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INSTALLATION MANAGEMENT AGENCY
FORT BRAGG, NORTH CAROLINA

DECISION DOCUMENT FOR RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) REMEDIAL ACTION (RA) SOLID WASTE MANAGEMENT UNIT (SWMU) 9, (DSERTS #FTBR009) FORT BRAGG, NORTH CAROLINA

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FOR RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)
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1.0 SCOPE OF THE DECISION DOCUMENT/REMEDIAL ACTION

a. A Resource Conservation and Recovery Act of 1976 (RCRA) facility investigation (RFI) has been completed for Operable Unit (OU) 3 at the Fort Bragg Military Reservation, North Carolina. OU3 consists of Solid Waste Management Units (SWMUs) 8, 9, and 2/14, abandoned landfills occupying the flanks of a north-south-trending stream valley formed by Beaver Creek and its tributaries. The scope of this Decision Document (DD) is limited to SWMU 9. The other SWMUs of OU3 are addressed in other DDs.

b. The following conclusions and recommendations were made based on the data collected in 1994 and 1995 RFI for SWMU 9 (U.S. Geological Survey (USGS) 1996), and the corrective measures study (CMS) investigations conducted by Science Applications International Corporation Engineering of North Carolina, incorporated in 1999, 2000, and 2001:

(1) Five contaminants in soil were discovered exceeding limits: benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, and beryllium in surface soil and total petroleum hydrocarbons (TPH) in subsurface soil. A restriction of future residential land use at SWMU 9 documented in the Base Master Plan (BMP) would alleviate any risk posed by the constituents in surface soil. The TPH (3,800 mg/kg) in one subsurface soil sample exceeded the TPH cleanup level of 480 mg/kg determined by the site sensitivity evaluation. No further action (NFA) was recommended for the TPH contaminants because the human health risk assessment did not identify any specific petroleum hydrocarbon in the study. Beryllium was detected at only one location at a concentration that barely exceeded the risk-based concentration. The maximum concentration of arsenic (5.3 mg/kg) found was comparable to the maximum arsenic concentration (4.0 mg/kg) observed at a background location; therefore, NFA was recommended for metals because arsenic was close to levels found at the background site and beryllium was only detected in one sample, which barely exceeded its risk-based criterion. The RFI recommended that a CMS should be performed to examine

requirements for further action based on declared future land-use scenarios based on the requirements of RCRA.

(2) Five contaminants in groundwater were discovered: benzene, vinyl chloride, 2,4,6-trinitrotoluene, arsenic, and iron. The Fort Bragg water treatment plant provides treated municipal water to the cantonment area for drinking water purposes; groundwater in the cantonment area is not used as drinking water. The RFI recommended that if Fort Bragg adhered to this practice in the future and did not use groundwater at SWMU 9 as a water supply source, this should alleviate any groundwater risk posed to potential future residents.

(3) One constituent, benzo(a)pyrene, was found in the streambed sediment at SWMU 9; however, restriction of future land use at SWMU 9 should alleviate the risk posed to potential future residents.

(4) Thirty-four ecological contaminants were identified in surface soil, including 2 volatile organic compounds (VOCs), 19 semivolatile organic compounds (SVOCs), dichlorodiphenyldichloroethane, and 12 metals. Results of the risk characterization indicated that terrestrial wildlife species that might live or forage at SWMU 9 were unlikely to be at risk from exposure to contaminants in surface soil at the site. Adverse effects to terrestrial invertebrates from exposure to the contaminants in surface soil were also unlikely. Maximum and average exposure point concentrations of aluminum, chromium, and vanadium exceeded plant reference toxicity values, which indicated that sensitive plant species potentially could be at risk from exposure to these ecological comtaminant of potential concerns in surface soil. Any potential risks posed by these analytes, however, might not be site-related because background concentrations of aluminum, chromium, and vanadium also exceeded their respective reference toxicity values based on investigative background samples.

(5) Iron and manganese were the only contaminants identified for surface water. For streambed sediment, 14 SVOCs and 5 metals were identified from sampling events. The RFI concluded that wildlife receptors were unlikely to be at risk from exposure to contaminants in surface water and sediment associated with SWMU 9. Aquatic receptors downstream from SWMU 9 might be at risk from exposure to iron in surface water because concentrations of iron exceeded available benchmarks. Groundwater discharging to the Beaver Creek tributaries from the landfill at SWMU 9 might be a source of iron. The iron

concentrations, however, were comparable to those detected at upstream locations and could be indicative of regional levels of this metal.

(6) The RFI also found that aquatic receptors in Beaver Creek might be at risk due to the presence of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, fluorene, phenanthrene, and pyrene in sediment at concentrations that exceeded screening values. These polycyclic aromatic hydrocarbons (PAHs) were detected in surface soil at SWMU 9 but were not detected in upstream sediment samples, indicating that SWMU 9 was a potential source of the PAHs. Other potential sources of PAHs in the vicinity of SWMU 9 included automobile exhaust from the All-American Freeway and the railroad yard bordering SWMU 9 to the north.

c. Additional characterization was performed at OU3, subsequent to the publication of the RFI, to more thoroughly evaluate the groundwater characteristics and the methane concentrations at the landfills in SWMU 8, SWMU 9, and SWMU 14. This DD utilizes information from the RFI report (USGS 1996), along with supplemental data collected from subsequent investigations, in 1999, 2000, and 2001. The combined information is used to develop and evaluate corrective actions for the abandoned landfill designated SWMU 9 to achieve the regulatory levels. Potentially applicable corrective action technologies and alternatives are screened and evaluated to address contamination and elevated levels of methane in soil at SWMU 9. Methane gas exists in the landfill at levels exceeding the Lower Explosive Limit (LEL) for methane.

d. Because of the probable inability to fence in the right-of-way and methane levels exceeding the LEL in the right-of-way, the selected alternative for SWMU 9 is Passive Venting, Institutional Controls, Groundwater and Methane Monitoring, Fencing, and Implementation of Operation and Maintenance (O&M) Plan. Passive venting will reduce methane buildup in the soil to safe levels, and monitoring will ensure the effectiveness of the remedy. Fencing in areas other than the right-of-way would eliminate personal contact with contamination found in soils. The estimated total project life-cycle cost of installing the vents, monitoring points, fence, and warning signs; performing groundwater monitoring; administering activities associated with acquisition of legal controls; performing O&M activities; and providing management and oversight is $483,000 ($233,000 capital costs and $250,000 O&M costs). This is assuming a 5-event life cycle. The O&M costs could continue if the landfill continues to emit methane after 10 years or if additional groundwater sampling is needed.

1.1 SITE BACKGROUND. The SWMU 9 consists of an abandoned, unlined landfill that was in operation from 1970 to 1975 and covers approximately 30 acres (see figure 3-1). The SWMU 9 is bounded on the northeast and south by tributaries to Beaver Creek and is bisected by the All-American Freeway. The types of wastes disposed at the landfill were not documented; however, exposed material on the landfill flanks includes road tar, construction materials, sheet metal, and corrugated pipes. The landfill is unlined and the depth of fill is unknown. The landfill has a vegetative cover consisting of grasses and scrub pines.

1.2 REGULATORY BACKGROUND.

a. Fort Bragg is a U.S. Department of Defense facility in the Installation Restoration Program (IRP). Under the IRP, the facility is required to work toward compliance with federal and state environmental laws and regulations. In 1988, a RCRA facility assessment of the reservation was performed to identify areas of concern with respect to compliance with RCRA and the Hazardous and Solid Waste Amendments (Kearney, Inc., and DPRA, Inc. 1988). Fort Bragg holds a RCRA permit issued by the U.S. Environmental Protection Agency (EPA) Region 4 and the North Carolina Department of Environment and Natural Resources (NCDENR). An RFI was performed to address environmental conditions at 31 SWMUs and 7 areas of concern at Fort Bragg in accordance with RCRA corrective action guidelines. The RFI included a field investigation of OU3 in 1994 and 1995 to determine the nature and extent of contamination in soil and groundwater and the potential for migration of contamination from the source areas. Soil gas surveys were performed to obtain preliminary information for locating soil-boring sample collection and monitoring well installation sites. The RFI report for OU3 was completed in December 1996 (USGS 1996). Additional field investigations to update information on contamination levels at OU3 were conducted in March and April 1999, March 2000, March 2001, and August 2002.

b. The regulatory authority governing the action at SWMU 9 is the RCRA 40 *Code of Federal Regulations* 264, Title II, Subpart C, Section 3004 (42 USC 690 et seq.). Regulatory criteria and guidance for corrective actions at SWMU 9 include both soil and groundwater cleanup standards as well as methane monitoring and mitigation criteria.

c. Soil cleanup criteria include the risk-based remedial goal objectives (RGOs) calculated by the USGS in the 1996 RFI. Other guidance used in establishing remedial levels for soil include the North Carolina TPH guidance levels for soils (NCDENR 1993) and the *Revised Interim Soil Lead Guidance for CComprehensive Environmental Response, Compensation, and Liability Act and RCRA Corrective Action Facilities*, EPA Office of Solid Waste and Emergency Response Directive 9355.4-12 (EPA 1994).

d. For groundwater, the criteria for cleanup include the North Carolina Standards for Groundwater Protection: 15A North Carolina Administrative Code 2L.0202 (hereafter called NC 2L), EPA maximum contaminant levels (MCLs) for drinking water, and interim maximum acceptable concentration (IMAC).

e. The methane results collected were compared to the LEL for methane of five percent. Levels at the landfill exceed the LEL for methane. As a reference point, the North Carolina operational requirements for permitted municipal solid waste landfills (Title 15A, Chapter 13, Subchapter 13B, Section 1600) require owners and operators to ensure that:

(1) The concentration of methane gas generated by the facility does not exceed 25 percent of the LEL for methane in facility structures (1.25 percent), and

(2) The concentration of methane gas does not exceed the LEL for methane at the facility property boundary.

1.3 SITE OVERVIEW.

a. Fort Bragg is situated in northwestern Cumberland County and northern Hoke County. Cumberland County occupies approximately 661 mile^2 and has a population of approximately 303,000 people. Hoke County occupies approximately 414 mile^2 and has a population of approximately 34,000 people (U.S. Census Bureau 2000).

b. Fort Bragg had a combined military and civilian population of approximately 29,000 in 2000 (U.S. Census Bureau 2000). The principal population centers near Fort Bragg are the city of Fayetteville, five miles southeast, and Spring Lake, adjacent to the northeastern boundary of Fort Bragg. The estimated populations of Fayetteville and Spring Lake in 2000 were 121,000 and 8,000, respectively (U.S. Census Bureau 2000).

c. With the exception of the urban areas of Fayetteville and Spring Lake, land near Fort Bragg is primarily forested, with scattered private dwellings, farms, and small communities. Property use in the vicinity of OU3 is summarized as follows. The Knox Street Railroad yard and two abandoned landfills (SWMUs 4 and 5, which are part of the Fort Bragg IRP) are located to the north of SWMU 9 (see figure 3-1). The All-American Freeway intersects the SWMU. Tributaries to Beaver Creek lie to the northeast and south of the SWMU. The SWMU 8B lies on the other side of the southern branch of the tributary downstream of SWMU 9. The land to the southeast is marshy. Honeycutt Road is west of the SWMU, and, to the southwest, there is a freeway ramp and a jogging trail.

d. Drinking water supplies for Fort Bragg and surrounding areas are primarily obtained from surface water sources. Water used at Fort Bragg is obtained from the Little River, which has a drainage area of about 348 $mile^2$. There are 28 water-supply wells at Fort Bragg. Reported well depths range from 62 to 600 ft below land surface (BLS), with a median reported depth of 93 ft; reported yields range from 5 to 170 gallons per minute. Water levels in these 28 wells range from 11.5 to 85 ft BLS. Depths of the screened intervals and in which aquifer they are screened are unknown.

e. Eleven of the 28 wells at Fort Bragg are located in the cantonment area. All are used to irrigate golf courses. Well 10, approximately 5 miles east of SWMU 9 at Smith Lake Bath House and 320 ft BLS, provided potable water at the time of the RFI (USGS 1996). The Smith Lake well was plugged and abandoned in 2002. Five of the eleven irrigation wells (Wells 12 to 16) are located at the Officers Club Golf Course, north and upgradient of OU3, and are in the Beaver Creek Drainage area. The bottoms of the well screens are estimated to be at elevations ranging from 150 to 220 ft, suggesting that Wells 12 to 16 are screened in the Middendorf aquifer and the underlying Cape Fear aquifer. Based on regional groundwater flow directions, it is unlikely that contaminants potentially present at SWMU 9 would affect the quality of water at these wells.

f. The remaining wells at Fort Bragg are outside of the cantonment area and are used for potable water supply. Of these wells, Wells 8 and 9 are the potable water wells nearest OU3 and are approximately 5 miles west of OU3. These wells do not meet the criteria to be considered Public Drinking Water Wells under the Clean Water Act. Because groundwater from SWMUs at OU3 flows directly to Beaver Creek, it is not likely to affect Wells 8 or 9 or the more distant potable supply wells.

1.4 TOPOGRAPHY, PHYSIOGRAPHY, AND CLIMATE. Fort Bragg is situated in the Sandhills hydrologic zone of the North Carolina Coastal Plain. The Coastal Plain extends westward from the Atlantic Ocean to the Fall Line, a distance of approximately 130 miles. The Fall Line is the boundary between the Coastal Plain and Piedmont physiographic provinces. The Sand Hills area is characterized by deep, sandy soil and has the most variable topography and highest land-surface elevations in the Coastal Plain. Gently-to-steeply sloping ridges characterize topography at Fort Bragg; the highest ridges are in the western and central part of the military reservation. Elevations range from approximately 550 ft above mean sea level (AMSL) in the western part of the military reservation to approximately 150 ft AMSL in the northeastern part, along the Little River.

1.5 SITE GEOLOGY.

a. Geologic units in the Fort Bragg area, from oldest to youngest, consist of the Carolina Slate Belt rocks, which comprise the basement rock, the Cape Fear Formation, and the Middendorf Formation. Carolina Slate Belt rocks, which underlie the younger sedimentary rocks, are of Precambrian and Cambrian age and are composed of metavolcanic, metasedimentary, and igneous rock (USGS 1996). The elevation of the top of basement rock ranges from 180 ft above sea level at Southern Pines (USGS 1996), near the western edge of the military reservation, to 110 ft below sea level near the confluence of the Cape Fear River and Rockfish Creek (USGS 1996). The Cape Fear and Middendorf Formations overlie the basement rock and saprolite. These formations are part of the generally southeastward dipping and thickening wedge of sediments that constitutes the Atlantic Coastal Plain deposits. These formations generally are considered to be representative of an upper delta-plain environment (USGS 1996).

b. The soils within the Fort Bragg cantonment area are the result of weathering of the unconsolidated sandy sediments of the Coastal Plain. The soils range from moderately to excessively well drained. Soils in upland areas are sandy, acidic, low in organic matter, and have low fertility. The upland soils have brittle, loamy or clayey subsoils associated with Blaney, Gilead, and Lakeland soil types. Soils in low-lying areas typically have a heavier texture (containing more organic and clayey material) than upland soils. Soils in low-lying areas are poorly drained, resulting in swampy areas along streams. Johnston loam typically is found in low-lying areas of Fort Bragg (USGS 1996). Because many of these soils have similar properties, transition zones between the soil types are not always apparent.

1.6 SITE HYDROLOGY.

a. An east-to-west trending ridge divides Fort Bragg into two drainage subbasins. The northern subbasin drains into Little River; the southern subbasin drains into tributaries of Cross Creek and Rockfish Creek. Surface runoff at SWMU 9, which is in the southern subbasin, drains into the north and south fork of a Beaver Creek tributary. Beaver Creek flows into Cumberland Creek, a tributary of the Cape Fear River, which is east of Fort Bragg. S treams located on the military reservation generally are low gradient and, in many areas, have poorly defined channels, which grade into swampy areas. Streambeds consist of unconsolidated materials, typically silt or clay.

b. Several impoundments are present at Fort Bragg and include Lake McArthur in the northwestern corner of the military reservation, McKellers Pond in the northeastern part of the military reservation, and Smith Lake in the southeastern part of the military reservation. There are no natural lakes at Fort Bragg.

c. Groundwater in the lower part of the Middendorf aquifer is commonly under confined or semi-confined conditions, as determined by interbedded clay layers; whereas, groundwater in the upper part of the Middendorf aquifer is under unconfined conditions. The potentiometric surface of the aquifer is as much as 80 feet BLS in upland areas of the military reservation, and near land surface along perennial streams (discharge areas for the Middendorf aquifer).

d. The sandy soils, which cover most of Fort Bragg and the Sand Hills hydrologic area, are leached beds of the Middendorf Formation. These sands are highly permeable and allow rapid infiltration of precipitation, which is the primary source of groundwater recharge.

1.7 SITE ECOLOGY.

a. SWMU 9 is in the south-central part of the Fort Bragg cantonment area and is an unlined, mostly covered, abandoned landfill. The SWMU 8 is located just downstream of SWMU 9.

Ecological receptors at SWMU 9 include terrestrial, wetland, and aquatic animals and plants. Species or groups that are known to occur at the installation and that might occur within SWMU 9 include the cotton mouse, short-tailed shrew, red fox, eastern meadowlark, red-tailed hawk, raccoon, and great blue heron. No rare, endangered, or threatened species are known to occur at SWMU 9 (USGS 1996).

b. SWMU 9 is bounded to the northeast and south by tributaries to Beaver Creek, and on the west by a wooded area between the landfill and Honeycutt Road. Vegetation at SWMU 9 consists primarily of grasses, with some scrub pines present along the tributaries. There is also a small depression in the central portion of the landfill. This depression is believed to have been formed by subsidence of landfill material. Aquatic receptors in the tributary that flows into Beaver Creek, and surrounding wetlands, include invertebrates, plants, algae, amphibians, and fish.

2.0 JUSTIFICATION AND PURPOSE OF CORRECTIVE ACTION. The EPA has provided risk based corrective action guidance that specify the major components to be considered in selecting a corrective action. These include the following threshold criteria: (1) protect human health and the environment and the management of wastes; (2) attain media cleanup standards set by the implementing agency (i.e., NCDENR); (3) control the source of the releases so as to reduce or eliminate, to the extent practicable, further releases that might pose a threat to human health and the environment; (4) comply with any applicable standards for management of wastes; and (5) other factors. Corrective action alternatives meeting the threshold criteria are then balanced against the following: (1) long-term reliability and effectiveness; (2) reduction of toxicity, mobility, or volume of wastes; (3) short-term effectiveness; (4) implementability; and (5) cost.

2.1 CORRECTIVE ACTION OBJECTIVES. Due to the presence of residual soil above residential RGOs and groundwater contaminants above regulatory criteria, and elevated levels of methane in the subsurface soil within the boundaries and the immediate vicinity of SWMU 9, corrective action is warranted. The remedial response objectives for SWMU 9 are to evaluate the groundwater to determine whether further action is needed based on trends identified by periodic sampling, to prevent inadvertent human exposure to buried waste and any residual soil contaminants, and to protect the public from potential hazards associated with elevated levels of methane within the landfill.

The selected corrective actions would provide the technologies necessary to minimize exposure to contaminants in the soil and groundwater, provide adequate protection of the public from elevated methane levels, and achieve the best overall results with respect to such factors as effectiveness, implementability, and cost.

2.2 SCREENING OF CORRECTIVE ACTIONS.

a. This section identifies corrective action technologies applicable to the SWMU 9 abandoned landfill in OU3 and screens the technologies with respect to effectiveness, implementability, and cost. The technologies that are retained following screening are presented as corrective action alternatives that address limiting exposure to contaminated groundwater and surface soil and reducing potential hazards associated with elevated levels of methane in subsurface soil. The corrective action alternatives are then evaluated with respect to protection of human health, implementability, and life-cycle cost. Technologies and alternatives to address the elevated methane present in the soils at SWMU 9 are discussed separately from the groundwater and soil technologies and alternatives.

b. The first step in the development of corrective action alternatives involves the identification and screening of suitable remedial technologies for meeting the stated remedial response objectives. The technologies presented are evaluated for their general ability to protect and reduce the risk to human health. Relative screening-level costs are included for each corrective action technology.

2.3 EVALUATION OF CORRECTIVE ACTION TECHNOLOGIES. A no-action with groundwater monitoring alternative and five categories of corrective action technologies were identified for the soil and groundwater: (1) Source removal, (2) institutional controls (land-use controls and physical barriers), (3) capping, (4) native soil cover, and (5) groundwater monitoring. The no-action alternative provides a baseline against which other technologies can be compared. Under the no-action alternative, no further action would be taken to mitigate risks posed by materials in the landfill. Groundwater monitoring would be performed to document contaminant concentrations. This alternative has the lowest associated cost. The acceptability of the no-action alternative is judged in relation to the assessment of known site risks and by comparison with other corrective action technologies. The no-action alternative is not considered viable because it provides no reliable or effective method for protecting human health; therefore, the no-action alternative has been eliminated from further evaluation.

a. Source Removal would excavate the buried waste and contaminated soils. Proper disposal of the buried waste, site and safety health plans, and remedial actions would be the greatest cost. Groundwater would require monitoring until action levels drop below NC 2L groundwater standards. This would be the most expensive of actions with a cost exceeding $6.5M. Investigation has determined the waste extends into the groundwater and employing this method would not achieve reuse of the land. The All-American Freeway poses an impediment to removal of waste as it bisects the SWMU 9 landfill. Removal actions would temporarily close this major artery into the installation. As this landfill is within the existing greenbelt of the installation with no planned construction projects; removal of the waste is not warranted and this alternative was removed from consideration.

b. Institutional controls include actions taken to restrict access to contaminated areas by establishing land-use controls or by providing physical barriers. Land-use controls include controls implemented through the BMP. Requirements would be documented in the BMP. Physical barriers include installation of chain-link fencing and placement of signs or markers around the landfill boundaries or contaminated areas. Land use restrictions documented in the BMP will prohibit training, intrusive activites, and residential use. Land-use restrictions and/or physical barriers would provide effective, readily implementable, and cost-effective methods for preventing inadvertent human exposure to buried waste at the site; therefore, this technology has been retained for further consideration.

c. Capping would include placing a low-permeability clay cover on the landfill. Placement of the clay cap would require a state-approved erosion control plan and silt fencing around the perimeter of the site. The capped area would be seeded with grass to minimize erosion of the area. The clay cap would minimize infiltration into the buried debris and minimize the potential for human exposure to the buried waste. The depth of the waste is unknown and is considered to be below the water table; therefore, the effectiveness of a low-permeability cap to prevent leaching is uncertain. Current land uses at the landfill create impediments to implementation of a low-permeability cap. The All-American Freeway at SWMU 9 precludes capping over a large area of this landfill. For other areas at SWMU 9, a mature stand of pines would have to be removed before a cap could be placed. The site is located in the Green Belt of Fort Bragg. In addition, placement of a low-permeability cap could encourage further migration of the methane outside the landfill boundaries. For these reasons, the low-permeability cap has been eliminated from further evaluation.

d. Placement of a native soil cover on the landfill would minimize inadvertent human exposure to buried waste, minimize transport of contaminants through surface water runoff and air dispersion, and allow the methane within the landfill to dissipate. A minimum cover for permitted landfills under NCDENR regulations is 18- to 24-in thick with native vegetation to minimize erosion. Some native soil cover is present over part of the landfill. As with the cap, current land uses impose impediments to placement of a native soil cover. The cover could be used to treat hot spots within the landfill with existing little or no ground cover. Placement of the native cover would require a state approved soil erosion control plan and installation of silt fencing around the perimeter of the site. This technology was retained for further consideration.

e. Groundwater monitoring would include sampling and analysis of site monitoring wells to establish contaminant concentration trends or to verify that hazardous constituents leaching from buried waste are not posing a threat to human health. Groundwater monitoring is effective, readily implementable, and can be a cost-effective method for monitoring changes in the site conditions and providing an early warning to prevent potential human exposure to contaminated groundwater. Therefore, groundwater monitoring has been retained for further consideration.

2.4 Technologies for Methane in Subsurface Soil. A no-action alternative and three categories of corrective actions for the elevated methane concentrations were identified: (1) institutional controls, (2) active methane venting with physical barriers, and (3) passive methane venting with physical barriers. The technologies were evaluated using the screening criteria of effectiveness, implementability, and cost. The no-action alternative provides a baseline against which other technologies can be compared. Under the no-action alternative, no further methane monitoring and no methane mitigation would be performed. No cost would be associated with the selection of this alternative. The acceptability of the no-action alternative is judged in relation to the assessment of known site risks and by comparison with other corrective action technologies. Methane levels exceed allowable limits (5 percent at the SWMU boundary) at SWMU 9. Therefore, the no-action alternative for methane is not considered to be viable because it provides no reliable, or effective, method for ensuring human safety and has been eliminated from further evaluation.

a. Institutional controls include actions taken to restrict access to areas at the landfill potentially containing elevated methane levels by establishing land-use controls or by providing physical barriers that would prevent excavation or subsurface construction activities and monitoring. Land-use controls include restrictions implemented through the BMP and placement of signs restricting access or activities conducted at the site. Physical barriers could include installation of chain-link fencing around the landfill boundaries or around areas found to contain elevated methane levels. Monitoring includes installation of permanent soil gas monitoring points within the landfill and inside buildings on or near the landfill or in areas of high soil gas measurements outside the landfill. Land-use restrictions, monitoring, and/or physical barriers would provide effective, readily implementable, and cost-effective methods for preventing human exposure to elevated methane levels at the site. Therefore, institutional controls have been retained for further consideration, which will be documented in the BMP.

b. Passive venting of methane would relieve soil gas pressures and allow monitoring and control at selecte points within the landfill. Passive venting relies on natural pressure gradients and convection to move the methane gas to the vent wells and to the atmosphere. This is simple and cost effective measure, which would create minimal impact to the Green Belt. Passive venting has been retained for further consideration.

c. Active vacuum venting is not feasible at this site based on site surveys. The soil porosity is relatively high allowing methane flow without providing expensive pumping equipment. Pump tests at SWMU 9 indicate low vacuum impact. The relatively low potential of explosive build-up of methane gasses decreases the potential safety threat to very low. Active vacuum extraction of methane at this site is not warranted and was eliminated from consideration. The cost difference between active and passive methane venting is negligible and was not a factor in the decision process.

2.5 CORRECTIVE ACTION ALTERNATIVES. The technologies retained following the screening step were combined in various ways to develop alternatives that would meet the remedial response objective of protection of human health and safety. Regardless of the alternative chosen, the landfills will require a civil survey to establish the legal landfill boundaries for the BMP and long-term monitoring of groundwater will be required based on exceedance of the NC 2L standards.

a. Alternative 1: Institutional Controls (BMP, Chain Link Fence Barrier, Fence-Mounted Warning Signs), Groundwater and Methane Monitoring, and Implementation of O&M Plan. In this alternative, signs and fencing would be placed to keep trespassers out of areas on and around SWMU 9 that contain elevated levels of methane in the soil. A potential location of the fence is shown in Figure 3-1.

(1) The restrictions documented in the BMP would ensure that no inappropriate land uses (intrusive activites, training, or residential) would be undertaken during the remediation period. The USGS identified two PAH compounds, dibenz(a,h)anthracene and benzo(a)pyrene. Native ground cover was removed from consideration due to the impacts on wetlands, erosion control issues, and endangered species habitat.

(2) The signs and fencing will be used to ensure safety from the methane gas. The landfill was active from 1970 to 1975. Landfills typically stop generating methane gas after a 25-year period. Since the landfill is still emitting gas, it will be assumed that it will continue for an additional five years. Methane monitoring will be conducted every nine months, at the five permanent soil gas monitoring points that were installed during the 2001 investigation, for a total of five events.

(3) Following the 5-year period, the status of the landfill would be reviewed and the decision would be made, based on the soil gas monitoring results, whether to discontinue monitoring, land-use restrictions, and maintenance of the signs and fence. Groundwater would be sampled every nine months for five sampling events. The wells listed in Table 2.1 would be sampled during the first sampling event. Samples from the first sampling event will be analyzed for RCRA metals, VOCs, SVOCs, PAHs, and pesticides/polychlorinated biphenyl (PCBs). Constituents detected during the initial sampling event would be screened against background (for metals only), Federal MCLs, and NC 2L or IMAC groundwater standards.

Table 2-1. Proposed Monitoring Well Network for SWMU 9, Fort Bragg, North Carolina

Well Designation	Water Level Elevation[a] (ft)	Rationale
9MW1	213.93	Monitoring well located downgradient of western portion of SWMU 9 containing arsenic, iron, manganese and benzene at concentrations above the NC 2L Groundwater Protection Standards.
9MW3	217.12	Upgradient well designated as background well for SWMU 9 during the RFI. Only iron, during one of three sampling events, slightly exceeded the NC 2L Groundwater Protection Standard.
9MW6	208.67	Monitoring well located downgradient of central portion of SWMU 9. Contained iron and manganese at concentrations above the NC 2L Groundwater Protection Standards during the RFI.
9MW8	206.19	Downgradient well containing cadmium, iron, manganese, benzene, and vinyl chloride concentrations above NC 2L Groundwater Protection Standards.
9MW9	204.47	Downgradient well containing arsenic, iron, manganese, benzene, TPH, and vinyl chloride concentrations above NC 2L Groundwater Protection Standards.
9MW10	204.5	Downgradient well containing iron, manganese, benzene, and TPH concentrations above NC 2L Groundwater Protection Standards.
9MW12	203.5	Downgradient well that has contained concentrations of arsenic, iron, manganese, benzene, TPH, and vinyl chloride above NC 2L Groundwater Protection Standards.
9MW13	209.97	Downgradient well that contained concentrations of iron and manganese above NC 2L Groundwater Protection Standards during the RFI.
9MW14	207.88	Downgradient well that contained concentrations of iron, manganese, and lead above NC 2L Groundwater Protection Standards during the RFI.
9MW15	205.41	Downgradient well containing iron, manganese, and benzene at concentrations above the NC 2L Groundwater Protection Standards.

[a]Water levels measured 12/14/02.
NC = North Carolina.
RFI = Resource Conservation and Recovery Act Facility Investigation
SWMU = Solid Waste Management Unit
TPH = Total petroleum hydrocarbons.

(4) A list of substances exceeding MCL or NC 2L standards would be developed following the screening process. The wells to be sampled on a routine basis to monitor the groundwater will be identified and will include only those wells in that exceeded standards in the first sampling event. Analytes will be limited to the substances that exceeded standards. These data also would be reviewed following the fifth sampling event and, based on the trends established by the periodic sampling, a decision would be made to discontinue groundwater monitoring, continue monitoring, or implement remedial measures for groundwater.

(5) The BMP would prohibit installation of potable water wells at the site until a final decision is reached. No wells may be installed on the base for purposes other than monitoring without first establishing risk from groundwater use. The results of the groundwater and methane sampling would be presented in an annual report, in association with the O&M report. Annual reports will include a table presenting historical groundwater monitoring data and updated hydrogeologic cross sections. The North Carolina Department of Transportation (NCDOT) commented on an earlier draft of this document that the fencing proposed within the NCDOT right-of-way would interfere with maintenance. Because the NCDOT controls land use within its right-of-way, the fencing cannot be constructed as shown in Figure 4-1. The fencing alternative is not implementable based on NCDOT restricitions. This is the less expensive of the two alternatives for SWMU 9, with a life-cycle cost of approximately $456,000.

b. Alternative 2: Passive Venting, Institutional Controls, BMP, Physical Barrier and Signs, Groundwater and Methane Monitoring, and Implementation of O&M Plan. In addition to the technologies described above, 25 passive vents would be installed to reduce the concentration of methane gas in the landfill soil.

(1) Physical barriers (fences) would be erected to enclose the landfill, to ensure safety of the public and to protect the vents from damage. Signs would be posted on the fence at approximately 200-ft intervals.

(2) Eleven permanent soil gas-monitoring points (in addition to the five already in place) would be installed to demonstrate the effectiveness of the passive vent system. A gate would be placed at the southeast corner of the new fence in order to allow access if needed. Vents south of the freeway

will not be required as the marshy nature of the land and the stream will impose a hydraulic barrier to methane migration. Soil gas would be sampled from the 25 methane gas vents and 16 soil gas monitoring points every 9 months for 5 years. Groundwater would be sampled every 9 months for five sampling events. The wells indicated in Table 2-1 would be sampled during the first sampling event. The NCDOT has asked that the vents not be installed within the clear recovery zone or present an obstacle to sight distance. For traffic and other activities in the freeway right-of-way, the vents can be placed outside of the right-of-way without severely decreasing their effectiveness. No fences will be installed in the NCDOT right-of-way. This alternative is more expensive than Alternative 1. The cost of this alternative is approximately $483,000.

Samples from the first sampling event will be analyzed for RCRA metals, VOCs, SVOCs, PAHs, and pesticides/PCBs. Substances detected during the initial sampling event would be screened against background (for metals only), Federal MCLs, and NC 2L or IMAC groundwater standards. A list of substances exceeding NC 2L or MCL standards would be produced following the screening process. The wells to be sampled every 9 months to monitor the groundwater will be identified and will include only those wells, which exceeded MCL or NC 2L standards during the first sampling event. Analytes will be limited to the substances that exceeded the standards. After the fifth sampling event, groundwater trends and soil gas data will be reviewed and, based on the data, maintenance of the vents and groundwater sampling might be discontinued, continued, or more aggressive remedial measures could be undertaken. The BMP would prohibit installation of potable water wells or disturbance of soil at the site.

c. No wells may be installed on the Base for purposes other than monitoring without first establishing risk from groundwater use. The results of the groundwater and methane sampling would be presented in an annual report, in association with the O&M report. Annual reports will include a table presenting historical groundwater monitoring data and updated hydrogeological cross sections.

2.6 EVALUATION FACTORS. Based on the results of the technology screening, institutional controls, access restrictions, and passive venting are considered applicable to the site; therefore, three primary evaluation factors were used to select the preferred corrective action alternative: (1) protection of human health, (2) implementability, and (3) life-cycle costs.

a. Protection of Human Health. For the soil and groundwater, each alternative's effectiveness at protecting human health is dependent upon its ability to prohibit human activity associated with the disturbance of soil and the usage of groundwater. For the methane alternatives, effectiveness at protecting human health is dependent upon each alternative's ability to protect humans from the explosion hazard associated with elevated levels of methane contained in the soils. For each alternative the level of protection of human health was evaluated and compared with those of the other alternatives for that medium.

b. Implementability. Implementability addresses the technical and administrative feasibility of implementing an alternative, and the availability of various services required during its implementation. Technical feasibility assesses the ability to construct and operate a technology, reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the alternative. Administrative feasibility is addressed in terms of the ability to obtain approval from appropriate regulatory agencies.

c. Life-Cycle Costs. The life-cycle cost estimates are budget estimates based on conceptual designs and are to be used for alternative comparisons. Costs are estimated for capital construction, administration, and O&M. As the SWMU 9 landfill has not been operational for the past 25 years (since 1975), an O&M period of 10 years was deemed to be sufficient for SWMU 9. The cost estimates were derived from current information, including vendor quotes and conventional cost-estimating guides. The life-cycle cost estimates are not adjusted to present worth costs, and no escalation factors have been applied.

3.0 SELECTED CORRECTIVE ACTIONS. Because of the inability to fence in the right-of-way and methane levels exceeding the LEL in the right-of-way, the selected alternative for SWMU 9 is *Alternative 2, Passive Venting, Institutional Controls, Groundwater and Methane Monitoring, and Implementation of O&M Plan.* Passive venting will reduce methane buildup in the soil to safe levels, and monitoring will ensure the effectiveness of the remedy.

a. The institutional controls portion of this alternative will provide a combination of land-use restrictions and prohibitions, as well as providing a physical barrier with warning signs to restrict access to the abandoned landfill. Land-use restrictions will be documented and enforced through the BMP, fencing, and signage. Alternative 2 will provide a sufficient level of protection of human health and the environment and is cost-effective. This alternative will provide an adequate degree of long-term reliability and effectiveness, as well as short-term effectiveness.

b. Groundwater monitoring will be performed to evaluate contaminant concentration trends, and a decision will be made on the need for further action after five sampling events.

3.1 COST.

a. The estimated total project life-cycle cost of installing the vents, monitoring points, fence, and warning signs; performing groundwater monitoring; administering activities associated with acquisition of legal controls; performing O&M activities; and providing management and oversight is $483,000 ($233,000 capital costs and $250,000 O&M costs). This is assuming a 5-event life cycle.
No cost is associated with inclusion of land use restrictions in the BMP.

b. O&M costs could continue if the landfill continues to emit methane after 10 years or if additional groundwater sampling is needed.

3.2 ESTABLISHMENT OF CONTROLS.

a. Prior to beginning construction at the landfill, land-use restrictions (e.g. no training uses, intrusive activities, or residential use) for the site will be incorporated into the BMP, which will include all restrictions and provisions documented in this DD. The BMP will include a description of institutional controls provided in this DD. The appropriate implementing documents will include land-use prohibitions and restrictions, including those related to activities that disturb the subsurface and to construction of structures. Groundwater use also would be prohibited.

b. A survey plat for SWMU 9 will be prepared by a professional land surveyor certified by the State of North Carolina. The plat will be included in the BMP. The survey plat will indicate the location and dimension of the landfill with respect to permanently surveyed benchmarks. The plat will contain a prominently displayed note that states Fort Bragg’s obligation to prohibit disturbance of the landfill in accordance with this CMS.

c. Five-year reviews will be used to determine whether the controls are adequate, no longer needed, or should be expanded. These reviews will use the groundwater data and soil gas monitoring data that are to be collected to determine what, if any, action to take. The reviewers also may implement soil sampling to establish whether concentrations above remedial levels are still present.

3.3 FENCING AND WARNING SIGNS.

a. Approximately 2,800 linear ft of 6-ft-high, chain-link fence will be installed at SWMU 9. Fencing will block access to the areas having elevated methane levels north of the freeway. Double-swing gates (20-ft wide) will be provided to allow access to the fenced-off areas of the landfill. Details of the fencing are shown in Figure 3.1. No smoking signs will be posted on the jogging trail.

b. Twenty permanent warning signs would be installed on the fence at SWMU 9 (at approximate 200-ft intervals). The signs on the vent well gates and on the SWMU 9 fence will be worded as follows:

FORMER LANDFILL
EXPLOSIVE GAS WARNING
NO TRESSPASSING
CONTACT PWBC (910) 396-3341, EXT.353
REGARDING USE RESTRICTIONS

Each sign will have the dimension of 24 by 24 in. Warning signs will be metal plates with reflective paint and weather-resistant construction. The signs will have a brown background and white lettering. All signs will be permanently labeled on the back with an identification number.

c. The fence and warning signs will be inspected every 9 months in accordance with the O&M Plan. Damaged fencing and signs will be repaired, or replaced, as needed. Repair or replacement of the fence or signs will occur within one month of inspection. Should damage be observed between inspections, repair or replacement will occur within 1 month of observation.

3.4 GROUNDWATER MONITORING.

a. Groundwater will be monitored every 9 months for five sampling events. Seventeen of these wells will be sampled in the first sampling event and analyzed for RCRA metals, VOCs, SVOCs, PAHs, and pesticides/PCBs to establish a baseline. The 17 wells to be sampled are presented in Table 2-2. Contaminants detected during the initial sampling event would be screened against background (metals only), federal MCLs, and NC 2L or IMAC groundwater standards. Following this initial event, the wells and analysis to be conducted in future sampling events will be selected based on exceedance of the NC 2L or IMAC standards. If there is no NC 2L or IMAC standard, then the remedial level is set equal to the Federal MCL.

b. Thereafter, the analyte list will be limited to the compounds for which remedial levels were set. The wells that will be routinely sampled will be those in which one or more of the compounds on the analyte list exceeded regulatory criteria. The purpose of the monitoring is to establish contaminant concentration trends and determine whether additional actions are needed to address the groundwater. These data would be reviewed following the fifth sampling event and, based on the trends established by the periodic sampling, the decision would be made to discontinue groundwater monitoring, continue monitoring, or implement remedial measures.

4.0 CONCLUSION. The selected alternative for SWMU 9 is *Alternative 2, Passive Venting, Institutional Controls, Groundwater and Methane Monitoring, and Implementation of O&M Plan*. Passive venting will reduce methane buildup in the soil to safe levels, and monitoring will ensure the effectiveness of the remedy. The estimated total project life-cycle cost of installing the vents, monitoring points, fence, and warning signs; performing groundwater monitoring; administering activities associated with acquisition of legal controls; performing O&M activities; and providing management and oversight is $483,000 ($233,000 capital costs and $250,000 O&M costs.

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ACRONYMS

AMSL	above mean sea level
BGS	below ground surface
BHC	benzene hexachloride
BLS	below land surface
BMP	Base Master Plan
CMS	corrective measures study
COC	contaminant of concern
COPC	contaminant of potential concern
DRO	diesel-range organic
EPA	U.S. Environmental Protection Agency
GRO	gasoline-range organic
HHCOC	human health contaminant of concern
HQ	hazard quotient
IMAC	interim maximum acceptable concentration
IRP	Installation Restoration Program
LEL	lower explosive limit
MCL	maximum contaminant level
NCDENR	North Carolina Department of Environment and Natural Resources
NCDOT	North Carolina Department of Transportation
NFA	no further action
O&M	operations and maintenance
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppm	parts per million
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act of 1976
RD	remedial design
RFI	RCRA facility investigation
RGO	remedial goal objective
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TOC	total organic carbon
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VOC	volatile organic compound

Figure 3-1 SWMU 9

SWMU 9 Vicinity Map / Fort Bragg, NC