Final Report to:
Washington State
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Remedial Investigation and Feasibility Study for the Landsburg Mine Site

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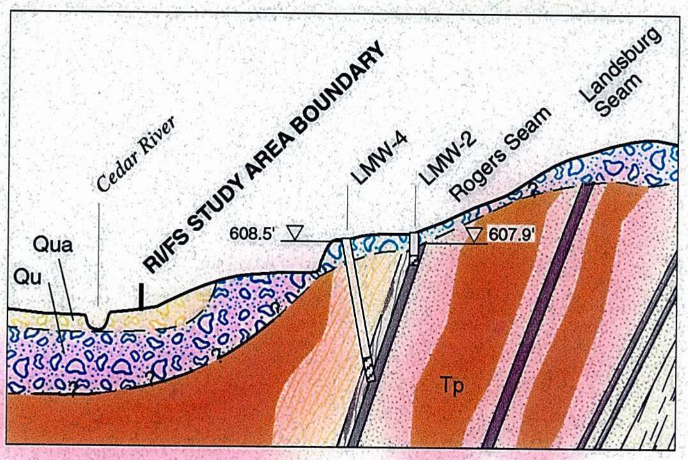

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FINAL
REMEDIAL INVESTIGATION AND FEASIBILITY STUDY (RI/FS) FOR THE LANDSBURG MINE SITE

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on behalf of:

The Landsburg PLP Steering Committee

for:

The Washington State Department of Ecology

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EXECUTIVE SUMMARY

This report, prepared by Golder Associates Inc. (Golder) for the Landsburg Mine Potentially Liable Parties Group (PLP Group), presents the results of the Remedial Investigation (RI) and Feasibility Study (FS) for the Landsburg Mine site. The Landsburg Mine site is a State of Washington Priority Listed site under the auspices of the Model Toxics Control Act (MTCA), Chapter 70.105D RCW. Pursuant to the Washington State Department of Ecology's authority under MTCA, Ecology issued Agreed Order No. DE 983TC-N273 (WDOE 1993a) on July 21, 1993, which directed the Landsburg PLP Group to conduct this RI/FS. This RI/FS report has been prepared in accordance with the Agreed Order, the *Landsburg Phase I Remedial Investigation/Feasibility Study (RI/FS) Work Plan* (Golder 1992a), and the requirements of WAC 173-340-350 State Remedial Investigation and Feasibility Study. This RI/FS will be used to support final remedy selection as documented in the Cleanup Action Plan (CAP) for the site.

REMEDIAL INVESTIGATION

The Landsburg Mine site is a former underground coal mine located approximately 1.5 miles northwest of Ravensdale in southeast King County, Washington. The Cedar River passes within approximately 500 feet of the site to the north. The mine site occupies property owned by Palmer Coking Coal Company (PCC) and Plum Creek Timber Company, L.P. PCC operated an underground coal mine known as the Landsburg Mine from the late 1940s until approximately 1975. The Rogers Seam was mined from 1959 until 1975. The mined section of the Rogers coal Seam has a near vertical dip and consists of coal and interbedded shale approximately 16 feet wide. The mined section is about a mile in length. Mining occurred at depths of up to 750 feet using a mining method locally called "booming" which followed the coal seam vertically. As a result of underground mining of the Rogers Seam, a subsidence trench developed on the land surface above the mine workings. The dimensions of the trench vary, from about 60 to 100 feet wide, between 20 to 60 feet deep, and about 3/4 mile long.

Based on currently available information, this trench was used in the late 1960s to the late 1970s for disposal of various industrial waste materials, construction materials, and land-clearing debris. Drums, liquid from tanker trucks and other industrial materials were disposed of in the northern portion of the trench. Disposal of land clearing debris continued until the early 1980s. Currently, the site is secured by a fence and locked gate which encloses the northern portion of the trench where disposal occurred.

Several preliminary environmental investigations have been performed at the site (Geraghty and Miller 1990; Applied Geotechnology 1990; Washington State Department of Health 1992). During these preliminary investigations, hazardous substances were not detected in area private and public supply wells, mine portal groundwater discharges or soil gases.

Due to continued concerns over potential environmental hazards posed by the Mine, however, Ecology commissioned a Site Hazard Assessment (SHA) study in 1991 (Ecology and Environment 1991). Ecology then requested potentially liable parties (PLPs) to perform an expedited response action (ERA) which resulted in the removal of over 100 exposed 55-gallon drums from the trench (Landsburg PLP Steering Committee 1991). These investigations found hazardous substances, including volatile and semi-volatile organic compounds, PCBs, cyanide and metals, in drum contents, adjacent soils and ponded surface water within the northern portion of the trench where prior waste disposal occurred.

On the basis of these results, Ecology and the PLP Group entered into an Agreed Order (WDOE 1993a) which directed the PLP Group to conduct an RI/FS to evaluate the need for remedial action. The scope of work for the RI was outlined in the *Landsburg Phase I Remedial Investigation/Feasibility Study (RI/FS) Work Plan* (Golder 1992a) which was incorporated by reference into the Agreed Order. The approach taken during the RI was to focus environmental sampling efforts on potential pathways of chemicals leaving the mine and not on wastes present within the mine itself. Investigation of wastes in the mine was limited due to physical constraints and dangers, and difficulties associated with taking samples in the mine. Data collection activities conducted under the RI included the following primary tasks:

- **Air Monitoring.** A series of air surveys was conducted down the centerline of the trench to monitor for the presence of organic vapors which could be associated with waste disposal.

- **Source Characterization in Rogers Trench (Geophysical Investigation).** A magnetometer survey was conducted along the centerline of the Rogers Seam trench to identify areas of potential buried waste.

- **Private Well Survey.** A well survey was conducted to identify private and public wells within the Study Area, and to support the selection (in consultation with the State Department's of Health and Ecology) of wells for quarterly sampling.

- **Monitoring Well Drilling and Installation.** Seven new monitoring wells (LMW-1 through -7) were installed at the site. Wells LMW-2/4 and LMW-3/5 consisted of nested well pairs installed within the coal at each end of the trench at the points of expected mine groundwater discharge. LMW-1 was installed overtop a suspected location of a fault and tunnel connecting offset portions of the Rogers Seam. Wells LMW-6 and -7 were installed in adjacent coal seams (Frasier and Landsburg Seams) to provide indications of water quality typical of adjacent coal seams. Angled drilling methods were used at the LMW-4 and LMW-7 well locations to intercept the vertical coal seam.

- **Quarterly monitoring of surface water and groundwater.** Surface water associated with Rogers Mine portals #2 and #3, and groundwater from the seven site wells and from 14 selected area private wells were sampled for chemical analysis over four rounds of quarterly sampling. The samples were submitted for a broad range of chemical analyses including metals and cyanide, volatile and semi-volatile organics, pesticides and PCBs, and general chemical parameters.

- **Surface Soil Sampling.** Surface soils around the trench rim perimeter and downslope of portal #3 were sampled for chemical analysis.

- **Topographic Survey and Geodetic Control.** Using aerial photogrammetry techniques, a topographic base map of the site was prepared to 2 ft contours. Horizontal control was established based on the Washington State Plane Coordinate System as required under MTCA.

On the basis of the RI data, the following primary conclusions were reached:

Nature and Extent of Chemicals in the Environment. Chemicals associated with the prior waste disposal activities at the site do not appear to be exiting the mine (Section 5.4). Extensive sampling of air, soil, groundwater and surface water at the site have indicated that chemicals associated with the waste are limited only to soils located within that portion of the trench known to have been used for prior waste disposal; levels of chemicals throughout the remainder of the Study Area are consistent with typical background conditions.

Source Characteristics. Geophysical data, the results of sampling and historical information indicate that any potential remaining wastes in the trench appear to be confined to the northern half of the trench in the areas utilized for waste disposal (Section 3.2). The nature of these potential remaining waste materials is uncertain beyond that which is known regarding what was disposed in the trench. Wastes remaining could include some intact and partially intact drums buried beneath the trench bottom surface at some depth. However, based on the condition of the drums observed in the ERA, the duration of burial, physical damage known to occur during placement, etc., the vast majority of the drums have probably already ruptured or deteriorated in some manner.

Potential Future Pathways of Chemicals Exiting the Mine. As part of the RI, it was necessary to evaluate the *potential* pathways for chemical migration from the mine. The groundwater pathway represents the most significant potential pathway (Section 3.6.4). Waste present in the trench is believed to be confined to the northern half of the site. Groundwater flow beneath this portion of the site is to the north through the mined out and highly permeable Rogers Seam. Flow laterally away from the mine is negligible due to the tightness of faults and the vertical orientation and layering of low-permeability strata. The primary pathway of chemicals potentially exiting the mine is through the Rogers seam to the north. Future groundwater monitoring activities should focus on the detection of potential releases from the north end of the mine. The chance that such a discharge could occur at the southern end is unlikely given the direction of groundwater flow and the absence of waste in this portion of the mine.

Once exiting the site, any potential chemical constituents leaving the northern portion of the mine would flow primarily to the north and northeast towards the Cedar River, consistent with the local ground surface topography (Figure 3-24). This flow would occur within the Rogers coal Seam and within the glacial outwash materials which overlie the coal. No drinking water wells are currently located along this primary pathway of groundwater flow. The two monitoring wells (LMW-2 and -4) located along this pathway did not show any evidence of contamination during the RI.

While the primary flow direction is towards the river, it is also possible that some flow could occur to the northwest within the glacial outwash deposits located to the north of the mine. If groundwater were to flow in this direction, potential receptor points would include the wells located to the northwest of portal #2 along the Summit-Landsburg Road. Well PW-4 is the closest well and is approximately 1,500 ft away from the trench. It is not considered likely, however, that groundwater flow would occur to these wells given the strong topographic gradient towards the river.

At the southern end of the mine, potential receptors include the cluster of wells along the Kent-Kangley Road just southwest of portal #3, and the Clark Springs facility. The Clark Springs facility is approximately 2,500 ft from the portal. It is not likely that these wells would ever be impacted, however, as discharge of chemicals from the mine's southern end is a remote possibility.

Applicable or Relevant and Appropriate Requirements (ARARs). The primary potential ARARs for the site include the following (Chapter 4):

- Model Toxics Control Act (MTCA) RCW 70.105D and MTCA Cleanup Regulations WAC 173-340; and

- Minimum Functional Standards for Solid Waste Handling WAC 174-304.

In addition, portions of the dangerous waste regulations (WAC 173-303) may be relevant and appropriate.

Adequacy of RI Data. The data collected under this Remedial Investigation are considered adequate to characterize site conditions and to support evaluation and selection of a preferred remedial alternative in the FS. This document, therefore, represents a complete and final RI and FS set of documents that will be sufficient to enable Ecology to make decisions regarding the final Cleanup Action Plan (CAP) for the site.

FEASIBILITY STUDY

The Feasibility Study (FS) for the Landsburg Mine site consists of the following elements:

- **Development of remedial action objectives.** Objectives and cleanup levels are established that provide the basis for developing and evaluating alternatives for remediation of the site.

- **Identification and screening of remediation technologies.** Candidate technologies are screened to obtain a list of feasible technologies for use in assembling remediation alternatives.

- **Identification and screening of remediation alternatives.** Remediation technologies are assembled into a wide range of alternatives for remedial action at the site. The alternatives are then screened to obtain a focused list of alternatives for further consideration.

- **Development and evaluation of remediation alternatives.** Alternatives remaining after screening are further developed and subjected to detailed evaluation. Consideration of the evaluation results in a preferred alternative for the site.

Remedial Action Objectives

Remedial action objectives (RAOs) are site-specific goals based on acceptable exposure levels that are protective of human health and the environment and consider applicable or relevant and appropriate requirements (ARARs). Remedial action objectives identify risk pathways that remedial actions should address, and identify acceptable exposure levels for residual constituents of concern. The remedial action objectives for this site are:

- Minimize the potential for future direct exposure of human or ecological receptors to any waste constituents that may remain at the site.

- Reduce the potential for migration of any waste constituents from the trench in groundwater, surface water or airborne dust.

Identification and Screening of Remediation Technologies

Potentially applicable remediation technologies have been identified for each of the general response actions. Technologies have been considered for each of the following categories:

- Institutional controls (including monitoring)
- Containment
- Removal
- Ex-Situ Treatment (including reuse and recycling)
- In-Situ Treatment
- Disposal

The technologies have been screened based on effectiveness, implementability, and cost to obtain a set of technologies that could be applied at the Landsburg Mine site.

Identification of Remediation Alternatives

Remediation technologies retained following the screening process are then assembled into remediation alternatives. The technologies are combined to create a wide range of alternatives that represent various approaches to achieving remedial action objectives. Remediation alternatives are developed to meet the following MTCA requirements:

- Protect human health and the environment,

- Comply with cleanup standards,

- Comply with applicable laws and regulations,
- Provide for compliance monitoring,
- Use permanent solutions to the maximum extent practicable, and
- Provide for a reasonable restoration time frame.

Consideration of public concerns is performed by Ecology after the FS is completed and is based on public comments on the draft Cleanup Action Plan (CAP). Public concerns may result in modifications to the remedial action proposed in the draft CAP. Any modifications would be incorporated into the final CAP.

The following alternatives were developed for remediation of the Landsburg Mine site:

Alternative 1: No Action. A "no action" alternative is included as a baseline for comparison to the other alternatives. This alternative would leave the site in its current state, assuming no restrictions on future site use and no site maintenance or monitoring.

Alternative 2: Institutional Controls and Monitoring. Institutional controls include deed restrictions, fencing and warning signs, and groundwater use restrictions, as well as periodic site inspections and maintenance of the physical components of the controls. Groundwater use restrictions would be employed to prevent exposure to site groundwater. Thus, if site groundwater were to become affected by waste constituents, there would be no immediate exposure. Exposure could occur only following off-site migration. Routine, periodic monitoring would detect constituents of concern in groundwater were it to become affected.

Alternative 3: Trench Backfill. This alternative would protect human health and the environment by providing long-term containment of any waste and affected soil in the trench. This alternative would consist of filling the trench in the area where waste disposal occurred, combined with grading to provide proper stormwater drainage and prevent stormwater collection in the trench area. Institutional controls and periodic maintenance and monitoring would also be included.

Alternative 4: Soil Cap. This alternative would protect human health and the environment by providing reliable long-term containment of any waste and affected soil in the trench. As with Alternative 3, the trench would be filled only in the area where waste disposal occurred, combined with grading to provide proper stormwater drainage and prevent stormwater collection in the trench area. The backfill would be covered by a soil cap to provide additional protection, and add a thicker vegetated soil layer for improved evapotranspiration and erosion control. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 5: Low-Permeability Soil Cap. This alternative is very similar to Alternative 4, except that a low-permeability liner, constructed by compacting suitable soil, would be included in the cap design to decrease the amount of infiltration through the cap, thus decreasing the potential for affecting groundwater. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 6: FML Cap. This alternative is very similar to Alternative 5, except that the low-permeability liner would be constructed using a synthetic flexible membrane liner (FML) instead of compacted soil. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 7: FML/GCL Cap. This alternative is very similar to Alternative 6, except that a geosynthetic clay liner (GCL) would be added to provide two low-permeability liners instead of one. Two liners do not provide lower infiltration than a single liner, but provide additional reliability for long-term protection. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 8: Excavation and Off-Site Disposal of Surficial Affected Soil and Capping. This alternative would consist of removal of surficial soil in the trench containing concentrations of constituents of concern above remediation goals followed by off-site disposal. The trench would then be backfilled and graded for proper stormwater drainage. Because waste and affected soil would presumably remain buried in the trench, a cap meeting minimum functional standards under WAC 173-304 would be placed over the trench. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 9: Excavation and Off-Site Disposal of All Waste and Affected Soil. In this alternative, all waste and affected soil would be removed from the trench for off-site disposal. Appropriate disposal facilities would be used, depending on the waste designation (hazardous, dangerous, or non-hazardous). Institutional controls, maintenance, and monitoring would not be necessary for this alternative because all waste and affected soil would be removed from the site.

Screening of Alternatives

The remediation alternatives summarized above were evaluated based on effectiveness, implementability, and cost. Based on the screening evaluation (Section 7.3.3), the following alternatives were retained for detailed development and evaluation:

Alternative 1: No Action
Alternative 2: Institutional Controls and Monitoring
Alternative 4: Soil Cap
Alternative 5: Low-Permeability Soil Cap
Alternative 6: FML Cap
Alternative 7: FML/GCL Composite Cap
Alternative 9: Excavation and Off-Site Disposal of All Waste and Affected Soil.

Threshold Requirements

Under MTCA, remediation alternatives must meet the following threshold requirements (WAC 173-340-360(2)):

- Protection of human health and the environment
- Compliance with cleanup standards

- Compliance with ARARs
- Provision for compliance monitoring

For reasons discussed in Section 9.1, the following alternatives do not meet one or more of the MTCA threshold criteria for selection as the preferred alternative:

Alternative 1 (No Action)
Alternative 2 (Institutional Controls and Monitoring)
Alternative 4 (Soil Cap).

These alternatives are retained for the full evaluation, however, because their inclusion provides perspective on the benefits and costs of the alternatives, much as the "no action" alternative provides a baseline for comparison. It is minimal additional effort to include the alternatives in the full evaluation, and excluding them would not change the evaluation scoring or preferred alternative.

The remaining alternatives 5, 6, 7 and 9 meet the minimum requirements of the MTCA threshold criteria.

Use of Permanent Solutions and Comparative Evaluation of Alternatives

WAC 173-340-360(3) specifies that the remediation alternatives must use permanent solutions to the maximum extent practicable. WAC 173-340-360(5) specifies that "Ecology recognizes that permanent solutions [defined at WAC 173-340-360(5)(b)] may not be practicable for all sites. A determination that a cleanup action satisfies the requirement to use permanent solutions to the maximum extent practicable is based on consideration of a number of factors." The specified factors, or criteria, are:

- Overall protectiveness
- Long-term effectiveness and reliability
- Short-term effectiveness
- Reduction in toxicity, mobility, and volume
- Implementability
- Cost
- Community acceptance

These criteria are described in Section 9.2. Selection of a remediation alternative is based on comparative evaluation of the alternatives (that satisfy the threshold criteria) using 5 permanence criteria: 1) long-term effectiveness and reliability, 2) short-term effectiveness, 3) reduction in toxicity, mobility, and volume, 4) implementability, and 5) cost. Overall protectiveness and community concerns are not included in the comparative evaluation for reasons discussed in Section 9.2.

Each alternative is scored relative to the other alternatives for the four non-cost permanence criteria. Because of the nature of the criteria and the uncertainties in the evaluation, the scores for these four criteria are expressions of relative qualitative or semi-quantitative professional judgments. A scale of 0 (worst) to 10 (best) is used. The evaluation scores are shown in Table ES-1 and discussed in Section 9.4.

The relative values of the non-cost criteria are then determined. The relative criteria values are expressions of what a scoring unit of one criterion is worth compared to a scoring unit of another criterion. The assigned relative values are converted to criteria weightings, i.e., percentage of the overall score. The scores for the four non-cost criteria are combined using the criteria weightings to give overall alternative scores. These scores express the net benefit of the alternatives. The net benefit, or overall non-cost scores, are given in Table ES-1. Using these scores, the preference ranking of the alternatives before consideration of cost is as follows (most to least preferred):

1. Alternative 5 (Low-Permeability Soil Cap)
2. Alternative 6 (FML Cap)
3. Alternative 7 (FML/GCL Cap)
4. Alternative 4 (Soil Cap)
5. Alternative 2 (Institutional Controls and Monitoring)
6. Alternative 1 (No Action)
7. Alternative 9 (Excavation and Disposal).

It should not be surprising that Alternative 9 (Excavation and Disposal) has an overall score less than Alternative 1 (No Action). This ranking reflects the many problems associated with excavation and the uncertain benefit (i.e., lack of reliability). Alternative 9 (Excavation and Disposal) would be much more likely than Alternative 1 (No Action) to cause actual harm to humans in the form of construction accidents for site workers and traffic accidents in the community. It would also be much more likely to cause exposure to waste constituents, meaning greater risk to both human and ecological receptors. These known risks must be balanced against the potential risks of no action.

After the non-cost evaluation, a comparison of the cost and benefit of the alternatives is made. Under WAC 173-340-360(5)(d)(vi), "a cleanup action shall not be considered practicable if the incremental cost of the cleanup action is substantial and disproportionate to the incremental degree of protection it would achieve over a lower preference cleanup action." Thus, the alternative with the highest ratio of incremental benefit to incremental cost is the preferred alternative. As show in Table ES-1, Alternative 5 (Low-Permeability Soil Cap) provides the best incremental cost-effectiveness of the alternatives.

Conclusion

Alternative 5 (Low-Permeability Soil Cap) provides the best incremental cost-effectiveness, in addition to providing the best net benefit. Alternative 5 meets all threshold criteria (protection of human health and the environment, compliance with cleanup standards, compliance with ARARs, and provision for compliance monitoring). It provides the optimum combination of long-term effectiveness and reliability, short-term effectiveness, implementability, and reduction of toxicity, mobility, and volume. In addition, this alternative provides good cost-effectiveness. Considering the criteria and approach specified in WAC 173-340-360(5), Alternative 5 is the remediation alternative for the Landsburg Mine site that is "permanent to the maximum extent practicable", and is therefore the preferred alternative.

TABLE ES-1

SUMMARY OF REMEDIATION ALTERNATIVE EVALUATION

Criteria [a]			Alternative Scores [c]						
	Relative Value of Criterion [b]	Calculated Criteria Weights	1 No Action	2 Inst. Controls	4 Soil Cap	5 Low-P Cap	6 FML Cap	7 FML/GCL Cap	9 Excavate
Long-Term Effectiveness and Reliability									
Effectiveness (50% of criterion)		50%	0	1	5.7	8.3	9	9.5	10
Reliability (50% of criterion)		50%	0	1	9.5	9.5	9	8.5	4
Overall criterion score	1	53%	0	1	7.6	8.9	9	9	7
Short-Term Effectiveness	0.4	21%	10	9	7	6.8	6.6	6.4	0
Reduction in Toxicity, Mobility, and Volume	0.1	5%	0	0	2	2	2	2	5
Implementability	0.4	21%	10	9	7	6.8	6.4	6	0
Net Benefit		100%	4.2	4.3	7.1	**7.7**	7.6	7.5	3.9
Incremental benefit			NA	0.1	2.7	0.6	-0.1	-0.1	-3.5
Cost (present value, millions)			$0	$0	$1	$1	$1	$1	$24
Benefit : cost (i.e., cost-effectiveness)			NA	14.7	7.5	7.6	6.4	5.6	0.2
Incremental cost			NA	$0.29	$0.65	$0.06	$0.18	$0.16	$22.53
Incremental benefit : incremental cost			NA	0.4	4.2	**10**	-0.4	-0.8	-0.2

[a] See text for criteria definitions.

[b] The numeric value of one scoring unit of the criterion relative to one scoring unit of the long-term effectiveness and reliability criterion.

[c] See text for score basis.

ACRONYMS

ARAR	applicable or relevant and appropriate requirement
ARI	Analytical Resources Inc.
BGS	below ground surface
CAP	Cleanup Action Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COC	contaminants of concern
COPC	contaminants of potential concern
CQA	construction quality assurance
DNR	Washington State Department of Natural Resources
DNS	Determination of Nonsignificance
DQO	Data Quality Objective
EA	Environmental Assessment
Ecology	Washington State Department of Ecology
EDR	Environmental Data Resources
EIS	Environmental Impact Statement
EMI	electromagnetic inductance
EPA	United States Environmental Protection Agency
ERA	Expedited Response Action
FID	flame ionization detector
FML	flexible membrane liner
FS	feasibility study
GCL	geosynthetic clay liner
gpm	gallons per minute
GPR	ground penetrating radar
HQ	hazard quotient
KCC	King County Code
LICR	lifetime incremental cancer risk
LMW	Landsburg Monitoring Well
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MFS	Minimum Functional Standards
MSL	mean sea level
MTCA	Model Toxics Control Act
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act
NGVD	national geodetic vertical datum
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
OSM	Office of Surface Mining
OVA	organic vapor analyzer

ACRONYMS (Cont.)

OVM	organic vapor monitor
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyls
PCC	Palmer Coking Coal Company
PDF	probability distribution function
PHS/HRTG	Priority Habitat and Species and Natural Wildlife Heritage Data Maps
PID	photo-ionization detector
PLP	Potentially Liable Party
PLPSC	Potentially Liable Party Steering Committee
POTW	publicly-owned treatment works
PQL	practical quantification limit
PSAPCA	Puget Sound Air Pollution Control Authority
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of the State of Washington
RI	remedial investigation
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SDG	Sample Delivery Group
SEPA	State Environmental Policy Act
SHA	Site Hazard Assessment
SIDS	Sample Integrity Data Sheets
SMCL	Secondary Maximum Contaminant Level
SVOA	semi-volatile organics analysis
TAL	target analyte list
TBC	To Be Considered
TCE	trichloroethene
TCL	target compound list
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TPH	total petroleum hydrocarbon
TSCA	Toxic Substances Control Act
USGS	United States Geological Survey
UCL	upper confidence limit
UTL	upper tolerance limit
VOA	volatile organic analysis
VOC	volatile organic compound
WAC	Washington Administrative Code
WDOE	Washington State Department of Ecology
WDOH	Washington State Department of Health
WDW	Washington State Department of Wildlife

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF APPENDICES

1. INTRODUCTION

This report, prepared by Golder Associates Inc. (Golder) for the Landsburg Mine Potentially Liable Party Group (PLP Group), presents the results of the Landsburg Mine Site Remedial Investigation (RI) and Feasibility Study (FS). The Landsburg Mine site is a State of Washington Priority Listed site under the auspices of the Model Toxics Control Act (MTCA), Chapter 70.105D RCW. Pursuant to Ecology's authority under MTCA, Ecology issued Agreed Order No. DE 983TC-N273 (WDOE 1993a) on July 21, 1993 which directed the Landsburg PLP Group to conduct this RI/FS. This RI/FS report has been prepared in accordance with the Agreed Order and the requirements of WAC 173-340-350 State Remedial Investigation and Feasibility Study.

Under the terms of the Agreed Order, the Landsburg RI/FS was to be conducted using a phased approach, if necessary. The scope of work for the first phase was outlined in the *Landsburg Phase I Remedial Investigation/Feasibility Study (RI/FS) Work Plan* (Golder 1992a) which was prepared by the PLP Group, approved by Ecology, and incorporated by reference into the Agreed Order. The scope of work for a Phase II RI/FS, if one was required, would be negotiated by Ecology and the PLPs upon completion of the Phase I RI/FS. However, during the performance of the Phase I RI, it became apparent to the PLP Group that additional RI phases were not warranted to adequately characterize site conditions, and approval was received from Ecology to finalize the FS without a Phase II RI. This document, therefore, represents a complete and final RI and FS set of documents that will be sufficient to enable Ecology to make decisions regarding the final Cleanup Action Plan (CAP) for the Landsburg Mine site.

1.1 Purpose and Rationale

The objective of the RI/FS process is to gather sufficient information to support an informed risk management decision regarding disposition of the site consistent with the requirements of WAC 173-340-360. Data are required to determine whether significant human health or environmental risk is posed by the site and to select the most appropriate remedial alternative. The key concept in the RI/FS process is to gather sufficient information to meet the data needs while recognizing that removing all uncertainty is not necessary or achievable.

The Work Plan (Golder 1992a) and support project plans together with *the Conceptual Model of the Landsburg Mine Site* (Golder 1992b) provide the necessary rationale and details for implementation of the RI/FS. The conceptual model (GAI 1992b) presented data available at the time of Work Plan preparation for project scoping and summarized the understanding of site conditions available at that time. The support project plans include: Health and Safety Plan (HSP), Quality Assurance Project Plan (QAPP), and Data Management Plan (DMP).

1.2 Background

The Landsburg Mine site consists of a former underground coal mine located approximately 1.5 miles northwest of Ravensdale in southeast King County, Washington. The site is located directly south and east of the S.E. Summit-Landsburg Road and north of the Kent-Kangley Road. The Cedar River passes within approximately 500 ft of the site to the north. The location of the site in the Seattle, Washington area is shown in Figure 1-1. Figures 1-2 and 1-3 depict the immediate site vicinity.

The mine site occupies property owned by Palmer Coking Coal Company (PCC) and Plum Creek Timber Company, L.P. and is located within sections 24 and 25, Township 22 N., Range 6 E. The Landsburg Mine site was defined in the Work Plan (Golder 1992a) as land extending 400 feet on either side of the mine trench lineation and bounded by the Summit-Landsburg Rd. to the north and the electrical transmission line easement to the south. The Study Area for the site is depicted in Figures 1-2 and 1-3. Property boundaries for the site are shown in Figure 1-4.

PCC operated an underground coal mine known as the Landsburg Mine from the late 1940s until approximately 1975. The Landsburg Mine consisted of two adjacent coal seams: the Landsburg Seam and the Rogers Seam. Mining began in the Landsburg Seam in the late 1940s and continued until 1959. In 1959, mining of the Landsburg Seam ceased and mining began on the Rogers Seam. The Rogers Seam was mined from 1959 until 1975. The two seams are separated by about 600 ft. In addition to these two seams, mining has also been conducted at the nearby Frasier seam. This seam, located some 800 ft northwest of the Rogers Seam, was mined intermittently from the late 1800s to the mid 1940s.

The mined section of the Rogers coal seam has a near vertical dip and consists of coal and interbedded shale approximately 16 ft wide. The mined section is about a mile in length. Mining occurred at depths of up to 750 feet using a mining method locally called "booming" which followed the coal seam vertically. As a result of underground mining of the Rogers Seam, a subsidence trench developed on the land surface above the mine workings. The dimensions of the trench vary, from about 60 to 100 feet wide, between 20 to 60 feet in depth and about 3/4 mile in length.

Based on currently available information, this trench was used in the late 1960s to the late 1970s for disposal of various industrial waste materials, construction materials, and land-clearing debris. Drums, liquid from tanker trucks and other industrial materials were disposed of in the northern portion of the trench. Disposal of land clearing debris continued until the early 1980s. Currently, the site is secured by a fence and locked gate which encloses the northern portion of the trench where disposal occurred.

Several preliminary environmental investigations have been performed at the site. These investigations have included a limited soil gas survey (Applied Geotechnology 1990), sampling of area private wells (WDOH 1992), sampling surface water emanating from mine portals (Geraghty and Miller 1990), and limited sampling of ponded surface water, drum contents and soils for a site hazard assessment (Ecology and Environment [E&E] 1991). These investigations have detected hazardous substances, including volatile and semi-volatile organic compounds, PCBs, cyanide and metals, in drum contents, adjacent soils and ponded surface water within the trench. These hazardous substances have not been detected in adjacent private and public supply wells, mine portal groundwater discharge or soil gases.

An Expedited Response Action (ERA), involving the removal of over 100 55-gallon drums, was undertaken by the Landsburg PLP Steering Committee (PLPSC) during the summer of 1991 (Landsburg PLP Steering Committee 1991). Additional data and information on the site are available in the form of mine maps, agency files, and interviews with site personnel.

1.3 Overview of the RI/FS Process

In accordance with EPA guidance (EPA 1988), an RI/FS is generally conducted in the following steps:

RI Process

1. Develop and implement an RI program.
2. Present and evaluate the RI data.
3. Evaluate the physical, ecological and social setting of the site. This evaluation uses data obtained during the RI as well as other available information.
4. Determine the nature and extent of contamination in environmental media.
5 Estimate the future fate and transport of contaminants in the environment.
6. Evaluate risks for human health and ecological exposure to contamination through the performance of a baseline risk assessment.

FS Process

7. Establish remedial action objectives (RAOs) (cleanup goals) for contaminants and media of interest. These objectives are developed based on the findings of the baseline risk assessment, and the applicable or relevant and appropriate requirements (ARARs).
8. Identify the applicable general response actions (e.g., containment, removal, and treatment).
9. Estimate the areas and volumes of contaminated media that exceed the remedial action objectives based on information developed in the RI.
10. Identify and screen the potentially applicable remediation technologies for each contaminated media to obtain a set of feasible technologies for use in achieving RAOs.
11. Assemble the retained technologies into remediation alternatives that cover the full range of possible response actions. The alternatives are then screened based on effectiveness, implementability, and cost to eliminate alternatives that are impractical, infeasible or too costly relative to the other alternatives.

12. Develop and evaluate the retained alternatives in sufficient detail to support selection of a site remedy.

In accordance with the Agreed Order (WDOE 1993a), this report consists of the Final RI and FS for the Landsburg Mine site. The RI portions of this report, together with the Work Plan (Golder 1992a) contain steps 1 through 6. Data collected during the RI include four quarters of groundwater monitoring performed at site monitoring wells and selected private wells in the Study Area, as well as soil and surface water sampling in the vicinity of the trench. With respect to step 6 (Baseline Risk Assessment), a formal baseline risk assessment has not been conducted as part of this RI due to the very limited extent of chemical contamination which was found in the RI. The Landsburg PLP Group received approval from Ecology (South 1994) to conduct an abbreviated risk assessment, consisting essentially of comparisons of site data to risk-based regulatory criteria (MTCA cleanup levels).

The FS portions of this report consist of steps 7 through 12 (outlined above) which includes all the steps necessary in a final FS to support selection of a site remedy.

1.4 Report Organization

This RI/FS report is organized into the following sections:

- **Chapter 1, Introduction** - This section.

- **Chapter 2, Data Collection Activities** - This section presents the RI data collection activities by the tasks presented in the Work Plan (Golder 1992a).

- **Chapter 3, Physical Characteristics of the Site** - This section describes the physical characteristics of the site and Study Area on the basis of previous studies, referenced information, and the data collected as part of the RI. Physical characteristics discussed include the regional and site geology, hydrogeology, hydrology, and meteorology as well as local ecological and social characteristics and the condition of the Mine itself.

- **Chapter 4, Applicable or Relevant and Appropriate Requirements (ARARs)** - This section presents the ARARs for the site which are considered in development and evaluation of remedial alternatives.

- **Chapter 5, Nature and Extent of Chemical Constituents Exceeding ARARs** - This section presents the results of the sampling and chemical analysis conducted for the RI and compares the data to ARARs to determine whether past waste disposal at the mine has resulted in a significant risk to human health and the environment.

- **Chapter 6, RI Summary** - An overall summary and the conclusions of the RI are provided in this section.

- **Chapter 7, Remedial Action Objectives and Assembly of Remediation Alternatives** - This chapter develops remedial action objectives (RAOs) for the site and assembles and screens remediation technologies. The retained technologies are assembled into remediation alternatives, and the alternatives are screened to obtain the alternatives for detailed evaluation.

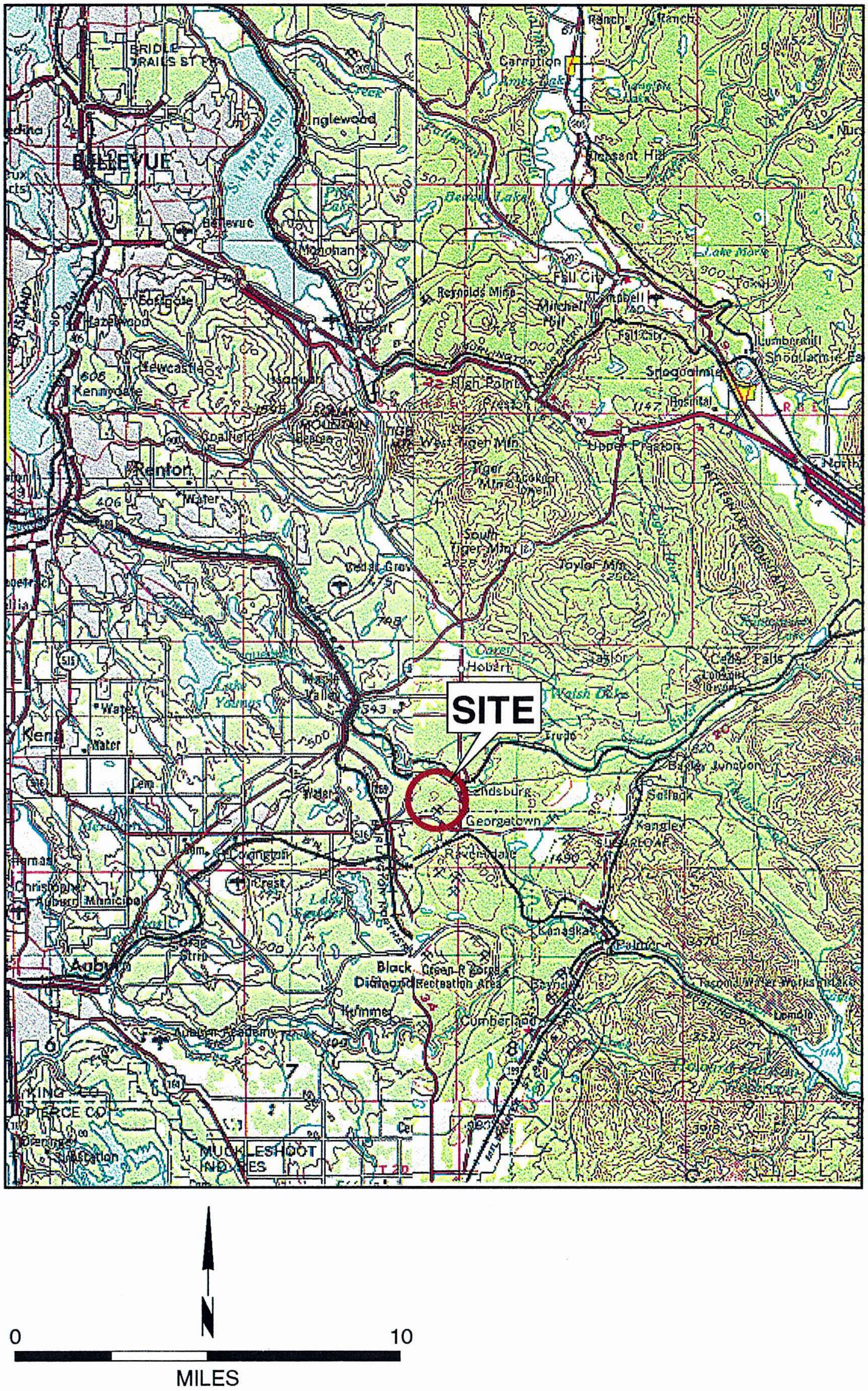
- **Chapter 8, Development of Alternatives** - This chapter consists of detailed development and description of the retained remediation alternatives.

- **Chapter 9, Evaluation of Alternatives** - This chapter consists of detailed evaluation of the remediation alternatives to support selection of a site remedy.

- **Chapter 10, References** - This section cites the documentation referenced in the body of this report.

- **Appendices** - Supporting RI and FS data are included in Appendices A thru K.

Chapters 1 through 10 of the report, along with tables and figures, are included as Volume I. Volume II consists of the appendices.

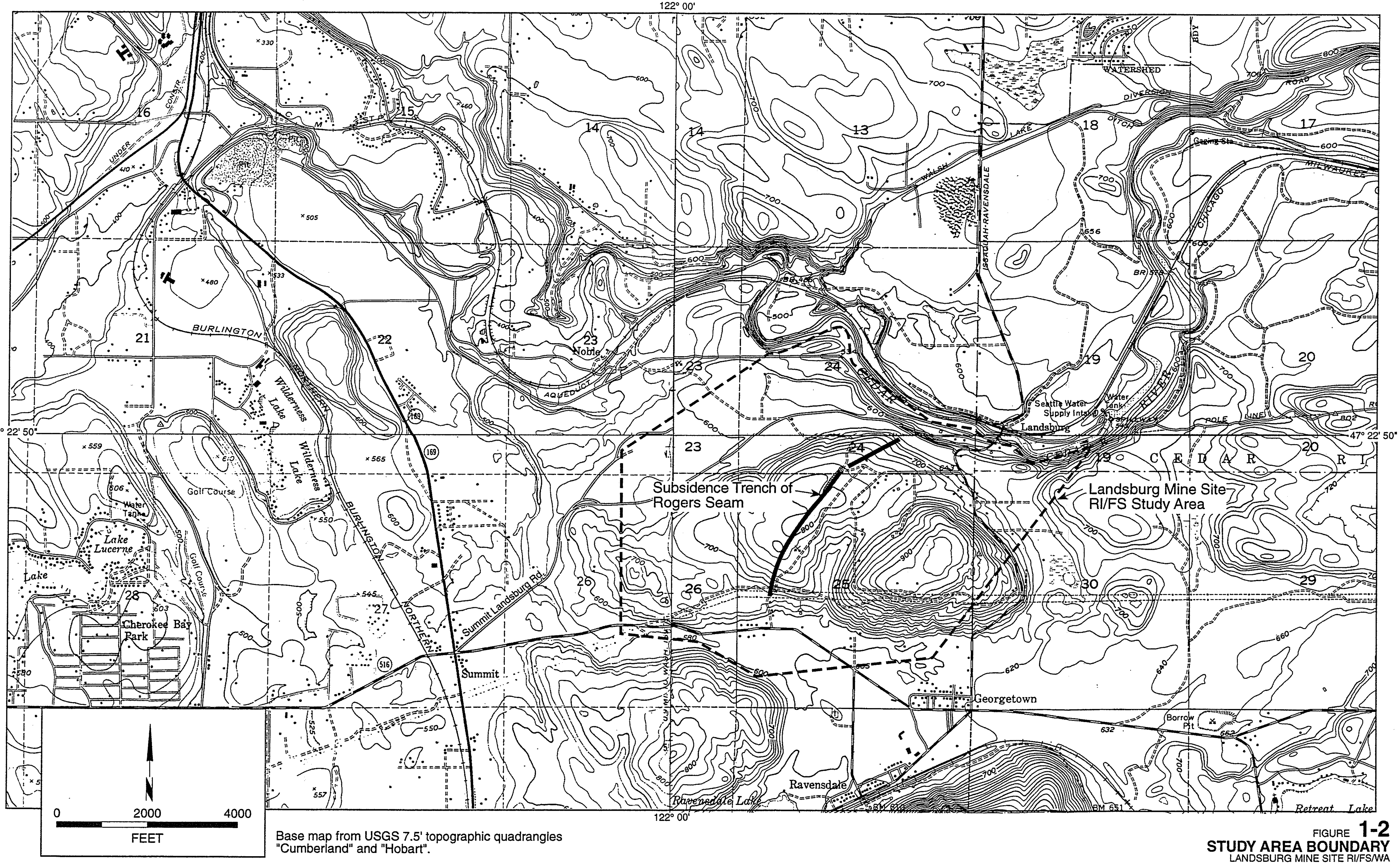


SOURCE: USGS 1:250,000 sheets
"Seattle" and "Wenatchee".

FIGURE **1-1**

SITE LOCATION

LANDSBURG MINE SITE RI/FS/WA



Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

FIGURE **1-2**

STUDY AREA BOUNDARY

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 46226 DATE 5/11/95 DRAWN BY CB

Golder Associates

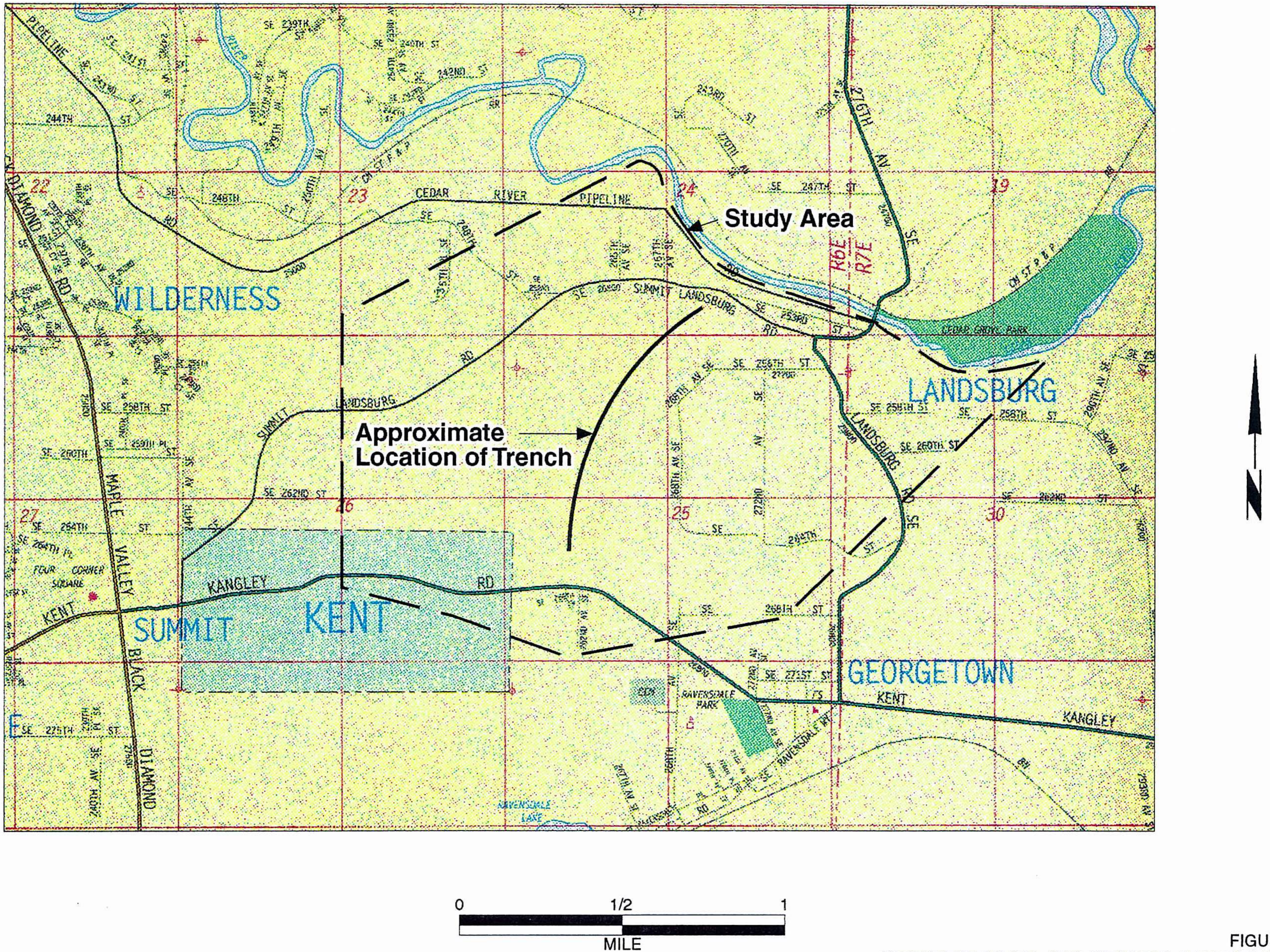


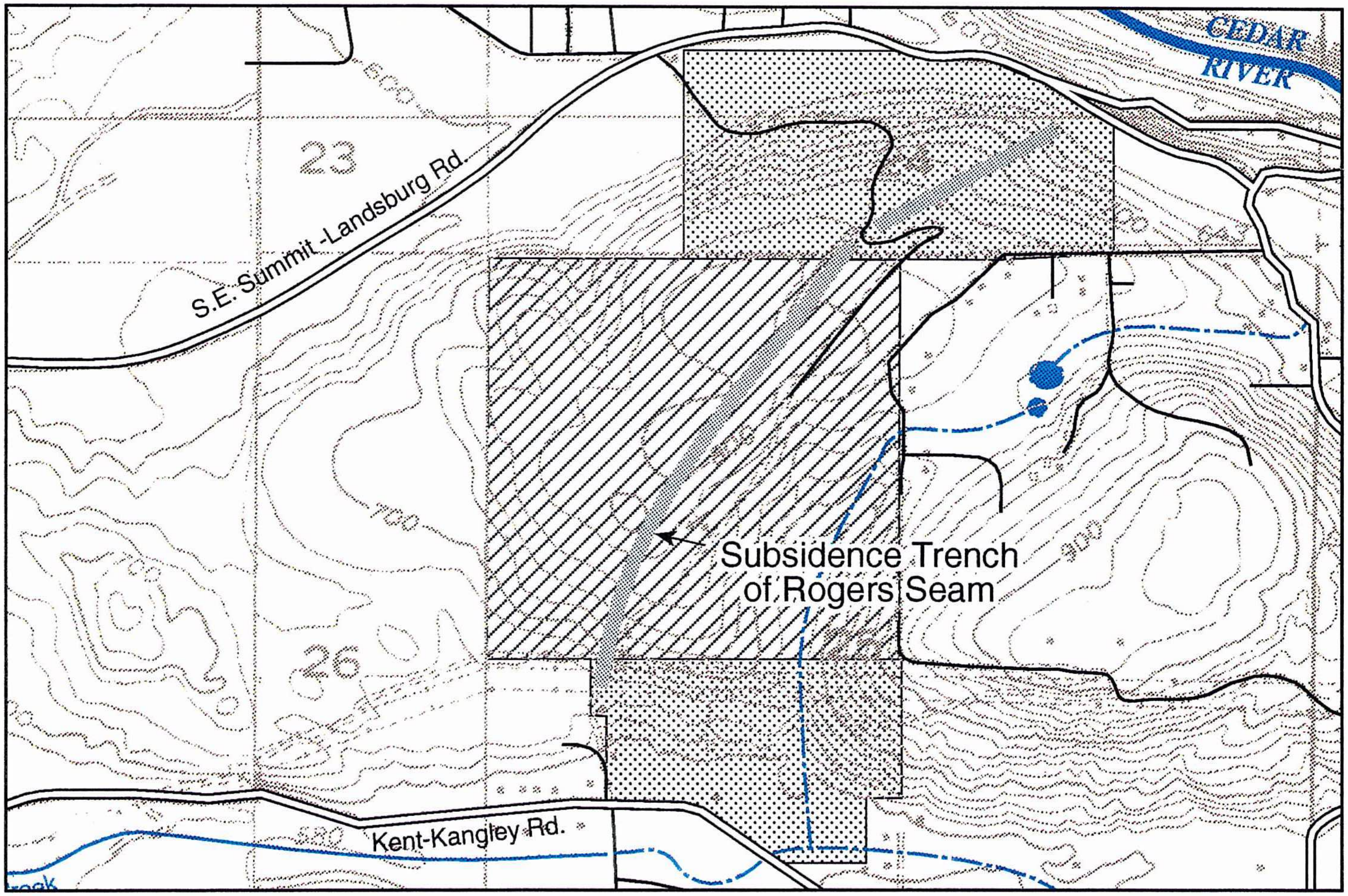
FIGURE **1-3**

STREET MAP OF STUDY AREA VICINITY

LANDSBURG MINE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 50656 DATE 5/23/95 DRAWN BY EA

Golder Associates



EXPLANATION

▒ PCC Property

▨ Plum Creek Timber Property

Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

IMPORTANT: This is not a Plat of Survey. Boundaries shown are approximate.

FIGURE **1-4**

PCC AND PLUM CREEK TIMBER PROPERTY BOUNDARIES

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 55315 DATE 3/8/95 DRAWN BY CB

Golder Associates

2. RI/FS DATA COLLECTION ACTIVITIES

This chapter describes the data collection tasks and activities completed during the course of the RI/FS. All tasks were conducted in substantive accordance with procedures detailed in the *Landsburg Phase I Remedial Investigation/Feasibility Study Work Plan* (Golder 1992a). Interpretations of the data collected as part of these tasks are provided in subsequent chapters of this report.

The approach taken during the RI was to focus environmental sampling efforts on potential pathways of chemicals leaving the mine and not on wastes present within the mine itself. Investigation of wastes in the mine was limited due to physical constraints, dangers and difficulties associated with taking samples in the mine. It is important to note that the approach of focusing on pathways of chemicals leaving the mine specifically excludes characterization of the Cedar River. As such, data collection activities conducted under the RI included the following primary tasks:

- Task 3 - Air Monitoring
- Task 4 - Facility Environmental Assessment (Level 1)
- Task 5 - Private Well Survey
- Task 6 - Surface Water Sampling and Flow Monitoring From Portals #2 and #3
- Task 7 - Surface Soil Sampling
- Task 8 - Source Characterization in Rogers Trench (Geophysical Investigation)
- Task 9 - Monitoring Well Drilling and Installation
- Task 10 - Groundwater Sampling and Analysis
- Task 11 - Topographic Survey and Geodetic Control
- Task 12 - Ecological and Social Data
- Task 13 - Geologic Reconnaissance

All environmental sampling activities were conducted under an approved Quality Assurance Project Plan (QAPP) which was included as part of the Work Plan (Golder 1992a). Most field and data collection activities, described in this chapter, were completed during the period of October, 1993 to January, 1995.

2.1 Task 3 - Air Monitoring

Air monitoring was conducted in order to evaluate the potential for mobilization, via air dispersion, of potential volatile organic compounds from the subsidence trench. A total of three air monitoring surveys were conducted during the field investigation.

All three air monitoring events were conducted along the subsidence trench bottom in the northern half of the mine trench within the fenced and secured former disposal areas (Figure 2-1). Measurements were taken along the trench bottom at intervals of approximately 25 feet. Two readings using organic vapor instrumentation were taken at each monitoring location - one reading at breathing zone level, and one at a height of approximately 6 inches above the trench floor. The three air monitoring surveys were conducted on November 3, 1993;

August 1, 1994; and January 16, 1995. Data collected during the three air monitoring events are discussed in Section 5.3.1 and summarized in Tables 5-14, 5-15 and 5-16.

In accordance with the Site Health and Safety Plan (Golder 1992a), a three person team was used during air monitoring along the trench bottom. Two people conducted the actual survey along the trench bottom while the third person remained outside of the subsidence trench and maintained visual and/or audible contact with personnel inside the trench.

The Foxboro Century System Model OVA-128 Portable Organic Vapor Analyzer (OVA) and the Thermo Environmental Model 580A Organic Vapor Monitor (OVM) instruments were used in conducting the air monitoring surveys. The OVA and OVM are highly sensitive electronic instruments designed to measure trace quantities of organic materials in air by means of a flame ionization detector (FID) and photoionization detector (PID), respectively.

Calibration, operation and use of the OVA and OVM instruments were conducted in accordance with the controls specified in GAI procedure P-12.0-1, "Calibration and Maintenance of Measuring and Test Equipment" as referenced in the QAPP. In addition, the OVA was used in accordance with procedure TP-2.3-2, "Calibration, Operation and Maintenance of Organic Vapor Analyzers", as referenced in the QAPP. Instruments were calibrated at the start and at the conclusion of each air monitoring survey. In addition, the instruments were periodically checked and recalibrated if necessary during the course of the surveys.

Additional air monitoring was conducted in association with monitoring well drilling. A Microtip PID instrument was used for air monitoring during drilling operations. Calibration and use of the Microtip followed procedures as detailed above. Air monitoring procedures during drilling operations consisted of periodic checks for the presence of organic vapors in work area breathing zones and in air being discharged from the borehole. These data were recorded on health and safety data sheets and are discussed in Chapter 5.

2.2 Task 4 - Facility Environmental Assessment

A Level I Environmental Assessment (EA) was completed for the Landsburg Mine site and is included as Appendix A of this report. The EA was completed utilizing many of the same resources available for the remedial investigation. The purpose of the Level I EA was to identify historical land uses, ownership, or activities that may have resulted in the generation, storage or disposal of hazardous materials at the site. Although considerable information is available concerning mining and subsequent waste disposal activities within the subsidence trench, the EA focused on locations outside of the trench and on activities prior to and during mining operations potentially unrelated to waste disposal, that may have lead to environmental degradation. Such activities could have included fuel oil storage and general equipment maintenance areas where underground or above ground storage tanks may have been housed and degreasing solvents may have been used.

The Level I EA also examined the areas surrounding the Landsburg Mine site to determine if previous land use or private or commercial activity may have impacted the subject property.

The EA did not include any additional (beyond that which was conducted in conjunction with the RI) soil, surface or ground water sampling.

The EA included the following activities:

- A review of the title history for the site.
- Interviews with personnel who may have been knowledgeable about site activities.
- A review of available ground water quality data and background information regarding development of the site.
- A comprehensive review of federal and state environmental databases which monitor the use of regulated and hazardous materials.
- An aerial photograph review.
- A visual reconnaissance of site conditions as described by personnel conducting the remedial investigation.

2.2.1 Title History Report

Golder contracted with Stewart Title Insurance of Seattle, Washington to complete a title history search for the Landsburg Mine site properties. The purpose of the title review is to identify previous land owners and to determine if the site may have ever been used for generation, storage, or disposal of hazardous materials. The title history describes site ownership from the 1940's to the present.

2.2.2 Interviews

Golder interviewed state and local representatives in order to gather additional site information that may not have been included in other sources. This process also included discussions with the Landsburg Mine property owners and mining company personnel, waste haulers and neighbors who may have been knowledgeable of site waste disposal activities. The interviewees were questioned about underground storage tanks, septic systems, material spills, or any incident or activity related to environmental issues.

2.2.3 Review of Available Ground Water Quality Data

Evaluation of historical groundwater quality data provides a base to assess if any ground water quality degradation has occurred as a result of activities at the site or surrounding properties. Golder reviewed a report from the Washington State Department of Health titled *An Evaluation of Drinking Water Quality In The Vicinity of the Landsburg Mine, Ravensdale, Washington* (WDOH

1992). The report was completed in February 1992 and discusses water quality sampling and analysis performed for ten residential drinking water wells surrounding the mine and from the City of Kent's Clark Springs Well. In addition to the 10 private wells, water samples from the south portal (portal #2) of the mine were also obtained and analyzed.

2.2.4 Review of Government Records

Golder contracted with Environmental Data Resources, Inc. (EDR) of Southport, Connecticut to perform a search of all available federal and state environmental databases to identify listings within a one mile radius of the Mine site. The databases included federal and state hazardous waste cleanup lists, lists of registered and leaking underground storage tanks, small quantity hazardous waste generators, and hazardous waste usage notifiers. The search was completed in conformance with current ASTM Standards (E-1527).

2.2.5 Aerial Photograph Review

Golder contacted both private and government agencies in order to gain information about aerial photographic coverage of the site. Walker & Associates of Seattle, Washington, David C. Smith & Associates of Portland, Oregon and Western Aerial Contractors, Inc. of Eugene, Oregon were contacted for information. In addition, the Cartographic Branch of the National Archives, the U.S. Department of Agriculture Aerial Photographic Field Office, the Washington State Department of Natural Resources and the King County Assessor were also contacted.

Based on these sources a review of available aerial photographs dating from the 1930's to the present was conducted in order to obtain information concerning development of the site and surrounding areas. The site and surrounding areas were examined for evidence that hazardous materials were generated, stored or disposed. One aerial photograph was available for each decade with the exception of the 1940's and 1950s. The lack of coverage during those years is attributed to the relative remoteness of the location at that point in time.

2.2.6 Site Reconnaissance

Site reconnaissance was completed as part of the continuing remedial investigation activities. Subsequent to the field work, an Environmental Assessment checklist was prepared based on observations and notes from field staff. Features evaluated through the site reconnaissance include a description of physical features such as topography, surface water drainage and the presence of cultural features such as buildings and roadways. Observations of potential underground storage tanks, abandoned drums, stained soils, stressed vegetation or other possible signs of environmental distress were also recorded if noted.

2.3 Task 5 - Private Well Survey

The private well survey was conducted to document the location, ownership, usage and construction characteristics of private wells within the RI/FS Study Area (Figure 1-2). This was necessary in order to assess possible risks posed by potential migration of chemicals in groundwater, and also to provide supplementary data in support of hydrogeologic characterization. Based on the results of the survey and in consultation with the Washington State Departments of Ecology and Health, selected private wells were included in the quarterly groundwater sampling program.

2.3.1 Well Inventory, Inspection and Verification

The well inventory, inspection and verification was conducted, to the extent possible, for all private wells within the defined Study Area. In general, the Study Area boundaries were selected (by Ecology) to include the area within an approximately one-half mile radius of the Rogers Trench. The survey was conducted as follows:

- All available logs of wells within the Study Area were obtained from Ecology's well data files. Additional information on the wells within the Study Area was obtained from the Department of Health.
- Public notice was issued for well owners in the Study Area to contact Ecology. This consisted of a mailed newsletter to homes on the Landsburg Mine site mailing list and an article in the November 24th, 1993 edition of the *Voice of the Valley* newspaper.
- The identified wells were then field inspected to verify their existence, current ownership, use, construction, condition, water levels, and other relevant details.
- In addition, suspected locations for unreported wells were visited within the Study Area.

A total of 56 private wells, providing water for approximately 91 homes and approximately 236 people, were identified within or near the Study Area. Some of these wells were located slightly outside the Study Area boundaries, but were included in the survey in consideration of requests made by the well owners to Ecology. Table 2-1 summarizes the results of the well inventory, inspection and verification. The approximate well locations are illustrated on Figure 2-2. Copies of available well logs are included in Appendix B. Information gathered during the private well inventory and inspection was used to assist in Study Area hydrogeologic characterization (Section 3.5), and in the selection of specific private wells to be included in quarterly groundwater sampling (Task 10). The results of the well survey are discussed in greater detail in Section 3.7.2.2.

2.3.2 Selection of Private Wells Included in Groundwater Sampling Program

Thirteen private wells and the City of Kent-Clark Springs facility were selected by Golder Associates, with approval from Ecology and the Washington State Department of Health (WDOH), for inclusion in the quarterly groundwater sampling program. The selection criteria consisted of the following considerations:

- Geographic/hydrogeologic location. Priority was given to those wells located potentially downgradient of the site. In addition, priority was given to those wells considered to be representative of the deeper groundwater system or to be of value in characterizing the Study Area hydrogeology. In addition, a representative number of upgradient wells were also selected to obtain indications of background water quality.

- Availability of access. Preference was given to wells having sampling ports that facilitated the collection of representative groundwater samples (i.e., wells with ports on or near the well head). Wells with poor surface seals, abandoned wells or wells without operating pump systems were not considered for inclusion in the sampling program.

- Water use. Preference was given to those wells that are utilized as drinking water sources. Private wells that supply drinking water to multiple homes were given priority.

- Owner requested well to be included in RI/FS sampling program. Preference was given to those wells that met the above criteria and whose owner(s)/tenant(s) requested their wells be included in the groundwater monitoring program. Requests were submitted in response to the above mentioned Public Notice and from public comments submitted during a Public Hearing held on June 30, 1993 at the Central Service Building of the Tahoma School District.

Following selection of the 13 private wells and the City of Kent-Clark Springs facility, access agreements, permitting access to the well owner's properties, were obtained from the 14 selected well owners/tenants. Mr. Steve Hulsman, from WDOH, assisted GAI personnel during initial contact with well owners and during initial field inspection of private well systems. Groundwater sampling and analysis of the private wells was performed in accordance with the monitoring well quarterly sampling program detailed in Section 2.8.1. Groundwater sampling was conducted similarly to procedures used by Mr. Hulsman during the private well sampling conducted previously by WDOH (as described in Section 2.2.3 of this report).

2.4 Task 6 - Surface Water Sampling and Flow Monitoring from Portals #2 and #3

Discharge of groundwater to the surface occurs at the northern end (portal #2) and at the southern end (portal #3) of the Landsburg Mine (Figure 2-3). These surface flows are believed to represent a discharge of groundwater from the mine through collapsed portals. In order to assess the significance of groundwater discharge from the mine as a contaminant migration pathway, a program of periodic monitoring was established in which water quantity and water quality data were collected.

2.4.1 Flow Monitoring

Groundwater discharge to the surface at portal #2 is confined within the boundaries of a small pool in a depression at the northern end of the subsidence trench. No actual flow from the portal was observed by Golder during the RI. Fluctuations in water levels at portal #2 were monitored through periodic water level measurements utilizing installed staff gauges. Two staff gauges were required to measure periods of high and low water levels. The staff gauges were installed within the pooled water and were tied into the site's geodetic system.

Groundwater from portal #3 is discharged to the surface from a seepage area at the southern end of the mine site. Down slope of the seepage the natural topography directs the discharge into a narrow channel. Within this channel system a small collection dam was constructed (Figure 2-4). The collection dam captures the seepage water and directs it through an eight inch PVC pipe. Water discharge flow rates from the PVC pipe were periodically monitored by capturing a known volume of water in a measured amount of time and then calculating the flow rate in gallons per minute. During periods of high precipitation, surface runoff water was also naturally collected in the dam and measured with the flow rate.

Water level measurements collected from portal #2, as well as flow rates collected from the portal #3 seepage, have been compiled and are graphically illustrated in Appendix B.

2.4.2 Surface Water Sampling

The collection of surface water quality data has been conducted through quarterly sampling and analysis of water emanating from portal #2 in the northern portion of the mine and from portal #3 in the southern portion of the mine. Four sampling events have been completed. The first sampling event was conducted in April 1994. Subsequent sampling events occurred in August 1994, December 1994 and March 1995. Surface water analytical data have been compiled and are provided in Table 5-5 of this report. Complete analytical summary tables are included in Appendix C. Some surface water sampling was previously performed in 1990 by Geraghty and Miller, Inc. (1990). Results of the 1990 sampling event are discussed in Section 3.2.2.

Sample collection and handling followed strict QA protocols and procedures as outlined in the QAPP. Just prior to or immediately following collection of surface water samples, the pH, temperature, electrical conductivity, and turbidity were measured. All instruments used for field analysis were calibrated in accordance with procedure P-12.0-1, "Calibration and Maintenance of Measuring and Test Equipment."

Samples were collected in properly cleaned bottles of appropriate volume and type and were preserved as directed by the analytical facility. After filling, the bottles were sealed, labeled and placed in a cooler maintained at 4° C. Samples were then transported to the analytical facility under formal chain of custody documentation in sufficient time to conduct the requested analyses within the specified holding times. All analyses were completed on un-filtered samples. Samples for metals analysis were field acidified.

Documentation of sampling included bottle labels, completion of Sample Integrity Data Sheets, Field Report Forms and Chain of Custody Records. Chain of custody was maintained in accordance with the procedure TP-1.2-23, "Sample Handling and Chain of Custody."

Portal #2 surface water samples were collected directly from an undisturbed area of the accumulated water. Unpreserved sample containers were filled by completely submerging the container under the water until full. The sample containers containing preservatives were filled by transferring water from one of the clean sample containers into the preserved sample container(s).

Portal #3 surface water samples were collected directly from a one-inch perforated PVC pipe which was driven laterally into the natural slope of the seepage area. The seepage area has an approximate 2 to 3 percent slope which allows discharge from the inserted perforated PVC pipe. A small pit was dug under the discharge end of the PVC to allow space for sample containers to be placed during filling. The PVC pipe was initially driven into the seepage and left undisturbed approximately four hours prior to collection of the first quarter samples. The pipe was left in-place and was utilized for each subsequent sampling round.

Surface water samples collected from portals #2 and #3 were analyzed for Target Analyte List (TAL) metals, cyanide, wet chemistry/anions, volatile organics (EPA Method 524.2), semivolatile organics (EPA Method 8270), pesticides and PCBs (EPA Method 8080 first, second and fourth quarters, EPA Method 508 third quarter). General water quality parameters and drinking water standards were also analyzed. In addition, analysis by EPA Method 525 (pesticides/PAHs) was conducted during the first and third quarter sampling rounds. The 500 series analysis were performed by Inland Environmental Laboratory in Spokane, Washington; all other analyses were conducted by Analytical Resources Incorporated in Seattle, Washington. Table 2-2 summarizes the surface water sampling activities, including sample identifications, dates of sampling, and analyses conducted.

2.5 Task 7 - Surface Soil Sampling

The surface soil sampling program was designed to determine and assess the extent of potential impacts on surface soils and possible contaminant exposure due to past waste disposal activities along the rim of the trench. This task was aimed at characterizing soils which are located outside of the mine subsidence trench only. Some materials within the trench have been analyzed previously in the Site Hazard Assessment by Ecology and Environment (1991) and the report on the Landsburg Mine Drum Removal Project by Landsburg PLP Steering Committee (1991). These results are discussed in Section 3.2.2.

Surface soil sampling was conducted along the trench rim perimeter and in the drainage areas of portals #2 and #3. Table 2-3 provides a summary of surface soil sampling activities. Soil sampling analytical results are discussed in Section 5.2. Summary tables of all soil sampling analytical results are provided in Appendix C.

2.5.1 Trench Rim Perimeter Soils

Surface soil sampling was conducted for the trench rim perimeter soils to assess potential contamination associated with historic waste disposal and handling activities which occurred along the trench rim area. Additional potential sources of surface soil contamination may also be attributed to material handling and equipment decontamination activities associated with the drum removal efforts conducted by the Landsburg PLPSC in 1991. Available records have indicated that most waste handling, placement, and removal activities and equipment decontamination took place within two access areas on either side of the mine trench. These areas, designated Access Area 1 and Access Area 2, are shown in Figure 2-5. These are the areas where sampling was focused. An additional control area was selected for soil sampling in a portion of the site away from previous waste disposal/waste handling activities and is expected to be representative of background levels.

Golder personnel conducted the trench rim soil sampling task on November 11-12, 1993. A total of 13 composite soil samples were collected for analysis. Of the thirteen samples, four were collected from Area 1, four from Area 2, four were collected from the selected background area, and one duplicate sample was collected. The locations of the samples are shown in Figure 2-5. Each of the samples was comprised of a composite of four discrete sub-samples taken from within zones chosen on the basis of the site selection criteria described below. Four zones were established in each area. In Areas 1 and 2, three of the four zones were selected as suspect areas defined on the basis of the following criteria:

- presence of vegetative stress,
- presence of soil discoloration,
- history of past waste storage and disposal,
- proximity to known waste handling or equipment decontamination areas.

The fourth zone in Areas 1 and 2, consisted of the entirety of the area, exclusive of the three previously selected zones. The four background soil sampling sites were defined by dividing the background area into four equal quadrants. Composite samples were then collected from within each quadrant. The duplicate sample was collected at one of the previously sampled sites, selected at random by field personnel.

From within each of the selected sampling zones, four subsamples were collected from the upper three to six inches of soil from discrete random locations. The subsamples were composited into a single sample within the sample containers. After compositing and filling, the sample bottles were immediately sealed, labeled, and placed in a cooler maintained at 4° C. All samples were transported under formal chain of custody procedures to Analytical Resources, Inc. in Seattle, Washington for laboratory analysis. Soil samples were submitted for Target Analyte List (TAL) metals, cyanide, volatile organics (Method 8240), pesticides/PCBs (Method 8080), semi-volatile organics (Method 8270), and anions (Cl, F, SO_4, NO_2, and NO_3).

All surface soil sampling activities conducted under this task were performed in accordance with Golder Technical Procedure TP-1.2-18 "Technical Procedure for Sampling Surface Soil for Chemical Analysis" as referenced in the QAPP. Samples were collected in properly cleaned bottles of appropriate volume and type as specified in the QAPP. All equipment utilized was properly decontaminated prior to collecting soil at each sampling location. Decontamination of the sampling equipment consisted of a non-phosphate detergent rinse, followed by a reagent-grade methanol rinse, then an approved tap water rinse, and a final organic free distilled/ deionized water rinse.

2.5.2 Portal Soils

The portal #2 and portal #3 surface soil sampling program was designed to determine and assess the extent of potential impacts on nearby surface soils due to potential contaminant migration through the mine workings and groundwater discharge to the ground surface at the portals. Because the portals represent an avenue of potential contaminated groundwater discharge from the mine, surficial materials adjacent to and downgradient from the drainage of each portal were sampled.

A total of four samples were collected from along the drainage at each portal area. Figures 2-5 and Figure 2-6 show the location of samples collected at portal #2 and portal #3, respectively. Sample locations were at approximate 50 foot intervals. Each sample consisted of a discrete sample collected from within the upper three to six inches of the soil column. One soil sample was collected at the opening of the Frasier Seam drainage (sample FNS-1), a possible background location (Figure 2-5). Surface soil sampling from portals was conducted by Golder personnel on February 18, 1994. Soil sampling was conducted using procedures outlined in Golder Technical Procedures TP-1.2-18, "Technical Procedures for Sampling Surface Soil for Chemical Analysis."

All soil samples collected under this task were shipped under formal chain of custody to Analytical Resources, Inc. in Seattle, Washington for analysis. Soil samples were submitted for Target Analyte List (TAL) metals, cyanide, volatile organics (Method 8240), pesticides/PCBs (Method 8080), semi-volatile organics (Method 8270), and anions (Cl, F, SO_4, NO_2, and NO_3). Equipment decontamination procedures were identical to those used for the trench rim soil sampling

2.6 Task 8 - Geophysical Investigation

2.6.1 Source Characterization in Rogers Trench

Source characterization of the Rogers Trench was accomplished using magnetometry for the ground geophysical survey. The magnetometer measures the earth's natural magnetic field and detects variations (i.e. anomalies) in this field caused by ferrous objects. In gradiometer mode the magnetometer utilizes two sensors to measure the total magnetic field and the vertical gradient of the field. The magnetometer survey consists of recording measurements of the magnetic field at fixed intervals along a survey transect. The data are plotted in profile to identify distinct anomalies in the magnetic field. Magnetometer surveys are useful in environmental investigations since significant magnetic anomalies are often produced by buried ferrous objects, such as pipelines, steel drums, and storage tanks. The magnitude of the anomaly produced by the object is dependent on its size, orientation, depth of burial, and magnetic properties. In addition to changes in the earth's magnetic field caused by ferrous objects, there are changes resulting from solar storms, and diurnal drift. A base station was established and re-occupied periodically during the survey to monitor these variations. The base reading was then used to correct the data for significant diurnal variations.

The geophysical survey in the trench was restricted to magnetometry since a primary aim was to identify buried metallic debris. Use of other techniques, such as EM, would not be expected to provide significant additional benefit. Use of GPR was prohibitive due to access difficulties associated with operating the GPR equipment in the trench.

The magnetometer survey was conducted with an EG&G 856 proton precession magnetometer that is capable of total field and vertical gradient measurements. This is a portable instrument consisting of two sensors mounted on a staff and a digital display unit carried in a harness by the operator. The data are recorded digitally in the instrument memory and later downloaded to a computer.

All geophysical characterization work was conducted by ground surveys. The Work Plan (Golder 1992a) originally anticipated that portions of the geophysical survey were to be conducted by aerial reconnaissance. Geophysical instruments were to be deployed via a cable or cargo net suspended below a helicopter. Upon further inspection of site conditions and in consultation with the project geophysicist and helicopter operators, it was determined that suspended geophysical instruments could potentially become entangled in the heavy brush which is prevalent throughout the mine site. In consideration of this safety issue, and coupled with the fact that equivalent or better data could be obtained by ground surveys, it was decided that the aerial surveying should not be attempted.

The ground magnetometer survey was conducted on September 30, October 1, 15 and 21, 1993. The survey was conducted along the central axis of the Rogers Seam following 100 foot station markers established along the mine workings. The station markers began with 0+00 at the south end of the seam and ended with 48+20 at the north end of the seam (near Summit-Landsburg Road). Figure 2-7 shows the locations where the geophysical surveys were conducted.

The area is heavily vegetated and it was necessary to clear a trail for much of the survey line. In areas where it was not possible to access the bottom of the surface depression the stationing was extended perpendicular to the seam along a trail on the east side of the mine. The 100 foot stationing was continued along this trail until access could be reestablished. The offset stations were then extended back to the eastern edge of the surface depression. The stations at the edge of the depressions were easily visible from within the depressions during data collection. Irregularities in the straightness of the survey line, laying the survey tape over surface obstructions, and extending stationing perpendicular to the axis of the seam all contributed to a degree of error in the 100-foot stationing. Therefore, the stationing is considered rough control for conducting the survey and relocating areas of interest.

Total field and vertical gradient data were collected at 10-foot intervals along nearly the entire length of the seam. The 10-foot intervals were based on pacing between the 100-foot control points. Three small data gaps exist (19+60 to 19+90, 25+90 to 26+10, and 31+90 to 32+50) due to an inability to access the base of the trench at those areas. Results of the geophysical survey are discussed in Section 3.2.3 of this report and are graphically depicted in Figure 3-6. Raw geophysical data are included in Appendix K.

2.6.2 Geophysical Surveys at Monitoring Well Locations

Additional geophysical surveys were conducted to assist in the determination of monitoring well drilling locations. The objective of the surveys was to locate the coal seam at four of the proposed drilling sites (LMW-2&4, LMW-3&5, LMW-6, and LMW-7). At the fifth site (LMW-1), the objective was to locate a tunnel which connects two sections of the Rogers Seam offset by a fault. To achieve these objectives, the electromagnetic (EM-31 and EM-34) and ground penetrating radar (GPR) methods were employed. Figures 2-7 to 2-12 indicate the areas where EM and GPR surveys were conducted. Additional information regarding determination of well locations is presented in Section 2.7.1. The raw geophysical data are included in Appendix K.

An electromagnetic (EM) survey measures terrain conductivity. Variations in terrain conductivity are produced by buried materials, various soil and rock types, and hydrogeologic conditions. These would include the presence of coal-bearing strata and also large voids such as the rock tunnel. EM instruments introduce an electromagnetic field into the ground via a transmitter coil. This field generates eddy currents in the subsurface which produce a secondary magnetic field that is measured by the receiver coil along with the primary field. The ratio of electromagnetic field detected by the receiver coil to the electromagnetic field produced by the transmitter coil is directly proportional to terrain conductivity. The instrument is designed to convert this ratio to a reading of millisiemens per meter (mS/m). These readings are known as the quadrature components and are presented in this report as terrain conductivity values.

The EM surveys were conducted using the Geonics EM-31 and EM-34 instruments. The EM-31 is a portable one-person instrument with a transmitter and receiver coil at opposite ends of a 12-foot boom with a display meter at the center. The EM-34 is a two-person instrument with a transmitter and receiver coil attached by a cable with a display meter carried by one operator. The EM-34 can take measurements at 10, 20, and 40 meter coil separations. A larger coil separation produces a conductivity measurement for material at greater depth.

Measurements can be made with the coils oriented both horizontally and vertically. The vertical orientation provides information from greater depth than the horizontal mode. The EM-31 has a maximum penetration depth of about 18 feet. The EM-34 has a maximum penetration depth of 50, 100, and 200 feet for the 10, 20, and 40 meter coil separation, respectively.

Ground penetrating radar (GPR) is a high frequency electromagnetic technique which transmits radar pulses into the subsurface and records the subsequent radar pulse reflections. A radar antenna is pulled along the ground surface, and radar pulses are transmitted into the ground for every few inches of forward motion. The transmitted pulses are reflected from subsurface discontinuities that have contrasting electrical properties. Reflections can be produced by a number of subsurface conditions: layering in the soils; changes in moisture content; the water table; discrete objects such as pipes, drums, storage tanks, and miscellaneous debris. A graphic record is produced in the field which depicts a cross-sectional view of the subsurface along the survey transect. A location mark, indicated by a vertical line on the GPR records, is recorded by the geophysical technician pulling the antenna as the antenna crosses locations marked on the ground.

The GPR survey was conducted with a GSSI SIR System 4. This system consists of a 120 or 300 Mhz antenna, a control unit, and a 200-ft cable connecting the antenna to the control unit. The data were displayed on an EPC 8700 thermal graphic recorder. The system was powered by two 12-volt automotive batteries.

Site LMW-1

The objective of the geophysical survey at LMW-1 was to locate a tunnel connecting two sections of the Rogers Seam that are offset by a right-lateral fault. The fault and suspected tunnel are located where the access road crosses the Rogers Seam. The well was to be located to intercept the tunnel.

The electromagnetic survey was performed along two survey lines oriented perpendicular to the strike of the tunnel and separated by 20 feet as shown on the site sketch map (Figure 2-8). Each survey line was run at a ten foot station spacing with the EM-31 and a 20 foot station spacing with the EM-34. Coil separations of 10, 20, and 40 meters with the EM-34 were used to sound different depths of investigation.

The EM-31 profiles show a sharp increase in conductivity between 80 and 120 feet on line 1 and between 70 and 120 on line 2. This conductivity increase is interpreted to be possibly the location of the tunnel. The EM-34 profiles also show an increase in conductivity at approximately 80 feet, however, due to the large coil separation, the other side of the anomaly is not well-resolved.

Historical records indicate that the tunnel is at a depth of 180 feet. At that depth any influence on the conductivity measurements would be expected to be apparent in the larger coil separations and the vertical mode of the EM-34 profiles. The EM-34 vertical mode profiles for line 1 show a small decrease in conductivity between 60 and 80 feet at the 20m and 40m coil separation. The EM-34 vertical mode profiles for line 2 show a conductivity minimum at 80 feet for the 40m coil separation. The 20m separation shows a minimum at 60 feet and a sharp decrease at 120 feet. The low reading at 120 feet is not consistent with any other profile and is considered a noisy reading. These decreases in conductivity may possibly show the influence of the tunnel directly or a change in hydrogeologic conditions caused by the tunnel. Based on these conductivity lows, it was estimated that the tunnel is between 60 and 80 feet on survey line 1.

A line was also drawn connecting the terminus of the surface depressions on either side of the survey area. This line represents a rough geometrical estimate of where the tunnel is expected to be located. This line crosses survey line 1 at 77 feet. This is in close agreement with the estimate of 60 to 80 feet based on the geophysics.

Site LMW-2 & LMW-4

An electromagnetic survey was performed at the original LMW-2 and LMW-4 site (adjacent to the Cedar River pipeline road) to locate the northern portion of the Rogers coal seam for drill hole placement. A GPR and radio-detection survey were then performed in the vicinity of the suspected seam location to locate the City of Seattle water pipeline and any other utilities that may affect or be impacted by drilling operations.

The electromagnetic survey was performed along four survey lines oriented parallel to Pipeline Road and perpendicular to the strike of the coal seam as shown in Figure 2-9. Lines 1-4 were surveyed with the EM-31 at a station spacing of 10 feet. The EM-31 conductivity profiles show a conductivity low at approximately 170, 150, and 130 feet on lines 1, 2, and 3 respectively. These conductivity lows are interpreted to be the location of the coal seam. The alignment of these three conductivity lows gives a strike that is consistent with the overall strike of the coal seam. The EM-31 response along line 4 was flat with a lower conductivity value. Line 4 is located along the north side of Pipeline Road close to the power lines and the Cedar River. The lower conductivity and flat response is thought to be a combination of interference from the power lines and possible sandy sediments associated with the Cedar River.

The use of the EM-34 at this site was limited by power line interference, thick vegetation, and topography. The EM-34 is susceptible to powerline noise, especially at large coil separation. Therefore the EM-34 survey was run at the 10m and 20m coil separation along line 1 (the line furthest away from the power lines). The EM-34 conductivity profiles for line 1 (horizontal mode) show a similar shape as the EM-31 profiles but the conductivity variations were much more subtle. The cause of the negative values at the 10m coil separation is unknown but may be the result of the powerlines. The vertical mode profiles were very noisy and cannot be reliably interpreted.

The objective of the GPR survey at this site was to locate the water pipeline and any other utilities that exist in the area. A total of 15 transects were run from approximately 10 feet south to 100 feet north of Pipeline Road (Figure 2-9). The coverage extended from approximately 100 feet east to 200 feet west of the coal seam location determined from the electromagnetics survey. In addition to the GPR survey the area was covered with a model RD-400 radio-detection instrument. This instrument is a Very Low Frequency (VLF) receiver and is capable of detecting conductive utilities like cables and metallic pipe. Several pipe-like GPR targets and one radio detection target were found within the area. A pipe-like GPR target was found just south of Pipeline Road on lines 70E to 120W at a depth of 8 to 12 feet. A second pipe-like GPR target was identified on all the transects approximately 7 feet north of the south edge of Pipeline Road at a depth of 3 feet. A third pipe-like GPR target was identified just north of Pipeline Road on lines 10W to 200W. A radio-detection target was identified approximately 3 feet north of the 3 foot deep GPR target within the road bed. The radio-detection target is thought to be the telephone cable that is said to be buried along the road. Later backhoe excavation to the top of the water supply pipeline identified the 3 foot depth GPR target within the road bed as the City of Seattle water line. The excavation was not dug to great enough depth to identify the other GPR targets. Continuing concerns about the condition of the old concrete City of Seattle water supply pipeline as well as difficult drilling access, resulted in relocating LMW-2 and LMW-4 to their present position.

Site LMW-3 and LMW-5

LMW-3 and LMW-5 are located at the southern end of the Rogers Seam. The objective of the geophysical investigation at this site was to locate (for drill hole placement) the coal seam and a mine portal that had been collapsed and bulldozed over. An issue at this location involved possible interferences from the nearby powerlines. This is the only location at the site where powerline interferences was a concern. The possible interference is limited to the EM data as GPR is not affected by power lines. The extent of the EM interferences is discussed below.

The GPR survey consisted of six lines run perpendicular to the strike of the coal seam and one line run semi-parallel to the coal seam as shown in Figure 2-10. Two GPR targets were identified at 118 feet on line 1 and 110 feet on line 2. These targets identify areas of increased signal strength on the radar record about 20 feet wide. These targets are interpreted as possible coal seam locations. A pipe-like GPR target was followed from lines 1 and 2 south to the portal #3 seepage area. This may be a drainage pipe from a portal feature. The north-south GPR line shows a decrease in signal amplitude in the wet area compared to the drier areas to the north and south. This indicates a change in soil or moisture conditions in this area.

The EM survey consisted of surveying the GPR anomalies along GPR lines 1, 2, and 3 with the EM-31 and EM lines 1, 2 and 3 with the EM-34 (Figure 2-10). The EM-31 showed background conductivity values of 35-40 mS/m that decreased to 0-15 mS/m over the GPR anomalies GPR-1 and GPR-2. This response is consistent with a change in soil type produced by a coal seam.

The EM-34 was affected by interference from the powerlines to the south. Oscillations of 10 mS/m were observed on most lines while in a stationary position. The conductivity profile for the lines and coil separations where data were recorded show an increase in conductivity for the vertical mode from 100 to 160 feet on line 1. This is the area around GPR anomaly GPR-1 and also suggests a possible change in soil type. The reason for increased conductivity values with the EM-34 and decreased conductivity values with the EM-31 is unknown, but powerline interference with the EM-34 is one possible explanation. In the horizontal mode reasonable data could only be recorded at the 10m coil separation. These data show little response along profile. The negative values for this mode suggests the readings are affected by powerline noise.

Reasonable data could only be collected at the 10-meter coil separation and vertical mode for line 2. The conductivity values show a general increase between 100 and 160 feet with a sharp decrease at 140 feet. Interference from the power lines was especially bad on this line and the reliability of these readings for interpretation are questionable.

Line 3 was located along the trail crossing the strike of the coal seam just south of the first surface depression on the Rogers Seam. The origin of the magnetometer survey is located at -5 feet on line 3 and this should be the approximate location of the coal seam crossing. The horizontal mode shows a decrease in conductivity upslope from 100 to 20 feet and a level response from 20 to -100 feet. The vertical mode shows a decrease in conductivity from 10 to -80 with a minimum at -40 feet and -20 feet for the 10m and 20m coil separation. These conductivity minimums in the vertical mode probably indicate the coal seam.

Site LMW-6

The objective of the geophysical survey at LMW-6 was to locate the Frasier coal seam for drill hole placement. The general location of the seam was taken from maps of the mine showing the location of the Frasier Seam in relation to the access road that crosses it.

The EM survey consisted of EM-31 and EM-34 surveying along 3 lines oriented perpendicular to the strike of the coal seam as shown in Figure 2-11.

EM-31 data were formally recorded for line 1. On lines 2 and 3 only the location of anomalies were flagged. The conductivity profile for line 1 shows a maximum conductivity at 80 feet. This conductivity maximum is interpreted as the coal seam location with the increase in conductivity resulting from an increase in near surface moisture. Two conductivity minimums were flagged on lines 2 and 3 at 104 feet and 118 feet respectively and are interpreted as the location of the coal seam. The alignment of these three anomalies gives a strike direction consistent with that shown on mine maps.

EM-34 data were recorded at all three coil separations for line 1. The horizontal mode data show a consistent decrease in conductivity along line 1 and no anomalous reading at the location of the EM-31 anomaly. The vertical mode data, however, show a conductivity minimum at 80 ft and 60 ft for the 10m and 20m coil separation. The opposite sign of this anomaly compared to the EM-31 data can be explained by the deeper depth of investigation, the EM-34 readings are more influenced by the shallow geology and less by the near surface moisture conditions. On line 2 the EM-34 data show a subtle minimum at 80-100 feet. This is in close agreement with the EM-31 anomaly at 104 feet. On line 3 the horizontal mode EM-34 data show a subtle minimum at 120 feet, 2 feet from the EM-31 anomaly at 118 feet. The vertical mode EM-34 data was scattered and show no interpretable trends.

Site LMW-7

The objective of the geophysical survey at LMW-7 site was to locate the Landsburg coal seam. The general location of the geophysical survey was based on a seam location from a geodetic survey crew that relocated the seam from old mine maps.

The electromagnetic survey consisted of EM-31 surveying along 3 lines oriented perpendicular to the strike of the coal seam as shown in Figure 2-12. EM-34 surveying was performed on line 1 only.

The EM-31 conductivity profiles show a relatively flat response along line 1. The conductivity minimum at 120 feet is within 10 feet of the seam location based on old mine maps at 110 feet. The conductivity minimum is less than 1 mS/m different from the surrounding data values. Although the conductivity minimum and surveyed seam location are in good agreement, the conductivity minimum is more subtle than would be expected from a coal seam. Line 2 shows a conductivity maximum at 110 feet. The conductivity variation along line 2 corresponds to local topography with the conductivity maximum at the base of a local depression. These conductivity variations probably indicate variations in moisture content from small scale topography. Line 3 shows a conductivity maximum at 120 feet. This corresponds to a wet area on the surface and is probably related to near-surface moisture content.

The EM-34 conductivity profiles show a relatively flat response along line 1. No anomalies are seen on the horizontal or vertical mode data that could be interpreted as a coal seam.

2.7 Task 9 - Monitoring Well Drilling and Installation

The purpose of installing groundwater monitoring wells was to obtain hydrogeologic, chemical, and hydraulic data to assess the hydrogeologic conditions in the immediate vicinity of the mine and to determine the extent and potential migration of any chemical compounds. A total of seven monitoring wells were completed during the RI. The seven monitoring wells were designated LMW-1 through LMW-7 (LMW - Landsburg Monitoring Well). In addition to the seven monitoring wells, a temporary monitoring well, designated LMW-1A, was completed during drilling operations in the LMW-1 area.

2.7.1 Determination of Well Locations

Monitoring wells LMW-2/LMW-4 and LMW-3/LMW-5 were completed as clustered monitoring wells that monitor shallow and deeper zones of the Rogers coal seam. The LMW-2 and LMW-4 wells were set in the northern portion of the Rogers Seam, and LMW-3 and LMW-5 wells were set in the southern portions of the Rogers Seam. Monitoring of hydrologic conditions in the Frasier seam and the Landsburg seam, located to the east and west respectively of the Rogers Seam, was accomplished through the installation of LMW-6 in the Frasier seam and LMW-7 in the Landsburg seam. LMW-1 was located to intercept the tunnel which was constructed during mining operations to connect sections of the Rogers coal seam offset by a fault. Monitoring well locations are shown in Figure 2-3.

A thorough understanding of coal seam locations and the fault zone tunnel location was required in order to properly determine monitoring well drilling sites. As such, the geophysical surveys, described in section 2.6.2, were performed at each of the proposed monitoring well locations. In addition, Cramer & Niclas, Inc. of Kent, Washington were contracted to conduct geodetic surveying of the coal seam locations and the location of the fault zone tunnel. The geodetic surveys were based on projecting the locations of the coal seams from historical mining maps to the surface in the area of the drill site.

Based on a combination of the geophysical and geodetic surveys, a surficial projection of the coal seams was established at each drill site. Utilizing the surface projections and recorded information on the dip of the coal seam and tunnel depth, drilling locations and estimated depths were then established for the seven monitoring wells.

Boreholes LMW-2 and LMW-4 were initially to be located just south of the Seattle Water Department's Lake Youngs Aqueduct (a 96-inch diameter water pipe with a 10-inch thick steel reinforced concrete wall). This location was originally chosen so that core samples of coal which had not been altered by mining activities could be obtained. The Seattle Water Department expressed concerns over the possibility of damage to the aqueduct from the weight of the drill rig and from ground vibrations produced during drilling. Upon further consultation with Seattle Water Department and with the approval of Ecology, LMW-2 and LMW-4 borehole locations were relocated to intercept the Rogers Seam at the northern most point downgradient of the mine workings but still on land owned by Landsburg PLP members (Figure 2-3).

2.7.2 Drilling and Well Installation

Burlington Environmental, Inc. of Groveport, Ohio was contracted by the PLP Group to perform all borehole drilling and well installation activities for the RI. All monitoring wells were drilled using the air rotary method with driven steel casing. Burlington utilized a Schramm T-660 rotary drilling rig and eight-inch diameter steel casing. The air compressor on the drill rig was equipped with an operable air filter to remove entrained hydrocarbons so the pressured air was of "D" breathable quality.

Prior to conducting any drilling operations, the rotary rig, drill rods, bits, and steel drive casing were decontaminated with a pressure washer and steam cleaner. The rig and tools were thoroughly decontaminated between each borehole drilling operation, and prior to demobilization from the site. Decontamination activities were conducted within the confines of a bermed plastic-lined decontamination area (Figure 2-13). Decontamination water was collected and stored in labeled 55-gallon Department of Transportation approved drums.

After decontamination, the air rotary rig was set up at each site using levels to ensure a stable, plumb borehole. Boreholes LMW-4 and LMW-7 were drilled at an angle (20 degrees off vertical) to aid in the intersection of the coal seam at depth. All other boreholes were drilled vertically. Drilling consisted of driving an eight-inch steel casing behind a 7 7/8-inch tricone bit until consolidated material was reached. The purpose of the steel casing was to maintain the open borehole in the unconsolidated soils and to channel all return circulation and cuttings through the casing to a cyclone, via a diverter and flexible hose. After setting the casing, drilling continued in the open borehole to depth by 7 7/8-inch tricone bit or 7 7/8-inch downhole hammer with button bit (dependent on drilling conditions). During drilling, grab samples of the encountered formation(s) were collected at five foot intervals for geologic logging and interpretation.

Cores of the Rogers coal seam were obtained from boreholes LMW-2, LMW-3, and LMW-5. The cores were obtained using a 2 1/8-inch inside diameter double-tube split core barrel with sample catcher. The first coring was conducted in the southern end of the Rogers coal seam during drilling of LMW-3 and LMW-5. Core sampling of the coal was conducted from 49.4 to 76 feet below ground surface (BGS) in LMW-3, and from 227 to 238 feet BGS in LMW-5. Core sampling in the northern portion of the Rogers coal seam was conducted from 25 to 35 feet BGS during the drilling of LMW-2. A new coring bit and core catcher were used for coring in LMW-2. No core runs were attempted on LMW-4 due to the unconsolidated nature of the coal seam at the depths it was encountered within this borehole (197 to 233 feet below ground surface). Core samples obtained were field logged, placed in plastic liners, and then stored in labeled wooden core boxes in accordance with Golder Technical Procedures TP 1.2-2 "Rock Core Logging." Cores were attempted using both air and potable water injection, but the presence of voids and the soft friable nature of the coal resulted in poor core recovery from all three wells. Photographs of the coal recovered during coring operations are displayed in Appendix D.

Boreholes LMW-2, LMW-3, LMW-4, LMW-5, LMW-6, and LMW-7 were located successfully to encounter the coal seams/mine workings as anticipated. Due to a communications error between GAI personnel and the geodetic surveyors, the first attempt (designated LMW-1A) at drilling into the fault zone tunnel was unsuccessful. The drill location was incorrectly interpreted from the mining maps. Additional surveying was conducted, and a second borehole was drilled in an attempt to intercept the fault zone tunnel. Interception of the tunnel on the second borehole (designated LMW-1) was inconclusive during drilling. No evidence of intercepting a void area was encountered during drilling of LMW-1 (i.e. loss of air pressure, drill rods freely falling, etc.), however, evidence of significant voids/fractures was observed during the well installation process (i.e. loss of grout and sand), and the well is believed to be in fairly good communication with the tunnel.

Upon drilling to the desired depth, each of the seven boreholes was completed as a monitoring well. A summary of the depths drilled and well completion details are included in Table 2-4. Individual borehole logs and monitoring well completion logs are provided in Appendix E. All monitoring well installations were supervised by a GAI hydrogeologist and constructed in accordance with Golder Technical Procedure TP-1.2-12 "Monitoring Well Drilling and Installation," as provided in the QAPP. These wells are also in conformance with State well construction regulations (WAC 173-160).

In general, the monitoring wells were completed using 4-inch diameter stainless steel well screen (15 feet in length) and casing with O-ring seals between the joints. Stainless steel, 4-inch nominal diameter, flush-coupled screen with a wire wrapped 0.020-inch slot was used. The well screens were centered in the borehole using stainless steel centralizers installed at the bottom and top of the screen and continued at a maximum 40 feet spacing. A 5 or 20 foot length of nominal 4-inch diameter stainless steel riser casing was installed above the screen. The remainder of the well to land surface was constructed using 4-inch, schedule 80 PVC, flush-coupled blank well casing.

With the exception of LMW-5 and LMW-7 a filter pack using 10/20 Colorado silica sand was installed to a depth approximately three feet above the topmost slot on the screen. The top of the filter pack was periodically measured during placement using a weighted engineering tape. A bentonite seal was then placed immediately on top of the filter sand pack. The bentonite seal was placed by hand pouring medium bentonite chips down the annulus and allowing sufficient time for the chips to hydrate. Following completion of the filter pack and bentonite seal, the remainder of the annular space was filled to the ground surface using a Volclay (bentonite grout) or a cement bentonite grout. All grout mixtures were injected into the annular space via a side discharge tremie pipe. The 8-inch steel outer casing was pulled in conjunction with the final grouting of the annulus.

The following well installation alterations were required to meet variabilities encountered at the mine site:

- After setting the sand pack and bentonite seal in LMW-1, attempts to fill the annulus with volclay grout failed due to the presence of a void and/or fractures located at approximately 100 to 140 feet below the ground surface. A column of 8-10 Colorado sand followed by a column of bentonite chips were utilized to fill this zone of the annulus. Volclay grout was then used to fill the annulus to the surface.

- Only a 10 foot screen was used in LMW-2 due to the shallow nature of the well.

- The 15 feet of stainless steel screen used in LMW-4 consisted of a bottom 10-foot prepacked screen welded to a 5-foot piece of regular screen. The prepacked screen was used in anticipation of the screen bottom becoming slightly embedded in the soft sloughed in material at the bottom of LMW-4.

- The screen section of LMW-5 was set in the southern portion of the Rogers Seam mine workings. The presence of the open mine workings precluded the setting of the filter pack. Thus, a 10-foot prepacked screen was used, and a stainless steel "catch" was welded to the riser pipe. The purpose of the catch was to serve as a platform on which the bentonite chips would bridge forming a seal in the annulus. A thick cement bentonite grout plug was placed above the bentonite chips, and the remained of the annulus was volcay grouted. The configuration of the catch device is shown on the well completion diagram for LMW-5 in Appendix E.

- The screen section of LMW-7 was set in the open mine workings of the Landsburg seam. The void area associated with the mine workings precluded the setting of a filter pack. A "catch" system similar to LMW-5 was constructed for completion of the well. Sand was tremied down the annulus and used to form the bridge on top of the catch. Bentonite chip were not used to form the bridge, because the angle of LMW-7 would not permit the bentonite chips to be passed down the annulus. Once a suitable base of sand was established, the remainder of the annulus was grouted as described for LMW-5. During pulling of the 8-inch steel outer casing, the steel casing became stuck and could not be completely removed from the borehole. A backhoe was used to remove soil from around the 8-inch casing to a depth of 18 feet. The casing was then cut at this depth and the soil was backfilled around the casing. The annulus was then grouted to the surface and the 18-foot section of 8-inch casing was removed.

All monitoring wells were completed with protective anodized aluminum well monuments having lockable lids. Three concrete filled steel posts ("bumper posts") were placed in a triangular array around each protective monument to provide additional protection for the monument. A domed concrete pad was constructed around the base of the monument to divert water runoff away from the well.

The additional borehole (LMW-1A) was completed with a 2-inch schedule 40 PVC screen (20 feet in length) and casing. A 4-inch PVC, with an 8-inch packer on the bottom end, was inserted into the borehole over the 2-inch casing to a depth of 22 feet below the ground surface. The 8-inch packer served as a catch for the bentonite chips which were used to seal the annulus to the surface. The well was completed with a steel monument with a lockable lid. LMW-1A was used for monitoring hydrogeologic conditions only. Groundwater samples were not taken from this well.

Following installation of the groundwater monitoring wells, and after adequate time had elapsed for the grout to harden, the monitoring wells were developed by air lifting water from the well. The air rotary drilling rig was used to air lift and develop each well until relatively silt-free water flowed from the well. The purpose of this initial development was to remove as much of the silt and sand as possible from the well prior to the installation of the dedicated sampling pump system.

The drill cuttings produced during drilling operations were collected in labeled 55-gallon Department of Transportation approved drums. The drums were then transported to a storage area inside the fenced portion of the mine site. At the completion of the drilling process composite samples of captured cuttings from each borehole were obtained and analyzed for volatile organics (EPA Method 8240), semivolatile organics (EPA Method 8270), PCBs and pesticides (EPA Method 8080) and metals (EPA Method 6010) analysis. A summary of analytical results for these samples is listed in Appendix C.

There were no organic compounds detected above MTCA Method B cleanup values in any of the composite 55-gallon drum samples. Based on these analytical results and after receiving approval from Ecology, the collected soil cuttings were disposed of into the Landsburg trench. After being emptied, the 55-gallon drums were pressure washed and delivered to a recycling facility. Information concerning disposal of the drill cuttings is provided in Pancoast (1994a).

Large volumes of formation water encountered during drilling at LMW-2, LMW-3, LMW-4, and LMW-5 were collected and stored in large (4,000, 6,500 and 21,000 gallon) Baker tanks. Groundwater produced during the development process was also collected in the Baker tanks, and in 55-gallon drums for LMW-1. Characterization of the captured groundwater was determined from the results of groundwater sample analysis during the first monitoring period.

After receipt, validation, and evaluation of the groundwater sample analysis and after receiving approval from Ecology, the groundwater stored in the Baker tanks in the vicinity of LMW-2 and LMW-4 (north end of the trench) was pumped from the tanks into the Landsburg trench at a location approximately 150 feet southwest of portal #2 (Figure 2-14). The water stored in Baker tanks at the LMW-3 and LMW-5 site was pumped to an infiltration area approximately 300 feet southeast of LMW-3 (Figure 2-15). Formation water collected in 55-gallon drums was disposed of in conjunction with the disposal of drill cuttings as described above. Information regarding the disposal of groundwater produced during well construction and development is presented in Pancoast (1994b).

Disposal of groundwater stored in Baker tanks was used as an opportunity to collect additional hydrogeologic data. Electronic data loggers were used to monitor LMW-1, LMW-2, LMW-3, and LMW-4 for changes in water level during draining of the Baker tanks and for a period of time following disposal of the water. Results of the hydrologic monitoring are presented in Appendix B and discussed in Section 3.6.3.3.

2.7.3 Inclinometer Surveys

The inclination of monitoring wells LMW-1, LMW-4 and LMW-7 was measured by Golder geophysics personnel using an Applied Physics Systems Model 544 Miniature Angular Orientation Sensor. This system contains both a 3 axis accelerometer and a 3 axis fluxgate magnetometer, as well as two temperature probes for calibration purposes. Roll and vertical inclination angles are determined from the accelerometer unit. After these values are known, the magnetometer unit is used to determine the horizontal azimuth angle. The Model 544 is battery operated and contains a microprocessor that interfaces with a field computer for data display and storage. The sensor is contained in a 3-inch diameter downhole probe that is connected to the surface via a cable marked at 10-ft intervals.

LMW-4 was logged prior to well installation while the other two boreholes were logged after well installation. LMW-4 and -7 were logged to determine the true dip of the boreholes, which were drilled at an intended 20 degree inclination. LMW-1 was logged to determine any deviation from the intended vertical orientation. The inclination of each of the three wells was measured at 10-ft intervals.

The inclination of LMW-1 ranges from about 1 to 4.5 degrees. It is approximately 9 ft off of vertical at the bottom of the 177-ft deep hole. The inclination of LMW-4 ranges from about 20 to 30 degrees. The bottom of the borehole is approximately 20 ft off from the intended 20 degree inclination. The inclination of LMW-7 ranges from about 17 to 23 degrees. The bottom of the borehole is less than 3 ft off from the intended 20 degree inclination. The deviations of these boreholes from their intended inclinations are considered normal under typical drilling conditions and operations.

2.7.4 Hydraulic Testing

A thorough knowledge of hydraulic parameters at the Landsburg Mine site in general, and the Rogers Seam in particular, is essential for the characterization of site hydrogeology. Aquifer hydraulic conductivities were estimated at monitoring wells LMW-1, LMW-2, LMW-3, LMW-4, and LMW-5 primarily by performing piezometer, or slug, tests on each well. Pumping tests (drawdown/recovery tests) were also attempted at each well pair. Additional hydraulic data were obtained by monitoring water levels in selected wells during the Baker tank water disposal. A discussion of hydraulic testing procedures is provided below. Presentation of results are provided in Section 3.6. Detailed discussion of the data analysis procedures are provided in Appendix F.

2.7.4.1 Slug Testing

Piezometer tests, also referred to as slug tests, are a method commonly utilized to determine in-situ hydraulic parameters at a single piezometer or monitoring well. Slug tests are initiated by inducing an instantaneous change in water level by adding, displacing, or removing, a known volume, or "slug" of water. Water levels within the well are monitored over time as they recover to pre-test conditions. A variety of data analysis methods are available to account for varying hydrogeologic conditions. Slug tests provide a simple, cost-effective method of determining aquifer parameters. However, the accuracy of the tests are dependent upon the design and construction of the tested well and possible disrupting effects of the borehole drilling process. Therefore, the aquifer parameters determined by the analysis of slug test data is generally considered to be accurate only to within an order of magnitude of actual in-situ conditions.

Slug tests were performed at the Landsburg Mine site in monitoring wells LMW-1, LMW-2, LMW-3, LMW-4, and LMW-5 on March 4, 1994. All testing was performed by Golder personnel utilizing procedures outlined in Golder Technical Procedure TP-1.2-17 "Rising Head Slug Test" and the QAPP. Water levels were monitored in each well with a down-hole pressure transducer and an automatic data recorder positioned at the top of the well (the pressure transducer and the single channel Aquistar DL-1 data recorder are products of Instrumentation Northwest, Inc., of Redmond, Washington). The data recorder was programmed to acquire and record data at scan intervals ranging from one second to ten minutes during the test interval. The scanning sequence was initiated as the slug was introduced to, or removed from, the well. Following the test, the data recorder was accessed with a portable personal computer and the data was downloaded to a 3.5-inch floppy disk. The data files were then imported into an Excel format file for analysis.

The slug utilized for each of the tests consisted of a five-foot section of two-inch diameter Schedule 40 PVC pipe filled with sand and capped at both ends with PVC slip caps. The slip caps were held in place with stainless steel set screws. The slug was raised and lowered with a section of nylon rope tied to a stainless steel eye bolt installed at one end of the slug. In order to prevent cross-contamination between wells, the slug underwent a decontamination procedure and a new section of rope was used for each test. When fully submerged in the well. the slug displaces approximately 0.11 ft^3, or 0.82 gallons of water.

Two slug tests were conducted in well LMW-5, both of which involved inserting the slug into the water and inducing a water level rise. After the first test, an attempt was made to run another test after removing the slug from the water and inducing a drop in water level. However, the transducer cable became tangled with the slug cord as the slug was being removed. This displaced the transducer, making a determination of its position, at any given time relative to the initial water table, impossible. After allowing enough time for the water table to fully recover to pre-test levels, the second slug insertion test was conducted.

In order to prevent the cord tangling problems experienced during the LMW-5 tests while testing at well LMW-3, the transducer cable was attached directly to the slug body with PVC cable-ties. Just prior to initiating the test, the slug and transducer were lowered into the well and held in a position with the slug resting a few inches above the water table. In order to induce the water level rise, the slug and transducer were simultaneously dropped into the well and secured at a level that resulted in the slug being completely submerged at all times during the test. The initial LMW-3 test was terminated when it was discovered that the water level had dropped below the top of the slug just prior to reaching full recovery. This indicated that the transducer had not been lowered enough when the test was started. Prior to starting Test 2, the slug and transducer were lowered to ensure that the slug would remain below the static water level until the well had fully recovered. Test 2 was initiated by quickly raising the slug and transducer (inducing a water level drop) and securing it at a level that ensured the slug was well above the static water level, but maintained the transducer below the current water level and well below the static water level. Water level monitoring continued until the water level had recovered to the pre-testing level.

Three individual slug tests were conducted in monitoring well LMW-2. Testing procedures were similar to those used in well LMW-5 with the separate transducer and slug assemblies. The relatively shallow water table did not require the slug to be raised and lowered to depths as great as those needed in LMW-3 and LMW-5. This minimized problems with tangling of the slug cord and transducer cable. Test 1 was initiated by lowering and submerging the slug. When water levels had fully recovered, Test 2 was initiated by quickly removing the slug, inducing a water level drop. Test 3 was initiated by pouring approximately 2.25 gallons of distilled/deionized water. Water levels recovered relatively quickly during all three testing periods. The three LMW-2 slug tests were conducted immediately following well development activities at monitoring well LMW-4 and just prior to similar activity in LMW-2. It was reported that LMW-4 remained at the static water level throughout the development process.

Two individual slug tests were performed in monitoring well LMW-4. Testing procedures were similar to those used at wells LMW-2 and LMW-5. Test 1 was initiated by lowering and submerging the slug, while Test 2 consisted of raising the slug out of the water and monitoring the water level recovery. It should be noted that the LMW-4 testing was conducted while well LMW-2 was being developed. Development pumping rates at LMW-2 were low (approximately 5 gallons per minute) and did not appear to have a discernible effect on water levels at LMW-4.

One slug test was conducted in monitoring well LMW-1. Well LMW-1 was drilled and completed within the sandstone bedrock which lies on either side of the Rogers coal seam. Because the sandstone was suspected to have a relatively low hydraulic conductivity, the slug test was conducted over an approximately 12 hour time period. Due to the depth to water in LMW-1 (approximately 140 feet below ground surface) the transducer cable was again attached to the slug body to prevent tangling of the cable and the slug cord. After lowering the transducer into the water and allowing for full recovery to static conditions, the test was initiated by quickly lowering and submerging the slug and transducer and securing the cables at the surface. The test was allowed to continue overnight.

2.7.4.2 Pump Testing

Pumping tests were conducted at each of the well pairs located at the north and south ends of the Rogers Seam. In each instance, groundwater was pumped at a constant rate from the deeper of the two wells while water levels were monitored in both the deep and shallow wells in the well pair. The Grundfos sampling pumps installed in each well (described below in Section 2.7.5) were utilized for the pumping tests. During each test a constant flow rate of approximately six gallons per minute (gpm) was maintained for the duration of the test. Water was discharged directly into on-site Baker tanks for storage. Water levels were monitored in each well with a down-hole pressure transducer and an automatic data recorder positioned at the top of the well. Test 1 consisted of pumping from well LMW-4 and monitoring water levels in LMW-2. Test 2 consisted of pumping from well LMW-5 and monitoring water levels in LMW-3. Test 1 was conducted over a 253 minute period, while Test 2 was completed in approximately 178 minutes. Both pump tests were conducted on March 24, 1994.

2.7.5 Installation of Dedicated Sampling Pumps

All groundwater monitoring wells were completed with permanent dedicated sampling pump systems. The Redi-Flo2 stainless steel submersible pump (manufactured by Grundfos), with teflon-lined polyethylene discharge hose and sealed motor lead wires, was selected for installation because of their reliability and proven performance in other monitoring well situations. The pumps purge groundwater under positive pressure. Production rates range from a slight trickle, which is preferred for sampling, to approximately 4 to 5 gpm for purging. The groundwater samples only contact stainless steel and teflon materials in the pump assembly and production casing. The pumps installed in wells LMW-3, LMW-4, LMW-5, and LMW-6 are equipped with a viton packer assembly approximately 10 feet above the pump unit. The packer assembly is inflated with nitrogen sealing off the water column above the packer thus significantly reducing the volume of purge water required during sampling.

2.8 Task 10 - Groundwater Sampling and Analysis

As discussed in GAI (1992b), the groundwater pathway represents the major potential pathway for contaminant migration and potential exposure from the Landsburg Mine site. In order to assess the extent or presence of any groundwater contamination at the site or in groundwater wells contiguous to the site, the 14 wells selected under Task 5, and the seven monitoring wells installed under Task 9, were sampled in accordance with the Work Plan (Golder 1992a).

2.8.1 Private Well Groundwater Sampling

Sampling and analysis was performed on a quarterly basis for the selected 13 private wells and the City of Kent-Clark Springs facility. A total of four rounds have been completed. The first quarterly sampling was conducted in May 1994. Subsequent sampling periods occurred in August 1994, December 1994 and March 1995. The fourth sampling round was conducted at a reduced list of private wells, consisting of 7 of the 14 wells, as approved by Ecology. These wells included PW-2, -3, -4, -9, -10, -12, and -13. Table 2-2 provides a summary of private well sampling activities. The overall objective of the off-site groundwater sampling is to provide sufficient information for WDOH and Ecology to evaluate the existing groundwater quality conditions in drinking water wells around the site. These data will also be used to assess the hydrogeologic conditions of the Study Area.

Groundwater samples collected from the private wells were analyzed for Target Analyte List (TAL) metals, cyanide, wet chemistry/anions, volatile organics (EPA Method 524.2), semivolatile organics (EPA Method 8270), pesticides and PCBs (EPA Method 8080 first, second and fourth quarters, EPA Method 508 third quarter). General water quality parameters and drinking water standards were also analyzed. Due to low turbidity levels, all analyses were conducted on unfiltered samples. Samples for metals analysis were field acidified.

In addition to the analytes obtained through the above referenced EPA analytical methods, Ecology and WDOH recommended analyzing private well water samples using EPA Method 525 for lower detection limits on specific organic compounds and to detect additional pesticide compounds. Private well samples were analyzed using EPA Method 525 during the first and third monitoring periods. Analysis using EPA Methods 524.2, 508 and 525 were conducted by Inland Environmental Laboratory in Spokane, Washington, a WDOH certified laboratory. All other analyses were conducted by Analytical Resources Inc., in Seattle, Washington. Table 5-4 provides a summary of analytes detected in groundwater samples from private wells. A complete summary of all analytes tested for and results is provided in Appendix C.

Each sampling event included the following general activities:

- observation of the general condition of the well, well seals, monuments and protective covers, well houses, etc.
- measurement of static water level from a surveyed reference point,
- well purging to insure sample representativeness,
- measurement of field parameters pH, electrical conductance, temperature and dissolved oxygen periodically during purging, and
- collection of representative groundwater samples in appropriate containers.

Each of these activities were subject to controls and strict QA protocols and procedures specified in the relevant technical procedures referenced in the QAPP. Water levels were taken according to the specifications of procedure TP-1.4-6 "Water Level Measurements". Sample collection and handling was performed as described in procedure TP-1.2-20 "Collection of Groundwater Quality Samples". All instruments used for field analysis were calibrated in accordance with procedure P-12.0-1, "Calibration and Maintenance of Measuring and Test

Equipment". Chain of custody was maintained in accordance with the procedure TP-1.2-23, "Sample Handling and Chain of Custody".

Static water levels were measured at each well prior to the initiation of any other activities. An electric well sounder was used for all manual water level measurements. The sounder was cleaned before and after each use with organic free distilled/deionized water. Water levels were measured from the top of the well casing and were recorded to the nearest 0.01 feet.

Purging consisted of the removal of a minimum of three well volumes from a well prior to sample collection. Wells with extremely low production rates (PW-6, PW-7, PW-8, and PW-15) would pump dry prior to purging the minimum three well volumes goal. The low-producing wells were purged until dry, allowed sufficient time to recover, and were then immediately sampled. Private wells were purged utilizing the well's existing pump. Private well PW-10 utilizes a jet pump, the City of Kent-Clark Springs uses a gravity collection system, and all other private wells sampled are equipped with submersible pumps. During purging, field parameters pH, electrical conductivity and temperature were periodically measured. All field parameter measurements and purge volumes collected were recorded on Sample Integrity Data Sheets for maintenance in the project file.

Samples were collected from faucets located at the well head or as close to the well head as possible. To ensure that samples collected were representative of groundwater from the well and not of water within the well system, no samples were collected from faucets located "after" holding tanks or pressure tanks. Samples collected at the City of Kent-Clark Springs facility were obtained from a brass fitting connected to the 18-inch mainline in the surge room.

Samples were collected in properly cleaned bottles of appropriate volume and type. Samples were preserved as required. After filling, the bottles were immediately sealed, labeled and placed in a cooler maintained at 4° C. Samples were transported to the analytical facilities under formal chain of custody documentation and in sufficient time to conduct the requested analyses within the specified holding times.

Documentation for sampling included bottle labels, completion of Sample Integrity Data Sheets, Field Report Forms and Chain of Custody Records. Sample coolers were secured with chain of custody seals. The Field Report Form and Sample Integrity Data Sheet were used to document daily site activities and sample collection.

2.8.2 Monitoring Well Groundwater Sampling

Sampling and analysis has been performed on a quarterly basis for the seven monitoring wells installed under Task 9. Four sampling rounds have been completed. The first quarterly sampling was conducted in April 1994. Subsequent sampling periods occurred in August 1994, December 1994 and March 1995. Table 2-2 provides a summary of monitoring well sampling activities.

Groundwater samples collected from the monitoring wells were analyzed for TAL metals, cyanide, wet chemistry/anions, volatile organic compounds (EPA Method 524.2), semi-volatile compounds (EPA Method 8270), pesticides/PCBs (EPA Method 8080 first, second and fourth quarters, EPA Method 508 third quarter) and other general water quality parameters. All analyses, with the exception of LMW-1 metals, were conducted on un-filtered samples. LMW-1 metals sample was filtered through a 0.45 *u*m in-line filter. Samples for metals were field acidified.

In addition to the analytes obtained through the above referenced EPA analytical methods, Ecology and WDOH recommended analyzing monitoring well water samples using EPA Methods 525, 504, 515.1 and 531.1 for lower detection limits on specific organic compounds and to detect additional pesticide compounds. All monitoring well samples were analyzed using EPA Methods 525, 504, 515.1 and 531.1 during the first and third monitoring periods. Analysis by Method 504 was also conducted during the second round. Analysis using referenced methods 524.2, 504, 508, 525, 515.1 and 531.1 were conducted by Inland Environmental Laboratory in Spokane, Washington, a WDOH certified laboratory. All other analyses were conducted by Analytical Resources Inc., in Seattle, Washington. Table 5-3 provides a summary of all analytes detected in groundwater samples from monitoring wells. A complete summary of all analytes tested for and results is provided in Appendix C.

General monitoring well sampling procedures parallel those described above for the private well groundwater sampling. Sampling activities were subject to controls and strict QA protocols and procedures specified in the above listed technical procedures.

Static water levels were measured at each well prior to the initiation of any other activities. An electric well sounder was used for all manual water level measurements. The sounder was cleaned before and after each use. Water levels were measured from the elevation survey mark and were recorded to the nearest 0.01 feet. All recordings, dates, times and well designations were recorded on Water Level Readings Forms and Sample Integrity Data Sheets for maintenance in the project file.

As detailed for the private wells, a minimum of three well volumes was purged from the monitoring wells prior to sample collection. All monitoring wells were purged with the dedicated sampling pumps described in Section 2.7.5. During purging, field parameters pH, electrical conductivity, turbidity and temperature were periodically measured. All field parameter measurements and purge volumes were recorded on Sample Integrity Data Sheets. During purging of wells LMW-3, LMW-4, LMW-5, and LMW-6, the packer was inflated prior to groundwater removal, hence one volume of well water represented the entrained water below the packer. As a result of the low yielding nature of LMW-1, purging of three well volumes was not possible. LMW-1 was purged until dry, allowed sufficient time to recover, and then sampled.

Purge water produced during the first two sampling rounds was collected in the Baker Tanks and in 55-gallon drums for LMW-1 and LMW-7. As described in Section 2.7.2, final disposal of the collected groundwater was conducted within the confines of the mine site. Purge water produced during the third and fourth quarter sampling was discharged to the surrounding soil.

Samples were collected in properly cleaned bottles of appropriate volume and type. Samples were preserved as required. After filling, the bottles were immediately sealed, labeled and placed in a cooler maintained at 4° C. Samples were transported to the analytical facilities under formal chain of custody documentation and in sufficient time to conduct the requested analyses within the specified holding times.

Documentation for sampling included bottle labels, completion of Sample Integrity Data Sheets, Field Report Forms and Chain of Custody Records. Sample coolers were secured with chain of custody seals. The Field Report Form and Sample Integrity Data Sheet were used to document daily site activities and sample collection.

2.9 Task 11 - Topographic Survey and Geodetic Control

Performance of the Landsburg Mine RI/FS requires detailed and accurate maps for reporting and presentation purposes, and for accurate evaluations of trench volumes, site surface water drainage patterns and other site characteristics. An accurate system of horizontal and vertical geodetic control has been established for the mine site. All elevations have been established to United States Geological Survey (USGS) datum of mean sea level. Horizontal surveys reference Washington State Plane Coordinates in accordance with WAC 173-340-840(4)(e) and (f). Site topographic and geodetic control has been established through a combination of aerial photogrammetry and site geodetic surveys.

DeGross Aerial Mapping of Bothell, Washington was contracted to perform aerial photogrammetry and topographic base map preparation of the Landsburg Mine site area. Figure 2-16 provides a composite copy of the aerial photos taken of the site area. The aim of the survey was to develop a topographic base map of the site vicinity along the Rogers trench which could be utilized in development of detailed plan view site maps. The base map was generated from stereoscopic images obtained in an aerial fly-over.

The base map was prepared to 2 foot contours with a scale of 1 inch = 100 feet. The topographic base map was developed in an AutoCad computer format for use in site plan development and preparation of report figures (e.g., Figure 2-3).

Cramer & Niclas, Inc., of Kent, Washington was contracted to set up photogrametry reference points and perform geodetic (x, y, and z) surveys of all sampling locations, private wells and other miscellaneous features. The survey was of Third Order Accuracy and Precision. Surveyed locations were entered into the AutoCad program and incorporated into the topographic base map. Surveyed well elevation data are shown in Table 2-4.

2.10 Task 12 - Ecological and Social Data

In order to assess the potential impacts of the Landsburg Mine site on the surrounding environment, data pertaining to certain relevant ecological and social characteristics were collected. Information collected include meteorologic and hydrologic data, data concerning the possible presence of endangered or threatened species and sensitive habitat, and current land and water use. Collection of this information is subdivided into the following activities:

- Meteorology
- Surface Water Flow (Cedar River)
- Land Use (Zoning and Sensitive Areas)
- Endangered Species
- Priority Habitats and Species

Information for each of these areas was obtained over the established Study Area. The Study Area is defined as outlined in Figure 1-2.

2.10.1 Meteorology

A meteorologic station operated by the City of Seattle Water Department is located on the Cedar River at the City's water intake facility (Figure 2-2). The station represents the closest official weather monitoring point to the Landsburg Mine and is therefore expected to be representative of conditions at the site. Monthly summary reports for the station have been obtained from the City of Seattle for the time period of April 1992 to January 1995. In addition, monthly precipitation and temperature data for the station have been obtained for the period 1931-1993 (Hydrosphere Data Products 1993a). Regional and site meteorological characteristics are discussed in Section 3.5.

2.10.2 Surface Water Flow Data (Cedar River)

Two flow gauging stations are located on the Cedar River in the vicinity of Seattle's water intake facility. One is approximately 1 mile upstream of the water intake, and the second is immediately downstream of the diversion. Flow data observations taken from these stations are available in Hydrophere Data Products (1993b). Included in these reports are monthly mean, minima and maxima flow rates based on all years that data are available.

Additional monitoring of the Cedar River was obtained through periodic measurements taken of the rivers surface elevation. Measurements were taken from a surveyed point on the bridge crossing the Cedar River on Landsburg Road SE. Cedar River elevation measurements have been graphed and are included in Appendix B. Surface water characteristics are discussed in Section 3.5.

2.10.3 Land Use

Relevant maps pertaining to the current zoning of the Study Area, as mandated by the King County Zoning Ordinance Title 21, were reviewed at the King County Department of Development and Environmental Services, Land Use Services Division in Bellevue, Washington. Additional maps were obtained and reviewed to identify the presence of sensitive areas, as defined by the Sensitive Areas Ordinance (King County Ordinance 9614), within the site area. Section 3.7.1 describes the current zoning of the Study Area. Sensitive areas are described in Section 3.7.3.3.

2.10.4 Endangered Species

This activity consisted of the collection of existing information on sightings of endangered or threatened species in the Study Area. Information was obtained from the United States Department of Interior Fish and Wildlife Service in Olympia, Washington and the Washington State Department of Wildlife. Information collected is discussed in Section 3.7.3.1.

2.10.5 Priority Habitat and Species

This activity consisted of the collection of existing information from the Washington State Department of Wildlife's (WDW) Fisheries, Habitat and Wildlife Management Division. Priority Habitat & Species and Natural Wildlife Heritage Data maps (PHS/HRTG), produced by WDW, were obtained for the Study Area. In addition, information on potential sensitive habitats (i.e. wetlands) located within the site area were documented during site walk overs conducted throughout the RI. Section 3.7.3.2 contains a discussion of priority habitats and species within the Study Area.

2.11 Task 13 - Geologic Reconnaissance

The purpose of this task was to further characterize the geologic setting of the Landsburg Mine area by collecting general information on local geologic features and to aid in the precise locating of the exploratory boreholes/monitoring wells. The geologic information was used to further develop the overall conceptual understanding of geologic conditions and features, and their importance to groundwater flow, contaminant migration, and the geological engineering aspects of site remedial actions.

The geologic reconnaissance activities consisted of geologic mapping of surface geologic features in the mine area and of the subsurface in the immediate vicinity of the trench. As such, two activities were completed for this task:

- Site Walk Over and Geologic Mapping
- Backhoe Trenching Perpendicular to Rogers Seam for Geologic Definition

2.11.1 Site Walk Over and Geologic Mapping

This activity consisted of several site walk overs and geologic reconnaissance activities by GAI personnel conducted throughout the field RI process. The objectives of this activity were as follows:

- To verify the surficial geologic conditions of the site, note general geologic features, map the site surface water drainage patterns, and locate any springs (in both wet and dry seasons) that may be present in the site vicinity,

- observe the surface water discharge characteristics of portals #2 and #3 in order to evaluate the optimum method to be used in surface water sample collection and flow rate monitoring at the two portals. This served as input for Task 6 as described in Section 2.4.
- Locate Frasier and Landsburg seam portals for input to Tasks 6 and 7. The portals were evaluated to assess their suitability for background surface soil sampling and surface water sampling.
- To locate any potential wetlands or other potentially sensitive habitat that may be present in the site vicinity. Information regarding wetlands served as input to Task 12 - Ecological and Social Data.
- Locating the outcrop or subcrop of the coal seams for placement of monitoring wells in Task 9 - Drilling and Well Installation.

All relevant features identified as part of the surveys were marked in the field and included in the site geodetic survey. Information obtained during the surveys was utilized in the completion of various tasks during the RI process and is described in Chapter 3.

2.11.2 Activity 13b - Backhoe Trenching Perpendicular to Rogers Seam for Geologic Definition

The purpose of this activity was to collect data related to the near-field geologic setting of the mine trench area. The activity included geologic mapping, by a qualified geologist, of three shallow trenches dug perpendicular to the Rogers Seam. The primary aim of the trenching was to define the nature of bedding within the bedrock materials on either side of the Rogers Seam, including the stratigraphic sequence, thickness and orientation of units, structure and moisture. Information regarding the stratigraphy of bedrock materials adjacent to the trench is important in understanding the potential for chemical migration laterally away from the mine. Some additional trenching was conducted to assist in the location and placement of monitoring well drilling locations.

Trenches were dug at three locations at the mine site with a backhoe. Two of the trenches were dug on the east side and one was dug on the west side of the subsidence trench. Figure 2-5 shows the three trench locations. The trenches extend away from the mine subsidence trench in a perpendicular fashion and were dug to a maximum depth of 4 feet. Important structural and stratigraphic features were recorded on field log records. The recorded trench stratigraphic logs are included in Appendix E.

A composite sample was obtained of the excavated soils from each pit and was analyzed for TAL and TCL constituents. Sampling was conducted following the procedures and requirements described in Section 2.5 - Surface Soil Sampling. Results of the soil sampling and analysis are provided in Table 5-8 and Appendix C.

Four additional trenches were dug in the revised LMW-2 and LMW-4 drilling area to locate the northern extent of the Rogers coal seam outcrop near the Summit-Landsburg Road. One long trench (approximately 40 feet) was excavated to the west of the estimated coal seam, and three shorter (approximately 10 feet) trenches were excavated to the east. No *in situ* coal was encountered in any of the excavations. However, evidence of a filled depression (based on stratigraphy encountered and nature of the fill) was noted near the previously estimated outcrop location. The Rogers Seam, in the vicinity of LMW-2 and -4, had been surfaced mined to a depth of approximately 25 feet. The information obtained from these excavations was then used in the surface projection of the Rogers Seam, and subsequently in the locating of boreholes LMW-2 and LMW-4.

All work under this activity was performed in compliance with GAI procedure TP-1.3-1, "Technical Procedure for Geologic Mapping of Soils Exposed in Test Pits", as discussed in the QAPP.

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TABLE 2-1

RESULTS OF PRIVATE WELL SURVEY

Well ID (Figure 2-2)	Well Owner/Tenant(s)	Address	Water Supply Source For (# of)		Well Specifications			Well Log Available	Comments
			Homes	People (approx.)	Date Installed	Depth (ft)	Depth to Water (ft BGS)		
A* (PW-1)	New Arcadia Water System	25041 - 255th Place SE Ravensdale, WA 98051	11	30	NA	154	79	No	Elev - 529.22 N-140,024.600 : E-1,710,685.524
B* (PW-2)	Palmer Coking Coal Bill Kombol	26017 SE 252nd ST Ravensdale, WA 98051	4	12	Aug-79	163	98	Yes	Elev - 608.32 N-139,211.034 : E-1,712,758.000
C	Suzuki and Carlsen	26020 SE 252nd ST Ravensdale, WA 98051	1	NA	NA	NA	NA	No	Unable to contact well owner
D	Unknown	26022 SE 252nd ST Ravensdale, WA 98051	1		Jun-82	160	148	Yes	
E	William J. Doyle	26108 SE 252nd St Maple Valley, WA 98038	1	2	Jun-82	169	152	Yes	
F	George Wilson	26214 SE 252nd St Ravensdale, WA 98051	1	4	1950's	NA	NA	No	No access to well
G	Kevin Satre	26202 SE 252nd St Ravensdale, WA 98051	1	4	Aug-90	138	104	Yes	
H	Chris Morris	17224 SE 265th St Ravensdale, WA 98051	1	1	Oct-80	38	20	Yes	
I	Paul Drillevich	26318 SE Summit Landsburg Rd Ravensdale, WA 98051	1	2	Aug-77	44	30	Yes	
J* (PW-3)	Well 429641 Tenants	25005 - 265th AV SE Ravensdale, WA 98051	4	11	Aug-87	51	25	Yes	Elev - 617.08 N-140,049.071 : E-1,713,890.354
K* (PW-4)	Landsburg Estates Greg Putnam	25041 - 267th AV SE Ravensdale, WA 98051	8	18	Apr-78	167	127	Yes	Elev - 618.53 N-139,946.902 : E-1,714,848.720
L	Richard Zoss	SE 253rd ST Ravensdale, WA 98051	1	4	Jan-86	25	12	Yes	
M* (PW-5)	Robert Sherrard	26004 - 268th AV SE Ravensdale, WA 98051	1	4	Jul-89	160	21	Yes	Elev - 748.57 N-136,450.767 : E-1,715,166.522
N	Pat Sherrard	268th Ave SE Ravensdale, WA 98051	1	1	NA	<20	NA	No	Shallow Hand Dug Well
O* (PW-6)	John and Kristin Lindell	25714 - 268th Av SE Ravensdale, WA 98051	1	4	Oct-79	400	235	Yes	Elev - 779.27 N-137,905.449 : E-1,715,221.014
P	John Blankenship	268th AV SE Ravensdale, WA 98051	1	2	NA	<20	NA	No	Shallow Hand Dug Well
Q	Ed Woodriff	27001 - SE 256th Ravensdale, WA 98051	1	2	NA	<20	NA	No	Shallow Hand Dug Well
R* (PW-7)	Richard & Wendy Melewski	25620 - 272nd Ave SE Ravensdale, WA 98051	1	4	Jun-90	100	11	Yes	Elev - 730.74 N-137,868.374 : E-1,716,688.835
S	Frank Willis	272 nd Ave SE Ravensdale, WA 98051	1	2	Jun-05	<20	NA	No	Shallow Hand Dug Well
T	Edward Bythral	27429 SE 256th ST Ravensdale, WA 98051	1	3	Nov-89	200	50	Yes	
U	Gary Habenicht Charlie Schantz	27405 SE 256th ST Ravensdale, WA 98051	2	4	NA	<20	NA	No	Shallow Hand Dug Well

TABLE 2-1

RESULTS OF PRIVATE WELL SURVEY

Well ID (Figure 2-2)	Well Owner/Tenant(s)	Address	Water Supply Source For (# of)		Well Specifications			Well Log Available	Comments
			Homes	People (approx.)	Date Installed	Depth (ft)	Depth to Water (ft BGS)		
V* (PW-8)	Mike and Fran Carey	27406 SE 256th ST Ravensdale, WA 98051	1	5	Jan-88	160	70	Yes	Elev - 631.84 N-138,427.719 : E-1,717,099.198
W	Toni and Debi Curtis	Landsburg Road SE Ravensdale, WA 98051	1	2	<1935	NA	NA	No	Old deep drilled well Low production, No access
X	Leslie L. Trueblood	28202 SE 258th ST Ravensdale, WA 98051	2	5	May-86	176	150	Yes	
Y	Dr. Chuck Emig	Landsburg Road SE Ravensdale, WA 98051	1	1	NA	<20	NA	No	Shallow Dug Well
Z	Scott and Karen Freed	Landsburg Road SE Ravensdale, WA 98051	1	4	NA	25-30	NA	No	Shallow Dug Well, Water is not consumed.
AA	Francis Willis	25828 Landsburg Road Ravensdale, WA 98051	1	2	NA	25-30	NA	No	
BB	Mr. Underehl	Landsburg Road SE Ravensdale, WA 98051	1	3	May-05	NA	NA	No	Unable to obtain water level
CC	James Polley	28115 SE 260th ST Ravensdale, WA 98051	1	2	Oct-84	303	97	Yes	
DD	Jack Heckenlively	30217 188th SE Kent, WA 98031	1	4	Mar-81	320	35	Yes	
EE	Melvin Preedy	SE 264th Street Ravensdale, WA 98051	1	2	Sep-79	23	11	Yes	
FF	Jeff Preedy	SE 264th St Ravensdale, WA 98051	1	4	May-90	30	4	Yes	
GG	Albert Johnson	26712 268th Ave SE Ravensdale, WA 98051	1	2	Feb-91	40	6	Yes	
HH	Mike Willis	26710 SE 268th St Ravensdale, WA 98051	1	2	NA	20	NA	No	Unable to obtain water level
II	Walter Rex	26708 SE 268th St Ravensdale, WA 98051	1	4	NA	20	NA	No	Unable to obtain water level
JJ* (PW-10)	S.J. Lorang	26128 SE Kent-Kangley RD Ravensdale, WA 98051	1	1	1940's	29	10	No	Elev - 590.22 N-134,616.925 : E-1,712,963.122
KK	Gary Gribble	26204 SE Kent-Kangley RD Ravensdale, WA 98051	1	2	May-93	140	40	Yes	
LL & MM* (PW-9)	Bridle Trails South (Dennis McCullum)	262nd Av SE Ravensdale, WA 98051	14	42	Nov-79 Sep-73	59 54	7 10	Yes Yes	Both wells are used in conjunction N-134,095.680 : E-1,713,160.554 Elev - 588.59
NN	Bob Laford (previous Owner) Current Owner Unknown	26127 SE Kent-Kangley Rd Ravensdale, WA 98051	1	NA	NA	NA	NA	No	Unable to contact well owner.
OO	Chris Fox	26106 SE Kent-Kangley Rd Ravensdale, WA 98051	1	2	NA	20-25	NA	No	Unable to obtain water level
PP	Jim Dunn	26030 Kent-Kangley Rd Ravensdale, WA 98051	1	2	NA	35	NA	No	Unable to obtain water level
QQ	Ron Davis	26025 Kent-Kangley Rd Ravensdale, WA 98051	1	2	Apr-79	40	9	Yes	

TABLE 2-1

RESULTS OF PRIVATE WELL SURVEY

Well ID (Figure 2-2)	Well Owner/Tenant(s)	Address	Water Supply Source For (# of)		Well Specifications			Well Log Available	Comments
			Homes	People (approx.)	Date Installed	Depth (ft)	Depth to Water (ft BGS)		
RR	Ken and Debi Hutchinson	26018 Kent-Kangley Rd Ravensdale, WA 98051	1	4	NA	20-25	NA	No	Unable to obtain water level
SS	Joel Worthen	26006 Kent-Kangley Rd Ravensdale, WA 98051	1	1	NA	20	NA	No	Shallow, 4 feet diameter, hand dug
TT* (PW-12)	Clayton and Lorrane Donnelly	26005 Kent-Kangley RD Ravensdale, WA 98051	1	2	Jun-05	23	9	No	Elev - 587.24 N-134,232.458 : E-1,712,422.462
UU* (PW-13)	City of Kent-Clark Springs	248 th Avenue SE Ravensdale, WA 98051	NA	NA	Late 40's	13-15	NA	No	Groundwater is collected through a branched lateral drainage system
VV	Dale Quick	24705 SE Summit-Landsburg Rd Ravensdale, WA 98051	1	2	NA	130	19	No	
WW	Jack Geroux	24800 SE 262nd ST Ravensdale, WA 98051	1	2	Jul-77	200	36	Yes	
XX	Donald Miller (owner) Ben Giddings (occupant)	24924 SE 262nd ST Ravensdale, WA 98051	1	2	Jan-78	160	75	Yes	
YY	Pat and Jerry	24901 SE 262nd ST Ravensdale, WA 98051	1	4	Sep-76	140	3	Yes	
ZZ	Wayne Demmig	25021 SE 262ns St Ravensdale , WA 98051	1	2	May-82	80	20	Yes	
AAA	Joan Burlengame Tom Balschko	25119 SE 262nd Ravensdale, WA 98051	1	4	Mar-83	240	166	Yes	
BBB* (PW-14)	Keith Felderman	25118 SE 262nd ST Ravensdale, WA 98051	1	4	Dec-82	320	196	Yes	Elev - 715.22 N-132,797.128 : E-1,711,390.584
CCC* (PW-15)	Ralph & Kathleen Toenjost	24735 Summit Landsburg Rd Ravensdale, WA 98051	1	2	NA	140-150	80	No	Elev - 640.45 N-130,893.685 : E-1,711,072.086

NA - Unable to obtain information
* - These wells were included in the groundwater sampling program as described in Section 2.3.2.
Northings and Eastings are listed in the comments section for sampled private wells. The locations reference Washington state plane coordinates.
Copies of well logs included in Appendix B.

TABLE 2-2

GROUNDWATER AND SURFACE WATER SAMPLING SUMMARY

			Chemical Analysis											
			Analytical Resources, Inc.						Inland Environmental					
	Number of	Sampling	Metals/Cyanide[c]	Pest./PCB	Semi-VOA	TDS	pH, Cond, Turb,	Cl, F, SO4,	EPA Method					
Sample Location	Samples[a]	Dates		(EPA 8080	(EPA 8270)		Carb, Bicarb.	NO2, NO3	524.2	525	504	508	515.1	531.1
ROUND 1														
Surface Water														
Portal 2 and Portal 3	2	4/13 - 4/20/94	X	X	X	X	X	X	X	X				
Ground Water														
Landsburg Monitoring Wells	7	4/13 - 4/20/94	X	X	X	X	X	X	X	X	X		X	X
Private Wells	14	5/3 - 5/12/94	X	X	X	X	X	X	X	X				
ROUND 2														
Surface Water														
Portal 2 and Portal 3	2	8/8 - 8/10/94	X	X	X	X	X	X	X					
Ground Water														
Landsburg Monitoring Wells	7	8/8 - 8/10/94	X	X	X	X	X	X	X		X[b]			
Private Wells	14	8/22 - 8/30/94	X	X	X	X	X	X	X					
ROUND 3														
Surface Water														
Portal 2 and Portal 3	2	12/5 - 12/7/94	X		X	X	X	X	X	X		X		
Ground Water														
Landsburg Monitoring Wells	7	12/5 - 12/7/94	X		X	X	X	X	X	X	X	X	X	X
Private Wells	14	12/12 - 12/19/22	X		X	X	X	X	X	X		X		
ROUND 4														
Surface Water														
Portal 2 and Portal 3	2	3/15 - 3/22/95	X	X	X	X	X	X	X					
Ground Water														
Landsburg Monitoring Wells	7	3/15 - 3/22/95	X	X	X	X	X	X	X					
Private Wells[d]	7	3/22 - 4/3/95	X	X	X	X	X	X	X					

[a] Additional samples were taken in association with Quality Control Procedures. Table 5-1 provides a summary of quality control samples (trip and field blanks).

[b] During Round 2, analysis 504 (EDB/DBCP) was also performed by Analytical Resources, Inc. on split samples from LMW-2 and LMW-5.

[c] Cyanide was not analyzed in the first round.

[d] Round 4 private well sampling was limited to wells PW-2, -3, -4, -9, -10, -12 and -13.

524.2 - Volatile Organic Compounds
525 - Pestcides/PAH's
504 - EDB/DBCP
508 - Pesticides/PCB's (Chlorinated Pesticides)
515.1 - Pesticides/PAH's (Chlorinated Acids)
531.1 - Pesticides/PAH's (N-Methylcarbamoyloximes and N-Methylcarbamates)

SOIL SAMPLING SUMMARY

				Chemical Analysis[b]					
Sample ID	Soil Sampling Locations[a]		Sampling	Metals/Cyanide	VOA	Pest/PCB	Semi-VOA	Total	Cl, F, SO4
	Northing	Easting	Date		(EPA 8240)	(EPA 8080)	(EPA 8270)	Solids	NO2, NO3
Rogers Trench Rim									
LRS-1-11/11	138,447.295	1,714,939.225	11/11/93	X	X	X	X	X	X
LRS-2-11/11	138,541.360	1,715,030.976	11/11/93	X	X	X	X	X	X
LRS-3-11/11	138,609.190	1,715,101.730	11/11/93	X	X	X	X	X	X
LRS-4-11/11A	138,647.739	1,715,184.559	11/11/93	X	X	X	X	X	X
LRS-4-11/11B	138,600.887	1,715,067.764	11/11/93	X	X	X	X	X	X
LRS-4-11/11C	138,603.895	1,714,975.408	11/11/93	X	X	X	X	X	X
LRS-4-11/11D	138,401.315	1,714,924.521	11/11/93	X	X	X	X	X	X
LRS-5-11/11	138,110.983	1,714,643.512	11/11/93	X	X	X	X	X	X
LRS-6-11/11	137,911.711	1,714,456.774	11/11/93	X	X	X	X	X	X
LRS-7-11/11	137,760.440	1,714,282.888	11/11/93	X	X	X	X	X	X
LRS-8-11/11A	137,649.271	1,714,212.593	11/11/93	X	X	X	X	X	X
LRS-8-11/11B	137,849.557	1,714,353.655	11/11/93	X	X	X	X	X	X
LRS-8-11/11C	138,066.560	1,714,556.412	11/11/93	X	X	X	X	X	X
LRS-8-11/11D	138,186.343	1,714,751.043	11/11/93	X	X	X	X	X	X
LRS-9-11/12	137,689.558	1,714,020.193	11/12/93	X	X	X	X	X	X
LRS-10-11/12	137,631.685	1,714,055.357	11/12/93	X	X	X	X	X	X
LRS-11-11/12	137,705.591	1,714,114.780	11/12/93	X	X	X	X	X	X
LRS-12-11/12	137,743.001	1,714,060.300	11/12/93	X	X	X	X	X	X
Portal 2 and 3									
P2S-2/18-1	138,931.359	1,715,567.409	2/18/94	X	X	X	X	X	X
P2S-2/18-2	138,970.410	1,715,616.198	2/18/94	X	X	X	X	X	X
P2S-2/18-3	138,995.836	1,715,657.708	2/18/94	X	X	X	X	X	X
P2S-2/18-4	139,019.242	1,715,726.712	2/18/94	X	X	X	X	X	X
P3S-2/18-1	135,133.804	1,713,092.467	2/18/94	X	X	X	X	X	X
P3S-2/18-2	135,073.296	1,713,092.535	2/18/94	X	X	X	X	X	X
P3S-2/18-3	135,011.903	1,713,085.252	2/18/94	X	X	X	X	X	X
P3S-2/18-4	134,960.848	1,713,096.847	2/18/94	X	X	X	X	X	X
FNS-2/18/1	139,791.501	1,715,236.506	2/18/94	X	X	X	X	X	X
Backhoe Trench									
BT1-3/8-1	137,651.484	1,714,192.794	3/8/94	X	X	X	X	X	X
BT2-3/8-1	138,024.380	1,714,513.630	3/8/94	X	X	X	X	X	X
BT3-3/8-1	138,535.575	1,715,048.388	3/8/94	X	X	X	X	X	X

[a] Figures 2-5 and 2-6 illustrate soil sampling locations based on the locations listed above.
Coordinate locations reference Washington state plane coordinates

[b] Chemical analysis for all soil samples was performed by Analytical Resources, Inc. of Seattle, Washington.
All soil samples were collected from the upper 3-6 inches of the soil column.

Table 2-4

MONITORING WELL CONSTRUCTION SUMMARY

Well Number	Date Installation Completed	Location* Coordinates		Top of 4" PVC Elevation (ft.ags)/(elev.)	Top of Monument Elevation (ft.ags)/(elev.)	Ground Surface Elevation (ft amsl)	Total Borehole Depth (ft.bgs)/(elev.)	Borehole Diameter (inches)	Well Casing Diameter (inches)	Screen/Casing Materials	Depth to Top of Screen (ft. bgs.)/(elev.)	Depth to Bottom of Screen (ft. bgs.)/(elev.)	Screen Slot Size (inches)	Depth to Top of Filter Pack (ft. bgs.)/(elev.)
		Northing	Easting											
				2.92	3		220				128.8	148.8		
LMW-1A	2/7/94	ND	ND	759.51	759.59	756.59	536.59	8	2	PVC	627.79	607.79	0.02	NA
				2.21	3		180				162.1	177.1		158.2
LMW-1	1/23/94	138,337.272	1,714,869.601	761.45	762.24	759.24	579.24	8	4	Stainless/PVC	597.14	582.14	0.02	601.04
				2.36	3.01		45.8				27.9	38.1		24.8
LMW-2	2/11/94	139,135.481	1,715,850.935	614.15	614.8	611.79	565.99	8	4	Stainless/PVC	583.89	573.69	0.02	586.99
				2.67	3.19		76				49.8	64.8		47.1
LMW-3	11/22/93	135,249.948	1,713,098.272	653.51	654.03	650.84	574.84	8	4	Stainless/PVC	601.04	586.04	0.02	603.74
				2.25	2.83		233.04				195.27	209.74		210.49
LMW-4	2/19/94	139,180.387	1,715,744.075	615.7	616.28	613.45	380.41	8	4	Stainless/PVC	418.18	403.71	0.02	402.96
				2.89	3.55		247				231.8	241.8		231.8
LMW-5	12/8/93	135,263.636	1,713,019.163	654.78	655.44	651.89	404.89	8	4	Stainless/PVC	420.09	410.09	0.02	381.65
				2.78	3.43		105.9				90.9	105.9		82.5
LMW-6	1/13/94	138,772.683	1,714,004.781	628.8	629.45	626.02	520.12	8	4	Stainless/PVC	535.12	520.12	0.02	543.52
				2.63	3.06		253.72				239.62	253.72		
LMW-7	1/10/94	138,112.107	1,715,362.186	767.68	768.11	765.05	511.33	8	4	Stainless/PVC	525.43	511.33	0.02	NA

Note: Below ground surface depths and elevations have been corrected to account for the 70 degree inclination of wells LMW-4 and LMW-7.
NA - Not Applicable
* Locations reference Washington state plane coordinates
ags - Above Ground Surface
amsl - Above Mean Sea Level
bgs - Below Ground Surface
ND - Not Determined

Table 2-4

MONITORING WELL CONSTRUCTION SUMMARY

Well Number	Depth to Bottom of Filter Pack (ft. bgs.)/(elev.)	Filter Pack Material	Depth to Top Stainless Steel Casing (ft. bgs.)/(elev.)	Depth to Bottom Stainless Steel Casing (ft. bgs.)/(elev.)	Depth to Top of Bentonite Seal (ft. bgs)/(elev.)	Depth to Bottom of Bentonite Seal (ft. bgs)/(elev.)	Bentonite Seal Material	Grout Seal Bottom Elev. to Ground Surf. (ft. bgs)/(elev.)	Grout Seal Material	Depth to Water (ft. bgs)/(elev.) 2/23/94	Depth to Pump intake (ft. bgs)/(elev.)	Depth to Packer (ft. bgs)/(elev.)
					0	22	Volclay Bent.			140.6		
LMW-1A	NA	NA	NA	NA	756.59		Medium Chips	NA	NA	618.91	NA	NA
	177.1		117.1	162.1	152.4	158.2	Volclay Bent.	152.4	Volclay	140.66	161.79	
LMW-1	582.14	10-20 CSSI	642.14	597.14	606.84	601.04	Medium Chips	606.84	Grout	618.58	597.45	NA
	38.9		22.9	27.9	16.7	27.9	Volclay Bent.	16.7	Volclay	3.89	27.64	
LMW-2	572.89	10-20 CSSI	588.89	583.89	595.09	583.89	Medium Chips	595.09	Grout	607.9	584.15	NA
	69		44.8	49.8	42.2	47.1	Bentonite	42.2	Cement	8.84	49.33	39.33
LMW-3	581.84	10-20 CSSI	606.04	601.04	608.64	603.74	Grout	608.64	5% Bent.	642	601.51	611.51
	188.88		176.50	195.27	169.14	188.88	Pure Gold	169.14	Volclay	5.40	197.34	187.34
LMW-4	424.57	10-20 CSSI	436.95	418.18	444.31	424.57	Bentonite	444.31	Grout	608.05	416.11	426.11
	241.8	10-20 CSSI	206.7	231.8	201.7	212.4	Volclay Bent.	201.7	Volclay/Bent.	10.14	232.11	222.11
LMW-5	371.65	pre-packed	445.19	420.09	450.19	439.49	Medium Chips	450.19	Grout	641.75	419.78	429.78
	105.9		94.9	90.9	77.4	82.5	Volclay Bent.	77.4	Volclay	18.94	91.22	81.22
LMW-6	520.12	10-20 CSSI	531.12	535.12	548.62	543.52	Medium Chips	548.62	Grout	607.08	534.8	544.8
			202.00	239.62	171.96	194.05	Bentonite	171.96	Volclay	216.07	242.44	
LMW-7	NA	NA	563.05	525.43	593.09	571.00	Grout	593.09	Grout	551.61	522.61	NA

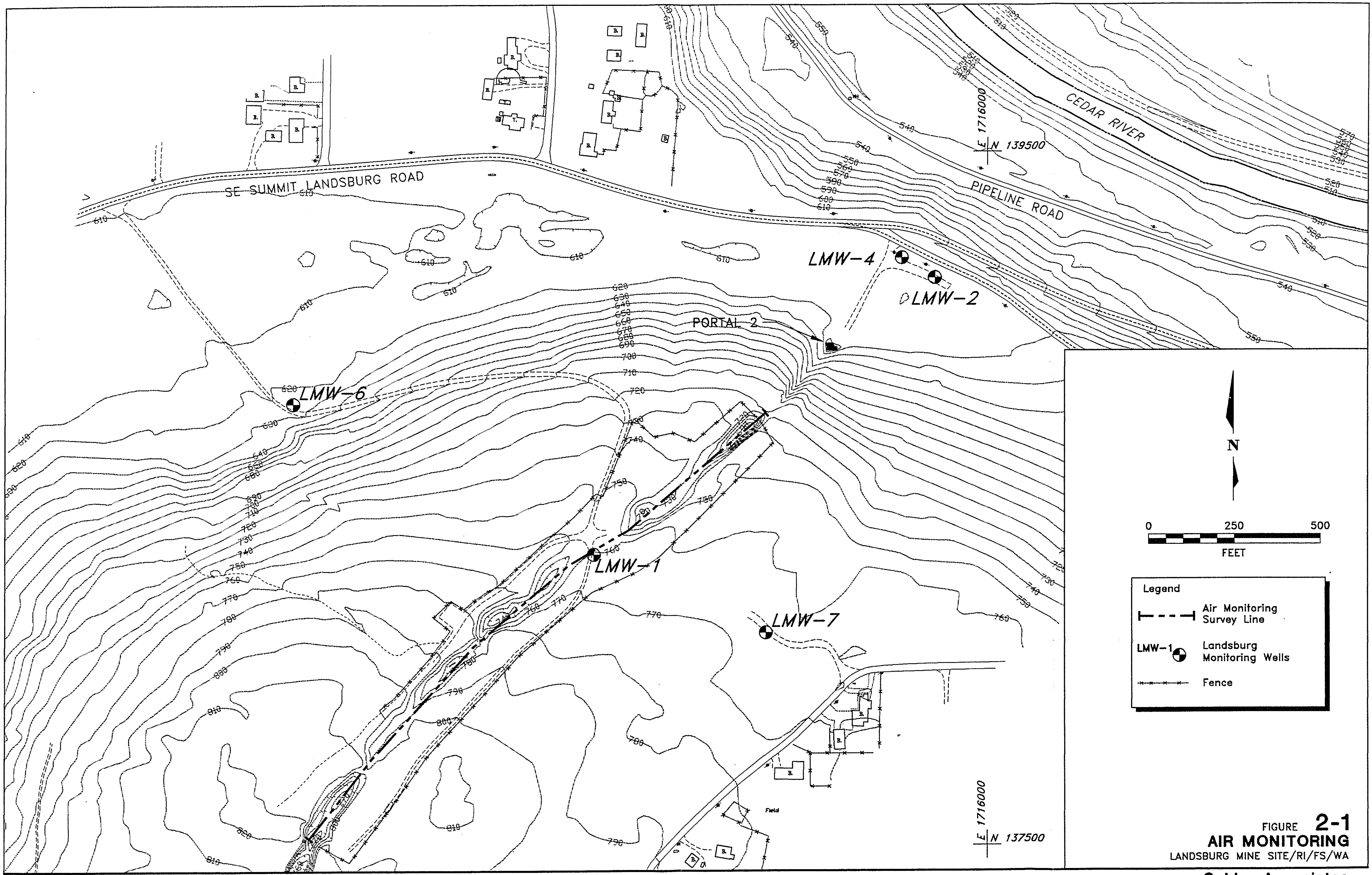


FIGURE **2-1**

AIR MONITORING

LANDSBURG MINE SITE/RI/FS/WA

C:\JPM\9231000\147\57167 5-24-95 8:26

Golder Associates

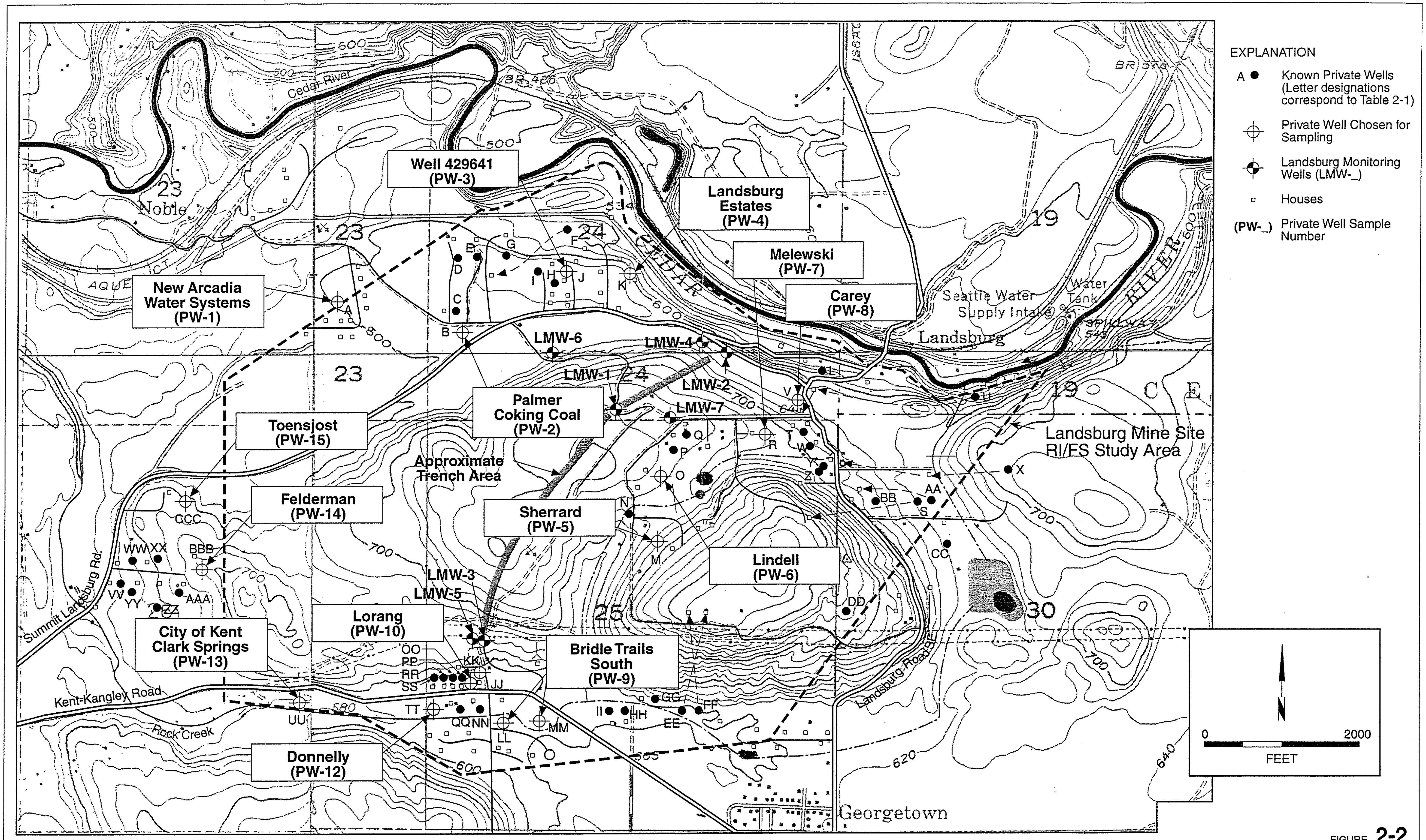


FIGURE **2-2**

PRIVATE WELL LOCATIONS

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 50655 DATE 5/11/95 DRAWN BY CB

Golder Associates

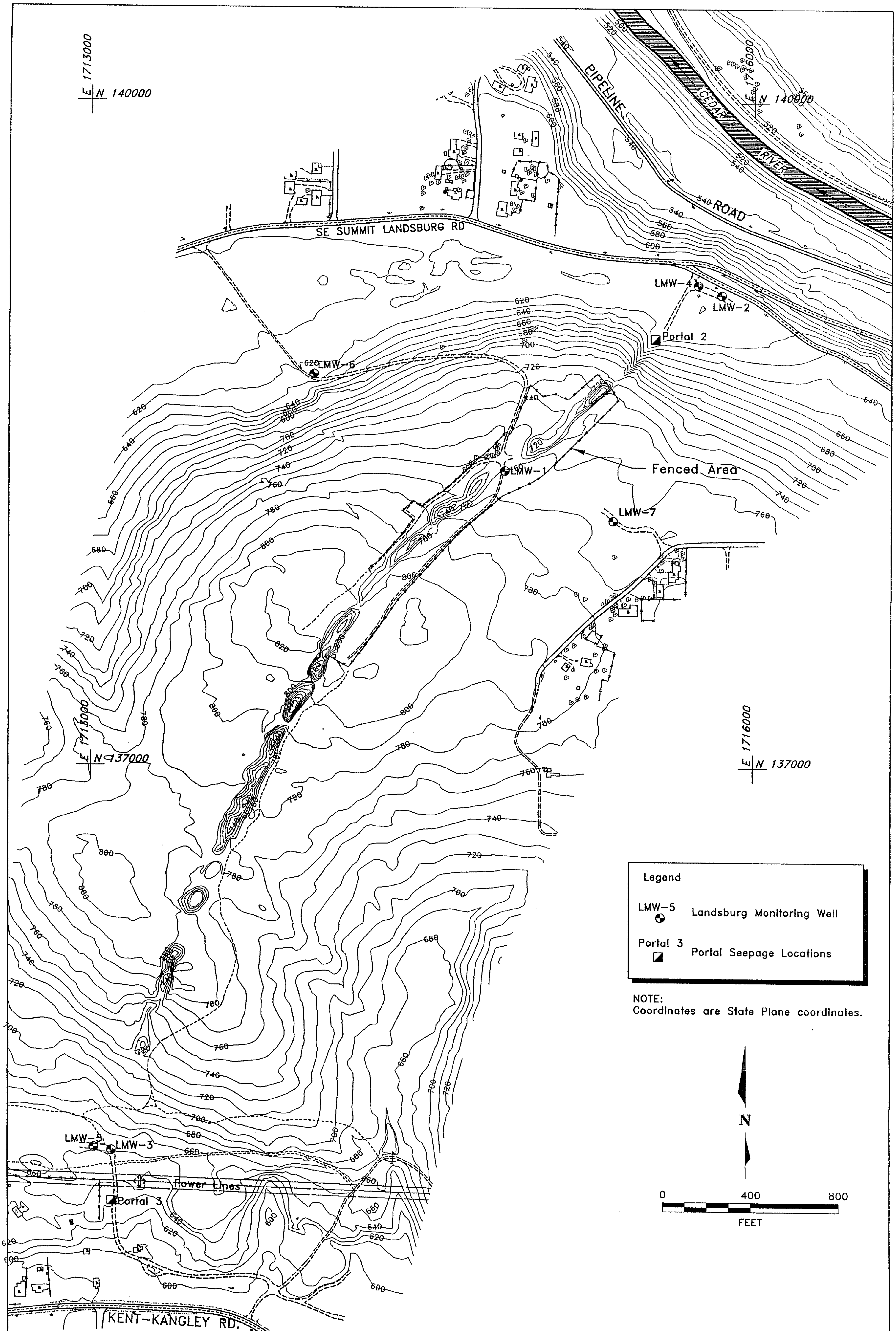


FIGURE 2-3

MONITORING WELL AND PORTAL LOCATIONS

LANDSBURG MINE SITE/RI/FS/WA

C:\DPT\9231000\147\57166 8-28-95 10:00

Golder Associates

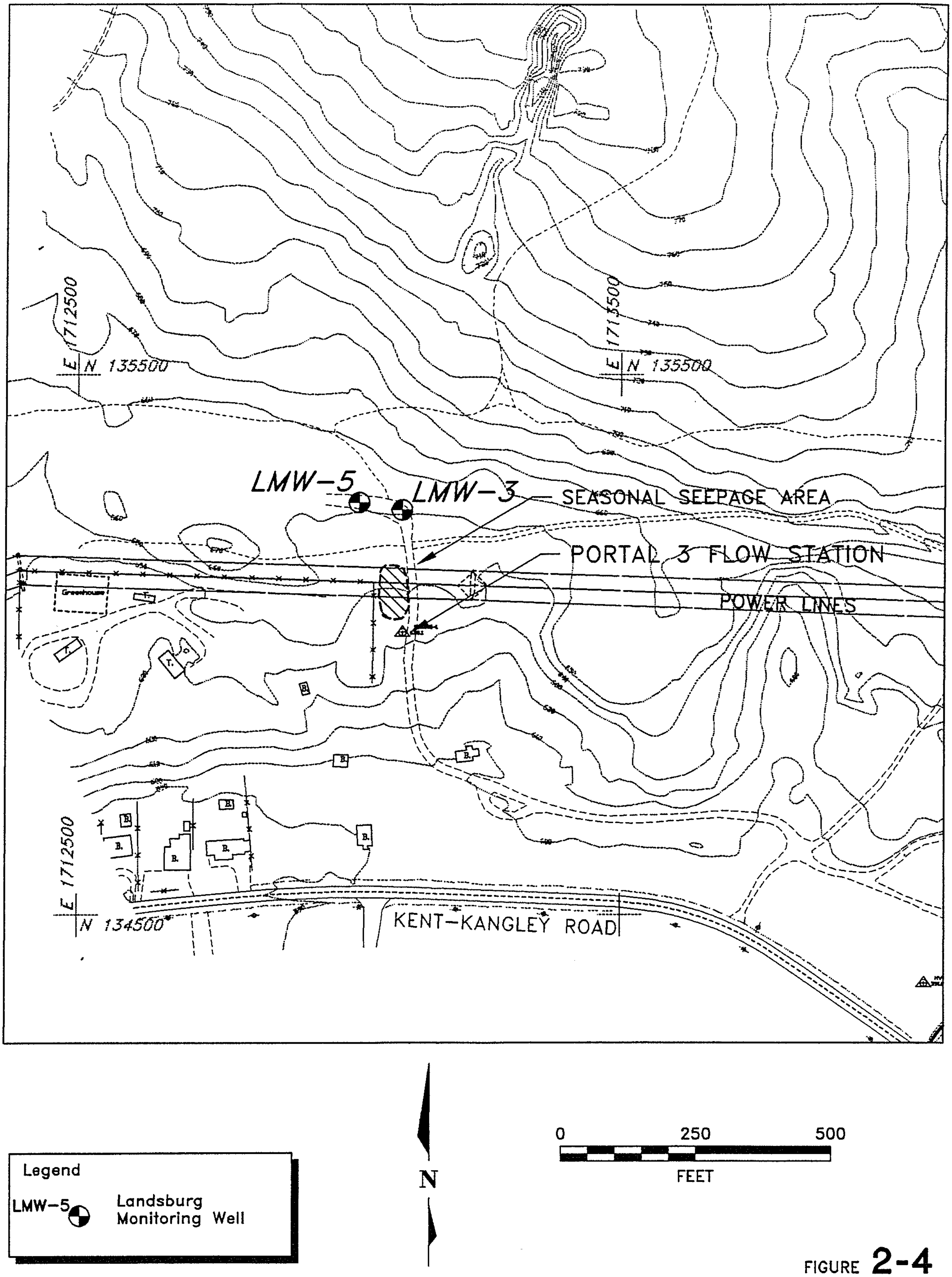


FIGURE **2-4**

PORTAL 3 FLOW STATION

LANDSBURG MINE SITE/RI/FS/WA

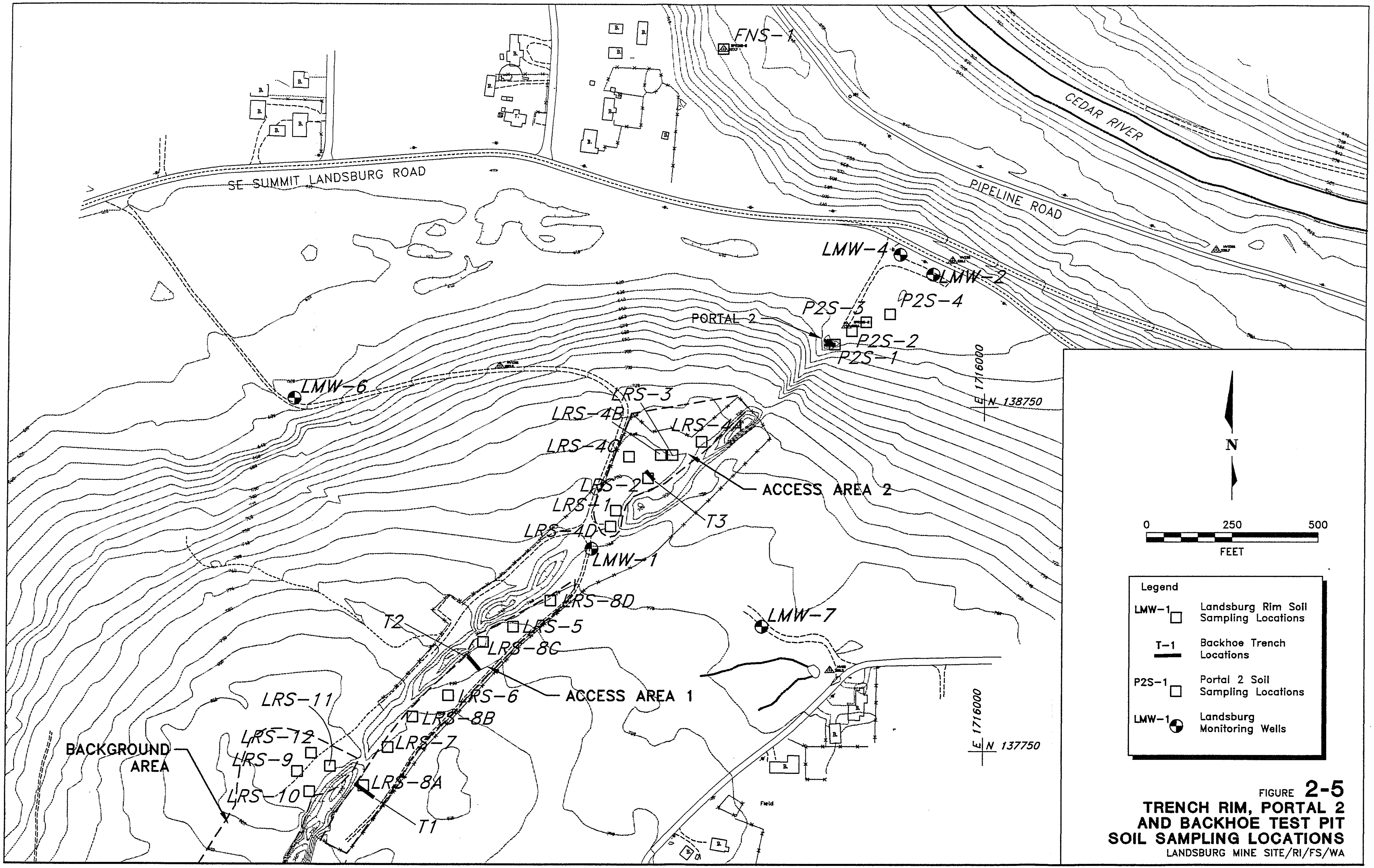


FIGURE **2-5**
TRENCH RIM, PORTAL 2 AND BACKHOE TEST PIT SOIL SAMPLING LOCATIONS
LANDSBURG MINE SITE/RI/FS/WA

C:\DPT\9231000\147\57164 8-28-95 10:24

Golder Associates

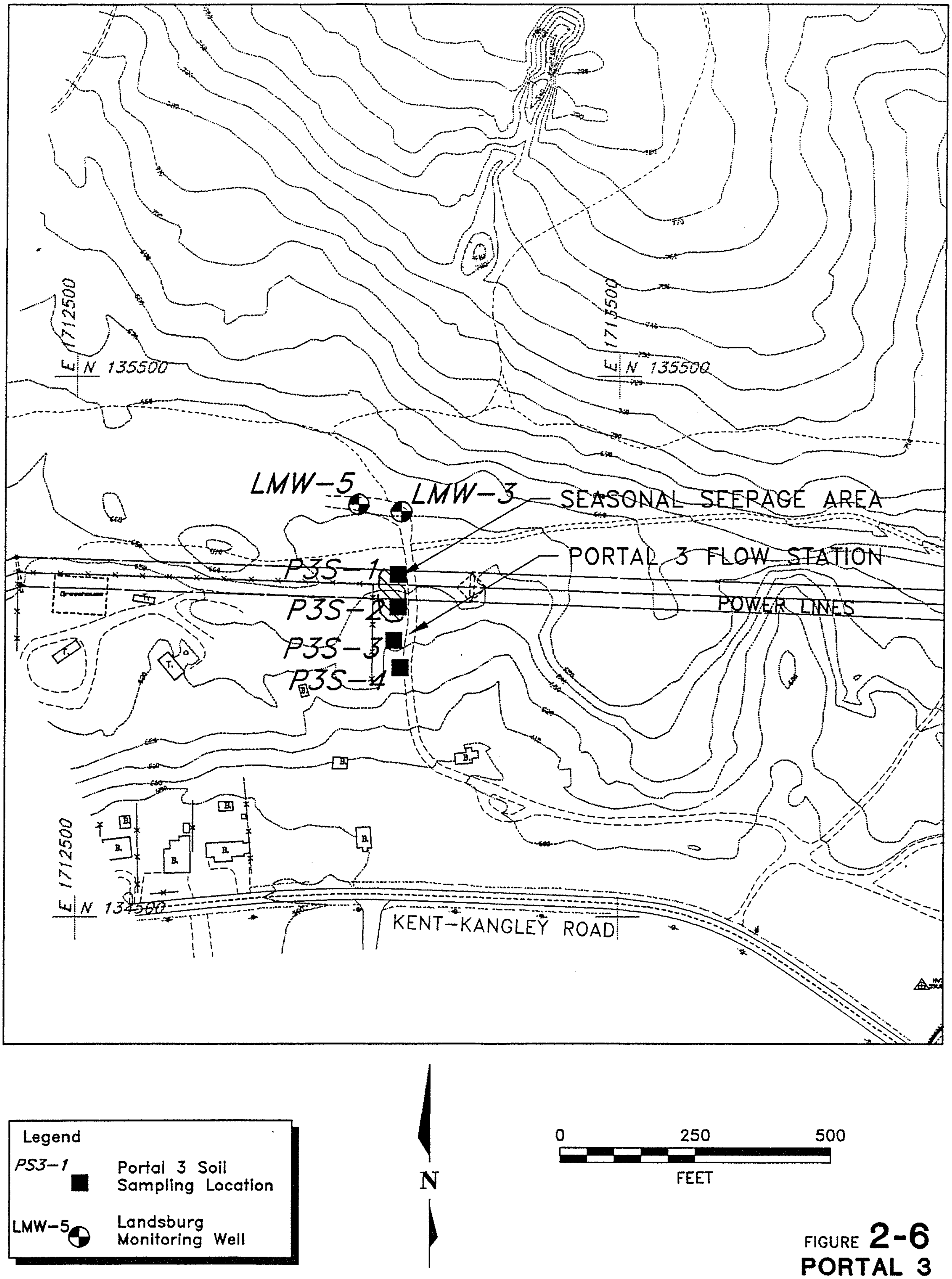


FIGURE **2-6**

PORTAL 3

SOIL SAMPLING LOCATIONS

LANDSBURG MINE SITE/RI/FS/WA

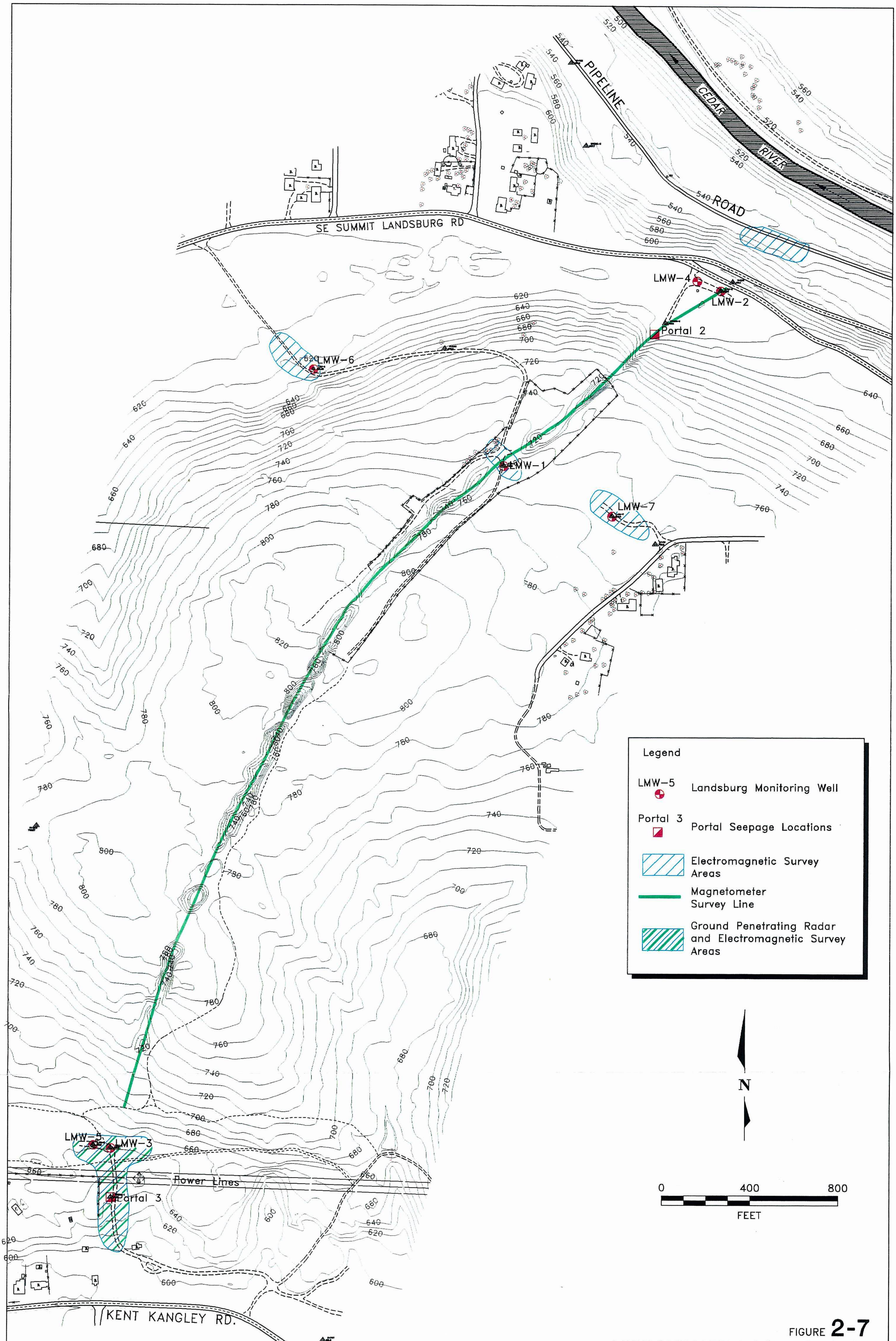


FIGURE **2-7**

APPROXIMATE LOCATIONS OF GEOPHYSICAL SURVEYS

LANDSBURG MINE SITE/RI/FS/WA

C:\DPT\9231000\147\57163 DATE 8-28-95 9:40

Golder Associates

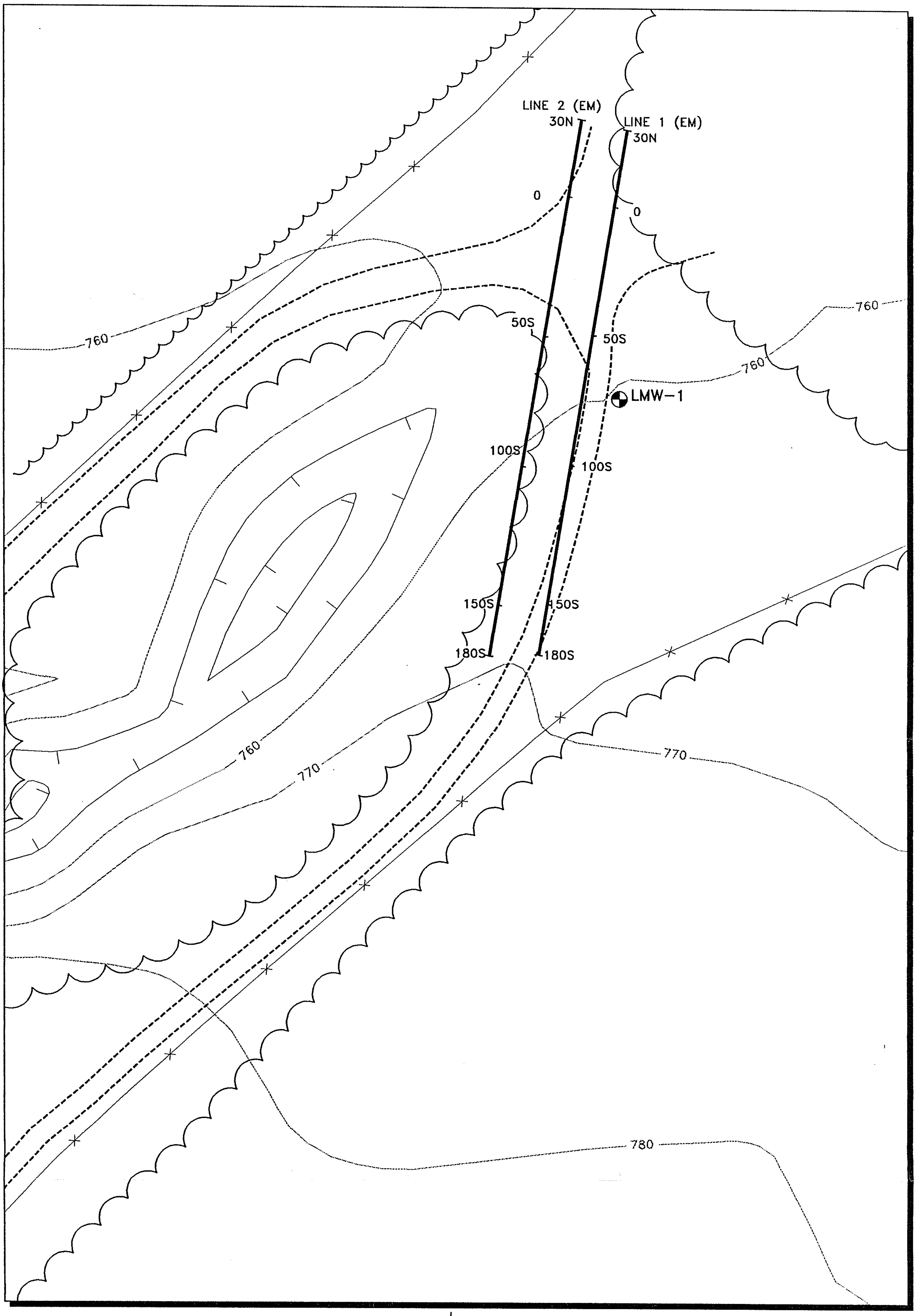


FIGURE **2-8**

LOCATION OF GEOPHYSICAL SURVEY LINES IN THE VICINITY OF LMW-1

LANDSBURG MINE SITE/RI/FS/WA

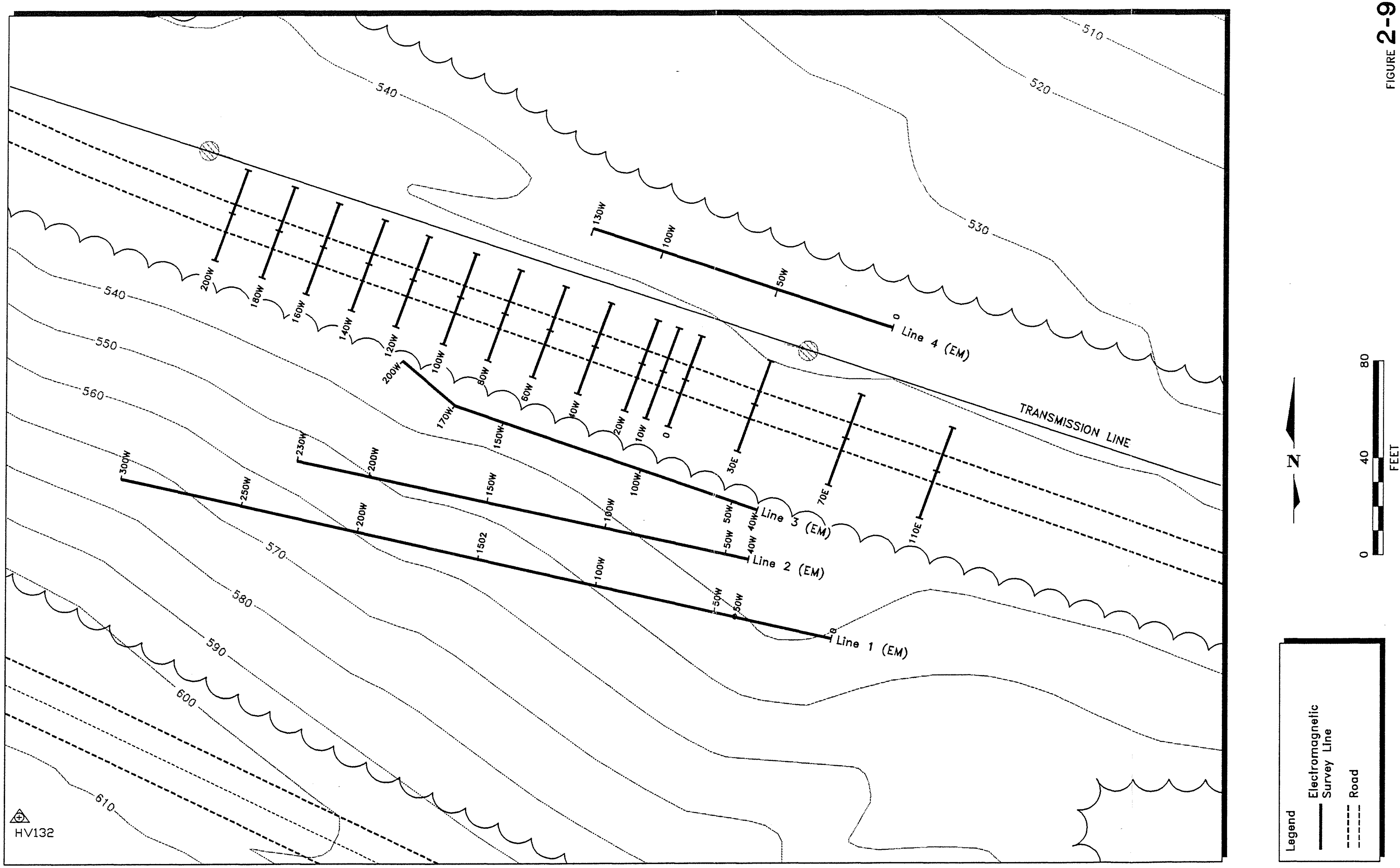


FIGURE 2-9

LOCATION OF GEOPHYSICAL SURVEY LINES NORTH OF LMW-2 AND LMW-4 BY CEDAR RIVER

LANDSBURG MINE SITE/RI/FS/WA

Golder Associates

DWG ID: C:\CAD_4\9231000\147\5715 DATE 5-12-95 16:52 DRAWN DH

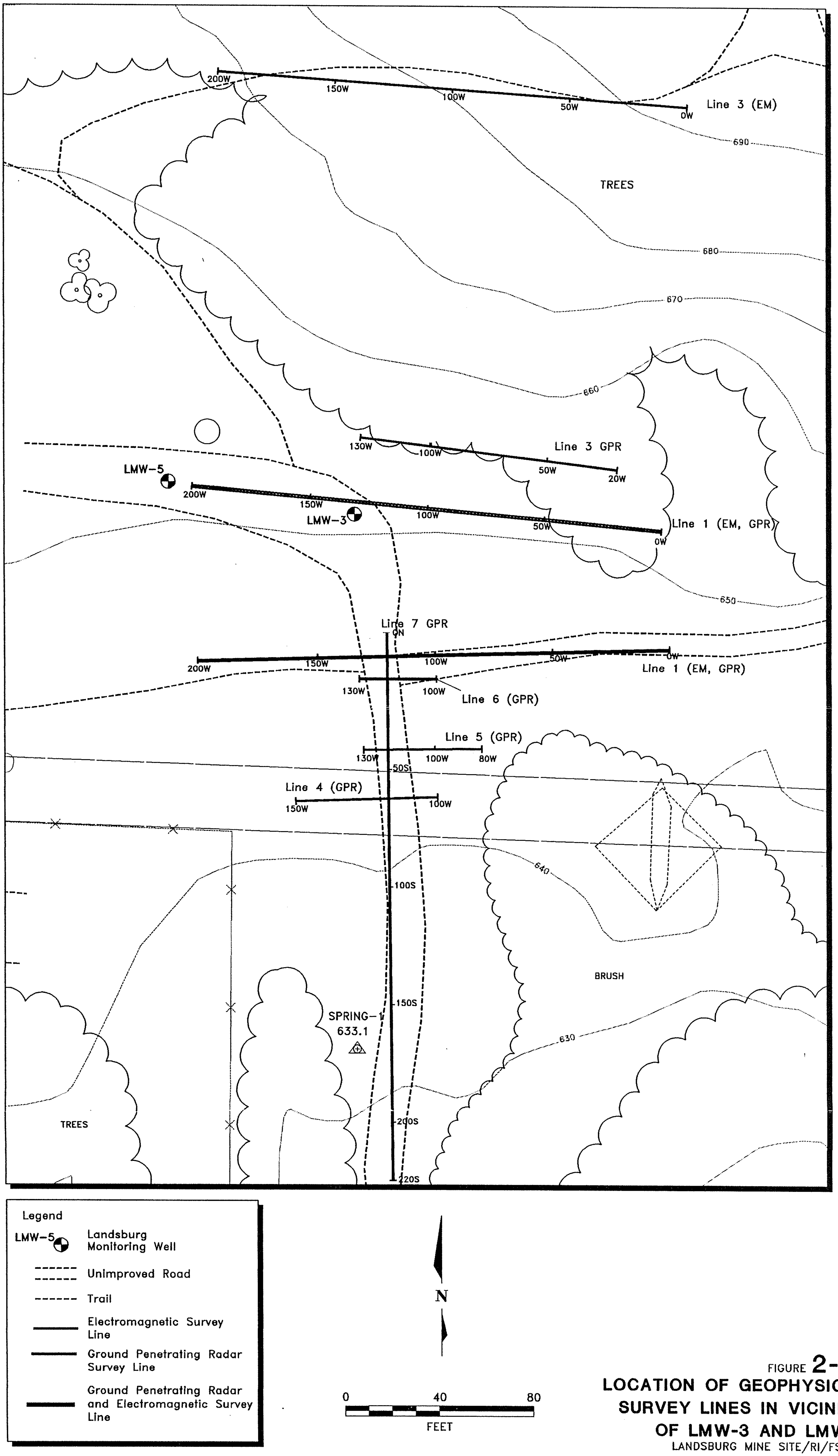


FIGURE **2-10**

LOCATION OF GEOPHYSICAL SURVEY LINES IN VICINITY OF LMW-3 AND LMW-5

LANDSBURG MINE SITE/RI/FS/WA

DWG ID: \DJH\9231000\147\57159 DATE 3-6-95 17:54

Golder Associates

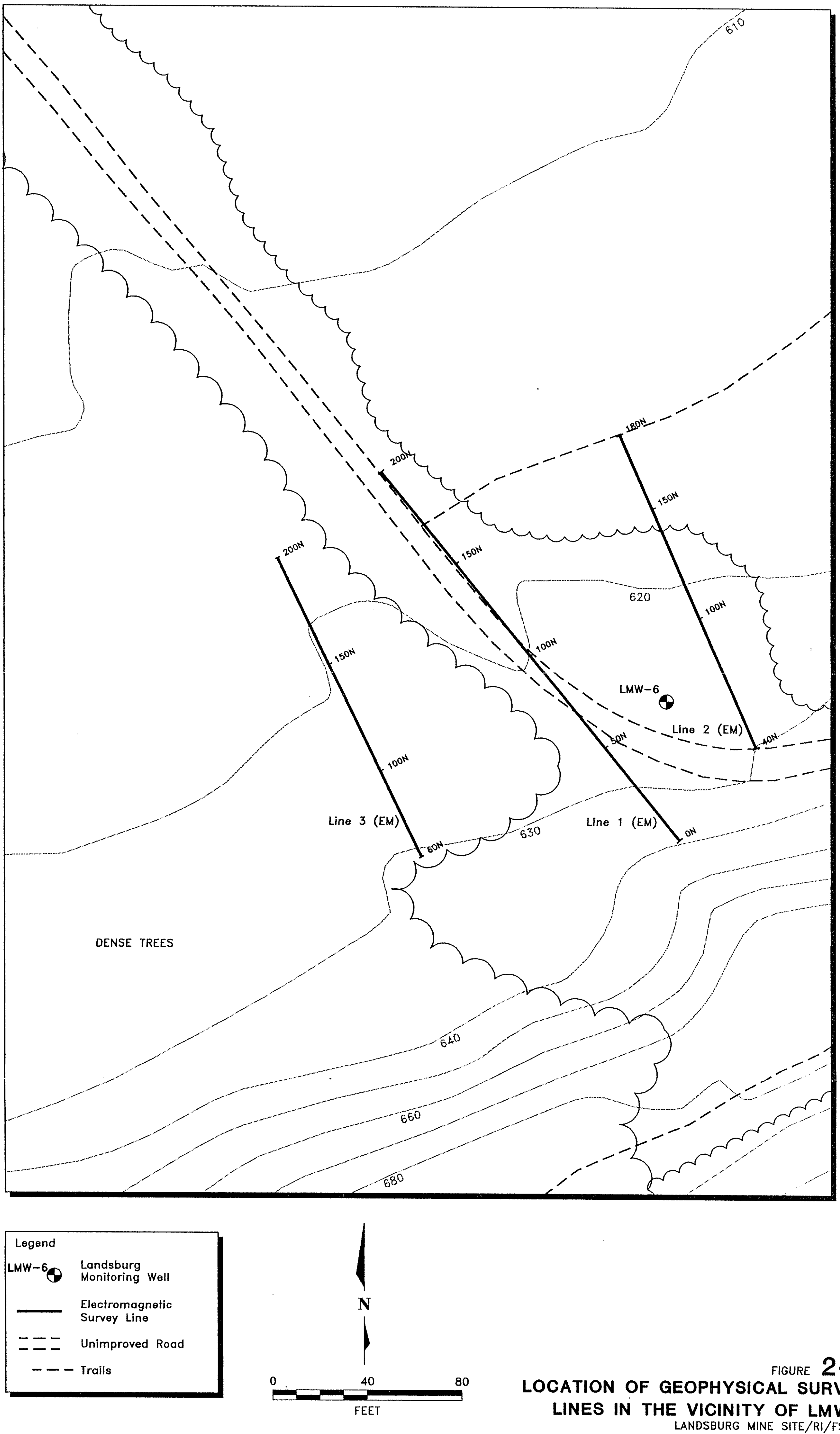


FIGURE **2-11**

LOCATION OF GEOPHYSICAL SURVEY LINES IN THE VICINITY OF LMW-6

LANDSBURG MINE SITE/RI/FS/WA

\DJH\9231000\147\57160 3-6-95 17:04

Golder Associates

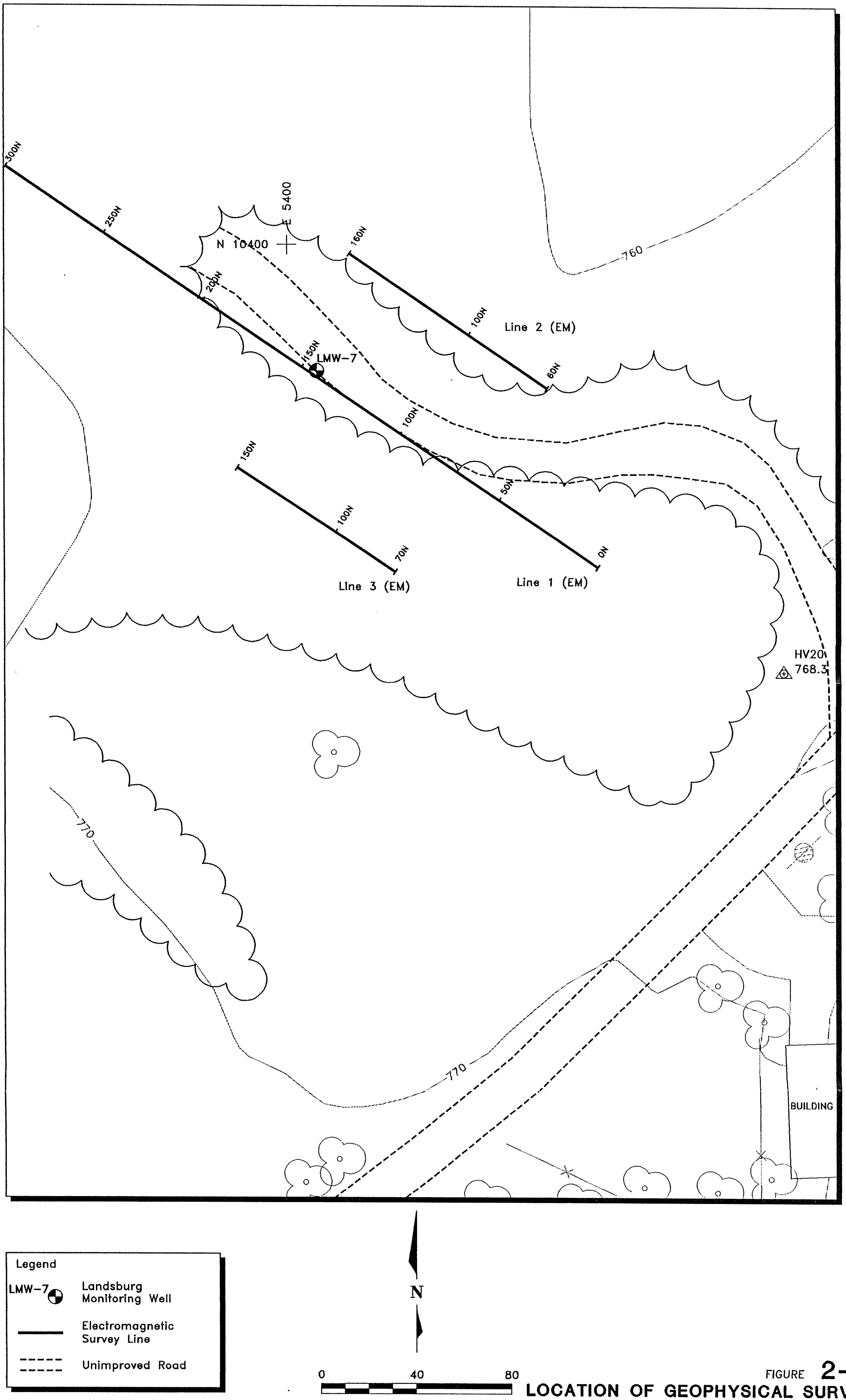


FIGURE **2-12**

LOCATION OF GEOPHYSICAL SURVEY LINES IN THE VICINITY OF LMW-7

LANDSBURG MINE SITE/RI/FS/WA

C:\CAD_4\9231000\147\57161 5-12-95 16:56

Golder Associates

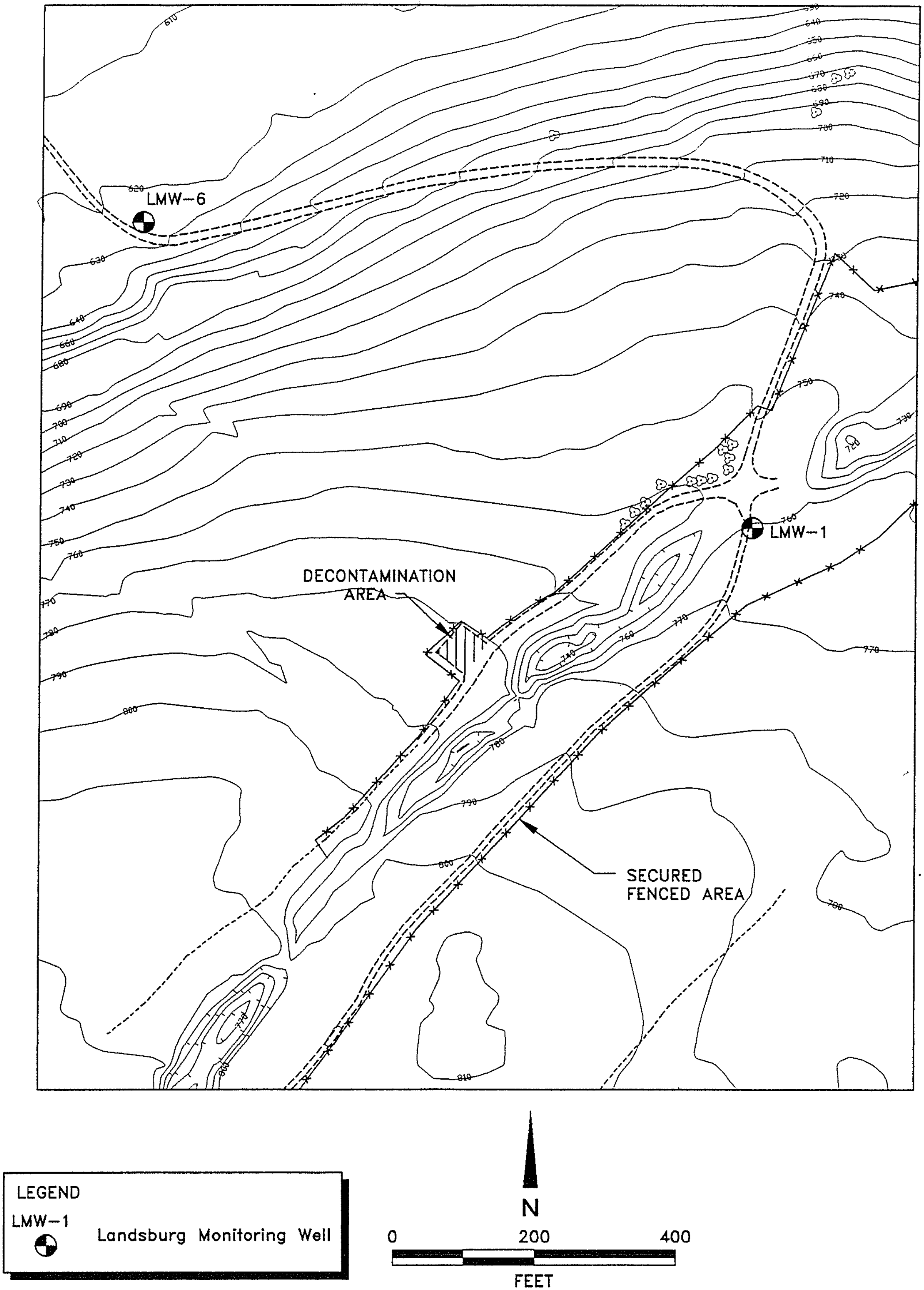


FIGURE **2-13**

DECONTAMINATION AREA

LANDSBURG MINE SITE/RI/FS/WA

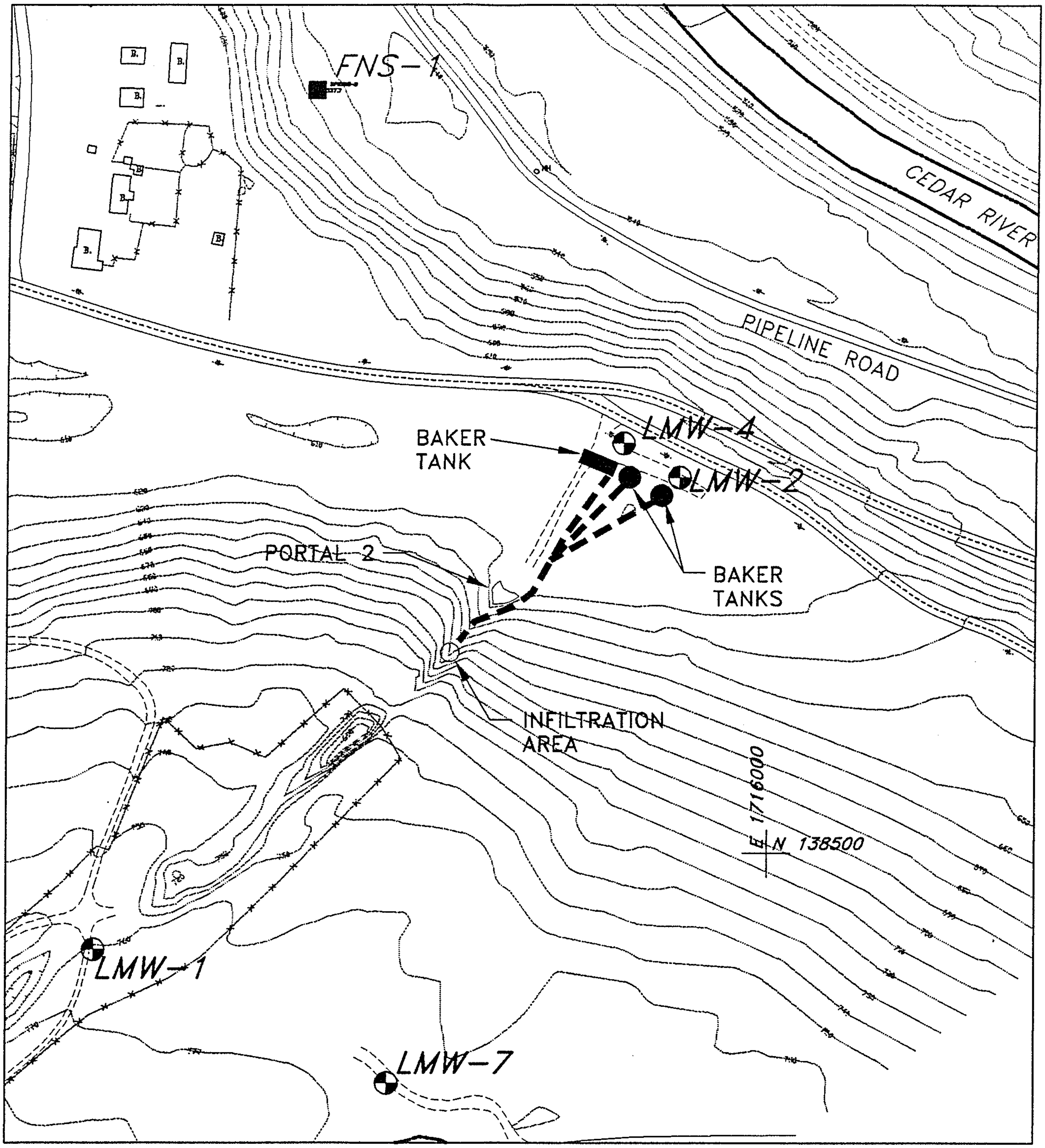


FIGURE **2-14**

GROUNDWATER DISPOSAL LOCATION AT NORTH END OF TRENCH

LANDSBURG MINE SITE/RI/FS/WA

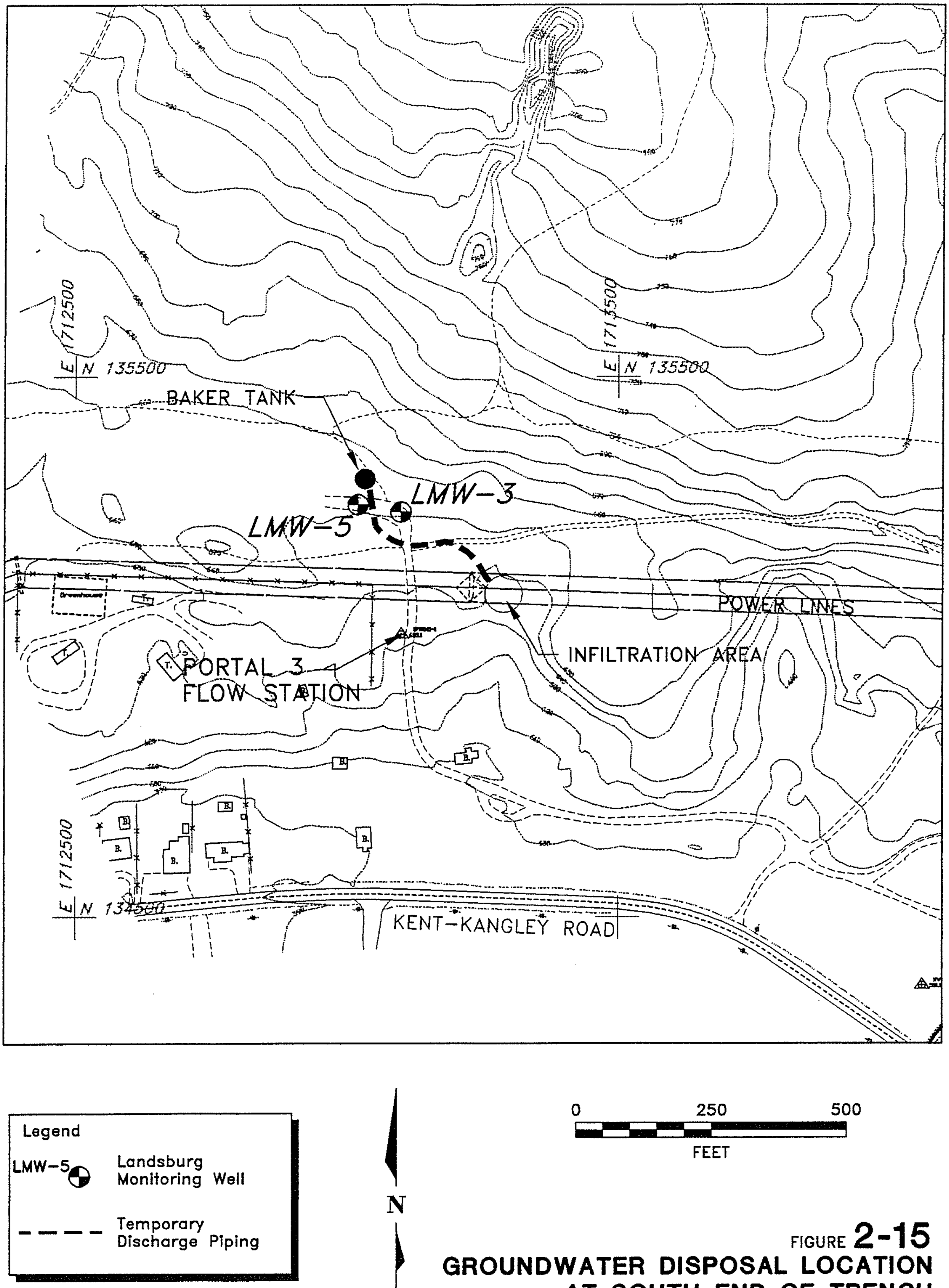


FIGURE **2-15**

GROUNDWATER DISPOSAL LOCATION AT SOUTH END OF TRENCH

LANDSBURG MINE SITE/RI/FS/WA

Scale: 1"≠ 650'

Source: Walker and Associates. Photos taken 3-9-94.

FIGURE **2-16**

AERIAL PHOTO OF SITE

LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 54212 DATE 3/17/95 DRAWN BY TK

Golder Associates

3. SITE PHYSICAL DESCRIPTION

This chapter provides a description of the relevant physical, ecological and social characteristics of the Landsburg Mine site and Study Area. Descriptions are presented of the site location and topography, waste source characteristics, geology, mine history and condition, surface water hydrology, hydrogeology, meteorology, social characteristics and ecology.

3.1 Site Location And Topography

The Landsburg Mine site consists of a former underground coal mine located approximately 1.5 miles northwest of Ravensdale in a rural area of southeast King County, Washington. The site is situated directly south and east of the S.E. Summit-Landsburg Road and north of the Kent-Kangley Rd (State Highway 516). Downtown Seattle is approximately 20 miles to the northwest. The Cedar River passes within approximately 500 ft of the site to the north. The location of the site is shown in Figures 1-1, 1-2 and 1-3. The topography of the site and general site features are depicted in Figure 3-1. An aerial image of the site is shown in Figure 2-16.

The mine site occupies property owned by Palmer Coking Coal Company (PCC) and Plum Creek Timber Company, L.P. and is located within sections 24 and 25, Township 22 N., Range 6 E. Figure 1-4 depicts the PCC and Plum Creek Timber property boundaries at the site. The site is located in the northwest corner of the Cumberland 7.5 minute quadrangle along the boundary with the Hobart quadrangle.

The *Landsburg Mine site* was defined in the Work Plan (Golder 1992a) as land extending 400 feet on either side of the mine trench lineation and bounded by the S.E. Summit-Landsburg Rd. to the north and the electrical transmission line easement to the south. A defined Study Area for the site, prescribed by Ecology for the purposes of this RI/FS, is depicted in Figure 1-2. In general, the Study Area was intended to include the area within an approximately one-half mile radius of the Rogers trench (Golder 1992a).

Apart from the Mine, the only development in the Study Area is residential with approximately 90 residences contained within the Study Area. The nearest residences to the site are to the southwest approximately 800 ft from the trench. Drinking water for area residences is supplied by groundwater, either through private wells or small community water supply systems. Domestic sewage disposal throughout the Study Area is provided by residential septic systems.

A dirt road accesses the property and trails run parallel to the east and west sides of the trench. The access road begins near S.E. Summit-Landsburg Road and follows along the northern portion of the trench. A locked gate secures the site at the access road entrance, and the portion of the trench where disposal occurred is currently enclosed by an 8 ft tall chain link security fence. Dense vegetation covers the site and includes blackberry, alder, cedar, hemlock, cottonwood, maple and fir.

The Landsburg Mine property sits atop a gently sloping hill which reaches a maximum elevation of approximately 800 ft mean sea level (MSL) near the central portion of the site. At the site's northern end (Figure 3-1), this hill slopes steeply downwards towards the S.E. Summit-Landsburg Rd. (elevation of approximately 615 ft) and continuing to the Cedar River (elevation approximately 500 ft). The southern portion of the site slopes more gradually downwards to the south toward the Kent-Kangley Rd. and Rock Creek drainage located at an elevation of approximately 600 ft. The site is bounded to the east by a somewhat larger hill which rises to a maximum elevation of approximately 940 ft.

Electrical transmission lines and a Bonneville Power Administration property easement cross the southern portion of the site in an east-west direction. Approximately 3/4 mile upstream of the site along the Cedar River at Landsburg, the City of Seattle Water Department maintains a drinking water supply intake known as the Landsburg Diversion. Water is conveyed from the intake through a 96-in diameter pipeline to the Lake Youngs Reservoir, located some 5 miles to the northwest of Landsburg (Brown and Caldwell 1978a). The pipeline passes just to the north of the site and is located near the bottom of the slope between the S.E. Summit-Landsburg Rd. and the Cedar River. An unpaved service road (Pipeline Road) parallels the pipeline right-of-way. A meteorologic data collection and river gaging station, operated by the City of Seattle, are located at the water intake structure. The location of the supply intake is shown in Figure 1-2. Pipeline Road is depicted in Figure 3-1. Approximately 1 mile upstream from the Landsburg Diversion on the Cedar River, a river gaging station is maintained by the USGS (Landsburg Gaging Station).

3.2 Source Characteristics

This section describes information regarding the characteristics of the wastes disposed in the Rogers trench. This information includes data reported in previous investigations as well as information gathered in this RI. Waste characterization activities conducted as part of this RI consisted of the Task 8 Geophysical Investigation described in Section 2.6.1.

3.2.1 Site Mining and Waste Disposal Activities

Palmer Coking Coal (PCC) operated an underground coal mine known as the Landsburg Mine from the late 1940s until approximately 1975. Mining was conducted in two adjacent coal seams: the Landsburg seam and the Rogers Seam. Mining began in the Landsburg seam in the late 1940s and continued until 1959. In 1959, mining of the Landsburg seam ceased and mining began on the Rogers Seam. The Rogers Seam was mined from 1959 until 1975 when all active mine openings were closed by blasting. In addition to these two coal seams, the Frasier seam, located some 800 ft to the north of the Rogers Seam, was mined intermittently from the 1800s to the mid-1940s. Figure 3-2 depicts the layout of the mines completed within the three seams.

The mined section of the Rogers coal seam has a near vertical dip and consists of coal and interbedded shale approximately 16 ft wide. The mined section is about a mile in length. Mining occurred at depths of up to 750 feet using a mining method locally called "booming" which followed the coal seam vertically. The reader is referred to Section 3.4 for a detailed history of mining at the site (specifically in the Rogers Seam) and a description of mining methods used.

As a result of underground mining at the site, a subsidence trench with near vertical walls developed on the land surface above the mine workings. The dimensions of the trench vary, from about 60 to 100 feet wide, between 20 to 70 feet deep, and about 3/4 mile long. The trench is not continuous along its whole length but is comprised of a series of separate subsided segments. Each trench section is separated by a pillar wall. Figure 3-3 depicts a topographic profile along the centerline of the mine trace.

Available information on the prior waste disposal activities at the site are summarized in Ecology and Environment (1991), Landsburg PLP Steering Committee (1991) and Golder (1992b) from which this discussion is based. Beginning in 1969, the trench over the Rogers Seam was used for the disposal of various waste materials, including industrial wastes, construction and land-clearing debris, tires and miscellaneous household garbage. Materials were disposed into the mine trench from the site access road indicated in Figure 3-1.

Industrial wastes were contained in drums or dumped directly from tanker trunks. Based on invoice records from Palmer Coking Coal Company, an estimated 4,500 drums of waste and about 200,000 gallons of oily waste water and sludges were disposed into the trench. Available documented interviews with waste haulers indicate that wastes included paint wastes, solvents, metal sludges and oily water and sludge (WDOE 1990). It is expected that many of the drums were only partially full. While disposal of materials into the trench continued intermittently until 1983, the last documented disposal of hazardous substances was in 1978, as described in the waste disposal summary below:

1969	Disposal of industrial wastes including drummed wastes and land clearing debris in the trench. The specific nature of the industrial wastes placed at the site is unknown (WDOE 1990).
Summer of 1971	Fires occurred in the trench on June 16 and 28, July 22, and August 2 and 3 (Office of the Zoning and Subdivision Examiner 1974).
August 16, 1971	The King County Department of Building and Land Development placed a stop work order on dumping operations due to the fires (WDOE 1971).
August 28, 1972	The King County Council approved, on recommendations of the Zoning and Subdivision Examiner, an unclassified use permit for Palmer for a period of 5 years (proposed ordinance number 71-631). This permit allowed disposal of stumps, brush, natural vegetation, and earth cover materials (WDOE 1972).
1972-1978	No evidence of industrial waste disposal activity.
May/June 1978	A complaint was filed with Ecology that on May 18, 1978, a double-unit tanker truck was observed entering the Mine property. As a result of the complaint, it was determined that approximately 30,000 gals of oily sludge had been disposed of in the trench in an operation which commenced in May 1978. Operations were halted in June 1978 by Ecology (WDOE 1990).

1983	The trench reportedly was being filled with demolition debris. Evidence of nonhazardous materials, including scrap lumber and construction debris, and old drums from previous activities were observed in the trench (Ecology and Environment 1984).

3.2.2 Previous Investigations

Investigations that provided waste, soil, soil gas, surface water, and groundwater analytical data have been conducted since 1990 and include the following:

- Surface Water Sampling at Landsburg Mine (Geraghty and Miller 1990).
- Soil Gas Survey Report, Old Landsburg Mine Site, Georgetown, Washington (Applied Geotechnology 1990).
- Private Well Sampling and Surface Water Sampling at Rogers #3 Portal - Landsburg Mine, Ravensdale, Washington (Washington State Department of Health 1992).
- Landsburg Mine Site Hazard Assessment (Ecology and Environment 1991).
- Landsburg Mine Drum Removal Project (Landsburg PLP Steering Committee 1991).

Sampling of surface water discharging from Rogers Mine portals #2 and #3 on January 10 and 18, 1990 (Geraghty and Miller 1990) did not reveal any priority pollutant organic compounds or metals, except zinc at 210 $\mu g/L$ and arsenic at 6 $\mu g/L$. The zinc was reported to exceed a Washington State Surface Water Quality Standard of about 0.1 mg/l. At the time of the investigation, there was no State surface water quality criteria for arsenic. The occurrence of the zinc and the arsenic, however, were both attributed in the report to natural background associated with coal deposits and coal mine drainage.

The soil gas survey conducted within the Rogers trench (Applied Geotechnology Inc. 1990) did not detect any priority pollutant volatile organic compounds. Positive readings on OVA-FID and OVA-PID field instruments were attributed to the occurrence of methane.

At the end of winter 1990, groundwater from nine private wells, the City of Kent, Clark Springs Well and the south portal (Rogers #3) were sampled and analyzed for priority pollutant organic compounds and metals (Washington State Department of Health 1992). The analytical results did not reveal any contamination above acceptable drinking water standards. Levels of metals detected were reported to be consistent with those for background water quality. The report concluded that the quality of the drinking water in the Mine area had not been adversely affected by Mine disposal activities.

Therefore, sampling of surface water, groundwater and soil gas during several investigations conducted in 1990 did not detect any contamination above naturally-occurring background levels. Due to continued concerns over potential environmental threats posed by the Mine, Ecology commissioned a Site Hazard Assessment (SHA) study in 1991 which was performed by Ecology and Environment. Ecology then requested potentially liable parties (PLPs) to perform an expedited response action (ERA) to remove surficial drums and secure the site from unauthorized access. These investigations conducted during 1991 did reveal the presence of contaminants above acceptable standards and also included the characterizations of contents within exposed drums. Observations and analytical results of these studies are summarized below.

3.2.2.1 Site Hazard Assessment

In 1991, Ecology and Environment, Inc. (E&E) conducted a Site Hazard Assessment (SHA) for the WDOE pursuant to Chapter 173-340-320 of the MTCA Cleanup Regulation. The SHA included two phases of field work: 1) a site reconnaissance and geophysical survey; and 2) limited drum, surface water and soil sampling and analysis. The second phase of work included the collection of 14 surface and subsurface soil samples from within the trench, surface water samples from 2 ponds, and liquids sampling from three exposed drums. Samples were analyzed for volatile organic compounds, semi-volatile organics, pesticides/PCBs, and cyanide. The locations of the sampling conducted as part of the SHA are indicated in Figure 3-4.

Visual reconnaissance and geophysical surveys indicated that waste material appeared to be confined to the northern half of the trench in three areas (A, B and C) separated by pillar walls. The three sections are shown in Figure 3-4. In these sections of the trench, personnel observed fill areas which were covered by soils along much of the trench floor and sidewalls. These fill areas resulted from past disposal activities, which usually included covering the waste periodically with soil. Native soil generally was bulldozed over the trench edge to cover the waste material. The thickness of introduced fill and naturally eroded soils is unknown.

The waste materials appeared to consist of construction waste (wood and scrap metal), as well as drums containing various organic and inorganic constituents. A major group of approximately 50 exposed drums was observed in Section B (Figure 3-4) and other smaller groupings of drums were noted throughout trench sections B and C. Inspectors noted drum deterioration, bullet holes and liquids/solids within some of the accessible drums. Magnetometer survey results indicated a high likelihood of buried metal (possibly drums) in Section C. Two areas of ponded water were also observed within the trench area both in the vicinity of the exposed drums.

The three drums sampled indicated the presence of concentrated metals, cyanide, VOCs, semivolatile organics and PCBs. These contents indicated the potential for classification of the drum materials as Extremely Hazardous Waste (EHW) or Dangerous Waste (DW) according to Chapter 173-303 WAC. Soil and surface water sampling conducted along the entire length of the trench indicated that, in general, contamination was not found except near a group of drums visible in Section C (sample LS-8) and Section B (LDS-1). MTCA Method B cleanup levels for soil were exceeded at these locations for chromium, lead, bis(2-ethylhexyl)phthalate, and PCBs.

Soil chemical data collected as part of the SHA are presented further in Chapter 5 and incorporated into the overall data evaluation performed as part of this RI.

3.2.2.2 Expedited Response Action

During August and September 1991, the Landsburg PLP Steering Committee conducted an expedited response action to remove surficial drums from the Landsburg Mine site. A total of 116 drums were removed during this action. In addition, sampling and analysis was conducted on drum contents, and on oily sludges from a so-called "sludge pond" north of the trench cross-over road.

Drum Removal

Drums were removed from two areas of the site, as shown on Figure 3-5: "Area 1a" and "Area 2". Area 1, which includes Areas 1a and 1b, corresponds to Section B of the SHA, and Area 2 corresponds to Section C. The SHA identified two areas containing drums in Section B (Area 1). One of these was designated as Area 1a in the drum removal project. However, drums were not found in the second area, which was designated 1b. Area 1b did contain a number of separate fill areas.

At Area 1a, drums were located in a pile starting about 25 to 30 feet below the east rim of the trench and extending down slope 40 to 45 feet. Drums were piled 2 to 5 high and had bullet holes and punctures in the upper layers with many of the drums in the lower layers crushed or deformed. A total of 103 drums were removed from this area. Ten of these were reportedly empty or contained some residues. About 10% of the drums were reported to contain liquids with the rest containing solids and sludgy solids.

Thirteen drums were removed from Area 2. Eleven of these were located around a "sludge pond" area. Ten of these drums were open top without lids and were lying on their sides with some of the contents spilled onto the ground. One of the drums had a ruptured bung type lid. Two additional bung type drums were removed from a stump pile of logging and construction debris located on the northwest bank of the trench just north of the pond area. One of these drums was empty and the other contained green solids. During removal of these drums, ten additional drums were observed mixed in with stump pile debris. These drums were left in place. All the drums in Area 2 had multiple bullet holes or punctures.

Drums were overpacked into 85 gallon drums for removal. Spilled contents were also removed and placed in the overpack drum. If large amounts of liquids were present in the drums, the liquids were transferred to new drums and removed. About 10% of the drums from area 1a were placed in 1 cubic yard bulk bags because they were too crushed or deformed to fit into the overpack drums.

Drum sampling was conducted to classify and characterize the wastes and prepare waste profiles required by the RCRA treatment, storage and disposal facilities where the waste was sent. Only screening level analysis was conducted to determine physical properties and presence of specific regulated substances. Samples were generally composited for screening analysis for:

- physical characteristics - specific gravity, % free liquids, pH, flash point
- oxidizers
- chlorinated compounds
- hexavalent chrome
- cyanides
- sulfides
- phenolics
- PCBs
- total cadmium, chromium and lead

Wastes in the drums were solids, solid/liquid mixtures, sludges or semi-solids. Some of the drums contained free liquids (1 to 50%) and some were burnable. Some of the wastes tested positive for hexavalent chromium, phenolics, chlorinated compounds, and oxidizers. Cyanides and sulfides were not detected. PCBs were detected in 6 of 12 composite samples tested. Concentrations of PCBs were greater than 100 mg/kg in four of the composite samples. Relatively low levels of total cadmium were detected ranging from less than 0.83 to 22 mg/kg. Chromium levels ranged from 62 to 4,900 mg/kg. Lead ranged from 1,000 to 16,000 mg/kg.

Based on these screening level analyses the wastes in the drums have the potential to be classified as DW or EHW for a variety of waste codes. Potential waste designations pursuant to WAC 173-303 include:

- Ignitable (D001) based on flash point and presence of oxidizers,
- Persistent (WP01 or WP02) based on presence of chlorinated compounds
- Toxic Characteristic for chromium (D007) and lead (D008)

This type of screening level analysis is not comprehensive enough to identify all potential dangerous waste codes or for complete comparison with MTCA cleanup standards. However, based on the results, wastes did exceed MTCA Method B cleanup levels for soils in at least some samples for cadmium, chromium, lead and PCBs.

Pond Sludge Sampling

The pond in Area 1A is an area of soft oily sludge and water about 24 feet in diameter (Figure 3-5). The PLP contractor reported the sludge material in the pond appeared to be paint waste, petroleum products, and resins. They observed different multicolored layers in the material, possibly representing different periods of dumping the various wastes. The depth of the material was estimated to be about 4 feet with a total volume estimate of between 65 and 70 cubic yards.

The PLP contractor collected four samples from the pond sludge, using a hand auger, which were combined into one composite for analysis. The samples were collected at 1 foot, 2 foot, 3 foot and 4 foot depths. They observed a 1 to 2 second spike of 500 to 700 ppm on an organic vapor analyzer (OVA) when the soil was disturbed.

The PLP contractor reported detecting the following VOCs in the pond sludge; methylene chloride (1,690 ppm), trichlorofluoromethane (299 ppm), 1,1,2-trichlorotrifluoroethane (216 ppm), 1,1,1-trichloroethane (317 ppm), trichloroethene (1,530 ppm), toluene (141 ppm), ethylbenzene (270 ppm), and total xylenes (1,320 ppm). In addition, the sludge contained 67,000 ppm total petroleum hydrocarbons (TPH), and 4.9 ppm of PCBs (Arochlor 1254). Analysis for RCRA TCLP metals was reportedly negative except for lead. The PLP contractor report indicated detecting lead at 0.84 ppm. It is unclear from their report whether this was a total metals analysis measured in mg/kg, or a leach procedure measured in mg/L. In either case the concentration detected is less than the DW designation limit for lead of 5 mg/L.

Golder (1992b) reported that concentrations of methylene chloride, trichlorethene and PCBs detected in the pond sludge exceed MTCA Method B soil cleanup levels. For TPH, the concentration detected in the sludge exceeds the Method A number for TPH (other) of 200 mg/kg, which is based on protection of groundwater. Ethylbenzene, toluene and xylenes would also exceed the soil cleanup standards based on 100 times the groundwater cleanup standards.

Chemical data for the pond sludge are presented further in Chapter 5 and incorporated into the overall chemical data evaluation performed as part of this RI.

3.2.3 Results of the Rogers Trench Geophysical Survey

As described in Section 2.6.1, a magnetometer survey was performed as part of this RI along the central axis of the Rogers Seam from north of the mine yard at Highway 516 to the S.E. Summit-Landsburg Rd. The location of the survey is shown in Figure 2-7. This survey was performed to identify areas along the seam that may contain ferrous metallic debris. This ferrous debris would potentially include drums or other metallic objects associated with prior waste disposal.

Total field data for the top and bottom sensor, and the vertical gradient data were plotted in profile form. The anomalous zones for each of these data were in general agreement. There is a greater variation, however, in the baseline values of the total field data compared to the vertical gradient data. This variability is interpreted as the effects of topography and diurnal variations on the total field that do not effect the vertical gradient. For this reason, the vertical gradient is considered a more reliable indicator of debris locations. The vertical gradient data are therefore shown in Figure 3-6 and used for the following interpretations. Figure 3-6 shows the vertical gradient data superimposed on a site base sheet. Annotations made by the field operators are indicated on the figure to assist in data interpretation.

The vertical gradient profile shown in Figure 3-6 can be divided into two zones. One zone from 0+00 to 23+80 is relatively free of anomalies while a second zone from 23+80 to the end of the profile contains many anomalies. Anomolies are interpreted to represent possible waste sources (i.e. drums). This is consistent with the current understanding of the waste disposal history at the site in which dumping is believed to have been confined to the northern portion of the trench.

Zone 1

Within the first zone, from about 00+00 to 11+00, the vertical gradient is relatively constant with only minor variations about zero. Based on this response and the absence of any surface debris, this area is interpreted to be free of ferrous metallic debris.

A small anomaly at approximately 11+00 is located at the base of one of the surface depressions with no visible surface debris. Because the anomaly is only one reading with small magnitude, it is not considered a significant concentration of debris.

From about 12+10 to 16+00 a series of small to moderate anomolies exist. The largest reading is due to an old clothes dryer. Several small mounds and two tires with hubs were also identified. The anomolies are of low to moderate magnitude and can probably be accounted for by the small amount of domestic debris seen on the surface and a minor amount of additional debris at shallow depth.

Two small anomolies near 18+00 and 19+20 are due to the magnetometer sensors being within 5 ft of the rock wall at these locations. From these points to about 23+80 the vertical gradient shows no anomolies and this area is interpreted to be free of ferrous debris.

Zone 2

The area from about 23+80 to 29+00 contains a concentration of large magnitude anomolies. Within this area there is various domestic and demolition debris (e.g. domestic garbage, refrigerator, sheet metal, wood debris) visible on the surface. Based on the high density and magnitude of the anomolies, there is probably a significant concentration of ferrous debris located below the surface. This area corresponds approximately to the "Area 1b" designated in the drum removal project report (Landsburg PLP Steering Committee 1991). A large anomoly from 30+30 to 31+30 corresponds to a backfilled saddle in the surface depression. In addition, the east edge of the surface depression from 31+00 to 31+30 has the appearance of a ramp used for dumping. The surficial evidence and the large magnitude of the magnetic anomolies suggest a significant concentration of ferrous debris.

A single point anomoly with a large magnitude is seen at about 33+00. This reading represents the only reading obtained near the base of a dumping area that is now covered with a black plastic tarp. The area from about 32+40 to 33+00 was not accessible due to topography. The high gradient seen near 33+00 does suggest that ferrous objects probably do exist at the base of the black plastic tarp.

The area from about 33+20 to 37+00 contains no significant anomolies and is considered free of any detectable concentration of ferrous objects. A few household garbage bags and a pile of old tires were found but no metallic debris was observed in this area.

The area from about 37+00 to 40+70 contains a large number of high magnitude anomalies, including two drums in the vicinity of 37+70. Demolition debris, wood debris, and some small metallic objects were observed throughout the area. From about 38+80 to 40+70 the west side of the trench has been reworked and backfilled. The large concentration and magnitude of the magnetic anomolies and the evidence of the debris at the surface suggest there is probably a significant concentration of ferrous debris buried in this area of the trench. This area corresponds roughly to the "Area 2" designated in the drum removal project report (Landsburg PLP Steering Committee 1991).

The area from about 40+70 to 45+20 does not contain any anomolies and is considered free of any detectable concentrations of ferrous debris.

The area from about 45+20 to 48+50 contains several anomalies with moderate magnitude. This area covers the last surface depression before the S.E. Summit-Landsburg Rd. A small amount of domestic debris, including some metallic objects, was observed throughout the area and can probably account for some of the anomolies. The number of anomalies suggests there is possibly a moderate amount of additional ferrous debris below the ground surface. The probability of the debris being domestic refuse from the general public is greater due to the close proximity of this area to the S.E. Summit-Landsburg Rd. and the easy access to the area. In addition, the area was reportedly surface mined for coal due to the proximity of the coal to the surface in this area of the site. Mine spoils back-filled into the excavation may also account for the observed anomalies.

Therefore, the results of the magnetometer survey work performed in the trench appear to confirm the prior understanding regarding the locations of potential waste materials in the trench. Dumping does not appear to have occurred in the southern half of the trench consistent with observations made in Ecology and Environment (1991) and Landsburg PLP Steering Committee (1991). In the northern half, there is the possibility that additional waste materials occur at some depth beneath the base of the trench. These materials are located in the areas where dumping is thought to have taken place in the past, namely the Areas 1 and 2 designated in the drum removal work (Figure 3-5) (Landsburg PLP Steering Committee 1991) and areas A, B & C designated in the SHA (Figure 3-4)(E&E 1991). These areas which may potentially contain waste materials buried beneath the surface are depicted in Figure 3-6.

3.3 Geological Characteristics

This section describes the geologic characteristics of the site and region. The region consists of a loosely defined area encompassing the south-central portion of King Co. The regional geology is based primarily on geologic mapping of the Cumberland quadrangle (Gower and Wanek 1963) and the Hobart and Maple Valley quadrangles (Vine 1962), as well as work by Luzier (1969). Site specific details were obtained from mine records and plans obtained from Palmer Coking Coal Company, driller's logs of Study Area wells on file with Ecology, and the borehole drilling conducted as part of this RI. Figure 3-7 depicts the generalized surficial geology in the Study Area vicinity.

3.3.1 Regional Geology

The Landsburg Mine site Study Area is located along the eastern margin of the Puget Sound Lowland, a broad, gently rolling glacial drift plain whose surface is commonly about 400 to 600 ft above mean sea level. In the vicinity of the Study Area, the lowland merges eastward with the glaciated foothills of the Cascade Range. The foothills are protruding parts of a Tertiary bedrock surface that descends westward beneath thick deposits of Quaternary age. Rocks of Tertiary age in the vicinity of the Study Area include sedimentary and volcanic rocks of the Puget Group (Tp), intrusive igneous rocks (Ti), and andesitic volcanic rocks (Ta). The thickness of these rocks is not known with certainty but may be on the order of several thousand feet. Of these, the Puget Group rocks are of primary relevance to this Study Area.

3.3.1.1 Stratigraphy

Puget Group (Tp) Bedrock

The oldest rocks exposed in the region vicinity are the nonmarine coal-bearing volcanic and sedimentary rocks of the Tertiary-aged Puget Group (Tp) (Gower and Wanek 1963). Beginning about 55 million years ago in the Eocene epoch of the Tertiary, these materials were deposited in a broad coastal plain which existed in the present position of the Cascade Range and Puget Sound Lowland. Great thickness of arkosic sediments derived from the North American continental plate to the east accumulated in the plain. Volcanic rocks and sediments derived from volcanoes were occasionally interbedded with the arkosic sediments, along with extensive swamp deposits formed under a sub-tropical climate. Toward the end of Eocene time, the source of the arkosic sediment was cut off from the coastal plain, probably by volcanic activity and uplift in the present position of the Cascade Range. Over time and through compaction at depth, these sediments were lithified into the sandstones, siltstones, shale and coal of the Puget Group. In middle or late Miocene time, most of the Tertiary formations of western Washington were extensively folded and faulted as a result of tectonic forces occurring along the continental margin.

The Puget Group is composed of sandstone and siltstone with numerous carbonaceous shale and coal beds and minor amounts of claystone and conglomerate. All gradations between sandstone and siltstone are present, and most of the rocks are either silty sandstone or sandy siltstone. The sandstone beds are typically yellowish gray to light olive gray, fine grained, micaceous, and arkosic or feldspathic. Most of the sandstone beds are cross-laminated and form massive outcrops. Some beds are ripple marked, and convolute bedding and intraformational breccia occur in a few places. The siltstone beds commonly are medium light gray to dark gray and contain varying amounts of finely disseminated carbonaceous fragments (Gower and Wanek 1963). The Landsburg Mine coal seams and associated shales and sandstones are within the Puget Group.

Excellent exposures of Puget Group rocks occur in the canyon of the Green River, where a 6000 ft thick section is exposed. Neither the base nor the top of the Puget Group is exposed in this section. The aggregate thickness of the Puget Group rocks is felt to approach nearly 11,000 ft locally (Vine 1962).

In the Tiger Mountain-Taylor Mountain area, about 8 miles north of the Study Area, Vine (1962) has sub-divided the Puget Group into the Tiger Mountain, Tukwila, and Renton Formations. The Tiger Mountain Formation consists of nearly 2,000 ft of a medium grained arkosic and feldspathic micaceous sandstone. The upper part is interstratified with the overlying volcanic rocks of the Tukwila Formation. A zone of carbonaceous shale and coal occurs, at least locally, near the top of the lower main body of the Tiger Mountain Formation. The Tukwila Formation consists of andesitic volcanic rocks about 7,000 ft thick. Epiclastic volcanic sandstone, tuffaceous siltstone, tuff-breccia, volcanic conglomerate, and thin vesicular lava flows or sills compose the bulk of the Tukwila Formation. The Renton Formation is the youngest formation recognized in the Puget Group and is comprised of arkosic and feldspathic micaceous sandstone, siltstone, carbonaceous claystone and coal, as much as 2,250 ft thick.

With respect to the Study Area, fossil leaves collected at a locality between the Landsburg and Rogers Seams were identified in Wolfe et al. (1961) as of probable middle Eocene age. The Puget Group rocks exposed in the Study Area, therefore, are probably of pre-Tukwila age and may be equivalent to a part of the lower main body of the Tiger Mountain Formation.

The upper part of the Puget Group intertongues with the base of the overlying andesitic volcanic rocks (Ta), a heterogeneous assemblage of late Eocene- to early Oligicene-aged volcanic and volcanic sedimentary rocks. In the Study Area vicinity, however, these rocks are essentially absent and occur only in small, isolated outcrops. The igneous intrusives (Ti) are poryphyritic andesite sills ranging in thickness from 5 to 100 ft. These rocks are similar in composition and are presumably related to the andesitic volcanic rocks that overlie the Puget Group. Igneous rocks (Ti) intrude the Puget Group in the Cumberland and Hobart quadrangles, however, none are present in the vicinity of the Study Area (Figure 3-7).

Glacial Drift (Qvt, Qvr, Qva, Qvi)

Cyclic cooling and warming periods during the Pleistocene resulted in alternating glacial and interglacial periods in the Puget Sound Region. There is evidence of at least four advances of a vast and thick ice sheet which flowed south from British Columbia, reaching its maximum extent in southern Thurston County. During the most recent glacial stage, the Vashon, which occurred some 13,500 to 15,000 years ago, ice thickness reached 3,000 ft near Renton, 2000 ft over Tacoma, and at least 1,500 ft near Black Diamond along the mountain front (Luzier 1969).

Most of the surface in the Study Area vicinity is thickly mantled by deposits associated with the Vashon glacial episode (Figure 3-7). During advance of the Vashon ice sheet, unconsolidated deposits beneath the ice were compacted and the land surface mantled by till laid down at the base of the ice sheet as it passed over the landscape. During recession, melting ice lobes produced large quantities of melt water which released stratified outwash. Locally, other deposits representing one or more of the older drift sheets may also be present below the Vashon drift. These are observed (Pre-Vashon drift - Qu) in exposures in the Cedar River Valley as till, fluvial sand and gravel, lacustrine sand, silt, clay and peat (Figure 3-7).

Vashon drift in the Study Area vicinity consists mostly of recessional outwash (Qvr) and till (Qvt) with some minor occurrences of advance outwash (Qva) and ice-contact deposits (Qvi) (Vine 1962; Luzier 1969). The outwash deposits are composed of stratified gravel, sand, silt, and clay and are confined largely to the lowlands areas, where locally they may exceed thicknesses of 250 ft. Thicknesses are generally less than 100 ft (Gower and Wanek 1963; Luzier 1969). Recessional outwash (Qvr) is comprised of a well-sorted sand and pebble-cobble deposited chiefly as an outwash plain. Till (Qvt), which also occurs in the lowlands but most commonly mantles the hillsides, consists of a compact mixture of gravel and occasional boulders in a clayey, silty sand matrix. In appearance, till is somewhat like concrete. Thickness is generally 10 to more than 50 ft. As seen in Figure 3-7, till mantles the hills of Tertiary bedrock comprising much of the Study Area while recessional outwash fills in the lowland areas around the perimeter of the Study Area boundaries.

Ice-contact deposits (Qvi), which consist of silty sand and pebble-cobble gravel, were deposited chiefly as kames and kame terraces. These may include large boulders, lenses of till, and lenses of silt and clay. The material is characterized by abrupt changes in grain size, degree of sorting, and stratification. An extensive area of ice-contact deposits is located to the southwest of the Study Area near Retreat Lake (Figure 3-7).

Peat and Swamp Deposits (Qp)

Peat and swamp deposits are scattered over the surface of the glacial drift. Several occur in the Study Area vicinity (Figure 3-7). These consist mainly of peat and muck deposited in areas of closed or poorly drained depressions in the glacial drift, and include silt and clay. Thickness of the material is generally less than 25 ft. Several isolated occurrences of this material are mapped around the perimeter of Study Area boundary (Figure 3-7).

Alluvium (Qua)

Alluvial deposits of gravel, sand, and silt occur along all the large streams and rivers. These deposits include modern alluvium in the river channel in river valleys and the bordering low-lying terraces. Only those deposits along the Cedar River are extensive enough to be identified on the geological map (Figure 3-7).

3.3.1.2 Structure

Throughout most of the mapped area, the early Tertiary rocks are highly folded and faulted. In the Cumberland quadrangle the major period of deformation is assumed to have occurred during Miocene time. Only gentle warping occurred after the deposition of the late Miocene sediments (Gower and Wanek 1963).

Folds

Bedrock in the Study Area vicinity has been extensively folded into a series of north and northeast-trending folds (Gower and Wanek 1963). Most of these structures are south-plunging asymmetric folds with east-dipping axial planes. The strata most commonly dip 50° to 70° on the steeper limbs and 25° to 50° degrees on the opposite limbs.

Faults

The rocks in the study area have been displaced by numerous faults. Strike-slip, normal and high angle reverse faults have been recognized, but the type of movement along most of the faults is unknown (Gower and Wanek 1963). Thrust faults are anticipated to be present in the region (Zoback and Zoback 1980). Most faults in the region trend northwest, and the majority are apparently down thrown on the northeast side (Gower and Wanek 1963). Displacement ranges from a few inches to as much as several thousand feet.

Stress

Regional stress directions are useful for understanding local fault systems. The Puget Sound - Olympic Peninsula province is characterized with the major principal horizontal stress being a north-south compression. The minor principal horizontal stress direction throughout this province averages about east-west (Zoback and Zoback 1980). While local perturbations may exist, on a regional basis faults that are steeply dipping with east-west strikes (across the coal seams in the Study Area) should therefore be tight due to the north-south compression.

3.3.2 Site Geology

3.3.2.1 Stratigraphy

Geologic cross-sections depicting the stratigraphy of the Study Area are shown in Figures 3-8 through 3-13. Figure 3-8 depicts the cross-section locations. Figure 3-9 is a section orientated along strike of the Rogers coal seam while Figures 3-10, -11 and -12 are drawn perpendicular to the seam. A detailed depiction of the stratigraphy in the immediate vicinity of the Rogers Seam is shown in Figure 3-13. These cross-sections are based on the geologic mapping of Luzier (1969), shown in Figure 3-7, mine construction records and drawings, well logs of private wells in the area, and the borehole drilling conducted as part of monitoring well installation activities. Borehole and well construction logs and test pit logs for boreholes and test pits completed as part of this RI are shown in Appendix E. Photographs of cores obtained during drilling are shown in Appendix D.

The stratigraphy of the site, as observed during drilling activities, is generally consistent with the description presented above in Section 3.3.1 for the region, and generally conforms to the conceptual model of site geology described in Golder (1992b). Site stratigraphy consists of a thick sequence of folded Tertiary bedrock of the Puget Group mantled by glacial drift of the Vashon (and possibly Pre-Vashon) glacial stage.

Puget Group

Puget Group rocks encountered at the site consist of interbedded siltstone, sandstone, shale and coal. These materials are typically fine-grained, unweathered, and yellowish brown in color. Except for the coal, which is typically very weak and friable, these materials are generally medium strong to strong and well-cemented. The depth to these rocks varies from near 0 ft at the higher elevations to in excess of 100 ft at lower elevations where thicker sequences of Quaternary deposits have accumulated. The base of the Puget Group was not encountered during drilling as the thickness of the material is expected to be on the order of several thousand feet.

A typical east-west section through the Rogers Seam is shown in Figure 3-13. On the east side of the seam is a massive sandstone bed and one foot thick layer of shale. The coal seam itself is approximately ten ft in thickness. On the west side is a five to eight ft thick carbonaceous shale and a massive sandstone (Eltz 1992). The thickness of the individual beds, as seen in the test pit logs (Figures F-8 to F-10), varies from a few feet to 10s of feet.

Glacial Drift

The glacial drift materials at the site are comprised primarily of till and recessional outwash. Minor occurrences of advance outwash and ice-contact deposits also occur near the Study Area but are of little significance to the site itself. Recent alluvium is confined to the stream and river channels of the Cedar River, and possibly Rock Creek. Isolated swamp deposits, consisting of peat and lacustrine muds, are scattered about the perimeter of the Study Area.

The till consists of a compact mixture of gravel in a clayey, silty sand matrix. Recessional outwash is comprised of a well-sorted mixture of sand and gravel. Till mantles the hillsides and recessional outwash generally fills in the lowlands. Additional till may occur below the outwash deposits. The till may possibly overlie deposits of Pre-Vashon age which may be present atop the bedrock.

The total thickness of the glacial deposits ranges from near 0 ft near the hilltops to possibly in excess of 100 ft in the lowland areas and stream channels. In most areas of the site itself, the thickness of the drift is probably between about 10 to 50 ft. In the shallow depression formed between the two primary hills at the site, however, the thickness of glacial drift deposits apparently exceeds 100 ft (Figure 3-11).

3.3.2.2 Structure

Folds

The site and Study Area are situated over the western limb of a northeast trending anticline. Puget Group strata dip steeply with dip angles of the Rogers coal seam and adjacent strata near 90 degrees on the north end of the site and 63 degrees at the south end of the mine (Figure 3-14).

Faults

Several faults were encountered during mining of the Rogers coal seam and were documented on the mine superintendents drawings. Figure 3-9 illustrates the location and trace of faults observed during mining operations.

Most noteworthy is the fault in the northern portion of the mine where approximately 75 feet of displacement (PCC 1992) required a 130 ft long rock tunnel to reconnect mining operations to the coal seam. This was the only mapped fault which resulted in complete loss of the coal seam. The fault extends vertically through all four levels of the Rogers Mine to land surface where the unmined and hence uncollapsed rock pillar is used for the trench cross-over roadway. This fault also appears to have been encountered when mining the Landsburg seam some 750 ft east of the Rogers Seam (Falk 1992); the location of this contact indicates that the fault strikes approximately east-west. Records from the mining operations on the adjacent

Frazier seam also have indications that a fault displacement may have been encountered close to the eastward extension of this same fault observed in the Rogers and Landsburg seams.

Mine records were reviewed to determine the characteristics of the fault, such as the nature and extent of any gouge present. Review of mine inspector's reports, mine drawings and the mine superintendent's map for the periods when the rock tunnel was being constructed have found no reference to fault gouge. In addition, there is no indication of the need for ground support in the rock tunnel that would undoubtedly be required if weak zones were encountered. The absence of the information leads to the conclusion that the disturbed/altered zone is very narrow. The conclusion is consistent with interviews with retired mine personnel regarding the lack of water when mining through this fault (Simmons 1992).

Pertinent features of the smaller faults include; offsets of from 2-to-16 ft (Mine Superintendent's Drawings); polished surfaces (Eltz 1992); and tightness (reports by all interviewed personnel that mining through fault zones did not result in increased water flow).

In addition to these faults observed during mining, the geologic map for the area (Figure 3-7) depicts an apparent reverse fault located at the southern end of the mine site and extending towards Georgetown to the southeast. The fault occurs just to the south of the mined portion of the Rogers Seam. No mention of the fault is noted in mine records. The fault has been observed in the Ravensdale No. 5 coal bed located just south of Georgetown (Gower and Wanek 1963). The trace of the fault has been inferred to the Landsburg Mine area to explain the apparent offset of the Ravensdale coal beds from the Landsburg coal beds. The two series of coal seams are presumably correlated. The inferred trace of the fault results in a northwesterly trend. The fault apparently truncates the Landsburg coal seams where they intercept the fault (Gower and Wanek 1963). The northern side is indicated as the downthrown side. It is speculated that this fault may be a continuation of the Green River fault, a major fault in the eastern portion of the Cumberland quadrangle which has resulted in significant movement along the contact between the Puget Group and overlying andesitic volcanic rocks.

Joints

Joints were observed in the exposed sandstones along both the hanging and foot walls within the trench of the Rogers Seam during site reconnaissance by GAI. The joints were minor and appeared tight. Two sets of joints were observed which appeared perpendicular to each other in the exposure. Joints within each set had a spacing of approximately three feet. The strike of these joint sets are expected to be parallel to site faults. The reviewed literature and data did not provide information on jointing in the study area.

3.4 Site Mining Related Characteristics

This section of the report describes the history of mining at the Landsburg Mine site, provides details on coal characteristics and quality, and addresses the stability of the remaining trench.

3.4.1 Mining History

Historical data, pertinent to the Landsburg Mine site, was collected from a variety of sources, including:

1. Records from the Washington State Division of Natural Resources (DNR), including:
    - Mine Map Collection, File K55, Landsburg and Rogers Mines.
    - Structural Geology maps.
    - Open File Reports on coal mining in King County.
    - Annual Report of Coal Mines (1959 - 1962)
    - Seattle Water Department, Cedar River Wellfield reports.

2. Records held by the Palmer Coking Coal Company, including:
    - Daily Mine Safety inspections and Reports: The daily mine inspection reports indicate that methane was never detected in any of the Rogers Seam mines. Carbon monoxide was occasionally detected along with depleted oxygen conditions indicating that spontaneous combustion, a precursor to mine fires, was occurring.

    - Annual Production Reports: Data from these reports has been used to construct mine raw coal and clean coal production estimates.

    - USBM Coal Mine Inspection Reports: These reports describe the conditions in the operating mines and include reference to roof control plans and mining methods.

    - Coal Analysis Reports: These reports contain the results of laboratory tests that were carried out to determine the moisture, ash, carbon, sulfur and other volatile matter content and BTU values for Rogers Seam coal samples.

3. Interviews with retired mining personnel, including:
    - Mr. Jack Morris, President of PCC during Rogers mine(s) operations.
    - Mr. Evan Morris, Vice President of PCC during Rogers mine(s) operations.
    - Mr. Carl Falk, Secretary of PCC during Rogers mine(s) operations.
    - Mr. Archie Eltz, Miner at Rogers mine(s).
    - Mr. Cameron Rich, Engineer for Rogers mine(s).
    - Mr. Alva "Bud" Simmons, Mine Superintendent, Rogers mine(s).

Three operating mines have been documented in the Mine Inspectors Reports for the Rogers Seam:

- Rogers Mine: Operated from 1959 to 1962 from the Rogers No.1 slope.
- Rogers No.2: Operated from 1960 to 1966 from the Rogers No.2 slope.
- Rogers No.3: Operated from 1963 to 1975 from the Rogers No.3 slope.

Two other underground mines were operated adjacent to the property in the Landsburg seam to the east and in the Frazier seam to the west (see Figure 3-2); summary information for mines operated in these three seams is presented below.

3.4.1.1 General Description

Frasier Seam The Frasier seam, located to the west of the Rogers Seam, was mined intermittently from the late 1800s to the mid 1940s. A small section of the north end of the Frasier was strip mined in the 1970s. The 1946 map of the Danville mine (in the Upper Frasier seam) workings indicated the presence of a tunnel that drained water to the northern end of the mine (adjacent to pipeline road). The entrance to this tunnel has collapsed but still provides egress for groundwater. Several other shafts and slopes provided access to the Frasier seam workings but were not locatable during site reconnaissance.

Landsburg Seam The Landsburg seam, located to the east of the Rogers Seam, actually consists of the three separate seams (18 ft, 10 ft, and 6 ft seams). The northern end of the underground mine was worked between the 1930s and 1940s. The southern end was worked from the late 1940s until about 1960. The last mining activity was a stripping operation at the southern end of the mine that was completed in 1977. Slope accesses to the Landsburg seam mines, located to the north (adjacent to pipeline road), were not located during site reconnaissance.

Rogers Seam The Rogers Seam was discovered in the late 1950's when a bulldozer, prospecting for coal, cut across the strata with a minimum of cover; the bulldozer operator's name was Enoch Rogers and the seam was named in his honor. The Rogers Seam was mined from four (4) different levels accessed from three (3) slopes/declines as shown on Figures 3-2 and 3-9; a "water level" tunnel was also constructed to facilitate water removal from the upper level. The seam was mined from 1959 until 1975 when all active mine openings were closed by blasting. During this time frame, approximately 490,000 tons of clean coal were produced.

The steep inclination of the coal seam led to the use of mining methods typically associated with the hardrock mining industry and associated terminology. For example, in this mine, the mine roof is referred to as the "hanging wall" and the mine floor is termed the "foot wall"; other terminology definitions are provided below.

3.4.1.2 Coal Seam Characteristics

As discussed above in Section 3.3, the Rogers Seam strikes approximately northeast-southwest and dips from between 90° at the north end near the Cedar River to about 70° at the southern limit. A typical east-west section through the seam (Figure 3-13) locates a massive sandstone footwall, one foot shale, four (4) feet bottom coal, two (2) feet muck, four (4) feet top coal, four to seven (4 to 7) feet carbonaceous shale and shale, and a massive sandstone hanging wall (Eltz 1992). "Muck" consists of a carbonaceous shale.

Coal analysis results (see Table 3-1) indicate that the Rogers Seam coal contains up to 65 percent carbon, from 5-15 percent ash, and one half percent sulphur. The sulphur content is typical of Washington coals which are reported to range from about .4 to 1.1% (Fuste et al. 1983). The coal is classified as high volatile bituminous with a calorific value of between 10,500 and 13,000 BTU/lb.

3.4.1.3 Mining Method

Due to the vertical orientation of the coal seam, the Rogers mines utilized a system of coal extraction more typically used in the hardrock mining industry. This system involved the development of "levels" with coal extracted by "booming" between underlying and overlying levels.

The initial development work involved constructing both an access slope and a return-airway slope from the surface to the mine level. Once the exhausting ventilation circuit was established, a level entry or "gangway" and "counter" were advanced along strike to the mine limit (either property boundary, fault, or other location determined by mine management). The gangway was driven at an upward slope of approximately 3% to promote drainage back to the access slope where a small sump was located to facilitate water handling. Gangways were typically mined 14 -to- 16 ft wide by 10 ft high with a 10 ft by 10 ft counter mined approximately 30 ft above. Vertical chutes, approximately 9 feet wide, were driven between the gangway and counter on 50-to-75 ft centers. All excavation was by drill and blasting off the solid, however, in later years, a vertical kerf cutter (large chain saw) was used to mine a relieving slot prior to drilling blast holes. Ground support consisted of wooden sets (two 16-to-24 inch diameter, upright timber posts with a 16-to-24 inch diameter, timber crossbar) on seven (7) feet centers with 2 x 4 inch wooden lagging between sets. Coal was loaded into 5-ton mine cars and hauled to the slope bottom by an electric locomotive and from there to the surface by continuous rope haulage using a large surface hoist.

Once the selected boundary was reached, the zone above the counter was developed ready for "booming". This process involved additional chutes mined upwards and crosscuts mined parallel to the counter on approximately 30 ft centers. The uppermost crosscut was located to leave 50-to-75 ft of coal between the crosscut and overlying gangway or surface. Four (4) inch boreholes were typically drilled upwards from the top crosscut in levels 2 and 3 to drain water from the overlying workings.

A majority of the coal mined from the Rogers mines was extracted by "Booming". This mining term, unique to mines in the Landsburg, Rogers, and Frazier seams, simply refers to the process of blasting pillars of coal isolated between adjacent crosscuts/entries and chutes. The booming round (see Figure 3-13) was initially fired in the uppermost pillar to start the cave. Coal was then "pulled/drawn" through the first open chute and loaded into mine cars. Pillar booming then proceeded downwards towards the gangway where part of the pillar between the gangway and counter was occasionally left due to poor conditions. Pillar booming then proceeded back towards the slope allowing for concurrent booming and crosscut/chute development.

There is some disagreement between the retired Palmer Coking Coal personnel interviewed regarding whether blast holes were drilled only in the coal or into both the coal and hanging wall rock. A section of the booming round, drawn in 1963 after a cave from the 2nd level ran through to the surface gravels in the southern end of the mine, indicates that holes were drilled to within about two (2) feet of the hanging wall. This round would result in a caving width of about 14 -to- 16 ft consistent with the width reported by personnel who worked underground (Eltz 1992; Simmons 1992).

In the upper level, booming typically resulted in a cave to surface and coal was drawn down until the miners could see daylight (Simmons 1992; Eltz 1992). This process caused short circuiting of the ventilation system requiring that the caved area be periodically backfilled from the surface (Simmons 1992). In the 2nd and subsequent levels, blastholes were drilled to within a few feet of the overlying level gangway thus connecting with the overlying caved zone. Coal was subsequently drawn down until rock and/or gravel appeared in the gangway. The rock, being heavier than the coal, would often work its way to the bottom (loading area) first, presenting mine management with the dilemma of whether to load out the rock in order to recover additional coal. One miner reported seeing daylight from the third level (Eltz 1992), however, this phenomena was not confirmed by other underground personnel. Observation of the caved zone from the upper crosscut in the level being mined indicated that the caving area was full of broken material confirming that material was being drawn from the level above.

3.4.1.4 Mine Layout and Sequencing

Details of the mine layout and sequencing of mining operations are based on maps and working drawings retrieved from Palmer Coking Coal and the Washington Division of Natural Resources (Table 3-2) supplemented by Mine Inspectors Reports and personnel interviews. Key elements of the sequence of operations in each of the three Rogers mines are shown in Tables 3-3, 3-4, and 3-5.

The Rogers No. 1 (referred to in the records only as the "Rogers Mine") Slope was constructed prior to 1959 and was then abandoned due to the presence of a fault. The slope was re-entered in March, 1959 and a 130 ft long rock tunnel was driven to the south to intersect the coal seam. A return air slope was subsequently completed and a gangway and counter were driven to the southern boundary of the upper level by January of 1960. Rogers No. 2 access and return air slopes were completed in 1960 while coal was being boomed from the 1st level; coal extraction in the 1st level was completed in 1962.

Mining of the 2nd level gangway and counter was completed in December, 1961 and the Rogers No. 3 slope was driven from the 2nd level to the surface during 1962. Pillar recovery ("booming") was completed in the second level in June of 1965. The 3rd level gangway and counter were driven, concurrent with 2nd level booming, starting in January of 1964. These entries were mined a distance of approximately 4950 ft from the Rogers No. 3 slope to the northern property line and were completed in May, 1966.

Although no precise dates are provided on the mine drawings, the water level tunnel and counter were constructed and coal was "boomed" to the base of the overlying "strip pit" between 1965 and 1966, based on an examination of sequential mine drawings. From November, 1966 to July, 1967 coal was removed from beneath the Rogers No. 2 Slope portal to a point located 300 ft to the north. This area, initially covered by about 13 ft of gravel, is shown as extensively caved on the mine superintendent's drawings. In addition, based on a reference in Coal Mine Inspectors Report No. A23 and the interview with Archie Eltz (Eltz 1992), it is suspected that the excavation may have daylighted in this area. Photographs supplied by Palmer Coking Coal Company (PCC 1992) also indicate the presence of caved areas and that coal was surface mined in this area during 1975.

Completion of the Rogers No. 3 Slope to the fourth level and construction of the 4th level gangway and counter also commenced in July of 1967. Fourth level development and 3rd level booming continued through September of 1969 when the 4th level gangway and counter were completed. This area was then left open until booming of the 3rd level to within 250 ft of the Rogers No. 3 slope was completed in June of 1970. Significant floor heave was encountered on returning to the fourth level requiring additional excavation. Additional crosscuts and chutes were also constructed prior to firing the first 4th level boom in September, 1970. It should be noted at this point that the area in the 3rd level, immediately above the first two booming rounds in the 4th level, was not extracted due to collapse of the hanging wall in the upper 3rd level crosscut. It is therefore likely that the first two 4th level booming rounds only caved as far as the 3rd level gangway.

Booming was completed in the 4th level in October, 1974. Pillars adjacent to the Rogers No. 3 slope were extracted during the following year and the Rogers No. 3 mine was abandoned in August of 1975. The mine was permanently closed on December 12, 1975 by blasting in the access and return air slope portals. A bulldozer regraded the surface to its present generally level topography.

3.4.1.5 Coal Production and Extraction Ratio

Coal production data obtained from Palmer Coking Coal Co. (PCC), Division of Natural Resources (DNR), and the State's Annual Report of Coal Mines have been summarized and presented in Table 3-6. A total of approximately 890,000 tons of raw coal was produced during the life of the three mines resulting in about 494,000 tons of clean coal.

Extraction ratios were estimated using the following steps:

(1) Coal in place was estimated by measuring the sectional area of the extraction zone in each mine and multiplying by the reported coal thickness.

(2) The extracted coal volume was estimated using the clean coal tonnages and a coal density of 67 lb/ft^3.

(3) The extraction ratio was estimated by dividing the extracted volume by the in place volume.

This simplified analysis provides an average extraction ratio of about 80% for the Rogers Seam and individual level estimates of 62% Rogers No. 1, 69% Rogers No. 2 and 90% Rogers No. 3.

3.4.1.6 Water Inflow and Pumping Data

Groundwater control was accomplished in the Rogers mine(s) by grading the gangway at a slight incline with positive drainage back towards the bottom of the mine access slope. Water gravity drained, via a shallow ditch dug in the footwall, to a small sump at the slope bottom and was pumped, from there, out of the mine.

Two types of pumps were typically used for water removal. Centrifugal pumps were used when larger than usual pumping rates were required due to water accumulation following a power failure. These pumps were characteristically low head, high volume and had to be used in stages (e.g., water was first pumped from the 3rd level to the 4th, from there to the 2nd and so on). The type of pump most frequently used for routine mine dewatering was the Bean pump; one large Bean (Model 345) with a maximum rating of 80 gpm and two smaller Beans (Model 55) with a combined capacity of about 60 gpm. The Bean pumps were typically located in a cut out between the gangway and counter with suction lines deployed to the sump; the big pump was typically run continuously even when there was no water in the sump. A Bean pump is a piston pump as opposed to the centrifugal pumps used for large volumes.

It is difficult to precisely estimate the quantity of water entering and pumped from the Rogers mine(s) as, consistent with standard practice, pumping records were not kept. However, an approximate range in inflow rates can be estimated based on mine personnel estimates and notes on mine maps, back-analysis of water accumulations observed during power outages and pump capacity/utilization.

The first source of inflow rate data is an interview with Mr. Bud Simmons (Simmons 1992) who estimated a pumping rate of 35 to 40 gpm. He also noted that the mine was typically dry in the summer months and this is confirmed by a note on the 1963 mine map which states, "Very little water being made. Pumped 1/2 hour each week during summer and fall prior to winter and rainy season". This note references water removal from the bottom of the Rogers No.1 slope during mining of the 2nd level at the southern end of the mine. This would indicate that the primary source of inflows into the mine was direct infiltration of rainfall. As noted earlier, faults were generally reported as tight and did not produce significant quantities of water.

The second estimate is based on telephone interviews with Mr. Bud Simmons and Mr. Bob Morris. Mr. Simmons reported that power outages of from 3-to-4 hours typically resulted in water rising in the gangway a distance of 1-to-2 feet. Mr. Morris remembered a situation between 1972 and 1975 when power was out for 24 hours and resulted in a rise in water level of about five (5) feet. Back-calculation of these two events provides inflow estimates of 36 gpm (Morris) and 35 gpm (Simmons).

It is therefore appropriate to state a range in probable inflow rates with qualifying assumptions:

Min. Expected Value for Pumping Rate:	20 gpm.
Most Likely Value for Pumping Rate:	35 gpm (calculated for wet season).
Max. Expected Value for Pumping Rate:	80 gpm (capacity of large Bean pump).

3.4.2 Remnant Condition of the Rogers Seam, Underground Workings and Surface Site

Coal extraction in this near vertical coal seam, and associated caving at the outcrop, has produced an intermittent trench up to 100 feet wide and 70 feet deep (see Figure 3-1 and 3-3). The walls of the trench are typically steep sided and composed of massive sandstone. However, in some areas (e.g., north of the rock bridge), the sandstone bed forming the eastern side of the trench (mine footwall) has failed exposing the shale material behind. Areas where the shale has been exposed are not as steep as those where the sandstone is still intact because the shale is weaker and less able to support steep slopes. In most areas, the sandstone hanging wall forming the western side of the trench remains intact.

3.4.2.1 Trench Bottom Stability

Failure of the sandstone footwall may have resulted in voids being left beneath the base of the trench. This potential remnant condition is based on the observations of retired PCC personnel who observed large slabs of sandstone sliding off the footwall into the trench. It is believed that these slabs could mask underlying voids.

A similar method of analysis to that used for extraction ratio calculation has been used to estimate the potential for remaining open voids in the Rogers Seam:

(1) The total volume of rock and coal loosened by booming was calculated by multiplying the total extraction zone area by the width of the booming round (up to approximately 16 ft according to mine records and interviews with retired miners). Total volume calculated as 1,500,000 yd^3.

(2) The volume of bulked rock remaining in situ was estimated by subtracting the volume of raw coal from the total volume and multiplying the result by a bulking factor of 1.35. Total remaining volume calculated as 970,000 yd^3.

(3) The bulked volume of rock which has caved into the mine workings was estimated by multiplying the length of the caved zone (from the 1974 mine map) by the trench cross-sectional area (taken from a section drawn by C. Falk dated 1974) and a bulking factor of 1.35. Caved volume calculated as 400,000 yd^3.

(4) The estimated volume of open voids was calculated by subtracting the remaining in situ and caved rock volume from the total volume, expressing the result as a percentage of the total volume. Calculated as 8%.

Significant uncertainty exists regarding the absolute value of this ratio as the precise volume of originally open trench cannot be determined from the available data and at least one of the personnel interviewed stated that material from outside the trench area was used for backfill during mine operations. As shown in Figure 3-15, backfilling during mining and subsequent deposition of demolition debris has filled all but about 200,000 cubic yards of the original subsidence trench.

A more rigorous engineering analysis of the stability of the trench bottom is not warranted at this stage as conditions below the base of the trench are unknown. Nevertheless, although it is likely that a majority of trench bottom subsidence has already occurred, it is prudent to allow for further subsidence and trench base instability when evaluating and designing any remedial measures.

3.4.2.2 Trench Sidewall Stability

The strata forming the trench sidewall were mapped in trenches that were excavated perpendicular to the trench rim in areas 8 and 9 (Figures F-8 to F-10, Appendix F; and Section 3.3.2.1). The mapped sequence included interbedded sandstone, shale, and siltstone; no evidence of sidewall instability was observed. However, slabbing failure, similar to that observed by retired PCC personnel, may occur if material is removed from the trench bottom or if further subsidence occurs.

3.4.2.3 Potential for Waste Movement After Dumping

According to Evan Morris (Morris, E. 1992) a majority of the drummed waste was deposited in the trench north of the rock bridge (major fault in northern part of mine). The last mining beneath this area was completed at the end of 1967 approximately one year prior to waste deposition. Fourth level mining beneath the trench immediately to the south of the rock bridge began in September of 1970 and was completed in 1974. While there was some potential for movement of the contained waste after deposition north of the rock bridge, it is considered unlikely that significant deformations occurred. There is a modestly higher probability that waste in the trench to the south of the rock bridge has settled since deposition. Settlement of the waste could result in debris moving down into the mine.

3.5 Surface Water and Meteorologic Characteristics

This section describes the surface water and meteorologic characteristics of the Study Area vicinity. Information was collected from a number of sources including review of available technical literature, computer databases and site reconnaissance.

3.5.1 Surface Water

The major surface water features at the Study Area are the Cedar River along the Study Area's northern boundary and Rock Creek within the southern boundary. The Study Area is situated along a drainage divide separating the Cedar River mainstem and the Rock Creek Subbasins. Drainage from the northern half of the site flows to the Cedar River mainstem, while drainage from the southern half of the site flows into the Rock Creek subbasin. Rock Creek ultimately drains into the Cedar River approximately 2 miles downstream of the site. In addition to these major features, the site itself contains a number of small minor unnamed and primarily ephemeral drainages and shallow depressions. These features of the Study Area are discussed below. Figure 3-16 depicts the primary surface water flow pattern and features of the Study Area.

3.5.1.1 Cedar River

The major surface water characteristic in the Study Area vicinity is the Cedar River which is located approximately 500 ft from the northern end of the trench. The Cedar River valley drainage system extends from the south end of Lake Washington to the crest of the Cascade Range (King County Dept. of Public Works 1993). Major features of the system include Lake Washington, the Rock Creek tributary, and the City of Seattle water intake structure at Landsburg.

The largest lake in the system is Lake Washington which is presently the endpoint for water flowing westward from the Cedar River. The Cedar River supplies approximately 54% of Lake Washington's supply. The river is considered a significant regional water supply providing 70% of the water needs for the City of Seattle and surrounding areas (King County Dept. of Public Works 1993).

The Cedar River is of A (excellent) quality from Lake Washington to the State Highway 169 overpass in Renton, Washington. Nearer to the Landsburg Mine site, the river has been rated AA (extraordinary) which is described as "markedly and uniformly exceeding the requirements for all or substantially all beneficial uses." Water quality in the Cedar River mainstem is considered excellent (King County Dept. of Public Works 1993).

Flow data for the river are available for two gaging stations located in the Study Area vicinity (Hydrosphere Data Products 1993b). The USGS maintains a gaging station approximately 1 mile upriver of the diversion. Data for this station are available for the period 1895 to 1994. Below the diversion structure, a gaging station is operated by the City of Seattle. Data for this period are available only for 1992 to 1994. Table 3-7 summarizes the daily average flows in the river by month for each of these two stations. As seen in the table, above the diversion structure the daily average flow varies from a low of approximately 322 cfs in September to a maximum of about 975 cfs in January. A long, relatively wet season is indicated from November through June where average daily flows vary between approximately 700 and 975 cfs. The dry season is July to September with average daily flows of about 300 to 500 cfs. Below the diversion, data compiled from 1992 to 1994 indicate the daily average flow in the river varies from a high of only 591 cfs in December to a low of 160 cfs in September. The difference between daily average flows at the two gaging points is generally in the 150 to 450 cfs range. This presumably represents the approximate diversion taking place at the City of Seattle diversion structure.

3.5.1.2 Rock Creek

Rock Creek is located in the southern portion of the site and is tributary to the Cedar River. The creek represents the only perennial creek or stream within the Study Area boundaries. The creek becomes ephemeral in the south-central portion of the Study Area approximately where it crosses under the Kent-Kangley Rd. (Figure 3-16). The relatively high flow rate which is generated within several hundred ft of this point indicates the creek is gaining in the portion located within the Study Area (i.e. sustained by groundwater discharge). Presumably the source of flow in the creek is groundwater inflow from the east through the permeable glacial outwash deposits.

The Rock Creek sub-basin drains over 7,000 acres and is considered to be the least disturbed and most pristine of the five tributary subbasins of the Cedar River (King Co. Dept. of Public Works 1993). Based on the pristine, rural nature of the area, the water quality in the creek is thought to be very good although few data are available.

Flow data for Rock Creek near the City of Kent diversion was available for the years 1945 through 1948. The average daily flow for this time was 29 cfs. Daily averages for the creek over this period varied from a minimum of 6.3 cfs in August to 56 cfs in December (Hydrosphere Data Products 1993b).

3.5.1.3 Site Drainage Features

The mine site itself has only ephemeral drainages which discharge during prolonged or intense periods of rainfall. The southern portion of the mine site drains towards Rock Creek and the northern half drains to the Cedar River. The generalized surface water flow patterns at the site and the locations of major features are shown in Figure 3-16.

The lower elevations around the perimeter of the Study Area are covered by relatively permeable outwash sands and gravels at the land surface without defined drainage patterns. Rainfall is expected to readily infiltrate these materials. The elevated portions of the site either have surface outcrops of bedrock or a thin veneer of glacial drift (till) which will inhibit infiltration relative to the permeable outwash deposits. In general then, surface water flow at the site is expected to run-off the hills, collect in ephemeral drainages and flow to the lower elevations where it infiltrates into the outwash deposits or flows into Rock Creek or the Cedar River. Some run-off also flows into the mine trench, depending on the local topography and drainage patterns. Run-off flowing into the mine trench collects in several ephemeral pools where it infiltrates or evaporates.

Field reconnaissance by GAI personnel confirmed six wet areas within the trench or immediate vicinity (Figures 3-16 and 3-17). Two of these consist of the mine portals #2 and #3. Water occurrence at these locations is perennial and is expected to represent natural groundwater discharge, as discussed in Section 3.6. Another, the so-called "sludge pond" located just to the north of well LMW-1, is also perennial. The other four areas consist of localized pools which are ephemeral and have been observed to go dry during the months of June through November. These pools, as discussed in Section 3.6, are not believed to represent groundwater, but rather are more accurately characterized as ephemeral pools of surface run-off which flows into the trench due to local topography and is then temporarily retained.

The water present at portal #2 occurs as a pool which is completely retained and enclosed as a shallow depression. Drainage from portal #2 at the north end of the mine was reported during earlier investigations by Ecology and Environment in February 1991, but was not observed by GAI at any time during the RI. Portal #3 occurs as seepage where water emanates along a sloping seepage face, flows along the ground surface for a short distance, and gradually re-infiltrates back into surficial soils. Surface water run-off from portal #3 was never observed to extend beyond the Kent-Kangley Rd. Flow rates measured at the portal during this RI (shown in Appendix B) varied from about 2 gpm to 100 gpm with the minimum flow occurring in late summer and the maximum flow occurring in winter.

Other localized pools or shallow ponds also occur in the Study Area. These are shown in Figure 3-16. One is located along the southwest side of the hill located to the east of the trench. This pond is located along one of the major ephemeral drainages at the site and is perennial. Discharge from the pond occurs through a culvert which passes beneath the adjacent dirt road. Discharge through the culvert apparently ceases during the summer months. Two other shallow ponds, which are also associated with the major ephemeral drainages at the site are present along the north side this hill. Miscellaneous occurrences of standing water at the higher elevations are common in the wetter months.

3.5.2 Meteorological Characteristics

3.5.2.1 Regional Characteristics

The climate of the Puget Sound region is typified as a marine climate with cool summers and mild, rainy winters. Summer temperatures generally remain below 80° Fahrenheit. Winter temperatures are usually above freezing. Warm, moisture-laden winds move landward from the Pacific Ocean and are forced upward by the west slope of the Cascade Mountain Range. As the air rises, it is cooled and the resulting condensation of moisture produces precipitation in the form of rain and snow. The wet season will typically last from October to March. Because of mild winter temperatures, the growing season is long and conducive to the development of dense evergreen forest (Brown and Caldwell 1978b).

Within the Cedar River Basin, temperatures are considered moderate and precipitation ranges from snowfalls of 200 inches per year in the Cascade Mountains, to 100 to 200 inches of precipitation in the upper basin, to about 30 to 50 inches in the middle and lower basins where the Landsburg Mine site is located (King County Dept. of Public Works 1993).

3.5.2.2 Site Characteristics

Meteorological data for the site were obtained for the weather observation station located at the City of Seattle intake structure on the Cedar River at Landsburg (Hydrosphere Data Products 1993a). These data consists of monthly precipitation, snowfall, and temperature data for the years 1931 through June of 1993. The data are summarized in Tables 3-8 and 3-9.

The climatological data indicates that for nearly sixty years the average precipitation at the site ranges from slightly less than 1.5 inches in July to nearly 8 inches in December. In general, the months of July through September are driest, and October through January are the wettest. Yearly precipitation averages 56.52 inches with a maximum of 76.39 and a minimum of 32.93 inches.

Snowfall data for the site indicates that on average 10.61 inches of precipitation falls as snow. The highest recorded monthly snow fall occurred in January of 1950 when more than 35 inches of snow fell.

On average, January is the coldest month and August the warmest with average daily low temperatures ranging from 37° F to 49° F and average daily maximum temperatures ranging from 51° F to 85° F. The lowest recorded temperature was 18° F recorded in January 1950. The highest recorded temperature was 85° F in August 1967.

In addition to the monthly data discussed above, additional data consisting of daily climatological observations for the station at Landsburg for December 1993 to January 1995 were obtained directly from the Seattle Water Department. These data cover the period of the RI. Daily precipitation amounts are plotted in Appendix B. The maximum daily precipitation measured over this time period was about 2 in. 24-hour rainfalls in excess of 1 in. occurred on 4 occasions.

3.6 Groundwater Characteristics

This section describes the regional, Study Area and mine-specific (site) hydrogeologic conditions. As with Section 3.3 (Geologic Conditions), the regional description refers generally to the southwestern portion of King County. The description of regional and Study Area hydrogeology is based primarily on Luzier (1969) and studies of the Cedar River groundwater basin presented in Brown and Caldwell (1978a,b, 1980). Site conditions are described primarily on the basis of the field investigative activities conducted as part of this RI.

3.6.1 Regional Hydrogeology

As discussed in Section 3.3, the Study Area is situated along the eastern margin of the Puget Sound Lowland, a broad glacial drift plain that merges eastward with the glaciated foothills of the Cascade Range. The foothills are the protruding parts of a Tertiary bedrock surface (Puget Group sedimentary rocks) that descends westward beneath the Quaternary drift deposits more than 1,000 ft thick. The Tertiary bedrock materials together with the glacial drift comprise the two primary hydrostratigraphic units in the region.

Tertiary rocks are a secondary source of groundwater in southwestern King County (Luzier 1969). The relatively fine-grained nature of the Puget Group sediments precludes the possibility of obtaining well yields more than about 50 gpm. Groundwater movement through these materials is chiefly through joints, bedding planes and faults. Luzier (1969) reported that large yields could be obtained by drilling into flooded mine workings; however, the use of such water could be limited by water quality.

Quaternary deposits are the chief source of groundwater in the region. They form a lens-shaped mass that may exceed 2,000 ft in thickness in the central portion of the Puget Sound Lowland. Along the eastern margin of the Lowland, such as in the Study Area, these deposits thin and pinch out in places in the vicinity of bedrock highs and along the Cascade Range.

The most productive aquifers in southwestern King County are the buried valley fills of Vashon advance outwash, thick ice-contact and recessional outwash deposits also of Vashon age, and outwash bodies of Pre-Vashon drift, such as the Salmon Springs Drift. These deposits can be highly productive and wells commonly yield 300 to more than 2,000 gpm. Recessional outwash and ice-contact deposits give rise to springs with discharges that range from 1,000 to more than 20,000 gpm. These springs are the principal sources of water for the cities of Kent, Auburn, Black Diamond and Enumclaw (Luzier 1969).

Vashon till forms a relatively thin but areally widespread and nearly impermeable blanket over most of the glacial drift in the region. The low permeability of the till restricts recharge to underlying groundwater, and often results in the formation of peat bogs, swamps and lakes. Where till is overlain by recessional outwash, perched groundwater is likely to occur. In other areas, the till may be important as a confining layer. Despite the low permeability of till, small domestic supplies of water have been obtained from numerous uncased shallow wells dug into the till. The wells are generally less than about 30 ft deep and from 3 to 6 ft in diameter. The chief sources of groundwater for these wells are perched water-bearing zones in the upper less-compact part of the till. These wells generally supply meager supplies of water and often go dry in late summer.

Groundwater is confined or partially confined in most Pleistocene aquifers older than Vashon till, and is unconfined in the Vashon recessional outwash and most alluvial aquifers. The water table and piezometric surfaces fluctuate less than about 10 ft per year in response to seasonal changes in groundwater storage.

The chemical quality of most groundwater in the region is excellent for drinking purposes. Iron-rich groundwaters occur irregularly with apparently little systematic relationship to individual geologic units. Luzier (1969) reported that organic-rich deposits such as peat may contribute to the presence of iron in groundwater. The least mineralized water occurs in the Vashon recessional outwash and ice-contact deposits in the eastern part of the glacial drift plain. These deposits are recharged almost entirely by precipitation whereas most of the other important aquifers, because of their stratigraphic or topographic position, are indirectly recharged by movement of groundwater from overlying, adjacent or underlying geologic units.

3.6.2 Study Area General Conditions

The Study Area is located within the Cedar River groundwater basin. Consistent with the regional view, the primary hydrostratigraphic units of the basin and Study Area include: 1) the Quaternary glaciofluvial outwash and recent alluvium deposits of interstatified clay, silt, sand and gravel; and 2) Tertiary bedrock composed of interbedded sandstones, shales, siltstones and coal seams of the Puget Group.

The most productive aquifers are the glaciofluvial outwash and alluvium deposits. These materials are characterized by permeabilities orders of magnitude greater than the permeability of the bedrock. As such, the majority of the groundwater flow within the basin occurs through the outwash sands and gravels. The Mine site and the central portion of the Study Area are situated atop a Puget Group bedrock high which protrudes up through permeable deposits of glacial outwash. Groundwater flow through these outwash deposits occurs primarily from east to west. In the vicinity of the Study Area, groundwater moving in through these deposits from the east is diverted around the bedrock hills through the valley fill deposits present in the lower elevations around the perimeter of the Study Area. At the southern portion of the Study Area, these flows discharge to Rock Creek and are the principle source of water at the City of Kent

Clark Springs water intake. Generalized directions of groundwater flow within the valley-fill deposits are illustrated in Figure 3-18.

Due to the interbedded nature of the Puget Group deposits and the presence of fine-grained siltstones and shales, groundwater flow across bedding is expected to be very small. Groundwater flow within the bedrock aquifer is expected to be controlled by the more permeable strata and structural features.

Due to the presence of the bedrock high discussed above, glaciofluvial deposits are generally less than about 100 ft thick in the Study Area. Approximately 1 to 2 miles to the northwest of the Study Area, over the central portion of the Cedar River basin trough, these materials thicken to in excess of 700 ft (Brown and Caldwell 1980). This area was the subject of a preliminary evaluation by the City of Seattle in the late 1970s to determine if a 30 to 90 mgd well field could be developed to augment water supply during Cedar River low flows. Field investigations conducted as part of the study revealed a thick sequence of permeable glacial valley fill representing the full cycle of Vashon aged glacial advance and recession overlying several units of pre-Vashon drift. At least two areally extensive, confined artesian aquifers of pre-Vashon age were identified and judged to be capable of sustaining high production rates from a well field.

The primary source of groundwater throughout the Cedar River basin is precipitation. Aquifer recharge occurs mainly during the winter and spring wet season. Recharge mechanisms include direct infiltration of precipitation, aquifer underflow from adjacent aquifers, leakage from surface streams that drain elevated bedrock areas, and intercommunication between the valley-filled outwash deposits and the bedrock.

The mechanisms of groundwater discharge include seepage into surface steams, discharge at wells and springs, evapotranspiration and aquifer underflow out of the Study Area. Other than evapotranspiration and well discharge, all groundwater within the Study Area ultimately discharges to the Cedar River as seepage. Stream gauge data confirm that the Cedar River gains throughout its course in the Cedar River Basin (Brown and Caldwell 1978). Discharge from private wells and springs are considered to be relatively small, with the possible exception of the City of Kent's Clark Springs extraction system in the Rock Creek alluvial system.

3.6.3 Mine Site Groundwater Conditions

3.6.3.1 Groundwater Occurrence

Groundwater at the Mine site occurs within the following geologic units:

- sedimentary bedrock of the Puget Group,
- the glacial outwash materials present in lower elevations of the Study Area, and
- the relatively thin glacial drift (till) which mantles the Puget Group bedrock along the hill sides.

The first two of these comprise the primary groundwater flow system at the Study Area. Groundwater in the latter of these represents relatively minor occurrences of perched groundwater and is of secondary importance. The hydrogeology of each of these materials is discussed in detail below. Water level measurements taken throughout the RI at monitoring wells and portal #2 are summarized and plotted in a series of hydrographs in Appendix B. Water levels are shown in cross-section in Figures 3-9, -10, -11, -12. The piezometric surface of the primary groundwater flow system is shown in Figure 3-19.

3.6.3.1.1 Puget Group

Water Levels/Hydrographs

Within the bedrock deposits, groundwater occurs at depths ranging from about 10 ft to in excess of about 200 ft below ground surface, depending on topographic position. The deeper groundwater occurs beneath the higher elevations of the Study Area and Mine site. For instance, depths to groundwater at wells LMW-1, LMW-7 and PW-6, located in the central portion of the Mine site, are about 140, 215 and 235 ft bgs, respectively. Groundwater occurs relatively close to the ground surface, however, in wells located around the base of the Mine site hill. At wells LMW-2, -3, -4, -5 and -6 the depth to water is all generally less than about 20 ft.

Within the Mine trench itself (Figure 3-9), the depth to groundwater varies from about 150 ft in the central portion of the trench to near zero at either end. This water occurs under water table or unconfined conditions as any potential confining layers are now absent due to mining. Bedrock groundwater elsewhere in the Study Area may occur locally under confined to semi-confined conditions due to the presence of till which mantles much of the area.

Hydrographs of water levels in the site monitoring wells are shown in Appendix B. These cover the period January 1994 through April 1995. As seen in Figure B-1, water levels vary seasonally with the highest levels occurring in winter and spring and the lowest levels occurring during late summer. The amount of seasonal fluctuation varies in the wells from a minimum of about 2 ft at LMW-7 to a maximum of about 30 ft at LMW-6. Water levels at the north and south ends of the trench (wells LMW-2 to -5) vary only a few feet while levels at well LMW-1 in the central portion of the trench fluctuated by about 20 ft.

Hydrographs of wells LMW-2/4 (Figure B-3) show that water levels varied in an identical manner at each well over the one year period. This indicates that the shallow and deeper portions of the coal seam, where the two wells are installed, are hydraulically well-interconnected, as expected. A similar response was observed at the LMW-1/1A (Figure B-2) and the LMW-3/5 well pairs (Figure B-4). Due to the small head difference between the shallow and the deep well at each nested well pair, there is apparently very little vertical gradient within the trench. The gradient is weakly upward at the north end and weakly downward at the south end.

As seen in Figure B-1, water level elevations in the Mine wells (wells LMW-1, -1A, -2, -3, -4 and -5) fluctuate similarly, indicating that these wells are installed in a common hydrostratigraphic unit. However, the water level variation at the wells installed in the adjacent coal seams differs, especially at LMW-6. Water levels at LMW-6 fluctuate considerably more than the Mine wells during the summer months. This suggests that wells installed away from the Mine communicate poorly, if at all, with Mine groundwater.

This is supported by the large difference in hydraulic head (approximately 50 to 70 ft) observed between the mine wells and well LMW-7 (Figure B-1). This difference in head suggests that geologic materials between LMW-7 and the mine (including the fault) are tight and do not provide a permeable pathway for the flow of groundwater away from the mine. The water level variation observed at LMW-6 and the large difference in hydraulic head seen between LMW-7 and the mine wells suggest that groundwater flow away from the mine across bedding (lateral flow) is negligible.

Water levels measured at portal #2 are shown in Figures B-7 and B-8. As seen in the figures, the elevation of water at the portal is intermediate between the elevations at LMW-1 and LMW-2/4, and the levels at each of these points fluctuated identically. This confirms that water at portal #2 represents a surface expression of the water table surface and is fed by groundwater.

As discussed previously in Section 3.5.1, several areas of surface water accumulation were identified during the RI within the trench. These are depicted in Figures 3-16 and -17. Elevation measurements of ponded water at areas 1 and 3 taken April 28, 1994, were 745.2 and 730.9 ft amsl, respectively. As shown in Figure 3-19, the maximum water table surface elevation within the trench is about 650 ft amsl, or at least 100 ft below these measured values. In addition, the elevation in area 3 was about 15 ft lower than in area 1, in spite of the fact that area 3 is located in a topographically higher portion of the mine trench. These observations indicate that these bodies do not represent groundwater but rather ephemeral accumulations of surface water which occur as a result of surface water runoff into the trench.

Recharge/Discharge

Figure B-11 shows measured daily precipitation values at Landsburg overlain on the hydrograph plots. As seen in the figure, increases and decreases in precipitation are generally reflected by corresponding variations in water level. Variations in the discharge rate of water at portal #3 (Figure B-9) also display a seasonal pattern. These patterns of seasonal variation, which closely coincide with wet and dry periods of the year, confirm that bedrock groundwater is recharged through direct precipitation of rainfall. The presence of the trench, which naturally serves as a surface water collection point and lacks any overlying layers of low permeability till which would restrict infiltration, probably accelerates recharge to bedrock materials in the immediate vicinity of the Mine.

Discharge of water from the bedrock materials is strongly controlled by the orientation of bedding. In the horizontal direction, groundwater can flow either laterally away from the mine, or parallel (along strike) to the mine. Evidence presented earlier (Sections 3.3.2.2 and 3.6.3.1.1) indicate that faults are tight and do not serve as significant pathways. Because of the near vertical orientation of bedding at the site, lateral flow of groundwater would have to occur perpendicular to and across the individual bedding layers adjacent to the mine. Parallel flow would occur within the mined-out Rogers seam. The rate at which water can move laterally away from the mine is a function of K_z, the equivalent hydraulic conductivity of the layered system. K_z is strongly dominated by the hydraulic conductivities of the least permeable materials present in the system, since groundwater can only move as rapidly as the least permeable zone will allow. Groundwater flow along strike of the mine, or parallel to the bedding, is a function of K_x, the hydraulic conductivity of the individual bed, in this case of the mined-out seam. The conductivity of this disturbed zone is certainly orders of magnitude larger than the conductivity of individual undisturbed layers paralleling the mine, especially the fine-grained siltstones and shales. As a result, the value of K_z is also orders of magnitude smaller than K_x. This creates a strong preference for flow along strike of the mined out seam rather than laterally away from the mine.

Within this context, flow will generally occur as a subdued reflection of surface topography. In the northern half of the trench, flow is primarily to the northeast since the ground surface elevation of the mined-out seam declines in this direction, and in the southern part of the trench, the flow is to the southwest. From the south end of the trench, water discharges at portal #3 as seepage. This water flows briefly overland before re-infiltrating into the valley outwash aquifer. At the north end of the mine, the trench discharges through the Rogers Seam to the northeast into the adjacent glacial drift materials before reaching the Cedar River. In general then, discharge of water from the Mine site bedrock materials is primarily to the Cedar River with some discharge at the southern end to the Rock Creek alluvium and outwash materials.

3.6.3.1.2 Glacial Outwash

Groundwater occurs within about 5 to 15 ft of the ground surface in the outwash materials around the Study Area perimeter, which are most prevalent in the valley at the south of the site. This aquifer is unconfined and is a part of the large regional system of the Cedar River basin to the east. Areally extensive outwash deposits to the east discharge through the valley fill material located to the south of the site. The total thickness of this aquifer is on the order of 100 ft in the vicinity of the site. Significant flow occurs through this material as evidenced by the discharge which occurs to Rock Creek. Rock Creek is a gaining stream in the Study Area vicinity and is fed by groundwater discharges from the outwash aquifer.

3.6.3.1.3 Till

Groundwater is also present at the site within the glacial drift deposits which mantle the bedrock in the higher elevations. This material consists of compact sand and gravel (till) and reaches thicknesses of up to about 100 ft in some areas. Generally, the material is less than about 50 ft in thickness. Groundwater present in the till is tapped by a number of shallow private wells within the Study Area and is probably perched over the bedrock system.

3.6.3.2 Groundwater Flow Directions

Based on the description presented above, the bedrock materials and the surrounding glacial outwash deposits form a near continuous groundwater system at the Study Area. Minor occurrences of groundwater are also present above the bedrock in the till present at the site. This groundwater is probably perched over the primary groundwater system and is of secondary importance.

A generalized depiction of the piezometric surface of this groundwater system is shown in Figure 3-19. This figure depicts the overall patterns of groundwater flow in the bedrock materials at the site and the surrounding glacial outwash. As seen in the figure, groundwater flow throughout most of the Study Area generally reflects the surface topography. Within the trench, flow occurs along strike to the northeast in the major portion of the trench, and to the southwest in the southern portion of the trench. Discharge occurs at each end to the glacial outwash deposits surrounding the site. Flow is then controlled primarily by surface topography. At the north end of the mine, the discharge continues downslope towards the Cedar River. At the southern end, the discharge enters into the Rock Creek valley materials and flows downstream to the west.

3.6.3.3 Hydraulic Properties

As discussed in Chapter 2, slug tests and pumping tests were conducted on selected RI monitoring wells to obtain estimated hydraulic conductivity values. The results are summarized below. Full details regarding analytical methods and results are presented in Appendix F. A summary of results showing the estimated values of hydraulic conductivity determined from the slug tests is shown in Table 3-10.

3.6.3.3.1 Slug Test Analytical Results

The results of the slug test analyses demonstrate that the Rogers Seam is highly conductive. Calculated hydraulic conductivity values for wells LMW-2, LMW-4, and LMW-5 are quite high and range from about 0.009 to 0.036 ft/s (0.3 to 1.1 cm/s). Those for LMW-3 and LMW-1 are several orders of magnitude lower (10^{-5} to 10^{-6} ft/s).

These results generally confirm the view that the Rogers coal seam is highly conductive and capable of transmitting a large quantity of water. This conclusion is not surprising considering the wells were located within or near previously mined or altered portions of the coal seam where large void spaces are known or suspected to exist. The results of the LMW-3 slug testing, which suggest a hydraulic conductivity which is two to three orders of magnitude lower than those calculated for LMW-2, LMW-4 and LMW-5 (see 3-10), may be representative of hydraulic conditions in unaltered coal. Test results for well LMW-1, which was completed within the sandstone adjacent to the Rogers Seam, suggests that the sandstone has a hydraulic conductivity at least four orders of magnitude lower than the portions of the mined-out Rogers Seam.

3.6.3.3.2 Pumping Test Results

Pumping test hydrographs and discussion of results are presented in Appendix F. As discussed in Appendix G, the data generated by the two pumping tests was generally not useable for data analysis purposes as a result of very low pumping rates and correspondingly small drawdowns in the highly conductive material. Qualitatively, however, the data do generally support and confirm the slug test results which indicated extremely high conductivity of the material within the Rogers coal seam.

3.6.3.3.3 Baker Tank Discharge

Water collected in Baker tanks was drained at two site locations, one of which was directly within the trench. During the discharge of this water, dataloggers were installed in wells LMW-1, -3 and -4 to monitor any resulting water level changes. The plot of the observed water levels in these wells is shown in Figure B-12. Wells LMW-6 and LMW-7 were manually monitored (infrequently) during the test. The pond at portal #2 was monitored visually. The results of the monitoring at LMW-6 and -7 are shown in Table B-2. Private wells were not monitored because of the difficulty in obtaining access, and because LMW-6 and LMW-7 were already being monitored.

Water was introduced at the north end of the trench in the immediate vicinity of portal #2 (Figure 2-14), and at the south end of the site at a location some 200 ft to the northeast from portal #3 (Figure 2-15). Disposal at the north end occurred directly to the trench. Disposal at the south end was outside the trench and away from the Roger's seam. At the north end, water was drained from 1:45 to 8:10 pm on August 16, 1994. At the south end, water was drained from 11:42 AM to 12:32 PM on the same date. Approximately 3,200 gallons were drained at the south end, and about 24,700 gallons at the north end. While it is not possible to analyze these data quantitatively to assess hydraulic properties of the coal seam, the data can be qualitatively evaluated.

Changes in water levels were noted at wells LMW-1 and -4. The water level increased at LMW-1 by about 1 ft and at LMW-4 by about 0.3 ft. The water level at LMW-3 was essentially unchanged. The lack of response at LMW-3 is not surprising given that the discharge point was downslope from the well and the water was not introduced directly into the coal seam.

The water level responses at wells LMW-1 and -4 occurred very rapidly following the introduction of the water. Water levels began to increase in both wells within about 1 to 2 hours. LMW-1 is approximately 800 ft away (upslope) from the discharge point, and LMW-4 is about 300 ft away (downslope). Water was pumped at the north end for about 6.5 hours. The water levels began to decline in each well about 30 hours following the cessation of pumping. Neither well had returned to its original level when the water level measurements were discontinued, which was about 60 hours after the cessation of pumping for LMW-1 and about 130 hrs after the cessation of pumping for LMW-4.

Based on visual observations, the pond water at portal #2 rose several inches during discharge. As shown in Table B-2, no effects were observed at wells LMW-6 and LMW-7.

These observed results generally support the contention that the Rogers coal seam is highly conductive and capable of rapidly transmitting large quantities of water. Water introduced into the trench, either as precipitation or waste, moves quickly downward through the collapsed mine workings to the water table where it then moves rapidly to either the northerly or southerly mine discharge points. The travel time of any liquid materials potentially released to the trench is quite small and may be on the order of hours from the time of release. Evidence for lateral migration away from the mine was not provided.

Given the rapid water level response which occurred at well LMW-1 following Baker tank discharge, these results also indicate that the two portions of the trench separated by the fault in the vicinity of well LMW-1 are in good hydraulic communication with each other. This would indicate that the rock tunnel installed through the fault, and/or other mine workings in the vicinity of this part of the mine, allow effective hydraulic communication through the fault area, and the two portions of the trench are not isolated from each other by the fault offset. The mine may therefore be thought of as forming one relatively continuous, highly conductive zone.

3.6.3.3.4 Mass Balance Calculation

Another method of estimating the hydraulic conductivity of the Rogers Seam is to examine the mass balance of flow in the trench. As discussed earlier in section 3.6.3.1.1, recharge of groundwater in the trench is expected to occur primarily as a result of direct rainfall infiltration and runoff from surrounding areas. As shown in table 3-8, an average of about 55 inches of rainfall falls annually at the site. Given that no runoff of this water occurs in the trench and that evapotranspiration is probably very low, it is reasonable to expect very nearly all of this rainfall actually infiltrates to the water table. Since the trench is about 4,000 ft in length and approximately 50 ft in width, the average flow rate through the trench (and discharge from the two ends) is therefore estimated to be about 10 to 20 gpm.

The hydraulic conductivity for the mined out seam can be estimated by dividing this flow rate by the hydraulic gradient and cross-sectional area of flow. Assuming that the flow is split evenly between the two ends of the trench, and assuming a gradient of about 0.005 and cross-sectional area of 16 ft by 100 ft, the hydraulic conductivity is estimated at about 3 to 5 cm/s. This is in reasonable agreement with the results of the slug test analyses.

3.6.3.3.5 Summary of Hydraulic Analyses

The results of these hydraulic analyses indicate the following:

- The Rogers Seam is highly conductive and capable of rapidly transmitting high quantities of water.
- The fault in the vicinity of LMW-1 does not appear to act as a significant barrier to flow between the north and south portions of the mine. The two portions of the trench separated by the fault are therefore in good hydraulic communication with each other, and the mine may be thought of as forming one relatively continuous, highly conductive zone. This is because the rock tunnel installed through the fault, and/or other mine workings, allow effective hydraulic communication through the fault area.
- The hydraulic conductivity of the mined out Rogers Seam is probably on the order of about 1 to 5 cm/s, based on well tests and mass balance considerations. The conductivity of the surrounding bedrock strata is several orders of magnitude lower.

3.6.3.4 Geochemistry

The inorganic chemistry data have been compiled and presented for visual inspection in Figures 3-20 through 3-23 for the four rounds of groundwater sampling, respectively. These figures, termed Piper diagrams, are useful for visually describing differences in major-ion chemistry in groundwater flow systems and identifying major groupings or trends. Review of these figures results in the following observations.

There is essentially no differentiation between the samples on the basis of the anionic composition. Bicarbonate (HCO_3^-) is the dominant anion in all of the samples analyzed. Bicarbonate content in groundwater is usually derived from interactions between soil zone CO_2 and calcite ($CaCO_3$) and dolomite ($MgCO_3$). These minerals, which occur in significant amounts in nearly all sedimentary basins, are readily soluble in contact with CO_2-charged water (Freeze and Cherry 1979, p. 242-243).

With respect to the cationic composition of the samples, however, two general groupings of wells can be discerned. The first, a calcium-dominant type groundwater, consists of wells LMW-1 through LMW-6, samples of mine groundwater discharge collected at the portals, and the private wells installed in the glacial outwash deposits surrounding the site, or in till overlying the Puget Group (as in PW-7). The second grouping, a sodium-dominant type groundwater, consists of the relatively deep wells completed in Puget Group materials located away from the mine. These include wells LMW-7, PW-5, -6, -8, -14 and -15.

The occurrence of Na^+ and HCO_3^- as the dominant ions can be explained by the combined effects of cation exchange and calcite or dolomite dissolution. High $Na\text{-}HCO_3$ waters can be produced in sequences of strata that have significant amounts of calcite or dolomite and clay minerals with exchangeable Na^+ (Freeze and Cherry 1979, p. 287). As stated above, calcite and dolomite are present in nearly all sedimentary basins. The shales and coal-bearing layers of the Puget Group may afford suitable opportunities for the exchange of calcium and magnesium with sodium.

The interpretation offered, therefore on the basis of these data, is that the Ca-bicarbonate groundwater type represents younger groundwater derived from relatively recent rainfall runoff and infiltration that has followed a relatively short flowpath from the recharge zone. The Ca^{2+}, Mg^{2+} and HCO_3^- in this water are derived from CO_2-rich rainfall and the dissolution of calcite and dolomite in the soil zone. The Na-bicarbonate groundwater, on the other hand, represents older groundwater that, while originating as rainfall runoff, has followed a longer flowpath. During the course of this flowpath, the water has encountered a series of fine-grained sedimentary layers, including siltstones, shales and/or coal beds, where cation exchange has taken place thereby replacing the Ca^{2+} and Mg^{2+} with Na^+.

Groundwater within the undisturbed (unmined) portions of the Puget Group is therefore isolated to an extent from the mine site groundwater. If the Puget Group wells away from the mine were in direct hydraulic connection with mine groundwater, through a fault conduit for example, the cation-anion composition of these wells would be more similar to that observed at the mine wells. This interpretation is significant because it supports the view, stated above in Section 3.6.3.1.1, that the movement of groundwater laterally away from the mine is negligible.

3.6.4 Conceptual Model of Site Groundwater Flow

This sub-section summarizes the characterization of Study Area and Mine site hydrogeologic conditions into a conceptual model of site groundwater flow and potential transport of chemicals. This conceptual model is a general description which, while not addressing every aspect of groundwater hydrology at the site, is sufficient to gain an overall understanding of groundwater flow patterns and conditions and potential chemical receptor points. This conceptual model is based on the information presented in Sections 3.6.1, 3.6.2 and 3.6.3. The reader is referred to these sections for additional details regarding groundwater conditions at the Mine site.

3.6.4.1 Groundwater Flow

The primary hydrogeologic system at the site consists of a continuous to semi-continuous groundwater system comprised of the Puget Group bedrock materials and the surrounding glacial outwash aquifer. Minor occurrences of groundwater in till overlying the bedrock are likely perched and of secondary importance. The bedrock materials, which make up the hills within the Study Area, protrude up through and discharge to the glacial outwash which fills the surrounding valleys and lower elevations around the perimeter of the Study Area.

The trench of the Rogers coal seam is highly permeable with hydraulic conductivities on the order of 1 to 5 cm/s. The two portions of the trench separated by the fault near LMW-1 are in good hydraulic communication with each other, and the mine may be thought of as forming one relatively continuous, highly conductive zone or conduit. The effective hydraulic conductivity of the fine-grained sediments located to either side of the seam is at least several orders of magnitude less than the mined out seam. Faults through the coal seam are probably tight and do not act as significant conduits, based on the regional state of stress, mine reports, water level measurements, and geochemical analyses. Vertical gradients, and therefore vertical flow, also appear to be small within the coal seam. Therefore, groundwater flow in the trench primarily occurs horizontally and along strike through the highly permeable mined out Rogers Seam. Flow laterally away from the Mine (across bedding or via faults) is considered negligible. The trench can therefore be thought of as a highly conductive "slot". Groundwater within this "slot" moves longitudinally, with very little movement laterally away from the trench.

Since lateral flow away from the mine is not considered to be an operable pathway of groundwater flow, wells which are installed in Puget Group materials laterally away from the mine are considered hydraulically isolated from the mine workings. These include wells LMW-6 and LMW-7, installed in the adjacent coal seams, and the private wells completed in Puget Group bedrock materials to the east and west of the mine (i.e., PW-5 through -8, and PW-14 and -15). This is important because it indicates that there is no observable pathway for chemicals to migrate to these wells from the mine.

Mine reports, geochemical data, and the rapid response of groundwater levels to seasonal rainfall patterns suggests that recharge of the coal seam is primarily by direct rainfall infiltration. The trench effectively collects and concentrates rainfall and runoff from the surrounding area. This runoff readily infiltrates through the porous structure of the mined out seam.

Due to the preference for longitudinal flow within the trench and site topography, and as evidenced by the discharge observed at portals #2 and #3, discharge from the mine occurs at either end. A groundwater divide is therefore present within the trench. To the north of this divide, flow is to the north, and to the south of the divide, flow is to the south. There is some uncertainty with respect to the location of this divide, however, based on the high conductivity of the trench, topography and presence of ponded water in the trench, the divide is believed to occur within the southern third of the mine. The majority of flow from the mine and in particular that portion of the mine trench utilized for waste disposal is therefore to the north.

Mass balance considerations, flow measurements made at portal #3, and the reports of mine dewatering have indicated that the total flow rate of water entering as infiltration and exiting near the portals is on the order of about 10 to 20 gpm.

3.6.4.2 Primary Potential Pathways and Receptors

Geophysical data and historical information presented in this RI have indicated that potential waste buried beneath the bottom of the trench is generally confined to the northern half of the site. Given that groundwater flow beneath this portion of the site is to the north, the primary pathway of contaminants potentially exiting the mine is to the north. Future groundwater monitoring activities should therefore focus on detecting potential releases at the northern end. The chance that such a discharge could occur at the southern end is considered unlikely given the direction of groundwater flow and the apparent absence of waste in this portion of the Mine.

Once exiting the site, any potential chemical constituents leaving the northern portion of the mine will flow primarily to the north and northeast towards the Cedar River, consistent with the local ground surface topography. Discharge to the river would occur at a point approximately one mile downstream of the City of Seattle's water intake at Landsburg. This flow will occur within the Rogers coal seam, which presumably extends downslope towards the river, and within the glacial outwash materials which overlie the coal. This is consistent with the observation by field personnel of springs and seeps along the slope leading down to the river. Figure 3-19 depicts the piezometric surface contours of the site groundwater system. Figure 3-24 depicts the primary pathway of potential mine chemicals exiting the site. As seen in the figure, there are no drinking water wells located along the primary pathway of groundwater flow.

While the primary groundwater flow direction is towards the river, it is also possible that some flow could occur to the northwest within the glacial outwash to the north of the mine. If groundwater flows in this direction, potential receptor points would include wells PW-4 and PW-3 and the other private wells located along the Summit-Landsburg Rd (Figure 3-19). Well PW-4 is the closest well and is approximately 1,500 ft away from the trench. It is not considered likely, however, that groundwater flow would occur to these wells given the strong topographic gradient towards the river.

As indicated previously in section 3.6.4.1, wells installed in Puget Group materials and located laterally away from the mine are considered to be hydraulically isolated from the mine workings. There is no observable pathway for chemicals to migrate from the mine to these wells. These include wells LMW-6 and -7, and private wells PW-5 through -8, and PW-14 and -15.

At the southern end of the mine, potential receptors include the cluster of wells along the Kent-Kangley Rd. just southwest of portal #3, and the Clark Springs facility. The series of wells near portal #3 are within about 300 ft of the portal. The Clark Springs facility is approximately 2,500 ft from the portal. It is not considered likely that these wells would ever be impacted, however, as discharge of chemicals from the mine's southern end is considered a very remote possibility.

3.7 Social And Ecological Characteristics

Social and ecological data include a description of current land and water use, and ecological issues including identification of endangered species and discussion of sensitive habitats and areas.

3.7.1 Land Use

The Study Area zoning was determined by reviewing zoning maps at the King County Department of Development and Land Services. The zoning codes from the map were updated to reflect the new Title 21A Zoning Code adopted in June 1993. Full implementation of the new Zoning Code is not complete, but is anticipated by June 1995. The site zoning is shown on Figure 3-25. In general, zoning in the Study Area vicinity is intended to protect the forest resources of the area, to encourage moderate rural development and to protect water quality in the Cedar River and Rock Creek watersheds.

The bulk of the Study Area, including much of the central portion of the site and the former mine workings, has been assigned an RA, Rural Area Zone classification. This zoning, formerly classified as G-5 under KCC Title 21, indicates that land use will maintain an area-wide rural character, will prevent urban developments in areas without adequate urban services, preserve environmentally sensitive areas, and minimize land use conflicts with nearby agricultural, forest, or mineral extraction production districts. In addition, permitted uses will limit residential density to be compatible with rural character and which can be supported by rural service levels.

The western portion of the Study Area from the coal mine areas to Summit-Landsburg Road, has been designated F for forest use. This zoning is designed to preserve the forest land base, to protect the long-term productivity of forest land and restrict uses to those which are compatible with forestry. Compatible uses include outdoor recreation, conservation, and protection of municipal watersheds and wildlife habitats.

In addition, to these zoning classifications, the City of Kent and City of Seattle maintain municipal watershed lands along the western and eastern boundaries of the Study Area, respectively, for the protection of drinking water supplies associated with Rock Creek and the Cedar River.

In addition, under the Shoreline Management Plan of King County, the Cedar River shoreline throughout the Study Area vicinity has been designated a 'Conservancy' environment. The Conservancy designation objective is to conserve, protect, and manage existing areas of irreplaceable natural or aesthetic features in their native state while providing for limited shoreline use at public sites (King County Dept. of Public Works 1993). The Conservancy designation for the Cedar River extends from River Mile 3.4 to the river's headwaters.

3.7.2 Water Use

3.7.2.1 Surface Water

The City of Seattle has used the Cedar River as a source of drinking water since 1901. A large water diversion structure exists upstream of the Mine site area at Landsburg. This structure is a 96-inch diameter pipeline that diverts approximately 150 million gallons per day (mgd) from the Cedar River. The structure splits into two 78-inch diameter pipelines which deliver water to the Lake Youngs Reservoir (Brown and Caldwell 1978b) located some 5 miles to the northwest of the site (Figure 1-1).

Rock Creek has been diverted by the City of Kent since the early 1900s for use as a municipal water source. The diversion by the City of Kent represents approximately 26% of the mean annual flow of the creek and the majority of the creeks flow during the low-flow months of September and October (King County Dept. of Public Works 1993). The existing diversion structure, referred to as the Clark Springs Facility, was built in the 1940s and consists of a lateral gravity drainage collection system installed approximately 13 to 15 ft below ground surface in the creek alluvium. This facility was sampled as part of this RI and was referred to as the Clark Springs Well (PW-13).

3.7.2.2 Groundwater

Groundwater at the Study Area is used for domestic supply, small community water supply systems and for a municipal water supply (City of Kent). Table 2-1 provides the results of a survey of private wells conducted in the Study Area. The table summarizes relevant information including well depth and construction, date of installation, number of houses served, and depth to water. Available well logs for study area private wells are included in Appendix B.

The survey identified a total of 56 wells within the Study Area. Excluding the Clark Springs facility which serves the City of Kent, these wells serve approximately 91 homes at the Study Area and 236 people. The wells were installed since about 1930 with the majority of the wells being installed since about 1970.

The wells range in depth from less than twenty feet to a maximum depth of about 400 feet. Water levels in the wells ranged from as little as 4 feet to as much as 235 feet below ground surface. Many of the shallow wells were hand dug and range between 20 and 30 feet in depth. During the well survey, GAI was unable to determine a depth to water primarily due to access problems for many of the shallow wells. The shallow wells are presumably installed in the glacial drift, while the deeper wells extend into the bedrock materials of the Puget Group.

Forty-six of the wells are domestic service wells providing water to a single residence. Two wells provide water to two residences, and one services four homes. Four of the wells service community water supply systems. These wells, New Arcadia (PW-1), Landsburg Estates (PW-4), Well 429641 (PW-3), and Bridal Trails South (PW-9) provide water to 37 homes around the Study Area. All of the community supply wells were sampled during the remedial investigation.

The City of Kent Clark Springs well (PW-13) is a branched lateral gravity drainage system installed in the Rock Creek alluvium, as discussed above in Section 3.7.2.1.

3.7.3 Ecology

Ecological data collected as part of this RI/FS included identification of endangered and threatened species, priority habitats and species, and sensitive areas. These are described below in Sections 3.7.3.1, 3.7.3.2, and 3.7.3.3, respectively, and are depicted in Figure 3-26.

Information concerning endangered or threatened species was gathered via correspondence with the United States Fish and Wildlife Service (USFWS) and the Washington State Department of Wildlife (WDW).

The WDW provided information about priority habitats and species, nongame heritage database listings and spotted owl sites. The Priority Habitats and Species (PHS) Maps from depict known use areas by species requiring protective measures. Additional data from the WDW Nongame Heritage Database document point observations of nongame species of concern in the area by reputable sources. This database can include endangered, threatened, sensitive, candidate, and monitor species.

Sensitive areas discussed in Section 3.7.3.2 are defined by the King County Sensitive Areas Ordinance as lands that are subject to natural hazards and that contain unique, fragile, or valuable natural resources. Sensitive area information was obtained by reviewing the Sensitive Areas maps created by the King County Department of Building, Land Use and Development.

3.7.3.1 Endangered Species

Endangered and threatened species are categorized as listed, proposed, and candidate. Listed endangered species are defined as those species known to be experiencing or that have experienced failing or declining populations due to factors such as limited numbers, disease, predation, exploitation, or loss of suitable habitat. Proposed endangered species are under consideration for protection. Candidate species are species that may be proposed and listed in the future.

The USFWS identified the bald eagle as the only listed endangered species sighted near the Study Area. The search area for this determination represented an approximately one mile search radius extending from the Study Area and included Sections 23 to 26 of Township 22 North, Range 06 East, and Sections 19 and 20 of Township 22 North, Range 07 East. Bald eagles may winter within this area from approximately October through March.

Several candidate species were also identified by the USFWS as potentially occurring in the Study Area. These include the bull trout, mountain quail, northern goshawk, northern red-legged frog, northwestern pond turtle, pacific fisher, and the spotted frog. The USFWS did not identify any proposed species in the Study Area vicinity.

3.7.3.2 Priority Habitats and Species

3.7.3.2.1 Habitats

Priority habitats consist of any habitat type with unique or significant value to many species. Of primary relevance to this RI are wetlands and critical fish habitat.

Wetlands

"Officially" identified (i.e. mapped) wetlands occur in two areas within the Study Area. These were mapped on the WDW PHS maps and the King County Sensitive Areas maps. These areas are shown in Figure 3-26. In this discussion of wetlands, there is some overlap with Section 3.7.3.3 below since wetlands are also a type of Sensitive Area, as defined by the Sensitive Areas ordinance.

The first of these consists of an area identified by the WDW in the northern trench area. This area is indicated as a priority wetland habitat that is a part of the Cedar River wetlands. While field reconnaissance by GAI personnel did identify a number of wet areas within the trench, the area identified by the WDW was never observed to contain water during this RI.

The second area occurs just inside the southern site boundary. The area is identified as a WDW priority habitat part of the Cedar River wetlands. The PHS map indicates this is a palustrine (swampy) environment. Field reconnaissance of this area indicates it is associated with an ephemeral stream. Currently, a number of residences are located within the mapped wetland. This area is also shown on the King County sensitive areas maps, as discussed below.

Other potential wetland areas, not shown on any governmental maps, were identified by GAI field reconnaissance. These include minor wet areas within the trench as well as other areas of ponded water located in the Study Area. Figure 3-26 depicts the potential wetland areas identified by GAI. Final determination, if necessary, of the status of these areas as wetlands would require a site visit by a qualified biologist or ecologist.

Critical Fish Habitats

The WDW has mapped the Cedar River along the northern Study Area boundary as a critical spawning habitat for resident species. This portion of the river has also been identified as an anadromous fish run and as having resident species present.

Rock Creek is not identified as a critical fish habitat by the WDW. However, it is considered a high-quality salmonid habitat and a 2.5 mile stretch of Rock Creek has been designated a Regionally Significant Resource Area by the Cedar River Watershed Management Committee because of the high-quality aquatic habitat it maintains (King County Dept. of Public Works 1993).

3.7.3.2.2 Species

A priority species is defined as a wildlife species requiring protective measures for their perpetuation. The WDW has established three criteria for describing priority species, listed, vulnerable and recreationally important species. A WDW listed species are those officially designated as listed, proposed, and candidate endangered species by the USFWS. A vulnerable species includes those susceptible to population decline because they are uncommon. Recreationally important species are those species with high recreational importance or public profile and are vulnerable to habitat loss or predation.

The WDW indicates that bald eagles are a priority species and have used areas near Black Diamond as a breeding area. In addition, a bald eagle nest was identified by WDW along the Green River Gorge approximately six miles to the south of the mine Study Area. The Upper Green River Gorge was identified as a priority breeding habitat for harlequin ducks.

The WDW Non-Game Heritage Data System documents point observations of nongame species of concern in the area by reputable sources. Osprey were found nesting in two places along the Green River Gorge to the south of the Study Area. A great blue heron colony was found near Black Diamond, approximately five miles south of the Study Area. A western pond turtle was observed near Black Diamond, but was later removed to the Woodland Park Zoo.

There is no spotted owl activity within the Study Area. A spotted owl was noted more than seven miles to the north of the study area at Rattlesnake Mountain in 1993.

3.7.3.3 Sensitive Areas

Sensitive areas as defined by the King County Sensitive Areas Ordinance (Ordinance 9614) consist of land areas described as environmentally sensitive or that are subject to natural hazards, and lands that support unique, fragile, or valuable natural features. These areas include wetlands, areas prone to stream and flood hazards, erosion hazards, seismic hazards, and coal mine hazards. The purpose of the Sensitive Areas Ordinance was to implement the goals and policies of the Washington State Environmental Policy Act and the King County Comprehensive Plan which call for protection of the natural environment and the public health and safety by establishing development standards to protect defined sensitive areas.

Development of land within identified sensitive areas requires special development standards as well as special studies to assesses impacts and to propose adequate mitigation, maintenance, monitoring and contingency plans for those areas.

Sensitive Areas Maps based on the ordinance from King County were reviewed to determine what sensitive areas exist within the Study Area.

A wetland area is defined as being inundated or saturated by ground or surface water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. As discussed above in Section 3.7.3.2.1, there is one small wetland area within the southern site boundary identified in the King County Sensitive Areas map. This wetland is shown on Figure 3-26 and is discussed in Section 3.5. as a potential tributary of Rock Creek. This area is also depicted on the Washington WDW priority habitat and species map as a palustrine (swampy) environment that is part of the Cedar River wetlands. Currently, a number of residences are situated within this area. This area is located over 1,000 ft from the trench.

Streams are considered sensitive areas because of their esthetic values, their ability to provide recreation, support wildlife, and moderate flooding and erosion. The Cedar River is identified as a Class I stream for its length from Landsburg to Renton. This indicates the river is inventoried as a Shoreline of the State under the King County Management Plan. The Cedar River is currently under review for final designation as a Regionally Significant Resource Area (RSRA) by the Cedar River Management Committee (King County Public Works 1993).

Rock Creek to the south of the site is a Class II stream that flows year-round during years of normal rainfall and is used by salmonids. The creek is ephemeral to the east of were it crosses beneath the Kent-Kangley Rd. (Figure 3-16).

Erosion hazards areas are described as areas where soils are susceptible to erosion as a result of development. Factors affecting erosion include the physical and chemical characteristics of the soil, the presence or absence of vegetative cover, slope length and gradient, the intensity of rainfall and velocity of runoff. Two large areas of the site are described as susceptible to erosion. The first is the steep northern slope along the Cedar River. The second is the steep hillside in the eastern portion of the study area between the trench and Study Area boundary. These areas are shown in Figure 3-26.

Landslide hazard maps delineate areas where the topographic and geologic conditions indicate a potential for hillslope failure. There are no landslide hazard areas identified for the site. Seismic hazards are defined as areas subject to severe risk of earthquake damage as a result of seismically induced settlement or soil liquefaction. There are no such potential areas identified at the site.

Coal mine hazard areas are mapped because of their potential for gradual or sudden collapse of underground mine workings leading to surface ground failure. Surficial ground collapse can cause damage to structures, as well as personal injury. Additional risk may be posed by the presence of unstable mine spoils piles that are subject to failure. As expected, the portions of the Landsburg mine site where coal removal occurred are mapped as coal mine hazard areas. These are shown in Figure 3-26.

0106RHL1.CH3

TABLE 3-1

COAL ANALYSIS REPORT SUMMARIES - ROGERS SEAM

Date	Mine	Moisture Content (%)	Ash (%)	Hydrogen (%)	Oxygen (%)	Carbon (%)	Sulphur (%)	Nitrogen (%)	Volatile Matter (%)	BTU (/lb)	Condition
1966 (1)	SP	14	13							10,700	As Received
1965 (2) (P)	R2	10.7	4.9			43.4			41		
1965 (2) (U)	R2		4.9	6.1	21.6	65.2	0.5	1.7			Dry Basis
1965 (2) (P)	R2	14.4	7.8			43			34.8	13,000	Dry Basis
1966 (5)	SP	16.3	12.9							12,130	Dry Basis
1967 (5)	R2	14	14.6							11,640	
1967 (5)	R2	13.4	13.1							11,825	
1970	R2	15	8.9			44.6	0.5		41.9	12,400	Dry Basis
1970 (6)	SP	10.8	7.5			47.9	0.65		44.6	13,110	Dry Basis
1970 (6)	SP	11.1	12			49.3	0.83		38.7	12,700	Dry Basis
1971 (4)	SP	15.4	9.6			39.8	0.5		40.5	12,400	Dry Basis
1971 (4)	SP	12.4	9.4			40.9	0.6		41.3	12,400	Dry Basis
1971 (4)	SP	13	11.5			39.8	0.6		40.5	12,400	Dry Basis

References:
(1) Guteberlet Laboratories, Seattle, WA
(2) USBM Reports
(3) J. M. Knisely Engineering Corporation
(4) Washington State Department of Highways (MTL)
(5) University of Washington
(6) Bennets Chemical Laboratory

Key:
R2 - Rogers No. 2 Mine
SP - Stock pile
(P) - Proximate Analysis
(U) - Ultimate Analysis

TABLE 3-2

ROGERS SEAM - MINE MAPS

Map No.	Year	Description
14	4/22/66	Plan of Rogers 1/2 showing Rogers 3 in development. Shows surface "strip pit" between Rogers portal and return air slope.
27	Undated	Working drawings for Rogers No. 1 development and booming.
236.A	10/1/60	NE extension surface plan showing hoists and bunkers.
236.B	10/1/60	Plan and sectional views of Rogers No. 1 and 2 slopes, major northern fault, and sump.
354	4/24/61	Plan of Rogers 1 and 2 showing Rogers 2 in development.
357	3/29/60	Plan of Rogers 1 and 2 showing Rogers 2 in development.
392	4/22/66	Plan of Rogers 1 and 2 showing Rogers 3 in development.
657	2/27/74	Shows A-A, A-B sections from #672.
662	Undated	Working drawings, Rogers No.2. Shows pillaring operations from fault (chute #8) to chute #39.
672	Undated	Shows plan of caved area above Rogers seam and Landsburg workings.
692	Approx. 1974	Working Map of 3rd and 4th levels. Shows pattern of development and booming. Shows extent of caving. Indicates 80-to-90 % extraction. One ton = 2 cu. yds.
704	Undated	Superintendents Plan, Rogers No.2
DNR 1	1975	Superintendent's Plan, Rogers No. 2.
DNR 2	1965	Section through Rogers Mine at abandonment.
DNR 3	Unknown	Section showing 1st and 2nd level development and mining.
DNR 4	1970	Section showing 1st, 2nd, 3rd, and 4th level development and mining.

TABLE 3-3

SEQUENCE OF MINING IN THE FIRST LEVEL

Approx Date	Activity	Notes
Pre-1959	Complete Rogers Slope.	Work halted due to fault (Morris, J., 1992).
Mar, 1959	Mine 130' rock tunnel to intersect coal.	No inflow of water when mining through fault. Probably same fault encountered in landsburg (Falk, 1992).
Apr, 1959	Complete return air slope.	
Jan, 1960	Complete gangway and counter to southern end of 1st level.	Mining controlled by need to promote drainage. Presence of gravel in this area prevented further mining. Holes not drilled through hardpan (Falk, 1992: Eltz, 1992). One hole reported making 7-15 gpm (Simmons, 1992); other holes wet.
Jun, 1960	Complete area designated as "coal extracted by booming".	Area at surface caved (2). Coal reported as "100% extracted " in this area (Eltz, 1992).
Dec, 1960	Complete booming from 1150 to 1250 ft.	Chutes holed through to surface, surface caved. Reported able to see daylight from gangway.
Jul, 1962	Complete booming to rock tunnel.	Surface caved extensively. Small pillars remain where coal pillars left underground for mine fire control. Caved zone periodically filled from the surface.
Unknown	Coal stripped from southern end of major fault using truck mounted drilling rig and dragline.	Area between base of "strip pit" and No. 1 return slope shown as removed.
Unknown	Coal stripped to north of fault (depth = 30')	Coal stripped approx 100 ft north of Rogers No. 2 portal.
1965 to 1966	Water level tunnel and counter constructed. Coal boomed to base of "strip pit".	

TABLE 3-4

SEQUENCE OF MINING IN THE SECOND LEVEL

Approx Date	Activity	Notes
1960	Mine Rogers No. 2 Slope and Return Air Slope.	
Dec, 1961	Mine gangway and counter to southern end of mine; complete development crosscuts and chutes.	150 ft of solid coal left between upper crosscut in 2nd level and gangway in Rogers No.1. Rogers No.1 kept dewatered and periodically inspected. Test holes bored to define proximity to gravel layer at southern end of level.
Sep, 1963	Complete booming to below southern limit of 1st level workings.	Areas caved through to surface (subsequently backfilled). Pillars left in 2nd level from directly below southern limit of 1st level for approximately 250 ft towards south. Mud inflow occurred August, 1963. Bulkheads and stoppings set to prevent inflow and control fires. Extraction ratios from 80 to 90 % reported.
Feb, 1965	Complete booming to rock tunnel.	Pillars left for fire control (Simmons, 1992). Often remnant pillars chosen to coincide with fault (Simmons, 1992). Holes drilled through to 1st level gangway to drain water (Simmons, 1992, Mine Maps). Caved zone inspected daily and periodically backfilled (Simmons, 1992). Booming round drilled within few feet of first level; often broke through caving to gangway.
Jun, 1965	Complete booming to No. 2 return air-slope.	Pillars left for mine fire control. Coal between top of booming round and 1st level gangway reportedly caved without blasting.
Nov, 1966 to Jul, 1967	Mine area beneath No. 2 Slope 300 ft north of portal.	Area mined from 3rd level with extensive caving.

TABLE 3-5

SEQUENCE OF MINING IN THE THIRD AND FOURTH LEVELS

Approx Date	Activity	Notes
1962	Mine Rogers No.3 Access slope and return airway to surface.	Slope and aircourse for the Rogers No. 3 level were driven to the surface from the Rogers No. 2 gangway.
May, 1966	Mine 3rd gangway and counter 4,950 ft to northern property boundary.	Level 3 is referred to in the Coal Mine Inspectors Reports as the Rogers No. 3, 2nd level.
1967	Drive Rogers No.3 slope to 4th level.	Level 4 is referred to in the Coal Mine Inspectors Reports as the Rogers No. 3, 3rd level.
Jul, 1967	Boom 3rd level to beneath bottom of Rogers No.2 slope.	Surface in this area initially overlain by 13 ft of gravel. Zone extending 300 ft north of Rogers No. 2 portal shown as caved to surface; this was also reported in Coal Mine Inspector Report A23, and may be the location referred to By Archie Eltz when daylight could be seen from the 3rd level. Portions of caved zone shown as backfilled on the Mine Superintendent's drawings.
Dec, 1967	Boom 3rd level to rock tunnel	Four inch holes drilled through 90 ft pillar to 2nd level for drainage.
Jan, 1969	Boom 3rd level to beneath northern end of 1st level zone designated as "Coal Extracted by Booming".	Four inch holes drilled through 50 to 60 ft pillar to 2nd level for drainage.

TABLE 3-5

SEQUENCE OF MINING IN THE THIRD AND FOURTH LEVELS (Continued)

Approx Date	Activity	Notes
Jul, 1967 to Sep, 1969	Mine 4th level gangway and counter to major fault.	End of 4th level approximately 3200 ft from bottom of Rogers No.3 slope. gangway finished approximately one year before booming started.
June, 1970	Boom 3rd level to within 250 ft of Rogers No. 3 slope.	Four inch holes drilled through 50 to 60 ft pillar to 2nd level for drainage.
Sep, 1970	First booming round on 4th level.	First two booming rounds shown as caved to 3rd level. Area immediately above these two rounds in 3rd level shown as left in place due to hanging wall collapse in 3rd level crosscut.
Oct, 1974	Complete booming on 4th level.	Small (15 ft) pillars left between booming rounds. Four inch test holes drilled through 100 ft pillar to 3rd level.
1975	Complete mining 3rd level, Rogers No.3 slope pillar.	Pillars extracted prior to abandonment of level.
1975	Complete mining 2nd level, Rogers No.3 slope pillar.	Pillars extracted prior to abandonment of level.
Dec, 1975	Abandon Rogers No. 3 Mine	On December 12, 1975 the Rogers No. 3 slope and return airway were sealed by blasting from the surface. Remaining voids were filled using a dozer.

TABLE 3-6

LANDSBURG MINE - ROGERS SEAM
MINE/WASHED COAL TONNAGES

Year	Mine, Rogers No.	Raw Coal (tons)	Clean Coal (tons)	Seam Thkns (ft)	Notes
1956					
1957					
1958					
1959	1	23205	15217		Washington State DNR, OFR 84-6, Plate 2 of 2
1960	1	17960	12573	7.5	Palmer Coking Coal Records
1960	2	12400	8678	7.5	Palmer Coking Coal Records
1961	1	14200	8516	7.5	Palmer Coking Coal Records
1961	2	49900	32472	7.5	Palmer Coking Coal Records
1962	1	21920	14375	ND	Mine Inspectors Reports
1962	2	23865	15763	ND	Mine Inspectors Reports
1963	2	42620	28152		Washington State DNR, OFR 84-6, Plate 2 of 2
1963	3	8160	5383		Washington State DNR, OFR 84-6, Plate 2 of 2
1964	2	39120	25838		Washington State DNR, OFR 84-6, Plate 2 of 2
1964	3	46418	22780		Washington State DNR, OFR 84-6, Plate 2 of 2

TABLE 3-6

LANDSBURG MINE - ROGERS SEAM
MINE/WASHED COAL TONNAGES (Continued)

Year	Mine, Rogers No.	Raw Coal (tons)	Clean Coal (tons)	Seam Thkns (ft)	Notes
1965	2	38610	25502		Washington State DNR, OFR 84-6, Plate 2 of 2
1965	3	17910	8824		Washington State DNR, OFR 84-6, Plate 2 of 2
1966	2	25100	16574		Washington State DNR, OFR 84-6, Plate 2 of 2
1966	3	47440	23372		Washington State DNR, OFR 84-6, Plate 2 of 2
1967	2				
1967	3	79230	39069		Washington State DNR, OFR 84-6, Plate 2 of 2
1968	2				
1968	3	70426	34698		Washington State DNR, OFR 84-6, Plate 2 of 2
1969	2				
1969	3	78881	38862		Washington State DNR, OFR 84-6, Plate 2 of 2
1970	3	45594	22463		Washington State DNR, OFR 84-6, Plate 2 of 2
1971	3	65517	30105	8	Palmer Coking Coal Records
1972	3	59525	28572	8	Palmer Coking Coal Records
1973	3	31336	16295	8	Palmer Coking Coal Records
1974	3	27884	14500	8	Palmer Coking Coal Records
1975	3	9188	5051	8	Mine closed 8/20/75.

TABLE 3-7

DAILY AVERAGE STREAM FLOW DATA[1] FOR THE CEDAR RIVER (in cfs)

NEAR LANDSBURG (1895-1994)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	975	899	796	783	803	757	487	350	322	387	708	943
Max	6020	5450	4500	2790	2020	2550	2130	1020	1220	1850	13600	7550
Min	224	255	318	288	256	263	153	108	83	126	96	148
BELOW DIVERSION (1992-1994)												
Average	534	588	324	424	463	325	211	148	160	263	410	591
Max	1390	1320	871	1060	1080	804	440	366	282	318	574	1240
Min	311	284	225	197	206	122	87	78	96	190	276	297

[1] Hydrosphere Data Products (1993b).

TABLE 3-8

PRECIPITATION AND SNOWFALL DATA AT LANDSBURG FOR 1931-1993 (in inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Average Monthly Precipitation	7.34	5.79	5.56	4.33	3.37	3.09	1.43	1.69	3.21	5.12	7.59	7.97	56.52
Maximum Monthly Precipitation	17.52	12.54	10.81	8.62	7.83	7.11	3.93	6.61	8.51	11.38	17.79	22.63	76.39
Minimum Monthly Precipitation	1.86	0.49	1.26	0.73	0.63	0.40	0	0.03	0.1	0.39	1.40	2.03	32.93
Average Monthly Snowfall	4.55	2.24	1.20	0.10	0	0	0	0	0	0.01	1.15	2.23	10.61
Maximum Monthly Snowfall	35.20	23.30	24.00	5.10	0	0	0	0	0	0.60	21.40	24.7	35.20
Minimum Monthly Snowfall	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0

Source: Hydrosphere Data Products (1993a).

TABLE 3-9

TEMPERATURE DATA AT LANDSBURG FOR 1931-1993

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average Maximum	43	48	53	58	65	70	76	75	70	60	50	44
Maximum Temperature	51	58	64	67	73	75	83	85	77	67	57	52
Year of Maximum	1961	1941	1941	1934	1940	1992	1958	1967	1974	1952	1939	1940
Average Minimum	31	32	34	37	42	47	49	49	45	40	35	32
Minimum Temperature	18	23	29	32	37	42	45	44	41	35	26	24
Year of Minimum	1950	1936	1954	1975	1950	1949	1954	1973	1965	1972	1985	1985
Source: Hydrosphere Data Products (1993a).												

TABLE 3-10

RESULTS OF SLUG TEST ANALYSES[1]
LANDSBURG MINE SITE

Well	Method of Analysis	Hydraulic Conductivity (ft/s)		
		Test 1	Test 2	Test 3
LMW-1	Hvorslev (1951)	4.14E-06		
LMW-2	Uffink (1984)	0.05 to 0.07	0.008 to 0.013	0.009 to 0.012
LMW-3	Hvorslev (1951)	1.04E-05	1.00E-05	
LMW-4	Uffink (1984)	0.007 to 0.017	0.016 to 0.027	
LMW-5	Uffink (1984)	0.025 to 0.036	0.014 to 0.027	

[1] Analysis of slug test data is presented in Appendix F.

0228rhl1.310

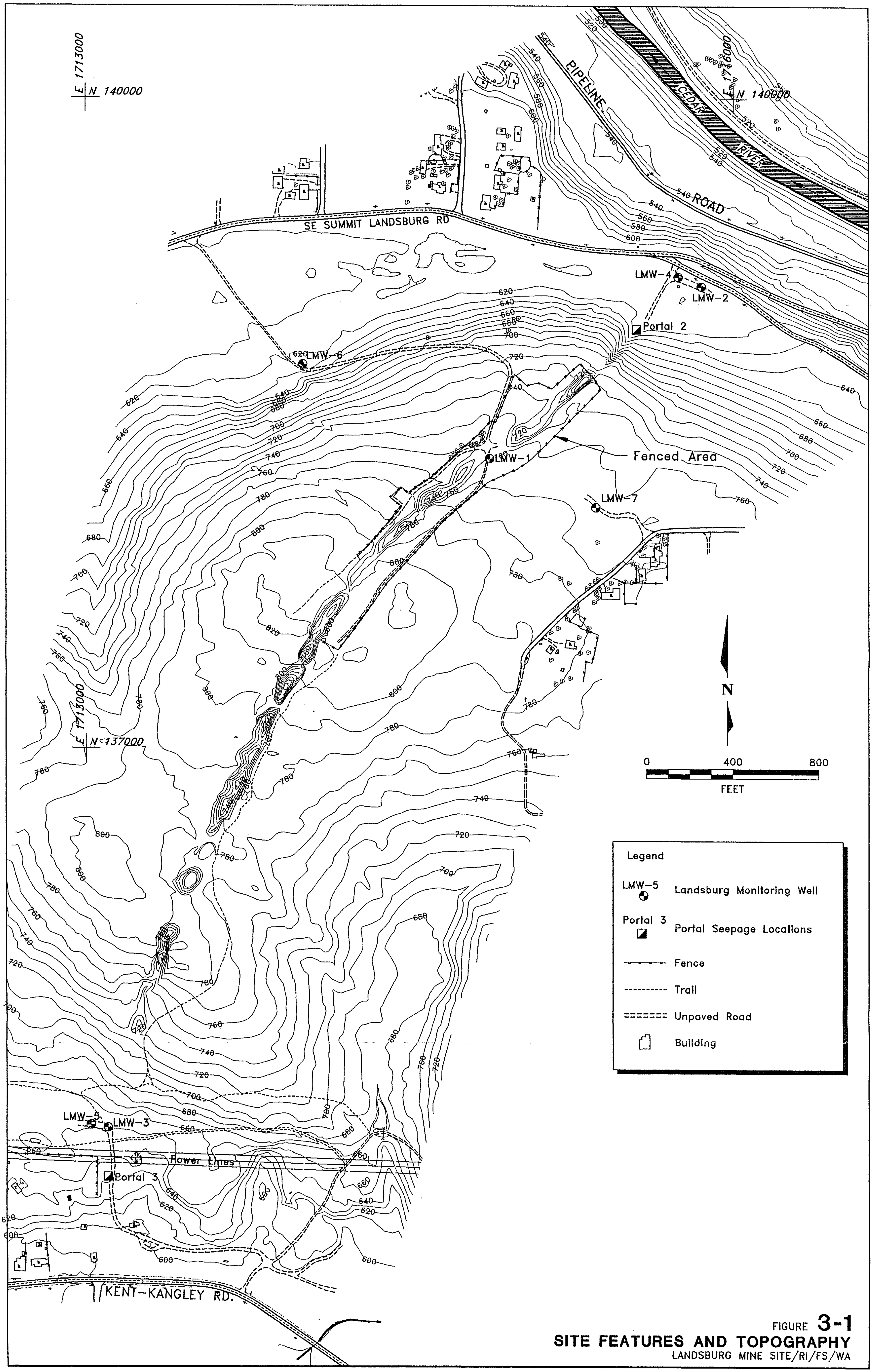


FIGURE **3-1**

SITE FEATURES AND TOPOGRAPHY

LANDSBURG MINE SITE/RI/FS/WA

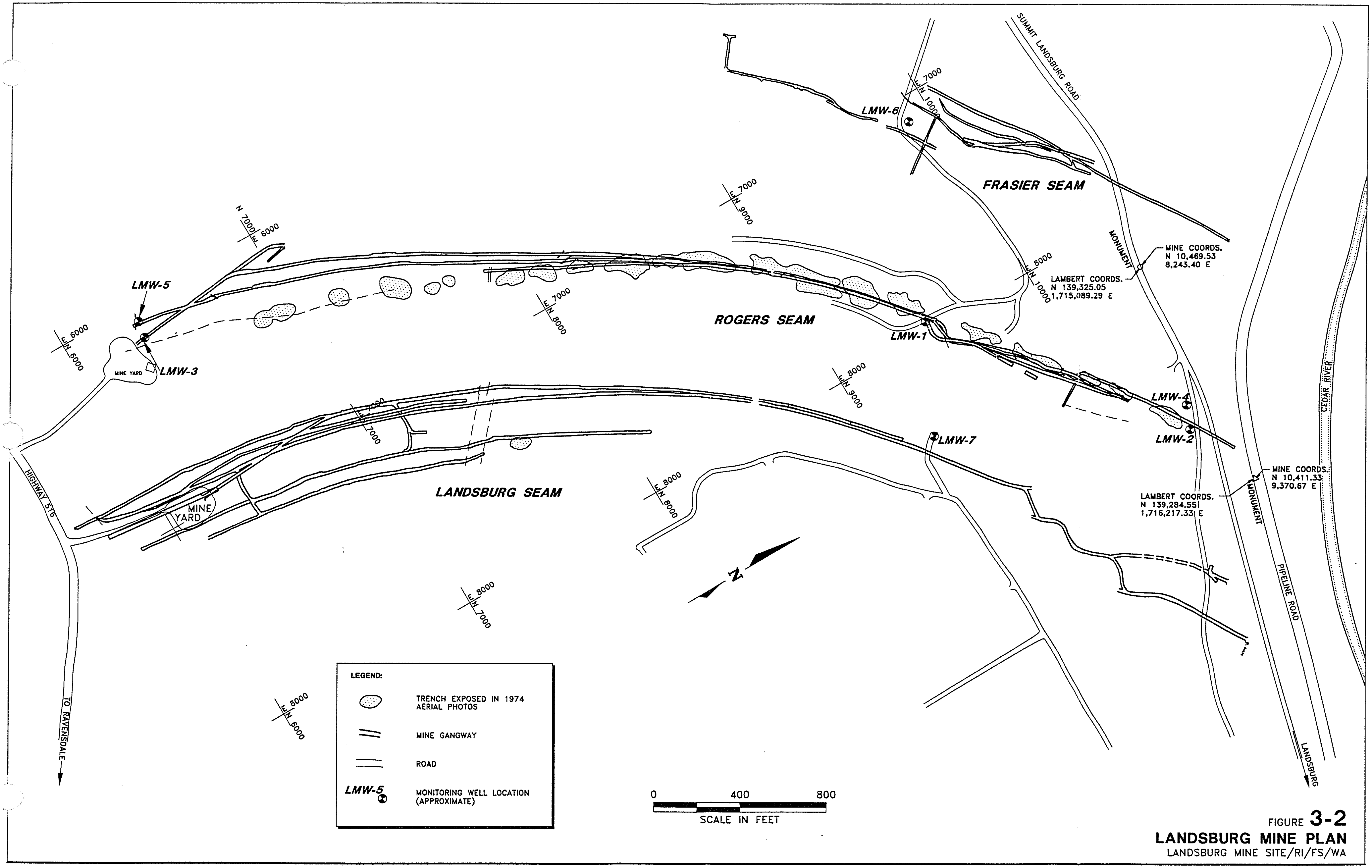
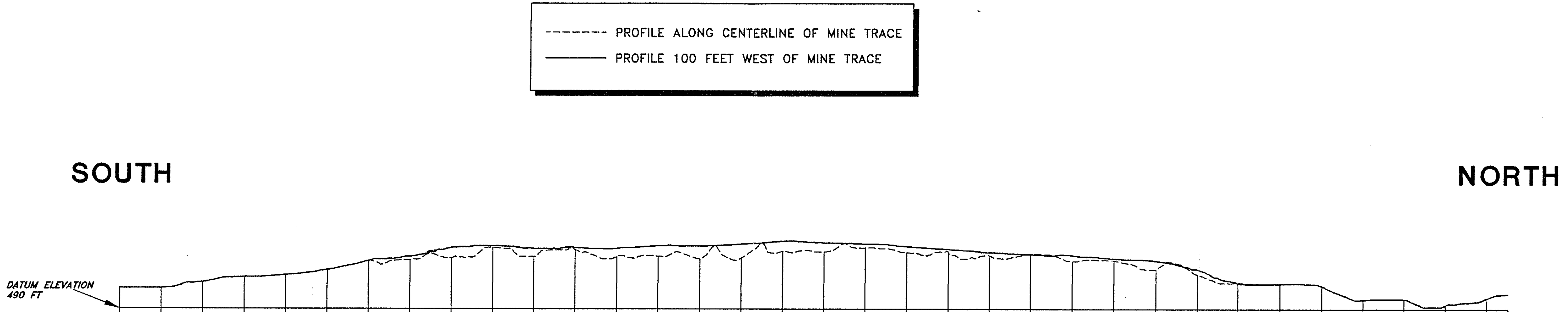


FIGURE **3-2**

LANDSBURG MINE PLAN

LANDSBURG MINE SITE/RI/FS/WA



ELEVATION OF CENTERLINE ABOVE DATUM	591.9	591.5	622.4	638.9	654.9	692.6	726.0	728.0	738.0	788.5	744.0	778.4	744.3	746.0	734.0	738.8	770.8
STATION	0+00		4+00		8+00		12+00		16+00		20+00		24+00		28+00		32+00
ELEVATION 100 FT WEST OF CENTERLINE ABOVE DATUM	590.1	591.4	620.0	645.6	656.1	680.0	724.2	745.8	788.4	798.0	784.6	788.9	784.2	797.6	796.8	806.5	820.6

ELEVATION OF CENTERLINE ABOVE DATUM	766.9	787.5	764.0	764.4	749.7	756.7	722.2	725.8	683.5	657.7	618.0	610.6	606.0	539.7	540.3	504.0	533.8
STATION		36+00		40+00		44+00		48+00		52+00		56+00		60+00		64+00	
ELEVATION 100 FT WEST OF CENTERLINE ABOVE DATUM	812.5	807.8	795.3	781.7	765.6	756.6	751.3	736.7	725.6	684.0	616.4	614.0	602.9	536.8	539.1	510.9	543.8

FIGURE **3-3**

PROFILE ALONG LANDSBURG MINE TRACE

LANDSBURG MINE SITE/RI/FS/WA

DWG ID: JSS\9231000\147\57154 DATE 2-10-95 10:49

Golder Associates

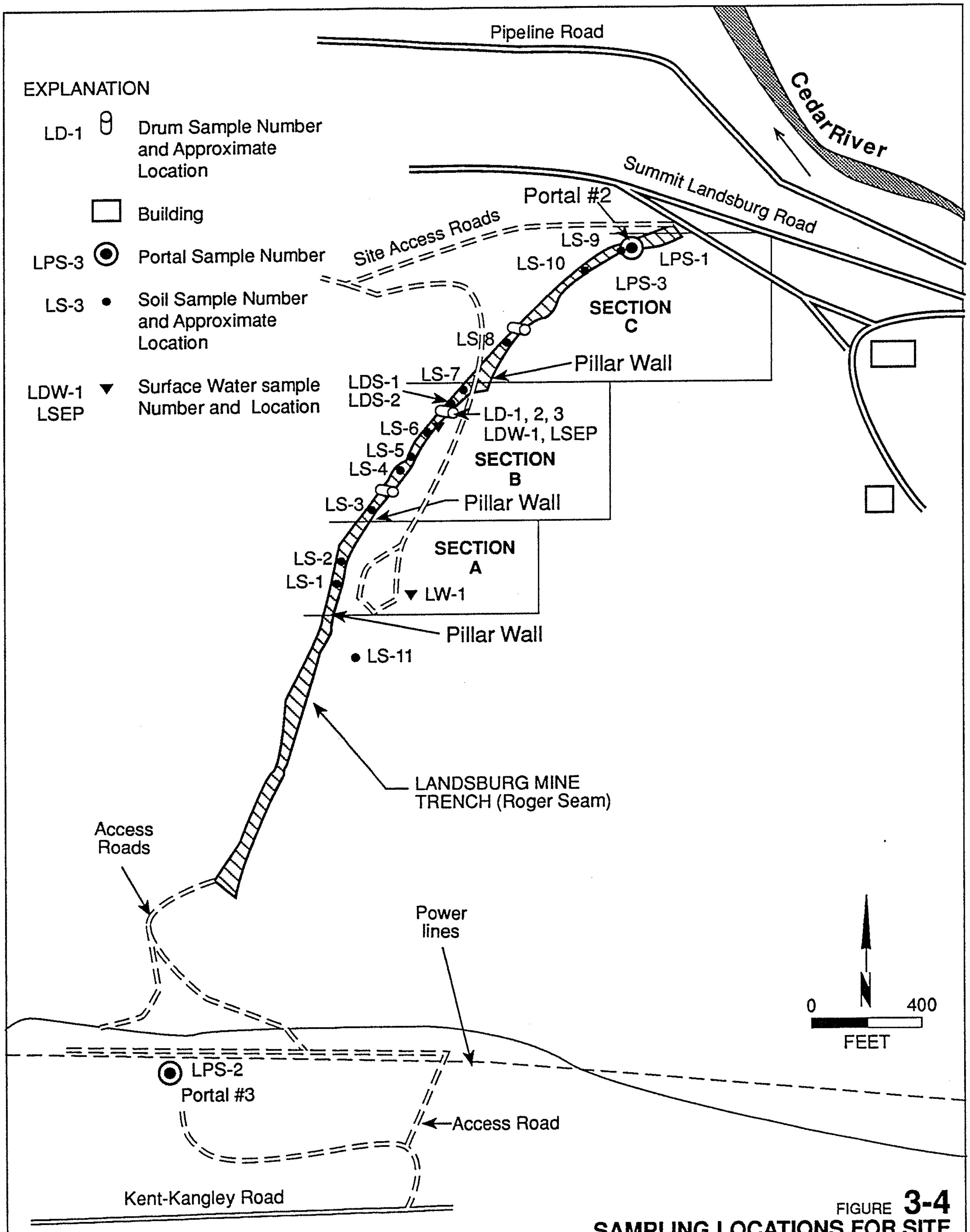


FIGURE **3-4**

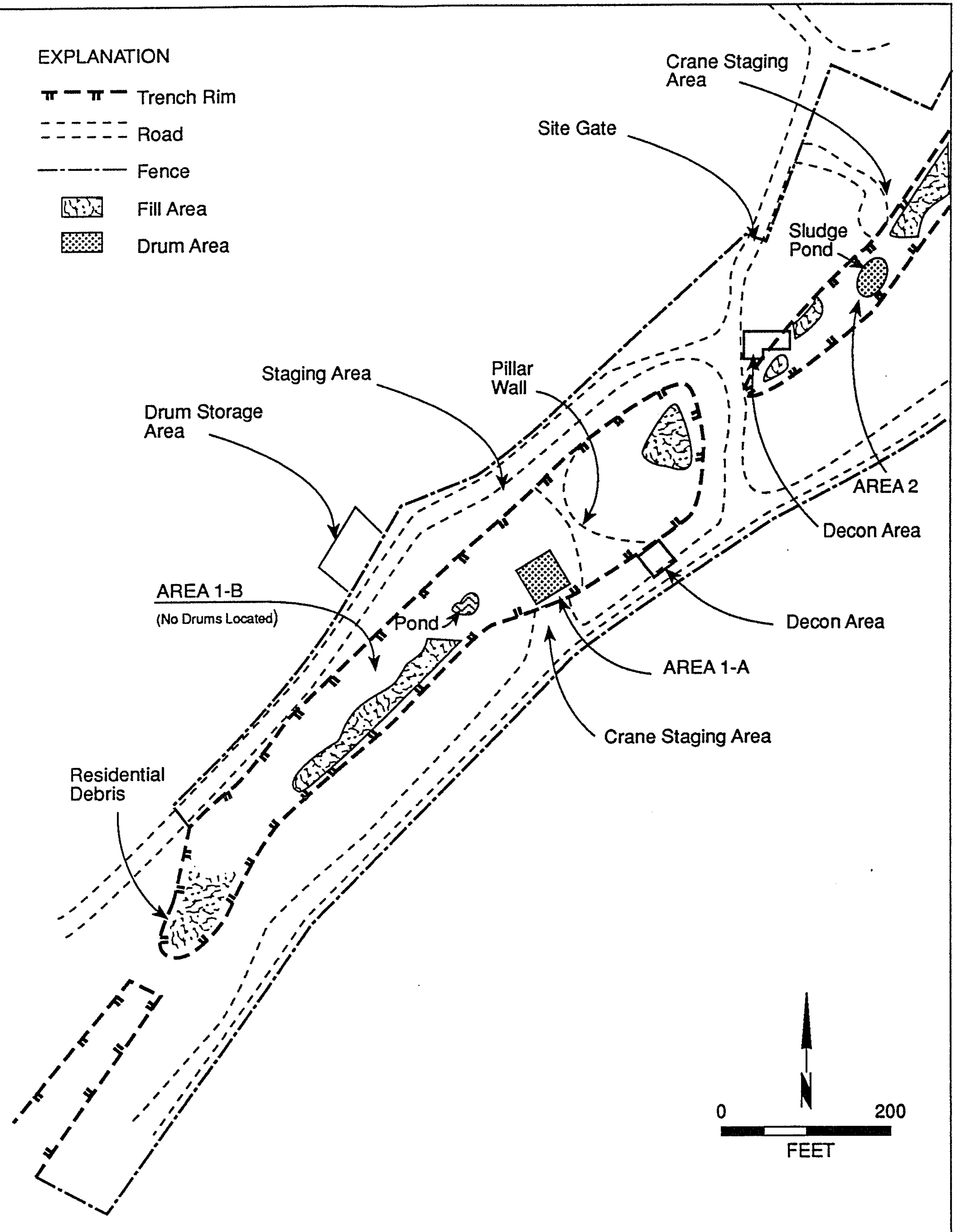
SAMPLING LOCATIONS FOR SITE HAZARD ASSESSMENT

LANDSBURG MINE SITE RI/FS/WA

Source: Modified from Ecology and Environment (1991)

PROJECT NO. 923 1000.147 DRAWING NO. 27754 DATE 3/2/95 DRAWN BY TB

Golder Associates



Source: Landsburg PLP Steering Committee 1991

FIGURE **3-5**
DRUM REMOVAL CONDUCTED DURING ERA
LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 27755 DATE 2/10/95 DRAWN BY TB

Golder Associates

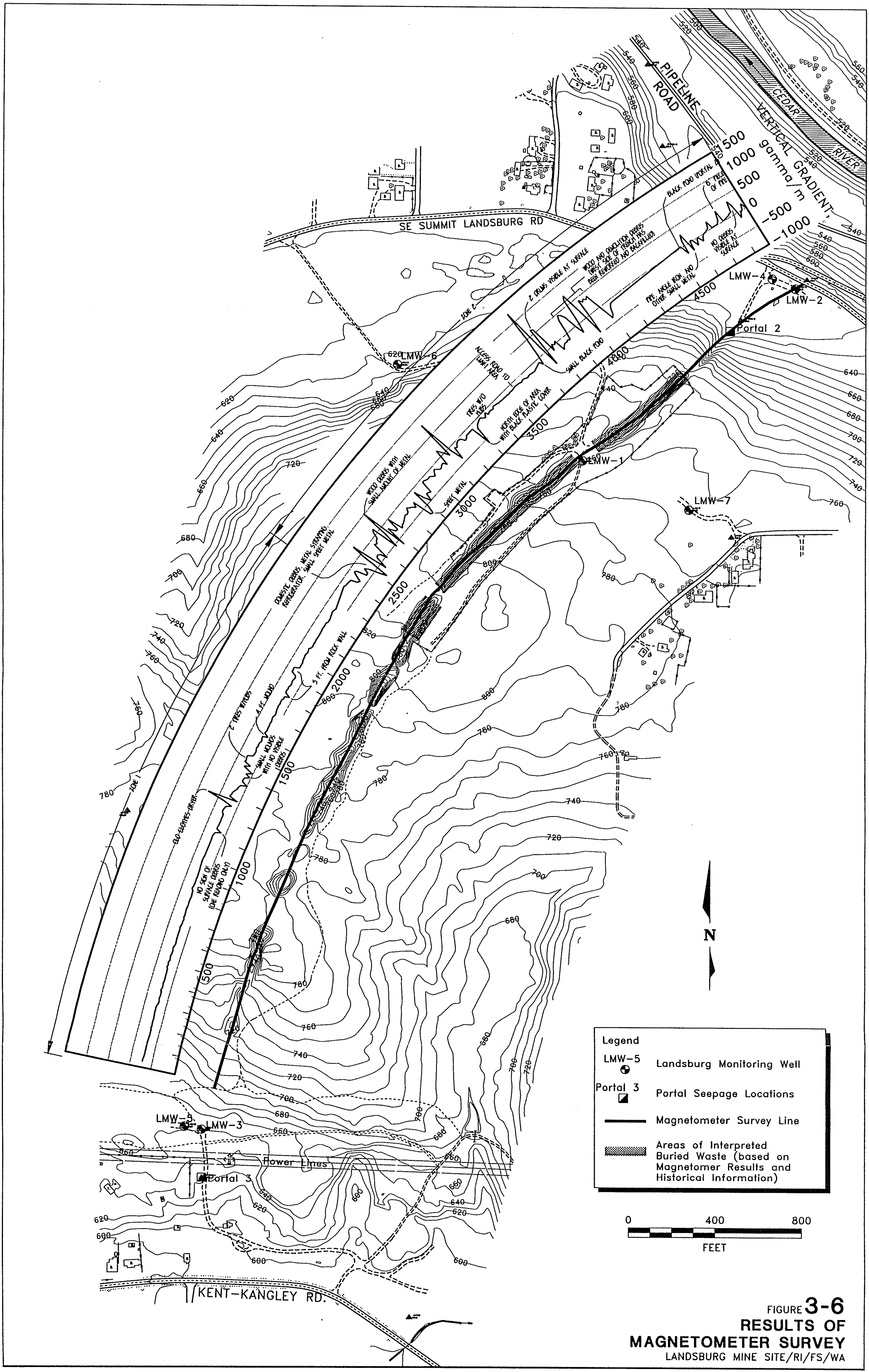
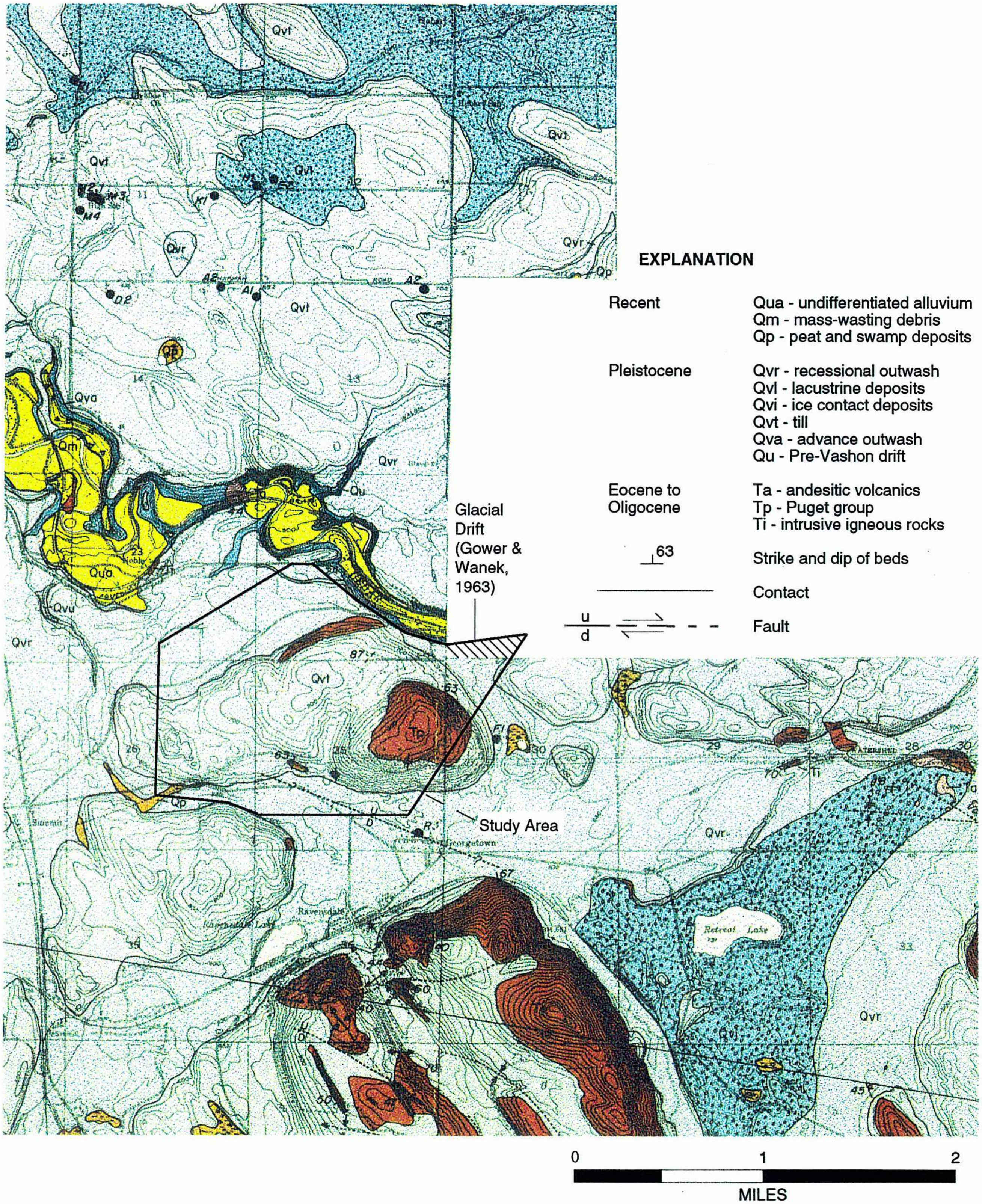


FIGURE **3-6**
RESULTS OF MAGNETOMETER SURVEY
LANDSBURG MINE SITE/RI/FS/WA

C:\JPM\9231000\147\WORK 1-18-96 9:42 xrf: NONE

Golder Associates



NOTE: The axis of the anticline referred to in Section 3.3.2.2 is east of the Study Area and not shown.

SOURCE: Luzier (1969)

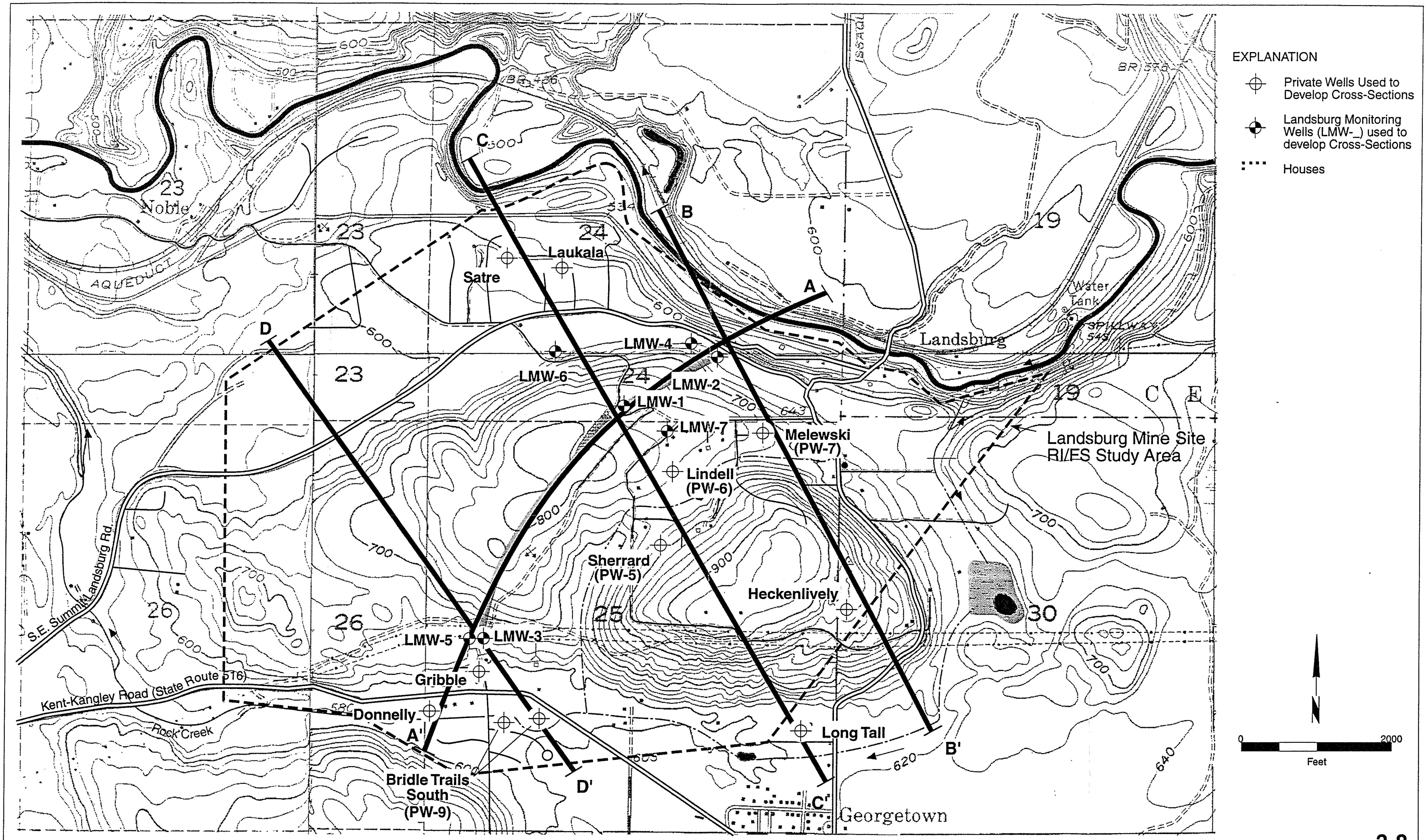
FIGURE **3-7**

SURFICIAL GEOLOGY OF THE STUDY AREA VICINITY

LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923-100.147 DRAWING NO. 50388 DATE 1/12/96 DRAWN BY TK

Golder Associates



Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

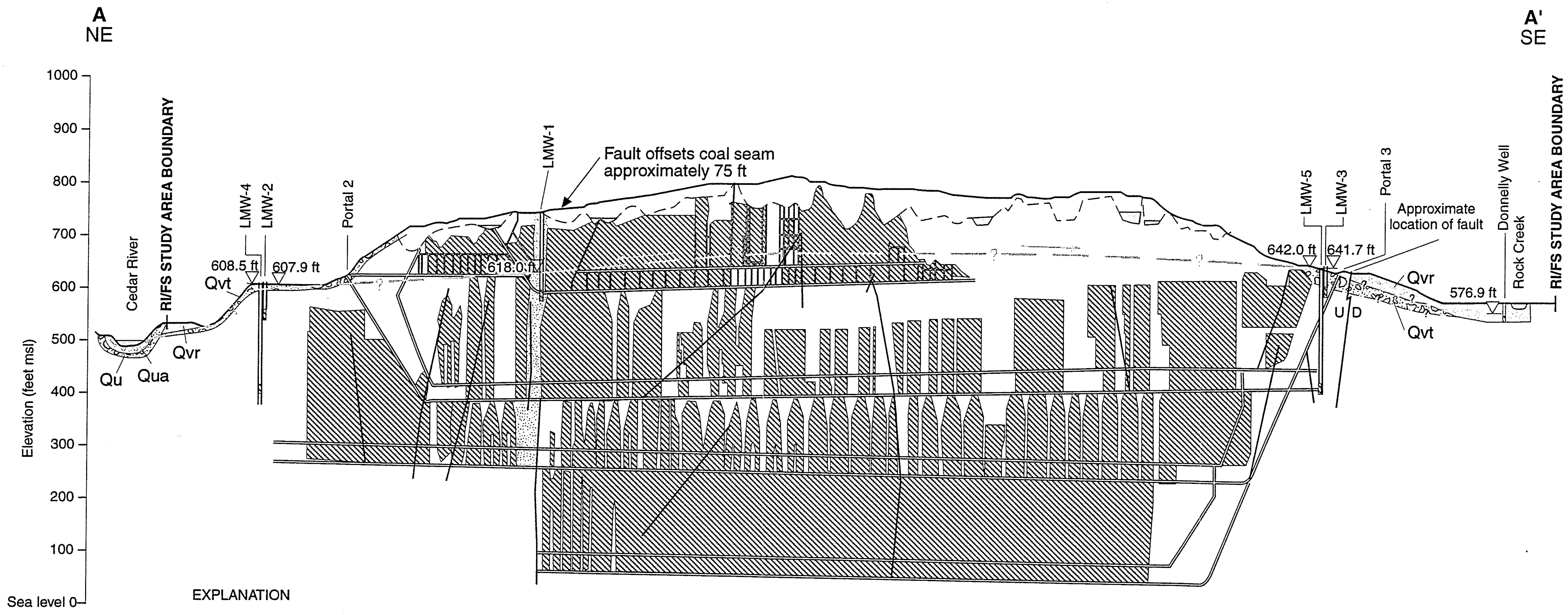
FIGURE **3-8**

MAP VIEW FOR LANDSBURG CROSS-SECTIONS

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 50020 DATE 1/8/96 DRAWN BY CB

Golder Associates



EXPLANATION

- ⟵ Potentiometric surface and inferred direction of groundwater flow
- ▨ Area of Coal Extraction
- ⌃ General outline of trench bottom
- ▽ Water Level (ft. amsl) 2/23/94
- Qvt (Till) - compact mixture of gravel, occasional boulders in clayey silty sand matrix
- Sandstone
- Surface water feature (approximate)
- Qu (Pre-Vashon Drift) - till, fluvial sand and gravel, lacustrine sand, silt, clay and peat
- Qvr (Recessional outwash) - well sorted sand and pebble-cobble
- Qua (Undifferentiated alluvium) - pebble-cobble gravel and sand
- ▨ Monitoring Interval
- | Fault

0 500
FEET

Sources for the Geology and Mine Information:

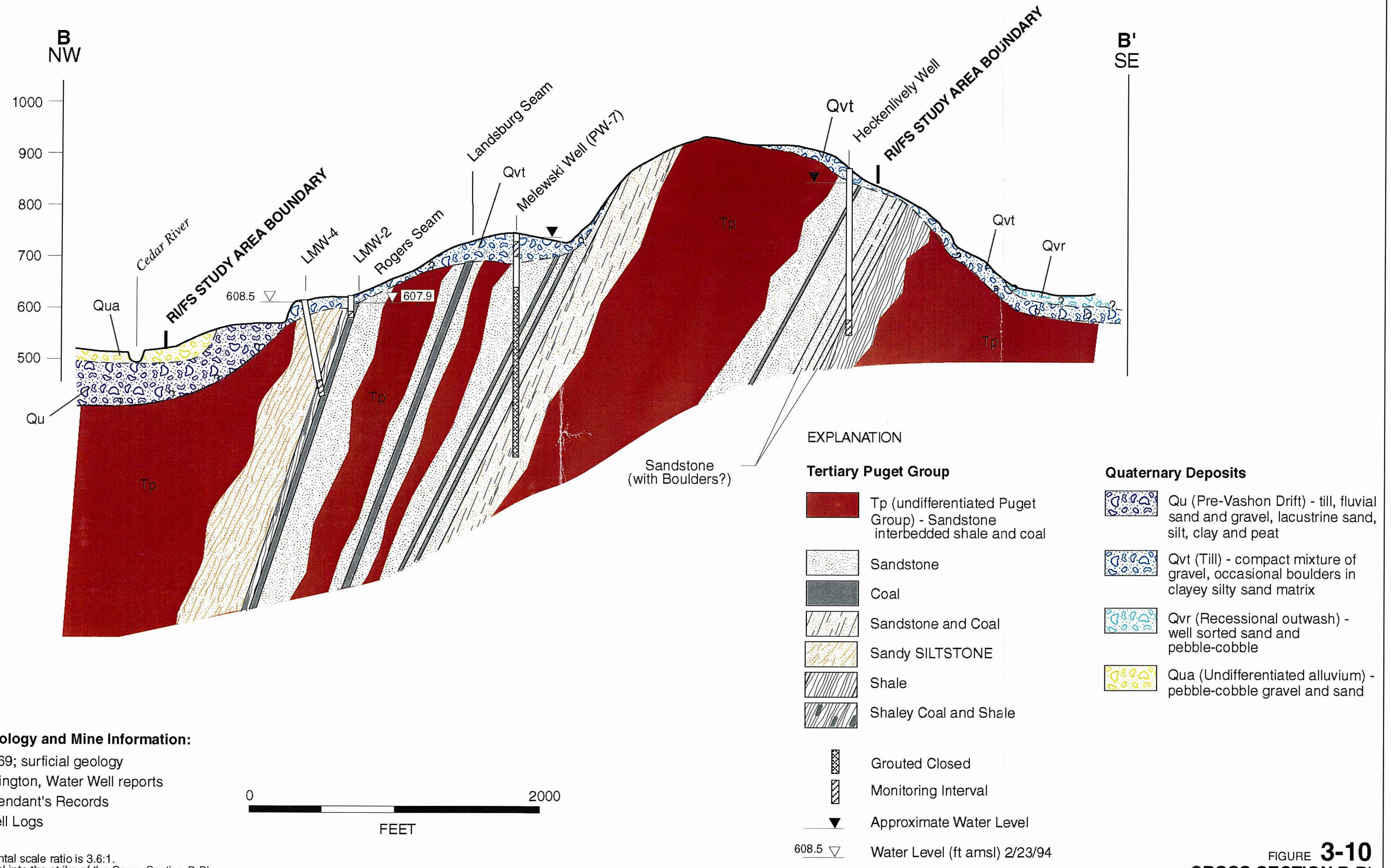
- J.E. Luzier 1969; surficial geology
- State of Washington, Water Well reports
- Mine Superintendant's Records
- Landsburg Well Logs

NOTE: Vertical to horizontal scale ratio is 2.5:1
Wells are projected normal into the strike of the Cross-Section A-A'

FIGURE **3-9**
CROSS-SECTION A-A'
ALONG STRIKE AT COAL SEAM
LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 49820 DATE 1/8/96 DRAWN BY CB

Golder Associates



Sources for the Geology and Mine Information:

- J.E. Luzier 1969; surficial geology
- State of Washington, Water Well reports
- Mine Superintendant's Records
- Landsburg Well Logs

NOTE: Vertical to Horizontal scale ratio is 3.6:1.
Wells are projected normal into the strike of the Cross-Section B-B'.
Cross-sections are inferred from limited data and should be considered approximate.

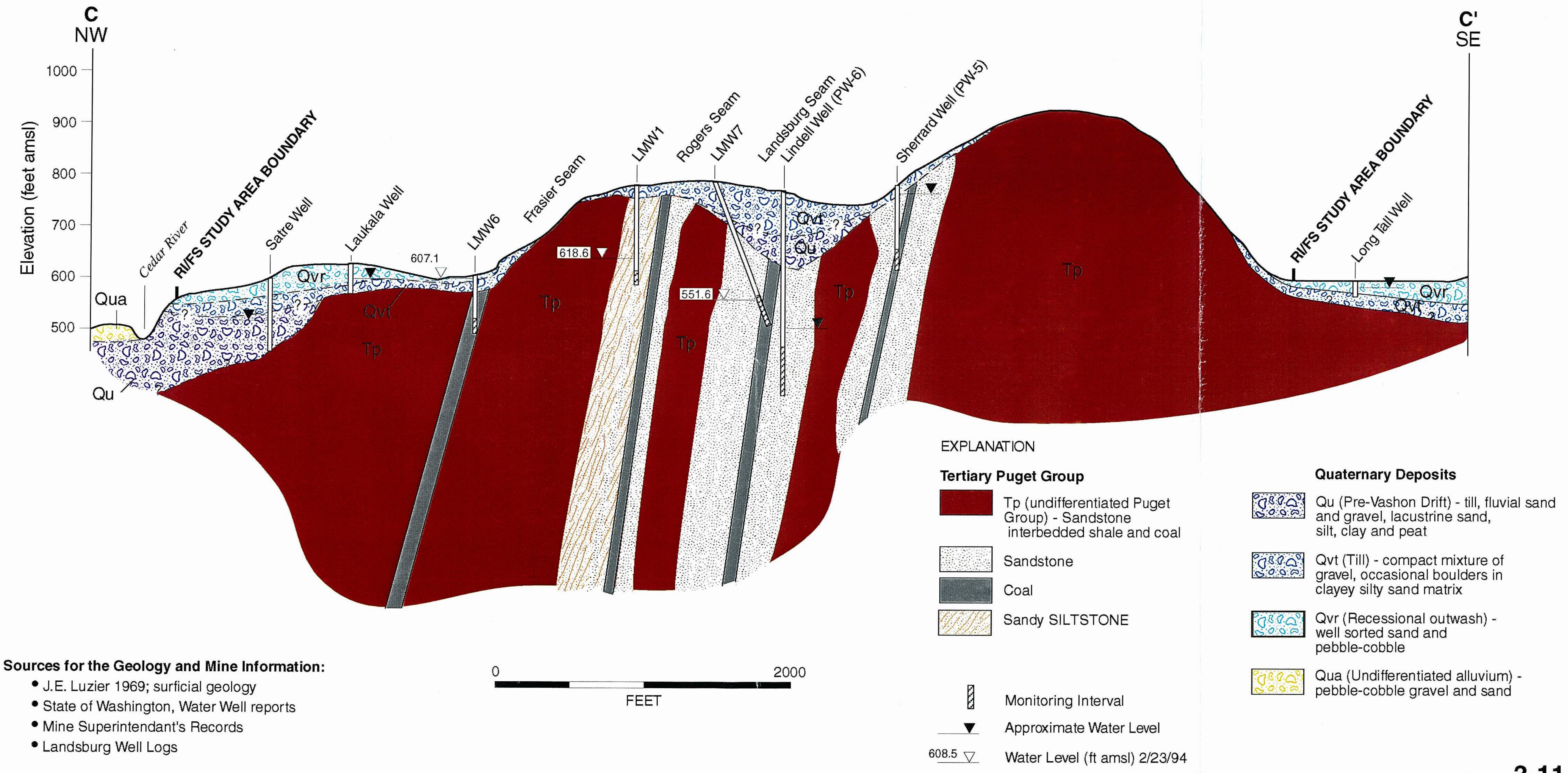
FIGURE **3-10**

CROSS SECTION B-B'

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 49819 DATE 1/8/96 DRAWN BY CB

Golder Associates

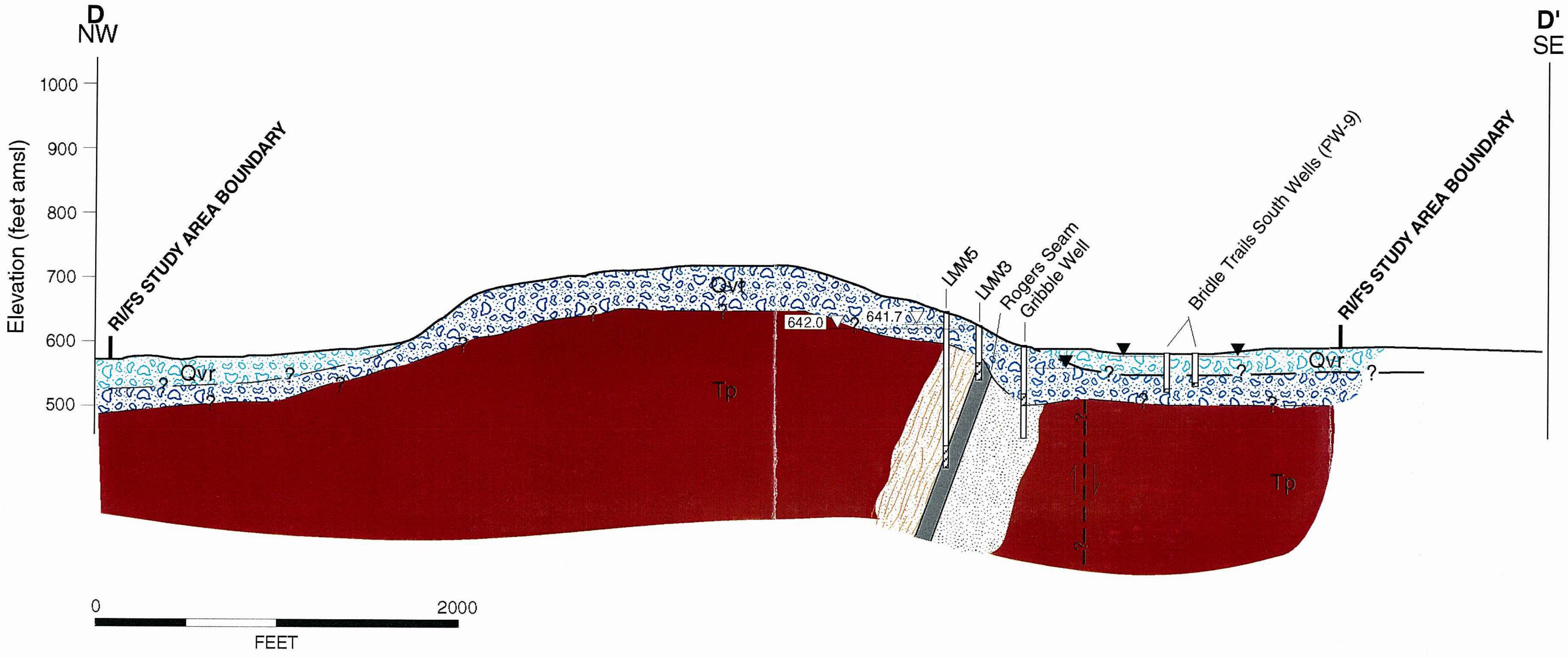


Sources for the Geology and Mine Information:

- J.E. Luzier 1969; surficial geology
- State of Washington, Water Well reports
- Mine Superintendant's Records
- Landsburg Well Logs

NOTE: Vertical to Horizontal scale ratio is 3.6:1.
Wells are projected normal into the strike of the Cross-Section C-C'.
Cross-sections are inferred from limited data and should be considered approximate.

FIGURE **3-11**
CROSS SECTION C-C'
LANDSBURG MINE SITE RI/FS/WA



EXPLANATION

Tertiary Puget Group

- 🟥 Tp (undifferentiated Puget Group) - Sandstone interbedded shale and coal
- ░ Sandstone
- ■ Coal
- ▨ Sandy SILTSTONE

Quaternary Deposits

- ▩ Qvt (Till) - compact mixture of gravel, occasional boulders in clayey silty sand matrix
- ▩ Qvr (Recessional outwash) - well sorted sand and pebble-cobble

- ▯ Monitoring Interval
- ▼ Approximate Water Level
- 608.5 ▽ Water Level (ft amsl) 2/23/94
- ⇅ Fault, dashed where inferred, queried where uncertain

Sources for the Geology and Mine Information:

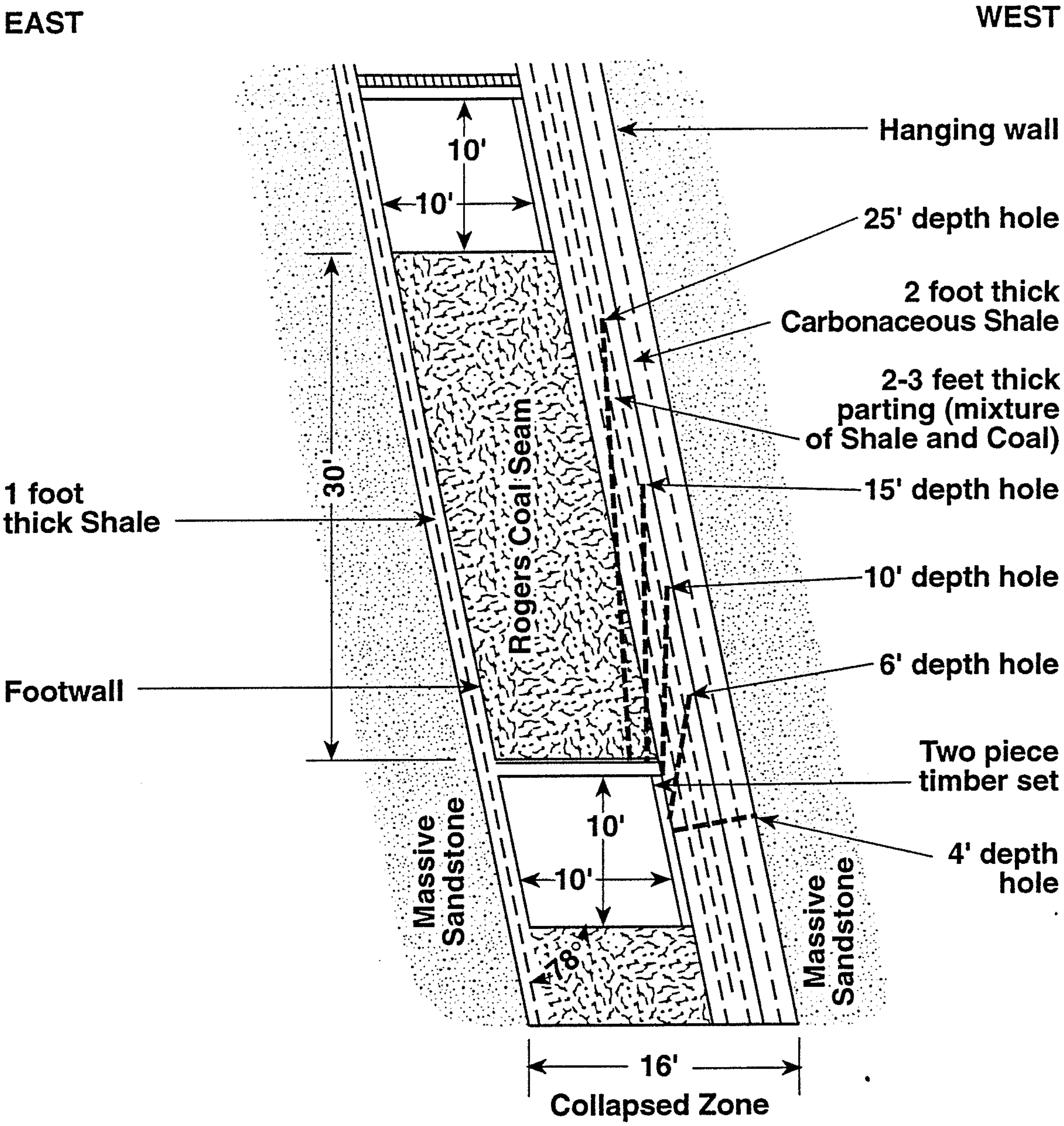
- J.E. Luzier 1969; surficial geology
- State of Washington, Water Well reports
- Mine Superintendant's Records
- Landsburg Well Logs

NOTE: Vertical to Horizontal scale ratio is 3.6:1.
Wells are projected normal into the strike of the Cross-Section D-D'.
Cross-sections are inferred from limited data and should be considered approximate.

FIGURE **3-12**
CROSS SECTION D-D'
LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 49818 DATE 1/12/96 DRAWN BY CB

Golder Associates



Coal seam includes 4 ft. bottom coal, 2 ft. muck (Carbonaceous Shale), and 4 ft. top coal.

FIGURE **3-13**

GENERALIZED SECTION THROUGH ROGERS COAL SEAM ILLUSTRATING LAYOUT OF "BOOMING" ROUND

PALMER/LANDSBURG/WA

PROJECT NO. 923 1000.147 DRAWING NO. 61000 DATE 1/19/96 DRAWN BY TB

Golder Associates

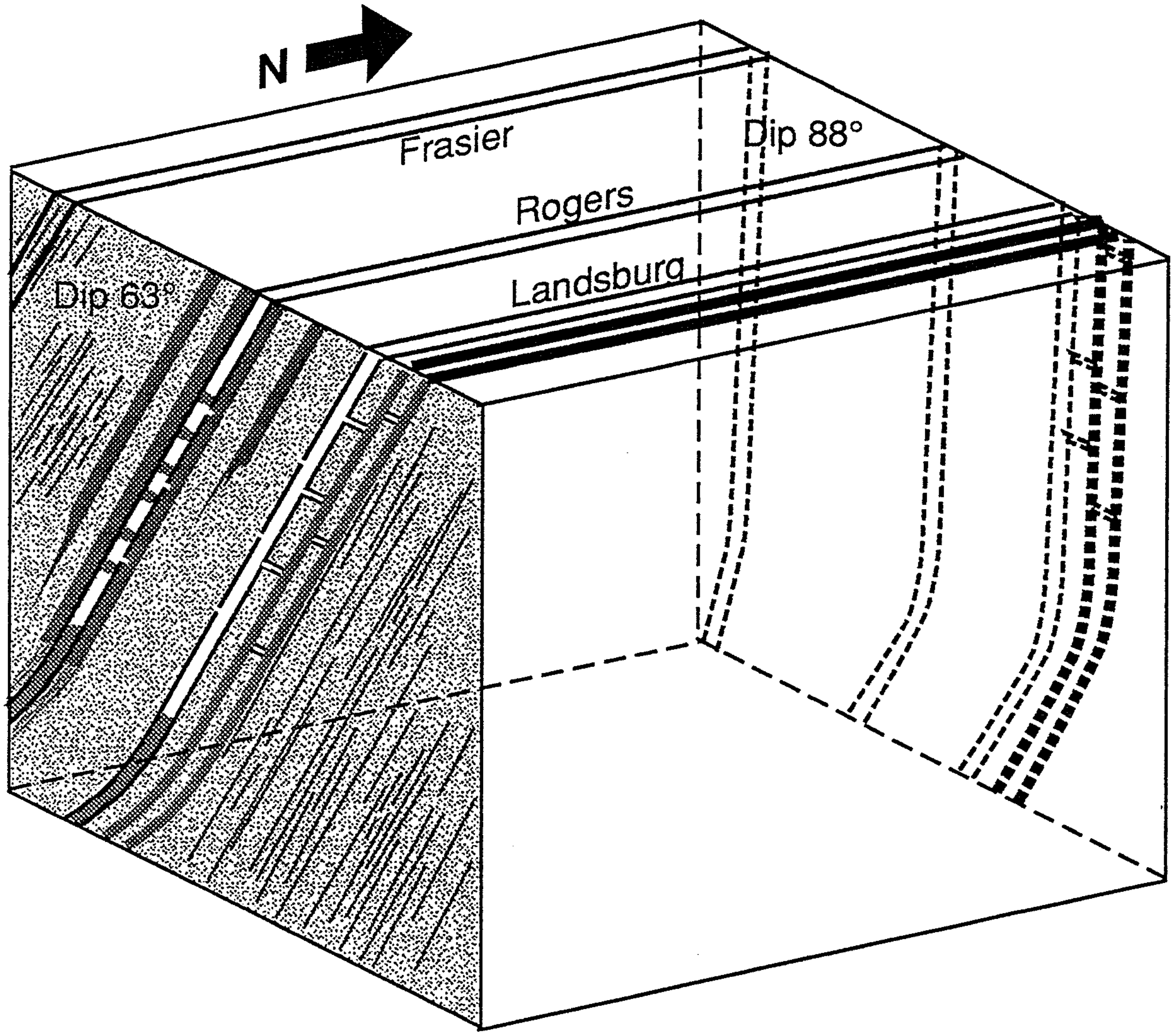


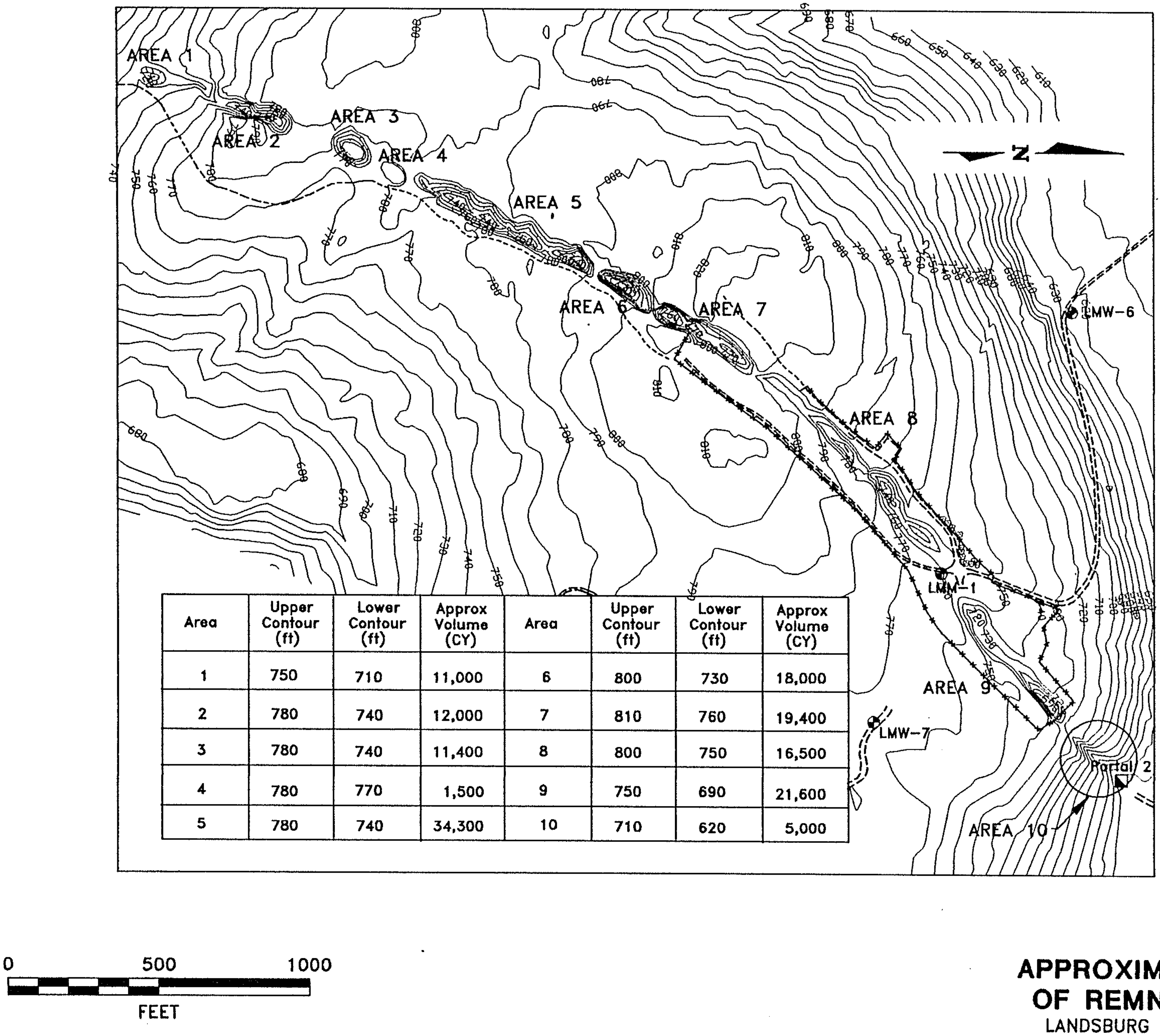
FIGURE **3-14**

LANDSBURG MINE BEDROCK STRUCTURE

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 27745 DATE 2/21/95 DRAWN BY TB

Golder Associates



Area	Upper Contour (ft)	Lower Contour (ft)	Approx Volume (CY)	Area	Upper Contour (ft)	Lower Contour (ft)	Approx Volume (CY)
1	750	710	11,000	6	800	730	18,000
2	780	740	12,000	7	810	760	19,400
3	780	740	11,400	8	800	750	16,500
4	780	770	1,500	9	750	690	21,600
5	780	740	34,300	10	710	620	5,000

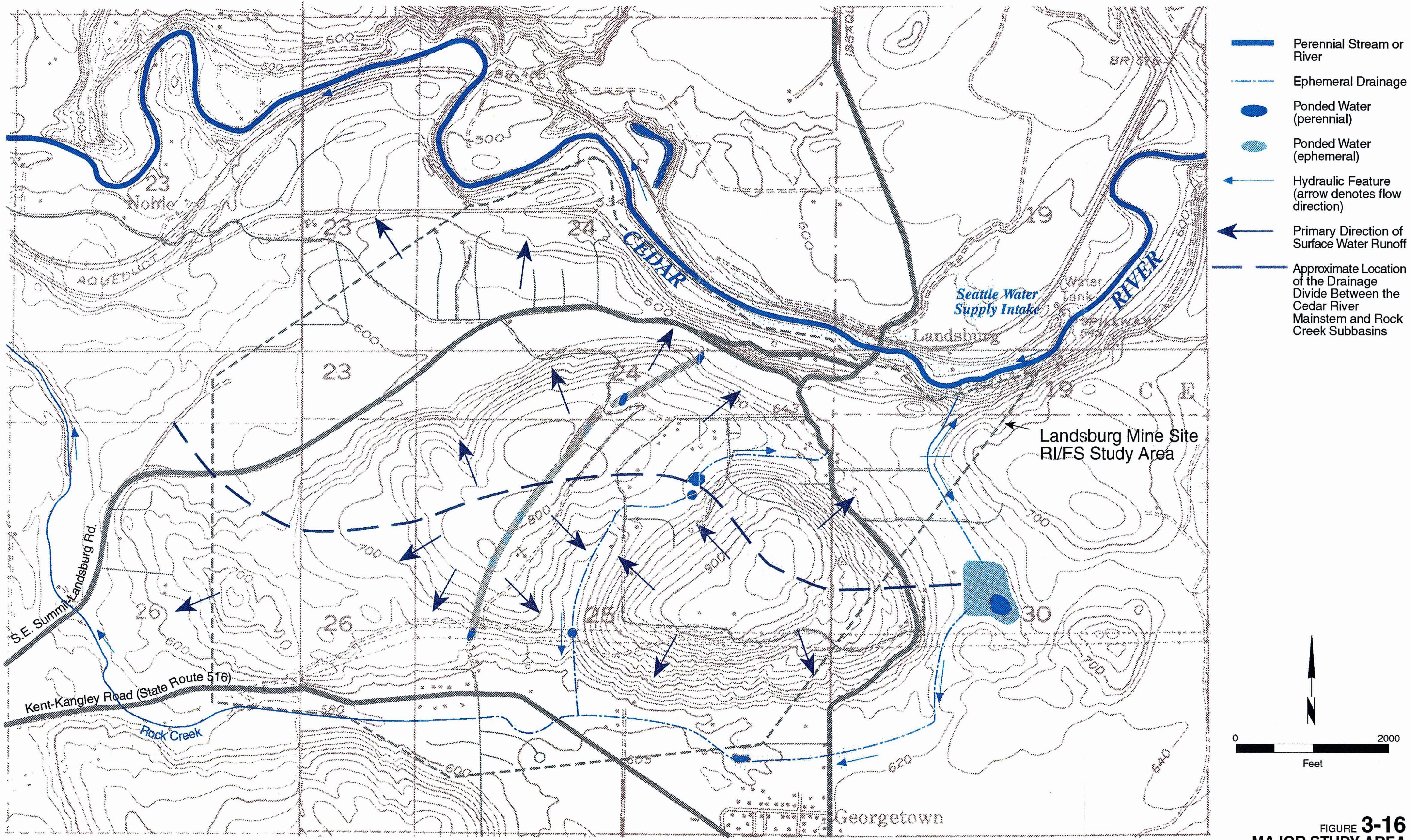
FIGURE **3-15**

APPROXIMATE VOLUME OF REMNANT TRENCH

LANDSBURG MINE SITE/RI/FS/WA

C:\CAD_4\9231000\147\57155 5-12-95 13:58

Golder Associates



Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

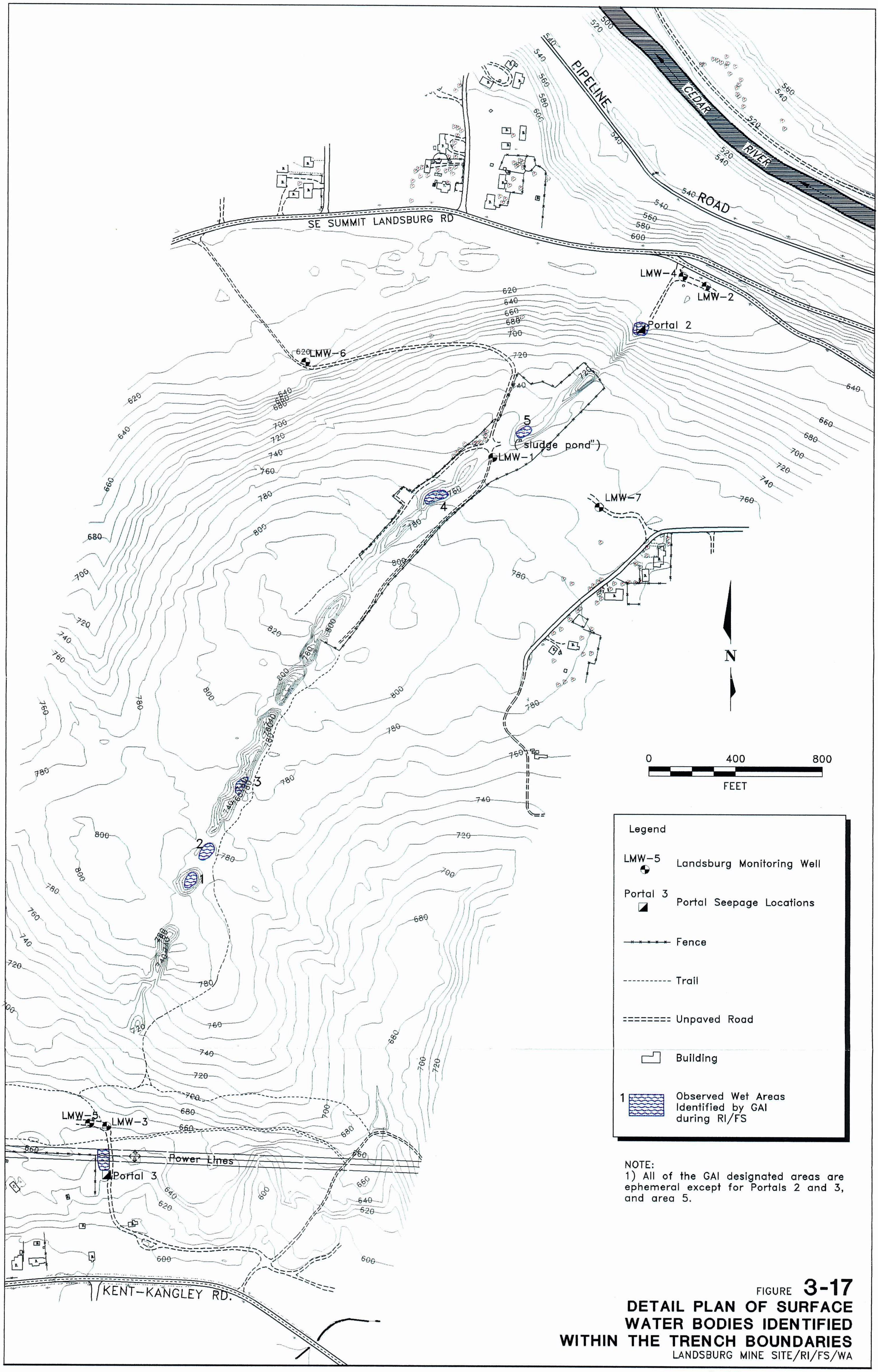
FIGURE **3-16**

MAJOR STUDY AREA SURFACE WATER FEATURES

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 55316 DATE 5/23/95 DRAWN BY EA

Golder Associates



NOTE:
1) All of the GAI designated areas are ephemeral except for Portals 2 and 3, and area 5.

FIGURE **3-17**

DETAIL PLAN OF SURFACE WATER BODIES IDENTIFIED WITHIN THE TRENCH BOUNDARIES

LANDSBURG MINE SITE/RI/FS/WA

DWG ID: \JPM\9231000\147\57206 DATE 2-28-95 9:10

Golder Associates

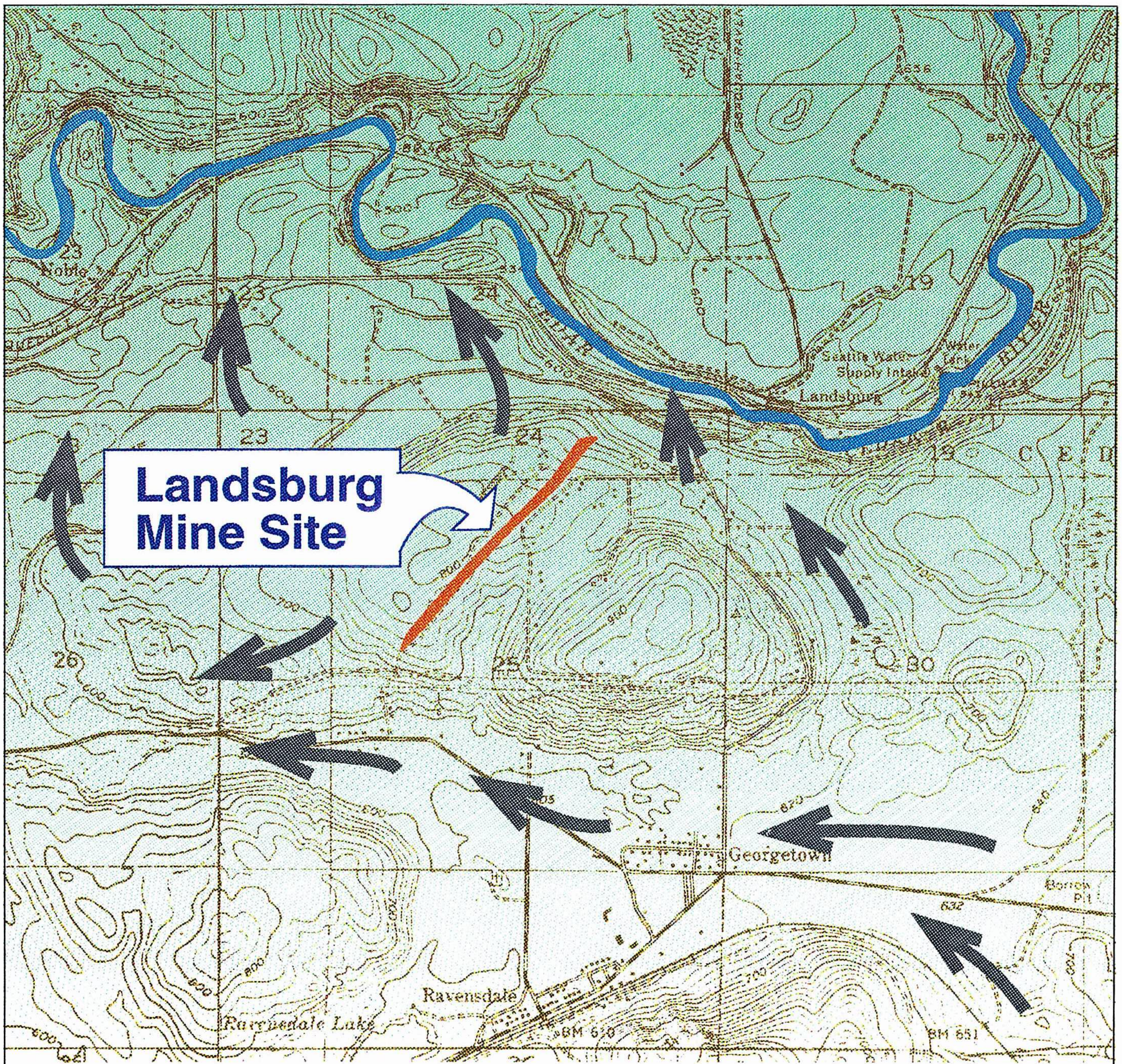


FIGURE **3-18**
CONCEPTUAL GROUNDWATER FLOW IN THE GLACIAL DRIFT DEPOSITS
LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 50412 DATE 3/8/95 DRAWN BY TB

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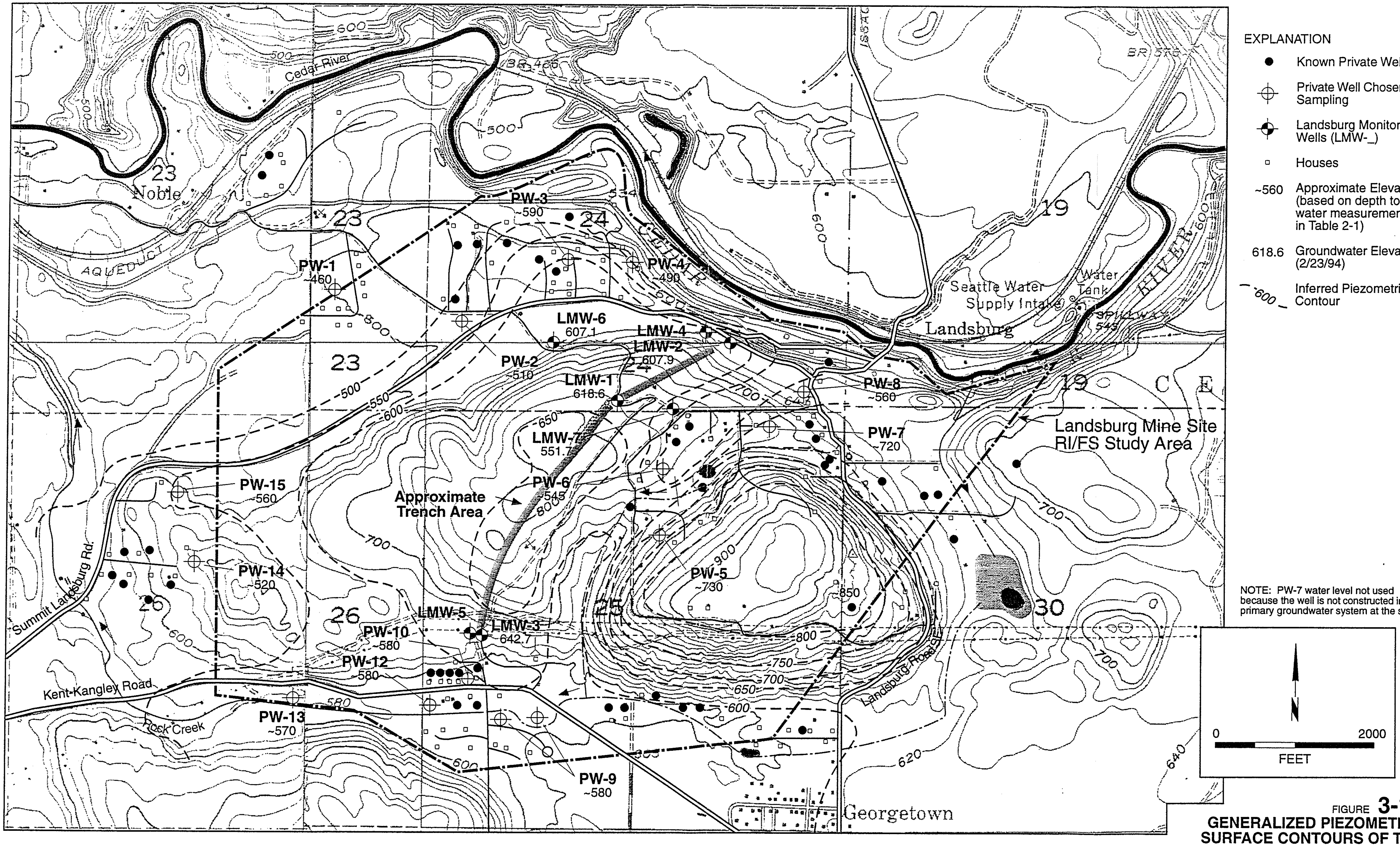

NOTE: PW-7 water level not used because the well is not constructed in the primary groundwater system at the site.

FIGURE **3-19**

GENERALIZED PIEZOMETRIC SURFACE CONTOURS OF THE PRIMARY GROUNDWATER SYSTEM

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 50419 DATE 5/11/95 DRAWN BY TK

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1)	LMW1
2)	LMW2
3)	LMW3
4)	LMW4
5)	LMW5
6)	LMW6
7)	LMW7
8)	PRT2
9)	PRT3
A)	PW1
B)	PW10
C)	PW11
D)	PW12
E)	PW13
F)	PW14
G)	PW15
H)	PW2
I)	PW3
J)	PW4
K)	PW5
L)	PW6
M)	PW7
N)	PW8
O)	PW9

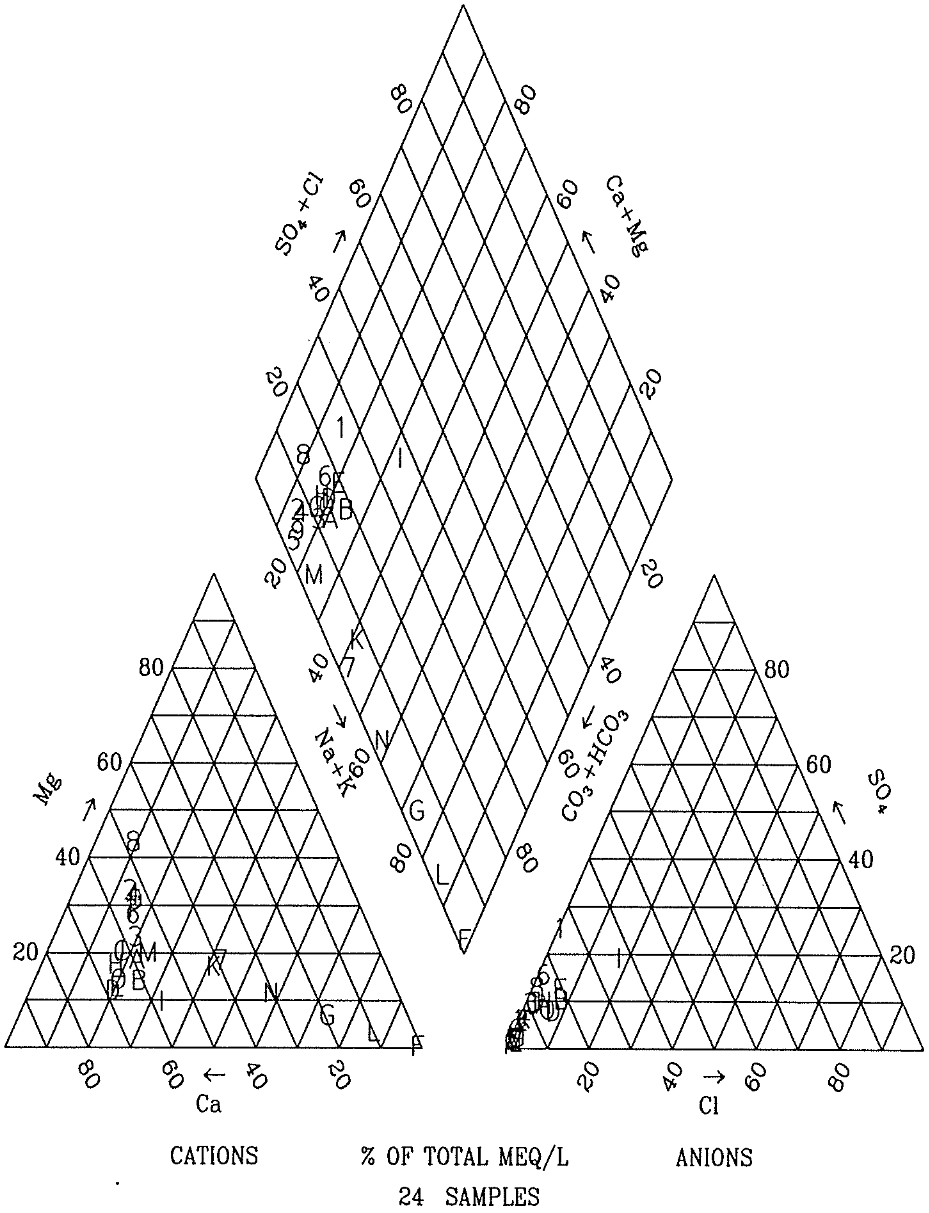


FIGURE **3-20**

TRILINEAR PLOT

1st ROUND

GROUNDWATER DATA

LANDSBURG MINE SITE RI/FS/WA

1)	LMW1
2)	LMW2
3)	LMW3
4)	LMW4
5)	LMW5
6)	LMW6
7)	LMW7
8)	PRT2
9)	PRT3
A)	PW1
B)	PW10
C)	PW11
D)	PW12
E)	PW13
F)	PW14
G)	PW15
H)	PW2
I)	PW3
J)	PW4
K)	PW5
L)	PW6
M)	PW7
N)	PW8
O)	PW9

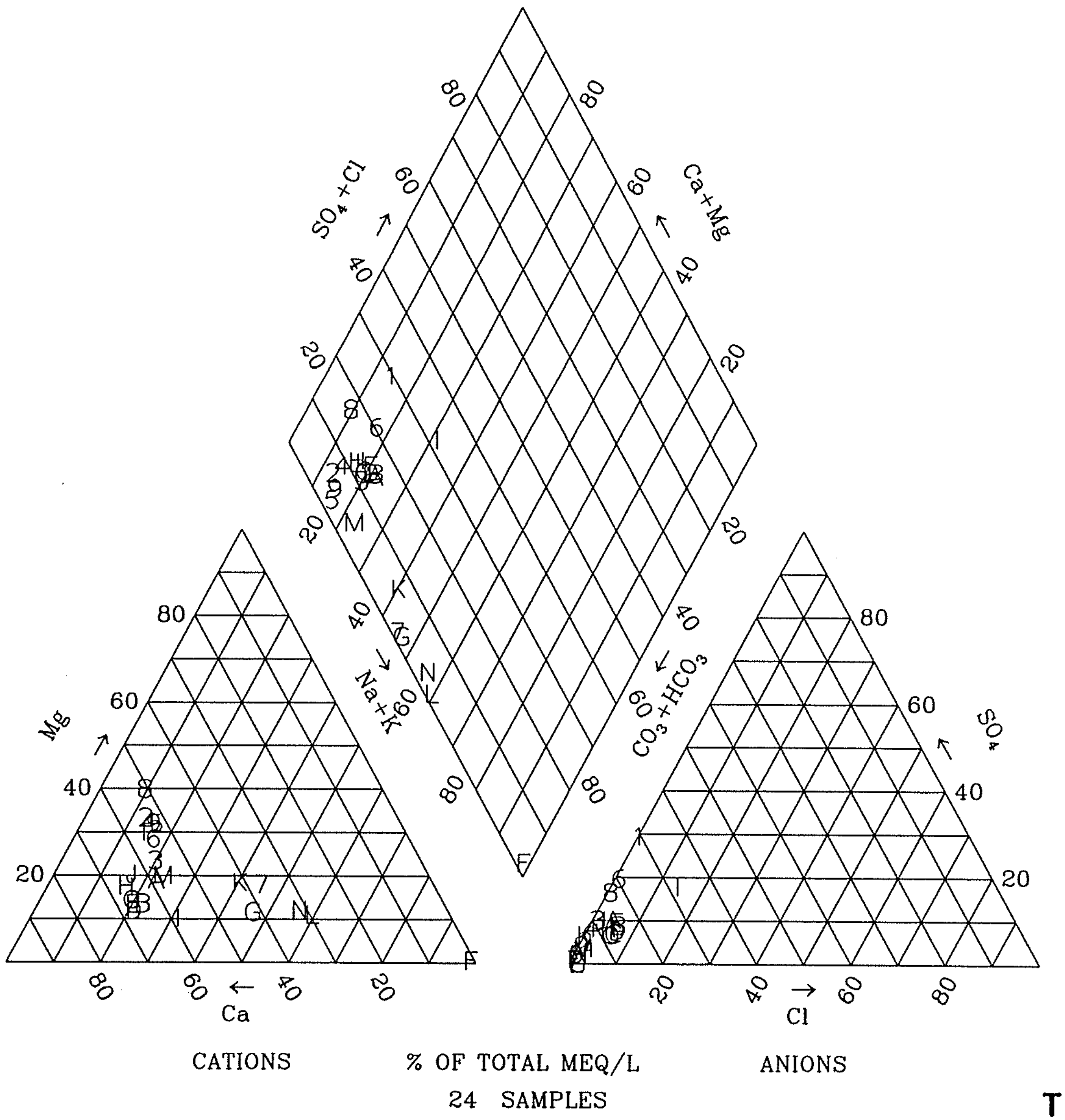


FIGURE **3-21**

TRILINEAR PLOT
2nd ROUND
GROUNDWATER DATA
LANDSBURG MINE SITE RI/FS/WA

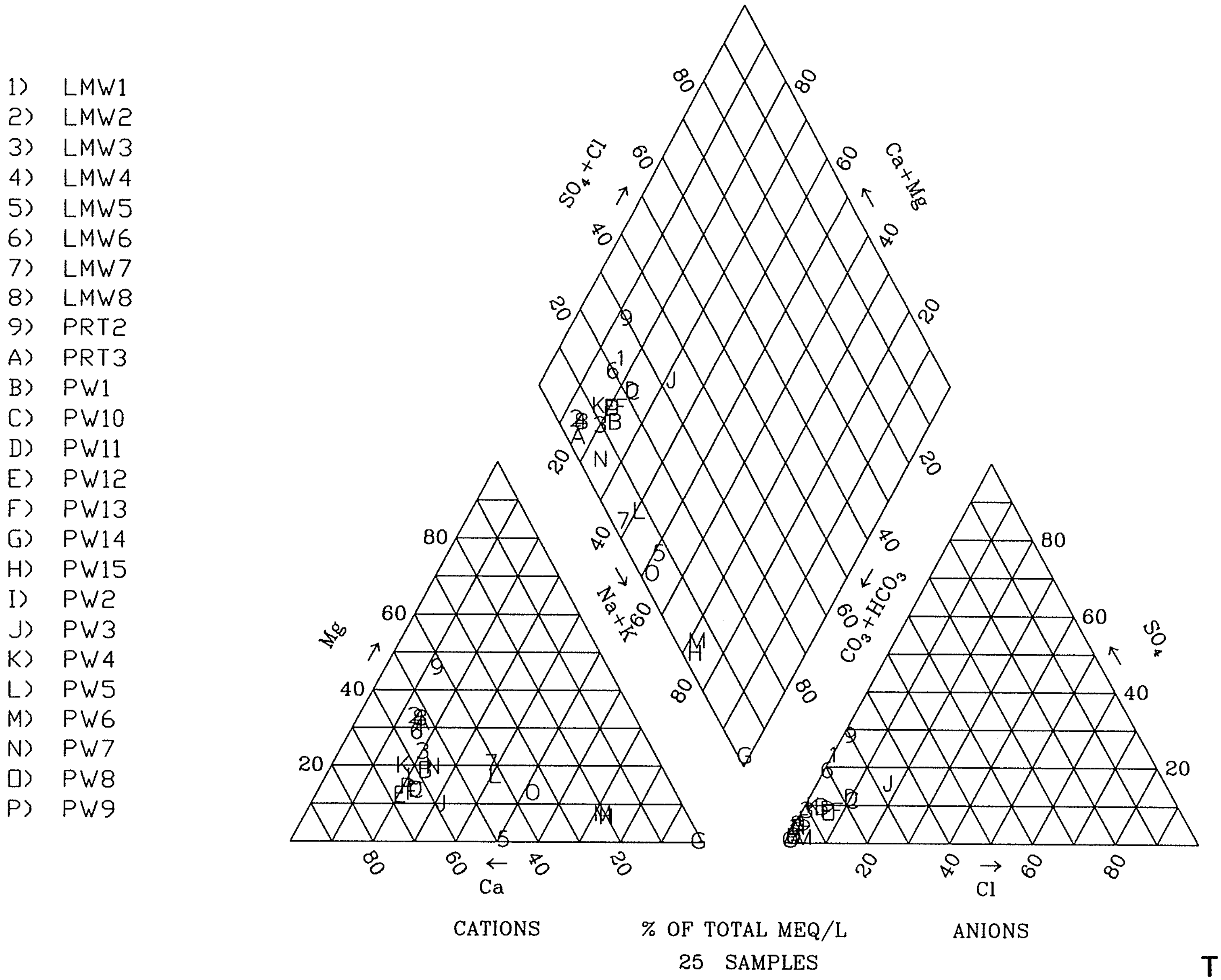


FIGURE **3-22**

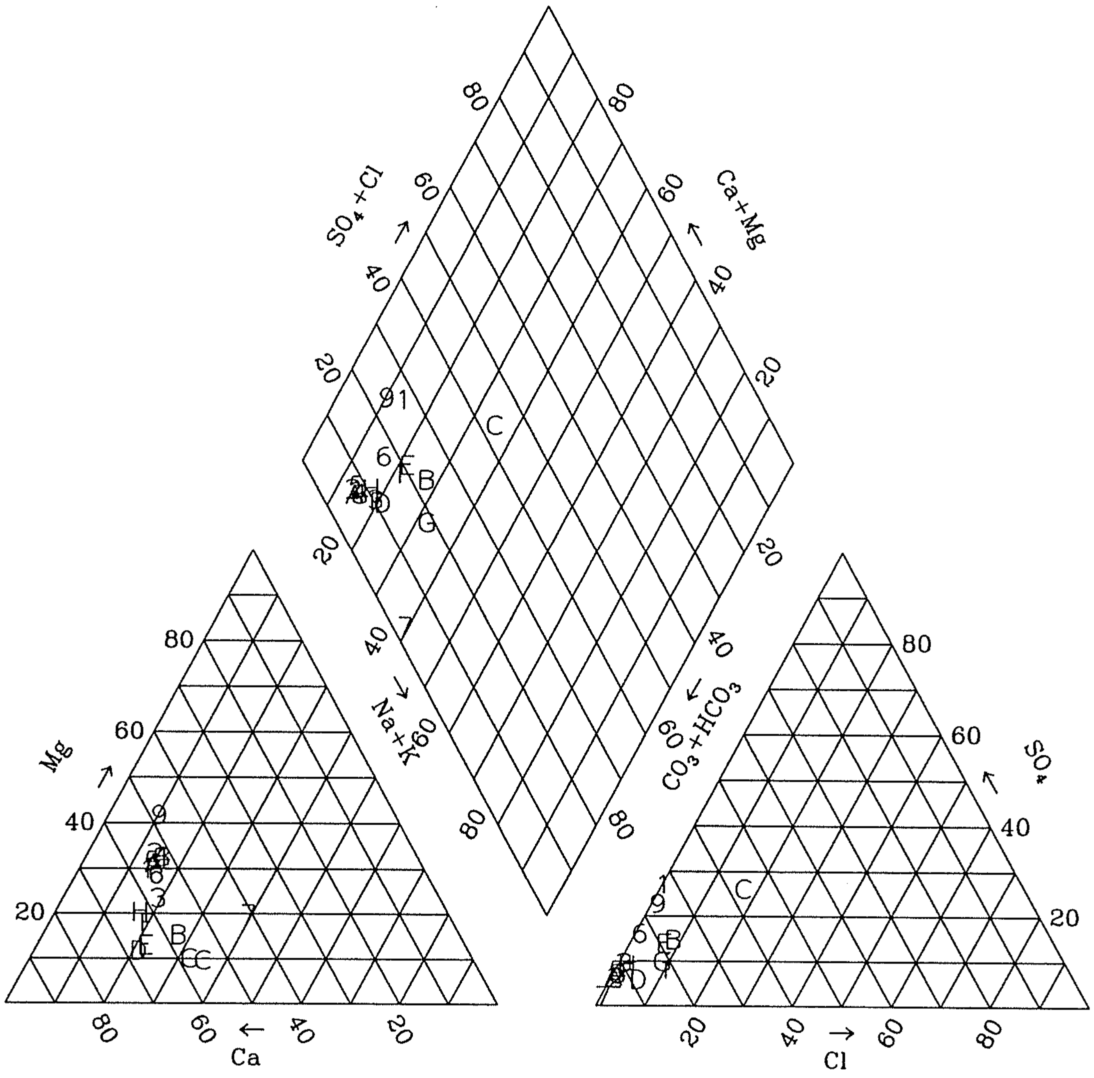
TRILINEAR PLOT

3rd ROUND

GROUNDWATER DATA

LANDSBURG MINE SITE RI/FS/WA

1) LMW1
2) LMW2
3) LMW3
4) LMW4
5) LMW5
6) LMW6
7) LMW7
8) LMW8
9) PRT2
A) PRT3
B) PW10
C) PW11
D) PW12
E) PW13
F) PW2
G) PW3
H) PW4
I) PW9



18 SAMPLES

FIGURE 3-23
TRILINEAR PLOT
4th ROUND
GROUNDWATER DATA
LANDSBURG MINE SITE RI/FS/WA

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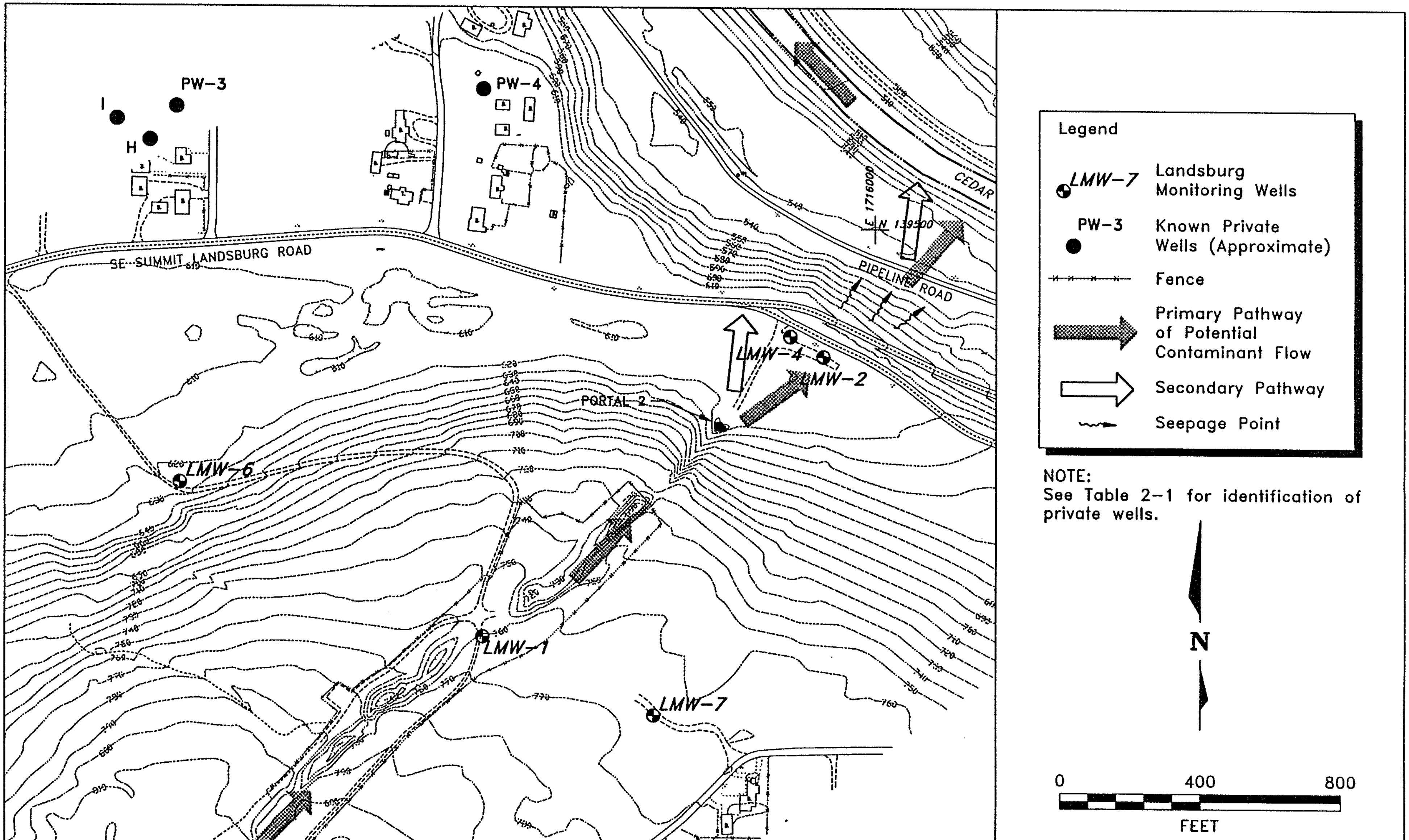

NOTE:
See Table 2-1 for identification of private wells.

FIGURE **3-24**

POTENTIAL CONTAMINANT PATHWAYS

LANDSBURG MINE SITE/RI/FS/WA

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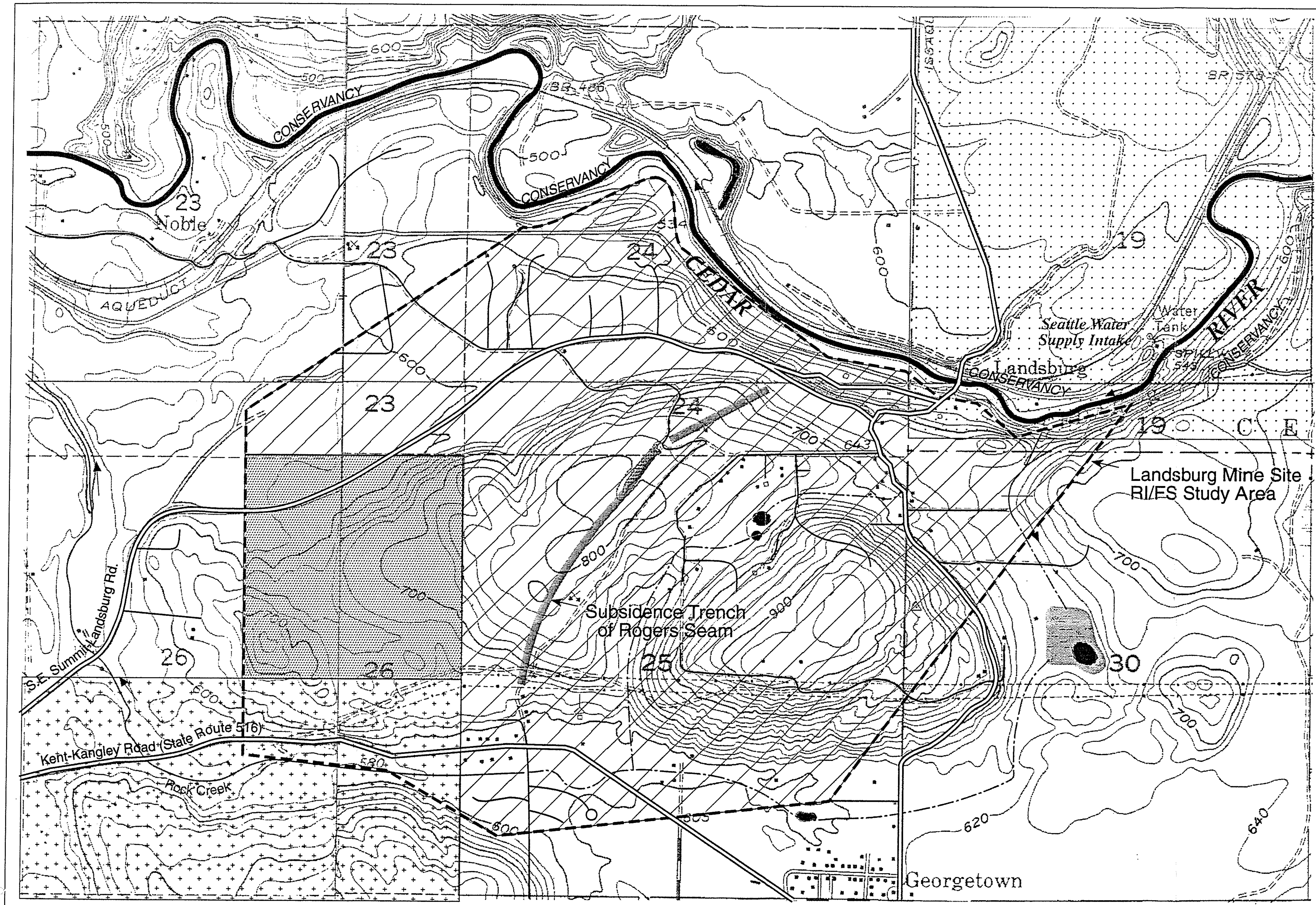


▨ Portion of Study Area Zoned RA Rural Area

▒ Portion of Study Area Zoned F Forest

＋ City of Kent Watershed

⋯ City of Seattle Cedar River Watershed

Conservancy area extends from River Mile 3.4 to the headwaters of the Cedar River.

Zoning codes shown here reflect the new Title 21A Zoning Code which is expected to be fully implemented in mid-1995.

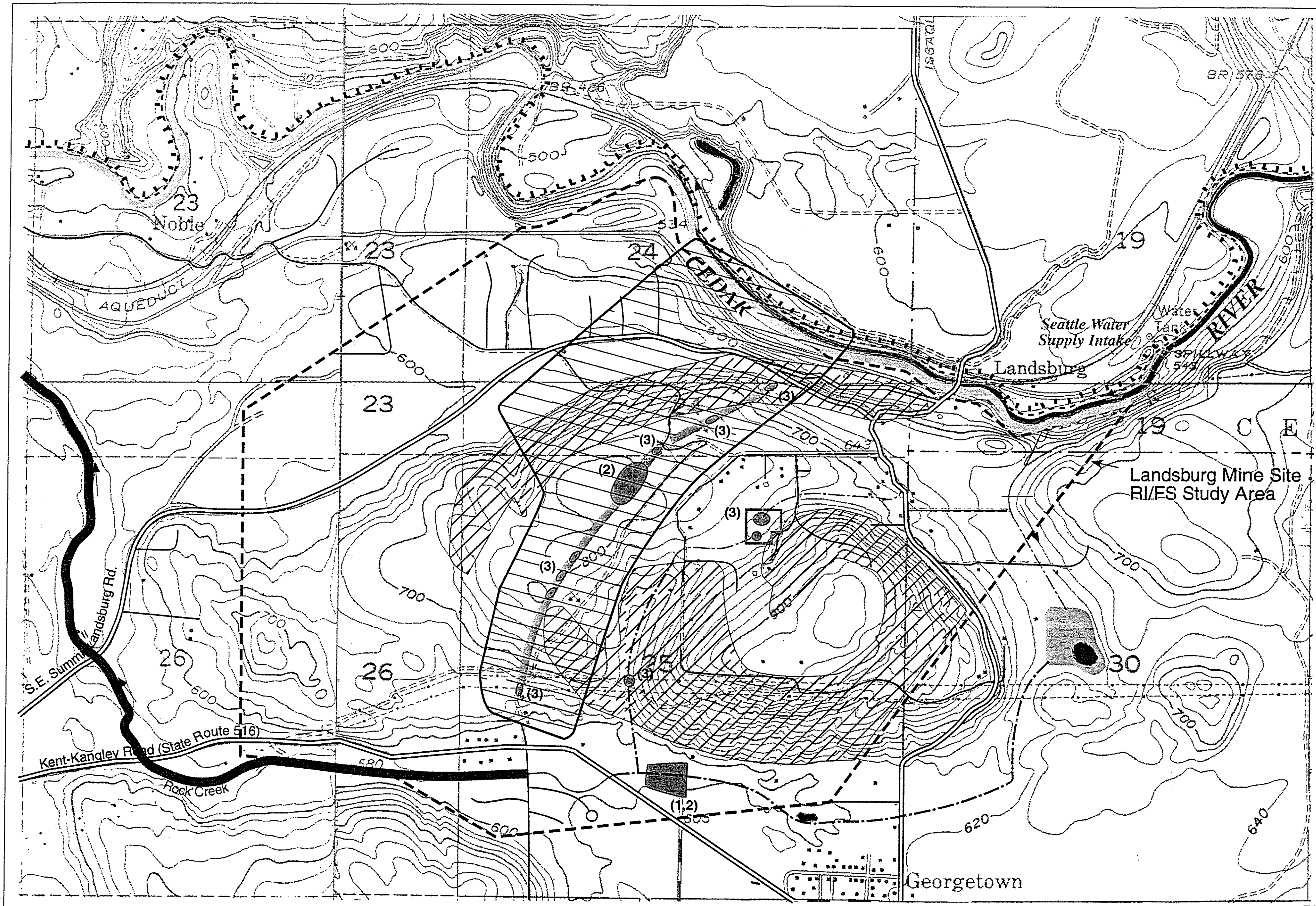
Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

FIGURE **3-25**

STUDY AREA ZONING

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 55312 DATE 1/8/96 DRAWN BY CB



▨ Potential Wetland Areas
(1) King County, Sensitive areas map
(2) Washington Dept. of Wildlife Priority Habitat and Species Map
(3) Observed by GAI during field reconnaissance

▨ Erosion Hazard

▨ Coal Mine Hazard

- - - - Designation (WDW) as Critical Spawning Habitat for Resident Species

▨ Listed Resident Fish Present

▪ ▪ ▪ ▪ Anadromous Fish Run

▬ Designated as Regionally Significant Resource Area by Cedar River Watershed Management Committee

N

0 2000
Feet

FIGURE **3-26**
POTENTIAL WETLANDS, SENSITIVE AREAS AND PRIORITY HABITATS WITHIN THE STUDY AREA
LANDSBURG MINE SITE RI/FS/WA

Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

PROJECT NO. 923 1000.147 DRAWING NO. 45185 DATE 1/8/96 DRAWN BY TB

Golder Associates

4. POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

4.1 Introduction/Overview

This section identifies and evaluates federal and state requirements that are potentially applicable or relevant and appropriate (ARARs) for remedial actions at the Landsburg Mine site. The ARAR identification process is based on criteria presented in WAC 173-340-710. Final ARARs will be determined in accordance with the requirements of the Agreed Order.

WAC 173-340-360(2) and 173-340-710(1)(a) require that cleanup actions conducted under the Model Toxics Control Act (RCW 70.105D) ("MTCA") shall comply with applicable federal and state laws. Applicable laws are defined as those requirements that are legally applicable, as well as those that Ecology determines to be both relevant and appropriate.

In order to be defined as a "legally applicable" requirement, the requirement must be promulgated under state or federal law and must specifically address a hazardous substance, cleanup action, location or other circumstance at the site. "Relevant and appropriate" requirements are limited to those requirements promulgated under state and federal laws that, while not legally applicable, are determined by Ecology to address circumstances sufficiently similar to those encountered at the site such that the use of the requirements is well suited to particular site conditions. WAC 173-340-710(3) also includes a limited number of regulations which are automatically considered to be relevant and appropriate requirements.

Identification of ARARs must be made on a site-specific basis and involves a two-part analysis: first, a determination is made whether a given promulgated requirement is applicable; then, if it is not applicable, a determination is made whether it is both relevant and appropriate. A requirement may be either "applicable" or "relevant and appropriate," but not both.

The following discussion focuses on the most significant potential ARARs. The full list of potential ARARs is presented and discussed in Tables 4-1 and 4-2. Potential specific regulatory limits (cleanup criteria) for groundwater, surface water, and soil are presented in Tables 4-3, 4-4, and 4-5, respectively.

4.2 ARARs Based on Federal Laws

National Primary Drinking Water Regulations - 40 CFR 141

Requirements of the National Primary Drinking Water Regulations (40 CFR 141) promulgated under the Safe Drinking Water Act (SDWA) address contamination in community water systems, which are defined as public water systems having at least 15 service connections or serving an average of at least 25 year-round residents. The primary drinking water regulations establish maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs). MCLs are enforceable standards for specific contaminants EPA has determined have an adverse effect on human health. MCLGs, in contrast, are non-enforceable, strictly health-based standards which do not take cost or feasibility into account. Where applicable, the regulations of the SDWA are applied at the tap. Secondary maximum contaminant levels (SMCLs) are also established pursuant to the SDWA and are set forth in 40 CFR 143.

MTCA requires that where groundwater is a current or potential future source of drinking water, cleanup levels shall be at least as stringent as the MCLs, SMCLs and non-carcinogen MCLGs established under the SDWA. Although site groundwater is not currently used for drinking water purposes, SDWA requirements are applicable. Table 4-3 summarizes the MCLs, SMCLs and non-carcinogen MCLGs for selected groundwater constituents.

Resource Conservation and Recovery Act (RCRA) - 40 CFR 260-268

RCRA provides requirements that address the generation, transport, storage, treatment, and disposal of hazardous waste. In Washington, the majority of RCRA authority has been delegated to Ecology and is implemented through the Dangerous Waste Regulations (WAC 173-303). Detailed discussion of the Washington State Dangerous Waste Regulations is presented below.

4.3 ARARs Based on State Laws

Model Toxics Control Act - RCW 70.105D

MTCA is the key governmental regulation governing the conduct of the overall investigation and cleanup process for the site and is therefore applicable. MTCA describes the requirements for selecting cleanup actions, preferred technologies, policies for use of permanent solutions, the time frame for cleanup, and the process for making decisions. The regulation specifies that all cleanup actions be protective of human health, comply with all applicable state and federal regulations, and provide for appropriate compliance monitoring.

Specific criteria for the various cleanup methods are presented in the MTCA regulations. The MTCA regulations specify that cleanup actions utilize permanent solutions to the maximum extent practicable. Although MTCA identifies a hierarchy of preferred technologies that should be evaluated for use in the cleanup action, cost may also be a factor in determining points of compliance and selection of cleanup actions. For example, if the cost of cleanup action is substantial and disproportionate to the incremental increase in protection compared to a lesser preferred cleanup action, the less preferred action may be selected.

Recent amendments to MTCA (RCW 70.105D.090) exempt remedial actions conducted pursuant to an Agreed Order or a Consent Decree from the procedural requirements of several state laws. These include the State Clean Air Act (RCW 70.94), Solid Waste Management - Reduction and Recycling Act (RCW 70.95), Hazardous Waste Management Act (RCW 70.105), Water Pollution Control Law (RCW 90.48), Shoreline Management Act (RCW 90.58), and Construction Projects in State Waters (RCW 75.20). In addition, the exemption also applies to the procedural requirements of any laws requiring or authorizing local governmental permits or approval for the remedial action. Therefore, while substantive compliance is necessary, permits and approvals are not required for remedial actions at the site. Substantive requirements are included in the Consent Decree, Agreed Order, or Enforcement Order implementing a cleanup action.

Model Toxics Control Act Cleanup Regulations - WAC 173-340

Regulations under Chapter 173-340 WAC, which implement the requirements of MTCA, are the primary regulatory vehicle under which the Landsburg Mine site RI/FS process is being conducted and are therefore applicable. These regulations establish administrative processes and standards to identify, investigate and cleanup facilities where hazardous substances have been released.

WAC 173-340-700 establishes cleanup levels for environmental media, including groundwater, soil, and surface water. This regulation also contains standards for air emissions. Three methods are presented for determining cleanup levels: Method A (routine, using tables), Method B (standard), and Method C (conditional, primarily for industrial sites). All three MTCA methods for determining cleanup levels require compliance with other federal or state ARARs, and consideration of cross-media contamination. Method A is generally used for routine cleanups with relatively few contaminants. Method A standards are presented in tables in the MTCA rule. Since it is unlikely that the cleanup at the Landsburg Mine site would be considered routine, Method A is probably not uniformly applicable to this site. However, no cleanup levels shall be more stringent than an established area background for the site.

Method B is the standard method for determining cleanup levels. Currently, Method B soil cleanup levels assume a residential use scenario, although Ecology may develop Method B industrial soil cleanup standards. Method B groundwater cleanup standards do not currently differentiate between residential and industrial use assumptions. Method B levels are determined using federal or state ARARs or are based on risk equations specified in MTCA regulations. For individual carcinogens, the cleanup levels are based on the upper bound of the excess lifetime cancer risk of one in one million (1×10^{-6}). Total excess cancer risk under Method B for multiple substances and pathways cannot exceed one in one hundred thousand (1×10^{-5}), and the total hazard index for substances with similar types of toxic response must be less than 1.

Method C cleanup levels are used where Method A and B are not appropriate. One of the following conditions must be met: Method A or B cleanup levels are below area background concentrations; cleanup to Method A or B levels has the potential for creating greater overall threat to human health and the environment than Method C; cleanup to Method A or B is not technically possible; or the site meets the definition of an industrial site. The requirements for qualification as a Method C industrial site are specified in WAC 173-340-740 and -745.
Method C cleanups must comply with applicable state and federal laws, must use all practicable levels of treatment and must incorporate institutional controls as specified in WAC 173-340-740 and 720. Risk-based equations for Method C cleanup levels for soil are specified in WAC 173-340-740 for residential and WAC 173-340-745 for industrial exposure assumptions. Method C cleanup standards for groundwater do not currently differentiate between residential and industrial use assumptions and are determined as specified in WAC 173-340-720. Total excess cancer risk for Method C, and the risk associated with individual compounds, cannot exceed 1 in one hundred thousand (1×10^{-5}), and the total hazard index for substances with similar types of toxic response must be less than 1. Method C cleanup levels that protect beneficial uses of groundwater other than drinking water are established by Ecology on a case-by-case basis.

For all three methods of establishing cleanup levels, Ecology must select a "point of compliance" for determining whether the cleanup level has been met. The point of compliance is defined as the point or points throughout the site where cleanup levels are established in accordance with the cleanup requirements for groundwater and soil specified in Sections 173-340-720 and -750. The point of compliance for soil cleanup levels based on the protection of groundwater are to be achieved in all soils throughout the site. For soil cleanup levels based on human exposure via direct contact, the point of compliance shall be established throughout the site from the ground surface to a depth of 15 feet. These depths represent the extent that soils may be potentially excavated or disturbed as a result of site development.

For cleanup alternatives that involve containment of hazardous substances, the soil cleanup levels are not required to be met at the points of compliance described above. WAC 173-340-720(6)(c) provides that where hazardous substances remain on-site as part of the cleanup action, Ecology may approve a conditional point of compliance for groundwater cleanup which shall be as close as practicable to the source of hazardous substances, not to exceed the property boundary. Where a conditional point of compliance is proposed, the person performing the cleanup action must still demonstrate that all practicable methods of treatment are utilized. In these cases, compliance monitoring and other requirements identified in 173-340-360(8) are required to ensure long-term integrity of the containment system.

Potential cleanup levels for groundwater, surface water and soil under MTCA are summarized in Tables 4-3 through 4-5.

State Environmental Policy Act (SEPA) - WAC 197-11, 173-802

SEPA is applicable to remedial actions at the Landsburg Mine site. Ecology is the lead agency for MTCA remedial actions performed under a Consent Decree or an Agreed Order pursuant to WAC 197-11-253.

The SEPA process is triggered when a governmental action is taken on a public or private proposal. According to WAC 197-11-784, a proposal includes both regulatory decisions of agencies and actions proposed by applicants. If the proposal is not "exempt", Ecology will require the submission of a SEPA checklist which solicits information regarding how the proposal will affect elements of the environment, such as air, water, etc.

If the proposal is determined by Ecology to have a "probable significant adverse environmental impact", an environmental impact statement (EIS) will be required which examines potential environmental problems that would be caused by the proposal and options for mitigation. If in Ecology's opinion, there will be no significant adverse environmental impact, a Determination of Nonsignificance (DNS) will be issued and the SEPA process is completed without preparation of an EIS.

Any public comment period required under SEPA must be combined with any comment period associated with the MTCA process in order to expedite and streamline public input. According to WAC 197-11-259, if Ecology makes a determination that the proposal will not have a probable significant adverse environmental impact, the DNS can be issued with the draft Cleanup Action Plan prepared pursuant to MTCA.

Dangerous Waste Regulations - WAC 173-303

The Washington State Dangerous Waste Regulations (WAC 173-303) are the state equivalent of the federal RCRA legislation, and contain a series of rules relating to the generation, handling, storage and disposal of dangerous waste. Recent MTCA amendments, as discussed above, exempt cleanup actions conducted under an Agreed Order or Consent Decree from the procedural requirements of several state laws, including the Hazardous Waste Management Act. Since implementation of the Act is afforded through the Dangerous Waste Regulations, this exemption also applies to the 173-303 rules. In addition, a recent amendment to the state Hazardous Waste Management Act (RCW 70.105) provides a conditional exemption to state-only dangerous wastes generated when a remedial action is conducted pursuant to a Consent Decree with Ecology. The exemption is not applicable to material that is a hazardous waste under RCRA. The Consent Decree must provide management practices for the waste being generated, and must include a treatment or disposal location approved by Ecology. In addition, waste being treated or disposed on site must be managed in a manner approved by Ecology. The amendment also allows "extremely hazardous wastes" to be managed on site as part of a remedial action under a Consent Decree.

Therefore, no WAC 173-303 procedural requirements will be applicable to remedial actions conducted at the site if the actions are conducted pursuant to a Consent Decree or Agreed Order. WAC 173-303 substantive requirements pertaining to dangerous waste generation, handling, storage, and disposal may be applicable, however if non-exempt dangerous waste is generated and/or transported off the site unit boundary during cleanup. Table 4-2 summarizes key elements of the Dangerous Waste Regulations which may be ARARs.

The dangerous waste regulations also include performance standards for closure and post-closure care and monitoring of dangerous waste landfills. Because the Landsburg Mine site stopped receiving waste materials prior to the effective date of this regulation and does not meet the definition of a regulated facility, these requirements of WAC 173-303 are not legally applicable to the site. Some of these regulations are potentially relevant and appropriate, however, to the Landsburg Mine site.

General closure and post-closure standards are given in WAC 173-303-610. Most of the requirements of this section are procedural, and not relevant because of the MTCA exemption for procedural requirements. Subsection 610(2), "Closure performance standard", corresponds to threshold requirements under MTCA. Therefore, the remedy selected by Ecology will satisfy this closure performance standard by definition.

The most relevant portion of Section 610 is subsection (7), "Postclosure care and use of property". This subsection requires 30-year post-closure maintenance and monitoring, including groundwater monitoring "as applicable". Subsection (7)(b)(i) further specifies that Ecology may "Shorten the postclosure care period applicable to the dangerous waste management unit, or facility, if all disposal units have been closed, if it finds that the reduced period is sufficient to protect human health and the environment...." Post-closure use of property is addressed at Section 610(7)(d), and states that post-closure use of property must not be allowed to disturb the integrity of the final cover, unless the disturbance is necessary to the proposed property use and will not increase the potential hazard to human health or the environment, or unless the disturbance is necessary to reduce a threat to human health or the environment. Section (10) requires a notice in the property deed. The relevant requirements of Section 610(7) and (10) may be appropriate for the Landsburg Mine site.

WAC 173-303-645 regulates releases from regulated units. Although the Landsburg Mine site does not meet the definition of a regulated dangerous waste unit, the requirements of this section are relevant. Portions of this section may be appropriate, such as:

- Groundwater protection standard, 645(3)
- Compliance period, 645(7)
- General groundwater monitoring requirements, 645(8)
- Detection monitoring program, 645(9)
- Compliance monitoring program, 645(10).

The relevance and appropriateness of these sections will be considered in the preparation and review of the Compliance Monitoring Program required under MTCA.

Design standards specific to dangerous waste landfills are found in WAC 173-303-665. Of these, liner and operating standards are not relevant to closure of the Landsburg Mine site. Potential leachate will be addressed by groundwater monitoring pursuant to the approved MTCA Compliance Monitoring Program. Section 665(6) addresses closure and post-closure care, which is relevant to this site. The design standard for the final cover, which may or may not be appropriate for this site, consists of the following [WAC 173-303-665(6)(a)]:

> "(i) Provide for long-term minimization of migration of liquids through the closed landfill
> (ii) Function with minimum maintenance;
> (iii) Promote drainage and minimize erosion or abrasion of the cover;
> (iv) Accommodate settling and subsidence so that the cover's integrity is maintained; and
> (v) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present."

Minimum Functional Standards for Solid Waste Handling - WAC 173-304

WAC 173-304 ("Minimum Functional Standards for Solid Waste Handling") (MFS) describes requirements for the management of solid waste. WAC 173-304-407 and -460 describe closure and post-closure standards and landfill standards, respectively. WAC 173-340-710 specifies that the MFS are the "minimum requirements" for landfill closure conducted as a MTCA cleanup action. On this basis, the MFS are applicable to the site. Capping requirements under WAC 173-304-460 include a minimum 2 ft. thick clay layer having a permeability of 1 x 10^{-6} or lower. Alternately, a synthetic liner material may be substituted for the soil layer. The MFS standards are the primary capping criteria to consider in the FS.

TABLE 4-1

IDENTIFICATION OF POTENTIAL FEDERAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
Archeological and Historic Preservation Act Title 16 USC 469a	Applicable	This act requires that actions conducted at the site must not cause the loss of any archeological and historic data. This act mandates preservation of the data and does not require protection of the actual facility. The requirements of this Act are potentially applicable based on a determination of whether such archaeological data occur on site.
Clean Air Act of 1977, as amended Title 42 USC 7401 et seq.	Applicable	The Clean Air Act (CAA) regulates emission of hazardous pollutants to the air. Controls for emissions are implemented through federal, state, and local programs. Pursuant to the CAA, EPA has promulgated National Ambient Air Quality Standards, National Emission Standards for Hazardous Air Pollutants, and New Source Performance Standards. The Clean Air Act is implemented in the State of Washington through the Washington Clean Air Act. Washington Clean Air Act criteria which are potentially ARAR for the Landsburg Mine site are presented in Table 4-2 under the State ARAR discussions.
Clean Water Act of 1977 Title 33 USC 1251, as amended		The Clean Water Act establishes the guidelines and standards to control discharge of pollutants to waters of the U.S. Selected sections are discussed below.
Water Quality Standards 40 CFR 131	Applicable	40 CFR 131 establishes the requirements and procedures for states to develop and adopt water quality standards based on federal water quality criteria that are at least as stringent as the federal standards. Washington State has received EPA approval and has adopted more stringent water quality criteria under WAC 173-201A. These criteria are presented in detail as state ARARs, and are listed in Table 4-4.
Section 404 40 CFR 230.10	Applicable	These sections of the Clean Water Act and associated regulations prohibit discharge of dredge or fill material to wetlands as defined by the U.S. Army Corps of Engineers. The Section 404 requirements are potentially applicable based on a determination of the occurrence of wetlands on the Mine site.
National Pollutant Discharge Elimination System (NPDES) 40 CFR 122 to 125	Applicable	The NPDES program controls release of toxic pollutants through monitoring requirements and implementation of a best management practices program. The substantive requirements of the program would be required if discharge of treated waste water were to occur as part of remediation; however, a permit would not be required due to a MTCA exemption.
Endangered Species Act of 1973 Title 16 USC 1531 et seq.	Applicable	The Endangered Species Act of 1973 establishes requirements for the protection of threatened and endangered species. The requirements of this act are potentially applicable based on a determination of whether such species occur on the Mine site or could be impacted by site remedial activities.

IDENTIFICATION OF POTENTIAL FEDERAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
Executive Order 11990	Applicable	Executive Order 11990 requires the protection of wetlands from destruction and specifies that construction activities in the area of wetlands be minimized. The federal agencies are to implement these considerations through existing federal requirements, such as the National Environmental Policy Act. The Executive Order is potentially applicable based on a determination of the whether wetlands are present on the Mine site or could be affected by site remedial activities.
Hazardous Materials Transportation Act 49 USC 1801, et seq		
Hazardous Materials Regulation 49 CFR 171	Applicable	No person may offer to accept hazardous material for transportation in commerce unless the material is properly classed, described, packaged, marked, labeled, and in condition for shipment. These requirements are applicable to hazardous material generated during remedial activities that would be sent offsite for disposal.
Hazardous Materials Tables, Hazardous Materials Communications Requirements, and Emergency Response Information Requirements 49 CFR 172	Applicable	These requirements are applicable if hazardous waste is generated during remediation and is transported offsite. Tables are used to identify requirements for labeling, packaging, and transportation based on categories of waste types. Specific performance requirements are established for packages used for shipping and transport of hazardous materials.
National Historic Preservation Act of 1966 Title 16 USC 470	Applicable	The National Historic Preservation Act requires that historically significant properties be protected. The National Register of Historic Places is a list of sites, buildings or other resources identified as significant to United States history. An eligibility determination provides a site the same level of protection as a site listed on the National Register of Historic Places. The requirements of this federal law are potentially applicable based on a determination of whether such properties occur on the Mine site.
National Oil and Hazardous Substances Contingency Plan (NCP) 40 CFR 300	Relevant & Appropriate	Since the Landsburg Mine site is not on the NPL, the NCP is not applicable to this RI/FS. Sections of the NCP may be relevant and appropriate, however, depending on site conditions.
Resource Conservation and Recovery Act Title 42 USC 6901 et seq	Portions Applicable	The Resource Conservation and Recovery Act (RCRA) consists of standards and criteria controlling the treatment, storage and disposal of hazardous wastes. The EPA has granted the State of Washington the authority to implement RCRA through the Department of Ecology's dangerous waste program (WAC 173-303). Therefore, to avoid redundancy, RCRA criteria which are potentially ARAR for the Landsburg Mine site are not detailed here. The State of Washington equivalent criteria are presented in the state ARAR discussions and in Table 4-2.

TABLE 4-1

IDENTIFICATION OF POTENTIAL FEDERAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
Safe Drinking Water Act of 1974 Title 42 USC 300, et seq.		
National Primary and Secondary Drinking Water Standards 40 CFR 141, 143	Applicable	MTCA requires that groundwater cleanup levels be at least as stringent as maximum contaminant levels (MCLs), secondary maximum contaminant levels (SMCLs), and non-carcinogen maximum contaminant level goals (MCLGs) established under the Safe Drinking Water Act where groundwater is a current or potential future source of drinking water. MCLs, SMCLs and non-carcinogen MCLGs for public drinking water are presented in Table 4-3 for selected compounds.
Surface Mining, Control and Reclamation Act of 1977 30 USC 1201 et seq.		
Underground Mining General Performance Standards 30 CFR 717	Not ARAR	This regulation provides general operational performance standards for underground mines, including reclamation activities. Since the Mine activities had ceased prior to the effective date of this law, these regulations are not applicable.
Abandoned Mine Land Reclamation-General Reclamation Requirements 30 CFR 874	Applicable	These rules describe the eligibility of coal lands for reclamation with money from the Abandoned Mine Reclamation Fund. Coal lands are eligible for reclamation activities if they were mined for coal prior to August 3, 1977, and were left or abandoned in either an unreclaimed or inadequately reclaimed condition. Potentially, this may be applicable to the mine site remedial activities. Funds could be available from the fund to remediate physical hazards posed by the mine and not for any hazards posed by chemical contamination being addressed by Ecology.
Toxic Substance Control Act (TSCA) Title 15 USC 2601 et seq.		
Regulation of PCBs 40 CFR 761	Applicable	TSCA requires that material contaminated with PCBs at concentrations of 50 ppm or greater be disposed of in an incinerator or by an alternate method that achieves an equivalent level of performance. Liquids at concentrations between 50 and 500 ppm and soils above 50 ppm may also be disposed in a chemical waste landfill. TSCA requirements do not apply, however, to PCBs at concentrations less than 50 ppm. TSCA requirements are potentially applicable to remedial actions at the site if PCBs are detected above this level in excavated soils. To date, however, PCBs have not been detected above this concentration at the site.

TABLE 4-2

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
STATE ARARs		
Model Toxics Control Act Ch. 70.105D RCW	Applicable	MTCA is the key governmental regulation governing the conduct of the overall investigation and cleanup process for the site and is therefore applicable. MTCA describes the requirements for selecting cleanup actions, preferred technologies, policies for use of permanent solutions, the time frame for cleanup, and the process for making decisions. The regulation specifies that all cleanup actions be protective of human health, comply with all applicable state and federal regulations, and provide for appropriate compliance monitoring. Specific criteria for the various cleanup methods are presented in the MTCA regulations. The MTCA regulations specify that cleanup actions utilize permanent solutions to the maximum extent practicable. Although MTCA identifies a hierarchy of preferred technologies that should be evaluated for use in the cleanup action, cost may also be a factor in determining points of compliance and selection of cleanup actions. For example, if the cost of cleanup action is substantial and disproportionate to the incremental increase in protection compared to a lesser preferred cleanup action, the less preferred action may be selected. Generally, technologies that recycle or re-use materials are preferred most, followed by methods that destroy or detoxify hazardous substances, and cleanup methods that may leave contaminants on-site. Recent amendments to MTCA (RCW 70.105D.090) exempt remedial actions conducted pursuant to an Agreed Order or a Consent Decree from the procedural requirements of several state laws. These include the State Clean Air Act (RCW 70.94), Solid Waste Management - Reduction and Recycling Act (RCW 70.95), Hazardous Waste Management Act (RCW 70.105), Water Pollution Control Law (RCW 90.48), Shoreline Management Act (RCW 90.58), and Construction Projects in State Waters (RCW 75.20). In addition, the exemption also applies to the procedural requirements of any laws requiring or authorizing local governmental permits or approval for the remedial action. Therefore, while substantive compliance is necessary, permits and approvals are not required for remedial actions at the site.
Model Toxics Control Act Cleanup Regulations WAC 173-340	Applicable	WAC 173-340, which implement the requirements of MTCA, contains the primary regulations under which the Landsburg Mine site RI/FS process is being conducted and are therefore applicable. These regulations establish administrative processes and standards to identify, investigate and cleanup facilities where hazardous substances have been released.

TABLE 4-2

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
Regulation of Public Groundwater Ch. 90.44 RCW		
Water Quality Standards for Groundwater WAC 173-200	Not ARAR	The rule establishes groundwater quality standards to provide for the protection of public health and existing/future beneficial uses. This standard specifically exempts CERCLA and MTCA cleanup actions, and provides for groundwater cleanup standards at such sites to be developed under WAC 173-340-720. Therefore, WAC 173-200 is neither applicable nor relevant and appropriate to the Landsburg Mine site.
Department of Health Standards for Public Water Supplies WAC 246-290	Applicable	The rule established under WAC 246-290 defines the regulatory requirements necessary to protect consumers using public drinking water supplies. The rules are intended to conform with the federal Safe Drinking Water Act (SDWA), as amended. WAC 246-290-310 establishes maximum contaminant levels (MCLs) which define the water quality requirements for public water supplies. WAC 246-290-310 establishes both primary and secondary MCLs and identifies that enforcement of the primary standards is the Department of Health's first priority. The standards set under WAC 246-290-310 are set at the levels established under the federal SDWA. These levels are shown in Table 4-3.
Department of Game Procedures WAC 232-012	Applicable	This standard defines the requirements that the Department of Game must take to protect endangered or threatened wildlife. These requirements may be applicable if endangered or threatened wildlife are identified at the site or within Department of Natural Resources records searches.
Shoreline Management Act Guidelines WAC 173-16	Applicable	The act provides guidelines for the development of master programs regulating the use of shorelines. The substantive requirements of the Act are potentially applicable to the Landsburg Mine site if remedial activities occur within 200 ft of the Cedar River shoreline area.

TABLE 4-2

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
State Environmental Policy Act (SEPA) Ch. 43-21C RCW		
SEPA Rules WAC 197-11 SEPA Procedures WAC 173-802	Applicable	SEPA is applicable to remedial actions at the Landsburg Mine site. Ecology is the lead agency for MTCA remedial actions performed under a Consent Decree or an Agreed Order pursuant to WAC 197-11-253. The SEPA process is triggered when a governmental action is taken on a public or private proposal. According to WAC 197-11-784, a proposal includes both regulatory decisions of agencies and actions proposed by applicants. If the proposal is not "exempt", Ecology will require the submission of a SEPA checklist which solicits information regarding how the proposal will affect elements of the environment, such as air, water, etc. If the proposal is determined by Ecology to have a "probable significant adverse environmental impact", an environmental impact statement (EIS) will be required which examines potential environmental problems that would be caused by the proposal and options for mitigation. If in Ecology's opinion, there will be no significant adverse environmental impact, a Determination of Nonsignificance (DNS) will be issued and the SEPA process is completed without preparation of an EIS. Any public comment period required under SEPA must be combined with any comment period associated with the MTCA process in order to expedite and streamline public input. According to WAC 197-11-259, if Ecology makes a determination that the proposal will not have a probable significant adverse environmental impact, the DNS can be issued with the draft Cleanup Action Plan prepared pursuant to MTCA.
Hazardous Waste Management Act 70.105 RCW		Recent amendments to MTCA (RCW 70.105D.090) exempt cleanup actions conducted pursuant to a Consent Decree or Agreed Order from the procedural requirements of this law. The exemption does not apply to the substantive provisions, however, which still may apply depending on site conditions. Also, recent amendments to RCW 70.105 provide a conditional exemption to state-only dangerous wastes generated during a cleanup action conducted under a Consent Decree. Therefore, substantive provisions of this Act may be applicable if non-exempt dangerous wastes are generated during cleanup.

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
Dangerous Waste Regulations WAC 173-303		A partial list of potentially applicable sections of the Dangerous Waste Regulations are included below.
Designation of Waste WAC 173-303-070	Applicable	These requirements establish the methods and procedures to determine if solid waste requires management as dangerous waste. The substantive requirements of this section may be applicable if remedial activities involve the generation of waste.
Requirements for Generators of Dangerous Waste WAC 173-303-170	Applicable	Substantive requirements for generators of dangerous waste established under this chapter may be applicable to remedial actions performed at the site if dangerous waste is generated.
Closure and Post Closure WAC 173-303-610	Potentially relevant and appropriate	This section describes closure and postclosure performance standards for dangerous waste units, including requirements for plan preparation, maintenance and monitoring of waste containment systems, groundwater monitoring, deed notices, etc. Because the Landsburg Mine site stopped receiving waste materials prior to the effective date of this regulation and does not meet the definition of a regulated facility, these requirements of WAC 173-303 are not legally applicable to the site. Most of the requirements of this section are procedural, and not relevant because of the MTCA exemption for procedural requirements. Subsection 610(2), "Closure performance standard", corresponds to threshold requirements under MTCA. Therefore, the remedy selected by Ecology will satisfy this closure performance standard by definition. Some of these regulations may be relevant and appropriate, however. The most relevant portion of Section 610 is subsection (7), "Postclosure care and use of property". This subsection addresses post-closure maintenance and monitoring, including groundwater monitoring. Section (10) requires a notice in the property deed. The relevant requirements of Section 610(7) and (10) may be appropriate for the Landsburg Mine site.
Releases from Regulated Units WAC 173-303-645	Potentially relevant and appropriate	WAC 173-303-645 regulates releases from regulated units. Although the Landsburg Mine site does not meet the definition of a regulated dangerous waste unit, the requirements of this section are relevant. Portions of this section may be appropriate, such as:

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
Landfills WAC 173-303-665	Potentially relevant and appropriate	• Groundwater protection standard, 645(3) • Compliance period, 645(7) • General groundwater monitoring requirements, 645(8) • Detection monitoring program, 645(9) • Compliance monitoring program, 645(10). The relevance and appropriateness of these sections will be considered in the preparation and review of the Compliance Monitoring Program required under MTCA. Design standards specific to dangerous waste landfills are found in WAC 173-303-665. Of these, liner and operating standards are not relevant to closure of the Landsburg Mine site. Potential leachate will be addressed by groundwater monitoring pursuant to the approved MTCA Compliance Monitoring Program. Section 665(6) addresses closure and post-closure care, which is relevant to this site. The design standard for the final cover, which may or may not be appropriate for this site, consists of the following [WAC 173-303-665(6)(a)]: "(i) Provide for long-term minimization of migration of liquids through the closed landfill (ii) Function with minimum maintenance; (iii) Promote drainage and minimize erosion or abrasion of the cover; (iv) Accommodate settling and subsidence so that the cover's integrity is maintained; and (v) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present."
Solid Waste Management, Recovery, and Recycling Act Ch. 70.95 RCW		Recent amendments to MTCA (RCW 70.105D.090) exempt cleanup actions conducted pursuant to a Consent Decree or Agreed Order from the procedural requirements of this law. The exemption does not apply to the substantive provisions, however, which still may apply depending on site conditions.
Minimum Functional Standards (MFS) for Solid Waste Handling WAC 173-304	Applicable	MTCA regulations [WAC 173-340-710(b)(c)] specify that WAC 173-304 contains the "minimum requirements" for landfill closure conducted as a MTCA cleanup action.

TABLE 4-2

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
General Closure and Post-Closure Requirements, Landfilling Standards WAC 173-304-407, -460	Applicable	WAC 173-304-460 capping requirements include a minimum 2 ft. thick clay layer having a permeability of 1 x 10^{6} or lower. Alternately, a synthetic liner material may be substituted for the soil layer. The MFS represent the primary capping criteria to consider in this FS.
Criteria for Municipal Solid Waste Landfills (MSWLF) WAC 173-351	Not ARAR	The purpose of the regulation is to establish minimum state-wide standards for all municipal solid waste landfill (MSWLF) units. This regulation implements rulemaking by the EPA under the authority of Subtitle D of RCRA, as amended in 1984. The criteria apply only to new and existing MSWLF. MSWLF units that stopped receiving waste prior to October 9, 1991 are subject to closure and post-closure rules under chapter 173-304. Because the Landsburg Mine site is not a MSWLF and stopped receiving waste prior to the applicable date, these rules are not ARAR to the site. All other solid waste disposal facilities that are not regulated under Subtitle C of RCRA (and the State of Washington equivalent - WAC 173-303) are subject to the criteria under WAC 173-304 "Minimum Functional Standards for Solid Waste Handling."
Water Well Construction CH. 18.104 RCW		
Minimum Standards for Construction and Maintenance of Water Wells WAC 173-160	Applicable	These requirements are applicable to remedial actions that include construction of wells used for groundwater extraction, monitoring, or injection of treated groundwater or wastes. These requirements also include standards for well abandonment.
Water Pollution Control/Water Resources Act Ch. 90.48 RCW/Ch. 90.54 RCW		Recent amendments to MTCA (RCW 70.105D.090) exempt cleanup actions conducted pursuant to a Consent Decree or Agreed Order from the procedural requirements of this law. The exemption does not apply to the substantive provisions, however, which still may apply depending on site conditions.
Surface Water Quality Standards WAC 173-201A	Applicable	Since water quality standards are set at levels protective of aquatic life, these standards are only applicable to surface waters at the site which either support or have the potential to support aquatic life. Groundwater beneath the site may discharge to the Cedar River, therefore surface water quality criteria established under this chapter may potentially be applicable to the groundwater at the point of discharge to the river. Ecology has announced anticipated rule development for the purpose of adopting risk-based numeric limits for protection of public health as required by the federal CWA (WSR-18-095). Other proposed changes to the standard were also announced in WSR-94-16-056. Table 4-4 lists criteria for selected compounds.

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
State Waste Discharge Program WAC 173-216	Applicable	Requirements of this program may be applicable to remedial actions that include discharges to the ground. The chapter implements a permit system applicable to industrial and commercial operations that discharge to the groundwater, surface waters, or municipal sewerage systems. Specific discharges prohibited under the program are identified. Cleanup actions conducted under a Consent Decree or Agreed Order are exempt, however, from procedural requirement (permits).
National Pollution Discharge Elimination System Permit Program WAC 173-220	Applicable	Establishes a state permit program pursuant to the national NPDES system. Substantive sections of the regulation may be applicable to remedial alternatives that involves discharges to surface waters. Discharges may include site run-off, spillage, leaks, sludge, or treated waste disposal.
Washington Clean Air Act Ch. 70.94 RCW and Ch. 43.21A RCW		Recent amendments to MTCA (RCW 70.105D.090) exempt cleanup actions conducted pursuant to a Consent Decree or Agreed Order from the procedural requirements of this law. The exemption does not apply to the substantive provisions, however, which still may apply depending on site conditions.
General Regulations for Air Pollution Sources WAC 173-400	Applicable	Substantive standards established for the control and prevention of air pollution under this regulation may be applicable to remedial actions proposed for the operable unit. The regulation requires that all sources of air contaminants meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions. The Puget Sound Air Pollution Control Agency enforces and administers these requirements in the greater Puget Sound Area. Refer to discussion under PSAPCA.
Controls for New Sources of Air Pollution WAC 173-460	Applicable	This standard requires that new sources of air emissions provide emission estimates for toxic air contaminants listed in the regulation. The standard requires that emissions be quantified and used in risk modeling to evaluate ambient impacts and establish acceptable source impact levels. These standards are applicable since the regulation specifically lists sites subject to MTCA actions.
Puget Sound Air Pollution Control Agency (PSAPCA)		PSAPCA, activated under the Washington State Clean Air Act (RCW 70.94) has jurisdiction over regulation and control of the emission of air contaminants and the requirements of state and federal Clean Air Acts from all sources in the King, Pierce, Snohomish and Kitsap county areas.
Regulation 1	Applicable	Regulation 1 establishes the general requirements and programs the agency uses to administer its regulatory program. Substantive aspects of this regulation may be applicable to the mine site if remediation activities may result in the emission of air contaminants regulated by the agency. Specific requirements of the program concern: registration of sources, new source review, emission standards and ambient air quality standards and control methods required.

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
Regulation 2	Not ARAR	Regulation 2 provides for the control of photochemically reactive volatile organic compounds (VOCs), precursors to low atmospheric ozone formation, in order to meet National Ambient Air Quality Standards (NAAQS) for Ozone. The regulation identifies specific source categories regulated under the standard. Regulation 2 is not ARAR since the Landsburg Mine site does not meet the definition of any of the sources regulated nor are VOCs anticipated to be released in quantities significant for the standard to be considered relevant and appropriate.
Regulation 3	Applicable	Regulation 3 controls the emission of toxic air contaminants, sources of, and development of strategies to protect public health and the environment from impacts of toxic air contaminants and may be applicable if toxic air contaminants are emitted. Ambient air concentrations for toxic air contaminants are established by PSAPCA for the Puget Sound Region. Best Available Control Technology (BACT) is required for sources that emit toxic air contaminants. Toxic air contaminants are listed in Appendix A of Regulation 3 or listed in Subpart D, 40 CFR 372. Appendix A also identifies Acceptable Source Impact Levels (ASILs) for toxic air contaminants. Specific procedures for asbestos emission control are also addressed under Regulation 3.
Surface Mined-Land Reclamation Act Ch. 78.44 RCW		
Surface Mined-Land Reclamation WAC 332-18	Not ARAR	These regulations specify reclamation requirements for surface mines in the State of Washington. However, since the Landsburg Mine is an underground Mine, and involved coal mining, which is specifically exempted in the Act, the requirements of these regulations are not applicable or relevant and appropriate to closure activities conducted at the site. Primacy for regulation of coal mining in the State of Washington rests with the federal Office of Surface Mining.
LOCAL ARARs[a]		
King Co. Zoning Code Title 21 KCC	Applicable	Substantive requirements of the County zoning ordinance are applicable to remedial actions at the Landsburg Mine site. However, remedial actions are exempt from permitting and procedural requirements under MTCA.

TABLE 4-2

IDENTIFICATION OF POTENTIAL STATE AND LOCAL ARARS FOR THE LANDSBURG MINE SITE

Requirements	Applicable or Relevant & Appropriate	Comment
Special Control Areas and Flood Hazard Areas Ch. 21.54 KCC		
Sensitive Areas Ordinance and Rules Ordinance 9614	Applicable	Sensitive Areas in King County are defined and regulated by the Sensitive Areas Ordinance, King County Code Chapter 21.54, and its administrative rules. The locations of sensitive areas are identified in the Sensitive Areas Map folio for wetlands, streams, flood hazards, erosion hazards, landslide hazards, seismic hazards, and coal mine hazards. The Sensitive Areas Rules set forth procedures and standards to be followed when a development proposal involves a sensitive area. The main portion of the Mine site is identified in the folio as a coal mine hazard area. Other portions of the site are mapped as erosion hazard areas. Since the Mine site is included in a sensitive area, the substantive requirements of the Sensitive Areas Ordinance are applicable to remedial action at this site. However, remedial actions are exempt from procedural and permitting requirements under MTCA.

[a] Under RCW 70.105D.090, cleanup actions conducted under Consent Decrees or Agreed Orders are exempt from the procedural requirements of any laws requiring or authorizing local government permits or approvals for the remedial action.

TABLE 4-3

POTENTIAL ARAR VALUES FOR GROUNDWATER

Compound Detected[k]	Washington State Model Toxics Control Act WAC 173-340-720[h] Method B, μg/L		Drinking Water Standards[l] 40 CFR 141[a] and 40 CFR 143[b] μg/L	Minimum Value[j], μg/L
	Carcinogenic	Non-carcinogenic		
METALS				
Aluminum		16000	50[b]	50
Antimony		6.4	6[a,c]	6
Arsenic		5[d]	50[a]	5
Barium		1120	2000[a,c]	1120
Beryllium	0.0203	80	4[a,c]	0.0203
Cadmium		8	5[a,c]	5
Calcium				-
Chromium		80[i]	100[a,c]	80
Cobalt		960	-	960
Copper		592	1000[b]	592
Iron			300[b]	300
Lead		5[e]	15[m]	5
Magnesium				-
Manganese		80	50[b]	50
Mercury		4.8	2[a,c]	2
Nickel		320	100[a,c]	100
Potassium				-
Selenium		80	50[a,c]	50
Silicon				-
Silver		80	100[b]	80
Sodium				-
Thallium		1.12	.5[c]	0.5
Vanadium		112	-	112
Zinc		4800	5000[b]	4800
GENERAL CHEMISTRY				
pH			6.5-8.5[b]	6.5-8.5
Carbonate, μg/L CaCO$_3$				-
Bicarbonate, μg/L CaCO3				-
Hardness, μg/L CaCO3				-
Conductivity, μmhos/cm				-
TDS, μg/L			500000[b]	500000
Turbidity, NTU				-
Fluoride		960	2000[b]	960
Chloride			250000[b]	250000
Nitrate (as N)		5780	10000[a,c]	5780
Nitrite (as N)		487	1000[a,c]	487
Sulfate			250000[b]	250000
ORGANICS				
Benzene	1.51		5[a]	1.51
Bis(2-ethylhexyl)phthalate	6.25	320	6[a,g]	6
1,2-dibromo-3-chloropropane	0.0312		0.2[a,n]	0.0312
1,3-dichlorobenzene		720[f]		720
Diethylphthalate		12,800		12800
Endrin		4.8	2[a]	2
1,3,5-trimethylbenzene				-

[a] Primary MCLs.

[b] Secondary MCLs.

[c] Non-carginogen MCLGs under 40 CFR 141.50.

[d] Cleanup level based on background concentration for the State of Washington as noted in Table 1, footnote b, WAC 173-340-720.

[e] There is no Method B cleanup level for lead. Cleanup level based on MTCA Method A.

[f] Used 1,2-dichlorobenzene as a surrogate.

[g] Used di(2-ethylhexyl)phthalate as a surrogate.

[h] Cleanup levels based on the January 1995 Update to the MTCA Cleanup Levels and Risk Calculations (CLARC II) Database (WDOE 1995).

[i] Assumes Cr(VI).

[j] Utilized in Chapter 5 for comparison to ARARs.

[k] Compounds detected in this RI (See Chapter 5).

[l] Value shown is the minimum of MCL, SMCL and non-carcinogen MCLG.

[m] Action level, per 40 CFR 141.80.

[n] Used value listed for dibromochloropropane

TABLE 4-4

POTENTIAL ARAR VALUES FOR SURFACE WATER

Compound Detected[e]	Washington State Model Toxics Control Act WAC 173-340-720[a] Method B (Surface Water), μg/L		Washington State Surface Water Quality Standards WAC 173-201A Freshwater[c]		Minimum Value[d], μg/L
	Carcinogenic	Non-carcinogenic	Acute, μg/L	Chronic, μg/L	
METALS					
Aluminum					-
Antimony		1040			1040
Arsenic	0.0842	17.7	360	190	0.0842
Barium					-
Beryllium	0.0793	682			0.0793
Cadmium		20.3	4.5	3.6	3.6
Calcium					-
Chromium		810[b]	1571.5	275.3	275.3
Cobalt					-
Copper		2660	32.0	22.8	22.8
Iron					-
Lead			91.0	1.5	1.5
Magnesium					-
Manganese					-
Mercury			2.4	0.012	0.012
Nickel		1100	1443.3	225.0	225
Potassium					-
Selenium			20	5	5
Silicon					-
Silver		25900	0.1		0.1
Sodium					-
Thallium		1.56			1.56
Vanadium					-
Zinc		16500	164.5	151.3	151.3
GENERAL CHEMISTRY					
pH					-
Carbonate, μg/L $CaCO_3$					-
Bicarbonate, μg/L CaCO3					-
Hardness, μg/L CaCO3					-
Conductivity, μmhos/cm					-
TDS, μg/L					-
Turbidity, NTU					-
Fluoride					-
Chloride			860000.0	230000.0	230000
Nitrate (as N)					-
Nitrite (as N)					-
Sulfate					-
ORGANICS					
Diethylphthalate		28400		-	28400
Analysis 524.2					
1,1-Dichloroethane					-

[a] Cleanup levels based on the January 1995 Update to the MTCA Cleanup Levels and Risk Calculations (CLARC II) Database (WDOE 1995).

[b] Assumes Cr(VI).

[c] Freshwater criteria for Cd, Cr, Cu,Pb, Ni, Ag, and Zn based on an assumed hardness of 200 mg/L - $CaCO_3$.

[d] Utilized in Chapter 5 for comparison to ARARs.

[e] Compounds detected in this RI (See Chapter 5).

TABLE 4-5

POTENTIAL ARAR VALUES FOR SOIL

Compounds Detected[f]	Washington State Model Toxics Control Act WAC 173-340-720[d,h]			
	Method B, mg/kg		Method C, mg/kg	
	Carcinogenic	Non-carcinogenic	Carcinogenic	Non-carcinogenic
METALS				
Aluminum		80000		320000
Antimony		32		128
Arsenic[a]		7	57.1	240
Barium		5600		22400
Beryllium	0.233	400	9.3	1600
Cadmium		80		320
Calcium				
Chromium[b]		400		1600
Cobalt		4800		19200
Copper		2960		11800
Iron				
Lead[c]		250		1000
Magnesium				
Manganese		11200		44800
Mercury		24		96
Nickel		1600		6400
Potassium				
Selenium		400		1600
Silver		400		1600
Sodium				
Thallium		5.6		22.4
Vanadium		560		2240
Zinc		24000		96000
ORGANICS				
Acetone		8000		32000
Aroclor-1242[g]	1.6		6.4	
Aroclor-1254	1.6		6.4	
benzene	34.5		1380	
benzo(a)pyrene	0.137		5.48	
Bis(2-ethylhexyl)phthalate	71.4	1600	2860	6400
2-butanone (MEK)		48000		192000
butylbenzylphthalate		16000		64000
carbon disulfide		8000		32000
chrysene	0.137		5.48	
dibutylphthalate		8000		32000
1,2-dichlorobenzene		7200		28800
1,4-dichlorobenzene	41.7		1670	
dibenzofuran[e]		3200		12800
diethylphthalate		64000		256000
dimethylphthalate		80000		320000
4,4'-DDT	2.94	40	118	160
ethylbenzene		8000		32000
fluorene		3200		12800
isophorone	1050	16000	42100	64000
methylene chloride	133	4800	5330	19200
2-methylnaphthalene[e]		3200		12800
naphthalene		3200		12800
phenanthrene[j]		2400		9600
styrene	33.3	16000	1330	64000
tetrachloroethene	19.6	800	784	3200
toluene		16000		64000
total petroleum hydrocarbons (TPH)		200[i]		200[i]
1,1,1-trichloroethane		72000		288000
trichloroethene	90.9		3640	
1,1,2-trichloro-1,2,2-trifluoroethane[k]		1000000		1,000,000
trichlorofluoromethane		24,000		1,000,000
total xylenes		160000		640000

TABLE 4-5

POTENTIAL ARAR VALUES FOR SOIL

[a] Method B cleanup level based on background concentration for the State of Washington as defined in WDOE (1994).
[b] Assumes Cr(VI).
[c] There is no Method B or C cleanup level for lead. Cleanups level based on MTCA Method A and Method A (Industrial).
[d] Cleanup levels based on the January 1995 Update to the MTCA Cleanup Levels and Risk Calculations (CLARC II) Database (WDOE 1995).
[e] Naphthalene used as a surrogate.
[f] Compounds detected in soil in this RI and in the Site Hazard Assessment (E&E [1991]) (See Chapter 5).
[g] Aroclor-1254 used as a surrogate.
[h] Values shown do not account for protection of groundwater.
[i] There is no Method B or C cleanup value for TPH. Value shown represents the Method A value.
[j] Pyrene used as a surrogate.
[k] Method B value presented in the CLARC II database ($2.4x10^6$ mg/kg) is not reasonable.
Therefore, have adjusted value to $1x10^6$ mg/kg.

5. NATURE AND EXTENT OF CHEMICAL CONSTITUENTS EXCEEDING REGULATORY CRITERIA

This chapter provides a description of the nature and extent of chemical constituents detected in environmental media at the Landsburg Mine site. The primary purpose of this chapter is to identify the chemical compounds *resulting from waste disposal activities conducted at the mine* which potentially pose a human or environmental health risk and/or which exceed potential regulatory criteria. The compounds which are identified as such are termed the contaminants of concern (COC). The COC are identified for each media which represent a potential chemical exposure route and are chosen through a step-wise screening process which considers laboratory and field blank data, background concentrations, appropriate regulatory criteria, and other considerations. The data evaluation performed in this chapter is based on regulatory guidelines presented in WDOE (1992, 1993b, 1994, and 1995).

5.1 Approach

The overall aim of the screening is to identify the COCs, i.e. the compounds which exceed ARARs *and* are the result of waste disposal activities at the mine. The approach conducted herein to identify the COCs consists of the following steps:

- **Analytical data validation.** Data validation is a task related to quality assurance which validates the overall correctness and accuracy of the analytical data obtained in the RI. The result is a database of analytical results which have been confirmed through a standard data validation procedure and which are considered useable for decision making purposes;

- **Comparison of analytical data to ARARs.** Once a validated database has been compiled, the data are then compared to the chemical-specific regulatory criteria (ARARs) defined in Chapter 4 to identify which compounds pose a potential risk to human health and/or exceed regulatory criteria. The compounds which exceed the regulatory screening criteria are retained for further consideration in the screening process. Compounds which do not exceed regulatory screening criteria are eliminated from further considerations in this RI.

  It is important to note that site data are usually compared to background levels prior to comparisons to regulatory criteria. However, in the case of this RI, it was not practicable to define site-specific background for much of the data (groundwater and surface water). For groundwater for instance, this was because of the large number of different hydrostratigraphic units which were monitored by the site monitoring wells and private wells each of which would have required its own definition of background. Given this fact, the regulatory comparison was performed first in order to reduce the total number of compounds retained in the screening. Any background comparisons which could be made were then made on the reduced list of compounds.

- **Consideration of other factors and criteria to identify the Contaminants of Potential Concern (COPC).** The next step in the screening process consists of the consideration of other criteria, such as background data (if available), field and trip blank detects, and the consistency of detection to further refine the retained list of compounds. The resulting list is list termed the Contaminants of Potential Concern (COPC). COPC are defined for each media and represent those compounds which exceed the regulatory screening values and whatever background data are available for the site. It is important to note, however, that the COPC do not necessarily represent compounds resulting from mine waste disposal activities since site-specific background data are limited (such as for groundwater).

- **Identification of Contaminants of Concern (COC).** The final step of the screening consists of the identification of the Contaminants of Concern (COC). This is performed by considering groundwater quality typical of coal mines in the State of Washington to identify those COPCs, if any, which are actually believed to have resulted from waste disposal in the Rogers seam. Coal mine water quality data are used because of the lack of site-specific background data for groundwater. The COCs represent those chemicals in environmental media at the site which exceed regulatory criteria *and* are believed to be the result of waste disposal rather than just natural background conditions.

This step-wise screening process is presented below in Section 5.2. Section 5.3 describes the distribution throughout the Study Area of the various media-specific COPC identified in Section 5.2. Section 5.4 identifies the COC and summarizes the major conclusions of this chapter.

5.2 Data Screening

5.2.1 Media Addressed

The *Conceptual Model of the Landsburg Mine Site* (Golder 1992b) identified exposure to contaminated soil and groundwater as the primary exposure pathways which needed to be evaluated in this RI. Airborne and surface water contamination were also identified as potentially significant exposure pathways, however, these were designated as secondary pathways and were not considered as significant as the soil and groundwater pathways. The scope of work outlined in the Work Plan (Golder 1992a) was therefore aimed at evaluating chemical occurrences in these four media. As discussed in Chapter 2, data collection activities for these media consisted of the following:

- air monitoring data collected along the trench bottom in a series of three site walk-throughs and during drilling for health and safety purposes;

- four quarters of groundwater sampling from seven newly installed site monitoring wells and 14 existing private wells (round 4 sampling was performed on a reduced set of 7 wells);

- four quarters of surface water sampling from the two mine portals (portals #2 and #3); and

- surface soil sampling in three areas of the site: the trench rim, portals #2 and 3, and test pit locations.

These are the data which will be screened in this sub-section. In addition to these data, the screening will also address soil contaminant data collected within the trench itself during the SHA (E&E 1991) and ERA (Landsburg PLP Steering Committee 1991). Summaries of the data collection activities conducted as part of this RI are included in Chapter 2. Tables 2-2 and 2-3 summarize the number of soil, groundwater and surface water samples collected in this RI and analyses performed, as well as other pertinent sampling information. Complete summaries of all soil, groundwater and surface water data are included in Appendix C.

The screening process conducted here is not applied to the air monitoring data. Air regulatory criteria are chemical-specific in nature. The air data collected, however, consist of *total* volatile organics concentrations, as measured by field monitoring instrumentation. Rather than comparing these data to regulatory criteria, the data will be used qualitatively (in Section 5.3) to assess the overall significance of the air pathway as a potential exposure route.

It is important to note that, as indicated in Chapter 2, the approach taken during the RI was to focus environmental sampling efforts on potential pathways of chemicals leaving the mine. As such, the RI did not include sampling of the Cedar River.

5.2.2 Data Validation

The first step in the data evaluation process consists of data validation. Data validation was conducted for all laboratory chemical analyses conducted as part of this RI, i.e. all soil, groundwater and surface water chemical testing. Laboratory data validation was conducted in accordance with guidelines presented in Bleyler (1988a,b), the Quality Assurance Project Plan (QAPP) (Golder 1992a) and Golder technical procedure TP-2.2-3, "Analytical Data Validation and Data Management". Table 5-1 summarizes the results of data validation for the RI chemical data.

Data validation was conducted by Golder chemistry personnel who, upon receipt of data packages from the analytical laboratory, conducted a detailed review and calculation overcheck process to ensure that the laboratory met all contractual requirements, all applicable reference method requirements, and the data quality objectives specified in the QAPP.
A separate data validation report was prepared for each sample delivery group (SDG). An SDG is defined in this RI as a group of samples delivered to a lab under a single chain-of-custody. As seen in Table 5-1, there were a total of 33 SDGs for this RI. Each data validation report documents the evaluation of laboratory blanks, duplicates, matrix spike/matrix spike duplicates, laboratory control samples, calibration data, and any requalification of analytical results that was required as part of the data validation exercise. All data validation reports are routed to the permanent project records file, as required by the Data Management Plan (Golder 1992a). Permanent records are maintained at Golder's offices in Redmond, WA.

As shown in Table 5-1, the DQOs defined in the QAPP for analytical data were generally attained, with a few minor deficiencies which are noted in the table. Overall, between 99 and 100% of the total number of requested analytical determinations were determined to be valid which exceeds the goal established in the QAPP of 90% for a given SDG.

It is important to note that, while the data validation process did include adjustments (requalifications) to the data on the basis of laboratory (method) blank data, such adjustments were not made on the basis of detects observed in field or trip blanks. This is not normally included as part of data validation. Detects in field or trip blanks could be indicative of sample contamination which occurred in sample transit or as a result of sampling procedures. Consideration of any required adjustments on the basis of field or trip blank data will be made in Section 5.2.4. Field and trip blank sample IDs collected for each SDG are shown in Table 5-1. All detects in field and trip blank samples are summarized in Table 5-2.

5.2.3 Comparison to Potential ARARs (Screening)

The next step in the screening process is to compare the analytical results validated above in Section 5.2.2 to relevant regulatory criteria (ARARs). The determination of potential ARARs for the Landsburg Mine site, including action- and location-specific ARARs as well as the chemical-specific ARARs, is given in Chapter 4. The reader is referred to Chapter 4 for a detailed discussion of the federal, state and local laws considered potentially ARAR for this site. Compliance with ARARs is a requirement of MTCA (WAC 173-340-710).

The following chemical-specific laws and regulations are considered to be the primary ARARs to consider for the Landsburg site:

Groundwater	MTCA (WAC 173-340) and the federal Primary and Secondary Drinking Water Regulations (40 CFR 141 and 143)
Surface Water	MTCA (WAC 173-340) and the State Surface Water Quality Criteria (WAC 173-201A)
Soil	MTCA (WAC 173-340)

These are the criteria utilized in the regulatory screening conducted herein. The procedure used in the screening is to compare the maximum value for each detected compound to the ARAR concentration limit for that medium. When multiple potential ARARs exist for a particular compound, the minimum ARAR value is used in the screening. A complete listing of the groundwater, surface water and soil ARARs is presented in Tables 4-3, 4-4, and 4-5, respectively.

It is important to note that the use of these potential ARARs is not to be considered an acknowledgment by the PLP Group of the applicability of a particular law or regulation to remedial actions conducted at the Mine. For instance, there is some uncertainty as to the applicability of the State Surface Water Quality Criteria and the MTCA surface water requirements to the surface water samples (portals) collected as part of the RI. These ARARs are utilized in the screening, however, to present all of the potential ARARs for comparison purposes.

Compounds detected in site monitoring wells and Study Area private wells for the four sampling rounds are summarized in Tables 5-3 and 5-4, respectively. The chemical-specific regulatory screening concentrations are also listed in the tables. Detected concentrations in surface water and the associated screening values are shown in Table 5-5. Tables 5-6, 5-7 and 5-8 summarize the compounds detected in trench rim soils, portal soils, and backhoe test pit soils, respectively, along with the regulatory screening values. Table 5-9 summarizes the compounds detected along the bottom of the trench as part of the SHA and ERA, along with regulatory screening values. Exceedance of a screening value is indicated by shading in the tables. Exceedance of a screening value at this point in the screening does not necessarily indicate a significant human or environmental health hazard, but only the need to retain the compound for further consideration.

5.2.3.1 Groundwater

Monitoring Wells. Compounds detected in site groundwater monitoring wells and the associated regulatory screening values are summarized in Table 5-3. As seen in the table, constituents which exceed the screening values consist of aluminum, iron, manganese, thallium, and total dissolved solids (TDS). One organic compound was detected (1,2-dibromo-3-chloropropane [DBCP]), however, the 2 detected values (both at 0.025 J μg/L) did not exceed the minimum potential regulatory criteria (0.0312 μg/L) and the compound is not considered further.

Aluminum was detected at a maximum concentration of 140 μg/L versus the screening value of 50 μg/L. Iron was detected at a maximum value of 2,230 μg/L versus a screening value of 300 μg/L. Manganese was detected at a maximum value of 299 μg/L versus a screening value of 50 μg/L. Thallium was observed at a maximum concentration of 2 μg/L versus a screening value of 0.5 μg/L, and TDS was measured at a maximum value of 780,000 μg/L versus a screening value of 500,000 μg/L. Apart from thallium, all of these screening values consist of Secondary Maximum Contaminant Levels (SMCLs). SMCLs are not health-based standards, but are protective of aesthetic qualities of water only. The screening value for thallium is a Maximum Contaminant Level Goal (MCLG) value specified under federal drinking water standards. The MTCA Method B standard for manganese of 80 μg/L, while not the minimum ARAR for the compound, was also exceeded in some instances in addition to the SMCL.

Private Wells. Compounds detected in the Study Area private wells and the associated regulatory screening values are summarized in Table 5-4. As seen in the table, constituents which exceed the screening values consist of aluminum, arsenic, iron, lead, manganese, thallium, and pH. Several organic compounds were detected in the private wells. Of these, one compound, bis(2-ethylhexyl)phthalate, exceeds potential regulatory criteria.

Aluminum was detected at a maximum concentration of 2,560 μg/L vs the screening value of 50 μg/L. Arsenic was detected at a maximum value of 19 μg/L vs the screening value of 5 μg/L. Iron was detected at a maximum value of 5,400 μg/L vs a screening value of 300 μg/L. Lead was observed at a maximum concentration of 16 μg/L as compared to the regulatory screening concentration of 5 μg/L. Manganese was detected at a maximum value of 416 μg/L vs a screening value of 50 μg/L. Thallium was observed at a maximum concentration of 3 μg/L as compared to a screening value of 0.5 μg/L. Bis(2-ethylhexyl) phthalate was observed at a maximum level of 6.7 μg/L vs a screening value of 6 μg/L, and pH was measured at levels below the minimum pH value of 6.5 and above the maximum value of 8.5. The screening values for aluminum, iron, manganese, and pH all consist of SMCLs. The screening values for arsenic and lead are MTCA Method B values, and the screening value for bis(2-ethylhexyl)phthalate is an MCL value. The screening value for thallium is an MCLG. As with the monitoring wells, the Method B standard for manganese of 80 μg/L, while not the minimum ARAR for the compound, was also exceeded in some instances in addition to the SMCL.

Table 5-10 summarizes the compounds exceeding potential ARARs in all groundwater samples, including the maximum detected values, screening values, number of samples, number of detected values, mean concentrations and number of samples exceeding the screening value. This list of compounds exceeding ARARs for monitoring wells and private wells is evaluated further below in Section 5.2.4 to arrive at the COPC for groundwater.

5.2.3.2 Surface Water

Compounds detected in surface water samples collected as part of the RI and the associated regulatory screening criteria are presented in Table 5-5. As seen in the table, one compound, arsenic, was identified as exceeding a potential surface water ARAR. Arsenic was detected at a maximum concentration in surface water of 3 μg/L vs a screening value of 0.0842 μg/L. The arsenic ARAR consists of a Method B cleanup level for surface water.

Table 5-11 summarizes the compounds exceeding potential ARARs in surface water. This list of compounds is evaluated further below in Section 5.2.4 to arrive at the surface water COPC.

5.2.3.3 Soil

Compounds detected in trench rim soils, portal soils, backhoe test pit soils and from within the trench itself along with the associated regulatory screening values are presented in Tables 5-6, 5-7, 5-8, and 5-9, respectively. As seen in the tables, compounds exceeding potential ARARs outside of the trench include arsenic (for trench rim soils, portal soils, and test pit soils), and beryllium (for trench rim soils and test pit soils). For materials inside the trench (soils and sludge) sampled as part of the SHA and ERA, compounds exceeding potential ARARs include arsenic, chromium, lead, PCBs and bis(2-ethylhexyl)phthalate (for trench soils) and methylene chloride, TCE, TPH and PCBs (for the sludge pond). A number of organic compounds were detected in soils both inside and outside of the trench; however, no organic compounds detected outside the trench exceeded any potential regulatory criteria.

In the trench rim soils, arsenic was detected at a maximum concentration of 16 mg/kg versus a regulatory screening level of 7 mg/kg. Beryllium was detected at a maximum value of 1 mg/kg versus the regulatory screening value of 0.23 mg/kg. Arsenic was detected at a maximum value of 26 mg/kg in the portal soils and a maximum concentration of 11.4 mg/kg in the test pit soils versus a screening value of 7 mg/kg. Beryllium in the test pit soils was detected at a maximum value of 0.8 mg/kg. All of these screening values represent Method B values.

For soils inside the trench, arsenic was detected at a maximum value of 19 mg/kg versus a screening value of 7 mg/kg. Lead was detected at a maximum concentration of 3200 mg/kg versus the screening value of 250 mg/kg. Chromium was detected at a maximum value of 912 mg/kg versus a screening value of 400 mg/kg. Aroclor-1242 and -1254 were detected at maximum values of 7.9 mg/kg and 27.2 mg/kg, respectively, versus a regulatory screening value of 1.6 mg/kg. Bis(2-ethylhexyl)phthalate was detected at a maximum value of 178 mg/kg versus a screening value of 71.4 mg/kg.

For the pond sludge sample, methylene chloride was detected at a concentration of 1690 mg/kg versus a screening value of 133 mg/kg. TCE was detected at 1530 mg/kg vs. 90.9 mg/kg. TPH was observed at 67,000 mg/kg versus a screening value of 200 mg/kg, and PCBs were detected at a concentration of 4.9 mg/kg versus 1.6 mg/kg. All of these screening values are Method B values except for TPH which is a Method A.

Table 5-12 summarizes the compounds exceeding potential ARARs for soils. This list of compounds is evaluated further below in Section 5.2.4 to arrive at the soil COPC.

5.2.4 Consideration of Other Criteria

In this section, additional screening criteria, including background concentrations (when available), consistency of detection, and field blank results, are applied to define the lists of COPC. The aim is to eliminate results which are detected inconsistently, or are indicative of background levels or sample contamination, so that these data are excluded from consideration in the RI.

5.2.4.1 Field and Trip Blank Data

The purpose of conducting chemical analyses on field and trip blank samples is to eliminate sample detects which may have resulted from sample contamination. Such contamination could occur during sample transit or as a result of improper or inadequate sample collection procedures. The purpose of this section is to check whether any of the compounds identified above can be eliminated on the basis of field or trip blank data.

Per Bleyler (1988a,b), sample detects (in actual samples rather than blank samples) which fall below calculated blank adjustment factors are adjusted to non-detects. Blank adjustment factors are calculated by multiplying the detected concentration in the blank sample by a factor of 5 or 10, depending on the compound. The resulting blank adjustment factor is then compared to the analytical results associated with the SDG (see Section 5.2.2 for SDG definition). Any detected value which is less in magnitude than the blank adjustment factor is considered a non-detection.

Detected values observed in field and trip blank samples collected as part of this RI are summarized in Table 5-2. All of the field or trip blank samples are associated with groundwater samples. In comparing the compounds detected in blanks in each of the SDGs versus the list of compounds exceeding ARARs for groundwater, it is apparent that no maximum detected values for these compounds fall below any blank adjustment factors. Therefore, no adjustments can be made on the basis of field or trip blank data.

5.2.4.2 Consistency of Detection

Several compounds exceeding ARARs, all of which are for groundwater, can be eliminated because they were detected very inconsistently. The consistency of detection for these compounds was so low that the presence of the compounds in the site groundwater is highly questionable, and it is therefore not reasonable for the compounds to be retained in this screening. These compounds include the following:

For monitoring wells:

- thallium

For private wells:

- thallium
- bis(2-ethylhexyl)phthalate
- lead.

In the case of the monitoring wells, thallium was detected only 5 times out of 28 samples (Table 5-10). The maximum value of 2 μg/L was only very slightly above the regulatory screening value of 0.5 μg/L. All of the detects were very close to the detection limit of 1 μg/L. There were no detects in round 3 and only 1 detect in round 4. Only at one well (LMW-2) was there more than 1 detect over the four rounds.

For private wells, there was only a single detected value of thallium in round 1, and there were no detects in rounds 3 and 4. The maximum concentration (3 μg/L) only very marginally exceeds the screening value of 0.5 μg/L and the detection limit of 1 μg/L. The maximum value for thallium (3 μg/L) was detected at a well (PW-8) which is hydraulically isolated from the mine. There is therefore no observable pathway for the compound to have migrated from the mine to the well (see Section 3.6.4.1).

Bis(2-ethylhexyl)phthalate was detected only twice in 49 samples. Only a single sample exceeded the screening value. The one exceedance (6.7 μg/L) was by a very slight margin (screening value of 6 μg/L). The compound was not detected in any mine site wells. None of the detects were repeated more than once at a well. The detect at well PW-5 occurred in a well that is hydraulically isolated from the mine. The compound is a common laboratory contaminant.

Lead was detected at levels above the screening level at only 2 of 49 samples. At the two wells where the exceedances occurred, three of the four other results were ND with one result of only 1 μg/L. The maximum value for lead (16 μg/L) was detected at a well (PW-15) which is hydraulically isolated from the mine.

Because of the inconsistent nature of the detects, the very low values and the lack of observable pathways from the mine, it is not reasonable to carry these compounds forward in the screening. Therefore, they are eliminated from further consideration.

5.2.4.3 Background Data

It is not possible to perform any background screening on groundwater or surface water media at the site due to an absence of adequate site-specific or area background data. However, it is possible to conduct background screening for metals in soil, as described below.

The requirements under MTCA for determining natural background concentrations for chemicals in soil are provided in WAC 173-340-708 (11). Two types of background may be determined: an "area" and "natural". The derivation of natural background requires the collection of at least 10 samples, while derivation of area background requires at least 20 samples. Since fewer than this number of samples were collected as part of this RI which could be considered representative of background, a site-specific assessment of background for the Landsburg Mine site soils was not performed.

In lieu of site-specific determinations, however, information provided in a recently published Ecology report can be used. *Natural Background Soil Metals Concentrations in Washington State* (WDOE 1994) defines a range of values that represent the natural concentrations of metals in surficial soils throughout Washington. State-wide and regional 90th percentile values are presented. There are no restrictions on the use of the state-wide values. These can be used for comparison against data collected from any site in the State. The regional values are to be compared against data from those regions only.

The state-wide 90th percentile values for beryllium, arsenic, chromium and lead are shown in Table 5-13. When comparing site data vs background, the 95% upper confidence limit (UCL) of a given data set is compared against the 90th percentile of the background data set, per WDOE (1992). As seen in the table, the maximum detect and the 95% UCL for beryllium (for trench rim soils and test pit soils) are less than the 90th percentile value. Beryllium can therefore be eliminated for soil.

With respect to arsenic, the maximum detected values at each of the areas sampled and the calculated UCL values exceed the reported arsenic background value of 6.99 mg/kg. UCL values were calculated of 8.47 mg/kg, 15.28 mg/kg and 11.87 mg/kg for the trench rim soils, portal soils, and test pit soils, respectively. Maximum concentrations for these areas are only 16 mg/kg, 26 mg/kg, and 11.4 mg/kg, respectively. The maximum level in the trench soils is 19 mg/kg. Despite the fact that the maximum levels and the UCLs for these areas exceed the reported background concentration, however, these levels of arsenic do not suggest arsenic contamination in the soil, but rather a site-specific arsenic background which is elevated over the reported background value for the state. As seen in Tables 5-6, 5-7, 5-8 and 5-9, the arsenic levels observed throughout the various sampling locations are quite uniform, ranging from a minimum of 4 mg/kg to only 26 mg/kg. If arsenic contamination was indeed present, the data would be less uniform and likely contain isolated instances of much higher arsenic levels. The fact that these "spikes" do not exist suggests that the levels represent the area background and not contamination. In addition, the sample collected near the Frasier seam portal (sample FNS-

1, Table 5-7), away from potential contamination associated with waste disposal, exhibits one of the highest arsenic levels measured at the site (18.4 mg/kg). All of the measured arsenic levels at the site are within the range (0.5 to 28.6 mg/kg) of the reported state-wide background samples. Therefore, for these reasons the arsenic measured in the soil is not considered to represent contamination, but rather, the area background and arsenic is eliminated from further consideration.

The maximum detected values for lead (3,200 mg/kg) and chromium (912 mg/kg) are significantly elevated over their respective background values of 17.09 mg/kg and 41.83 mg/kg. These two compounds cannot therefore be eliminated. It is not possible to calculate a UCL value for the lead and chromium since only a single sample was collected at each sampling area. However, there was only a single exceedance of the lead and chromium screening values, and it was for one sample (sample location LS-8) collected within the trench (see Figure 3-4).

5.2.4.4 Lists of COPC

Therefore, on the basis of the additional screening considerations presented above a number of compounds listed in Tables 5-10, 5-11 and 5-12 are eliminated. For groundwater, thallium is eliminated from the monitoring well screening group, and thallium, lead, and bis(2-ethylhexyl)phthalate) are eliminated from the private well screening group. For soils, arsenic and beryllium are eliminated from all soils. For surface water, no compounds were eliminated. The list of COPC therefore consists of the following:

GROUNDWATER

Monitoring Wells

- aluminum
- iron
- manganese
- total dissolved solids

Private Wells

- aluminum
- arsenic
- iron
- manganese
- pH

SURFACE WATER

- arsenic

SOIL

- chromium (trench only)
- lead (trench only)
- bis(2-ethylhexyl)phthalate (trench only)
- PCBs (trench only)
- methylene chloride (trench only)
- TCE (trench only)
- TPH (trench only)

5.3 Extent Of Contaminants of Potential Concern (COPC)

The purpose of this section is to describe the distribution throughout the site and Study Area of the COPCs. A primary focus will be on assessing whether any of the observed chemicals in groundwater or surface water are related to the prior waste disposal activities conducted at the site. In addition, the results of the air monitoring survey, which were not screened vs. ARARs as with the other media, are presented. Air monitoring data were not screened against ARARs because the air data were in terms of total organics, and regulatory criteria are generally chemical-specific.

5.3.1 Air

Air monitoring conducted in this RI consisted of three surveys through the mine trench and health and safety monitoring conducted during drilling activities. The performance of the surveys through the mine trench is described in Section 2.1. Figure 2-1 depicts the locations of the surveys. Results of the three surveys are summarized in Tables 5-14, -15 and -16.

As seen in the table, the levels of volatile organics measured in the trench were generally non-detectable or indistinguishable from background. Several readings taken at various locations within the trench registered up to 1 ppm on the OVA; however, these readings are more indicative of instrument drift or background than the actual detection of any organic vapors.

The only location where detectable levels were observed consists of the "sludge pond" in the trench to the north of the LMW-1 access road. At this location, readings ranged up to 3.1 ppm. This pond is known to contain organic chemicals on the basis of the sampling performed as part of the ERA (Landsburg PLP Steering Committee 1991). The extent of these emissions is quite limited, however, as the measurements fell to non-detectable values within a short distance (approximately 20 ft) on either side of the pond.

Air monitoring data conducted during monitoring well drilling were recorded on Air Monitoring Data Sheets and are maintained in the project file. This monitoring was conducted for health and safety purposes and consisted of periodic readings around the drill rig (breathing zone, over borehole, and at cyclone discharge) using a Microtip photo-ionization detector (PID). Readings were taken at approximately 15 to 60 minute intervals. The results of this monitoring indicated generally non-detect values at all locations monitored. Very occasional spikes were noted in the 1 to 10 ppm range. These spikes were brief and may have been the result of water vapor (mist) used in the drilling as PID instruments are sensitive to the presence of moisture.

These results are consistent with the results of the soil gas survey performed at the site in 1990 (Applied Geotechnology 1990) which did not find detectable concentrations of VOCs in the trench.

5.3.2 Groundwater

This sub-section will describe the distribution of the various groundwater COPC identified earlier in Section 5.2.4. The primary aim is to assess whether the prior waste disposal practices at the mine have contributed to the observed groundwater concentrations or if the distribution of chemicals which is observed is the result of naturally occurring background conditions. Figures 5-1 and 5-2 depict the quarterly results of COPC at monitoring wells and private wells, respectively.

5.3.2.1 Distribution of COPC

Aluminum. Aluminum was detected sporadically throughout the Study Area with detects occurring in 12 of the 21 wells sampled. The compound was measured at concentrations up to 2560 μg/L, however, except for this one value, no detects exceeded 140 μg/L. The maximum detected values occurred at wells LMW-6 (140 μg/L), LMW-7 (100 μg/L), PW-5 (120 μg/L), PW-7 (90 μg/L) and PW-15 (2560 μg/L). Regulatory criteria for aluminum includes a SMCL of 50 μg/L and a Method B standard of 16,000 μg/L.

There is little spatial regularity to the observed distribution of aluminum in the Study Area. Occurrences of the compound, however, appear to be related to wells installed within coal or other materials of the Puget Group. Significant aluminum concentrations were not detected in any of the wells installed around the perimeter of the Study Area in the glacial outwash deposits (PW-3, -9, -10, -12, and -13, for instance). The higher values were noted at LMW-6 and LMW-7, and in PW-5 and PW-15. Each of these wells, with the possible exception of PW-15, is installed directly in coal (Figure 3-11). The well construction for PW-15 is not known; however, it is probable that the well is completed within the Puget Group given its location and depth (140 to 150 ft). Each of these wells is hydraulically isolated from the mine (Section 3.6.4.1).

Another important factor which may be contributing to the observed aluminum occurrences is related to sample turbidity. As discussed in Chapter 2, analysis for metals was performed on unfiltered samples (except for LMW-1). Immediately upon sample collection the samples were preserved by acidification. This procedure can result in elevated metals results if sediment is present in the sample. Sample acidification will tend to drive into solution any metals which are present in sediment particulates (either sorbed or as precipitate). Metals commonly sorb to negatively charged clay particles since they are positively charged.

Field turbidities measured at each well during the four sampling rounds are summarized in Table 5-17. These values are plotted vs the measured aluminum results in Figure 5-3. The data shown suggest a relationship between sample turbidity and the measured aluminum values. All of the higher aluminum levels (greater than about 50 μg/L) were also characterized by turbidity levels in excess of 1 NTUs. In contrast, aluminum levels were generally very low (less than 50 μg/L) in wells with turbidities less than 1 NTU. In the Rogers Seam wells, aluminum was detected only at LMW-3. This is also the well which displayed the highest turbidity levels of the five Rogers Seam wells (except for LMW-1, where samples were filtered due to excessive turbidity). This observed relationship between turbidity and aluminum concentration suggests that a major component of the observed aluminum concentrations consists of a sorbed phase which was driven into solution as a result of sample preservation and which would not normally be mobile in groundwater.

Arsenic. Arsenic was detected sporadically in the Study Area with detects occurring in ten of the 21 wells. The maximum detected value was 19 μg/L (PW-8). The MCL for arsenic is 50 μg/L and the Method B cleanup level is 5 μg/L (based on a State of Washington background value [WAC 173-340-720, Table 1, footnote b]). Only five detected values exceeded the 5 μg/L regulatory value. These values occurred at only three wells (PW-7, -8 and -15). Similar to aluminum, there is little spatial regularity to the distribution of the compound throughout the Study Area, except that it appears to occur in association with coal and/or other rocks of the Puget Group. There were no detects in the outwash wells around the perimeter of the Study Area. Also, as with aluminum, there were no regulatory exceedances in any of the monitoring wells installed at the mine. The maximum values of arsenic occurred at wells (PW-7, -8 and -15) which are hydraulically isolated from the mine (Section 3.6.4.1). There is no pathway for chemicals to migrate to these wells from the mine.

Iron. Iron is very prevalent throughout the Study Area with detects in all but 2 wells (PW-9 and -13). The maximum value observed is 5400 μg/L. The iron SMCL is 300 μg/L. There are no other regulatory criteria for iron. In contrast to arsenic and aluminum, iron is observed at levels in excess of the regulatory limit in the Rogers Seam monitoring wells. In fact, levels are relatively high in these wells as compared to elsewhere in the Study Area (1360 μg/L at LMW-4 and 1200 μg/L at LMW-2). Higher values occur at LMW-6 (2300 μg/L), PW-6 (2040 μg/L), PW-15 (5400 μg/L) and PW-7 (4000 μg/L). As with the other compounds, the wells installed in the outwash deposits are generally low in iron (less than 200 μg/L in general). There is, again, little discernible spatial pattern to the occurrence of the iron except that it is associated with the wells installed in Puget Group materials. The maximum values for iron occurred in wells (LMW-6, PW-6, PW-7 and PW-15) which are hydraulically isolated from the mine.

The observed relationship between iron and field turbidity is shown in Figure 5-3. While there may be some affect on the reported iron concentrations due to turbidity, the dependence is not as definite as with aluminum. A number of samples with very low turbidity (less than 1 NTU) exhibit quite high iron levels. Therefore, while turbidity may contribute somewhat to elevated iron levels, the occurrence of iron cannot be attributed to the presence of sediment as with the case of aluminum.

Manganese. The observed distribution of manganese is very similar to iron. The maximum value observed is 416 μg/L (PW-7) as compared to the SMCL of 50 μg/L (and the MTCA Method

B value of 80 μg/L). Exceedances of the screening limit occur in the Roger seam wells, as with iron (LMW-1 to -5) with a maximum value in these wells of 280 μg/L (LMW-4). Comparable or higher values occur in LMW-7 (299 μg/L) and PW-7 (416 μg/L). Other regulatory exceedances include PW-4 (54 μg/L), PW-15 (99 μg/L), and PW-6 (55 μg/L). The relationship between turbidity and observed manganese levels is also similar to that with iron, and is shown in Figure 5-3.

Total Dissolved Solids. Total dissolved solids range up to 780,000 μg/L (LMW-4). The only regulatory limit for TDS consists of a SMCL of 500,000 μg/L. The highest values of TDS are associated with the LMW wells with exceedances of the SMCL occurring at LMW-1, LMW-2, LMW-4 and LMW-5. Levels in private wells are lower and range from about 50,000 μg/L in the wells located around the perimeter of the Study Area to 333,000 μg/L at PW-14, 208,000 μg/L at PW-6, and 201,000 μg/L at PW-4. No private wells exceeded the SMCL for TDS.

In summary, while some compounds do exceed regulatory limits in the Mine vicinity and Study Area, there is little spatial regularity or pattern to the distribution of groundwater constituents which would suggest the Mine is the source of these compounds. The presence of aluminum in Study Area groundwater, which was not detected to any significant extent in the Rogers Seam wells, appears to be related to levels of turbidity in unfiltered samples. Arsenic was detected at very low levels in only a few isolated occurrences. The compound occurred in only one of the five Rogers Seam wells (LMW-1). Neither aluminum nor arsenic exceeded a regulatory standard in any of the mine wells. Iron and manganese, which occur very prevalently throughout the Study Area, occur at their highest levels in wells which are hydraulically isolated from the Mine (LMW-6, LMW-7, PW-5, PW-6, PW-7 and PW-15). There is no observable pathway for chemicals to migrate from the mine to these wells.

The indication, therefore, is that compounds identified as COPC in groundwater occur naturally at the site at levels which happen to be above regulatory limits. This is consistent with information reported elsewhere regarding the water quality of coal mine drainage and groundwater in contact with coal deposits. This is discussed below in Section 5.3.2.2.

5.3.2.2 Water Quality Typical of Coal-Mine Drainage

The USGS studied coal-mine drainage at approximately 100 abandoned coal mines in Western Washington to characterize the water quality of drainage from abandoned mines in the 11 coal-bearing areas of the state (Fuste et al. 1983). Table 5-18 presents a summary of the mean concentrations and ranges of values for selected water-quality parameters measured in the study. For comparative purposes, data collected from this RI, consisting of averages of the monitoring well and portal surface water data, are also shown in the table. The monitoring well and portal surface water data are used here (and not the private well data) since these represent the data most comparable to that reported for coal-mine drainages.

As seen in the table, the mean and maximum values measured at the Mine are generally consistent with the values reported in the USGS study. Exceptions include aluminum and manganese where the maximum values for the site are outside the range reported by Fuste et al. (1983). However, for both of these compounds, the mean values fall within the reported ranges. It must be noted that the data from the USGS study represent only the dissolved constituents while the Landsburg data represent "total" quantities, i.e. the dissolved portion plus any portion sorbed to sediment which may be present in the sample.

The comparison of the two data sets therefore indicates that the quality of groundwater at the Mine is typical of water-quality observed at other coal mines throughout the State of Washington.

Other available information indicates that coal-bearing materials are apparently common sources for iron and manganese in groundwater and surface water. Fuste and Mayer (1987) report on the quality of water in ten streams located in two coal-bearing areas in southwest Washington. The purpose of the study was to investigate the effects of strip mining for coal on surface water quality. In the study, consistently higher concentrations of iron, manganese, and zinc were found in the bottom sediments of streams located in the mined basins. Hem (1985) reported levels of iron in coal-mine drainage up to 15,000 μg/L and indicated that manganese and iron are commonly present in streams receiving coal-mine drainage. Organic materials (i.e., coal) are identified in Hem (1985) as a common source of iron in groundwater.

Fuste and Mayer (1987) suggest a dependence on Eh and dissolved O_2 concentration for dissolved iron and manganese levels in water. Increased O_2 causes iron and manganese minerals to be oxidized and to precipitate out of solution. Low dissolved O_2 and an associated reducing environment can promote mineral dissolution and relatively high dissolved iron and manganese concentrations. This dependence on Eh is also indicated in Hem (1985), where it is stated that iron and manganese are highly dependent on the levels of oxidation or reduction. Where relatively low Eh can be maintained, and iron and manganese minerals are present, considerable iron and manganese concentrations can be attained.

Since the presence of organic matter (in coal for instance) can deplete O_2 levels in groundwater and lead to a chemically reducing environment, it is considered likely that the coal-bearing materials at the site naturally promote conditions which support relatively high iron and manganese concentrations in groundwater.

Finally, widespread excessive iron and manganese has been reported for the Puget Sound region (Turney 1986) in a compilation of regional groundwater quality data. Iron exceeded the SMCL of 300 μg/L in 14% of all samples collected. Manganese exceeded the 50 μg/L SMCL in 40% of all samples. These exceedances were attributed to natural occurrences of the two compounds. In general, the two compounds were found to correlate quite strongly with one another: the manganese standard was exceeded in almost every well where the iron standard was exceeded. High iron and manganese were thought to be due to low oxygen content which leads to a chemically-reducing environment. This tends to keep the two compounds in solution leading to high-iron and manganese waters.

5.3.3 Surface Water

Arsenic exceeds the method B standard for surface water at portal #3 and portal #2 (Table 5-5 and 5-11). Water emanating at the portals represents groundwater discharge. The concentration of arsenic measured at the portals is consistent with levels observed in mine groundwater, i.e. arsenic in the low $\mu g/L$ range. Because seepage water at the portals consists of mine groundwater discharge, and mine groundwater has been shown to exhibit natural background levels and not to have been impacted by mine waste disposal activities, these surface water exceedances of arsenic also represent a natural background condition.

5.3.4 Soil

For soils outside the trench, no compounds were identified as a COPC for soil (Section 5.2.4.4). Within the trench, chromium, lead, PCBs, bis(2-ethylhexyl)phthalate, methylene chloride, TCE and TPH exceeded regulatory criteria. These exceedances were associated with soil sampling conducted as part of the SHA, and pond sludge sampling performed during the ERA. For the soils, the exceedances were confined to two samples (LS-8 and LDS-1). These samples are both associated with the northern portion of the trench (Figure 3-4) where prior disposal is thought to have occurred. The sludge pond exceedances were associated with a single sample taken to characterize contaminant levels in the sludge pond area.

5.4 Conclusions and Identification of COCs

On the basis of the information presented in this chapter the following conclusions can be drawn:

AIR

- Throughout nearly the entire trench, no volatile organic compounds were detected in air. Detectable levels of volatile organic compounds in air were restricted to one small area within the trench in the vicinity of the sludge pond. These levels are not expected to pose any significant health hazard.

GROUNDWATER

- Groundwater was sampled from 21 groundwater wells in the immediate vicinity of the Mine over four quarterly sampling rounds and analyzed for a wide variety of chemical constituents, including volatile and semi-volatile organics, metals, cyanide, PCBs and pesticides, and general chemical characteristics. The results indicate that no federal drinking water standards (Maximum Contaminant Levels) are being exceeded at the Mine site itself or amongst any of the private wells sampled in the Study Area. The Method B standard for arsenic (5 $\mu g/L$) was exceeded at three private wells (levels up to 19 $\mu g/L$) and the Method B standard for manganese (80 $\mu g/L$) was exceeded at 5 monitoring wells (levels up to 299 $\mu g/L$) and 3 private wells (levels up to 416 $\mu g/L$).

- Secondary Maximum Contaminant Levels, which are not health based standards but are intended to be protective of aesthetic water qualities only, are exceeded for aluminum, iron, manganese, total dissolved solids and pH at a number of wells located throughout the Study Area, including both private wells and monitoring wells. SMCLs were exceeded at every monitoring well. Of the 14 private wells sampled, seven of the wells had at least one exceedance of a SMCL over the four rounds of sampling. Iron is the most prevalent compound exceeding an SMCL.

- Although a few organic compounds were detected in wells sampled, all of the detects were very low and inconsistent (not repeated in more than a single round). In addition, none of the organic compounds exceeded any established regulatory standards, except for one instance of bis(2-ethylhexyl)phthalate, a common laboratory contaminant, which occurred slightly above the Method B standard in round 2 in a private well, but was not detected in either of the other two rounds. There is therefore no indication of organics contamination in groundwater at the mine.

- The distribution of COPC around the Study Area indicates that the Mine is not the source of these compounds. Maximum levels occur, in many instances, in wells which are hydraulically isolated from the Mine. Also, the levels observed at the Mine are consistent with reports in the literature which indicate that coal is a natural and well-known source for these chemical constituents. The levels observed fall within the range of values typical for coal-mine drainages in the State. Therefore, while SMCLs are exceeded for several compounds and a Method B cleanup level is exceeded for two compounds, the occurrence of these compounds is not related to prior waste disposal activities at the Mine, but rather to natural background levels typical of coal-bearing sediments. There are therefore no COCs for groundwater at the Landsburg Mine site.

SURFACE WATER

- Arsenic exceeded a Method B standard for surface water at portal #3 and portal #2. The levels observed are consistent with groundwater levels measured at the mine site. As discussed above, the occurrence of the arsenic in groundwater (and therefore surface water) is a result of natural background conditions. There are therefore no COCs for surface water at the site.

SOIL

- There are no identified COC for soils outside the trench. All potential regulatory exceedances for soils outside the trench can be attributed to background.

- Within the trench, chromium, lead, PCBs, bis-(2-ethylhexyl)phthalate, methylene chloride, TCE and TPH exceed background and Method B standards in an area confined to the northern portion of the trench where waste disposal is thought to have occurred in the past. Soil contamination was not noted outside this area. On the basis of limited sampling conducted to date, however, and in conjunction with historical information and geophysics, potential contamination is believed to be restricted to the northern portion of the trench.

Therefore, apart from soils within the trench located in the area of known prior waste disposal activities, soil, groundwater and surface water media in the Study Area do not exhibit concentrations of chemical constituents above naturally occurring background levels. The COCs for the Landsburg Mine site consist of the following:

Media	Contaminants of Concern
Groundwater	None
Surface Water	None
Air	None
Soils	
Outside Trench	None
Inside Trench	Chromium Lead PCBs TPH bis(2-ethylhexyl)phthalate methylene chloride TCE

TABLE 5-1

DATA VALIDATION SUMMARY

Sample Delivery Group	Data Validation Report Date	Samples Validated	Sampling Round	Lab	DQOs^4				Major Deficiencies	Analyses	Field and Trip Blank Samples^5
					Precision	Accuracy	Detection Limits	Completeness			
1	8-Jun-94	Private Wells (All)	1	ARI	√	√	√	100%	None	General Chem,TAL metals, pesticides/PCBs,SVOA	PW2-51094FB
2	7-Jun-94	Private Wells (All)	1	Inland	√	√	√	100%	None	525.1, 524.2	PW2-5594TB, PW2-51094FB
3	19-May-94	Portal Soils	1	ARI	√	√	√	99.60%	See Note 1	TCL VOAs and SVOAs, pesticides/PCBs, TAL metals, anions, cyanide	None
4	18-May-94	Monitoring Wells and Portal (Surface) Water	1	ARI	√	√	√	100%	NONE	TCL SVOAs, pesticides/PCBs,TAL metals,general chemistry	LMW1-GW-41494FB
5	25-May-94	Monitoring Wells and Surface Water	1	Inland	√	√	√	100%	NONE	515.1,504,525.1,524.2, 531	LMW1-GW-41494FB
6	17-May-94	Backhoe Trench Soils	1	ARI	√	√	√	100%	NONE	anions, cyanide,TAL metals,TCL VOAs and SVOAs, pesticides/PCBs	Trip Blank
7	18-May-94	Trench Rim Soils	1	ARI	√	√	√	99.00%	See Note 1	anions, cyanide,TAL metals,TCL VOAs and SVOAs, pesticides/PCBs	None
8	18-May-94	Soil Drum Composites	NA	ARI	√	√	√	100%	None	TCL VOAs and SVOAs, pesticides/PCBs, TAL metals	None
9^3	6-Oct-94	Private Wells (All)	2	Inland	See Note 2	√	√	100%	None	VOA (524.2)	PW6-82394FB PW7-82394TB PW10-82394TB PW9-82394TB PW6-82394TB
10^3	6-Oct-94	PW-2, PW-10	2	ARI	See Note 2	√	√	100%	None	General chem, cyanide, TAL metals, TCL VOAs, pesticides/PCBs	None
11^3	6-Oct-94	PW-4,-5,-6 and -7	2	ARI	See Note 2	√	√	100%	None	General chem, cyanide, TAL metals, TCL VOAs, pesticides/PCBs	PW6-82394FB
12^3	6-Oct-94	PW-1,-12,-14, and -15	2	ARI	See Note 2	√	√	100%	None	General chem, cyanide, TAL metals, TCL VOAs, pesticides/PCBs	None
13	7-Oct-94	PW-3,-8,-9, and -13	2	ARI		√	√	100%	None	General chem, cyanide, TAL metals, TCL VOAs, pesticides/PCBs	None

TABLE 5-1

DATA VALIDATION SUMMARY

Sample Delivery Group	Data Validation Report Date	Samples Validated	Sampling Round	Lab	DQOs[4]				Major Deficiencies	Analyses	Field and Trip Blank Samples[5]
					Precision	Accuracy	Detection Limits	Completeness			
14[3]	11-Oct-94	Monitoring Wells and Portal (Surface) Water	2	ARI and Inland		√	√	100%	None	general chem, cyanide, 524.2, 525.1, 504, TAL metals	LMW5-GW-80894FB LMW5-GW-80894TB LMW3-GW-80894TB LMW2-GW-80894TB
15	24-Jan-95	LMW1, PRT2,LMW7,LMW4,LMW8,LMW6, LMW2, LMW3, PRT3, LMW5,PW1, PW7, PW5, PW1, PW3, PW15, PW2, PW4, PW10, PW11, PW6, PW8, PW14, PW13, PW9, PW12	3	Inland	√	√	√	100%	None	VOA, SVOCs, pesticide/PCB, herbicides	LMW5-GW-120794FB PW15-121294FB LMSW5 GW-120794TB
16	25-Jan-95	PW3, PW15	3	ARI	See Note 6	√	√	100%	None	TCL SVOCs, metals, general chemistry	PW15-121294FB
17	19-Jan-95	LMW2, LMW4, LMW6	3	ARI	√	See note 7	√	100%	None	SVOCs, metals, general chemistry	None
18	19-Jan-95	LMW1, LMW7, PRT2	3	ARI	See note 8	√	√	100%	None	SVOCs, metals, general chemistry	None
19	19-Jan-95	PW2, PW4, PW10,PW11	3	ARI	See note 9	√	√	100%	None	TCL SVOC, metals, general, chemistry	None
20	19-Jan-95	PW9, PW12, PW13	3	ARI	See note 10	√	√	100%	None	SVOCs, metals and general chemistry	None
21	19-Jan-95	PW6, PW8, PW14	3	ARI	See note 11	√	√	100%	None	SVOCs, metals and general chemistry	None
22	19-Jan-95	LMW3, PRT3, LMW5	3	ARI	See note 12	√	√	100%	None	SVOCs, metals and general chemistry	LMW5-GW-120794FB
23	19-Jan-95	PW5	3	ARI	√	√	√	100%	None	SVOCs, metals and general chemistry	None
24	19-Jan-95	PW1, PW7	3	ARI	√	√	√	100%	None	SVOCs, metals and general chemistry	None
25	11-May-95	LMW3, PRT3, LMW5, LMW1	4	ARI	√	√	√	100%	None	General chemistry, cyanide, TAL metals, SVOAs, pesticides/PCBs	LMW3-GW-31595FB
26	12-May-95	LMW2, LMW4, PRT2, LMW6, LMW1, LMW5, PRT3, LMW3, LMW7	4	Inland	√	√	√	100%	None	VOA (524.2)	LMW4-GW-32195TB
27	11-May-95	LMW6, LMW7, PRT2	4	ARI	√	√	√	100%	None	General chemistry, cyanide, TAL metals, SVOAs, pesticides/PCBs	None
28	11-May-95	LMW4, LMW8, LMW2	4	ARI	√	√	√	100%	None	General chemistry, cyanide, TAL metals, SVOAs, pesticides/PCBs	None

TABLE 5-1

DATA VALIDATION SUMMARY

Sample Delivery Group	Data Validation Report Date	Samples Validated	Sampling Round	Lab	DQOs[4]				Major Deficiencies	Analyses	Field and Trip Blank Samples[5]
					Precision	Accuracy	Detection Limits	Completeness			
29	11-May-95	PW10, PW12	4	ARI	√	√	√	100%	None	General chemistry, cyanide, TAL metals, SVOAs, pesticides/PCBs	PW10-32995FB
30	11-May-95	PW2, PW13, PW3, PW4, PW10, PW12, PW9	4	Inland	√	√	√	100%	None	VOA (524.2)	PW10-32995FB, PW12-32995TB
31	11-May-95	PW13, PW3, PW4	4	ARI	√	√	√	100%	None	General chemistry, cyanide, TAL metals, SVOAs, pesticides/PCBs	None
32	11-May-95	PW2	4	ARI	√	√	√	100%	None	General chemistry, cyanide, TAL metals, SVOAs, pesticides/PCBs	None
33	11-May-95	PW9	4	ARI	√	√	√	100%	None	General chemistry, cyanide, TAL metals, SVOAs, pesticides/PCBs	None

1 - Spike recovery for fluoride was unacceptable resulting in qualification of selected sample results as unusable.
2 - Laboratory did not analyze a matrix spike duplicate, therefore it was not possible to determine if the precision goals specified in the work plan were met.
3 - A limited review of sample results was conducted. No raw data were submitted with sample results data package. Quality of data has not been determined.
4 - DQOs are defined in the Work Plan (Golder, 1992a).
5 - No adjustments were made during data validation on the basis of detects in these samples.
6 - Silicon was detected in the method blank. The RPD for lead was unacceptable in the laboratory blank. The TDS analysis was performed out of the holding time. These deficiencies resulted in the qualification of data as estimated.
7 - Spike recovery for silicon was unacceptable resulting in qualification of selected sample results as estimated.
8 - Aluminum, lead and silicon were detected in the lab blank. The laboratory RPD for Al was unacceptable . The TDS analysis was performed out of the holding time. These deficiencies resulted in the qualification of data as estimated.
9 - The laboratory duplicate result for lead is unacceptable. The qualification of the data is estimated.
10 - Silicon was detected in the method blank. The laboratory duplicate result for lead was unacceptable. These deficiencies resulted in the qualification of data as estimated.
11 - The laboratory duplicate result for lead is unacceptable. Turbidity was detected in the laboratory method blank. The qualification of the data is estimated.
12- Silicon was detected in the method blank. The RPD for sodium was unacceptable in the laboratory duplicate. These deficiencies resulted in the qualification of data as estimated.

FB - Field Blank
TP - Trip Blank
ARI - Analytical Resources, Inc.
Inland - Inland Environmental Laboratories
DQOs - Data Quality Objectives
TAL - Target Analyte List
TCL - Target Compound List
VOAs - Volatile Organic Compounds
SVOAs - Semi-Volatile Organic Compounds

<u>Anions</u>
chloride
fluoride
nitrate and nitrate
sulfate

<u>General Chemistry</u>
pH
conductivity
Total Dissolved Solids
Hardness
Turbidity

Chloride
Fluoride
Nitrate and Nitrite
Sulfate
Carbonate and Bicarbonate

TABLE 5-2

COMPOUNDS DETECTED IN FIELD AND TRIP BLANKS

Sample Delivery Group[a]	Sample ID	Compound	Result	Qualifier	units
1	PW2-51094FB	calcium	10		μg/L
		thallium	1		μg/L
		zinc	7		μg/L
2	PW2-51094FB	toluene	0.9		μg/L
4	LMW1-GW-41494FB	calcium	30		μg/L
		iron	31		μg/L
		manganese	2		μg/L
		zinc	5		μg/L
		chloride	1100		μg/L
		bicarbonate	1200		μg/L - $CaCO_3$
9	PW10-82294TB	chloroform	3.4	B	μg/L
		toluene	0.4	JB	μg/L
	PW6-82394FB	chloroform	6.3	B	μg/L
11	PW6-82394FB	calcium	130		μg/L
		magnesium	30		μg/L
		silicon	430		μg/L
		sodium	190		μg/L
		zinc	13		μg/L
		nitrate	37		μg/L - N
14	LMW3-GW-80894TB	methylene chloride	1.3	B	μg/L
	LMW5-GW-80894FB	bromodichloromethane	0.9		μg/L
		chloroform	6.2		μg/L
		methylene chloride	0.8	B	μg/L
		calcium	100		μg/L
		magnesium	30		μg/L
		sodium	120		μg/L
		thallium	1		μg/L
		nitrate	26		μg/L - N
		silicon	380		μg/L
		zinc	5		μg/L
15	LMW5-GW-120794FB	chloroform	1.2		μg/L
		methylene chloride	0.5	B	μg/L
	LMW5-GW-120794TB	methylene chloride	3.8		μg/L
	PW15-121294FB	chloroform	0.7		μg/L
		choloromethane	3.9		μg/L
16	PW-15-121294FB	calcium	140		μg/L
		sodium	600		μg/L
		zinc	5		μg/L
		nitrate	38		μg-N/L
22	LMW5-GW-120794FB	calcium	140		μg/L
		lead	2		μg/L
		magnesium	20		μg/L
		sodium	270	J	μg/L
		zinc	7		μg/L
		bicarbonate	1500		μg/L $CaCO_3$
		nitrate	29		μg-N/L

TABLE 5-2

COMPOUNDS DETECTED IN FIELD AND TRIP BLANKS

Sample Delivery Group[a]	Sample ID	Compound	Result	Qualifier	units
25	LMW3-GW-31595FB	bicarbonate	23		mg/L $CaCo_3$
		hardness	27		mg/L $CaCo_3$
		TDS	41		mg/L
		fluoride	0.98		mg/L
		chloride	3.6		mg/L
		nitrate	0.15		mg/L-N
		sulfate	2.9		mg/L
		barium	0.003		mg/L
		calcium	8.98		mg/L
		iron	0.03		mg/L
		magnesium	1.08		mg/L
		silicon	4.20	J	mg/L
		sodium	1.96		mg/L
26	LMW4-GW-32195TB	chloroform	5.7		µg/L
29	PW10-32995FB	bicarbonate	22		mg/L $CaCo_3$
		hardness	27		mg/L $CaCo_3$
		fluoride	0.97		mg/L
		chloride	3.3		mg/L
		nitrate	0.18		mg/L-N
		barium	0.004		mg/L
		calcium	8.9		mg/L
		iron	0.03		mg/L
		magnesium	1.08		mg/L
		manganese	0.002		mg/L
		potassium	0.4		mg/L
		silicon	4.34		mg/L
		sodium	2.01		mg/L
		aluminum	0.02		mg/L
		zinc	0.006		mg/L
30	PW10-32995FB	bromodichloromethane	1.5		µg/L
		chloroform	22.6		µg/L
	PW12-32995TB	bromodichloromethane	1.4		µg/L
		chloroform	18.9		µg/L

[a] Sample Delivery Groups defined in Table 5-1.

B - The constituent was detected in the associated lab blank. This qualifier is applied by the lab. The data should be considered useable.

J - The concentration is less than the contract required quantitation limit but greater than the instrument detection limit. The data should be consiered useable.

TABLE 5-3

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG MONITORING WELLS

	Minimum Screening Value[a]	LMW-1				LMW-2			
Chemical Name	(µg/L)	1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(µg/L)				(µg/L)			
ALUMINUM	50	ND	ND	ND	30	ND	ND	ND	ND
ANTIMONY	6	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	5	4	2	3	2	ND	ND	ND	ND
BARIUM	1120	57	46	48	52	246	230	229	225
BERYLLIUM	0.0203	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	5	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	-	90600	88000	78800	92400	142000	140000	137000	134000
CHROMIUM	80	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	960	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	592	ND	2	ND	ND	ND	ND	ND	ND
IRON	300	316	310	320	380	979	1200	930	820
LEAD	5	ND	ND	ND	ND	ND	ND	ND	ND
MAGNESIUM	-	47900	47000	44200	48600	87500	86000	84300	83700
MANGANESE	50	32	23	23	29	276	270	249	249
MERCURY	2	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	100	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	-	3200	3500	3000	2900	4300	4400	4400	4000
SELENIUM	50	ND	1	ND	ND	2	1	1	2
SILICON	-	13600	14200	13000	13200 J	10100	9790	9670J	1100 J
SILVER	80	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	-	21900	19000	21400	20100	30700	29000	29800	29900
THALLIUM	0.5	ND	1	ND	ND	2	1	ND	ND
VANADIUM	112	ND	ND	3	ND	2	ND	ND	ND
ZINC	4800	ND	ND	ND	ND	4	ND	ND	ND
GENERAL CHEMISTRY									
pH	6.5-8.5	7.23	7.6 J	6.9	7.1	7.09	6.92 J	6.8	6.8
Carbonate, µg/L $CaCO_3$	-	ND	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	-	356000	332000	330000	350000	718000	740000	720000	680000
Hardness, µg/L CaCO3	-				430000	715000		689000	680000
Conductivity, µmhos/cm	-	808	865	800	810	1250	1280	1300	1200
TDS, µg/L	500000	504000	477000	480000J	540000	732000	713000	760000	760000
Turbidity, NTU	-	5.6	33	30	1.8	9.1	13.8	9.1	4.9
Fluoride	960	110	120	100	120	ND	ND	ND	ND
Chloride	250000	2200	1500	1700	1400	5700	6000	4200	6100
Nitrate (as N)	5780	ND	87	11	16	ND	ND	ND	ND
Nitrite (as N)	487	ND	47	ND	ND	ND	ND	ND	ND
Sulfate	250000	122000	138000	100000	130000	44600	38900	30000	44000
ORGANICS									
1,2-Dibromo-3-chloropropane	0.0312	ND	ND	ND	ND	0.025 J	ND	ND	ND

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Value represents minimum potential ARAR in Table 4-3.

TABLE 5-3

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG MONITORING WELLS

Chemical Name	Minimum Screening Value[a] (µg/L)	LMW-3				LMW-4			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(µg/L)				(µg/L)			
ALUMINUM	50	40	20	ND	ND	ND	ND	ND	ND
ANTIMONY	6	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	5	1	ND	ND	ND	ND	ND	ND	ND
BARIUM	1120	99	92	89	89	226	210	212	210
BERYLLIUM	0.0203	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	5	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	-	45800	44000	42700	44100	138000	140000	135000	132000
CHROMIUM	80	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	960	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	592	ND	ND	ND	ND	ND	ND	ND	ND
IRON	300	60	80	80	90	954	1300	1360	1230
LEAD	5	1	ND	ND	ND	ND	ND	ND	1
MAGNESIUM	-	18600	18000	17900	17800	84300	85000	83100	81800
MANGANESE	50	99	110	107	97	289	280	249	236
MERCURY	2	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	100	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	-	2300	2400	2300	2100	4300	4500	4200	4200
SELENIUM	50	ND	ND	2	ND	2	1	1	ND
SILICON	-	11100	10800	10200	9200 J	9940	9990	9560J	1150 J
SILVER	80	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	-	13200	13000	12900J	12600	33800	33000	34400	34900
THALLIUM	0.5	1	ND	ND	ND	ND	ND	ND	1
VANADIUM	112	ND	ND	ND	ND	ND	ND	ND	ND
ZINC	4800	ND	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY									
pH	6.5-8.5	7.62	7.56 J	7.3	6.7	6.96	6.9 J	6.8	6.7
Carbonate, µg/L $CaCO_3$	-	ND	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	-	195000	191000	200000	190000	730000	732000	710000	660000
Hardness, µg/L CaCO3	-	191000		180000	180000	692000		679000	670000
Conductivity, µmhos/cm	-	384	392	430	360	1240	1300	1300	1200
TDS, µg/L	500000	213000	202000	230000	220000	769000	735000	740000	780000
Turbidity, NTU	-	1.74	0.72	0.42	0.49	7.1	19.8	19	19
Fluoride	960	ND	ND	ND	ND	ND	ND	ND	ND
Chloride	250000	2500	2000	2100	2000	6400	5700	4400	6300
Nitrate (as N)	5780	16	ND	ND	ND	ND	33	ND	ND
Nitrite (as N)	487	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	250000	21000	21400	19000	20000	52000	64500	37000	51000
ORGANICS									
1,2-Dibromo-3-chloropropane	0.0312	ND	ND	ND	ND	ND	ND	ND	ND

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a]Value represents minimum potential ARAR in Table 4-3.

TABLE 5-3

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG MONITORING WELLS

	Minimum Screening Value[a]	LMW-5				LMW-6			
Chemical Name	(µg/L)	1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(µg/L)				(µg/L)			
ALUMINUM	50	ND	ND	ND	ND	**100**	**140**	**140**	ND
ANTIMONY	6	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	5	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM	1120	238	220	225	259	87	88	91	85
BERYLLIUM	0.0203	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	5	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	-	94600	91000	89100	99600	28800	29000	29900	27700
CHROMIUM	80	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	960	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	592	ND	ND	ND	ND	ND	ND	ND	ND
IRON	300	**304**	210	**580**	190	**2150**	**2200**	**2230**	**2130**
LEAD	5	ND	ND	ND	1	ND	ND	ND	2
MAGNESIUM	-	55200	55000	53600	57500	14600	15000	15600	14300
MANGANESE	50	**265**	**260**	**240**	**275**	37	33	36	30
MERCURY	2	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	100	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	-	3000	2600	2900	2900	1000	1200	900	500
SELENIUM	50	ND	ND	1	ND	ND	ND	1	ND
SILICON	-	9770	9720	9340	8830 J	11000	11600	10900J	ND
SILVER	80	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	-	25100	25000	24600J	22700	7640	7900	7870	7680
THALLIUM	0.5	ND	ND	ND	ND	ND	ND	ND	ND
VANADIUM	112	2	ND	ND	ND	3	ND	ND	ND
ZINC	4800	ND	ND	ND	ND	7	ND	4	ND
GENERAL CHEMISTRY									
pH	6.5-8.5	6.95	6.91 J	6.7	6.8	6.98	7.1 J	**6.4**	6.5
Carbonate, µg/L $CaCO_3$	-	ND	ND	53000	ND	ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	-	520000	504000	430000	490000	126000	121000	130000	130000
Hardness, µg/L CaCO3	-	464000		440000	480000			139000	130000
Conductivity, µmhos/cm	-	866	830	870	870	266	294	310	280
TDS, µg/L	500000	497000	483000	480000	**550000**	157000	141000	170000	120000
Turbidity, NTU	-	0.57	3.4	3.7	2.7	2.7	3.3	4.2	0.1 J
Fluoride	960	ND	ND	ND	ND	110	100	ND	110
Chloride	250000	2500	2400	2000	2300	2100	1400	1200	1600
Nitrate (as N)	5780	ND	35	ND	ND	ND	ND	ND	20
Nitrite (as N)	487	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	250000	11200	10300	9800	41000	23500	29600	31000	25000
ORGANICS									
1,2-Dibromo-3-chloropropane	0.0312	0.025 J	ND	ND	ND	ND	ND	ND	ND

ND - Analyte was Not Detected.
Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.
[a]Value represents minimum potential ARAR in Table 4-3.

TABLE 5-3

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG MONITORING WELLS

	Minimum Screening Value[a]	LMW-7			
Chemical Name	(µg/L)	1st Round	2nd Round	3rd Round	4th Round
METALS		(µg/L)			
ALUMINUM	50	100	ND	ND	ND
ANTIMONY	6	ND	ND	ND	ND
ARSENIC	5	2	1	2	1
BARIUM	1120	557	570	532	559
BERYLLIUM	0.0203	ND	ND	ND	ND
CADMIUM	5	ND	ND	ND	ND
CALCIUM	-	63900	62000	68100	66400
CHROMIUM	80	ND	ND	ND	ND
COBALT	960	ND	ND	ND	ND
COPPER	592	ND	ND	ND	ND
IRON	300	910	820	1140	1070
LEAD	5	ND	ND	ND	ND
MAGNESIUM	-	30000	30000	34100	31900
MANGANESE	50	157	130	299	195
MERCURY	2	ND	ND	ND	ND
NICKEL	100	ND	ND	ND	ND
POTASSIUM	-	3600	4000	3600	3000
SELENIUM	50	ND	2	2	ND
SILICON	-	11100	11000	9550	ND
SILVER	80	ND	ND	ND	ND
SODIUM	-	65600	72000	59800	61000
THALLIUM	0.5	ND	ND	ND	ND
VANADIUM	112	ND	ND	ND	ND
ZINC	4800	5	ND	ND	ND
GENERAL CHEMISTRY					
pH	6.5-8.5	7.18	7.19 J	6.8	6.9
Carbonate, µg/L $CaCO_3$	-	ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	-	415000	446000	200000	440000
Hardness, µg/L CaCO3	-				300000
Conductivity, µmhos/cm	-	709	797	810	779
TDS, µg/L	500000	421000	439000	460000J	410000
Turbidity, NTU	-	5.3	8.4	7.9	9.1 J
Fluoride	960	170	170	130	150
Chloride	250000	2800	2300	2300	2300
Nitrate (as N)	5780	ND	11	14	ND
Nitrite (as N)	487	ND	ND	ND	ND
Sulfate	250000	7500	3500	3200	8600
ORGANICS					
1,2-Dibromo-3-chloropropane	0.0312	ND	ND	ND	ND

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a]Value represents minimum potential ARAR in Table 4-3.

TABLE 5-4

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG PRIVATE WELLS

Chemical Name	Minimum Screening Value[a] (µg/L)	PW-1				PW-2			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(ug/L)				(ug/L)			
ALUMINUM	50	ND	ND	ND		ND	ND	ND	ND
ANTIMONY	6	ND	ND	ND		ND	ND	ND	ND
ARSENIC	5	ND	ND	ND		1	ND	1	2
BARIUM	1120	ND	ND	ND		ND	1	2	ND
BERYLLIUM	0.0203	ND	ND	ND		ND	ND	ND	ND
CADMIUM	5	ND	2	ND		ND	ND	ND	ND
CALCIUM	-	15000	15000	14300		21400	24000	21600	19900
CHROMIUM	80	ND	ND	ND		ND	ND	ND	ND
COBALT	960	ND	ND	ND		ND	ND	ND	ND
COPPER	592	ND	ND	ND		3	9	3	ND
IRON	300	7	ND	30		24	240	20	ND
LEAD	5	ND	ND	3J		ND	7	ND	ND
MAGNESIUM	-	4680	4800	4600		5750	6300	5840	5610
MANGANESE	50	ND	ND	1		2	6	2	1
MERCURY	2	ND	ND	ND		ND	ND	ND	ND
NICKEL	100	ND	ND	ND		ND	ND	ND	ND
POTASSIUM	-	ND	ND	600		ND	600	1000	900
SELENIUM	50	ND	ND	ND		2	ND	ND	ND
SILICON[b]	-		11500	10800			11800	10500	9970
SILVER	80	ND	ND	ND		ND	ND	ND	ND
SODIUM	-	5240	5340	5140		5470	5500	5890	5470
THALLIUM	0.5	ND	2	ND		1	ND	ND	ND
VANADIUM	112	ND	ND	2		ND	ND	ND	2
ZINC	4800	42	ND	62		35	80	33	26
GENERAL CHEMISTRY									
pH	6.5-8.5	7.4	7.77 J	7.1		7.39	7.39 J	7	6.8
Carbonate, µg/L $CaCO_3$	-	ND	ND	ND		ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	-	56600	57500	56000		77500	80700	80000	77000
Hardness, µg/L CaCO3	-	56700		54600					
Conductivity, µmhos/cm	-	132	134	130		172	177	180	170
TDS, µg/L	500000	87000	59000	61000		106000	95000	110000	97000
Turbidity, NTU	-	0.05	ND	ND		0.08	ND	0.18	0.1
Fluoride	960	ND	ND	ND		ND	ND	ND	ND
Chloride	250000	2100	2200	2000		2500	2100	1800	1700
Nitrate (as N)	5780	713	726	720		1280	1910	930	830
Nitrite (as N)	487	ND	ND	ND		ND	ND	ND	ND
Sulfate	250000	6200	6800	6200		9000	7400	8500	6600
ORGANICS									
BIS(2-ETHYLHEXYL)PHTHALATE	6	ND	ND	ND		ND	6.7	ND	ND
DIETHYLPHTHALATE	12800	ND	ND	ND		ND	ND	ND	ND
1,3-DICHLOROBENZENE	720	ND	ND	ND		ND	ND	ND	ND
Analysis 524.2									
BENZENE	1.51	ND	ND	ND		ND	ND	ND	ND
1,3-DICHLOROBENZENE	720	ND	ND	ND		ND	ND	ND	ND
1,3,5-TRIMETHYLBENZENE	-	ND	ND	ND		ND	ND	ND	ND
Analysis 525									
Endrin	2	ND	ND	ND		ND	ND	ND	ND

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Value represents minimum potential ARAR in Table 4-3.

[b] The analytical laboratory did not analyze for Silicon during the 1st quarterly sampling period.

TABLE 5-4

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG PRIVATE WELLS

Chemical Name	Minimum Screening Value[a] (µg/L)	PW-3				PW-4			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(ug/L)				(ug/L)			
ALUMINUM	50	ND	30	ND	ND	ND	ND	ND	ND
ANTIMONY	6	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	5	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM	1120	ND	ND	2	ND	1	1	2	ND
BERYLLIUM	0.0203	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	5	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	-	7200	8200	8040	6000	41000	44000	42100	42300
CHROMIUM	80	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	960	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	592	ND	ND	ND	ND	ND	ND	ND	ND
IRON	300	12	ND	ND	ND	64	67	80	60
LEAD	5	ND	ND	2	ND	ND	ND	ND	ND
MAGNESIUM	-	1210	1400	1370	1030	13300	14000	13400	13600
MANGANESE	50	ND	ND	1	ND	43	54	47	44
MERCURY	2	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	100	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	-	ND	ND	600	ND	1000	500	1300	1100
SELENIUM	50	ND	ND	ND	ND	1	ND	ND	ND
SILICON[b]	-		7800	6890	6290		12000	11500	11200
SILVER	80	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	-	3660	4000	3750	3360	10400	11000	10300	10500
THALLIUM	0.5	ND	2	ND	ND	ND	ND	ND	ND
VANADIUM	112	ND	ND	ND	ND	ND	ND	ND	ND
ZINC	4800	90	25	28	21	20	ND	18	22
GENERAL CHEMISTRY									
pH	6.5-8.5	6.22	6.57 J	6.3	6.8	7.01	7.06 J	6.8	6.6
Carbonate, µg/L $CaCO_3$	-	ND	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	-	15900	22300	20000	36000	164000	166000	160000	160000
Hardness, µg/L CaCO3	-	23000	26200	26000	19000				160000
Conductivity, µmhos/cm	-	70.2	75.4	78	62	345	347	330	330
TDS, µg/L	500000	52000	39000	48000J	48000	201000	185000	210000	190000
Turbidity, NTU	-	0.11	ND	ND	ND	0.24	0.38	0.76	0.24
Fluoride	960	ND	ND	ND	ND	ND	ND	ND	ND
Chloride	250000	2500	2700	3200	2200	3000	3200	3000	2700
Nitrate (as N)	5780	2130	2100	2100	1600	530	503	530	560
Nitrite (as N)	487	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	250000	5100	6000	4900	4400	17000	18400	18000	16000
ORGANICS									
BIS(2-ETHYLHEXYL)PHTHALATE	6	ND	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	12800	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	720	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2									
BENZENE	1.51	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	720	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-TRIMETHYLBENZENE	-	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 525									
Endrin	2	ND	ND	ND	ND	ND	ND	ND	ND

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Value represents minimum potential ARAR in Table 4-3.

[b] The analytical laboratory did not analyze for Silicon during the 1st quarterly

TABLE 5-4

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG PRIVATE WELLS

Chemical Name	Minimum Screening Value[a] (µg/L)	PW-5				PW-6			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(ug/L)				(ug/L)			
ALUMINUM	50	70	120	40		20	20	30	
ANTIMONY	6	ND	ND	ND		ND	ND	ND	
ARSENIC	5	2	2	1		4	3	4	
BARIUM	1120	92	93	83		43	88	89	
BERYLLIUM	0.0203	ND	ND	ND		ND	ND	ND	
CADMIUM	5	ND	ND	ND		2	ND	ND	
CALCIUM	-	26700	27000	27000		7970	19000	14800	
CHROMIUM	80	ND	ND	ND		ND	ND	ND	
COBALT	960	ND	ND	ND		ND	ND	ND	
COPPER	592	ND	ND	ND		ND	ND	ND	
IRON	300	91	170	80		270	590	2040	
LEAD	5	ND	ND	ND		ND	2	3J	
MAGNESIUM	-	11000	12000	11200		2760	7000	5280	
MANGANESE	50	16	19	17		20	55	60	
MERCURY	2	ND	ND	ND		ND	ND	ND	
NICKEL	100	ND	ND	ND		ND	ND	ND	
POTASSIUM	-	1400	600	1500		1000	1300	1800	
SELENIUM	50	ND	ND	ND		4	ND	ND	
SILICON[b]	-		10000	9720			11000	8480	
SILVER	80	ND	ND	ND		ND	ND	ND	
SODIUM	-	25300	26000	24800		68400	37000	49800	
THALLIUM	0.5	ND	ND	ND		ND	ND	ND	
VANADIUM	112	ND	ND	ND		2	ND	ND	
ZINC	4800	55	ND	35		91	190	268	
GENERAL CHEMISTRY									
pH	6.5-8.5	8.13	7.91 J	7.6		8.52	7.8 J	7.8	
Carbonate, µg/L $CaCO_3$	-	ND	ND	ND		ND	ND	ND	
Bicarbonate, µg/L CaCO3	-	160000	160000	160000		179000	159000	170000	
Hardness, µg/L CaCO3	-			114000				58700	
Conductivity, µmhos/cm	-	298	316	320		317	284	320	
TDS, µg/L	500000	193000	176000	210000		208000	151000	190000	
Turbidity, NTU	-	1.09	2.1	1.2		2.3	3.6	4.9	
Fluoride	960	250	250	220		300	170	160	
Chloride	250000	1900	1900	2700		2900	2300	2100	
Nitrate (as N)	5780	ND	ND	12		ND	ND	4500	
Nitrite (as N)	487	ND	ND	ND		ND	ND	ND	
Sulfate	250000	10800	11000	11000		ND	ND	ND	
ORGANICS									
BIS(2-ETHYLHEXYL)PHTHALATE	6	ND	1.8	ND		ND	ND	ND	
DIETHYLPHTHALATE	12800	ND	1.2	ND		ND	ND	ND	
1,3-DICHLOROBENZENE	720	ND	ND	ND		ND	ND	ND	
Analysis 524.2									
BENZENE	1.51	ND	ND	ND		ND	ND	ND	
1,3-DICHLOROBENZENE	720	ND	ND	ND		ND	ND	ND	
1,3,5-TRIMETHYLBENZENE	-	ND	ND	ND		ND	ND	ND	
Analysis 525									
Endrin	2	ND	ND	ND		ND	ND	ND	

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Value represents minimum potential ARAR in Table 4-3.

[b] The analytical laboratory did not analyze for Silicon during the 1st quarterly

TABLE 5-4

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG PRIVATE WELLS

Chemical Name	Minimum Screening Value[a] (μg/L)	PW-7				PW-8			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(ug/L)				(ug/L)			
ALUMINUM	50	60	90	60		50	ND	ND	
ANTIMONY	6	ND	ND	ND		ND	ND	ND	
ARSENIC	5	5	11	5		19	12	19	
BARIUM	1120	7	14	6		78	77	79	
BERYLLIUM	0.0203	ND	ND	ND		ND	ND	ND	
CADMIUM	5	ND	ND	ND		ND	ND	ND	
CALCIUM	-	20100	22000	20700		19000	20000	20200	
CHROMIUM	80	ND	ND	ND		ND	ND	ND	
COBALT	960	ND	ND	ND		ND	ND	ND	
COPPER	592	ND	5	ND		3	ND	3	
IRON	300	410	4000	110		217	34	40	
LEAD	5	ND	4	ND		ND	1	ND	
MAGNESIUM	-	7240	7700	7320		7140	7600	7440	
MANGANESE	50	54	416	26		33	9	14	
MERCURY	2	ND	ND	ND		ND	ND	ND	
NICKEL	100	ND	ND	ND		ND	ND	ND	
POTASSIUM	-	1600	1400	2200		400	500	1100	
SELENIUM	50	1	ND	1		ND	ND	ND	
SILICON[b]	-		11000	9720			10000	8550	
SILVER	80	ND	ND	ND		ND	ND	ND	
SODIUM	-	7110	7600	6980		35600	35000	29100	
THALLIUM	0.5	ND	1	ND		ND	3	ND	
VANADIUM	112	4	ND	ND		3	ND	ND	
ZINC	4800	70	240	46		123	180	181	
GENERAL CHEMISTRY									
pH	6.5-8.5	8.23	7.95 J	7.7		8.24	7.41 J	8.00	
Carbonate, μg/L $CaCO_3$	-	ND	ND	ND		ND	ND	ND	
Bicarbonate, μg/L CaCO3	-	95800	100000	95000		151000	157000	140000	
Hardness, μg/L CaCO3	-			81800		76800	80200	81100	
Conductivity, μmhos/cm	-	184	195	190		284	276	280	
TDS, μg/L	500000	105000	104000	96000		166000	148000	170000	
Turbidity, NTU	-	1.5	26	1.3		2.4	ND	0.27	
Fluoride	960	140	140	ND		ND	ND	ND	
Chloride	250000	1000	1200	ND		1500	1600	1500	
Nitrate (as N)	5780	26	ND	48		203	136	240	
Nitrite (as N)	487	ND	ND	ND		ND	ND	ND	
Sulfate	250000	2700	3600	4200		ND	3300	ND	
ORGANICS									
BIS(2-ETHYLHEXYL)PHTHALATE	6	ND	ND	ND		ND	ND	ND	
DIETHYLPHTHALATE	12800	ND	ND	ND		ND	ND	ND	
1,3-DICHLOROBENZENE	720	ND	ND	ND		ND	ND	ND	
Analysis 524.2									
BENZENE	1.51	ND	ND	ND		ND	ND	ND	
1,3-DICHLOROBENZENE	720	ND	1.3	ND		ND	ND	ND	
1,3,5-TRIMETHYLBENZENE	-	ND	ND	ND		ND	ND	ND	
Analysis 525									
Endrin	2	0.3	ND	ND		ND	ND	ND	

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Value represents minimum potential ARAR in Table 4-3.

[b] The analytical laboratory did not analyze for Silicon during the 1st quarterly

TABLE 5-4

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG PRIVATE WELLS

Chemical Name	Minimum Screening Value[a] (µg/L)	PW-9				PW-10			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(ug/L)				(ug/L)			
ALUMINUM	50	ND	ND	ND	ND	ND	ND	ND	ND
ANTIMONY	6	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	5	ND	ND	ND	1	ND	ND	ND	ND
BARIUM	1120	2	2	2	1	2	2	3	2
BERYLLIUM	0.0203	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	5	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	-	13300	14000	14000	12300	9660	12000	12700	8580
CHROMIUM	80	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	960	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	592	ND	ND	ND	ND	24	33	6	7
IRON	300	ND	ND	ND	ND	1040	890	360	630
LEAD	5	ND	1	1J	ND	ND	ND	ND	1
MAGNESIUM	-	2900	3000	3120	2270	2230	2500	2720	2260
MANGANESE	50	ND	ND	ND	ND	7	8	3	2
MERCURY	2	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	100	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	-	ND	ND	700	500	ND	ND	800	700
SELENIUM	50	1	ND	ND	ND	1	ND	ND	ND
SILICON[b]	-		8300	7880	6210		7370	6770	6350
SILVER	80	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	-	3640	3700	3860	3470	3570	3750	4000	3410
THALLIUM	0.5	ND	2	ND	ND	ND	ND	ND	ND
VANADIUM	112	ND	ND	ND	ND	ND	ND	ND	ND
ZINC	4800	ND	5	5	6	8	14	6	ND
GENERAL CHEMISTRY									
pH	6.5-8.5	7.18	7.17 J	6.9	7.2	6.61	6.44 J	6.5	6.6
Carbonate, µg/L $CaCO_3$	-	ND	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	-	47700	48400	46000	39000	33400	42600	39000	27000
Hardness, µg/L CaCO3	-		46200	47800	40000				31000
Conductivity, µmhos/cm	-	109	111	110	98	86.1	96.9	110	81
TDS, µg/L	500000	82000	56000	80000	60000	74000	53000	64000	38000
Turbidity, NTU	-	ND	ND	ND	ND	9.1	0.84	1.6	3.1
Fluoride	960	ND	ND	ND	ND	ND	ND	ND	ND
Chloride	250000	2600	2400	2500	2200	2500	2600	2500	1900
Nitrate (as N)	5780	667	669	690	2700	876	516	2900	1100
Nitrite (as N)	487	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	250000	4600	3600	4800	3900	4300	4300	5700	5300
ORGANICS									
BIS(2-ETHYLHEXYL)PHTHALATE	6	ND	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	12800	ND	ND	1.5	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	720	1.3	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2									
BENZENE	1.51	ND	ND	ND	ND	ND	0.6	ND	ND
1,3-DICHLOROBENZENE	720	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-TRIMETHYLBENZENE	-	ND	ND	ND	ND	ND	0.7	ND	ND
Analysis 525									
Endrin	2	ND	ND	ND	ND	ND	ND	ND	ND

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Value represents minimum potential ARAR in Table 4-3.

[b] The analytical laboratory did not analyze for Silicon during the 1st quarterly

TABLE 5-4

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG PRIVATE WELLS

Chemical Name	Minimum Screening Value[a] (µg/L)	PW-12				PW-13			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(ug/L)				(ug/L)			
ALUMINUM	50	ND	ND	ND	ND	20	ND	ND	ND
ANTIMONY	6	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	5	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM	1120	2	2	2	2	2	2	2	2
BERYLLIUM	0.0203	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	5	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	-	12200	13000	14700	11800	12700	13000	13200	11200
CHROMIUM	80	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	960	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	592	3	ND	ND	ND	4	19	7	3
IRON	300	210	30	40	20	ND	ND	ND	ND
LEAD	5	ND	ND	ND	ND	ND	ND	1J	ND
MAGNESIUM	-	2140	2310	2670	2030	2420	2600	2640	2210
MANGANESE	50	6	1	1	1	ND	ND	ND	ND
MERCURY	2	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	100	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	-	ND	ND	700	600	ND	ND	800	500
SELENIUM	50	1	ND	ND	ND	ND	ND	ND	ND
SILICON[b]	-		6300	6410	5780		6900	6560	5930
SILVER	80	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	-	3150	3700	3780	3120	3510	3600	3940	3310
THALLIUM	0.5	ND	2	ND	ND	ND	1	ND	ND
VANADIUM	112	ND	ND	ND	ND	ND	ND	ND	ND
ZINC	4800	5	ND	4	5	11	38	6	6
GENERAL CHEMISTRY									
pH	6.5-8.5	7.15	7.4 J	6.8	6.8	7.01	6.43 J	6.9	6.9
Carbonate, µg/L $CaCO_3$	-	ND	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	-	39900	42000	47000	38000	40400	43700	41000	33000
Hardness, µg/L CaCO3	-			47700	38000		43300	43800	37000
Conductivity, µmhos/cm	-	98.1	104	120	92	98.9	103	110	94
TDS, µg/L	500000	71000	50000	69000	72000	70000	59000	71000	60000
Turbidity, NTU	-	1.75	0.79	0.26	0.1	0.05	ND	0.29	ND
Fluoride	960	ND	ND	ND	ND	ND	ND	ND	ND
Chloride	250000	2800	2400	2500	1600	2200	2100	2400	1800
Nitrate (as N)	5780	756	751	1100	860	1290	691	1900	1200
Nitrite (as N)	487	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	250000	3800	3700	4500	2500	6400	4900	4200	5900
ORGANICS									
BIS(2-ETHYLHEXYL)PHTHALATE	6	ND	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	12800	ND	ND	ND	ND	ND	ND	1.2	ND
1,3-DICHLOROBENZENE	720	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2									
BENZENE	1.51	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	720	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-TRIMETHYLBENZENE	-	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 525									
Endrin	2	ND	ND	ND	ND	ND	ND	ND	ND

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Value represents minimum potential ARAR in Table 4-3.

[b] The analytical laboratory did not analyze for Silicon during the 1st quarterly

TABLE 5-4

ANALYTES DETECTED IN GROUNDWATER SAMPLES FROM LANDSBURG PRIVATE WELLS

Chemical Name	Minimum Screening Value[a] (μg/L)	PW-14				PW-15			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(ug/L)				(ug/L)			
ALUMINUM	50	ND	ND	ND		130	2560	130	
ANTIMONY	6	ND	ND	ND		ND	ND	ND	
ARSENIC	5	ND	ND	ND		2	7	2	
BARIUM	1120	18	18	18		27	64	28	
BERYLLIUM	0.0203	ND	ND	ND		ND	ND	ND	
CADMIUM	5	ND	ND	ND		ND	ND	ND	
CALCIUM	-	1330	1400	1350		10300	19000	10900	
CHROMIUM	80	ND	ND	ND		ND	ND	ND	
COBALT	960	ND	ND	ND		ND	ND	ND	
COPPER	592	2	ND	45		13	84	10	
IRON	300	89	67	90		329	5400	310	
LEAD	5	ND	ND	4J		ND	16	1	
MAGNESIUM	-	480	480	460		3610	5200	3540	
MANGANESE	50	2	2	3		16	99	15	
MERCURY	2	ND	ND	ND		ND	ND	ND	
NICKEL	100	ND	ND	ND		ND	ND	ND	
POTASSIUM	-	600	ND	600		700	1100	1000	
SELENIUM	50	2	1	ND		ND	ND	1	
SILICON[b]	-		4400	4550			8800	6660	
SILVER	80	ND	ND	ND		ND	ND	ND	
SODIUM	-	139000	148000	143000		38400	20000	38400	
THALLIUM	0.5	ND	2	ND		ND	2	ND	
VANADIUM	112	ND	ND	ND		2	9	ND	
ZINC	4800	17	ND	36		70	1320	27	
GENERAL CHEMISTRY									
pH	6.5-8.5	9	9.02 J	9		8.91	8.52 J	8.4	
Carbonate, μg/L $CaCO_3$	-	37000	36600	35000		7900	ND	ND	
Bicarbonate, μg/L CaCO3	-	289000	286000	280000		102000	113000	130000	
Hardness, μg/L CaCO3	-			5270				42000	
Conductivity, μmhos/cm	-	579	585	580		201	215	240	
TDS, μg/L	500000	333000	306000	330000		133000	78000	150000J	
Turbidity, NTU	-	0.46	0.27	ND		1.8	31	2	
Fluoride	960	610	540	480		100	ND	110	
Chloride	250000	1900	2100	1900		1500	1900	1400	
Nitrate (as N)	5780	14	ND	16		15	ND	ND	
Nitrite (as N)	487	ND	ND	ND		ND	ND	ND	
Sulfate	250000	ND	ND	ND		ND	ND	ND	
ORGANICS									
BIS(2-ETHYLHEXYL)PHTHALATE	6	ND	ND	ND		ND	ND	ND	
DIETHYLPHTHALATE	12800	ND	ND	ND		ND	ND	ND	
1,3-DICHLOROBENZENE	720	ND	ND	ND		ND	ND	ND	
Analysis 524.2									
BENZENE	1.51	ND	ND	ND		ND	ND	ND	
1,3-DICHLOROBENZENE	720	ND	ND	ND		ND	ND	ND	
1,3,5-TRIMETHYLBENZENE	-	ND	ND	ND		ND	ND	ND	
Analysis 525									
Endrin	2	ND	ND	ND		ND	ND	ND	

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Value represents minimum potential ARAR in Table 4-3.

[b] The analytical laboratory did not analyze for Silicon during the 1st quarterly

TABLE 5-5

ANALYTES DETECTED IN SURFACE WATER SAMPLES FROM PORTAL #2 AND PORTAL #3

Chemical Name	Minimum Screening Value[a] (μg/L)	Portal #2				Portal #3			
		1st Round	2nd Round	3rd Round	4th Round	1st Round	2nd Round	3rd Round	4th Round
METALS		(μg/L)				(μg/L)			
ALUMINUM	-	90	150	180J	ND	ND	ND	ND	ND
ANTIMONY	1040	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	0.0842	ND	ND	1	ND	2	3	2	2
BARIUM	-	49	117	29	42	233	232	216	235
BERYLLIUM	0.0793	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	3.6	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	-	37400	82800	22000	32400	86400	86400	79900	86200
CHROMIUM	275.3	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	-	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	22.8	ND	ND	ND	ND	ND	ND	ND	ND
IRON	-	430	2160	200	340	758	1640	5500	940
LEAD	1.5	ND	ND	ND	1	ND	ND	ND	ND
MAGNESIUM	-	33800	65000	24300	28000	50600	51500	47400	49100
MANGANESE	-	254	1510	48	62	233	214	227	219
MERCURY	0.012	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	225	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	-	2800	5600	3700	2000	2800	2600	2600	2600
SELENIUM	5	2	1	1	ND	2	1	ND	ND
SILICON	-	1810	4990	ND	1090 J	9800	9480	9130	8730 J
SILVER	0.1	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	-	4300	9990	2830	4880	22500	22500	22100J	20300
THALLIUM	1.56	ND	ND	ND	ND	ND	ND	ND	ND
VANADIUM	-	ND	ND	ND	ND	ND	ND	ND	ND
ZINC	151.3	4	ND	5	13	ND	ND	ND	ND
GENERAL CHEMISTRY									
pH	-	7.37	6.72 J	7.2	7.2	7.09	6.99 J	6.9	6.9
Carbonate, μg/L $CaCO_3$	-	ND	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, μg/L CaCO3	-	194000	421000	110000	150000	444000	474000	440000	430000
Hardness, μg/L CaCO3	-	233000			200000	424000		400000	420000
Conductivity, μmhos/cm	-	424	864	350	370	798	828	800	760
TDS, μg/L	-	203000	474000	180000J	190000	420000	436000	430000	470000
Turbidity, NTU	-	3.1	6.3	5	3.6 J	3.2	9.8	2.2	4.7
Fluoride	-	100	130	180	ND	ND	ND	ND	ND
Chloride	230000	2300	3500	1900	2200	2100	1800	2600	2000
Nitrate (as N)	-	ND	14	480	140	ND	ND	ND	53
Nitrite (as N)	-	ND	ND	52	ND	ND	ND	ND	ND
Sulfate	-	29000	82500	45000	45000	18600	20200	9400	29000
ORGANICS									
DIETHYLPHTHALATE	28400	ND	ND	ND	ND	1	ND	ND	ND
ANALYSIS 524.2									
1,1-DICHLOROETHANE	-	ND	1	ND	0.5	ND	ND	ND	ND

ND - Analyte was Not Detected.

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a]Value represents minimum potential ARAR in Table 4-4.

TABLE 5-6

ANALYTES DETECTED IN LANDSBURG RIM SOIL SAMPLES[e]

Chemical Name[c]	Method B Screening Value[a] (mg/kg)	LRS-1 (mg/kg)	LRS-2 (mg/kg)	LRS-3 (mg/kg)	LRS-4 (mg/kg)	LRS-5 (mg/kg)	LRS-6 (mg/kg)	LRS-7 (mg/kg)	LRS-8 (mg/kg)	LRS-9[d] (mg/kg)	LRS-10[d] (mg/kg)	LRS-11[d] (mg/kg)	LRS-12[d] (mg/kg)
METALS													
ALUMINUM	80000.00	25600	14900	10200	17500	22600	16500	2700	4730	13500	24600	27400	28300
ARSENIC	7.00	6.7	4	8.5	5.3	4.3	16	8.4	8.9	4.4	5.1	4.9	3.3
BARIUM	5600.00	182	226	114	119	103	114	28.9	37.4	72.5	123	152	105
BERYLLIUM	0.23	1	1	0.8	0.7	0.5	1	0.2	0.3	0.4	0.5	0.6	0.4
CADMIUM	80.00	0.4	0.3	0.3	0.2	0.3	0.3	ND	ND	ND	ND	0.3	ND
CALCIUM		2410	832	508	1430	2910	2490	93	711	1500	2310	2680	2650
CHROMIUM	400.00	34.7	35.7	33	34	31.8	29.5	9.1	12.8	20.7	30.5	31.2	30.8
COBALT	4800.00	10.5	15.8	18.2	9.9	10.2	24.4	1.5	5.5	6.2	7.8	8.8	7.5
COPPER	2960.00	33.9	35.8	36.5	27.6	22.6	47.7	6.4	9.7	15	20.9	20.2	19.1
IRON		29500	40100	37200	26200	25300	45000	10700	14500	14200	19900	21000	20200
LEAD	250.00	10.1	9.7	16.5	21.6	5.6	12.5	5.4	6.7	6.7	5.3	7.2	3.8
MAGNESIUM		2230	1420	892	1870	3950	1930	174	565	2200	3640	3430	4120
MANGANESE	11200.00	844	701	560	446	436	1040	61.7	165	227	332	482	243
MERCURY	24.00	0.08	0.09	ND	0.07	ND	0.1	ND	ND	ND	ND	0.06	ND
NICKEL	1600.00	36	30	24	25	28	38	2	11	16	26	28	23
POTASSIUM		1250	1570	1210	1250	880	1670	550	620	640	970	970	740
SELENIUM	400.00	0.2	ND	0.2	ND	ND	0.2	ND	ND	ND	ND	ND	ND
SILVER	400.00	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM		113	66	ND	87	130	76	63	ND	77	123	155	167
THALLIUM	5.60	ND	ND	ND	ND	ND	0.1	ND	ND	ND	0.2	ND	ND
VANADIUM	560.00	55.5	53.5	50.6	45.2	53.2	61.3	15.6	21.7	34.2	51.4	54.9	53.7
ZINC	24000.00	89.1	84.4	81	71	43.2	83	13.4	29.2	26.4	40.1	55.1	28
ORGANICS													
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	1000000.00	ND	ND	0.0072J	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACETONE	8000.00	ND	ND	ND	ND	ND	ND	ND	ND	0.0085 J	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	71.40	ND	ND	ND	ND	ND	ND	1.9[b]	ND	0.96	ND	ND	ND
BUTYLBENZYLPHTHALATE	16000.00	ND	0.074	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1254	1.60	ND	ND	ND	0.037 J	ND	ND	ND	ND	ND	ND	ND	ND

ND - Not Detected

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

J - The J qualifier indicates the constituent was analyzed for and detected, but the detection was at a concentration which is less than the Practical Quantitation Limit (PQL) but greater than the Instrument Detection Limit (IDL).

[a] Minimum Method B value shown in Table 4-5.

[b] Bis(2-ethylhexyl)phthalate was detected in sample LRS-7, but was not detected by the lab in the blind duplicate of LRS-7.

[c] Some anionic compounds (fluoride, chloride, etc.) were also detected in soil, but the concentrations were several orders of magnitude or more less than the Method B levels.

[d] Background Samples

[e] Sample locations shown in Figure 2-5.

TABLE 5-7

ANALYTES DETECTED IN PORTAL SOIL SAMPLES[d]

Chemical Name[b]	Method B Screening Value[a] (mg/kg)	P2S-1 (mg/kg)	P2S-2 (mg/kg)	P2S-3 (mg/kg)	P2S-4 (mg/kg)	P3S-1 (mg/kg)	P3S-2 (mg/kg)	P3S-3 (mg/kg)	P3S-4 (mg/kg)	FNS-1[c] (mg/kg)
METALS										
ALUMINUM	80000.00	16400	13200	11800	17500	18400	7920	12600	8890	12900
ARSENIC	7.00	5.9	7.4	5.5	8	5.8	26	5.8	14.2	18.4
BARIUM	5600.00	119	109	77.4	121	128	235	184	494	665
CALCIUM		3960	6580	2470	7590	3840	40700	17100	245000	5220
CHROMIUM	400.00	23	18	20	20	20	17	18	7	10
COBALT	4800.00	6.4	7	10.4	7	8	25	7.9	29	16
COPPER	2960.00	10	21.9	18.9	30.8	18.2	24.5	23.5	12	5
IRON		15300	16700	23600	16700	18400	20600	17900	16000	92400
LEAD	250.00	23	45	22	28	11.7	12	10	7.1	4.2
MAGNESIUM		3380	3330	2010	3780	3450	3220	4420	5980	2180
MANGANESE	11200.00	619	565	542	636	232	2510	514	4730	9170
MERCURY	24.00	0.1	0.13	0.07	0.1	ND	ND	ND	ND	ND
NICKEL	1600.00	27	24	24	28	27	40	21	48	36
POTASSIUM		500	700	1000	600	500	700	1000	500	400
SELENIUM	400.00	0.7	ND	ND	ND	ND	ND	0.3	0.8	ND
SODIUM		117	80	62	91	117	226	318	218	88
THALLIUM	5.60	ND	ND	ND	ND	ND	ND	0.3	ND	ND
VANADIUM	560.00	35.6	31.2	38.5	32	42.8	35.4	39.9	18	26
ZINC	24000.00	36	327	59	84	54	64	41	42	38
ORGANICS										
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	1000000.00	ND	0.0034	0.0039	0.008	ND	0.015 J	0.0039 J	ND	0.0055 J
ACETONE	8000.00	ND	ND	ND	ND	0.02	0.052 J	ND	ND	ND
2-METHYLNAPHTHALENE	3200.00	ND	ND	ND	ND	ND	0.11	0.092	ND	ND
BENZO(A)PYRENE	0.14	ND	0.089 M	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	71.40	ND	ND	ND	ND	ND	ND	ND	0.210	ND
CHRYSENE	0.14	ND	.090 M	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	64000.00	ND	0.099	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	2400.00	ND	ND	ND	ND	ND	0.070	0.088	ND	ND
4,4'-DDT	2.94	ND	0.0024 J	ND	ND	ND	0.0018 J	0.0021 J	ND	ND

ND - Not Detected

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

J - The J qualifier indicates the constituent was tested for and detected, but the detection was at a concentration which is less than the calculated detection limit.
During data validation the J qualifier may be applied to indicate a minor quality control deficiency.

B - The B qualifier indicates the constituent was analyzed for and detected in the associated laboratory blank.

M - The M qualifier indicates an estimated value of an analyte detected and confirmed by analyst with low spectral match parameters.

[a] Minimum Method B value shown in Table 4-5.

[b] Some anionic compounds (fluoride, chloride, etc.) were also detected in soil, but the concentrations were several orders of magnitude or more less than the Method B levels.

[c] Background Sample

[d] Sample locations shown in Figures 2-5 and 2-6.

TABLE 5-8

ANALYTES DETECTED IN BACKHOE TRENCH SOIL SAMPLES[c]

Chemical Name[b]	Method B Screening Value[a] (mg/kg)	BT1-1 (mg/kg)	BT2-1 (mg/kg)	BT3-1 (mg/kg)
ALUMINUM	80000.00	2360	6420	4720
ARSENIC	7.00	9.8	10	11.4
BARIUM	5600.00	27.6	124	50.6
BERYLLIUM	0.23	0.6	0.8	0.8
CALCIUM		1210	1430	1060
CHROMIUM	400.00	18	21	16
COBALT	4800.00	9.2	16.8	21.1
COPPER	2960.00	10.4	40	38.5
IRON		28100	34000	29400
LEAD	250.00	5.6	9	10
MAGNESIUM		2420	1080	858
MANGANESE	11200.00	539	1020	456
MERCURY	24.00	ND	0.09	0.12
NICKEL	1600.00	17	39	32
POTASSIUM		570	1210	1090
SILVER	400.00	ND	1	ND
SODIUM		49	45	39
THALLIUM	5.60	ND	ND	0.3
VANADIUM	560.00	38.8	44.3	31.3
ZINC	24000.00	43.5	68.4	91.9

ND - Not Detected

Shading indicates exceedance of the screening value. Exceedance of a screening value does not necessarily indicate a significant risk or health hazard, only the need to retain the compound for further evaluation.

[a] Minimum Method B value shown in Table 4-5.

[b] Some anionic compounds (fluoride, chloride, etc.) were also detected in soil, but the concentrations were several orders of magnitude or more less than the Method B levels.

[c] Sample locations shown in Figure 2-5.

TABLE 5-9

SUMMARY OF HISTORICAL SOIL SAMPLING DATA WITHIN TRENCH

Chemical Compounds Detected[a]	Range of Values, mg/kg	Number of Detections	MTCA Method B Cleanup Level[b], mg/kg	Number of Samples > ARAR	Locations where ARAR is Exceeded[c]
TRENCH SOILS (E&E 1991)					
METALS					
ANTIMONY	ND -14	1	32.00	0	
ARSENIC	4-19	13	7.00	5	LDS-1, LS-4, LS-5, LS-6, LS-8
CADMIUM	ND - 22	2	80.00	0	
CHROMIUM	14 - 912	13	400.00	1	LS-8
COPPER	10 - 702	13	2960.00	0	
LEAD	ND - 3200	2	250.00	1	LS-8
MERCURY	ND - 3.7	1	24.00	0	
NICKEL	12 - 43	13	1600.00	0	
SELENIUM	ND - 2	2	400.00	0	
SILVER	ND - 4	1	400.00	0	
ZINC	31 - 2130	13	24000.00	0	
Volatile Organic Compounds					
1,1,1-TRICHLOROETHANE	ND - .011	1	72000.00	0	
TRICHLOROETHENE	ND - .137	1	90.90	0	
1,2-DICHLOROBENZENE	ND - .016	1	7200.00	0	
1,4-DICHLOROBENZENE	ND - .0096	1	41.70	0	
ACETONE	ND - .251	2	8000.00	0	
ETHYLBENZENE	ND - .0085	1	8000.00	0	
STYRENE	ND - .0083	1	33.30	0	
TETRACHLOROETHENE	ND - .056	1	19.60	0	
TOTAL XYLENES	ND - .045	1	160000.00	0	
Semi-Volatile Organic Compounds					
BIS(2-ETHYLHEXYL) PHTHALATE	ND -178	3	71.40	1	LS-8
BUTYL BENZYL PHTHALATE	ND - 10	2	16000.00	0	
DIBUTYL PHTHALATE	ND - 7	1	8000.00	0	
DIMETHYL PHTHALATE	ND - 23	1	80000.00	0	
ISOPHORONE	ND - 2.3	1	1050.00	0	
Pesticides /PCBs					
AROCLOR-1242	ND - 7.9	1	1.60	1	LS-8
AROCLOR-1254	ND - 27.2	3	1.60	2	LDS-1, LS-8
SLUDGE (LPLPSC 1991)[d]					
methylene chloride	1690	NA[e]	133.00	NA[e]	sludge pond
trichlorofluoromethane	299	NA	24000.00	NA	sludge pond
1,1,2-trichlorotrifluoroethane	216	NA	1000000.00	NA	sludge pond
1,1,1-trichloroethane	317	NA	72000.00	NA	sludge pond
trichloroethene	1530	NA	90.90	NA	sludge pond
toluene	141	NA	16000.00	NA	sludge pond
ethylbenzene	270	NA	8000.00	NA	sludge pond
total xylenes	1320	NA	160000.00	NA	sludge pond
TPH	67,000	NA	200.00	NA	sludge pond
AROCLOR-1254	4.9	NA	1.60	NA	sludge pond

NA - Not Applicable

ND - Not Detected

Shading indicates exceedance of a screening value.

[a] Compounds detected in subsurface soil samples and drum area surface soil samples in Ecology & Environment (1991). A total of 13 samples were col

[b] Minimum Method B value from Table 4-5

[c] Sample locations shown in Figures 3-4 and 3-5.

[d] Represents a single sample of the "sludge pond" located north of the LMW-1 pillar wall. LPLPSC (1991) does not provide the laboratory report for the data, so it is unclear if this represents all of the chemicals detected for this sample.

[e] Only a single sample was collected of the sludge. Therefore the number of detections, etc. is not relevant.

TABLE 5-10

PRELIMINARY LIST OF COMPOUNDS EXCEEDING POTENTIAL ARARS FOR GROUNDWATER

Compound[a]	Potential ARAR[b]		Maximum Detect	Mean Value	Location	Total	no. detects	no. samples > ARAR
	value, µg/L	ARAR	µg/L		of Max Detect	No. samples		
MONITORING WELLS								
Aluminum	50	SMCL	140	28	LMW-6	28	7	4
Iron	300	SMCL	2230	869	LMW-6	28	28	22
Manganese	50[d]	SMCL[d]	299	163	LMW-7	28	28	20
Thallium	0.5	MCLG	2	0.6	LMW-2	28	5	5
Total Dissolved Solids	500000	SMCL	780000	470821	LMW-4	28	28	11
PRIVATE WELLS								
Aluminum	50	SMCL	2560	77	PW-15	49	15	8
Arsenic	5	Method A	19	2.4	PW-8	49	19	5
Iron	300	SMCL	5400	371	PW-15	49	36	11
Lead	5	Method B	16	1.3	PW-15	49	14	2
Manganese	50[d]	SMCL[d]	416	23	PW-7	49	36	6
Thallium	0.5	MCLG	3	0.8	PW-8	49	10	10
Bis(2-ethylhexyl)phthalate	6	MCL	6.7	0.7	PW-2	49	2	1
pH (pH units)[c]	6.5-8.5	SMCL	9.02 J	7.4	PW-14	49	NA	10

[a] Compounds exceeding potential ARARs, from Tables 5-3 and 5-4.

[b] Groundwater ARARs summarized in Table 4-3.

[c] Four values fell below the minimum pH value of 6.5, and six exceeded the maximum pH value of 8.5.

[d] Besides a SMCL for manganese of 50 µg/L, there is also a Method B value of 80 µg/L which is exceeded at several locations.

SMCL - Secondary Maximum Contaminant Level (under 40 CFR 143).

MCLG - Maximum Contaminant Level Goal (under 40 CFR 141.50).

TABLE 5-11

PRELIMINARY LIST OF COMPOUNDS EXCEEDING POTENTIAL ARARS FOR SURFACE WATER

Compound[a]	Potential ARAR[b]		Maximum Detect, μg/L	Location of Max Detect	Total No. samples	no. detects	no. samples > ARAR
	value, μg/L	ARAR					
Arsenic	0.0842	Method B (SW)	3	Portal 3	8	5	5

[a] Compounds exceeding potential ARARs, from Table 5-5.

[b] Surface Water ARARs summarized in Table 4-4.

SW- Surface Water

TABLE 5-12

PRELIMINARY LIST OF COMPOUNDS EXCEEDING POTENTIAL ARARS FOR SOIL

Compound[a]	Potential ARAR[b]		Maximum Detect, mg/kg	Location of Max Detect	Total No. samples	no. detects	no. samples > ARAR
	value, mg/kg	ARAR					
TRENCH RIM SOILS[c]							
Beryllium	0.23	Method B	1	LRS-1, -2, -6	12	12	11
Arsenic	7	Method B	16	LRS-6	12	12	4
PORTAL SOILS[d]							
Arsenic	7	Method B	26	P3S-2	9	9	5
TEST PIT SOILS[c]							
Beryllium	0.23	Method B	0.8	BT2-1,BT3-1	3	3	3
Arsenic	7	Method B	11.4	BT3-1	3	3	3
TRENCH SOILS[e]							
Arsenic	7	Method B	19	LS-8	13	13	5
Lead	250	Method B	3200	LS-8	13	2	1
Chromium	400	Method B	912	LS-8	13	13	1
Bis(2-ethylhexyl)phthalate	71.4	Method B	178	LS-8	13	3	1
Aroclor-1242	1.6	Method B	7.9	LS-8	13	1	1
Aroclor-1254	1.6	Method B	27.2	LDS-1,LS-8	13	3	2
POND SLUDGE[f]							
Methylene chloride	133	Method B	1690	sludge pond	1	1	1
TCE	90	Method B	1530	sludge pond	1	1	1
TPH	200	Method A	67,000	sludge pond	1	1	1
Aroclor-1254	1.6	Method B	4.9	sludge pond	1	1	1

[a] Compounds exceeding potential ARARs, from Tables 5-6, 5-7, 5-8 and 5-9.
[b] Soil ARARs summarized in Table 4-5.
[c] Sample locations shown in Figure 2-5.
[d] Sample locations shown in Figure 2-5 and 2-6.
[e] Sample locations shown in Figure 3-4.
[f] Sample locations shown in Figure 3-5.

TABLE 5-13

STATE-WIDE SOIL BACKGROUND VALUES FOR METALS EXCEEDING REGULATORY CRITERIA

Compound[a]	Background Values[b]		95% UCL	Maximum Detect	Screening Value[c]
	90th Percentile	Range			
RIM SOILS					
Arsenic	6.99	0.5-28.6	8.47	16	7
Beryllium	1.44	0.1-2.79	0.9	1	0.23
PORTAL SOILS					
Arsenic	6.99	0.5-28.6	15.28	26	7
BACKHOE TRENCH SOILS					
Arsenic	6.99	0.5-28.6	11.87	11.4	7
Beryllium	1.44	0.1-2.79	0.93	0.8	0.23
TRENCH SOILS					
Arsenic	6.99	0.5-28.6	NA	19	7
Chromium	41.83	2.56-235	NA	912	400
Lead	17.09	2.1-207.5	NA	3,200	250

[a] Compounds exceeding potential ARARs in soil, from Table 5-6, 5-7, 5-8 and 5-9.

[b] WDOE (1994)

[c] Minimum Method B value from Table 4-5.

UCL - Upper confidence limit of the mean

TABLE 5-14

RESULTS OF AIR MONITORING SURVEY IN ROGERS TRENCH (FIRST EVENT)

STATION	OVA[1]		OVM[2]		COMMENTS
	0.5 FT	4 FT	0.5 FT	4 FT	
26+50	0	0	0.1		
26+75	0	0	0.1	0.1	
27+00	0	0	0.1	0.1	
27+25	0	0	0.1	0.1	
27+50	0	0	0.1	0.1	
27+75	0	0	0.1	0.1	
28+00	0	0	0.1	0.1	
28+25	0	0	0.1	0.1	
28+50	0	0	0.1	0.1	
28+75	0	0	0.1	0.1	
29+00	0	0	0.1	0.1	
29+25	0	0	0.1	0.1	
29+50	0	0	0.1	0.1	
29+75	0	0	0.1	0.1	
30+00	0	0	0.1	0.1	
30+25	0	0	0.1	0.1	
30+50	0	0	0.1	0.1	
30+75	0	0	0.1	0.1	
31+00	0	0	0.1	0.1	
31+25	0	0	0.1	0.1	
31+50	0	0	0.1	0.1	
31+75	0	0	0.1	0.1	
Background Measurement		0		0.1	
32+00	0	0	0.1	0.1	Black Plastic Area
32+25	0	0	0.1	0.1	
32+40	0	0	0.1	0.1	
32+60	0	0	0.1	0.1	
32+75	0	0	0.1	0.1	
33+00	0	0	0.1	0.1	
33+50	0	0	0.1	0.1	
33+75	0	0	0.1	0.1	
34+00	0	0	0.1	0.1	
34+25	0	0	0.1	0.1	
34+50	0	0	0.1	0.1	
Background Measurement	0	0	0	0.1	
36+00	0	0	0	0	
36+25	0	0	0	0	
36+50	0	0	0	0	
Black Pool	<0.1	0	0.1	0.1	
37+00	0	0	0	0	

RESULTS OF AIR MONITORING SURVEY IN ROGERS TRENCH (FIRST EVENT)

STATION	OVA[1]		OVM[2]		COMMENTS
	0.5 FT	4 FT	0.5 FT	4 FT	
37+20	0	0	0	0	Exposed Drum
37+25	0	0	0	0	
37+50	0	0	0	0	
37+75	0	0	0	0	
38+00	0	0	0	0	
38+25	0	0	0	0	
38+50	0	0	0	0	
39+00	0	0	0	0	
39+25	0	0	0	0	
39+50	0	0	0	0	
39+75	0	0	0	0	
40+00	0	0	0	0	
40+25	0	0	0	0	
40+50	0	0	0	0	
40+75	0	0	0	0	
41+00	0	0	0	0	End of fenced area

[1] OVA-Organic Vapor Analyzer (Flame Ionization Detector)
[2] OVM- Organic Vapor Monitor (Photo-Ionization Detector)
[3] Location of the survey is shown in Figure 2-1

RESULTS OF AIR MONITORING SURVEY IN ROGERS TRENCH (SECOND EVENT)

STATION	OVA[1]		OVM[2]		COMMENTS
	0.5 FT	4 FT	0.5 FT	4 FT	
24+00	0	0	0	0	South end of fenced trench area, enter trench
24+25	0	0	0	0	
24+50	0	0	0	0	
24+75	0	0	0	0	
25+00	0	0	0	0	
25+25	0	0	0	0	
25+50	0	0	0	0	Vegetative cover too thick, exit trench
26+25	1	1	0	0	OVA 1.0 reading background, instrument drift
26+50	1	1	0	0	
26+75	1	1	0	0	
27+00	1	1	0	0	Wasp nest ! exit trench
27+25	0.4	0.4	0	0	Re-calibrate OVA settting 2.52 for 9PPM CH4
27+50	0.4	0.4	0	0	
27+75	0	0	0	0	
28+00	0	0	0	0	
28+25	0.2	0.2	0	0	
28+50	0	0	0	0	
28+75	0	0	0	0	
29+00	0	0	0	0	
29+25	0	0	0	0	
29+50	0	0	0	0	
29+75	0	0	0	0	
30+00	0	0	0	0	
30+25	0	0	0	0	
30+50	0	0	0	0	
30+75	0	0	0	0	
31+00	0	0	0	0	
31+25	0	0	0	0	
31+50	0	0	0	0	
31+75	0	0	0	0	Exit trench, black plastic at 32+00
34+00	0	0	0.4	0.4	Re-calibrate OVA settting 2.92 for 9PPM CH4
33+75	0	0	0	0	
33+50	0	0	0	0	
33+25	0	0	0	0	
33+00	0	0	0	0	
32+75	0	0	0	0	
32+50	0	0	0	0	Exit trench
35+75	0	0	0	0	Re-enter trench north LMW-1
36+00	0	0	0	0	
36+25	0	0	0	0	

RESULTS OF AIR MONITORING SURVEY IN ROGERS TRENCH (SECOND EVENT)

STATION	OVA[1]		OVM[2]		COMMENTS
	0.5 FT	4 FT	0.5 FT	4 FT	
36+50	0	0	0	0	
36+55	0	0	2	2	Approximately 20ft from sludge pool
36+75	0	0	1.4	3.1	Sludge pool, exit trench
37+00	0	0	0.4	0.4	Approximately 25ft from sludge pond
37+25	0	0	0	0	
37+50	0	0	0	0	
37+75	0	0	0	0	
38+00	0	0	0	0	
38+25	0	0	0	0	
38+50	0	0	0	0	
38+75	0	0	0	0	
39+00	0	0	0	0	
39+25	0	0	0	0	
39+50	0	0	0	0	
39+75	0	0	0	0	
40+00	0	0	0	0	
40+25	0	0	0	0	
40+50	0	0	0	0	
40+75	0	0	0	0	
41+00	0	0	0	0	Finish air monitoring at north fence

[1] OVA-Organic Vapor Analyzer (Flame Ionization Detector)
[2] OVM- Organic Vapor Monitor (Photo-Ionization Detector)
[3] Location of the survey is shown in Figure 2-1

RESULTS OF AIR MONITORING SURVEY IN ROGERS TRENCH (THIRD EVENT)

STATION	OVA[1]		OVM[2]		COMMENTS
	0.5 FT	4 FT	0.5 FT	4 FT	
24+00	0	0	0	0	Start at the south end of the trench below fence
24+25	0	0	0	0	
24+50	0	0	0	0	
24+75	0	0	0	0	
25+00	0	0	0	0	
25+25	0	0	0	0	
25+50	0	0	0	0	Exiting trench by south end
26+25	0	0	0	0	Background by trench OVA/OVM 0.0. Check background then enter trench
26+50	0	0.2	0	0	
26+75	0	0	0	0	
27+00	0	0	0	0	
27+25	0	0	0	0	
27+50	0	0	0	0	
27+75	0	0	0	0	
28+00	0	0	0	0	
28+25	0	0	0	0	
28+50	0	0	0	0	
28+75	0	0	0	0	
29+00	0	0	0	0	
29+25	0	0	0	0	
29+50	0	0	0	0	
29+75	0	0	0	0	
30+00	0	0	0	0	
30+25	0	0	0	0	
30+50	0	0	0	0	
30+75	0	0	0	0	
31+00	0	0	0	0	
31+25	0	0	0	0	
31+50	0	0	0	0	Measurement taken at cuttings disposal area in trench. Can't take anymore readings along this portion of the trench; water in trench all the way to plastic. Exit middle section of trench.
32+75	0	0	0	0	Enter pit, head toward plastic

TABLE 5-16

RESULTS OF AIR MONITORING SURVEY IN ROGERS TRENCH (THIRD EVENT)

STATION	OVA[1]		OVM[2]		COMMENTS
	0.5 FT	4 FT	0.5 FT	4 FT	
33+00	0	0	0	0	
33+25	0	0	0	0	Survey location by tires
33+50	0	0	0	0	Still located by tires
33+75	0	0	0	0	
34+00	0	0	0	0	Exit pit.
LMW-1	-	0	-	0	Background reading after recalibration.
35+75	0	0	0	0	Enter pit by LMW-1
36+00	0	0	0	0	
36+25	0	0	0	0	
36+50	0.1	0	0.5	0	At pond. Readings at pond level.
36+55	0	0	2	2	Approximately 20ft from sludge pool
36+75	0	0	0	0	Enter pit, work back toward pool.
37+00	0	0	0	0	
37+25	0	0	0	0	
37+50	0	0	0	0	
37+75	0	0	0	0	
38+00	0	0	0	0	
38+25	0	0	0	0	
38+50	0	0	0	0	
38+75	0	0	0	0	
39+00	0	0	0	0	
39+25	0	0	0	0	
39+50	0	0	0	0	
39+75	0	0	0	0	
40+00	0	0	0	0	
40+25	0	0	0	0	
40+50	0	0	0	0	
40+75	0	0	0	0	
41+00	0	0	0	0	Exit pit. Check calibration.

[1] OVA-Organic Vapor Analyzer (Flame Ionization Detector)
[2] OVM- Organic Vapor Monitor (Photo-Ionization Detector)
[3] Location of the survey is shown in Figure 2-1

FIELD GROUNDWATER TURBIDITY MEASUREMENTS (in NTUs)

Well	Round 1	Round 2	Round 3	Round 4
PW-1	0.46	0.6	IM	NS
PW-2	0.2	0.3	0.32	0.43
PW-3	0.45	0.2	0.25	0.18
PW-4	2.1	0.91	0.58	0.49
PW-5	2.9	2	IM	NS
PW-6	4.14	4.5	6.21	NS
PW-7	8	1.5	IM	NS
PW-8	1	NR	3.47	NS
PW-9	0.01	0.2	0.21	0.19
PW-10	3.5	2	1.79	NR
PW-12	2.28	2.4	0.34	NR
PW-13	0.1	0.3	0.28	0.35
PW-14	2	3	1.36	NS
PW-15	3.5	2.4	2.99	NS
LMW-1[a]	0.15	1.8	0.29	2.3
LMW-2	0.9	2.6	0.35	0.5
LMW-3	3.6	4.8	0.39	0.2
LMW-4	0.7	0.5	0.48	0.7
LMW-5	0.7	0.7	0.32	0.16
LMW-6	2.7	7	2.22	0.1
LMW-7	3.7	0.9	0.53	1.5

NS - Not Sampled

NR - Not Recorded

IM - Instrument Malfunction. Value not recorded.

[a] Filtered sample.

TABLE 5-18

WATER-QUALITY TYPICAL OF COAL-MINE DRAINAGES IN THE STATE OF WASHINGTON COMPARED TO LANDSBURG MINE WATER QUALITY

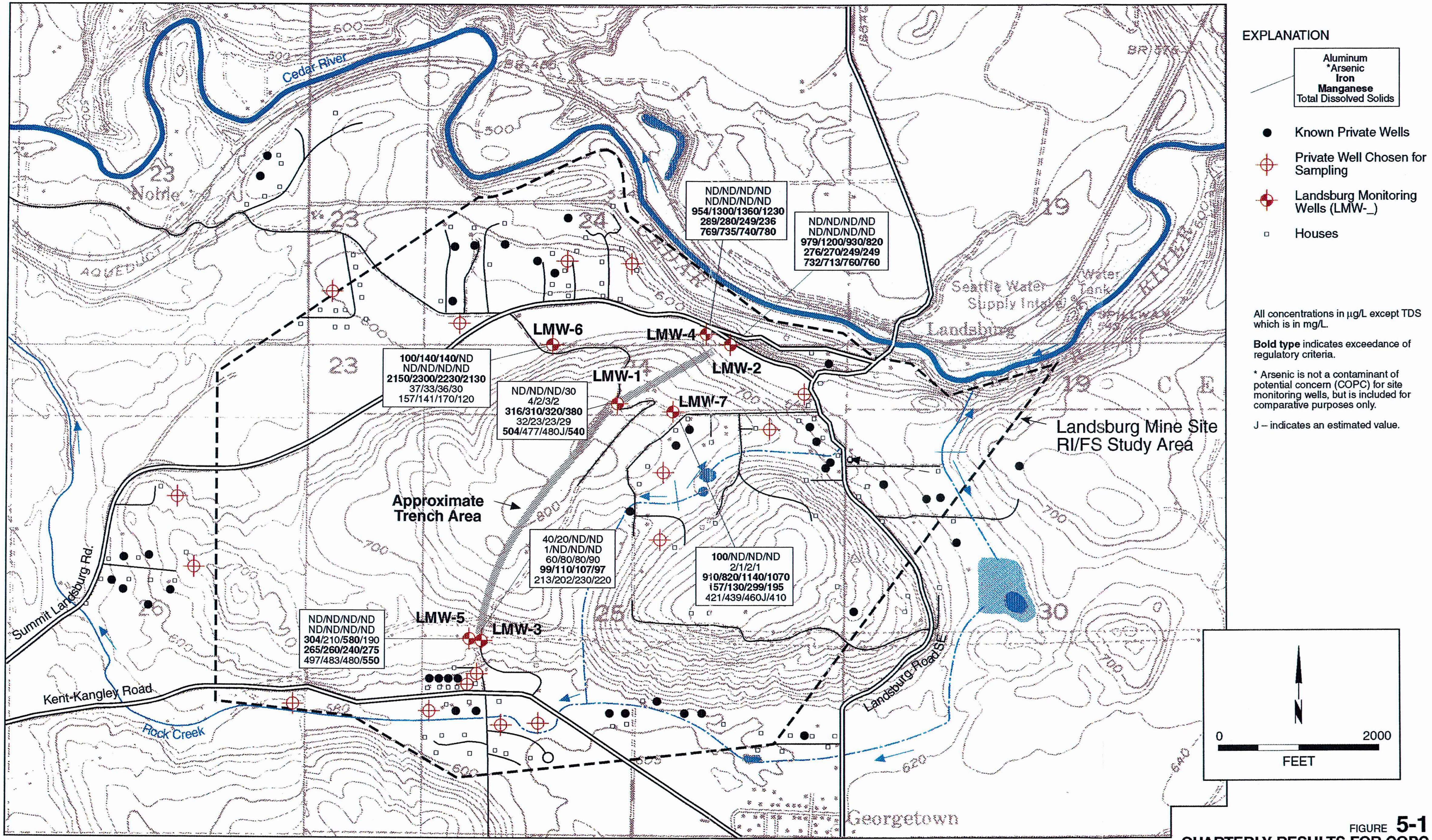
SELECTED CONSTITUENTS[c]	USGS Study[a]					Landsburg Phase I RI Study[b]				
	Mean	Standard Deviation	Min	Max	Number of Samples	Mean	Standard Deviation	Min	Max	Number of Samples
ALUMINUM	19	17	ND	50	17	34.7	49	<20	180	36
ARSENIC	2	5	ND	18	16	1.1	0.9	<1	4	36
CALCIUM	45000	40000	12000	180000	18	76870	38800	28800	142000	36
IRON	2300	6400	ND	39000	44	1009	1022	60	5500	36
LEAD	3	2	ND	10	17	0.6	0.3	<1.0	2	36
MAGNESIUM	19000	21000	1600	90000	18	47000	24730	14600	87500	36
MANGANESE	140	140	8	500	16	204	245	23	1510	36
MERCURY	ND	-	ND	0.1	17	<0.1	0.0	<0.1	<0.1	36
POTASSIUM	2500	2100	200	8000	17	3053	1126	1000	5600	36
SODIUM	82000	116000	1500	450000	18	24610	17100	4300	72000	36
SULFATE	78000	1270000	3500	520000	29	39340	34840	3500	138000	36
pH	7	0.5	5.6	8.4	50	7.00	0.28	6.40	7.62	36
HARDNESS	189000	184000	37000	820000	18	416000	208000	191000	715000	21
BICARBONATE	245000	270000	14000	1340000	30	401360	209780	121000	740000	36

[a] Fuste et al. 1983. All results reported as "Dissolved", except for iron which is "Total".

[b] Based on results from wells LMW-1 thru LMW-7, and surface water samples collected from portals #2 and #3.

[c] Selected constituents reported in Fuste et al. 1983.

All units in μg/L, except pH.



All concentrations in µg/L except TDS which is in mg/L.

Bold type indicates exceedance of regulatory criteria.

* Arsenic is not a contaminant of potential concern (COPC) for site monitoring wells, but is included for comparative purposes only.

J – indicates an estimated value.

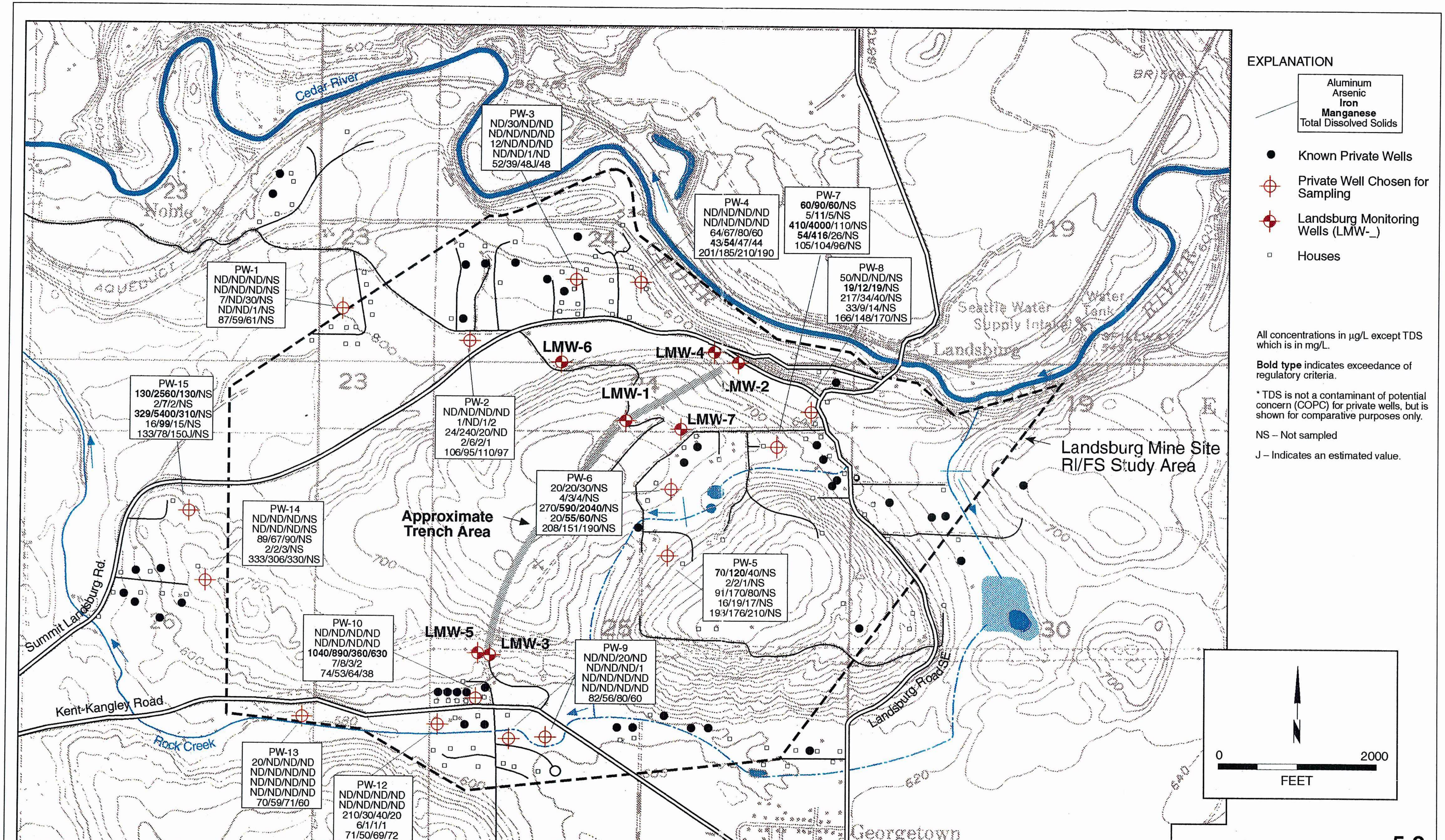
FIGURE **5-1**

QUARTERLY RESULTS FOR COPC AT MONITORING WELLS

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 55277 DATE 8/25/95 DRAWN BY CB

Golder Associates



All concentrations in µg/L except TDS which is in mg/L.

Bold type indicates exceedance of regulatory criteria.

* TDS is not a contaminant of potential concern (COPC) for private wells, but is shown for comparative purposes only.

NS – Not sampled

J – Indicates an estimated value.

FIGURE **5-2**

QUARTERLY RESULTS FOR COPC AT PRIVATE WELLS

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 55278 DATE 8/29/95 DRAWN BY CB

Golder Associates

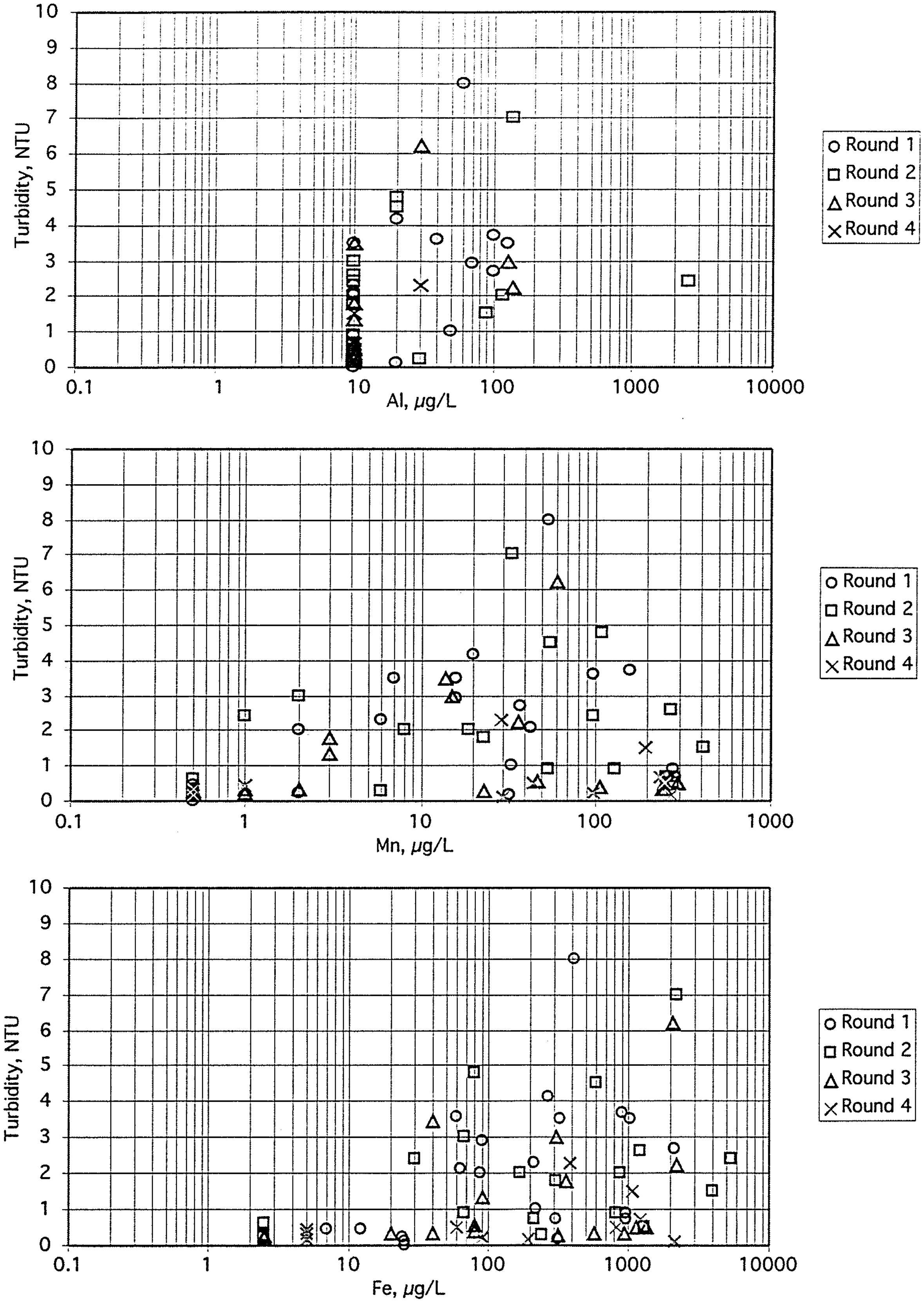


FIGURE **5-3**

TURBIDITY VS MEASURED
AL, FE AND MN
LANDSBURG MINE SITE RI/FS/WA

Note: ND values plotted at 1/2 the detection limit

PROJECT NO. 923 1000.147 DRAWING NO. 50736 DATE 3/3/95 DRAWN BY EA

Golder Associates

6. RI SUMMARY

This chapter summarizes the RI portions of the RI/FS document. The primary aim of the chapter is to highlight key RI findings and conclusions in order to serve as an introduction to the FS, and to focus the FS on the most important aspects of the site physical setting, ARARs, and extent of chemical constituents in environmental media.

6.1 Site Background

The Landsburg Mine site consists of a former underground coal mine located approximately 1.5 miles northwest of Ravensdale in southeast King County, Washington. The site is located directly south and east of the S.E. Summit-Landsburg Road and north of the Kent-Kangley Road. The Cedar River passes within approximately 500 ft of the site to the north. The location of the site in the Seattle, Washington area is shown in Figure 1-1. Figures 1-2 and 1-3 depict the immediate site vicinity.

The mine site occupies property owned by Palmer Coking Coal Company (PCC) and Plum Creek Timber Company, L.P. and is located within sections 24 and 25, Township 22 N., Range 6 E. A defined Study Area for the site, prescribed by Ecology for the purposes of this RI/FS, is depicted in Figures 1-2 and 1-3. Property boundaries for the site are shown in Figure 1-4.

PCC operated an underground coal mine known as the Landsburg Mine from the late 1940s until approximately 1975. The Rogers Seam, one of three seams mined at the site, was mined from 1959 until 1975. The mined section of the seam has a near vertical dip and consists of coal and interbedded shale approximately 16 ft wide. The mined section is about a mile in length. Mining occurred at depths of up to 750 feet using a mining method locally termed "booming" which followed the coal seam vertically. As a result of underground mining of the Rogers Seam, a subsidence trench developed on the land surface above the mine workings. The dimensions of the trench vary, from about 60 to 100 feet wide, between 20 to 60 feet in depth and about 3/4 mile in length.

A portion of the trench was used in the late 1960s to the late 1970s for disposal of various industrial wastes, construction materials, and land-clearing debris. Drums, liquid from tanker trucks and other industrial materials were disposed of in the northern portion of the trench. Disposal of land clearing debris continued until the early 1980s. Currently, the site is secured by a fence and locked gate which encloses the northern portion of the trench where disposal occurred.

Several preliminary environmental investigations have been performed at the site, including a limited soil gas survey (Applied Geotechnology 1990), sampling of area private wells (WDOH 1992), and sampling surface water emanating from mine portals (Geraghty and Miller 1990). No hazardous substances above naturally-occurring background levels were detected in any of these investigations.

Due to continued concerns over potential environmental hazards posed by the Mine, however, Ecology commissioned a Site Hazard Assessment (SHA) study in 1991. Ecology then requested potentially liable parties (PLPs) to perform an expedited response action (ERA) which resulted in the removal of over 100 55-gallon drums from the trench. These investigations did detect hazardous substances, including volatile and semi-volatile organic compounds, PCBs, cyanide and metals, in drum contents, adjacent soils and ponded surface water within the northern portion of the trench where prior waste disposal is believed to have occurred.

On the basis of these results, Ecology and the PLPs entered into an Agreed Order (WDOE 1993a) in July 1993 which directed the Landsburg PLP Group to conduct an RI/FS to evaluate human and environmental health risks posed by the site and develop appropriate remedial alternatives. The data collected under the RI are considered adequate to characterize site conditions and support evaluation and selection of a preferred remedial alternative in the FS. A summary of the RI is presented below.

6.2 RI Data Collection Activities

The Work Plan (Golder 1992a) and support project plans together with the *Conceptual Model of the Landsburg Mine Site* (Golder 1992b) provided the necessary rationale and details for implementation of the RI/FS. Data collection activities conducted under the RI included the following tasks:

- **Task 3 - Air Monitoring.** Three air monitoring surveys were conducted along the subsidence trench bottom in the northern half of the mine within the fenced and secured former disposal areas to monitor for the presence of volatile organic compounds.

- **Task 4 - Facility Environmental Assessment (Level 1).** A Level I Environmental Assessment (EA) was completed to identify historical land uses, ownership, and previous activities that may have resulted in the generation, storage or disposal of hazardous materials at the site.

- **Task 5 - Private Well Survey.** A well survey was conducted to identify private and public wells within the Study Area, and to support the selection of wells for quarterly sampling.

- **Task 6 - Surface Water Sampling and Flow Monitoring From Portals #2 and #3.** Surface water associated with Rogers mine portals #2 and #3 was sampled for chemical analysis over four rounds of quarterly sampling. The flow rate of water emanating from portal #3 was measured on a weekly basis.

- **Task 7 - Surface Soil Sampling.** Surface soils around the trench rim perimeter and downslope of portal #3 were sampled for chemical analysis.

- **Task 8 - Source Characterization in Rogers Trench (Geophysical Investigation).** A magnetometer survey was conducted along the centerline of the Rogers Seam trench to identify areas of potential buried waste. Additional EM/magnetometer and GPR surveys were conducted at both ends of the Landsburg Mine to determine monitoring well placement.

- **Task 9 - Monitoring Well Drilling and Installation.** Seven new monitoring wells (LMW-1 through -7) were installed at the site. Wells LMW-2/4 and LMW-3/5 consisted of nested well pairs installed within the coal at each end of the trench at the points of expected mine groundwater discharge. LMW-1 was installed overtop a suspected location of a fault and tunnel connecting offset portions of the Rogers Seam. Wells LMW-6 and -7 were installed in the Frasier and Landsburg seams, respectively, to provide indications of water quality typical of adjacent coal seams. Angled drilling methods were used at the LMW-4 and LMW-7 well locations to intercept the coal seam. Cores of the coal seam were obtained from LMW-2, -3 and -5. Slug tests were conducted in selected wells to determine hydraulic properties. The wells were equipped with dedicated sampling systems to facilitate periodic sampling.

- **Task 10 - Groundwater Sampling and Analysis.** Fourteen selected private wells and the newly installed groundwater monitoring wells were sampled over four quarterly sampling rounds. The samples were submitted for a broad range of chemical analyses including metals and cyanide, volatile and semi-volatile organics, pesticides and PCBs, and general chemical parameters. Private well sampling during round 4 was conducted at a reduced number of wells.

- **Task 11 - Topographic Survey and Geodetic Control.** Using aerial photogrammetry techniques, a topographic base map of the site was prepared to 2 ft contours. Horizontal control was established based on the Washington State Plane Coordinate System as required under MTCA.

- **Task 12 - Ecological and Social Data.** Relevant ecological and social data were obtained for the site and Study Area, including information on meteorologic and surface water characteristics, land use (zoning) and water use at the Study Area, endangered species, priority habitats, and sensitive areas. This information was obtained largely from readily available sources.

- **Task 13 - Geologic Reconnaissance.** Geologic reconnaissance activities consisted of limited geologic mapping to confirm the understanding of surficial geology presented in the Conceptual Model, and the excavation of backhoe test pits to examine subsurface lithology in the immediate vicinity of the Rogers Seam.

All environmental sampling activities were conducted under an approved Quality Assurance Project Plan (QAPP) which was included as part of the Work Plan (Golder 1992a). Most field and data collection activities were completed during the period from October, 1993 to May, 1995.

6.3 Site Physical Conditions

6.3.1 General

Apart from the former Mine operations, the only development in the Study Area is residential with approximately 90 residences contained within the Study Area. A dirt road accesses the property and trails run parallel to the east and west sides of the trench (Figure 3-1). The access road begins near S.E. Summit-Landsburg Road and follows along the northern portion of the trench. A locked gate secures the site at the access road entrance, and the portion of the trench where disposal occurred is currently enclosed by an 8 ft tall chain link security fence. Dense vegetation covers the site. The Mine property sits atop a gently sloping hill which reaches a maximum elevation of approximately 800 ft mean sea level (MSL) near the central portion of the site. At the site's northern end (Figure 3-1), this hill slopes steeply downwards towards the S.E. Summit-Landsburg Rd. (elevation of approximately 615 ft) and continuing to the Cedar River (elevation approximately 500 ft). The southern portion of the site slopes more gradually downwards to the south toward the Kent-Kangley Rd. and Rock Creek drainage located at an elevation of approximately 600 ft. The site is bounded to the east by a somewhat larger hill which rises to a maximum elevation of approximately 940 ft.

Electrical transmission lines and a Bonneville Power Administration property easement cross the southern portion of the site in an east-west direction. Approximately 3/4 mile upstream of the northern portion of the site along the Cedar River at Landsburg, the City of Seattle Water Department maintains a drinking water supply intake known as the Landsburg Diversion which serves as a major source of water for the Seattle area. Water is conveyed from the intake through a 96-in diameter pipeline to the Lake Youngs Reservoir. The pipeline passes just to the north of the site and is located at the toe of the slope between the S.E. Summit-Landsburg Rd. and the Cedar River. A meteorologic data collection and river gaging station, operated by the City of Seattle, are located at the water intake structure.

6.3.2 Source Characteristics

Beginning in 1969, a portion of the trench was used for the disposal of various waste materials, including industrial wastes, construction and land-clearing debris, tires and miscellaneous household garbage. Materials were disposed into the mine trench from the site access road indicated in Figure 3-1. Hazardous materials were dumped until 1978. Dumping of other materials continued intermittently until about 1983. Industrial wastes were contained in drums or dumped directly from tanker trunks. Based on invoice records from Palmer Coking Coal Company, an estimated 4,500 drums and about 200,000 gallons of oily waste water and sludges were disposed into the trench. Available documented interviews with waste haulers indicate that some of the drums contained wastes including paint wastes, solvents, metal sludges and oily water and sludge (WDOE 1990).

The approach taken during the RI was to focus environmental sampling efforts on potential pathways of chemicals leaving the mine, and not on wastes present within the mine itself. Therefore, what is known regarding the contents of the mine is based on visual reconnaissance, records searches, and geophysical surveys. On the basis of these sources of information, previous waste disposal and any potential remaining wastes appear to be confined to the northern half of the trench in three sections separated by pillar walls. Pillar walls are areas where subsidence has not occurred. These three sections are shown in Figures 3-4 and 3-6. In these sections, fill areas are present along much of the trench floor and sidewalls. These fill areas resulted from past disposal activities, which usually included covering the waste periodically with soil. Native soil generally was bulldozed over the trench edge to cover the waste material. Magnetic anomalies, which are indicative of buried ferrous metallic objects, which may include drums, were detected in these three sections. The thickness of introduced fill, potential waste materials and naturally eroded soils present within the trench is unknown. The nature of any remaining waste materials is uncertain beyond that which is known regarding what was disposed in the trench. Given that up to 4,500 drums were reportedly placed in the trench and approximately 100 were recovered during the ERA, it is reasonable to expect that wastes potentially remaining include a significant number of drums buried beneath the trench bottom surface at some depth. It is important to note, however, that based on the condition of the drums observed in the ERA, the length of burial, physical damage during placement, reported fires, etc., the vast majority of drums have ruptured, deteriorated or been destroyed.

6.3.3 Geology

Site stratigraphy consists of a thick sequence of folded Tertiary bedrock of the Puget Group mantled by glacial drift of the Vashon (and possibly Pre-Vashon) glacial stage. The glacial drift materials at the site are comprised primarily of till and recessional outwash. The till consists of a compact mixture of gravel in a clayey, silty sand matrix. Recessional outwash is comprised of a well-sorted mixture of sand and gravel. Till mantles the hillsides and recessional outwash generally fills in the lowlands. The total thickness of the glacial deposits ranges from near 0 near the hilltops to possibly in excess of 100 ft in the lowland areas and stream channels. In most areas of the site itself, the thickness of the drift is probably between about 10 to 50 ft.

The Puget Group is composed of non-marine sandstones and siltstones with numerous carbonaceous shale and coal beds and minor amounts of claystone and conglomerate. All gradations between sandstone and siltstone are present, and most of the rocks are either silty sandstone or sandy siltstone. These materials are typically fine-grained, and except for the coal which is typically very weak and friable, are generally well-cemented and strong. The thickness of the Puget Group rocks at the site is not known but is probably at least several thousand ft.

A typical east-west section through the Rogers Seam is shown in Figure 3-13. On the east side of the seam is a massive sandstone bed and one foot thick layer of shale. The coal seam itself is approximately ten ft in thickness. On the west side is a four to seven ft thick carbonaceous shale, and a massive sandstone (Eltz 1992). The thickness of individual beds varies from a few ft to tens of ft.

The bedrock in the Study Area vicinity has been extensively folded into a series of north and northeast-trending folds (Gower and Wanek 1963). Most of these structures are south-plunging asymmetric folds with east-dipping axial planes. The site and Study Area are situated over the western limb of a northeast trending anticline. Puget Group strata dip steeply with dip angles of the Rogers coal seam and adjacent strata near 90° on the north end of the site and 63° at the south end of the mine (Figure 3-14).

The rocks in the Study Area have been displaced by numerous faults (Figure 3-9). Most noteworthy is the fault in the northern portion of the mine where approximately 75 feet of displacement (PCC 1992) required a 130 ft long rock tunnel to reconnect mining operations to the coal seam. This was the only mapped fault which resulted in complete loss of the coal seam. The fault extends vertically through all four levels of the Rogers Mine to land surface where the unmined and hence uncollapsed rock pillar is used for the trench cross-over roadway. This fault also appears to have been encountered when mining the Landsburg seam some 750 ft east of the Rogers Seam (Falk 1992); the location of this contact indicates that the fault strikes approximately east-west. Water inflows into the mine from this fault were not noted by mine personnel. Review of mine records found no evidence of fault gouge.

Pertinent features of the smaller faults include; offsets of from 2 to 16 ft (Mine Superintendent's Drawings); polished surfaces (Eltz 1992); and tightness (reports by all interviewed personnel that mining through fault zones did not result in increased water flow). The Puget Sound - Olympic Peninsula province is characterized with the major principal horizontal stress being a north-south compression. Faults that are steeply dipping with east-west strikes should therefore be tight due to the north-south compression.

6.3.4 Mine History and Condition

6.3.4.1 History

The Rogers Seam was mined from four (4) different levels accessed from three (3) slopes/declines as shown on Figures 3-2 and 3-9; a "water level" tunnel was also constructed to facilitate water removal from the upper level. The seam was mined from 1959 until 1975 when all active mine openings were closed by blasting. During this time frame, approximately 490,000 tons of clean coal were produced.

Two other underground mines were also operated in seams adjacent to the property (see Figure 3-2). The Frasier seam, located to the west of the Rogers Seam, was mined intermittently from the late 1800s to the mid 1940s. The Landsburg seam, located to the east of the Rogers Seam, was worked intermittently from the 1930s to about 1977.

6.3.4.2 Mining Methods

Due to the vertical orientation of the coal seam, the Rogers mines utilized a system of coal extraction involving the development of "levels" with coal extracted by "booming" between underlying and overlying levels. This mining term, simply refers to the process of blasting pillars of coal isolated between adjacent crosscuts/entries and chutes. The booming round (see Figure 3-13) was initially fired in the uppermost pillar to start the cave. Coal was then "pulled/drawn" through the first open chute and loaded into mine cars.

Groundwater control was accomplished by grading the gangway at a slight incline with positive drainage back towards the bottom of the mine access slope. Water gravity drained, via a shallow ditch dug in the footwall, to a small sump at the slope bottom and was pumped, from there, out of the mine. It is difficult to precisely estimate the quantity of water entering and pumped from the Rogers mine(s), however, an approximate range in inflow rates is possible based on mine personnel estimates, back-analysis of water accumulations observed during power outages, and pump capacity/utilization. The most likely value for pumping is about 35 gpm with a minimum expected value of 20 gpm, and a maximum value of 80 gpm.

6.3.4.3 Mine Stability

Trench Bottom. Slabbing failure of the sandstone footwall has been reported by mine personnel. As coal was drawn down during mining operations, areas of the sandstone sidewall were observed to "slide" into the trench bottom. It is believed that these slabs could mask underlying voids. Voids may also remain at great depth due to the incomplete collapse of the workings, however, because of their greater depth these voids are of lower concern with regard to trench bottom stability. Using an approximate method of analysis, the overall volume of remaining voids was estimated to be less than 10%. Although it is likely that a majority of trench bottom subsidence has already occurred, it is prudent to allow for further subsidence when evaluating and designing any remedial measures.

Trench Sidewall. The mapped sequence of strata forming the trench sidewall included interbedded sandstone, shale, and siltstone; no evidence of sidewall instability was observed. However, slabbing failure, similar to that observed by retired PCC personnel, may occur if material is removed from the trench bottom or if further subsidence occurs.

Potential for Waste Movement After Dumping. A majority of the drummed waste was deposited in the trench north of the rock bridge (major fault in northern part of mine). The last mining beneath this area was completed at the end of 1967 approximately one year prior to waste deposition. Fourth level mining beneath the trench immediately to the south of the rock bridge began in September of 1970 and was completed in 1974. While there was some potential for movement of the contained waste after deposition north of the rock bridge, it is considered unlikely that significant deformations occurred. There is a modestly higher probability that waste in the trench to the south of the rock bridge has settled since deposition. Settlement of the waste could result in debris moving down into the mine.

6.3.5 Meteorology and Surface Water

6.3.5.1 Surface Water

The major surface water features at the Study Area are the Cedar River along the Study Area's northern boundary and Rock Creek within the southern boundary. Rock Creek represents the only perennial creek or stream within the Study Area boundaries. Rock Creek ultimately drains into the Cedar River approximately 2 miles downstream of the site. Figure 3-16 depicts the primary surface water flow pattern and features of the Study Area.

The mine site itself has only ephemeral drainages which discharge during prolonged or intense periods of rainfall. The southern portion of the mine site drains towards Rock Creek and the northern half drains to the Cedar River.

The lower elevations around the perimeter of the Study Area are covered by relatively permeable outwash sands and gravels at the land surface. Rainfall is expected to readily infiltrate these materials. The elevated portions of the site either have surface outcrops of bedrock or a thin veneer of glacial drift (till) which will inhibit infiltration relative to the permeable outwash deposits. In general, surface water flow at the site is expected to run-off the hills, collect in ephemeral drainages and flow to the lower elevations where it infiltrates into the outwash deposits or flows into Rock Creek or the Cedar River. Some run-off also flows into the mine trench, depending on the local topography and drainage patterns. Run-off flowing into the mine trench collects in several ephemeral pools where it infiltrates or evaporates.

Water occurrence at portals #2 and #3 is perennial and is expected to represent natural groundwater discharge. Another pool, the so-called "sludge pond" located just to the north of well LMW-1, is also perennial but not an expression of groundwater. The water present at portal #2 occurs as a pool which is completely retained and enclosed as a shallow depression. Mine portal #3 occurs as seepage where water emanates along a sloping seepage face, flows along the ground surface for a short distance, and gradually re-infiltrates back into surficial soils.

6.3.5.2 Meteorological Characteristics

The average precipitation at the site ranges from slightly less than 1.5 inches in July to nearly 8 inches in December. In general, the months of July through September are driest, and October through January are the wettest. Yearly precipitation averages 56.52 inches with a maximum of 76.39 and a minimum of 32.93 inches. On average, January is the coldest month and August the warmest with average daily low temperatures ranging from 37° to 49° and average daily maximum temperatures ranging from 51° to 85°.

6.3.6 Hydrogeology

The primary hydrogeologic system at the site consists of a continuous to semi-continuous groundwater system comprised of the Puget Group bedrock materials and the surrounding glacial outwash aquifer. Minor occurrences of groundwater in till overlying the bedrock are likely perched and of secondary importance. The bedrock materials, which make up the hills within the Study Area, protrude up through and discharge to the glacial outwash which fills the surrounding valleys and lower elevations around the perimeter of the Study Area.

The mined/backfilled Rogers coal seam is a highly permeable conduit with hydraulic conductivities on the order of about 1 to 5 cm/s. The two portions of the trench separated by the fault near LMW-1 are in good hydraulic communication with each other, and the mine may be thought of as forming one relatively continuous, highly conductive zone. The fine-grained sediments located to either side of the seam are at least several orders of magnitude less permeable than the mined out seam. Faults through the coal seam are probably tight and do not act as significant conduits, based on the regional state of stress, mine reports, water level measurements, and geochemical analyses. Vertical gradients, and therefore vertical flow, also appear to be small within the coal seam. Therefore, groundwater flow in the trench primarily occurs horizontally and along strike through the highly permeable mined out Rogers Seam. Flow laterally away from the Mine (across bedding or via faults) is considered negligible. The trench can therefore be thought of as a highly conductive "slot" or "pipe". Groundwater within this "slot" moves longitudinally with very little movement laterally away from the trench. Wells installed in Puget Group materials and located laterally away from the mine are hydraulically isolated from the mine workings. There is no observable pathway for chemicals to migrate from the mine to these wells. These include wells LMW-6 and -7, and private wells PW-5 through -8, and PW-14 and -15.

Mine reports, geochemical data and the rapid response of groundwater levels to seasonal rainfall patterns suggests that recharge of the coal seam is primarily by direct rainfall infiltration. The trench effectively collects and concentrates rainfall and runoff from the surrounding area. This runoff readily infiltrates through the porous structure of the mined out seam and recharges the local water table.

Due to the preference for longitudinal flow within the trench and site topography, and as evidenced by the discharge observed at portals #2 and 3, discharge from the mine occurs at either end. A groundwater divide is therefore present within the trench. To the north of this divide, flow is to the north, and to the south of the divide, flow is to the south. There is some uncertainty with respect to the location of this divide, however, based on the high conductivity of the trench, topography and presence of ponded water in the southern portion of the trench, the divide is believed to occur within the southern third of the Mine. The majority of flow from the mine and in particular for that portion of the trench utilized for waste disposal is therefore to the north.

Mass balance considerations, flow measurements made at portal #3, and the reports of mine dewatering have indicated that the total flow rate of water entering as infiltration and exiting near the portals is on the order of about 10 to 20 gpm.

6.3.7 Ecologic and Social Characteristics

6.3.7.1 Land Use (Zoning)

The bulk of the Study Area, including much of the central portion of the site and the former mine workings, has been assigned an RA, Rural Area Zone classification. The western portion of the Study Area from the coal mine areas to Summit-Landsburg Road, has been designated F for forest use. In addition to these zoning classifications, the City of Kent and City of Seattle maintain municipal watershed lands along the western and eastern boundaries of the Study Area, respectively, for the protection of drinking water supplies associated with Rock Creek and the Cedar River. Also, under the Shoreline Management Plan of King County, the Cedar River shoreline throughout the Study Area vicinity has been designated a "Conservancy" environment. The site zoning is shown on Figure 3-25.

6.3.7.2 Water Use

Surface Water. The City of Seattle has operated a large water diversion structure upstream of the Mine site at Landsburg since 1901. The structure diverts approximately 150 million gallons per day (mgd) from the Cedar River. An infiltration gallery adjacent to Rock Creek has been used by the City of Kent since the early 1900s for use as a municipal water source. The existing diversion, referred to as the Clark Springs facility, consists of a lateral gravity drainage collection system installed approximately 13 to 15 ft below ground surface in the creek alluvium. This facility was sampled as part of this RI and was referred to as well PW-13.

Groundwater. A survey of private wells in the area, summarized in Table 2-1, identified a total of 56 wells within the Study Area. Excluding the Clark Springs facility which serves the City of Kent, these wells serve approximately 91 homes at the Study Area and 236 people. The wells range in depth from less than twenty feet to a maximum depth of about 400 feet. Many of the shallow wells were hand dug and range between 20 and 30 feet in depth.

6.3.7.3 Endangered Species

The USFWS identified the bald eagle as the only listed endangered species sighted near the Study Area. Bald eagles may winter within this area from approximately October through March. Several candidate species were also identified by the USFWS as potentially occurring in the Study Area. These include the bull trout, mountain quail, northern goshawk, northern red-legged frog, northwestern pond turtle, pacific fisher, and the spotted frog. The USFWS did not identify any proposed species in the Study Area vicinity.

6.3.7.4 Priority Habitats and Species

Wetlands. Mapped wetlands occur in two areas within the Study Area. These are shown in Figure 3-26. The first of these consists of an area identified by the Washington Department of Wildlife (WDW) in the northern trench area. While field reconnaissance by GAI personnel did identify a number of wet areas within the trench, the area identified by the WDW was never observed to contain water during this RI. The second area occurs just inside the southern site boundary and is shown on the King County sensitive areas maps, as discussed below.

Other potential wetland areas, not shown on any governmental maps, were identified by GAI field reconnaissance. These include minor wet areas within the trench as well as other areas of ponded water located in the Study Area. Figure 3-26 depicts the potential wetland areas identified by GAI. Final determination of the status of these areas as wetlands will require a site visit by a qualified biologist or ecologist and will be performed during subsequent remedial planning tasks.

Habitats. The WDW has mapped the Cedar River along the northern Study Area boundary as a critical spawning habitat for resident species. This portion of the river has also been identified as an anadromous fish run and as having resident species present. Rock Creek is not identified as a critical fish habitat by the WDW; however, it is considered a high-quality salmonid habitat and a 2.5 mile stretch of Rock Creek has been designated a Regionally Significant Resource Area by the Cedar River Watershed Management Committee (King County Dept. of Public Works 1993).

Species. The WDW indicates that bald eagles are a priority species and have used areas near Black Diamond as a breeding area. There are no documented sitings in the Study Area, however.

The WDW Non-Game Heritage Data System documents point observations of nongame species of concern in the area by reputable sources. While observation for several species occur in the vicinity of the Study Area, there are no documented observations in the Study Area itself. In addition, there is no documented spotted owl activity within the Study Area.

6.3.7.5 Sensitive Areas

Sensitive areas as defined by the King County Sensitive Areas Ordinance (Ordinance 9614) include wetlands, areas prone to stream and flood hazards, erosion hazards, seismic hazards, and coal mine hazards. Development of land within identified sensitive areas requires special development standards as well as special studies to assesses impacts and to propose adequate mitigation, maintenance, monitoring and contingency plans for those areas. Identified sensitive areas are shown in Figure 3-26.

As discussed above in Section 6.3.7.4, there is one small wetland area within the southern site boundary identified in the King County Sensitive Areas map. This area is located over 1,000 ft from the trench.

Streams are considered sensitive areas because of their esthetic values, their ability to provide recreation, support wildlife, and potentials for flooding and erosion. The Cedar River is identified as a Class I stream for its length from Landsburg to Renton. This indicates the river is inventoried as a Shoreline of the State under the King County Management Plan. Rock Creek to the south of the site is classified as a Class II stream that flows year-round during years of normal rainfall and is used by salmonids. Rock Creek is ephemeral to the east of where it crosses beneath the Kent-Kangley Road.

Two large areas of the site are described as susceptible to erosion. The first is the steep northern slope along the Cedar River. The second is the steep hillside in the eastern portion of the Study Area between the trench and Study Area boundary.

There are no landslide hazard areas identified for the site or identified seismic hazard areas.

The portions of the Landsburg Mine site where coal removal occurred are mapped as coal mine hazard areas.

6.4 ARARs

This section briefly summarizes information presented in Chapter 4 focusing on the most significant potential applicable or relevant and appropriate requirements (ARARs) for the Landsburg Mine site. The full list of potential ARARs is presented and discussed in Tables 4-1 and 4-2. Potential specific regulatory limits (cleanup standards) for groundwater, surface water, and soil are presented in Tables 4-3, 4-4, and 4-5, respectively. The primary potential ARARs for the site include the following:

- Model Toxics Control Act (MTCA), RCW 70.105D, and MTCA Cleanup Regulations, WAC 173-340; and
- Minimum Functional Standards for Solid Waste Handling, WAC 174-304.

In addition, portions of the dangerous waste regulations (WAC 173-303) may be relevant and appropriate. These are discussed briefly below.

Model Toxics Control Act (MTCA), RCW 70.105D, and MTCA Cleanup Regulations, WAC 173-340. MTCA is the key governmental regulation governing the conduct of the overall investigation and cleanup process for the site and is therefore applicable. MTCA describes the requirements for selecting cleanup actions, preferred technologies, policies for use of permanent solutions, the time frame for cleanup, and the process for making decisions.

Specific criteria for the various cleanup methods are presented in the MTCA regulations. Generally, technologies that recycle or re-use materials are preferred most, followed by methods that destroy or detoxify hazardous substances, and cleanup methods that may leave contaminants on-site. Although MTCA identifies a hierarchy of preferred technologies that should be evaluated for use in the cleanup action, cost may also be a factor in determining points of compliance and selection of cleanup actions.

Recent amendments to MTCA (RCW 70.105D.090) exempt remedial actions conducted pursuant to an Agreed Order or a Consent Decree from the procedural requirements of several state laws. These include the State Clean Air Act (RCW 70.94), Solid Waste Management - Reduction and Recycling Act (RCW 70.95), Hazardous Waste Management Act (RCW 70.105), Water Pollution Control Law (RCW 90.48), Shoreline Management Act (RCW 90.58), and Construction Projects in State Waters (RCW 75.20). In addition, the exemption also applies to the procedural requirements of any laws requiring or authorizing local governmental permits or approval for the remedial action. Therefore, while substantive compliance is necessary, permits and approvals are not required for remedial actions at the site.

WAC 173-340-700 establishes cleanup levels for environmental media, including groundwater, soil, surface water and also contains standards for air emissions. Three methods are presented for determining cleanup levels: Method A (routine, using tables), Method B (standard), and Method C (conditional, primarily for industrial sites). Method A is generally used for routine cleanups with relatively few contaminants. Method B is the standard method for determining cleanup levels and assumes a residential use scenario. Method C cleanup levels are used in circumstances where Method A or B are not appropriate, as specified in WAC 173-340-706. Methods B and C levels are determined using federal or state ARARs or are based on risk-based equations specified in MTCA regulations. All three MTCA methods for determining cleanup levels require compliance with other federal or state ARARs, and consideration of cross-media contamination. For groundwater cleanup criteria, the regulations specifically identify federal Maximum Contaminant Levels (MCLs), Secondary Maximum Contaminant Levels (SMCLs), and non-carcinogen Maximum Contaminant Level Goals as applicable.

Dangerous Waste Regulations - WAC 173-303. The Washington State Dangerous Waste Regulations (WAC 173-303) are the state equivalent of the federal hazardous waste (RCRA) regulations, and contain a series of rules relating to the generation, handling, storage and disposal of "dangerous waste." Recent MTCA amendments, as discussed above, exempt cleanup actions conducted under an Agreed Order or Consent Decree from the procedural requirements of these regulations. In addition, a recent amendment to the state Hazardous Waste Management Act (RCW 70.105) provides a conditional exemption to state-only dangerous wastes generated when a remedial action is conducted pursuant to a Consent Decree with Ecology. The exemption is not applicable to material that is a hazardous waste under RCRA.

Therefore, no WAC 173-303 procedural requirements will be applicable to remedial actions conducted at the site if the actions are conducted pursuant to a Consent Decree or Agreed Order. WAC 173-303 substantive requirements pertaining to dangerous waste generation, handling, storage, and disposal may be applicable, however if non-exempt dangerous waste is generated and/or transported off the site unit boundary during cleanup.

Closure and post-closure standards in the dangerous waste regulations are To Be Considered (TBC). Some of these standards (WAC 173-303-610, -645, and -665) are relevant to the Landsburg Mine site. Portions of these regulations may be appropriate, and therefore ARAR.

Minimum Functional Standards (MFS) for Solid Waste Handling - WAC 173-304. WAC 173-304-407 and -460 describe closure and post-closure standards and landfill standards, respectively. Under, MTCA, MFS the "minimum requirements" for landfill closure conducted as a MTCA cleanup action. On this basis, the MFS are applicable to this site. WAC 173-340-460 capping requirements include a minimum 2 ft. thick soil layer having a permeability of 1 x 10^{-6} or lower. Alternately, a synthetic liner material may be substituted for the soil layer. The MFS standards are the primary capping criteria to consider in this FS.

6.5 Nature And Extent Of Chemical Constituents

The air, soil, groundwater, and surface water analytical data collected as part of the RI, as well as other data collected during the preliminary investigations (the SHA and ERA), were evaluated in this RI to assess the nature and extent of chemical constituents in environmental media at the Landsburg Mine site. The primary purpose of this evaluation was to identify the chemical compounds potentially posing a human or environmental health risk and/or which exceed potential regulatory criteria, and which are the result of the prior waste disposal activities. Such compounds are termed the Contaminants of Concern (COC). In order to accomplish this, the data were evaluated through a step-wise screening process which considered laboratory and field blank data, background concentrations (if available) and appropriate regulatory criteria (ARARs).

On the basis of the data screening performed, the following conclusions were drawn:

Air. Throughout nearly all of the trench, volatile organic compounds were not detected at all in air. Detectable levels of volatile organic compounds in air were very low and restricted to only a small area within the trench in the vicinity of the sludge pond. Air monitoring conducted during drilling did not detect significant levels of volatile organic compounds.

Groundwater. The results of groundwater sampling indicate that no federal drinking water standards (Maximum Contaminant Levels) are being exceeded at the Mine site itself or amongst any of the private wells sampled in the Study Area. The State of Washington MTCA Method B standard for arsenic (5 μg/L) was exceeded at three private wells (levels up to 19 μg/L) and the MTCA Method B standard for manganese (80 μg/L) was exceeded at 5 monitoring wells (levels up to 299 μg/L) and 3 private wells (levels up to 416 μg/L).

Secondary Maximum Contaminant Levels, which are not health based standards but are intended to be protective of aesthetic water qualities only, were exceeded for aluminum, iron, manganese, total dissolved solids and pH at a number of wells located throughout the Study Area, including both private wells and monitoring wells. SMCLs were exceeded at every monitoring well. Of the 14 private wells sampled, seven of the wells had at least one exceedance of a SMCL over the four rounds of sampling. Iron is the most prevalent compound exceeding an SMCL.

Although a few organic compounds were detected in wells sampled, all of the detects were very low and inconsistent (not repeated in more than a single round). In addition, none of the organic compounds exceeded any established regulatory standards, except for one instance of bis(2-ethylhexyl)phthalate, a common laboratory contaminant, which occurred slightly above the MTCA Method B standard in round 2 in a private well, but was not detected in either of the other three rounds. There is therefore no indication of organics contamination in groundwater at the Study Area.

The observed distribution of chemical constituents in groundwater around the Study Area indicate that waste disposal activities at the Mine are not the source of these compounds. Maximum levels of some compounds occur in wells which are hydraulically isolated from the Mine with no apparent pathway for chemical migration. Also, the levels observed at the Mine are consistent with reports in the literature which indicate that coal is a natural and well-known source for these chemical constituents. The levels observed fall within the range of reported values considered typical for coal-mine drainages in the State. Therefore, while SMCLs are exceeded for several compounds and a MTCA Method B cleanup level is exceeded for two compounds, the occurrence of these compounds is not related to prior waste disposal activities at the Mine, but rather to natural background levels typical of coal-bearing strata. There are therefore no Contaminants of Concern for groundwater at the Landsburg Mine site.

Surface Water. Arsenic exceeded a MTCA Method B standard for surface water at portal #2 and #3. The levels of arsenic observed are consistent with groundwater levels measured at the mine site. As discussed above, the occurrence of the compound in groundwater (and therefore surface water) is a result of natural background conditions. There are therefore no Contaminants of Concern for surface water at the site.

Soil. There are no identified contaminants of concern for soils outside of the trench. Within the trench, chromium, lead, PCBs, bis-(2-ethylhexyl)phthalate, methylene chloride, TCE and TPH exceed Method B standards in an area confined to the northern portion of the trench where waste disposal is thought to have occurred in the past. Soil contamination was not noted outside this area. These compounds are designated as COCs for soil inside the trench. On the basis of trench sampling conducted to date, however, and in conjunction with historical information and geophysics, potential contamination is believed to be restricted to the northern portion of the trench.

Therefore, apart from soils located within the subsidence trench in the area of known prior waste disposal activities, soil, groundwater and surface water media in the Study Area do not exhibit concentrations of chemical constituents above naturally occurring background levels. The only COCs identified in this RI are the 6 compounds indicated above for soils inside the trench.

6.6 Conceptual Model of Waste Fate and Migration

6.6.1 Prior Materials Discharged to Trench

As discussed above in Section 6.5, the RI data collection and evaluation activities have resulted in the conclusion that no chemical constituents are migrating off of the site in surface water or groundwater above naturally-occurring background levels. Chemicals are present above background and regulatory limits only in soils within the trench itself, and these occurrences are confined to the areas of known waste disposal. Other than these occurrences in soil, there are no observed measurable impacts within or outside of the Study Area from prior waste disposal activities.

These conclusions have been arrived at in spite of the reported disposal of significant volumes of waste at the site. It is therefore appropriate at this point to discuss the potential mechanisms or factors which may have resulted in the observed distribution (or lack thereof) of site chemicals, and specifically on the reasons why chemicals are not being detected off-site. There are four mechanisms proposed below that may explain, either singly or in combination, the apparent lack of chemical residues in groundwater and surface water leaving the mine site. There is uncertainty as to the cause, however, and the actual explanation probably represents a combination of factors. The best explanation that can be offered at this time is that the great majority of the liquid wastes disposed to the mine (in drums and as free liquids from trucks) was consumed in the fires and/or has already been discharged from the trench due to the very permeable nature of the trench materials and deterioration which typically occurs with drums. Some constituents were sorbed onto the coal or soil and remain immobilized. Much of the wastes were relatively inert or innocuous. A minor number of drums may be still intact and contain liquids. Solid wastes may also still be present in intact and damaged drums. A combination of four mechanisms probably occurred.

1. Wastes disposed in the trench are no longer present, either because they were consumed in the fires known to have occurred or have already discharged through the highly permeable mined out Rogers Seam.

2. The residual coal remaining in the mine, with its high sorptive capacity, has immobilized the wastes in-place.

3. Some of the drums were either empty when dumped or filled with relatively inert or innocuous substances. Much of the 200,000 gallons of oily wastewater would have had very low concentrations of chemicals.

4. Wastes are contained within intact drums and have not yet been released.

Mechanism 1. As discussed in Section 3.2.1, a series of major fires are known to have occurred in the trench during 1972. Most of the flammable materials present in the trench at that time was probably consumed. Also, as was shown in Section 3.6.3.3 (Hydraulic Properties), the mined out Rogers Seam is highly conductive and has the potential to transmit large quantities of water. Movement through the unsaturated zone would be very rapid also since the material present above the water table consists of loose, mined out debris which is essentially similar to the material present below the water table. Liquids discharged to the trench therefore would move rapidly downward to the water table where they would then travel quickly downgradient and exit from the mine. Since disposal was in the northern portion of the trench, liquids would have discharged to the northeast once they reached the water table. Discharge from the seam would have been to the glacial outwash deposits bordering the site and ultimately to the Cedar River and Puget Sound. However, given the lack of contamination observed in the fine-grained, carbonaceous deposits associated with the mine, the chance that chemicals have been retained within the coarse-grained fluvial deposits of the Cedar River is considered extremely unlikely.

Mechanism 2. Adsorption is where soluble substances are removed from solution by binding to the surface of a solid. Activated-carbon treatment of wastewater is a standard treatment technology to remove dissolved organic matter. Coal is commonly used in the production of activated carbon because it has a high sorptive capacity. The mine probably offered a significant capacity to adsorb (and absorb) organic contaminants due to the presence of coal and the large amount of surface area which was likely available for such interactions. Some quantity of the wastes discharged to the mine have been bound in a sorbed phase onto the coal surfaces.

Mechanism 3. It is not known whether the approximately 4,500 drums disposed in the trench were full, partially full, or empty. Likewise, it is not known what substances were contained in the drums. While many drums presumably contained flammable liquids (as evidenced by the fires), it is possible that a significant percentage of the drums were only partially full or empty. Likewise, it is possible that many of the drums contained inert materials. The same may be true of the oily wastewaters.

Mechanism 4. The results of the geophysical survey performed along the centerline of the Rogers Seam identified areas where ferrous materials are potentially buried beneath the trench floor. Records suggest that up to 4,500 drums were originally placed in the mine while about 100 were removed during the ERA. There is a high likelihood, therefore, that a large number of drums still remain in the trench at some depth below the trench bottom. Some of these drums may still be intact. The chance that the observed lack of contamination at the site is due to the wastes being contained within the drums is considered to be low, however. Mutch and Sutherland (1990), in a study estimating the life of landfilled drums, reported that corrosive pitting begins to compromise drum integrity within about two to nine years after landfilling, depending on pH and soil aeration. In case studies of drum life in landfills, drums began to leak within a few years of their deposition as a result of corrosive pitting. In addition, observations suggest a significant percentage of drums undergo immediate disruption and leakage as a result of rough handling, compaction, or intentional puncturing during landfilling. Therefore, while some wastes are probably still present within drums, most of the drums ruptured during placement, or have rusted and/or deteriorated over the years. Most of the drums removed during the ERA were severely deteriorated. Much of the liquid wastes contained within the drums has therefore been released. Any liquids released from drums would have moved rapidly through the trench, as with mechanism 1 above. In addition, 200,000 gallons of free liquids were reportedly discharged from trucks and were not subject to any containment. There is still the potential, however, that a limited quantity of liquid and solid waste may still be present within the trench in intact or partially intact drums.

6.6.2 Current Condition

The primary mode of potential chemical migration from the mine consists of the groundwater pathway. Geophysical data and historical information presented in this RI have indicated that potential waste may be buried beneath the bottom of the trench and is generally confined to the northern half of the site. Given that groundwater flow beneath this portion of the site is to the north and flow laterally away from the mine is considered to be negligible, the primary pathway of chemicals potentially exiting the mine is to the north. Future groundwater monitoring activities should therefore focus on detecting potential releases at the northern end. The chance that such a discharge could occur at the southern end is considered unlikely given the direction of groundwater flow and the apparent absence of waste in this portion of the Mine.

Once exiting the site, potential chemical constituents leaving the northern portion of the mine will flow primarily to the north and northeast towards the Cedar River, consistent with the local ground surface topography. Discharge to the river would occur at a point approximately one mile downstream of the City of Seattle's water intake at Landsburg. This flow will occur within the Rogers coal seam, which presumably extends downslope towards the river, and within the glacial outwash materials which overlie the coal. Figure 3-19 depicts the piezometric surface contours of the site groundwater system. Figure 3-24 depicts the primary pathway of potential mine chemicals exiting the site. As seen in the figure, there are no drinking water wells located along the primary pathway of groundwater flow.

While the primary flow direction is towards the river, it is also possible that flow could occur to the northwest within the glacial outwash to the north of the mine. If groundwater flows in this direction, potential receptor points would include wells PW-4 and PW-3 and the other private wells located along the Summit-Landsburg Rd (Figure 3-19). Well PW-4 is the closest well and is approximately 1,500 ft away from the trench. It is not considered likely, however, that groundwater flow would occur to these wells given the strong topographic gradient towards the river.

At the southern end of the mine, potential receptors include the cluster of wells along the Kent-Kangley Rd. just southwest of portal #3, and the Clark Springs facility. The series of wells near portal #3 are within about 300 ft of the portal. The Clark Springs facility is approximately 2,500 ft from the portal. It is not considered likely that these wells would ever be impacted.

7. REMEDIAL ACTION OBJECTIVES AND ASSEMBLY OF REMEDIATION ALTERNATIVES

This chapter presents the following Feasibility Study (FS) elements:

- **Development of remedial action objectives.** Objectives and cleanup levels are established that provide the basis for developing and evaluating alternatives for remediation of the site.
- **Identification and screening of remediation technologies.** Candidate technologies are screened on a site-specific basis to obtain a list of technologies feasible for use in assembling remediation alternatives.
- **Identification and screening of remediation alternatives.** Remediation technologies are assembled into a wide range of alternatives for remedial action at the site. The alternatives are then screened to obtain a focused list of potentially feasible alternatives for further consideration.

These components are presented in the following sections. The detailed development and evaluation of retained alternatives is presented in Chapter 8 and 9. Together these three chapters provide a complete FS for this site.

7.1 Development Of Remedial Action Objectives

Remedial action objectives (RAOs) are site-specific goals based on acceptable exposure levels that are protective of human health and the environment and consider applicable or relevant and appropriate requirements (ARARs). RAOs combine consideration of applicable or relevant and appropriate requirements (ARARs) and the specific constituents, affected media, and potential exposure pathways of the site. Remedial action objectives identify risk pathways that remedial actions should address, and identify site-specific acceptable exposure concentrations consistent with applicable regulations.

7.1.1 Remedial Action Objectives

As discussed in Section 6.5, the only identified constituents of concern found at the site as a result of past site activities were found at relatively low concentrations in surficial soil in the northern portion of the trench. Soils outside the northern portion of the trench, groundwater and surface water are not affected by the Landsburg Mine site.

Considering the information collected in the RI, the potential risk of identified constituents of concern, and potential migration pathways of materials disposed at the site, the remedial action objectives for this site are:

- Minimize the potential for future direct exposure of human or ecological receptors to any waste constituents that may remain at the site.

- Reduce the potential for migration of any waste constituents from the trench in groundwater, surface water, or airborne dust.

7.1.2 Preliminary Remediation Goals

Preliminary remediation goals (PRGs) are numeric expressions of remedial action objectives. A remediation goal is the maximum acceptable concentration of a constituent of concern to which the human or ecological receptors would be exposed via a specified exposure route (e.g., direct contact) under a specified exposure scenario (e.g., industrial land use). Remediation goals are generally established for constituents of concern as the lower of a numeric chemical-specific ARAR or a risk-based cleanup concentration. Remediation goals are presented as preliminary in the FS because the final remediation goals, or cleanup levels, are set in the Cleanup Action Plan (CAP).

Only a few constituents of potential concern due to disposal activities at the site were identified in the trench, and none in area surface or ground waters. Because of the variety of wastes that have reportedly been disposed in the Landsburg Mine trench, identified constituents of concern for the trench cannot be taken as representative of other wastes which may be buried in the trench. Additional constituents of concern could be encountered either during site excavation or in the event groundwater were to become affected. Therefore, it would have little meaning to establish remediation goals (cleanup levels) based on the few identified constituents of concern. In addition, setting PRGs for specific constituents is not necessary for remedies not involving removal of affected media (i.e., capping).

Nevertheless, the general framework which would be used to determine remediation goals for any identified constituents of concern can be established. Under MTCA, acceptable exposure levels for carcinogens are concentration levels that represent potential lifetime incremental cancer risk to an individual of 10^{-6} for individual constituents in a residential exposure scenario, 10^{-5} for individual constituents in an industrial exposure scenario, and 10^{-5} for combined constituent risks in both scenarios. For non-carcinogens, acceptable exposures levels are concentrations that correspond to a hazard index less than 1.0. In addition, as discussed in Section 4, MCLs are relevant and appropriate to this site.

Remediation goals for remedial action involving excavation are set as the MTCA Method B concentrations for site constituents of concern detected in excavated soil. Remediation goals for groundwater, for purposes of monitoring or groundwater removal, are set as the MCLs for site constituents of concern. Remediation goals are only applicable to constituents of concern that result from waste disposal activities at the Landsburg Mine site. As discussed in Section 6.5, remediation goals are not applicable, relevant, or appropriate for other constituents because they are present due to natural site conditions.

7.2 Identification And Screening Of Technologies

This section identifies and screens technologies that may be included as part of remediation alternatives for the Landsburg Mine site. A comprehensive list of technologies and process options that are potentially applicable to this site is developed to cover all the applicable general response actions. The list of technologies are then screened to develop a refined list of potentially feasible technologies that can then be used to develop remediation alternatives for the site. The remediation technologies are screened using the following criteria:

> **Effectiveness** - The potential effectiveness of the technology to (1) address site-specific conditions, including applicability to the media and constituents of concern for this site, (2) meet remedial action objectives, (3) minimize human health and environmental impacts during implementation, and (4) provide proven and reliable remediation under site conditions.
>
> **Implementability** - The technical and administrative feasibility of implementing a technology. Technical considerations cover site-specific factors that could prevent successful use of a technology, such as physical interferences or constraints, practical limitations of a technology, and soil properties. Administrative considerations include the ability to obtain permits and the availability of qualified contractors, equipment, and disposal services.
>
> **Cost** - The capital and operation and maintenance costs associated with the technology. Costs that are excessive compared to the overall effectiveness of the technology may be considered as one of several factors used to eliminate technologies. Technologies providing effectiveness and implementability similar to that of another technology by employing a similar method of treatment or engineering control, but at greater cost, may be eliminated. At the screening level, the cost evaluation is based on engineering judgment of relative costs.

The technologies and process options are screened against the criteria in the priority order listed above using the "fatal flaw" approach. This approach ranks the criteria in order of importance, as listed above. Once a technology is rejected based on effectiveness, it is not further evaluated based on implementability or cost. Similarly, if a technology is effective, but not implementable, the technology is rejected and evaluation of cost is not undertaken. This approach streamlines the evaluation of technologies while maintaining the MTCA screening methodology.

Evaluation and screening of technologies are performed in a single step. The key criterion in selecting the screening level (technology class, individual technology, or process option) is whether there is a significant difference between the technologies or process options when evaluated against the screening criteria (effectiveness, implementability, and cost). Technologies and process options that are judged to have significant differences are screened separately, and the retained technologies or process options will be developed into separate remediation alternatives to allow full evaluation and comparison.

Process options retained for any given technology that are screened together (i.e., not evaluated separately) are considered equally suitable (at the screening level of evaluation). Selection of representative process options is performed during the development of alternatives, so that best engineering judgment may be used to select and combine appropriate technologies and process options into cohesive, integrated remediation alternatives.

The potentially applicable technologies considered for the Landsburg Mine site are presented in Table 7-1. The technology screening is also summarized in this table. Brief descriptions of the listed technologies and discussions of the screening evaluations are provided below. Technologies retained through this screening process are then incorporated into remediation alternatives in Section 7.3.

7.2.1 General Response Actions

General response actions are broad categories of remedial actions that can be combined to meet remedial actions at a site. The following general response actions are generally applicable to most sites, including the Landsburg Mine site:

- No action
- Institutional controls (including monitoring)
- Containment
- Removal
- Ex-Situ Treatment (including reuse and recycling)
- In-Situ Treatment
- Disposal

Except for "no action," each of these response actions represents a category of technologies. The applicable technologies will vary depending on the media (e.g., soil or groundwater) and constituents of concern (e.g., organic compounds or metals). The discussion of technologies is organized below by general response actions for soil and groundwater (the applicable media).

7.2.2 Institutional Controls And Monitoring

Institutional controls are legal and physical restrictions to exposure to constituents of concern at the site. Risk is eliminated by institutional controls to the extent that they prevent exposure to affected media. However, institutional controls do not prevent off-site transport of constituents. Institutional controls include any maintenance required for ongoing effectiveness. Institutional controls are effective within their limitations, are easily implemented, and are low in cost. Institutional controls are typically included in any remedy where constituents of concern will remain after completion of remediation.

Site Access Restrictions. Access restrictions involve preventing access by unauthorized persons. Fencing, combined with warning signs, is the most common means of restricting access. Security patrols are sometimes included for high-risk areas, but would not be warranted for this site. Fencing provides a physical barrier to site access. Warning signs discourage trespass by warning potential intruders of the hazards of entering the area. Fencing and warning signs are retained for further consideration.

Land Use Restrictions. Land use restrictions are legal controls such as deed restrictions that guide development or activities at the site. Deed restrictions are notices of land use restrictions that accompany the deed to the property in a manner that is legally binding and must be transferred to all subsequent owners of the property. The restrictions would include a description of the site and reasons for the limits on future activity. Such restrictions would prevent activities or development that would cause direct exposure to constituents of concern, or that would compromise the integrity of the remedy. For example, deed restrictions could prohibit site development that could impair the effectiveness of a cap remedy. The site is currently considered a Coal Mine Hazard under the King County Sensitive Areas ordinance, which affects development activities. Land use restrictions are retained for further consideration.

Groundwater Use Restrictions. Withdrawal or use of site groundwater can be restricted by legal controls. These controls can eliminate or minimize risk due to exposure to groundwater affected by constituents of concern. For this site, there is no identified affected groundwater. However, groundwater use restrictions could be combined with monitoring to prevent exposure in the event that site groundwater were to become affected by waste constituents. Groundwater use restrictions are retained for further consideration.

Alternate Water Supply. Where constituents of concern are impacting an existing drinking water supply, an alternate source of drinking water may be supplied. Drinking water supplies are not currently impacted by the Landsburg Mine site. However, as discussed in Section 6.6, there is a slight possibility that local water supply wells could become affected in the future by site waste constituents. Provision of an alternate water supply would be a rapid, easily implemented means of responding to a groundwater problem, and is therefore retained for further consideration.

Monitoring. Site monitoring is a required component of any site remedy (including "no action"). Short-term monitoring is conducted to ensure that potential risks to human health and the environment are controlled while a site remedy is being implemented. Long-term monitoring is conducted to measure the effectiveness of the remedy and thereby ensure that the remedy continues to be protective of human health and the environment. Long-term monitoring would include periodic site inspections as necessary to determine maintenance needs (e.g., for fencing or a cap). A monitoring plan will be developed for the selected remedial action. The type of monitoring performed will depend on the nature of the remedy. Monitoring could include periodic sampling and analysis of air, surface water, and groundwater, as appropriate.

7.2.3 Containment

In-situ containment is a general response action used to prevent exposure to material affected by constituents of concern that are left in place, and to control migration of constituents. Containment technologies are identified and screened in this section.

7.2.3.1 Trench Backfill

The site contains a trench that, due to its depressed elevation, collects surface water drainage. The collected surface water then infiltrates into the groundwater, increasing the local groundwater flow rate and the potential for migration of any constituents of concern in the subsurface. Backfilling the trench in the area of waste disposal would prevent direct contact with any constituents of concern in the trench. The backfill would provide a thick physical barrier that would greatly enhance the effectiveness and reliability of a cap or other containment remedy. The backfill, even without a cap, would also prevent off-site migration of constituents of concern in airborne dust or surface water. By significantly reducing infiltration of stormwater run-on currently collected in the trench, backfilling would also greatly decrease the potential for groundwater becoming affected by any constituents of concern. In addition, filling the trench in the area of waste disposal would make stormwater management easier for capping. Trench backfill would be restricted to the area of former waste disposal.

The trench also presents physical hazards which are the result of historic coal mining activities and are not the result of waste disposal activities. Backfilling the trench as part of environmental remediation would result in incidental reduction of these hazards. However, the scope of MTCA and remediation at this site is limited to environmental effects of waste disposal activities. Therefore, removal of physical trench hazards is not a remedial action goal at this site. Hazards resulting from historic mining activities fall under the jurisdiction of the Office of Surface Mining (OSM) of the U.S. Department of the Interior. The OSM has a program for addressing mine subsidence such as the Landsburg Mine trench under the Abandoned Mine Reclamation Fund. Coal lands are eligible for reclamation under this program if they were mined prior to August 3, 1977, were subsequently abandoned, and are in need of partial or complete reclamation. Therefore, trench backfilling or other methods of addressing any physical hazards at this site due to mining hazards would need to be addressed under the OSM Abandoned Mine Reclamation Fund program.

Suitable fill material would include any inert material capable of bearing overlying loads without undo settlement. Such materials could include, but are not limited to, coal refuse, shale, sandstone, broken concrete, and soils. The trench would not require backfilling to current grade, so long as good stormwater drainage is provided. This could be achieved by a combination of cut and fill to achieve the desired grading, and by other stormwater controls discussed in Section 7.2.3.4. Topography after trench backfill, cut-and-fill, grading, and stormwater drainage are addressed in the detailed development of alternatives (Chapter 8). Backfilling the trench is retained for further consideration.

7.2.3.2 Capping

Capping is proven, effective technology for providing reliable long-term containment and preventing or minimizing off-site migration of constituents. Capping minimizes risk by preventing direct contact with waste and affected soil, and preventing off-site migration of constituents in surface water or airborne dust. Where infiltration through waste or affected soil is a concern, a low-permeability cap design is used to minimize the potential for constituent migration into groundwater by minimizing infiltration of precipitation.

Caps may be constructed of a variety of natural materials (i.e., clay, sand, and other soils), synthetic liners, geotextiles, and other geomembranes, and other synthetic materials (e.g., asphalt or concrete). They may consist of a single layer or be a composite of several layers. Caps provide containment in three primary ways:

- A cap serves as a physical barrier to prevent humans, other animals, and vegetation from coming in contact with materials affected by constituents of concern.
- A cap prevents erosion of soil by surface water and wind, thereby preventing off-site transport of constituents of concern via these media.
- A low-permeability cap contributes to run-on and run-off control and minimizes infiltration of surface water, decreasing the potential for transport of constituents of concern from waste or affected soil to groundwater.

Caps can be designed to be compatible with many potential future site uses. Land use restrictions and other institutional controls are typically employed along with capping to prevent future site activities that could violate the integrity of the cap (e.g., excavation or support pilings for buildings). Long-term maintenance and monitoring are required.

Capping is readily implemented using standard design and construction techniques. It is relatively low cost, and thus highly cost-effective (i.e., high incremental protection relative to remediation cost). A wide variety of cap designs are possible that vary in effectiveness, implementability and cost. The following representative cap designs have been identified and screened for consideration:

- Soil
- Paving
- Low-permeability clay with vegetative soil cover
- Synthetic membrane with vegetative soil cover
- Combined synthetic membrane and bentonite liners with vegetated soil cover
- RCRA Subtitle C design

These designs are illustrated in Figure 7-1 and discussed below.

Soil Cap. As shown in Figure 7-1(a), a soil cap would consist of a minimum of 18 inches of clean soil fill overlain by 6 inches of vegetated topsoil. The soil cover would augment the containment provided by trench backfill, and provide additional evapotranspiration to decrease infiltration. A soil cover would be just as effective as low-permeability cap designs at preventing direct contact and off-site migration of constituents in surface water or airborne dust. While not as effective as a low-permeability design at minimizing infiltration, most of the decrease in infiltration (for any cap design) compared to current conditions ("no action") would be provided by the combined effects of trench backfill preventing stormwater run-on and the evapotranspiration provided by the soil cap. A soil cap would be easier to construct and less costly. Because of possible mine subsidence and trench settlement, it would be easier to maintain. This cap design is retained for further consideration.

Paving. Asphalt and/or concrete pavement is suitable for providing a cap for some sites. However, paving as a cap is generally considered for developed areas where there is a need to combine containment with continued commercial or industrial use (e.g., as a parking lot). Paving requires higher maintenance than caps with soil or synthetic liners, and is prone to cracking. Trench settlement would increase maintenance costs. Paving would increase stormwater run-off velocities, which at this site (given its topography) could enhance erosion of surrounding areas. Paving is therefore not retained as a cap design.

Low-Permeability Soil Cap. As shown in Figure 7-1(b), a low-permeability soil cap would consist of a liner of 2 feet of compacted low-permeability soil, overlain by 6 inches of vegetated topsoil. The cap would be designed to meet MFS (WAC 173-304). By providing a low-permeability liner in addition to stormwater diversion, this cap design would decrease infiltration through the disposal area and thereby decrease the potential for groundwater becoming affected by constituents of concern. A soil liner would be easier to repair in the event of settlement than a synthetic liner. This cap design is therefore retained for further consideration.

FML Cap. As shown in Figure 7-1(c), a FML Cap would consist of a synthetic flexible membrane liner (FML) under 6 inches of clean fill soil and 6 inches of vegetated topsoil. The cap would be designed to meet MFS (WAC 173-304). As with the low-permeability soil cap, a FML cap would provide additional protection against the potential for groundwater to become affected by constituents of concern. The FML, properly installed and maintained, is less permeable than a low-permeability soil liner. However, FML is susceptible to failure with settlement. A low-permeability soil cap could be more reliable because soil tends to be self-sealing, and would also be somewhat easier to maintain. Both are readily constructed using standard methods and contractors routinely employed for landfills. This cap design is retained for further consideration.

FML/GCL Cap. As shown in figure 7-1(d), the composite FML/GCL cap would consist of 2 liners: a FML and a geosynthetic clay liner (GCL). The GCL is essentially very low permeability clay (bentonite) between geotextile layers. The liners would be covered by 6 inches of clean fill soil and 6 inches of vegetated topsoil. Because of the redundant liners, the FML would not need to be as thick as in the FML cap. The FML/GCL cap would exceed MFS (WAC 173-304). By providing redundant liners, this cap would be more reliable and therefore somewhat more protective than the FML or low-permeability soil cap designs described above. However, the liners are susceptible to failure with settlement. Having two liners would increase the difficulty in installation and the cost of the cap over a single-liner design. The FML/GCL cap design is included to allow consideration of the marginal benefit of conservative cap design, and is retained for further consideration.

RCRA Subtitle C Cap. Design standards for hazardous waste landfills under RCRA (40 CFR 264) provide the most conservative cap design. This composite cap type provides combined low-permeability soil and synthetic liners (similar to the FML/GCL cap), specifies lower permeability soil (10^{-7} cm/sec instead of 10^{-6} cm/sec), and adds a drainage layer above the liners to route infiltration from the vegetative layer away from the liner. This complex design, although implementable, would be significantly more difficult to install and much more expensive than the other designs. The design permeability of a RCRA cap would not be less than the FML or FML/GCL caps, and would not reduce infiltration significantly compared to the low-permeability soil cap. The RCRA cap is designed to provide additional protection by adding reliability, in the form of redundant protection against infiltration. However, at this site, a RCRA cap would be susceptible to failure with settlement. Given the limited potential risk at this site, the lower implementability, and greater cost, the marginal added benefit is not justified. This cap design is therefore not retained.

7.2.3.3 Dust Control

Dust control incorporates any measures to prevent wind dispersion of soil affected by constituents of concern. Several approaches to dust control are available. Water is the most common method of short-term dust control. For long-term dust control, vegetation can be planted to hold the soil together and reduce wind velocity at the ground surface. Migration of site constituents via dust is not a problem at this site. However, excavation of the trench could generate dust from affected soil; therefore, dust controls are retained for possible use in conjunction with excavation.

7.2.3.4 Surface Water Controls

Surface water management involves controlling surface water run-on and run-off at the site. The purpose of these controls is to minimize erosion that can entrain exposed soil affected by constituents of concern, and expose underlying affected materials. Surface water controls by themselves are not generally effective as a permanent remedy. These controls may be used as short-term measures (e.g., during excavation), or as long-term measures (e.g., as part of capping). Surface water controls are proven technology, effective, easily implemented and inexpensive. They are therefore retained for use in conjunction with other remediation technologies.

Grading. Grading is used to promote stormwater drainage, which reduces infiltration through a cap, while minimizing erosion. At the trench, grading would also prevent or minimize stormwater run-on, thereby decreasing infiltration through the trench.

Stormwater Drainage Controls. In addition to grading, stormwater drainage can be controlled by berms and ditches or swales. Ditches and swales are channels designed to collect stormwater and route it to a desired discharge point. They may be unlined or, to reduce erosion, lined with gravel, concrete, synthetic membranes, or other materials. Piping can also be used to route collected stormwater to the desired discharge point. Retention basins can be used to slow flow velocities and trap sediment, thereby decreasing erosion potential.

Vegetative Cover. Vegetative cover is a common, highly effective means of reducing soil erosion. Once established, vegetation requires little or no maintenance. Vegetation also provides evapotranspiration that reduces infiltration of stormwater through a cap.

7.2.3.5 Vertical Barriers

Vertical barriers are intended to minimize lateral flow of groundwater, thereby preventing or minimizing migration of constituents of concern. For reliable containment, vertical barriers should be keyed into a continuous low-permeability stratum or an artificial horizontal barrier to prevent migration underneath the vertical barrier. Slurry walls, sheet pile walls, grout walls, and cryogenic walls are established technologies for constructing vertical barriers under appropriate site conditions.

Slurry Walls. Slurry walls are constructed by excavation of a vertical trench and adding admix to soil in a slurry to construct a low-permeability vertical wall. The slurry mixture is used to shore the trench to prevent collapse during construction and serves as part of the low-permeability backfill. Bentonite and cement/bentonite are common admixes. Cement admixes are used where structural strength is required in addition to low permeability.

Grout Wall. A vertical barrier can be constructed with grout, using grout injection, "deep soil mixing", or a combination of these methods. As with slurry walls, a grout wall must be keyed into a horizontal confining layer to provide complete containment. Grout injection involves drilling boreholes and pressure-injecting grout into the boreholes and outward into the surrounding soil. The boreholes are spaced closely enough to obtain overlapping grout zones, forming a continuous wall. Deep soil mixing uses a hollow-shaft auger to mix soil and grout. As the augers are advanced vertically, grout is injected into the soil and blended.

Sheet Pile Wall. Sheet pilings are interlocking steel sheets that are driven into the soil to form a wall. Sheet piling is primarily used for providing structural containment in excavations. Leaking can occur between individual sheets unless special measures are taken (such as grouting) to seal the seams. Steel piles will eventually deteriorate via corrosion.

Cryogenic Wall. A cryogenic wall (freeze wall) is an established technology for short-term containment during dam construction and deep excavation, where technical difficulties can make this expensive technology cost-effective. Frozen soil is substantially less permeable than unfrozen soil, forming a barrier to migration of constituents of concern. A cryogenic wall is formed by installing steel pipes using drilling techniques and circulating refrigerant to freeze the water in the surrounding soil. Freeze walls may be installed vertically or, using slant drilling, at an angle. A freeze wall can thus be used to prevent both vertical and horizontal migration. Freeze walls for long-term containment are unproven technology. Continuous operation of a cryogenic (refrigerant) unit is required to prevent the wall from melting, making it an active barrier, in contrast to more permanent and proven passive barriers. This technology is therefore not considered suitable as permanent containment.

Screening. The subsurface bedrock and coal would make it difficult to surround the trench with any vertical barrier. In addition, the site does not provide a continuous stratum into which a vertical barrier could be keyed. The great majority of the groundwater flow through the mine occurs along strike of the Rogers coal seam, towards the portals at the north and south ends of the mine. Groundwater flow across bedding is very small due to the layered nature of the materials and the low permeability of the bedrock strata which lay to either side of the disposal trench. Experience with inflow during mining indicates that existing side walls are at least as effective as barrier walls.

Barriers, if they were to be installed, would be placed across the coal seam at the ends of the mine where groundwater discharge occurs. However, hydraulic containment (see Section

7.2.3.7) would provide effective, more easily implemented, and less costly containment, should this become necessary in the future. Therefore, no vertical barrier technologies are retained.

7.2.3.6 Horizontal Barriers

Horizontal barriers are intended to minimize the vertical migration of constituents of concern in groundwater in an aquifer, into deeper aquifers, or under vertical barriers. Grout injection and cryogenic barriers are technologies that could be used to construct horizontal barriers under appropriate site conditions.

Grout Injection. A horizontal grout barrier is constructed by drilling inclined or horizontal boreholes under the zone containing constituents of concern. Grout is injected into the boreholes and outward into the surrounding soil. An overlapping pattern of holes should form a continuous grout barrier under the affected zone. However, grout injection to form a low-permeability horizontal barrier is unproven technology that has not been performed at full scale. Inclined and horizontal drilling is more difficult to accomplish and control than vertical drilling, and requires specialized equipment. The continuity of the completed barrier is difficult to verify, particularly with heterogeneous materials in the subsurface.

Cryogenic Wall. Ground freezing (cryogenic barriers) has been proposed for constructing horizontal barriers. This is the same technology has been proposed for vertical barriers (see preceding discussion). This technology is unproven for long-term containment. The cryogenic plant is required to operate indefinitely to maintain the barrier, making it an active barrier in contrast to more permanent and proven passive barriers. This technology is therefore not considered suitable as permanent containment.

Screening. In general, horizontal barriers are difficult to implement. They would be very difficult or impossible to construct at this site because of the combination of near-surface bedrock and coal. Because of difficulties in construction and verification (quality control), horizontal barriers have questionable effectiveness and reliability. Given the subsurface mining performed at this site, the reliability would be even less than elsewhere. In addition, they would be ineffective at limiting potential migration through mine portals, which is the primary means of constituent transport at this site. For these reasons, no horizontal barrier technologies are retained.

7.2.3.7 Hydraulic Groundwater Containment

Hydraulic containment consists of active manipulation of groundwater heads to prevent off-site migration of groundwater. The containment may be accomplished by lowering groundwater elevations so that groundwater flows into (and not out of) the zone affected by constituents of concern. Alternatively, groundwater may be intercepted at the boundary of the affected zone to prevent off-site migration. At this site, groundwater already meets remediation goals. Therefore, hydraulic containment is not necessary, and hydraulic containment technologies are not retained.

7.2.4 Removal

Removal is a general response action for media affected by constituents of concern prior to ex-situ treatment (on-site or off-site) or disposal. Groundwater removal would be a component of hydraulic containment (see Section 7.2.3.7). Removal can be complete (i.e., all portions of soil or groundwater with constituents above remediation goals), or partial (i.e., the highest concentrations of a constituent of concern). Removal by itself is not a complete remedial action, but must be combined with subsequent disposition of the removed media.

7.2.4.1 Excavation

Removal of waste and affected soil from the trench may be technically feasible. Equipment that would be considered includes backhoes, loaders, bulldozers, clamshells, and draglines. The choice of equipment is typically made by the excavation contractor and is not normally part of design.

For a variety of reasons, excavation at this site would be difficult, expensive, and hazardous. In addition, trench excavation would have the potential to cause adverse impacts on groundwater and create risks to human health and the environment. Excavation concerns include the following:

- **Stability of the trench base.** Because the trench is likely underlain by shallow mine openings and voids, it would not be safe to complete the excavation with heavy equipment inside of the excavation. Although the current trench subgrade might support light equipment, the risk of a subgrade collapse would increase as the soils were removed. Thus the majority of the work would probably have to be performed from above. This would require large draglines which would be expensive and difficult to control.

- **Stability of the trench sidewalls.** There would be no safe, practical method to work inside of the excavation. It would be difficult to control sidewall failures or fill collapse. These types of problems would slow down the excavation operation, significantly impacting costs and schedule. A variety of methods are available to shore the sidewalls such as soldier piles (with tiebacks or internal cross-lot bracing), structural slurry walls, several different grouting techniques, and others. However, these methods are very expensive and not appropriate for this type of application. It would be less expensive and less time consuming to simply deal with the sidewall problems when and if they occur then to install a structural shoring system.

- **Rupture of buried drums.** In all likelihood, excavation would damage drums, resulting in release of their contents to the environment. Release of drummed chemicals would create exposure to site workers, and increase the potential for off-site exposure of human and ecological receptors. The potential risk includes the potential for affecting groundwater that currently meets remediation goals. Chemical release also creates the potential for fire or explosion if the materials are flammable.

- **Worker exposure.** In addition to high potential for new releases from drums, excavation exposes site workers to constituents of concern in any affected soil, or in releases due to drum rupture or spillage. Appropriate personal protection equipment would be used to lessen this risk, but the risk would still be greater than without excavation.

- **Mobilization of constituents of concern.** By disturbing any constituents of concern that are currently buried and immobile (as evidenced by groundwater data), excavation creates the potential for mobilization of constituents to air, surface water, and groundwater. Appropriate measures would be used to lessen this risk, but the risk would still be greater than without excavation.

Excavation of waste and affected soil (partial or complete) would be necessary to allow ex-situ treatment or off-site disposal. Therefore, despite the many problems and concerns associated with it, excavation is retained to allow consideration of a full range of alternatives.

7.2.4.2 Groundwater Extraction

Groundwater may be removed for the purpose of treatment or containment. Extraction wells and interceptor trenches are common technologies for groundwater removal. However, groundwater at this site already meets remediation goals. Therefore, there is no need for groundwater removal or treatment, and no groundwater extraction technologies are retained.

7.2.5 Ex-Situ Treatment

7.2.5.1 Waste and Affected Soil

This section considers a wide range of technologies for ex-situ treatment following excavation. There is no identified need for treatment of waste or affected soil at this site. Soil identified as affected by waste constituents is found only in a limited area of the trench with relatively low constituent concentrations. However, in the event that the trench is excavated, there is a possibility that waste or affected soil would be encountered that would require treatment prior to disposal. A treatability study would be necessary to determine the appropriate treatment method, should the trench be excavated and material requiring treatment be encountered. Ex-situ treatment technologies are therefore identified and screened for this eventuality.

Treatment is intended to reduce the toxicity, mobility or volume of material affected by constituents of concern. Many treatment technologies convert constituents of concern to less toxic forms. Destruction or degradation of organic compounds is possible (e.g., oxidation to carbon dioxide and water) although not always feasible or cost-effective. However, metals cannot be destroyed by treatment. Metal toxicity can be reduced via chemical conversion to a less toxic compound of the metal, and metals can be immobilized by fixation (stabilization).

Reuse/Recycling. MTCA identifies reuse and recycling as first priority for consideration in site remediation. However, no waste materials have been identified at this site with the potential for reuse or recycling. Reuse or recycling typically requires a relatively homogenous material;

recycling processes are usually not feasible for complex mixtures of heterogeneous waste and affected soil. This technology is therefore not retained.

Dry Soil Sieving. Dry soil sieving is an ex-situ physical separation process that is performed without the addition of water. Soil is passed through one or more screens and separated into various size fractions. The concept behind remediation using this technology is that the concentrations of constituents of concern in soil particles often increase with decreasing particle size. In addition, large-mesh screens (e.g., a grizzly) are commonly used to remove debris and other large objects from waste and affected soil to facilitate handling. Although not as effective as physical soil washing, it is easy to implement and much less costly (generally a few dollars per ton of soil treated). When effective, it is highly cost-effective because of reduction in disposal costs. Therefore, this technology is retained for possible use in separating clean soil, debris, and affected soil in conjunction with excavation.

Physical Soil Washing (Aqueous Physical Separation). The term "soil washing" has been used to describe a variety of treatment processes. As used here, physical soil washing refers to soil washing for physical separation; "chemical extraction" is used to refer to processes using aqueous and non-aqueous solvents for extraction of constituents of concern. Physical soil washing is applicable to soil where the constituents of concern are concentrated in a particular size fraction. In practice, the majority of constituents of concern in soils are often associated with the silt and clay soil fractions (collectively called the fines), with coarser soil (sand and gravel) being relatively clean.

The effectiveness of physical soil washing is highly variable, depending on the constituents of concern and site-specific conditions. In addition, treatment of the washwater is necessary prior to discharge, and the fines must be dewatered for landfill disposal. Physical soil washing is also a relatively complex process and requires use of specialized contractors. Soil washing systems for site remediation are innovative and currently in various stages of development and implementation. Physical soil washing would not provide proven, reliable treatment for this site, would be difficult to implement, and would add significantly to remediation costs. This technology is therefore not retained.

Chemical Extraction. Chemical extraction is a generic term for treatment processes where a liquid solvent is used to extract constituents of concern from waste or affected soil. The spent solvent must then be treated or recovered and recycled. The terms "soil washing" and "solvent extraction" are sometimes used for processes included in this treatment category. Aqueous soil washing is included in this category when the purpose of the treatment is removal of constituents of concern from the soil, rather than separation of soil into affected and clean fractions as in physical soil washing. Other solvents and reagents that can be used include surfactants, liquid carbon dioxide, and triethylamine (TEA) for organic compounds; petroleum solvents for oil recovery; and acids or complexing agents for metals.

A number of chemical extraction processes, including extractive soil washing, have been attempted at bench and pilot scales with varying degrees of success. The effectiveness of chemical extraction is highly dependent on the constituents of concern and site-specific waste characteristics. Published data show large variations in effectiveness between sites. Chemical extraction at this site would have all of the problems cited for physical soil washing, but to a greater degree. It is less proven technology, more complex and difficult to implement, and more costly. This technology is therefore not retained.

Fixation (Chemical Stabilization). Fixation, also called chemical stabilization or simply stabilization, involves mixing soil affected by constituents of concern with binding agents to form a solid matrix that immobilizes the constituents of concern, and thereby reduces constituent mobility (leachability) and associated risk. Fixation typically uses pozzolanic agents, such as cement, fly ash, and lime. Proprietary additives are available that are claimed to improve immobilization. Fixation is a common, established technology for treatment of wastes and soils affected by heavy metals and high-molecular-weight organic compounds. Metals are typically immobilized by both chemical bonding and physical entrapment; organic compounds are immobilized only by entrapment. Fixation is a proven technology for immobilization of a variety of constituents, and is not difficult to implement on-site or off-site. This technology is therefore retained for possible use, if required to meet regulatory requirements for treatment prior to off-site disposal.

Biological Treatment. Biological treatment is a class of technologies commonly applied for destruction of organic constituents of concern. Biological treatment can be performed ex-situ and in-situ, with varying effectiveness, and may be accomplished by aerobic oxidation or anaerobic reduction processes. Biological treatment technologies for soils generally fall into two classes: land treatment or soil piles, and aqueous biotreatment of slurries in tanks or ponds. Biological treatment can have high effectiveness for some constituents, such as petroleum hydrocarbons, and poor effectiveness for many others, such as PCBs and other chlorinated organic compounds. Biological treatment will not destroy metals or remove them from soil. It is usually not suitable for solids wastes with high concentrations of constituents of concern. The difficulty of implementation can vary widely, depending on the matrix and the constituents of concern. When effective, biological treatment is usually inexpensive relatively to other organic destruction technologies. Because of its limitations, and the uncertainties in treatment needs at this site, biological treatment technologies are not retained.

Chemical Oxidation/Reduction. Chemical oxidation-reduction reactions can be used to reduce toxicity or to transform a substance to one more easily handled. Oxidizing or reducing reagents (as appropriate) are added to cause or promote the desired reaction. For example, oxidizing agents can be used to destroy or detoxify organic compounds. However, chemical oxidation/reduction of solid waste or affected soil is unproven technology that would be expensive because it would require the addition of relatively large quantities of reagent. Other effective and less costly technologies are available for removal of organic compounds. This technology is therefore not retained.

Thermal Treatment. Thermal treatment technologies are primarily designed for destruction of organic constituents of concern. Incineration is the most common thermal treatment technology, of which there are a number of processes with varying strengths and weakness. Thermal desorption is another thermal treatment technology which can remove and recover constituents of concern for subsequent incineration. Some thermal desorber designs operate at temperatures that provide organic compound destruction via thermal cracking (pyrolysis). Thermal treatment is required in lieu of or prior to land disposal of some wastes. It does not destroy or immobilize metals; thus the ash from incineration is often treated by fixation before landfill disposal. Volatile metals (e.g., mercury) may vaporize during thermal treatment, requiring special treatment of the offgas.

Thermal treatment is typically the most effective technology for destruction of organic compounds, with few limitations on the organic constituents of concern that can be treated successfully. It is the most complex and expensive organic treatment process. Thermal treatment would be used only if required by waste disposal regulations (i.e., RCRA land disposal restrictions).

On-site thermal treatment would be difficult to implement both from a technical standpoint, and also administratively due to air permitting requirements and resistance often encountered from the public. On-site thermal treatment is therefore not retained. Off-site thermal treatment is retained in the event it is necessary to meet waste disposal requirements for waste that might be encountered if the trench disposal area is excavated.

7.2.5.2 Groundwater

Groundwater at this site already meets remediation goals; therefore, there is no current need to treat the groundwater. In the event that groundwater became affected in the future (see Section 6.6), groundwater treatment technologies would be selected based on the constituents of concern identified at that time. Potential groundwater treatment technologies that would be considered are listed in Table 7-1. However, as there is no current need to treat groundwater and groundwater treatment is not expected to be required in the future, groundwater treatment technologies are not retained.

7.2.6 In-Situ Treatment

This section considers technologies that treat constituents of concern in place. As with ex-situ treatment, the purpose of in-situ treatment is to reduce the toxicity, mobility or volume of constituents of concern. The same classes of treatment that are available for ex-situ soil and groundwater treatment are generally available for in-situ treatment. However, the treatment conditions are very different. There are a number of in-situ treatment technologies that could be considered, were there an identified need. These include:

- Biological treatment (soil/groundwater)
- Chemical oxidation/reduction (soil/groundwater)
- In-situ fixation (e.g., grout injection or deep soil mixing)
- Soil flushing
- Vapor extraction (soil/groundwater)

When feasible, the key advantage to in-situ treatment is that excavation of the soil is avoided. However, the key disadvantage to in-situ treatment is that the treatment process cannot be controlled nearly as well as the same treatment in a reactor or other process equipment following excavation. This lesser control results from a combination of greater difficulties in achieving desired process conditions, and the inherent heterogeneity of the subsurface. Therefore, an in-situ treatment process is generally less effective at achieving treatment objectives and less reliable in achieving uniform treatment than the corresponding ex-situ treatment process. Treatment effectiveness is also often difficult to verify.

At this site, there is no identified need for treatment. Therefore, in-situ treatment would not be more protective than capping and there is no need for in-situ treatment. For this site, treatment would be better performed ex-situ, if required. Given the disadvantages to in-situ treatment and the lack of an identified need for such treatment, no in-situ treatment technologies are retained.

7.2.7 Disposal

Disposal is a general response action for final disposition of excavated waste and affected soil, or waste generated by treatment processes. Because no on-site treatment technologies have been retained, this discussion of disposal is limited to landfill disposal of excavated waste and affected soil.

Landfill disposal relocates constituents of concern from one place to another for long-term containment; it is not treatment to destroy or detoxify constituents of concern. However, if needed, treatment can be used prior to disposal. For example, sludge is commonly treated by fixation (chemical stabilization) prior to disposal. The options for disposal following excavation are an on-site constructed landfill, and off-site landfill disposal (including any treatment under land disposal regulations).

On-Site Disposal (Constructed Landfill). The near-surface bedrock and other subsurface conditions, described in Section 3.3, would make construction of a lined landfill difficult at this site. In addition, these same subsurface conditions provide limited natural containment. For example, as described in Section 3.6, there is general north-south channeling of groundwater in the area of the trench.

Infiltration through a properly designed landfill is controlled by the cap, not the liner. Because of the thickness of trench backfill, in-place containment would provide greater protection against direct contact. In-place containment would also avoid the many problems involved with excavating the trench (see Section 7.2.4.1). Capping with groundwater monitoring would provide sufficient protection of human health and the environment, would be much easier to implement, and would be much less expensive. Off-site disposal would be available in the event an excavation alternative were selected. On-site disposal in a constructed landfill is therefore not retained.

Off-Site Disposal. Commercial or municipal landfills could be used for disposal of waste or affected soil excavated from the trench. The appropriate landfill would depend on the nature of the material for disposal. For hazardous or dangerous waste, the nearest acceptable landfill would be the Chemical Waste Management facility in Arlington, Oregon. For other wastes, non-hazardous landfills could be considered. Municipal landfills are allowed to accept waste that is not classified as hazardous under federal (RCRA) regulations or as dangerous under Washington State regulations. Off-site disposal is retained for further consideration.

7.3 Assembly And Screening Of Remediation Alternatives

Remediation technologies retained following the screening process are assembled into remediation alternatives in this section. The technologies are combined to create a wide range of alternatives that represent various approaches to achieving remedial action objectives. The methodology for assembling alternatives is briefly discussed in Section 7.3.1. Each alternative is described in Section 7.3.2 in sufficient detail to distinguish primary strengths and weaknesses. Section 7.3 presents a screening evaluation of the assembled alternatives based on three general criteria: effectiveness, implementability, and cost. The purpose of the screening evaluation is to reduce the number of alternatives for detailed development and evaluation in Chapter 8. A summary of the retained alternatives is provided in Section 7.3.4.

7.3.1 Assembly Of Alternatives

Remediation alternatives are developed to meet the following MTCA requirements:

- Protect human health and the environment,
- Comply with cleanup standards,
- Comply with applicable laws and regulations,
- Provide for compliance monitoring,
- Use permanent solutions to the maximum extent practicable, and
- Provide for a reasonable restoration time frame.

Consideration of public concerns is performed by Ecology after the FS is completed and is based on public comments on the draft Cleanup Action Plan (CAP). Public concerns may result in modifications to the remedial action proposed in the draft CAP. Any modifications would be incorporated into the final CAP.

Clean up technologies are considered in the following order of descending preference per WAC 173-340-360(4):

1. Reuse or recycling;
2. Destruction or detoxification;
3. Separation or volume reduction;
4. Immobilization of hazardous substances;
5. On-site or off-site disposal at an engineered facility;
6. Isolation or containment with attendant engineering controls; and
7. Institutional controls and monitoring.

To meet these goals, a broad range of remediation alternatives is initially developed using the following strategies:

1. No action (baseline for comparison to other alternatives).
2. Limited action (e.g., institutional controls).
3. In-place containment of waste, affected soil, or affected groundwater without treatment, but still achieving protection of human health and the environment.
4. Excavation and disposal (containment), with or without treatment as appropriate.

7.3.2 Description Of Alternatives

The remediation alternatives for the Landsburg Mine site are summarized in Table 7-2 and described below.

Alternative 1: No Action

A "no action" alternative is included as a baseline for comparison to the other alternatives. This alternative would leave the site in its current state, assuming no restrictions on future site use, no site maintenance, and no monitoring.

Alternative 2: Institutional Controls and Monitoring

The purpose of this alternative would be to decrease site risks by preventing exposure to constituents of concern or resulting from waste disposal activities at the site. Long-term maintenance and monitoring would be included to ensure the continued effectiveness of the remedy.

To prevent site exposure, institutional controls would include deed restrictions, fencing, and warning signs. Fencing around the trench would provide a physical barrier against trespass. Warning signs would be placed on the fencing to discourage trespass. Stormwater run-on would continue to collect in the trench and infiltrate to groundwater through soil potentially containing constituents of concern. Periodic site inspections and maintenance of the fencing, signs, and any other physical components of the institutional controls would be included.

Groundwater use restrictions would be employed to prevent exposure to site groundwater. Thus, if site groundwater were to become affected by waste constituents, there would be no immediate exposure. Exposure could occur only following off-site migration. Routine, periodic monitoring would detect constituents of concern in groundwater were it to become affected.

Groundwater currently meets remediation goals. Therefore, no groundwater containment or treatment is currently necessary. In the event that groundwater were to become affected by waste constituents from the site, groundwater containment and/or treatment could be readily implemented. Alternate water supplies (e.g., bottled water) could be provided while appropriate action for groundwater cleanup were being implemented. Therefore, with this contingency available, institutional controls and monitoring addresses the possibility of future groundwater concerns.

Alternative 3: Trench Backfill

This alternative would protect human health and the environment by providing long-term containment of any waste and affected soil in the trench. This alternative would consist of backfilling the trench in the area where waste disposal occurred, combined with leveling and grading to provide proper stormwater drainage and prevent stormwater collection in the trench area. It would greatly decrease infiltration to groundwater by preventing stormwater run-on and collection. The backfill would provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The top layer of backfill would be 6 inches of vegetated soil to provide evapotranspiration and minimize erosion. Appropriate stormwater control measures would be included. Institutional controls and periodic maintenance and monitoring would be included as described for Alternative 2.

The major steps in this alternative are:

1. Backfill the trench in the waste disposal area, including a vegetated soil cover.
2. Grade and provide appropriate stormwater controls.
3. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

Alternative 4: Soil Cap

This alternative would protect human health and the environment by providing reliable long-term containment of any waste and affected soil in the trench. The trench would be backfilled in the waste disposal area (as in Alternative 3) and covered by a soil cap. This cover would prevent collection and infiltration of stormwater run-on, provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The soil cap would provide a thicker vegetated soil layer than Alternative 3 for improved evapotranspiration and long-term erosion control. The extent of the backfill and cap would be limited to the waste disposal area.

The major steps in this alternative are:

1. Backfill the trench in the waste disposal area as required for capping.
2. Place a clean soil cap over the trench backfill, including appropriate stormwater controls.
3. Maintain the cap for 20 years.
4. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

Alternative 5: Low-Permeability Soil Cap

This alternative would protect human health and the environment by providing proven, reliable long-term containment of any waste and affected soil in the trench. The trench would be backfilled in the waste disposal area and covered by a low-permeability soil cap. This cover would prevent collection and infiltration of stormwater run-on, provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The key difference between this alternative and Alternative 4 is the inclusion of a low-permeability soil liner in the cap. The liner would decrease the amount of infiltration through the cap, thus decreasing the potential for affecting groundwater. The cap would meet MFS (WAC 173-304). The extent of the backfill cap would be limited to the waste disposal area.

The major steps in this alternative are:

1. Backfill the trench in the waste disposal area as required for capping.
2. Place a low-permeability soil cap over trench backfill, including appropriate stormwater controls.
3. Maintain the cap for 20 years.
4. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

Alternative 6: FML Cap

This alternative would protect human health and the environment by providing proven, reliable long-term containment of any waste and affected soil in the trench. The trench would be backfilled in the waste disposal area and covered by a low-permeability FML cap. This cover would prevent collection and infiltration of stormwater run-on, provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The key difference between this alternative and Alternative 4 is the inclusion of a synthetic low-permeability liner in the cap. The liner would decrease the amount of infiltration through the cap, thus decreasing the potential for affecting groundwater. As a barrier to infiltration, a synthetic liner and 2 feet of low-permeability soil (as in Alternative 5) are approximately equivalent. However, synthetic liners are more susceptible to failure with settlement than soil liners. The cap would meet MFS (WAC 173-304). The extent of the backfill cap would be limited to the waste disposal area.

1. Backfill the trench in the waste disposal area as required for capping.
2. Place a FML cap over the trench backfill, including appropriate stormwater controls.
3. Maintain the cap for 20 years.
4. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

Alternative 7: FML/GCL Cap

This alternative would protect human health and the environment by providing proven, reliable long-term containment of any waste and affected soil in the trench. The trench would be backfilled in the waste disposal area and covered by a low-permeability FML/GCL cap. This cover would prevent collection and infiltration of stormwater run-on, provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The key difference between this alternative and the preceding alternatives is the inclusion of 2 low-permeability liners. The cap would exceed MFS (WAC 173-304). Two liners do not provide lower infiltration than a single liner (provided it is properly designed, installed, and maintained), but provide additional reliability for long-term protection. However, synthetic liners are more susceptible to failure with settlement than soil liners. The extent of the backfill and cap would be limited to the waste disposal area.

The major steps in this alternative are:

1. Backfill the trench in the waste disposal area as required for capping.
2. Place a composite FML/GCL cap over the trench backfill, including appropriate stormwater controls.
3. Maintain the cap for 20 years.
4. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

Alternative 8: Excavation and Off-Site Disposal of Surficial Affected Soil and Capping

In this alternative, identified surficial soil within the trench containing concentrations of constituents of concern above remediation goals would be excavated and disposed off-site. However, protection of human health and the environment would be provided primarily by long-term containment of any waste and affected soil remaining in the trench. Following excavation of surficial affected trench soil, the trench would be backfilled and graded for proper stormwater drainage. Because waste and affected soil would presumably remain buried in the trench, a cap meeting MFS (WAC 173-304) would be placed over the trench (e.g., a low-permeability soil cap as in Alternative 5 or a FML cap as in Alternative 6). Groundwater protection is provided by the low-permeability liner included in the cap, which would minimize infiltration through residual waste and affected soil.

As discussed in Section 7.2.4.1, excavation creates risks for site workers and could result in exposure to or mobilization of constituents that are currently contained and immobile.

The major steps in this alternative are:

1. Excavate identified surficial affected soil in the trench and haul to an off-site commercial landfill for disposal.
2. Backfill the trench as required for capping.
3. Place a vegetated low-permeability cap (soil or FML) meeting MFS over backfill material, including appropriate stormwater controls.
4. Maintain the cap for 20 years.
5. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

Alternative 9: Excavation and Off-Site Disposal of All Waste and Affected soil

This alternative would provide long-term protection of human health and the environment by finding and removing all waste and affected soil from the trench for off-site disposal. The major steps in this alternative are:

1. Excavate the trench and remove all waste and affected soil.
2. Treat excavated material on-site or off-site as required to allow landfill disposal.
3. Haul waste and affected soil to off-site commercial landfill for disposal.

As discussed in Section 7.2.4.1, excavation creates risks for site workers and could result in exposure to or mobilization of constituents that are currently contained and immobile.

Appropriate disposal facilities would be used, depending on the waste designation (hazardous, dangerous, or non-hazardous). Treatment would be included in this alternative to the extent required to meet land disposal restrictions or other regulatory requirements. The need for treatment has not been established, and the type of any treatment cannot be determined at this time, due to the limited knowledge of specific constituents that would be encountered. Any required treatment would be performed either on-site or off-site, as determined appropriate at the time the need for treatment were identified.

Institutional controls, maintenance, and monitoring would not be necessary for this alternative because all waste and affected soil would be removed from the site.

7.3.3 Screening Of Alternatives

In this section, the remediation alternatives are screened to produce a refined list for detailed development and evaluation. The criteria for screening alternatives, as for technologies, are effectiveness, implementability and cost (see Section 7.2 for definitions). An alternative can be rejected because it is not sufficiently effective relative to another alternative or is not feasible to implement. An alternative can also be rejected by comparison to another alternative that is at least as effective for less cost, or is easier to implement for equivalent cost. An alternative can also be rejected in the case where the additional increase in effectiveness or implementability is not justified by the increased cost, provided the retained alternative is sufficiently protective of human health and the environment.

Alternative 3 (Trench Backfill) would fill the trench and provide proper stormwater drainage, which provides most of the protection in the other containment alternatives. However, Alternative 4 (Soil Cap) provides slightly more protection and reliability (due to a thicker vegetative soil layer) at nearly the same cost. Alternative 3 is therefore not retained.

Because waste and affected soil is presumed to remain buried in the trench, removal of a small quantity of surficial soil containing constituents of concern as provided in Alternative 8 (Excavation and Off-Site Disposal of Surficial Affected Soil and Capping) does not provide significant additional protection over the other containment alternatives. The identified affected soil in the trench is suitable for in-place containment. As with Alternatives 5 and 6, a low-permeability cap would still be included. Alternative 8 would remain primarily a containment alternative, but would be more difficult to implement and cost more, and is therefore not retained.

Alternative 9 (Excavation and Off-Site Disposal of All Waste and Affected Soil) would be very difficult to implement and by far the most costly alternative. Given the lack of constituents of concern in groundwater, the benefit (if any) is likely to be small. However, Alternative 9 is retained for detailed development and evaluation to allow comparison of the containment alternatives to an alternative that does not rely on on-site containment.

The remaining alternatives are protective of human health and the environmental, are implementable, and relatively cost-effective. These alternatives are therefore retained for detailed development and evaluation.

7.3.4 Summary Of Retained Alternatives

Based upon the screening of alternatives in the preceding section, the following alternatives are retained for detailed development and evaluation:

Alternative 1: No Action
Alternative 2: Institutional Controls and Monitoring
Alternative 4: Soil Cap
Alternative 5: Low-Permeability Soil Cap
Alternative 6: FML Cap
Alternative 7: FML/GCL Cap
Alternative 9: Excavation and Off-Site Disposal of All Waste and Affected Soil.

TABLE 7-1

SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

Technology	Screening Comments	Retained? (Yes/No)
INSTITUTIONAL CONTROLS AND MONITORING		
Site Access Restrictions		
Fencing	Effective, easy to implement, low cost	Yes
Warning signs	Effective, easy to implement, low cost	Yes
Security patrols	Expensive and unnecessary	No
Land Use Restrictions	Effective, easy to implement, cost uncertain (affects land value)	Yes
Groundwater use restrictions	Effective, easy to implement, low cost	Yes
Alternate water supply	Potentially feasible	Yes (contingency only)
Monitoring	Required component of site remedy	Yes
CONTAINMENT		
Trench backfill	Necessary component of many alternatives (e.g., capping). Prevents direct contact with any waste and affected soil in the trench by a thick layer of clean fill, greatly enhancing the effectiveness and reliability of any containment remedy. Prevents off-site migration of constituents of concern in airborne dust or surface water; reduces the potential for affecting groundwater by eliminating current collection and infiltration of stormwater run-on.	Yes
Capping	Capping is proven, effective technology for providing reliable long-term containment and preventing or minimizing off-site migration of constituents of concern.	
Soil cap	Potentially effective; readily implemented; inexpensive	Yes
Pavement cap (asphalt/concrete)	Subject to cracking; inconsistent with expected land use; not as reliable as other cap options of comparable cost	No

SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

Technology	Screening Comments	Retained? (Yes/No)
Low-permeability soil cap	Effective and readily implemented	Yes
FML cap	Effective and readily implemented; potential for failure in event of trench settlement	Yes
FML/GCL cap	Effective and readily implemented; potential for failure in event of trench settlement	Yes
RCRA Subtitle C cap	Other cap options provide sufficient protection for much less cost; potential for failure in event of trench settlement	No
Dust control	Potentially necessary during excavation or capping	Yes
Surface water controls Grading Stormwater drainage controls Vegetative cover	Useful component of cap remedy	Yes
Vertical barriers Slurry wall Grout wall Sheet pile wall Cryogenic wall (freeze wall)	Hydraulic containment effective, more reliable, and more constructable at this site.	No
Horizontal barriers Grout injection Cryogenic barrier	Not feasible for site conditions	No
Hydraulic groundwater containment	Groundwater already meets remediation goals; therefore, no need for hydraulic containment.	No
REMOVAL		
Excavation (soil/waste) Backhoe Loader Bulldozer Clamshell Dragline	Excavation would be feasible, but much more difficult than normal and expensive. Worker health and safety would be a concern, and constituents of concern not currently exposed to the environment would become exposed. Excavation concerns include: (1) stability of the trench base, (2) stability of the trench sidewalls, (3) rupture of buried drums, (4) worker exposure, and (5) mobilization of constituents of concern. See text for discussion.	Yes

TABLE 7-1

SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

Technology	**Screening Comments**	**Retained? (Yes/No)**
Groundwater extraction Extraction wells Interceptor trenches	Groundwater already meets remediation goals; therefore, no need for groundwater extraction.	No
EX-SITU SOIL TREATMENT		
Reuse/recycling	No waste materials identified with the potential for reuse or recycling; usually not feasible for complex mixtures of heterogeneous waste and affected soil	No
Dry sieving	Potentially effective; easy to implement; inexpensive means of reducing off-site disposal costs	Yes
Physical soil washing	May not be effective at this site; not established technology; difficult to implement due to the complexity and site constraints, unlikely to be cost-effective	No
Chemical extraction	Unproven; may not be effective at this site; difficult to implement; costly	No
Fixation (chemical stabilization)	Proven, effective treatment for metals and high-molecular-weight organic compounds; relatively easy to implement; moderate cost	Yes
Biological treatment	Not effective on many constituents of potential concern, such as chlorinated organic compounds and metals, therefore not suitable as general treatment for this site	No
Chemical oxidation/reduction	Unproven; may not be effective for site constituents of concern; other technologies are at least as effective and less costly	No
Thermal treatment On-site Off-site	On-site thermal treatment difficult to implement due to physical constraints and permitting difficulties; off-site retained in case needed to meet waste disposal requirements.	 No Yes

TABLE 7-1

SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

Technology	Screening Comments	Retained? (Yes/No)
EX-SITU GROUNDWATER TREATMENT Gravity separation Solids filtration Sludge dewatering Air stripping Biological treatment Carbon adsorption Chemical oxidation/reduction UV oxidation Ion exchange Precipitation Reverse osmosis Membrane filtration	Groundwater already meets remediation goals; therefore, groundwater treatment is not needed.	No
IN-SITU TREATMENT Biological treatment Chemical oxidation/reduction In-situ fixation Soil flushing Vapor extraction	In-situ treatment technologies are inherently more difficult to control than the corresponding ex-situ treatment technologies. Treatment effectiveness is often difficult to verify. At this site, no need for treatment has been identified. Therefore, in-situ treatment would not be more protective than capping and there is no need for in-situ treatment.	No
DISPOSAL		
On-site disposal (constructed landfill)	In-place containment (capping in combination with natural subsurface conditions) would provide sufficient protection; difficult to construct a lined landfill due to near-surface bedrock.	No
Off-site commercial landfill	Potentially feasible; expensive	Yes

TABLE 7-2

SUMMARY OF REMEDIATION ALTERNATIVES AND SCREENING

Alternative No.	Name	Description (Key Elements)	Retained? (Yes/No)
1	No Action	Current site conditions (no monitoring).	Yes
2	Institutional Controls and Monitoring	Deed restrictions; fencing and warning signs; periodic site inspection, maintenance, and monitoring.	Yes
3	Trench Backfill	1. Backfill the trench and grade for proper stormwater drainage. 2. Cover backfill with a 6-inch layer of vegetated soil. 3. Implement and maintain institutional controls and monitoring.	No
4	Soil Cap	1. Backfill the trench and grade as required for capping. 2. Place a clean soil cap over trench backfill, including appropriate stormwater controls. 3. Maintain the cap for 20 years. 4. Implement and maintain institutional controls and monitoring.	Yes
5	Low-Permeability Soil Cap	1. Backfill the trench and grade as required for capping. 2. Place a low-permeability soil cap over trench backfill, including appropriate stormwater controls. 3. Maintain the cap for 20 years. 4. Implement and maintain institutional controls and monitoring.	Yes
6	FML Cap	1. Backfill the trench and grade as required for capping. 2. Place a FML cap over trench backfill, including appropriate stormwater controls. 3. Maintain the cap for 20 years. 4. Implement and maintain institutional controls and monitoring.	Yes
7	FML/GCL Cap	1. Backfill the trench and grade as required for capping. 2. Place a composite FML/GCL cap over trench backfill, including appropriate stormwater controls. 3. Maintain the cap for 20 years. 4. Implement and maintain institutional controls and monitoring.	Yes

TABLE 7-2

SUMMARY OF REMEDIATION ALTERNATIVES AND SCREENING

Alternative No.	Name	Description (Key Elements)	Retained? (Yes/No)
8	Excavation and Off-Site Disposal of Surficial Affected Soil and Capping	1. Excavate identified surficial trench soil containing concentrations of constituents of concern exceeding remediation goals; haul to off-site commercial landfill for disposal. 2. Backfill the trench and grade as required for capping. 3. Place a vegetated clay or FML cap meeting minimum function standards over backfill material, including appropriate stormwater controls. 4. Maintain the cap for 20 years. 5. Implement and maintain institutional controls and monitoring.	No
9	Excavation and Off-Site Disposal of All Waste and Affected Soil	1. Excavate the trench and remove all waste and affected soil containing concentrations of constituents of concern exceeding remediation goals. 2. Treat excavated material on-site or off-site as required to allow landfill disposal. 3. Haul excavated waste and affected soil to off-site commercial landfill for disposal.	Yes

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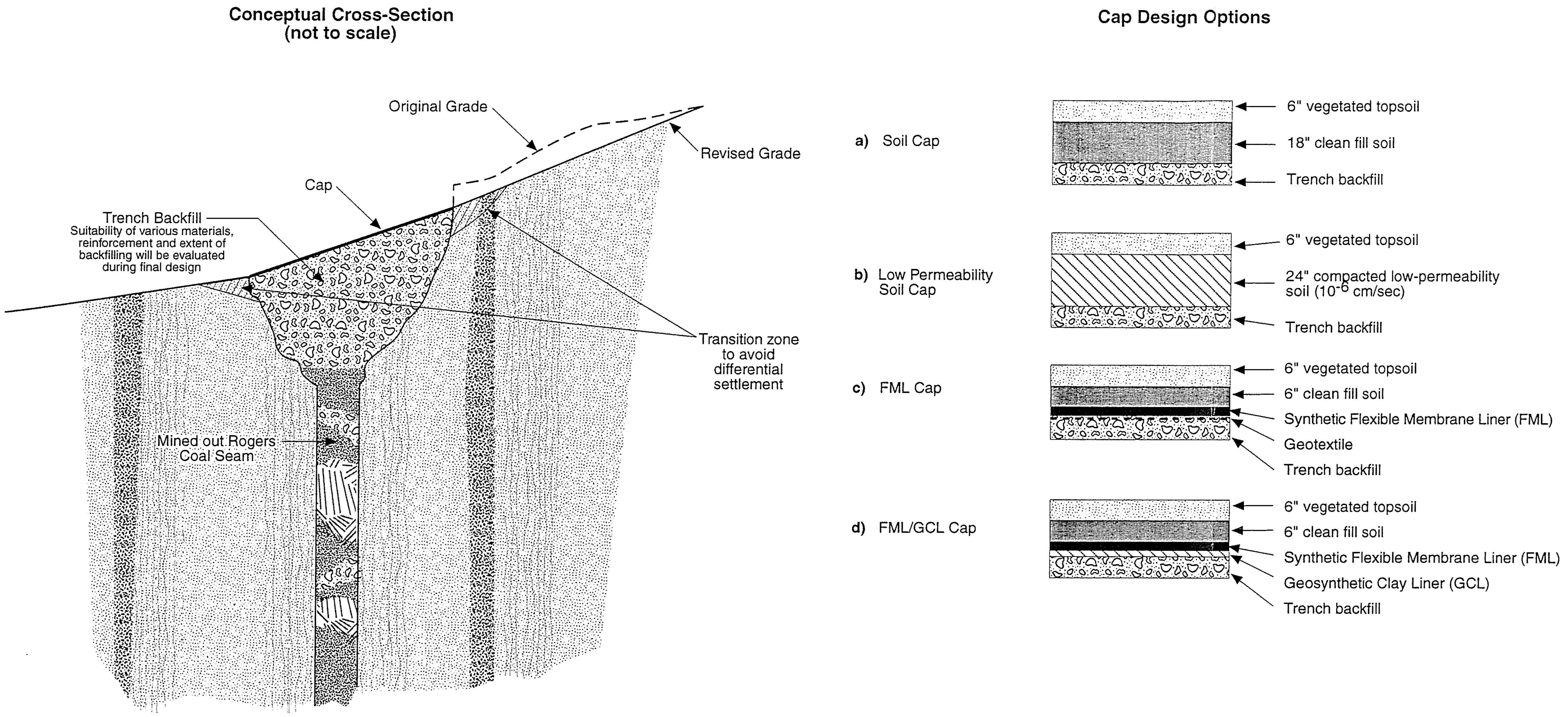

FIGURE **7-1**
CAP DESIGNS
LANDSBURG MINE SITE/RI-FS/WA

8. DEVELOPMENT OF ALTERNATIVES

In this chapter, remediation alternatives retained after screening in Chapter 7 are further developed to allow detailed evaluation. Based upon the screening of alternatives in the preceding chapter, the following alternatives have been retained for detailed development and evaluation:

Alternative 1: No Action
Alternative 2: Institutional Controls and Monitoring
Alternative 4: Soil Cap
Alternative 5: Low-Permeability Soil Cap
Alternative 6: FML Cap
Alternative 7: FML/GCL Cap
Alternative 9: Excavation and Off-Site Disposal of All Waste and Contaminated Soil.

For simplicity, Alternative 9 is referenced henceforth as "Excavation and Disposal".

It is necessary to make a number of design assumptions to fully develop and evaluate each alternative. These design assumptions are representative of the technologies used in the alternatives. However, the design assumptions used here are not necessarily the same as the design basis that would be used for the final, detailed design. In most cases, additional investigations would be necessary to allow final design. For example, additional soil sampling would be performed prior to excavation to better define the extent of soil contamination. Waste characterization would be required following excavation for potential treatment or disposal.

8.1 Common Elements

Several alternatives share common elements in their formulation. To avoid repetition, this section presents the descriptions of elements common to two or more alternatives. These common elements are then referenced in the descriptions of the alternatives.

8.1.1 Institutional Controls

All of the alternatives where contaminated material may remain on-site include institutional controls, with the exception of Alternative 1 (No Action). Alternative 9 (Excavation and Disposal) does not include institutional controls because no waste would remain on-site after completion of remediation. Institutional controls are a key component of the alternatives for maintaining long-term effectiveness.

Deed restrictions would be instituted to ensure that site use restrictions remain in force regardless of the property owner, and to notify any prospective purchasers of the presence of subsurface waste. Site use restrictions would prohibit using the site for any purpose incompatible with a waste disposal site. For capping alternatives, these restrictions would prohibit penetrating the cap and any site use that could damage the cap or significantly reduce its effectiveness. Warning signs would be used to provide notice of the presence of a waste site. Site use restrictions would remain in force indefinitely.

For Alternative 2 (only), fencing around the trench would be included to provide a physical barrier against trespass. Fencing is not needed for capping alternatives because the trench backfill would provide a very thick barrier against contact with any waste material, such that incidental trespass (which fencing is designed to prevent) or limited utilization of the site would not present a health risk.

Periodic site inspections and maintenance of a cap, fencing, signs, and any other physical components of the institutional controls would be included.

Groundwater use restrictions would be employed to prevent exposure to site groundwater. Thus, if site groundwater were to become affected by waste constituents, there would be no immediate exposure. Exposure could occur only following off-site migration. Routine, periodic monitoring would detect constituents of concern in groundwater were it to become affected prior to off-site migration.

Groundwater currently meets remediation goals. Therefore, no groundwater containment or treatment is currently necessary. In the event that groundwater were to become affected by waste constituents from the site, groundwater containment and/or treatment could be readily implemented. Alternate water supplies (e.g., bottled water) could be provided while appropriate action for groundwater cleanup was being implemented. Therefore, with this contingency available, institutional controls and monitoring address the possibility of future groundwater concerns.

8.1.2 Monitoring

Monitoring is included as part of all alternatives, except Alternative 1 (No Action). Separate monitoring programs will be used for the short term (during remedial action) and the long term (following completion of remediation). Detailed monitoring plans will be developed for the selected remedy during final design and presented in the Compliance Monitoring Plan for approval by Ecology.

8.1.2.1 Short-Term Monitoring

Short-term monitoring is conducted during remediation to ensure that there are no adverse effects from remediation activities, to provide quality control, and to confirm the attainment of cleanup standards and/or relevant performance criteria. Health and safety monitoring is also performed to ensure that site workers are not exposed to undue or unexpected risks.

Attainment of cleanup standards is applicable only for Alternative 9 (Excavation and Disposal) because the other alternatives use containment and monitoring rather than removal. Short-term monitoring for Alternative 9 would include confirmatory soil sampling and analysis to verify the attainment of cleanup standards in trench soil. Short-term monitoring for the other alternatives would primarily consist of construction quality assurance (CQA) to confirm attainment of construction specifications. CQA specifications would address acceptable materials for trench backfill, soil compaction, final grades, liner installation (i.e., for FML and GCL liners), and other aspects of the remedy that affect performance.

8.1.2.2 Long-Term Monitoring

Long-term, or confirmational, monitoring is conducted to 1) verify that the remedy performs as expected over time, and 2) allow timely maintenance of a cap and other physical components of the alternative. Periodic site inspections and surveys would be sufficient for determining maintenance needs and monitoring cap performance. Cap performance is also monitored by groundwater monitoring. No long-term monitoring would be required for Alternative 9, assuming all waste could be removed from the trench. Long-term monitoring would continue during the post-closure period, assumed for the purposes of the FS to last 20 years per WAC 173-304, and then cease.

Cap Monitoring. Cap monitoring would consist primarily of visual inspections for damage and subsidence. The cap would be periodically examined for the presence of off-sets, scarps, low-points, ponded water, odd changes in grade, excessive erosion, and the condition of the vegetative layer. For the first year, such inspections may be performed on a quarterly basis and would eventually be reduced to once a year until the end of the post-closure period. The cap monitoring program would essentially be identical for all cap alternatives.

Groundwater Monitoring. Groundwater monitoring would include periodic groundwater sampling and analysis at selected key locations throughout the site to confirm that concentrations of constituents of concern from waste disposal activities do not exceed acceptable limits. Site groundwater currently meets remediation goals, so the monitoring program will be designed for detection of release of waste constituents into site groundwater, should it occur. Because groundwater from the trench is channeled by the trench sidewalls with vertically sloping rock strata, providing some natural containment, monitoring where the groundwater exits the trench (i.e., the north and south portals) is sufficient to detect any release that could occur. As discussed in Section 3.6, the primary pathway of constituents of concern potentially exiting the mine is to the northeast toward the Cedar River. Therefore, groundwater monitoring would focus on detecting potential releases at the northern end (i.e., LMW-2 at portal #2). However, to detect the highly unlikely occurrence of constituent release to the south, monitoring may be provided there also (i.e., LMW-3 at portal #3). In the event that a release is detected, then the potential migration of affected groundwater would be evaluated and additional wells sampled and analyzed as necessary to monitor movement of the affected groundwater.

If a release were to occur, it would be more likely during or immediately after when the trench is being filled. Based upon the reported handling of drums during placement in the trench, and given the length of time since placement, most drums are probably already breached. The additional load of the backfill, however, may further collapse the drums, increasing the potential for a release. Affected soil could also be compressed, potentially (but not probably) leading to migration of constituents of concern. After trench consolidation, the stresses would have equilibrated and the potential for a release would be much less. Considering that the travel time of a release, were it to occur, could be as low as a few days, frequent monitoring is appropriate during backfill placement. Therefore, the sampling program would have two components: 1) near-term, frequent monitoring (which could be considered short-term monitoring) during trench backfilling; and 2) confirmational monitoring for the remainder of the 20-year post-closure care period.

Details of the groundwater monitoring will be developed during final design and presented in the Compliance Monitoring Plan. It is anticipated that the program will include the following elements:

- Monitoring would be performed using 2 monitoring wells, one each at the north and south portals (e.g., existing wells LMW-2 and LMW-3). Because the hydraulic conductivity is much greater longitudinally in the mine than laterally (see Section 3.6.3), monitoring these two locations would be sufficient to detect release of constituents of concern. If constituents were detected at levels of concern in these 2 monitoring wells, then additional wells could be sampled and analyzed to determine the extent of constituent migration. However, if constituents of concern are not detected at the north or south portals, then it is safe to assume that no other wells are affected by mine constituents of concern, and monitoring additional wells would simply be wasted effort.

- Frequent monitoring of these 2 wells would be performed during trench backfill and cap construction, which is estimated to take approximately 8 weeks. Samples would be obtained two times per week from these wells and analyzed for pH, specific conductance (as an indicator for metals and other inorganic compounds), and a screening-level analysis for organic compounds. An organic compound screening analysis would be selected capable of detecting a wide range of potential organic compounds. One suitable analysis would be Method 418.1 (which detects any carbon-hydrogen bond by infrared spectrophotometry) modified to report detection of any organic compound. Any detections or anomalies in the screening analyses would be subject to more detailed laboratory analysis. For confirmation, samples would be analyzed every other week for pH, key metals, and TOC.

- If an acute release is to occur, it is most likely to occur when the load is imposed (i.e., during trench backfill). However, for added safety, near-term monitoring would continue for an additional 4 weeks. This monitoring would consist of weekly sampling and analysis for pH, key metals, and TOC.

- Long-term (confirmational) monitoring would start quarterly, then decrease to annual as warranted by monitoring results. For this FS, it was assumed that the monitoring frequency would be quarterly for the first year, semi-annual for the next four years, and annual thereafter until completion of the 20-year post-closure period.

- Long-term monitoring would consist of annual and screening-level monitoring. Annual monitoring would provide comprehensive monitoring for specific constituents of potential concern, and would consist of full GC/MS analysis (volatiles, semivolatiles, and pesticides/PCBs) and key metals. Selected general water quality parameters (pH, specific conductance, TSS, and TDS) would also be included. Screening-level monitoring would be conducted when the monitoring is more frequent than annual (i.e., quarterly or semi-annually), and would use indicator parameters. More in-depth analysis would then be performed if screening monitoring were to indicate that constituents could be present at levels of concern.

8.1.3 Trench Backfill

All of the capping alternatives include first filling the trench to provide a surface for cap construction. The backfill would also provide a thick physical barrier that would greatly enhance the effectiveness and reliability of the cap.

The trench also presents physical hazards which are the result of coal mining and not the result of waste disposal activities. Remediation at this site is limited to environmental effects of waste disposal activities. Therefore, removal of physical trench hazards is not a remedial action goal at this site (see Section 7.2.3.1 discussion). The trench would not require backfilling to current grade, so long as good stormwater drainage is provided (see Section 8.1.4). However, backfilling the trench as part of environmental remediation would result in incidental reduction of physical hazards. Only the areas to be capped (Figures 8-1 and 8-2; see Section 8.1.5) would be filled.

Outside the trench, the ground surface would be cleared and grubbed to remove organic debris. The topsoil would be stockpiled for use in the vegetative cover layer of the cap. In the trenches, trees and large brush would be removed to prevent vertical transmissive zones through the backfill, when the trees eventually decay. This would also prevent excessive settlement of the backfill, which might occur if backfill is placed on a "mat" of small trees. Because of safety concerns, small equipment inside the excavation or cranes outside the excavation would be appropriate.

Suitable fill material would include any inert material capable of bearing overlying loads without excessive settlement. The most economical local source of suitable fill would be used; the selection of the source(s) of trench backfill will be made during final design. For purposes of this FS, it is assumed that backfill would consist primarily of soil and rock from areas adjacent to the trench area to be capped. Additional material from the south area of the site would probably also be needed. On this basis, the trench fill is assumed to consist of a silty sand and gravel (till), sand and gravel (outwash), and/or excavated rock fill (which would likely breakup into a silty granular fill).

Filling the trench will induce settlements which must be accounted for in the design and installation of a cap. The existing materials in the trench are expected to be moderately compressible due to their loose nature and inclusion of construction debris and organic materials. Backfilling is expected to induce compression of these materials which will result in surface settlement on the order of 6 inches to a foot. Settlement of the new fill depends on the type of fill used and the method of placement. End-dumped fill of poor quality could settle on the order of 2 to 4 feet. A better quality fill with moderate compaction effort might settle on the order of 3 to 6 inches.

About 75 percent of the settlement would be expected to occur within a few weeks of fill placement provided the cover restricts future infiltration of water. The remainder of the settlement will continue gradually for many years at a decreasing rate. The trench could be over-filled by about 4 feet for a period of about one month to both add a small "surcharge" and to allow time for most of the settlement to occur. After the surcharge period, the backfill would be graded for cap placement.

A conceptual cross section of the backfilled trench is shown on Figure 7-1. The lower zone of the trench backfill would not be compacted because of the unacceptably high safety risk of sudden trench collapse caused by heavy vibrating equipment. The upper portion of the backfill would be compacted to reduce the settlement of the cap foundation. Once the trench has been filled, the backfill would be allowed to settle and consolidate. Final grading and cap construction should be delayed until after the surcharge period. A period of at least one month should be sufficient for this purpose.

There will be a tendency for a sharp differential settlement to occur at the location of the trench sidewalls. In addition, use of poor quality and variable fills can result in differential settlements away from the trench sidewalls. To limit abrupt differential settlement, over-excavation and backfill would be considered at the top of the sidewalls to create a transition zone, as shown on Figure 7-1.

The concern over potential settlement is greatest where a synthetic liner is included in the cap design (Alternatives 6 and 7) because liner failure (i.e., tearing under the stress of settlement) would be difficult and expensive to repair. Soil caps (Alternatives 4 and 5) are relatively easy to repair.

Filling will increase the load on the buried drums and thus creates the potential for collapse of intact drums (if any) that may be in the trench. Drum rupture induced by such loading would be expected to occur quickly, i.e., within a week of the loading. For safety, a period of one month of monitoring after completion of backfill has been included in the short-term groundwater monitoring program to address the possibility of intact drum collapse leading to significant release of chemicals to groundwater. However, drum failure would be more likely to result in slow leakage of liquid (if present). In addition, surrounding soil would provide containment and some adsorption of any released liquid (especially considering the coal content, which will act as an adsorbent similar to activated carbon). Therefore, drum failure would not necessarily lead to groundwater impacts. Collapse of drums would induce surface settlements on the order of only a few inches.

8.1.4 Grading and Surface Water Management

The area to be backfilled and capped (see Section 8.1.5) would be graded to provide proper stormwater drainage. At the present time, runoff from the area surrounding the trench, especially to the southeast, flows into the trench (see Figure 8-3). Thus, trench backfill and grading would decrease the stormwater flow into the trench, and thereby significantly decrease the infiltration even without a cap.

As part of excavating the borrow material for trench backfill, drainage ditches would be constructed at the margins of the cap to intercept surface runoff and convey it away from the trench. These ditches are shown on Figure 8-2. For this FS, the ditches are assumed to be triangular in cross section, 3 feet deep, with 3H:1V side slopes. To minimize cost and maintenance, it is desirable to line the ditches with natural vegetation. Final ditch configurations, locations, and details would be determined using standard hydraulic design methods as part of final design.

8.1.5 Capping

A cap for this site would consist of one or more layers of soil and/or geosynthetic materials installed over the trench backfill. Materials and thicknesses of the candidate caps are shown on Figure 7-1. The area that would be capped is shown on Figure 8-2. This area is based on the areas of suspected waste presence (see Figures 3-6 and Figure 3-15). The cap would extend slightly beyond the trench on both sides to provide anchor zones and "overhang" to reduce the potential for lateral migration of infiltration. Surface water runoff from the cap would be collected in drainage ditches and conveyed off-site.

The major benefit of capping this site would be to reduce infiltration through the waste. Another common benefit of capping, prevention of direct contact and off-site migration in stormwater or dust, is provided by the trench backfill.

The major limitation of a cap is the possibility of damage and the consequent need for inspection and maintenance. The different cap designs have different degrees of vulnerability depending on their components. For example, the low-permeability soil cap would resist settlement better than the FML or FML/GCL caps. If damage did occur, repair of a soil cap would be much easier, requiring only removal of the vegetative soil and adding more low-permeability soil, while repair of the FML or FML/GCL caps would require specialized personnel and equipment.

All cap designs include a top layer of 6 inches of vegetated topsoil to promote evapotranspiration and decrease erosion. This material would be obtained from the area immediately adjacent to the trench. No moisture conditioning is expected, and this soil would not be compacted, in order to provide a loose medium for establishing the vegetative cover. To establish vegetation, the topsoil would be seeded with grasses suitable for the local climate.

8.2 Description Of Remediation Alternatives

8.2.1 Alternative 1: No Action

A "no action" alternative is included as a baseline for comparison to the other alternatives. This alternative would leave the site in its current state, assuming no restrictions on future site use and no site maintenance or monitoring.

8.2.2 Alternative 2: Institutional Controls and Monitoring

This alternative would consist of implementing and maintaining institutional controls as described in Section 8.1.1 and long-term monitoring as described in Section 8.1.2. Institutional controls would prevent direct exposure to waste or affected soil through fencing and site use restrictions. Institutional controls would also prevent use of site groundwater, thereby preventing exposures to constituents of concern if site groundwater were to become affected. Exposure to groundwater could then occur only after off-site migration. If a release were to occur, monitoring would detect constituents of concern in site groundwater prior to off-site migration, which would be followed by appropriate remedial action.

8.2.3 Alternative 4: Soil Cap

This alternative provides a soil cap, as shown on Figure 7-1, over the trench backfill. Because it does not include a low-permeability liner, this cap would not meet the specifications of WAC 173-304. The major steps in this alternative are:

1. Backfill the trench as required for capping (see Section 8.1.3).
2. Allow the backfill to consolidate.
3. Place a soil cap over the trench backfill, including grading and surface water management (see Sections 8.1.4 and 8.1.5).
4. Maintain the cap for 20 years.
5. Implement and maintain institutional controls and monitoring (as described in Sections 8.1.1 and 8.1.2).

The soil cap consists of 18 inches of clean fill soil beneath 6 inches of vegetated topsoil. Cap materials would be obtained from site sources and moisture conditioned. Although the cap soil would be compacted, this cap does not include a permeability specification. It is assumed that the permeability of the soil cap would be greater than the low-permeability soil cap of Alternative 5. This alternative includes regrading and drainage ditches to control surface water as described above.

Installation of this cap could be performed readily using standard earth-moving equipment. A large number of qualified contractors are available. CQA would primarily consist of verifying cap thickness and grading.

Because of its simplicity, little maintenance would be required for this alternative. Any settling after cap installation would be repaired by filling and regrading in the same manner as initial installation. The thickness of the cap would provide long-term protection against erosion.

8.2.4 Alternative 5: Low-Permeability Soil Cap

This alternative provides a low-permeability soil cap, as shown on Figure 7-1, over the trench backfill. The permeability of this soil would be no higher than 10^{-6} cm/sec, and the cap would thus meet MFS specifications in WAC 173-304. The major steps in this alternative are:

1. Backfill the trench as required for capping (see Section 8.1.3).
2. Allow the backfill to consolidate.
3. Place a low-permeability soil cap over the trench backfill, including grading and surface water management (see Sections 8.1.4 and 8.1.5).
4. Maintain the cap for 20 years.
5. Implement and maintain institutional controls and monitoring (as described in Sections 8.1.1 and 8.1.2).

The low-permeability soil cap consists of 24 inches of compacted low-permeability soil beneath 6 inches of vegetated topsoil. For this FS, it is assumed that the spoils at the south end of the trench area near Portal 3 would be suitable. A laboratory permeability test on a single sample (Appendix J) indicated a permeability of about 6×10^{-7} cm/sec. A preliminary field reconnaissance suggests that a sufficient quantity of material is available. The suitability of this or other site sources, in terms of both quality and quantity, would need confirmation during final design. A gravel haul road would be constructed along the existing trail from Portal 3 to trench area 7 to bring soil from the borrow area in the south to the area to be capped in the north. Should site sources not be suitable, the cost of this cap could be greater than the estimates in this FS, in which case the cap design should be reconsidered.

Installation of this cap could be performed readily using standard earth-moving equipment. A large number of qualified contractors are available. CQA would primarily consist of verifying the soil liner meets the permeability specification, as well as verifying cap thickness and grading.

Because of its simplicity, little maintenance would be required for this alternative. Any settling after cap installation would be repaired by filling, compacting, and regrading in the same manner as initial installation. The thickness of the cap would provide long-term protection against erosion.

8.2.5 Alternative 6: FML Cap

This alternative provides a cap with an FML liner, as shown on Figure 7-1, over the trench backfill. By including a synthetic low-permeability liner, the cap would meet MFS specifications in WAC 173-304. The major steps in this alternative are:

1. Backfill the trench as required for capping (see Section 8.1.3).
2. Allow the backfill to consolidate.
3. Place an FML cap over the trench backfill, including grading and surface water management (see Sections 8.1.4 and 8.1.5).
4. Maintain the cap for 20 years.
5. Implement and maintain institutional controls and monitoring (as described in Sections 8.1.1 and 8.1.2).

This alternative consists of a FML overlain by 6 inches of clean fill and 6 inches of vegetated soil. A geotextile would be included below the FML to act as a cushion over the trench backfill and prevent puncturing. The FML thickness is assumed to be 50-mil to comply with the requirements of WAC 173-304.

Installation of this cap requires specialized contractors qualified in FML installation. However, a reasonable number of qualified contractors are available. The most important part of CQA for an FML cap is testing liner integrity after installation. The thickness and quality of the FML would also be subject to CQA, as well as cover soil thickness and grading.

FML is more susceptible to failure on settling than a soil cap. FML is able to stretch in response to settling, but within limits. The detrimental effects of settling on a soil cap are easily repaired by simply replacing the soil. FML settling requires removing and replacing the settled cap section. The repaired area would require careful subgrade preparation to avoid low spots in the liner. New seams, which are a weak point, are created around the repaired area. For this reason, the consolidation period for trench backfill would be critical for this cap design.

FML is not self-sealing against leaks, as is usually the case with soil caps. Thus, inspection and maintenance are more critical than for soil caps. Despite these drawbacks, FML is a common component of landfill caps and would be suitable for this site.

8.2.6 Alternative 7: FML/GCL Cap

This alternative provides a cap with an FML/GCL liner, as shown on Figure 7-1, over the trench backfill. By including two low-permeability liners, the cap would exceed MFS specifications in WAC 173-304. The major steps in this alternative are:

1. Backfill the trench as required for capping (see Section 8.1.3).
2. Allow the backfill to consolidate.
3. Place an FML/GCL cap over the trench backfill, including grading and surface water management (see Sections 8.1.4 and 8.1.5).
4. Maintain the cap for 20 years.
5. Implement and maintain institutional controls and monitoring (as described in Sections 8.1.1 and 8.1.2).

This alternative is similar to the FML cap, except that a GCL is installed in place of the geotextile. Less FML thickness is needed because of the underlying GCL. An FML thickness of 20-mil should be sufficient and is consistent with EPA guidance for a RCRA Subtitle C cap.

Installation of this cap requires specialized contractors qualified in FML installation and also in GCL installation. A limited number of qualified contractors would be available. CQA would be complex, requiring verification of proper installation of both the FML and GCL layers.

Because the GCL is not a thick layer, this cap would be as susceptible to failure due to settling as an FML cap. In the event of cap failure, repair would require removing and replacing the settled cap section. The repaired area would require careful subgrade preparation to avoid low spots in the liner. New seams, which are a weak point, are created around the repaired area. The repair would be more difficult than for FML because two liners would need to be aligned and resealed. For this reason, the consolidation period for trench backfill would be critical for this cap design.

The GCL would add protection against leakage, and GCL would tend to be self-sealing. Inspection and maintenance would be more critical than for soil caps, but less than for the FML cap.

8.2.7 Alternative 9: Excavation and Disposal

This alternative would protect human health and the environment by finding and removing any waste and affected soil from the trench for off-site disposal. The major steps in this alternative are:

1. Excavate the trench and remove all waste and affected soil.
2. Treat excavated material on-site or off-site as required to allow landfill disposal.
3. Haul waste and affected soil for off-site disposal.

Because no waste or affected soil would remain on-site, institutional controls and long-term maintenance and monitoring would not be required for this alternative. This assumes that all waste and affected soil can be located and excavated successfully and that confirmatory monitoring indicates no impacts to groundwater.

Trench backfilling is not included because removal of physical hazards due to an open trench are not a remedial action goal for this site. This alternative would not provide the removal of physical hazards incidental to trench backfilling provided by the capping alternatives.

The nature of contamination and the depth that excavation might be required to be carried to are unknown. It is assumed that excavation to the water table (70 or 80 feet below trench bottom) would be both necessary and sufficient to remove all waste and affected soil. Drums containing some liquid waste are potentially present in the suspected waste areas. Given the quality of site groundwater, it is unlikely that waste or affected soil is present below the water table. However, any waste below the water table would not be found or excavated in this alternative.

There are major concerns with this alternative for worker safety, implementability, and the increased cost to meet these concerns. There is high risk of collapse of the trench bottom (due to voids from mining) and sidewall failure (which has occurred already in some trench sections) as trench material is excavated and destabilizes trench sections. This risk is increased by the suspected presence of subsurface voids masked by sandstone slabs that are believed to exist in the trench (based on interviews with retired mine personnel conducted during the RI). For these reasons, workers or heavy equipment would not be placed in the trench to perform excavation.

Backhoes, loaders, and bulldozers are the most common excavation equipment. However, this equipment could not excavate the trench without operating in the base of the trench. While operations could be conducted using remote controlled equipment, this is atypical, high cost, and not without risk. For example, if voids were encountered, equipment could become jammed in the trench requiring personnel to access the trench bottom. Conventional excavation would require workers entering the trench to reach equipment. Such an activity would be extremely dangerous given the strong potential for trench failure.

A clamshell or dragline could be used to excavate from the top of the trench. However, the long, thin, and steep sides of the trench are not suited to dragline excavation. Furthermore, the rock bridge is the only stable area where a dragline could effectively operate limiting its access to those areas within 40 to 50 feet of the rock bridge. The clamshell is therefore considered to be the safest and most versatile of the available methods for excavating the trench. While much of the near surface materials can be successfully excavated using the clamshell, areas that are below the point at which the trench narrows and starts to follow the dip of the coal seam, may not be recoverable. In addition, as the dip increases, there is considerable potential for jamming the bucket. Thus, it may not be possible to reach all waste and affected soil without unacceptable worker risk.

A clamshell would probably rupture any intact or semi-intact containers in the excavation. Thus, there is a significant potential for excavation to cause release of constituents of concern to groundwater. This risk is much higher (assuming intact drums are present) than the risk of rupture identified for trench backfill prior to capping (see Section 8.1.3). This alternative would bring buried waste and affected soil to the surface for exposure to site workers and the environment; currently this material is protected from exposure. During excavation, the trench would be open to weather and infiltration. Increased exposure to rain could cause migration to the water table of constituents of concern that may be present.

Waste characterization would be performed on stockpiles after excavation. If, as is likely, clean soil is excavated from the trench along with affected soil, this clean soil would be separated to the extent practical. Stockpiles areas would require construction near the trench, congesting trench access. Stockpiling and separation would involve double- or triple-handling excavated material, slowing remedial action and increasing its difficulty and cost.

CQA would be difficult for this alternative. Confirmational soil samples would need to be obtained from the bottom of the trench, and these samples would have to be obtained remotely.

The excavated waste and affected soil would be hauled off-site for disposal. Appropriate disposal facilities would be used, depending on the waste designation (hazardous, dangerous, or non-dangerous). Treatment would be included in this alternative to the extent required to meet land disposal restrictions or other regulatory requirements. The need for treatment has not been established, and the type of any treatment cannot be determined at this time, due to the limited knowledge of constituents that would be encountered. Any required treatment would be performed either on-site or off-site (i.e., at the disposal facility), as determined appropriate at the time the need for treatment were identified based on the type and extent of treatment. If drums of liquid solvent or soil heavily affected by solvent are found, hazardous waste incineration could be required. Soil containing high concentrations of heavy metals could require fixation (chemical stabilization). It is assumed that most waste and affected soil could be landfilled.

Hauling creates risks of injury in traffic accidents and chemical exposure to leaks or spills. Truck traffic carrying waste materials would be significantly increased through a populated area.

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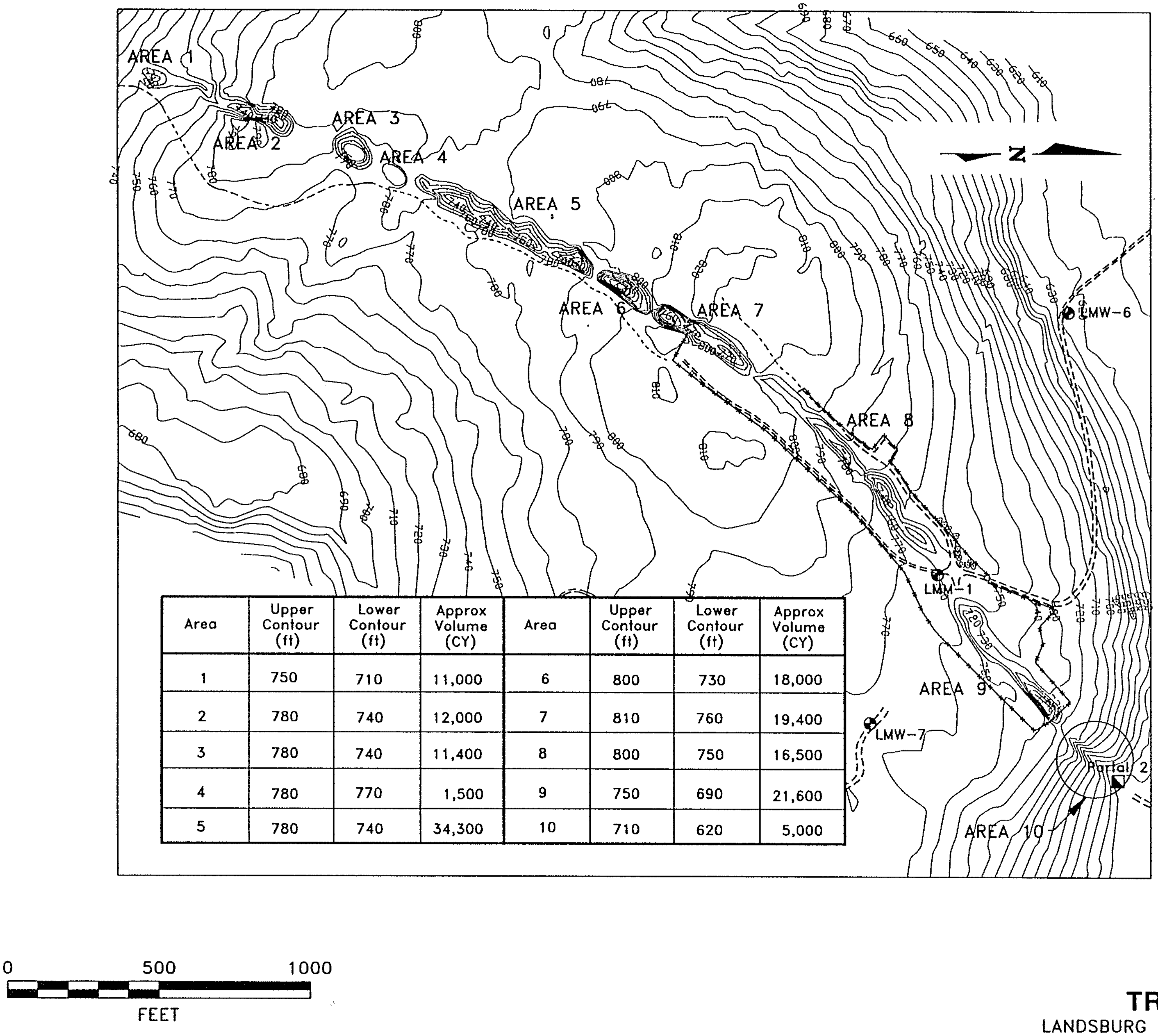
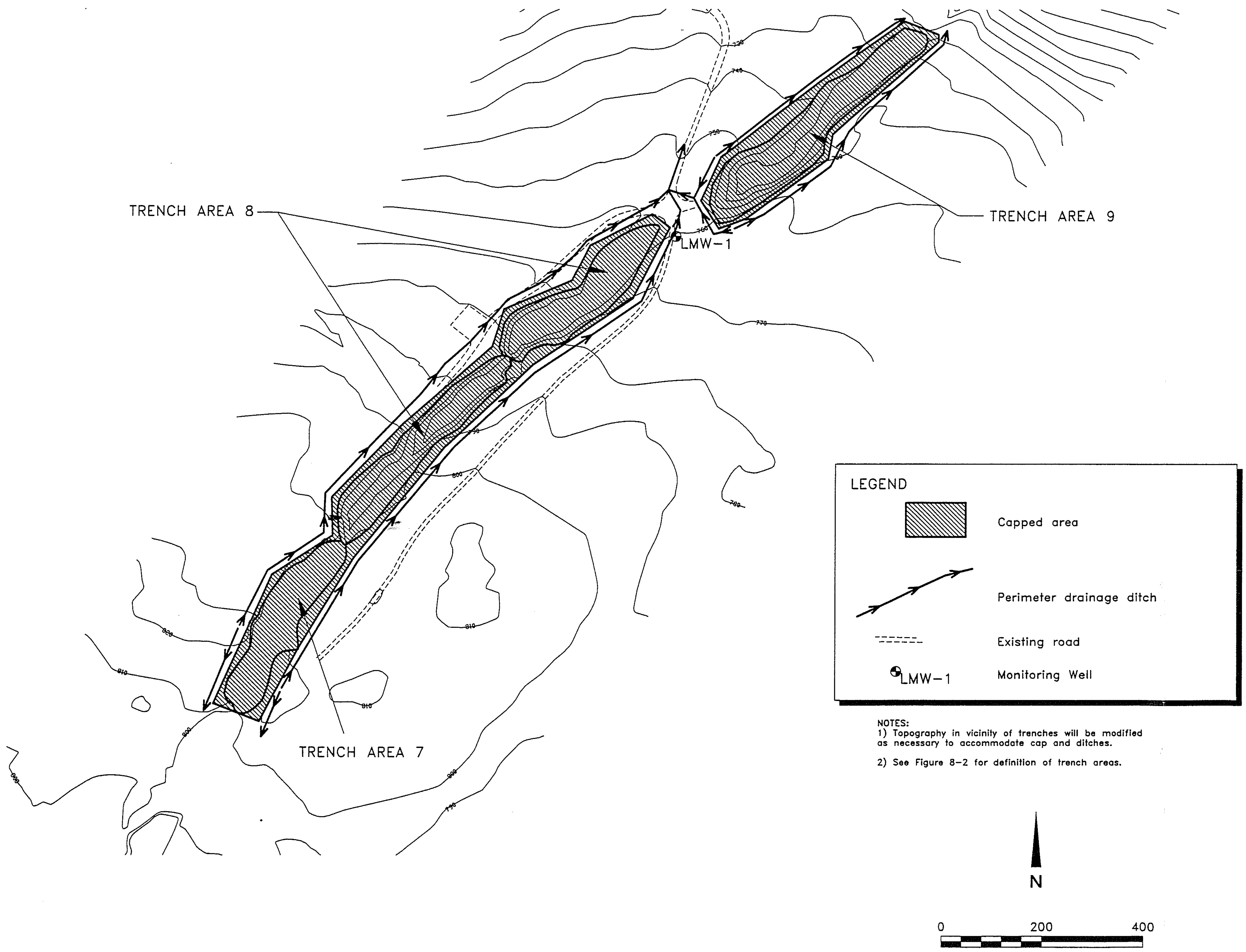


Area	Upper Contour (ft)	Lower Contour (ft)	Approx Volume (CY)	Area	Upper Contour (ft)	Lower Contour (ft)	Approx Volume (CY)
1	750	710	11,000	6	800	730	18,000
2	780	740	12,000	7	810	760	19,400
3	780	740	11,400	8	800	750	16,500
4	780	770	1,500	9	750	690	21,600
5	780	740	34,300	10	710	620	5,000

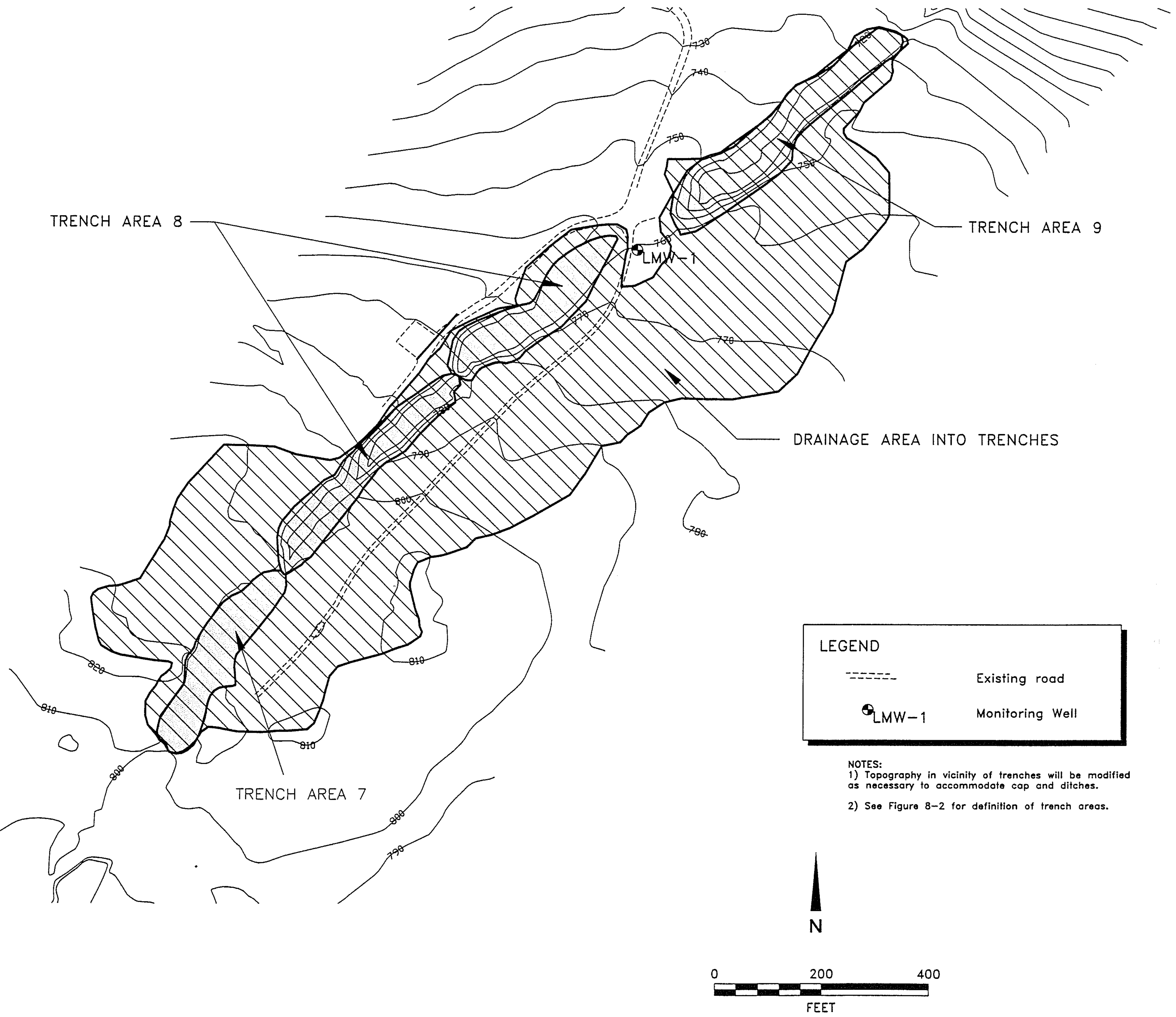
FIGURE 8-1
TRENCH AREAS
LANDSBURG MINE SITE/RI/FS/WA



NOTES:
1) Topography in vicinity of trenches will be modified as necessary to accommodate cap and ditches.

2) See Figure 8-2 for definition of trench areas.

FIGURE **8-2**
CAPPED AREA AND DRAINAGE DITCHES
LANDSBURG MINE SITE/RI-FS/WA



NOTES:
1) Topography in vicinity of trenches will be modified as necessary to accommodate cap and ditches.
2) See Figure 8-2 for definition of trench areas.

FIGURE **8-3**

CURRENT TOPOGRAPHY AND STORMWATER DRAINAGE

LANDSBURG MINE SITE/RI-FS/WA

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9. EVALUATION OF ALTERNATIVES

The remediation alternatives described in the previous chapter are evaluated in this chapter. The evaluation concludes with a discussion of the overall evaluation and scoring, and identification of the preferred alternative.

9.1 Threshold Evaluation

Under MTCA, remediation alternatives must meet the following threshold requirements (WAC 173-340-360(2)):

- Protection of human health and the environment
- Compliance with cleanup standards
- Compliance with ARARs
- Provision for compliance monitoring

Each alternative is evaluated individually against the threshold criteria in the following sections.

9.1.1 Protection of Human Health and the Environment

As a threshold criterion, protection of human health and the environment addresses whether a remediation alternative would result in sufficiently low residual risk to human and ecological receptors after completion of the alternative, resulting in a minimum acceptable level of protection. The relative degree of protection provided by the alternatives is considered in the comparative evaluation. One measure of sufficient protectiveness is the second threshold criteria, compliance with cleanup standards (see Section 9.1.2). Evaluation of protection of human health and the environment also considers short-term risks posed by remedial action (i.e., if remedial action could result in as much harm as benefit).

The fact that no current groundwater risk was found, even with an open trench that collects stormwater and promotes its infiltration to groundwater, indicates the low risk posed by this site. However, Alternative 1 does not mitigate potential exposure pathways (i.e., potential constituent migration in groundwater, surface water, and airborne dust). Alternative 9 (Excavation and Disposal) is only protective if it can be implemented reliably, which is questionable. In addition, the short-term risks posed by excavation in Alternative 9 offset much of the potential benefit of waste removal from the site.

All of the other alternatives prevent direct exposure to any waste and affected soil in the trench or site groundwater in the event it were to become affected by waste constituents from the site. The cap alternatives (4 through 7) also prevent off-site migration in surface water or airborne dust, and decrease the quantity of infiltration through the trench disposal area, as expected for containment actions per WAC 173-340-360(8)(f). Alternative 2 (Institutional Controls and Monitoring) does not meet this regulatory expectation.

9.1.2 Compliance with Cleanup Standards

Compliance with cleanup standards is defined by meeting the requirements of WAC 173-340-700 through -760. Compliance with cleanup standards does not require removal of all waste or affected soil from a site; these regulations include provisions for meeting cleanup standards through containment (e.g., WAC 173-340-700(2)(b) and (c)).

All of the alternatives except Alternative 1 (No Action) would comply with MTCA cleanup standards. Alternative 2 (Institutional Controls) would rely on institutional controls. Alternative 9 (Excavation and Disposal) is the only alternative that would meet cleanup standards by removal of waste and affected soil from the site. The remaining alternatives would rely on containment (natural and engineered).

9.1.3 Compliance with ARARs

Compliance with ARARs addresses whether an alternative complies with all applicable or relevant and appropriate requirements (ARARs), as defined in Chapter 4.

Alternative 1 (No Action) does not comply with ARARs because it does not comply with cleanup standards in accordance with WAC 173-340-700. Alternatives 2 (Institutional Controls and Monitoring) and 4 (Soil Cap) do not comply with all ARARs because they do not meet the minimum functional standards (MFS) for a landfill cap under WAC 173-304. In addition, Alternative 2 does not meet the regulatory expectation of preventing stormwater run-off from contacting waste materials under WAC 173-340-360(8)(f).

All of the other alternatives comply with all ARARs, including the applicable or relevant and appropriate sections of WAC 173-303 and 173-304.

9.1.4 Provision for Compliance Monitoring

Compliance monitoring requirements are defined at WAC 173-340-410. Compliance monitoring includes: 1) "protection monitoring" to confirm that human health and the environment are adequately protected during implementation of an alternative; 2) "performance monitoring" to confirm that cleanup standards or other performance standards (e.g., cap permeability) have been attained; and 3) "confirmational monitoring" to monitor the long-term effectiveness of the remedy after completion of the alternative.

Alternative 1 (No Action) does not provide compliance monitoring, and therefore does not meet this requirement. Alternative 9 (Excavation and Disposal) would include protection and performance monitoring during remedial action, but would not require long-term monitoring (if successful) because all waste and affected soil would be removed from the site, and therefore meets this requirement. All of the remaining alternatives meet this requirement by providing appropriate protection, performance, and confirmational monitoring.

9.1.5 Summary of Threshold Evaluation

Based on the preceding evaluations, the following alternatives do not meet one or more of the MTCA threshold criteria for selection as the preferred alternative:

Alternative 1 (No Action)
Alternative 2 (Institutional Controls and Monitoring)
Alternative 4 (Soil Cap).

The remaining alternatives meet the minimum requirements of the MTCA threshold criteria.

9.2 Use of Permanent Solutions

WAC 173-340-360(3) specifies that the remediation alternatives must use permanent solutions to the maximum extent practicable. WAC 173-340-360(5) specifies that "Ecology recognizes that permanent solutions [defined at WAC 173-340-360(5)(b)] may not be practicable for all sites. A determination that a cleanup action satisfies the requirement to use permanent solutions to the maximum extent practicable is based on consideration of a number of factors." The specified factors, or criteria, are:

- Overall protectiveness
- Long-term effectiveness and reliability
- Short-term effectiveness
- Reduction in toxicity, mobility, and volume
- Implementability
- Cost
- Community acceptance

These criteria and the basis for evaluating the alternatives against them are defined and discussed below. These definitions are consistent with MTCA regulations, but have been refined to minimize the overlap of considerations in the criteria. This allows decision makers to consider each criterion independently and minimizes double-counting of criteria. In addition, use of independent criteria allows better comparisons between the criteria; i.e., determining the value of each criterion in terms of the other criteria. Well-defined criteria minimize misunderstandings between the concerned parties and facilitate effective communication during selection of a preferred alternative.

9.2.1 Overall Protectiveness

Overall protectiveness addresses the degree to which each alternative attains cleanup standards and is protective of human health and the environment, considering both long-term and short-term risks. This criterion is derived from the evaluation of the other criteria. It is not an independent criterion, but more a summary of the overall evaluation. Therefore, the overall comparative evaluation (net benefit) of the other non-cost criteria is taken as the overall protectiveness of the alternative. In addition, overall protectiveness is evaluated as a threshold criterion in Section 9.1.1.

9.2.2 Long-Term Effectiveness and Reliability

This criterion addresses risks remaining at the site after the remediation alternative has been implemented, and the reliability of the alternative at reducing risks over an extended period of time. Risks during the implementation period are addressed under short-term effectiveness. Evaluation of long-term effectiveness involves estimation of the residual risk associated with each alternative in comparison to baseline risk, and can be measured by the degree to which remedial action objectives are met (Section 7.1). Reliability involves estimating the longevity of the remedy, (e.g., the lifespan of institutional controls or containment) and the chances of remedy failure.

This criterion is evaluated using the following two sub-criteria:

1. **Long-term effectiveness**

- The alternatives are qualitatively compared for reducing the magnitude of residual risk, including meeting RAOs. The long-term effectiveness criterion addresses both residual human health and ecological risk. However, for this site there is no need to evaluate alternatives for these risks separately. Each alternative provides long-term effectiveness by eliminating or controlling pathways of exposure for human health risks in the same manner as ecological risks. Therefore, there would be no difference in the comparative analysis between alternatives if these risks were evaluated separately.

- Relative reduction in infiltration after remediation was taken as an objective measure of long-term effectiveness or risk reduction.

2. **Reliability**

- Reliability addresses "the degree of certainty that the alternative will be successful" as specified in WAC 173-340-360(5)(d)(ii).

- Alternatives are qualitatively evaluated for their reliability in achieving the anticipated degree of effectiveness (i.e., immediately after completion of remedial action).

- Alternatives are qualitatively evaluated for the estimated longevity of the remedy *at its expected degree of effectiveness*. An alternative that scores less than another for effectiveness can score higher for reliability if it is expected to maintain its effectiveness longer or more reliably.

- Reliability includes qualitative evaluation of the amount of long-term maintenance and monitoring required. The greater the requirement for maintenance and monitoring, the lower the reliability.

The overall score for this criterion is obtained by giving equal weight to the two sub-criteria.

9.2.3 Short-Term Effectiveness

This criterion addresses short-term effects on human health and the environment while the alternative is being implemented. The evaluation includes consideration of the following factors:

- Risk to site workers
- Risk to the community
- Risk to the environment (short-term ecological risk)
- Time needed to complete remedial action.

Short-term effectiveness was primarily scored based on evaluation of the degree of risk to site workers. The primary risk to site workers would be due to construction accidents. In addition, for cap alternatives, the relative complexity of the caps is a measure of the relative man-hours required, and therefore the relative worker risk.

Because remedial action would include controls as necessary to ensure that the remedy does not create an unacceptable risk to the community, risk to the community is not as significant in distinguishing between alternatives as worker risk. However, Alternative 9 (Excavation and Disposal) would create the potential for human exposure to off-site release of excavated waste during remedial action, and this risk is considered in the evaluation. The considerations for ecological risk are very similar to those for community risk, in that Alternative 9 would create potential for ecological exposure to release of excavated waste during remedial action. The other alternatives do not involve these risks.

Time to complete remedial action includes preparation of MTCA planning documents, remedial design, Ecology and public review, and implementation time. Time estimates are from completion of the final CAP.

9.2.4 Reduction of Toxicity, Mobility, and Volume

This criterion addresses the degree to which a remediation alternative reduces the inherent toxicity, ability of contaminants to migrate in the environment, or the quantity of contaminated material. This criterion is also used to expresses the preference hierarchy for cleanup technologies under 173-340-360(4), and the use of recycling or treatment under WAC 173-340-360(5). Effectiveness and reliability of the treatment, which are addressed under long-term effectiveness and permanence, are not addressed under this criterion.

9.2.5 Implementability

This criterion addresses the degree of difficulty in implementing each alternative. Implementability issues are important because they address the potential for delays, cost overruns, and failure. Known implementation difficulties with quantifiable cost impacts are included in the cost estimates. The implementability criterion focuses on less quantifiable known and potential difficulties. Implementability is evaluated considering the following:

- **Technical Feasibility.** Technical feasibility addresses the potential for problems during implementation of the alternative and related uncertainties. The evaluation includes the likelihood of delays due to technical problems and the ease of modifying the alternative, if required.

- **Availability of Services and Materials.** The availability of experienced contractors and personnel, equipment, and materials needed to implement the alternative. Availability of disposal capacity is also included in the evaluation.

- **Administrative Feasibility.** The degree of difficulty anticipated due to regulatory constraints and the degree of coordination required between various agencies.

- **Scheduling.** The time required until remedial action would be complete, and any difficulties associated with scheduling.

- **Complexity and Size.** The more complex or larger a remedial action, the more difficult it is to construct or implement. In addition, the more items there are that can go wrong, the greater the chance of failure that could affect remedy effectiveness.

- **Other Considerations.** Monitoring requirements, access for construction and operation and maintenance, integration with existing operations and current or potential remedial action, and other factors were considered in accordance with WAC 173-340-360(5)(d)(v).

9.2.6 Cost

This criterion is used to consider the costs of performing each alternative, including capital, operation and maintenance, and monitoring costs. Alternative costs are compared on a net present value basis. Known implementation difficulties with quantifiable cost impacts are included in the cost estimates.

9.2.7 Community Acceptance

After the FS is finalized, an alternative is selected as the proposed remedial action. The proposed remedial action is described along with the basis for its selection in the draft Cleanup Action Plan (CAP). Determination of community concerns is based on public comments on the draft CAP. Therefore, community acceptance is not included in the FS comparative evaluation. Instead, Ecology evaluates community acceptance after the FS is completed. The proposed remedial action may be modified to address community concerns based on public comments on the draft CAP.

9.3 Comparative Evaluation Methodology

Selection of a remediation alternative is based on comparative evaluation of the alternatives (that satisfy the threshold criteria) using 5 permanence criteria: 1) long-term effectiveness and reliability, 2) short-term effectiveness, 3) reduction in toxicity, mobility, and volume, 4) implementability, and 5) cost. Overall protectiveness and community concerns are not included in the comparative evaluation for reasons discussed in Section 9.2. The following methodology was used for the comparative evaluation:

1. Each alternative is scored relative to the other alternatives for the 4 non-cost permanence criteria. Because of the nature of the criteria and the uncertainties in the evaluation, the scores for these 4 criteria are expressions of relative qualitative or semi-quantitative professional judgments. A scale of 0 (worst) to 10 (best) is used. Qualitative scoring for the criteria is appropriate and is typically conducted when the information to provide meaningful and defensible quantitative scoring is not available. Estimated infiltration rates were used to provide a quantitative basis for scoring the long-term effectiveness of cap alternatives.

2. The relative values of the non-cost criteria are determined. The relative criteria values are expressions of what a scoring unit of one criterion is worth compared to a scoring unit of another criterion. In other words, relative criteria values express how much a decreased value (lower score) of one criterion is acceptable to obtain an improvement (higher score) for another criterion. The relative criteria values are dependent on the scoring scales; a change in the basis of the scoring (i.e., scoring scale) requires changing the relative values assigned to the criteria to express the same value system. The assigned relative values are converted to criteria weightings, i.e., percentage of the overall score.

3. The scores for the 4 non-cost criteria are combined using the criteria weightings to give overall alternative scores. These scores express the net benefit of the alternatives.

4. A comparison of the cost and benefit of the alternatives is made. The alternative with the best benefit and cost:benefit ratio is the preferred alternative.

5. Sensitivity analyses are provided to show how remedy selection is affected by potential variations in scoring or relative criteria values.

As the expression of a value system, relative criteria values are inherently subjective. For this FS, criteria values were assigned relative to the criterion of long-term effectiveness and permanence. For example, assigning a relative value of 0.5 to a short-term effectiveness means that this criterion is taken to be half as important as long-term effectiveness. In terms of trade-offs between criteria, increasing the short-term effectiveness score of an alternative by 2 (for a given scale used to score short-term effectiveness) would be equivalent to increasing the long-term effectiveness and reliability score by 1 (for a given scale used to score long-term effectiveness and reliability); either change would result in the same change to the overall score.

The best professional judgment of the FS authors was used to set the relative criteria values for this FS. Given the criteria definitions and basis for scoring used in this FS, the following criteria values were assumed relative to the criterion of long-term effectiveness and reliability:

Criterion	Relative Value
Long-term effectiveness and reliability	1
Short-term effectiveness	0.4
Reduction in toxicity, mobility, and volume	0.1
Implementability	0.4

It is important to note that the relative value assumed for reduction in toxicity, mobility, and volume is based on the definition of this criterion in Section 9.2.4. Reduction in toxicity, mobility, and volume is generally considered important because it is associated with improved long-term effectiveness and reliability. However, the comparative evaluation used herein assumes independent criteria. Therefore, the reduction criterion has been defined as expressing the cleanup technology hierarchy under WAC 173-340-360(4) and the preference for permanent solutions under WAC 173-340-360(5)(a), *apart from the resultant improvements to long-term effectiveness and reliability*. The improvements to long-term effectiveness and reliability resulting from treatment or other reduction in toxicity, mobility, and volume are accounted for under the criterion of long-term effectiveness and reliability. This approach avoids double-counting benefits.

9.4 Evaluation of Remediation Alternatives for Permanence

This section provides a comparative evaluation of the alternatives using 5 of the 7 permanence criteria (see Sections 9.2 and 9.3). For completeness and perspective, all of the retained alternatives are included in the evaluation, even if they do not meet the threshold criteria (evaluated in Section 9.1). The basis for the scoring is provided below. The evaluation and scoring of the alternatives is summarized in Table 9-2.

9.4.1 Long-Term Effectiveness and Reliability

Restricted access to the trench, where any waste is located, already limits direct exposure to constituents of concern. The relatively greatest potential for migration of and exposure to site constituents is via groundwater. The fact that groundwater meets remediation goals (cleanup levels), even with an open trench that collects stormwater and promotes its infiltration to groundwater, indicates the lack of current risk posed by this site. Evaluation of this criterion was therefore based on the ability of the alternatives to reduce potential future risks.

9.4.1.1 Effectiveness

Alternative 1 (No Action) does not decrease site risks, and is therefore given an effectiveness score of 0. Alternative 2 (Institutional Controls) provides some decrease in site risk, but much less than capping or excavation and off-site disposal. Alternative 2 is therefore given an effectiveness score of 1. Alternative 9 (Excavation and Disposal) is given a score of 10 on the assumption that all waste could be removed.

The infiltration as a percentage of no-action infiltration is used as the basis for the effectiveness scores of the cap alternatives. The relative performance of the various cap designs was estimated using the Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.01 (EPA 1994), and site-specific monthly temperature and precipitation data. The results are summarized in Table 9-1; HELP input and output data are presented in Appendix G. For comparison purposes, the total inflow to the trench under current conditions was also estimated. This inflow is the sum of the runoff from the surrounding area (see Figure 8-2) and the precipitation falling directly into the trench. Runoff from outside the trench was estimated using the HELP model and is roughly equal to the estimated current infiltration due to precipitation falling directly in the trench. Thus, regrading and ditches alone would significantly reduce infiltration through trench waste and affected soil. The estimated net reduction in infiltration by the various caps (Table 9-1) include the benefits of stormwater controls.

The effectiveness scores for the cap alternatives are the estimated percent reduction in infiltration divided by 10 (to match the 0 to 10 scale), less 0.5 score units to reflect that on-site containment is somewhat less effective than destruction or off-site containment in a lined landfill. On this basis, the cap alternatives scores are:

Alternative	Score
Alternative 4: Soil Cap	5.7
Alternative 5: Low-Permeability Soil Cap	8.3
Alternative 6: FML Cap	9.0
Alternative 7: FML/GCL Composite Cap	9.5

9.4.1.2 Reliability

The sub-criterion of reliability is scored based on professional judgment and experience in the ability of the remedies to achieve and maintain their estimated effectiveness. As the base case, Alternative 1 (No Action) is given the score of 0. Under MTCA, the reliability of institutional controls is considered low in comparison to engineered containment or removal; Alternative 2 is therefore given a score of 1.

As discussed in Section 8.2.6, it is highly questionable that excavation, if implementable, could be certain of removing all waste from the trench. In addition, there is a significant risk of spreading contamination around the site and a high likelihood of impacts to groundwater. Alternative 9 is therefore has poor reliability. It is given a score of 4, which is higher than Alternatives 1 and 2, but lower than the cap alternatives.

Alternatives 4 (Soil Cap) and 5 (Low-Permeability Soil Cap) are both very reliable because of their longevity, thickness, ease of maintenance and repair, and simplicity. Unlike synthetic liners, soil layers do not deteriorate with time. Damage due to settlement is relatively easy to repair in soil caps. These two alternatives are therefore given a score of 9.5.

Alternative 6 (FML Cap) is reasonably reliable, and is given a score of 9. The score is less than the soil cap alternatives because FML will deteriorate and lose effectiveness over time. It is much more likely to rupture (e.g., with settlement) or leak than soil-based caps, and much harder to repair. In contrast, soil liners tend to be self-sealing.

Alternative 7 (FML/GCL Cap) provides 2 liners, so that one liner may remain intact to offset failure of the other liner. However, this enhanced effectiveness was the basis for the score for effectiveness. The GCL layer is thin and just as susceptible to rupture with settlement as FML. An FML/GCL cap would be more difficult to repair than an FML or soil cap. An FML/GCL cap is not as reliable at maintaining the estimated high level of effectiveness. Alternative 7 is therefore given a lower score of 8.5.

9.4.1.3 Overall Score for the Long-Term Effectiveness and Reliability Criterion

The overall score for the criterion of long-term effectiveness and reliability is taken as the average of the two sub-criteria, which gives equal weight to the sub-criteria. The overall criterion scores are:

Alternative	Score
Alternative 1: No Action	0
Alternative 2: Institutional Controls	1
Alternative 4: Soil Cap	7.6
Alternative 5: Low-Permeability Soil Cap	8.9
Alternative 6: FML Cap	9
Alternative 7: FML/GCL Composite Cap	9
Alternative 9: Excavation and Disposal	7

9.4.2 Short-Term Effectiveness

Alternative 1 (No Action) does not subject site workers to any risk and would take no time to complete; therefore, this alternative is given a score of 10. Alternative 2 (Institutional Controls and Monitoring) involves relatively little site work and could be completed in about 2 months; therefore, this alternative is given a score of 9.

On the other extreme, there are major risks involved with trench excavation in Alternative 9 (Excavation and Disposal), as discussed in Section 8.2.6. In addition, Alternative 9 creates risk of human and ecological exposure through potential off-site release of chemicals during excavation and off-site transport of waste. Alternative 9 would take between one and two years to complete, depending on the degree of excavation difficulties encountered. Therefore, Alternative 9 (Excavation and Disposal) is given a score of 0.

The capping alternatives have greater short-term effectiveness than excavation and disposal, but less than Alternatives 1 and 2. For cap alternatives, the relative complexity of the caps is a measure of the relative man-hours required, and therefore the relative worker risk. All of the cap alternatives would take about one year to complete. On this basis, the cap alternatives are scored as follows:

Alternative	Score
Alternative 4: Soil Cap	7
Alternative 5: Low-Permeability Soil Cap	6.8
Alternative 6: FML Cap	6.6
Alternative 7: FML/GCL Cap	6.4

9.4.3 Reduction in Toxicity, Mobility and Volume

Treatment is the most effective means of providing permanent reduction in toxicity, mobility, and volume. The only alternative that would provided treatment is Alternative 9 (Excavation and Disposal). However, the need for treatment has not been identified, and treatment would be provided only to the extent required for landfill disposal. Intact or partially intact drums of liquid wastes, if found, would require incineration or other treatment. Alternative 9 is given a score of 5 to reflect the partial treatment that this alternative is presumed to provide.

Alternatives 1 (No Action) and 2 (Institutional Controls and Monitoring) do not provide any reduction in toxicity, mobility, and volume, and are therefore given scores of 0.
The cap alternatives (4 through 7) reduce infiltration through waste and affected soil, which decreases the potential for constituent migration into groundwater and therefore decreases the mobility of these constituents. These alternatives are therefore given scores of 2.

9.4.4 Implementability

Alternative 1 (No Action) would be the easiest to implement; therefore, it is given a score of 10. Alternative 2 (Institutional Controls and Monitoring) would be very easy to implement, and is therefore given a score of 9.

On the other extreme, as discussed in Section 8.2.6, there would be severe difficulties in attempting to excavate the trench. The feasibility of excavating waste from the trench is questionable, and excavation would not attempt to find and remove any waste that might be present below the water table. Therefore, Alternative 9 (Excavation and Disposal) is given a score of 0.

All of the cap alternatives would be much easier to implement than Alternative 9. Alternative 4 (Soil Cap) would be the easiest to implement, and is given a score of 7. Alternative 5 (Low-Permeability Soil Cap) is given the slightly lower score of 6.8 because it requires compaction to a permeability specification.

Synthetic liners require installation by specialized contractors. The liners are subject to puncture or rupture during installation, and require careful QA/QC. Alternative 6 (FML Cap) is therefore less implementable than Alternatives 4 and 5, and is given a score of 6.4. Alternative 7 (FML/GCL Cap) is given a lower score of 6, because it has two liners in its cap and is correspondingly more difficult to install.

9.4.5 Net Benefit (Overall Non-Cost Evaluation)

The net benefit of the alternatives is determined by combining the criteria scores with the scores weighted based on the relative values assigned to the criteria (see Section 9.3). The net benefit, or overall non-cost scores, are given in Table 9-2. Using these scores, the preference ranking of the alternatives before consideration of cost is as follows (most to least preferred):

1. Alternative 5 (Low-Permeability Soil Cap)
2. Alternative 6 (FML Cap)
3. Alternative 7 (FML/GCL Cap)
4. Alternative 4 (Soil Cap)
5. Alternative 2 (Institutional Controls and Monitoring)
6. Alternative 1 (No Action)
7. Alternative 9 (Excavation and Disposal).

Of these, based on evaluation of threshold criteria (Section 9.1), Alternatives 1, 2, and 4 do not meet minimum requirements.

It should not be surprising that Alternative 9 (Excavation and Disposal) has an overall score less than Alternative 1 (No Action). This ranking reflects the many problems associated with excavation and the uncertain benefit (i.e., lack of reliability). Alternative 9 (Excavation and Disposal) would be much more likely than Alternative 1 (No Action) to cause actual harm to humans in the form of construction accidents for site workers and traffic accidents in the community. It would also be much more likely to cause exposure to waste constituents, meaning greater risk to both human and ecological receptors. These known risks must be balanced against the potential risks of no action.

9.4.6 Cost

The estimated costs for the alternatives are summarized in Table 9-2. Detailed cost estimates are presented in Appendix H. The cost for Alternative 1 (No Action) is zero because it does not include any remedial action or monitoring. The estimated cost for Alternative 2 (Institutional Controls and Monitoring) is approximately $0.3 million. The estimated costs for the capping alternatives (4 through 7) range from $0.9 million to $1.3 million. The estimated cost for Alternative 9 (Excavation and Disposal) is $24 million.

The cost estimates in this FS are based on the description of the alternatives and associated design assumptions in Chapter 8. The design assumptions used here are representative and sufficient for the purposes of comparative evaluation of the alternatives, but are not necessarily the same as the design basis that would be used for the final, detailed design. Pre-design investigations would be included in the final design phase for any of these remedial actions, and the results of these investigations could result in changes from the preliminary designs presented in this FS.

The estimates were prepared to allow comparative evaluation of alternatives, not for budgeting purposes. The design basis is subject to change during final, detailed design of the selected alternative, and these changes would affect the cost of the remedy. The uncertainties in the FS designs and associated cost estimates are such that actual costs could vary significantly from these estimates. However, the uncertainty in the *relative* cost of the alternatives is much less than the uncertainty in the magnitude of the costs, and these cost estimates are suitable for comparative evaluation of the alternatives. Cost uncertainties were estimated stochastically (probabilistically), and are presented and discussed in the uncertainty analysis (Section 9.4.8).

9.4.7 Cost : Benefit Analysis and Overall Evaluation

Under WAC 173-340-360(5)(d)(vi), "a cleanup action shall not be considered practicable if the incremental cost of the cleanup action is substantial and disproportionate to the incremental degree of protection it would achieve over a lower preference cleanup action." The determination of practicability is made using an analysis of cost vs. benefit. The cost-benefit analysis can be performed quantitatively using the overall scoring of the non-cost criteria as the net benefit.

Figure 9-1 shows a graph of cost versus net benefit for all of the alternatives. To show the differences between cap alternatives better, Figure 9-2 graphs cost versus net benefit for just the cap alternatives. The error bars on these graphs show the range from the 10th to the 90th percentiles from the stochastic uncertainty analysis (see Section 9.4.8).

The ratio of net benefit to estimated cost, which is a measure of cost-effectiveness, is given in Table 9-2. On a strict cost:benefit basis, Alternative 2 (Institutional Controls and Monitoring) would be preferred if it met the threshold criteria. Alternative 5 (Low-Permeability Soil Cap) provides the next-best cost-effectiveness.

However, the MTCA regulations refer to incremental cost and benefit. To evaluate incremental cost-effectiveness, the difference in cost between alternatives is calculated, going from the least costly alternative to the most costly. The corresponding difference in net benefit (overall non-cost score) is then calculated. Dividing the incremental benefit by the incremental cost results in a value that is the incremental cost-effectiveness. These values are shown for the alternatives on Table 9-2.

Based on the cost-benefit graphs (Figures 9-1 and 9-2) and the incremental cost-effectiveness values (Table 9-2), two key conclusions can be drawn:

1. In the non-cost evaluation (Section 9.4.5), Alternative 9 (Excavation and Disposal) has already been shown to be a poor choice. In addition, Alternative 9 has very poor incremental cost-effectiveness. In other words, the incremental cost of the cleanup action is clearly substantial and disproportionate to the incremental degree of protection it would achieve (if any) over a lower preference cleanup action. Alternative 9 therefore does not meet the requirements of MTCA for a preferred alternative.

2. Alternative 5 (Low-Permeability Soil Cap) provides the best incremental cost-effectiveness, in addition to providing the best net benefit. Alternative 5 meets all threshold criteria (protection of human health and the environment, compliance with cleanup standards, compliance with ARARs, and provision for compliance monitoring). It provides the optimum combination of long-term effectiveness and reliability, short-term effectiveness, implementability, and reduction of toxicity, mobility, and volume. In addition, this alternative provides good cost:benefit. Considering the criteria and approach specified in WAC 173-340-360(5), Alternative 5 is the remediation alternative for the Landsburg Mine site that is "permanent to the maximum extent practicable", and is therefore the preferred alternative.

9.4.8 Uncertainty Analysis

The uncertainties in the evaluation of the alternatives have been analyzed stochastically (probabilistically). For the analysis, the evaluation scoring, net benefit calculations, and cost estimates were implemented in a computer spreadsheet (i.e., Table 9-2 and the Appendix G cost tables were set up in Excel®). Probability distribution functions (PDFs) were then estimated for non-cost scores, relative criteria values, and key cost parameters (documented in Appendix I). Using these PDFs, a Monte Carlo simulation (i.e., stochastic analysis) was performed using Crystal Ball®, an Excel add-in. This analysis results in estimated PDFs for selected calculated values, in this case the net benefit and costs of the alternatives. The output from this analysis is summarized in Table 9-3, and details are provided in Appendix I.

The error bars in Figures 9-1, 9-2, and 9-3 show the range from the 10th to the 90th percentiles for the values from the stochastic analysis. In other words, it is estimated that there is an 80% probability that the value of the calculated parameter (net benefit or cost) lies in the range shown by the error bars. The difference between Figures 9-2 and 9-3 is the value shown as the "best estimate." Figure 9-2 uses the deterministic values of net benefit and cost as the best estimates (Table 9-2). Figure 9-3 uses the mean values of the probabilistic analysis as the best estimates (Table 9-3). Of significance, as shown by these figures, the relative cost-effectiveness is not changed by which set of values is used for the best estimate.

As shown in Figure 9-1, there is no overlap in ranges (error bars) between the cap alternatives (4 through 7) and Alternative 9 (Excavation and Disposal). This indicates that no defensible combination of alternative scores and relative criteria values would result in preference for Alternative 9.

In addition, Alternative 9 has a very large uncertainty in cost ($9 million to $48 million), indicating that selection of this alternative would involve a very large cost risk. This uncertainty is primarily due to uncertainty in 1) the quantity of volume of waste and affected soil that would require disposal, and 2) the average unit cost of this disposal. Unit disposal costs could range from less than $\$50/yd^3$ for non-hazardous waste landfill to over $\$1,000/yd^3$ for incineration, with the average unit cost being somewhere in between. The deterministic estimate is based on the estimated volume given in Table 9-1 and an average unit cost for disposal (including any required treatment) of $\$300/yd^3$.

Although the error bars for Alternative 2 (Institutional Controls and Monitoring) and Alternative 1 (No Action) overlap, this is somewhat misleading. The net benefits of these two alternatives will rise and fall together, given that Alternative 1 is the baseline for comparison. Consequently, Alternative 2 would virtually always be preferred relative to Alternative 1.

The uncertainty in relative ranking of the cap alternatives (4 through 7) is somewhat more complex. As can be seen from Figure 9-2, there is significant overlap in the ranges for net benefit and cost for these alternatives. However, the net benefits in the cap alternatives are somewhat correlated (i.e., the scores rise and fall together), in that they are based on a common general technology (capping) and have the common benefits and drawbacks of backfilling the trench.

Given the definition of the cap designs, Alternative 5 (Low-Permeability Soil Cap) will always provide at least some improvement in long-term effectiveness and reliability over Alternative 4 (Soil Cap), and in most cases give better net benefit. Alternative 5 will also always be more expensive than Alternative 4, although the differential cost (and thus the incremental cost-effectiveness) could vary significantly if off-site soil is required for the low-permeability cap (raising its cost).

Similarly, because both cap designs include an FML liner, Alternative 7 (FML/GCL Cap) will always provide equal or better long-term effectiveness and less reliability than Alternative 6 (FML Cap). Alternative 7 will also always cost more than Alternative 6. Based on the non-cost scores and associated PDFs, the probability that Alternative 7 would have better net benefit than Alternative 6 is low.

The primary uncertainty with a significant possibility of affecting selection between cap alternatives is the assumed availability of sufficient suitable site soil for construction of the low-permeability soil cap. Based on available data (see Section 8.2.4 and Appendix J), it appears that this assumption is warranted and has a reasonable probability of being valid. However, if this assumption is not true, then the differential cost between Alternative 5 (Low-Permeability Soil Cap) will change. In the extreme, Alternative 5 could be more expensive than Alternative 6 (FML Cap). Given that the net benefit of these two alternatives is very close, selection of Alternative 5 over Alternative 6 is primarily based on their relative cost-effectiveness. Any factor significantly affecting the cost of either alternative could change the relative ranking of these two alternatives. Therefore, although it is considered most probable that Alternative 5 is the best alternative, Alternative 6 should be retained as a contingency.

TABLE 9-1

ESTIMATED INFILTRATION FOR DIFFERENT CAP DESIGNS

INPUT ASSUMPTIONS

Parameter	Value	Units
Trench area (areas 7 [partial], 8, 9)	132,022	ft^2
Drainage area (not including trench area)	501,227	ft^2
Runoff outside of trenches	10	in
Infiltration into open trenches	45	in
Direct Infiltration into trenches	495,083	ft^3
Runoff into trenches	417,689	ft^3
Total volume of water into trenches	912,772	ft^3

RESULTS

Cap Type	Average Annual Infiltration through Cap		Percent Reduction from Current [a]	HELP Run (Appendix G)
	(inches)	(ft^3)	(ft^3)	
Trench backfill only, $k = 10^{-2}$ cm/sec	38.12	419,390	54%	0A-SOIL
18-inch soil cap, $k = 10^{-3}$ cm/sec	36.19	398,156	56%	1A-SOIL
18-inch soil cap, $k = 10^{-4}$ cm/sec	35.76	393,426	57%	1B-SOIL
18-inch soil cap, $k = 10^{-5}$ cm/sec	31.84	350,298	62%	1D-SOIL
24-inch clay cap, $k = 10^{-6}$ cm/sec	9.91	109,028	88%	2A-CLAY
FML cap	4.31	47,418	95%	3D-FML
FML/GCL cap	0.003	33	> 99%	4A-FML-GCL

[a] Includes reduction due to stormwater redirection

TABLE 9-2

SUMMARY OF REMEDIATION ALTERNATIVE EVALUATION

Criteria [a]			Alternative Scores [c]						
	Relative Value of Criterion [b]	Calculated Criteria Weights	1 No Action	2 Inst. Controls	4 Soil Cap	5 Low-P Cap	6 FML Cap	7 FML/GCL Cap	9 Excavate
Long-Term Effectiveness and Reliability									
Effectiveness (50% of criterion)		50%	0	1	5.7	8.3	9	9.5	10
Reliability (50% of criterion)		50%	0	1	9.5	9.5	9	8.5	4
Overall criterion score	1	53%	0	1	7.6	8.9	9	9	7
Short-Term Effectiveness	0.4	21%	10	9	7	6.8	6.6	6.4	0
Reduction in Toxicity, Mobility, and Volume	0.1	5%	0	0	2	2	2	2	5
Implementability	0.4	21%	10	9	7	6.8	6.4	6	0
Net Benefit		100%	4.2	4.3	7.1	**7.7**	7.6	7.5	3.9
Incremental benefit			NA	0.1	2.7	0.6	-0.1	-0.1	-3.5
Cost (present value, millions)			$0	$0.29	$0.94	$1.00	$1.18	$1.34	$24
Benefit : cost (i.e., cost-effectiveness)			NA	14.7	7.5	7.6	6.4	5.6	0.2
Incremental cost			NA	$0.29	$0.65	$0.06	$0.18	$0.16	$22.53
Incremental benefit : incremental cost			NA	0.4	4.2	**10**	-0.4	-0.8	-0.2

[a] See text for criteria definitions.

[b] The numeric value of one scoring unit of the criterion relative to one scoring unit of the long-term effectiveness and reliability criterion.

[c] See text for score basis.

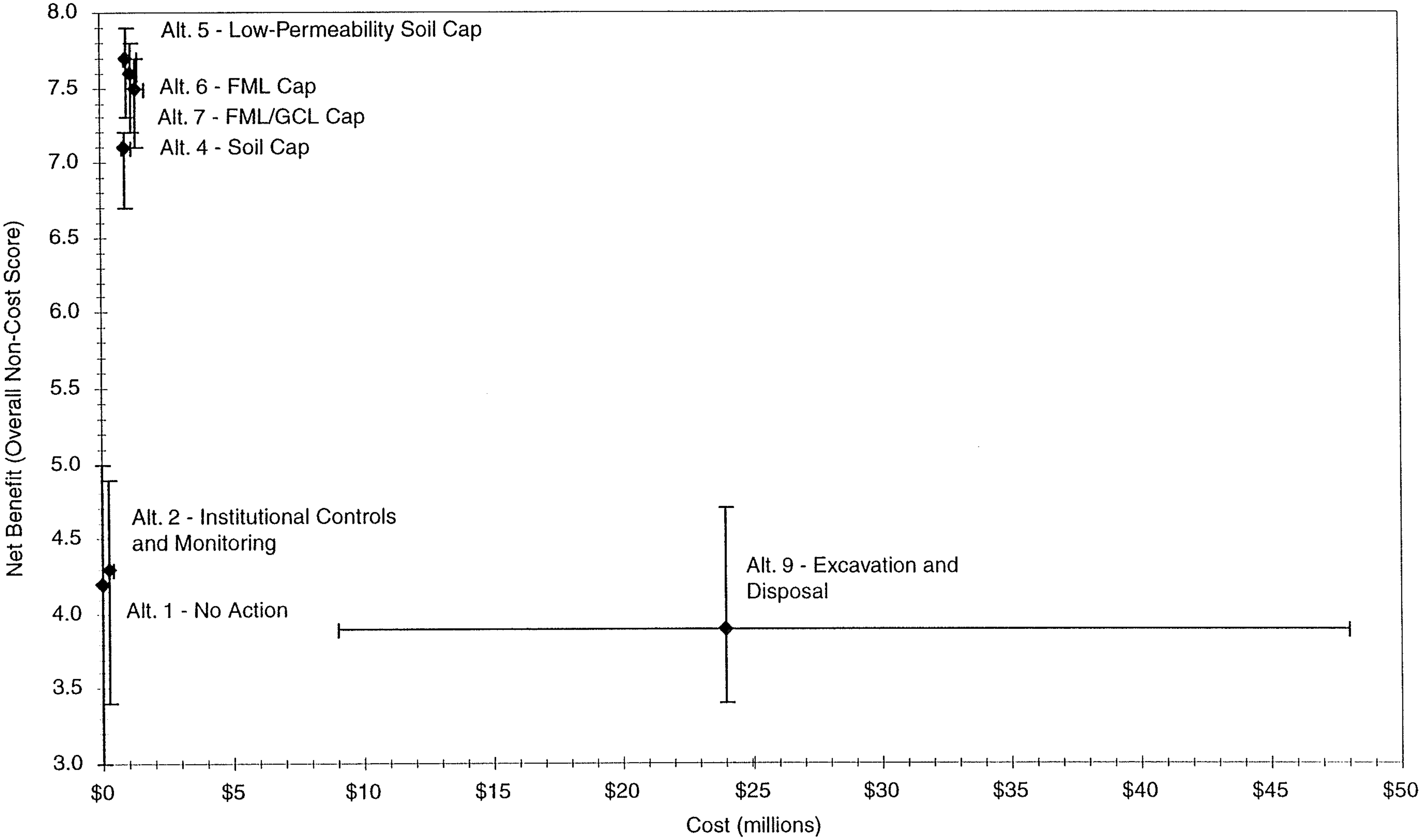
TABLE 9-3

SUMMARY OF STOCHASTIC UNCERTAINTY ANALYSIS

	Alternative	Deterministic Value [a]	Percentiles [b] 10%	25%	Median	MEAN	75%	90%
			Net Benefit (Overall Non-Cost Score)					
1	No Action	4.2	3.0	3.6	4.1	4.1	4.6	5.0
2	Institutional Controls and Monitoring	4.3	3.4	3.8	4.2	4.2	4.6	4.9
4	Soil Cap	7.1	6.7	6.8	7.0	7.0	7.1	7.2
5	Low-Permeability Soil Cap	7.7	7.3	7.4	7.6	7.6	7.7	7.9
6	FML Cap	7.6	7.2	7.3	7.5	7.5	7.7	7.8
7	FML/GCL Cap	7.5	7.1	7.2	7.4	7.4	7.5	7.7
9	Excavation and Disposal	3.9	3.4	3.7	4.0	4.0	4.4	4.7
			Estimated Cost (millions)					
1	No Action	$0				$0		
2	Institutional Controls and Monitoring	$0.29	$0.26	$0.28	$0.31	$0.32	$0.35	$0.39
4	Soil Cap	$0.94	$0.80	$0.87	$0.96	$0.98	$1.07	$1.18
5	Low-Permeability Soil Cap	$1.00	$0.90	$1.00	$1.13	$1.14	$1.27	$1.40
6	FML Cap	$1.18	$1.02	$1.10	$1.21	$1.22	$1.32	$1.44
7	FML/GCL Cap	$1.34	$1.15	$1.24	$1.37	$1.38	$1.50	$1.64
9	Excavation and Disposal	$24	$9	$15	$23	$26	$36	$48

[a] Deterministic values are approximately equal to stochastic modes (most likely values) for most probability distributions.

[b] Percentiles and mean values estimated by Monte Carlo simulation as described in text. Simulation output in Appendix I.



NOTE: Error bars are from 10th to 90th percentiles derived by probabilistic uncertainty analysis (Appendix

FIGURE **9-1**

COST VS. BENEFIT FOR ALL ALTERNATIVES

LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923-1000.147 DRAWING NO. 60821 DATE 1/16/96 DRAWN BY TK

Golder Associates

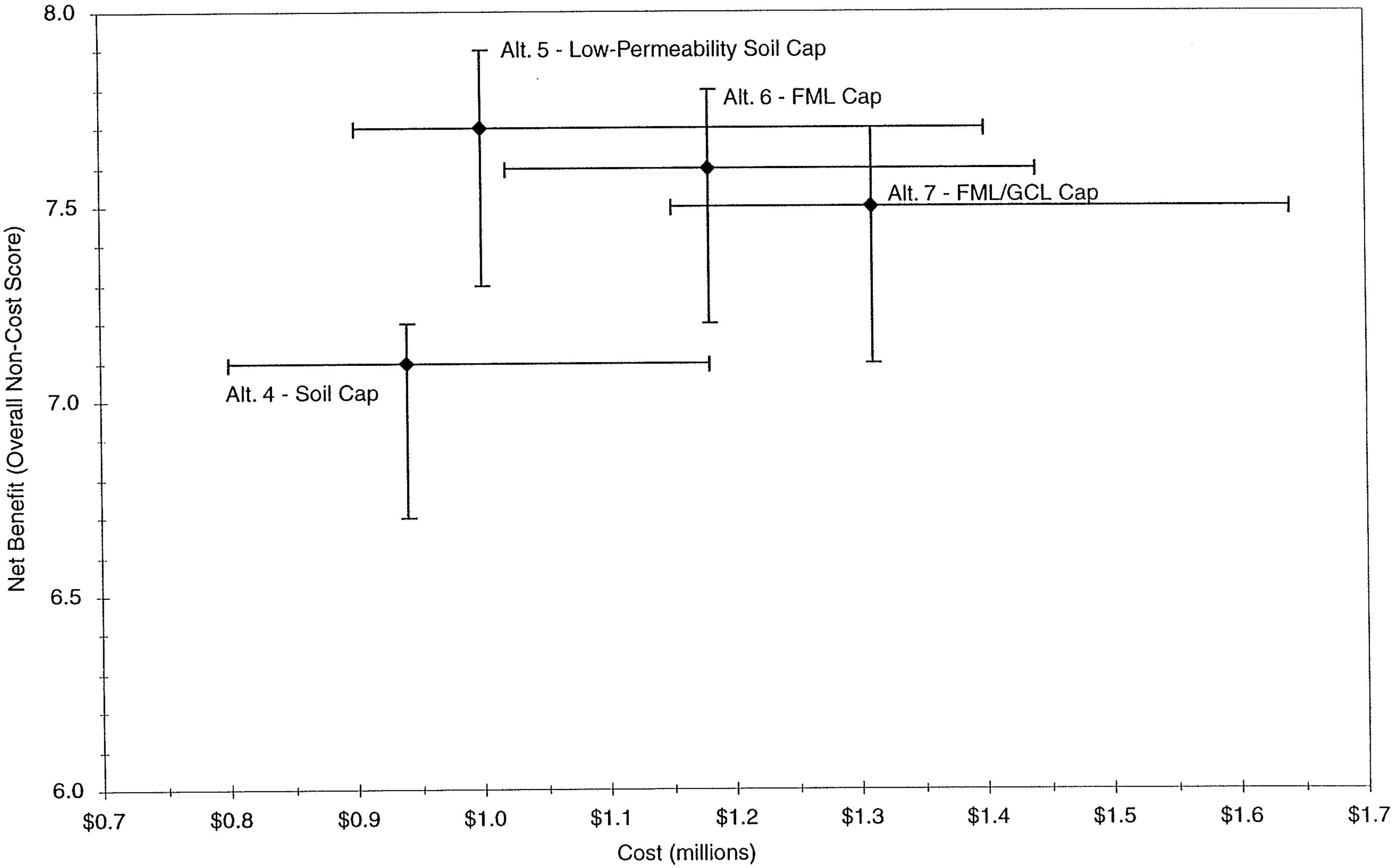


FIGURE **9-2**

COST VS. BENEFIT FOR CAP ALTERNATIVES USING DETERMINISTIC BEST ESTIMATES

LANDSBURG MINE SITE/RI/FS/WA

NOTE: Error bars are from 10th to 90th percentiles derived by probabilistic uncertainty analysis (Appendix I).

PROJECT NO. 923-1000.147 DRAWING NO. 60822 DATE 1/16/96 DRAWN BY TK

Golder Associates

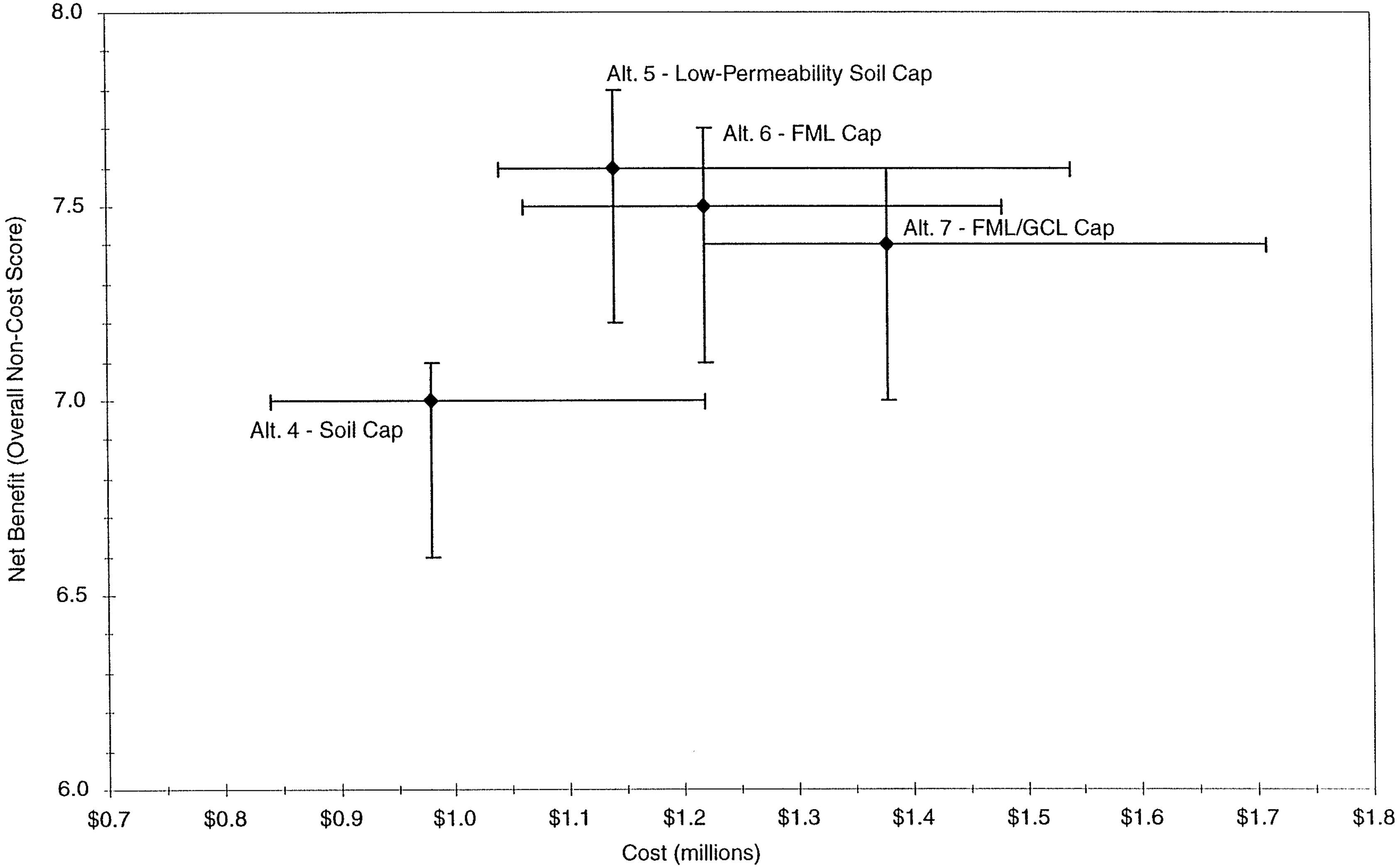


FIGURE **9-3**

COST VS. BENEFIT FOR CAP ALTERNATIVES USING PROBABILISTIC BEST ESTIMATES

LANDSBURG MINE SITE/RI/FS/WA

NOTE: Error bars are from 10th to 90th percentiles derived by probabilistic uncertainty analysis (Appendix I).

PROJECT NO. 923-1000.147 DRAWING NO. 65048 DATE 1/16/96 DRAWN BY TK

Golder Associates

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APPENDIX A

LEVEL I ENVIRONMENTAL ASSESSMENT FOR THE LANDSBURG MINE SITE

February 1, 1996

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TABLE OF CONTENTS

LIST OF FIGURES

ATTACHMENTS

EDR Radius Search Report
Property History Reports (Stewart Title Company)

A.1 INTRODUCTION

A Level I Environmental Assessment (EA) was completed for the Landsburg Mine site Study Area. The Landsburg Mine Study Area is located approximately 1.5 miles northwest of Ravensdale, in rural southeast King County, Washington. The Landsburg Mine site is a listed site on the Washington State Hazardous Sites List and is currently under remedial investigation. Documented evidence of drummed and bulk chemical and industrial waste disposal exists. Groundwater sampling conducted at the site indicates that the contaminants do not appear to be migrating from the site. The Study Area location is shown in Figure A-1.

The EA was completed by utilizing many of the same resources that were available for the remedial investigation. The purpose of the Level I EA was to identify historical land uses, ownership, or activities that may have resulted in the generation, storage or disposal of hazardous materials at the site. Although considerable information is available concerning mining and subsequent waste disposal activities within the trench at the site, the EA focused on locations outside of the trench and activities prior to mining, potentially unrelated to waste disposal, that may have lead to environmental degradation. Such activities could have included fuel oil storage and general equipment maintenance where underground or above ground storage tanks may have been housed or where degreasing solvents may have been in use.

The Level I EA also examined the areas surrounding the Landsburg mine to determine if previous land use or private or commercial activity may have impacted the subject property.

Sampling and testing the site soils, surface water or ground water were not conducted as part of this Level I Assessment. Inspections of buildings or their contents was not completed because the site is currently free of structures. In conducting this Level I Assessment the following activities were conducted:

1. Reviewed federal government databases from a specialized search firm, Environmental Data Resources, Inc. (EDR) of Southport, Connecticut. These databases as described by EDR included:

    - The Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS). The CERCLIS list contains information on sites identified by the US EPA as abandoned, inactive, or uncontrolled hazardous waste sites which may require cleanup.

    - The Emergency Response Notification System (ERNS). ERNS records information reported to the US EPA and Coast Guard National Response Center on reported releases of oil and hazardous substances.

- The National Priorities List (NPL). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program.

- The Resource Conservation and Recovery Information System (RCRIS). RCRIS includes selective information on sites that generate, transport, and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act. (RCRA)

- The Facility Index System (FINDS). FINDS contains facility information and "pointers" to other sources that contain more detail. These include: RCRIS, PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), FATES (FIFRA[Federal Insecticide, Rodenticide, and Fungicide Act] and TSCA Enforcement System, FTTS [FIFRA/TSCA Tracking System]), CERCLIS, DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), FRDS (Federal Reporting Data System), SIA (Surface transporters/disposers), TRIS and TSCA.

- The PCB Activity Database (PADS). PADS identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

- The RCRA Administrative Tracking System (RAATS). RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA.

- The Toxic Chemical Release Inventory (TRIS). TRIS identifies facilities that release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

- The Toxic Substances Control Act (TSCA). TSCA identifies manufacturers and importers of chemical substance included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site.

- The Hazardous Materials Information Reporting System (HMIRS). HMIRS contains hazardous material spill incidents reported to the DOT.

- The Federal Superfund Liens (NPL Liens).

2. Reviewed State of Washington databases. These databases included:

   - The Leaking Underground Storage Tank List (Lust). LUST records contain an inventory of reported leaking underground storage tank incidents.

   - State Hazardous Waste Sites List. This is the Washington State Confirmed and Suspected Contaminated Sites (C&SCS) Report. This report included sites that are determined to need additional investigation after an initial report of contamination.

   - The State Hazardous Sites List (HSL). This is a subset of the C&SCS Report that contains sites that have been ranked using the Washington Ranking Method.

   - The Registered Underground Storage Tanks List (UST). This is a list of registered underground storage tanks.

3. Reviewed the title history for the site.

4. Interviewed personnel who worked at the site, local residents, federal, state, and local officials who might be knowledgeable of activities at the site or in the surrounding area.

5. Reviewed available background information about the site in order to understand the site environmental setting.

6. Reviewed United States Geological Survey topographic maps to assess drainage patterns and land use.

7. Reviewed aerial photographs dating from the 1930's to the present time.

8. Conducted a site reconnaissance to determine the current environmental status at the site.

A.2 REVIEW OF GOVERNMENT DATABASES

Golder contracted with EDR of Southport, Connecticut to conduct the search of federal and state databases for listings of the subject site or surrounding sites. EDR conducted the search in accordance with the ASTM Standard (E-1527). The purpose of the search is to locate sites that appear on one or more of the state and federal databases listed above. Golder also reviewed the Washington C&SCS and Hazardous Sites lists dated November 16, 1994 as a quality control measure.

The databases were searched by EDR for any sites with the same longitude and latitude and zip code as the subject site. Sites within the same zip code and ASTM search distance were flagged and if they fell within the ASTM designated search distances of the subject site, were identified in a summary table. The summary table is included with the EDR Report that is included as an attachment.

The subject property has been identified on four databases, CERCLIS, RCRIS-Large quantity generator, FINDS, and the Washington C&SCS. The CERCLIS listing indicates that the site is currently under investigation to assess the need for further action. FINDS and the RCRIS-LQG listings indicate that Palmer Coking Coal Company has provided EPA with notification that hazardous materials are generated at the site, however, no quantities are listed. Materials reportedly generated include ignitable waste, lead, mercury, benzene, and X003 undefined waste. It is not certain why the site is listed under the FINDS and RCRIS-LQG databases; however, it is assumed to be the result of the Expedited Response Action conducted in 1991. The Washington C&SCS list identifies the site as a state hazardous waste site with confirmed soil contamination and suspected ground water contamination.

No surrounding properties were identified as a member of any database.

Thirteen "orphan" sites were identified by EDR. An "orphan" site is a site that is not located because of incompatible information in the address. The only "orphan " site of interest is the L-Bar products ,Inc. site which is identified as a Washington State hazardous waste site. This site is located approximately one-mile from the southern site boundary of the Landsburg Mine Study Area. The L-Bar site has suspected priority pollutant metal and corrosive waste contamination. Because of the distance from the subject property and the nature of the potential contamination, this site should have no impact on the Landsburg Mine Study Area.

No Federal Superfund sites were identified within the ASTM search radius.

A.3 REVIEW OF THE TITLE HISTORY

Golder contracted with Stewart Title Company of Seattle, Washington to perform a title history report for the site, based on tax lot information provided by Palmer Coking Coal. The title history documents ownership of the mined area and the resultant surface trench, from 1945 to the present. The title history for the entire Study Area was not obtained for this EA. The title history for the site is presented in two separate reports. The complete title reports and supporting documentation are included as an attachment to this report.

The areas that were mined for coal are contained within 7 parcels of land labeled A through H. The legal descriptions of each Parcel is as follows:

PARCEL A
The north half of the southeast quarter of the southwest quarter of Section 24, Township 22 North, Range 06 East, W.M., in King County, Washington.

PARCEL B
That portion of the southwest quarter of the southeast quarter of the Section 24, Township 22 North, Range 06 East, W.M., in King County, Washington, lying southerly of the southerly margin of S.E. Summit-Landsburg Road; EXCEPT county road.

PARCEL C
The northwesterly quarter of Section 25, Township 22 North, Range 06 East, W.M., in King County, Washington.

PARCEL D
That portion of the northeast quarter of the Southwest quarter of Section 25, Township 22 North, Range 06 East, W.M., in King County, Washington, lying northeasterly of the northerly margin of Kent-Kangley Road; EXCEPT the east 275 feet of the south 625 feet thereof.

PARCEL E
The north half of the northeast quarter of the northwest quarter of the southwest quarter of Section 25, Township 22 North, Range 06 East, W.M., in King County, Washington.

PARCEL F
The north half of the south half of the northeast quarter of the northwest quarter of the southwest quarter of Section 25, Township 22 North, Range 06 East, W.M., in King County, Washington.

PARCEL G
The south half of the south half of the northeast quarter of the northwest quarter of the southwest quarter of Section 25, Township 22 North, Range 06 East, W.M., in King County, Washington; EXCEPT the west 20 feet thereof; Together with that portion of the southeast quarter of the northwest quarter of the southwest quarter of said Section 25 lying northerly EXCEPT the west 20 feet thereof.

PARCEL H
The south half of the southeast quarter of the southwest quarter of Section 24, Township 22 North, Range 6 East, W.M., in King County, Washington.

The parcels and ownership are depicted on Figure A-2.

Parcels A, B and H were obtained by the Palmer Coking Coal Company in transactions in 1937 and 1949. In 1937, Morris Brothers Coal Mining executed a Quit Claim deed to Palmer Coking Coal Co. On March 28, 1949, the parcels were transferred from the

Continental Land Company to the Danville Coal Mining Company. The land was conveyed to the Palmer Coking Coal Company 2 days later.

Parcel C was deeded to BN Timberlands by the Burlington Northern Railroad Company as part of a very large property transaction on July 18, 1983. The total acreage of the transaction was 28,199.83 acres. On June 21, 1989, PCTC, Inc. (formerly BN Timberlands, Inc. then Plum Creek Timber Company, Inc.) conveyed parcel C to the Plum Creek Timber Company, L.P. The Parcel C portion of the transaction was 240 acres. PCTC, Inc. retained all of the oil and gas and mineral rights to the property including rights to coal, lignite, and peat, precious metals, industrial minerals, fissionable materials, sand clay gravel and aggregate, and any other naturally occurring element, compounds or substances in solid, liquid, or gaseous state. The deed also allowed PCTC ingress and egress to the property for exploration, extraction, and processing any minerals, oil or gas that might exist on the property.

In December of 1992 a correction deed was filed by PCTC, Inc. that invalidated a clause of the Timberlands Conveyance in the original deed with the Plum Creek Timber Company, L.P that would have allowed Plum Creek Timber Company, L.P to acquire the mineral rights and certain oil and gas rights to the property after ten years from conveyance.

Parcel D was first conveyed by means of a warranty deed from Martin and Magdalena Hock to Carl G. and Nina Elizabeth Falk on September 21,1950. The Falks conveyed the property to Palmer Coking Coal on March 28, 1951.

The smallest Parcels, E,F, and G, were obtained between February and March 1964 by Palmer Coking Coal in a series of Deed And Release Agreements with several parties who owned 1/144th shares in the property. The division of the property was in as little as .6/144 to 24/144. The Deed and Release Agreements released Palmer Coking Coal and the Northern Pacific Railway from any damages that might occur due to mining activities on the property.

The first deed for Parcels, E,F, and G was dated February 20, 1964 with Peter Charles Mattioda. Two deeds were recorded February 28, 1964, the first with Tom Mattioda and the second with Michele Mattioda. On March 2, 1964, a deed was recorded with Mary Hall and on March 5, 1964 with Mary Tobacco.

The largest interest in Parcels E, F and G was conveyed on March 11, 1964 when a number of fractional interests were obtained from Pietro-Carlo Peradotto, Domenico Peradotto, Michele Pagliero, Rodolfo Pagliero, Giovanni-Battista Mattioda, Elvira Mattioda, Pio Mattioda, Ines Mattioda, Domenica Mattioda, Pierino Mattioda, Adelina Mattioda, Guilio Mattioda, Laurina Mattioda, Rosina Mattioda, Bruna Mattioda, Riccardo Mattioda, Ernesto Mattioda, Silvana Mattioda, Carlo Castagna, Domenica Castagna, Grancesco Castagna, and Catarina Iano.

The final transaction for Parcels E, F, & G was March 13, 1964 with Constance Natalie Mattioda, the sole legatee of Charles Mattioda.

A.4 INTERVIEWS

Golder has interviewed federal, state and local officials in order to gather site information that may not have been included in site documentation. This process also included discussions with the property owners and mining company personnel on site during coal removal, haulers who may have been knowledgeable of waste disposal activities at the site and neighbors potentially knowledgeable of local environmental concerns. The interviewees were questioned about mining activities, underground storage tanks, septic systems, material spills, or any incident which may have been of importance. The contents of the following sections are paraphrased from the interviews and reflect statements made by that person.

Mr. Steve Hulsman, Washington State Department of Health

Mr. Hulsman was contacted for information pertaining to disposal activities or other environmental concerns with regard to the mine. Mr. Hulsman had conducted a drinking water well survey of wells near the mine, but was not familiar with details of disposal activities at the site. The survey results suggested that ground water near the mine was not being impacted by disposal activity.

Mr. Evan Morris, Vice President of Palmer Coking Coal Company

Mr. Morris indicated that there was no waste disposal inside of the Landsburg Mine. Barrels of waste were placed in the trench to the north of the rock bridge that corresponds to the fault at the bottom of the Rogers No. 1 slope. Building debris and stumps typified material placed in the southern portion of the trench. Mr. Morris said that miners had noted oil in the fourth level sump after tankers had discharged material. The oil apparently disappeared after a few days. He also mentioned that three fires occurred in the waste at the Roger mine which were allowed to burn out.

Mr. Archie Eltz, Miner, Palmer Coking Coal Company

Mr. Eltz was responsible for mining the gangways, counters and crosscuts at the mine. He did remember smelling diesel fumes in the mine in concurrence with disposal of material from a tanker.

A.5 MAP AND AERIAL PHOTOGRAPH REVIEW

A.5.1 Map Review

The map review included the following topographic and geologic maps:

* United States Geological Survey, "Cumberland Quadrangle, Washington", 7.5 Minute Series topographic map. Dated 1953, photorevised 1968 and 1973.

* Washington Department of Natural Resources, Division of Mines and Geology, "Geologic Map of King County, Washington". Dated 1970.

The subject property is located along the margin of the Puget Lowlands and the Cascade Range foothills. The site is bounded to the north by the S.E. Summit-Landsburg Rd. and to the south by the Kent-Kangley Rd. The towns of Ravensdale and Georgetown are located approximately 1-1/2 and 1 miles to the southeast, respectively. The Cedar River passes within approximately 500 ft of the northern end of the trench.

The site is situated atop a gently sloping hill which reaches a maximum elevation of approximately 800 ft msl near the central portion of the site. The topography slopes steeply to the north in the northern portion of the site down to the Cedar River which occurs at an elevation of about 500 ft.. The Cedar River is a critical water source for the City of Seattle. The southern portion of the site slopes more gradually to the south towards Rock Creek and the Kent-Kangley Rd. which occur at about 600 ft msl. A somewhat larger hill which reaches an elevation of about 940 ft msl is located to the east of the site.

There are no perennial surface water drainage features at the site. The only such features in the Study Area include Rock Creek and the Cedar River. A number of relatively minor wetlands are scattered about the Study Area. Surface water collects in a number small depressions within the trench. The water collection areas within the trench are ephemeral and were observed to be dry during the months of June through November. Water is present throughout the year at the abandoned mine portals #2 and 3. This water is believed to represent discharge of groundwater from the mined out Rogers seam. The water at portal #2 does not flow overland but is contained within a small depression.

The geology of the Landsburg Mine Site consists of the recent glacial drift deposits underlain by the Eocene-aged Puget Group sedimentary rocks. The Puget Group rocks include the coal-bearing formations removed from the mine. In general, glacial till mantles the hillsides and recessional outwash deposits cover the lower elevations. The thickness of the drift deposits is generally less than about 50 ft at the site. The thickness of the Puget Group bedrock is not known but probably exceeds several thousand ft.

A.5.2 Aerial Photograph Review

Golder obtained aerial photograph enlargements of the subject property for the years 1974, 1985, 1988 from Walker & Associates of Seattle, Washington. Additional photocopied aerial photographs from 1965, 1980, 1981, 1982, and 1985 were obtained from the Washington State Department of Natural Resources, Resource Mapping Section. Because of the poor qualities of the photocopies, no detailed information concerning the site or surrounding areas could accurately be determined. Therefore, the descriptions for the years 1965, 1981, and 1982, present general observations. The enlarged photographs from 1974, 1985, and 1988 were reviewed for relevant site uses and features. The following observations were recorded with regard to the site and surrounding property.

1965 Black and White Photo. Scale 1:12,000

In the 1965 aerial photograph a long, light scar is visible that presumably is the mine trench. There is a small residential area immediately to the east of the site. There is little development further east. To the south of the site, limited development is visible near a large power-line right-of-way. To the west of the subject property there is no development.

1974 Black and White Photo. Scale 1"=190 feet.

In the 1974 enlargement the primary feature is the trench . There is a clear distinction between the north and south portions of the trench as divided by a rock bridge, visible at the surface as a point where a road crosses from the north side of the trench to the south. The north part of the trench appears to be shallower than the south and the walls of the feature are not as sheer. The southern portion of the trench has many large individual collapsed pits. One of the pits located approximately 1200 feet south of the rock bridge may contain water. There are large elongate mounds approximately 400 feet south of the rock bridge that suggest earth moving. There no wet areas at the mine portals that indicate drainage from the mine.

To the east of the site, there is a small development of single family homes and forest land. To the south of the trench there are small buildings within the power line right-of-way that appear to be related to the mine workings. Further south, there are a few small homes and heavily forested land. To the west of the trench the land is undeveloped and covered by dense forest.

1981 Black and White Photo. Scale 1:12,000

In the 1981 photograph, the most distinctive feature is a massive clear-cut of the dense forests that were located to the west of the southern portion of the trench. The clear cut appears to extend to the edge of the trench. There are few changes to the north, east and south.

1982 Black and White Photo. Scale 1:12,000

In the 1982 photograph, the site and surrounding areas appear the same as in the 1981 photograph.

1985 Black and White Photo. Scale 1"=190 feet.

In the 1985 photograph it appears as though the north part of the trench and a large portion of the south trench have been partially filled with dirt. Bulldozer patterns suggest that materials have been pushed in from the south wall of the trench. There is no water visible in any of the collapsed pits in the south trench, however, it appears as though there is an extensive wet area at the north portal of the mine.

There appears to be little new development to the north or east of the trench. To the south the small buildings in the power line right-of-way are no longer present.

1988 Black and White Photo. Scale 1"=200 feet.

In the 1988 photograph it appears as though there has been significant re-vegetation along the length of the trench. There are no wet areas visible within the trench or at the mine portals. There are no changes visible within the range of the photograph to the north or east of the trench. To the south of the trench, south of Kent-Kangley Road near the area of small single family homes, a large, new clear-cut is visible. To the west of the trench it appears that extensive reforestation of the western clear-cut has begun.

A.6 SITE SURVEY

Several site surveys have been completed by Golder throughout the course of the RI. The Landsburg Mine site is defined as the land extending 400 feet on either side of the subsidence trench lineation and bounded by the Summit-Landsburg Road to the north and the electrical transmission line easement to the south. The site is accessed via a dirt road that begins at Summit-Landsburg Road and follows the north portion of the trench. A locked gate secures the site at the Summit-Landsburg Road entrance. The northern portion of the site trench where waste disposal occurred is enclosed by an eight foot chain link security fence. Dirt trails line both sides of the trench. The surrounding area is covered with dense vegetation including blackberry bushes, alder, cedar, hemlock, cottonwood, maple and fir..

Mine Portal 2 is located at the northernmost extent of the mine, at the base of a steep slope. The portal consists of an enclosed depression where water is contained. The depression stays wet throughout the year, however, in the summer the size of the area is reduced considerably.

Along the body of the northern portion of the site, the trench appears as a series of 40 to 50 foot deep depressions. The walls of the depressions are nearly vertical and small scale wall failure was observed during the site visit. Standing water was noted in one of the depressions.

The south portion of the trench is similar to the north, appearing as a series of deep depressions with near vertical side walls. Several of the depressions were filled with water.

Miscellaneous debris, including an old clothes dryer, wood and demolition debris, tires, and domestic refuse were noted in several of the trench depressions. Two 55-gl drums were visible at the surface just north of the road which crosses the trench. There was no other evidence of waste disposal at the site. No drums were observed at Parcel D where Ecology has apparently received anecdotal reports of drum disposal.

No underground or above ground storage tanks, potential PCB transformers, stressed vegetation, soil staining or other signs of environmental impairment were noted during the site visit.

Because there are no structures at the site, there are no expected conditions associated with lead paint, lead pipes, asbestos, or radon accumulations.

There is no evidence that a septic tank or drainfield were in service at the site. However, mine operations occurred at the site for nearly twenty years and there is a potential that a septic system may have been in use.

The site is surrounded by an undeveloped area. There is no evidence to suggest that surrounding land uses in the past or present may have resulted in environmental degradation at the site.

A.7 SUMMARY

The results of the EA are summarized below.

A.7.1 Review of Government Databases

Golder contracted with EDR of Southport, Connecticut to conduct the search of federal and state databases for listings of the subject site or surrounding sites. No surrounding properties were identified as a member of any database.

The subject property was identified on four databases, CERCLIS, RCRIS-Large quantity generator, FINDS, and the Washington C&SCS. The CERCLIS listing indicates that the site is currently under investigation to assess the need for further action. FINDS and the

RCRIS-LQG listings indicate that Palmer Coking Coal Company has provided EPA with notification that hazardous materials are generated at the site, however, no quantities are listed. Materials reportedly generated include ignitable waste, lead, mercury, benzene, and X003 undefined waste. The Washington C&SCS list identifies the site as a state hazardous waste site with confirmed soil contamination and suspected ground water contamination.

A.7.2 Review of Title History

The title history indicated that the subject property is owned by Palmer Coking Coal and the Plum Creek Timber Company L.P. Plamer Coking Coal has been associated with the property since about 1937. PCC owns the parcels at the northern and southern ends of the site. Plum Creek Timber owns the central portion of the property which was obtained in 1983 from Burlington Northern Railroad, a parent company of Plum Creek.

A.7.3 Interviews

Interviews were conducted with personnel potentially knowledgeable of the site. The interviews indicated that drummed and bulk chemical wastes were disposed of at the northern portion of the trench. There was no evidence that waste generation, storage or disposal has taken place at any surrounding properties.

A.7.4 Map and Aerial Photo Review

The map review indicates that the site lies in a hilly, sparsely developed area of southeast King County. The surficial deposits at the site are composed of glacial till and outwash. The subsurface bedrocks are composed of the coal-bearing members of the Puget Group. The coal areas were mined out and a large subsidence trench was created over the abandoned mine workings.

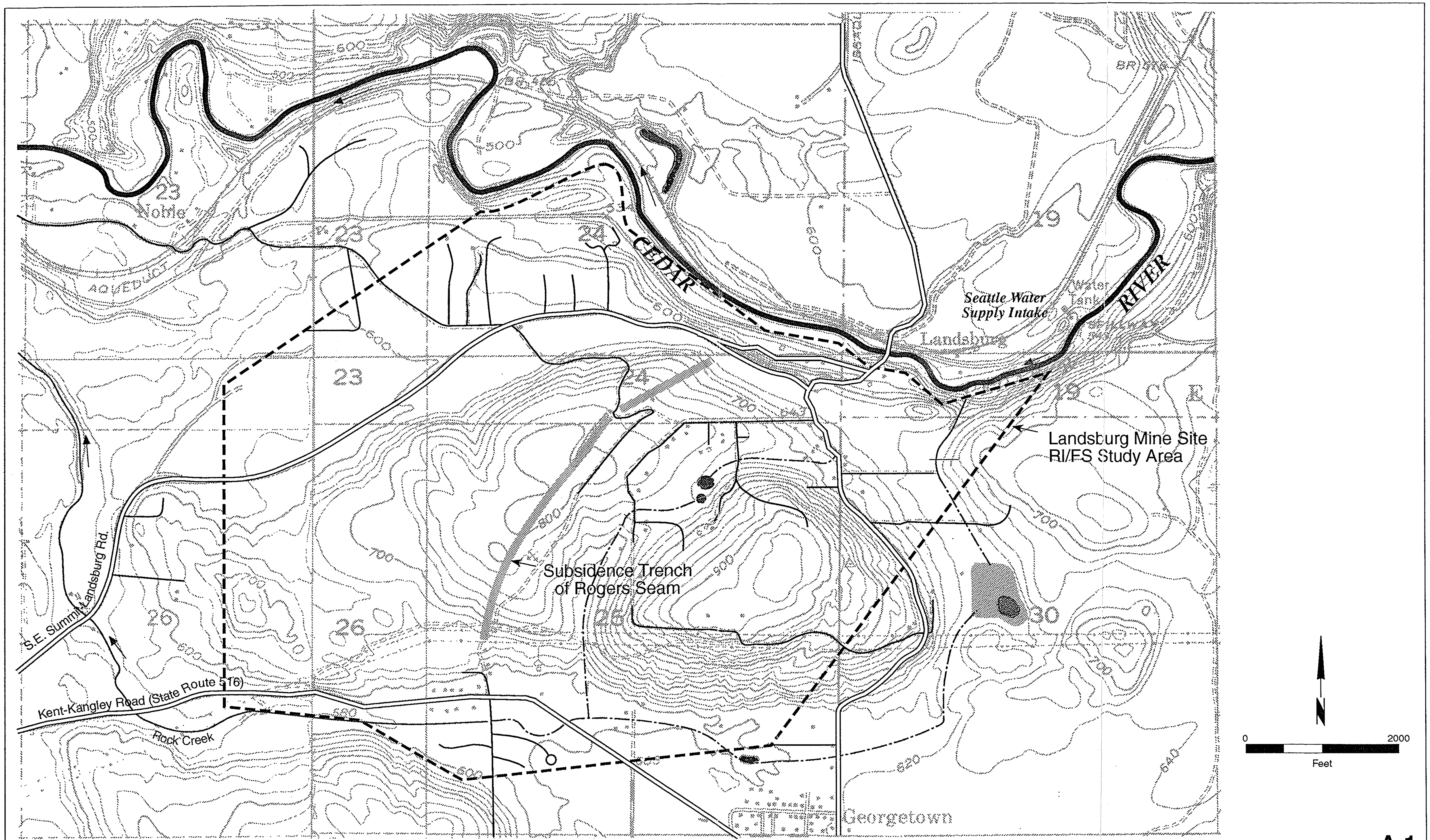
Aerial photograph coverage for the years 1974 through 1988 was available for the site. The aerial photographs did not provide direct evidence of the waste disposal activities that occurred at the site, but did document the subsidence trench and surrounding land use. No evidence was found at the surrounding properties to suggest that hazardous materials had been generated, stored or disposed .

A.7.5 Site Survey

The site survey indicated that the primary feature at the site is the large subsidence trench formed by mining of the subsurface coal. The site was secured. Some miscellaneous items, primarily debris and domestic refuse, were observed in the trench. There was no evidence of current hazardous waste disposal in the trench areas. No evidence was found at the surrounding properties to suggest that hazardous materials had been generated, stored or disposed.

A.8 CLOSURE

The Landsburg Mine site is currently under remedial investigation. Documented evidence of drummed and bulk chemical and industrial waste disposal within the trench at the site exists. Groundwater sampling at the site performed by the WDOH has indicated that the wastes do not appear to be migrating from the site. The EA has confirmed that waste disposal occurred at the site, and that there is no evidence to suggest that similar activity took place in the surrounding land areas or beyond the known margins of the trench.



Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

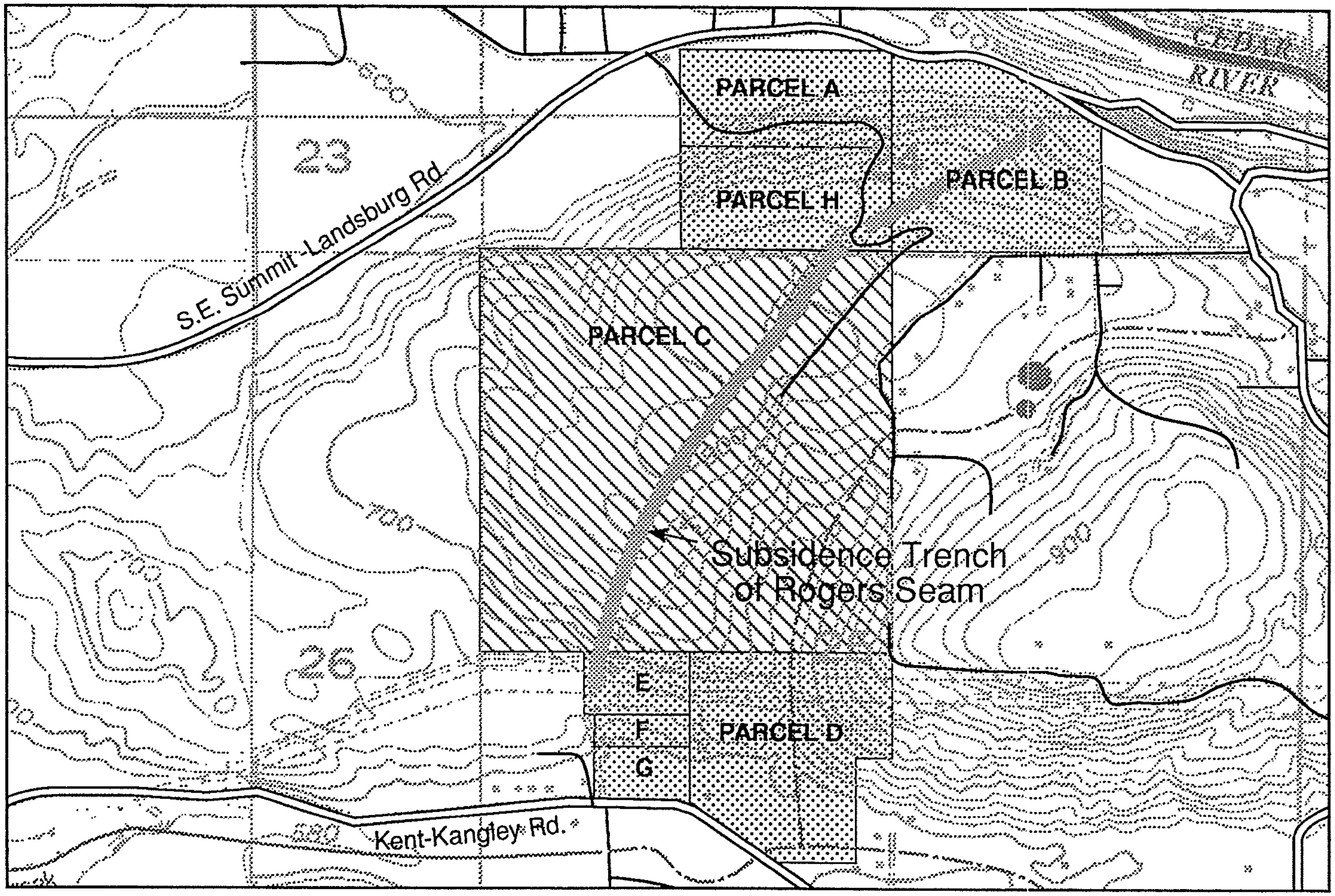
FIGURE **A-1**

SITE LOCATION MAP

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 55317 DATE 2/21/95 DRAWN BY EA

Golder Associates

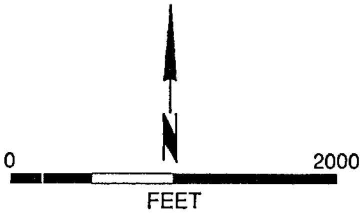


EXPLANATION

Current Ownership

▒ PCC

▨ Plum Creek Timber L.P.



Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

IMPORTANT: This is not a Plat of Survey. Boundaries shown are approximate.

FIGURE **A-2**

PARCEL MAP

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 55318 DATE 3/2/95 DRAWN BY CB

Golder Associates

EDR-RADIUS SEARCH™ REPORT

Landsburg Mine Site
Landsburg Mine Site
Ravensdale, WA 98051

February 03, 1995

Lat: 47.3694 Long: -121.9833

Inquiry Number: 67429.1s

Environmental Data Resources, Inc.

Creators of Toxicheck/®

The Source For Environmental Risk Management Data

3530 Post Road
Southport, Connecticut 06490

Nationwide Customer Service

Telephone: 1-800-352-0050
Facsimile: 1-800-231-6802

1. The EDR - Radius Search/Plus Report

The EDR - Radius Search/Plus Report is a radius search report which focuses on both a target property and adjoining or nearby sites which may impact the target property. The search distance for specific government records varies according to the requirements of the draft ASTM Standard, and/or client specifications.

For questions or assistance
Please call EDR Nationwide Customer Service at
1-800-352-0050 (8am - 8pm EST)
with questions or comments about your report.

Thank you for your business!

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

To maintain currency of the following federal and state databases, EDR contacts the appropriate governmental agency on a monthly or quarterly basis, as required.

Elapsed ASTM days: Provides confirmation that this EDR report meets or exceeds the 90-day updating requirement of the ASTM standard.

FEDERAL ASTM RECORDS:

CERCLIS: Comprehensive Environmental Response, Compensation, and Liability Information System
Source: EPA/NTIS
Telephone: 703-416-0702
CERCLIS: Comprehensive Environmental Response, Compensation and Liability Information System. CERCLIS contains information on sites identified by the USEPA as abandoned, inactive or uncontrolled hazardous waste sites which may require cleanup.

Date of Government Version: 10/31/94
Date Made Active at EDR: 01/30/95
Date of Data Arrival at EDR: 12/16/94
Elapsed ASTM days: 45

ERNS: Emergency Response Notification System
Source: EPA
Telephone: 202-260-2342
ERNS: Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 12/31/93
Date Made Active at EDR: 05/25/94
Date of Data Arrival at EDR: 04/11/94
Elapsed ASTM days: 44

NPL: National Priority List
Source: EPA
Telephone: 703-603-8852
NPL: National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program.

Date of Government Version: 12/16/94
Date Made Active at EDR: 01/30/95
Date of Data Arrival at EDR: 12/21/94
Elapsed ASTM days: 40

RCRIS: Resource Conservation and Recovery Information System
Source: EPA/NTIS
Telephone: 202-260-3393
RCRIS: Resource Conservation and Recovery Information System. RCRIS includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA).

Date of Government Version: 07/01/94
Date Made Active at EDR: 11/02/94
Date of Data Arrival at EDR: 10/05/94
Elapsed ASTM days: 28

FEDERAL NON-ASTM RECORDS:

FINDS: Facility Index System
Source: EPA/NTIS
Telephone: 800-908-2493
FINDS: Facility Index System. FINDS contains both facility information and "pointers" to other sources that contain more detail. These include: RCRIS, PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), FATES (FIFRA [Federal Insecticide Fungicide Rodenticide Act] and TSCA Enforcement System, FTTS [FIFRA/TSCA Tracking System]), CERCLIS, DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), FRDS (Federal Reporting Data System), SIA (Surface Impoundments), CICIS (TSCA Chemicals in Commerce Information System), PADS, RCRA-J (medical waste transporters/disposers), TRIS and TSCA.

Date of Government Version: 09/14/93 Date of Next Scheduled Update: 03/13/95

PADS: PCB Activity Database System
Source: EPA
Telephone: 202-260-3992
PADS: PCB Activity Database. PADS Identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 07/11/94 Date of Next Scheduled Update: 12/19/94

RAATS: RCRA Administrative Action Tracking System
Source: EPA
Telephone: 202-564-4104
RAATS: RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA.

Date of Government Version: 04/06/94 Date of Next Scheduled Update: 04/01/95

TRIS: Toxic Chemical Release Inventory System
Source: EPA/NTIS
Telephone: 202-260-2320
TRIS: Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/92 Date of Next Scheduled Update: 10/02/95

TSCA: Toxic Substances Control Act
Source: EPA/NTIS
Telephone: 202-260-1444
TSCA: Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site. USEPA has no current plan to update and/or re-issue this database.

Date of Government Version: 05/15/86 Date of Next Scheduled Update: 03/13/95

HMIRS: Hazardous Materials Information Reporting System
Source: U.S. Department of Transportation
Telephone: 202-366-4555
HMIRS: Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 06/30/93 Date of Next Scheduled Update: 05/02/95

NPL LIENS: Federal Superfund Liens
Source: EPA
Telephone: 202-260-3733
NPL LIENS: Federal Superfund Liens. Under the authority granted the USEPA by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner receives notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

Date of Government Version: 10/15/91 Date of Next Scheduled Update: 04/18/95

STATE OF WASHINGTON ASTM RECORDS:

LUST: Leaking Underground Storage Tanks Site List
Source: Department of Ecology
Telephone: 206-407-7204
LUST: Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tank incidents. Not all states maintain these records, and the information stored varies by state.

Date of Government Version: 10/03/94	Date of Data Arrival at EDR: 11/07/94
Date Made Active at EDR: 01/13/95	Elapsed ASTM days: 67

SHWS: Confirmed & Suspected Contaminated Sites List
Source: Department of Ecology
Telephone: 206-407-7200
SHWS: State Hazardous Waste Sites. State hazardous waste site records are the states' equivalent to CERCLIS. These sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup using state funds (state equivalent of Superfund) are identified along with sites where cleanup will be paid for by potentially responsible parties. Available information varies by state.

Date of Government Version: 11/07/94	Date of Data Arrival at EDR: 12/07/94
Date Made Active at EDR: 01/30/95	Elapsed ASTM days: 54

SWF/LS: Solid Waste Facilities Handbook
Source: Department of Ecology
Telephone: 206-407-6132
SWF/LS: Solid Waste Facilities/Landfill Sites. SWF/LS type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Section 2004 criteria for solid waste landfills or disposal sites.

Date of Government Version: 04/11/94	Date of Data Arrival at EDR: 05/16/94
Date Made Active at EDR: 06/08/94	Elapsed ASTM days: 23

UST: Statewide UST Site/Tank Report
Source: Department of Ecology
Telephone: 206-407-7179
UST: Registered Underground Storage Tanks. UST's are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

Date of Government Version: 04/11/94	Date of Data Arrival at EDR: 04/21/94
Date Made Active at EDR: 05/25/94	Elapsed ASTM days: 34

Historical and Other Database(s)

Former Manufactured Gas (Coal Gas) Sites: The existence and location of Coal Gas sites is provided exclusively to EDR by Real Property Scan, Inc. ©Copyright 1993 Real Property Scan, Inc. For a technical description of the types of hazards which may be found at such sites, contact your EDR customer service representative.

Disclaimer Provided by Real Property Scan, Inc.

The information contained in this report has predominantly been obtained from publicly available sources produced by entities other than Real Property Scan. While reasonable steps have been taken to insure the accuracy of this report, Real Property Scan does not guarantee the accuracy of this report. Any liability on the part of Real Property Scan is strictly limited to a refund of the amount paid. No claim is made for the actual existence of toxins at any site. This report does not constitute a legal opinion.

Area Radon Information: The National Radon Database has been developed by the U.S. Environmental Protection Agency (USEPA) and is a compilation of the EPA/State Residential Radon Survey and the National Residential Radon Survey. The study covers the years 1986 – 1992. Where necessary data has been supplemented by information collected at private sources such as universities and research institutions.

FRDS: Federal Reporting Data System
Source: EPA/Office of Drinking Water
FRDS provides information regarding public water supplies and their compliance with monitoring requirements, maximum contaminant levels (MCL's), and other requirements of the Safe Drinking Water Act of 1986.

Oil/Gas Pipelines/Electrical Transmission Lines: This data was obtained by EDR from the USGS in 1994. It is referred to by USGS as GeoData Digital Line Graphs from 1:100,000-Scale Maps. It was extracted from the transportation category including some oil, but primarily gas pipelines and electrical transmission lines.

Sensitive Receptors: There are individuals who, due to their fragile immune systems, are deemed to be especially sensitive to environmental discharges. These typically include the elderly, the sick, and children. While the exact location of these sensitive receptors cannot be determined, EDR indicates those facilities, such as schools, hospitals, day care centers, and nursing homes, where sensitive receptors are likely to be located.

SEARCH FINDINGS

Direction Distance	Site	Database(s)	EDR ID Number EPA ID Number

Coal Gas Site Search: No site was found in a search of Real Property Scan's ENVIROHAZ database.

Direction Distance	Site	Database(s)	EDR ID Number EPA ID Number
Target Property	LANDSBURG MINE-ROGERS SEAM KENT-KANGLEY RD / 268TH AVE SE RAVENSDALE, WA 98010	SHWS	S101189009 N/A

Washington Hazardous Waste Additional Data: N/A

Direction Distance	Site	Database(s)	EDR ID Number EPA ID Number
Target Property	LANDSBURG MINE SITE T22N R6E S24 & 25 RAVENSDALE, WA 98051	FINDS RCRIS-LQG	1000659517 WAD988491908

RCRIS:
Owner: PALMER COKING COAL CO

Contact:WILLIAM KOMBOL
(206) 886-2841

Waste	Quantity	Info Source	Waste	Quantity	Info Source
D001	Not reported	Notification	D008	Not reported	Notification
D009	Not reported	Notification	D018	Not reported	Notification
X003	Not reported	Notification			

Direction Distance	Site	Database(s)	EDR ID Number EPA ID Number
Target Property	LANDSBURG MINE, ROGERS SEAM KENT-KANGLEY ROAD BLACK DIAMOND, WA 98010	CERCLIS SHWS FINDS	1000192558 WAD980976161

CERCLIS Classification Data:
Site Incident Category: Not reported Federal Facility: NO
Ownership Status: OTHER NPL Status: NOT ON NPL
EPA Notes: CUMBERLAND QUAD: T 22N, R 6E, SEC 24-SW 1/4. DIRT ROAD OFF SE SUMMIT-LANDSBURG ROAD ABOUT 1.7 MI FROM THE KENT-KANGLEY ROAD.

CERCLIS Assessment History:

Assessment:	SCREENING SITE INSPECTION	Completed:	02/25/85
Assessment:	DISCOVERY	Completed:	09/01/83
Assessment:	PRELIMINARY ASSESSMENT	Completed:	02/25/85
Assessment:	SCREENING SITE INSPECTION	Completed:	09/01/88

CERCLIS Site Status:
This site is currently under investigation by the government to assess the extent of further action
CERCLIS Alias Name(s):
LANDSBURG MINE, ROGERS SEAM

Washington Hazardous Waste Additional Data -
Affected Media: SOIL Status: CONFIRMED
Affected Media: GROUNDWATER Status: SUSPECTED

SEARCH FINDINGS SUMMARY

Database	Target Property	Search Distance (Miles)	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
NPL		1.000	0	0	0	0	NR	0
RCRIS-TSD		1.000	0	0	0	0	NR	0
State Haz. Waste	X	1.000	0	0	0	0	NR	0
CERCLIS	X	0.500	0	0	0	NR	NR	0
State Landfill		0.500	0	0	0	NR	NR	0
LUST		0.500	0	0	0	NR	NR	0
UST		0.125	0	NR	NR	NR	NR	0
RAATS		TP	NR	NR	NR	NR	NR	0
RCRIS Sm. Quan. Gen.		0.125	0	NR	NR	NR	NR	0
RCRIS Lg. Quan. Gen.	X	0.125	0	NR	NR	NR	NR	0
HMIRS		TP	NR	NR	NR	NR	NR	0
PADS		TP	NR	NR	NR	NR	NR	0
ERNS		TP	NR	NR	NR	NR	NR	0
FINDS	X	TP	NR	NR	NR	NR	NR	0
TRIS		TP	NR	NR	NR	NR	NR	0
NPL Liens		TP	NR	NR	NR	NR	NR	0
TSCA		TP	NR	NR	NR	NR	NR	0
Coal Gas		1.000	0	0	0	0	NR	0

TP = Target Property

NR = Not Requested at this Search Distance

* Sites may be listed in more than one database

432 – 1286
24605 Mpb Val |BD Rd 55

ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)	Facility ID
DURHAM	U001128605	FORMER ELKCOAL SERVICE STATION	28700 KANASKAT KANGLEY ROAD	98051	UST	101914
KANASKAT	1000199605	WDOE NRO KANASKAT DRUMS	SE 307TH AVE	98051	RCRIS-LQG	
KANASKAT	S100270346	WALKER & DAUGHTERS LTD.	33832 SE GREEN RV/HEADWORKS RD	98051	SHWS	
KANASKAT	S101189345	WALKER & DAUGHTERS LTD.	33832 SE GREEN RV/HEADWORKS RD	98051	SHWS	
KANASKAT	S101189344	WALKER & DAUGHTERS LTD.	33832 SE GREEN RV/HEADWORKS RD	98051	SHWS	
KANASKAT	S101189346	WALKER & DAUGHTERS LTD.	33832 SE GREEN RV/HEADWORKS RD	98051	SHWS	
PALMER	U001124622	HOWARD A HANSON DAM	FOREST SERVICE ROAD NUMBER 212	98051	UST	006688
RAVENSDALE	U001121972	RESERVE SILICA CORPORATION	26000 BLACK DIAMOND-RAVENSDALE RD.	98051	SWF/LF, UST	000386
RAVENSDALE	S100562909	L-BAR PRODUCTS INC.	26000 BLK DIAMOND/RAVENSD RD.	98051	SHWS	
RAVENSDALE	S101188994	L-BAR PRODUCTS INC.	26000 BLK DIAMOND/RAVENSD RD.	98051	SHWS	
RAVENSDALE	1000659492	RAVENSDALE SAND PLT	26000 RAVENSDALE BLACK DIAOND RD	98051	FINDS, RCRIS-LQG	
RAVENSDALE	U000593559	LAKE RETREAT CAMP & CONF CENTER	27850 RETREAT KANASKAT ROAD SE	98051	UST	009223
RAVENSDALE	U001122915	RAVER SUBSTATION	30725 SE RETREAT-KANASKET RD	98051	UST	002838

EPA Waste Codes Addendum

Code	Description
D001	IGNITABLE HAZARDOUS WASTES ARE THOSE WASTES WHICH HAVE A FLASHPOINT OF LESS THAN 140 DEGREES FAHRENHEIT AS DETERMINED BY A PENSKY-MARTENS CLOSED CUP FLASH POINT TESTER. ANOTHER METHOD OF DETERMINING THE FLASH POINT OF A WASTE IS TO REVIEW THE MATERIAL SAFETY DATA SHEET, WHICH CAN BE OBTAINED FROM THE MANUFACTURER OR DISTRIBUTOR OF THE MATERIAL. LACQUER THINNER IS AN EXAMPLE OF A COMMONLY USED SOLVENT WHICH WOULD BE CONSIDERED AS IGNITABLE HAZARDOUS WASTE.
D008	LEAD
D009	MERCURY
D018	BENZENE
X003	NOT DEFINED

STEWART TITLE COMPANY
OF WASHINGTON, INC.
1201 Third Avenue, Suite 3800
Seattle, Washington 98101
Senior Title Officer, Julie Goodman
Title Officer, Lori Gamman
Assistant Title Officer, LaVonne Bowman
Unit No. 8
FAX Number 206-343-8403
Telephone Number 206-343-1328

Golder Associates
4104 148th Avenue Northeast
Redmond, Washington 98052
Attention: Judy Papesh
Customer Ref.: 923-1000

STW Order No.: 263107

PROPERTY HISTORY REPORT	Amount	$330.00
	Tax	$ 27.06
WORK CHARGE	Amount	$ 75.00
	Tax	$ 6.15

Effective Date: February 6, 1995, at 8:00 a.m.

A. Name of Assured:

GOLDER ASSOCIATES

B. The land referred to in this report is situate in the county of King, state of Washington, and described as follows:

As on page 2, attached.

C. Stewart Title Company of Washington, Inc. certifies that an examination of the public records of King County, Washington discloses the following deeds, real estate contracts, leases, and/or memoranda thereof describing the land referred to in this report recorded during the period beginning February 6, 1945 and ending on the effective date above.

The public records are those records established under state statutes for the purpose of imparting constructive notice of matters relating to real property to purchasers of value and without knowledge.

The land referred to in this report is situated in the county of King, state of Washington, and described as follows:

PARCEL A:

The north half of the southeast quarter of the southwest quarter of Section 24, Township 22 North, Range 6 East, W.M., in King County, Washington.

PARCEL B:

That portion of the southwest quarter of the southeast quarter of Section 24, Township 22 North, Range 6 East, W.M. in King County, Washington, lying southerly of the southerly margin of Southeast Summit-Landsburg Road;
EXCEPT county road.

PARCEL C:

The northwesterly quarter of Section 25, Township 22 North, Range 6 East, W.M. in King County, Washington.

PARCEL D:

That portion of northeast quarter of the southwest quarter of Section 25, Township 22 North, Range 6 East, W.M., in King County, Washington, lying northeasterly of the northerly margin of Kent-Kangley Road;
EXCEPT the east 275 feet of the south 625 feet thereof.

PARCEL E:

The north half of the northeast quarter of the northwest quarter of the southwest quarter of Section 25, Township 22 North, Range 6 East, W.M., in King County, Washington.

PARCEL F:

The north half of the south half of the northeast quarter of the northwest quarter of the southwest quarter of Section 25, Township 22 North, Range 6 East, W.M., in King County, Washington;
EXCEPT the west 20 feet thereof.

PARCEL G:

The south half of the south half of the northeast quarter of the northwest quarter of the southwest quarter of Section 25, Township 22 North, Range 6 East, W.M., in King County, Washington;
EXCEPT the west 20 feet thereof;

TOGETHER WITH that portion of the southeast quarter of the northwest quarter of the southwest quarter of said Section 25 lying northerly of the northerly margin of Kent-Kangley Road;
EXCEPT the west 20 feet thereof.

END OF LEGAL DESCRIPTION

PROPERTY HISTORY DOCUMENT LIST

1. TYPE OF DOCUMENT: Warranty Deed
   DATED: March 28, 1949
   RECORDING NUMBER: 3888531

   FIRST PARTY: Continental Land Company, a Washington corporation

   SECOND PARTY: Charles R. Carey, receiver of the Danville Coal Mining Company

   AFFECTS: Parcels A, B and other property

2. TYPE OF DOCUMENT: Deed
   DATED: March 30, 1949
   RECORDING NUMBER: 3906597

   FIRST PARTY: Charles R. Carey, Receiver of the Danville Coal Mining Company, a corporation

   SECOND PARTY: Palmer Coking Coal Company, a corporation

   AFFECTS: Parcels A, B and other property

3. TYPE OF DOCUMENT: Quit Claim
   DATED: October 21, 1937
   RECORDING NUMBER: 3930647

   FIRST PARTY: Morris Brothers Coal Mining Co., Inc., of the State of Washington

   SECOND PARTY: Palmer Coking Coal Company, a corporation

   AFFECTS: Parcels A, B and other property

4. TYPE OF DOCUMENT: Warranty Deed
   DATED: September 21, 1950
   RECORDING NUMBER: 4062601

   FIRST PARTY: Martin Hock and Magdalena Hock, husband and wife

   SECOND PARTY: Carl G. Falk and Nina Elizabeth Falk, husband and wife

   AFFECTS: Parcel D and other property

(continued)

5. TYPE OF DOCUMENT: Quit Claim
DATED: March 28, 1951
RECORDING NUMBER: 4124059

FIRST PARTY: Carl G. Falk and Nina Elizabeth Falk, husband and wife

SECOND PARTY: Palmer Coking Coal Company, a Washington corporation

AFFECTS: Parcel D

6. TYPE OF DOCUMENT: Deed and Release and Agreement
DATED: February 20, 1964
RECORDING NUMBER: 5758584

FIRST PARTY: Peter Charles Mattioda, as his separate estate

SECOND PARTY: Palmer Coking Coal Company, Inc., a corporation

AFFECTS: Parcels E, F, G and other property

7. TYPE OF DOCUMENT: Deed and Release and Agreement
DATED: March 11, 1964
RECORDING NUMBER: 5758585

FIRST PARTY:
Pietro-Carlo Peradotto, Domenico Peradotto, Michele Pagliero, Rodolfo Pagliero, Giovanni-Battista Mattioda, Elvira Mattioda, Pio Mattioda, Ines Mattioda, Domencia Mattioda, Domencia Mattioda, Pierino Mattioda, Adelina Mattioda, Guilio Mattioda, Laurina Mattioda, Rosina Mattioda, Bruna Mattioda, Riccardo Mattioda, Ernesto Mattioda, Silvana Mattioda, Carlo Castagna, Domenica Castagna, Grancesco Castagna, Caterina Iano

SECOND PARTY: Palmer Coking Coal Company, Inc.
AFFECTS: Parcels E, F, G and other property

8. TYPE OF DOCUMENT: Deed and Release and Agreement
DATED: March 2, 1964
RECORDING NUMBER: 5758586

FIRST PARTY: Mary Hall, as her separate estate

SECOND PARTY: Palmer Coking Coal Company, Inc., a corporation

AFFECTS: Parcels E, F, G and other property

(continued)

9. TYPE OF DOCUMENT: Deed and Release and Agreement
DATED: February 28, 1964
RECORDING NUMBER: 5758587

FIRST PARTY: Tom Mattioda, as his separate estate

SECOND PARTY: Palmer Coking Coal Company, Inc., a corporation

AFFECTS: Parcels E, F, G and other property

10. TYPE OF DOCUMENT: Deed and Release and Agreement
DATED: March 13, 1964
RECORDING NUMBER: 5758588

FIRST PARTY: Constance Natalie Mattioda, a single person and sole legatee under the Will of her father, Charles Mattioda

SECOND PARTY: Palmer Coking Coal Company, Inc., a corporation

AFFECTS: Parcels E, F, G and other property

11. TYPE OF DOCUMENT: Deed and Release and Agreement
DATED: February 28, 1964
RECORDING NUMBER: 5758589

FIRST PARTY: Michele Mattioda, as his separate estate

SECOND PARTY: Palmer Coking Coal Company, Inc., a corporation

AFFECTS: Parcels E, F, G and other property

12. TYPE OF DOCUMENT: Deed and Release and Agreement
DATED: March 5, 1964
RECORDING NUMBER: 5758590

FIRST PARTY: Mary Tobacco, as her separate estate

SECOND PARTY: Palmer Coking Coal Company, Inc., a corporation

AFFECTS: Parcels E, F, G and other property

(continued)

13. TYPE OF DOCUMENT: Special Warranty Deed
DATED: July 18, 1983
RECORDING NUMBER: 8309190365

FIRST PARTY: Burlington Northern Railroad Company, a Delaware corporation

SECOND PARTY: BN Timberlands Inc., a Delaware corporation

AFFECTS: Parcel C and other property

14. TYPE OF DOCUMENT: Deed
DATED: June 21, 1989
RECORDING NUMBER: 8907070390

FIRST PARTY: PCTC, Inc., a Delaware corporation (formerly known as Plum Creek Timber Company, Inc., and BN Timberlands, Inc.)

SECOND PARTY: Plum Creek Timber Company, L.P., a Delaware limited partnership

AFFECTS: Parcel C and other property

15. TYPE OF DOCUMENT: Correction Deed
DATED: December 21, 1992
RECORDING NUMBER: 9212212402

FIRST PARTY: PCTC, Inc., a Delaware corporation (formerly known as Plum Creek Timber Company, Inc., and BN Timberlands, Inc.

SECOND PARTY: Plum Creek Timber Company, L.P., a Delaware limited partnership

AFFECTS: Parcel C and other property

END OF REPORT

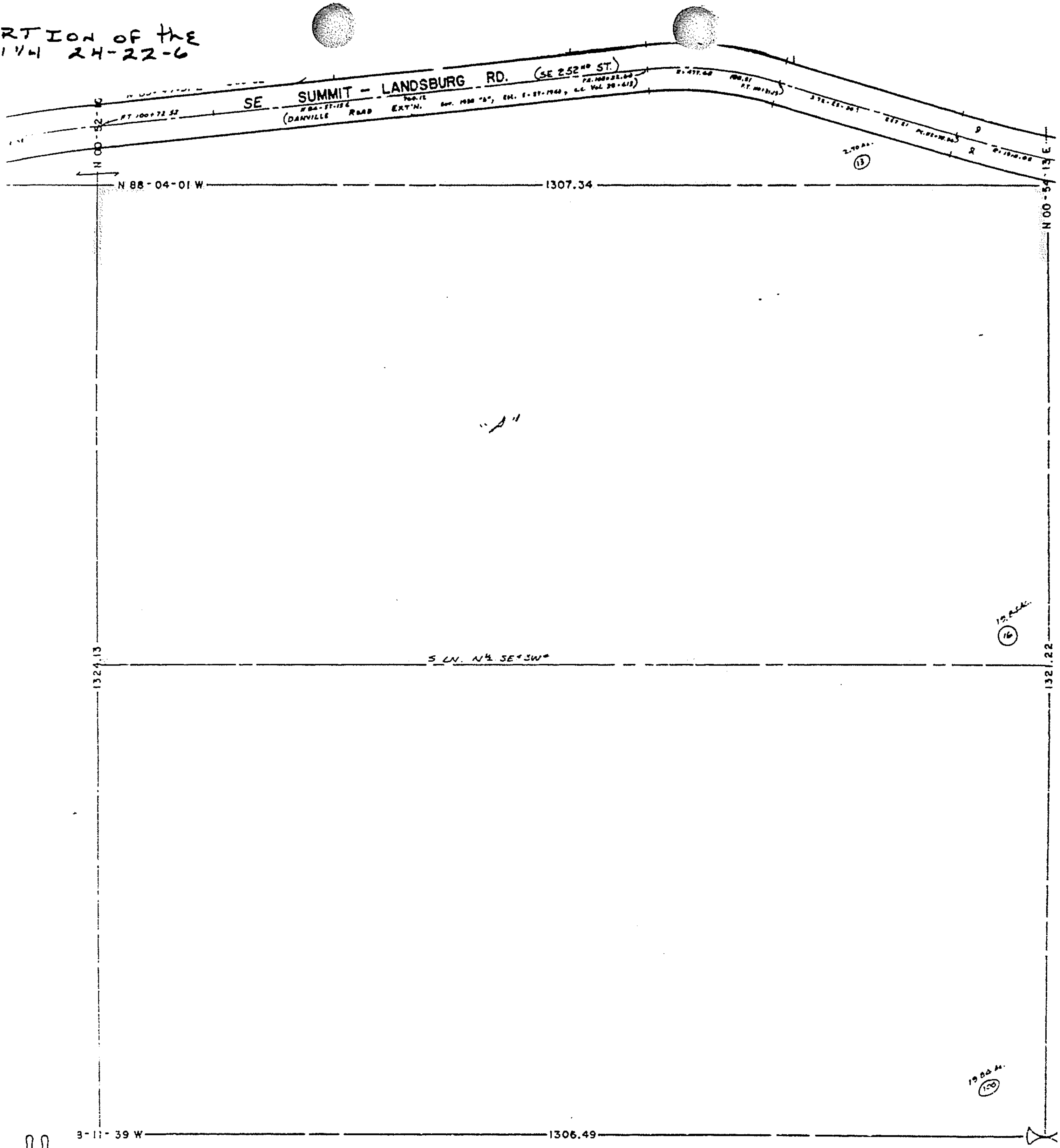
Title to this property was examined by:

Allan Knight

Any inquiries should be directed to one of the title officers set forth in Schedule A.

AFK/tdt/9172Q

PORTION of the
SW1/4 24-22-6



STEWART TITLE COMPANY OF WASHINGTON, INC.

"A Tradition of Excellence"

Order No. 263107

IMPORTANT: This is not a Plat of Survey. It is furnished as a convenience to locate the land indicated hereon with reference to streets and other land. No liability is assumed by reason of reliance hereon.

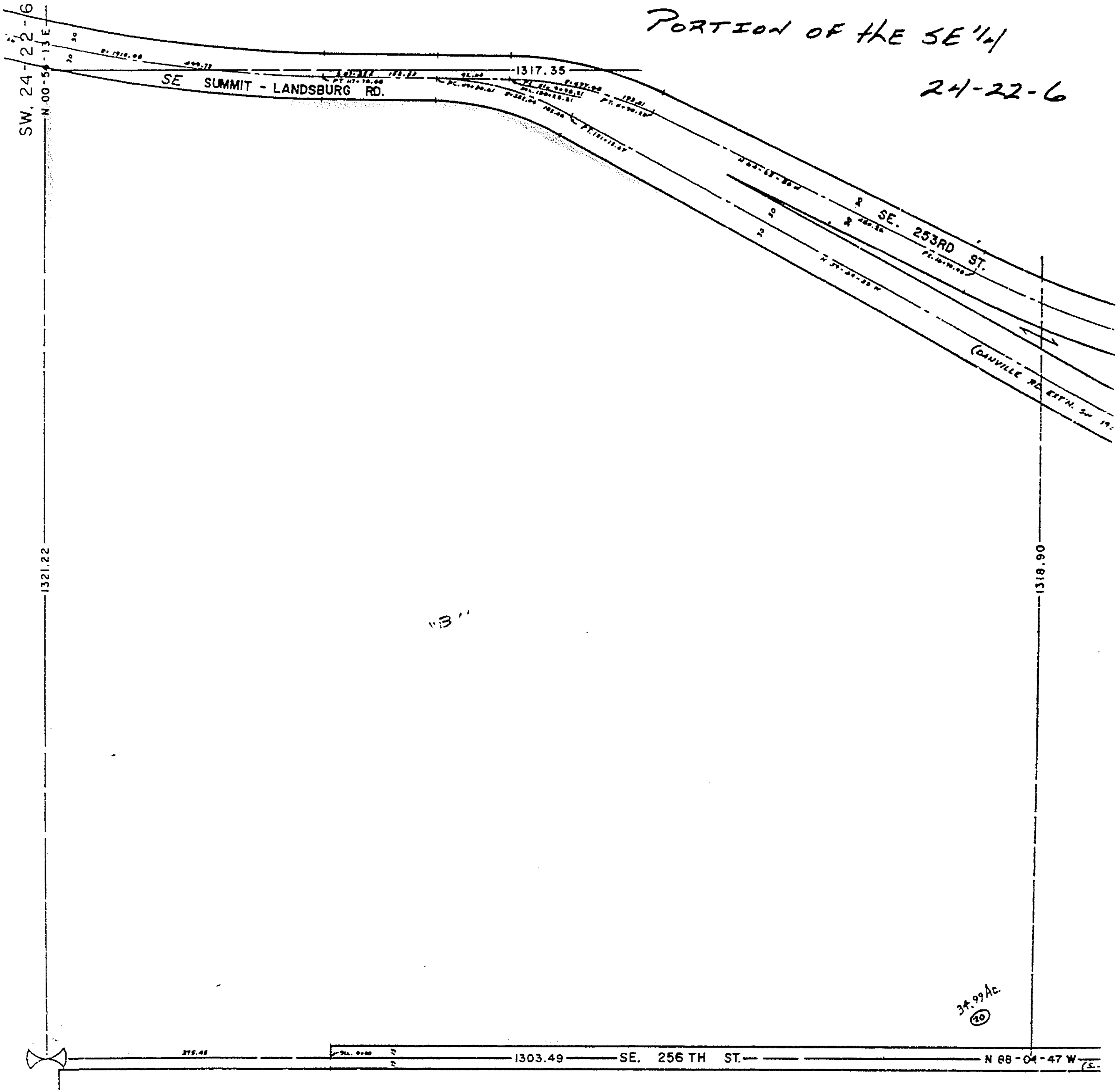
NORTH

↕

SOUTH

PORTION OF THE SE 1/4

24-22-6



STEWART TITLE COMPANY OF WASHINGTON, INC.

"A Tradition of Excellence"

Order No. 263107

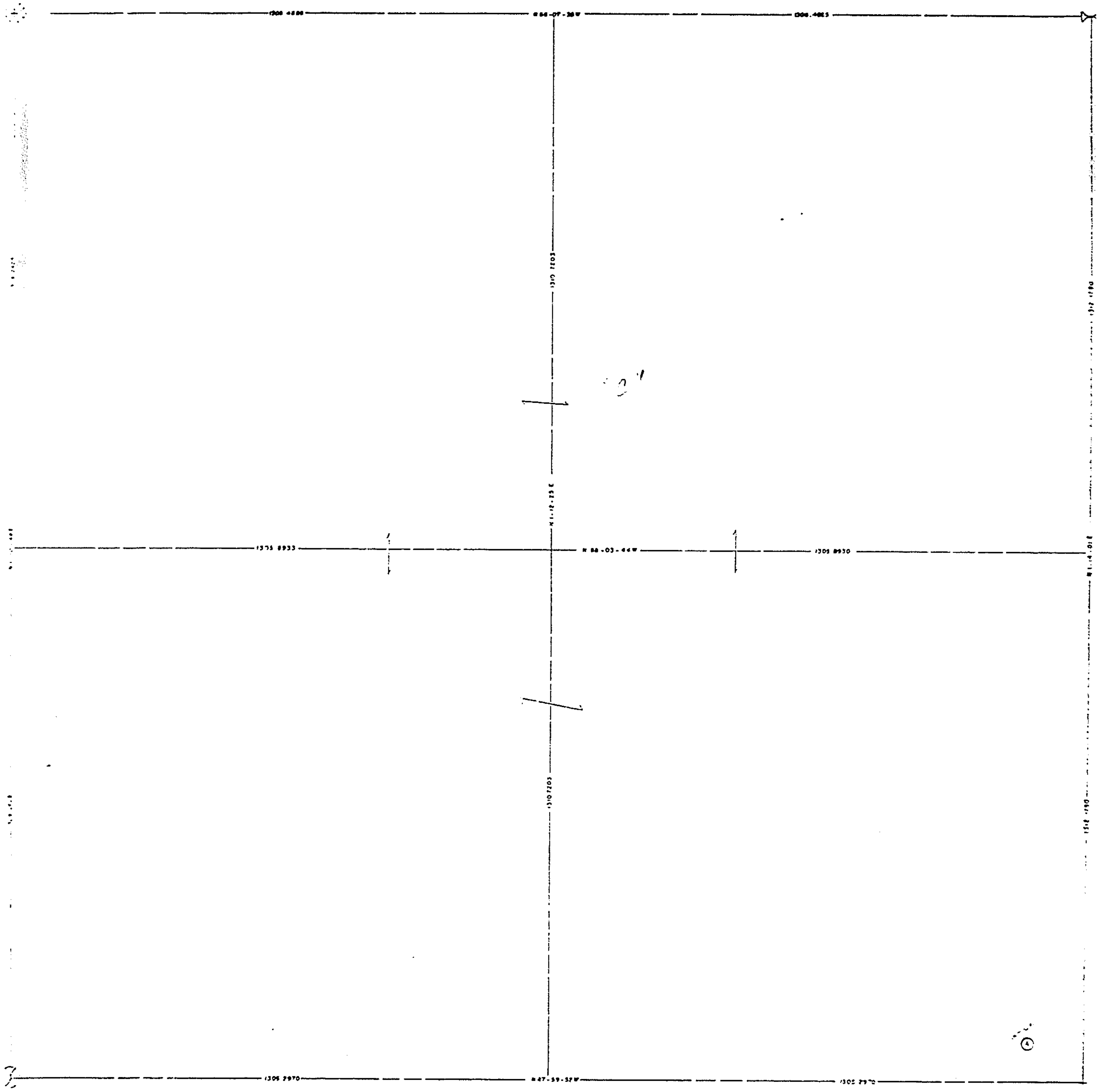
IMPORTANT: This is not a Plat of Survey. It is furnished as a convenience to locate the land indicated hereon with reference to streets and other land. No liability is assumed by reason of reliance hereon.

NORTH

↕

SOUTH

N.W. 1/4 25-22-6



STEWART TITLE COMPANY OF WASHINGTON, INC.

"A Tradition of Excellence"

Order No. 263107

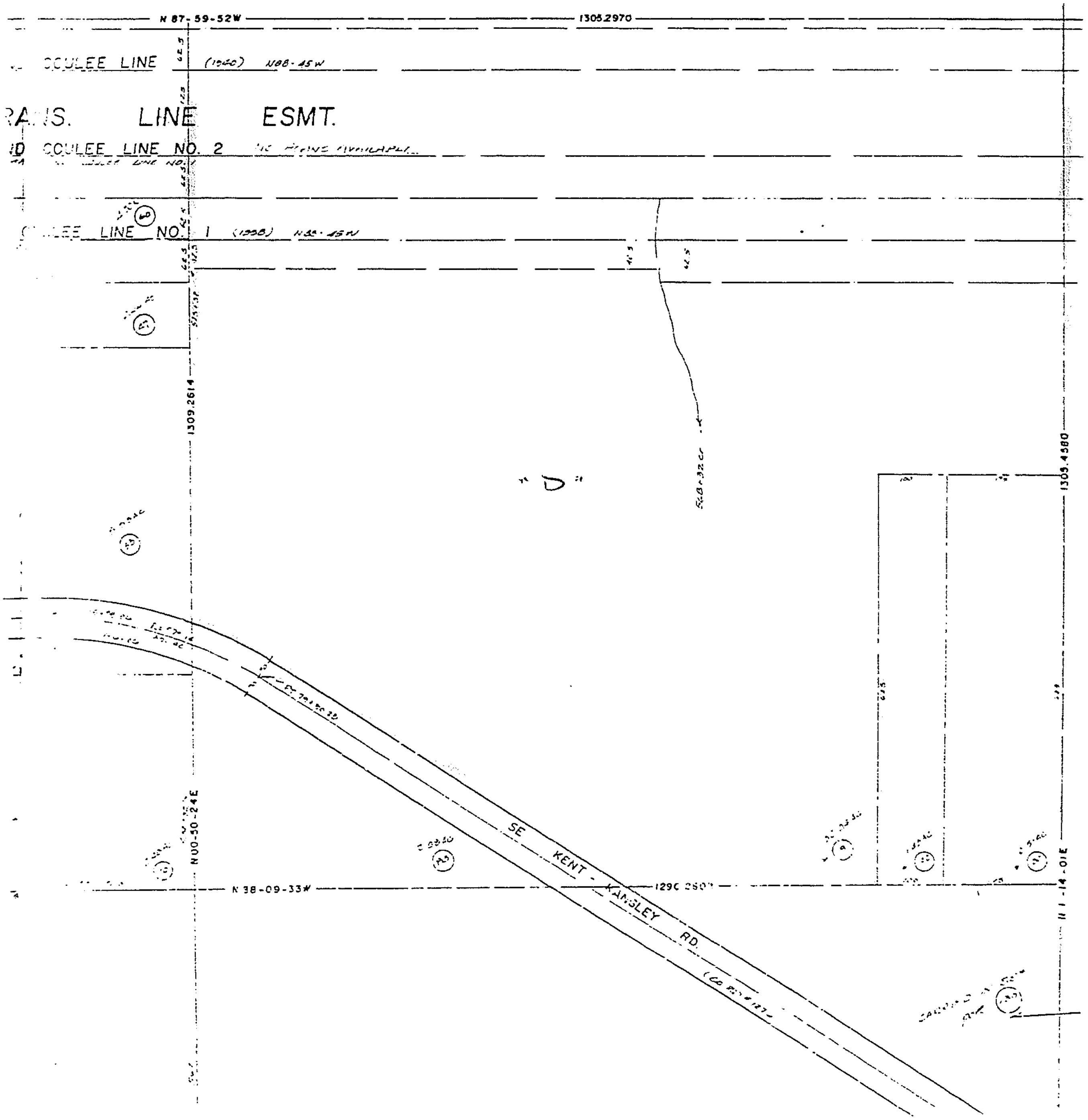
IMPORTANT: This is not a Plat of Survey. It is furnished as a convenience to locate the land indicated hereon with reference to streets and other land. No liability is assumed by reason of reliance hereon.

NORTH

↕

SOUTH

PORTION OF THE SW 1/4 25-22-6



STEWART TITLE COMPANY OF WASHINGTON, INC.

"A Tradition of Excellence"

NORTH

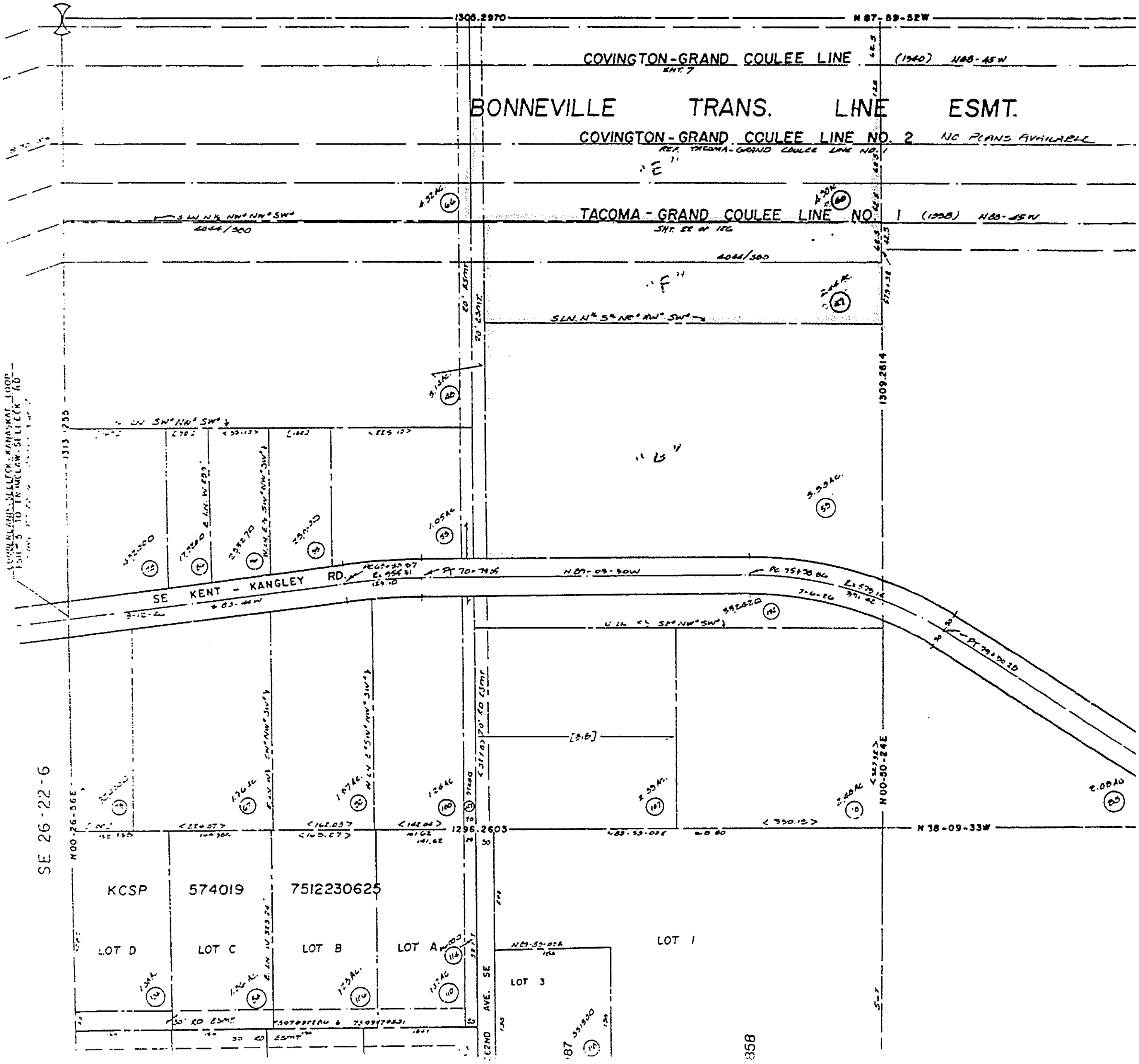
↕

SOUTH

Order No. 263107

IMPORTANT: This is not a Plat of Survey. It is furnished as a convenience to locate the land indicated hereon with reference to streets and other land. No liability is assumed by reason of reliance hereon.

PORTION OF THE S.W. 1/4 25-22-6



STEWART TITLE COMPANY OF WASHINGTON, INC.

"A Tradition of Excellence"

Order No. 263/07

NORTH

SOUTH

IMPORTANT: This is not a Plat of Survey. It is furnished as a convenience to locate the land indicated hereon with reference to streets and other land. No liability is assumed by reason of reliance hereon.

D Mar 31-49 3888531 135
Mar 28-49 $9500.00 $10.45rx & $9.50stx
Continental Land Company, a Wash corp
to Charles R Carey, Receiver of the Danville Coal M. ing Company
The fp does hrby g b s & cnvy to sp the fdre sit kcw ptcly bounded &df:

Gov Lot 12 and the SW¼ of the SE¼ and the S½ of the SW¼ of sec 24 twp 22 NR 6 EWM, excepting therefrom a tt of land conveyed to the CofS by deed rec in ao of kcw in vol 212 Dp 201, Subject, however, to the flg esmnts:

Esmnt granted to the CofS for a Pipe Line r/w 66 ft in width, over and across sd lot 12;

Esmnt granted to the Seattle Power Company, a corp, for Pipe line r/w 40 ft in width, over and across sd lot 12 and the SW¼ of the SE¼; &

Esmnt granted to the Chicago, Milwaukee & St.Paul Railway Company for the rght to erect and maintain an elec transmission system along and across sd Lot 12 sd system consisting of 3 cribs and the necessary trolley and transmission wires, anchors and guys, and the right to clear trees from endangering the line, there being three anchors.

Tgw all rights, esmnts, Excepting, however, roads, school-house sites, cemetery sites, rights of way, flumes, ditches and esmnts heretofore granted or existing, and also, excepting taxes, assessments or instlmnts of assessments due or to become due since Oct 22, 1923.

Covs: gpp; warr & def;

IWW the sd fp hs caused these presents to be subscrbd by its VPres & its crpslto be hrnto afxd and attested by its Scry

Continental Land Company
(crpsl) By R R Morrison, VPres
Attest: Barbara C Bateman, Scry

Spokane Co Wash Mar 28-49 by R R Morrison and Barbara C Bateman, VPres& Scry rsptvly of sd corp (cf) bef Gladys Myers, now Gladys Troup npfor Wn resat Spokane (ns Apr 26-50) Mlto Alley, Carey & Wm. Roney 719 2nd AvBldg City4

Cont Mar 31-49 3888532 2830/140
Feb 10-49
Gordon Rowe and Irene E Rowe, h&w
to Chris Jacobsen and Margaret A Jacobsen
The fps will sell & sps will buy, the fdre sit kcw:

Lot 8 in blk ~~xx~~ 1 of Whitham's Second Highland Add as per plat rec in vol 43 of plats on pg 21 recs of King Co; sit in kcw

Ffi, except: Restrictions of record.

The pp is $4500 of whch $1000 is paid rcpt ack & bal of sdpp shall b paid as fls: $35 or more per mo incdg int atthe rate of 6%pa on the upd bal First pymt shall become due and pbl on or bef Mar 10-49 Subseq pymts sall become due and pbl on or bef the 10th day of ech and every mo thrftr until the amt of this cont tgw int as abv specified has been paid in full. All pymts shall be credited first to the int then to the princ All pymts shall be made to Gordon Rowe 16707 Aurora Av Seattle, kcw or as he may later direct.

The purchr agrees:----same as 2956029--a WD-- poss on Feb10-49--

Gordon Rowe
[illegible]

Tht certain stor m loc at 7533 Bothell Wa ttle, Wn and more ptcly loc on the :

Lot 10 blk 5 Gardner J Cwinus Add to the CofS, accdg to plat thof rec in vol 26 of plats pg 42, recs of sd county.

For term of 5 yrs from Jun 1949 at the molyz minimum rent or sum of $100 pbl in advance on 15th day of ech & every mo during sd term. tgw sum of 8% on all gross repts of the business hin to beoperated, in excess of $1000 per mo, pbl on 15th day of ech & every mo covering the sd gross repts for the previous calendar month.

The fp hrby acks rcpt of sum of $500 representing the last 5 months rent in advance, during term of this lease.

It is hrby agreed tht sp agrees not to let or underlet the whole or any part of sd prem nor assign this lease, or any int thin, without written consent of sd fp;

(signed & ackd by all parties) Mlto Anderson & Rosebarg 420 N Joshua Green Bldg, City1

3906597 2347
8

DJun2-49

Mar 30-49 $10 & ogvc $5.50tx & $5.stx

Charles R Carey, Receiver of the Danville Coal Mining Company, a corp

to Palmer Coking Coal Company, a corp

Whas, pursuant to order of Court signed Mar 25-49 and fld and entrd Mar 30-49 in these proceedings entitld "In the Superior Court of the State of Washington in and for King County, Sam L Levinson, Plntf, vs. Danville Coal Company, a corp, Dfndt. No.229184," sd Court did order and direct the fp hin as such receiver to convey all his right, title and int in and to the ppty hrnftr desbd, to sp

Now, Therefore the fp does hrby g b s & cnvy to sp all his right, title and int in and to the fdre:

Gov Lot 12 and the SW$\frac{1}{4}$ of the SE$\frac{1}{4}$ and the S$\frac{1}{2}$ of the SW$\frac{1}{4}$ of sec 24 Twp 22 NR 6 EWM, excepting therefrom a tt of land conveyed to the CofS by Deed recdd in ao of kcw in vol 212 Dp 201,

Subj, however, to the flg esmnts:

Esmnt granted to the CofS for a pipe line r/w ~~8~~ 66 ft in width, over and across sd lot 12;

Esmnt granted to the Seattle Power Company, a corp, for pipe line r/w 40 ft in width over and across sd lot 12 and the SW$\frac{1}{4}$ of the SE$\frac{1}{4}$; and,

Esmnt granted to the Chicago, Milwaukee & St.Paul Railway Company for the right to erect and maintain an electric transmission system along and across sd Lot 12 sd system consisting of three cribs and the necessary trolley and transmission wires, anchors and guys, and the right to clear trees from endangering the line, there being three anchors.

The NW$\frac{1}{4}$ of the NW$\frac{1}{4}$ of sec 25 and the NE$\frac{1}{4}$ of NE$\frac{1}{4}$ of sec 26 in twp 22 NR 6 ~~EWM~~ EW Principal M, subj, however, to the rights of V. Garravam under cont dtd May 12-27 to cut and remove the timber from the sd NW$\frac{1}{4}$ of the NW$\frac{1}{4}$ of sec 25 and to occupy and use the surface thof in logging operations. sit in kcw

Charles R Carey, Receiver of the Danville Coal
Mining Company

Aprvd by: Ward Roney, JUDGE

kcw Mar 30-49 by Charles R Carey, Receiver of the Danville Coal Mining Company, a corp, bef Vera B Smith npfor Wnresat S(ns Feb 14-53) Mlto Palmer Coking Coal Co Black Diamond, King Co Wn

---

vls

M Aug 22 49 3930
Aug 18 49
Charles N. Perry and Mrs. Stella B. Perry, hwf
to Seattle-First National Bank, Greenwood Branch
fp mtgc to sp the fd re sit kcw

40
Ind. 2533
2-36

Lot 29 and the W 8 and 1/3 ft of lot 30 blk 3 of Greenwood Park Add
to Seattle. Address known as 510 W 82nd.
tgw all fxtrs and appliance
tsp $1724.70 and int ned
pvds for sch of rec on fol

Charles N. Perry
Mrs. Stella B. Perry

kcw Aug 18 49 by Charles N. Perry and Mrs. Stella B. Perry bf H. C.
Sanford np for wn res S (ns Oct 22 52)Ml Sea 1st Nat Bk 403 N 85th S,w

---

M Aug 22 49 3930646 2533 / 236 40 R
Aug 11 49
Marion L. Lehman and Hengry M. Lehman, ~~hx~~her husband
tothe West Seattle National Bank of Seattle, a natl bkng assn
fp mtg to sp tsp $1184.63 acdg to ned the fd re sit kcw

Lot 20 in blk 2 of Claremont Add to Seattle, wn accdg to plat throf
recddd in vol 10 of plats pg 68 recs of kc
Ins $1184.63

Marion L. Lehman
Henry M. Lehman

kcw Aug 11 49 by Marion L. Lehman and Henry M. Lehman bf T. C. Ehorn
np for wn rs S (ns Jan 13 53)Ml cp 4203 W Alaska St. S, wn

D Aug 22 49 3930647 2868 / 2871 M R
Oct 21 37 $1.00
Morris Bros. Coal Mining Co., Inc., of the State of Wn
to Palmer Coking Coal Company, a corp
fp cys and qcs to sp all int in the fd re sit kcw

SW¼ of SW¼; SE¼ of SW¼; SW¼ of SE¼ and Govt lot 212.
All in sect 24 twp 22 N R 6 E W.M. Except roads and Except the prt of
sd govt lo2 12 andSW¼ of SE¼ condemned in kc Sup Crt Cause No. 201476 A, B ←
for r/w for aqueduct as prvded by Ord No. 52768 of the C of S
IWW sd corp has caused thisinstr tobe exctd by its proper ofcrs
andits cp sl to be hrunto affx

Morris Bros. Coal Mining Co., Inc.
Jonas Morris, pres
John H. Morris, secy

cp sl omitted

kcw Oct 21 37 by Jonas Morris and John H. Morris pres and secy of abv
sd corp (cf) bf A. A. Lafromboise np for wn res Enumclaw (ns Dec 3 37)M
Ml sp Black Diamond. wn

----fb

l 3/4

D Sep 29 50   4062601 /

Sep 21 50 $10. $7.15 IRX $6.50 Stx

Martin Hock and Magdalena Hock, hwf

to Carl G. Falk and Nina Elizabeth Falk, hwf

fp c&W to sps the fdrc sit in kcw:

NE¼ of SW¼ of Sec 25 Twp 22 NR 6 EWM Except portn S of Kent-Kingley Road and except co rds; Subj to permanent easmnt and right of way ovr, upon, undr and across sd prems, grntd by Martin Hock and Magdalena Hock, hwf, to United States of America by instru rec undr aud No. 3160321 rec of sd co; and reservtns contd in deed from Northwestern Improvemnt Company, a New Jersey corp to Marguerite Erickson, rec under aud No. 1772600 rec of sd co;

Witnesses: Martin Hock X(her mark

Thomas S. Dobson

Fred W. Akers

Kcw Sep 21 50 by Martin Hock and Magdalena Hock, hwf, bef E. M. Conklin, np for Wn res at renton ns Mar 7 57   (Mail to Tom Dobson & Loan, Renton,Wn)

----

klm

4124059

D Apr 5 51
Mch 28 51 $10
Carl G. Falk and Nina Elizabeth Falk, hwf
to Palmer Coking Coal Company, a Wn corp
Fp cy and gr [illegible] sp the fl des re stt kcw

NE¼ of SW¼ of sec 25 twp 22 nr 6 ewm, Exept ptn [illegible] of the Kent-Kangley Road and Exept co roads,
Sub to permanent easmt and r/w over upon undr and across sd prem grntd by Martin Hock and Magdalena Hock, hwf to USA by inst rec undr aud fl No 3160321 rec of sd co; and resvtns cont in dd frm Northwestern Improvement Company, a NJ corp to Marguerite Erickson, rec undr aud fl No 1772600 rec of sd co

Carl G. Falkk
Nina Elizabeth Falk

kcw Mch 28 51 by Carl G. Falk and Nina Elizabeth Falk, hwf bf E. M. Conklin np for the sw res at Renton ns Mch 7 52 (ml Tom Dobson & Co. 911 3rd Ave, Renton Wn)

RR

5758541

Railway Company as set forth in Deed to Blanche Mercer dated June 26, 1899, as recorded in Volume 424 of Deeds, at page 112, records of the Auditor of King County, Washington.

and the said grantor for consideration as aforementioned, convey s and quit claims to Palmer Coking Coal Company, Inc., a corporation, the following described real estate situated in said county, including any interest therein which the grantor may hereafter acquire:

1. The said 20 feet of the East side of said Parcel A above described,
2. The said 20 feet of the West side of said Parcel B above described,
3. The said 20 feet of the West side of said Parcel C above described, and
4. The said 20 feet of the West side of said Parcel D above described, and Kent-Kangley Road

The grantor for consideration as aforesaid hereby release s Palmer Coking Coal Company, Inc. and the Northern Pacific Railway Company for any damages caused by either of them to the above described real property or to the grantor occasioned by mining activities on the said real property, and thereby agrees to the dismissal with prejudice and without costs of King County Superior Court Cause Nos. 571367 and 571956.

DATED this 20th day of February, 1964.

Peter Charles Mattioda
Peter Charles Mattioda

STATE OF WASHINGTON) SS.
COUNTY OF KING)

On this day personally appeared before me PETER CHARLES MATTIODA, to me known to be the individual described in and who executed the within and foregoing instrument, and acknowledged that he signed the same as his free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal this 20th day of February, 1964.

Notary Public in and for the State of Washington, residing at Seattle

JUL 8 - 1964 · 8 30 Filed by WTI

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(1)

B-127052

5.50

DEED and RELEASE and AGREEMENT

THE GRANTOR , PETER CHARLES MATTIODA, as his separate estate, for and in consideration of good and valuable consideration, receipt of which is hereby acknowledged, conveys and warrants to Palmer Coking Coal Company, Inc., a corporation, a 4/144 undivided interest in the following described parcels of real estate situated in the County of King, State of Washington:

Parcel A. The North half of the Northwest Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT twenty feet of the east side thereof for public road.

Parcel B. North one-half of the Northeast Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of the west side for public road.

Parcel C. North one-half of the South one-half of the Northeast Quarter of Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads.

Parcel D. The South one-half of the South one-half of Northeast Quarter of Northwest Quarter of Southwest Quarter and the North one-half of the Southeast Quarter of the Northwest Quarter of Southwest Quarter in Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads and EXCEPT Kent-Kangley Road.

SUBJECT TO:

1. Easements granted to the United States of America for the use of Bonneville Power Administration, said easements totalling 375 feet in width and running in a generally easterly-westerly direction, as shown by instruments recorded in Volume 2070 of Deeds at page 174 and Volume 4044 of Deeds at page 380, records of the Auditor of King County, Washington.

2. Easements and reservations in favor of Northern Pacific

SALES TAX LIEN
PAID
JUL 7 1964
A. A. TREMPER
KING COUNTY TREASURER
T560637

2 sheets

JUL 8 - 1964 · 8 30

Filed by WTI

5758585 (F)

DEED and RELEASE and AGREEMENT

THE GRANTORS,

PIETRO-CARLO PERADOTTO	12/144
DOMENICO PERADOTTO	12/144
MICHELE PAGLIERO	12/144
RODOLFO PAGLIERO	12/144
GIOVANNI-BATTISTA MATTIODA	6/144
ELVIRA MATTIODA	2/144
PIO MATTIODA	2/144
INES MATTIODA	2/144
DOMENICA MATTIODA	6/144
DOMENICA MATTIODA	.6/144
PIERINO MATTIODA	.6/144
ADELINA MATTIODA	.6/144
GIULIO MATTIODA	.6/144
LAURINA MATTIODA	.6/144
ROSINA MATTIODA	.6/144
BRUNA MATTIODA	.6/144
RICCARDO MATTIODA	.6/144
ERNESTO MATTIODA	.6/144
SILVANA MATTIODA	.6/144
CARLO CASTAGNA	8/144
DOMENICA CASTAGNA	8/144
GRANCESCO CASTAGNA	8/144
CATERINA IANO	24/144

1.50
1.63

for and in consideration of good and valuable consideration, receipt of which is hereby acknowledged, convey and warrant to Palmer Coking Coal Company, Inc., a corporation, the undivided interest shown opposite their names of the following described parcels of real estate situated in the County of King, State of Washington:

Parcel A. The North half of the Northwest Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.; EXCEPT twenty feet of the east side thereof for public road.

Parcel B. North one-half of the Northeast Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of the west side for public road.

NO SALES TAX REQUIRED
1560846
[illegible]
A. A. TREMPER

3 — additional sheets

JUL 8 - 1964 · 8 30 Filed by WTI

Parcel C. North one-half of the South one-half of the Northeast Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads.

Parcel D. The South one-half of the South one-half of Northeast Quarter of Northwest Quarter of Southwest Quarter and the North one-half of the Southeast Quarter of the Northwest Quarter of Southwest Quarter in Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads and EXCEPT Kent-Kangley Road.

SUBJECT TO:

1. Eastments granted to the United States of America for the use of Bonneville Power Administration, said easements totalling 375 feet in width and running in a generally easterly-westerly direction, as shown by instruments recorded in Volume 2070 of Deeds at page 174 and Volume 4044 of Deeds at page 380, records of the Auditor of King County, Washington.

2. Easements and reservations in favor of Northern Pacific Railway Company as set forth in Deed to Blanche Mercer dated June 26, 1899, as recorded in Volume 424 of Deeds, at page 112, records of the Auditor of King County, Washington.

and the said grantors for consideration as aforementioned, convey and quit claim to Palmer Coking Coal Company, Inc., a corporation, the undivided interest shown opposite their names of the following described real estate situated in said county, including any interest therein which the grantors may hereafter acquire:

1. The said 20 feet of the East side of said Parcel A above described,

2. The said 20 feet of the West side of said Parcel B above described,

3. The said 20 feet of the West side of said Parcel C above described, and

4. The said 20 feet of the West side of said Parcel D above described, and Kent-Kangley Road.

The grantors for consideration as aforesaid hereby release

5758885

Palmer Coking Coal Company, Inc. and the Northern Pacific Railway Company for any damages caused by either of them to the above described real property or to the grantors occasioned by mining activities on the said real property, and thereby agree to the dismissal with prejudice and without costs of King County Superior Court Cause Nos. 571367 and 571956.

DATED this 11th day of the month of March, 1964.

PIETRO-CARLO PERADOTTO
DOMENICA PERADOTTO
MICHELE PAGLIERO
RODOLFO PAGLIERO
GIOVANNI-BATTISTA MATTIODA
ELVIRA MATTIODA
PIO MATTIODA
INES MATTIODA
DOMENICA MATTIODA
DOMENICA MATTIODA
PIERINO MATTIODA
ADELINA MATTIODA
GIULIO MATTIODA
LAURINA MATTIODA
ROSINA MATTIODA
BRUNA MATTIODA
RICCARDO MATTIODA
ERNESTO MATTIODA
SILVANA MATTIODA
CARLO CASTAGNA
DOMENICA CASTAGNA
GRANCESCO CASTAGNA
CATERINA IANO

BY: CONSUL OF THE REPUBLIC OF ITALY

By Eugenio Mazzarini
Eugenio Mazzarini
Acting-Consul of Italy

STATE OF WASHINGTON)
) SS:
COUNTY OF KING)

On this 12th day of March, 1964, before me, the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared Eugenio Mazzarini to me known to be the individual described in and who executed the foregoing instrument for and on behalf of the Grantors herein and is authorized so to do, and acknowledged to me that

5758595

he signed and sealed the said instrument as his free and voluntary act and deed for the uses and purposes therein mentioned.

WITNESS my hand and official seal hereto affixed the day and year in this certificate above written.

Notary Public in and for the State
of Washington, residing at Seattle.

JUL 8 - 1984 · 8 30 Filed by WTI

5758586

DEED and RELEASE and AGREEMENT

THE GRANTOR, MARY HALL, as her separate estate,

for and in consideration of good and valuable consideration, receipt of which is hereby acknowledged, conveys and warrants to Palmer Coking Coal Company, Inc., a corporation, a 4/144 undivided interest in the following described parcels of real estate situated in the County of King, State of Washington:

Parcel A. The North half of the Northwest Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT twenty feet of the east side thereof for public road.

Parcel B. North one-half of the Northeast Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of the west side for public road.

Parcel C. North one-half of the South one-half of the Northeast Quarter of Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads.

Parcel D. The South one-half of the South one-half of Northeast Quarter of Northwest Quarter of Southwest Quarter and the North one-half of the Southeast Quarter of the Northwest Quarter of Southwest Quarter in Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads and EXCEPT Kent-Kangley Road.

SUBJECT TO:

1. Easements granted to the United States of America for the use of Bonneville Power Administration, said easements totalling 375 feet in width and running in a generally easterly-westerly direction, as shown by instruments recorded in Volume 2070 of Deeds at page 174 and Volume 4044 of Deeds at page 380, records of the Auditor of King County, Washington.

2. Easements and reservations in favor of Northern Pacific

NO SALES TAX REQUIRED
E561645
JUL 27 1962
A. A. TREMPER

2 sheets

JUL 8 - 1964 ·8 30

Filed by WTI

Railway Company as set forth in Deed to Blanche Mercer dated June 16, 1899, as recorded in Volume 424 of Deeds, at page 112, records of the Auditor of King County, Washington.

and the said grantor for consideration as aforementioned, conveys and quit claims to Palmer Coking Coal Company, Inc., a corporation, the following described real estate situated in said county, including any interest therein which the grantor may hereafter acquire:

1. The said 20 feet of the East side of said Parcel A above described,
2. The said 20 feet of the West side of said Parcel B above described,
3. The said 20 feet of the West side of said Parcel C above described, and
4. The said 20 feet of the West side of said Parcel D above described, and Kent-Kangley Road

The grantor for consideration as aforesaid hereby releases Palmer Coking Coal Company, Inc. and the Northern Pacific Railway Company for any damages caused by either of them to the above described real property or to the grantor occasioned by mining activities on the said real property, and thereby agrees to the dismissal with prejudice and without costs of King County Superior Court Cause Nos. 571367 and 571956.

DATED this 2nd day of March, 1964.

Mary Hall
Mary Hall

On this day personally appeared before me MARY HALL, to me known to be the individual described in and who executed the within and foregoing instrument, and acknowledged that she signed the same as her free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal this 2nd day of March, 1964.

A Notary Public in and for the Province of British Columbia A Commissioner for taking affidavits within British Columbia

JUL 8 - 1964 · 8 30 Filed by WTI

5758587

DEED and RELEASE and AGREEMENT

THE GRANTOR , TOM MATTIODA, as his separate estate,

for and in consideration of good and valuable consideration, receipt of which is hereby acknowledged, conveys and warrants to Palmer Coking Coal Company, Inc., a corporation, a 4/144 undivided interest in the following described parcels of real estate situated in the County of King, State of Washington:

Parcel A. The North half of the Northwest Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT twenty feet of the east side thereof for public road.

Parcel B. North one-half of the Northeast Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of the west side for public road.

Parcel C. North one-half of the South one-half of the Northeast Quarter of Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads.

Parcel D. The South one-half of the South one-half of Northeast Quarter of Northwest Quarter of Southwest Quarter and the North one-half of the Southeast Quarter of the Northwest Quarter of Southwest Quarter in Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads and EXCEPT Kent-Kangley Road.

SUBJECT TO:

1. Easements granted to the United States of America for the use of Bonneville Power Administration, said easements totalling 375 feet in width and running in a generally easterly-westerly direction, as shown by instruments recorded in Volume 2070 of Deeds at page 174 and Volume 4044 of Deeds at page 380, records of the Auditor of King County, Washington.

2. Easements and reservations in favor of Northern Pacific

NO SALES TAX
REQUIRED
E560644
JUL 27 1954
A. A. TREMPER

2 sheets

JUL 3-1984 · 8 30

Filed by WTI

5754597

Railway Company as set forth in Deed to Blanche Mercer dated June 26, 1899, as recorded in Volume 424 of Deeds, at page 112, records of the Auditor of King County, Washington.

and the said grantor for consideration as aforementioned, conveys and quit claims to Palmer Coking Coal Company, Inc., a corporation, the following described real estate situated in said county, including any interest therein which the grantor may hereafter acquire:

1. The said 20 feet of the East side of said Parcel A above described,
2. The said 20 feet of the West side of said Parcel B above described,
3. The said 20 feet of the West side of said Parcel C above described, and
4. The said 20 feet of the West side of said Parcel D above described, and Kent-Kangley Road

The grantor for consideration as aforesaid hereby releases Palmer Coking Coal Company, Inc. and the Northern Pacific Railway Company for any damages caused by either of them to the above described real property or to the grantor occasioned by mining activities on the said real property, and thereby agrees to the dismissal with prejudice and without costs of King County Superior Court Cause Nos. 571367 and 571956.

DATED this 28th day of February, 1964.

Tom Mattioda
Tom Mattioda

STATE OF WASHINGTON }
COUNTY OF KING } SS.

On this day personally appeared before me TOM MATTIODA, to me known to be the individual described in and who executed the within and foregoing instrument, and acknowledged that he signed the same as his free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal this 28th day of February, 1964.

Notary Public in and for the State of Washington, residing at Seattle

JUL 8 - [illegible] 8 30 Filed by WTI

72 1 1 2

5756588

DEED and RELEASE and AGREEMENT

THE GRANTOR , CONSTANCE NATALIE MATTIODA, a single person, and sole legatee under the Will of her father, Charles Mattioda, said Will being dated February 28, 1945, and on file with the King County Clerk under Cause No. 167474, for and in consideration of good and valuable consideration, receipt of which is hereby acknowledged, conveys and warrants to Palmer Coking Coal Company, Inc., a corporation, a 4/144 undivided interest in the following described parcels of real estate situated in the County of King, State of Washington:

3-17 pd 72

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Parcel A. The North half of the Northwest Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT twenty feet of the east side thereof for public road.

Parcel B. North one-half of the Northeast Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of the west side for public road.

Parcel C. North one-half of the south one-half of the Northeast Quarter of Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads.

Parcel D. The South one-half of the South one-half of Northeast Quarter of Northwest Quarter of Southwest Quarter and the North one-half of the Southeast Quarter of the Northwest Quarter of Southwest Quarter in Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads and EXCEPT Kent-Kangley Road.

SUBJECT TO:

1. Easements granted to the United States of America for the use of Bonneville Power Administration, said easements totalling 375 feet in width and running in a generally easterly-westerly direction, as shown by instruments recorded in Volume 2070 of Deeds at page 174 and Volume 4044 of Deeds at page 380, records of the Auditor of King County, Washington.

2. Easements and reservations in favor of Northern Pacific

NO SALES TAX
REQUIRED
AFF. No. E560643
JUL 7 1964
A. A. TREMPER
KING COUNTY TREAS.
By

2 sheets

JUL 8-1964 · 8 30

Filed by WTI

5725548

Railway Company as set forth in Deed to Blanche Mercer dated June 26, 1899, as recorded in Volume 424 of Deeds, at page 112, records of the Auditor of King County, Washington.

and the said grantor for consideration as aforementioned, conveys and quit claims to Palmer Coking Coal Company, Inc., a corporation, the following described real estate situated in said county, including any interest therein which the grantor may hereafter acquire:

1. The said 20 feet of the East side of said Parcel A above described,
2. The said 20 feet of the West side of said Parcel B above described,
3. The said 20 feet of the West side of said Parcel C above described, and
4. The said 20 feet of the West side of said Parcel D above described, and Kent-Kangley Road

The grantor for consideration as aforesaid hereby releases Palmer Coking Coal Company, Inc. and the Northern Pacific Railway Company for any damages caused by either of them to the above described real property or to the grantor occasioned by mining activities on the said real property, and thereby agrees to the dismissal with prejudice and without costs of King County Superior Court Cause Nos. 571367 and 571956.

DATED this 12th day of March, 1964.

Constance Natalie Mattioda
Constance Natalie Mattioda

STATE OF WASHINGTON }
COUNTY OF KING } SS.

On this day personally appeared before me CONSTANCE NATALIE MATTIODA, to me known to be the individual described in and who executed the within and foregoing instrument, and acknowledged that she signed the same as her free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal this 12th day of March, 1964.

Notary Public in and for the State of Washington, residing at Seattle

JUL 8 - 1964 · 8 30

Filed by WTI

5758589

(6)

DEED and RELEASE and AGREEMENT

THE GRANTOR, MICHELE MATTIODA, as his separate estate,

for and in consideration of good and valuable consideration, receipt of which is hereby acknowledged, conveys and warrants to Palmer Coking Coal Company, Inc., a corporation, a 4/144 undivided interest in the following described parcels of real estate situated in the County of King, State of Washington:

Parcel A. The North half of the Northwest Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT twenty feet of the east side thereof for public road.

Parcel B. North one-half of the Northeast Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of the west side for public road.

Parcel C. North one-half of the South one-half of the Northeast Quarter of Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads.

Parcel D. The South one-half of the South one-half of Northeast Quarter of Northwest Quarter of Southwest Quarter and the North one-half of the Southeast Quarter of the Northwest Quarter of Southwest Quarter in Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads and EXCEPT Kent-Kangley Road.

SUBJECT TO:

1. Easements granted to the United States of America for the use of Bonneville Power Administration, said easements totalling 375 feet in width and running in a generally easterly-westerly direction, as shown by instruments recorded in Volume 2070 of Deeds at page 174 and Volume 4044 of Deeds at page 380, records of the Auditor of King County, Washington.

2. Easements and reservations in favor of Northern Pacific

NO SALES TAX
REQUIRED
E560642
JUL 7 1964
A. A. TREMPER

2 sheets

JUL 8 - 1964 · 8 30 Filed by WTI

5758549

Railway Company as set forth in Deed to Blanche Mercer dated June 26, 1899, as recorded in Volume 424 of Deeds, at page 112, records of the Auditor of King County, Washington.

and the said grantor for consideration as aforementioned, conveys and quit claims to Palmer Coking Coal Company, Inc., a corporation, the following described real estate situated in said county, including any interest therein which the grantor may hereafter acquire:

1. The said 20 feet of the East side of said Parcel A above described,
2. The said 20 feet of the West side of said Parcel B above described,
3. The said 20 feet of the West side of said Parcel C above described, and
4. The said 20 feet of the West side of said Parcel D above described, and Kent-Kangley Road

The grantor for consideration as aforesaid hereby releases Palmer Coking Coal Company, Inc. and the Northern Pacific Railway Company for any damages caused by either of them to the above described real property or to the grantor occasioned by mining activities on the said real property, and thereby agrees to the dismissal with prejudice and without costs of King County Superior Court Cause Nos. 571367 and 571956.

DATED this 28th day of February, 1964.

x Michele Mattioda
Michele Mattioda

On this day personally appeared before me MICHELE MATTIODA, to me known to be the individual described in and who executed the within and foregoing instrument, and acknowledged that he signed the same as his free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal this 28th day of February, 1964.

A Notary Public in and for the Province
of British Columbia, A Commissioner for
taking affidavits within British Columbia

JUL 3 - 1964 · 8 30 Filed by WTI

32052

5758590

(5)

B-720052

DEED and RELEASE and AGREEMENT

THE GRANTOR, MARY TOBACCO, as her separate estate,

for and in consideration of good and valuable consideration, receipt of which is hereby acknowledged, conveys and warrants to Palmer Coking Coal Company, Inc., a corporation, a 4/144 undivided interest in the following described parcels of real estate situated in the County of King, State of Washington:

Parcel A. The North half of the Northwest Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT twenty feet of the east side thereof for public road.

Parcel B. North one-half of the Northeast Quarter of the Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of the west side for public road.

Parcel C. North one-half of the South one-half of the Northeast Quarter of Northwest Quarter of the Southwest Quarter of Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads.

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Parcel D. The South one-half of the South one-half of Northeast Quarter of Northwest Quarter of Southwest Quarter and the North one-half of the Southeast Quarter of the Northwest Quarter of Southwest Quarter in Section 25, Township 22 North, Range 6 East, W.M.,; EXCEPT 20 feet of west side for public roads and EXCEPT Kent-Kangley Road.

SUBJECT TO:

1. Easements granted to the United States of America for the use of Bonneville Power Administration, said easements totalling 375 feet in width and running in a generally easterly-westerly direction, as shown by instruments recorded in Volume 2070 of Deeds at page 174 and Volume 4044 of Deeds at page 380, records of the Auditor of King County, Washington.

2. Easements and reservations in favor of Northern Pacific

NO SALES TAX REQUIRED
E560647
JUL 27 1964
A. A. TREMPER

2 sheets

JUL 8 - 1964 · 8 30

Filed by WTI

5755510

Railway Company as set forth in Deed to Blanche Mercer dated June 26, 1899, as recorded in Volume 424 of Deeds, at page 112, records of the Auditor of King County, Washington.

and the said grantor for consideration as aforementioned, conveys and quit claims to Palmer Coking Coal Company, Inc., a corporation, the following described real estate situated in said county, including any interest therein which the grantor may hereafter acquire:

1. The said 20 feet of the East side of said Parcel A above described,
2. The said 20 feet of the West side of said Parcel B above described,
3. The said 20 feet of the West side of said Parcel C above described, and
4. The said 20 feet of the West side of said Parcel D above described, and Kent-Kangley Road

The grantor for consideration as aforesaid hereby releases Palmer Coking Coal Company, Inc. and the Northern Pacific Railway Company for any damages caused by either of them to the above described real property or to the grantor occasioned by mining activities on the said real property, and thereby agrees to the dismissal with prejudice and without costs of King County Superior Court Cause Nos. 571367 and 571956.

DATED this 5th day of March, 1964.

Mary Tobacco
Mary Tobacco

STATE OF WASHINGTON)
COUNTY OF King) SS.

On this day personally appeared before me MARY TOBACCO, to me known to be the individual described in and who executed the within and foregoing instrument, and acknowledged that she signed the same as her free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal this 5th day of March, 1964.

Notary Public in and for the State
of Washington, residing at Seattle

JUL 3 - 1964 · 8 30

Filed by WTI

8309190365

NO SALES TA
307415
AFF. No.______
SEP 1 9 PAID
OFFICE OF THE COMPTROLLER
King County, Washington
By______________Deputy

Contract No. 560-2.011508

Document No. 34753

WASHINGTON CONFIRMATION SPECIAL WARRANTY DEED

GRANTOR, BURLINGTON NORTHERN RAILROAD COMPANY, a Delaware corporation, (formerly named Burlington Northern Inc.) whose General Office address is 176 East 5th Street, St. Paul, Minnesota 55101, a wholly owned subsidiary corporation of Burlington Northern Inc., (successor in interest and title by merger to the Northern Pacific Railway Company and Great Northern Railway Company) in confirmation for record of a distribution of its properties, including the "premises" hereinafter described, made by the Grantor named herein for no consideration and without assumption of liabilities unto its sole shareholder Burlington Northern Inc., and in confirmation for record of a contemporaneous contribution of certain of said properties so received including the "premises" hereinafter described made by Burlington Northern Inc., for no consideration and without assumption of liabilities to the capital structure of the Grantee named herein, DOES HEREBY CONVEY AND WARRANT unto GRANTEE, BN TIMBERLANDS INC., a Delaware corporation, a wholly owned subsidiary of Burlington Northern Inc., whose general office address is Central Building, 810 Third Avenue, Suite 650, Seattle, Washington 98104, all of GRANTOR's right, title and interest, legal and equitable, whatsoever, in and to the real property, the personal property if any, the hereditaments and appurtenances subject to the encumbrances thereon including but not limited to those described herein and in the attached Exhibit "A" Description of Property, incorporated herein and made a part hereof to the same extent as if set forth in full herein, (collectively "premises").

The above described lands contains an area of 28,199.68 acres, more or less, and are subject to an easement in the public for any public roads heretofore laid out or established; and

Also subject to all easements, restrictions, reservations, encumbrances and water rights, if any, of record.

TO HAVE AND TO HOLD all and singular said premises unto GRANTEE its successors and assigns FOREVER.

AND FURTHER, except as otherwise stated in said Description of Property, GRANTOR, for itself and its successors, does hereby covenant with GRANTEE, its successors and assigns, that GRANTOR has not made, done, executed or suffered any act or thing whatsoever whereby said premises, or any part thereof, now are, or at any time hereafter shall or may be imperiled, charged or encumbered in any manner whatsoever, AND subject to said encumbrances the title to the said premises against all persons lawfully claiming same from, by, through, or under GRANTOR, GRANTOR WILL WARRANT AND DEFEND.

IN WITNESS WHEREOF, the GRANTOR has caused this instrument to be executed by its proper officers duly authorized this 18th day of July, 1983.

Attest

By Susanna N. Lyman
Susanna N. Lyman
Assistant Secretary

BURLINGTON NORTHERN RAILROAD COMPANY

By David D. Leland
David D. Leland
Vice President, Timber and Land

17.00
22

8309190365

ACKNOWLEDGMENT

STATE OF WASHINGTON)
: SS
COUNTY OF KING)

On this 18th day of July, 1983, before me, the undersigned, a Notary Public in
and for the State of Washington, duly commissioned and sworn, personally ap-
peared David D. Leland and Susanna N. Lyman to me known to be the Vice
President, Timber and Land, and Assistant Secretary, respectively, of
Burlington Northern Railroad Company, the corporation that executed the fore-
going instrument, and acknowledged the said instrument to be the free and
voluntary act and deed of said corporation, for the uses and purposes therein
mentioned, and on oath stated that they were authorized to execute the said
instrument and that the seal affixed is the corporate seal of said
corporation.

Witness my hand and official seal hereto affixed the day and year first above written.

Notary Public in and for the State
of Washington. Residing at Seattle.
My commission expires 3/22/84.

EXHIBIT A

DESCRIPTION OF PROPERTY
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

Description of the real property, the personal property if any, the hereditaments and appurtenances, and the encumbrances thereon, conveyed and warranted by that certain Confirmation Special Warranty Deed above referred to, of which this Description of Property is a part, made by GRANTOR, BURLINGTON NORTHERN RAILROAD COMPANY and running in favor of GRANTEE, BN TIMBERLANDS INC. situate in the County of King, State of Washington, Willamette Meridian to wit:

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
N1/2, SW1/4, N1/2SE1/4, LESS 53.46 AC. CONVEYED BY NORTHWESTERN IMPROVEMENT COMPANY TO THE UNITED STATES OF AMERICA BY DEED DATED AUG. 8, 1956 AND 0.96 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO KING COUNTY WATER DISTRICT NO. 108 BY DEED DATED MAR. 22, 1976	25	23N	5E	505.58
S1/2NW1/4, E1/2SW1/4	35	24N	5E	160.00
LOTS 3,4, BLOCK 5, O. H. DICKSON CORRECTION PLAT ADDITION TO THE CITY OF ENUMCLAW	25	20N	6E	3.16
GOVT. LOTS 1,2,3,4, S1/2N1/2, S1/2	1	21N	6E	651.10
GOVT. LOTS 1,2,3,4, S1/2N1/2, S1/2	2	21N	6E	651.00
GOVT. LOTS 1,2,3, THE EAST 21.47 AC. OF GOVT. LOT 4, S1/2NE1/4, SE1/4	3	21N	6E	389.24
W1/2NE1/4, N1/2NW1/4, SE1/4NW1/4, S1/2 AND THAT PART OF SE1/4NE1/4 LYING WESTERLY OF THE EASTERLY R/W LINE OF COUNTY ROAD, AND THE NORTH 30 FT. EASTERLY OF COUNTY ROAD	9	21N	6E	541.00
W1/2NW1/4, LESS 2.00 AC. BURLINGTON NORTHERN RAILROAD R/W	11	21N	6E	78.00
SW1/4SE1/4SE1/4, N[illegible] SE1/4SE1/4, [illegible]1/4SE1/4, N1/2SE[illegible] W1/2	15	21N	6E	470.00
N1/2, [illegible]E1/4SW1/4 [illegible]1/4	21	21N	6E	520.00
NE1/4NE1/4NE1/4, S1/2N1/2NE1/4, S1/2NE1/4, NE1/4NW1/4, S1/2NW1/4, NE1/4NW1/4NW1/4, S1/2NW1/4NW1/4, SW1/4, N1/2SE1/4, LESS 5.87 AC. CONVEYED BY NORTHWESTERN IMPROVEMENT CO. TO THE STATE OF WASHINGTON BY DEED DATED MAY 12, 1948	23	21N	6E	478.36

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
GOVT. LOTS 1,2,3,4,5,10,11, NE1/4SE1/4, SE1/4NE1/4, SW1/4SW1/4, S1/2SE1/4, LESS THOSE PARTS OF GOVT. LOTS 2,3,4,5, LOST BY DECREE OF COURT DATED MAY 13, 1971, SUPERIOR COURT NO. 706833, RECORDED MAY 13, 1971, REEL 341, FRAME 148, JUDGEMENT FILE NO. 44341; AND LESS THOSE PARTS OF GOVT. LOT 2, NE1/4SE1/4, SE1/4NE1/4, CONTAINING 36.60 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO THE STATE OF WASHINGTON BY DEED DATED AUG. 4, 1980, AND LESS STRIPS OF LAND IN LOT 5 AND SW1/4SW1/4 CONTAINING 9.47 AC. CONVEYED BY NORTHWESTERN IMPROVEMENT CO. TO THE STATE OF WASHINGTON BY DEED DATED MAY 12, 1948, RECORDED JUNE 14, 1948, VOL. 2753, P. 340	25	21N	6E	405.23
N1/2NW1/4, SW1/4SW1/4, LESS 1.40 AC. LOST UNDER DECREE OF COURT DATED MAR. 6, 1978, SUPERIOR COURT NO. 765079.	27	21N	6E	118.60
THE SOUTH 34.00 AC. OF SE1/4NE1/4	23	22N	6E	34.00
THAT PART OF LOT 11 LYING SOUTH OF CHICAGO MILWAUKEE AND ST. PAUL RAILWAY COMPANY R/W, LESS A 100 FT. STRIP OF LAND CONVEYED BY THE NORTHERN PACIFIC RAILWAY COMPANY TO THE CITY OF SEATTLE BY DEED DATED FEB. 7, 1899, RECORDED JULY 27, 1899, VOL. 240 OF DEEDS, PG. 347, A.F. 178644; 3.18 AC. CONVEYED BY THE NORTHWESTERN IMPROVEMENT COMPANY TO THE CITY OF SEATTLE BY DEED DATED JUNE 14, 193[illegible] RECORDED OCT. 27, 1930, A.F. 2[illegible]3315, 1.41 AC. CONVEYED BY NOR[illegible]RN PACIFIC RAILWAY COMPANY TO [illegible] CITY OF SEATTLE BY DEED DATE[illegible] [illegible]. 3, 1966, RECORDED UNDER A.[illegible] 6101250.	23	22N	6E	20.09
NE1/4NW1/4SW1/4, N1/2NW1/4NW1/4SW1/4, LESS 1.97 AC. CHICAGO MILWAUKEE AND ST. PAUL RAILWAY COMPANY R/W	23	22N	6E	13.03
SE1/4SW1/4, NE1/4SE1/4, S1/2SE1/4	23	22N	6E	160.00
NW1/4, SE1/4SW1/4, SW1/4SE1/4	25	22N	6E	240.00
NE1/4, N1/2NW1/4	26	22N	6E	240.00

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
THOSE PARTS OF THE SW1/4NW1/4 AND NW1/4SW1/4 LYING NORTH OF THE BURLINGTON NORTHERN RAILROAD R/W, LESS 0.70 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO GORDON T. OSBORNE BY DEED DATED FEB. 5, 1980.	33	22N	6E	62.22
SE1/4SE1/4 LESS 4.66 AC. BURLINGTON NORTHERN RAILROAD R/W	33	22N	6E	35.34
ALL LESS 14.01 AC. BURLINGTON NORTHERN RAILROAD R/W	35	22N	6E	625.99

N1/2, SECTION 36, TOWNSHIP 22 NORTH, RANGE 6 EAST, W.M., LESS THE FOLLOWING:
14.25 AC. BURLINGTON NORTHERN RAILROAD R/W, 3.13 AC. CONVEYED BY NORTHWESTERN IMPROVEMENT CO., HEREINAFTER REFERRED TO AS N.W.I., TO KING COUNTY SCHOOL DIST. NO. 109 BY DEED DATED OCT. 26, 1927; 2.04 AC. CONVEYED BY BURLINGTON NORTHERN RAILROAD CO. TO KING COUNTY FIRE DIST. NO. 43 BY DEED DATED OCT. 13, 1981; 0.11 AC. CONVEYED BY N.W.I. TO EVOR MORGAN BY DEED DATED SEPT. 25, 1946; 0.10 AC. CONVEYED BY N.W.I. TO SECUNDO TOBACCO BY DEED DATED SEPT. 25, 1946; 0.22 AC. CONVEYED BY N.W.I. TO JOHN PETER BOOS BY DEED DATED SEPT. 25, 1946; 0.16 AC. CONVEYED BY N.W.I. TO EDWARD S. GOGOLA BY DEED DATED SEPT. 25, 1946; 0.16 AC. CONVEYED BY N.W.I. TO ANTON POLESKI, JR. BY DEED DATED SEPT. 25, 1946; 0.15 AC. CONVEYED BY N.W.I. TO LOUIE VAIENTE BY DEED DATED SEPT. 25, 1946; 0.1[illegible] AC. CONVEYED BY N.W.I. TO BERNICE VELEMA GOGOLA BY DEED DATED SEPT. 25, 1946; 0.15 AC. CONVEYED BY N.W.I. TO WILLIAM SHIMMEL BY DEED DATED SEPT. 25, 1946; 0.1[illegible] AC. CONVEYED BY N.W.I. TO JOHN M[illegible]KUS BY DEED DATED SEPT. 25, 1946; 0.13 AC. CONVEYED BY N.W.I. TO LOUIS AND JOSEPH SAFTICH BY DEED DATED SEPT. 25, 1946; 0.21 AC. CONVEYED BY N.W.I. TO WAINO TOIVONEN BY DEED DATED SEPT. 25, 1946; 0.69 CONVEYED BY N.W.I. TO WILLIAM AND CATERINA LUCIA MARCHETTI BY DEED DATED SEPT. 25, 1946; 0.10 AC. CONVEYED BY N.W.I. TO BRUNO MILLER BY DEED DATED DEC. 17, 1946; 0.12 AC. CONVEYED BY N.W.I. TO FRANK VISCONIC BY DEED DATED APR. 28, 1947;

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
(CONTINUED) 0.10 AC. CONVEYED BY N.W.I. TO OTTO MATTSON BY DEED DATED NOV. 15, 1947; 0.47 AC. CONVEYED BY N.W.I. TO A. BUTLER BY DEED DATED JAN. 19, 1948; 0.16 AC. CONVEYED BY N.W.I. TO THOMAS AND ANNE HOLDER BY DEED DATED FEB. 16, 1948; 0.22 AC. CONVEYED BY N.W.I. TO RAYMOND L. AND ANNE BISYAK BY DEED DATED FEB. 16, 1948; 0.22 AC. CONVEYED BY N.W.I. TO ELEANOR DAMBROSKI BY DEED DATED FEB. 3, 1948; 0.22 AC. CONVEYED BY N.W.I. TO ARVID AND SOPHIA HILL BY DEED DATED MAY 24, 1948; 0.10 AC. CONVEYED BY N.W.I. TO JOSEPH WILSKO BY DEED DATED JULY 9, 1948; 0.10 AC. CONVEYED BY N.W.I. TO JOHN MATTSON BY DEED DATED MAY 12, 1949; 0.10 AC. CONVEYED BY N.W.I. TO JULIUS SWORD BY DEED DATED JUNE 27, 1949; 0.22 AC. CONVEYED BY N.W.I. TO MYRTLE A. BELLEMAN BY DEED DATED NOV. 8, 1949; 0.22 AC. CONVEYED BY N.W.I. TO R.A. RYDER BY DEED DATED NOV. 8, 1949; 0.22 AC. CONVEYED BY N.W.I. TO ANDREW J. LANG BY DEED DATED NOV. 30, 1949; 0.22 AC. CONVEYED BY N.W.I. TO HERMAN AND GRACE E. CALLAHAN BY DEED DATED DEC. 29,. 1949; 0.41 AC. CONVEYED BY N.W.I. TO JOHN AND ANNA NOVACK BY DEED DATED JAN. 27, 1950; 0.22 AC. CONVEYED BY N.W.I. TO FRANK AND SOPHIE HOLLY BY DEED DATED APR. 19, 1951; 0.19 AC. CONVEYED BY N.W.I. TO RAY AND MARGARET THOMPSON BY DEED DATED MAY 21, 1951; 0.16 AC. CONVEYED BY N.W.I. TO CASCADE RIFLE AND PISTOL CLUB, INC. BY DEED DATED SEPT. 10, 1951; 0.22 AC. CONVEYED BY N.W.I. TO RAY AND [illegible] TWEDT BY DEED DATED DEC. [illegible], 1952; 0.19 AC. CONVEYED BY NORTHERN PACIFIC RAILWAY CO., HEREINAFTER REFERRED TO AS N.P.RY.CO., TO FRANK VISCONIC BY CORRECTION DEED DATED OCT. 19, 1959; 0.10 AC. CONVEYED N.P.RY.CO. TO TONY BARRAGAGE BY DEED DATED SEPT. 28, 1959; 0.30 AC. CONVEYED BY N.P.RY.CO. TO EVOR AND MARGARET MORGON BY DEED DATED JULY 15, 1960; 0.21 AC. CONVEYED BY N.P.RY.CO. TO FRANK E. VISCONIC BY DEED DATED AUG. 1, 1963; 0.25 AC. CONVEYED N.P.RY. CO. TO FRANK E. VISCONIC BY DEED DATED JUNE 20, 1967	36	22N	6E	293.12

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
S1/2 LESS 4.00 AC. BURLINGTON NORTHERN RAILROAD R/W	36	22N	6E	316.00
SW1/4NW1/4, W1/2SW1/4	3	23N	6E	120.00
GOVT. LOTS 1,2,3,4, S1/2N1/2, S1/2, LESS PARTS OF GOVT. LOTS 3,4 WEST OF HIGHWAY CONTAINING 22.00 AC. CONVEYED BY NORTHWESTERN IMPROVEMENT CO. TO CARL A. ERICKSON BY DEED DATED OCT. 24, 1932, 3.00 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY CO. TO WILLIAM T. BAKER BY DEED DATED FEB. 28, 1899	5	23N	6E	593.64
ALL	9	23N	6E	640.00
NE1/4NE1/4, S1/2NE1/4, N1/2SE1/4, SE1/4SE1/4	29	23N	6E	240.00
NE1/4, SE1/4NW1/4, NW1/4SE1/4	33	23N	6E	240.00
NE1/4, N1/2NW1/4, SE1/4NW1/4, NE1/4SW1/4, N1/2SE1/4, SE1/4SE1/4	13	24N	6E	440.00
SW1/4NE1/4, FRL. NW1/4SW1/4, FRL. NW1/4 LESS 7.50 AC. IN THE FRL. NW1/4NW1/4 CONVEYED BY BURLINGTON NORTHERN INC. TO COUGAR MOUNTAIN ASSOCIATES BY DEED DATED AUG. 23, 1971	19	24N	6E	235.11
THOSE PARTS OF NW1/4NE1/4 AND GOVT. LOT 1 AS CONVEYED BY B. F. GREENWOOD TO THE NORTHERN PACIFIC RAILWAY CO. BY DEED DATED FEB. 1, 1967, RECORDED FEB. 9, 1967, VOL. 4892, PG. 669, A.F.6137249, LESS 3.95 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY CO. TO THE STATE OF WASHINGTON BY DEED DATED FEB. [illegible],1968, RECORDED APRIL 22, 1968, [illegible] 5076 OF DEEDS, PG. 464, A.F. [illegible]36289; 2.09 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO THE CITY OF BELLEVUE BY DEED DATED MAR. 31, 1980.	19	24N	6E	24.10
THAT PART OF GOVT. LOT 1 AS CONVEYED BY THE CITY OF BELLEVUE TO BURLINGTON NORTHERN INC. BY DEED DATED APRIL 16, 1980.	19	24N	6E	.70
S1/2, NE1/4	23	24N	6E	480.00

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 24753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
N1/2NE1/4, SW1/4NE1/4, NE1/4SW1/4, NW1/4, AND THAT PART OF W1/2SW1/4 LYING NORTH OF BURLINGTON NORTHERN RAILROAD R/W	25	24N	6E	366.29
N1/2NW1/4SE1/4	25	24N	6E	20.00
NE1/4 LESS 0.10 AC. BURLINGTON NORTHERN RAILROAD R/W, NE1/4NW1/4	27	24N	6E	199.90
SW1/4SE1/4	29	24N	6E	40.00
ALL FRACTIONAL	31	24N	6E	641.82
GOVT. LOTS 1,2,3,4,5,6,7,8,9,10, 11,12, S1/2	1	21N	7E	716.32
GOVT. LOTS 3,4,5,6,11,12, SW1/4, LESS 19.08 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY CO. TO THE UNITED STATES OF AMERICA BY CORRECTION DEED DATED BY MAY 14, 1963	3	21N	7E	338.92
GOVT. LOTS 1,2,3,4,5,6,7,8,9,10, 11,12, S1/2, LESS 22.11 AC. BURLINGTON NORTHERN RAILROAD R/W, 25.08 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY CO. TO THE UNITED STATES OF AMERICA (B.P.A.) FOR RAVER SUBSTATION BY DEED DATED JUNE 25, 1965	5	21N	7E	667.52
E1/2NE1/4, E1/2W1/2NE1/4	7	21N	7E	120.00
ALL, LESS 16.19 AC. BURLINGTON NORTHERN RAILROAD R/W, LESS 5.29 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY CO. TO THE UNITED STATES OF AMERICA BY CORRECTION DEED DATED MAY 14, 1963 AND 1.23 AC. CONVEYED BY NORTHERN PACIFIC RAILWAY CO. TO THE UNITED STATES OF AMERICA BY CORRECTION DEED DATED MAY 14, 1963	9	21N	7E	617.29
N1/2 LESS 0.70 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY CO. TO THE UNITED STATES OF AMERICA BY CORRECTION DEED DATED MAY 14, 1963	11	21N	7E	319.30
E1/2SE1/4, NW1/4SE1/4, NE1/4SW1/4	11	21N	7E	160.00
THE ABANDONED CHICAGO MILWAUKEE AND ST. PAUL RAILWAY CO. R/W IN THE W1/2SW1/4 AND THAT PART OF SW1/4SW1/4 LYING NORTHEASTERLY OF THE BURLINGTON NORTHERN RAILROAD R/W AND SOUTHEASTERLY OF THE FORMER CHICAGO MILWAUKEE AND ST. PAUL RAILWAY COMPANY R/W	11	21N	7E	8.73

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
THAT PART SW1/4SW1/4 OF SECTION 12 DESCRIBED AS FOLLOWS: BEGINNING AT A POINT ON A CURVE INTERSECTING THE WEST SECTION LINE OF SAID SECTION 12 DISTANCE 2177.94 FT. SOUTHERLY, MEASURED ALONG SAID WEST SECTION LINE, FROM THE WEST QUARTER CORNER THEREOF; THENCE ON A CURVE TO THE RIGHT FROM A RADIUS POINT WHICH BEARS S 37°31'50"E AND DISTANT 280 FT. THROUGH A CENTRAL ANGLE OF 34°16'50" AN ARC DISTANCE OF 167.53 FT TO A POINT OF TANGENCY; THENCE N 86°45'00"E 332.76 FT.; THENCE N 16°14'17"E 125.64 FT.; THENCE N 2°59'58"W 682.23 FT., MORE OR LESS, TO THE NORTH LINE OF THE SAID SW1/4SW1/4; THENCE WESTERLY ALONG SAID NORTH LINE 532.80 FT., MORE OR LESS, TO THE NORTHWEST CORNER OF SAID SW1/4SW1/4; THENCE SOUTHERLY ALONG SAID WEST LINE OF SAID SECTION 12, 886.63 FT., MORE OR LESS, TO THE POINT OF BEGINNING.	12	21N	7E	10.00
E1/2NE1/4, LESS 7.80 AC. LOST UNDER DECREE OF COURT DATED OCT. 2, 1964; 2.06 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO THE CITY OF TACOMA BY DEED DATED SEPT. 20, 1974.	13	21N	7E	70.14
NW1/4NW1/4, S1/2NW1/4, S1/2, LESS THE FOLLOWING: 27.77 AC. LOST UNDER DECREE OF COURT DATED OCT. 2, 1964; 3.50 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO THE CITY OF TACOMA BY DEED DATED SEPT. 20, 1974; 1.30 AC. CONVEYED BY NORTHERN PACIFIC RAILW[illegible] COMPANY, HEREINAFTER REFERRED [illegible]S N.P.RY. CO., TO GREEN RIVER [illegible]RES INC. BY DEED DATED JULY 17[illegible]67; 1.04 AC. CONVEYED BY N.P.RY CO. TO THE UNITED STATES OF AMERICA BY DEED DATED AUG. 16, 1963; 4.96 AC. CONVEYED BY N.P. RY.CO. TO THE UNITED STATES OF AMERICA BY DEED DATED MAY 14, 1963, 64.63 AC. LOST BY DECREE OF COURT DATED APRIL 2, 1957, CIVIL COURT NO. 4355.	13	21N	7E	336.80

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
S1/2, NW1/4, S1/2NE1/4, LESS 44.77 AC. BURLINGTON NORTHERN RAILROAD R/W, AND THAT PART OF N1/2NE1/4 LYING SOUTH OF THE BURLINGTON NORTHERN RAILROAD R/W, LESS 18.50 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY COMPANY TO THE UNITED STATES OF AMERICA BY CORRECTION DEED DATED MAY 14, 1963.	15	21N	7E	549.18
E1/2, SECTION 17, TOWNSHIP 21 NORTH, RANGE 7 EAST, W.M., LESS 52.85 AC. DESCRIBED AS FOLLOWS; ALL THE PART OF THE SW1/4NE1/4 AND THE NW1/4SE1/4 OF SAID SECTION 17, DESCRIBED AS FOLLOWS; COMMENCING ON THE NORTH LINE OF SAID SECTION 17 AT A POINT N 89°49'44"W A DISTANCE OF 1768.72 FT. FROM THE NORTHEAST CORNER OF SAID SECTION 17; THENCE S 0°31'03"W 1735.84 FT. TO THE TRUE POINT OF BEGINNING; THENCE CONTINUING S 0°31'03"W 757.61 FT.; THENCE S 63°54'34"W 950.67 FT. TO THE WEST LINE OF THE SE1/4 OF SAID SECTION 17; THENCE N 0°31'33" E TO A POINT THAT BEARS N 89°49'44"W FROM THE TRUE POINT OF BEGINNING; THENCE S 89°49'44"E TO THE TRUE POINT OF BEGINNING; AND ALSO, ALL THAT PART OF THE W1/2NE1/4 OF SAID SECTION 17, DESCRIBED AS FOLLOWS: BEGINNING ON THE NORTH LINE OF SAID SECTION 17 AT A POINT N 89°49'44"W A DISTANCE OF 1768.72 FT. FROM THE NORTHEAST CORNER OF SAID SECTION 17; THENCE S 0°31'03"W 1[illegible].84 FT.; THENCE N 89°49'44"W [illegible] THE WEST LINE OF THE [illegible]1/4 OF SAID SECTION 17; THENCE N 0°31'03" [illegible] TO THE NORTH QUARTER CORNER OF SAID SECTION 17; THENCE S 89°49'4[illegible] E 850.00 FT. TO THE POINT OF BEGINNING	17	21N	7E	267.15

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EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 13, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
NE1/4, E1/2NW1/4, LESS 16.99 AC. BURLINGTON NORTHERN RAILROAD R/W AND 2.70 AC. CHICAGO MILWAUKEE AND ST. PAUL RAILWAY COMPANY R/W	21	21N	7E	220.31
W1/2NW1/4, N1/2SW1/4, SE1/4SW1/4, LESS 2.92 AC. BURLINGTON NORTHERN RAILROAD R/W, LESS 0.54 AC. CONVEYED BY NORTHWESTERN IMPROVEMENT CO. TO PUGET SOUND POWER AND LIGHT CO. BY DEED DATED MAY 12, 1949	21	21N	7E	196.54
N1/2SE1/4 LESS 14.78 AC. BURLINGTON NORTHERN RAILROAD R/W AND 3.96 AC. CHICAGO MILWAUKEE AND ST. PAUL RAILWAY COMPANY R/W	21	21N	7E	61.26
THAT PART OF SW1/4SE1/4 LYING NORTHWESTERLY OF BURLINGTON NORTHERN RAILROAD R/W	21	21N	7E	4.71
SE1/4SE1/4 LESS 2.54 AC. CHICAGO MILWAUKEE AND ST. PAUL RAILWAY COMPANY R/W	21	21N	7E	37.46
ALL	23	21N	7E	640.00
ALL	25	21N	7E	640.00
NE1/4SE1/4, SE1/4NE1/4, S1/2SE1/4, N1/2NE1/4 (LESS COAL)	26	21N	7E	240.00
SW1/4NE1/4, E1/2W1/2, SW1/4SW1/4, NW1/4SE1/4	26	21N	7E	280.00
ALL	27	21N	7E	640.00
W1/2NE1/4, W1/2	29	21N	7E	400.00
THE EAST 990 FT. OF LOTS 1 AND 4, LESS 5.52 AC. BURLINGTON NORTHERN RAILROAD R/W	29	21N	7E	55.18
SE1/4NW1/4	31	21N	7E	40.00
NW1/4, N1/2SW1/4, SE1/4, LESS 0.63 AC. CONVEYED BY BURLINGTON NORTHERN RAILROAD CO. TO ROBERT K. AND DONNA L. CHRISTIANSON BY DEED DATED JULY 14, 1983, DESCRIBED AS FOLLOWS: BEGINNING AT THE NORTHEAST CORNER OF THE NW1/4NW1/4 OF SECTION 33, THENCE N 88°24'07" W ALONG THE NORTH LINE OF SAID SECTION 33 FOR A DISTANCE OF 192.09 FT., THENCE S 01°35'53" W FOR A DISTANCE OF 143.28 FT., THENCE S 88°24'07" E FOR A DISTANCE OF 192.09 FT., THENCE N 01°35'53" E FOR A DISTANCE OF 143.28 FT. TO THE POINT OF BEGINNING.	33	21N	7E	399.37

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EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
THAT PART OF THE NW1/4SW1/4 DESCRIBED AS FOLLOWS; BEGINNING AT A POINT 428 FT. SOUTH OF THE NORTHWEST CORNER OF THE NW1/4SW1/4 THENCE SOUTH 200 FT.; THENCE EAST 100 FT.; THENCE N 12° 17'00"E TO A POINT WHICH BEARS DUE EAST FROM THE POINT OF BEGINNING; THENCE DUE WEST TO THE POINT OF BEGINNING.	34	21N	7E	0.57
ALL	35	21N	7E	640.00
SW1/4	23	22N	7E	160.00
ALL	25	22N	7E	640.00
E1/2NE1/4, W1/2	27	22N	7E	400.00
NE1/4NW1/4NW1/4, S1/2NW1/4NW1/4, NE1/4NW1/4, SW1/4, E1/2, S1/2NW1/4 LESS 4.10 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY CO. TO WASHINGTON EDUCATION ASSN. BY DEED DATED SEPT. 3, 1965	29	22N	7E	625.90
GOVT. LOTS 3,4, E1/2SW1/4, SE1/4	30	22N	7E	292.38
GOVT. LOTS 1,2,3,4, E1/2W1/2, E1/2, LESS 21.22 AC. BURLINGTON NORTHERN RAILROAD R/W AND THAT PART OF THE EAST 1805.50 FT. OF THE S1/2NE1/4 LYING SOUTH OF THE BURLINGTON NORTHERN RAILROAD R/W	31	22N	7E	562.09
THAT PART OF THE SHORE, BED AND WATERS OF FISH LAKE LYING BETWEEN A LINE 25 FEET NORTH AND A LINE 25 FEET SOUTH, MEASURED AT RIGHT ANGLES FROM THE CENTER LINE OF THE WATER PIPE LINE NOW SUPPLYING THE TOWN OF RAVENSDALE, SAID LINES TO BE DRAWN PARALLEL TO SAID WATER PIPE LINE BEGINNINNG AT THE GOVERNMENT MEANDER LINE AND SHALL EXTEND 25 FEET EASTERLY OF THE LAKE END OF THE WATER PIPE LINE AS NOW CONSTRUCTED.	32	22N	7E	.07
THAT PART OF THE W1/2NW1/4NW1/4 LYING SOUTH OF THE SOUTHERLY R/W MARGIN OF SOUTHEAST KENT-KANGLEY ROAD AND NORTHEASTERLY OF A LINE BEGINNING AT THE NORTHWEST CORNER OF THE SW1/4NW1/4NW1/4, RUNNING SOUTHEASTERLY TO THE SOUTHEAST CORNER OF SAID SUBSECTION; EXCEPT THE WEST 30 FT. THEREOF.	32	22N	7E	6.00

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	**SEC.**	**TWP.**	**RGE.**	**ACRES**
ALL	33	22N	7E	640.00
ALL	35	22N	7E	640.00
GOVT. LOTS 1,2, SE1/4NE1/4, LESS 66.76 AC. HWY. CONVEYED BY BURLINGTON NORTHERN INC. TO THE STATE OF WASHINGTON BY DEEDS DATED JULY 8, 1974 AND MAR. 3, 1980.	1	23N	7E	53.04
SE1/4	1	23N	7E	160.00
GOVT. LOTS 1,2,3,4, E1/2W1/2, E1/2 LESS 25.17 AC. CONVEYED BY THE NORTHERN PACIFIC RAILWAY COMPANY TO THE STATE OF WASHINGTON BY DEED DATED JULY 11, 1960	31	23N	7E	627.61
E1/2 LESS THE NORTH 50 FT. THEREOF	31	24N	7E	317.00
GOVT. LOTS 1,2,3,4, E1/2W1/2, E1/2	7	23N	8E	640.86
GOVT. LOTS 1,2,8, N1/2NE1/4 LESS 14.10 AC. CONVEYED BY THE NORTHWESTERN IMPROVEMENT COMPANY TO THE UNITED STATES OF AMERICA (B.P.A.) BY DEED DATED JULY 8, 1948	25	26N	11E	150.85
THAT PART OF THE N1/2NE1/4NW1/4 LYING EAST OF BECKLER RIVER	25	26N	11E	7.00
S1/2N1/2NW1/4 LESS 13.00 AC. CONVEYED BY THE NORTHWESTERN IMPROVEMENT COMPANY TO FRANK SUTTON BY DEED DATED JAN. 22, 1948.	25	26N	11E	27.00
SE1/4SE1/4 LESS 1.06 AC. BURLINGTON NORTHERN RAILROAD R/W	25	26N	11E	38.94
GOVT. LOTS 1,2, S1/2SE1/4 LESS BURLINGTON NORTHERN RAILROAD R/W	6	25N	12E	156.01
THAT PART OF THE SE1/[illegible]/4 LYING SOUTH OF BURLINGTON NORTHERN RAILROAD R/W	26	26N	12E	35.71
THAT PART OF THE SE1/4SW1/4 AND THE S1/2SE1/4 LYING SOUTH OF THE BURLINGTON NORTHERN RAILROAD R/W	27	26N	12E	38.40

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: FEE

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
THAT PART OF THE SE1/4SW1/4 AND THE SW1/4SE1/4 LYING SOUTH OF BURLINGTON NORTHERN RAILROAD R/W	28	26N	12E	20.23
THE EAST 2/3 OF THE SOUTH 3/4 OF THE SE1/4SE1/4	30	26N	12E	20.00
N1/2NE1/4NE1/4, W1/2NE1/4, GOVT. LOTS 1,2,3,4, E1/2W1/2, SE1/4, LESS 23.23 AC. BURLINGTON NORTHERN RAILROAD R/W	31	26N	12E	551.57
ALL THAT PART OF THE N1/2SE1/4NE1/4 LYING NORTHEASTERLY OF THE BURLINGTON NORTHERN RAILROAD R/W AND SOUTHWESTERLY OF THE CENTER LINE OF THE FOSS RIVER LESS A TRACT OF LAND CONVEYED BY THE NORTHWESTERN IMPROVEMENT COMPANY TO MRS. ROY E. SMITH BY DEED DATED JUNE 21, 1928	31	26N	12E	.93
NW1/4SE1/4, SW1/4NE1/4, NE1/4NW1/4 AND NW1/4NE1/4 LYING SOUTH OF THE BURLINGTON NORTHERN RAILROAD R/W	32	26N	12E	139.00
N1/2NE1/4, NW1/4NW1/4, LESS 9.30 AC. BURLINGTON NORTHERN RAILROAD R/W	34	26N	12E	110.70
SE1/4 LESS 11.00 AC. BURLINGTON NORTHERN RAILROAD R/W	30	26N	13E	149.00

EXHIBIT A

DESCRIPTION OF PROPERTY CONTINUED
TO
CONFIRMATION SPECIAL WARRANTY DEED NO. 34753
DATED JULY 18, 1983

LAND TYPE: SURFACE ONLY

LEGAL DESCRIPTION	SEC.	TWP.	RGE.	ACRES
NE1/4NE1/4	28	21N	7E	40.00
A 20 FOOT WATER PIPE LINE R/W ACROSS NW1/4SW1/4 AND GOVT. LOT 4 AS RESERVED IN DEED FROM THE NORTHWESTERN IMPROVEMENT COMPANY TO CHARLES D. RAYMER DATED MAR. 5, 1941.	32	22N	7E	.45
THAT PART OF THE S1/2 LYING SOUTH OF THE BURLINGTON NORTHERN RAILROAD R/W	25	26N	12E	232.20
THAT PART OF THE S1/2SE1/4 LYING SOUTH OF THE BURLINGTON NORTHERN RAILROAD R/W	29	26N	12E	17.25
W1/2SW1/4 LYING WEST OF BURLINGTON NORTHERN RAILROAD R/W, SE1/4SW1/4 LYING EAST OF THE BURLINGTON NORTHERN RAILROAD R/W, SE1/4NW1/4, NE1/4SW1/4 LESS 11.86 AC. BURLINGTON NORTHERN RAILROAD R/W	32	26N	12E	97.18
ALL LESS 7.06 AC. BURLINGTON NORTHERN RAILROAD R/W	33	26N	12E	632.94

King, Co.
26

KING COUNTY
EXCISE TAX PAID
JUL 07 1989
E1070865

KING COUNTY
EXCISE TAX PAID
JUL 07 1989
E1070866

KING COUNTY
EXCISE TAX PAID
JUL 07 1989
E1070867

Commonwealth Land Title
425 Pike St
Suite 600
Seattle, WA 98101

RECEIVED THIS DAY

8907070390

0789-5-2

DEED TO PLUM CREEK TIMBER COMPANY, L.P.

THIS DEED CONTAINS PROVISIONS REQUIRING THAT CERTAIN MATTERS BE SUBMITTED TO ARBITRATION

89/07/07 #0390 D
RECD F 26.00
CASHSL ***26.00
55

PCTC, INC., a Delaware corporation (formerly known as Plum Creek Timber Company, Inc. and BN Timberlands, Inc.) ("Grantor") whose address is 999 Third Avenue, Seattle, Washington 98104, for and in consideration of One Dollar and other good and valuable consideration in hand paid, the receipt and sufficiency of which are hereby acknowledged, grants, bargains, sells and conveys to PLUM CREEK TIMBER COMPANY, L.P., a Delaware limited partnership ("Grantee"), whose address is 999 Third Avenue, Seattle, Washington 98104, Grantor's right, title and interest in and to the real property described in Exhibit "A" attached hereto, and all rights and appurtenances thereto, together with Grantor's after acquired title therein and all of Grantor's water, water rights, and ditch rights in existence on the date hereof, whether real or personal property and however evidenced, and used or intended to be used in connection with the real property described in Exhibit "A" (collectively, the "Subject Property"), provided Grantor reserves unto itself:

(a) all oil, gas and other hydrocarbons, regardless of gravity and whether produced in liquid or gaseous form (including, without limitation, all gas occurring in coal or lignite seams, beds or deposits, but except as occurring in coal or lignite seams, beds, or deposits when vented as a non-commercial substance in conjunction with coal or lignite development or extraction operations) and all substances necessarily produced in association with such oil, gas and other hydrocarbons in, on or under the Subject Property (such oil, gas and other hydrocarbons, together with such substances, are collectively called "Reserved Oil and Gas"), together with rights of ingress and egress for the purpose of drilling for, exploring for, producing, storing, treating, transporting and processing Reserved Oil and Gas with the right to remove any and all property Grantor places on the Subject Property, provided such rights of ingress and egress shall be subject to the provisions set forth below; and

(b) all minerals, metals and ores of every kind and nature, and whether surface or subsurface in, on or under the Subject Property except for Reserved Oil and Gas and all sources of geothermal energy (such minerals and sources are called the "Reserved Minerals", and include without limitation and without regard to their intended use or current commercial value:

(i) coal, lignite, and peat (including gas occurring in coal or lignite seams, beds or deposits to the extent the same is vented as a non-commercial substance in conjunction with coal or lignite development or extraction operations);

(ii) precious metals such as gold and silver and other metals such as copper, iron, lead, and zinc;

(iii) industrial minerals, including without limitation talc, calcium carbonate, mica, and kaolin;

(iv) fissionable source materials, including without limitation uranium, vanadium, and thorium;

(v) sand, clay, gravel, aggregate, granite, stone, rock, including without limitation decorative rock and rock of a unique character; provided, Grantee may use so much of the items described in this clause (v) as it reasonably requires in connection with its use and enjoyment of the Subject Property or with the construction, maintenance, and repair of roads serving the Subject Property, so long as the use of such items is incidental to such other uses and is not a primary use;

(vi) all other naturally occurring elements, compounds and substances, whether similar or dissimilar, metallic or non-metallic, in whatsoever form and whether occurring, found, extracted or removed in solid, liquid or gaseous state; and

(vii) all of the constituent products of all or any of the foregoing and all other substances necessarily produced in association therewith),

together with rights of ingress and egress for the purpose of prospecting and exploring for Reserved Minerals by any means, and for the purpose of drilling, extracting, mining, developing, producing, treating and processing Reserved Minerals by all methods (including without limitation mining by strip, auger, open pit, in-situ combustion, solution, and underground methods); and of erecting, operating, maintaining and working any mining, extraction, production, treatment or processing facility by all procedures, whether such means, methods, or procedures are now known or hereafter discovered, and of taking out, storing, stockpiling, removing, transporting and marketing Reserved Minerals, together with the right to commingle Reserved Minerals or any other material produced from the Subject Property with minerals or any other material produced from any other property and to use the Subject Property for any of the aforesaid activities with respect to such minerals and materials when related to like activities involving Reserved Minerals, provided these rights of ingress and egress shall be subject to the provisions set forth below.

THIS DEED AND THE RESERVATIONS HEREUNDER ARE MADE SUBJECT TO THE TIMBERLANDS CONVEYANCE AND ASSUMPTION AGREEMENT BY AND BETWEEN GRANTOR AND GRANTEE OF EVEN DATE HEREWITH. SUCH AGREEMENT CONTAINS PROVISIONS, WHICH AMONG OTHERS, PERMIT THE GRANTEE TO ACQUIRE WITHIN THE TEN YEARS FROM THE DATE HEREOF CERTAIN RESERVED MINERALS AND CERTAIN SURFACE RIGHTS WITH RESPECT TO SUBJECT OIL AND GAS.

The term "Mineral Owner" means at the time of the execution and delivery of this instrument Grantor, and thereafter any owner of Reserved Oil and Gas or Reserved Minerals.

The term "Surface Owner" means at the time of the execution and delivery of this instrument Grantee, and thereafter any owner of Subject Property.

1. Use

Mineral Owner shall not interfere unreasonably with Surface Owner's use of the Subject Property and shall use only so much of the surface of the Subject Property as may be reasonably necessary for purposes for which the rights of ingress and egress are reserved. Mineral Owner shall give Surface Owner reasonable advance notice of all operations (other than those which are irregular, of brief duration, and which will not cause significant damage) it intends to conduct on the Subject Property.

As to a Mineral Owner of Reserved Minerals, each notice such owner gives shall be in writing and include a map or plat showing the location on the Subject Property where the operations are to be conducted and the roads to be used. This notice shall include a description of the timber and improvements which must be removed in order to conduct the operations, and a schedule of the anticipated dates on which the operations are to be commenced and be concluded.

Unless first consented to in writing by Surface Owner, no oil or gas well shall be drilled nearer than 200 feet to any Compensable Structure (as defined below). When requested by Surface Owner, Mineral Owner of the Reserved Oil and Gas will bury all oil or gas pipelines to below a depth necessary to avoid interference with Surface Owner's operations, provided, it shall not be required to bury pipelines to a depth below three feet. All buried pipelines will be marked at road crossings and enclosed in casings with sufficient strength to permit the passing of heavy equipment over the road without damage to the pipeline.

2. Roads

Mineral Owner also reserves the right to use in common with Surface Owner such rights as Surface Owner has to use roads (not public) whether now existing or hereafter constructed on lands outside but serving the Subject Property, excluding, however, those rights which by their terms may not be so reserved. Mineral Owner also reserves the right to use in common with Surface Owner roads whether now existing or hereafter constructed on the

Subject Property. Mineral Owner's right to use such roads (whether on or serving the Subject Property) is subject to the conditions (i) that Mineral Owner shall not use any such road in violation of the provisions of any instrument creating or affecting Surface Owner's right of use and shall not cause a surcharge on such right, and (ii) that before using any road for other than a casual, irregular use, Mineral Owner shall pay and agree to pay to the Surface Owner and to other appropriate parties amounts necessary to compensate Surface Owner and the other parties for those costs incurred for construction, reconstruction, and maintenance of the road, which are attributable to Mineral Owner's proposed and actual use; provided that as to construction costs alone, Mineral Owner shall not be required to make payments to Surface Owner in respect of costs which Surface Owner or its predecessors in interest incurred before the date hereof.

Surface Owner shall have the right to use in common with Mineral Owner any roads Mineral Owner constructs on the Subject Property provided that such use shall not interfere unreasonably with Mineral Owner's operations. All roads constructed by Mineral Owner shall, upon Mineral Owner's abandonment, become the property of Surface Owner; provided, Surface Owner may require that Subject Property covered by said roads be reclaimed and restored as nearly as reasonably practical to their original condition upon such abandonment. If before Mineral Owner's abandonment, Surface Owner uses for other than a casual, irregular use any road constructed by Mineral Owner, Surface Owner shall pay Mineral Owner amounts necessary to properly compensate Mineral Owner for the costs Mineral Owner incurs for construction, reconstruction and maintenance of the road which are attributable to Surface Owner's proposed and actual use.

Surface Owner and Mineral Owner shall consult with one another with regard to the manner of and scheduling the use of those roads on the Subject Property and those roads serving the Subject Property which Mineral Owner is entitled to use in common with Surface Owner, as provided in this paragraph 2. Mineral Owner acknowledges that the roads may be subject to sharing arrangements with third parties and scheduling constraints, and both Surface Owner and Mineral Owner will each endeavor to accommodate the other's need for the roads and that of third parties.

3. Surface Owner's Compensation

If Mineral Owner conducts operations on the Subject Property, Mineral owner shall pay to Surface Owner just and reasonable compensation for all actual damage caused by the operations to (i) improvements, (ii) growing crops and timber (whether merchantable or pre-merchantable), and (iii) the surface of the Subject Property, provided items covered in clauses (i) and (ii) shall not also be included in this clause (iii). The foregoing notwithstanding, the payments the Mineral Owner of Reserved Oil and Gas shall pay under clause (i) with respect to building and improvements shall be limited to actual damage to Compensable Structures. "Compensable Structure" means any building or improvement constructed or placed on the Subject Property by Surface Owner after the date hereof which does not interfere unreasonably with the reasonable use by the Mineral Owner of Reserved Oil and Gas of the surface of the Subject Property for the exploration and development of Reserved Oil and Gas. The existence of a reasonably economic and otherwise suitable drillsite on a portion of the Subject Property outside of the portion occupied by the building or improvement for the exploration and development of the Reserved Oil and Gas beneath such building or improvement, shall conclusively establish that the building or improvement is a Compensable Structure.

In addition, if Mineral Owner conducts operations on the Subject Property requiring substantial use of the surface for more than one year (including periods needed for repair of significant surface damage), Mineral Owner shall pay to Surface Owner a damage payment equal to the then bare land fair market value of that portion of the Subject Property so used by Mineral Owner, less any amount paid pursuant to clause (iii) of the preceding paragraph. Such damage payment shall entitle Mineral Owner to have the free use of such portion of the Subject Property until it is no longer necessary or convenient to Mineral Owner's exercise of its rights thereon.

Mineral Owner's operations shall not be postponed or delayed pending reasonable effort to agree upon, or have determined, the amount of any payment to be made pursuant to this paragraph 3.

The payments provided for herein shall be full compensation to Surface Owner for all damage to the improvements, growing crops and timber, and surface in respect of which the payment is made. Any obligation of Mineral Owner hereunder shall be limited to and measured by Surface Owner's interest in the ownership of the surface of the Subject Property and any improvements, growing crops, or timber thereon, and if Surface Owner owns a lesser interest in the surface and/or improvements, growing crops or timber thereon than the entire and undivided whole thereof, then any payments hereunder shall be paid to Surface Owner only in the proportion that Surface Owner's interest bears to the entire and undivided surface estate or to the ownership of said improvements, growing crops and timber.

If Surface Owner and Mineral Owner fail to agree upon the amount of any payment to be made pursuant to this paragraph 3, the amount shall be determined by arbitration pursuant to the Commercial Arbitration Rules of the American Arbitration Association. If at any relevant time the American Arbitration Association is not fulfilling its arbitration function substantially as on the date hereof, and Surface Owner and Mineral Owner are not themselves able to agree on the amount of any payment to be made, they shall each, within ten days after written notice given by either party, appoint an appraiser and within fifteen days after such appointment, the two appraisers so appointed shall agree upon and appoint a third appraiser. If a party fails to appoint an appraiser as required, or if the two appraisers fail to agree upon and appoint a third appraiser as required, such appointment shall be made, upon application by either party, by the judge of the federal district court in which the relevant portion of the Subject Property is situate, then senior in service. All appraisers designated pursuant to this provision must be of good reputation, be experienced in appraising real property and timber (whether merchantable or pre-merchantable), and be willing to conduct the appraisal as required herein. The three appraisers shall proceed diligently to determine the amount of the payment, assuming a cash sale not subject to any indebtedness. The appraisers shall complete their appraisal not later than 60 days following the designation of the third appraiser, and deliver the results thereof to Surface Owner and Mineral Owner. If the three appraisers cannot agree on the amount of the payment, the amount shall be the average of the two closest appraised values. Each party shall pay the fees and expenses of its appraiser and they shall pay equal shares of the fees and expenses of the third appraiser.

4. Indemnification

Notwithstanding any other provision of this Deed, Surface Owner and Mineral Owner shall each, to the fullest extent permitted by applicable law, indemnify, defend and hold harmless the other, its officers, directors, employees, successors and assigns, of and from any and all claims, demands, costs, liabilities, causes of action and expenses, including court costs and attorneys' fees, for violations of and obligations or governmental or private claims under, environmental law which violations, obligations, or claims arise from or are connected with any operations by the indemnifying party on the Subject Property, including without limitation any act or omission of the indemnifying party, its agents or contractors, whether negligent or intentional.

Additional Provisions

The aforesaid conveyance is made subject to all liens, encumbrances, restrictions, defects and other matters affecting the Subject Property, whether or not of record.

Grantor reserves the benefit of and the right to enforce the covenants and warranties made by Grantor's predecessor in interest, if any, with respect to the Reserved Oil and Gas and the Reserved Minerals.

All provisions contained herein shall be binding on the successors and assigns of Grantor and Grantee, and the covenants and conditions hereof shall burden and run with the land.

Executed on June 21, 1989, but effective as of June 21, 1989,

Attest:

By Susanna N. Lyman
Susanna N. Lyman,
Secretary

PCTC, INC.

By David D Leland
David D. Leland,
President and Chief
Executive Officer

1981

STATE OF WASHINGTON)
) ss.
COUNTY OF KING)

On this 21 day of June, 1989

WASHINGTON
Before me personally appeared David D. Leland and Susanna N. Lyman, to me known to be the President and Chief Executive Officer and Secretary, respectively, of PCTC, Inc., the corporation that executed the within and foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that they were authorized to execute said instrument and that the seal affixed is the corporate seal of said corporation.

MONTANA
Before me, a Notary Public for the State of Washington, personally appeared David D. Leland and Susanna N. Lyman, known to me to be the President and Chief Executive Officer and Secretary, respectively, of PCTC, Inc., the corporation that executed the foregoing instrument and they acknowledged to me that such corporation executed the same.

IDAHO
Before me, a Notary Public in and for the State of Washington, personally appeared David D. Leland and Susanna N. Lyman, known or identified to me to be the President and Chief Executive Officer and Secretary, respectively, of PCTC, Inc., the corporation that executed the instrument or the persons who executed the instrument on behalf of said corporation, and acknowledged to me that such corporation executed the same.

In witness whereof, I have hereunto set my hand and affixed my official seal on the day and year first above written.

Marguerite Rus
Notary Public in and for the State of Washington

Residing at Seattle

My commission expires: 3/22/92

MARGUERITE RUS
MAR. 22, 1992

DOCUMENT NO. 36335
PLUM CREEK TIMBER CO. INC.

EXHIBIT A

KING COUNTY WA

8907070390

SECTION	TWP	RGE	DESCRIPTION	ACRES
25	20 N	6 E	LOTS 3 & 4 IN BLOCK 5 OF O.H. DICKSON CORRECTION PLAT ADDITION TO THE CITY OF ENUMCLAW.	3.16
31	20 N	5 E	LOTS 1 & 2, E1/2NE1/4, SE1/4, S1/2SW1/4, NW1/4SW1/4	445.13
02	21 N	6 E	ALL FRL. LESS 8.78 AC BEING THAT PORTION WITHIN SEC.2, TWP 21N, RGE 6E, OF A PARCEL OF LAND LYING SOUTHERLY OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY AND NORTHERLY OF THE RAVENSDALE-BLACK DIAMOND ROAD LOCATED IN THE SE1/4 OF SEC 35 AND THE SW1/4 OF SEC. 36, TWP. 22N, RGE. 6E, AND THE NE1/4 OF SECTION 2, TWP 21N RGE 6E, W.M., MORE PARTICULARLY DESCRIBED AS FOLLOWS: FROM THE INTERSECTION OF THE CENTER LINES OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY AND THE RAVENSDALE-BLACK DIAMOND ROAD SOUTH 37 DEGREES 00' WEST 96.0 FEET TO THE POINT OF BEGINNING, THENCE SOUTH 28 DEGREES 10' WEST 90 FEET; THENCE SOUTH 50 DEGREES 00' WEST 650 FEET; THENCE SOUTH 45 DEGREES 30' WEST 850 FEET; THENCE SOUTH 45 DEGREES 30' WEST 480 FEET; THENCE SOUTH 40 DEGREES 30' WEST 811 FEET; THENCE SOUTH 55 DEGREES 00' WEST 1592 FEET; THENCE NORTH 24 DEGREES 30' WEST 1135 FEET TO THE SOUTHERLY RIGHT-OF-WAY LINE OF SAID RAILROAD; THENCE NORTH 66 DEGREES 24' EAST 3674.7 FEET, MORE OR LESS, ALONG SAID RIGHT-OF-WAY LINE TO THE POINT OF BEGINNING.	650.30
03	21 N	6 E	LOTS 1,2,3, EAST 21.47 AC. OF LOT 4, S1/2NE1/4, SE1/4	389.24
09	21 N	6 E	W1/2NE1/4, N1/2NW1/4, SE1/4NW1/4, S1/2, PART OF SE1/4NE1/4 LYING WESTERLY OF COUNTY ROAD & N. 30 FT. LYING EAST OF COUNTY ROAD	541.00
11	21 N	6 E	W1/2NW1/4, LESS 2.00 AC. B.N. INC. R/W	78.00
15	21 N	6 E	NW1/4, S1/2, LESS SE1/4SE1/4SE1/4	470.00
21	21 N	6 E	E1/2, NW1/4, NE1/4SW1/4	520.05
23	21 N	6 E	NE1/4 NE1/4 NE1/4, S1/2 N1/2 NE1/4. S1/2 N1/2, N1/2 SE1/4, SE1/4 NW1/4, NE1/4 SW1/4 NW1/4, S1/2 NW1/4 NW1/4. SW1/4 LESS 5.87 ACRES RIGHT-OF-WAY SOLD BY WARRANTY DEED RECORDED 6-14-48, BOOK 2753. P 336 KING COUNTY BOOK OF DEEDS.	479.36
25	21 N	6 E	LOTS 1,3,4,5,10,11, LOT 2, SE1/4NE1/4, SW1/4SW1/4,	351.23

DOCUMENT NO. 36335
PLUM CREEK TIMBER CO. INC.

EXHIBIT A

KING COUNTY WA

8907070390

SECTION	TWP	RGE	DESCRIPTION	ACRES
25	21 N	6 E	NE1/4SE1/4, LESS 9.47 AC. SOLD BY DEED RECORDED 5-14-48 IN BOOK 2753, PAGE 336 ALSO THE S1/2SE1/4. LESS 54.00 ACRES, MORE OR LESS, IN LOTS 2 & 3, & SW1/4SE1/4 SOLD BY DEED DATED 6-16-89 AND RECORDED 6-16-89 UNDER A.F.#8906161504.	
27	21 N	6 E	N1/2NW1/4, SW1/4SW1/4, LESS 1.40 AC. BY AMENDED JUDGMENT OF SUPERIOR COURT 3-6-72; RECORDED UNDER S.C.# 765079	118.60
23	22 N	6 E	S 34 AC OF SE4NE4; PART OF LOT 11 S OF MILWAUKEE R/W, LESS 8.19 AC CITY OF SEATTLE R/W; NE4NW4SW4, N2NW4NW4SW4 LESS 1.97 AC MILWAUKEE R/W; SE4SW4, NE4SE4, S2SE4	227.12
25	22 N	6 E	NW1/4, & THAT PART OF SE1/4SW1/4, SW1/4SE1/4 LYING SOUTHWESTERLY OF THE NORTHEASTERLY BOUNDARY OF THE KENT-KANGLEY ROAD	211.00
26	22 N	6 E	NE1/4, N1/2NW1/4	240.00
33	22 N	6 E	SE1/4SE1/4 LESS 4.66 AC BN R/W	35.34
35	22 N	6 E	ALL; LESS 14.01 ACRES WITHIN BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY, LESS 4.30 ACRES SOLD IN SW1/4 SW1/4 AS CONVEYED BY QUITCLAIM DEED RECORDED 4-7-87, A.F #8704071610 BOOK OF DEEDS, KING COUNTY; LESS THAT PORTION OF THE W1/2SW1/4 LYING SOUTHERLY OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY - PARCEL 003 DEEDED TO MERIDIAN MINERALS	556.69
36	22 N	6 E	N1/2, SECTION 36, TOWNSHIP 22 NORTH, RANGE 6 EAST, W.M., LESS THE FOLLOWING: 14.25 AC. BURLINGTON NOTHERN RAILROAD R/W, 3.13 AC. CONVEYED BY NORTHWESTERN IMPROVEMENT CO., HEREINAFTER REFERED TO AS N.W.I., TO KING COUNTY SCHOOL DIST. NO.109 BY DEED DATED OCT.26, 1927; RECORDED IN BOOK 1410, P.405; 2.04 AC. CONVEYED BY BURLINGTON NORTHERN RAILROAD CO. TO KING COUNTY FIRE DIST. NO. 43 BY DEED DATED OCT 13, 1981; RECORDED 10-14-81, A.F.#8110140670; 0.11AC CONVEYED NWI TO E. MORGAN BY DEED DATED SEPT. 25, 1946; RECORDED IN BK.2613, P. 270; 0.11 AC CONVEYED TO SEGUNDO TOBACCO BY UNRECORDED DEED DATED SEPT. 25, 1946; 0.22 AC. CONVEYED BY N.W.I. TO JOHN PETER	550.25

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
36	22 N	6 E	BODS BY DEED DATED SEPT. 25, 1946; RECORDED IN BK. 2581, P.293; 0.16 AC. CONVEYED BY N.W.I. TO EDWARD S. GOGOLA BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2581, P.295; 0.16 AC. CONVEYED BY N.W.I. TO ANTON POLESKI, JR. BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2581, P.297; 0.15 AC. CONVEYED BY N.W.I. TO LOUIE VALENTE BY DEED DATED SEPT.25, 1949; RECORDED IN BK.2594, P.514; 0.16 AC. CONVEYED BY N.W.I. TO BERENICE VELEMA GOGOLA BY DEED DATED SEPT. 25 1949 RECORDED IN BK.3341, P.374; 0.15 AC. CONVEYED BY N.W.I. TO WILLIAM SHIMMEL BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.3761, P.477; 0.18 AC. CONVEYED BY N.W.I. TO JOHN MARKUS BY DEED DATED SEPT. 25, 1949; RECORDED IN BK. 2578, P.222; 0.13 AC. CONVEYED BY N.W.I. TO LOUIS & JOSEPH SAFTICH BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2550, P.254; 0.21 AC. CONVEYED BY N.W.I. TO WAINO TOIVONEN BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2585, P.626; 0.69 AC. CONVEYED BY N.W.I. TO WILLIAM & CATERINA LUCIA MARCHETTI BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2565, P.77; 0.10 AC. CONVEYED BY N.W.I. TO BRUNO MILLER BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2624, P.127; 0.12 AC. CONVEYED BY N.W.I. TO FRANK VISCONIC BY DEED DATED APR. 28, 1947; RECORDED IN BK. 3666, P.134; 0.10 AC. CONVEYED BY N.W.I. TO OTTO MATTSON BY DEED DATED NOV.15, 1947; RECORDED IN BK.3763, P.608; 1.47 AC CONVEYED BY N.W.I. TO A. BUTLER BY DEED DATED JAN. 19, 1948; RECORDED IN BK.2819, P.324; 0.16 AC. CONVEYED BY N.W.I. TO THOMAS & ANNE HOLDER BY DEED DATED FEB. 16, 1949; RECORDED IN BK.3897, P.494; 0.22 AC. CONVEYED BY N.W.I. TO RAYMOND L. & ANNE BISYAK BY DEED DATED FEB. 16, 1948; RECORDED IN BK. 2812, P.349; 0.22 AC. CONVEYED BY N.W.I. TO ELLEANOR DAMBROSKI BY DEED DATED FEB. 3, 1948; RECORDED IN BK. 2929, P. 36; 0.22 AC. CONVEYED BY N.W.I. TO ARVID & SOPHIA HILL BY DEED DATED MAY 24, 1948; RECORDED IN BK.2776, P.621; 0.10 AC CONVEYED BY N.W.I. TO JOSEPH WILSKO BY DEED DATED JULY 9, 1948; RECORDED IN BK.278, P.610; 0.10 AC. CONVEYED BY N.W.I. TO JOHN MATTSON BY DEED DATED MAY 12, 1947; RECORDED IN BK. 2987, P.150; 0.18 AC. CONVEYED BY N.W.I. TO JULIUS SWORD BY DEED DATED JUNE 27, 1949; RECORDED IN BK. 2875, P.525; 0.22 AC. CONVEYED BY N.W.I. TO MYRTLE A. BELLEKAN BY DEED DATED NOV.8, 1949; RECORDED IN BK.2913, P.325; 0.22AC. CONVEYED BY N.W.I. TO R.A. RYDER BY DEED DATED NOV. 8, 1949; RECORDED IN BK.2915, P.156; 0.22 AC. CONVEYED BY N.W.I. TO ANDREW J. LANG BY DEED DATED NOV.30, 1949; RECORDED IN BK. 2914, P.328; 0.22 AC. CONVEYED BY N.W.I. TO HERMAN & GRACE	

EXHIBIT A

KING COUNTY WA

8907070390

SECTION	TWP	RGE	DESCRIPTION	ACRES
36	22 N	6 E	E. CALLAHAN BY DEED DATED DEC. 29, 1949; RECORDED IN BK.2919 P.175; 0.41 AC. CONVEYED BY N.W.I. TO JOHN & ANNA NOVACK BY DEED DATED JAN. 27,1950; RECORDED IN BK.2928, P.457; 1.22AC. CONVEYED BY N.W.I. TO FRANK & SOPHIE HOLLY BY DEED DATED APR.19, 1951; RECORDED IN BK.3047, P.439; 0.19 AC. CONVEYED BY N.W.I. TO RAY & MARGARET THOMPSON BY DEED DATED MAY 21, 1951; RECORDED IN BK. 3153, P.601; 0.16 AC. CONVEYED BY N.W.I. TO CASCADE RIFLE & PISTOL CLUB, INC. BY DEED DATED SEPT. 10, 1951; RECORDED IN BK.3093, P.416; 0.22 AC. CONVEYED BY N.W.I. TO RAY & EVELYN TWEDT BY DEED DATED DEC. 16, 1952; RECORDED IN BK. 3217, P.603; 0.19 AC. CONVEYED BY NORTHERN PACIFIC RAILWAY CO., HEREINAFTER REFERRED TO AS N.P.RY.CO., TO FRANK VISCONIC BY CORRECTION DEED DATED OCT. 19, 1959; RECORDED IN BK.3965, P.501; 0.10 AC. CONVEYED BY N.P.RY.CO. TO TONY BARRAGAGE BY DEED DATED SEPT. 28, 1957; RECORDED IN BK.3970, P.154; 0.30 AC. CONVEYED BY N.P.RY.CO. TO EVOR & MARGARET MORGON BY DEED DATED JULY 15, 1960; RECORDED IN BK.4069, P. 82; 0.21 AC. CONVEYED BY N.P.RY.CO. TO FRANK E VISCONIC BY DEED DATED AUG. 1, 1963; RECORDED IN BK.4456, P.336; 0.25 AC. CONVEYED BY N.P.RY.CO. TO FRANK E. VISCONIC BY DEED DATED JUNE 20, 1967; RECORDED IN BK.496, P.513; S1/2 LESS 4.00 AC. BURLINGTON NOTHERN RAILROAD R/W. LESS 45.80 AC. BEING THAT PORTION WITHIN SEC. 36, TWP22N, RGE6E, OF A PARCEL OF LAND LYING SOUTHERLY OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY AND NORTHERLY OF THE RAVENSDALE-BLACK DIAMOND ROAD LOCATED IN THE SE1/4 OF SEC.35 AND THE SW1/4 OF SEC.36, TWP22N, RGE6E, AND THE NE1/4 OF SEC.2, TWP21N, RGE6E, W.M., MORE PARTICULARLY DESCRIBED AS FOLLOWS: FROM THE INTERSECTION OF THE CENTER LINES OF THE BURLINGTON NOTHERN RAILROAD RIGHT-OF-WAY AND THE RAVENSDALE-BLACK DIAMOND RD. SOUTH 37 DEGREES 00' WEST 96.0 FEET TO THE POINT OF BEGINNING, THENCE SOUTH 28 DEGREES 00' WEST 90 FEET THENCE SOUTH 50 DEGREES 00' WEST 850 FEET; THENCE SOUTH 45 DEGREES 30' WEST 850 FEET; THENCE SOUTH 45 DEGREES 30' WEST 480 FEET; THENCE SOUTH 40 DEGREES 30' WEST 811 FEET; THENCE SOUTH 55 DEGREES 00' WEST 1592 FEET; THENCE NORTH 24 DEGREES 30' WEST 1135 FEET TO THE SOUTHERLY RIGHT-OF-WAY LINE OF SAID RAILROAD; THENCE NORTH 66 DEGREES 24' EAST 3674.7 FEET, MORE OR LESS, ALONG SAID RIGHT-OF-WAY LINE TO THE POINT OF BEGINNING.	
29	23 N	6 E	E1/2E1/2, SW1/4NE1/4, NW1/4SE1/4	240.00
33	23 N	6 E	NE1/4, SE1/4NW1/4 LESS THAT PORTION OF THE S1/2NE1/4 AND	138.10

DOCUMENT NO. 36335
PLUM CREEK TIMBER CO. INC.

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
33	23 N	6 E	SE1/4NW1/4 LYING EASTERLY OF THE BONNEVILLE POWER ADMINISTRATION POWERLINE RIGHT-OF-WAY, SOUTHERLY OF SE LAKE DESIRE RD AND WESTERLY OF LAKE DESIRE ROAD SE.	
01	21 N	7 E	ALL FRL.	716.32
03	21 N	7 E	FRACTIONAL W1/2, LESS 19.08 ACRES CONVEYED TO THE U.S.A. BY FEDERAL DIST. COURT UNDER CAUSE NO. 4355 DATED MAR. 28, 1957	338.92
05	21 N	7 E	ALL FRACTIONAL, LESS 22.11 ACRES WITHIN THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY, LESS 25.48 ACRES OF RAVER SUB-STATION LANDS SOLD AND CONVEYED BY WARRANTY DEED FEE AND EASEMENT RECORDED 12-13-65, BOOK 4730, P 193, BOOK OF DEEDS KING COUNTY AND LESS THE HIGHWAY RIGHT-OF-WAY.	667.52
07	21 N	7 E	E1/2NE1/4, E1/2W1/2NE1/4	120.00
09	21 N	7 E	ALL, LESS 16.19 ACRES IN THE BURLINGTON NORTHERN RIGHT-OF-WAY, LESS A 5.29 AC. U.S. DIST.COURT CAUSE # 4355 DATED 3-28-57. AND LESS 1.23 AC. TRACT SOLD BY DEED RECORDED 5-6-59, IN VOL.3909, PAGE 543, A.F.# 5029604, TO NTHE U.S.A. LESS 93.00 ACRES, MORE OR LESS , IN NE1/4SE1/4, NE1/4, SE1/4NW1/4, AND N1/2SW1/4 SOLD BY DEED DATED 6-16-89 AND RECORDED 6-16-89 UNDER A.F.#8906161504.	524.29
11	21 N	7 E	N1/2, LESS 0.07 AC CONVEYED TO U.S.A. BY DIST. COURT DECREE RECORDED UNDER CAUSE NO. 4355 DATED MAR. 28, 1957 E1/2SE1/4, NW1/4SE1/4, NE1/4SW1/4. AND THAT PORTION OF THE SW1/4SW1/4 LYING NORTHERLY OF THE BURLINGTON NORTHERN RIGHT-OF-WAY AND SOUTHERLY OF CHICAGO, MILWAUKEE AND ST. PAUL RAILROAD RIGHT-OF-WAY. LESS THE S1/2NE1/4NW1/4, THE NW1/4NW1/4, THAT PORTION OF THE S1/2NW1/4 LYING NORTHEASTERLY OF THE CHICAGO MILWAUKEE, ST. PAUL AND PACIFIC RAILROAD RIGHT OF WAY AND NORTHERLY OF SE HUDSON RD. (FORMERLY SE 304TH STREET), THE NE1/4SW1/4, THE NW1/4SE1/4, AND THAT PORTION OF THE E1/2SE1/4 AND S1/2NE1/4 LYING NORTHERLY OF SAID SE HUDSON ROAD AND SOUTHERLY OF SE COURTNEY ROAD.	195.03
12	21 N	7 E	PART OF SW1/4SW1/4	10.00

DOCUMENT NO. 36335
PLUM CREEK TIMBER CO. INC.

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
13	21 N	7 E	E1/2NE1/4, LESS 7.80 AC. LOST UNDER DECREE OF COURT DATED OCT. 2, 1964; RECORDED UNDER U.S. DIST. COURT CAUSE # 5643; 2.06 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO THE CITY OF TACOMA BY DEED DATED SEPT. 20, 1974; RECORDED UNDER AUDITORS FILE #741010297; NW1/4NW1/4, S1/2NW1/4, S1/2, LESS THE FOLLOWING: 27.77 AC. LOST UNDER DECREE OF COURT DATED OCT. 2, 1964; RECORDED UNDER U.S. DIST. COURT CAUSE #5643; 3.50 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO THE CITY OF TACOMA BY DEED DATED SEPT. 20, 1974; RECORDED UNDER A.F.# 741010297; 1.30 AC. CONVEYED BY NORTHERN PACIFIC RAILWAY COMPANY, HEREINAFTER REFERRED TO AS N.P.RY.CO., TO GREEN RIVER SHORES INC. BY DEED DATED JULY 17, 1967; RECORDED IN BK.5019, P.318; 1.04 AC. CONVEYED BY N.P.RY.CO. TO THE U.S.A BY DEED DATED AUG. 16, 1963; RECORDED IN BK.4574, P.175; 4.96 AC. CONVEYED BY N.P.RY.CO. TO THE U.S.A. BY DEED DATED MAY 14, 1963; RECORDED UNDER A.F.#5592728; 64.63 AC. CONVEYED TO U.S.A. BY DIST. COURT DECREE UNDER CAUSE # 4355 DATED MAR 28, 1957.	406.94
15	21 N	7 E	PORTION OF N1/2 NE1/4 SOUTH OF BURLINGTON NORTHERN RAILROAD R/W, LESS 18.50 AC. CONVEYED TO U.S.A BY DIST. COURT DECREE RECORDED UNDER CAUSE NO. 4355 DATED MAR.28, 1957; DATED 3-28-57; S1/2NE1/4, N1/2NW1/4, LESS 5.84 AC. BUR. NORTHERN RAILROAD RIGHT-OF-WAY; S1/2 NW1/4 LESS 13.47 ACRES WITHIN THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY; S1/2, LESS 25.46 ACRES WITHIN THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY.	549.18
17	21 N	7 E	E1/2, LESS 52.85 ACRES SOLD AND CONVEYED BY 2 WARRANTY DEEDS (33.87 AC.) RECORDED UNDER A.F.#8308180845 AND (18.98 AC.) RECORDED UNDER A.F.# 8308180846, BOOK OF DEEDS, KING COUNTY.	267.15
21	21 N	7 E	N1/2, N1/2 S1/2, SE1/4 SE1/4, SE1/4 SW1/4, THAT PORTION OF SW1/4 SE1/4 LYING WESTERLY OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY; LESS 34.69 ACRES WITHIN THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY, AND 8.96 ACRES WITHIN THE MILWALKEE RAILROAD RIGHT-OF-WAY AND 0.54 ACRES SOLD AND CONVEYED BY A WARRANTY DEED IN BOOK 2847, P 183, BOOK OF DEEDS, KING COUNTY.	520.23
21	21 N	7 E	RAILROAD R/W IN E1/2SE1/4 AS CONVEYED TO CHICAGO, MILW., ST. PAUL & PACIFIC RR CO. BY DEEDS RECORDED UNDER RECORDING NOS. 672893 & 698291, EXCEPT THAT PART LYING WITHIN KUZACK ROAD.	7.50

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EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
23	21 N	7 E	ALL	640.00
25	21 N	7 E	ALL	640.00
26	21 N	7 E	E1/2W1/2, SW1/4SW1/4, NW1/4SE1/4, SW1/4NE1/4	280.00
26	21 N	7 E	N1/2NE1/4, SE1/4NE1/4, NE1/4SE1/4, S1/2SE1/4	240.00
27	21 N	7 E	ALL	640.00
28	21 N	7 E	NE1/4NE1/4	40.00
29	21 N	7 E	EAST 990 FT OF LOTS 3 & 4, W1/2, E1/2NE1/4; LESS 5.52 AC BN R/W	455.18
30	21 N	7 E	SE1/4NW1/4	40.00
31	21 N	7 E	LOT 1, NE1/4NW1/4, S1/2NE1/4	161.23
32	21 N	7 E	SE1/4, N1/2SW1/4, NW1/4, LESS 0.63 AC. SOLD BY DEED RECORDED 11-30-83 UNDER AUDITORS FILE NO. 8311301224.	399.37
34	21 N	7 E	THAT PART OF THE NW1/4SW1/4 DESCRIBED AS FOLLOWS; BEGINNING AT A POINT 423 FT. SOUTH OF THE NORTHWEST CORNER OF THE NW1/4SW1/4 THENCE SOUTH 280 FT.; THENCE EAST 100 FT.; THENCE N 12 DEGREES 17'00"E TO A POINT WHICH BEARS DUE EAST FROM THE POINT OF BEGINNING; THENCE DUE WEST TO THE POINT OF BEGINNING.	.57
35	21 N	7 E	ALL	640.00
23	22 N	7 E	SW1/4	160.00
25	22 N	7 E	ALL	640.00
30	22 N	7 E	FRL S1/2	297.38
31	22 N	7 E	ALL FRL, LESS 21.22 AC BN R/W, LESS THAT PART OF THE E 1805.58 FT OF S1/2NE1/4, LYING SOUTH OF BN R/W	562.09

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EXHIBIT A

KING COUNTY WA

9907070390

SECTION	TWP	RGE	DESCRIPTION	ACRES
32	22 N	7 E	50 FT. R/W IN FRONT OF LOT 4 ACROSS SHORE LANDS, BED AND WATER OF FISH LAKE; PART OF NW1/4NW1/4 LYING SOUTH OF KENT-KANGLEY ROAD	6.07
32	22 N	7 E	A 20 FT. WATER PIPELINE R/W ACROSS NW1/4SW1/4 & GOVT. LOT 4	.45
33	22 N	7 E	ALL	640.00
35	22 N	7 E	ALL	640.00
[illegible]	23 N	7 E	THAT PART OF SE1/4NE1/4 LYING SOUTHERLY OF INTERSTATE 90, SE1/4.	201.04
[illegible]	23 N	7 E	ALL LESS 25.17 AC SOLD BY WARRANTY DEED RECORDED 1-23-61 IN BOOK 4116, P 599, BOOK OF DEEDS, KING COUNTY. LESS 40.00 AC SOLD BEING THAT PORTION OF THE N1/2 LYING EASTERLY OF S.R. 18 (PHS#2), NORTHWESTERLY OF THE WEST BANK OF HOLDER CREEK AND NORTHERLY OF A LINE WHICH IS 2200 FEET SOUTH OF AND PARALLEL TO THE NORTH LINE OF THE NE1/4.	537.61
17	24 N	7 E	NW1/4NW1/4, W1/2NE1/4NW1/4, S1/2NW1/4, SW1/4NE1/4, SW1/4SE1/4, SE1/4SW1/4	260.00
31	24 N	7 E	E1/2 LESS NORTH 150 FT THEREOF	311.62
31	24 N	7 E	THE SOUTH 100 FT. OF THE NORTH 150 FT. OF THE NE1/4	5.38
13	23 N	8 E	N1/2, SE1/4	480.00
11	23 N	8 E	W1/2W1/2	160.00
17	23 N	8 E	ALL	640.00
18	23 N	8 E	NE1/4	160.00
20	23 N	8 E	N1/2	320.00
24	23 N	8 E	N1/2SE1/4, SE1/4SE1/4	120.00
25	23 N	8 E	NW1/4, E1/2NE1/4, W1/2SE1/4	320.00
26	23 N	8 E	N1/2SE1/4, NE1/4SW1/4	120.00
27	23 N	8 E	ALL FRL	640.85
31	23 N	9 E	FRL. W1/2	309.00

DOCUMENT NO. 36335
PLUM CREEK TIMBER CO. INC.

EXHIBIT A

KING COUNTY WA

8907070390

SECTION	TWP	RGE	DESCRIPTION	ACRES
13	20 N	9 E	ALL FRL.	630.00
14	20 N	9 E	ALL FRL.	630.80
15	20 N	9 E	S1/2	320.00
16	20 N	9 E	FRL. NE1/4, FRL. S1/2	460.61
17	20 N	9 E	NE1/4	160.00
18	20 N	9 E	NW1/4	160.00
[illegible]	20 N	9 E	N1/2	320.00
13	20 N	9 E	SW1/4	160.00
15	20 N	9 E	NW1/4, FRL. S1/2,	449.84
17	20 N	9 E	ALL FRL.	608.64
19	20 N	9 E	FRL. NW1/4, FRL. N1/2SW1/4, E1/2,	547.21
21	20 N	9 E	ALL	640.00
23	20 N	9 E	ALL	640.00
25	21 N	9 E	ALL	640.00
27	2? N	9 E	NE1/4, NE1/4NW1/4	200.00
29	20 N	9 E	NW1/4, N1/2SW1/4, W1/2NE1/4, NE1/4NE1/4	360.00
35	21 N	9 E	NE1/4, NE1/4NW1/4	200.00
12	21 N	9 E	LOTS 2,6,7,8,9,12, S1/2SW1/4, SW1/4SE1/4	274.14
15	21 N	9 E	SW1/4	160.00
16	21 N	9 E	LOTS 3,5,6,9, SW1/4NW1/4, SW1/4, W1/2SE1/4, SE1/4SE1/4	425.99
17	21 N	9 E	W1/2	320.00
18	21 N	9 E	FRL. W1/2, SE1/4	477.60
19	21 N	9 E	ALL FRL	6[illegible].72

8907070390

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
20	21 N	9 E	ALL	640.00
21	21 N	9 E	ALL	640.00
22	21 N	9 E	LOTS 2,3,4,7,8, W1/2NW1/4, SW1/4, S1/2SE1/4	471.27
23	21 N	9 E	S1/2S1/2, NW1/4SW1/4, NE1/4SE1/4	240.00
25	21 N	9 E	LOTS 1,4,6,7, NE1/4NE1/4, S1/2NE1/4, S1/2	547.40
26	21 N	9 E	ALL	640.00
27	21 N	9 E	ALL	640.00
28	21 N	9 E	ALL	640.00
29	21 N	9 E	ALL	640.00
30	21 N	9 E	LOTS 1,2,3,4, E1/2NW1/4, NE1/4, NE1/4SW1/4, NW1/4SE1/4, E1/2SE1/4	558.08
31	21 N	9 E	ALL FRL.	639.76
32	21 N	9 E	N1/2N1/2, SE1/4NE1/4, SW1/4SW1/4	240.00
33	21 N	9 E	E1/2	320.00
34	21 N	9 E	ALL	640.00
35	21 N	9 E	N1/2NW1/4	80.00
36	21 N	9 E	ALL	640.00
01	19 N	10 E	ALL FRL.	610.48
03	19 N	10 E	ALL FRL.	626.45
05	19 N	10 E	ALL FRL.	637.89
09	19 N	10 E	N1/2, NW1/4SW1/4	360.00
11	19 N	10 E	N1/2, N1/2S1/2,	480.00
01	21 N	10 E	FRL. NW1/4, S1/2	472.55
07	20 N	10 E	FRL. N1/2, FRL. SE1/4	461.17

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE IT IS DUE TO THE QUALITY OF THE DOCUMENT.

M930003/-2

9301152402

930115-2402 04:12:00 PM KING COUNTY RECORDS 016 JD 22.00

E1289838 01/15/1993 22.00 .00

After recording, return to:
TRANSAMERICA TITLE INSURANCE COMPANY
1200 Sixth Avenue
Seattle, WA 98101
Attn: Carol Garner
File Number: 510-2.89-1500

CORRECTION DEED

PCTC, INC., a Delaware corporation (formerly known as Plum Creek Timber Company, Inc. and BN Timberlands, Inc.) ("Grantor") whose address is 999 Third Avenue, Suite 4500, Seattle, Washington 98104, did grant, bargain sell and convey to PLUM CREEK TIMBER COMPANY, L.P., a Delaware limited partnership ("Grantee"), whose address is 999 Third Avenue, Suite 2300, Seattle, Washington 98104, Grantor's right, title and interest in and to certain real property as described in that Deed to Plum Creek Timber Company, L. P. executed on June 21, 1989, effective as of June 8, 1989, recorded in King County, Washington on July 7, 1989 under No. ~~9887070390;~~ 8907070390 and

WHEREAS, such deed contains the following paragraph (the "Subject Paragraph"):

> THIS DEED AND THE RESERVATIONS HEREUNDER ARE MADE SUBJECT TO THE TIMBERLANDS CONVEYANCE AND ASSUMPTION AGREEMENT BY AND BETWEEN GRANTOR AND GRANTEE OF EVEN DATE HEREWITH. SUCH AGREEMENT CONTAINS PROVISIONS WHICH, AMONG OTHERS, PERMIT THE GRANTEE TO ACQUIRE WITHIN THE TEN YEARS FROM THE DATE HEREOF CERTAIN RESERVED MINERALS AND CERTAIN SURFACE RIGHTS WITH RESPECT TO SUBJECT OIL AND GAS.

WHEREAS, with respect to the property located in King County, Washington, described on Exhibit "A" attached hereto and incorporated herein by this reference as though fully set forth, the parties did not and do not intend that the Deed and Reservations thereunder be subject to or conditioned upon said Timberlands Conveyance and Assumption Agreement;

NOW, THEREFORE, this Correction Deed is granted to delete the Subject Paragraph from the Deed to Plum Creek Timber Company, L.P., as it relates to the real property located in King County, Washington, as described on Exhibit "A" attached hereto.

Except as amended by this Correction Deed, said Deed to Plum Creek Timber Company, L.P. is hereby confirmed and remains in full force and effect.

FILED FOR RECORD AT REQUEST OF
TRANSAMERICA TITLE INSURANCE CO.
320 108TH AVE. NE
P.O. BOX 1493
BELLEVUE, WA 98009

IN WITNESS WHEREOF, Grantor and Grantee have caused their corporate names to be subscribed and their corporate seals to be affixed, by their proper officers, on this 21st day of December, 1992.

ATTEST:

By [illegible]
Title: Ass't Secretary

PCTC, INC.

By [illegible]
Title: VP Taxes

Attest:

Susanna N. Duke
Susanna N. Duke, Director
Law and Secretary

PLUM CREEK TIMBER COMPANY, L.P.
By Plum Creek Management Company
General Partner

David D. Leland
David D. Leland, President and
Chief Executive Officer

9301152402

ACKNOWLEDGMENT

STATE OF WASHINGTON)
) ss
COUNTY OF KING)

On this 23rd day of December, 1992, before me personally appeared [illegible] and L. David Danover, to me known to be the VP Taxes and Ass't Secretary, respectively, of PCTC, Inc., the corporation that executed the within and foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation for the uses and purposes therein mentioned, and on oath stated that they were authorized to execute said instrument and that the seal affixed is the corporate seal of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

Kathleen L Croll
Notary Public for the
State of Washington
Residing at Seattle, WA
My Commission Expires 4-17-93

ACKNOWLEDGMENT

STATE OF WASHINGTON)
)ss
COUNTY OF KING)

On this 29th KLC day of December, 1992, before me personally appeared David D. Leland and Susanna N. Duke, to me known to be the President and Chief Executive Officer and the Director Law and Secretary, respectively, of Plum Creek Management Company, general partner of Plum Creek Timber Company, L.P., the limited partnership that executed the within and foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said limited partnership for the uses and purposes therein mentioned, and on oath stated that they were authorized to execute said instrument on behalf of the limited partnership and that the seal affixed is the seal of said limited partnership.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

Kathleen L. Croll
Notary Public in and for the
State of Washington
Residing at Seattle, WA
My Commission Expires 4-17-93

KATHLEEN L. CROLL
4-17-93

9301152402

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
25	20 N	6 E	LOTS 3 & 4 IN BLOCK 5 OF O.H. DICKSON CORRECTION PLAT ADDITION TO THE CITY OF ENUMCLAW.	3.16
01	21 N	6 E	LOTS 1 & 2, S1/2NE1/4, SE1/4, S1/2SW1/4, NW1/4SW1/4	445.13
02	21 N	6 E	ALL FRL. LESS 0.70 AC BEING THAT PORTION WITHIN SEC.2, TWP 21N, RGE 6E,OF A PARCEL OF LAND LYING SOUTHERLY OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY AND NORTHERLY OF THE RAVENSDALE-BLACK DIAMOND ROAD LOCATED IN THE SE1/4 OF SEC 35 AND THE SW1/4 OF SEC. 36, TWP. 22N, RGE. 6E, AND THE NE1/4 OF SECTION 2, TWP 21N RGE 6E, W.M., MORE PARTICULARLY DESCRIBED AS FOLLOWS: FROM THE INTERSECTION OF THE CENTER LINES OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY AND THE RAVENSDALE-BLACK DIAMOND ROAD SOUTH 37 DEGREES 00' WEST 96.0 FEET TO THE POINT OF BEGINNING, THENCE SOUTH 28 DEGREES 00' WEST 90 FEET; THENCE SOUTH 50 DEGREES 00' WEST 650 FEET; THENCE SOUTH 45 DEGREES 30' WEST 650 FEET; THENCE SOUTH 45 DEGREES 30' WEST 480 FEET; THENCE SOUTH 40 DEGREES 30' WEST 811 FEET; THENCE SOUTH 55 DEGREES 00' WEST 1592 FEET; THENCE NORTH 24 DEGREES 30' WEST 1135 FEET TO THE SOUTHERLY RIGHT-OF-WAY LINE OF SAID RAILROAD; THENCE NORTH 66 DEGREES 24' EAST 3674.7 FEET, MORE OR LESS, ALONG SAID RIGHT-OF-WAY LINE TO THE POINT OF BEGINNING.	650.30
03	21 N	6 E	LOTS 1,2,3, EAST 21.47 AC. OF LOT 4, S1/2NE1/4, SE1/4	389.24
09	21 N	6 E	W1/2NE1/4, N1/2NW1/4, SE1/4NW1/4, S1/2, PART OF SE1/4NE1/4 LYING WESTERLY OF COUNTY ROAD & N. 30 FT. LYING EAST OF COUNTY ROAD	541.00
11	21 N	6 E	W1/2NW1/4, LESS 2.00 AC. B.N. INC. R/W	78.00
15	21 N	6 E	NW1/4, S1/2, LESS SE1/4SE1/4SE1/4	470.00
21	21 N	6 E	E1/2, NW1/4, NE1/4SW1/4	520.00
23	21 N	6 E	NE1/4 NE1/4 NE1/4, S1/2 N1/2 NE1/4. S1/2 N1/2, N1/2 SE1/4, NE1/4 NW1/4, NE1/4 NW1/4 NW1/4, S1/2 NW1/4 NW1/4. SW1/4 LESS 5.87 ACRES RIGHT-OF-WAY SOLD BY WARRANTY DEED RECORDED 6-14-48, BOOK 2753. P 336 KING COUNTY BOOK OF DEEDS.	478.36
25	21 N	6 E	LOTS 1,3,4,5,10,11, LOT 2, SE1/4NE1/4, SW1/4SW1/4,	351.23

9301152402

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
25	21 N	6 E	NE1/4SE1/4, LESS 9.47 AC. SOLD BY DEED RECORDED 6-14-43 IN BOOK 2753, PAGE 336 ALSO THE S1/2SE1/4. LESS 54.80 ACRES, MORE OR LESS, IN LOTS 2 & 3, & SW1/4SE1/4 SOLD BY DEED DATED 6-16-89 AND RECORDED 6-16-89 UNDER A.F.#8906161334.	
27	21 N	6 E	N1/2NW1/4, SW1/4SW1/4, LESS 1.40 AC. BY AMENDED JUDGMENT OF SUPERIOR COURT 3-6-78; RECORDED UNDER S.C.# 765079	118.60
28	22 N	6 E	S 34 AC OF SE4NE4; PART OF LOT 11 S OF MILWAUKEE R/W, LESS 8.19 AC CITY OF SEATTLE R/W; NE4NW4SW4, N2NW4NW4SW4 LESS 1.97 AC MILWAUKEE R/W; SE4SW4, NE4SE4, S2SE4	227.12
25	22 N	6 E	NW1/4, & THAT PART OF SE1/4SW1/4, SW1/4SE1/4 LYING SOUTHWESTERLY OF THE NORTHEASTERLY BOUNDARY OF THE KENT-KANGLEY ROAD	211.00
26	22 N	6 E	NE1/4, N1/2NW1/4	240.00
33	22 N	6 E	SE1/4SE1/4 LESS 4.66 AC BN R/W	35.34
35	22 N	6 E	ALL; LESS 14.01 ACRES WITHIN BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY, LESS 4.30 ACRES SOLD IN SW1/4 SW1/4 AS CONVEYED BY QUITCLAIM DEED RECORDED 4-7-87, A.F.#8704071619 BOOK OF DEEDS, KING COUNTY; LESS THAT PORTION OF THE W1/2SW1/4 LYING SOUTHERLY OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY - PARCEL 003 DEEDED TO MERIDIAN MINERALS	556.69
36	22 N	6 E	N1/2, SECTION 36, TOWNSHIP 22 NORTH, RANGE 6 EAST, W.M., LESS THE FOLLOWING: 14.25 AC. BURLINGTON NOTHERN RAILROAD R/W, 3.13 AC. CONVEYED BY NORTHWESTERN IMPROVEMENT CO., HEREINAFTER REFERED TO AS N.W.I., TO KING COUNTY SCHOOL DIST. NO.109 BY DEED DATED OCT.26, 1927; RECORDED IN BOOK 1410, P.405; 2.04 AC. CONVEYED BY BURLINGTON NORTHERN RAILROAD CO. TO KING COUNTY FIRE DIST. NO. 43 BY DEED DATED OCT 13, 1981; RECORDED 10-14-81, A.F.#8110140670; 0.11AC CONVEYED NWI TO E. MORGAN BY DEED DATED SEPT. 25, 1946; RECORDED IN BK.2613, P. 270; 0.11 AC CONVEYED TO SEGUNDO TOBACCO BY UNRECORDED DEED DATED SEPT. 25, 1946; 0.22 AC. CONVEYED BY N.W.I. TO JOHN PETER	550.25

9301152402

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
36	22 N	6 E	BOOS BY DEED DATED SEPT. 25, 1946; RECORDED IN BK. 2581, P.293; 0.16 AC. CONVEYED BY N.W.I. TO EDWARD S. GOGOLA BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2581, P.295; 0.16 AC. CONVEYED BY N.W.I. TO ANTON POLESKI, JR. BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2581, P.297; 0.15 AC. CONVEYED BY N.W.I. TO LOUIE VALENTE BY DEED DATED SEPT.25, 1949; RECORDED IN BK.2594, P.514; 0.16 AC. CONVEYED BY N.W.I. TO BERENICE VELEMA GOGOLA BY DEED DATED SEPT. 25 1949 RECORDED IN BK.3341, P.374; 0.15 AC. CONVEYED BY N.W.I. TO WILLIAM SHIMMEL BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.3761, P.477; 0.18 AC. CONVEYED BY N.W.I. TO JOHN MARKUS BY DEED DATED SEPT. 25, 1949; RECORDED IN BK. 2578, P.222; 0.13 AC. CONVEYED BY N.W.I. TO LOUIS & JOSEPH SAFTICH BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2550, P.254; 0.21 AC. CONVEYED BY N.W.I. TO WAINO TOIVONEN BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2585, P.626; 0.69 AC. CONVEYED BY N.W.I. TO WILLIAM & CATERINA LUCIA MARCHETTI BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2565, P.77; 0.10 AC. CONVEYED BY N.W.I. TO BRUNO MILLER BY DEED DATED SEPT. 25, 1949; RECORDED IN BK.2624, P.127; 0.12 AC. CONVEYED BY N.W.I. TO FRANK VISCONIC BY DEED DATED APR. 28, 1947; RECORDED IN BK. 3668, P.134; 0.10 AC. CONVEYED BY N.W.I. TO OTTO MATTSON BY DEED DATED NOV.15, 1947; RECORDED IN BK.3763, P.608; 0.47 AC CONVEYED BY N.W.I. TO A. BUTLER BY DEED DATED JAN. 19, 1948; RECORDED IN BK.2819, P.324; 0.16 AC. CONVEYED BY N.W.I. TO THOMAS & ANNE HOLZER BY DEED DATED FEB. 16, 1948; RECORDED IN BK.3697, P.494; 0.22 AC. CONVEYED BY N.W.I. TO RAYMOND L. & ANNE BISYAK BY DEED DATED FEB. 16, 1948; RECORDED IN BK. 2842, P.349; 0.22 AC. CONVEYED BY N.W.I. TO ELLEANOR DAMBROSKI BY DEED DATED FEB. 3, 1948; RECORDED IN BK. 2929, P. 36; 0.22 AC. CONVEYED BY N.W.I. TO ARVID & SOPHIA HILL BY DEED DATED MAY 24, 1948; RECORDED IN BK.2778, P.621; 0.10 AC CONVEYED BY N.W.I. TO JOSEPH WILSKO BY DEED DATED JULY 9, 1948; RECORDED IN BK.278, P.610; 0.18 AC. CONVEYED BY N.W.I. TO HOHN MATTSON BY DEED DATED MAY 12, 1949; RECORDED IN BK. 2907, P.150; 0.11 AC. CONVEYED BY N.W.I. TO JULIUS SWORD BY DEED DATED JUNE 27, 1949; RECORDED IN BK. 2895, P.525; 0.22 AC. CONVEYED BY N.W.I. TO MYRTLE A. BELLEMAN BY DEED DATED NOV.8, 1949; RECORDED IN BK.2913, P.325; 0.22AC. CONVEYED BY N.W.I. TO R.A. RYDER BY DEED DATED NOV. 8, 1949; RECORDED IN BK.2915, P.156; 0.22 AC. CONVEYED BY N.W.I. TO ANDREW J. LANG BY DEED DATED NOV.30, 1949; RECORDED IN BK. 2914, P.328; 0.22 AC. CONVEYED BY N.W.I. TO HERMAN & GRACE	

9301152402

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
36	22 N	6 E	E. CALLAHAN BY DEED DATED DEC. 29, 1949; RECORDED IN BK.2918 P.175; 0.41 AC. CONVEYED BY N.W.I. TO JOHN & ANNA NOVACK BY DEED DATED JAN. 27,1950; RECORDED IN BK.2928, P.457; 0.22AC. CONVEYED BY N.W.I. TO FRANK & SOPHIE KELLY BY DEED DATED APR.19, 1951; RECORDED IN BK.3049, P.439; 0.19 AC. CONVEYED BY N.W.I. TO RAY & MARGARET THOMPSON BY DEED DATED MAY 21, 1951; RECORDED IN BK. 3153, P.601; 0.16 AC. CONVEYED BY N.W.I. TO CASCADE RIFLE & PISTOL CLUB, INC. BY DEED DATED SEPT. 10, 1951; RECORDED IN BK.3093, P.616; 0.22 AC. CONVEYED BY N.W.I. TO RAY & EVELYN TWEDT BY DEED DATED DEC. 16, 1952; RECORDED IN BK. 3217, P.603; 0.19 AC. CONVEYED BY NORTHERN PACIFIC RAILWAY CO., HEREINAFTER REFERRED TO AS N.P.RY.CO., TO FRANK VISCONIC BY CORRECTION DEED DATED OCT. 19, 1959; RECORDED IN BK.3965, P.501; 0.10 AC. CONVEYED BY N.P.RY.CO. TO TONY BARRAGASE BY DEED DATED SEPT. 28, 1959; RECORDED IN BK.3970, P.154; 0.38 AC. CONVEYED BY N.P.RY.CO. TO EVOR & MARGARET MORGON BY DEED DATED JULY 15, 1960; RECORDED IN BK.4069, P. 82; 0.21 AC. CONVEYED BY N.P.RY.CO. TO FRANK E VISCONIC BY DEED DATED AUG. 1, 1963; RECORDED IN BK.4456, P.336; 0.25 AC. CONVEYED BY N.P.RY.CO. TO FRANK E. VISCONIC BY DEED DATED JUNE 20, 1967; RECORDED IN BK.496, P.513; S1/2 LESS 4.00 AC. BURLINGTON NOTHERN RAILROAD R/W. LESS 45.80 AC. BEING THAT PORTION WITHIN SEC. 36, TWP22N, RGE6E, OF A PARCEL OF LAND LYING SOUTHERLY OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY AND NORTHERLY OF THE RAVENSDALE-BLACK DIAMOND ROAD LOCATED IN THE SE1/4 OF SEC.35 AND THE SW1/4 OF SEC.36, TWP22N, RGE6E, AND THE NE1/4 OF SEC.2, TWP21N, RGE6E, W.M., MORE PARTICULARLY DESCRIBED AS FOLLOWS: FROM THE INTERSECTION OF THE CENTER LINES OF THE BURLINGTON NOTHERN RAILROAD RIGHT-OF-WAY AND THE RAVENSDALE-BLACK DIAMOND RD. SOUTH 37 DEGREES 00' WEST 96.0 FEET TO THE POINT OF BEGINNING, THENCE SOUTH 28 DEGREES 00' WEST 90 FEET THENCE SOUTH 50 DEGREES 00' WEST 850 FEET; THENCE SOUTH 45 DEGREES 30' WEST 650 FEET; THENCE SOUTH 45 DEGREES 30' WEST 490 FEET; THENCE SOUTH 40 DEGREES 30' WEST 811 FEET; THENCE SOUTH 55 DEGREES 00' WEST 1592 FEET; THENCE NORTH 20 DEGREES 30' WEST 1135 FEET TO THE SOUTHERLY RIGHT-OF-WAY LINE OF SAID RAILROAD; THENCE NORTH 66 DEGREES 24' EAST 3674.7 FEET, MORE OR LESS, ALONG SAID RIGHT-OF-WAY LINE TO THE POINT OF BEGINNING.	
29	23 N	6 E	E1/2E1/2, SW1/4NE1/4, NW1/4SE1/4	240.00
33	23 N	6 E	NE1/4, SE1/4NW1/4 LESS THAT PORTION OF THE S1/2NE1/4 AND	138.10

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
33	23 N	6 E	SE1/4NW1/4 LYING EASTERLY OF THE BONNEVILLE POWER ADMINISTRATION POWERLINE RIGHT-OF-WAY, SOUTHERLY OF SE LAKE DESIRE RD AND WESTERLY OF LAKE DESIRE ROAD SE.	
01	21 N	7 E	ALL FRL.	716.32
03	21 N	7 E	FRACTIONAL W1/2, LESS 19.88 ACRES CONVEYED TO THE U.S.A. BY FEDERAL DIST. COURT UNDER CAUSE NO. 4355 DATED MAR. 28, 1957	338.92
05	21 N	7 E	ALL FRACTIONAL, LESS 22.11 ACRES WITHIN THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY, LESS 25.88 ACRES OF RAVER SUB-STATION LANDS SOLD AND CONVEYED BY WARRANTY DEED FEE AND EASEMENT RECORDED 12-13-65, BOOK 4730, P 193, BOOK OF DEEDS KING COUNTY AND LESS THE HIGHWAY RIGHT-OF-WAY.	667.52
07	21 N	7 E	E1/2NE1/4, E1/2W1/2NE1/4	120.00
09	21 N	7 E	ALL, LESS 16.19 ACRES IN THE BURLINGTON NORTHERN RIGHT-OF-WAY, LESS A 5.29 AC. U.S. DIST.COURT CAUSE # 4355 DATED 3-28-57. AND LESS 1.23 AC. TRACT SOLD BY DEED RECORDED 5-8-59, IN VOL.3909, PAGE 543, A.F.# 5029684, TO NTHE U.S.A. LESS 93.00 ACRES, MORE OR LESS, IN NE1/4SE1/4, NE1/4, SE1/4NW1/4, AND N1/2SW1/4 SOLD BY DEED DATED 6-16-89 AND RECORDED 6-16-89 UNDER A.F.#8906161584.	524.29
11	21 N	7 E	W1/2, LESS 0.07 AC CONVEYED TO U.S.A. BY DIST. COURT DECREE RECORDED UNDER CAUSE NO. 4355 DATED MAR. 28, 1957 E1/2SE1/4, NW1/4SE1/4, NE1/4SW1/4. AND THAT PORTION OF THE SW1/4SW1/4 LYING NORTHERLY OF THE BURLINGTON NORTHERN RIGHT-OF-WAY AND SOUTHERLY OF CHICAGO, MILWAUKEE AND ST. PAUL RAILROAD RIGHT-OF-WAY. LESS THE S1/2NE1/4NW1/4, THE NW1/4NW1/4, THAT PORTION OF THE S1/2NW1/4 LYING NORTHEASTERLY OF THE CHICAGO MILWAUKEE, ST. PAUL AND PACIFIC RAILROAD RIGHT OF WAY AND NORTHERLY OF SE HUDSON RD. (FORMERLY SE 304TH STREET), THE NE1/4SW1/4, THE NW1/4SE1/4, AND THAT PORTION OF THE E1/2SE1/4 AND S1/2NE1/4 LYING NORTHERLY OF SAID SE HUDSON ROAD AND SOUTHERLY OF SE COURTNEY ROAD.	195.83
12	21 N	7 E	PART OF SW1/4SW1/4	10.00

9301152402

EXHIBIT A

KING COUNTY WA

9301152402

SECTION	TWP	RGE	DESCRIPTION	ACRES
13	21 N	7 E	E1/2NE1/4, LESS 7.95 AC. LOST UNDER DECREE OF COURT DATED OCT. 2, 1964; RECORDED UNDER U.S. DIST. COURT CAUSE # 5643; 2.66 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO THE CITY OF TACOMA BY DEED DATED SEPT. 28, 1974; RECORDED UNDER AUDITORS FILE #741010297; NW1/4NW1/4, S1/2NW1/4, S1/2, LESS THE FOLLOWING: 27.77 AC. LOST UNDER DECREE OF COURT DATED OCT. 2, 1964; RECORDED UNDER U.S. DIST. COURT CAUSE #5643; 3.50 AC. CONVEYED BY BURLINGTON NORTHERN INC. TO THE CITY OF TACOMA BY DEED DATED SEPT. 28, 1974; RECORDED UNDER A.F.# 741010297; 1.30 AC. CONVEYED BY NORTHERN PACIFIC RAILWAY COMPANY, HEREINAFTER REFERRED TO AS N.P.RY.CO., TO GREEN RIVER SHORES INC. BY DEED DATED JULY 17, 1967; RECORDED IN BK.5819, P.318; 1.84 AC. CONVEYED BY N.P.RY.CO. TO THE U.S.A BY DEED DATED AUG. 16, 1963; RECORDED IN BK.4574, P.175; 4.96 AC. CONVEYED BY N.P.RY.CO. TO THE U.S.A.BY DEED DATED MAY 14, 1963; RECORDED UNDER A.F.#5592728; 54.63 AC. CONVEYED TO U.S.A. BY DIST. COURT DECREE UNDER CAUSE # 4355 DATED MAR 28, 1957.	486.94
15	21 N	7 E	PORTION OF N1/2 NE1/4 SOUTH OF BURLINGTON NORTHERN RAILROAD R/W, LESS 18.50 AC. CONVEYED TO U.S.A BY DIST. COURT DECREE RECORDED UNDER CAUSE NO. 4355 DATED MAR.28, 1957; DATED 3-28-57; S1/2NE1/4, N1/2NW1/4, LESS 5.64 AC. BUR. NORTHERN RAILROAD RIGHT-OF-WAY; S1/2 NW1/4 LESS 13.47 ACRES WITHIN THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY; S1/2, LESS 25.46 ACRES WITHIN THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY.	549.18
17	21 N	7 E	E1/2, LESS 52.85 ACRES SOLD AND CONVEYED BY 2 WARRANTY DEEDS (33.87 AC.) RECORDED UNDER A.F.#8308180845 AND (18.98 AC.) RECORDED UNDER A.F.# 8308180846, BOOK OF DEEDS, KING COUNTY.	267.15
21	21 N	7 E	N1/2, N1/2 S1/2, SE1/4 SE1/4, SE1/4 SW1/4, THAT PORTION OF SW1/4 SE1/4 LYING WESTERLY OF THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY; LESS 34.69 ACRES WITHIN THE BURLINGTON NORTHERN RAILROAD RIGHT-OF-WAY, AND 8.96 ACRES WITHIN THE MILWAUKEE RAILROAD RIGHT-OF-WAY AND 0.54 ACRES SOLD AND CONVEYED BY A WARRANTY DEED IN BOOK 2847, P 183, BOOK OF DEEDS, KING COUNTY.	528.28
21	21 N	7 E	RAILROAD R/W IN E1/2SE1/4 AS CONVEYED TO CHICAGO, MILW., ST. PAUL & PACIFIC RR CO. BY DEEDS RECORDED UNDER RECORDING NOS. 672893 & 698251, EXCEPT THAT PART LYING WITHIN KUZACK ROAD.	7.58

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
23	21 N	7 E	ALL	640.00
25	21 N	7 E	ALL	640.00
26	21 N	7 E	E1/2W1/2, SW1/4SW1/4, NW1/4SE1/4, SW1/4NE1/4	280.00
26	21 N	7 E	N1/2NE1/4, SE1/4NE1/4, NE1/4SE1/4, S1/2SE1/4	240.00
27	21 N	7 E	ALL	640.00
28	21 N	7 E	NE1/4NE1/4	40.00
29	21 N	7 E	EAST 990 FT OF LOTS 1 & 4, W1/2, W1/2NE1/4; LESS 5.52 AC BN R/W	455.18
31	21 N	7 E	SE1/4NW1/4	40.00
31	21 N	7 E	LOT 1, NE1/4NW1/4, S1/2NE1/4	161.23
33	21 N	7 E	SE1/4, N1/2SW1/4, NW1/4, LESS 0.63 AC. SOLD BY DEED RECORDED 11-30-83 UNDER AUDITORS FILE NO. 8311301224.	399.37
34	21 N	7 E	THAT PART OF THE NW1/4SW1/4 DESCRIBED AS FOLLOWS; BEGINNING AT A POINT 422 FT. SOUTH OF THE NORTHWEST CORNER OF THE NW1/4SW1/4 THENCE SOUTH 200 FT.; THENCE EAST 100 FT.; THENCE N 12 DEGREES 17'00"E TO A POINT WHICH BEARS DUE EAST FROM THE POINT OF BEGINNING; THENCE DUE WEST TO THE POINT OF BEGINNING.	.57
35	21 N	7 E	ALL	640.00
23	22 N	7 E	SW1/4	160.00
25	22 N	7 E	ALL	640.00
30	22 N	7 E	FRL S1/2	292.38
31	22 N	7 E	ALL FRL, LESS 21.22 AC BN R/W, LESS THAT PART OF THE E 1805.50 FT OF S1/2NE1/4, LYING SOUTH OF BN R/W	562.09

9301152402

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
32	22 N	7 E	50 FT. R/W IN FRONT OF LOT 4 ACROSS SHORE LANDS, BED AND WATER OF FISH LAKE; PART OF NW1/4NW1/4 LYING SOUTH OF KENT-KANGLEY ROAD	6.07
32	22 N	7 E	A 20 FT. WATER PIPELINE R/W ACROSS NW1/4SW1/4 & GOVT. LOT 4	.45
33	22 N	7 E	ALL	640.00
35	22 N	7 E	ALL	646.11
01	23 N	7 E	THAT PART OF SE1/4NE1/4 LYING SOUTHERLY OF INTERSTATE 90, SE1/4.	201.04
31	23 N	7 E	ALL LESS 25.17 AC SOLD BY WARRANTY DEED RECORDED 1-23-41 IN BOOK 4116, P 599, BOOK OF DEEDS, KING COUNTY. LESS 40.00 AC SOLD BEING THAT PORTION OF THE N1/2 LYING EASTERLY OF S.R. 18 (PHS#2), NORTHWESTERLY OF THE WEST BANK OF HOLDER CREEK AND NORTHERLY OF A LINE WHICH IS 2200 FEET SOUTH OF AND PARALLEL TO THE NORTH LINE OF THE NE1/4.	597.61
07	24 N	7 E	NW1/4NW1/4, W1/2NE1/4NW1/4, S1/2NW1/4, SW1/4NE1/4, SW1/4SE1/4, SE1/4SW1/4	260.00
31	24 N	7 E	E1/2 LESS NORTH 150 FT THEREOF	311.62
31	24 N	7 E	THE SOUTH 100 FT. OF THE NORTH 150 FT. OF THE NE1/4	5.38
10	23 N	8 E	N1/2, SE1/4	480.00
11	23 N	8 E	N1/2N1/2	160.00
17	23 N	8 E	ALL	640.00
18	23 N	8 E	NE1/4	160.00
21	23 N	8 E	N1/2	320.00
24	23 N	8 E	N1/2SE1/4, SE1/4SE1/4	120.00
25	23 N	8 E	NW1/4, E1/2NE1/4, W1/2SE1/4	320.00
25	23 N	8 E	N1/2SE1/4, NE1/4SW1/4	120.00
27	23 N	8 E	ALL FRL	640.65
31	23 N	9 E	FRL. N1/2	309.00

9301152402

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
33	20 N	9 E	ALL FRL.	630.00
34	20 N	9 E	ALL FRL.	630.88
35	20 N	9 E	S1/2	320.00
06	21 N	9 E	FRL. NE1/4, FRL. S1/2	450.61
07	21 N	9 E	NE1/4	160.00
08	21 N	9 E	NE1/4	160.00
09	21 N	9 E	N1/2	320.00
13	21 N	9 E	SE1/4	160.00
15	21 N	9 E	NW1/4, FRL. S1/2,	449.84
17	21 N	9 E	ALL FRL.	618.64
19	21 N	9 E	FRL. NW1/4, FRL. N1/2SW1/4, E1/2,	547.21
21	21 N	9 E	ALL	640.00
23	21 N	9 E	ALL	640.00
25	21 N	9 E	ALL	640.00
27	21 N	9 E	NE1/4, SE1/4NW1/4	200.00
29	21 N	9 E	NW1/4, N1/2SW1/4, W1/2NE1/4, NE1/4NE1/4	360.00
35	21 N	9 E	SE1/4, NE1/4NW1/4	200.00
10	21 N	9 E	LOTS 2,6,7,8,9,12, S1/2SW1/4, SW1/4SE1/4	274.14
15	21 N	9 E	SW1/4	160.00
16	21 N	9 E	LOTS 3,5,6,9, SW1/4NW1/4, SW1/4, W1/2SE1/4, SE1/4SE1/4	425.99
17	21 N	9 E	N1/2	320.00
18	21 N	9 E	FRL. W1/2, SE1/4	477.60
19	21 N	9 E	ALL FRL	636.72

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
20	21 N	9 E	ALL	640.00
21	21 N	9 E	ALL	640.00
22	21 N	9 E	LOTS 2,3,4,7,8, W1/2NW1/4, SW1/4, S1/2SE1/4	471.27
23	21 N	9 E	S1/2S1/2, NW1/4SW1/4, NE1/4SE1/4	240.00
24	21 N	9 E	LOTS 1,4,6,7, NE1/4NE1/4, S1/2NE1/4, S1/2	547.40
26	21 N	9 E	ALL	640.00
27	21 N	9 E	ALL	640.00
28	21 N	9 E	ALL	640.00
29	21 N	9 E	ALL	640.00
30	21 N	9 E	LOTS 1,2,3,4, E1/2NW1/4, NE1/4, NE1/4SW1/4, NW1/4SE1/4, E1/2SE1/4	558.88
31	21 N	9 E	ALL FRL.	639.76
32	21 N	9 E	N1/2N1/2, SE1/4NE1/4, SW1/4SW1/4	240.00
33	21 N	9 E	E1/2	320.00
34	21 N	9 E	ALL	640.00
35	21 N	9 E	N1/2NW1/4	80.00
36	21 N	9 E	ALL	640.00
01	19 N	10 E	ALL FRL.	610.48
03	19 N	10 E	ALL FRL.	626.45
05	19 N	10 E	ALL FRL.	637.89
09	19 N	10 E	N1/2, NW1/4SW1/4	360.00
11	19 N	10 E	N1/2, N1/2S1/2,	480.00
01	20 N	10 E	FRL. NW1/4, S1/2	472.55
07	20 N	10 E	FRL. N1/2, FRL. SE1/4	461.17

9301152402

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
09	20 N	10 E	ALL	640.00
11	20 N	10 E	ALL	640.00
13	20 N	10 E	FRL. N1/2, FRL. SW1/4,	468.51
15	20 N	10 E	ALL FRL	596.97
17	20 N	10 E	FRL. N1/2, FRL. SE1/4	438.57
19	20 N	10 E	FRL. W1/2, FRL. SE1/4	448.05
23	20 N	10 E	FRL. S1/2S1/2	176.64
25	20 N	10 E	ALL	640.00
27	20 N	10 E	FRL. S1/2, FRL. NE1/4	540.06
29	20 N	10 E	FRL S1/2, FRL NW1/4	527.35
31	20 N	10 E	ALL FRL.	621.04
33	20 N	10 E	ALL	640.00
35	20 N	10 E	ALL	640.00
09	24 N	10 E	SW1/4	160.00
01	19 N	11 E	ALL FRL.	625.54
03	19 N	11 E	ALL FRL.	621.08
05	19 N	11 E	ALL FRL.	616.73
07	19 N	11 E	ALL FRL.	642.32
09	19 N	11 E	ALL	640.00
11	19 N	11 E	ALL	640.00
15	19 N	11 E	N1/2, SW1/4	480.00
15	19 N	11 E	SE1/4	160.00
17	19 N	11 E	ALL	640.00

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
29	19 N	11 E	NE1/4, NE1/4NW1/4, NE1/4SE1/4	240.00
03	20 N	11 E	THAT PART S1/2 AND SE1/4NE1/4 LYING SOUTHERLY BNRR R/W.	278.09
05	20 N	11 E	ALL FRL.	625.28
09	20 N	11 E	S1/2SW1/4, SE1/4, E1/2NE1/4 AND THOSE PORTIONS OF THE W1/2NE1/4, SE1/4NW1/4, N1/2SW1/4 LYING SOUTHERLY OF THE BNRR R/W.	469.77
11	20 N	11 E	ALL	640.00
15	20 N	11 E	ALL	640.00
17	20 N	11 E	THOSE PORTIONS OF THE NE1/4, N1/2SE1/4, N1/2S1/2SE1/4 LYING EASTERLY OF BNRR R/W	223.65
21	20 N	11 E	W1/2NE1/4, SE1/4NE1/4, W1/2SW1/4, AND THE NE DIAGONAL 1/2 OF THE SW1/4NE1/4 AND THE SW DIAGONAL 1/2 OF THE E1/2SW1/4.	260.00
23	20 N	11 E	ALL	640.00
25	20 N	11 E	ALL	640.00
27	20 N	11 E	E1/2E1/2 AND THE NE DIAGONAL 1/2 OF THE W3/4	480.00
29	20 N	11 E	ALL	640.00
31	20 N	11 E	ALL FRL.	622.24
33	20 N	11 E	ALL	640.00
35	20 N	11 E	ALL	640.00
05	21 N	11 E	E1/2 FRL, E1/2NW1/4 FRL.	395.72
07	21 N	11 E	E1/2 FRL, E1/2NW1/4, SW1/4NW1/4	436.72
17	21 N	11 E	SW1/4	160.00
19	21 N	11 E	NE1/4 FRL, E1/2SE1/4	243.25
21	21 N	11 E	FRL. N1/2, SW1/4	457.92
21	21 N	11 E	SE1/4	160.00

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE	DESCRIPTION	ACRES
23	21 N	11 E	FRL. N1/2, SW1/4, N1/2SE1/4	566.80
23	21 N	11 E	S1/2SE1/4	80.00
25	21 N	11 E	ALL, LESS 22.04 AC. B.N. R/W	617.96
27	21 N	11 E	ALL	640.00
29	21 N	11 E	ALL	640.00
31	21 N	11 E	ALL FRL.	642.69
33	21 N	11 E	N1/2, SW1/4	480.00
35	21 N	11 E	ALL, LESS 92.24 AC. B.N. R/W	547.76
17	22 N	11 E	W1/2, SE1/4, E1/2NE1/4, NW1/4NE1/4, LESS 12.86 AC. RR. R/W 3.35 AC. HWY. R/W. AND LESS 0.03 AC. SOLD BY DEED RECORDED 9-22-58 IN VOL.3829 PAGE 616 UNDER A.F.# 4945781; ALSO 0.28 AC. SOLD BY DEED RECORDED 9-22-58 IN VOL. 3829, PAGE 619 UNDER A.F.# 4945782.	582.13
19	22 N	11 E	ALL FRL.	511.12
03	19 N	12 E	ALL FRL.	747.03
11	19 N	12 E	ALL	640.00
27	21 N	12 E	ALL FRL.	525.12
33	21 N	12 E	W1/2NE1/4, W1/2	400.00
35	21 N	12 E	E1/2NE1/4, SE1/4	240.00

STEWART TITLE COMPANY
OF WASHINGTON, INC.
1201 Third Avenue, Suite 3800
Seattle, Washington 98101
Senior Title Officer, Julie Goodman
Title Officer, Lori Gamman
Assistant Title Officer, LaVonne Bowman
Unit No. 8
FAX Number 206-343-8403
Telephone Number 206-343-1328

Golder Association
4104 148th Avenue Northeast
Redmond, Washington 98052
Attention: Rob Long
Customer Ref.: Palmer Coking Coal

STW Order No.: 264236

PROPERTY HISTORY REPORT

Amount	$312.00
Tax	$ 25.58

Effective Date: February 27, 1995, at 8:00 a.m.

A. Name of Assured:

GOLDER ASSOCIATES

B. The land referred to in this report is situate in the county of King, state of Washington, and described as follows:

The south half of the southeast quarter of the southwest quarter of Section 24, Township 22 North, Range 6 East, W.M., in King County, Washington.

C. Stewart Title Company of Washington, Inc. certifies that an examination of the public records of King County, Washington discloses the following deeds, real estate contracts, leases, and/or memoranda thereof describing the land referred to in this report recorded during the period beginning February 27, 1945 and ending on the effective date above.

The public records are those records established under state statutes for the purpose of imparting constructive notice of matters relating to real property to purchasers of value and without knowledge.

PROPERTY HISTORY DOCUMENT LIST

1. TYPE OF DOCUMENT: Warranty Deed
   DATED: March 28, 1949
   RECORDING NUMBER: 3888531

   FIRST PARTY: Continental Land Company, a Washington corporation

   SECOND PARTY: Charles R. Carey, receiver of the Danville Coal Mining Company

   AFFECTS: Said premises and other property

2. TYPE OF DOCUMENT: Deed
   DATED: March 30, 1949
   RECORDING NUMBER: 3906597

   FIRST PARTY: Charles R. Carey, Receiver of the Danville Coal Mining Company, a corporation

   SECOND PARTY: Palmer Coking Coal Company, a corporation

   AFFECTS: Said premises and other property

3. TYPE OF DOCUMENT: Quit Claim
   DATED: October 21, 1937
   RECORDING NUMBER: 3930647

   FIRST PARTY: Morris Brothers Coal Mining Co., Inc., of the State of Washington

   SECOND PARTY: Palmer Coking Coal Company, a corporation

   AFFECTS: Said premises and other property

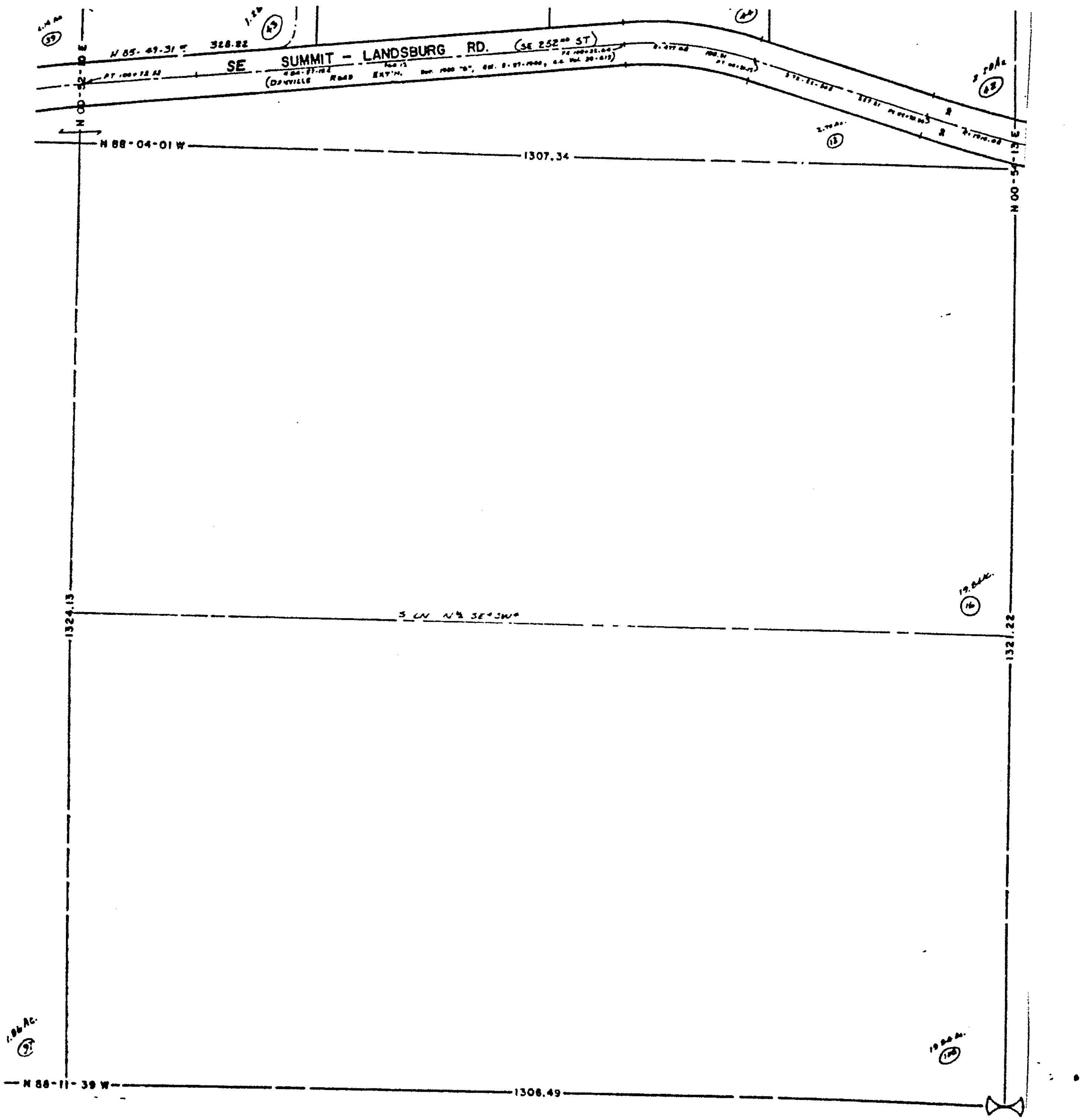
END OF REPORT

Title to this property was examined by:

Anne Knight

Any inquiries should be directed to one of the title officers set forth in Schedule A.

AWK/pja/0720I



STEWART TITLE COMPANY OF WASHINGTON, INC.

"A Tradition of Excellence"

Order No. 264236

IMPORTANT: This is not a Plat of Survey. It is furnished as a convenience to locate the land indicated hereon with reference to streets and other land. No liability is assumed by reason of reliance hereon.

NORTH

↕

SOUTH

D Mar 31-49 3888531 28[illegible] / 135
Mar 28-49 $9500.00 $10.45irx & $9.50stx
Continental Land Company,a Wash corp
to Charles R Carey, Receiver of the Danville Coal Mining Company
The fp does hrby g b s & cnvy to sp the fdre sit kcw ptcly bounded &df:

Gov Lot 12 and the SW¼ of the SE¼ and the S½ of the SW¼ ofsec 24 twp 22 NR 6 EWM,excepting therefrom a tt of land conveyed to the CofS by deed rec in ao of kcw in vol 212 Dp 201, Subject, however, to the flg esmnts:

Esmnt granted to the CofS for a Pipe Line r/w 66 ft in width, over and across sd lot 12;

Esmnt granted to the Seattle Power Company,a corp,for Pipe line r/w 40 ft in width,over and across sd lot 12 and the SW¼ of the SE¼; &

Esmnt granted to the Chicago, Milwaukee & St.Paul Railway Company for the rght to erect and maintain an elec transmission ~~x~~ system along and across sd Lot 12-sd system consisting of 3 cribs and the necessary trolley and transmission wires, anchors and guys, and the right to clear trees from endangering the line, there being three anchors.

Tgw all rights, esmnts, Excepting, however, roads, school-house sites, cemetery sites, rights of way, flumes, ditches and esmnts heretofore granted or existing, and also,excepting taxes, assessments or instlmnts of assessments due or to become due since Oct 22, 1923.

Covs: opp; warr & def;

IWW the sd fp hs caused these presents to be subscrbd by its VPres & its crpslto be hrnto afxd and attested by its Scry

Continental Land Company
By R R Morrison, VPres
(crpsl)
Attest: Barbara C Bateman,Scry

Spokane Co Wash Mar 28-49 by R R Morrison and Barbara C Bateman, VPres& Scry rsptvly of sd corp (cf)bef Gladys Myers, now Gladys Troup npfor Wn resat Spokane(ns Apr 26-50) Mlto Alley,Carey & Wm.Roney 719 2nd AvBldg City4

Cont Mar 31-49 3888532 2830 / 140
Feb 10-49
~~Gxx~~ Gordon Rowe and Irene E Rowe,h&w
to Chris Jacobsen and Margaret A Jacobsen
The fps will sell & sps will buy,the fdre sit kcw:

Lot 8 in blk ~~xx~~ 1 of Whitham's Second Highland Add as per plat rec in vol 43 of plats on pg 21 recs of King Co; sit in kcw

Ffi,except: Restrictions of record.

The pp is $4500 of which $1000 is paid rcpt ack & bal of sdpp shall be paid as fls: $35 or more per mo incdg int atthe rate of 6%pa on the unpd bal First pymt shall become due and pbl on or bef Mar 10-49 Subseq pymts shall become due and pbl on or bef the 10th day of ech and every mo thrftr until the amt of this cont tgw int as abv specified has been paid in full. All pymts shall be credited first to the int then to the princ All pymts shall be made to Gordon Rowe 16707 Aurora Av Seattle,kcw or as he may later direct.

The purchr agrees:-----same as 2956029--a WD-- poss on Feb10-49--

Gordon Rowe
Irene E Rowe
Chris Jacobsen

kcw Feb 9-49 by Gordon Rowe and Irene E Rowe, bef Geo.F.Heinrichs npfor Wnresat S(ns Dec 23-49) Mlto Harold H Chase 1421 Boren Av,City1

Lease Jun 2-49 ED ONLY) 3 96
May 28-49 (used for abst to be examined om record)

123
334

C H P Guyer and Lillian R Guyer, hwf
to John Mathison
The fps hrby lease & demise unto sp the fdre & prem sit in CofS,kcw:

Tht certain store room loc at 7533 Bothell Way Seattle, Wn and more ptcly loc on the fdre:

Lot 10 blk 5 Gardner J Cwinus Add to the CofS,acdg to plat thof rec in vol 26 of plats pg 42, recs of sd county.

For term of 5 yrs from Jun 15-49 at the molyg minimum rent or sum of $100 pbl in advance on 15th day of ech & every mo during sd term, tgw sum of 8% on all gross rcpts,of the business hin to beoperated, in excess of $1000 per mo,pbl on 15th day of ech & every mo covering the sd gross rcpts for the previous calendar month.

The fp hrby acks rcpt of sum of $500 representing the last 5 months rent in advance, during term of this lease.

It is hrby agreed tht sp agrees not to let or underlet the whole or any part of sd prem nor assign this lease, or any int thin,without written consent of sd fp;
(signed & ackd by all parties) Mlto Anderson & Reseberg 420 Joshua Green Bldg,City1

3906597

2847
82

DJun2-49
Mar 30-49 $10.& ogvc $5.50tx & $5.stx
Charles R Carey,Receiver of the Danville Coal Mining Company,a corp
to Palmer Coking Coal Company, a corp
Whas, pursuant to order of Court signed Mar 25-49 and fld and entrd Mar 30-49 in those proceedings entitld "In the Superior Court of the State of Washington in and for King County, Sam L Levinson, Plntf, vs. Danville Coal Company,a corp, Dfndt, No.229184," sd Court did order and direct the fp hin as such receiver to convey all his right,title and int in and to the ppty hrnftr desbd, to sp

Now,Therefore the fp does hrby g b s & cnvy to sp all his right, title and int in and to the fdre:

Gov Lot 12 and the SW¼ of the SE¼ and the S½ of theSW¼ of sec 24 Twp 22 NR 6 EWM,excepting therefrom a tt of land conveyed tothe CofS by Deed recdd in ao of kcw in vol 212 Dp 201,

Subj, however, to the flg esmnts:

Esmnt granted to the CofS for a pipe line r/w 66 ft in width, over and across sd lot 12;

Esmnt granted to the Seattle Power Company,a corp,for pipe line r/w 40 ft in width over and across sd lot 12 and theSW¼ of the SE¼ ; and,

Esmnt granted to the Chicago,Milwaukee & St.Paul Railway Company for the right to erect and maintain an electric transmission system along and across sd Lot 12 sd system consisting of three cribs and the necessary trolley and transmission wires, anchors and guys, and the right to clear trees from endangering the line, there being three anchors.

The NW¼ of the NW¼ of sec 25 and the NE¼ of NE¼ of sec 26 in twp 22 NR 6 EW Principal M, subj, however, to the rights of V. Garravara under cont dtd May 12-27 to cut and remove the timber from the sd NW¼ of the NW¼ of sec 25 and to occupy and use the surface thof in logging operations. sit in kcw

Charles R Carey, Receiver of the Danville Coal
Mining Company

Aprvd by: Ward Roney,JUDGE

kcw Mar 30-49 by Charles R Carey,Receiver of the Danville Coal Mining Company,a corp,bef Vera B Smith npfor WnresatS(ns Feb 14-53) Mlto Palmer Co King Coal Co Black Diamond, King Co Wn

----

vls

J. E. Wickstrom, an [illegible]married man
to Ragna M. Rin[illegible]d, an unmarried woman
fp mtgs to sp tsp $[illegible]0. accdg to ned the fd re si[illegible] w

233 Q

Lot 3 in blk 25 of D. T. Denny's Home Add to the C of S as per plat
recdd in vol 3 of plats on pg 115 recs of kc sit in the C of S
Ins not less than the unpd bal of this mtg

J. E. ~~We~~Wickstrom

kcw Aug 19 49 by J. E. Wickstrom, an unmarried man bf Clifford Hoof
np for wn res S (ns Oct 9 50)Ml Nat Bk of Com Queen Anne Br S, wn

-----

3930645 Md 2533 / 234

M Aug 22 49
Aug 18 49
Charles N. Perry and Mrs. Stella B. Perry, hwf
to Seattle-First National Bank, Greenwood Branch
fp mtgs to sp the fd re sit kcw

Lot 29 and the W 8 and 1/3 ft of lot 30 blk 3 of Greenwood Park Add
to Seattle. Address known as 610 W 82nd.
tgw all fxtrs and appliance
tsp $1724.70 and int ned
pvds for sch of rec on fcl

Charles N. Perry
Mrs. Stella B. Perry

kcw Aug 18 49 by Charles N. Perry and Mrs. Stella B. Perry bf H. C.
Sanford np for wn res S (ns Oct 22 52)Ml Sea 1st Nat Bk 408 N 35th S, w

---

3930646 2533 / 236

M Aug 22 49
Aug 11 49
Marion L. Lehman and Henry M. Lehman, ~~his~~her husband
tothe West Seattle National Bank of Seattle, a natl bkg assn
fp mtg to sp tsp $1184.63 accdg to ned the fd re sit kcw

Lot 20 in blk 2 of Claremont Add to Seattle, wn accdg to plat throf
recddd in vol 10 of plats pg 68 recs of kc
Ins $1184.63

Marion L. Lehman
Henry M. Lehman

kcw Aug 11 49 by Marion L. Lehman and Henry M. Lehman bf T. C. Ebert
np for wn rs S (ns Jan 13 5[illegible])Ml sp 4203 W Alaska St. S, wn

----

3930647 2868 / 2871

D Aug 22 49
Oct 21 37 $1.00
Morris Bros. Coal Mining Co., Inc., of the State of Wn
to Palmer Coking Coal Company, a corp
fp cys and qcs to sp all int in the fd re sit kcw

SW¼ of SW¼; SE¼ of SW¼; SW¼ of SE¼ and Govt lot 12.
all in sect 24 twp 22 N R 6 E W.M. Except roads and Except the prt of
sd govt lot 12 andSW¼ of SE¼ condemned in kc Sup Crt Cause No. 201476
for r/w for aqueduct as prvded by Ord No. 52768 of the C of S
IWW sd corp has caused thisinstr tobe exctd by its proper ofcrs
andits cp sl to be hrunto affx

Morris Bros. Coal Mining Co., Inc.
Jonas Morris, pres
John H. Morris, secy

cp sl omitted
kcw Oct 21 37 by Jonas Morris and John H. Morris pres and secy of abv
sd corp (cf)bf A. A. Laframboise np for wn res Enumclaw (ns Dec 3 37)M
Ml sp Black Diamond, wn

-----fb

EXHIBIT A

KING COUNTY WA

8907070390

SECTION	TWP	RGE	DESCRIPTION	ACRES
09	20 N	10 E	ALL	640.00
11	20 N	10 E	ALL	640.00
13	20 N	10 E	FRL. N1/2, FRL. SW1/4,	468.53
15	20 N	10 E	ALL FRL	396.97
17	20 N	10 E	FRL. N1/2, FRL. SE1/4	438.57
19	20 N	10 E	FRL. W1/2, FRL. SE1/4	440.05
23	20 N	10 E	FRL. S1/2S1/2	176.64
25	20 N	10 E	ALL	640.00
27	20 N	10 E	FRL. S1/2, FRL. NE1/4	540.06
29	20 N	10 E	FRL S1/2, FRL NW1/4	527.35
31	20 N	10 E	ALL FRL.	621.04
33	20 N	10 E	ALL	640.00
35	20 N	10 E	ALL	640.00
07	24 N	18 E	SW1/4	160.00
01	19 N	11 E	ALL FRL.	625.04
03	19 N	11 E	ALL FRL.	621.00
05	19 N	11 E	ALL FRL.	610.73
07	19 N	11 E	ALL FRL.	642.32
09	19 N	11 E	ALL	640.00
11	19 N	11 E	ALL	640.00
13	19 N	11 E	N1/2, SW1/4	480.00
15	19 N	11 E	SE1/4	160.00
17	19 N	11 E	ALL	640.00

EXHIBIT A

KING COUNTY WA

3907070390

SECTION	TWP	RGE	DESCRIPTION	ACRES
21	19 N	11 E	NE1/4, NE1/4NW1/4, NE1/4SE1/4	240.00
03	20 N	11 E	THAT PART S1/2 AND SE1/4NE1/4 LYING SOUTHERLY BNRR R/W.	279.09
05	20 N	11 E	ALL FRL.	625.23
09	20 N	11 E	S1/2SW1/4, SE1/4, E1/2NE1/4 AND THOSE PORTIONS OF THE W1/2NE1/4, SE1/4NW1/4, N1/2SW1/4 LYING SOUTHERLY OF THE BNRR R/W.	408.77
11	20 N	11 E	ALL	640.00
13	20 N	11 E	ALL	640.00
17	20 N	11 E	THOSE PORTIONS OF THE NE1/4, N1/2SE1/4, N1/2S1/2SE1/4 LYING EASTERLY OF BNRR R/W	223.65
21	20 N	11 E	N1/2NE1/4, SE1/4NE1/4, W1/2SW1/4, AND THE NE DIAGONAL 1/2 OF THE SW1/4NE1/4 AND THE SW DIAGONAL 1/2 OF THE E1/2SW1/4.	260.00
23	20 N	11 E	ALL	640.00
25	20 N	11 E	ALL	640.00
27	20 N	11 E	E1/2E1/2 AND THE NE DIAGONAL 1/2 OF THE W3/4	400.00
29	20 N	11 E	ALL	640.00
31	20 N	11 E	ALL FRL.	622.24
33	20 N	11 E	ALL	640.00
35	20 N	11 E	ALL	640.00
05	21 N	11 E	E1/2 FRL, E1/2NW1/4 FRL.	395.72
07	21 N	11 E	E1/2 FRL, E1/2NW1/4, SW1/4NW1/4	436.72
07	21 N	11 E	SW1/4	160.00
09	21 N	11 E	NE1/4 FRL, E1/2SE1/4	243.25
21	21 N	11 E	FRL. N1/2, SW1/4	499.92
21	21 N	11 E	SE1/4	160.00

EXHIBIT A

KING COUNTY WA

SECTION	TWP	RGE.	DESCRIPTION	ACRES
23	21 N	11 E	FRL. N1/2, SW1/4, N1/2SE1/4	566.80
23	21 N	11 E	S1/2SE1/4	80.00
25	21 N	11 E	ALL, LESS 22.24 AC. B.N. R/W	617.76
27	21 N	11 E	ALL	640.00
29	21 N	11 E	ALL	640.00
31	21 N	11 E	ALL FRL.	642.68
33	21 N	11 E	N1/2, SW1/4	480.00
35	21 N	11 E	ALL, LESS 92.24 AC. B.N. R/W	547.76
17	22 N	11 E	W1/2, SE1/4, E1/2NE1/4, NW1/4NE1/4, LESS 12.86 AC. RR. R/W 3.35 AC. HWY. R/W. AND LESS 0.83 AC. SOLD BY DEED RECORDED 9-22-58 IN VOL.3827 PAGE 616 UNDER A.F.# 4945781; ALSO 0.28 AC. SOLD BY DEED RECORDED 9-22-58 IN VOL. 3829, PAGE 618 UNDER A.F.# 4945782.	582.13
19	22 N	11 E	ALL FRL.	510.12
03	19 N	12 E	ALL FRL.	747.03
11	19 N	12 E	ALL	640.00
27	28 N	12 E	ALL FRL.	525.12
35	22 N	12 E	W1/2NE1/4, S1/2	400.00
35	24 N	12 E	E1/2NE1/4, SE1/4	240.00

8907070390

ED11745

COMMONWEALTH LAND TITLE
425 PIKE STREET
SUITE 600
SEATTLE, WA 98101

8907070390

APPENDIX B

PRIVATE WELL LOGS AND GENERAL HYDROLOGIC DATA

February 1, 1996

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

AVAILABLE WELL LOGS
FOR STUDY AREA
PRIVATE WELLS

B (PW-2)

Johnson Well Drilling 255-7385
SW1/4, SW1/4 Section 24-22-6 (Summit-Landsburg Road)
Date Drilled: August 22-27, 1979

Drill Log

0-2'	Surface
2-28'	Brown Hardpan
28-98'	Brown Hardpacked gravel, seepage
98-118'	Brown Hardpan, rocks
118-140"	Brown Hard packed gravel, seepage
140-158"	Grey hardpan
158-163"	~~Wat~~ Brown water sand and gravel
163"	Grey Sandstone

Specifications:

6" Well
Water stands 152' deep from Surface
Mills Knife cut: 74'; 90'; 110'; 120'

[illegible]

(D) 2216-24M

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. [redacted]

Permit No. ....

Ingram

(1) OWNER: Name [redacted] Address [redacted]

(2) LOCATION OF WELL: County King [redacted] ¼ [redacted] ¼ Sec. [redacted] T. [redacted] N., R. [redacted] W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 160 ft. Depth of completed well 160 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 160 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level 148 ft. below top of well Date 6/15/82
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 4 ft. drawdown after 3 hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Gray hardpan gravel	0	70
Brown hardpan gravel	70	154
Brown water sand & gravel	154	160

Tax Lot 34 (sec 24)

HM?

RECEIVED
JUL 16 1982
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

JUL -6 1982
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

Work started 6/11 1982. Completed 6/15 1982

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc. (Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Brad Johnson (Well Driller)

License No. 0233 Date 6/15, 1982

(USE ADDITIONAL SHEETS IF NECESSARY)

In Hobart Area
Also near Northgate

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

ph. 432-0759 **STATE OF WASHINGTON**

(E)

Application No. 22/6-24 M

Permit No. ....

(1) OWNER: Name William J. Doyle Address 26108 SE 252 ST Ravensdale 9805

(2) LOCATION OF WELL: County King E1/2 W1/2 Gov't 6 NW¼ SW¼ Sec 24 T 22 N., R 6 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 169 ft. Depth of completed well 169 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 169 ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☒ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 152 ft. below top of well Date 6/21/82
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" .... " .... " .... "
" .... " .... " .... "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 12 gal./min. with 6 ft. drawdown after 3 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	1
Brown hardpacked gravel	1	18
Brown hardpan	18	80
Brown loose gravel	80	140
Gray hardpan	140	160
Brown water gravel	160	169

Tax lot 40 (sec 24)
(N of Palmer Coal #1)

RECEIVED
JUN 28 1982
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

#18

Work started 6/15, 1982 Completed 6/21, 1982

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co. Inc. (Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Brad Johnson (Well Driller)

License No. 0233 Date 6/21, 1982

(USE ADDITIONAL SHEETS IF NECESSARY)

In study area [illegible]
[illegible] from N[illegible]

(G)

22/06 1 -

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 075515

Permit No. ....

(1) OWNER: Name Kevin Satre Address 26202 SE 252nd, Ravensdale

(2) LOCATION OF WELL: County King — NW¼ SW¼ Sec 24 T 22 N., R 6 W.M.

Bearing and distance from section or subdivision corner same

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☑ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 138 ft. Depth of completed well 138 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 138 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☑
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☑
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level ...... ft.
Static level 104 ft. below top of well Date 8-13-90
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" 20gpm stem set at 134' 2½ hrs
" " " air jet

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Tan gravel sand	0	15
Tan gravel sand-clay	15	33
Gray gravel sand	33	47
Brown gravel sand clay	47	69
Tan gravel sand clay	69	115
Tan gravel sand	115	120
Brown gravel sand-clay	120	131
Brown water sand-gravel	131	138

#20

RECEIVED
AUG 21 1990
DEPT. OF ECOLOGY

Work started 8-11, 1990 Completed 8-17, 1990

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc.
(Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Red Johnson
(Well Driller)

License No. 0233 Date 8-17, 1990

(USE ADDITIONAL SHEETS IF NECESSARY)

In Study Area
North of Summit-Landsburg

Drilled in 1980 before Start card

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT 24M

STATE OF WASHINGTON

Application No.

Permit No.

(H)

(1) **OWNER:** Name John Morris 17224 SE 263rd Address Kent Wa. 98031

LOCATION OF WELL: County King NW ¼ SW ¼ Sec 24 T 22 N., R 6 W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 38 ft. Depth of completed well 38 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: " Diam. from ft. to ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ 6" Diam. from 0 ft. to 38 ft.

Perforations: Yes ☒ No ☐
Type of perforator used
SIZE of perforations 3/8 in. by 3 in.
40 perforations from 32 ft. to 36 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 12 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 20 ft. below top of well Date 10-25-80
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 20 gal./min. with 5 ft. drawdown after 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Rock and soil	0	5
Boulders	5	28
Sandy clay.	28	29
Gravel water.	29	38

(west of Lauksla)

Tax Lot 57

242206-9057-0

E 98038

#21222?

RECEIVED
MAR 30 1999
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

AUG 1 1999
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

Work started 10-10, 1980 Completed 10-15, 1980

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Muller Drlg. (Person, firm, or corporation) (Type or print)

Address 3770 S 168

[Signed] H. F. Muller (Well Driller)

License No. 0930 Date , 19

(USE ADDITIONAL SHEETS IF NECESSARY)

36316 Summit - Landsburg Rd
Maple Valley

(1)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

?

WATER WELL REPORT

STATE OF WASHINGTON

Application No. 22/06-24

Permit No. Maple Valley, WA

(1) OWNER: Name Paul Drillwich Address 36316 SE Summit Landsburg Rd.

(2) LOCATION OF WELL: County King N1/2 of E1/2 of E1/2 NE ¼ SW ¼ Sec. 24 T. 22 N., R. 6E W.M.

Bearing and distance from section or subdivision corner Except Lot 6 — NE¼ SW¼ Sec 24 T22N R6E

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 44 ft. Depth of completed well 44 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 44 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P.....

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level 30 ft. below top of well Date 8/10/77
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?.....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test.....
Bailer test 20 gal./min. with 4 ft. drawdown after 3 hrs.
Artesian flow..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	3
Brown hardpan gravel	3	16
Gray hardpan	16	23
Brown hardpan gravel	23	38
Brown water gravel	38	44

242206-4075-0

26318 SE Summit
Landsburg Rd

#23

Work started 8/10, 1977 Completed 8/10, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Ehlson Drilling Co, Inc.
(Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] B. Johnson
(Well Driller)

License No. 0233 Date 8/10, 197-

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

[illegible] 22/06-24L

WATER WELL REPORT

J (PW-3)

STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Marvin Laukala Address approx. 26600 SE Summit-Landsburg Rd. Ravensdale

(2) LOCATION OF WELL: County King W 1/2, W 1/2 - NE 1/4 SW 1/4 Sec. 24 T. 22 N., R. 6E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 51 ft. Depth of completed well 51 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 51 ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☒ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 25 ft. below top of well Date 8-12-87
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....

Yield: gal./min.	with ft. drawdown	after hrs.
20	15	2 1/2
		Air Jet

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test .... gal./min. with .... ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	3
Brown hardpan	3	20
Gray hardpan	20	28
Gray clay	28	32
Brown gravel-clay	32	42
Brown sand&gravel-water	42	51
Brown hardpan	51	—

#24-28

RECEIVED
AUG 17 1987
DEPT. OF ECOLOGY

Work started 8-3 1987 Completed 8-12 1987

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc. (Person, firm, or corporation) (Type or print)
Address 19415 108th Ave SE Renton 98055
[Signed] Brad Johnson (Well Driller)
License No. 0233 Date 8-12, 1987

(USE ADDITIONAL SHEETS IF NECESSARY)

Landsburg Estates (K (PW-4)) 22-6-24 L

ile Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

– CI7, Sanders 22/6-24

Application No. G1-23374
Permit No. ....

(1) OWNER: Name (Don Sanders) Don Sanders Address (approx) 267 S.E., Maple Valley, Wa. 98038

OCATION OF WELL: County King E½ no. W 310' – NE ¼ SW ¼ Sec. 24 T. 22 N., R. 6E W.M.

Be...ng and distance from section or subdivision corner Lot 2 – S 240' of N 915' [illegible]

3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

5) DIMENSIONS: Diameter of well 8 inches.
Drilled 167 ft. Depth of completed well 167 ft.

6) CONSTRUCTION DETAILS:

Casing installed: 8" Diam. from 0 ft. to 167 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

7) PUMP: Manufacturer's Name ......
Type: ...... H.P. ......

) WATER LEVELS: Land-surface elevation above mean sea level.... ...... ft.
atic level 127 ft. below top of well Date 4/14/78
tesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

) WELL TESTS: Drawdown is amount water level is lowered below static level
as a pump test made? Yes ☐ No ☒ If yes, by whom? ......
eld: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " "
" " "
covery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test —
iler test 15 gal./min. with 20 ft. drawdown after 4 hrs.
tesian flow ...... g.p.m. Date ......
mperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	2
Gray hardpan boulders	2	27
Brown clay gravel, boulders	27	83
Brown hardpan	83	98
Brown sandy clay	98	116
Brown hardpan	116	124
Brown sandy clay gravel	124	142
Gray hardpan gravel	142	152
Gray gravel (water)	152	167

#19-36

Work started 4/12 1978 Completed 4/14 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc.
(Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Brad Johnson
(Well Driller)

License No. 0233 Date 4/14 1978

(USE ADDITIONAL SHEETS IF NECESSARY)

[illegible]

Original and First Copy with
›partment of Ecology
›cond Copy — Owner's Copy
›ird Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

22/06/24R (L)

Application No. ....

Permit No. ....

(1) OWNER: Name Richard Zoss Address 27515 SE 253rd Ravensdale, Wa.

(2) LOCATION OF WELL: County King — SE ¼ SE ¼ Sec 24 T 22 N., R 6E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 25 ft. Depth of completed well 25 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 25 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite & Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level ...... ft.
Static level 8 ft. below top of well Date 1-18-86
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
Bailer test 11 gal./min. with 6 ft. drawdown after 2 hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Topsoil	0	2
Brn. Cemented Sand & Gravel	2	24
Water Bearing Sand & Gravel	24	25

[illegible]
APR 1 [illegible]
DEPART [illegible]
[illegible]

Work started 1-18-86, 19...... Completed 1-18-86, 19......

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME NW Pump & Drilling Co. (Person, firm, or corporation) (Type or print)

Address 3245 Auburn Way South

[Signed] R. B. DeKemer (Well Driller)

License No. 0097 Date 1-23-86, 19......

(USE ADDITIONAL SHEETS IF NECESSARY)

✓

M (PW-5)

22/06-25 ~~H~~ G

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. 014559

Permit No. ....

(1) **OWNER:** Name Robert Sherrard Address 26004 268th SE Ravensdale

(2) **LOCATION OF WELL:** County King ~~SE~~ ¼ ~~NW~~ ¼ Sec. 25 T. 22 N., R. 6 5 W.M.

Bearing and distance from section or subdivision corner SW NE

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 160 ft. Depth of completed well 160 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from 0 ft. to 20 ft.
Threaded ☐ PC 4" Diam. from -1 ft. to 160 ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☒ No ☐
Type of perforator used Saw
SIZE of perforations 1/8 in. by 3 in.
80 perforations from 130 ft. to 160 ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay / cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) **PUMP:** Manufacturer's Name ......
Type: ...... H.P. ......

(8) **WATER LEVELS:** Land-surface elevation above mean sea level.... ft.
Static level 60 ft. below top of well Date 7-18-89
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ......
Yield: gal./min. with ft. drawdown after hrs.
" 3 gpm "stem set at 140' 2 1/2 hrs
" "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Surface loam	0	7
Brown decayed rock	7	10
Gray sandstone	10	105
Coal	105	125
Decayed coal - water	125	135
Gray sandstone	135	160

Tax lot 0025

AUG 1 4 1989
ECOLOGY
REGION

A38

Work started 7-15 1989 Completed 7-18 1989

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc. (Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Bud Johnson (Well Driller)

License No. 0233 Date 7-18 1989

(USE ADDITIONAL SHEETS IF NECESSARY)

O (PW-6) 22/06-25B

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

Lindell

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....

Permit No. ....

(1) **OWNER:** Name Clifton M Smith Address 25714 268th Ave SE Ravensdale 98051

(2) **LOCATION OF WELL:** County King N 1/2, SW 1/4 – NW¼ NE¼ Sec 25 T. 22 N., R. 6E W.M.

B[illegible]g and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 4 inches.
Drilled 400 ft. Depth of completed well 400 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 8" Diam. from 0 ft. to 165 ft.
Threaded ☐ 6" Diam. from 0 ft. to 280 ft.
Welded ☒ 4" Diam. from 0 ft. to 400 ft.

Perforations: Yes ☒ No ☐
Type of perforator used Torch
SIZE of perforations 1/5 in. by 3 in.
32 perforations from 300 ft. to 400 ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) **PUMP:** Manufacturer's Name ....
Type: .... H.P. ....

(8) **WATER LEVELS:** Land-surface elevation above mean sea level.... .... ft.
Static level 235 ft. below top of well Date 10/15/79
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 1 1/2 gal./min. with 120 ft. drawdown after 3 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	3
Brown hardpan	3	18
Gray hardpan	18	45
Gray clay & gravel	45	70
Gray clay	70	110
Gray silt	110	150
Gray hardpan	150	163
Brown hardrock	163	170
Gray clay	170	206
Gray hardpan	206	245
Gray gravel-clay	245	273
Gray decayed rock	273	310
Gray medium rock-seepage	310	400

Tax Lot 0010

#40

Work started 10/3, 1979 Completed 10/15, 1979

NOV 13 1979
DEPT OF ECOLOGY

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc.
(Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Brad Johnson
(Well Driller)

License No. 0233 Date 10/15, 1979

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

✓ * [illegible] Sent request to be [illegible] R(PW-7) 22/6-25 P

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. 028179
Permit No. ....

(1) OWNER: Name Richard Melewski Address PO Box 123 Hobart

(2) LOCATION OF WELL: County King — NE¼ NE¼ Sec. 25 T. 22 N., R. 6 W.M.

Bearing and distance from section or subdivision corner 2724X 256th SE, Nr Ravensdale

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 420 ft. Depth of completed well 300 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 62 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☒ No ☐
Type of perforator used Holte
SIZE of perforations 1/8 in. by 2 in.
100 perforations from 22 ft. to 40 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☒ No ☐ Size of gravel: pea
Gravel placed from 300 ft. to 310 ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal pudding clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	6
Gray clay gravel	6	14
Gray sand-clay	14	18
Gray hardpacked gravel-clay	18	36
Gray hardpan	36	55
Gray sandstone-medium	55	205
Coal	205	208
Gray sandstone	208	227
Coal	227	230
Gray sandstone	230	270
Gray sandstone-coal	270	310
Gray decayed soft rock	310	320
Gray sandstone-coal	320	420
Well capped for further development		
#44		

RECEIVED
JUL 03 1990
DEPT OF ECOLOGY

Work started 6-15, 19 90 Completed 6-21 19 90

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co. Inc
(Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] B Johnson
(Well Driller)

License No. 0233 Date 6-21, 19 90

(USE ADDITIONAL SHEETS IF NECESSARY)

Bythral

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

(See Health Dept. Notes)

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 015287

(T)

Water Right Permit No. ____

(1) OWNER: Name Gary Habenicht Address 27405 SE 256 Ravensdale wa

(2) LOCATION OF WELL: County King NE ¼ NE ¼ Sec 25 T 22 N., R 6E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Same as above 27429 SE 250th

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 200 feet. Depth of completed well 200 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from 0 ft. to 32 ft.
Welded ☐ Liner installed ☒ Threaded ☐ 4½ PVC " Diam. from 0 ft. to 200 ft.
" Diam. from ____ ft. to ____ ft.

Perforations: Yes ☒ No ☐
Type of perforator used Saw
SIZE of perforations 1/16 ~~x 3~~ in. by 3 in.
perforations from 100 ft. to 200 ft.
perforations from ____ ft. to ____ ft.
perforations from ____ ft. to ____ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 50 ft. below top of well Date 11/14/89
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.))

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test 3/4 gal./min. with 135 ft. drawdown after 2 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water 50° Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown till	0	15
Gray till Rocks	15	29
Light Gray sandstone	29	200

#48

RECEIVED
NOV 29 1989
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

Work started 11/2, 1989 Completed 11/14, 1989

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME MORRIS DRILLING CO. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 7215-122 Ave. S.E, Renton, Wa. 98056

(Signed) Thomas J Morris (WELL DRILLER) License No. 0327

Contractor's Registration No. MORRIDC181PS Date 11/14, 1989

(USE ADDITIONAL SHEETS IF NECESSARY)

V(PW-8) 22/06-24 A
mislabeled - B 25A

Original and First Copy with
partment of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....

Permit No. ....

(1) OWNER: Name Gary Habenicht Address 27405 SE 256 - Ravensdale

LOCATION OF WELL: County King — ~~NE~~ ¼ ~~NE~~ ¼ Sec. 24 T. 22 N., R. 6 W.M.

Bearing and distance from section or subdivision corner Big Blue house SE¼ SE¼

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 160 ft. Depth of completed well 156 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from -0- ft. to 33 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☒ No ☐
Type of perforator used Drill
SIZE of perforations 1/8 in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from 72 ft. to 79 ft.
..... perforations from 155 ft. to 100 ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal ....
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ..... Depth of strata .....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 660 ft.
Static level 35 ft. below top of well Date 1-19-88
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" ..... " ..... " ..... "
" ..... " ..... " ..... "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 3/4 gal./min. with 120 ft. drawdown after 4 hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Compact Till Brown	-0-	13'
Decomposed Sandstone	13'	32'
grey Sandstone	32	75
white "	75	120
grey "	120	160
fracture at 75'		
" " 120'		
Bailed 300 gallons		
before reaching 3/4 gpm		

#49

RECEIVED
JAN 21 1988
DEPARTMENT OF ECOLOGY

Work started Jan, 19 88. Completed Jan 19, 19 88

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Evergreen Drilling
(Person, firm, or corporation) (Type or print)

Address 25627 SE 192 Maple Valley

[Signed] Roland [illegible]
(Well Driller)

License No. 0139 Date 1-20, 19 88

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

?

WATER WELL REPORT

STATE OF WASHINGTON

(X)

22/07/30C
Application No.

Permit No.

(1) OWNER: Name Leslie L Trueblood Address 28202 SE 258th, Ravensdale

) LOCATION OF WELL: County King — NE ¼ NW ¼ Sec. 30 T. 22 N., R. 7 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 176 ft. Depth of completed well 176 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 176 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 150 ft. below top of well Date 5-2-86
Artesian pressure lbs. per square inch Date
Artesian water is controlled by
(Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?

Yield:	gal./min. with	ft. drawdown after	hrs.
" 17	" 11	" 2½	"
"	"	" AIR JET	"

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface loam	0	6
Brown hardpan-gravel	6	28
Gray hardpacked gravel	28	163
Brown water sand & gravel	163	175
Brown hardpacked-gravel	175	176

51852

RECEIVED
MAY 1
DEPARTMENT

Work started 4-30 1986 Completed 5-2 1986

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co, Inc
(Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Brad Johnson
(Well Driller)

License No. 0233 Date 4-2 1986

(USE ADDITIONAL SHEETS IF NECESSARY)

22/07-30C

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. CC
Permit No. ....

(1) OWNER: Name James A. Polley Address 8520-45th St. W. Tacoma, Wa. 98466

(2) LOCATION OF WELL: County King — NE ¼ NW ¼ Sec. 30 T. 22 N., R. 7E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 1
XXXXXXXXXX Method: Dug ☐ Bored ☐
Deepened ☒ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 175 ft. Depth of completed well 303 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from x0x ft. to 128 ft.
PVC Threaded ☐ 4" Diam. from 23 ft. to 303 ft.
Welded ☐ " Diam. from ft. to ft.

Perforations: Yes ☒ No ☐
Type of perforator used Torch cut
SIZE of perforations ½ in. by 4 in.
4 per ft perforations from 243 ft. to 283 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? ft.
Material used in seal Already in
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 97 ft. below top of well Date 10-3-84
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 180 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date 10-3-84
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sandstone layers of coal & seams of grey clay with some peat, last 7' was coal	128	303

house
in summer
not enough for
all uses

JAN 11 1985

submersible in well
pressure tank
faucet at barn
from shallow tank
faucet

Work started 10-3, 19 84 Completed 10-3, 19 84

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Richardson Well Drilling Co.
(Person, firm, or corporation) (Type or print)

Address P.O. Box 44427 Tacoma, Wa. 98444

[Signed] (Well Driller)

License No. 0419 Date 11-12, 19 84

(USE ADDITIONAL SHEETS IF NECESSARY)

*In study Area
Well tested 3/1/90

File Original and First Copy with Department of Ecology 723-7748
Second Copy — Owner's Copy
Third Copy — Driller's Copy 631-7740

WATER WELL REPORT
STATE OF WASHINGTON

#60
Tested 3/1/90

Application No. 22/06-25H
Permit No. ....

DD

(1) **OWNER:** Name Jack Heckenlively Address 30217 188th S.E., Kent, WA 98031

(2) **LOCATION OF WELL:** County KING — SE ¼ NE ¼ Sec. 25 T. 22 N., R. 6 E W.M.
Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 320 ft. Depth of completed well 320 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from 0 ft. to 284'6" ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal bentonite & cement
Did any strata contain unusable water? Yes ☐ No ☐
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) **PUMP:** Manufacturer's Name.....
Type: ..... H.P. .....

(8) **WATER LEVELS:** Land-surface elevation above mean sea level.... ft.
Static level 35 ft. below top of well Date 3/26/81
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?.....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test.....
Bailer test 35 gal./min. with 102 ft. drawdown after 1 hrs.
Artesian flow..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
topsoil, brown, dry	0	3
glacial till, brown, moist	3	11
sandstone, grey, dry, moist in spots	11	64
coal, blue, dry, ½ GPM 60'	64	69
sandstone, grey, dry, moist in spots	69	190
granite, blue, dry	190	220
sandstone, grey, dry	220	245
granite, blue dry, small amount	245	268
water	~~268~~xx	xx~~320~~
shale, blue, dry, 45 GPM 300'	268	320

Tax lot 0124
(Lot 26)

#60

Work started 3/12/81 19..... Completed 3/26/81 19.....

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME NORTHWEST PUMP & DRILLING CO. (Person, firm, or corporation) (Type or print)

Address 3245 Auburn Way South, Auburn, WA

[Signed] R. B. DeClemente (Well Driller)

License No. 0097 Date 3/30/81, 19.....

(USE ADDITIONAL SHEETS IF NECESSARY)

Close to Study Area, N. of Georgetown

22/06-25G

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

Preedy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

EE

(1) **OWNER:** Name Melvin Preedy (approx) Address SE 268th Ravensdale, Wa

(2) **LOCATION OF WELL:** County King NW ¼ SE ¼ Sec. 25 T. 22 N., R. 6 W.M.
ng and distance from section or subdivision corner see attached

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 23 ft. Depth of completed well 23 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6 " Diam. from 0 ft. to 23 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ....

(7) **PUMP:** Manufacturer's Name ....
Type: .... H.P. ......

(8) **WATER LEVELS:** Land-surface elevation above mean sea level .... ft.
Static level 11 ft. below top of well Date 9/7/79
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by .... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....

Yield: gal./min.	with ft. drawdown	after hrs.
"	"	"
"	"	"

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
Bailer test 15 gal./min. with 3 ft. drawdown after 3 1/2 hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	3
Brown clay	3	11
Brown hardpan	11	18
Brown water sand & gravel	18	23
Brown clay sand	23	—

Tax Lot 0045
(Lot 9)

in South 1/2 of SE 1/4 of 1/4 1/4 G

#61 or #62

Work started 9/7, 1979 Completed 9/7, 1979

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co, Inc. (Person, firm, or corporation) (Type or print)
Address 19415 108 [illegible] SE Renton 98055

DEPT. OF ECOLOGY REGIONAL OFFICE REDMOND 98052

[Signed] Bud Johnson (Well Driller)

License No. 0233 Date 9/7, 1979

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

Very Close but above [illegible] (FF)

any [illegible] ^

File Original and First Copy with
Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

62

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 073410
22/06E - 25K

Water Right Permit No. ______

(1) **OWNER:** Name Jeff Preedy Address 13787 NE 65 # 567, Redmond

(2) **LOCATION OF WELL:** County King NW ¼ SE ¼ Sec 25 T. 22 N., R 6 W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) 27025 SE 268th, Ravensdale

(3) **PROPOSED USE:** ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ______

Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Cable ☐ Rotary ☑ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.

Drilled ~~30~~ 26 feet. Depth of completed well 26 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from 0 ft. to 26 ft.

Welded ☒ ______" Diam. from ______ ft. to ______ ft.

Liner installed ☐ ______" Diam. from ______ ft. to ______ ft.

Threaded ☐

Perforations: Yes ☐ No ☑

Type of perforator used ______

SIZE of perforations ______ in. by ______ in.

______ perforations from ______ ft. to ______ ft.

______ perforations from ______ ft. to ______ ft.

______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☑

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel ______

Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal puddling clay

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

(7) **PUMP:** Manufacturer's Name ______

Type: ______ H.P. ______

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ______ ft.

Static level 4 ft. below top of well Date 5-9-90

Artesian pressure ______ lbs. per square inch Date ______

Artesian water is controlled by ______ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☑ If yes, by whom? ______

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.

Airtest 20 gal./min. with stem set at 22 ft. for 2 1/2 hrs.

Artesian flow ______ g.p.m. Date ______

Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☑

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Surface	0	3
Brown sand-gravel	3	10
Brown hardpan	10	15
Brown sand-gravel - seepage	15	18
Brown water sand gravel	18	26
Brown hardpan	26	30

#61 " #62

RECEIVED
MAY 16 1990
DEPT. OF ECOLOGY

Work started 5-9, 19__. Completed 5-9, 1990

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Johnson Drilling Co, Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 19415 108th Ave SE Renton 98055

(Signed) ______ (WELL DRILLER) License No. 0233

Contractor's Registration No. JOHNSDC207GM Date 5-9, 1990

(USE ADDITIONAL SHEETS IF NECESSARY)

In [illegible]

File Original and First Copy with
Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 028177

(GG)

Water Right Permit No. ____

(1) **OWNER:** Name John Johnsen Address 26712 268th SE Ravensdale

(2) **LOCATION OF WELL:** County King NE ¼ SW ¼ Sec 25 T 22 N., R 6 W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) same

(3) **PROPOSED USE:** ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ____

Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.

Drilled 40 feet. Depth of completed well 40 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6 " Diam. from 0 ft. to 40 ft.

Welded ☒ ____ " Diam. from ____ ft. to ____ ft.

Liner installed ☐

Threaded ☐ ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes ☒ No ☐

Type of perforator used Hotte star wheel

SIZE of perforations 1/8 in. by 2 in.

30 perforations from 18 ft. to 20 ft.

____ perforations from ____ ft. to ____ ft.

____ perforations from ____ ft. to ____ ft.

Screens: Yes ☐ No ☒

Manufacturer's Name ____

Type ____ Model No. ____

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ____

Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal puddling clay

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? ____ Depth of strata ____

Method of sealing strata off ____

(7) **PUMP:** Manufacturer's Name ____

Type: ____ H.P. ____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ____ ft.

Static level 6 ft. below top of well Date 2-6-91

Artesian pressure ____ lbs. per square inch Date ____

Artesian water is controlled by ____ (Cap, valve, etc.))

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☒ If yes, by whom? ____

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____

Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.

Airtest 25 gal./min. with stem set at 20 ft. for 1 hrs.

Artesian flow ____ g.p.m. Date ____

Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
surface	0	3
Brown sand gravel	3	7
Brown hardpan	7	14
Brown sand-gravel	14	17
Brown water sand-gravel	17	20
Gray sandstone	20	40

FEB 19 1991

DEPT. OF ECOLOGY

Work started 2-5, 19__ Completed 2-6, 1991

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Johnson Drilling Co., Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 19415 108th Ave SE Renton 980

(Signed) Bill Johnson (WELL DRILLER) License No. 0233

Contractor's Registration No. JOHNSDC2076D Date 2-6, 1991

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

* In study area
*

22/6E/25M

(KK

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 219192

UNIQUE WELL I.D. # ____

Water Right Permit No. 98188

(1) OWNER: Name Gary Gribble Address 7120 S. Grady Way, Tukwila

(2) LOCATION OF WELL: County King NW ¼ SW ¼ Sec. 25 T 22 N., R 6E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) 26204 SE Kent Kangley Rd., Ravensdale

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ____

Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 140 feet. Depth of completed well 140 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 91 ft.
Welded ☐ ____ " Diam. from ____ ft. to ____ ft.
Liner installed ☐ ____ " Diam. from ____ ft. to ____ ft.
Threaded ☐

Perforations: Yes ☒ No ☐
Type of perforator used holte starwheel
SIZE of perforations 1/8 in. by 3 in.
80 perforations from 73 ft. to 83 ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 40 ft. below top of well Date 5-6-93
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.))

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 12 gal./min. with stem set at 90 ft. for 2½ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Surface	0	3
Brown hardpan	3	23
Gray hardpan	23	47
Gray clay	47	73
Brown sandgravel-water	73	83
Gray hardpan	83	91
Gray sandstone	91	140

RECEIVED
MAY 19 1993
DEPT. OF ECOLOGY

#67

Work started 4-29, 19. Completed 5-6, 1993

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Johnson Drilling Co., Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 19415 108th Ave SE Renton 98055
(Signed) Bud Johnson (WELL DRILLER) License No. 0223
Contractor's Registration No. JOHNSDC207GM Date 5-6, 1993

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with the Division of Water Management
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

(LL) PW-4

Application No. 22/06-25 N

Permit No. ....

(1) OWNER: Name WALTER CHAMBERS Address P.O. BOX 178 Ravensdale WN

(2) LOCATION OF WELL: County King NE 1/4 SW 1/4 SW 1/4 Sec 25 T. 22 N., R. 6 W.M.

Bearing and distance from section or subdivision corner 230' EAST and 360' South of N.W. CORNER

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) II

New well ☐ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.

Drilled 59 ft. Depth of completed well 56 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8" Diam. from -0- ft. to 45 ft.

Threaded ☐ ......" Diam. from ...... ft. to ...... ft.

Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒

Type of perforator used ......

SIZE of perforations ...... in. by ...... in.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

Screens: Yes ☒ No ☐

Manufacturer's Name Hydrophilics

Type Plastic Model No. ......

Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Diam. 8" Slot size 020 from 45 ft. to 56 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......

Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.

Material used in seal BentoniTe

Did any strata contain unusable water? Yes ☐ No ☐

Type of water? ...... Depth of strata ......

Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......

Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 680 ft.

Static level 6 ft. below top of well Date 11-20-79

Artesian pressure ...... lbs. per square inch Date ......

Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☒ If yes, by whom? ......

Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......

Bailer test 25 gal./min. with 47 ft. drawdown after 3 hrs.

Artesian flow ...... g.p.m. Date 11-21-79

Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	-0-	3'
grey Till - compact	3	20'
Brown Sandy loam	20	41'
Lenses of SAND	41	56
grey SAND stone	56	59

Well # 1 on WFI

~~Not In Use~~

~~"Capped"~~

~~This is the well that is ~200' to the east of the well by the pump house~~

DEC 03 1979
DEPT. OF ECOLOGY

Well currently in use next to pump house.

Work started Nov, 19 79. Completed Nov 21, 19 79

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

432-9616

NAME Evergreen Drilling (Person, firm, or corporation) (Type or print)

Address 25627 SE 192 Maple Valley

[Signed] Roland Lukey (Well Driller)

License No. 0134 Date Nov 23, 19 79

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 5-69)—5-69.

...py with
...wner's Copy
Driller's Copy

MM (PW-41) 22/06 25N

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G1-20735
Permit No. ....

(1) OWNER: Name WALTER A CHAMBERS Address 22415 212th SE MAPLE VALLEY, WA.

(2) LOCATION OF WELL: County KING SW ¼ SW ¼ Sec 25 T 22 N., R 6 E W.M.
...ng and distance from section or subdivision corner 790' EAST & 1290' NORTH FROM SW CORNER OF SEC 25

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 2
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 54 ft. Depth of completed well 47 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8 " Diam. from -0- ft. to 43 ft.
Threaded ☐ ______ " Diam. from ______ ft. to ______ ft.
Welded ☒ ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Telescoping Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. 8 Slot size 020 from 43 ft. to 47 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ______ ft.
Static level 10 ft. below top of well Date 9-12-73
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Driller
Yield: 35 gal./min. with 33 ft. drawdown after 24 hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
1:00	43	1:04	15'	1:07	11'
1:02	30'	1:05	13	1:08	10'
1:03	20'	1:06	12		

Date of test 9-12-73
...r test 20 gal./min. with 18 ft. drawdown after 4 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
TOPSOIL & LOOSE gravel and rocks.	0	5'
glacial Till - compact Impervious material	5	26'
Bailed 7 gpm	(26'	6" thick
Till - compact - hard - impervious - grey	26'	43
coarse SAND & gravel water bearing	43	47
coarse SAND gravel very Tight formation less water	47	50
SANDSTONE	50	54

No longer used

#3 drilled ~100' to the ~~North~~ south of the barn

12232-7

was ~~[illegible]~~ used for the trailer by the barn

Work started 9-4, 1973. Completed 9-12, 197

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report i true to the best of my knowledge and belief.

NAME EVERGREEN DRilling (Person, firm, or corporation) (Type or print)
Address 15407 - 42 Ave So Seattle
[Signed] Roland Fueling (Well Driller)
License No. 223-02-3719 Date 9-15, 197

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

In study area

WATER WELL REPORT

(QQ) 22/06-25M

Application No.

Ron Davis , STATE OF WASHINGTON

Permit No. 2 ~~Ravensdale~~ Wa. Ravensdale

(1) OWNER: Name Ron Davis Address [illegible] 26025 Kent Kangley [illegible]

(2) LOCATION OF WELL: County King W1/2 ~~[illegible]~~ ¼ Sec. 25 T. 22 N., R. 6E W.M.

Bearing and distance from section or subdivision corner W1/2 of SW1/4 of NW1/4 of SW1/4

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.

Drilled 40 ft. Depth of completed well 40 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 40 ft.

Threaded ☐ ......" Diam. from ...... ft. to ...... ft.

Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒

Type of perforator used

SIZE of perforations ...... in. by ...... in.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒

Manufacturer's Name

Type ...... Model No.

Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:

Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal puddling clay

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? ...... Depth of strata

Method of sealing strata off

(7) PUMP: Manufacturer's Name

Type: ...... H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level...... ft.

Static level 9 ft. below top of well Date 4/11/79

Artesian pressure ...... lbs. per square inch Date

Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☒ If yes, by whom?

Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test

Bailer test 45 gal./min. with 15 ft. drawdown after 3 hrs.

Artesian flow ...... g.p.m. Date

Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	3
Brown hardpan gravel	3	18
Gray water sand & gravel	18	40

Tax lot 67

#74 & 75

Work started 4/11, 1979. Completed 4/11, 197

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc
(Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98

[Signed] Brad Johnson
(Well Driller)

License No. 0233 Date 4/11, 197

(USE ADDITIONAL SHEETS IF NECESSARY)

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epartment of Ecology
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WATER WELL REPORT (WW)

STATE OF WASHINGTON

Application No. 22/06-20

Permit No. ....

(1) OWNER: Name JACK GEROUX Address 30933 19th Place SW, Federal Way

(2) LOCATION OF WELL: County King — SE ¼ NW ¼ Sec. 26 T. 22 N., R. 6E W.M.

earing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.

Drilled 200 ft. Depth of completed well 200 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 200 ft.

Threaded ☐ " Diam. from ft. to ft.

Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒

Type of perforator used

SIZE of perforations in. by in.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

Screens: Yes ☐ No ☒

Manufacturer's Name

Type Model No.

Diam. Slot size from ft. to ft.

Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:

Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal bentonite & cement

Did any strata contain unusable water? Yes ☐ No ☐

Type of water? Depth of strata

Method of sealing strata off

(7) PUMP: Manufacturer's Name

Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.

Static level 26 ft. below top of well Date 7/22/77

Artesian pressure lbs. per square inch Date

Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☐ If yes, by whom?

Yield: gal./min. with ft. drawdown after hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test

Bailer test 2 gal./min. with 150 ft. drawdown after 1 hrs.

Artesian flow g.p.m. Date

Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	6
sand & gravel cemented	6	25
coal with layer of sandstone	25	40
sandstone	40	122
coal	122	136
sandstone	136	200

#84

Work started 7/21/77, 19 Completed 7/21/77, 19

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME NORTHWEST PUMP & DRILLING CO. (Person, firm, or corporation) (Type or print)

Address 3245 Auburn Way South, Auburn, WA

[Signed] Richard B DeRose (Well Driller)

License No. 0096 Date 7/22/77, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Out but close N SE 26Z N[illegible]

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ent of Ecology
Copy — Owner's Copy
opy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

XX

Application No. 22106-26 F

Permit No. ....

OWNER: Name Don Miller Address 24715 SE Lousburg Rd. Ravensdale

OCATION OF WELL: County King E½ NW¼ – SE ¼ NW ¼ Sec. 26 T. 22 N., R. 6E W.M.

ring and distance from section or subdivision corner

PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

DIMENSIONS: Diameter of well 6 inches.
Drilled 160 ft. Depth of completed well 160 ft.

CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to ~~160~~ 74 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

) **PUMP:** Manufacturer's Name
Type: H.P.

) **WATER LEVELS:** Land-surface elevation above mean sea level.... ft.
tic level 75 ft. below top of well Date 1/18/78
esian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

) **WELL TESTS:** Drawdown is amount water level is lowered below static level
s a pump test made? Yes ☐ No ☒ If yes, by whom?
ld: gal./min. with ft. drawdown after hrs.
" " "
" " "

covery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
iler test 6.5 gal./min. with 30 ft. drawdown after 3½ hrs.
tesian flow g.p.m. Date
mperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Brown sandy clay	0	9
Coal	9	15
Gray soft sandstone	15	40
Coal	40	55
Gray soft sandstone	55	60
Coal	60	72
Sandstone water seepage	72	160

#85

Work started 1/16, 1978. Completed 1/18, 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc.
(Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Brad Johnson
(Well Driller)

License No. 6233 Date 1/18, 1978

(USE ADDITIONAL SHEETS IF NECESSARY)

Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy 22/6E/26/L

WATER WELL REPORT
STATE OF WASHINGTON

? OU(YY) 22/06-26L
Permit No. ....

(1) OWNER: Name Dick VanMeter Address 24711 Summit-Landsburg Rd.

(2) LOCATION OF WELL: County King — NE ¼ SW ¼ Sec. 26 T22 N., R 6E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 140 ft. Depth of completed well 140 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 44 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type ...... Model No.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite & Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ...... H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 3 ft. below top of well Date 9-2-76
Artesian pressure ...... lbs. per square inch Date
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 4 gal./min. with 117 ft. drawdown after 2 hrs.
Artesian flow ...... g.p.m. Date
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Topsoil	0	4
Brn. Till	4	21
Coal	21	33
Sandstone	33	118
Coal	118	126
Sandstone	126	140

86

Work started 8-31-76, 19...... Completed 9-2-76, 19......

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME N.W. Pump & Drilling Co.
(Person, firm, or corporation) (Type or print)

Address 3245 Auburn Way So.

[Signed] R. B. [illegible]
(Well Driller)

License No. 0097 Date 9-23-76, 19......

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

most Likely out

WATER WELL REPORT
STATE OF WASHINGTON

(22)

Application No. ....
Permit No. ....

(1) OWNER: Name Wayne Dimmig Address ....

(2) LOCATION OF WELL: County King — NE ¼ SW ¼ Sec. 26 T. 22 N., R. 6 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 80 ft. Depth of completed well 75 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from -0- ft. to 21 ft.
Threaded ☐ ....“ Diam. from .... ft. to .... ft.
Welded ☑ ....“ Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☑
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Plastic
Type P.V.C. Model No. ....
Diam. " Slot size .... from .... ft. to .... ft.
Diam. 4½ Slot size .... from 45 ft. to 75 ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☑ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 640 ft.
Static level 22 ft. below top of well Date 5-13-82
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" .... " .... " ....
" .... " .... " ....

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 2 gal./min. with 60 ft. drawdown after 3 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Brown clay -	0	15'
Brown Sandstone	15'	75'
Coal	75'	80'
Seepage at 47' -	55'	- 71'

RECEIVED
MAY 20 1982
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

H87

Work started May, 19 82 Completed May, 19 82

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Evergreen Drilling (Person, firm, or corporation) (Type or print)

Address 25627 SE 192 Maple Vall

[Signed] Roland [illegible] (Well Driller)

License No. 0139 Date May 17, 19 82

(USE ADDITIONAL SHEETS IF NECESSARY)

Out, out close to west edge

(AAA) 22/6-26F.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....

Permit No. ....

(1) **OWNER:** Name John Burlingame approx. Address 25119 - SE 262nd, Ravensdale, Wa

(2) **LOCATION OF WELL:** County King - SE ¼ NW ¼ Sec 26 T 22 N., R 6E W.M.

Bearing and distance from section or subdivision corner Lot 4 - Short Platt # 779041

(3) **PROPOSED USE:** Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)........

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 & 4 inches.

Drilled 240 ft. Depth of completed well 240 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from 0 ft. to 21 ft.

Threaded ☐ 4" Diam. from 0 ft. to 242 ft.

Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☒ No ☐

Type of perforator used Torch

SIZE of perforations 1/8 in. by 3 in.

32 perforations from 170 ft. to 234 ft.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☑

Manufacturer's Name........

Type........ Model No........

Diam. .... Slot size .... from .... ft. to .... ft.

Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: ....

Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal puddling clay - cement

Did any strata contain unusable water? Yes ☐ No ☒

Type of water?........ Depth of strata........

Method of sealing strata off........

(7) **PUMP:** Manufacturer's Name........

Type: .... H.P........

(8) **WATER LEVELS:** Land-surface elevation above mean sea level........ ft.

Static level 166 ft. below top of well Date 3/16/83

Artesian pressure .... lbs. per square inch Date........

Artesian water is controlled by........ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☑ If yes, by whom?........

Yield:	gal./min. with	ft. drawdown after	hrs.
"	"	"	"
"	"	"	"

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test........

Bailer test 5 gal./min. with 50 ft. drawdown after 3 hrs.

Artesian flow........ g.p.m. Date........

Temperature of water........ Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	3
Brown decayed rock	3	15
Gray sandstone	15	102
Coal	102	115
Dark gray rock	115	130
Coal	130	135
Gray rock	135	200
Gray rock seepage	200	240
Coal	240	

#88

Work started 3/14, 1983 Completed 3/16, 1983

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co., Inc (Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Brad Johnson (Well Driller)

License No. 0233 Date 3/16, 1983

ADDITIONAL SHEETS IF NECESSARY)

Out, but close to western site boundary 22/6—26/F

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

BBB (PW-14)

Application No. ....

Permit No. ....

(1) OWNER: Name Keith Feldmann Address 25760 SE 262nd Maple Valley wa

(2) LOCATION OF WELL: County King E 1/2 SE 1/4 NW 1/4 Sec. 26 T. 22 N., R. 6E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐

Deepened ☐ Cable ☐ Driven ☐

Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.

Drilled 320 ft. Depth of completed well 320 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 20 ft.

Threaded ☐ 4" Diam. from 0 ft. to 320 ft.

Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☒ No ☐

Type of perforator used Torch

SIZE of perforations 1/8 in. by 3 in.

24 perforations from 200 ft. to 315 ft.

..... perforations from ..... ft. to ..... ft.

..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒

Manufacturer's Name ....

Type .... Model No. ....

Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....

Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal puddling clay, cement

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? ..... Depth of strata .....

Method of sealing strata off .....

(7) PUMP: Manufacturer's Name ....

Type: .... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level ..... ft.

Static level 170 ft. below top of well Date 12/8/82

Artesian pressure ..... lbs. per square inch Date .....

Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☐ If yes, by whom? .....

Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....

Bailer test 8 gal./min. with 60 ft. drawdown after 3 hrs.

Artesian flow ..... g.p.m. Date .....

Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface	0	2
Brown decayed rock—coal	2	22
Gray sandstone	22	100
Coal	100	120
Gray sandstone	120	262
Coal	262	276
Gray sandstone—water	276	320

F89

Work started 12/6 19 82 Completed 12/8 19 82

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Johnson Drilling Co, Inc (Person, firm, or corporation) (Type or print)

Address 19415 108th Ave SE Renton 98055

[Signed] Brad Johnson (Well Driller)

License No. 0233 Date 12/8 19 82

(USE ADDITIONAL SHEETS IF NECESSARY)

TABLE B-1

LANDSBURG MINE SITE MONITORING WELL WATER LEVELS

Water level measurements in feet below top of 4" PVC casing (bTPVC) and feet above mean sea level (amsl).																		
	LMW-1A		LMW-1		LMW-2		LMW-3		LMW-4			LMW-5		LMW-6		LMW-7		
Date	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (btpvc)*	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (btpvc)*	ft (bTPVC)	ft (amsl)
12/16/93							12.20	641.31				13.49	641.29					
12/17/93	137.92	621.59					12.25	641.26				13.52	641.26					
12/18/93	138.57	620.94					12.27	641.24				13.55	641.23					
12/19/93	138.72	620.79					12.30	641.21				13.56	641.22					
12/11/93							12.32	641.19				13.61	641.17					
12/21/93							12.36	641.15				13.65	641.13					
12/22/93							12.21	641.30				13.68	641.10					
1/5/94	139.52	619.99					12.01	641.50				13.46	641.32					
1/6/94	138.32	621.19					11.87	641.64				13.31	641.47					
1/7/94	137.22	622.29					11.81	641.70				13.28	641.50					
1/8/94	136.72	622.79					11.82	641.69				13.28	641.50					
1/9/94							11.85	641.66				13.32	641.46					
1/10/94	136.83	622.68					11.89	641.62				13.35	641.43			230.76	216.84	550.84
1/11/94	137.01	622.50					11.90	641.61				13.35	641.43			230.88	216.96	550.72
1/12/94	137.20	622.31					11.88	641.63				13.32	641.46			230.88	216.96	550.72
1/13/94							11.80	641.71				13.25	641.53			230.73	216.82	550.86
1/19/94	137.22	622.29					11.88	641.63				13.34	641.44	21.48	607.32	230.40	216.51	551.17
1/20/94							11.91	641.60				13.36	641.42			230.40	216.51	551.17
1/22/94							11.95	641.56				13.41	641.37	21.47	607.33	230.39	216.50	551.18
1/23/94							11.90	641.61				13.35	641.43	21.35	607.45	230.16	216.28	551.40
1/24/94	138.82	620.69	142.09	619.36			11.98	641.53				13.40	641.38	21.26	607.54	230.30	216.41	551.27
1/25/94			142.07	619.38			11.92	641.59				13.50	641.28	21.23	607.57	230.49	216.59	551.09
1/26/94			141.88	619.57			11.93	641.58						21.15	607.65	230.62	216.71	550.97
1/27/94			141.70	619.75			11.94	641.57				13.48	641.30	21.13	607.67	230.70	216.79	550.89
1/28/94			143.72	617.73			11.91	641.60				13.46	641.32	23.84	604.96	230.64	216.73	550.95
2/7/94	141.22	618.29	143.65	617.80			12.08	641.43				13.66	641.12	22.17	606.63	230.22	216.34	551.34
2/8/94							12.16	641.35				13.71	641.07			230.53	216.63	551.05
2/9/94	141.61	617.90	144.07	617.38			12.18	641.33				13.74	641.04	22.67	606.13	230.55	216.65	551.03
2/10/94							12.20	641.31				13.74	641.04			230.50	216.60	551.08
2/11/94	141.81	617.70	144.40	617.05			12.20	641.31				13.75	641.03	23.04	605.76	230.74	216.82	550.86
2/12/94	142.05	617.46	144.60	616.85	7.90	606.25	12.18	641.33				13.75	641.03	23.18	605.62			
2/13/94	142.09	617.42	144.60	616.85	7.85	606.30	12.17	641.34				13.74	641.04	23.13	605.67	230.35	216.46	551.22
2/14/94	142.10	617.41	144.57	616.88	7.44	606.71	12.10	641.41				13.66	641.12	23.20	605.60	230.50	216.60	551.08
2/15/94	142.09	617.42	144.39	617.06	7.43	606.72	12.08	641.43				13.63	641.15	22.69	606.11	230.25	216.36	551.32
2/16/94	142.17	617.34	144.66	616.79	7.02	607.13	12.01	641.50				13.56	641.22	22.36	606.44	230.12	216.24	551.44
2/17/94	142.19	617.32	144.40	617.05	6.81	607.34	11.88	641.63				13.44	641.34	21.74	607.06	229.80	215.94	551.74
2/18/94					6.51	607.64	11.67	641.84	8.09	7.60	608.10	13.23	641.55			230.20	216.32	551.36
2/19/94	140.61	618.90	142.09	619.36	6.51	607.64	11.47	642.04	8.05	7.56	608.14	13.04	641.74	20.96	607.84	230.27	216.38	551.30
2/23/94	140.60	618.91	142.87	618.58	6.25	607.90	10.79	642.72	8.14	7.65	608.05	13.03	641.75			229.94	216.07	551.61
2/25/94	139.53	619.98	141.76	619.69	6.21	607.94	11.34	642.17	8.02	7.54	608.16	12.91	641.87	19.68	609.12	229.72	215.87	551.81
2/28/94	136.83	622.68	139.18	622.27	6.04	608.11	10.82	642.69	7.84	7.37	608.33	12.39	642.39	18.93	609.87	229.58	215.73	551.95
3/1/94	137.03	622.48	139.19	622.26	6.05	608.10			7.83	7.36	608.34			18.82	609.98	229.44	215.60	552.08
3/2/94			139.59	621.86	6.02	608.13	10.83	642.68	7.84	7.37	608.33	12.43	642.35					
3/3/94	137.22	622.29	138.84	622.61	5.80	608.35	10.42	643.09	7.57	7.11	608.59	11.98	642.80	18.39	610.41	229.30	215.47	552.21
3/4/94							10.03	643.48				11.58	643.20			229.42	215.58	552.10
3/5/94	134.52	624.99	136.85	624.60	5.85	608.30	9.48	644.03	7.63	7.17	608.53	11.64	643.14	18.03	610.77			
3/11/94	139.76	619.75	142.57	618.88	6.31	607.84	11.04	642.47	8.14	7.65	608.05	12.61	642.17	19.50	609.30	229.20	215.38	552.30
3/16/94	142.45	617.06	145.36	616.09	6.63	607.52	11.46	642.05	8.51	8.00	607.70	12.99	641.79	20.17	608.63	228.88	215.08	552.60
3/18/94	143.19	616.32	145.78	615.67	6.40	607.75	11.35	642.16	8.35	7.85	607.85	12.92	641.86	20.11	608.69	228.95	215.14	552.54

TABLE B-1

LANDSBURG MINE SITE MONITORING WELL WATER LEVELS

Water level measurements in feet below top of 4" PVC casing (bTPVC) and feet above mean sea level (amsl).

Date	LMW-1A		LMW-1		LMW-2		LMW-3		LMW-4			LMW-5		LMW-6		LMW-7		
	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (btpvc)*	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (bTPVC)	ft (amsl)	ft (btpvc)*	ft (bTPVC)	ft (amsl)
4/14/94			141.46	619.99										18.86	609.94	228.74	214.95	552.73
4/18/94					6.50	607.65	10.77	642.74	8.40	7.89	607.81	12.36	642.42					
4/28/94	142.70	616.81	146.54	614.91	7.08	607.07	11.54	641.97	9.10	8.55	607.15	13.14	641.64	20.17	608.63	229.04	215.23	552.45
5/2/94			147.30	614.15	7.27	606.88	11.84	641.67	9.32	8.76	606.94	13.28	641.50	21.52	607.28	229.40	215.57	552.11
5/17/94	145.90	613.61	148.51	612.94	7.66	606.49	12.00	641.51	9.79	9.20	606.50	13.54	641.24	23.58	605.22	229.52	215.68	552.00
6/2/94	146.02	613.49	149.22	612.23	7.95	606.20	12.16	641.35	10.06	9.45	606.25	13.74	641.04	26.87	601.93	229.62	215.77	551.91
6/16/94			148.95	612.50	7.75	606.40	12.15	641.36	9.86	9.27	606.43	13.79	640.99	32.63	596.17	230.00	216.13	551.55
6/22/94			148.80	612.65	7.88	606.27	12.28	641.23	10.00	9.40	606.30	13.84	640.94	32.87	595.93	229.96	216.09	551.59
7/5/94			149.22	612.23	8.10	606.05	12.28	641.23	10.22	9.60	606.10	13.98	640.80	34.95	593.85	230.36	216.47	551.21
7/13/94			149.44	612.01	8.19	605.96	12.49	641.02	10.31	9.69	606.01	14.02	640.76	36.46	592.34	230.44	216.54	551.14
7/29/94			149.77	611.68			12.56	640.95	10.43	9.80	605.90	14.12	640.66	39.08	589.72	230.75	216.83	550.85
8/8/94							12.63	640.88				14.17	640.61					
8/9/94					8.34	605.81			10.48	9.85	605.85							
8/10/94			149.96	611.49										40.59	588.21	231.00	217.07	550.61
8/15/94					8.34	605.81			10.50	9.87	605.83							
8/16/94			149.77	611.68			12.68	640.83				14.23	640.55	41.19	587.61	231.07	217.13	550.55
8/17/94												14.21	640.57	41.30	587.50	231.04	217.11	550.57
8/19/94			150.02	611.43	8.14	606.01	12.72	640.79	10.27	9.65	606.05	14.23	640.55	41.47	587.33	231.08	217.14	550.54
8/22/94					8.22	605.93			10.36	9.74	605.96							
8/30/94			149.97	611.48	8.33	605.82	12.72	640.79	10.49	9.86	605.84	14.29	640.49	42.76	586.04	231.22	217.28	550.40
9/27/94			150.17	611.28	8.34	605.81	12.70	640.81	10.49	9.86	605.84	14.28	640.50	45.60	583.20	231.43	217.47	550.21
10/6/94			150.24	611.21	8.38	605.77	12.82	640.69	10.53	9.89	605.81	14.37	640.41	46.20	582.60	231.82	217.84	549.84
10/14/94			150.22	611.23	8.34	605.81	12.80	640.71	10.49	9.86	605.84	14.37	640.41	46.45	582.35	231.60	217.63	550.05
11/3/94			149.00	612.45	7.96	606.19	12.52	640.99	10.08	9.47	606.23	14.12	640.66	46.62	582.18	231.33	217.38	550.30
12/6/94			139.92	621.53	6.58	607.57	11.50	642.01	8.52	8.01	607.69	13.02	641.76	28.78	600.02	230.70	216.79	550.89
12/16/94	141.65	617.86	144.62	616.83	6.70	607.45	11.86	641.65	8.75	8.22	607.48	13.38	641.40	25.40	603.40	230.60	216.69	550.99
12/21/94	130.25	629.26	133.52	627.93	5.78	608.37	9.45	644.06	7.70	7.24	608.46	10.94	643.84	22.53	606.27	230.37	216.48	551.20
1/5/95	137.71	621.80	140.87	620.58	6.28	607.87	10.97	642.54	8.23	7.73	607.97	12.52	642.26	21.51	607.29	228.89	215.09	552.59
1/16/95			144.75	616.70	6.74	607.41	11.57	641.94	8.69	8.17	607.53	13.13	641.65	22.94	605.86	229.90	216.04	551.64
2/7/95	137.83	621.68	140.73	620.72	6.29	607.86	10.04	643.47	8.25	7.75	607.95	11.96	642.82	22.17	606.63	228.92	215.11	552.57
2/14/95	140.78	618.73	143.46	617.99	6.60	607.55	10.96	642.55	8.57	8.05	607.65	12.52	642.26	22.79	606.01	229.17	215.35	552.33
2/28/95	137.24	622.27	140.25	621.20	6.20	607.95	10.34	643.17	8.14	7.65	608.05	11.90	642.88	21.63	607.17	227.87	214.13	553.55
3/17/95			140.36	621.09	6.04	608.11	10.55	642.96	7.96	7.48	608.22	12.08	642.70	20.83	607.97	228.35	214.58	553.10
3/29/95			141.95	619.50	6.42	607.73	10.79	642.72	8.37	7.87	607.83	12.35	642.43	21.21	607.59			
5/12/95			147.22	614.23	7.42	606.73	12.13	641.38	9.50	8.93	606.77	13.69	641.09	26.97	601.83	228.85	215.05	552.63

ft (bTPVC) - Feet Below Top of PVC casing.

ft (amsl) - Feet Above Mean Sea Level.

*The first column under LMW-4 and LMW-7 indicate water levels as measured in the field; the second and third columns have been corrected for the 70 degree inclination of the wells.

TABLE B-2

MANUAL WATER LEVEL MEASUREMENTS TAKEN AT WELLS LMW-6 AND LMW-7 DURING DRAINAGE OF THE BAKER TANKS

Monitoring Well	Date	Time	Water Level (ft BTOC)
LMW-6	8/16/94	1049	41.19
LMW-6	8/16/94	1600	41.18
LMW-6	8/16/94	1909	41.20
LMW-6	8/17/94	1630	41.30
LMW-6	8/30/94	1345	42.76
LMW-7	8/16/94	1039	231.07
LMW-7	8/16/94	1532	231.04
LMW-7	8/16/94	1930	231.08
LMW-7	8/17/94	1522	231.04
LMW-7	8/30/94	1212	231.22
Note: Baker tank discharge at north end of trench occurred on 8/16/94 from 1:45 to 8:10 PM. Approximately 24,700 gls were discharged at the location shown on Figure 2-14.			

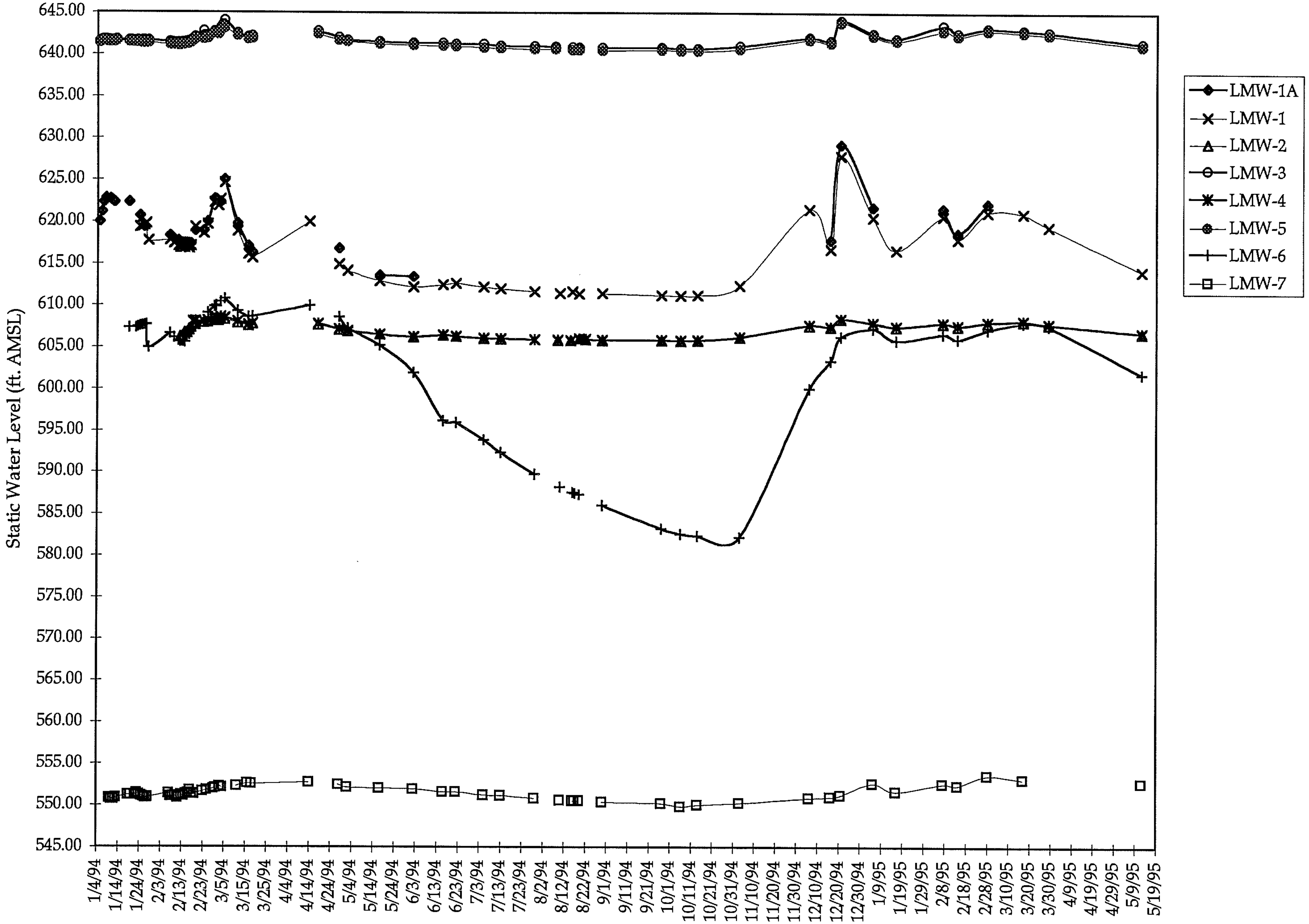


FIGURE B-1

HYDROGRAPH OF LANDSBURG MONITORING WELLS

LANDSBURG MINE SITE/RI/FS/WA

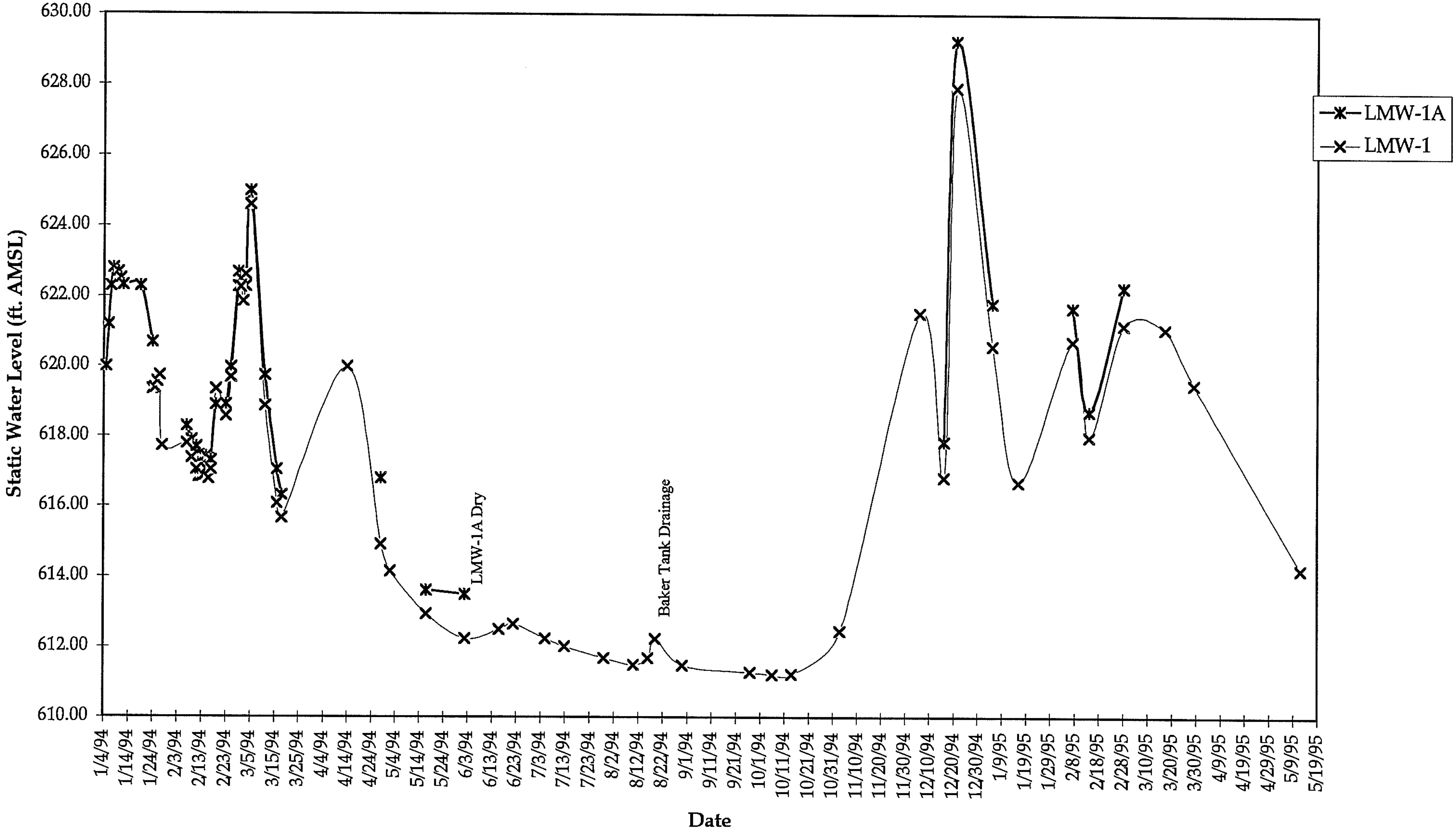


FIGURE **B-2**

HYDROGRAPH OF LMW-1A AND LMW-1

LANDSBURG MINE SITE RI/FS/WA

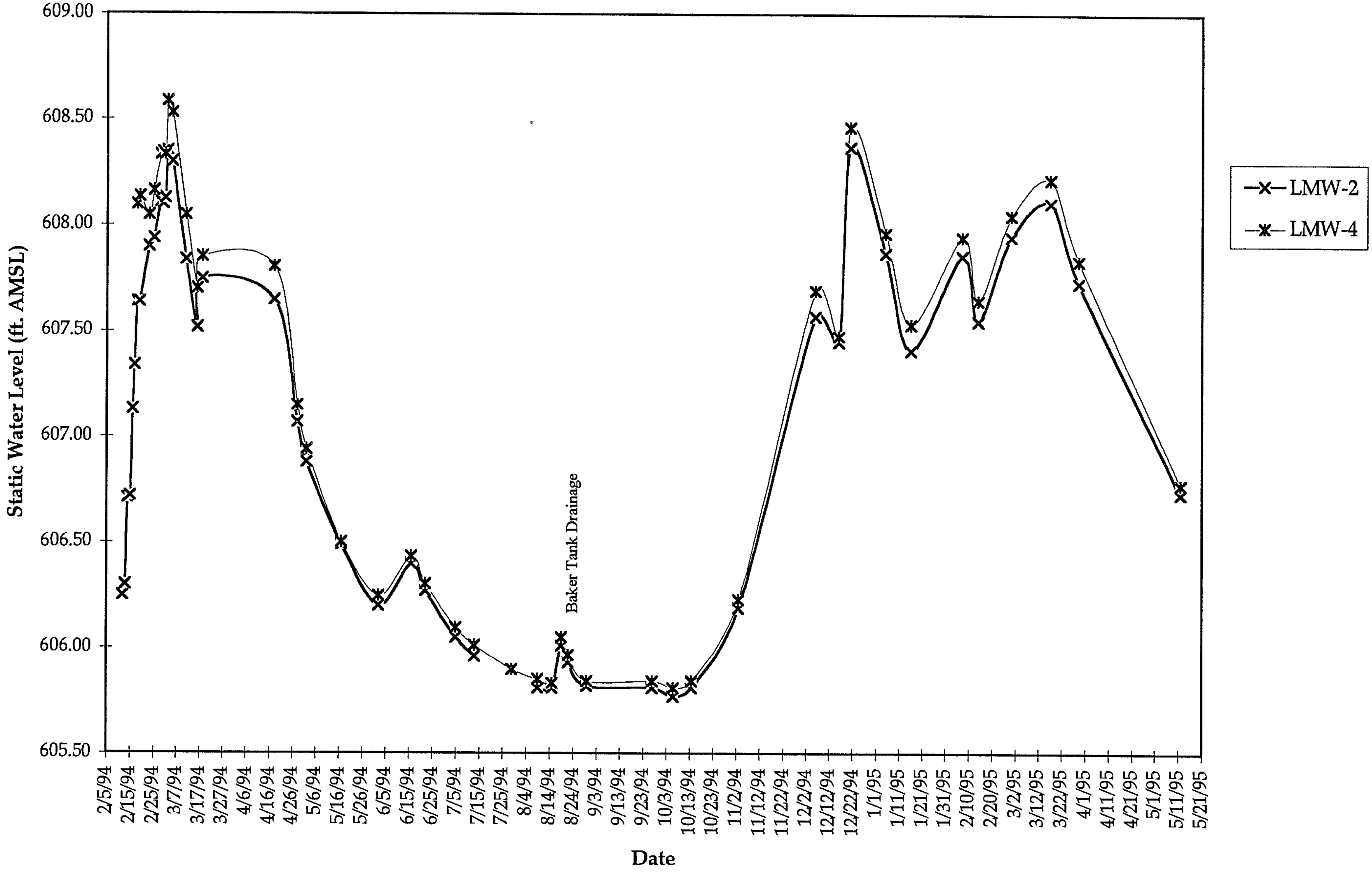


FIGURE **B-3**

HYDROGRAPH OF LMW-2 AND LMW-4

LANDSBURG MINE SITE RI/FS/WA

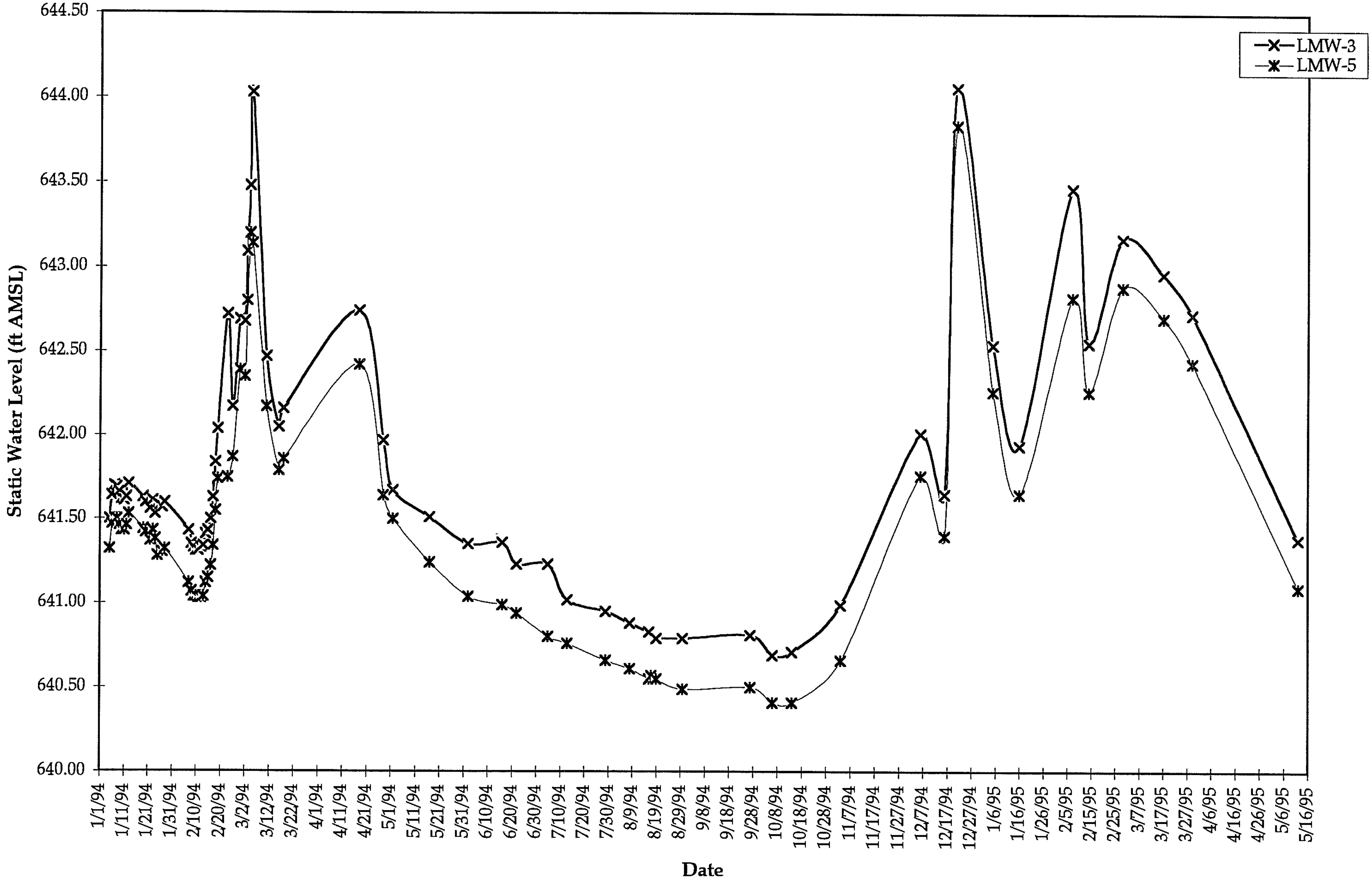


FIGURE **B-4**

HYDROGRAPH OF LMW-3 AND LMW-5

LANDSBURG MINE SITE RI/FS/WA

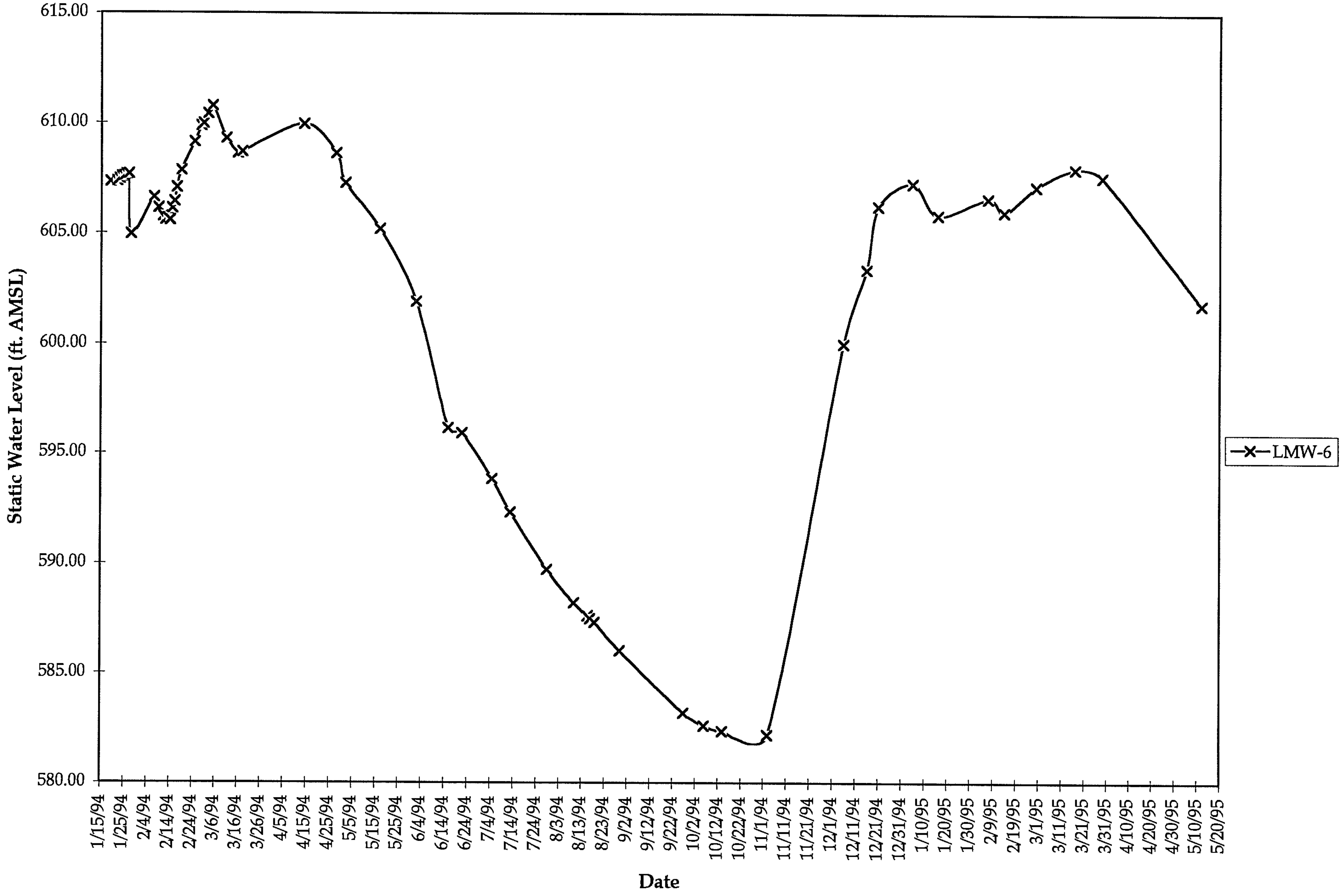


FIGURE **B-5**

HYDROGRAPH OF LMW-6

LANDSBURG MINE SITE RI/FS/WA

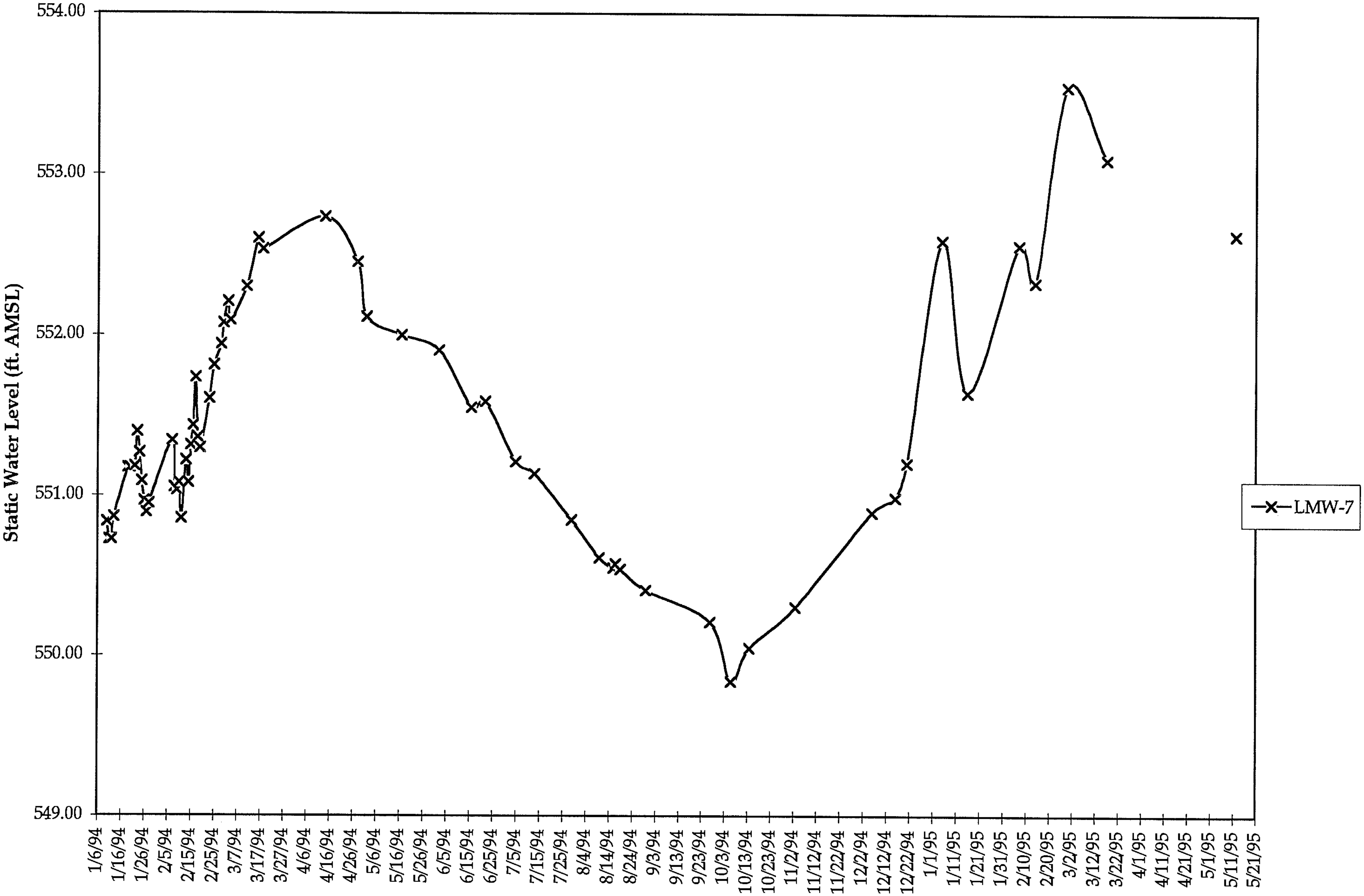


FIGURE **B-6**

HYDROGRAPH OF LMW-7

LANDSBURG MINE SITE RI/FS/WA

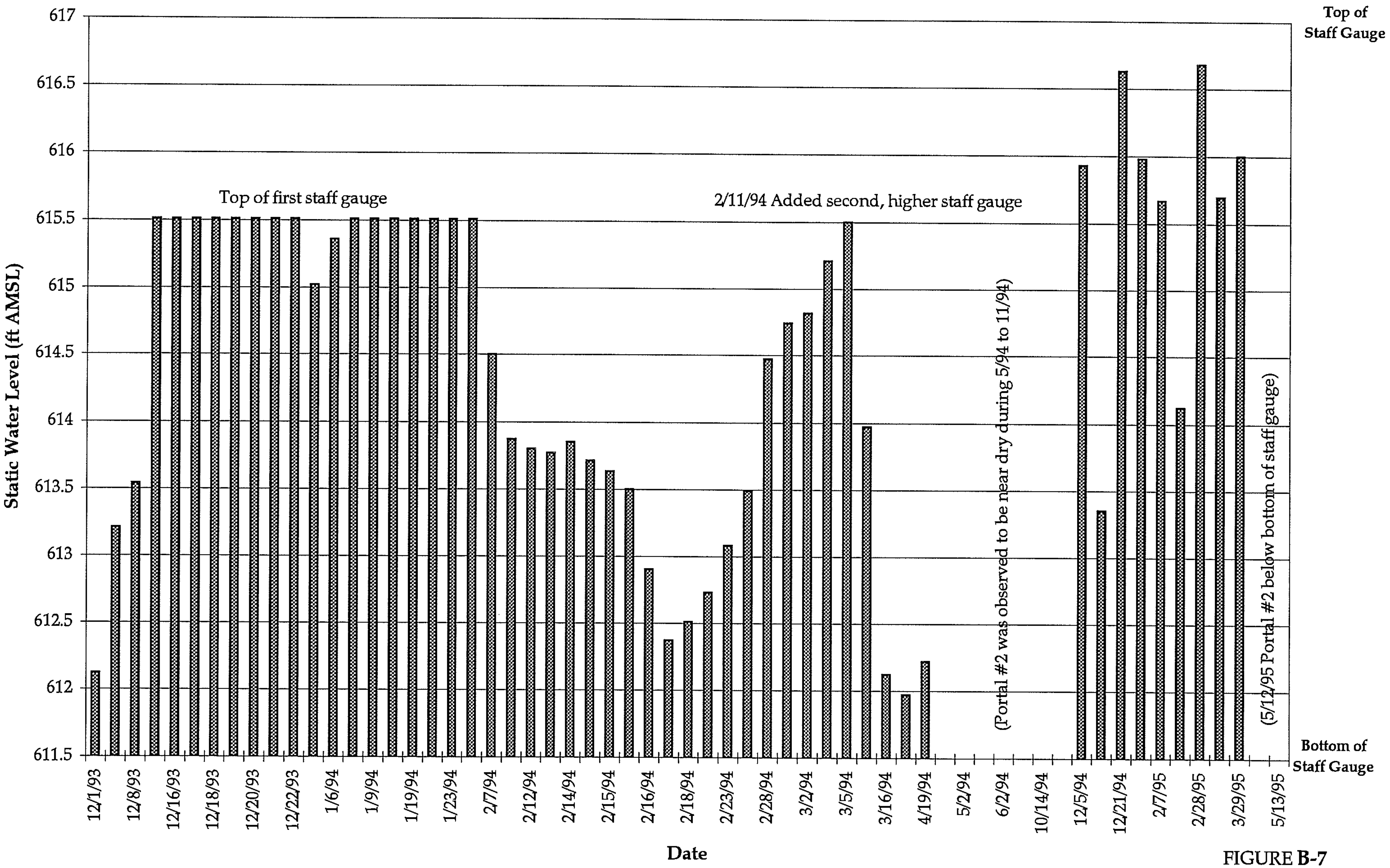


FIGURE **B-7**

PORTAL #2 WATER LEVEL

LANDSBURG MINE SITE RI/FS/WA

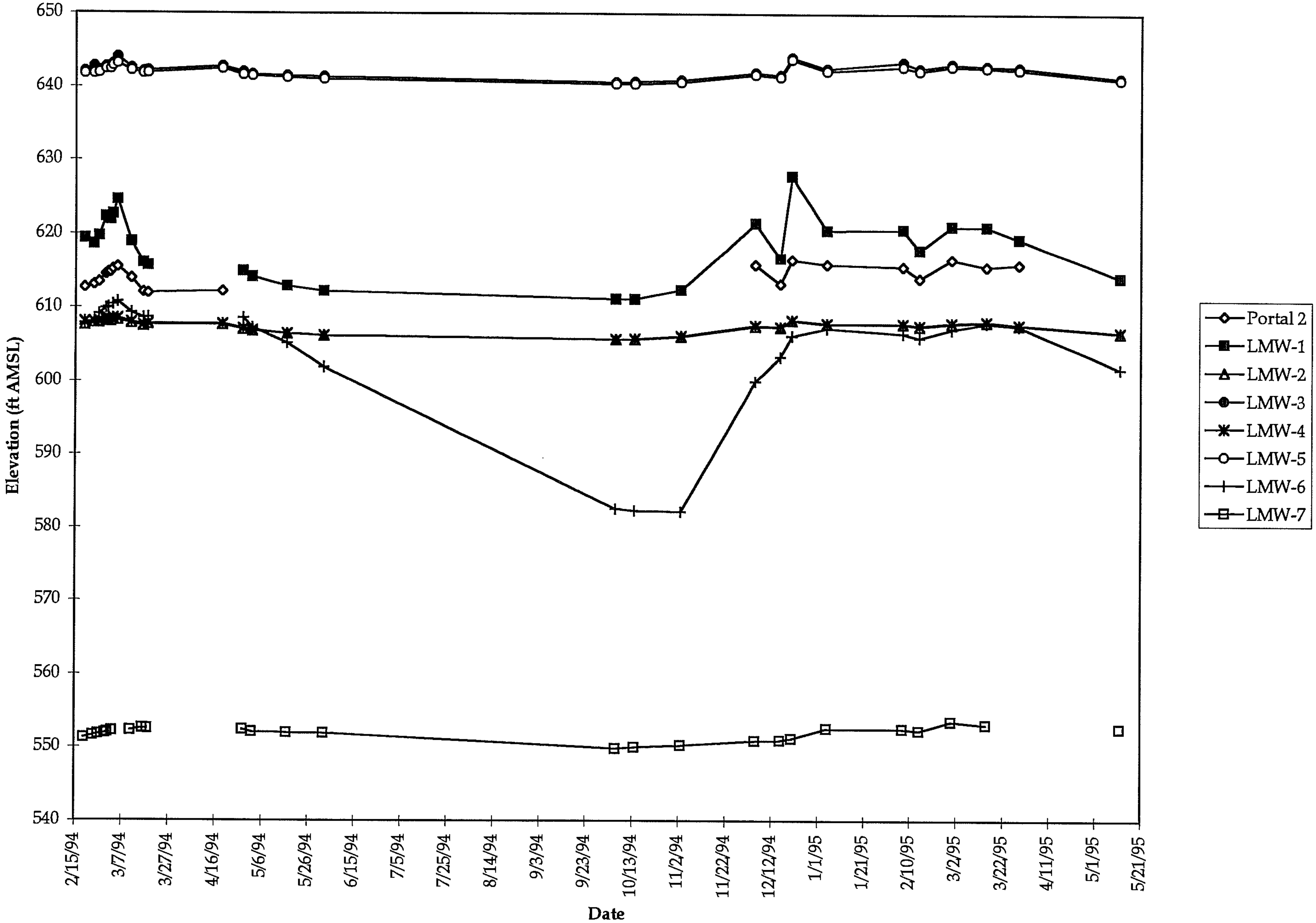


FIGURE **B-8**

PORTAL #2 AND LMW HYDROGRAPHS

LANDSBURG MINE SITE RI/FS/WA

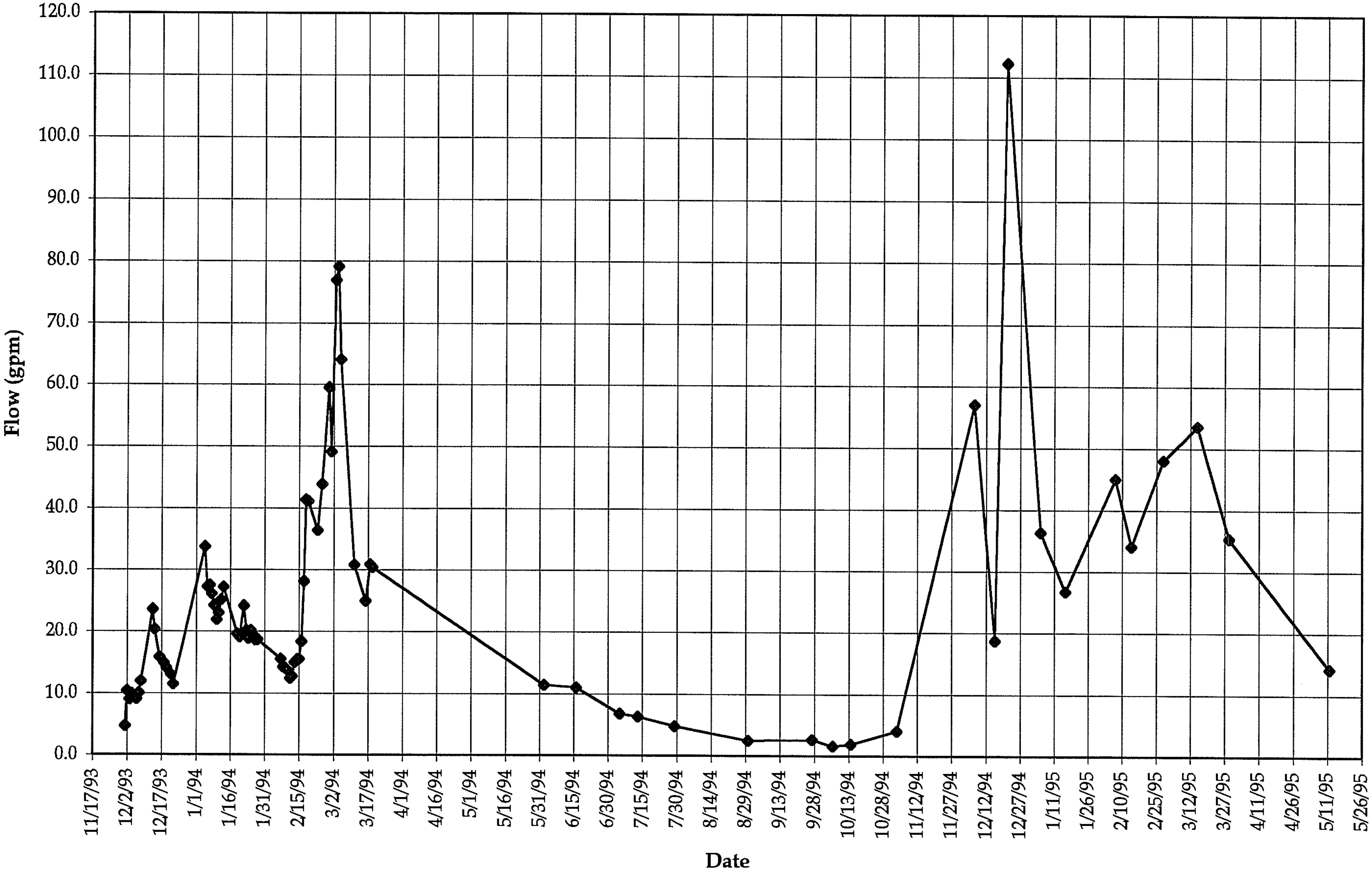


FIGURE **B-9**

PORTAL #3 FLOW RATE

LANDSBURG MINE SITE RI/FS/WA

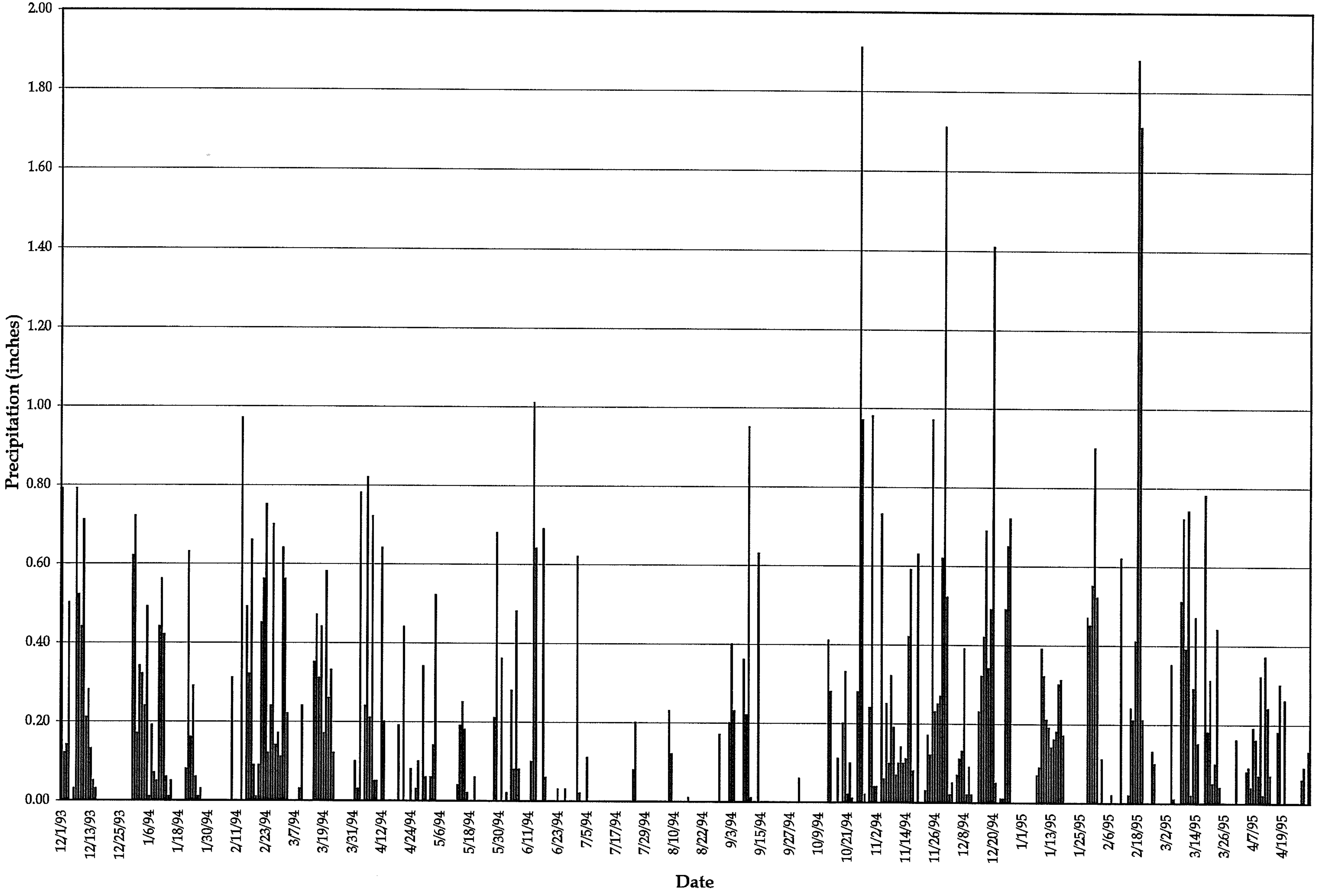


FIGURE **B-10**

RECORDED PRECIPITATION DATA

LANDSBURG MINE SITE RI/FS/WA

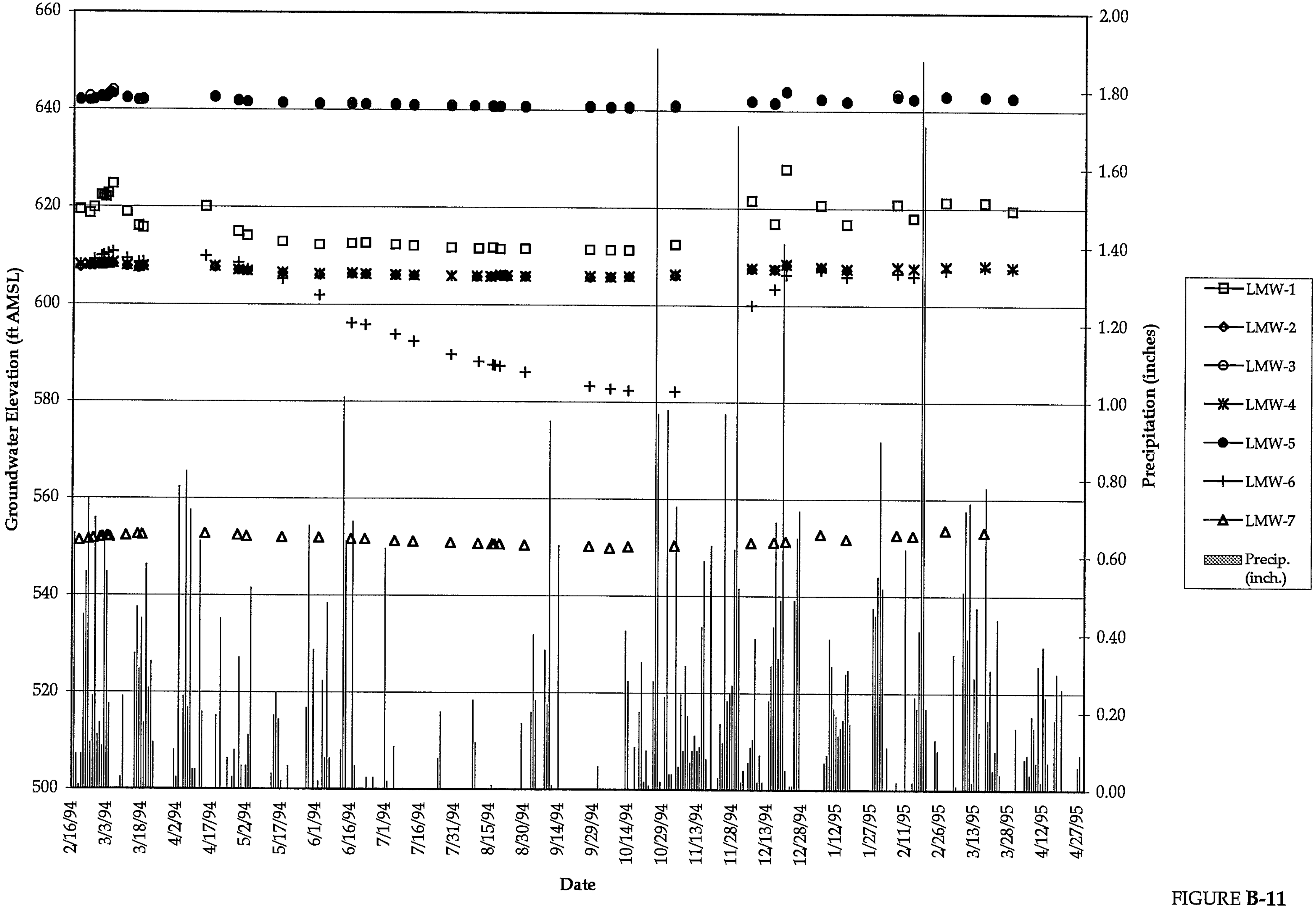


FIGURE **B-11**

PRECIPITATION AND MONITORING WELL HYDROGRAPHS

LANDSBURG MINE SITE/RI/FS/WA

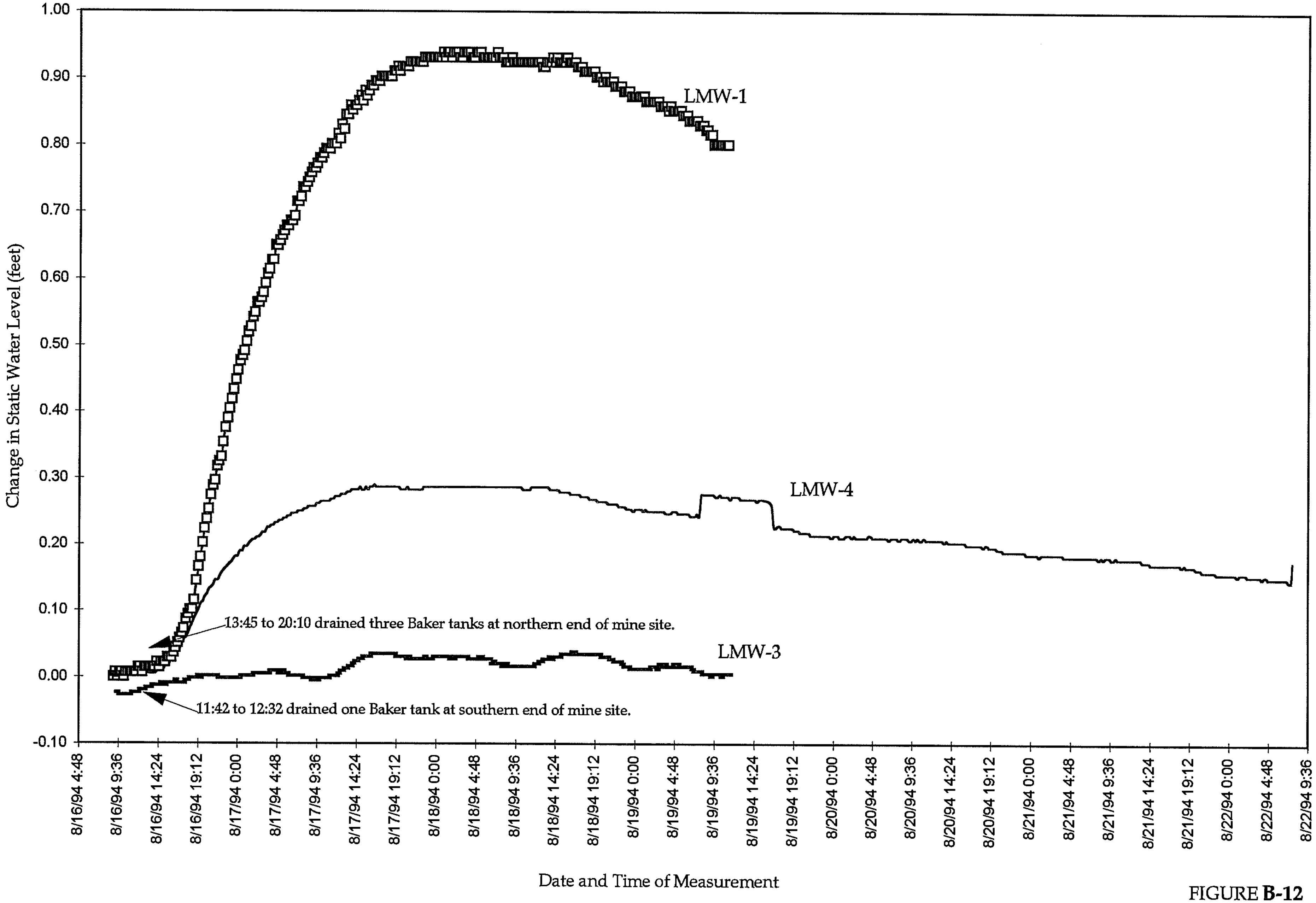


FIGURE **B-12**

HYDROGRAPHS OF SELECTED LMW WELLS
DURING BAKER TANK DRAINAGE

LANDSBURG MINE SITE RI/FS/WA

APPENDIX C

SUMMARY OF ANALYTICAL DATA

TABLE OF CONTENTS

LIST OF TABLES

TABLE C-1
LANDSBURG TRENCH RIM SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	LRS-1 (mg/kg)	LRS-2 (mg/kg)	LRS-3 (mg/kg)	LRS-4 (mg/kg)	LRS-5 (mg/kg)	LRS-6 (mg/kg)	LRS-7 (mg/kg)	LRS-8 (mg/kg)	LRS-9 (mg/kg)	LRS-10 (mg/kg)	LRS-11 (mg/kg)	LRS-12 (mg/kg)
METALS												
ALUMINUM	25600	14900	10200	17500	22600	16500	2700	4730	13500	24600	27400	28300
ANTIMONY	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	6.7	4	8.5	5.3	4.3	16	8.4	8.9	4.4	5.1	4.9	3.3
BARIUM	182	226	114	119	103	114	28.9	37.4	72.5	123	152	105
BERYLLIUM	1	1	0.8	0.7	0.5	1	0.2	0.3	0.4	0.5	0.6	0.4
CADMIUM	0.4	0.3	0.3	0.2	0.3	0.3	ND	ND	ND	ND	0.3	ND
CALCIUM	2410	832	508	1430	2910	2490	93	711	1500	2310	2680	2650
CHROMIUM	34.7	35.7	33	34	31.8	29.5	9.1	12.8	20.7	30.5	31.2	30.8
COBALT	10.5	15.8	18.2	9.9	10.2	24.4	1.5	5.5	6.2	7.8	8.8	7.5
COPPER	33.9	35.8	36.5	27.6	22.6	47.7	6.4	9.7	15	20.9	20.2	19.1
IRON	29500	40100	37200	26200	25300	45000	10700	14500	14200	19900	21000	20200
LEAD	10.1	9.7	16.5	21.6	5.6	12.5	5.4	6.7	6.7	5.3	7.2	3.8
MAGNESIUM	2230	1420	892	1870	3950	1930	174	565	2200	3640	3430	4120
MANGANESE	844	701	560	446	436	1040	61.7	165	227	332	482	243
MERCURY	0.08	0.09	ND	0.07	ND	0.1	ND	ND	ND	ND	0.06	ND
NICKEL	36	30	24	25	28	38	2	11	16	26	28	23
POTASSIUM	1250	1570	1210	1250	880	1670	550	620	640	970	970	740
SELENIUM	0.2	ND	0.2	ND	ND	0.2	ND	ND	ND	ND	ND	ND
SILVER	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	113	66	ND	87	130	76	63	ND	77	123	155	167
THALLIUM	ND	ND	ND	ND	ND	0.1	ND	ND	ND	0.2	ND	ND
VANADIUM	55.5	53.5	50.6	45.2	53.2	61.3	15.6	21.7	34.2	51.4	54.9	53.7
ZINC	89.1	84.4	81	71	43.2	83	13.4	29.2	26.4	40.1	55.1	28
VOLATILES												
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROPROPANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLOROETHYLVINYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BROMODICHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BROMOFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON DISULFIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-1
LANDSBURG TRENCH RIM SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	LRS-1 (mg/kg)	LRS-2 (mg/kg)	LRS-3 (mg/kg)	LRS-4 (mg/kg)	LRS-5 (mg/kg)	LRS-6 (mg/kg)	LRS-7 (mg/kg)	LRS-8 (mg/kg)	LRS-9 (mg/kg)	LRS-10 (mg/kg)	LRS-11 (mg/kg)	LRS-12 (mg/kg)
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBROMOCHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRANS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRANS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
VINYL ACETATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	ND	ND	0.0072J	ND	ND	ND	ND	ND	ND	ND	ND	ND
BROMOMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROFLUOROMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
XYLENES (TOTAL)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-BUTANONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-HEXANONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-METHYL-2-PENTANONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACETONE	ND	ND	ND	ND	ND	ND	ND	ND	0.0085 J	ND	ND	ND
SEMI-VOLATILES												
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-1
LANDSBURG TRENCH RIM SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	LRS-1 (mg/kg)	LRS-2 (mg/kg)	LRS-3 (mg/kg)	LRS-4 (mg/kg)	LRS-5 (mg/kg)	LRS-6 (mg/kg)	LRS-7 (mg/kg)	LRS-8 (mg/kg)	LRS-9 (mg/kg)	LRS-10 (mg/kg)	LRS-11 (mg/kg)	LRS-12 (mg/kg)
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	1.9[a]	ND	0.96	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	0.074	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-1
LANDSBURG TRENCH RIM SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	LRS-1 (mg/kg)	LRS-2 (mg/kg)	LRS-3 (mg/kg)	LRS-4 (mg/kg)	LRS-5 (mg/kg)	LRS-6 (mg/kg)	LRS-7 (mg/kg)	LRS-8 (mg/kg)	LRS-9 (mg/kg)	LRS-10 (mg/kg)	LRS-11 (mg/kg)	LRS-12 (mg/kg)
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PESTICIDE/PCB												
ALDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALPHA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BETA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DELTA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN I	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GAMMA-BHC (LINDANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALPHA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIELDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN II	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN ALDEHYDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-1
LANDSBURG TRENCH RIM SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	**LRS-1 (mg/kg)**	**LRS-2 (mg/kg)**	**LRS-3 (mg/kg)**	**LRS-4 (mg/kg)**	**LRS-5 (mg/kg)**	**LRS-6 (mg/kg)**	**LRS-7 (mg/kg)**	**LRS-8 (mg/kg)**	**LRS-9 (mg/kg)**	**LRS-10 (mg/kg)**	**LRS-11 (mg/kg)**	**LRS-12 (mg/kg)**
ENDRIN KETONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GAMMA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHOXYCHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1016/1242	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1232	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1248	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1254	ND	ND	ND	0.037 J	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1260	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1221	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOXAPHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY												
Total Solids (%)	77.66	81.51	83.75	84.56	82.69	83.56	83.18	82.48	84.67	79.54	79.8	84.62
Nitrite (mg-N/kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate (mg-N/kg)	0.74	0.52	2.15	0.59	0.54	0.63	0.52	1.64	0.51	0.57	0.53	0.48
Chloride	443	212	754	393	374	513	13.2	243	335	120	48.5	69.4
Fluoride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	1230	431	1430	604	628	1070	76.9	430	577	269	169	171
ortho-Phosphate (mg-P/kg)	3.88 J	2.41 J	3.38 J	3.16 J	3.05 J	4.81 J	1.58 J	3.21 J	3.18 J	6.27 J	3.09 J	2.57 J
Cyanide-Total (mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND - Analyte was Not Detected

[a] Bis(2-ethylhexyl)phthalate was detected in sample LRS-7, but was not detected by the lab in the blind duplicate of LRS-7.

J - The J qualifier indicates the constituent was analyzed for and detected, but the detection was at a concentration which is less than the Practical Quantitation Limit (PQL) but greater than the Instrument Detection Limit (IDL).

TABLE C-2
PORTAL SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	P2S-1 (mg/kg)	P2S-2 (mg/kg)	P2S-3 (mg/kg)	P2S-4 (mg/kg)	P3S-1 (mg/kg)	P3S-2 (mg/kg)	P3S-3 (mg/kg)	P3S-4 (mg/kg)	FNS-1 (mg/kg)
METALS									
ALUMINUM	16400	13200	11800	17500	18400	7920	12600	8890	12900
ANTIMONY	ND	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	5.9	7.4	5.5	8	5.8	26	5.8	14.2	18.4
BARIUM	119	109	77.4	121	128	235	184	494	665
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	ND	ND	ND	0.8	ND	ND	ND	ND	ND
CALCIUM	3960	6580	2470	7590	3840	40700	17100	245000	5220
CHROMIUM	23	18	20	20	20	17	18	7	10
COBALT	6.4	7	10.4	7	8	25	7.9	29	16
COPPER	10	21.9	18.9	30.8	18.2	24.5	23.5	12	5
IRON	15300	16700	23600	16700	18400	20600	17900	16000	92400
LEAD	23	45	22	28	11.7	12	10	7.1	4.2
MAGNESIUM	3380	3330	2010	3780	3450	3220	4420	5980	2180
MANGANESE	619	565	542	636	232	2510	514	4730	9170
MERCURY	0.1	0.13	0.07	0.1	ND	ND	ND	ND	ND
NICKEL	27	24	24	28	27	40	21	48	36
POTASSIUM	500	700	1000	600	500	700	1000	500	400
SELENIUM	0.7	ND	ND	ND	ND	ND	0.3	0.8	ND
SILVER	ND	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	117	80	62	91	117	226	318	218	88
THALLIUM	ND	ND	ND	ND	ND	ND	0.3	ND	ND
VANADIUM	35.6	31.2	38.5	32	42.8	35.4	39.9	18	26
ZINC	36	327	59	84	54	64	41	42	38
VOLATILES									
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROPROPANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BROMODICHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BROMOFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON DISULFIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-2
PORTAL SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	P2S-1 (mg/kg)	P2S-2 (mg/kg)	P2S-3 (mg/kg)	P2S-4 (mg/kg)	P3S-1 (mg/kg)	P3S-2 (mg/kg)	P3S-3 (mg/kg)	P3S-4 (mg/kg)	FNS-1 (mg/kg)
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBROMOCHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
STYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRANS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRANS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	ND	0.0034	0.0039	0.008	ND	0.015 J	0.0039 J	ND	0.0055 J
BROMOMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROFLUOROMETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
XYLENES (TOTAL)	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-BUTANONE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-HEXANONE	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-METHYL-2-PENTANONE	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACETONE	ND	ND	ND	ND	0.02	0.053 J	ND	ND	ND
SEMI-VOLATILES									
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	0.11	0.092	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-2
PORTAL SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	P2S-1 (mg/kg)	P2S-2 (mg/kg)	P2S-3 (mg/kg)	P2S-4 (mg/kg)	P3S-1 (mg/kg)	P3S-2 (mg/kg)	P3S-3 (mg/kg)	P3S-4 (mg/kg)	FNS-1 (mg/kg)
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	0.089 M	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	0.210	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	.090 M	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-2
PORTAL SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	P2S-1 (mg/kg)	P2S-2 (mg/kg)	P2S-3 (mg/kg)	P2S-4 (mg/kg)	P3S-1 (mg/kg)	P3S-2 (mg/kg)	P3S-3 (mg/kg)	P3S-4 (mg/kg)	FNS-1 (mg/kg)
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	0.099	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	0.070	0.088	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCB									
ALDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALPHA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALPHA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
BETA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND
DELTA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN I	ND	ND	ND	ND	ND	ND	ND	ND	ND
GAMMA-BHC (LINDANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND
GAMMA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	0.0024 J	ND	ND	ND	0.0018 J	0.0021 J	ND	ND
DIELDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN II	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN ALDEHYDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN KETONE	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-2
PORTAL SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	**P2S-1 (mg/kg)**	**P2S-2 (mg/kg)**	**P2S-3 (mg/kg)**	**P2S-4 (mg/kg)**	**P3S-1 (mg/kg)**	**P3S-2 (mg/kg)**	**P3S-3 (mg/kg)**	**P3S-4 (mg/kg)**	**FNS-1 (mg/kg)**
METHOXYCHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1016/1242	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1232	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1248	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1254	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1260	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1221	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOXAPHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY									
Total Solids (%)	69.91	58.54	72.01	53.99	54.61	44.52	77.48	50.99	38.96
Nitrite + Nitrate (mg-N/kg)	2.33	4.45	2.48	10	0.35	0.29	0.21	0.45	0.51
Chloride	170	25.3	234	29.2	82.6	47.5	118	57.2	54.3
Fluoride	ND	2.7 J	ND	ND	ND	ND	ND	ND	ND
Sulfate	ND	ND	ND	402	ND	ND	ND	ND	ND
ortho-Phosphate (mg-P/kg)	3 J	2.5 J	0.5 J	0.9 J	1 J	ND	0.4 J	ND	ND
Cyanide-Total (mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND - Analyte was Not Detected

J - The J qualifier indicates the constituent was tested for and detected, but the detection was at a concentration which is less than the calculated detection limit. During data validation the J qualifier may be applied to indicate a minor quality control deficiency.

M - The M qualifier indicates an estimated value of an analyte detected and confirmed by analyst with low spectral match parameters.

TABLE C-3
BACKHOE TRENCH SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	**BT1-1 (mg/kg)**	**BT2-1 (mg/kg)**	**BT3-1 (mg/kg)**
METALS			
ALUMINUM	2360	6420	4720
ANTIMONY	ND	ND	ND
ARSENIC	9.8	10	11.4
BARIUM	27.6	124	50.6
BERYLLIUM	0.6	0.8	0.8
CADMIUM	ND	ND	ND
CALCIUM	1210	1430	1060
CHROMIUM	18	21	16
COBALT	9.2	16.8	21.1
COPPER	10.4	40	38.5
IRON	28100	34000	29400
LEAD	5.6	9	10
MAGNESIUM	2420	1080	858
MANGANESE	539	1020	456
MERCURY	ND	0.09	0.12
NICKEL	17	39	32
POTASSIUM	570	1210	1090
SELENIUM	ND	ND	ND
SILVER	ND	1	ND
SODIUM	49	45	39
THALLIUM	ND	ND	0.3
VANADIUM	38.8	44.3	31.3
ZINC	43.5	68.4	91.9
VOLATILES			
1,1,1-TRICHLOROETHANE	ND	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND
1,2-DICHLOROPROPANE	ND	ND	ND
BENZENE	ND	ND	ND
BROMODICHLOROMETHANE	ND	ND	ND
BROMOFORM	ND	ND	ND
CARBON DISULFIDE	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND
CHLOROBENZENE	ND	ND	ND
CHLOROFORM	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	ND
CIS-1,3-DICHLOROPROPENE	ND	ND	ND
DIBROMOCHLOROMETHANE	ND	ND	ND
ETHYLBENZENE	ND	ND	ND
STYRENE	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND
TOLUENE	ND	ND	ND

TABLE C-3
BACKHOE TRENCH SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	BT1-1 (mg/kg)	BT2-1 (mg/kg)	BT3-1 (mg/kg)
TRANS-1,2-DICHLOROETHENE	ND	ND	ND
TRANS-1,3-DICHLOROPROPENE	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	ND	ND	ND
2-BUTANONE	ND	ND	ND
2-CHLOROETHYLVINYLETHER	ND	ND	ND
2-HEXANONE	ND	ND	ND
4-METHYL-2-PENTANONE	ND	ND	ND
ACETONE	ND	ND	ND
BROMOMETHANE	ND	ND	ND
CHLOROETHANE	ND	ND	ND
CHLOROMETHANE	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND
TRICHLOROFLUOROMETHANE	ND	ND	ND
VINYL ACETATE	ND	ND	ND
VINYL CHLORIDE	ND	ND	ND
XYLENES (TOTAL)	ND	ND	ND
SEMI-VOLATILES			
1,2,4-TRICHLOROBENZENE	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND
ACENAPHTHENE	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND
ISOPHORONE	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND
NAPHTHALENE	ND	ND	ND
NITROBENZENE	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND
PHENOL	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND

TABLE C-3
BACKHOE TRENCH SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	BT1-1 (mg/kg)	BT2-1 (mg/kg)	BT3-1 (mg/kg)
2-NITROANILINE	ND	ND	ND
2-NITROPHENOL	ND	ND	ND
3-NITROANILINE	ND	ND	ND
BENZYL ALCOHOL	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND
BENZOIC ACID	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND
ANTHRACENE	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND
CARBAZOLE	ND	ND	ND
CHRYSENE	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND
DIBENZOFURAN	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND
FLUORANTHENE	ND	ND	ND
FLUORENE	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND
PHENANTHRENE	ND	ND	ND
PYRENE	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND
4-NITROANILINE	ND	ND	ND
4-NITROPHENOL	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND
PESTICIDES\PCB			
ALDRIN	ND	ND	ND
ALPHA-BHC	ND	ND	ND
ALPHA-CHLORDANE	ND	ND	ND
BETA-BHC	ND	ND	ND
DELTA-BHC	ND	ND	ND
ENDOSULFAN I	ND	ND	ND
GAMMA-BHC (LINDANE)	ND	ND	ND

TABLE C-3
BACKHOE TRENCH SOIL SAMPLING ANALYTICAL RESULTS

Chemical Name	**BT1-1 (mg/kg)**	**BT2-1 (mg/kg)**	**BT3-1 (mg/kg)**
GAMMA-CHLORDANE	ND	ND	ND
HEPTACHLOR	ND	ND	ND
HEPTACHLOR EPOXIDE	ND	ND	ND
4,4'-DDD	ND	ND	ND
4,4'-DDE	ND	ND	ND
4,4'-DDT	ND	ND	ND
DIELDRIN	ND	ND	ND
ENDOSULFAN II	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND
ENDRIN	ND	ND	ND
ENDRIN ALDEHYDE	ND	ND	ND
ENDRIN KETONE	ND	ND	ND
METHOXYCHLOR	ND	ND	ND
AROCLOR-1016/1242	ND	ND	ND
AROCLOR-1232	ND	ND	ND
AROCLOR-1248	ND	ND	ND
AROCLOR-1254	ND	ND	ND
AROCLOR-1260	ND	ND	ND
AROCLOR-1221	ND	ND	ND
TOXAPHENE	ND	ND	ND
GENERAL CHEMISTRY			
Total Solids (%)	85.26	82.75	85.13
Nitrite (mg-N/kg)	ND	0.16	ND
Nitrate (mg-N/kg)	0.45	0.18	0.4
Chloride	105	76.4	214
Fluoride	1.28 J	ND	ND
Sulfate	ND	124	ND
Cyanide-Total (mg/kg)	ND	ND	ND

ND - Analyte was Not Detected

J - The J qualifier indicates the constituent was analyzed for and detected, but the detection was at a concentration which is less than the Practical Quantitation Limit (PQL) but greater than the Instrument Detection Limit (IDL).

TABLE C-4
BOREHOLE SOIL CUTTINGS ANALYTICAL RESULTS

Chemical Name	LMW1-C (mg/kg)	LMW2-C (mg/kg)	LMW3-C (mg/kg)	LMW4-C (mg/kg)	LMW5-C (mg/kg)	LMW6-C (mg/kg)	LMW7-C (mg/kg)
METALS							
ALUMINUM	9360	14700	21900	11100	14800	6570	12200
ANTIMONY	ND	ND	10	ND	ND	ND	ND
ARSENIC	11.5	1.7	4.3	2	4.8	5.1	2.3
BARIUM	133	135	128	86	99.1	213	109
BERYLLIUM	0.8	0.9	0.3	0.7	0.4	0.7	0.5
CADMIUM	0.6	ND	ND	ND	ND	ND	ND
CALCIUM	13300	3740	10200	11700	9400	4160	11400
CHROMIUM	19	33	77.2	28.2	48	22	29.9
COBALT	20.8	8.9	15	15.5	13.3	13.4	14
COPPER	54	66	35.9	34.1	30.2	53.3	28.5
IRON	46000	17100	30400	35500	30200	22000	34100
LEAD	12	8.1	5	7.2	4.9	10	5
MAGNESIUM	9610	4890	14400	9260	11000	4850	10300
MANGANESE	843	234	539	699	515	285	615
MERCURY	0.08	0.07	ND	0.07	ND	0.07	0.1
NICKEL	42	26	87	35	54	33	38
POTASSIUM	1720	900	1830	1770	1540	970	1250
SELENIUM	ND	0.4	ND	ND	ND	ND	ND
SILVER	ND	ND	0.5	ND	ND	ND	ND
SODIUM	183	319	466	329	352	143	366
THALLIUM	2	ND	ND	ND	ND	0.3	ND
VANADIUM	52	79.4	60.4	46.9	52.7	74	57.1
ZINC	105	75	65.4	78.7	64	76.2	69.8
VOLATILES							
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROPROPANE	ND	ND	ND	ND	ND	ND	ND
BROMODICHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND
BROMOFORM	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND
CIS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND	ND
DIBROMOCHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	0.015 J	ND	ND	0.0029 J
STYRENE	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND
TRANS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND
TRANS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND
BENZENE	0.0016 J	ND	ND	0.0069 J	ND	ND	ND
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	ND	ND	ND	ND	ND	ND	0.0043 J
BROMOMETHANE	ND	ND	ND	ND	ND	ND	ND

TABLE C-4
BOREHOLE SOIL CUTTINGS ANALYTICAL RESULTS

Chemical Name	LMW1-C (mg/kg)	LMW2-C (mg/kg)	LMW3-C (mg/kg)	LMW4-C (mg/kg)	LMW5-C (mg/kg)	LMW6-C (mg/kg)	LMW7-C (mg/kg)
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	0.069	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	0.069	0.064 M	ND	0.061	ND	ND	ND
PHENANTHRENE	0.093	0.1	ND	0.33	0.071	0.096	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	1.2	1.1	1.8	1.7	4.1	2.6	2.8
PESTICIDES\PCB							
ALDRIN	ND	ND	ND	ND	ND	ND	ND
ALPHA-BHC	ND	ND	ND	ND	ND	ND	ND
ALPHA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND
BETA-BHC	ND	ND	ND	ND	ND	ND	ND
DELTA-BHC	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN I	ND	ND	ND	ND	ND	ND	ND
GAMMA-BHC (LINDANE)	ND	ND	ND	ND	ND	ND	ND
GAMMA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND
DIELDRIN	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN II	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND	ND	ND	ND	ND

TABLE C-4
BOREHOLE SOIL CUTTINGS ANALYTICAL RESULTS

Chemical Name	LMW1-C (mg/kg)	LMW2-C (mg/kg)	LMW3-C (mg/kg)	LMW4-C (mg/kg)	LMW5-C (mg/kg)	LMW6-C (mg/kg)	LMW7-C (mg/kg)
CHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
CHLOROMETHANE	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	0.0043 J	0.0027 J	0.0026 J	ND
TRICHLOROFLUOROMETHANE	ND	ND	ND	0.01 J	0.0023 J	0.0041 J	ND
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND
TOLUENE	0.0027 J	ND	0.0012	0.03 J	0.0042 J	0.0013 J	0.0025 J
2-BUTANONE	ND	ND	ND	0.0089 J	ND	ND	ND
2-CHLOROETHYLVINYLETHER	ND	ND	ND	ND	ND	ND	ND
2-HEXANONE	ND	ND	ND	ND	ND	ND	ND
4-METHYL-2-PENTANONE	ND	ND	ND	ND	ND	ND	ND
VINYL ACETATE	ND	ND	ND	ND	ND	ND	ND
XYLENES (TOTAL)	0.0072 J	ND	ND	0.025 J	0.0047 J	ND	0.0071 J
CARBON DISULFIDE	0.014 J	ND	ND	0.0027 J	0.002 J	0.0028 J	ND
ACETONE	0.025 J	0.0087 J	0.018	0.03 J	ND	0.071 J	ND
SEMI-VOLATILES							
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	0.11	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	0.21	ND	ND	0.12	ND	ND	0.055
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND

TABLE C-4

BOREHOLE SOIL CUTTINGS ANALYTICAL RESULTS

Chemical Name	LMW1-C (mg/kg)	LMW2-C (mg/kg)	LMW3-C (mg/kg)	LMW4-C (mg/kg)	LMW5-C (mg/kg)	LMW6-C (mg/kg)	LMW7-C (mg/kg)
ENDRIN	ND	ND	ND	ND	ND	ND	ND
ENDRIN ALDEHYDE	ND	ND	ND	ND	ND	ND	ND
ENDRIN KETONE	ND	ND	ND	ND	ND	ND	ND
METHOXYCHLOR	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1016/1242	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1232	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1248	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1254	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1260	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1221	ND	ND	ND	ND	ND	ND	ND
TOXAPHENE	ND	ND	ND	ND	ND	ND	ND

ND - Not Detected

J - The J qualifier indicates the constituent was analyzed for and detected, but the detection was at a concentration which is less than the calculated detection limit.

During data validation the J qualifier may be applied to indicate a minor quality control deficiency.

M - The M qualifier indicates an estimated value of an analyte detected and confirmed by analyst with low spectral match parameters

TABLE C-5a
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	Portal # 2 (μg/L)	Portal # 3 (μg/L)
METALS		
ALUMINUM	90	ND
ANTIMONY	ND	ND
ARSENIC	ND	2
BARIUM	49	233
BERYLLIUM	ND	ND
CADMIUM	ND	ND
CALCIUM	37400	86400
CHROMIUM	ND	ND
COBALT	ND	ND
COPPER	ND	ND
IRON	430	758
LEAD	ND	ND
MAGNESIUM	33800	50600
MANGANESE	254	233
MERCURY	ND	ND
NICKEL	ND	ND
POTASSIUM	2800	2800
SELENIUM	2	2
SILICON	1810	9800
SILVER	ND	ND
SODIUM	4300	22500
THALLIUM	ND	ND
VANADIUM	ND	ND
ZINC	4	ND
SEMI-VOLATILES		
1,2,4-TRICHLOROBENZENE	ND	ND
1,2-DICHLOROBENZENE	ND	ND
1,3-DICHLOROBENZENE	ND	ND
1,4-DICHLOROBENZENE	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND
2-CHLORONAPHTHALENE	ND	ND
2-CHLOROPHENOL	ND	ND
2-METHYLNAPHTHALENE	ND	ND
2-METHYLPHENOL	ND	ND
4-METHYLPHENOL	ND	ND
ACENAPHTHENE	ND	ND
ACENAPHTHYLENE	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND
DIMETHYLPHTHALATE	ND	ND
ISOPHORONE	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND
NAPHTHALENE	ND	ND
NITROBENZENE	ND	ND
2,4-DIMETHYLPHENOL	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND
HEXACHLOROBUTADIENE	ND	ND
HEXACHLOROETHANE	ND	ND
PHENOL	ND	ND
2,4-DICHLOROPHENOL	ND	ND
4-CHLOROANILINE	ND	ND

TABLE C-5a
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	Portal # 2 (μg/L)	Portal # 3 (μg/L)
2,4,5-TRICHLOROPHENOL	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND
2-NITROANILINE	ND	ND
2-NITROPHENOL	ND	ND
3-NITROANILINE	ND	ND
BENZYL ALCOHOL	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND
2,4-DINITROPHENOL	ND	ND
BENZOIC ACID	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND
ANTHRACENE	ND	ND
BENZO(A)ANTHRACENE	ND	ND
BENZO(A)PYRENE	ND	ND
BENZO(B)FLUORANTHENE	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND
BENZO(K)FLUORANTHENE	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND
CARBAZOLE	ND	ND
CHRYSENE	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND
DIBENZOFURAN	ND	ND
DIETHYLPHTHALATE	ND	1
FLUORANTHENE	ND	ND
FLUORENE	ND	ND
HEXACHLOROBENZENE	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND
PHENANTHRENE	ND	ND
PYRENE	ND	ND
2,4-DINITROTOLUENE	ND	ND
2,6-DINITROTOLUENE	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND
4-NITROANILINE	ND	ND
4-NITROPHENOL	ND	ND
PENTACHLOROPHENOL	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND
PESTICIDES\PCB		
ALDRIN	ND	ND
ALPHA-BHC	ND	ND
ALPHA-CHLORDANE	ND	ND
BETA-BHC	ND	ND
DELTA-BHC	ND	ND
ENDOSULFAN I	ND	ND
GAMMA-BHC (LINDANE)	ND	ND
GAMMA-CHLORDANE	ND	ND
HEPTACHLOR	ND	ND
HEPTACHLOR EPOXIDE	ND	ND
4,4'-DDD	ND	ND

TABLE C-5a
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	Portal # 2 (μg/L)	Portal # 3 (μg/L)
4,4'-DDE	ND	ND
4,4'-DDT	ND	ND
DIELDRIN	ND	ND
ENDOSULFAN II	ND	ND
ENDOSULFAN SULFATE	ND	ND
ENDRIN	ND	ND
ENDRIN ALDEHYDE	ND	ND
ENDRIN KETONE	ND	ND
METHOXYCHLOR	ND	ND
AROCLOR-1016/1242	ND	ND
AROCLOR-1232	ND	ND
AROCLOR-1242	ND	ND
AROCLOR-1248	ND	ND
AROCLOR-1254	ND	ND
AROCLOR-1260	ND	ND
AROCLOR-1221	ND	ND
TOXAPHENE	ND	ND
ANALYSIS 524.2		
Benzene	ND	ND
Bromobenzene	ND	ND
Bromochloromethane	ND	ND
Bromodichloromethane	ND	ND
Bromoform	ND	ND
Bromomethane	ND	ND
n-Butylbenzene	ND	ND
sec-Butylbenzene	ND	ND
tert-Butylbenzene	ND	ND
Carbon tetrachloride	ND	ND
Chlorobenzene	ND	ND
Chloroethane	ND	ND
Chloroform	ND	ND
Chloromethane	ND	ND
2-Chlorotoluene	ND	ND
4-Chlorotoluene	ND	ND
Dibromochloromethane	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND
1,2-Dibromomethane	ND	ND
Dibromomethane	ND	ND
1,2-Dichlorobenzene	ND	ND
1,3-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
Dichlorodifluoromethane	ND	ND
1,1-Dichloroethane	ND	ND
1,2-Dichloroethane	ND	ND
1,1-Dichloroethene	ND	ND
cis-1,2-Dichloroethene	ND	ND
trans-1,2-Dichloroethene	ND	ND
1,2-Dichloropropane	ND	ND
2,2-Dichloropropane	ND	ND
1,1-Dichloropropene	ND	ND
Ethylbenzene	ND	ND
Hexchlorobutadiene	ND	ND

TABLE C-5a
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	**Portal # 2 ($\mu g/L$)**	**Portal # 3 ($\mu g/L$)**
Isopropylbenzene	ND	ND
p-Isopropyltoluene	ND	ND
Methylene chloride	ND	ND
Naphthalene	ND	ND
n-Propylbenzene	ND	ND
Styrene	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
Tetrachloroethene	ND	ND
Toluene	ND	ND
1,2,3-Trichlorobenzene	ND	ND
1,2,4-Trichlorobenzene	ND	ND
1,1,1-Trichloroethane	ND	ND
1,1,2-Trichloroethane	ND	ND
Trichloroethene	ND	ND
Trichlorofluoromethane	ND	ND
1,2,3-Trichloropropane	ND	ND
1,2,4-Trimethylbenzne	ND	ND
1,3,5-Trimethylbenzne	ND	ND
Vinyl Chloride	ND	ND
o-Xylene	ND	ND
m-Xylene	ND	ND
p-Xylene	ND	ND
cis-1,3-Dichloropropene	ND	ND
trans-1,3-Dichloropropene	ND	ND
Carbon disulfide	ND	ND
Acetone	ND	ND
2-Butanone	ND	ND
4-Methyl-2-pentanone	ND	ND
2-Hexanone	ND	ND
Vinyl acetate	ND	ND
ANALYSIS 525		
Alachlor	ND	ND
Atrazine	ND	ND
Chlordane	ND	ND
Heptachlor	ND	ND
Heptachlor epoxide	ND	ND
Lindane	ND	ND
Methoxychlor	ND	ND
PCB	ND	ND
Toxaphene	ND	ND
Pentachlorophenol	ND	ND
Hexachlorobenzene	ND	ND
Hexachlorocylopentadiene	ND	ND
Metachlor	ND	ND
Simazine	ND	ND
Aldrin	ND	ND
Endrin	ND	ND
Di(ethylhexyl)adipate	ND	ND
Di(ethylhexyl)phthalate	ND	ND
Dieldrin	ND	ND
Dinoseb	ND	ND

TABLE C-5a

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	Portal # 2 (μg/L)	Portal # 3 (μg/L)
Acenaphthylene	ND	ND
Fluorene	ND	ND
Phenanthrene	ND	ND
Anthracene	ND	ND
Pyrene	ND	ND
Chrysene	ND	ND
Benzo(a)pyrene	ND	ND
Benzo(a)anthracene	ND	ND
Benzo(b)fluoranthene	ND	ND
Benzo(k)fluoranthene	ND	ND
Benzo(ghi)perylene	ND	ND
Dibenzo(ah)anthracene	ND	ND
Indeno(123-cd)pyrene	ND	ND
4,4'-DDD	ND	ND
4,4'-DDE	ND	ND
4,4'-DDT	ND	ND
GENERAL CHEMISTRY		
pH	7.37	7.09
Carbonate, μg/L CaCO3	ND	ND
Bicarbonate, μg/L CaCO3	194000	444000
Hardness, μg/L CaCO3	233000	424000
Conductivity, μmhos/cm	424	798
TDS, μg/L	203000	420000
Turbidity, NTU	3.1	3.2
Fluoride	100	ND
Chloride	2300	2100
Nitrate (as N)	ND	ND
Nitrite (as N)	ND	ND
Sulfate	29000	18600

ND - Analyte was Not Detected

TABLE C-5b
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (2ND QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
METALS		
ALUMINUM	150	ND
ANTIMONY	ND	ND
ARSENIC	ND	3
BARIUM	117	232
BERYLLIUM	ND	ND
CADMIUM	ND	ND
CALCIUM	82800	86400
CHROMIUM	ND	ND
COBALT	ND	ND
COPPER	ND	ND
IRON	2160	1640
LEAD	ND	ND
MAGNESIUM	65000	51500
MANGANESE	1510	214
MERCURY	ND	ND
NICKEL	ND	ND
POTASSIUM	5600	2600
SELENIUM	1	1
SILICON	4990	9480
SILVER	ND	ND
SODIUM	9990	22500
THALLIUM	ND	ND
VANADIUM	ND	ND
ZINC	ND	ND
SEMI-VOLATILES		
BENZYL ALCOHOL	ND	ND
2,4-DIMETHYLPHENOL	ND	ND
4-METHYLPHENOL	ND	ND
1,4-DICHLOROBENZENE	ND	ND
4-CHLOROANILINE	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND
PHENOL	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND
2,4-DICHLOROPHENOL	ND	ND
DIMETHYLPHTHALATE	ND	ND
ACENAPHTHYLENE	ND	ND
2,4-DINITROPHENOL	ND	ND
1,3-DICHLOROBENZENE	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND
BENZOIC ACID	ND	ND
HEXACHLOROETHANE	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND

TABLE C-5b

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (2ND QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
ISOPHORONE	ND	ND
ACENAPHTHENE	ND	ND
HEXACHLOROBUTADIENE	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND
2-NITROANILINE	ND	ND
2-NITROPHENOL	ND	ND
NAPHTHALENE	ND	ND
2-METHYLNAPHTHALENE	ND	ND
2-CHLORONAPHTHALENE	ND	ND
2-METHYLPHENOL	ND	ND
1,2-DICHLOROBENZENE	ND	ND
2-CHLOROPHENOL	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND
NITROBENZENE	ND	ND
3-NITROANILINE	ND	ND
4-NITROANILINE	ND	ND
4-NITROPHENOL	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND
HEXACHLOROBENZENE	ND	ND
ANTHRACENE	ND	ND
2,4-DINITROTOLUENE	ND	ND
PYRENE	ND	ND
DIBENZOFURAN	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND
BENZO(B)FLUORANTHENE	ND	ND
FLUORANTHENE	ND	ND
BENZO(K)FLUORANTHENE	ND	ND
CHRYSENE	ND	ND
BENZO(A)PYRENE	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND
BENZO(A)ANTHRACENE	ND	ND
2,6-DINITROTOLUENE	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND
DIETHYLPHTHALATE	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND
PHENANTHRENE	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND
FLUORENE	ND	ND
CARBAZOLE	ND	ND
PENTACHLOROPHENOL	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND

TABLE C-5b
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (2ND QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
PESTICIDES/PCB		
HEPTACHLOR EPOXIDE	ND	ND
ENDOSULFAN SULFATE	ND	ND
AROCLOR-1260	ND	ND
AROCLOR-1254	ND	ND
AROCLOR-1221	ND	ND
AROCLOR-1232	ND	ND
AROCLOR-1248	ND	ND
AROCLOR-1016	ND	ND
ALDRIN	ND	ND
ALPHA-BHC	ND	ND
BETA-BHC	ND	ND
DELTA-BHC	ND	ND
ENDOSULFAN II	ND	ND
4,4'-DDT	ND	ND
ALPHA-CHLORDANE	ND	ND
GAMMA-CHLORDANE	ND	ND
AROCLOR-1242	ND	ND
ENDRIN KETONE	ND	ND
GAMMA-BHC (LINDANE)	ND	ND
DIELDRIN	ND	ND
ENDRIN	ND	ND
METHOXYCHLOR	ND	ND
4,4'-DDD	ND	ND
4,4'-DDE	ND	ND
ENDRIN ALDEHYDE	ND	ND
HEPTACHLOR	ND	ND
TOXAPHENE	ND	ND
ENDOSULFAN I	ND	ND
Analysis 524.2		
Benzene	ND	ND
Bromobenzene	ND	ND
Bromochloromethane	ND	ND
Bromodichloromethane	ND	ND
Bromoform	ND	ND
Bromomethane	ND	ND
n-Butylbenzene	ND	ND
sec-Butylbenzene	ND	ND
tert-Butylbenzene	ND	ND
Carbon tetrachloride	ND	ND
Chlorobenzene	ND	ND
Chloroethane	ND	ND
Chloroform	ND	ND
Chloromethane	ND	ND
2-Chlorotoluene	ND	ND
4-Chlorotoluene	ND	ND

TABLE C-5b
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (2ND QUARTER)

Chemical Name	**Portal #2 (μg/L)**	**Portal #3 (μg/L)**
Dibromochloromethane	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND
1,2-Dibromomethane	ND	ND
Dibromomethane	ND	ND
1,2-Dichlorobenzene	ND	ND
1,3-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
Dichlorodifluoromethane	ND	ND
1,1-Dichloroethane	1	ND
1,2-Dichloroethane	ND	ND
1,1-Dichloroethene	ND	ND
cis-1,2-Dichloroethene	ND	ND
trans-1,2-Dichloroethene	ND	ND
1,2-Dichloropropane	ND	ND
2,2-Dichloropropane	ND	ND
1,1-Dichloropropene	ND	ND
Ethylbenzene	ND	ND
Hexchlorobutadiene	ND	ND
Isopropylbenzene	ND	ND
p-Isopropyltoluene	ND	ND
Methylene chloride	ND	ND
Naphthalene	ND	ND
n-Propylbenzene	ND	ND
Styrene	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
Tetrachloroethene	ND	ND
Toluene	ND	ND
1,2,3-Trichlorobenzene	ND	ND
1,2,4-Trichlorobenzene	ND	ND
1,1,1-Trichloroethane	ND	ND
1,1,2-Trichloroethane	ND	ND
Trichloroethene	ND	ND
Trichlorofluoromethane	ND	ND
1,2,3-Trichloropropane	ND	ND
1,2,4-Trimethylbenzne	ND	ND
1,3,5-Trimethylbenzne	ND	ND
Vinyl Chloride	ND	ND
o-Xylene	ND	ND
m-Xylene	ND	ND
p-Xylene	ND	ND
cis-1,3-Dichloropropene	ND	ND
trans-1,3-Dichloropropene	ND	ND
Carbon disulfide	ND	ND
Acetone	ND	ND
2-Butanone	ND	ND

TABLE C-5b

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (2ND QUARTER)

Chemical Name	**Portal #2 (µg/L)**	**Portal #3 (µg/L)**
4-Methyl-2-pentanone	ND	ND
2-Hexanone	ND	ND
Vinyl acetate	ND	ND
GENERAL CHEMISTRY		
pH	6.72	6.99
Carbonate, µg/L CaCO3	ND	ND
Bicarbonate, µg/L CaCO3	421000	474000
Conductivity µmhos/cm	864	828
Total Disolved Solids µg/l	474000	436000
Turbidity, NTU	6.30	9.80
Fluoride	130	ND
Chloride	3500	1800
Nitrate (as N)	14	ND
Nitrite (as N)	ND	ND
Sulfate	82500	20200
Total Cyanide	ND	ND

ND - Analyte was Not Detected

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESUTLS (3rd QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
METALS		
ALUMINUM	180 J	ND
ANTIMONY	ND	ND
ARSENIC	1	2
BARIUM	29	216
BERYLLIUM	ND	ND
CADMIUM	ND	ND
CALCIUM	22000	79900
CHROMIUM	ND	ND
COBALT	ND	ND
COPPER	ND	ND
IRON	200	5500
LEAD	ND	ND
MAGNESIUM	24300	47400
MANGANESE	48	227
MERCURY	ND	ND
NICKEL	ND	ND
POTASSIUM	3700	2600
SELENIUM	1	ND
SILICON	ND	9130
SILVER	ND	ND
SODIUM	2830	22100 J
THALLIUM	ND	ND
VANADIUM	ND	ND
ZINC	5	ND
SEMI-VOLATILES		
BENZYL ALCOHOL	ND	ND
2,4-DIMETHYLPHENOL	ND	ND
4-METHYLPHENOL	ND	ND
1,4-DICHLOROBENZENE	ND	ND
4-CHLOROANILINE	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND
PHENOL	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND
2,4-DICHLOROPHENOL	ND	ND
DIMETHYLPHTHALATE	ND	ND
ACENAPHTHYLENE	ND	ND
2,4-DINITROPHENOL	ND	ND
1,3-DICHLOROBENZENE	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND
BENZOIC ACID	ND	ND
HEXACHLOROETHANE	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND

TABLE C-5c

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESUTLS (3rd QUARTER)

Chemical Name	**Portal #2 (μg/L)**	**Portal #3 (μg/L)**
ISOPHORONE	ND	ND
ACENAPHTHENE	ND	ND
HEXACHLOROBUTADIENE	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND
2-NITROANILINE	ND	ND
2-NITROPHENOL	ND	ND
NAPHTHALENE	ND	ND
2-METHYLNAPHTHALENE	ND	ND
2-CHLORONAPHTHALENE	ND	ND
2-METHYLPHENOL	ND	ND
1,2-DICHLOROBENZENE	ND	ND
2-CHLOROPHENOL	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND
NITROBENZENE	ND	ND
3-NITROANILINE	ND	ND
4-NITROANILINE	ND	ND
4-NITROPHENOL	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND
HEXACHLOROBENZENE	ND	ND
ANTHRACENE	ND	ND
2,4-DINITROTOLUENE	ND	ND
PYRENE	ND	ND
DIBENZOFURAN	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND
BENZO(B)FLUORANTHENE	ND	ND
FLUORANTHENE	ND	ND
BENZO(K)FLUORANTHENE	ND	ND
CHRYSENE	ND	ND
BENZO(A)PYRENE	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND
BENZO(A)ANTHRACENE	ND	ND
2,6-DINITROTOLUENE	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND
DIETHYLPHTHALATE	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND
PHENANTHRENE	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND
FLUORENE	ND	ND
CARBAZOLE	ND	ND
PENTACHLOROPHENOL	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND

TABLE C-5c
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESUTLS (3rd QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
PESTICIDES/PCB (Analysis 508)		
Aldrin	ND	ND
Chlordane-alpha	ND	ND
Chlordane-gamma	ND	ND
Chlorneb	ND	ND
Chlorobenzilate	ND	ND
Chlorothalonil	ND	ND
DCPA	ND	ND
4,4'-DDD	ND	ND
4,4'-DDE	ND	ND
4,4'-DDT	ND	ND
Dieldrin	ND	ND
Endosulfan I	ND	ND
Endosulfan sulfate	ND	ND
Endrin	ND	ND
Endrin aldehyde	ND	ND
Endosulfan II	ND	ND
Etridiazole	ND	ND
HCH-alpha	ND	ND
HCH-beta	ND	ND
HDH-delta	ND	ND
HCH-gamma	ND	ND
Heptachlor	ND	ND
Heptachlor epoxide	ND	ND
Hexachlorobenzene	ND	ND
Methoxychlor	ND	ND
cis-Permethrin	ND	ND
trans-Permethrin	ND	ND
Propachlor	ND	ND
Trifluralin	ND	ND
Toxaphene	ND	ND
Chlordane	ND	ND
Aroclor 1016	ND	ND
Aroclor 1221	ND	ND
Aroclor 1232	ND	ND
Aroclor 1242	ND	ND
Aroclor 1248	ND	ND
Aroclor 1254	ND	ND
Aroclor 1260	ND	ND
Analysis 524.2		
Benzene	ND	ND
Bromobenzene	ND	ND
Bromochloromethane	ND	ND
Bromodichloromethane	ND	ND
Bromoform	ND	ND
Bromomethane	ND	ND

TABLE C-5c
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESUTLS (3rd QUARTER)

Chemical Name	**Portal #2 (μg/L)**	**Portal #3 (μg/L)**
n-Butylbenzene	ND	ND
sec-Butylbenzene	ND	ND
tert-Butylbenzene	ND	ND
Carbon tetrachloride	ND	ND
Chlorobenzene	ND	ND
Chloroethane	ND	ND
Chloroform	ND	ND
Chloromethane	ND	ND
2-Chlorotoluene	ND	ND
4-Chlorotoluene	ND	ND
Dibromochloromethane	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND
1,2-Dibromomethane	ND	ND
Dibromomethane	ND	ND
1,2-Dichlorobenzene	ND	ND
1,3-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
Dichlorodifluoromethane	ND	ND
1,1-Dichloroethane	ND	ND
1,2-Dichloroethane	ND	ND
1,1-Dichloroethene	ND	ND
cis-1,2-Dichloroethene	ND	ND
trans-1,2-Dichloroethene	ND	ND
1,2-Dichloropropane	ND	ND
2,2-Dichloropropane	ND	ND
1,1-Dichloropropene	ND	ND
Ethylbenzene	ND	ND
Hexchlorobutadiene	ND	ND
Isopropylbenzene	ND	ND
p-Isopropyltoluene	ND	ND
Methylene chloride	ND	ND
Naphthalene	ND	ND
n-Propylbenzene	ND	ND
Styrene	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
Tetrachloroethene	ND	ND
Toluene	ND	ND
1,2,3-Trichlorobenzene	ND	ND
1,2,4-Trichlorobenzene	ND	ND
1,1,1-Trichloroethane	ND	ND
1,1,2-Trichloroethane	ND	ND
Trichloroethene	ND	ND
Trichlorofluoromethane	ND	ND
1,2,3-Trichloropropane	ND	ND
1,2,4-Trimethylbenzne	ND	ND

TABLE C-5c
PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESUTLS (3rd QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
1,3,5-Trimethylbenzne	ND	ND
Vinyl Chloride	ND	ND
o-Xylene	ND	ND
m-Xylene	ND	ND
p-Xylene	ND	ND
cis-1,3-Dichloropropene	ND	ND
trans-1,3-Dichloropropene	ND	ND
Carbon disulfide	ND	ND
Acetone	ND	ND
2-Butanone	ND	ND
4-Methyl-2-pentanone	ND	ND
2-Hexanone	ND	ND
Vinyl acetate	ND	ND
Analysis 525		
Alachlor	ND	ND
Atrazine	ND	ND
Chlordane	ND	ND
Heptachlor	ND	ND
Heptachlor epoxide	ND	ND
Lindane	ND	ND
Methoxychlor	ND	ND
PCB	ND	ND
Toxaphene	ND	ND
Pentachlorophenol	ND	ND
Hexachlorobenzene	ND	ND
Hexachlorocylopentadiene	ND	ND
Metachlor	ND	ND
Simazine	ND	ND
Aldrin	ND	ND
Endrin	ND	ND
Di(ethylhexyl)adipate	ND	ND
Di(ethylhexyl)phthalate	ND	ND
Dieldrin	ND	ND
Dinoseb	ND	ND
Acenaphthylene	ND	ND
Fluorene	ND	ND
Phenanthrene	ND	ND
Anthracene	ND	ND
Pyrene	ND	ND
Chrysene	ND	ND
Benzo(a)pyrene	ND	ND
Benzo(a)anthracene	ND	ND
Benzo(b)fluoranthene	ND	ND
Benzo(k)fluoranthene	ND	ND
Benzo(ghi)perylene	ND	ND
Dibenzo(ah)anthracene	ND	ND

TABLE C-5c

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESUTLS (3rd QUARTER)

Chemical Name	**Portal #2 (μg/L)**	**Portal #3 (μg/L)**
Indeno(123-cd)pyrene	ND	ND
4,4'-DDD	ND	ND
4,4'-DDE	ND	ND
4,4'-DDT	ND	ND
GENERAL CHEMISTRY		
pH	7.2	6.9
Phenolphthalein Alkalinity, μ/L CaCO3	ND	ND
Carbonate, μg/L $CaCO_3$	ND	ND
Bicarbonate, μg/L CaCO3	110000	440000
Hardness, μg/L CaCO3		400000
Conductivity, μmhos/cm	350	800
TDS, μg/L	180000 J	430000
Turbidity, NTU	5	2.2
Fluoride	180	ND
Chloride	1900	2.6
Nitrate (as N)	480	ND
Nitrite (as N)	52	ND
Sulfate	45000	9400
Total Cyanide	ND	ND

ND - Analyte was Not Detected

J - The J qualifier indicates the constituent was analyzed for and detected. Due to a minor quality control defiency identified during data validation the associated data have been qualified as estimated.

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
METALS		
ALUMINUM	ND	ND
ANTIMONY	ND	ND
ARSENIC	ND	2
BARIUM	42	235
BERYLLIUM	ND	ND
CADMIUM	ND	ND
CALCIUM	32400	86200
CHROMIUM	ND	ND
COBALT	ND	ND
COPPER	ND	ND
IRON	340	940
LEAD	1	ND
MAGNESIUM	28000	49100
MANGANESE	62	219
MERCURY	ND	ND
NICKEL	ND	ND
POTASSIUM	2000	2600
SELENIUM	ND	ND
SILICON	1090 J	8730 J
SILVER	ND	ND
SODIUM	4880	20300
THALLIUM	ND	ND
VANADIUM	ND	ND
ZINC	13	ND
SEMI-VOLATILES		
BENZYL ALCOHOL	ND	ND
2,4-DIMETHYLPHENOL	ND	ND
4-METHYLPHENOL	ND	ND
1,4-DICHLOROBENZENE	ND	ND
4-CHLOROANILINE	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND
PHENOL	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND
2,4-DICHLOROPHENOL	ND	ND
DIMETHYLPHTHALATE	ND	ND
ACENAPHTHYLENE	ND	ND
2,4-DINITROPHENOL	ND	ND
1,3-DICHLOROBENZENE	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND
BENZOIC ACID	ND	ND
HEXACHLOROETHANE	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND

TABLE C-5d

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
ISOPHORONE	ND	ND
ACENAPHTHENE	ND	ND
HEXACHLOROBUTADIENE	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND
2-NITROANILINE	ND	ND
2-NITROPHENOL	ND	ND
NAPHTHALENE	ND	ND
2-METHYLNAPHTHALENE	ND	ND
2-CHLORONAPHTHALENE	ND	ND
2-METHYLPHENOL	ND	ND
1,2-DICHLOROBENZENE	ND	ND
2-CHLOROPHENOL	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND
NITROBENZENE	ND	ND
3-NITROANILINE	ND	ND
4-NITROANILINE	ND	ND
4-NITROPHENOL	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND
HEXACHLOROBENZENE	ND	ND
ANTHRACENE	ND	ND
2,4-DINITROTOLUENE	ND	ND
PYRENE	ND	ND
DIBENZOFURAN	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND
BENZO(B)FLUORANTHENE	ND	ND
FLUORANTHENE	ND	ND
BENZO(K)FLUORANTHENE	ND	ND
CHRYSENE	ND	ND
BENZO(A)PYRENE	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND
BENZO(A)ANTHRACENE	ND	ND
2,6-DINITROTOLUENE	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND
DIETHYLPHTHALATE	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND
PHENANTHRENE	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND
FLUORENE	ND	ND
CARBAZOLE	ND	ND
PENTACHLOROPHENOL	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND

TABLE C-5d

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
PESTICIDES/PCB		
alpha-BHC	ND	ND
beta-BHC	ND	ND
delta-BHC	ND	ND
gamma-BHC (Lindane)	ND	ND
Heptachlor	ND	ND
Aldrin	ND	ND
Heptachlor Epoxide	ND	ND
Endosulfan I	ND	ND
Dieldrin	ND	ND
4,4'-DDE	ND	ND
Endrin	ND	ND
Endosulfan II	ND	ND
4,4'-DDD	ND	ND
Endosulfan Sulfate	ND	ND
4,4'-DDT	ND	ND
Methoxychlor	ND	ND
Endrin Ketone	ND	ND
gamma Chlordane	ND	ND
alpha Chlordane	ND	ND
Toxaphene	ND	ND
Aroclor 1016	ND	ND
Aroclor 1242	ND	ND
Aroclor 1248	ND	ND
Aroclor 1254	ND	ND
Aroclor 1260	ND	ND
Aroclor 1221	ND	ND
Aroclor 1232	ND	ND
Analysis 524.2		
Benzene	ND	ND
Bromobenzene	ND	ND
Bromochloromethane	ND	ND
Bromodichloromethane	ND	ND
Bromoform	ND	ND
Bromomethane	ND	ND
n-Butylbenzene	ND	ND
sec-Butylbenzene	ND	ND
tert-Butylbenzene	ND	ND
Carbon tetrachloride	ND	ND
Chlorobenzene	ND	ND
Chloroethane	ND	ND
Chloroform	ND	ND
Chloromethane	ND	ND
2-Chlorotoluene	ND	ND
4-Chlorotoluene	ND	ND
Dibromochloromethane	ND	ND

TABLE C-5d

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	**Portal #2 (μg/L)**	**Portal #3 (μg/L)**
1,2-Dibromo-3-chloropropane	ND	ND
1,2-Dibromomethane	ND	ND
Dibromomethane	ND	ND
1,2-Dichlorobenzene	ND	ND
1,3-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
Dichlorodifluoromethane	ND	ND
1,1-Dichloroethane	0.5	ND
1,2-Dichloroethane	ND	ND
1,1-Dichloroethene	ND	ND
cis-1,2-Dichloroethene	ND	ND
trans-1,2-Dichloroethene	ND	ND
1,2-Dichloropropane	ND	ND
2,2-Dichloropropane	ND	ND
1,1-Dichloropropene	ND	ND
Ethylbenzene	ND	ND
Hexchlorobutadiene	ND	ND
Isopropylbenzene	ND	ND
p-Isopropyltoluene	ND	ND
Methylene chloride	ND	ND
Naphthalene	ND	ND
n-Propylbenzene	ND	ND
Styrene	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
Tetrachloroethene	ND	ND
Toluene	ND	ND
1,2,3-Trichlorobenzene	ND	ND
1,2,4-Trichlorobenzene	ND	ND
1,1,1-Trichloroethane	ND	ND
1,1,2-Trichloroethane	ND	ND
Trichloroethene	ND	ND
Trichlorofluoromethane	ND	ND
1,2,3-Trichloropropane	ND	ND
1,2,4-Trimethylbenzne	ND	ND
1,3,5-Trimethylbenzne	ND	ND
Vinyl Chloride	ND	ND
o-Xylene	ND	ND
m-Xylene	ND	ND
p-Xylene	ND	ND
cis-1,3-Dichloropropene	ND	ND
trans-1,3-Dichloropropene	ND	ND
Carbon disulfide	ND	ND
Acetone	ND	ND
2-Butanone	ND	ND
4-Methyl-2-pentanone	ND	ND

TABLE C-5d

PORTAL #2 AND PORTAL #3 SURFACE WATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	Portal #2 (μg/L)	Portal #3 (μg/L)
2-Hexanone	ND	ND
Vinyl acetate	ND	ND
GENERAL CHEMISTRY		
pH	7.2	6.9
Carbonate, μg/L $CaCO_3$	ND	ND
Bicarbonate, μg/L CaCO3	150000	430000
Hardness, μg/L CaCO3	200000	420000
Conductivity, μmhos/cm	370	760
TDS, μg/L	190000	470000
Turbidity, NTU	3.6 J	4.7
Fluoride	ND	ND
Chloride	2200	2000
Total Cyanide, μg/L	ND	ND
Nitrate (as N)	140	53
Nitrite (as N)	ND	ND
Sulfate	45000	29000

ND - Analyte was Not Detected

J - The J qualifier indicates the constituent was analyzed for and detected. Due to a minor quality control defiency identified during data validation the associated data have been qualified as estimated.

TABLE C-6a
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (1ST QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
METALS							
ALUMINUM	ND	ND	40	ND	ND	100	100
ANTIMONY	ND	ND	ND	ND	ND	ND	ND
ARSENIC	4	ND	1	ND	ND	ND	2
BARIUM	57	246	99	226	238	87	557
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND
CADMIUM	ND	ND	ND	ND	ND	ND	ND
CALCIUM	90600	142000	45800	138000	94600	28800	63900
CHROMIUM	ND	ND	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	ND	ND	ND
COPPER	ND	ND	ND	ND	ND	ND	ND
IRON	316	979	60	954	304	2150	910
LEAD	ND	ND	1	ND	ND	ND	ND
MAGNESIUM	47900	87500	18600	84300	55200	14600	30000
MANGANESE	32	276	99	289	265	37	157
MERCURY	ND	ND	ND	ND	ND	ND	ND
NICKEL	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	3200	4300	2300	4300	3000	1000	3600
SELENIUM	ND	2	ND	2	ND	ND	ND
SILICON	13600	10100	11100	9940	9770	11000	11100
SILVER	ND	ND	ND	ND	ND	ND	ND
SODIUM	21900	30700	13200	33800	25100	7640	65600
THALLIUM	ND	2	1	ND	ND	ND	ND
VANADIUM	ND	2	ND	ND	2	3	ND
ZINC	ND	4	ND	ND	ND	7	5
SEMI-VOLATILES							
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND

TABLE C-6a

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (1ST QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCB							
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1260	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1254	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1221	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1232	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1248	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1016	ND	ND	ND	ND	ND	ND	ND
ALDRIN	ND	ND	ND	ND	ND	ND	ND
ALPHA-BHC	ND	ND	ND	ND	ND	ND	ND
BETA-BHC	ND	ND	ND	ND	ND	ND	ND

TABLE C-6a

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (1ST QUARTER)

Chemical Name	**LMW-1 (μg/L)**	**LMW-2 (μg/L)**	**LMW-3 (μg/L)**	**LMW-4 (μg/L)**	**LMW-5 (μg/L)**	**LMW-6 (μg/L)**	**LMW-7 (μg/L)**
DELTA-BHC	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN II	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND
ALPHA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND
GAMMA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1242	ND	ND	ND	ND	ND	ND	ND
ENDRIN KETONE	ND	ND	ND	ND	ND	ND	ND
GAMMA-BHC (LINDANE)	ND	ND	ND	ND	ND	ND	ND
DIELDRIN	ND	ND	ND	ND	ND	ND	ND
ENDRIN	ND	ND	ND	ND	ND	ND	ND
METHOXYCHLOR	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND
ENDRIN ALDEHYDE	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR	ND	ND	ND	ND	ND	ND	ND
TOXAPHENE	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN I	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2							
Benzene	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND
Hexchlorobutadiene	ND	ND	ND	ND	ND	ND	ND

TABLE C-6a
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (1ST QUARTER)

Chemical Name	LMW-1 ($\mu g/L$)	LMW-2 ($\mu g/L$)	LMW-3 ($\mu g/L$)	LMW-4 ($\mu g/L$)	LMW-5 ($\mu g/L$)	LMW-6 ($\mu g/L$)	LMW-7 ($\mu g/L$)
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND
Analysis 525							
Alachlor	ND	ND	ND	ND	ND	ND	ND
Atrazine	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND
PCB	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND
Hexachlorocylopentadiene	ND	ND	ND	ND	ND	ND	ND
Metachlor	ND	ND	ND	ND	ND	ND	ND
Simazine	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Di(ethylhexyl)adipate	ND	ND	ND	ND	ND	ND	ND
Di(ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
Dinoseb	ND	ND	ND	ND	ND	ND	ND

TABLE C-6a

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (1ST QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND
Benzo(ghi)perylene	ND	ND	ND	ND	ND	ND	ND
Dibenzo(ah)anthracene	ND	ND	ND	ND	ND	ND	ND
Indeno(123-cd)pyrene	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND
Analysis 504							
1,2-Dibromo-3-chloropropane	ND	**0.025 J**	ND	ND	**0.025 J**	ND	ND
Ethylene dibromide	ND	ND	ND	ND	ND	ND	ND
Analysis 515.1							
2,4-D	ND	ND	ND	ND	ND	ND	ND
2,4,5-TP	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND
Dalapon	ND	ND	ND	ND	ND	ND	ND
Dinoseb	ND	ND	ND	ND	ND	ND	ND
Dicamba	ND	ND	ND	ND	ND	ND	ND
Picloram	ND	ND	ND	ND	ND	ND	ND
Analysis 531.1							
Aldicarb	ND	ND	ND	ND	ND	ND	ND
Aldicarb sulfoxide	ND	ND	ND	ND	ND	ND	ND
Aldicarb sulfone	ND	ND	ND	ND	ND	ND	ND
Carbofuran	ND	ND	ND	ND	ND	ND	ND
Carbaryl	ND	ND	ND	ND	ND	ND	ND
3-Hydroxycarbofuran	ND	ND	ND	ND	ND	ND	ND
Methomyl	ND	ND	ND	ND	ND	ND	ND
Oxamyl (vydate)	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY							
pH	7.23	7.09	7.62	6.96	6.95	6.98	7.18
Carbonate, μg/L CaCO3	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, μg/L CaCO3	356000	718000	195000	730000	520000	126000	415000
Hardness, μg/L CaCO3		715000	191000	692000	464000		
Conductivity, μmhos/cm	808	1250	384	1240	866	266	709
TDS, μg/L	504000	732000	213000	769000	497000	157000	421000
Turbidity, NTU	5.6	9.1	1.74	7.1	0.57	2.7	5.3
Fluoride	110	ND	ND	ND	ND	110	170
Chloride	2200	5700	2500	6400	2500	2100	2800
Nitrate (as N)	ND	ND	16	ND	ND	ND	ND
Nitrite (as N)	ND	ND	ND	ND	ND	ND	ND
Sulfate	122000	44600	21000	52000	11200	23500	7500

ND - Analyte was Not Detected

J - The J qualifier indicates the constituent was tested for and detected, but the detection was at a concentration which is less than the calculated detection limit.

TABLE C-6b

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
METALS							
ALUMINUM	ND	ND	20	ND	ND	140	ND
ANTIMONY	ND	ND	ND	ND	ND	ND	ND
ARSENIC	2	ND	ND	ND	ND	ND	1
BARIUM	46	230	92	210	220	88	570
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND
CADMIUM	ND	ND	ND	ND	ND	ND	ND
CALCIUM	88000	140000	44000	140000	91000	29000	62000
CHROMIUM	ND	ND	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	ND	ND	ND
COPPER	2	ND	ND	ND	ND	ND	ND
IRON	310	1200	80	1300	210	2200	820
LEAD	ND	ND	ND	ND	ND	ND	ND
MAGNESIUM	47000	86000	18000	85000	55000	15000	30000
MANGANESE	23	270	110	280	260	33	130
MERCURY	ND	ND	ND	ND	ND	ND	ND
NICKEL	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	3500	4400	2400	4500	2600	1200	4000
SELENIUM	1	1	ND	1	ND	ND	2
SILICON	14200	9790	10800	9990	9720	11600	11000
SILVER	ND	ND	ND	ND	ND	ND	ND
SODIUM	19000	29000	13000	33000	25000	7900	72000
THALLIUM	1	1	ND	ND	ND	ND	ND
VANADIUM	ND	ND	ND	ND	ND	ND	ND
ZINC	ND	ND	ND	ND	ND	ND	ND
SEMI-VOLATILES							
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND

TABLE C-6b

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCB							
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1260	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1254	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1221	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1232	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1248	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1016	ND	ND	ND	ND	ND	ND	ND
ALDRIN	ND	ND	ND	ND	ND	ND	ND
ALPHA-BHC	ND	ND	ND	ND	ND	ND	ND
BETA-BHC	ND	ND	ND	ND	ND	ND	ND

TABLE C-6b
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
DELTA-BHC	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN II	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND
ALPHA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND
GAMMA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1242	ND	ND	ND	ND	ND	ND	ND
ENDRIN KETONE	ND	ND	ND	ND	ND	ND	ND
GAMMA-BHC (LINDANE)	ND	ND	ND	ND	ND	ND	ND
DIELDRIN	ND	ND	ND	ND	ND	ND	ND
ENDRIN	ND	ND	ND	ND	ND	ND	ND
METHOXYCHLOR	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND
ENDRIN ALDEHYDE	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR	ND	ND	ND	ND	ND	ND	ND
TOXAPHENE	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN I	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2							
Benzene	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND
Hexchlorobutadiene	ND	ND	ND	ND	ND	ND	ND

TABLE C-6b
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND
Analysis 504 - INLAND ENVIRONMENTAL LAB							
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND
Ethylene dibromide	ND	ND	ND	ND	ND	ND	ND
Analysis 504 - ANALYTICAL RESOURCES LAB							
1,2-Dibromo-3-chloropropane		ND			ND		
Ethylene dibromide		ND			ND		
GENERAL CHEMISTRY							
pH	7.60	6.92	7.56	6.90	6.91	7.10	7.19
Phenolphthalein Alkalinity, μg/L CaCO3	ND	ND	ND	ND	ND	ND	ND
Carbonate, μg/L CaCO3	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, μg/L CaCO3	332000	740000	191000	732000	504000	121000	446000
Conductivity, μmhos/cm	865	1280	392	1300	830	294	797
TDS, μg/L	477000	713000	202000	735000	483000	141000	439000
Turbidity, NTU	33	13.8	0.72	19.8	3.4	3.3	8.4
Fluoride	120	ND	ND	ND	ND	100	170
Chloride	1500	6000	2000	5700	2400	1400	2300
Nitrate (as N)	87	ND	ND	33	35	ND	11
Nitrite (as N)	47	ND	ND	ND	ND	ND	ND
Sulfate	138000	38900	21400	64500	10300	29600	3500
Total Cyanide (μg/L)	ND	ND	ND	ND	ND	ND	ND

ND - Analyte was Not Detected

TABLE C-6c
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (3RD QUARTER)

Chemical Name	LMW-1 (µg/L)	LMW-2 (µg/L)	LMW-3 (µg/L)	LMW-4 (µg/L)	LMW-5 (µg/L)	LMW-6 (µg/L)	LMW-7 (µg/L)
METALS							
ALUMINUM	ND	ND	ND	ND	ND	140	ND
ANTIMONY	ND	ND	ND	ND	ND	ND	ND
ARSENIC	3	ND	ND	ND	ND	ND	2
BARIUM	48	229	89	212	225	91	532
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND
CADMIUM	ND	ND	ND	ND	ND	ND	ND
CALCIUM	78800	137000	42700	135000	89100	29900	68100
CHROMIUM	ND	ND	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	ND	ND	ND
COPPER	ND	ND	ND	ND	ND	ND	ND
IRON	320	930	80	1360	580	2230	1140
LEAD	ND	ND	ND	ND	ND	ND	ND
MAGNESIUM	44200	84300	17900	83100	53600	15600	34100
MANGANESE	23	249	107	249	240	36	299
MERCURY	ND	ND	ND	ND	ND	ND	ND
NICKEL	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	3000	4400	2300	4200	2900	900	3600
SELENIUM	ND	1	2	1	1	1	2
SILICON	13000	9670J	10200	9560J	9340	10900J	9550
SILVER	ND	ND	ND	ND	ND	ND	ND
SODIUM	21400	29800	12900J	34400	24600J	7870	59800
THALLIUM	ND	ND	ND	ND	ND	ND	ND
VANADIUM	3	ND	ND	ND	ND	ND	ND
ZINC	ND	ND	ND	ND	ND	4	ND
SEMI-VOLATILES							
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND

TABLE C-6c
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (3RD QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCB (Analysis 508)							
Aldrin	ND	ND	ND	ND	ND	ND	ND
Chlordane-alpha	ND	ND	ND	ND	ND	ND	ND
Chlordane-gamma	ND	ND	ND	ND	ND	ND	ND

TABLE C-6c
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (3RD QUARTER)

Chemical Name	**LMW-1 (μg/L)**	**LMW-2 (μg/L)**	**LMW-3 (μg/L)**	**LMW-4 (μg/L)**	**LMW-5 (μg/L)**	**LMW-6 (μg/L)**	**LMW-7 (μg/L)**
Chlorneb	ND	ND	ND	ND	ND	ND	ND
Chlorobenzilate	ND	ND	ND	ND	ND	ND	ND
Chlorothalonil	ND	ND	ND	ND	ND	ND	ND
DCPA	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
Endosulfan I	ND	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND
Etridiazole	ND	ND	ND	ND	ND	ND	ND
HCH-alpha	ND	ND	ND	ND	ND	ND	ND
HCH-beta	ND	ND	ND	ND	ND	ND	ND
HDH-delta	ND	ND	ND	ND	ND	ND	ND
HCH-gamma	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND
cis-Permethrin	ND	ND	ND	ND	ND	ND	ND
trans-Permethrin	ND	ND	ND	ND	ND	ND	ND
Propachlor	ND	ND	ND	ND	ND	ND	ND
Trifluralin	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND
Aroclor 1016	ND	ND	ND	ND	ND	ND	ND
Aroclor 1221	ND	ND	ND	ND	ND	ND	ND
Aroclor 1232	ND	ND	ND	ND	ND	ND	ND
Aroclor 1242	ND	ND	ND	ND	ND	ND	ND
Aroclor 1248	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2							
Benzene	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND

TABLE C-6c

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (3RD QUARTER)

Chemical Name	LMW-1 (µg/L)	LMW-2 (µg/L)	LMW-3 (µg/L)	LMW-4 (µg/L)	LMW-5 (µg/L)	LMW-6 (µg/L)	LMW-7 (µg/L)
Chloroform	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND
Hexchlorobutadiene	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND

TABLE C-6c
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (3RD QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
Acetone	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND
Analysis 525							
Alachlor	ND	ND	ND	ND	ND	ND	ND
Atrazine	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND
PCB	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND
Hexachlorocylopentadiene	ND	ND	ND	ND	ND	ND	ND
Metachlor	ND	ND	ND	ND	ND	ND	ND
Simazine	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Di(ethylhexyl)adipate	ND	ND	ND	ND	ND	ND	ND
Di(ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
Dinoseb	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND
Benzo(ghi)perylene	ND	ND	ND	ND	ND	ND	ND
Dibenzo(ah)anthracene	ND	ND	ND	ND	ND	ND	ND
Indeno(123-cd)pyrene	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND
Analysis 504							
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND
Ethylene dibromide	ND	ND	ND	ND	ND	ND	ND
Analysis 515.1							
2,4-D	ND	ND	ND	ND	ND	ND	ND
2,4,5-TP	ND	ND	ND	ND	ND	ND	ND

TABLE C-6c

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (3RD QUARTER)

Chemical Name	**LMW-1 (μg/L)**	**LMW-2 (μg/L)**	**LMW-3 (μg/L)**	**LMW-4 (μg/L)**	**LMW-5 (μg/L)**	**LMW-6 (μg/L)**	**LMW-7 (μg/L)**
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND
Dalapon	ND	ND	ND	ND	ND	ND	ND
Dinoseb	ND	ND	ND	ND	ND	ND	ND
Dicamba	ND	ND	ND	ND	ND	ND	ND
Picloram	ND	ND	ND	ND	ND	ND	ND
Analysis 531.1							
Aldicarb	ND	ND	ND	ND	ND	ND	ND
Aldicarb sulfoxide	ND	ND	ND	ND	ND	ND	ND
Aldicarb sulfone	ND	ND	ND	ND	ND	ND	ND
Carbofuran	ND	ND	ND	ND	ND	ND	ND
Carbaryl	ND	ND	ND	ND	ND	ND	ND
3-Hydroxycarbofuran	ND	ND	ND	ND	ND	ND	ND
Methomyl	ND	ND	ND	ND	ND	ND	ND
Oxamyl (vydate)	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY							
pH	6.9	6.8	7.3	6.8	6.7	6.4	6.8
Phenolphthalein Alkalinity, μg/L CaCO3	ND	ND	ND	ND	26000	ND	ND
Carbonate, μg/L $CaCO_3$	ND	ND	ND	ND	53000	ND	ND
Bicarbonate, μg/L CaCO3	330000	720000	200000	710000	430000	130000	200000
Hardness, μg/L CaCO3		689000	180000	679000	440000	139000	
Conductivity, μmhos/cm	800	1300	430	1300	870	310	810
TDS, μg/L	480000J	760000	230000	740000	480000	170000	460000J
Turbidity, NTU	30	9.1	0.42	19	3.7	4.2	7.9
Fluoride	100	ND	ND	ND	ND	ND	130
Chloride	1700	4200	2100	4400	2000	1200	2300
Total Cyanide (μg/L)	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	11	ND	ND	ND	ND	ND	14
Nitrite (as N)	ND	ND	ND	ND	ND	ND	ND
Sulfate	100000	30000	19000	37000	9800	31000	3200

ND -Analyte was Not Detected

J - The J qualifier indicates the constituent was analyzed for and detected. Due to a minor quality control defiency identified during data validation the associated data have been qualified as estimated.

TABLE C-6d

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	**LMW-1 (μg/L)**	**LMW-2 (μg/L)**	**LMW-3 (μg/L)**	**LMW-4 (μg/L)**	**LMW-5 (μg/L)**	**LMW-6 (μg/L)**	**LMW-7 (μg/L)**
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND

TABLE C-6d

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
PESTICIDES/PCB							
alpha-BHC	ND	ND	ND	ND	ND	ND	ND
beta-BHC	ND	ND	ND	ND	ND	ND	ND
delta-BHC	ND	ND	ND	ND	ND	ND	ND
gamma-BHC (Lindane)	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND	ND
Endosulfan I	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND
Endrin Ketone	ND	ND	ND	ND	ND	ND	ND
gamma Chlordane	ND	ND	ND	ND	ND	ND	ND
alpha Chlordane	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
Aroclor 1016	ND	ND	ND	ND	ND	ND	ND
Aroclor 1242	ND	ND	ND	ND	ND	ND	ND
Aroclor 1248	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	ND	ND	ND	ND	ND	ND	ND
Aroclor 1221	ND	ND	ND	ND	ND	ND	ND
Aroclor 1232	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2							
Benzene	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND

TABLE C-6d
LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND
Hexchlorobutadiene	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND

TABLE C-6d

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	LMW-1 (μg/L)	LMW-2 (μg/L)	LMW-3 (μg/L)	LMW-4 (μg/L)	LMW-5 (μg/L)	LMW-6 (μg/L)	LMW-7 (μg/L)
2-Hexanone	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY							
pH	7.1	6.8	6.7	6.7	6.8	6.5	6.9
Carbonate, μg/L $CaCO_3$	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, μg/L CaCO3	350000	680000	190000	660000	490000	130000	440000
Hardness, μg/L CaCO3	430000	680000	180000	670000	480000	130000	300000
Conductivity, μmhos/cm	810	1200	360	1200	870	280	779
TDS, μg/L	540000	760000	220000	780000	550000	120000	410000
Turbidity, NTU	1.8	4.9	0.49	19	2.7	0.1 J	9.1 J
Fluoride	120	ND	ND	ND	ND	110	150
Chloride	1400	6100	2000	6300	2300	1600	2300
Total Cyanide, μg/L	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	16	ND	ND	ND	ND	20	ND
Nitrite (as N)	ND	ND	ND	ND	ND	ND	ND
Sulfate	130000	44000	20000	51000	41000	25000	8600

ND -Analyte was Not Detected

J - The J qualifier indicates the constituent was analyzed for and detected. Due to a minor quality control defiency identified during data validation the associated data have been qualified as estimated.

TABLE C-6d

LANDSBURG MONITORING WELLS GROUNDWATER ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	LMW-1 (µg/L)	LMW-2 (µg/L)	LMW-3 (µg/L)	LMW-4 (µg/L)	LMW-5 (µg/L)	LMW-6 (µg/L)	LMW-7 (µg/L)
METALS							
ALUMINUM	30	ND	ND	ND	ND	ND	ND
ANTIMONY	ND	ND	ND	ND	ND	ND	ND
ARSENIC	2	ND	ND	ND	ND	ND	1
BARIUM	52	225	89	210	259	85	559
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND
CADMIUM	ND	ND	ND	ND	ND	ND	ND
CALCIUM	92400	134000	44100	132000	99600	27700	66400
CHROMIUM	ND	ND	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	ND	ND	ND
COPPER	ND	ND	ND	ND	ND	ND	ND
IRON	380	820	90	1230	190	2130	1070
LEAD	ND	ND	ND	1	1	2	ND
MAGNESIUM	48600	83700	17800	81800	57500	14300	31900
MANGANESE	29	249	97	236	275	30	195
MERCURY	ND	ND	ND	ND	ND	ND	ND
NICKEL	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	2900	4000	2100	4200	2900	500	3000
SELENIUM	ND	2	ND	ND	ND	ND	ND
SILICON	13200 J	1100 J	9200 J	1150 J	8830 J	ND	ND
SILVER	ND	ND	ND	ND	ND	ND	ND
SODIUM	20100	29900	12600	34900	22700	7680	61000
THALLIUM	ND	ND	ND	1	ND	ND	ND
VANADIUM	ND	ND	ND	ND	ND	ND	ND
ZINC	ND	ND	ND	ND	ND	ND	ND
SEMI-VOLATILES							
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND

TABLE C-7a
PRIVATE WELL ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	PW-1 (µg/L)	PW-2 (µg/L)	PW-3 (µg/L)	PW-4 (µg/L)	PW-5 (µg/L)	PW-6 (µg/L)	PW-7 (µg/L)	PW-8 (µg/L)	PW-9 (µg/L)	PW-10 (µg/L)	PW-12 (µg/L)	PW-13 (µg/L)	PW-14 (µg/L)	PW-15 (µg/L)
METALS														
ALUMINUM	ND	ND	ND	ND	70	20	60	50	ND	ND	ND	20	ND	130
ANTIMONY	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	ND	1	ND	ND	2	4	5	19	ND	ND	ND	ND	ND	2
BARIUM	ND	ND	ND	1	92	43	7	78	2	2	2	2	18	27
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	15000	21400	7200	41000	26700	7970	20100	19000	13300	9660	12200	12700	1330	10300
CHROMIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	ND	3	ND	ND	ND	ND	ND	3	ND	24	3	4	2	13
IRON	7	24	12	64	91	270	410	217	ND	1040	210	ND	89	329
LEAD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MAGNESIUM	4680	5750	1210	13300	11000	2760	7240	7140	2900	2230	2140	2420	480	3610
MANGANESE	ND	2	ND	43	16	20	54	33	ND	7	6	ND	2	16
MERCURY	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	ND	ND	ND	1000	1400	1000	1600	400	ND	ND	ND	ND	600	700
SELENIUM	ND	2	ND	1	ND	4	1	ND	1	1	1	ND	2	ND
SILVER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	5240	5470	3660	10400	25300	68400	7110	35600	3640	3570	3150	3510	139000	38400
THALLIUM	ND	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
VANADIUM	ND	ND	ND	ND	ND	2	4	3	ND	ND	ND	ND	ND	2
ZINC	42	35	9	20	55	91	70	123	ND	8	5	11	17	70
SEMI-VOLATILES														
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	1.3[a]	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7a
PRIVATE WELL ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	PW-1 (μg/L)	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-5 (μg/L)	PW-6 (μg/L)	PW-7 (μg/L)	PW-8 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)	PW-14 (μg/L)	PW-15 (μg/L)
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCB														
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1260	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1254	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7a
PRIVATE WELL ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	PW-1 (µg/L)	PW-2 (µg/L)	PW-3 (µg/L)	PW-4 (µg/L)	PW-5 (µg/L)	PW-6 (µg/L)	PW-7 (µg/L)	PW-8 (µg/L)	PW-9 (µg/L)	PW-10 (µg/L)	PW-12 (µg/L)	PW-13 (µg/L)	PW-14 (µg/L)	PW-15 (µg/L)
AROCLOR-1221	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1232	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1248	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALPHA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BETA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DELTA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN II	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALPHA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GAMMA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1242	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN KETONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GAMMA-BHC (LINDANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIELDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHOXYCHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN ALDEHYDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOXAPHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN I	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2														
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7a
PRIVATE WELL ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	PW-1 (μg/L)	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-5 (μg/L)	PW-6 (μg/L)	PW-7 (μg/L)	PW-8 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)	PW-14 (μg/L)	PW-15 (μg/L)
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexchlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 525														
Alachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Atrazine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7a
PRIVATE WELL ANALYTICAL RESULTS (1st QUARTER)

Chemical Name	PW-1 (μg/L)	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-5 (μg/L)	PW-6 (μg/L)	PW-7 (μg/L)	PW-8 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)	PW-14 (μg/L)	PW-15 (μg/L)
Lindane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorocylopentadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Simazine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND
Di(ethylhexyl)adipate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di(ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dinoseb	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(ghi)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo(ah)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(123-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY														
pH	7.4	7.39	6.22	7.01	8.13	8.52	8.23	8.24	7.18	6.61	7.15	7.01	9	8.91
Carbonate, μg/L $CaCO_3$	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	37000	7900
Bicarbonate, μg/L CaCO3	56600	77500	15900	164000	160000	179000	95800	151000	47700	33400	39900	40400	289000	102000
Hardness, μg/L CaCO3	56700		23000					76800						
Conductivity, μmhos/cm	132	172	70.2	345	298	317	184	284	109	86.1	98.1	98.9	579	201
TDS, μg/L	87000	106000	52000	201000	193000	208000	105000	166000	82000	74000	71000	70000	333000	133000
Turbidity, NTU	0.05	0.08	0.11	0.24	1.09	2.3	1.5	2.4	ND	9.1	1.75	0.05	0.46	1.8
Fluoride	ND	ND	ND	ND	250	300	140	ND	ND	ND	ND	ND	610	100
Chloride	2100	2500	2500	3000	1900	2900	1000	1500	2600	2500	2800	2200	1900	1500
Nitrate (as N)	713	1280	2130	530	ND	ND	26	203	667	876	756	1290	14	15
Nitrite (as N)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	6200	9000	5100	17000	10800	ND	2700	ND	4600	4300	3800	6400	ND	ND

ND - Analyte was Not Detected

[a] 1,3-Dichlorobenzene was also analyzed under analysis 524.2, but was not detected. In addition, the laboratory PQL is lower for analysis 524.2 (0.500 μg/L) than for the GC/MS Semi-VOA analysis (1.0 μg/L).

TABLE C-7b
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	PW-1 (μg/L)	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-5 (μg/L)	PW-6 (μg/L)	PW-7 (μg/L)	PW-8 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)	PW-14 (μg/L)	PW-15 (μg/L)
METALS														
ALUMINUM	ND	ND	30	ND	120	20	90	ND	ND	ND	ND	ND	ND	2560
ANTIMONY	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	ND	ND	ND	ND	2	3	11	12	ND	ND	ND	ND	ND	7
BARIUM	ND	1	ND	1	93	88	14	77	2	2	2	2	18	64
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	15000	24000	8200	44000	27000	19000	22000	20000	14000	12000	13000	13000	1400	19000
CHROMIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	ND	9	ND	ND	ND	ND	5	ND	ND	33	ND	19	ND	84
IRON	ND	240	ND	67	170	590	4000	34	ND	890	30	ND	67	5400
LEAD	ND	7	ND	ND	ND	2	4	1	1	ND	ND	ND	ND	16
MAGNESIUM	4800	6300	1400	14000	12000	7000	7700	7600	3000	2500	2310	2600	480	5200
MANGANESE	ND	6	ND	54	19	55	416	9	ND	8	1	ND	2	99
MERCURY	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	ND	600	ND	500	600	1300	1400	500	ND	ND	ND	ND	ND	1100
SELENIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND
SILICON	11500	11800	7800	12000	10000	11000	11000	10000	8300	7370	6300	6900	4400	8800
SILVER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	5340	5500	4000	11000	26000	37000	7600	35000	3700	3750	3700	3600	148000	20000
THALLIUM	2	ND	2	ND	ND	ND	1	3	2	ND	2	1	2	2
VANADIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9
ZINC	ND	80	25	ND	ND	190	240	180	5	14	ND	38	ND	1320
SEMI-VOLATILES														
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7b
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	**PW-1** (µg/L)	**PW-2** (µg/L)	**PW-3** (µg/L)	**PW-4** (µg/L)	**PW-5** (µg/L)	**PW-6** (µg/L)	**PW-7** (µg/L)	**PW-8** (µg/L)	**PW-9** (µg/L)	**PW-10** (µg/L)	**PW-12** (µg/L)	**PW-13** (µg/L)	**PW-14** (µg/L)	**PW-15** (µg/L)
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	**6.7**	ND	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7b
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	PW-1 (µg/L)	PW-2 (µg/L)	PW-3 (µg/L)	PW-4 (µg/L)	PW-5 (µg/L)	PW-6 (µg/L)	PW-7 (µg/L)	PW-8 (µg/L)	PW-9 (µg/L)	PW-10 (µg/L)	PW-12 (µg/L)	PW-13 (µg/L)	PW-14 (µg/L)	PW-15 (µg/L)
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCB														
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1260	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1254	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1221	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1232	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1248	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALPHA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BETA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DELTA-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN II	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ALPHA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GAMMA-CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AROCLOR-1242	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN KETONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GAMMA-BHC (LINDANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIELDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHOXYCHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN ALDEHYDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOXAPHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN I	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2														
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.6	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7b
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	PW-1 (μg/L)	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-5 (μg/L)	PW-6 (μg/L)	PW-7 (μg/L)	PW-8 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)	PW-14 (μg/L)	PW-15 (μg/L)
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	1.3	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexchlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7b
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (2nd QUARTER)

Chemical Name	PW-1 (μg/L)	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-5 (μg/L)	PW-6 (μg/L)	PW-7 (μg/L)	PW-8 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)	PW-14 (μg/L)	PW-15 (μg/L)
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.7	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY														
pH	7.77 J	7.39 J	6.57 J	7.06 J	7.91 J	7.8 J	7.95 J	7.41 J	7.17 J	6.44 J	7.4 J	6.43 J	9.02 J	8.52 J
Phenolphthalein Alkalinity, μg/L CaCO3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	18300	ND
Carbonate, μg/L $CaCO_3$	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	36600	ND
Bicarbonate, μg/L CaCO3	57500	80700	22300	166000	160000	159000	100000	157000	48400	42600	42000	43700	286000	113000
Hardness, μg/L CaCO3			26200					80200	46200			43300		
Conductivity, μmhos/cm	134	177	75.4	347	316	284	195	276	111	96.9	104	103	585	215
TDS, μg/L	59000	95000	39000	185000	176000	151000	104000	148000	56000	53000	50000	59000	306000	78000
Turbidity, NTU	ND	ND	ND	0.38	2.1	3.6	26	ND	ND	0.84	0.79	ND	0.27	31
Fluoride	ND	ND	ND	ND	250	170	140	ND	ND	ND	ND	ND	540	ND
Chloride	2200	2100	2700	3200	1900	2300	1200	1600	2400	2600	2400	2100	2100	1900
Total Cyanide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	726	1910	2100	503	ND	ND	ND	136	669	516	751	691	ND	ND
Nitrite (as N)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	6800	7400	6000	18400	11000	ND	3600	3300	3600	4300	3700	4900	ND	ND

ND - Analyte was Not Detected

J - The J qualifier indicates the constituent was analyzed for and detected. Due to a minor quality control defiency identified during data validation the associated data have been qualified as estimated.

TABLE C-7c
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (3rd QUARTER)

Chemical Name	PW-1 (µg/L)	PW-2 (µg/L)	PW-3 (µg/L)	PW-4 (µg/L)	PW-5 (µg/L)	PW-6 (µg/L)	PW-7 (µg/L)	PW-8 (µg/L)	PW-9 (µg/L)	PW-10 (µg/L)	PW-12 (µg/L)	PW-13 (µg/L)	PW-14 (µg/L)	PW-15 (µg/L)
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	1.5	ND	ND	1.2	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCB (Analysis 508)														
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane-alpha	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane-gamma	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorneb	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzilate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorothalonil	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DCPA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7c
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (3rd QUARTER)

Chemical Name	PW-1 (μg/L)	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-5 (μg/L)	PW-6 (μg/L)	PW-7 (μg/L)	PW-8 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)	PW-14 (μg/L)	PW-15 (μg/L)
METALS														
ALUMINUM	ND	ND	ND	ND	40	30	60	ND	ND	ND	ND	ND	ND	130
ANTIMONY	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ARSENIC	ND	1	ND	ND	1	4	5	19	ND	ND	ND	ND	ND	2
BARIUM	ND	2	2	2	83	89	6	79	2	3	2	2	18	28
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CADMIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CALCIUM	14300	21600	8040	42100	27000	14800	20700	20200	14000	12700	14700	13200	1350	10900
CHROMIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
COPPER	ND	3	ND	ND	ND	ND	ND	3	ND	6	ND	7	45	10
IRON	30	20	ND	80	80	2040	110	40	ND	360	40	ND	90	310
LEAD	3J	ND	2J	ND	ND	3J	ND	ND	1J	ND	ND	1J	4J	1J
MAGNESIUM	4600	5840	1370	13400	11200	5280	7320	7440	3120	2720	2670	2640	460	3540
MANGANESE	1	2	1	47	17	60	26	14	ND	3	1	ND	3	15
MERCURY	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NICKEL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	600	1000	600	1300	1500	1800	2200	1100	700	800	700	800	600	1000
SELENIUM	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	1
SILICON	10800	10500	6890	11500	9720	8480	9720	8550	7880	6770	6410	6560	4550	6660
SILVER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SODIUM	5140	5890	3750	10300	24800	49800	6980	29100	3860	4000	3780	3940	143000	38400
THALLIUM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
VANADIUM	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ZINC	62	33	28	18	35	268	46	181	5	6	4	6	36	27
SEMI-VOLATILES														
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7c
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (3rd QUARTER)

Chemical Name	PW-1 (µg/L)	PW-2 (µg/L)	PW-3 (µg/L)	PW-4 (µg/L)	PW-5 (µg/L)	PW-6 (µg/L)	PW-7 (µg/L)	PW-8 (µg/L)	PW-9 (µg/L)	PW-10 (µg/L)	PW-12 (µg/L)	PW-13 (µg/L)	PW-14 (µg/L)	PW-15 (µg/L)
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan I	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Etridiazole	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HCH-alpha	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HCH-beta	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HDH-delta	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HCH-gamma	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-Permethrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-Permethrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Propachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trifluralin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1221	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1232	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1242	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1248	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2														
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7c
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (3rd QUARTER)

Chemical Name	PW-1 (µg/L)	PW-2 (µg/L)	PW-3 (µg/L)	PW-4 (µg/L)	PW-5 (µg/L)	PW-6 (µg/L)	PW-7 (µg/L)	PW-8 (µg/L)	PW-9 (µg/L)	PW-10 (µg/L)	PW-12 (µg/L)	PW-13 (µg/L)	PW-14 (µg/L)	PW-15 (µg/L)
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexchlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Analysis 525														
Alachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Atrazine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE C-7c
PRIVATE WELL GROUNDWATER ANALYTICAL RESULTS (3rd QUARTER)

Chemical Name	PW-1 (μg/L)	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-5 (μg/L)	PW-6 (μg/L)	PW-7 (μg/L)	PW-8 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)	PW-14 (μg/L)	PW-15 (μg/L)
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorocylopentadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Simazine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di(ethylhexyl)adipate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di(ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dinoseb	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(ghi)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo(ah)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(123-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY														
pH	7.1	7	6.3	6.8	7.6	7.8	7.7	8.00	6.9	6.5	6.8	6.9	9	8.4
Phenolphthalein Alkalinity, μ/L CaCO3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	18000	ND
Carbonate, μg/L CaCO$_3$	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	35000	ND
Bicarbonate, μg/L CaCO3	56000	80000	20000	160000	160000	170000	95000	140000	46000	39000	47000	41000	280000	130000
Hardness, μg/L CaCO3	54600		26000		114000	58700	81800	81100	47800		47700	43800	5270	42000
Conductivity, μmhos/cm	130	180	78	330	320	320	190	280	110	110	120	110	580	240
TDS, μg/L	61000	110000	48000J	210000	210000	190000	96000	170000	80000	64000	69000	71000	330000	150000J
Turbidity, NTU	ND	0.18	ND	0.76	1.2	4.9	1.3	0.27	ND	1.6	0.26	0.29	ND	2
Fluoride	ND	ND	ND	ND	220	160	ND	ND	ND	ND	ND	ND	480	110
Chloride	2000	1800	3200	3000	2700	2100	ND	1500	2500	2500	2500	2400	1900	1400
Total Cyanide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	720	930	2100	530	12	4500	48	240	690	2900	1100	1900	16	ND
Nitrite (as N)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	6200	8500	4900	18000	11000	ND	4200	ND	4800	5700	4500	4200	ND	ND

ND - Analyte was Not Detected

J - The J qualifier indicates the constituent was analyzed for and detected. Due to a minor quality control defiency identified during data validation the associated data have been qualified as estimated.

TABLE C-7d
PRIVATE WELL ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)
2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND	ND
DIBENZ(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
4,6-DINITRO-2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND	ND
2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND	ND
BUTYLBENZYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND	ND
PENTACHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
3,3'-DICHLOROBENZIDINE	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCB							
alpha-BHC	ND	ND	ND	ND	ND	ND	ND
beta-BHC	ND	ND	ND	ND	ND	ND	ND
delta-BHC	ND	ND	ND	ND	ND	ND	ND
gamma-BHC (Lindane)	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND	ND
Endosulfan I	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND

TABLE C-7d
PRIVATE WELL ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	**PW-2 (μg/L)**	**PW-3 (μg/L)**	**PW-4 (μg/L)**	**PW-9 (μg/L)**	**PW-10 (μg/L)**	**PW-12 (μg/L)**	**PW-13 (μg/L)**
4,4'-DDE	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND
Endrin Ketone	ND	ND	ND	ND	ND	ND	ND
gamma Chlordane	ND	ND	ND	ND	ND	ND	ND
alpha Chlordane	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
Aroclor 1016	ND	ND	ND	ND	ND	ND	ND
Aroclor 1242	ND	ND	ND	ND	ND	ND	ND
Aroclor 1248	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	ND	ND	ND	ND	ND	ND	ND
Aroclor 1260	ND	ND	ND	ND	ND	ND	ND
Aroclor 1221	ND	ND	ND	ND	ND	ND	ND
Aroclor 1232	ND	ND	ND	ND	ND	ND	ND
Analysis 524.2							
Benzene	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND
2-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND

TABLE C-7d
PRIVATE WELL ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)
4-Chlorotoluene	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND	ND	ND
1,2-Dibromomethane	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND
Hexchlorobutadiene	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND

TABLE C-7d
PRIVATE WELL ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	PW-2 (µg/L)	PW-3 (µg/L)	PW-4 (µg/L)	PW-9 (µg/L)	PW-10 (µg/L)	PW-12 (µg/L)	PW-13 (µg/L)
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzne	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND
Vinyl acetate	ND	ND	ND	ND	ND	ND	ND
GENERAL CHEMISTRY							
pH	6.8	6.8	6.6	7.2	6.6	6.8	6.9
Carbonate, µg/L $CaCO_3$	ND	ND	ND	ND	ND	ND	ND
Bicarbonate, µg/L CaCO3	77000	36000	160000	39000	27000	38000	33000
Hardness, µg/L CaCO3		19000	160000	40000	31000	38000	37000
Conductivity, µmhos/cm	170	62	330	98	81	92	94
TDS, µg/L	97000	48000	190000	60000	38000	72000	60000
Turbidity, NTU	0.1	ND	0.24	ND	3.1	0.1	ND
Fluoride	ND	ND	ND	ND	ND	ND	ND
Chloride	1700	2200	2700	2200	1900	1600	1800
Total Cyanide, µg/L	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	830	1600	560	2700	1100	860	1200
Nitrite (as N)	ND	ND	ND	ND	ND	ND	ND
Sulfate	6600	4400	16000	3900	5300	2500	5900

ND - Analyte was Not Detected

TABLE C-7d
PRIVATE WELL ANALYTICAL RESULTS (4TH QUARTER)

Chemical Name	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)
METALS							
ALUMINUM	ND	ND	ND	ND	ND	ND	ND
ANTIMONY	ND	ND	ND	ND	ND	ND	ND
ARSENIC	2	ND	ND	1	ND	ND	ND
BARIUM	ND	ND	ND	1	2	2	2
BERYLLIUM	ND	ND	ND	ND	ND	ND	ND
CADMIUM	ND	ND	ND	ND	ND	ND	ND
CALCIUM	19900	6000	42300	12300	8580	11800	11200
CHROMIUM	ND	ND	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	ND	ND	ND
COPPER	ND	ND	ND	ND	7	ND	3
IRON	ND	ND	60	ND	630	20	ND
LEAD	ND	ND	ND	ND	1	ND	ND
MAGNESIUM	5610	1030	13600	2270	2260	2030	2210
MANGANESE	1	ND	44	ND	2	1	ND
MERCURY	ND	ND	ND	ND	ND	ND	ND
NICKEL	ND	ND	ND	ND	ND	ND	ND
POTASSIUM	900	ND	1100	500	700	600	500
SELENIUM	ND	ND	ND	ND	ND	ND	ND
SILICON	9970	6290	11200	6210	6350	5780	5930
SILVER	ND	ND	ND	ND	ND	ND	ND
SODIUM	5470	3360	10500	3470	3410	3120	3310
THALLIUM	ND	ND	ND	ND	ND	ND	ND
VANADIUM	2	ND	ND	ND	ND	ND	ND
ZINC	26	21	22	6	ND	5	6
SEMI-VOLATILES							
BENZYL ALCOHOL	ND	ND	ND	ND	ND	ND	ND
2,4-DIMETHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
4-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLOROANILINE	ND	ND	ND	ND	ND	ND	ND
2,2'-OXYBIS(1-CHLOROPROPANE)	ND	ND	ND	ND	ND	ND	ND
PHENOL	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND

TABLE C-7d
PRIVATE WELL ANALYTICAL RESULTS (4TH QUARTER)

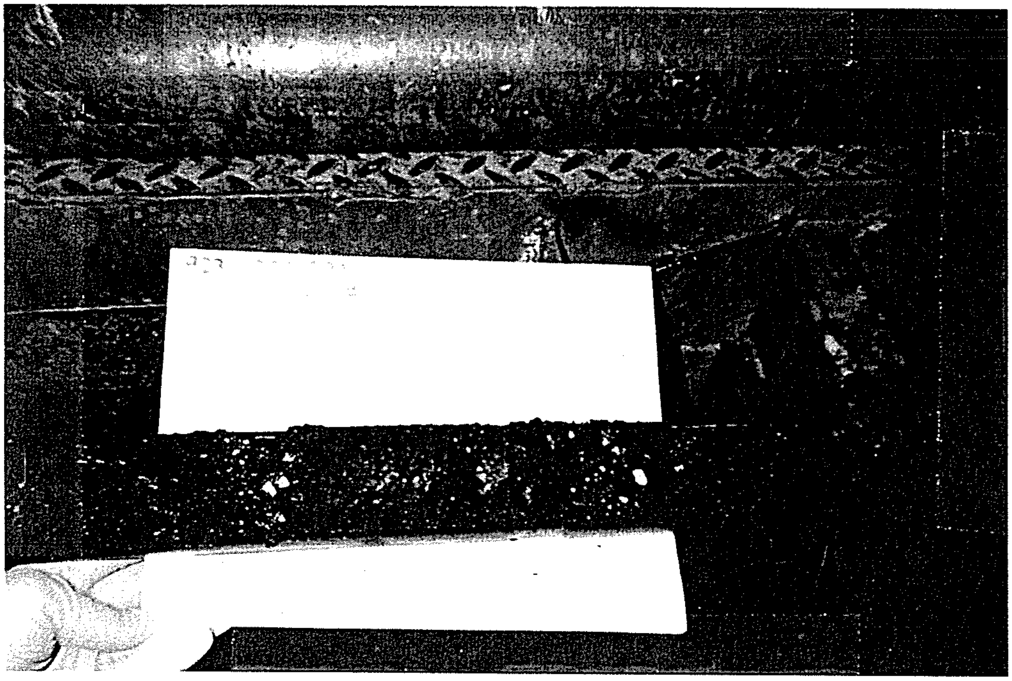
Chemical Name	PW-2 (μg/L)	PW-3 (μg/L)	PW-4 (μg/L)	PW-9 (μg/L)	PW-10 (μg/L)	PW-12 (μg/L)	PW-13 (μg/L)
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2,4-DICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
DIMETHYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
4-CHLORO-3-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
N-NITROSO-DI-N-PROPYLAMINE	ND	ND	ND	ND	ND	ND	ND
BENZOIC ACID	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROCYCLOPENTADIENE	ND	ND	ND	ND	ND	ND	ND
ISOPHORONE	ND	ND	ND	ND	ND	ND	ND
ACENAPHTHENE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND	ND	ND
2,4,6-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
2-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
NAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND	ND
2-METHYLPHENOL	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
2-CHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
2,4,5-TRICHLOROPHENOL	ND	ND	ND	ND	ND	ND	ND
NITROBENZENE	ND	ND	ND	ND	ND	ND	ND
3-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROANILINE	ND	ND	ND	ND	ND	ND	ND
4-NITROPHENOL	ND	ND	ND	ND	ND	ND	ND
4-BROMOPHENYL-PHENYLETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND
DI-N-OCTYLPHTHALATE	ND	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND	ND

APPENDIX D

CORE PHOTOS

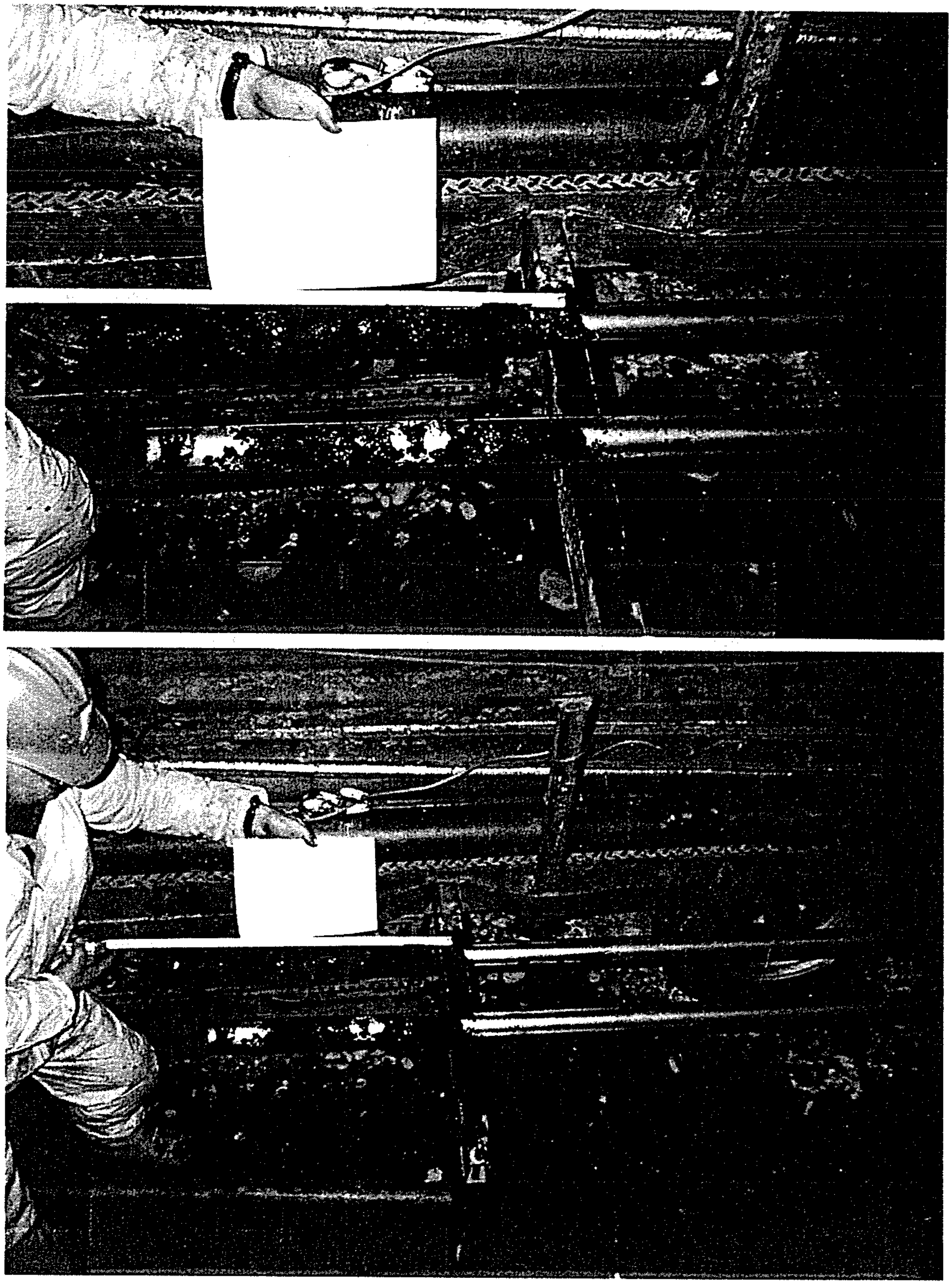
TABLE OF CONTENTS

LIST OF FIGURES



Borehole: LMW-2
Date of Core: 2-8-94
Core Run Number: 1
Depth Interval of Core: 25ft - 35ft
Recovery: 1.7ft

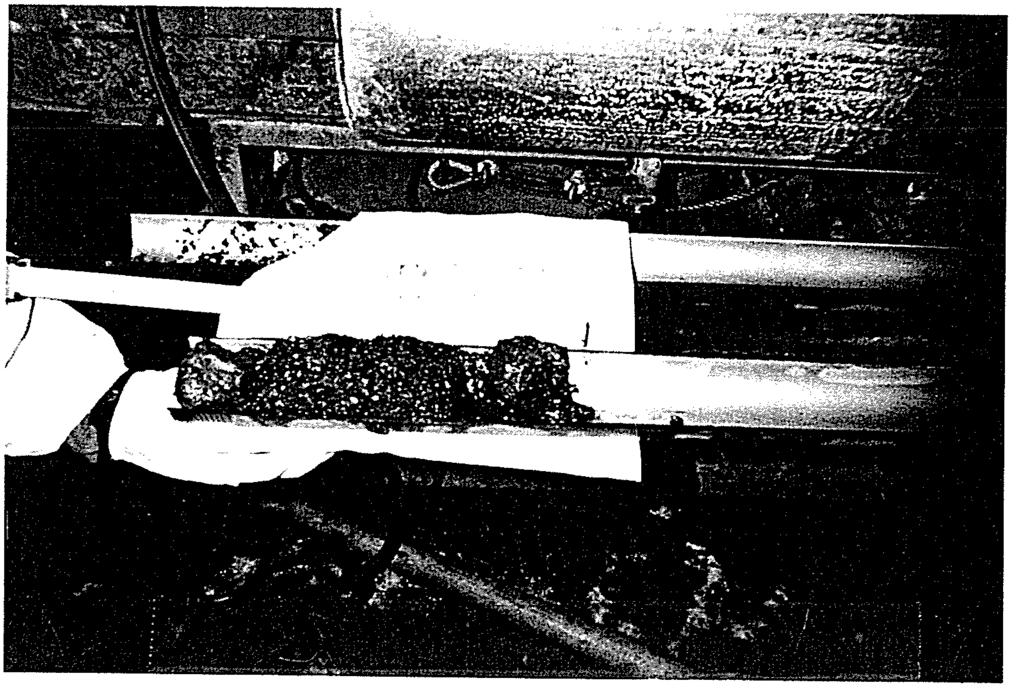
FIGURE **D-1**
(1 OF 2)
LMW-2 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA



Borehole: LMW-2
Date of Core: 2-8-94
Core Run Number: 1
Depth Interval of Core: 25ft - 35ft
Recovery: 1.7ft

FIGURE **D-1**
(2 OF 2)
LMW-2 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA

Golder Associates



Borehole: LMW-2
Date of Core: 2-9-94
Core Run Number: 2
Depth Interval of Core: 35ft - 37ft
Recovery: 0.7ft

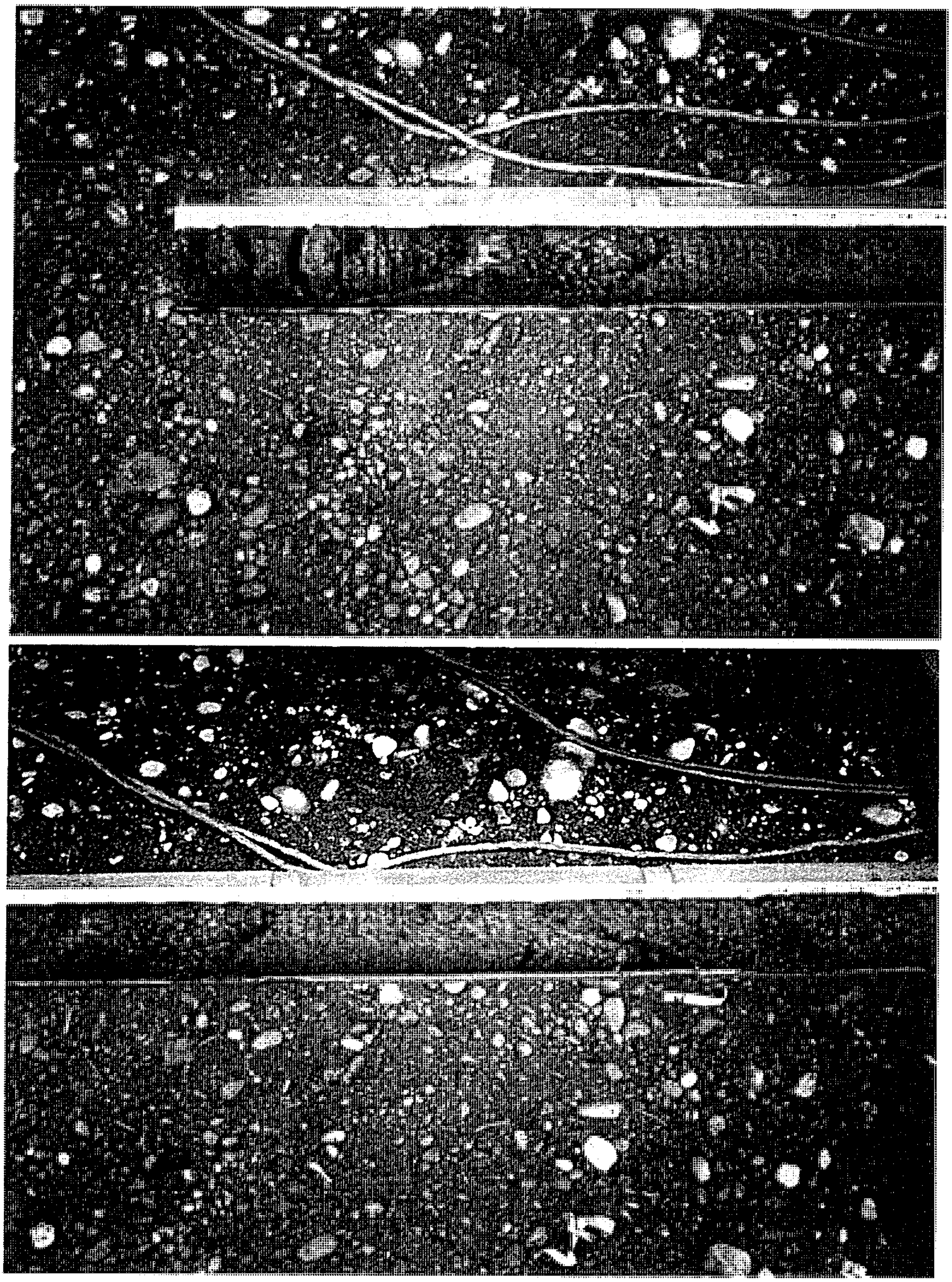
FIGURE **D-2**
LMW-2 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA

Golder Associates

Borehole: LMW-3
Date of Core: 11-20-93
Core Run Number: 1
Depth Interval of Core: 49ft - 59ft
Recovery: 6.5 ft

FIGURE **D-3**
(1 OF 4)
LMW-3 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA

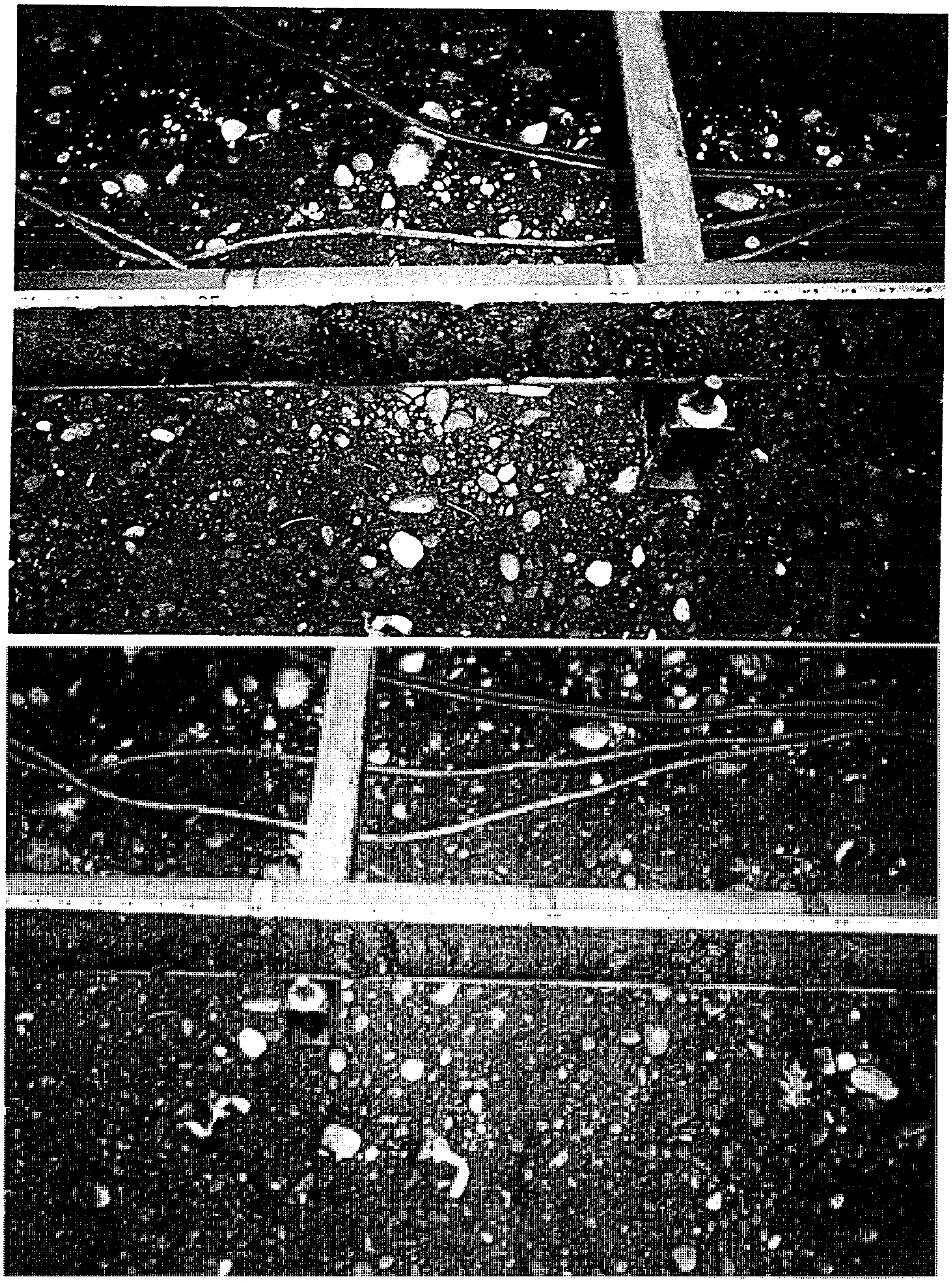
Golder Associates



Borehole: LMW-3
Date of Core: 11-20-93
Core Run Number: 1
Depth Interval of Core: 49ft - 59ft
Recovery: 6.5 ft

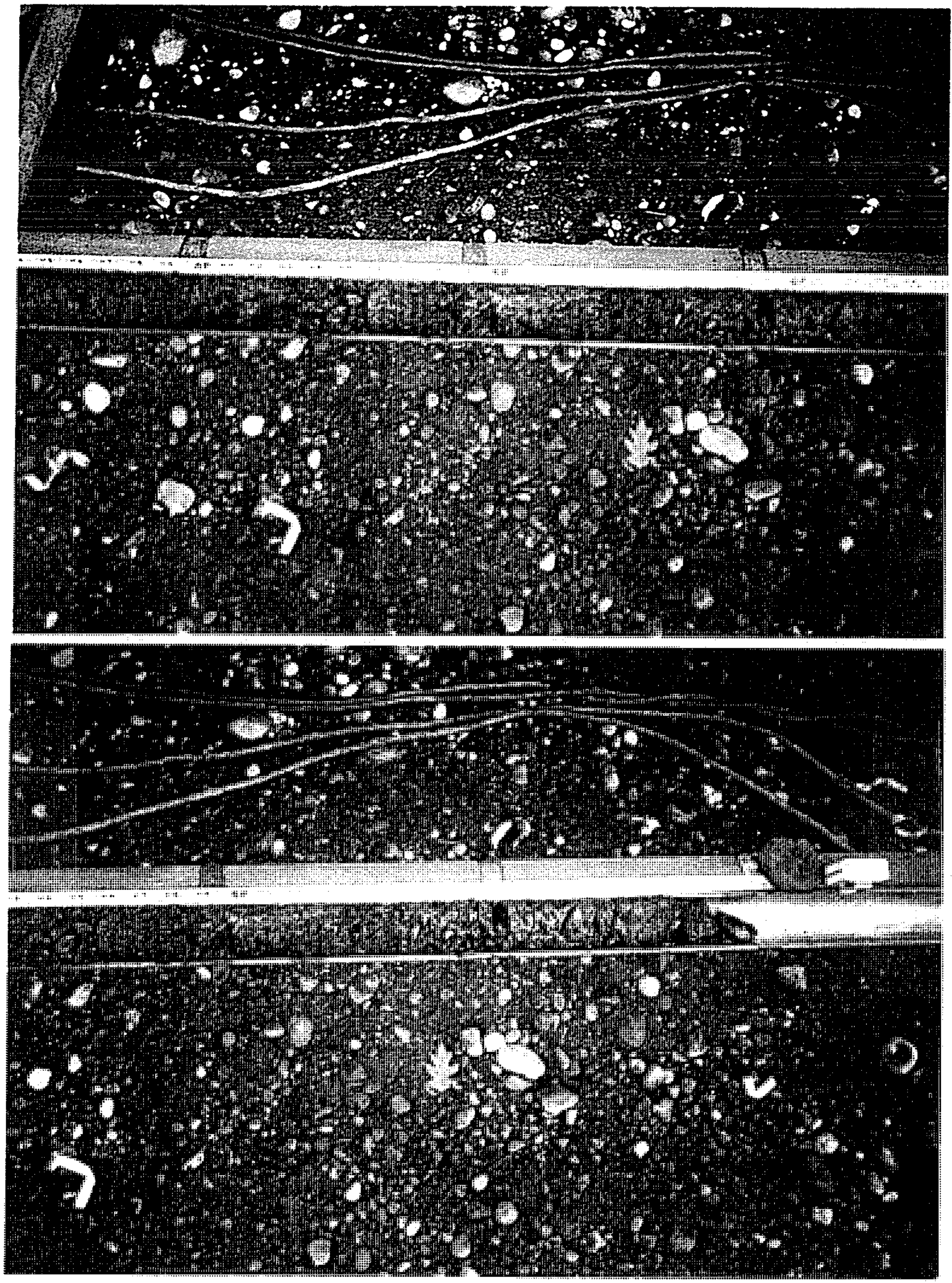
FIGURE **D-3**
(2 OF 4)
LMW-3 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA

Golder Associates



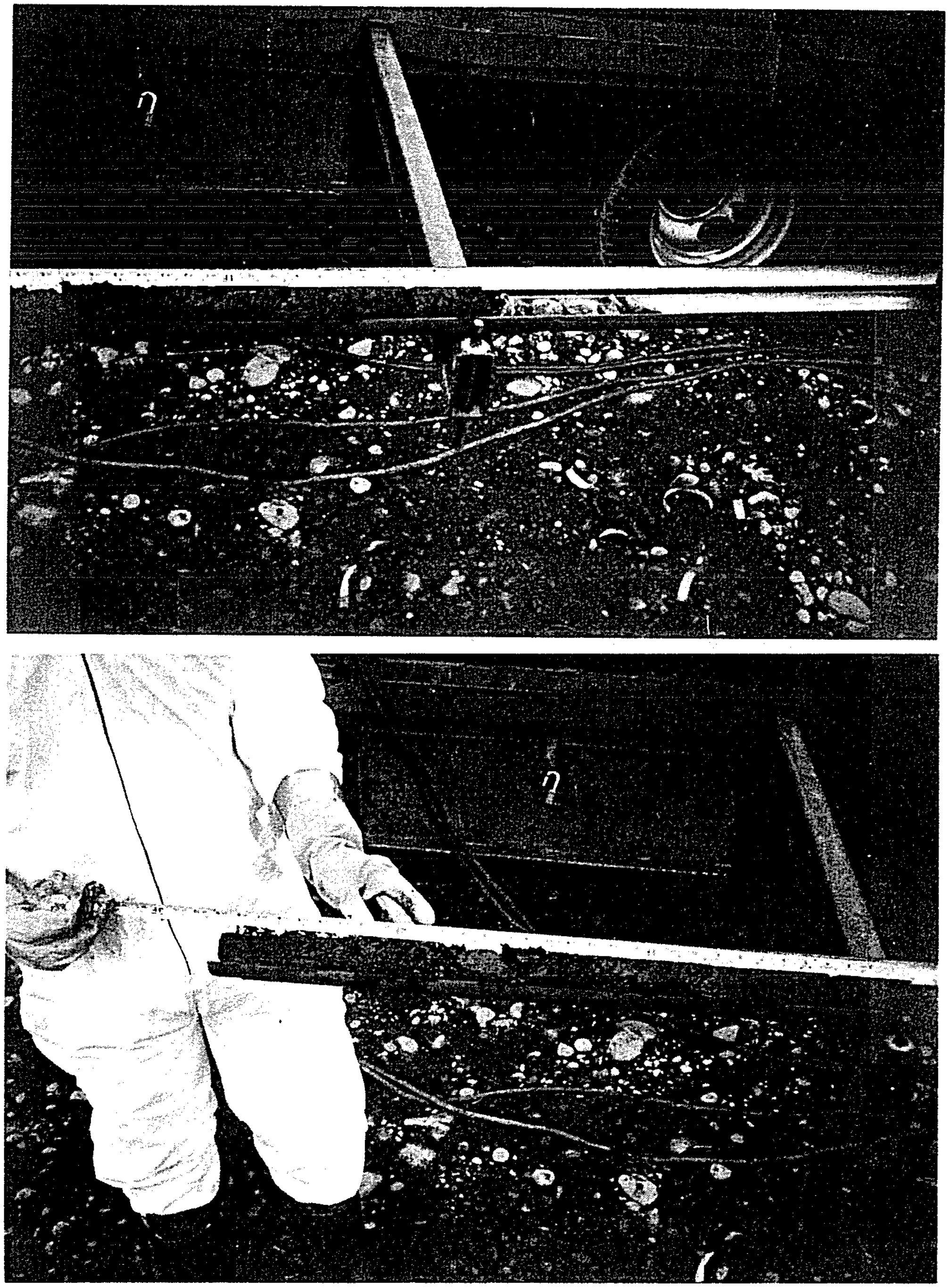
Borehole: LMW-3
Date of Core: 11-20-93
Core Run Number: 1
Depth Interval of Core: 49ft - 59ft
Recovery: 6.5 ft

FIGURE **D-3**
(3 OF 4)
LMW-3 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA



Borehole: LMW-3
Date of Core: 11-20-93
Core Run Number: 1
Depth Interval of Core: 49ft - 59ft
Recovery: 6.5 ft

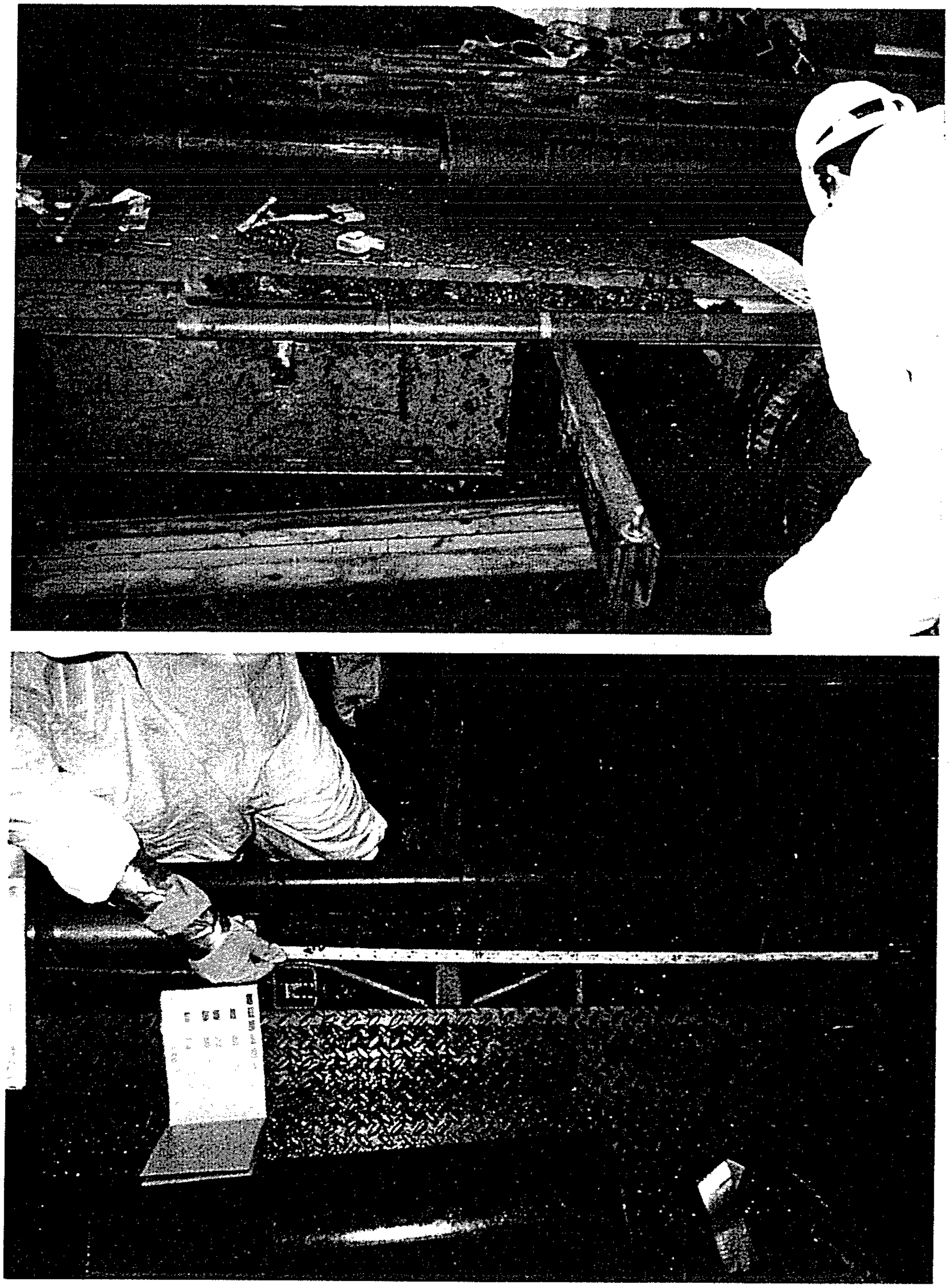
FIGURE **D-3**
(4 OF 4)
LMW-3 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA



Borehole: LMW-3
Date of Core: 11-20-93
Core Run Number: 2
Depth Interval of Core: 59ft - 66 ft
Recovery: 2.8 ft

FIGURE **D-4**
LMW-3 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA

Golder Associates



Borehole: LMW-5
Date of Core: 11-30-93
Core Run Number: 1
Depth Interval of Core: 227ft - 238ft
Recovery: 3.0 ft

FIGURE **D-5**
LMW-5 CORE SAMPLE
LANDSBURG MINE SITE/RI/FS/WA

APPENDIX E

BOREHOLE AND WELL CONSTRUCTION LOGS AND BACKHOE TRENCH LOGS

February 1, 1996

923-1000.R147
0525rdl1.ape

TABLE OF CONTENTS

LIST OF FIGURES

STRATIGRAPHY
ENCOUNTERED DURING
ROTARY DRILLING

DEPTH IN FEET — GENERAL SOIL DESCRIPTION — GRAPHIC LOG

2.0 Sandy GRAVEL and COBBLE (FILL)

Moderate yellowish brown (10YR 5/4), fine sandy SILT
9.5 to silty fine SAND, trace gravel

Highly weathered, dark yellowish brown (10YR 4/2), very fine sandy SILTSTONE, dry

28.0

Fresh, pale yellowish brown (10YR 6/2), very fine sandy SILTSTONE, dry

48.0

Fresh, dark yellowish brown (10YR 4/2), very fine sandy SILTSTONE, damp

67.0

Fresh, pale yellowish brown (10YR 6/2), very fine sandy SILTSTONE, dry

105.0

Fresh, light olive gray (5Y 6/1) very fine sandy SILTSTONE, dry

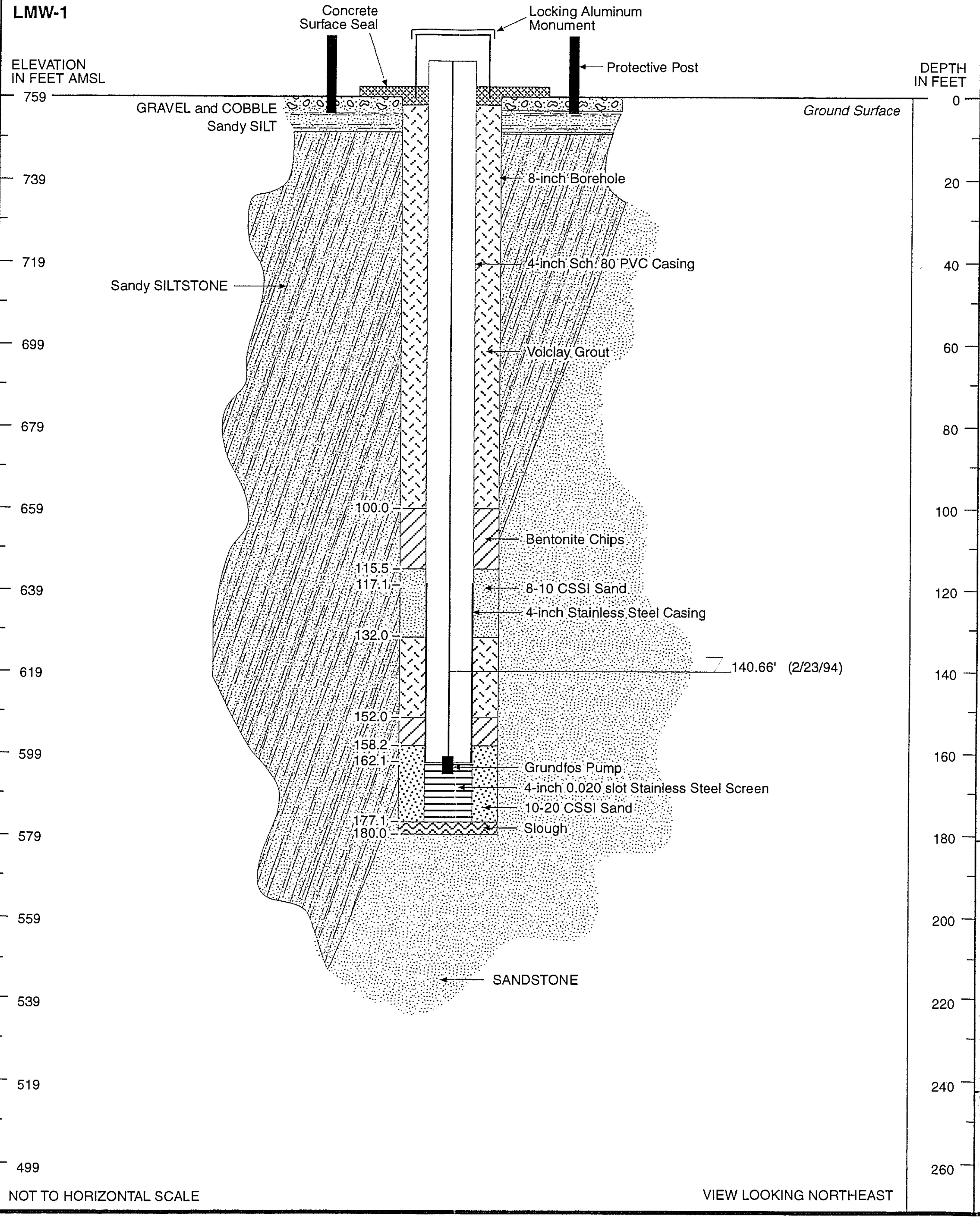
142.0

Dry to approximately 150'
Fresh, dark yellowish brown (10YR 4/2), very fine sandy SILTSTONE, wet

170.0

Fresh, dusky yellowish brown (10YR 2/2), fine
180.0 SANDSTONE, wet

Total Depth 180.0'
Water encountered at approximately 150'



CONSTRUCTION SUMMARY

MONITORING WELL: LMW-1
SURVEY COORDINATES: N-138,337.2724, E-1,714,869.6009
GROUND SURFACE ELEVATION (MSL): 759.24'
TOP OF CASING (PVC) ELEVATION: 761.45'

DRILLING SUMMARY

TOTAL DEPTH:	180.0' bgs
BOREHOLE DIAMETER:	8-inch
INCLINATION:	90°
DRILLER:	Burlington Environmental
ENGINEER:	G. Zimmerman
DRILL METHOD(S):	Air Rotary
DRILL RIG	Schramm T-660
BITS:	7 7/8-Tricone
DRILLING FLUID:	Air

WELL DESIGN AND SPECIFICATIONS

CASING STRING(S) C = CASING S = SCREEN

STRINGS	DEPTH (FT)	ELEVATION (MSL)
C1	(-3 – 15)	(762.24 – 744.24)
C2	-2.21 – 117.1	761.45 – 642.14
C3	117.1 –162.1	642.14 – 597.14
S1	162.1 – 177.1	597.14 – 582.14

CASING: C1	8-inch Temporary Steel Casing (removed)
CASING: C2	4-inch Diameter PVC
CASING: C3	4-inch Diameter Stainless Steel Casing
SCREEN: S1	0.020-inch Slotted 4-inch Dia. Stainless Steel
FILTER PACK:	10-20 CSSI Sand
GROUT SEAL:	Volclay Grout
BENTONITE:	Bentonite Chips

PUMP AND PACKER SUMMARY

Dedicated Sampling Pump: 2-horsepower Grundfos
Submersible Pump Model MPI

STRINGS	DEPTH (FT)	ELEVATION (MSL)
Sampling Pump Intake	161.79	597.45
Packer Assembly	No packer	No packer

FIGURE **E-1**
STRATIGRAPHY AND WELL COMPLETION LOG LMW-1
LANDSBURG MINE SITE/RI/FS/WA

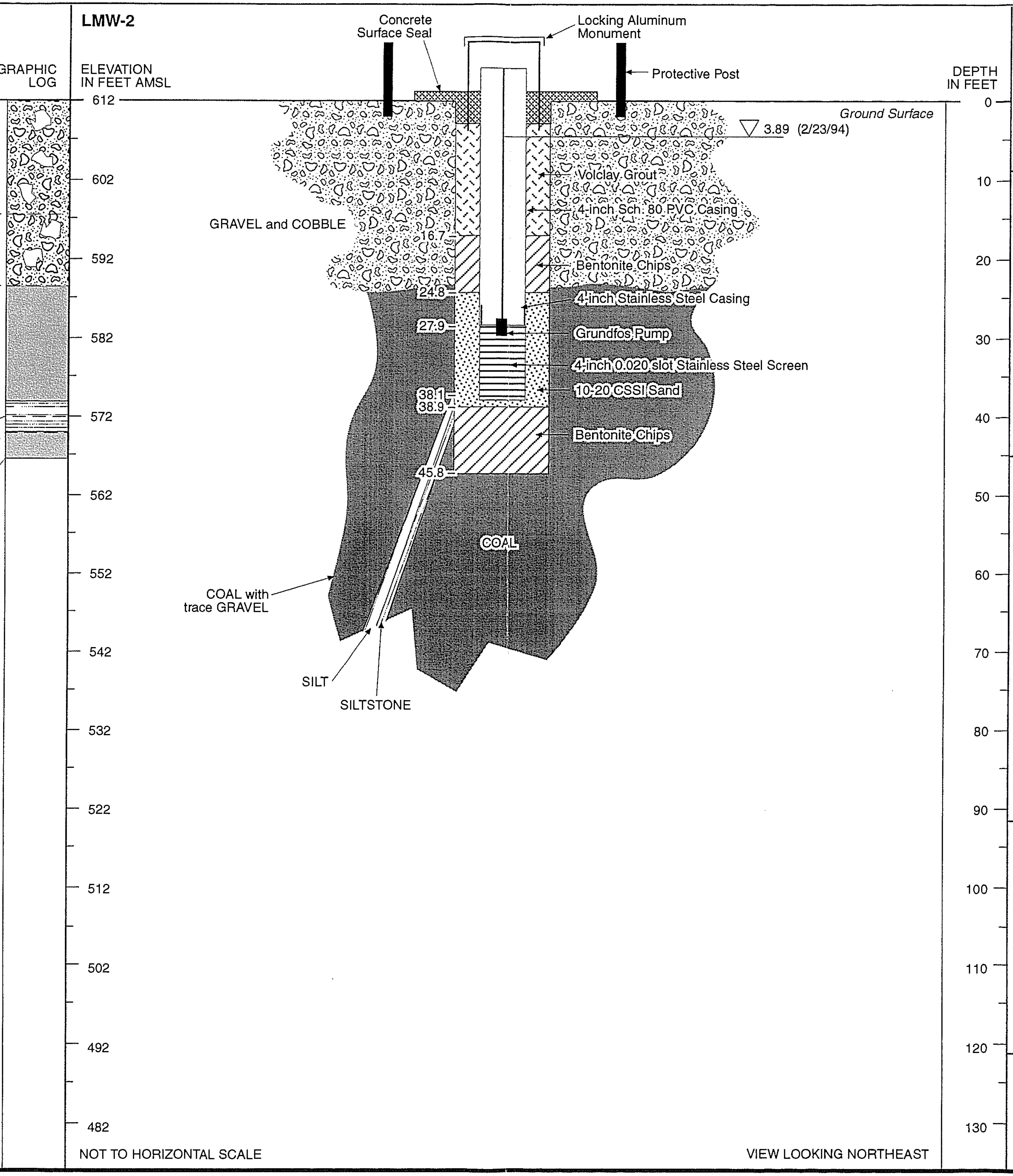
PROJECT NO. 923 1000.147 DRAWING NO. 50630 DATE 5/24/95 DRAWN BY EA

Golder Associates

STRATIGRAPHY
ENCOUNTERED DURING
ROTARY DRILLING

DEPTH IN FEET	GENERAL SOIL DESCRIPTION
0	Grayish brown (5YR 3/2,) poorly sorted, subangular, GRAVEL and PEBBLES, little, medium to coarse Sand, dry (FILL)
14.5	Dusky brown (5YR 2/2), poorly sorted, subangular, GRAVEL and PEBBLES, little, medium to coarse Sand, little decayed wood and organic debris, moist (FILL)
23.0	Brownish black (5YR 2/1) to grayish black (N2), COAL (fragments), trace fine gravel, (probably caved material) dry High increase in moisture 35'-38'
38.0	
40.0	Dusky yellowish brown (10YR 2/2), clayey SILT, little gravel, moist
42.0	Fresh Dusky brown (5YR 2/2), fine sandy SILTSTONE, dry
45.8	Fresh Black (N1), COAL, damp

Total Depth 45.8'
Water encountered at approximately 35'-48'



NOT TO HORIZONTAL SCALE

VIEW LOOKING NORTHEAST

CONSTRUCTION SUMMARY

MONITORING WELL: LMW-2
SURVEY COORDINATES: N-139,135.4807, E-1,715,850.9350
GROUND SURFACE ELEVATION (MSL): 611.79'
TOP OF CASING (PVC) ELEVATION: 614.15'

DRILLING SUMMARY

TOTAL DEPTH:	45.8' bgs
BOREHOLE DIAMETER:	8-inch
INCLINATION:	90°
DRILLER:	Burlington Environmental
ENGINEER:	G. Zimmerman
DRILL METHOD(S):	Air Rotary
DRILL RIG	Schramm T-660
BITS:	7 7/8-Tricone
DRILLING FLUID:	Air

WELL DESIGN AND SPECIFICATIONS

CASING STRING(S) C = CASING S = SCREEN

STRINGS	DEPTH (FT)	ELEVATION (MSL)
C1	(-2.5 – 40)	(614.29 – 571.79)
C2	-2.36 – 22.9	614.15 – 588.89
C3	22.9 – 27.9	588.89 – 583.89
S1	27.9 – 38.1	583.89 – 573.69

CASING: C1	8-inch Temporary Steel Casing (removed)
CASING: C2	4-inch Diameter, Schedule 80 PVC
CASING: C3	4-inch Stainless Steel Casing
SCREEN: S1	0.020-inch Slotted 4-inch Diameter Stainless Steel
FILTER PACK:	10-20 CSSI Sand
GROUT SEAL:	Volclay Grout
BENTONITE:	Bentonite Chips

PUMP AND PACKER SUMMARY

Dedicated Sampling Pump: 2-horsepower Grundfos Submersible Pump Model MPI

STRINGS	DEPTH (FT)	ELEVATION (MSL)
Sampling Pump Intake	27.64	584.15
Packer Assembly	No packer	No packer

FIGURE **E-2**

STRATIGRAPHY AND WELL COMPLETION LOG LMW-2

LANDSBURG MINE SITE/RI/FS/WA

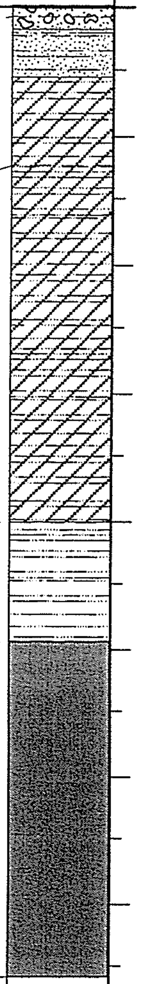
PROJECT NO. 923 1000.147 DRAWING NO. 50631 DATE 5/24/95 DRAWN BY EA

Golder Associates

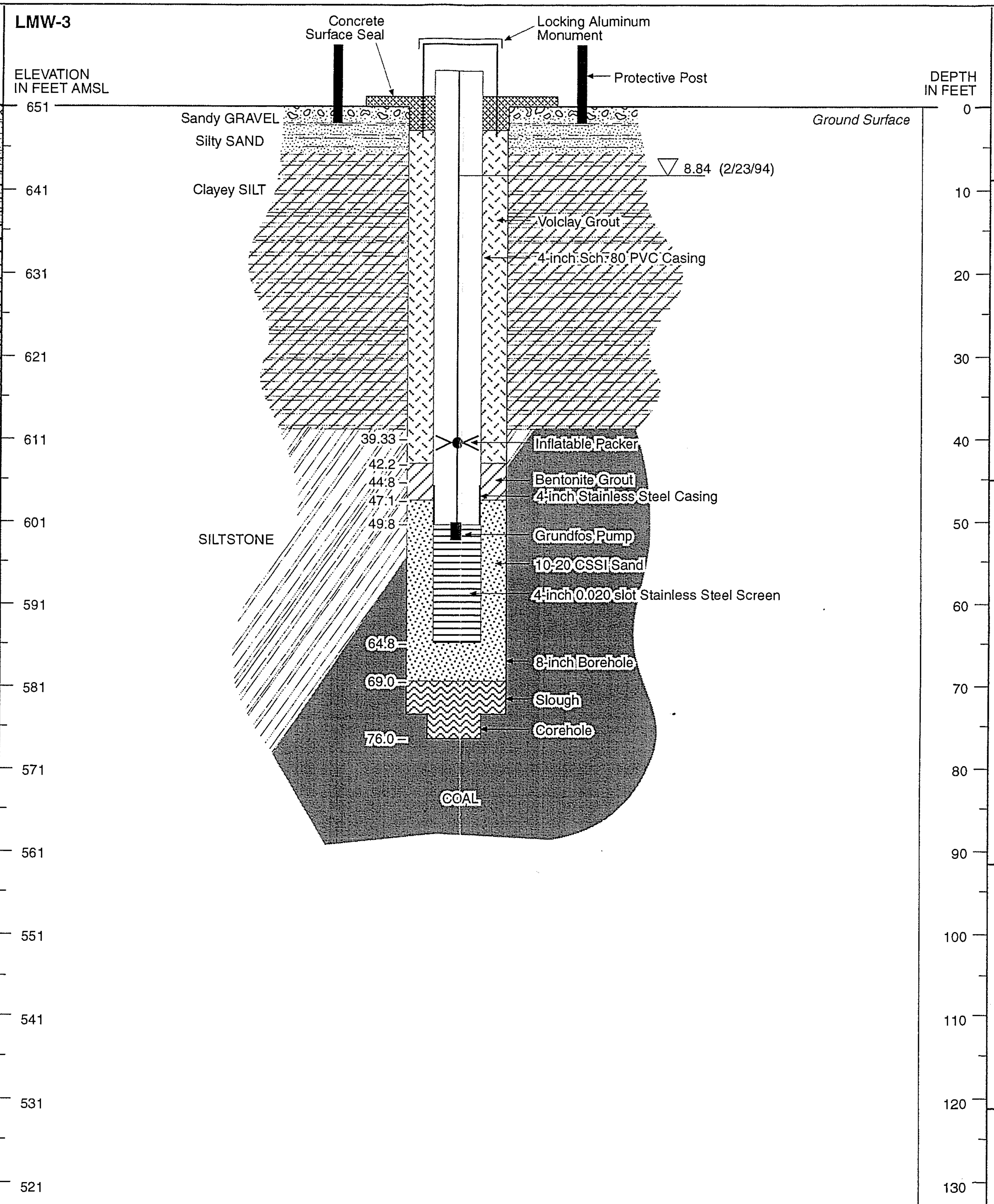
STRATIGRAPHY
ENCOUNTERED DURING
ROTARY DRILLING

DEPTH IN FEET	GENERAL SOIL DESCRIPTION
0.5	Sandy GRAVEL
5.0	Pale yellowish brown (10YR 6/2), fine sandy SILT to silty fine SAND, little gravel, dry
12.0	Olive gray (5Y 3/2), clayey SILT (moderate plasticity), damp
20.0	Olive gray (5Y 3/2), clayey SILT, trace to little fine Sand, dry to moist
	Slight increase in moisture
40.0	Fresh, dark yellowish brown (10YR 4/2), SILTSTONE, (hard, dense fragments)
49.0	Fresh, brownish black (5YR 4), COAL, (finely ground fragments)
	Total Depth 76.0' Water encountered at approximately 50' bgs

GRAPHIC LOG



LMW-3



NOT TO HORIZONTAL SCALE

VIEW LOOKING NORTH

CONSTRUCTION SUMMARY

MONITORING WELL: LMW-3
SURVEY COORDINATES: N-135,249.9481, E-1,713,098.2723
GROUND SURFACE ELEVATION (MSL): 650.84'
TOP OF CASING (PVC) ELEVATION: 653.51'

DRILLING SUMMARY

TOTAL DEPTH:	76.0' bgs
BOREHOLE DIAMETER:	8-inch
INCLINATION:	90°
DRILLER:	Burlington Environmental
ENGINEER:	R. Blegen
DRILL METHOD(S):	Air Rotary
DRILL RIG	Schramm T-660
BITS:	7 7/8-Tricone
DRILLING FLUID:	Air

WELL DESIGN AND SPECIFICATIONS

CASING STRING(S) C = CASING S = SCREEN

STRINGS	DEPTH (FT)	ELEVATION (MSL)
C1	(-2.0 – 6.0)	(652.84 – 646.84)
C2	-2.67 – 44.8	653.51 – 606.04
C3	44.8 – 49.8	606.04 – 601.04
S1	49.8 – 64.8	601.04 – 586.04

CASING: C1	8-inch Temporary Steel Casing (removed)
CASING: C2	4-inch Diameter Schedule 80 PVC
CASING: C3	4-inch Stainless Steel Casing
SCREEN: S1	0.020-inch slotted 4-inch Diameter Stainless Steel
FILTER PACK:	10-20 CSSI Sand
GROUT SEAL:	Volclay Grout
BENTONITE:	Bentonite Chips

PUMP AND PACKER SUMMARY

Dedicated Sampling Pump: 2-horsepower Grundfos Submersible Pump Model MPI

STRINGS	DEPTH (FT)	ELEVATION (MSL)
Sampling Pump Intake	49.33	601.51
Packer Assembly	39.33	611.51

FIGURE **E-3**

STRATIGRAPHY AND WELL COMPLETION LOG LMW-3
LANDSBURG MINE SITE/RI/FS/WA

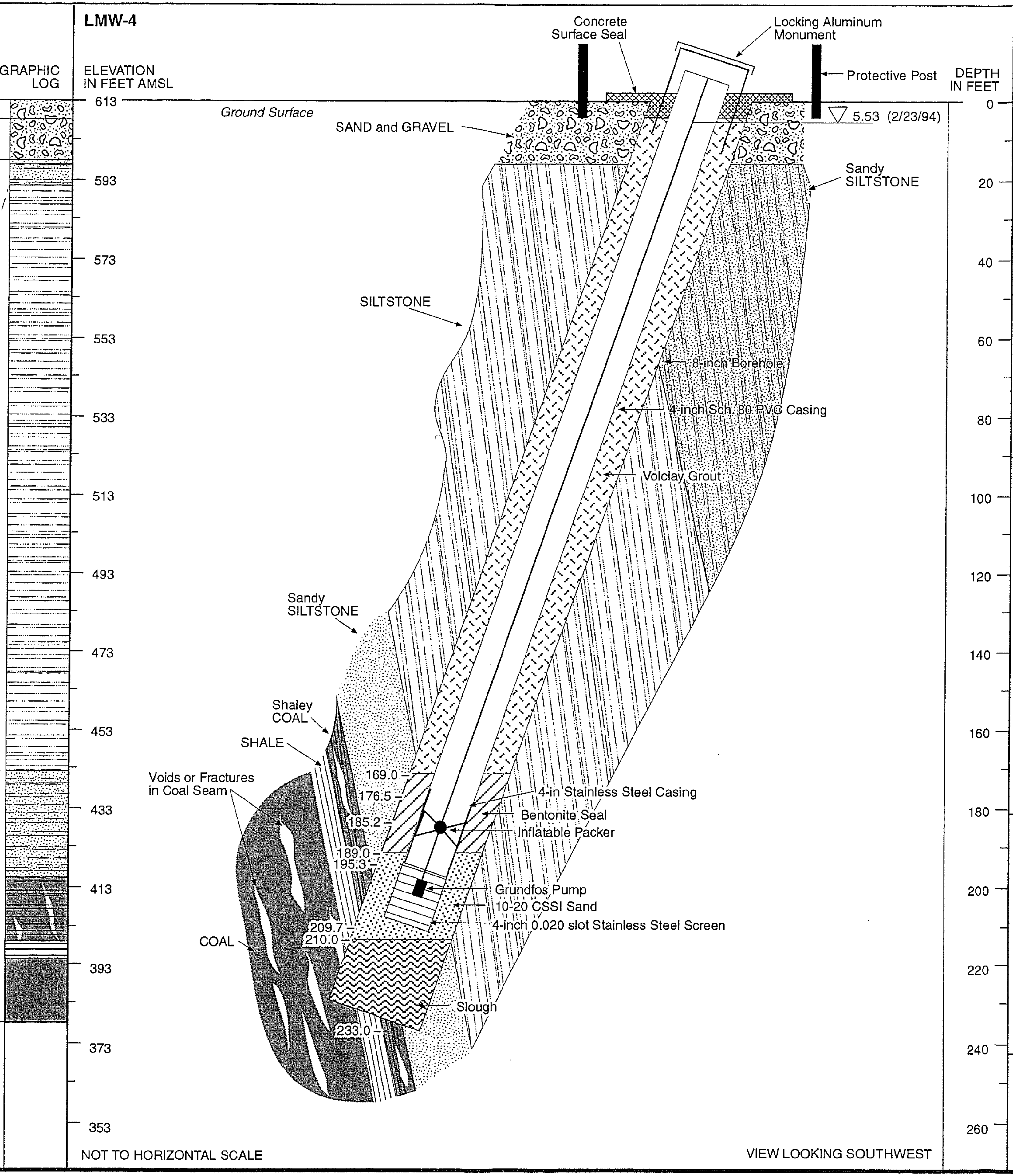
PROJECT NO. 923 1000.147 DRAWING NO. 50632 DATE 5/24/95 DRAWN BY EA

Golder Associates

STRATIGRAPHY
ENCOUNTERED DURING
ROTARY DRILLING

DEPTH IN FEET	GENERAL SOIL DESCRIPTION
4.7	Dark yellowish brown (10YR 4/2), medium to coarse, subangular, SAND, damp
15.0	Pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), coarse GRAVEL, some to little, medium subangular sand, dry
28.0	Fresh, pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2), very fine sandy SILTSTONE, dry
	Fresh, pale yellowish brown (10YR 6/2), SILTSTONE, damp
171.0	Fresh, dark yellowish brown (10YR 4/2), fine sandy SILTSTONE, damp
187.9	Fresh, pale yellowish brown (10YR 6/2), fine sandy SILTSTONE, damp
197.3	Fresh, shaley COAL, highwater discharge
214.2	(Void 202.9 to 203.9)
218.0	Fresh, SHALE
	(Void 218.0 to 219.8)
	Fresh, black (N1), COAL
233.0	Total Depth 233.0' Water encountered at approximately 197' bgs

DEPTH IN FEET: 0, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260



CONSTRUCTION SUMMARY

MONITORING WELL: LMW-4
SURVEY COORDINATES: N-139,180.3874, E-1,715,744.0750
GROUND SURFACE ELEVATION (MSL): 613.45'
TOP OF CASING (PVC) ELEVATION: 615.70'

DRILLING SUMMARY

TOTAL DEPTH:	233.0' bgs
BOREHOLE DIAMETER:	8-inch
INCLINATION:	70°
DRILLER:	Burlington Environmental
ENGINEER:	G. Zimmerman
DRILL METHOD(S):	Air Rotary
DRILL RIG	Schramm T-660
BITS:	7 7/8-Tricone and 7 7/8 Button Bit
DRILLING FLUID:	Air

WELL DESIGN AND SPECIFICATIONS

CASING STRING(S) C = CASING S = SCREEN

STRINGS	DEPTH (FT)	ELEVATION (MSL)
C1	(-4 – 16)	(617.4 – 597.4)
C2	-2.25 – 176.5	615.7 – 436.9
C3	176.5 – 195.3	436.9 – 418.15
S1	195.3 – 209.7	418.15 – 403.75

CASING: C1	8-inch Temporary Casing (removed)
CASING: C2	4-inch Diameter Schedule 80 PVC
CASING: C3	4-inch Diameter 30 Stainless Steel Casing
SCREEN: S1	0.020-inch slotted 4-inch Diameter Stainless Steel
FILTER PACK:	10-20 CSSI Sand
GROUT SEAL:	Volclay Grout
BENTONITE:	Bentonite Chips

PUMP AND PACKER SUMMARY

Dedicated Sampling Pump: 2-horsepower Grundfos Submersible Pump Model MPI

STRINGS	DEPTH (FT)	ELEVATION (MSL)
Sampling Pump Intake	197.3	416.1
Packer Assembly	187.3	426.1

FIGURE **E-4**

STRATIGRAPHY AND WELL COMPLETION LOG LMW-4

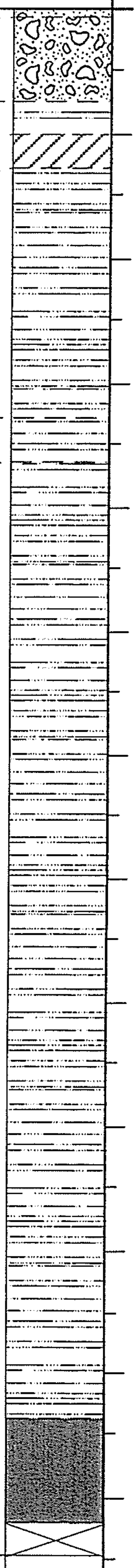
LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 50633 DATE 5/24/95 DRAWN BY EA

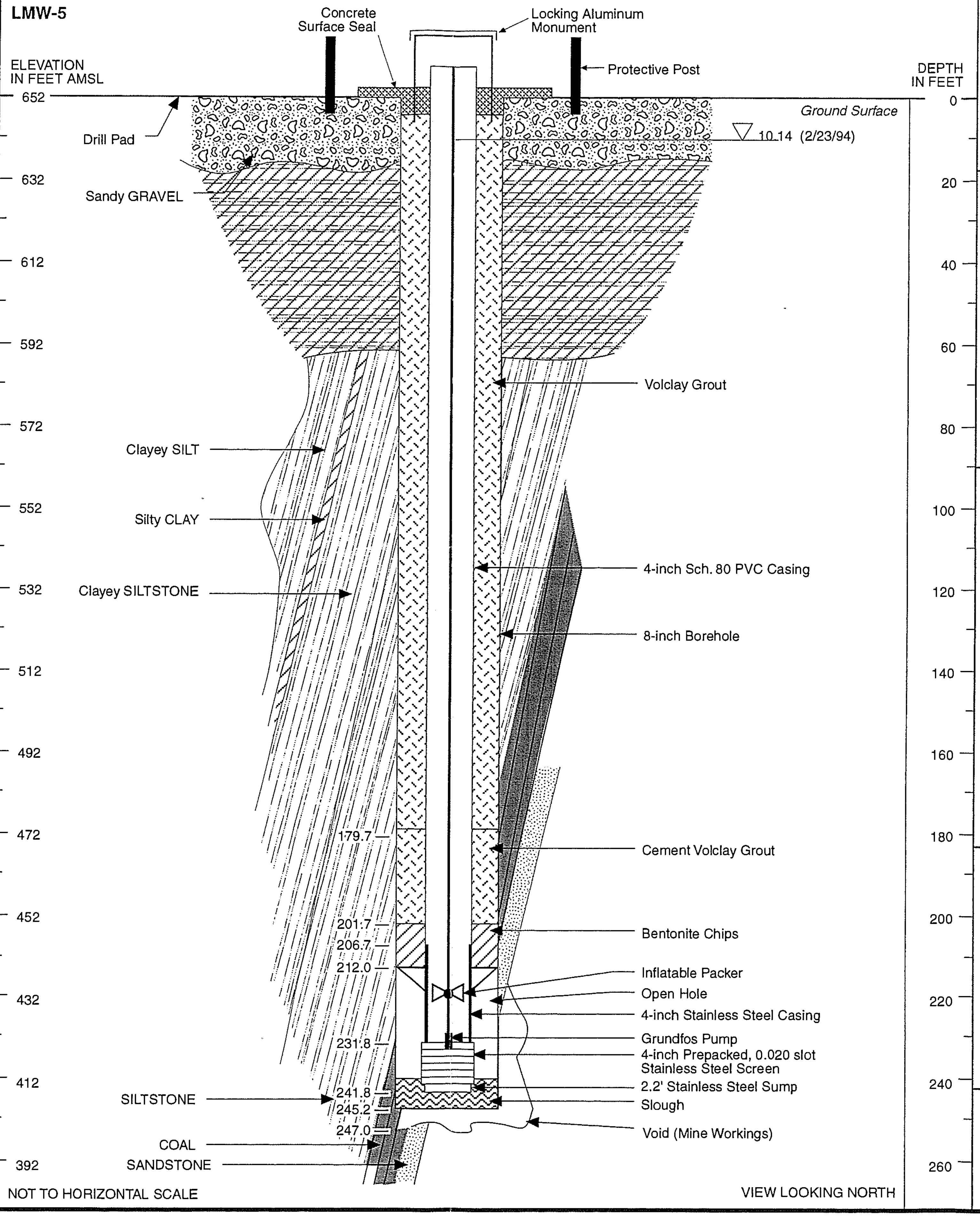
Golder Associates

STRATIGRAPHY
ENCOUNTERED DURING ROTARY DRILLING

DEPTH IN FEET	GENERAL SOIL DESCRIPTION
0-0.5	Sandy GRAVEL (drill pad)
	Dark yellowish brown (10YR 6/2), gravelly SAND to sandy GRAVEL, moist
15.0	Dusky yellowish green (10GY 3/2), clayey SILT, slightly moist
20.0	
25.0	Dark greenish gray (5G 4/1), silty CLAY, very moist
	Greenish black (5G 2/1), clayey SILT, slightly moist
	Greenish black (5G 2/1), fine sandy clayey SILT, trace gravel, slightly moist
66.0	Fresh, pale yellowish brown (10YR 6/2), clayey SILTSTONE, slightly moist
72.0	Fresh, pale yellowish brown (10YR 6/2), fine sandy to clayey SILTSTONE, slightly moist
228	Black (N1) COAL, little dark yellowish brown (10YR 4/2) Siltstone at 255'
243	
247	VOID
	Total Depth 247' bgs Drilled to 243.5' bgs Void to 247'. Encountered water at approximately 140.0' bgs



LMW-5



NOT TO HORIZONTAL SCALE

VIEW LOOKING NORTH

CONSTRUCTION SUMMARY

MONITORING WELL: LMW-5
SURVEY COORDINATES: N-135,263.6364, E-1,713,019.1629
GROUND SURFACE ELEVATION (MSL): 651.89'
TOP OF CASING (PVC) ELEVATION: 654.78'

DRILLING SUMMARY

TOTAL DEPTH:	245.2' bgs
BOREHOLE DIAMETER:	8-inch
INCLINATION:	90°
DRILLER:	Burlington Environmental
ENGINEER:	G. Zimmerman
DRILL METHOD(S):	Air Rotary
DRILL RIG	Schramm T-660
BITS:	7 7/8-Tricone
DRILLING FLUID:	Air

WELL DESIGN AND SPECIFICATIONS

CASING STRING(S) C = CASING S = SCREEN

STRINGS	DEPTH (FT)	ELEVATION (MSL)
C1	(-3.0 – 15.0)	(654.89 – 636.89)
C2	-2.89 – 206.7	654.78 – 445.19
C3	206.7 – 231.8	445.19 – 420.09
S1	231.8 – 241.8	420.09 – 410.09

CASING: C1	8-inch Temporary Steel Casing (removed)
CASING: C2	4-inch Diameter, Schedule 80 PVC
CASING: C3	4-inch Stainless Steel Riser
SCREEN: S1	0.020-inch Slotted 4-inch Diameter Stainless Steel Prepacked CSSI 10-20 Sand

PUMP AND PACKER SUMMARY

Dedicated Sampling Pump: 2-horsepower Grundfos Submersible Pump Model MPI

STRINGS	DEPTH (FT)	ELEVATION (MSL)
Sampling Pump Intake	232.11	419.78
Packer Assembly	222.11	429.78

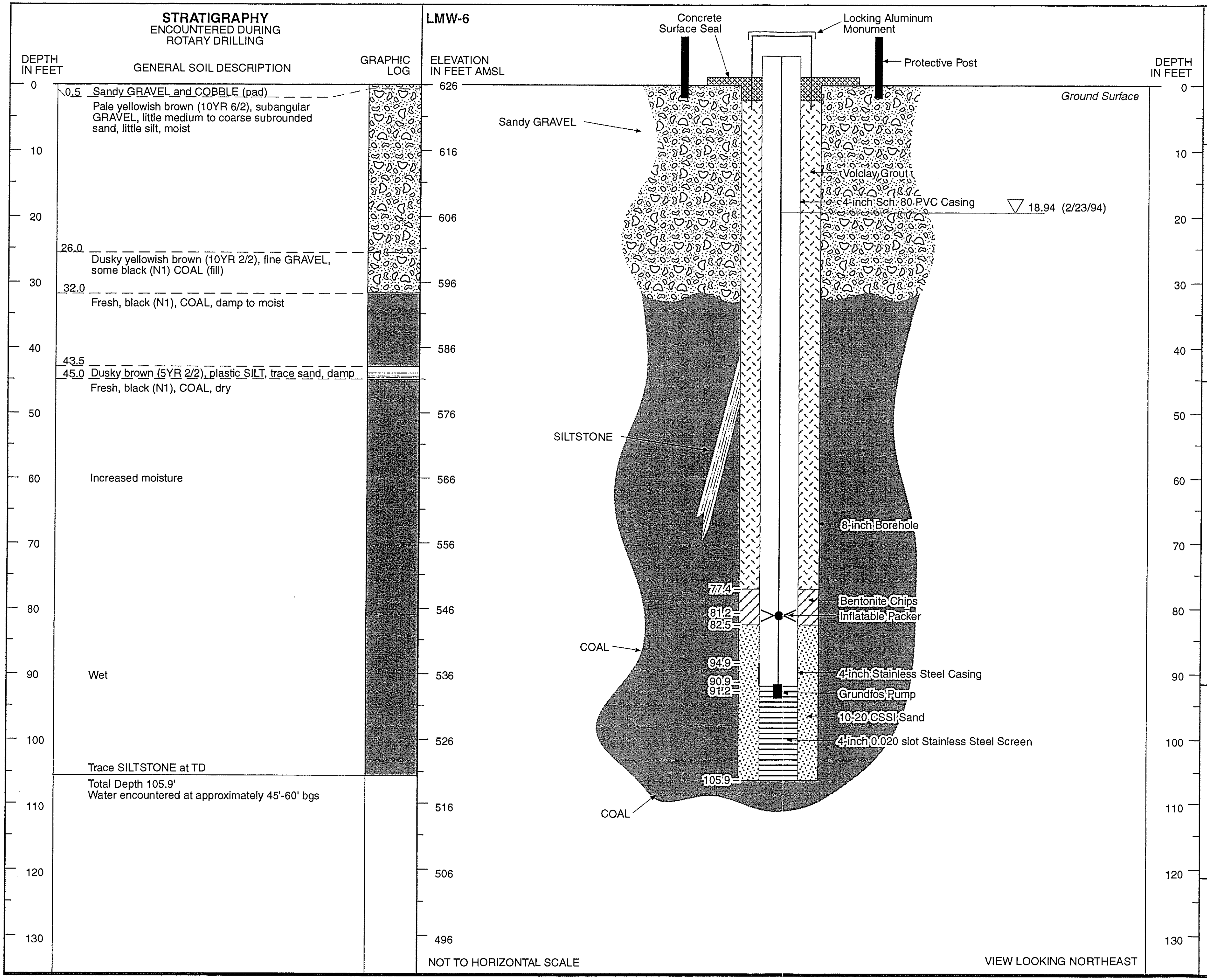
FIGURE **E-5**

STRATIGRAPHY AND WELL COMPLETION LOG LMW-5

LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 50634 DATE 5/24/95 DRAWN BY EA

Golder Associates



STRATIGRAPHY
ENCOUNTERED DURING
ROTARY DRILLING

DEPTH IN FEET	GENERAL SOIL DESCRIPTION
0.5	Sandy GRAVEL and COBBLE (pad)
	Pale yellowish brown (10YR 6/2), subangular GRAVEL, little medium to coarse subrounded sand, little silt, moist
26.0	Dusky yellowish brown (10YR 2/2), fine GRAVEL, some black (N1) COAL (fill)
32.0	Fresh, black (N1), COAL, damp to moist
43.5	
45.0	Dusky brown (5YR 2/2), plastic SILT, trace sand, damp
	Fresh, black (N1), COAL, dry
	Increased moisture
	Wet
	Trace SILTSTONE at TD
	Total Depth 105.9' Water encountered at approximately 45'-60' bgs

CONSTRUCTION SUMMARY

MONITORING WELL: LMW-6
SURVEY COORDINATES: N-138,772.6829, E-1,714,004.7812
GROUND SURFACE ELEVATION (MSL): 62602'
TOP OF CASING (PVC) ELEVATION: 628.80'

DRILLING SUMMARY

TOTAL DEPTH:	105.9' bgs
BOREHOLE DIAMETER:	8-inch
INCLINATION:	90°
DRILLER:	Burlington Environmental
ENGINEER:	G. Zimmerman
DRILL METHOD(S):	Air Rotary
DRILL RIG	Schramm T-660
BITS:	7 7/8-Rotary
DRILLING FLUID:	Air

WELL DESIGN AND SPECIFICATIONS

CASING STRING(S) C = CASING S = SCREEN

STRINGS	DEPTH (FT)	ELEVATION (MSL)
C1	(-2.1 – 34.5)	(628.12 – 591.52)
C2	-2.78 – 94.9	628.80 – 531.12
C3	94.9 – 90.9	531.12 – 535.12
S1	90.9 – 105.9	535.12 – 520.12

CASING: C1	8-inch Temporary Steel Casing (removed)
CASING: C2	4-inch Diameter Schedule 80 PVC
CASING: C3	4-inch Diameter Stainless Steel Casing
SCREEN: S1	0.020-inch Slotted 4-inch Diameter Stainless Steel
FILTER PACK:	10-20 CSSI Sand
GROUT SEAL:	Volclay Grout
BENTONITE:	Bentonite Chips

PUMP AND PACKER SUMMARY

Dedicated Sampling Pump: 2-horsepower Grundfos Submersible Pump Model MPI

STRINGS	DEPTH (FT)	ELEVATION (MSL)
Sampling Pump Intake	91.22	534.80
Packer Assembly	81.22	544.80

FIGURE **E-6**
STRATIGRAPHY AND WELL COMPLETION LOG LMW-6
LANDSBURG MINE SITE/RI/FS/WA

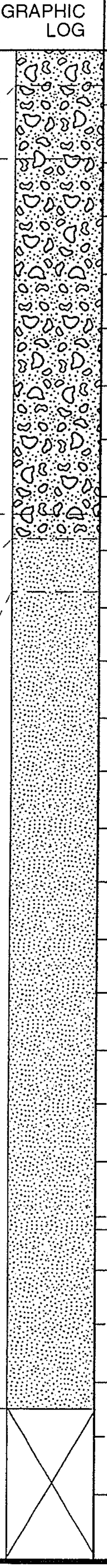
PROJECT NO. 923 1000.147 DRAWING NO. 50635 DATE 5/24/95 DRAWN BY EA

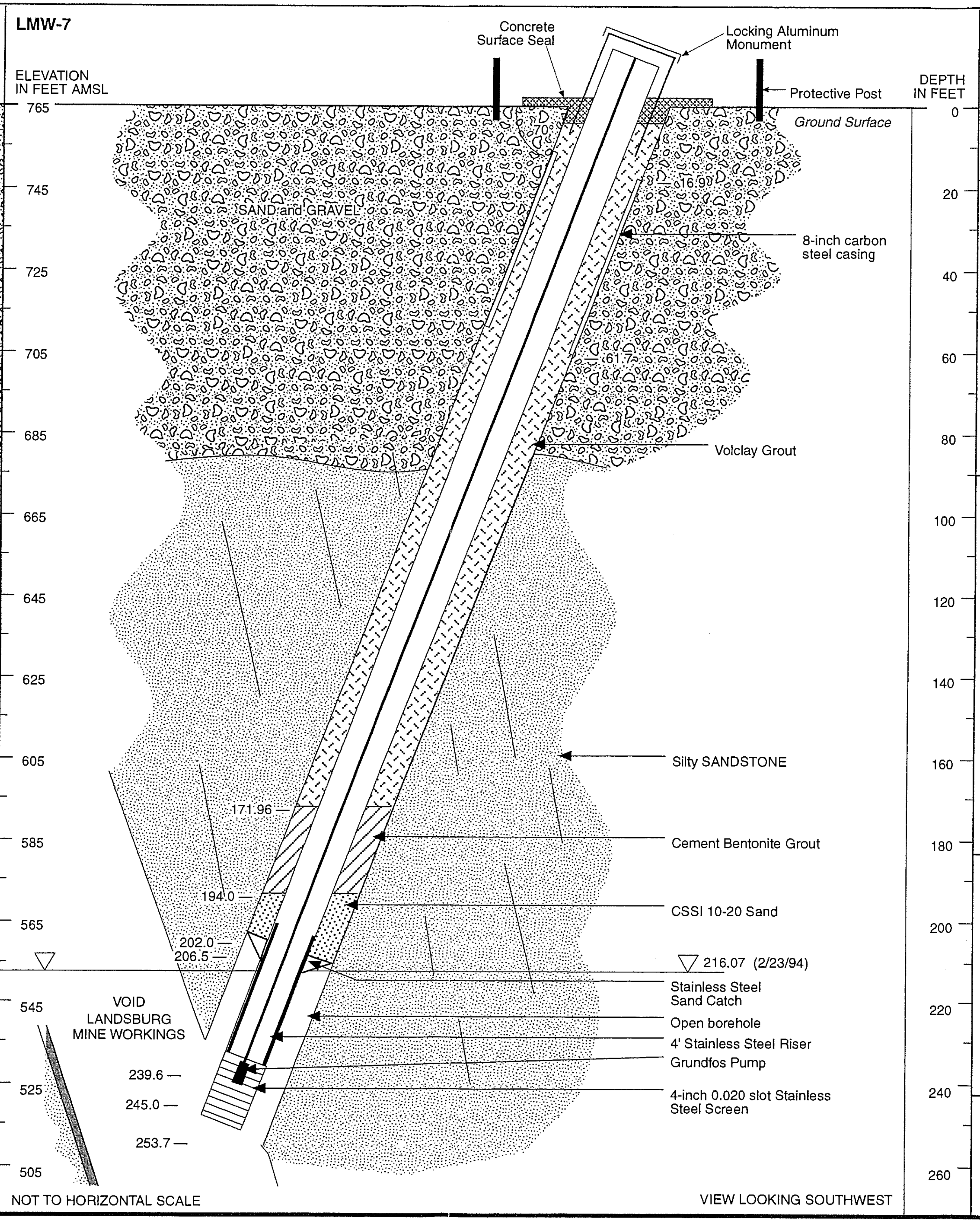
Golder Associates

STRATIGRAPHY
ENCOUNTERED DURING
ROTARY DRILLING

DEPTH IN FEET	GENERAL SOIL DESCRIPTION
4.5	Dark yellowish brown (10YR 4/2) GRAVEL and SAND (drill pad and fill)
18.7	Medium gray (N5) clean BOULDER and COBBLE to olive gray (5Y4/1) sandy GRAVEL
	Olive gray (5Y 4/1) gravelly, silty fine SAND to dark yellowish brown (10YR 4/2) SAND and GRAVEL, moist
82	
87	Dark gray (N3) to grayish black (N2), ,silty fine SAND, little coal, little gravel
98	Fresh, dusky yellowish brown (10YR 2/2) to pale yellowish brown (10YR 6/2) silty SANDSTONE, slightly moist
	Fresh, pale yellowish brown (10YR 6/2), silty, clayey, SANDSTONE, slightly moist
245	
253.7	Void 245.0-281.0

Total Depth 281.0' bgs
Drilled to 253.7' bgs
Void to 281.0' bgs
Encountered water at approximately 225.0' bgs





CONSTRUCTION SUMMARY

MONITORING WELL: LMW-7
SURVEY COORDINATES: N-138,112.1074, E-1,715,362.1856
GROUND SURFACE ELEVATION (MSL): 765.05'
TOP OF CASING (PVC) ELEVATION: 767.68'

DRILLING SUMMARY

TOTAL DEPTH:	253.72' bgs
BOREHOLE DIAMETER:	8-inch
INCLINATION:	70°
DRILLER:	Burlington Environmental
ENGINEER:	G. Zimmerman
DRILL METHOD(S):	Air Rotary
DRILL RIG	Schramm T-660
BITS:	7 7/8-Tricone
DRILLING FLUID:	Air

WELL DESIGN AND SPECIFICATIONS

CASING STRING(S) C = CASING S = SCREEN

STRINGS	DEPTH (FT)	ELEVATION (MSL)
C1	18.0 – 61.7	747.15 – 703.35
C2	-2.63 – 202.0	767.68 – 563.05
C3	202.0 – 239.6	563.05 – 525.45
S1	239.6 – 253.7	525.45 – 511.35

CASING: C1	8-inch Temporary Steel Casing
CASING: C2	4-inch Diameter, Schedule 80 PVC
CASING: C3	4-inch Stainless Steel Riser
SCREEN: S1	0.020-inch Slotted 4-inch Diameter Stainless Steel
FILTER PACK:	10-20 CSSI Sand
GROUT SEAL:	Volclay Grout
BENTONITE:	Bentonite Chips

PUMP AND PACKER SUMMARY

Dedicated Sampling Pump: 2-horsepower Grundfos Submersible Pump Model MPI

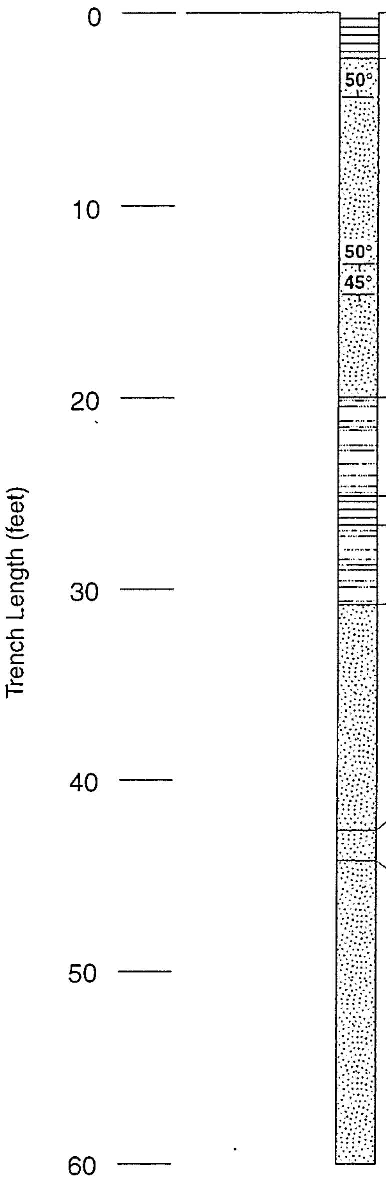
STRINGS	DEPTH (FT)	ELEVATION (MSL)
Sampling Pump Intake	242.44	522.61
Packer Assembly	NA	NA

FIGURE **E-7**
STRATIGRAPHY AND WELL COMPLETION LOG LMW-7
LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 50636 DATE 5/24/95 DRAWN BY EA

Golder Associates

Rogers Seam Subsidence Trench



Brownish gray (5YR 4/1) to brownish black (5YR 2/1), friable SHALE. Trace Iron-oxide stains

Compact, light olive gray (5Y 6/1), fine to medium SAND. Iron-oxide stains common. Linear to curvilinear clay-filled fractures at 5 feet and approximately 8 feet. Iron-oxide staining typically follows fracture pattern.

Firm, brownish gray (5YR 4/1), sandy SILTSTONE. Iron-oxide staining common.

Hard, brownish gray (5YR 4/1), SHALE. 10-12% fine sand. Micaceous.

Firm, brownish gray (5YR 4/1), sandy SILTSTONE.

Moderate yellowish brown (10YR 5/4), SANDSTONE. Medium sand sized particles. Highly friable. Iron-oxide staining common.

Hard dense, moderate reddish brown (10R 4/6) to moderate brown (5YR 4/4), SANDSTONE.

Moderate yellowish brown (10YR 5/4), SANDSTONE. Medium sand-sized particles. Highly friable. Iron-oxide staining common.

Backhoe Operator: M. Trueblood
Logged By: R.Blegen

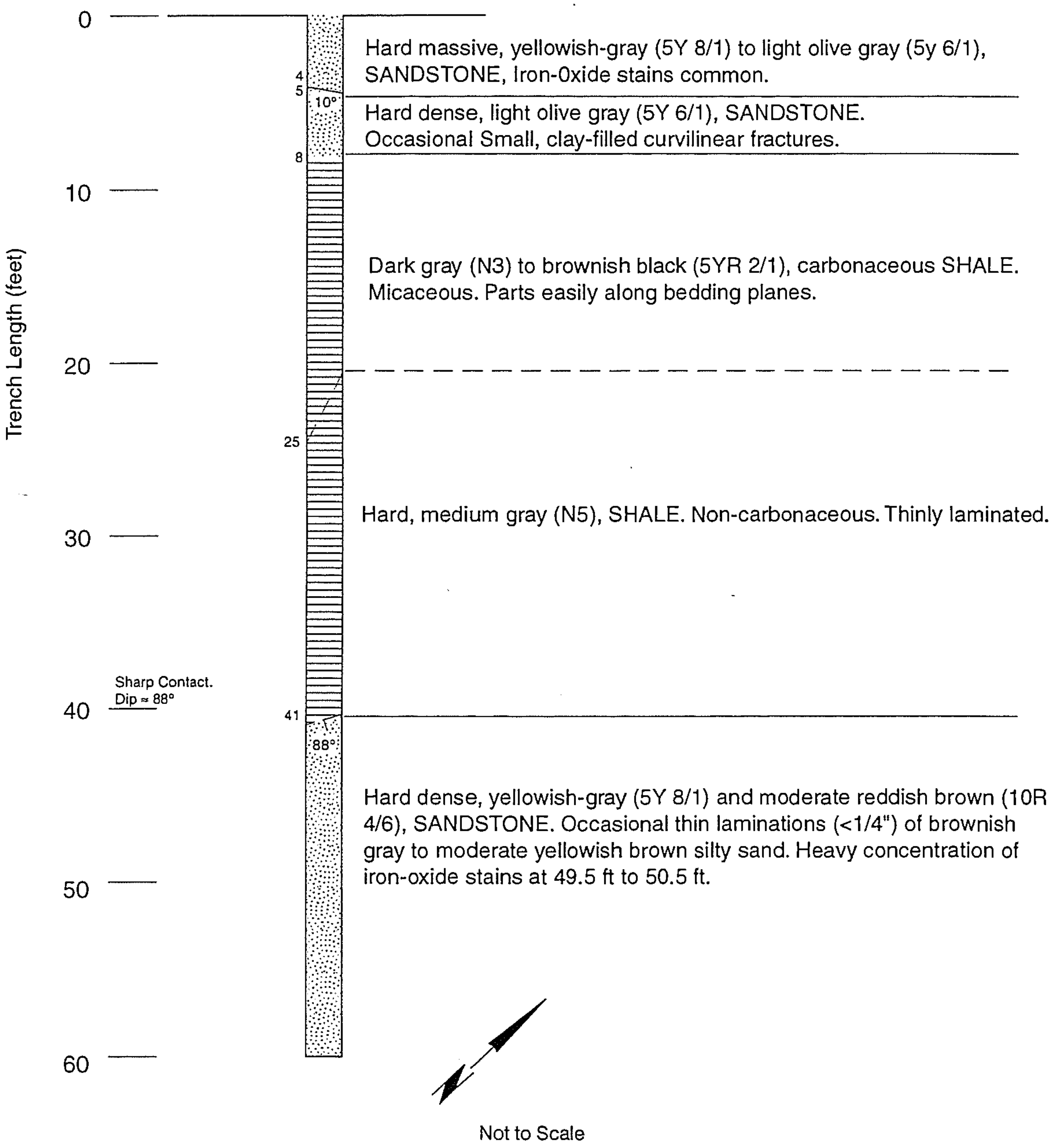
Not to Scale

FIGURE **E-8**
BACKHOE TRENCH 1 LOG
LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 48726 DATE 05/24/95 DRAWN BY TB

Golder Associates

Rogers Seam Subsidence Trench



Hard massive, yellowish-gray (5Y 8/1) to light olive gray (5y 6/1), SANDSTONE, Iron-Oxide stains common.

Hard dense, light olive gray (5Y 6/1), SANDSTONE. Occasional Small, clay-filled curvilinear fractures.

Dark gray (N3) to brownish black (5YR 2/1), carbonaceous SHALE. Micaceous. Parts easily along bedding planes.

Hard, medium gray (N5), SHALE. Non-carbonaceous. Thinly laminated.

Hard dense, yellowish-gray (5Y 8/1) and moderate reddish brown (10R 4/6), SANDSTONE. Occasional thin laminations (<1/4") of brownish gray to moderate yellowish brown silty sand. Heavy concentration of iron-oxide stains at 49.5 ft to 50.5 ft.

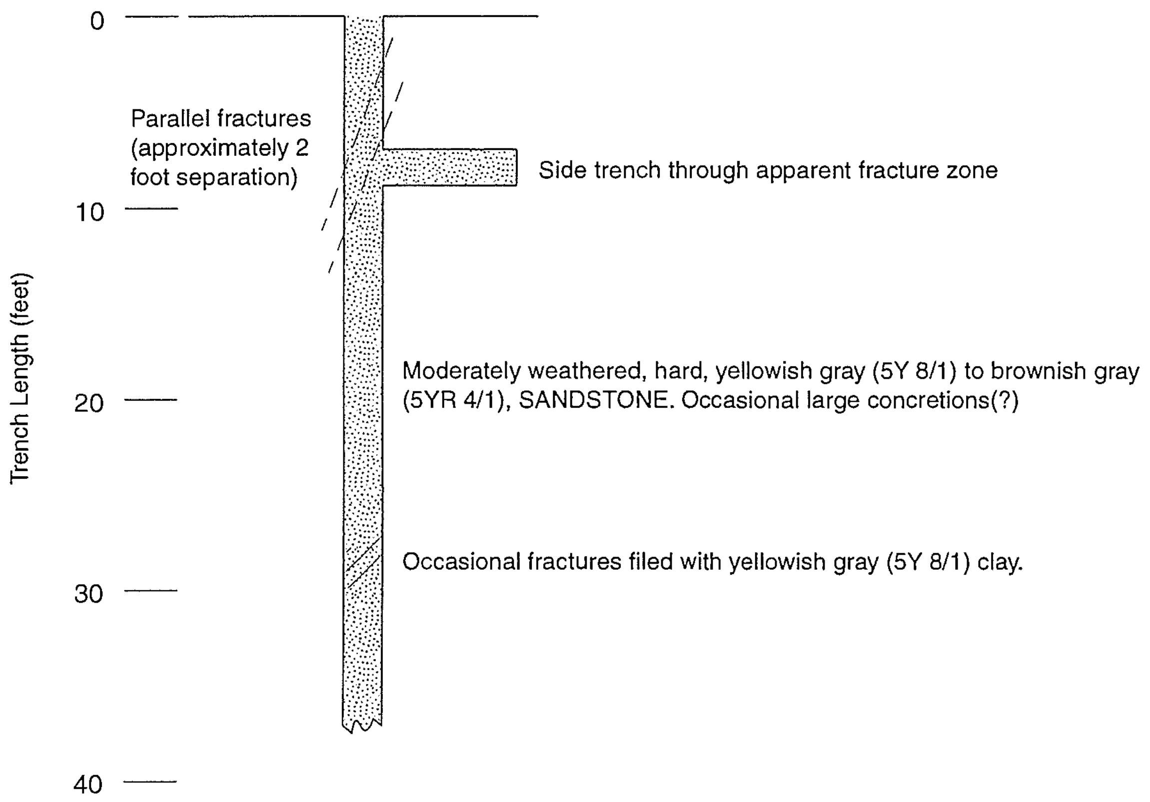
Backhoe Operator: M. Trueblood
Logged By: R.Blegen

FIGURE **E-9**
BACKHOE TRENCH 2 LOG
LANDSBURG MINE SITE/RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 48724 DATE 5/26/95 DRAWN BY TB

Golder Associates

Rogers Seam Subsidence Trench



Backhoe Operator: M. Trueblood
Logged By: R.Blegen

Not to Scale

FIGURE **E-10**
BACKHOE TRENCH 3 LOG
LANDSBURG MINE SITE/RI/FS/WA

APPENDIX F

WELL TESTING AND DATA ANALYSIS

February 1, 1996

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TABLE OF CONTENTS

LIST OF FIGURES

Hydraulic testing conducted during the RI consisted of slug tests at wells LMW-1 through LMW-5, and pumping tests at the two well clusters (LMW-2/4 and LMW-3/5). The results of these tests and the analysis of data are presented below.

F.1 SLUG TESTS

Slug test data generated at the Landsburg Mine site were analyzed by one of two analytical methods. Data from tests at wells LMW-1 and LMW-3 were analyzed using the method developed by Hvorslev (1951). Test data from wells LMW-2, LMW-4, and LMW-5 required an analysis method which accounted for oscillating water levels resulting from inertial forces within the water column and a lack of dampening effects within the well. These data were analyzed with a method developed by Uffink (1984). Both methods are detailed below.

F.1.1 Method of Hvorslev (1951)

The method of Hvorslev (1951) is the simplest interpretation of recovery-data and is for a point piezometer open only over a short interval at its base. The method is based on the reasoning that the rate of flow with time, q, into or out of the piezometer at any time, t, is proportional to the hydraulic conductivity, K, and the unrecovered head difference, H-h.

$$q(t) = \pi r^2 \frac{dh}{dt} = FK(H - h) \qquad [1]$$

where F is a shape factor dependent on the dimensions of the piezometer. The basic time lag, T_0, is defined as follows,

$$T_0 = \frac{\pi r^2}{FK} \qquad [2]$$

and when substituted into Eq. [1], results in an ordinary differential equation. The solution, with the initial condition that the h = H_0 at t = 0, is,

$$\frac{(H - h)}{(H - H_0)} = e^{-t/T_0} \qquad [3]$$

where H is the head of water in the well prior to any drawdown, h is the head at time t, and H_0 is the water level in the well at the instant of slug insertion or withdrawal. When $\ln(H\text{-}h/H\text{-}H_0) = -1$, $T_0 = t$. The basic time lag, T_0, therefore, can be determined graphically from a plot of the natural logarithm of $(H-h)/(H-H_0)$ versus elapsed time. Hydraulic conductivity can then be determined from Eq.[2].

Hvorslev (1951) evaluated the shape factor, F, and with a piezometer of length L and radius, r, the resulting expression for K is

$$K = \frac{r^2 \ln(L/r)}{2LT_0} \qquad [4]$$

The analysis above assumes that the medium is homogeneous, infinite, and isotropic and that the medium and water are both incompressible. These assumptions and conditions have not been completely satisfied in the conditions present at the site, principally the restriction on homogeneity. As a result, estimates obtained by this method should be viewed as only rough approximations to the actual parameters.

The data generated during the slug tests performed in wells LMW-1 and LMW-3 were analyzed using the Hvorslev method. The water level responses measured during the LMW-1 and LMW-3 slug tests are presented graphically in Figures F-1, F-5 and F-6. Calculation details and the resulting hydraulic conductivities are presented in Figure F-11.

F.1.2 Method of Uffink (1984)

When slug tests are performed in wells completed within highly permeable formations, the water level in the well may oscillate in response to an instantaneous change in water level. This is generally attributed to inertial properties of the rising or lowering water level and the lack of dampening properties within the well and the surrounding formation. This phenomenon can also be seen in deep wells. Most slug test analysis methods neglect the forces of inertia because the water level generally returns to equilibrium exponentially. Several methods have been developed which account for the inertial effects, but all have the disadvantage of requiring prior knowledge of aquifer storativity and potential skin effects within the well.

The method developed by Uffink (1984) as detailed in Kruseman and de Ridder (1991) was utilized for the analysis of water level data generated during the slug tests performed in wells LMW-2, LMW-4, and LMW-5. These data sets are displayed graphically in Figures F-2 through F-4 and F-6 through F-9, which display the slowly dampening oscillations indicative of strong inertial effects. The figures represent only the initial 50 to 100 seconds of the test period prior to the complete dampening of the water level oscillations. For the purposes of estimation, storativities were estimated to range from 0.005 to 0.00005 (Freeze and Cherry, 1979). Also for estimation purposes, the wells were assumed to be 100 percent efficient and skin effects were assumed to be negligible (skin = 1.00).

The oscillation response in a well is defined by Uffink (1984) as

$$h_t = h_o e^{-\gamma t} \cos\omega t \qquad [5]$$

where h_o represents the instantaneous change in the head at $t_o(=0)$, h_t is the head in the well at time t ($t>t_o$), γ is the damping constant of head oscillation, and ω is the angular frequency of head oscillation. The damping constant and angular frequency of oscillation can be expressed as

$$\gamma = \omega_o B \qquad [6]$$

and

$$\omega = \omega_o \sqrt{1-B^2} \qquad [7]$$

where ω_o is the damping free frequency of head oscillation. The values of γ, ω, ω_o, and B are derived as follows from the oscillation time t_n, and the ratio between two subsequent minima and maxima, $\ln(h_n/h_n+1) = \delta$, of the observed oscillation

$$\gamma = \frac{\delta}{\tau_n} \qquad [8]$$

$$\omega_o = \frac{\sqrt{\delta^2 + 4\pi^2}}{\tau_n} \qquad [9]$$

$$B = \frac{\delta}{\sqrt{\delta^2 + 4\pi^2}} \qquad [10]$$

$$\omega_o = \frac{\sqrt{\delta^2 + 4\pi^2}}{\tau_n} \qquad [11]$$

Uffink further defined the relationship between the oscillation frequency and damping and the aquifer hydraulic conductivity as

$$\frac{1}{B}\ln\left[\frac{1.26KD}{r_c^2\omega_o} \times \frac{1}{\alpha}\right] + \frac{\Theta - \pi}{\sqrt{1-B^2}} = \frac{8KD}{r_c^2\omega_o} \qquad [12]$$

where

$$\alpha = S\frac{r_w^2}{r_c^2}e^{-2\,\mathrm{skin}}\text{, and} \qquad [13]$$

$$\Theta = \tan\left(\frac{\sqrt{1-B^2}}{B}\right) \qquad [14]$$

The skin term in equation 13 is the aforementioned skin effect discussed briefly above. The r_W and r_c terms refer to the radius of the well intake screen and the radius of the well casing in which the water level changes occur. In the case of the Landsburg Mine wells, both terms are equal to two inches (0.166 feet). Given our estimated range for the aquifer storativity (S), a ranges from 2.67×10^{-3} to 2.67×10^{-5}.

The D term refers to the thickness of the aquifer, which, in the Uffink method, is assumed to be fully penetrated. Due to the unusual geometry of the Rogers coal seam and the angles of intersection between the boreholes and the seam, it is highly unlikely that the aquifer material can be considered to be fully penetrated by the well screens. For estimation purposes, however, we have assumed that this condition has been met and D is represented by the well screen length. For wells LMW-2 and LMW-4, D is equal to 15 feet, while in LMW-5, D is equal to 10 feet.

Uffink developed a nomogram (refer to Uffink, 1984, or Kruseman and de Ridder, 1991) which gives the relationship between B and $(r_c^2\, \omega_0)/4KD$ for varying values of a. Solving for K provides an estimate of the aquifer hydraulic conductivity. The water level responses measured during the LMW-2, -4 and -5 slug tests are presented graphically in Figures F-2 through -4, and F-7 through -10. Calculations and the resulting hydraulic conductivities are presented in Figure F-11.

F.2 PUMPING TESTS

Pumping tests were performed at each of the two well pairs, LMW-2/4 and LMW-3/5. Pumping took place in the deeper of the two wells at each cluster. Water levels were measured in each of the 4 wells. Pump test hydrographs for the wells are presented in Figures F-12 through F-15.

Very low drawdowns were noted in the wells, essentially due to the low flow rates of the Grundfos pumps used to perform the tests and the relatively high conductivities typical of the mined-out Rogers seam. Because of these factors, the tests did not produce any significant stress on the water-bearing capabilities of the coal seam. The pumps were operated at their maximum pumping rates throughout the test (of about six gallons per minute). This resulted in a drawdown of less than 0.15 ft at LMW-4 and less than 0.1 ft at LMW-2. The LMW-4 data are also extremely erratic and much of the observed change in water level may be due to the inherent noise in the measuring equipment rather than actual water level fluctuations. Similar results are evident for the test conducted at the LMW-5/LMW-3 well pair, although slightly larger drawdowns were obtained.

Because of the very small drawdowns produced during the tests and the lack of stress which was induced on the formation, the data are generally not considered useable from analytical perspective. The highly conductive nature of the mined-out Rogers Coal Seam would require a much higher capacity pumping capability or a longer time period in order to obtain usable pump testing data. In a qualitative sense, however, the low drawdowns are indicative of a generally high conductivity for the seam, as indicated in the slug test data as well.

References

Hvorslev, M.J. 1951. *Time lag and soil permeability in groundwater observations.* U.S Army Corps of Engineers, Waterways Exp. Sta. Bull. 36, Vicksburg, Miss.

Kruseman, G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data.* International Institute for Land Reclamation and Improvement Publication 47. Wageningen, The Netherlands.

Uffink, 1984. *Theory of the oscillating slug test.* Nat. Institute for Public Health and Environmental Hygiene, Bilthoven. Unpublished research report. 18 pp. (in Dutch).

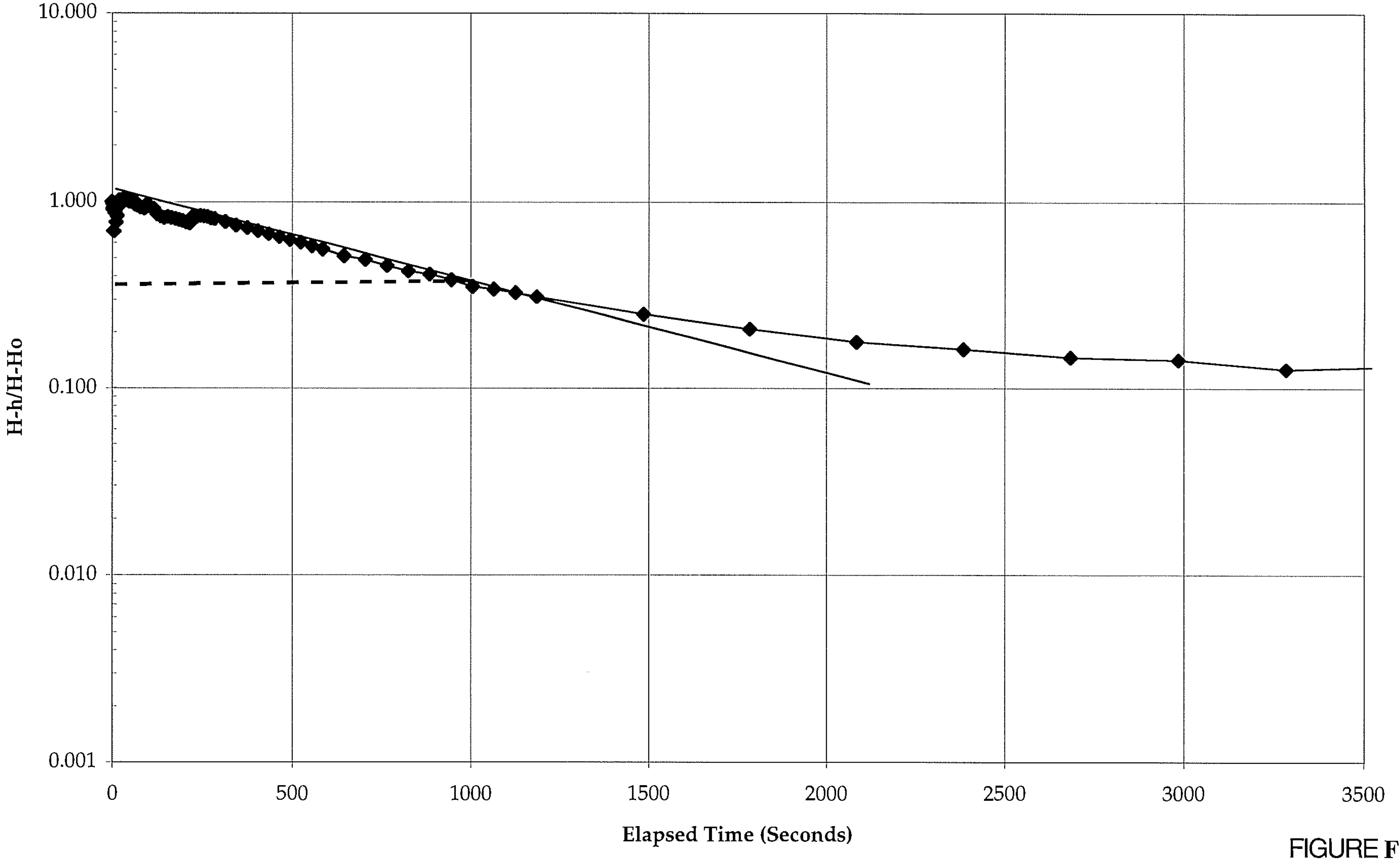

FIGURE F-1
LMW-1 TEST 1
SLUG INTRODUCTION
LANDSBURG MINE SITE RI/FS/WA

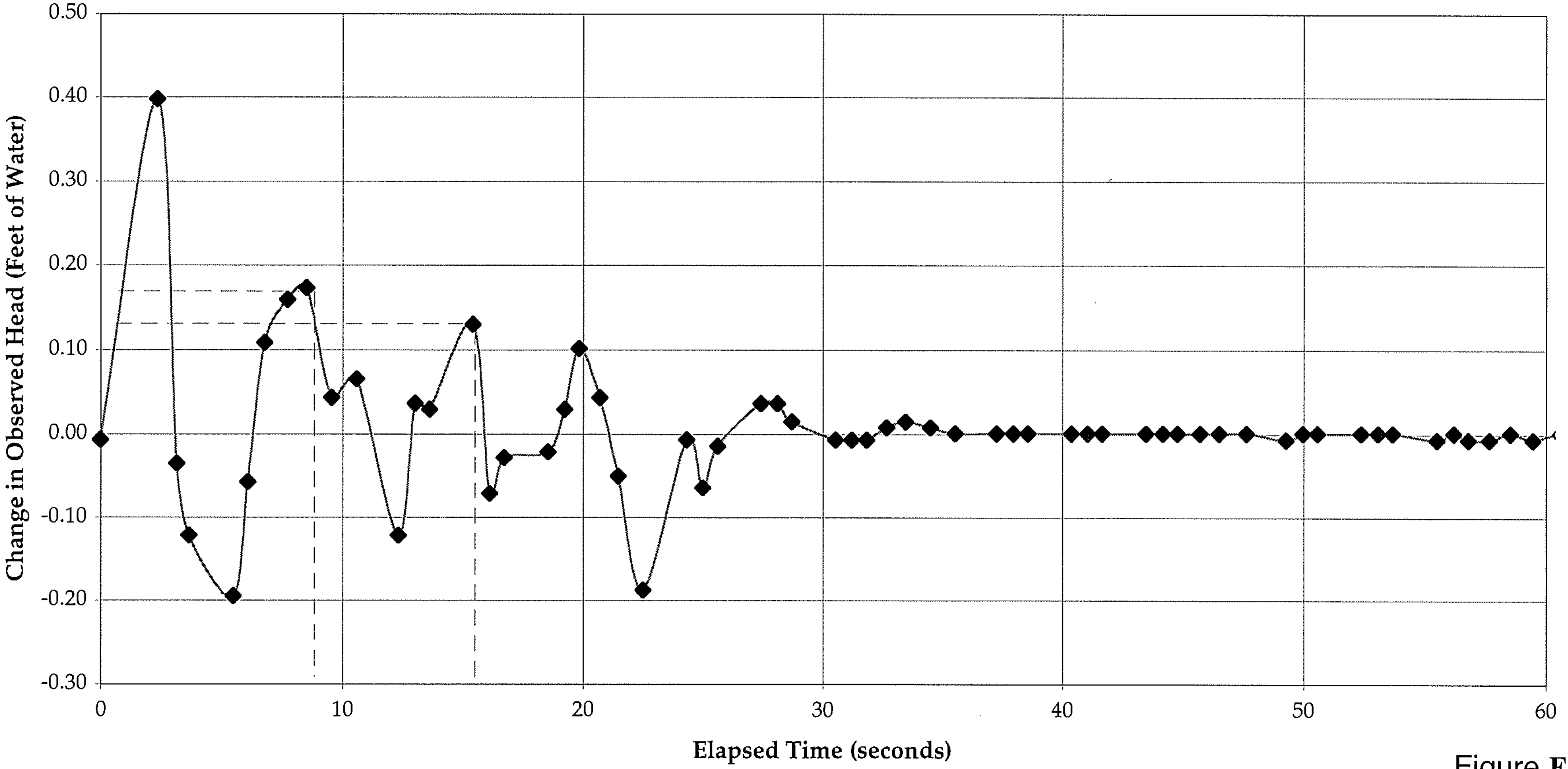

Figure **F-2**
LMW-2 TEST 1
SLUG INTRODUCED
LANDSBURG MINE SITE RI/FS/WA

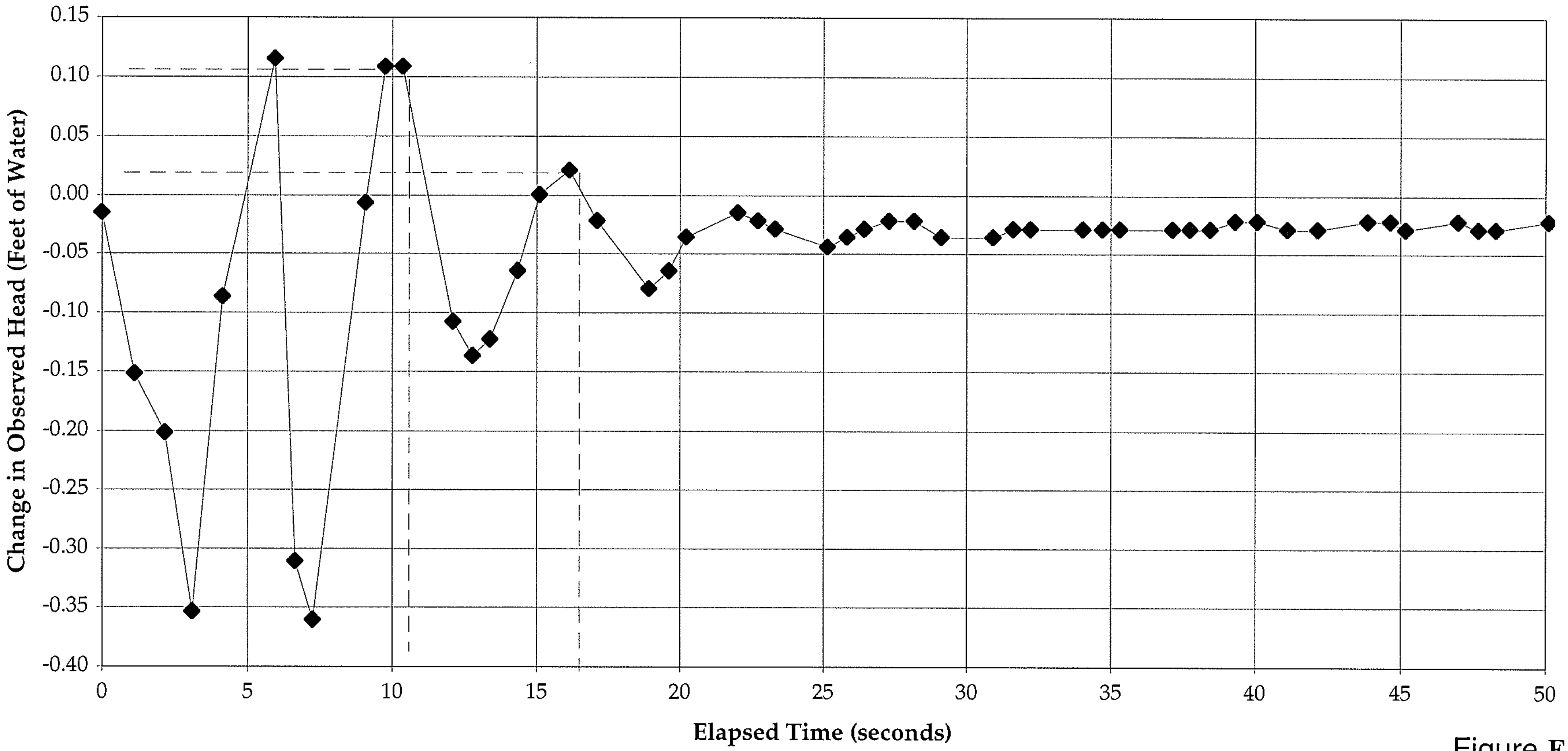

Figure **F-3**

LMW-2 TEST 2

SLUG REMOVED

LANDSBURG MINE SITE RI/FS/WA

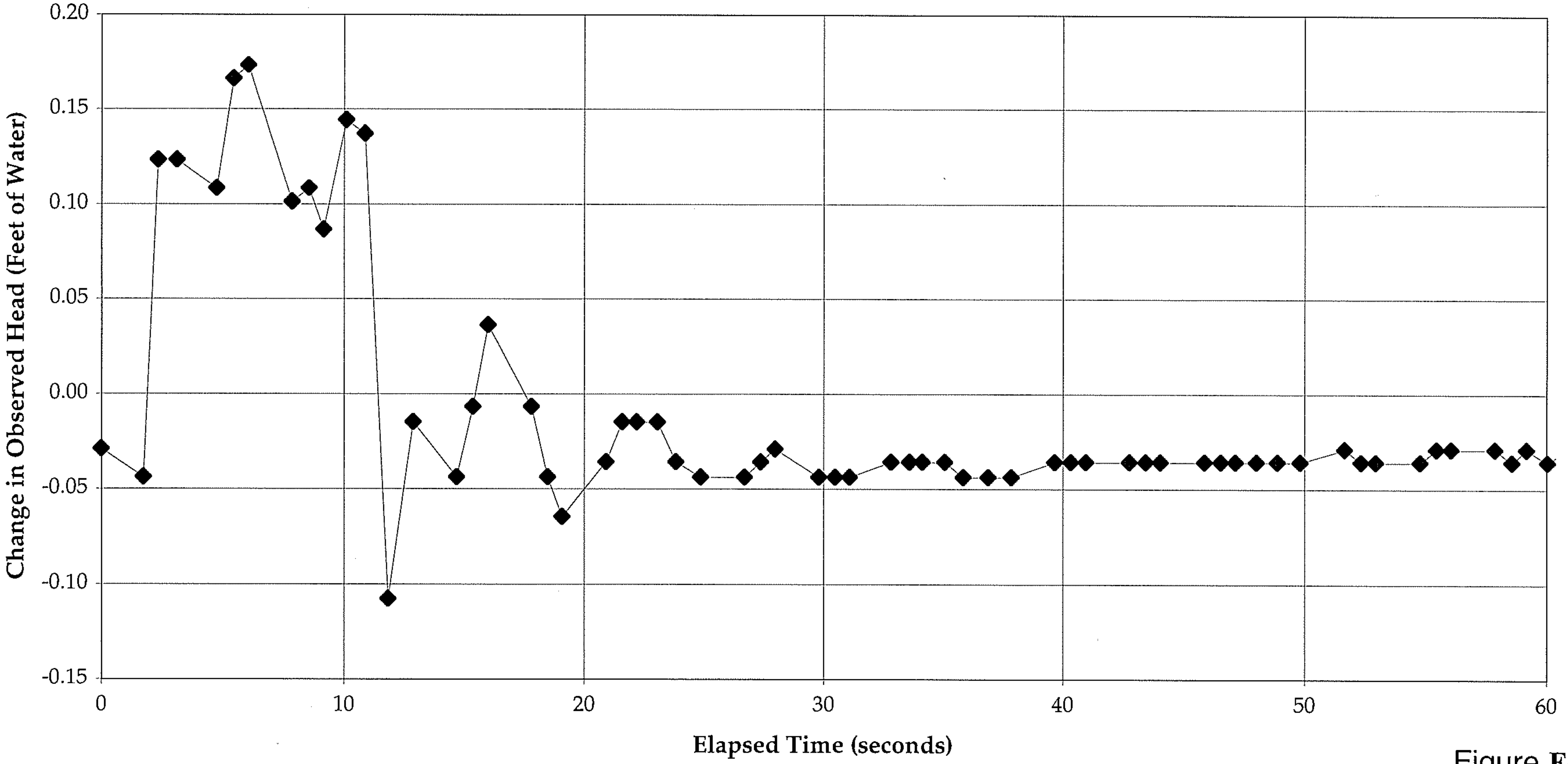

Figure **F-4**

LMW-2 TEST 3

2.25 gl SLUG INTRODUCED

LANDSBURG MINE SITE RI/FS/WA

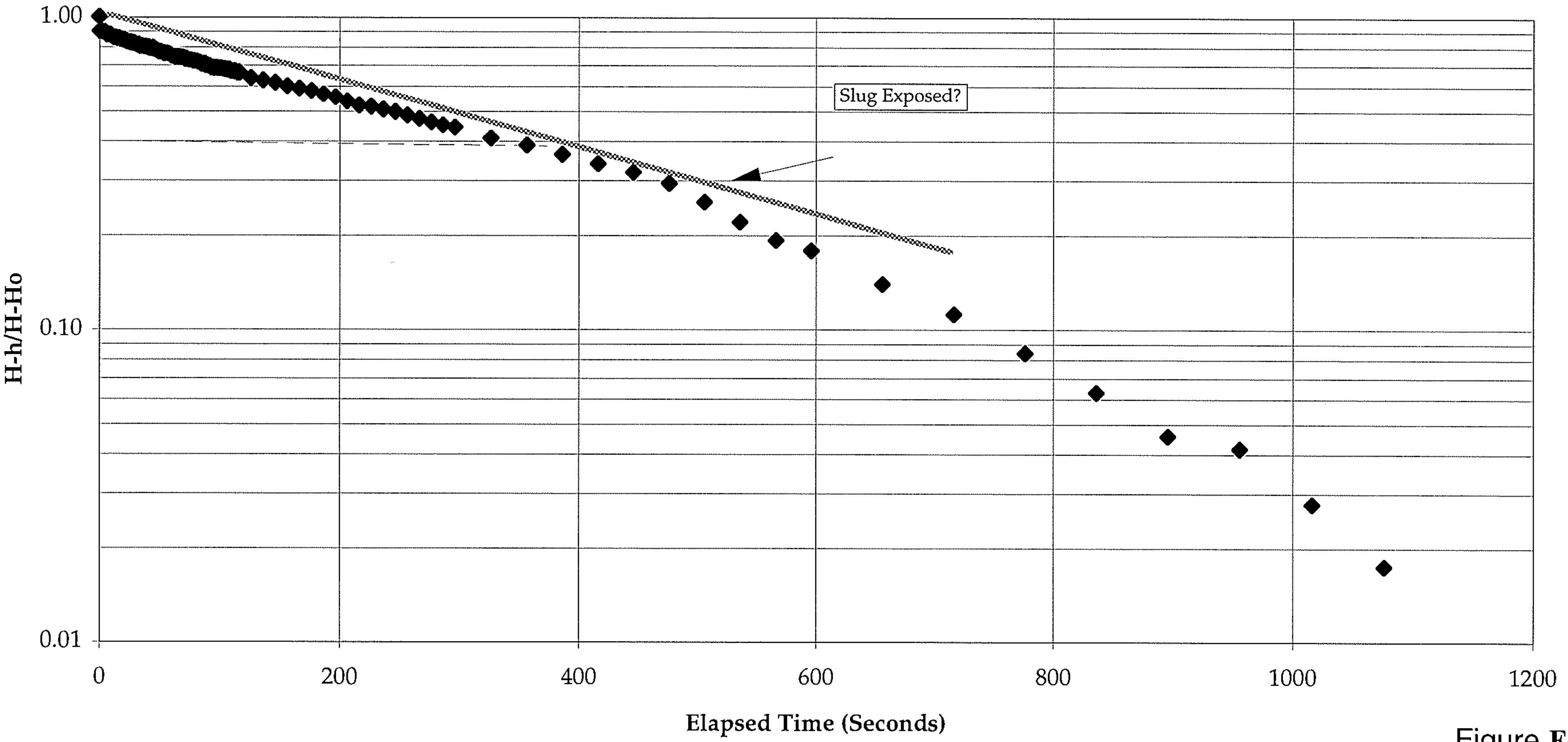

Figure **F-5**

LMW-3 TEST 1

SLUG INSERTED

LANDSBURG MINE SITE RI/FS/WA

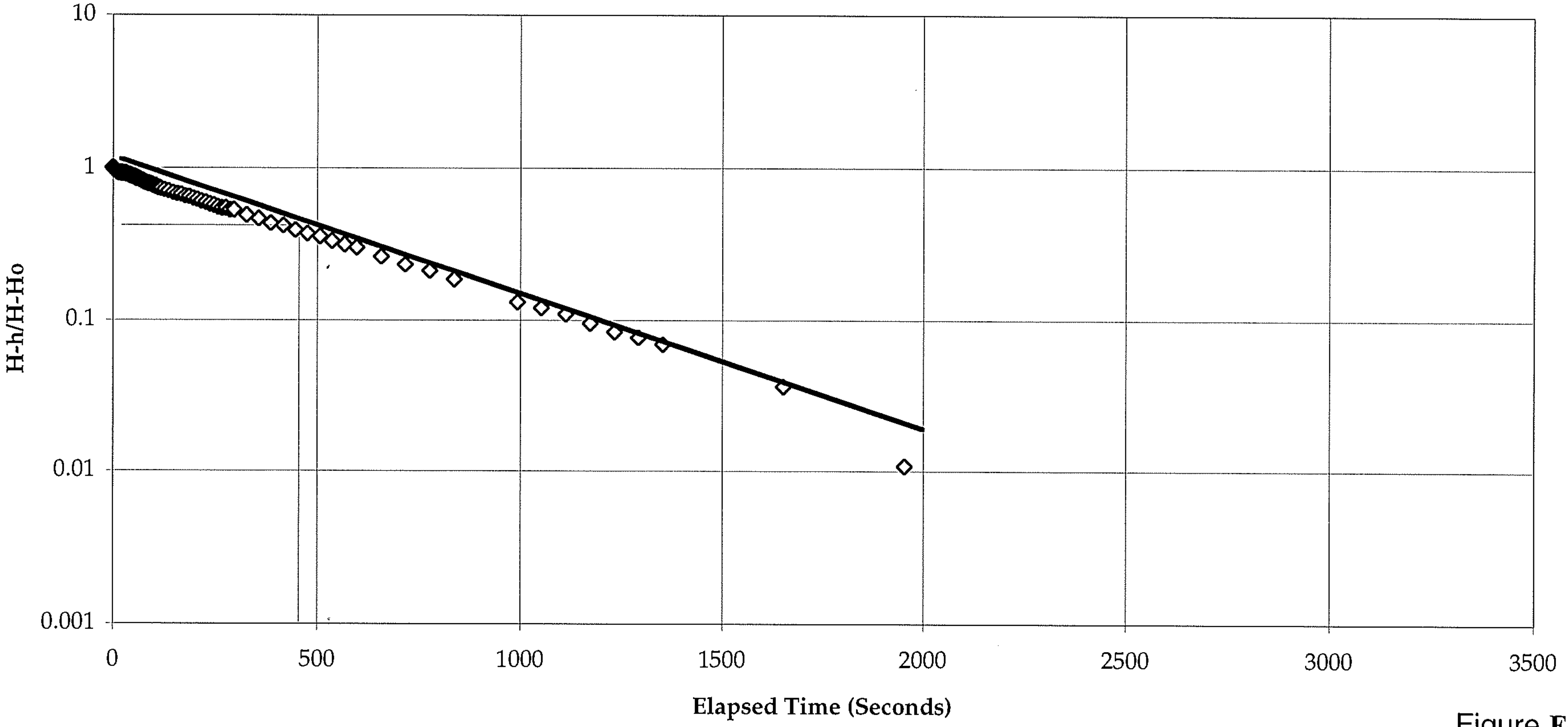

Figure **F-6**

LMW-3 TEST 2

SLUG REMOVAL

LANDSBURG MINE SITE RI/FS/WA

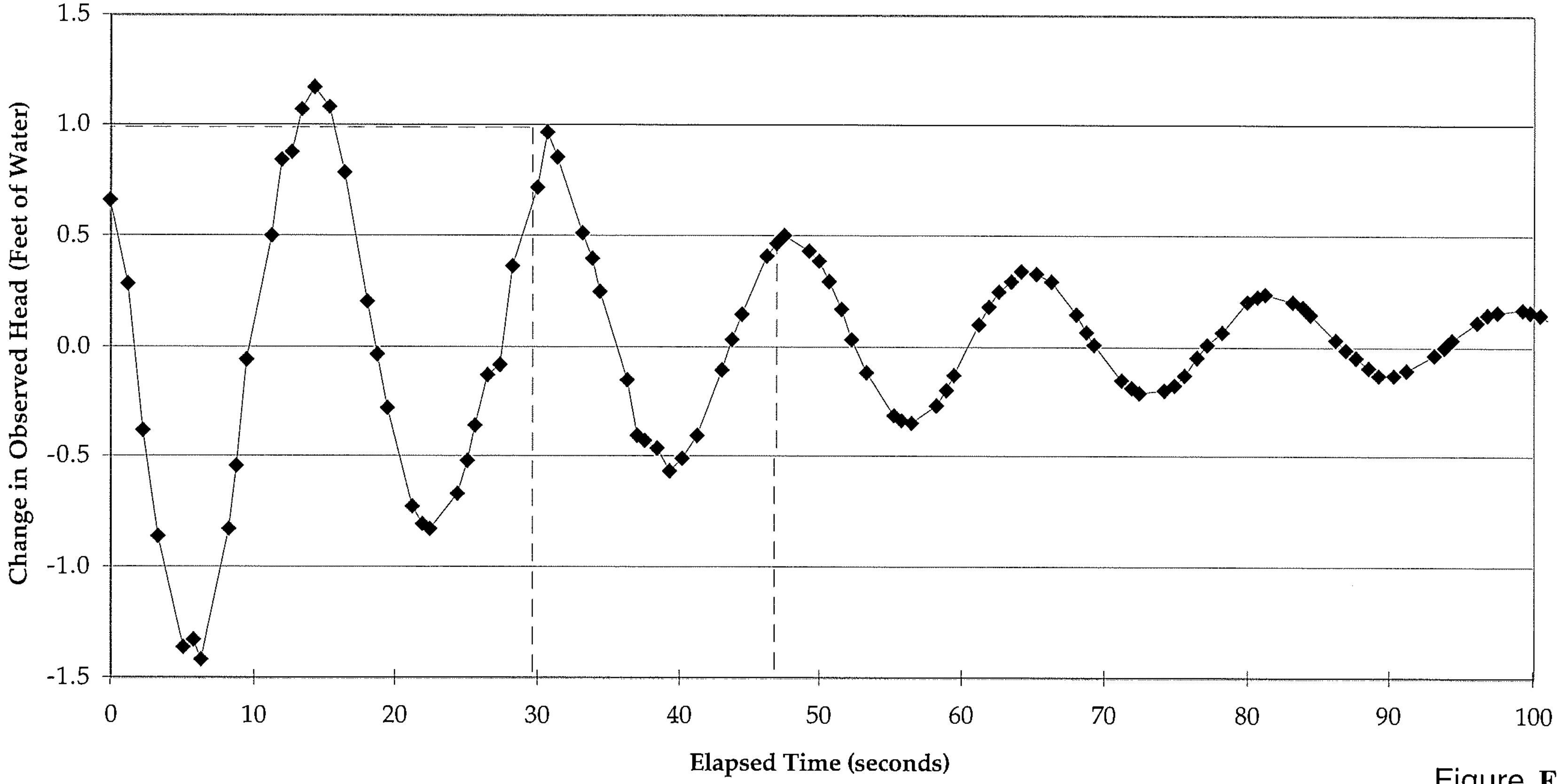

Figure **F-7**
LMW-4 TEST 1
SLUG INTRODUCED
LANDSBURG MINE SITE RI/FS/WA

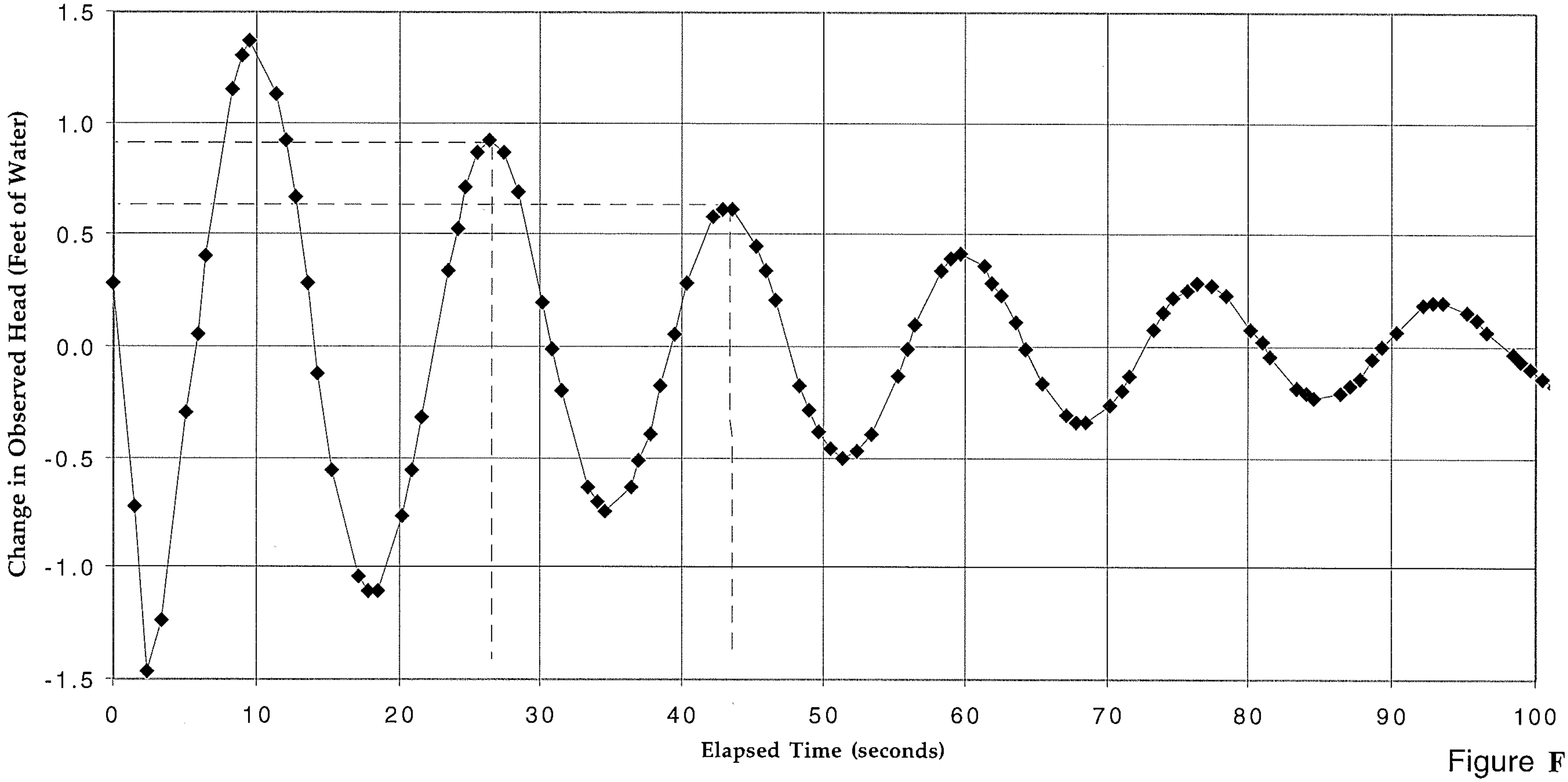

Figure **F-8**

LMW-4 TEST 2

SLUG REMOVED

LANDSBURG MINE SITE RI/FS/WA

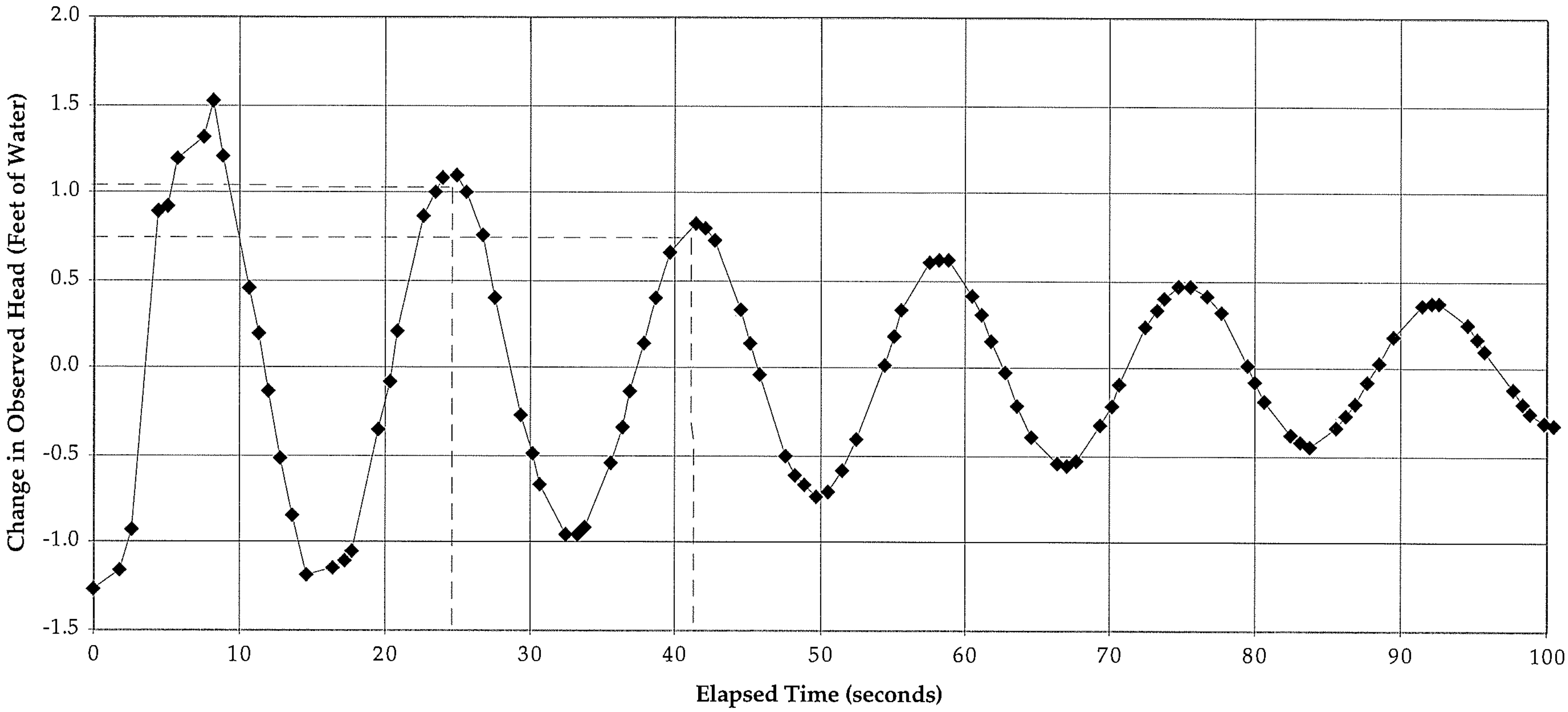

Figure **F-9**
LMW-5 TEST 1
SLUG INTRODUCED
LANDSBURG MINE SITE RI/FS/WA

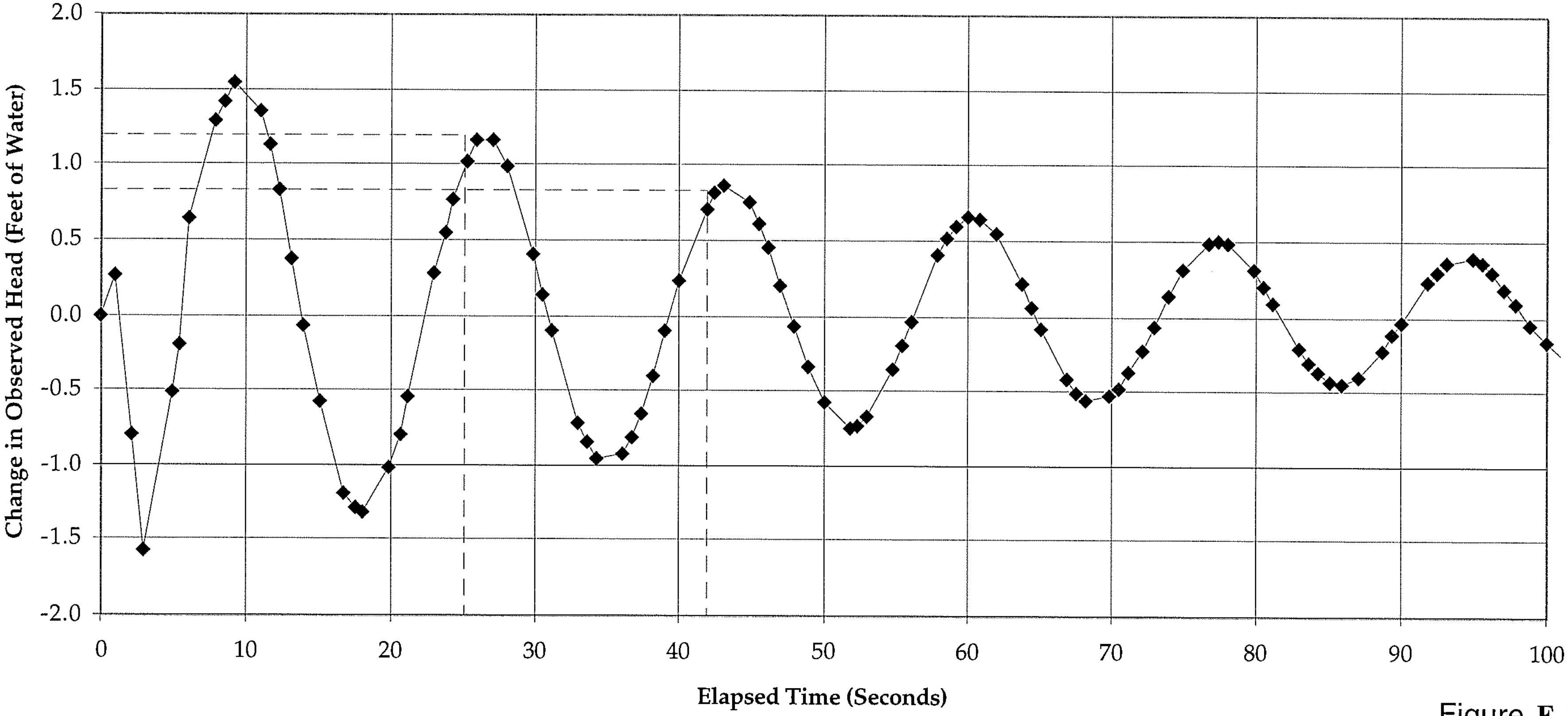

Figure **F-10**
LMW-5 TEST 2
SLUG INTRODUCED
LANDSBURG MINE SITE RI/FS/WA

Well	Test	Method of Analysis															
		Hvorslev (1951)					Uffink (1984)										
		r, ft	R, ft	L, ft	T_0,s	$K = \frac{r^2 \ln (L/R)}{2 L T0}$, ft/s	r_c, ft	r_w, ft	t_n,s	h_n, ft	h_{n+1}, ft	$\delta = \ln\left(\frac{hn}{hn+1}\right)$	$\omega_0 = \frac{\sqrt{\delta^2 + 4\pi^2}}{t_n}$	$B = \frac{\delta}{\sqrt{\delta^2 + 4\pi^2}}$	$\alpha = \frac{Sr^2{}_w e^{-2skin}}{r^2{}_c}$	$\frac{r^2{}_c\omega_0}{4KD}$	K, ft/s
LMW-1	1	.166	.08	15	1000	4.14×10^{-6}											
LMW-2	1						.166	.166	6.7	0.17	0.13	0.27	0.94	0.04	2.67E-3 to 2.67E-5	8E-3 to 6E-3	.05 to .07
	2						.166	.166	5.6	.11	.02	1.70	1.16	.26	2.67E-3 to 2.67E-5	6.6E-2 to 4E-2	.008 to .013
	3						.166	.166	6.25	.035	-.014	1.33	1.03	.21	2.67E-3 to 2.67E-5	.053 to .04	.009 to .012
LMW-3	1	.08	.08	15	385	1.04×10^{-5}											
	2	.08	.08	15	401	1.0×10^{-5}											
LMW-4	1						.166	.166	16.9	.95	.495	.65	.37	.1	2.67E-3 to 2.67E-5	0.023 to 0.01	0.007 to 0.017
	2						.166	.166	18.2	.88	.63	.33	.35	.052	2.67E-3 to 2.67E-5	0.01 to 0.006	0.016 to 0.027
LMW-5	1						.166	.166	16.8	1.09	.80	.31	.37	.049	2.67E-3 to 2.67E-5	.01 to .007	.025 to .036
	2						.166	.166	16.3	1.18	.82	.36	.39	.06	2.67E-3 to 2.67E-5	0.013 to 0.0085	0.014 to 0.021

NOTE:

Assume skin = 1, and S = .005 to .00005
For wells LMW-2 and -4, D = 15 ft, for LMW-5, D = 10 ft.
$\frac{r^2{}_c\omega_0}{4KD}$ determined from nomagram of Uffink (1984).

FIGURE **F-11**

SLUG TEST CALCULATIONS

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923 1000.147 DRAWING NO. 55342 DATE 5/24/95 DRAWN BY CB

Golder Associates

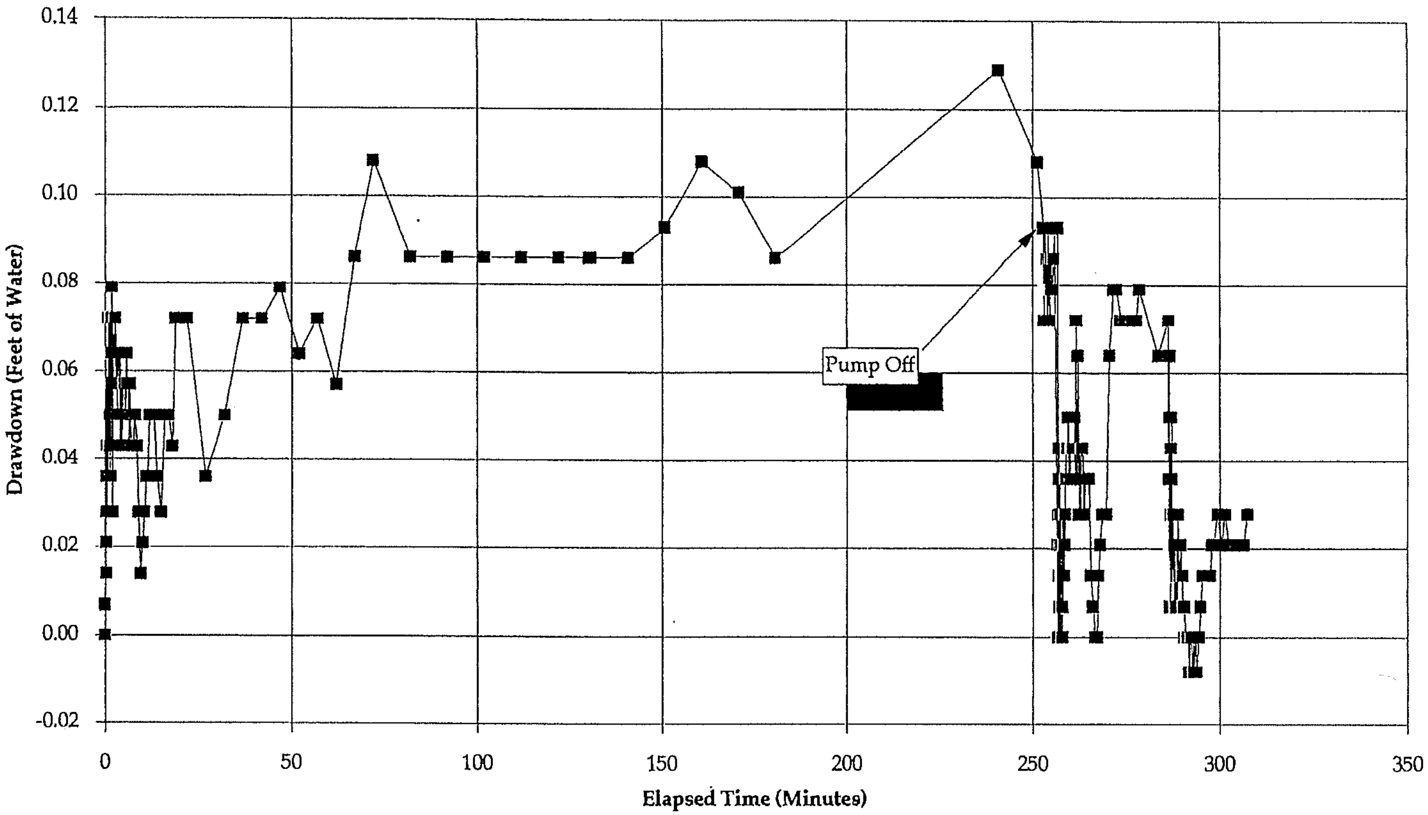

FIGURE **F-12**

LMW-4 HYDROGRAPH
LMW-2/4 PUMPING TEST

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923-1000.147 DRAWING NO. 50413 DATE 5/24/95 DRAWN BY TK

Golder Associates

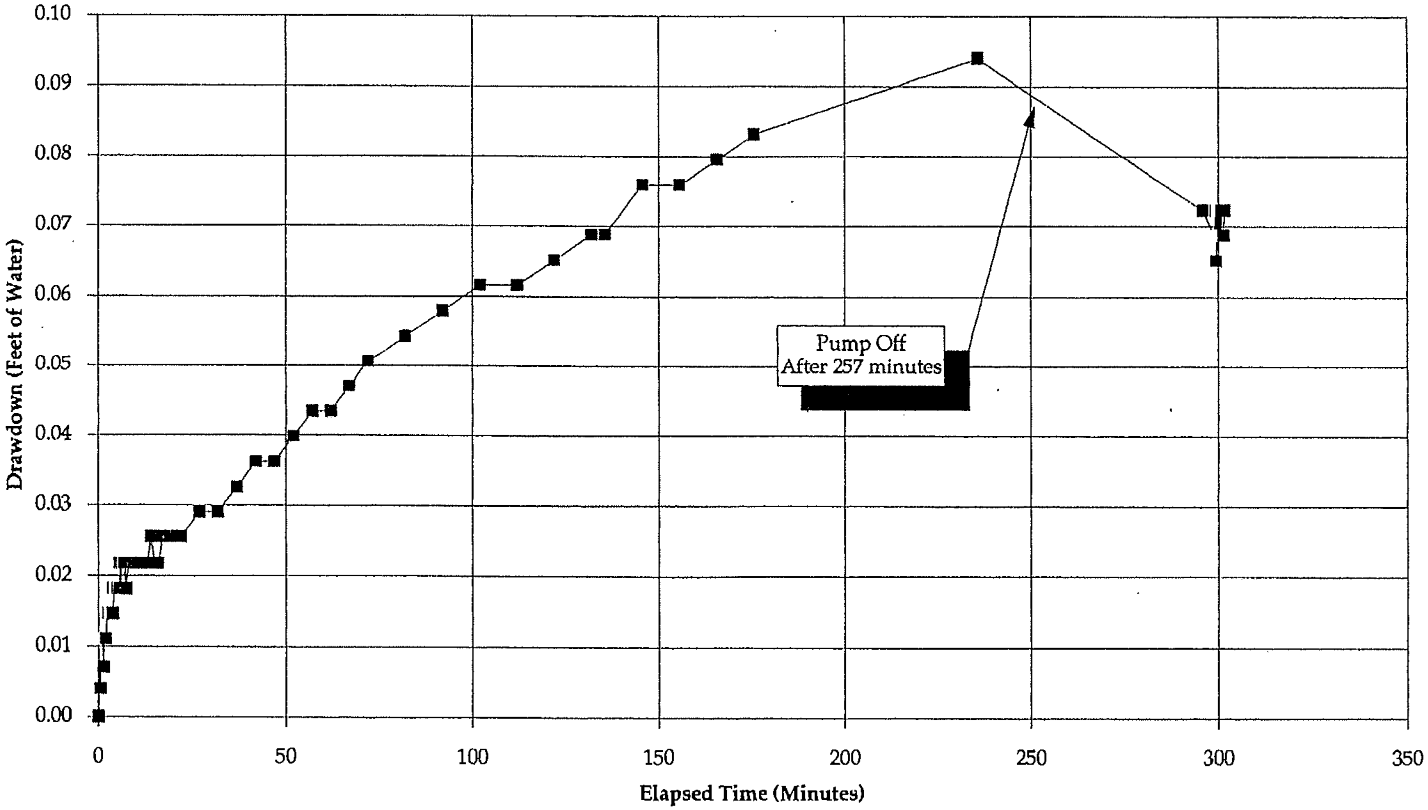

FIGURE **F-13**

LMW-2 HYDROGRAPH

LMW-2/4 PUMPING TEST

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923-1000.147 DRAWING NO. 50414 DATE 5/24/95 DRAWN BY TK

Golder Associates

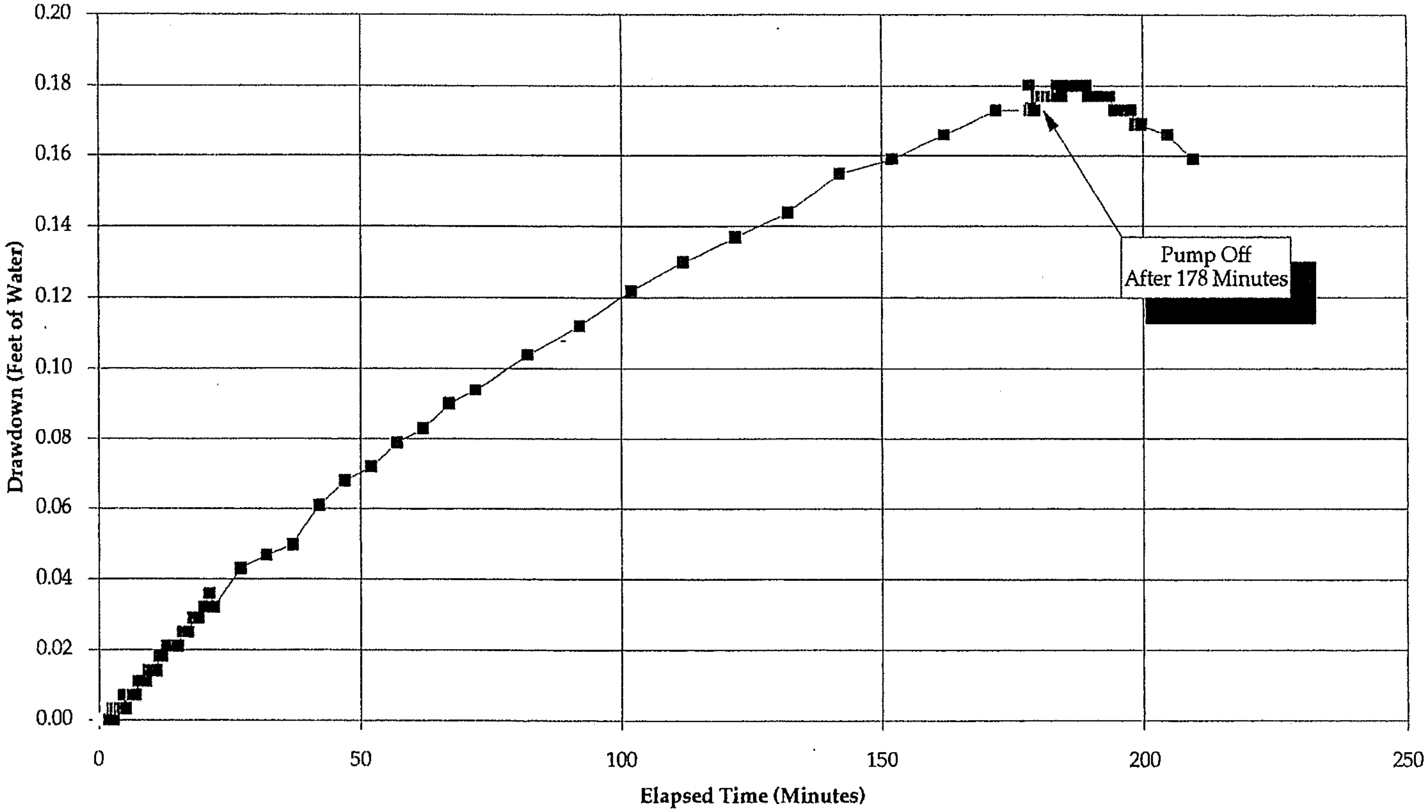

FIGURE **F-14**

LMW-3 HYDROGRAPH

LMW-3/5 PUMPING TEST

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923-1000.147 DRAWING NO. 50415 DATE 5/24/95 DRAWN BY TK

Golder Associates

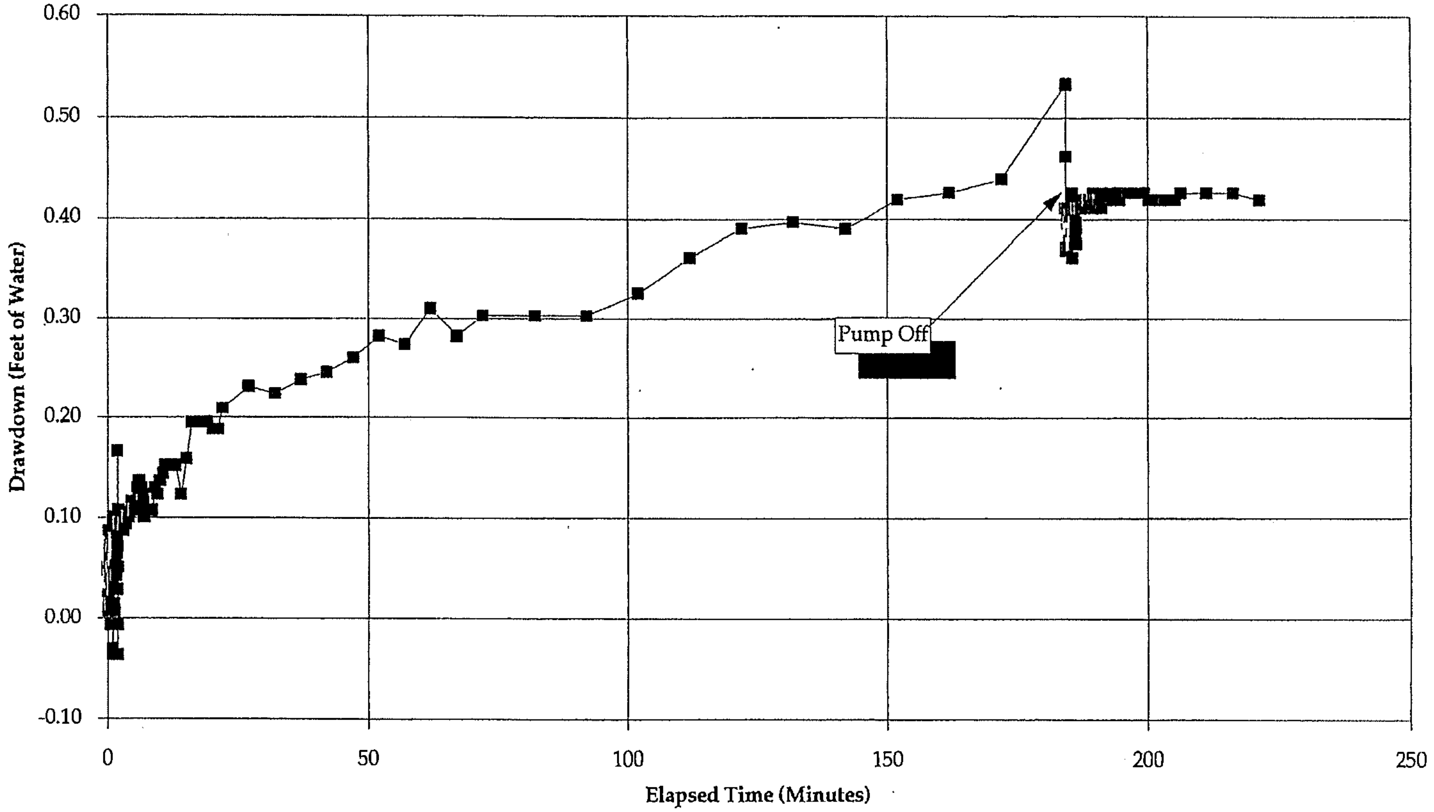

FIGURE **F-15**

LMW-5 HYDROGRAPH
LMW-3/5 PUMPING TEST

LANDSBURG MINE SITE RI/FS/WA

PROJECT NO. 923-1000.147 DRAWING NO. 50416 DATE 5/24/95 DRAWN BY TK

Golder Associates

APPENDIX G

HELP MODEL OUTPUT

February 1, 1996

923-1000.147
0829RHL1.APG

TABLE OF CONTENTS

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3.01\LANDSBRG\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP3.01\LANDSBRG\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3.01\LANDSBRG\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3.01\LANDSBRG\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3.01\DATA10.D10
OUTPUT DATA FILE:            C:\HELP3.01\0A-SOIL.OUT


TIME:   0:18     DATE:   4/25/1995


******************************************************************************

     TITLE:  Landsburg Mine Closure Covers

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                      LAYER  1
                                      --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   1
           THICKNESS                 =       6.00   INCHES
           POROSITY                  =       0.4170 VOL/VOL
           FIELD CAPACITY            =       0.0450 VOL/VOL
           WILTING POINT             =       0.0180 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.1013 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                          LAYER  2
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   1
     THICKNESS                     =     18.00   INCHES
     POROSITY                      =      0.4170 VOL/VOL
     FIELD CAPACITY                =      0.0450 VOL/VOL
     WILTING POINT                 =      0.0180 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.1289 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   1
     THICKNESS                     =    120.00   INCHES
     POROSITY                      =      0.4170 VOL/VOL
     FIELD CAPACITY                =      0.0450 VOL/VOL
     WILTING POINT                 =      0.0180 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.1587 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
           GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
           AND A SLOPE LENGTH OF  100. FEET.

   SCS RUNOFF CURVE NUMBER              =     40.10
   FRACTION OF AREA ALLOWING RUNOFF     =    100.0     PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
   EVAPORATIVE ZONE DEPTH               =     20.0     INCHES
   INITIAL WATER IN EVAPORATIVE ZONE    =      2.388   INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE   =      8.340   INCHES
   LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.360   INCHES
   INITIAL SNOW WATER                   =      0.000   INCHES
   INITIAL WATER IN LAYER MATERIALS     =     21.967   INCHES
   TOTAL INITIAL WATER                  =     21.967   INCHES
   TOTAL SUBSURFACE INFLOW              =      0.00    INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           OLYMPIA              WASHINGTON
```

```
            MAXIMUM LEAF AREA INDEX                      =  4.50
            START OF GROWING SEASON (JULIAN DATE)        =   135
            END OF GROWING SEASON (JULIAN DATE)          =   278
            AVERAGE ANNUAL WIND SPEED                    =  6.70 MPH
            AVERAGE 1ST QUARTER RELATIVE HUMIDITY        = 84.00 %
            AVERAGE 2ND QUARTER RELATIVE HUMIDITY        = 73.00 %
            AVERAGE 3RD QUARTER RELATIVE HUMIDITY        = 74.00 %
            AVERAGE 4TH QUARTER RELATIVE HUMIDITY        = 87.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA             WASHINGTON

                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        7.34        5.79        5.56        4.33        3.37        3.09
        1.43        1.69        3.21        5.12        7.59        7.97


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA             WASHINGTON

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       37.00       40.00       43.50       47.50       53.50       58.50
       62.50       62.00       57.50       50.00       42.50       38.00


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA             WASHINGTON

                       STATION LATITUDE  = 46.58 DEGREES




*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH   30
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS                  7.16     6.07     5.46     4.97     3.43     2.72
                            1.31     1.32     2.96     5.04     7.22     7.96

    STD. DEVIATIONS         2.21     1.94     1.90     1.47     1.83     1.35
                            1.13     0.81     1.64     1.95     2.81     2.17
```

```
  RUNOFF
  ------
    TOTALS                  0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS         0.000    0.000    0.000    0.000    0.000    0.000
                            0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                  0.465    0.687    1.718    2.852    2.760    2.766
                            1.325    1.258    1.820    1.006    0.462    0.357

    STD. DEVIATIONS         0.064    0.101    0.185    0.379    0.806    1.017
                            1.065    0.688    0.749    0.199    0.051    0.058

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS                  7.3011   5.8280   5.0436   3.3785   2.2255   1.5167
                            1.1574   0.7047   0.4923   0.5493   3.5666   6.3530

    STD. DEVIATIONS         1.8888   1.7238   1.7181   1.2192   0.6708   0.6700
                            0.4164   0.1549   0.0897   0.5874   2.9136   2.2564

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES              CU. FEET      PERCENT
                               -------------------    -------------   ---------
 PRECIPITATION                  55.62    (   6.592)     201904.2      100.00

 RUNOFF                          0.000   (  0.0000)          0.00       0.000

 EVAPOTRANSPIRATION             17.476   (  2.1039)      63436.37      31.419

 PERCOLATION/LEAKAGE THROUGH    38.11659 (  5.65997)    138363.234     68.52914
   FROM LAYER  3

 CHANGE IN WATER STORAGE         0.029   (  1.8917)        104.61       0.052
*******************************************************************************
```

```
*******************************************************************************

             PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                               3.09         11216.699

      RUNOFF                                      0.000            0.0000

      PERCOLATION/LEAKAGE THROUGH LAYER  3        1.560272      5663.78662

      SNOW WATER                                  3.67         13307.0205


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.2175

      MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0052

*******************************************************************************
```

```
****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR   30
    --------------------------------------------------------------------
                LAYER          (INCHES)       (VOL/VOL)
                -----          --------       ---------
                  1             0.5389          0.0898

                  2             2.5175          0.1399

                  3            19.7747          0.1648

              SNOW WATER        0.000

****************************************************************************
****************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3.01\DATA4.D4
TEMPERATURE DATA FILE:        C:\HELP3.01\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\HELP3.01\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3.01\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3.01\DATA10.D10
OUTPUT DATA FILE:             C:\HELP3.01\1A-SOIL.OUT


TIME:  14: 8     DATE:   4/25/1995


******************************************************************************

     TITLE:  Landsburg Mine Closure Covers

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   7
          THICKNESS                    =        6.00   INCHES
          POROSITY                     =        0.4730 VOL/VOL
          FIELD CAPACITY               =        0.2220 VOL/VOL
          WILTING POINT                =        0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT   =        0.2388 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =    0.520000001000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   5
     THICKNESS                     =      18.00    INCHES
     POROSITY                      =       0.4570 VOL/VOL
     FIELD CAPACITY                =       0.1310 VOL/VOL
     WILTING POINT                 =       0.0580 VOL/VOL
     INITIAL SOIL WATER CONTENT    =       0.2458 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =    0.100000005000E-02 CM/SEC


                              LAYER  3
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   1
     THICKNESS                     =     120.00    INCHES
     POROSITY                      =       0.4170 VOL/VOL
     FIELD CAPACITY                =       0.0450 VOL/VOL
     WILTING POINT                 =       0.0180 VOL/VOL
     INITIAL SOIL WATER CONTENT    =       0.1594 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =    0.999999978000E-02 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
            GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
            AND A SLOPE LENGTH OF  100. FEET.

   SCS RUNOFF CURVE NUMBER              =     69.40
   FRACTION OF AREA ALLOWING RUNOFF     =    100.0     PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
   EVAPORATIVE ZONE DEPTH               =     20.0     INCHES
   INITIAL WATER IN EVAPORATIVE ZONE    =      4.839   INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE   =      9.236   INCHES
   LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.436   INCHES
   INITIAL SNOW WATER                   =      0.000   INCHES
   INITIAL WATER IN LAYER MATERIALS     =     24.981   INCHES
   TOTAL INITIAL WATER                  =     24.981   INCHES
   TOTAL SUBSURFACE INFLOW              =      0.00    INCHES/YEAR


               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

   NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
            OLYMPIA             WASHINGTON
```

```
            MAXIMUM LEAF AREA INDEX                      =  4.50
            START OF GROWING SEASON (JULIAN DATE)        =   135
            END OF GROWING SEASON (JULIAN DATE)          =   278
            AVERAGE ANNUAL WIND SPEED                    =  6.70 MPH
            AVERAGE 1ST QUARTER RELATIVE HUMIDITY        = 84.00 %
            AVERAGE 2ND QUARTER RELATIVE HUMIDITY        = 73.00 %
            AVERAGE 3RD QUARTER RELATIVE HUMIDITY        = 74.00 %
            AVERAGE 4TH QUARTER RELATIVE HUMIDITY        = 87.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA             WASHINGTON

                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        7.34        5.79        5.56        4.33        3.37        3.09
        1.43        1.69        3.21        5.12        7.59        7.97


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA             WASHINGTON

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       37.00       40.00       43.50       47.50       53.50       58.50
       62.50       62.00       57.50       50.00       42.50       38.00


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA             WASHINGTON

                         STATION LATITUDE  = 46.58 DEGREES



*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------

   TOTALS                  7.16     6.07     5.46     4.97     3.43     2.72
                           1.31     1.32     2.96     5.04     7.22     7.96

   STD. DEVIATIONS         2.21     1.94     1.90     1.47     1.83     1.35
                           1.13     0.81     1.64     1.95     2.81     2.17
```

```
  RUNOFF
  ------
    TOTALS                  0.034    0.013    0.001    0.000    0.000    0.000
                            0.000    0.000    0.001    0.004    0.042    0.037

    STD. DEVIATIONS         0.062    0.051    0.003    0.000    0.002    0.000
                            0.000    0.000    0.005    0.020    0.126    0.067

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                  0.463    0.684    1.748    3.208    3.487    3.298
                            1.420    1.315    1.835    1.004    0.453    0.354

    STD. DEVIATIONS         0.064    0.101    0.157    0.288    0.776    1.157
                            1.083    0.723    0.825    0.184    0.053    0.058

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS                  7.2613   5.8492   5.0431   3.3539   2.2046   1.3186
                            1.1349   0.7341   0.4909   0.4358   2.4819   5.8813

    STD. DEVIATIONS         1.8669   1.7104   1.6309   1.2227   0.6961   0.4961
                            0.3712   0.1616   0.0738   0.1639   2.5751   2.4372

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET        PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  55.62    (   6.592)     201904.2      100.00

 RUNOFF                          0.132   (  0.1566)       480.53        0.238

 EVAPOTRANSPIRATION             19.268   (  2.2834)      69944.54      34.642

 PERCOLATION/LEAKAGE THROUGH    36.18958 (  5.39706)    131368.156     65.06460
   FROM LAYER  3

 CHANGE IN WATER STORAGE         0.031   (  1.8824)       110.97        0.055

*******************************************************************************
```

```
******************************************************************************

             PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------    -------------
    PRECIPITATION                                3.09         11216.699

    RUNOFF                                       0.332         1204.3258

    PERCOLATION/LEAKAGE THROUGH LAYER  3         1.602101      5815.62744

    SNOW WATER                                   3.67         13307.0205


    MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3472

    MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0559

******************************************************************************
```

```
******************************************************************************

           FINAL WATER STORAGE AT END OF YEAR   30
       ----------------------------------------------------------------------
            LAYER          (INCHES)       (VOL/VOL)
            -----          --------       ---------
              1             1.3956          0.2326

              2             4.6810          0.2601

              3            19.8217          0.1652

          SNOW WATER        0.000

******************************************************************************
******************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**               FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3.01\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP3.01\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3.01\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3.01\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3.01\DATA10.D10
OUTPUT DATA FILE:            C:\HELP3.01\1b-soil.OUT


TIME:    0: 3     DATE:    5/ 8/1995


******************************************************************************

     TITLE:  Landsburg Mine Closure Covers

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                     LAYER  1
                                     --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   7
          THICKNESS                    =       6.00   INCHES
          POROSITY                     =       0.4730 VOL/VOL
          FIELD CAPACITY               =       0.2220 VOL/VOL
          WILTING POINT                =       0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.2394 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   0.520000001000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
        THICKNESS                     =     18.00   INCHES
        POROSITY                      =      0.4570 VOL/VOL
        FIELD CAPACITY                =      0.1310 VOL/VOL
        WILTING POINT                 =      0.0580 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.3118 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-04 CM/SEC


                              LAYER  3
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   1
        THICKNESS                     =    120.00   INCHES
        POROSITY                      =      0.4170 VOL/VOL
        FIELD CAPACITY                =      0.0450 VOL/VOL
        WILTING POINT                 =      0.0180 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.1605 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC


                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

      NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
               GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
               AND A SLOPE LENGTH OF  100. FEET.

     SCS RUNOFF CURVE NUMBER              =    69.40
     FRACTION OF AREA ALLOWING RUNOFF     =   100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE   =     1.000  ACRES
     EVAPORATIVE ZONE DEPTH               =    20.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE    =     5.732  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE   =     9.236  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE   =     1.436  INCHES
     INITIAL SNOW WATER                   =     0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS     =    26.310  INCHES
     TOTAL INITIAL WATER                  =    26.310  INCHES
     TOTAL SUBSURFACE INFLOW              =     0.00   INCHES/YEAR


                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               OLYMPIA              WASHINGTON
```

```
          MAXIMUM LEAF AREA INDEX                        =  4.50
          START OF GROWING SEASON (JULIAN DATE)          =   135
          END OF GROWING SEASON (JULIAN DATE)            =   278
          AVERAGE ANNUAL WIND SPEED                      =  6.70 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY          = 84.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY          = 73.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY          = 74.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY          = 87.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR     OLYMPIA             WASHINGTON

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
    -------      -------      -------      -------      -------      -------
     7.34         5.79         5.56         4.33         3.37         3.09
     1.43         1.69         3.21         5.12         7.59         7.97


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR     OLYMPIA             WASHINGTON

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
    -------      -------      -------      -------      -------      -------
     37.00        40.00        43.50        47.50        53.50        58.50
     62.50        62.00        57.50        50.00        42.50        38.00


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR     OLYMPIA             WASHINGTON

                     STATION LATITUDE  = 46.58 DEGREES




*******************************************************************************

       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS                 7.16     6.07     5.46     4.97     3.43     2.72
                           1.31     1.32     2.96     5.04     7.22     7.96

    STD. DEVIATIONS        2.21     1.94     1.90     1.47     1.83     1.35
                           1.13     0.81     1.64     1.95     2.81     2.17
```

```
 RUNOFF
 ------
   TOTALS                    0.052     0.019     0.003     0.000     0.001     0.000
                             0.000     0.000     0.001     0.007     0.062     0.055

   STD. DEVIATIONS           0.088     0.067     0.007     0.002     0.005     0.000
                             0.000     0.000     0.005     0.034     0.172     0.088

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    0.462     0.683     1.746     3.200     3.489     3.694
                             1.437     1.299     1.818     1.000     0.450     0.353

   STD. DEVIATIONS           0.064     0.102     0.156     0.293     0.775     1.141
                             1.089     0.711     0.817     0.187     0.053     0.058

 PERCOLATION/LEAKAGE THROUGH LAYER  3
 ------------------------------------
   TOTALS                    7.2366    5.8424    5.1284    3.3669    2.2940    1.3269
                             1.2548    0.8390    0.5491    0.4238    1.9748    5.5260

   STD. DEVIATIONS           1.8331    1.6790    1.6465    1.1921    0.7525    0.5035
                             0.4144    0.1467    0.0608    0.0469    2.3245    2.6002

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES              CU. FEET       PERCENT
                               -------------------     -------------   ---------
 PRECIPITATION                  55.62     (   6.592)     201904.2      100.00

 RUNOFF                          0.202    (  0.2139)        731.63       0.362

 EVAPOTRANSPIRATION             19.629    (  2.3165)      71254.23      35.291

 PERCOLATION/LEAKAGE THROUGH    35.76259  (  5.33346)    129818.195    64.29692
   FROM LAYER  3

 CHANGE IN WATER STORAGE         0.028    (  1.8203)        100.18       0.050
*******************************************************************************
```

```
******************************************************************************

                 PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
------------------------------------------------------------------------
                                                   (INCHES)      (CU. FT.)
                                                  ----------    -------------
   PRECIPITATION                                     3.09         11216.699

   RUNOFF                                            0.439         1591.9412

   PERCOLATION/LEAKAGE THROUGH LAYER  3              1.514883      5499.02441

   SNOW WATER                                        3.67         13307.0205

   MAXIMUM VEG. SOIL WATER (VOL/VOL)                       0.3998

   MINIMUM VEG. SOIL WATER (VOL/VOL)                       0.0571

******************************************************************************
```

```
*******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    -----------------------------------------------------------------------
                    LAYER        (INCHES)        (VOL/VOL)
                    -----        --------        ---------
                      1            1.4011          0.2335

                      2            6.0305          0.3350

                      3           19.7065          0.1642

                  SNOW WATER       0.000

*******************************************************************************
*******************************************************************************
```

```
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**               HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                    USAE WATERWAYS EXPERIMENT STATION                      **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3.01\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP3.01\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3.01\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3.01\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3.01\DATA10.D10
OUTPUT DATA FILE:            C:\HELP3.01\1D-SOIL.OUT


TIME:    0:16     DATE:    5/ 8/1995


*******************************************************************************

     TITLE:  Landsburg Mine Closure Covers

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                    LAYER  1
                                    --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   0
             THICKNESS                     =      6.00   INCHES
             POROSITY                      =      0.4730 VOL/VOL
             FIELD CAPACITY                =      0.2220 VOL/VOL
             WILTING POINT                 =      0.1040 VOL/VOL
             INITIAL SOIL WATER CONTENT    =      0.2951 VOL/VOL
             EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC


                                    LAYER  2
```

```
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                      =     18.00    INCHES
   POROSITY                       =      0.4570 VOL/VOL
   FIELD CAPACITY                 =      0.1310 VOL/VOL
   WILTING POINT                  =      0.0580 VOL/VOL
   INITIAL SOIL WATER CONTENT     =      0.4404 VOL/VOL
   EFFECTIVE SAT. HYD. COND.      =  0.999999975000E-05 CM/SEC


                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   1
   THICKNESS                      =    120.00    INCHES
   POROSITY                       =      0.4170 VOL/VOL
   FIELD CAPACITY                 =      0.0450 VOL/VOL
   WILTING POINT                  =      0.0180 VOL/VOL
   INITIAL SOIL WATER CONTENT     =      0.1600 VOL/VOL
   EFFECTIVE SAT. HYD. COND.      =  0.999999978000E-02 CM/SEC


             GENERAL DESIGN AND EVAPORATIVE ZONE DATA
             ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  100. FEET.

 SCS RUNOFF CURVE NUMBER                =     69.40
 FRACTION OF AREA ALLOWING RUNOFF       =    100.0     PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE     =      1.000  ACRES
 EVAPORATIVE ZONE DEPTH                 =     20.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE      =      7.923  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE     =      9.236  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE     =      1.436  INCHES
 INITIAL SNOW WATER                     =      0.000  INCHES
 INITIAL WATER IN LAYER MATERIALS       =     28.899  INCHES
 TOTAL INITIAL WATER                    =     28.899  INCHES
 TOTAL SUBSURFACE INFLOW                =      0.00   INCHES/YEAR


              EVAPOTRANSPIRATION AND WEATHER DATA
              -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          OLYMPIA                  WASHINGTON

     MAXIMUM LEAF AREA INDEX                  =   4.50
```

```
         START OF GROWING SEASON (JULIAN DATE)   =   135
         END OF GROWING SEASON (JULIAN DATE)     =   278
         AVERAGE ANNUAL WIND SPEED               =  6.70 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY   = 84.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY   = 73.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY   = 74.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY   = 87.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR     OLYMPIA              WASHINGTON

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
    -------      -------      -------      -------      -------      -------
      7.34         5.79         5.56         4.33         3.37         3.09
      1.43         1.69         3.21         5.12         7.59         7.97


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR     OLYMPIA              WASHINGTON

            NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
    -------      -------      -------      -------      -------      -------
     37.00        40.00        43.50        47.50        53.50        58.50
     62.50        62.00        57.50        50.00        42.50        38.00


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR     OLYMPIA              WASHINGTON

                       STATION LATITUDE  = 46.58 DEGREES



*******************************************************************************

      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                   7.16     6.07     5.46     4.97     3.43     2.72
                            1.31     1.32     2.96     5.04     7.22     7.96

   STD. DEVIATIONS          2.21     1.94     1.90     1.47     1.83     1.35
                            1.13     0.81     1.64     1.95     2.81     2.17

 RUNOFF
```

```
  ------
    TOTALS                       0.794     0.417     0.158     0.037     0.009     0.014
                                 0.000     0.000     0.016     0.139     0.798     0.855

    STD. DEVIATIONS              0.919     0.674     0.342     0.128     0.047     0.073
                                 0.000     0.000     0.087     0.410     1.418     0.853

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                       0.455     0.676     1.734     3.180     3.491     4.533
                                 1.662     1.230     1.822     0.959     0.432     0.345

    STD. DEVIATIONS              0.062     0.099     0.154     0.281     0.768     0.920
                                 1.212     0.683     0.805     0.192     0.057     0.057

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS                       6.4463    5.3116    5.2904    3.3238    2.4572    1.3064
                                 1.1970    0.9780    0.6205    0.4635    0.7299    3.7182

    STD. DEVIATIONS              1.6012    1.4660    1.4659    1.1372    0.8224    0.3253
                                 0.5274    0.2038    0.0842    0.0533    0.8968    2.2795

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                         INCHES            CU. FEET     PERCENT
                                   ------------------    -------------  ---------
 PRECIPITATION                       55.62    (   6.592)    201904.2    100.00

 RUNOFF                               3.236   (  1.8192)     11746.43     5.818

 EVAPOTRANSPIRATION                  20.518   (  2.2817)     74478.74    36.888

 PERCOLATION/LEAKAGE THROUGH         31.84281 (  4.51143)   115589.391   57.24962
   FROM LAYER  3

 CHANGE IN WATER STORAGE              0.025   (  2.1149)        89.68     0.044

*******************************************************************************
```

```
******************************************************************************

          PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------    -------------
  PRECIPITATION                                3.09          11216.699

  RUNOFF                                       2.775         10071.8857

  PERCOLATION/LEAKAGE THROUGH LAYER  3         0.487724       1770.43750

  SNOW WATER                                   3.67          13307.0205

  MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.4545

  MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0621

******************************************************************************
```

```
******************************************************************************

                FINAL WATER STORAGE AT END OF YEAR   30
      ----------------------------------------------------------------------
                 LAYER          (INCHES)         (VOL/VOL)
                 -----          --------         ---------
                   1              2.4826           0.4138

                   2              8.0337           0.4463

                   3             19.1241           0.1594

               SNOW WATER         0.000

******************************************************************************
******************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3.01\LANDSBRG\DATA4.D4
TEMPERATURE DATA FILE:        C:\HELP3.01\LANDSBRG\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\HELP3.01\LANDSBRG\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3.01\LANDSBRG\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3.01\DATA10.D10
OUTPUT DATA FILE:             C:\HELP3.01\2A-CLAY.OUT


TIME:   0:42      DATE:   4/25/1995


******************************************************************************

    TITLE:  Landsburg Mine Closure Covers

******************************************************************************


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   7
           THICKNESS                     =       6.00   INCHES
           POROSITY                      =       0.4730 VOL/VOL
           FIELD CAPACITY                =       0.2220 VOL/VOL
           WILTING POINT                 =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT    =       0.4623 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =   0.520000001000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =     24.00   INCHES
  POROSITY                     =      0.4450 VOL/VOL
  FIELD CAPACITY               =      0.3930 VOL/VOL
  WILTING POINT                =      0.2770 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.4450 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.999999997000E-06 CM/SEC


                        LAYER  3
                        --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   1
  THICKNESS                    =    120.00   INCHES
  POROSITY                     =      0.4170 VOL/VOL
  FIELD CAPACITY               =      0.0450 VOL/VOL
  WILTING POINT                =      0.0180 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.1219 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC


             GENERAL DESIGN AND EVAPORATIVE ZONE DATA
             ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  100. FEET.

SCS RUNOFF CURVE NUMBER              =     69.40
FRACTION OF AREA ALLOWING RUNOFF     =    100.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
EVAPORATIVE ZONE DEPTH               =      6.0     INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      2.774   INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      2.838   INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.624   INCHES
INITIAL SNOW WATER                   =      0.000   INCHES
INITIAL WATER IN LAYER MATERIALS     =     28.078   INCHES
TOTAL INITIAL WATER                  =     28.078   INCHES
TOTAL SUBSURFACE INFLOW              =      0.00    INCHES/YEAR


              EVAPOTRANSPIRATION AND WEATHER DATA
              -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         OLYMPIA              WASHINGTON
```

```
            MAXIMUM LEAF AREA INDEX                       =  4.50
            START OF GROWING SEASON (JULIAN DATE)         =   135
            END OF GROWING SEASON (JULIAN DATE)           =   278
            AVERAGE ANNUAL WIND SPEED                     =  6.70 MPH
            AVERAGE 1ST QUARTER RELATIVE HUMIDITY         = 84.00 %
            AVERAGE 2ND QUARTER RELATIVE HUMIDITY         = 73.00 %
            AVERAGE 3RD QUARTER RELATIVE HUMIDITY         = 74.00 %
            AVERAGE 4TH QUARTER RELATIVE HUMIDITY         = 87.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA               WASHINGTON

                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        7.34        5.79        5.56        4.33        3.37        3.09
        1.43        1.69        3.21        5.12        7.59        7.97


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA               WASHINGTON

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       37.00       40.00       43.50       47.50       53.50       58.50
       62.50       62.00       57.50       50.00       42.50       38.00


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA               WASHINGTON

                      STATION LATITUDE  = 46.58 DEGREES




*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH   30
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS                  7.16     6.07     5.46     4.97     3.43     2.72
                            1.31     1.32     2.96     5.04     7.22     7.96

    STD. DEVIATIONS         2.21     1.94     1.90     1.47     1.83     1.35
                            1.13     0.81     1.64     1.95     2.81     2.17
```

```
  RUNOFF
  ------
    TOTALS                     5.544    4.365    2.798    1.178    0.226    0.123
                               0.000    0.000    0.213    1.752    5.184    6.143

    STD. DEVIATIONS            2.220    1.893    1.608    1.031    0.525    0.343
                               0.000    0.000    0.585    1.610    2.976    1.947

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                     0.473    0.700    1.765    3.247    3.227    2.600
                               1.268    1.154    1.863    1.036    0.481    0.366

    STD. DEVIATIONS            0.067    0.104    0.169    0.364    0.914    1.158
                               1.018    0.599    0.776    0.198    0.052    0.058

  PERCOLATION/LEAKAGE THROUGH LAYER  2
  ------------------------------------
    TOTALS                     1.3109   1.1706   1.2564   1.0929   0.6381   0.3118
                               0.1002   0.1052   0.3749   0.9968   1.2514   1.3045

    STD. DEVIATIONS            0.0243   0.0131   0.0728   0.2145   0.2819   0.2313
                               0.1413   0.1397   0.3505   0.3090   0.0244   0.0057

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS                     1.1004   1.1400   1.2964   1.2488   1.3274   1.0070
                               0.7955   0.5835   0.4221   0.2836   0.1819   0.5330

    STD. DEVIATIONS            0.2616   0.0524   0.0174   0.0610   0.1915   0.1747
                               0.2153   0.1046   0.0833   0.1098   0.1817   0.4198

-------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ACROSS LAYER  2
  -------------------------------------
    AVERAGES                   5.6129   5.4983   4.7716   3.4720   1.3445   0.6153
                               0.1366   0.1067   0.8625   3.4526   5.4414   5.6902

    STD. DEVIATIONS            0.2765   0.3291   0.8662   1.1644   0.9388   0.6601
                               0.2363   0.1712   1.0240   1.4855   0.5683   0.1297

*******************************************************************************


*******************************************************************************

      AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                   INCHES            CU. FEET      PERCENT
                             -------------------   -------------  ---------
 PRECIPITATION                 55.62     (   6.592)    201904.2     100.00

 RUNOFF                        27.526    (  5.4755)    99919.65     49.489
```

```
 EVAPOTRANSPIRATION                 18.181    (  2.1886)       65996.15       32.687

 PERCOLATION/LEAKAGE THROUGH         9.91380 (   0.80060)      35987.090      17.82384
   FROM LAYER  2

 AVERAGE HEAD ACROSS TOP             3.084 (     0.237)
   OF LAYER  2

 PERCOLATION/LEAKAGE THROUGH         9.91946 (   0.70644)      36007.652      17.83403
   FROM LAYER  3

 CHANGE IN WATER STORAGE            -0.005    (  1.2596)         -19.24       -0.010
********************************************************************************
```

```
******************************************************************************

               PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
   PRECIPITATION                                  3.09        11216.699

   RUNOFF                                         3.240       11759.8955

   PERCOLATION/LEAKAGE THROUGH LAYER  2           0.042519      154.34422

   AVERAGE HEAD ACROSS LAYER  2                   6.000

   PERCOLATION/LEAKAGE THROUGH LAYER  3           0.077094      279.85104

   SNOW WATER                                     3.67        13307.0205

   MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4730

   MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0667

******************************************************************************
```

```
******************************************************************************

               FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
               LAYER          (INCHES)        (VOL/VOL)
               -----          --------        ---------
                 1              2.7850          0.4642

                 2             10.6800          0.4450

                 3             14.4538          0.1204

              SNOW WATER        0.000

******************************************************************************
******************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.01    (14 OCTOBER 1994)                 **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3.01\LANDSBRG\DATA4.D4
TEMPERATURE DATA FILE:        C:\HELP3.01\LANDSBRG\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\HELP3.01\LANDSBRG\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3.01\LANDSBRG\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3.01\DATA10.D10
OUTPUT DATA FILE:             C:\HELP3.01\3D-FML.OUT


TIME:   2: 0     DATE:   4/25/1995


******************************************************************************

     TITLE:  Landsburg Mine Closure Covers

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                     LAYER  1
                                     --------

                          TYPE 1 - VERTICAL PERCOLATION LAYER
                              MATERIAL TEXTURE NUMBER   7
           THICKNESS                      =       6.00   INCHES
           POROSITY                       =       0.4730 VOL/VOL
           FIELD CAPACITY                 =       0.2220 VOL/VOL
           WILTING POINT                  =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT     =       0.4641 VOL/VOL
           EFFECTIVE SAT. HYD. COND.      =   0.520000001000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   5
     THICKNESS                    =       6.00    INCHES
     POROSITY                     =       0.4570 VOL/VOL
     FIELD CAPACITY               =       0.1310 VOL/VOL
     WILTING POINT                =       0.0580 VOL/VOL
     INITIAL SOIL WATER CONTENT   =       0.4570 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =   0.100000005000E-02 CM/SEC


                              LAYER  3
                              --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  37
     THICKNESS                    =       0.05    INCHES
     POROSITY                     =       0.0000 VOL/VOL
     FIELD CAPACITY               =       0.0000 VOL/VOL
     WILTING POINT                =       0.0000 VOL/VOL
     INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =   0.199999999000E-10 CM/SEC
     FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
     FML INSTALLATION DEFECTS     =       8.00    HOLES/ACRE
     FML PLACEMENT QUALITY        =   3 - GOOD


                              LAYER  4
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   1
     THICKNESS                    =     120.00    INCHES
     POROSITY                     =       0.4170 VOL/VOL
     FIELD CAPACITY               =       0.0450 VOL/VOL
     WILTING POINT                =       0.0180 VOL/VOL
     INITIAL SOIL WATER CONTENT   =       0.1088 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =   0.999999978000E-02 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
           GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
           AND A SLOPE LENGTH OF  100. FEET.

 SCS RUNOFF CURVE NUMBER                =      69.40
 FRACTION OF AREA ALLOWING RUNOFF       =     100.0     PERCENT
```

```
        AREA PROJECTED ON HORIZONTAL PLANE    =      1.000  ACRES
        EVAPORATIVE ZONE DEPTH                =     12.0    INCHES
        INITIAL WATER IN EVAPORATIVE ZONE     =      5.527  INCHES
        UPPER LIMIT OF EVAPORATIVE STORAGE    =      5.580  INCHES
        LOWER LIMIT OF EVAPORATIVE STORAGE    =      0.972  INCHES
        INITIAL SNOW WATER                    =      0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS      =     18.581  INCHES
        TOTAL INITIAL WATER                   =     18.581  INCHES
        TOTAL SUBSURFACE INFLOW               =      0.00   INCHES/YEAR


                    EVAPOTRANSPIRATION AND WEATHER DATA
                    -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  OLYMPIA              WASHINGTON

             MAXIMUM LEAF AREA INDEX                 =  4.50
             START OF GROWING SEASON (JULIAN DATE)   =   135
             END OF GROWING SEASON (JULIAN DATE)     =   278
             AVERAGE ANNUAL WIND SPEED               =  6.70 MPH
             AVERAGE 1ST QUARTER RELATIVE HUMIDITY   = 84.00 %
             AVERAGE 2ND QUARTER RELATIVE HUMIDITY   = 73.00 %
             AVERAGE 3RD QUARTER RELATIVE HUMIDITY   = 74.00 %
             AVERAGE 4TH QUARTER RELATIVE HUMIDITY   = 87.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA              WASHINGTON

                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
   -------      -------      -------      -------      -------      -------
    7.34         5.79         5.56         4.33         3.37         3.09
    1.43         1.69         3.21         5.12         7.59         7.97


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA              WASHINGTON

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
   -------      -------      -------      -------      -------      -------
    37.00        40.00        43.50        47.50        53.50        58.50
    62.50        62.00        57.50        50.00        42.50        38.00


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR     OLYMPIA              WASHINGTON

                         STATION LATITUDE  = 46.58 DEGREES
```

```
******************************************************************************

     AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
PRECIPITATION
-------------

  TOTALS                    7.16     6.07     5.46     4.97     3.43     2.72
                            1.31     1.32     2.96     5.04     7.22     7.96

  STD. DEVIATIONS           2.21     1.94     1.90     1.47     1.83     1.35
                            1.13     0.81     1.64     1.95     2.81     2.17

RUNOFF
------

  TOTALS                   5.645    4.459    2.918    1.334    0.197    0.070
                           0.000    0.000    0.015    0.821    4.916    6.215

  STD. DEVIATIONS          2.209    1.889    1.617    1.063    0.483    0.266
                           0.000    0.000    0.075    1.240    3.051    1.942

EVAPOTRANSPIRATION
------------------

  TOTALS                   0.462    0.684    1.750    3.240    3.576    4.373
                           1.646    1.252    1.941    0.994    0.448    0.353

  STD. DEVIATIONS          0.063    0.101    0.156    0.276    0.745    1.020
                           1.193    0.713    0.838    0.186    0.054    0.058

PERCOLATION/LEAKAGE THROUGH LAYER  3
------------------------------------

  TOTALS                  1.2238   1.0825   1.1203   0.9396   0.6873   0.3470
                          0.0153   0.0023   0.0803   0.5030   1.0905   1.2216

  STD. DEVIATIONS         0.0345   0.0333   0.0904   0.1367   0.1323   0.1825
                          0.0304   0.0093   0.1671   0.3179   0.1800   0.0139

PERCOLATION/LEAKAGE THROUGH LAYER  4
------------------------------------

  TOTALS                  0.4687   0.9158   1.1854   1.1282   1.1303   0.9029
                          0.8496   0.6281   0.4422   0.3519   0.2061   0.1036

  STD. DEVIATIONS         0.3515   0.1920   0.0476   0.0749   0.1197   0.0996
                          0.1174   0.0775   0.0430   0.0518   0.0719   0.1731


------------------------------------------------------------------------------
           AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


DAILY AVERAGE HEAD ACROSS LAYER  3
------------------------------------

  AVERAGES               11.6574  11.5195  10.8370   9.4890   6.8410   3.5379
```

```
                             0.1407    0.0189    0.8036    4.9054   10.8508   11.7176

     STD. DEVIATIONS         0.2220    0.3184    0.8023    1.3111    1.2609    1.8836
                             0.2916    0.0805    1.6957    3.0859    1.7325    0.1182

*******************************************************************************


*******************************************************************************

      AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                        INCHES           CU. FEET       PERCENT
                                  -------------------   -------------   ---------
 PRECIPITATION                     55.62     (   6.592)    201904.2      100.00

 RUNOFF                            26.588    (  5.3494)     96514.82      47.802

 EVAPOTRANSPIRATION                20.719    (  2.3732)     75211.28      37.251

 PERCOLATION/LEAKAGE THROUGH        8.31340 (  0.59070)     30177.646     14.94652
   FROM LAYER  3

 AVERAGE HEAD ACROSS TOP            6.860 (     0.482)
   OF LAYER  3

 PERCOLATION/LEAKAGE THROUGH        8.31287 (  0.75073)     30175.701     14.94555
   FROM LAYER  4

 CHANGE IN WATER STORAGE            0.001    (  1.4054)         2.43       0.001
*******************************************************************************
```

```
******************************************************************************

              PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
  ----------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
    PRECIPITATION                                  3.09        11216.699

    RUNOFF                                         3.257       11823.5928

    PERCOLATION/LEAKAGE THROUGH LAYER  3           0.040486      146.96301

    AVERAGE HEAD ACROSS LAYER  3                  12.000

    PERCOLATION/LEAKAGE THROUGH LAYER  4           0.052802      191.66989

    SNOW WATER                                     3.67        13307.0205

    MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4650

    MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0629
******************************************************************************
```

```
*******************************************************************************

           FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
               LAYER          (INCHES)        (VOL/VOL)
               -----          --------        ---------
                 1             2.7886           0.4648

                 2             2.7420           0.4570

                 3             0.0000           0.0000

                 4            13.0704           0.1089

             SNOW WATER        0.000

*******************************************************************************
*******************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************




PRECIPITATION DATA FILE:    C:\HELP3.01\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP3.01\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP3.01\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3.01\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3.01\DATA10.D10
OUTPUT DATA FILE:           C:\HELP3.01\4A-FM-GC.OUT



TIME:   2:26     DATE:   4/25/1995



******************************************************************************

     TITLE:  Landsburg Mine Closure Covers

******************************************************************************



     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.



                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =        6.00   INCHES
           POROSITY                   =        0.4730 VOL/VOL
           FIELD CAPACITY             =        0.2220 VOL/VOL
           WILTING POINT              =        0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =        0.4730 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =    0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   5
THICKNESS                        =        6.00   INCHES
POROSITY                         =        0.4570 VOL/VOL
FIELD CAPACITY                   =        0.1310 VOL/VOL
WILTING POINT                    =        0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT       =        0.4570 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =    0.100000005000E-02 CM/SEC


                              LAYER  3
                              --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  37
THICKNESS                        =        0.05   INCHES
POROSITY                         =        0.0000 VOL/VOL
FIELD CAPACITY                   =        0.0000 VOL/VOL
WILTING POINT                    =        0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT       =        0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =    0.199999999000E-10 CM/SEC
FML PINHOLE DENSITY              =        1.00   HOLES/ACRE
FML INSTALLATION DEFECTS         =        8.00   HOLES/ACRE
FML PLACEMENT QUALITY            =    3 - GOOD


                              LAYER  4
                              --------

                   TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  51
THICKNESS                        =        0.25   INCHES
POROSITY                         =        0.5500 VOL/VOL
FIELD CAPACITY                   =        0.4000 VOL/VOL
WILTING POINT                    =        0.2000 VOL/VOL
INITIAL SOIL WATER CONTENT       =        0.5500 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =    0.999999972000E-09 CM/SEC


                              LAYER  5
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   1
THICKNESS                        =      120.00   INCHES
POROSITY                         =        0.4170 VOL/VOL
FIELD CAPACITY                   =        0.0450 VOL/VOL
WILTING POINT                    =        0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT       =        0.0453 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =    0.999999978000E-02 CM/SEC
```

```
               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
              SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
              GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
              AND A SLOPE LENGTH OF  100. FEET.

    SCS RUNOFF CURVE NUMBER                =      69.40
    FRACTION OF AREA ALLOWING RUNOFF       =     100.0     PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE     =       1.000   ACRES
    EVAPORATIVE ZONE DEPTH                 =      12.0     INCHES
    INITIAL WATER IN EVAPORATIVE ZONE      =       5.580   INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE     =       5.580   INCHES
    LOWER LIMIT OF EVAPORATIVE STORAGE     =       0.972   INCHES
    INITIAL SNOW WATER                     =       0.000   INCHES
    INITIAL WATER IN LAYER MATERIALS       =      11.151   INCHES
    TOTAL INITIAL WATER                    =      11.151   INCHES
    TOTAL SUBSURFACE INFLOW                =       0.00    INCHES/YEAR


                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              OLYMPIA             WASHINGTON

        MAXIMUM LEAF AREA INDEX                   =  4.50
        START OF GROWING SEASON (JULIAN DATE)     =   135
        END OF GROWING SEASON (JULIAN DATE)       =   278
        AVERAGE ANNUAL WIND SPEED                 =  6.70 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY     = 84.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY     = 73.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY     = 74.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY     = 87.00 %


     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR     OLYMPIA              WASHINGTON

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  7.34        5.79        5.56        4.33        3.37        3.09
  1.43        1.69        3.21        5.12        7.59        7.97


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR     OLYMPIA              WASHINGTON
```

```
           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
      37.00       40.00       43.50       47.50       53.50       58.50
      62.50       62.00       57.50       50.00       42.50       38.00


        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR     OLYMPIA            WASHINGTON

                       STATION LATITUDE  = 46.58 DEGREES



*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                  7.16     6.07     5.46     4.97     3.43     2.72
                           1.31     1.32     2.96     5.04     7.22     7.96

   STD. DEVIATIONS         2.21     1.94     1.90     1.47     1.83     1.35
                           1.13     0.81     1.64     1.95     2.81     2.17

 RUNOFF
 ------
   TOTALS                 6.868    5.492    3.944    2.074    0.537    0.199
                          0.000    0.000    0.028    1.164    6.114    7.483

   STD. DEVIATIONS        2.237    1.963    1.802    1.261    0.777    0.445
                          0.000    0.000    0.130    1.573    3.195    1.983

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                 0.459    0.681    1.744    3.226    3.587    4.840
                          2.165    1.263    1.948    0.978    0.439    0.350

   STD. DEVIATIONS        0.063    0.101    0.156    0.274    0.741    0.719
                          1.349    0.712    0.841    0.189    0.054    0.057

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 ------------------------------------
   TOTALS                 0.0053   0.0047   0.0051   0.0044   0.0038   0.0024
                          0.0002   0.0000   0.0004   0.0024   0.0048   0.0053

   STD. DEVIATIONS        0.0001   0.0000   0.0002   0.0003   0.0004   0.0007
                          0.0003   0.0000   0.0008   0.0014   0.0006   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
```

```
    TOTALS                  0.0001   0.0002   0.0002   0.0003   0.0003   0.0003
                            0.0003   0.0003   0.0003   0.0002   0.0001   0.0001

    STD. DEVIATIONS         0.0002   0.0001   0.0001   0.0001   0.0001   0.0001
                            0.0001   0.0001   0.0001   0.0001   0.0001   0.0001


-------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ACROSS LAYER  4
  -------------------------------------
    AVERAGES               11.9578  11.8623  11.4733  10.4515   8.6746   5.5975
                            0.5082   0.0224   0.8577   5.3744  11.3467  11.9725

    STD. DEVIATIONS         0.0285   0.0991   0.4007   0.8054   0.8823   1.6123
                            0.7566   0.0955   1.8176   3.2797   1.4543   0.0146

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                   55.62     (   6.592)    201904.2     100.00

 RUNOFF                          33.903    (  5.5676)    123069.22     60.954

 EVAPOTRANSPIRATION              21.679    (  2.2624)     78695.52     38.977

 PERCOLATION/LEAKAGE THROUGH      0.03875 (  0.00249)       140.647     0.06966
   FROM LAYER  4

 AVERAGE HEAD ACROSS TOP          7.508 (     0.477)
   OF LAYER  4

 PERCOLATION/LEAKAGE THROUGH      0.00276 (  0.00081)        10.037     0.00497
   FROM LAYER  5

 CHANGE IN WATER STORAGE          0.036    (  1.1238)       129.45      0.064
*******************************************************************************
```

```
*******************************************************************************

          PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
-------------------------------------------------------------------------
                                              (INCHES)     (CU. FT.)
                                             ----------  -------------
  PRECIPITATION                                 3.09       11216.699

  RUNOFF                                        3.430      12450.4932

  PERCOLATION/LEAKAGE THROUGH LAYER  4          0.000171       0.61948

  AVERAGE HEAD ACROSS LAYER  4                 12.000

  PERCOLATION/LEAKAGE THROUGH LAYER  5          0.000016       0.05704

  SNOW WATER                                    3.67       13307.0205


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4650

  MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0645

*******************************************************************************
```

```
********************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ------------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1           2.8284          0.4714

                      2           2.7420          0.4570

                      3           0.0000          0.0000

                      4           0.1375          0.5500

                      5           6.5126          0.0543

                  SNOW WATER      0.000

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APPENDIX H

COST ESTIMATES

February 1, 1996

923-1000.R147
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TABLE OF CONTENTS

LIST OF TABLES

TABLE H-1

SUMMARY OF ESTIMATED COSTS FOR REMEDIATION ALTERNATIVES

Alternative		Estimated Costs (millions) [a]		
		Capital [b]	O&M [c]	Total
1	No Action	$0	$0	$0
2	Institutional Controls and Monitoring	$0.16	$0.14	$0.29
4	Soil Cap	$0.71	$0.24	$0.94
5	Low-Permeability Soil Cap	$0.77	$0.24	$1.00
6	FML Cap	$0.88	$0.30	$1.18
7	FML/GCL Cap	$0.97	$0.37	$1.34
9	Excavation and Disposal	$24	$0	$24

[a] Costs are for mid-1995.

[b] Includes operating costs during remedial action.

[c] Long-term maintenance and monitoring for 20 years; net present value assuming 5% interest (net of inflation).

TABLE H-2

ESTIMATED COST FOR ALTERNATIVE 2: Institutional Controls and Monitoring

Item	Quantity	Units	Unit Cost	Cost[a]	Notes
CAPITAL COSTS					
Implement institutional controls				$50,000	
Fencing	4,500	lf	$10	$45,000	
Subtotal:				$95,000	
Contractor overhead and profit			20%	$19,000	
Engineering and construction surveillance			20%	$19,000	
Contingency			25%	$24,000	
TOTAL CAPITAL COSTS				$157,000	
POST-CLOSURE CARE COSTS					Present value calculation
Fence maintenance	4,500	lf-yr	$0.50	$28,000	20 years; 5% net interest
Present value of groundwater monitoring costs				$81,834	20 years; see Table H-11
Subtotal:				$109,834	
Contingency			25%	$27,000	
NET PRESENT VALUE COST FOR POST-CLOSURE CARE[b]				$136,834	
TOTAL ALTERNATIVE COST (NET PRESENT VALUE)[c]				$293,834	

[a] Costs are for mid-1995.

[b] Maintenance and monitoring for 20 years; interest (discount) rate of 5 percent, net of inflation.

[c] The sum of capital and operating costs and the net present value of the post-closure care costs.

TABLE H-3

ESTIMATED COST FOR ALTERNATIVE 4: Soil Cap

Item	Quantity	Units	Unit Cost	Cost[a]	Notes
CAPITAL COSTS					
Implement institutional controls				$50,000	
Clear and grub	12.40	acres	$3,500	$43,000	
Clear trees in trench	2.48	acres	$2,100	$5,000	
Haul road	2,880	lf	$6.90	$20,000	Access to borrow area
Backfill trench	57,500	cy	$4.35	$250,000	
Soil cap	188,000	sf	$0.26	$49,000	
Drainage Ditch	4,000	lf	$1.80	$7,000	
Seeding	4.32	acres	$850	$4,000	
Subtotal:				$428,000	
Contractor overhead and profit			20%	$86,000	
Engineering and construction surveillance			20%	$86,000	
Contingency			25%	$107,000	
TOTAL CAPITAL COSTS				**$707,000**	
POST-CLOSURE CARE COSTS					Present value calculation
Cap maintenance and monitoring	4.32	ac-yr	$2,000	$108,000	20 years; 5% net interest
Present value of groundwater monitoring costs				$81,834	20 years; see Table H-11
Subtotal:				$189,834	
Contingency			25%	$47,000	
NET PRESENT VALUE COST FOR POST-CLOSURE CARE[b]				**$236,834**	
TOTAL ALTERNATIVE COST (NET PRESENT VALUE)[c]				**$943,834**	

[a] Costs are for mid-1995.

[b] Maintenance and monitoring for 20 years; interest (discount) rate of 5 percent, net of inflation.

[c] The sum of capital and operating costs and the net present value of the post-closure care costs.

TABLE H-4

ESTIMATED COST FOR ALTERNATIVE 5: Low-Permeability Soil Cap

Item	Quantity	Units	Unit Cost	Cost[a]	Notes
CAPITAL COSTS					
Implement institutional controls				$50,000	
Clear and grub	12.40	acres	$3,500	$43,000	
Clear trees in trench	2.48	acres	$2,100	$5,000	
Haul road	2,880	lf	$6.90	$20,000	Access to borrow area
Backfill trench	57,500	cy	$4.35	$250,000	
Low-permeability soil cap	188,000	sf	$0.46	$86,000	10^{-6} cm/sec
Drainage Ditch	4,000	lf	$1.80	$7,000	
Seeding	4.32	acres	$850	$4,000	
Subtotal:				$465,000	
Contractor overhead and profit			20%	$93,000	
Engineering and construction surveillance			20%	$93,000	
Contingency			25%	$116,000	
TOTAL CAPITAL COSTS				$767,000	
POST-CLOSURE CARE COSTS					Present value calculation
Cap maintenance and monitoring	4.32	ac-yr	$2,000	$108,000	20 years; 5% net interest
Present value of groundwater monitoring costs				$81,834	20 years; see Table H-11
Subtotal:				$189,834	
Contingency			25%	$47,000	
NET PRESENT VALUE COST FOR POST-CLOSURE CARE[b]				$236,834	
TOTAL ALTERNATIVE COST (NET PRESENT VALUE)[c]				$1,003,834	

[a] Costs are for mid-1995.

[b] Maintenance and monitoring for 20 years; interest (discount) rate of 5 percent, net of inflation.

[c] The sum of capital and operating costs and the net present value of the post-closure care costs.

TABLE H-5

ESTIMATED COST FOR ALTERNATIVE 6: FML Cap

Item	Quantity	Units	Unit Cost	Cost[a]	Notes
CAPITAL COSTS					
Implement institutional controls				$50,000	
Clear and grub	12.40	acres	$3,500	$43,000	
Clear trees in trench	2.48	acres	$2,100	$5,000	
Haul road	2,880	lf	$6.90	$20,000	Access to borrow area
Backfill trench	57,500	cy	$4.35	$250,000	
FML cap	188,000	sf	$0.81	$152,000	
Drainage Ditch	4,000	lf	$1.80	$7,000	
Seeding	4.32	acres	$850	$4,000	
Subtotal:				$531,000	
Contractor overhead and profit			20%	$106,000	
Engineering and construction surveillance			20%	$106,000	
Contingency			25%	$133,000	
TOTAL CAPITAL COSTS				$876,000	
POST-CLOSURE CARE COSTS					Present value calculation
Cap maintenance and monitoring	4.32	ac-yr	$3,000	$161,000	20 years; 5% net interest
Present value of groundwater monitoring costs				$81,834	20 years; see Table H-11
Subtotal:				$242,834	
Contingency			25%	$61,000	
NET PRESENT VALUE COST FOR POST-CLOSURE CARE[b]				$303,834	
TOTAL ALTERNATIVE COST (NET PRESENT VALUE)[c]				$1,179,834	

[a] Costs are for mid-1995.

[b] Maintenance and monitoring for 20 years; interest (discount) rate of 5 percent, net of inflation.

[c] The sum of capital and operating costs and the net present value of the post-closure care costs.

TABLE H-6

ESTIMATED COST FOR ALTERNATIVE 7: FML/GCL Cap

Item	Quantity	Units	Unit Cost	Cost[a]	Notes
CAPITAL COSTS					
Implement institutional controls				$50,000	
Clear and grub	12.40	acres	$3,500	$43,000	
Clear trees in trench	2.48	acres	$2,100	$5,000	
Haul road	2,880	lf	$6.90	$20,000	Access to borrow area
Backfill trench	57,500	cy	$4.35	$250,000	
FML / GCL cap	188,000	sf	$1.10	$207,000	
Drainage Ditch	4,000	lf	$1.80	$7,000	
Seeding	4.32	acres	$850	$4,000	
Subtotal:				$586,000	
Contractor overhead and profit			20%	$117,000	
Engineering and construction surveillance			20%	$117,000	
Contingency			25%	$147,000	
TOTAL CAPITAL COSTS				$967,000	
POST-CLOSURE CARE COSTS					Present value calculation
Cap maintenance and monitoring	4.32	ac-yr	$4,000	$215,000	20 years; 5% net interest
Present value of groundwater monitoring costs				$81,834	20 years; see Table H-11
Subtotal:				$296,834	
Contingency			25%	$74,000	
NET PRESENT VALUE COST FOR POST-CLOSURE CARE[b]				$370,834	
TOTAL ALTERNATIVE COST (NET PRESENT VALUE)[c]				$1,337,834	

[a] Costs are for mid-1995.

[b] Maintenance and monitoring for 20 years; interest (discount) rate of 5 percent, net of inflation.

[c] The sum of capital and operating costs and the net present value of the post-closure care costs.

TABLE H-7

ESTIMATED COST FOR ALTERNATIVE 9: Excavation and Disposal

Item	Quantity	Units	Unit Cost	Cost[a]	Notes
CAPITAL COSTS					
Clear and grub	12.40	acres	$3,500	$43,000	
Clear trees in trench	2.48	acres	$2,100	$5,000	
Excavate trench	57,500	cy	$25	$1,438,000	
Waste disposal	43,100	cy	$300	$12,930,000	Assume 75% of excavated quantity
Air monitoring				$50,000	During remedial action
Subtotal:				$14,466,000	
Contractor overhead and profit			20%	$2,893,000	
Engineering and construction surveillance			20%	$2,893,000	
Contingency			25%	$3,617,000	
TOTAL CAPITAL COSTS				$23,869,000	
POST-CLOSURE CARE COSTS				$0	
TOTAL ALTERNATIVE COST (NET PRESENT VALUE)[b]				$24,000,000	Rounded

[a] Costs are for mid-1995.

[b] The sum of capital and operating costs and the net present value of the post-closure care costs.

TABLE H-8

ESTIMATED QUANTITIES

Item	Value	Units	Source/Comments
Clearing and Grubbing:			
Length	1,800	ft	Figure 3-6: potential waste area only
Width	300	ft	150 ft each side of trench centerline
Trench Backfill:			
Length	1,800	ft	Figure 3-6: potential waste area only
Width	60	ft	Estimate
Depth	40	ft	Estimate
Volume	57,500	cy	Figure 3-15
Capping:			
Length	1,800	ft	Figure 3-6: potential waste area only
Width	100	ft	Trench width plus overhang
Area	188,000	sq ft	Figure 8-2
Haul Road Length:	2,880	ft	S. Portal to existing gravel road
Drainage Ditch Length	4,000	ft	Figure 8-2
Excavation:			
Length	1,500	ft	
Width	16	ft	
Thickness	70	ft	To water table
Volume	57,500	cy	
Percentage requiring disposal	75%		
Waste and contaminated soil for disposal	43,100	cy	

TABLE H-9

BASIC UNIT COSTS

Item	Unit Cost	Units	Std. Dev.[a]	Source/Comments
SITE WORK (labor, materials and equipment):				Not including contractor overhead & profit
Site Preparation				
Haul road	$6.90	lf	b	Means 1994, 022 308 0370 * 1.03; 30-ft width
Clear and grub (outside of trench)	$3,500	acre	$1,050	Means 1994, 021 104 0160 * 1.03
Clear trees (in trench only)	$2,100	acre	b	Means 1994, 021 104 0100 * 1.03
Seeding	$850	acre	b	Means 1994, 029 308 0100 * 1.03
Drainage Ditch	$1.80	lf	b	Means 1994, 022 278 2400 * 1.03
Fencing	$10	lf	$3.00	Means 1994, 028 308 0200 * 1.03
Materials (in place):				
Topsoil	$2.00	cy	$0.60	Estimated assuming site source
Clean fill soil	$4.00	cy	$1.20	Estimated assuming site source
Trench backfill	$4.35	cy	$1.31	Estimated assuming site source; 50% compacted
Low-permeability soil, 10^{-6} cm/sec	$5.70	cy	c	Estimated assuming site source
FML, 20 mil	$0.17	sf	$0.05	
FML, 50 mil	$0.42	sf	$0.13	
Geotextile	$0.13	sf	$0.04	
GCL	$0.67	sf	$0.20	
OTHER:				
Excavation	$25	cy	$13	Means 1994 + $5/cy for double-handling
Off-site disposal, including haulin	$300	cy	d	Unit cost assumes hazardous waste landfill cost as approximate average unit cost for combination of non-hazardous landfill, hazardous waste landfill, and incineration.
Fence maintenance	$0.50	lf-yr	$0.15	Allowance
Soil/clay cap maintenance	$2,000	ac-yr	$600	Allowance
FML cap maintenance	$3,000	ac-yr	$900	Allowance
FML/GCL cap maintenance	$4,000	ac-yr	$1,200	Allowance
Air monitoring costs	$50,000	LS	$15,000	Allowance
Implement institutional controls	$50,000	LS	$15,000	Allowance

[a] Standard deviation of unit cost assumed for probabilistic uncertainty analysis.

[b] Fixed unit cost used for probabilistic uncertainty analysis due to small percentage of total costs.

[c] Triangular distribution with range of $0 to $25 used in uncertainty analysis.

[d] Triangular distribution with range of $0 to $1000 used in uncertainty analysis.

TABLE H-10

CAP UNIT COSTS

Item	Quantity	Units	Unit Cost
Soil Cap:			
Topsoil	0.5	ft/sf	$0.04
Clean fill soil	1.5	ft/sf	$0.22
Soil Cap Unit Cost			**$0.26**
Clay Cap			
Topsoil	0.5	ft/sf	$0.04
10^{-6} Soil	2	ft/sf	$0.42
Clay Cap Unit Cost			**$0.46**
FML Cap			
Topsoil	0.5	ft/sf	$0.04
Clean fill soil	1.5	ft/sf	$0.22
FML, 50 mil	1	sf	$0.42
Geotextile	1	sf	$0.13
FML Cap Unit Cost			**$0.81**
FML / GCL Cap			
Topsoil	0.5	ft/sf	$0.04
Clean fill soil	1.5	ft/sf	$0.22
FML, 20 mil	1	sf/sf	$0.17
GCL	1	sf/sf	$0.67
FML / GCL Cap Unit Cost		sf	**$1.10**

TABLE H-11

ESTIMATED GROUNDWATER MONITORING COSTS

Item	Quantity	Units	Unit Cost	Cost	Notes
Screening analytical costs, per well per event					
GC/MS Volatiles				$250	
Total organic carbon (TOC)				$100	
Indicator metals				$100	
				$450	
Comprehensive analytical costs, per well per event					
GC/MS Volatiles				$250	
GC/MS Semivolatiles				$350	
GM/MC Pesticides/PCBs				$350	
Metals (comprehensive list)				$200	
General parameters				$120	
				$1,270	
Number of wells monitored	2	wells			
Annual Monitoring, Quarterly					Wells plus QA sample
Screening analysis, 3 events	9	samples	$450	$4,050	
Comprehensive analysis, 1 event	3	samples	$1,270	$3,810	
Labor and reporting	60	hrs	$70	$4,200	
Annual Cost				**$12,060**	
Annual Monitoring, Semi-Annual					Wells plus QA sample
Screening analysis, 1 event	3	samples	$450	$1,350	
Comprehensive analysis, 1 event	3	samples	$1,270	$3,810	
Labor and reporting	35	hrs	$70	$2,450	
Annual Cost				**$7,610**	
Annual Monitoring, Annual Event					Wells plus QA sample
Comprehensive analysis, 1 event	3	samples	$1,270	$3,810	
Labor and reporting	24	hrs	$70	$1,680	
Annual Cost				**$5,490**	
Present-value cost of monitoring	20	yr		**$81,834**	Present value of cash flow; assumes 5% net interest.

APPENDIX I

PROBABILISTIC UNCERTAINTY ANALYSIS

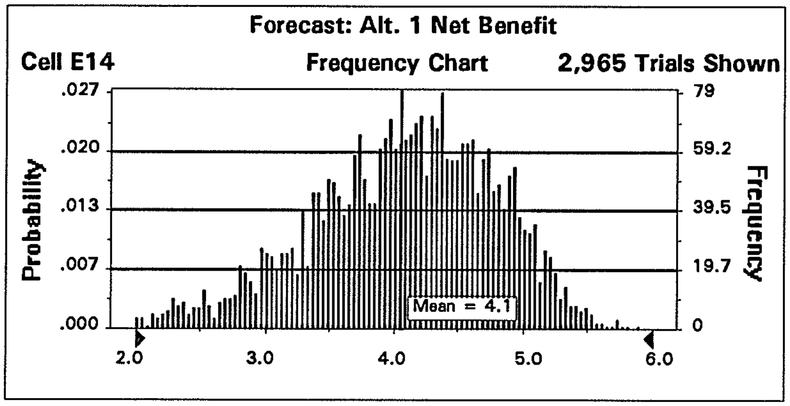
APPENDIX I

PROBABILISTIC UNCERTAINTY ANALYSIS

3,000 trials
Latin Hypercube Sampling; Sample Size = 100

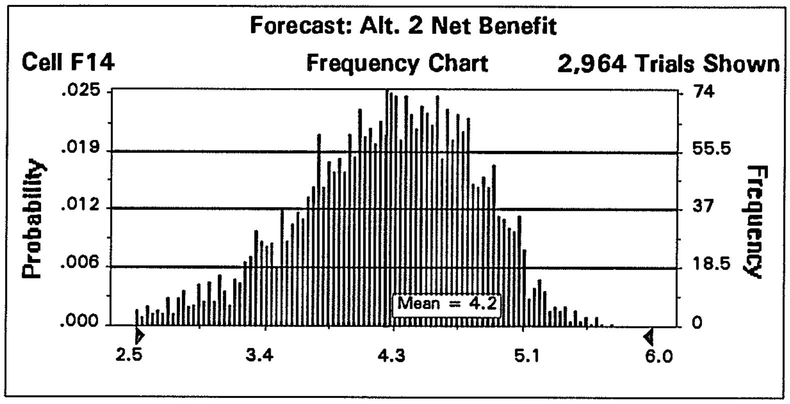
Estimated Probabilities for Net Benefit of Alternatives

Forecast: Alt. 1 Net Benefit



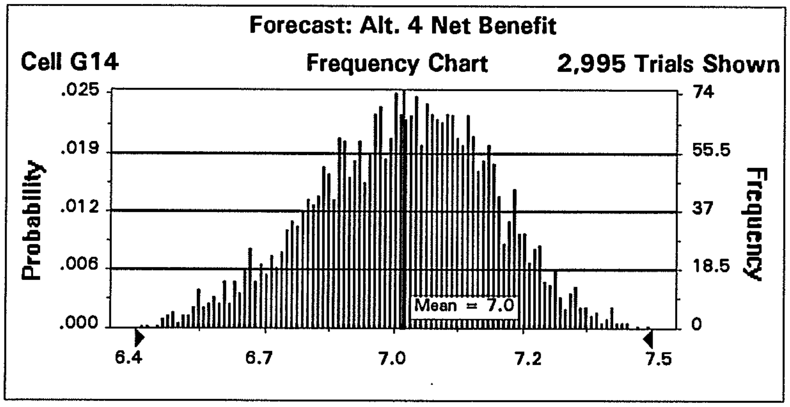
Percentile	Value
0%	1.0
10%	3.0
25%	3.6
50%	4.1
75%	4.6
90%	5.0
100%	5.9

Forecast: Alt. 2 Net Benefit



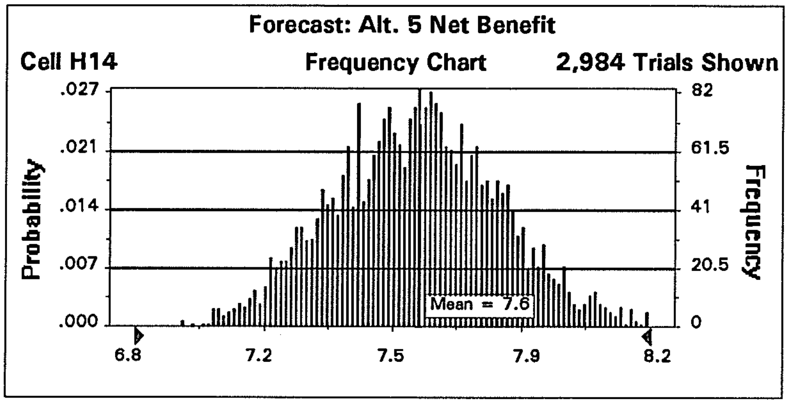
Percentile	Value
0%	1.7
10%	3.4
25%	3.8
50%	4.2
75%	4.6
90%	4.9
100%	5.7

Forecast: Alt. 4 Net Benefit



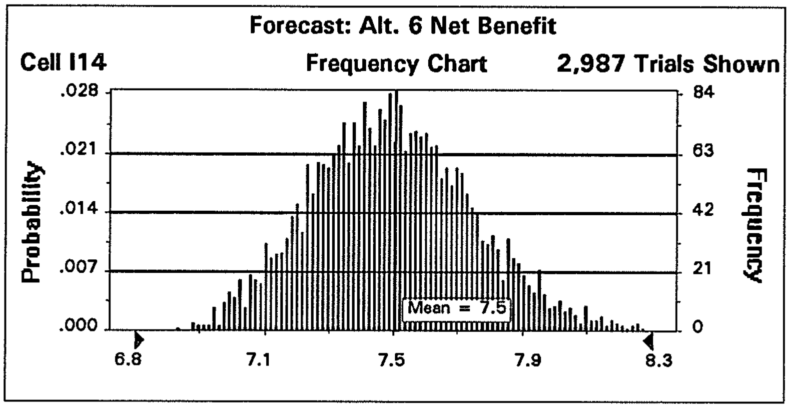
Percentile	Value
0%	6.3
10%	6.7
25%	6.8
50%	7.0
75%	7.1
90%	7.2
100%	7.6

Forecast: Alt. 5 Net Benefit



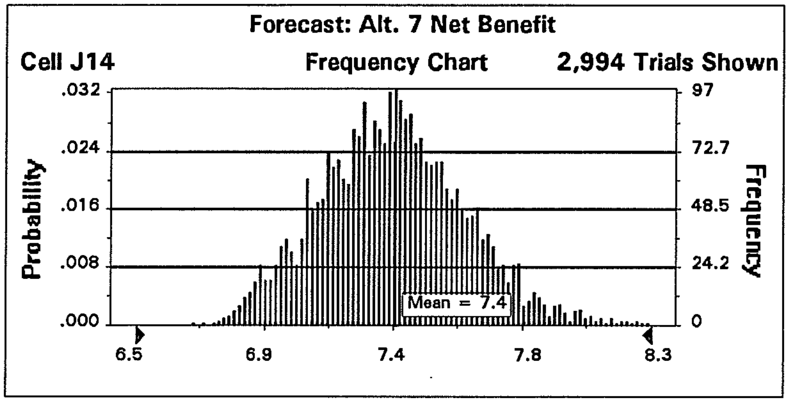
Percentile	Value
0%	6.9
10%	7.3
25%	7.4
50%	7.6
75%	7.7
90%	7.9
100%	8.6

Forecast: Alt. 6 Net Benefit



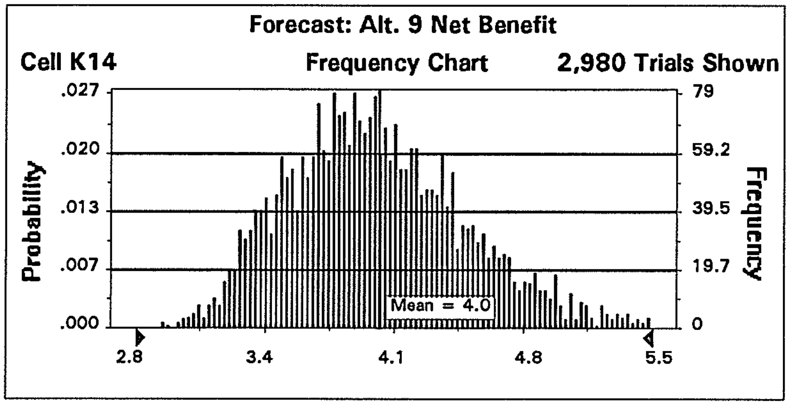
Percentile	Value
0%	6.9
10%	7.2
25%	7.3
50%	7.5
75%	7.7
90%	7.8
100%	8.6

Forecast: Alt. 7 Net Benefit



Percentile	Value
0%	6.7
10%	7.1
25%	7.2
50%	7.4
75%	7.5
90%	7.7
100%	8.5

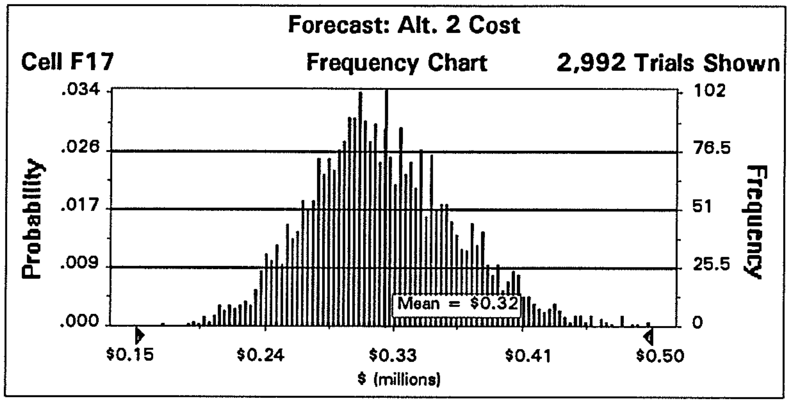
Forecast: Alt. 9 Net Benefit



Percentile	Value
0%	2.9
10%	3.4
25%	3.7
50%	4.0
75%	4.4
90%	4.7
100%	6.3

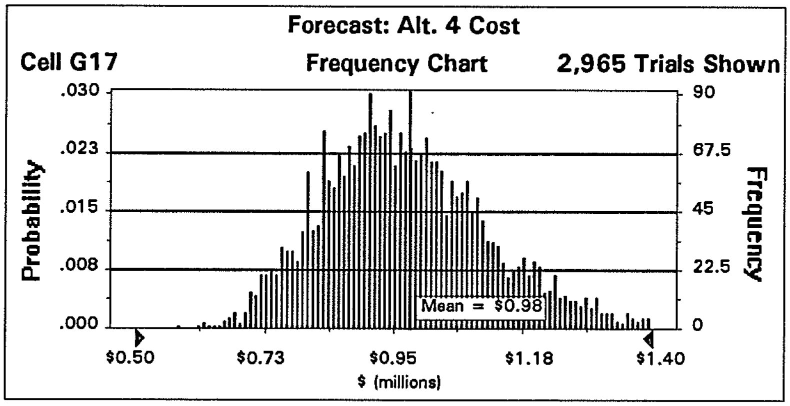
Estimated Probabilities for Total Alternative Costs

Forecast: Alt. 2 Cost



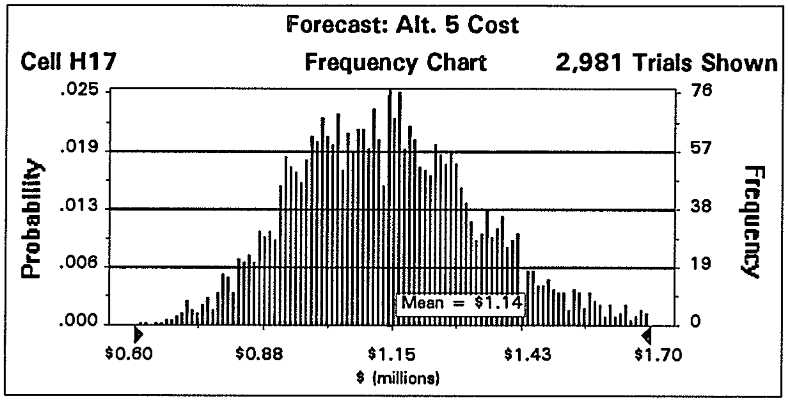
Percentile	$ (millions)
0%	$0.17
10%	$0.26
25%	$0.28
50%	$0.31
75%	$0.35
90%	$0.39
100%	$0.53

Forecast: Alt. 4 Cost



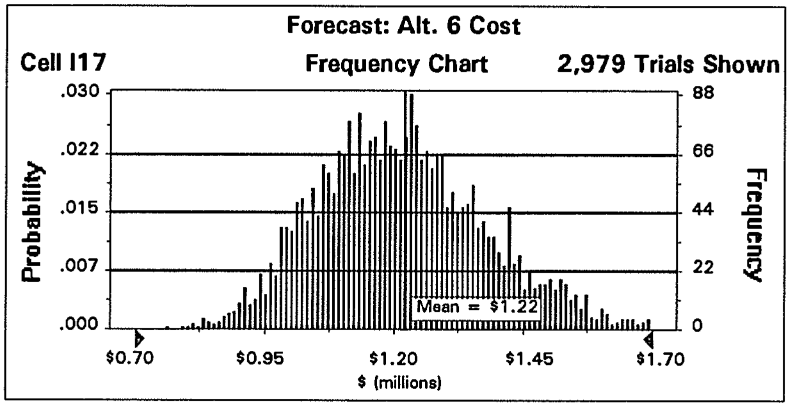
Percentile	$ (millions)
0%	$0.58
10%	$0.80
25%	$0.87
50%	$0.96
75%	$1.07
90%	$1.18
100%	$1.63

Forecast: Alt. 5 Cost



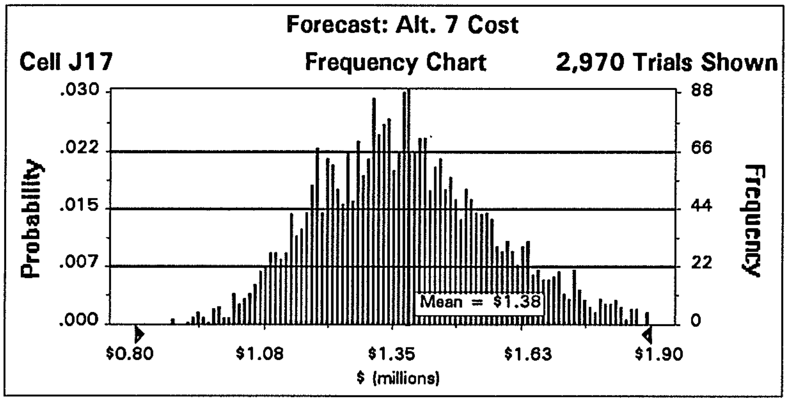
Percentile	$ (millions)
0%	$0.61
10%	$0.90
25%	$1.00
50%	$1.13
75%	$1.27
90%	$1.40
100%	$2.07

Forecast: Alt. 6 Cost



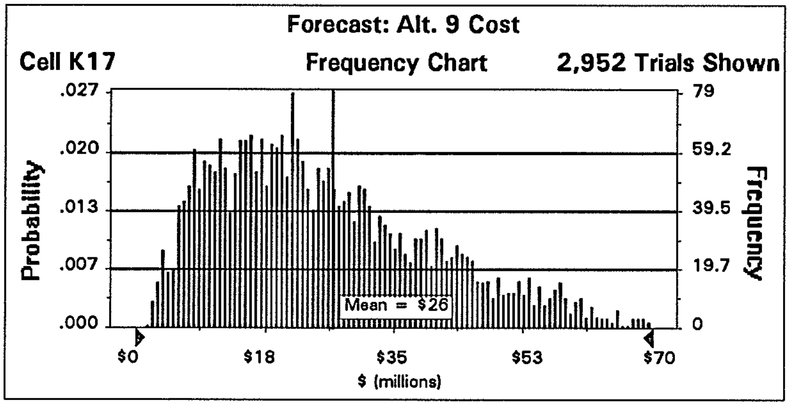
Percentile	$ (millions)
0%	$0.77
10%	$1.02
25%	$1.10
50%	$1.21
75%	$1.32
90%	$1.44
100%	$1.96

Forecast: Alt. 7 Cost



Percentile	$ (millions)
0%	$0.88
10%	$1.15
25%	$1.24
50%	$1.37
75%	$1.50
90%	$1.64
100%	$2.11

Forecast: Alt. 9 Cost



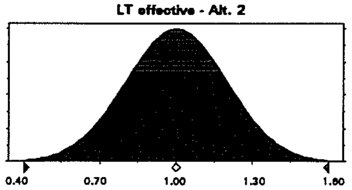
Percentile	$ (millions)
0%	$1
10%	$9
25%	$15
50%	$23
75%	$36
90%	$48
100%	$101

Assumptions

Assumption: LT effective - Alt. 2

Normal distribution with parameters:	
Mean	1.00
Standard Dev.	0.20

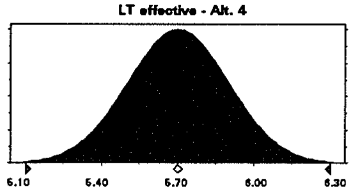
Mean value in simulation was 1.00



Assumption: LT effective - Alt. 4

Normal distribution with parameters:	
Mean	5.70
Standard Dev.	0.20

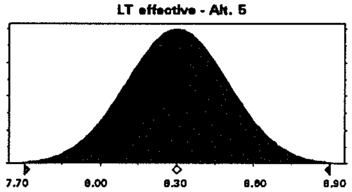
Mean value in simulation was 5.70



Assumption: LT effective - Alt. 5

Normal distribution with parameters:	
Mean	8.30
Standard Dev.	0.20

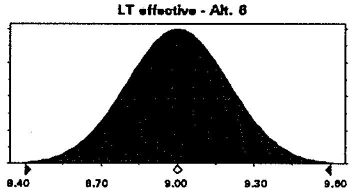
Mean value in simulation was 8.30



Assumption: LT effective - Alt. 6

Normal distribution with parameters:	
Mean	9.00
Standard Dev.	0.20

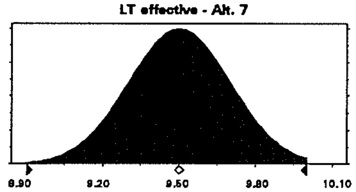
Mean value in simulation was 9.00



Assumption: LT effective - Alt. 7

Normal distribution with parameters:	
Mean	9.50
Standard Dev.	0.20

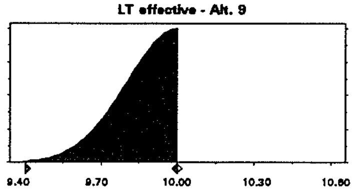
Mean value in simulation was 9.50



Assumption: LT effective - Alt. 9

Normal distribution with parameters:	
Mean	10.00
Standard Dev.	0.20

Mean value in simulation was 9.84

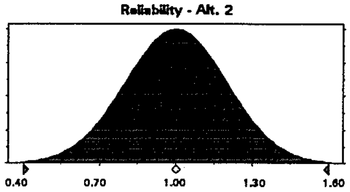


Assumption: Reliability - Alt. 2

Normal distribution with parameters:

Mean	1.00
Standard Dev.	0.20

Mean value in simulation was 1.00

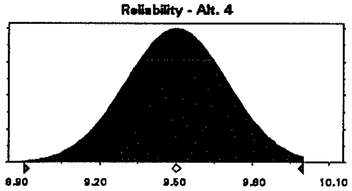


Assumption: Reliability - Alt. 4

Normal distribution with parameters:

Mean	9.50
Standard Dev.	0.20

Mean value in simulation was 9.50

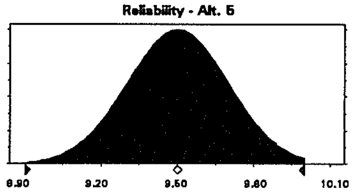


Assumption: Reliability - Alt. 5

Normal distribution with parameters:

Mean	9.50
Standard Dev.	0.20

Mean value in simulation was 9.50

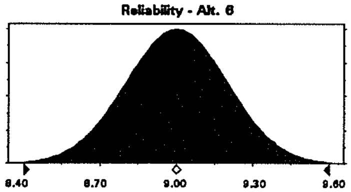


Assumption: Reliability - Alt. 6

Normal distribution with parameters:

Mean	9.00
Standard Dev.	0.20

Mean value in simulation was 9.00

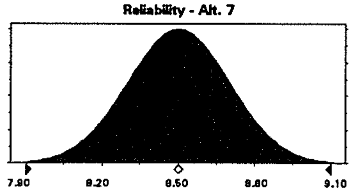


Assumption: Reliability - Alt. 7

Normal distribution with parameters:

Mean	8.50
Standard Dev.	0.20

Mean value in simulation was 8.50

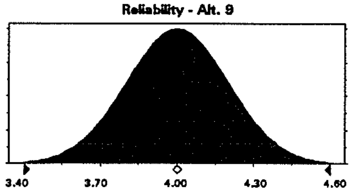


Assumption: Reliability - Alt. 9

Normal distribution with parameters:

Mean	4.00
Standard Dev.	0.20

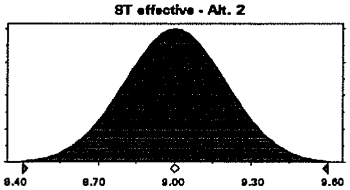
Mean value in simulation was 4.00



Assumption: ST effective - Alt. 2

Normal distribution with parameters:	
Mean	9.00
Standard Dev.	0.20

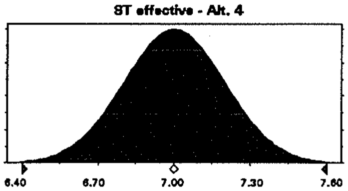
Mean value in simulation was 9.00



Assumption: ST effective - Alt. 4

Normal distribution with parameters:	
Mean	7.00
Standard Dev.	0.20

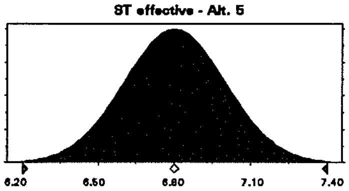
Mean value in simulation was 7.00



Assumption: ST effective - Alt. 5

Normal distribution with parameters:	
Mean	6.80
Standard Dev.	0.20

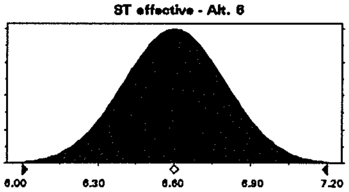
Mean value in simulation was 6.80



Assumption: ST effective - Alt. 6

Normal distribution with parameters:	
Mean	6.60
Standard Dev.	0.20

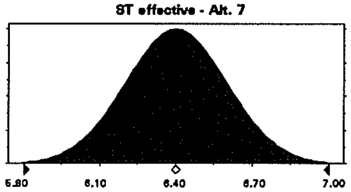
Mean value in simulation was 6.60



Assumption: ST effective - Alt. 7

Normal distribution with parameters:	
Mean	6.40
Standard Dev.	0.20

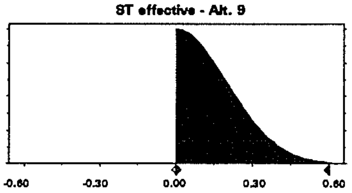
Mean value in simulation was 6.40



Assumption: ST effective - Alt. 9

Normal distribution with parameters:	
Mean	0.00
Standard Dev.	0.20

Mean value in simulation was 0.16

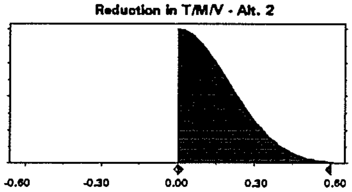


Assumption: Reduction in T/M/V - Alt. 2

Normal distribution with parameters:

Mean	0.00
Standard Dev.	0.20

Mean value in simulation was 0.16

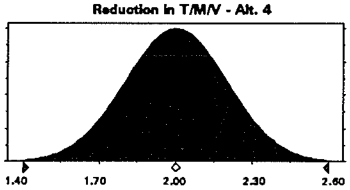


Assumption: Reduction in T/M/V - Alt. 4

Normal distribution with parameters:

Mean	2.00
Standard Dev.	0.20

Mean value in simulation was 2.00

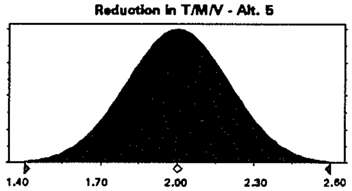


Assumption: Reduction in T/M/V - Alt. 5

Normal distribution with parameters:

Mean	2.00
Standard Dev.	0.20

Mean value in simulation was 2.00

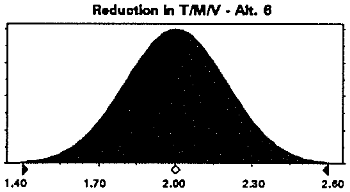


Assumption: Reduction in T/M/V - Alt. 6

Normal distribution with parameters:

Mean	2.00
Standard Dev.	0.20

Mean value in simulation was 2.00

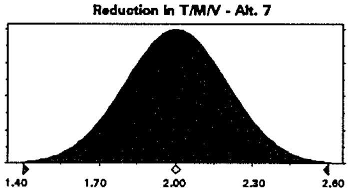


Assumption: Reduction in T/M/V - Alt. 7

Normal distribution with parameters:

Mean	2.00
Standard Dev.	0.20

Mean value in simulation was 2.00

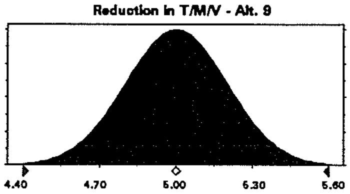


Assumption: Reduction in T/M/V - Alt. 9

Normal distribution with parameters:

Mean	5.00
Standard Dev.	0.20

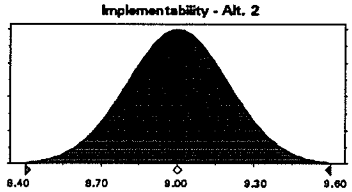
Mean value in simulation was 5.00



Assumption: Implementability - Alt. 2

Normal distribution with parameters:	
Mean	9.00
Standard Dev.	0.20

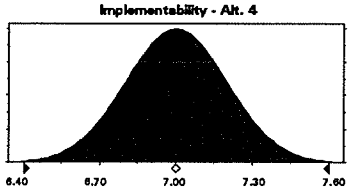
Mean value in simulation was 9.00



Assumption: Implementability - Alt. 4

Normal distribution with parameters:	
Mean	7.00
Standard Dev.	0.20

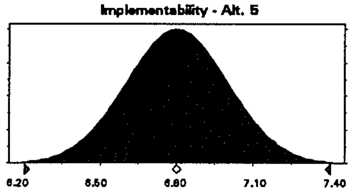
Mean value in simulation was 7.00



Assumption: Implementability - Alt. 5

Normal distribution with parameters:	
Mean	6.80
Standard Dev.	0.20

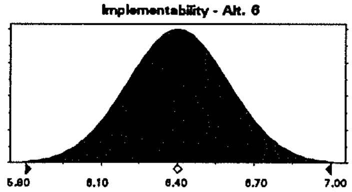
Mean value in simulation was 6.80



Assumption: Implementability - Alt. 6

Normal distribution with parameters:	
Mean	6.40
Standard Dev.	0.20

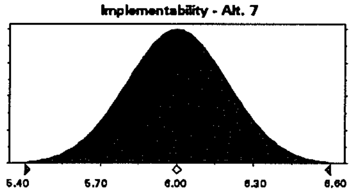
Mean value in simulation was 6.40



Assumption: Implementability - Alt. 7

Normal distribution with parameters:	
Mean	6.00
Standard Dev.	0.20

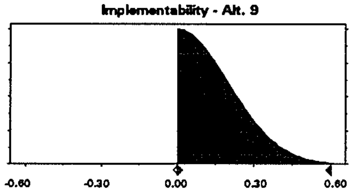
Mean value in simulation was 6.00



Assumption: Implementability - Alt. 9

Normal distribution with parameters:	
Mean	0.00
Standard Dev.	0.20

Mean value in simulation was 0.16

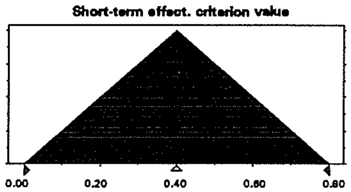


Assumption: Short-term effect. criterion relative value

Triangular distribution with parameters:

Minimum	0.00
Likeliest	0.40
Maximum	0.80

Mean value in simulation was 0.40

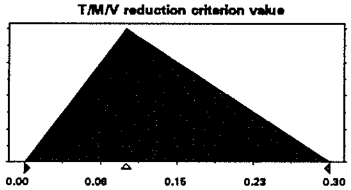


Assumption: T/M/V reduction criterion relative value

Triangular distribution with parameters:

Minimum	0.00
Likeliest	0.10
Maximum	0.30

Mean value in simulation was 0.13

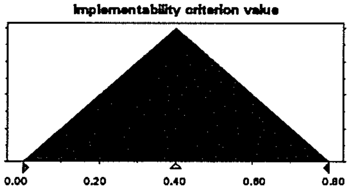


Assumption: Implementability criterion relative value

Triangular distribution with parameters:

Minimum	0.00
Likeliest	0.40
Maximum	0.80

Mean value in simulation was 0.40

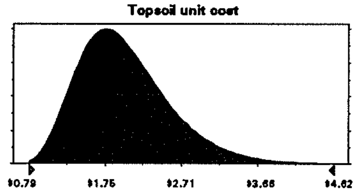


Assumption: Topsoil unit cost

Lognormal distribution with parameters:

Mean	$2.00
Standard Dev.	$0.60

Mean value in simulation was $2.00

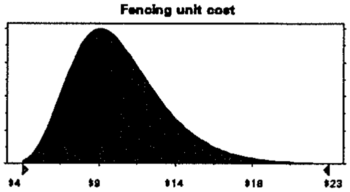


Assumption: Fencing unit cost

Lognormal distribution with parameters:

Mean	$10
Standard Dev.	$3

Mean value in simulation was $10

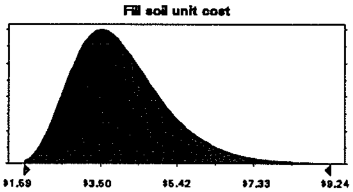


Assumption: Fill soil unit cost

Lognormal distribution with parameters:

Mean	$4.00
Standard Dev.	$1.20

Mean value in simulation was $4.00

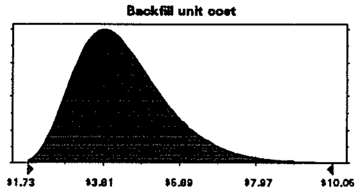


Assumption: Backfill unit cost

Lognormal distribution with parameters:

Mean	$4.35
Standard Dev.	$1.31

Mean value in simulation was $4.35

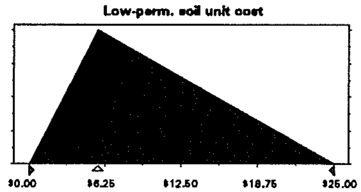


Assumption: Low-permeability soil unit cost

Triangular distribution with parameters:

Minimum	$0.00
Likeliest	$5.70
Maximum	$25.00

Mean value in simulation was $10.23

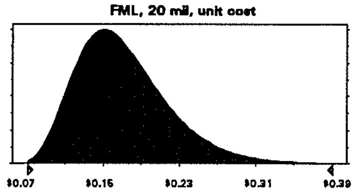


Assumption: FML, 20 mil, unit cost

Lognormal distribution with parameters:

Mean	$0.17
Standard Dev.	$0.05

Mean value in simulation was $0.17

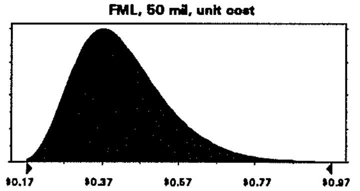


Assumption: FML, 50 mil, unit cost

Lognormal distribution with parameters:

Mean	$0.42
Standard Dev.	$0.13

Mean value in simulation was $0.42

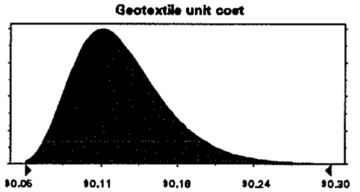


Assumption: Geotextile unit cost

Lognormal distribution with parameters:

Mean	$0.13
Standard Dev.	$0.04

Mean value in simulation was $0.13

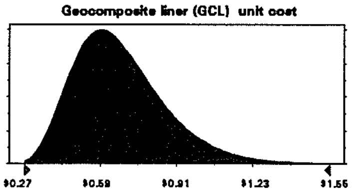


Assumption: Geocomposite liner (GCL) unit cost

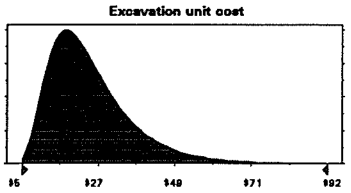
Lognormal distribution with parameters:

Mean	$0.67
Standard Dev.	$0.20

Mean value in simulation was $0.67



Assumption: Excavation unit cost

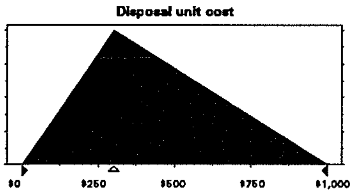


Lognormal distribution with parameters:

Mean	$25
Standard Dev.	$13

Mean value in simulation was $25

Assumption: Disposal unit cost

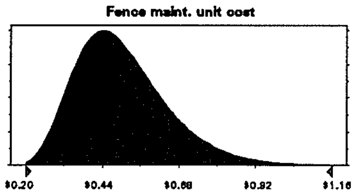


Triangular distribution with parameters:

Minimum	$0
Likeliest	$300
Maximum	$1,000

Mean value in simulation was $433

Assumption: Fence maint. unit cost

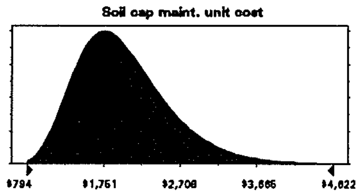


Lognormal distribution with parameters:

Mean	$0.50
Standard Dev.	$0.15

Mean value in simulation was $0.50

Assumption: Soil cap maint. unit cost

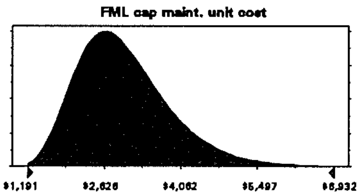


Lognormal distribution with parameters:

Mean	$2,000
Standard Dev.	$600

Mean value in simulation was $2,000

Assumption: FML cap maint. unit cost

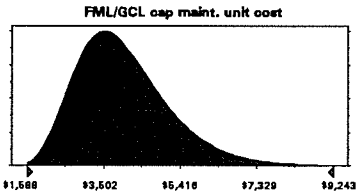


Lognormal distribution with parameters:

Mean	$3,000
Standard Dev.	$900

Mean value in simulation was $3,000

Assumption: FML/GCL cap maint. unit cost



Lognormal distribution with parameters:

Mean	$4,000
Standard Dev.	$1,200

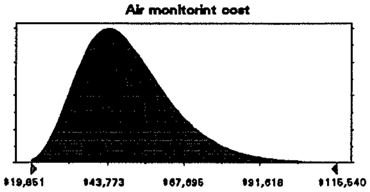
Mean value in simulation was $3,999

Assumption: Air monitoring cost

Lognormal distribution with parameters:

Mean	$50,000
Standard Dev.	$15,000

Mean value in simulation was $49,983

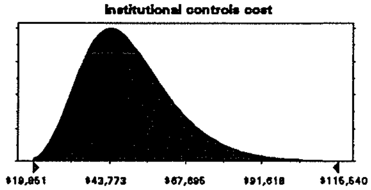


Assumption: Institutional controls cost

Lognormal distribution with parameters:

Mean	$50,000
Standard Dev.	$15,000

Mean value in simulation was $50,034

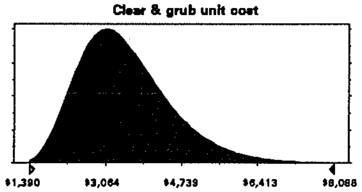


Assumption: Clear & grub unit cost

Lognormal distribution with parameters:

Mean	$3,500
Standard Dev.	$1,050

Mean value in simulation was $3,504

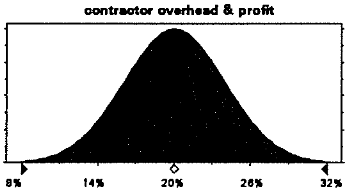


Assumption: Contractor overhead & profit

Normal distribution with parameters:

Mean	20%
Standard Dev.	4%

Mean value in simulation was 20%

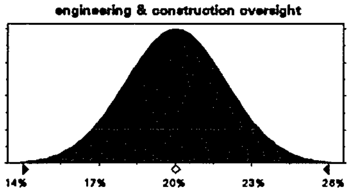


Assumption: Engineering & construction oversight

Normal distribution with parameters:

Mean	20%
Standard Dev.	2%

Mean value in simulation was 20%

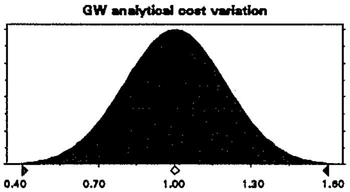


Assumption: GW analytical cost variation

Normal distribution with parameters:

Mean	1.00
Standard Dev.	0.20

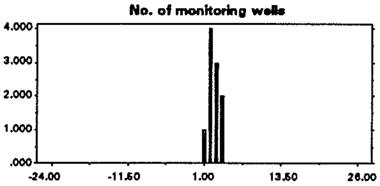
Mean value in simulation was 1.00



Assumption: No. of monitoring wells

No. wells	Relative Prob.
1	1
2	4
3	3
4	2
Total Relative Probability	10

Mean value in simulation was 2.60

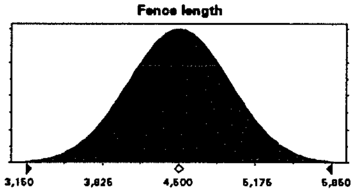


Assumption: Fence length (ft)

Normal distribution with parameters:

Mean	4,500
Standard Dev.	450

Mean value in simulation was 4,500

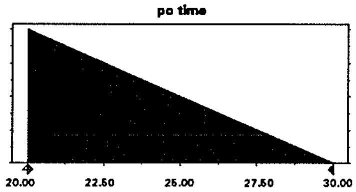


Assumption: Post-closure time (yrs)

Triangular distribution with parameters:

Minimum	20.00
Likeliest	20.00
Maximum	30.00

Mean value in simulation was 23.33

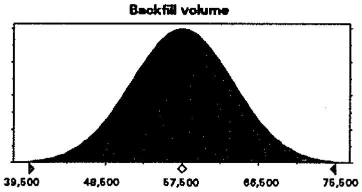


Assumption: Backfill volume (yd^3)

Normal distribution with parameters:

Mean	57,500
Standard Dev.	6,000

Mean value in simulation was 57,504

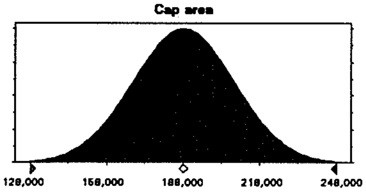


Assumption: Cap area (ft^2)

Normal distribution with parameters:

Mean	188,000
Standard Dev.	20,000

Mean value in simulation was 188,012

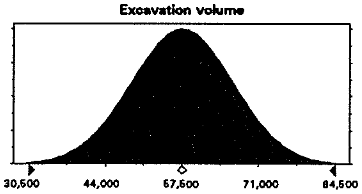


Assumption: Excavation volume (yd^3)

Normal distribution with parameters:

Mean	57,500
Standard Dev.	9,000

Mean value in simulation was 57,516

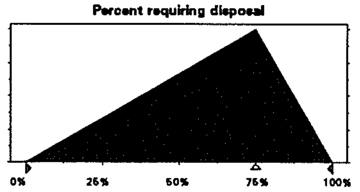


Assumption: Percent requiring disposal

Triangular distribution with parameters:

Minimum	0%
Likeliest	75%
Maximum	100%

Mean value in simulation was 58%



APPENDIX J

GEOTECHNICAL SOIL DATA

February 1, 1996

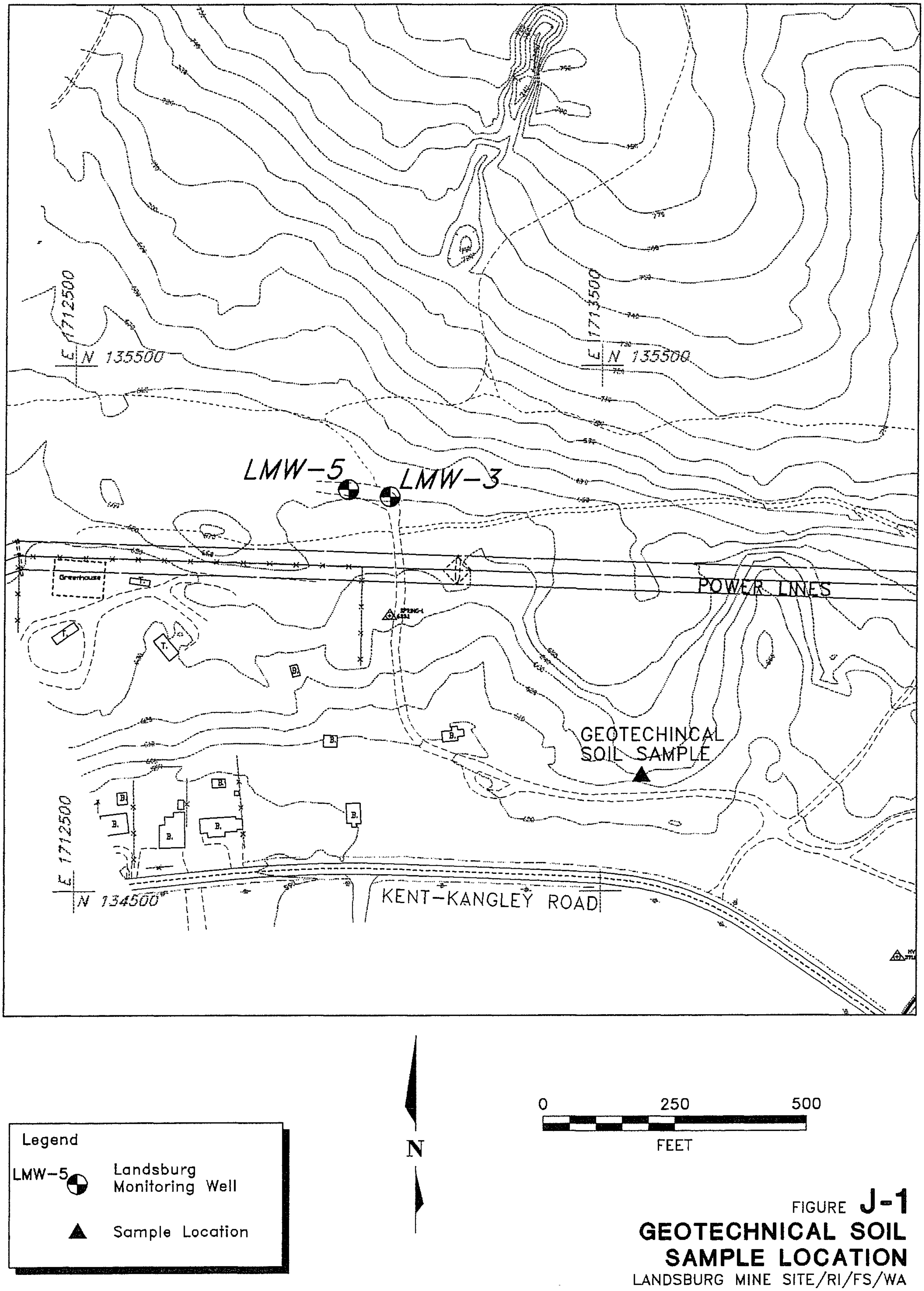


FIGURE **J-1**

GEOTECHNICAL SOIL SAMPLE LOCATION

LANDSBURG MINE SITE/RI/FS/WA

GOLDER ASSOCIATES INC., REDMOND, WA
PERMEABILITY TEST SPREADSHEET ASTM D-5084
(Multiple samples - common cell & inflow)

Project Number:	923-1000.147
Project Description:	LANDSBURG MINE SITE RI/FS / WA
Sample Number:	BUCKET
Sample Description:	Recompacted, dark olive brown (2.5 Y 3/3), c-f SAND, some clayey silt, some c-f gravel, (SM).

TEST RESULTS

K = 5.8×10^{-7} cm/second

Tested by: MSB
Reviewed by: DPO

Spreadsheet updated 5-8-91, D. Oster

Board number: L0016
Cell number: L0200

Sample Dimensions (cgs):	Initial	Final
Height:	7.124	7.069
Diameter:	7.254	7.287
Area:	41.33	41.70
Volume:	294.4	294.8

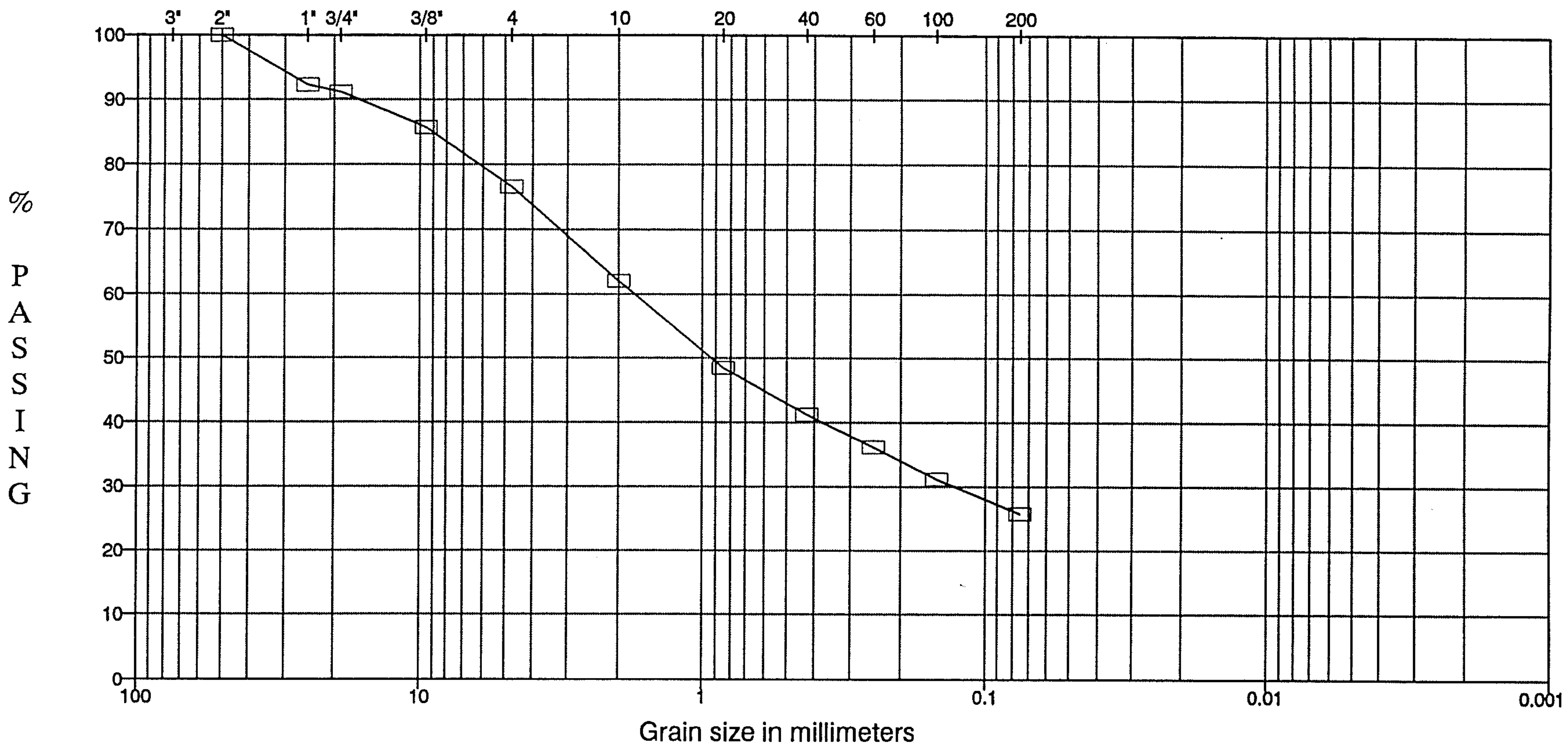
Sample Properties:	Initial	Final
Wet Weight (g):	562.52	567.40
Moisture (%):	19.7	20.7
Wet Density (pcf):	119.3	120.1
Dry Density (pcf):	99.7	99.5
Dry Weight (g):	470.09	470.09
Specific Grav. (est.):	2.50	2.50
Void Ratio:	0.57	0.57
Saturation (%):	87	91

Target Test Cond. (psig):	Saturation	During Test
Cell:	100.0	100.0
Top Stone:	92.5	91.0
Bottom stone:	92.5	94.0
B - coefficient:	1.000	N.A.
Gradient:	0	30

Test Method: Flexible wall permeameter with back pressure saturation (const. head computations)

						Elapsed	Inflow		Outflow Volumes (cc)				Transducer Readings (psi)			Head	K (cm/s)
yr	m	da	hr	mi	sec	(min.)	Reading	Fill	Reading	Drain	Delta	Total	Cell	Bottom	Top	(cm H20)	Delta
95	4	27	12	15	0	0.00	0.0	0.0	25.0	0.0	0.0	0.0	100.0	94.0	91.0	236.0	0
95	4	27	12	42	0	27.00	0.3	0.0	23.2	0.0	1.8	1.8	99.8	93.9	90.9	233.9	8.0E-07
95	4	27	12	59	0	44.00	0.6	0.0	22.2	0.0	1.0	2.8	99.8	93.8	90.8	232.6	7.1E-07
95	4	27	13	10	0	55.00	0.8	0.0	21.6	0.0	0.6	3.4	99.8	93.9	90.8	238.9	6.5E-07
95	4	27	13	43	0	88.00	1.1	0.0	19.7	0.0	1.9	5.3	99.7	93.8	90.7	236.7	6.8E-07
95	4	27	13	59	0	104.00	1.4	0.0	18.7	0.0	1.0	6.3	99.8	93.9	90.8	235.4	7.5E-07
95	4	27	14	26	0	131.00	1.7	0.0	17.3	0.0	1.4	7.7	99.8	93.9	90.8	233.7	6.2E-07
95	4	27	14	45	0	150.00	1.9	0.0	16.2	0.0	1.1	8.8	99.7	93.9	90.8	232.4	7.0E-07
95	4	27	15	2	0	167.00	2.1	2.1	15.4	9.6	0.8	9.6	99.7	93.9	90.8	231.4	5.7E-07
95	4	28	8	28	0	0.00	0.0	0.0	25.0	0.0	0.0	9.6	100.0	94.0	91.0	236.0	0
95	4	28	8	39	0	11.00	0.2	0.0	24.3	0.0	0.7	10.3	100.2	94.0	91.0	235.1	7.6E-07
95	4	28	8	55	0	27.00	0.3	0.0	23.4	0.0	0.9	11.2	100.1	94.0	91.0	234.1	6.8E-07
95	4	28	9	7	0	39.00	0.5	0.0	22.7	0.0	0.7	11.9	100.1	94.0	91.0	233.2	7.1E-07
95	4	28	9	23	0	55.00	0.7	0.0	21.9	0.0	0.8	12.7	100.1	94.0	91.0	232.2	6.1E-07
95	4	28	11	2	0	154.00	1.8	0.0	17.0	0.0	4.9	17.6	100.1	93.9	91.0	219.2	6.2E-07
95	4	28	11	40	0	192.00	2.1	0.0	15.2	0.0	1.8	19.4	100.0	93.9	90.9	224.1	6.0E-07
95	4	28	12	22	0	234.00	2.6	0.0	13.2	0.0	2.0	21.4	100.0	93.9	90.9	221.6	6.0E-07
95	4	28	13	12	0	284.00	3.2	0.0	10.9	0.0	2.3	23.7	99.9	93.9	90.9	218.7	5.9E-07
95	4	28	14	16	0	348.00	3.7	0.0	8.2	0.0	2.7	26.4	99.9	93.9	90.9	215.5	5.5E-07
95	4	28	15	18	0	410.00	4.4	0.0	5.5	0.0	2.7	29.2	99.9	93.9	90.9	212.1	5.9E-07
95	4	28	16	17	0	469.00	5.0	0.0	2.9	0.0	2.6	31.7	99.9	93.9	90.9	208.9	5.8E-07

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



Coarse	Fine	C	Med	Fine	FINES (Silt or Clay)
GRAVEL		SAND			

SAMPLE ID	DEPTH	W%	LL	PL	PI	USCS	DESCRIPTION
BUCKET		15.4	35	25	10	SM	Dark olive brown (2.5 Y 3/3), c-f SAND, some clayey silt, some c-f gravel, (SM).

PROJECT: **LANDSBURG MINE SITE RI/FS / WA**

PROJECT NO.: **923-1000.147** DATE: 4-21-95 TECH: MSB REVIEW: DPO

GOLDER ASSOCIATES INC.
REDMOND, WA

ASTM GRAIN SIZE ANALYSIS
MECHANICAL SIEVE
ASTM D-1140, C-136 D-2216

PROJECT TITLE:	LANDSBURG MINE SITE RI/FS / WA	**Boring No.:**	
PROJECT NUMBER:	923-1000.147	**Sample No.:**	BUCKET
		Depth:	

WATER CONTENT (Delivered Moisture)

tare no.	103
wt soil & tare,moist	1787.20
wt soil & tare,dry	1590.20
wt tare	310.99
wt moisture	197.00
wt dry soil	1279.21
% water	15.4%

SIEVE Size	wt ret (cumulative)	% PASSING	SIEVE Size
tare	310.53		
3"	310.53	100.0%	3"
2"	310.53	100.0%	2"
1"	409.25	92.3%	1"
3/4"	424.81	91.1%	3/4"
3/8"	494.49	85.6%	3/8"
#4	611.20	76.5%	#4
#10	794.88	62.1%	#10
#20	970.3	48.4%	#20
#40	1062.8	41.2%	#40
#60	1126.8	36.2%	#60
#100	1191.4	31.1%	#100
#200	1258.7	25.9%	#200

D10:	N/A
D30:	N/A
D60:	N/A
Cu:	N/A
Cz:	N/A

% C GRVL	8.9%
% F GRVL	14.6%
% C SAND	14.4%
% M SAND	20.9%
% F SAND	15.3%
% FINES	25.9%
% TOTAL	100%

Sample: BUCKET

LL	35
PL	25
PI	10

Wet Color: Description: Dark olive brown (2.5 Y 3/3),
c-f SAND, some clayey silt,
some c-f gravel, (SM).

USCS: SM

TECH	MSB
DATE	4-21-95
REVIEWED	DPO

GOLDER ASSOCIATES

REDMOND, WA

GOLDER ASSOCIATES INC., REDMOND, WA

ATTERBERG LIMITS
ASTM D 4318

PROJECT: LANDSBURG MINE SITE RI/FS / WA
PROJECT NO: 923-1000.147
DATE: 4-24-95
TECH: MSB
REVIEWER: DPO

BOREHOLE NUMBER	
SAMPLE NUMBER	BUCKET
DEPTH (ft)	

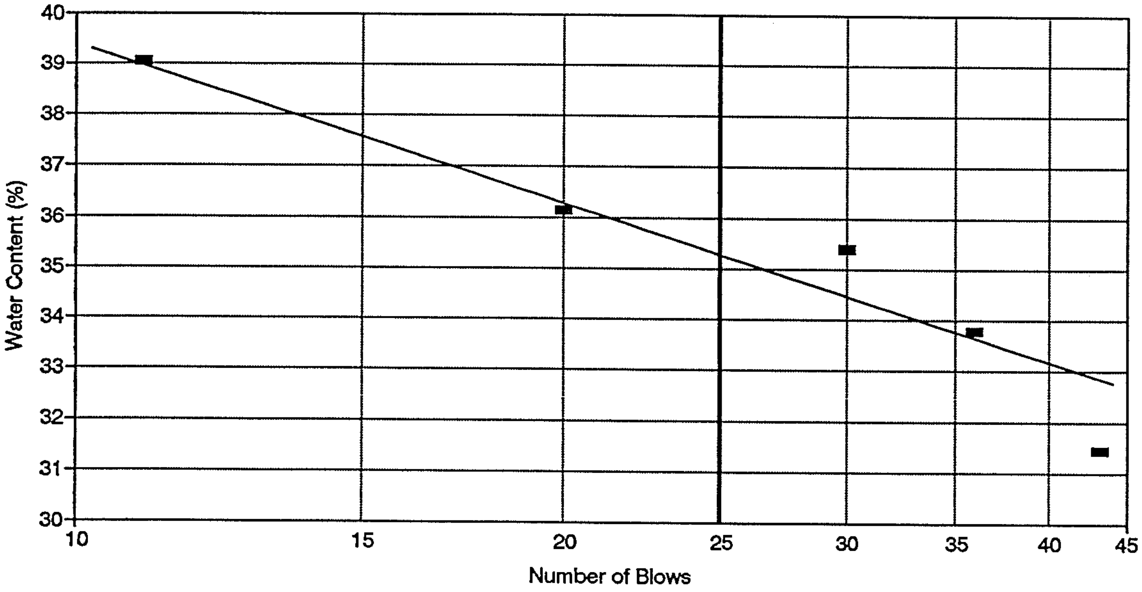
LIQUID LIMIT	35
PLASTIC LIMIT	25
PLASTICITY INDEX	10
MOISTURE CONTENT	15.4%
LIQUIDITY INDEX	0

Description: Dark olive brown (2.5 Y 3/3), c-f SAND, some clayey silt, some c-f gravel, (SM).

USCS: SM

	PLASTIC LIMIT		NATURAL MOISTURE
Tare Number	T-72	T-86	103
Wet Weight + Tare (g)	36.71	35.70	1787.20
Dry Weight + Tare (g)	35.16	34.37	1590.20
Tare Weight (g)	29.08	29.10	310.99
Water Content (%)	25.5%	25.2%	15.4%

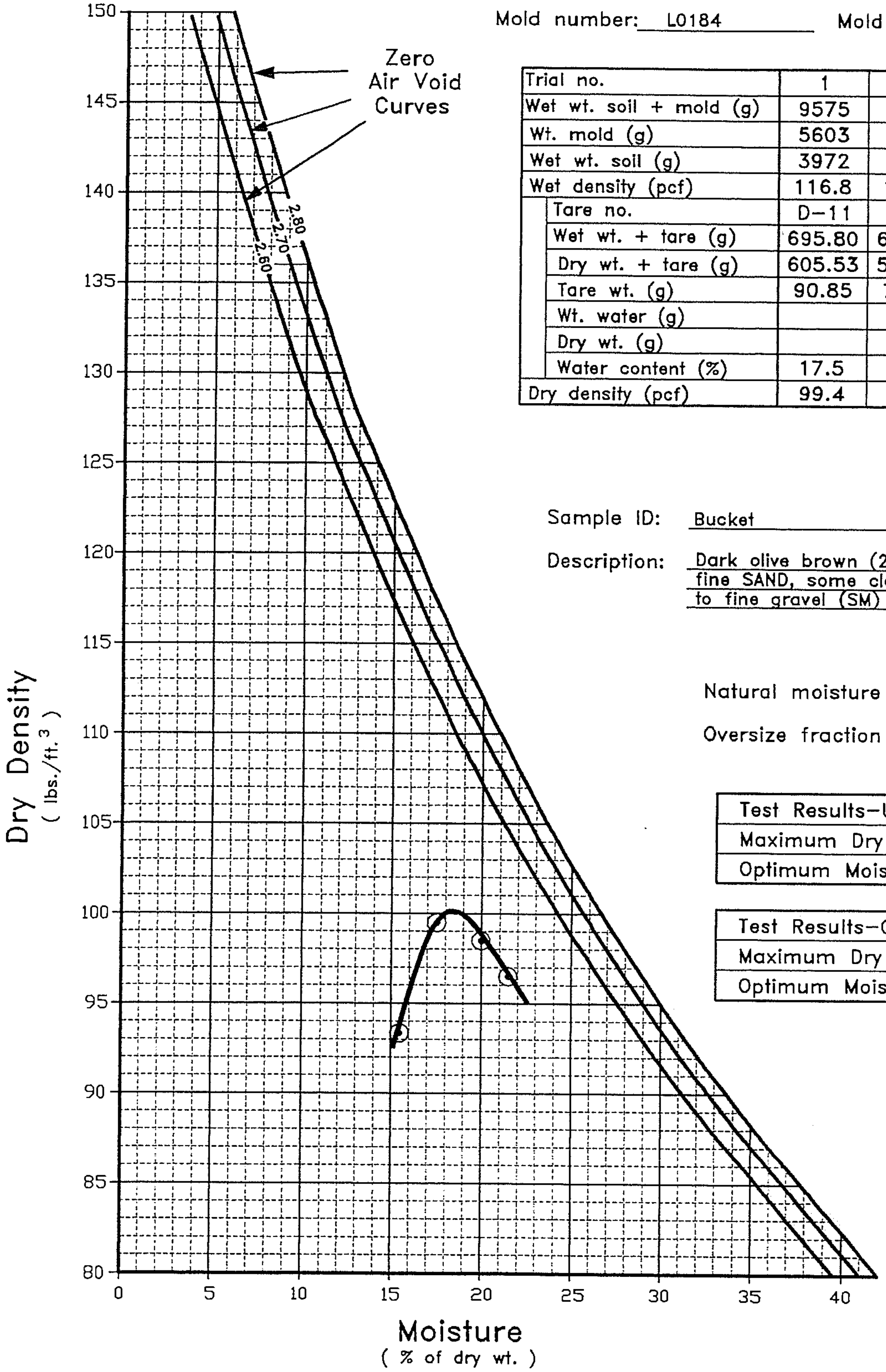
	LIQUID LIMIT				
Number of Blows	43	36	20	11	30
Tare Number	T-91	T-109	T-114	T-120	T-68
Wet Weight + Tare (g)	43.98	35.40	36.94	41.08	36.99
Dry Weight + Tare (g)	38.42	31.65	32.66	35.42	32.93
Tare Weight (g)	20.73	20.55	20.82	20.93	21.46
Water Content (%)	31.4%	33.8%	36.1%	39.1%	35.4%



Test Method: ASTM D 698-C

Mold number: L0184 Mold volume (cf): 0.07496

Trial no.		1	2	3	4	
Wet wt. soil + mold (g)		9575	9627	9587	9269	
Wt. mold (g)		5603	5603	5603	5603	
Wet wt. soil (g)		3972	4024	3984	3666	
Wet density (pcf)		116.8	118.3	117.2	107.8	
	Tare no.	D-11	D-8	26	D-3	
	Wet wt. + tare (g)	695.80	634.23	554.52	571.26	
	Dry wt. + tare (g)	605.53	540.74	469.99	506.29	
	Tare wt. (g)	90.85	73.38	76.35	89.22	
	Wt. water (g)					
	Dry wt. (g)					
	Water content (%)	17.5	20.0	21.5	15.6	
Dry density (pcf)		99.4	98.6	96.5	93.3	



Sample ID: Bucket

Description: Dark olive brown (2.5Y 3/3), coarse to fine SAND, some clayey silt, some coarse to fine gravel (SM)

Natural moisture (%): 15.4

Oversize fraction (%): 8.9

Test Results-Uncorrected	
Maximum Dry Density (pcf)	100.1
Optimum Moisture (%)	18.6

Test Results-Corrected for Oversize	
Maximum Dry Density (pcf)	103.4
Optimum Moisture (%)	17.1

MOISTURE-DENSITY RELATIONSHIP OF SOIL

Project LANDSBURG MINE SITE/RI-FS/WA

Project No. 923-1000.147 Date 4/21/95 Tested By MSB Approved By DPO

Golder Associates

5-9-95 10:05 C:\JPM\9231000\147\52261

GOLDER ASSOCIATES INC., REDMOND, WA

OVERSIZE CORRECTION OF PROCTOR VALUES
ASTM D-4718

PROJECT: LANDSBURG MINE SITE RI/FS / WA
PROJ. NO: 923-1000.147
DATE: 4-21-95
TECH: MSB
REVIEWER: DPO

SAMPLE ID	BUCKET

COMPACTION METHOD	ASTM D 698-C

UNCORRECTED PROCTOR VALUES	
DRY DENSITY (pcf)	100.1
WATER CONTENT (%)	18.6

CORRECTED PROCTOR VALUES	
DRY DENSITY (pcf)	103.4
WATER CONTENT (%)	17.1

OVERSIZE FRACTION DATA	
PERCENT OF TOTAL SAMPLE (%)	8.9
WATER CONTENT (assumed) (%)	2.0
SPECIFIC GRAVITY (assumed)	2.50

APPENDIX K

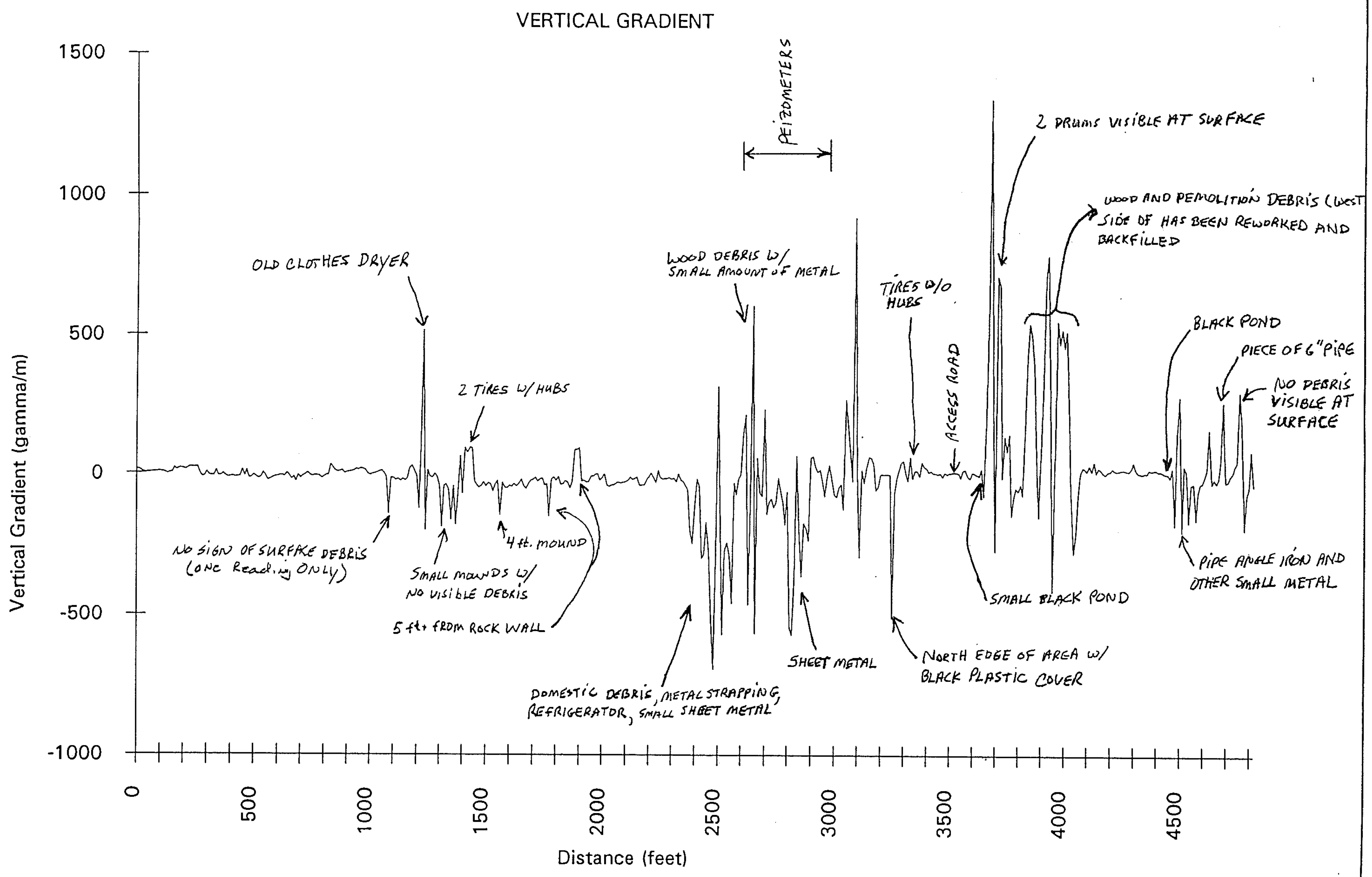
GEOPHYSICAL DATA

February 1, 1996

923-1000.R147
0108rdl1.apk

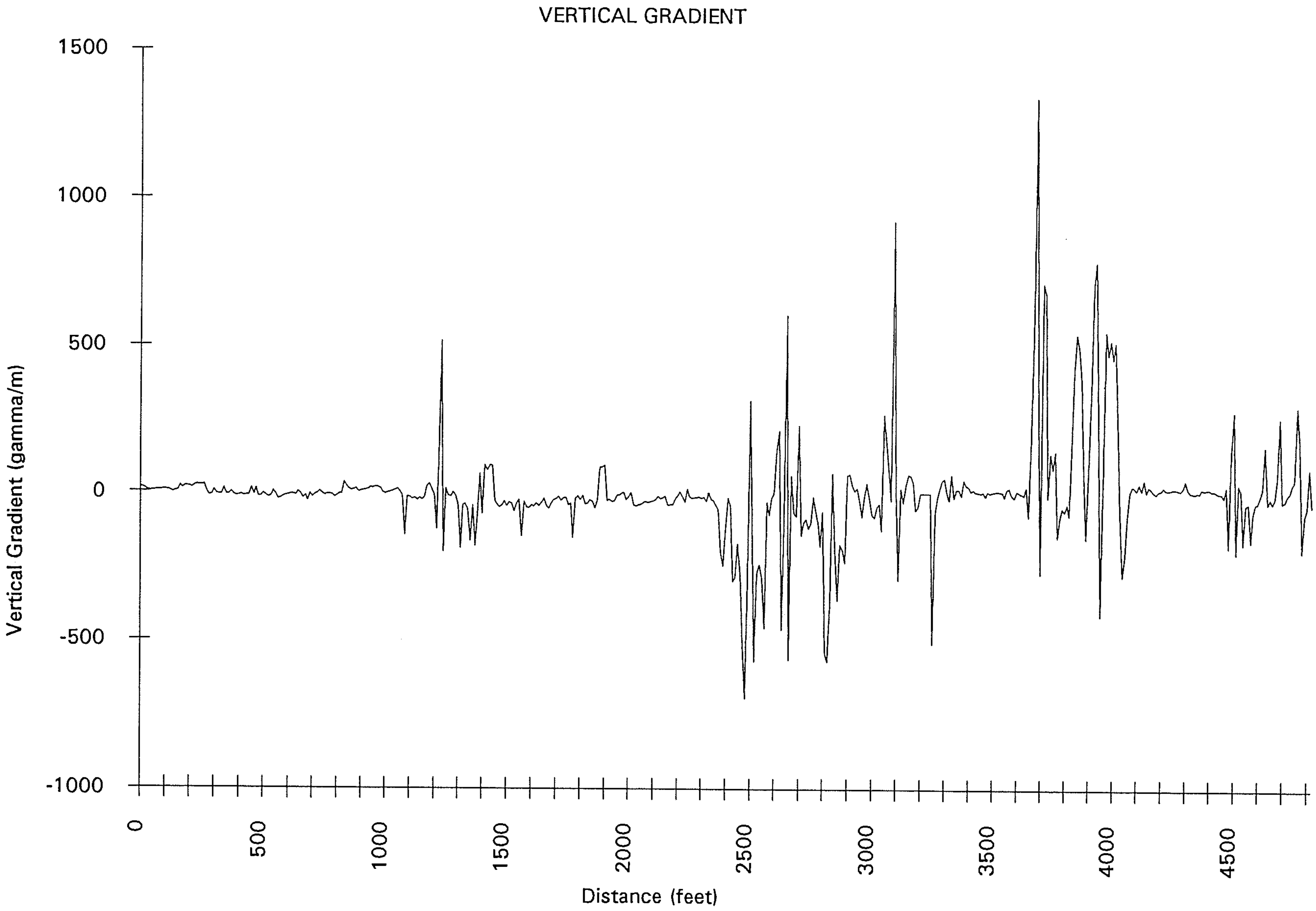
TABLE OF CONTENTS

Magnetometry Data Profiles
Rogers Seam



PROJECT NO. DWG. NO. DATE DRAWN APPROVED

Golder Associates



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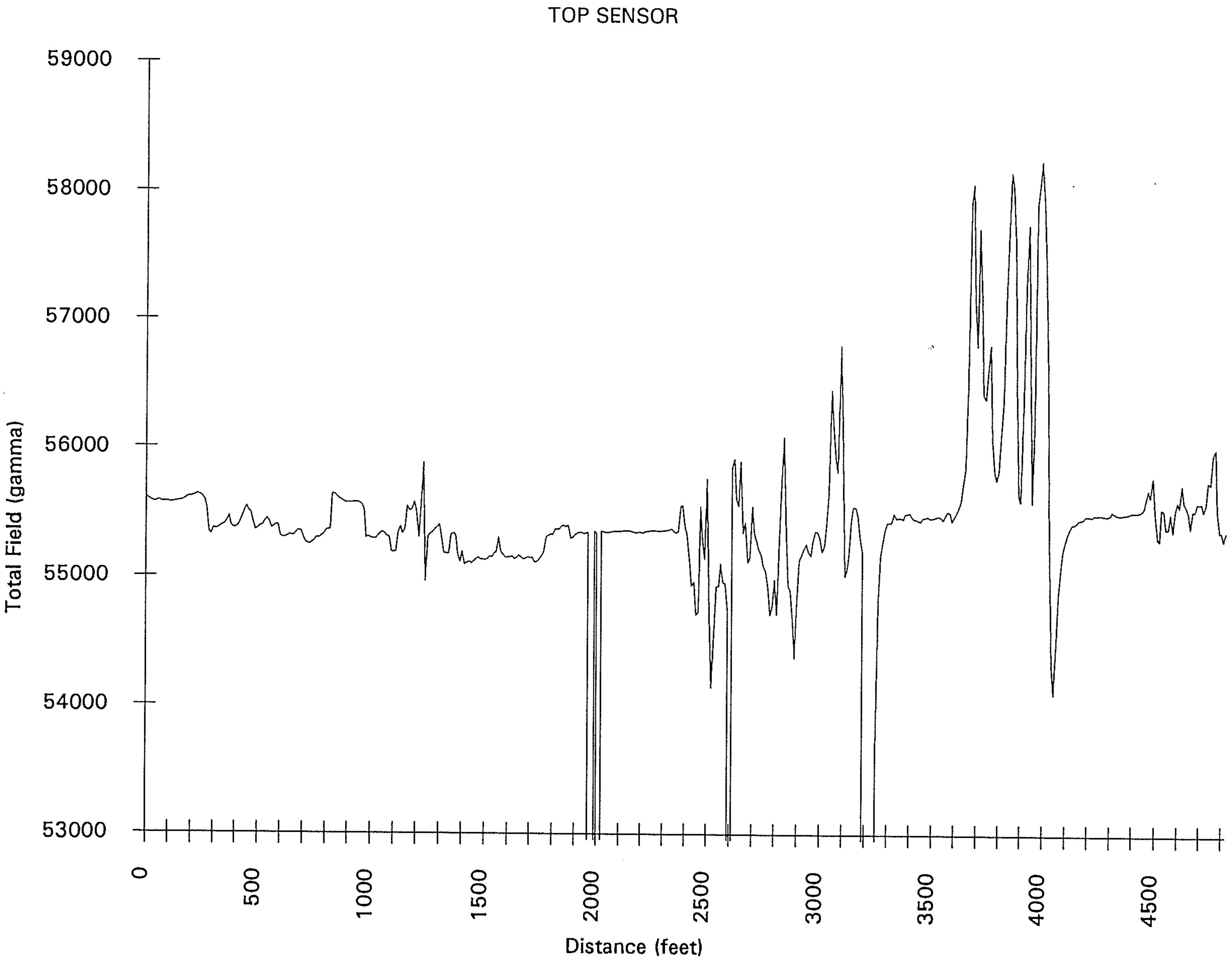
Golder Associates



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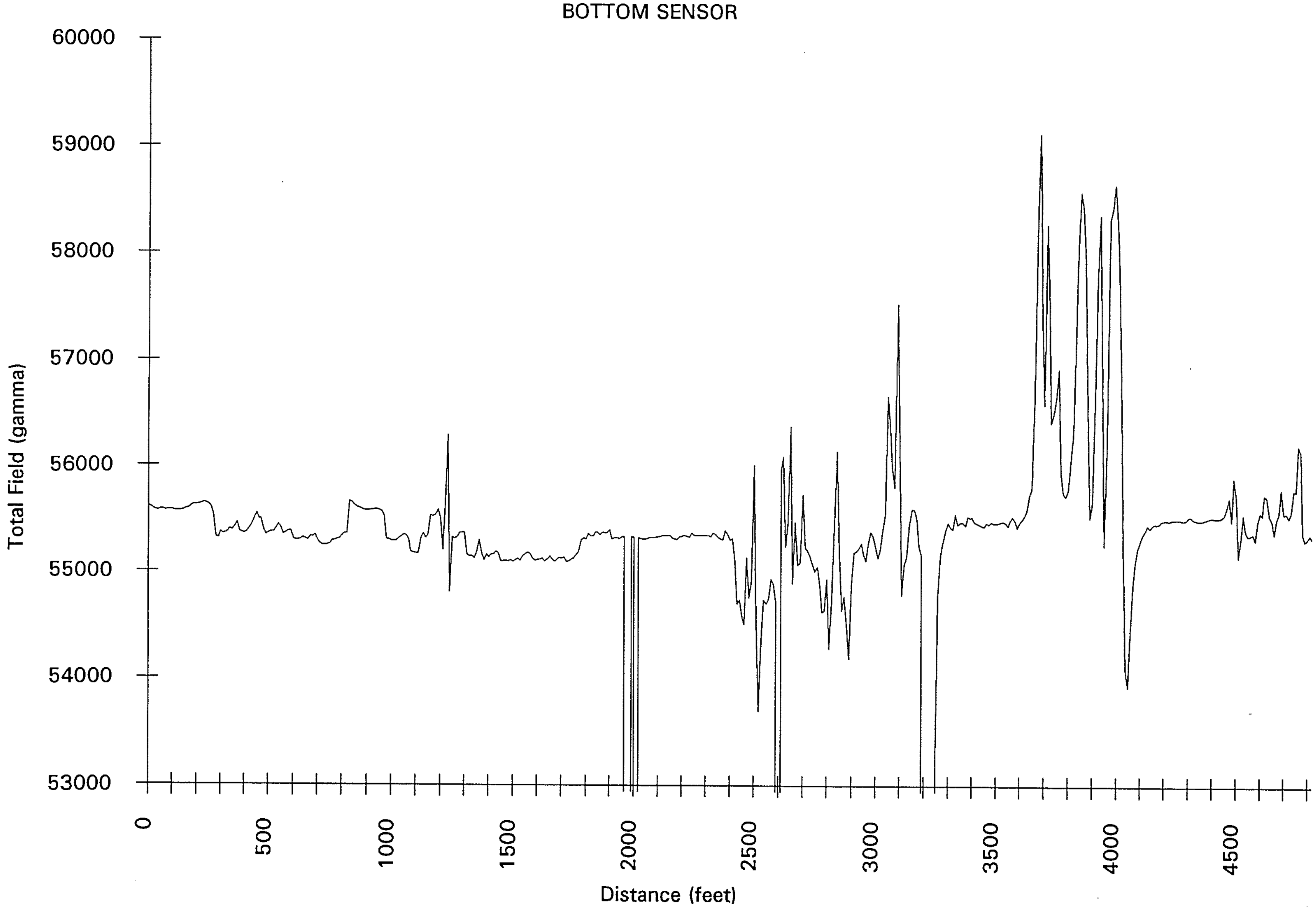
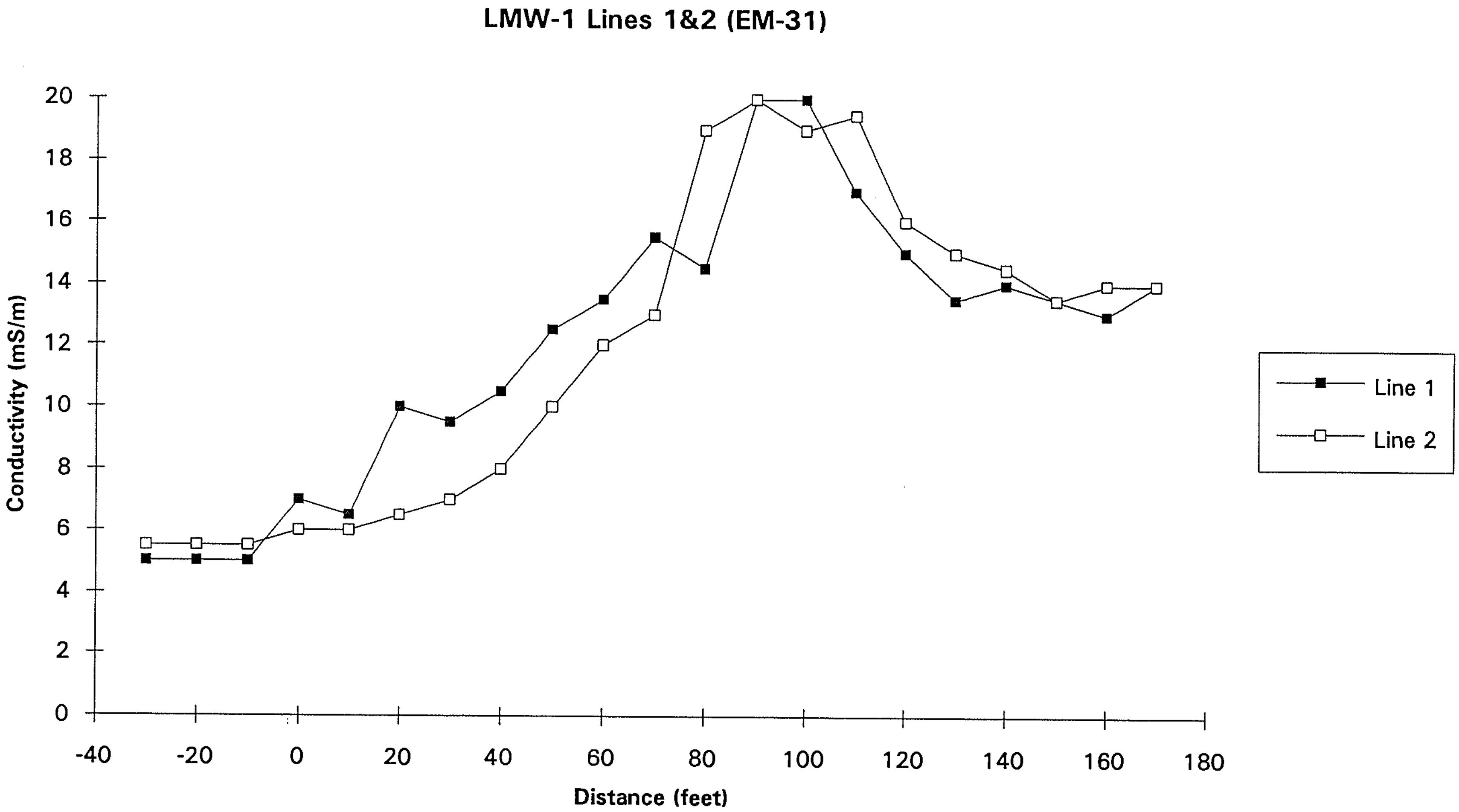
Golder Associates

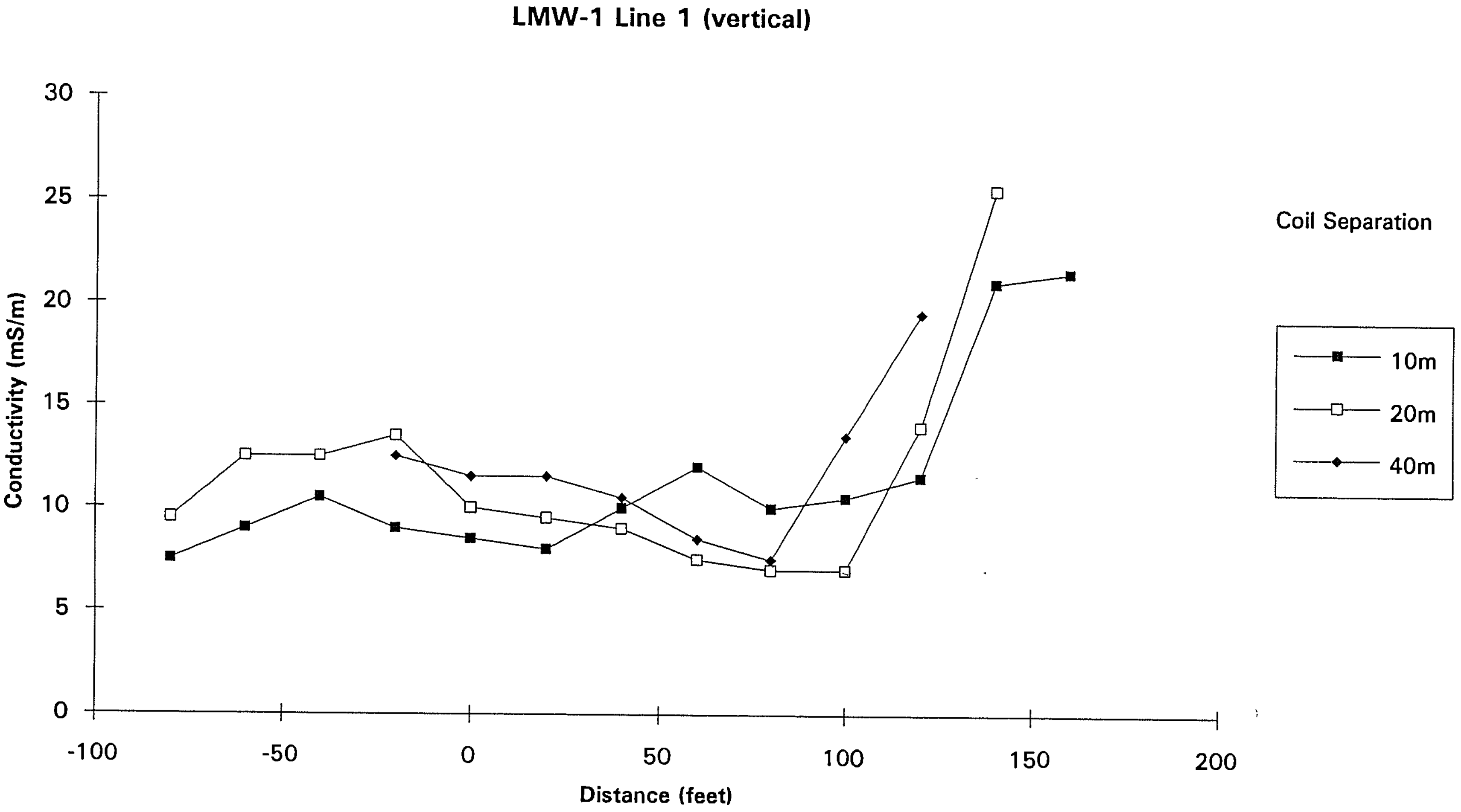


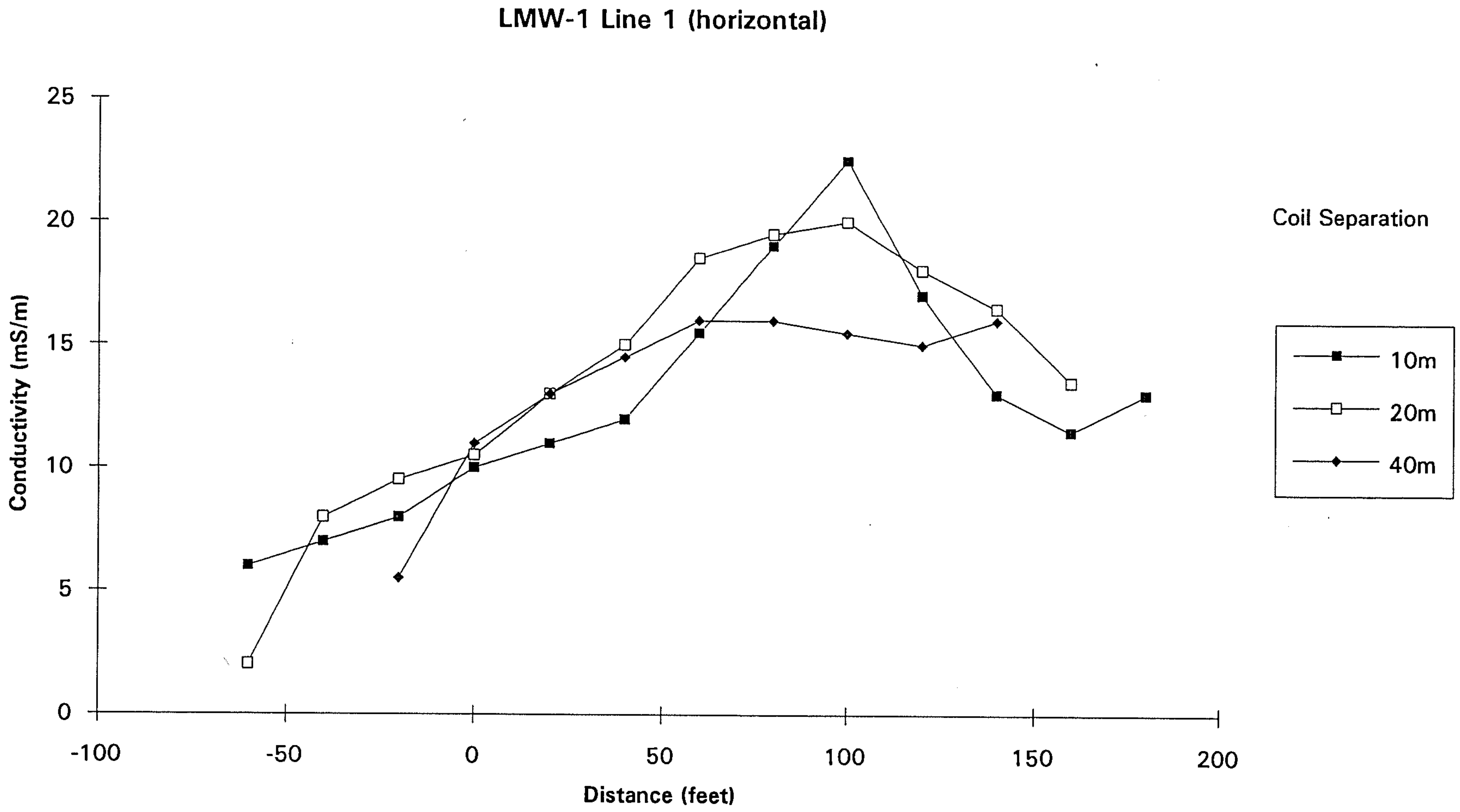
PROJECT NO. DWG. NO. DATE DRAWN APPROVED

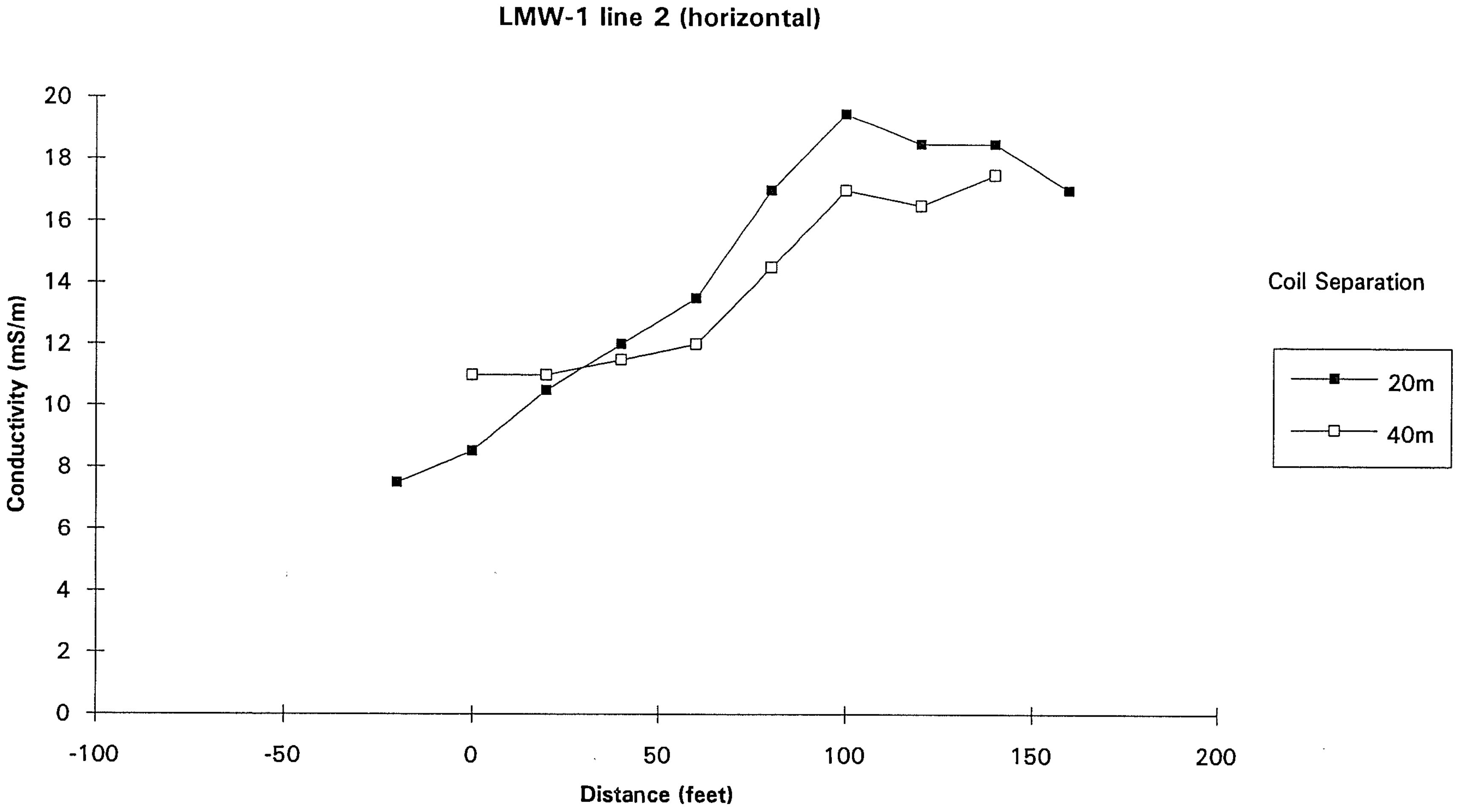
Golder Associates

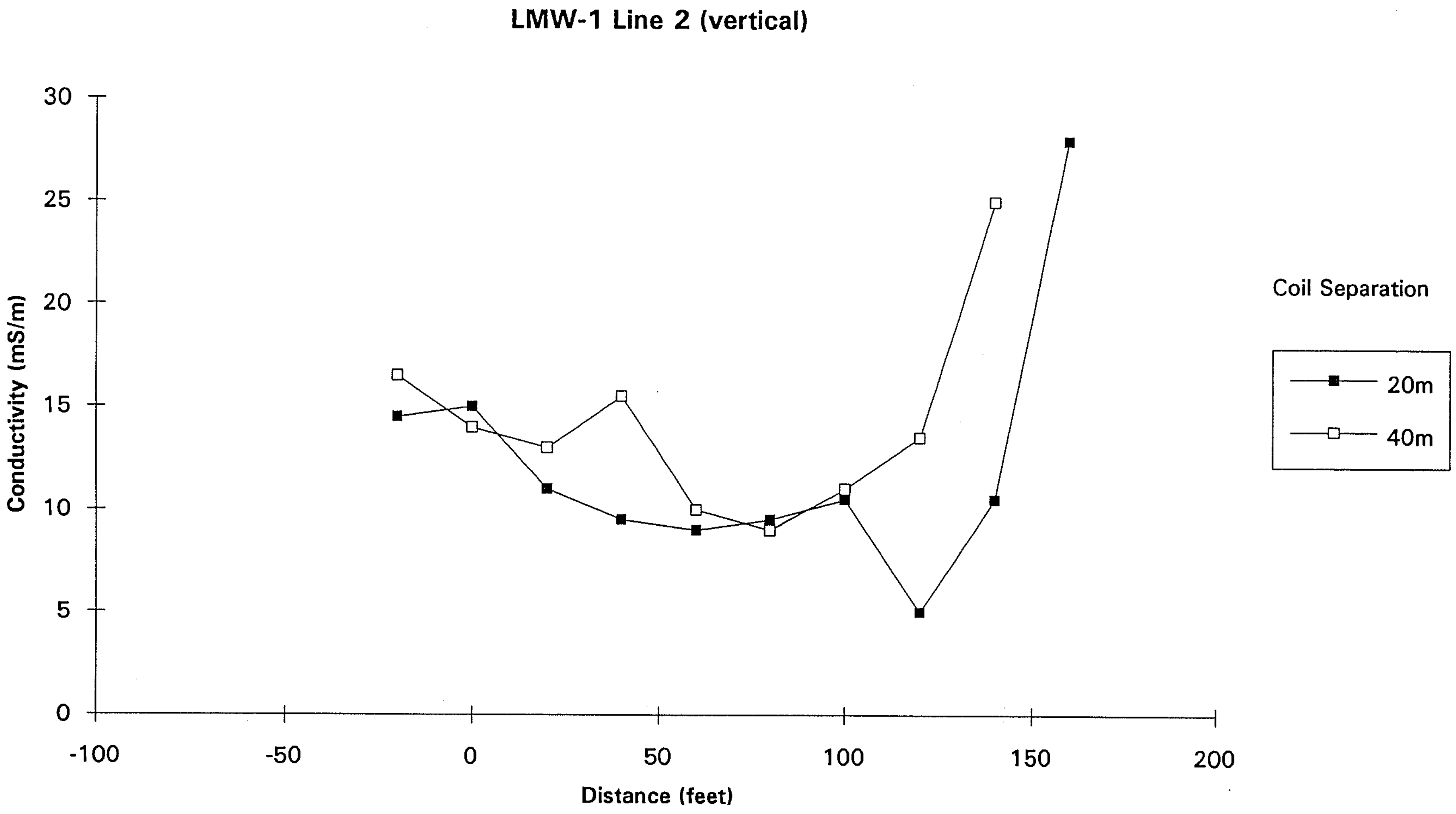
EM-31 and EM-34 Conductivity Profiles

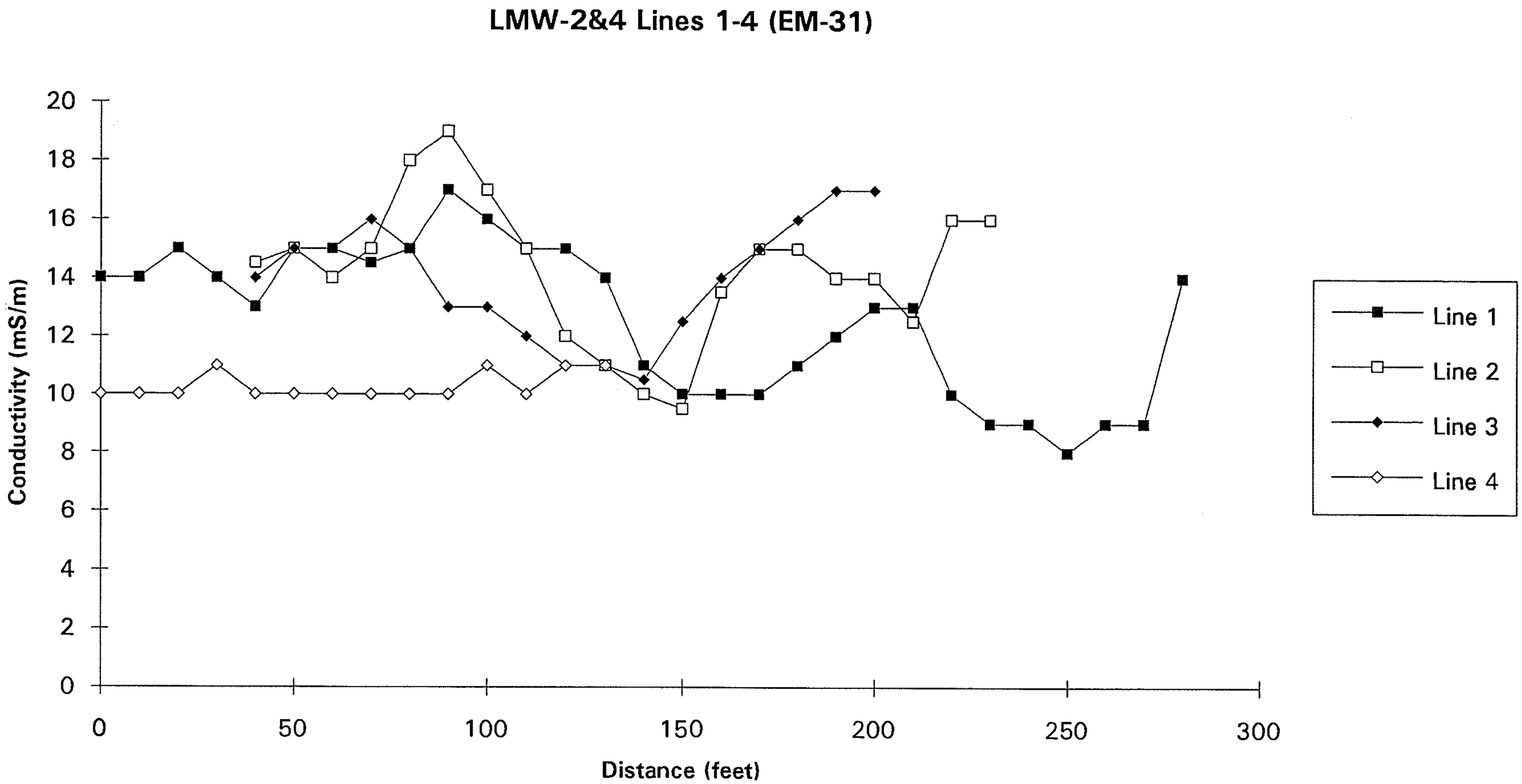

LMW-1 Lines 1&2 (EM-31)
Conductivity (mS/m)
20
18
16
14
12
10
8
6
4
2
0
-40
-20
0
20
40
60
80
100
120
140
160
180
Distance (feet)
Line 1
Line 2

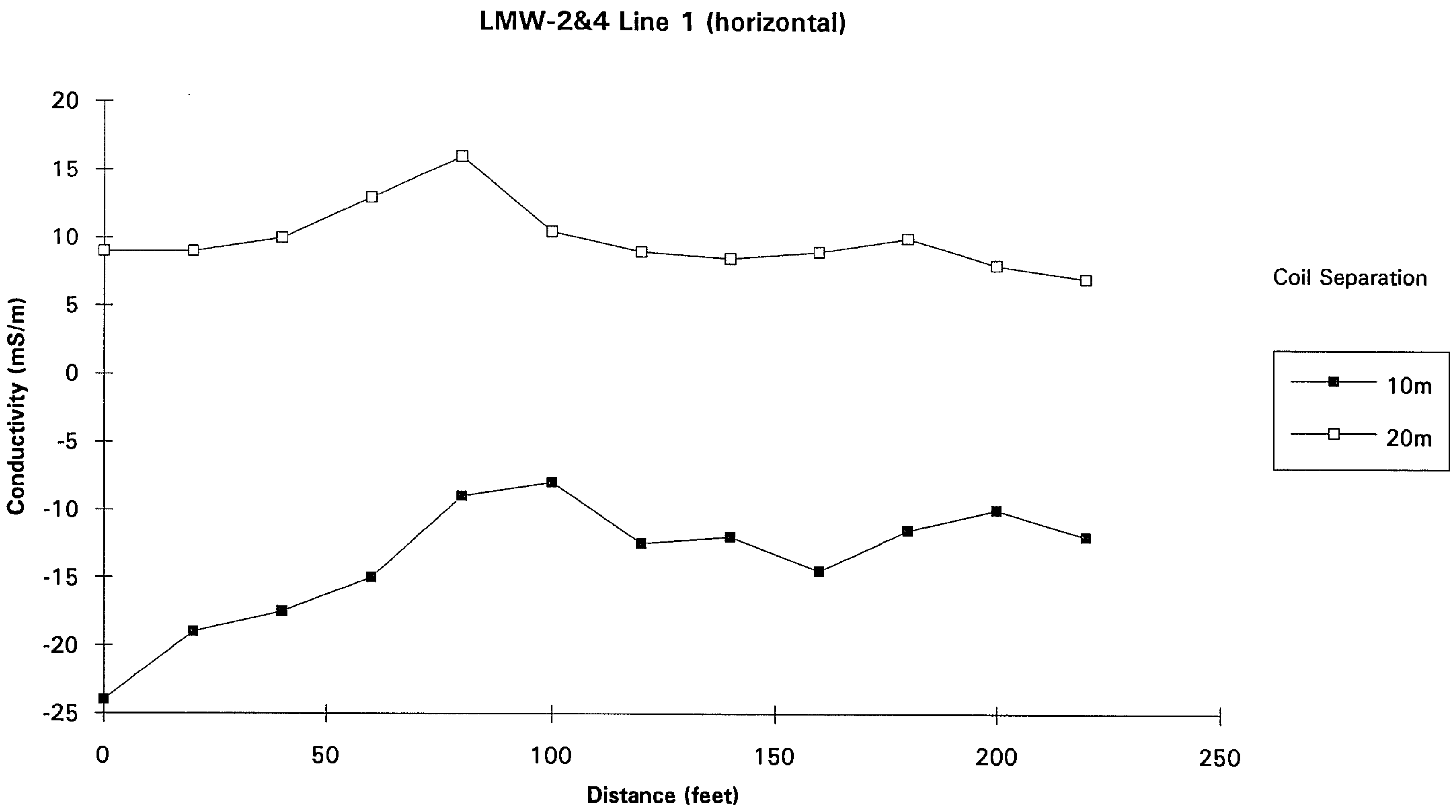

LMW-1 Line 1 (vertical)
Conductivity (mS/m)
30
25
20
15
10
5
0
-100
-50
0
50
100
150
200
Distance (feet)
Coil Separation
10m
20m
40m

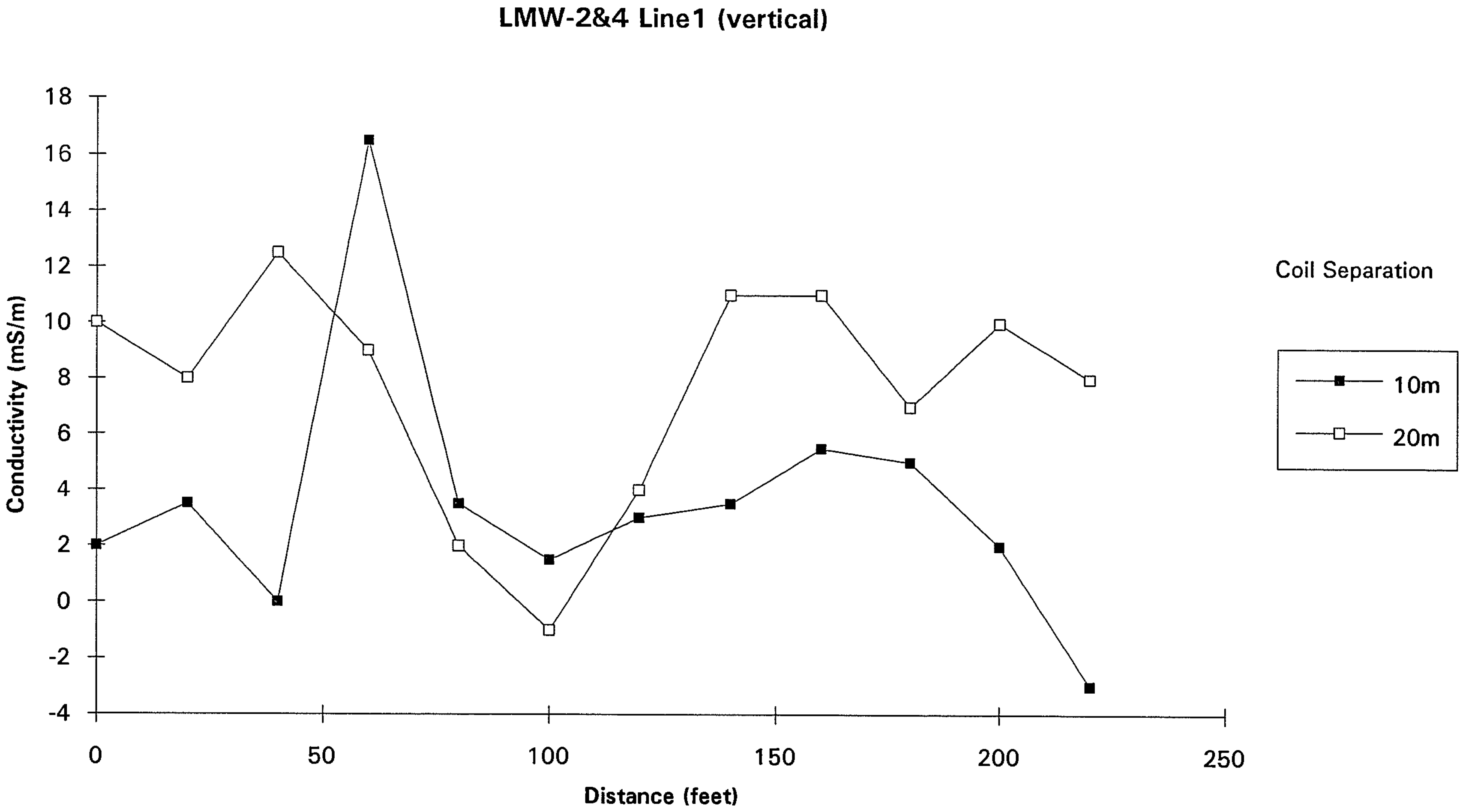

LMW-1 Line 1 (horizontal)
Conductivity (mS/m)
25
20
15
10
5
0
-100
-50
0
50
100
150
200
Distance (feet)
Coil Separation
10m
20m
40m


LMW-1 line 2 (horizontal)
Conductivity (mS/m)
20
18
16
14
12
10
8
6
4
2
0
-100
-50
0
50
100
150
200
Distance (feet)
Coil Separation
20m
40m

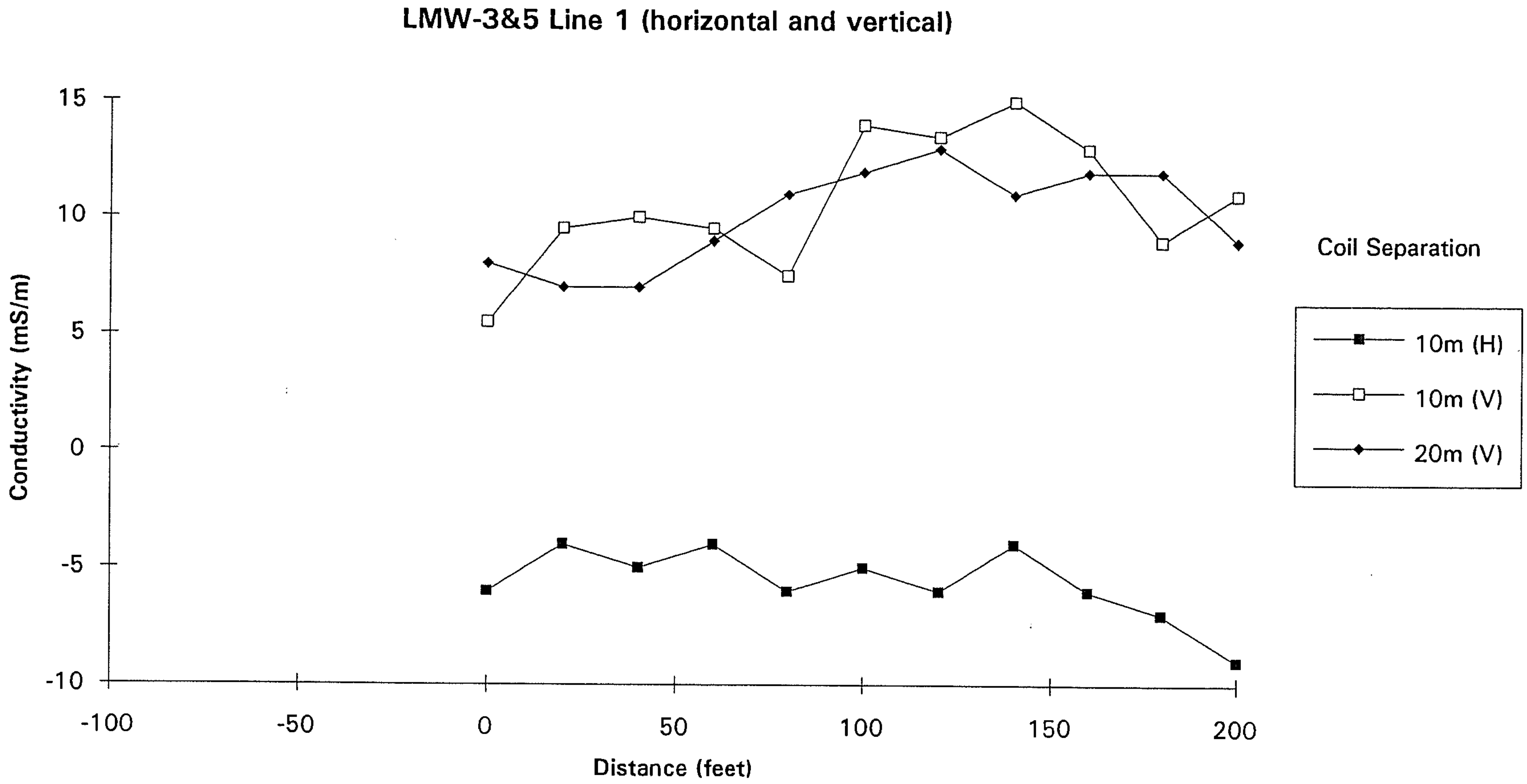

LMW-1 Line 2 (vertical)
Conductivity (mS/m)
30
25
20
15
10
5
0
-100
-50
0
50
100
150
200
Distance (feet)
Coil Separation
20m
40m

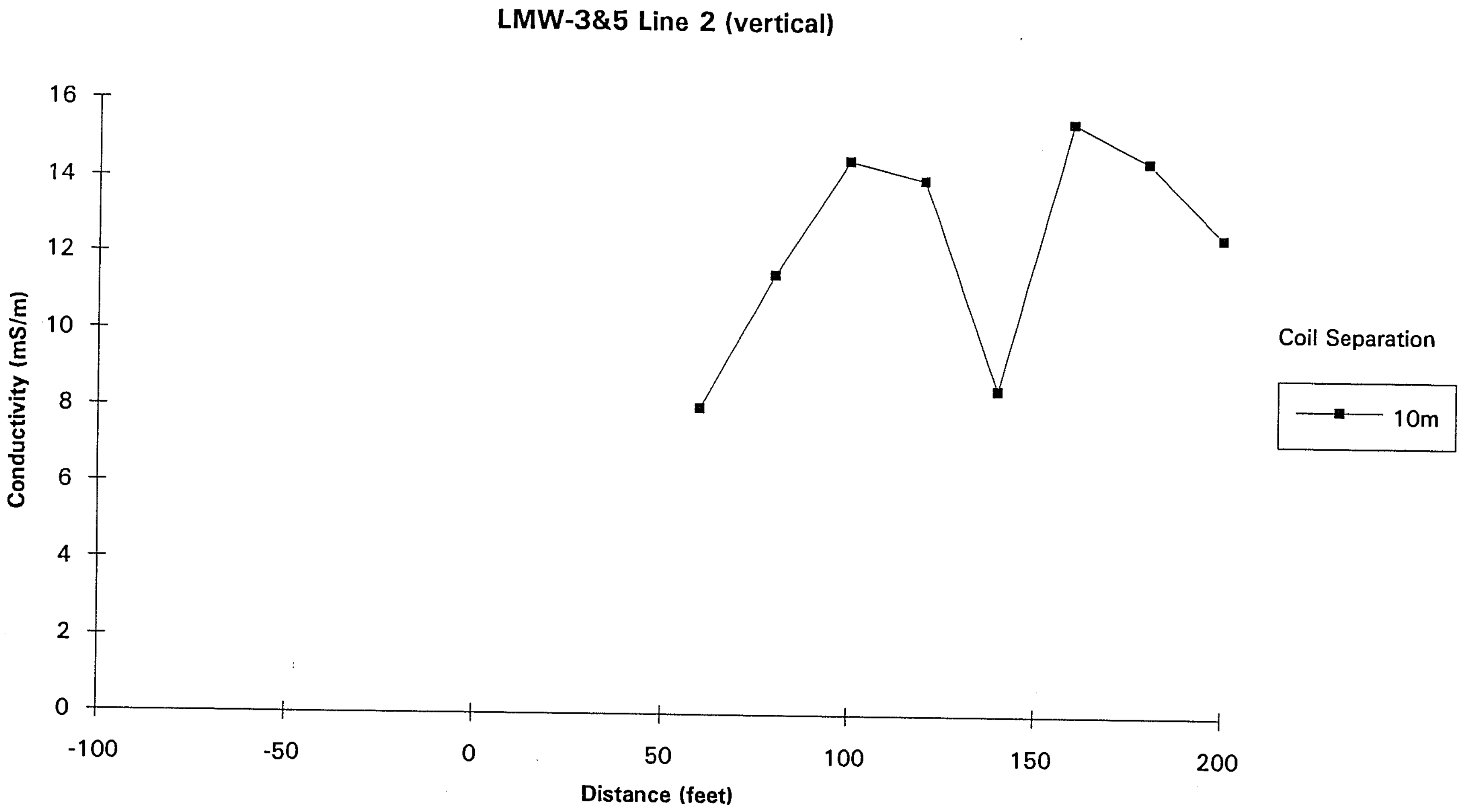

LMW-2&4 Lines 1-4 (EM-31)
Conductivity (mS/m)
20
18
16
14
12
10
8
6
4
2
0
0
50
100
150
200
250
300
Distance (feet)
Line 1
Line 2
Line 3
Line 4

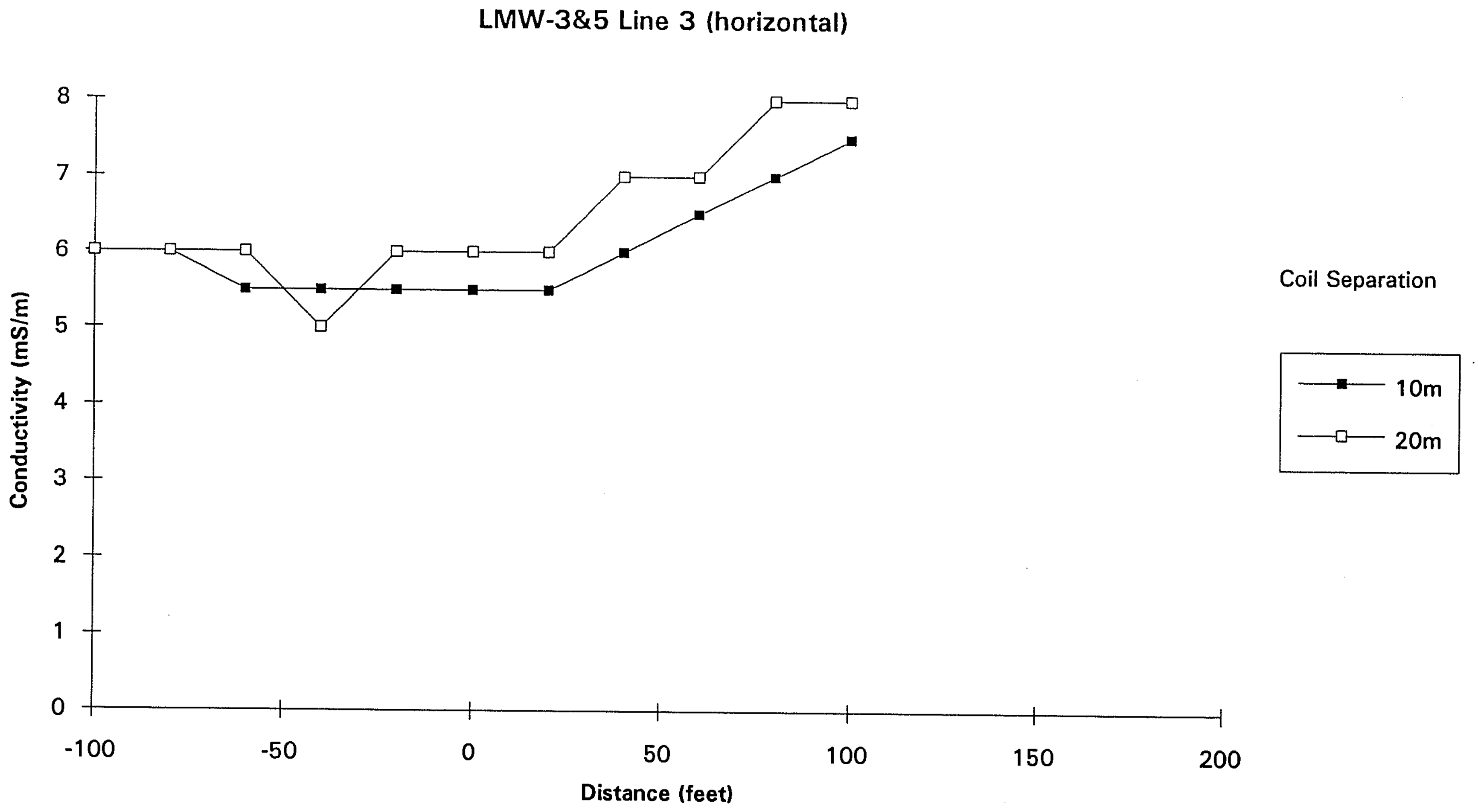

LMW-2&4 Line 1 (horizontal)
Conductivity (mS/m)
20
15
10
5
0
-5
-10
-15
-20
-25
0
50
100
150
200
250
Distance (feet)
Coil Separation
10m
20m

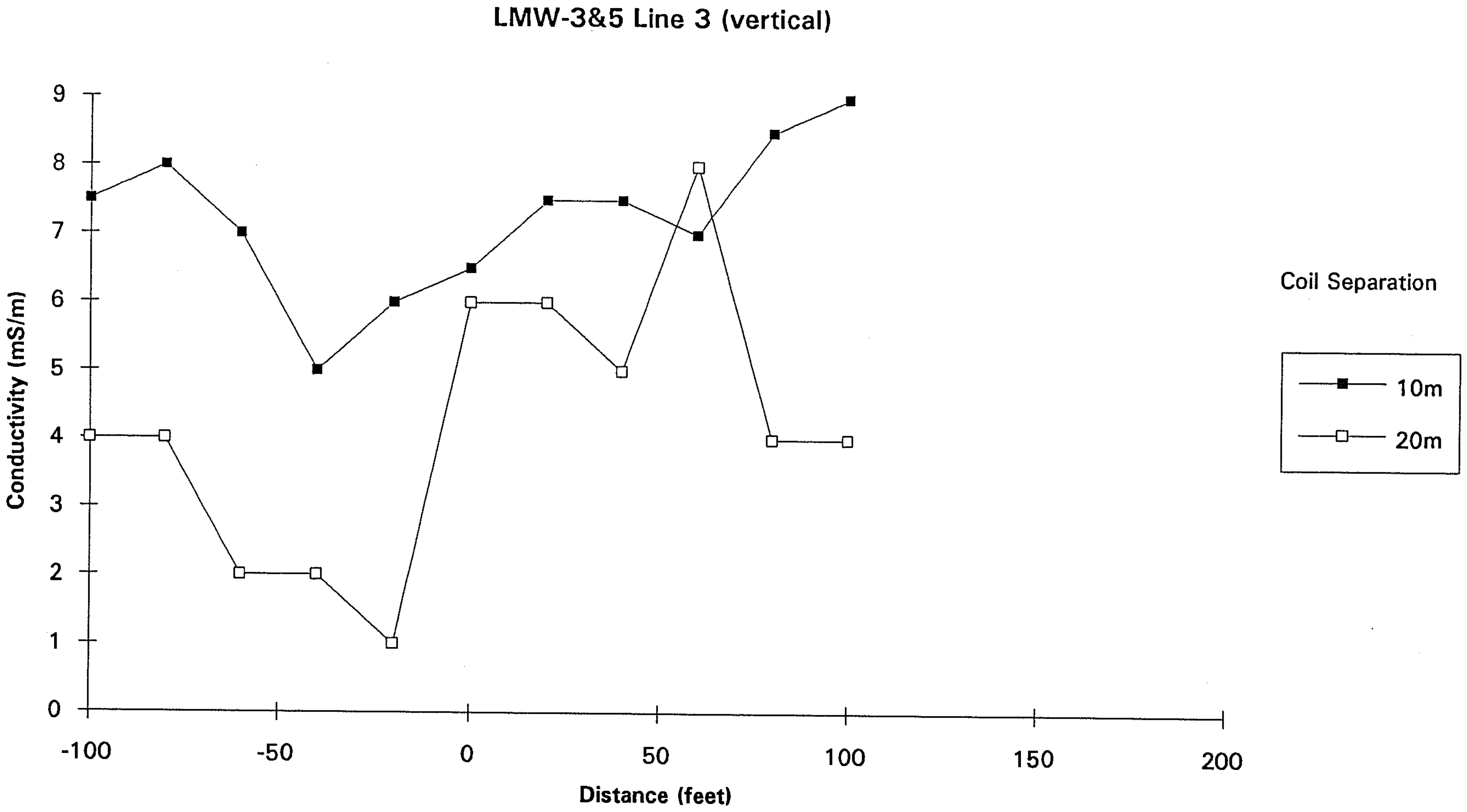

LMW-2&4 Line1 (vertical)
Conductivity (mS/m)
18
16
14
12
10
8
6
4
2
0
-2
-4
0
50
100
150
200
250
Distance (feet)
Coil Separation
10m
20m

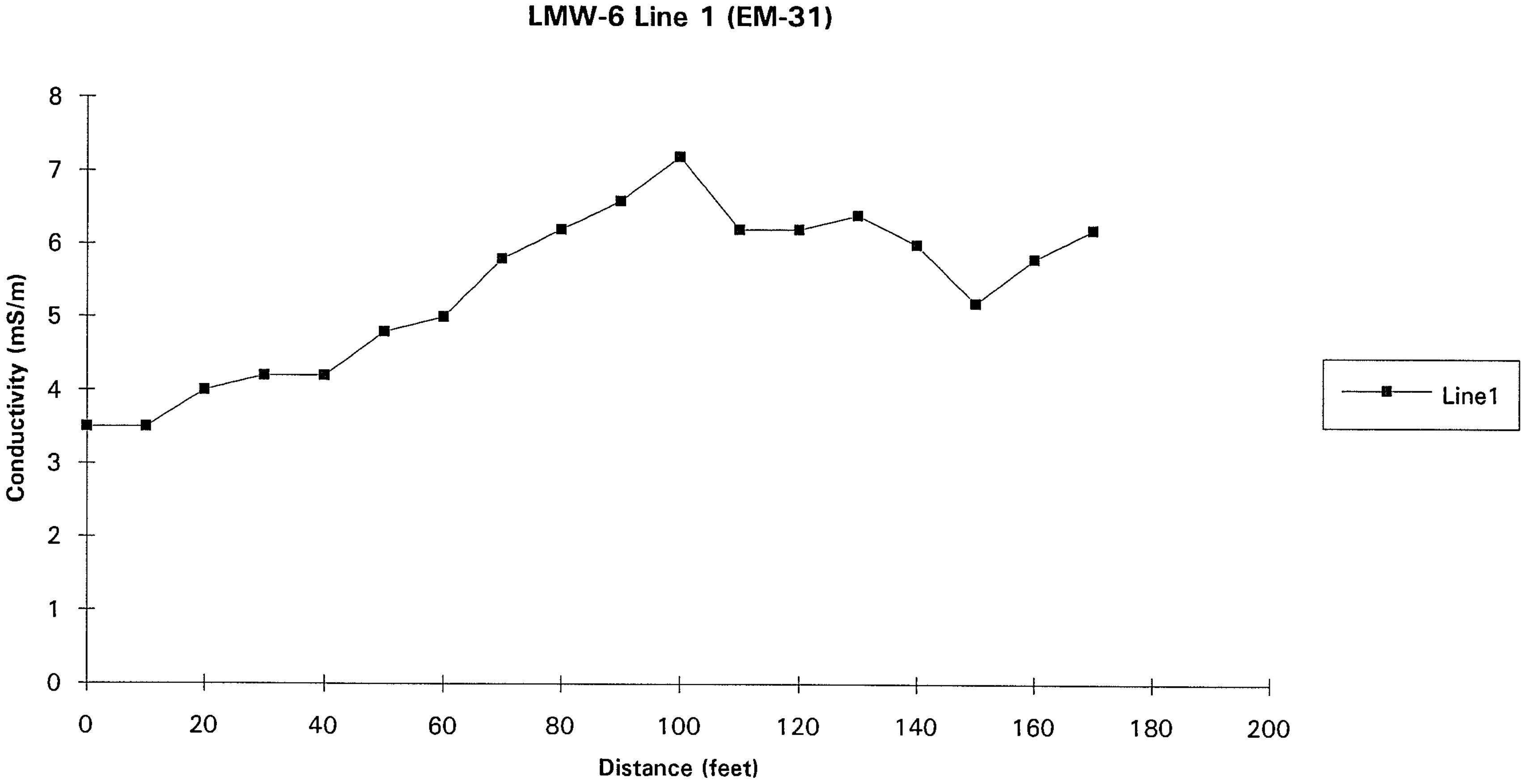
MW35L1HV.XLC

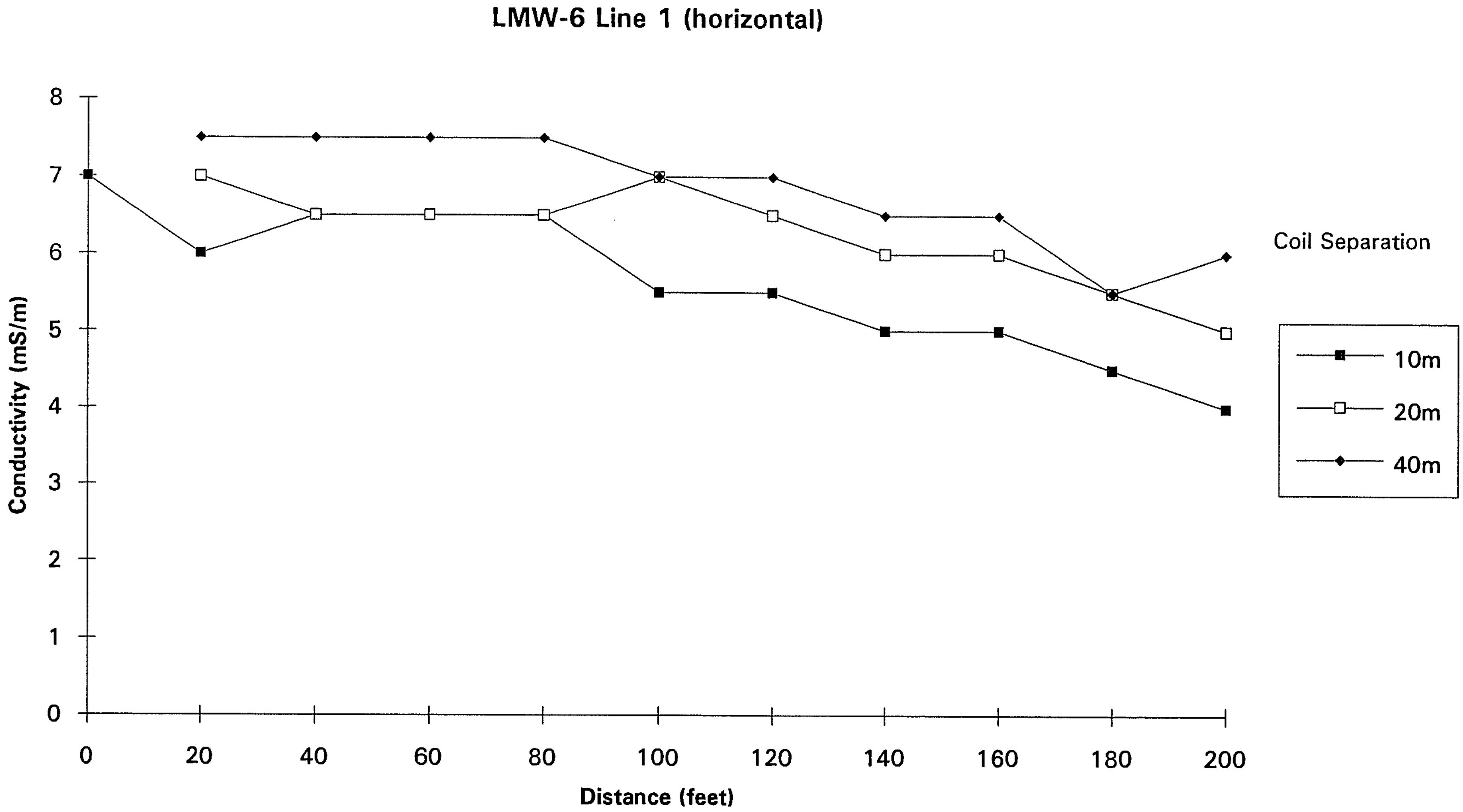


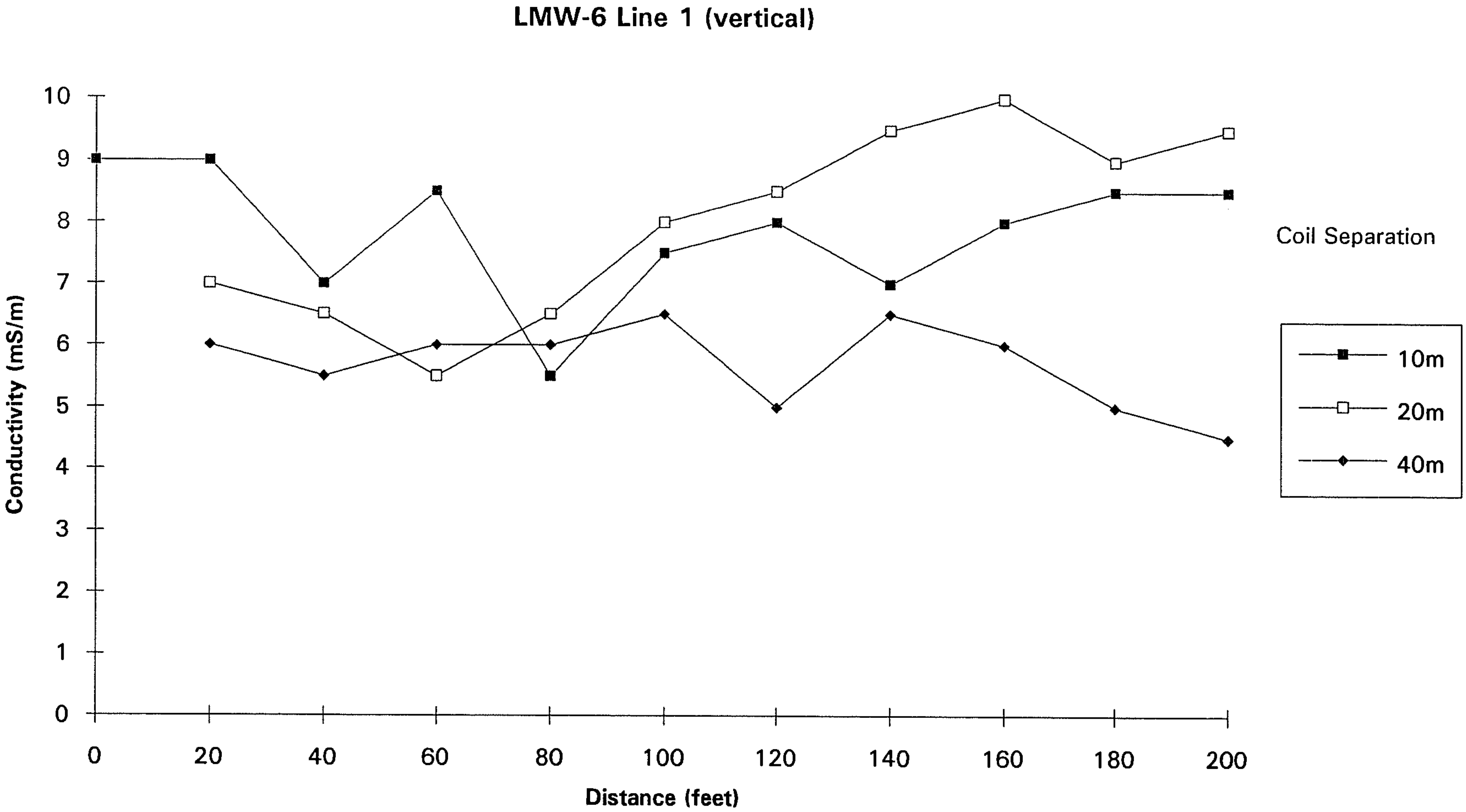

LMW-3&5 Line 2 (vertical)
Conductivity (mS/m)
16
14
12
10
8
6
4
2
0
-100
-50
0
50
100
150
200
Distance (feet)
Coil Separation
10m

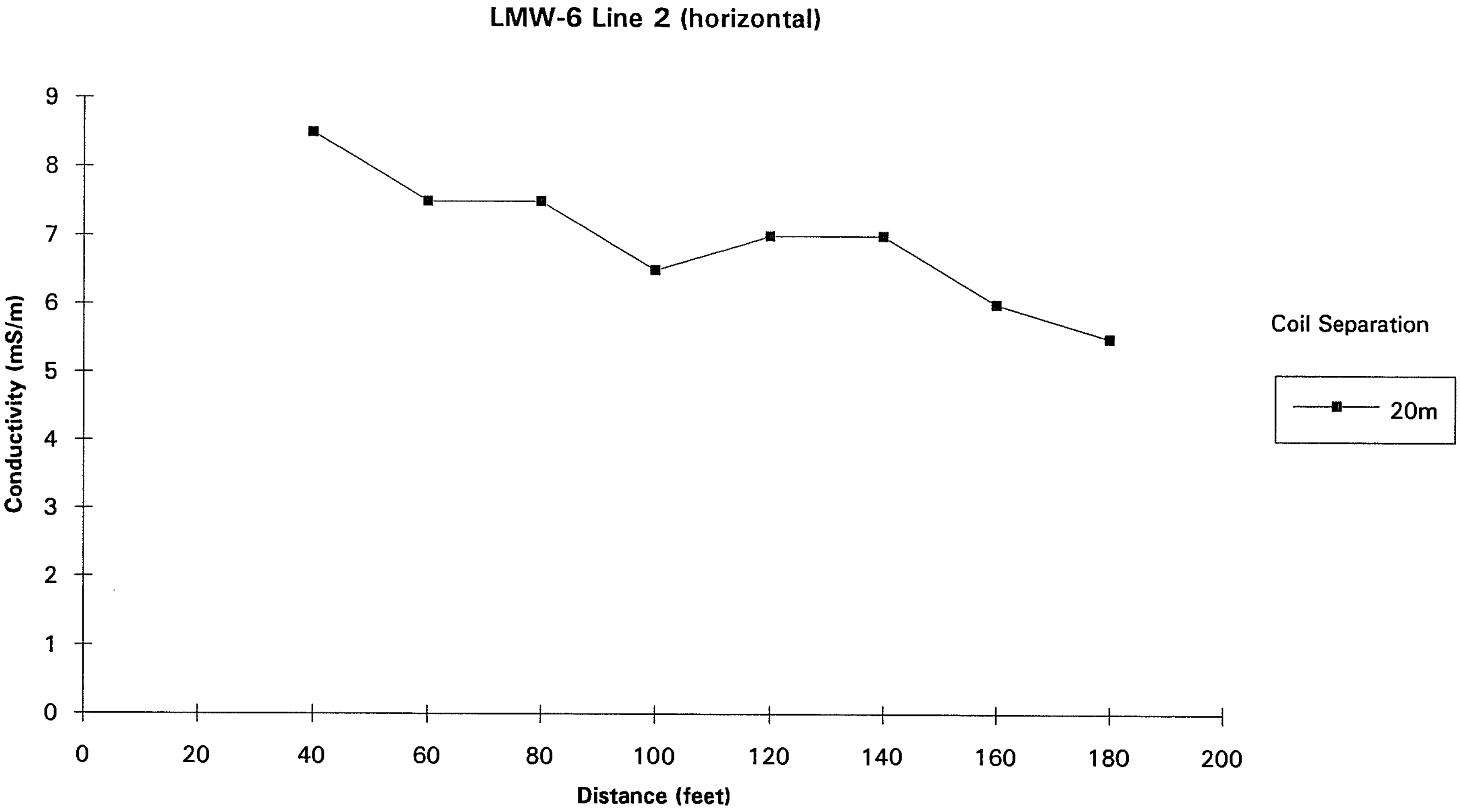

LMW-3&5 Line 3 (horizontal)
Conductivity (mS/m)
8
7
6
5
4
3
2
1
0
-100
-50
0
50
100
150
200
Distance (feet)
Coil Separation
10m
20m

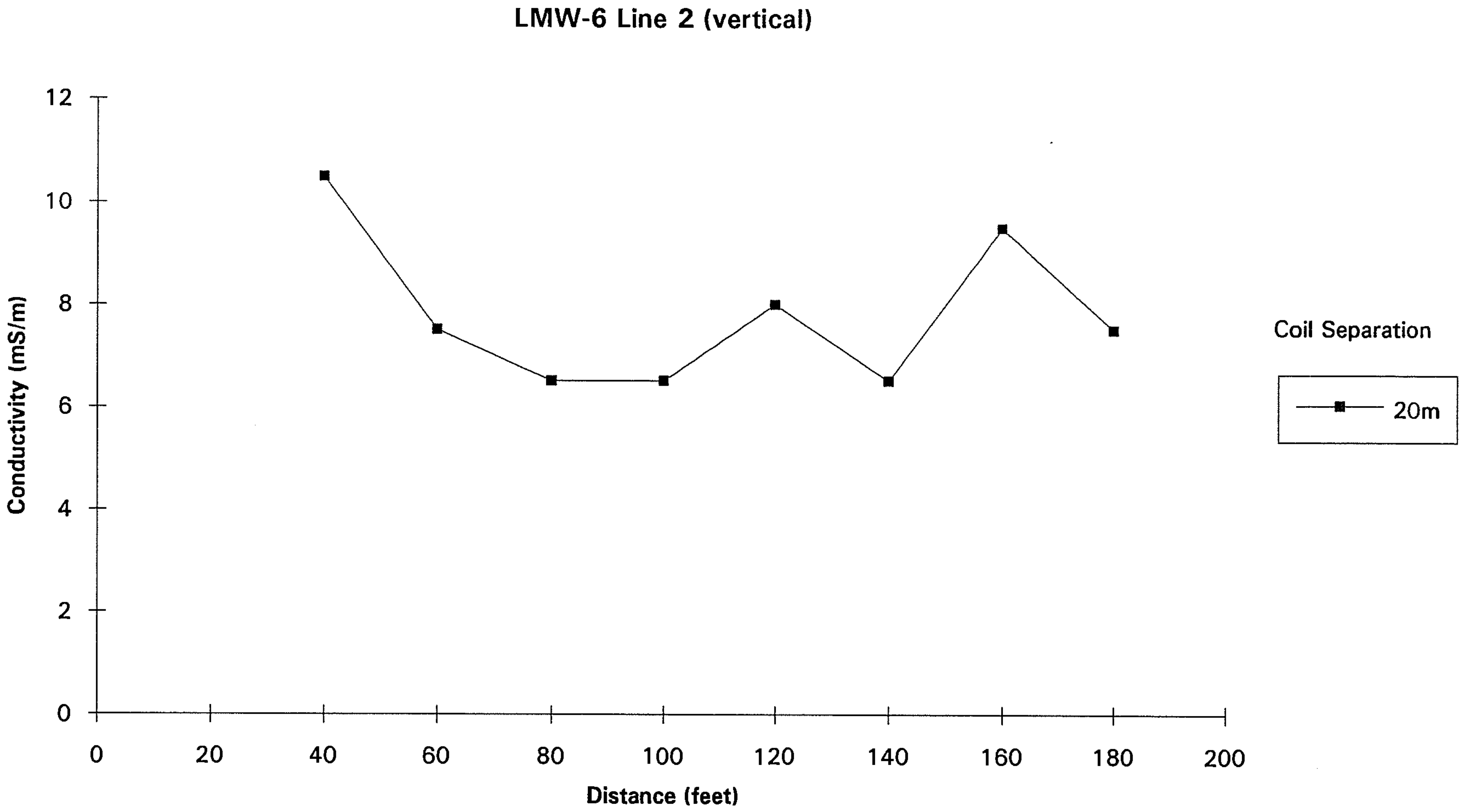

LMW-3&5 Line 3 (vertical)
Conductivity (mS/m)
9
8
7
6
5
4
3
2
1
0
-100
-50
0
50
100
150
200
Distance (feet)
Coil Separation
10m
20m

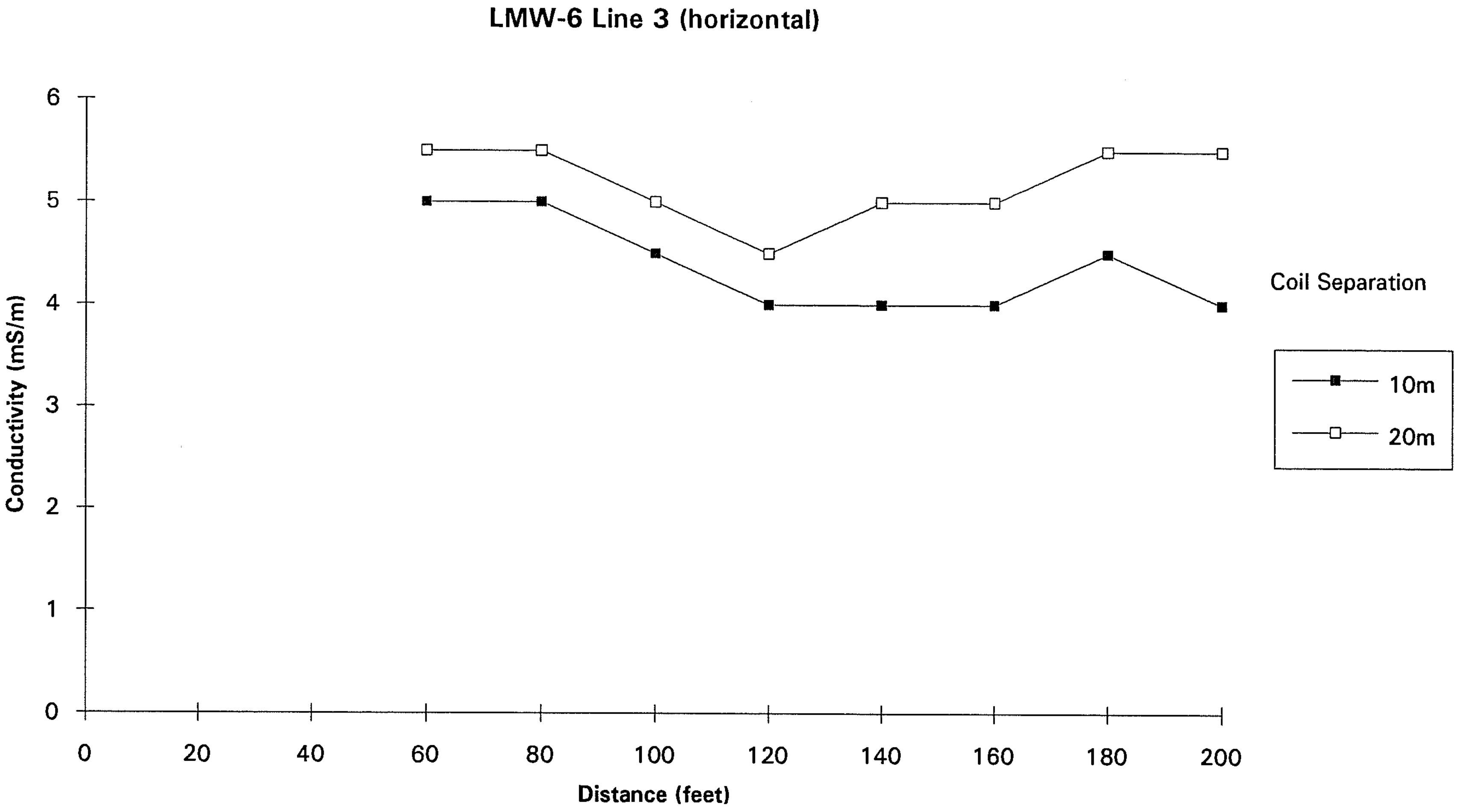

LMW-6 Line 1 (EM-31)
Conductivity (mS/m)
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
Distance (feet)
Line1

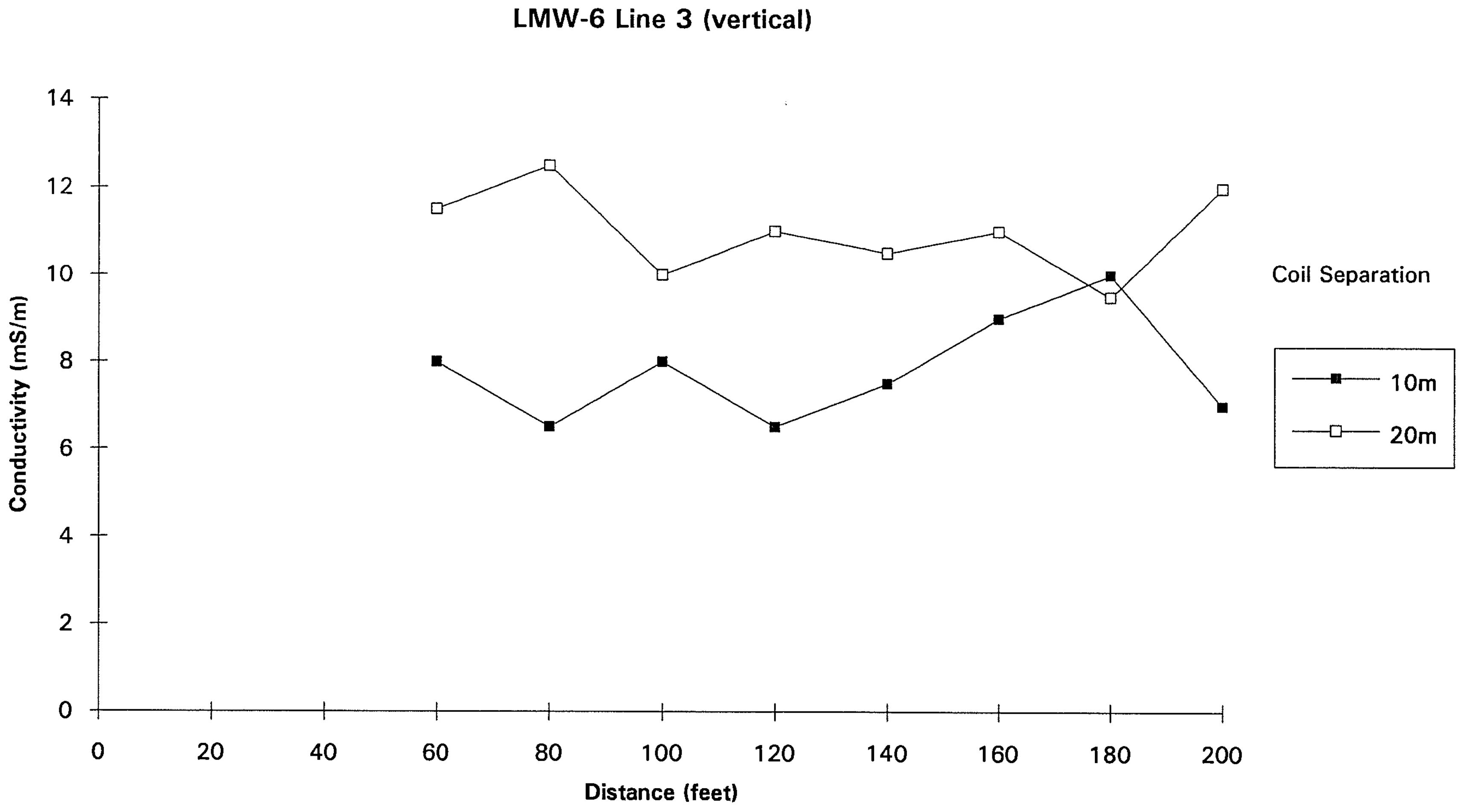

LMW-6 Line 1 (horizontal)
Conductivity (mS/m)
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
Distance (feet)
Coil Separation
10m
20m
40m


LMW-6 Line 1 (vertical)
Conductivity (mS/m)
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
Distance (feet)
Coil Separation
10m
20m
40m

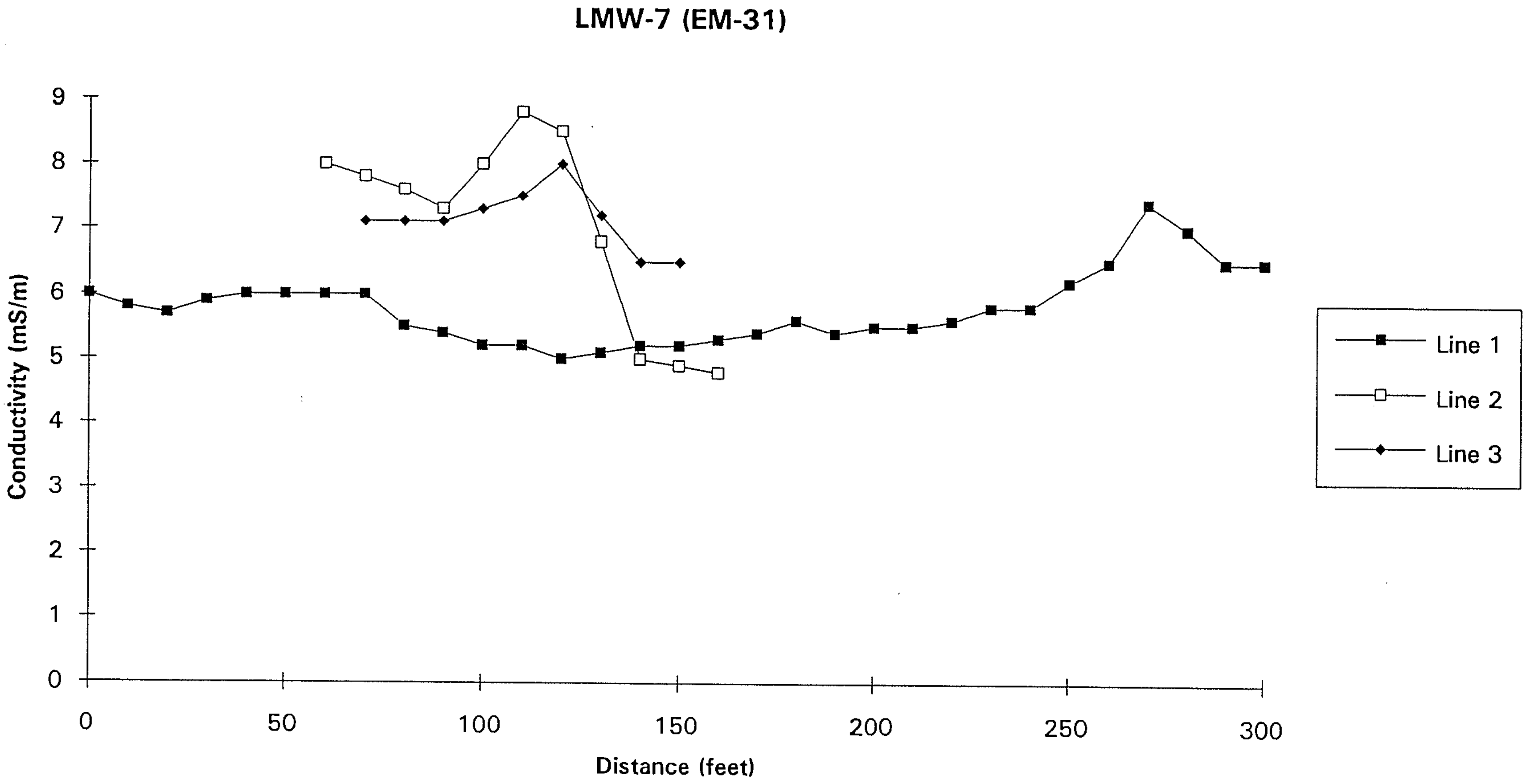

LMW-6 Line 2 (horizontal)
Conductivity (mS/m)
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
Distance (feet)
Coil Separation
20m

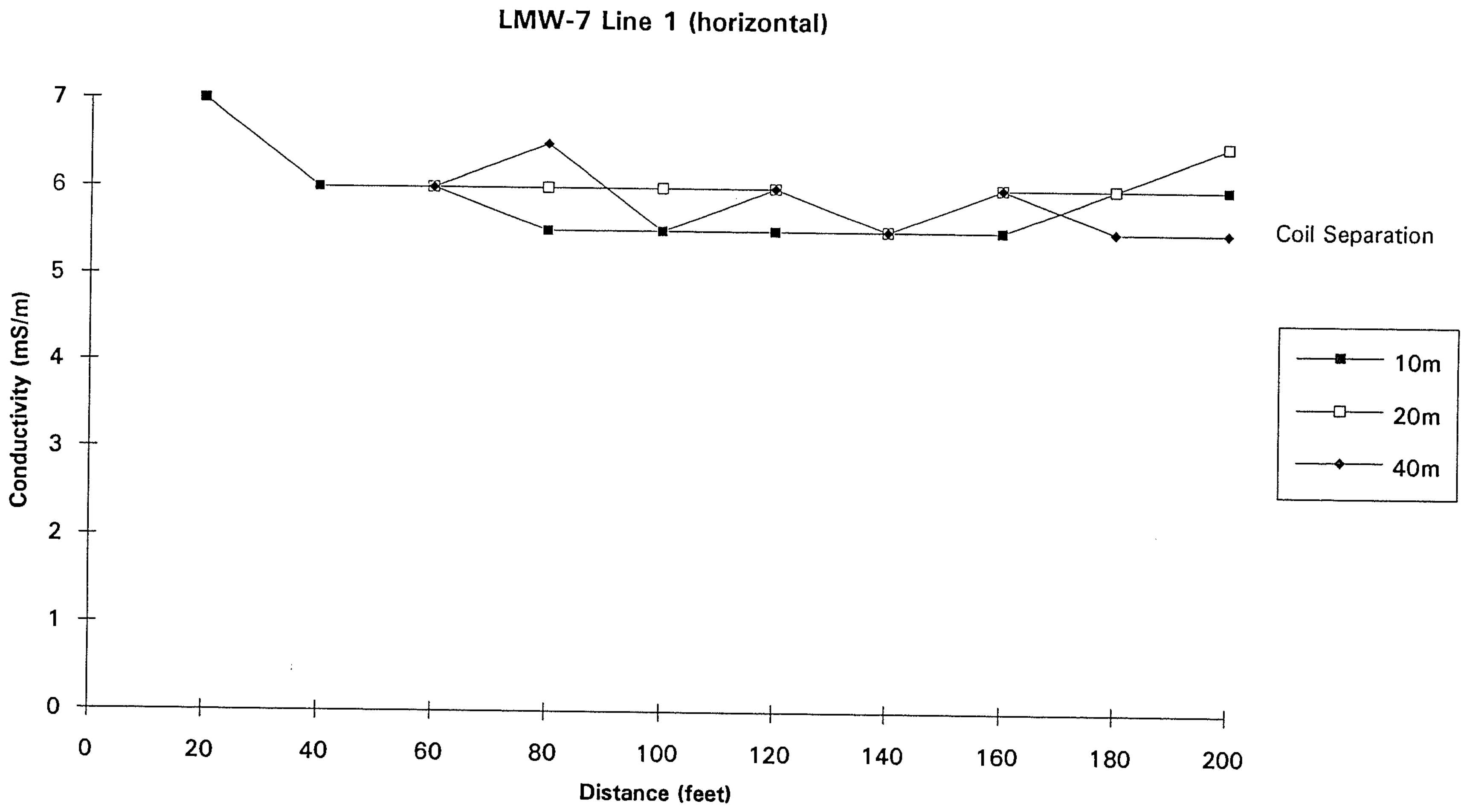

LMW-6 Line 2 (vertical)
Conductivity (mS/m)
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
180
200
Distance (feet)
Coil Separation
20m

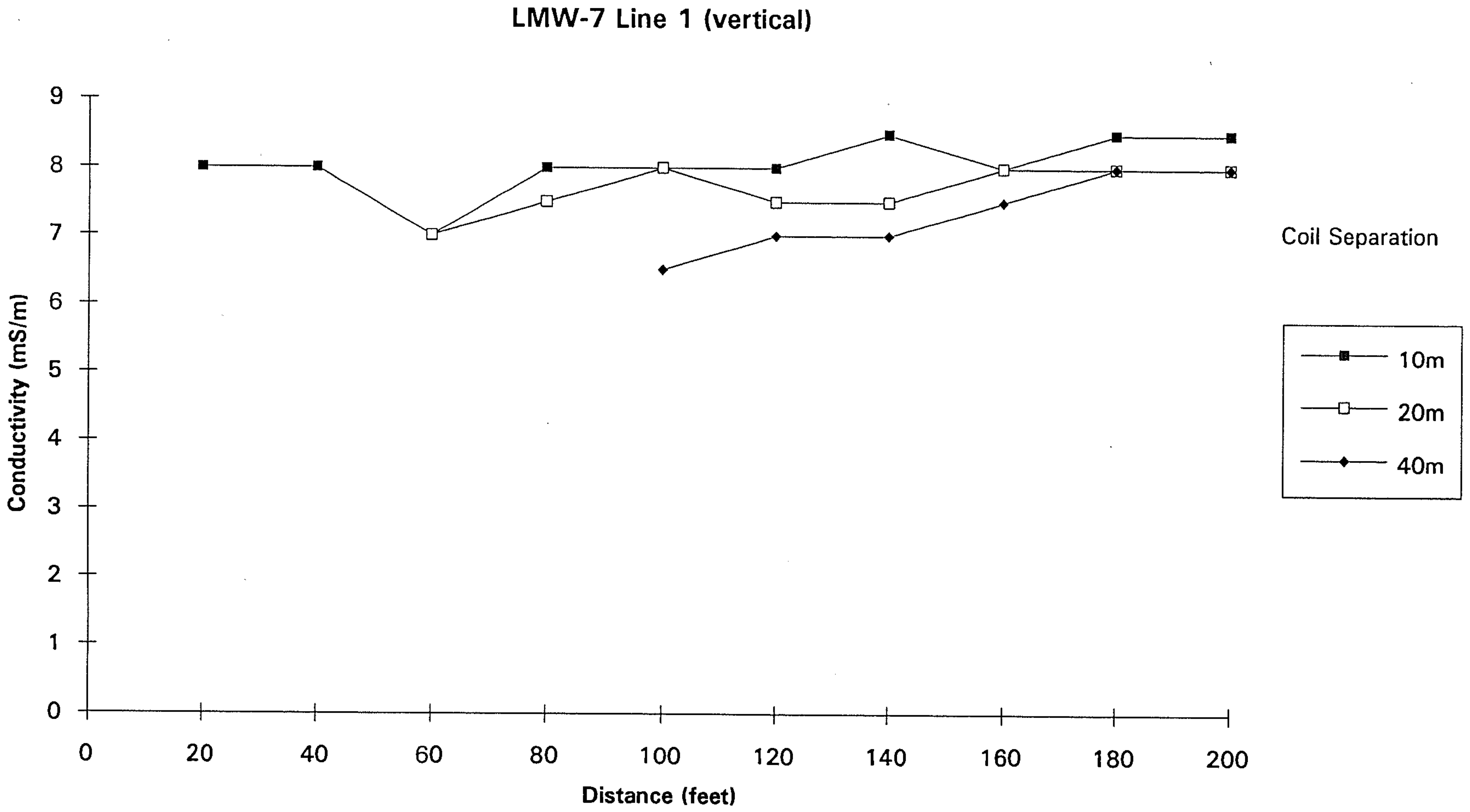

LMW-6 Line 3 (horizontal)
Conductivity (mS/m)
0
1
2
3
4
5
6
Distance (feet)
0
20
40
60
80
100
120
140
160
180
200
Coil Separation
10m
20m


LMW-6 Line 3 (vertical)
Conductivity (mS/m)
14
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
180
200
Distance (feet)
Coil Separation
10m
20m

MW7L13EM.XLC



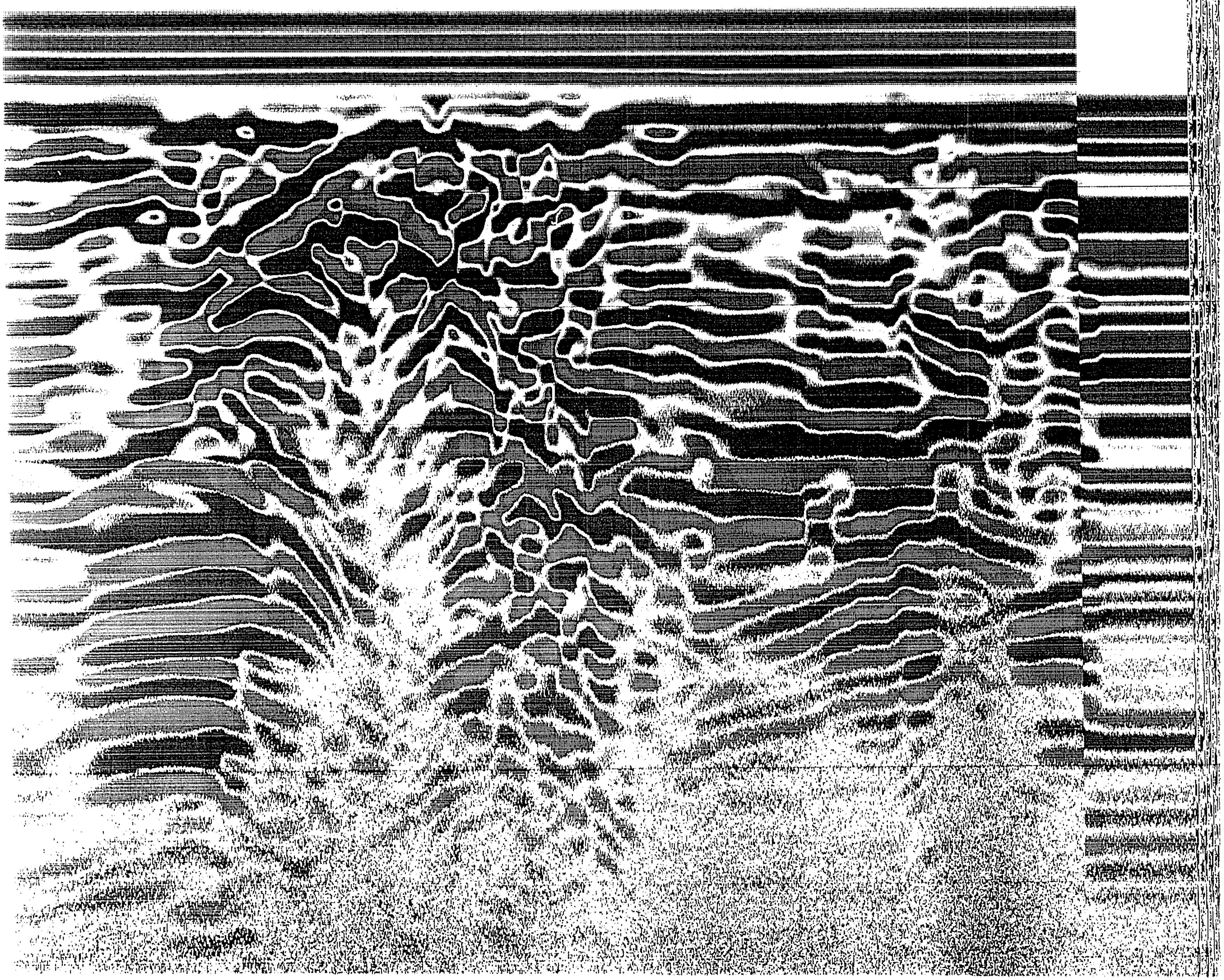

LMW-7 Line 1 (horizontal)
Conductivity (mS/m)
0
1
2
3
4
5
6
7
Distance (feet)
0
20
40
60
80
100
120
140
160
180
200
Coil Separation
10m
20m
40m


LMW-7 Line 1 (vertical)
Conductivity (mS/m)
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
Distance (feet)
Coil Separation
10m
20m
40m

GPR Records
Site LMW-2&4 Utility Survey
Pipeline Road

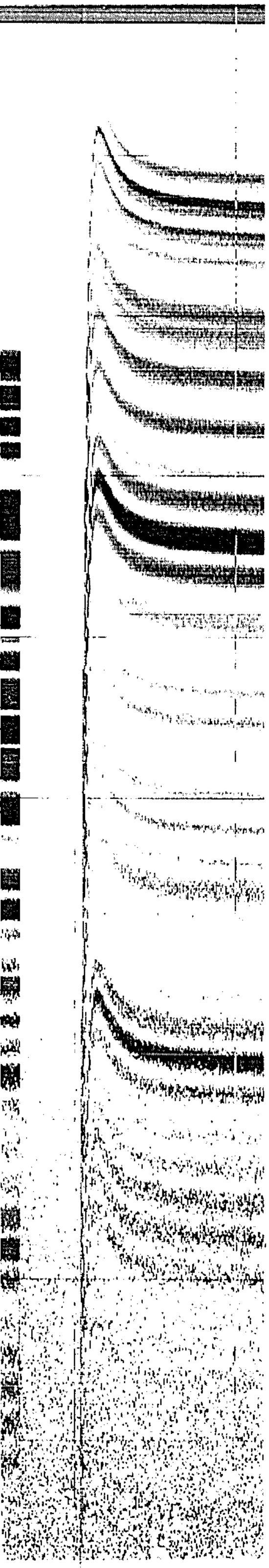
GPR RECORDS
Pipeline Road
Oct 4, 1993

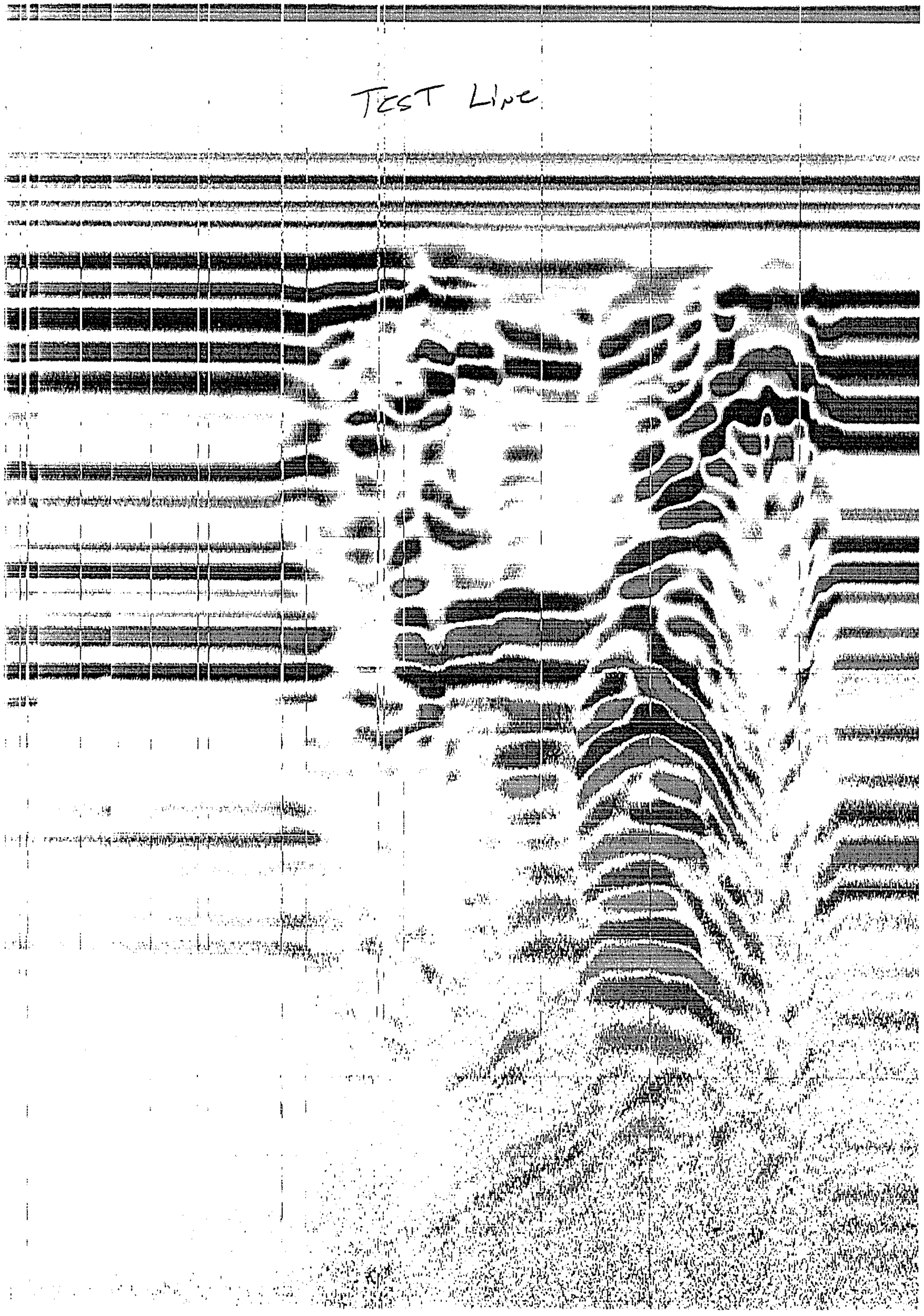
Test Line



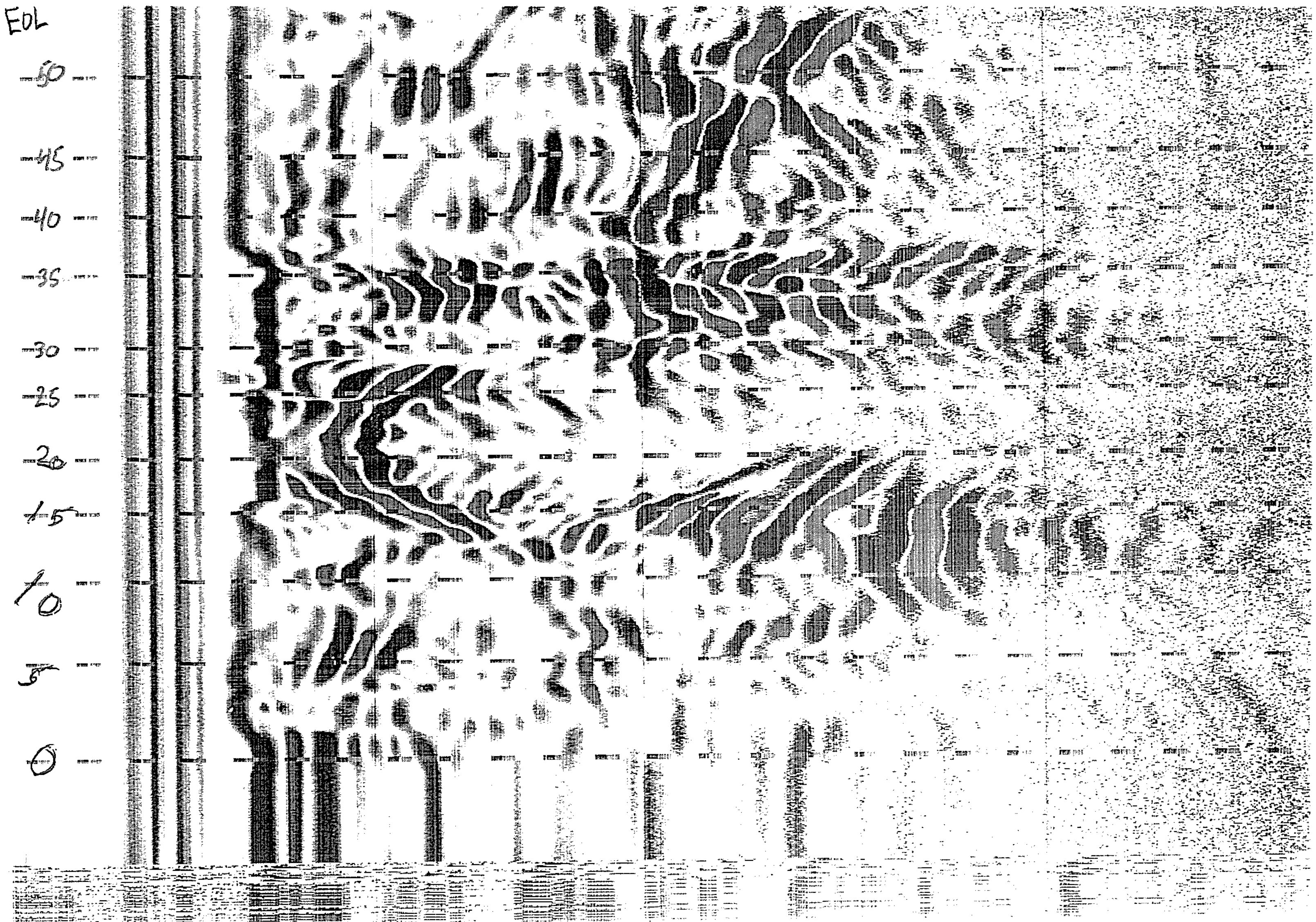
Pipe line Rd. 200 ns

Oct 4, 1993

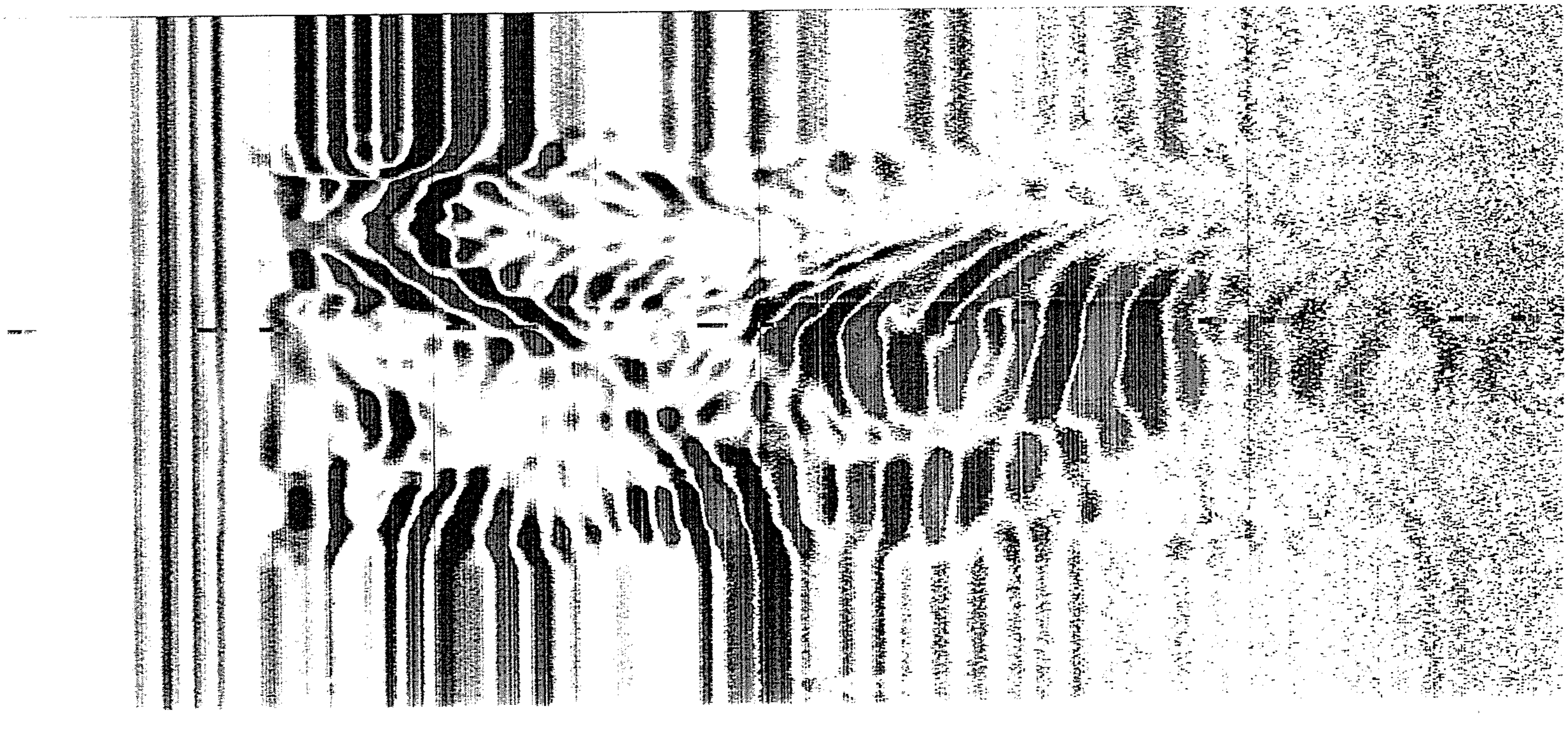


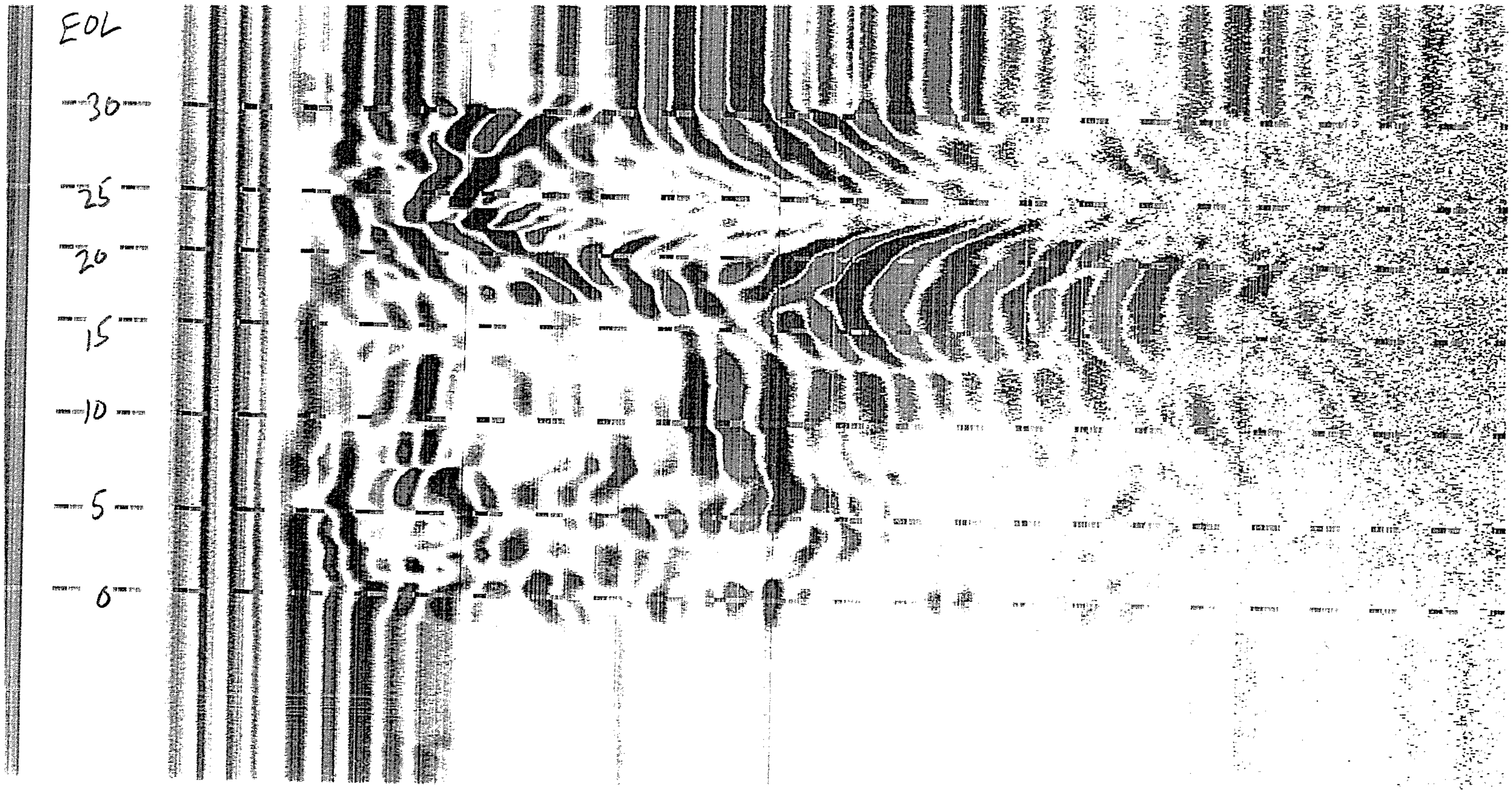


TEST Line

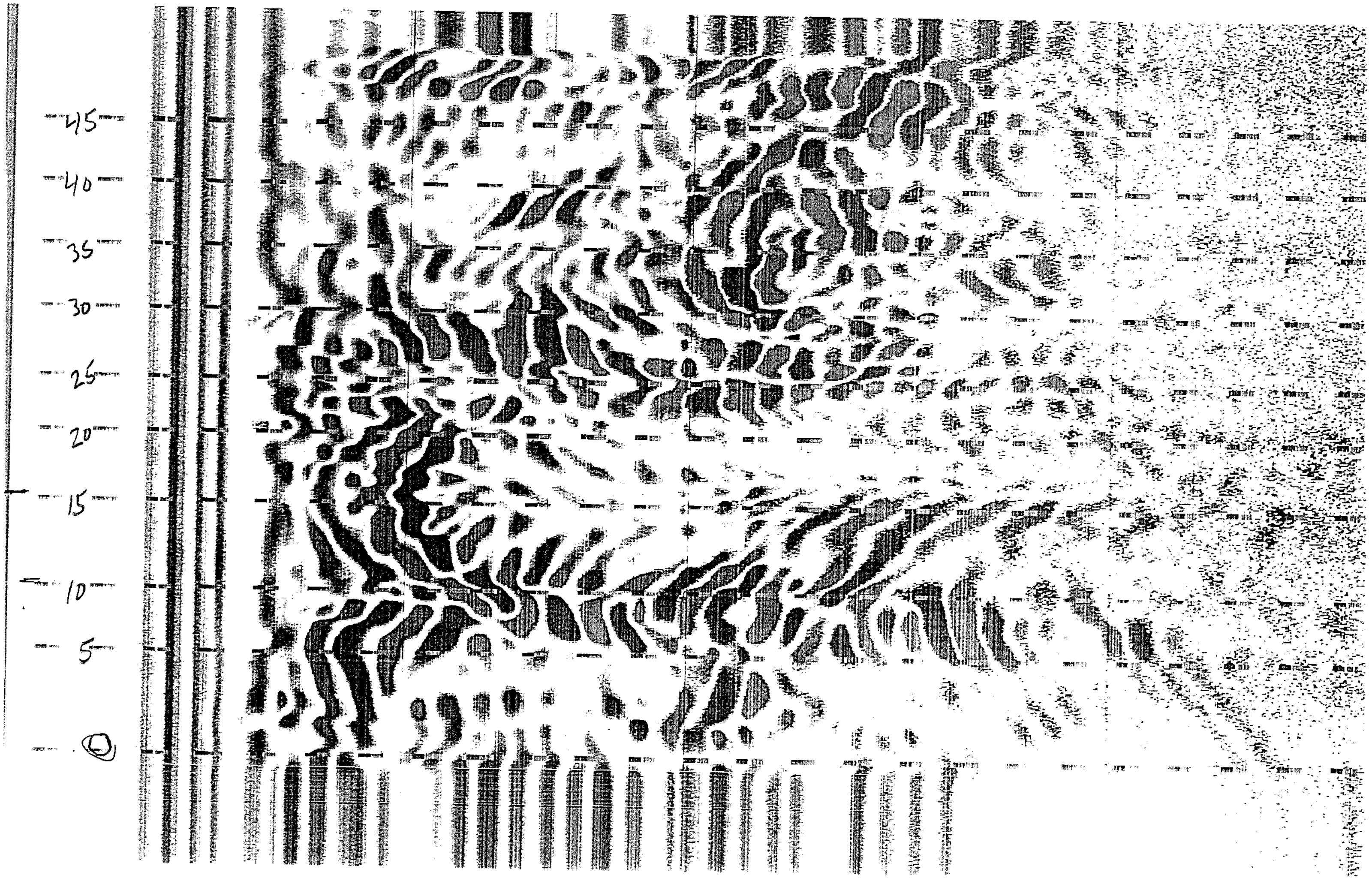


Mown. line 200ns





L-3 200NS



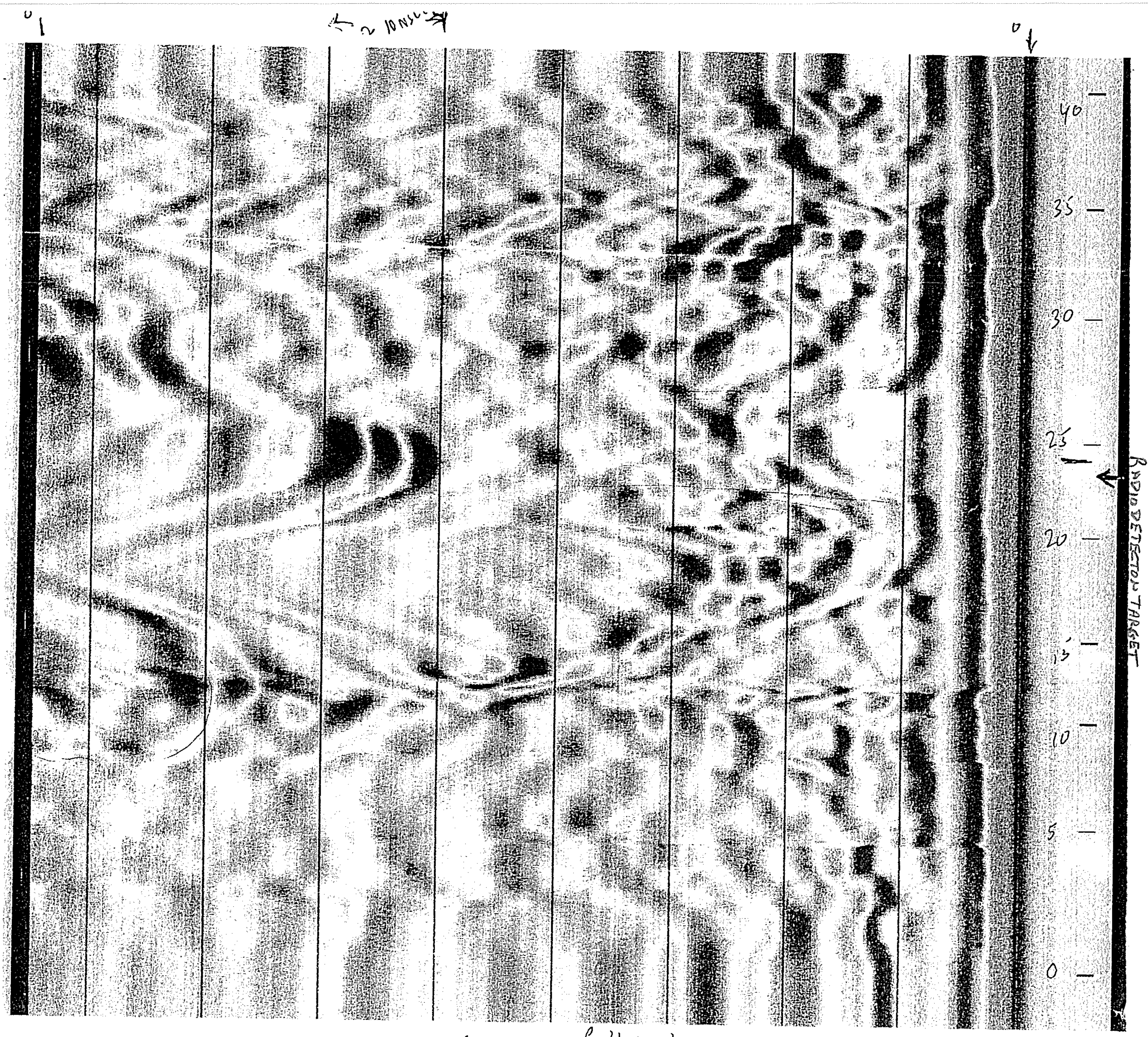
L-2 200ns

10-26-93
GPR 300 MHz
80 NSec

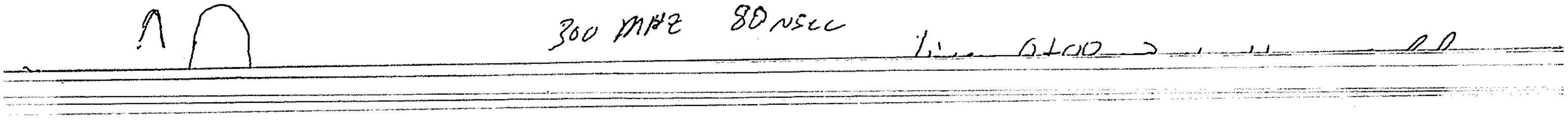
Landsburg Mine
Pipeline Road GPR Survey
923-1000

R. Ratzlaff
R. Blazer

Line ~~2+80~~ 1+80

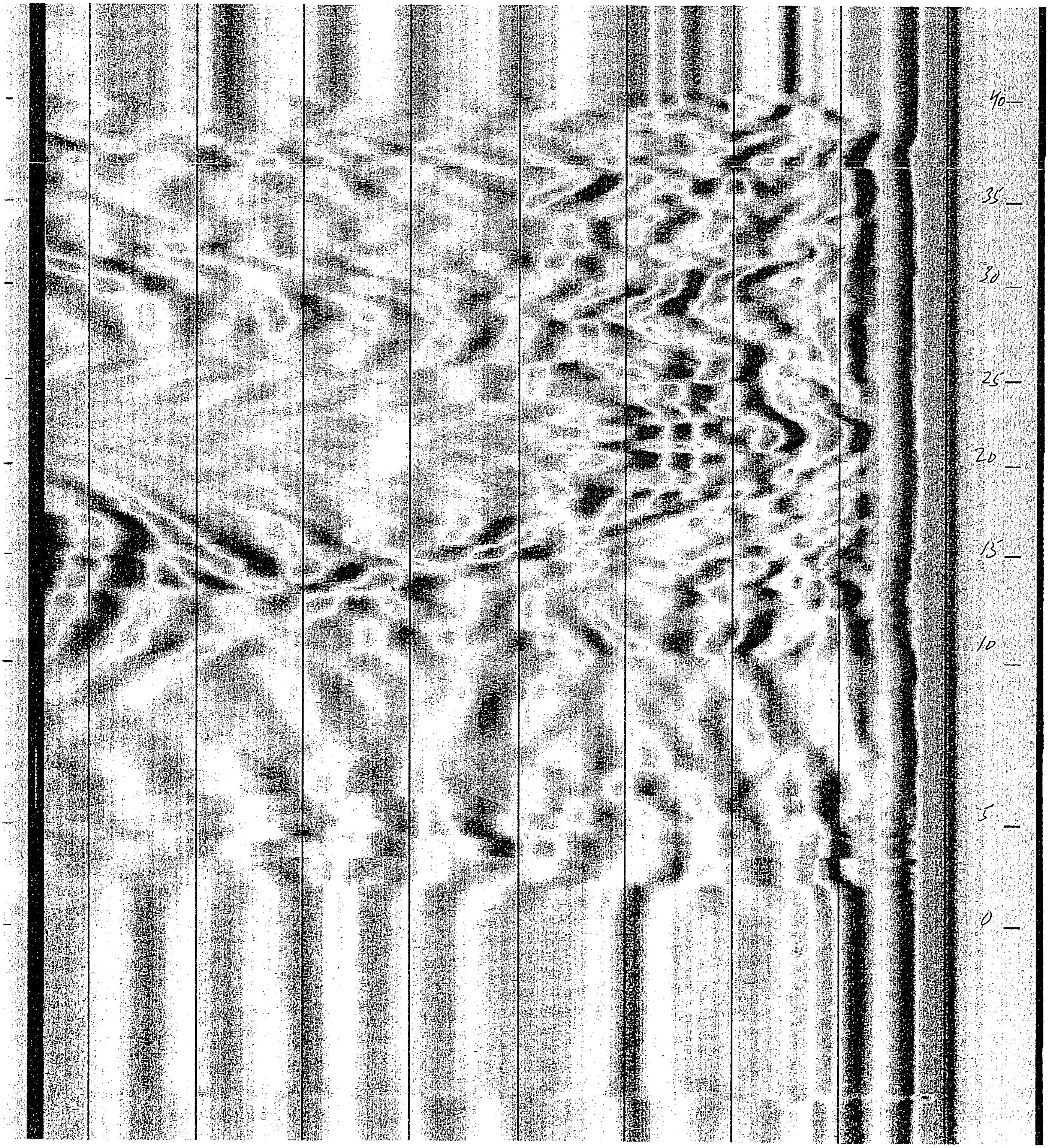


80 nsec full scale



Lordsburg Mine
GPR Line 00
→ North Across Rd.
Line 2+4
P/Line Rd

Line @ 0+10 Start @ 5' mark → north



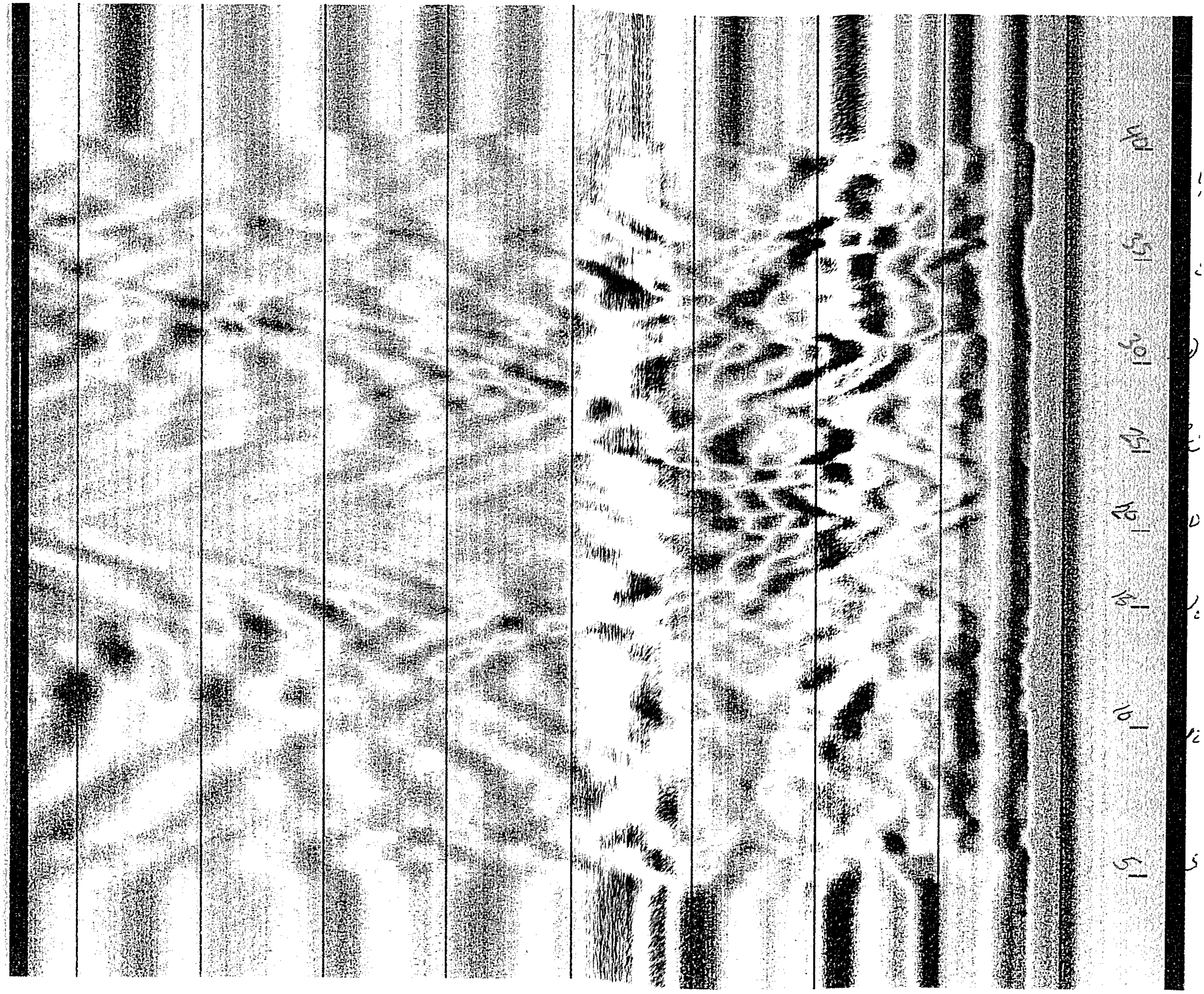
80 nsec 300 mHz

Line @ 0+20W → north Across Rd.

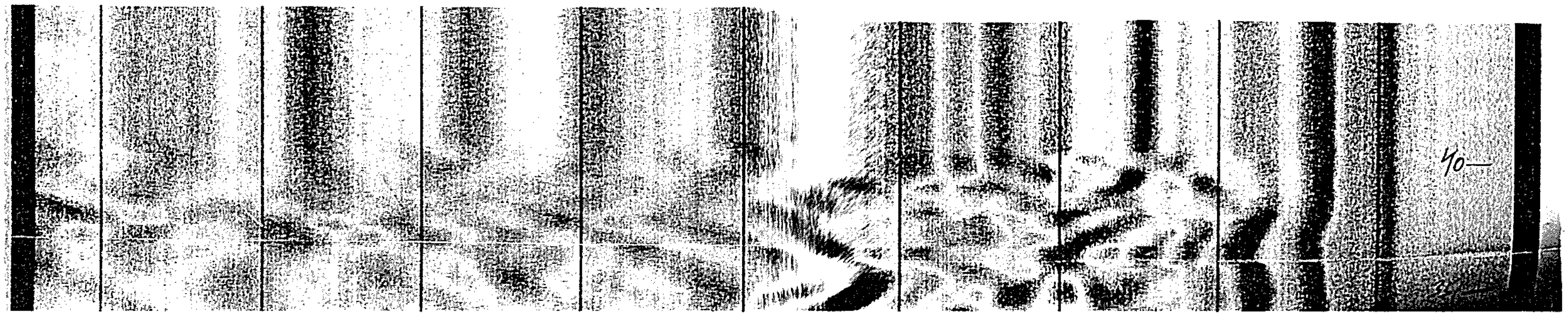
80

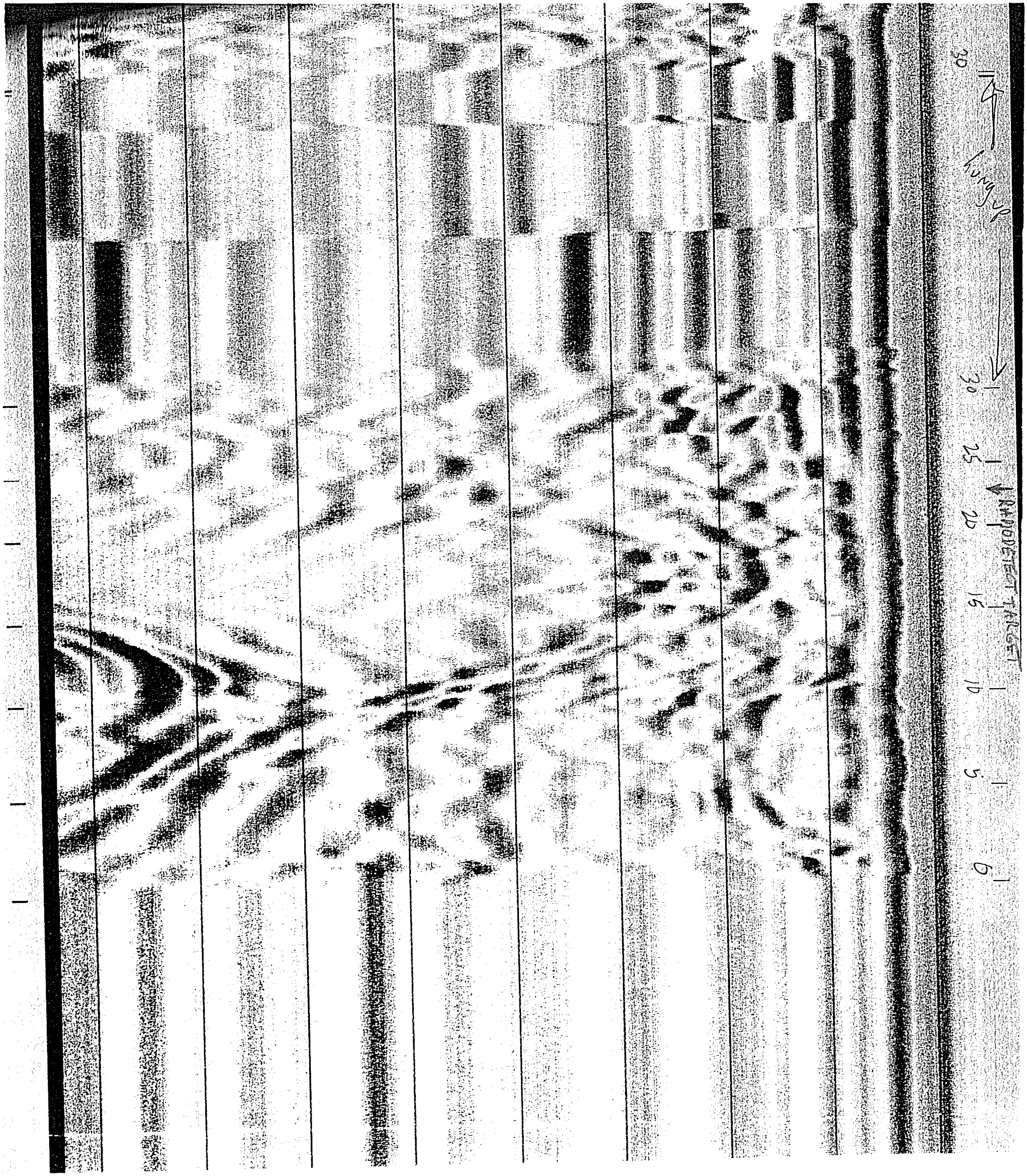
← nnsec →

line @ 0+40 start @ 0 → north accross Rd.

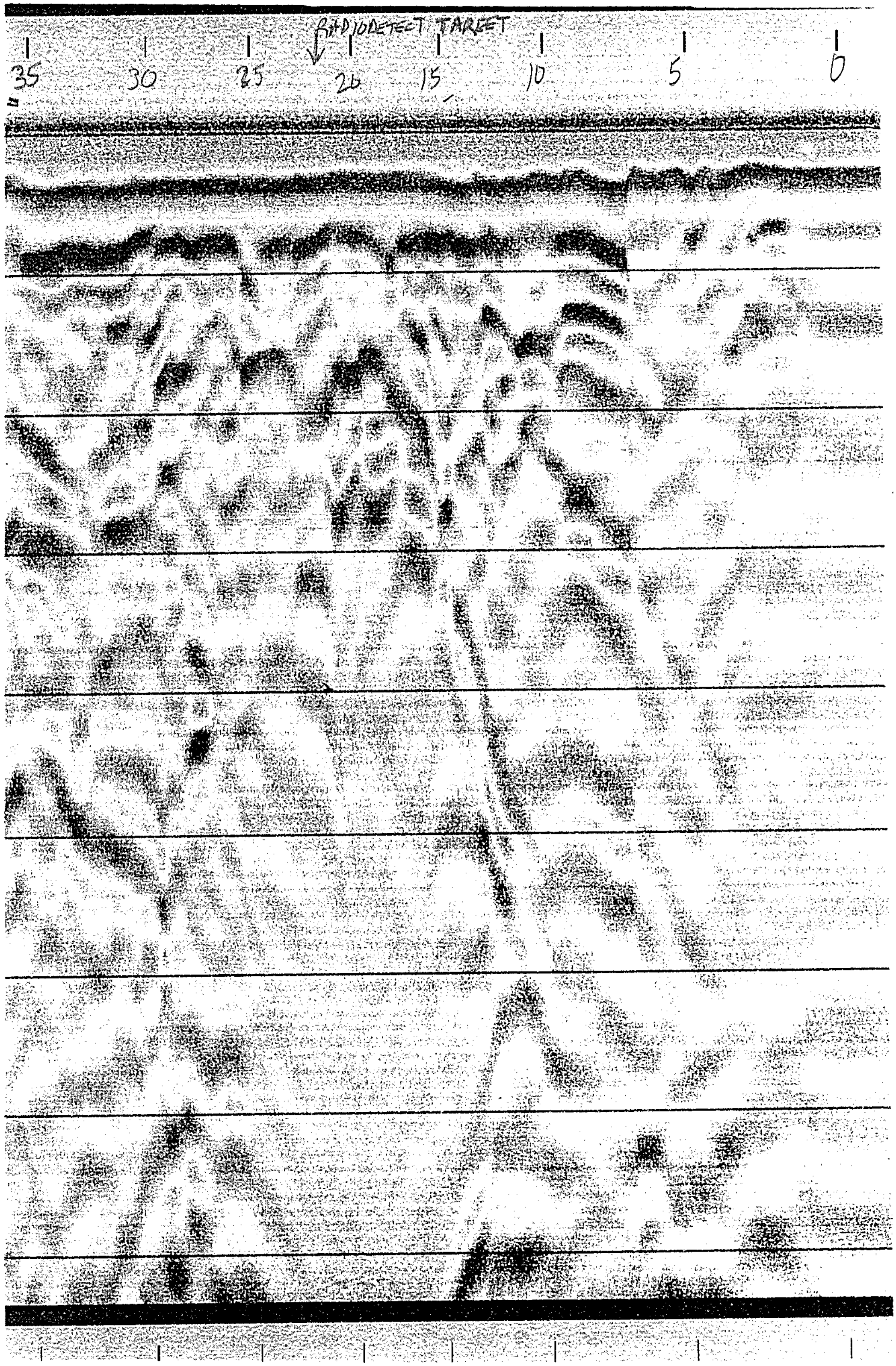


80 nsec
Line @ 0+10W start @ 5' mark → north

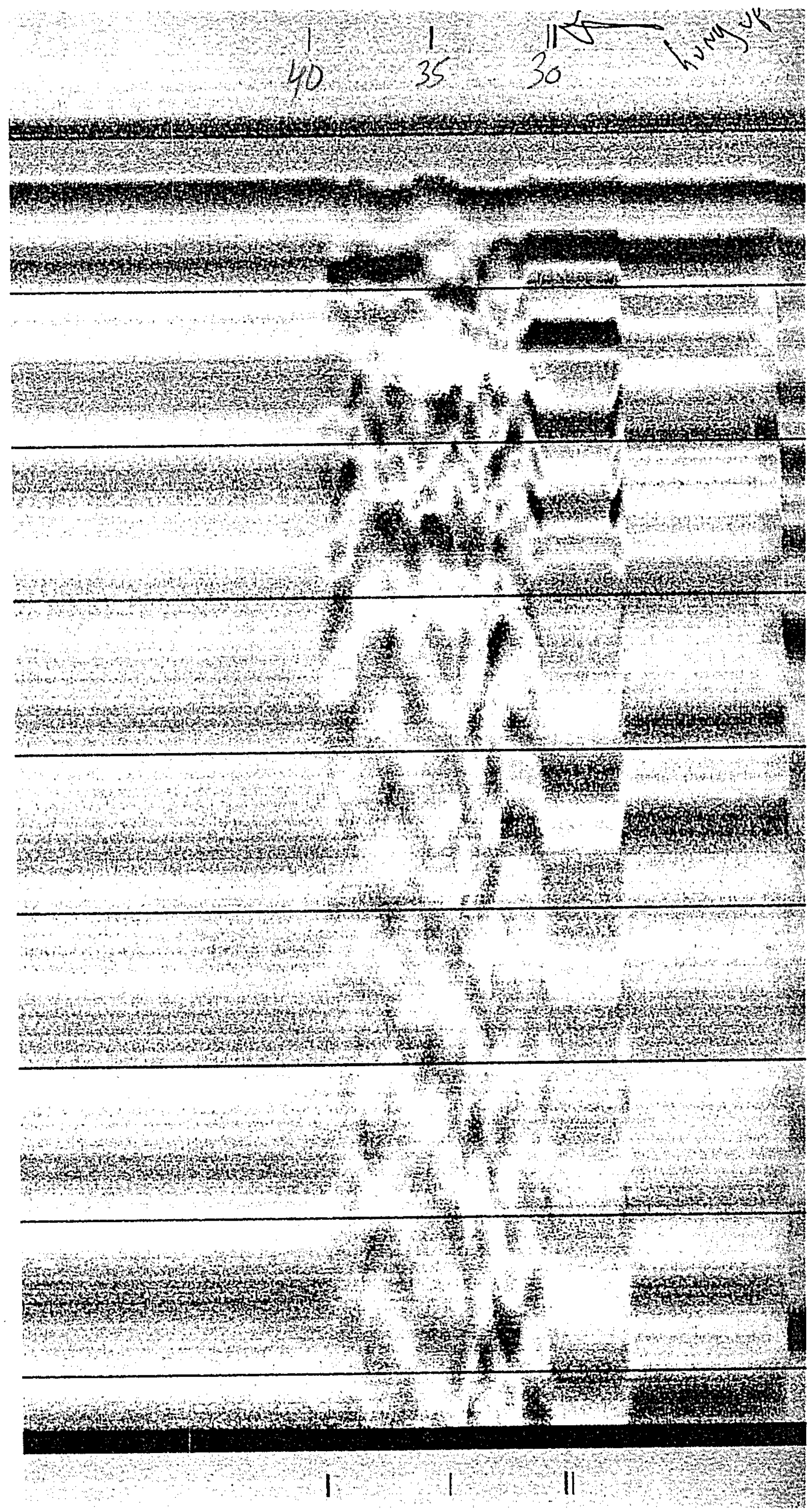




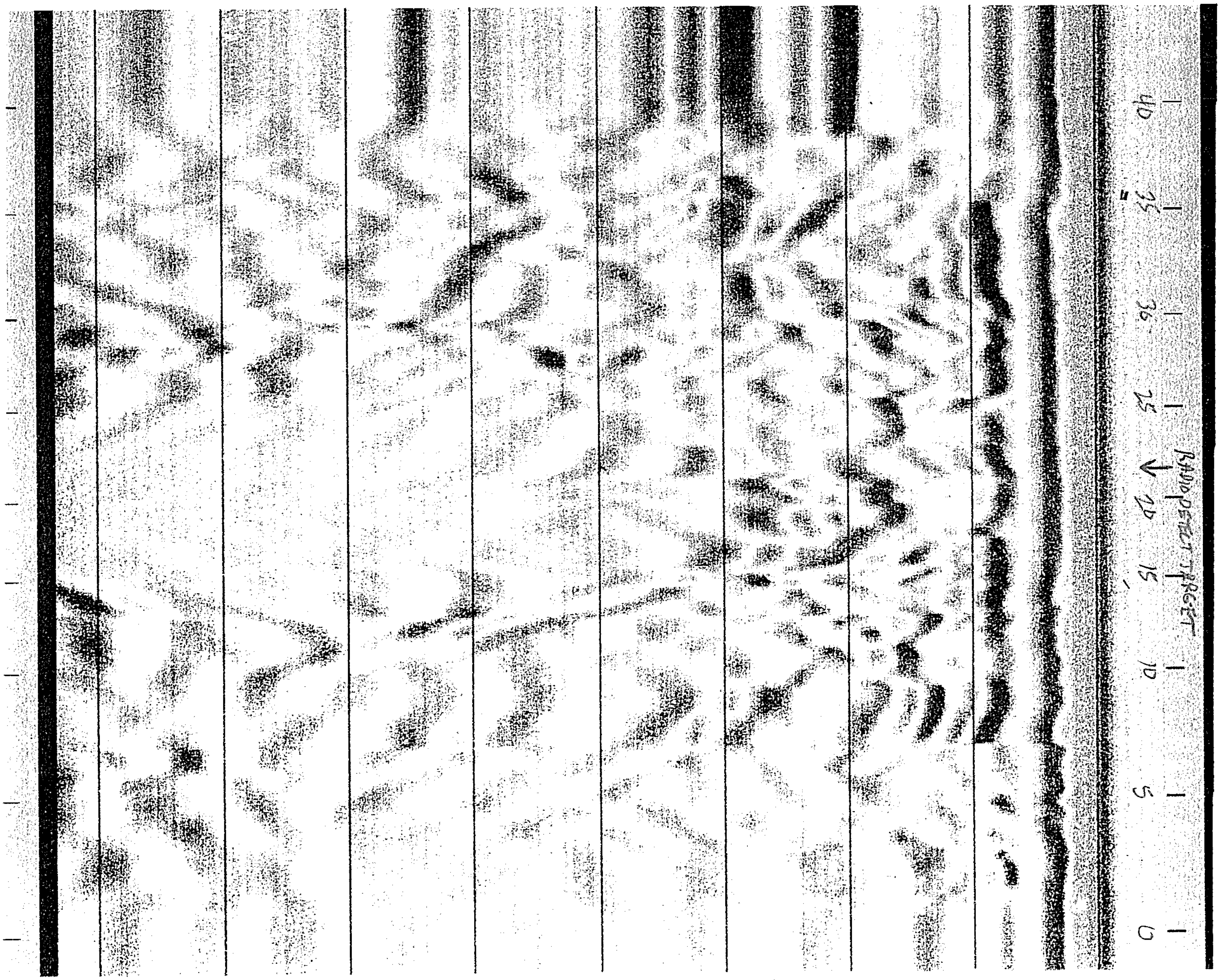
line e 0+40W start @ 0 → north accross Rd.



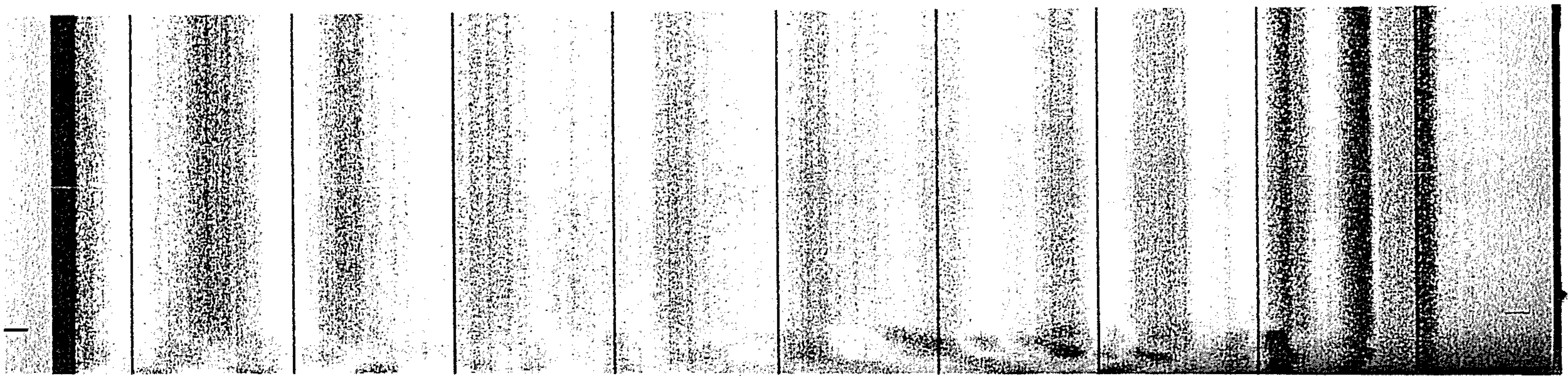
line 0+60W @ @ 0→north 80 nsec

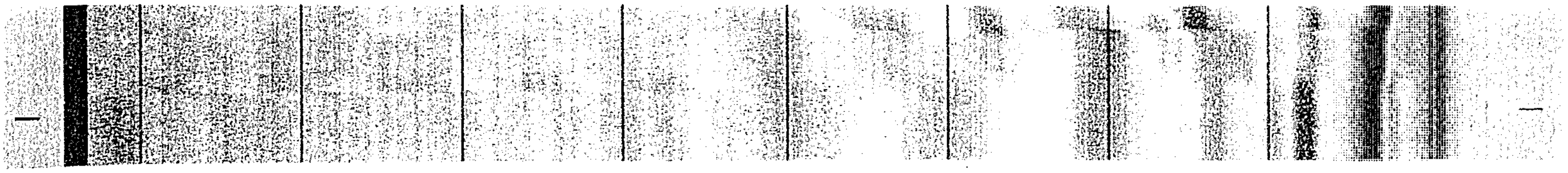


line 0+80 0 → north

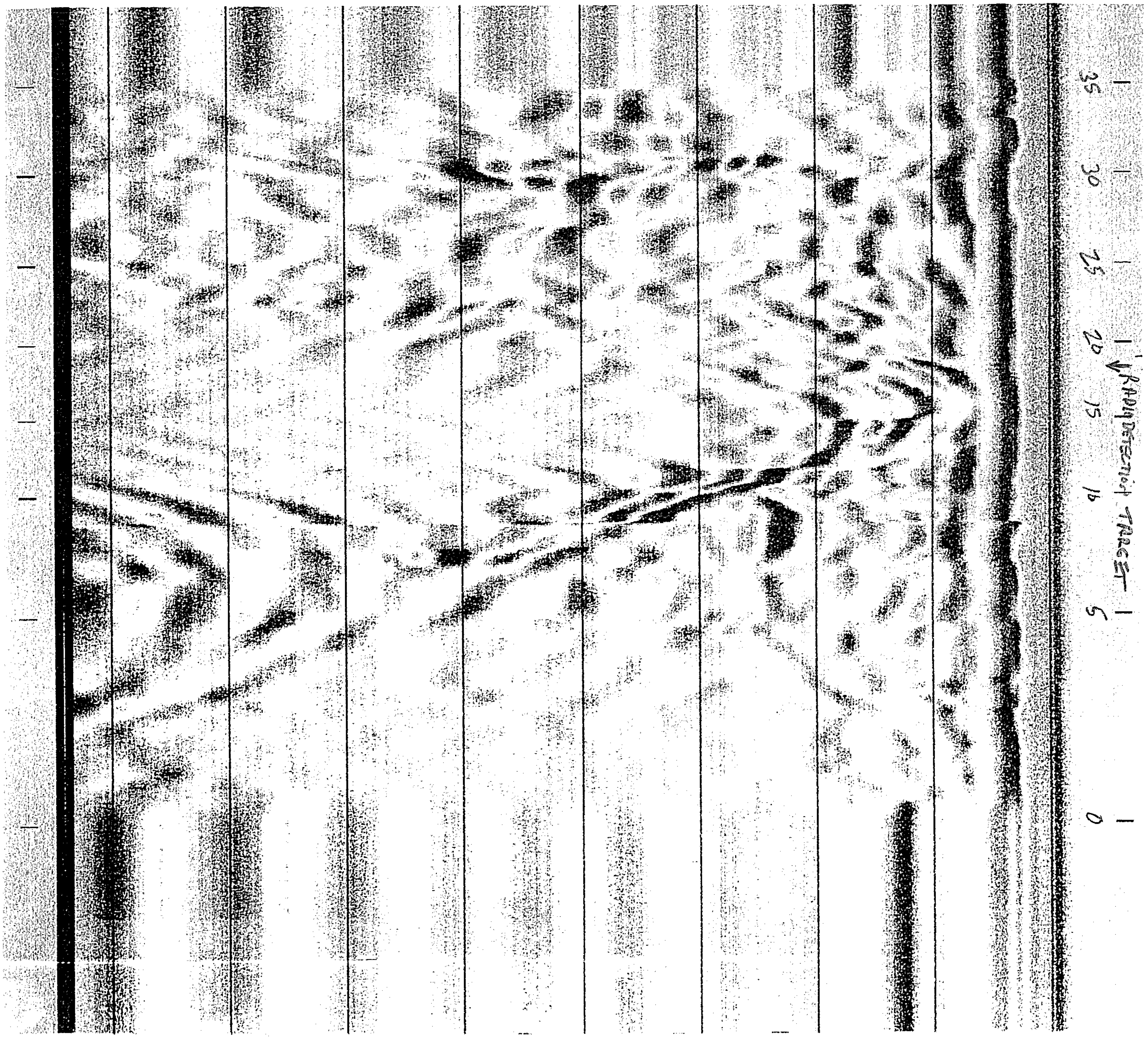


line 0+60W @ @ 0 → north 80 nsec

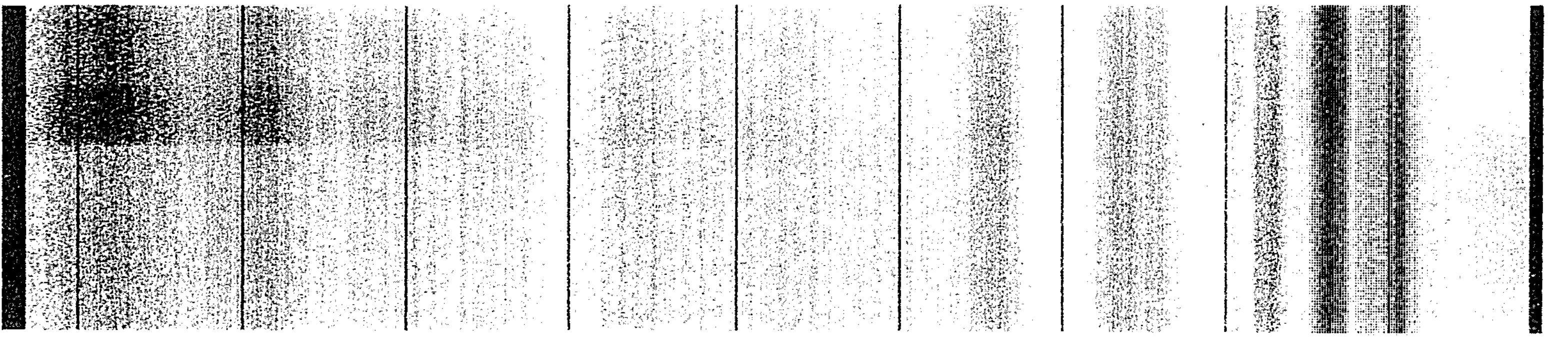




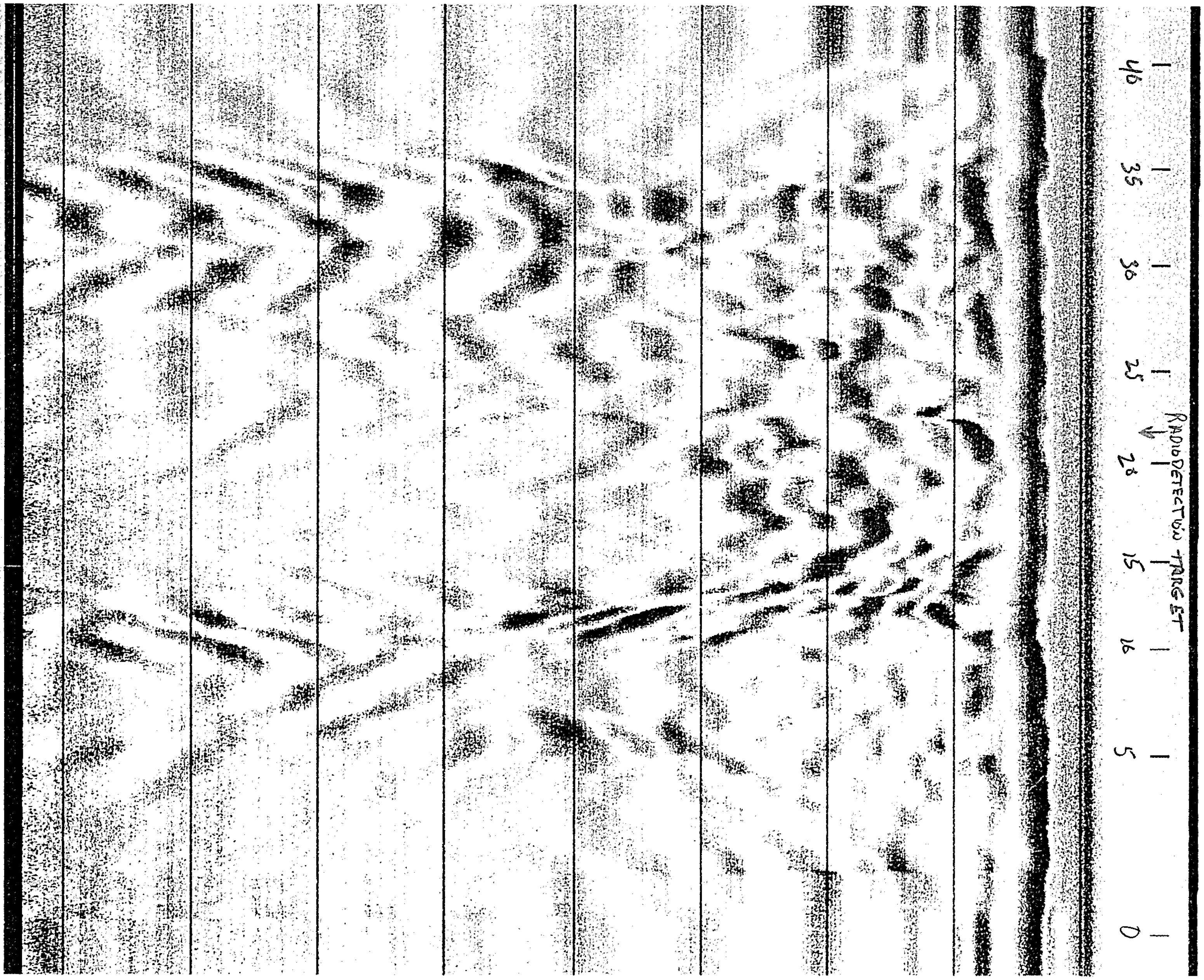
line 1+00 0→north 80 nsec



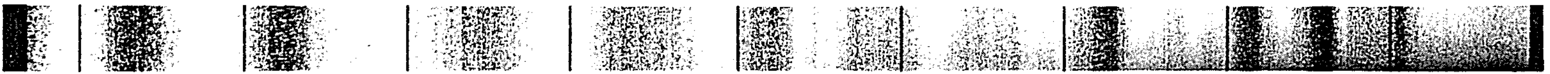
line 0+80W 0→north 80 nsec



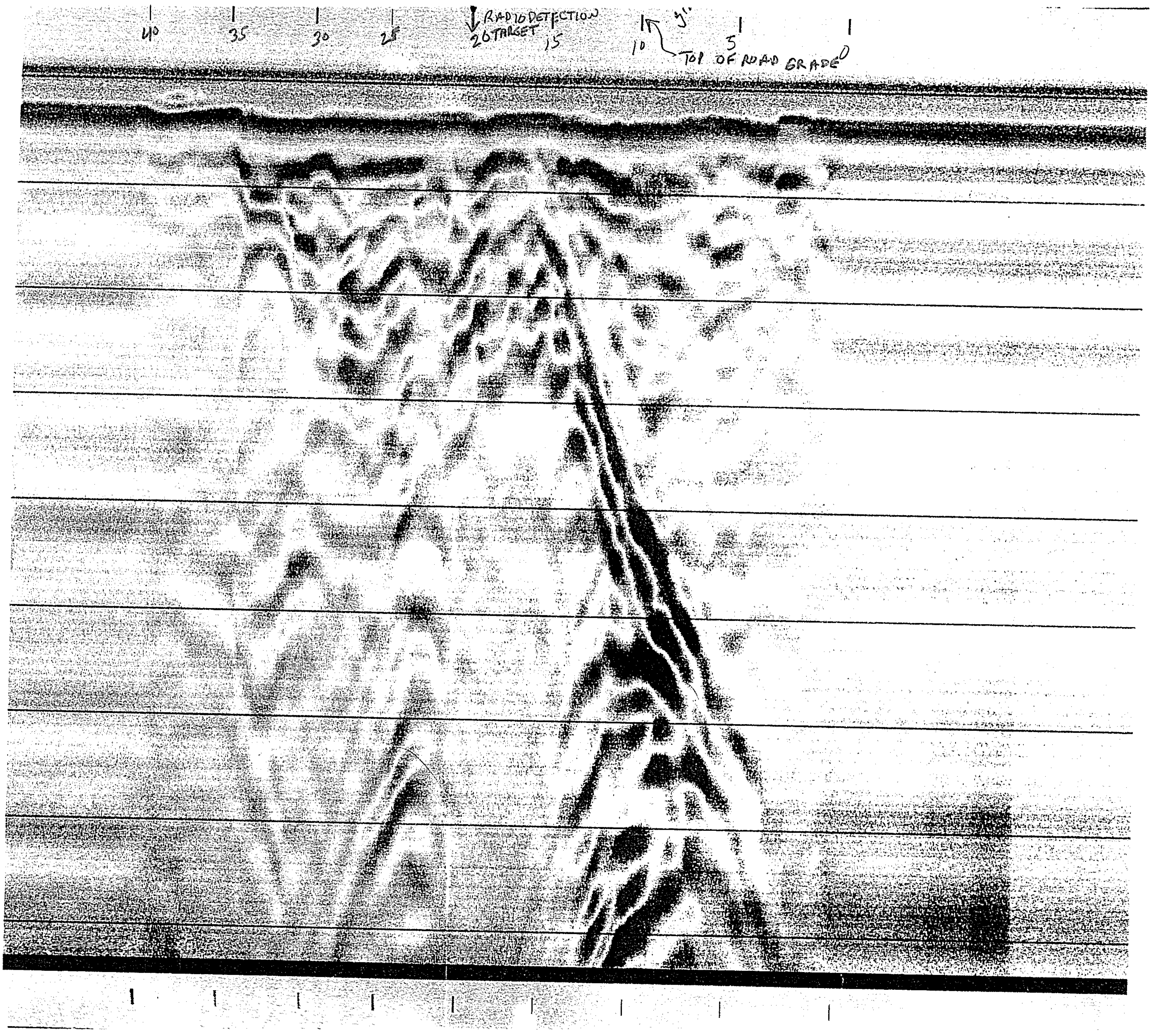
line 1+20 0->north



line #00W 0<-> north 80 nsec

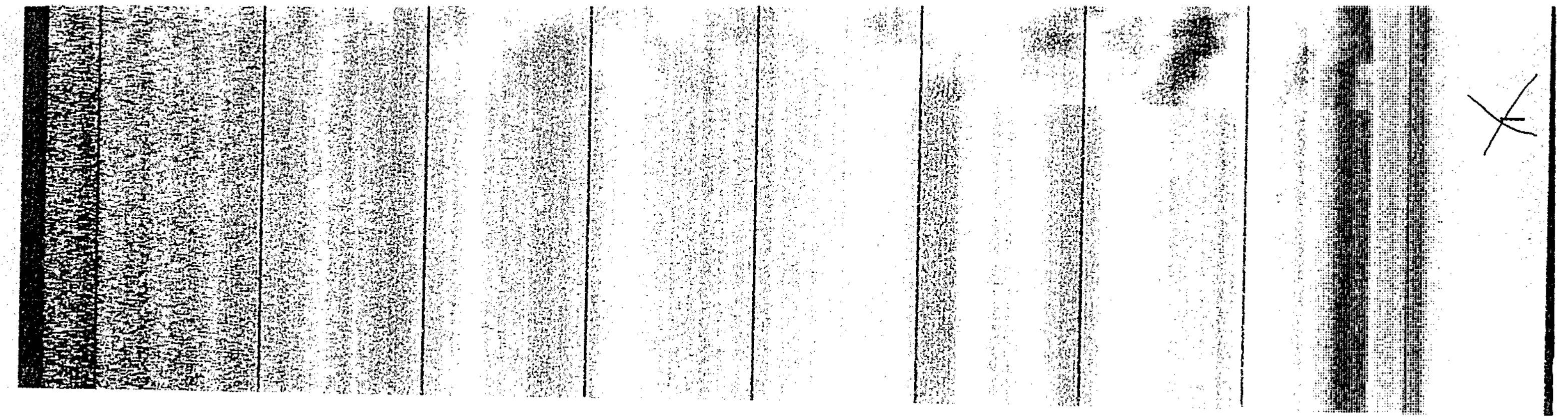


line 1+40

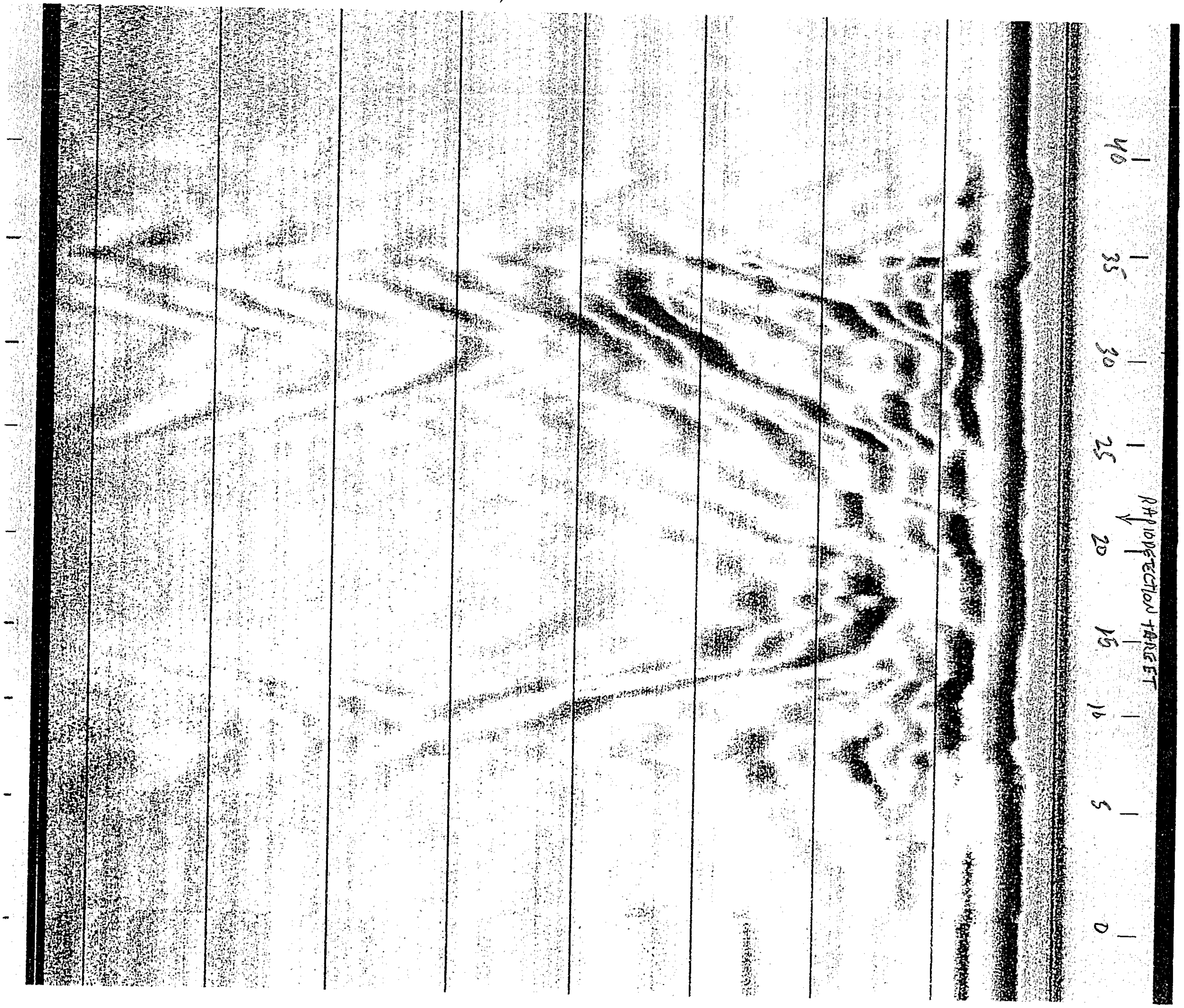


80 nsec

line 1+20W 0->north

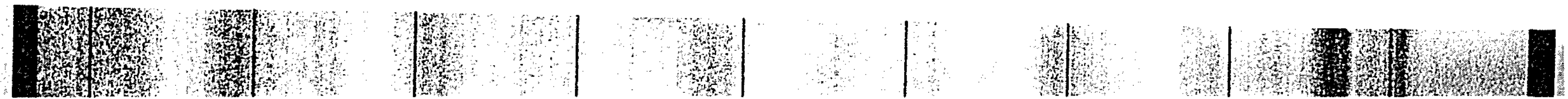


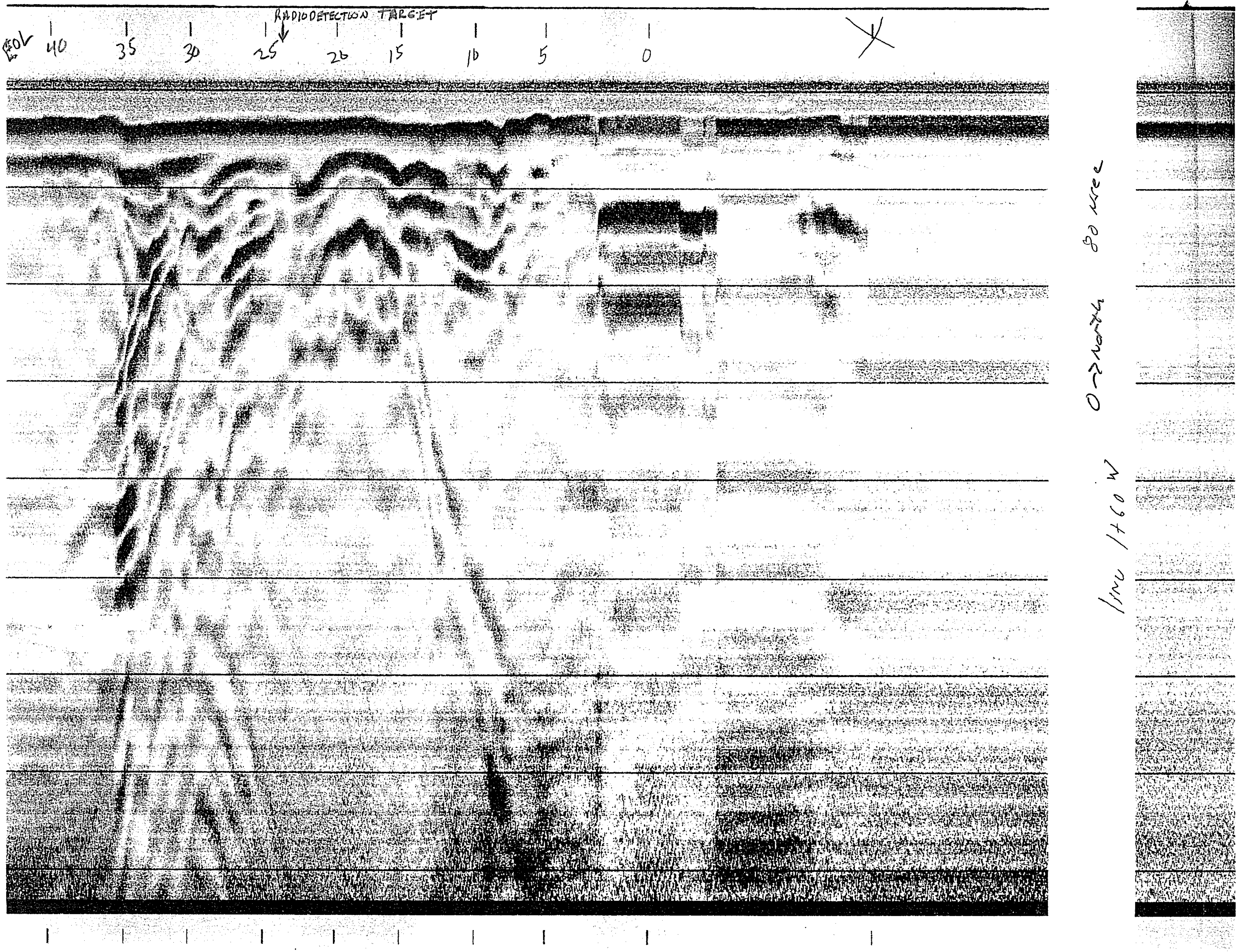
line 1+60



line 1+40

0 → North 80 nsec

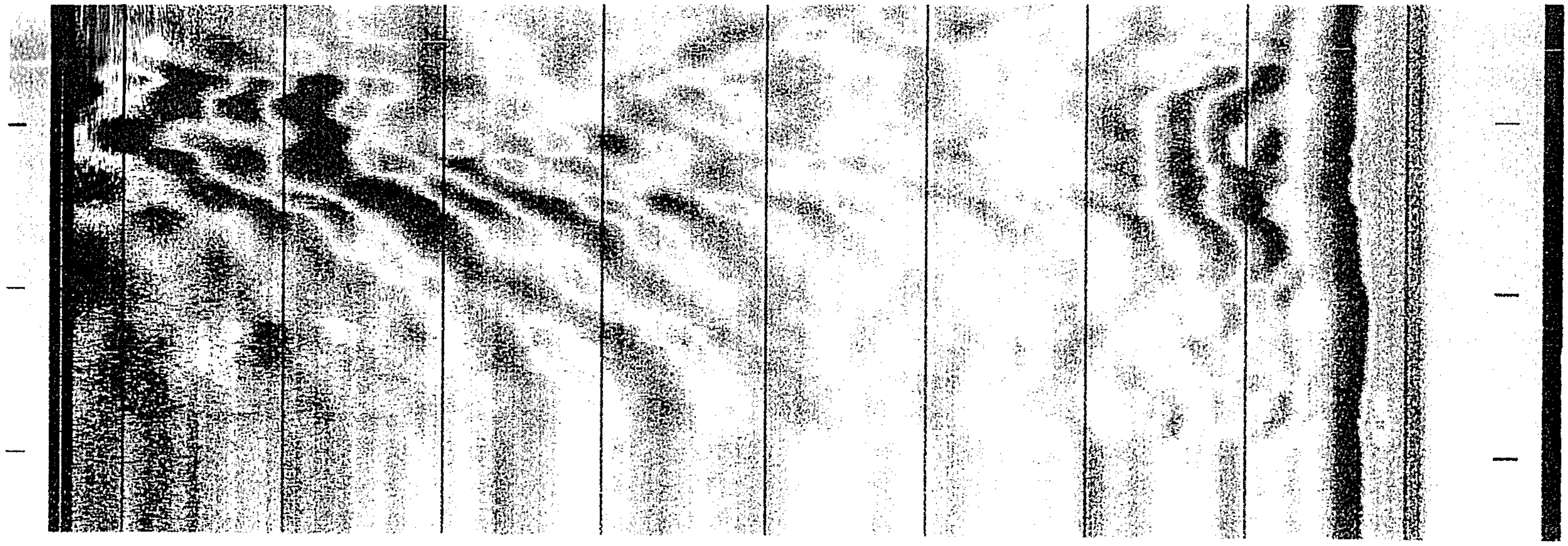




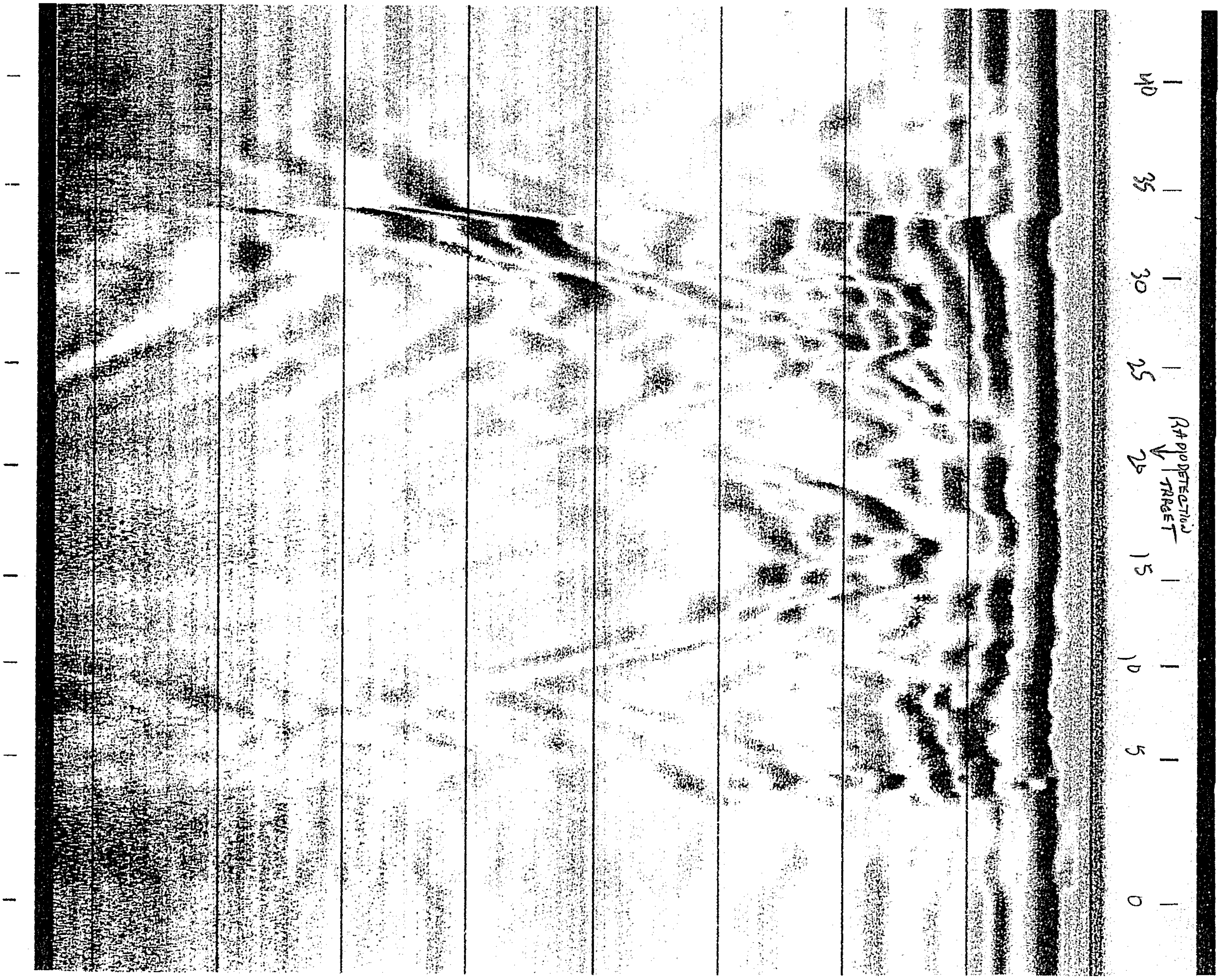
line 1+60W

0→North

80 nsec



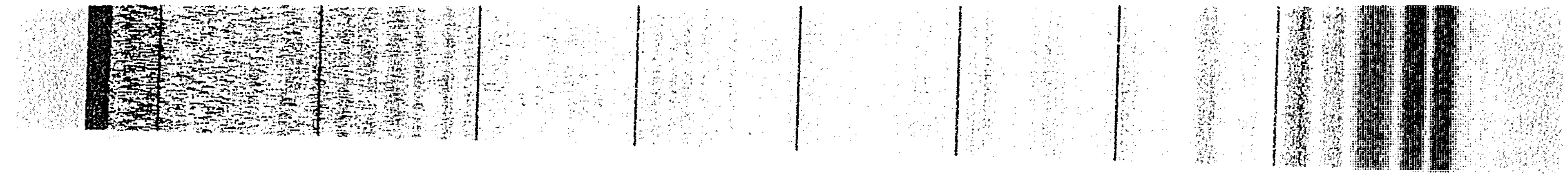
line 2+00



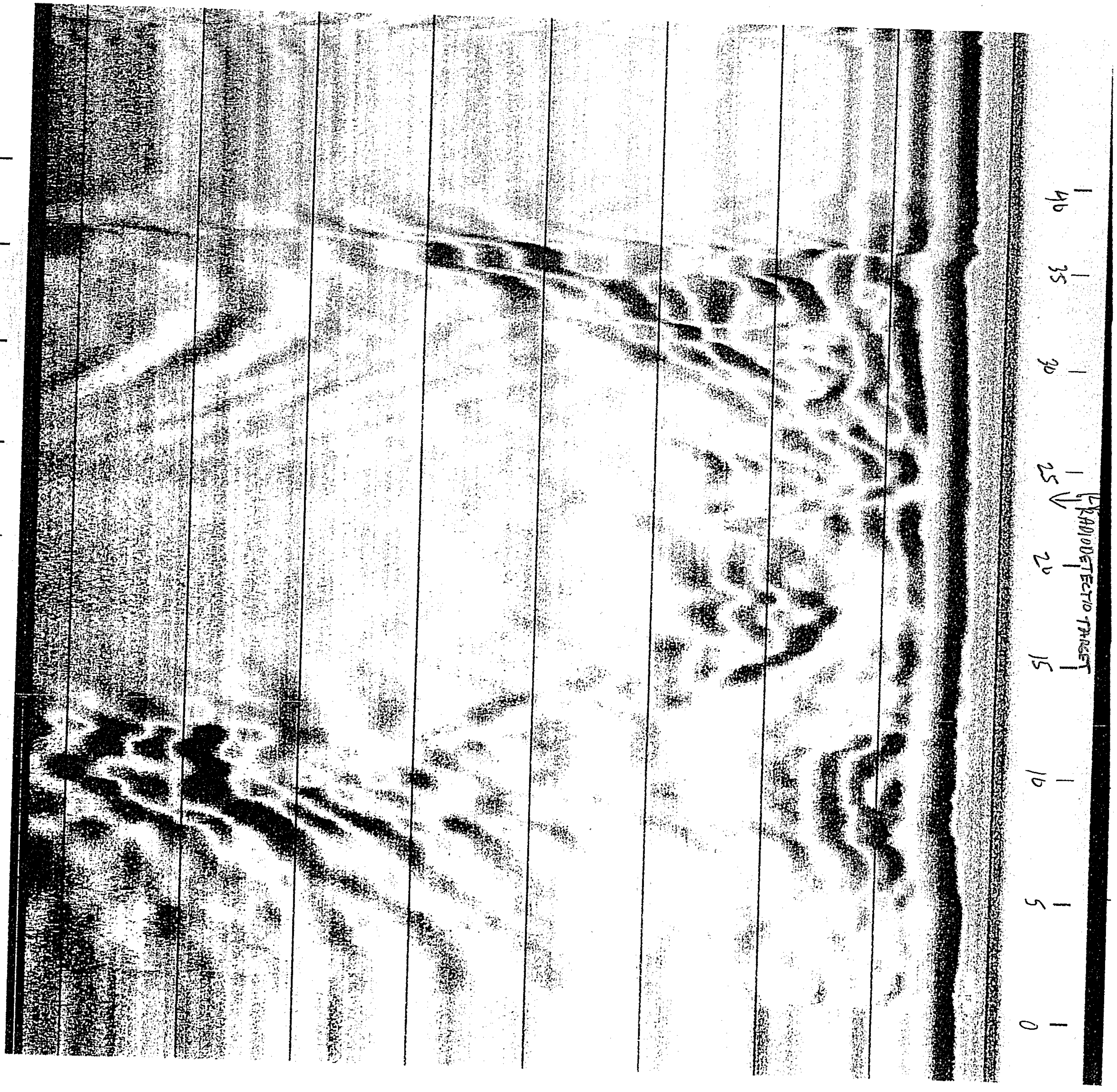
line 1+80 w

80 Nsec

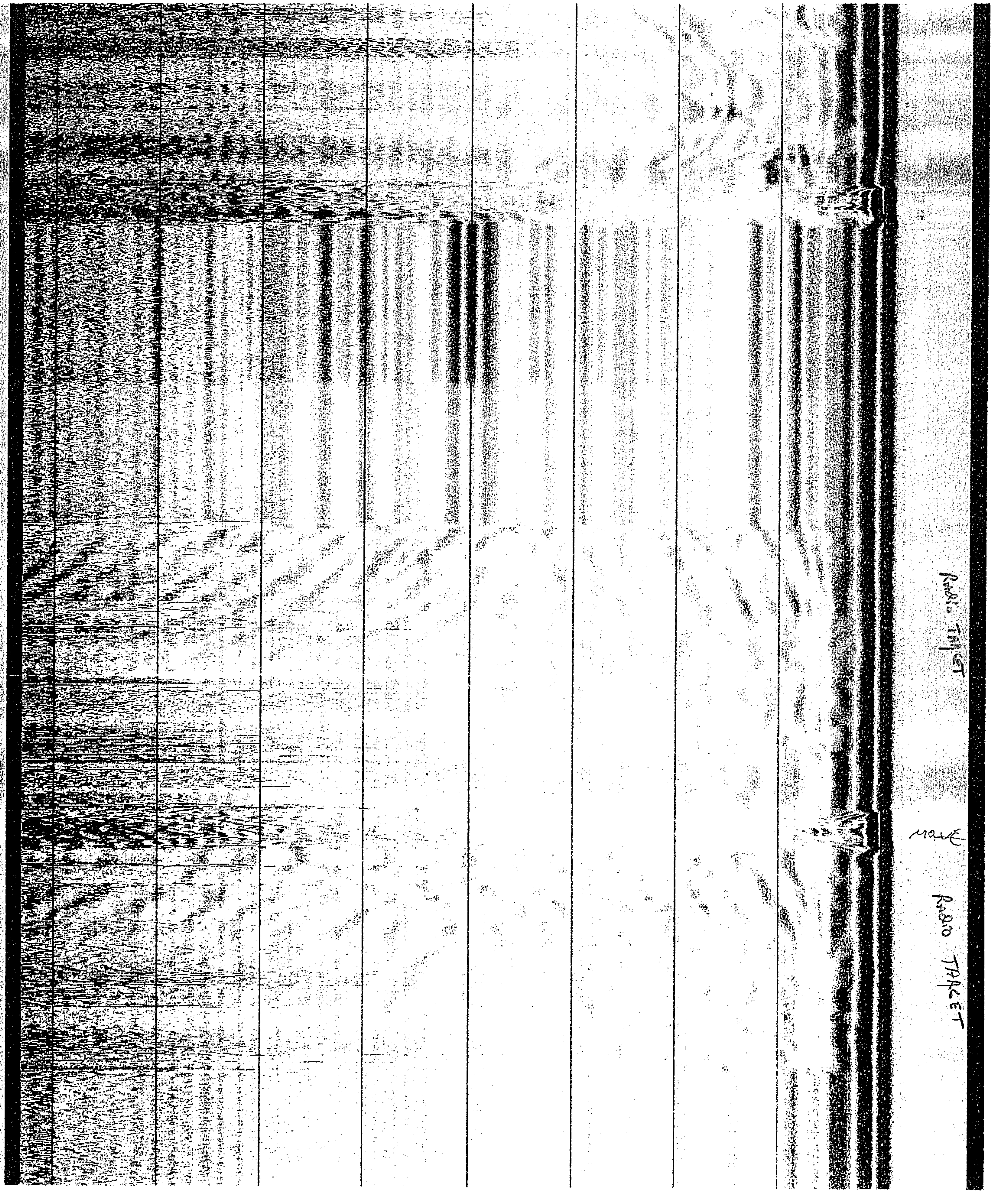
0->North



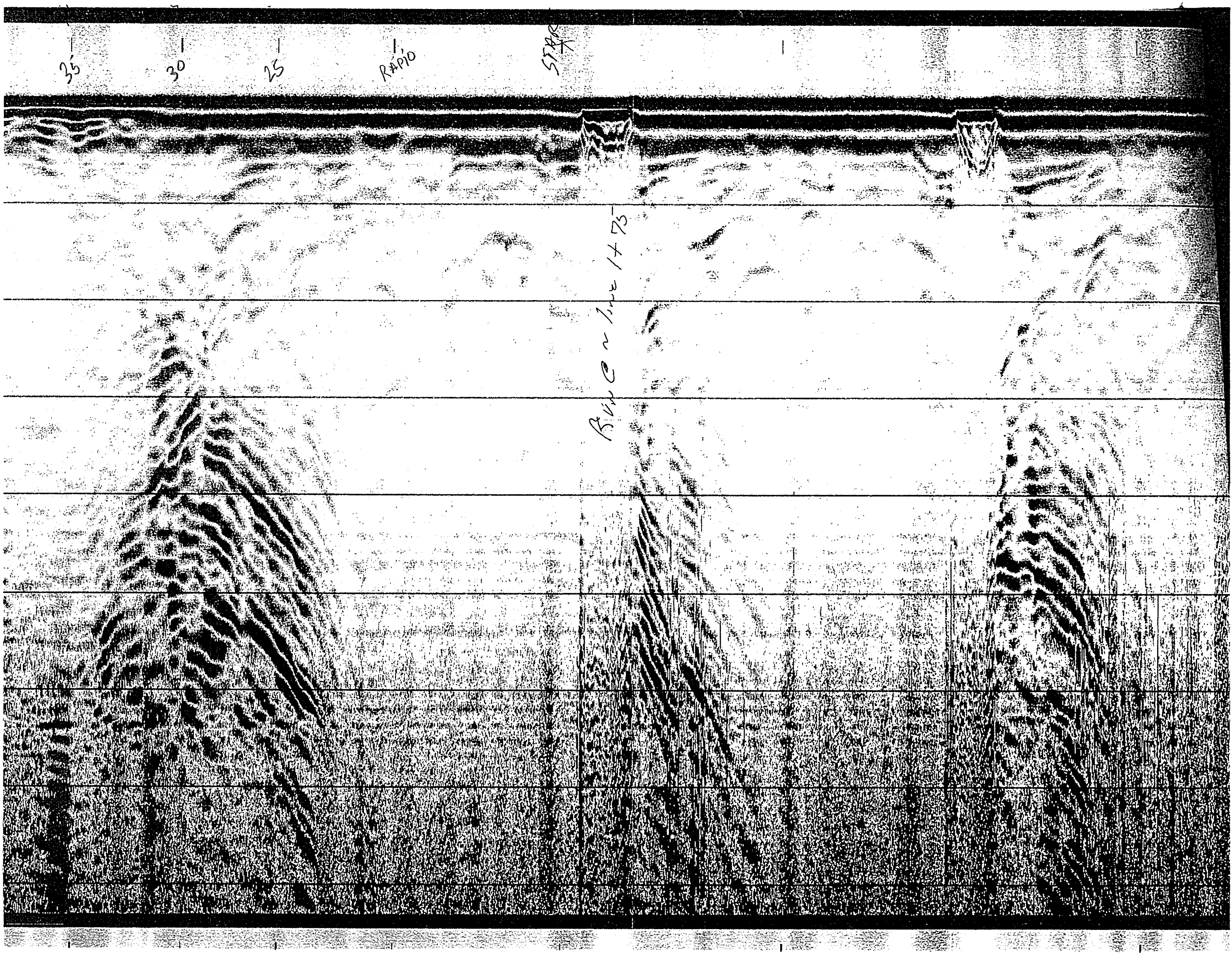
run 500MHz over radio detect.



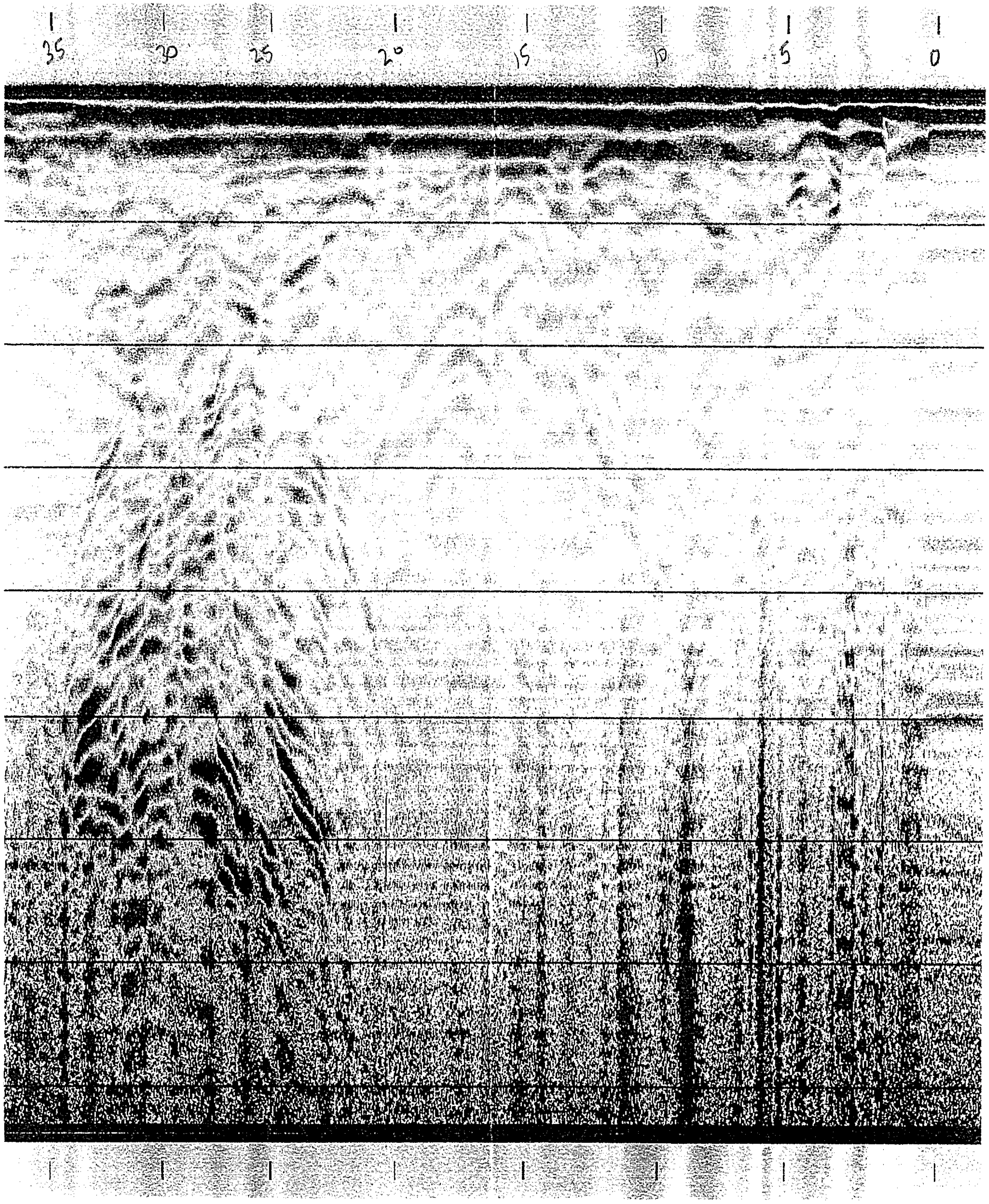
line 2+00 0->north 80nsec



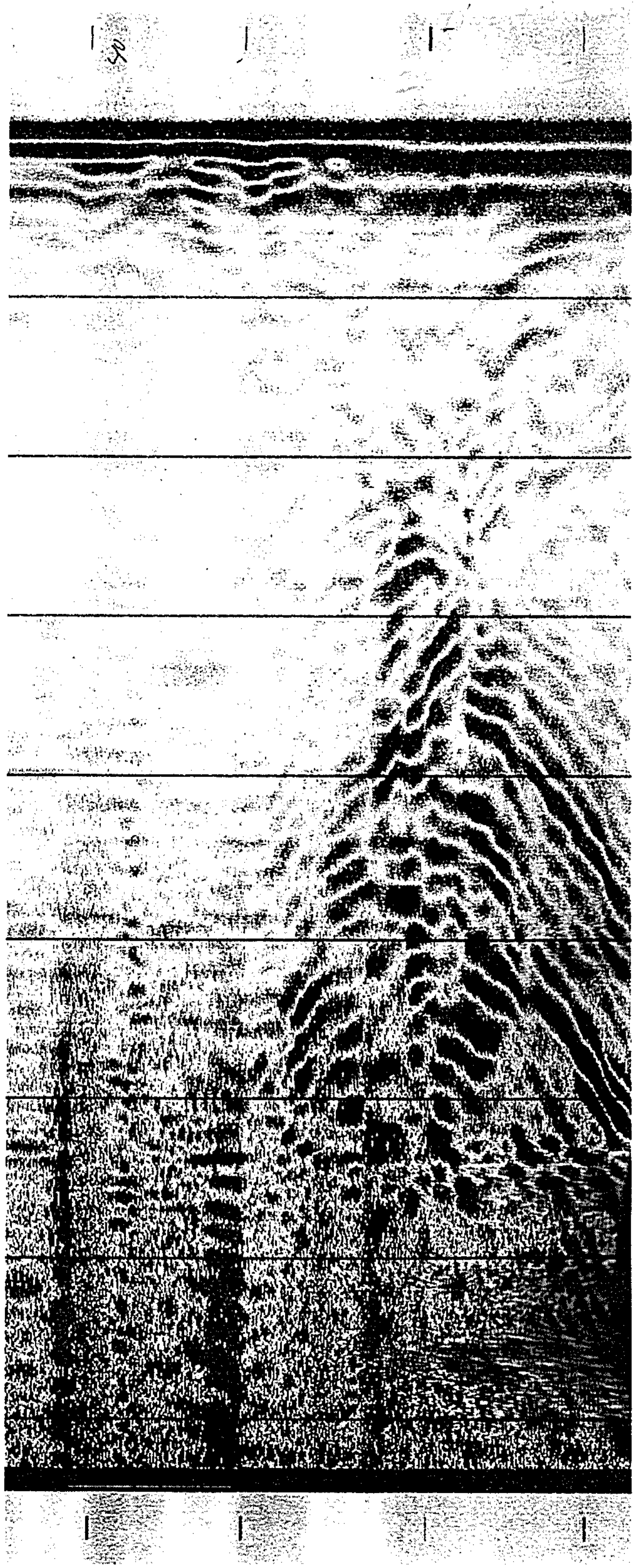
run 500m 108 over radio detect.

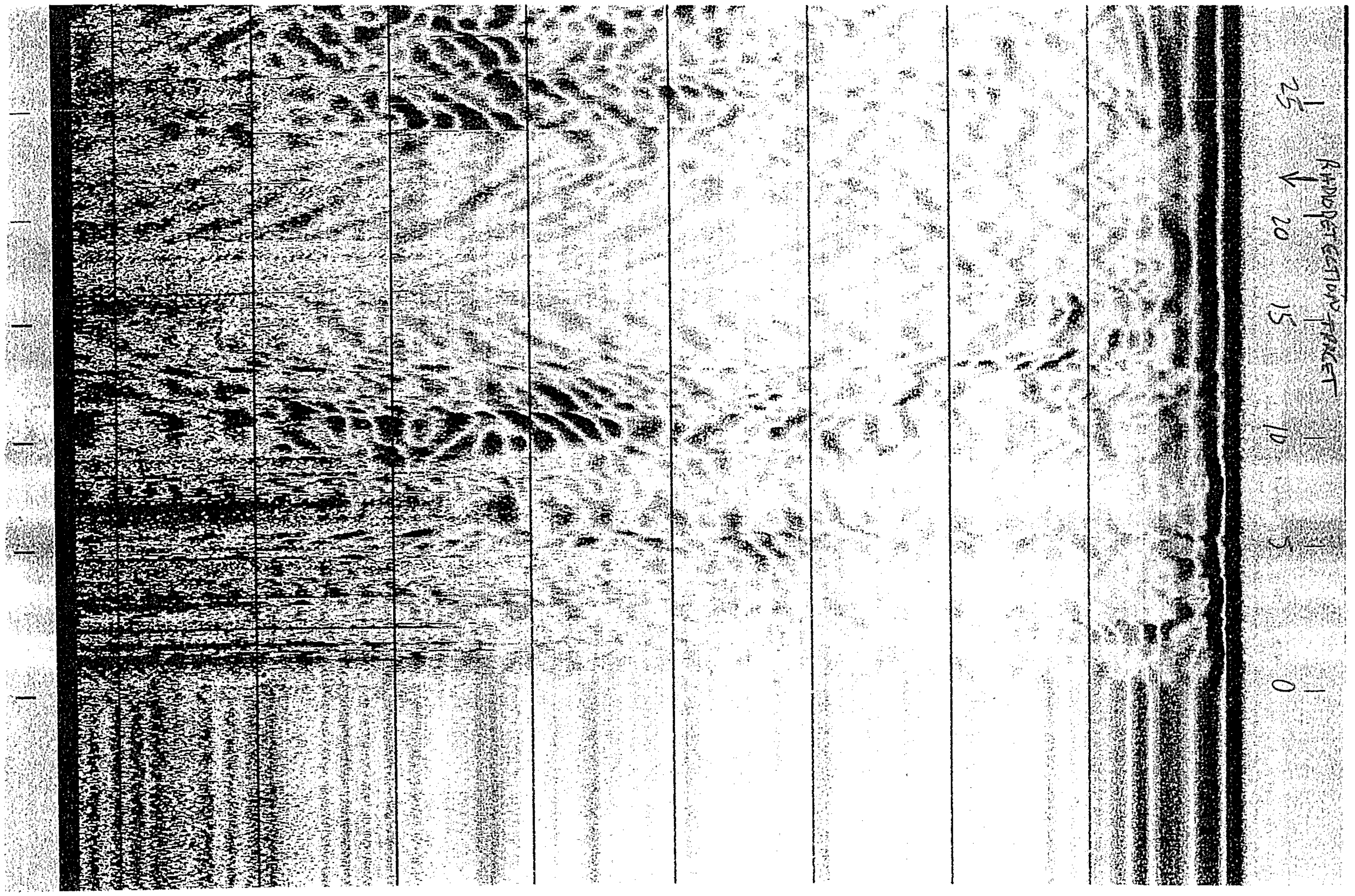


Run @ ~ line 1+75

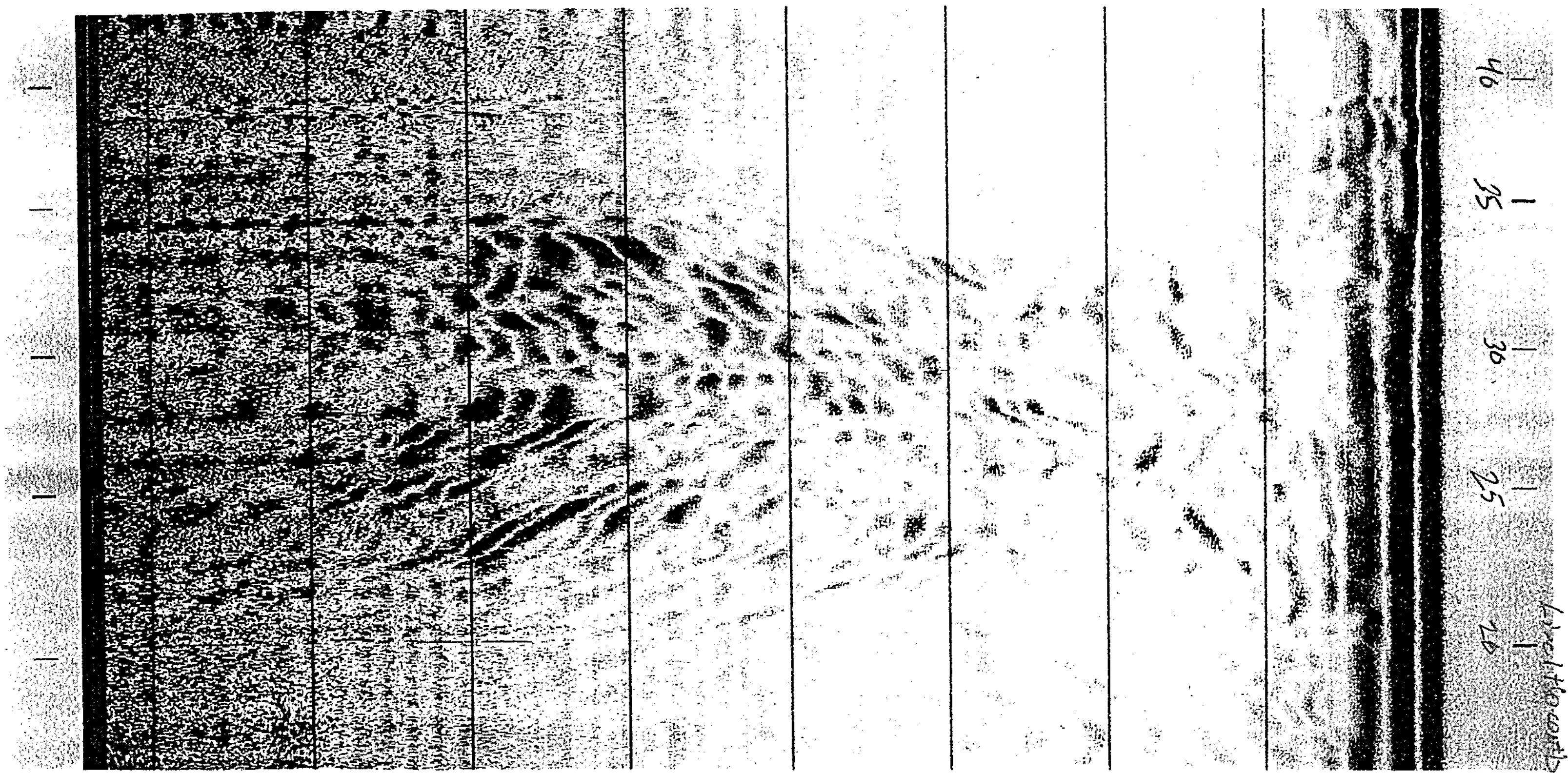


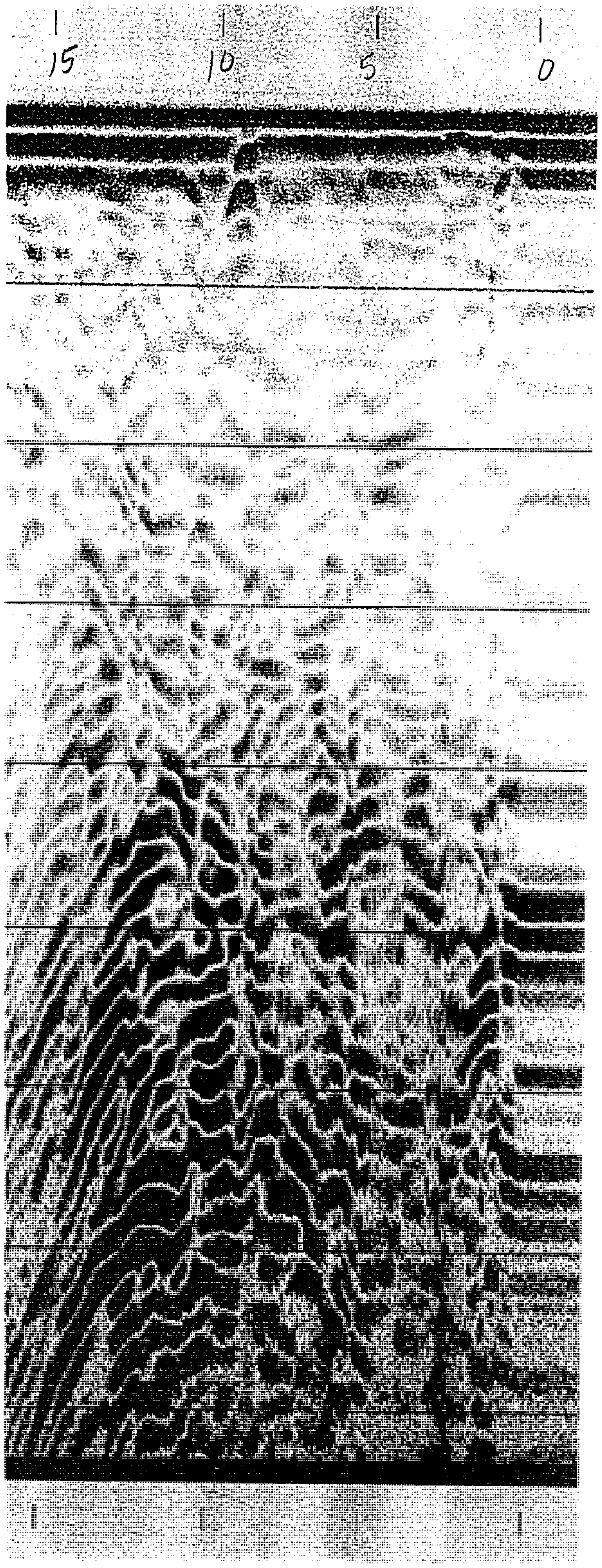
line 1+80 500mHz 80nsec



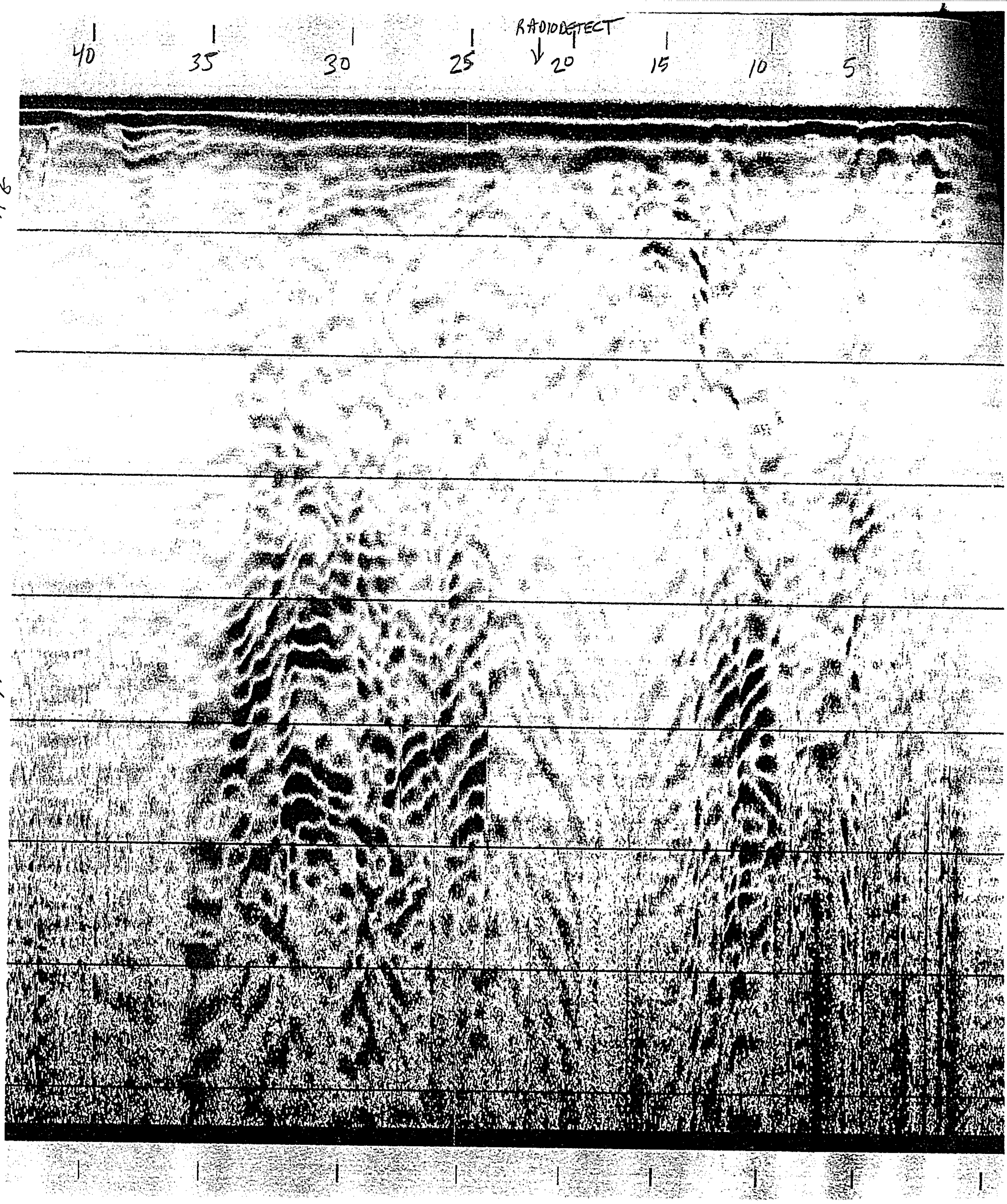


line 1+00 0->north 500 mHz

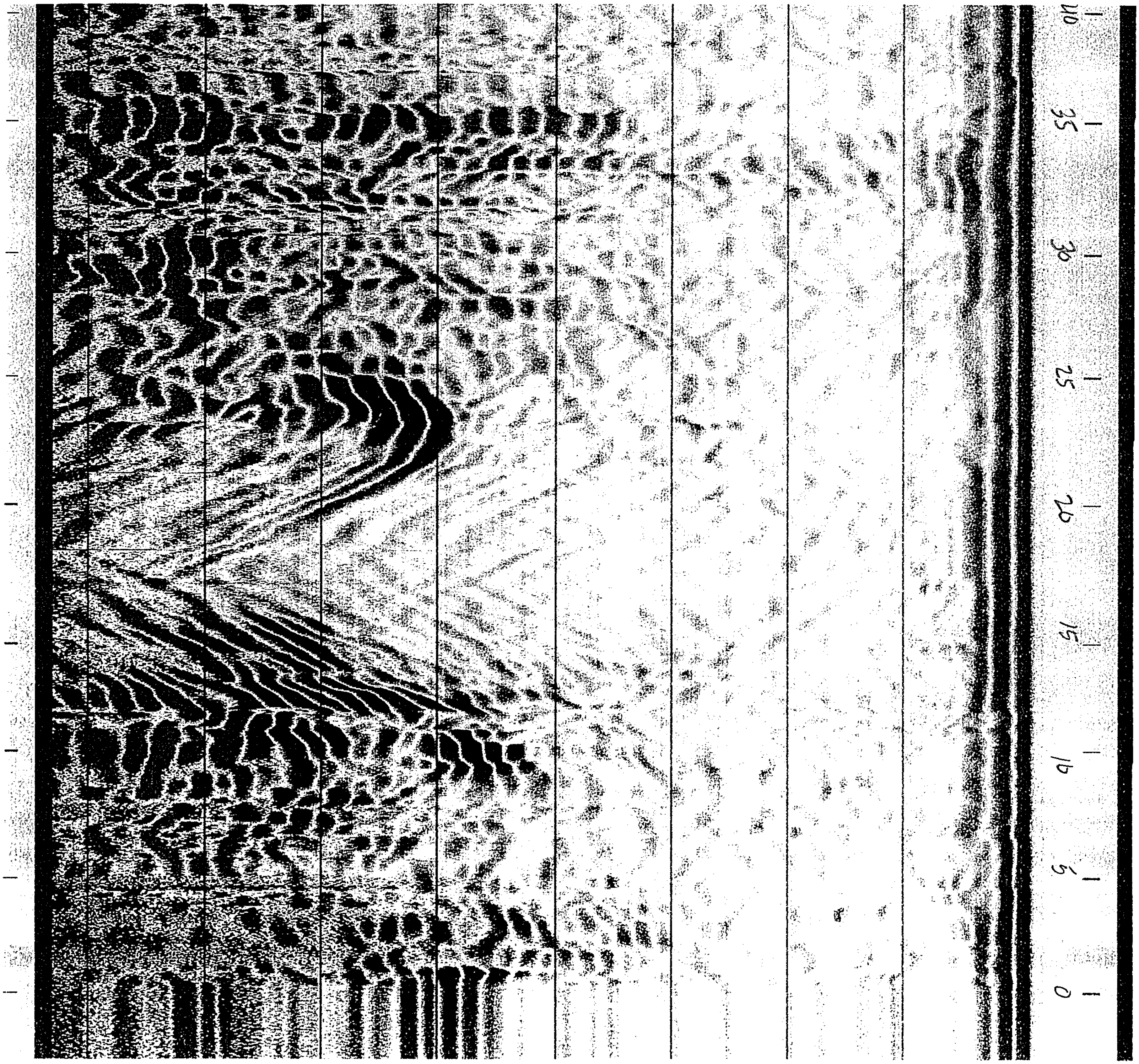




line 8+40 0->north 500 mHz

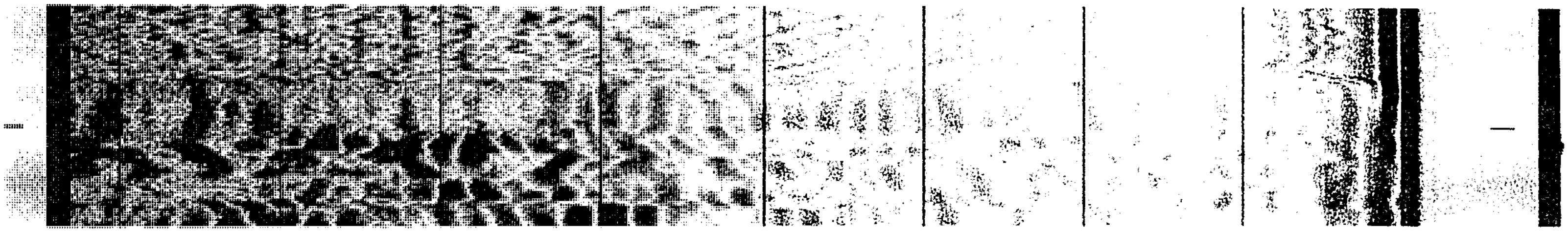


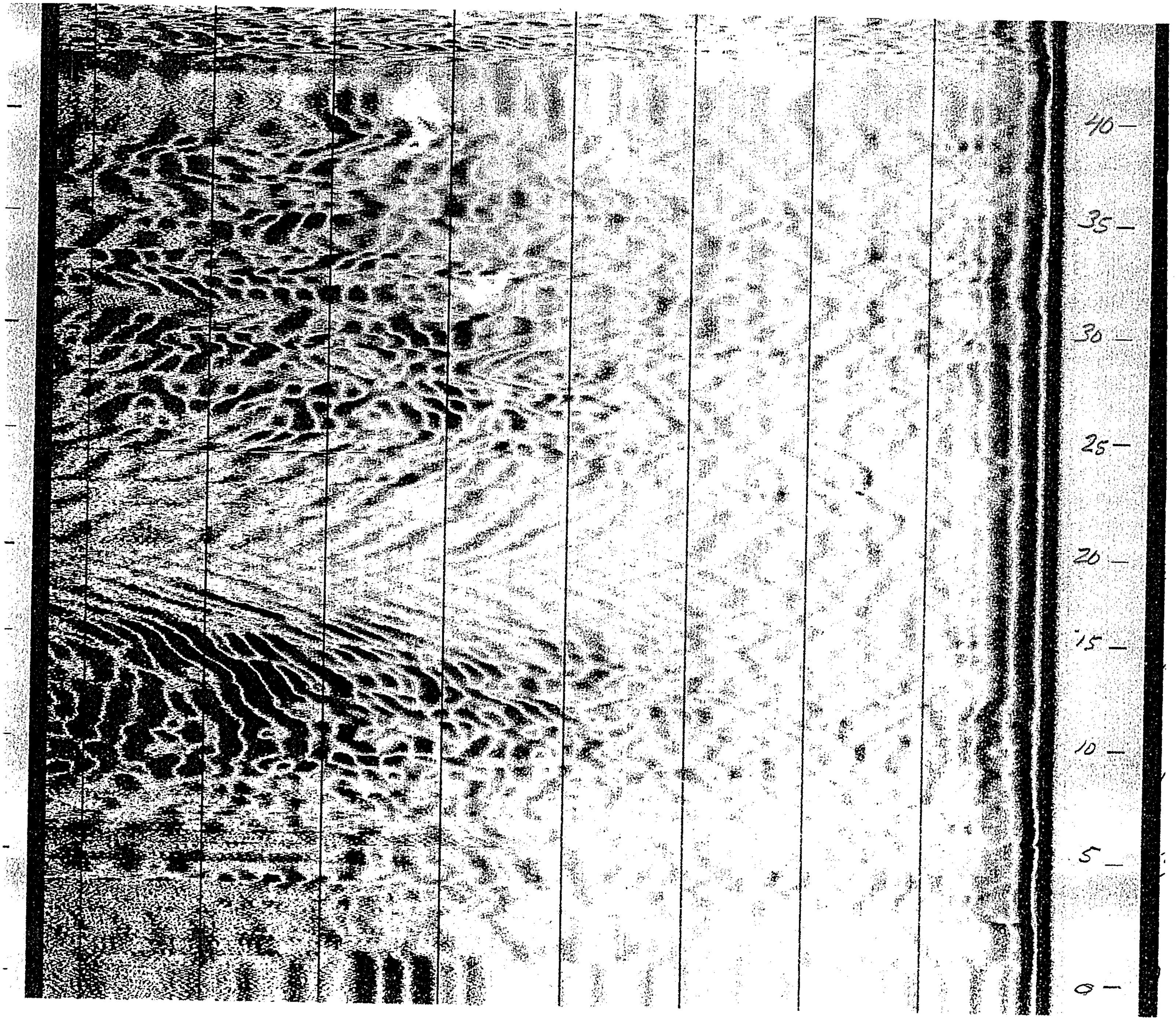
line 0-20 0→north 500mH



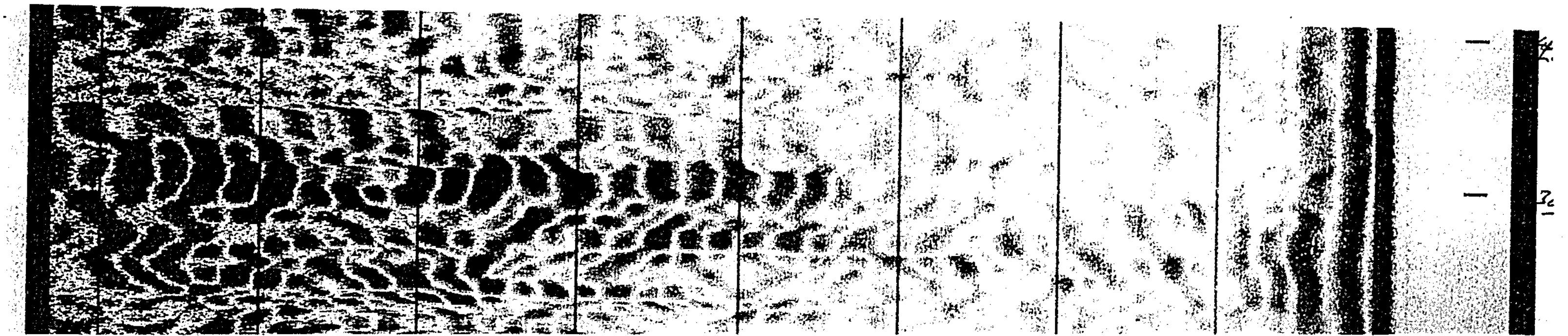
500mHz 80nsec

line 0+00





line - 0-20 0 → north 500m Hz



GPR Records
Site LMW-3&5 Portal Survey

GPR RECORDS

LMW 3+5 (Portal)

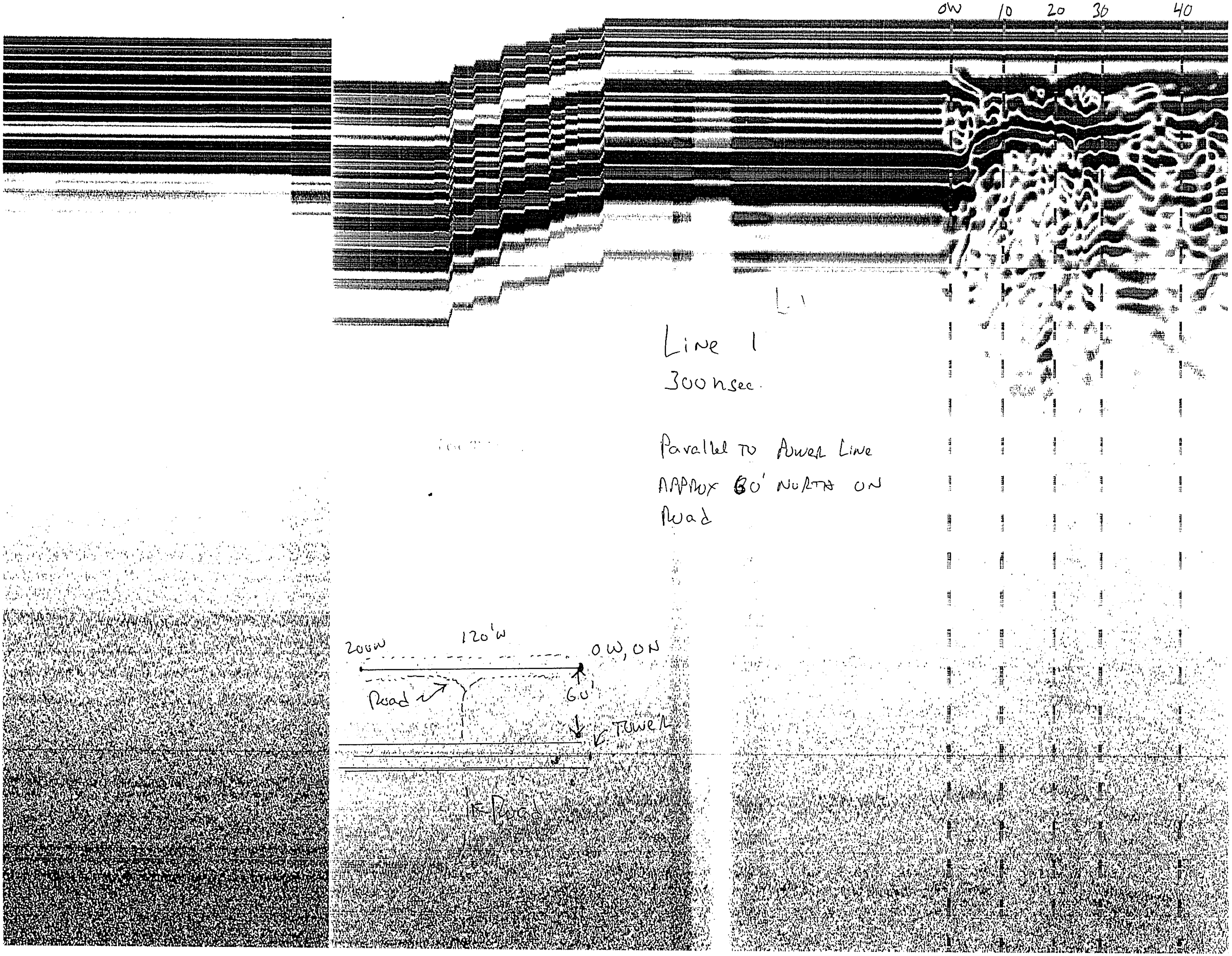
OCT 4, 1993

GPR 120MHz

LANDSBURG MINE

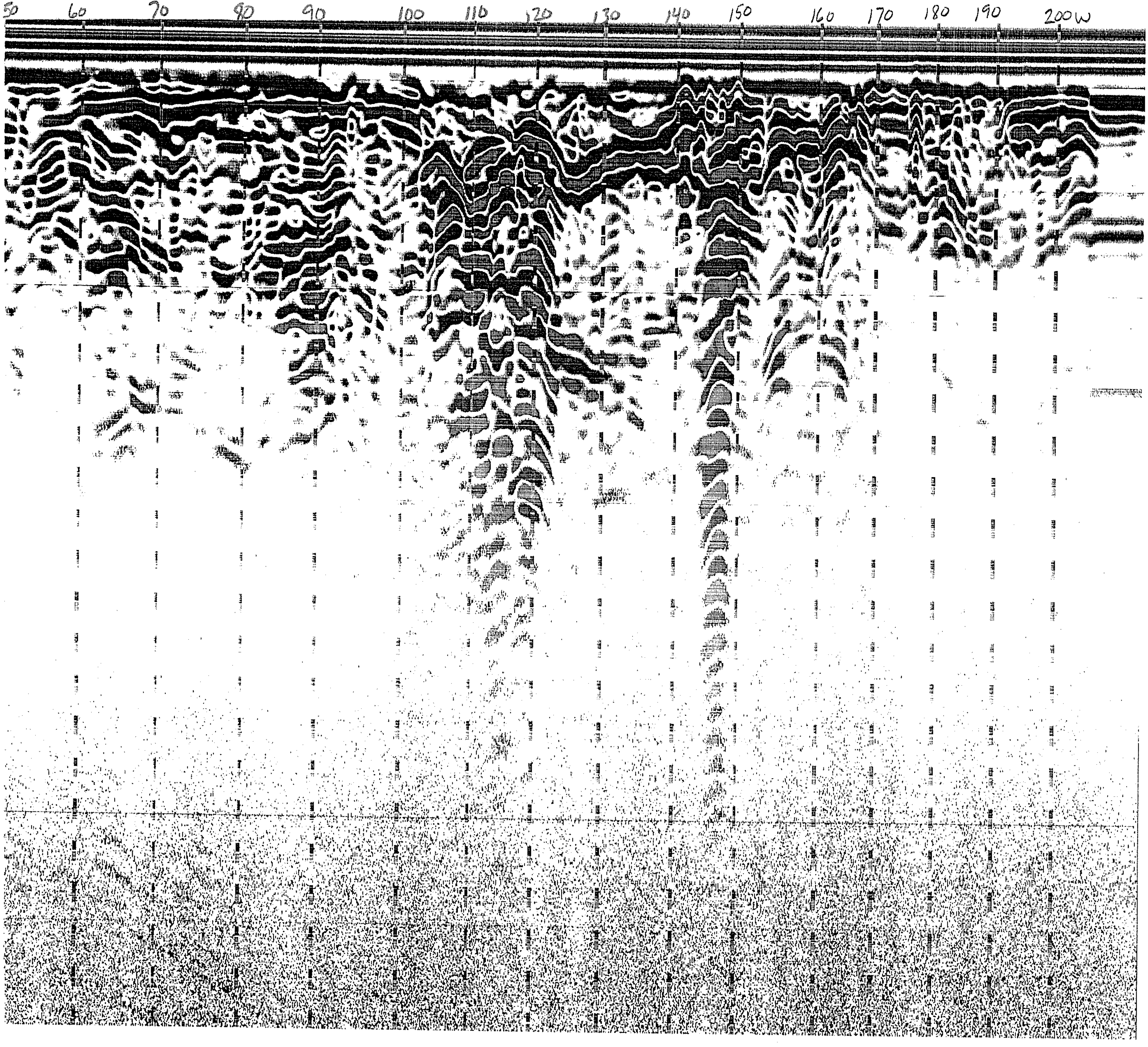
PORTAL SURVEY
WATER LINE SURVEY

923-1000.082



Line 1
300nsec

Parallel to Power Line
Approx 60' North on
Road



Line 2

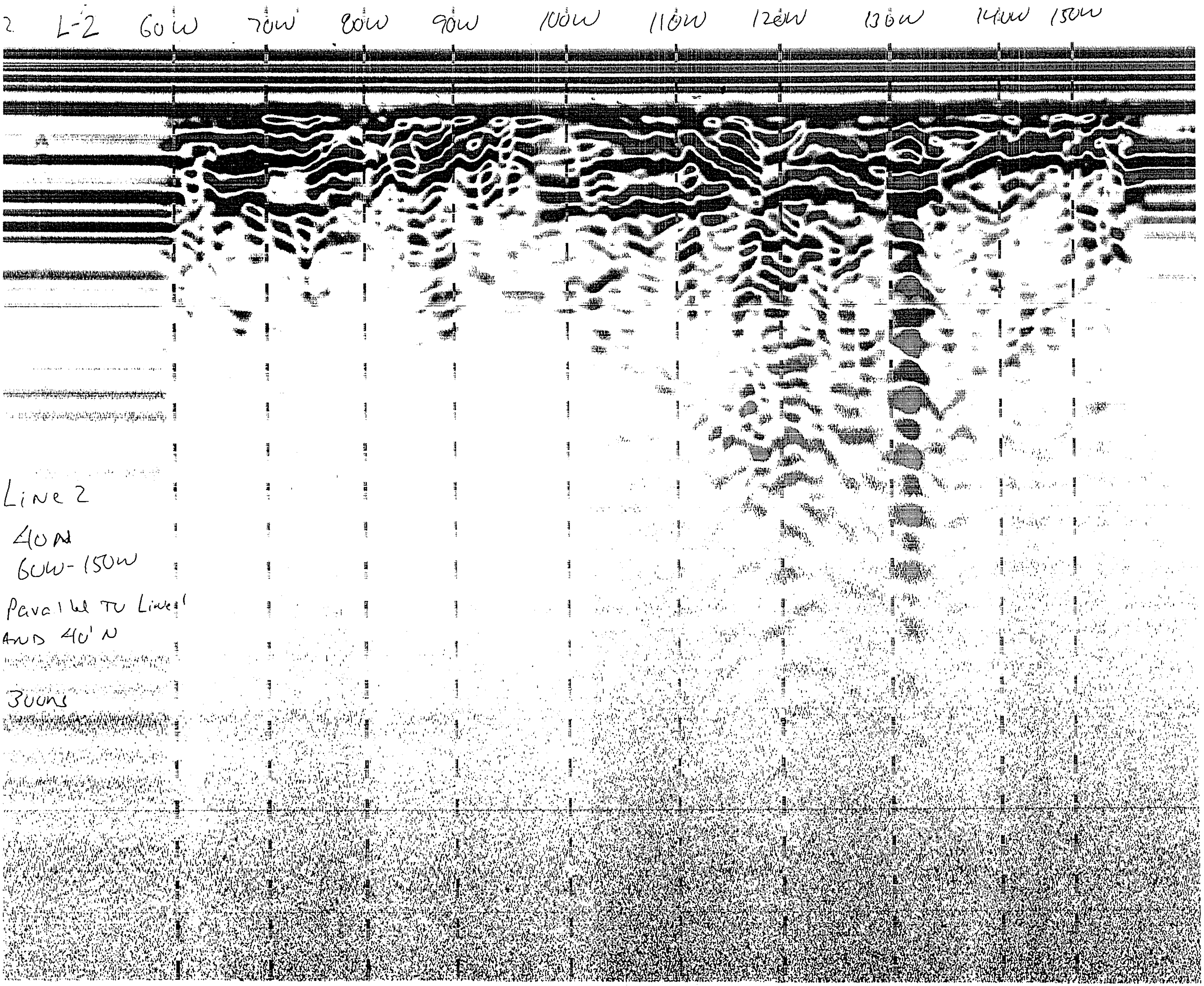
40N

60W-1

Paralle

AND 40

300ns



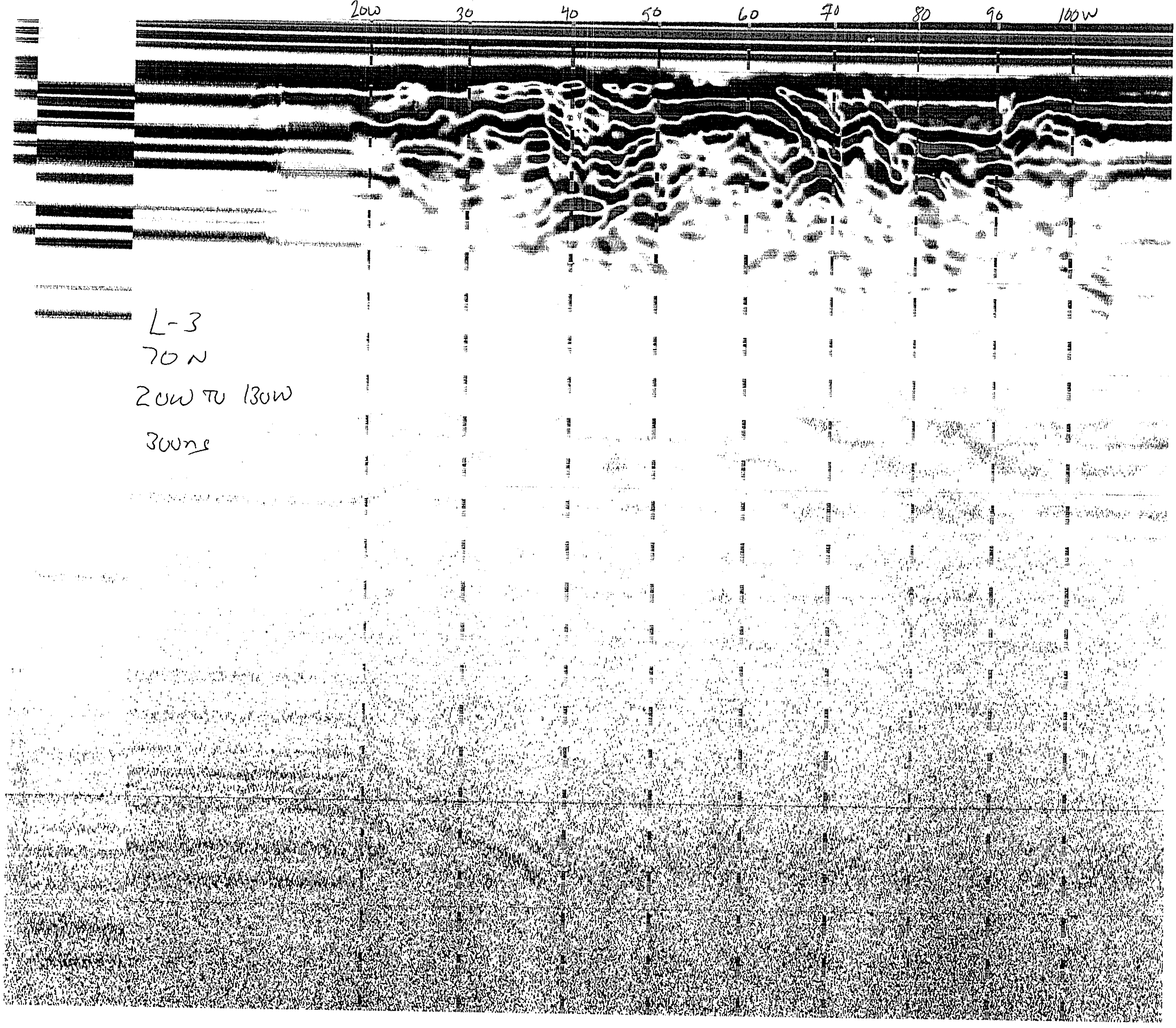
Line 2

40N
60W-150W

Parallel TU Line 1
AND 40' N

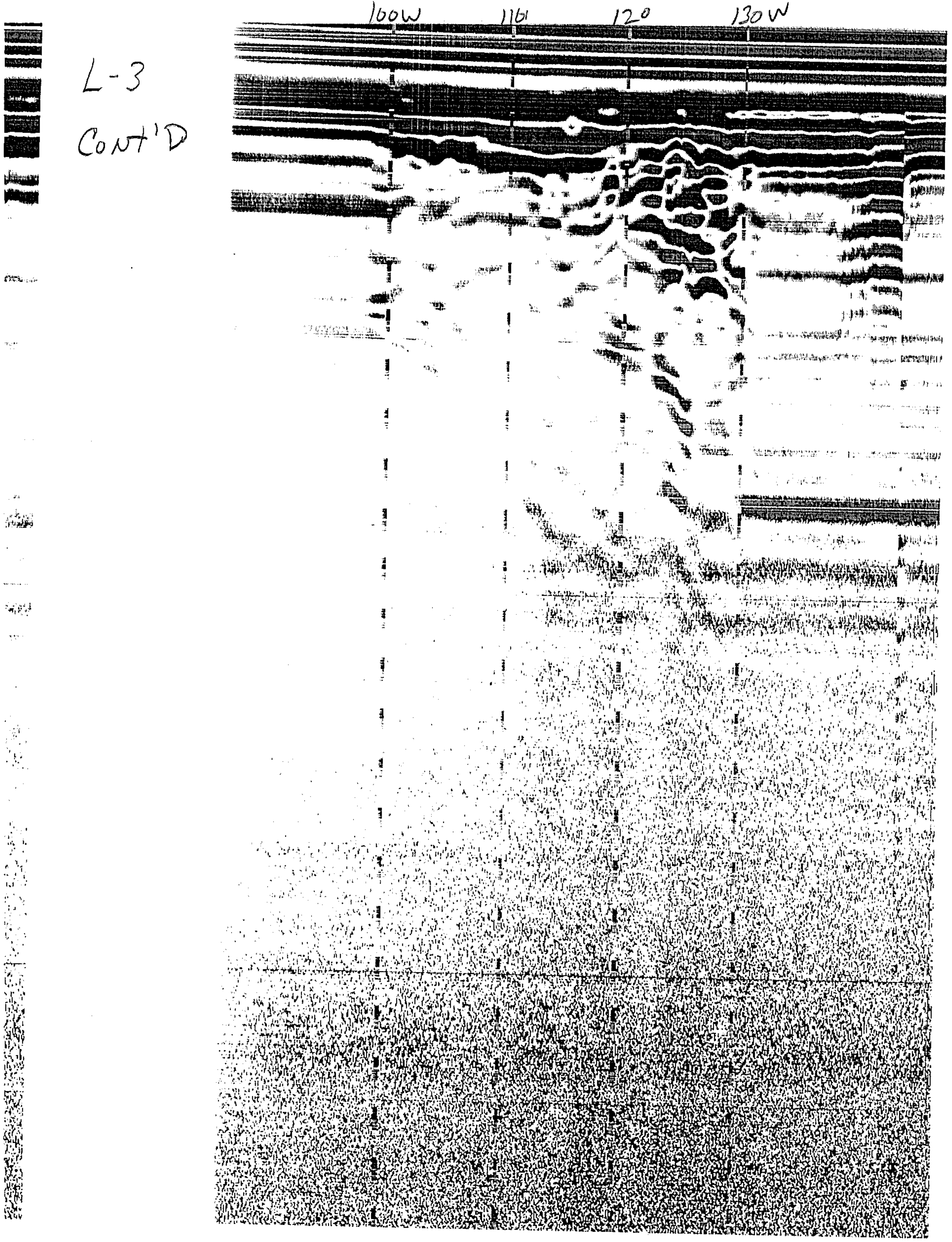
300ns

L-1
70N

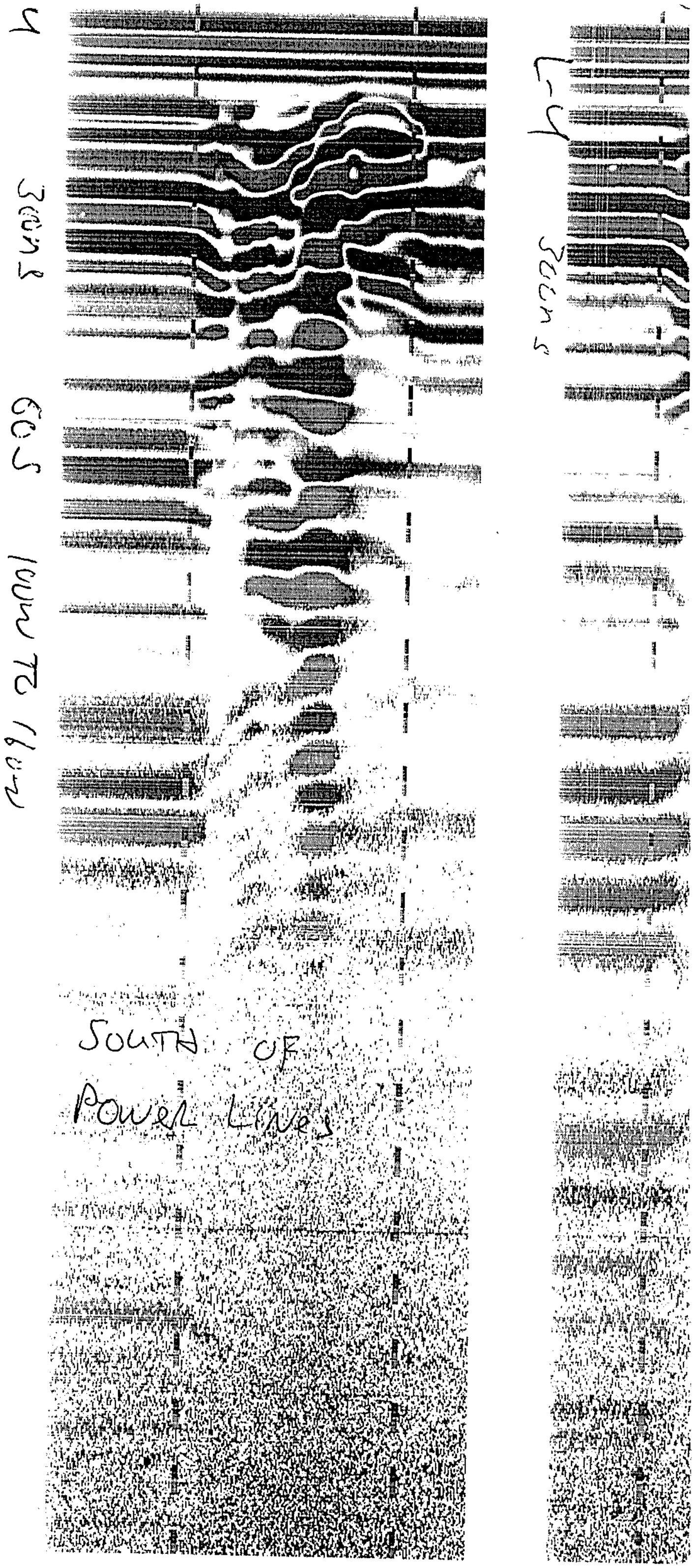


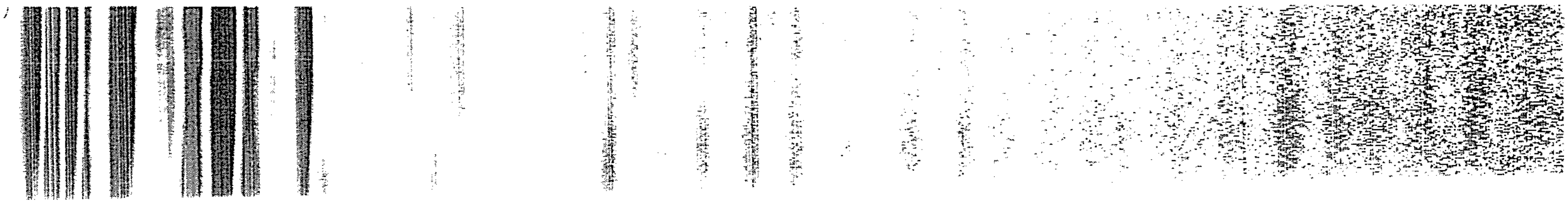
L-3
70N
20W TO 130W
300ns

L-3
CONT'D

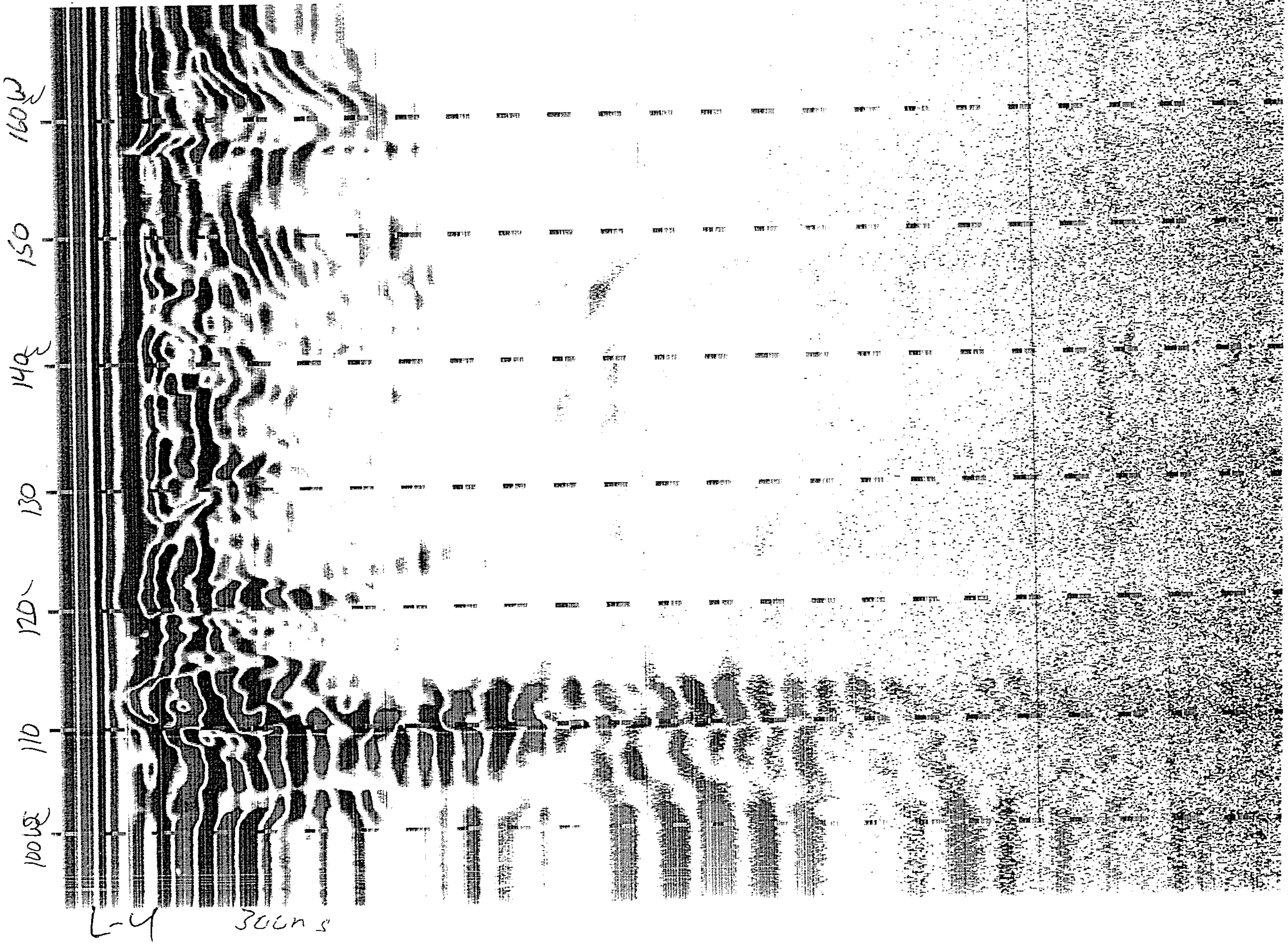

100W
110
120
130W

L-4

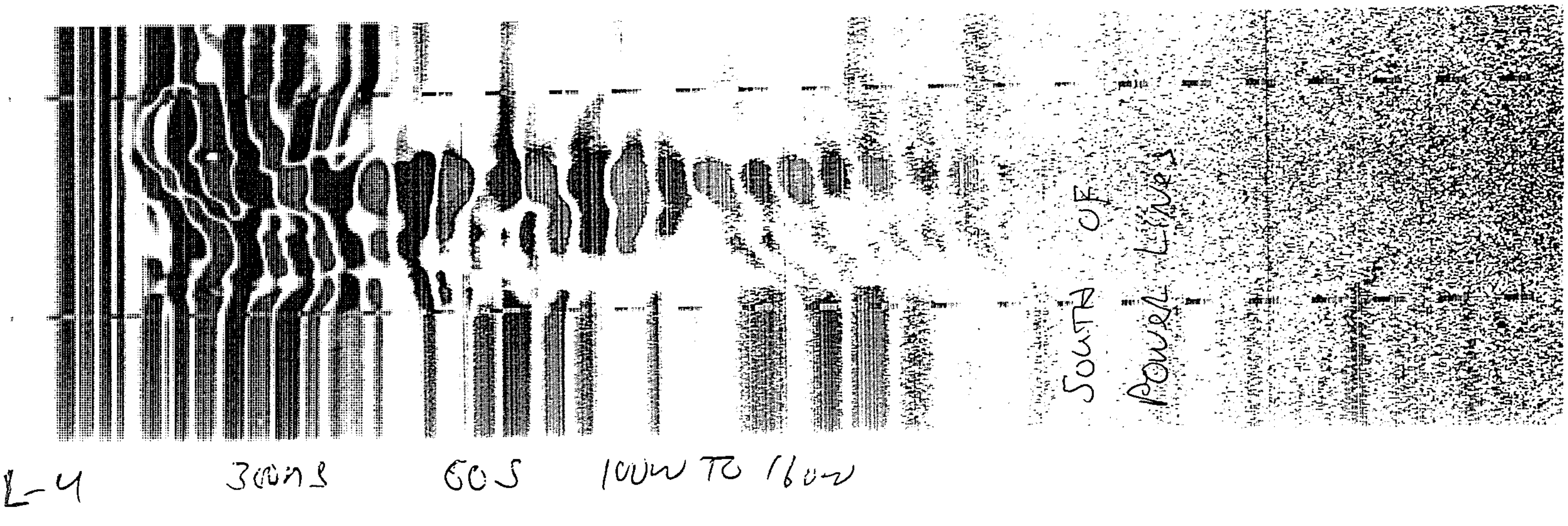

S
300ns
60S
100W TO 160W
SOUTH OF
POWER LINES
L-4
300ns



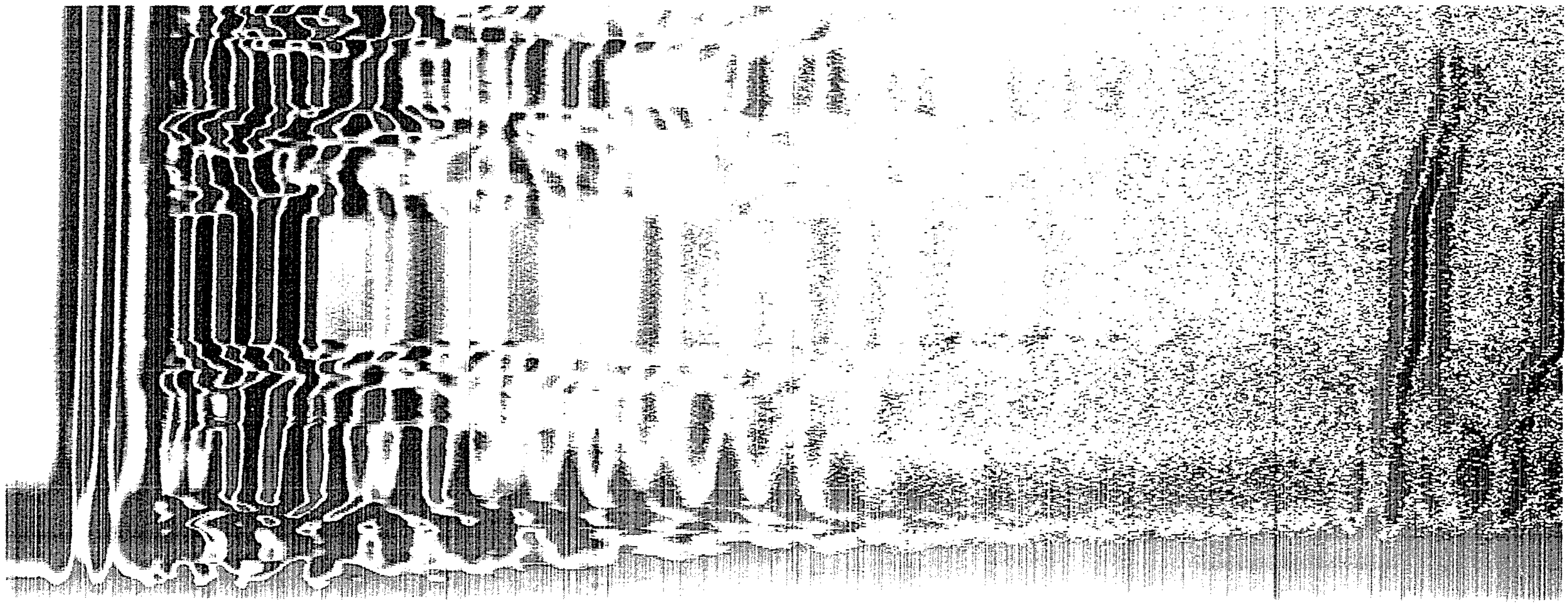
L- 5 40S 80W TO 130W



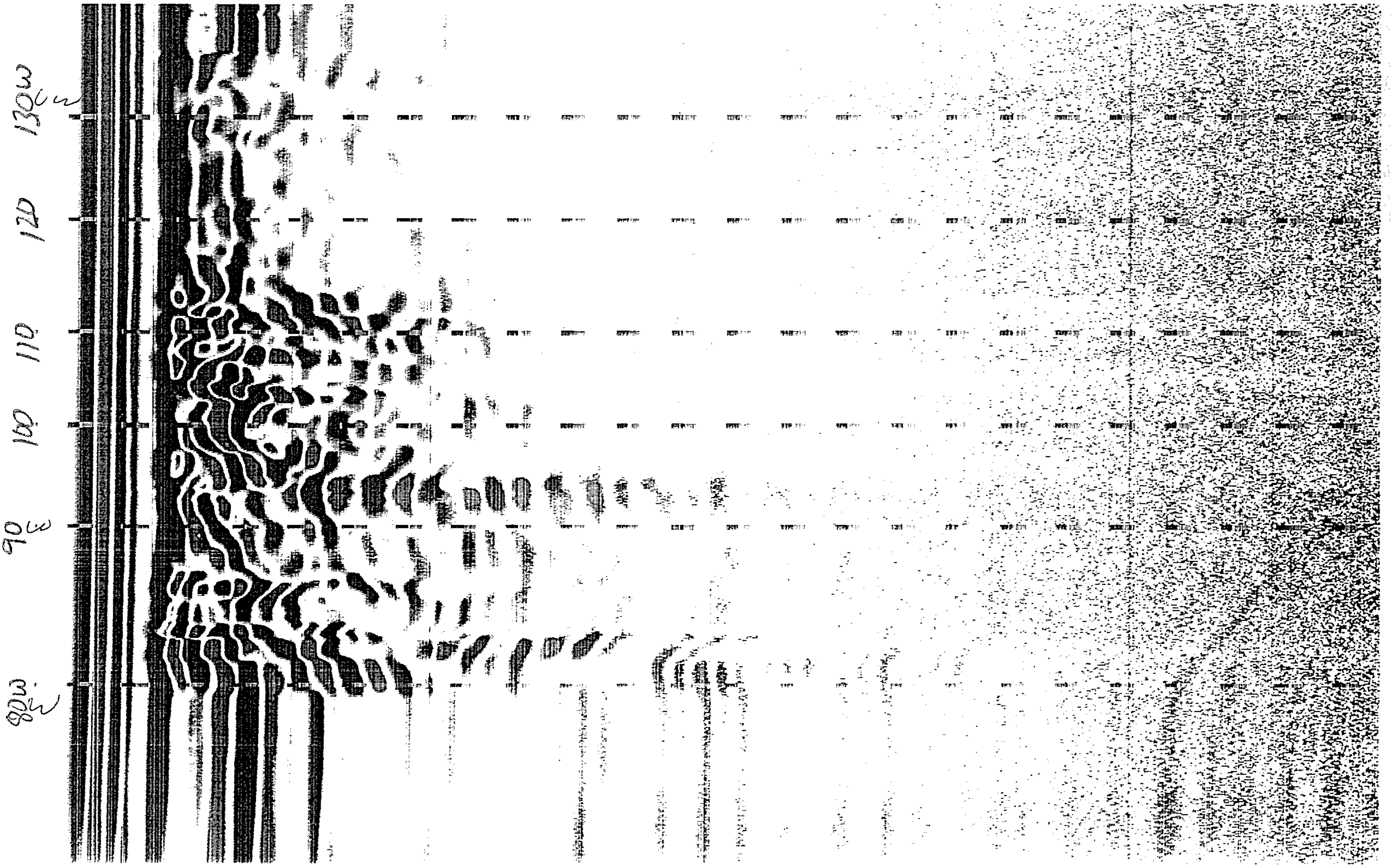
L-4 300ns



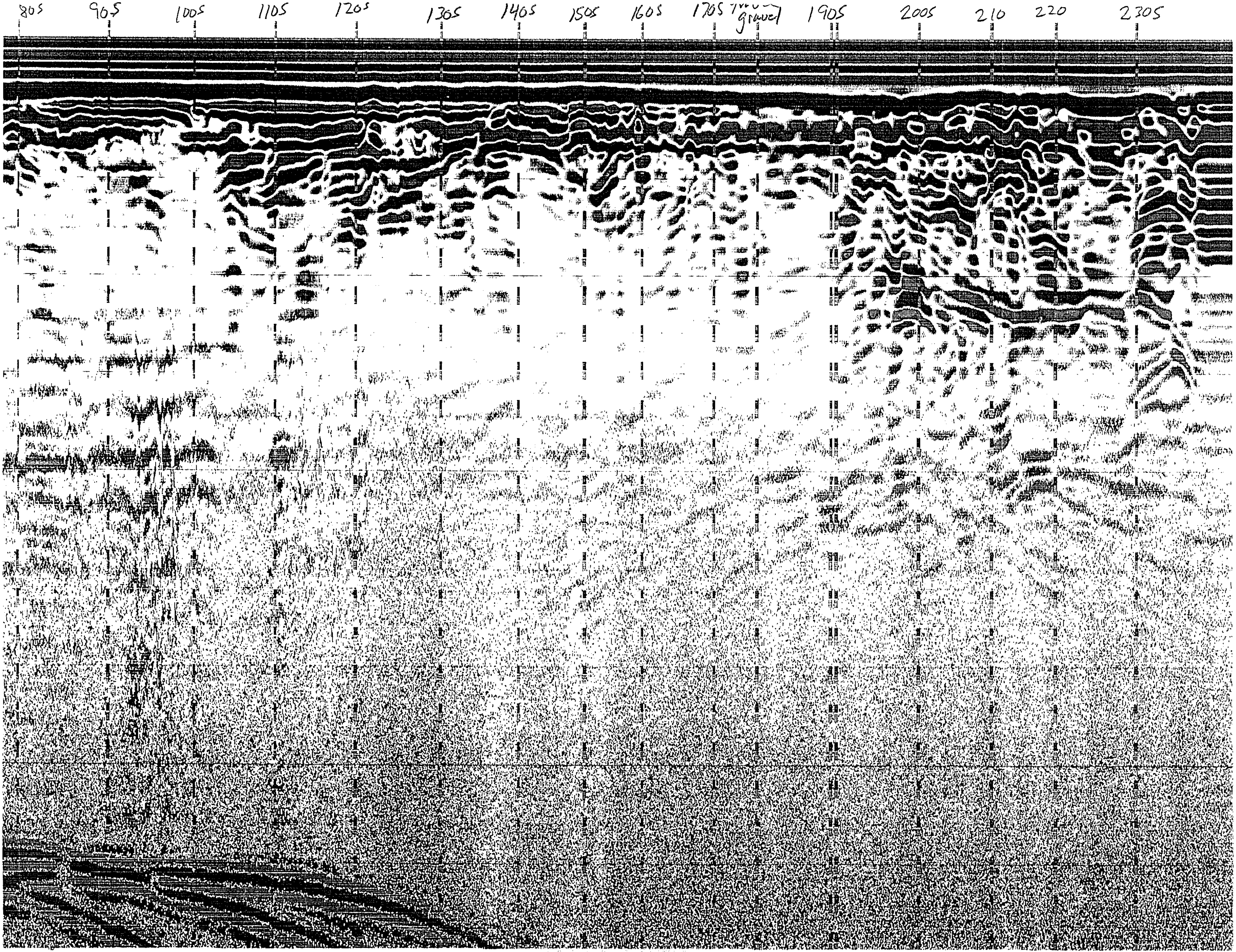
L-4 300ns 60S 100W TO 160W



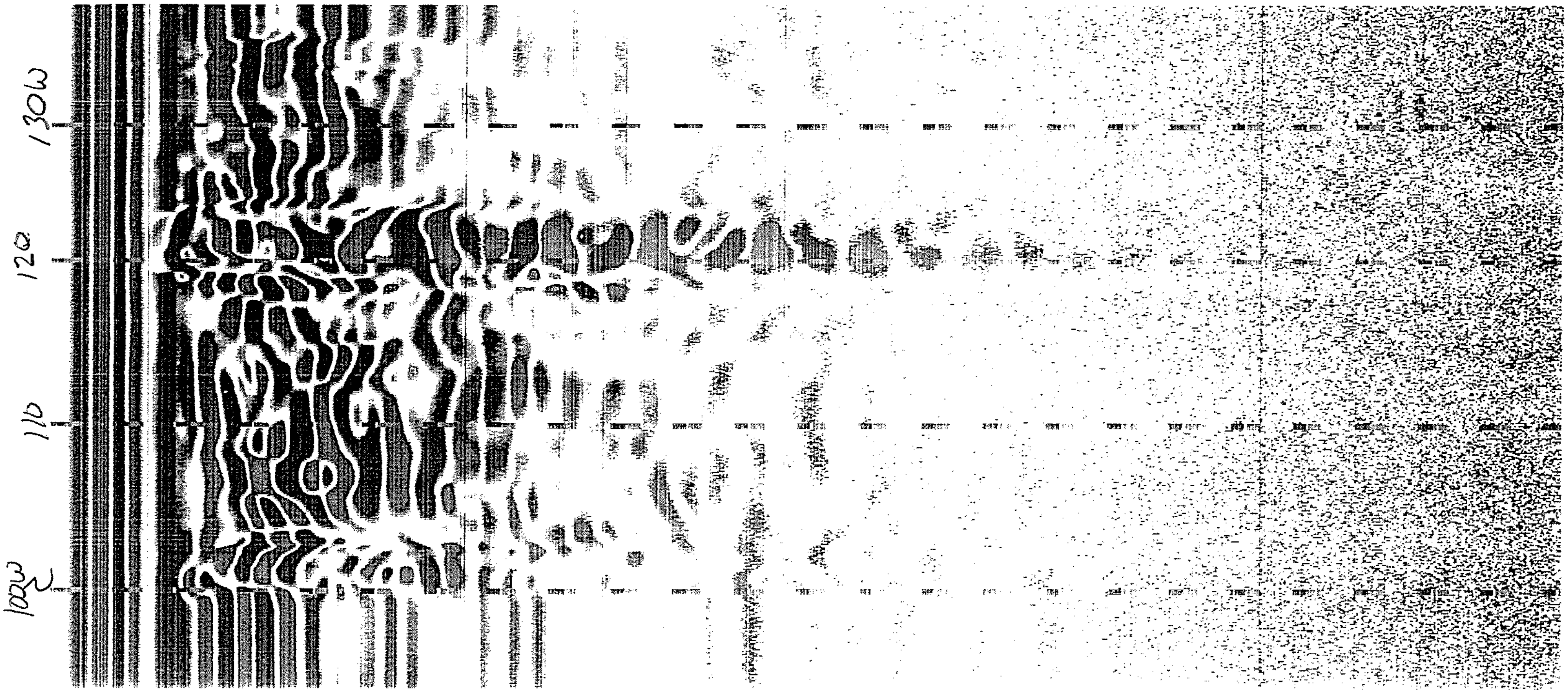
P.L.



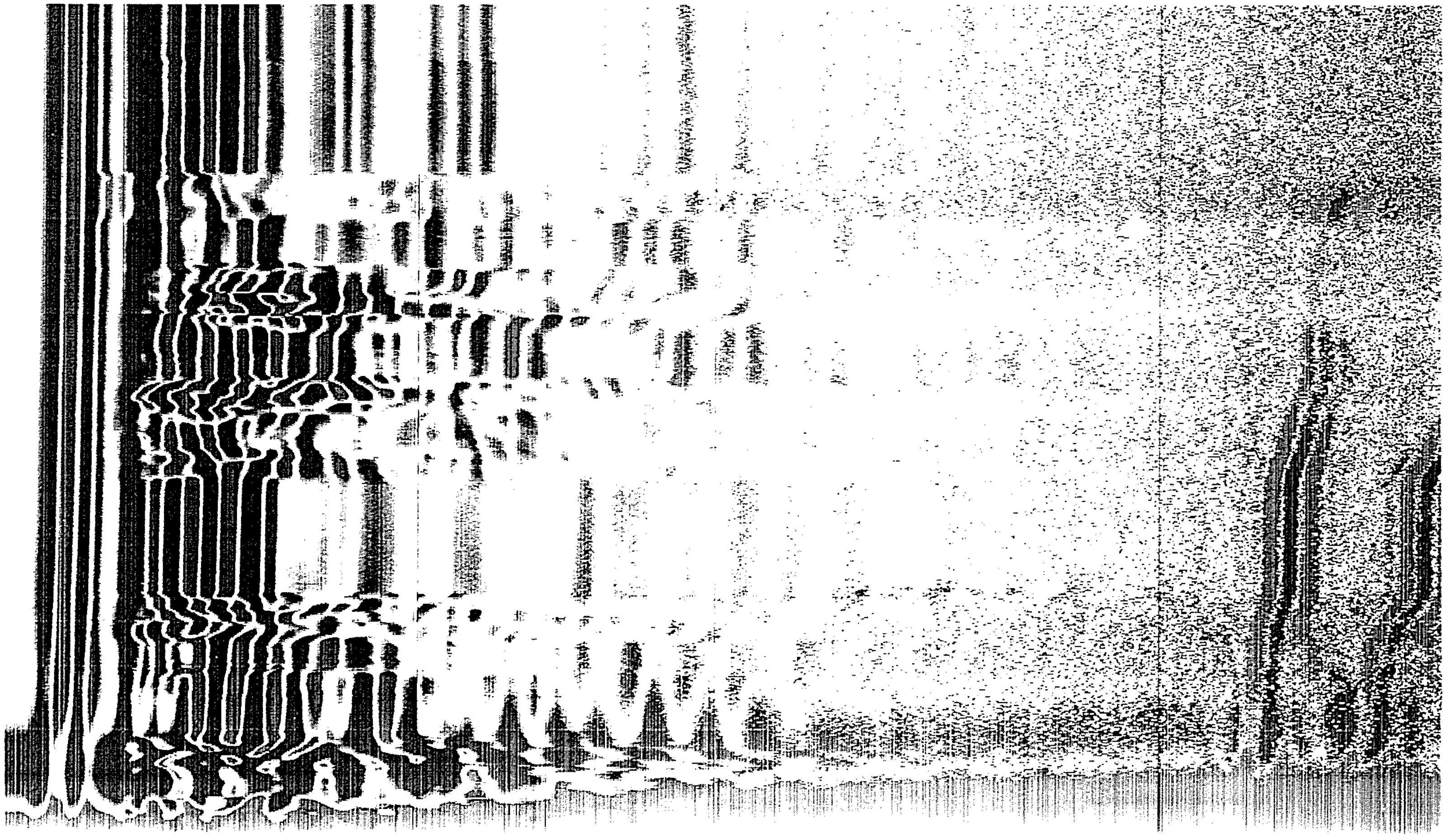
L-5 405 80W TO 130W


80S
90S
100S
110S
120S
130S
140S
150S
160S
170S
Gravel
190S
200S
210
220
230S

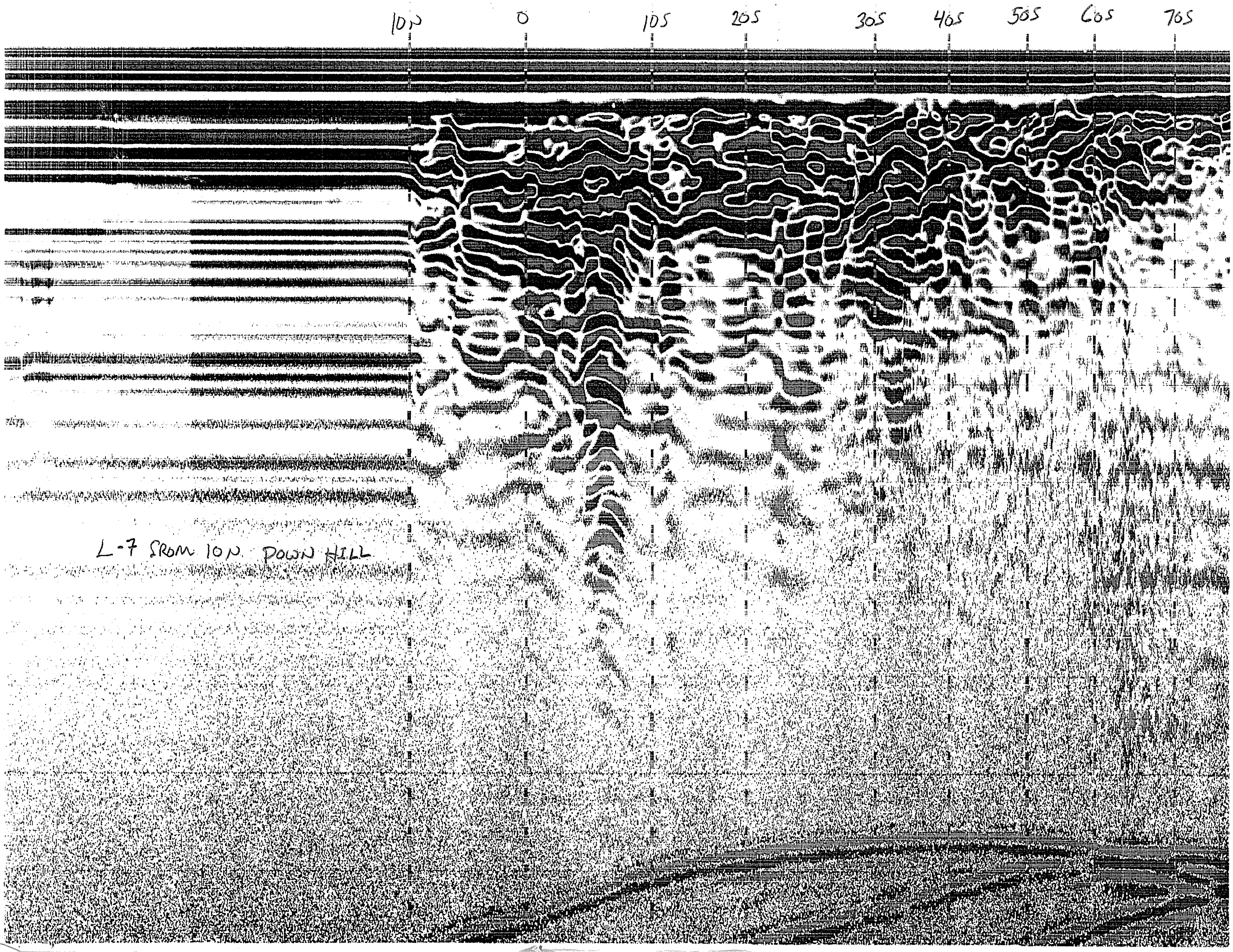
L-5 FROM 10N Down 4.11



L-6 10S 100W TO 130W



P. L.


10N
0
10S
20S
30S
40S
50S
60S
70S
L-7 SROM 10N DOWN HILL