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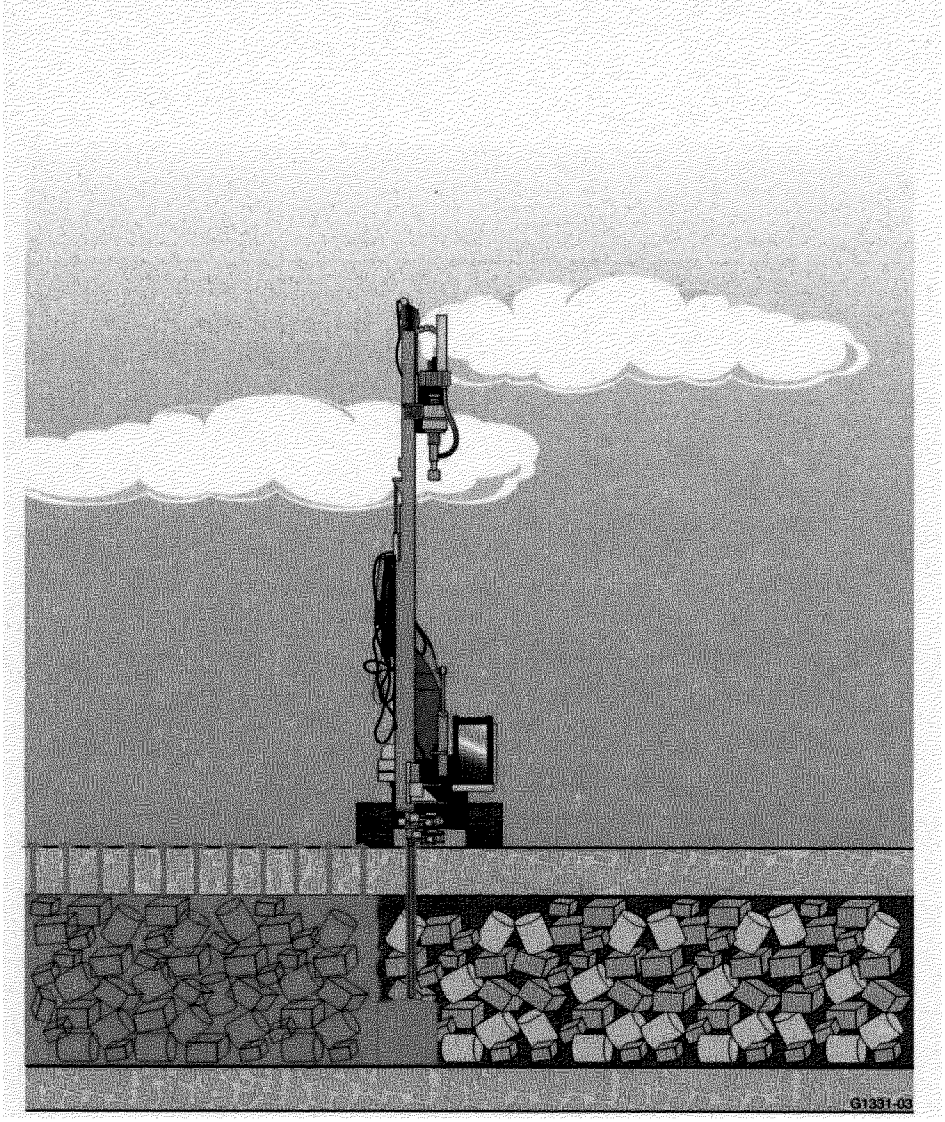
Engineering Studies Report for the OU 7-13/14 In Situ Grouting Project



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Bechtel BWXT Idaho, LLC

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Engineering Studies Report for the OU 7-13/14 In Situ Grouting Project

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Idaho Completion Project
Idaho Falls, Idaho 83415

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Engineering Studies Report for the OU 7-13/14 In Situ Grouting Project

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Engineering Studies Report for the OU 7-13/14 In Situ Grouting Project

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Approved by

Karen L. Shropshire, project cost account manger OU 7-13/14 In Situ Grouting Project	9/29/04 Date
David F. Nickelson, project engineer OU 7-13/14 In Situ Grouting Project	9/29/04 Date
Tracy A. Langenwalter, design project engineer OU 7-13/14 In Situ Grouting Project ICP Central Engineering Services	9/29/04 Date
Edward C. Anderson, P.E. Mechanical Engineering Group supervisor ICP Central Engineering Services	9/29/04 Date
FOR V. BALLS Vondell J. Balls, P.E. Civil, Structural, Architectural Engineering Group supervisor ICP Central Engineering Services	9/29/04 Date
FOR W Reed William H. Reed, P.E. Electrical Engineering Group supervisor ICP Central Engineering Services	9/29/04 Date

LICENSED ARCHITECT
BYRON L. BLAKELY
AR-871
9/29/04
IDAHO FALLS, IDAHO
STATE OF IDAHO

REGISTERED PROFESSIONAL ENGINEER
2990
9/29/04
State of Idaho
Paul J. Bunnell

PROFESSIONAL ENGINEER
REGISTERED
11200
9/29/04
STATE OF IDAHO
DOUGLAS W. CLARK

PROFESSIONAL ENGINEER
REGISTERED
7059
9-29-04
STATE OF IDAHO
KENNETH E. GRAFF

PROFESSIONAL ENGINEER
REGISTERED
4003
9/29/04
STATE OF IDAHO
SCOTT ALAN JENSEN

REGISTERED PROFESSIONAL
ENGINEER
5214
9/28/04
STATE OF IDAHO
BRIAN D. RAIVO

PROFESSIONAL ENGINEER
REGISTERED
7574
9/29/04
STATE OF IDAHO
DAVID L. STEPHENS

ABSTRACT

A number of parallel and integrated engineering studies were performed to conceptually define the Operable Unit 7-13/14 In Situ Grouting Project in this engineering study. These studies are in preparation for and provide a technical basis for cost and schedule estimates; safety and environmental evaluations; and identification of possible requirements for a design, build, and operate performance specification.

The project will use a grouting process to stabilize contaminants of concern disposed of in the Subsurface Disposal Area, a radioactive hazardous waste landfill at the Radioactive Waste Management Complex located on the Idaho National Engineering and Environmental Laboratory. In situ grouting, as it will be applied at the Subsurface Disposal Area, will use a high-pressure jet grouting process similar to processes used in the construction industry to inject grout below grade, mix the grout with the buried waste, and form grout-waste monoliths. These monoliths will reduce water infiltration, stabilize contaminants, and provide additional ground stabilization to structurally support a future environmental cap over the entire Subsurface Disposal Area.

In situ grouting at the Subsurface Disposal Area will be accomplished in two phases. The phase 1 process focuses on stabilizing the corrosion of a number of isolated beryllium reactor components containing carbon-14 through use of a paraffin-based grout. The phase 2 process, which is the focus of this engineering studies report, is broader in nature of application and will use cement-based grout injected in large selected areas of the Subsurface Disposal Area to immobilize fission and activation products. Together, these two phases will mitigate the most imminent risk to human health and the environment by reducing contaminant migration from the Subsurface Disposal Area to the Snake River Plain Aquifer. Phase 1 was completed in the summer of 2004. Phase 2 is scheduled to begin in the summer of 2005 and continue each summer until 2010.

ACKNOWLEDGEMENTS

This engineering studies report is the culmination of the professional work accomplished by a dedicated team of Idaho Completion Project and Idaho National Engineering and Environmental Laboratory engineers and technical support staff. The following professionals, who formed the core of the team, merit individual acknowledgement for executing the work associated with this project:

N. Kim Rogers, P.E., design project engineer	Design lead, February–July 2004
Tracy Langenwalter, design project engineer	Design lead, August-September 2004
Paul J. Bunnell, P.E., advisory engineer	Measurement and control
Douglas W. Clark, P.E., advisory engineer	Fire protection
Alma J. Cram, P.E., staff engineer	Grout delivery, storage, and mixing
Randy L. Eastman, P.E., advisory engineer	Support systems
Kenneth E. Graff, P.E., advisory engineer	Electrical utilities
Scott A. Jensen, P.E., senior advisory engineer	Grout selection, Subsurface Disposal Area conditions
James A. Johnesee, senior advisory engineer	Requirements
Brian D. Raivo, P.E., senior advisory engineer	Trackhoe and drilling unit, support vehicles
Brian L. Searle, technical specialist	Architectural, civil, structural design, and drafting
David L. Stephens, P.E., staff engineer	Foundation grouting
Elden B. Thompson, senior consulting technical specialist	Operations, maintenance, and logistics; environmental, safety, and health
Ernie E. Carter, P.E., Carter Technologies Co.	Grouting consultant
Deborah H. Manwill, senior technical specialist	Electrical design and drafting
Jim L. Moncur, principal drafter	Mechanical design and drafting
LauraLee Gourley, business/operations specialist	Technical writing and editing
R. Brad Holder, consulting business/operations specialist	Technical writing, editing, and document development

CONTENTS

ABSTRACT xi

ACKNOWLEDGEMENTS xiii

ACRONYMS xix

NOMENCLATURE xxiii

1. INTRODUCTION 1

   1.1 Project Overview 1

   1.2 History of Grouting at the INEEL 2

2. FACILITY OVERVIEW 3

   2.1 Historical Overview 3

   2.2 Pits, Trenches, and Vaults 5

      2.2.1 Transuranic Waste Pits and Trenches 5
      2.2.2 Low-Level Waste Pits and Trenches 5
      2.2.3 Soil Vaults 6

   2.3 Subsidence 6

3. PROJECT REQUIREMENTS 7

4. ALTERNATIVES ANALYSIS SUMMARY 11

5. PROJECT DESCRIPTION 13

   5.1 Acquisition Strategy 13

   5.2 Areas to be Grouted 14

   5.3 Grout Injection 16

   5.4 Batch Plant 18

   5.5 Grout Delivery 19

   5.6 Operational Crew 20

6. SUPPORT SYSTEMS 21

   6.1 Facility Structures and Trailers 21

6.1.1 Shift Office and Maintenance Trailer 21
6.1.2 Relocatable Maintenance Building 21
6.1.3 Restroom Trailer 24
6.1.4 Decontamination Pad 24
6.1.5 Supporting Utilities and Equipment 24

7. RADIATION CONTAMINATION CONTROL AND INDUSTRIAL HEALTH 25

7.1 General Radiological and Chemical Contamination Controls 25

7.2 Contamination Control and Prevention 25

7.3 Welding 26

8. REFERENCES 27

Appendix A — Alternative Analysis Section Meeting Minutes and Reports 31

Attachment 1 — TFR-267, "Requirements for the OU 7-13/14 In Situ Grouting Project (Customer, Project, and System)" 79

Attachment 2 — TFR-269, "Requirements (Subsystem) for the OU 7-13/14 In Situ Grouting Project" 81

Attachment 3 — TFR-280, "Requirements (Assumptions) for the OU 7-13/14 In Situ Grouting Project" 83

Attachment 4 — EDF-5146, "OU 7-13/14 In Situ Grouting Project Grout Selection Basis" 85

Attachment 5 — EDF-5028, "OU 7-13/14 In Situ Grouting Project Foundation Grouting Study" 87

Attachment 6 — EDF-5147, "OU 7-13/14 In Situ Grouting Project Subsurface Disposal Area Site Conditions" 89

Attachment 7 — EDF-5153, "OU 7-13/14 In Situ Grouting Project Hydraulic Excavator and Drill-Injection Rig" 91

Attachment 8 — EDF-5155, "OU 7-13/14 In Situ Grouting Project Operations, Maintenance, and Logistics" 93

Attachment 9 — EDF-5135, "OU 7-13/14 In Situ Grouting Project Grout Storage and Mixing" 95

Attachment 10 — EDF-5102, "OU 7-13/14 In Situ Grouting Project Grout Delivery System" 97

Attachment 11 — EDF-5144, "OU 7-13/14 In Situ Grouting Project Support Facilities" 99

Attachment 12 — EDF-4933, "OU 7-13/14 In Situ Grouting Project Measurement and Control" 101

Attachment 13 — EDF-5122, "OU 7-13/14 In Situ Grouting Project Electrical Utilities" 103

Attachment 14 — EDF-5150, "OU 7-13/14 In Situ Grouting Project Support Systems" 105

Attachment 15 — EDF-5054, "OU 7-13/14 In Situ Grouting Project Fire Protection" 107

Attachment 16 — EDF-5162, "OU 7-13/14 In Situ Grouting Project Support Vehicles" 109

Attachment 17 — EDF-5152, "OU 7-13/14 In Situ Grouting Project Environmental, Safety, and Health" 111

FIGURES

1. Subsurface Disposal Area..... 4

3. Stages of the OU 7-13/14 In Situ Grouting Project..... 13

4. Grout storage, mixing, delivery, and injection process. 15

5. Standard 90,000-lb class trackhoe combined with a mast-mounted rotary percussion drill rig. 16

6. Jet grouting drill stem in soil and waste matrix showing grout returns..... 17

7. Possible in situ grouting batch plant layout..... 18

8. Dry grout ingredients being offloaded into portable batch plant silos. 19

9. Radioactive Waste Management Complex plot plan showing in situ grouting staging and work area. 22

10. In situ grouting subcontractor shift office and maintenance trailer..... 23

11. In situ grouting relocatable maintenance building..... 23

12. Mobile restroom trailer..... 24

TABLES

1. Contaminant and foundation grouting locations..... 15

2. In situ grouting project proposed operational crew staffing levels..... 20

ACRONYMS

AEC	Atomic Energy Commission (DOE predecessor)
Be	beryllium
C	carbon
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (42 USC § 9601 et seq., 1980)
CFA	Central Facilities Area
CFR	*Code of Federal Regulations*
CH	contact-handled
COC	contaminant of concern
COCA	Consent Order and Compliance Agreement
cpm	counts per minute
D&D	decontamination and demolition
DOE	U.S. Department of Energy
EDF	engineering design file
EPA	Environmental Protection Agency
EXT	external (INEEL technical report designation)
EZ	entry zone
FA	fission and activation
FFA/CO	Federal Facility Agreement and Consent Order
FR	Federal Register
FTL	field technical lead
GPS	global positioning system
HEO	heavy equipment operator
HSO	health and safety officer

ICP	Idaho Completion Project
ID	Idaho Operations Office (DOE)
ID-EM	Idaho Operations Office, Office of Environmental Management (DOE)
INEEL	Idaho National Engineering and Environmental Laboratory
ISG	in situ grouting
LLW	low-level waste
MCP	management control procedure
NEPA	National Environmental Policy Act of 1969 (42 USC § 4321 et seq.)
NPL	National Priorities List
NTCRA	non-time critical removal action
OU	operable unit
PDSA	preliminary documented safety analysis
P.E.	professional engineer
PEL	permissible exposure limit
PERA	preliminary evaluation of remedial alternatives
PPE	personal protective equipment
PRD	program requirements document
psi	pounds per square inch
psig	pounds per square inch gauge
RCRA	Resource Conservation and Recovery Act of 1976 (42 USC § 6901 et seq.)
RCT	radiological control technician
RH	remote-handled
RWP	radiation work permit
SAR	safety analysis report
SDA	Subsurface Disposal Area

SSO	site safety officer
STR	subcontract technical representative
T&FR	technical and functional requirement
Tc	technetium
TLV	threshold limit value
TOC	table of contents
TRU	transuranic
TSA	temporary storage area
TWA	time-weighted average
USC	United States Code
WAG	waste area group
WBS	work breakdown structure

NOMENCLATURE

≈	approximately equal to
=	equal to
-	minus
/	per (also, divided by)
+	plus
§	section
x	times (also, by)
e.g.	for example (Latin abbreviation for “exempli gratia”)
e-mail	electronic mail
et al.	and others (abbreviation for Latin feminine plural “et aliae,” masculine plural “et alil,” or neutral plural “et alia”)
etc.	and so forth (abbreviation for Latin “et cetera”)
et seq.	and those that follow (abbreviation for Latin “et sequens”)
fax	facsimile
ft	foot
ha	hectare
i.e.	that is (abbreviation for Latin “id est”)
in.	inch
in situ	in position; in the natural or original position (Latin)
km	kilometer
mi	mile
mR/h	milliroentgen per hour
nCi/g	nanocuries per gram
RadCon	radiological control

Engineering Studies Report for the OU 7-13/14 In Situ Grouting Project

1. INTRODUCTION

This report presents the fundamental strategy resulting from engineering studies of facilities and processes for the operable unit (OU) 7-13/14 In Situ Grouting (ISG) Project (also referred to as the "project"). The project is managed by the Idaho Completion Project (ICP) prime contractor (also referred to as the "company") for the U.S. Department of Energy (DOE) Idaho Operations Office, Office of Environmental Management (ID-EM). The intent of this report is to provide a technical basis for cost and schedule estimates; safety and environmental evaluations; and identification of possible requirements for a performance specification to procure a design, build, and operate subcontract for the project.

Ongoing assessments of the risk and remediation strategies will impact the final project scope. The scope presented in this report is a bounding case that represents a large-scale ISG remediation strategy. It is possible that ISG deployment in the Radioactive Waste Management Complex (RWMC) Subsurface Disposal Area (SDA) will be of a lesser scope than that presented in this document.

1.1 Project Overview

In situ grouting supports the ICP mission of reducing risks posed by contamination and waste left at the Idaho National Engineering and Environmental Laboratory (INEEL) from past missions, while protecting workers, the public, the environment, and future generations.

This project focuses on early action (i.e., action that can be initiated before the record of decision) and continuing action to reduce near-term risks by employing a high-pressure grouting process to stabilize fission and activation (FA) products at the RWMC SDA. Remedial actions using ISG to mitigate the near-term risk posed by areas containing FA products are recommended in both the *Second Revision to the Scope of Work for the Operable Unit 7-13/14 Waste Area Group 7 Comprehensive Remedial Investigation/Feasibility Study* (Holdren and Broomfield 2003) and the *Preliminary Evaluation of Remedial Alternatives for the Subsurface Disposal Area* (PERA) (Zitnik et al. 2002).

Field monitoring data and modeling of contaminant fate and transport suggest that mobile, long-lived FA products (e.g., carbon-14 [C-14] and technetium-99 [Tc-99]) pose the most immediate health risks from the SDA according to the *Ancillary Basis for Risk Analysis at the Subsurface Disposal Area* (Holdren et al. 2002). The risk can be reduced by acting early to stabilize these contaminants of concern (COCs) using ISG and other actions that reduce infiltration. Early action using ISG allows the ICP to:

- Obtain experience for potential use of ISG to remediate all or part of Rocky Flats Plant[a] transuranic (TRU) waste if ISG becomes part of the remedial action in the record of decision for OU 7-13/14
- Reduce near-term human health risks by curtailing migration of FA products—the most immediate risk from the SDA

[a] The Rocky Flats Plant is located 26 km (16 mi) northwest of Denver. In the mid-1990s, it was renamed Rocky Flats Environmental Technology Site. In the late 1990s, it was again renamed, to its present name, Rocky Flats Plant Closure Project.

- Foster the public's faith in the intention and ability of DOE to remediate the SDA.

Grouting will be accomplished using two techniques—contaminant grouting and foundation grouting. Contaminant grouting will be used to encapsulate waste in contiguous grout columns to form waste monoliths, which will stabilize the contaminants. Foundation grouting will be used to form structural columns spread at intervals to support an environmental cap to prevent water infiltration into the waste matrix. Contaminant and foundation grouting are done using the same equipment and the same grout, the only differences being where the grout is placed in the waste matrix and the grout admixtures.

1.2 History of Grouting at the INEEL

Jet grouting has been successfully used throughout the nation for at least 20 years, particularly in the oil industry and in dam projects and other civil engineering projects (e.g., footings for bridges and buildings). Since 1994, the INEEL has been investigating ISG processes to treat buried waste, and it has been concluded that high-pressure jet grouting is a viable method to remediate waste in the SDA. ISG test demonstrations at the INEEL have included:

- 1994 test that demonstrated ISG technology and evaluated the capability to contain contaminant spread using simulated Rocky Flats Plant TRU waste buried in shallow landfill pits (Loomis, Thompson, and Heiser 1995)

- 1994 test that demonstrated high-pressure jet grouting technology and remote retrieval (i.e., using a remote-operated backhoe) of simulated TRU waste (Loomis and Thompson 1995)

- 1995 test that demonstrated jet grouting with four proprietary grout materials and one commercially available grout (Loomis, Zdinak, and Bishop 1996)

- 1997 test in which a series of grout injections through a thrust block into disturbed soil with simulated waste produced a large monolith, which was removed intact as a unit with a front-end loader (Loomis et al. 1998a)

- 1997 test, which was the first radiologically hot use of ISG technology at the INEEL and resulted in successful permeation of grout into soil and waste at the SDA Acid Pit (Loomis et al. 1998b)

- 2001 test on simulated waste at the INEEL Cold Test Pit where cementacious grout was shown to form columns in INEEL soil and permeate simulated waste forms (Loomis et al. 2002).

The *Evaluation of In Situ Grouting for Operable Unit 7-13/14* report, issued in 2002 (Armstrong, Arrenholz, and Weidner 2002), summarized the application of ISG to radioactively contaminated waste and soil sites across the United States and reported technology performance data where available. The document presented an analysis of jet grout-emplaced close-coupled barriers, as demonstrated at DOE's Hanford Site and implemented at the Brookhaven Laboratory Glass Hole waste site.

2. FACILITY OVERVIEW

Contaminants in the SDA landfill include TRU waste resulting from weapons manufactured at the Rocky Flats Plant; FA products and other waste resulting from onsite and offsite reactor operations, nuclear weapons manufacturing, and other sources; and hazardous chemicals associated with waste sources. While plans for comprehensive remediation of the SDA are currently being developed, preliminary evaluations of assembled alternatives for SDA remediation have identified high-pressure jet grouting as a technology that can be effective for (1) in situ stabilization of FA products, (2) in situ stabilization of Rocky Flats Plant TRU waste, and (3) ground modification to provide structural support for a surface barrier cap (Zitnik et al. 2002).

2.1 Historical Overview

The RWMC was established in the early 1950s as a disposal site for solid low-level waste generated by operations at the INEEL and other DOE laboratories. Radioactive waste materials were buried in underground pits, trenches, and soil vaults at the SDA. Two types of solid radioactive waste are located in the SDA, TRU waste and low-level waste (LLW). TRU waste is radioactive waste that contains alpha-emitting radionuclides with an atomic number greater than 92 (elements heavier than uranium) and a half-life of greater than twenty years. During the period when TRU waste was buried in the SDA, it was determined to have an activity concentration greater than 10 nanocuries per gram (nCi/g). LLW is non-TRU waste that contains beta- and gamma-emitting radionuclides. LLW is still being disposed of the INEEL. TRU waste from the Rocky Flats Plant was disposed of underground in the SDA from 1954 to 1970. After 1970, incoming shipments of TRU waste were placed in interim storage containers on above-ground asphalt pads at the Temporary Storage Area (TSA). The Rocky Flats Plant primarily produced components for nuclear weapons.

In August 1987, pursuant to the *Resource Conservation and Recovery Act* (RCRA), Section 3008(h), DOE and the Environmental Protection Agency (EPA) entered into a Consent Order and Compliance Agreement (COCA). The COCA required DOE to conduct an initial assessment and screening of all solid waste and hazardous waste disposal units at the INEEL and set up a process for conducting any necessary corrective actions. On July 14, 1989, the EPA, under the authority granted to them by the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) (42 USC § 9601 et seq.), as amended by the *Superfund Amendments and Reauthorization Act of 1986* (SARA) (PL 99-499, 1986), proposed that INEEL be listed on the National Priorities List (NPL) (54 Federal Register [FR], FR 29820). The final rule that listed the INEEL on the NPL was published on November 21, 1989, in 54 FR 48184. On December 9, 1991, because of the INEEL's listing on the NPL, DOE, EPA, and the Idaho Department of Health and Welfare entered into the Federal Facility Agreement and Consent Order (FFA/CO) (DOE/ID 1991). Under the FFA/CO, the INEEL is divided into 10 Waste Area Groups (WAGs). These WAGs are further subdivided into operable units (OUs). The RWMC has been designated as WAG 7 and is subdivided into 14 OUs.

The strategy for evaluating buried waste at the INEEL under CERCLA includes the analyses of waste treatment technology options for the remediation of the RWMC. The waste under investigation is buried in the SDA within the RWMC. Figure 1 shows the layout of the SDA, including pits and trenches.

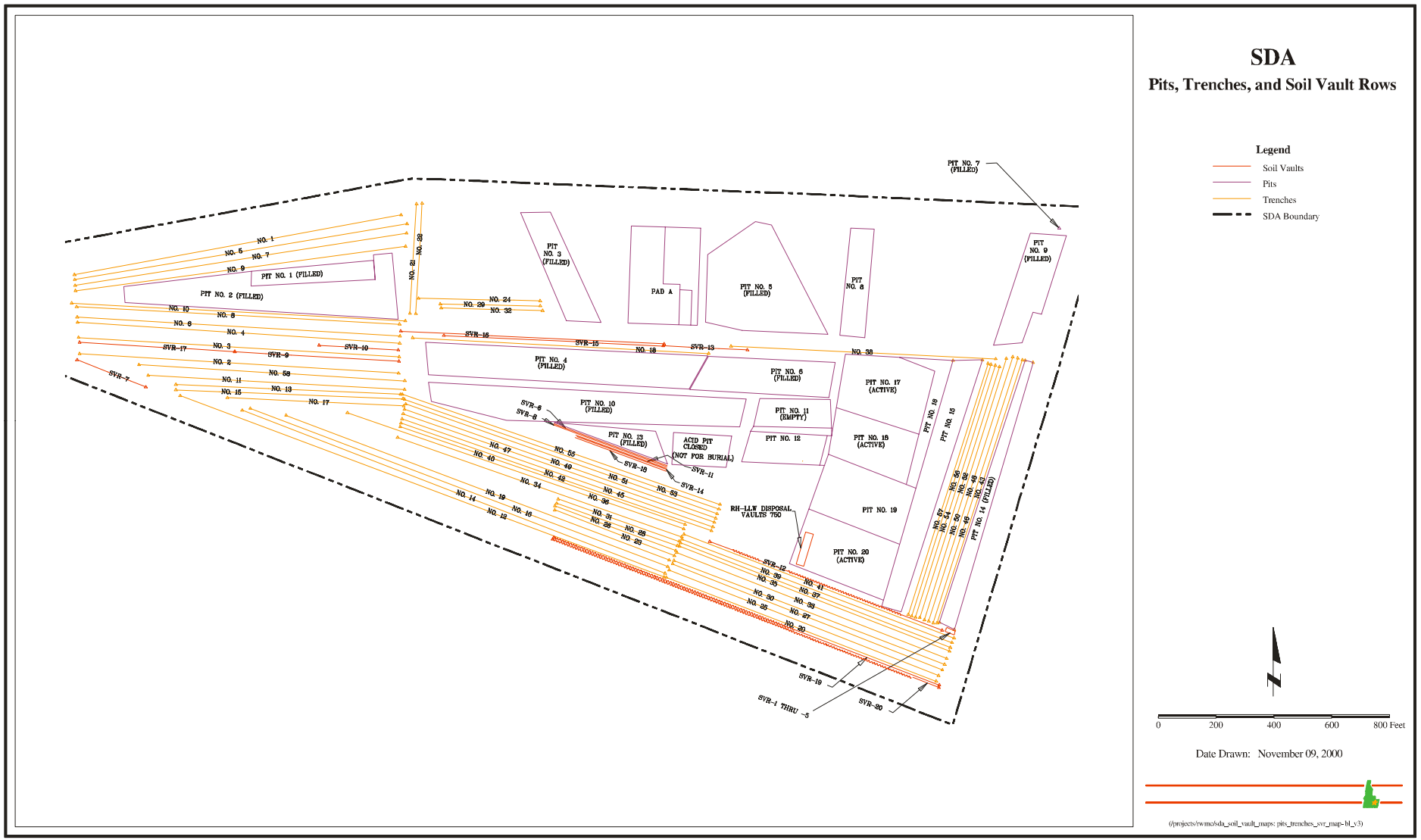

Figure 1. Subsurface Disposal Area.

The SDA encompasses 96.8 acres of land on the western portion of the RWMC. The area includes Pad A, trenches, pits, and vaults that have been used for disposal. Currently, only pits 17 through 20 and concrete-lined vaults are used to dispose of LLW. Dikes and drainage channels are strategically located to channel water away from the SDA to prevent flooding.

2.2 Pits, Trenches, and Vaults

There are 20 disposal pits and 58 trenches within the SDA, as shown in Figure 1, which contain either TRU waste or LLW. ISG is being considered for use in either or both TRU and LLW pits and trenches. Waste has been disposed of in drums; cardboard, wood, and metal boxes; and other containers. Most containers are believed to have been breached.

2.2.1 Transuranic Waste Pits and Trenches

The TRU waste pits and trenches are those that operated between 1952 and 1970 when both LLW and TRU waste were intermingled for burial at the SDA. Waste from onsite generators was primarily LLW. From 1960 until 1963, LLW was also accepted from private entities licensed by the Atomic Energy Commission (AEC), a DOE predecessor. TRU waste was received from Rocky Flats Plant and other generators beginning in 1954. Burial of TRU waste was discontinued in 1970. Much of this waste also contains hazardous material. Pits 1 through 6 and 9 through 12 and trenches 1 through 10 are known to contain TRU waste. Trenches 11 through 15 are suspected to contain TRU. The remaining pits and trenches contain only LLW.

Trenches were used for all ranges of radioactive waste, including both contact-handled (CH) waste and remote-handled (RH) waste. From 1952 through 1957, the waste was buried only in trenches. Trenches were excavated to basalt and averaged 6 feet (ft) wide, 900 ft long, and 13 ft deep. In the latter 1960s, the minimum trench depth increased and ranged from 16 ft to 18 ft, the bottoms of excavations were lined with at least 2 ft of soil underburden, waste was compacted by dropping a heavy steel plate on the waste in some trenches, and the minimum soil cover was increased from 2 ft to 3 ft. Adjacent trench centerlines were separated by no more than 16 ft.

Waste with high radiation levels was handled remotely using special shielded containers and mobile cranes. As waste disposal became more rigorously controlled, the trenches were used more frequently for high-radiation waste until they were replaced by soil vaults. Metal liners were placed over some trenches as they were filled. The metal liners prevented the trench from sloughing off and provided shielding. Concrete monuments identify trench locations, and a brass plate on each monument is stamped with the trench number and the opening and closing dates.

Beginning in 1957, the larger open pits were excavated for disposing of large bulky items. Initially, waste was stacked horizontally in the pits. From 1963 until 1969, drums from the Rocky Flats Plant were dumped into pits rather than stacked to reduce labor costs and personnel exposure. The pits are approximately 100 ft wide, 13 to 32 ft deep, and vary in length from 200 to 1200 ft. Concrete monuments mark the corners of the pits, and a brass plate on each monument includes the pit number, boundary directions, and opening and closing dates.

2.2.2 Low-Level Waste Pits and Trenches

LLW pits and trenches have been filled since 1970. The same types of LLW continued to be disposed after 1970, but disposal practices improved over time. The use of trenches for LLW disposal was

replaced with pits and concrete vaults. Compaction, restrictive packaging criteria, and enlarged pit volumes were employed to improve space utilization. Close-packed array stacking was employed in the pits. Pits were expanded by using heavy equipment and explosive fracturing to remove fractured basalt from the base of the pits. A soil underburden at least 2 ft thick was used to cover basalt before waste was emplaced, and a final layer of compacted soil at least 3 ft thick was used to cover the buried waste. In 1985, a geotextile liner was incorporated into the upper portion of the pit floor soil cover to add stability to the waste stack and support mobile equipment. In recent years, the waste has been carefully stacked. Current pits are excavated into rock to a depth of 30 ft, then backfilled with a least 3 ft of soil.

The burial of most mixed wastes was terminated in 1982. Thus, pits and trenches filled after that time do not contain hazardous materials, only radioactive waste.

2.2.3 Soil Vaults

Soil vaults were used between 1977 and 1995 to dispose of RH-LLW, which is solid, non-TRU waste having exposure rates higher than 500 milliroentgen per hour (mR/hr) at 1 meter. This waste was typically isolated in a steel container. To conserve space, a design change was made to switch from using soil vaults to concrete vaults (i.e., vaults that have a concrete liner). Only the soil vaults are being considered for ISG.

The soil vaults are positioned in rows adjacent to pits and trenches throughout the SDA. They are unlined holes 1.3 to 6.5 ft in diameter and bored to bedrock in rows. Depths vary from 17 to 25 ft. Individual vaults are at least 2 ft apart. The holes were backfilled with 2 ft of soil to create a base and then filled to a depth that allowed a minimum of 3 ft of soil over the top waste container. The amount of soil cover was calculated and compared to available soil vault depth before each discharge. Additional soil was added when necessary to reduce exposure rate above the covered vault to less than 1 mR/hour at the soil surface.

Concrete monuments identify the soil vault locations, and a brass plate on each monument is stamped with the vault number and opening and closing date. Periodic inspection and maintenance is conducted to ensure that soil vaults have at least 6 ft of cover.

2.3 Subsidence

Subsidence occurs frequently in the SDA, mostly in the spring. Subsidence is expected to continue unless measures to eliminate void spaces in the waste zone are implemented. Between 1996 and 2001, the number of occurrences ranged from five in 2001 to 17 in 1998. Some areas of subsidence have been long and narrow, while others were almost square. Depths ranged from 3 inches (in.) to 12 ft.

Subsidence areas are repaired by filling holes with soil obtained from the spreading areas. Soil is hauled to the area, dumped close to the subsidence, and pushed into the hole with a front-end loader. The soil is compacted by hand or by driving a front-end loader over the filled area. During spring thaw, vehicles are prohibited from driving over waste disposal areas in the SDA. Radiation levels were measured below 100 counts per minute (cpm) for each occurrence, except in April 2001, when 1,000 cpm was measured at Pit 4.

3. PROJECT REQUIREMENTS

Plans for comprehensive remediation of the SDA are currently being developed. Preliminary evaluation of assembled alternatives for remediation of the SDA (Zitnik et al. 2002) identified high-pressure jet grouting as a technology that can be effective for (1) in situ immobilization of COCs, and (2) foundation for a future surface barrier.

The PERA (Zitnik et al. 2002) and the *Second Revision to the Scope of Work for the Operable Unit 7-13/14 Waste Area Group 7 Comprehensive Remedial Investigation/Feasibility Study* (Holdren and Broomfield 2003) identify ISG as an alternative, focusing on COCs with the potential for migration to the vadose zone. The PERA states that ISG "has been shown to be highly effective in immobilizing a wide range of contaminants and will adequately address the majority of waste streams identified in the SDA." Because the migration of contaminants suggested by field monitoring data has been slower than predicted, the opportunity is available to use ISG to immobilize contaminants before they migrate beyond the point where ISG can be employed as a remedial alternative (Shropshire et al. 2004).

The initial grouting effort to target mobile FA product COCs will be conducted as a non-time-critical removal action by DOE with concurrence of the EPA and Idaho Department of Environmental Quality under the CERCLA (42 USC § 9601 et seq., 1980) *Contingency Plan* (40 CFR 300). Further ISG of other COCs or inhibiting subsidence to improve performance of a surface barrier may follow in later years under other non-time-critical removal actions or remedial actions. These would also be conducted by DOE with concurrence of the EPA and Idaho Department of Environmental Quality, or as specified in the record of decision for final remediation of the RWMC.

The ISG project provides a technically and operationally simple method for using ISG to immobilize contaminants buried in the SDA and provide support for a later environmental cap, while maintaining protection of workers, the public health, and the environment. Although the scope of this project does not include remediation of TRU contaminants, if the final record of decision for the SDA identifies ISG as a remedial action, then this project will have provided valuable experience that could support and accelerate use of ISG in areas containing TRU waste from the Rocky Flats Plant.

This project is operated under DOE's nuclear safety requirements established in 10 CFR 830 Subpart B, "Safety Basis Requirements," and DOE orders and contractor program requirements documents, as well as company implementing procedures. This will be documented in an addendum to the *Radioactive Waste Management Complex Safety Analysis Report* (SAR-4), which will address this project.

This project will also operate under the OU 7-13/14 Project Execution Plan when it is approved. In the interim, the *Conceptual Design Plan for the OU-7-13/14 In Situ Grouting Project — Phase 2* (ICP/EXT-03-00039) and the *Idaho Completion Project – Project Execution Plan* (INEEL/EXT-03-00387) will be used.

The INEEL is a federal facility, and DOE, as the responsible federal entity, is ultimately responsible for the INEEL. As such, DOE has the authority to identify and implement non-time critical removal actions (NTCRAs) when they are deemed necessary. Federal statutes, agreements, and enforceable deadlines drive evaluation of the SDA for potential remediation actions. The INEEL was added to the EPA National Priorities List (NPL) of Superfund sites (54 FR 48184, 1989) under CERCLA. In 1991, the FFA/CO for the INEEL (DOE/ID 1991) established the procedural framework for identifying

and implementing appropriate actions that must be implemented to protect human health and the environment at the INEEL in accordance with the following:

- National Contingency Plan (40 CFR 300)
- CERCLA
- RCRA (42 USC § 6901 et seq., 1976)
- Idaho Hazardous Waste Management Act (Idaho Code § 39-4401 et seq., 1983).

Continued performance of grouting project early actions as a NTCRA is consistent with DOE accelerated cleanup objectives as well as the objectives of the EPA Superfund Accelerated Cleanup Model. To implement NTCRA, the project will adhere to requirements of the *Contingency Plan* (40 CFR 300) and relevant EPA guidance documentation. This will be accomplished by preparing an engineering evaluation and cost analysis, conducting required public involvement activities, and documenting the approach in an action memorandum. The FFA/CO, therefore, clearly acknowledges DOE authority to conduct CERCLA Section 104 removal actions in the place of or in support of CERCLA Section 120 remedial actions that are subject to provisions of the FFA/CO.

The project team will also satisfy internal INEEL requirements and DOE orders. Companywide Manual 8, *Environmental Protection and Compliance*, documents the BBWI Environmental Protection Program. Responsibilities for implementing the program are defined in a number of environmental program requirements documents (PRDs) and management control procedures (MCPs). Environmental requirements and instructions associated with a CERCLA action are documented through implementation of MCP-3480, "Environmental Instructions for Facilities, Processes, Materials and Equipment." An environmental checklist, prepared in accordance with MCP-3480, will define additional environmental requirements for the project. Additional DOE orders defining related environmental requirements include DOE O 450.1, "Environmental Protection Program," and DOE O 5400.5, "Radiation Protection of the Public and the Environment."

Based on DOE policy, the CERCLA (42 USC § 9601 et seq. 1980) process will be relied on to address National Environmental Policy Act (NEPA) (42 USC § 4321 et seq. 1970) values and public involvement procedures. Consequently, no separate NEPA implementation is required for CERCLA projects at the INEEL.

In addition to the aforementioned Environmental Protection Program regulations, DOE directives, and company implementing documents, the project will comply with all applicable companywide and RWMC-specific procedures in the execution of their work. Subcontractor personnel will comply with all contractually binding sections of the company *Subcontractor Requirements Manual* (Table of Contents [TOC]-59).

The following three ISG project documents define the proposed requirements for the OU 7-13/14 In Situ Grouting Project:

- TFR-267, "Requirements for the OU 7-13/14 In Situ Grouting Project (Customer, Project, and System)," (see Attachment 1) defines those requirements that form the basis for the design criteria delineated in the project engineering design files (EDFs)

- TFR-269, “Requirements (Subsystem) for the OU 7-13/14 In Situ Grouting Project,” (see Attachment 2) defines those requirements that were derived from the design criteria contained in the project EDFs

- TFR-280, “Requirements (Assumptions) for the OU 7-13/14 In Situ Grouting Project,” (see Attachment 3) defines the assumptions that were derived from the project EDFs, as well as other documentation, experience, and lessons learned.

4. ALTERNATIVES ANALYSIS SUMMARY

Early in the planning of the effort, it was recognized that there were a number of different ways to inject grout in the SDA. As a result, a series of activities were planned and conducted to identify and select the optimum alternative (see Appendix A for a detailed record of these activities). The selected alternative then became the basis for the process description in Section 5 and for the attached EDFs.

Seven ISG alternatives were evaluated during the preconceptual design phase of the project in February through March 2004. These alternatives included:

1. Crane-mounted drill rig
2. Track-mounted drill
3. Metal superstructure
4. X-Y plotter on tracks
5. Crawler and excavator
6. Bridge crane
7. Highway concrete paver.

Through a facilitated and logical process, the final selection for the alternative of choice—alternative 5, crawler excavator or trackhoe drill—was made.

The process of selecting the trackhoe drill option began with developing and identifying an initial list of plausible alternatives. A number of assumptions were also developed at that time. Following that activity, a list of criteria was developed for evaluation of the identified alternatives. The seven alternatives were then evaluated and graded using GroupSystems Software. Based on the rating of the seven alternatives against seven criteria, the highest scoring alternative was determined to be alternative 5, crawler and excavator (now called the trackhoe drill). Finally, the results of the aforementioned activities were reviewed and the alternative selection confirmed. A work breakdown structure (WBS) was then developed for the selected alternative.

5. PROJECT DESCRIPTION

5.1 Acquisition Strategy

This engineering studies report was developed to provide a technical scope baseline for an upcoming subcontract procurement process scheduled to start in early FY-05. This baseline is intended to guide the preparation of technical specifications and subsequent bid documents to subcontract the design, fabrication, and operation of a complete grout supply, delivery, and injection system. A stock trackhoe can be married to a rotary-percussion drill mast to inject grout into the underground waste matrix (see Section 4, "Alternatives Analysis Summary).

The majority of supporting systems and personnel required to sustain this operation will also be furnished and operated by the subcontractor.

The project is scheduled to begin grouting in the summer of 2005. Initially, one trackhoe-based system (see Figure 2) is proposed. Then it is proposed that three trackhoe systems be employed to continue operations each year from April through November, with grouting operations completing in 2010. (Figure 3 provides a high-level flow of the project.)

Figure 2. Trackhoe-based grouting system.

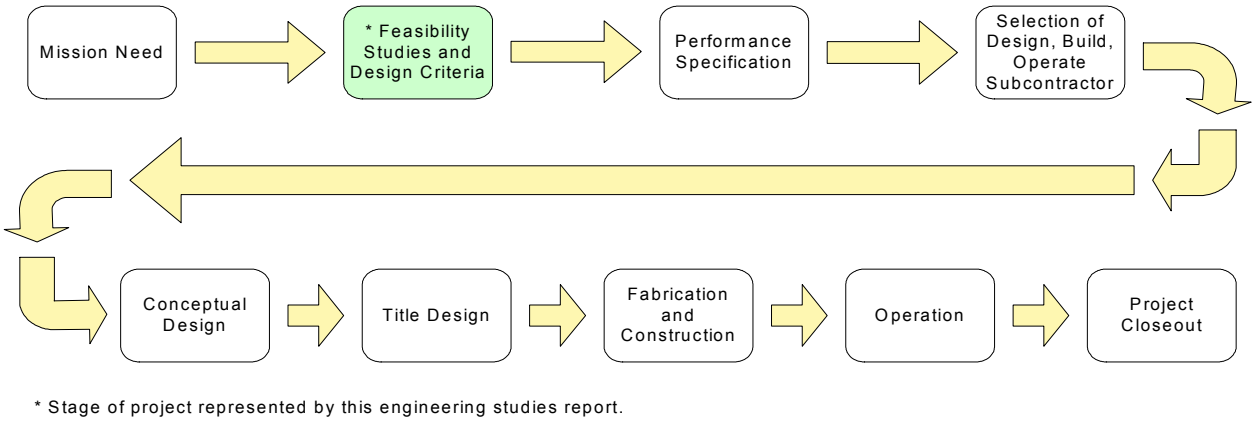

Figure 3. Stages of the OU 7-13/14 In Situ Grouting Project.

The technical baseline and acquisition strategy described in this report is based on:

- Use of commercially available equipment, including a stock trackhoe married to a standard rotary-percussion drill mast
- Dexterity of a large trackhoe to rapidly maneuver around in the SDA injecting grout at high pressure to produce grout columns in the buried waste matrix
- Flexibility of the equipment to be used for both contaminant grouting and foundation grouting.

To fix contaminants within the waste zone, the design team developed an approach that uses a low-cost, cement-based grout and standard, off-the-shelf equipment. The design is based upon driving a drill stem to the bottom of the waste matrix (basalt), then injecting grout at high pressure as the drill stem is extracted at a predetermined rate. EDF-5146, "OU 7-13/14 In Situ Grouting Project Grout Selection Basis," (see Attachment 4) provides detailed grout design information.

The objective of contaminant grouting is to encapsulate buried waste in contiguous grout columns to form waste monoliths that will stabilize the contaminants. The objective of foundation grouting is to stabilize the overall waste matrix to improve the long-term structural performance of the environmental cap. EDF-5028, "OU 7-13/14 In Situ Grouting Project Foundation Grouting Study," (see Attachment 5) provides a detailed foundation grouting study.

As a form of in situ remediation, jet grouting creates a simultaneous horizontal and vertical barrier by forming a solid monolith of the buried waste and encapsulating the waste. The resultant monolith would provide a structurally stable waste form that will meet subsidence requirements. The monolith also lowers water permeability through the material, thus reducing contaminant transport.

Jet grouting involves driving a drill stem through the waste and injecting grout at 8,000 psig through the rotating drill stem while withdrawing the drill stem in precise increments. Repeated applications on a nominal 20-in. triangular pitch create a series of interconnected columns that eventually turn the soil and waste matrix into a solid monolith. Grout returns are expected to flow to the surface during normal drilling operations—a condition seen in normal grouting operations and testing performed under low pressure at the INEEL and elsewhere. The volume is proportional to the density of the waste matrix or the soils in which the grout is being injected. Returns will be allowed to ooze around the drill-to-soil interface and flow out horizontally. Radiation contamination carried up, if any, to the top surface of the returns will be monitored and, if detected, contained using a spray-on fixative. The process for storing, mixing, delivering, and injecting grout is depicted in Figure 4.

5.2 Areas to be Grouted

Contaminant grouting will be performed in selected SDA pits, soil vault rows, and trenches, specifically in the following areas:

- Pits 7, 8, 13, 14, 15, and 16
- Soil vault rows 1 through 21, except beryllium block soil vault locations grouted during FY-04
- Trenches 11 through 58, except beryllium block trench locations grouted during FY-04.

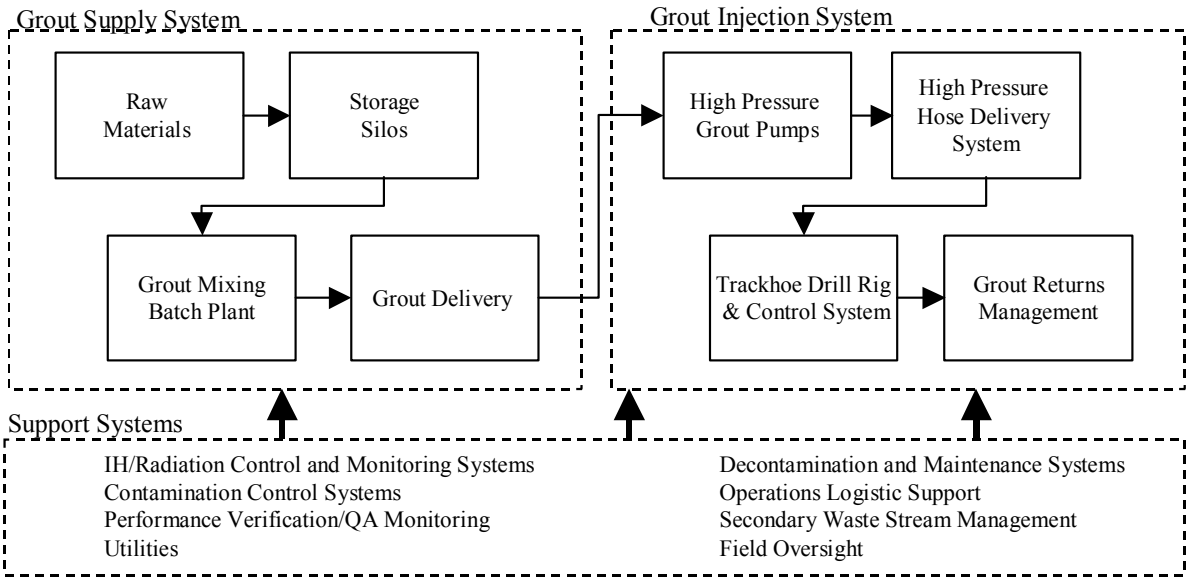

Figure 4. Grout storage, mixing, delivery, and injection process.

Foundation grouting will be performed in the following trenches and pits:

- Trenches 1 through 10, except trenches that are contaminant grouted, retrieved areas within trenches, and trench areas where it is determined that additional foundation enhancement for the future cap is not required

- Pits 1, 2, 3, 4, 5, 6, 9, 10, 11, and 12, except pits that are contaminant grouted, retrieved areas within pits, and pit areas where it is determined that additional foundation enhancement for the future cap is not required.

Future foundation grouting scope will include Pits 17, 18, 19, and 20 (active low-level pits) after closure, except pits that are contaminant grouted and retrieved areas within pits. Table 1 summarizes the locations for contamination and foundation grouting.

Table 1. Contaminant and foundation grouting locations.

	Contaminant Grouting	Foundation Grouting
Pits	7-8, 13-16	1-6, 9-12, (17-20 after closure)
Trenches	11-28	1-10
Soil Vault Rows	1-21	-------

EDF-5147, "OU 7-13/14 In Situ Grouting Project Subsurface Disposal Area Site Conditions," (see Attachment 6) describes the access parameters to the SDA.

5.3 Grout Injection

Studies to date have indicated that the ISG process could include the use of a large, 90,000-lb class, hydraulic commercial trackhoe combined with a mast-mounted rotary percussion drill rig configured for drilling or driving a high-pressure grout injection drill string. The drill rig replaces the normal bucket on the end of the trackhoe stick. The drill rig includes a mast-mounted rotary percussion drill rig capable of impact and rotary drilling and grout injection as shown in Figure 5. EDF-5153, "OU 7-13/14 In Situ Grouting Project Hydraulic Excavator and Drill-Injection Rig," (see Attachment 7) provides detailed trackhoe and injection information.

The anticipated normal operating scenario would be for the equipment operator located inside of the trackhoe cab to:

1. Position the drill string point at a preselected location using the trackhoe tracks for gross movement

2. Use the trackhoe chassis pivot for horizontal angular setup

3. Use the boom, stick, and bucket motion controls to achieve vertical positioning and plumbness and for precision hole location setup.

The operator could be assisted in the location of the drill point by the use of a global positioning system (GPS) coupled with an electronic feedback system. The control panel and displays would be located inside of the operator cab.

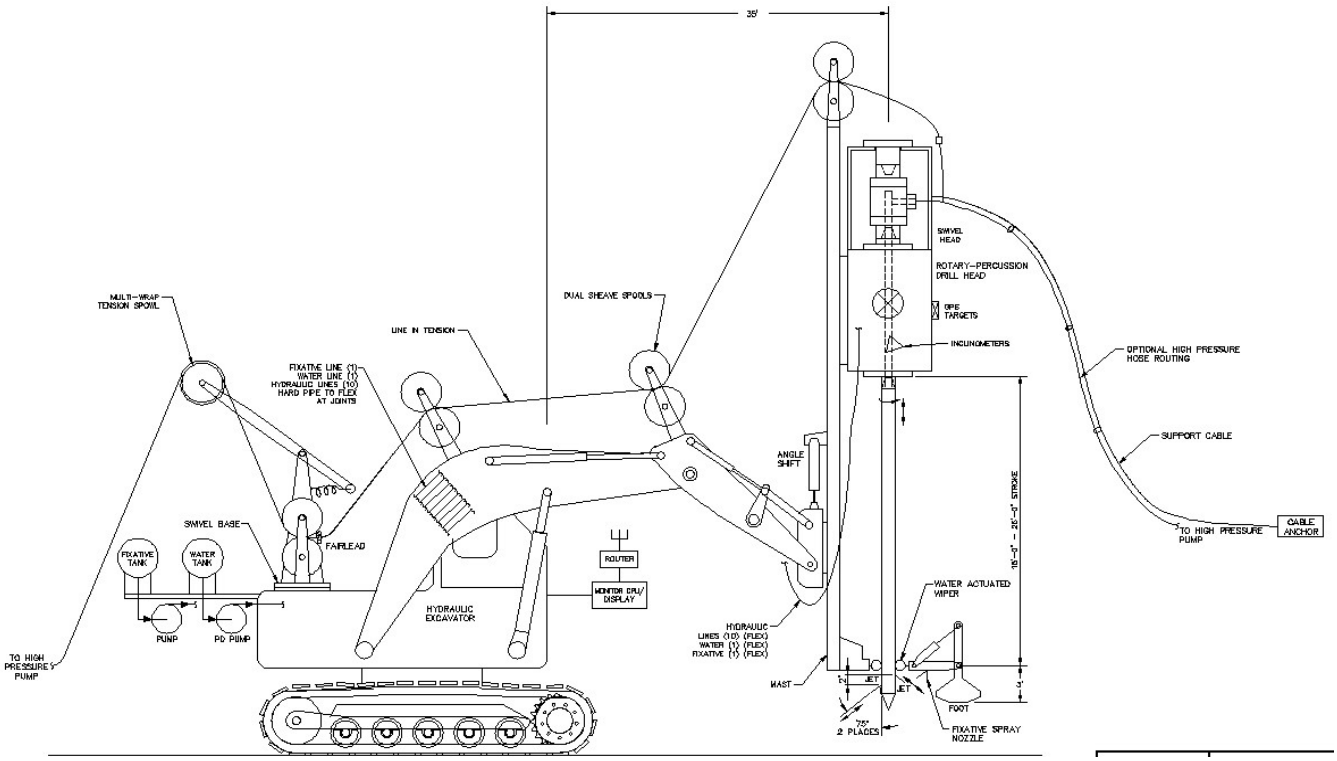

Figure 5. Standard 90,000-lb class trackhoe combined with a mast-mounted rotary percussion drill rig.

The drill string design uses one drill pipe of sufficient length to enable single-pass drilling and single-fluid grout injection. High-pressure grout fluid is delivered to the drill pipe at approximately 8000 pounds per square inch gauge (psig) by way of a swivel located on the drill head. The swivel provides the interface from the high-pressure hose connection to the rotating drill string via the rotary head.

The drill head supplies the drill pipe and bit rotary and percussion motions, which are hydraulically actuated. The drill head and mast assembly would have sufficient mass to supply the necessary vertical force to advance the drill. No additional down force is required from the trackhoe boom and stick. The drill pipe would be connected to the drill head by way of a quick-connect for easy remote removal. The drill string torque jaws required for breaking the joint and removal of the drill string from the head are located at the bottom of the mast assembly. Reverse rotary motion for unthreading the drill pipe is supplied by the rotary head.

The drill point would then be driven down to the basalt layer or the point of drill stem refusal and slowly raised in small incremental steps while simultaneously injecting grout. The drill stem would be raised to the elevation that coincides with the interface of the waste and overburden interface, and then high-pressure grouting will be discontinued for that hole (see Figure 6). Testing has shown that the grout will continue to weep (pumped at low-pressure) while the drill is extracted and moved to a new location.

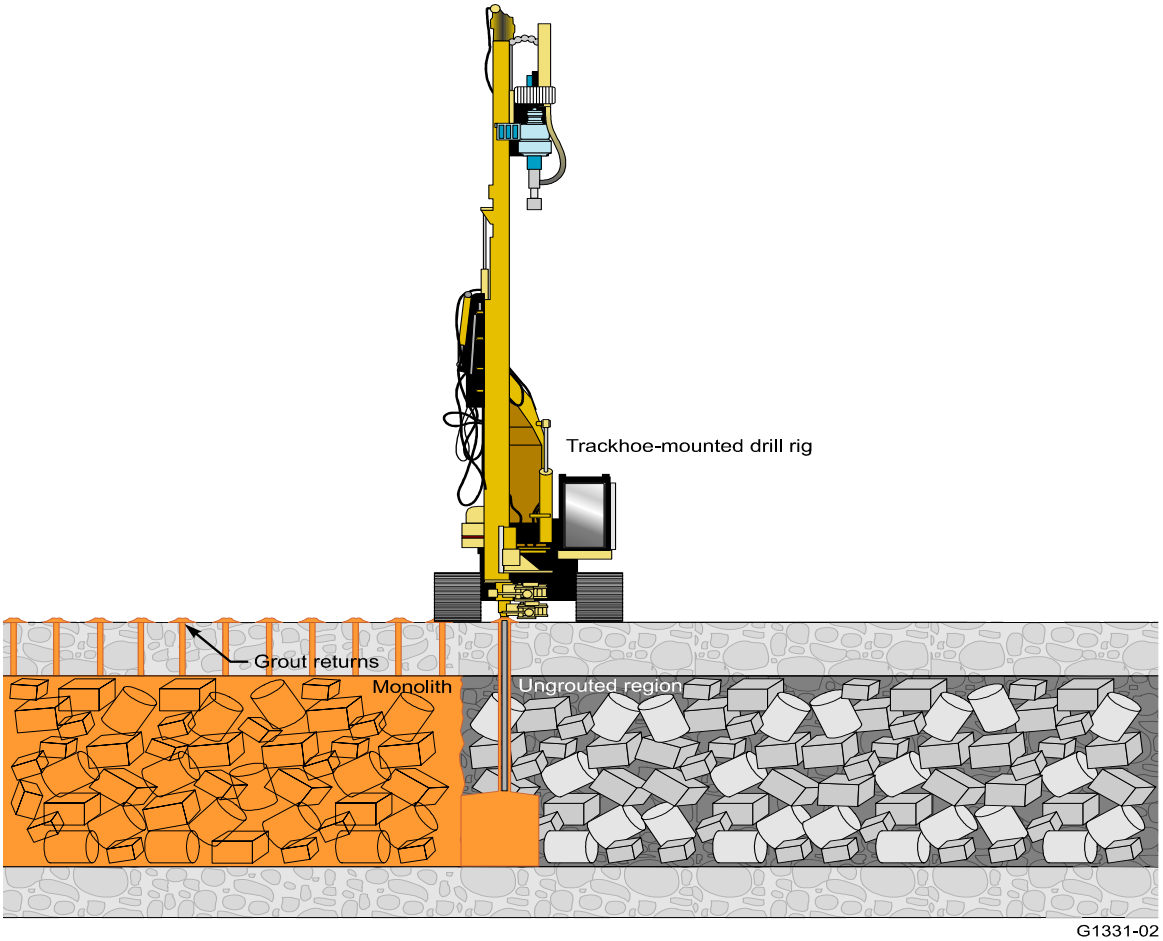

Figure 6. Jet grouting drill stem in soil and waste matrix showing grout returns.

EDF-5155, "OU 7-13/14 In Situ Grouting Project Operations, Maintenance, and Logistics," (see Attachment 8) provides detailed information on ISG operations, maintenance, and logistics.

5.4 Batch Plant

The ISG grouting process design is anticipated to receive dry grout ingredients that are trucked to the site and offloaded into portable batch plant silos set up on the south-central side of the SDA. The dry ingredients required include sand, cement, blast furnace slag, and silica fume for containment grout and sand and cement for foundation grout. Truck offloading and transfer would be done pneumatically. The grout storage system consists of the truck unloading equipment, mechanical and pneumatic conveyors, storage silos, silo bin vents and dust collectors, water tanks, and screw augers from the silos to a chute above the batch mixer. Water and electrical power will be obtained on site. The concept is illustrated in Figure 7 and Figure 8.

Grout mixing would be done in a batch mixer. The batch plant would be equipped with automatic controls for metering ingredients. The mixing portion of the system includes the grout batch plant, grout feed line, and agitator tank located adjacent to the SDA for loading grout into standard concrete ready-mix trucks. A slurry tank with an agitator may be required to feed a low-pressure pump, which in turn delivers the grout "over the fence" to a mixer truck inside the SDA. (The intent is to leave the mixer trucks inside the SDA unless they need to be removed for routine maintenance or breakdown repairs.) The size and number of silos for dry material storage were chosen to facilitate grout mix changes. EDF-5135, "OU 7-13/14 In Situ Grouting Project Grout Storage and Mixing," (see Attachment 9) provides more detail about grout storage and mixing.

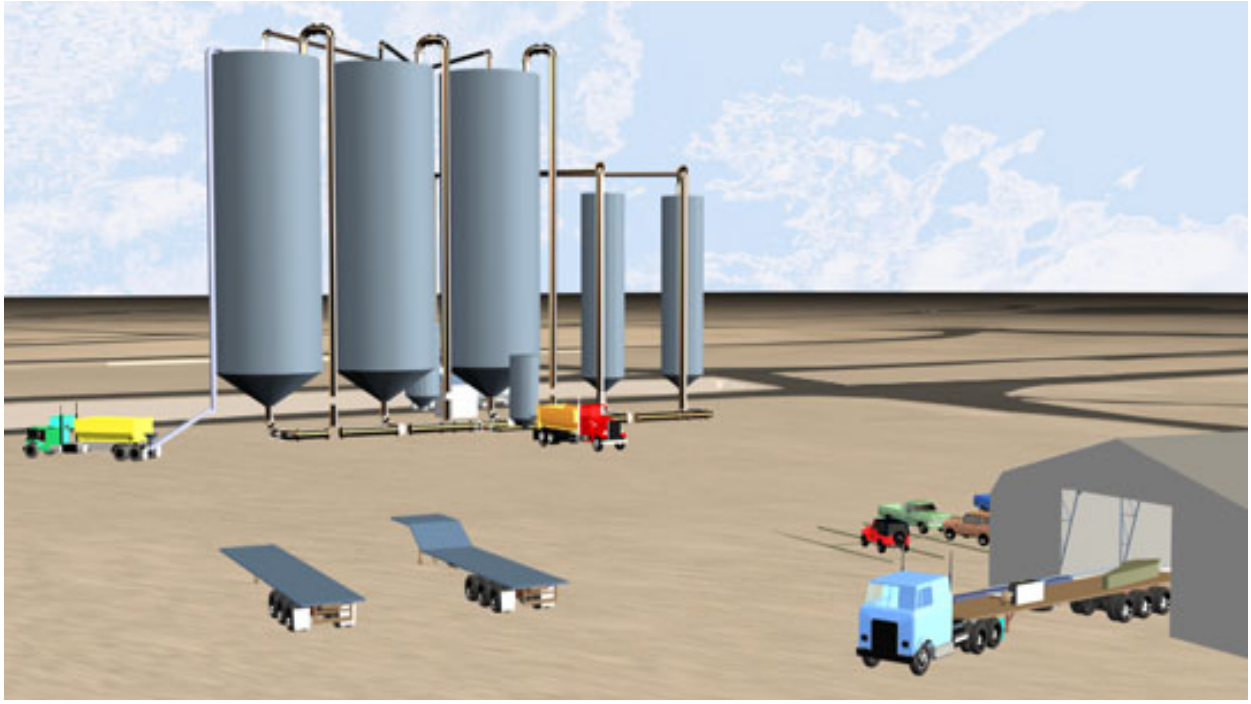

Figure 7. Possible in situ grouting batch plant layout.

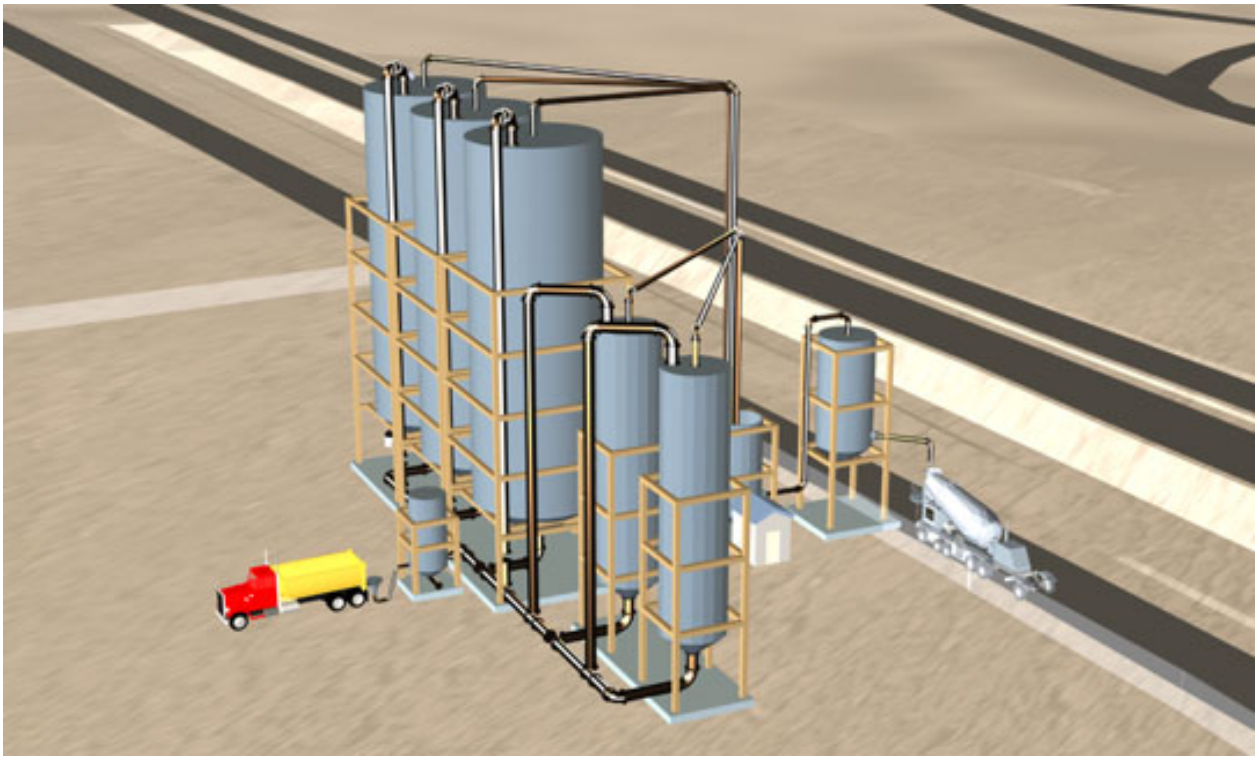

Figure 8. Dry grout ingredients being offloaded into portable batch plant silos.

5.5 Grout Delivery

The main components of the grout delivery subsystem, which is detailed in EDF-5102, "OU 7-13/14 In Situ Grouting Project Grout Delivery System," (see Attachment 10) are the:

- Grout receiving hopper
- Shaker screen
- Low-pressure pump
- Low-pressure piping to the high-pressure pump
- High-pressure grout pump
- High-pressure piping
- Hoses to the drill string swivel
- Drill stem and drill bits.

The hopper and low-pressure pump could be mounted on a lowboy trailer located inside the SDA, with the high-pressure grout pump located on another lowboy trailer. The high-pressure pump delivers grout at high pressure to the drill string by way of a high-pressure hose. The hose would need to be approximately 200 ft long, with a 2-in. inside diameter, and have a rated working capacity of 10,000 psi. Additional components include water cleanout equipment and drill bit changeout equipment. The delivery side of the grouting system would be self-contained with engine-driven generators.

It has been assumed that the subcontractor will require some facilities to accommodate planned and unplanned maintenance work, spare parts storage, decontamination facilities, and facilities to accommodate the operations personnel (see Section 6).

5.6 Operational Crew

It is anticipated that the project will operate the first year, FY-05, with one crew using one trackhoe-mounted drill. It is further anticipated that the second and succeeding years, FY-06 through FY-10, ISG will operate two crews on a sliding four 12-hour shift rotation with three trackhoe-mounted drills. Table 2 summarizes proposed operational crew staffing levels for the life of the project.

Table 2. In situ grouting project proposed operational crew staffing levels.

Proposed ISG Crew	FY-05 Operating Plan	FY-06 through -10 Operating Plan
Operator – heavy equipment operator (HEO)	2	4
Job supervisor	1	1
Site safety officer (SSO)	1	1
Roving field team leader (FTL) (job supervisor relief)	0.25	0.5
High- and low-pressure pump operators	3	6
Spotter	1	2
Radiological Control technician (RCT)	2	4
Facility RCT (relief)	0.25	0.5
Laborers	1	2
Total crew	11.5	21
Times crews per drill rig	11.5	63

6. SUPPORT SYSTEMS

Potential support facility needs for subcontracted grouting operations were identified during the engineering studies process. This engineering studies report anticipates the facilities that a subcontractor may need to assemble at the SDA to do the work. This engineering studies report forms a basis for cost estimating and planning this future work.

6.1 Facility Structures and Trailers

The RWMC has a very limited capacity to house additional new operations in existing buildings, and subcontractor use of them is not anticipated. It is envisioned that the subcontractor will utilize mobile units for the majority of facilities. A staging and work area has been identified for the subcontractor just outside the south gate in the center of the SDA as shown in Figure 9. This area would be used to set up the portable batch plant and a temporary maintenance structure. The facilities identified that the subcontractor may need include:

- Shift office and field maintenance trailer
- Relocatable maintenance building (50 x 100 ft)
- Restroom trailer (8½ x 14 ft)
- Decontamination pad.

The subcontractor could use the RWMC lunchroom facilities at WMF-637 or the Central Facilities Area (CFA) cafeteria. Radiological control support could be provided in the form of a government-furnished 5-ton truckvan. EDF-5144, "OU 7-13/14 In Situ Grouting Project Support Facilities," (see Attachment 11) provides detailed support facilities information.

6.1.1 Shift Office and Maintenance Trailer

This type of trailer could be approximately 53 ft 0 in. x 8 ft 6 in. x 13 ft 6 in., with multiple expansion options. A mobile shift crew office and maintenance facility of this type would provide a conference room for approximately six people in the nose of the trailer, an office area with two workstations for data collection in the middle, and a field maintenance area at the rear of the trailer (see Figure 10).

6.1.2 Relocatable Maintenance Building

A 50- x 100-ft maintenance and storage facility could support maintenance activities of large trackhoe(s) with attached grout drill mast(s), plus high-pressure and low-pressure grouting unit(s). It is anticipated that the grouting operations will require immediate response when it comes to maintenance and repairs. To best accommodate these needs and to enhance the performance of grouting, several spare refurbished drill mast assemblies could be placed on flatbed semi-trailers as surge storage and staged inside the SDA to replace those in operation. These drill mast assemblies would be rotated from the SDA on the flatbed semi-trailers into the maintenance and storage facility, as shown in Figure 11, to be refurbished and then restaged again on a flatbed semi-trailer inside the SDA adjacent to grouting. This facility would contain shop tools and equipment for maintenance.

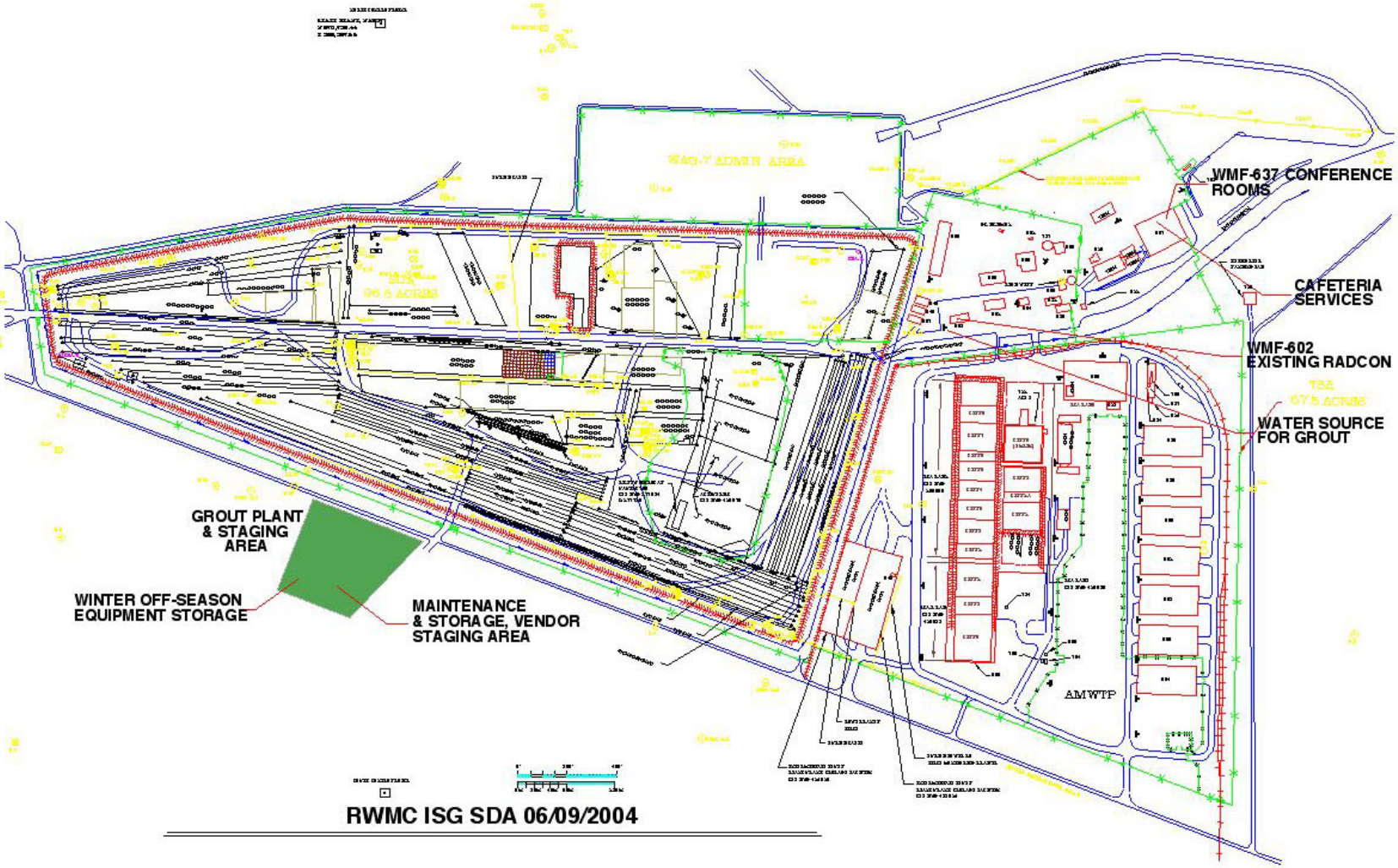

Figure 9. Radioactive Waste Management Complex plot plan showing in situ grouting staging and work area.

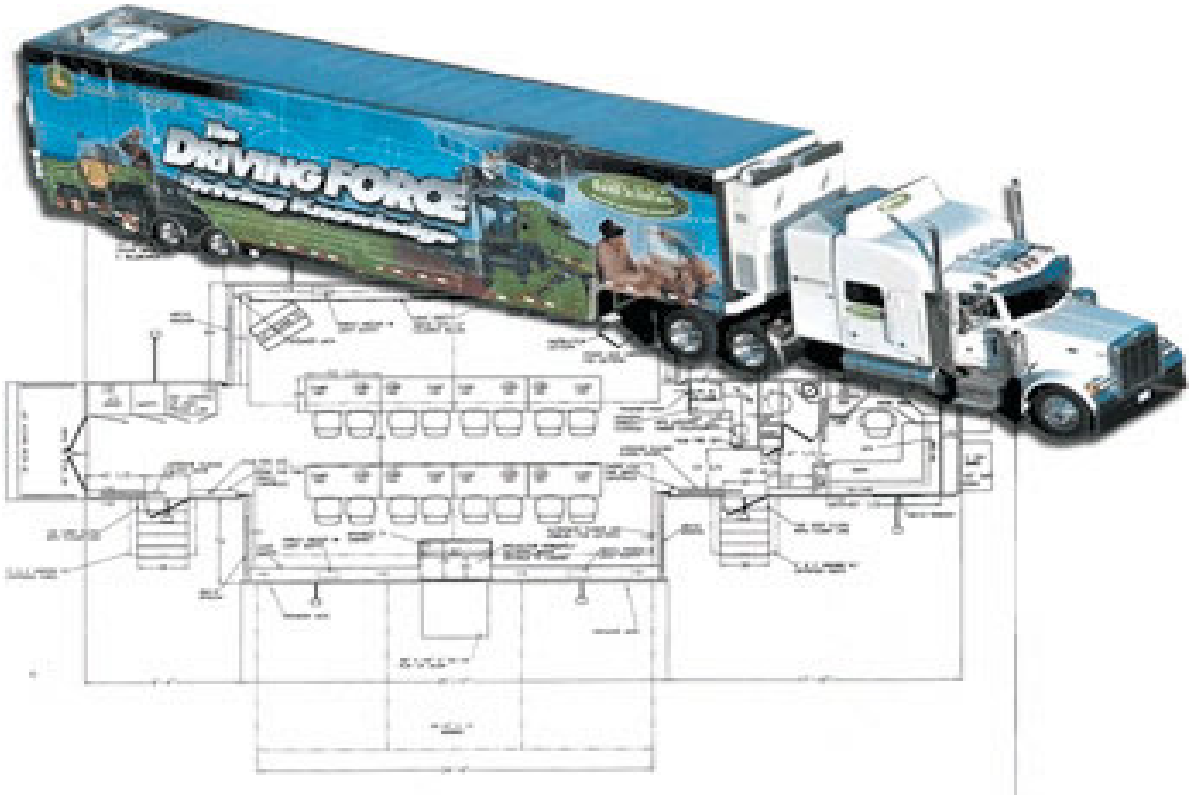

Figure 10. In situ grouting subcontractor shift office and maintenance trailer.

Figure 11. In situ grouting relocatable maintenance building.

6.1.3 Restroom Trailer

An 8-½ x 14-ft mobile restroom trailer complete with handwashing facilities could be provided, such as the one shown in Figure 12.

Figure 12. Mobile restroom trailer.

6.1.4 Decontamination Pad

Equipment exiting the SDA will be required to be surveyed for radioactive contamination. A decontamination area or pad will need to be erected just inside the south gate entrance to the SDA. The pad will be constructed of an impermeable geotextile or similar material to allow the heavy equipment to be driven onto it and washed down to decontaminate. The water will be collected and allowed to evaporate.

6.1.5 Supporting Utilities and Equipment

Utilities required to conduct ISG operation include power, measurement and controls, water, operations tanks and vessels, fire protection, and supporting vehicles. These utilities and equipment are detailed in the following EDFs:

- EDF-4933, "OU 7-13/14 In Situ Grouting Project Measurement and Control" (see Attachment 12)
- EDF-5122, "OU 7-13/14 In Situ Grouting Project Electrical Utilities" (see Attachment 13)
- EDF-5150, "OU 7-13/14 In Situ Grouting Project Support Systems" (see Attachment 14)
- EDF-5054, "OU 7-13/14 In Situ Grouting Project Fire Protection." (see Attachment 15)
- EDF-5162, "OU 7-13/14 In Situ Grouting Project Support Vehicles" (see Attachment 16).

7. RADIATION CONTAMINATION CONTROL AND INDUSTRIAL HEALTH

This section provides a summary of radiation contamination control and industrial health measures considered important to the safe and efficient completion of this project. EDF-5152, "OU 7-13/14 In Situ Grouting Project Environmental, Safety and Health," provides more detailed environmental, safety and health information (see Attachment 17).

7.1 General Radiological and Chemical Contamination Controls

During normal operations of the ISG a radiological control (RadCon) trailer will be located adjacent to the task site area. Site boundaries or "zones" will be established to ensure that access into the project area is controlled, and that project and non-project personnel are aware of controlled and potential hazard areas. Access into and egress from the project site entry zone (EZ) will be through the RadCon trailer at the specified entry and egress control points. Portable radiological survey instruments for performing hand and foot surveys at the boundaries will be located at normal entry and egress points, and whole-body surveys on an Eberline PCM-2 or equivalent monitor will be required prior to leaving the SDA. Radiological survey instrumentation will include portable beta, gamma, and neutron radiation detection instruments and alpha, beta, and gamma contamination instruments that will be maintained under control of the RWMC radiation protection organization.

Air sampling for radioactive and hazardous constituents will be obtained at the point of penetration of the drill into the soil and, when possible, utilizing real-time air sampling techniques. When real-time sampling is not possible, samples will be collected and sent offsite for analysis. Sampling will either be performed in close proximity to the drill mast, or performed on or near the exposed employees. During all drilling operations, beta, gamma, and neutron radiation levels will be monitored near the area of penetration of the drill point into the soil surface during all drilling operations.

If chemical contamination levels are detected at or above the threshold limit value—time-weighted average/permissible exposure limits (TLV-TWA/PEL) or applicable action levels for specific chemical contaminants, responses will be implemented in accordance with established procedures.

Beta, gamma and/or neutron radiation fields and/or radioactive contamination detected above the limits specified on the radiation work permit (RWP) will require the work activity to be stopped in a safe manner and all personnel will exit the work area until RadCon personnel allow reentry.

7.2 Contamination Control and Prevention

Radiological decontamination of equipment, materials, and sample containers will be a regular part of the drilling operations. Sample containers used for the collection of grout return samples will have the highest chance for encountering radiological contamination.

Every effort will be made to prevent radiological contamination of personnel and equipment through:

- Use of engineering controls
- Isolation of source materials

- Continuous RCT monitoring of radiation, contamination, and airborne radioactivity
- Use of PPE
- Personnel training
- Compliance with and implementation of all applicable requirements and procedures for handling radiologically contaminated material.

Radiological contamination control procedures will be implemented during drilling activities to minimize personnel contact with contaminated surfaces.

Radiological decontamination procedures for personnel and equipment will be necessary to control contamination from radiological and hazardous constituents and protect personnel if it is encountered. All radiological decontamination operations for equipment and areas shall be performed in accordance with the following companywide manuals:

- Manual 15A, *Radiation Protection–INEEL Radiological Control Manual* (PRD-183)
- Manual 15B, *Radiation Protection Procedures*
- Manual 15C, *Radiological Control Procedures*
- Manual 15D, *Radiological Instrument Calibration Procedures*

Both hazardous constituents and radiological contamination will be decontaminated from surfaces. Because of the nature of the radiological and chemical contamination source material at ISG project sites (TRU mixed waste) and limitations of direct-reading organic-vapor instrumentation, radiological contamination will serve as the best proxy for detecting both radiological and nonradiological surface contamination. Industrial hygiene instrumentation and sampling also will be used to detect surface contamination of equipment.

Engineering controls, in conjunction with project radiation, radiological contamination prevention and control practices, and proper use of PPE that includes appropriate donning and doffing procedures will serve as the primary means to eliminate the need for personnel radiological decontamination.

7.3 Welding

It may be necessary to perform welding activities on the SDA to perform maintenance and repair activities on ISG equipment. Welding activities will be performed in accordance with the *INEEL Welding Manual* and PRD-5110, “Cutting, Welding and Other Hot Work.” Additional radiation control measures may be imposed to minimize the spread of contamination and protect the workers. Welding activities will require review and approval by a qualified BBWI employee as identified by PRD-5110.

8. REFERENCES

40 CFR 300, 2003, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*, Office of the Federal Register, November 2003.

42 USC § 4321 et seq., 1970, "National Environmental Policy Act of 1969," *United States Code,* January 1, 1970.

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Appendix A

Alternative Analysis Section Meeting Minutes and Reports

Appendix A

Alternative Analysis Section Meeting Minutes and Reports

This appendix contains the meeting minutes and reports that resulted from a series of ISG alternatives meetings that were convened to determine–through quantitative, analytical methods–the optimum approach for conducting ISG of buried waste at the RWMC SDA. The following meeting minutes and reports are presented in their original unedited, unabridged form.

ISG Phase II

Alternative Development

On February 10, 2004 a meeting was held to discuss and determine a number of alternatives for In-Situ Grouting (ISG) of the Subsurface Disposal Area (SDA) pits and trenches at the Radioactive Waste Management Complex (RWMC). This action is Phase II of the ISG Project for the INEEL. Previous associated work done included preliminary conceptual design, which was part of a Preliminary Documented Safety Analysis (PDSA). The requirements document was developed from the CD Plan, the In-Situ grouting process, specifications, and special conditions that were developed for Phase I In-Situ Grouting. The schedule dictates that significant progress be shown by 2012. The functions of the grouting system include foundation grouting (stability for a future cap), and contaminant grouting (grouting remedy for the contaminants of concern).

The grouting concept is a number of non-time critical actions that target the contaminants of concern;

- Surgical, rather than monolith grouting.
- Includes TRU and non-TRU grouting. The work to date has been done only on TRU although demonstrations and bench tests have been done for non-TRU.
- Any use of In-Situ grouting in the SDA.

Phase I of the ISG is the grouting of the Beryllium Blocks in the SDA, Phase II is grouting the TRU and non-TRU pits and trenches in the SDA, and Phase III is handling the Rocky Flats TRU waste.

Jim Johnesee will incorporate appropriate comments from the meeting in the requirements document and additional comments following the meeting should be sent Jim for review and incorporation.

The preconceptual work that was done included a Mobile Containment Structure. No thrust block was used and grout returns were managed and contained by forms with a grout layer over the returns and soil over the grout layer. The drill rig was mounted to a bridge crane. Ancillary systems are required for grout delivery, transporting the mobile structure, off gas system, electrical and water supplies. Electric systems were selected over hydraulic systems because of concerns with fire hazards, fuel spills, and motor sizes. The projected drilling rate of 7 years was based on 3 structures and 7 x 24 operations.

Grout Process

- 6,000 psi
- Drill string – roto-percussion
- Weight of the drilling rig, with a 3-inch diameter drill rod, is about 3 ton.
- Drill to refusal
- Grout on the upstroke
- Grouting can be on the down stroke – from the top down and leave the stinger in the ground – assumed contamination control

- Two foot columns – move 2 feet and construct a new column – columns will provide the foundation support
- Grout will be discontinued within 3 feet of the surface, the overburden area
- A total of 30 acres will be grouted – 11-14 acres non-TRU and 17 acres TRU
- Grouting will be complete by 2016.

Grout Delivery Methods

- INEEL on-site batch plant – mix arrives dry
- Rail Delivery – mix arrives dry – less expensive – requires material storage on site
- Molten tanks – delivered already mixed
- Sub-contract – delivery or batch plant managed by the sub-contractor.

Issues

- We may need multiple sub-contractors to meet the schedule; resources for this type of work are limited.
- What is the rad con requirement for containment?
  - The grout is the containment while it is wet. A polymer coat will be added to seal the grout.
- For Cementacious grout the system must be shutdown and cleaned about once every 4 hours.
- RWMC subsidence – water infiltration from rain and snow could potentially shutdown work during the spring. Mud and subsidence are the issues.

Ideas

- Implement a separate structure to cover the pumps, as they require more frequent maintenance.
- Consider working on a 9-month schedule.
- Prepare a liner to cover the area one year prior to grouting to keep the area dry. Consider a vacuum extraction system to pull off moisture.
- Use mobile equipment with self-contained enclosures for operator and pumps, etc. Minimize the need for personnel on the ground.
- Use seamless high-density poly pipe for grout loops, 6-inch lines, minimizes freezing. There may be a need to heat the re-circulation lines for freeze protection.
- Use GPS unit for hole positioning for the grout.
- Allow viscous returns and accompanying subsurface pressure to be generated.
- Consider multi-point injection – force the pipe in the ground and fill all at once.
- Capability for diagnostics is very important – logging during drilling and post logging of returns and pressures.

Assumptions

- The equipment used for Phase II will be designed to meet multiple needs of the SDA.
- The future of the SDA will be a “surgical” emplacement of grout.
- Phase II will proceed independent of the “retrieve” court action, as a non-time critical early action.
- No area from which waste will be retrieved will be in-situ grouted.

- The Conceptual Design is for the interim action of grouting for a long-term cap.
- Returns can be left on the SDA; they may need to be covered with a spray or clean material, grout or polymer.

Actions

Assigned	Action
All	Review the requirements document and send comments on the document to Jim Johnesee.
K. Rogers	Meet with rad con on the proposed design concept.
K. Rogers	Define the equipment weight that can be supported at the RWMC, considering subsidence issues.
Design Team	Evaluate the need for enclosing support services, e.g., grout mixing, pumps, lines, etc. Evaluate purchasing equipment in weather-contained skids.
B. Malone	Investigate or resurrect data on subsidence issues at the RWMC and provide the data to K. Rogers.

Alternative Discussion Ideas

1) Top Down application of Grout
   - Insert grout from the top as you drill down
   - Leave the drill string in the hole – disconnect it below grade
   - No structure (containment) is required
   - Precedent for leaving the drill string is established with the Type A probes
   - Leaving the drill string adds structural properties.

   - **Issues**
     - Cost of the drill string – design and manufacture
     - Labor to replace the drill string – this activity may already be automated
     - The drill string may be a potential pathway for water and corrosion
     - The length of the string in the ground – may have to be cut due to different levels of refusal.

2) A pool of liquid grout on top of the 3 feet of overburden that is in place.
   - Provides primary containment
   - The returns from the jet grouting process make the pool
   - No containment structure is required
   - Does not impact the machine that runs on tracks to do the grouting
   - A layer of non-contaminated material will be placed on top of the pool.

   - **Issue**
     - The returns would not serve as a diagnostic tool for information.

3) Rubber Mat – Geotextile Cover
   - Contains the grout returns
   - Cleans the jet string as it passes through the cover

- The mat is disposable or can be cleaned if contaminated
- The mat can stay in place for a temporary short-term cover or the first barrier for a long-term cover.

- **Issues**
  - The method is not proven
  - The mat is not rated for driving on it
  - Returns and pressures are not available for diagnostic information.

4) Crane Mounted Drill
   - Man in the cab
   - Controlled environment
   - Manages the grout returns

   - **Issues**
     - Handling of high-pressures hoses and keeping them out of the way of the machine.

5) Mini mobile units – Mechanized equipment that is self-contained.
   - Minimizes footprint that is left behind in each area
   - Less work per setup

6) Mobile Containment

Plus	Minus
• Allows crews to work in any weather condition to accommodate year round work	• The concept has not been tested at this site
• Allows work in any location on the SDA	• Cost
• Accommodates TRU and non-TRU material	• There is no floor in the structure
• Provides containment	• Structurally weak
	• Complicated
	• Difficulty in moving the structure on uneven terrain

7) Weather Enclosure

Plus	Minus
• Allows crews to work in any weather condition to accommodate year round work	• Putting more equipment in the weather enclosure causes safety issues
	• Does not provide contamination control
	• Only protects pumps or major equipment - hoses, lines, etc. are still outside

8) Open Air Environment

Plus	Minus
• Ease of maintenance	• Operating window is based on the climate, weather conditions
• Operability	• Must go through the re-start process when weather conditions improve

9) Fixed Containment

Plus	Minus
• Allows crews to work in any weather condition to accommodate year round work	• Demolition costs
• Larger building	
• Accommodates TRU and non-TRU material	
• Provides containment	

10) Hot Permeation of the Grout into the Ground

Plus	Minus
• Low pressure	• Does not provide any structural stability
• Can preheat the ground	

Alternatives Identified for Development and Evaluation

1. Crane Mounted (cab) Drill Rig – a large crane used to suspend a drilling machine.

2. Track Mounted Drill – smaller rig with the drill string close to the track. The entire machine moves to the next hole.

3. Metal Superstructure over the Drilling Surface-Option is to provide a metal structure to raise the work area, which the drilling machine will work from.

4. Mobile Drilling Structure – an X, Y plotter on tracks, with or without a building

5. Large Track Hoe – A drill rig is mounted to the boom, articulated hydraulic arm – units are available

6. X, Y plotter on rails – covers a large area.

Recommended Criteria to be used for alternative Evaluation

- Demonstrated at the INEEL
- Ability to get the hole in the right place
- Effectiveness (ease) of grout operation – widely separated holes
- Staying out of the returns

- Capital and operating costs
- LCC discounted
- Measure the grout flow
- Control contamination for both normal and off-normal conditions
- Cycle time – set up and time to generate columns
- Ease of cleaning the grout system
- Susceptibility to internal contamination
- Can operate in all weather conditions
- Simplicity
- Ease of moving between areas
- Maturity (proven) technology – off the shelf vs. development
- Ease of maintenance
- Spare parts availability
- Reliability of equipment
- Robustness – work in the harder areas
- Ease of operations – remote – PPEs, number of personnel required
- Ease of interface with other systems
- Safety of the system

February 10, 2004

EROB 249

Objectives: Identify several alternatives for the Delivery System for Phase II In-Situ Grouting of the SDA.

Develop the path forward for the development and cost analysis of the alternatives.

Agenda

8:00	Welcome/Meeting Purpose	K. Rogers
8:15	Introductions/Agenda	L. Seward
8:25	Review Requirements	J. Johnesee
9:00	Background • CD Plan	K. Rogers
9:30	BREAK	
9:45	Brainstorm Alternatives	All
10:15	Develop the Alternatives • Are characteristics from other Alternatives applicable? • What variations make it faster, better, cheaper?	All
12:00	LUNCH	
12:30	Finalize Development of the Alternatives • What is the criteria?	All
1:15	Determine Alternatives to Move Forward	All
2:00	Assign Actions for further Development and Cost Estimates	L. Seward
2:30	Adjourn	

Meeting Participants

Name	Phone	E-Mail
Ambrose, Jeffrey P	526-5862	AMBRJP
Balls, Vondell J	526-2703	BALLVJ
Bechtold, Thomas E	526-7738	BECHTE
Blakely, Byron L	526-2778	BLB6
Clark, Douglas W	526-6465	CLARDW
Eastman, Randy L	526-7111	EASTRL
Graff, Kenneth E	526-4688	KEG
Jensen, Scott A	526-0544	SAJ5
Johnesee, James A	526-1345	JOHNJA
Malone, William S	526-8569	WSM2
Nickelson, David F	526-9061	DFN
Perkes, Brian M	526-9358	PERKBM
Plum, Martin M	526-1108	PLUMMM
Raivo, Brian D	526-6758	RAIVBD
Rogers, Norman K	526-7775	ROGENK
Sentieri, Paul J	526-9595	PIS
Shropshire, Karen L	526-7260	WZL
Thompson, Elden B	526-7513	EBT
Seward, Linda C - Facilitator	526-7800	LCA

ISG PHASE II CRITERIA SELECTION WORKSHOP RECORD

March 3, 2004

1330-1700 hours

EROB Conference Room 133

Idaho Falls, Idaho

Facilitated by:
Linda Seward
208-526-7800
lca@inel.gov

and

William "Buck" West
208-526-1314
weshwh@inel.gov

Workshop Objectives 45

Attendees 45

Actions 45

Decisions or Conclusions 45

Process 46

Appendix A: Put title here 47

Appendix B: Results Of Sorting The Draft Criteria Into High, Medium And Low Importance 50

Not Applicable or Non-Discriminating Criteria ..... **Error! Bookmark not defined.**

Sorted criteria 50

High Importance 50
Medium Importance 51
Low Importance 51

Second Tier Screening Criteria 51

Workshop Objectives

The workshop objectives were to reduce the list of decision criteria to a reasonable number and assign a weight factor to the final criteria. The weight factor will be assigned at a separate meeting.

Attendees

Jeff Ambrose
Byron Blakely
Paul Bunnell
Ernie Carter (telecon)
Randy Eastman
Darnell Evans
Ken Graff
Scott Jensen
Jim Johnesee
William Malone
Loran Marler
Dave Nickelson
Brian Raivo
Kim Rogers
Karen Shropshire
David Stephens
Elden Thompson
Linda Seward, Facilitator
W. H. (Buck) West, Facilitator

Actions

The participants will review the reduced list of criteria from this meeting for discussion at the next team meeting on March 10, 2004 at 3:30 p.m. in EROB 133. The criteria review should include the following aspects:

- Recommended wording to clarify ambiguous criteria.
- Recommended combination of similar criteria.
- For each criteria indicate what would good be a good attribute for that criterion and what would be a bad attribute (e.g. for cycle time: good = less than or equal to 20 minutes from stop of drilling to start of drilling on holes 10 feet apart, bad = greater than 60 minutes from stop of drilling to start of drilling on holes 10 feet apart).

Decisions or Conclusions

The team sorted the refined criteria into High, Medium and Low importance to the decision. Additional comments and explanation on some of the criteria can be found in Appendix B, pages 8-9, of this record. The final sorted criteria are:

High Importance

1. Precision - Ability to get the hole in the right place
2. Cycle time - moving, set up and time to generate columns
3. Contamination control
4. Ease of operation in all weather conditions
5. Ease of moving between areas (not between holes in the same area).
6. Deployment costs/efforts.
7. Ease of maintenance of jets or drill bits
8. Ease of operations

Medium Importance

1. Flexibility to do different drill patterns.
2. Ease of interface with other systems
3. Adaptability - Ease of modifying the alternative if requirements or conditions change.
4. Number of ancillary support systems needed.
5. Level of effort for site preparation and D&D when drilling is done.

Low Importance

1. Demonstrated at the INEEL

Process

The team started with a brief technical review and identification of technical issues for each of the alternatives. Information from that technical discussion can be found in Appendix A of this record. The team then discussed each of the criteria. After the technical discussion the team was asked if any of the alternatives, based on the technical discussion, were not viable and should be removed from any further consideration. The team indicated that all the alternatives were still viable.

The team then discussed each of the criteria. The purpose of the discussion was to determine if a criterion would discriminate between the alternatives, if each criterion were understandable and measurable, and if several criteria could be combined. Following the screening, the criteria were identified as High, Medium, or Low importance.

Meeting participants will review the criteria for any further refinement, and combination. An identification of the good and bad attribute for each of the criteria will be established by each participant and discussed at the next team meeting.

Appendix A: Alternatives Technical Issues

General Issues

- Contamination flowing up from the drilling. Will a pool of grout contain the contamination?
- What is the compressive strength of the pool of grout?
- Diagnostics to accomplish the work on a system.

1. Alternative #1 **Crane**

+ An advantage is that it keeps the operator away from the hole and contamination. This is a contamination control and a safety issue.
+ The operator will be about 25 feet from the work.
- The operator can't see the hole well without some kind of camera.
- A possible disadvantage is that we don't know how many units can be purchased off the shelf and may require some engineering to integrate the components.
- It may be difficult to get evenly spaced holes as a result of the puller grip and a constant radius of the crane arm.
- Equipment will be difficult to put in any kind of enclosure because of the large size of the crane.
- Constant radius is an issue in an area with a wide area, but this is less of an issue when working on a small narrow trench.
- Positioning control with the crane on tracks is not good.
- Changing the swivel is more difficult on top of the crane unit. A person has to go up in a lift to do this maintenance activity.
- Can only have a single drill stream per unit.
- The drill pulls down the bit. The crane does not drive it down. The crane actually holds the bit from going down too fast.

2. Alternative #2 **Track Mounted**

+ Equipment is common in industry and the project can have multiple units on the site.
+ The units are easily acquired.
+ The units are easy to maintain.
- Disadvantage is that the operator is closer to the hole and to contamination.
- Probably can have only a single drill stream per operating unit.
- Could spread contamination from the returns if the tracks get into the returns (may be able to do some earth work to keep the tracks clean).
- Have to relocate the monitoring instruments as often as you move the units.
- There is an operator standing next to the machine, contamination issues and may be splattered by the grout.
- May be able to modify the machine to operate remotely.
- The unit may be capable of rotating the boom relative to the tracks.

3. Alternative #3 **Super structure over the SDA area – beam, bridge crane on rails**

+ Can have multiple drill rigs with multiple drill streams on each unit. All the monitoring instruments are on the platform.
+ Will have a control booth for the operator on the platform.
+ This unit allows modularization of multiple drilling operations.
+ The unit will provide for faster and more accurate positioning of the drill units.

- A disadvantage is that a large crane is needed at the end of the structure to rotate and move the platforms.
- The need for a large crane to move the platforms is an expense to the project in time and money.
- There may be an issue with the amount of the work needed to level the platform.
- Will need follow-on grout system that can rotate and trail the first platform. This grout system may also need to be moved by the crane.
- Will need to deliver the grout from the edge of the SDA. It may be possible to mix the grout on the platform by transporting the raw material from the edge of the SDA to where the mixer is on the platform.
- A significant amount of engineering work may be involved for maintenance, repair and changing of the bits. This unit may be a specially designed machine at a high cost (the cost will depend on the quality level and/or certification required).

- The drill will be on beams instead of tracks.
- The superstructure will span the area where drilling is occurring.
- The grout return could stack up between the rails of the superstructure.
- The platform frame should be three feet off the ground.
- It is anticipated that the rails will be perpendicular to the SDA.

4. Alternative #4 **X, Y Plotter on tracks – forms to contain the grout, moves to another location, glove box maintenance.**

+ Forms can be lowered to contain the grout.
+ The unit has the ability to precisely position holes.
+ The unit is up and out of the grout.
+ The unit is mobile.
+ The unit can be equipped with an operator gallery.
- This alternative will require sheet piling placed in the ground ahead of the process. This is necessary to contain the grout. The unit will require some engineering to integrate the components.
- There may be an issue with the management of the hoses from the grout supply.

5. Alternative #5 **Crawler/Excavator**

+ The unit will be easier to position the drill holes wherever you want them. Uniform distribution of the holes is not a problem.
+ It would be possible to lay down the drill mast for maintenance and maintenance could be done from a platform closer to the ground.
+ This alternative keeps the unit away from the contamination.
+ The larger the machine the easier it is to keep the tracks away from the grout returns.
- This unit may have a disadvantage in how precisely the operator can position the holes.
- Viewing the hole is a problem.
- It may be necessary to engineer the interface between components.
- The option loses many if it's advantages if it is placed in an enclosure and depending on the size of the unit it may not fit in an enclosure.
- Can only have a single drill head per unit.

6. Alternative #6 **Concrete foundation with bridge crane – perpendicular to trenches for subsidence issues**

+ The unit is up and out of the grout returns.
+ The unit offers easy indexing.

+ Could have multiple cranes operating at the same time and multiple drills on each crane.
+ There is a better potential to operate year round because you are operating on a secure foundation.
+ It would be easy to put a building over the machine.
+ Can get greater span width with concrete than with steel rails – this provides a subsidence advantage.
- There may be a disadvantage with inefficient delivery of the grout.
- There may be an issue with the management of the hoses from the grout supply.
- Will need electrical power to each rail. It may be possible to use a self-powered drill in place of electrical power.
- Once the foundations are in place it may be difficult to drill underneath the concrete foundations. With a concrete pre-cast you could move the rails to drill underneath the rails.
    - This alternative is not a good one-size-fits all alternatives because you will be locked into a standard and fixed span width.

- This alternative may have a disadvantage because of the amount of engineering needed to place the rails and other components.
- There may be a high cost if the rails are left in place. Not as big an issue if the rails are moveable. There may also be a cost issue if you need a crane to move the rails.
- If the rails are perpendicular to the SDA, there may be an issue with the roads becoming unusable when the rails are in place. The idea was to place the rails perpendicular to the SDA in an effort to reduce the subsidence problem.

7. Alternative #7 Highway/Concrete Paver

+ Can have multiple drill units (1-4) per platform.
+ The machine is computer controlled or controlled automatically.
+ The hydraulics will keep the platform level.
+ Should be able to span whatever width is necessary.
+ The platform will be above the ground surface and away from the contamination.
+ This unit has the advantage of being self-contained while operating - diesel generator and hold tank for the grout.
- The distribution of weight on the platform is a concern.
- A disadvantage is that this will be a semi custom design and will require some engineering work for the components (will increase the cost).
- There is a potential contamination of the mud pool that is used to cap the grout area. Will the pool of grout contain the contamination? This alternative can go either parallel or perpendicular to the SDA.
- Gross soil subsidence may be an issue - this may apply to all the alternatives.
- What diagnostics will be needed to accomplish the job?
- What is the structural strength of the cap left from the grout pool? Will it be possible to drive the unit on top of the solidified grout pool?

Appendix B: Results Of Sorting The Draft Criteria Into High, Medium And Low Importance

Not Applicable or Non-Discriminating Criteria

The following criteria were identified by the team as not applicable to the decision or as a criterion that would not help to discriminate between the alternatives.

1. Ease of measuring the grout flow
    - This is measured at the pump and not at the drill
2. Ease of cleaning the grout system
3. Simplicity
4. Robustness - work in the harder areas
5. Safety of the system
6. Capability to measure the grout returns

Sorted criteria

Criteria sorted by High, Medium or Low importance to the decision between alternatives.

High Importance

1. Precision - Ability to get the hole in the right place
2. Cycle time - moving, set up and time to generate columns
    - Time to move from one hole to the next hole
    - Productivity of the alternative
3. Contamination control
    - Staying out of the returns
    - Control contamination for both normal and off-normal conditions
    - Susceptibility of the alternative to internal contamination (e.g. could contamination go backwards into the jets or into other components of the machine).
4. Ease of operation in all weather conditions
    - This will have an impact on project schedule.
    - How much stress will be placed on the operator in different weather conditions?
    - Is a structure needed to allow operation in any weather condition?
5. Ease of moving between areas (not between holes in the same area).
    - Includes the ability to get into tight spots.
6. Deployment costs and efforts.
    - Maturity (proven) technology - off the shelf vs. need for component integration and engineering required
7. Maintenance, Reliability, Availability
    - Ease of maintenance of jets or drill bits
    - Spare parts availability
    - Reliability of equipment
    - Ability to move the machine to a clean site off of a contaminated area.

8. Ease of operations
    - Remote vs. direct operation
    - PPE's required
    - Number of personnel required to run the equipment

Medium Importance

1. Flexibility to do different drill patterns.
    - Effectiveness (ease) of grout operation - to do closely or widely separated holes.
2. Ease of interface with other systems
    - Grout delivery, fuel, and power etc. interfaces.
    - Monitoring systems, cameras, and grout measuring interfaces.
    - Recording/documenting where we have grouted.
3. Adaptability - Ease of modifying the alternative if requirements or conditions change.
4. Number of ancillary support systems needed.
5. Level of effort for site preparation and D&D when drilling is done.

Low Importance

1. Demonstrated at the INEEL

Second Tier Screening Criteria

The following criteria were identified as important to the second tier of screening because not enough is known about the alternatives at this time to assess these criteria.

1. Capital and operating costs
2. LCC discounted

ISG ALTERNATIVE SELECTION WORKSHOP RECORD

March 16, 2004

0800-1600 hours

EROB Conference Room 350

Idaho Falls, Idaho

Facilitated by:

Linda Seward
208-526-7800
lca@inel.gov

and

William "Buck" West
208-526-1314
westwh@inel.gov

Workshop Objectives 55

Attendees 55

Actions 55

Path Forward 55

Decisions or Conclusions 56

Adverse Consequences/Potential Risks with Alternative #5 56

Process 57

Analysis Of Results 62

Appendix A: Raw Scores from GroupSystems Software 66

Criteria Scores Within an Alternative 66

Alternative Scores Within a Criterion 70

Workshop Objectives

- Select a preferred alternative from the seven available alternatives.
- Identify risk associated with the preferred alternative.

Attendees

Name	Phone	MS	Mail Id
Ambrose, Jeffrey P	526-5862	3920	AMBRJP
Blakely, Byron L	526-2778	3650	BLB6
Bunnell, Paul J	526-3389	3670	BUNNPJ
Carter, Ernie	281-495-2603		Cartertech@prodigy.net
Eastman, Randy L	526-7111	3650	EASTRL
Evans, Dan K	526-3589	5205	EVANDK
Graff, Kenneth E	526-4688	3670	KEG
Johnesee, James A	526-1345	3765	JOHNJA
Malone, William S	526-8569	3765	WSM2
Meagher, Brandt G	526-9767	3920	ZBM
Nickelson, David F	526-9061	3670	DFN
Raivo, Brian D	526-6758	3765	RAIVBD
Rogers, Norman K	526-7775	3650	ROGENK
Shropshire, Karen L	526-7260	3920	WZL
Stephens, David L	526-4816	3650	SD6
Thompson, Elden B	526-7513	3710	EBT
Wells, Franklin D	526-0932	5312	WELLFD
Wooley, Kelly A	526-4731	3920	WLY

Actions

- Define the accuracy required for the 3-D model of the In Situ Grouting. Talk with Ken Beard about the requirements.

Path Forward

The team will meet again on March 25, 2004 to flesh out the alternative and develop a Work Breakdown Structure with subsystems and modifications required. Include utilities, site preparation activities, crew sizes, and automation. The deliverable of the meeting will be the information required to move forward with the Conceptual Design. The Conceptual Design for the ISG of the Subsurface Disposal Area (SDA) is to be complete by September 30, 2004.

Decisions or Conclusions

Based on the rating of seven alternatives against seven criteria[b] the highest scoring alternative is Alternative #5, Crawler/Excavator (now called the Trackhoe). The overall weighted score for each alternative is:

- Alternative 1-Crane (score=0.526[c])
- Alternative 2-Track Mounted (score=0.543)
- Alternative 3-Super Structure (score=0.344)
- Alternative 4-X, Y Plotter (score=0.357)
- Alternative 5-Crawler/Excavator (score=0.607)
- Alternative 6-Bridge Crane (score=0.363)
- Alternative 7-Highway Paver (score=0.435)

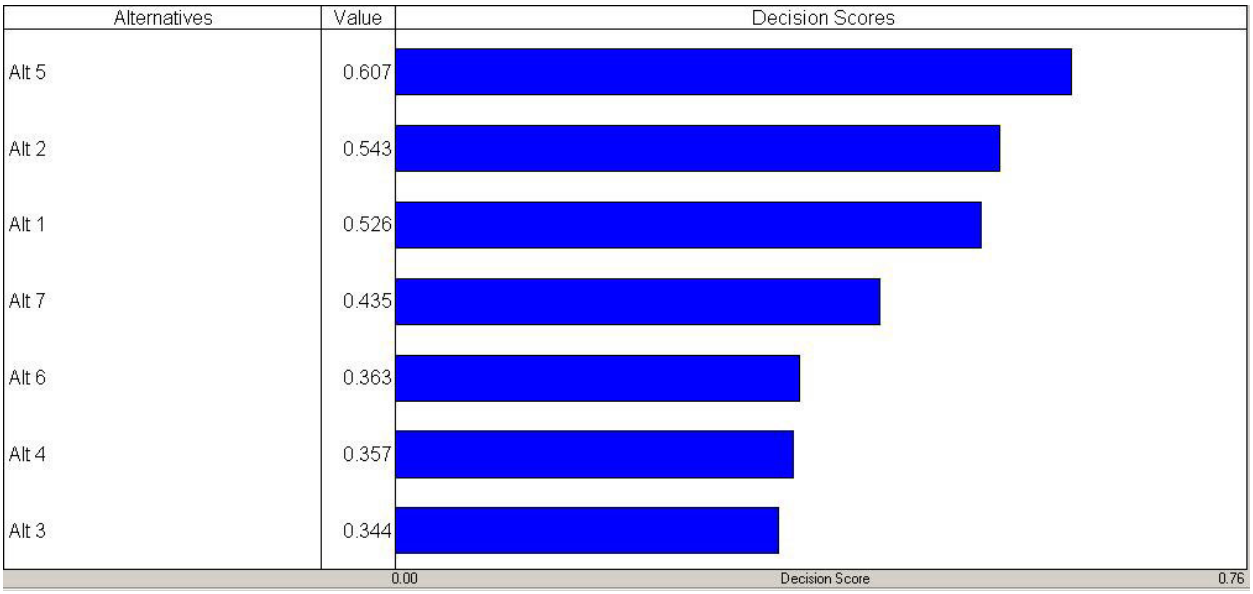

Figure 1. Alternative decision scores

Adverse Consequences/Potential Risks with Alternative #5

The team brainstormed the adverse consequences/risk associated with the preferred alternative (alternative 5).

- The equipment cannot achieve the accuracy of the data required for the 3-D model.
- Lack of control for the grout returns.

---

[b] Criteria for productivity are not included in this record due to questions abut the validity of the information provided on productivity.

[c] All results presented in this record are after conversion to *Criterium Decision Plus*© software and may not be exactly the same as originally presented in the meeting.

- Chance for human error, manually controlled, human monitored.
- Equipment is too heavy for soil bearing limits.
- The bit change box may be difficult to use.
- Length of the high-pressure lines and the number of joints required for routing.
- Low-pressure piping system may not function as proposed.
- Multiple machines, grout delivery equipment and systems, crews, spares, etc. may make it difficult to manage the logistics of the operation.
- Rad con may require a confinement system.
- How do we move the equipment if it breaks down (throws a track)?
- Equipment sinks into the SDA.
- Management of adverse weather conditions.
- Re-starts, inspection, training, permits, etc. Effort required to shut down for winter months, winterization. Staging of the equipment.
- Monitoring for air borne contaminants.

Process

The workshop opened with a brief review of each of the seven alternatives. Alternatives had been identified over time by the development team and had been discussed and refined at several meetings previous to this selection meeting. The alternatives presented and discussion notes include:

- Alt 1-Crane
  - Auger with a crane has only been done one time (team knowledge).
  - Makes larger columns because jets are larger.
  - Changing the bit is difficult
  - Integration of the drill with the equipment is complex.
  - It is a powerful auger that does not stop when it hits metal, etc.
  - Can grout up or down.
  - Has a tendency to bring debris up out of the hole.
- Alt 2-Track Mounted
  - Is close to the grout surface/returns
  - The mast will tilt and lower to allow change out.
  - If sitting on an uneven surface the equipment levels the mast.
  - The arc of the swing is a small radius, 6 to 8 feet.
  - Hole to hole time is about 1 minute.
- Alt 3-Super Structure
  - High accuracy with the grid.
  - Good control and documentation for the grouting.
  - Limited use for foundation grouts.
  - High speed.
  - Ground heaves could impact the alternative.
- Alt 4-X, Y Plotter
  - Sheet piling above the ground contains the grout returns.
  - Free roving on tracks.
  - Tracks rotate 360°
- Alt 5-Crawler/Excavator
  - Size of the crawler is determined for reach and stability.

- The Gradall comes with a swivel, hydraulic power.
- The long reach makes it difficult to line up the hole accurately. It could be automated.
- Equipment is reliable, mass-produced.

- Alt 6-Bridge Crane
  - Concrete strip footings span 50-100 feet.
  - Requires a person on the ground to move the concrete footings.
  - Ground heaves could impact this alternative.
- Alt 7-Highway Paver
  - The platform is self-leveling.
  - Requires a control room for instrumentation that is weather proof.

After the alternatives had been reviewed, a brief overview was presented on the costs of each alternative. Estimates did not include the grout or grout mixing/delivery equipment, maintenance cost of the equipment, nor operation of the equipment. The cost estimate for each alternative is:

Alt. #	Description	Cost
1.	Crane	$10,390,000.00
2.	Track Mounted Drill	$10,580,000.00
3.	Super Structure	$16,260,000.00
4.	X, Y Plotter	$22,000,000.00
5.	Crawler/Excavator	$12,980,000.00.
6.	Bridge Crane	$24,070,000.00
7	Highway Paver	$11,020,000.00

The evaluation criteria and scales were reviewed with the team for clarity. The criteria and scales proposed were:

1. Effectiveness
   1.1 Effectiveness (7 =drill point is within +/- 1-inch with respect to target location, 5=point is within +/- 2-inches of target, 1=point is within +/- 6-inches of target)
2. Contamination Control
   2.1 In grout returns (7=Equipment does not run in the grout returns, 1=Equipment runs in the returns)
   2.2 Operator distance (7= Personnel are 15 or more feet away from the grout returns, 5= Personnel are less than 10 feet away from the grout returns, 1= Personnel are 5 or fewer feet away from the grout returns)
3. Productivity
   3.1 Time to do a square (7=10 or fewer hours, 5=20 hours, 1=30 or more hours)
   3.2 Time to move between squares (7=1 or fewer hours, 5=10 hours, 1=20 or more hours)
4. Operational Ease
   4.1 Number of personnel (7=3 or fewer operations personnel, 1=8 or more operations personnel)
   4.2 Year round (7=Operate year round, 1=Down > 4 months of the year)
5. Development/Deployment
   5.1 Engineering time (7= low engineering time, 5=moderate engineering time, 1=high engineering time)
6. Simplicity
   6.1 Maintenance (7=low maintenance required, 5=moderate maintenance required, 1=high maintenance required)

6.2 Number of interfaces (7=2 or fewer interfaces required, 5=5 or fewer interfaces required, 1=10 or more interfaces required)
6.3 Support systems (7=no support systems needed, 5= 2 support systems required, 1=3 or more support systems required)

Questions were raised about the productivity values developed for each alternative. During the discussion, the group agreed to evaluate productivity of each piece of equipment on a standard trench seven feet wide, 1000 feet long, containing a total of 1750 drill holes. It was further established that there would be only four holes across the seven-foot width of the trench. Members were instructed not to score the productivity criterion as the values for productivity would be calculated based on 1750 drill holes. The facilitator would enter that value, based on the calculation.

The group then discussed the operational ease criteria. The discussion concluded that each of the alternatives could operate year-round under various configurations and that each alternative could be operated with about the same number of operators. The group agreed that operations ease was a decision criteria, but the best they could do with the criteria was to rank each alternative in order of how easy each member thought the alternative would be to operate.

The group concluded that the number of support systems and number of interfaces sub-criteria under simplicity were referring to the same aspect of an alternative. The group agreed to drop the support systems sub-criterion.

After the discussion the final criteria for evaluating the seven alternatives were:
1. Effectiveness
    1.1 Effectiveness (1=point is within +/- 6-inches of target, 5=point is within +/- 2-inches of target, 7 =drill point is within +/- 1-inch with respect to target location)
2. Contamination Control
    2.1 In grout returns (1=Equipment runs in the returns, 7=Equipment does not run in the grout returns)
    2.2 Operator distance (1= Personnel are 5 or fewer feet away from the grout returns, 5= Personnel are less than 10 feet away from the grout returns, 7= Personnel are 15 or more feet away from the grout returns)
3. Productivity
    3.1 Time to do a square (Do not score this)
    3.2 Time to move between squares (Do not score this)
4. Operational Ease
    4.1 Operational Ease (Give the easiest option a 7, the next easiest a 6, ..., the least easiest a 1, Use a number only once!)
5. Development/Deployment
    5.1 Engineering time (1=high engineering time, 5=moderate engineering time, 7= low engineering time)
6. Simplicity
    6.1 Maintenance (1=high maintenance required, 5=moderate maintenance required, 7=low maintenance required)
    6.2 Number of interfaces (1=10 or more interfaces required, 5=5 or fewer interfaces required, 7=2 or fewer interfaces required)

The group then scored the seven alternatives against the modified criteria, leaving the productivity values to be scored by the facilitator based on the evaluation numbers provided. After group scoring, the facilitator applied weights to the criteria. Weights were determined by project directors (Karen Shropshire, David Nickelson, Frank Webber, and Kim Rogers) at a meeting on March 12, 2004. The weights assigned to each criterion are shown in Table 1.

Weight	Criteria
	Effectiveness
7.8%	1.1 Effectiveness
	Contamination Control
6.4%	2.1 In grout returns
6.4%	2.2 Operator distance
	Productivity
10.25%	3.1 Time to do a square
10.25%	3.2 Time to move between squares
	Operational Ease
12.8%	4.1 Operational Ease
	Development/Deployment
25.6%	5.1 Engineering time
	Simplicity
10.25%	6.1 Maintenance
10.25%	6.2 Number of interfaces

Table 1. Criteria weights.

Initial weighted raw scoring results[d] are presented in Figure 2.

[d] These results have not been Processed through *Criterium Decision Plus*© software package and can not be directly compared to other results presented in this record.

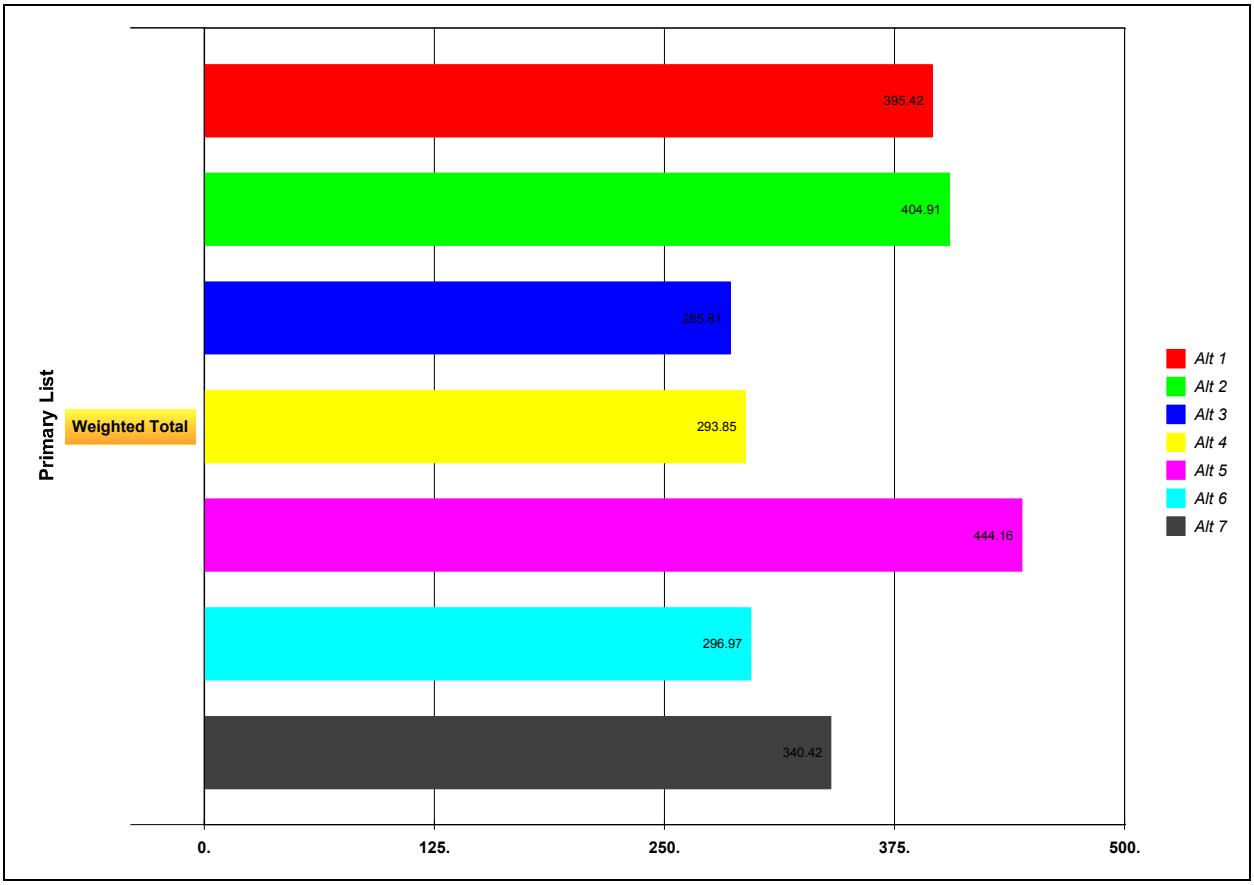

Figure 2. Initial, weighted scoring results.

The group reviewed various aspects of the initial results and clarified information on a criterion and how an alternative responded to a criterion. Some members of the group also indicated they may have scored an alternative incorrectly; either scored one of the sub-criterion that was to be scored by the facilitator only or reversed the scale and scored an alternative with a low number when it should have been scored with a high number.

Based on the discussion the group was permitted to change their scores. During the second round of scoring the group was permitted to reuse the same number for the rank order for Operational Ease (two or more alternatives could receive the same score). The scores for Productivity were also set to 1 to effectively remove that criterion from the evaluation. The results of this second round of scoring are found in Figure 1 and all remaining analyses in this record are based on the second round of scoring.

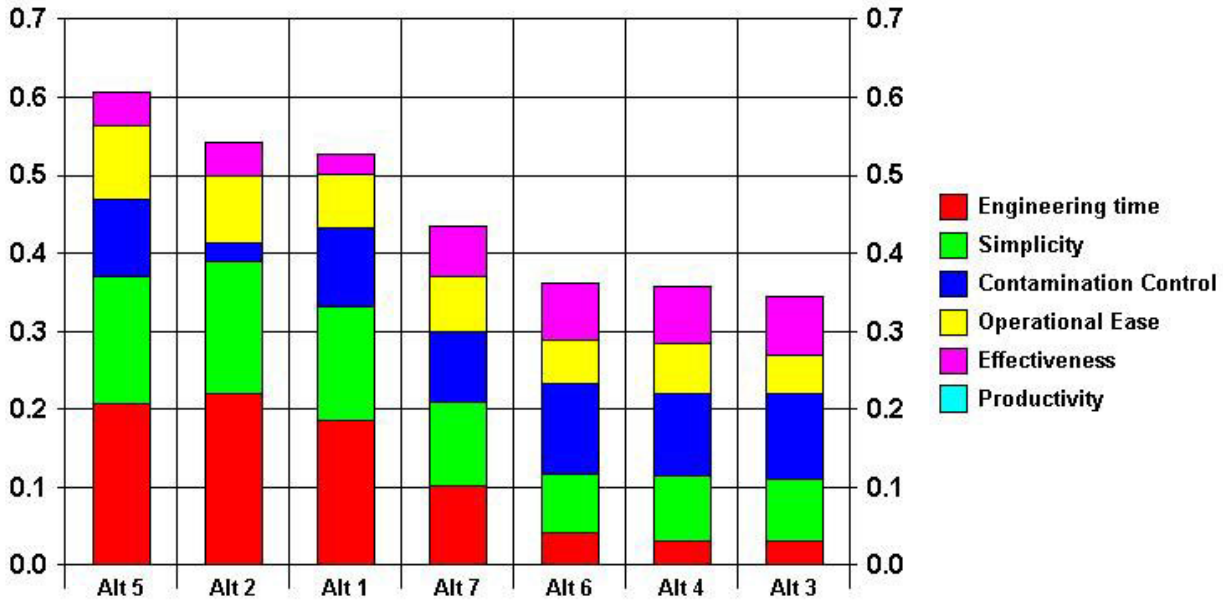

Figure 3. Weighted contribution of individual criterion to overall alternative score.

Analysis Of Results

The criteria were examined for how well they contributed to the selection of the preferred alternative. This examination focused on:

1. Was there any discrimination between the alternatives for that criterion?
2. Was the rating group in consensus on their alternatives scores?
3. How much uncertainty is there in the scoring of the alternatives against the criteria?
4. How sensitive are the criterion to changes in their weights?

All the criteria showed some discrimination between the options. The least discriminating criteria were "Operational Ease" and "Maintenance." The scores for Operational Ease ranged from 3.33 to 5.44, while the scores for Maintenance ranged from 3.33 to 5.72. Because there was some separation between the alternatives for these criteria no strong argument could be made for eliminating the two criteria.

The alternative scores of the group exhibited the highest degree of consensus for Alternative 3 (Super Structure), followed closely by Alternatives 4 (X, Y Plotter), 5 (Crawler/Excavator) and 6 (Bridge Crane). Consensus scores were calculated using the Ventana Coefficient of Consensus (VCC). VCC is a measure of the agreement or disagreement on the group's rating. The smaller the spread in scores compared to the possible range in scores, the better the level of consensus. A value of 1.00 represents complete consensus (no variation between scores) while a value of 0.00 represents no consensus (maximum variation between scores). The VCC values show moderate to high consensus on the scoring of each alternative/criterion combination (see page 66 for individual combinations). Figure 4 shows the frequency of consensus scores for the 49-alternative/criterion combinations. The following table shows the range of consensus score for the three options.

	Low	High	Mean
Alt 1 – Crane	0.37	0.67	0.50
Alt 2 – Track Mounted	0.35	0.57	0.44
Alt 3 – Super Structure	0.36	0.74	0.56
Alt 4 – X, Y Plotter	0.34	0.74	0.53
Alt 5 – Crawler/Excavator	0.34	0.74	0.54
Alt 6 – Concrete Foundation w/Bridge Crane	0.28	0.87	0.55
Alt 7 – Highway Paver	0.38	0.50	0.44

Table 2. Ventana Coefficient Of Consensus Scores For Each Alternative.

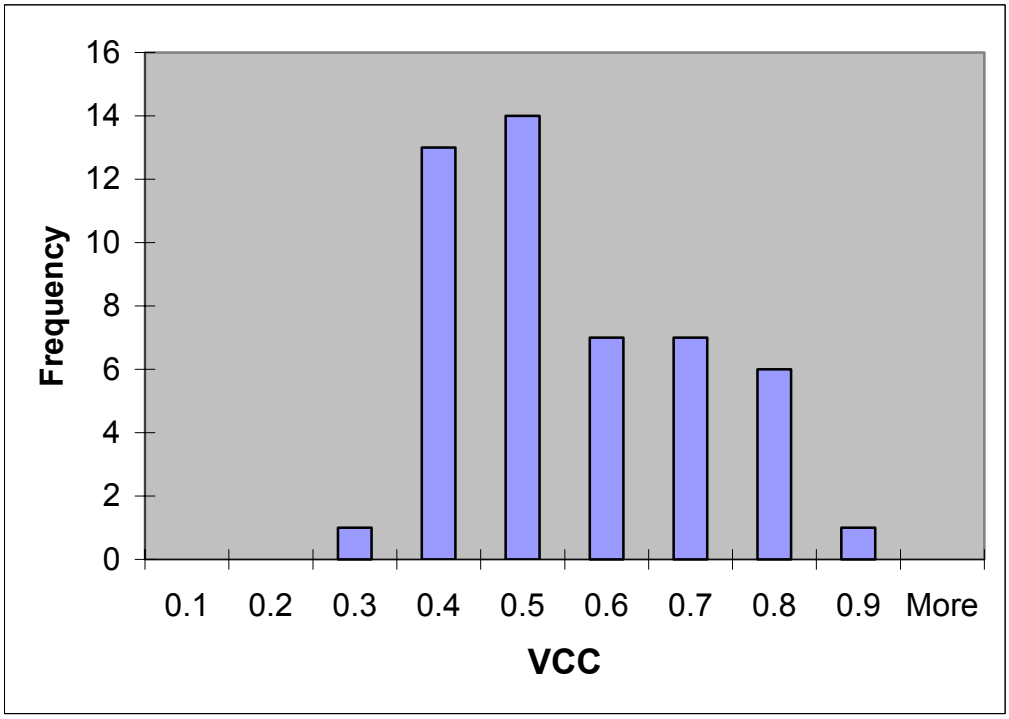

Figure 4. Distribution of VCC Consensus Scores

The group means and standard deviations for each alternative/criterion combination were entered into the *Criterium Decision Plus*© software. The possible decision scores for each alternative were calculated along with the probability that the alternative could have a specific score. Figure 5 shows the probability distributions for the top five alternative scores.

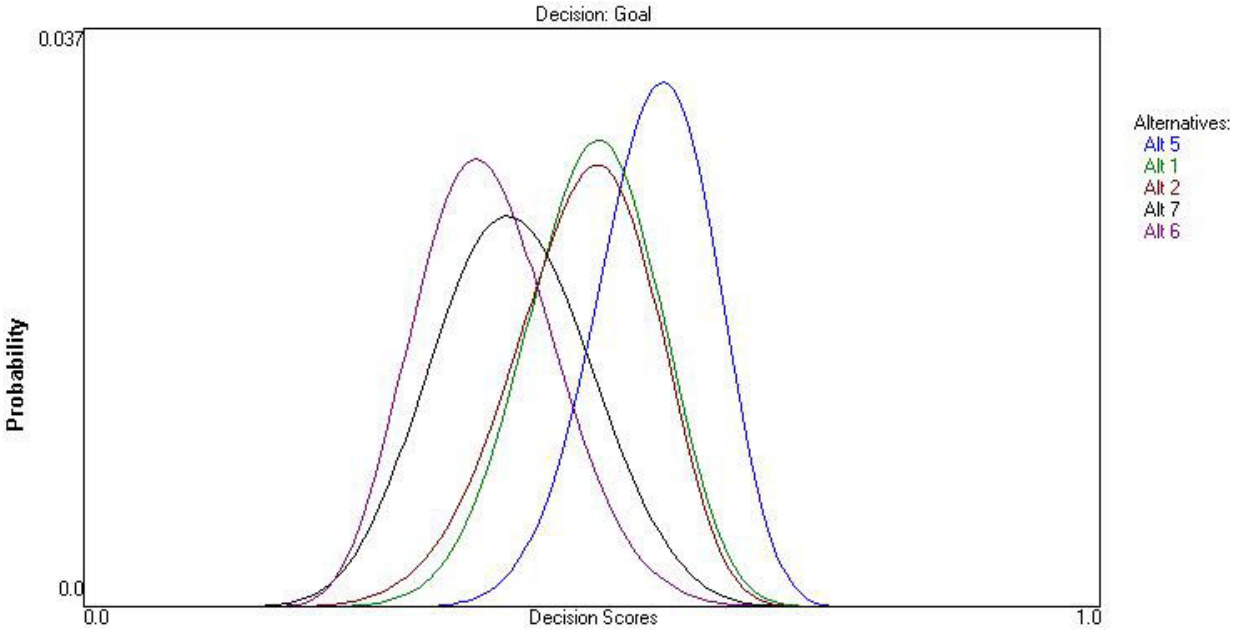

Figure 5. Probability distribution for the top five alternatives.

Alternative 5 had both the highest score of all the alternatives and the highest probability distribution for its scores. Alternative 5 had the lowest uncertainty of any of the alternatives for three of the seven criteria. These criteria were also the highest weighted criteria by the decision makers. In other words, the team was most confident about the three criteria that were most important to the decision makers.

For the second and third best alternatives (Alternative 2 and 1), Alternative 1(Crane) has slightly less uncertainty than Alternative 2 (Track Mounted Drill). When uncertainty is incorporated into the scoring, alternatives 1 and 2 switch position (mid line of the gray bar in Figure 6) with regards to which alternative would be best.

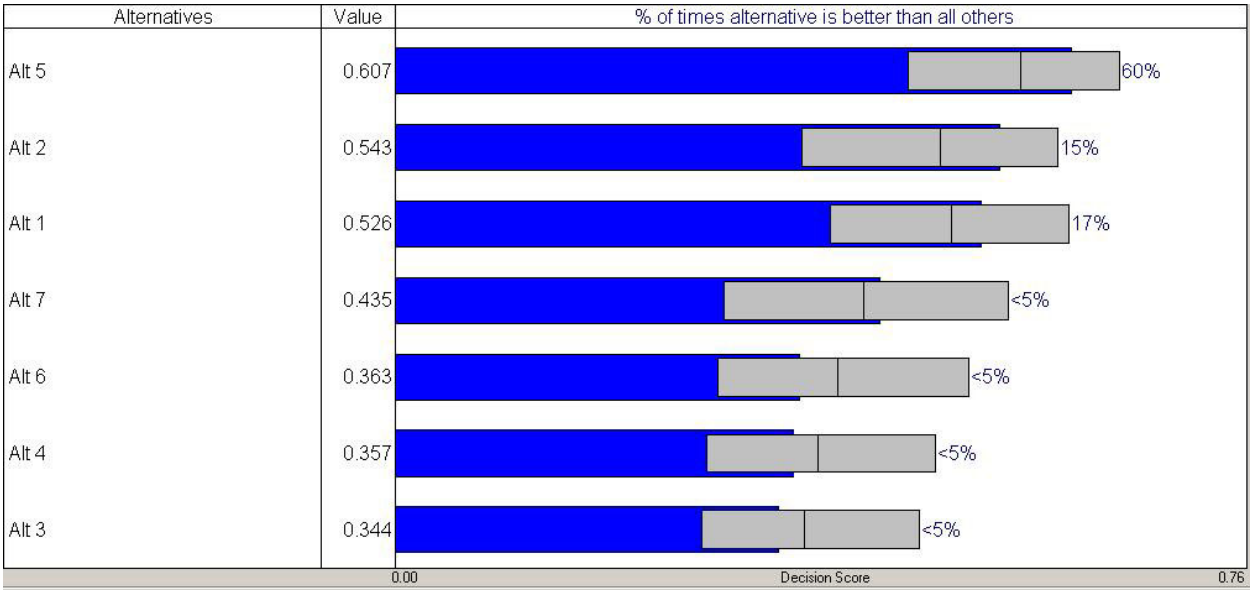

Figure 6. Alternative scores considering uncertainty.

In general we are more confident (less uncertain) that the scores for Alternative 5 are between 0.530 and 0.710 than any other alternative within that range of scores. If the goal were to reduce risk in the project, Alternative 5 would be the best selection.

Sensitivity analysis of a criterion shows how much the weight of a criterion would have to change (keeping all other weights fixed) before alternatives would change position. Alternative 5 is relatively insensitive to changes in the weights of the criterion compared to any of the other alternatives. The weights would have to change significantly to replace Alternative 5 as the best alternative.

Appendix A: Raw Scores from GroupSystems Software

This table shows the average scores for each of the criteria within an option. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus.

		Alternative									
	Weight	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**Alt 6**	**Alt 7**	**Total**	**Mean**	**STD**
1. Effectiveness	7.80	3(3.00)	4(4.33)	7(6.67)	7(6.67)	4(4.33)	7(6.67)	6(5.89)	37.56	5(5.37)	1.48
2.Contamination Control											
2.1 In grout returns	6.40	6(5.61)	2(2.17)	7(6.61)	6(5.89)	6(5.78)	7(6.83)	5(5.44)	38.33	5(5.48)	1.55
2.2 Operator distance	6.40	6(5.94)	2(2.00)	6(5.78)	6(6.00)	6(5.61)	6(6.17)	5(5.00)	36.50	5(5.21)	1.47
3.Productivity											
3.1 Time to do a square	10.25										
3.2 Time to move between squares	10.50										
4.Operational Ease	12.80	4(4.17)	5(5.06)	3(3.33)	4(3.94)	5(5.44)	4(3.61)	4(4.33)	29.89	4(4.27)	0.76
5. Engineering time	25.60	5(5.33)	6(6.17)	2(1.72)	2(1.72)	6(5.83)	2(2.00)	3(3.39)	26.17	4(3.74)	2.00
6.Simplicity											
6.1 Maintenance	10.25	5(5.17)	6(5.72)	4(3.61)	3(3.33)	6(5.72)	3(3.28)	4(3.61)	30.44	4(4.35)	1.13
6.2 Number of interfaces	10.25	5(5.39)	6(6.17)	3(3.00)	4(3.61)	6(5.83)	3(3.00)	5(4.72)	31.72	5(4.53)	1.33
Total		34.61	31.61	30.72	31.17	38.56	31.56	32.39			
Mean		5(4.94)	5(4.52)	4(4.39)	4(4.45)	6(5.51)	5(4.51)	5(4.63)			
STD		1.02	1.78	1.95	1.78	0.54	1.99	0.92			
Weighted Total		395.42	404.91	285.81	293.85	444.16	296.97	340.42			

Criteria Scores Within an Alternative

This table shows the distribution of scores (1-7) across the nine criteria for each of the alternatives. The number within a criteria/score cell indicates the number of participants that used that score for that criterion. Within an alternative, the criteria are sorted from the highest to the lowest score.

Primary List	Weight	Score 1	2	3	4	5	6	7	Total	Mean	STD	n	Weighted Total	VCC
Alt 1-Crane														
Effectiveness	7.8	5	4	2		7			54	3(3.00)	1.75	18	23.40	0.42
Contamination Control														
Operator distance	6.4		1			5	4	8	107	6(5.94)	1.30	18	38.04	0.57
In grout returns	6.4	1	1	1		4	2	9	101	6(5.61)	1.88	18	35.91	0.37
Productivity														
Time to do a square	10.25											0		
Time to move between squares	10.25											0		
Operational Ease	12.8	1	1	4	3	7	1	1	75	4(4.17)	1.47	18	53.33	0.51
Engineering time	25.6		1	1		8	5	3	96	5(5.33)	1.28	18	136.53	0.57
Simplicity														
Number of interfaces	10.25			1		11	3	3	97	5(5.39)	0.98	18	55.24	0.67
Maintenance	10.25	1	1		2	7	2	5	93	5(5.17)	1.69	18	52.96	0.44
Alt 2-Track Mounted														
Effectiveness	7.8	2	2	2	1	7	1	3	78	4(4.33)	1.94	18	33.80	0.35
Contamination Control														
Operator distance	6.4	12	1	1		3		1	39	2(2.17)	1.95	18	13.87	0.35
In grout returns	6.4	10	4	1		3			36	2(2.00)	1.50	18	12.80	0.50
Productivity														
Time to do a square	10.25											0		
Time to move between squares	10.25											0		
Operational Ease	12.8		3	1	2	2	6	4	91	5(5.06)	1.80	18	64.71	0.40
Engineering time	25.6	1	1			1	2	13	111	6(6.17)	1.79	18	157.87	0.40
Simplicity														
Number of interfaces	10.25		1			3	4	10	111	6(6.17)	1.29	18	63.21	0.57
Maintenance	10.25		1	1	1	4	3	8	103	6(5.72)	1.53	18	58.65	0.49
Alt 3-Super Structure														

	Score													
Primary List	**Weight**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Mean**	**STD**	**n**	**Weighted Total**	**VCC**
Effectiveness	7.8				1		3	14	120	7(6.67)	0.77	18	52.00	0.74
Contamination Control														
Operator distance	6.4				1	1	2	14	119	7(6.61)	0.85	18	42.31	0.72
In grout returns	6.4				2	6	4	6	104	6(5.78)	1.06	18	36.98	0.65
Productivity														
Time to do a square	10.25											0		
Time to move between squares	10.25											0		
Operational Ease	12.8	3	5	3	1	3	2	1	60	3(3.33)	1.91	18	42.67	0.36
Engineering time	25.6	11	4	1	1	1			31	2(1.72)	1.18	18	44.09	0.61
Simplicity														
Number of interfaces	10.25	4	1	3	2	6	2		65	4(3.61)	1.79	18	37.01	0.40
Maintenance	10.25	5	2	5		6			54	3(3.00)	1.64	18	30.75	0.45
Alt 4-X, Y Plotter														
Effectiveness	7.8			1			2	15	120	7(6.67)	0.97	18	52.00	0.68
Contamination Control														
Operator distance	6.4					5	8	5	108	6(6.00)	0.77	18	38.40	0.74
In grout returns	6.4				2	6	2	8	106	6(5.89)	1.13	18	37.69	0.62
Productivity														
Time to do a square	10.25											0		
Time to move between squares	10.25											0		
Operational Ease	12.8	3	2	3	1	4	4	1	71	4(3.94)	1.98	18	50.49	0.34
Engineering time	25.6	13	1	1	2	1			31	2(1.72)	1.32	18	44.09	0.56
Simplicity														
Number of interfaces	10.25	5	1	1	3	6	1	1	65	4(3.61)	1.97	18	37.01	0.34
Maintenance	10.25	4	4	1		9			60	3(3.33)	1.78	18	34.17	0.41
Alt 5-Crawler/Excavator (Trackhoe)														
Effectiveness	7.8	1	1	3	2	9	1	1	78	4(4.33)	1.46	18	33.80	0.51

	Score													
Primary List	**Weight**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Mean**	**STD**	**n**	**Weighted Total**	**VCC**
Contamination Control														
Operator distance	6.4	1		1	1	1	7	7	104	6(5.78)	1.63	18	36.98	0.46
In grout returns	6.4		1		2	7		8	101	6(5.61)	1.46	18	35.91	0.51
Productivity														
Time to do a square	10.25											0		
Time to move between squares	10.25											0		
Operational Ease	12.8	1	1	2		4	1	9	98	5(5.44)	1.98	18	69.69	0.34
Engineering time	25.6			1	1	4	6	6	105	6(5.83)	1.15	18	149.33	0.62
Simplicity														
Number of interfaces	10.25					7	7	4	105	6(5.83)	0.79	18	59.79	0.74
Maintenance	10.25				3	5	4	6	103	6(5.72)	1.13	18	58.65	0.62
Alt 6-Bridge Crane														
Effectiveness	7.8				1	1	1	15	120	7(6.67)	0.84	18	52.00	0.72
Contamination Control														
Operator distance	6.4						3	15	123	7(6.83)	0.38	18	43.73	0.87
In grout returns	6.4					5	5	8	111	6(6.17)	0.86	18	39.47	0.71
Productivity														
Time to do a square	10.25											0		
Time to move between squares	10.25											0		
Operational Ease	12.8	3	5	1	3	2	1	3	65	4(3.61)	2.15	18	46.22	0.28
Engineering time	25.6	11	3		2	1	1		36	2(2.00)	1.61	18	51.20	0.46
Simplicity														
Number of interfaces	10.25	5	3	2		6	2		59	3(3.28)	1.93	18	33.60	0.36
Maintenance	10.25	5	3	3	1	6			54	3(3.00)	1.68	18	30.75	0.44
Alt 7-Highway Paver														
Effectiveness	7.8	1				5	4	8	106	6(5.89)	1.49	18	45.93	0.50
Contamination Control														

	Score													
Primary List	**Weight**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Mean**	**STD**	**n**	**Weighted Total**	**VCC**
Operator distance	6.4		2		3	3	3	7	98	5(5.44)	1.69	18	34.84	0.44
In grout returns	6.4	1	1		4	5	3	4	90	5(5.00)	1.68	18	32.00	0.44
Productivity														
Time to do a square	10.25											0		
Time to move between squares	10.25											0		
Operational Ease	12.8	2	1	2	4	5	1	3	78	4(4.33)	1.85	18	55.47	0.38
Engineering time	25.6	3	3	3	2	7			61	3(3.39)	1.58	18	86.76	0.47
Simplicity														
Number of interfaces	10.25	1	1	2	2	7	2	3	85	5(4.72)	1.67	18	48.40	0.44
Maintenance	10.25	3	3	2	2	7		1	65	4(3.61)	1.79	18	37.01	0.40

Alternative Scores Within a Criterion

This table shows the distribution of scores (1-7) across the four alternatives for each of the criteria. The number within an alternative/score cell indicates the number of participants that used that score for that alternative. Within a criterion, the alternatives are sorted from the highest to the lowest score.

	Score											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Mean**	**STD**	**n**	**VCC**
1.Effectiveness												
Alt 3-Super Structure				1		3	14	120	7(6.67)	0.77	18	0.74
Alt 6-Bridge Crane				1	1	1	15	120	7(6.67)	0.84	18	0.72
Alt 4-X, Y Plotter			1			2	15	120	7(6.67)	0.97	18	0.68
Alt 7-Highway Paver	1				5	4	8	106	6(5.89)	1.49	18	0.50
Alt 5-Crawler/Excavator	1	1	3	2	9	1	1	78	4(4.33)	1.46	18	0.51
Alt 2-Track Mounted	2	2	2	1	7	1	3	78	4(4.33)	1.94	18	0.35

	Score											
	1	2	3	4	5	6	7	Total	Mean	STD	n	VCC
Alt 1-Crane	5	4	2		7			54	3(3.00)	1.75	18	0.42
2.Contamination Control												
2. Contamination Control												
2.1 In grout returns												
Alt 6-Bridge Crane						3	15	123	7(6.83)	0.38	18	0.87
Alt 3-Super Structure				1	1	2	14	119	7(6.61)	0.85	18	0.72
Alt 4-X, Y Plotter				2	6	2	8	106	6(5.89)	1.13	18	0.62
Alt 5-Crawler/Excavator	1		1	1	1	7	7	104	6(5.78)	1.63	18	0.46
Alt 1-Crane	1	1	1		4	2	9	101	6(5.61)	1.88	18	0.37
Alt 7-Highway Paver		2		3	3	3	7	98	5(5.44)	1.69	18	0.44
Alt 2-Track Mounted	12	1	1		3		1	39	2(2.17)	1.95	18	0.35
2.2 Operator distance												
Alt 6-Bridge Crane					5	5	8	111	6(6.17)	0.86	18	0.71
Alt 4-X, Y Plotter					5	8	5	108	6(6.00)	0.77	18	0.74
Alt 1-Crane		1			5	4	8	107	6(5.94)	1.30	18	0.57
Alt 3-Super Structure				2	6	4	6	104	6(5.78)	1.06	18	0.65
Alt 5-Crawler/Excavator		1		2	7		8	101	6(5.61)	1.46	18	0.51
Alt 7-Highway Paver	1	1		4	5	3	4	90	5(5.00)	1.68	18	0.44
Alt 2-Track Mounted	10	4	1		3			36	2(2.00)	1.50	18	0.50
3.Productivity												
3.1 Time to do a square												
Alt 1-Crane											0	
Alt 2-Track Mounted											0	
Alt 3-Super Structure											0	
Alt 4-X, Y Plotter											0	
Alt 5-Crawler/Excavator											0	
Alt 6-Bridge Crane											0	
Alt 7-Highway Paver											0	

	Score											
	1	2	3	4	5	6	7	Total	Mean	STD	n	VCC
3.2 Time to move between squares												
Alt 1-Crane											0	
Alt 2-Track Mounted											0	
Alt 3-Super Structure											0	
Alt 4-X, Y Plotter											0	
Alt 5-Crawler/Excavator											0	
Alt 6-Bridge Crane											0	
Alt 7-Highway Paver											0	
4.Operational Ease												
Alt 5-Crawler/Excavator	1	1	2		4	1	9	98	5(5.44)	1.98	18	0.34
Alt 2-Track Mounted		3	1	2	2	6	4	91	5(5.06)	1.80	18	0.40
Alt 7-Highway Paver	2	1	2	4	5	1	3	78	4(4.33)	1.85	18	0.38
Alt 1-Crane	1	1	4	3	7	1	1	75	4(4.17)	1.47	18	0.51
Alt 4-X, Y Plotter	3	2	3	1	4	4	1	71	4(3.94)	1.98	18	0.34
Alt 6-Bridge Crane	3	5	1	3	2	1	3	65	4(3.61)	2.15	18	0.28
Alt 3-Super Structure	3	5	3	1	3	2	1	60	3(3.33)	1.91	18	0.36
5.Development/Deployment												
5.1 Engineering Time												
Alt 2-Track Mounted	1	1			1	2	13	111	6(6.17)	1.79	18	0.40
Alt 5-Crawler/Excavator			1	1	4	6	6	105	6(5.83)	1.15	18	0.62
Alt 1-Crane		1	1		8	5	3	96	5(5.33)	1.28	18	0.57
Alt 7-Highway Paver	3	3	3	2	7			61	3(3.39)	1.58	18	0.47
Alt 6-Bridge Crane	11	3		2	1	1		36	2(2.00)	1.61	18	0.46
Alt 3-Super Structure	11	4	1	1	1			31	2(1.72)	1.18	18	0.61
Alt 4-X, Y Plotter	13	1	1	2	1			31	2(1.72)	1.32	18	0.56
6.Simplicity												
6.1 Maintenance												
Alt 5-Crawler/Excavator				3	5	4	6	103	6(5.72)	1.13	18	0.62

	Score											
	1	2	3	4	5	6	7	Total	Mean	STD	n	VCC
Alt 2-Track Mounted		1	1	1	4	3	8	103	6(5.72)	1.53	18	0.49
Alt 1-Crane	1	1		2	7	2	5	93	5(5.17)	1.69	18	0.44
Alt 3-Super Structure	4	1	3	2	6	2		65	4(3.61)	1.79	18	0.40
Alt 7-Highway Paver	3	3	2	2	7		1	65	4(3.61)	1.79	18	0.40
Alt 4-X, Y Plotter	4	4	1		9			60	3(3.33)	1.78	18	0.41
Alt 6-Bridge Crane	5	3	2		6	2		59	3(3.28)	1.93	18	0.36
6.2 Number of interfaces												
Alt 2-Track Mounted		1			3	4	10	111	6(6.17)	1.29	18	0.57
Alt 5-Crawler/Excavator					7	7	4	105	6(5.83)	0.79	18	0.74
Alt 1-Crane			1		11	3	3	97	5(5.39)	0.98	18	0.67
Alt 7-Highway Paver	1	1	2	2	7	2	3	85	5(4.72)	1.67	18	0.44
Alt 4-X, Y Plotter	5	1	1	3	6	1	1	65	4(3.61)	1.97	18	0.34
Alt 3-Super Structure	5	2	5		6			54	3(3.00)	1.64	18	0.45
Alt 6-Bridge Crane	5	3	3	1	6			54	3(3.00)	1.68	18	0.44

ISG Conceptual Design

Preferred Alternative Development

March 25, 2004

On March 25, 2004 a team met to discuss the preferred alternative for the ISG Conceptual Design and develop the Work Breakdown Structure (WBS) for the alternative. The criterion used in the previous meeting was reviewed and special attention was paid to the Productivity criteria. The effect of the productivity score on the alternative was discussed. The preferred alternative, Alternative #5, Trackhoe Drill, was the highest scoring with or without the productivity number included. Following this discussion the remainder of the meeting was used to develop the details of the WBS for the alternative.

This information will be used to define the scope of work for the Design Leads on the project. Task Baseline Agreements will be completed for the leads. The Design Team will continue to meet each Wednesday at 3:30 p.m. in EROB 133.

Information generated during the meeting is included along with the WBS and the Rough-Order-of-Magnitude Estimate for personnel required for each drill operation. These numbers were generated to provide the team with planning numbers for support facilities.

Meeting Participants:

Byron Blakely	Ken Graff	Kim Rogers
Paul Bunnell	Scott Jensen	Peter Shaw
Ernie Carter	Jim Johnesee	Karen Shropshire
Doug Clark	Bill Malone	David Stephens
Al Cram	Dave Nickelson	Elden Thompson
Randy Eastman	AnnMarie Phillips	Linda Seward, Facilitator
Darnell Evans	Brian Raivo	Buck West, Computer Support

Information Needed:

- To what level (depth) do we need to grout? Design of the bit may be affected by the level – what plumbness?
- Clear understanding of data collection requirements – manual vs. electronic or combination – cost – storage - analysis of data.
- Who will run the operation – sub contractor or internal?
- Do we want to increase the dwell time in the 'X' inches of the hole to spread more grout across the bottom (barrier effect)?
- Define/prove performance criteria.
- Would a lubricant in the grout be beneficial?
- Grout loops verses truck delivery.
- Can we have hoses and lines on the SDA?

Assumptions:

- This project is consumer grade.
- The grout set time is about 20 minutes.
- 500 gallons of water will be used for the high volume flush.

Issues:

- Having the measurement within a specified number of inches was not a criterion in the evaluation. With a 2-foot diameter column the instruments will augment to get the positioning we need. The stiffness, rigidity of the drill is similar to all options.
- Cleanout water from the truck delivering grout.
- One large batch plant or several small ones.
- Personnel on the ground in the work area.

Personnel Needs
Per Shift/One Trackhoe Drill

Trackhoe Drill Operator	1.5
High Pressure Pump Operator	1.5
Grout Truck Driver	3.0
Water Truck Driver	3.0
Batch Plant Operator	2.0
RCT	2.0
Industrial Hygiene	0.5
Site Safety Officer	1.0
Instrumentation & Electronics Technician	1.0
Quality Control	1.0
Maintenance	1.0
Construction STR	1.0
Hose Tenders	2.0
General Laborers	2.0
Sampling	1.0

ISG WBS

Track hoe Raivo	Drilling Unit Raivo	Grout Delivery System Cram	Support Facilities Blakely	Diesel Fuel System Eastman	Drill Pipe & Bits Cram	Waste Matrix Grouting Thompson/Shaw	Foundation Grouting Stephens	Utilities Mechanical Eastman	Utilities Electric Graff	Fire Protection Doug Clark	Logistics Thompson
Vendor Search Soil pressure Trackhoe & Drill Unit Interface Hose Management Grout System Interface Measurement Control Interface Cont Control Manufacturer Support Operator ergonomics ≅ 90,000 lb. Class Rigid system/hang drill Vendor provided maint. Trackhoe recovery (throws a track, etc) Enhance filtering on cab WebCam attached to Trackhoe Drill	Vendor search Parts Trackhoe Interface Hose Management Flexible Shroud Bit Maint area Bit change box Verticality sensor Depth feedback Swivel change Rotation & vertical control system Corrective actions Space below jets w/in drill point	HP pump Storage tank Hose Mangmt Batch Plant Delivery Truck Corrective Actions Certify for 10K psi Hydrotest after component change HP hose change before failure HP pump continuous monitoring Diesel vs. electric pumps Soil samples for mix recipe Filter system to screen rocks (solids)	RadCon office Lunchroom Changeroom Shift office Diesel Storage Liquid Additive Storage Silo Grout Storage Maint. & Repairs Contamination control structures Spare Part Storage Sample Mangmt Trailers Contamination (drill shower stall) Decon structure	Storage Pumping LP Hose management Delivery – special tank truck?	Change box Cavity Diameter Deflection Stuck pipe recovery Drill pipe size Drill pipe length Bit change box threads (tolerate misalignment when changing, tolerate dirt when changing) Drill pipe storage Bit selection Bit storage Bit redressing/repair	Soil moisture content Mapping Air travel path Void ratio Define where we grout Type of grout Volume of grout	Soil Moisture Mapping Procedure Void Ratio Areas for foundation grout Sampling Grout type	Compressed air Potable water Sanitation Design descrip. Codes and Stds Design Criteria Technical risks Quality rqmts	A/C power Outdoor lighting Communication Data Management Lines Data collection (position, pressure, RPM, start/end time, flow rate, jet size Lightning protection	Manual Automatic Water supply Chemical Support facilities Operation facilities Equipment systems Firewater supply Fire Hazards Analysis/ Checklist	Daily shutdown & Clean out High volume flush contained Operation cycle Shift change Crew size Track hoe accident rate forecast Daily startup Operational strategy Industrial grouting accident rate Sampling Multiple vehicles Emergency shutdown procedure (recovery plan) Internal emergency Shutdown Annual start up/shut down

Measurement & Control Systems Bunnell	SDA Jensen	Jets Cram	Hoses & Fittings Eastman	Tanks & Vessels Eastman	Support Vehicles Raivo	Radiation Protection/IH Thompson	Regulations Thompson	Grout Storage and Mixing Cram	Secondary Waste Management	Off gas Control Eastman	Grout Jensen/Shaw
Plumbness/Vertical (how accurate – put bounds on) Grout pressure Grout flow Grout set time Drill string position Grout volume Grout returns Emergency shutdown Data Mangmt Operation Risk Data Collection Rad Monitoring IH Monitoring (air monitor) Monitor torque LP gro pump Level sensing for dry mix tank Flush water volume Drill string position for Op. interface Gamma camera Be Block instrumentation lessons	Subsidence Mud Grading – lag time until cap, prevent water pooling Grout returns management Water mgmt Snow removal Roads & Grounds Grout returns management (spray, cover with dirt)	Lift sequence Jet selection – D. Keller about Be spec Jet parameters (size, slope, angle) Changing jets Jet wear Jet plugging Unplugging Nominal RPM 10-15 Changing jets/bits use standard pipe thread	Vendor search Hydrostatic test Hose change out Certification/ Pedigree of components Avoid hydraulic fittings - solids issue Compatibility of hose & fittings - pressure req'ts. Be lessons – D. Keller	Vendor search Dry mix tank (vessel) Dry bulk material storage Water tanks, cement tanks, etc Level sensing Agitate, rotate, mix grout Tank washing/ clean out Tank material	Water truck Bit change box Pump trailer/dozer All terrain forklift Fuel truck Grout truck Mobile support facility Rad Con support vehicle (smears) Road grader Sewer/wastewater truck Flatbed/pickups Golf carts (shuttle)	Monitoring Decontamination Sampling Cover grout returns Rad work permit Safe work permit Air Permitting (EC, APAD, Waste Streams) Sampling (env., rad swipes, grout compressive strength)	Air permitting Sampling requirements VOC release Grout return samples Permitting	LP pump Raw product Storage – rail, trucks? Mixed prod. Storage Mixer – grout specs, quality (measure at grout plant to keep in spec) Grout compression (static instrument measure) Batch plant Mixed product Delivery – grout loop? Flexibility for grout changes	Decon structures Decon equipment Secondary waste storage Waste streams for grout Maintenance waste Waste Character Waste minimization Filters - air, water, grout Hoses Used Drill Bits Permitting Rad Waste Industrial Waste PPE's	VOCs Rad. Contamination Localized ventilation (versus run a small sample tube around the boom rather than an elephant trunk)	Anti-fluid loss (do not want water phase moving away from solid phase) Gel strength (particles stay suspended) Admixtures (critical recipe for density and viscosity measures) Set time Robustness to handle a variety of material in the trenches

Apply the following to appropriate WBS Areas:	
• Design description	• Technical risks
• Design Criteria	• Quality Requirements
• Codes and Standards	• Operation Risks
• Maintenance Requirements	• Drawings
• EDF's	

Attachment 1

TFR-267, "Requirements for the OU 7-13/14 In Situ Grouting Project (Customer, Project, and System)"

TO VIEW ATTACHMENT 1 SEE:

TFR-267, REV.00

Attachment 2

TFR-269, “Requirements (Subsystem) for the OU 7-13/14 In Situ Grouting Project”

TO VIEW ATTACHMENT 2 SEE:

TFR-269, REV.00

Attachment 3

TFR-280, “Requirements (Assumptions) for the OU 7-13/14 In Situ Grouting Project”

TO VIEW ATTACHMENT 3 SEE:

TFR-280, REV.00

Attachment 4

EDF-5146, “OU 7-13/14 In Situ Grouting Project Grout Selection Basis”

TO VIEW ATTACHMENT 4 SEE:

EDF-5146, REV.00

Attachment 5

EDF-5028, "OU 7-13/14 In Situ Grouting Project Foundation Grouting Study"

TO VIEW ATTACHMENT 5 SEE:

EDF-5028, REV.00

Attachment 6

EDF-5147, "OU 7-13/14 In Situ Grouting Project Subsurface Disposal Area Site Conditions"

TO VIEW ATTACHMENT 6 SEE:

EDF-5147, REV.00

Attachment 7

EDF-5153, “OU 7-13/14 In Situ Grouting Project Hydraulic Excavator and Drill-Injection Rig”

TO VIEW ATTACHMENT 7 SEE:

EDF-5153, REV.00

Attachment 8

EDF-5155, “OU 7-13/14 In Situ Grouting Project Operations, Maintenance, and Logistics”

TO VIEW ATTACHMENT 8 SEE:

EDF-5155, REV.00

Attachment 9

EDF-5135, “OU 7-13/14 In Situ Grouting Project Grout Storage and Mixing”

TO VIEW ATTACHMENT 9 SEE:

EDF-5135, REV.00

Attachment 10

EDF-5102, “OU 7-13/14 In Situ Grouting Project Grout Delivery System”

TO VIEW ATTACHMENT 10 SEE:

EDF-5102, REV.00

Attachment 11

EDF-5144, “OU 7-13/14 In Situ Grouting Project Support Facilities”

TO VIEW ATTACHMENT 11 SEE:

EDF-5144, REV.00

Attachment 12

EDF-4933, “OU 7-13/14 In Situ Grouting Project Measurement and Control”

TO VIEW ATTACHMENT 12 SEE:

EDF-4933, REV.00

Attachment 13

EDF-5122, “OU 7-13/14 In Situ Grouting Project Electrical Utilities”

TO VIEW ATTACHMENT 13 SEE:

EDF-5122, REV.00

Attachment 14

EDF-5150, “OU 7-13/14 In Situ Grouting Project Support Systems”

TO VIEW ATTACHMENT 14 SEE:

EDF-5150, REV.00

Attachment 15

EDF-5054, “OU 7-13/14 In Situ Grouting Project Fire Protection”

TO VIEW ATTACHMENT 15 SEE:

EDF-5054, REV.00

Attachment 16

EDF-5162, “OU 7-13/14 In Situ Grouting Project Support Vehicles”

TO VIEW ATTACHMENT 16 SEE:

EDF-5162, REV.00

Attachment 17

EDF-5152, “OU 7-13/14 In Situ Grouting Project Environmental, Safety, and Health”

TO VIEW ATTACHMENT 17 SEE:

EDF-5152, REV.00