FINAL
ENGINEERING EVALUATION/COST ANALYSIS
STUDY REPORT
FOR

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTHWEST FUNSTON LANDFILL

FORT RILEY MILITARY INSTALLATION
FORT RILEY, KANSAS

Prepared for:

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LIST OF ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
A-E	Architect-Engineer
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
CAL	Corrective Action Level (RCRA)
CEMRD	Corps of Engineers - Missouri River Division
CEMRK	Corps of Engineers - Missouri River Division, Kansas City District
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
cm	Centimeter
CWA	Clean Water Act
DA	Department of the Army
DDE	Dichlorodiphenyldichloroethylene
DEH	Directorate of Engineering and Housing
DOD	Department of Defense
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
gpm	Gallons Per Minute
H	Horizontal
IAG	Inter-Agency Agreement
IRP	Installation Restoration Program
KAR	Kansas Administrative Regulations
KDHE	Kansas Department of Health and Environment
kg	Kilogram
KGS	Kansas Geological Survey
km	Kilometers
LEGS	Law Environmental, Inc., Government Services Division
m	Meter
MCL	Maximum Contaminant Level

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

MSL	Mean Sea Level
MDL	Method Detection Limit
mg	Milligram
mg/kg	Milligram per Kilogram
MSL	Mean Sea Level
NAAQS	National Ambient Air Quality Standard
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List (Superfund List)
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
ppb	Part Per Billion
ppm	Part Per Million
PSCS	Preliminary Site Characterization Summary
PRC	PRC Environmental Management, Inc.
QA/QC	Quality Assurance/Quality Control
QCSR	Quality Control Summary Report
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SFL	Southwest Funston Landfill
SOW	Scope of Work
TBC	To Be Considered
TRC	Technical Review Committee
TRPH	Total Recoverable Petroleum Hydrocarbons
µg/kg	Microgram Per Kilogram
µg/L	Microgram Per Liter
USACE	United States Army Corps of Engineers
USATHAMA	United States Army Toxic and Hazardous Materials Agency
USC	United States Code

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

USDA	United States Department of Agriculture
USDASCS	United States Department of Agriculture - Soil Conservation Service
USGS	United States Geological Agency
V	Vertical
VOC	Volatile Organic Compound
WPC	Water Pollution Control
WQC	Water Quality Criteria
WWTP	Wastewater Treatment Plant
XRF	X-ray Fluorescence

EXECUTIVE SUMMARY

Law Environmental, Inc., has prepared this report for the Southwest Funston Landfill at Fort Riley, Kansas, under contract to the U.S. Army Corps of Engineers (USACE), Missouri River Division, Kansas City District. The purpose of this report is to present the results of an Engineering Evaluation/Cost Analysis which was conducted to identify non-time-critical removal action alternatives addressing the bank stabilization of the Southwest Funston Landfill along the Kansas River and the landfill cover.

The Southwest Funston Landfill (SFL) is located in the southern portion of Fort Riley on the north bank of the Kansas River. The SFL, which encompasses approximately 107 acres, was operated between the mid-1950s and 1981, and ceased operations in 1981. Most wastes disposed at SFL consisted of domestic refuse and wastewater treatment sludges, but some waste motor oils and degreasing solvents were also disposed in the landfill. Spot dumping may have occurred in localized areas within the wooded area west of Threemile Creek, but this activity could not be documented. Recovery of these disturbed areas is well under way. The wooded area is not included in this removal action EE/CA because only a small fraction of waste materials placed at the SFL may be located in this area, and remediation will require the clearing of this forested area providing wildlife habitat. The landfill closure in 1983-1984 included placement of a clayey to silty loam soil cover, portions of which were obtained from a former rifle range berm, which has been found to contain elevated lead concentrations but not at levels exceeding those established for non-residential use areas.

The landfill surface is presently covered by areas of tall weeds and underbrush and is relatively level. Surface erosion and settlement have led to ponding over approximately five percent of the landfill surface. Some landfill debris was observed in two areas of the landfill (less than three total acres). These materials are believed to have been dumped on the surface.

A review of the Kansas River Fort Riley Gauge records since Milford Dam was constructed in 1965 indicated that, on average, river rises to within four feet of the SFL bank height (1044 MSL) occurred once per year for an average 5.2 day duration. River influence on the observed groundwater levels in the SFL monitoring wells was evident during the July 1992 river rise event. The groundwater beneath the SFL is believed to be significantly influenced by Kansas River levels.

Erosion and slope failure have occurred at certain locations along the adjacent river bank, with the most prominent failures in the western perimeter of the landfill. Bank failures appear to be the result of streambed scour, toe erosion, and water table drawdown due to rapid fluctuations of the river water levels. To determine the recent migration of the Kansas River bank along the SFL, aerial photographs taken in 1971 and 1992 were overlain onto a topographic map prepared from a 1984 aerial photograph. A slight (less than five feet) migration was observed between survey points 2 and 4 which is along and upstream from the southwest corner of the landfill. No additional channel movement was observed.

The scope of non-time-critical removal actions for both the landfill cover repairs/improvements and river bank stabilization focuses on reducing or eliminating visually identified areas of concern, but does not address the removal or treatment of contaminated media at the site. Specific objectives of a removal action include providing adequate landfill cover and improving surface drainage, reduce potential for leachate generation and contaminant migration due to infiltration, minimizing erosion of cover soils and the river bank, and preventing further movement or erosion of the river channel by stabilizing the bank along the landfill.

The EE/CA Guidance Memorandum (EPA 1988) suggests that non-time-critical removal actions should address Applicable or Relevant and Appropriate Requirements (ARARs) to the extent possible. Site-specific ARARs were identified, which included only location-specific and action-specific requirements.

Evaluation criteria were then selected to determine the need for landfill surface repairs/improvements and river bank repairs/improvements as removal actions. Identified criteria for the landfill surface included erosion potential, extent of existing vegetation and soil cover, river flooding impacts, and ponding and infiltration of surface water. Application of the landfill cover evaluation criteria concluded that, without repairs/improvements to the cover, ponding of storm water will continue, landfill cover materials may be eroded, and infiltration of surface water is likely to increase. The review of Kansas River gauge heights has projected that the SFL was inundated once since Milford Dam was constructed.

Identified evaluation criteria for river bank repairs/improvements included the likelihood of flooding, river velocity and erosion potential, historic river movement, existing riverbank conditions, uncertainties of waste content and location adjacent to the river bank, and potential threats to human health and the environment by maintaining the current situation. Application of river bank repairs/improvement evaluation criteria concluded that, without improvements to minimize impacts of flooding and high water, river bank erosion patterns are likely to continue, leading to the possible exposure and erosion of landfill waste. Threats to human health and the environment if the current condition is maintained include exposure and migration downstream of landfill contents due to erosion of streambank and cover soils. Chemical constituents identified in soils and ground water at the SFL are not likely to present a significant threat to human health or the environment under current uses of the SFL.

Alternatives developed and presented in this EE/CA are intended to illustrate the range of alternatives available to meet the removal objectives. Removal action alternatives were based on the evaluation criteria identified. Landfill surface repair/improvement alternatives consist of site filling and grading, including grading to fill depressions and erosion channels; a complete soil cover with constant surface slope; and a complete soil cover with a low permeability soil cap. Evaluation and screening of these alternatives, based on effectiveness, implementability, and cost, have been performed in this study. The site filling and grading alternative is the recommended non-time-critical removal action.

River bank repair/improvement alternatives consist of the following slope protection/stabilization methods: nonstructural methods (vegetation and bank shaping), structural methods (riprap, rubble, revetment, structural walls, grout blankets, gabions, sand-cement bags, used tires, fences, Kellner jacks, and dikes), and river rerouting. Evaluation and screening of these alternatives have been performed, and the quarry run stone toe revetment with baffles is the recommended non-time-critical removal action.

The final design of the selected removal action, following public comment, will be further developed and refined prior to implementation.

1.2 APPLICABILITY AND STEPS IN THE EE/CA PROCESS

The Engineering Evaluation/Cost Analysis (EE/CA) process can be used to accomplish Expedited Response Actions at Fort Riley NPL sites which are determined to require non-time-critical removal actions.

The steps in the EE/CA process are as follows:

A. EE/CA Study and Report Preparation

The EE/CA report is prepared to characterize the site, identify removal action objectives and alternatives, analyze removal alternatives and propose removal action.

B. Public Comment Period

The EE/CA report is added to the Administrative Record, and a 30-calendar-day public comment period is held in accordance with the IAG and NCP.

C. Action Memorandum Document and Responsiveness Summary

This document describes the proposed SFL bank stabilization and landfill cover enhancements removal actions and secures approval by the DA and concurrence by KDHE, and EPA to implement these actions. The responsiveness summary provides Ft. Riley's responses to significant public comments.

D. Implementation of Removal Action

Implementation entails construction of the removal action.

2.0 SITE CHARACTERIZATION

2.1 SITE DESCRIPTION

2.1.1 Site Location

Fort Riley is located near the confluence of the Republican and Smoky Hill Rivers, and is bordered by rural areas and the cities of Ogden to the east and Junction City to the southwest (Figure 2-1). Fort Riley occupies approximately 150 square miles in Geary and Riley counties in Kansas.

The Southwest Funston Landfill (SFL) is located in the southern portion of Fort Riley on the north bank of the Kansas River, west of Camp Funston, south of Huebner Road, and east of an old channel of the Kansas River (Figure 2-2). Based upon aerial photographs, a geophysical survey, and a soil gas survey, the inferred surface area of the SFL encompasses approximately 107 acres not including the wooded areas north of Well House Road and west of Threemile Creek. Additional random placements of wastes are believed to have occurred within the wooded areas to the west of Threemile Creek, and also north of Well House Road outside of this inferred area. During the SFL wetlands survey performed by the USACE in March 1993, evidence of previous disturbances within this wooded area west of Threemile Creek were noted (USACE, 1993). Localized spot burial of wastes within this forested area west of Threemile Creek may have occurred, but these events cannot be documented or positively identified using aerial photographs. The present condition of this wooded area west of Threemile Creek and its predominant coverage by trees and vegetation shows that the recovery from previous disturbances in the area is well under way. These wooded areas west of Threemile Creek and north of Well House Road have not been included in the evaluation because relative to the inferred landfill limits, they are likely to contain only a small fraction of the total volume of wastes disposed at the SFL. Additionally, remedial efforts in this area would require the clearing of this established woodland area which provides ecological habitat along Threemile Creek. The elevation of the landfill surface varies slightly from 1040 to 1055 feet MSL.

2.1.2 Site Physical Characteristics

2.1.2.1 Climate - The climate of the SFL (based on information from Fort Riley Marshall Airfield Weather Station) is classified as temperate. Mean monthly temperatures for the area range from 26.1 degrees Fahrenheit (°F) in January to 78.6°F in July. Mean yearly temperature is 54.1°F. Rainfall in the area averages approximately 31 inches (in), with June and July being the wettest months (5.2 and 4.1 in) and January being the driest month (0.9 in). Precipitation in the form of snowfall averages approximately 22 in per year with approximately equal distribution between the months of December, January, February, and March. The net annual estimated evapotranspiration is 19 inches per year. Prevailing winds are from the south-southwest, except for January through March, when they are from a northerly direction. The mean windspeed varies between 7.6 and 10.9 miles per hour (NOAA, 1991).

2.1.2.2 Geology - Fort Riley lies within the Osage Plains section of the Central Lowlands physiographic province. The rocks exposed in the Fort Riley area range in age from Lower Permian to Recent and consist of alternating limestones and shales. The principal Permian strata exposed in the Fort Riley area are the Winfield, Doyle, Barneston, Matfield, and Wreford Formations of the Chase Group. Distinct members of alternating limestones and shales of variable thickness occur within each formation. The Kansas River has cut downward into the underlying Council Grove Group, which consists of the Speiser, Funston, Blue Rapids, Crouse, Easly Creek, Bader, and Stearns Formations. These formations also consist of alternating limestone and shale members that are not exposed at the surface in the Fort Riley area but are present in the subsurface underlying the river alluvium.

Overlying the bedrock are alluvial deposits and windblown loess of Pleistocene and Recent age. The windblown loess is the oldest of the unconsolidated deposits and is believed to be partly Pleistocene and partly Recent in age. The loess deposits on Fort Riley range from 0 to 1.8 ft in thickness. The loess is composed of approximately 15 percent fine sand and 85 percent silt and clay material.

The SFL lies on a geological-topographical unit known as the "alluvial bottom lands" of the Kansas and Republican Rivers. Relief in this area ranges from 25 to 60 ft. (USATHAMA, 1984). The alluvial deposits underlying the SFL are part of the flood plain deposits of the Republican and Kansas Rivers (Terrain Analysis Center, 1977). The alluvium near the surface consists of silt, clay, and very fine sand; at greater depths, coarser sand and gravel are the predominant sediment types. The coarser sediment at the bottom of the alluvium may, in part, be colluvium from the weathered shale and limestones of the adjacent river valley. The maximum thickness of the alluvium on Fort Riley as determined from well logs was 84.4 ft. These alluvial deposits are present along the banks and the bottom of the Kansas River, in the vicinity of the SFL, as described in the next section. Depths to the shale/limestone bedrock in the vicinity of the SFL range from 34 to 67 feet.

2.1.2.3 Soils - The general area along the Kansas River in which the SFL lies naturally contains soils characterized as Haynie Series calcareous alluvial soils. These soils usually occur on the floodplains along rivers and are formed in calcareous alluvium. The series varies from very fine sandy loam to silty clay loam, 50 to 60 inches deep. The soil type has moderate permeability.

The central portion of the landfill naturally contains soil characterized as Haynie Series calcareous soils. It has moderate permeability and is readily flooded. Well boring SFL92-603 (Figure 2-3) which was installed at the landfill perimeter, revealed the uppermost horizon as silty sand of very low plasticity, sand, clayey silt, or silt underlain with a mixture of sand, silt, gravel, and minor clay down to the bedrock The landfill operation, particularly surface grading and placement of fill soil, has modified the surficial soils. Soil cover at the landfill surface (0 to 6 inch depths) was generally a clay to silty loam with very few rock fragments (PRC, 1993) which was obtained from a former rifle range berm in conjunction with landfill closure completed in 1983.

Soils along the river bank are characterized as Sarpy Series. These soils are formed from alluvial sediments and are described as loamy fine sands to fine sands with very high permeability. All layers of the soil profile below the surface layer are loose when dry and are very susceptible to erosion (USDA, 1975). Well boring SFL92-403 (figure 2-3) which is located approximately 370 feet north from the river bank revealed the uppermost horizon as non plastic clayey, fine-grained sand underlain with a mixture of sand and gravel down to the top of bedrock, which is approximately 20 feet below the elevation of the Kansas River bottom. Boring SFL92-303 (Figure 203) also revealed fine-grained sand surface soils underlain by silt, silty sand, sand, and gravel down to bedrock elevation, which is below the river bed. This boring is located approximately 50 feet north from the river bank. These borings confirm the presence of sands, silts, and gravels along the river bank area adjacent to the SFL which are prone to erosion.

2.1.2.4 Surface Waters - The Kansas River and one of its major tributaries, the Republican River, form portions of the southern boundary of the installation. The numerous streams which originate on or flow through the installation eventually discharge into one of these major tributaries. Perennial streams located on the installation include Wildcat Creek, Madison Creek, Timber Creek, and Threemile Creek. Threemile Creek flows along the eastern boundary of the SFL. As part of the levee improvement, the original channel alignment of Threemile Creek between the SFL and the levee east of the SFL was straightened to parallel the levee alignment. A former channel meander depression along the west bank of the creek can be seen approximately midway between Well House Road and the Kansas River. The lower portion of Threemile Creek is perennial due to the discharge of water from the Custer Hill wastewater treatment plant (WWTP). Threemile Creek's mean annual discharge rate, observed in May 1977, was 1,032 liters per minute (USATHAMA, 1984).

The nearest surface water body, other than the Kansas River, of the SFL is Whitside Lake, an oxbow lake that was formed as a result of the 1951 flood. This lake is about a half mile northwest of the SFL site. Whitside Lake had been dried up gradually through droughts, but was refilled during excessive precipitation of the summer of 1992 (Fish and Wildlife Administrator, Fort Riley, 1992). No direct drainage from the SFL site into Whitside Lake was observed during a previous field investigation.

2.1.2.5 Hydrogeology - This section provides a general description of the hydrogeology at the SFL. The SFL site lies entirely within the alluvial bottomlands of the Kansas River, which are floodplain deposits consisting of mainly silts, sands, coarse sands, and some gravels. At the natural surface, silts and fine sands predominate, with coarse sands and gravels occurring at greater depths. In general, these materials are unconsolidated, with high permeability. A comparison of the monitoring well water level elevations and river elevations has shown that ground-water levels within the SFL are influenced by the Kansas River stage. Local reversals in ground-water gradients have been observed at times when the Kansas River levels have risen significantly. During periods of elevated river levels, the Kansas River has been observed to recharge the aquifer within the SFL, and water levels appear to have been influenced by the river more than 1000 feet from the river. These fluctuations of the local water table within the SFL area (controlled by changes in the Kansas River elevation) are expected to cause ground water to saturate landfill wastes, potentially resulting in leachate production.

The SFL cover soils were generally a clay to silty loam, and soil borings at the SFL revealed clayey, fine-grained sands at the surface. Underlying soils revealed from borings verified the presence of silty sands, sands, and gravels characteristic of the alluvial bottomlands. Settlement on the landfill surface is widespread and has caused poor surface water runoff, and ponding of surface water occurs within the depressions on the surface. The variable thickness of SFL silty loam cover soils and retention of storm water due to poor surface drainage is likely to result in increased infiltration with the potential for leachate production.

2.1.2.6 Flooding and River Movement - The Kansas River historically exhibits high water stages (typical Kansas River at the Ft. Riley Gauge heights over 12.50) from the last part of

February through the first part of June. The lowest river stages usually occur from late October through January (typical Ft. Riley Gauge heights of 3.40 to 5.50). Prior to the 1965 construction of Milford Reservoir and Tuttle Creek Reservoir on the Big Blue River (1962), major flooding of three-to-five day duration occurred approximately every 8 to 10 years along the Kansas River. Historical records indicate that the SFL site, and adjacent Camp Funston, experienced repeated flooding and were damaged by a record flood in 1951. This flooding event resulted in the expansion of an existing levee to protect Camp Funston from a 100-year flood. The levee is located east of Threemile Creek between Camp Funston and the landfill (Figure 2-3).

According to the Federal Emergency Management Agency (FEMA), as presented on their flood insurance rate map dated April 1, 1982, the entire area of the SFL is within the 100-year flood boundary (Figure 2-4)(FEMA, 1982). Data from the Kansas City District USACE, which appears to be consistent with the FEMA information, indicates that the estimated elevation of the 100-year flood is 1061.3 above Mean Sea Level (MSL) at Camp Funston (Kansas River Mile 164.8) (Figure 2-2), which is adjacent to the SFL. The reported 50-year flood elevation is 1052.6 MSL at the same location. Available topographic information shows the elevation of the top of the river bank to be typically less than 1048 MSL. The elevation of the SFL surface is primarily less than 1052 MSL. The 100-year and 50-year flood will cover the SFL, as shown on Figure 2-4.

Based on a review of data collected during investigation for the EE/CA and river gauge readings at Fort Riley (Kansas River Mile 168.9) (Figure 2-1), during these investigations an approximate drop of 7 to 8 feet in river elevation exists between the Fort Riley Gauge and the SFL. During periods of high water in the Kansas River, an approximate correlation between the SFL water levels and the Fort Riley Gauge readings was made as follows: on July 23, 1992, the river level at the SFL was surveyed and found to be approximately 1044.2. The location of this river level measurement was adjacent to well SFL92-303 (Figure 2-3). The Riley Gauge reading on this date was recorded as 14.48. Subtraction of the gauge reading from the SFL water level of 1044.2 results in an estimated 1029.7-foot difference between the Ft. Riley Gauging Station reading and the corresponding river surface elevation at the SFL. Using this relationship, a Fort Riley gauge reading of 18.3 feet will result in a river level at the top of bank elevation of 1048. The following comparison between measured gauge heights and projected elevations at the SFL can be made to estimate the frequency of high water:

Event	Ft. Riley River Gauge Reading	SFL River Elevation	Exceedances (days) since 1965
50-year Flood	22.9	1052.6	1
100-year Flood	31.6	1061.3	0
SFL Bank Overtapping	18.3	1048.0	12
SFL completely flooded	22.3	1052.0	1

A review of the daily mean river gauge heights from 1965 through September 1992 indicates that the Fort Riley Gauge height of 18.3 feet was exceeded 12 days during two distinct events since Milford Dam was constructed. The river stage has been within 2 feet of the top of bank, based on a review of gauge heights, a total of 47 days since Milford Dam was constructed. Based on the review of 27 years of Ft. Riley gauge readings, it is anticipated that the river flooding events historically exceed the top of bank (elevation 1048) at the SFL approximately once every 13 to 14 years.

Historical movement or meandering of the Kansas River, and its effects on the erosion of the river banks has been studied by USACE, Kansas City District (USACE, 1988). Documented channel migration since the late 1800s shows that the channel in the area of Camp Funston has been migrating, though the amount of migration after 1951 (period of record flood event) has been significantly less than prior to that time, based on review of reliable maps and aerial photographs. During the 1951 flood, a bend of the river along the west border of the present SFL was cut off from the altered main flow of the river. This former bend, which is illustrated on Figure 2-5, forms a oxbow lake referred to as Whitside Lake. The USACE report also documented channel migration toward the northwest vicinity of the SFL.

Available aerial photographs dated prior to 1951, and also in 1971, 1984 and 1992, were reviewed to estimate migration of the river channel in the vicinity of the SFL during the time period between 1951 and 1992. An interpretation of Kansas River movements from the late 1800s until 1984 in the vicinity of the SFL is presented in Figure 2-5. An interpretation of the river migration between 1971 and 1992 is included on Figure 2-6. Figure 2-6 shows two overlays of a topographic map prepared from a 1984 aerial photograph superimposed on digitized copies of 1971 and 1992 aerial photographs (USACE, 1993). This figure was produced using an Intergraph Microstation PC system, which raster scanned and digitized the 1971 and 1992 aerial photographs which were then scaled electronically and "merged" with the 1984 topographic map file to create the overlay drawing files. The figures depict an apparent slight (less than five feet) movement of the river channel toward the SFL along the bend of the river between survey points 2 and 4 as shown at the western section of the landfill. This is within the area that is along what was formerly the old river channel prior to the 1951 flood. With allowances made for slight differences in scale and alignment, there has been very little change in the outline of the Kansas River bank along the SFL from 1971 to 1992 downstream from survey point 4.

2.1.3 Field Reconnaissance Results

2.1.3.1 Landfill Surface - The landfill is presently covered by tall weeds and overgrown with grass or trees, and displays little relief compared to the surrounding land surface. A walking visual survey of the landfill was conducted in August 1992 to observe the existing condition of the landfill cover. The observed conditions are illustrated on Figure 2-7. Surface erosion in some areas has resulted in the development of rills and channels and has resulted in partial loss of soil cover material. These rills and channels run parallel with site drainage and are therefore expected to be due to surface water runoff rather than settlement. In general the surface erosion features are localized and do not extend across large portions of the site. Depressions of one to two feet were observed at several locations due to common and widespread settlement in areas suspected of being the former disposal trenches. During periods of wet weather, localized ponding of water was observed in these depressions with no predominant drainage pathway existing at the site. There were also numerous burrows (three to six inches in diameter) throughout the landfill, most likely due to burrowing by small animals. Not all areas of the landfill were accessible or visible at the time of the visit due to the presence of tall weeds and thick undergrowth.

Some debris, consisting of rusted oil and coffee cans, old aluminum soft drink cans, wood debris, wire, cable, and concrete debris, was observed on the surface of the landfill as shown on Figure 2-7. Based on visual observation it is expected that this material is due to surface dumping rather than exposure of the previously buried landfill contents, and occurred in two areas, approximately 1 to 2 acres each, in the northeastern quadrant of the landfill.

the water elevation was estimated at twelve feet below the top of the bank. The main section along the bank that was affected by a localized slope failure (soil sloughing) was midway between survey sections 3 and 4 (Figure 2-8). The area from just east of section 5 to section 7 did not have noticeable slope failure. Rubble, covering portions of the bank slope, had been placed in this area. The area from sections 7 to 11 had sloughing problems. A local slope slide had occurred between sections 7 and 8 at a location where no concrete rubble was evident. The area from sections 11 to 12 had some minor sloughing, but some construction rubble was noted along the bank. Materials such as steel cable, steel fencing and an occasional crushed empty drum were seen protruding from the bank at this section. The area from section 12 to slightly east of section 13 had some sloughing problems. Natural deposition of river sediments was occurring from just east of section 13 to section 15, and in other areas toward the eastern portion of the site. This area, and areas downstream along the SFL (Sections 16 to 20) to Threemile Creek, did not show any significant erosion or sloughing problems. Rubble was also noted in this area.

During the field reconnaissance, in addition to the 20 bank profiles, a total of 14 locations were selected to obtain approximate river depths along the landfill bank. Depths were determined using the following procedure: a stake was driven at each location along the bank as close as possible to the edge of water. A one hundred-foot long steel tape was stretched into the river, perpendicular to the bank as the boat was slowly backed away from the shore. One end of the tape was held at the driven stake on the bank, and the other end was held by one person in a boat. A survey pole was lowered into the river approximately every ten feet. At places where the river depth was in excess of about 12.5 feet, the depth was measured using a depth finder securely mounted at the rear of the boat. During the collection of this data, the depth finder reading was compared to the survey pole depth measurement, at least once every other section, as an approximate comparison check. The measurements were determined relative to a reference mark (reinforcing bar) on the river bank, which was subsequently surveyed. Elevations of the river bed and river bank at the 14 locations were calculated by the surveyor and plotted. A reproduction of the survey plots is included in Appendix A.

2.2 SITE BACKGROUND

Fort Riley was established in the 1850s in response to the need to provide military protection for the westward expansion of civilian populations. Development and growth for Fort Riley proceeded in response to changes in the American military mission, tactics and equipment over the years since its establishment. Since its inception, Fort Riley has continually served as a major center for military training and military readiness, including the supply and maintenance of facilities and equipment. The installation's function has historically required management and disposal of wastes associated with these activities.

The SFL was operated between the mid-1950s and 1981. It was closed in 1983 pursuant to the closure plan approved by the Kansas Department of Health and Environment (KDHE) (Permit No. 370). The operation of the landfill included both area and trench disposal methods. There is no specific data recording the waste types disposed in the landfill. By volume, most wastes generated and disposed at Fort Riley consisted of domestic refuse, construction debris and sludge from wastewater treatment facilities; however, waste petroleum products and waste solvents were apparently also disposed in the SFL. From 1950 to 1970, waste motor oils and degreasing solvents from vehicle maintenance operations were mixed, then disposed by dumping in this landfill. During this 20-year time period, most degreasing solvents used consisted of chlorinated hydrocarbons, including trichloroethylene, tetrachloroethylene, and carbon tetrachloride (USATHAMA, 1984).

A description of apparent landfilling activities since the 1950s, based on a review of available aerial photographs and other sources, is as follows: Signs of landfilling were evident in a 1960 aerial photograph, and more extensive operations within the landfill limits were seen in more recent photographs. Waste disposal near the river bank has also been detected. From a series of low altitude aerial photos taken in February 1972, at least six open trenches were seen in an area adjacent to the river bank in the southwest portion of the landfill. According to documentation provided with the photos and personal communications, these trenches contained oil and grease. Several debris piles (anticipated to be scrap metal and construction debris) were scattered throughout the southern portion of the landfill. The debris piles were graded and the trenches were covered at least by the time of closure in 1983, since they were not evident in more recent photographs and topographic maps. A portion of the landfill cover soils was removed from the former rifle range berm, and has been found to contain elevated concentrations of lead but at levels below those established for non-residential areas.

Stabilization or protection of the river bank has apparently been attempted in the recent past. During operation of the landfill, field observations and historical photos show that material conducive to erosion control (including construction demolition debris and other large unmanageable white goods, such as household appliances) were segregated and were dumped within the southern portion of the landfill against certain areas of the bank in an attempt to provide erosion control (Law, 1993). The construction demolition debris included concrete debris, such as broken pieces of slabs, walls, and pavement, bricks, concrete blocks and other related debris. Subsequent erosion continued after the placement of this debris. The General Foreman for Mobile Operations at Fort

Riley familiar with the site background indicated that a two-day white goods retrieval and bank repair project occurred approximately in 1989. During this operation, a crane was used to retrieve readily accessible debris along the bank. One badly eroded area along the bank was filled with soil. This location was not documented and could not be positively located. The white goods retrieved during this operation were disposed within the Fort Riley construction-demolition landfill (Law, 1993). The material placed for erosion control has apparently been limiting erosion and slope failure to some degree, but many unstable areas exist.

2.2.1 Landfill Characterization Activities

The Remedial Investigation will present descriptions of activities which have been performed at the landfill site. These include a surface features investigation and collection and analyses of sediment, surface water, sub-surface soil and ground-water samples. As part of the work, 20 monitoring wells were installed at the SFL in 1992. The well locations are shown on Figure 2-3.

A topographic contour map of the SFL site was produced in November 1991, with 2-foot contour intervals referenced to the Lambert Coordinate System. The limits of the map were bound to the north just beyond Well House Road, to the south at the north bank of the Kansas River, to the east on the west bank of Threemile Creek, and to the west on the east bank of the old channel which borders the open field adjacent to the landfill. Other topographic map files of the surrounding area were obtained by Law Environmental from the Kansas City Corps of Engineers and the ten-foot contour intervals were merged together to provide an adequate site location map of the SFL (Figure 2-3). In general, topographic comparison and merging of elevation contours did not show any major discrepancies. Variations of one to two feet in some areas were noted, which is typical when aerial and on-the-ground topography is merged.

Soil sampling and screening analysis of the landfill cover soils was performed in July 1992, by PRC Environmental Management, Inc. as reported in PRC's "Trip Report and Data Summary," which was updated by the "Revised Data Summary" issued in March 1993 (PRC, 1993). The purpose of the investigation was to determine the presence and extent of potential lead and copper contamination in the landfill cover materials from small arms bullets. The soils were sampled on an established grid pattern, and were analyzed for lead, copper and zinc. Screening analyses were completed using X-ray fluorescence on 114 soil samples with confirmation analyses of nine samples and a duplicate by EPA Contract Laboratory Program (CLP) lab analyses (See Section 2.3.2). Since the source of the landfill cover was off-site borrow areas, landfill cover soils were not analyzed for organic constituents associated with landfill operations.

In order to evaluate the lateral boundaries of the SFL site, geophysical surveys were conducted from late October to early November 1991. The geophysical survey consisted of 25 magnetometer survey lines totaling 24,680 linear feet and two EM survey lines totaling 7,800 linear feet. Magnetometer readings were recorded at linear intervals of 10, 25, 50, or 100 feet, depending on proximity to known or suspected anomalies. EM readings were recorded continuously with an analog recorder. Laterally extensive anomalies were interpreted as resulting from landfill materials; laterally limited anomalies were interpreted as pipes or other isolated metallic objects within the landfill.

In late October and early November 1991, a soil gas survey of unsaturated or vadose zone soils at the SFL was conducted based on historical photographs, maps, surface features, and the results of the geophysical survey. The objective of this survey was to help evaluate the limits of the landfill, the location of possible soil and ground-water contamination at the SFL and to aid in the placement of the monitoring wells. Soil samples were collected at 61 locations at the SFL site. The results were used to select monitoring well locations and to confirm the inferred extent of the landfill estimated from the geophysical survey.

2.3 ANALYTICAL DATA

2.3.1 Sediment Sampling and Analysis

The surface water and sediment results indicate that SFL is not contributing organic contaminants to the Kansas River. The results of the ground-water samples collected from the monitoring wells located beside the river confirm this. Metals were detected in both upstream and downstream samples. Results indicate that SFL may be contributing low levels of chromium and arsenic to the sediments adjacent to the site.

2.3.2 Soil Sampling and Analysis

The surface soil investigation (PRC, 1992) focused on the cover material of the landfill from the rifle range berm. To locate sampling points a 200-foot grid was established which produced 114 sampling locations across the landfill surface. Each sample consisted of five aliquots taken from 0 to 6-inch depths. The initial report stated that 40 of the 114 samples gave positive results near or above the method detection limit of 100 ppm for lead; one sample produced positive results for zinc above the MDL of 100 ppm; and all soil samples were non-detect for copper. The MDL for copper was 100 ppm. All of these samples were analyzed by x-ray fluorescence (XRF). Nine samples and a duplicate were submitted to the Region VII EPA CLP laboratory for conformational total metals analysis. Results of the XRF field analysis for copper and zinc showed a satisfactory agreement with the CLP results, suggesting that the copper and zinc concentrations observed in the landfill cover soils approached background levels. Zinc was detected in three samples at levels estimated not to exceed 238 mg/kg. Copper was detected in two samples at levels not exceeding 110 mg/kg. The recalculated XRF lead values and the projected lead results for CLP analysis indicated lead levels in the soils at the landfill were not significantly elevated. Correlation of the XRF and CLP lead data indicated that lead concentrations in the surface soils of the landfill are generally less than 200 mg/kg, and did not exceed 440 mg/kg (PRC, 1993).

Subsurface soils were sampled at depths ranging from 14 to 59 feet and chemically analyzed by Law Environmental during the summer of 1992. These soil samples were obtained during installation of the deep monitoring wells along the perimeter of the landfill and within the existing tree line. The perimeter well borings may represent either virgin soils or soils previously disturbed by landfill activities, but are not expected to be representative of landfill contents.

The chemical results of the subsurface soil analysis indicate the presence of volatile organics, a pesticide degradation product (DDE), Aroclor-1248, and phthalates. The volatile and pesticide concentrations, which occurred in three isolated, widespread samples, are limited and below RCRA Corrective Action Levels (CALs). The phthalate concentrations occur at various depths and throughout the site; however, concentrations are below CALs. The Aroclor-1248 concentration exceeded the CAL of 90 $\mu g/L$ at the location of monitoring well cluster 2. The measured concentration of Aroclor-1248 was 250 $\mu g/L$ which was collected from the 16 to 20-foot depth. Therefore, surface exposure to Aroclor-1248 is not likely. Aroclor-1248 migration is not likely due to low water solubility and high soil adsorption potential. Various metals were detected in the soil samples upgradient and downgradient of the site. Only beryllium and thallium concentrations in the soil samples analyzed exceeded CALs. These elements were also found to exceed CALs in background samples. Petroleum hydrocarbons (as TRPH) were detected at low levels in samples from background samples and locations potentially impacted by the landfill.

2.3.3 Ground-Water Sampling and Analysis

The results of the chemical analyses of ground-water samples indicate volatile contamination of the ground water. The highest concentrations of volatile organics were detected in ground-water samples from monitoring well clusters 5 and 8. The contaminants seem to be localized in each location. The MCL for vinyl chloride and benzene and the proposed MCL for 1,1,2-trichloroethane were exceeded during the baseline sampling event. Although metals were detected in the ground water at the site, the only MCLs exceeded for metals were the proposed MCL for beryllium and the secondary MCLs for manganese, iron and aluminum. All of these elements were detected in both upgradient and downgradient samples indicating that the metals are naturally occurring above secondary (aesthetic) MCLs in this area.

The baseline ground-water samples were collected in July 1992. These samples were collected to provide baseline data concerning ground-water quality at the site. However, due to the unusually high amount of precipitation during the weeks prior to this sampling event, the Kansas River was nearly at flood stage during sampling. This condition caused the direction of ground-water flow at the site to move away from the Kansas River, instead of toward the river (as is typical). Subsequent analytical data from the November 1992 sampling event were not consistent with the July sampling event. A decrease in volatile organics was noted in samples from well clusters 5 and 8 in the first quarterly sampling event. In well cluster 3, metals concentrations increased in the first quarter sampling.

2.4 SITE CONDITIONS THAT WARRANT REMOVAL ACTION

2.4.1 Landfill

The surface of the SFL is irregular, with several areas of depressions and erosion. There is not a continuous grade over the entire site to promote well-distributed drainage of storm water off of the landfill surface. Depressions which are suspected to have formed from settling of disposal trenches, as well as naturally occurring low topographic features which may not have been filled in, retain stormwater during wet weather. Retention of storm water due to poor surface drainage is likely to increase surface infiltration through the landfill cover, resulting in leachate production.

As detailed in section 2.1.3.1 the soil on portions of the site has also eroded, as evidenced by erosion channels. Exposed debris is believed to have been dumped on the surface within a small area, as indicated on Figure 2-7. Rusted oil and coffee cans, old aluminum soft drink cans, wood debris, wire, cable, and concrete debris were observed. Other signs of soil cover disturbance have been observed, including evidence of burrowing by animals. Repair of eroded and other disturbed areas, as well as re-establishment/improvement of drainage patterns may be warranted.

Based on the determined correlation between the Fort Riley Gauge readings and the SFL river levels, one Kansas River flooding event has inundated the landfill cover since Milford Dam was constructed in 1965. Landfill surface flooding, though infrequent, is likely to result in percolation of standing water through cover soils, and subsequent generation of landfill leachate. As observed during the July 1992 ground-water sampling event, during which river levels at the SFL were approximately at elevation 1044 MSL, ground-water elevations within the landfill can be raised several feet by high water levels in the river, causing a local reversal in gradients (i.e., ground-water flow from the river into the landfill). The field-observed gradient reversal caused by five consecutive days of high water levels in the river appeared to impact ground-water levels as distant as 1,600 feet from the river. The extent of such impact would be dependent on the duration of high water levels in the river.

A review of historical streamflow records on the Kansas River since 1965 has shown that the average duration of streamflows exceeding the July 23, 1992, event was historically equaled or exceeded once per year. In addition, a former oxbow in the river located adjacent to the west end of the landfill will likely influence the landfill water table. Highly permeable alluvial deposits in the former river channel may contribute to the expected rapid fluctuations in the SFL water table in areas further from the river than would normally be affected by lateral infiltration adjacent to the river bank.

2.4.2 Riverbank

Riverbank erosion and slope failure are occurring at certain locations along the bank of the Kansas River, along the western perimeter of the landfill site, as discussed in Section 2.1.3. This process is a normal occurrence on the upper reaches of the Kansas River, which includes the Fort Riley area, particularly in areas where bank protection and/or stabilization are limited or non-existent.

Based on limited survey data and visual observation, the riverbank along the north side of the Kansas River was found to be in a distressed condition at various areas from the west end of the landfill to section 15 (Figure 2-8). The distressed condition includes erosion of the slope face and slope failure. While erosion of the slope face was typical along the distressed area, slope failure was observed at areas where no concrete rubble or debris were present. Riverbank erosion occurs when individual soil particles at the bank's surface are carried away by a tractive force applied by moving water. The streambank failure in the area appears to be due to streambed scour or erosion of the toe of the slope and/or rapid drawdown of water on the river side of the bank face. For short time periods, following rapid drawdowns, ground-water pressure within the bank tends to contribute to bank instability.

The major causes of the bank erosion along the Kansas River appear to be stream currents, rainfall seepage, overbank drainage, wave attack, and debris impact. These five mechanisms are probably acting in combination to place the riverbank in a distressed condition. Figure 2-9 is an illustration of the possible mechanisms involved in slope failure at the landfill riverbank. An apparent slight movement (less than five feet) of the river channel toward the SFL along the bend of the river (between sections 2 and 4) has occurred since 1971. This area is adjacent to the southwest corner of the SFL site, in the area that was the old river channel prior to the 1951 flood, and is likely less consolidated and more susceptible to erosion than other areas of the river bank. There has been very little change in the river bank location along the SFL since 1971 in all other areas.

3.0 REMOVAL ACTION OBJECTIVES AND CONSIDERATIONS

3.1 STATUTORY LIMITS ON REMOVAL ACTIONS

Under CERCLA Section 104, the federal government is empowered to respond to releases of hazardous substances and pollutants or contaminants. SARA amended Section 104 to increase the maximum funding and time limits on removal actions. However, on Department of Defense sites such as the Fort Riley SFL site, statutory limits for funding and time to complete removal actions do not apply (Executive Order 12580, October 22, 1991).

3.2 REMOVAL ACTION SCOPE

The scope of the non-time-critical removal actions for both the landfill cover and river bank focuses on reducing or eliminating visually identified areas of concern, but does not address the removal or reduction of contaminated media at the site. Removal actions will be evaluated for their consistency with final remedial actions at the site that may be implemented. Early implementation of actions to address areas of concern is an objective of the removal actions.

3.2.1 Landfill

Specific objectives considered for the landfill are:

- Provide and maintain adequate cover over the waste;

- Minimize erosion and migration of the landfill cover soils caused by stormwater run-on and run-off;

- Minimize erosion of landfill cover soils during Kansas River flooding conditions;

- Reduce stormwater ponding and control infiltration to the extent practical to reduce potential for leachate generation;

- Attainment of Applicable or Relevant and Appropriate Requirements (ARARs).

- Be consistent with final remedial action.

3.2.2 Riverbank

Specific objectives for the riverbank are:

- Minimize erosion of the bank;

- Prevent exposure and erosion of landfill contents;

- Stabilize bank slopes to prevent further movement of the river channel toward the landfill; and
- Attainment of ARARs.

3.3 REMOVAL ACTION SCHEDULE

Although removal action has no specific time constraint, it will be implemented as soon as practicable to limit the potential for further degradation of the riverbank and the landfill surface. The schedule will depend on time required for: reaching a decision on the type of removal action needed; collecting necessary detailed field data for design; the design, bidding and construction process; and obtaining funding. The type and method of removal action selected will determine how quickly the action can be implemented. Typical weather conditions which may create problems during construction will be considered during the scheduling.

3.4 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED REQUIREMENTS

A basic requirement for CERCLA evaluation is that remedial response actions must comply with the environmental laws which are determined to be "applicable or relevant and appropriate requirements" (ARARs). An ARAR determination is not required for removal actions. However, the EE/CA Guidance Memorandum (EPA 1988) suggests that removal actions should address ARARs to the extent possible. Thus, an ARAR identification plan has been included as part of this report.

In addition to ARARs, To Be Considered (TBC) requirements are also identified during removal response actions. The TBCs are non-promulgated advisories or guidance issued by the state or federal government that are not legally binding and thus do not have the status of potential ARARs. TBCs are used, however, in conjunction with ARARs to aid in determination of appropriate response actions.

ARARs and TBCs are identified on a site-specific basis. In general, the identification process involves comparing a number of site-specific factors with the statutory or regulatory requirements of the relevant environmental laws. These factors may include:

- Hazardous substances present;
- Types of remedial actions considered; and
- Physical characteristics of the site.

Removal actions taken under CERCLA may have to comply with several different types of requirements. According to the IAG, "with releases of hazardous waste covered by this Agreement, RCRA shall be considered an applicable or relevant ARAR pursuant to Section 121 of CERCLA." Three types of ARARs and TBCs may be determined: chemical-specific, location-specific, and action-specific. Since the removal actions being considered at the SFL are to be integrated into the final site remedial activities, compliance with ARARs is a primary objective. These ARARs are discussed below.

3.4.1 Chemical-Specific ARARs

Chemical-specific ARARs do not apply to the project since the removal action objectives do not include treatment and removal of contaminants. However, OSHA Regulations (29 CFR Part 1926 Subpart D - Occupational Health and Environmental Controls) will be applicable to the project. Specifically, exposure of employees to inhalation, ingestion, skin absorption, or contact with any material or substance at a concentration above those specified in the "Threshold Limit Values of Airborne Contaminants" of the American Conference of Governmental Industrial Hygienists (ACGIH) will be avoided when scarifying and/or recompacting the existing subgrade. To achieve compliance with these OSHA regulations, administrative or engineering controls must first be implemented whenever feasible. When such controls are not feasible to achieve full compliance, protective equipment or other protective measures shall be used to keep the exposure of employees to air contaminants to within the ACGIH prescribed limits.

Secondly, these OSHA regulations specify medical services and first aid, sanitation, and noise exposure requirements that must be met by the contractor selected to perform the work.

No chemical-specific TBCs were identified for this project.

3.4.2 Location-Specific ARARs

Location-specific ARARs are regulations which are applicable to the removal action because of the physical features of the site. Potentially applicable ARARs are as follows.

3.4.2.1 Flood Plain Management, Executive Order 11988, 16 USC 661 et seq, 40 CFR 6.302, Appendix A - Executive Order 11988, Floodplain Management, regulates direct and indirect development of a floodplain to avoid adverse effects due to flooding. Since the removal action will be performed within the 50-year floodplain, these regulations will apply to the project. Prior to performing filling within the 100 year flood plain, the Army will be required to obtain a Conditional Letter of Map Revision (CLOMR), which is issued by the Federal Emergency Management Agency (FEMA). In order to obtain the CLOMR allowing filling, the Army is required to submit to FEMA the results of a technical evaluation of the effects of the proposed filling on the flood plain in the vicinity of the project. This information is likely to consist of a hydraulic study of the existing flood plain, and the proposed flood plain following the site grading effort. Flood elevation effects (increases) caused by the site filling are evaluated. If the filling causes an increase in the flood elevations at the site, mitigative measures may be considered necessary as a condition of the CLOMR. Localized flood plain elevation increases may be allowed in some cases if the Army can obtain agreements with all potentially affected property owners. An additional requirement of this ARAR is that as-built drawings and a certification letter showing substantial compliance with the project design be submitted upon completion of the project.

3.4.2.2 Protection of Wetlands (Executive Order 11990, 40 CFR 6.302, Appendix A) - Executive Order 11990, Protection of Wetlands, regulates action involving management of property in wetland areas to avoid adverse effects, minimize potential harm, and preserve and protect wetlands to the extent possible; these requirements may apply because although no formally delineated wetlands appear to exist at the site, the Kansas River and its associated biota could constitute a wetlands region. USACE has conducted a wetlands delineation survey for the SFL site. The results of this survey indicate that no wetlands are identified which could be impacted by the site (USACE, 1993). Therefore, protection of wetlands is not an ARAR.

3.4.2.3 Endangered Species Act of 1973 (16 USC 1531-1544) - These regulations protect or conserve the habitats of endangered or threatened species. Fort Riley falls within an area that eight federally endangered species and thirteen additional candidate species for the federal endangerment listing are likely to inhabit. Examples of these species include the bald eagle, the peregrine falcon, the prairie mole cricket, and Henslow's sparrow. Of the 21 total species, two federally endangered species are also present in the Fort Riley area. Confirmed sightings along the river corridor include the bald eagle and the eastern hognose snake.

3.4.2.4 Fish and Wildlife Protection (16 USC 661-666c, 16 USC 2901 et seq, 33 CFR 320-330; 40 CFR 6.302) - The Fish and Wildlife Coordination Act, 16 U.S.C. 661 *et seq.*, requires Federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose, to take action to protect the fish and wildlife resources which may be affected by the action. The Fish and Wildlife Service and the appropriate State agency shall be consulted to ascertain the means and measures necessary to mitigate, prevent and compensate for project-related losses of wildlife resources and means to enhance the resources. These regulations may be applicable to this site because several different species of animals have been identified at Fort Riley, including the American burying beetle, the Texas horned lizard, the loggerhead shrike, and the regal fritillary butterfly, and because the natural stream and river embankment may be modified.

3.4.2.5 Surface Water Use Designations (KAR 28.16.28d) - These regulations provide criteria for approved uses of certain types of waters. Surface waters located at the SFL site exist principally in isolated small areas of localized ponding and within Threemile Creek. The Kansas River is classified for "non-contact recreational use" and "consumptive recreational use" in the area. In addition, the Kansas River is also designated as an expected aquatic life region. This ARAR is applicable because site grading activities can impact water quality.

3.4.2.6 Designation of Critical Water Quality Management Areas (KAR 28, 16.70) - These regulations provide criteria for watersheds or portions of watersheds to be designated as critical water quality management areas because of pollutant sources which cause or may reasonably be expected to cause, damages to resources of the State; public nuisance or health hazards; destruction of fishery habitat; excessive deposition of sediments on river bottoms; additional risk to threatened or endangered fish or wildlife; or violation of water quality standards. Provisions of this ARAR protective of fish habitat maintenance and control of sediment deposition in the water will apply to the SFL site.

3.4.2.7 Historic, Architectural, Archeological, and Cultural Sites (Executive Order 11593, 40 CFR 6.302) - Under section 106 of the National Historic Preservation Act and Executive Order 11593, if an EPA undertaking affects any property with historic, architectural, archeological or cultural value that is listed on or eligible for listing on the National Register of Historic Places, procedures for consultation and comment promulgated by the Advisory Council on Historic Preservation in 36 CFR part 800 shall be complied with. Properties affected by the project that are potentially eligible for listing on the National Register shall be identified and a request for a determination of eligibility from the Keeper of the National Register, Department of the Interior, under the procedures in 36 CFR part 3 shall be made. The ARAR is retained because culturally significant findings may be discovered during construction.

3.4.2.8 Clean Water Act, Section 404 Permitting Requirements (3 U.S.C. 1341, 33 CFR 320 through 330, 40 CFR 230) - Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into waters of the U.S., including wetlands. It is the nation's primary wetlands protection mechanism. Regulatory authority is vested with the USACE with oversight by the EPA. Regulations governing the Section 404 program are contained in 33 CFR 320 through 330, and 40 CFR 230. The 404(b)1 Guidelines (the Guidelines) contained within 40 CFR 230 dictates the selection of the least environmentally damaging practicable alternative when a discharge of material to the aquatic environment is involved. The Guidelines also include actions that should be taken to minimize adverse affects to the aquatic environment. While no special aquatic sites as defined by the Guidelines will be impacted by the bank stabilization project, there will be deposition of fill material associated with bank stabilization activities. Therefore, Section 404 and its associated regulations are ARARs applicable to this project. The Army (Fort Riley) should pursue a Nationwide Permit 13 under Section 404 for bank stabilization. This will require a pre-discharge notification describing the purpose and anticipated environmental impacts to be submitted to the district engineer of the Kansas City District, prior to construction, as early as possible.

3.4.2.9 Clean Water Act, Section 401 Water Quality Certification (33 U.S.C. 1341) - Section 401 of the Clean Water Act (the Act) requires that for the bank stabilization, Fort Riley obtain a certification from the appropriate State water quality agency that the discharge complies with the applicable provision of Section 301, 302, 303, 306, and 307 of the Act and any other appropriate requirements of State law, such as State water quality criteria. Since proposed site activities include a discharge of material during bank stabilization, this ARAR is applicable. However, no additional requirement should be imposed by this ARAR beyond those discussed in 3.4.2.5 and 3.4.2.6.

No location-specific TBCs were identified for this project.

3.4.3 Action-Specific ARARs

Action-specific ARARs are technology-based or activity-based requirements or limitations on proposed removal actions at the site. By definition, action-specific ARARs depend on the proposed removal actions. Although potential action-specific ARARs cannot be firmly established prior to identification of the removal action, potential action-specific ARARs that may apply are presented. These potential action-specific ARARs do not in themselves determine the appropriate removal action, but indicate the performance levels to be achieved by the alternatives. Potential ARARs are as follows.

3.4.3.1 National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 61) - These regulations provide national emission standards for listed hazardous air pollutants and other constituents that are under consideration to be added to the list of hazardous air pollutants. Provisions of this ARAR may be applicable to clearing, grading, and capping activities depending upon the potential for airborne emissions of contaminants detected in the soils at the SFL site.

3.4.3.2 National Ambient Air Quality Standards (NAAQS) (CAA 40 CFR 50) - These regulations define the levels of air quality necessary to protect public health. Since grading and clearing of surficial soils may generate the emissions of contaminated dust, this ARAR may be applicable to proposed site activities.

3.4.3.3 Ambient Air Quality Standards and Air Pollution Control Regulations (KAR 28.19) - These regulations provide state emission standards for listed hazardous air pollutants and state air quality standards to protect public health. Provisions of this ARAR may be applicable to clearing, grading, and capping activities depending upon the potential for airborne emissions of contaminants detected in the soils at the site.

3.4.3.4 Solid Waste Management Regulations (KAR 28.29 Part II) - These regulations describe state requirements for solid waste management, including all aspects of storage, treatment, and transport. Provisions of this ARAR may be applicable to grading of slopes to install river bank stabilization improvements/repairs if landfill contents are exposed.

3.4.3.5 Stormwater Discharge Requirements, National Pollutant Discharge Elimination System (CWA 40 CFR 122.26) - The SFL is located immediately adjacent to the Kansas River. The federal Storm-Water Discharge Requirements and National Pollution Discharge Elimination System requirements therefore apply to this site, because of the potential for stormwater to drain off the site. This drainage would constitute a surface water discharge.

No action-specific TBCs were identified for this project.

4.0 DEVELOPMENT OF EVALUATION CRITERIA

The evaluation criteria which have been selected to determine the need for landfill surface repairs/improvements and river bank repairs/improvements as a removal action are presented in this section. They have been developed to ensure that the removal action objectives previously identified in Section 3.2 are achieved.

4.1 LANDFILL SURFACE REPAIRS/IMPROVEMENTS

4.1.1 Identification of Evaluation Criteria

The need to repair or improve the landfill cover was evaluated based on the following criteria:

- Erosion potential
- Extent of existing vegetation and soil cover
- Kansas River flooding impacts
- Areal extent of ponding and infiltration of surface water
- Uncertainties associated with the existing landfill cover

4.1.2 Application of Evaluation Criteria to Landfill Cover

This section describes the current conditions at the SFL which are relevant to the specified evaluation criteria which will be evaluated for their potential improvement if an alternative is implemented.

4.1.2.1 Erosion Potential - Erosion of the existing soil cover has been observed in some localized areas within the landfill limits, as evidenced by erosional features such as rills and channels. The existing topography and vegetative cover over the landfill surface do not control surface water run-off sufficiently to prevent erosion of the soil. Without improvements to the landfill cover, erosion will likely continue and probably accelerate over time.

4.1.2.2 Extent of Existing Vegetation and Soil Cover - The landfill is presently partially covered with grass and brush. Some areas are covered by dense vegetation, while other portions have little or no vegetation. The integrity and extent of the existing soil cover is questionable due to the observed uneven and eroded areas, and because of the evidence of landfill and construction debris in an approximate three-acre area on the surface. In this area, the observed debris was probably dumped on top of the cover. In order to ensure the integrity of the soil cover, the landfill surface improvement alternatives will be evaluated for the potential to improve the existing vegetation and soil cover conditions.

4.1.2.3 Kansas River Flooding Impact - Flooding can have an adverse impact on the integrity of the landfill cover and is likely to cause additional infiltration as discussed in Section 2.4.1. A review of available information on flood elevations for various return periods, as discussed in Section 2.1.2.5, indicates that the landfill surface will be inundated during a 50-year flood. A review of daily river stage data at the Fort Riley Gauge which has been approximately correlated to the resulting river levels at the SFL indicates that the SFL has been inundated once since 1965, when the Milford Dam was constructed on the Kansas River.

When flooding events inundate the landfill surface, some erosion of cover material is likely. The proposed repairs and additions to the existing cover will therefore be evaluated in terms of minimizing the potential for erosion, infiltration, and exposure of the waste material beneath the soil cover.

4.1.2.4 Areal Extent of Ponding and Infiltration of Surface Water - During previous field reconnaissance (August 1992), depressions with standing water and areas with poor surface drainage characteristics were observed in several locations on the landfill surface. The approximate locations and areal extent of the observed ponding are illustrated in Figure 2-7. It is likely that more such areas exist since not all areas of the landfill were accessible or visible at the time of the site visit.

Soils information obtained during monitoring well installation (refer to Appendix B) indicates that the cover layer is silty to clayey fine sand. It is important that the landfill surface repair/improvement alternatives take into consideration the presence of the depressions and poor drainage conditions of the existing landfill surface and the characteristics of the existing soil cover. Improving surface runoff is likely to reduce infiltration.

4.1.2.5 Uncertainties Associated with the Existing Landfill Cover Evaluation - The thickness of soil cover over landfill debris at the SFL was not determined during the PRC field event (PRC 1993), or the previous field activities. Debris is exposed in an approximate area of less than two percent of the landfill. Documentation of the cover thickness is limited to the approved closure grading plan (Wilson & Company, 1982) and file notes made during the closure. A telephone conversation with a representative of the Ft. Riley Directorate of Engineering and Housing (DEH) indicated that the cover soils were installed after removal of some scrap metal, and were installed in a minimum two feet thickness, with no compaction other than the weight of grading equipment. No field density tests were performed.

Widespread local depressions on the landfill surface and ponding water following rainfall events indicate that the variable in-situ permeability of the landfill cover soils affect the rate of surface water infiltration into the landfill. Localized infiltration rates across the landfill are likely to vary widely due to the variability in soil thickness, physical characteristics, and density across the SFL site.

4.2 RIVER BANK REPAIRS/IMPROVEMENTS

4.2.1 Identification of Evaluation Criteria

The need to repair or improve the river bank was evaluated based on the following criteria:

- Likelihood of flooding and high water
- River velocity and erosion potential
- The historic movement of the Kansas River
- Existing condition of the river bank
- Uncertainties of waste content and waste location relative to the river bank
- Estimated potential threats to human health and the environment by maintaining the current situation

4.2.2 Application of Evaluation Criteria to Bank Stabilization

This section describes the current conditions along the Kansas River bank which are relevant to the specific evaluation criteria, which will be evaluated for their potential improvement if an alternative is implemented.

4.2.2.1 Likelihood of Flooding and High Water - A review of the Fort Riley Gauge heights, as discussed in Section 2.1.2, indicates that the SFL river bank elevation (1048 MSL) has been inundated a total of 12 days during two high water events, since Milford Dam was completed in 1965. During this time period, it is estimated that the SFL has been totally inundated one time by high river levels. River stage data also showed that water levels predicted to be four feet below the SFL bank height (1044 MSL) occurred on 141 days during 28 separate events. The 1044 MSL event occurred an average of once a year, averaging 5.2 days of high water for each event. Lower water level rises occurred much more frequently in the Kansas River. Because high water conditions routinely encroach on the river bank, remedial measures are required to minimize adverse impacts caused by the high water.

4.2.2.2 River Velocity and Erosion Potential - Based on a review of literature (USACE, 1988), the greatest likelihood for high river velocity and erosion potential will occur during flood events. As discussed previously, limited flooding frequently occurs along the river. However, the location of the bank relative to the river alignment influences the erosion potential. The outside bank of a bend in the river, such as in the western section of the landfill, is generally more unstable and likely to fail than inside bends and straight reaches of the river. Stabilization of the river bank is consequently more important in the western section of the landfill than in the eastern section.

4.2.2.3 <u>Historic Movement of the Kansas River</u> - There has been an apparent improvement of the river channel toward the landfill in the recent past. The U.S. Army Corps of Engineers (USACE) has recently evaluated the movement by overlapping the digitized 1984 topographic map, 1971 and 1992 aerial photographs of the river channel in the area. The USACE evaluation indicated some evidence of slow migration of the river channel towards the landfill. A small amount (five feet or less) of movement was observed towards the northeast direction in the vicinity of survey profile points 2, 3, and 4. The review of recent river migration did not show any identifiable channel migration along the SFL downstream from section 4.

4.2.2.4 <u>Existing Condition of the River Bank</u> - Erosion has been observed in several areas, particularly along the bend in the river. Construction rubble, which is located on about 20 percent of the slopes of the river bank, has apparently been reducing erosion and slope failure to some degree, but is very limited in extent. As discussed in Section 2.2.2, the river bank along the western section is unstable in many areas. The existing conditions of the bank slopes in these areas indicate the need for a non-time-critical removal action to stabilize these slopes.

4.2.2.5 <u>Uncertainties of Waste Content and Waste Location Relative to the River Bank</u> - Limited documentation exists concerning the proximity of waste materials to the river bank, and the content of the waste. Construction debris and white goods were apparently placed on certain sections of the river bank for erosion control. However, available information (including soil gas and geophysical surveys), from project work performed previously, suggests that other unknown waste materials may be located in close proximity to the river bank. The fact that these uncertainties exist emphasizes the need for stabilization and protection of the river bank to minimize the possible exposure and erosion of the landfill waste.

4.3 ESTIMATED THREATS TO HUMAN HEALTH AND ENVIRONMENT BY MAINTAINING CURRENT SITUATION

Bank sections along the Kansas River are believed to be eroding toward the landfill disposal areas under current conditions at the site. The landfill cover will be inundated during floods which are expected to occur more frequently than the 50-year event. Flooding over the existing landfill cover is likely to cause some surface erosion of the cover, especially in areas without established vegetation. Erosion of the streambank and cover soils could potentially expose and transport landfill contents into the environment, which would adversely affect areas along the Kansas River downstream from the site.

The current SFL cover retains surface water in several low areas which pond water for extended periods following rainfall events. This increases the potential for landfill leachate which can mobilize and transport contaminants into the ground water and the Kansas River. The discharge of contaminated ground water from the alluvial aquifer under the SFL into the Kansas River or river sediments is a potential pathway of contaminant transport.

Past investigation activities at the SFL have included the collection and analyses of ground water, surface water, sediment, and subsurface soil samples obtained during the installation of monitoring wells. Landfill surface soils were also sampled using on-site X-ray fluorescence (XRF) field screening analyses for lead, copper, and zinc, as described in Section 2.3.2. A Baseline Risk Assessment, to be performed in conjunction with the RI Report for the SFL, will identify contaminants of concern.

Analytical tests indicated that lead levels in cover soils did not exceed 440 mg/kg. Zinc levels were estimated not to exceed 238 mg/kg, and copper levels were estimated not to exceed 110 mg/kg. These results indicate that lead levels in cover soils are below the soil cleanup levels of 500 to 1000 mg/kg established for Superfund sites in the "Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites" (OSWER, undated). Copper and zinc were detected infrequently at low levels in cover soils, and are not potentially identified as contaminants of concern in surface soils. Additional chemical constituents in cover soils were not evaluated because a major source of cover soils is believed to be a former rifle range berm. Therefore, cover soils are not likely to present an immediate threat to human health or the environment.

In subsurface soils, Aroclor-1248 was detected in one sample, and only thallium and beryllium were detected at levels exceeding RCRA Corrective Action Levels. Other metals detected in subsurface soils were estimated to occur within the range of background concentrations. Phthalate contamination occurs at all subsurface depths. Low levels of pesticides and volatile organics detected in subsurface soils are all below RCRA Action Levels. Subsurface soils directly in the source areas (fill trenches) were not collected during sampling. Considering the extent of detected contaminants in subsurface soils, and that intrusive activities are not expected in the SFL, an exposure pathway does not exist. Therefore, subsurface soils do not present a significant exposure threat to human health or the environment.

Surface water and sediment sample analyses did not detect organic contaminants in the Kansas River at measurable levels. Several metals were detected; however, their concentrations did not differ significantly from upstream to downstream locations, except in the case of slightly elevated levels of arsenic and chromium.

In the ground water at the SFL, volatile organics including vinyl chloride, benzene, and 1,1,2-trichloroethane were detected at low levels not exceeding 35 μg/L, but above federal Maximum Contaminant Levels (MCLs) during the July 1992 sampling event. Volatile organic contamination in Well Clusters 5 and 8, however, was not detected by the first quarter (November 1992) sampling event. Only the proposed MCL for beryllium and the secondary MCLs for manganese, iron, and aluminum were exceeded for metals detected in the ground water in either sampling event. The metal concentrations that were detected were generally consistent for the upgradient and downgradient locations and probably indicate the metals to be naturally occurring.

Ground water at the SFL is not currently used as a potable water source, and a public water supply is available for use in the area. An irrigation well located west of the SFL site which could potentially be impacted by the SFL is used for agricultural purposes. Contaminants were not detected "at the tap" from this well. Therefore, under current conditions, ground-water media are not believed to present a significant threat to human health or the environment.

In summary, the main potential environmental threats appear likely to be bank erosion and, to a lesser extent, poor cover grading and drainage. Based on current land and water use scenarios, exposure to soils and ground water in the vicinity of the SFL do not appear to present immediate threats to human health or the environment.

5.0 IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES

5.1 INTRODUCTION

The following potential non-time-critical removal alternatives have been identified:

Landfill Surface:

- Improve soil cover for more effective drainage and erosion control and to reduce potential for exposing landfill debris.

River Bank:

- Stabilize western section of the bank along the bend in the river. Stabilization should include toe reinforcement and protection of the slope to withstand the effects of river erosion and surface water runoff.

- The eastern section of the river bank is not believed to be eroding significantly or require stabilization of the slope. Therefore no protection is being proposed.

5.2 LANDFILL SURFACE REPAIRS/IMPROVEMENTS

5.2.1 Soil Cover Enhancement

This category involves actions which are intended to:

- Minimize erosion and migration of the landfill cover soils caused by stormwater run-on and run-off

- Limit potential leaching of constituents in soil to ground water

- Provide and maintain adequate cover over the waste to prevent human contact with the waste

The following alternatives for soil cover enhancement were considered:

5.2.1.1 Site Filling and Grading - This alternative involves a repair of the existing landfill cover by placement and grading of fill to remove depressions, erosion channels and other low areas within the landfill limits. The limits of filling will be determined by the amount of soil placement needed to obtain positive drainage on the landfill without any cutting or grading (lowering) of existing elevations. This will reduce the potential for ponding of surface water and enhance drainage off the landfill. Existing vegetation will be mowed and burned prior to placement of fill, and grass cover will be established. Development of an established grass cover across the entire landfill will increase evapotranspiration and therefore decrease potential infiltration. The required earthwork will be far less extensive than that for a complete soil cover.

5.2.1.2 Complete Soil Cover - This alternative involves construction of a soil cover with a minimum two percent surface slope over the entire site, within the clear area outside of the existing tree line at the site (Figure 5-1). This alternative will include: clearing and grubbing of existing vegetation and subgrade stabilization in order to prepare the surface for placement of fill; placement of fill and grading of the surface at a continuous two percent slope in all areas to create positive drainage off the landfill; construction of interior drainage swales to control stormwater run-off; and establishment and maintenance of grass for erosion control. In addition, existing monitoring wells and other related structures may need to be reconstructed (extended) or replaced, depending on the final surface elevations and monitoring requirements.

5.2.1.3 Complete Soil Cover with Clay Cap - This alternative involves construction of a complete soil cover within the clear area outside of the existing tree line and providing a low permeability clay cap with a minimum surface slope of three percent (Figure 5-2). This alternative will provide positive surface drainage, effectively eliminate erosion and migration of existing landfill cover soils, and control potential leaching of contaminants in existing landfill soils and waste to the ground water.

This alternative includes clearing and grubbing of existing vegetation and subgrade stabilization prior to fill placement; installation of fill to provide the desire surface slope; installation of an 18-inch low permeability clay cap with a three percent surface slope; construction of interior drainage swale to control stormwater run-off; and establishment and maintenance of grass cover. Reconstruction or replacement of existing monitoring wells will also be required.

5.3 RIVER BANK REPAIRS/IMPROVEMENTS

5.3.1 Non-Structural Slope Protection

Non-structural slope protection involves the use of natural measures, such as the planting and maintenance of vegetation, and grading of the bank to protect the slope from erosion. Protection of the toe of slope to prevent slope failure is not included in this category.

5.3.1.1 Vegetation - Vegetation is a commonly used method for protecting a river bank because it is relatively easy to establish and maintain. The root system of vegetation can hold the soil together and exposed plant structure can help protect the soil from surface erosion caused by stream flow, rainfall and storm water runoff. Further, vegetation takes water from the soil and may improve bank stability.

Vegetation is generally divided into two broad categories: grasses and woody plants. The grasses are less costly to plant on an eroding bank above the toe and require a shorter period of time to become established. Woody plants offer greater protection against erosion because of their more extensive root systems; however, under some conditions the weight of the plant will offset the advantage of the root system.

The major factor affecting species selection is the length of time required for the plants to become established on the slope. Species selection should be based on compatibility with the soil, air temperature ranges, total rainfall, distribution of rainfall, bank slope, and ability of the soil to store water for plant growth during dry periods. Vegetation is effective on the slope only if the toe of slope is otherwise stabilized.

5.3.1.2 Bank Shaping - This method involves grading the bank to remove irregularities (protrusions or indentations) in order to reduce eddy currents which may severely erode the bank. It also involves shaping the bank to a slope less than the maximum slope at which the bank can stand without danger of failing. This method is effective only if the toe of the slope is otherwise stabilized.

5.3.2 Structural Slope Protection/Stabilization

5.3.2.1 Riprap - Riprap consists of sound, durable pieces of stone, ranging in size from a few inches to two feet or more, depending on the design requirements. General uses of riprap on slopes are as follows:

- Placement along the toe of the bank to minimize scour and stabilize the slope (Figure 5-4)

- A blanket laid on the bank slope to prevent erosion (Figure 5-4)

Stabilization of a bank toe with riprap in conjunction with protection of the upper bank offers an effective approach to bank protection if toe scour is a problem.

Riprap blankets can be used to protect stream banks in areas where quality stone is economically available. Riprap blankets are widely used as protection for an entire bank face or for the portion of the bank below the high water mark. The blanket is stabilized at its base with a key trench or apron to prevent the stone from sliding down the bank. The upstream and downstream ends of the blanket are tied into the bank to prevent stream currents from unravelling the blanket.

5.3.2.2 Rubble - Rubble generally includes construction debris (such as broken pavement, bricks, blocks) and quarry waste. This material can provide an economical alternative approach to riprap for bank protection. The major problem associated with using rubble is that there is often no control over the type and size of materials. As a result, some of the rubble with insufficient weight may not completely stabilize the bank. In addition, voids are often formed by the irregular shapes and sizes of materials, allowing erosion.

5.3.2.3 Rock Revetment - Rock revetment includes the placement by dumping of graded quarry run stone along the toe of the bank and as a blanket on the bank to prevent erosion (Figures 5-5 through 5-7). The stone is piled with the outside edge of the slope at the toe of the bank. Stability is increased by weighing down the toe of the bank. No attempt is made to orient the rocks during placement, which can be completed successfully in freezing weather if there is no ice in the river which may hinder rock installation. Construction under water can be accomplished by dumping. Revetment is usually graded coarse to fine, and rock sizes needed for each job are determined by the expected velocity conditions and severity of erosion conditions. Slope shaping prior to placement is not needed.

The revetment at the SFL will be placed at a 1.5 horizontal to 1 vertical slope which is steeper than the existing bank (2.5 horizontal to 1 vertical) at the SFL with baffles at a spacing of 75 feet. As river sediments are gradually deposited between the baffles, the river bank will be filled in, increasing the stability of the revetment structure and also increasing the buffer between the landfill and the bank face.

5.3.2.4 Structural Walls - This alternative involves the construction of a vertical containment wall for bank stabilization. The wall would be constructed close to the existing toe of the bank. Three types of walls were considered as options:

- Sheet Pile Wall
- Concrete Retaining Wall
- Reinforced Earth Type Wall

When comparing the types of structural walls relative to each other, the reinforced earth type wall and concrete wall did not warrant detailed consideration. Further consideration was not given to these technologies for the following reasons:

- The reinforced earth type wall will not hold up to the hydraulic and erosive forces of river flows, particularly major flood flows. These types of walls are not structurally suitable for use on river banks.

- Reinforced earth and concrete walls require sound foundations. The excavation required for installation could uncover landfill contents.

- A reinforced earth wall and concrete retaining wall would require cofferdams around the bank for construction.

- Implementation of these technologies would result in significant sediment disturbance which could increase the environmental impact of construction activities.

A sheet pile wall was selected as the most appropriate type of structural wall for consideration as an alternative to bank stabilization.

The advantages of the sheet pile wall, when compared to the other technologies, are summarized below.

- No requirement for excavation into the bank
- Minimal access problems
- Limited disturbance of the river channel

5.3.2.5 Grout Blankets - Grout blankets are pre-manufactured geotextile forms which are placed and anchored on a graded uniform slope and filled with fine-aggregate concrete (structural grout). This method is effective only if the toe of the slope is otherwise stabilized.

5.3.2.6 Gabions - Gabions are flexible manufactured woven-wire units composed of one or more separate cells which are installed on the surface to be protected, filled with stone, and securely tied together. They are an alternative that can be used if stone of a sufficient size to be used as riprap is not available. Effective placement of gabion baskets requires excavation of a support apron at the toe of the slope, and careful construction in order to stabilize the slope. The major drawback is that gabion baskets or mattresses generally cost more to place than a comparable riprap blanket.

Over time, gabion structures generally become consolidated by soil, siltation, or vegetation which becomes trapped in the void space between the rock fill. When the long term durability of gabion structures is considered, the physical properties of the rock fill is of prime importance. Fill material subject to weathering greatly reduces the useful life of the structure. Gabion mesh has a limited service life depending on the atmospheric conditions and whether it is in contact with water. Gabions are unaffected by frost heave. They are highly permeable and are self-draining, which reduces the potential for hydrostatic head buildup behind them. They are flexible and can tolerate substantial settlement without failure.

5.3.2.7 Sand-Cement Bags - Sand-cement bags can be used to protect the river bank if riprap of suitable size and quality is not available at a reasonable cost. Sand-cement bag revetment construction is not economically competitive in areas where good stone is readily available.

5.3.2.8 Used Tires - Used tires can often be found in large quantities in some localities. The tires are generally bound together to form a mat structure and the mattress is tied into the bank by deadman anchors to prevent it from sliding down the bank or floating. If scour is anticipated, riprap or other structural stabilization material are placed at the toe of the mattress for additional protection.

5.3.2.9 Fences - Fence construction parallel to a bankline can reduce the velocity of the stream near the bank so that erosion will be minimal. Fences perpendicular to the bank encourage sediment deposition as a result of the lower stream velocity.

The fencing is constructed of wood or wire. It is designed and constructed to withstand the expected forces of water and debris. Double row fences are sometimes constructed to provide additional resistance to stream attack, with the gap between the fences filled with brush, stone, or other debris.

5.3.2.10 Kellner Jacks - A string of Kellner jacks can be placed along a bankline to prevent erosion in the same manner as a fence. Jacks are assembled from material such as angle iron, timber, pipes, rebar or precast concrete. Each jack consists of three members bolted or welded together at their midpoint such that each member is at right angles to the other two. The members are then laced together with cable, and the jacks are cabled together to form a string along the bankline. Additional strings can be placed perpendicular to the bankline to tie the main string in with the bank and to reduce the stream velocity against the bank.

5.3.2.11 Dikes - Dikes can be constructed to protect the river bank by:

- Reducing stream velocity as the current passes through the dike so that sediment deposition occurs instead of erosion (permeable dike); or

- Deflecting the current away from the bank (impermeable dike).

The permeable dike is most effective on river flows carrying heavy sediment loads. As sediment-laden flow moves through the dike, the sediment will be deposited on the streambed and bank if there is sufficient reduction in water velocity. Deposited soil particles will build up the eroded bank and can lead to volunteer vegetation growth.

Although some types of impermeable dikes pass a small amount of flow, their major function is to divert eroding currents away from a bank. Impermeable dikes should be constructed with material heavy enough to stay in place and not be carried away by stream currents. The first dike along an eroding bank is constructed immediately upstream from the location on the bank where erosion is initially apparent. Other dikes are normally constructed downstream from the first dike, on both sides of the stream, in order to deflect the current so that it remains in midstream and does not touch either bank. The flow characteristics of the stream may change as the stream moves from a low water to flood condition. Thus, the path of the current could change depending on the depth of the river. Generally dike locations are determined when the stream is at a depth where the most erosion occurs.

5.3.3 River Rerouting

The last alternative considered was rerouting the river. Relocation would be accomplished by excavating a pilot channel from a point upstream of the distressed bank to a point downstream from the bank. If the length of the pilot channel was shorter than the length of the natural channel, the slope of the pilot channel would be greater than that of the natural channel. Thus, the river would tend to flow through the pilot channel in lieu of the natural channel. Eventually, as soil eroded from the banks and bed of the pilot channel, the pilot channel would capture the river flow as the channel enlarged and/or sediment was deposited in the natural channel.

6.0 EVALUATION AND SCREENING OF REMOVAL ACTION ALTERNATIVES

6.1 INTRODUCTION

Several removal action alternatives have been identified and screened as potentially suitable for landfill improvements and river bank stabilization/protection. Site-specific feasibility of each removal action measure was based on the following criteria:

6.1.1 Effectiveness

- Potential threats to the community or to construction workers resulting from implementation of removal action?
- Will completed action meet removal action objectives?
- Is the time required for completion of implementation compatible with desired schedule?
- Potential adverse environmental impacts resulting from implementation of removal action?
- Potential exposure to remaining risks after action is taken?
- Does it have long-term reliability for providing continued protection, and is it expected to be part of the final remedy for the site?

6.1.2 Implementability

- Is the technology technically feasible, considering the local environmental conditions?

- Does it comply with identified ARARs and TBCs?

- Has the technology been used to remedy other similar conditions and has it achieved satisfactory results?

- Is the action consistent with the long-term remedy for the site?

- Are the required materials and equipment available?

- Any site control (maintenance) requirements after removal action completion?

- Will it likely be accepted by the public?

- Can required approvals or substantive permit requirements be obtained?

6.1.3 Cost

- What is estimated total cost (present worth) of the technology, including capital costs and future maintenance costs?

Initially, identified alternatives were screened for effectiveness and implementability. Cost estimates have been developed for those alternatives which passed the initial criteria. Any alternative receiving a negative response for one of the individual screening criteria was considered to be infeasible, and therefore, failed the screening evaluation. The results of this screening are presented in Tables 6-1 and 6-2. The rationale used to screen the alternatives is summarized in the tables, and is discussed in Sections 6.2 and 6.3. Conceptual construction costs for potentially feasible alternatives are presented on Tables 6-3 through 6-10.

6.2 LANDFILL SURFACE REPAIRS/IMPROVEMENTS

Surface filling associated with implementing any of the landfill repair/improvement alternatives will lie within the 50- and 100-year floodplains of the Kansas River. The entire SFL site will be inundated during these flood events. However, the SFL area is predominantly within the overbank area of the river and not within the floodway of the river.

Flow velocities over the landfill within the overbank area are expected to be significantly below five feet per second, which is typically taken to be the threshold limit for erosion of grass-covered soils (USACE, 1991). Therefore, washout of landfill cover soils is not expected. Therefore, flooding levels in the vicinity of the SFL are not expected to be affected significantly by filling operations. A study of flood levels may be necessary to verify that the river level impacts caused by filling are in compliance with Executive Order 11988 (see Section 3.4.2.1).

6.2.1 Site Filling and Grading

This alternative requires a limited disturbance of the entire landfill site. Existing vegetation will be mowed or burned prior to filling so the established vegetative cover over the landfill will be retained at and below grade. The area to be filled and graded will depend on the ability to create a positive drainage on the finished surface and eliminate all depressions without cutting into existing slopes. Implementation will decrease the potential for erosion and reduce the potential for concentrated infiltration of surface water through the landfill because depressions will be eliminated. Additionally, establishing a complete grass cover will increase evapotranspiration and reduce infiltration. The alternative is easily implemented, is expected to be able to comply with identified ARARs, and is consistent with the potential long-term remedy for the site.

6.2.2 Complete Soil Cover

This alternative requires disturbance of the entire landfill surface. However, there is limited environmental risk to the community or to construction workers because the existing landfill cover will not be penetrated, and landfill waste will not be contacted. As described in Section 3.4.2.3, the site is a potential habitat for several threatened or endangered species of wildlife. Confirmed sightings at the site (along the river corridor) include the bald eagle and eastern hognose snake. Grading of the landfill cover is not likely to impact habitat for either, because the hognose snake habitat is along the river, and the bald eagle would not likely reside in the open areas of the landfill. No indications of historically significant sites in the SFL area were noted.

Because a minimum two percent grade for the landfill cover is considered to provide positive site drainage, this potential removal action will require a cover over the entire exposed landfill area. Implementation will decrease both erosion potential and the potential for concentrated infiltration of surface water through the landfill. The alternative is relatively simple to implement and is expected to comply with identified ARARs. The investigation of effects of the extensive filling on the river floodplain will be required prior to completion of detailed design. In addition, removal of the required fill material from on-post borrow locations on the Fort Riley reservation would likely cause major disturbance to large surface areas.

6.2.3 Complete Soil Cover with Clay Cap

This alternative will cause disturbance of the entire landfill surface but limited risk due to limited contact with existing landfill waste as described in Section 6.2.2. Wildlife habitat described previously (Section 6.2.2) would not be expected to be impacted.

Because the EPA guidance recommends a minimum of three percent slope on landfill caps, a complete cover will be required, with the relatively impermeable compacted clay cap installed with a minimum thickness of 18 inches over the entire filled landfill area. Implementation would achieve most removal action objectives, but would also encroach on the 50 and 100-year floodplains, requiring further study prior to final design (6.2.2). Removal of fill material from on-post borrow areas would cause major disturbance to large surface areas. Also, if material for the clay cap is removed from on-post areas, extensive disturbance will be required because suitable clay material on-post, if available at all, is reportedly widespread and in relatively shallow, near surface deposits.

In the ground water, volatile organics analytical data from the first quarter (November 1992) sampling confirmed only one detection of benzene at a low level (less than 10 parts per billion). Other organics detected in the July 1992 sampling were not confirmed by the first quarter sampling. However, the first quarter sampling had three detections of 1,2-DCA and one detection of benzene that were not previously detected in the baseline sampling event. Volatile organic detections in the baseline sampling were at low levels (less than 35 parts per billion). Volatile organic maximum detections in the first quarter sampling (less than 20 parts per billion) were lower than the July 1992 sampling results. Metals were consistently detected during the July 1992 and November 1992 first quarter sampling events. Only the proposed MCL for beryllium and the secondary MCLs for manganese, iron, and aluminum were exceeded. Since metals concentrations in on-site and off-site wells were consistent, metals are naturally occurring. Considering these results and also considering the observed effects on water levels (rises) in SFL monitoring wells believed to be due to infiltration caused by rises in the Kansas River, the effectiveness of a landfill cap in preventing water contact with the waste will be reduced. A significant portion of the total infiltration into the landfill is believed to be from the river. Additional information will be presented in the RI Report.

6.3 RIVER BANK REPAIRS/IMPROVEMENTS

6.3.1 Non-Structural Slope Protection

6.3.1.1 Vegetation - Vegetation has been successfully used on upper banks but only in conjunction with structural protection on lower banks. Existing vegetation should be left as undisturbed as possible in areas where erosion of the toe is not occurring or the weight of the vegetation and its root mass is not causing or likely to cause a bank failure. Sandy soils along the lower bank are not conducive to vegetative growth. An erosion control matting and vegetation system may be feasible on upper embankments disturbed by construction, however, an all-vegetation scheme is not feasible.

6.3.1.2 Bank Shaping - Since there are no protrusions or indentations causing eddy currents to severely erode the bank, the only option to shape the bank would be to cut the bank slope back. Bank sloping is not recommended since intrusion into the existing limits of the landfill is likely to occur in order to cut the bank back far enough to minimize the possibility of failure. Further, bank cut-backs are effective only if the toe of the slope is otherwise stabilized.

6.3.2 Structural Slope Protection/Stabilization

6.3.2.1 Grout Blankets - Grout blankets must be installed on prepared, uniform slopes. Existing rubble would have to be moved to the toe of the bank or removed from the site. This will cause some potential environmental impact due to excavation. Existing slopes must be graded to a flatter slope for stability of blanket. Blankets are available that can withstand flood flows, including high-velocity areas of river channel, however, the toe must be otherwise stabilized. This technology will meet all removal action objectives to stabilize the bank slope. It can be completed within the time schedule. It has long-term reliability, if designed and installed correctly, to withstand hydrostatic uplift and freeze/thaw action. It is a proven technology and is easily implemented as long as the slope can be graded properly.

6.3.2.2 Riprap - Durable stone is economically available in the area. A riprap blanket is relatively flexible and can conform to minor changes in the bank slope due to settlement or scour. Riprap is free draining and not subject to hydrostatic pressures. Because it is free draining, it also tends to be frost resistant. In addition, riprap blankets are relatively easy to construct. Construction can proceed from the top of the bank, no special equipment is necessary, and the river does not need to be diverted. It can be easily placed under water. Filter fabric or graded filter material should be placed under the riprap for separation of materials, stabilization of the riprap and filtration of ground water to prevent hydrostatic pressure build-up. Riprap is highly recommended for slope protection and toe stabilization.

6.3.2.3 Rubble - Because of the poor control which is typically exercised over the type and size of materials delivered to the project site, it is recommended that rubble not be used for slope protection. It is recommended, however, that rubble currently on the bank be relocated to the toe of the bank to supplement placement of riprap at that location.

6.3.2.4 Rock Revetment - At the SFL site, considering the river conditions, a rock revetment alternative can provide bank protection that is equivalent to a riprap alternative at less cost. Revetment is a proven technology that has been used successfully along the Kansas River for bank stabilization. An advantage of this alternative is that no grading or shaping of the bank is needed prior to revetment placement. Revetment will protect the bank from river currents and gradually create an additional buffer between the bank and the landfill, as deposited river sediments gradually fill in the space between the baffles. Revetment is placed by dumping quarry run stone onto the toe of the bank, and placement can be completed during freezing weather if there is no ice on the river. Revetment can be easily repaired or extended in the future if additional stabilization is needed. Disadvantages of using revetment are that the upper slope of the bank is not protected, and sediment deposition which further stabilizes the river bank occurs gradually and is dependent on the frequency and magnitude of high water events in the river. The river elevation must exceed the baffle height to allow sediment deposition between the baffles where low-velocity flow conditions will occur. Since quarry run stone is believed to be readily available in the area, this alternative will be recommended.

The potential environmental/ecological impacts on the river caused by installation of a rock revetment would include: a minimal reduction in quantity of wildlife habitat; possible loss of water surface area; possible destruction or burial of cultural resources; alteration of established invertebrate and algal communities; short term reduction of fish habitat; and minimal loss of riparian timber through clearing of access roads. These potential environmental impacts are considered to be limited. Considering that the majority of the Kansas River bank is alluvial deposits and not rock or gravel, the revetment may potentially improve the diversity of animal habitats along the bank. Historical or cultural resources are not known to exist at the SFL site, therefore adverse impacts to cultural resources are not expected. Losses of riparian timber through access road clearing is expected to be minor, because the majority of the bank to be stabilized is not covered with trees.

The rock revetment will not contain more than fifteen percent fines less that three inches in diameter, and the erodable fraction of placed materials is expected to be significantly less than three inches. Little sedimentation is expected during the operation. Considering the sediment load characteristically in the Kansas River, the impact of the revetment placement will be minimal.

6.3.2.5 Gabions - The main disadvantages of gabions are price and durability. They are labor-intensive to construct, because the baskets, once placed, have to be filled with rocks. Depending on local labor costs, the time involved can become expensive. The long-term durability of the wire is always in question. Eventually, the gabion wire will deteriorate, especially if it is in contact with water. Based on available information, stone is apparently readily available in sufficient size to remain in place on the bank during flood flows without requiring wire mesh to hold it in place. For these reasons, gabions are not recommended.

6.3.2.6 Sheet Pile Wall - This alternative will have limited environmental impact if it is constructed near the toe of the bank. It will meet all removal action objectives for bank stabilization and protection. No excavation of the slope is required. Sheet piling is technically feasible and has proven reliability in similar conditions, however, it will be expensive to construct.

6.3.2.7 Sand-Cement Bags - Sand-cement bags are not recommended since riprap of suitable size and quality is available at a lower cost.

6.3.2.8 Used Tires - The use of used tires is not a proven technology in similar situations. This alternative is very labor intensive. To allow the tires to fit together better, they must be presorted by size. Drilling holes through modern steel reinforced tires to prevent flotation is not accomplished rapidly. Packing the tires individually with stone will require extensive hand work and hand trimming even when the operation is augmented by heavy equipment. Screw anchors or other forms of anchors must be fastened to the mattress and secured into the bank at various points on the revetment face. Installation of screw anchors will likely be difficult due to rubble fill along banks. Availability of sufficient quantities of materials is extremely limited, if available at all. For these reasons, used tires have been eliminated as a potential removal action.

6.3.2.9 Fences and Kellner Jacks - The use of fencing and Kellner jacks will allow sediment deposition to build up the bank, however, the deposition process would likely be slow, and the potential for bank erosion extending into the limits of the existing landfill will remain high until this build-up is accomplished. Erosion will likely occur in the future during major flood stages even with these devices in place. Long-term substantial sediment deposition leading to increased bank stabilization appears unlikely along the SFL if Kellner jacks are used. For these reasons, fencing and Kellner jacks have been eliminated as a potential removal action.

6.3.2.10 Dikes - Like fences or Kellner Jacks, permeable dikes will result in sediment deposition, but the potential for bank erosion extending into the limits of the existing landfill will remain high until this build-up is accomplished. Erosion will likely occur in the future during river flooding. Therefore, dikes are not recommended.

Impermeable dikes are also not recommended since they would deflect erosive currents away from the bank onto the opposite river bank, causing potential erosive conditions to develop on the opposite side of the river.

6.3.3 River Rerouting

River rerouting may cause serious future problems. Shortening the length of the channel would upset the natural balance of the river. An upset of the natural balance could result in bank erosion upstream from the pilot channel and flooding downstream. The long-term effects are hard to predict. In addition, considerable costs are expected for the acquisition of lands necessary for the channel construction since the channel would need to be constructed off military property. The alternative to relocate the river was therefore eliminated from further consideration.

7.0 COMPARATIVE ANALYSIS

7.1 LANDFILL SURFACE REPAIRS/IMPROVEMENTS

Based on the evaluation of each alternative for landfill surface repairs/improvements, the Army has identified the following advantages and disadvantages of each alternative.

7.1.1 Site Filling and Grading

7.1.1.1 Advantages -

- Implementation will decrease erosion potential and improve drainage conditions and vegetative cover, reducing infiltration.

- Removal of fill from on-post borrow areas will cause relatively minor disturbance of surface areas.

- Implementation is consistent with the long-term remedy for the site.

- Implementation is significantly less expensive than the other surface improvement alternatives.

7.1.1.2 Disadvantages -

- Additional settlement will possibly lead to other isolated low spots.

- Possible locations with insufficient landfill cover would not be enhanced.

- Installation of fill will encroach on 50-year and 100-year floodplains and may require investigation of encroachment impacts prior to final design.

7.1.2 Complete Soil Cover

7.1.2.1 Advantages -

- Implementation will reduce erosion potential, improve drainage conditions and reduce infiltration, while reducing the impact of possible future settlement on surface conditions.

- Addition of fill will provide additional cover to areas of questionable cover thickness.

- Implementation is generally consistent with long-term remedy for the site.

7.1.2.2 Disadvantages -

- Removal of fill from on-post borrow areas will cause major disturbance of surface areas.

- Installation of fill will encroach on 50-year and 100-year floodplains to a greater extent than the Site Filling and Grading Alternative and will require investigation of encroachment prior to final design.

- Implementation is significantly more expensive than the Site Filling and Grading Alternative.

7.1.3 Complete Soil Cover with Clay Cap

7.1.3.1 Advantages -

- Implementation will reduce erosion potential and improve drainage conditions, including providing a minimum of three percent slope.
- Additional fill will provide minimum cover to areas of questionable cover thickness.
- Installation of clay cap will significantly reduce infiltration of surface water through landfill.
- Implementation is generally consistent with long-term remedy for the site.

7.1.3.2 Disadvantages -

- Removal of fill from on-post borrow areas will cause major disturbance of surface areas.
- Removal of clay fill for landfill cap from on-post borrow areas will cause major disturbance of surface areas, if available in sufficient quantities. If on-site clay fill is not available, off-site clay cover material will likely be very expensive due to haul expenses.
- Installation of fill will encroach on 50-year and 100-year floodplains, and require investigation of encroachment prior to final design.

- Implementation is significantly more expensive than the Site Filling and Grading and Complete Soil Cover alternatives.

7.2 RIVER BANK REPAIRS/IMPROVEMENTS

Based on the evaluation of each alternative for repairs/improvements to the Kansas River bank, the following advantages and disadvantages of each alternative have been identified.

7.2.1 Grout Blankets

7.2.1.1 Advantages -

- Completed action, together with toe of bank stabilization, will meet all removal action objectives to minimize erosion and stabilize the bank.

- It has long-term reliability for bank stabilization if designed and constructed properly.

- The technology has demonstrated satisfactory results in other similar situations.

- Materials required for construction are readily available with proper lead times.

- It will have minimal adverse impact on river flows.

- Grout blanket can be quickly installed, during adequate weather and low river flow conditions, after the bank slope has been prepared.

7.2.1.2 Disadvantages -

- Existing rubble on the bank may need to be relocated, either to the toe of the bank or off the bank, in order to grade the slope.
- Grading the slope may potentially expose landfill debris.
- Erosion control measures required.
- Must be carefully designed and constructed with strict QA/QC procedures.

7.2.2 Riprap

7.2.2.1 Advantages -

- Installation of riprap for toe protection and slope protection will meet all removal action objectives.
- It has long-term reliability for bank stabilization if designed and constructed properly.
- The technology has demonstrated satisfactory results in other similar situations.
- Materials required for construction are readily available with proper lead times.
- It will have minimal adverse impact on river flows.
- Grading of the slope will not need to be as extensive as required for grout blankets.

- Riprap can be placed on a prepared slope during most weather conditions.

- Riprap is more free draining and more flexible (able to conform to subgrade changes) than grout blankets.

- Cost is slightly less than rock revetment (within ten percent).

7.2.2.2 Disadvantages -

- Where grading of the slope is required, it may potentially expose landfill debris.

- Removal of existing rubble and clearing and grubbing will be required.

- Erosion control measures may be required.

- Riprap cannot be placed in freezing weather nor during high water conditions.

7.2.3 Rock Revetment

7.2.3.1 Advantages -

- Will meet removal action objectives to minimize erosion and stabilize the bank.

- Excavation and shaping of the bank is not required.

- Provides additional buffer between bank and SFL landfill debris.

- Easily installed in all weather conditions except when river is frozen.

- Easily modified, repaired and maintained.

- Materials for construction are believed to be readily available.

- The technology is proven effective on the Kansas River.

- Has long-term stability and reliability if properly sized and placed.

- Cost is within uncertainty range of lowest cost alternate (riprap).

- Can be installed under water effectively.

7.2.3.2 Disadvantages -

- Upper slope is not protected from erosion.

- Waiting period until river sediment deposition fills in and stabilizes the installation.

- Will have a greater potential to adversely impact river flows because bank is extended into the river.

7.2.4 Sheet Pile Wall

7.2.4.1 Advantages -

- Excavation of the bank is not required.
- It will meet all removal action objectives.
- It has long-term reliability for bank stabilization if designed and constructed properly.
- Materials required for construction are readily available with proper lead times.
- It will have minimal adverse impact on river flows.

7.2.4.2 Disadvantages -

- Construction area must be cleared of vegetation and debris.
- Adverse subsurface conditions may be encountered, increasing difficulty of installation.
- Sheet pile construction is significantly more expensive than other alternatives.

8.0 PROPOSED REMOVAL ACTION

8.1 LANDFILL SURFACE REPAIRS/IMPROVEMENTS

The recommended alternative for non-time-critical removal action at the landfill is the repair of the existing cover by Site Filling and Grading. This will involve placing, grading, and compacting fill in depressions, erosion channels and other low areas, and to create positive drainage within the landfill limits in order to decrease the potential for erosion of the cover and to improve drainage off the landfill. Specifically, the recommended alternative includes:

- Mowing or burning of existing vegetation within clear area outside of the treeline;
- Placement, grading and compaction of fill; and
- Establishment and maintenance of grass on new fill areas for erosion control.

This alternative will reduce erosion potential by improving surface drainage and establishing a consistent vegetative cover on the landfill surface. Leaching potential will be reduced by eliminating the current long-term retention of storm water in surface depressions and improving evapotranspiration. This alternative will provide an adequate cover over the areas of exposed landfill debris. The alternative will be consistent with the final remedy which could include additional filling on the surface of the SFL. Identified ARARs can be met through proper implementation of site controls during construction, with the exception that floodplain impacts caused by filling may need to be verified as minimal in accordance with Executive Order 11988.

8.2 RIVER BANK REPAIRS/IMPROVEMENTS

The recommended non-time-critical removal action alternative for repairs/improvements to the Kansas River bank adjacent to the landfill is placement of revetment (quarry run stone) on the bank slope and at the toe of the bank, as described below:

- Place quarry run stone revetment along the perimeter of the western section of the landfill. This would include approximately 1200 linear feet along the river, from just west of survey point 4 to survey point 12 (Figure 5-3).

Bank stabilization will prevent or significantly reduce the erosion of the river bank and should limit potential river movement. By stabilizing the river bank, future exposure and migration of landfill contents will be unlikely. Bank stabilization will be consistent with the final remedies to physically stabilize the site. Identified ARARs can be met through proper implementation of site controls during construction. Floodplain impacts due to construction are expected to be minimal; however, verification of this conclusion may be needed to satisfy Executive Order 11988.

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