Screening and Evaluation of Remediation Technologies and Process Options, Former Communications Site, Fort Wainwright, Alaska

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This technical memorandum has been prepared as a stand-alone document to provide an expanded discussion of the screening and evaluation of remedial technologies and process options associated with the *Feasibility Study, Former Communications Site, Fort Wainwright, Alaska*. CH2M HILL prepared this document under contract to Jacobs and the U.S. Army Corps of Engineers.

BACKGROUND

The FCS is located in the western-central portion of Fort Wainwright and has a history of mixed uses, including barracks and company headquarters, communication and radar systems, salvage/reclamation yard activities, debris disposal, garden plots, possible ammunition storage, and firefighter training. The FCS currently consists of the nearly completed Taku Gardens family housing development, which covers approximately 54 acres. Environmental contamination and buried debris containing munitions-related items were discovered during the course of Taku Gardens family housing construction. The 110 housing units (55 buildings) have been constructed, but will not be released for occupancy until the Army, Alaska Department of Environmental Conservation (ADEC), and U.S. Environmental Protection Agency (EPA) agree that the area is safe for future residential occupation.

In July 2011, the Army issued the *Final Remedial Investigation, FWA 102 Former Communications Site, Fort Wainwright, Alaska* (Remedial Investigation [RI] report), which documented the results of data collection efforts conducted to characterize site conditions, determine the nature and extent of contamination, and support informed risk-management decisions regarding potential risks to human health and the environment. The RI indicated that previous site use had resulted in soil, soil gas, and groundwater contamination at the FCS. The identified contaminants of concern (COCs) for soil and groundwater are presented in Tables 1 and 2, respectively. No COCs were identified for the soil gas media.

The human health risk assessment (HHRA) that accompanied the RI report evaluated two exposure cases: (1) the reasonably anticipated future use (residential) scenario considers restrictions that preclude digging onsite and prevent use of shallow groundwater from areas outside the existing Fort Wainwright water supply wells; and (2) the hypothetical unrestricted exposure scenario uses conservative default assumptions regarding domestic use of shallow groundwater and direct contact with soil to 15 feet below ground surface

(bgs) anywhere across the site, regardless of the existence of current or future measures precluding exposure to these media. The HHRA also included evaluation of potential exposure to recreational/site visitors, maintenance workers, and excavation workers who may use the site in the future. The results of the HHRA indicated that under the reasonably anticipated future use scenario, even if cumulative exposure occurs to the highest levels at any surface soil and subslab soil gas locations, and is combined with exposure from domestic use of Fort Wainwright-supplied water, the resulting risk estimates do not exceed the EPA and ADEC risk threshold values. However, the results of the HHRA under the unrestricted use scenario indicate that resulting risk estimates exceed the ADEC risk threshold.

The Army issued the *Final Feasibility Study, Former Communications Site, Fort Wainwright, Alaska* (Feasibility Study [FS] report) in July 2011. The FS was prepared to conservatively evaluate alternatives for the hypothetical, unrestricted use scenario. The FS evaluated remediation approaches for the soil and groundwater media. Remediation approaches for soil gas were not evaluated because identified contamination in this media did not pose a significant risk to human health under either the reasonably anticipated future use scenario or unrestricted use scenario, and no COCs for this media were identified.

SCREENING AND EVALUATION OF REMEDIATION TECHNOLOGIES

The screening and evaluation of remediation technologies was presented in Section 4 of the FS). The screening and evaluation process consists of two steps: 1) potential remediation technologies are screened for applicability, and 2) technologies deemed applicable are further evaluated for effectiveness, implementability, and cost. The applicability screening considers the ability of a process option to address COCs and media of concern, and how reliable and proven the process is with respect to site-specific contamination and conditions. The effectiveness of a technology is evaluated based on site-specific contamination and conditions, and it considers how effective the technology will be at mitigating the COCs within the media (or medium) of concern. Implementability considers how readily implementable the technology is at the site from both the administrative and logistical standpoints. The costs for each technology are also evaluated relative to one another. This two-step screening and evaluation process for the FCS was summarized in Tables 4-1 and 4-2 of the FS.

General response actions describe those actions that can potentially achieve established remedial action objectives (RAOs). Remedial technologies are defined as the general categories of remedies or technology type under a general response action. Process options are specific processes within each technology. The process options are used to implement each remedial technology. For example, the remedial technology of removal could be implemented using one of several process options including excavation and groundwater extraction. Typically, several process options are combined to form remedial alternatives. For example, a complete "pump and treat" remedial alternative for groundwater might include the groundwater extraction, air stripping, groundwater monitoring, and institutional controls process options.

Remedial technologies and process options for the remediation of contamination at the FCS can be grouped under the following general response actions:

- Institutional Controls
- Monitoring
- Containment
- Removal
- Treatment
- Disposal

The specific remedial technologies and process options for each of these general response actions are discussed below.

Institutional Controls

Institutional controls are administrative or governmental controls (e.g., zoning, deed restrictions, land use policies, dig permits, etc.) that can be used to minimize or prevent exposure to contaminants in various media including soil and groundwater (the two media of concern at the FCS). For the FCS, institutional controls would be used to control the transportation and disposition of exhumed soil and to prohibit installation of dewatering wells, monitoring wells, or potable water wells for whatever reason without prior approval from the Fort Wainwright Department of Public Works (DPW). The institutional controls would be implemented by the Army through a Garrison Policy. The Garrison policy was considered to be applicable because the FCS is owned and controlled by the Army. It was also considered to be effective because it would restrict soil movement and access to groundwater thereby eliminating or minimizing potential human exposure to COCs. The legal mechanisms and processes are already in place at Fort Wainwright to implement and enforce a Garrison Policy. The cost associated with implementing and enforcing a Garrison Policy is negligible because the infrastructure and personnel at DPW are already in place. Institutional controls were retained in the FS to become an alternative for soil (Alternative S2) and component of several alternatives for groundwater (Alternatives GW2, GW3, and GW4).

Monitoring

Under the monitoring general response action, groundwater monitoring and monitored natural attenuation (MNA) were identified as process options for groundwater at the FCS. No monitoring technologies or process options were identified for the soil medium.

Groundwater monitoring consists of the collection and analysis of groundwater samples to evaluate contaminant concentrations and migration rates in groundwater. In most cases, the groundwater monitoring process option is not a standalone remedial alternative, but this process option is combined with other process options to form a complete alternative. Groundwater monitoring was consisted to be potentially applicable, and effective for addressing all COCs in groundwater at the FCS. It was also considered to be readily implementable. The groundwater monitoring process option was retained and incorporated into all of the remedial alternatives for the FCS (Alternatives GW-2, GW-3, and GW-4).

MNA consists of the collection and analysis of groundwater samples to verify that organic contaminants (e.g., hydrocarbons and organic solvents) are degrading naturally and their

degradation rate. The analysis of the samples typically includes the target COCs and general water quality parameters such as dissolved oxygen and oxidation-reduction potential (ORP). MNA was considered potentially applicable for assessing the degradation of COCs present in groundwater at the FCS (the primary COCs are diesel range petroleum, PCE, TCE, and 1,2,3-trichloropropane). MNA, which has been demonstrated as a viable process option for several other sites at Fort Wainwright, does not remediate groundwater contamination by itself; however, natural degradation processes facilitate the gradual reduction in the volume and toxicity of the contaminants. Because of the relatively low concentrations of contaminants in groundwater at the FCS and relatively low groundwater migration rates, MNA is considered an effective process option for the FCS. MNA is also readily implementable and relatively low cost. MNA was retained for consideration and was incorporated into two groundwater alternatives (GW-2 and GW-4).

Containment

Under the containment general response action, one physical/impermeable barrier and two hydraulic barriers were evaluated to address the groundwater medium. No containment general response actions were identified for soil.

The physical/impermeable barrier consisted of the installation of a slurry wall, sheet piling, or barrier wall that would physically prevent the migration of contaminated groundwater. While this technology was considered to be potentially applicable and effective, it was not considered to be implementable at the FCS. Groundwater contamination at the FCS is present in several distinct plumes located in different areas of the FCS that would require an extensive area of containment. Installation of the barrier over an extensive area would be impractical because of the existing residential housing and related infrastructure on the site. In addition, the cost of an extensive barrier system would be very high relative to other potential alternatives. Due to the lack of implementability and high relative cost, this technology was eliminated from further consideration.

Two hydraulic barriers were identified. The first consists of an extraction well network, and the second consists of a combined extraction and injection well network. Both of these technologies would be used to prevent the migration of contaminated groundwater by extracting (or extracting and re-injecting) water to artificially reduce the hydraulic gradient of the water table thereby minimizing groundwater movement within the zone of influence. This technology was considered to be potentially applicable and effective. While implementable, because groundwater contamination at the FCS is present in several distinct plumes located in different areas, each distinct area would require a containment well network. Although feasible, installation and maintenance of the well networks would be difficult within a residential housing area. The cost of the containment well networks (including O&M) would be moderate to high relative to other potential technologies.

Removal

Under the removal general response action, excavation was identified as a remediation technology for the soil medium, and groundwater extraction was identified as a remediation technology for groundwater.

Excavation consists of physically removing contaminated material (i.e., soil) from the site. Soil excavation was identified as potentially applicable in that it is capable of addressing all

COCs in soil at the FCS, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and non-VOCs (e.g., metals). However, it was considered to be incompatible with existing residential development at the FCS (excavation would require the disturbance or destruction and replacement of existing infrastructure). In addition, soil excavation was not considered to be effective. Residual concentrations of contamination in soil at the FCS do not appear to represent a significant threat to onsite groundwater if left in place. Only if the soil is exhumed from the site and disposed of offsite does it appear to pose a possible threat to groundwater, surface water, or human health. The cost for soil excavation, including the repair or replacement of existing infrastructure is also very high. Because soil excavation had limited implementability, a lack of effectiveness, and high relative cost, this technology was eliminated from further consideration.

Groundwater extraction consists of the installation of groundwater extraction wells that are used to physically extract contaminated water from the groundwater system. Extracted water is typically treated to remove or destroy contaminants and disposed. Groundwater extraction was considered to be a potentially applicable and effective technology for removal of COCs in groundwater at the FCS. It is also effective in controlling the lateral and vertical migration of groundwater contamination. While implementable, because groundwater contamination at the FCS is present in several distinct plumes located in different areas, each distinct area would require a groundwater extraction well network. Although feasible, installation and maintenance of the extraction well networks would be difficult within a residential housing area. The overall cost of the extraction well networks (including O&M) would be high relative to other potential technologies.

Treatment

Within the treatment general response action, four different remedial technologies and eight process options were identified for groundwater at the FCS. One remedial technology and one process option was identified for the soil medium.

Under the ex situ physical treatment remedial technology, the process options of granulated activated carbon (GAC) and air stripping were identified for groundwater. These process options are not considered to be stand-alone alternatives for groundwater remediation, but rather a component of an alternative (e.g., GAC could be combined with the groundwater extraction process option to form a complete "pump and treat" alternative). Both process options were considered to be potentially applicable treatment options. However, both process options have limited ability to treat diesel range hydrocarbons, which would limit the use of these options to only the VOC contaminants in groundwater (i.e., PCE, TCE, and 1,2,3-trichloropropane). Although these process options are effective for VOCs, a lack of effectiveness for diesel range hydrocarbons (one of the contaminants in groundwater at the FCS) and high overall relative cost eliminated these options from further consideration.

Under the ex situ chemical treatment remedial technology, the process option of advanced oxidation was identified for groundwater. This process option is not considered to be a stand-alone alternative for groundwater remediation, but rather a component of an alternative. Advanced oxidation was considered to be a potentially applicable treatment option. However, this process option has limited ability to treat diesel range hydrocarbons, which would limit the use of this option to only the VOCs in groundwater (i.e., PCE, TCE, and 1,2,3-trichloropropane). Although this process option is effective for volatiles, a lack of

effectiveness for diesel range hydrocarbons (one of the contaminants in groundwater at the FCS) and high overall relative cost eliminated this option from further consideration.

Under the in situ chemical treatment remedial technology, the process options of a permeable reactive barrier (PRB), chemical oxidation, and chemical reduction were identified for groundwater. The PRB and chemical oxidation process options were considered to be potentially applicable and effective because these options are suitable for groundwater COCs at the FCS. Chemical reduction was also considered to be potentially applicable, but its effectiveness may be limited because it is not likely to be readily effective for fuels (i.e., diesel range organics). All three process options were considered to be implementable; however, the implementability of the PRB process option may be somewhat limited due to the intrusiveness of the technology (i.e., a large trench must be excavated to facilitate installation of the PRB) and its potential affect on existing residential infrastructure on site. The relative overall cost of the PRB option (including O&M) is moderate to high, and the relative overall cost of the chemical oxidation and chemical reduction process options (including O&M) are moderate. The chemical oxidation process option was retained for consideration and was incorporated into groundwater alternative GW-3, and the PRB process option was retained for consideration and was incorporated into groundwater alternative GW-4. Please note that during further evaluation of groundwater alternative GW-4 it was determined that although the PRB is capable of treating COCs, the hydraulic conductivity of the formation at 10^{-1} centimeters per second (cm/s) is about an order of magnitude higher than typical PRB materials (10^{-2} cm/s); therefore, there is likely to be no flow through the barrier, rendering it ineffective. In addition, because of the depth to which the PRB would need to be installed (greater than 20 feet bgs), installation of the PRB would be highly disruptive and costly. Therefore, groundwater alternative GW-4 was eliminated from further evaluation.

Under the in situ biological treatment remedial technology, the process options of aerobic biodegradation, enhanced reductive dechlorination (anaerobic biodegradation), and biosparging were identified for groundwater. All three process options were considered to be potentially implementable. However, aerobic biodegradation and biosparging are not effective at addressing chlorinated compound such as PCE and TCE. The anaerobic biodegradation process option is effective for fuel constituents (i.e., diesel range organics). All three process options are considered to be implementable, although the biosparing process option may be intrusive and not readily compatible with existing residential development. The overall relative cost of these three process options is moderate.

Under the in situ thermal treatment remedial technology, the process option of steam stripping was identified for the soil medium. Steam stripping was not considered to be applicable for soil at the FCS. Although this process option is well suited to volatile contaminants, it is less effective for semi-volatiles and ineffective for non-volatiles. Soil contamination at the FCS consists of a wide range of VOCs, SVOCs, and non-VOCs; therefore, this process option is not applicable to all COCs in soil at the FCS and was eliminated from further consideration.

Disposal

For the disposal general response action, offsite disposal was identified as a remedial technology for the soil medium and treated water reuse was identified as a remedial technology for ground water.

Under the remedial technology of offsite disposal, the process option of disposal at an offsite landfill was considered for the soil medium. This process option involves the transport and disposal of contaminated soil from the FCS to an appropriate offsite landfill. This may include disposal at a Class I or Class III facility depending on the characteristics of the soil and types and concentrations of residual contaminants in the soil. This process option is not considered to be a stand-alone alternative for soil, but rather a component of an alternative (e.g., offsite disposal could be combined with the soil excavation process option to form a complete soil removal alternative). This process option was considered potentially applicable, effective, and readily implementable; however, if Class I disposal is required, the soil may need to be transported a significant distance, resulting in high cost.

Under the treated water reuse remedial technology, six process options were identified consisting of irrigation/land application, engineered wetlands, discharge to a municipal water district, discharge to the sanitary sewer system, discharge to a local water body, and aquifer reinjection. These process options are not considered to be stand-alone alternatives for groundwater, but rather components of groundwater alternatives. Four of the process options, irrigation/land application, engineered wetlands, discharge to a municipal water district, and aquifer reinjection, were deemed not to be applicable. Irrigation/land application and discharge to a municipal water district were not considered to be applicable because of the likely negative public perception of reusing treated water for irrigation and/or domestic purposes. An engineered wetland was considered not to be applicable because creation of the wetlands would require significant space that is not available onsite due to the existing residential development. The process options of discharge to the sanitary sewer system and discharge to a local water body were considered to be applicable and effective disposal options for treated water as long as the water meets discharge requirements. Both process options were considered to be implementable, but may require coordination with local authorities and permits. Discharge to the sanitary sewer system is believed to be a relatively low cost process option. Discharge to a local water body is believed to be a relatively high cost process option because it will likely require extensive treatment to meet discharge requirements protective of ecological receptors in the receiving water body.

TABLE 1
Identification of COCs for Soil
Former Communications Site, Fort Wainwright, Alaska

COCs	Analytical Group
1,1,2- Trichloroethane	VOC
1,2,4-Trichlorobenzene	VOC
1,2-Dichloroethane	VOC
1,2,3-Trichloropropane	VOC
1,2-Dichloropropane	VOC
1,2-Dibromomethane	VOC
Benzene	VOC
Chloroform	VOC
Dibromochloromethane	VOC
Methylene chloride	VOC
Tetrachloroethene (PCE)	VOC
Trichloroethene (TCE)	VOC
Vinyl chloride	VOC
2-Hexanone	VOC
Gasoline Range Organics (GRO)	TPH
Diesel Range Organics (DRO)	TPH
4-Chloroaniline	SVOC
4-Nitroaniline	SVOC
2,4-Dinitrotoluene	SVOC
2,6-Dinitrotoluene	SVOC
Hexachlorobenzene	SVOC
n-Nitrosodimethylamine	SVOC
n-Nitroso-di-n-propylamine	SVOC
Pentachlorophenol	SVOC
Bis-(2-Chloroethoxy)methane	SVOC
Bis-(2-Chloroethyl)ether	SVOC
Bis-(2-Chloroisopropyl)ether	SVOC
Beta-BHC	Pesticide
Gamma-BHC	Pesticide
2,4,5-T	Herbicide
Aroclor 1260	PCB
Arsenic	Metal
Aluminum	Metal
Copper	Metal
Manganese	Metal

TABLE 2
Identification of COCs for Groundwater
Former Communications Site, Fort Wainwright, Alaska

COCs	Analytical Group
Diesel Range Organics (DRO)	TPH
Resdiual Range Organics (RRO)	TPH
1,1,2,2-Tetrachloroethane	VOC
1,2,3-Trichloropropane	VOC
Trichloroethene (TCE)	VOC
Arsenic	Metal
Cobalt	Metal
Iron	Metal