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TECHNOLOGY EVALUATION REPORT

SITE PROGRAM DEMONSTRATION OF A TRIAL EXCAVATION AT THE MCCOLL SUPERFUND SITE

RISK REDUCTION ENGINEERING LABORATORY OFFICE OF RESEARCH AND DEVELOPMENT U.S. ENVIRONMENTAL PROTECTION AGENCY CINCINNATI, OHIO 45268

NOTICE

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FOREWORD

The Superfund Innovative Technology Evaluation (SITE) program was authorized in the 1986 Superfund amendments. The program is a joint effort between EPA's Office of Research and Development and Office of Solid Waste and Emergency Response. The purpose of the program is to assist the development of hazardous waste treatment technologies necessary to implement new cleanup standards which require greater reliance on permanent remedies. This is accomplished through technology demonstrations which are designed to provide engineering and cost data on selected technologies.

This project describes the trial excavation performed at the McColl Hazardous Waste Site. Excavation at this site presented unique problems due to the high potential for release of sulfur dioxide and volatile odorous compounds contained in the waste. The excavation demonstration was used to obtain information on the utilization of an enclosure and associated air treatment systems around the excavation to minimize air emissions, and the use of foam vapor suppressants to reduce emissions from the waste during excavation. In addition, information was obtained on processing the tar fraction of this waste by mixing with cement and fly ash.

> E. Timothy Oppelt, Director Risk Reduction Engineering Laboratory

ABSTRACT

A trial excavation of approximately 137 cubic yards of waste was performed at the McColl Superfund Site in Fullerton, CA to better determine the nature of this waste, any treatment needed to improve its handling characteristics, and the extent of air emissions that might occur during excavation. This type of information is necessary to plan full-scale remediation of this highly acidic petroleum refinery waste buried at this site. The trial excavation was conducted within a temporary enclosure with air exhausted from the enclosure through a sodium hydroxide-based wet scrubber and activated-carbon bed adsorber to reduce air emissions of sulfur dioxide and organic compounds. Foam was used in an attempt to suppress atmospheric releases from the raw waste during excavation, storage, and processing. The air exhaust was monitored for total hydrocarbons and sulfur dioxide before and after the air emission control system. In addition, total hydrocarbons and sulfur dioxide were monitored along the site perimeter to determine potential impact of air emissions on the nearby community.

This waste consisted of layers of overburden, mud, tar, and char. Excavation was conducted with a track hoe and the waste was separated into stockpiles of mud, tar, and char for subsequent study and experimentation. Upon completion of the work, the waste was replaced into the excavation pit and covered with topsoil to minimize atmospheric releases.

This report describes the equipment used to measure and control emissions, the excavation progress, and resulting emissions before and after the air control system. An assessment of the foam vapor suppressants is also provided as well as information on the costs incurred for the field portion of this study. The information contained in this report will assist in planning the full-scale remediation of the McColl site and other similar waste sites throughout the country.

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(Note: Appendices A through i, as referenced here and in the body of the report, are available in limited number. Please mail your request to: Jack Hubbard, U.S. Environmental Protection Agency. 26 West Martin Luther King Drive, Cincinnati, OH 45268.)

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ABBREVIATIONS AND SYMBOLS

AA	Atomic Absorption
acfm	Actual cubic feet per minute
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
BNA	Base neutral/acid (extractable)
CAM-WET	California Wet Extraction Test for Metals
CEM	Continuous Emission Monitor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
cm/s	Centimeters per second
cfm	Cubic feet per minute
ft ³	Cubic feet
yd ³	Cubic yard
DAS	Data acquisition system
DSA	Drum storage area
EPA	Environmental Protection Agency
EP Tox	Extraction Procedure Toxicity Test-leach test
FID	Flame ionization detector
ft/s	Feet per second
g/mL	Grams per milliliter
GC/MS	Gas chromatograph/mass spectrometer
h	Hour
hp	Horsepower

ABBREVIATIONS AND SYMBOLS (continued)

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HSWA	Hazardous and Solid Waste Amendments to RCRA-1984
ICP	Inductively-coupled plasma
kW	Kilowatt(s)
lb/min	pounds per minute
m/s	meters per second
MDL	Method detection limit
mg/kg	Milligrams per killogram
mg/m²/min	Milligrams per square meter per minute
mg/L	Milligrams per liter
mL/g	Milliliters per gram
NCP	National Contingency Plan
NPL	National Priorities List
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Act
OSWER	Office of Solid Waste and Emergency Response
PAHs	Polycyclic aromatic hydrocarbon
Pb	Lead
PID	Photo ionization detector
ррb	Parts per billion
PPE	Personal protection equipment
ppm	Parts per million
psi	Pounds per square inch
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act of 1976
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative Percent Difference
RREL	Risk Reduction Engineering Laboratory

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ABBREVIATIONS AND SYMBOLS (continued)

SARA	Superfund Amendments and Reauthorization Act of 1986				
SITE	Superfund Innovative Technology Evaluation Program				
so ₂	Sulfur dioxide				
TCEP	Totally encapsulating chemical suit				
TCLP	Toxicity Characteristic Leaching Procedure				
THC	Total hydrocarbons				
тимнс	Total nonmethane hydrocarbons				
TOC	Total organic carbon				
TSCA	Toxic Substances Control Act of 1985				
μm	Micrometer				
µg/L	Micrograms per liter				
µg/m³	Micrograms per cubic meter				
VOC	Volatile organic compound				

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SECTION 1

EXECUTIVE SUMMARY

Region IX of the U.S. Environmental Protection Agency (EPA), in cooperation with EPA's Air and Energy Engineering Research Laboratory (AEERL), and EPA's Superfund Innovative Technology Evaluation (SITE) Program, and with assistance from the California Department of Health Services (DHS), conducted a trial waste excavation project at the McColl Superfund site in Fullerton, California.

The information gained from the trial excavation will be presented in two separate reports. This report (Technical Evaluation Report) will present the raw data collected during the trial excavation and analysis. An Application Analysis (AA) Report will follow this report. The AA report will analyze the data presented in this report in more detail, and will evaluate the application of technologies used during the trial excavation to the final remediation of McColl and other Superfund sites.

In the early to mid-1940's, the McColl site was used for disposal of acidic refinery sludge, and in 1982, it was placed on the National Priorities List (NPL). The McColl waste is known to release volatile organic compounds (VOCs) and sulfur dioxide (SO₂) whenever disturbed. Since 1984, the entire site has been covered with soil in an attempt to minimize atmospheric emissions of VOCs and SO₂.

In February 1989, EPA and DHS issued a proposed plan for the McColl project selecting thermal destruction, either on or off site, as the preferred remedy. An important component of this remedy is the excavation and waste-handling activities that must occur as a precursor to thermal destruction. The overall goal of the trial excavation was to obtain information pertaining to these activities to support the selection of thermal destruction as the preferred remedy and to aid in the design of a thermal destruction remedy after its selection in a Record of Decision (ROD).

EPA determined that the trial excavation was necessary to ascertain if the McColl waste could be excavated with conventional equipment without releasing significant amounts of VOCs and SO_2 to the surrounding community. The trial excavation was also necessary to define the treatment needed, if any, to improve the handling characteristics of the waste as a precursor to thermal destruction.

1.1 Objectives

The trial excavation was conducted on a portion of the Los Coyotes sump L-4 (see Figure 10 in Section 3). The objectives of the trial excavation are presented below. Based on the goal and objectives of the project, EPA believes that the trial excavation was successful and significant information was obtained that will be useful in the design phase of the McColl remediation process.

Objective 1: To excavate approximately 100 yards of waste to assess wastehandling characteristics and to determine if any treatment is required to improve handling characteristics as a precursor to thermal destruction.

More than 130 solid cubic yards of waste material (mud, tar, and char) was excavated under the enclosure using conventional excavation methods (Table 9).

During the trial excavation, it was determined that the mud and char material did not need further treatment. For the mud, it was apparent that the waste could be easily sized to the nominal 2-inch-diameter thermal destruction requirement. For the char, it was determined that more than 50 percent of the excavated char was under 2 inches in diameter and that the remaining material could easily be sized using conventional methods [i.e., pug mill, shredder (Section 4.5.3)].

The tar material was determined to require additional treatment to allow for future processing into a thermal destruction unit. This was accomplished by mixing the tar with cement or fly ash and water in a pug mill. The result of this treatment process was pellets that were less than 2 inches in diameter (Section 4.5.1).

Objective 2: To determine the atmospheric emissions resulting from the excavation activities.

This objective was only partially achieved during the trial excavation. Data for SO_2 and total hydrocarbons (THC) are reported; however, no data for organic species or reduced sulfur species are reported.

High quality data were obtained for SO_2 and THC emissions exiting the enclosure exhaust treatment system. Five-minute averages for SO_2 emissions were maintained at less than 1 ppm throughout the project. The highest 5-minute average for THC emissions was 98.1 ppm (Sections 4.2 through 4.4).

Samples for organic and reduced sulfur compounds were collected from the stack and analyzed, but were determined invalid by an EPA audit (Section 4.3).

It is known that benzene (a known carcinogen), toluene, ethyl benzene, and xylenes are the major constituents of the THC concentrations reported, but no quantifiable concentrations for these compounds can be reported for the reason listed above.

Objective 3: To assess the degree of SO_2 and THC emission control achieved through the use of an enclosure and an enclosure exhaust treatment system.

This objective was achieved by erecting an enclosure around the excavation area and exhausting the ventilation air through an enclosure exhaust treatment system consisting of a sodium-hydroxide wet scrubber and an activated carbon unit.

The daily average removal efficiency for SO_2 ranged from 71.8 percent to 99.9 percent with the majority of the days achieving over 90 percent removal (Table 20).

The daily average removal efficiency for THC ranged from 15.8 percent to 90.7 percent with the majority of the days achieving over 50 percent removal (Table 21).

Objective 4: To determine the emission levels for SO_2 and VOCs at the fenceline of the McColl site as an indicator of impacts on the local community.

This objective was partially achieved for the reasons outlined in Objective 2. Reliable data for SO_2 and THC emissions were collected at four perimeter monitoring stations (see Figure 66 in Section 4) with no levels being detected that would adversely affect the surrounding community (Section 4.2).

Samples for organic and reduced sulfur compounds were collected at the fence-line and in the community and analyzed, but were determined invalid by an EPA audit (Section 4.3).

It is known that benzene (a known carcinogen), toluene, ethyl benzene, and xylenes are the major constituents of the THC concentrations reported, but no quantifiable concentrations for these compounds can be reported for the reason listed above.

Objective 5: To assess the effectiveness of vapor-suppressing foam.

This objective was partially achieved. Reduction efficiency rates have been calculated for dynamic conditions. Reduction efficiency rates could not be calculated for static conditions because analytical data were determined invalid by an EPA audit.

In dynamic conditions, it has been estimated that the vapor-suppression foam can be up to 80 percent effective for SO_2 control and 60 percent effective for THC control (Section 4.4).

Static flux chamber measurements were conducted on the mud, tar, and char within the enclosure. The gas streams from these tests were analyzed for organic compounds and reduced-sulfur compounds. An EPA audit, however, determined the data to be invalid (Section 4.4.2).

Objective 6: To assess potential problems that might occur during excavation.

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Assessments were made regarding problems that occurred due to the following: higher-than-expected emissions of SO_2 and THC from the tar and char; high particulate diesel emissions; heat gain; working in Level B and Level A; excess water in a confined space; and seepage of tar material (Section 4.6).

1.2 Excavation and Waste Processing

Removal of overburden and excavation of the underlying waste were readily performed with a trackhoe equipped with an extended boom and a 1-yd³ bucket. The waste, which was found to be fairly well segregated into layers, was placed in roll-off bins or piles for subsequent use. Removal of the overburden proceeded routinely, followed by excavation of a 3-foot-thick mud layer. A 4-foot-thick tar layer was excavated next. After the tar was removed, a trench shield was placed in the excavated area to reduce seepage of additional tar into the opening. After the tar layer was excavated, a hard, coal-like, char layer was encountered. This material was broken up and excavated ed with the trackhoe.

During the tar excavation, SO_2 and THC levels within the enclosure increased dramatically and reached 5-minute average values of 1000 (June 12th) and 492 ppm (June 14), respectively. The enclosure exhaust treatment system removed up to 99.9 percent of the SO_2 and 60 percent of the THC during this excavation period. The use of the enclosure and enclosure exhaust treatment system prevented any significant amounts of these pollutants from reaching the site perimeter, as evidenced by the low concentrations measured there. Detailed air concentrations data are presented in Section 4 and Appendix B. The higher-than-expected concentrations within the enclosure required an upgrading of personal protection equipment to Level A (completely encapsulated suit with supplied air).

Char excavation was also accompanied by high concentrations of SO_2 and THC, reaching 5-minute average values of 755 and 350 ppm, respectively. The enclosure exhaust treatment system operated efficiently during the entire study with up to 99 percent removal of the SO_2 and up to 90.7 percent removal of the THC.

Higher-than-expected levels of SO₂ and THC within the enclosure were caused by the failure of vapor-suppressing foams to form an impermeable membrane over the exposed wastes. The foams reacted with the extremely acidic waste, which severely impacted the foam's ability to suppress emissions. This ability was improved somewhat, however, when the concentration of foam reagents in water was increased. Though difficult to estimate, the overall reduction achieved by applying foam was estimated at up to 80 percent for SO₂ and 60 percent for THC, based on concentrations measured at the enclosure exhaust treatment system inlet during excavation activities with and without foam.

In all, 137 yd³ of waste and 101 yd³ of overburden were excavated. Maximum and average trial excavation rates are summarized in Table 1.

TABLE 1. MAXIMUM AND AVERAGE TRIAL EXCAVATION RATES (yd ³ /h)				
Component	Maximum	Average		
Overburden	51	7.6		
Mud	66	4.1		
Tar	58	4.3		
Char	9	2.6		

The average excavation rates achieved during this trial excavation will be increased considerably during full-scale excavation as fewer observations and measurements would be needed. Anticipated average excavation rates that could be achieved during full-scale excavation are estimated at 49, 32, and 25 yd³/h for overburden and mud, tar, and char, respectively.

The tar waste was further processed to reduce its size and to form a solid and easier-to-handle pellet. This was accomplished by mixing the tar with cement, fly ash, and water in a pug mill. Ten test runs were made within the enclosure at various ratios of tar, cement, fly ash, and water. A ratio of 1 part tar to between 2.3 and 7 parts cement and fly ash and from 0.26 to 1 part water formed a solid, easy-to-handle pellet. Tar processing rates of approximately 3 tons/h were achieved during the trial excavation, and it is estimated that this rate could be increased by up to a factor of 2 with a more continuous operation. Indications were evident that tar processing with alkaline materials such as cement and fly ash reduced the amount of SO₂ released by the tar. The mud and char waste fractions did not require further processing, but could have been fed through the pug mill, if necessary.

1.3 Air Emission Controls

Previous investigations at the McColl site indicated that the waste has the potential to emit significant amounts of VOCs, organic sulfur compounds, and SO_2 . For this reason, excavation of the waste could potentially have significant air emission impacts on workers and the community.

For the trial excavation, this potential air emission impact was mitigated from a community impact standpoint by the erection of a temporary enclosure 60 feet wide, 160 feet long, and 26 feet high at the center over the excavation area. Air from the enclosure was vented through an enclosure exhaust treatment system consisting of a sodium-hydroxide-based wet scrubber and an activated-carbon adsorber in series before being released to the ambient air.

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For the trial excavation, this potential air emission impact was mitigated from a worker impact standpoint by having workers wear Level B or Level A protection at all times while inside the enclosure.

Concentrations of SO₂ and THC were continuously monitored before and after the enclosure exhaust treatment system. As part of a supplemental sampling and analytical effort, samples for speciation of organic and reduced sulfur compounds occurred at the stack inlet and outlet, fence-line, and in the community. However, these data are not reported because of invalidation by an EPA audit. The basis for the enclosure exhaust treatment system design is presented in Appendix D.

1.4 Waste Characterization

Samples of excavated waste were analyzed to determine heat value and the concentrations of selected constituents. The information obtained by these analyses is summarized in Table 2, based on information presented in Subsection 4.7.

TABLE 2. WASTE CHARACTERISTICS, AS-RECEIVED BASIS					
	Mud	Tar	Treated tar	Char	
Moisture, %	13.2	11.6	8.1	21.2	
Sulfur, %	0.8	10.6	3.6	4.5	
Fixed carbon, %	0.2	16.9	2.0	4.0	
Ash, %	82.9	1.6	75.9	54.7	
Benzene, ppm	<0.7	240	NAG	97	
Toluene, ppm	1.5	580	NA	150	
Xylene, ppm	8.6	910	NA	220	
Ethylbenzene, ppm	0.9	140	NA	35	
Heat value, Btu/1b	<500	9160	2200	5200	

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NA = Not analyzed. Use of cement additive would reduce concentrations found in raw tar sample.

Toxicity characteristics of the raw tar and char were determined by the Toxicity Characteristics Leaching Procedure (TCLP) and California Wet Test. No metal constituents exceeded the regulatory limit in either case. Benzene in the tar and char waste extract exceeded the EPA TCLP limit of 500 μ g/liter by greater than a factor of 2.

1.5 Community Impact

Perimeter air monitoring for SO_2 and THC was conducted continually during this study. Windspeed and direction were also recorded continually at the site. This information was obtained to comply with the Community Contingency Plan, which mandates that all site work be stopped if SO_2 levels at the perimeter exceed 0.5 ppm for 5 minutes or if THC levels exceed 70 ppm for 30 seconds. These levels were never reached during this study. The maximum 1-hour readings obtained at any perimeter station in June, which was the period of highest emissions from the waste, were 0.08 ppm for SO₂ and 21.9 ppm for THC.

Specific compounds in the air at the perimeter and in the neighborhood were sampled and analyzed; however, these data are not included in this report because they were deemed invalid by an EPA audit.

1.6 Costs of Excavation and Tar Processing

The costs for the field aspects of this trial excavation work consisted of those involved with the enclosure and enclosure exhaust treatment system, actual excavation labor and equipment, foam application, tar processing, and air monitoring. Much of the equipment for this project (e.g., enclosure framework, scrubber, and excavation machinery) was rented on a monthly basis; therefore, total costs were comprised of the monthly machinery charges, labor, and fixed costs required to mobilize and demobilize. These costs, which are presented in Section 6 of this report, are summarized in Table 3 for the 2-month duration of the field work.

Item	Total cost, \$
Enclosure Air exhaust control system Foam vapor suppressants Excavation Tar processing Air monitoring	70,976 40,415 89,591 82,512 17,367 <u>100,160</u>
Total	401,021
2	

TABLE 3. SUMMARY OF ONSITE COSTS

^a Based on 18 days of excavation.

1.7 Conclusions

This section presents the conclusion reached from the data obtained during the trial excavation. It is important to remember that the trial excavation was a research

project designed to gather information for use in the design of the final remediation for Superfund sites and specifically for the McColl Superfund site in Fullerton, California. 2

The overall goal of the trial excavation was to obtain information pertaining to excavation and waste-handling activities to support the selection of thermal destruction as the preferred remedy and to aid in the design of a thermal destruction remedy after selection in a Record of Decision (ROD). An important question to answer with information from the trial excavation is whether the McColl waste can be excavated with conventional equipment without significant impacts to the community. Based on this goal, the following conclusions have been reached pertaining to the trial excavation:

- Excavation of more than 130 solid cubic yards of waste material from sump L-4 was accomplished with conventional excavation equipment without significant adverse impacts on the community.
- Excavation under an enclosure is technically feasible.

The enclosure used during the trial excavation was successfully operated at or near negative pressure, which allowed for emissions generated during the excavation activities to be processed through an enclosure exhaust treatment system consisting of a sodium hydroxide wet scrubber and an activated carbon unit.

Although unanticipated problems during the trial excavation impeded the ability to excavate under the enclosure, EPA believes that these problems can be resolved by engineering practices during the design of the final remedy. The most important impediment of the trial excavation was the higher-than-expected THC and SO₂ emissions within the enclosure.

The higher-than-expected emissions of SO_2 and THC during the trial excavation necessitated upgrading the personal protective equipment for the workers within the enclosure from Level B protection to Level A protection (completely enclosed chemical-resistant suit with supplied air).

During the final remediation of McColl, the high emission rates of SO_2 and THC could still occur and the collection and treatment of the emissions generated using an enclosure and enclosure exhaust treatment system is appropriate and recommended.

- Excavation and waste handling activities are not technically feasible without an enclosure and enclosure exhaust treatment system.
- SO₂ emissions generated from the excavation activities can be effectively treated (up to 99% removal efficiency) using existing technologies.

The high SO_2 emissions entering the sodium hydroxide wet scrubber were efficiently treated to less than 1 ppm throughout the trial excavation. The removal efficiencies were greater than 95 percent for the majority of the trial excavation and reached up to 99 percent removal.

THC emissions generated from the excavation activities can be effectively treated (up to 90.7% removal efficiency) using existing technologies.

Although the THC emissions were not controlled as effectively as expected (greater than 90%) with activated carbon, the removal efficiency ranged from 40 to 90.7 percent throughout the trial excavation. EPA believes that the less-than-expected removal efficiencies can be remedied during the design phase of the final remediation. Therefore, based on other experiences with activated carbon, it is an appropriate technology for removal of organics entering the enclosure exhaust control system.

The waste material was successfully treated to improve its handling characteristic so as to allow easy processing into a thermal destruction unit, if desired.

Visual observations indicated that the char and mud fraction of the waste did not need further size reduction to ensure easy processing into a thermal destruction unit. It was determined that more than 50 percent of the char material excavated was less than 2 inches in diameter (the criterion for solids processed into a thermal destruction unit) and that the remaining other material could be easily processed with conventional equipment (i.e., pug mill, shredder, etc.).

The tar material was treated with mixtures of cement, fly ash, and water in a pug mill. Both the cement and fly ash worked well in improving the handling characteristics of the tar material. The field test has shown that the optimum ratio (pound/pound) of tar to char/fly ash has ranged from 1:7 to 2.3:7. Mixtures within this range produced an easily handled solid with the majority of the material being less than 2 inches in diameter.

Excavation and treatment of the waste material at McColl can be effectively performed by workers in protective clothing.

All excavation and treatment during the trial excavation were performed with workers in either Level B or Level A protective clothing within the enclosure. Although productivity is affected when employee work is conducted in protective clothing, the trial excavation demonstrated that conventional excavation equipment can be effectively operated in both Level B and Level A protective gear. Processing of the tar material also was conducted effectively in both levels of protection.

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The trial excavation had no significant adverse impacts (i.e., exceedance of health-based levels established in the McColl Contingency Plan) on the surrounding community.

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Based on personnel observations during the trial excavation, the noise level related to the excavation and treatment activities was minimal. At no time during the trial excavation were the health-based levels (established in the McColl contingency plan for SO_2 and THC) exceeded at the fence-line monitoring stations. Although odor complaints were received during the trial excavation period, they were not excessive. Most of the complaints were received after the trial excavation/treatment activities were completed for the day, and may not have been related to the excavation/treatment activities.

The vapor-suppressing foam did not perform as anticipated in controlling SO₂ and THC emission within the enclosure, and cannot be relied upon exclusively to control emissions during activity-related waste disturbances.

Because analytical data were deemed invalid as a result of an EPA audit, no results are available concerning the static effectiveness of the vaporsuppressing foam in relation to the McColl waste.

Visual observations and dynamic-condition calculations, however, indicate that the vapor-suppressing foam was not as efficient as anticipated in controlling emissions from activities related to excavating and processing the waste. Visual observations indicated that the foam chemically reacted with the McColl waste, which inhibited its ability to form a vaporsuppressing seal on the waste. This reaction caused the foam to change color (from yellow to red and orange) and to disintegrate before forming a seal on the waste.

Dynamic-condition calculations indicated that the effectiveness of the vapor-suppressing foam ranges from 50 to 80 percent, depending on the activity and the compound of concern.

Based on toxicity characteristic leaching procedure (TCLP) results on the raw waste, it has been determined that the waste would not pass the RCRA Land Ban toxicity characteristics (TC Rule) requirement for benzene in the char and tar.

1.8 Observations

This section lists observations made regarding activities that occurred during the trial excavation. These observations are qualitative in nature, and no quantitative data exists to support them; however, they represent best engineering judgment in relation to activities related to the trial excavation.

- It is believed that community communication on this project was effective, and a necessary part of the project. The community interaction was important to the success of the trial excavation and to the passive odor and health effects survey conducted by the California Department of Health Services.
- Excess water introduced into the enclosure through the foaming activities had a significant impact on operations within the enclosure. The excess water made the ground surface slippery for both workers and equipment.
- Based on visual observation and qualitative calculations, it has been determined that the trench shield was a very effective tool in minimizing the amount of tar material that could seep into the excavation area. It was also determined that the trench shield was not needed to shore up the soils or char material within the excavation area.
- Having workers in Level A protective gear adversely affected their productivity and communication, but did not make excavation activities unfeasible.
- Lower airflow rates through the activated carbon unit increased the THC removal efficiencies. This supports the theory that residence time is a critical factor in the ability of activated carbon to remove organic compounds in an air stream.
- Contrary to original plans, EPA had to move major equipment into and out of the enclosure during operations. It has been determined that no adverse impacts on the community or workers resulted from opening the enclosure for short periods of time (under 1 hour) to allow for efficient equipment movement.
- It is believed that the pug mill, based on the results of the tar processing, could be used to process the char and mud fractions of the McColl waste effectively for use in a thermal destruction remedy.

Due to tar seepage into the excavation area, approximately 100 cubic yards of material could not be replaced into the excavation pit at the completion of the project. This material was stockpiled on site in the staging area under a plastic liner covered by topsoil.

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- It is believed that under true field conditions (not research-restricted conditions) the excavation rating associated with the equipment could be achieved. The excavation rates achieved during the trial excavation were artificially constrained to allow for data collected and visual observations. The excavation rates were also constrained by unexpected high SO₂ and THC emissions rates.
- The observation camera used was an invaluable tool in observing/ recording activities that occurred within the enclosure. The camera also allowed all workers to be observed from a health and safety standpoint. The camera also assisted in reducing the number of employees necessary within the enclosure, which allowed for more efficient operations and reduced the risk of employee accidents.

SECTION 2

DESCRIPTION OF TECHNOLOGIES

A number of measures were implemented during excavation operations to ensure that these operations did not create a public health impact. These measures were aimed at controlling air emission releases from the operations, since this was the only potential source of impact expected. The following measures were implemented for this purpose:

- Use of enclosure structure
- SO₂ scrubber
- Activated carbon unit
- Use of vapor-suppressing foam

Waste processing technologies planned during this program consisted of size reduction by crushing the char and mud wastes, and tar solidification using cement and fly ash mixtures.

2.1 Enclosure and Exhaust Air Control System

2.1.1 Excavation Enclosure

A rigid-frame, PVC-covered enclosure structure was erected over part of the L-4 sump and adjoining land prior to the start of excavation. Before its erection, the site was graded to provide a smooth, level area. The enclosure, supplied by Sprung Instant Structures and shown in Figures 1 and 2, was nominally 60 feet wide by 157 feet long, and 26 feet high at the center. The white, opaque PVC cover was 26 mils thick and impervious to gaseous emissions. The lower edge was covered by 12 to 18 inches of soil along the ground level to prevent air leakage. Translucent panels located along the roof peak allowed light to enter. Personnel entry was through an airlock door which minimized fugitive emissions during entry. Equipment was moved inside the enclosure through a sliding door that was 14 feet high and 9 feet, 5 inches wide.

The volume of the enclosure was approximately 192,000 ft^3 and air was drawn through the building at a rate of approximately 1,000 ft^3 /min. This air entered the



Figure 1. Enclosure plan and section.

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View from east side.



View from west side showing air emission control system and monitoring trailer.

Figure 2. Excavation site enclosure.

building through five small adjustable slot type air vents and was exhausted through three dampered openings along the west side of the building. This exhaust system provided an air turnover rate of about 7 air changes per day and maintained a slight negative pressure of about 0.005 inch of water inside the enclosure. This ventilation air rate was based on maintaining the SO₂ level in the enclosure below 100 ppm. This was in turn based on an estimated SO₂ release from the exposed waste and a 95 percent reduction in these releases by use of foam suppressants.

The enclosure proved to be very effective in preventing the escape of any air emissions and proved quite satisfactory even though it made for a confined work space and increased temperatures approximately 20°F above the outdoor temperature.

2.1.2 Air Emission Control System

The enclosure ventilation air was passed through an emission control system consisting of a wet scrubber and activated carbon bed in series, followed by a fan and vent stack as shown in Figures 3 and 4. The basis for design of the air control system is provided in Appendix D.

Wet Scrubber

A counter-flow packed-bed wet scrubber that used sodium hydroxide (NaOH) in water mixture was used to control sulfur dioxide emissions. The system was designed for a nominal gas flow rate of 1,000 ft³/min at 1000°F and a maximum outlet SO₂ concentration of 2 ppm. The maximum inlet SO₂ concentration was estimated to be 200 ppm and the required control efficiency was therefore 99 percent. A maximum pressure drop of 10 inches of water was specified. The scrubber selected based on these specifications was supplied by Interel Corp. in Englewood, Colorado. The specification for the actual scrubber and fan are shown in Table 4 and the scrubber cross-section is shown in Figure 5.

In operation, scrubber liquid was initially maintained at a pH of 10 to 13. Considerable scrubber liquor foaming was encountered at this pH level, and the pH was reduced to the 7 to 10 range after operation showed that high SO₂ removal could be maintained in this range without foaming. The nominal liquor recirculation rate of 20 gpm provided a liquor-to-gas ratio (L/G) of 20 gallons per 1000 ft³/min.

Activated Carbon Bed

To reduce emissions of volatile organic compounds, a granular activated carbon bed was installed after the wet scrubber. A knockout chamber was inserted between the scrubber and carbon bed to trap any liquid carryover from the scrubber. Specifications for this adsorber called for a 95 percent minimum removal of total



Figure 3. Ventilation air cleaning equipment general arrangement.

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Figure 4. Ventilation air cleaning equipment and ducting layout.

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TABLE 4. SCRUBBER AND FAN SPECIFICATIONS^a

<u>Scrubber</u>

Scrubber size GWX 1200_ 1,200 ft³/min Design flowrate 24 inches Diameter 190 gallons Sump capacity Circulation rate 25 GPM Pump motor 1.5 hp 2-inch hollow spheres Type of packing Packing height 11 feet Scrubber overall height 17 feet Type of mist eliminator Chevron Empty weight 650 lb Operating weight PURCHASE PRICE 2350 lb \$22,600.00 Fan Material of construction Steel Polyurethane Corrosion resistant coating Gas flowrate (standard air density) 1,200 ft/min Static pressure (Neg/Pos) 20 inches WG Motor rating 7.5 hp PURCHASE PRICE: \$2,200.00

^a Supplied by Interel Corp. 5/14/90



Figure 5. Scrubber cross section.
organics at a flow rate of 1000 ft³/min at 100 • F and a pressure drop not to exceed 5 inches of water.

A radial flow type packed bed carbon adsorber was selected from Tigg Corp. in Pittsburgh, PA (NIXTOX Model 1500). Specifications for this unit are shown in Table 5.

Flow rate, max. Temperature, max. Connections Diameter/height Adsorbent fill Minimum contact Shipping weight Materials of construction	1500 ft ³ /min 350°F 7-in. duct 32-in./44-in. 300 lb virgin TIGG 5C 0410 (coal-based) 0.4 seconds 475 lb Coated mild steel with 316 stainless steel screen
Purchase price	<pre>\$2450 FOB plant (including initial carbon fill)</pre>
Lease payment per month Virgin TIGG 5C 0410, per fill	\$700 \$600

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TABLE 5.	SPECIFICATIONS	FOR	CARBON	BED	ADSORBER

^a From Tigg Corporation, March 3, 1990.

2.2 Foam Vapor Suppressants

Two types of water-based commercially available foam supplied by 3-M Corporation were selected for this study: a temporary foam that is effective for up to about 1 hour, and a stabilized more permanent foam that is effective for at least one day. These foam reagents are mixed with water and sprayed onto the waste through a hand-held nozzle. The temporary foam is a mixture of 6 percent concentrate and 94 percent water, and the more permanent foam is produced by adding 6 percent of the stabilizer to the temporary foam mixture. The foam was generated in a self-contained, trailer mounted system (Boots & Coots Model 100) outside of the enclosure and pumped through a hose that passed under the enclosure's edge to an air-aspirating nozzle. The temporary foam was sprayed on freshly excavated waste surfaces in the excavation pit and on waste in storage areas. Stabilized foam was sprayed on all exposed waste after completing each day's work. According to 3M, 200 gallons of foam concentrate (FX 9162) and 200 gallons of foam stabilizer (FX 9161) are required to form a 1-inch-thick layer over 1 acre of surface, or about 0.9 gallon per 100 ft². The properties of the two types of foam used in this work are shown in Table 6.

Properties	FX-9161 foam stabilizer	FX-9162 foam concentrate
Appearance	Yellow, clear	Amber liquid
Density, 1b/gal	8.99	8.51
Viscosity at 77°F (25°C), cps	1500	2300
Specific gravity at 77°F (25°C)	1.08	1.02
pH at 77°F (25°C)	-	7.8
Flash point, *F	200	-
Freeze point, *F	-	28
Minimum use temperature, *F	-	32
Storage temperature, *F	40 to 100	35 to 120
Non-corrosive	Yes	Yes
Moisture sensitive	Yes	No
Price, \$/1b	4.65	2.55

TABLE 6. PROPERTIES OF FOAM REAGENTS³

^a From 3M Corp., St. Paul, MN.

2.3 Waste Treatment Techniques

2.3.1 Tar Treatment

Because of its viscous nature and size (as excavated), it was anticipated that tar would require some type of solidification and size reduction before it could be fed to a thermal destruction system. The two solidification agents most widely used with hazardous waste are portland cement and lime-based pozzolana (Arniella 1990). In addition to stabilization, these agents were expected to reduce the acidity of the low-pH tar to mitigate SO₂ emissions during processing. Both of these agents were evaluated during McColl tar treatment operations.

Pozzolana are materials which contain aluminum and silica and which harden at ambient temperatures in the presence of lime and water (by themselves, however, they display no cementing reactions). The two most common pozzolanic materials are fly ash and cement kiln dust. Fly ash from a nearby power plant was used for the McColl tests since it was readily available (cement kiln dust is itself considered a hazardous material in California and therefore more difficult to transport and use). The chemical and physical properties of the fly ash and portland cement delivered to the McColl Site are summarized in Table 7.

	Fly ash	Portland cement
Silicon dioxide, % Aluminum oxide, % Iron oxide, % Sulfur trioxide, %	61.04 18.59 5.16 1.07	22.61 3.78 3.25 1.84
Calcium oxide, % Loss on ignition, % Bulk density ^b , lb/ft ³	5.97 0.29 86	65.15 0.88 78 Type V

TABLE 7. FLY ASH AND PORTLAND CEMENT PROPERTIESa

^a From Amcal Minerals Corporation, 1990.

^b From field measurements.

Excavated tar was combined with portland cement, fly ash, and water in a pug mill to both mix these materials and reduce the size of tar lumps. The pug mill used for this project was a Barber Green Mixer (Model 848), shown in Figure 6, that reportedly was built during the 1950's. Tar, cement, and fly ash were charged at one end of the mill into a small feed hopper with a capacity of approximately 1.2 yd³. Material moved down through the hopper and flowed onto a moving belt. The clearance between the bottom of the hopper and the belt was almost 8 inches. The belt transported the material to the head of the pug mill where water was added manually. The mill consisted of two shafts fitted with short heavy paddles which rotated in the opposite inward direction (from the bottom towards the top) in an open half cylinder. The mixing/conveying action of the paddles pushed the material from the head of the mill to its tail, where the mixed material fell into a small product hopper (approximately 2 yd³ capacity). The hopper, in turn, emptied directly onto the ground. The feed belt and paddle shafts were powered by a 175-horsepower diesel engine.

The pug mill cylinder was approximately 10 feet long, 45 inches wide, and 27 inches deep, corresponding to an overall volume of 5.1 yd³. The paddles were 7 inches long and 4 inches wide at the tip. Two paddles (set at 180 degrees from each other) were set every 6 inches along the two tapered shafts; this resulted in a clearance of 2 inches between paddle sets. As shown in Figure 7, each set was offset 90 degrees from adjoining sets. The throughput capacity of the mill was reported to be almost 100 tons/hour.



Figure 6. Pug mill (with product hopper in foreground).



Figure 7. Pug mill paddles during tar processing.

2.3.2 Char and Mud Treatment

The objective of the char and mud processing operations planned for this project was to reduce the size of these materials to less than 2 inches so they would be suitable for feed to a thermal destruction system. The crusher brought on site for this purpose was a Masterskreen Explorer, manufactured by M&KK Quarry Plant Ltd. in 1989. With this system, material is dumped into a 4-yd³ tray feed hopper fitted with 6-inch stationary bars. From the hopper, material is transported by a feed belt into the jaws of the crusher. After passing through the crusher, material is picked up by a product conveyor and transported to a vibrating screen with 2-inch square openings. Undersize material passes through the screen to the ground while oversize material rolls off the screen to another pile on the ground. The conveyor belts, crusher, and hydraulic control system were powered by a diesel engine.

The crusher was expected to operate on both char alone and a mixture of char and mud. A schematic of the crusher is shown in Figure 8. The overall dimensions of the unit were 51 feet long, 7 feet wide, and 17 feet high.



Figure 8. Char/mud crusher schematic.

SECTION 3

FIELD DEMONSTRATION

This section presents a brief history of the site, a description of waste characteristics, and a description of the various aspects of work conducted during this trial excavation study.

3.1 Site Description and Waste Characteristics

3.1.1 Site Description and History

The McColl hazardous waste site is an inactive waste disposal facility located at 2650 Rosecrans Avenue in the city of Fullerton, Orange County, California (Figure 9). The site was used in the early and mid-1940s for the disposal of acidic refinery sludge, a byproduct from the production of aviation fuel. A series of pits or sumps were excavated on the site to receive the refinery sludge at that time. Onsite disposal of refinery sludge ceased in 1946. From 1951 through 1962, fill material (soil) and drilling mud from oil exploration activities near the Coyote Hills were deposited in some of the pits in an attempt to make the site suitable for future development.

By 1962, the Upper Ramparts area had been covered with soil, and has existed since that time as unoccupied open space. In the early 1980s, a clay cap was placed on the Lower Ramparts area to reduce odors. The Los Coyotes area was covered with 4 to 5 feet of soil and developed as part of the Los Coyotes Country Club golf course.

Areas east of McColl site were subdivided and developed for residential housing in the late 1970s and the early 1980s. Recreational facilities were constructed west of the site at the Ralph B. Clark (formerly Los Coyotes) Regional Park. As the population increased and development continued, residents began complaining of odors emanating from the site. Odor complaints were first received by the Orange County Health Department in 1978. Subsequent environmental investigations at the site identified extensive contamination.

In 1982, the McColl site was placed on the National Priority List (NPL), which made remediation of the site eligible for funding through CERCLA.



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Figure 9. Site location map, McColl Site, Fullerton, California.

3.1.2 Site Characteristics

The site is approximately 20 acres in size, of which approximately 8 acres contain waste in pits or sumps. As shown in Figure 10, the site is divided into two distinct areas, the Ramparts area and the Los Coyotes area. The Ramparts area comprises the eastern portion of the site and contains six buried waste pits or sumps. The Los Coyotes area, located immediately southwest of the Ramparts area, also contains six pits (L-1 through L-6). The six pits in this area were covered with soil during the construction of the golf course. The site is bordered by the West Coyote Hills Oil Field to the north, housing developments to the east and south of the Ramparts area, Los Coyotes Country Club golf course to the south, and the Ralph B. Clark Regional Park to the west. All pits are covered with soil, and the site is secured with a chain-link fence and 24-hour guard.

The trial excavation work in this project was conducted in the L-4 pit in the Los Coyotes area. This pit contains approximately 3300 cubic yards of waste, of which approximately 100 cubic yards was planned to be excavated.

3.1.3 Waste Characteristics

Three major waste types are present at the McColl site: 1) hard, black char-like asphaltic wastes; 2) viscous, black, tar-like wastes; and 3) gray, sludge-like drilling mud. The predominant waste type found at the site is a black asphaltic waste that is apparently the result of chemical and physical changes in acidic refinery sludge that have occurred over the last 40 years. This asphaltic waste has a low pH (acidic) and contains elevated levels of organic compounds. When disturbed, the waste emits sulfur dioxide (SO₂) and hydrocarbon vapors. Based on field observations, the following changes have occurred since this waste was disposed of (Radian 1983).

- Sulfuric acid reactions with oil constituents have continued, as evidenced by large amounts of SO₂ found on site.
- Some separation in the oil/acid emulsion has occurred, which has resulted in a contamination of the soil/sand formation below the waste. The soil below the waste shows pH values from about 2 to 4 and contains acid waste and salts.
- Solidification, polymerization, and coagulation of hydrocarbon constituents have occurred, which has resulted in zones or layers of very hard, asphaltic-type waste.
- Some fluid components in the waste, including entrained oil, have separated from the waste and are very mobile, and they occasionally seep to the surface.



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Figure 10. McColl Site.

Borings previously made in the L-4 sump showed that both tar and char were present in fairly segregated layers under a layer of moist soil or mud, which was in turn under approximately 8 feet of overburden soil. The anticipated waste configuration based on these boring is indicated in Figure 11; this information was used to plan the excavation work for the study (Geotechnical Professionals 1989).

Table 8 lists the waste characteristics of Pit L-4, based on the analytical results of two waste samples collected in 1989 (CH2M Hill 1989).

During previous studies at this site, two types of air emissions were observed when the waste was disturbed. Initial disturbance generally caused a high level or "puff" release of contaminants, followed by a rapid decline to lower levels (Radian 1983). These steady-state emission levels were then observed for longer periods of time and gradually decreased over several hours. The emission potential in the Ramparts area ranged from 130 to 130,000 mg/m² per min for SO₂ and 10 to 3600 mg/m² per min for total hydrocarbons (THC) for all disturbed waste types. Average steady-state emissions from asphaltic waste were 5200 mg/m² per min for SO₂ and 190 mg/m² per min for THC. Hydrocarbon analysis of air samples showed an average composition of 60 percent aliphatic and oxygenated species, 30 percent aromatic species, and 10 percent organic sulfur species. The waste composition did vary, however, from sump to sump and even with depth within a sump (Schmidt 1989).

3.2 Waste Excavation

This section describes the equipment used for waste excavation activities and presents a summary of the chronology of excavation operations. This summary is based on the daily operations log contained in Appendix A. This information and related geotechnical information provided the basis for excavation rates calculated for the various materials encountered.

3.2.1 Excavation Equipment

The equipment used under the enclosure for the trial excavation fell into three general categories: excavation, transport, and storage. In addition, operating personnel were equipped with personal protection equipment (PPE) in response to the hazards present inside the enclosure.

Excavation equipment included a diesel-powered (Caterpillar Model 215 DLC) tractor-mounted backhoe (or trackhoe), shown in Figure 12. This trackhoe was equipped with an extended boom and 1-yd³ bucket. With the extended boom, the trackhoe had an effective digging depth of 20 feet. The trackhoe was used for excavation of overburden, mud, tar, and char. In addition to the trackhoe, the backhoe portion



ORIGINAL SAND/SOIL

Figure 11. Approximate cross section of L-4 sump based on boring logs (Geotechnical Professionals 1989).

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Constituent	Concentration range, mg/kg
<u>Organics</u>	
На	1.0 - 1.4
Methylene chloride	0 - 0.32
Acetone	0 - 0.36
Chloroform	ND°
2-Butanone	0 - 49
Benzene	0.2 - 11
2-Hexanone	ND
Toluene	0.4 - 24
Ethyl benzene	0.1 - 8
Total xylenes	0.5 - 41
2-Methyl phenol	ND
4-Methyl phenol	ND
Benzoic acid	ND
Naphthalene	ND - 14
2-Methyl naphthalene	ND - 17
Diethyl phthalate	ND
Fluorene	NU
Phenanthrene	ND
Di-n-Duty: phinalate	
Bis(2-ethyinexyi)phthalate	NU - 11
Others	ND - 21
Total organic carbon	13 - 000
Total organic carbon	5 - 624
Metals	
A]uminum	7900
Arsenic	ND
Barium	63
Beryllium	ND
Calcium	2120
Chromium	19
Copper	7.5
Cobalt	5.7
Iron	9300
Lead	8.2
Manganese	126
Nickel	ND
lin Zing	ND
	32
Reteries um	1910
Fotassium	150
Socium	150
Vanaoium	25

TABLE 8. CHEMICAL CHARACTERIZATION OF WASTE IN PIT L-4ª

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* Source: Supplemental Reevaluation of Alternatives, Final Draft, Appendices (pp. D-8, D-9, D-11, and D-12), February 1, 1989.

* ND = Not detected.

* Organic compounds not on the Hazardous Substances List.



Figure 12. Caterpillar Model 215 DLC trackhoe.



Figure 13. John Deere Model 710 loader/backhoe.

of a diesel-powered (John Deere Model 710) loader/backhoe (see Figure 13) was also used for some excavation operations. At 1/3 yd³, the backhoe bucket was smaller than the trackhoe bucket and was used primarily during placement of the trench shield. The effective digging depth of the wheel-mounted backhoe was about 15 feet.

The loader portion of the loader/backhoe was used for material transport operations such as carrying excavated waste from the pit staging area to stockpiles. The 1-yd³ loader bucket was approximately 7.5 feet in width. A diesel-powered Bobcat Model 743 loader was also used for materials transport when the floor of the enclosure became too muddy and slippery for the John Deere loader/backhoe to operate properly. The muddy conditions were caused by the water in the foam vapor suppressants and by blowdown water associated with foam application. As shown in Figure 14, the Bobcat was fitted with special chain-like tracks over its wheels to provide adequate traction on the wet floor. The bucket of the Bobcat was 5 feet wide and had a capacity of $1/4 \text{ yd}^3$.

For material storage, standard 40-yd³ steel roll-off bins were utilized. These bins, shown in Figure 15, were of the same (internal) dimensions: 6 feet high, 21.8 feet long, and 7.4 feet wide. The bins were mounted on steel rollers. At the front, two doors swung open to provide access to material transport equipment. The top of the door frame was 82 inches above the bottom of the bin, which limited access by the loader/backhoe. In most cases, the bins were lined with polyethylene sheeting before material was placed inside. A total of five bins were used during the trial excavation for storage of mud, tar (two), fly ash, and portland cement.

Additional equipment used during the excavation was the trench shield (see Figure 16). The trench shield was designed to prevent collapse of overburden and side walls during excavation operations. For the McColl trial excavation, the trench shield also proved to be valuable in mitigating tar seepage into the excavated pit after the pit level had reached the tar layer. The trench shield employed during this program had dimensions of approximately 15 feet long, 10 feet wide, and 10 feet high. Figure 16 shows that the trench shield was bolted together at two ends with cross-members. After the trench shield frame was lowered into the pit, the open ends were closed off by slipping two steel plates into position and securing them with backfill.

Excavation work inside the enclosure was conducted either in Level B or Level A personal protective equipment. Level B equipment consisted of supplied-air respirators, coated Tyvek overalls, steel-toed boots, inner and outer gloves, and a hard hat. Air bottles were mounted on the trackhoe, loader/backhoe, and Bobcat for operator air supply; other members of the crew used air lines supplied from air cylinders located outside the enclosure. Level A requirements added a totally encapsulated chemical protective (TECP) suit to the preceding equipment list. Air supplies to these suits were either from air lines (as previously discussed) or from



Figure 14. Bobcat Model 743 loader.



Figure 15. Roll-off bin.



Figure 16. Small and large trench shields (without end plates).

self-contained breathing apparatus worn inside the suits. Level B and Level A ensembles are pictured in Figures 17 and 18, respectively.

3.2.2 Excavation Operations Chronology

This section summarizes the daily progress of the excavation operations between June 7 and June 26. More detailed information on these activities is provided in the daily operations log summaries and the Summary of Geotechnical Observations in Appendix A.

Date	Excavation activity
June 7/Th	Trackhoe and loader operated without digging in the morning for background emissions data. Overburden excavation started in the afternoon.
June 8/F	Overburden excavation continued until mud layer was encountered at the 8-foot level. After moving mud bin into position, mud excavation started. Excavation halted in the afternoon because of leakage at the foam-mixing trailer and plugging of foam nozzles.
June 9/Sa	Repairs made to foam system. Mud excavation completed. Tar excavation started at the 11-foot level after tar bin was moved into position. Tar excavation halted when top of char layer was reached at the 15-foot level.
June 10/Su	Onsite activity avoided on Sundays.



Figure 17. Level B personal protection equipment.



Figure 18. Level A personal protection equipment.

Date	Excavation activity
June 11/M	In attempts to improve foaming effectiveness, surface of tar bin was leveled and platform was installed for applying foam to bin. New layer of foam was applied. No materials were excavated.
June 12/Tu	After moving trench shield and bins into position, discovered that excavated tar and associated mud had seeped into pit during the previous two days. Excavation was halted due to high emission levels.
June 13/W	Second tar bin was brought into enclosure and moved into position. Excavated tar and associated mud had seeped into pit overnight. Began overexcavation of pit walls to make room for trench shield. Trench shield was lowered into pit, but became hung up on one side.
June 14/Th	Overexcavation of pit walls continued until trench shield was moved into position. Trench shield end plates were positioned in pit.
June 15/F	Excavated small amount of tar that had seeped under trench shield into pit overnight. Began char excavation.
June 16/Sa	Changed caustic soda scrubber solution. Replaced coal-derived activated carbon with coconut-derived activated carbon. No excavation activity.
June 17/Su	Onsite activity avoided on Sundays.
June 18/M	No excavation operations. Site safety plan being revised/reviewed.
June 19/T	No excavation operations. Site safety plan being revised/reviewed.
June 20/W	No excavation operations. Site safety plan being revised/reviewed. Refueled equipment. Revised decontamination line for Level A.
June 21/Th	Overburden excavated on west side of pit to a depth of 5 feet, to form ramp-down bench. Trackhoe positioned on bench.
June 22/F	No excavation operations because of failure of Level A suits to pass pressure test.
June 23/Sa	Level A suits were being repaired. No excavation operations.
June 24/Su	Onsite activity avoided on Sundays.
June 25/M	Instrument problems and the need to refill foam tank delayed start of activities inside enclosure. By midday, heat stress concerns related to Level A suits warranted against further operations for the day.

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Date	Excavation activity
June 26/T	Excavated small amount of tar seepage and overburden that had fallen into the pit during ramp-down. Char excavation recommenced and continued until high emission levels caused work to be halted at the 25-foot level. Excavation operations completed.

All of the excavation operations described above were conducted in Level B gear until the final two days, June 25 and 26; on these days, operating personnel worked in Level A suits.

On June 27, the trench shield was pulled from the pit and preparations for tar treatment operations began on June 28.

The following descriptions of the excavated overburden and waste materials are taken from the geotechnical observations report in Appendix A and are presented here to avoid subsequent confusion when the terms are discussed.

- Overburden Olive brown, sandy/silty clay, dry, stiff to hard, with a thin lens of uniformly coarse sand at the 5-foot level.
- Mud Greenish grey silty clay, moist, plastic, firm, with inclusions of tar chunks.
- Tar Black, no soil inclusion, deformability varies with temperature and overburden pressure, mostly stiff when freshly excavated, becomes sticky and flowing after exposure to warmer temperatures.
- Char Black, cemented coal-like material, no soil or tar inclusions, very hard, nonplastic.

3.2.3 Excavation Quantities and Rates

Excavation of overburden and waste was conducted over 9 work days. The quantities and volumes of materials excavated on these days are summarized in Table 9. A total of 137 solid cubic yards of waste (mud, tar, and char) are estimated to have been removed during the trial excavation together with 101 solid cubic yards of overburden. (Solid cubic yards refers to the volumes of material in the ground, and corresponds to the dimensions of the pit spaces from which materials are removed.)

After removal, solid materials generally tend to expand volume, or bulk. (The bulking factors are the estimated ratios of material volumes before excavation to material volumes after excavation. Multiplying solid cubic yards by bulking factors

Date	Excavation quantity, solid cubic yards					
(1990)	Overburden	Mud	Tar	Char	Total ^b	
6/7 6/8 6/9 6/12 6/13 6/14 6/15 6/21	27 10 0 <2 <2 20 0 42	0 20 <2 5 5 7 0	0 <2 20 25 20 7 2 <2	0 0 <2 <2 <2 <2 <2 <2 7 0	27 31 22 32 27 35 9 43	
6/26	ō	õ	<2	11	12	
Total solid cubic yards Estimated bulking factor ^a	101 1.5	38 1.5	77 1.2	22 1.2	238	
Total bulk cubic yards ^C Bulk density, lb/ft ^{3d}	152 120	57 84	92 33	26 74	327	
Excavation tonnage ^e	245	65	41	26	377	

TABLE 9. EXCAVATION QUANTITY ESTIMATES^a

^a Based on information in Appendix A.

^b For totals, 1 cubic yard assumed for <2-cubic-yard estimates.

^C Solid cubic yards x bulking factor.

^d Based on field measurements (see Appendix F).

^e Bulk cubic yards x 27 ft^3/yd^3 x bulk density/2000 lb/ton.

yields bulk cubic yards.) Waste materials thus amounted to 175 bulk cubic yards after excavation.

Bulk cubic yards can be converted to a weight basis using the bulk density measurements obtained from the field and appropriate conversion factors. Applying these factors results in estimates of 132 tons of waste excavated and 245 tons of overburden.

Based on the operating time recorded in the operating log summaries, and the excavation volume estimates in the geotechnical report (Appendix A), Table 10 was prepared to summarize calculations of excavation rates. For each day on which material was excavated, the elapsed time for excavation has been calculated by using the beginning and ending times for excavation operations. In addition, the lengths of the effective workdays inside the enclosure have been calculated based on the initial entry and final exit times. The effective workday lengths include nonoperating periods such as lunch breaks, work breaks, and equipment-related stoppages.

A "maximum" excavation rate has been calculated as excavation volume divided by the elapsed excavation time. This is referred to as a maximum rate because it does not include time for normal work stoppages (e.g., lunch breaks). An "average" excavation rate has also been calculated as the excavation volume divided by the effective workday length inside the enclosure. This rate is always lower than the maximum excavation rate because it includes nonproductive time for work breaks and other stoppages. Also, since this was a trial, excavation breaks were required for observation and measurement.

Considering first the maximum excavation rates, the data in Table 10 show that maximum rates for overburden removal ranged from 12 to 81 yd³/hour; the higher and more representative rate associated with the ramp-down operations on June 21. The two rates calculated for mud excavation were 15 and 66 yd³/hour. Of these, the second is more representative because the first was calculated over a short time period (4 minutes). The most representative days for tar excavation rates were June 9, 12, and 13 when at least 20 yd³ were excavated on each day and tar was the major component of the material excavated. The average maximum tar excavation rate for these three days was 56 yd³/hour. The two maximum rates calculated for char excavation were 4 and 9 yd³/hour. The first rate was lower than the second because it was the first time that char had been encountered and because more time was taken for visual observations and for flux chamber measurements on char samples. As a result, the second or higher rate is considered more representative of trial excavation operations.

In calculating average excavation rates it was necessary, in most cases, to combine the excavated volumes of two or more types of materials. The average excavation rate for overburden on June 7 was 7.6 yd³/hour. The average excavation rates for the remaining 8 days, which included excavation of char, tar, mud, and over

Excavation time				Effective work day inside enclosure				Excavation rate, yd'/h			
Period No.	Date (1990)	Begin	End	Elasped time, h	Material type*	Initial entry	Final exit	Day length, h	Excavated volume, solid yd²	Maximum**	t Average
1	June 7	1327	1418	0.85	0	1045	1418	3.55	27	32	7.6
2a 2b	June 8 June 8	0800 1021	0952 1040	0.87 0.32	0 M/T	0800	1530	7.50	10 21	12 66	4.1 ^{tt}
3a 3b	June 9 June 9	1033 1345	1037 1429	0.07 0.73	M T/C	1033	1543	5.17	1 21	15 29	4.3 ^{††}
4	June 12	1408	1449	0.68	T/M/O/C	0725	1520	7.92	32	47	4.0 ^{tt}
5a 5b	June 13 June 13	1606 1623	1623 1651	0.28 0.47	T/M/C 0	0652	1925	12.55	26 1	92 2	2.2 ^{tt}
6	June 14	1015	1115	1.00	0/M/T/C	0920	1720	8.00	35	35	4.4 ^{tt}
7	June 15	1035 1115	1115 1300	0.67 1.75	T C	0900	1300	4.00	2 7	3 4	2.3##
8	June 21	1000	1032	0.53	0/T	0831	1423	5.87	43	81	7.3
9a 9b 9c	June 26 June 26 June 26	0647 0710 0920	0710 0744 1000	0.38 0.57 0.67	T/M C C	0628	1110	4.70	1 11	3ş 9	2.6 ^{††}

TABLE 10. MAXIMUM AND AVERAGE EXCAVATION RATES

• O = Overburden, M = Mud, T = Tar, C= Char.

Excavation volume/excavation elapsed time.

+ Excavation volume/effective work day length.

Average rate for all materials excavated on the subject day.

§ Rates apply to Periods 9b and 9c combined.

burden, fell within a narrow range of 2.2 to 4.3 yd^3 /hour. The most representative average excavation rates for mud, tar, and char were 4.1, 4.3, and 2.6 yd^3 /hour, respectively, based on those days when a majority of each waste type was excavated.

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Excavation rates were also estimated based on the use of a tractor-mounted backhoe with a 1 yd³ bucket under routine excavation conditions for these types of waste materials. These estimates, as contained in Appendix E, indicated that average excavation rates of approximately 49, 32, and 25 yd³/h could be obtained for overburden and mud, tar, and char, respectively.

3.2.4 Use of Trench Shield

As discussed in Section 3.2.1, the trench shield was employed during the trial excavation primarily as a means of minimizing tar seepage into the pit. In the opinion of the geotechnical engineer observing the excavation, the walls of the pit at the overburden and mud levels were stable enough that the shield was not necessary to prevent sloughing or collapse of the walls. However, after the excavation depth had reached the char layer, the trench shield became necessary to prevent the pit from refilling with tar (at least to the tar level). Before the trench shield was positioned, an estimated 25 yd³ of seeped tar had to be excavated on June 12 and 20 yd³ of seeped tar had to be excavated early on June 13. After the trench shield frame (two sides) was lowered partially into position on June 14. After the shield was lowered into the final position and the end plates were installed on June 14, tar seepage was reduced to minor amounts (less than 2 yd³/night).

A smaller trench shield was available on site to use for shoring of the pit walls at the char level. However, because the char proved to be very hard and the walls quite stable, the smaller trench shield was not required.

3.2.5 Waste Sample Collection/Shipping Procedures

Samples of char, raw tar, treated tar, and mud were collected in 8-ounce and 4ounce glass containers from double-lined, 55-gallon sample drums. The sample drums had been filled inside the enclosure with the front-end loader and bobcat and then moved outside the enclosure into a staging area prior to transportation to the onsite drum storage area. Since the char, raw tar, and mud in the sample drums had already been mixed during excavation, storage, and movement operations prior to drumming, grab samples from single drums were collected for these materials. Samples of treated tar (discussed in the next subsection) were collected from the drum containing the product material from Run 10 of the tar treatability tests.

The samples were collected in the middle of the afternoon of July 16, 1990. Within one hour after collection, the glass containers were placed in insulated shipping boxes and packed with ice. A sample chain-of-custody form was filled out for the samples and sent with them. They were picked up by an express delivery van between 5:00 and 5:30 P.M. and shipped via overnight delivery to PEI Associates, Inc., in Cincinnati, Ohio.

3.3 Waste Treatment Tests

Treatment tests were conducted on tar wastes with the pug mill and feed additives discussed in Subsection 2.3. No treatment tests were conducted on the char and mud wastes with the crusher because most of these waste components were less than 2 inches in size after excavation, and there was no need for further crushing. This section discusses the test conditions and procedures used for the tar treatment tests.

3.3.1 Tar Treatment Test Conditions

The tar treatment tests were designed to investigate a range of mixing ratios for tar, portland cement (i.e., cement), fly ash (i.e., ash), and water. In addition, it was decided to operate the pug mill at both a nominal throughput rate and a maximum throughput rate. For all tests, the desired end product was a free-flowing material with most, if not all, particles less than 2 inches in size.

A total of 10 treatment tests were conducted within the enclosure over the 4-day period July 10 through July 13. Table 11 summarizes the volumes and weights of tar, cement, water, and ash fed into the pug mill during these 10 tests. The material weights shown are based on the known volumes of the backhoe bucket and water pails and the results of the field bulk density measurements, as reported in Appendix F. The backhoe was equipped with a 1/3-yd³ bucket. The 5-gallon water pails were approximately 90 percent full when their contents were added to the mill, for an effective volume of 4.5 gallons/pail.

The first nine runs in Table 11 were conducted at the low idle paddle rotation speed, whereas the tenth run was conducted at maximum paddle rotation speed. Run 1 was a "dry run," conducted without water, to investigate the operability of the pug mill while processing tar without the complications that water addition might cause. Runs 2, 3, 4, and 8 were tests in which only cement and water were added to the tar at low paddle idle speed. In Run 3, the water/cement ratio was increased over that in Run 2. In Run 4, the tar/cement ratio was increased over that in Run 2. At the end of Run 4, the paddle speed was increased to about 3/4 maximum speed to observe the effects on treated tar. A tar/cement ratio between the Run 2 and Run 4 levels was selected for Run 8. Run 10 was a repeat of Run 2, except that the paddle was set to the maximum level.

		TROLE THE		TEOT TEED QU					
	-	Feed quantities to pug mill, lb							
Run No.	Date (1990)	Tar	Cement	Water	Fly ash	Total			
1	7/10	294	1390	0	0	1684			
2	7/10	294	2085	351	0	2730			
3	7/11	294	2085	585	0	2964			
4	7/11	588	1390	273	0	2251			
5	7/11	294	1390	312	766	2762			
6	7/11	294	695	312	1532	2833			
7	7/12	588	695	156	766	2205			
8	7/12	588	2085	312	0	2985			
9	7/12	588	0	234	3064	3886			
10	7/12	294	2085	312	0	2691			

TABLE 11. TAR TREATMENT TEST FEED QUANTITIES

Fly ash was added to the feed mix in Runs 5, 6, 7, and 9. The ash/(cement + ash) ratio was doubled between Runs 5 and 6. The tar/(cement+ash) ratio was increased in Run 7 over the levels of the two preceding runs. Finally, in Run 8, tar was combined with fly ash and water alone (i.e., no cement).

3.3.2 Tar Treatment Testing Procedures

The operating procedures used to conduct the pug mill tests were essentially the same from one test to the next. The first step was to use the backhoe to load thefeed materials into the pug mill feed hopper. Cement and ash were removed from their respective roll-off storage bins by the Bobcat and placed on the ground in staging areas. From there, the cement and ash were picked up by the backhoe bucket and loaded into the pug mill feed hopper. Tar was loaded by the backhoe, either directly out of the tar bins or from a staging area where it was separated from associated mud.

The feed materials were layered into the feed hopper. A bucketful of cement or ash was loaded first, followed by tar, and then by any remaining cement or ash. With this approach, there was always some cement or ash in the mill before the tar reached the mill. Water was manually added to the head of the mill in 5-gallon pails, which were filled from a hose that ran from outside the enclosure to the pug mill inside. Water addition did not begin until solid materials from the feed hopper had reached the mill, and it continued at regular intervals during solids feeding. After the feed hopper was loaded with solids in the desired ratios and the water pails had been filled, the pug mill diesel engine was started up. After engine operation steadied (generally within a minute), the control rod on the mill was engaged. This action simultaneously started the turning of the feed belt below the hopper and the rotation of the paddles in the mill. Feed belt movement transported materials from the feed hopper to the head of the mill. Material was mixed and pushed through the mill by the rotating action of the paddles. After passing over a small dam at the tail end of the mill, treated material rolled through the open product hopper and onto the ground below.

If material became plugged in the feed hopper, the product hopper, or the mill, the paddles and feeder belt could be stopped by using the manual control rod. After the material flow out of the mill was stopped or reduced to a trickle, the paddles and feeder belt were idled and immediately thereafter the diesel engine was stopped. This completed the test run. The only remaining operations were to move the treated material from under the product hopper into either a sample drum or the excavation pit; both operations were accomplished with the Bobcat.

As previously indicated, the pug mill was operated in a batch mode during the tar treatment tests to provide a high level of control over feeding operations. In addition, the amount of tar, cement, and ash available for processing and the time available for testing dictated a batch operations approach. Had there been a desire to process more tar or to continue a given set of conditions over a longer time period, the pug mill could have been operated in a continuous mode as well.

The starting and stopping times for the tar treatment tests are summarized in Table 12, along with the number and reasons for feeder belt/paddle stoppages during the testing periods. In Subsection 4.5, these start/stop times and the feed weights from Table 11 are translated into material throughput rates.

3.4 Foam Application and Efficiency Tests

This section describes the foam application and control efficiency tests.

3.4.1 Foam Application

As described earlier in Subsection 2.2, temporary and stabilized foams supplied by 3M Corporation were mixed with water in a self-contained portable mixing/pumping system (i.e., foam generator), which was powered by a small gasoline engine. The foam reagents [either temporary foam (FX 9162) or temporary foam with stabilizer (FX 9161)] were mixed with water and pumped through a hose and nozzle for manual application to the waste as required. At least two people were required to operate this system--one at the foam generator and one at the nozzle inside the enclosure. During most periods of char excavation, two men were positioned inside the enclosure with

Run No.	Date (1990)	Start time	Stop time	Elapsed time, min	Stoppages	Cause
1	7/10	0817	0832	15	1	Feed hopper blockage
2	7/10	1350	1407	17	0	N/A ^a
3	7/11	0738	0755	17	3	 Hopper doors closed Clear material in product hopper
4	7/11	0821	0830	9	2	Clear material in mill and product hopper
5	7/11	1056	1108	12	3	Clear material in mill
6	7/11	1328	1337	9	1	Clear material in mill
7	7/12	0847	0852	5	0	N/A
8	7/12	0911	0917	6	0	N/A
9	7/12	1104	1118	14	1	Feed hopper blockage
10	7/13	0659	0703	4	0	N/A

TABLE 12. TAR TREATMENT TEST OPERATIONAL DATA

^a N/A = Not applicable.

foam nozzles--one in the excavation pit area and one in the stockpile area. In the pit area, temporary foam was applied to exposed waste surfaces in the pit and to each bucketful of waste after it was removed from the pit and placed in the staging area next to the pit. This material was picked up by the front-end loader and carried to a waste stockpile or storage bin, where exposed waste surfaces were again covered with temporary foam from the second nozzle.

After an application of stabilized foam, the hose was flushed with water to prevent plugging. Temporary foam was also flushed from hoses prior to extended work breaks, such as for lunch or during equipment malfunctions. Normally these flushes, which lasted for 30 to 60 seconds, were directed into 55-gallon drums or a water storage tank. If a drum was not immediately available, however, the flush water was directed onto the waste pit/pile or ground nearby. In addition, when foam use was started, water alone was sprayed from the nozzles during the first 30 to 60 seconds; this water was also directed onto the waste or ground nearby. As a result of this water flush at the beginning or end of the foaming operation and the breakdown of foam applied to char, a considerable amount of water collected on the ground inside the enclosure. This had the following adverse effects: it made footing difficult for workers, it made movement of loaded storage bins impossible, and it made movement

of wheel-mounted equipment difficult to control. As a result, the wheel-mounted frontend loader had to be replaced with a smaller, tractor-mounted Bobcat.

This system operated satisfactorily after making initial practice runs and adjustments to the foam generation. The temporary foam was usually applied to waste surfaces in the pit, on the staging pile, and on waste stockpiles/bins, as previously discussed. During some periods of operation, however, misunderstandings between personnel inside the enclosure, due to the difficulty of communicating in Level A and Level B protective clothing, resulted in waste being excavated without foam being applied for periods of several minutes up to a half-hour. During the workday, the stabilized or "permanent" foam was applied to waste surfaces only if emission levels exceeded safety plan action levels. At the end of each workday, the stabilized foam was applied to all exposed waste surfaces. Beginning June 21, the stabilizer reagent was increased from 6 to 10.5 percent in the permanent foam in an effort to form a more impermeable layer of foam.

3.4.2 Foam Efficiency Tests

In an attempt to quantify the foam's ability to reduce emissions, testing was conducted over 3 days on the following three types of waste materials: tar (June 13, 1990), mud (June 14, 1990), and char (June 15, 1990). The tar and mud were excavated prior to the testing, placed in steel bins, and covered with stabilized foam. The char was excavated on the day of testing. Flux measurements were performed by a flux chamber method per the EPA guidance document (U.S. EPA 1986). In total, 11 flux chamber measurements were performed: blank measurement, uncontrolled tar, duplicate uncontrolled tar, temporary foam on tar, stabilized foam on tar, uncontrolled muds, temporary foam on muds, stabilized foam on muds, uncontrolled char, temporary foam on char. Grab samples were collected for each measurement and submitted for offsite analyses. Evacuated stainless steel canisters were used to sample for the speciation of volatile hydrocarbons, and Tedlar bags were used to sample for SO₂ and reduced sulfur compounds.

The results of these tests did not yield consistent results and the analytical data did not meet the Agency's quality controls. This information is contained in the raw data file maintained by EPA Region IX, but is not included in this report.

3.5 Air Sampling and Analysis

3.5.1 Enclosure Exhaust Air Stream Monitoring - Total Hydrocarbons (THC) and Sulfur Dioxide (SO₂) Operating Procedures

The trial excavation at the McColl site was conducted within an enclosure which exhausted air emissions through a filter, wet scrubber, and carbon bed adsorber. The filter controlled large particulate, the scrubber controlled particulate/SO₂ emissions,

and the carbon bed controlled hydrocarbon emissions. Continuous emission monitors (CEM) for SO₂ and THC were used to monitor air emissions at the inlet and outlet of the air emission control system (filter, scrubber, and carbon bed). Sampling was conducted continuously from the start of excavation (June 7) through the completion of the project (July 18). Five hours of each day was used for CEM calibration and system maintenance; the balance (19 hours) was the goal for daily on-line monitoring.

Daily Site Activities

Each morning there was a pretest meeting to discuss the day's strategy and activities. Enclosure SO_2 and THC levels were reported at this time. Target concentration levels for SO_2 and THC were then set to indicate when excavation should continue, slow down, or stop. During any enclosure work, communication between the trailer and CEM operator was continuous.

Morning calibrations (4-point) were conducted immediately after the meeting. The first enclosure work session would begin immediately after calibrations. Strip charts were marked according to type of instrument, concentration range, date, sample location (inlet/outlet), chart speed, and time (24-h). Log books recorded all strip chart calibration data (chart response versus gas concentrations), dates, time, and enclosure events. Calculations of linear regression equations, calibration error, and correlation coefficients were also entered in the notebook. Also included were span and zero checks, comparisons of computer and strip chart data, and changes in instrument ranges. After the morning test session, the data from the data logger cartridge was copied to the computer hard drive. The transfer was checked and then the cartridge was erased and put back on-line. The data were then transferred to a floppy disk. Records of data were recorded on the strip charts, hard drive, and floppy disk.

After completion of daily enclosure activities, the CEM's were span and zero checked. Sample conditioning systems were cleaned, calculations completed, and the previous days computer hourly and calibration data were printed out. These data along with the log book were placed in the central file.

Inlet Sample Location (Site 1)

The inlet sample location, Figure 19, is located outside the site enclosure, just prior to the scrubber. This duct contained all exhaust gases from the excavation process. Sampling ports were installed to meet EPA Method 1 sample location requirements. CEM sample probes were located at the inlet sample site. The initial ranges were 0 to 50 ppm SO₂ and 0 to 200 ppm THC. These ranges were changed at times when emissions went offscale. Changes were docurnented on strip charts and in the field log books. Initial inlet and outlet SO₂/THC concentration ranges were estimated based on readings taken around soil borings during a site survey.

TO SCRUBBER 0 12 in. 1.D. ENCLOSURE		
	TRAVERSE POINT NO.	FRACTION OF STACK I.D.
	1	2.1
	2	6.7
CROSS SECTION	3	11.8
	4	17.7
VERTICAL PORT	5	25.0
	6	35.6
	7	64.4
	8	75.0
	9	82.3
	10	88.2
	11	93.3
12	12	97.9

Figure 19. McColl inlet site.

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Outlet Sample Location (Site 2)

The outlet sample location, Figure 20, is located after the scrubber and carbon bed control system. This duct contained all treated gases from the excavation process. Sampling ports were installed to meet EPA Method 1 sample location requirements. The SO₂ and THC CEM sample probes were located at the outlet sample site. The initial ranges were 0 to 50 ppm SO₂ and 0 to 100 ppm THC. The SO₂ monitor range was never changed. The THC range was changed periodically and documented as mentioned previously.

CEM Trailer

The CEM trailer was located within 60 feet of both the inlet and outlet sample locations. The trailer contained the CEM systems, sample pumps, strip chart recorders, and ODESSA data system. The trailer was climate controlled for the proper operation of the instruments.

Sampling Strategy and Sampling Procedures

The sampling procedures are summarized in Table 13.

Sample stream	Access	Analytical parameter	Sampling equipment	Procedure/per run frequency
Inlet/outlet	Duct	SO2	EPA Method 6C - Chemiluminescent analyzer - Strip chart recorder - EPA Protocol 1 calibration gases	Continuous extraction and analysis. Daily operation 19 h. Four point calibrations every 24 hours. Single span and zero checks during daily excavations.
Inlet/outlet	Duct	Total organics	EPA Method 25A - Flame ionization analyzer - Master gas certified gases - Strip chart recorder	Same as above

TABLE 13. SAMPLING PROCEDURES, EQUIPMENT, AND METHODS

The field testing consisted of continuously monitoring SO_2 and THC emissions at the inlet and outlet sites for 19 hours per day during the entire field program. Approximately 5 hours per day was required for calibration of instruments and system maintenance (filter changes, cleaning, and changing sample pumps). Included in the field testing program was background sampling which involved sampling ambient air prior to excavation procedures. This ensured system operation and supplied background information on SO_2 and THC levels.



Figure 20. McColl outlet site.

M-3758-12-8/90-10

Inlet-Outlet SO₂ Sampling System

Sampling and analysis for SO_2 emissions was accomplished using a continuous extractive pulsed fluorescent analyzer. The sampling apparatus is shown in Figure 21 and meets all design specifications of Method 6C. It consisted of:

<u>Probe</u> - 0.375-in. stainless steel. Probe was hooked directly to 0.25-in.-o.d. Teflon sample line.

<u>Sample Line</u> - 60-ft, 0.25-in.-o.d. Teflon line was used to transport sample gases and calibration gases.

<u>Sampling Conditioning Apparatus</u> - A glass wool filter was used in the stack to eliminate particulate. Two Teflon impingers immersed in an ice bath were used to remove moisture. Moisture removal is essential to the proper operation of a SO₂ monitor.

<u>Sample Pump</u> - Leak-free vacuum pumps provided a constant steady flow of sample gas through the analyzer.

<u>Transfer Sampling Pump</u> - A leak-free Teflon pump was used to transport gas 60 ft from the stack to the manifold system.

Rate Meter - A rotameter was used to measure air flow through the analyzer.

Manifold - A Teflon manifold was used to deliver sample gases to the monitor.

<u>Bubble Meter</u> - A bubble meter was used to check flow rates leaving the manifold and to ensure sample and calibration gas flows.

<u>Calibration Gases</u> - SO_2 standards in air will be used to calibrate the instruments. Ambient grade zero air is used to zero the monitors. Three EPA Protocol 1 gases were used in the sampling range. The following are gases used for this program:

Inlet, ppm	Outlet, ppm	
Zero	Zero	
1.9	1.9	
24.6	24.6	
45.3	45.3	
400		



BACK INTO THE EXCAVATION AREA



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Source monitors were chosen because they have a variety of ranges, and the minimum detection limit can be as low as 1 ppm. The additional 400 ppm calibration gas made it possible to quantitate concentrations above 50 ppm. Higher concentrations were not expected and additional calibration gases were not available for this study.

<u>Data Recorder</u>: A Yokogawa strip chart type recorder was used to continuously record data. This will provide a permanent record of data. An ODESSA DSM 3260 data logging system was used to record all data including calibrations. Transfer of data was done on a central processing computer. This system was used for all data reductions.

SO₂ Monitor

A Thermo Electron pulsed fluorescent analyzer was used to measure SO_2 concentrations at the inlet and outlet test sites. The fluorescent analyzer uses pulsating ultraviolet light focused through a filter into the fluorescent chamber.

The UV light excites the SO_2 molecules and they give off a characteristic decay radiation. A second filter allows only this radiation to fall on a photomultiplier tube. The light energy is then electronically processed and displayed in a reading which is directly proportional to the SO_2 concentration.

The instrument has detection ranges of 0 to 50, 0 to 100, 0 to 500, 0 to 1000, and 0 to 5000 ppm. The Thermo Electron SO_2 analyzers meet EPA Method 6C performance guidelines.

Daily SO₂ Instrument Operation

Prior to the start of daily excavation, the SO₂ system was calibrated with three calibration gases and zero air. The calibration was checked for linearity; an acceptable correlation coefficient was \geq 0.999. Filters and condensers were checked/changed prior to sampling. Strip chart recorders were marked listing sample locations, range, calibration gases, chart speed, date, and time of sampling. The ODESSA data acquisition system was used to record data every minute and calculate hourly averages. When range changes were made, a factor was used to reduce computer data based on the range (range change from 50 to 500 used a 10 multiplier). During daily excavations, the system was span and zero checked and filters and condensers changed. Emissions were also monitored during nonexcavation periods.
EPA Method 6" was used to perform audits on the Method 6C sampling systems. One Method 6 sample was collected at both the inlet and outlet test sites to verify monitor data. These data were collected June 13, 20, and 29, and are summarized in Section 5.1.

Method 6 Sampling Apparatus

The SO₂ sampling train used in these tests meets design specifications established by the Federal EPA and was assembled by PEI personnel. The Method 6 sampling was conducted to compare with the CEM Method 6C results. It consists of:

<u>Probe</u> - 0.375-in. stainless steel probe. A plug of glass wool is placed in the end of the probe to remove particulate matter.

<u>Impingers</u> - Four impingers connected in series with glass ball joints. The first and third impingers are of the Greenburg-Smith design. The second and fourth impingers are modified by replacing the tip with a 1/2-in.-i.d. glass tube extending to within 1/2 in. from the bottom of the flask. Glass wool is placed in the first U-joint to prevent sulfuric acid mist carryover.

<u>Metering System</u> - Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 5°F, dry gas meter with 2 percent accuracy, and related equipment to maintain a constant sampling rate and to determine total sample volume.

<u>Barometer</u> - Aneroid type to measure atmospheric pressure to \pm 0.1 in.Hg.

Sampling Reagents

<u>Water</u> - Deionized, distilled to conform to ASTM specifications D1193-74, Type 3.

Isopropanol, 80%

Hydrogen Peroxide, 3%

Analytical Reagents

<u>Water</u> - Deionized, distilled

Isopropanol, 100%

* 40 CFR 60, Appendix A.

Thorin Indicator

Barium Perchlorate Solution, 0.01 N

Sulfuric Acid Standard, 0.0100 N

Ammonium Sulfate Standard, 0.0100 N

Sampling Procedure

After the sampling site and the required traverse points were selected, the stack pressure, temperature, moisture, and range of velocity head were measured according to procedures described in Methods 1 through 4.*

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One sampling point was chosen and the train was assembled as follows: 30 ml of 80 percent isopropanol in the first impinger, 30 ml of 3 percent hydrogen peroxide in both the second and third impingers, and 30 g of silica gel in the fourth impinger. A portion of each reagent was retained for use as a blank. The train was assembled as shown in Figure 22. The sampling train was leak-checked at the sampling site before and after each test by plugging the inlet to the first impinger and pulling a 10-in.Hg vacuum. All leaks were corrected before sampling began. The probe heater setting was adjusted during sampling to prevent any visible condensation. Crushed ice was placed around the impingers and more ice was added during the test to keep the temperature of the gases leaving the last impinger at 68°F or less.

At the completion of each test, the train was removed from the stack and purged for 15 minutes.

Sample Recovery

The contents of the first impinger were measured and discarded. The contents of the second and third impingers were measured and placed in a leak-free polyethylene container. The second and third impingers and connecting glassware were then rinsed with distilled, deionized water and this rinse was added to the same polyethylene container. The container was sealed and identified, and the liquid level was marked.

Analytical Procedures

The volume of each sample was recorded and diluted to 100 ml with deionized distilled water. An appropriate aliquot of this solution was pipetted into a 250-ml

40 CFR 60, Appendix A.



Erlenmeyer flask. Deionized, distilled water was added to bring the volume to 20 ml. Eighty ml of 100 percent isopropanol and two to four drops of thorin indicator are added. The solution was titrated to a pink end point using 0.01 N barium perchlorate. A blank was titrated in the same manner as the samples. An EPA Method 6 audit solution was analyzed as a check on the analysis procedure. ٤.

Inlet-Outlet THC Emissions

Sampling and analysis for THC emissions was accomplished using a flame ionization analyzer (FIA). The sampling apparatus is shown in Figure 23 and meets all design specifications of Method 25A. It consists of:

<u>Particulate Filter</u> - A short piece of 1/2-in. diameter stainless steel pipe packed with glass wool and attached to the end of the sample probe.

<u>Sample Probe</u> - 1/4-in. stainless steel tubing inserted into the gas stream being sampled.

<u>Sample Line</u> - 1/4-in. o.d. heated Teflon line with controller to maintain a sample temperature of 250°F. Heated sample line is required to prevent condensation of hydrocarbon emissions.

<u>Calibration Gases</u> - Methane standards in air and zero air (less than 0.1 ppm THC) are used to calibrate the monitor. Master Gas Certified gases were used for this program. EPA Protocol 1 gases are not available in methane standards. Gases are certified to be ± 2 percent of label values.

Inlet, ppm	Outlet, ppm
Zero	Zero
49.9	25.1
91.5	49.9
180.0	91.5
900	

The following gases were chosen for this program:

These monitors and gases were chosen to allow for measurements on a variety of ranges. If instruments went offscale on the original scale, a 900-ppm calibration gas was available to calibrate on higher ranges. Higher concentrations were not expected and additional calibration gases were not available for this study.



Figure 23. Outlet and inlet THC sample systems.

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<u>Fuel and Air</u> - A cylinder of 100 percent hydrogen and a cylinder of compressed air were used to provide fuel and an air supply for the analyzer's flame.

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<u>Chart Recorder</u> - Heath strip chart recorder is used to provide a permanent record of hydrocarbon concentration data. An ODESSA DSM 3260 was used to record data including calibrations. Transfer of data was done on a central processing computer. This system was used for all data reductions.

THC Monitor

A Ratfisch total hydrocarbon analyzer that works on the principle of flame ionization was used. All critical sample-handling components of the analyzer were contained in a heat-controlled oven. The oven temperature was maintained at 250°F. The following analyzer specifications were provided by the manufacturer:

Full-scale sensitivity: Adjustable from 5 ppm methane to 100,000 ppm (percent methane)

Response time (0 to 95 percent of full scale): Less than 1.5 seconds

Electronic stability: ±1 percent of full scale per 24 hours, with ambient temperature change of less than 10°F.

Precision: 0.1 percent of full scale

Zero drift: ±0.5 percent of full scale/24 hours

Reproducibility: ±1 percent of full scale for successive identical samples

Output: 0 to 10V, 4 to 20 MA

The magnitude of the analyzer response to carbon atoms depends on the chemical environment of this atom in its molecule. Typical ratios of monitor response relative to methane for carbon atoms in various molecular structures are listed in Table 14.

VARIOUS MOLECULAR STRUCTURES						
Molecular structure	Response relative to methane, %					
Aliphatic compound	100					
Aromatic compound	100					
Olefinic compound	95					
Acetylenic compound	130					
Carbonyl radical	0					
Nitrile radical	30					

TABLE 14. MONITOR RESPONSE FOR

THC Monitor Setup and Calibration

The monitor setup and checkout procedures outlined below were performed prior to sampling. The monitor was calibrated by introducing zero and high-level calibration gases to the calibration port of the sampling manifold. The predicted response for low-level and mid-level calibration gases was calculated, assuming that the monitor response is linear. The low-level and mid-level gases were then introduced into the monitor. If actual responses for the gases differed from the predicted responses by more than 5 percent, the monitoring system was inspected and repaired before sampling begins.

Once the monitor was calibrated, a system integrity check was performed. Zero air and one of the methane standards were sampled through the sample probes and lines to make sure that the sampling system was not diluting or contaminating the samples. A stainless-steel tee with a leg left open to the atmosphere was placed on the end of the probe during this step so that calibration gases being sent from the cylinders did not pressurize the sampling system.

Once the sample lines were checked out, a response-time test was performed. This test consisted of introducing zero gas to the probes and switching to the highlevel calibration gas when the system was stabilized. The response time is the time from the concentration change until the measurement system response is equivalent to 95 percent of the response for the high-level calibration gas. The test was performed three times, and the results were averaged.

Daily THC Instrument Operation

Daily calibrations for each range were performed with three calibration standards (low-level, mid-level, and high-level) and zero air. Each calibration range was checked by linear regression calculations, which indicate linear responses and are used to reduce field data. When sampling was completed, a calibration drift check was performed on the monitor by introducing the zero and span gas to the monitor.

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CEM Data Reduction

The ODESSA DSM 3260 data acquisition unit was used to collect, average, and compute 5-minute and hourly averages of the four CEM's. The system was set up to summarize all calibration points and reflect the accuracies of each calibration. The system reduces data, based on full scale and zero input values. Each calibration gas value was also programmed into the computer. Deviations from calibration gas actual values versus expected values were then computed for each calibration point. Calibration data were marked with a C and were not used in the data averages.

The following were programmed readings for each instrument:

SO₂ inlet - Full scale 48.2 ppm SO₂ outlet - Full scale 48.2 ppm THC inlet - Full scale 209.3 ppm THC outlet - Full scale 104.0 ppm

When range changes were made, a multiplier was used to adjust the computer data. A range change on the SO_2 monitor from 50 to 500 ppm scale would use a multiplier of 10 to adjust the data. Strip chart calibration responses were used to validate computer data. Strip chart calibration data was calculated using linear regression equations. This data was also used to check instrument linearity and drift. One hour of reduced strip chart data was compared daily to one hour of computer data during this program.

Sampling Equipment Calibration Procedures

All sampling equipment was calibrated before the test program according to the procedures contained in the Quality Assurance Handbook for Air Pollution Measurement systems, Volume III EPA-600/4-77-027b, or as specified in the method. In addition, onsite calibration checks were made prior to the start of testing to ensure that equipment was not damaged during packing and transport to the field site. Table 15 summarizes the sampling equipment calibrations that were performed for this project and Table 16 summarizes the field checks that were performed.

3.5.2 Site Perimeter Air Monitoring

In an effort to determine the ambient impact of the trial excavation, and to monitor the concentrations of pollutants emanating from the site, a network of ambient air monitors was established at locations selected by EPA and the South Coast Air Quality Management District. Total hydrocarbons (THC) and sulfur dioxide (SO₂) were moni-

Equipment	Calibrated against	Allowable difference
EPA Method 6 box	Bubble meter	Posttest Y ±0.05 Y
SO ₂ monitor	EPA protocol gases	±1%
THC Monitor	Master Gas Certified	±2%
Digital temperature indicator	Millivolt signal	±0.5%
Thermocouple	ASTM-3F thermometer	±1.5°F
Impinger (or condenser) thermometer	ASTM-3F	±2°F
Dry-gas thermometer	ASTM-3F	±5°F
Balance	Type-S weights	±0.5 g
Barometer	NBS-traceable barometer	±0.1 in.Hg

TABLE 15. FIELD EQUIPMENT CALIBRATION SUMMARY^a

^a As recommended in "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III." Stationary Source Specific Methods. EPA-600/4-77-027b. August 1977.

TABLE 16. FIELD CHECKS OF SAMPLING EQUIPMENT

Equipment	Checked against	Allowable difference
Pitot tube	Inspection	No visible damage
Digital temperature indicator	Millivolt signal	±0.5%
Thermocouples	ASTM 2F or 3F	±1.5%
SO ₂ monitor	Method 6	± 10%

tored at each of the locations shown in Figure 24. Additionally, air samples were taken for subsequent analysis for organic and reduced sulfur compounds at these locations utilizing a Tedlar bag instantaneous sampling technique. This air monitoring was performed to ensure compliance with the Community Safety/Contingency Resource Plan established by the Interagency Committee (IAC). This plan had established criteria levels for implementing actions to protect the community from possible effects of excessive air concentrations, as follows:



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Figure 24. McColl site showing perimeter monitor locations.

	<u>Action leve</u>	time period	
Compounds	Shut down	Shelter	Relocation
SO ₂	0.5	15.0	20.0
	(5 min)	(2 min)	(2 min)
ТНС	70.0	80.0	145.0
	(30 s)	(2 min)	(2 min)

Thus, if a concentration of 0.5 ppm SO_2 was reached and sustained for 5 minutes, all site work would stop immediately and foam would be applied to reduce emissions.

Shelter and relocation criteria were designed for short-term situations when emission levels could not be immediately reduced by onsite mitigation, and evacuation or taking shelter would be necessary to prevent population exposures. These values were based on acute toxicity data in humans for SO₂ and THC. Levels detected at the perimeter of the site were assumed to be the same as levels in the ambient air of the community. However, because emissions would be diluted as they move away from the site, the actual community levels would be lower.

Sulfur Dioxide

Monitor Labs Model 8850 SO₂ analyzers, set on a 0- to 10-ppm SO₂ range, were deployed at each of the four sampling locations. The monitors were operated on a 24-hour, continuous basis with associated strip chart recorders. Each monitor was connected to a visual and audible alarm system to provide an indication of sustained concentrations of SO₂ for a 5-minute duration above the 0.50-ppm SO₂ by volume alarm level. The contingency plan has established this 0.5-ppm level sustained over 5 minutes as the shutdown level for general public safety.

The SO₂ instruments were calibrated by challenging each instrument with known concentrations of SO₂ at zero and three upscale points using National Bureau of Standards (NBS) traceable gases. Generally, the three upscale points were established at 20, 40, and 90 percent of the full-scale range of the SO₂ monitoring instrument. Calibrations were performed at the beginning of the study, at the midpoint of the study, and at the completion of the study. On a daily basis, a zero and a single point span check at approximately 0.60 ppm SO₂ were performed and the instrument was adjusted, as necessary. All instrumentation adjustments were documented in the project and instrument log books, as well as on the strip charts. The 0.60-ppm concentration was chosen so that the alarm system would be activated and tested daily, as well.

Total Hydrocarbons

Foxboro Model 128 Organic Vapor Analyzers were used to measure total hydrocarbons at each of the sampling locations. The monitors were operated on the 0to 100-ppm scale. The THC instruments were calibrated with known concentrations at zero and three upscale points (approximately 20, 50, and 75 percent of full scale) using NBS traceable methane in air. :

The monitors were operated on a continuous basis, 24 hours a day. Each monitor had a strip chart recorder and the monitors were connected to a visual/ audible alarm to provide an indication of sustained concentrations above 70 ppm of THC for 30 seconds duration. This action level was established in the contingency plan to shut down excavation activities.

On a daily basis, a zero and single point span check, at approximately 75 ppm THC, were performed and the instruments adjusted as necessary. All instrumentation adjustments were documented in the project and instrument log books as well as on the associated strip chart. The 75-ppm concentration was selected so that the alarm system would be activated and tested daily as well.

Organic and Reduced Sulfur Compounds

Five-liter Tedlar bags were collected over approximately 5-minute time periods at each of the four perimeter site locations. The Tedlar bag samples are collected twice per week for the analysis of organic and reduced-sulfur compounds. The grab bag sampling train consisted of a Teflon sample probe, a 5-liter Tedlar bag contained in an airtight 5-gallon container, and a foot-operated bellows-type pump to evacuate the rigid container. Tedlar bags were leak checked at the laboratory by inflating the bag with zero nitrogen and observing the bag for deflation over a 24-hour period.

The bags were filled in approximately 5 minutes to capacity, which represents the total sample volume. Upon completion of sampling, the bag was disconnected, sealed, and uniquely labeled including date and time of collection and sample location. The sample technician also recorded the ambient temperature and barometric pressure for each sample collection. A courier delivered the samples to Performance Analytical, Inc., for analyses within 24 hours of collection.

Meteorological Parameters

A meteorological monitoring system was also established during the course of this pilot excavation. The meteorological parameters monitored included wind speed, wind direction, and standard deviation of wind data. A Met One Model 024A wind direction sensor was installed on a 10-meter tower. The sensor was operated on a 1- to 540-degree compass range. The sensor was installed and an initial orientation was performed using four compass points (90-, 180-, 270-, and 360-degree compass) to properly align the sensor. A Met One Model 014A wind speed sensor was installed on the 10-meter tower. The sensor was operated on a 0- to 100-mile-per-hour (mph) range. The sensor was calibrated in PEI's audit system verification center (ASVC) prior to shipment to the site. A Met One Model 076B Temperature Sensor with Radiation Shield was installed on the 10-meter tower. The sensor had an operating range of +50°C to -50°C. The sensor was factory calibrated prior to shipment to the McColl site. This unit, however, did not operate properly and temperature data were not valid.

All meteorological sensors were connected to a Met One Model 120 Translator for output in analog form to an Odessa Model DSM 3260/AQM Data Acquisition System (DAS). The DAS recorded hourly averages for wind speed, wind direction and ambient temperature. The DAS also calculated the standard deviation of the wind direction, with respect to wind speed in degrees compass.

3.5.3 Air Speciation Measurements

Beginning June 12, 1990, grab bag samples were collected at the enclosure control system inlet and outlet, selected ambient locations (Perimeter Stations 3 and 4), and the surrounding neighborhood (Cul-de-Sac-Tiffany Court). Three samples were subjected to both a gas chromatography-mass spectroscopy (GC-MS) and gas chromatography with flame photometric detector (GC-FPD) analyses for select organics, thiophene, and sulfur compounds. The primary target analyte list of compounds included: tetrahydrothiophene, benzene, toluene, m,p-xylene, o-xylene, naphthalene, methyltetrahydrothiophenes, dimethyltetrahydrothiophenes, ethyltetrahydrothiophenes, dimethylthiophenes, dimethylthiophene.

Table 17 summarizes sample collection activities including dates/times and location, and a brief summary of waste processing.

Sampling Procedures

A grab bag sample system was used to collect samples at each location. The system consisted of a Teflon sample probe, a 5-liter Tedlar bag contained in a sized container and a foot-operated bulloros-type pump to fill the bag. Prior to sample collection, the system (probe and pump connections to container) was visually inspected to ensure all connections were in place and tightly sealed. This sample probe and pump connector hose were leak checked periodically by connecting the probe to the pump hose, plugging the probe end, and evacuating the line with the foot pump until the pump was flat and no upward movement in the pump was observed.

Date (1990) and Time (24 H)	Sample location	Designated sample run number	Waste processing activity	Comments
6/12 - 1415 6/12 - 1418 6/12	Scrubber inlet Scrubber outlet -	SI-1 0-1 B-1 (blank)	Tar excavation w/o fcam Tar excavation w/o foam	
6/13 - 1157 6/13 - 1206 6/13 - 1418 6/13 - 1423 6/13	Scrubber inlet Scrubber outlet Perimeter (Sta. 4) Perimeter (Sta. 3) -	SI-2 O-2 P-1 P-2 B-2 (blank)	None None Enclosure sliding door open Enclosure sliding door open	Sample taken at seepage Sta. 3
6/14 - 1128 6/14 - 1137 6/14 - 1203 6/14 - 1211 6/14 -	Scrubber outlet Scrubber inlet Perimeter (Sta. 3) Neighborhood	0-3 SI-3 P-3 NH-1 B-3 (blank)	Tar material loaded to second bin; temp. foam applied	
6/15 - 1112 6/15 - 1118 6/15 -	Scrubber inlet Scrubber outlet -	SI-4 0-4 B-4 (blank)	Seeped tar cleanout; foam applied as excavated; char excavation	
6/19 - 1025 6/19 - 1031 6/19 - 1108 6/19 - 1123 6/19 -	Scrubber outlet Scrubber inlet Perimeter (Sta. 3) Neighborhood	0-5 SI-5 P-4 NH-2 B-5 (blank)	None - foaming, moving soil, refueling	
6/26 - 0730 6/26 - 0738 6/26 - 0806 6/26 - 0813 6/26 -	Scrubber outlet Scrubber inlet Perimeter (Sta. 3) Neighborhood	D-6 S1-6 P-5 NH-3 B-6 (blank)	Tar/char excavation	
6/29 - 1057 6/29 - 1130 6/29 - 1155 6/29 - 1303 6/29 -	Perimeter (Sta. 3) Scrubber inlet Scrubber outlet Neighborhood	P-60 S1-70 O-7 NH-3A0 B-7 (blank)0	Char transfer into pit	● - RTI audit samples
7/2 - 1011 7/2 - 1016 7/2 - 1028 7/2 - 1030 7/2 - 1040 7/2 - 1044 7/2 - 1055 7/2 - 1100 7/2 -	Scrubber outlet Scrubber outlet Scrubber inlet Scrubber inlet Perimeter (Sta. 3) Perimeter (Sta. 3) Neighborhood Neighborhood	0-8 0-8-D1● SI-8 SI-8-D1● P-7 P-7-D1● NH-4 NH-4-D1● B-8 (blank)	Mud transfer from bin to stockpile	• - Duplicate sample
7/11 - 1103 7/11 - 1108 7/11 - 1117 7/11 - 1122 7/11 -	Scrubber outlet Scrubber outlet Scrubber inlet Scrubber inlet	0-9 0-9-D20 SI-9 SI-9-D20 B-9 (blank)*	Tar processing (Run 5)	 Duplicate samples (stabi- lity check) Blank air bubbled through H O prior to col- lection

TABLE 17. SUMMARY OF AIR SPECIATION BAG COLLECTION ACTIVITIES

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(continued)

Date (1990) and Time (24 H)	Sample location	Designated sample run number	Waste processing activity	Comments
7/12 - 0908 7/12 - 0912 7/12 - 0930 7/12 - 0940 7/12 -	Scrubber outlet Scrubber inlet Perimeter (Sta. 3) Neighborhood	0-10 SI-10 P-8 NH-5 B-10 (blank)	Tar processing (Run 8)	

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TABLE 17 (continued)

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No attempt was made to leak check the sample bags to preclude the possibility of sample contamination. For the scrubber inlet and outlet tests, the sample probe was placed at the duct centroid and purged with stack gas using a Thomas pump before connecting the sample bag. Samples were collected over approximately a 5-minute period or until the bag was full. At each location, the date/time, barometric pressure, wind direction, and temperature were recorded. Each sample was uniquely identified (see Table 17) and chain-of-custody forms were filled out for each set of samples collected. Samples were then couriered to Performance Analytical, Inc. Canoga Park, California for analysis within a 24 hour period. Blank samples were collected daily by filling a bag with zero air and submitting for analysis with each sample lot. Additionally, duplicate samples were collected to access field precision and sample stability.

Analytical Procedures

Each sample was subjected to a GC-MS and GC-FPD analysis. The volatile organic compounds were analyzed using procedures described in EPA Method TO-14. Analyses were performed using a Finnigan 4500 Quadrupole GC/MS/DS system interfaced to a Tekmar 501067 automatic desorber and a Dessage GS 3/2 gas sampler. Sulfur-bearing organics and thiophene were semi-quantified from the mass spectra data generated during these analyses. These compounds were quantified by correlating their response to tetrahydrothiophene and assuming a 1:1 response relative to that compound. A separate "aliquot" from each bag was directly injected into a GC-FPD to quantify reduced sulfur compounds. The reduced sulfur analysis generally followed the GC-FPD criterion established in EPA Reference Method 16. In addition to the method blank, field blank, and duplicate sample analyses, internal standards and surrogate spike compounds were added to each sample analyzed by T014 to access data accuracy. The internal standards and surrogates are those specified in Method 8240 of EPA SW846.

Analytical procedures were audited by Research Triangle Institute. As discussed in Section 5, the Agency determined that the resulting data did not meet the necessary quality control criteria, and these data were not used. This information is contained in the EPA Region IX raw data file.

3.5.4 Odor Survey

To evaluate the possibility of fugitive emissions entering the neighborhood adjacent to the McColl site, the California State Department of Health Services (CDHS) planned to conduct an odor surveillance study in the McColl community. There are several highly odoriferous chemicals characteristic of the acidified asphaltic petroleum sludges buried at McColl. One of these, tetrahydrothiophene (THT) and its alkylated (methyl-, dimethyl-, and ethyl-) derivatives, can be detected by most human noses at 1 part per billion (ppb). This is below the analytical detection limit for most laboratory equipment; consequently, people can be better detectors than machines. Thus, by involving community members in reporting odors characteristic of McColl, the agencies could assess possible community exposures to emissions resulting from the excavation of the buried wastes. To verify potential exposures, select members of the community would also be recruited to collect grab samples (5-liter Tedlar bags) of ambient or indoor air during odor "episodes." This section of the report describes the plan that was developed by CDHS and what was accomplished.

To maximize the number of neighborhood air grab samples that would contain measurable amounts of odorous chemicals, it was deemed necessary to train a panel of community members to evaluate odor intensity. This was to be accomplished by utilizing the professional services of Odor Science and Engineering (OSE), Hartford, Connecticut. In brief, OSE would train people to judge the intensity of an odor by matching it to one of eight serial dilutions (from 1:16 to 1:2000) of butanol in water. Ideally, a member of the odor panel would compare the odor he or she detected from McColl with that from one of the eight bottles and only collect an air sample that would be characterized as "strong" (low dilution factor). OSE would also equip and train select members of the odor panel on how to collect an air sample. The equipment consisted of a sealed 5-gallon bucket containing a Tedlar bag vented to the outside air with Teflon tubing. By use of a foot pump, one can evacuate the air from the bucket and cause the bag to inflate, thereby collecting a grab sample. Each designated odor panel member would initially be given three Tedlar bags and an inflation device.

Selection of odor panel members was to be based on several criteria. In order to collect the most concentrated air sample, the member should live very near the site. Initially, this was defined as residing on Fairgreen Drive or Tiffany Place. The panel member should also be at home during the hours of planned excavation. Also, because some people have very poor odor thresholds, which would not be desirable, the panel member must have successfully completed the odor intensity training. In order to increase the probability of recruiting at least six households that would meet these criteria, the area solicited was expanded to include homes on Fairford Drive, Crown Way, and Regency Circle. Ideally, one adult member from nine households would be trained, with six being selected as primary sample collectors and the other three as alternates. While initial community interest seemed high, actual volunteers were few. Therefore, in addition to letters being sent to each eligible household, 47 families were also contacted by telephone. Only two households could be recruited that met the requirements previously outlined. Unfortunately, this would not have provided adequate coverage of the perimeter of the site, so the odor panel training was canceled. The lack of participation could be attributed to attempting to recruit for a period of time when many people take summer vacations (June and July) and the fact that many people work during the day.

In order to still assess the frequency of odor complaints originating from the site, the CDHS opted to perform a "passive" surveillance of the McColl neighborhood. While the initial odor survey would have required active participation on the part of cer-

tain community members, a passive surveillance is designed to allow large numbers of residents to respond when they choose. Thus, CDHS set up an "800" telephone number through which the community could telephone in odor complaints any time after experiencing odorous emissions from the site. The telephone number remained in service from May 29 through August 15, providing essentially 24-hour coverage before, during, and after the trial excavation. Actual odor complaints were received and documented by the Orange County Department of Environmental Health and relayed to CDHS, EPA, and the South Coast Air Quality Management District (SCAQMD).

To determine whether emissions were reaching the community, the EPA's SITE Program implemented a limited community air sampling program. Five-liter air samples were collected on random days near the perimeter air monitoring stations and in the community at the cul-de-sac of Tiffany Place. These ambient air grab samples were analyzed as described in Subsection 5.5.3. The reduced organosulfur compounds quantified by Performance Analytical, Inc. (PAI) were specifically chosen because they had previously been identified by GC/MS analysis of a Tedlar bag sample collected in response to an odor complaint at 10:30 p.m. on April 16, 1982, at 1837 Fairgreen Drive (TRC, July 1982). None of the eight perimeter samples or the five neighborhood air grab samples contained detectable amounts of the reduced organosulfur target compounds. These data did not, however, meet analytical quality controls, and were deemed invalid by the Agency. There were no odor complaints from the community on the days the neighborhood air samples were collected.

Odor complaints were reported on the 2 days prior to the last round of EPA's neighborhood air sampling (July 12). The reports of odors originated from homeowners immediately adjacent to the site, near the intersection of Tiffany Place and Fairgreen Drive. Examination of meteorological data at the time of the complaints suggests that wind conditions (274 degrees/10 mph and 200 degrees/<3 mph) were such that emissions from the stack could be transported or diffused in the direction of these homes. Examination of the Site Activity Logs indicates that stack emission flow rates from the air scrubber were reduced from 1100 ft³/min on July 9 to 350 ft³/min on July 11. This reduction in exhaust airflow probably resulted from a buildup on the packing balls in the scrubber. This problem was remedied on July 11. However, exhaust airflow rates were reduced on July 10, the first day of odor complaints. The effect of reduced airflow rates is to decrease the vertical dispersion of emissions, allowing for increased horizontal transport (the winds were from 274 degrees at 10 mph the evening of July 10). The essentially calm wind conditions on the evening of July 11 could have allowed diffusion of these odorous compounds into the neighborhood. However, because of the presence of the large seep at Pit L-1 and a smaller one near perimeter Monitoring Station 3 (which are nearer the affected homes than the stack and yet are in line with the stack and the homes), it is difficult to determine the contribution of the stack emissions to the odors detected in the neighborhood. Interestingly, there were other times during the trial excavation when meteorological

conditions would have allowed the diffusion of odorous emissions from the seeps into the community, but odor complaints were not registered. However, it should be noted that odor perception/detection requires that a person be in the right place at the right time; the absence of an odor complaint may simply reflect the absence of a human receptor.

The very low number of odor complaints registered by the McColl community during the course of the trial excavation may have several explanations. Control measures may have reduced concentrations of organosulfur compounds such that air dispersion would allow sufficient dilution to nondetectable levels. Also, daytime winds during the course of the trial excavation were predominantly from the south-southwest, which would tend to disperse the stack emissions toward the Los Coyotes oil fields and away from the residential areas. Summertime temperatures were also in excess of 100°F, which would tend to keep most residents indoors with their air conditioners operating. As noted earlier, there may not have been many residents home during the davtime due to adult members of the household being at work or possibly on summer vacations. In this regard, it will be difficult to assess whether nighttime or weekend excavation activities would have affected the incidence of odor complaints, since excavation did not occur at these times. There is also the possibility that the almost continuous presence of rather large seeps at McColl induced a tolerance effect on the perception of odors by nearby residents. Nearby residents may have become acclimated to low levels of McColl odors such that it may take significant increases above background for these odors to become objectionable. For example, some people notice the ever-present odors at McColl more readily after returning from vacations out of the local area.

Although the CDHS original odor survey was not implemented, the CDHS passive odor surveillance and the meteorological measurements did provide for limited odor monitoring during the trial excavation. The results indicate that fugitive emissions from the site did not result in excessive odor complaints during the 6-week trial excavation.

SECTION 4

RESULTS OF FIELD DEMONSTRATION

This section presents and discusses the results of the activities performed during the trial excavation. The topics covered in this section are as follows: inlet and outlet SO_2 and THC emissions; performance of the wet scrubber and activated carbon unit; excavation pit emissions; exhaust gas flow rates; perimeter SO_2 and THC ambient air levels; air speciation data; foam efficiency evaluation; tar processing evaluation; equipment performance evaluation; and waste characterization.

Also, at the beginning of this chapter is a discussion of the method used to reduce the inlet and outlet SO_2 and THC emission data.

4.1 Enclosure Air Emission Control System Monitoring

4.1.1 Background Ambient Air and Diesel Engine Testing Concentration Data

Prior to the start of excavation, background testing was conducted on 1) ambient air outside the enclosure, 2) air from an empty enclosure with no activity, and 3) air from the enclosure while diesel engines were running. During the diesel engine measurements, the air exhaust system was in operation and the samples were taken at the air control system inlet site. These data give an indication of SO₂ and THC levels prior to any excavation activity. The background data are presented in Table 18.

The ambient air and empty enclosure SO_2 and THC levels were low as expected. During the diesel engine background testing, both the SO_2 and THC concentrations gradually increased. The THC levels started at 5.5 ppm (0645), peaked at 18.2 ppm (1035), decreased to 4.6 ppm (1150), and were in the 4- to 6-ppm range thereafter. Although the SO_2 concentrations also increased gradually during the diesel engine/background testing, some of the increase may have resulted from monitor drift during these initial tests. The drift was attributed to moisture condensation when the sample gas entered the monitoring trailer. This drift was specific to the SO_2 analyzers. The problem was corrected when discovered.

	_		Avg. concentration, p		
Sample conditions	Date (1990)	Time (24-h)	\$0 ₂	тнс	
Ambient air	6/6	1525-1555	<1.0 ^a	2.0 ^b	
Empty enclosure	6/2	0955-1035	<1.0	3.4	
Enclosure with diesel engines operated ^c	6/7	0700-0800 0800-0900 0900-1000 1000-1100 1100-1200 1200-1300	<1.0 2.0 5.7 ^d 7.7 ^d <1.0 1.6	9.6 13.3 16.1 14.7 5.7 4.2	

r/	R	IF	18	BAC	KGR	OUIND	ATR	DATA
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^a Method Detection Limit was 2% of full scale (1 ppm).

^b Method Detection Limit was 2% of full scale (2 ppm).

- ^C Engines started at 0645 and stopped at 1035.
- ^d SO₂ readings are believed to be biased high due to drift as a result of moisture condensation in the system.

4.1.2 Inlet and Outlet Data Reduction Process

The most important data for the evaluation of the air emission control system are the SO_2 and THC results before and after the caustic scrubber and activated carbon air units. The SO_2 and THC concentrations were measured in the enclosure ventilation air leaving the enclosure and entering the scrubber-carbon system (inlet), and in the air discharged from the stack (outlet) into the atmosphere.

The following discussion presents examples of the SO₂ and THC data from the enclosure exhaust control system. The example data are from the SO₂ and THC continuous emission monitors and represent a short-time interval of approximately 2 hours on June 9 when the SO₂ and THC emissions in the enclosure rapidly increased during the excavation activities. Table 19 represents the 2-hour time interval of 1330 (1:30 PST) to 1540 (3:40 PST) on June 9, 1990. It reflects a continuous record of 5-minute average data points that were generated by the computerized automatic data aquisition system that was calibrated to accept the inputs from the two SO₂ monitors and the two THC monitors. Figures 25 and 26 represent graphical plots of the inlet and outlet SO₂ and THC data highlighted during the same time interval and constructed from the 5-minute data shown in Table 19. Figures 27 and 28 are segments of the continuous strip chart records that are also highlighted to show the same time interval on June 9, 1990. The strip chart records contain the actual observations and

Time	SO ₂ (ppm) Inlet	SO ₂ (ppm) Outlet	THC (ppm) Inlet	THC (ppm) Outlet
· 13:30	0.1	0.0	12.5	4.2
13:35	0.1	0.0	12.3	4.0
13:40	0.0	0.0	12.2	4.7
13:45	0.1	0.0	15.5	45
13.50	1 0	0.0	19.0	4.8
14:00	4.3	0.0	23.9	5.9
14:05	14.8	0.0	29.5	6.2
14:10	27.0	0.0	34.6	7.5
14:15	41.6	0.0	40.0	8.1
14:20	34.4ª	0.0	46.6	10.9
14:25	37.6°	0.0	49.9	11.8
14:30	37.4ª	0.0	49.7	12.8
14:35	38.1 ^a	0.0	61.1	14.8
14:40	12.4 ⁶	0.0	81.7	18.8
14:45	13.6b	0.0	91.6	23.0
14:50	12.8 _b	0.0	88.0	25.7
14:55	10.2b	0.0	/9.8	22.7
15:00	8./b	0.0	103.4	20.1
15:05	0.2b	0.0	107.0	29.9
15:10	20 Fa	0.0	90.5	20.0
15.15	20.5 34 na	0.0	87 9	5.0 ^C
15.25	31 8a	0.0	84.5	41.0 ^C
15:30	30.7ª	0.0	22.1°	23.1
15:35	27.4 ^a	0.0 ^C	79.6 ^d	26.3
15:40	28.1 ^{a,d}	14.0 ^C	95.5	37.2

TABLE 19. EXAMPLE SO2 AND THC DATA FOR JUNE 9

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^a Scale change from 0-50 ppm to 0-100 ppm. Data must be multiplied by 2 to obtain real value (i.e., @ 14:20 $34.4 \times 2 = 68.8$).

- ^b Scale change from 0-100 ppm to 0-500 ppm. Data must be multiplied by 10 to obtain real value. Multiply by 2 for change from 0-50 ppm to 0-100 ppm and then multiply by 5 for change from 0-100 ppm to 0-500 ppm (i.e., @ 14:40 12.4 x 2 x 5 = 124).
- ^C Calibration period. Data reported is calibration data point which represents the concentration of the calibration standard for SO₂ and THC and does not represent true data points.
- ^d Span run. Data reported is span check quality control check point and does not represent a true data point.













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Figure 28. Late afternoon portion of THC outlet strip chart for June 9.

notations by the on-site analyst who was continually maintaining and operating the SO₂ and THC monitors during all periods of activity within the enclosure.

Please note on Table 19 at 14:45 the SO₂ inlet concentration is shown as 13.6 ppm [which is actually 136 ppm due to scale change (Footnote B)]. Figure 25 also identifies the 136 ppm SO₂ at 14:45 and Figure 26 (strip chart record) also shows 136 ppm SO₂ at 14:45. The outlet SO₂ concentrations being emitted to the atmosphere were all less than 1 ppm SO₂.

4.1.3 Sulfur Dioxide Concentrations Before and After the Enclosure Exhaust System

On June 7, 1990, sampling began for sulfur dioxide at the inlet and outlet of the enclosure exhaust control system. The continuous emission monitors (CEMs) ran continuously until the completion of the program on July 18, 1990. For a chronological listing of excavation activities during this time period, see Section 3.2.2 of this report, and refer to the daily operating logs presented in Appendix A.

Table 20 presents the SO_2 data generated. The table lists the enclosure exhaust control system inlet and outlet concentrations (ppm) expressed as daily averages, maximum values, second-highest values, and minimum values. The maximum and minimum values are 5-minute average values. All of the data were generated from the DAS generated 5-minute averages.

Also presented in this table are SO₂ removal efficiencies calculated for each 5-minute data set and averaged for each day. These data will be discussed in subsection 4.1.4. Figure 29 is a legend of the data plots for Figures 30 through 65. Figures 30 through 46 present plots of inlet and outlet SO₂ concentrations. Additional plots of SO₂ concentrations versus time are presented in Appendix B-1. The days presented were chosen becaused of work activity occuring within the enclousre and the resulting SO₂ and THC emissions.

4.1.4 Wet Scrubber Performance

The SO₂ scrubber used during the trial excavation was designed to achieve an outlet SO₂ concentration of 2 ppm on a continuous basis, assuming that the average inlet SO₂ concentration would be near 10 ppm and that the maximum inlet SO₂ concentration would be 200 ppm. The data in Table 20 show that the 2-ppm outlet SO₂ concentration limit was met with few exceptions. One exception was a 50-minute period on June 13 when the scrubbing liquor pH was inadvertently allowed to drop to 2.9, well below the specified control range of 10 to 13. During this period, the outlet SO₂ concentration rose to a 5-minute average maximum of 12 ppm. The achievement of the outlet SO₂ design criteria was especially impressive in light of the high inlet SO₂ concentrations experienced during a large portion of the operation.

<u> </u>		SO, inle	t, ppm			SO, outle	et. ^a ppm			
Date (1990)	Daily average	Maximum	2nd highest	Minimum	Daily average	Maximum	2nd highest	Minimum	Average daily efficiency	Activity
6/7 ^C	<1.0	11.4	8.0	<1.0	2.4	9.0	8.0	<1.0	d	Background data
6/8 ^C	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	2.0	<1.0	d	Excavate overburden
6/9	8.4	135.9	128	<1.0	<1.0	<1.0	<1.0	<1.0	96.7	Excavate tar/foam
6/10	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	d	-
6/11	<1.0	2.5	2.3	<1.0	<1.0	1.1	1.1	<1.0	d	Excavate tar/foam
6/12	121.8	1000.0	641.5	<1.1	<1.0	1.1	<1.0	<1.0	99.8	Excavate tar/foam
6/13 ^e	127.5	466.1	463.9	19.9	<1.0	11.9	11.5	<1.0	99.5	Excavate tar/foam
6/14	127.6	637.7	564.4	12.6	<1.0	<1.0	<1.0	<1.0	99.9	Moved tar/foam
6/15	203.6	754.8	744.2	21.2	<1.0	<1.0	<1.0	<1.0	99.7	Excavate tar/char/foam
6/16	68.8	126.8	126.3	<1.0	<1.0	<1.0	<1.0	<1.0	99.9	-
6/17	50.5	61.3	60.3	5.8	<1.0	<1.0	<1.0	<1.0	99.8	-
6/18	40.0	65.0	59.4	24.9	<1.0	<1.0	<1.0	<1.0	99.2	-
6/19	29.8	42.1	41.4	21.0	<1.0	<1.0	<1.0	<1.0	99.4	-
6/20	18.7	31.6	31.2	<1.0	<1.0	<1.0	<1.0	<1.0	98.2	-
6/21	7.1	25.4	24.8	<1.0	<1.0	<1.0	<1.0	<1.0	97.0	Overburden/foam
6/22	5.3	10.5	10.5	1.5	<1.0	<1.0	<1.0	<1.0	96.1	Stab. foam
6/23	5.9	11.6	11.4	2.3	<1.0	<1.0	<1.0	<i.û< td=""><td>97.6</td><td>-</td></i.û<>	97.6	-
6/24	6.1	11.7	11.4	3.1	<1.0	<1.0	<1.0	<1.0	97.5	-
6/25	6.2	10.7	10.5	3.2	<1.0	<1.0	<1.0	<1.0	94.6	-
6/26	115.3	593.3	576.5	3.6	2.9 ^f	39.9 ^f	38.9 ^f	<1.0	94.9	Excavate tar/char/foam
6/27	41.5	83.2	79.1	13.6	<1.0	2.4	2.4	<1.0	97.8	Tar seepage
6/28	19.0	82.4	81.9	2.5	<1.0	<1.0	<1.0	<1.0	98.5	Moved char/tar
6/29	35.4	213.8	213.5	5.6	<1.0	<1.0	<1.0	<1.0	97.4	Moved char

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TABLE 20. SO, INLET AND OUTLET CONCENTRATIONS

(continued)

TABLE 20	(cont [:]	inued)
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Date (1990)	SO, inlet, ^a ppm									
	Daily average	Maximum	2nd highest	Minimum	Daily average	Maximum	2nd highest	Minimum	Average daily efficiency	Activity
6/30	7.3	10.6	10.4	3.4	<1.0	1.1	1.1	<1.0	87.5	-
7/1	6.6	12.6	12.3	2.4	1.1	1.7	1.7	<1.0	78.8	-
7/2	29.3	162.9	160.3	2.4	<1.0	1.4	1.4	<1.0	89.1	Moved tar/mixed waste
7/3	1.2	2.7	2.7	<1.0	<1.0	<1.0	<1.0	<1.0	71.8	Equipment activity
7/4	<1.0	1.7	1.7	<1.0	<1.0	<1.0	<1.0	1.1	d	-
7/5	<1.0	1.7	1.7	<1.0	<1.0	1.5	1.5	<1.0	d	-
7/6	<1.0	<1.0	<1.0	<1.0	g	-	-	-	đ	-
7/7	<1.0	<1.0	<1.0	<1.0	g	-	-	-	d	-
7/8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	d	-
7/9	<1.0	1.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	d	-
7/10	4.9	38.8	37.4	<1.0	<1.0	<1.0	<1.0	<1.0	99.8	Run 1/Run 2 - tar
7/11	2.1	8.9	8.4	<1.0	<1.0	1.1	<1.0	<1.0	98.4	Runs 3, 4, 5, & 6 - tar
7/12	1.9	9.0	8.6	<1.0	<1.0	<1.0	<1.0	<1.0	92.5	Runs 7, 8, & 9 - tar
7/13	<1.0	<1.0	<1.0	<1.0	<1.0	2.1	1.2	<1.0	d	Run 10 - tar
7/14	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	d	-
7/15	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	d	-
7/16	6.4	40.8	39.4	<1.0	<1.0	1.2	<1.0	<1.0	91.5	Move tar
7/17	14.9	85.3	81.7	<1.0	<1.0	2.7	2.7	<1.0	82.0	Move tar
7/18	<1.0	1.1	1.0	<1.0	<1.0	4.5	4.3	<1.0	d	Material handling

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(continued)

TABLE 20 (continued)

^a Method Detection Limit (MDL) was 2% of scale (0 to 50 ppm) or 1 ppm. Daily average value is based on 24-hour period. Maximum and minimum values are from 5-minute average values.

 $\frac{b}{\text{Efficiency}} = \frac{\text{Inlet 5-minute averages - outlet 5-minute averages}}{\text{Inlet 5-minute average}} \times 100.$

^C SO₁ inlet and outlet data on 6/7 and SO₂ outlet data on 6/8 are biased high from moisture, which caused the instruments to drift. Values are assumed to be below the detection limit.

 d Efficiencies were not calculated when inlet values were at the method detection limit (1 ppm).

e SO, outlet values increased on 6/13 because scrubber pH went down to 2.9, which is below the normal operating pH of 7 to 10.

f SO, outlet values are biased high as a result of drift caused by moisture in the monitor.

^g Monitor off line as a result of moisture in monitor.

NOTE: Inlet site is air from the enclosure system (untreated). Outlet site is exhaust air from the scrubber and carbon treatment systems.

- 1. The full calibration period is the injection of three calibration gases and zero air. The calibration is performed to insure the system is operating properly and to enable data reduction. The calibration takes approximately one hour.
- 2. Reading data storage cartridge is the transfer of CEM data from the data acquisition system (DAS) to the computer disk. The transfer of data temporarily impedes data to be recorded to the DAS. Transfer of data takes approximately 30 minutes.
- 3. Span and zero checks are conducted on each CEM when there was a convenient break in excavation. These checks are conducted to insure proper system operation. Span and zero checks take 30 minutes.
- 4. The probe was taken out of the sampling port for several reasons: a) to clean the sampling system, b) to inject calibration gases through the sample system, and c) to replace the sample filters. Also, at certain times the probe fell out of the stack from fan vibration.
- 5. Condensers were emptied on the SO₂ instruments. These instruments require water condensers to prevent moisture from entering the instrument.
 - The above occurrences show up on the graphs as "gaps" in the data. The gaps in data are times when data were not being recorded to the data acquisition system. The six items are abbreviated for use in the text.
 - SO₂/THC In Designates sample location at the inlet to the air treatment system. The inlet site samples untreated gases from the enclosure.
 - SO₂/THC Out Designates sample location at the outlet to the air treatment system (scrubber and carbon bed). The outlet site samples treated gases from the enclosure.
 - The vertical graph axis is the concentration of the pollutant (SO_2/THC) in parts per million (ppm).
 - The horizontal axis is the time of day in two-hour increments.

Figure 29. Legend for data plots on Figures 30 through 65.







Figure 32. Plot of SO2 concentrations vs time for June 13, 1990.





Figure 34. Plot of SO2 concentrations vs time for June 15, 1990.


Figure 35. Plot of SO2 concentrations vs time for June 18, 1990.

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Figure 36. Plot of SO2 concentrations vs time for June 26, 1990.

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Figure 37. Plot of SO2 concentrations vs time for June 28, 1990.



Figure 38. Plot of SO2 concentrations vs time for June 29, 1990.



Figure 39. Plot of SO2 concentrations vs time for July 2, 1990.



Figure 40. Plot of SO2 concentrations vs time for July 10, 1990.



Figure 41. Plot of SO2 concentrations vs time for July 11, 1990.

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Figure 42. Plot of SO2 concentrations vs time for July 12, 1990.







Figure 44. Plot of SO2 concentrations vs time for July 14, 1990.



Figure 45. Plot of SO2 concentrations vs time for July 16, 1990.



Figure 46. Plot of SO2 concentrations vs time for July 17, 1990.

As a result of these high inlet and low outlet concentrations, the SO₂ removal efficiency of the scrubber was higher than expected. For the operating days in Table 20 for which daily average SO₂ inlet concentrations were above 10 ppm, the daily average SO₂ removal efficiencies were always above 95 percent. On many of these days, SO₂ removal efficiencies exceeded 99 percent.

The normal operating range for the scrubber liquor pH was established at 10 to 13 by the scrubber manufacturer prior to the trial excavation. It was noted, however, that operation near the high end of this range often caused excessive foaming of the scrubber liquor near the bottom of the packed tower, with subsequent overflow of liquor out through the inlet duct and into the filter box. In light of the high SO₂ removal levels demonstrated by the scrubber, the decision was made to reduce the pH operating range to 7 to 10. This change had the effect of eliminating the liquor foaming and overflow problem, while maintaining consistently low outlet SO₂ concentrations.

Besides foaming, the only other operational problem encountered with the SO₂ scrubber was occasional restrictions in the tower, which caused low ventilation airflow. The first episode occurred on June 15 and was diagnosed as excessive solids passing through the filter (upstream of the scrubber) and building up in the scrubber packing. The low airflow conditions were relieved by blowing down the scrubber liquor, washing down the packing, and increasing the frequency of filter inspections and changes. The filter system used during the trial excavation was a low-efficiency, field-fabricated system which relied upon residential furnace filters as the filter media.

The second episode of low airflow occurred on July 11. The solids content of the scrubber liquor at this time was much lower than during the first episode. Inspection of the packing balls through the lower access port showed that many contained a buildup of black, soot-like material that appeared to be composed of very fine particulate matter. By experimenting, it was found that the airflow could be returned to normal levels by decreasing the liquor recirculation flowrate from its normal range of 15 to 20 gallons/minute to near 5 gallons/minute. Since the outlet SO₂ concentration remained low even at the lower liquor recirculation flowrate, this rate was maintained for the duration of the program.

At the conclusion of operations, the scrubber was shut down and opened at the top cone and the bottom access port for inspection. At the top of the scrubber, the demister pad was clean and free of any buildup. The packing balls at the top of the scrubber were in a similar condition. At the bottom of the scrubber, packing balls near the access port were found to be partially obstructed with the black buildup described previously plus a white crystalline material speculated to be crystallized sodium hydroxide. Together, the combined solids filled approximately 25 percent of the volume of these packing balls. However, after the first 6 inches of balls were removed from the lower access port, it was clear that the packing balls in the center of the tower were free of significant buildup. The air-distribution grid at the bottom of the packed

tower was also free of solids buildup. Thus, the cause of the second incident of low ventilation airflow could not be identified. All other portions of the scrubber were in good working order at the completion of program operations.

With respect to a final remediation scrubber, one change recommended as a result of trial excavation operations would be the installation of a high-efficiency industrial particulate collection device upstream of the scrubber. The device should be designed to capture both large and fine particulate (e.g., diesel engine emissions) to a high degree and thereby prevent the buildup of solids in the scrubber liquor and packing material. Alternatively, a more open SO₂ absorber design could be employed, such as a spray tower. In addition, an automatic pH control system should be added that will maintain the desired pH range by addition of caustic soda, as opposed to the manual system employed during the trial excavation.

4.1.5 Total Hydrocarbon Concentrations Before and After the Enclosure Exhaust Control System

As mentioned in Section 4.1.2, the CEMS at the inlet and outlet of the enclosure exhaust control system operated continuously from June 7 until July 18. In addition to SO₂ monitoring, total hydrocarbon (THC) monitoring took place at the inlet and outlet to the enclosure exhaust control system. A chronological listing of excavation activities during this time period is included in Section 3.2.2 of this report, and is also contained in the daily operating logs in Appendix A.

Table 21 presents the THC data generated. The table lists the enclosure exhaust control system inlet and outlet concentrations (ppm) expressed as daily averages, minimum and maximum values. The maximum and minimum values are 5-minute average values. All of the data were generated from the DAS generated 5-minute averages.

Also presented in this table are THC removal efficiencies calculated for each 5minute data set and averaged for the day. These data will be discussed in detail in Section 4.1.6.

Graphs were generated from the 5-minute data sets displaying THC inlet and outlet concentrations versus time. Figures 47 through 65 display the variations of THC inlet and outlet concentrations for selected days during the trial excavation.

Additional plots of THC concentrations versus time are presented in Appendix B-1.

		THC inle	at, ppm		THC outlet, b ppm					
Date (1990)	Daily average	Maximum	2nd highest	Minimum	Daily average	Maximum	2nd highest	Minimum	Average daily efficiency	Activity
6/7	7.6	18.2	18.0	<4.0	2.7	6.2	5.4	<2.0	61.8	Background data
6/8	9.9	20.6	20.3	4.2	3.5	5.9	5.8	<2.0	61.2	Excavate overburden
6/9	27.1	107.8	103.4	5.5	10.9	37.2	32.7	3.0	54.2	Excavate tar/foam
6/10	29.2	40.5	40.5	21.0	11.9	15.1	15.0	4.3	59.6	-
6/11	31.3	58.9	58.3	<4.0	13.6	17.2	17.1	2.6	55.5	Foam applied
6/12	69.9	305.6	273.1	12.8	25.8	62.5	61.4	8.9	53.1	Excavate tar/foam
6/13	103.7	221.8	219.1	22.9	52.5	117	110	22.3	50.0	Excavate tar/foam
6/14	193.1	492.3	464.0	7.5	82.6	284.3	224.2	49.3	49.4	Moved tar/foam
6/15	225.2	341.4	340.5	10.7	98.1	151.3	151.3	14.9	56.0	Excavate tar/char/foam
6/16	92.9	228.9	222.0	<4.0	20.9	85.3	81.1	<2.0	84.0	Change to coconut carbon
6/17	87.3	288.6	104.2	5.3	8.7	27.6	25.7	<2.0	90.7	-
6/18	82.7	101.2	101.2	42.4	15.6	22.4	22.3	11.6	81.4	-
6/19	90.3	117.4	110.4	77.8	25.0	37.3	36.9	18.1	72.5	-
6/20	67.3	98.6	98.5	<4.0	27.9	36.6	36.6	20.5	67.9	-
6/21	53.4	131.9	128.0	<4.0	31.1	70.7	70.6	14.9	58.4	Overburden/foam
6/22	57.3	74.9	74.8	27.7	22.3	32.3	32.1	13.7	60.4	Stab. foam applied
6/23	54.9	72.0	71.8	40.1	20.6	29.9	29.6	3.5	61.9	-
6/24	47.2	61.6	61.4	35.2	19.1	25.3	25.2	15.9	58.6	-
6/25	47.7	66.2	65.5	<4.0	14.2	26.2	26.2	<2.0	72.3	-
6/26	121.9	345.3	326.5	33.6	29.9	76.7	75.3	<2.0	78.1	Tar/excavate char/foam
6/27	95.8	278.4	359.5	<4.0	37.6	71.9	71.6	26.1	60.3	Tar seepage
6/28	80.2	161.2	158.5	52.4	42.8	67.5	66.6	4.4	44.4	Moved char and tar
6/29	83.6	714.8	649.9	<4.0	46.5	83.4	82.8	24.6	39.2	Moved char

TABLE 21. THC INLET AND OUTLET CONCENTRATIONS

(continued)

TABLE 21 (continued)

	THC inlet, ppm				THC outlet, ^b ppm					
Date (1990)	Daily average	Maximum	2nd highest	Minimum	Daily average	Maximum	2nd highest	Minimum	Average daily efficiency	Activity
6/30	48.5	65.8	65.7	4.3	37.0	76.7	68.0	11.2	24.7	-
7/1	55.2	86.0	84.7	37.2	33.3	51.9	51.8	25.3	38.6	-
7/2	98.6	174.0	173.8	44.5	49.7	92.6	92.2	21.7	47.7	Moved tar and mixed waste
7/3	43.4	67.8	67.3	18.3	30.5	45.0	44.7	16.6	39.4	Equipment activity
7/4	46.8	60.3	60.1	39.2	25.6	42.0	41.3	17.0	44.4	-
7/5	41.6	50.3	49.3	35.9	22.7	36.4	36.2	14.8	44.4	-
7/6	13.0	39.5	39.5	<4.0	9.2	24.6	24.6	<2.0	Offline	-
7/7	<4.0	<4.0	<4.0	<4.0	<2.0	<2.0	<2.0	<2.0	Offline	-
7/8	<4.0	<4.0	<4.0	<4.0	<2.0	<2.0	<2.0	<2.0	Offline	-
7/9	21.4	37.9	37.5	<4.0	15.4	29.8	29.7	<2.0	31.3	-
7/10	108.5	193.4	192.6	19.3	29.7	117.8	92.7	12.4	55.9	Pug mill Runs 1 & 2
7/11	193.3	358.0	358.0	88.2	51.1	106.4 ^d	106.4 ^d	25.5	71.6	Pug mill Runs 3, 4, 5, & 6
7/12	149.2	548.5	278.3	18.0	84.4	132.1	131.6	<2.0	42.1	Pug mill Runs 7, 8, & 9
7/13	75.2	134.1	132.9	18.5	67.6	106.4 ^d	106.4 ^d	32.0	15.8	Pug mill Run 10
7/14	58.1	78.1	77.5	40.0	54.9	65.6	65.5	29.0	23.6	-
7/15	47.1	54.0	54.Ū	33.3	37.7	55.2	55.2	2.4	59.2	
7/16	84.4	175.5	172.9	12.3	56.9	106.4 ^d	106.4 ^d	2.1	45.4	Move tar
7/17	84.5	278.3	278.3	<4.0	34.7	121.7	120.6	<2.0	73.3	Move tar
7/18	39.1	94.5	89.2	<4.0	34.5	71.5	71.5	<2.0	24.2	Material handling

a Inlet detection limit was 4 ppm. Inlet site is air from the enclosure system (untreated).

b Outlet detection limit was 2 ppm. Outlet site is exhaust air from the scrubber and carbon treatment systems.

d Values are low because the voltage signal was at its maximum (10 volts).

NOTE: Maximum and minimum values are from 5-minute average values.



Figure 47. Plot of THC concentrations vs time for June 7, 1990.



Figure 48. Plot of THC concentrations vs time for June 8, 1990.







Figure 50. Plot of THC concentrations vs time for June 12, 1990.



Figure 51. Plot of THC concentrations vs time for June 13, 1990.



Figure 52. Plot of THC concentrations vs time for June 14, 1990.



Figure 53. Plot of THC concentrations vs time for June 15, 1990.



Figure 54. Plot of THC concentrations vs time for June 18, 1990.



Figure 55. Plot of THC concentrations vs time for June 26, 1990.

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Figure 56. Plot of THC concentrations vs time for June 28, 1990.



Figure 57. Plot of THC concentrations vs time for June 29, 1990.



Figure 58. Plot of THC concentrations vs time for July 2, 1990.



Figure 59. Plot of THC concentrations vs time for July 10, 1990.



Figure 60. Plot of THC concentrations vs time for July 11, 1990.



Figure 61. Plot of THC concentrations vs time for July 12, 1990.



Figure 62. Plot of THC concentrations vs time for July 13, 1990.

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Figure 63. Plot of THC concentrations vs time for July 14, 1990.



Figure 64. Plot of THC concentrations vs time for July 16, 1990.



Figure 65. Plot of THC concentrations vs time for July 17, 1990.

4.1.6 Carbon Adsorber Performance

As discussed in Subsection 2.1, two types of granular activated carbons were used in the carbon adsorber to remove hydrocarbon pollutants from the ventilation air stream. The first was a coal-based carbon installed on June 5. This carbon was used during the first 9 days of excavation operations between June 7 and 15. On June 16, the coal-based carbon was replaced with a coconut-based carbon. The coconut-based carbon was used during the remaining operation period until system shutdown on July 18, for a total of 32 operating days.

To assess the performance of these carbons, the hydrocarbon removal efficiencies associated with the maximum 5-minute average inlet THC concentrations shown in Table 21 were calculated and compared over time for the two carbon types. These data show that the average daily hydrocarbon removal efficiency for the coal-based carbon ranged from 61.8 percent (fresh carbon) to 49.4 percent over a nine-day period from June 7 to June 15. For the coconut-based carbon, average hydrocarbon removal efficiency ranged from 90.7 on June 17 (first full day of operation on new carbon) to 58.4 percent over the first nine days of operation. By comparison, the performance of the coconut-based carbon was slightly superior to that of the coalbased carbon with respect to both initial activity and activity over a nine-day period.

For the remainder of the coconut-based carbon operating period, average hydrocarbon removal efficiency declined from 78.1 percent on June 26 to 24.2 percent on July 18. The exception to this trend was an increase in average removal efficiency to 55.9 percent on July 10 and 71.6 percent on July 11. During other short-term periods on those days, hydrocarbon removal efficiencies reached 93 percent on July 10 and 92 percent on July 11. The high removal efficiencies on July 11 corresponded closely to the periods of low airflow rates measured on this day; after the airflow rate was returned to normal levels (by adjustment of the scrubber recirculation rate), the hydrocarbon removal efficiencies decreased. Although no airflow rate data are available for July 10, the hydrocarbon removal efficiency data suggest that the flow rate was also low on this day.

Post-operative inspection of the activated carbon unit showed no visible damage to nor buildup on the spent carbon particles. Water corrosion was evident on the steel rollers at the bottom of the accumulator cabinet, however. It is unlikely that this water came in the form of carryover water droplets from the wet scrubber, since the scrubber demister packing was in good order at the end of operations and the knockout pot (installed between the scrubber and carbon unit) showed very little water accumulation when checked regularly. A more likely source of water was air moisture condensation on the inside of the accumulator cabinet during the cool nighttime and early morning hours. The air entering the cabinet was no doubt saturated after passing through the packed-bed scrubber. Contact of this saturated gas with cold carbon cabinet walls would be sufficient to cause water condensation and accumulation.
Such condensation and accumulation was noted on the top inside panel of the accumulator cabinet during periodic field inspections. The presence of water in the carbon unit was also supported by the hard black powdery deposits found on the fan vanes and housing after operations were completed. These deposits were likely formed by the combination of moisture and fine pieces of carbon that attrited from the activated carbon unit.

The presence of moisture in the carbon unit helps to explain the lower-thanexpected hydrocarbon removal performance of this system during the trial excavation. The design specifications for this system were 95 percent THC removal. However, the inlet THC concentration was much higher than expected due to the low vapor suppression effectiveness of the foam. Nevertheless, the manufacturer of the carbon unit still expected performance levels to be above 90 percent removal. Moisture condensation onto carbon particles with subsequent reduction in active surface area remains the most likely explanation for under design performance. This explanation is consistent with the gradual loss of carbon THC removal efficiency observed over time, as well as the increase in removal efficiency that occurred when the airflow rate was significantly reduced on July 10 and 11.

A number of options would be available to eliminate moisture condensation problems for a final remediation activated-carbon unit. These include installation of an air dryer upstream of the carbon unit to lower scrubbed ventilation air moisture content, use of a dry scrubber in place of the wet scrubber used for the trial excavation, adding insulation/heaters to the accumulator cabinet, and operating a duct heater upstream of the carbon unit to maintain ventilation air temperature above the stream's dewpoint. The technical and economic merits of these options should be evaluated, either separately or in combination, for potential application during final remediation.

4.1.7 Sulfur Dioxide Monitoring at the Excavation Area

As a result of the revised Health and Safety Plan, a Thermo Electron SO_2 analyzer sampling system similar to the scrubber monitoring system, was set up to monitor the work environment at the excavation area. The monitor was calibrated using a span and zero gas to determine a parts-per-million (ppm) -per-chart-division (CD) formula. The monitor was calibrated on the 0- to 1000-ppm scale of the instrument. Only during periods when the SO_2 level exceeded the detection limit (2 percent of full scale or 20 ppm) were the strip-chart data reduced. Table 22 presents the excavation area SO_2 concentration levels including the arithmetic average. This instrument was put on line June 26 and ran through July 18.

4.1.8 Exhaust Gas Flow Rates

Exhaust gas flow rate measurements were taken at the inlet and outlet test sites as a check on fan flow. Table 23 summarizes exhaust gas conditions during this

Date (1990)	Time (24-h)	Average,	Highest, ppm	2nd highest, ppm	Minimum, ppm	Comments
6/26	0700-0800	323.2	797.9	434.3	30.3	Tar moving
	0800-0900	363.6	424.2	399.0	313.1	Char evaporation
	0900-1000	373.7	489.9	464.6	262.6	
	1000-1100	429.3	868.6	424.2	308.1	
	1100-1200	363.6	686.8	686.8	222.2	
	1200-1300	171.7	222.2	222.2	135.4	
	1300-1400	111.1	136.4	136.4	90.9	Foaming
	1400-1500	80.8	90.9	90.9	70.7	
	1500-1600	65.7	70.7	70.7	60.6	
	1600-1700	60.6	75.8	70.7	53.5	
	1700-1800	65.7	101.0	93.9	50.5	
	1800-1900	70.7	96.0	93.9	50.5	
	1900-2000	68.7	85.9	80.8	55.6	
	2000-2100	55.6	63.6	60.6	50.5	
	2100-2200	58.6	68.7	68.7	50.5	
	2200-2300	85.9	114.1	111.1	63.6	Tar seepage
	2300-2400	90.9	101.0	99.0	75.8	
6/27	0000-0100	70.7	75.8	75.8	63.6	Tar seepage
	0100-0200	65.7	65.7	65.7	60.6	
	0200-0300	60.6	60.6	60.6	60.6	
	0300-0400	58.6	60.6	60.6	55.6	
	0400-0500	55.6	55.6	55.6	55.6	
	0500-0600	53.5	53.5	53.5	53.5	
	0700-0800	59.6	82.2	64.7	54.4	Tar seepage
	0800-0900	51.4	61.6	56.5	36.0	
	0900-1000	131.5	246.5	188.0	66.8	
	1000-1100	69.8	102.7	85.3	51.3	
	1100-1200	100.7	184.9	184.9	51.3	
	1200-1300	49.3	71.9	71.9	25.7	
	1300-1400	25.7	30.8	28.8	23.6	
	1400-1500	20.5	23.6	23.6	18.5	

TABLE 22. EXCAVATION AREA SO2 DATA

(continued)

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Date 1990)	Time (24-h)	Average, ppm	Highest, ppm	2nd highest.ppm	Minimum, ppm	Comments
5/28	1000-1100	57.7	164.0	142.1	27.8	Moved char
	1100-1200	54.7	129.2	84.5	34.8	Moved tar
	1200-1300	27.8	37.8	34.8	22.9	
	1300-1400	19.9	22.9	22.9	17.9	
j/29	1100-1200	63.9	268.8	266.7	<20.3	Char moved
	1200-1300	142.0	302.2	238.3	76.1	
	1300-1400	65.9	74.0	60.9	53.8	
	1400-1500	69.0	187.6	182.3	43.6	
	1500-1600	233.2	365.1	339.7	142.0	
	1600-1700	116.6	172.4	121.7	81.1	
	1700-1800	76.1	91.3	81.1	63.9	
	1800-1900	50.7	63.9	63.9	38.5	
	1900-2000	33.5	38.5	38.5	23.3	
	2000-2100	20.2	25.4	25.4	<20.3	
/2	0700-0800	53.3	150.3	129.0	<19.4	
	0800-0900	158.1	232.8	169.7	116.4	Moved tar
	0900-1000	145.5	201.8	194.0	106.7	Moved and mixed waste
	1000-1100	97.0	140.6	129.0	58.2	
	1100-1200	48.5	61.1	61.1	38.8	
	1200-1300	22.3	24.2	24.2	19.4	
	1300-1500		Below det	ection limit		
	1500-1600	46.6	158.1	130.9	<19.4	
	1600-1700	32.0	43.6	38.8	24.2	
	1700-1800	24.2	29.1	27.1	19.4	
	1800- 7/16 0900		Below det	ection limit		
/16	0900-1000	89.5	119.3	102.4	49.7	Moved tar
	1000-1100	104.4	114.3	109.3	99.4	
	1100-1200	32.8	42.7	39.8	22.9	
	1200- 7/17 0700		Below dete	ction limit		

TABLE 22 (continued)

Date (1990)	Time (24-h)	Average, ppm	Highest, ppm	2nd highest, ppm	Minim⊔m, ppm	Comments
7/17	0700-0800	98.9	128.6	123.6	84.1	
	0800-0900	69.2	101.9	82.1	39.6	
	0900-1000	47.5	64.3	59.3	34.6	
	1000-1100	64.3	74.2	72.2	54.4	
	1100-1200	47.5	69.2	62.3	29.7	
	1200-1300	29.7	39.6	39.6	24.7	
	1300-1400		Below det	ection limit		

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	TABLE	22 ((continued)
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	_		Flow	rate		
Run No.	Date (1990)	Time (24-h)	acfm ^a	dscfm ^b	Temperature, •F	Moisture volume, % ^C
			Stack	outlet		
M-1	6/7	1540	1391	1276	95	3.0
M-2b	6/15	0754	845	802	81	3.0
M-2	6/18	0840	1094	1040	80	3.0
M-3	6/21	1306	1017	9 58	83	3.0
M-4	6/25	1242	778	702	105	3.0
M-5	6/27	1252	1332	1181	111	3.0
M-6	6/28	1210	1309	1183	102	3.0
M-7	6/29	1737	1385	1265	96	3.0
M-8	7/2	1559	1084	979	103	3.0
M-9	7/3	1419	621	560	103	3.0
M-10	7/9	1313	1267	1167	95	3.0
M-11	7/11	0914	458	415	104	3.0
M-12	7/12	1433	1460	1307	103	3.0
M-13	7/13	1507	1557	1392	103	3.0
M-14	7/16	1500	1561	1414	98	3.0
<u>M-15</u>	7/17	1440	1521	1362	103	3.0
	<u>. </u>		Scrubbe	r inlet		
M-1	6/7	1530	1174	1092	93	2.0
M-2	6/18	0815	940	920	70	2.0
M-3	6/21	1258	766	730	81	2.0
M-4	6/26	1224	810	745	99	2.0
M-5	6/27	1245	1195	1079	106	2.0
M-6	6/28	1158	1182	1093	95	2.0
M-7	6/29	1745	1292	1219	84	2.0
M-8	7/2	1616	683	633	95	2.0
M-9	7/3	1428	581	537	95	2.0
M-10	7/9	1320	1099	1030	91	2.0

TABLE 23. SUMMARY OF EXHAUST GAS CONDITIONS

Run No.	Date (1990)	Time (24-h)	acfm ^a	dscfm ^b	Temperature, °F	Moisture volume, % ^c
M-11	7/11	0905	359	339	86	2.0
M-12	7/12	1420	1356	1225	103	2.0
M-13	7/13	1520	1494	1353	101	2.0
M-14	7/16	1450	1584	1455	96	2.0
M-15	7/17	1436	1485	1348	100	2.0

TABLE 23 (continued)

^a Flue gas flow rate at actual temperature and pressure.

^b Flue gas flow rate in dry standard cubic feet per minute; 68°F, 29.92 in.Hg., and zero percent moisture.

^C Moisture based on stack temperature and Method 6 results.

program. When flows decreased, the system was checked and the problems were corrected. The flow through the system affected the concentration levels in the enclosure. It obviously took longer for the concentration levels in the enclosure to decrease when there was a decrease in exhaust flow.

4.2 Perimeter Air Monitoring

As part of EPA's commitment to the community as embodied in the McColl Community Response Contingency Plan, four perimeter air emission monitors were situated around the site to continuously monitor for SO₂ and THC. See Figure 66 for perimeter monitoring locations. There were no exceedances of the established work stoppage levels of 0.5 ppm SO₂ for 5 minutes or 70 ppm THC for 30 seconds during the trial excavation.

4.2.1 Sulfur Dioxide

The highest concentrations of SO_2 for the month of May occurred on May 25 at Station No. 1 during the 0300 hour at 0.08 ppm. During June, the highest concentration was recorded on June 25 at 0.09 ppm at Station No. 4 during the 1100 hour. During July, the highest concentration was recorded at 0.01 ppm, which was recorded numerous times during the activities. The arithmetic mean for SO_2 during the trial excavation was less than 0.01 ppm.

4.2.2 Total Hydrocarbons

The highest concentration of THC for May occurred on May 27 at Station 1 at 3.2 ppm during the 0400 hour. For June, the highest concentration was recorded on June 12 at Station 4 at 21.9 ppm during the 1900 hour. In July, the highest concentration was recorded on July 11 at Station 2 at 9.8 ppm during the 1800 hours. The arithmetic mean for May, June, and July were 0.15 ppm, 0.75 ppm, and 0.93 ppm respectively. It is important to note that the highest monthly reading occurred when excavation activities at the site were not occurring. This indicated that a portion of the THC emissions recorded during the trial excavation were not related to the McColl excavation site, but may have resulted from seeps. Seeps are common at the McColl site, and some were close in relationship to the monitor stations.

4.3 Air Speciation Data

As part of the objectives of the trial excavation, it was desirable to undertake a sampling and analytical study to evaluate the organic and inorganic air pollutant species that were emitted during the excavation activities at McColl. A sampling and analytical plan was prepared as part of the McColl project requirements. Subcontract arrangements were made with Pacific Analytical, Inc. (PAI) to perform gas chromatographic analysis using flame photometric detection to analyze air samples for trace



Figure 66. McColl site in Fullerton, California.

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quantities of sulfur-containing compounds. PAI was also requested to perform gas chromatography-mass spectrometry (GC/MS) analysis on the same air samples to determine a broad spectrum of organic species that also might be emitted from McColl wastes. The intent of the use of the air speciation data was to help assist the EPA and the CHS in evaluating the potential health risks for future planning for the cleanup of McColl.

Air samples were taken at designated times during excavation activities. The air samples were collected in Tedlar bags on each designated day and delivered by special courier to the PAI laboratories. The samples were analyzed within 24 hours after receipt as prescribed in the analytical protocol.

Unfortunately, during a subsequent EPA quality assurance audit, it was determined that the PAI air speciation results did not meet the data quality requirements and were not valid. The results are therefore not discussed in this report and cannot be used as originally intended. However, the results will be maintained in a "RAW DATA FILE" by EPA Region 9. The summary of the EPA quality assurance audit, which was conducted by the Research Triangle Institute (RTI), is presented in Appendix H.

4.4 Foam Efficiency Evaluation

4.4.1 Field Use of Foam During Excavation

Vapor-suppressing foams had been used successfully on other similar waste and were therefore selected to test their effectiveness to reduce air emissions during this excavation work. The earlier reported foam effectiveness values were based on measurements of emissions from stationary samples of waste (i.e., static conditions) with and without foam application. No reported data were available on the ability of the foam to control emissions during actual excavation operations (i.e., under dynamic conditions).

During this work, temporary foam was sprayed manually on freshly excavated waste material or initially on stored material. Stabilized foam was then sprayed on all waste surface areas at the end of each work day. The overall qualitative assessment of the foam vapor suppressants used during this trial was that they were not as effective as expected. This assessment was based on visual observation of the foam which disintegrated and did not adhere well to the raw wastes nor form a cohesive film. The foam appeared to react with the highly acidic waste and at times turned from greenish yellow to deep red. More over, total hydrocarbon and sulfur dioxide concentrations in the enclosure exhaust control system stream were higher than expected (see Section 4.1); this is due mainly to lack of control by the foam. When stabilized foam was placed on the waste at the end of a period of activity, air concentrations slowly decreased. However, this decrease was in part due to no fresh waste being

excavated and exposed, and in part to a constant flow of ambient ventilation air sweeping across the enclosure, which had the effect of reducing concentration to an equilibrium level. In an effort to increase the stabilized foam's effectiveness, the concentration of stabilizer was increased June 21. The intent was to double the stabilizer concentration. Analytical data from 3M indicated the concentration increased from 9.6 to 10.5 percent. The increase in the foaming strength resulted in increasing the foam's effectiveness, but did not cure the problems cited above.

The determination of foam efficiency, as applied under field conditions, is very difficult since many factors affect the emissions at any given time. These factors include the excavation activity (how much waste is being excavated or disturbed), the flux rate of the particular waste, the enclosure air exhaust rate, the ambient temperature, and any covering such as foam placed on the waste. In addition, the hydrocarbons emitted by diesel engines increasd the THC measured in the enclosure exhaust, and thus decreased any effect due to foam application. The following estimates of foam efficiency application (based on selected increments of activity) were determined by measurements made at the exhaust air system inlet monitoring location. (See previous plots of concentration vs. time and also Appendix B).

- On 6/11, tar was leveled off in bins and total hydrocarbon (THC) concentration was 50 ppm. Stabilized foam was applied at 1246 to all mud and tar and THC decreased to 30 ppm by 1530 indicating a foam reduction efficiency of 40 percent. SO₂ was fairly low and constant all day.
- On 6/12, tar excavation proceeded for about 25 minutes without foam due to a communications problem. At 1433, temporary foam was applied, resulting in a decrease in SO₂ levels of about 40 percent (from 1000 ppm to 600 ppm) and a decrease in THC levels of about 40 percent (from about 250 ppm to 150 ppm).
- On 6/13, stabilized foam was applied to all mud and tar storage areas at 0945 to 1005. SO₂ decreased from 140 to 25 ppm by noon indicating an efficiency of about 80 percent. THC decreased from 100 to 40 ppm over the same time period (a 60 percent control).

In addition to assessing the effectiveness of stabilized foam under field conditions, the effectiveness of temporary foam applied under conditions of waste excavation and movement was desired. Operating periods have been identified in which mud, tar, and char were either excavated or moved within the enclosure. The SO₂ and THC concentrations within the enclosure during these periods, as measured at the inlet to the wet scrubber, have been summarized in Tables 24, 25, and 26, respectively. The SO₂/THC activity periods shown in the tables correspond to the selected operating periods, but include allowances for system time lags between the start/finish of an operation and the time at which changes in pollutant concentrations

SO, concentration inside enclosure								THC concentration inside enclosure						
Date (1990)	SO,/THCa activity period	Start, ppm	(time) ^C	Peak, ppm	(time) ^c	Change, ppm	Change rate, ppm/min	Start, ppm	(time) ^C	Peak, ppm	(time) ^c	Change, ppm	Change rate, ppm/min	(S)ingle- or (D)ouble- strength foam
Mud exca	vation without	foam												
6/8	1021-1045	0.1	(1020)	0.5	(1045)	0.4	0.0	12	(1020)	21	(1045)	9	0.4	NA
Hud exca	vation with fo	am												
6/9	1033-1037	0	(1030)	0.1	(1035)	0.1	0.0	6.3	(1030)	6.3	(1035)	0	0.0	S
Hud move	ment without	foam												
7/2 7/2	1003-1150 1346-1505	145 29	(1000) (1350)	145 29	(1000) (1350)	0 0	0.0 0.0	155 133	(1000) (1350)	164 151	(1100) (1435)	9 18	0.2 0.4	NA NA
Average						0	0.0					14	0.3	

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TABLE 24. EFFECT OF FOAM USE DURING MUD EXCAVATION AND MOVEMENT

^a Emissions activity period corresponding to mud excavation and movement, taking into consideration time lags in the system.

b Based on 5-minute average emission data.

^C Start of corresponding 5-minute average period.

d Not applicable.

			SO, con	centratio	on inside e	enclosure			THC co	ncentrat	on inside e	nclosure		
Date (1990)	SO,/THC activity period	Start,	(time) ^C	Peak, ppm	(time) ^C	Change,	Change rate, ppm/min	Start,	(time) ^C	Peak,	(time) ^C	Change, ppm	Change rate, ppm/min	(S)ingle- or (D)ouble- strength foam
Tar exca	vation without	foam												
6/9 6/12	1345-1414 1408-1433	0.1 0.3	(1345) (1405)	27 1000	(1410) (1450)	27 <u>1000</u>	1.1 22.2	13 23	(1345) (1405)	35 306	(1410) (1445)	22 <u>283</u>	0.9 <u>7.1</u>	NA NA
Average						514	11.7		<u>.</u>			153	4.0	·······
Tar exca	vation with fo	am												
6/9 6/13 6/14 6/15	1414-1449 1606-1700 1325-1535 1035-1115	27 152 119 62	(1410) (1605) (1325) (1035)	136 342 564 142	(1445) (1700) (1520) (1110)	109 190 445 <u>80</u>	3.1 3.5 3.9 2.3	35 104 136 226	(1410) (1605) (1325) (1035)	92 155 464 226	(1445) (1700) (1515) (1050)	57 51 328 0	1.6 0.9 3.0 <u>0.0</u>	s s s
Average						206	3.2					109	1.4	
Tar move	ment without f	foam												
7/16 7/16 7/17 7/17	0845-0950 1351-1445 0725-0748 1025-1045	0 7 5 70	(0845) (1350) (0725) (1025)	41 18 85 73	(0950) (1430) (0745) (1030)	41 11 80 3 24	0.6 0.3 4.0 <u>0.6</u>	16 117 95 278	(0845) (1350) (0725) (1030)	117 176 200 278	(0945) (1425) (0745) (1030)	101 59 105 0 66	1.7 1.7 5.3 <u>0.0</u> 2.2	NA NA NA
Average						34	1.9							•
Tar move	ment with foam	n												
6/14 7/17 7/17 7/17	1115-1200 0759-0815 0927-1030 1045-1115	123 82 31 67	(1115) (0800) (0925) (1045)	183 82 73 73	(1150) (0800) (1030) (1055)	60 0 42 6	1.7 0.0 0.6 <u>0.6</u>	149 231 166 263	(1115) (0800) (0925) (1045)	193 231 278 267	(1155) (0800) (1025) (1050)	44 0 112 4	1.1 0.0 1.9 <u>0.8</u>	s s s
Average strength	- single					27	0.7					40	1.0	
6/29 7/2	1545-1615 0700-0730	195 3.5	(1545) (1700)	195 19	(1514) (1725)	0 <u>16</u>	0.0 <u>0.6</u>	249 45	(1545) (1700)	249 78	(1545) (1725)	0 _ <u>33</u>	0.0 <u>1.3</u>	D D
Average strength	- double					8	0.3					19	0.6	

TABLE 25. EFFECT OF FOAM USE DURING TAR EXCAVATION AND MOVEMENT

a Emissions activity period corresponding to char excavation and movement, taking into consideration time lags in the system.

b Based on 5-minute average emission data.

^C Start of corresponding 3-minute average period.

d Not applicable.

			SO, con	entratio	n inside er	iclosure ^b		THC concentration inside enclosure						
Date (1990)	SO _s /THC activity period	Start,	(time) ^C	Peak, ppm	(time) ^C	Change,	Change rate, ppm/min	Start, ppm	(time) ^C	Peak, ppm	(time) ^C	Change,	Change rate, ppm/min	(S)ingle- or (D)ouble- strength foam
Char exca	avation with i	foam												
8/15 6/26 8/26	1115-1315 0710-0744 0908-1003	142 35 316	(1115) (0710) (0905)	755 462 594	(1145) (0740) (0945)	613 427 <u>278</u>	20.4 14.2 <u>7.0</u>	270 83 126	(1115) (0710) (0905)	341 142 345	(1130) (0730) (0955)	71 59 <u>219</u>	4.7 3.0 <u>4.4</u>	s s s
Average						439	13.9					116	4.0	
Char move	ement with for	m												
6/26 6/28	0908-1003 0935-1100	316 23	(0905) (0930)	594 81	(0945) (1055)	278 _58	7.0 <u>0.7</u>	126 92	(0905) (0930)	345 145	(0955) (1040)	219 _52	4.4 <u>0.7</u>	\$ \$
Average - strength	-single					168	3.9					136	2.6	
6/29 6/29 7/2 7/2	1123-1215 1441-1545 0730-0830 0917-1000	13 47 19 117	(1120) (1435) (0725) (0915)	162 214 155 163	(1200) (1520) (0815) (0940)	149 167 136 _46	3.7 3.7 2.7 <u>1.8</u>	59 91 78 125	(1120) (1435) (0725) (0915)	139 250 143 159	(1155) (1540) (0815) (0955)	80 159 65 _ <u>34</u>	2.3 2.4 1.3 <u>0.9</u>	D D D D
Average - strength	- double					125	3.0					85	1.7	

TABLE 26. EFFECT OF FOAM USE DURING CHAR EXCAVATION AND MOVEMENT

^a Emissions activity period corresponding to tar excavation and movement, taking into consideration time lags in the system.

b Based on 5-minute average emission data.

^c Start of corresponding 5-minute average period.

are measured at the scrubber. The five-minute data sets used for this section is presented in Table 27. The 5-minute data sets show the general trends of the enclosure gas concentrations. Foam use refers to the temporary foam applied during these operations; stabilized foam was only applied at the completion of a day's activities.

Foam Use During Mud Excavation and Movement

The data in Table 24 show SO_2 and THC concentration changes during mud excavation with and without foam application and during mud movement without foam application; no data are available for mud movement with foarn application. The table shows that no significant SO_2 emissions were observed for either mud excavation or movement.

Small increases were recorded in THC concentrations during these operations. These were likely due both to THC emissions from operating equipment diesel engines and to emissions from mud waste. Because of the limited number of comparison periods and the low emission levels recorded for excavation with and without foam, no substantial foam control effectiveness conclusions can be drawn.

Foam Use During Tar Excavation and Movement

Table 25 summarizes the available data for tar excavation and movement both with and without foam use. During tar movement periods, both single- and double-strength foams were applied; these periods are grouped together in the table. The concentration change rate data in the table show considerable variability, especially for SO_2 . While limited with respect to variability and number, the comparison periods do suggest trends in foam control effectiveness based on the average concentration change rates calculated. For tar excavation, use of single-strength foam resulted in a 73 percent reduction in the average SO_2 change rate and a 65 percent reduction in the average SO_2 change rate. Use of single-strength foam change rate is directly proportional to the waste emission rate. Use of single-strength foam during tar movement operations resulted in a 50 percent reduction in the average SO_2 change rate and a 55 percent reduction in the average SO_2 percent reduction in the average SO_2 change rate.

Increasing the foam concentration to double strength resulted in a 79 percent reduction in average SO_2 change rate and a 73 percent reduction in the THC change rate. No data are available for tar excavation with double-strength foam.

Foam Use During Char Excavation and Movement

Because of the high emissions potential expected and observed for char excavation and movement, these operations were always conducted with foam being applied. As a result, no data are available for char operations without foam and, hence,

TABLE 27.	FIVE-MINUTE	DATA	AVERAGES
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Date	Time (24-b)	SO, Inlet	SO, Outlot	THC	THC	
	(24-11)					
06/08/90	10:20	0.1	0.4	12.3	4.0	Mud excavation without foam (1021
06/08/90	10:25	0.2	0.4	14.2	4.6	- 1037)
06/08/90	10:30	0.2	0.4	15.9	3.8	
06/08/90	10:35	0.3	0.4	17.6	5.0	
06/09/90	10:30	0.0	0.0	6.3	3.5	Mud excavation with foam (1033 -
06/09/90	10:35	0.1	0.0	6.3	3.8	1037)
06/09/90	13:45	0.1	0.0	13.3	4.6	Tar excavation without foam (1345
06/09/90	13:50	0.2	0.0	16.0	4.5	- 1414)
06/09/90	15:55	1.0	0.0	19.0	4.8	
06/09/90	14:00	4.3	0.0	23.9	5.9	
06/09/90	14:05	14.9	0.0	29.5	6.2	
06/09/90	14:10	27.0	0.0	34.6	7.5	
06/09/90	14:15	41.6	0.0	40.0	8.1	Tar excavation with foam (1414 -
06/09/90	14:20	68.8	0.0	45.6	10.9	1449)
06/09/90	14:25	75.2	0.0	49.9	11.8	
06/09/90	14:30	74.9	0.0	49.7	12.1	
06/09/90	14:35	76.2	0.0	61.1	14.1	
06/09/90	14:40	124.1	0.0	81.7	18.8	
06/09/90	14:45	135.9	0.0	91.5	23.0	
06/12/90	14:05	0.3	0.2	23.0	11.2	Tar excavation without foam (1408
06/12/90	14:10	0.4	0.2	27.5	11.9	1433)
06/12/90	14:15	5.8	0.2	42.2	13.7	
06/12/90	14:20	18.5	0.2	46.7	15.3	
06/12/90	14:25	16.3	0.3	55.2	16.1	
06/12/90	14:30	262.4	0.2	106.0	21.3	Tar excavation with foam (1433 -
06/12/90	14:35	630.5	0.3	172.0	32.7	1450)
06/12/90	14:40	633.8	0.3	96.4	36.8	
06/12/90	14:45	641.5	0.2	305.6	49.0	
06/12/90	14:50	1000	0.2	253.3	50.0	
06/13/90	16:05	152.1	0.5	104.2	34.3	Tar excavation with foam (1606 -
06/13/90	16:10	167.0	0.5	113.9	35.8	1700)
06/13/90	16:15	178.6	0.6	117.9	37.3	
06/13/90	16:20	201.5	0.6	120.3	39.4	
06/13/90	16:25	210.9	0.6	125.9	40.9	
06/13/90	16:30	206.8	0.7	126.0	41.6	
06/13/90	16:35	215.7	0.8	131.6	44.3	
06/13/90	16:40	230.2	0.7	138.2	46.7	
06/13/90	16:45	291.4	1.0	150.9	49.5	
06/13/90	16:50	327.0	1.7	150.9	51.3	
06/13/90	16:55	333.3	3.1	150.8	51.9	
06/13/90	17:00	341.7	5.0	154.7	52.9	
06/14/90	11:10	107.2	0.0	139.5	69.6	Tar movement with foam (1115 -
06/14/90	11:15	123.4	0.0	148.9	70.4	1200)
06/14/90	11:20	132.6	0.0	153.8	73.2	
06/14/90	11:25	141.5	0.0	159.3	75.3	
06/14/90	11:30	149.4	0.0	168.1	75.7	
06/14/90	11:35	164.8	0.0	175.6	76.4	
06/14/90	11:40	177.1	0.0	179.7	79.5	
06/14/90	11:45	182.9	0.0	180.1	80.6	
06/14/90	11:50	183.4	0.0	186.1	80.7	
06/14/90	11:55	182.9	0.0	192.8	83.3	

	Time	SO,	S0,	THC	THC	
Date	(24-h)	Inlet	Outlet	Inlet	Outlet	
06/14/90	13:25	118.6	0.0	135.9	76.1	Tar excavation with foam (1325 -
06/14/90	13:30	123.4	0.0	143.1	74.9	1535)
06/14/90	13:35	129.7	0.0	154.5	76.5	
06/14/90	13:40	130.1	0.0	163.7	79.6	
06/14/90	14:35	127.7	0.1	168.9	82.5	
06/14/90	13:50	124.7	0.0	172.3	86.5	
06/14/90	13:55	122.4	0.1	175.8	88.5	
06/14/90	14:00	122.7	0.1	172.6	91.2	
06/14/90	14:05	120.5	0.0	175.1	93.3	
06/14/90	14:10	114.0	0.0	173.1	93.8	
06/14/90	14:15	111.6	0.0	173.6	92.6	
06/14/90	14:20	110.6	0.1	175.0	95.4	
06/14/90	14:25	109.2	0.0	174.2	95.2	
06/14/90	14:30	112.1	0.1	179.4	94.8	
06/14/90	14:35	104.6	0.1	179.0	94.8	
06/14/90	14:40	123.9	0.1	150.7	96.6	
06/14/90	14:45	147.5	0.1	210.8	101.0	
06/14/90	14:50	143.4	0.1	207.3	131.6	
06/14/90	14:55	168.5	0.2	217.9	99.5	
06/14/90	15:00	238.6	0.1	246.1	101.8	
06/14/90	15:05	333.3	0.1	270.8	108.7	
06/14/90	15:10	329.2	0.1	276.1	109.8	
06/14/90	15:15	331.4	0.0	464.0	143.6	
06/14/90	15:20	564.4	0.1	324.6	139.0	
06/14/90	15:25	335.5	0.1	283.2	131.6	
06/14/90	15:30	319.3	0.1	272.6	130.4	
06/14/90	15:35	306.6	0.1	272.6	128.1	
06/15/90	10:35	62.1	0.2	225.8	94.6	Tar excavation with foam (1035 -
06/15/90	10:40	62.7	0.1	226.7	92.4	1115)
06/15/90	10:45	62.8	0.2	225.8	91.8	
06/15/90	10:50	62.8	0.1	225.8	89.6	
06/15/90	10:55	62.3	0.1	225.0	86.8	
06/15/90	11:00	63.7	0.2	231.1	89.0	
06/15/90	11:05	58.9	0.1	264.7	90.7	
06/15/90	11:10	142.4	0.1	270.0	92.4	
06/15/90	11:15	295.5	0.1	292.0	95.7	
00 (15 (00	11.00	600 0	• •		00.0	
06/15/90	11:20	608.8	0.1	312.3	99.6	Char excavation with foam (1115 -
06/15/90	11:25	612.1	0.2	332.6	105.2	1315)
06/15/90	11:30	714.8	0.2	341.4	112.9	
06/15/90	11:35	/13.8	0.2	327.3	120.2	
06/15/90	11:40	732.2	0.1	335.2	125.7	
06/15/90	11:45	754.8	0.1	340.5	133.0	
06/15/90	11:50	744.2	0.1	337.0	136.9	
06/15/90	11:55	739.9	0.2	332.6	140.2	
06/15/90	12:00	731.7	0.1	325.5	141.9	
06/15/90	12:05	721.1	0.1	322.0	143.6	
06/15/90	12:10	717.7	0.1	319.4	143.0	
06/15/90	12:15	711.4	0.1	319.4	144.7	
06/15/90	12:20	Miss	Miss	Miss	Miss	
06/15/90	12:25	Miss	Miss	Miss	Miss	
06/15/90	12:30	Bad	Bad	Bad	Bad	

TABLE 27 (continued)

Date	Time (24-h)	SO, Inlet	SO, Outlet	THC Inlet	THC Outlet	
	12.25	605 5	0.3	314 1	151 3	Char excavation with foam (1115 -
06/15/90	12:35	690.5	0.1	308 8	149 7	1315) (continued)
06/15/90	12:40	670 0	0.1	205.0	149.7	1515) (Continued)
06/15/90	12:45	670.0	0.1	206.1	143.7	
06/15/90	12:50	659.9	0.1	300.1	151.5	
06/15/90	12:55	655.0	0.1	304.4	151.3	
06/15/90	13:00	649.7	0.1	303.5	150.2	
06/15/90	13:05	643.0	0.1	301.7	148.0	
06/15/90	13:10	634.8	0.1	299.1	14/.4	
06/15/90	13:15	631.4	0.1	297.3	150.2	
06/26/90	07:10	34.8	38.2	82.6	30.6	Char excavation with foam (0710 -
06/26/90	07:15	35.0	38.4	94.8	32.3	0/44)
06/26/90	07:20	43.8	38.3	105.7	35.4	
06/26/90	07:25	64.9	Bad	120.7	38.9	
06/26/90	07:30	73.2	Bad	141.8	43.8	
06/26/90	07:35	229.4	Bad	138.5	46.0	
06/26/90	07:40	462.2	Bad	139.0	47.0	
06/29/90	09:05	316.7	Bad	125.6	37.8	Char excavation with foam (0908 -
06/26/90	09:10	309.0	Bad	125.7	37.6	1003)
06/26/90	09:15	306.1	Bad	130.4	38.2	
06/26/90	09:20	321.0	Bad	139.8	39.8	Char movement with foam (0908 -
06/26/90	09:25	350.9	Bad	157.3	44.4	1003)
06/26/90	09:30	424.6	Bad	232.3	51.0	
06/26/90	09:35	474.8	Bad	263.7	58.9	
06/26/90	09:40	530.2	Bad	298.3	66.2	
06/26/90	09:45	593.2	Bad	326.5	72.0	
06/26/90	09:50	569.2	0.5	326.5	75.3	
06/26/90	09:55	576.5	0.5	345.3	76.7	
06/26/90	10:00	550.9	0.6	321.3	74.2	
6/28/90	09:30	22.5	0.2	91.7	46.0	Char movement with foam (0930 -
6/28/90	09:35	26.1	0.1	99.5	48.3	1100)
6/28/90	09.40	30 1	0 1	108.2	50.0	,
6/28/90	09.45	32.1	0 0	116.3	53.2	
6/28/90	09.50	36.8	0.0	135.3	60 4	
6/28/90	09.55	39.2	0.0	126.6	60.7	
6/28/90	10.00	40.8	0.0	127 6	62 1	
6/28/00	10.00	42.0	0.0	128 1	62.8	
6/28/00	10.05	42.0	0.0	128 6	62 1	
6/28/90	10.10	43.2	0.0	128.9	61 5	
6/28/00	10.15	44.1	0.0	124 7	60.8	
6/28/00	10.20	42.2	0.0	124 A	61 3	
6/28/00	10.25	11 2	0.0	130 2	64 9	
6/28/00	10:30	70 1	0.0	133.2	6. 5	
6/28/90	10.33	70.1	0.0	141.5	67 5	
6/20/90	10.40	73.3 82 A	0.2	144.0	65 G	
0/20/90	10:45	02.4	0.1	143.0	64.1	
6/28/90	10:50	01.9	0.1	144.1	62 2	
6/28/90	11:00	72.3	0.3	145.9	61.7	
6 / 20 / 20	11.00	12.2	0.1	E0 0	25 F	Chan movement with form (1122
6/23/90	11.20	13.3	0.1	50.0	33.0	1215) single strength
6/23/30	11:20	22 7	0.1	70 6	37.2	ILID) SINGLE SLIENGLN
6/29/90	11:30	22.7	0.3	70.0	30.0 20 F	
6/29/90	11:35	20.9	0.2	/0.0	33.5	
6/29/90	11:40	35.0	0.1	103.1	43.9	
6/29/90	11:45	82.2	0.1	110.8	4/.4	
6/29/90	11:50	102.7	0.1	119.7	49.8	

TABLE 27 (continued)

	Time	50.	<u> </u>	—————————————————————————————————————	тнс	
Date	(24-h)	Inlet	Outlet	Inlet	Outlet	
6/29/90	11:55	151.6	0.6	139.3	53.0	Char movement with foam (1123 -
6/29/90	12:00	162.4	0.1	138.7	56.3	1215) single strength (continued)
6/29/90	12:05	151.1	0.1	126.9	56.8	
6/29/90	12:10	134.0	0.0	125.5	55.8	
6/29/90	12:15	125.8	0.0	126.7	55.3	
6/29/90	14:35	47.2	0.7	91.4	49.0	Char movement with foam (1441 -
6/29/90	14:40	49.9	0.7	101.9	49.9	1545) single strength
6/29/90	14:45	/9.8	0.7	11/.0	52.0	
6/29/90	14:50	145.3	0.7	152.1	59.3	
6/29/90	15:00	165.6	0.7	164.4	64.3	
6/29/90	15:05	171.1	0.6	169.8	68.1	
6/29/90	15:10	179.8	0.6	170.1	69.6	
6/29/90	15:15	199.8	0.7	189.6	71.9	
6/29/90	15:20	213.8	0.7	240.0	73.1	
6/29/90	15:25	211.8	0.7	233.4	74.2	
6/29/90	15:30	213.5	0.8	239.6	/b.3 78 6	
6/29/90	15:35	212.0	0.7	249.1	80.5	
6/29/90	15:40	194 7	0.8	249.1	82.2	Tar movement with foam (1545 -
6/29/90	15:50	192.8	0.8	257.4	82.8	1615) single strength
6/29/90	15:55	187.0	0.8	247.0	83.4	
6/29/90	16:00	157.9	0.7	226.0	80.1	
6/29/90	16:05	138.8	0.8	260.0	77.0	
6/29/90	16:10	132.8	0.8	181.8	74.4	
6/29/90	16:15	129.4	0.8	182.6	73.8	
7/02/90	07:00	3.5	0.0	44.5	29.3	Tar movement with foam (0700 -
7/02/90	07:05	3.6	0.0	47.7	29.8	0730) single strength
7/02/90	07:10	4.0	0.0	55.8	31.8	
7/02/90	07:15	10 9	0.0	71 7	32.7	
7/02/90	07:25	18.5	0.0	77.9	36.5	Char movement with foam (0730 -
7/02/90	07:30	21.4	0.0	84.1	37.5	0830) single strength
7/02/90	07:35	25.7	0.0	90.7	39.8	
7/02/90	07:40	35.5	0.2	97.3	42.6	
7/02/90	07:45	23.3	0.3	102.1	44.9	
7/02/90	07:50	74.2	0.3	109.8	47.4	
//02/90	07:55	95.4	0.2	118.5	50.1	
7/02/90	08:35	133.0	0.0	130.8	55.4 66 5	
7/02/90	08-45	Bad	Bad	130.0 Bad	Bad	
7/02/90	08:50	127 7	0.3	136.3	69 0	
7/02/90	08:55	124.8	0.4	130.9	69.3	
7/02/90	09:00	123.9	0.6	128.2	70.0	
7/02/90	09:05	122.2	0.5	127.8	69.6	
7/02/90	09:10	118.3	0.4	128.1	69.9	Char movement with foam (0917 -
7/02/90	09:15	116.6	0.4	124.5	70.8	1000) single strength (6.75)
7/02/90	09:20	125.8	0.5	133.2	72.6	
//02/90	09:25	147.7	0.4	142.7	/6.2	
7/02/90	09:30	155.0	0.5	140.7	10.3	
7/02/90	09:35	162 0	0.1	152 1	82.8	
7/02/90	09.45	159 1	0.4	152.6	85.2	
7/02/90	09:50	153.3	0.1	154.8	87.0	
7/02/90	09:55	147.5	0.0	159.4	88.0	

TABLE 27 (continued)

	Time	S0,	SO,	THC	THC	
Date	(24-h)	Inlet	Outlet	Inlet	Outlet	
7/02/00	10.00	144 6	0.2	154 0	90.1	Mud movement without form (1003 -
7/02/90	10.00	130 5	0.2	153 3	01 2	1150)
7/02/90	10.05	133.5	0.2	155.5	90.2	1150)
7/02/90	10:10	133.5	0.0	154.0	03.3	
7/02/90	10:15	122.4	0.0	152.0	91.0	
7/02/90	10:20	117.8	0.2	150.1	92.0	
7/02/90	10:25	11/.1	0.1	152.8	92.2	
7/02/90	10:30	115.0	0.0	162.4	89.9	
7/02/90	10:35	111.1	0.0	161.9	90.6	
7/02/90	10:40	106.5	0.0	161.1	90.6	
7/02/90	10:45	102.2	0.0	160.7	89.8	
7/02/90	10:50	97.6	0.0	161.4	90.7	
7/02/90	10:55	93.7	0.0	162.6	89.1	
7/02/90	11:00	88.9	0.0	163.9	89.5	
7/02/90	11:05	83.4	0.4	161.2	90.4	
7/02/90	11:10	74.5	0.0	149.5	88.2	
7/02/90	11:15	70.9	0.0	149.8	86.7	
7/02/90	11:20	66.0	0.0	148.7	85.1	
7/02/90	11:25	62.4	0.2	145.6	82.4	
7/02/90	11:30	59.5	0.0	144.1	79.5	
7/02/90	11:35	Miss	Miss	Miss	Miss	
7/02/90	11:40	Miss	Miss	Miss	Miss	
7/02/90	11:45	Miss	Miss	Miss	Miss	
7/02/90	11:50	Miss	Miss	Miss	Miss	
7/02/90	11:55	Bad	Bad	Bad	Bad	
7/02/90	13:40	27.5	0.4	95.3	51.8	Mud movement without foam (1346 -
7/02/90	13.45	20 0	0.5	127 7	51 6	1505)
7/02/90	13.50	29 4	0.6	133 3	40.8	1505)
7/02/90	13.55	28 2	0.2	132 0	58 0	
7/02/90	14.00	27 0	0.1	132 2	58 2	
7/02/90	14.00	26 3	0.5	133 7	58 1	
7/02/90	14.05	25.3	0.5	137 6	58 7	
7/02/90	14.15	24 3	0.5	140 0	59.0	
7/02/90	14.15	23 0	0.5	140.0	59.7	
7/02/30	14.20	21.0	0.5	146.0	50.7	
7/02/90	14.20	21.5	0.5	140.5	59.5	
7/02/90	14.30	10 9	0.5	150.0	50.0	
7/02/90	14.33	18 9	0.5	100.0	50 7	
7/02/90	14.40	10.0	0.5	144.0	55./	
7/02/90	14:45	16.0	0.5	137 6	0.80	
7/02/00	14.50	16.5	0.0	137.0	60.0 62 E	
7/02/90	14:00	16.4	0.0	130.0	61 2	
7/02/90	15.00	15.0	0.0	142 4	61 0	
// VL/ 90	10.00	19.9	0.0	140.4	01.0	
7/16/90	08:40	0.0	0.5	13.1	28.7	Tar movement without foam (0842 -
//16/90	08:45	0.0	0.6	16.0	30.2	0950)
//16/90	08:50	0.0	0.4	18.8	31.4	
//16/90	08:55	0.2	0.4	25.1	31.1	
7/16/90	09:00	2.5	0.4	43.6	34.1	
7/16/90	09:05	11.7	0.4	64.2	42.6	
7/16/90	09:10	28.7	0.4	70.2	46.2	
7/16/90	09:15	37.3	0.4	75.8	48.8	
7/16/90	09:20	25.6	0.3	90.7	51.2	
7/16/90	09:25	19.0	0.3	88.0	51.2	

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TABLE 27 (continued)

	the second s				and the second	
	Timo	50	50	THC	тыс	
Nate	(24-b)	Julet	0utlet	Inlet	Outlet	
Date	(24-11)	10160			outret	
7/16/90	09:30	30.0	0.4	83.8	49.5	Tar movement without foam (0842 -
7/16/90	09:35	27.1	0.5	81.8	48.5	0950)
7/16/90	09:40	32.0	0.5	96.5	52.4	
7/16/90	09:45	39.4	0.6	117.4	57.8	
7/16/90	09:50	40.8	0.5	115.0	62.1	
07/16/90	13:50	7.3	0.4	117.4	88.9	Tar movement without foam (1351 -
07/16/90	13:55	8.2	0.3	121.6	91.2	1445)
07/16/90	14:00	9.8	0.3	143.4	97.4	
07/16/90	14:05	11.6	0.3	146.9	99.8	
07/16/90	14:10	12.0	0.3	149.9	101.8	
07/16/90	14:15	13.3	0.3	163.7	105.6	
07/16/90	14:20	16.0	0.3	168.9	106.4	
07/16/90	14:25	17.8	0.3	175.5	106.4	
07/16/90	14:30	18.2	0.3	172.9	106.4	
07/16/90	14:35	16.3	0.3	166.7	106.1	
07/16/90	14:40	15.8	0.3	158.4	103.1	
07/16/90	14:45	14.9	0.2	139.7	102.7	
07 (17 (00	07.00			74 5	0 - J	
07/17/90	07:20	1.7	0.0	74.5	bao Rad	lar movement without toam (0/25 -
07/17/90	07:25	4.8	0.0	94.9	Bad	0/45}
07/17/90	07:30	38.3	0.0	144.5	Bad	
0//1//90	07:35	49.3	0.0	1/2.0	Bad	
0//1//90	07:40	79.2	0.0	188.1	Bad	
07/17/90	07:45	85.3	0.0	100.0	Bad	
07/17/90	07.50	76 9	0.0	207 6	Bad	Tar movement with foam (0759 -
07/17/90	07:55	74 5	0.0	219 2	Bad	0815)
07/17/90	08.00	81 7	0.0	230 8	Bad	00137
07/17/90	08:05	72 4	0.0	228 2	Bad	
07/17/90	08.10	67 5	0.0	224 6	Bad	
07/17/90	08-15	62 3	0.0	217 4	Bad	
07/17/90	08.20	58 5	0.0	210 3	Bad	
07/17/90	08.25	55 0	0.0	203 1	Bad	
07/17/00	08-20	52.0	0.0	107 7	Bad	
07/17/00	08.30	J2.2	0.0	197.7	Bad	
07/17/00	08.35	43.4	0.0	193.3	Bad	
07/17/90	00:40	47.0	0.0	100.0	Bad	
07/17/00	08.50	44.0	0.0	100.2	Bad	
07/17/30	00:50	46.0	0.0	100./	Dau	
07/17/90	00:55	40.2	0.0	170.3	Dao	
07/17/90	09:00	38.8	0.0	1/5.4	Bad	
07/17/90	09:05	36.9	0.0	170.9	Bad	
0//1//90	09:10	34.7	0.0	170.0	Bad	
0//1//90	09:15	33.7	0.0	168.2	Bad	• · · · · · · · · · · · · · · · · · · ·
0//1//90	09:20	32.3	0.0	165.5	Bad	lar movement with foam (0927 -
07/17/90	09:25	31.4	0.0	165.5	Bad	1030)
07/17/90	09:30	38.6	0.0	202.2	Bad	
07/17/90	09:35	42.8	0.0	219.2	Bad	
07/17/90	09:40	40.7	0.0	233.5	Bad	
07/17/90	09:45	42.3	0.0	235.2	Bad	
07/17/90	09:50	45.7	0.0	244.3	Bad	
07/17/90	09:55	50.4	0.0	256.8	Bad	
07/17/90	10:00	53.5	0.0	257.7	Bad	

TABLE 27 (continued)

TABLE 27 (continued)

Date	Time (24-h)	SO, Inlet	SO, Outlet	THC Inlet	THC Outlet	
07/17/90	10:05	58.1	0.0	268.4	Bad	Tar movement with foam (0927 -
07/17/90	10:10	56.7	0.0	259.5	Bad	1030) (continued)
07/17/90	10:15	59.6	0.0	265.7	Bad	
07/17/90	10:20	70.7	0.0	277.4	Bad	
07/17/90	10:25	69.7	0.0	278.3	Bad	Tar movement without foam (1030 -
07/17/90	10:30	73.0	0.0	278.3	Bad	1045)
07/17/90	10:35	70.3	0.0	271.1	Bad	•
07/17/90	10:40	68.1	0.0	265.7	Bad	Tar movement with foam (1045 -
07/17/90	10:45	66.7	0.0	263.1	Bad	1115)
07/17/90	10:50	70.4	0.0	266.6	Bad	.
07/17/90	10:55	72.5	0.0	264.8	Bad	
07/17/90	11:00	70.0	0.0	257.7	Bad	
07/17/90	11:05	66.4	0.0	246.1	Bad	
07/17/90	11:10	64.5	0.0	241.6	Bad	
07/17/90	11:15	63.3	0.1	237.1	Bad	

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no foam control effectiveness levels can be established. The data in Table 26 do show, however, that foam-controlled average SO_2 and THC concentration change rates were higher for char excavation than for tar excavation.

With respect to char movement, average SO_2 concentration change rates were 23 percent lower with double-strength foam than with single-strength foam. Average THC change rates were 35 percent lower with double-strength foam than with single-strength foam. Foam-controlled average change rates for both SO_2 and THC were higher for char movement than for tar movement.

While the average pollutant concentration change rates just discussed are useful in considering the effects of foam application on waste excavation and movement operations, both the average and maximum emission rates should be considered in the design of final remediation systems.

4.4.2 Static Flux Chamber Measurements For Foam Effectiveness Evaluations

As part of the evaluation of vapor-supressing foams as described previously in Section 3.4.2, flux chamber tests were performed on the two foam types. Since the flux chamber tests are unique methods for determining the evaluation of emissions from a variety of waste materials, it was decided to subcontract the flux chamber tests to a recognized expert in this type of testing. The flux chamber tests were completed according to the prescribed plan. The flux chamber Tedlar bag samples were submitted to PAI on June 13, 14, and 15, 1990. The contractor shipped the other flux chamber stainless steel canister samples to Radian Laboratories in Austin, Texas, on June 15, 1990.

The samples were analyzed and the air speciation results were reported by PAI and Radian. The flux chamber tedlar bag sample results from PAI did not meet the data quality requirements and were found to be invalid as determined by an EPA quality assurance audit. The stainless steel canister sample results were also audited and found invalid. These data are not of sufficient quality to include in this report, but the data will be maintained in the "RAW DATA FILE" previously mentioned in Section 4.3.

4.5 Tar Processing

4.5.1 Use of Portland Cement and Fly Ash as Stabilization Agents

Portland cement and pozzolanic fly ash were originally selected as stabilization agents to be mixed with tar because of the anticipated viscous, runny nature of this waste material. As discussed in Subsection 3.2, tar material, as excavated, was in the form of blocks and chunks that were pliable and plastic, but not viscous or mobile at enclosure temperatures. Nevertheless, the excavated tar material will require further size reduction to be used as feed to most thermal treatment devices.

Material Processing Rates

Data related to tar processing rates and total material processing rates for the 10 pug mill tests are summarized in Table 28. As stated previously, all but Runs 4 and 10 were conducted at low idle paddle speed on the pug mill. Most of Run 4 was also conducted at low idle speed, except during the last minute, when the speed was increased to about 3/4 of maximum speed. All of Run 10 was conducted at maximum paddle speed.

	Feed quantities. 1b				Elapsed		Tar	Total material	
Run No.	Tar	Cement	Water	Fly ash	Total	time, 	Mill stoppages	processing rate, tons/h	processing rate, tons/h
1	294	1390	0	0	1684	15	1	0.59	3.37
2	294	2085	351	٥	2730	17	0	0.52	4.82
3	294	2085	585	С	2964	17	3	0.52	5.23
4	588	1390	273	0	2251	9	2	1.96	7.50
5	294	1390	312	765	2762	12	3	0.74	6.91
6	294	695	312	1532	2833	9	1	0.98	9.44
7	588	695	156	766	2205	5	0	3.53	13.23
8	588	2085	312	0	2 985	6	0	2.94	14.93
9	588	0	234	3064	3886	14	1	1.26	8.33
10	294	2085	312	0	2691	4	0	2.21	20.18

TABLE 28. TAR AND TOTAL MATERIAL PROCESSING RATES

The data in the table indicate that other factors in addition to paddle speed had a significant effect on the total material processing rate. As expected, the highest total material processing rate of 20.2 tons/hour was observed during Run 10. This rate was more than five times higher than the rate for Run 2, which had nearly identical conditions except for paddle speed. However, Run 2 was the first run conducted with tar, and more than the usual amount of time was allowed for the start of tar feeding and for clearing of material from the mill at the end of the run. A more representative total material processing rate at low idle speed, but with no stoppages, is given by the results of Runs 7 and 8 (i.e., an average of 14.1 tons/hour). These data indicate that increasing the paddle speed from low idle to maximum resulted in a 43 percent increase in the total material processing rate.

It is clear from the data in Table 28 that mill stoppages also had a significant effect on processing rates. The results from Runs 3 through 9 show that the highest rates were associated with runs with no stoppages, while the lowest rates were associated with runs with no stoppages.

Paddle speed and mill stoppages had similar effects on tar processing rates during the 10 runs. In addition, the effect of the amount of tar charged to the feed hopper must be considered in evaluating these data. The highest tar processing rates of Runs 7 and 8 correspond to low paddle speed, no stoppages, and high tar feed concentrations. The tar processing rate for Run 10 was lower than those for Runs 7 and 8 (even though the paddle speed was higher) because only half as much tar was initially charged to the feed hopper. It is also interesting to note that the amounts of time required for processing the higher tar feed concentrations (in Runs 4, 7, 8, and 9) were not significantly greater than those for lower tar feed concentrations. This result indicates that the pug mill operation was not tar-feed-rate-limited during these runs. Thus, if the tar feed concentration in Run 10 had been doubled, it is reasonable to expect that the tar processing rate would also have doubled to near 4 tons/hour.

The tar and total material processing rates observed during tar treatment tests correspond to batch operation of the pug mill. Processing rates are characteristically low with batch operations, since time must be allowed near the end of the run for the mill inventory to empty (to avoid contamination with the next batch). In addition, no product material is generated during the first minute or more of pug mill operation, since material must travel from the feed hopper to the head of the mill and then fill the mill to the point where material overflows from the tail-end dam. If continuous operation were maintained, these allowances for mill inventory purging and startup delays would be eliminated and the overall processing rate would increase. The ease with which the pug mill processed the tar and other material during these treatment tests suggests that continuous operation of the pug mill would have been possible. It is estimated that use of continuous operation would have increased processing rates by a factor of at least 2.

The pug mill sustained no physical damage as a result of the tar treatment tests. A small layer of cement built up on the paddles and internal surfaces of the mill, and had to be chiseled off after decontamination. This buildup could be eliminated in future operations by washing the mill with water at the completion of each processing period.

Product Characteristics

Another important area of results for the tar treatment tests concerns the physical characteristics of the treated tar. Table 29 summarizes the characteristics recorded for the product material from the 10 pug mill tests: size distribution, flowability, and angle of repose. Size distribution is important, since it was desired to produce material that was less than 2 inches in size to facilitate feeding the material to a thermal treatment system. The degree to which product material is free-flowing will dictate the ease with which it can be transported from the pretreatment area to the final treatment area. The angle of repose will determine the height to which a given quantity of material can be stacked and the amount of ground space required for storage. The table also summarizes the important feed ratios, namely tar-to-cement-plus-ash [T/(C+A)], water-to-cement-plus-ash [W/(C+A)], and ash-to-cement-plus-ash [A/(C+A)].

		Feed ratio	S	Pro	duct size	distributio	n, wt %	Free	Angle of
Run No.	T/(C+A)	W/(C+A)	A/(C+A)	-2 in.	-1 in.	-0.5 in.	-0.25 in.	flowing, Y/N	repose, degree
1	0.21	0.00	0.00	100	-	95	80	Y	30
2	0.14	0.17	0.00	100	-	9 5	80	Y	45
3	0.14	0.28	0.00	95	-	-	-	N	10-20
4	0.42	0.20	0.00	90-85	-	-	-	Y	-
5	0.14	0.14	0.36	95	-	90	80	Y	30
6	0.13	0.14	0.69	95	-	90	80	Y	30
7	0.40	0.11	0.52	95	90	-	85	Y	45
8	0.28	0.15	0.00	99	95	-	90	Y	45
9	0.19	0.08	1.00	95	90	-	85	Y	45
10	0.14	0.15	0.00	99	95		90	Y	45

TABLE 29. TAR TREATMENT PRODUCT CHARACTERISTICS

The table shows that the product size distribution did not change greatly during the 10 tests despite the change in feed ratios indicated. Essentially, all the product material was less than 2 inches in size for Runs 1, 2, 8, and 10. During these runs, the T/(C+A) ratio ranged from 0.14 to 0.28; the W/(C+A) ratio ranged from 0 to 0.17; and the A/(C+A) ratio was 0 to 1.0. The most significant difference among these products was the lower angle of repose observed during Run 1 with no water added.

The only run which resulted in a product that was not free flowing was Run 3, conducted at a W/(C+A) ratio of 0.28. This product was described as a "watery paste-like mass" with a repose angle of 10 to 20 degrees. All other runs, conducted at W/(C+A) ratios of 0.2 or less produced product material that was free flowing. Although this material was dry to the touch, it would cake if squeezed by hand; when dropped, the caked material would break apart. It was also observed that the product material would set overnight into a more rigid mass. This indicates that the cementitious reactions expected when mixing water with cement and pozzolanic fly ash were slow and required approximately 16 hours to produce noticeable setting.

These results suggest that a tradeoff may apply during final remediation when adding water to cement and ash during tar treatment. Adding water reduces dusting in the mill and makes the product more stackable, thereby requiring less ground space for storage. However, adding water may also cause the product material to set after several hours or days, which could make it more difficult to move the material from a stockpile or storage hopper. The use of ash in place of cement appeared to increase the amount of >2-inch material slightly (from 0 to 1 percent with cement alone to about 5 percent with ash or ash/cement mixtures). Again, this indicates a tradeoff may occur in the final design of such a system, since ash is generally less costly than cement but additional costs will be incurred to recycle the >2-inch material.

It is of interest to note that the product size distribution did not change markedly during the final run when the paddle speed was increased to its maximum. This indicates that acceptable product material could be obtained at the highest throughput rate for the pug mill as configured. Use of continuous operation of the pug mill instead of batch operation would not be expected to change this result.

The greatest amount of >2-inch product material was produced during Run 4 when the paddle speed was increased at the end of the run. Visual observation showed that this change caused more agitation of materials in the mill and more "jumping" on the part of tar lumps in the middle and tail end of the mill. As a result, oversized lumps bumped along the top of the paddles and exited the mill over the dam without being further reduced in size. This behavior was not observed during Run 10, also conducted at high paddle speed. In Run 10, tar lumps were broken up at the head of the mill as they fell off the feeder belt. These results indicate that the paddles should be maintained near a constant speed during tar processing operations. If paddle speed increases are required, they should be made after the inventory in the mill has been largely cleared. After the paddle speed change has been made, tar processing can resume.

Physical inspection of the tar pellets processed through the pug mill showed that the exterior of the pellet was coated with a thin (1-millimeter to 1/4-inch) layer of cement and ash (if present). The middle of the tar pellet did not contain a significant amount of cement or ash. A processed pellet that was broken into two pieces is shown in Figure 67. These conditions suggest that large tar lumps from the feed hopper were broken into smaller lumps, or pellets, by the shearing action of the paddles in the pug mill. These smaller pellets, in turn, were coated by cement or ash as they passed through the mill. The amount of water added to the mill may have been a factor in determining the thickness of the cement/ash coating that built up on the tar pellets.

Analytical Results

The proximate and ultimate analyses reported in Subsection 4.7 indicate that the volatiles, fixed carbon, and heating value all declined between raw tar and treated tar. (The treated tar sample came from the Run 10 product material.) These declines would be expected, since the water and cement added to the tar in the pug mill act to reduce these values and increase the moisture and ash contents, all other things being equal. The data in Table 30 show that the as-received treated tar proximate



Figure 67. Treated tar pellet broken into two pieces.

	Raw ta	r	Treated	Projected		
Proximate analysis	As received	MAF ^b	As received	MAF	treated tar	
Moisture, % Volatiles, % Fixed carbon, % Ash, %	11.6 69.9 16.9 1.6	80.5 19.5	8.1 14.0 2.0 75.9	87.5 12.5	12.9 7.7 1.9 77.6	
Heating value, Btu/lb	9160	10,553	2200	13,750	1000	

TABLE 30.	PROXIMATE	ANALYSIS	COMPARISONS	AMONG	RAW	AND	TREATED	TAR
					-			

^a From Tar Treatment Run No. 10

^b Moisture- and ash-free basis.

analysis agrees well with the analysis projected from the raw tar analysis and the feed quantities specified in Table 29.

The volatile and fixed carbon contents of raw and treated tar can also be calculated on a moisture-and-ash-free (MAF) basis to eliminate the effects of the added water and cement, as shown in Table 30. These data surprisingly indicate that the volatile content of the tar increased somewhat between raw tar and treated tar, while the fixed carbon content decreased. This result is reinforced by the increase in MAF heating value from 10,553 Btu/lb in raw tar to 13,750 Btu/lb in treated tar. An analogous trend was seen in the hydrogen/carbon (H/C) ratio from the ultimate analyses; the H/C ratio increased from 0.08 in raw tar to 0.50 in treated tar. These results suggest that no devolatilization of the tar took place in the pug mill during tar treatment.

4.5.2 Use of Cement and Fly Ash for Emission Control During Tar Treatment

A secondary effect of using portland cement and fly ash during tar treatment in the pug mill was the substantial reduction of SO_2 emissions below expected levels. The emissions data in Table 31 show that the SO_2 concentrations in the enclosure air rose by a maximum of about 5 ppm during the tar treatment tests and, in most cases, remained essentially unchanged. This was surprising in view of the shearing action of the pug mill paddles, which had the effect of exposing new tar surface area for devolatilization, including SO_2 . Such low emission increases were in contrast to periods during the same operating days in which the digging of tar out of storage bins alone resulted in SO_2 emission increases of more than 40 ppm. Much less new tar surface area was exposed during the latter operation than the former.

Based on the appearance of the treated tar pellets, it is speculated that the cement and/or fly ash in the pug mill effectively sealed exposed tar surfaces before any significant devolatilization could occur. The data in the table indicate there was no significant difference between cement, fly ash, and cement/ash mixtures in limiting SO_2 emissions during tar treatment.

		Feed ratio	s	Elapsed	Preliminary THC emissions, ppm			Preliminary SO ₂ emissions,		
Run No.	T/(C+A)	₩/(C+A)	A/(C+A)	time, min	Beginning	End	Change	Beginning	End	Change
1	0.21	0.00	0.00	15	20	90	70	<10	<10	0
2	0.14	0.17	0.00	17	145	196	51	20	15	-5
3	0.14	0.28	0.00	17	142	164	22	<10	<10	0
4	0.42	0.20	0.00	9	168	198	30	<10	<10	0
5	0.14	0.14	0.36	12	240	320	80	<10	15	5+
6	0.13	0.14	0.69	9	300	420	120	15	15	0
7	0.40	0.11	0.52	5	148	260	112	6	10	4
8	0.28	0.15	0.00	6	260	340	80	7	6	-1
9	0.19	80.0	1.00	14	240	300	60	5	4	-1
10	0.14	0.15	0.00	4	77	110	33	1	1	0

TABLE 31. EMISSION CHANGES DURING TAR TREATMENT TESTS

Emissions of THC showed an increase during tar treatment operations ranging from about 20 to 120 ppm. However, another major source of THC emissions during pug mill operation was the mill's diesel engine. Based on the devolatilization behavior discussed previously, it is suspected that the THC emission increases observed during treatment tests were a result of the engine operation. Attempts to correlate THC emission increases with pug mill operating duration (as measured by elapsed times) did not produce any significant relationships.

4.5.3 Potential Use of Pug Mill and Solidification Agents for Char and Mud Processing

Although no treatment tests were conducted with char and mud in the pug mill, the ease with which the mill processed the tar suggests that the same treatment approach could be used for char and mud. Excavated char and mud lumps would likely require less power to process in a pug mill, since they will be easier to break up than the plastic-like tar lumps. The presence of cement and/or fly ash in the mill should act to limit SO₂ and THC emissions during processing, as was observed during tar treatment. However, because of the high emission flux rates observed for char, it is not certain that char treatment emissions will be controlled to the same degree as reported for tar.

4.6 Equipment-Related Operational Factors

The equipment-related operational problems encountered during excavation and processing of the McColl wastes are summarized in Table 32 according to the date on which they occurred, the nature and cause of the problems, and the action taken to remedy or address it during the trial excavation. The table is a synopsis of the operational factors discussed in the Appendix A operations log summaries. A total of 12 separate operational factors are listed (two occurred more than once). All of these either caused work to be stopped or caused significant slowdowns in work progress.

Review of the nature of the factors listed in the table shows that they can be grouped into three general categories: 1) mechanical equipment failures, 2) waste emissions-related problems, and 3) engine emissions-related problems. Each of these categories will be discussed in this section with respect to the action taken during the trial excavation and the remedies recommended for full-scale remediation, assuming the same general approach will be employed for excavation and treatment of waste material.

4.6.1 Mechanical Equipment Failures

The general approach recommended for problems related to mechanical equipment failures is to conduct frequent inspection of operating equipment, follow a regular maintenance program, and maintain an adequate supply of spare parts. The inspection and regular maintenance activities will act to spot and address mechanical problems before they impact work progress. An adequate supply of spare parts will allow timely repair of those mechanical systems that will inevitably fail during an operation of this type. These approaches would likely have eliminated the trial excavation problems related to the missing check valve, foam concentrate feed line pinching, and leaks in Level A PPE suits.

The foam stabilizer became contaminated from the use of the foam mixing trailer on another training assignment before being used at McColl without flushing of

Date (1990)	Operational problem	Cause	Action taken
6/8	Foam leak at mixing trailer.	Check valve in feed line missing.	Installed missing check valve.
6/8	Foam nozzles and hose plugged with stabilized foam.	Contaminated batch of foam stabilizer.	Drained contaminated stabilizer from trailer tank. Replaced with new stabilizer.
6/12	High SO, and THC levels inside enclosure caused work stop- page.	High waste emission rates. Low foam vapor suppression effectiveness.	Stopped work. Applied stabilizer foam. Waited for ventilation system to reduce pollutant concentrations overnight.
6/13	Low visibility inside enclo- sure caused work stoppage.	Diesel engine particulate emissions from trackhoe and loader/backhoe obscured visi- bility. Dust from excavation operations.	Stopped work. Waited for ventilation system to clear enclosure air overnight.
6/15	Low ventilation airflow rate through wet scrubber.	High pressure drop across scrubber caused by solids buildup in scrubber solution.	Blew down scrubber solution and replaced with fresh solution. Initiated twice/day checking of particulate filters upstream of scrubber and changing of filters when loaded.
6/21	Poor-quality stabilized foam.	Feed line from foam concentrate storage tank pinched, shutting off supply of foam to mix system.	Feed line tied off and shielded to prevent further pinching.
6/22	Level A suits failed pressure test.	Suits had not been used in years and had developed leaks in storage.	Patched leaks in old suits and ordered new suits.
6/22	Observation camera would not tilt up and down.	Several teeth on plastic gear inside tilt unit were sheared off.	Tilt unit replaced with new one.
6/26	High SO, levels inside enclo- sure caused work stoppage.	High waste emission rates. Low foam vapor suppression effectiveness.	Stopped work. Applied stabilized foam. Waited for ventilation system to reduce pollutant concentrations overnight.
6/27	High temperatures inside en- closure and related heat stress concerns caused work stoppage.	High ambient temperatures, solar gain, exhaust heat from diesel engines, and Level A PPE.	Stopped work. Waited until the following day to re- sume work.
6/28	Steering and braking control problems with loader/backhoe.	Attack of steering and braking system by dirt, dust, and waste emissions.	Steam cleaning of loader/backhoe steering and braking systems corrected control problems.
6/28	Mud layer on floor of enclo- sure caused traction diffi- culties for wheel-mounted loader.	Breakdown of foam and accumulation of sta- bilized-foam purge water.	Replaced wheel-mounted loader with track-mounted Bob- cat.

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TABLE 32. OPERATIONAL FACTORS AFFECTING TRIAL EXCAVATION

(continued)

TABLE 32 (continued)

Date (1990)	Operational problem	Cause	Action taken
7/11	Low ventilation airflow rate through wet scrubber.	High pressure drop across scrubber. Cause of high pressure drop not identified.	Scrubber liquid recirculation rate lowered to reduce liquid hold-up in tower, thereby reducing pressure drop and increasing airflow to normal levels.
7/25	White powdery buildup on alu- minum I-beams of enclosure structure.	White powder speculated to be aluminum sulfate, caused by the attack of sulfuric acid (formed by SO, and moisture) on alu- minum surfaces.	None required during trial excavation. Beams manually cleaned of deposits offsite after demobilization using commercial phosphoric acid-based cleaner.

the material in the tanks. This points out the need for fresh, high-quality materials to be used for the full-scale remediation and the requirement that all equipment be adequately cleaned and flushed before coming on site. It is likely that a new, dedicated foam mix trailer would be used for full-scale remediation if continued use of foam for vapor suppression were called for.

Solids buildup in the wet scrubber solution was addressed during the trial excavation by more frequent inspection and changing of the dust filters upstream of the scrubber. The filters used during this program were common household furnace filters. For full-scale remediation, an industrial-type particulate collection system is recommended, should be upstream of other ventilation air pollution control equipment. This system would likely consist of a wet venturi-type scrubber or an electrostatic precipitator (ESP). Alternatively, a wet scrubber or ESP designed for both particulate and SO₂ removal could be employed.

The problems observed with steering and braking of the backhoe/loader would be mitigated by the emission reduction procedures discussed later in this section. However, it may also be desirable to enclose sensitive systems to isolate them from dirt, dust, and other emissions. Enclosure of the observation camera and zoom lens during the trial excavation was successful in avoiding operating problems with these sensitive devices.

Finally, the traction difficulties encountered by the wheel-mounted loader on the muddy floor of the enclosure were due to the chemical breakdown of temporary and stabilized foam by the char and tar wastes and the accumulation of purge water from stabilized foam applications. At the completion of stabilized-foam applications, foam and water had to be purged from the delivery lines to prevent set-up of foam in the system; purging was not required after temporary foam applications. The result of the foam breakdown and purge water accumulation was a layer of mud and foam on the floor that was 6 to 12 inches deep. Besides making traction difficult for the loader, the mud also prevented the free movement of tar and waste bins about the enclosure (due to sinking) and made personnel footing quite uncertain.

For the trial excavation, the problem was addressed by substituting a trackmounted Bobcat for the wheel-mounted loader. Because of the Bobcat's smaller bucket size, this change reduced the waste-moving productivity of operating personnel. In addition, personnel took more care in directing the stabilized-foam purge water into 55-gallon drums rather than onto the enclosure floor.

If foam application is retained for a full-scale remediation, it may be necessary to devise a drainage system around waste-handling areas to drain off accumulated water. In addition, portable blowdown tanks should be located near foaming operations to catch purge water and to remove it periodically from the enclosure. Depending on the success of these systems, track-mounted equipment may be required for material-handling operations.

4.6.2 Waste Emission-Related Problems

The high emission levels of SO_2 and THC measured for the tar and char waste materials during the trial excavation caused work stoppages. These were due to health and safety concerns, interfered with equipment steering and braking systems, and the formation of aluminum sulfate on the enclosure support I-beams. As discussed else-where in this report, the emission flux rates from char and tar wastes were higher than expected during the trial excavation and the vapor suppression ability of the foam used was lower than expected. Since the ventilation air flow rate was fixed, this system was not able to provide enough fresh air to keep pollutant concentrations below design levels.

To address these concerns in the full-scale remediation, a more effective vapor control system would be desirable. Alternative formulations for foams should be investigated, especially those which contain chemical bases and have the potential to chemically bond with the surface of the acidic McColl waste. Improvements to foam application techniques such as leveling of waste surfaces to minimize foam sloughing may be possible. Alternatively, other vapor-suppression systems should be evaluated, including the use of a lime or limestone slurry such as has been applied in coal mines for dust suppression.

However, even with improvements, the vapor-suppression system cannot be expected to provide complete control of waste emissions due to the dynamic conditions of waste excavation and movement. To maintain pollutant concentrations inside the enclosure below Immediately Dangerous to Life and Health (IDLH) or Permissible Exposure Limit (PEL) levels, a larger air-ventilation system will in all likelihood be called for. This will require a larger fan, air pollution control devices (APCDs), and associated ducting. By generating a higher airflow rate, the larger ventilation system would provide for more frequent turnover of the air inside the enclosure, and hence lower pollutant concentrations.

4.6.3 Engine Exhaust-Related Problems

During the trial excavation, diesel engines were operated on the trackhoe, backhoe/loader, Bobcat, and pug mill. The emissions from these engines directly contributed to a work stoppage due to heat stress, to a work stoppage due to low visibility, and to work stoppages related to high THC levels. The exhaust gases from diesel engines add heat, particulate matter, and hydrocarbon species to the enclosure air (SO₂ contributions were likely small in light of the low amount of sulfur in diesel fuel). One approach for the full-scale remediation would be to use electric engines in place of diesel engines. The pug mill could have been equipped with an electric engine for the trial excavation except that the electrical demand requirements would have exceeded the supply available on site. Further work should be conducted on the size of the pug mill required for full-scale remediation and associated power requirements. In addition, it may be possible to use an electrically-powered gantry crane system inside the enclosure for movement of material and for excavation of some or all of the waste materials.

If diesel engines on some operating equipment cannot be feasibly eliminated for the full-scale remediation, a system for directly venting engine exhaust to the APCDs should be investigated. It may be possible to suspend movable ducting from the enclosure ceiling that could be connected to engine exhausts and directly transport exhaust gases to the APCD system without their entering the enclosure air. This would be easiest to accomplish on equipment that did not move about greatly within the enclosure (e.g., pug mill or trackhoe). For more mobile equipment, it might prove feasible to direct exhaust gases through a filter, carbon canister, and water cooler system mounted directly on the machine. This approach would likely require frequent changing of the filter media, carbon, and water to maintain effectiveness.

4.7 Waste Characterization

Samples of raw mud, raw tar, raw char, and treated tar were taken during this project for subsequent analyses. The treated tar sample was from Run 10. Previous samples from the L-4 sump were taken from borings made at this site and, where appropriate, these earlier analytical data are presented for comparison.

4.7.1 Proximate and Ultimate Analyses

Table 33 presents the results of the proximate and ultimate analyses performed on the four sets of samples. In all of these analyses, some volatile matter was driven off of the sample when it was heated to 105°C to determine the moisture fraction. Also, the moisture content of these samples may be higher than undisturbed waste due to the foam vapor suppressants sprayed on the waste, which contained large amounts of water. Results for these analyses are included in Appendix F.

These data show the mud fraction of this waste (the upper layer) consisted largely of inorganic, noncombustible material with an ash content of 82.9 percent and a heating value of less than 500 Btu/lb. The raw tar sample contained a high percentage of combustible material and had a heating value of over 9000 Btu/lb, an ash content of less than 2 percent, and a high sulfur content of 10.6 percent. The treated tar sample contained cement dust and fly ash (low-sulfur, high-ash components), and the addition of this material decreased all of the combustible parameters and increased

the ash value. Raw char has a fairly high ash level of about 55 percent, a sulfur level of 4.5 percent, and a heating value of 5200 Btu/lb.

Parameter	Raw mud	Raw tar	Treated tar	Raw char
Proximate				
Moisture, %ª	13.2	11.6	8.1	21.2
Volatiles, %	3.7	69.9	14.0	20.1
Fixed carbon, % ^b	0.2	16.9	2.0	4.0
Ash, %	82.9	1.6	75.9	54.7
Btu/lb	<500	9160	2200	5200
Ultimate				
Carbon, %	1.1	51.1	2.4	8.6
Hydrogen, %	2.5	5.4	2.1	3.7
• • •	$(1.0)^{c}$	$(4.1)^{c}$	(2.1) ^c c	$(1.3)^{c}$
Sulfur, %	0.8	10.6	3.6	4.5
Nitrogen, %	0.1	0.1	0.1	0.1
Oxygen, ^{%d}	12.5	31.1	15.8	28.3
	(0.8) ^c	(20.8) ^c	(8.6) ^c	(9.5)°

TABLE 33. TRIAL EXCAVATION WASTE SAMPLE ANALYSIS - PROXIMATE AND ULTIMATE (AS-RECEIVED BASIS)

^a Moisture includes some volatiles lost at 105°C.

^b Fixed carbon determined by difference in proximate analysis.

^C Excludes hydrogen and oxygen contained in water.

^d Oxygen determined by difference in ultimate analysis.

Previous data on the proximate and ultimate analyses of waste from the L-4 sump were obtained from core samples at various depths but were not specified as mud, tar, or char (GPI 1989). Table 34 presents these data, which are shown here for comparison purposes. Though not exactly comparable, the bore sample at 15 to 16 feet deep is probably in the tar layer and, except for the ash and fixed carbon, compares approximately with the samples from the trial excavation. The deeper samples are probably in the char layer and again compare with the values obtained during this study except for the sulfur contents, which were much higher in the bore samples.

	15-16	18-19	24-25
Proximate			
Moisture, %	10.7	14.0	11.5
Volatiles, %	66.0	31.8	32.5
Fixed carbon, %	8.7	4.9	2.2
Ash, %	14.7	49.4	53.8
Btu/lb	9057	3503	1179
<u>Ultimate</u>			
Carbon, %	44.5	19.5	8.6
Organic hydrogen, %	5.9	2.2	1.8
Sulfur, %	14.5	10.4	10.4
Nitrogen, %	0.2	0.2	0.2
Oxygen, %	7.4	4.4	13.7

TABLE 34. BORE SAMPLES - PROXIMATE AND ULTIMATE ANALYSES (AS-RECEIVED BASIS)

4.7.2 Selected Chemical Analyses

A common indicator for petroleum waste is the concentration of benzene, toluene, ethylbenzene, and xylene (BTEX). Samples of the McColl waste were analyzed for these compounds, as presented in Table 35. These data show that the tar fraction of this waste contains the highest levels of these compounds and that the mud layer contains only a relatively small portion of these compounds.

TABLE 35.	BTEX C	OF WAST	
Compound	Mud	<u>Tar</u>	Char
Benzene	<0.7	240	97
Toluene	1.5	580	150
Ethylbenzene	0.9	140	35
Total xylenes	8.6	910	220

Previous analytical data on bore hole samples from the L-4 sump did not yield values that were this high. The maximum values measured were 11, 24, 8, and 41 ppm for benzene, toluene, ethylbenzene, and xylene respectively (CH2M Hill 1989; Table D-6).

4.7.3 Leach Procedure Tests

Toxicity characteristics of the excavated waste and the treated tar were determined by the Toxicity Characteristic Leaching Procedure (Federal Register 1986) and
the California wet test (Calif. Admin. Code 1985). In the EPA TCLP test an acetic acid based leaching solution is mixed with waste which has been crushed to pass through a 9.5 mm screen at a 20:1 ratio. The leaching is performed in a zero head space extractor for 18 hours. The California wet test uses a 0.2 M sodium citrate extraction solution mixed with waste that is crushed to pass through a 2 mm screen at a 10:1 ratio. Leaching is carried out over 48 hours. Analytical data for these tests, including blank values and matrix spike recovery data, are presented in Appendix F.

Metals

The TCLP and California wet test results for designated metals are presented in Table 36. These data show fairly low levels of these metals and all of the TCLP results are well below regulatory levels. Some chromium was evident in all the samples except mud. Lead and barium were also present in the treated tar, possibly from the cement/fly ash additive.

A more extensive list of metals is analyzed in the California wet test. A higher detection limit, due to dilutions required by the high sodium levels in the extract, was evident in these tests. Chromium, vanadium, and zinc were found in all of these sample extracts. Antimony, copper, lead, and molybdenum were also found in the treated tar sample extract.

Organic Compounds

Designated volatile organic compounds were analyzed as specified in the EPA-TCLP procedure. Semivolatile compounds were also analyzed by the EPA-TCLP and in the California wet test extracts. The California wet test procedure does not lend itself to volatile organic compound analyses since no zero head space extraction apparatus is used.

Benzene and 2-butanone (MEK) were detected in the volatile organic compound analyses in all sample extracts except mud as shown in Table 37. The benzene concentration in the treated tar sample was below the regulatory level of 500 μ g/liter and was found at the 1000 μ g/liter level in tar and char extracts. Matrix spike recoveries for these compounds were generally good and within prescribed limits.

Semivolatile compounds were not detected in any extracts from the EPA-TCLP and California wet test except for pyridine found in the char California wet test extract at a concentration of 1100 μ g/liter (Table 38).

Metal	Mud	Tar	Treated tar	Char	Regulatory limits				
TCLP analysis for metals									
Arsenic	<0.01	<0.01	<0.01	<0.01	5.0				
Barium	<0.2	<0.2	0.6	<0.02	100				
Cadmium	<0.005	<0.005	<0.005	<0.005	1.0				
Chromium	<0.01	0.09	0.15	0.23	5.0				
Lead	<0.05	<0.05	0.12	<0.05	5.0				
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	0.2				
Selenium	<0.005	<0.005	<0.005	<0.005	1.0				
Silver	<0.01	<0.01	<0.01	<0.01	5.0				
		California	a wet test for	metals					
Antimony	<0.6	<0.6	0.9	<0.6	15				
Arsenic	<0.25	<0.25	<0.25	<0.25	5.0				
Barium	<2	<2	<2	<2	100				
Beryllium	<0.05	<0.05	<0.05	<0.05	0.75				
Cadmium	<0.05	<0.05	<0.05	<0.05	1.0				
Chromium	0.2	0.3	1.1	0.6	560				
Cobalt	<0.5	<0.5	<0.5	<0.5	80				
Copper	<0.25	<0.25	0.44	<0.25	25				
Lead	<0.5	<0.5	0.8	<0.5	5.0				
Molybdenum	<0.2	<0.2	0.3	<0.2	350				
Mercury	<0.002	<0.002	<0.002	<0.002	0.2				
Nickel	<0.4	<0.4	<0.4	<0.4	20				
Selenium	<0.125	<0.125	<0.125	<0.125	1.0				
Silver	<0.1	<0.1	<0.1	<0.1	5				
Thallium	<0.25	<0.25	<0.25	<0.25	7.0				
Vanadium	0.9	1	0.9	1.4	24				
Zinc	1	1	0.2	1.6	250				

TABLE 36. SAMPLE EXTRACTION TESTS FOR METALS (mg/liter)

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Parameter	Mud	Tar	Treated tar	Char	Regulatory limits				
Volatile organic compounds									
Vinvl chloride	<10	<100	<10	<50	200				
1.1-Dichloroethene	<5	<50	<5	<25	700				
Chloroform	<5	<50	<5	<25	6,000				
1.2-Dichloroethane	<5	<50	<5	<25	500				
2-Butanone	<10	350	29	310	200,000				
Carbon tetrachloride	<5	<50	<5	<25	500				
Trichloroethene	<5	<50	<5	<25	500				
Benzene	<5	1100	88	1000	500				
Tetrachloroethene	<5	<50	<5	<25	700				
Chlorobenzene	<5	<50	<5	<25	100,000				
Semivolatile organic co	ompound	ls							
1.4-Dichlorobenzene	<10	<100	<100	<100	7,500				
Hexachloroethane	<10	<100	<100	<100	3,000				
Nitrobenzene	<10	<100	<100	<100	2,000				
Hexachlorobutadiene	<10	<100	<100	<100	500				
2,4,6-Trichlorophenol	<10	<100	<100	<100	2,000				
2,4,5-Trichlorophenol	<50	<500	<500	<500	400,000				
2,4-Dinitrotoluene	<10	<100	<100	<100	130				
Hexachlorobenzene	<10	<100	<100	<100	130				
Pentachlorophenol	<50	<500	<500	<500	100,000				
Total Methylphenol	<10	<100	<100	<100					
Pyridine	<50	<500	<500	<500	5,000				

TABLE 37. TCLP ORGANIC COMPOUNDS (µg/liter)

TABLE 38. CALIFORNIA WET TEST SEMIVOLATILE ORGANIC COMPOUNDS $(\mu g/liter)$

Parameter	Mud	Tar	Treated tar	Char
1.4-Dichlorobenzene	<10	<10	<10	<100
Hexachloroethane	<10	<10	<10	<100
Nitrobenzene	<10	<10	<10	<100
Hexachlorobutadiene	<10	<10	<10	<100
2,4,6-Trichlorophenol	<10	<10	<10	<100
2,4,5-Trichlorophenol	<50	<50	<50	<500
2,4-Dinitrotoluene	<10	<10	<10	<100
Hexachlorobenzene	<10	<10	<10	<100
Phentachlorophenol [®]	<50	<50	<50	<500
Total methylphenol	<10	<10	<10	<100
Pyridine	<50	<50	<50	1100

^a Regulatory limit is 1700 μ g/liter. Other compounds are not listed in California Regulations.

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SECTION 5

QUALITY ASSURANCE SUMMARY

This section summarizes the information used to check the quality of the data obtained during this study. Two audit reports will be prepared by Research Triangle Institute to assess data quality. The first, documenting audits of onsite activities, is included in Appendix H. The second report, describing the audit of data quality, will be included in the raw data file.

5.1 Enclosure Exhaust Air Monitoring for SO₂ and Hydrocarbons

As described in Section 3, a continuous emission monitoring (CEM) system was installed to measure SO_2 and total hydrocarbons before and after the exhaust air control system. This system was subject to stringent quality assurance procedures. PEI Associates was responsible for these data, the quality assurance plans, and internal quality assurance review of the sampling procedure and data reduction.

5.1.1 CEM System Audits

An EPA audit was conducted during the beginning stages of this test program (June 5-8) prior to any excavation. The audit was performed by EPA quality assurance staff and Research Triangle Institute (RTI), a contractor for EPA. Auditors observed CEM sampling procedures relative to the guidelines set forth in the Quality Assurance Project Plan (QAPP) prepared for this project and included in Appendix I. The following additions to the QAPP were recommended by the audit team and implemented for this project:

- 1) CEM data were recorded in bound log books. The information on the original CEM field data sheets was copied into the log book, and these logs were kept in a file box in the CEM trailer.
- Strip charts were left on the recorders for a 1-week period before being sent back to PEI and copied. This reduced the amount of paper handling and improved organization.

- 3) A file system was set up for all CEM-related test data. The file was used to store weekly strip charts, log books, floppy disks, ODESSA computer data, Method 6 data, and velocity data.
- 4) Settings of the zero and span potentiometers on the CEM's were recorded daily to document CEM stability.

The CEM sampling systems were also checked with audit gases supplied by RTI. Audit gas values were compared with values generated from the strip charts and the ODESSA data logging system. This audit validated the CEM sampling system operation, responses from chart recorders, and data generated by the ODESSA. Results of the audit are presented in Table 39. Percentage differences were calculated based on each audit gas concentration value. These data show that the measured values were within 5.5 percent of the audit values at concentrations about 10 ppm and within 27.4 percent at the 1.75-ppm level.

5.1.2 CEM Quality Assurance Objective

The steps taken to ensure quality data during this test program included:

- Initial leak checks were made of the sample system.
- Initial calibrations were injected directly into the instruments and compared with calibrations throughout the sample system. Daily calibrations were performed by direct injection to the analyzer. Periodic samplesystem injections were made throughout the program.
- Sample flow rates were checked to ensure excess flow to each analyzer.
- External (RTI) audits were performed to ensure accuracy in sampling and analyses.
- The gases used were EPA protocol calibration gases (± 1%) for SO₂ instruments and Master Gas Certified (± 2%) gases for the THC instruments. Certificates are in Appendix B.
- Daily 4-point and span/zero checks were performed throughout the program.
- Performance of manual SO₂ tests by EPA Method 6 for comparison with CEM data.

Audit,	Computer,	Chart divisions	Chart, ppm	Difference comp-audit	Difference, X	Chart-Aud	Difference, %
				SO ₂ Inlet CEM			
40.86 30.44 20.7	38.8 29.4 20.3	82 62 42	38.6 29.1 19.64	-2.06 -1.04 -0.4	-5 -3.4 -1.9	-2.26 -1.34 -1.06	-5.5 -4.4 -5.1
1.75	1.95	3.8	1.52	0.2	11.4	-0.23	-13.1
				SO, Outlet CEM			
40.86 30.44 20.7 10.37 1.75 0	43 32.1 21.2 10.6 1.6 0	91 68 44.5 22.5 3.3 0	42.4 31.6 20.6 10.3 1.27 -0.3	2.14 1.66 0.5 0.23 -0.15 0	5.2 5.5 1.6 2.2 -8.5	1.54 1.16 -0.1 -0.07 -0.48 -0.3	3.8 3.8 -0.5 -0.7 -27.4
				THC Inlet CEM			
98 25.2 0	98.8 24.5 0	48 12 0.2	99.3 25 0.7	0.8 -0.7 0	0.8 -2.8	1.3 -0.2 0.7	1.3 -0.8
			1	THC Outlet CEM			
98 25.2 0	95.7 24.7 0.1	93.5 24.3 0	96.7 25 -0.2	-2.3 -0.5 0.1	-2.3 -1.9	-1.3 -0.2 -0.2	-1.3 -0.8

TABLE 39.RTI CEM SAMPLE SYSTEM AUDITJUNE 5, 1990

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Percent difference = $\frac{Audit ppm - chart ppm}{Audit ppm} \times 100$

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The objectives for critical measurements for the CEM system are presented in Table 40. The Method Detection Limit (MDL) is based on the instrument's ability to quantitate concentrations at an accuracy of 2 percent full scale. The SO₂ analyzer had a full-scale value of 50 ppm, which corresponds to an MDL of 1 ppm. Any SO₂ values less than 1 ppm should be interpreted as being below the detection abilities of the analyzer. Precision was defined as the percentage difference between duplicate calibration gas injections. It should be noted that discussions about the use of a daily afternoon span check, as a daily precision check, were held in the initial stages of the project. The span and zero afternoon checks were a good indication of morning to afternoon drift, but not of instrument precision. Precision was defined as the instrument's ability to quantitate a gas concentration as accurately as possible between duplicate injections of the calibration gas. The data that more accurately show instrument precision were taken from actual duplicate injections of the span gas. Table 41 presents the precision data which show that precision was always within the objective of 4 percent. The difference (drift) between morning and afternoon calibrations was also calculated.

Analyzer calibration error is the difference between the gas analyzer response and the known concentration of the calibration gas. Calibration error values are used to determine the instrument accuracy. Strip chart data were reduced daily by calculating the analyzer calibration error by linear regression equations. Calibration error data, along with drift data for example days are presented in Tables 42 and 43 for SO₂ and THC, respectively. Calibration errors based on the span gas injections only, were all under 5 percent of span.

Drift was defined as the difference in the initial morning calibration of the instrument and the following morning calibration. Drift data are also presented in Tables 42 and 43. Calculations of daily (24-hour) drift were performed with the strip chart data. A drift greater than 5 percent was considered excessive and this only occurred twice during the study. A complete track of calibration and drift information was maintained in the field log books.

Completeness is the amount of on-line sampling data collected over each 24-hour day. The goal of 80 percent completeness was met during most of the program.

Response time is the amount of time necessary for the instrument to display 95 percent of a change in gas concentration on the data recorder. Response time tests were conducted at the beginning and end of this program. Results are presented in Table 44. Injections were made into the front end of the sample system to represent actual sampling conditions. Responses show good sample flow and quick response by all instruments.

Critical measurement	Matrix type	Reference Method	MDL a ppm	Preci-b sion, X	Sensi- c tivity, X	Analyzer cali-d bration error, %	Drift, X ^e	Completer ness, %
Inlet - SO ₂ (Scale 0-50 ppm)	Process exhaust air	EPA Method 6C	1	4	2	5	5	80
Outlet - SO, (Scale 0-50 ppm)	Control device exhaust air	EPA Method 6C	1	4	2	5	5	80
Inlet - THC (Scale 0-200 ppm)	Process exhaust air	EPA Method 25A	4	4	2	5	5	80
Outlet - THC (Scale 0-100 ppm)	Control device exhaust air	EPA Method 25A	2	4	2	5	5	80

TABLE 40. QA OBJECTIVES FOR PRECISION, ANALYZER CALIBRATION ERROR, COMPLETENESS, AND METHOD DETECTION LIMIT

MDL = Method Detection Limit.

b As percent difference of duplicate calibration gas injection. Four percent of full scale was used for this program.

c Recommended manufacturers instrument sensitivity. Two percent of full scale was used.

d The difference between the gas analyzer response and the known concentration of the calibration gas. Five percent of full scale was used.

e The difference in the initial calibration of the instrument and the following calibration at the zero and span values. Five percent of full scale was used.

f Calibrations, changing filters, and system maintenance required 5 hours per day. The 80 percent completeness is based on monitoring emissions 19 hours out of a 24-hour day. Calibrations were conducted when minimal emissions were anticipated.

Note: The precision, analyzer calibration error, and drift percentages are slightly higher than the EPA Reference Method guidelines for source analyzers. The instruments were on the lower detection ranges, which make it very difficult to meet the source instrument guidelines.

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			Concentrat	· · · · · · · · · · · · · · · · · · ·	
CEM	Date	Time	Injection 1	Duplicate	Precision ^b
SO ₂ Inlet	6/6	1046	45.3	45.8	1.1
SO ₂ Outlet	6/6	1100	45.4	46.1	1.5
THC Inlet	6/6	1025	180.3	180.3	0.0
THC Outlet	6/6	1010	91.3	91.6	0.3
SO ₂ Inlet	6/8	0645	45.3	46.0	1.5
SO ₂ Outlet	6/8	0710	45.4	45.7	0.7
SO ₂ Inlet	7/13	1315	43.9	44.1	0.5
SO ₂ Outlet	7/13	1330	44.9	44.9	0.0
THC Inlet	7/13	1245	182.2	182.2	0.0
THC Outlet	7/13	1300	90.4	90.4	0.0

TABLE 41. CEM PRECISION DATA

^a Concentration in parts per million, calculated from the strip chart.

^b Percent difference of duplicate gas injections.

Precision =
$$\frac{C_1 - C_2}{(C_1 + C_2)/2} \times 100$$

where C_1 and C_2 are the observed values.

Date	Span drift ^a	Zero drift ^a	Correlation coefficient	Calibration error, ^b % of span					
Inlet									
6/9	0.0	-0.2	0.9999	0.02					
6/12	-3.0	0.0	0.9999	0.02					
6/14	-5.0	-0.2	0.9999	-0.41					
6/17	-2.0	-0.5	0.9996	-0.20					
6/21	-6.8	+3.0	0.9999	0.62					
6/25	+0.5	+0.3	0.9999	-0.20					
6/26	+1.0	-0.5	0.9999	0.00					
6/29	-0.5	+0.2	0.9999	-0.90					
7/9	+2.0	-0.5	0.9999	0.10					
7/11	+4.7	0.0	0.9999	-0.08					
7/13	-1.0	0.0	0.9999	0.25					
//16	-2.0	-0.1	0.9999	0.41					
//1/	-1.0	0.0	0.9999	-0.41					
	<u></u>	Outl	et	<u></u>					
6/9	+0.7	-0.5	0.9999	0.65					
6/12	-1.0	0.0	0.9999	0.23					
6/14	-3.0	-0.3	0.9999	-0.21					
6/17	+3.5	-0.3	0.9999	-0.21					
6/21	+1.0	+0.2	0.9999	-0.42					
6/25	+2.0	+0.5	0.9999	-0.40					
6/26	+4.5	+0.7	0.9999	0.00					
6/29	-2.0	-0.5	0.9999	-0.20					
1/2	-0.5	0.0	0.9999	0.20					
//9	+2.0	-0.2	0.9999	-0.60					
7/11	-1.0	-0.2	0.9999	0.20					
7/12	-0.5	+0.6	0.9999	0.00					
7/13	-1.0	+0.6	0.9999	0.00					
//16	+0.5	+2.5	0.9992	-1.30					
//1/	+4.0	0.0	0.9999	-0.44					

TABLE 42. SO2 CALIBRATION SUMMARY

B Drift = Final % of full scale - Initial % of full scale

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Analyzer calibration error = $\left[\frac{Calibration \ gas \ conc. - \ conc. \ indicated}{full-span \ concentration}\right] \times 100$

Date	Span drift ^a	Zero drift ^a	Correlation coefficient	Calibration error, ^b % of span					
Inlet									
6/9	0.0	0.0	0.9999	0.20					
6/12	-3.0	-0.2	0.9999	0.19					
6/14	+4.3	0.0	0.9999	0.29					
6/17	-1.0	0.0	0.9999	-0.19					
6/22	-0.5	0.0	0.9999	0.05					
6/25	-2.3	0.0	0.9999	0.00					
6/26	-0.5	+0.3	0.9999	-0.10					
6/28	-2.0	0.0	0.9999	0.00					
6/29	+0.7	0.0	0.9999	-0.10					
7/9	+3.5	0.0	0.9999	-0.20					
7/11	+4.5	+0.2	0.9999	0.20					
7/13	-1.0	+0.1	0.9998	0.50					
7/15	+9.0	0.0	-	-					
7/16	+0.5	+0.2	0.9999	0.25					
_7/17	+1.0	-0.1	0.9999	0.35					
		Outle	t						
6/9	-0.3	+0.2	0.9999	0.10					
6/12	+2.2	0.0	0,9999	0.00					
6/14	+0.8	0.0	0,9999	0.00					
6/17	0.0	0.0	0.9999	0.10					
6/21	+2.5	0.0	0.9999	-0.20					
6/22	1.5	0.0	0.9999	-0.10					
6/25	-1.5	0.0	0.9999	0.10					
6/26	-1.5	0.0	0.9999	0.10					
6/28	0.0	0.0	0.9999	0.10					
6/29	0.0	0.0	0.9999	0.40					
7/9	+1.0	+1.5	0.9998	0.50					
7/11	-0.3	0.0	0.9999	-0.10					
7/13	-1.5	-0.2	0.9999	-0.10					
7/15	-4.0	0.0	-	-					
7/16	+2.5	0.0	0.9999	-0.15					
7/17	+1.0	0.0	0.9998	0.38					
<u></u>									

TABLE 43. THC CALIBRATION SUMMARY

a Drift = Final % of full scale - Initial % of full scale

Analyzer calibration error = [Calibration gas conc. - conc. indicated] x 100

CEM	Date	Time (24-h)	Response, seconds ^a
SO ₂ Inlet	6/6	1045	<120
SO ₂ Outlet	6/6	1100	<120
THC Inlet	6/6	1015	<15
THC Outlet	6/6	1025	<15
SO ₂ Inlet	7/13	0610	<120
SO ₂ Outlet	7/13	0625	<120
THC Inlet	7/13	0640	<20
THC Outlet	7/13	0650	<20

TABLE 44. CEM RESPONSE TIME RESULTS

Calculations of response time were based on calibration gas injections through the sample system (sample line, conditioning systems, and sample pumps).

Comparison of strip chart data and ODESSA data were made during a 1-hour sampling period each day. These hourly comparisons were used to validate the ODESSA computer data results. Examples of these data for SO_2 and THC are presented in Tables 45 and 46, respectively.

5.1.3 Method 6 and Velocity QA Procedures

Sampling was conducted periodically according to EPA Method 6 (a manual method for measuring SO₂ concentrations) as an independent check on CEM SO₂ values. Testing was performed at the inlet and outlet test sites. Results of the Method 6 sampling are presented in Table 47 along with the corresponding CEM values. The outlet levels were too low to be measured by this manual technique, and the inlet values agreed within 12.5 percent of the average at higher values and within 30.4 percent at the single check at lower values. Considering the basic experimental inaccuracies in the manual test method and the difficulty in comparing the exact time intervals for the CEM and manual tests, these comparisons are reasonable.

Velocity measurements were also conducted at the inlet and outlet sites. These data were presented in Subsection 3.5.1. The following steps were taken to ensure quality data from the Method 6 and velocity sampling:

- Calibration of field sampling equipment. Table 48 summarizes calibration of equipment used for this test series.
- Train configuration and calculation checks.

		Inlet concentration, ppm		Outlet conce	ntration, ppm
Date	Time	Strip chart*	ODESSA ^b	Strip chart ^a	ODESSA ^b
6/9	1100-1200	$0.0 (< 1.0)^{c}$	$0.1 (< 1.0)^{c}$	0.0 (< 1.0) ^C	$0.1 (< 1.0)^{C}$
6/12	1000-1100	0.5	0.5	0.2	0.1
6/14	1100-1200	149.0	146.0	0.0	0.0
6/19	1600-1700	30.7	30.9	0.0	0.0
6/21	1500-1600	12.3	11.6	0.1	0.1
6/26	1300-1400	153.5	147.7	1.5	2.0
6/28	0800-0900	18.9	18.4	0.1	0.0
7/2	1000-1100	119.1	117.0	0.2	0.1
7/9	1000-1100	0.0	0.0	0.0	0.0
7/11	0700-0800	0.0	< 1.0 ^d	0.0	0.0
7/13	0700-0800	0.2	0.3	0.3	0.0
7/16	1600-1700	8.8	7.3	0.3	0.3
7/18	0900-1000	1.9	0.0	0.0	0.0

TABLE 45. COMPARISON OF STRIP CHART HOURLY DATA WITH ODESSA HOURLY DATA FOR SO₂ INLET

^a Strip chart data are reduced by linear regression equations by using calibration gas values versus responses on strip charts.

^b ODESSA data are calculated by set concentration levels given to the zero and full-scale points.

^c Method detection limit is 1 ppm, or 2% of full scale (full scale = 50 ppm).

^d Scale was 0 to 400 ppm, MDL \leq 8.0 ppm.

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		Inlet concentration, ppm		Outlet concentration, ppm	1
Date	Time	Strip chart ^e	ODESSA ^b	Strip chart ^a ODESSA	b
6/9	1100-1200	10.0 ^c	9.0 ^c	4.4 ^c 4.0 ^d	1
6/12	1000-1100	32.7	34.4	13.7 15.2	
6/14	1100-1200	162.0	163.0	75.0 75.0	
6/19	1600-1700	75.8	78.4	21.5 25.9	
6/21	1500-1600	78.8	78.0	31.1 31.2	
6/26	1300-1400	183.4	180.8	47.2 43.8	
6/28	0800-0900	74.4	75.1	43.3 40.8	
1/2	1000-1100	161.1	157.4	86.2 90.7	
7/9	1000-1100	31.6	32.5	28.0 29.4	
7/11	0700-0800	152.0	157.5	69.0 59.4	
7/13	0700-0800	120.4	120.1	105.2 96.2	
7/16	1600-1700	128.1	131.3	91.3 91.4	
7/18	0900-1000	58.8	58.3		
7/18	1000-1100	-	-	61.8 55.9	

TABLE 46. COMPARISON OF STRIP CHART HOURLY DATA WITH ODESSA HOURLY DATA FOR THC

* Strip chart data are reduced by linear regression equations by using calibration gas values versus responses on strip charts.

^b ODESSA data are calculated by set concentration levels given to the zero and full-scale points.

^c Method detection limit is 4 ppm, or 2% of full scale (full-scale = 200 ppm).

Run	Location	Date	Time	Hethod 6	CEM ppm	Difference, X ^a
S0S-1	Stack outlet	6,13/90	1557-1617	<1.3 ^b	<1.0 ^C	NA
S0S-2	Stack outlet	6,'20/90	1013-1033	<1.3 ^b	<1.0 ^C	NA
S05-3	Stack outlet	6,'29/90	1434-1454	<1.3 ^b	<1.0 ^C	NA
SIS-1	Scrubber Inlet	6,13/90	1640-1700	366	323	-12.5
SIS-2	Scrubber Inlet	6/20/90	929-949	17	23.1	30.4
SIS-3	Scrubber Inlet	6/29/90	1501-1521	216	191	-12.3

TABLE 47. SUMMARY OF SO_2 EMISSION DATA COMPARISON

a % Difference = $\frac{(CEM - Method 6)}{(CEM + Method 6)/2} \times 100\%$

b Below the detection limit of 1.3

C Below the detection limit of 1.0

Equipment	ID No.	Calibrated against	Allowable error	Actual error	Within allowable limits	Comments
Meter box	VB-2	Bubble meter	(Y ± 0.05 post-test)	0.03	Yes	
Pitot tube	242 505	Geometric speci- fications	a a	a a	ОК ОК	Visually inspected on site
Digital indicator	VB-2	Millivolt signals	±0.5%	0.23%	Yes	Maximum reading from 10 test points
Stack ther- mocouple	432 101	ASTM-3F	±1.5%	0.20% 0.20%	Yes Yes	Maximum difference Maximum difference
Balance	198	Type S weights	±0.5 g	0.1 g	Yes	
Barometer	411	NBS-traceable barometer	±0.10 in.Hg (±0.20 in.Hg, post-test)	0.05	Yes	
Dry gas thermocouple	VB-2	ASTM-3F	±5°F	2•F	Yes	Inlet

TABLE 48. FIELD EQUIPMENT CALIBRATION

^a See Appendix B.

- On-site quality assurance checks such as sampling train, pitot tube, and sample line leak checks.
- Use of designated analytical equipment and sampling reagents.
- Use of designated analytical procedures.
- Internal and external audits to ensure accuracy in analysis. Table 49 summarizes the results of the laboratory audit.

Date	Туре	True value, mg/dscm	Obtained value, mg/dscm	Difference, %
6/21	Lot 0881-3246	190.7	189.2	-0.8
7/2	Lot 0881-4205	2402.2	2424.6	+0.9

TABLE 49. SUMMARY OF LABORATORY SO, AUDIT RESULTS

Sampling equipment, reagents, and analytical procedures for this test series followed and met all necessary guidelines set forth for accurate test results. All sampling equipment was calibrated within limits described for EPA Methods 2 and 6.^{*} A sulfur dioxide analytical audit was conducted to ensure the quality of the laboratory data. The results of the audit were within the acceptable limits. The blank results for the hydrogen peroxide sampling reagent were higher than normal, but they did not affect results.

5.2 Air Speciation Measurements

Air speciation samples were taken by PEI field staff and analyzed within 24 hours by Performance Analytical, Inc. (PAI). This laboratory was certified for air analysis by the State of California, was close enough to the site to allow prompt delivery of the samples, and had previous experience with air sample analyses. This phase of the study was performed under the direction of PEI Associates. Analytical data were reviewed by PEI and by Research Triangle Institute (RTI), who also performed a laboratory audit of the PAI facilities.

The air speciation results obtained from these samples did not meet the quality control limits and were therefore not included in this study.

⁴⁰ CFR 60, Appendix A, Reference Method 2 and 6.

Analytical data were considered unsatisfactory because of poor recoveries and reported nondetectable values. The tetrahydrothiophene results were within acceptable limits, but other compounds such as toluene and xylene were not acceptable. Hydrogen sulfide data were also reported inaccurately and acetone was reported above the blank values in audit samples, as determined by RTI. The analytical data received from PAI are part of the raw data file for this study, but as previously stated, are not included in this report.

5.3 Waste Characterization

The TCLP and California wet tests were conducted by IT Analytical Services in Export, Pennsylvania. This laboratory is certified under EPA's Contract Laboratory Program and adheres to the quality assurance procedures required therein. The IT project manager reviewed all data and transmitted it to PEI for use in this study.

Proximate and ultimate analyses of the waste samples were run by Broeman Laboratories in Cincinnati, Ohio, using ASTM standard methods for fuels. This laboratory had been previously audited by PEI for these types of analyses.

Data quality assurance for the analyses of raw mud, raw tar, raw char, and treated tar included the analyses of blank samples, duplicate analyses, matrix spike, and surrogate spike recoveries. Duplicate analyses were run on one set of metals and one set of semivolatile analyses, and matrix spike recovery samples were run on all EPA TCLP tests. The analytical methods used are referenced as follows:

Method Reference:

Toxicity Characteristic Leaching Procedure (TCLP)	Federal Register, Vol. 55, No. 61, Thursday, March 29, 1986, Appendix II.
Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by FLAA or ICP-Spectroscopy	Method 3010, <u>Test Methods for Evaluating</u> Solid Waste, USEPA SW-846, 3rd Ed., 1986
Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Furnace Atomic Absorption Spectrometry	Method 3020, <u>Test Methods for Evaluating</u> <u>Solid Waste</u> , USEPA SW-846, 3rd Ed., 1986.
Inductively Coupled Plasma Method	Method 6010, Test Methods for Evaluating Solid Waste, USEPA SW-846, 3rd Ed., 1986.

Arsenic, Furnace Method	Method 7060, <u>Test Methods for Evaluating</u> Solid Waste, USEPA SW-846, 3rd Ed., 1989.
Selenium (Furnace Method)	Method 7740, <u>Test Methods for Evaluating</u> Solid Waste, USEPA SW-846, 3rd Ed., 1986.
Mercury, Manual Coid Vapor	Method 7470, <u>Test Methods for Evaluating</u> Solid Waste, USEPA SW-846, 3rd Ed., 1986
Thallium; AA Furnace Technique	Method 7841, <u>Test Methods for Evaluating</u> Solid Waste, USEPA SW-846, 3rd Ed., 1986.
CAM-WET Extraction	<u>California Administrative Code</u> , Title 22, Social Security Revision Record for Register 85, No. 2-B, January 12, 1985.
Gas Chromatography/Mass Spectrometry for Volatile Organics Including BTEX	Method 8240, <u>Test Methods for Evaluating</u> <u>Solid Waste</u> , USEPA SW-846, 3rd Edition, 1986.
Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique	Method 8270, <u>Test Methods for Evaluating</u> <u>Solid Waste</u> , USEPA SW-846, 3rd Edition, 1986.

The range of method detection limits established for each analyses type is summarized in Tables 50 and 51. None of the listed compounds was detected in the blank samples.

For the TCLP metals analyses, the analytical and matrix spike recovery percentages were generally within the ranges specified in the methods. The exception was the element selenium, which exhibited poor recovery for the majority of samples analyzed. One possible explanation for this was the presence of sulfates in the samples, which was a major interference in the selenium analysis causing low response in the analytical instrumentation used (Atomic Absorption). Table 52 presents example matrix spike recovery data for these analyses.

The TCLP analysis for volatile organic compounds exhibited matrix surrogate spike recoveries generally within the limits specified by the methods. Table 53 presents example data for these analyses.

Parameter	TCLP Analysis	CAMWET Analysis
<u>Metals</u>		
Arsenic	0.01	0.25
Barium	0.2	2
Cadmium	0.005	0.05
Chromium	0.01	0.1
Lead	0.05	0.5
Mercury	0.0002	0.002
Selenium	0.005	0.005
Silver	0.01	0.1
Antimony	-	0.6
Beryllium	-	0.05
Cobalt	-	0.5
Copper	-	0.25
Molybdenum	-	0.2
Nickel	-	0.4
Thallium	-	0.25
Vanadium		0.5
Zinc	-	0.2

TABLE 50. WASTE CHARACTERIZATION METHOD DETECTION LIMITS, METALS (mg/L)

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Parameters	TCLP	CAMWET
Volatile organics		
Vinyl chloride 1,1-Dichloroethene Chloroform 1,2-Dichloroethane 2-Butanone Carbon tetrachloride Trichloroethene Benzene Tetrachloroethene Chlorobenzene	10-50 5-25 5-25 5-25 10-50 5-25 5-25 5-25 5-25 5-25 5-25	Not applicable Not applicable Not applicable Not applicable Not applicable Not applicable Not applicable Not applicable Not applicable Not applicable
<u>Semivolatile organics</u>		
1,4-Dichlorobenzene Hexachloroethane Nitrobenzene Hexachlorobutadiene 2,4,6-Trichlorophenol 2,4,5-Trichlorophenol 2,4-Dinitrotoluene Hexachlorobenzene Pentachlorophenol Total methyl phenol	10-100 10-100 10-100 10-100 50-500 10-100 10-100 50-500 10-100	10 10 10 10 10 50 10 10 50 10

TABLE 51. WASTE CHARACTERISTICS METHOD DETECTION LIMITS, ORGANICS (μ g/L)

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Parameter	Matrix spike percent recovery
Arsenic	92
Barium	93
Cadmium	92
Chromium	86
Lead	90
Mercury	114
Selenium	0 to 60
Silver	106

TABLE 52. SAMPLE MATRIX SPIKE RECOVERY DATA, METALS

TABLE 53. EXAMPLE MATRIX AND SURROGATE SPIKE DATA, ORGANICS

		Surrogate spike recovery, %		
Parameter	Matrix spike percent recovery	Toluene d8	1,2-dichloro- ethane d4	4-Bromofluoro benzene
Vinyl chloride	98	92-102	105-106	99-107
1,1-Dichloroethene	92			
Chloroform	98			
1,2-Dichloroethane	98			
2-Butanone	102			
Carbon tetrachloride	88			
Trichloroethene	98			
Benzene	104			
Tetrachloroethene	88			
Chlorobenzene	100			

The TCLP semivolatile organic analyses data exhibited matrix and surrogate recoveries generally within the limits specified by the methods. The exception was phenolic compounds which exhibited poor recoveries consistently for each waste type. One possible explanation is mentioned in SW-846 Method 8270 as being poor, or erratic, chromatograph behavior for these type of compounds. Erratic chromatography coupled with potential sample matrix effects would tend to result in poor recoveries.

5.4 Flux Chamber Measurements

Analyses of the samples collected for the flux chamber tests were performed by two companies under the direction of Dr. C. E. Schmidt, Environmental Consultant, who performed these tests. Radian Corporation in Austin, Texas, performed analyses on canister samples for VOC, and PAI performed analyses on Tedlar bag samples for SO₂. The Radian data were the responsibility of the project rnanager at Radian and were issued to Dr. Schmidt and PEI for review and use. The PAI SO₂ results were reviewed by the PAI manager and were also submitted to Dr. Schmidt and PEI

Associates. The quality control concerns previously mentioned in Section 5.2 regarding the PAI analyses also affected the SO_2 data used for these tests and they are not included in this report.

The canister analyses performed by Radian utilized Varian 3700 and HP 5880 gas chromatographs equipped with multiple detectors, including a flame ionization detector (FID), a photoionization detector (PID), and a halogen-specific detector (HSD).

A multipoint calibration of the FID was performed during the analysis period. Three concentrations of a hexane standard plus an ultrahigh-purity nitrogen blank were analyzed to establish a multipoint slope response factor based on carbon. The detector response was considered acceptable if the correlation coefficient for the resulting calibration curve was >0.9950. A weekly response factor check was performed to assess any potential drift. The acceptance criteria for the single-point check was ± 20 percent of the multipoint slope.

The analysis of compounds performed on the canister samples was subject to the following detection limits:

Alkanes	0.2 to 1 ppb
Aikenes	0.2 to 1 ppb
Alkynes	0.2 to 1 ppb
Aromatics	0.2 to 1 ppb
Halogenated compounds	0.2 to 1 ppb
Ketones and esters	1 to 5 ppb
Aldehydes and esters	3 to 15 ppb
Sulfur and nitrogen compounds	3 to 15 ppb

Based on a review of the canister sample analyses by RTI, the data did not meet Agency quality control requirements and are therefore not included in this report.

SECTION 6

TRIAL EXCAVATION STUDY COSTS

This section summarizes the on-site costs associated with the various aspects of this trial excavation. These cost values may also be expressed on a dollars-percubic-yard basis by dividing by 137; the amount of waste excavated. Because this study represents an experimental trial excavation, the costs per unit of waste excavated are high and could be greatly reduced when the economy of excavating on a large scale is considered.

6.1 Enclosure and Air Exhaust Controls

Table 54 presents the costs of erecting and using the temporary enclosure described in Subsection 2.1. These costs consist of fixed costs of \$29,087 for erecting and eventually dismantling the building, purchasing the PVC covering, and a monthly rental of \$11,463. A supervisor and five-person team erected the building on a smoothly graded site in 5.5 days. A supervisor and a three-person team accomplished the dismantling in 3 days. A remote-control video camera with zoom lens and a 19-inch monitor were also rented for \$2500 per month; these costs are added to the enclosure cost because the video system was necessary to monitor progress and to assess any safety problems. The addition of these items brings the total cost for the enclosure system to \$70,976 for a 3-month period [$$29,087 + (3 \times $13,963)$].

The major components of the air exhaust control system (consisting of the scrubber and carbon adsorber) were leased for this study; therefore, most of the costs are incurred on a monthly basis. The fixed costs include the ductwork system and fan, the initial installation, and the freight (as summarized in Table 55).

These data show that initial costs of \$20,775 were incurred to get the basic control equipment and ancillary equipment installed at the site. Installation of electrical lines and switchgear for this system was the single highest cost. A monthly charge of \$9820 was incurred during operation, of which the scrubber rental at \$5650 per month was the major cost item. The total cost for 2 months of operation amounts to the fixed initial cost plus 2 months of operation, for a total of \$40,415 [\$20,775 + 2 (\$9,820)].

Item	Cost, \$
Fixed costs Site clearing ^a Erection (equip. and labor) PVC enclosure covering Dismantling and return Decontamination of framework	3,000 5,000 9,600 5,300 <u>6,187</u>
Total fixed costs	29,087
Rental costs Rental of 60-ft x 160-ft enclosure Video camera with zoom lens and 19-inch monitor	11,463/mo _2 <u>,500</u> /mo
Total rental cost	13,963/mo

TABLE 54. COSTS ASSOCIATED WITH TEMPORARY ENCLOSURE

^a Site was fairly level and free of large objects.

Item	Cost, \$
Fixed Costs	
Fan	2,200
Ductwork	3,500
Drum pump	680
Installation	2,300
Freight	2,095
Electrical lines and switchgear	10,000
Total	20,775
	\$/month
Operating costs	
Scrubber rental	5,650 ^a
Carbon adsorber and housing	1,600
Carbon consumption	600
Caustic consumption	270
Spent caustic disposal ^C	400
Maintenance labor ^u	800
Electricity	500
Total	9,820

TABLE 55. COSTS FOR AIR CONTROL SYSTEM

^a 2-month minimum rental.

^b Based on one carbon charge per month at \$600.

^C Average cost per month.

^d Based on 2 days/month and \$50/hour.

6.2 Foam Costs

Costs to apply foam consisted of the foam reagents (foamer and stabilizer); the rental of the foam generator (mixer and pump); labor to apply the foam; and miscellaneous charges for water, hose-line rental, and fuel. These charges are itemized in Table 56. The major costs are for foam reagents and labor, which account for \$38,741 and \$45,800, respectively, of the total of \$89,591.

Item	Costs, \$
Foamer (FX-9162)	12,635
Stabilizer (FX-9161)	26,106
Equipment rental (2 months)	3,050
Application labor ^a	45,800
Miscellaneous supplies ^b	2,000
Total	89,591
2	

TABLE 56. FOAM APPLICATIONS COSTS

^a Includes personnel safety equipment.

^b Hoses, fuel, compressed nitrogen gas.

6.3 Tar Processing Costs

The costs associated with the tar processing operation include the mobilization/ demobilization of the pug mill, pug mill rental, operating labor, personnel safety equipment, and delivered costs of portland cement and fly ash. The charges incurred for the week of tar treatment during the trial excavation are summarized in Table 57. As shown, the major costs are for field labor, safety equipment, and pug mill rental. If the total incurred costs are divided by the amount of tar processed during the week, the per-ton costs for the waste treatment experiments amount to almost \$7,400.

However, this is not a realistic estimate of the per-ton costs for waste treatment that would apply to a full-scale remediation since the costs for labor, safety equipment, and pug mill rental would remain essentially unchanged while the amount of waste processed would increase dramatically. As an example, based on a 40 ton/hour waste processing rate with a waste/total material ratio of 0.25, processing costs of \$340/ton of waste are projected for a 7 hour/day, 5 day/week operation.

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Item	Cost, \$
Pug mill mobilization/demobilization	1,406
Pug mill rental	4,022
Field labor Manager (3.5 days at \$628/day) 2,198 Equipment operator (3.5 days at \$380/day) 1,330 Two helpers (3.5 days at \$576/day) 2,016 Safety officer (3.5 days At \$600/day)2,100 Subtotal	7,644
Personnel safety equipment: Level B at \$180/person/day	3,150
Portland cement (6.95 tons at \$115/ton)	799
Fly ash (3.06 tons at \$113/ton)	346
Total costs	17,367

6.4 Excavation Costs

Costs to excavate the overburden and waste consist of excavation equipment charges, field labor, and other equipment (e.g., personnal safety equipment). In addition, equipment mobilization and demobilization charges and equipment decontamination charges are incurred regardless of the amount of time spent on site. Table 58 summarizes the daily charges for excavation labor and equipment incurred during this study. Charges for the pug mill are not included here because they are part of the waste processing cost already presented. The data in Table 58 show a daily charge of \$4584 for a six-person team equipped with Level B personal protection (\$2564 + \$940 + \$1080).

6.5 Air Monitoring

Costs for air monitoring include the rental cost for instruments, recorders, and data loggers; operating labor; and fixed costs for calibration gases and other expendable supplies. These costs are summarized in Table 59 and amount to a variable cost of \$46,580/month plus a fixed cost of \$7000.

For 2 months of monitoring, these costs amount to $100,160 [(2 \times 46,580) + 7,000].$

Item	Cost, \$
Field Labor	
Manager Two equipment operators Two helpers Safety officer	628/day 760 576 600
Subtotal	2564
Excavation Equipment	
Trackhoe Backhoe Trench shield	464/day 234 242
Subtotal	940
Personal Safety Equipment	
Level B at \$180/person/day Level A at \$360/person/day	
Mobilization and demobilization costs	
Trackhoe and backhoe	250
Decontamination costs for field equipment	-5000

TABLE	58.	EXCAVATION	LABOR AND	EOUIPMENT	COSTS

TABLE 59. AIR MONITORING COSTS

Item	\$/month
Enclosure inlet and outlet monitors Shelter, chart records, data loggers, computer Perimeter monitors Shelters, chart records, data logger Labor ^a	8,000 1,550 4,880 2,150 <u>30,000</u>
Subtotal	46,580
<u>Fixed costs</u> Calibration gases and supplies Electrical hookups and data transmission wiring	3,000 4,000

^a 1-1/3 people for enclosure monitors and 1 person for perimeter monitors at 60 hours/week each or 600 hours/month at \$50/hour.

6.6 Cost Summary

The total costs expended for the field work of this trial excavation are summarized in Table 60. Item 1 consists of the initial site preparations and erection of the enclosure, enclosure and video camera rental, and dismantling. These costs totaled \$70,976 over the 3-month minimim rental period for the enclosure. The air emission control costs in Item 2 include both erection and dismantling charges and rental over a 2-month period. These costs amounted to \$40,415. A large amount of foam vapor suppressant reagents were used in an attempt to control the air emissions released during excavation. The reagent cost and application labor costs in addition to equipment charges totaled \$89,591 for this item. Item 4 includes the equipment, labor, and supplies, incurred at a rate of \$4,584 per day over an 18-day period. The tar processing runs were conducted at a total cost of \$17,367 including labor, additives, and equipment as shown in Item 5.

Continuous air monitoring at the air emission control system inlet and outlet and at the four perimeter sites costs \$100,160. This cost includes all equipment, labor, and supplies over a 2-month period.

Item	Cost, \$
1. Temporary enclosure (3 month minimum)	70,976
2. Air emission controls (2 months)	40,415
Foam vapor suppressants (as used)	89,591
Excavation (based on 18 days)	82,512
5. Tar processing (10 test runs)	17,367
6. Air monitoring (2 months)	100,160
Total	401,021

TABLE 60. SUMMARY OF TRIAL EXCAVATION FIELD COSTS

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