4.0 ENVIRONMENTAL CONSEQUENCES

This section describes the environmental consequences of the alternatives—the ORNL/Y-12 Site (the preferred alternative), the PNNL/Hanford Site 100-H Area, and No Action. The analyses are based on the type of work and research activities that would be expected to occur on the FRC.

4.1 Oak Ridge National Laboratory/Y-12 Site

4.1.1 Earth Resources

4.1.1.1 Topography

FRC research activities would not change the landscape (e.g., large-area bulldozing, large-scale clearing, and excavation.) Activities to support site characterization, to obtain research-quality samples, and *in situ* research would not impact the general topography of the proposed FRC because of the small-scale nature (less than one acre) of the proposed activities.

4.1.1.2 Geology

The geology of Bear Creek Valley provides a unique opportunity to investigate the physiographic influence of geologic units affecting the movement and containment of contaminants. FRC research activities should provide researchers insight into how the stratigraphy of Bear Creek Valley affects vadose zone contaminants. Because of the small scale of investigations (less than one acre and to a depth of up to 75 feet), no impacts to the large geologic units are anticipated as a result of proposed FRC activities.

When drilling deep boreholes within the FRC, there would be a small potential for downhole migration of shallow contaminants to deeper zones through the borehole annular space. Procedures for preventing this migration, such as installing conductor casing across the unconsolidated zone and sealing with low permeability grout or bentonite prior to drilling to deeper bedrock zones, would be developed and described in the FRC management documents.

4.1.1.3 Soils

Soils within the FRC are previously disturbed and composed of man-made fill, alluvium and colluvium. Proposed FRC activities would disturb these soil types only in areas where drilling, boring, or well installation would occur. Uncontaminated soils would be redistributed around the test plot. Contaminated soils would be disposed of in accordance with site-specific management plans. Soils obtained as research-quality samples would be characterized for potential hazardous contaminants prior to laboratory experimentation. It is estimated that the quantity of soil removed as a result of research activities at a test plot would be small (1.2 cubic feet per bore hole; 10 to 15 bore holes per test plot); therefore, impacts to soils would be minimal.

4.1.2 Climate and Air Quality

ORR/Y-12 emissions are within standards set by the NAAQS for priority pollutants. Additional criteria pollutants generated as a result of small-scale temporary drilling, clearing, or other site development activities would be small and would not cause NAAQS violations. Because ORR/Y-12 is in an attainment area for all criteria pollutants, a conformity determination is not needed.

Drilling and associated sampling actions would not produce significant amounts of fugitive dust. It is expected that these activities would generate much less dust than normal farming practices in the surrounding Oak Ridge area. Because of the large number of existing wells and existing NABIR research support infrastructure at ORNL, it is anticipated that minimal land disturbance would be required.

Operation of the FRC would use standard, construction best management practices to mitigate any airborne releases. Common measures include application of water for dust suppression and to control fugitive emissions during drilling and other activities. It is anticipated that these and other construction/drilling management practices should adequately control fugitive emissions of radionuclides and any other air pollutants.

The release of radiological contaminants into the atmosphere at ORR/Y-12 occurs almost exclusively as a result of Y-12 plant production, maintenance, and waste control activities. In 1997, 46 of the Y-12 Plant's 58 stacks were considered major sources of radionuclide emissions (ORNL 1998). A major source, as defined under National Emissions Standard for Hazardous Air Pollutants (NESHAP) in 40 *CFR* 61, Subpart H, is a stack/vent that contributes more than 0.1 mrem per year to an offsite individual It is not anticipated that FRC activities would result in additional radiological contaminants being released into the atmosphere. Final project plans would be evaluated for applicability of these best management practices and the requirements of any permits would be complied with if required.

Other substances, which could be released into the air at the FRC, include oxygen, hydrogen, nitrogen, and methane. None of these are regulated under state or federal air regulations. Groundwater collected during the research activities would not be expected to contain pollutants that would volatize into the air.

No adverse impacts to air quality would be expected from FRC activities.

4.1.3 Water Resources

4.1.3.1 Surface Water

The primary surface water feature of the FRC in BCV is Bear Creek. Bear Creek is supplemented by other small tributaries and springs emanating primarily from the base of Chestnut and Pine Ridges. Surface water and spring samples collected during 1997 show that spring discharges and water in the upper reaches of Bear Creek contain many of the contaminants found in the groundwater.

FRC activities to support site characterizations, obtain research-quality samples, and perform *in situ* research would occur away from all surface waters including Bear Creek. Research generally would take place approximately 100 feet or more from Bear Creek. Research activities would be temporary and small in scale. Any potential runoff occurring as a result of ground-disturbing activities, coupled with rain events, would be reduced by implementing best management practices such as silt fencing at site-specific research areas within the FRC.

The potential exists that groundwater additives injected as part of *in situ* research at either the background or contaminated areas might pass through groundwater to the surface waters of Bear Creek. As described in Appendix A, small quantities of nontoxic tracers, nutrients, electron donors or acceptors, microorganisms, or other substances might be injected either in the background or contaminated areas of the FRC in accordance with state and federal regulations, best management practices and close monitoring of environmental conditions. While *in situ* research at the background and contaminated areas would provide additional information on groundwater flow paths and the movement of injected materials, sufficient information currently exists to permit estimates of potential impacts from the injection of these materials.

4.1.3.1.1 Tracers

To better understand groundwater flow paths and speed, nontoxic and nonpersistent tracers could be injected in concentrations ranging from less than 500 parts per million (ppm) to 10,000 ppm at both the background and contaminated areas of the proposed FRC. Examples of tracers that might be used include bromide, sodium chloride (NaCl), dyes such as fluorescein or rhodamine WT, noble gases (e.g., neon or helium), sulfur hexafluoride, microspheres, or bacteriophages (i.e., a virus that attacks bacteria.) In some cases, more than one tracer might be injected during the course of a field study. Injections at the background area would not occur in close proximity to Bear Creek (greater than 300 feet); however, because injections at the contaminated area could be as close as 100 feet to Bear Creek, the potential exists for tracers to reach the surface waters of Bear Creek.

At least two different types of tracers have been injected within 100 feet of Bear Creek in the proposed contaminated area within the past few years. In one test, approximately 9 gallons (40 L) of a magnesium bromide tracer was injected into a well that is about 100 feet from Bear Creek at a concentration of 10,000 ppm bromide (Watson and Gu 1998). The maximum concentration of bromide detected in a groundwater seep adjacent to Bear Creek was 0.57 ppm, for a dilution factor of 17,500. In Bear Creek, the dilution factor under dry base flow conditions was 70,000. In addition, the concentration of bromide in the seep returned to background levels within 15 days after the tracer was injected. In a second test, 500 grams of fluorescein dye was added to a 3 grams per liter solution of NaCl. Approximately 2,320 gallons (10,220 L) of the solution was injected into a dry part of the Bear Creek stream bed in an attempt to better understand the groundwater flow paths (Geraghty and Miller 1989). At downstream points in Bear Creek where the dye emerged, no adverse effects on aquatic life were detected. Finally, in a third test, 5 gallons of a 5,000 ppm bromide solution was injected less than 100 feet from the creek. Bromide was not detected above background levels in seeps or in Bear Creek (Watson 1999a). Based on these studies, tracers injected in the contaminated area appear to be greatly diluted, and in at least one case were not detectable in Bear Creek.

Different tracers move and diffuse into the groundwater at different rates. Therefore, the use of more than one tracer at the same time provides additional information about the subsurface than would be possible with only one tracer. The use of multiple tracers at one time would not be expected to result in an increased possibility that any of the tracers would reach Bear Creek. Multiple tracers have been used at another field site on the Oak Ridge Reservation. The results of this study suggest not only that the movement of one tracer is not affected by another, but that all of the tracers become diluted very quickly (Jardine et al. 1999a). Similarly, the use of multiple tracers at the contaminated area would be expected to result in movement and diffusion profiles for each tracer consistent with their individual movement and diffusion profiles.

Tracer concentrations would not be expected to exceed 10,000 ppm. This, coupled with the apparent high degree of dilution (matrix diffusion) of tracers in the groundwater of the contaminated area, and the lack of adverse environmental impacts to aquatic resources from much higher levels of a tracer, suggests that no environmental impacts would be expected from the injection of tracers. Further information on the proposed use of groundwater tracers at the FRC is available in Appendix A.

4.1.3.1.2 Electron Donors and Acceptors and Other Nutrients

To stimulate the activity and growth of microorganisms, electron donors or acceptors or other nutrients could be injected in concentrations ranging from 100 ppm to 1,000 ppm (i.e., 100 mg/L to 1,000 mg/L) at both the background and contaminated areas of the proposed FRC. Examples of electron donors that might be used include acetate, glucose, lactate, pyruvate, molasses, or biomass remnants (e.g., yeasts). Examples of electron acceptors that might be used include oxygen, nitrate, methane or sulfate. Other nutrients might include nitrogen and phosphorus. Injections at the background area would not occur in close proximity (within 300 feet) to Bear Creek. However, because injections at the contaminated area could be as close as 100 feet to Bear Creek, the potential exists for electron donors, electron acceptors, and nutrients to reach the surface waters of Bear Creek. Should they reach Bear Creek in sufficient concentration, they could stimulate microbial populations in the vicinity of the point of entry.

While there have been no direct injections of electron donors or acceptors, or nutrients at either the background or contaminated areas, there has been an addition of an electron donor (specifically a carbon source) to the subsurface in the contaminated area. During construction of one of the two permeable reactive barriers in the contaminated area, approximately 80,000 gallons of a guar gum biopolymer slurry was pumped into the trench to keep the side walls from collapsing. Once the construction effort was completed, an enzyme was added to the subsurface to break down the guar gum. This resulted in an extremely large source of carbon for the subsurface microbial community and a source that also moved with the groundwater and seeped into Bear Creek (Watson and Gu 1999). Guar gum entering the creek formed a sheen that extended less than 100 feet downstream. In addition, there was a strong sulfur smell (due to the growth of sulfate-reducing bacteria) that lasted for several months. However, no long-term ecological impacts were observed in Bear Creek from this discharge (Watson 1999b). While this situation suggests that at sufficient concentration electron donors could reach Bear Creek, the amount of electron donors that might be added at the contaminated area would be thousands of times less than the amounts that were added in this situation (Watson 1999b).

More typical of the amount of electron donors that might be added to the contaminated area would be the amounts used in a recent field study at a contaminated site in Schoolcraft, Michigan (Dybas et al. 1997). In the Schoolcraft study, both acetate and microorganisms were added to a sandy aquifer to degrade carbon tetrachloride. Initial acetate concentrations were 100 ppm, but subsequent analyses indicated that only 50 ppm was sufficient to degrade the carbon tetrachloride. Based on data collected from downstream monitoring wells, acetate concentrations were at background within about three feet (three meters) of the injection well. Therefore, it appears that the bacteria used the acetate as a carbon source while degrading the carbon tetrachloride, and that the acetate was completely used up within about three feet of the injection point (Criddle 1999a).

There was a possibility that the microbial community (the mix of species of microorganisms in a given volume of the sediment) might be permanently altered, or that the effect of the additions might extend some great distance from the injection point. To study this, the scientists involved in the Schoolcraft study have been monitoring conditions in downstream wells for almost two years. While changes have been detected in microbial communities downstream from the injection well, these changes appeared only up to a distance of about three feet from the injection well and they have been stable for almost two years (Criddle 1999b). In addition, it appears that as the concentration of the acetate decreases with distance from the injection point, the microbial community appears to return to the original community. The phenomena of localized changes to the microbial community apparently is not that unusual. Two recent studies at two different field sites likewise discuss shifts in the mix of species present in contaminated soils and groundwater from that present in nearby uncontaminated areas (Konopka et al. 1999, Rooney-Varga et al. 1999). In both studies, changes in the microbial community were again attributable only to the presence of contamination (i.e., the contaminant or nutrient addition had to be present to result in changes in the microbial community). Taken together, these studies suggest that when nutrients or contaminants are “added” to the subsurface, the microbial community structure changes, but the changes are localized and occur only in the presence of the addition (i.e., a carbon source, a contaminant, etc.)

Injection of electron donors or acceptors or nutrients into the contaminated area would be at levels more consistent with those used at the Schoolcraft site rather than the levels encountered during the guar gum situation. For example, as part of another program, ORNL scientists are planning to inject less than 700 ppm of lactate (an electron donor) to stimulate the microbial community in another field site on the Oak Ridge Reservation to examine whether cobalt contamination can be mitigated (Jardine 1999b; Brooks et al. 1999). Another reason for injecting only low levels of electron donors or acceptors or nutrients is that at high concentrations, the injection of electron donors or acceptors or nutrients could overstimulate microbial reproduction and result in well clogging. Consistent with the findings from the Schoolcraft study, electron donors or acceptors or nutrients injected into the contaminated area would not be expected to migrate the minimum 100 feet to Bear Creek. Rather, they would be used by native microorganisms and would be undetectable within 25 feet of the injection point. Further information on the proposed use of electron donors and acceptors and nutrients at the FRC is available in Appendix A.

4.1.3.1.3 Microorganisms

To determine whether it might be feasible to add microorganisms to a contaminated subsurface environment, a small quantity (2×10^7 colony forming units per ml [cfu/ml]) of native or non-native microorganisms could be injected into the background and contaminated areas of the proposed FRC. Native microorganisms would be isolated from the contaminated area and then reinjected. Reinjection of native microorganisms would not be expected to be of concern either at the background or contaminated area. Non-native (but not genetically engineered) microorganisms might be obtained from some other field site, but then injected at both the contaminated and background areas. For the non-native microorganisms, a possible consequence of injecting these microorganisms would be the possible movement of the non-native bacteria through the groundwater to Bear Creek.

Because no injections of bacteria have been undertaken either at the background or contaminated areas of the proposed FRC, or on the Oak Ridge Reservation, it is difficult to speculate how far non-native microorganisms might move either in the background or contaminated areas. However, there have been a number of recent field site remediation studies involving the injection of non-native microorganisms into a variety of geologically different, and contaminant-specific, subsurface environments (Bourquin et al. 1997, Dybas et al. 1997, Stefan et al 1999). Results from these studies could be extrapolated to the background and contaminated areas of the proposed FRC.

Non-native bacteria (10^9 cells/mL) were injected into a sandy groundwater aquifer at a contaminated site in Wichita, Kansas on two separate occasions (Bourquin et al. 1997). In the first instance, bacteria only were injected. Just 0.005% of the injected bacteria were recovered in an extraction well that was less than one foot (30 centimeters) away. Even though this was a sandy aquifer, the bacteria hardly moved. In the second instance, glucose and other nutrients were added along with the bacteria in a pulsed mode. The bacteria moved only slightly farther than in the first test. Overall, the results suggest that 98% of the bacteria injected moved less than one inch (two centimeters) from the point of injection (Reardon 1999). A second study involving the injection of a non-native strain into a sandy aquifer at Schoolcraft, Michigan, has already been described in section 4.1.3.1.2 (Dybas et al. 1997). The results suggest that non-native bacteria do not move great distances, most likely because the carbon source (acetate) concentrations decrease to background within a few yards. Both of these studies suggest very limited movement of microorganisms in sandy aquifers.

In contrast, a third study involved the injection of a non-native strain of bacteria (at 1×10^{11} cfu/ml) along with oxygen into a contaminated silty sand aquifer in Pennsauken, New Jersey. The bacteria were found to move as much as 65 feet in 20 days (Stefan et al. 1999). For this site, movement was needed to get dispersal of the bacteria to large parts of the contaminated area; in fact, the strain of bacteria used was specifically selected because it did not adhere to aquifer solids. Yet, in spite of the adhesion-deficient character of this strain of bacteria, most of the bacteria remained concentrated near the injection well.

The studies cited suggest that non-native microorganisms that would be used at the contaminated area would not move any great distance from the point of injection unless they were adhesion-deficient. Even so, the highest concentrations of microorganisms would be expected to remain near the injection well. Finally, the concentrations of microorganisms used in all of these studies and the amounts injected were used in attempts to achieve site remediation. Because site-remediation experiments at the contaminated area are not part of this action, the concentrations and amounts of microorganisms that would be injected would be much less than in these studies. Taken together, non-native microorganisms would not be expected to reach Bear Creek. Further information on the proposed use of microorganisms at the FRC is available in Appendix A.

4.1.3.1.4 Other Substances

Two classes of other substances that could be injected at the background or contaminated areas are biosurfactants and chelators. To examine the influence of surfactants produced by certain microorganisms (biosurfactants) on contaminant characteristics and on the microbial community, biosurfactants could be injected. Biosurfactants would include rhamnolipids, polysulfonates, and polyalcohols.

The injection of a biosurfactant either into the background or the contaminated areas might be conducted to examine the influence of the biosurfactant on native microorganisms, on the interactions between native microorganisms and the contaminants, or for other reasons. Because biosurfactants are biodegradable, they would not be expected to be persistent if injected, and they would be degraded within a short distance of the injection point.

To investigate the mobilization and immobilization of metals and radionuclides, chelators could be injected in the background and contaminated areas. Typical chelators would include ethylenediaminetetracetic acid (EDTA), nitrilotriacetic acid (NTA), Natural Organic Matter such as humics, or quinones. Injection concentrations would be expected to range from 100 ppm to 1,000 ppm, although most injections would be at the lower concentrations. Movement of these substances through the aquifer to Bear Creek should be considered.

Metals and radionuclides would be expected to complex more readily with chelators than with aquifer solids, and the resulting metal or radionuclide/chelate complexes would therefore become more mobile in the groundwater. However, results from an on-going study at another field site on the Oak Ridge Reservation suggest that at least for some radionuclide/chelate complexes, sediment minerals outcompete the chelator and complex with the radionuclide (Jardine et al. 1999b). The study was conducted at a field site with geologic and chemical characteristics that are similar to those at the contaminated area. In this study, injected radionuclide/chelate complexes were dissociated within 60 feet of the injection point and the radionuclides were attenuated by the sediments. The results suggest that radionuclide/chelate complexes that might be injected at the contaminated area might not remain as complexes (and thereby promote mobilization), but that they might be broken apart such that the radionuclide would be immobilized after a short distance and would not reach Bear Creek.

4.1.3.2 Floodplain and Wetlands

Bear Creek traverses the length of the proposed FRC. Thus, it includes associated sections of the 100-year floodplain. In 1993, DOE published a "Notice of Floodplain/Wetlands Involvement for Environmental Restoration and Waste Management Activities at the DOE's Oak Ridge Reservation; Oak Ridge, TN, (58 FR 51624)." In 1996, the "Floodplain Assessment for Site Investigation Activities at the Oak Ridge Y-12 Area of Responsibility" (DOE 1993) was published. The assessment addressed general construction, sample collection, and environmental monitoring. In addition, the assessment considered both intrusive and nonintrusive activities. On March 3, 1997, DOE issued a "Floodplain Statement of Findings for Site Investigation Activities at the Oak Ridge Y-12 Plant Area of Responsibility." The Statement of Findings states, "Most of the activities addressed by the floodplain assessment will result in no measurable impact of floodplain cross-sections or flood stage, and thus do not increase the risk of flooding." The activities proposed for the FRC fall within the terms of the Notice of Floodplain and Wetlands Involvement. The Notice of Involvement, a summary of the Floodplain Assessment, and the Statement of Findings are included in Appendix D.

The only FRC activities expected to occur within floodplain areas would be well drilling and monitoring (e.g., installation of piezometers). Typical installations of wells or piezometers, using for example, 2 foot by 6 inch (0.41 meter by 15.24 centimeter) diameter protective casing and 4 foot by 3 inch (0.82 meter by 7.62 centimeter) diameter bollards with a concrete pad 3 inches high and 2 feet long (7.62 centimeters by .41 meters) may reduce the cross-sectional area of the floodplain by 1.64 square feet (.5 square meters). This reduction in volume of even several wells would be negligible within the total cross-sectional area of the floodplain. Well and piezometer construction therefore, would have a negligible impact on the floodplain. The well pads would minimize the erosion potential of the wells and bollards.

Procedures for preventing migration of contaminants down boreholes would be developed and described in the FRC management documents. These procedures would include sealing the upper few feet of shallow boreholes with low permeability bentonite or grout and installing conductor casing across the unconsolidated zone and sealing with grout or bentonite prior to drilling to deeper bedrock zones.

At the appropriate time, wells would be plugged (backfilled with clean soils) and abandoned. Well plugging and abandonment would result in the removal of surface structures (e.g. wellheads) and restoration of the former grade. This activity would have little impact on floodstage or floodplain cross-sectional area, nor would there be an increase in erosional potential since the wellhead and other surface equipment would be removed and the site restored to the original grade.

No structures or facilities would be constructed in the floodplain. Movement of heavy equipment through the floodplain would be a temporary occurrence and would not impact the capacity of the floodplain to store or carry water. The impacts from the movement of heavy equipment alone is expected to be negligible. To the extent practicable, staging areas and access roads would be temporary, construction would be limited to periods of low precipitation, and stabilization and restoration of the affected areas would be initiated promptly.

Wetlands are interspersed throughout the proposed FRC. Many are often small and are classified as palustrine forested, shrub-scrub, or emergent wetland types (Cowardin et al. 1979). Because FRC research would take place on small test plots (less than one acre), it is anticipated that any wetlands found in proposed selected research areas could be avoided. In addition, the limited ground-disturbing activities associated with FRC research should preclude damage to adjacent wetlands that might be in proximity to selected research areas. The U.S. Army Corps of Engineers (USACOE) and TDEC have regulatory responsibility for wetland management and for mitigation of impacted resources. FRC management would consult with USACOE and TDEC if the potential for impacts to wetlands would to occur.

4.1.3.3 Groundwater

The primary geologic units of interest in the proposed FRC are the Nolichucky Shale (low permeability) and Maynardville Limestone (high permeability). The flow of shallow interval groundwater (up to 100 feet) in the limestone occurs through a system of interconnected fractures and solution conduits and cavities. Most groundwater flow in the shale formation occurs in the shallow interval and is oriented along geological strike and is very predictable. The shallow interval groundwater in both geologic units discharges to Bear Creek or its tributaries. Any additives to the groundwater introduced as a result of FRC research activities (e.g., nontoxic chemical tracers, nutrients, or microbes) might also reach surface water including Bear Creek. It is estimated that groundwater flow rates are as much as seven feet in 24 hours. Fate-and-effect information would be determined prior to initiation of FRC applications that include groundwater additives. Permeable reactive barriers have been constructed and installed by DOE EM-40 parallel and adjacent to Bear Creek. For some FRC studies in the vicinity of these barriers it might be possible to use the barriers to contain FRC groundwater additives.

The primary sources of groundwater contamination within the proposed FRC are the S-3 Disposal Ponds and the Boneyard/Burnyard (BY/BY). Both source areas are underlain by Nolichucky Shale. Contaminants within the proposed contaminated area include heavy metals, radionuclides, VOCs, and inorganics. The primary purpose of FRC activities would be to investigate these contaminants *in situ,* thus attempting to prevent the migration of contaminants offsite. Consequently, a possible net positive impact to groundwater is anticipated.

When drilling boreholes for the FRC, there would be a small potential for downhole migration of shallow contaminants to deeper zones. Procedures for minimizing migration of contaminants during drilling and abandonment of boreholes and wells would be developed and described in the FRC management documents. These procedures would include sealing the upper few feet of shallow boreholes with low permeability bentonite or grout and installing conductor casing across the unconsolidated zone and sealing with grout or bentonite prior to drilling to deeper bedrock zones.

Groundwater pumping activities at an FRC test plot (e.g., pump/slug and other pumping tests, and tracer experiments) would not collect more than 20,000 gallons (76,000 L) of groundwater per year. In years when long-term pumping tests were not performed, less than 2,000 gallons (7,600 L) of groundwater would be collected. Similar volumes would be collected at the background site. Contaminated groundwater would be collected in 55-gallon drums or other suitable containers. Tanker trucks with 10,000- to 20,000-gallon (38,000- to 76,000-L) capacity could also be used during long-term pumping tests with contaminated groundwater being transported to the nearby Y-12 West End Treatment Facility (WETF). The state also might allow discharge of contaminated water to infiltration basins as long as there would be no direct discharge to Bear Creek. In this case, treatment would be deferred to final cleanup under CERCLA. Clean groundwater collected from the background site would be released to the ground.

As described in Section 4.1.3.1, the introduction of nontoxic tracers, nutrients, electron donors and acceptors, microorganisms and other substances might have a local effect (several meters) on groundwater characteristics, but the overall groundwater quality and flow within Bear Creek Valley would not be affected. Any purged groundwater from drilling operations or well clean-out would be collected and disposed of as previously described.

Injection of small quantities of tracers, electron donors and acceptors and nutrients, microorganisms and other substances into the groundwater is part of the proposed action. Sufficient information already exists to permit estimates of the potential impacts of the injection of these materials into the groundwater.

4.1.3.3.1 Tracers

As described in Section 4.1.3.1.1, to better understand groundwater flow paths and speed, nontoxic and non-persistent tracers could be injected in concentrations ranging from 500 parts per million (ppm) to 10,000 ppm at both the background and contaminated areas of the proposed FRC. Worth considering would be potential alterations in the groundwater chemistry from the injection of tracers in both the background and contaminated areas.

For most studies at both the background and contaminated areas, the tracers that would be used would be non-reactive. That is, the chemical structure of the tracer that would be injected would be the same structure as the chemical that would be extracted in downstream wells. It is possible that reactive tracers such as bacteriophages or microspheres might be injected into both the background and contaminated areas. While these reactive tracers would be non-toxic, they could stick to mineral particles, colloids suspended in the groundwater, bacteria, and possibly even contaminants if injected into the contaminated area. However, because of the low concentrations and limited amounts that would be injected, changes to the groundwater chemistry would be expected to be localized to 30 or 40 feet from the injection point. Due to the apparent dilution processes operating in the subsurface at the background and contaminated areas, as described in Section 4.1.3.1.1, greater degrees of change to the groundwater chemistry would be expected close to the injection point, but these changes would drop off with distance from the injection point.

4.1.3.3.2 Electron Donors and Acceptors and Nutrients

As discussed in Section 4.1.3.1.2, to stimulate the activity and growth of microorganisms, electron donors or acceptors or other nutrients might be injected in concentrations ranging from 100 ppm to 1,000 ppm (i.e., 100 mg/L to 1,000 mg/L) at both the background and contaminated areas. Because of the addition of electron donors and acceptors or nutrients, it is possible that the groundwater chemistry might be directly or persistently changed, or that certain species of microorganisms might be stimulated to cause changes to the groundwater chemistry.

It is possible that there may be some localized changes in the groundwater chemistry of the background and contaminated areas due to the addition of electron donors or acceptors or nutrients. However, in light of the small quantities that might be added, and in light of the expectation that native microorganisms would use these electron donors or acceptors or nutrients fairly quickly, there should not be any sustained impact to the groundwater chemistry. Worth considering would be the impact from the injection of electron donors or acceptors or nutrients into the contaminated area. In this case, a change in groundwater chemistry could conceivably lead to a permanent change in the microbial community, or to the unwanted mobilization of a contaminant.

Again, there have been no direct injections of electron donors or acceptors, or nutrients at the contaminated area. However, the addition of an electron donor (guar gum) during the construction of the two permeable reactive barriers serves as a good example of what consequences might be expected (Watson and Gu 1999). As described in Section 4.1.3.1.2, the degradation of guar gum by subsurface microorganisms resulted in a strong sulfur smell along Bear Creek. Because the sulfur smell lessened and disappeared within a few months, it is most likely that the microbial populations involved in degrading the guar gum died out because they no longer had a food source. The reduction in smell thereby suggests that the microbial populations returned to their pre-exposure community structure. As for the possible mobilization of a contaminant in that area, contaminant concentrations were lower in wells downstream from the guar gum “plume” (Watson and Gu 1999).

4.1.3.3.3 Microorganisms

To determine whether adding microorganisms to a contaminated subsurface environment would impact contaminant mobility, a small quantity (2×10^7 cfu/ml) of native or non-native microorganisms might be injected into the background and contaminated areas of the proposed FRC. Native microorganisms would most likely be strains that would be isolated from the contaminated area and reinjected. Non-native (but not genetically engineered) microorganisms might be obtained from some other field site, but then injected at one or both the contaminated and background areas. For the non-native microorganisms, a possible consequence of injecting these microorganisms would be a possible, very localized permanent shift in the microbial community to one dominated by the non-native microorganism, or a possible permanent change in the groundwater chemistry. These possible changes would be limited to a few feet from the injection point.

As discussed in section 4.1.3.1.3, at the low injection concentrations that would be used, the microorganisms would not be expected to be present in a large area of the groundwater, and therefore they would be unlikely to change the groundwater chemistry of large areas.

4.1.3.3.4 Other Substances

As discussed in Section 4.1.3.1.3, two classes of other substances that might be injected at the background or contaminated areas are biosurfactants and chelators. Again, injection concentrations would be expected to range from 100 ppm to 1,000 ppm, although most injections would be at the lower concentrations.

Based on the discussion of the results from work at another Oak Ridge Reservation field site, as presented in Section 4.1.3.1.3, it does not appear that injection of chelators would significantly affect the groundwater characteristics of the contaminated area (Jardine et al. 1999). Chelators would not be added to the background area.

Also, as discussed in Section 4.1.3.1.3, the injection of biosurfactants in the background and contaminated areas would not be expected to affect a large area of the subsurface or be persistent. For these reasons, no large effect on groundwater would be anticipated.

4.1.4 Ecological Resources

Ecological resources evaluated for impacts include sensitive terrestrial and aquatic species, protected natural areas, and managed wildlife resources. These resources are discussed in the following paragraphs.

4.1.4.1 Terrestrial Resources

As described in Section 3.0, the proposed contaminated area and background area would be located within 200 acres of the BCV. However, because of the type of research preferred, only small portions of the FRC would be utilized. It is estimated that most research actions would have a footprint of less than one acre and likely would be situated in areas in which site clearing has occurred or past construction activities have already changed the predominant landscape. As a result, it is anticipated that few terrestrial resources would be impacted by FRC-related activities. In the event that previously unknown sensitive resources were discovered during FRC planning activities (e.g., site plan evaluations or site design construction), efforts to avoid impacts would be conducted and specific research sites would be moved away from sensitive resources.

As described in Appendix E, the U.S. Fish and Wildlife Service has indicated two federally listed endangered species, the gray bat (*Myotis grisescens*) and the Indiana bat (*Myotis sodalis*), may inhabit an area near the proposed FRC. Mistnetting has been conducted specifically for bats in the East Fork Poplar Creek basin (ORR personal communication). According to information provided by ORNL and Dr. Michael J. Harvey of Tennessee Technological University in Cookeville, Tennessee, significant mistnetting efforts were conducted in the East Fork Poplar Creek watershed, including Bear Creek, in 1992 and 1997. The 1997 efforts resulted in the collection of 14 bats representing six species. No Indiana bats or gray bats were captured in the 1997 efforts. The 1992 efforts were not as extensive as those in 1997, and four bats representing two species were collected. It was noted in both surveys that significant potential habitat for the Indiana bat existed in the East Fork Poplar Creek watershed. An Indiana bat was collected on the ORR in the 1950s, and survey efforts on the ORR have not been extensive enough to definitely establish or refute current use by this species.

In 1994, a moribund gray bat was found in the Beta-3 building of the Y-12 complex, near areas proposed for siting of the FRC. The specimen was identified by researchers at the University of Tennessee and submitted to the U.S. Fish and Wildlife Service. The condition of this juvenile specimen indicated it may have utilized the building as roosting habitat. Other suitable buildings on the ORR may also serve as roosting habitat for a variety of bat species. Little Turtle Cave, located on the ORR near the Y-12 plant, was surveyed by the Tennessee Department of Environment and

Conservation in 1996. Ten male gray bats were found in the cave and it was determined that the cave could serve as a hibernaculum for a bachelor colony.

In February 2000, Oak Ridge National Laboratory completed an Assessment and Evaluation of Potential Roosting and Foraging Habitats for the gray and Indiana bats (Appendix G.). The assessment was conducted in the BCV watershed, the location of the proposed FRC. The assessment did not include the EFPC watershed because the FRC would not be located or have an impact on the EFPC watershed. The assessment concluded that the proposed FRC would not adversely affect either bat species. Also, since no proposed or designated critical habitats are present on the site, none would be affected. The Fish and Wildlife Service concurred with this conclusion in a letter dated February 10, 2000 (Appendix E).

Within the contaminated area and background area, no other threatened or endangered species or critical habitat listed, or proposed to be listed, by the Fish and Wildlife Service is known to be present. In the event that a rare or sensitive species were identified during FRC planning activities, every effort to adjust specific research sites out of any area of concern would be made. NABIR would have the flexibility of adjusting field activities to new locations to allow for the protection of potentially sensitive habitats.

The entire length of Bear Creek, from its beginning within the proposed contaminated area through the background area, is designated an Aquatic Natural Area. In addition, much of the land adjacent to the proposed contaminated area and background area has been designated part of the Oak Ridge National Environmental Research Park (NERP). A portion of the proposed contaminated area (the Y-12 area) and the entire background area is contained within the NERP. Activities needed to support site characterizations, to obtain research-quality samples, and *in situ* research would not impact or interfere with these designated areas. Any ongoing research projects in areas considered part of the National Environmental Research Area or Reference Area would be avoided.

ORNL manages much of its land for game species including land within the proposed contaminated area and background area. As such, portions of these areas are utilized during hunting seasons. Efforts would be made to limit FRC activities during seasonal hunting periods. In addition, specific FRC field research areas would not be placed in areas popular with hunters. As a result, no impacts to managed wildlife resources would be anticipated.

4.1.4.2 Aquatic Resources

Much of the proposed contaminated area and background area are situated either within the riparian zone of Bear Creek or adjacent to it. Bear Creek has been quantitatively monitored and has been designated as having a degraded fish community especially in headwater locations. Most of the proposed contaminated area and background area are located at the headwaters of Bear Creek. Several minnow species were determined to be the predominant fish species in these upstream portions of Bear Creek and are indicative of a low species diversity (Southworth et al. 1992, Hinzman et al. 1995). Benthic invertebrate fauna collections show a similar pattern with a diverse benthic fauna well established at downstream locations (outside the proposed FRC) and a depauperate benthic community within the proposed contaminated area and background area adjacent to Bear Creek.

Recent research has indicated an improvement in species diversity within the upper reaches of Bear Creek; however, the fish population is still considered impaired. The Tennessee dace, a minnow, is listed by the Tennessee Wildlife Resource Agency as a sensitive species in need of management, and is the only sensitive species likely to be encountered in the proposed FRC study area. The dace was found at all sites including those at the headwaters of Bear Creek. As described in Section 4.1.3.1, the small scale of disturbance required to conduct FRC research within the contaminated area and background area, and the limited quantities of materials that would be injected should preclude any potential for impact. In addition, permeable reactive barriers have been constructed and installed by DOE Environmental Management parallel and adjacent to Bear Creek in the proposed contaminated area. For some FRC studies in the vicinity of these barriers it might be possible to use the barriers to contain FRC groundwater additives.

While it is not anticipated that FRC-related activities would have any impact on aquatic resources, the sensitive status of the Tennessee dace in Bear Creek makes it likely that additional measures to protect the species might be required if a specific research plot is chosen in proximity to Bear Creek. Any such additional measures would be determined and documented during the project's environmental review process. Other evaluation could include conducting monitoring activities to determine the pre-existing condition of specific reaches of Bear Creek in proximity to selected research plots. Periodic monitoring by ORNL of aquatic and benthic resources within adjacent reaches might be conducted to determine if FRC activities would result in impact to the Tennessee dace or its forage base.

4.1.5 Archaeological, Cultural, and Historic Resources

According to the Tennessee State Historic Preservation Officer, no cultural resources have been identified within the proposed contaminated area and background area (Appendix E). Several historic sites exist in proximity to the proposed FRC but none are located within its boundaries. Because the scale of potential disturbance would be small (less than one acre) and research would take place in previously disturbed areas, it is unlikely that previously unknown historic resources would be discovered during activities needed to support site characterizations, to obtain research-quality samples, or *in situ* research. If in the course of conducting FRC activities, archaeological, cultural, or prehistoric resources were discovered, the state historic preservation office would be notified and measures would be initiated to eliminate impact.

4.1.6 Land Use, Recreation, and Aesthetic Resources

The proposed contaminated area and background area lie entirely within the Bear Creek Valley at ORNL. Land uses within the BCV include developed areas such as those near the Y-12 plant, the S-3 Ponds Site, waste control areas that are open and highly visible, and closed forested areas that are part of the Y-12 reservation. While there may be hunting activities in these areas several times during the year, access is restricted.

New facilities that would be needed include two field office/laboratory trailers—one to be located at the contaminated area and one at the background area. The only intrusion expected to impact existing land uses would be the placement of the trailers to support activities near the location of discrete research areas within the FRC. In all cases, the trailer would be part of an already developed area and would be compatible with the immediate surroundings. In the background area, some clearing would need to be done to place a trailer in proximity to the research areas. However, every effort would be made to locate the trailer in an area that has been previously disturbed (e.g., powerline right of way or past area of research). Activities undertaken to support site characterizations, obtain research-quality samples, and conduct *in situ* research might result in short-term impacts to visual aesthetic resources, especially during the site characterization phase of research. Drill rigs, an increase in site personnel, and support vehicles might be needed.

Recreational uses in the area surrounding the ORR include fishing, boating, hunting, hiking, and camping. Access to the ORR is controlled, and recreational uses within ORR are limited to controlled hunts during certain seasons. Within the proposed contaminated area and background area, deer and turkey hunts are held annually except in areas immediately adjacent to the Y-12 plant and its disposal areas in Bear Creek Valley. Because these seasonal activities are scheduled well in advance, FRC management would plan to minimize activities during hunting seasons to avoid the potential for impact.

Visual/aesthetic resources range from relatively closed forests to developed areas that include waste control areas and storage yards for scrap metal and other materials. The only visual intrusions anticipated as a result of implementation of FRC research would be the placement of two support trailers and the temporary placement of drilling rigs and other equipment near specific research sites in the proposed contaminated area and background area. Efforts would be made to locate trailers and equipment in areas previously disturbed to limit the potential for visual intrusion. No impacts are expected from FRC activities.

4.1.7 Socioeconomic Impacts

As stated in Section 3.1.7, the labor force in the four county area in 1998 was 280,190. The work force for the proposed FRC is anticipated to be small: possibly a staff of up to six individuals, some of whom would be part-time employees of the FRC. Researchers from ORNL, other national laboratories, universities, and other research institutions would visit the proposed FRC to conduct experiments and collect samples. The numbers of visitors at any one time would be small, but could be as many as 24 on occasion. Visiting staff and scientists would contribute in a beneficial manner to the local economy by staying in local hotels and using local services. There would be no negative impact to the socioeconomics of the Oak Ridge area as a result of FRC activities.

4.1.8 Human Health

As described in Appendix C, ORNL would develop an overall Management Plan for the FRC that would explain the goals and objectives of the FRC, roles and responsibilities of FRC staff, procedures for investigators to follow, and procedures for storage of material and waste disposal. To address potential ES&H issues associated with human health and environmental protection, ORNL would also develop the following plans:

- an action-specific health and safety plan detailing potential pathways of exposure and best management practices to reduce those hazards;
- a characterization and waste control plan;
- a contingency plan to address offsite migration of any nutrients or other chemicals used in conjunction with NABIR research activities; and
- a site closure plan.

Although important for operating the proposed FRC, this EA seeks to evaluate potential impacts to human health and the environment prior to selecting the FRC. For purposes of this evaluation, health and safety issues to be evaluated include:

- exposure to contaminated soils and groundwater,
- occupational hazards associated with a drilling/construction site, and
- hazards associated with accidental releases of stored liquid chemicals or materials.

4.1.8.1 Exposure to Contaminated Soils and Groundwater

There are two primary human health issues associated with exposure to contaminated soils and groundwater from the contaminated area at ORNL. The first issue is potential radiation exposure from groundwater and soils/sediments with radioactive contaminants. The second issue is potential chemical toxicity of the contaminants that may be in groundwater and soils/sediments from the contaminated area.

Because of the proposed nature of operation, potential exposures could occur during drilling and sampling operations in the contaminated area and/or in the processing and analysis of samples obtained from the contaminated area. Such exposures could be to FRC staff or to scientists. To mitigate these potential exposures, a combination of personal protective equipment, personnel training, physical design features, and other controls (e.g., limiting exposure times) would be required to ensure that worker and visitor protection would be maintained for all proposed FRC-related activities. In addition, OSHA regulations that pertain to construction and well installation would be adhered to in all situations.

For the majority of scientists, potential exposures would be from samples obtained from the contaminated area and would occur while they performed sample processing or analyses. For scientists and FRC staff, who would be involved with drilling and sampling operations, potential exposures would be from accidents associated with drilling and sampling operations in the contaminated area.

Title 10, *CFR*, Part 835, "Occupational Radiation Protection," establishes radiation protection standards, limits, and program requirements for protecting workers and the general public from ionizing radiation resulting from the conduct of DOE activities. For workers, 10 *CFR* 835 requires a 5-rem per year dose limit. For the general public, 10 CFR 835 requires a 100 millirem (mrem) per year dose limit. In addition, it requires that measures be taken to maintain radiation exposure as low as reasonably achievable. The 5-rem dose limit would be applicable to FRC staff and those involved in drilling and sampling operations in the contaminated area. The 100 mrem dose limit would be applicable to scientists who process or analyze both soil/sediment and groundwater samples from the contaminated area.

For purposes of this EA, the maximum allowable exposure to FRC staff was assumed to be 100 mrem per year. In addition, because potential exposures most likely would be during drilling and sampling operations, the following analysis of potential doses was assumed to be for hypothetical workers involved in drilling and sampling operations.

Doses to workers were bounded by evaluating a "bounding analysis" scenario, in the absence of any existing data on worker doses for this kind of work in the field. Workers were assumed to spill small amounts of soil/sediment (1 gram of contaminated soil/sediment five times per year for a total of 5 grams) or groundwater (1 milliliter of contaminated groundwater five times per year for a total of 5 milliliters) on themselves during the course of sample extraction and processing. To maximize the potential dose, it was further assumed that the workers did not wash off the contamination, but actually ingested it.

Radionuclide ingestion was calculated from the average measured activity values for U-233, U-235, U-238, Pu-238 and Pu-239 in soil and groundwater (see Table 4-1). The measured data in Table 4.1 were obtained from the Remedial Investigation report for Bear Creek Valley (DOE 1997a). Totals were based on a yearly consumption of 5 grams of soil/sediment and 5 milliliters of groundwater. Dose factors for the Committed Effective Dose Equivalent were taken from the EPA report, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion, Federal Guidance Report No. 11" (EPA-5201/1-88-020), published in September 1988.

For the soil/sediment ingestion pathway, the total dose (for all radionuclides) came to less than 0.01 mrem/year, which is 10,000 times less than the limit of 100 mrem/year allowed for members of the public under 10 *CFR* 835, Section 208. The groundwater ingestion pathway is threes times smaller, with a total dose of approximately 0.003 mrem/year.

To estimate the total potential risk to workers from this "bounding analysis" exposure scenario, it was further assumed that the workers were exposed during the entire life of the project, which is ten years. The combined annual dose from both the soil and groundwater ingestion pathways was 1.26E-02 mrem per year (9.47E-03 + 3.09E-03). Over the ten-year lifetime of the project, the total dose was ten times that amount, or 1.26E-01 mrem. The lifetime fatal cancer risk is calculated by multiplying this ten-year dose by the dose-to-risk conversion factor of 4E-04 deaths per person-rem (NRC 1991). This calculation yields a lifetime risk of 6.28E-08, or roughly six in 100 million.

Table 4-1 Human Health Exposure Rates

Soil Ingestion (5 g/y)						**Groundwater Ingestion (5 ml/y)**		
Radionuclide	**mrem/ pCi**	**pCi/g (avg)**	**Total pCi**	**mrem/y**		**pCi/l (avg)**	**Total pCi**	**mrem/y**
U-233	2.89E-04	2.1	10.5	3.03E-03		660	3.3	9.54E-04
U-235	2.66E-04	0.12	0.6	1.60E-04		68.8	0.344	9.15E-05
U-238	2.55E-04	4.6	23	5.87E-03		1601	8.005	2.04E-03
Pu-238	3.20E-03	0.02	0.1	3.20E-04		0	0	0.00E+00
Pu-239	3.54E-03	0.005	0.025	8.85E-05		0	0	0.00E+00
			TOTAL:	**9.47E-03**			**TOTAL:**	**3.09E-03**

Although radioactive exposure would not be a problem, the potential chemical toxicity of the contaminants in the soils/sediments and groundwater from the proposed contaminated area also needs to be considered. Because the proposed contaminated area would be within a CERCLA site, contaminant concentrations are evaluated according to CERCLA standards. Based on the recent Remedial Investigation (RI) of Bear Creek Valley, the concentrations of a variety of radioactive and organic contaminants and other groundwater constituents within the contaminated area are of regulatory concern (DOE 1997a). Examples include lead, strontium, uranium, nitrate, acetone, and trichloroethylene.

Not all of these contaminants of concern are present in all existing wells within the contaminated area. However, they are found often enough to warrant caution and protection from exposure. For example, lead has been detected in 61 out of 82 wells within the Bear Creek Valley, and trichloroethylene (TCE) has been detected in 57 out of 83 wells within the Bear Creek Valley (DOE 1997a). Also, although these wells are in Bear Creek Valley, they are not necessarily within the proposed contaminated area. Finally, the concentration of these contaminants varies from one well to another. For lead, the maximum concentration detected was 0.23 mg/L, but the mean of the medians concentration was 0.0046 mg/L. For TCE, the maximum concentration detected was 460 mg/L, but the mean of the medians concentration was 21.9 mg/L. The specific contaminants of concern are identified in the RI report.

Most of the contaminants of concern would have an impact on human health only if ingested (i.e., by drinking contaminated groundwater or by swallowing contaminated soils/sediments). A few contaminants could have an impact if they contact skin. To guard against skin contact, personal protective equipment would be employed. Because groundwater from the contaminated area would not be used for drinking water, and because scientists would not consider drinking any groundwater collected either from the background or contaminated area, there should not be any potential for human exposure. Ingestion of contaminated soils/sediments likewise would not be considered by scientists and therefore would not result in human exposure.

Based on the information published in the RI, knowledge of the contaminated area and experienced drilling and field operations staff would be essential for guiding the drilling and sampling activities in the contaminated area. In addition, the staff of the proposed FRC would advise scientists on training and personal protective equipment and provide oversight of operations to ensure that worker and visitor protection would be maintained.

4.1.8.2 Site Specific Hazards and Accidents

Reasonably foreseeable accidents associated with the proposed FRC could involve: construction accidents associated with well-drilling and sampling; striking a subsurface structure during drilling; spilling a tank of stored liquid chemical, such as glucose or acetate; and leaks of contaminated purgewater from fittings and valves.

Very few accidents associated with well-drilling/sampling or striking a subsurface structure have occurred on the ORR. According to Oak Ridge National Laboratory (http://www.tis/eh/doe_gov/web/oeaf/orps/orps.html) only two accidents have occurred during the course of remedial investigations in the Bear Creek Valley. Both accidents involved the use of a drill rig and failure by the operators to follow operating procedures.

For accidents involving injuries to workers (e.g., during drilling operations at the background or contaminated areas), emergency services at Y-12 would be contacted to provide treatment and transport to the plant medical facility or a hospital, as needed. For accidents at ORNL facilities, assistance from the ORNL Laboratory shift superintendent would be obtained.

Although spills of chemicals used at the background or contaminated area would be possible, the quantities of materials stored or transported onsite would be small (i.e., a few gallons of concentrated material or at most 55 to several hundred gallons of a one percent solution). For experiments where long-term injections of nutrients, tracers or other materials would take place, the rate of injection is likely to be less than ten gallons per day. Therefore, 200 to 300 gallons of diluted material would last at least two weeks.

A direct spill to Bear Creek could cause a temporary localized decrease in oxygen due to increased microbial activity; however, the spill would be rapidly diluted, even during low-flow periods. Quantities that might be spilled would be small (less than 200 gallons) and dilute (equal to or less than one percent).

As identified in Section 4.1.3, there would be no impacts to groundwater or surface water as a result of injection of the materials.

In the event of a spill of a contaminated sample or chemical reagent at the contaminated area or background area, the research team would immediately contact the Y-12 Plant shift superintendent who would mobilize an emergency management team responsible for spill containment and cleanup. Accidents involving injuries to workers (e.g., during drilling operations) would involve contacting emergency services at Y-12 to provide treatment and transport to the plant medical facility or a hospital, as needed. Similarly, any laboratory spills or accidents at ORNL facilities would involve obtaining assistance from the ORNL Laboratory shift superintendent. In addition, a Health and Safety Plan would be developed for the FRC that would identify all appropriate requirements, such as training, monitoring, spill prevention and control measures, and emergency response procedures.

Overall, a spill directly into Bear Creek or to the ground would be expected to have little to no impact on environmental quality or human health.

Noise

Background data on noise levels at the proposed contaminated area and background area are not available. Much of the proposed contaminated area and parts of the background area are adjacent to Bear Creek Road, which has considerable employee traffic during shift changes at the plant and intermittent traffic during most of the workday. The western boundary of the background area would be adjacent to State Route 95, which had existing peak travel volumes of 970 vehicles per hour in 1997 (Table 3.7-2 in DOE 1997b). Noise levels 200 feet (60 m) from main thoroughfares such as State Route 95 have been estimated from traffic counts during rush hour to be between 55 and 60 dB/A. Noise levels at relatively isolated sites within the plant area may be lower than 55 dB/A (DOE 1997b).

Activities to be undertaken at the proposed contaminated area and background area are listed in Section 2.2.3. Noise associated with drilling would be temporary and would potentially disturb wildlife or other sensitive receptors for only short periods during daylight hours. Drilling operators would be required to meet all OSHA requirements.

Representative activities and average noise levels are presented below:

- The average noise level of a compressor at a point 1 foot (0.3 m) distant is 88-90 decibels (dB/A).
- The average noise level of well sampling is 75-78 dB/A for the sampler.
- The average noise level of a generator at a point 1 foot (0.3 m) distant is 93-95 dB/A.
- The average noise level of well drilling at a point 49 feet (15 m) distant is 89-111 dB/A.

Noise levels would not exceed noises heard during routine daily activities. Decibel levels are below that considered to be harmful (see Figure 3-6). Noise from FRC activities would be temporary and likely to disturb wildlife or other sensitive receptors for only short periods during daylight hours. Expected hours of operation would be from 8:00 a.m. to 6:00 p.m.

4.1.9 Waste Control

Wastes generated as a result of NABIR activities are estimated to be up to 12,000 gallons (about 46,000 L) of groundwater and 20 cubic feet (0.56 cubic meters) of soil per year. Similar volumes would be generated at the uncontaminated site but would be discharged to the ground. All wastes would be evaluated and managed in compliance with the appropriate requirements. The regulatory standards would be met through use of appropriate waste packaging and labeling; placement in designated waste storage areas, and routine inspections and maintenance. Best management practices would be instituted wherever applicable. The majority of non-hazardous solid waste material generated during drilling would be in the form of subsurface drill cuttings (soil materials). This soil material and bentonite clay would be used to backfill the test holes at the completion of field work. If there is any soil material remaining after backfilling, it would be distributed around each test plot.

Contaminated wastes (i.e., radioactive, chemical, and mixed wastes) would be handled under existing procedures for dealing with such wastes at Y-12 and ORNL, as appropriate (see Section 9.0, Applicable Environmental Regulations, Permits and DOE Orders). Purge water from drilling operations in the contaminated area likely would fill several 55-gallon drums. Other than pumping tests, which could generate up to 12,000 gallons of wastewater that would be collected in 20,000-gallon tanker trucks, groundwater extracted due to research activities would be collected in 55-gallon drums. All contaminated groundwater would be transported to the Y-12 West End Treatment Facility. Contaminated sediments and soils would be transferred to Bechtel Jacobs Corporation, the ORR waste control contractor, for disposal. All wastes generated from normal everyday activities by workers, including biological wastes, garbage, and similar materials, would be kept in containment and exported from the work sites to proper disposal facilities, to preclude leaving any wastes behind during and at the termination of this activity.

Trailers for the FRC would be equipped with portable chemical toilets, which would be serviced periodically. The Y-12 Environmental Management Division would be asked to help handle field investigation-derived wastes generated at the contaminated and background areas. ORNL laboratory wastes would be handled as part of the ongoing waste control program at ORNL.

4.1.10 Transportation

FRC staff and researchers would be required to travel roads between the contaminated area, background area and ancillary facilities located within ORNL. Public roads that would be traveled include Bear Creek Road, State Highway 95, and Bethel Valley Road. These roads are open-access public roads. Some use of limited access roads on the ORR would occur to access storage sites and other facilities. Due to the small number of staff and researchers involved, there would be minimal increases in traffic due to FRC activities. Some interruption of normal traffic flow might occur as a result of drilling rigs and on-site field trailer transport. This activity would be of short duration and would not result in long term impacts.

Miscellaneous chemicals, acids (e.g., sulfuric, nitric and hydrochloric), bases (sodium hydroxide), reagents (e.g., Hach Kit), formaldehyde, or other chemicals used onsite for conducting chemical analyses and sample preparation might be infrequently transported. Generally, less than 0.26 gallons (one liter) of these chemicals would be used on a yearly basis. U.S. Department of Transportation (DOT) Hazardous Materials Regulations (Title 49, *CFR*, Parts 171-180) establishes the requirements governing packaging and shipping hazardous materials. These standards would be applicable to any necessary shipments of hazardous materials to or from an FRC and would be followed, thus minimizing risks.

Collection and transport of samples from the contaminated area and background area would follow existing procedures and meet all environmental, safety, and health (ES&H) requirements as stipulated by ORNL. FRC research projects would be required to fill out an Environmental, Safety, and Health Quality Evaluation and transportation checklist prior to initiating any transportation action. Completion of this checklist would provide guidance to FRC researchers and minimize the potential for transportation impacts. If it were determined that transport of samples from ORNL were required, an ES&H transportation specialist would be contacted to assist with compliance with appropriate DOT and DOE shipping requirements. Use of these risk management procedures would result in minimal impacts.

4.1.11 Utilities and Infrastructure

Impacts to infrastructure features such as housing, education, health care, police and fire protection, and water and sewage are not anticipated as a result of implementation of proposed FRC research at ORNL. There would be no living facilities provided for workers at the work site. It is estimated that a staff as small as six individuals would be needed to conduct FRC-related research. Initiation of FRC-related activities supporting site characterizations, obtaining research-quality samples, and *in situ* research would not require an increase in staff as the majority of the activities would be implemented with existing personnel. Any additional personnel (e.g. visiting researchers) involved in FRC activities would be small in number (possibly up to 24 individuals) and would not impact existing infrastructure.

The existing facilities to be used, as mentioned in Section 3.0, would have ample office/laboratory space to allow for the addition of the small FRC staff and researchers.

ORNL proposes to locate a new office/laboratory trailer at the contaminated area, adjacent to the S-3 Ponds Site. Ample space is available. Electrical service to the office/laboratory trailer could be provided by existing power lines. Other trailers have been located in this area in the past (it is previously disturbed) and electrical lines are present. Trailers have not been located in the proposed background area in the past, but nearby power lines should enable a connection to be made easily. Hooking up water and sewer lines to the trailers would be avoided, but portable toilets and containers of drinking and distilled water would be provided.

A small area (50 feet by 50 feet) would be needed to park the drill rig, support truck and mobile decontamination trailer. This equipment is mobile and could be moved to where the work is to be conducted.

Staging areas would be used for material and equipment laydown and as temporary satellite accumulation areas for wastes (in drums, tanks, or other containers) generated by characterization actions (e.g., drill cuttings and decontamination wastes). Staging areas would be operated and maintained in compliance with site waste control procedures for the duration of their operation and during setup of decontamination trailers/change houses. Staging areas would be established in previously disturbed areas (or in areas that would require minimal grading) and would be covered with gravel or gravel and geotextile material. Temporary access roadways (or temporary extensions of existing roadways) might also be constructed, as necessary. Clearing of low brush or removal of trees and shrubs with the goal of minimization of clearing might also occur.

4.1.12 Environmental Justice

No potential impacts have been identified that would affect other ORNL/Y-12 employees or the offsite public, including low-income or minority populations. Socioeconomic analysis recently has been conducted on the potential for impacts to low-income and minority populations in association with the Spallation Neutron Source (SNS) EIS (DOE 1999a).

That analysis determined that radiological doses and normal air emissions are negligible and would not result in adverse human health or environmental effects on the offsite public. Furthermore, it was determined that prevailing winds follow the general topography of the ridges; up-valley winds come from the southwest during the daytime, and down-valley winds come from the northeast during the nighttime. The only concentration of minority and low-income population and non-minority higher income population is located to the northeast—in the path of the daytime prevailing winds. No populations are located to the southwest—the nighttime prevailing wind direction. However, because it was determined that there would not be high and/or adverse impacts to any of the population, there would be no disproportionate risk of significantly high and adverse impacts to minority and low income populations. The same analysis and findings would also hold true for FRC-related activities that would occur within BCV.

DOE is unaware of any subsistence populations residing in BCV nor are there any recognized Native American tribes within 50 miles of the proposed FRC (DOE 1999a). No discharges of contaminated water to surface waters would occur because any contaminated groundwater would be trucked to existing waste processing facilities at ORNL. As discussed in Section 4.1.3.1, there are no anticipated impacts to the surface waters (Bear Creek). All activities associated with this action that involved releases would be regulated and in compliance with federal and state regulations. As such, there would be no disproportionate and adverse impacts to low-income or minority populations.

4.2 Pacific Northwest National Laboratory/Hanford 100-H Area

4.2.1 Earth Resources

4.2.1.1 Topography

FRC research activities would not change the landscape (e.g., large-area bulldozing, large-scale clearing, and excavation.) Activities to support site characterization, to obtain research-quality samples, and *in situ* research would not impact the general topography of the proposed FRC because of the small-scale nature(less than one acre) of the proposed activities.

4.2.1.2 Geology

The 100-H area in which the proposed contaminated area and background area are located is dominated by the Hanford and Ringold formations, which contain primarily sand and gravel dominated facies. Because of the small-scale nature of investigations (less than one acre and to a depth of up to 75 feet), minimal impacts to these large geologic units are anticipated as a result of proposed FRC activities.

4.2.1.3 Soils

Within the 100-H Area, soils are classified as either Burbank loamy sand or Riverwash, with Riverwash occurring closer to the river. Proposed FRC activities would disturb these soil types only in areas where drilling, boring, or well installation would occur. Uncontaminated soils would be redistributed around the test plot. Contaminated soils would be disposed of in accordance with site-specific management plans. Soils obtained as research-quality samples would be characterized for potential hazardous contaminants prior to laboratory experimentation. It is estimated that the quantity of soil removed as a result of research activities at a test plot would be small (75 kilograms of soil per well or 825 kilograms of soil from 11 wells in a test bed); therefore, impacts to soils would be minimal.

4.2.2 Climate and Air Quality

The proposed contaminated area and background area lie entirely within Benton County of Washington State. Benton County is in “attainment” for all NAAQS except particulate matter (PM). For PM, the county is “unclassified.” PM is managed under the EPA Natural Events Policy of 1996, since high PM events are associated with natural blowing dust. In the past, EPA has exempted the rural fugitive dust component of background concentrations when considering permit application and the enforcement of air quality standards. EPA is working with the state of Washington to characterize and document the sources of PM emissions and develop appropriate control techniques. It is anticipated that activities supporting proposed FRC research would produce minor amounts of dust (particulate matter) as a result of site clearing, construction activities (e.g., access improvement, trailer placement), and associated construction traffic. Emissions resulting from equipment typically associated with well-drilling operations (e.g., gas powered generators) would be below NAAQS. Any particulate matter generated from these activities would be limited in amount and would occur over a short period of time. The “conformity rule” (40 *CFR* 51 Subpart T) applies only to areas classified as “nonattainment” or “maintenance” (40 *CFR* 51.394[b]). The conformity rule does not apply to “unclassified” areas.

Other airborne pollutants regulated by NAAQS that might be generated as a result of proposed FRC research could include vehicle exhaust and generators, and potentially point source air emissions of radionuclides resulting from drilling activities. Under Title 40, *CFR*, Part 61, Subpart H, and Washington Administrative Code (WAC) 246-247, radionuclide airborne emissions from all combined operations at the Hanford Site may not exceed 10 mrem/yr effective dose equivalent to the hypothetical off-site maximally exposed individual. WAC 246-247 requires verification of compliance, typically through periodic confirmatory air sampling. These radionuclide emissions standards would apply to any fugitive, diffuse, and point source air emissions of radionuclides generated during research operations at the proposed contaminated area. It is anticipated that any well installation activities that might occur in areas of known radionuclide contamination would incorporate appropriate safeguards into operations in order to limit the potential for airborne contamination.

It is anticipated that operations at the proposed FRC would use standard, construction best management practices to control any airborne releases. Common best management practices include application of water for dust suppression and to control fugitive emissions during drilling and other activities. It is anticipated that these and other construction/drilling BMPs should adequately control fugitive emissions of radionuclides and any other air pollutants. Final project plans would be evaluated for applicability of these best management practices and the substantive requirements of permits would be complied with if required. Any proposed activities at the FRC would not have any adverse impact on the current CERCLA remediation activities in the 100-H Area.

Other substances, which might be used at the proposed FRC, include oxygen, hydrogen, nitrogen, and methane. None of these is regulated under state or federal air regulations. Groundwater collected during the research activities would not be expected to contain pollutants that would volatize into the air.

No impacts to air quality would be expected from proposed FRC activities.

4.2.3 Water Resources

4.2.3.1 Surface Water

Surface waters within the 100-H Area are dominated by the Columbia River, which flows alongside the contaminated area of the proposed FRC (see Figure 3-9). The two background areas are located approximately one-half mile from the Columbia River. FRC activities to support site characterization, obtain research-quality samples, and perform *in situ* research would not occur any closer than 200 feet (60 meters) from all surface waters, including the Columbia River. Any potential runoff occurring as a result of ground-disturbing activities, coupled with rain events, would be reduced by implementing best management practices (e.g., silt fences).

The closest point where injection of materials might occur would be in the contaminated area 200 feet from the Columbia River. While it is conceivable that injected materials could reach the Columbia River if an injection well were installed at this point, PNNL anticipated the need to recover injected substances. PNNL proposed that they would install a series of groundwater extraction wells within each test plot to capture any substances injected into upstream injection wells. These extraction wells would be positioned to intercept groundwater flow moving toward the Columbia River. In addition, PNNL could make use of a secondary containment system of five existing extraction wells located within 150 feet of the Columbia River to ensure that substances injected as part of *in situ* research by investigators do not reach the Columbia River. The existing five extraction wells are part of an on-going CERCLA Interim Remedial Action that involves pumping and treating for chromium-contaminated groundwater. Filters to extract tracers, electron donors and acceptors, nutrients, microorganisms and other substances would be added to the extraction well systems. The pump and treat extraction wells have been operating constantly and will continue to do so (DOE/RL 1999c).

All contaminated water extracted from the proposed wells and existing pump and treat extraction wells would be collected in large truck-mounted tanks and transported to the Effluent Treatment Facility (ETF). Contaminated water extracted from the existing pump and treat extraction wells goes through a filtration system and is reinjected into the ground upstream from the pump and treat area. (See Section 4.2.10 for waste control information.) In the unlikely event that all of the existing and proposed extraction wells failed, the potential exists that groundwater additives injected as part of *in situ* research at either the background or contaminated areas could pass through groundwater channels in the highly porous loamy sand soils of the 100-H Area to the Columbia River.

As described in Appendix A, small quantities of nontoxic tracers, nutrients, electron donors or acceptors, microorganisms, or other substances might be injected as part of the *in situ* research activities. These substances might be injected either into the background or contaminated areas of the proposed FRC in accordance with state and federal regulations, best management practices and close monitoring of environmental conditions. While *in situ* research at the background and contaminated areas would provide additional information on groundwater flow paths and the movement of injected materials, sufficient information currently exists to permit estimates of potential impacts from the injection of these materials on surface waters.

4.2.3.1.1 Tracers

To better understand groundwater flow paths and speed, nontoxic and nonpersistent tracers could be injected in concentrations ranging from 500 parts per million (ppm) to 10,000 ppm at both the background and contaminated areas of the proposed FRC. Examples of tracers that might be used include bromide, chlorofluorocarbons, latex microspheres, alcohols, and non-radioactive strontium. Tracer injections at the two proposed background areas would be more than 1,500 feet from the Columbia River and concentrations would be expected to be unmeasurable by the time the tracer had traveled only half that distance. In part, this would be due to a slow groundwater flow rate of six inches per day and to the diffusion of the tracer into the subsurface matrix. In contrast, tracer injections into the contaminated area, particularly into test plots C and D, which are close to the Columbia River, could conceivably reach the surface waters if they were not captured by proposed NABIR extraction wells or existing pump and treat extraction wells.

As with tracers proposed for use at the ORNL FRC, tracers proposed for use at the background and contaminated areas of 100-H would also be greatly diluted by diffusion into the matrix of the 100-H Area subsurface. Assuming that no NABIR extraction wells were installed, injected tracers would be recovered in the continuously operating pump and treat extraction well systems.

Different tracers move and diffuse into the groundwater at different rates. Therefore, the use of more than one tracer at the same time provides additional information about the subsurface than would be possible with only one tracer. Injection of multiple tracers at one time in the contaminated area in an injection well 200 feet from the Columbia River would not be expected to result in an increased possibility that any of the tracers would reach the Columbia River. Again, both the proposed NABIR extraction well system and the existing pump and treat system would be employed to ensure that these tracers would not reach the Columbia River.

Tracer concentrations would not be expected to exceed 10,000 ppm. The use of nontoxic and non-persistent tracers coupled with the proposed and existing extraction well systems would ensure that tracers would not reach the Columbia River. Further information on the proposed use of groundwater tracers at the FRC is available in Appendix A.

4.2.3.1.2 Electron Donors and Acceptors and Other Nutrients

To stimulate the activity and growth of microorganisms, electron donors or acceptors or other nutrients could be injected in concentrations ranging from 100 ppm to 300 ppm (i.e., 100 mg/L to 300 mg/L) at both the background and contaminated areas of the proposed FRC. At maximum, these concentrations would be lower than those that would be considered at the ORNL FRC. Examples of electron donors that might be used include acetate, glucose, lactate, hydrogen, or molasses. Examples of electron acceptors that might be used include oxygen, nitrate, methane or sulfate. Other nutrients might include nitrogen and phosphorus. Injections at the background area would not occur in close proximity to the Columbia River (i.e., they would be more than 1,500 feet from the Columbia River).

Although injections at the contaminated area could be as close as 200 feet to the Columbia River, the likely approach for such injections would be a push-pull approach. In a push-pull experiment, electron donors, acceptors or nutrients would be “pushed” into a single injection well, and then “pulled” out of the same well after a short time of up to several hours (Schroth et al. 1998). Using this type of injection/extraction procedure in a single well, PNNL estimates that approximately 95 percent of the injected materials could be recovered through the injection well (Long 1999a).

In some cases, electron donors, electron acceptors, or nutrients could be injected into one well and extracted from another. In such a situation, the proposed series of NABIR extraction wells and the existing pump and treat extraction wells would mitigate any potential for electron donors, electron acceptors, or nutrients to reach the surface waters of the Columbia River. In addition, the proposed NABIR extraction wells and the existing pump and treat system would capture any contaminants that might be mobilized as a result of the addition of electron donors, electron acceptors, or nutrients in the contaminated area.

Another point to consider would be a shift in the existing microbial population due to the addition of electron donors, electron acceptors, or nutrients. Based on two other recent studies, even though the species that constitute the existing microbial populations might shift, the shift would only be detectable as long as the electron donor, electron acceptor or nutrient was present in the groundwater (Konopka et al. 1999, Rooney-Varga et al. 1999). Once the electron donor, acceptor or nutrient was removed from the groundwater through the extraction well systems, the microbial populations would return to their previous state, and there would be no change to inputs to the Columbia River.

Further information on the proposed use of electron donors and acceptors and nutrients at the FRC is available in Appendix A.

4.2.3.1.3 Microorganisms

To determine whether it might be feasible to add microorganisms to a contaminated subsurface environment, a small quantity ($2 \text{ X } 10^7$ colony forming units per ml [cfu/ml]) of native microorganisms could be injected into the background and contaminated areas of the proposed FRC. Native microorganisms would most likely be strains that would be isolated from the contaminated area and reinjected. Reinjection of native microorganisms would not be expected to be of concern either at the background or contaminated area. Although they would not be expected to move through the groundwater (Dybas et al. 1997), it is conceivable that they could proliferate. In some cases, the push-pull technique might be used; in other cases, one injection and one or more different extraction wells might be used. In either situation, the microorganisms would be captured in the proposed NABIR extraction wells or in the existing pump and treat extraction wells.

PNNL has stated that non-native microorganisms would be those from a non-Hanford field site (Long 1999b). Non-native microorganisms would not be injected either at the background or contaminated areas. Similarly, genetically engineered microorganisms would not be used either at the background or contaminated areas. Further information on the proposed use of microorganisms at the FRC is available in Appendix A.

4.2.3.1.4 Other Substances

As discussed in section 4.1.3.1.4, the two primary classes of other substances that might be injected would be biosurfactants and chelators. However, unlike the proposed ORNL FRC, PNNL would not consider using these two classes of substances either at the background or the contaminated areas. Because they would not be used, there would be no impacts to the surface waters of the Columbia River.

4.2.3.2 Floodplain and Wetlands

The only proposed FRC activities expected to occur within floodplain areas would be well drilling and monitoring (e.g., installation of piezometers). Typical installations of wells or piezometers, using for example, 2 foot by 6 inch (0.41 meter by 15.24 centimeter) diameter protective casing and 4 foot by 3 inch (0.82 meter by 7.62 centimeter) diameter bollards with a concrete pad 3 inches high and 2 feet long (7.62 centimeters by .41 meters) may reduce the cross-sectional area of the floodplain by 1.64 square feet (.5 square meters). This reduction in volume of even several wells would be negligible within the total cross-sectional area of the floodplain. Well and piezometer construction therefore, would have negligible impact on the floodplain. The well pads would minimize the erosion potential of the wells and bollards.

At the appropriate time, wells would be plugged (backfilled with clean soils) and abandoned. Well plugging and abandonment would result in the removal of surface structures (e.g. wellheads) and restoration of the former grade. This activity would have little impact on floodstage or floodplain cross-sectional area, nor would there be an increase in erosional potential since the wellhead and other surface equipment would be removed and the site restored to the original grade.

No structures or facilities would be constructed in the floodplain. Movement of heavy equipment through the floodplain would be a temporary occurrence and would not impact the capacity of the floodplain to store or carry water. The impacts from the movement of heavy equipment alone is expected to be negligible. To the extent practicable, staging areas and access roads would be temporary, construction would be limited to periods of low precipitation, and stabilization and restoration of the affected areas would be initiated promptly.

Wetlands in association with the Columbia River occur on the banks of the Columbia in proximity to the proposed contaminated area and background area. These wetlands are small in scale and are generally associated with the immediate bank of the Columbia River. Proposed FRC research would not occur in proximity to the wetlands and would not impact them.

4.2.3.3 Groundwater

The Ringold and Hanford Formations are continuous across the 100-H Area. Approximately 300 feet of suprabasalt sediment overlie the proposed FRC. The water table ranges from 0 feet at the

Columbia River to 107 feet in depth. The direction of the groundwater flow is toward the river. Under high river flows, the direction of groundwater flow may be reversed for several hundred feet inland.

The contaminated groundwater underlying the 100-H Area is contained within a CERCLA operable unit (100-HR-3). Contaminants of concern within 100-HR-3 include chromium, nitrate, technetium-99, and uranium. This operable unit is currently undergoing interim remediation by a pump and treat system. There are extraction wells located along the river to intercept and remove contaminated groundwater, thereby protecting the quality of surface water (i.e., the Columbia River). Both the background and the contaminated area would be located hydraulically upgradient of the pump and treat system.

Because of the somewhat limited field site information available for both the background and contaminated areas, one of the first field activities that could be expected at both the background and contaminated areas would be a groundwater gradient test. As with most groundwater gradient tests, modification of the groundwater gradient due to pump/slug tests would be expected to alter the groundwater gradient over an area of several hundred feet and over a time frame of weeks. However, groundwater pumping and monitoring activities would not generate more than 14,000 gallons per year of purge water.[2] These tests would not affect the existing direction of overall groundwater flow. The groundwater gradient would be expected to return to its pre-test level and the overall groundwater gradient would not be significantly altered.

As described in Appendix A, small quantities of nontoxic tracers, electron donors and acceptors, nutrients, microorganisms, or other substances might be injected as part of the *in situ* research activities. These substances might be injected either into the background or contaminated areas of the proposed FRC in accordance with best management practices and close monitoring of environmental conditions. Because the proposed contaminated area would be located in a CERCLA operable unit, permitting of discharges resulting from FRC activities would not be required. PNNL has obtained and currently holds several Categorical State Waste Discharge Permits that cover various categories of discharges, including experimental discharges from research activities. FRC work would be done within the bounds of these permits.

4.2.3.3.1 Tracers

As described in Section 4.2.3.1.1, to better understand groundwater flow paths and speed, nontoxic and non-persistent tracers in concentrations ranging from 500 ppm to 10,000 ppm might be injected at both the background and contaminated areas of the proposed FRC. As with the tracers proposed for use at the ORNL FRC, the tracers proposed for use at the background and contaminated areas of 100-H would also be greatly diluted by diffusion into the matrix of the 100-H Area subsurface.

Nonreactive tracers proposed for use at the background and contaminated areas would not be expected to alter the groundwater chemistry if used. Reactive tracers could conceivably alter the groundwater chemistry, but their use would be tested in the laboratory prior to use in the field. Based

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[2] In accordance with the Hanford purge water strategy, if groundwater were uncontaminated, it could be released onsite but not discharged directly to the Columbia River. If it were contaminated, it would be collected in tanker trucks until it could be transported to the ETF.

on the laboratory studies, reactive tracers that would alter the groundwater chemistry would not be used at the background or contaminated areas.

4.2.3.3.2 Electron Donors and Acceptors and Nutrients

To stimulate the activity and growth of microorganisms, electron donors or acceptors or other nutrients might be injected in concentrations ranging from 100 ppm to 300 ppm (i.e., 100 mg/L to 300 mg/L) at both the background and contaminated areas of the proposed FRC. At maximum, these concentrations would be lower than those that would be considered at the ORNL FRC. Injections at the background area would not occur in close proximity to the Columbia River (i.e., they would be more than 1,500 feet from the Columbia River).

As described in Section 4.2.3.1.2, injections at the contaminated area could be as close as 200 feet to the Columbia River and the most likely approach would be to use a push-pull approach. Again, approximately 95% of the injected materials could be recovered using the push-pull approach. With injection concentrations of up to 300 ppm, it is not likely that groundwater chemistry would be changed in a large area of the subsurface.

In some cases, electron donors, electron acceptors, or nutrients might be injected into one well and extracted from another. In such a situation, the proposed series of NABIR extraction wells and the existing pump and treat extraction wells would mitigate any potential for electron donors, electron acceptors, or nutrients to change the groundwater chemistry of large areas. For areas that would be changed such that a contaminant would become more mobile, the proposed NABIR extraction wells and existing pump and treat system would capture mobilized contaminants.

Possible shifts could occur in the existing microbial population due to the addition of electron donors, electron acceptors, or nutrients. However, at the low concentrations that would be used, changes in the microbial population would be limited in the area of the subsurface affected and would only persist if the electron donors, acceptors or nutrients were to continue to be added. Further information on the proposed use of electron donors and acceptors and nutrients at the FRC is available in Appendix A.

4.2.3.3.3 Microorganisms

To determine whether it might be feasible to add microorganisms to a contaminated subsurface environment, a small quantity (2×10^7 colony forming units per ml [cfu/ml]) of native microorganisms might be injected into the background and contaminated areas of the proposed FRC. As described in Section 4.2.3.1.3, native microorganisms would most likely be strains that would be isolated from the contaminated area and reinjected. Reinjection of native microorganisms would not be expected to be of concern either at the background or contaminated area. Although they would not be expected to move through the groundwater (Dybas et al. 1997), it is conceivable that they could survive. In some cases, the push-pull technique might be used to inject native microorganisms. In other cases, one injection and one or more different extraction wells might be used. In either situation, the microorganisms would be captured in the proposed NABIR extraction wells or in the existing pump and treat extraction wells.

If nutrients were to be added along with microorganisms, the added microorganisms could proliferate. While a proliferation of added microorganisms could effect a change in the groundwater chemistry such that a contaminant would be mobilized, any contaminants that might be mobilized would be captured either in the proposed NABIR extraction wells or in the existing pump and treat extraction wells.

PNNL has stated that non-native microorganisms would be those from a non-Hanford field site (Long 1999b). Non-native microorganisms would not be injected either at the background or contaminated areas. Similarly, genetically engineered microorganisms would not be used either at the background or contaminated areas. Further information on the proposed use of microorganisms at the FRC is available in Appendix A.

4.2.3.3.4 Other Substances

As discussed in section 4.2.3.1.4, the two primary classes of other substances that could be injected would be biosurfactants and chelators. However, unlike the proposed ORNL FRC, PNNL would not consider using these two classes of substances either at the background or the contaminated areas. Because they would not be used, there would be no impacts to the groundwater.

In summary, it is anticipated that NABIR basic research at the proposed contaminated area would serve to better define the nature of existing contamination and aid in the development of bioremediation technologies to assist in clean-up of both groundwater and sediments in the 100-H Area. Overall, the hydrogeology and geochemistry of the 100-H Area would not be altered by the small-scale research activities. Groundwater gradient modifications, including pump/slug tests, would only temporarily alter groundwater characteristics and would not affect the existing direction of overall groundwater flow. Injection of tracers, electron donors and acceptors, nutrients, and microorganisms in the small amounts proposed would not be expected to alter the groundwater chemistry of the background or contaminated areas. In cases where a push-pull system were to be used, approximately 95% of the injected material would be recovered. In cases where separate injection and extraction wells were to be used, the proposed NABIR extraction wells would be used to recover injected materials. Secondary containment would be provided by the existing pump and treat system (EPA 1996). Through the use of the extraction well systems, impacts beyond the background or contaminated areas would not be expected.

4.2.4 Ecological Resources

The proposed contaminated area and background area would be situated in what has been botanically characterized as a shrub-steppe ecosystem commonly referred to as high desert. The region contains plant and animal species adapted to a semi-arid environment. The areas identified are previously disturbed areas of shrub-steppe habitat; therefore, the proposed action would not adversely affect native plant and animal species.

4.2.4.1 Terrestrial Resources

Biological resources within the proposed contaminated area and background area are typical of a high desert, shrub-steppe, arid environment. Most of the site has not experienced tillage or livestock grazing since the early 1940s. Extensive remedial activity is occurring in proximity to the proposed contaminated area and background area. As a consequence, it is unlikely that significant wildlife resources are in the area. Moreover, because research activities would encompass a very small portion of the proposed contaminated area and background area, it is not anticipated that wildlife or terrestrial resources would be impacted.

The U.S. Department of Interior, Fish and Wildlife Service provided a list of threatened and endangered species, candidate species and species of concern, which may be present in the Benton County portion of the Hanford Site. In addition, PNNL conducted a biological review of the proposed FRC (see Appendix E). The U.S. Fish and Wildlife Service and PNNL's biological review concluded that there are no plant or animal species protected under the Endangered Species Act, candidates for such protection, or species listed by the Washington State government as state threatened or endangered within the proposed contaminated area or background area.

Bald eagle roost trees are located to the north and the south of 100-H Area. The Hanford Site Bald Eagle Site Management Plan (DOE 1994b) restricts routine work within 2,630 feet (800 m) of the roost sites between the hours of 10 a.m. and 2 p.m. Non-routine activities, such as excavations and well drilling, require case-by-case evaluations. However, the proposed contaminated area and background area would be located beyond the 2,630-foot radius from the night roost locations and would have no required restrictions.

4.2.4.2 Aquatic Resources

Much of the land area encompassing the proposed FRC is located immediately adjacent to the Columbia River. The Hanford Reach of the Columbia River is an important spawning ground for the Upper Columbia River steelhead, the Upper Columbia River spring-run chinook salmon, and the bull trout. All three species are federally listed as endangered. These important fish species would not be expected to be impacted as a result of proposed FRC research. However, because of their importance and status as federal endangered species, the National Marine Fisheries Service would be notified under Section 7 of the Endangered Species Act prior to implementation of any field research. No other sensitive plant or animal species are known to occur either within the proposed FRC or adjacent areas.

4.2.5 Archaeological, Cultural, and Historic Resources

According to PNNL, approximately half of the proposed contaminated area has been intensively surveyed for cultural resources (Appendix E). No archaeological or isolated artifacts were identified in the survey area. There are no known historic properties within the proposed contaminated area. The background area has also been surveyed for cultural resources. No cultural resources were located within the background area.

A portion of the proposed contaminated area is within about 440 yards (400 m) of the Columbia River. The Columbia River and its shorelines are considered culturally sensitive. Any intrusive research action conducted in this area would require a cultural resource expert to be present. Management of Hanford Site cultural resources follows the Hanford Cultural Resources Management Plan (PNL 1989). As such, any site in which development activities would be proposed would be evaluated prior to implementation of development plans.

4.2.6 Land Use, Recreation, and Aesthetic Resources

The proposed contaminated area and background area would not conflict with any existing land use at the 100-H Area. The size and shape of the proposed contaminated area and background area were determined in part through discussions with the Hanford Environmental Restoration Contractor. The proposed field sites were positioned to avoid any interference with existing haul routes, potential remediation sites, or other ongoing or anticipated activities.

The proposed contaminated area and background area would not adversely affect recreation activities or recreational experiences on the Columbia River. Recreational users on the river would most likely not be aware of FRC activities in the region. The locations in which the proposed contaminated area and background area would be situated are not currently used for any other recreational purpose.

Trailers supporting proposed FRC research would be needed only in the vicinity of the proposed contaminated area and background area. They would be removed upon completion of research activities.

The proposed contaminated area and background area locations in the 100-H Area would not adversely impact any component of visual or aesthetic resources.

4.2.7 Socioeconomic Impacts

Socioeconomic impacts would be minimal. The work force required for installation and operation of the proposed FRC would be small and drawn from the existing work force. Visiting staff and scientists would contribute in a beneficial manner to the local economy by staying in local hotels and using local services. There would be no negative impact to the socioeconomics of the Hanford area as a result of FRC activities.

4.2.8 Human Health

As described in Appendix C, PNNL would develop an overall Management Plan for the FRC that would explain the goals and objectives of the FRC, roles and responsibilities of FRC staff, procedures for investigators to follow, and procedures for storage of material and waste disposal. To address potential ES&H issues associated with human health and environmental protection, PNNL would also develop the following plans:

- an action-specific health and safety plan detailing potential pathways of exposure and best management practices to reduce those hazards;
- a characterization and waste control plan;
- a contingency plan to address offsite migration of any nutrients or other chemicals used in conjunction with NABIR research activities; and
- a site closure plan.

Although important for operating the proposed FRC, this EA seeks to evaluate potential impacts to human health and the environment prior to selecting the FRC. For purposes of this evaluation, health and safety issues to be evaluated include:

- exposure to contaminated soils and groundwater,
- occupational hazards associated with a drilling/construction site, and

- hazards associated with accidental releases of stored liquid chemicals or materials.

4.2.8.1 Exposure to Contaminated Soils and Groundwater

There are two primary human health issues associated with exposure to contaminated soils and groundwater from the contaminated area at PNNL. The first issue is potential radiation exposure from groundwater and soils/sediments with radioactive contaminants. The second issue is potential chemical toxicity of the contaminants that may be in groundwater and soils/sediments from the contaminated area.

Because of the proposed nature of operation, potential exposures could occur during drilling and sampling operations in the contaminated area and/or in the processing and analysis of samples obtained from the contaminated area. Such exposures could be to FRC staff or to scientists. To mitigate these potential exposures, a combination of personal protective equipment, personnel training, physical design features, and other controls (e.g., limiting exposure times) would be required to ensure that worker and visitor protection would be maintained for all proposed FRC-related activities. In addition, OSHA regulations that pertain to construction and well-installation would be adhered to in all situations.

For the majority of investigators, potential exposures would be from samples obtained from the contaminated area and would occur while they performed sample processing or analyses. For scientists and FRC staff, who would be involved with drilling and sampling operations, potential exposures would be from accidents associated with drilling and sampling operations in the contaminated area.

Title 10, *CFR*, Part 835, “Occupational Radiation Protection,” establishes radiation protection standards, limits, and program requirements for protecting workers and the general public from ionizing radiation resulting from the conduct of DOE activities. For workers, 10 *CFR* 835 requires a 5-rem per year dose limit. For the general public, 10 CFR 835 requires a 100 millirem (mrem) per year dose limit. In addition, it requires that measures be taken to maintain radiation exposure as low as reasonably achievable. The 5-rem dose limit would be applicable to FRC staff and those scientists involved in drilling and sampling operations in the contaminated area. The 100 mrem dose limit would be applicable to scientists who process or analyze both soil/sediment and groundwater samples from the contaminated area.

For purposes of this EA, the maximum allowable exposure to FRC staff or to scientists was assumed to be 100 mrem per year. In addition, because potential exposures most likely would be during drilling and sampling operations, the following analysis of potential doses was assumed to be for hypothetical workers involved in drilling and sampling operations.

Doses to workers were bounded by evaluating a “bounding analysis” scenario, in the absence of any existing data on worker doses for this kind of work in the field. Workers were assumed to spill small amounts of soil/sediment (1 gram of contaminated soil/sediment five times per year for a total of 5 grams) or groundwater (1 milliliter of contaminated groundwater five times per year for a total of 5 milliliters) on themselves during the course of handling the core samples. To maximize the potential dose, it was further assumed that the workers did not wash off the contamination, but actually ingested it.

Radionuclide ingestion was calculated from the average measured activity values for H^3, C^{14}, Sr^{90}, Tc^{99}, U^{233}, U^{238} and Am^{241} in soil and groundwater (see Table 4-2). Where average values were not available, maximum measured values were substituted. The measured data provided in Table 4-2 were obtained from several sources including Liikala et al. 1988, DOE 1993, and Peterson et al. 1996). Totals were based on a yearly consumption of 5 grams of soil and 5 milliliters of groundwater. Dose factors for the Committed Effective Dose Equivalent were taken from the EPA report, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion, Federal Guidance Report No. 11" (EPA-5201/1-88-020), published in September 1988. The dose factor for C-14 was taken from the value for labeled organic compounds.

For the soil ingestion pathway, the total dose (for all radionuclides) came to less than 0.004 mrem/year, which is 25,000 times less than the limit of 100 mrem/year allowed for members of the public under 10 *CFR* 835, Section 208. The groundwater ingestion pathway is slightly smaller, with a total dose of approximately 0.002 mrem/year.

To estimate the total potential risk to workers from this "bounding analysis" exposure scenario, it was further assumed that the workers were exposed during the entire life of the project, which is ten years. The combined annual dose from both the soil and groundwater ingestion pathways was 6.16E-03 mrem per year (3.85E-03 + 2.32E-03). Over the ten-year lifetime of the project, the total dose was ten times that amount, or 6.16E-02 mrem. The lifetime fatal cancer risk is calculated by multiplying this ten-year dose by the dose-to-risk conversion factor of 4E-04 deaths per person-rem (NRC 1991). This calculation yields a lifetime risk of 3.08E-08, or roughly three in 100 million.

Table 4-2: Human Health Exposure Rates

Soil Ingestion (5 g/y)						**Groundwater Ingestion (5 ml/y)**		
Radionuclide	**mrem/ pCi**	**pCi/g (max)**	**Total pCi**	**mrem/y**		**pCi/l (avg)**	**Total pCi**	**mrem/y**
H-3	6.40E-08	0	0	0.00E+00		3455	17.275	1.11E-06
C-14	2.09E-06	13.2	66	1.38E-04		72	0.36	7.52E-07
Sr-90	1.42E-04	1.4	7	9.94E-04		9.9	0.0495	7.03E-06
Tc-99	1.46E-06	6.2	31	4.53E-05		303	1.515	2.21E-06
U-233	2.89E-04	0.46	2.3	6.65E-04		18.6	0.093	2.69E-05
U-238	2.55E-04	1.4	7	1.79E-03		2.38	0.0119	3.03E-06
Am-241	3.64E-03	0.012	0.06	2.18E-04		125	0.625	2.28E-03
			TOTAL:	**3.85E-03**			**TOTAL:**	**2.32E-03**

Although radioactive exposure would not be a problem, the potential chemical toxicity of the contaminants in the soils/sediments and groundwater from the proposed contaminated area also needs to be considered. Because the proposed contaminated area would be within the 100-HR-3 CERCLA operable unit, contaminant concentrations are evaluated according to CERCLA standards. Several recent studies of the 100-H Area indicate that only chromium and nitrate are of regulatory concern (Liikala 1998, DOE 1993, and Peterson 1996). Chromium concentrations are not at a level that would be of concern to human health, but they are high enough to be of concern to Columbia River salmon that spawn nearby. The CERCLA pump and treat system in the 100-H Area was put into place to extract the chromium so that it would not enter the Columbia River. Nitrate concentrations are also of regulatory concern, but unlike many organic contaminants, nitrate does not pose a cancer risk. Because groundwater from the contaminated area would not be used for drinking water, and because scientists would not consider drinking any groundwater collected either from the background or contaminated area, there would not be any potential for human exposure.

4.2.8.2 Site Specific Hazards and Accidents

Reasonably foreseeable accidents associated with the proposed FRC could involve: construction accidents associated with well-drilling and sampling; striking a subsurface structure during drilling; spilling a tank of stored liquid chemical, such as glucose or acetate; and leaks of contaminated purgewater from fittings and valves.

Very few accidents associated with well-drilling/sampling or striking a subsurface structure have occurred recently at the Hanford Site (Dunigan 1999). For example, many years ago there was a fatality during a drilling operation. A drill operator became trapped in a well while trying to retrieve a drill component and suffocated. Over the past 20 years, there have also been a few instances where drill rigs were not properly stabilized and tipped over. In these cases the operators did not follow appropriate operating procedures.

Although spills of chemicals used at the background or contaminated area would be possible, the quantities of materials stored or transported onsite would be small (i.e., a few gallons of concentrated material or at most 55 to several hundred gallons of a one percent solution). For experiments where long-term injections of nutrients, tracers or other materials would take place, the rate of injection is likely to be less than ten gallons per day. Therefore, 200 to 300 gallons of diluted material would last at least two weeks.

A direct spill to the Columbia River would not be possible since the route from PNNL laboratories (where chemicals might be prepared) to the background and contaminated areas does not cross the Columbia River or any tributaries. In addition, FRC activities would not occur any closer than 150 feet to the Columbia River.

As discussed in Section 4.2.3, there would be no impacts to groundwater or surface water as a result of injection of the materials.

Noise

Activities to be undertaken at the proposed contaminated area and background area are listed in Section 2.2.3. Noise associated with drilling would be temporary and would potentially disturb wildlife or other sensitive receptors for only short periods during daylight hours. Drilling operators would be required to meet all OSHA requirements.

Representative activities and average noise levels are presented below:

- The average noise level of a compressor at a point 1 foot (0.3 m) distant is 88-90 decibels (dB/A).
- The average noise level of well sampling is 75-78 dB/A for the sampler.
- The average noise level of a generator at a point 1 foot (0.3 m) distant is 93-95 dB/A.
- The average noise level of well drilling at a point 49 feet (15 m) distant is 89-111 dB/A.

Noise levels would not exceed noises heard during routine daily activities. Decibel levels are below that considered to be harmful (see Figure 3-6). Noise from FRC activities would be temporary and likely to disturb wildlife or other sensitive receptors for only short periods during daylight hours.

Because of ES&H planning and controls, and the small-scale research expected at an FRC, there would be no adverse impacts to human health.

4.2.9 Waste Control

Washington Administrative Code (WAC) 173-303 requires the identification and appropriate management of dangerous wastes and the dangerous component of mixed wastes, and identifies standards for the treatment and land disposal of these wastes. The code would be applicable to wastes that are anticipated to be designated as mixed waste. DOE Order 435.1 provides requirements for radioactive waste control. WAC 173-304 requires the identification and appropriate management of solid wastes. It would be applicable to any solid waste generated at the proposed FRC.

In accordance with the Hanford Purgewater Strategy (July 1990), should purgewater contain levels of hazardous and radioactive constituents above agreed-to health and environmental-based criteria, the purgewater is sent to a central Hanford facility for future treatment and disposal. The "Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington" (WHC-MR-0039) was approved by DOE, EPA and Washington Department of Ecology on August 21, 1990. The strategy is incorporated by reference in Appendix F of the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement.)

All wastes would be evaluated and managed in compliance with the appropriate requirements. The regulatory standards would be met through the use of appropriate waste packaging and labeling; placement in designated waste storage areas, and routine inspections and maintenance. It is expected that solid wastes might be disposed of in the Environmental Restoration Disposal Facility (ERDF), the Low-Level Burial Grounds (LLBG), other Hanford Site waste control units, or at offsite permitted facilities. Liquid wastes would be disposed of in the ETF. Low-level radioactive contaminated materials might be disposed of in the LLBG.

The ERDF is designed to meet RCRA minimum technological requirements for landfills including standards for a double liner, a leachate collection system, leak detection, and final cover. It also meets performance standards under Title 10, *CFR*, Part 61 for disposal of low level waste. The LLBG meet the performance standards under 10 *CFR* 61. Any offsite facility to which dangerous waste would be sent would meet the requirements of RCRA.

Approximately 3,500 gallons of purgewater would be generated and considered waste for each research event. Four such events could be expected to occur each year. Purgewater would be collected in tanker trucks and disposed at the ETF. Soils waste is estimated to be approximately one-third of the total material removed during drilling. This would total approximately 275 kilograms per test bed. All wastes would be evaluated and managed in compliance with the appropriate requirements. The regulatory standards would be met through use of appropriate waste packaging and labeling; placement in designated waste storage areas, and routine inspections and maintenance. Best management practices would be instituted wherever applicable. The majority of non-hazardous solid waste material generated during drilling would be in the form of subsurface drill cuttings (soil materials). This soil material and bentonite clay would be used to backfill the test holes at the completion of field work. If there were any soil material remaining after backfilling, it would be distributed around each drill site.

Contaminated wastes (i.e., radioactive, chemical, and mixed wastes) would be handled under existing procedures for dealing with such wastes. All wastes generated from normal everyday activities by human workers, including biological wastes, garbage, and similar materials, would be kept in containment and exported from the work sites to proper disposal facilities, to preclude leaving any wastes behind during and at the termination of this activity. Trailers for the FRC would be equipped with portable chemical toilets, which would be serviced periodically.

4.2.10 Transportation

Miscellaneous chemicals, acids (e.g., sulfuric, nitric and hydrochloric), bases (sodium hydroxide), reagents (e.g., Hach Kit), formaldehyde, or other chemicals used onsite for conducting chemical analyses and sample preparation might be infrequently transported. Generally, less than 2.2 gallons (one liter) of these chemicals would be used on a yearly basis. U.S. Department of Transportation (DOT) Hazardous Materials Regulations (Title 49, *CFR*, Parts 171-180) establish the requirements governing packaging and shipping of hazardous materials. These standards would be applicable to any necessary shipments of hazardous materials to or from an FRC.

The PNNL Shipping and Transportation Program ensures compliance with the DOT Hazardous Materials Regulations and DOE requirements specific to packaging and transportation safety. The PNNL Hazardous Materials Transportation Officer would be consulted to assure the safe packaging and transport of any regulated samples, hazardous materials, or wastes.

4.2.11 Utilities and Infrastructure

The existing facilities proposed to be used, as mentioned in Section 3.0, have ample office/laboratory space to allow for the addition of the small number of FRC staff and researchers. Because of the small number of people expected to work at the FRC, impacts to infrastructure features such as housing, education, health care, police and fire protection, and water and sewage would not be anticipated as a result of implementation of FRC research. Initiation of FRC-related activities likely would not require an increase in staff, as the majority of the activities could be implemented with existing personnel. Any additional personnel involved in FRC activities, such as visiting researchers, would not impact existing infrastructure.

Staging areas (approximately 100 x 100 feet) would be used for material and equipment laydown and as temporary satellite accumulation areas for wastes (in drums, tanks, or other containers) generated by characterization actions (e.g., drill cuttings and decontamination wastes). Staging areas would be operated and maintained in compliance with site waste control procedures for the duration of their operation and during setup of decontamination trailers/change houses. Staging areas would be established in previously disturbed areas (or in areas that would require minimal grading) and would be covered with gravel or gravel and geotextile material. Temporary access roadways (or temporary extensions of existing roadways) might also be constructed, as necessary. Clearing of low brush or removal of trees and shrubs with the goal of minimization of clearing might also occur.

4.2.12 Environmental Justice

No potential impacts have been identified that would affect other 100-H employees or offsite public. The vicinity surrounding the 100-H Area is large and the proposed action would not result in adverse human health or environmental effects on the public, including low-income or minority populations.

The Hanford Site NEPA Characterization Report (Neitzel et al. 1999) determined that the 100-H Area is located within a census block that contains no residents. Sections 4.2.3.1 and 4.2.3.3 state that there would be no impacts to surface waters (i.e., the Columbia River) or the groundwater. Therefore, there would be no impacts to individuals using the Columbia River for subsistence fishing or other subsistence purposes. There would be no disproportionate and adverse impacts to low-income and minority populations.

4.3 No Action

Under the No Action alternative, there would be no FRCs at the Oak Ridge and Hanford sites. As a result, DOE would not be able to conduct integrated field-based research and no intrusive actions would be taken by the NABIR Program, resulting in no impacts to the affected environment at Oak Ridge and Hanford (as described in Section 3.0). Future research could take place at other field sites (e.g., STEFS); however, the site conditions would not meet the needed criteria or the preferred characteristics (see Section 2.2.1.2) that would enable the NABIR Program to assist DOE with identifying new bioremediation technologies.

5.0 CUMULATIVE EFFECTS OF THE ALTERNATIVES

Cumulative effects are those that result from the incremental impact of an action considered in addition to impacts of past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions (Title 40 *CFR*, Part 1508.7). Cumulative effects can result from individually minor but collectively significant actions taken over a period of time.

5.1 Cumulative Effects of Siting and Operating an FRC on the ORNL/Y-12 Site

The actions that DOE considers reasonably foreseeable and pertinent to the analysis of cumulative effects for the ORNL/Y-12 Site are described in the section below.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Activities in the Bear Creek Valley Watershed. The RI/FS for the Bear Creek Watershed has been completed to address contamination associated with former waste disposal activities in Bear Creek Valley. The Record of Decision is scheduled to be signed in calendar year 2000. Several CERCLA remedial actions have been identified for implementation in the Bear Creek Valley Watershed. Proposed CERCLA actions that could impact levels of groundwater and soil contamination within the proposed FRC boundaries include but are not limited to the following:

1. Hot spot removal and capping of the BY/BY. The purpose of this action is to reduce the flux of uranium discharging into Bear Creek and the Maynardville Limestone through North Tributary 3 (NT-3). It is anticipated that this action would eventually decrease the concentration of uranium in Bear Creek and the Maynardville Limestone downstream from NT-3.

2. S-3 Ponds plume tributary interception. The purpose of this action is to reduce the flux of contaminants from the S-3 groundwater plume into the surface stream NT-1 and the main-stem of Bear Creek.

3. Removal of soil and sediment hot spots of contamination within the Bear Creek floodplain.

Procedures and protocol ensuring FRC activities do not interfere with CERCLA remediation activities would be described in the FRC Management Plan. In addition, "Operating Instructions" describing these procedures and protocol would be added to the CERCLA Federal Facilities Agreement (FFA).

CERCLA Waste Disposal Facility. DOE has published a RI/FS for the disposal of ORR CERCLA wastes (DOE January 1998). Alternatives in the RI/FS study include disposal of CERCLA wastes offsite and in a new disposal facility, the Environmental Management Waste Management Facility (EMWMR) to be constructed on the ORR. Three alternative sites on the ORR have been considered: two just north of Bear Creek Road and the third along State Highway 95 at the interchange with State Highway 58. The Proposed Plan and Record of Decision for the CERCLA Waste Disposal Facility have not been published, so no decisions concerning the construction of this facility on the ORR have been made. It is not anticipated that the disposal cell would be constructed within the boundary of the proposed FRC. Due to controls used at the EMWMF there are no anticipated releases (DOE January 1998).

Construction and Operation of the Spallation Neutron Source. DOE issued a NEPA Record of Decision on June 30, 1999 (64 FR 125) to proceed with the construction and operation of a Spallation Neutron Source (SNS) facility at ORNL. The SNS is an accelerator-based research facility that will provide U.S. scientific and industrial research communities a source of pulsed neutrons. The facility will be used to conduct research in such areas as materials science, condensed matter physics, the molecular structure of biological materials, properties of polymers and complex fluids, and magnetism. The SNS is being built near the top of Chestnut Ridge approximately four miles (6 km) southwest of the proposed FRC contaminated area. According to the EIS for the SNS (DOE 1999a), radioactive contamination of the earthen berms surrounding the SNS is expected. However, SNS is located on a ridge (away from the proposed FRC) and there is no expected contamination of groundwater. Emissions from the SNS will drain into White Oak Creek in the Bethel Valley, whereas the proposed FRC, located in the Bear Creek Valley, would drain into Bear Creek. As described in Section 4.0, virtually no impact would be expected in developing and operating the FRC. Incremental impacts would be minimal and would not be cumulative with those associated with construction and operation of the SNS. SNS and the proposed FRC are in different drainage basins of the ORR. As neither activity is expected to produce adverse impacts from its liquid emissions, it is expected that there would be no cumulative impacts from these geographically separate facilities.

Transportation of Low-Level (Radioactive) Waste and Mixed Low-Level (Radioactive) Waste from the ORR to Offsite Treatment or Disposal Facilities. DOE proposes to package and transport low level waste (LLW) and mixed LLW offsite for treatment and disposal. Onsite disposal is not available for the expected lifecycle volumes nor the technical constituents of many Oak Ridge LLW streams. Because waste disposal is critical to ongoing environmental cleanup and reindustrialization of the Reservation as well as to ongoing research and defense missions, the DOE proposes to package and transport significant quantities of existing and forecasted ORR LLW to other DOE sites or to licensed commercial facilities for treatment or disposal. There are currently two draft EAs being prepared for these projects. Based on available information, some of the contaminated wastes from research conducted at the proposed FRC would be considered both LLW and mixed LLW and could be transported to an offsite facility for treatment or disposal. However, waste quantities have been estimated to be very small (12,000 gallons [about 46,000 L] of groundwater and 20 cubic feet [0.56 cubic meters] of soil per year). These volumes are less than one percent of the total ORR wastes considered in the EAs (DOE 1999a). It is expected that wastes from the proposed FRC would not contribute to cumulative effects of transporting LLW for the ORR.

5.1.1 Earth Resources

Operation of the proposed FRC would not contribute to the cumulative impact on geology or soils of the ORR or surrounding communities. As described in Section 4.1.1, no significant problems have been identified with regard to site stability or the soil medium that would constitute impacts by themselves or combined with existing or future conditions to create cumulative impacts. None of the projects or reasonably foreseeable activities described above are expected to affect the earth resources of the BCV, thus the minimal effects from proposed FRC activities would not contribute to cumulative impacts.

5.1.2 Climate and Air Quality

Operation of the proposed FRC would not contribute to the cumulative impact on the climate or air quality of the ORR. The ORR is in an attainment area for NAAQS and no activities (e.g., drilling or small-area land clearing) planned for the FRC would constitute an impact by themselves (see Section

4.1.2) or, combined with existing or future conditions, create cumulative impacts. None of the projects or reasonably foreseeable activities described above are expected to affect the climate or air quality of the BCV, thus the minimal effects from proposed FRC activities would not contribute to cumulative impacts.

5.1.3 Water Resources

Operation of the proposed FRC would not contribute to the cumulative impact on the surface water and groundwater of the ORR or surrounding communities. The possible addition of tracers, electron donors and acceptors, nutrients and microorganisms, and other substances (see Section 4.1.3) have been shown to have little consequence on the quality of the surface water (Bear Creek) or the surrounding groundwater. These activities would not constitute an impact by themselves or, combined with existing or future conditions, create cumulative impacts. None of the projects or reasonably foreseeable activities described above are expected to affect the water resources of the BCV, thus the minimal effects from proposed FRC activities would not contribute to cumulative impacts.

As stated in the Floodplain Assessment for Site Investigation Activities at the Oak Ridge Y-12 Area of Responsibility (DOE 1996), "The activities addressed by the floodplain assessment will result in no measurable impact of floodplain cross-sections or flood stage, and thus do not increase the risk of flooding." The proposed FRC activities planned within the floodplain would be small in nature (see Section 4.1.3.2) and would not constitute an impact by themselves or, combined with the existing or reasonably foreseeable future conditions, create cumulative impacts.

5.1.4 Ecological Resources

Terrestrial and aquatic species within the area of the proposed FRC would not be impacted (see Section 4.1.4) because of measures that would be taken to avoid areas of sensitivity (e.g., the Environmental Research Park and areas used for seasonal hunting). Section 4.1.3 discusses the potential impacts to Bear Creek and demonstrates that no impacts would be expected. The addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts. None of the projects or reasonably foreseeable activities described above are expected to affect the ecological resources of the BCV, thus the minimal effects from proposed FRC activities would not contribute to cumulative impacts.

5.1.5 Archaeological, Cultural, and Historic Resources

According to the Tennessee State Historic Preservation Officer, no cultural resources have been identified within the proposed contaminated area and background area (Appendix E). In addition, no historic sites are located within the proposed boundaries of the FRC. The addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.1.6 Land Use, Recreation, and Aesthetic Resources

The land uses of the Bear Creek Valley include developed areas such as those near the Y-12 Plant, the S-3 Ponds Site, and waste control areas that are open and highly visible. In addition, there are some forested areas. As discussed in Section 4.1.3, research similar in nature to that proposed for the FRC has been taking place. There would be no major changes in the existing use of the areas proposed for the FRC and no major construction necessary for the operation of the proposed FRC. Trailers, drill rigs and other equipment would be placed in previously disturbed areas. Areas used for seasonal hunting would be avoided during hunting season. The addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.1.7 Socioeconomic Conditions

Employees of the proposed FRC would be existing employees from ORNL and researchers would be small in number (see Section 4.1.7). The addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts. When combined with the number of workers and researchers expected to be present at the SNS when it becomes operational, workers on the FRC could contribute to minor positive economic impacts, and only minor effects on housing availability and regional community services.

5.1.8 Human Health

The proposed activities conducted at the FRC would not pose any potential for adverse impacts to workers or the offsite public (see Section 4.1.8). These activities would not add any significant quantities of radioactive emissions to the air, would not impact groundwater to levels above drinking water standards, and workers would not be exposed to any doses of radiation or chemicals that would be of concern. These activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.1.9 Waste Control

The approximate volume of waste generated and requiring storage for the proposed FRC would be minimal (see Section 4.1.9) in comparison with quantities generated through environmental remediation activities on the ORR (DOE 1998). These activities would not constitute an impact by themselves, or combined with the existing or future conditions, create cumulative impacts.

5.1.10 Transportation

The employees of the proposed FRC are currently employed by ORNL so there would be no impact to traffic within the ORR. In addition the number of expected visitors to the FRC is expected to be minimal (see Section 4.1.7). The main traffic route expected for the workers at the SNS facility will be via Bethel Valley Road and Bear Creek Road as FRC workers and researchers drive between ORNL and the FRC. It is expected that the FRC-related traffic will be very light and would not create any incremental or cumulative impacts. The majority of SNS-related traffic would occur during the construction period of the facility and then would decrease; this would occur approximately half-way through the expected ten-year life of the FRC.

Transportation of minimal quantities of hazardous materials is expected throughout the course of FRC operations (see Section 4.1.10). Transportation offsite of LLW and mixed LLW is currently being evaluated; however, the amounts generated from FRC operations would be insignificant in comparison to quantities generated by the ORR requiring transportation (DOE 1999e, DOE 1999f).

These activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.1.11 Utilities and Infrastructure

Impacts to utilities and infrastructure such as housing, education, health care, police and fire protection, and water and sewage are not anticipated as a result of the small number of individuals involved in the operation or research activities of the proposed FRC. No new construction would be required for operation of the FRC. The siting of trailers and small staging areas for support equipment would be in previously disturbed areas and therefore would have impact on existing infrastructure. These activities would not constitute an impact by themselves or combined with the existing or future conditions create cumulative impacts.

5.1.12 Environmental Justice

Based on the analysis in this document as well as information derived from the SNS EIS (DOE 1999a), there would be no disproportionate risk of significantly high and adverse potential impacts to low-income and minority populations (see Section 4.1.12). There are no known subsistence populations residing in or near the BCV. Therefore, the addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.2 Cumulative Effects of Siting and Operating an FRC on the PNNL/100-H Area

The actions that DOE considers reasonably foreseeable and pertinent to the analysis of cumulative effects for the PNNL/100-H Area are described in the section below.

Interim Remedial Action at the 100-HR-3 Operable Unit. The proposed FRC lies within the 100-HR-3 CERCLA Operable Unit that falls under the Tri-Party Agreement. This operable unit is currently undergoing an interim remedial action (pump-and-treat system) for chromium contamination in accordance with a CERCLA Interim Record of Decision. The proposed FRC would be located hydraulically upgradient of the pump-and-treat system. The system is currently pumping contaminated groundwater from two wells immediately adjacent to the Columbia River, passing the water through an ion-exchange filter, and injecting the treated water into several wells located 600 to 700 yards upgradient of the river. Through the CERCLA Interim Record of Decision, the EPA and DOE are scheduled to review the status and success of this pump-and-treat effort in 2002.

Excavation of the 107-H Retention Basin. The 107-H Retention Basin is currently undergoing excavation, which will continue into FY 2000. The excavation requires the removal of large quantities of contaminated soils by truck across the 100-H Area. The 107-H Retention Basin is located southeast of the proposed contaminated area and east of the proposed background areas. The proposed FRC was located in conjunction with the site environmental contractor to avoid the planned remediation activities. Due to the small number of investigators that would be involved at an FRC, there would be no increase in the overall traffic though the 100-H area.

H Reactor Building Cocooning. Within the next five years (1999 to 2004) the H Reactor Building is scheduled for “cocooning.” Cocooning involves the dismantlement of ancillary reactor facilities and placement of the reactor core into safe, interim storage. The core will be kept within a storage enclosure designed to provide safe storage for up to 75 years with minimal maintenance required. The H Reactor is located outside the proposed FRC contaminated area. The cocooning process will require a short-term increase in the traffic and number of workers traveling across the 100-H area.

Comprehensive Land Use Plan-Columbia River Corridor. The 100-H Area lies within an area defined in the Record of Decision for the Hanford Comprehensive Land-Use Plan EIS as the Columbia River Corridor (DOE/RL November 1999b). The Columbia River is used by the public and tribes for boating, water skiing, fishing and hunting of upland game birds and migratory waterfowl. Along the southern shoreline (access restricted) of the Columbia River Corridor, the 100 Areas occupy approximately 26 miles (68 km). RCRA closure permit restrictions have been placed in the vicinity of the 100-H Area, which is associated with the 183-H Solar Evaporation Basins. Additional deed restrictions or covenants for activities that potentially extend more than 15 feet (4.6 m) below ground surface are expected for the CERCLA remediation areas.

5.2.1 Earth Resources

Operation of the proposed FRC would not contribute to the cumulative impact on geology or soils of the 100-H Area or surrounding areas. As described in Section 4.2.1, no significant problems have been identified with regard to site stability or the soil medium that would constitute impacts by themselves or, combined with existing or future conditions, create cumulative impacts. None of the projects or reasonably foreseeable activities described above would be expected to affect the earth resources of the 100-H Area, thus the minimal effects from proposed FRC activities would not contribute to cumulative impacts.

5.2.2 Climate and Air Quality

Operation of the proposed FRC would not contribute to the cumulative impact on climate or air quality of the Hanford Site. The Hanford Site (in Benton County) is in attainment for NAAQS except for particulate matter (PM). Benton County is “unclassified” for PM. No activities (e.g., drilling or small-area land clearing) planned for the FRC would constitute an impact by themselves (see Section 4.2.2) or, combined with existing or future conditions, create cumulative impacts. None of the projects or reasonably foreseeable activities described above would be expected to affect the climate or air quality of the 100-H Area, thus the minimal effects from proposed FRC activities would not contribute to cumulative impacts.

5.2.3 Water Resources

Operation of the proposed FRC would not contribute to the cumulative impact on the surface water and groundwater of the 100-H Area or surrounding areas. The possible addition of tracers, electron donors and acceptors, nutrients and microorganisms, and other substances (see Section 4.2.3) would have little consequence on the quality of the surface water (the Columbia River) or the surrounding groundwater. These activities would not constitute an impact by themselves or, combined with existing or future conditions, create cumulative impacts. None of the projects or reasonably foreseeable activities described above would be expected to affect the water resources of the 100-H

Area, thus the minimal effects from proposed FRC activities would not contribute to cumulative impacts.

5.2.4 Ecological Resources

Terrestrial and aquatic species within the area of the proposed FRC would not be impacted (see Section 4.2.4). Section 4.2.3 discusses the potential impacts to the Columbia River and demonstrates that no impacts would be expected. The addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts. None of the projects or reasonably foreseeable activities described above would be expected to affect the ecological resources of the 100-H Area, thus the minimal effects from proposed FRC activities would not contribute to cumulative impacts.

5.2.5 Archaeological, Cultural, and Historic Resources

According to PNNL, no cultural resources have been identified within the proposed contaminated area and background area (Appendix E). A portion of the contaminated area is located within 440 yards (400 m) of the Columbia River. The Columbia River and its shorelines are considered culturally sensitive; however, consultation with PNNL's cultural resource experts would be required before any activities could take place in that area. The addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.2.6 Land Use, Recreation, and Aesthetic Resources

The proposed contaminated area and background area would not conflict with or have any adverse impacts to any existing land uses in the 100-H Area, including ongoing remediation activities. The designation in the Comprehensive Land Use Plan EIS as the Columbia River Corridor does not preclude the types of activities that have been discussed. Section 4.2.3 concluded that there were no impacts to the Columbia River by the injection of tracers, electron donors and acceptors and nutrients, microorganisms, and other substances. Therefore, use of the Columbia River for boating, fishing and water skiing would not be effected. The addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.2.7 Socioeconomic Conditions

Employees of the proposed FRC would be existing employees from PNNL and researchers would be small in number (see Section 4.2.7). The addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts. When combined with the number of workers and researchers expected to be present at the cocooning operations at the H-Reactor and the cleanup work at the 107-H Evaporative Basin, workers on the FRC could contribute to minor positive economic impacts, and only minor effects on housing availability and regional community services.

5.2.8 Human Health

The proposed activities conducted at the FRC would not pose any potential for adverse impacts to workers or the offsite public (see Section 4.2.8). These activities would not add any significant quantities of radioactive emissions to the air, would not impact groundwater to levels above drinking water standards, and workers would not be exposed to any doses of radiation or chemicals that would be of concern. These activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.2.9 Waste Control

The approximate volume of waste generated and requiring storage for the proposed FRC would be minimal (see Section 4.2.9) in comparison with the quantities generated through the environmental remediation activities on the Hanford Site (DOE 1998). The volumes of waste produced by the FRC would be less than one percent of the total waste produced on the Hanford Site. These activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.2.10 Transportation

The employees of the proposed FRC are currently employed by PNNL so there would be no impact to traffic within the 100-H area. In addition the number of expected visitors to the FRC would be expected to be minimal (see Section 4.2.7). It is expected that the FRC-related traffic would be very light and would not create any incremental or cumulative impacts. The majority of FRC-related traffic in the 100-H Area would occur during the start-up period of the FRC and then would decrease; this would occur approximately half-way through the expected ten-year life of the FRC.

Transportation of minimal quantities of hazardous materials would be expected throughout the course of FRC operations (see Section 4.2.10). These activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.2.11 Utilities and Services

Impacts to utilities and infrastructure such as housing, education, health care, police and fire protection, and water and sewage would not be anticipated as a result of the small number of individuals involved in the operation or research activities of the proposed FRC. No new construction would be required for operation of the FRC. The siting of trailers and small staging areas for support equipment would be in previously disturbed areas and therefore would have impact on existing infrastructure. These activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

5.2.12 Environmental Justice

No potential impacts have been identified that would affect 100-H employees or offsite public. The Columbia River is the only resource that could possibly cause disproportionate risk or significantly high and adverse impacts to low-income and minority populations, as it is potentially used for subsistence fishing (Neitzel et al. 1999). However, Section 4.2.3 concluded that there would be no impacts to the Columbia River as a result of FRC research. Therefore, the addition of the proposed FRC activities would not constitute an impact by themselves or, combined with the existing or future conditions, create cumulative impacts.

6.0 RELATED NEPA AND OTHER DOCUMENTS

Draft DOE/EA 1315, Department of Energy. *Draft Environmental Assessment for Transportation of Low-Level Radioactive Waste from the Oak Ridge Reservation to Offsite Treatment or Disposal Facilities, Oak Ridge, Tennessee,* 1999e.

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7.0 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

Based on the analysis in this EA, and based upon previously conducted research similar in nature to that which is preferred, no unavoidable adverse impacts are expected. (See Appendix F.)

8.0 SHORT-TERM USE AND LONG-TERM PRODUCTIVITY

The FRC would be used for approximately ten years to support bioremediation research. The various types of bioremediation research activities that would take place during the lifecycle of the FRC would result in a greater understanding of fundamental biogeochemical processes in a contaminated subsurface environment.

Resources (staff, land area, etc.) expected to be used during the lifecycle of the FRC, would be minimal. The proposed research at the FRC would not preclude any other activities that might take place at the field locations. However, all future research proposals would be analyzed for their potential to impact long-term productivity. This would be done under the NABIR Program's Tier II NEPA process (as described in Appendix A.)

9.0 APPLICABLE ENVIRONMENTAL REGULATIONS, EXECUTIVE ORDERS, PERMITS AND DOE ORDERS

All operations conducted at the FRC would be conducted in conformance with applicable environmental standards established by federal and state statutes and regulations, executive orders, DOE orders, work smart standards, and compliance and settlement agreements.

The principal regulatory agencies would be the U.S. EPA and state regulators. These agencies issue permits, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

The three DOE program offices with potential interest in the proposed FRC activities are the Office of Science, the Office of Environmental Management (EM), and the Office of Defense Programs. These program offices would be responsible for compliance with the environmental requirements applicable to activities associated with their individual missions. Depending on the nature of the activity to be conducted at the FRC, regulatory oversight and requirements of any of the three program offices might be applicable. Major federal environmental statutes that would apply to the various activities conducted by these programs include:

- Act to Authorize a Study of the Hanford Reach
- Anadromous Fish Conservation Act
- Atomic Energy Act of 1954
- Bald and Golden Eagle Protection Act
- Clean Air Act
- Clean Water Act, including 404 concerning wetlands requirements
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Endangered Species Act (ESA)
- Federal Land Policy and Management Act (FLPMA)
- Federal Wildlife Restoration Act
- Fish and Wildlife Coordination Act
- Hazardous Materials Transportation Act (HMTA)
- Migratory Bird Treaty Act (MBTA)
- Mineral Leasing Act
- National Environmental Policy Act (NEPA)
- National Historic Preservation Act (NHPA)
- Occupational Safety and Health Act (OSHA)
- Occupational Radiation Protection
- Oil Pollution Act
- Resource Conservation and Recovery Act (RCRA)

- Safe Drinking Water Act (SDWA)
- Sikes Act
- Surface Mining Control and Reclamation Act
- Toxic Substances Control Act (TSCA)
- Wild and Scenic Rivers Act

Executive orders would include:

- Executive Orders 11644 and 11989: Off-Road Vehicles on Public Lands
- Executive Order 11987: Exotic Organisms
- Executive Order 11988: Floodplain Management
- Executive Order 11990: Protection of Wetlands

The primary state statutes and resource management initiatives would be:

Tennessee

- Tennessee Air Quality Act
- Tennessee Hazardous Waste Management Act
- Tennessee Petroleum Underground Storage Tank Act
- Tennessee Solid Waste Disposal Act
- Tennessee Water Quality Control Act of 1977

Washington

- Draft Hanford Site Biological Resource Management Plan
- Draft Hanford Site Biological Resources Mitigation Strategy Plan
- Washington Administrative Code (WAC) 173-470 through 173-481, radionuclides and fluorides
- WAC 246-247, "Radiation Protection—Air Emissions"
- WAC 173-218, "Underground Injection Control Program"
- WAC 173-160, water well drilling on the Hanford site
- WAC 173-216, state permit program for the discharge of waste materials from industrial, commercial, and municipal operations into ground and surface waters of the state
- WAC 173-303, "Dangerous Waste Regulations"
- Washington State Hunting and Fishing Regulations
- Washington State Hydraulic Code
- Washington State Natural Heritage Program

- Washington State Priority Habitats and Species Program
- Washington State Shoreline Management Act
- Definitions of Public Land and their Applicability to Hanford

Relevant DOE policies and orders include:

- DOE P 142.1 and N 142.1, Unclassified Foreign Visits and Assignments
- DOE P 441.1, Radiological Health and Safety Policy
- DOE P 450.4, Safety Management System Policy
- DOE P 450.5, Line Environmental, Safety and Health Oversight
- DOE O 151.1, Chg. 2, Emergency Preparedness
- DOE O 232.1A, Occurrence Reporting
- DOE O 241.1, Scientific and Technical Information Management
- DOE O 430.1A, Life Cycle Asset Management
- DOE O 435.1, Radiological Waste Management
- DOE O 440.1A, Worker Protection
- DOE O 451.1A, National Environmental Policy Act Compliance Program
- DOE O 460.1A, Packaging and Transportation Safety
- DOE O 470.1, Chg. 1, Safeguards and Security Program
- DOE O 474.1, Control and Accountability of Nuclear Materials
- DOE O 1230.2, American Indian Tribal Government Policy
- DOE O 4300.1C, Chg. 1, Real Property Management
- DOE O 5400.5, Chg. 2, Radiological Protection of the Public and the Environment

Other regulations include:

- 49 *CFR* 397, Department of Transportation, “Transportation of Hazardous Materials: Driving and Parking Rules”
- 10 *CFR* 20.1002, Nuclear Regulatory Commission, “Possession License”
- U.S. Fish and Wildlife Service Mitigation Policy
- Public Trust Doctrine

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12.0 GLOSSARY

Abiotic: Not caused or produced by living beings.

Accelerated Bioremediation: Bioremediation accelerated beyond the normal actions of the naturally occurring microbial community and chemical and geological conditions, usually by the addition of nutrients or specialized microbes.

Aerobic: Living, active, or occurring only in the presence of oxygen.

Alluvium: Any stream-laid sediment deposit.

Anaerobic: Living, active, or occurring in the absence of free oxygen.

Anisotropy: The condition of exhibiting properties with different values when measured in different directions.

Anoxic: An environment without oxygen.

Aquifer: Stratum of permeable rock, sand, or gravel that can store and supply groundwater to wells and springs.

Archaea: A group of prokaryotic single-celled microorganisms that constitute the recently recognized Archaea phylogenetic domain. Archaea can be distinguished from bacteria in that their cell walls do not have murein, a peptidoglycan-containing muramic acid. Another unique feature of archaea is the presence of isopranyl ether lipids in their cell membranes. The Archaea domain includes the methanogens, most extreme halophiles (needing salt for growth), certain sulfate reducers, hyperthermophiles (optimum growth temperature of 80C or higher), and the genus Thermoplasma.

Areal: The measure of a planar region or the surface of a solid.

Bacteria: A group of prokaryotic single-celled microorganisms that constitute the Bacteria phylogenetic domain. Unlike archaea, their cell walls have murein, a peptidoglycan-containing muramic acid. Bacteria may have spherical (coccus), rod-like (bacillus), or curved (vibrio, spirillum, or spirochete) bodies. They inhabit virtually all environments, including soil, water, organic matter, and the bodies of eukaryotes.

Bacteriophage: A virus that attacks bacteria.

Basalt: A fine-grained igneous rock dominated by dark-colored minerals.

Bioaccumulation: Intracellular accumulation of environmental pollutants, such as heavy metals, by living organisms.

Bioaugmentation: The addition of microorganisms to the environment.

Biodegradation: The breakdown of organic materials into simpler components by microorganisms.

Bioremediation: The use of living organisms to reduce or eliminate environmental hazards resulting from accumulations of toxic chemicals and other hazardous wastes.

Biosequestration: The conversion of a compound through biological processes to a form that is chemically or physically isolated or inert.

Biostimulation: Addition of nutrients, oxygen, or other electron donors and acceptors to increase microbial activity and biodegradation.

Biotic: Caused or produced by living beings.

Biotransformation: Alteration of the structure of a compound by a living organism or enzyme.

Catalyst: A substance that activates a chemical reaction and is not itself changed in the process.

Chelator: Any of a class of relatively stable coordination compounds consisting of a central metal atom attached to a large molecule, called a ligand, in a cyclic or ring structure.

Clastic: A texture shown by sedimentary rocks from deposits of mineral and rock fragments.

Complexing Agent: A dissolved ligand that binds with a simple charged or uncharged molecular species in a liquid solution to form a complex, or coordination compound.

Contaminant: Harmful or hazardous matter introduced into the environment.

Denitrification: The formation of gaseous nitrogen (N_2) or nitrogen oxide (NO) from nitrate (NO_3-) or nitrite (NO_2-) by microorganisms.

Diagenesis: All of the changes that occur to a fossil (or more generally any sediment) after initial burial; includes changes that result from chemical, physical as well as biological processes.

Electromagnetics : Electromagnetic instruments work by emitting a current into the ground from a transmitting coil at one end of the instrument. A secondary magnetic field, which is proportional to the subsurface conductivity is received at the other end of the instrument and recorded. Later the operator, using a graphical computer program converts the readings (expressed in millmho per meter) into a two dimensional map.

Electron: A stable atomic particle that has a negative charge.

Electron Acceptor: Small inorganic or organic compound that is reduced in a metabolic redox reaction.

Electron Donor: Small inorganic or organic compound that is oxidized in a metabolic redox reaction.

Enzyme: A complex protein that acts as a catalyst in living organisms, regulating the rate at which chemical reactions proceed without itself being altered in the process.

Eukarya: The phylogenic domain consisting of one-celled and multicelled organisms called eukaryotes that maintain their genome within a defined nucleus.

Evapotranspiration: The loss of water from the soil, both by evaporation and by transpiration from the plants growing there.

Flow Cells: Containers that are a few meters in size and serve as tools for examining blocks of soils and subsurface cores that are larger than the laboratory-scale core samples. They provide "controlled environments" that simulate the natural subsurface environment in a laboratory setting without field releases.

Fungi: Spore-producing eukaryotic organisms that lack chlorophyll; examples of fungi include molds, rusts, mildews, smuts, mushrooms, and yeasts.

Ground Penetrating Radar (GPR): Emit short pulses of radio-frequency electromagnetic energy into the subsurface from a transmitting antenna. The energy passes through the ground and some is reflected back to the receiving antenna. A computer processes the reflected signal, measures the strength and time between emission and reception and produces a visual representation of the subsurface.

Groundwater: Water found beneath the earth's surface that fills pores between materials, such as sand, soil, or gravel; supplies wells and springs.

Heavy Metals: Metallic elements with high molecular weights. Such metals are often residual in the environment, exhibit biological accumulation, and are generally toxic in low concentrations. Examples include chromium, mercury, and lead.

Heterogeneity: Consisting of dissimilar constituents.

Hydraulic Conductivity: The rate at which water will move through soil in response to a given potential gradient.

Hydrology: The study of the occurrence, distribution, and circulation of natural waters of the earth.

Infrastructure: Utilities and other physical support systems needed to operate a laboratory or test facility. Included are electric distribution systems, water supply systems, sewage disposal systems, and roads.

Inorganic Compounds: Chemicals that do not contain carbon, which is usually associated with life processes; for example, metals are inorganic.

In situ: In the original position or place.

Intrinsic Bioremediation: Bioremediation at a given site as a function of the naturally occurring microbial population and naturally occurring chemical, biological, and geological conditions. Also known as natural attenuation when dominated by biological processes, or natural bioremediation.

Isotope: Any of two or more species of atoms of a chemical element with the same atomic number (number of protons) and nearly identical chemical behavior but with a different number of neutrons, hence a different atomic weight.

Karst: A barren limestone region characterized by fissures, caves, and underground channels.

Lysimeters/Caissons: Large (holding tons of soil) open-ended canisters that can be closed with a lid, creating a closed system. Soil and sediment can be placed in the lysimeter to simulate the natural environment.

Magnetometer: Uses a sealed vessel containing a coiled copper wire surrounded by oil. The instrument generates a small current that causes the protons within the oil to spin in the direction of magnetic north. The protons then generate a small signal, which is sent to the collection part of the device via the coiled wire. By measuring the signal intensity and comparing it to a known atomic constant—the gyromagnetic ration of the proton—the magnetic field intensity at a discrete location can be obtained.

Methanogen: Microorganism that produces methane.

Microbe (microorganism): any living organism invisible or barely visible to the naked eye and generally observable only through a microscope.

Multi-level Well Sampler: A device, up to six feet long with separators every five centimeters, that can be lowered into a well. The separators form vertical barriers to prevent water from flowing between sampling intervals. Researchers can collect samples from any depth within the well to study the water constituents, homogeneity or heterogeneity. The sampler can be left in the well for an extended period or removed after samples are collected daily.

Natural Attenuation: Degradation or transformation of contaminants in an environment via naturally occurring physical, chemical, and biological processes. May include intrinsic bioremediation.

Non-reactive Tracer: An inert substance, such as helium gas, perfluorocarbons, or bromide, that can be used to obtain a greater understanding of groundwater flow paths and movement. When extracted from a downgradient well, an inert tracer is the same chemical or compound as that injected. See "Reactive Tracer."

Operable Unit: A regulatory term meaning the division of cleanup of a release site into discrete action units that eliminate or mitigate a release, a threat of a release, or an exposure pathway.

Organic Compounds: Chemical compounds that contain carbon and hydrogen, elements usually associated with life processes.

Oxidation-Reduction Reaction: Coupled reactions in which one compound becomes oxidized, releasing electrons, while another becomes reduced, gaining the electrons released.

Pathogen: A specific causative agent (such as a bacterium or virus) of disease.

pH: A measure of acidity and alkalinity of a solution that is a number on a scale from 0 to 14. A value of 7 represents neutrality, lower numbers indicate increasing acidity, and higher numbers increasing alkalinity. Each unit of change represents a tenfold change in acidity or alkalinity. This change in acidity or alkalinity is the negative logarithm of the effective hydrogen-ion concentration or hydrogen-ion activity in gram equivalents per liter of the solution.

Phytoremediation: Remediation using plants to remove contaminants from soils.

Piezometers: Used to measure fluctuating groundwater levels. Piezometers are installed in monitoring wells and operate by converting pressure exerted on a submersed diaphragm into a frequency signal that is transmitted up the well to a data recorded via a wire. For each pressure, there is a corresponding frequency signal. The signal generated by each piezometer is collected in a central data recorder. The depth of groundwater is calculated factoring varying weather conditions, such as temperature and barometric pressure. Measurements of the water table can be collected at any specified time interval, depending on the researchers' needs.

Plume: An elongated body of fluid, usually mobile and varying in shape. Used to define the contaminated areas of an environment.

Precipitate: The process whereby a solid settles out of a solution.

Prokaryote: One-celled microorganism whose genome is not contained within a nucleus. Comprising the two domains Bacteria and Archaea.

Protozoan: Any of a phylum or subkingdom (Protozoa) of chiefly motile and heterotrophic unicellular protists (as amoebas, trypanosomes, sporozoans, and paramecia) that are represented in almost every kind of habitat.

Radioactivity: Spontaneous emission by radionuclides of energetic particles through the disintegration of their atomic nuclei; the rays emitted.

Radionuclide: A radioactive species of an atom. Tritium, strontium-90, and uranium –235 are radionuclides.

Reactive Tracer: A substance, such as sulfate or ammonium that may interact with groundwater, minerals in sediments, or microorganisms. When extracted from a downgradient well, a reactive tracer is not the same chemical or compound as that injected. See "Non-reactive Tracer."

Receptors: Plants, animals, and people that may be exposed to contamination. A receptor can be exposed via the air and soil pathways (e.g., inhalation, ingestion, and contact), and the surface and groundwater pathways (e.g., contact and ingestion).

Redox Reaction: Oxidation-reduction reaction, involving transfer of electrons.

Resistivity: A technique using electrodes in contact with the ground to measure electrical resistivity. The depth of investigation is a function of the electrode spacing and geometry.

Saturated Zone: An underground geologic layer in which all pores and fractures are filled with water.

Sediment: Material in suspension in water or deposited from suspension or precipitation.

Seismic Refraction: Works by inducing a sound wave into the ground by means of a percussive device and measuring the return signal at predetermined distances from the source. By measuring the time it takes for the sound wave to arrive at the receivers, the researcher is able to infer the nature of the subsurface material.

Siliceous: Of, relating to, or containing silica or a silicate.

Stratified Sedimentary Rock: Formed, deposited, or arranged sedimentary rock in a sheetlike mass of one kind lying between beds of other kinds.

Stratigraphy: A branch of geology that deals with the origin, composition, distribution, and succession of strata.

Substrate: The substance acted upon by an enzyme.

Subsurface: The geologic zone below the surface of the earth; includes rock and sediment materials lying near but not exposed to the earth's surface.

Subsurface Geophysical Tomography: Subsurface geophysical (cross hole) tomography allows the researcher to create a horizontal profile of the subsurface using a method similar to that used from the surface to generate a vertical profile. This method first requires that bore holes be installed. The depth and diameter of the bore holes used are limited only by the size of the instruments to be lowered into them and the depth to which researchers are concerned. Instruments are lowered into at least two bore holes and a current is induced on one end. On the other end, a receiver measures the current. That reading is sent to a computer where the researchers can map the subsurface profile in the horizontal plane. By repeating this process at varying depths throughout the bore holes, they are able to generate a three dimensional profile of the subsurface. The bore holes can be backfilled when researchers have collected the data desired.

Surfactant: A natural or synthetic chemical that promotes the wetting, solubilization, and emulsification of various types of organic chemicals.

Tracer Elements: See reactive and nonreactive tracers.

Transmissivity: The rate at which water is passed through a unit width of rock under a unit hydraulic gradient.

Unsaturated Zone: An underground geologic layer in which pores and fractures are filled with a combination of air and water.

Vadose Zone: The unsaturated zone above the water table. Also known as the zone of aeration.

Volatile Organic Compounds (VOCs): Organic compounds that evaporate at room temperature.

Water Table: The upper limit of a geologic layer wholly saturated with water.

Zone of Root Influence: Soils or sediments in which roots from surface plants may be found or that may have an altered geochemistry due to nearby root/fungal associations.

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