LANDSBURG MINE

COAL MINE HAZARD ASSESSMENT

Prepared For

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1 Introduction

This report was prepared by SubTerra, Inc. for the Landsburg Mine Site Potentially Liable Party (PLP) Group to address and evaluate coal mine hazards in the vicinity of the Landsburg Mine site (see Figure 1). As illustrated in Figure 2, the Landsburg Mine site includes three zones of north south striking coal seams that dip between vertical at the northern end and near vertical (70 degrees) at the southern end. The site incorporates three distinct mining areas:

1. The central mining area is known as the Rogers Mine and consists of the Rogers No.1, Rogers No.2, and the Rogers No.3 Mines. This mining area is the focus of remedial activities being undertaken by the Landsburg PLP Steering Committee.
2. The mining area to the west of the Rogers Mines is known as the Frazier Mine (also referred to as the Frazier Workings of the Danville Mine)
3. The mining area to the east of the Rogers Mines is known as the Landsburg Mine (also referred to as the Landsburg Workings of the Danville Mine) where several, near vertical coal seams ranging from 6 to 18-ft in width were mined.

These mines have also been collectively referred to as the Ravensdale and Danville Mines (Hart Crowser, 1993, 2003) in reports prepared for the Office of Surface Mining Reclamation and Enforcement (OSMRE).

A greater emphasis is placed on the Rogers Mines in this report, as these mines are the primary focus of the Potentially Liable Party (PLP) Group. However, all coal mine hazards have been evaluated consistent with the King County standards for coal mine hazard analysis.

1.1 Purpose and Scope

The purpose of this report is to document and evaluate coal mine hazards above the three north south trending coal mine areas described above. The explicit scope of work included:

1. Compile and field verify a plan and sections showing the mined out areas and surface features for all three seams and various mines on the different seams.
2. Prepare a plan view map and rectify to surface coordinates in a CAD format capable of being imported as a layer in an “arcview” GIS system.
   a. The surface plan to show the areas of surface depression above the Frazier, Rogers, and Landsburg seams.
   b. Show slag piles proposed for trench backfill and provide a justification / analysis for using said slag as trench backfill. Provide recommendations as appropriate for full excavation and reclamation of slag pile areas.
3. Cross sections will be prepared as appropriate to document mine conditions, depth to coal or voids.
4. Perform stability and risk analyses in accordance with the King County requirements, determining the potential for surface subsidence, and the need

for setbacks from potential subsidence areas in all three seams (i.e., Frazier, Rogers, and Landsburg).

5. Prepare subsidence reclassification (severe, moderate, or declassified) and recommendations of allowable land uses in severe and moderate areas.

1.2 Background

The Landsburg Mine site is the location of an ongoing remedial action under the State of Washington's Model Toxics Control Act (MTCA). As noted above, the site is the location of several abandoned underground coal mines that were operated from about 1896 to 1977 when the last of the underground mines, Rogers No. 3 was closed. The site is located approximately 1.5 miles northwest of Ravensdale, WA in Sections 24 and 25, Township 22N, Range 6E, WM as shown in Figure 1.

The mined section of the Rogers coal seam has a near vertical dip and consists of coal and interbedded shale, approximately 16-ft in width. The mine section is about a mile in length. Mining occurred at depths of up to 750-ft using a mining method called "booming" which followed the coal seam vertically. A trench with near vertical walls formed as the result of subsidence following the excavation of coal in the Rogers seam. The dimensions of the trench vary from between 60 to 100-ft wide, between 20 and 60-ft in depth and cover an area about ¾ mile in length.

The trench above the Rogers seam was used in the late 1960's and early 1970's for disposal of industrial waste materials, construction materials, and land clearing debris. Drums, liquids from tanker trucks, and other industrial materials were disposed of in the northern portion of the trench.

Several preliminary environmental investigations were performed prior to 1991 and the initial involvement of SubTerra, Inc. Since 1991, site environmental investigations and remedial planning have been managed by Golder Associates with SubTerra, Inc. being responsible for evaluating remnant mine stability and the preparation of this report.

1.3 Approach

The initial project work began in 1991 involving data collection and an initial assessment of the stability of the remnant trench above the Rogers Mines. A conceptual model of the mine site and surrounding area was initially prepared (Golder Associates, 1992) for use in the technical evaluation of remedial alternatives. This section describes our approach to developing the mine site model and our overall approach to resolving Coal Mine Hazards in the study area.

1.3.1 Documentation of Mine Workings

Several mine plan drawings were obtained from local sources (see Section 3.1), spanning the life of the mines (1896-1977), and were integrated to form a single plan map of the entire mine development and coal extraction area. The computer software package, AUTOCAD 2000 Land Development was then used to form a 3-dimensional model of the underground mining areas and the current surface development. Various cross sections were then prepared through the site to further evaluate the mined workings and potential for the occurrence of surface subsidence.

Surveying and proof drilling were carried out by other Contractors retained by the PRP Group including Cramer Northwest and Triad Associates (surveying) and Golder Associates (geological, geotechnical, and hydrogeological site characterization). Golder Associates were also responsible for the overall technical management of the project for the Landsburg Mine Site PLP Group.

Survey data were integrated with the mine plan drawings and the results of proof drilling were used to “anchor” the northern and southern ends of the Rogers Mine workings. Frazier and Landsburg Mine workings were positioned relative to the Rogers Mine using the available mine drawings.

1.3.2 Mine Site Hydrology

Input to the mine site hydrologic model was obtained from mine plans, mine records (e.g., pumping data) and from interviews with miners who had actually worked in the mine. Additional detailed hydrogeologic characterization was carried out by Golder Associates and described in separate project reports.

1.3.3 Coal Mine Hazard Assessment

The potential for subsidence development on the site was evaluated using techniques initially developed for use in Colorado (CLMRD, 1986; Breeds, 1995) and subsequently codified as Washington State, King County Department of Development and Environmental Services Standards for Coal Mine Hazards (K.C.C. 21A.24.210).

1.4 Report Organization

The report is organized into six sections and three Appendices. Sections 1 and 2 contain the introduction and a description of the subject site conditions. Section 3 documents the layout and remnant condition of the mine workings in the study area and Section 4 presents the Coal Mine Hazard analysis. Section 5 presents our conclusions and recommendations and Section 6 contains the study references and bibliography.

2 Site Conditions

This section presents a description of the physical characteristics of the study area. An understanding of the physical environment of the study area is necessary for development of the mine stability assessment.

2.1 Topography

The local area is comprised of heavily vegetated, rolling hills. Elevations range from a low of about 500 feet above main sea level (msl) along the Cedar River to about 940 feet on the hill to the immediate east of the mine (USGS 1973). Topographic contours shown on Figure 2 were developed from aerial photography and provided to us by Triad Associates. The Triad provided topographic information is consistent with USGS topographic contours; however, the absolute accuracy of the elevation data is unknown.

2.2 Regional Geology

This section on the geology of the study area is based primarily on geologic mapping of the Cumberland quadrangle (Gower and Wanek 1963) and of the Maple Valley Quadrangle (Vine 1962). Mine records and plans obtained from Palmer Coking Coal Company were used to provide site-specific details to general area geology. Figure 3 illustrates the generalized surface geology in the study area.

2.3 Stratigraphy

2.3.1 Puget Group (Tp) Bedrock)

The oldest rocks exposed in the Cumberland quadrangle are the non-marine coal-bearing sedimentary rocks of the Eocene-aged Puget Group. Excellent exposures of these rocks occur in the canyon of the Green River, where a section of about 6,000 feet of the Puget Group is exposed. Neither the base nor the top of the Puget Group is exposed in this section.

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 of sandy 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 from massive outcrops. Some beds are ripple marked, and convolute bedding, and intra-formational 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 (Figure 3).

Most of the rocks of the Puget Group in the Cumberland quadrangle appear to have been derived chiefly from a plutonic or metamorphic terrain, but they also contain some volcanic detritus. A 20-foot bed of volcanic conglomerate composed of sub-angular to sub-rounded pebbles and cobbles of porhyritic andesite outcrops north of Georgetown in the northwest part of the quadrangle (Gower and Wanek 1963).

2.3.2 Glacial Drift

Most of the study area is covered by deposits of glacial outwash and till. The outwash is composed of stratified gravel, sand, silt, and clay. The till consists of unsorted clay, sand, cobbles and boulders. The outwash is confined largely to the lowlands, where locally it may be quite thick. Till also occurs in the lowlands, but most commonly mantles the hillsides. Some of the hillside areas shown as bedrock in Figure 3 are partly covered by a thin veneer of glacial drift that is not extensive enough to be differentiated on the map.

The majority of the Landsburg Mine area is mantled with glacial drift deposits. The higher elevations along the Rogers Seam had a thin veneer of glacial drift (likely Vashon Till) over the Puget Group sedimentary bedrock. At lower elevations in the extreme north and especially over the southern half of the Rogers Seam, the glacial drift thickens and consists of outwash deposits at the surface. Based on the interpretation of employee interviews and mining records, glacial tills may be present along the surface of the bedrock below these outwash deposits.

2.4 Geologic Structure

Throughout most of the mapped area, early Tertiary rocks are highly folded and faulted. The principal deformation occurred after the extrusion and deposition of the andesite volcanic rocks and before the deposition of the late Miocene sediments. The age of the upper part of the andesite volcanic rocks is unknown, but in the nearby area, west of Issaquah, marine sedimentary rocks of early Miocene age have been involved in the principal deformation (Warren et al, 1945). Therefore, in the Cumberland quadrangle the major period of deformation is assumed to have occurred during Miocene Time. Only gentle warping occurring after the deposition of the late Miocene sediments (Gower and Wanek 1963).

2.4.1 Folds

The bedrock in the Cumberland quadrangle has been completely folded into a series of north and northeastern trending folds (Gower and Wanek 1963). The Landsburg mine site geologic structure represents the western limits of a northeast trending anticline. The Puget Group strata dip steeply at the Landsburg Site. Dip angles of the Rogers coal seam and adjacent strata are near 90 degrees on the north end and gradually reduce to 63 degrees on the south end of the mine.

2.4.2 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.

Numerous faults were encountered during mining the Rogers coal seam. Most noteworthy is the fault in the northern portion of the mine where sufficient displacement (approximately 75 feet based on examination of mine plans (PCC, 1992)) occurred requiring a rock tunnel to reconnect mining operations to the coal seam. This fault extends vertically through all four levels of the Rogers Mine to land surface where an un-mined, and hence un-collapsed, rock pillar is used for the trench cross-over roadway. From a review of mine plans and records available from the mining operations on the Landsburg seam, a fault apparently was encountered at coordinate 9500N, 9000E. If this represents the same fault encountered, in the Rogers seam, the strike would be directly east-west, which is somewhat different then the majority of faults in the region. Records from the mining operations on the adjacent Frazier seam also indicated that a fault displacement may have been encountered close to 9500N coordinate which also could represent the eastward extension of this same fault observed in the Rogers and Landsburg seams.

2.4.3 Joints

The reviewed literature and data did not provide information on jointing in the study area. Joints were observed in the exposed sandstones along both the hanging and footwalls within the trench of the Rogers seam during a site visit 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 is expected to be parallel to site faults.

2.4.4 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). Faults that are steeply dipping with east-west strikes, such as the one observed in the Rogers Seam at 9500N, 8000E should therefore be tight due to the north-south compression.

2.5 Mine Groundwater Conditions

In the northern portion of the Rogers Mine, sedimentary bedrock of the Puget Sound group is either exposed or mantled with only a thin veneer of what appears to be glacial till (Vashon Till). Northward from Rogers Portal #2, glacial outwash and possibly alluvium appear to be present and deposits up to a maximum of 100 feet thick occur. The thickness decreases to a thin veneer or is missing at the extreme southern end of the mine at Rogers Portal #3. Interviews with mine employees and information in the mine records indicate that a “hard pan” or glacial till may be present between permeable glacial outwash deposits and the bedrock over the southern portion of the mine. The location of this “hard pan” was important during mining to avoid disturbance and groundwater inflow to the mine. Although the outwash aquifer may have been hydraulically separated from the bedrock during pre-mining conditions, subsidence during and following mining is expected to have disrupted the continuity of this till and enhanced communications between the groundwater in the glacial outwash deposits and mine workings.

Under current conditions, groundwater recharge to the glacial outwash aquifer is from direct infiltration of precipitation and surface runoff from high ground, especially from those areas having low permeability bedrock or glacial till close to the surface. Groundwater in the mine is expected to result from: (1) direct infiltration of precipitation and surface water entering the mine trench, and (2) seepage from the glacial outwash aquifer. The total recharge area to the mine is anticipated to be limited to the topographic drainage pattern in the immediate area. An estimate of total recharge to the Rogers coal seam can be made from mine dewatering rates during active mining operations. As evaluated in Section 3.5.4, the estimated average dewatering extraction rate was about 35 gpm during the wet season for the entire mine. However, there is some uncertainty whether these dewatering rates reflect current conditions with potentially increased hydraulic intercommunication between the glacial outwash aquifer and the mine workings.

The mine in the Rogers Seam is expected to have re-saturated since operations ceased. The groundwater level within the mine is estimated to be currently at an elevation of about 630 to 650 feet MSL based on the elevation of the Rogers #2 and Rogers #3 portals. Groundwater is discharging from these portals, at least during the wet season. Since the vertical seam was typically mined without vertically continuous pillars being left in place and the mine opening was backfilled with rock, it is expected to be hydraulically continuous with very high transmissive characteristics. The groundwater level in the mine is therefore expected to be close to the elevation of the portals.

Groundwater flow from the mine in the Rogers seam is expected to be controlled by the structure and bedding of the sedimentary bedrock. Coal seams are commonly the most transmissive units in the Puget Group. The sandstone exposed on the hanging and footwalls of the trench appears to be low permeability possibly with significant silt content as is typical of sandstones in the Puget Group. Other units within the Puget Group in the immediate area around the mine are shales and probably siltstones with permeability's lower than the sandstones.

Faults are commonly conduits for groundwater movement in bedrock aquifers. However, interviews with mine employees revealed that groundwater inflow to the mine did not increase upon encountering a fault (Falk 1992; Eltz 1992; and Simmons 1992). Other research has shown that faults in the region are typically tightly sealed and are not conduits for groundwater movement (Pappajohn 1992). During displacement, the wall rock of sandstone shale and coal would be comminuted, and infill along the fault plane. Also, the regional stress field with major principal horizontal stress oriented N-S, will also tend to reduce the transmissive properties of faults oriented E-W, such as encountered in the northern section of the mine.

3 Coal Mine Workings in The Study Area

This section represents a summary of the process undertaken to locate underground workings associated with the Landsburg Mines in the study area. This information formed the basis for our evaluation of the potential for additional surface subsidence and subsidence hazards associated with future planned use of the site.

3.1 Landsburg Mine Site Coal Mines

As noted in the Introduction, the Landsburg Mine site incorporates three distinct mining areas:

1. The central mining area is known as the Rogers Mine and consists of the Rogers No.1, Rogers No.2, and the Rogers No.3 mines. This mining area is the focus of remedial activities being undertaken by the Landsburg PLP Steering Committee.
2. The mining area to the west of the Rogers Mines is known as the Frazier Mine (also referred to as the Frazier workings of the Danville Mine)
3. The mining area to the east of the Rogers Mines is known as the Landsburg Mine (also referred to as the Landsburg workings of the Danville Mine) where several, near vertical coal seams ranging from 6 to 18-ft in width were mined.

These mines have also been collectively referred to as the Ravensdale and Danville Mines (Hart Crowser, 1993, 2003) in reports prepared for the Office of Surface Mining Reclamation and Enforcement (OSMRE). Historic mine records also refer to the Frazier and Landsburg workings of the Danville Mine as noted above.

3.1.1 Rogers Mines

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

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

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 2 and 5; 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 was produced.

The steep inclination of the coal seam led to the use of mining methods typically associated with the hard rock 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.

3.1.2 Landsburg Mine

The Landsburg Mine (see Figure 6) was operated concurrent with the later stages of the Frazier Mine from the mid 1930's through 1961. Three principal coal seams were mined with early mining from outcrop at the northern end of the mine in the 18-ft seam. The initial decline was subsequently abandoned after it caught fire and a new decline was established to the east (circa 1940). This decline accessed the 8-ft seam, rejoining the 18-ft seam south of the abandoned area with workings advancing towards the south. Approximately 3,000-ft of southerly advance occurred in the 8-ft seam through the end of 1946 with one reported sinkhole near the County Road. The underground mine continued to be operated by Palmer Coking Coal Company through 1961. A small strip pit was later excavated at the south end of the 18-ft seam in 1976 and 1977 when approximately 31,000 tons were mined.

3.1.3 Frazier Mine

Watkin-Evan's 1912 report (Watkin-Evans, 1912) notes that the Danville Mines were prospected as early as 1896 with discovery of the easternmost coal seam, which became known as the Frazier Workings of the Danville Mine. Initial attempts to mine in the area were unsuccessful due to faulting and the difficulty of mining in a near vertical seam. Mine maps indicate that mining started as early as 1896. Various companies including, North Coast Colliery, Danville Coal Company, Success Coal Company (1924 to 1926), Thermal Coal Company, and Palmer Coking Coal Company (1937 to 1959) operated the mine. The mine extended over a strike length of approximately 4,000-ft mining to a depth of 100-ft MSL (see Figure 8). A small strip pit surface mine was later excavated near the central portion of the mined Frazier seam in 1975 when a little over 3,000 tons of coal was extracted.

3.2 Data Sources

The preliminary data search involved contacting industrial companies, regulatory and public agencies and retired mining personnel who had worked at the most recently active mine, the Rogers No. 3 mine.

3.2.1 Office of Surface Mining Reclamation and Enforcement OSMRE)

Ms Ginger Kaldenbach of the OSMRE was contacted to find out whether that agency had on file any pertinent documentation for the Rogers mines and to determine the status of the caved area above the Rogers seam with regard to reclamation funding. The content of this conversation is summarized below:

- The OSMRE was created after the closure of the Rogers mine and was not the recipient of records on underground mine operations in the King County coalfields. Maps are best located through the Washington Division of Natural Resources.

- The caved zone above the Rogers seam has been identified as a hazard by the OSMRE but is not currently at the top of OSMRE's priority list. It was agreed that a written request for clarification of this issue was appropriate.

Mr. William Kombol of Palmer Coking Coal subsequently followed up with OSMRE and five sinkholes above the Landsburg mine were backfilled by an OSMRE Contractor in 2003 (see Section 4.4 below).

3.2.2 Washington State Division of Natural Resources (WADNR)

A visit to the Washington DNR was arranged through Mr. Tim Walsh and carried out on January 15, 1992. Data reviewed included:

- 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.

Copies of four mine maps were retrieved along with structural geology maps covering the project area. Copies of the Wellfield reports were subsequently obtained directly from the City of Seattle.

A subsequent attempt to locate editions of the Annual Report of Coal Mines from 1962 to 1975 involved a series of referrals (the Washington State Librarian, the Washington Department of Labor and Industries, and the Mine Safety and Health Administration). No production data for this time period has been retrieved to date except for the summary data provided in DNR's Open File Report 84-6.

3.2.3 United States Bureau of Mines (USBM)

Personnel from the USBM, Denver Technical Center were contacted to determine the availability of records for the Rogers mine; no data has been retrieved from this source to date. However, USBM Mine Inspector records were located in the archived PCC files retrieved from William Kombol's office.

3.2.4 Palmer Coking Coal Company (PCCC)

A visit was made to Palmer Coking Coal's main office in Black Diamond on January 13, 1992 to recover records for mines in the Rogers seam. Approximately 40 sets of drawings and maps were identified from a master list provided by William Kombol (PCC) and reviewed; thirteen (13) sets were retrieved for copying.

Archived files for the period covering the Rogers mine(s) operations were reviewed and two boxes of documents were removed for further examination. Pertinent records consisted of:

- 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.

3.2.5 Interviews with Retired Mining Personnel

A series of six interviews were arranged using a list of retired Palmer Coking Coal mining personnel provided by William Kombol during the January 13, 1992 meeting. Interviewees included:

- Mr. Jack Morris: President of PCCC during Rogers mine(s) operations.
- Mr. Bob Morris: Miner at Rogers Mine No. 3.
- Mr. Evan Morris: Vice President of PCCC during Rogers mine(s) operations.
- Mr. Carl Falk: Secretary of PCCC 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).

All but one of the interviews were carried out over a three day period from January 22 to January 24, 1992 (Mr Cameron Rich was hospitalized on the day scheduled for his interview). Each interview was conducted on an informal basis at the residence of each retired miner. Each interviewee was informed that the information to be provided would be treated confidentially. Two base maps were used as discussion points

(1) Rogers mine section updated by C. Falk on 11/1/72.

(2) Rogers mine/Landsburg mine plan updated February, 1967.

Information was solicited regarding water inflows, fault conditions, mining method and sequence, extraction ratio, condition of subsurface after mining, etc. A summary of the topics covered is presented in Appendix B along with individual interview records.

3.2.6 Review of Aerial Photographs of the Area

Copies of historic aerial photographs of the area were provided by William Kombol, PCC (see Appendix G). These photographs confirmed the surface expression of historic mining activity, including the locations of surface mine facilities. However, the more detailed historic information, contained in the mine plans, was used to construct the drawings and cross-sections provided in this report.

3.3 Coal Seam Characteristics

The Rogers seam strikes approximately north south and dips from between 90^o at the north end near the Cedar River to about 70^o at the southern limit. A typical east-west section through the seam locates a massive sandstone footwall, one foot shale, four (4) feet bottom coal, two (2) feet muck, four (4) feet top coal, five to eight (5 to 8) feet carbonaceous shale and shale, and a massive sandstone hanging wall (interview with Archie Eltz; USBM Roof Control Plan). The coal is classified as high volatile bituminous (Mine Inspectors Reports) with a calorific value of between 10,500 and 11,500 BTU/lb.

Three coal seams were mined at the Landsburg Mine, a 6-ft seam, an 8-ft seam and an 18-ft seam. The Landsburg seams also strike approximately north south and dip from between vertical at the north end to about 70^{o} at the southern end,

The area to the south of the Frazier mine, also referred to as the Upper Frazier Workings, accessed the Frazier seam and a second seam (farthest west) called the Jones seam These seams dip between vertical and 88^{o}. These workings are evidently not connected to the Frazier workings to the north, which were located in a 90^{o} dipping section of the Frazier seam.

3.4 Mining Methods

Due to the vertical orientation of the coal seams, the Landsburg 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" (see Figure 4) 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 16 ft wide by 10 ft high with a 10 ft by 10 ft counter mined approximately 30 ft above. Vertical chutes 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 4) 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 16 ft consistent with the width reported by personnel who worked underground (see Appendix B, Archie Eltz, Bud Simmons).

In the upper level, booming typically resulted in a cave to surface and coal was drawn down until the miners could see daylight (see Appendix B, Bud Simmons, Archie Eltz). This process caused short circuiting of the ventilation system requiring that the caved area be periodically backfilled from the surface (see Appendix B, Bud Simmons). 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 both miner and 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 (see Appendix B, Archie Eltz), 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.

3.5 Rogers Mine

3.5.1 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 3.1) 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 3.1, 3.2, and 3.3.

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 Nov, 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, it is suspected that the excavation may have daylighted in this area.

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 re-graded the surface to its present generally level topography.

3.5.2 <u>Coal Production and Extraction Ratio</u>

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 3.5. A total of approximately 890,000 tons of raw coal produced during the life of the three mines resulting in about 494,000 tons of clean coal.

Extraction ratios were estimated by:

(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 is 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.

3.5.3 Faulting

Several faults were documented on the mine superintendents drawings and the mine maps. Only one of the mapped faults resulted in complete loss of the coal seam. This fault was initially discovered at the bottom of the Rogers No. 1 slope and required construction of a 130 ft long rock tunnel to rejoin the seam. This fault also appears to have been encountered when mining the Landsburg seam some 750 ft east of the Rogers seam (Appendix B, Carl Falk); the location of this contact indicates that the fault strikes approximately east-west. Pertinent features of the smaller faults include; offsets of from 2-to-16 ft (Mine Superintendent's Drawings); polished surfaces (Appendix B, A. Eltz); and tightness (Appendix B, reports by all interviewed personnel that mining through fault zones did not result in increased water flow).

3.5.4 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 4th level to the 3rd, 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.

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 Bud Simmons 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.

The second estimate is based on telephone interviews with Bud Simmons and 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).

3.5.5 Remnant Condition of the Underground Workings

The remnant condition of the abandoned Rogers mine(s) workings will affect long-term stability of the trench and the potential for sudden collapse when operating heavy equipment in the trench.

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 (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 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 some material from outside the trench area was used for backfill during mine operations. In addition, the trench was subsequently used for disposal of solid, non-putrefactive waste (stumps, demolition debris, etc.)

A more rigorous engineering analysis of the stability of the surface trench is not warranted as the majority of the trench consists of broken, caved material and backfill. Nevertheless, although it is likely that a majority of trench bottom subsidence has already occurred, it is prudent to investigate subsurface conditions before proceeding with remedial actions. This recommendation is further supported by observations of one of the retired PCC personnel who noted that large slabs of sandstone, which were seen to cave into the trench, could possibly span underlying voids (see Appendix B).

Reports of floor heave and failing roof support posts and crossbars in the lower levels confirms the expectation that significant movement of the hanging wall, and to a lesser extent the footwall, will have occurred at the relatively high extraction ratios estimated for the lower levels. There are two aspects of this mode of deformation, which may be of potential importance to this study. Firstly, movement will have occurred until a point of stability was reached where the horizontal stress is balanced by the strength of the caved material and hydrostatic pressure associated with the flooded workings. This action would serve to restrict major vertical deformations. Secondly, these deformations may have resulted in an increase in permeability, parallel to the bedding and strike of the coal seam in the footwall and hanging wall rock. Observations in the surface trench and photographs of the underground mine workings (e.g., see Appendix F) indicate that the disturbed area would be limited to a few feet in thickness.

3.6 Landsburg Mine

3.6.1 Mine Layout and Sequencing

The Landsburg mine was initially mined from the north via declines starting in the early 1930's. Mine records indicate that a single level was initially mined from the first decline towards the south. The initial decline was subsequently abandoned after it caught fire and a new decline was established to the east (circa 1940). This decline accessed the 8-ft seam, rejoining the 18-ft seam south of the abandoned area with workings advancing towards the south. Approximately 3,000-ft of southerly advance occurred in the 8-ft seam through the end of 1946 with one reported sinkhole near the County Road. Recovered records indicate that mining occurred from a single level, however, it is possible that mining also occurred in a level above the one shown on Figure 6 in the early mining stages. A third decline accessed the Landsburg seams from the south with mining on three levels indicated on the mine plans. It is also possible that an upper, fourth level was mined although no records were recovered that indicated it was.

Mining occurred primarily in the 18-ft seam, however, crosscuts were driven in the rock between the 18-ft and the 6-ft and 8-ft seams to access their coal reserves. The mine was reported to be subject to spontaneous combustion that was probably the cause of the earlier mine fire that led to the closure of the initial decline. The following description of the mining method was obtained from the State Inspectors Report:

> "Master chutes, next to the footwall on 45- to 50-degree angles are driven up, along strike and in the coal bed, off the gangway at regular intervals. The master chutes are equipped with a 2 ½ ft wide chute and a 3-ft gage track. From the master chutes, level rooms, designated as crosscuts, are driven about 35 to 45 ft apart vertically along the strike and next to the footwall of the coal bed for distances of about 200-ft inby and outby of the master chute. The level places are 10-ft in height and 10-ft wide. Intermediate transfer chutes were driven next to the footwall on a strike angle of 50 degrees about 50-ft apart, to transfer the coal to cars on the gangway. The 35-ft to 40-ft pillars of coal left between rooms or crosscuts are mined on full retreat by the "booming" method, working from the highest room down, in sequence. Long holes are drilled, loaded and fired and the loose coal is moved to the chute by either scraper or shaker conveyors."

One of the saddest moments in the life of a coal mine is when a fatality occurred and there were several reported fatalities in the Landsburg mine (see Appendix C). The first accident occurred in 1951 when John Henry, a 58-year old miner fell 100-ft down a coal chute. A second accident occurred in 1954 and involved the collapse of the floor in a counter causing two miners to fall into the chute below. The first of the miners, Ray Coutts was rescued unharmed but the body of the second miner, Harry English, could not be recovered despite 8-days of intense effort. Another accident was reported in January 1955 when four miners were killed by “a cave extending to surface filling the gangway and counter with water, mud and debris”. Records also indicate that the bodies of Frank Stebly, Louis Valenti, John Kovash, and Nathan Russel were not recovered. A memorial was established east of the Rogers No. 3 portal (see Figure 7) that commemorates the deaths and internment of these men in the Landsburg Mine.

Reports of these accidents indicate that the coal seam was caved to surface suggesting that similar conditions existed above the Landsburg mine as currently exist over the Rogers Mines.

3.6.2 Coal Production and Extraction Ratio

Coal tonnages for the Landsburg Mine were reported as 38,000 tons between 1932 and 1937. PCC took over the Danville mine in 1937 and coal tonnages for the Danville Mine (Landsburg and Frazier seams) are reported as 663,000 between 1937 and 1961. An additional 31,000 tons were mined from a strip pit at the south end of the 18-ft seam from 1976 to 1977. In 1984, WADNR’s inventory of Washington State abandoned coal mines listed the total Danville Mine production at 874,400 short tons.

The same mining method was used in the Landsburg mine as was subsequently used in the Rogers mines. Furthermore, similar amounts of coal were extracted from each of these mines along an approximately equal strike length suggesting an equivalence of extraction ratio (i.e., 70 to 90%).

3.6.3 Remnant Condition of the Underground Workings

Far less is known about the remnant condition of the underground workings in the Landsburg mine than was discernable for the more recently mined Rogers Mines. However, published records indicate that the same mining method was used at Landsburg as was subsequently used in he Rogers Mines so that similar remnant conditions are likely to exist. Sinkholes have been mapped above the Landsburg at both the southern and northern ends of the project. Sinkholes at the northern end appear to be associated with some of the earliest mining (see Figure 6) while sinkholes at the southern end appear to be associated with the most recent workings in the 18-ft seam.

Several of the sinkholes that developed above the northern end of the Landsburg Mine have been backfilled and marked with permanent monuments (see Appendix E; Hart Crowser, 2003, for OSMRE).

3.7 Frazier Mine

3.7.1 Mine Layout and Sequencing

Mine records indicate that mining started near the middle of the seam in 1896 but was not successful. This is probably because early mining occurred near surface in a faulted part of the seam (see Figure 8). Mining was subsequently carried out using two declines to access workings in the northern section of the Frazier seam. Up to three levels appear to have been worked from these declines. Additional mining occurred to the south from a third decline that accessed two vertically extensive mining levels.

A record of the make-up of the coal seam is contained in a 1934 publication by the University of Washington (Daniels, 1934):

Roof, coarse sandstone	
Coal, bone streaks	2’ 00”
Carbonaceous Shale, soft	03”
Coal, bone streaks	7’ 00”
Floor, dark gray shale	

3.7.2 Coal Production and Extraction Ratio

21000 tons of coal was reportedly mined from the Frazier seam between 1896 and 1928. Production records from 1937 onwards commingle tonnages produced from the Frazier and Landsburg workings of the Danville mine with accumulated tonnage reported at 874,400 short tons (WADNR, 1984).

Recovered mining sections indicate that similar mining methods were used to extract the 7-ft thick Frazier seam as were used to mine the Landsburg seams, and the range in extraction ratio (i.e., 70 to 90%) is therefore likely to be the same.

3.7.3 Remnant Condition of the Underground Workings

Even less is known about the remnant condition of the underground workings in the Frazier Mine than was discernable for either the Landsburg or Rogers Mines. However, similar mining methods were used in all three mines and it is likely that the remnant condition of the Frazier mine is similar to both the Landsburg and The Rogers Mines. Sinkholes have developed above the southern sections of the Frazier mine, as shown on Figures 2 and 8, and may have also occurred over the relatively shallow northern workings.

A shallow rock tunnel (see Figure 8) drains upper areas of the northern mine workings towards the Cedar River.

3.8 Evaluation of the Relative Position of Mine Workings and Surface Features

There is always some uncertainty regarding the precise location of historic, abandoned, coal mine workings due to the lack of accurately identifiable surface features and the age and accuracy of historic survey data. Part of our work therefore concentrated on placing the mine workings using historic survey data and then confirming placement accuracy by proof drilling.

3.8.1 Approach

We began the process by reviewing and digitally scanning all of the pertinent and available mine maps. Drawings generally consisted of plan (aerial) and cross-section (subsurface) map views of the Landsburg, Rogers and Frazier Seams at various levels of detail.

Supporting information included a collection of historic Landsburg Coal Mine maps provided by Palmer Coking Coal Company, data extracted from microfiche records in the

Washington State Coal Mine Collection, land survey information provided by Triad Associates, and previous reports prepared by Golder Associates, Inc.

The plan map information was then superimposed on the base survey map, and each available cross-section was then correlated with the overlying topography and established mining areas. Land section lines and surface topographic features were subsequently used as common reference points to locate the mining areas in relation to Triad's current (2002) survey. The established locations of the mining areas were then integrated to create a three-dimensional model using the AUTOCAD computer aided software package.

Even though the map collection included a complete set of plan (aerial) maps for the mining areas, several areas lacked correlating cross-section (subsurface production) information.

Through our review of the mine maps and previous reports, we have a high level of confidence in the relative positioning of the Rogers and Frazier Mines. We also have confidence in the positioning of the "Landsburg Strip" at the south end of the Landsburg mine. However, we have moderate uncertainty in the relative position of the underground workings on the north side of the Landsburg Seams.

3.8.2 Positioning of Rogers Mines

Map K of King County File K55 was used initially to position the Rogers Seam mines relative to the surface roads, section lines, and river. Proof drilling or Ground Proofing was subsequently carried out at the northern and southern ends of the Rogers mines during installation of monitoring wells.

Figure 9 show the results of proof drilling at the southern end of the Rogers mine adjacent to the Rogers No. 3 Portal. The observed offset can be eliminated and the portal area better matched with surface data if the mine is "moved" towards the south. Figure 10 demonstrates the accuracy of the "relocated" mine based on the southern proof drilling data. At the northern end, the "relocated" workings also better match the proof drilling data as illustrated in Figure 11.

3.8.3 Positioning of Frazier Mine

The Frazier mine workings are anchored on the north end by the located water level tunnel positioned just south of the pipeline road. The remainder of the mine was positioned using surface survey points shown on the historic mine drawings.

3.8.4 Positioning of Landsburg Mine

The northern end of the Landsburg mine workings were located, relative to the Rogers seam workings using Map K of KC File 55. The southern end was located using data from a section showing the 1976/1977 Landsburg Strip and a plan showing the relative location of the southern Rogers and Landsburg declines.

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4 Coal Mine Hazard Evaluation

4.1 King County Coal Mine Hazard Analysis Requirements

King County has previously identified coal mine hazard areas on an area wide basis without detailed analysis of site specific subsidence potential. Their sensitive Areas Ordinance (recently superceded by a Critical Areas Ordinance) requires that a Coal Mine Hazard assessment be conducted by a qualified Civil/Mining Engineer and that areas be classified as “Severe”. “Moderate”, or “Declassified”. A copy of the King County requirements is provided in Attachment A.

4.2 Subsidence Mechanics and Modes of Surface Failure

Traditional methods of subsidence prediction are not appropriate with regard to analyzing the long-term stability of the Landsburg Coal Mines where the coal seams are near vertical. Subsidence, in this case, has typically been confined to an area directly up-dip from the extraction zone where the migrating void forms a sinkhole. In the case of the Rogers Mines, a trench was formed where several sinkholes coalesced.

The remnant condition of the Rogers Mine Trench has been outlined above in Section 3.5.5. Trench wall stability, on the south side of the rock bridge, was further evaluated by excavating a 2-ft wide, temporary trench perpendicular to the east side of the larger trench. This exploratory trench encountered very hard sandstone and siltstone just below the weathered rock surface that could not be dug by the excavator.

Encountered materials were massive in nature with little to no evidence of cross-bed fracturing. The resultant rock mass strength was estimated to be in excess of 3,000 psi (estimated UCS > 8,000 psi) with trench wall stability controlled by bedding. This is consistent with the reports of trench wall failure involving “slabbing”.

The entire trench above the Rogers Mines will be backfilled as part of the remedial action so that any potential for trench wall failure will be restrained.

4.3 Use of Coal Mine Spoils for Trench Backfill

Coal mine spoil stockpiles are located at the southern end of the site just west of the Landsburg Mine Strip Pit; near the Frazier Mine; and north of SE 253rd Street (also known as the Morris Mine Connection Road). Additional stockpiles are also located off site in the town of Black Diamond. These stockpiles contain rock (e.g., sandstone and shale) that was hauled out of the mines with the coal and subsequently separated from the coal using mechanical methods and washing. Neither of these processing methods removed all the coal and the stockpiles therefore contain weathered shale, siltstone, and sandstone with disseminated coal.

These materials will generally be of low strength and should be suitable for general trench backfill where material strength is not important. The carbon content of the remnant coal and shale may provide beneficial attributes to the goal of filling the trench with benign material. The material may not be suitable for use as fill or cover above grade, however, this should be determined during final design of the trench cap based on strength tests of the stockpiled materials.

4.4 OSMRE Sinkhole Remediation

The Office of Surface Mining Reclamation and Enforcement (OSMRE) carried out two closure programs within the study area in 1993 and 2003.

4.4.1 OSMRE Navy Mine Project (1993)

OSMRE completed several coal mine hazard mitigation projects in the vicinity of the project in November 1993 (Hart Crowser, 1993). One AML feature, identified as L-01 in the previously referenced report, was thought to be a subsidence located above the Landsburg Mine workings. This feature was backfilled with approximately 200 cubic yards of controlled density fill to a depth of 12-ft below grade (see Appendix E).

4.4.2 OSMRE Project No. WA-03-002 Danville Mine Project (2003)

Five abandoned coalmine features (RV-01 through RV-05) located roughly above the Landsburg Mine (see Figure 2) were remediated by OSMRE in August 2003 (Hart Crowser, 2003). Prior to reclamation, the five features consisted of steep sided, near-circular depressions that ranged in diameter from 25 to 80-ft with an average depth between 8 and 30-ft. Each feature was filled and graded to a slope of about 2:1 (H:V), hydroseeded, and identified with a monument consisting of a steel pipe cast into concrete (see Appendix E).

4.5 Coal Mine Hazard Areas

4.5.1 Severe Coal Mine Hazard Areas

Severe coal mine hazards within the study area are associated with the subcrops and outcrops of the mined coal seams where sinkholes have either already formed or where there is a significant potential that sinkholes will form in the future. Three severe coal mine hazard areas have been established as shown on Figure 22:

1. Portions of the tract set aside for the Rogers Mines (Tract X).
2. The area surrounding the 6-ft, 8-ft, and 18-ft seams in the Landsburg Mines.
3. The area surrounding the Frazier Mine.

The areas identified as “severe” on Figure 22 also include foot-wall and hanging-wall buffers intended to account for uncertainty in the positioning of the underground mine workings. Descriptions of the affected property parcels are provided in Appendix H.

4.5.2 Moderate Coal Mine Hazard Areas

No areas have been classified as subject to moderate coal mine hazards.

4.5.3 Declassified Coal Mine Areas

The areas outside the previously noted coal mine hazard areas are deemed to be declassified coal mine areas.

5 Conclusions and Recommendations

The project work described in this report has been accomplished over a twelve year period starting in 1992 with the development of a conceptual mine model, and ending in 2005 with the preparation of this coal mine hazards assessment report. The following conclusions can be drawn from this work:

- Six seams have been mined in the project area, Jones, Frazier, Rogers, and Landsburg 8, 6, and 18-ft seams. These seams dip near vertical and have been extensively mined as shown on the drawings in this report.
- Sinkhole type subsidence has occurred throughout the project area immediately up dip of the underground workings. Typically, sinkholes have developed concurrent with and/or shortly after mining in the upper levels of the individual coal seams. However, there are areas over the Landsburg seams where sinkholes, associated with deeper levels, have been discovered after mining ceased. Therefore, while widespread future subsidence is unlikely, there is some potential for additional subsidence of this type to occur in the future.
- A significant volume of open subsidence trench exists above workings in the Rogers mines. Mine spoils can be used to backfill below grade portions of these trenches. However, this use must be acceptable to the Designer of the final trench cover, assuming that this remedial technology is eventually employed.

The following conclusions can be drawn regarding the positioning of abandoned mine workings:

1. The Rogers seam workings are positioned to an accuracy of ±25 feet in the east-west direction and ±50-ft in the north south direction.
2. The Frazier seam workings and the southern end of the Landsburg seam workings are positioned to an accuracy of ±50-ft.

The following conclusions can be drawn regarding groundwater flow and migration:

1. There were no incidences of inflows recorded along faults or cross-bedding on the mine plans or sections.
2. There were no incidences of inflows reported along faults or cross-bedding during interviews with historic mine personnel.
3. Inflow was reported and documented as occurring via the collapsed zone above the mine workings and through overlying unconsolidated deposits that were disturbed by subsidence from the mine workings.
4. An average inflow rate for the Rogers No. 3 mine was estimated at 35 gpm based on pumping data.

The following recommendations and/or suggestions are made:

- Some additional site characterization may be used to reclassify the areas between the mined seams at the Landsburg mine and between the Jones and Frazier seams at the Frazier mine.

- In the mean time, severe coal mine hazard areas may be utilized as suggested in Ordinance 21A.24.210 with the exception that structures should not be constructed above any areas that are judged to be prone to sinkhole type subsidence.

- The records indicate that a memorial was set up to commemorate the deaths of Frank Stebly, Louis Valenti, John Kovash, and Nathan Russel following the January, 1955 cave-in at the Landsburg Mine. This location and a picture of this memorial are shown in Figure 7.

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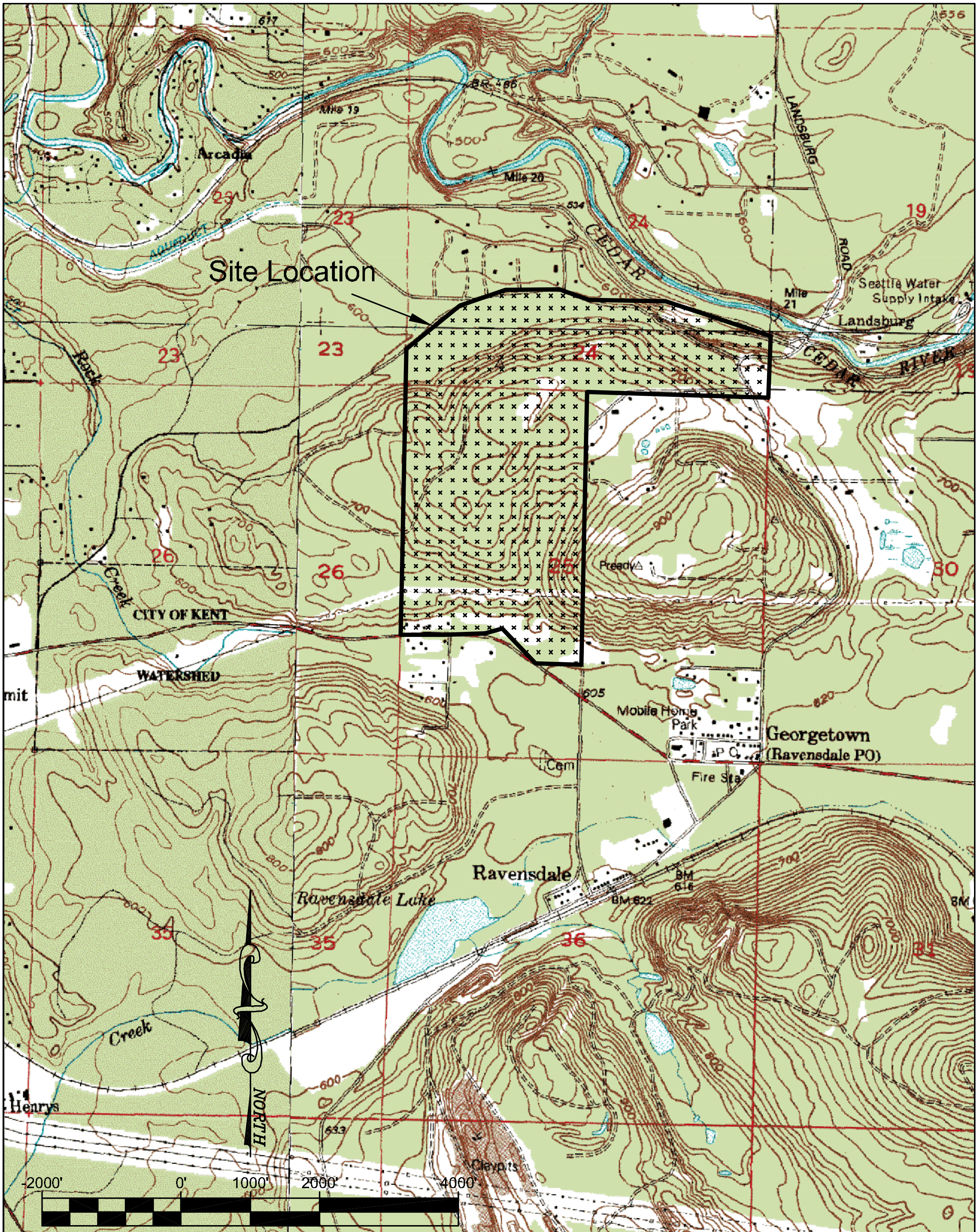

DESIGNED		SCALE
DATE	BY	1"=2000'
08-02-04	CDB	
DRAWN		
DATE	BY	
08-02-04	JLL	

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Figure 1
Landsburg Mine Site
Vicinity Map

Z:\Active Projects\2001_Projects\2001-45 Landsburg PLP Group - Landsburg AML\AutoCAD Drawings\New 08-02-04\Fig01,02,22.dwg 04/20/2005 10:04:18 AM PDT

Horizontal Datum: Nad 83/91 - (Based on King County Survey Control Point Numbers 6201, 6161 & 6234)
Vertical Datum: Navd 88 - (Based on Conversion of GPS Field Measurements Using The Geoid96 Program)

General Notes

1. Project Area Survey Performed By Triad Assoiates on April 18 & 19, 2002 To Determine the Horzontal Coordinates and Elevation on One Side of Each Sink Hole. A Combination of GPS and Conventional Survey Instruments Were Used During This Survey.

2. The Lot Lines Shown on this Exhibit Are For Reference Only. The Lot Lines Were Computed From Record Information and No Field Surveying Was Done to Ascertain the Location of the Lot Lines Shown on this Exhibit.

3	Revise Mine Locations	JLL	03/25/2005
2	Revise Rodgers Mine Location	JLL	08/02/2004
1	New topo and surface features	SGJ	01/20/2003

Surveyed Major Contours
Main Haulageways
Lot Lines
Roads
Subsidence Feature
Section Corners
Coal Mine Spoil Piles

HORIZONTAL SCALE 1"=200'
VERTICAL SCALE Same

DESIGNED
DATE 03-07-05 BY CDB

DRAWN
DATE 03-07-05 BY JLL

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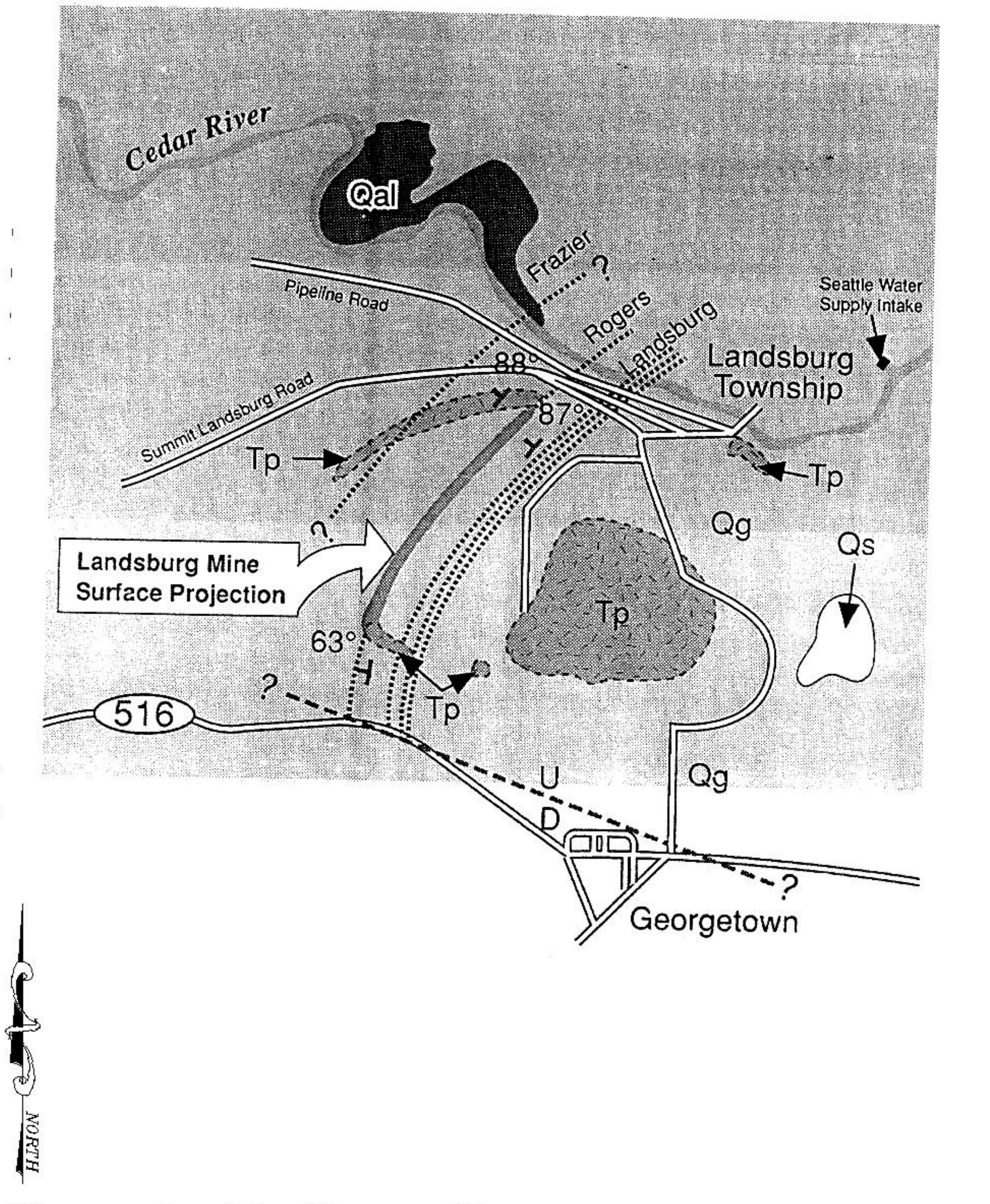
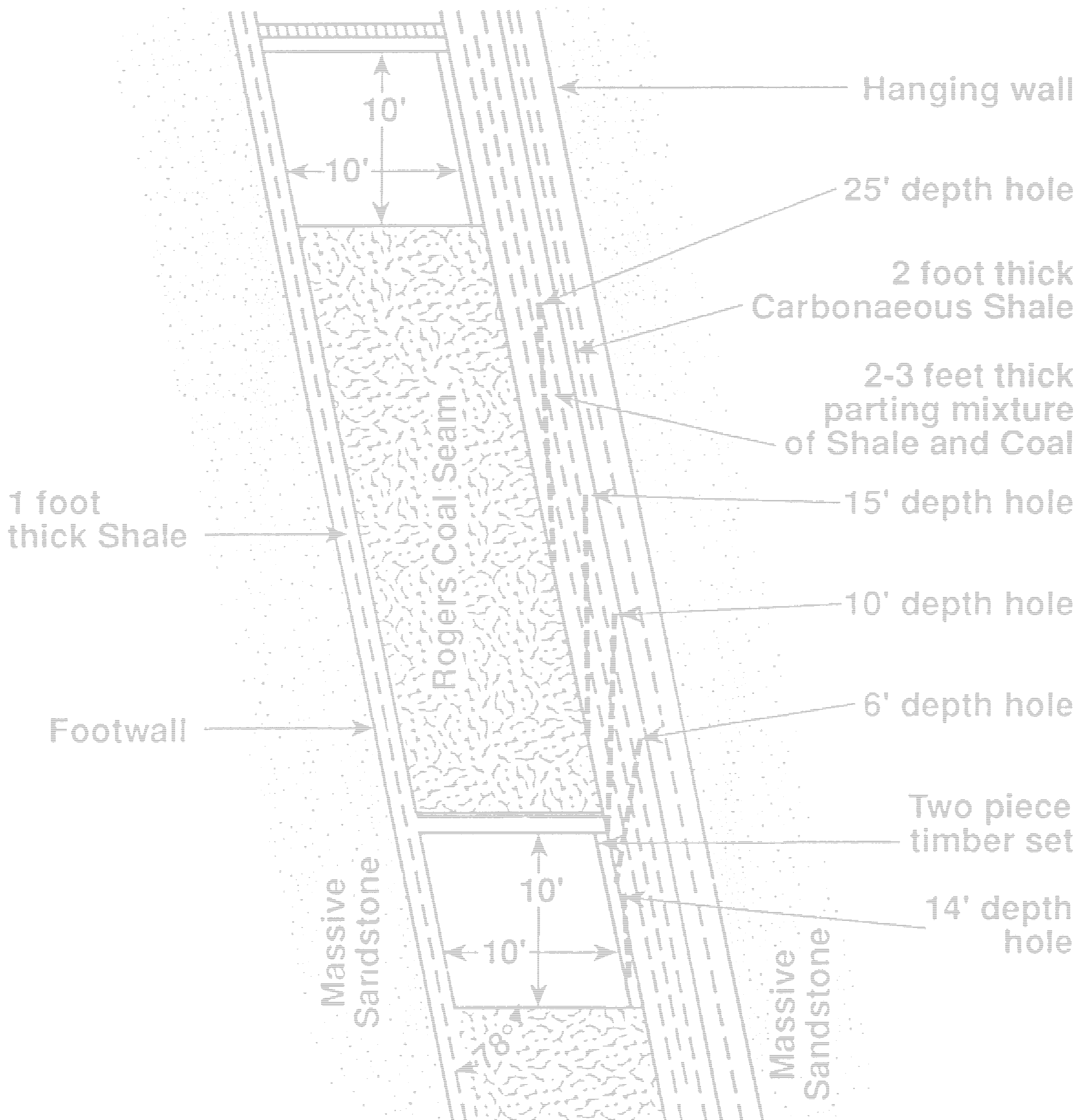
Figure 2
Landsburg Mine Site
Workings & Surrounding Area

Z:\Active Projects\2001_Projects\2001-45 Landsburg PLP Group - Landsburg AML\AutoCAD Drawings\New 08-02-04\Fig01,02,22.dwg 04/20/2005 10:04:18 AM PDT



DESIGNED		SCALE	SubTerra, Inc.® P.O. Box 520, 218 East North Bend Way, North Bend WA 98045 Telephone: (425) 888-5425 E-mail: SubTerra@subterra.us Fax: (425) 888-2725	Figure 3 Landsburg Mine Generalized Surface Geology
DATE	BY	1"=2000'		
03-04-05	CDB			
DRAWN				
DATE	BY			
03-04-05	JLL			

Z:\Active Projects\2001_Projects\2001-45 Landsburg PLP Group - Landsburg AML\AutoCAD Drawings\New 08-02-04\03-04 Geology and Section.dwg 08/08/2004 10:04:18 AM PDT



DESIGNED		SCALE
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03-04-05	CDB	
DRAWN		
DATE	BY	
03-04-05	JLL	

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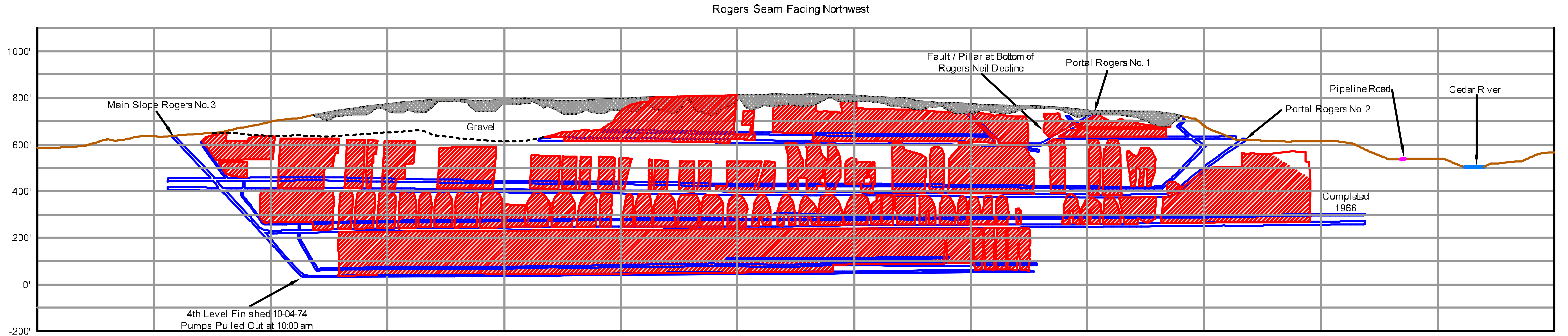
Figure 4
Section Through
Rogers Seam
Illustrating Layout of
Booming Round

Z:\Active Projects\2001_Projects\2001-45 Landsburg PLP Group - Landsburg AML\AutoCAD Drawings\New 08-02-04\Fig 03-04 Gelogy and Section.dwg 08/08/2004 10:04:18 AM PDT



Workings and ground were projected onto sections.
All elevations are based upon Mean Sea Level

Legend
Main Gangways
Ground Surface
Extracted Areas
Subsidence Feature

HORIZONTAL SCALE 1"=300'
VERTICAL SCALE Same
DESIGNED
DRAWN

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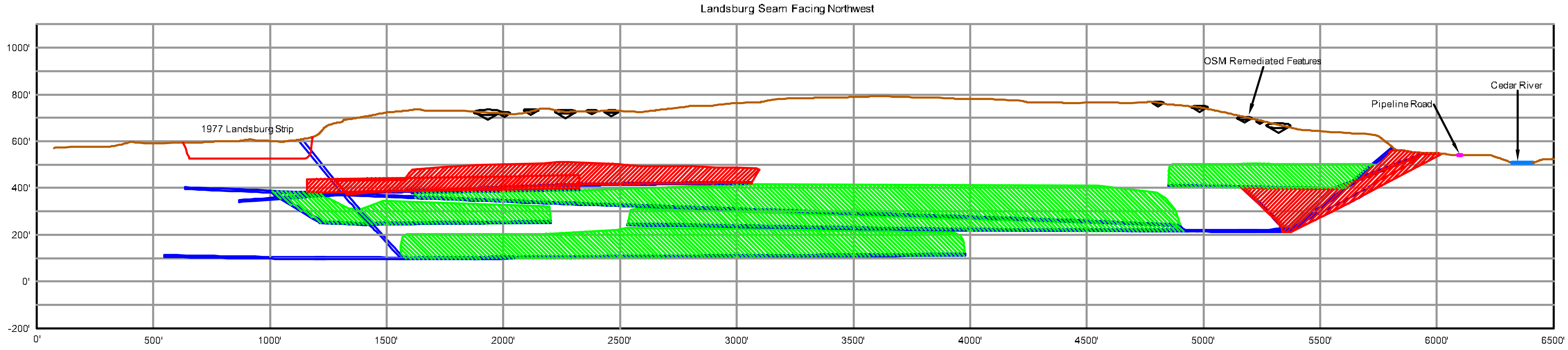
Figure 5
Projection of Rogers
Mine Workings



Workings and ground were projected onto sections.
All elevations are based upon Mean Sea Level

Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas
Subsidence Feature

HORIZONTAL SCALE 1"=300'
VERTICAL SCALE Same
DESIGNED
DRAWN

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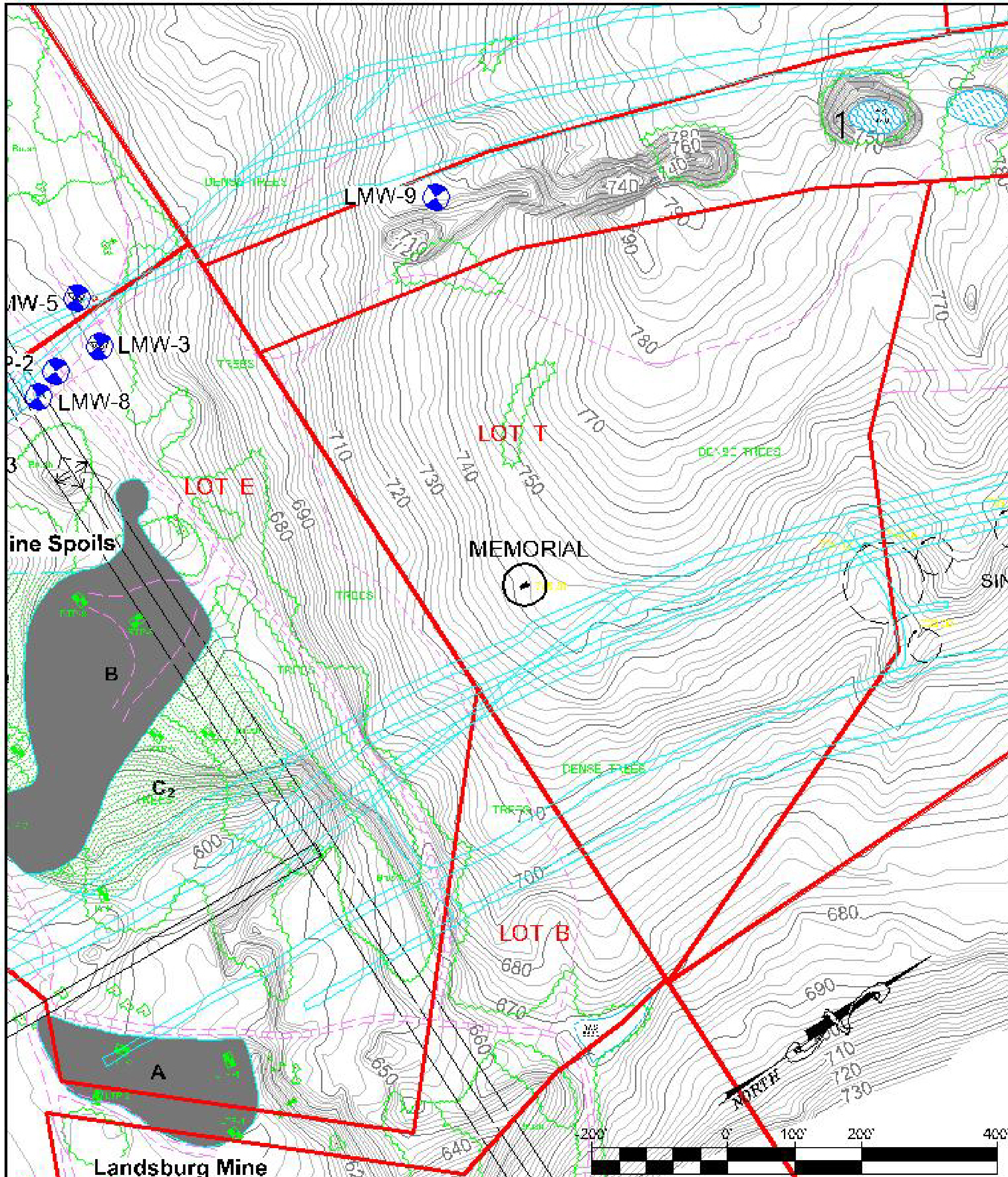
Figure 6
Projection of Landsburg
Mine Workings

Z:\Active Projects\2001_Projects\2001-45 Landsburg AML\AutoCAD Drawings\new dwgs 1-20-02\Landborg section.dwg 01/21/2003 03:47:33 PM PST



Horizontal Datum: NAD 83/91 (Based on King County Survey Control Point Numbers 2010 & 2234)
Vertical Datum: NAVD 88 (Based on Conversion of GPS Field Measurements Using The Geoid Program)

General Notes

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Surveyed Major Contours
Main Haulageways
Lot Lines
Roads
Subsidence Feature
Section Corners

HORIZONTAL SCALE 1"=200'
VERTICAL SCALE Same
DESIGNED
DRAWN

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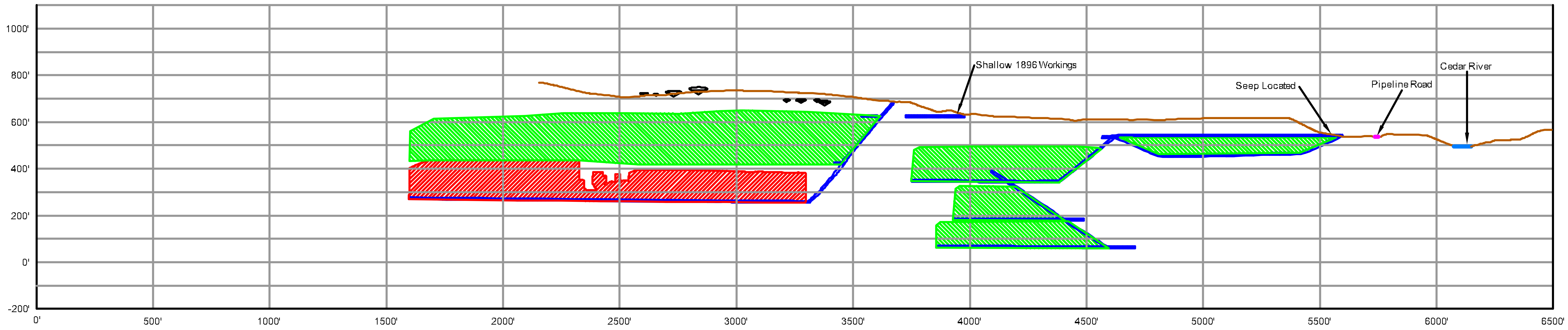
Figure 7
Landsburg Mines Memorial

Z:\Active Projects\2001_Projects\2001-45 Landsburg PLP Group - Landsburg AML\AutoCAD Drawings\New 08-02-04\Fig 07.dwg 04/20/2005 10:04:18 AM PDT

Frazier Seam Facing Northwest



Workings and ground were projected onto sections.
All elevations are based upon Mean Sea Level

Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas
Subsidence Feature

HORIZONTAL SCALE	1"=300'
VERTICAL SCALE	Same
DESIGNED	
DRAWN	

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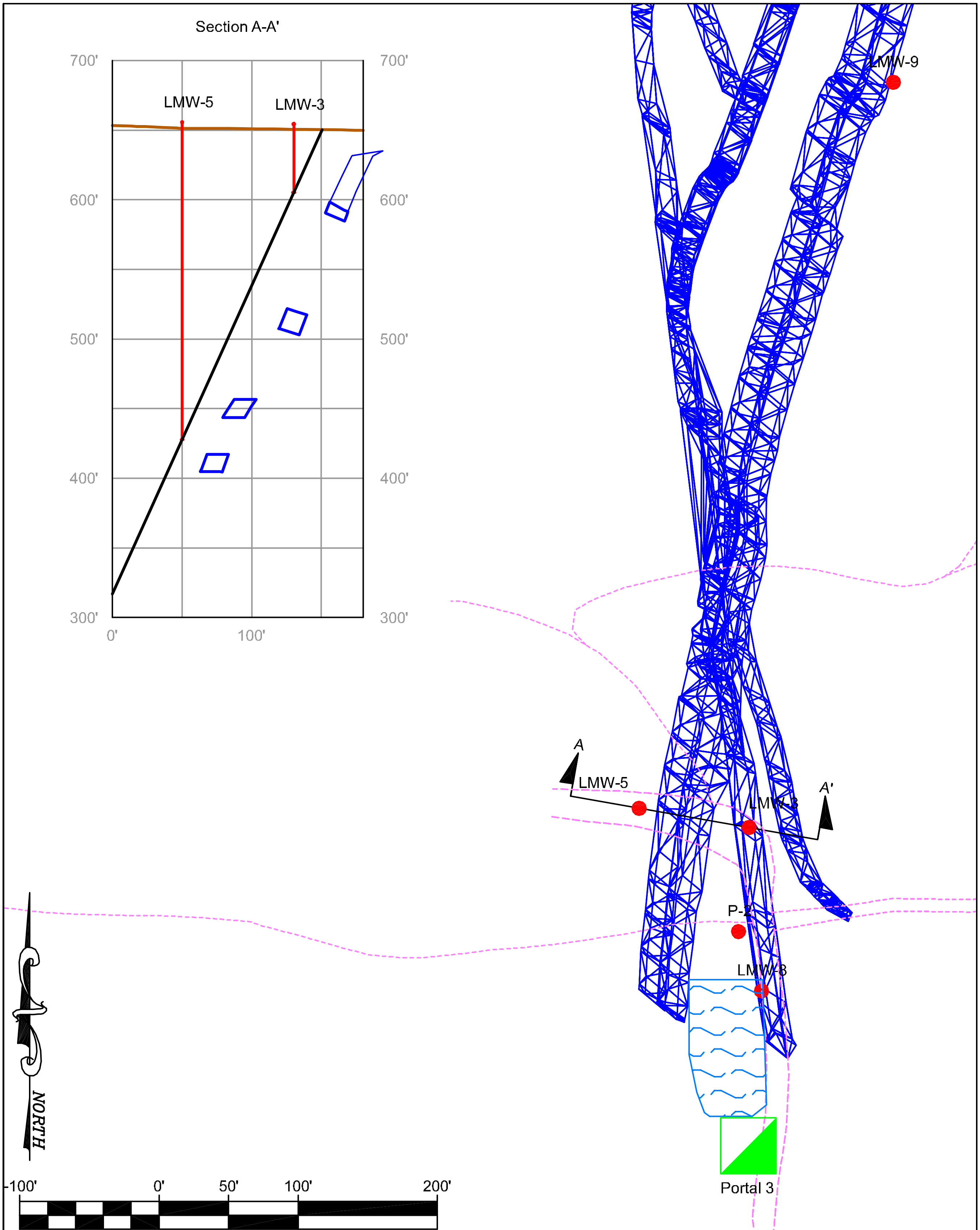
Figure 8
Projection of Frazier
Mine Workings

Z:\Active Projects\2001_Projects\2001-45 Landsburg AML\AutoCAD Drawings\New 08-02-04\Fig 08 Frasier Longitudinal Section.dwg 04/20/2005 04:10:11 PM PST



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DATE	BY	1"=100'
08-16-04	CDB	

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DRAWN	
DATE	BY
08-16-04	JLL

= Mine Location Based on King County Map K

Figure 9
Ground Proofing
Results at South End
of Rodgers Mine

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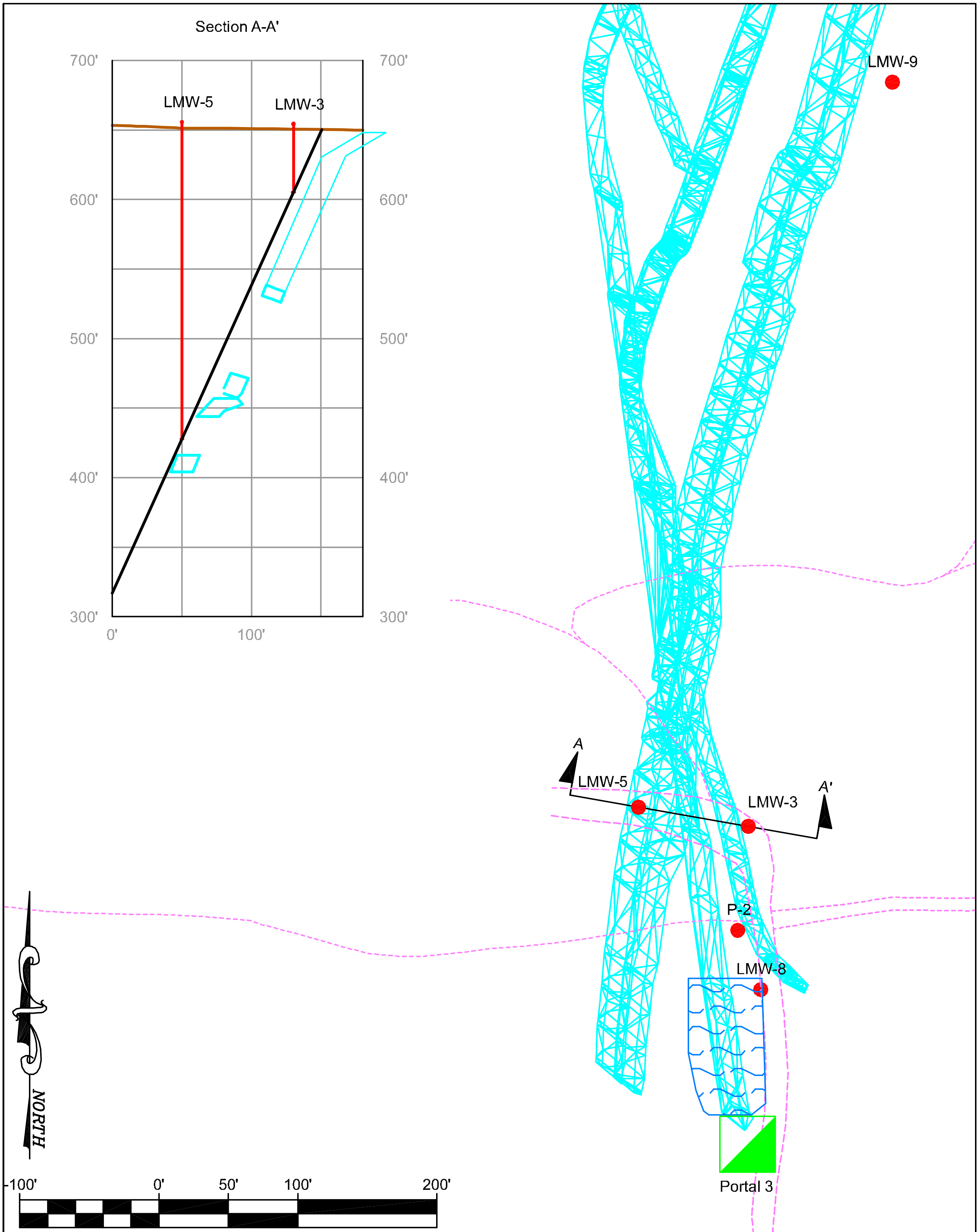

DESIGNED		SCALE
DATE	BY	1"=100'
08-16-04	CDB	
DRAWN		
DATE	BY	
08-16-04	JLL	

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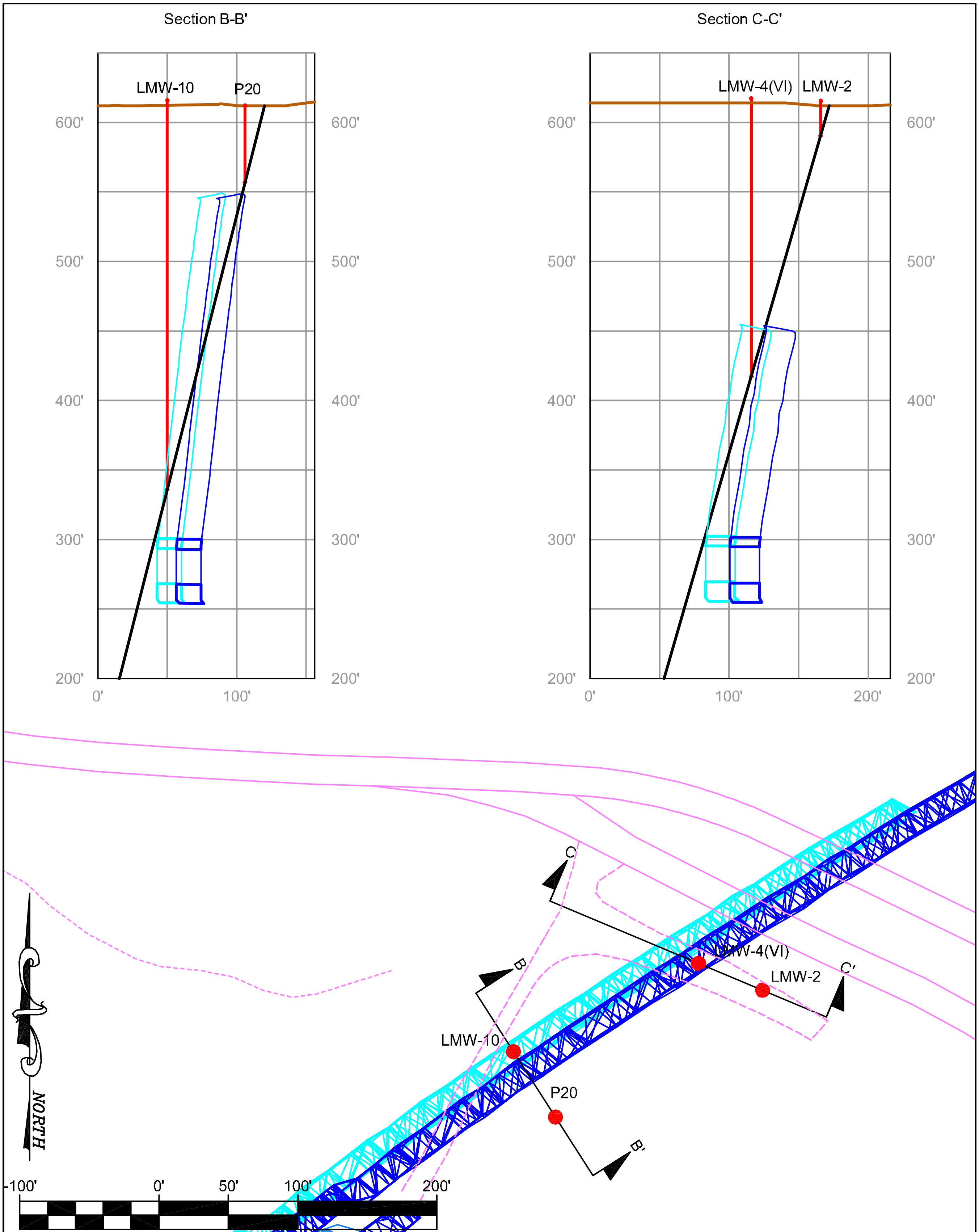
= Relocated Position For Southern Proof Drilling

Figure 10
Ground Proofing
Results at South End
of Rodgers Mine
(New Mine Location)

Z:\Active Projects\2001_Projects\2001-45 Landsburg PLP Group - Landsburg AML\AutoCAD Drawings\New 08-02-04\Fig 09-11 Ground Proofing.dwg 04/20/2005 10:04:18 AM P



DESIGNED		SCALE
DATE	BY	1"=100'
08-16-04	CDB	
DRAWN		
DATE	BY	
08-16-04	JLL	

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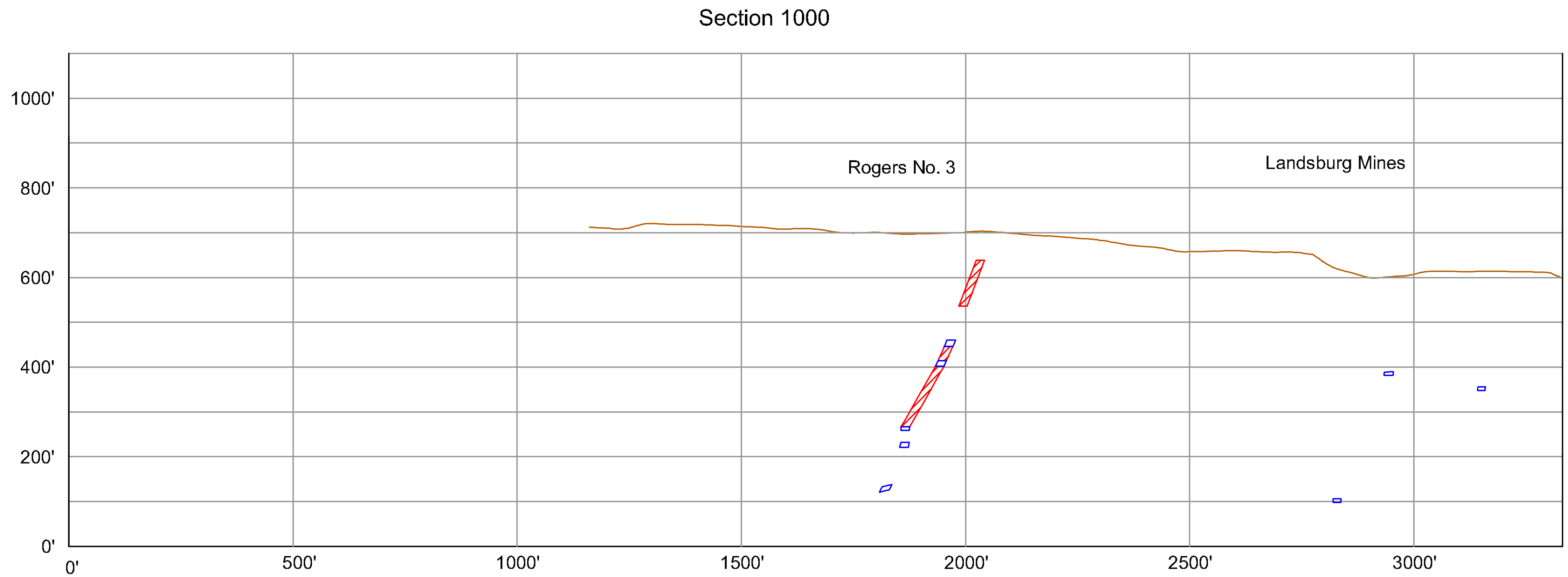
= Mine Location Based on King County Map K

= Relocated Position For Southern Proof Drilling

Figure 11
Ground Proofing
Results at North End
of Rodgers Mine



All Elevations are based upon Mean Sea Level

Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas

HORIZONTAL SCALE 1"=300'	
VERTICAL SCALE Same	
DESIGNED	
DATE 03-18-05	BY CDB
DRAWN	
DATE 03-18-05	BY JLL

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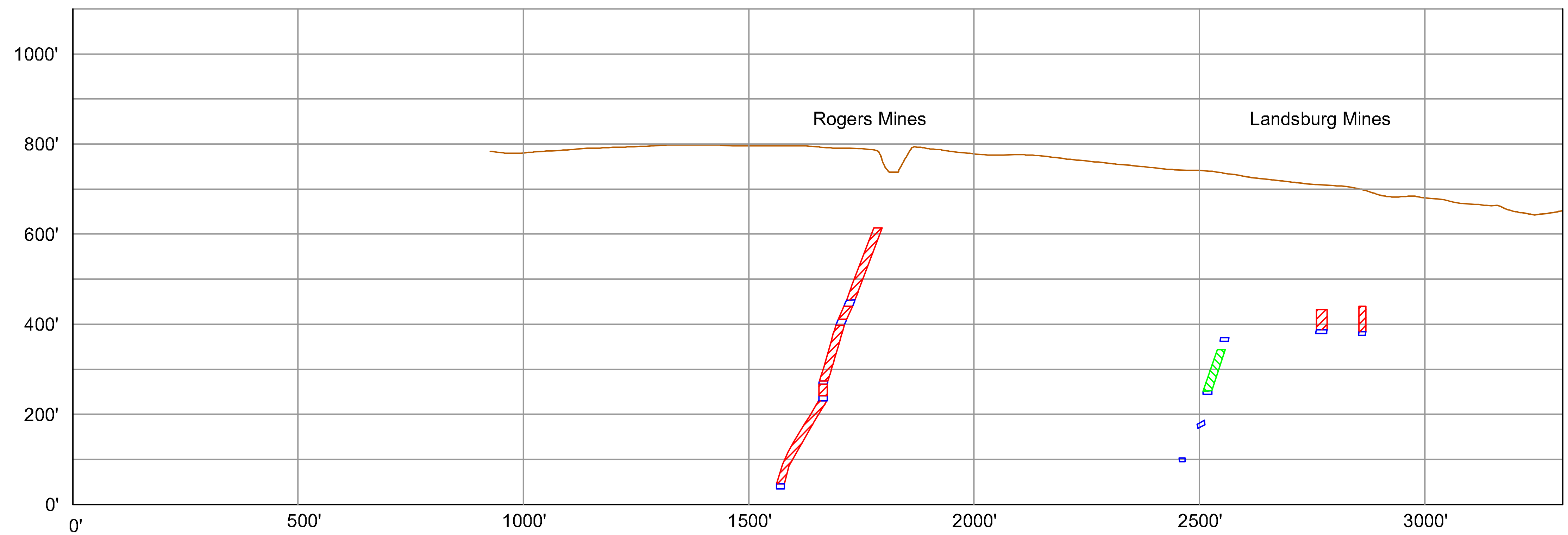
Figure 12
Section Line 1000:
Frazier/Rogers/Landsburg Mines

Section 1500



All Elevations are based upon Mean Sea Level

Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas

HORIZONTAL SCALE	1"=300'
VERTICAL SCALE	Same
DESIGNED	DATE 03-18-05, BY CDB
DRAWN	DATE 03-18-05, BY JLL

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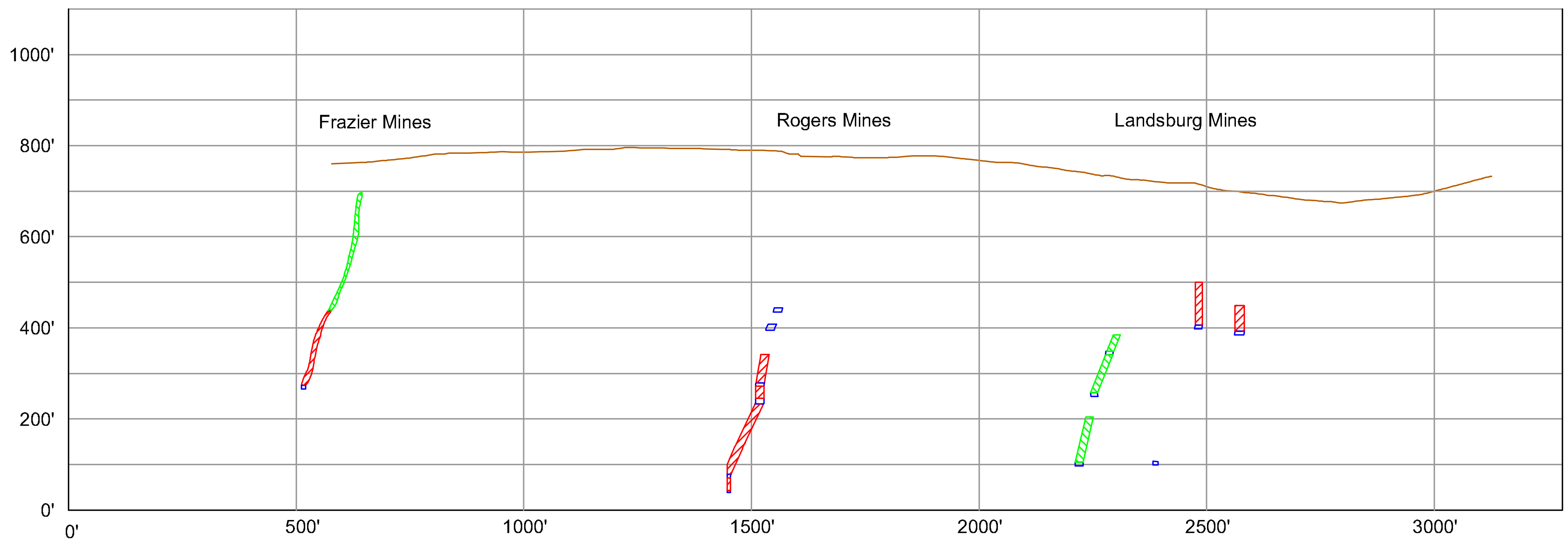
Figure 13
Section Line 1500:
Frazier/Rogers/Landsburg Mines

Section 2000



All Elevations are based upon Mean Sea Level

Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas

HORIZONTAL SCALE
1"=300'
VERTICAL SCALE
Same
DESIGNED

DATE	BY
03-18-05	CDB

DRAWN

DATE	BY
03-18-05	JLL

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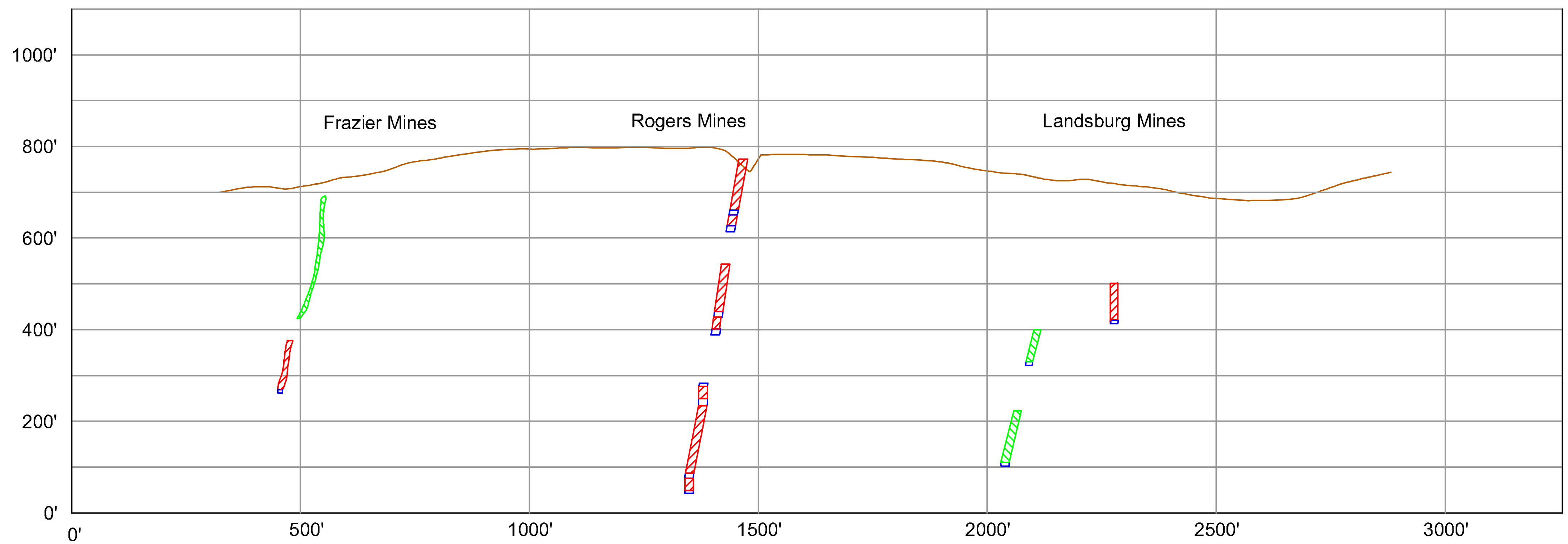
Figure 14
Section Line 2000:
Frazier/Rogers/Landsburg Mines

Section 2500



All Elevations are based upon Mean Sea Level

- Main Gangways
- Ground Surface
- Extracted Areas
- Potentially Extracted Areas

HORIZONTAL SCALE	1"=300'
VERTICAL SCALE	Same
DESIGNED	DATE 03-18-05, BY CDB
DRAWN	DATE 03-18-05, BY JLL

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Figure 15
Section Line 2500:
Frazier/Rogers/Landsburg Mines

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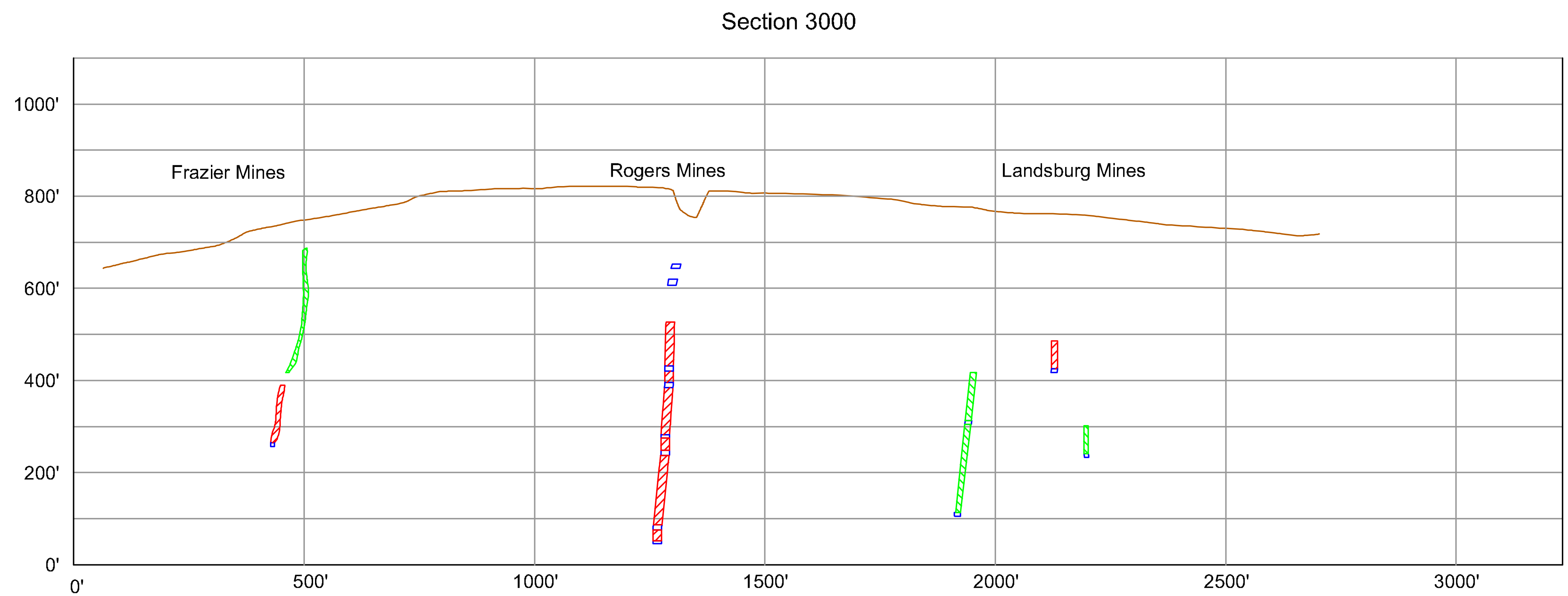

All Elevations are based upon Mean Sea Level

Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas

HORIZONTAL SCALE 1"=300'
VERTICAL SCALE Same
DESIGNED

DATE	BY
03-18-05	CDB

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DATE	BY
03-18-05	JLL

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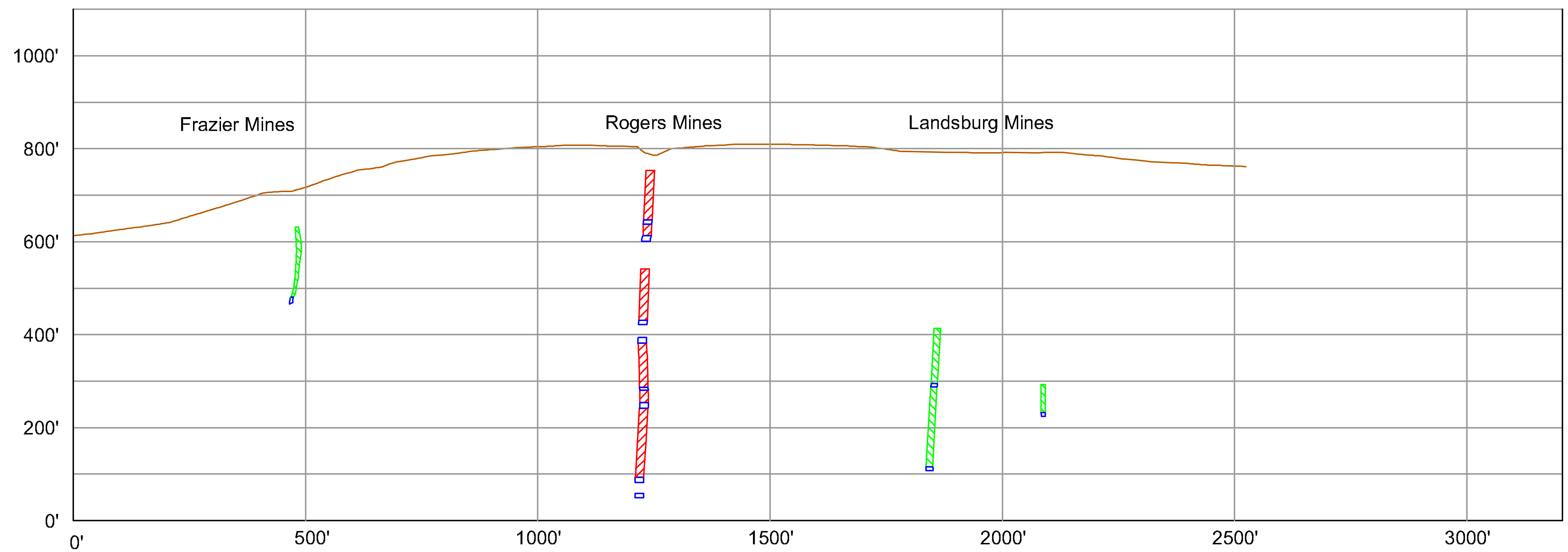
Figure 16
Section Line 3000:
Frazier/Rogers/Landsburg Mines

Section 3500



All Elevations are based upon Mean Sea Level

Legend
Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas

HORIZONTAL SCALE	1"=300'
VERTICAL SCALE	Same
DESIGNED	DATE 03-18-05 BY CDB
DRAWN	DATE 03-18-05 BY JLL

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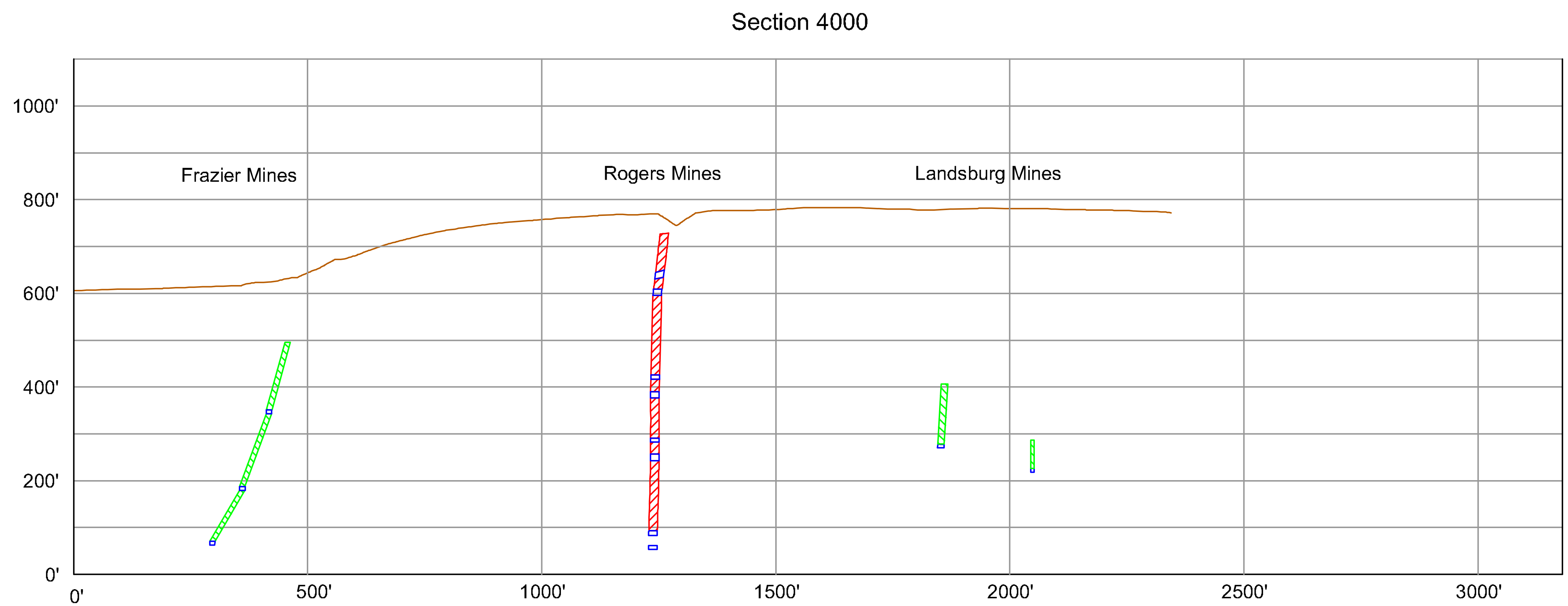
Figure 17
Section Line 3500:
Frazier/Rogers/Landsburg Mines



All Elevations are based upon Mean Sea Level

Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas

HORIZONTAL SCALE	1"=300'
VERTICAL SCALE	Same
DESIGNED	DATE 03-18-05 BY CDB
DRAWN	DATE 03-18-05 BY JLL

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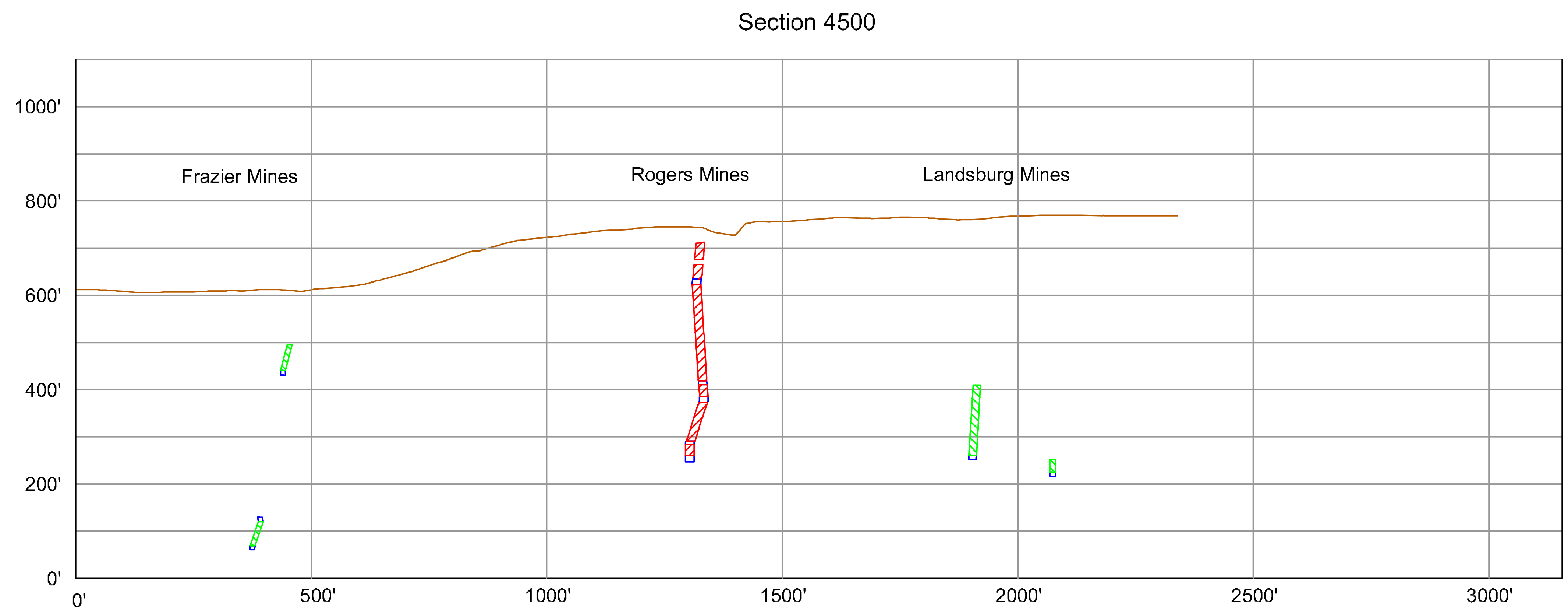
Figure 18
Section Line 4000:
Frazier/Rogers/Landsburg Mines



All Elevations are based upon Mean Sea Level

Main Gangways
Ground Surface
Extracted Areas
Potentially Extracted Areas

HORIZONTAL SCALE 1"=300'	
VERTICAL SCALE Same	
DESIGNED	
DATE 03-18-05	BY CDB
DRAWN	
DATE 03-18-05	BY JLL

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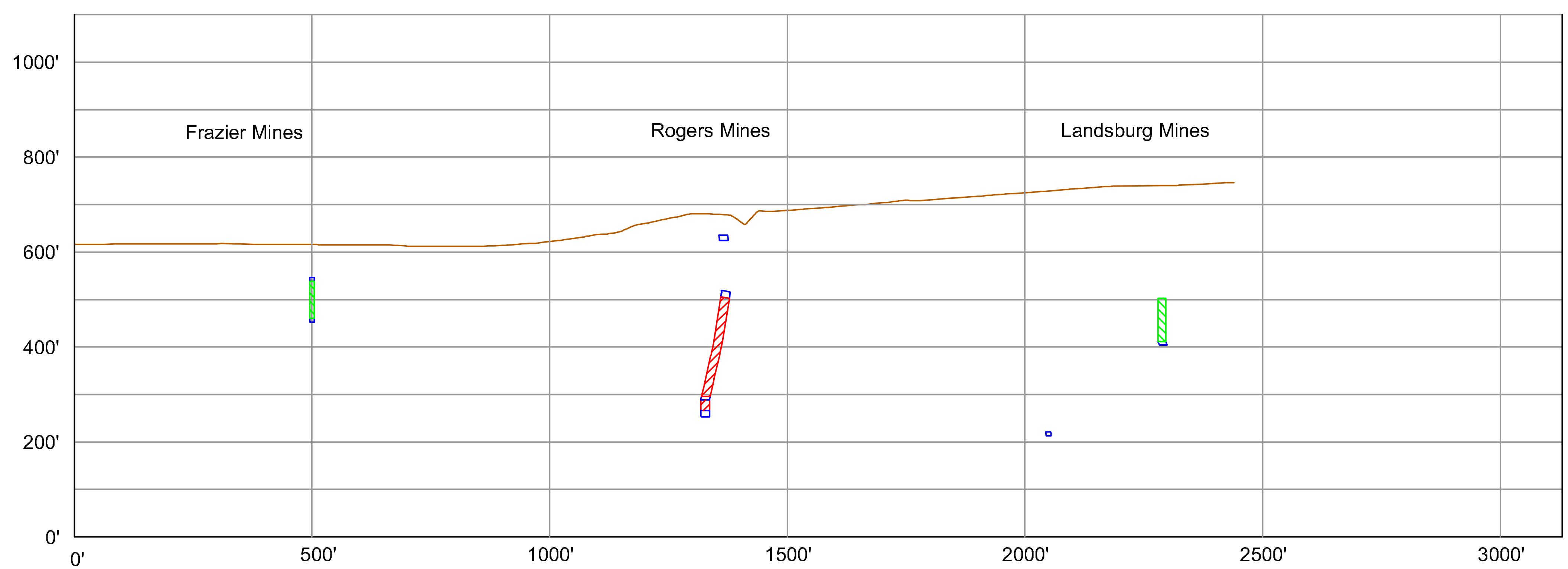
Figure 19
Section Line 4500:
Frazier/Rogers/Landsburg Mines

Section 5000



All Elevations are based upon Mean Sea Level

- Main Gangways
- Ground Surface
- Extracted Areas
- Potentially Extracted Areas

HORIZONTAL SCALE	1"=300'
VERTICAL SCALE	Same
DESIGNED	DATE 03-18-05, BY CDB
DRAWN	DATE 03-18-05, BY JLL

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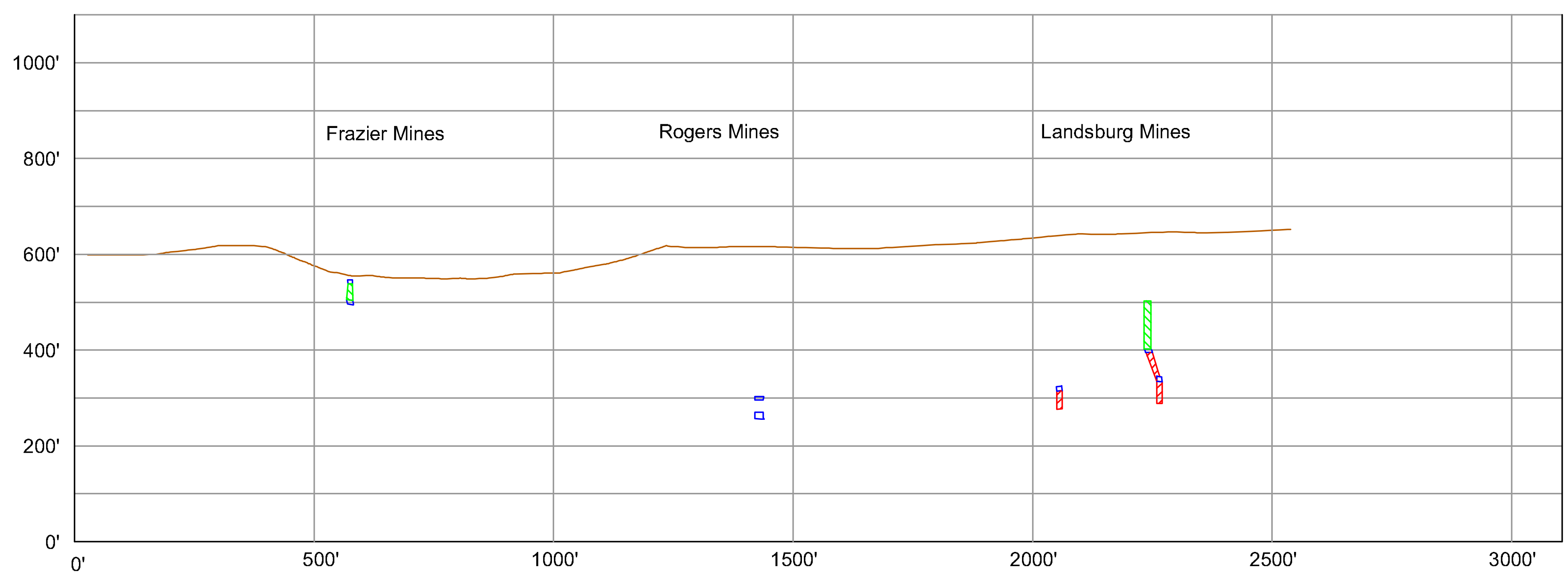
Figure 20
Section Line 5000:
Frazier/Rogers/Landsburg Mines

Section 5500



All Elevations are based upon Mean Sea Level

- Main Gangways
- Ground Surface
- Extracted Areas
- Potentially Extracted Areas

HORIZONTAL SCALE	1"=300'
VERTICAL SCALE	Same

DESIGNED

DATE	BY
03-18-05	CDB

DRAWN

DATE	BY
03-18-05	JLL

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Figure 21
Section Line 5500:
Frazier/Rogers/Landsburg Mines

Horizontal Datum: Nad 83/91 - (Based on King County Survey Control Point Numbers 6201, 6161 & 6234)
Vertical Datum: Navd 88 - (Based on Conversion of GPS Field Measurements Using The Geoid96 Program)

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2	Revise Rodgers Mine Location	JLL	08/02/2004
1	New topo and surface features	SGJ	01/20/2003

Surveyed Major Contours
Main Haulageways
Lot Lines
Roads
Subsidence Feature
Section Corners
Severe Coal Mine Subsidence Hazard Area
Coal Mine Spoil Piles

HORIZONTAL SCALE 1"=200'
VERTICAL SCALE Same
DESIGNED DATE 03-07-05 BY CDB
DRAWN DATE 03-07-05 BY JLL

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Figure 22
Landsburg Mine Site
Coal Mine Hazard Zones

Z:\Active Projects\2001_Projects\2001-45 Landsburg PLP Group - Landsburg AML\AutoCAD Drawings\New 08-02-04\Fig-01-02.dwg 03/15/2005 10:04:18 AM PDT

TABLE 1 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 1/2 showing Rogers 2 in development.
357	3/29/60	Plan of Rogers 1/2 showing Rogers 2 in development.
392	4/22/66	Plan of Rogers 1/2 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	Section through Rogers Mine at Abandonment
DNR 2	1965	Section documenting inspection of second level during 1963
DNR 3	Unknown	Section showing 1st and 2nd level development/mining
DNR 4	1970	Section showing 1st 2nd, 3rd, and 4th level development/mining

TABLE 2 SEQUENCE of MINING in the FIRST LEVEL

Approx Date	Activity	Notes
Pre-1959	Complete Rogers Slope.	Work halted due to fault (J. Morris).
Mar, 1959	Mine 130' rock tunnel to intersect coal.	No inflow of water when mining through fault. Probably same fault encountered in Landsburg (C. Falk).
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 (C. Falk, A. Eltz). One hole reported making 7-15 gpm (B. Simmons); 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 (A. Eltz).
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 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 (BS). Often remnant pillars chosen to coincide with fault (BS). Holes drilled through to 1st level gangway to drain water (BS, Maps). Caved zone inspected daily and periodically backfilled (BS). 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 4 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 4 SEQUENCE of MINING in the THIRD and FOURTH LEVELS

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 (App. III.3)

TABLE 5 LANDSBURG MINE - ROGERS SEAM MINED/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 5 LANDSBURG MINE - ROGERS SEAM MINED/WASHED COAL TONNAGES

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.

Appendix A

King County Sensitive / Critical Area Standards and Guidelines

A.1. Coal Mine Hazard Areas: Development Standards

A.2 Coal Mine Hazard Area Guidelines: Guidance on Analyses to Characterize Hazards and Develop Mitigation

21A.24.180 Sensitive area tracts and designations on site plans.

A. Sensitive area tracts shall be used to delineate and protect those sensitive areas and buffers listed below in development proposals for subdivisions, short subdivisions or binding site plans and shall be recorded on all documents of title of record for all affected lots:

1. All landslide hazard areas and buffers that are one acre or greater in size;
2. All steep slope hazard areas and buffers that are one acre or greater in size;
3. All wetlands and buffers; and
4. All streams and buffers.

B. Any required sensitive area tract shall be held in an undivided interest by each owner of a building lot within the development with this ownership interest passing with the ownership of the lot or shall be held by an incorporated homeowner's association or other legal entity which assures the ownership, maintenance and protection of the tract.

C. Site plans submitted as part of development proposals for building permits, master plan developments and clearing and grading permits shall include and delineate:

1. All flood hazard areas, if they have been mapped by FEMA or King County or if a special study is required;
2. Landslide, volcanic, coal mine and steep slope hazard areas;
3. Streams and wetlands;
4. Buffers; and
5. Building setbacks.

D. If only a part of the development site has been mapped pursuant to K.C.C. 21A.24.120C, the part of the site that has not been mapped shall be clearly identified and labeled on the site plans. (Ord. 14449 § 11, 2002: Ord. 14449 § 11, 2002: Ord. 10870 § 465, 1993).

21A.24.190 Alteration. Any human activity which results or is likely to result in an impact upon the existing condition of a sensitive area is an alteration which is subject to specific limitations as specified for each sensitive area. Alterations include, but are not limited to, grading, filling, dredging, draining, channelizing, applying herbicides or pesticides or any hazardous substance, discharging pollutants except stormwater, grazing domestic animals, paving, constructing, applying gravel, modifying for surface water management purposes, cutting, pruning, topping, trimming, relocating or removing vegetation or any other human activity which results or is likely to result in an impact to existent vegetation, hydrology, wildlife or wildlife habitat. Alterations do not include walking, fishing or any other passive recreation or other similar activities. (Ord. 10870 § 466, 1993).

21A.24.200 Building setbacks. Unless otherwise provided, buildings and other structures shall be set back a distance of 15 feet from the edges of all sensitive area buffers or from the edges of all sensitive areas, if no buffers are required. The following may be allowed in the building setback area:

A. Landscaping;

B. Uncovered decks;

C. Building overhangs if such overhangs do not extend more than 18 inches into the setback area; and

D. Impervious ground surfaces, such as driveways and patios, provided that such improvements may be subject to special drainage provisions specified in administrative rules adopted for the various sensitive areas. (Ord. 10870 § 467, 1993).

21A.24.210 Coal mine hazard areas: Development standards and permitted alterations.

A. Alterations within coal mine hazard areas shall not be permitted without prior acceptance of a coal mine hazard assessment report and provided that:

1. Based upon recommendations contained within the report, a studied site shall be classified as one or a combination of the following:

a. declassified coal mine areas;
b. moderate coal mine hazard areas; or
c. severe coal mine hazard areas.

2. The coal mine hazard assessment report shall be prepared by a professional engineer using methodology and assumptions consistent with standards or professional engineering guidelines adopted by the department. The report may contain the following as determined by the department to be necessary for the review of the proposed use:

a. a statement of the professional engineer's qualifications and licensing information, together with a signature and stamped seal;

b. a list of references utilized in preparation of the report;

c. a description of the analytical tools and processes that have been used in the report;

d. surface exploration data such as borings, drill holes, test pits, wells, geologic reports, and other relevant reports or site investigations that may be useful in making conclusions or recommendations about the site under investigation;

e. a description of historical data and information used in the evaluation, together with sources. Such data and information shall include:

(1) topographic maps at a scale and contour interval of sufficient detail to assess the site. The site boundaries and proposed site development shall be overlain with the mine plan view map, as appropriate;

(2) copies of illustrative coal mine maps showing remnant mine conditions, if available;

(3) aerial photography, as appropriate;

(4) geological data including geologic crosssections and other illustrative data as appropriate; and

(5) available historic mine records indicating the dates of operation, the date of cessation of active mining, the number of years since abandonment, mining methods, shoring and timbering information, the strength of the overlying rock strata, the extracted seam thickness, the dip or inclination of the strata, workings and surface, the projected surface location of the seam outcrop or subcrop, the estimated depth of the seam outcrop or subcrop, if covered by glacial outwash, glacial till or other materials at depth, total coal tonnage produced, estimated coal mine by-product material produced and the estimated extraction ratio.

f. a mine plan view map, reproduced at the same scale as the topographic map, showing the location of the mine, the extent of mining, the proposed site development, if applicable, and any remnant abandoned mine surface features. The following shall be included:

(1) the layout of the underground mine;

(2) the location of any mine entries, portals, adits, mine shafts, air shafts, timber shafts, and other significant mine features;

(3) the location of any known sinkholes, significant surface depressions, trough subsidence features, coal mine spoil piles and other mine-related surface features;

(4) the location of any prior site improvements that have been carried out to mitigate abandoned coal mine features; and

(5) zones showing varying overburden-cover-to-seam-thickness ratios, when appropriate.

g. a statement as to the relative degree of accuracy and completeness of the maps and information reviewed, especially regarding historic mine map accuracy, and reasons why such sources are considered reliable for the purpose of the hazard assessment report;

h. a mitigation plan containing recommendations for mitigation, as appropriate, for the specific proposed alteration;

i. recommendations for additional study, reports, development standards or architectural recommendations for subsequent and more specific proposed alterations, as appropriate;

j. analysis and recommendations, if any, of the potential for future trough subsidence and special mitigation; and

k. a delineation of coal mine hazard areas for the site under investigation using a map identifying the specific category (i.e., severe, moderate, or declassified) of mine hazard area. For the purposes of obtaining accurate legal descriptions, the mine hazard areas shall be surveyed and the survey map shall be drawn at a scale of not less than 1"=200'.

3. Giving great weight to the licensing requirements of professional engineers and standards of professional accountability and liability, the department shall review the coal mine hazard assessment report and within the time period specified in K.C.C. 20.20.050 either accept the report, recommend revisions or additions to the report or return the report to the applicant as unaccepted and detail the specific deficiencies. In the event of a disagreement, the applicant may submit the report to a mutually agreed-upon third party professional engineer who will conduct the review and issue a decision binding upon the department and applicant.

4. When a hazard assessment report has been accepted, the applicant shall record a notice on the title of the property as follows:

"NOTICE"

"This property is located in an area of historic coal mine activity. A coal mine hazard assessment report has been prepared to characterize the potential hazards contained on this property. The report is dated *[insert date of the final report]*, was prepared by *[insert name of professional engineer with license number]* at the direction of *[insert name of property owner]*, and reviewed by the King County department of development and environmental services *[and, if necessary, include name of peer reviewing professional engineer with license number]*. A review of the report is advised prior to undertaking unregulated or exempt land use activities and is required prior to undertaking regulated land use activities."

B. Permitted alterations within a coal mine hazard area are allowed as follows, subject to other King County Code permit requirements:

1. Within declassified coal mine areas all alterations are permitted.

2. Within moderate coal mine hazard areas and coal mine by-product stockpiles, all alterations are permitted subject to a mitigation plan to minimize risk of structural damage using appropriate criteria to evaluate the proposed use.

If required or recommended by the hazard assessment report, the mitigation plan to address potential trough subsidence must be prepared by a professional engineer and may be included in the coal mine hazard assessment report or may be an additional study or report, as appropriate.

3. Within severe coal mine hazard areas the following alterations are permitted:

a. all grading, filling, stockpile removal, and reclamation activities undertaken pursuant to a coal mine hazard assessment report with the intent of eliminating or mitigating threats to human health, public safety, environmental restoration or protection of property, provided that:

(1) signed and stamped plans have been prepared by a professional engineer;

(2) as-built drawings are prepared following reclamation activities; and

(3) the plans and as-built drawings shall be submitted to the department for inclusion with the coal mine hazard assessment report prepared for the property.

b. private road construction and maintenance activities, provided that mitigation to eliminate or minimize significant risk of personal injury are incorporated into road construction or maintenance plans.

c. buildings with less than four thousand square feet of floor area that contain no living quarters and that are not used as places of employment or public assembly, provided that mitigation to eliminate or minimize significant risk of personal injury are incorporated into site, building, and/or landscaping plans.

d. additional land use activities provided that they are consistent with recommendations contained within any mitigation plan required by the hazard assessment report. (Ord. 13319 § 7, 1998: Ord. 11896 § 1, 1995: Ord. 10870 § 468, 1993).

Guidance on Analyses to Characterize Hazards and Develop Mitigation

Proposed developments in Coal Mine Hazard Areas are required to mitigate specific hazards. King County will usually require specific studies as part of a sensitive area report that will evaluate and define these hazards and develop appropriate mitigation. Guidance is provided in this document on the appropriate geotechnical analyses necessary to characterize hazards and develop mitigation measures that will meet the standards in K.C.C. 21A.24.210. These guidelines include details of reporting requirements for abandoned mine related studies, procedures for evaluating potential hazards including ground failure mechanisms and analysis methods, determination of hazard areas, methods to eliminate hazards and reference materials.

A. GENERAL GUIDELINES FOR COAL MINE HAZARD EVALUATIONS

All permitted alterations within hazard areas must demonstrate to the satisfaction of the Department of Development and Environmental Services (DDES) that the hazard will not impact the alterations and that the alterations will not impact the hazard areas. In order to acceptably evaluate the potential impacts of and to the proposed alteration in Coal Mine Hazard Areas, the following aspects must be addressed:

- The potential impacts of catastrophic effects and/or predicted trough subsidence and associated ground deformations from the underlying coal mine workings.
- The response of proposed development activities to predicted ground deformations.
- The interaction of the proposed activity with the coal mine workings, including; potential impacts from introducing or removing water from the mine; changes to the subsurface environment that might lead to, or accelerate degradation processes; and plans for adequately sealing any new penetrations.
- Methods of mitigating impacts that are contained in the development proposal. Acceptable methods are contained in Section E.
- Conditions of occupancy in the proposed development.

This guidance provides details on conducting acceptable hazard evaluations and the format for providing that information to DDES.

B. GUIDANCE ON ABANDONED MINE RELATED STUDY AND REPORT SUBMITTALS

The abandoned mine studies and reports, referred to in this Section, shall be prepared by a qualified engineer or engineering geologist as defined in K.C.C. 21A.06. Reports will be required for:

- Determining whether coal mine areas will be regulated as hazard areas.
- Proposed developments in a coal mine hazard area.
- Proposals to change land use or zoning designations in a coal mine hazard area.

Studies and reports shall be submitted to the Department for review and approval, if acceptable. At its discretion, the Department may also require the qualified engineer or engineering geologist to present the results of their studies to Department staff.

Preliminary Site Evaluation Report (PSER). A preliminary site evaluation shall be required for proposed developments in any coal mine hazard area. This material should be submitted for and discussed in the preliminary application meeting. As a minimum, the PSER shall contain:

1. A work plan outlining the proposed approach to evaluating hazards, including reference to any analytical tools and processes that will be used, in subsequent stages, for hazard evaluation.
   - Reference to methods recommended in Section F shall demonstrate compliance with this requirement.
   - If hazards as described in K.C.C. 21A.24.240A are identified; a proposed program of site investigation to support engineering design for mitigation of those hazards shall be included in the Work Plan.

1. Historical data and sources for historical information used, or to be used, in the hazard evaluation. Such data and information shall include, as a minimum:
   - Coal Mine Hazards Maps.
   - Copies of the original coal mine maps, illustrating the remnant mine condition(s). Reproductions from original maps are acceptable as long as they clearly illustrate conditions that are important to the hazards analysis.
   - Aerial photographs. Where possible, aerial photographs showing the current, as well as the mine abandonment, surface conditions shall be provided.
   - Readily available records indicating the extracted seam thickness, dip/inclination of the workings, location of seam outcrop or subcrop, and dates of working.

1. Plan(s) showing the location of the mine(s) and the extent of mining; the proposed site development; and any remnant abandoned mine surface features. The plan(s) should include, as a minimum;
   - The layout of the underground mine(s)
   - The location of any mine entries, sinkholes, or surface depressions, recorded on title documents, in published records, or discovered during the preliminary site reconnaissance.
   - The location of any abandoned mine surface features.
   - The location of any prior site improvements that have been carried out to mitigate or eliminate catastrophic effects, including any remedial work performed by the Office of Surface Mining (OSM). Evidence of adequate sealing of sinkholes or mine entries shall include as-built drawings, completion records recorded with King County, and/or a letter from the Regional OSM Representative stating that the closure was performed to OSM's standards.
   - Statement as to the accuracy of locating the abandoned mine workings with respect to the surface, and the basis for the stated accuracy.
   - Any additional assumptions that limit the accuracy or completeness of the information provided.

1. The results of a preliminary surface-based reconnaissance of the proposed development site. A Preliminary Site Reconnaissance shall be required to identify any subsidence features or mine hazards that are present on or within 100 feet of the property including, but not limited to:

- surface depressions,
- sinkholes,
- mine shafts,
- mine entries,
- coal mine spoil piles, and
- any indication of combustion in underground workings or coal mine waste dumps.

The surface reconnaissance shall include, but not be limited to, inspection, review, and documentation of any known hazards that have previously been documented by the Office of Surface Mining, Abandoned Mined Land program (see references Lucas and Assoc., 1987; Skelly and Loy, 1988; and USHUD, 1977a for examples), or that have been identified from review and interpretation of air photographs or other sources.

1. Existing surface exploration data (borings, test pits, wells) that exist for the site and copies of any reports of other investigations in the vicinity of the project.

Site Investigation Program. Subsurface conditions for coal seams located within 200 feet of the ground surface are required to be investigated by drilling and logging of subsurface conditions consistent with the following:

- Drill holes shall be located adjacent to, but not within, coal pillars that are shown on the mine plans, unless the objective is to retrieve samples for testing purposes.
- Holes shall be drilled along the alignment of any linear structure, such as a road or utility line, where coal mines are indicated to be within 200 feet of the surface.
- Rotary drilling is an acceptable method of drilling provided it is used in combination with downhole geophysical logging, including caliper logs. Core drilling is preferred, but is not compulsory, immediately above and through the predicted coal seam location(s). Drill holes shall be logged continuously throughout their length, including lithology at 5-foot intervals for rotary drill holes, drill fluid circulation, penetration rate, and free fall of the drill string. Greater confidence will be placed in core drilling logs than in rotary drilling logs; this may result in less drill holes being required if core drilling is used in the vicinity of coal seams instead of rotary drilling.
- Hazards very near the surface such as slope entry portals, shaft collars, prospects and mine waste dumps may be investigated by test pits or trenching, providing the method enables investigation to an adequate depth for the hazard being investigated.
- Indirect means of subsurface evaluation, including geophysics, geologic projection, and evaluation of mining records, may be used to supplement drilling results, but shall not be used as the sole source for evaluating subsurface conditions.

Final Site Evaluation Report. A Final Site Evaluation Report shall be provided for all proposed permitted alterations in Coal Mine Hazard Areas. Repetition of information provided in the PSER is not required unless changes have occurred since the original submittal. As a minimum, the report shall contain:

1. The results of the hazards assessment performed according to the Work Plan submitted in the PSER.
2. If hazards were identified in the PSER. the report shall provide:
    - The results of the Site Investigation Program carried out to gather engineering data required for remedial designs.

- The results of subsidence predictions, including documentation of the trough subsidence evaluation.
- Plans, engineering studies, and specifications for proposed elimination of catastrophic effects and or mitigation of predicted trough subsidence effects.
- Proposed construction contractor(s) and estimated construction schedule for mitigation.

As-Built Hazards Mitigation Report. An As-Built Hazards Mitigation Report shall be required to document any remedial or mitigation activities carried out in Coal Mine Hazards Areas. The report shall contain, as a minimum:

1. As-built surveys showing the location of mine closures. Any closures carried out by the OSM, or its supporting contractor(s), are subject to these location reporting requirements.
2. Documentation certifying the mine closures have been constructed as designed.
3. Documentation, if appropriate, that mitigation for trough subsidence areas is not required as this will be controlled through building permit inspections. Such documentation will clearly identify the tilt and strain levels that any building permit will need to comply with.

C. PROCEDURES TO EVALUATE COAL MINE HAZARDS

This section presents the methods used for the evaluation of coal mine hazards. The section is composed of two parts. The first evaluates the potential for sinkhole development. This evaluation is used to determine if there is any site that will need to be mitigated because of an unacceptably high probability that a sinkhole could develop from shallow mine workings. The second section presents the recommended procedures for estimating the subsidence potential of underground mine workings and to the resulting forces any development would be subjected.

Potential for Sinkhole Development

Matheson (1991) has developed an equation to fit the sinkhole development probability curve (Figure 1).

$$P = 1.0 \qquad \text{(for } h/m < 6.2\text{)}$$
$$P = 1516\,(h/m)^{-4} \qquad \text{(for } h/m > 6.2\text{)}$$

where,

P	=	Probability of void creating a sinkhole
h	=	Depth to mine floor
m	=	Extracted seam height

The extracted seam height (m) used in the formulae should be adjusted for seam inclination as follows:

$$m = \frac{seamthickness}{\cos(\theta)}$$

This equation can be used to predict the probability of sinkhole development over areas where secondary or "retreat mining" has not been fully carried out and remnant pillars preserve the subsurface void space into which the mine roof can collapse.

Figure 1. Probability of Sinkhole Development

Source: Boulder County Subsidence Investigation report, Figure 8-3, page 8-36 (CMLRD, 1986).

No additional mitigation will be required if the maximum probability of sinkhole development is less than one percent (< 1%). The recommended procedure for determining the probability of sinkhole development simplifies what is otherwise a complex analysis. The threshold of P = 1% has been set bearing this in mind. If the probability is over 1%, then the potential for sinkhole development will have to be mitigated by the voids being filled, grouted or otherwise acceptably mitigated to the satisfaction of the department.

Alternative methods for evaluating sinkhole potential may be utilized provided they meet the intended standard of long-term surface stability. For example, methods commonly utilized in civil tunnel stability analyses may be utilized.

Estimation of Tilt and Strain from Potential Subsidence

The recommended procedure for calculating tilt and strain is based on the empirical methods in the Subsidence Engineers Handbook, 1975 (see References). Alternative methods of calculating potential subsidence magnitudes, strains, and tilts may be used provided they incorporate similar assumptions to those specified in the recommended procedure. If alternative calculation methods, design parameters or assumptions are proposed, detailed justification must be provided to the Department, in the PSER, for review and approval.

The recommended procedure includes the following steps:

1. Estimate the remaining equivalent mining height by either 1) direct subsurface exploration or 2) using mine records and published information on coal seam characteristics.

    - Subsurface conditions may be evaluated by drilling. Although drilling is not compulsory, it is the most acceptable method for providing information that is acceptable for reducing the remaining mining height value used in subsidence calculations.

- If the applicant wishes to conduct a subsurface investigation, the proposed approach must be submitted with the PSER for review and approval.
- If a drill hole encounters voids at or above the location of the coal seam, the cumulative length of the voids shall be added to the void observed at the coal seam horizon to determine the remaining mining height.
- Direct evidence of the condition of panels in the same seam with similar dimensions, similar extraction ratios, and at a similar or shallower depth, shall be accepted as evidence of the condition of mine workings at any point.
- Surface geophysics, or other indirect means, may be used to assist in projecting information between and beyond drill holes, but shall not be accepted as the sole method for evaluating the condition of underground mine workings and calculating remaining mining height. Assumptions concerning the extent of collapse of mine workings based on recorded extraction ratios shall be conservative because of possible inaccuracies of mine records, the likely presence of remnant pillars and the lack of data to accurately locate them, and because uncollapsed mine workings have been documented under similar conditions in King County.

2. In the absence of site specific data derived from drilling, the remaining equivalent mining height shall be estimated as follows:

- For workings between 0 and 200 feet, the REMH is assumed to be equal to the seam thickness or recorded mining height.
- For workings between 200 and 1000 feet deep, the REMH is estimated from Table 1 and the extracted thickness (from mine records or published data (see References A and B)). The extraction ratio shall be based on an examination of the detailed mining records. Where detailed maps or data are unavailable, or drawings are unclear, a "worst case" extraction ratio shall be used.

Table 1 - REMH for Workings Between 200 and 1000 ft

Extraction Ratio (%)	Remaining Equivalent Mining Height in terms of Extracted Thickness (%)
0	0
10	10
20	15
30	25
40	30
50	25
60	20
70	10
80 - 100	5

- For workings deeper than 1000 feet, the REMH is assumed to be 0.

3. Estimate the maximum vertical subsidence for each mining panel using the remaining equivalent mining height and the panel width to depth ratio applying corrections for limited face advance, where appropriate (see Fig. 3 and Fig. 4 of the Subsidence Engineers Handbook (SEH, 1975, pp. 8-11).

4. Estimate the maximum vertical subsidence for an inclined seam as the maximum subsidence that would be predicted for a horizontal seam, multiplied by the cosine of the seam dip.

5. Adjust the downdip, centerline, and updip limit angles for seam inclination using Table 2, and estimate the subsidence profile (see Section 3, SEH). Topography is considered in determining the point at which the limit angle intersects the ground surface, and hence the limits of predicted subsidence.

Table 2 - Down-Dip, Centerline, and Up-Dip Limit Angles

Seam Dip	Rise or Up-Dip Limit Angle	Centerline Projection Angle	Down-Dip Limit Angle
0	20	0	20
10	15	5	25
20	10	10	30
30	10	15	35
40	5	20	40
50	5	20	40
60	10	15	35

These values are based on a survey standard for the subsidence limit of 0.1 ft.

6. Estimate slope (tilt) from the predicted subsidence curve at intervals of 1/20th of the average seam depth.

7. Estimate maximum horizontal strain and the strain profile from either:

   - Ground curvature using the method outlined on pages 33 - 37 of the Subsidence Engineers Handbook, or,
   - Predicted subsidence and average seam depth using the method outlined in Section 3 of the Subsidence Engineers Handbook

8. For conditions involving multiple seams, separate predictions shall be made for each seam and superimposed.

No additional mitigation will be required if the maximum predicted ground slope change (tilt) is equal or less than 1:350 (V:H) and the predicted surface strains are equal or less than 0.003 (in/in). The recommended procedure for determining the predicted tilt and strain simplifies what is otherwise a complex analysis. For conditions where the predicted ground slope change is greater than 1:350 (V:H) and/or the predicted surface strains are greater than 0.003 (in/in), then the potential for damage form subsidence is significant and will need to be mitigated by designing the alterations to withstand the forces. Depending on the alteration proposed, K.C.C. 21A.24.210B identifies the safety factors required. Note that special designs may be needed to mitigate potential impacts.

D. DETERMINATION OF COAL MINE HAZARD AREA

The definition of Coal Mine Hazard Areas states that any area is defined as a hazard if, among other criteria, it is "subject to the risk of trough subsidence, catastrophic collapse or combustion...". Only those areas meeting the definition of Coal Mine Hazard Areas are subject to the requirements of the Sensitive Areas Code and K.C.C. 21A.24.210. This section provides guidance on how to determine if a site with identified coal mine workings is subject to these risks and therefore a regulated hazard area or not.

Demonstration of Risk

Combustion. *(Need a clear test for combustion*

Catastrophic Collapse. Risk of catastrophic collapse can be demonstrated by conducting the evaluation for potential sinkhole development presented in Section C. If the maximum probability of sinkhole development is less than one percent (< 1%), then the site is not at risk of sinkhole development.

Trough Subsidence. Risk of through subsidence can be demonstrated by conducting the evaluation for the estimation of tilt and strain from potential subsidence presented in Section C. If the maximum predicted tilt (ground slope change) is less than 1:350 (V:H) and the predicted surface strains are less than 0.003 (in/in), then the site is not at risk of trough subsidence. Alternative methods for demonstrating that abandoned workings will remain stable under existing and planned future loads are acceptable if the procedures presented below are used to evaluate remnant roof, floor and pillar stability.

Alternative Evaluation of Trough Subsidence Using Roof, Floor and Pillar Stability

The recommended procedures for evaluating roof, floor, and pillar stability are provided below. Alternative methods may be acceptable provided they incorporate similar assumptions.

Pillar Stability and Failure. Coal pillar stability is calculated assuming each pillar supports an area equivalent to its own area plus an area of roof spanning half the distance to the next pillar. The pillar load (or stress) is calculated using the following formula:

$$PL = (OL \times AT) / AP$$

where,

PL = Pillar load (lb/in^2, or lb/ft^2)
OL = Overburden Pressure, (lb/in^2, or lb/ft^2) calculated by multiplying the overburden thickness (ft) by the overburden unit weight (lb/ft^3)
AT = Total area supported by pillar (ft^2)
AP = Area of pillar (ft^2)

This equation can be re-written using the extraction ratio instead of the area supported by pillars:

PL = OL / (1 - ER)

where,

ER = Extraction ratio ((AT - AP) / AT)

Traditional pillar strength formulae account for the intact coal strength (determined in the laboratory) and the pillar's aspect ratio. Two methods are suggested in this guidance document.

1. Method suggested by Baushinger (described by Hustrulid (1976), p129; Peng (1978), p188):

PS = CRMS x (0.778 + 0.222(Wp/Hp))

where,

PS = Pillar Strength (lb/in^2, or lb/ft^2)
CRMS = Coal Rock Mass Strength (lb/in^2, or lb/ft^2)
Wp = Coal Pillar Width (ft)
Hp = Extracted Seam Height (ft)

2. Method suggested by Hustrulid, 1976:

PS = CRMS x SQRT(Wp/Hp)

The factor of safety (FS) is calculated from the ratio of pillar strength/pillar stress. Ranges in the value of FS, required for stability, have been suggested by Brady and Brown (1985)(FS = 1.3 to 1.9), and by Peng (1978) (FS = 1.5 to 2.0).

Floor Stability and Failure Floor stability or failure is a function of the ability of the floor rock to resist the shear forces associated with the pillar punching into the floor. Pillar punching is analogous to bearing capacity failure of a foundation and is analyzed using traditional foundation design methods; two solution methods are described below:

1. Method suggested by Brady and Brown (1985):

Qb = 1/2 (GMA x Wp x NG x SG) + (c x cot(PHI) x Nq x Sq) + (c x cot(PHI))

where,

Qb = Bearing Capacity (lb/in^2, or lb/ft^2)
Wp = Coal Pillar Width (ft)
NG = 1.5 x (Nq - 1) x tan(PHI)
Nq = $e^{PI \times tan(PHI)}$ x tan^2(PI/4 + PHI/2)
SG = 1.0 - 0.4(Wp / Lp)
Sq = 1.0 + sin(PHI)(Wp / Lp)
c = material cohesion (lb/in^2, or lb/ft^2)
PHI = material friction angle

2. Method suggested by Vesic, 1969 (Reported in CMLRD, 1986):

Qb = SS x Nc

where,

SS = Shear Strength (lb/in^2, or lb/ft^2)
Nc = 5.61 + 0.146(Wp / t) for Wp/t > 3.8
t = thickness of floor strata (ft)

The disturbing force is the vertical pillar load (PL) previously defined in **Pillar Stability and Failure**. The factor of safety is the ratio of the two forces (Qb / PL).

Roof Stability and Failure. The process of collapse over a mine opening involves loosening and relaxation of the horizontally bedded roof strata which induces tensile and shear stresses at the abutments. If these stresses exceed the material strengths, then failure will occur. This failure will progress up into the roof until a stable arch is formed or partial support is provided by the broken rock pile. An analysis of the bulking potential of roof strata, typical of the Laramie formation, indicates that movement would be arrested a distance approximately equal to 5-to-6 times the extracted seam height. This hypothesis has been field verified as part of work conducted by the CMLRD.

Roof stability or failure can be determined by analyzing the resisting and disturbing forces present in the roof strata immediately prior to failure. Assuming that the roof strata behave as a simple beam, the maximum tensile stress occurs at the outer fiber at the center of the beam.

TS = $(3 \times GMA \times L^2) / (4 \times t)$

where,

TS = Maximum Tensile Stress in Roof Beam (lb/ft^2)\
GMA = Unit Weight of Roof Strata (lb/ft^3)
L = Roof Span (ft)
t = Thickness of Roof Beam (ft)

The maximum shear stress occurs at both ends of the beam above the rib:

SS = (3 x GMA x L) / 4

where,

SS = Shear strength (lb/in^2, or lb/ft^2)

In the case where lateral deformation is restrained, and the roof can be considered to act as a beam clamped at both ends, the maximum tensile stress occurs at the upper side on both ends of the beam.

TS - (GMA x L2) / (2 x t)

The resisting forces are the tensile (ZIGt) and shear strengths (TOR) of the roof strata. The factor of safety is again expressed as the ratio between the two resisting and disturbing forces (ZIGt / TS), and (TOR / SS).

E. GUIDANCE ON THE ELIMINATION OF HAZARDS

This section provides additional guidance on acceptable methods for mitigating identified hazards in Coal Mine Hazard Areas.

Mine Entries, Shafts, and Existing Sinkholes. Mine entries, shafts, and existing sinkholes shall be permanently sealed using controlled backfill and/or grouting, or an approved, engineered seal.
Acceptable seal construction consists of a tapered, reinforced concrete plug constructed within a steel form; a below grade reinforced concrete cap constructed over shaft collars; and a reinforced concrete plug for sealing horizontal mine entries. Other proposed methods of sealing will be considered on a case by case basis.

Site preparation prior to installation of the plug shall include permanently diverting surface drainage away from the shaft or mine entry, and excavating loose rock and soil away from the collar of the shaft or the mine entry portal.

Shaft and slope entry seals shall be designed and installed so that they are bearing on competent bedrock or dense, competent glacial sediments. The top of the tapered plug or the base of the cap shall extend a minimum of two feet in all directions beyond the shaft or slope entry. The length of any plug used to seal a horizontal mine entry shall not be less than the maximum dimension of the entry. The need for installing additional backfill behind the seal of a horizontal mine entry to prevent potential subsidence over the entry shall be determined on a case by case basis.

Compaction grouting, in conjunction with placement of uncompacted fill, is an acceptable method of backfilling and grouting. Compaction grouting shall be carried out from the bottom of the filled zone to the top in increments/stages sufficient to ensure adequate filling, and compaction of voids.

Prospect Pits. Shallow Prospect Pits shall be backfilled to surface using controlled placement of suitable backfill. Surface drainage shall be permanently diverted away from existing sinkholes and prospect excavations.

Potential Sinkholes. Demonstrate by direct subsurface investigation that coal mine workings either do not exist, or that the workings have fully collapsed so that there is no remaining potential for sinkhole development; or show that the hazards associated with any voids that are identified are fully mitigated by backfilling, grouting, or other approved means such that the potential for sinkhole development is eliminated.

A fence shall be constructed along the sinkhole boundary to prevent access to the area if the potential for sinkhole development has not been eliminated. Signs shall be posted on the fence at intervals of no more than 100 feet warning of danger due to possible sinkholes.

Any sinkholes that develop shall be promptly backfilled and surface drainage shall be diverted away from the sinkhole.

Coal Mine Spoil Piles. Any coal mine spoil piles from which springs or seeps are discharging, or which shows evidence of seasonal discharge of springs or seeps, shall be removed or regraded to expose the source of the spring or seep.

The stability of the coal mine spoil pile(s) shall be verified by a slope stability analysis meeting the King County standards for such work.

All coal mine waste materials, incorporated within a development, shall be covered with a minimum of two feet of clean soil and shall be revegetated in accordance with applicable King County requirements.

No construction shall be permitted over coal mine waste material unless a geotechnical investigation is completed by a soils engineer, and specific design and construction criteria are developed to mitigate the potential impacts of the coal mine waste on foundation stability and performance. Construction shall not be permitted within 100 feet of any coal mine waste dump that shows evidence of current or past combustion.

Mine Gases. Potential hazards associated with mine gases shall be mitigated by backfilling all mine entries, shafts, and sinkholes in accordance with these Regulations.

Mine Fires. Construction shall not be permitted over workings where surface or subsurface investigations indicate the possible presence of combustion in the underlying seam or seams.

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Appendix B

Interviews with Retired Miners

GENERAL INTERVIEW QUESTIONS

Each interview was conducted on an informal basis at the residence of each retired miner. Each interviewee was informed that the information to be provided would be treated confidentially. Two base maps were used as discussion points

(1) Rogers mine section updated by C. Falk on 11/1/72.
(2) Rogers mine/Landsburg mine plan updated February, 1967.

Information was solicited regarding water inflows, fault conditions, mining method and sequence, extraction ratio, condition of subsurface after mining, etc.

Interviewees were asked to describe:

(1) Procedure for mining first level.
(2) Whether water was encountered in the fault penetrated at the base of the first level slope.
(3) Extent of water inflow at the southern extent of the 1st level.
(4) Extraction ratio in the southern-most section of coal mined.
(5) Reason for leaving intact coal pillars as shown.
(6) Extent of caving resulting from 1st level extraction.
(7) Whether any material had been removed by surface stripping.
(8) Procedure for mining second level.
(9) Nature and extent of inflow from boreholes drilled to locate the position of the gravel layer at the southern end of the Rogers seam.
(10) Reason for leaving intact coal pillars as shown.
(11) Whether water was encountered when mining through faults
(12) Source of notes on mine plan referring to "mined out, filled with broken shale, sandstone, etc.)
(13) Nature of excavation shown between Rogers and adjacent 3 ft seam.
(14) Procedure for mining third level.
(15) Reason for leaving intact coal pillars as shown.
(16) Whether water was encountered when mining through faults
(17) Whether an increase in water was encountered over that found in upper levels.
(18) Reason for not mining block of coal at northern end of mine adjacent to property boundary.
(19) Whether mining northern-most block in 3rd level resulted in surface subsidence.
(20) Had the area referred to in (19) been filled.
(21) Was much water drained through boreholes drilled through the 2nd level gangway during 3rd level development.
(22) Condition of underground caved zone and how observed.
(23) Procedure for mining fourth level.
(24) Reason for not leaving intact coal pillars as shown.

(25) Whether water was encountered when mining through faults
(26) Whether an increase in water was encountered over that found in upper levels.
(27) Why mining was not carried out beneath 3rd level workings in northern end of mine.
(28) Reason for change in cross-cut layout.
(29) Excavation during abandonment.
(30) How openings were sealed.
(31) Nature of "booming" drilling round; were holes drilled into the wall rock ?
(32) Size of underground openings.
(33) Type of mining equipment used.
(34) Nature of ventilation system.
(35) Any evidence of mine fires.
(36) Nature/Displacement of faults.
(37) Whether contaminants had been observed in the mine (e.g., seen, smelt ?).
(38) How much water was being pumped from the mine.
(39) Type of pumps being used, size, horsepower, capacity.
(40) How pumps were deployed.
(41) Size of sump used; how quickly sump/gangway filled during power outages.
(42) Any other pertinent information of use to the project.

LANDSBURG - MINER INTERVIEWS

Name	Telephone	Address	Notes
Jack A. Morris President	432-9909 (W) 432-3330 432-0117 (H)	Kerry/Morris Fuel	Msg: 2:09, 1/20/92 Friday Morning 8:00 am.
Evan Morris Vice President	432-5403 (W) 432-0451 (H)	The Summit Inn	Wednesday; 9:00 am.
Carl G. Falk Secretary	255-7033	18415 102nd SE Renton	Wednesday; 1:00 pm
Alva A. "Bud" Simmons Mine Superintendent	833-9390	3731 Auburn Way Sth Auburn	Friday at Noon (12:00 am)
Archie Eltz Miner	886-2476 (H)	32619 Union Drive Black Diamond	Thursday 8:30 am.
Tony Basselli Foreman		Carbonado	No Contact. Keep as backup if needed.
Cameron Rich	829-0286	170 North A st. Buckley	Thursday 2:00 pm

SubTerra Inc.

TELECON/CONTACT MEMORANDUM - RECORD of PERSONAL VISIT

Company Name: Not Applicable
Address: The Summitt Inn
Black Diamond, Washington

Person: Evan Morris

Job No: 91-13

Telephone: (206)-432-5403 Date: 1-22-1992 Time: 8:00 am

Remarks: Evan indicated that he knew little about the operating aspects of the Rogers mines as he had been primarily involved in management. A general discussion was held regarding the use of the Rogers and Newcastle mines for waste disposal; the following pertinent information was provided:

The Pollution Control Board may have conducted an earlier study of the waste at the Rogers mine; the name of Dave Mooney was provided.

Several fires (No. put at 3) that occurred in waste at the Rogers mine were effectively allowed to burn out.

There was no dumping in the Landsburg mine.

Most of the barrels were placed in the trench to the north of the rock bridge (existing roadway across the trench corresponding to the fault located at the bottom of the Rogers No.1 slope). Mainly building debris, stumps, etc placed to the south of the rock bridge.

Reported that one of the miners noted oil in the fourth level sump after tankers containing "bilge" (my word) water were dumped. Never was much oil; disappeared within a few days.

Did not think it was safe to operate a dozer in the bottom of the trench, however, was not the best person to ask about this.

Reported that a truck that entered the Landsburg mine (18 ft seam) through a sinkhole was eventually seen at the fourth mine level after three years.

Action/Next Contact: -

Recorded by: [signature]

SubTerra Inc.

TELECON/CONTACT MEMORANDUM - RECORD of PERSONAL VISIT

Company Name: Not Applicable
Address: 18415 102nd Street
Renton
Washington

Person: Carl Falk

Job No: 91-13

Telephone: (206)-255-7033 Date: 1-22-1992 Time: 1:00 pm

Remarks: Carl was the company secretary during the operation of the Rogers mine. He had good general knowledge of the mine operations but deferred to operating personnel for details.

1st Level:
- Large fault at bottom of first level slope is the same fault encountered in the Landsburg mine due directly east. Fault in Landsburg seam may have greater offset.
- Thought that drillholes were only drilled in the coal during development and booming.
- Did not believe that boreholes were drilled through the hardpan layer beneath the gravel at the southern end of the mine.

2nd Level:
- Pillars left to facilitate mine fire handling.

3rd Level:
- Did not believe that there was much difference in the water inflow in each of the levels.
- pillars left in third level to facilitate mine fire control left in areas of faulting.
- Coal left at northern property boundary to protect road.

Action/Next Contact:
1. Locate drilling records for property south of fault.
2. Check source of notes used by Carl during interview.

Recorded by: [signature]

Carl Falk

4th Level:
- Bean pump (2/3 " line) used in 4th level. Large Bean and two smaller pumps. Centrifugal pump used in 3rd level.
- No exploration for coal beyond the southern end of the Rogers mines from underground. Some surface based drilling was carried out south of the fault; indicated that the dip in this area was 45 degrees (should attempt to retrieve records).

Faults:
- The adjacent Landsburg mine was flooded at the time the Rogers seam was mined.
- Inflows of water were not encountered when mining through faults.

Did not believe that rock was backfilled into the mine workings from surface. His designation of "backfilled with crushed rock" on the section drawing was based on observations of underground conditions.

Where water flowed across the Rogers outcrop and/or gravel cover, ditches were graded to promote flow and reduce infiltration.

Frazier seam made a lot more water than the Rogers.

An excavation line shown on the plan between the Rogers and an adjacent 3 ft seam is probably a dozer cut. No rock tunnels were mined underground apart from those level tunnels mined around the major fault.

SubTerra Inc.

TELECON/CONTACT MEMORANDUM - RECORD of PERSONAL VISIT

Company Name: Not Applicable
Address: 32619 Union Drive
Black Diamond
Washington

Person: Archie Eltz   Job No: 91-13

Telephone: (206)-886-2476   Date: 1-23-1992   Time: 8:30 am

Remarks: Archie was responsible for mining the gangways, counters, and crosscuts (development work). He left the mine in 1972.

1st Level
- Holes not drilled through hardpan at southern end of mine.
- 100% of coal removed from area designated "coal extracted by booming" adjacent to gravel area.

2nd level
- Not sure whether cave caused disruption in gravel layer at southern end of mine.
- Pillars left to seal mine against mine fires.

3rd level
- Holes were drilled into the hanging-wall shale to promote caving. Width of caved zone may be up to 16 ft. Holes may have been drilled in coal only at upper levels.
- Booming round holes often were drilled within a few feet of the upper level gangway. Occasionally the floor was penetrated. caved material was drilled into.
- Pillar of coal left at northern end of mine to protect surface.
- Reported being able to see daylight from 3rd level. Any break to surface resulted in short circuiting of ventilating air; hole was usually filled from surface.

Action/Next Contact: -

Recorded by: [signature]

4th level
- Coal seam consisted of 4' bottom coal, 2' muck, 4' top coal, and several feet of shale in hanging-wall.
- Vertical kerf cutter used during excavation of gangway.
- Coal blasted and loaded using Joy gathering arm loader. water had to be sprayed on coal for dust control during summer months.
- 25 to 30 ft left between crosscuts initially.
- Gangway 16.5' x 10'; crosscuts and counter 10' x 10'.
- Did not believe that extraction ratio in 4th level was higher than 50%. (However, Archie did not work in mine during booming of 4th level).
- Large Bean pump and two smaller pumps used in 4th level. Pumps were run continuously, however, they were not always pumping water. Pumps are in shed adjacent to mine plant office in Black Diamond.
- 4th level gangways were mined out at least one year before booming was started. On returning to this area, significant floor lift (heave) was observed (up to 5 ft); additional excavation was required. Periodic floor excavation was required to permit access for mining equipment.
- 14" diameter timber posts and crossbeams were initially used in 4th level; these sometimes failed and had to be replaced. later 24" diameter posts and x-beams were used. large amount of wood remains underground.

Gas: Landsburg was a gassy mine, however, no methane found in Rogers mines. Carbon monoxide detected. This indicated spontaneous combustion.

Faults:
- First two faults (moving from northern end of mine) displaced about 12 ft towards west. Next fault displaced about 16-20 ft towards east. Sides of exposed rock at fault line were polished.
- No inflows of water when mining through faults.
- Thought that offset at major fault in Landsburg mine was at least 100 ft.

General: Archie did not believe that it would be safe to operate a large piece of equipment in the bottom of the trench as he had observed large slabs of sandstone spalling into the void and suspected that these might hide voids.

Reported smelling "diesel" fumes in mine. (note: Unable to provide precise time, however, believed to be associated with tanker dumping).

SubTerra Inc.

TELECON/CONTACT MEMORANDUM - RECORD of PERSONAL VISIT

Company Name: Not Applicable
Address: 170 North A Street
Buckley
Washington

Person: Cameron Rich

Job No: 91-13

Telephone: (206)-829-0286 Date: 1-23-1992 Time: 2:00 pm

Remarks: Cameron was taken ill prior to meeting.

Action/Next Contact: Reschedule meting after review of other interviews.

Recorded by: [signature]

SubTerra Inc.

TELECON/CONTACT MEMORANDUM - RECORD of PERSONAL VISIT

Company Name: Not Applicable
Address: Kerry/Morris Fuel
Black Diamond
Washington

Person: Jack Morris / Robert Morris

Job No: 91-13

Telephone: (206)-432-3330 Date: 1-24-1992 Time: 8:00 am

Remarks: Jack Morris was the President of PCC and was rarely involved in mining operations. Bob Morris worked in the mine during 4th level extraction and mine decommissioning.

1st level
- Direction for first level rock tunnel obtained by excavating surface outcrop.
- When fault at bottom of Rogers 1 slope was originally found, the mine was shut down.

4th level
- Bob reported that holes drilled into upper level made water; water drained fairly quickly.
- Thought that heave in 4th level was not as great as reported by Archie Eltz. Probably of the order of a few feet.
- Portal for Rogers 3 slope lagged with timber to prevent gravel inflow.
- Extraction ratio in 4th level very high. Usually stopped loader when gravel appeared.

Abandonmnt Openings were blasted shut during mine abandonment. Equipment and pump lines were salvaged.
- Part of pillar between main and return slopes mined prior to abandonment.

General Should contact David Morris regarding material for capping trench.

Action/Next Contact: 1. Find out how water level entry decommissioned (sealed).

Recorded by: [signature]

SubTerra Inc.

TELECON/CONTACT MEMORANDUM - RECORD of PERSONAL VISIT

Company Name: Not Applicable
Address: 3731 Auburn Way South
Auburn
Washington

Person: Alva "Bud" Simmons

Job No: 91-13

Telephone: (206)-833-9390 Date: 1-24-1992 Time: 1:00 pm

Remarks: Bud Simmons was the Mine Superintendent of the Rogers mine.

Records on his working drawings accurate. Not drawn to scale in some places.

1st Level:
- 1st level workings ended as ran out of coal. Had to maintain upward gradient to promote drainage.
- 100% of coal removed from area adjacent to gravel.
- Upper level caved too quickly. New layout of crosscuts adopted to control cave.
- Water, which normally flowed in surface gullies, was piped over trench area.
- Pillars left in coal to provide control of mine fires. Never actually saw a fire, however, carbon monoxide was found.
- Some coal was mined from the surface using a truck mounted rig and dragline (see "strip pit" on drawings).
- No water located in fault at base of 1st slope.
- Water drained through water level tunnel.
- 7.5 to 15 GPM noted on Bud's drawing as emanating from borehole drilled up into gravel layer; other boreholes designated as wet.

2nd level:
- Intact coal pillars left to facilitate control of mine fires.
- Fire control pillars typically left where fault encountered.
- No water encountered when mining through faults.

Action/Next Contact: _

Recorded by: [signature]

Bud Summons:

2nd level
- Thought that few voids remained underground. Cave was always full of coal and/or muck.
- Rock filled from surface on a regular basis. Caterpillar Operator would push sandstone over lip of trench until stable pile stacked against overhanging wall. Would then work out over broken rock pile until trench filled. Subsequent settlement of the order of 20 ft. Amount of material placed in this manner uncertain.
- Cave zone inspected every day.
- Gravel zone over southern end of mine did cave.
- Typically, coal pulled from cave until large amount of hanging-wall rock and/or gravel appeared. Seam was always full of material.

3rd level
- Did not recall being able to see daylight from 3rd level. Remembered seeing daylight from 1st level.
- Water inflows not encountered when mining through faults.
- No lateral rock tunnels were mined.

4th level
- Large Bean pump and smaller pumps used in 4th level. Large Bean pump only run intermittently.
- Estimated water pumping at 35 to 40 gpm.
- Did not think that water pumping changed with depth.

General:
Water drawn from Danville mine for washplant.
- Rogers mine used exhausting ventilation system.

Appendix C

Coal Mine Fatality Information

COAL MINE FATALITIES AT THE DANVILLE AND LANDSBURG COAL MINES; RAVENSDALE, WASHINGTON. DATA COLLECTED FROM THE WASHINGTON STATE ANNUAL COAL MINE INSPECTOR REPORTS: 1885-1962

LAST NAME	FIRST NAME	M.	MONTH	DAY	YEAR	MINE NAME	TOWN NAME	MAITAL STATUS	ETHNICITY	AGE
HARKINS	E	A	FEBRUARY	17	1927	DANVILLE	DANVILLE	MARRIED	AMERICAN	32
HENRY	JOHN		OCTOBER	29	1951	NEW LANDSBURG MINE	RAVENSDALE	MARRIED		58
ENGLISH	HARRY		JANUARY	6	1954	LANDSBURG	RAVENSDALE	MARRIED		40
KOVASH	JOHN	F	JANUARY	29	1955	LANDSBURG	RAVENSDALE	MARRIED		45
RUSSELL	NATHAN	D	JANUARY	29	1955	LANDSBURG	RAVENSDALE	MARRIED		49
STEBLY	FRANK		JANUARY	29	1955	LANDSBURG	RAVENSDALE	MARRIED		58
VAIENTI	LOUIS		JANUARY	29	1955	LANDSBURG	RAVENSDALE	MARRIED		58

LIST OF FATALITIES INSIDE AND OUTSIDE OF COAL MINES IN STATE OF WASHINGTON, JANUARY 1 TO DECEMBER 31, 1927

Date	NAME OF PERSON	Nationality	Occupation	Age	*	DEPENDENTS Widow	DEPENDENTS Child'n	NAME OF COMPANY	Name of Mine	County	Nature and Cause of Accident	Where Occurring
Jan. 25	Ernest Allen	American	Miner	32	S			Northwestern Improvement Co.	No. 8	Kittitas	Fall of cap rock	Working face
Feb. 7	John Davidson	American	Miner	26	M	1	1	Pacific Coast Coal Co.	Burnett	Pierce	Fall of coal	Working face
Feb. 17	E. A. Harkins	American	Miner	32	M	1	3	Tulloch Coal Co.	Danville	King	Fall of person in chute	Working face
Mar. 17	E. L. Brown	American	Carpenter	52	M	1	3	Morton Coal Co.	Morton	Lewis	Falling from bridge	On surface
April 6	W. H. Bird	English	Miner	38	M	1	2	Pacific Coast Coal Co.	Carbonado	Pierce	Surface cave-in down mine	Working face
April 8	Dan Dick	American	Miner	32	M	1	1	Pacific Coast Coal Co.	Carbonado	Pierce	Surface cave-in down mine	Working face
April 8	Frank Erspamer	Italian	Miner	45	M	1	4	Pacific Coast Coal Co.	Carbonado	Pierce	Surface cave-in down mine	Working face
April 8	A. P. Meshishnek	American	Miner	32	S			Pacific Coast Coal Co.	Carbonado	Pierce	Surface cave-in down mine	In chute
April 8	Edwin Smith	American	Loader	23	S			Pacific Coast Coal Co.	Carbonado	Pierce	Surface cave-in down mine	In chute
April 8	George Temby	American	Timberman	48	M	1		Pacific Coast Coal Co.	Carbonado	Pierce	Surface cave-in down mine	In cross-cut
April 8	T. E. West	American	Miner	43	M	1	7	Pacific Coast Coal Co.	Carbonado	Pierce	Surface cave-in down mine	In cross-cut
May 12	Jack Larson	American	Miner	52	M	1	1	Washington Union Coal Co.	Tono	Thurston	Fall of top coal	Working face
May 13	Peter Marino	Italian	Miner	69	S		1	Northwestern Improvement Co.	Roslyn No. 8	Kittitas	Run over by coal car	In room
June 20	Adam Brozdoski	Russian	Miner	52	M	1	3	Northwestern Improvement Co.	Cle Elum No. 7	Kittitas	Electrocuted by trolly wire	On entry
July 20	N. W. Suak	Polish	Miner	39	S			Northwestern Improvement Co.	Cle Elum No. 7	Kittitas	Electrocuted by trolly wire	On entry
Aug. 18	John Simpson	American	Miner	37	S		1	Northwestern Improvement Co.	Cle Elum No. 7	Kittitas	Electrocuted by trolly wire	On entry
Sept. 15	Stanley Angeski	Russian	Miner	48	S			Northwestern Improvement Co.	Cle Elum No. 7	Kittitas	Cave-in of roof	On incline
Oct. 4	Mike Krbavoc	Austrian	Miner	50	M	1	4	Pacific Coast Coal Co.	New Black Diamond	King	Fall of coal	In longwall
Oct. 5	Chas. S. Smith	American	Miner	35	M	1	2	Bellingham Coal Co.	Bellingham	Whatcom	Fall of coal	Working face
Nov. 19	Joe Ohodykin	Polish	Miner	41	M	1	3	Black Carbon Coal Co.	Black Carbon	Pierce	Explosion of powder	Working face
Dec. 3	P. P. Quinn	Scotch	Miner	50	M	1	4	Pacific Coast Coal Co.	Carbonado	Pierce	Gas explosion	Top of slope
Dec. 21	S. Starcovich	Austrian	Trackman	31	M	1	8	Northwestern Improvement Co.	No. 3	Kittitas	Fall of rock	On entry
Totals						15	48					

* M—married; S—single.

Palmer Coking Coal Company

Black Diamond, Washington

JOHN HENRY, occupation miner, about 40 years experience, age 58, married, four children, youngest about 13 years, the others 18, 20 and 22 years, respectively, was instantly killed when he fell a distance of about 100 feet down a chute at the New Landsburg Mine of the Palmer Coking Coal Co. at 11:30 A. M. of Monday, October 29, 1951.

An inspection of the scene of the fatal accident was made by State and Federal Inspectors, U. M. W. of A. representatives, Safety Committee and witnesses to the accident.

The coal bed at this mine is approximately twenty feet in thickness, standing almost vertical 87 degrees; the chutes are driven across pitch on the footwall on an angle of about 55 to 60 degrees, and the booming method of pillar extraction is employed.

The chute at the place of accident was nine feet high measured at right angle to the pitch of chute, and about 6½ feet wide, timbered with three piece sets, lagged roof and sides, with a center prop between the legs about four feet above the floor of the working place. A crosscut had been driven from the roof of the chute to a pillar above, and inby, of the place of accident. Two split lagging had been placed from the center prop to the floor of the chute to serve as a platform to stand on, according to the sworn evidence of Mr. Morton Mann, working partner of Mr. Henry. They were both drilling a vertical hole into the pillar paralleling the above mentioned crosscut to start blasting and booming out the pillar. The hole was to have been drilled a depth of fourteen feet, the first drill had been sunk to the collar and the extension attached when Mr. Henry stepped off the lagging platform onto the center leg so as to reach and place the wrenches used to attach the extension into a tool box on the rib side, when he lost his balance and fell over backward into the empty chute, falling and rolling down the chute a distance of about one hundred feet and was instantly killed.

When inspecting the scene of accident it was observed, and later at the inquiry it was found from sworn evidence that there was a plentiful supply of timber available to provide safe platforms and batteries.

It was recommended and ordered that to prevent a similar accident a safe platform be made, and a battery be so placed below the miners, so that in case of falling it would be the least possible distance.

All present concurred in the above findings.

Present at the investigation:

Sam Nicholls, Pres. U.M.W. of A.
Richard Francis, Sec.-Treas. U.M.W. of A.
John Morris, Gen. Mgr. Palmer Coking Coal Co.
John Morris, Jr., Supt.
Robert Pierce, Mine Supt.
A. Simmons, Foreman
Albert Donaty, Safety Com.
Frank Stobly, Safety Com.
Otto Mattson, Working Partner,
Morton Mann, Working Partner,
Evan Morris, Office Mgr.
Dee Zimmerman, Federal Inspector,
Clarence Holmes, Deputy Mine Inspector,
W. J. Evans, Chief Mine Inspector.

REPORT OF FATAL ACCIDENT
Palmer Coking Coal Company
Black Diamond, Wash.

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An inspection of the scene of the fatal accident was made by State and Federal Inspectors, U.M.W. of A. representatives officials, Safety Committee and witnesses to the accident. Then the above mentioned met at the company office where an inquiry was held.

The coal bed at this mine is approximately twenty feet in thickness, standing almost vertical 87 degrees; the chutes are driven across pitch on the footwall on an angle of about 55 to 60 degrees, and the booming method of pillar extraction is employed.

The chute at the place of accident was nine feet high measured at right angle to the pitch of chute, and about 6½ feet wide, timbered with three piece sets, lagged roof and sides, with a center prop between the legs about four feet above the floor of the working place above, and inby, of the place of accident. Two split lagging had been placed from the center prop to the floor of the chute to serve as a platform to stand on, according to the sworn evidence of Mr. Morton Mann, working partner of Mr. Henry. They were both working drilling a vertical hole into the pillar paralleling the above mentioned crosscut to start blasting and booming out the pillar. The hole was to have been drilled a depth of fourteen feet, the first drill had been sunk to the collar and the extension attached when Mr. Henry stepped off the lagging platform onto the center leg so as to reach and place the wrenches used to attach the extension into a tool box on the rib side when he lost his balance and fell over backward into the empty chute, falling and rolling down the chute a distance of about one hundred feet and was instantly killed.

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It was recommended and ordered that to prevent a similiar accident that a safe platform be made, and a battery be so placed below the miners, so that in case of falling it would be the least possible distance. All present concurred in the above findings.

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W. J. Evans, Chief Mine Inspector

W. J. Evans

W. J. EVANS
Chief Coal Mine Inspector
305 Harrison St.
Seattle 9, Wash.

REPORT OF FATAL ACCIDENT ON JANUARY 6th, 1954, ABOUT 10:40 A. M., AT THE LANDSBURG MINE OF THE PALMER COKING COAL COMPANY NEAR RAVENSDALE

Harry English and Roy Coutts, miners, were working in the counter a few feet in by the junction of No. 25 chute and the counter when the floor of the counter sloughed off, plunging Coutts into the chute from which he was rescued some four hours later, not seriously injured.

The coal bed lies on an angle of about 80° to the horizontal and averages 18 feet in width. The mining in done on the retreat, extraction of pillars by the booming method. A master chute is driven up on an angle of about 45° to 50°; wide enough for a 3-foot gauge track and a 2½-foot wide chute, places are driven on the strike about 35 feet apart, about 200 feet; inby and outby from the master chute. Chutes are driven on an agle of 50° about 50 feet apart to transfer the coal to cars on the gangway. All development work is on the foot wall side and timbered with three piece sets lagged overhead and on the hanging wall side. The recovery of the top block first and on down. Long holes are drilled and blasted and the coal is taken to the chute by a scraper and hoist, the face men working under the timber sets. The angle of the master chute parallels the line of full retreat. The men are always protected by the pillar above. Mr. Coutts was rescued by cutting over a bulkhead built partially across the chute about 10 feet above the gangway.

Inspection of the counter showed it filled tight to the roof with caved material which had run from above indicating a heavy cave had occurred following the sloughing above the chute.

Work to rescue Mr. English was started immediately after Mr. Coutt's rescue. A small skip was taken off the top coal of the chute to about 25 feet above the gangway where the roof turned up sharply and it became unsafe to go farther. Coal was then drawn from the chute, the cave in the counter watched and it was noted the material was running down from the cave inside and over the coal. A mat of ten 35-pound rails, 30 feet long, were pushed over the cave and 2-inch lagging placed on top of the rails, an attempt was made to timber under them and clean out the material to the chute. Pressure and caved material running from above made this too hazardous and it was abandoned. It was then decided to drive a small chute from the gangway and a crosscut in the pillar from the master chute leaving a 15-foot pillar below the counter and timber across the chute. This was accomplished and the chute emptied but we failed to find Mr. English.

A meeting was called at noon, Thursday, January 14th. Sam Nicholls, Al Donati, and Frank Stebly of the U.M.W.A.; L. H. McGuire and E. J. Grillos of the Federal Bureau of Mines; C. R. Holmes, Chief Coal Mine Inspector of the State of Washington; Robt. Pierce, Alva Simmons, Frank Merritt and John Morris of the Palmer Coking Coal Co. being present and opinions asked for regarding further recovery work. Due to the hazardous nature of conditions, the cave having gone to the surface, the gravel and water laying above, it was the unanimous opinion to continue recovery work would be too dangerous.

The work had gone on for eight gruelling days, twenty-four hours each day. Most of the time with water pouring down on the men, disagreeable and hazardous but there were no complaints from anyone. Supervisors and workers did outstanding work and were very disappointed that their efforts had not been successful.

Mr. English was 40 years old, is survived by his wife and two minor children. He had sixteen years of coal mining experience.

A hearing was conducted by C. R. Holmes, Chief Coal Mine Inspector of the State of Washington, on January 18, 1954, at the Palmer Coking Coal Company's office and testimony heard from Robert Pierce, Superintendent; Alva Simmons, Foreman; Ralph Barnett, Roy Coutts, Hans Saftich and John Skulus, miners; Al Donati, President of Local No. 6481 U.M.W.A. and Frank Stebly, miners and Safety Committeemen. Present also were Sam Nicholls, President of District 10, U.M.W.A.; John Morris, Sr.; John Morris, Jr.; Evan Morris; L. H. McGuire, Chief Accident Prevention and Health Division, Region II, U. S. Bureau of Mines, and E. J. Grillos, Federal Bureau of Mines Inspector.

Cause of Accident:

This accident was caused by the top coal of chute No. 25 sloughing off, the timbering supporting the counter went down the chute which started a cave from above filling chute and counter above it. The heavy rains of the three or four weeks preceding the accident are believed to be a contributing factor.

Recommendations:

The company has started a system of vertical chutes which should help to prevent accidents of this kind in the future.

1. Crews coming on shift should check chutes carefully and thoroughly for timbering and other unsafe conditions and make necessary repairs before running coal.
2. Chutes should be kept filled as much as practical for efficient operation.

C. R. HOLMES, Chief Coal Mine
Inspector, State of Washington

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
215 Federal Office Building
Seattle 4, Washington

Region II
Accident Prevention and
Health Division

January 29, 1954

Mr. John H. Morris, President
Palmer Coking Coal Company, Inc.
Box 8
Black Diamond, Washington

Dear Mr. Morris:

The enclosed report covers a Federal investigation of a fatal roof-fall accident that occurred at the Landsburg mine, Palmer Coking Coal Company, Inc., Landsburg, King County, Washington, on January 6-14, 1954.

Any comments that you may desire to make regarding this investigation or report will be appreciated.

Very truly yours,

L. H. McGuire

L. H. McGuire, Chief
Accident Prevention and
Health Division, Region II

Enclosures. 3

cc - J. A. Morris
Robert Pierce
Alva Simmons

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

REGION II

REPORT ON FATAL (CAVE-IN) ACCIDENT AND RESCUE EFFORTS
LANDSBURG MINE
PALMER COKING COAL COMPANY, INC.
LANDSBURG, KING COUNTY, WASHINGTON
(Post Office - Box 8, Black Diamond, Washington)

January 6-14, 1954

By

L. H. McGuire
Mining Engineer

Originating Office - Bureau of Mines
215 Federal Office Building, Seattle 4, Washington
L. H. McGuire, Chief
Accident Prevention and Health Division
Region II

REPORT ON FATAL (CAVE-IN) ACCIDENT AND RESCUE EFFORTS
LANDSBURG MINE
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January 6-14, 1954

By

L. H. McGuire
Mining Engineer

INTRODUCTION

Harry J. English and Roy Coutts, miners, were trapped by a cave-in at the counter entry, No. 25 chute, Landsburg No. 1 bed, Landsburg mine, Palmer Coking Coal Company, Inc., Landsburg, King County, Washington, at 10:40 a.m., Wednesday, January 6, 1954. Roy Coutts was rescued at 2:15 p.m., on the same day and suffered minor injuries. Rescue crews worked continuously from the time Roy Coutts was rescued until 7:00 a.m. January 14, 1954, when it was decided to stop the work because of danger to workmen. Harry J. English is buried permanently in the Landsburg mine. He was 40 years of age and had 16 years of mining experience. He is survived by his widow and two children under 18 years of age.

The Bureau of Mines was first notified of the accident at 2:00 p.m., January 6, 1954, by Clarence Holmes, chief, coal-mine inspector, State of Washington. Bureau of Mines personnel of the Seattle Safety Station responded immediately. Edward Roberts mining health and safety engineer, arrived at the mine at about 3:00 p.m., on the same day. The author and E. J. Grillos, health and safety engineer, relieved Mr. Roberts and assisted with the rescue efforts until the work was finally terminated on January 14, 1954.

GENERAL INFORMATION

The Landsburg mine is situated about 15 miles southeast of Renton, Washington. The mine is opened by four slopes; one pair, consisting of a haulageway and air course, is 600 feet in length and dips 38 degrees from horizontal; the other pair, also a haulageway and air course, is 380 feet in length and dips 40 degrees from horizontal. The latter haulage slope is used exclusively for hoisting coal, and it is about 1 mile from the gangway intersection of the other mine slope. Most of the coal is mined from the Landsburg No. 1 bed, which averages 18 feet in thickness. Two other parallel coal beds, known as the No. 6 and the 8-foot coal beds, are connected to the No. 1 workings by rock crosscuts. They are 15 feet and 8 feet in thickness, respectively. The 8-foot coal bed is under development. These coal beds generally dip 88 degrees from horizontal; however, at the location of the accident the bed dipped 80 degrees. The mine was opened in 1941. The coal is subject to spontaneous combustion and several mine fires have occurred from this cause in the past, however, no lives were lost in sealing off and extinguishing the fires. An explosion has not occurred at this mine.

Thirty-seven men were employed underground, and three men worked on the surface. Three shifts were worked daily, of which two were on production, 5 days a week. The average daily production was 200 tons of coal, which was loaded by scrapers discharging into gravity chutes and a tractor-crawler loader in the gangway.

Master chutes, next to the footwall on 45- to 50-degree angles are driven up, along the strike and in the coal bed, off the gangway at regular intervals. The master chutes are equipped with a 2-1/2-foot-width chute and a 3-foot-gage track. From the master chutes, level rooms, designated as crosscuts, are driven about 35 to 40 feet apart vertically along the strike and next to the footwall of the coal bed for distances of about 200 feet inby and outby the master chute. The level places are 10 feet in height and 10 feet wide. Intermediate transfer chutes were driven next to the footwall on a strike angle of 50 degrees, about 50 feet apart, to transfer the coal to cars on the gangway. The 35- to 40-foot pillars of coal left between rooms or crosscuts are mined on full retreat by the "booming" method, working from the highest room down, in sequence. Long holes are drilled, loaded, and fired and the loose coal is moved to the chute by either scraper or shaker conveyors. Facemen are at all times protected by timbering and lagging, in addition to the pillar above. The master chute parallels the line of full retreat.

The footwall is a hard, sandy shale and the hanging wall is a soft shale. A systematic method of timbering was followed; well-alined, framed timber 3-piece sets, on 5- to 7-foot centers, with lagging overhead and lagging on the hanging-wall side, were erected promptly as the development advanced in the gangway, counter, master chutes, and rooms. Intermediate angle transfer chutes between the gangway and counter entries were adequately supported during construction with rows of stulls on 7-foot centers, along the hanging and footwall sides of the chutes and overhead lagging along the hanging-wall side of the chute. To prevent knocking out timbers near the counter entry when the transfer chute is in operation, the footwall side of the chute is usually driven vertically for a distance of 8 to 10 feet immediately below the counter entry floor connection. The transfer chute timbers beneath the counter connection are inspected visually by the mine foreman and are replaced when necessary. As a further precaution, the counter sets on each side of the chute opening are reinforced for several sets with spreader timbers, installed halfway between the collar and the floor. This was the practice at chute No. 25 where the accident occurred as indicated by the spreader timbers recovered later from the bottom of the chute with grooves where the wire ropes of the scraper had rubbed.

Story of the Accident

Harry J. English and Roy Coutts, miners, were caught by a cave-in that occurred at the counter entry, No. 25 chute, Landsburg No. 1 bed at 10:40 a.m., Wednesday, January 6, 1954, when a brow of coal broke off on the hanging-wall side of the No. 25 chute opening. The break occurred at and beneath the floor level of the counter entry. (See sketch appended to this report.) According to statements by Roy Coutts, he was standing near the center of the chute on the hanging-wall side of the counter entry and Harry English was on the inby edge of the chute opening and near the hanging wall when the accident occurred. The timber supports in the counter entry were, in turn, dislodged when the pillar beneath gave way which resulted in the cave-in. Inspection of the counter entry immediately following the accident, indicated that it was filled tight to the roof with caved material that came from above. Because of the fact that the chute was nearly empty, Roy Coutts fell into the chute and slid down a considerable distance on top of the loose coal. When the cave-in from above occurred, he was carried on down with loose timbers, rock, and coal to the chute bulkhead approximately 10 feet above the gangway entry where he was rescued at about 2:15 p.m., on the same day. Mr. Coutts received a broken wrist, severe bruises to shoulders and hips, cuts about the face and body and physical shock.

Work to rescue Mr. English was started immediately after Mr. Coutts was rescued by removing a skip of coal along the hanging-wall side of the chute for a distance of 25 feet above the gangway, as shown by Step No. 1 on the attached sketch. Because of dangerous ground conditions and a sharp increase of the chute angle, it was necessary to abandon this search project at 5:00 a.m., on January 7, 1954.

It was then decided to draw chute No. 25. At this time, 21 cars of coal and rock were drawn in the hopes of recovering Mr. English. When large rocks appeared, it was known that the caved ground above the counter entry was coming through the chute and possibly passing over Mr. English. In the next attempt, Step No. 2, a mat consisting of ten 35-pound rails, 30 feet long, was pushed over the cave which extended about 15 feet above the floor of the counter entry. The rails were covered with 2-inch plank laid against each other (See sketch.) It was hoped that when the chute was drawn below, that the mat would close off the opening, preventing the chute from filling up with more rock from above and that Mr. English would be recovered.

On January 8, the mat was completed and 12 more cars of rock were drawn from No. 25 chute. It was then determined that the main run of rock was traveling down the chute beyond the ends of the rails, and glacial gravel was beginning to appear. Therefore, the further drawing of the chute was discontinued because of the danger of starting a major inrush of rock and gravel from above. It was then decided to try and support the rail mat and then excavate the loose rock beneath the mat with a scraper, and at the same time start a rescue chute from the gangway in the pillar of coal between No. 25 chute and the master chute. It required 2-1/2 shifts of difficult work to intall one 10- by 10-inch by 18-foot-length fir timber from wall to wall. Because of the slow progress, and danger of an inrush of rock and gravel from above, crushing the mat and trapping workmen underneath, the men were withdrawn from the counter entry on orders of the State coal-mine inspector during the morning of January 9, 1954. This decision was agreed to by

Mr. Sam Nicholls, president, District No. 10, United Mine Workers of America, safety committeemen, company officials, State and the Bureau of Mines representatives.

A survey, using the accessible openings of the pillar block between No. 25 chute and the master chute and the gangway and counter, was made on January 9, 1954, as it was decided to drive the rescue crosscut and rescue chute in the pillar between No. 25 chute and the master chute and eventually forepole and timber across the No. 25 chute, 15 feet below the floor of the counter level. As an added safety precaution, a bulkhead was installed in the master chute to prevent the possibility of an inrush of rock and gravel from above the counter.

The work was started on the afternoon shift January 9, 1954, and was completed on the day shift January 13, 1954 by working continuously with very experienced crews. After the bulkhead across No. 25 chute was carefully inspected, chute drawing commenced at 3:20 p.m., on January 13, 1954. The chute was finally emptied at 6:30 a.m., on the following day. Harry English was not found. Only timbers and tools near him were recovered. The bottom of the chute was thoroughly cleaned by men working with lifelines.

A meeting was held at 12:00 noon, January 14, 1954, to determine what course of action should be taken to recover Harry English. It was decided to appoint a committee to make a thorough underground investigation and report their findings individually.

The investigating party consisted of the following persons:

Representing:

Sam Nicholls, President, District No. 10, United Mine Workers of America

Albert Donati - Miner, (Safety Committeeman), President, Local Union No. 6481, U.M.W.A.

Frank Stebly - Miner, (Safety Committeeman), Local Union No. 6481, U.M.W.A.

Safety Division, Department of Labor and Industries, State of Wash.

Clarence Holmes - Chief Coal-Mine Inspector

Officials of the Company

Robert Pierce	Mine Superintendent
Bud Simmons	Mine Foreman

U. S. Bureau of Mines

E. J. Grillos	Health and Safety Engineer
Louis H. McGuire	Mining Engineer

Each and every member of the committee, whose names appear above, rendered individual and unbiased opinions, which were unanimous, in that any further work to recover Harry English would greatly endanger the lives of fellow workmen. Finally, the committee recommended that the area surrounding the location of the accident should be sealed off and permanently abandoned.

The company kindly donated an acre of land above the cave-in to the English family as a memorial.

A great deal of credit is due to the company officials, supervisors, and mine workers for their outstanding performance during 8 grueling days, 24 hours each day, in their all-out efforts to rescue Mr. English. The work was performed under difficult and trying conditions with water pouring down on them most of the time. Not a single complaint was heard and no injuries occurred.

A hearing was conducted by Clarence R. Holmes, chief coal-mine inspector of the State of Washington, on January 18, 1954, at the Palmer Coking Coal Company's office, Landsburg, Washington, for the purpose of determining the cause of the accident and obtaining appropriate recommendations to prevent a recurrence of a similar accident. Sworn testimony was heard from Robert Pierce, superintendent; Alva (Bud) Simmons, mine foreman; Albert Donati, miner (Safety Committeeman), president, Local Union No. 6481, United Mine Workers of America; Frank Stebly, miner, (Safety Committeemen); Roy Coutts, Ralph Barnett, Hans Saftich and John Skulus, miners. Present also were Sam Nicholls, president, District No. 10, United Mine Workers of America; John Morris, Sr., John Morris Jr., and Evan Morris, representing the Palmer Coking Coal Company, Inc., L. H. McGuire, and E. J. Grillos, representing the U.S. Bureau of Mines.

Cause of Accident

This accident was caused by a brow of coal breaking off on the hanging wall side of the No. 25 chute opening, at and beneath the floor level of the counter entry. The timber supports in the counter entry were in turn dislodged when the pillar beneath gave way, resulting in a cave-in from above, which filled the chute and counter entry above the chute. The heavy rains during a period of 4 weeks preceding the accident is believed to be a contributing factor. The author noted that the footwall was very wet and that water was dripping from numerous cleavage planes near the hanging-wall side of the coal bed in chute No. 25 at the top bulkhead. The original 8- by 8-foot opening in No. 25 chute was enlarged to 12 by 12 feet and in places up to 15 feet square below the top bulkhead which may be attributed in part to the action of the water in weakening the sides of the chute.

RECOMMENATIONS

Compliance with the following recommendations may prevent accidents of a similar nature in the future:

1. Workmen coming on shift should check chutes carefully for timbering and other unsafe conditions and make necessary repairs before running coal. Wet conditions in the chute area over a considerable period of time should be carefully considered by supervisors and workmen and necessary precautions taken.

2. Transfer chutes between the gangway and counter entries should be kept filled as much as practical for efficient operation.

The company has already started a system of vertical chutes which should help to prevent accidents of this type in the future.

ACKNOWLEDGMENT

The cooperation of the United Mine Workers of America officials, company officials, supervisors, and employees, and the State coal-mine inspector during the rescue work and investigation was outstanding and is gratefully acknowledged.

Respectfully submitted,

L. H. McGuire

L. H. McGuire, Chief
Accident Prevention and
Health Division, Region II

FATAL ACCIDENT DATA

1. Daily employment: 40 Time of Accident: 10:40 a.m.

2. General location of accident: No. 25 chute, No. 1 bed

3. Occupation when injured: Miner Regular occupation: yes

4. Age: 40 Approx. experience: Regular job when injured 12 In mines 16

5. Dependents: Widow x No. of children under 18 2

6. Method of loading in place where accident occurred:

   Mechanical x

ADDITIONAL INFORMATION REQUIRED IF FATALITY RESULTS FROM FALL OF ROOF,FACE,RIB

7. Location: Face ____ Room ____ Haulageway ____ Idle workings ____ Other counter

8. Type of permanent support in use at location where accident occurred:

   Posts x Crossbars x Lagging

9. Type of temporary support in place where accident occurred:

   Posts x Crossbars x

10. Did injury occur inby last permanent roof support? No x

11. Average distance from last supports to face: Permanent 6 ft. Temp. 5-6 feet

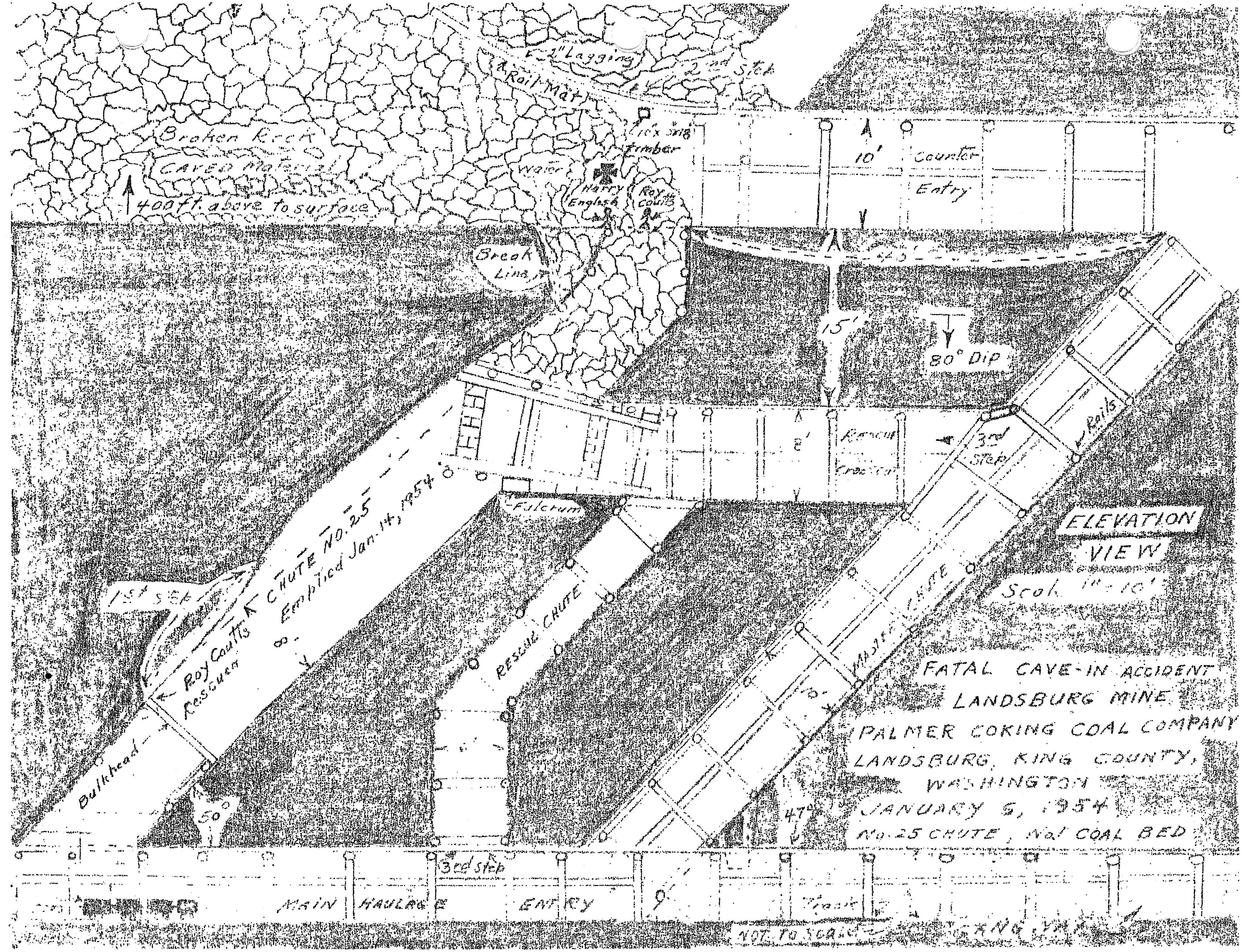
12. Was standard support plan in effect: Yes. Was it followed in this place? Yes

13. Last prior visit by mine officials: Date 1/6/54 Time 9:45 a.m.

14. Cave-in (see sketch) chute and counter above filled with rock and coal.

ADDITIONAL INFORMATION REQUIRED IF FATALITY RESULTS FROM HAULAGE ACCIDENTS:

DNA



2" Lagging
Rail Mat
2nd Step
Broken Rock
Caved Material
400 ft. above to surface
Water
Harry English
Roy Coutts
Break Line
10'
Counter Entry
15'
80° Dip
8'
Rescue Crosscut
3rd Step
Rails
Fulcrum
ELEVATION VIEW
Scale 1"=10'
1st Step
Roy Coutts Rescued
Chute No. 25
Emptied Jan. 14, 1954
Rescue Chute
Master Chute
Bulkhead
50°
47°
3rd Step
Main Haulage Entry
9'
Track
Not to Scale
FATAL CAVE-IN ACCIDENT
LANDSBURG MINE
PALMER COKING COAL COMPANY
LANDSBURG, KING COUNTY,
WASHINGTON
JANUARY 5, 1954
No. 25 CHUTE, No. 1 COAL BED

REPORT OF FATAL ACCIDENT ON JANUARY 6th, 1954, ABOUT 10:40 A.M., AT THE LANDSBURG MINE OF THE PALMER COKING COAL COMPANY NEAR RAVENSDALE

Harry English and Roy Coutts, miners, were working in the counter a few feet in by the junction of #25 chute and the counter when the floor of the counter sloughed off, plunging Coutts into the chute from which he was rescued some four hours later, not seriously injured.

The coal bed lies on an angle of about 80° to the horizontal and averages 18 feet in width. The mining is done on the retreat, extraction of pillars by the booming method. A master chute is driven up on an angle of about 45° to 50°; wide enough for a 3 foot gauge track and a 2½ foot wide chute, places are driven on the strike about 35 feet apart, about 200 feet; inbye and outbye from the master chute. Chutes are driven on an angle of 50° about 50 feet apart to transfer the coal to cars on the gangway. All development work is on the foot wall side and timbered with three piece sets lagged overhead and on the hanging wall side. The recovery of the top block first and on down. Long holes are drilled and blasted and the coal is taken to the chute by a scraper and hoist, the face men working under the timber sets. The angle of the master chute parallels the line of full retreat. The men are always protected by the pillar above. Mr. Coutts was rescued by cutting over a bulkhead built partially across the chute about 10 feet above the gangway.

Inspection of the counter showed it filled tight to the roof with caved material which had run from above indicating a heavy cave had occurred following the sloughing above the chute.

Work to rescue Mr. English was started immediately after Mr. Coutt's rescue. A small skip was taken off the top coal of the chute to about 25 feet above the gangway where the roof turned up sharply and it became unsafe to go farther. Coal was then drawn from the chute, the cave in the counter watched and it was noted the material was running down from the cave inside and over the coal. A mat of ten 35 pound rails, 30 feet long, were pushed over the cave and 2 inch lagging placed on top of the rails, an attempt was made to timber under them and clean out the material to the chute. Pressure and caved material running from above made this too hazardous and it was abandoned. It was then decided to drive a small chute from the gangway and a crosscut in the pillar from the master chute leaving a 15 foot pillar below the counter and timber across the chute. This was accomplished and the chute emptied but we failed to find Mr. English.

A meeting was called at noon, Thursday, January 14th. Sam Nicolls, Al Donati, and Frank Stebly of the U.M.W.A.; L. H. McGuire and E. J. Grillos of the Federal Bureau of Mines; C. R. Holmes, Chief Coal Mine Inspector of the State of Washington; Robt. Pierce, Alva Simmons, Frank Merritt and John Morris of the Palmer Coking Coal Co. being present and opinions asked for regarding further recovery work. Due to the hazardous nature of conditions, the cave having gone to the surface, the gravel and water laying above, it was the unanimous opinion to continue recovery work would be too dangerous.

The work had gone on for eight gruelling days, twenty four hours each day. Most of the time with water pouring down on the men, disagreeable and hazardous but there were no complaints from anyone. Supervisors and workers did outstanding work and were very disappointed that their efforts had not been successful.

Mr. English was 40 years old, is survived by his wife and two minor children. He had sixteen years of coal mining experience.

A hearing was conducted by C. R. Holmes, Chief Coal Mine Inspector of the State of Washington, on January 18, 1954, at the Palmer Coking Coal Company's office and testimony heard from Robert Pierce, Superintendent; Alva Simmons, Foreman; Ralph Barnett, Roy Coutts, Hans Saftich and John Skulus, miners; Al Donati, President of Local #6481 U.M.W.A. and Frank Stebly, miners and Safety Committeemen. Present also were Sam Nicholls, President of District 10, U.M.W.A.; John Morris, Sr.; John Morris, Jr.; Evan Morris; L. H. McGuire, Chief Accident Prevention & Health Division, Region II, U. S. Bureau of Mines, and E. J. Grillos, Federal Bureau of Mines Inspector.

CAUSE OF ACCIDENT:

This accident was caused by the top coal of chute #25 sloughing off, the timbering supporting the counter went down the chute which started a cave from above filling chute and counter above it. The heavy rains of the three or four weeks preceeding the accident are believed to be a contributing factor.

RECOMMENDATIONS:

The company has started a system of vertical chutes which should help to prevent accidents of this kind in the future.

1. Crews coming on shift should check chutes carefully and thoroughly for timbering and other unsafe conditions and make necessary repairs before running coal.

2. Chutes should be kept filled as much as practical for efficient operation.

C R Holmes

C. R. Holmes, Chief
Coal Mine Inspector
State of Washington

HEARING OF FATAL ACCIDENT ON JANUARY 6, 1954, AT LANDSBURG MINE, PALMER COKING COAL COMPANY

Hearing opened at 4 P.M., Monday, January 18, 1954, at the office of the Palmer Coking Coal Company near Ravensdale; conducted by C. H. Holmes, Chief Coal Mine Inspector for the State of Washington.

Mr. Holmes began with the testimony, under oath, of Roy Coutts. Since Mr. Coutts had not completely recovered from his experience in the accident, Mr. Holmes felt he would then be able to leave the hearing earlier if he wished.

ROY COUTTS: "We were working down there. Harry and I just went to the face. One big rock had come down. He said we'd drill, that was about twenty to eleven in the morning. We had one set in the face. I went for the drill. The coal broke near the foot. Harry and I looked toward the face. The next thing I knew, it came down, no crack, no sound. As I went down I grabbed a leg, I saw Harry still scrambling, trying to get a hold. I went down, stopped, got going again, then was in a kind of pocket with boards around me. I sat trying to think, my right hand was caught. I put my light on, hollered for Harry, there was no answer."

HOLMES: "Was there water in the face?"

ROY COUTTS: "Not much water in the face, a few drippers was all. Water was coming down the old chute."

HOLMES: "Were there timbers in the chute?"

COUTTS: "There were some sets put in before. Bud had us put them in."

HOLMES: "How long had Bud been in there previously?"

COUTTS: "Bud left between 9:30 and 10, closer to 10. We were there about an hour. We were to finish the shift if possible or back out. I went back for the drill, it was about 10 minutes later when it happened."

NICHOLLS: "Have you any recommendations, you had been working in there

COUTTS: "There was no squeeze or cracking, no indication of what was going to happen. The men were out to lunch, rock and coal was running. The chute was about a car from empty."

NICHOLLS: "Did you work the chute all empty?"

COUTTS: "We try to."

NICHOLLS: "If it remains full, how do you get air?"

COUTTS: "A booster did push air in."

NICHOLLS: "Where were timbers put in before?"

COUTTS: "At the apex."

NICHOLLS: "Do you have it almost full? Would you fill if it didn't get full to the counter each time?"

COUTTS: "About 10 seconds another cave in came."

NICHOLLS: "If the timbers were sunk to the hanging wall, would it help?"

COUTTS: "It was timbered that way. The middle of the chute was on the hanging side. We were working the face as we could. It was timbered as needed."

McGUIRE: "Were you standing in the center?"

COUTTS: "Not exactly, I was on the brow. Harry would be on the edge of the brow on the hanging side."

NICHOLLS: "How could we try to avoid another such accident?"

HOLMES: "We want no more such accidents."

JACK MORRIS, SR.: "We are certainly as anxious to correct this as anyone else."

MIKE GRILLOS: "What was the width of the top of the chute?"

COUTTS: "It is open dumping. 4 x 4 or 6 long x 5 wide. Visual inspection could be made into it. There was a grisly on top with timbers 18" apart."

McGUIRE: "Did the chute on the hanging wall come straight or at an angle?"

COUTTS: "On the back end feathers out to nothing. On the back side it is 8' at the master chute. The face side came to an angle, then the back end feathered up to nothing."

NICHOLLS: "If a man enters the chute?"

COUTTS: "At the time I fell, must have been backing."

NICHOLLS: "Would you keep the chute fuller?"

HOLMES: "The company is getting ready to use vertical chutes."

BUD (ALVA SIMMONS), Foreman, next took the oath, and was interrogated.

HOLMES: "You have a good idea of the chute, what is your thought?"

SIMMONS: "There were three sets on top of the chute. 16 feet top to counter. The lift was vertical there."

HOLMES: "When all coal is out, they take the timbers out for the next move. Have you any idea of what might have caused this?"

SIMMONS: "All I could see was water caused it."

HOLMES: "When in there on your inspection, was there dripping or

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any indication of unusual conditions?"

SIMMONS: "I was there about a quarter to ten, was outside at 10. I was standing approximately the same place as Roy. Told him if it got worse, we would let it go. There was no sign of sloughing. Al was on shift."

HOLMES: "Did you see anything wrong in the chute. Was there any increase in water?"

SIMMONS: "There was quite a bit of water the last couple of weeks. Tar paper and sheet iron had been put overhead to keep us dry when going under it."

NICHOLLS: "Was there any rock there?"

COUTTS: "There was rock and coal, pretty rocky. The night before it was worse, and just before it was pretty rocky."

HOLMES: "Your next drop would carry you back about 6 feet, wouldn't it?"

COUTTS: "Yes."

HOLMES: "If the coal moves, that determines how long to stay there, doesn't it?"

COUTTS: "Yes."

HOLMES: "How far was the face inside the chute?"

COUTTS: "There were two sets to the face from the end of the grisly. Two to the face would be 12 to 14 feet."

McGUIRE: "Have you any idea where it broke off the brow?"

COUTTS: "I have no idea just how much. There was a terrific cave. It must have been for the terrific wind that went past me when I first stopped. There was not too much the next time."

HOLMES: "Did a crash come with it?"

COUTTS: "No. The way the wind came, it must have been terrible but there was not too much pressure."

McGUIRE: "What is the capacity of the cars?"

MORRIS, SR.: "Around 3½ ton, 3.2 average."

McGuire: "How many cars would the chute contain when full?"

A. "About ten at the most when the original chute was driven. 8 x 8 feet was the original size of the chute."

HANS SAFTICH, Miner, was the next to take the oath and be questioned.

SAFTICH: "It held ten cars when originally made, yes."

HOLMES: "You were on the gangway when this happened, is that right?"

SAFTICH: "Yes, we were eating our dinner. Some fine stuff and water came down, and then another gust of air. We thought it was coal falling, then we heard some one hollering but couldn't tell where it was coming from. After lunch we came down to the chute, then went to the counter about 11:10."

NICHOLLS: "It was approximately four hours when you got Roy out, did the men all dig?"

SAFTICH: "I didn't dig, I was busy getting things the men needed to work with."

NICHOLLS: "How much coal do you pull out?"

SAFTICH: "We take the coal in the stumps. Four more were in the stumps. We take about six cars altogether."

NICHOLLS: "Do you use your own judgement in the amount you do take out?"

SAFTICH: "Yes, unless Bud tells us to take it from somewhere else."

HOLMES: "Who is supposed to work down there?"

SAFTICH: "The miners who load the cars in the stumps and pulls them back to the chute. John was about to pull the chute at the time. I was going to pull the fine coal loose when I heard moans. John ran up to the counter and found it was all caved in. Came back to gangway. Heard nothing."

COUTTS: "There was still stuff going into the chute."

HOLMES: "Was the counter caved in?"

SAFTICH: "There was a glory hole above and it continued coming down. We took a chance going in for Harry because it was still coming down."

NICHOLLS: "Is there anything to say to be beneficial?"

AL DONATI, Miner and President of Local 6481, gave his thoughts on the matter.

DONATI: "It didn't look too bad to us."

HOLMES: "How far above the bulkhead could you see the glory hole when it was empty?"

DONATI: "We went up to see that better, it was our idea that was what had let so much down. Had no idea how big the hole really was."

HOLMES: "If the chute was full would this have happened?"

COUTTS: "It might have settled a little."

NICHOLLS: "Is there any safe way? If the drawing chutes were all filled it would be good and solid and make for safeb traveling. A man falling wouldn't get too far. The boards are staggered as they go up, the boards on the side don't allow it to cave as well."

MORRIS, SR.: "We have never used these chutes for men, these are all for coal."

NICHOLLS: "If they drove a room up to the counter, would it be only for coal? If it is vertical, there is a chance for the passage blocking up."

JOHN SKULUS, Miner, next took the oath, and was questioned.

HOLMES: "Did you see some of this action?"

SKULUS: "I was working the stumps down there. I was down there and, after eating, had two cars loaded from the stumps. Four cars were empty and we were about ready to pull the chute when we heard the call for help. We knew it was at the face, then some one ran in saying some one was working up there. We let the coal down and then we heard Roy's voice. When we were at lunch we looked to see where everyone was. Someone went to poke the coal at the bulkhead, then when it caved in we thought the water had brought the cave in and was not excited then."

HOLMES: "How much time had elapsed after it was heard before you went back there?"

SKULUS: "It was about a half hour. After eating lunch we were ready to pull the chute. We thought perhaps John was in there, we could see the opening at the counter over the chute. It was rock in there, and we knew men were working up there."

ROBERT PIERCE, Supt., after being given the oath, told his story.

PIERCE: "I talked to Bud about 9:45, I wanted to take a look at the spot before lunch. After lunch, Stonebridge was working at the vertical chute. After loading and backing, looked up and saw a light. Went back to the vertical chute, someone was coming up the chute. Went in counter to the chute. There was ten feet of muck to the bottom. There were no sides left. All of it went down the chute. We went down and dug it out but were about four hours getting up. It was 11:30 (ROY COUTTS: "Twenty to eleven, I'd just put my watch in my pocket.") and we were until 2:15 getting Roy out."

RECOMMENDATIONS:

HOLMES: "I believe the move to adopt the vertical chute system is a good move. There will be no burden of weight and sloughage of the chutes then. This chute had been pulled too low, more coal could have been left in the chute."

PIERCE: "If it had been more full, we would have had a harder time getting Roy out. It would have let the coal down and killed Roy. The chute is at a 50° angle. There was no sign of coal back of the water. They had to clean the chute out to get the coal out."

MORRIS, SR.: "If the water begins gaining in the master chute, and work is on the retreat they are using, they should begin stepping back where there is less. There is the corner left there. We certainly want to use every precaution we can."

SIMMONS: "This is the first time we ever have had a wet chute. The places have all been dry."

HOLMES: "What do you think of the idea of keeping the chutes full?"

FRANK STEELY: "Good idea, I think, to keep the chutes full."

DONATI: "They could use a signal light to draw whatever they want."

McGUIRE: "Were there spreaders in the immediate vicinity, with supports and lagging above the set? Is it practical to use spreaders in the area, so that if the lower ones moved, the top would not come down?"

SIMMONS: "The men working these chutes timbered when driving the chutes up. Both sides are wedged as tight as possible so they can't move."

PIERCE: "There were two, and possibly three, spreaders between the chute and the face. The spreaders came down thru the chute, the spreaders had been between the legs."

McGUIRE: "If they could hitch the timbers into the counter wall, they would not need legs?"

COUTTS: "It was a counter leg I grabbed."

HOLMES: "They would have to support one end with legs."

McGUIRE: "If it is practical to recess in the coal on the hanging side and foot wall on the other side, the coal would support it. What size was the counter?"

A: "The counter was 10 x 10 feet."

HOLMES: "The vertical chutes will help out very much."

NICHOLLS: "With the vertical chutes, are they going to have a master chute too?" In a regular chute only coal goes in, no one goes there and so they do not know how wet it is in there."

A: "A man can see down 35 feet from block to block."

GRILLOS: "I doubt that at that degree it could be seen thru."

COMMENT: "If they drew only three or four cars, the man would not fall as far or the moving of a pillar would not go so far down and give him a chance to excape."

MORRIS, SR.: "This was an unusual accident. We might get more help with it some way."

GRILLOS: "There are two ways. With the unusually hard rainfall we have had, there could have been a crack in the floor but the coal would cover it and so not be seen. It was all well timbered, yet it gave away all at once. Probably best to keep the chutes full, it would only be good that way when one fell in, tho. Any chute down six to eight feet would not help."

MORRIS, SR.: "If the chute was full and the men emptied the chute, if there was no coal above no one would know what to do."

DONATI: "We had lights before. With lights to give a signal, they load only until the light goes out. They have to stop loading when the light goes out."

COMMENT: "They would have to hurry and replace the coal that had been drawn."

RETREAT:

COMMENT: "There are a few angle chutes to the counter. The block between the gangway and the counter is this way."

MORRIS, SR.: "With the vertical chutes it will work that way. If in the future they do not make the apex too thin, it would help. Reasonable precautions should be used. They should not make the apex too thin, especially where there is water."

QUESTION: "How are the chutes driven?"

A: "It is pretty vertical, not over 8 feet and then they go straight."

MORRIS, SR.: "Then thinking this way, your counter is the apex on the retreat. Would have to watch all overhang there."

HOLMES: "It should be watched and kept timbered well."

MORRIS, SR.: "They should see that it is not too shallow."

HOLMES: "They have this condition now, as these chutes are already driven, they would have to continue with them."

COMMENT: "Fine coal clogs the chute up and they have to put a man into the chute to clean out."

COMMENT: "The miners on shift should check the chute each day before going to work."

QUESTION: "What about timbering the chute?"

ANSWER: "We were doing that the last time Holmes and Mike were here."

STEELY: "The recommendations to keep the chute full is not too easy. With the light on they can drag the coal from the chute but not for long. They can take only three or four cars. When rock comes down they have to let it go until more coal comes down. If it was rock, they would have to leave the chute full."

MORRIS, SR.: " I believe our Safety Committee is very good, they do their work well."

HOLMES: "Then, we recommend that the timbering be examined each shift before starting work. Also, that the chute between the gangway and counter be kept full and when an unusual amount of water shows up, the men should drop back a bit."

COMMENT: "If the face is close to the draw hole, they should keep the chute as full as practical."

COMMENT: "When the loaders look up and see a glory hole, they should report it."

GRILLOS: "That is all right if it is possible to look up, but it is not always possible."

MORRIS, SR.: "Everyone has been very good and cooperated in every way. I would like to compliment both the men and the inspectors for their fine work. We appreciate it."

HOLMES: "Yes, the men were all good, they worked very hard and I did not at any time hear any grumbling or whimpering."

McGUIRE: "Yes, they all did their very best."

MORRIS, SR.: "We certainly kept McGuire busy here drawing plans up for a new way to get in when one failed."

HOLMES: "I would like to thank everyone present for attending this hearing and doing their best to help us find out what happened and how we might possibly prevent another such accident.".

The hearing closed at approximately 4:45 P.M.

Landsburg, Washington
January 14, 1954

REPORT OF FINDINGS

MINE ACCIDENT
LANDSBURG MINE
PALMER COKING COAL COMPANY, INC.
LANDSBURG, KING COUNTY, WASHINGTON

We, the committee, duly appointed and agreed to by company, union, State, and Federal officials, have carefully and thoroughly made, on this 14th day of January 1954, an examination at chute No. 25, No. 1 coal bed of the Landsburg mine, and the adjacent accessible mine openings, for the purpose of determining if any plan or method could be devised to successfully and safely recover Harry English, a miner, who was entombed by a cave-in that occurred on the morning of January 6, 1954 in the counter and adjacent to chute No. 25.

Each and every member of the committee, whose names appear below, have rendered individual and unbiased opinions, which are unanimous, in that any further work to recover Harry English would greatly endanger the lives of fellow workmen. Finally, the committee recommends that the area surrounding the location of the accident should be sealed off and permanently abandoned.

The committee, whose signatures and titles, as listed below, do hereby declare the results of their findings, as described above, as true in meaning and fact.

Representing:

Sam Nicholls, President, District No. 10
United Mine Workers of America

Albert Donati
Albert Donati

Miner, (Safety Committeeman)
President, Local Union #6481, UMWA

Frank Stebley — Miner, (Safety Committeeman), Local Union #6481, UNWA

Safety Division, Department of Labor and Industries
State of Washington

Clarence Holmes — Chief Coal-Mine Inspector

Officials of the Company

Robert Pierce — Mine Superintendent

Bud Simmons — Mine Foreman

U. S. Bureau of Mines

Emmanuel J. Grilles — Health and Safety Engineer

Louis H. McGuire — Mining Engineer

REPORT OF FATAL ACCIDENT JANUARY 29, 1955, 4:00 A.M., AT THE LANDSBURG MINE OF THE PALMER COKING COAL COMPANY

A cave extending to the surface filling the gangway and counter with water, mud and debris, caused the death of four men:

Frank Stebly, married; **Louis Valenti,** married and one dependent child; **John Kovash,** married and four dependent children; and **Nathan Russell,** married with one dependent child. All men were miners with long experience in steeply pitching coal beds. Mr. Frank Stebly had long been associated with safety work and was a former president of United Mine Workers of America Local No. 6481. He was a member of the general Safety Committee and on December 30, 1954, made a general safety inspection of this mine.

This mine was originally opened about a mile distant from the present slope near Cedar River. The gangway had been driven about 5,000 feet on a 3% grade and the present 41° hoisting slope and air way developed. Connecting rock tunnels had been driven and some coal had been mined from two other beds underlying, known as the 6′ and 8′, and some development work was being done in the 8′ bed. The accident occurred in the No. 1 Bed which is 18 feet in thickness and dips about 80°. The foot wall is hard sandy shale, the hanging wall softer with some soft coal next to the wall. The coal bed is quite uniform in thickness.

The coal had been mined to within approximately 600 feet of the slope and in 6 or 8 months mining in this level would have been completed.

Angle chutes pitching about 50° were driven between the gangway and counter at intervals of 75 to 100 feet at the time of development. For safer operation vertical chutes had replaced angle chutes for man ways and supply chutes.

Two parallel places were driven above the counter and the practice was to drill test holes into the coal above the upper place to check the amount of coal to the hard pan overlying, also for the presence of water, no water had been found in any holes.

The mining was done by long hole blasting, starting with the top place and leaving about 50 feet of coal below the hard pan as a barrier pillar, working the places down in sequence and taking the upper place out 20′ to 30′ in advance of the place below.

The powder charge was placed in the back of the hole and the lower ten feet was filled with stemming which would leave ten feet or so of coal on the timbers as a cushion. When gravel came down or wall rock showed up, the men moved back and fired the next line of holes. The coal was moved to the chute with a hoist and scraper and by gravity to the gangway. The miners were always working under timbers.

The caves came through to the surface usually about 200 feet behind the retreating faces. These cave holes were filled with gravel by a bulldozer and ditches cut around to prevent water from entering the mine.

Frank Stebley and Louis Vaiente were working in the gangway and John Kovash and Nathan Russell were working in the counter.

The morning of the disaster, January 29th, at about 4:00 A.M., Elmer Ranta, night watchman, stated the signal for the hoist started ringing. This had happened on occasions before when some object had fallen and caused a contact starting the signal; however, he tried to get in touch with the men by phone but failed. When the men for the morning shift came about 6:00 A.M., and two went down to investigate, they found the landing at the bottom of the slope filled with debris and water.

Officials were notified, who called me. On arriving at the mine a party consisting of the State and Federal Coal Mine Inspectors and company officials entered the mine and found the gangway filled with mud, debris and water. The counter was covered 2 feet to 3 feet deep with mud and other debris, it had been 4 feet to 5 feet deeper and some had settled down the chutes to the gangway. There was indication it had come with great force and none of the men could be alive. At the cave on the surface, some 1,000 feet from the mine portal, we saw a hole 40 feet to 50 feet across and estimated it 70 feet to 100 feet in depth with water accumulating at the bottom and the sides sloughing in.

It was considered unsafe to attempt any recovery work, a pump was installed at the bottom of the slope, however, very little water had come into the mine. Work filling the cave hole was started February 10th.

The State Coal Mining Board members were advised of the time of the investigation and were invited to attend, and to come in time to inspect the property previous to the meeting. Mr. Pascoe and Mr. Rushton came Friday. Mr. Walmsley, being ill, was unable to attend. An inspection tour was made by Mr. Pascoe and Mr. Rushton accompanied by company officials and myself.

The investigation was held in the company's office February 12th at 10:00 A.M. and testimony was given by Elmer Ranta, watchman; Chas. McAlister; Chas. Anselmo; John Skulas; Hubert Kravagna; Don Manson; Dave Manson; Ralph Barnett; William Zaputil, miners; and Fire Boss Al Parolini; company officials: Robt. Pierce, Supt.; Alva Simmons, foreman, and Jack Morris, Jr., general manager.

District U.M.W.A. President, Mr. Sam Nicholls, Mr. J. H. Pascoe and Mr. Charles Rushton were invited to question witnesses to bring out points to their own satisfaction.

Testimony indicated the general mining practice was good and there had been changes made since the mine was opened, safety being the objective in view. Minor accidents were few and not attributive to the mining method or practice.

All the men stated they thought the mine's general condition the last few weeks was better than usual; the coal seemed drier and no indication of any unusual or unsafe condition.

A company official thought a basin of water below the hard pan could have caused the accident, others who commented thought it possible. Steeply pitching coal beds present hazards not found in flatter beds.

It is doubtful if the bodies of the men will be recovered or if mining will be resumed in this coal bed in the immediate future.

It is recommended as a precaution to prevent a future recurrence of this nature should the company start any mining operation in these steeply pitching beds it would be with a method approved by a Committee composed of State and Federal Mine Inspectors, representatives from district and local U.M.W.A. and an agent from the Federal Bureau of Mines at Washington, D. C.

In addition to the men mentioned above present at the meeting was L. H. McGuire, Sub-District Supervisor, Health and Safety District H, U. S. Bureau of Mines; Al Donati, President of Local 6481, U.M.W.A.; Dave Evans, Safety Committee man and friends and relatives of the entombed men.

C. R. HOLMES,
Chief Coal Mine Inspector,
State of Washington.

ENUMCLAW
THE COURIER-HERALD
LUMBERING · DAIRYING-POULTRY RAISING · RECREATION · MINING
ENUMCLAW, KING COUNTY, WASHINGTON
THURSDAY, FEBRUARY 3, 1955
FIFTY-FOURTH YEAR

Mine Cave-in Kills Four

Cave-in At Landsburg Mine Saturday Traps Men On Two Levels; A Similar Accident Occurred There a Year Ago

Tragedy struck at the Landsburg Mine No. 1 just north of Ravensdale last Saturday and four miners were buried beneath hundreds of tons of earth, rock debris, and the whole area flooded with water. Due to the large area which sunk down, closing the mine shafts below, no attempt has been made to find the bodies of the four men, nor will an attempt be made to enter the mine again until caving stops, mine officials say.

All Leave Families

The four men are Louis Valiente, 58, Ravensdale; Frank Stebly, 58, Black Diamond; John Kovash, 44, Hobart, and Nathan D. Russell, 48, of Carbonado. All are married and have families. Valient, a wife, Madeline and married daughter; Kovash by his wife, Julia, and six sons and daughters, aged from 3 to 24 years; Stebly by his wife, Selma, to whom he was married a few months ago. He has two sons and one daughter by a previous marriage, and Russell by his wife, Wanda, and one daughter and two sons.

Only Four In Mine

The four men were the only ones working in the mine Saturday night when the cave-in occurred. They were working about 700-feet back in the mine at the 450-foot level. The earth gave way on the surface above them, filling the mine with dirt, gravel, coal, water and debris to the bottom of the shaft.

A gaping hole more than forty feet across, and estimated to be more than a hundred feet deep, was left on the surface directly over where the men had been working. The earth has continued to sluff off into the hole since.

Great Pressure Generated

The rush of air from the shaft as the cave-in occurred was so great that it was reported that it blew logs and timbers from the hole. The tragedy was discovered when the 20-man day shift entered the mine.

J. H. Morris, president of the Palmer Coking Coal Company, operators of the mine, and other miners estimated that the cave-in occurred at 4:30 a.m., Saturday. They base their belief on the fact that the night watchman, on the surface, heard a slight tinkle from a bell then. He thought the wires had short-circuted. His post was quite a distance from where the earth surface gave way.

May Not Recover Bodies

Morris said it might be weeks before diggers could reach the four men, as it would be a herculean task to empty the mine of-

(Continued on page 12)

Standard Oil Co. Leases Land And Explores For Oil

Standard Oil Company of California has completed its leasing program in the Enumclaw-Buckley area, and during the past two weeks company geologists have been busy in the Marion district just south of Buckley making seismographic tests.

Just how many acres of land the company now has under lease in the area is unknown, but it is safe to say that it has the majority of it on both sides of White River for three or four miles back from the river in the immediate Buckley-Enumclaw area. The Enumclaw city council leased the city-owned cemetery to Standard Oil, but no drilling would ever be done there.

Three drilling rigs were moved into the Marion District near Buckley by Standard Oil Co. of California last week after a leasing campaign which reportedly covers about half of the privately-held land in the area.

Standard Oil concluded uniform leases with numerous property owners, including Enumclaw School District which hopes Standard can strike black gold on a 160-acre tract owned by the district midway between the two cities.

The present drilling, however, is entirely exploratory. The rigs are not oil drills but seismographic outfits boring test holes.

Dynamite explosions set off in the depths are measured on portable seismographs, the reverberations charting the nature of the underlying strata. When the entire area with its heavy overburden of glacial gravel has been mapped, the company will have a

(Continued on page 12)

SCOUTS OBSERVE 45th BIRTHDAY

Girls Club House Receives Gift

That the Enumclaw Girls Club House holds a warm spot in the hearts of many individuals in the community was evidenced again last week when a generous check arrived from Mrs. F. G. Ulman.

Mrs. Ulman expressed her pleasure at the need which the building was filling in providing an attractive meeting place for the girls organizations. In her accompanying note she wrote, "It is such a satisfaction to know that this work will be carried on in the upbuilding in character of girls in this community."

Chief Operator Pacific Tel & Tel

MRS. FRANK BROWN

Mrs. Frank Brown was promoted to Chief Operator of the Enumclaw office of The Pacific Telephone and Telegraph Company effective February 1st, it was announced by L. M. Monti, manager. She replaces Mrs. Ruth Sanford who is being transferred to Auburn as Dial Chief Operator.

Mrs. Brown has lived here in Enumclaw eight years where she attended high school. Dawn is a member of the Business and Professional Women's Club and the Citizen's Advisory Committee where she holds the offices of treasurer and secretary respectively. The Browns have one daughter, Connie, age 7.

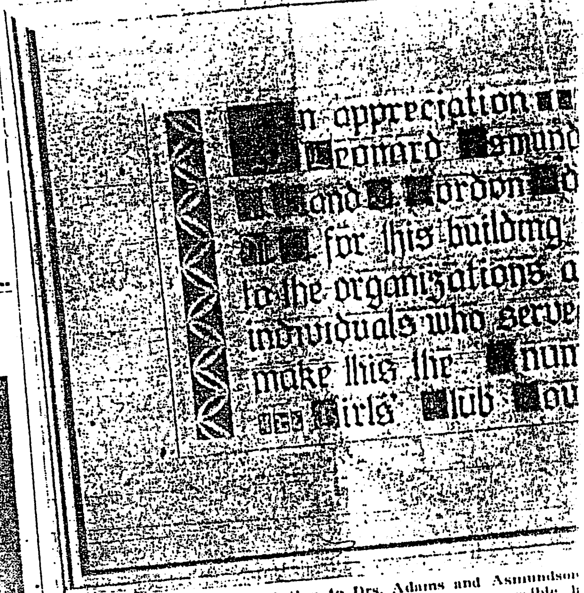
In being promoted to chief operator, Mrs. Brown assumes the responsibility of an office of approximately 30 telephone employees whose job it is to handle all local and long distance calls for Enumclaw. In addition, there are long distance calls to and from Buckley, Wilkeson, Black Diamond, Ravensdale and South Prairie which are handled by the local office.

Honor Enumclaw P. T. A. Founders, Past Presidents

Past presidents and founders of the Enumclaw Pre-School, Primary P. T. A. and high school P. T. A. groups will be honored guests tonight at the annual Founders Day observance.

A joint meeting of the P. T. A. groups will be held in the new elementary building. Dr. Rolland H. Upton will speak on "School Legislation" and Mrs. Frank Osborne will direct the grade school chorus in several numbers. The F. F. A. parliamentary procedure group, ... the direction of Martin ... their

Beautiful Framed "Scroll of Ap... Hung In Entrance Hall At Girls ...



A scroll expressing appreciation to Drs. Adams and Asmundson ... individuals who served to make the Girls Club House possible, h... the building. The beautifully executed parchment scroll was the ... teacher. The building is open after school Monday through F... is always welcome.

Plan To Close March Of Dimes Campaign Soon

Chairman M. O. York, of Enumclaw's March of Dimes campaign, today announced that he plans to wind up the campaign at the end of this week, with collection of the coin recepticles in business houses being made today or Friday.

Return of envelopes has been very good, York said, but there still are many yet to be turned in, and he urged all who have not yet contributed to the fight against polio to open up their hearts and help.

If you have a March of Dimes card put as much money in it as you can spare and mail it at once. If you wish to give direct you may do so either at the Courier-Herald office or at the First National Bank.

It is hoped that when results of the Salk vaccine tests are known later this spring, the good news may be spread that a conqueror of polio has been discovered. It will then take millions of dollars in March of Dimes funds to make vaccine so all children and all adults who desire immunization may have it, he said. It also must be remembered that there are thousands of boys and girls, young men and women who now have polio, who look to your help to help them through months some years of hospital care, he concluded.

Wm. E. Heidinger Former Enumclaw Resident Passes

... services were held at ...

Enumclaw Area To Have Reside... Deputy Sheriff

Note · Word was receive... Wednesday that Sheriff T... Cullough had re-appointed ... claw Police Chief Joe ... deputy sheriff.

As a result of last week' ...ier-Herald article telling ... dismissal of deputy sheri... the need of one in the En... area, local citizens conta... sheriff's office with the ... results quoted from a lett... C-H editor:

"Under Sheriff Don Sp... sured the Enumclaw area ... could expect the services ... ident deputy as of the ... ruary in a conference wi... J. Simundson of this cit... King County Sheriff's ... Friday noon January 29...

"As has been the cust... rural areas the Chief of ... receive the commission ... is the most logical pers... qualified for this positi...

"Mr. Simundson is a ... the Recreation Council ... mer member of the Enu... ice Dept and Mayor ... quested him to look in... ter and to see if he co... the appointment spec... that the recreational c... be assured of adequat... carrying out the ex... gram at the recreatio...

Name 126 O... First Semest... Roll of Hon...

We are proud to pu... of the Junior-Senior ... students who made t... ester Honor Roll "1... the basis of their ...

...irthday

...on its 45th birthday,
...k, Feb. 6 to 12.

...ation has enriched the
...aders. Truly Scouting
...rican life.

...nomic background are
...0,000 boys in its ranks.
...0 adults of good char-
...and talents to serve as
...rs and in many other
...ar... that has not felt

...out ...ecutive, a leader
...it is of vital importance
...r positions of leadership

...itizenship and physical
...and young men who are
...n cooperation with the
...ther community institu-
...r future citizens."

Federal Charter granted
...e "ability of boys to do
...rain them in Scoutcraft,
...self-reliance and kindred

...000 Scouting Units is in-
...e that is adding to his
...ult life."
...ily endorse on this note-

Mine Cave-in

(Continued from page 1)

debris to where they were work-
ing when the accident occurred.
Robert Pierce of Enumclaw, mine
foreman, said that there was no
hope of finding any of the miners
alive. The only hope is that some
bodies might be recovered. Later,
Morris said that probably the men
would remain entombed and that
part of the mine sealed off, the
same as for Harry English, whose
body lies in the same mine fol-
lowing a slide which entrapped
him about a year ago.

State Inspector At Scene

Clarence R. Holmes, state coal
mine inspector, arrived at the mine
and took charge of operations
shortly after the disaster was dis-
covered. After making a prelimin-
ary investigation Holmes stated
that no one will be allowed to go
down into the mine until all haz-
ard has been removed.

Crews began operating pumps to remove water and others began work to keep more surface water from entering the pit made by the cave-in.

Union Representatives At Mine

Sam Nichols, international rep-
resentative and district president
of the United Mine Workers, went
to the mine Monday. He question-
ed the men who worked in the
mine on the shift preceding the
one in which the cave-in occurred.
They told him everything was dry
and apparently all right; that
there was no water, no gravel
slipping.

Nichols had little to say about
mine safety, merely saying, "we
will investigate and see what can
be done." He did say, however,
that the mine had passed its reg-
ular safety check OK.

Leave Bodies In Mine

That the bodies of the four men
will not be removed from the
mine became more evident Mon-
day, when Morris pointed out the
hurculean task ahead if a try for
their recovery were made. He
stated that "it might not be pos-
sible to recover the bodies no mat-
ter how hard we tried."

"We'll have bulldozers fill up
the hole," said Morris. "Then we
probably will go down into the
mine and seal off the area where
the men are. That is the only prac-
tical way out."

Both Morris and inspector Hol-
mes said that due to continued
sloughing of the sides of the cave-
in, nothing can be done right now,
either on the surface or below.

Camp Fire Girls

(Continued from page 1)

Vashon Island and thirteen day
camps operated in state and city
parks throughout the summer.
The "mint" money buys only ac-
tual equipment and supplies for
the camps. Installation work is
done by the "Do-Dads" and "Mar-
velous Moms", parents who volun-
teer their services to accomplish
as much as possible with the pro-
ceeds from the sale.

During the past years the mint
money has built new cabins, im-
proved the waterfront, remodeled
a craft house, built a nature stu-
dio, provided storage space for
sports and games equipment, re-
paired bulkheads and built a much
needed shelter for evening meet-
ings.

This year's mint sale will pro-
vide health and sanitary facilities,
buy necessary camping and hand-
craft supplies, and the new build-
ings needed by rapidly growing
Camp Sealth.

Name 126 On

(Continued from page 1)

Dan Simmons, Sandra Fell, Jim
Olson, Jean Gunderson.
Tenth Grade: 23-- Charles Pan-

cerz... Swa... Eliz... ler, Gar... the... Pol... Sch... Sl... Ni... Ru...

P... va... P... M... I... I... A... J...

...R HEALTH!

...by the Staff of the
...CIENCES DIVISION
... OF WASHINGTON

...reatment of Colds

The virus of the common cold
...duces about 500 million colds
...ery year in this country and we
...y about $4,000,000 annually for
...e treatment of this ever-recur-
...ing ...ly.
T... ...al loss in wages because
... colds is estimated to be about
...120,000,000 each year for an es-
...mated 1½ billion days of misery
...nd reduced efficiency.

Medical researchers have been
...tudying the disease for many
...ears but the virus has not yet
...een isolated. Colds continue to be
...ne of medicine's most baffling
...mysteries.
... ... medical science has

Appendix D

Coal Production Data

MINE ACTIVITY – HISTORICAL – PART 1
(Tons per year per mine)

MORRIS BROS. COAL CO., INC.

YEAR	DURHAM #2	DURHAM #1	MORRIS	OCCIDENTAL	ANNUAL TOTALS
1922	21,127				**21,127**
1923	24,517				**24,517**
1924	27,866				**27,866**
1925	23,473				**23,473**
1926	29,189				**29,189**
1927	23,583				**23,583**
1928	18,889			23,509	**42,398**
1929	2,907			38,229	**41,136**
1930		4,946		43,454	**48,400**
1931			5,232	38,530	**43,762**
1932				28,060	**28,060**
1933				41,358	**41,358**
1934				17,809	**17,809**
1935				19,774	**19,774**
1936				20,877	**20,877**
1937				20,618	**20,618**
MINE TOTALS	**171,551**	**4,946**	**5,232**	**292,218**	**473,947**

MINE ACTIVITY – HISTORICAL – PART 4
(Tons per year per mine)

PACIFIC COAST COAL CO

YEAR	JOHN HENRY NO. 1	ANNUAL TOTALS
1986	4,432	**4,432**
1987	26,852	**26,852**
1988	105,072	**105,072**
1989	120,400	**120,400**
1990	32,553	**32,553** (1st Qtr)
MINE TOTALS	**289,309**	**289,309**

MINE ACTIVITY – HISTORICAL – PART 2
(Tons per year per mine)

PALMER COKING COAL CO., INC.

YEAR	DURHAM	DANVILLE	OCCIDENTAL	PALMER	FULTON STRIP PIT	FRANKLIN 10/11/& 12	FRANKLIN NO. 10	FRANKLIN/ FULTON	KUMMER	ROGERS NO. 1	ROGERS NO. 2	ROGERS NO. 3	ANNUAL TOTALS
1933	4,339												4,339
1934	20,469												20,469
1935	24,409												24,409
1936	28,732												28,732
1937	42,823	1,927											44,750
1938	28,063	2,088	20,274										50,425
1939	15,633	13,080	18,715										47,428
1940	10,721	34,348	14,512										59,581
1941	19,070	41,300	14.577										74,947
1942	31,326	28,359	5,124										64,809
1943	16,329	22,088											38,417
1944	13,969	13,255	5,944										33,168
1945		18,116	13,056	6,822									37,994
1946		20,416		12,039									32,455
1947		23,377		2,585	17,412								43,374
1948		18,201		1,492		34,242							53,935
1949		21,503				37,989							59,492
1950		26,839				42,474							69,313
1951		50,066				45,044							95,110
1952		48,846				44,147							92,993
1953		44,816				45,039							89,855
1954		46,790				87,594							134,384
1955		18,634				69,351							87,985
1956		21,420					15,042	37,221	7,527				81,210
1957		18,077						44,031					62,108
1958		37,952						42,685					80,637
1959		56,464						18,092		15,217			89,773
1960		33,967								12,573	8,678		55,218
1961		794						6,139		8,516	32,472		47,921
1962								15,789		14,375	15,763		45,927
1963								15,617			28,152	5,383	49,152
1964							2,267	5,029			25,838	22,780	55,914
1965							8,172				25,502	8,824	42,498
1966							8,043				16,574	23,372	47,989
1967							8,599					39,069	47,668
1968							6,080					34,698	40,778
1969							8,759					38,862	47,621
1970							9,330					22,463	31,793
1971							360					30,105	30,465
1972												28,572	28,572
1973												16,295	16,295
MINE TOTALS	255,883	662,723	92,202	22,938	17,412	405,880	66,652	184,603	7,527	50,681	152,979	270,423	2,189,903

MINE ACTIVITY – HISTORICAL – PART 3
(Tons per year per mine)

PALMER COKING COAL COMPANY, PARTNERSHIP

YEAR	ROGERS NO. 3	WILKESON– CHINASLOPE	LANDSBURG STRIP	FRASER STRIP	McKAY – SEC. 18	GEM – SEC. 18	McKAY – SEC. 12	BIG DIRTY	LAWSON SLAG	**ANNUAL TOTAL**
1974	14,500	450								**14,950**
1975	5,051	4,220	2,458	3,167						**14,896**
1976		9,081	6,058		7,957	696				**23,792**
1977		2,461	6,445		1,687	3,405				**13,998**
1978					6,287	9,448				**15,735**
1979					161	14,470				**14,631**
1980					8,736	7,710				**16,446**
1981					5,250	3,669				**8,919**
1982						2,625	1,529	3,094		**7,248**
1983						217	2,966	1,548	799	**5,530**
1984							6,726	2,068	8	**8,802**
1985							7,598	1,202	3,538	**12,338**
1986							7,924		3,186	**11,110**
MINE TOTALS	**19,551**	**16,212**	**14,961**	**3,167**	**30,078**	**42,240**	**26,743**	**7,912**	**7,531**	**168,395**

Appendix E

OSMRE Mine Closure Reports

United States Department of the Interior

OFFICE OF SURFACE MINING
Reclamation and Enforcement
Brooks Towers
1020 15th Street
Denver, Colorado 80202-2348

IN REPLY REFER TO:

March 22, 1994

Mr. William Kombol
Palmer Coking Coal Company
P.O. Box 10
Black Diamond, Washington 98010

Dear Bill:

Enclosed for your information is a copy of the final construction report for the mine closure constructed on your property for the Landsburg mine opening.

You should be aware that the concrete plug constructed in this opening was designed to prevent access into the mine but is not designed to support the load of a structure nor does it eliminate the potential for future subsidence of mine workings.

Thank you for your cooperation during this project. Please call me at (303) 844-3067 if you have questions.

Sincerely,

Ginger Kaldenbach

Ginger Kaldenbach
Project Manager

Enclosure

HARTCROWSER

Earth and Environmental Technologies

Hart Crowser, Inc.
1910 Fairview Avenue East
Seattle, Washington 98102
FAX 206.328.5581
206.324.9530

J-3109-40

December 3, 1993

Ms. Ginger Kaldenbach
U.S. Department of the Interior
Office of Surface Mining
1020 15th Street
Denver, Colorado 80202

Re: Final Construction Report
Navy Mine Reclamation Project
King County, Washington

Dear Ms. Kaldenbach:

Mitigation of the above-referenced abandoned coal mine hazards was completed on November 1, 1993. This letter summarizes the mine hazards, work accomplished, construction methods, problems encountered, and any significant changes made to the project plans and specifications.

The contractor's work was documented in our daily field reports previously submitted to the Office of Surface Mining (OSM). Sequence of the work is shown in Table 1, and a summary of the bid quantities is presented in Table 2, both of which are presented at the end of this report. A photographic record of construction activities for the closure of each mine feature is presented in Appendix A.

Each coal mine feature presented a hazard as an attractive nuisance. The locations of the mine features are shown on Figures 1 through 5. The features consisted of:

- Two vertical mine entries that appear to be related to the workings of the Navy Mine (N-01 and N-05);

- One inclined mine entry that extends into workings of the Navy Mine (DJ-01); and

- One mine feature that may be a subsidence located above workings related to the Landsburg Mine (L-01).

The scope of the initial reclamation project did not include closure of N-05. This opening was only discovered during site preparation activities for opening N-01. OSM authorized the contractor to close N-05 with a change order to the existing contract.

Reconnaissance of the area, information collected, and discussions of the mine features are described in Hart Crowser's Task 1 report to OSM (J-3109-26, dated April 15, 1993).

Conceptual reclamation designs were presented to OSM in Hart Crowser's Task 3 report (J-3109-26, dated June 22, 1993).

Construction was accomplished from September 27 to November 1, 1993, by Livingston Construction, Inc. Work was accomplished in general accordance with the project plans and specifications except as discussed herein.

CONSTRUCTION METHODS

Reinforced Concrete Wedges (N-01, N-05, and DJ-01)

Reclamation of openings N-01, N-05, and DJ-01 utilized a permanent closure method widely used by OSM. It involved excavating soil and/or rock materials around the openings, constructing steel wedge-shaped forms for each opening, backfilling the wedges with reinforced concrete, then backfilling with soil over each concrete wedge. As-built wedge placement is presented in Figure 6 for N-01, Figure 7 for N-05, and Figure 9 for DJ-01.

As-built wedge form reinforcement is presented on Figure 8 for N-01 and N-05 and on Figure 10 for DJ-01.

Excavation. The contractor excavated the soil around openings N-01 and N-05 with a Hitachi EX220 tracked excavator to prepare the area for wedge placement. The contractor excavated loose weathered rock and soil by hand around opening DJ-01 after a "Spyder" backhoe was unsuccessful at climbing the steep slope below the opening.

Wedge Fabrication. The wedges for openings N-01 and N-05 were similar to each other in size and resembled inverted four-sided pyramids. For opening DJ-01, the contractor constructed a six-sided wedge because of the irregular shape of the opening. The dimensions of the wedges are presented in Table 3. The steel wedges were fabricated on site in a staging area next to the gravel logging road leading to N-01 and N-05.

Wedge Placement. The tracked excavator was used to lower the wedges into position to seal openings N-01 and N-05. The wedge for DJ-01 was lowered into place using a Bell 204 helicopter. The contractor adjusted the position of the wedge in DJ-01 to orient it better using a 6-ton hoist with a cable attached to the large tree above the opening. He used concrete blocks to support the underside of the wedge during repositioning.

Concrete Placement in Wedges. The contractor elected to place concrete in wedges for N-01 and N-05 using the Bell helicopter instead of rehabilitating the old logging road across the clearcut area. Concrete was delivered to the site from Cadman Sand and Gravel in Black Diamond, offloaded into 1/2 cubic yard buckets, and transported to the openings with the helicopter. Each round trip of the helicopter took approximately 3 minutes. Once the wedges were full, concrete was placed around the outside of the wedges to form a seal between the form and the bearing soil. A total of 44 cubic yards of concrete was used for these two entries.

For opening DJ-01, the contractor pumped the concrete up the slope from behind the Williams residence to the opening using a concrete pump truck (Corbett Concrete Pumping). Cadman delivered 8 cubic yards of concrete to the site. The contractor placed about 4-1/2 cubic yards of concrete into the wedge and about 3-1/2 cubic yards around the outside of the wedge to form a seal between the form and the bearing soil/ weathered rock.

Concrete mix proportions are presented in Table 4 at the end of this report.

Site Restoration. Site restoration for N-01 and N-05 included backfilling over the wedges, grading to provide positive drainage away from the closure, smoothing out ruts, seeding, fertilizing, and covering the disturbed areas with straw mulch. Backfill was placed in about 12-inch lifts and tamped with the excavator bucket to a firm condition.

Site restoration at DJ-01 included backfilling above the wedge to the approximate surrounding grade, seeding, fertilizing, and covering the disturbed areas with an erosion mat. Backfill was placed in 6- to 12-inch lifts and compacted to a firm condition with a hand compactor. The contractor also placed one truckload (about 10 yards) of 5/8-inch crushed rock on the driveway because of disturbance from construction equipment traffic.

Controlled Density Fill (L-01)

Controlled density fill (CDF) was used to backfill mine subsidence feature L-01 in two stages. Cadman Sand and Gravel delivered the CDF to the site from Black Diamond and Issaquah. Corbett Concrete Pumping supplied a trailer-mounted concrete pump. CDF was pumped at a rate of about 60 cubic yards per hour. The Summit-Landsburg Road was closed during CDF placement.

CDF Placement. CDF was pumped a distance of about 150 feet through a 3-inch-diameter hose from the pump located on Summit-Landsburg Road, through a wooded area to the subsidence feature. CDF was discharged from the ground surface and was permitted to drop to the bottom of the subsidence feature (a maximum of 18 feet). The contractor elected to allow this free-fall distance because of concern for the safety of workers near the edge of the depression.

A total of 319 cubic yards of CDF was required to fill the subsidence feature. Initially, after placing about 150 cubic yards of CDF the OSM representative directed the contractor to stop because it appeared that the CDF was not filling the depression. However, as trucks that had been en route to the site were unloaded, the level of the CDF began to rise. With a total of 201 cubic yards placed, the CDF level had risen from 18 to 12 feet below the ground surface. About one week later, after OSM directed the contractor to resume backfilling, CDF placement continued. An additional 118 cubic yards were required to completely fill the subsidence feature. Figure 11 shows the levels and amounts of CDF placed in two stages in L-01.

The proportions of materials in the CDF mix are presented in Table 5 at the end of this report.

PROBLEMS ENCOUNTERED DURING CONSTRUCTION

In general, the contractor did not encounter any major problems during construction. Several minor problems that occurred are presented below.

N-01, N-05, and DJ-01

Poor weather prevented the helicopter from getting to the site for wedge and concrete placement as initially scheduled. The helicopter had to be rescheduled for use several days later.

DJ-01

Excavation around the opening and backfilling activities had to be accomplished by hand because the "Spyder" backhoe was unable to climb the steep slope below the opening. The backhoe became stuck in loose surficial soil about 1/4 of the way up the slope.

Following wedge placement with the helicopter and subsequent wedge reorientation in the opening, gaps between the weathered rock and the fabricated wedge still existed. The gaps ranged in width from 6 to 12 inches. The contractor plugged the gaps with wood, wire mesh and plastic sheeting. One of the plugged gaps on the top side of the wedge gave way during concrete placement and allowed a very small amount of concrete to pass along the side of the wedge.

The hoses from the concrete pump truck became plugged at the beginning of the concrete placement and caused about a 1/2 hour delay.

The contractor had significant difficulty placing the "Regular Curlex Blanket" one of two types of erosion mat suggested by OSM to aid revegetation around DJ-01. Consequently, the contractor decided to remove the "Curlex" material and use the other suggested product, "SuperGro", which was much easier to install.

L-01

The batch plant of the CDF supplier in Black Diamond, Cadman Sand and Gravel, broke down during CDF placement. As a result, Cadman delivered CDF from their Issaquah Plant (a farther distance from the site than Black Diamond), which caused a delay in CDF placement. As a result, the hoses from the concrete pump nearly became plugged during the wait for trucks.

DEVIATIONS FROM PLANS AND SPECIFICATIONS

In general, it was not necessary to deviate significantly from the project plans and specifications during construction. However, several minor changes occurred during the course of the project and these are described below.

N-01

The height of the wedge was about 1 foot taller than specified (11 feet versus 10 feet) and the apex angle of the wedge point was slightly smaller (53 degrees versus 60 degrees) than outlined in the plans.

The contractor did not use high early strength concrete inside the wedge form. OSM approved this change from the specifications at the pre-construction meeting.

No imported general fill or topsoil was required for backfilling above the opening.

The monument stickup was 1.3 feet versus the specified 2 feet.

The contractor substituted 10-20-20 fertilizer because the specified 16-16-8 fertilizer was not readily available.

N-05

The contractor submitted a contract change order for additional work required to complete the closure of N-05, which was only discovered during site preparation activities for N-01.

The height of the wedge was about 1 foot taller than specified (12 feet versus 10.9 feet) and the apex angle of the wedge point was slightly smaller (53 degrees versus 60 degrees) than outlined in the plans.

The contractor did not use high early strength concrete inside the wedge form. OSM approved this change from the specifications at the pre-construction meeting.

No imported general fill or topsoil was required for backfilling above the opening.

The monument stickup was 1.3 feet versus the specified 2 feet.

The contractor substituted 10-20-20 fertilizer because the specified 16-16-8 fertilizer was not readily available.

DJ-01

Due to the geometry of the opening, the apex angle of the wedge point was smaller (45 degrees versus 60 degrees) than outlined in the plans. This was acceptable to OSM during constuction.

The contractor did not use high early strength concrete inside the wedge form. OSM approved this change from the specifications at the pre-construction meeting.

No imported general fill or topsoil was required for backfilling above the opening.

The contractor substituted 10-20-20 fertilizer because the specified 16-16-8 fertilizer was not readily available.

OSM directed the contractor to use a biodegradable erosion mat on newly seeded steeply sloping areas around DJ-01, which were disturbed during construction. OSM recommended that the contractor select either "Regular Curlex Blanket" a wood fiber and plastic mesh composite or "SuperGro" a non-woven polypropylene blanket reinforced with polypropylene netting. The contractor initially selected the "Regular Curlex Blanket", but after difficulties with installation, "SuperGro" was used instead. Installation of the curlex blanket was problematic primarily because the wood fibers came apart from the plastic mesh when the composite was unrolled.

L-01

The contractor submitted a contract change order for mobilization of the concrete pumping truck for the second phase of CDF placement.

OSM allowed the contractor to place CDF into L-01 without the restriction that the CDF free-fall distance be limited to 4 feet or less. Limiting this free-fall would require workers to stand out at the edge of the subsidence depression. The contractor was concerned about the safety of workers in this position and proposed the deviation from the specifications prior to the CDF placement.

The monument stickup was 4.5 feet (per OSM's verbal direction) versus the specified 2 feet shown on the plans.

CLOSING

We accomplished our work for the exclusive use of the U.S. Department of the Interior, Office of Surface Mining (OSM), for the specific subject site. We performed our work in accordance with generally accepted geotechnical engineering practices for the nature and conditions of the work completed, in the same or similar localities, at the time the work was performed. No other warranty, express or implied, is made.

We enjoyed working with you on this project and look forward to the successful closure of additional abandoned mine openings. If you have any questions regarding this report or other aspects of the project, please call.

Sincerely,

HART CROWSER, INC.

STEPHEN A. SIEBERT — STATE OF WASHINGTON — 30329 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 1-16-94 — 12/3/93

J. JEFFREY WAGNER — STATE OF WASHINGTON — 23541 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 3-12-95 — 12/3/93

STEPHEN A. SIEBERT, P.E.
Senior Staff Engineer

J. JEFFREY WAGNER, P.E.
Associate

SAS/JJW:sde/cen
FINAL.lr

Attachments:
Table 1 - Project Sequence
Table 2 - Bid Quantities
Table 3 - Nominal Wedge Dimensions Used in Construction
Table 4 - Structural Concrete Mix Proportions (N-01, N-05, and DJ-01)
Table 5 - Controlled Density Fill Mix Proportions (L-01)
Figure 1 - Vicinity Map - N-01, N-05, and DJ-01
Figure 2 - Vicinity Map - L-01
Figure 3 - Site Plan for N-01 and N-05
Figure 4 - Site Plan for DJ-01
Figure 5 - Site Plan for L-01
Figure 6 - Opening N-01 Plan and Profile (As-Built)
Figure 7 - Opening N-05 Plan and Profile (As-Built)
Figure 8 - Wedge Form Reinforcement (N-01 and N-05) (As-Built)
Figure 9 - Opening DJ-01 Plan and Profile (As-Built)
Figure 10 - Wedge Form Reinforcement (DJ-01) (As-Built)
Figure 11 - Feature L-01 Plan and Profile (As-Built)
Appendix A - Construction Photographs

Table 1 - Project Sequence

Dates	Item
7/30/93	Invitation for bids issued by OSM.
8/12/93	Pre-bid site inspection.
9/8/93	Contract awarded to Livingston Construction of Olympia, Washington.
9/23/93	Pre-Construction meeting.
9/27/93	Contractor received notice to proceed and began mobilization and site preparation for N-01 and DJ-01.
9/28/93	Excavated around N-01.
9/29/93	Spyder backhoe unable to get up to DJ-01. Excavation completed around DJ-01 by hand.
9/30/93	New opening discovered during clearing of access road to N-01. New opening designated N-05.
10/4/93	Excavated around N-05.
10/4 - 10/6/93	Fabricated wedge for N-01.
10/7/93	Placed wedge in N-01.
10/8 - 10/11/93	Fabricated wedge for N-05.
10/12/93	Placed wedge in N-05.
10/12 - 10/13/93	Fabricated wedge for DJ-01.
10/14/93	Placed CDF in L-01. Backfilled hole with 201 cubic yards of CDF to a depth of 12 feet below ground surface.
10/15/93	Concrete placement in N-01 and N-05 wedge and DJ-01 wedge placement cancelled. Helicopter could not get to site due to poor weather.
10/18/93	Placed concrete in N-01 and N-05 and placed wedge in DJ-01 with helicopter. Placed 19 cubic yards of concrete in N-01 and 25 cubic yards of concrete in N-05.
10/19/93	Adjusted position of wedge in DJ-01.
10/20/93	Second stage of CDF placement at L-01. Depression backfilled to ground surface with 118 cubic yards of CDF. Backfilled N-05.
10/21/93	Backfilled N-01.

Table 1 - Project Sequence

Dates	Item
10/22/93	Placed 8 cubic yards of concrete in DJ-01.
10/25/93	Backfilled DJ-01.
10/21 - 10/28/93	Spread seed, fertilizer, and mulch around N-01 and N-05.
10/29/93	Spread seed and fertilizer around DJ-01 and attempted unsuccessfully to install "Curlex" erosion mat.
11/1/93	Removed Curlex erosion mat. Spread seed and fertilizer on slope that had been cleared for Spyder backhoe. Placed "Supergro" erosion mat in area around DJ-01 and on cleared slope.
11/2/93	Final walk-through with OSM representatives.

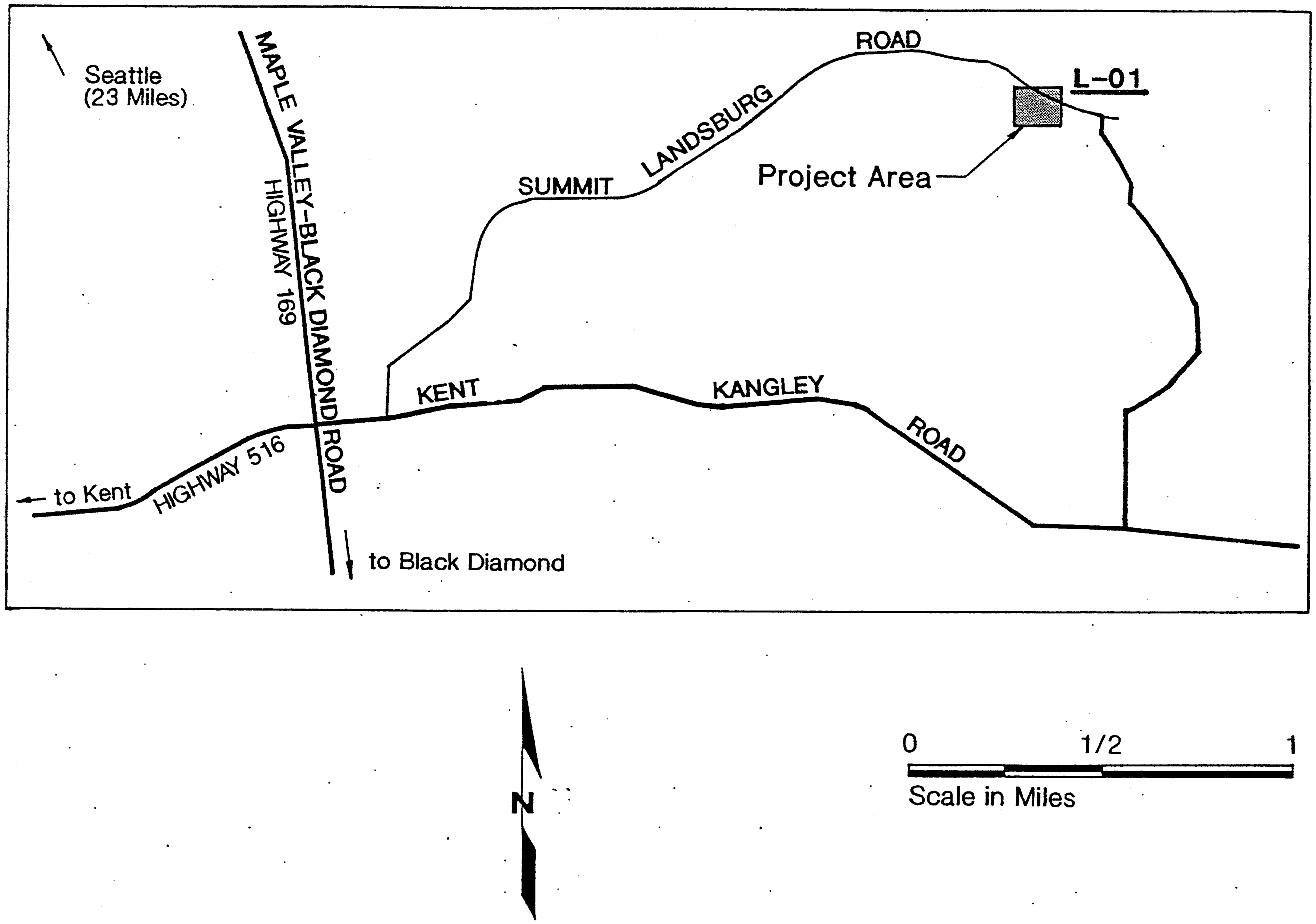
Table 2 - Bid Quantities

Item Description	Unit	Unit Cost	Estimated Quantity	Cost per Estimated Quantity	Actual Quantity	Cost per Actual Quantity
1. Mobilization and Site Preparation						
a) N-01	LS	$7,700	1	$7,700	1	$7,700
b) N-05	LS	$700	1	$700	1	$700
c) DJ-01	LS	$1,800	1	$1,800	1	$1,800
d) L-01	LS	$750	1	$750	1	$750
2. Excavation and Replacement						
a) N-01	CY	$35	70	$2,450	130	$4,550
b) N-05	CY	$35	70	$2,450	90	$3,150
c) DJ-01	LS	$3,750	1	$3,750	1	$3,750
3.Wedge Construction						
a) Wedge Form Construction						
i) N-01	LS	$16,400	1	$16,400	1	$16,400
ii) N-05	LS	$16,400	1	$16,400	1	$16,400
iii) DJ-01	LS	$14,600	1	$14,600	1	$14,600
b) Reinforced Structural Concrete						
i) N-01	CY	$470	25	$11,750	19	$8,930
ii) N-05	CY	$470	25	$11,750	25	$11,750
iii) DJ-01	CY	$180	15	$2,700	8	$1,440
4. Controlled Density Fill (L-01)	CY	$50	250	$12,500	319	$15,950
5.Backfill						
a) Imported General Backfill						
i) N-01	Ton	$50	35	$1,750	0	0
ii) N-05	Ton	$50	35	$1,750	0	0
iii) DJ-01	Ton	$50	35	$1,750	0	0
b) Imported Topsoil						
i) N-01	Ton	$20	9	$180	0	0
ii) N-05	Ton	$20	9	$180	0	0
iii) DJ-01	Ton	$50	7	$350	0	0
6. Revegetation						
a) N-01	LS	$500	1	$500	1	$500
b) N-05	LS	$500	1	$500	1	$500
c) DJ-01	LS	$500	1	$500	1	$500
d) L-01	LS	$500	1	$500	1	$500
7. Demobilization						
a) N-01	LS	$2,500	1	$2,500	1	$2,500
b) N-05	LS	$300	1	$300	1	$300
c) DJ-01	LS	$650	1	$650	1	$650
d) L-01	LS	$300	1	$300	1	$300
Total				$117,410		$113,620

Table 5 - Controlled Density Fill Mix Proportions (L-01)

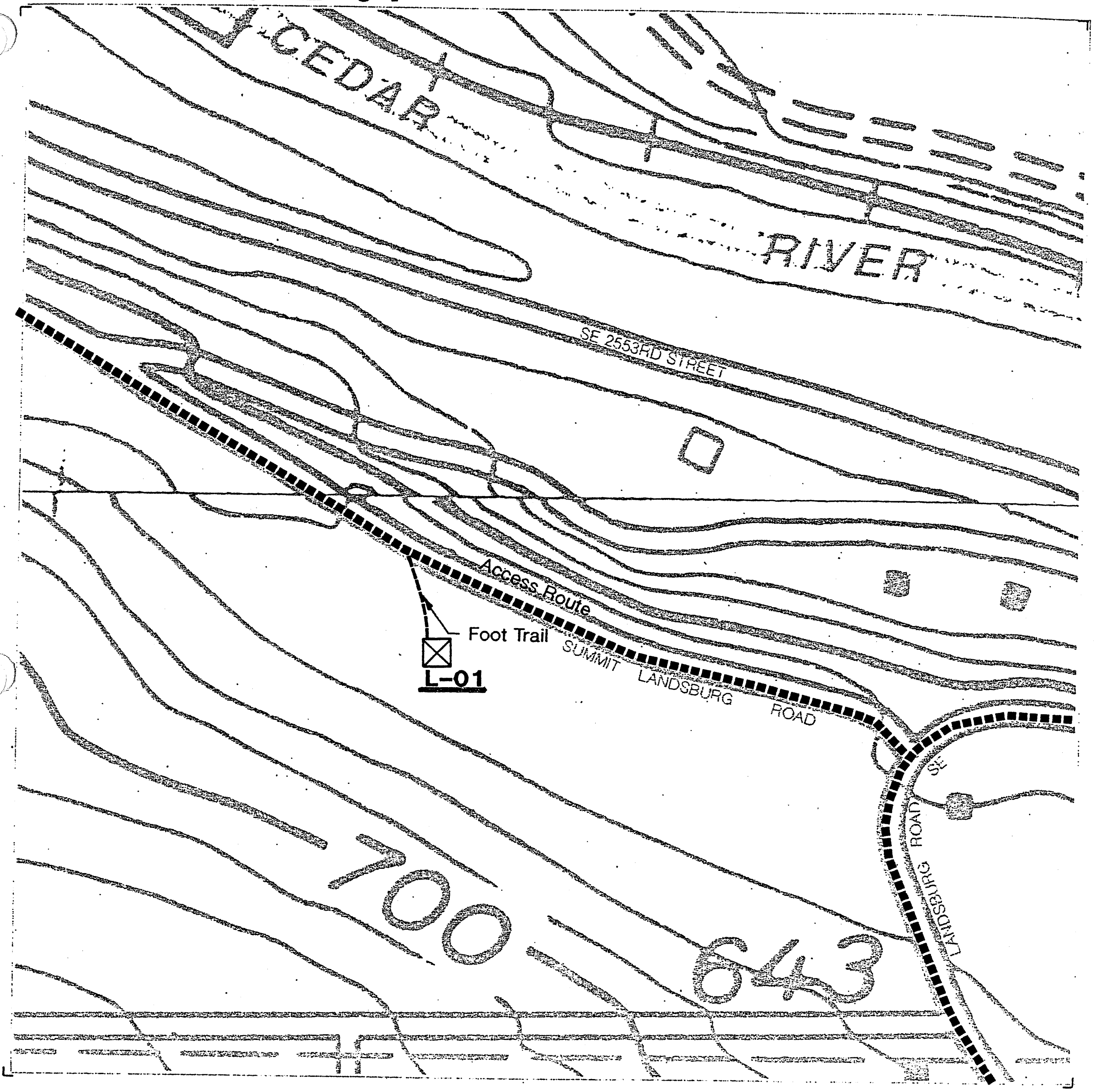
Item	Quantity per Cubic Yard
Portland Cement (Type I)	30 pounds
Fly Ash	300 pounds
Fine Aggregate (Building Sand)	3100 pounds
Water	300 pounds
Air Entraining Agent (ASTM C-2)	2 ounces

Vicinity Map
L-01



HARTCROWSER
J-3109-40 11/93
Figure 2

Site Plan for L-01



L-01 Mine Feature Location and Number

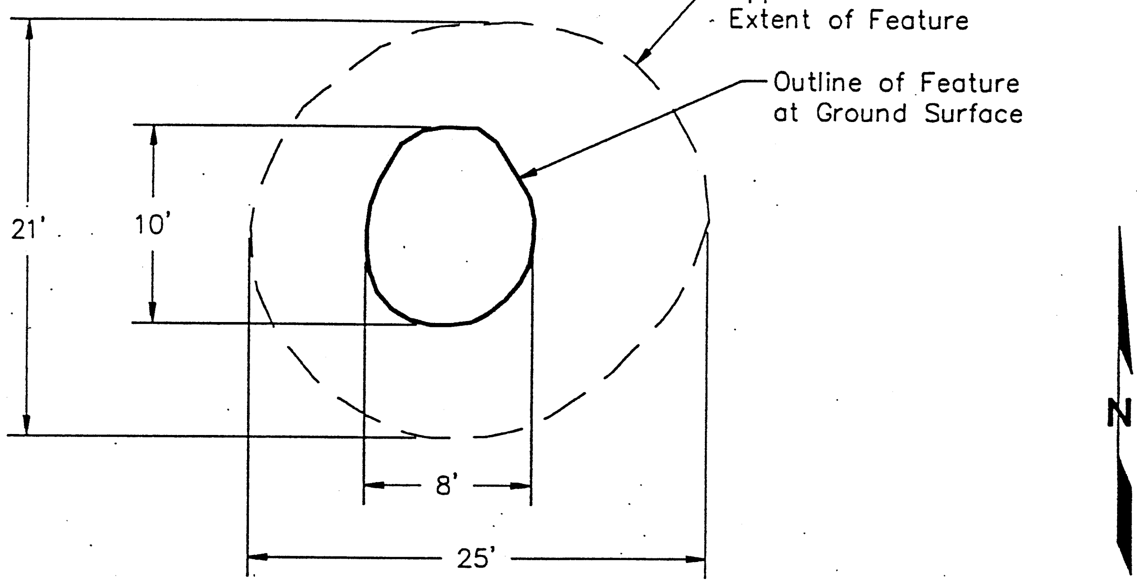
0 250 500
Scale in Feet

N

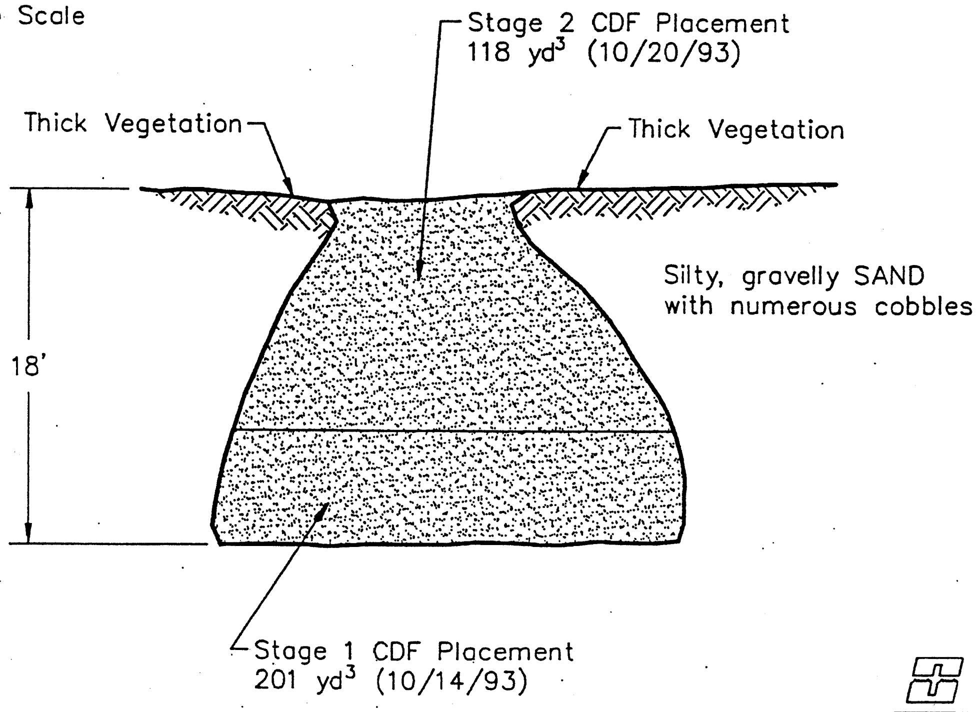
HARTCROWSER
J-3109-40 11/93
Figure 5

Feature L-01 Plan and Profile (As Built)

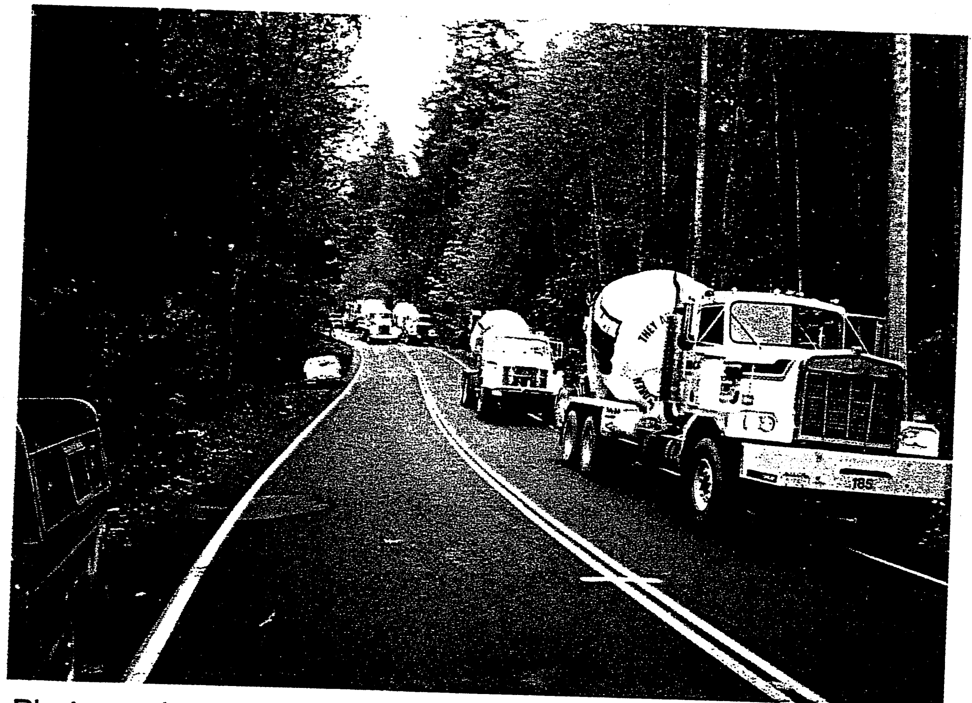
L-01 Plan
Not to Scale



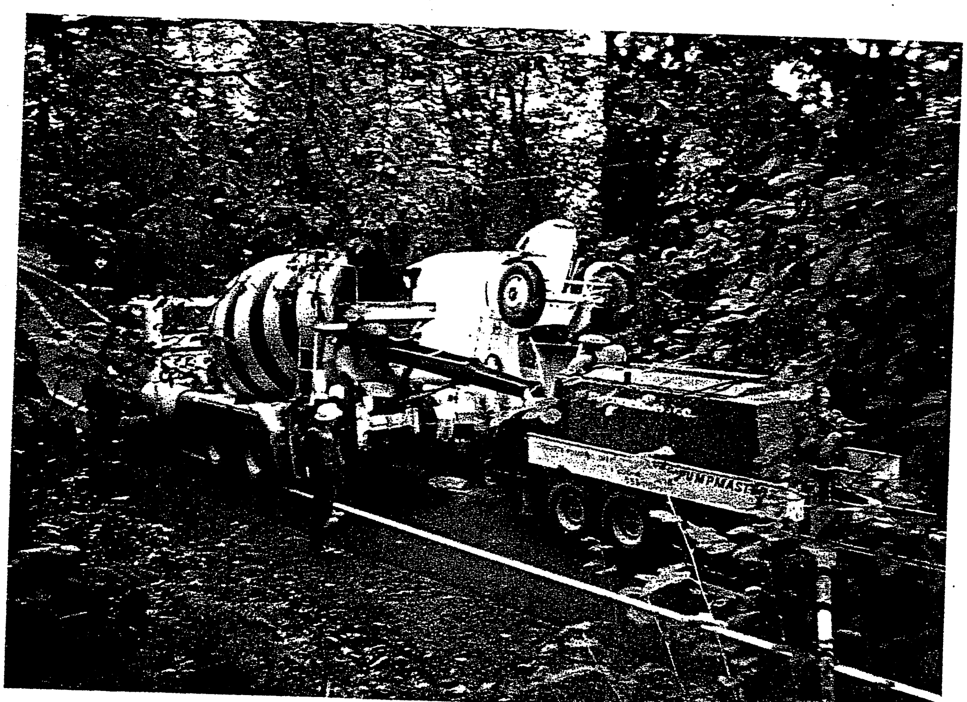
L-01 Profile
Not to Scale



HARTCROWSER
J-3109-40 11/93
Figure 11



Photograph 1 - Trucks with CDF for L-01 backfilling.



Photograph 2 - Unloading CDF into pump for placement into L-01.

Photograph 3 - Hoses from pump through wooded area to L-01.

Photograph 4 - CDF placement into L-01.

Photograph 5 - CDF in bottom of L-01.

Photograph 6 - CDF placement in L-01 nearly complete.

Photograph 7 - Completed CDF placement at L-01.

Photograph 8 - Monument at L-01. Site restoration complete.

STATEMENT OF WORK
GENERAL DESCRIPTION

110 SCOPE OF PROJECT

The purpose of this project is to close and reclaim three abandoned coal mine-related features located near the towns of Cumberland and Ravensdale in King County, Washington. The mine features are apparently related to the Navy Mine (N-01 and DJ-01) and the Landsburg Mine (L-01). A Regional Map and vicinity maps of the sites are presented as Figures 1, 2, and 3.

Reclamation of the three mine features will be accomplished in the following two ways:

1. **Mine Entries N-01 and DJ-01.** Excavation of soil and/or rock to expose a well-defined opening followed by construction of a reinforced concrete wedge to form a plug in the entry. A steel form is to be fabricated, placed in the opening, then filled with concrete. Soil backfill is to be placed from the top of the wedge to the ground surface.

2. **Mine Feature L-01.** Control Density Fill (CDF) is to be pumped (or tremied if groundwater is present) into the opening to fill it to the ground surface.

The purpose of the work is to permanently prevent access to the underground mine workings.

Methods, materials, submittals, execution of work, and other items are specified in the following sections of these Construction Specifications. The dimensions of each mine feature are based on measurements performed at the site during exploratory work. They are the Engineer's best estimates. Actual conditions may vary from these estimates. Construction dimensions for N-01 and DJ-01 shall be established in the field by the Contractor after excavating soil overburden to the extent directed by the OSM site representative to expose a well-defined opening.

120 SITE DESCRIPTIONS

N-01. The opening appears to be related to workings of the Navy Mine, based on current available mine maps. The opening is about 6 to 7 feet in diameter at the ground surface and 21 feet deep vertically. Reportedly this 21-foot depth marks the foot wall of a coal seam and the shaft then angles downward at about 45 degrees for an unknown depth. The vertical side walls along the upper portion of the shaft appear to generally consist of brown, silty, gravelly sand.

DJ-01. The opening appears to be an inclined entry that extends into workings of the Navy Mine. The opening is located on a steep side slope (about 1½ Horizontal to 1 Vertical [1½H:1V]) about 40 feet above the backyard of the residence of David and Lori Williams at 36108 312th Avenue S.E. in Cumberland, Washington. The mine opening appears to slope down into the hillside at an angle of about 45 degrees.

During investigative work, the opening was excavated by hand to observe the condition of rock surrounding the opening. The "crown" of the opening consists of moderately weathered, highly fractured sandstone and siltstone. The "invert" of the opening, as visible from the ground surface, consists of sloughed soil and sandstone. The apparent top of a coal seam is evident in the side wall of the opening, about 2 feet below the "roof." Opening dimensions are estimated to be about 3 to 4 feet by 3 to 4 feet.

1. Mobilization and Site Preparation

Payment for "Mobilization and Site Preparation" shall be at the contract lump sum price, which shall include full compensation for providing all equipment necessary to accomplish the work. Also included in this price are work area access (including temporary roads), the job trailer (optional), sign, safety tape and/or fences, sediment control, clearing and grubbing, preparing material storage areas, and purchase or rental of equipment required for safety. The total bid for "Mobilization and Site Preparation" shall not exceed 15 percent of the total of bid items 2 through 6. This price shall be separated into three separate lump sum prices to cover:

1a) N-01;
1b) DJ-01; and
1c) L-01.

2. Excavation and Replacement (N-01, DJ-01)

Payment for excavation of soil and/or weathered rock shall be made at the contract unit price per in-place cubic yard of material excavated, placed in stockpile(s), and subsequently placed and compacted above the finished reinforced concrete wedge. The price shall include all labor, equipment, and materials necessary to excavate all openings to expose competent bedrock or bearing soil, and a well-defined opening and to replace and compact the material as directed by OSM.

Quantities of excavated material will be determined by a cross section survey before and after excavation. The survey will be performed by OSM and may be reviewed by the Contractor. Survey points shall be along grid lines spaced approximately at intervals of 5 to 10 feet depending on the surrounding slope and as determined appropriate by OSM.

Excavated material shall be segregated and placed in one or more on-site stockpiles for reuse or disposal as directed by OSM. Stockpiles shall be protected from erosion and off-site sedimentation as specified. Cost for handling excavated material, stock-pile construction, reclamation, and erosion protection shall be incidental to other work.

Quantities of excavated material not reused on site, for whatever reason, shall be disposed of off site as directed by OSM. Payment shall be based on loose cubic yards in truck as estimated by OSM, for the purpose of negotiating an equitable change order.

This price shall be separated per opening as follows:

2a) N-01; and
2b) DJ-01.

3. Wedge Construction (N-01, DJ-01)

Closure operations for this type of mine plug will be paid by the following bid items:

SECTION 200
MOBILIZATION AND SITE PREPARATION

210 SCOPE

This work shall consist of performing all tasks necessary prior to reclamation of the openings. This preparatory work shall include the transportation of all equipment and personnel to the site; clearing, grubbing, and accessing the area; facility installation (such as job trailer, sign, and storage areas); sediment controls; and all safety precautions.

Equipment, materials, and any facilities moved on site shall be stored within the boundaries of the staging area. The designated staging area will be established during the pre-construction meeting with the contractor and OSM present at the site. The Contractor shall make every effort to minimize disturbance to the work site during this project. The Contractor shall be responsible for suppression of dust due to his operations.

230 SITE FACILITIES

A job trailer is optional and may be provided by the Contractor. If provided, the trailer shall be established within the designated staging area. The Contractor shall provide and maintain at least one sani-can in an inconspicuous location at each of the three sites (N-01, DJ-01, and L-01) during construction.

A sign shall be erected in plain view at the point of access to each project site as shown on the plans. This sign will be new and erected prior to any construction. It shall be maintained for the duration of the project and shall meet the following minimum specifications:

1. SIZE: The sign shall be at least three (3) feet in height and four (4) feet in width.

2. MATERIAL: The sign shall be painted on exterior type plywood of at least one-half-inch (½-inch) thickness and mounted on 2 x 4 (or heavier) posts.

3. PAINT: The sign shall be painted with at least two coats of paint, one of which is a primary coat. The paint shall be a quality exterior type comparable to that used in the general area for commercial exterior signs. Paint color shall be white with black letters. Letters shall be plain block letters no less than three (3) inches high.

4. DESIGN: The sign shall read as follows:

U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF SURFACE MINING - DENVER, COLORADO
NAVY MINE PROJECT
RECLAMATION OF ABANDONED COAL MINES
Project Manager: Ginger Kaldenbach
Phone: (303) 844-3067

The Contractor shall construct a wedge to fit inverted into the openings. Use Figure 11 to calculate the required wedge dimensions. The Contractor, in conjunction with the OSM representative, shall measure dimension D across the opening after excavation to top of competent bedrock or suitable bearing soil subject to OSM's approval.

Competent bedrock or suitable bearing soil shall be identified and defined by OSM. Bearing edges shall be uniform and free of loose rock or soil. Bedrock or soil edges supporting the form with an irregular surface of more than 6 inches are not acceptable.

Fabricate the steel wedge form as indicated on Figure 11. The wedge apex shall have an included angle of 60 degrees.

Perimeter plate angles shall be as needed to match the excavated opening at the top of rock. Packing shall be provided as necessary to limit the loss of concrete into the opening between the outer edges of the steel form and the rock/soil bearing edges.

Wedge construction configuration (external plate steel and internal reinforcing) shall be the responsibility of the contractor and submitted to OSM for review. The fabricated form shall be observed by OSM prior to placement.

During wedge form placement, the Contractor shall rock the form back and forth so that it fits properly into the opening. If it is not possible to achieve an adequate fit for the form with this procedure, the Contractor shall excavation more material around the opening or modify the form as directed by OSM. Form placement is to be observed and approved by OSM prior to concrete placement.

440 CONCRETE REINFORCING (N-01 and DJ-01)

Reinforcing shall be placed in the form and secured in the locations shown on Figure 12. Bar splices shall be lapped at least 24 inches. Rebar shall extend to within 3 inches of the inside of the steel form. Placement of rebar shall be approved by OSM prior to placement of concrete.

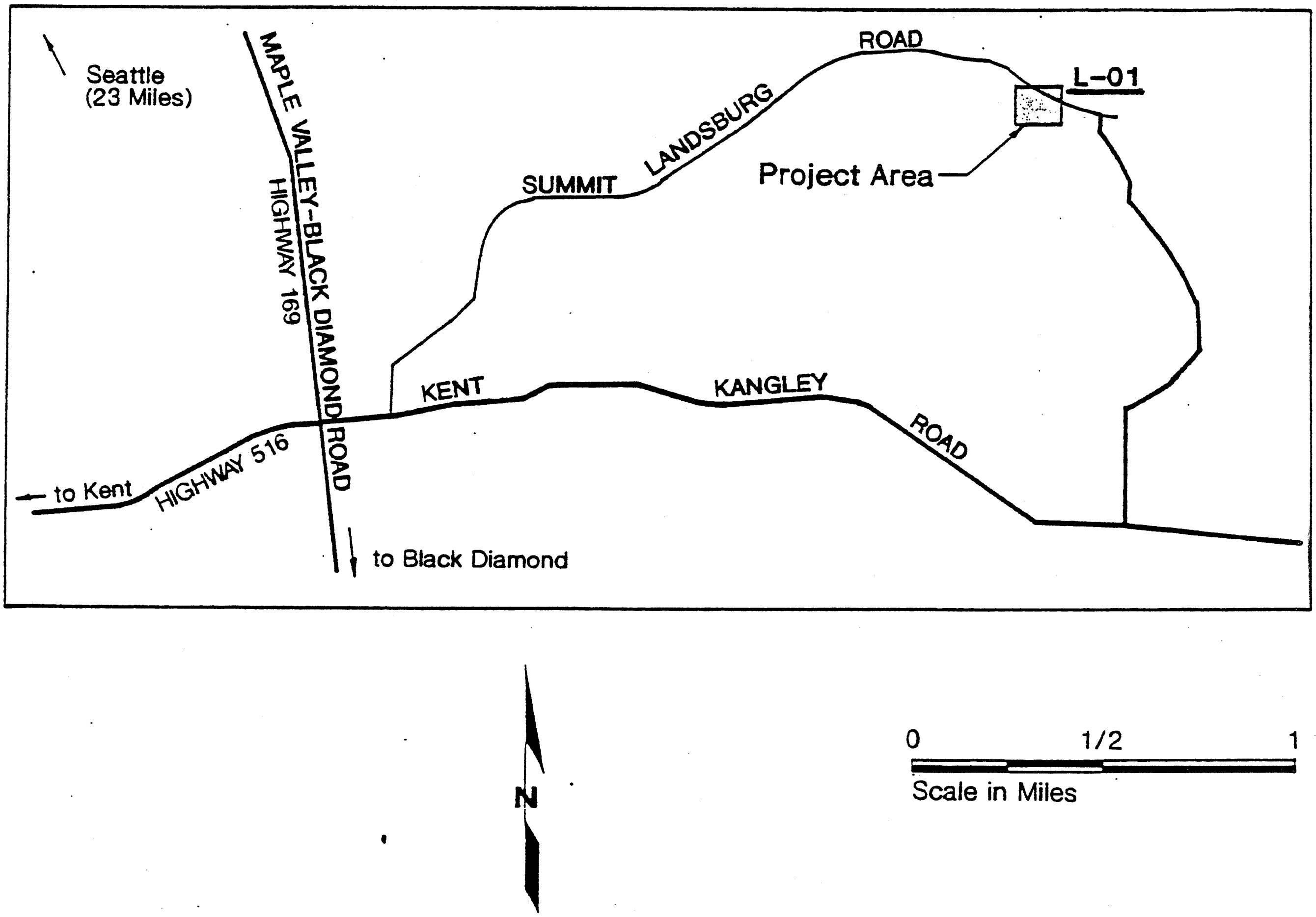
450 CONCRETE PLACEMENT (N-01 and DJ-01)

Concrete shall be placed into the form in one continuous pour. Concrete shall overtop the form to the area between the form and the bearing rock/soil. The OSM representative shall be on site during concrete placement.

460 CONTROLLED DENSITY FILL PLACEMENT (L-01)

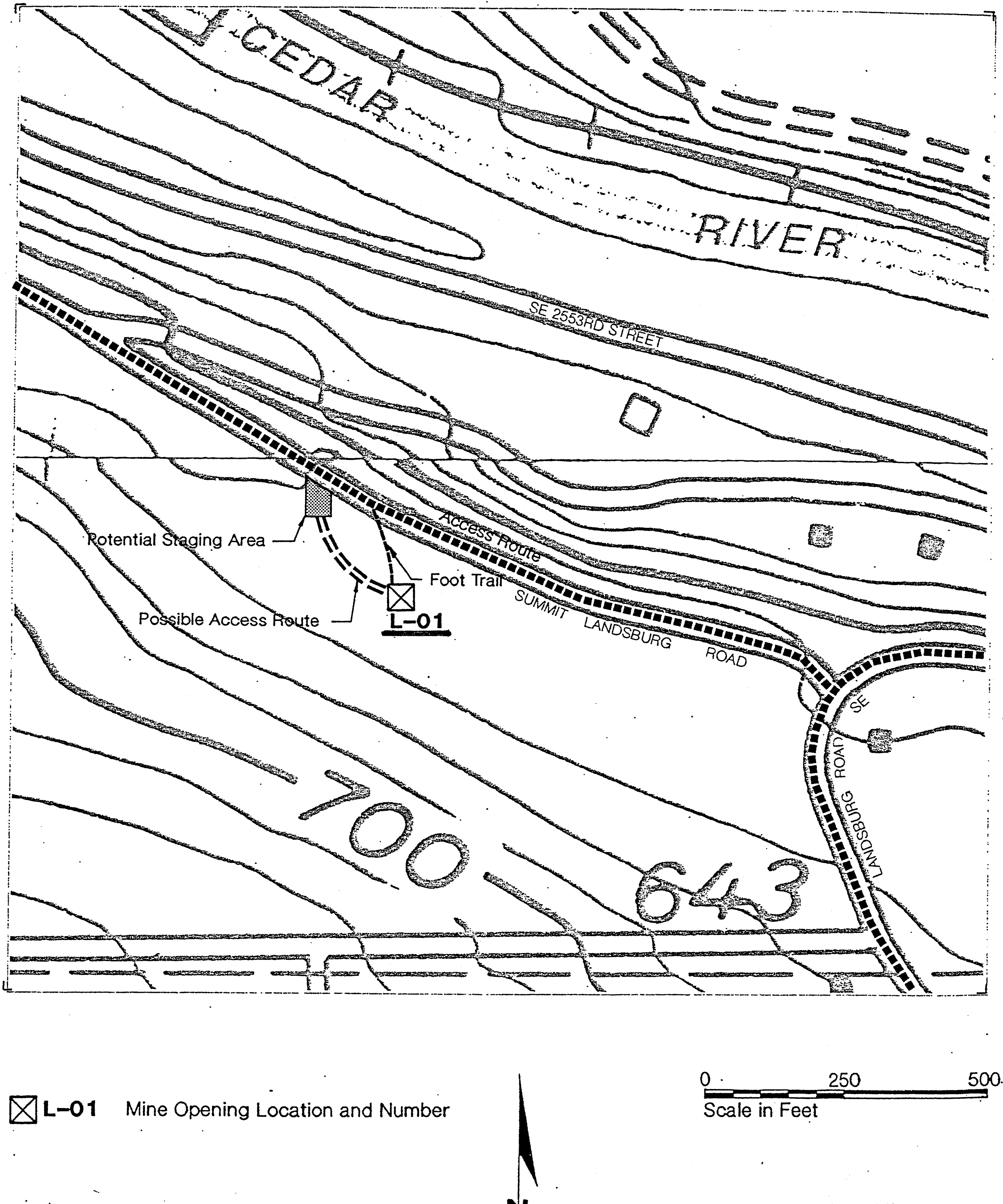
The CDF shall be placed by pumping or flowing through a chute, both of which shall prevent free fall of material by more than 4 feet. The point of depositing the mix shall be moved as needed to provide complete filling without necessity of raking the mix after it has been deposited. Figure 10 presents the approximate dimensions of opening L-01. The OSM representative shall be on site during CDF placement.

Vicinity Map



Navy Mine
Reclamation Project
King County, Washington
Figure 3 – Vicinity Map
June 1993

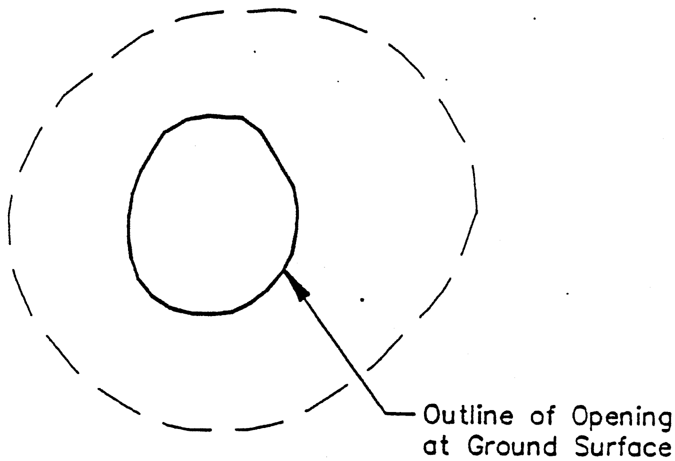
Access Routes/Site Plan for L-01



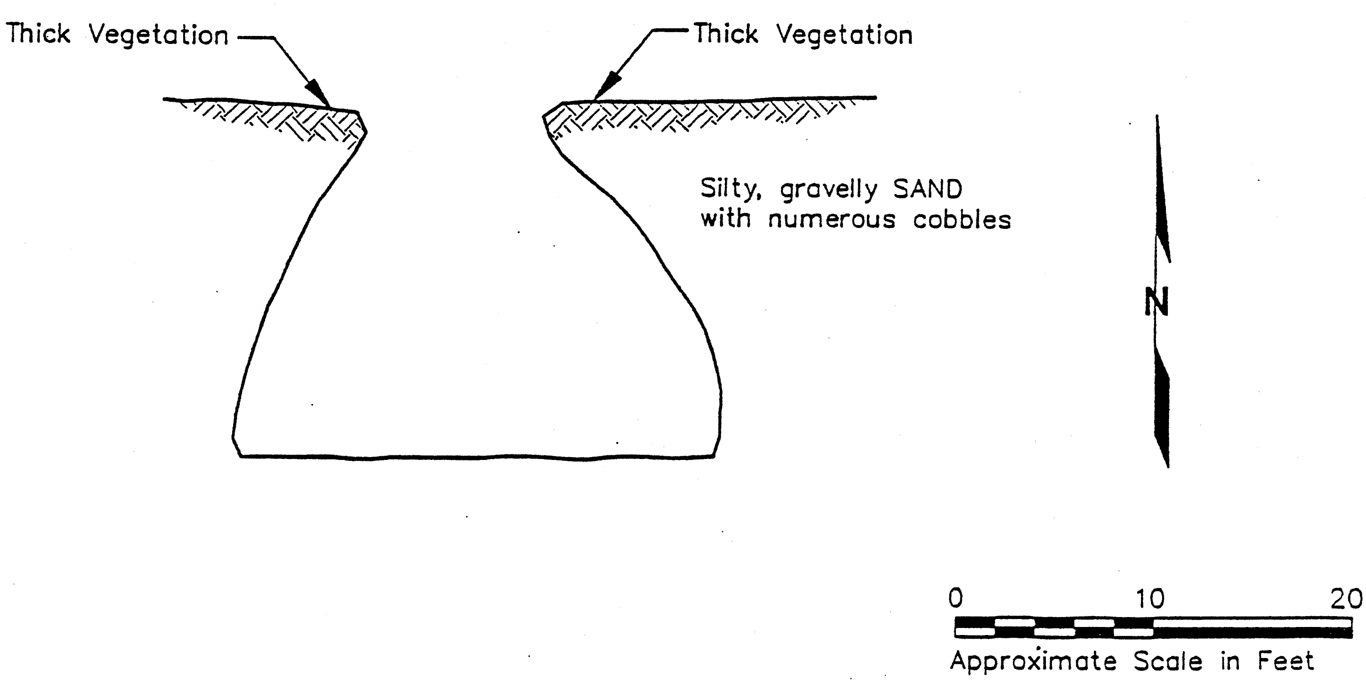
Navy Mine
Reclamation Project
King County, Washington
Figure 6 – Site Plan (L-01)
June 1993

Opening L-01 Plan and Profile

L-01 Plan



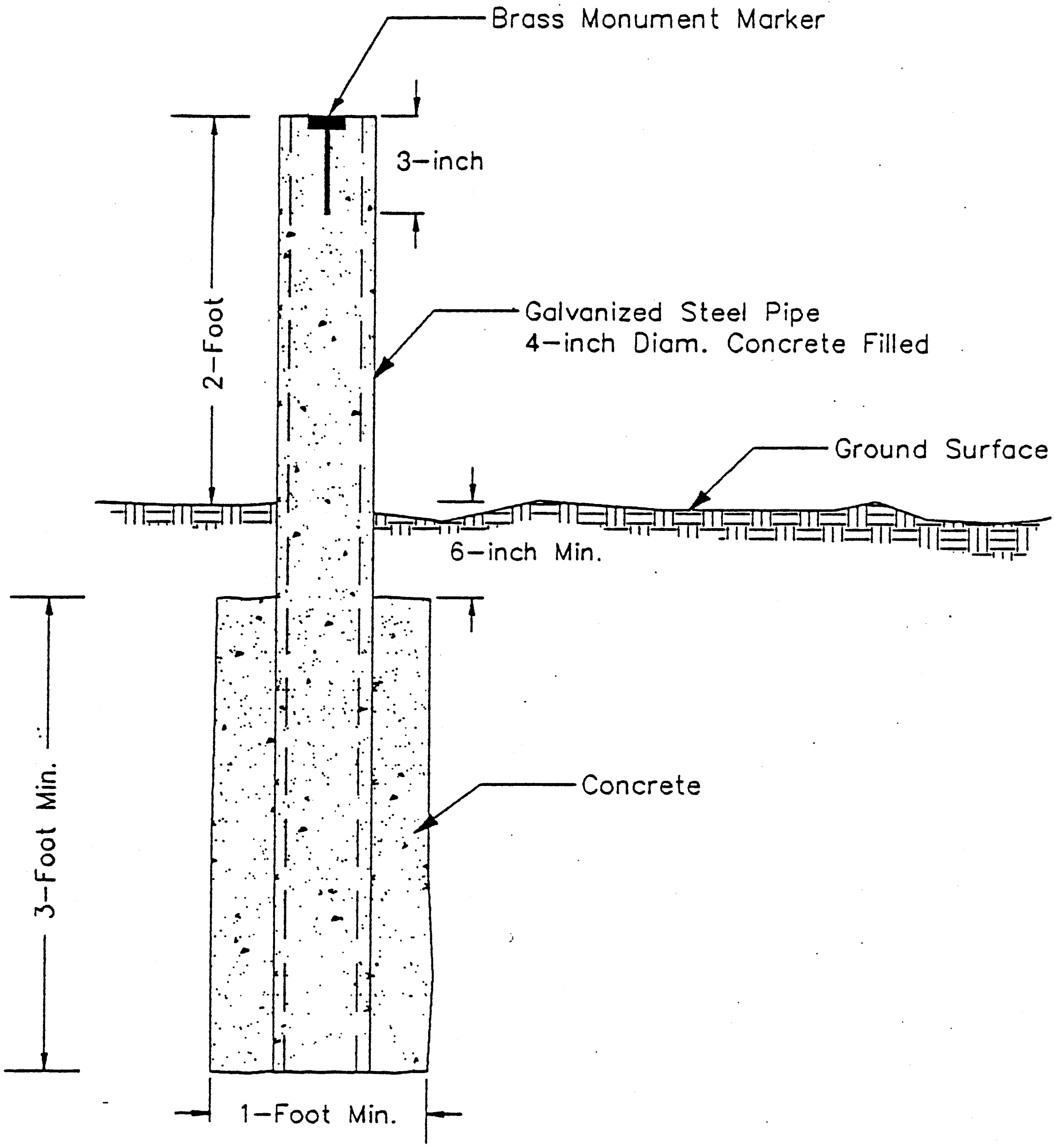
L-01 Profile



Approximate conditions during investigation
(April 1, 1993).

***Navy Mine
Reclamation Project
King County, Washington
Figure 10 - Mine Opening
June 1993***

Site Monument–Section View



Not to Scale

Navy Mine
Reclamation Project
King County, Washington
Figure 16 – Site Monument
June 1993

October 21, 2003

Ms. Ginger Kaldenbach
U.S. Department of the Interior
Office of Surface Mining
1999 Broadway, Suite 3320
Denver, CO 80202-5733

Re: Final Construction Report
Danville Mine Project
Features RV-01 through RV-05
OSM Project No. WA-03-002
Ravensdale (King County), Washington
7722-18

Dear Ms. Kaldenbach:

The abandoned coal mine subsidence features (designated RV-01 through RV-05) addressed in this report were first investigated by Hart Crowser in June 2002. Reclamation of the features was completed by C. Wyss and Son, LLC in August 2003 as described in this letter report. This letter summarizes the mine hazard, work accomplished, and the variances from the project plans and specifications during construction. Our work was conducted on behalf of the U.S. Department of the Interior, Office of Surface Mining (OSM) in accordance with our Contract No. 1438-51-CT-230020.

The Contractor's work was documented in our daily reports as it was accomplished. Table 1 lists the sequence of work, and Table 2 presents the summary of bid quantities and the actual quantities used in reclamation of the abandoned coal mine features. Sheet C-4 from the construction plans has been annotated to show changes in slope grades, and is included as an as-built drawing of the reclaimed features. Appendix A contains a photographic record of closure construction activities.

PROJECT BACKGROUND

The abandoned coal mining subsidences are apparently associated with the former Danville Coal Mine workings and are located on property presently owned by the Palmer Coking Coal Company about 2 miles north of Ravensdale, WA. The features are located in the southeast quarter of Section 24, Township 22 North, Range 6 East, on an undeveloped hill slope site that has recently been logged for timber production.

FEATURE DESCRIPTIONS

Prior to reclamation, the subsidence features RV-01 through RV-05 appeared as steep-sided, near-circular depressions in the landscape. They were estimated to have an average diameter ranging from 25 to 80 feet with an average depth ranging from 8 to 30 feet. During our initial site visit in 2002, water appeared in the bottom of three of the subsidences (RV-01, RV-02, and RV-04), while the remaining two (RV-03 and RV-05) were dry. During the on-site pre-bid meeting, only one subsidence feature (RV-01) contained water.

CONSTRUCTION METHODS

Hazard abatement work was accomplished by the specified construction method, as discussed below. Appendix A presents site photographs showing the construction sequence for reclamation of the feature.

Features RV-01 through RV-05

Closure of subsidence features RV-01 through RV-05 was accomplished by dewatering (where necessary) and regrading the side walls of the subsidence to a slope such that they would freely drain water and allow for easy egress. Erosion protection (including silt fences and hay bales) was placed on the down slope side of each feature prior to the start of grading activity. Following completion of grading activity, monuments were installed to permanently mark location of the subsidence features. A small excavation was made over the center of each feature, where an approximately 6-foot-long galvanized steel pipe was placed, allowing for about 3 feet of stickup above the graded ground surface. Subsequently, concrete was poured around each pipe to within approximately 6 inches below the adjacent grade. Concrete was then poured inside each pipe and monument markers (provided by OSM) were placed at a slight recess below the top of each pipe. After the concrete cured, on-site soil material was placed on top of the concrete and compacted with the track hoe bucket.

Revegetation of the site was completed by hydroseeding methods. The mulch, seed, fertilizer, and water mixture was applied to all disturbed surfaces using a truck-mounted spray hose. All erosion control measures (silt fence and straw bales) were left on site to provide erosion protection until revegetation is established.

The primary objective for final grading and site restoration was to minimize the hazards associated with the deep subsidence features. The secondary objective was to create positive surface drainage away from each feature such that they would no longer retain water. The third objective was to make the closures blend into the existing topography and terrain to the extent possible. These objectives were accomplished.

The reclamation was not designed to eliminate the potential for possible future subsidence. Future land uses should take into consideration that underground voids may exist and additional subsidence could occur.

NO SIGNIFICANT PROBLEMS ENCOUNTERED DURING CONSTRUCTION

No significant problems were encountered during construction activities.

VARIANCES FROM PLANS AND SPECIFICATIONS DURING CONSTRUCTION

Some modifications were made to the Plans and Specifications for the reclamation of subsidence features RV-01 through RV-05 as construction activities were performed in the field. These modifications were as follows.

- The final slopes for the subsidence features were typically graded to be 2H:1V, or flatter, rather than the 1.5H:1V slopes shown in the Plans and Specifications. The Contractor requested to make the slopes flatter, to simplify the regrading process and to avoid the expense of placing erosion control blankets, which were required for slopes steeper than 2H:1V. The base of each subsidence feature was graded to 10 percent or flatter to allow for free water drainage, as shown on the Plans.

The slope change outlined above as well as conservative estimates used for width and depth of the subsidence features resulted in less excavation (approximately 54 percent reduction) during reclamation than was anticipated at the time of bidding. As a result of the reduction in regraded volume, the unit price for regrading was renegotiated from that of the original bid.

CONCLUSION

Except for the changes and modifications noted above, reclamation of the Danville Mine subsidence features was generally completed in accordance with the plans and specifications.

We accomplished our work and completed this report for the exclusive use of the U.S. Department of the Interior, Office of Surface Mining (OSM), for the specific subject site. We performed our work in accordance with generally accepted engineering practices for the nature and conditions of the work completed, in the same or similar localities, at the time the work was performed. No other warranty, express or implied, is made.

We appreciate the opportunity to work for OSM on this project. Please call if you have any questions regarding this report or other aspects of the project.

Sincerely,

HART CROWSER, INC.

MATTHEW W. WOLTMAN, EIT
Project Geotechnical Engineer

Gregory H Botts for

JOSTEIN AASEN, EIT
Senior Staff Geotechnical Engineer

MICHAEL J. BAILEY, P.E.
Project Manager

Attachments:

Table 1	General Sequence of Work
Table 2	Bid Quantities and Cost, RV-01 through RV-05 Reclamation
Figure 1	Vicinity Map
Plan C-4	Typical Feature Cross Sections and Grading Plan
Appendix A	Construction Photographs

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Table 1 - General Sequence of Work

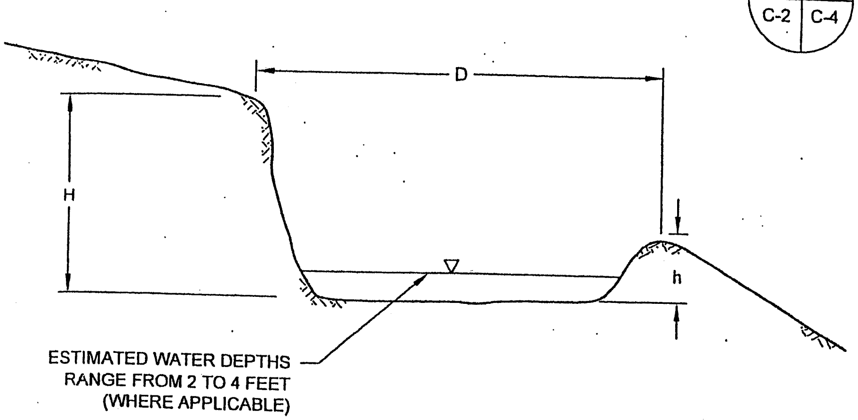
Date	Activity
8/19/2003	On-site pre-construction meeting with OSM Project Manager, Hart Crowser Project Manager and Field Representative, and Contractor.
8/23/2003	Mobilize CAT D-8 dozer and John Deere 590D excavator to site.
8/25/2003	Begin grubbing and regrading activity at features RV-05 and RV-04. Install erosion protection at features RV-05 and RV-04. Mobilize project sign and pumps and hoses to site.
8/26/2003	Complete grading of features RV-05 and RV-04. Begin grubbing and grading at feature RV-03 and grubbing of feature RV-02. Install erosion protection at feature RV-01.
8/27/2003	Complete grading of feature RV-03, begin grading activity at feature RV-02. Install erosion control at feature RV-02. Complete dewatering and begin grubbing and grading of feature RV-01.
8/28/2003	Complete grading of features RV-02 and RV-01. Complete monument placement at features RV-01 through RV-05.
8/29/2003	Backfill and compact monument areas with on-site fill soil. Mobilize hydroseed revegetation equipment to site. Complete revegetation of features RV-01 through RV-05 and other disturbed areas of site. Demobilization from site.

Table 2 - Bid Quantities and Cost
RV-01 through RV-05 Reclamation

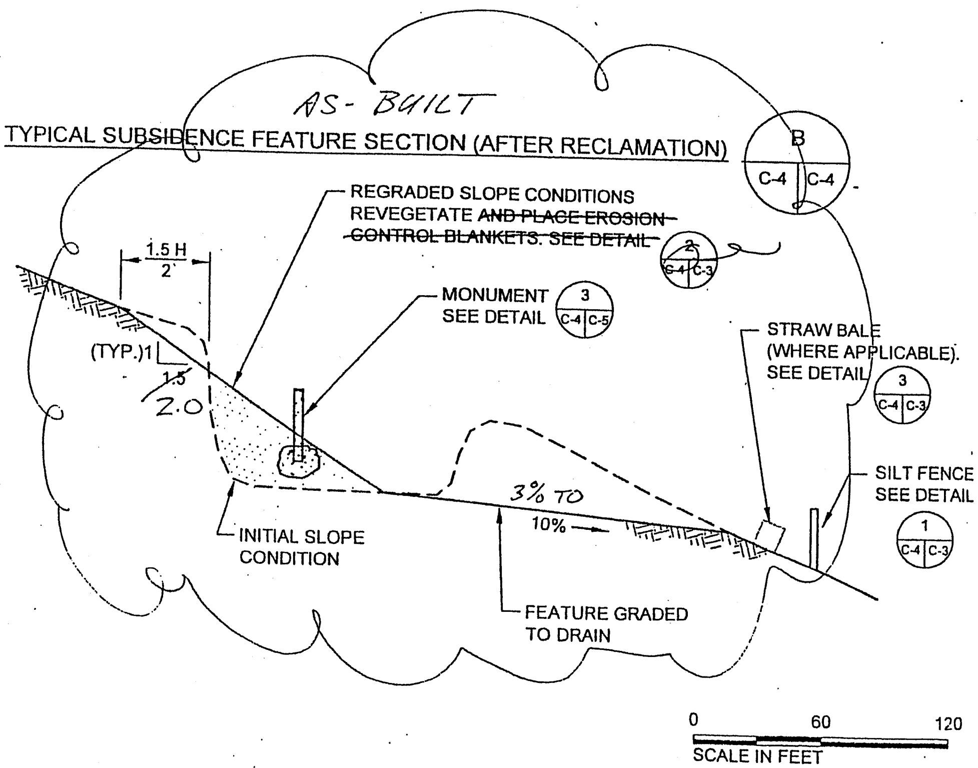
Item	Description	Units	Unit Price	Estimated Quantity	Bid Cost per Estimated Quantity	Actual Quantity	Cost per Actual Quantity
1	Mobilization	LS	$3,500.00	1	$3,500.00	1	$3,500.00
2	Site Preparation and TESC Placement	LS	$4,000.00	1	$4,000.00	1	$4,000.00
3	Grading[a]	CY	$1.50 $2.33	10,600	$15,900.00	4,880	$11,370.40
4	Monuments, Revegetation, and Demobilization	LS	$2,500.00	1	$2,500.00	1	$2,500.00
Total					**$25,900.00**		**$21,370.40**

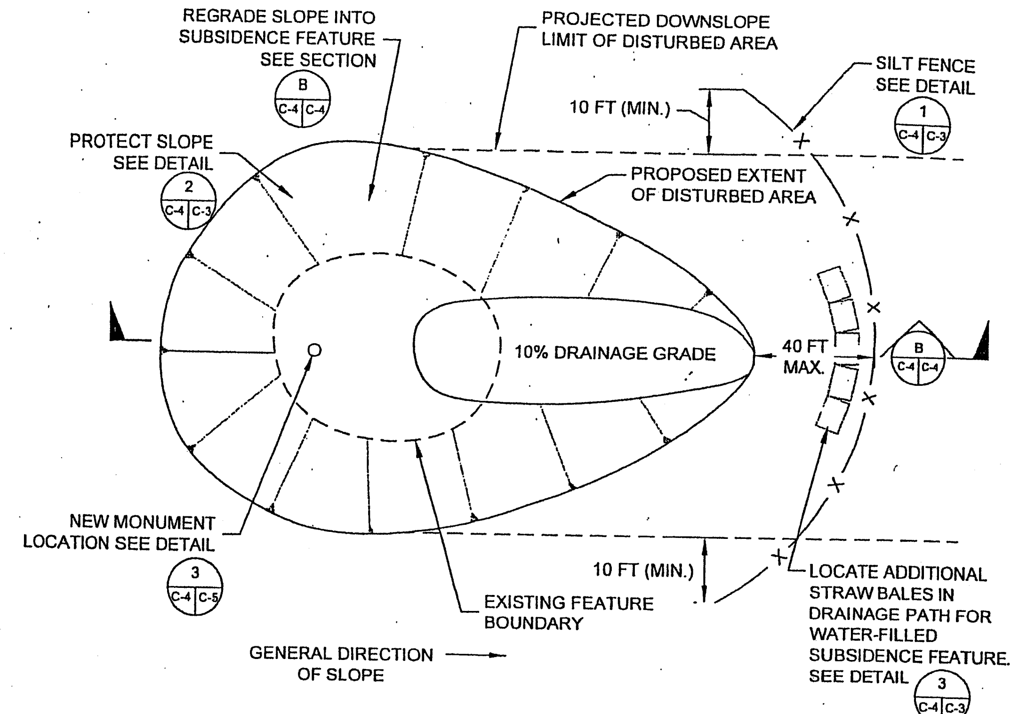
Notes:
[a]The unit price for grading was renegotiated after completion of construction due to a change in quantity. The unit price bid ($1.50/cubic yard) was adjusted to $2.33/cubic yard based on the Contractor's submittal dated September 17, 2003.

TYPICAL SUBSIDENCE FEATURE SECTION (EXISTING CONDITIONS)



TYPICAL SUBSIDENCE FEATURE SECTION (AFTER RECLAMATION)





TYPICAL SUBSIDENCE FEATURE GRADING PLAN

NOT TO SCALE

NOTES

1) CONTRACTOR SHALL GRADE UP-SLOPE SIDE FIRST. CONTRACTOR SHALL BEGIN GRADING AT AN APPROXIMATE SET-BACK DISTANCE OF H FROM THE CREST OF THE EXISTING UPPER SLOPE.
2) CONTRACTOR SHALL GRADE DOWN-SLOPE SIDE UPON COMPLETION OF UP-SLOPE GRADING.
3) FINAL SLOPES SHALL BE GRADED TO 1.5H:1V, OR FLATTER.
4) EROSION CONTROL BLANKETS TO BE PLACED ON ALL REGRADED SLOPE AREAS STEEPER THAN 2H:1V.

U.S. DEPARTMENT OF THE INTERIOR — OFFICE OF SURFACE MINING

MICHAEL J. BAILEY — STATE OF WASHINGTON — 22484 — REGISTERED PROFESSIONAL ENGINEER

EXPIRES 12.13.3

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY

HARTCROWSER — EARTH AND ENVIRONMENTAL TECHNOLOGIES

U.S. DEPARTMENT OF INTERIOR OFFICE OF SURFACE MINING

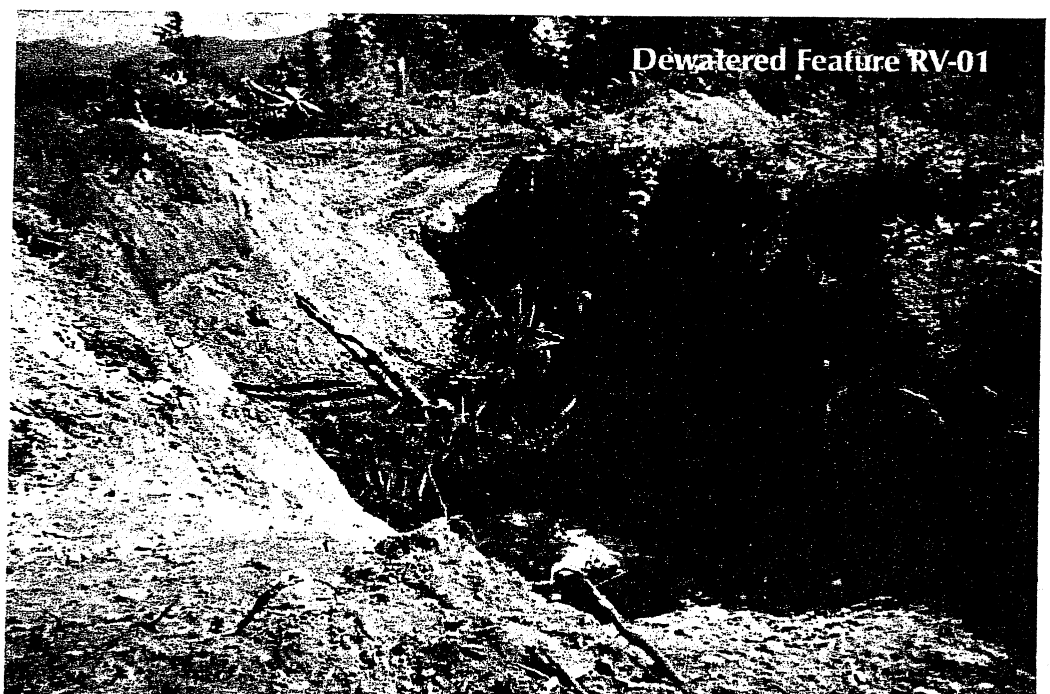
LANDSBURG DANVILLE MINE FEATURES

TYPICAL FEATURE CROSS SECTIONS AND GRADING PLAN

KING COUNTY — WASHINGTON

SIZE	DRAWN BY	DATE	JOB NO
B	C. SCOTT	6/24/2003	7722-18

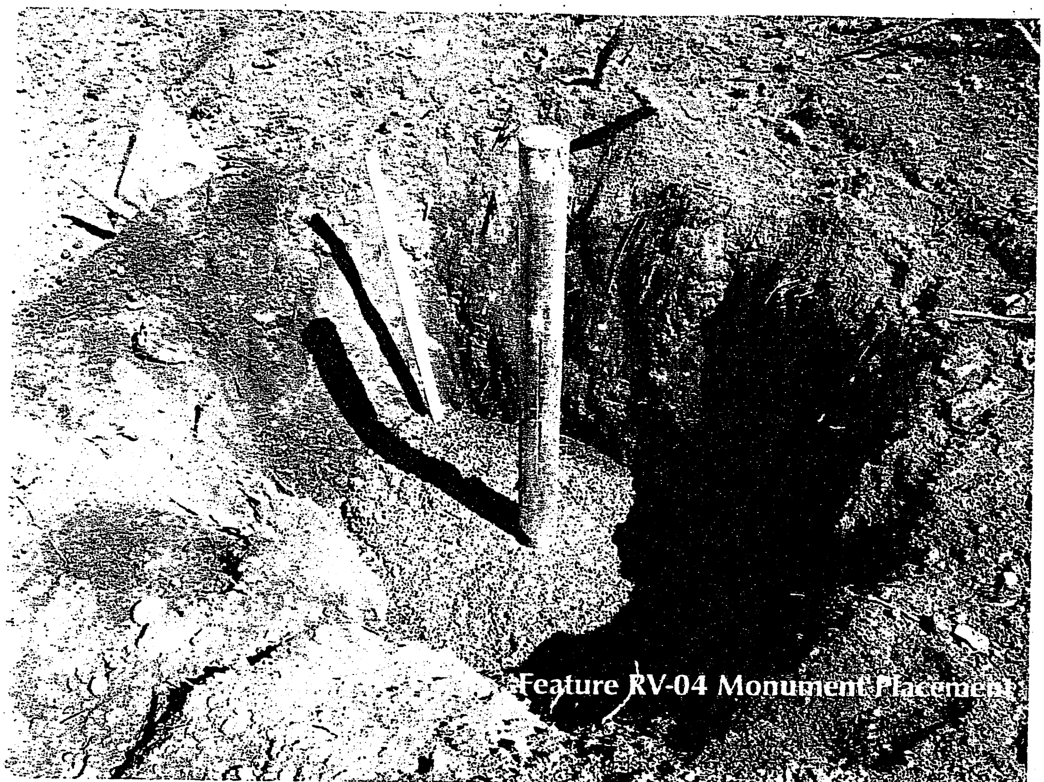
Photograph 1 Project sign, temporary erosion and sediment control, and dewatering hoses. Looking northeast.
(WA-009_RV-01_082503a_Misc Equipment.jpg)



Photograph 2 Feature RV-01 during dewatering. Looking east northeast.
(WA-009_RV-01_082703a_DewateredFeature.jpg)

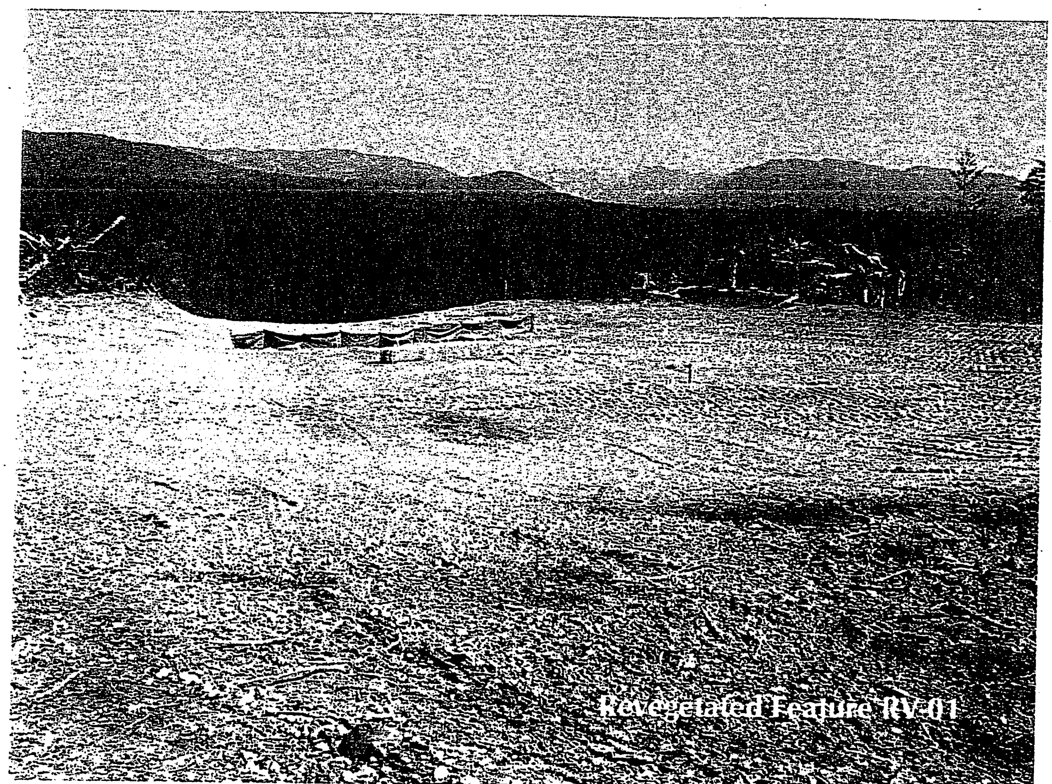
Photograph 3 Using Catepillar D-8 dozer and John Deere 200 trackhoe to prepare Feature RV-05. Looking northeast.
(WA-009_RV-05_082503c_Site Prep.jpg)

Photograph 4 Using Catepillar D-8 to grade Feature RV-05. Looking northeast.
(WA-009_RV-05_082503a_Grading.jpg)

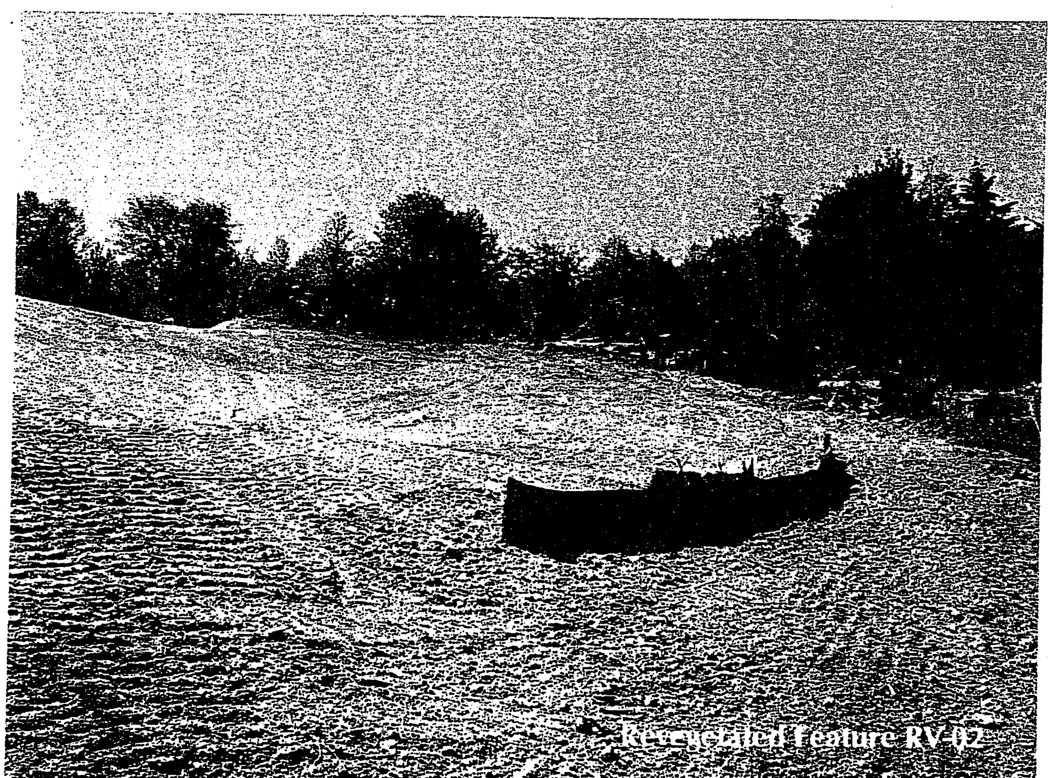


Photograph 5 Feature RV-04 and associated monument marker.
(WA-009_RV-04_082803b_MonumentPlacement.jpg)

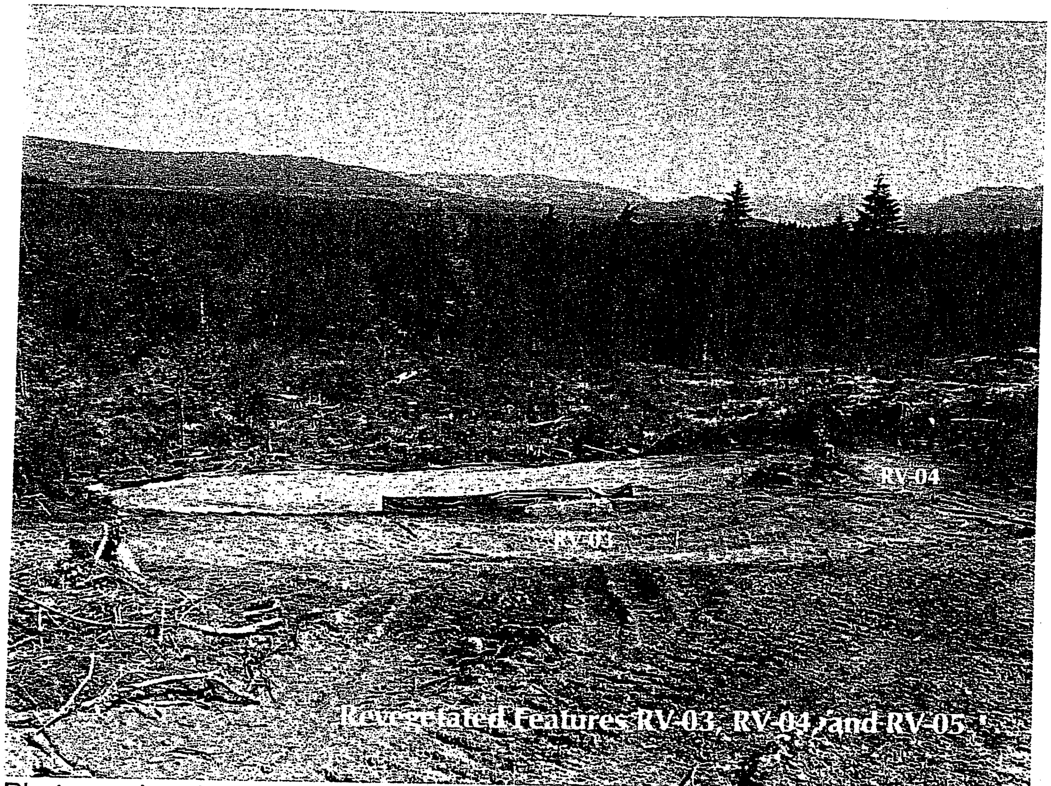
Photograph 6 Truck-mounted hydroseed equipment used for revegetation of the features.
(WA-009_RV-01_082903a_HydroseedEquipment.jpg)



Photograph 7 Feature RV-01 final grade and associated revegetation. Looking northeast.
(WA-009_RV-01_082903a_RevegetatedFeature.jpg)



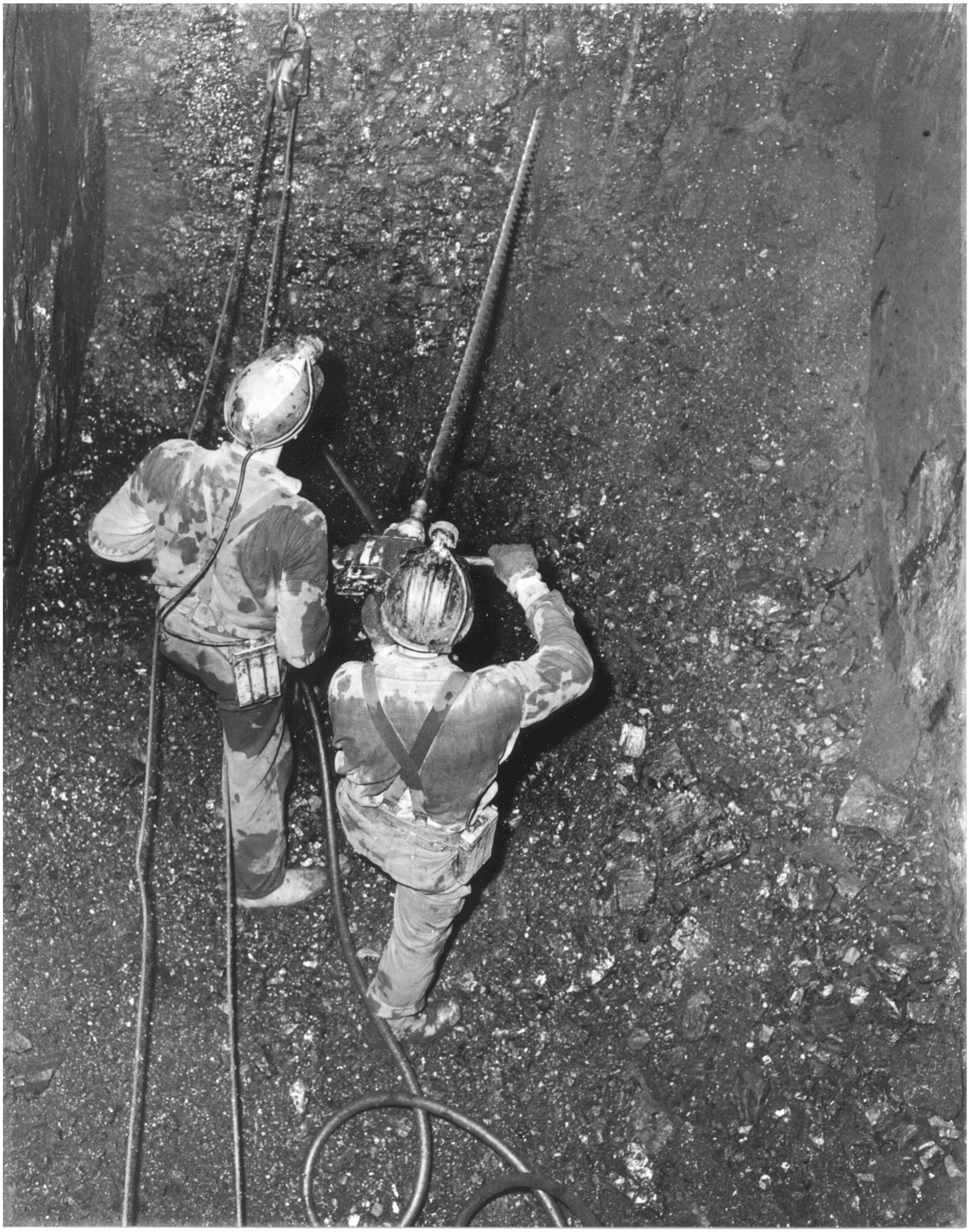
Photograph 8 Feature RV-02 final grade and associated revegetation. Looking southwest.
(WA-009_RV-02_082903a_RevegetatedFeature.jpg)



Photograph 9 Features RV-03, RV-04, and RV-05 final grade and associated revegetation. Looking northeast.
(WA-009_RV-03_082903a_RevegetatedFeature.jpg)

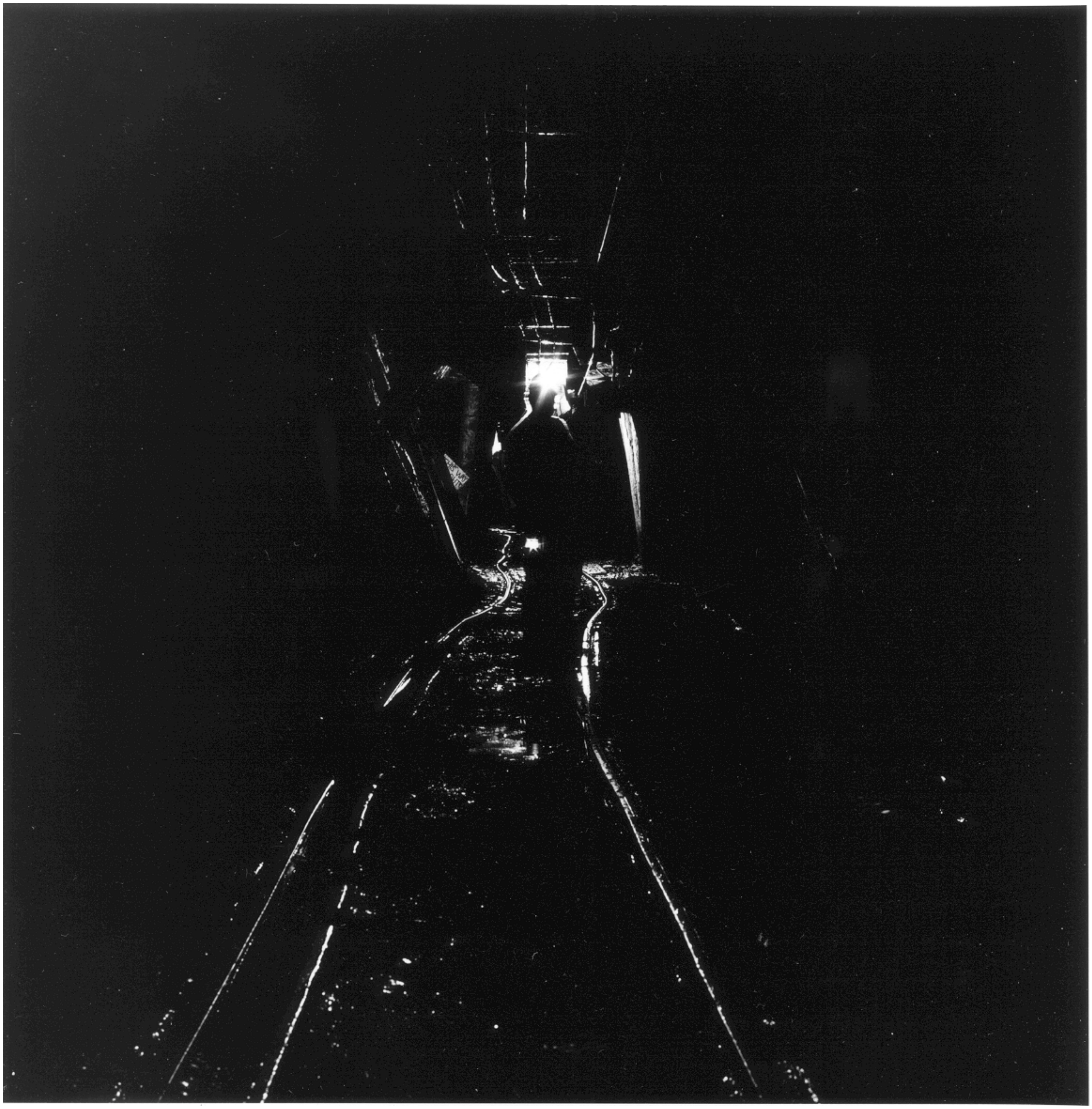
Appendix F

Select PCC Coal Mine Photographs



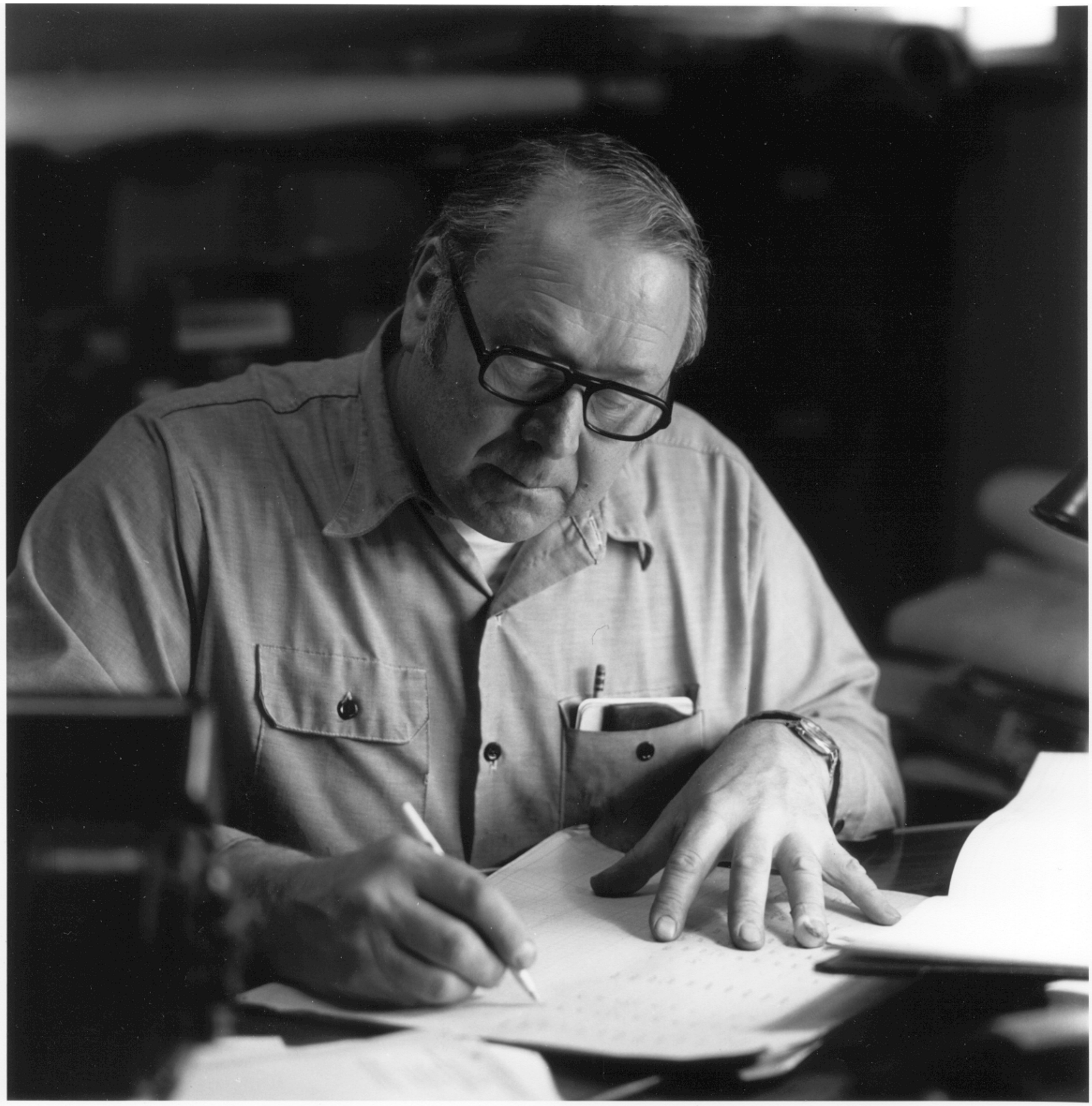
This wall of coal is being drilled with electric steel augers. The holes will be loaded with sticks of dynamite. After the charge has exploded, the loose coal will be loaded into coal cars for a 500-foot trip to the surface. Landsburg Mine, 1953. *Photograph by the Seattle Times*

After a blast of dynamite, **John Skulas** of Maple Valley pulls the shattered coal with a large bucket guided by steel cables and powered by an electric winch. –Landsburg Mine, circa 1953. *Photograph by the Seattle Times copyright 1978 Seattle Times P.O. Box 70, Seattle, WA 98111 all rights reserved; (206) 464-229.7 This picture has been purchased for personal use only and must not be published, reproduced, or used for advertising purposes without written permission from the Seattle Times.*

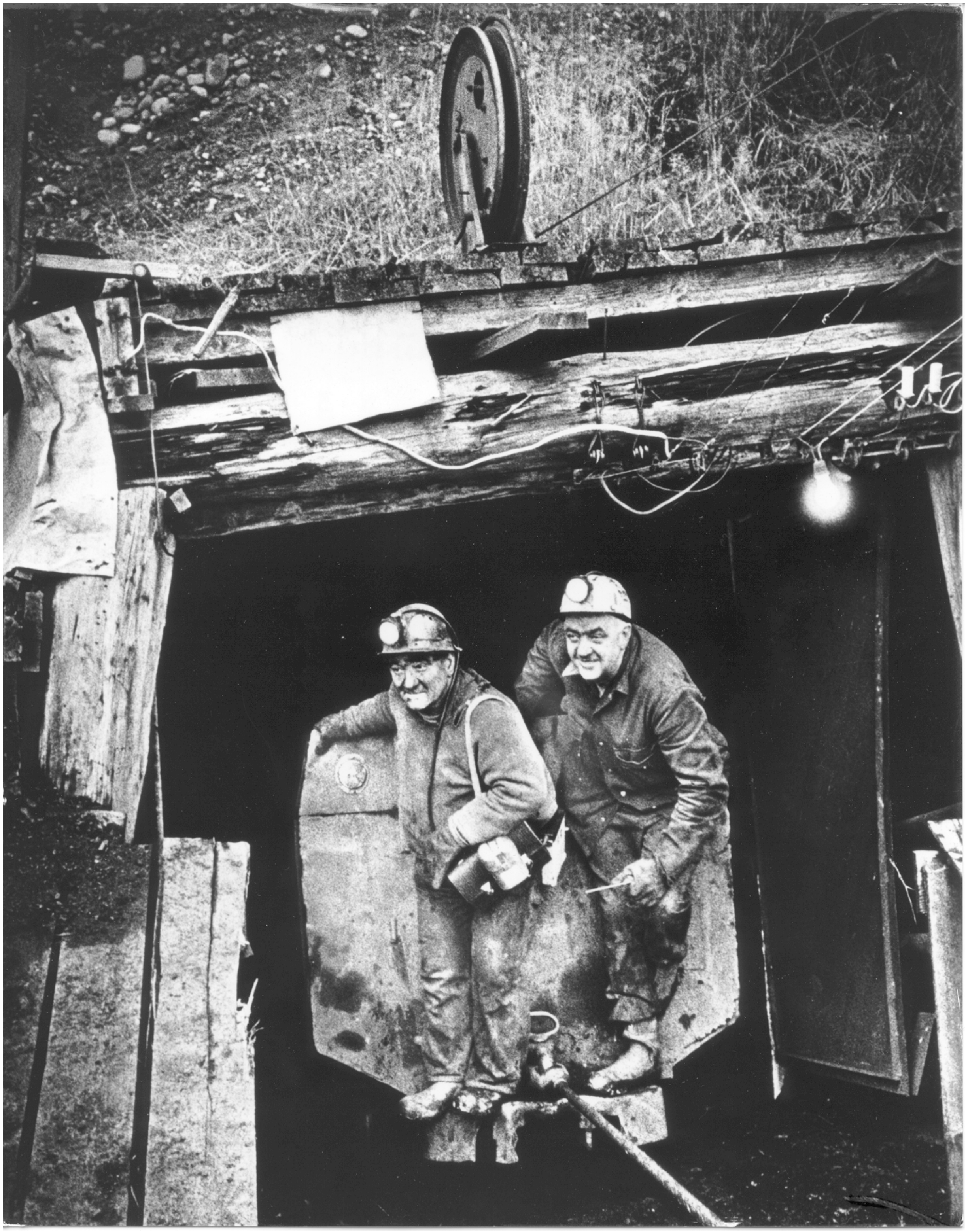


Rogers #3 underground coal mine, circa 1974. Light at the end of the tunnel.

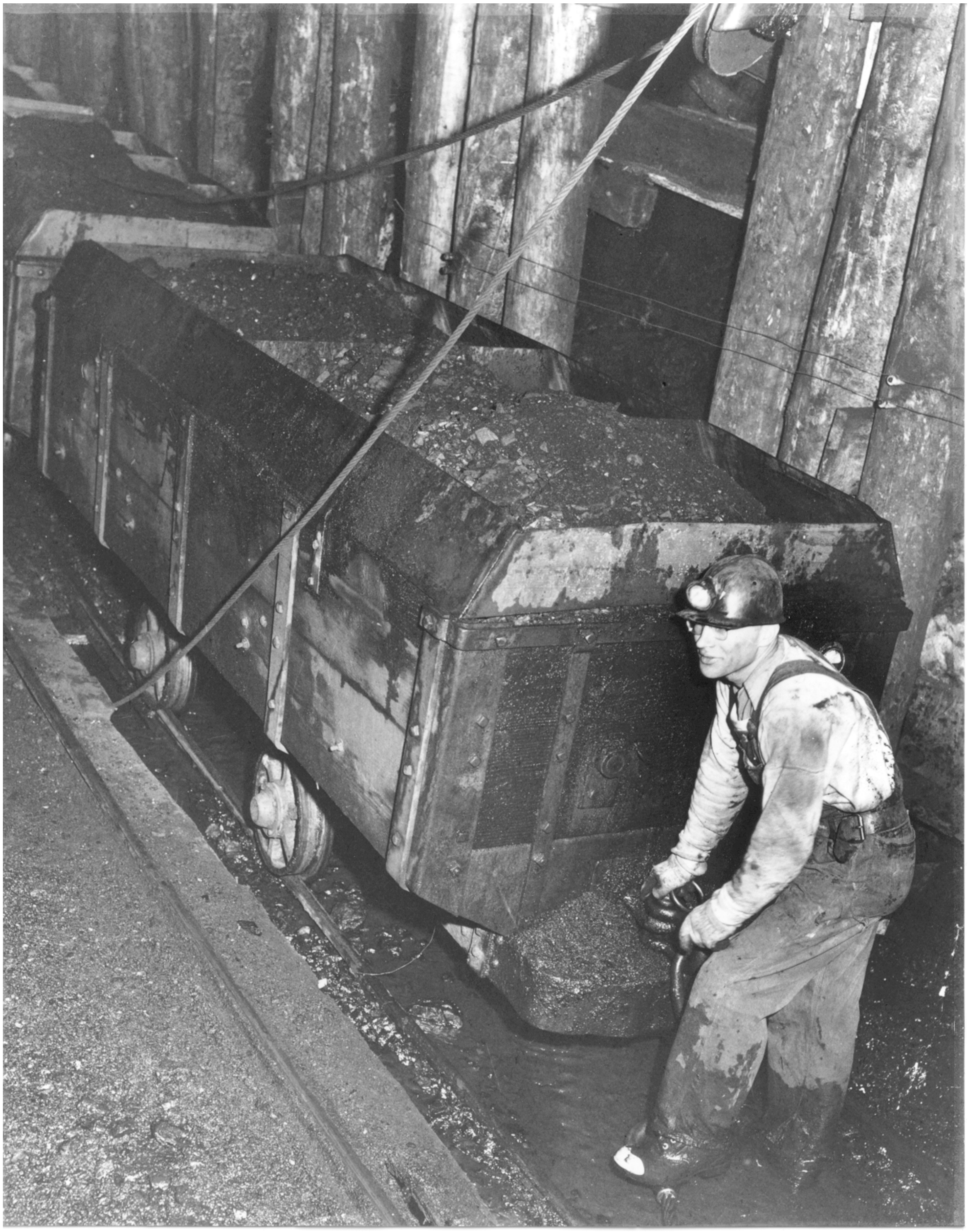
Coal cars from the underground Rogers #3 coal mine dumping on tipple, Ravensdale 1974



Carl Falk, Office Manager for Palmer Coking Coal Co. 1975 (1920 – 1997)



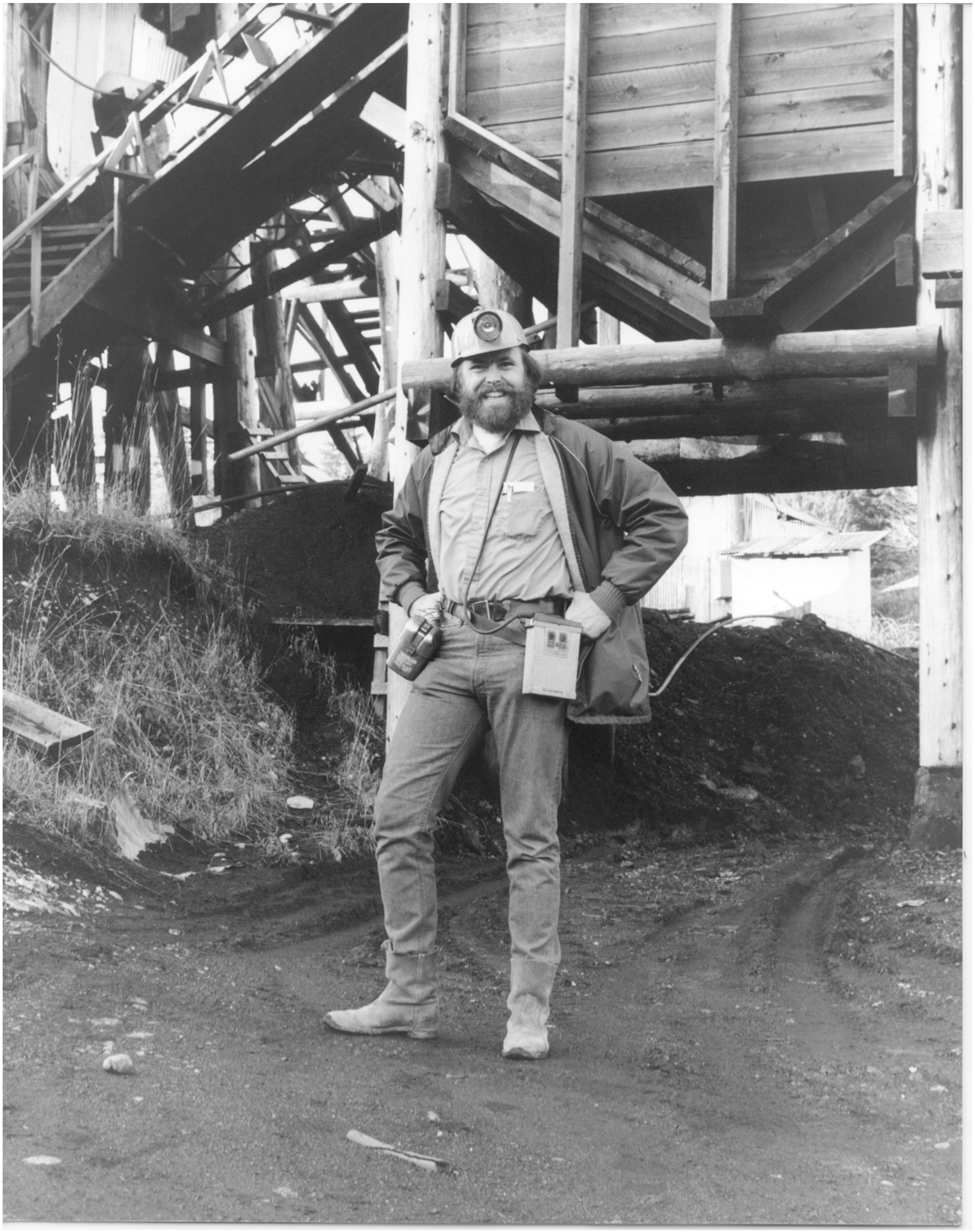
Tony Basselli and "Bud" Simmons ride a coal car coming out of the Rogers #3 mine, circa 1974. *Photograph by the Seattle Times copyright 1978 Seattle Times P.O. Box 70, Seattle, WA 98111 all rights reserved; (206) 464-229.7 This picture has been purchased for personal use only and must not be published, reproduced, or used for advertising purposes without written permission from the Seattle Times.*



Bill McLoughry hitches another coal car to the main hoisting cable. After the cable is attached, the coal car will be pulled 500 feet up an incline to the surface. Hoisting machinery at the Landsburg Mine pulled the cars one at a time with a 125 horsepower electrical motor. circa 1953. *Photograph by the Seattle Times copyright 1978 Seattle Times P.O. Box 70, Seattle, WA 98111 all rights reserved; (206) 464-229.7 This picture has been purchased for personal use only and must not be published, reproduced, or used for advertising purposes without written permission from the Seattle Times.*

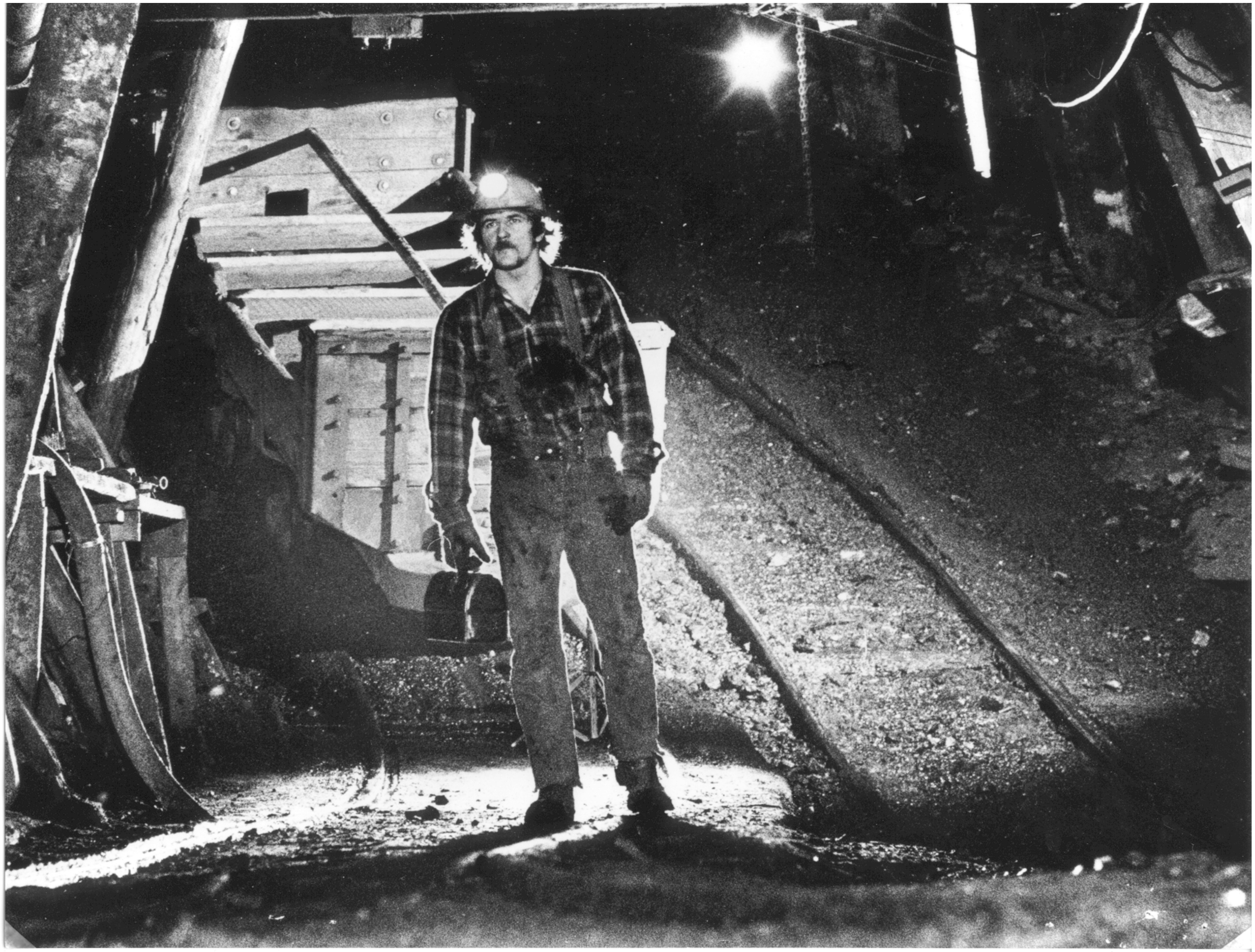
Underground coal mining at Rogers #3 coal seam, Ravensdale, circa 1974: **Tony Basselli**

Rogers #3 underground coal mine located off Kent-Kangley in Ravensdale, circa 1974.

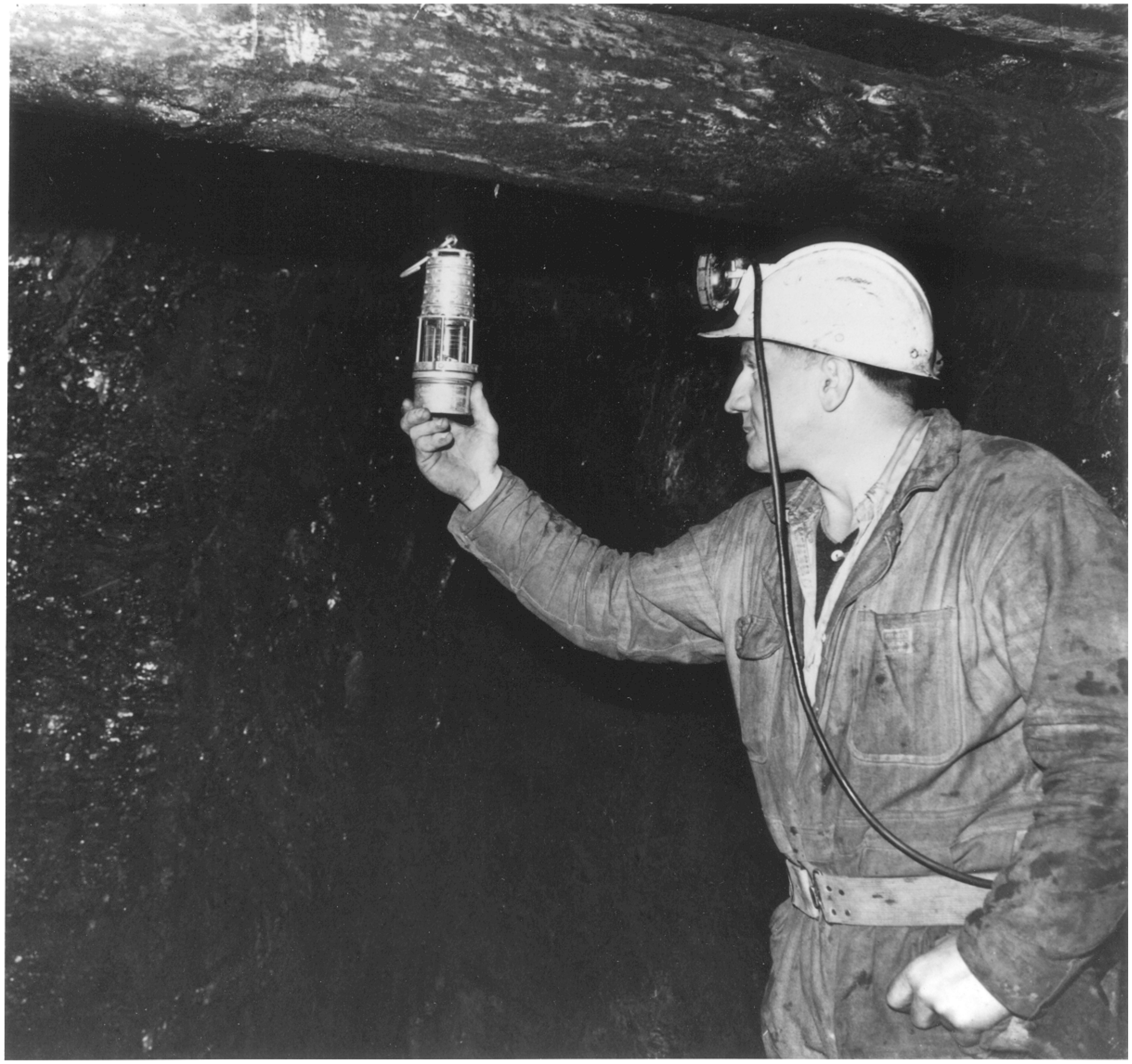


M.S.H.A. coal mine inspector, circa 1974

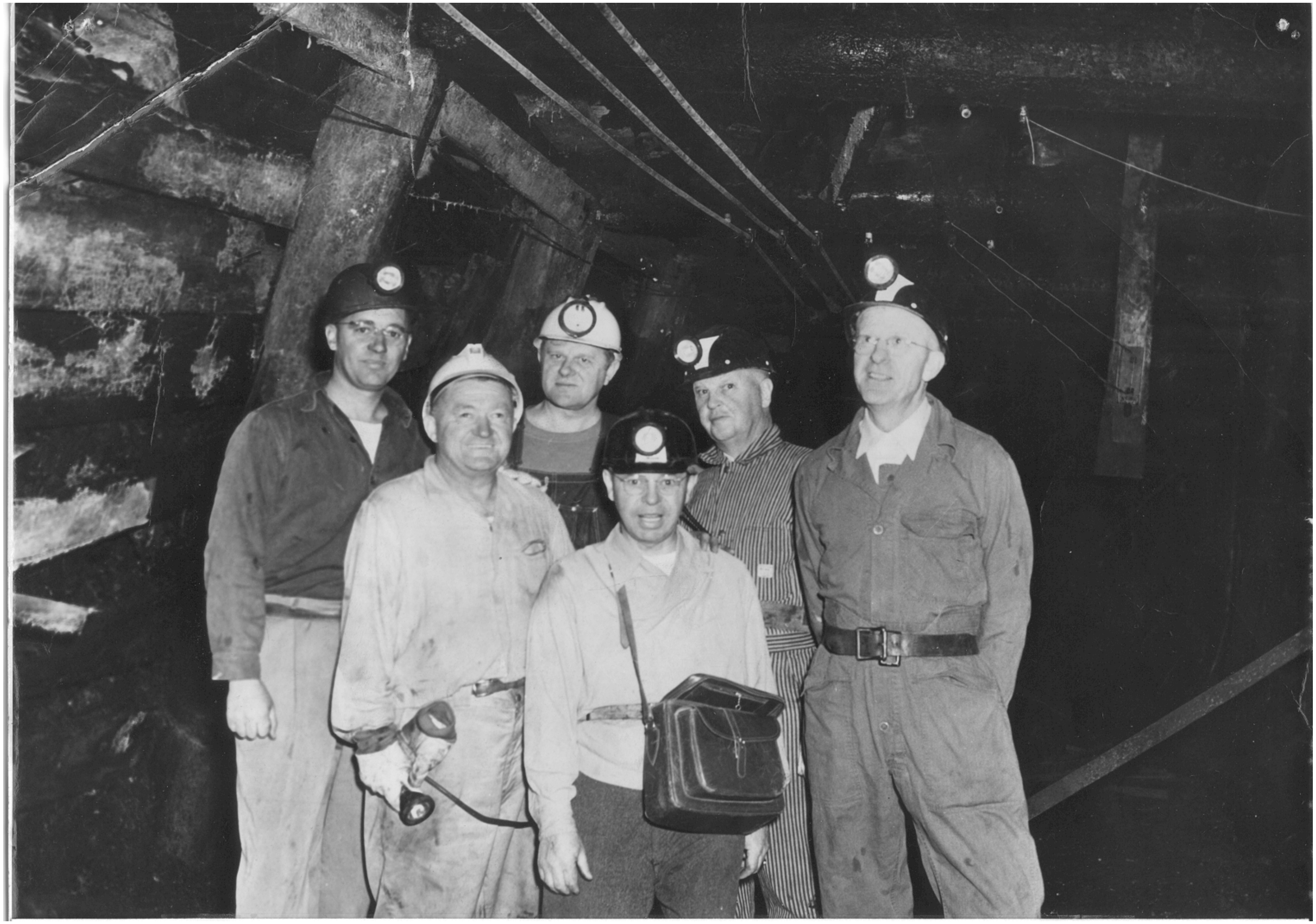
PALMER COKING COAL COMPANY FIRST AID CLASS 1954 FIRST ROW: Walt Gibson, Joe Zumek, Don Malagrini, Frank Zumek. SECOND ROW: Bill Petchnick, Bill Parkin, Ralph Barnett, George Morris, Albert Rossi, Jack Henry, George Costanich, Tom Maks, Jules Dal Santo. THIRD ROW: Bill McLoughry, Tim Harrington, Henry Babb, Arthur Eltz, Joe Wilsco, Bob Coutts, Don Manson, John Costanich, John Maks, Albert Donati. FOURTH ROW: Ed Johnson, Carl Falk, Jack Morris, Roy Coutts, Evan Johnson, John Saftinh, Arleigh Odom, Jack Kombol, Steve Androsko, Bill Eddy. FIFTH ROW: John Lombardini, Dick Wetton, Lew McCauly, Dave Evans, and Mort Mann. SIXTH ROW: Tom Zumek, Bob Pierce, Evan Morris, Dayle Walters, Bud Simmons, Lloyd Austin, John Umek, Al Parolini, John Skulas; Instructor: Wendell Fisher of the Department of Labor and Industries who conducted a Palmer Coking Coal Company class in mine safety and first aid training; circa 1954. WILBER PHOTO “PORTRAITS WITH PERSONALITY” RTE. 1, BOX 1003 – KENT – BLACK DIAMOND



Jim Thompson at the end of the main gangway where the slope to the surface, 1,300 feet above, ascends. Rogers #3 mine, 1974.



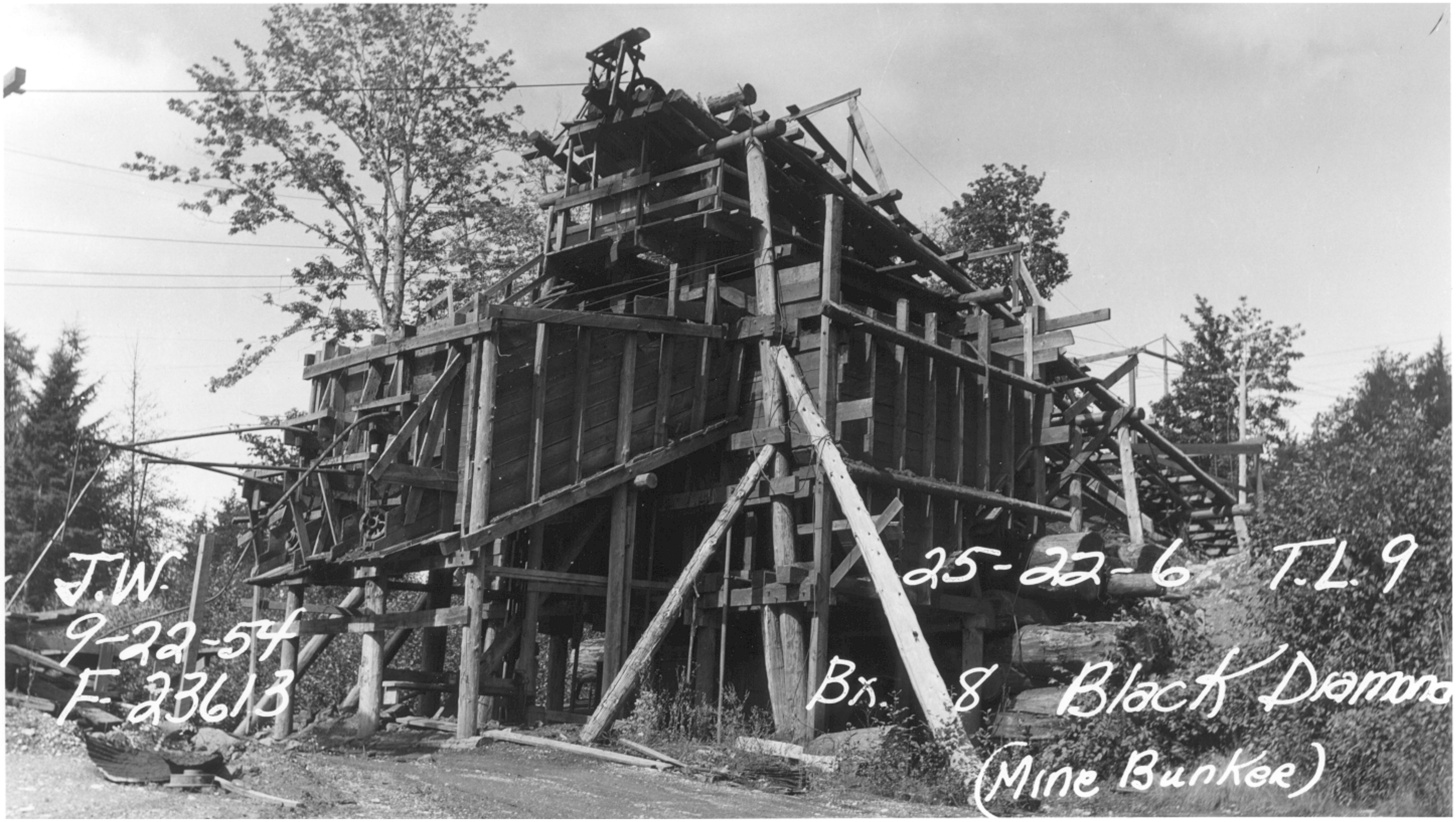
Robert Pierce Sr., Mine superintendent. Testing for dangerous methane gasses, circa 1953. If methane is present a blue flame will show inside the glass, but will not touch off an explosion. From Seattle Times 2-22-53. *Photograph by the Seattle Times copyright 1953 Seattle Times P.O. Box 70, Seattle, WA 98111 all rights reserved; (206) 464-229.7 This picture has been purchased for personal use only and must not be published, reproduced, or used for advertising purposes without written permission from the Seattle Times.*



Inside the Landsburg Mine, Big Seam, circa 1950's. Left to right: Roy Danielson, John H. Morris, Tom Dobson, Carl Roche, (unknown), (unknown). This photo was taken as part of a tour for members of the Renton Housing Authority, one of Palmer Coking Coal Company's customers.

Inside the Landsburg Mine, Big Seam, circa 1950's. Front Row: (unknown), Tom Dobson, Roy Danielson. Back Row: Alva "Bud" Simmons, John Skulas, and John H. Morris, (unknown), Archie Eltz, (unknown), Stan Hubber. This photo was taken as part of a tour for members of the Renton Housing Authority, one of Palmer Coking Coal Company's customers.

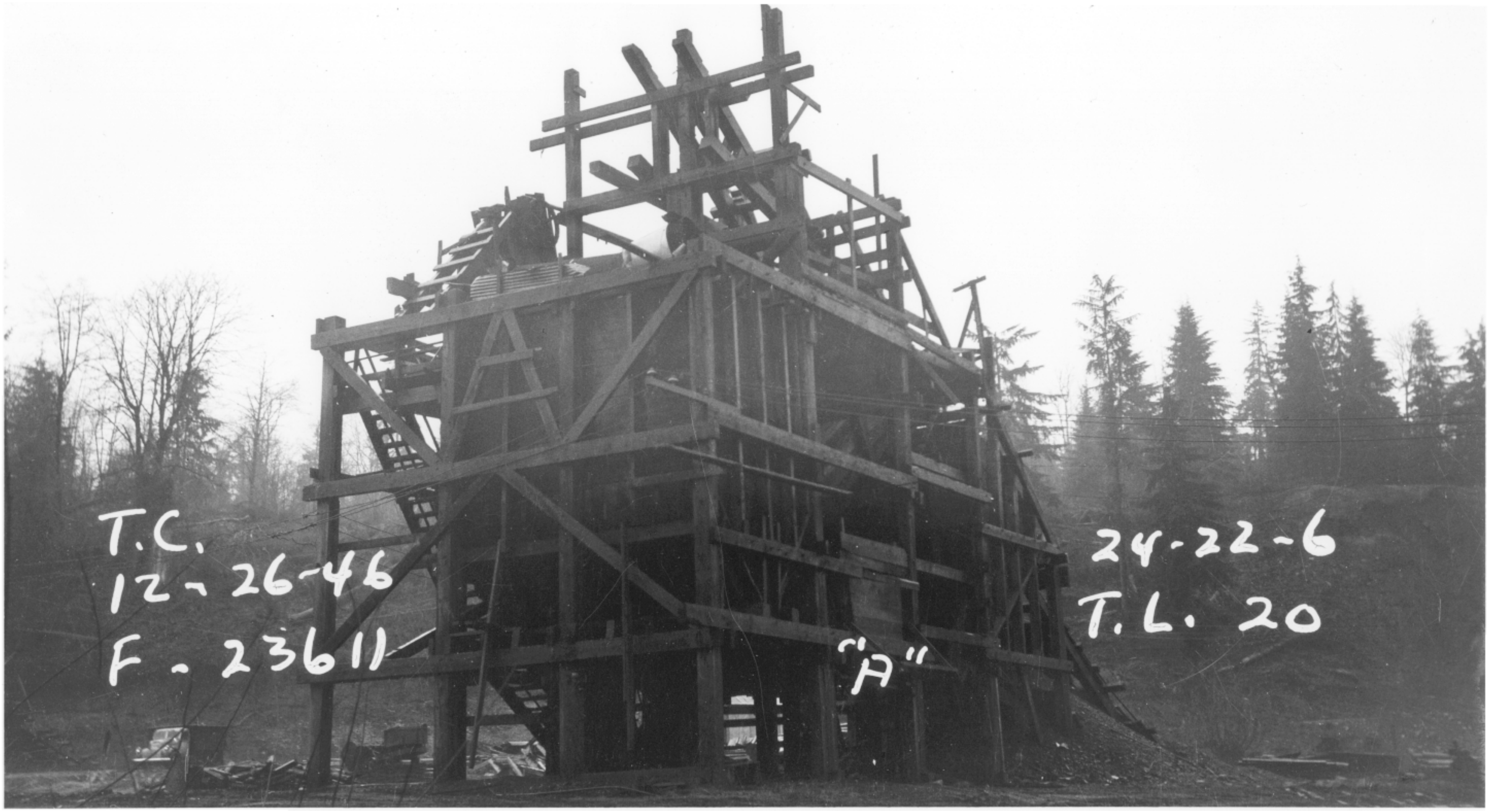
Jack A. Morris **operating a Caterpillar D-8 bulldozer on Franklin Hill, circa 1955. Jack A. Morris, son of company founder, John H. Morris, was President and Manager of Palmer Coking Coal Company from 1964-1976.**



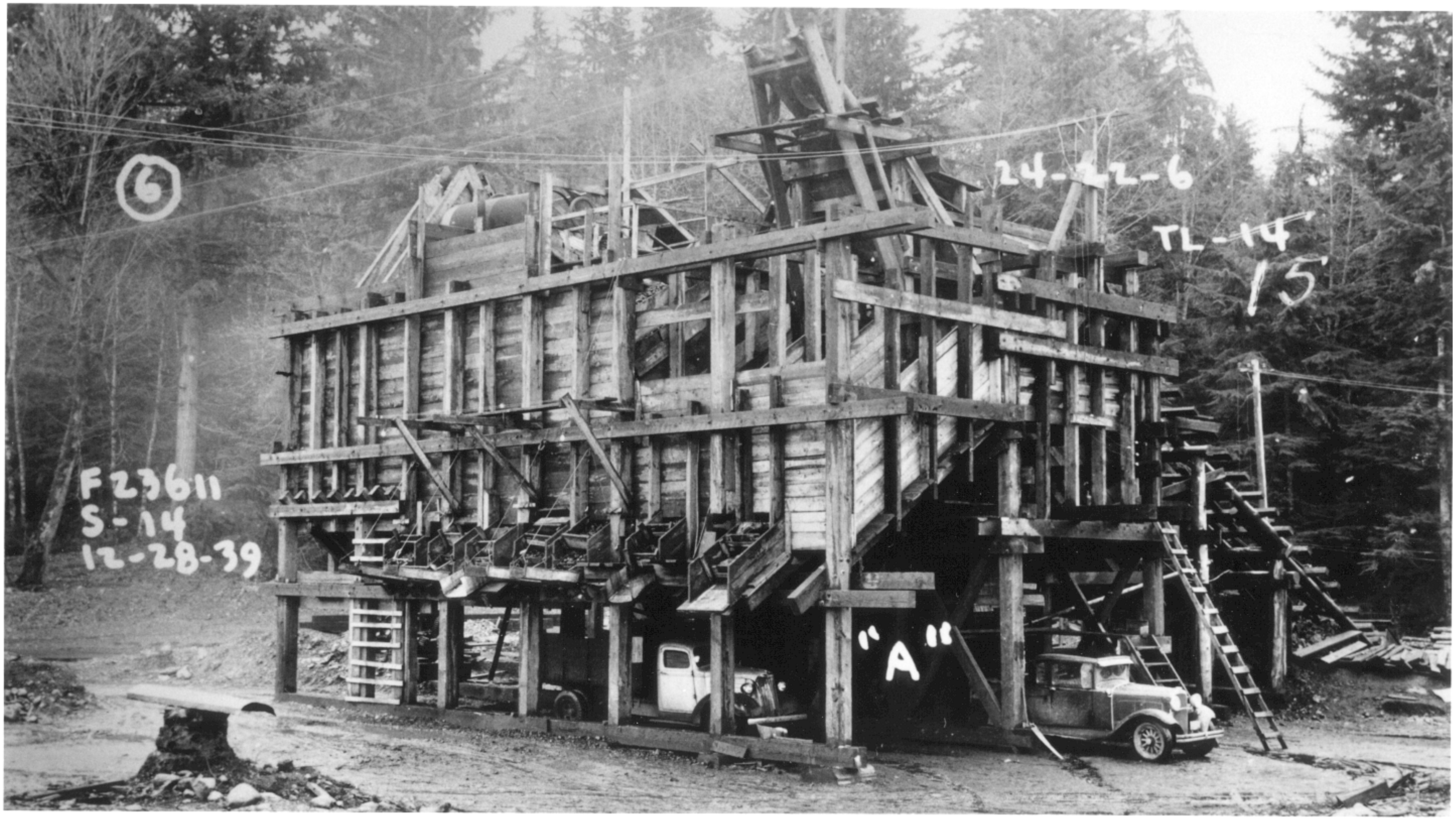
RAVENSDALE COAL BUNKERS (September 22, 1954; #252206-9009) These coal bunkers were for operation of the Landsburg underground coal mine location north of Kent Kangley and west of Ravensdale.

ROGERS #3 HOIST ROOM (circa 1966; #252206-9053) This building housed a large drum upon which a thick steel cable was spooled and unspoiled as coal cars were hoisted up and down the steep slope carrying coal from up an underground slope which was over 600 feet deep. Located at 26226 Kent-Kangley Road, near Ravensdale, the Rogers #3 coal mine operated from 1963-1975 and produced 290,000 ton of clean coal.

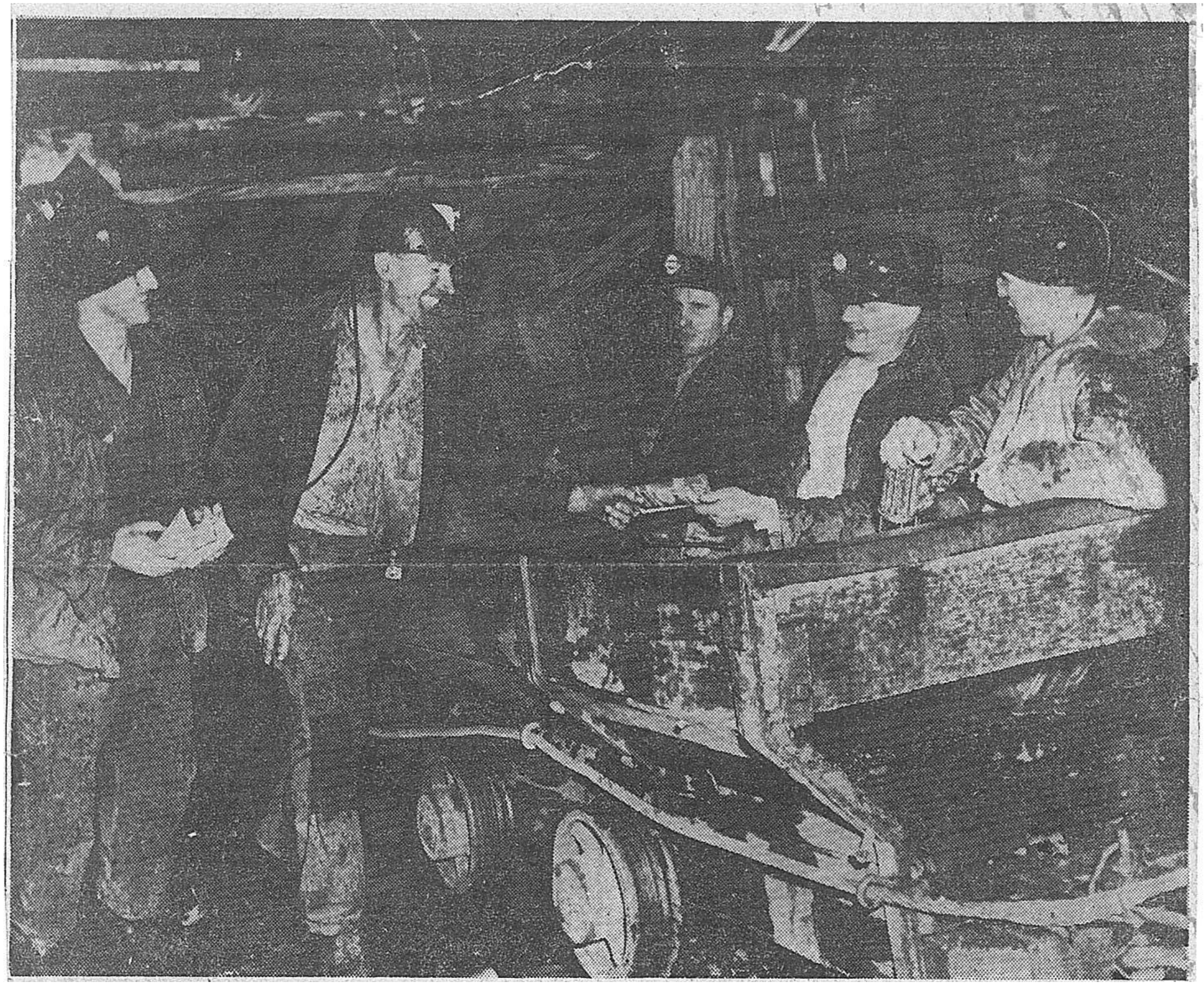
ROGERS #3 MINE SHOP (September, 1966; 252206-9053) This building housed machining tools, welders, parts and equipment for operating the Rogers #3 underground coal mine in Ravensdale. The entrance or portal to the mine is barely visible to the right of the photo. Located at 26226 Kent-Kangley Road under the BPA power lines, the Rogers #3 mine operated from 1963-1975 and produced 290,000 ton of clean coal.



LANDSBURG COAL BUNKERS (December 26, 1946; #242206-9020) This coal bunker or storage/processing facility owned by Palmer Coking Coal Company was located south of the Summit-Landsburg Road. Production during these years was listed from the Danville coal mine though production may have been from he Landsburg or Frazier coal seams.

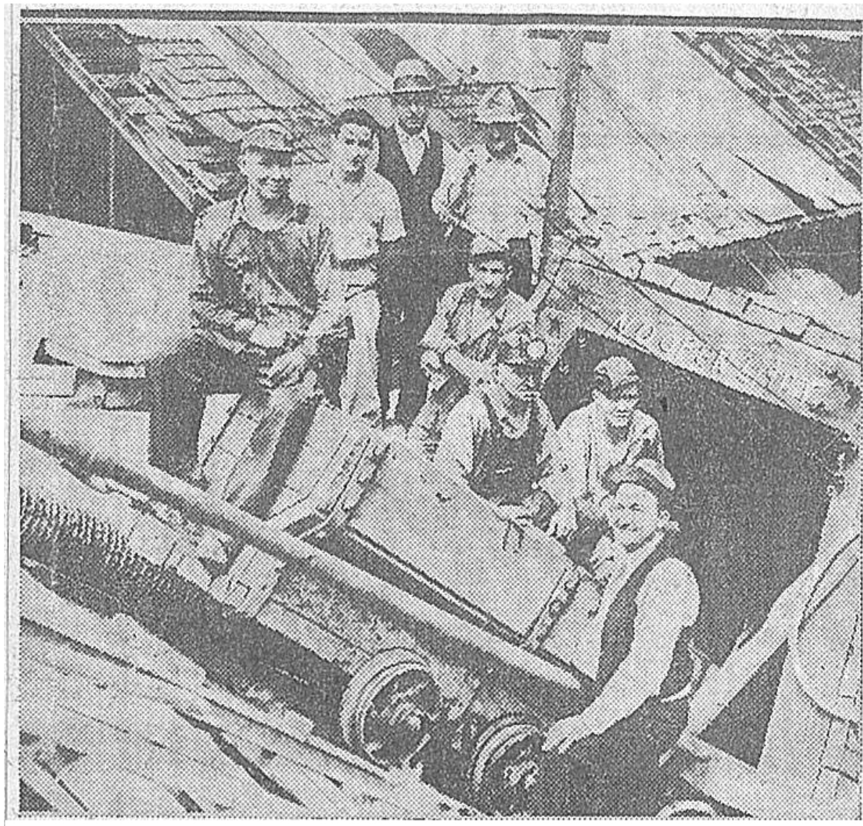


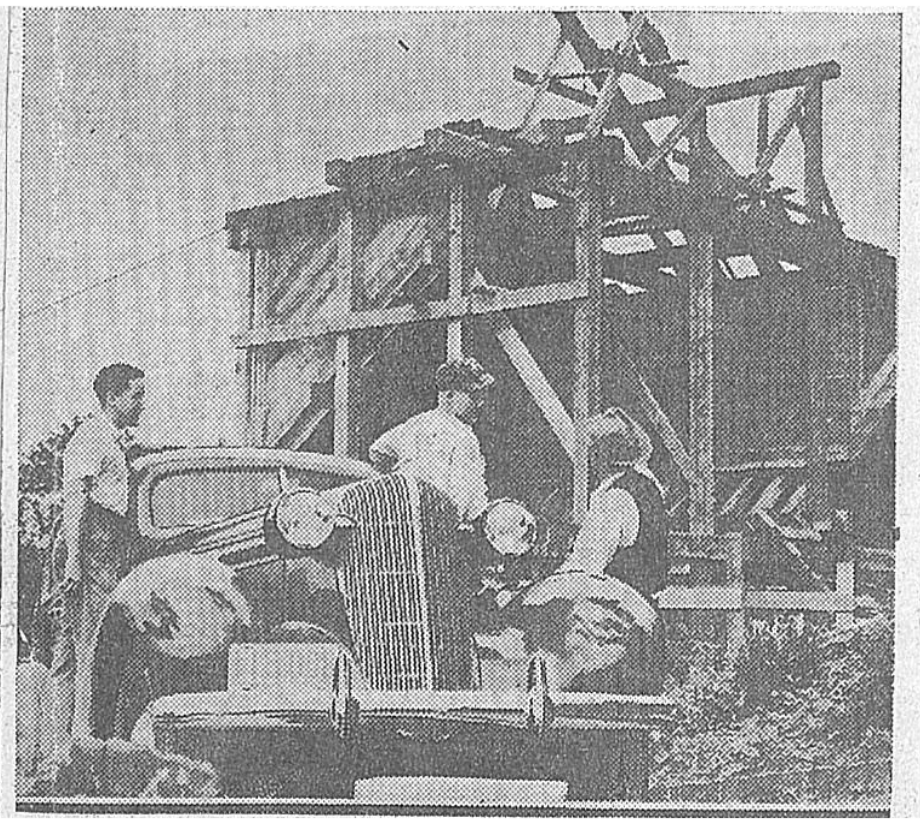
LANDSBURG COAL BUNKERS (December 28, 1939; #242206-9015) This was a fairly typical coal bunkers or storage/processing facility owned by Palmer Coking Coal Company and located south of the Summit-Landsburg Road. At the time of the photo, this coal bunker was fairly new. The Danville coal mine on the Landsburg coal seam was the associated underground mine.



LAST-MINUTE COLLECTIONS—Among the many belated United Good Neighbor solicitations being rushed to conclusion this week is the one at the Danville mine near Lake Wilderness. Harry English, left, secretary of United Mine Workers Union Local 6481, and Frank Stebly, president, give campaign literature to miners William Zaputil, Charles McAllister and Albert Parolini as they prepare to descend into mine shaft. Hundreds of other U. G. N. campaigners in King County are winding up their work before the final reporting meeting at noon Thursday in the Chamber of Commerce banquet hall.

OLDS VISITS COAL MINES





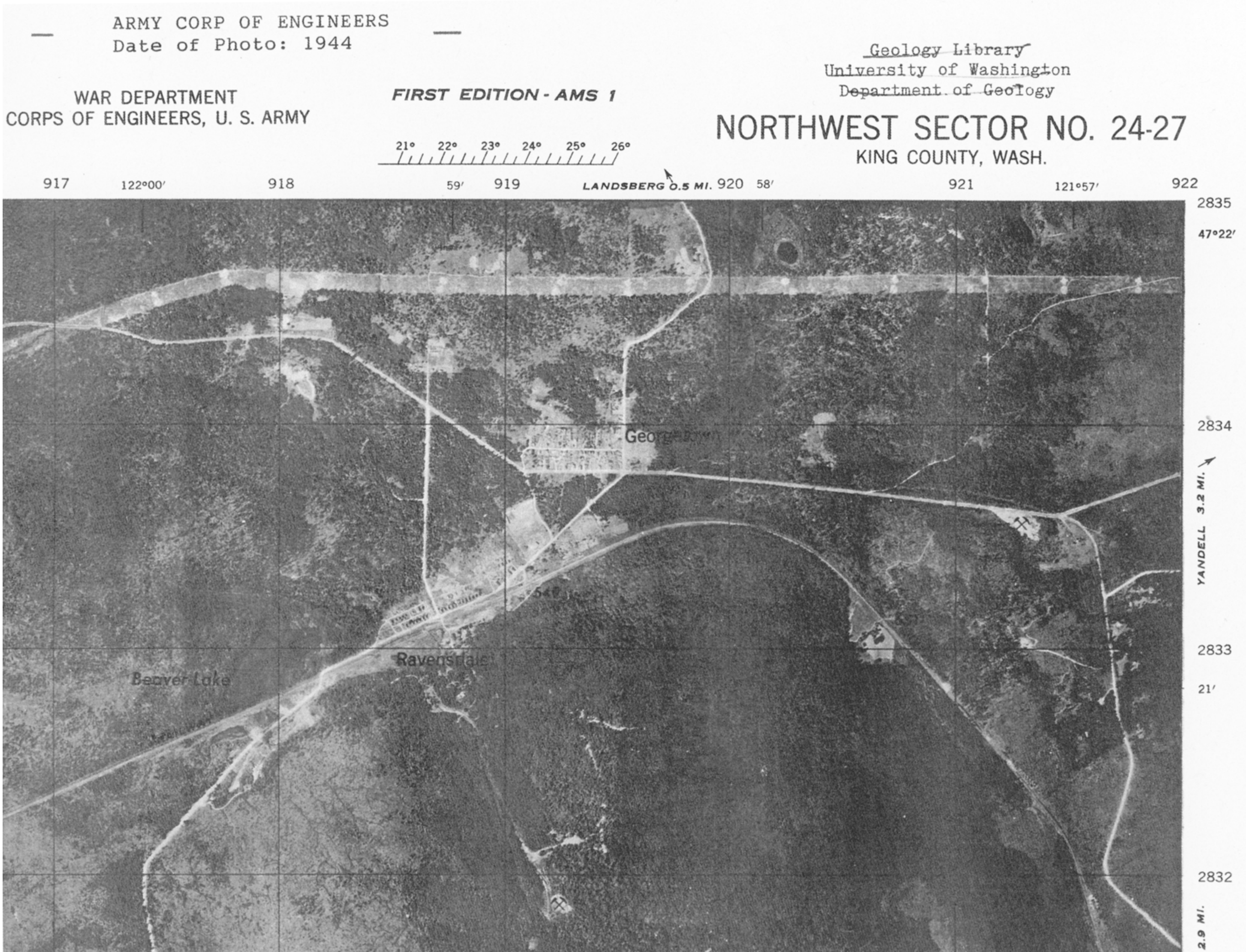
Forty miles from Seattle a party of Seattle motorists visited the Enumclaw mining district last week in a new Oldsmobile loaned by Charles Tyson of the Tyson Oldsmobile Company. A new mine is being opened at Durham by Jack Morris of the Palmer Coking Coal Mining Company, which motorists are invited to visit. Up from the depths (left and right) are Jim Thomas, George Morris, Gus Dallas, Jonas Morris, Bob Pierce, Dave Stonebridge, Jack Morris, Jr., and Jack Morris, president of the company. Below is the Olds standing in front of the new coal chutes.

Appendix G

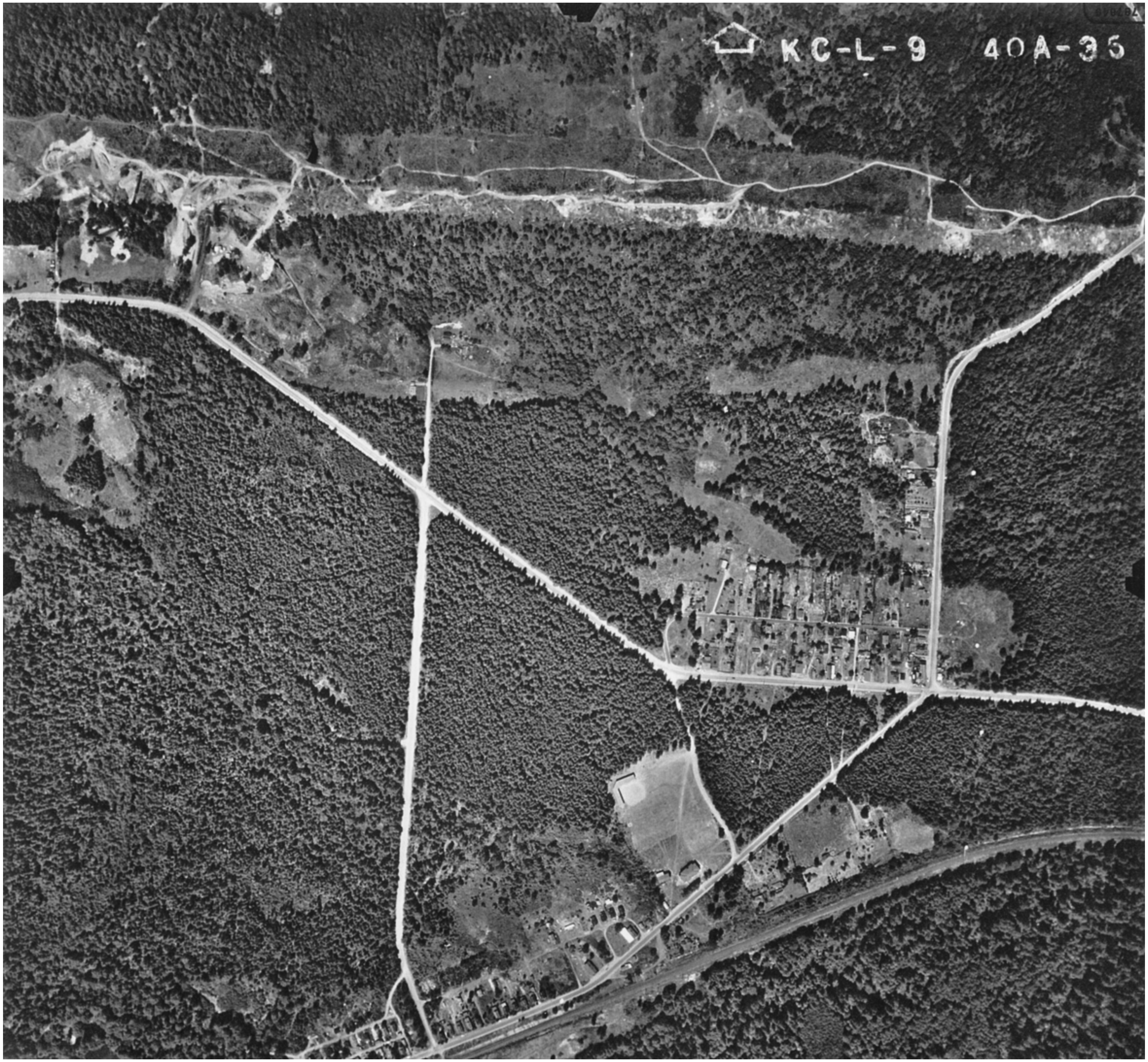
Historic Aerial Photographs

Landsburg Mine
Site Area Aerial Photograph 1936

Landsburg Mine
Site Area Aerial Photograph 1944



Landsburg Mine
Site Area Aerial Photograph 1959

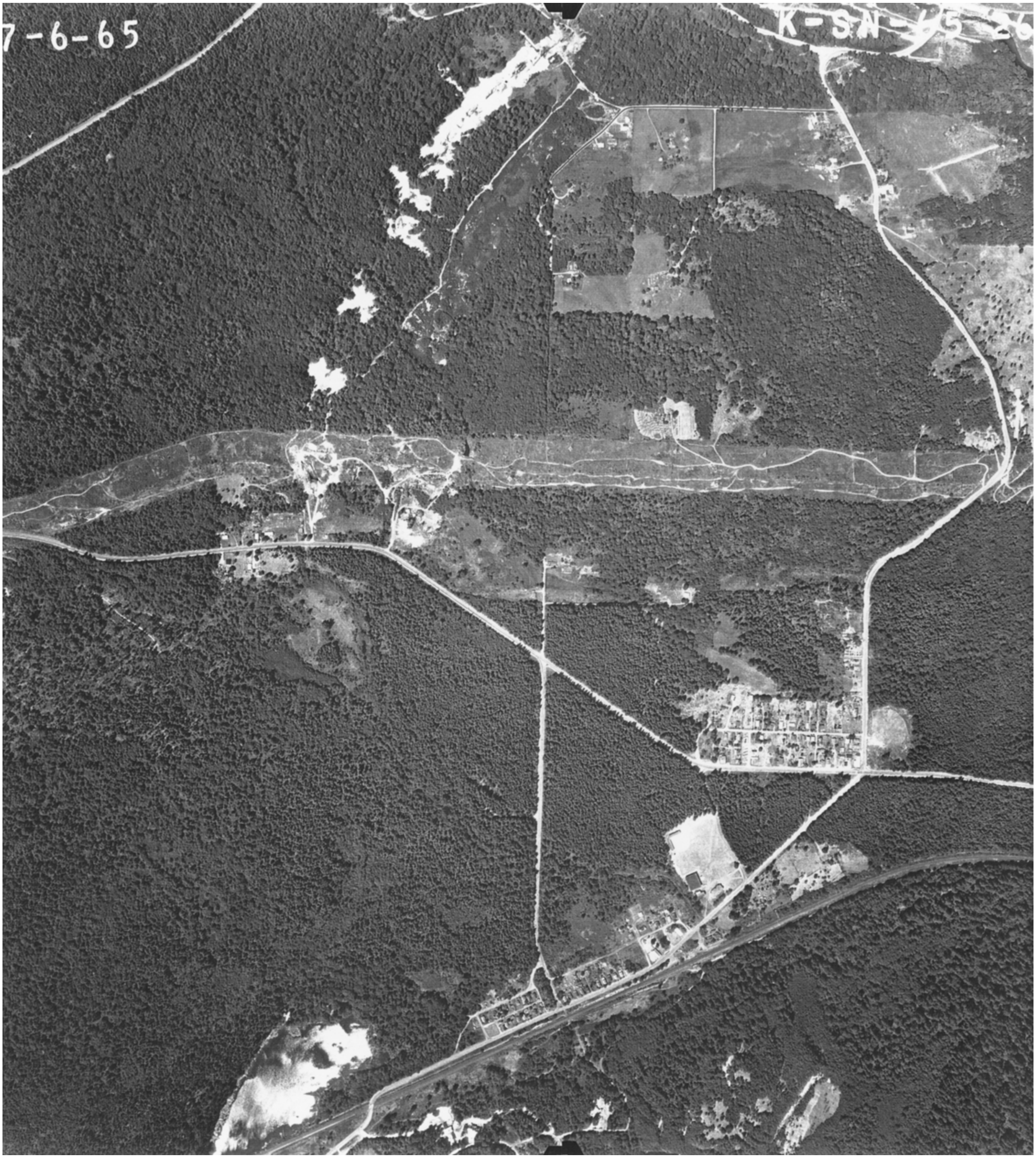


Landsburg Mine
Site Area Aerial Photograph 1959

Landsburg Mine
Site Area Aerial Photograph 1960

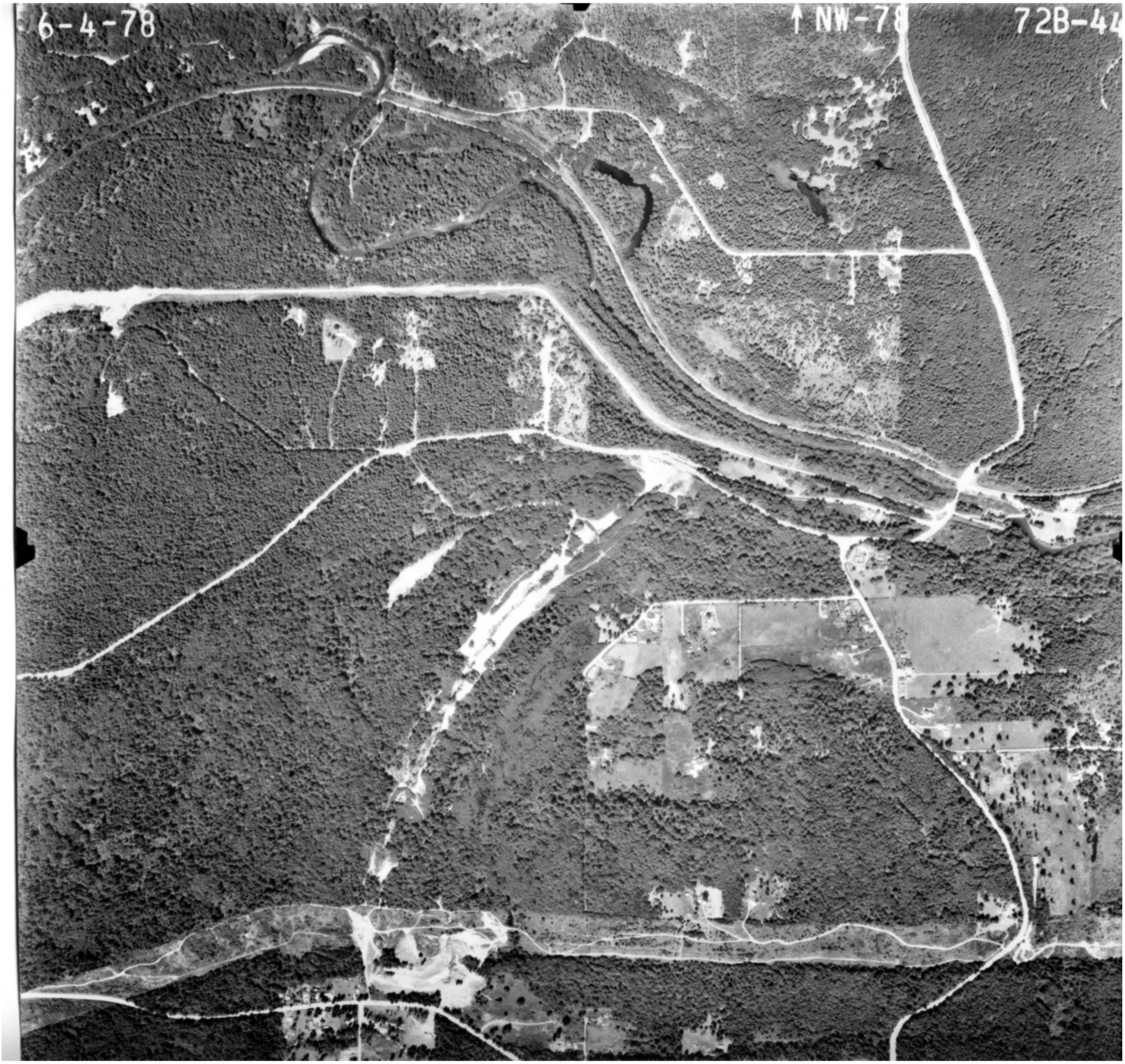
Landsburg Mine
Site Area Aerial Photograph 1960

Landsburg Mine
Site Area Aerial Photograph 1965



Landsburg Mine
Site Area Aerial Photograph 1970

Landsburg Mine
Site Area Aerial Photograph 1978



Landsburg Mine
Site Area Aerial Photograph 1980

Landsburg Mine
Site Area Aerial Photograph 1982

Landsburg Mine
Site Area Aerial Photograph 1994

Landsburg Mine
Site Area Aerial Photograph 1998

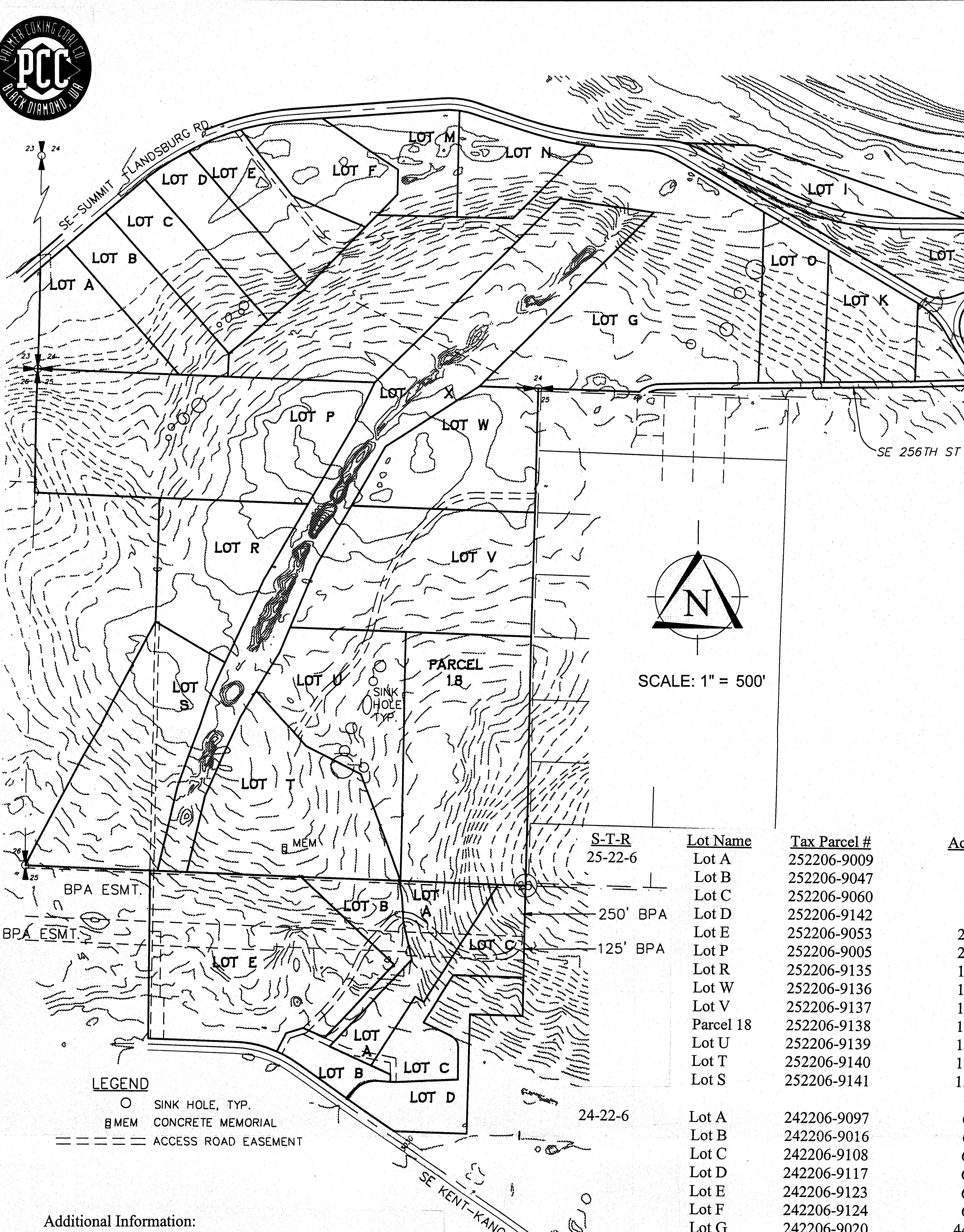
Landsburg Mine
Site Area Aerial Photograph 2001

Appendix H

Landsburg Mine Area

Parcel Descriptions

Jun 10, 2002 – 2:37pm
S:\PROJECTS\96030\DWGFILES\SEC 25-22-6\96030-034-EX-052802.DWG



S-T-R	Lot Name	Tax Parcel #	Acreage
25-22-6	Lot A	252206-9009	6.19
	Lot B	252206-9047	6.04
	Lot C	252206-9060	6.19
	Lot D	252206-9142	6.25
	Lot E	252206-9053	21.42
	Lot P	252206-9005	24.08
	Lot R	252206-9135	10.14
	Lot W	252206-9136	10.63
	Lot V	252206-9137	16.85
	Parcel 18	252206-9138	19.66
	Lot U	252206-9139	11.93
	Lot T	252206-9140	15.16
	Lot S	252206-9141	15.25
24-22-6	Lot A	242206-9097	6.38
	Lot B	242206-9016	6.18
	Lot C	242206-9108	6.08
	Lot D	242206-9117	6.00
	Lot E	242206-9123	6.25
	Lot F	242206-9124	6.23
	Lot G	242206-9020	44.70
	Lot X	242206-9126	26.06
	Lot I	242206-9106	4.14
	Lot J	242206-9098	5.29
	Lot K	242206-9021	6.01
	Lot M	242206-9119	5.50
	Lot N	242206-9013	5.50
	Lot O	242206-9125	6.25
	TOTAL		310.36

Additional Information:

Lots A-E; Section 25-22-6	BLA # L98L0145 Recording # 9905139008 Book 129, Pages 186, 186A
Lots A-O; Section 24-22-6	BLA # L98L0144 Recording # 20000419900001 Book 137, Pages 38A, 38B
Lots P-X; Sections 24 & 25	BLA#L01L0078 Recording # 20020516900007

SHEET NO. 1 of 1
JOB NO. 96-03
STAMP NOT VALID UNLESS SIGNED AND DATED

PROJECT MANAGER
PROJECT SURVEYOR
PROJECT ENGINEER
PROJECT LANDSCAPE ARCHITECT
FIRST SUBMITTAL DATE: 6/07/02
SCALE:

NO. | DATE | REVISION | BY | CK

BOUNDARY / TOPO EXHIBIT
10' CONTOURS (W/ EASEMENTS)

PALMER COKING COAL CO.
SECTIONS 24 & 25, TWP. 22 N., RGE. 6 E., W.M.

TRIAD ASSOCIATES
Land Development Consultants

Appendix I

Preparer Qualifications

SubTerra, Inc.

Dr. Chris D. Breeds, Ph. D., P.E.

EDUCATION:	B.Sc., Mining Engineering (Honors), University of Nottingham, U.K., 1973. Ph.D., Rock Mechanics, University of Nottingham, U.K., 1976.
AFFILIATIONS:	Member American Institute of Mining Engineers (SME) Charter Member, Institute of Shaft Drilling Technology (ISDT) Fellow Institute of Mining and Metallurgy (FIMM) International Society of Rock Mechanics Member, Construction Specifications Institute (CSI) Member American Concrete Institute (ACI), Committee 506. Member, International Society of Explosives Engineers (ISEE) Member, National Society of Professional Engineers (NSPE) Director, American Rock Mechanics Association (ARMA)
REGISTRATION:	Registered Professional Engineer (PE), Washington, Colorado, Oregon, Arkansas, Iowa, Montana and Nevada: Chartered Engineer, UK.

EXPERIENCE:

1991 to date	President, SubTerra Inc., North Bend, Washington. Director, SubTerra Engineering Ltd., UK.
1984 to 1991	Senior Mining Engineer then Associate, Golder Associates Inc., Redmond, Washington.
1979 to 1984	Mining Engineer, International Ground Support Systems Inc., Denver, Colorado
1976 to 1979	Assistant Professor, Mining Department, Virginia Polytechnic Institute and State University, Blacksburg, Virginia (VPI & SU).
1973 to 1976	Research Engineer, Mining Department, Nottingham University, U.K.

PROFESSIONAL SUMMARY

Dr. Breeds professional career has exposed him to a unique combination of education, applied research, engineering, and field experience on underground mining, civil and environmental engineering projects. His broad experience includes: subsurface rock mechanics and geotechnical engineering; subsidence engineering; shotcrete and concrete technology; feasibility studies and conceptual design for mined facilities; mine systems analysis; preparation of construction cost estimates, bid documents, and specifications; and project management for both private and government projects. This broad technical expertise is complimented by management experience, which includes incorporating and managing companies in the US and Europe as well as managing large multidisciplinary groups involved in project work.

SubTerra Inc. was set up in 1991 to operate as the focal point for a small network of independent consultants working in the mining, civil, and environmental industries. SubTerra Engineering, Ltd. was formed in 1992 to provide similar services in the UK and Europe.

EXPERIENCE in SUBSIDENCE ENGINEERING

Dr Breeds has extensive experience in predicting and analyzing the effects of subsidence on surface features and structures, and in the design of remedial measures, and site investigation programs. This experience has involved work with mining companies, federal agencies (DOE, USBM, USACE), developers, communities, and municipal, county, and state authorities. He is well versed in the application of predictive methods and has been directly involved with the development of computerized subsidence prediction models.

Related Resume Sections

Subsurface Design

Instrumentation and Data Acquisition

Geotechnical Engineering and Rock Mechanics

Abandoned Mine Impact Evaluation

Responsible for developing regulations for development over abandoned coal mines in the 6th largest county in the US. Responsible for analyzing impacts from abandoned mines in Virginia, Colorado, North Dakota, Indiana, Illinois, New York, Tennessee, Oklahoma and Washington on surface facilities ranging from landfills to commercial buildings.

- Evaluation of subsidence potential and impacts from historic, multi-level, copper mining operations in Ducktown, TN. Responsible for evaluating over 3,000 historic mine maps, selecting 240 for digitizing, digitizing and constructing a 3-D mine model that was subsequently used for subsidence evaluations in 3 mines, the Mary, Polk County and more recently, the Callaoway mine that was operated until 1985. For SAIC, EPA, and USACE. Ongoing project.
- Evaluation of subsidence impacts in the Picher Mining area of Northeastern Oklahoma. Selected to provide technical leadership to a Federal/State task force established to evaluate subsidence potential from old abandoned lead-zinc mines in the vicinity of Tar Creek, OK. For USACE. Ongoing project.
- Preparation of an Administrative Rule for use by the 13th largest county (2,200 sq.mi) in the US (King County, WA) for permitting development over abandoned mines. This rule contains; criteria and methodology for quantifying subsidence from abandoned mines; quantification of significant risk with regard to property damage from subsidence; and criteria for declassifying undermined areas that are not expected to pose a significant risk of property damage. For DDES, King County, Washington.
- Consultant to the City of Bellevue for Abandoned Mine Site evaluations. Responsible for maintaining City of Bellevue's AML maps and for reviewing developer submittals for properties underlain by abandoned mines.
  - Reviewed Quadrant plan for proof drilling shallow tunnels in the Primrose seam. Observed field work and reviewed field work report.
- Participation in expert panel convened by the City of Bellevue to review City's planned zoning regulations for the Newcastle-Coal Creek proposed annexation. Work included reviewing City's consultant work product and mining records, and suggesting appropriate methods of analysis to be used in redefining the City's proposed zones, for Forest Ridge Home Owners Association.

- Evaluation of subsidence potential and impacts following closure of US Gypsum's Plasterco mine. This 100-yr old mine contains extensive stopes mined from 14 levels. Subsidence ranging from 5 –to- 50 ft, will create a large surface water body and require re-routing of several roads. A detailed evaluation of subsidence was made for key mine areas and a proposed re-route alignment over solution mined cavities adjacent to the mine.
- Evaluation of subsidence potential from 2000 to 3000-ft deep solution mined brine wells with well-developed cavity systems. This project involved a detailed analysis of brine production records, back analysis of existing cave zones, and prediction of the area potentially subject to subsidence along with a risk analysis.
- Evaluation of impacts for closure of US Gypsum's Oakfield mine near Oakfield, New York. This 100-yr old mine has a strike length of over 10 miles and was worked using room and pillar methods. Workings are very shallow and rock cover over the mined out rooms varies from 20 –to- 100 ft. Subsidence effects are expected to be minimal due to the strong overlying rocks and the limited surface development.
- Evaluation of impacts for partial closure of US Gypsum's Hagersville mine. Involved a review of consultant work products related to subsidence and hydrogeologic impacts and proposed bulkhead siting and design for separating active and closed workings.
- Evaluation of Renton Avenue Property: Responsible for characterizing and evaluating the potential effects of near surface (100-200 ft deep) mine workings on a proposed surface residential development in Renton, WA.
- Habitat Newcastle Property. This project involved plotting and verifying the location of shallow mine workings relative to twelve condominiums to be constructed by Habitat for Humanity and developing recommendations for set-backs from the workings.
- Evaluation of Petrovitsky Road Property for DevCo, Inc. Responsible for evaluating a 25 acre property underlain by workings from two mines. Phase 1 involved the record review, preliminary site reconnaissance, scanning mine maps from 35 mm fiche, digitizing mine map and surface features for incorporation in an AUTOCAD drawing of the site, and preparation of a preliminary report. Phase 2 involved
- Landsburg Mine Site Investigation. This project involved compilation of mine maps and production records, mining sequence and extraction ratio, nature and degree of faulting, water inflow and pumping, and preliminary stability analyses for a unique, near vertical, four level coal mine.
- Subsidence Evaluation, Coal Creek Technological Center, Lafayette, Colorado for Affiliated National Bank. This study involved the evaluation of subsidence potential for a 33 lot commercial park underlain by workings from the Vulcan mine located from 75 to 160 feet beneath the site. Activities included data collection, analysis of previous deep boring and soils investigations, stability analyses, inspection of existing structures on and in the vicinity of the site, subsidence prediction, and presentation of methods which could be utilized to promote the stability of future structures.
- Investigation, analysis, and prediction of settlements for a proposed municipal landfill expansion over abandoned coal mine workings. This work has included: collection and review of historical mining and geotechnical/rock mechanics data; preliminary stability analyses (pillar, roof, and floor) based on collected, regional data; coring and laboratory testing to define site specific parameter values for input to the final stability analyses; final stability analyses including the use of probabilistic techniques; subsidence prediction (subsidence, strain, and

tilt); closure designs for two shafts and a decline; presentations to Colorado Department of Health and Colorado Geological Survey groups.

- Evaluation of proposed 105 acre development underlain by abandoned workings from the Newcastle mine, for the City of Bellevue, WA. Work included review of AML report submitted by the applicant, development of permit requirements and developer submittals, and review of developer work products. The engineered approach developed by Dr. Breeds for this project was eventually incorporated in the City of Bellevue's regulations for developments in abandoned coal mine areas.
- Review of subsidence evaluation report for municipal landfill site underlain by coal mine workings in six seams.
- A proposed 240 acre apartment development was found to be underlain by workings from the Spring Brook coal mine which was active from 1940 to 1952. Existing mine maps and mine production data suggested the presence of unmapped workings. Preliminary estimates of site investigation and remediation costs were made.
- Investigation of the potential impacts of the Richmond Stanley tunnel on proposed development.
- Investigation of site underlain by old (Circa 1900) coal mines to evaluate the potential for subsidence and potential impacts to a proposed housing project, for King County Housing Authority. The project involved researching historic data (mine plans, production records), interviewing state agency personnel and local residents, projection of mine data on surface plans and trenching to determine whether surface depressions were caused by underground workings.
- Abandoned/Active Salt Mine Evaluation Project Manager for the evaluation and analysis of abandoned and active salt mines for use as LLW disposal facilities in New York. This involved developing remedial designs for abandoned facilities, and partitioned disposal space in active mines, shaft design, long term stability analyses, and life-cycle cost estimates.
- Mechanical/Hydrological Characterization of Mechanically Disturbed Zone: This project involved an in depth analysis of the disturbed zone surrounding underground openings in salt with regard to sealing and backfilling. An extensive salt mine rock mechanics database was also established.

Active Mine Projects

- Preparation of input to Permit Revisions for the Twentymile Mine's Northern Mining District regarding subsidence effects on the railroad, county roads, Twentymile cliff (Rockfall hazards), Fish and Middle Creeks, and associated Alluvial Valley floors.
- Preparation of a report on Subsidence Related Horizontal Displacements and Strain Monitoring in the Western Coalfields, for the United States Bureau of Mines. This report examines the current approach to measuring and predicting strain (and related structural damage) based on Western US, longwall case study data.
- Preparation of subsidence predictions for the Belrock mining area, Cyprus Empire corporation. Project involved analysis of existing survey data from 300 to 900 ft deep workings and prediction of subsidence, tilt, and strain for the new panels.

- Preparation of subsidence predictions, damage potential, and remedial methods for the existing western area of the Foidel Creek mine, Cyprus Coal Company, Oak creek, Colorado. Presentation of findings to the Routt County planning commission as part of Cyprus' permit process.
- Development of mitigation for potential rockfall hazards associated with undermining a 200 ft high sandstone cliff in Colorado. This work involved mapping the site, retrieving geotechnical and topographic data for calibrating the CRSP model, evaluating rockfall hazards using the CRSP model, designing mitigation measures, and as-builting the completed project. Barrier designs that were evaluated included steel fences, a vertical, reinforced-soil wall and a 20-ft deep trench/berm combination.
- Preparation of subsidence predictions for Eastern expansion to Cyprus Coal Company's Foidel Creek mine involving 29 longwall panels, 840 ft wide and over 20,000 ft long. Subsidence, and related strain and slope, predicted for 3 alluvial valley floors, county road, railway line, and 3 sets of overhead electricity transmission lines. Report prepared as input to Cyprus' permit documentation.
- Preparation of subsidence displacements (subsidence, tilt, strain, and curvature) for 9 longwall panels planned for extraction beneath 3 overhead (345 KV) transmission lines. Detailed analysis of foundation displacements for 4-legged steel towers and wooden pylons and presentation of displacement predictions to the three major power companies involved in power transmission.
- Energy Spur, Southern Pacific Railroad. Prediction of track settlement and re-ballasting requirements for multi-panel undermining of SP's Energy spur. This project also involved preparation of a monitoring plan, scheduling track remediation, and interactions on a daily basis during live track re-leveling while the rail subsided up to 5 ft.
- Fish Creek Alluvial Valley Floor (AVF) Study. This project has involved back-analysis of subsidence and horizontal displacement survey data for single and multi-panel, longwall, coal extraction; development of start and transverse subsidence profiles for sub-critical (W/h=0.6) workings; prediction of subsidence impacts to an AVF affected by panels with W/h of 0.6 and 0.85; preparation of permit revisions; and development of monitoring plans.
- Preliminary evaluation of surface subsidence for a 24 panel longwall development for Wolf Creek Collieries, Kentucky. Project involved ground subsidence prediction, evaluation of potential impacts to wells, roads, railroads, and dwellings, and requirements for mining adjacent to the Big Sandy river.
- Liaison with USBM Denver Research Center on Mine Subsidence Engineering and development of Subsidence Information Center.
- Development of a strata simulator to model surface movements resulting from longwall coal extraction. Research sponsored by DOE.
- Subsidence Engineering with the NCB (National Coal Board, U.K.), North Nottinghamshire Area, involving:
  - Analysis of over 200 documented subsidence case studies involving longwall and partial (room and pillar) extraction coal mining in single and multiple (up to 7) seams. Analysis performed to provide a statistical evaluation of the effects of geology on the magnitude of mine subsidence deformations.
  - Investigation of CLASP (Consortium of Local Authorities Special Programs) structures subjected to mining subsidence: Phase I involved the analysis of over 50 case studies of

undermined CLASP structures. Phase II involved the instrumentation of a site containing both CLASP and conventional structures. Monitoring of the ground surface movements and structures was carried out during longwall undermining.

- Investigation of more than 15 undermined industrial sites to evaluate and quantify the effects of remedial measures used to control subsidence induced structural damage. Key projects included:
  - Subsidence investigation of a brick manufacturing plant; involved the monitoring of surface and structures at a site where trenching was used to reduce the damage due to longwall undermining.
  - Instrumentation of the Rolls Royce Hucknall site during longwall undermining; involved the instrumentation of large structures, hangars, precision machinery, runway and gas pipeline during undermining. Site and mining precautions were taken to minimize surface damage.
  - Instrumentation of a large textile factory; involved the monitoring of a large factory subjected to maximum compression from longwall mining. Several structural precautions, including trenching, were incorporated in and monitored at the site.
  - Bench scale modeling, field verification, and analysis of effectiveness of trenching used to protect structures from compressive ground strains resulting from longwall undermining.
  - Investigation of the impacts of longwall undermining of a large brickbuilt structure underlain by spacious, deep cellars. Project included structural precautions, surface subsidence and strain measurement (monument layout designed to facilitate principal strain magnitude and direction calculation).

EXPERIENCE IN INSTRUMENTATION AND DATA ACQUISITION

Over the past three decades, Dr. Breeds has provided Instrumentation Services for civil tunneling, underground mining, geotechnical engineering and blast monitoring projects. He has been involved with structural and geotechnical monitoring instrumentation throughout his career with programs ranging from simple SONDEX installations to a system involving a 3,000 channel DAS. This work has been undertaken for clients ranging from local contractors to National Laboratories (e.g., LANL, SNL) and projects sponsored by the US Army Corps of Engineers.

Related Resume Sections

Subsurface Design

Shotcrete and Concrete Technology

Nuclear Waste

Blast Design, Blasting, Blast Monitoring and Construction Vibrations

Geotechnical Instrumentation Projects

- Howard Hanson Dam (Ongoing): Responsible for the planning, installation and monitoring of inclinometers, Piezometers, Multipoint Borehole Extensometers, and load cells to monitor support loads and wall deflections during cofferdam excavation. Utilizes 3, Geomation 2380-80 MCUs for data acquisition. For Traylor Pacific.
- Leominster Bridge (Ongoing): Responsible for planning, installation and monitoring of fiber optic, dynamic structure monitoring system designed to evaluate the pre and post-tensioned performance of this 1880 stone bridge. Data acquisition and presentation via the internet. For Atkinson-Noland.
- Portland Treatment Plant: Installation and monitoring of multi-point, sondex system adjacent to pile driving operation at the PTP. For Callaway Ross.
- South Tacoma Trunkline: Installation and monitoring of dual-point Sondex System above a microtunnel being constructed beneath Interstate 5 in Tacoma, WA. For EJ Rody and Sons.
- Investigation of more than 15 undermined industrial sites to evaluate and quantify the effects of remedial measures used to control subsidence induced structural damage. Key projects included:
  - Instrumentation of the Rolls Royce Hucknall site during longwall undermining; involved the instrumentation of large structures, hangars, precision machinery, runway and gas pipeline during undermining.
  - Instrumentation of a large textile factory; involved the monitoring of a large factory subjected to maximum compression from longwall mining. Several structural precautions, including trenching, were incorporated in and monitored at the site.
- Specialist subcontractor to Los Alamos National Laboratory, EES-13, Las Vegas. Supporting the management of ESF testing at Yucca Mountain for the National High-Level Waste program. Involved in:
  - Provide technical input to geotechnical data collection requirements and geotechnical data as-building. Prepare technical memoranda on geologic mapping. Prepare test planning package and work plan for underground geologic mapping.

- Prepare test planning package and work plan for construction monitoring in the ESF. Responsible for liasing with Sandia National Laboratory for geomechanical testing, seismic and blast monitoring. Responsible for developing the ESF design data requirements in conjunction with M&O MK ESF designer.
- Prepare testing requirements for input to ESF design (based on ESFDR and TPP 91-5). Primary author of the ESF Design Requirements document.
- Preparation of TCO inputs to test interference (TIE) and waste isolation evaluations (WIE).
- Preparation of detailed design requirements for underground testing areas including; Alcoves 1-4, Thermal Testing Area; and Ghost Dance Fault Alcoves (6&7).

- Assistant Project Manager for Technical and Field Services, Underground Testing, Deaf Smith County, Texas ESF. Responsible for organization and fiscal management of multidisiplinary project ($2.5M p.a.) for site characterization of the proposed salt High Level Radioactive Waste Repository site.
- Principal Investigator for Shaft Site Characterization and Instrumentation, Deaf Smith County, Texas ESF. Responsible for managing and directing technical efforts of multidisciplinary group (geology, hydrology, rock mechanics, ADAS, thermomechanical) developing the instrumentation and testing program for 3,000-ft deep shafts in salt.

Blast and Construction Monitoring Projects

SubTerra, Inc. is the local distributor for Instantel blast monitoring products and has been involved in the development and use of both high frequency vibration and piezometeric monitoring at blast sites. SubTerra, under Chris Breeds' direction, is also the local agent for the OSMOS structural monitoring system which provides a complete DAS/Instrumentation system for dynamic structure monitoring, including dams.

- Yucca Mountain near-field blast monitoring program. Responsible for the design of a near-field blast monitoring system designed to quantify criteria for minimizing rock damage at the periphery of the excavation. Accelerometers and geophones were located 3-ft and 10-ft from the final profile and monitored using standard Blast Monitors. For LANL.
- Blast monitoring and optimization for a cut and fill stoping operation using cemented backfill. Involved monitoring both underground and at the surface with post-blast evaluation of firing sequence, explosives types, drill hole layout, blast damage, and impacts to stope wall and pillar stability. This project was one of the first to utilize near-field, high frequency blast monitoring for optimizing blasting practices.
- Responsible for designing and setting up a blast vibration and dynamic pore pressure measurement system for monitoring adjacent to blasting a cut-off trench below a FERC regulated earthfill dam. Dynamic pore pressure measurements are made in boreholes using 3/8-in diameter ICP-38, PCB sensors coupled to conventional Blast Monitoring Equipment. For the Benham Group, Oklahoma.
- Monitoring Pile Driving Operations for:
  - 124th Street Bridge, Redmond, WA
  - South Fork Bridge, North Bend, WA.
  - Preston Bridge, Preston, WA

- Tacoma Narrows Bridge, Tacoma, WA.
- Yakima Bridge, Yakima, WA
- SR18 Slide Repair (Driving 6-ft diameter shafts)
- University of Washington Field house (Driving 3-ft diameter, 130-ft deep shafts)
- Pioneer Square Renovations, Seattle
- Clackamass River, (Pile driving near gas pipelines), Oregon

- Monitoring Blast and Construction Vibrations at:
  - Oconee Nuclear Power Plant, Duke Energy, SC
  - Issaquah School District, Elementary School No. 13, Newcastle, WA.
  - Renton School District, Hazelwood Elementary, Newcastle, WA.
  - Howard Hanson Dam, Cumberland, WA. (Traylor/USACE)
  - Snoqualmie River Widening, Snoqualmie, WA (Goodfellow/USACE).
  - Rock Quarries (see Blast Monitoring Section).
  - Underground Mining and Tunneling projects (see Blast Monitoring Section).

EXPERIENCE IN GEOTECHNICAL ENGINEERING and ROCK MECHANICS

Over the past three decades, Dr. Breeds has provided geotechnical engineering services, in soil and rock, for underground mining and tunneling, and surface civil engineering applications. He has been involved with site investigation, geotechnical data reduction, preparation and review of geotechnical baseline reports, analysis of geotechnical data for input to design, slope stability assessments including wall design, and surface water management design. Dr. Breeds was recently appointed a Director of the American Rock Mechanics Association.

- As President and Chief Engineer of SubTerra, Inc., Dr. Breeds is the Responsible Engineer for SEPA projects undertaken by SubTerra. SEPA Projects that have involved site characterization/investigation; slope stability assessment; surface water management, including sediment and infiltration pond design; and other geotechnical work products include:
  - Lake Francis Gravel , King County
  - Littlerock Gravel, Pierce County
  - Wheeler Gravel, King County
  - 5-Mile Quarry, Snohomish County
  - Sunset Quarry, Pierce County
  - Ratlesnake Fill Site, King County
- Busted Butte (Nevada Test Site, Nevada): Responsible for highwall slope stability analysis and design of rock bolt and shotcrete wall support.
- Rockfall Hazard Assessment:: Development of mitigation for potential rockfall hazards associated with undermining a 200 ft high sandstone cliff in Colorado. This work involved mapping the site, retrieving geotechnical and topographic data for calibrating the CRSP model, evaluating rockfall hazards using the CRSP model, designing mitigation measures, and as-builting the completed project. Barrier designs that were evaluated included steel fences, a vertical, reinforced-soil wall and a 20-ft deep trench/berm combination.
- Home Depot Shotcrete wall: Responsible for evaluating the post-construction condition and proposed repair for a Shotcrete retaining wall. Client Confidential.
- City of Issaquah - MDRT Review Consultant: Responsible for geotechnical review of consultant work products for the Talus and Issaquah Highlands projects.
  - Soil Nail, Soldier Pile and MSE retaining walls and Rockeries
  - Coal mine hazards
  - Steep Slope CAS Standards
  - Reservoir stability
  - Slope Stability
- University of Washington: Invited lecturer in geotechnical aspects of site characterization and exploration, subsurface excavation and tunnel design in soil and rock.
- Site Investigation, Geotechnical Assessment, Expert Testimony and Design and Preparation for Geotechnical Baseline reports :
  - Caney Shaft (600-ft, 20-ft dia)
  - Sperry Mine Shaft, Sperry, Iowa (600-ft, 20-ft dia)
  - Frankfort Tunnel, Frankfort, KY (4,000-ft, 12-ft dia)
  - Shoal Creek Tunnel, Austin, TX (3,200-ft, 9-ft dia)

- Mineral Creek Diversion Tunnel, AZ (13,000-ft, 18-ft dia)
- East West Drift, Yucca Mountain, NV
- Boston Outfall Tunnel (45,000-ft, 25-ft dia)
- Boggy Creek Tunnel (540-ft, 54-in dia)
- West Seattle Tunnel (10,000-ft, 14-ft dia)
- Bryn Mawr Microtunnel (800-ft, 36-in dia)
- Spanaway Loop Microtunnel (3,000-ft, 7-ft dia)

EXPERIENCE IN EXCAVATION ENGINEERING, DRILL and BLAST and MECHANICAL EXCAVATION

Over the past three decades, Dr. Breeds has provided Excavation Engineering services for civil tunneling and underground mining projects. He has been involved with predicting and analyzing the performance of both drill-and-blast (tunnel and shaft) and mechanical excavation systems (e.g., TBM and Roadheader). He authored the Rapid Excavation section of the SME Mining Engineers Handbook, which provides a feasibility level approach to excavation method selection for tunnels, shafts, and mechanically bored raises. In 1998, SubTerra, Inc. acquired the Robbins Company's Rock Mechanics laboratory and now offers a full range of tests aimed at predicting the performance of mechanical rock excavation methods. Many of the project examples presented below are also listed under Subsurface Design, Construction, and Cost Estimating and Underground Blasting projects.

Related Resume Sections

Subsurface Design

Shotcrete and Concrete Technology

- St. Helier Stormwater Facility, Jersey. Evaluation of geological/geotechnical conditions, back-analysis of coring, boring, and back-reaming for a 1,500-ft, 10-ft diameter horizontal raise bore tunnel. For SEL and Balfour Beatty, UK.
- BHP Diamonds, 400-m long, 4-m diameter Raises: Evaluation of raise boring requirements and estimate of raisebore performance for the Panda Kimberlite Pipe located 320 km northeast of Yellowknife, NWT.
- Sperry Mine Ventilation Shaft: Professional Engineer of Record for the design of a 600-ft ventilation shaft constructed by raise boring. Responsible for design of geotechnical site investigation program, preparation of geotechnical baseline report, shaft design, construction drawings and specifications, and design support during construction. For US Gypsum, Sperry, Iowa.
- Evaluation of rock conditions for mechanically mining the Thermal Test Area and preparation of data collection requirements for assessing the AM75 Roadheader performance. Preparation of a Blast Monitoring and Optimization strategy to be used in conjunction with Drill and Blast construction in the ESF. For Yucca Mountain Project, Test Coordination Office (LANL).
- Preparation of the Rapid Excavation Chapter for (1992) SME Handbook. This work provides a "hand book" approach to selecting mechanized mining systems for constructing tunnels, declines, and shafts and compares the relative merits of TBM, Roadheader, Blind Boring, Raiseboring and conventional Drill and Blast methods.
- Project manager for blast optimization studies for the San Manuel mine's block caving operations. Project involved underground blast monitoring of development, production and test blasts and re-design of the blast rounds to reduce blast damage, drilling and explosives costs. For Magma Copper Co., Arizona.
- Boston Outfall Tunnel. Part of a team responsible for evaluating Differing Site Conditions claim and TBM performance on the Boston Outfall tunnel. This work included an evaluation of site investigation data, construction records, laboratory data and consultant reports relating

total hardness, UCS, BTS and dynamic rock properties to TBM performance. Client Confidential.

- Mineral Creek Diversion Tunnel. Project involving review and input to the design, ground support selection, geotechnical data and baseline reports for this 18-ft diameter TBM or Drill-and Blast driven tunnel. Also involves evaluating TBM performance, formulating the contracting strategy and developing the contract documents and bidding process. For ASARCO and Montgomery Watson.

- Preparation of the Geotechnical Baseline Report (GBR) for the East-West Drift at Yucca Mountain, NV. Responsible for back-analyzing data collected during TBM construction of the 5-mile, 25-ft diameter main tunnel and formulating the baseline for the new, 16' 8" diameter TBM driveage. For TRW Environmental Safety Systems, Inc., Las Vegas, Nevada.

Excavation Engineering laboratory support has been provided for:

- US Gypsum Sperry Mine: UCS and BTS for underground mine pillar stability and 600-ft Raise Bored Shaft, for US Gypsum.

- Karanjukar Project, Iceland: Punch Penetration and Cerchar abrasivity for large ($150M) hydroelectric project, Robbins Company, Seattle, WA.

- Shoal Creek Project: Punch Penetration, UCS, BTS, and Cerchar abrasion for sedimentary rock tunnel, Weston Solutions and City of Austin, TX.

- Seymour Capilano Project: Punch Penetration and Cerchar abrasivity for BC, Canada tunnel project, Hatch Mott McDonald.

- Effluent Interceptor project, Las Vegas, NV: UCS, BTS, and Cerchar abrasivity for planned tunnel project.

EXPERIENCE IN SUBSURFACE DESIGN, CONSTRUCTION, and COST ESTIMATING

Over the last twenty-five years, Chris Breeds has worked on numerous projects involving underground and surface construction, subsurface design, instrumentation, and testing. This broad experience provides the ability to develop a project from a concept, through preliminary design, site investigation, final design, bidding, Contractor selection, contract management, to finished product.

Related Resume Sections

Geotechnical Engineering and Rock Mechanics

Shotcrete and Concrete Technology

Abandoned Mine Engineering

- Sperry Mine Ventilation Shaft (Constructed): Professional Engineer of Record for the design of a 600-ft ventilation shaft constructed by raise boring. Responsible for design of geotechnical site investigation program, preparation of geotechnical baseline report, shaft design, construction drawings and specifications, and design support during construction. For US Gypsum, Sperry, Iowa.

- Shoals Creek Tunnel (Active). Lead Underground Designer for this 8 to 9-ft diameter tunnel to be completed in Del Rio Shale and Georgetown Limestone in Austin, TX. Responsible for shaft and tunnel design, support selection, GBR preparation, 30 through 100% designs, Contract Document, Drawing, and Specification preparation. This project also requires innovative approaches to designing connections of lateral sewers to the new tunnel using HDD, pilot bore microtunneling and/or raise boring. For Weston Solutions.

- Henderson Tunnel (Active). . Responsible for evaluating geotechnical conditions, designing grouting programs (materials and equipment selection, laboratory testing, field set up), design launch frame, and preparing submittals for a large diameter EPBM driven soft ground tunnel using bolted and gasketed segments for ground support. Responsible for developing jacking calculations and submittals for 5 Microtunnels. For Kenny-Northwest Boring, JV.

- Muskeg River Oils Sands Project (Constructed). Lead designer for four microtunnels drilled from a wet well into a cofferdam in the Athabasca River as part of the water intake structure for this multi-billion oils sands project. Responsible for contract document, drawing and specification preparation. For Fluor/AMEC.

- Lead Tunnel Designer for the West Frankfort Storm Sewer project (Constructed). Project to design a 4,000-ft long, 12-14 ft diameter main tunnel and 42-inch diameter microtunnel in Karstic limestone using either TBM or conventional drill-and-blast mining methods. Involved designing rock support for the portals, tunnel and shafts, locating and evaluating available TBMs, preparation of the GBR, and preparation of the plans, specifications, and contract documents. For WCG and the City of Frankfort, Kentucky.

- Mineral Creek Diversion Tunnel (Constructed). Project involving review and input to the design, ground support selection, geotechnical data and baseline reports for this 18-ft diameter TBM or Drill-and Blast driven tunnel. Also involves evaluating TBM performance, formulating the contracting strategy and developing the contract documents and bidding process. For ASARCO and Montgomery Watson.

- Tolt Pipeline Project, Redmond, WA (Constructed). Responsible for evaluating jacking frame set-up and designing backing for two microtunnels to be jacked from a 90-ft deep, 30-ft diameter shaft constructed in glacial soils. The first microtunnel will be 1,500-ft long and utilize a new Soltau jacking frame with 950-ton thrust capability in combination with three intermediate jacking stations. For Northwest Boring, Inc.

- South Interceptor Project, Renton, WA (Constructed). Responsible for preparing Contractor submittals for two 260-ft long, 9-ft diameter microtunnels that will be mined using an Earth Pressure Balance machine (EPBM) and jacked pipe. For Kenny-Northwest Boring, JV.

- South Interceptor Project, Renton, WA. Responsible for evaluating geotechnical conditions, designing grouting programs (materials and equipment selection, laboratory testing, field set up), and preparing submittals for an EPBM driven soft ground tunnel using bolted and gasketed segments for ground support. For Kenny-Northwest Boring, JV.

- Boggy Creek Interceptor, Austin, TX (Constructed). Project to design a 540-ft, 54-in undercrossing of US 183 in Austin, TX. Responsible for preparation of a GBR and specifications for hand mining, pipe-jacking or microtunneling this under crossing in soils containing cobbles and occasional boulders. For Weston Solutions and City of Austin.

- Spanaway Loop Interceptor Project, WA. Responsible for characterizing a microtunnel alignment in recessional outwash (cobbles and coarse gravel), including drilling (Becker Drill) and sampling 9-in diameter boreholes and point load testing of coarse gravel, and UCS testing to evaluate rock strength and hardness.

- Preparation of the Geotechnical Baseline Report (GBR) for the East-West Drift at Yucca Mountain, NV (Constructed). Responsible for back-analyzing data collected during TBM construction of the 5-mile, 25-ft diameter main tunnel and formulating the baseline for the new, 16' 8" diameter TBM driveage. For TRW Environmental Safety Systems, Inc., Las Vegas, Nevada.

- St. Helier Stormwater Facility, Jersey (Constructed). Evaluation of geological/geotechnical conditions, back-analysis of coring, boring, and back-reaming for a 1,500-ft, 10-ft diameter horizontal raise bore tunnel. For SEL and Balfour Beatty, UK.

- Busted Butte Test Facility, NTS (Constructed). Principal engineer for the site investigation, design, and design support during construction for the portal pad, highwall, rockfall hazards mitigation, portal, and main tunnel and alcove forming the Busted Butte Test Facility on the Nevada Test Site. Excavation dimensions varied from 3m x 3m to 7m x 7m. A fast-track design for the surface facilities was completed in two weeks and the overall design and specifications were completed in six weeks. For Los Alamos National Laboratory, NTS.

- Prepare Contractor Design Submittals for tail-tunnel (liner plate) and main tunnel (ribs and steel lagging) for 10-ft dia. 3,000-ft long, soft ground tunnel in sand, gravel, and cobbles, Folsom Interceptor 2B (FE2B). For Affholder Corporation, Sacramento, CA.

- Comparison of geotechnical baseline with actual conditions for a 38-in diameter Microtunnel beneath a river and municipal airport. Preparation of the technical basis for a differing site condition claim where the Contractor encountered logs, steel straps/chains, and other debris. For Northwest Boring, Woodinville, Washington.

- Evaluation of tunneling conditions, EPB machine performance, and muck balance with regard to settlement along the West Seattle Tunnel Alignment. This involved a detailed evaluation of geotechnical conditions, a projection of the performance of the EPBM under different operating modes, and a recommendation to complete the tunnel without installing the full muck-ring and auger. For McNally Tunneling Corporation, Seattle, Washington.

- EPBM troubleshooting. Assisted with the remediation of the West Seattle EPBM when it became grout bound. Evaluated issues regarding main bearing and seal deterioration. For McNally Tunneling Corporation, Seattle, Washington.

- Evaluation of segment installation and grouting program, design of low-strength sand/cement/flyash/bentonite mixes for grouting the segmented liner on the West Seattle Tunnel. For McNally Tunneling Corporation, Seattle, Washington.

- Design of cut-and-cover structure, tunnel access and wine caves in soft ground using steel arches and reinforced shotcrete (Constructed). Project involves top heading and bench excavation in raveling ground with portal connections to a large winery and car museum. For Underground Associates, Napa, CA.

- Review and revision of Construction Drawings for the Bradshaw Interceptor project in Sacramento, CA. For Affholder Corporation, Sacramento, CA.

- Preparation of the bid estimate for use of a refurbished Howden digger-shield on the Columbia Slough project in Portland, OR. A shield used on the London, UK Jubilee line was bid to three of the six Contractors. For Howden Tunneling, Scotland.

- SR 164 Culvert Enhancement. Evaluation of site conditions for 220-ft long culvert installation using pipe-jacking. This work included a detailed review of the current standards for geotechnical data collection, reporting, and disclosure, an interpretation of site conditions based on the contract documents, an evaluation of the impact of actual conditions on pipe-jacking operations and support during claims negotiation. Northwest Boring, Inc., Woodinville, WA.

- State Route 169 Conveyor Crossing. Evaluation of site conditions and alternative methods for 100 ft long conveyor undercrossing of SR 169 south of Black Diamond, WA, including preparation of site plan, construction method descriptions, cost estimates, and preliminary permit documents. Final design of cut-and-cover undercrossing to WSDOT standards including liasing with WSDOT during design. For Cadman, Inc., Redmond, Washington.

- Plymouth (UK) CSO. Blast monitoring for an 8 ft diameter tunnel being driven at a depth of approximately 60 feet beneath the City of Plymouth, UK.

- Boston Outfall Tunnel. Part of a team responsible for evaluating Differing Site Conditions claim and TBM performance on the Boston Outfall tunnel. This work included an evaluation of site investigation data, construction records, laboratory data and consultant reports relating total hardness, UCS, BTS and dynamic rock properties to TBM performance. Client Confidential.

- Evaluation of rock conditions for mechanically mining the Thermal Test Area and preparation of data collection requirements for assessing the AM75 Roadheader performance. Preparation of a Blast Monitoring and Optimization strategy to be used in conjunction with Drill and Blast construction in the ESF. For Yucca Mountain Project, Test Coordination Office (LANL).

- Preparation of the Rapid Excavation Chapter for (1992) SME Handbook. This work provides a "hand book" approach to selecting mechanized mining systems for constructing tunnels, declines, and shafts and compares the relative merits of TBM, Roadheader, Blind Boring, Raiseboring and conventional Drill and Blast methods.

- Project manager for blast optimization studies for the San Manuel mine's block caving operations. Project involved underground blast monitoring of development, production and test blasts and re-design of the blast rounds to reduce blast damage, drilling and explosives costs. For Magma Copper Co., Arizona.

- Design evaluation, inspection, and construction supervision of ground support for the Foidel Creek mine entries. Project involved design review, specification preparation, supervision of pre-construction testing, and inspection during construction. For Getty Mining Company (Now Cyprus-Amax), Steamboat, Colorado.

- Analysis of rock mechanics data and support design for underground pump chamber, shaft access tunnels, Strawberry tunnel project. Project involved design of an active, post-tensioned rock support system as a design change during construction and presentation of the design to the US Bureau of Reclamation. For Ohbayashi-Gumi and US Bureau of Reclamation, Denver, Colorado.

- Project Manager for the design of an undersea expansion for an existing quarry to determine the project feasibility. This work included; preparation of a site investigation/exploration plan to definitize offshore and on-shore reserves; design, using existing rock quality data, of the underground layout; estimation of the underground mining costs.

- Assess support requirements, evaluate/analyze lining design, supply shotcrete equipment, train mining crews and supervise installation of support for undersea coal mine entry, Donkin Morien project. For Beaver Underground Structures, Cape Breton, Nova Scotia.

- Assess support requirements, evaluate/analyze lining design, train engineers, inspectors, and labor force in support design, support installation and quality control for shotcrete placed as final support in a 2,600 ft coal mine decline. For Long Drain Slope project, Consolidation Coal Company/Frontier Kemper, Fairmont, WVa.

- Evaluation of rock mechanics problems associated with portal development at an oil shale mine. Installation of equipment and personnel training for support of a portal and mine entries using shotcrete. For Jasper Construction/Union Oil Shale Company, Parachute, Colorado.

- Assess support requirements, analyze/evaluate support design, train engineers and labor force and install shotcrete for temporary support of shafts and underground laboratories, University of Minnesota, Minneapolis, Minnesota. For Glenn Rehbein Excavating.

- Training of engineers, inspectors and labor force with respect to shotcrete technology. Installation of shotcrete in connecting station for production shafts. Installation of support stabilization and control of water in V/E shaft stations. For Occidental Petroleum's C-b Oil Shale mine, Rifle Colorado.

- Design and installation of shotcrete system for temporary support of eight shafts ranging from 28 to 38 ft in diameter. Training of mining crews, quality control, optimization of pneumatic transport system. For Kiewitt/Shea/Kenny J.V., Chicago Water Treatment Facility, Chicago, Illinois.

- Design of shotcrete support for mine entry and draw point stabilization. For CIA Minera Las Cuevas, San Luis Potosi, Mexico.
- Design of ground support system involving shotcrete for in situ recovery of heavy crude. For Fenix and Scisson/Getty Mining, Bakersfield, California.
- Design of transition points and final lining for the second street tunnel. Design and installation of temporary ground support in tunnel in St. Peter sandstone. For S.J. Groves and Sons, Minneapolis, Minnesota.
- Cost estimate for 3 tunnel locations considered as alternates to bridge construction for the American river crossing, Sacramento, CA.
- Review of construction contractor bid submittals for the Ohio DOT Steubenville tunnel.
- Guidance to FHWA regarding two stage contractor procurement (pre-qualification/bid and award), developed shotcrete specifications for the Cumberland Gap highway tunnels.
- Project Manager, Wolf Creek Collieries Caney Branch shaft site investigation. Managed and provided technical direction for shaft site investigation and preparation of geotechnical report for two coal mine shafts. Liaison with client and construction manager on geotechnical issues related to shaft design and construction.
- Remote lining of shaft using prototype shotcrete equipment developed under DOE/USBM contract; one of three person team responsible for equipment development and on-site demonstration. This project involved lining the foreshaft for a nuclear weapon test shaft at the Nevada Test Site using a remotely controlled prototype shaft lining system. An approximately 12 inch thick shotcrete lining was applied to a nominal 14 ft diameter, 140 feet deep augered shaft. Production time, excluding system delays associated with adjustments to the prototype equipment, was 28 hours. For Reynolds Electric and Engineering Company, Nevada Test Site, Nevada.
- Yucca Mountain Project, Nevada (Ongoing). Participant in; team review of final designs for the ESF portal and starter tunnel; site characterization to evaluate mining and ground support requirements; and geologic mapping and geotechnical data collection during drill & blast and tunnel boring operations.
- Technical review of M&O originated ESF design packages; rock mass monitoring data; geologic mapping data; tunnel stability and rock support analyses; etc. Provide technical input to geotechnical data collection requirements and geotechnical data as-building.
- Keystone Gold Project. Responsible for preparing the blasting and subsidence baseline studies for input to the permit for a new underground gold mine. For Terramatrix/ACZ and Energy Fuels, Denver, Colorado.
- Primary author of an underground low-level radioactive waste repository design procedure for the UK low-level waste repository at Sellafield, Cumbria, England. Report documents current European practice and presents design criteria, design alternatives, and flowcharted design procedures for individual repository components (waste form, waste package, backfill, disposal rooms, access tunnels, shafts and declines).

- Project Manager for the conceptual design for a 200 acre underground low-level radioactive waste repository for the state of New York. To date this project has involved development of design criteria for surface and underground structures; compilation of design data; conceptual design for 5 candidate sites; modeling groundwater flow to the facility; evaluation of long term stability and longevity of construction materials; industrial safety and dose rate analysis; and preparation of a detailed cost estimate.

- Design and evaluation of alternative sites and construction methods for the Wesleyville Cavern LLW Disposal project access shafts, Ontario. Responsible for development of criteria, conceptual designs for the possible construction alternatives (including freezing and conventional and blind boring construction methods), schedule and cost estimates.

- Evaluation of alternative shaft sinking techniques for NNWSI (Nevada HLW Repository program) exploratory shaft facility. Involved detailed analysis of the schedule and cost impacts of alternative test and construction methods (conventional, raisebore, V-mole); data quality and safety.

ADDITIONAL EXPERIENCE IN SHOTCRETE AND CONCRETE TECHNOLOGY:

As a voting member of ACI 506, Chris Breeds is responsible for coordinating and assembling the first Underground Shotcrete Guide Specification. He has been involved in numerous projects involving concrete and shotcrete. Each of the projects referenced below included: (1) preparation of specifications; (2) design and implementation of the quality control program; (3) selection of materials; (4) mix design; (5) equipment calibration; (6) training of shotcrete crews; and (7) operation of equipment used to produce and place concrete or shotcrete. He has liaised with numerous other projects and owners in an advisory capacity concerning the above topics (e.g., Los Alamos National Lab; US Bureau of Reclamation) and has been involved in the development and testing of concrete/shotcrete additives.

- Design/Evaluation/Inspection of shotcrete/rock bolt ground support system for Foidel Creek Mine entries, Getty Mining, steamboat, Colorado. Included items (1) through (5) inclusive.
- Shotcrete placed remotely to support a blind drilled shaft at the Nevada Test site for Reynolds Electric and Engineering Company, Las Vegas, Nevada. Included items (1) through (7) inclusive.
- Shotcrete for coal mine entry support, International Anthracite Corporation, Pennsylvania. Included (2), (4), (5), and (6).
- Shotcrete for undersea decline support, Donkin Morien Project, Cape Breton Island, Nova Scotia. Included items (1) through (7) inclusive.
- Shotcrete for permanent support of 2,600 feet coal mine decline, Long Drain Slope project, Consol/Frontier Kemper, Fairmont, W. VA. Included items (2) through (6).
- Construction Manager, Twin inverted 60 ft diameter, Shotcrete cones, Atlantic Cement. Responsible for on site construction supervision, quality control, and liaison with owner, contractor, and project management personnel. Included items (1) through (7) inclusive.
- Design, fabrication, demonstration and in mine operation of a dual purpose, mobile shotcrete and concrete batch plant. For Anaconda Minerals Company, Carr Fork Mine, Toele, Utah. Included items (2) through (5) inclusive.
- Support of portal and mine entries for oil shale development, Union Oil Shale, Parachute, Colorado. Included items (1) through (6) inclusive.
- Shotcrete for temporary support of eight shafts ranging from 28 to 38 feet in diameter, Chicago Water Treatment facility, Chicago, Illinois. Included items (1) through (6) inclusive.
- Permanent of shaft stations using shotcrete, C-b Oil Shale project, Occidental Oil Shale, Rifle, Colorado. Included items (1) through (7) inclusive.
- Shaft sinking and development of underground laboratories using shotcrete for temporary and permanent support, University of Minneapolis, Minnesota. Included items (1) through (7) inclusive.
- Shotcrete for temporary support of transitions and tunnel sections in St. peter sandstone, second Street Tunnel, Minneapolis, Minnesota. Include items (2) through (7).

- Evaluation of construction methods and materials used for Olympic Oval, Lake Placid, NY. Preparation of arbitration report concerning reasons for failure, quantitative assessment of future stability and evaluations of recommended repair. Supervised repair of Oval prior to 1980 Olympic games.

- Supervised repair of Olympic Luge Run, Lake Placid, NY. Evaluated original construction method, quality control procedures and materials used during construction of the Luge. Prepared a report concerning reasons for surface spalling, assessments of future stability, recommended and supervised repair.

EXPERIENCE IN BLAST DESIGN, BLASTING, BLAST MONITORING and CONSTRUCTION VIBRATIONS PREDICTION AND MONITORING

Dr. Breeds has over 25-years experience in surface and subsurface blasting for civil construction and mining. His experience includes teaching blast engineering at university level, designing underground and surface blast rounds, preparing blasting input to EIS and SEPA applications, pre-blast property inspections and surveys, blast monitoring, blast optimization, and developing blasting regulations for implementation at the State level. The following paragraphs illustrate Dr. Breed's explicit project experience.

Related Resume Sections

Subsurface Design

Instrumentation and Data Acquisition

Geotechnical Engineering and Rock Mechanics

Underground Blasting Projects

- Castille Falls Fish Passage Tunnel: Supervision and data reporting for SubTerra personnel monitoring of blasting to enlarge a Fish Passage tunnel at Castille Falls. BIC: Jerry Wallace, Wallace Technical Blasting. For Apollo, Inc.
- Cannon Mine, Wenatchee. Blast monitoring and optimization for a cut and fill stoping operation using cemented backfill. Involved monitoring both underground and at the surface with post-blast evaluation of firing sequence, explosives types, drill hole layout, blast damage, and impacts to stope wall and pillar stability.
- Yucca Mountain near-field blast monitoring program. Responsible for the design of a near-field blast monitoring system designed to quantify criteria for minimizing rock damage at the periphery of the excavation. Accelerometers and geophones were located 3-ft and 10-ft from the final profile and monitored using standard Blast Monitors. For LANL.
- Project manager for blast optimization studies for the San Manuel mine's block caving operations. Project involved underground blast monitoring of development, production and test blasts and re-design of the blast rounds to reduce blast damage, drilling and explosives costs. For Magma Copper Co., Arizona.
- Plymouth (UK) CSO. Blast monitoring for an 8 ft diameter tunnel being driven at a depth of approximately 60 feet beneath the City of Plymouth, UK.
- Preparation of a Blast Monitoring and Optimization strategy to be used in conjunction with Drill and Blast construction in the ESF. Involved establishing criteria for monitoring compliance and blast monitoring strategy to limit rockwall damage during subsurface construction. A combination of near- and far-field monitoring was implemented. For Yucca Mountain Project, Test Coordination Office (LANL).
- Blast monitoring and optimization for a cut and fill stoping operation using cemented backfill. Involved monitoring both underground and at the surface with post-blast evaluation of firing sequence, explosives types, drill hole layout, blast damage, and impacts to stope wall and pillar stability. This project was one of the first to utilize near-field, high frequency blast monitoring for optimizing blasting practices.
- Responsible for teaching Underground and Surface Blast Engineering while an Assistant Professor in the Mining Department at Virginia Polytechnic Institute and State University.

- Member of a Technical Board assembled by the Department of Labor and Industries to review and revamp WAC 296-52, the Washington Explosives Code.

Ongoing Projects (June , 2004)

- Hansen Dam: Selected to perform pre-blast surveys and monitoring during blasting for the Fish Passage and Cofferdam Excavation. For Traylor Pacific.
- Snoqualmie River Channel Widening at Snoqualmie Falls: Selected to perform pre-blast surveys and monitoring during blasting for this channel-widening project. For Goodfellow Brothers.
- Hazelwood Elementary: Responsible for review of planned blast work and blasting specifications and for blast monitoring and reporting during construction.
- South Fork Bridge, North Bend, WA: Responsible for evaluating vibrations from an Oscillating Pile Driver that was used to construct new bridge piers adjacent to the Snoqualmie River. For Malcolm Drilling.
- Tacoma Narrows Bridge: Responsible for evaluating vibrations from an Oscillating Pile Driver that was used to construct new bridge piers at the abutment of the Tacoma Narrows Bridge.
- Snoqualmie Quarry. Responsible for preparing Blasting input to a SEPA document to allow quarry blasting at this existing aggregate pit near Snoqualmie, Washington. Follow on work includes weekly monitoring, compliance documentation, and remote blast vibration and noise monitoring. For Glacier Northwest, Inc.
- Member of a Technical Board assembled by the Department of Labor and Industries to review and revamp WAC 296-52, the Washington Explosives Code.

Completed Projects (June 2004)

- Issaquah Elementary No. 13: Responsible for conducting pre-blast survey of residencies and for blast monitoring in proximity to the blast area located within the City of Newcastle. For Issaquah School District.
- Preston Bridge, Preston, WA: Responsible for monitoring vibrations from an Oscillating Pile Driver that was used to construct new bridge piers adjacent to the Raging River and preparing a report documenting vibration effects associated with this method of construction. For Malcolm Drilling.
- Responsible for designing and setting up a blast vibration and dynamic pore pressure measurement system for monitoring adjacent to blasting a cut-off trench below a FERC regulated earthfill dam. Dynamic pore pressure measurements are made in boreholes using 3/8-in diameter ICP-38, PCB sensors coupled to conventional Blast Monitoring Equipment. For the Benham Group, Oklahoma.
- University of Washington Fieldhouse: Responsible for advising on and monitoring vibrations from pile driving at this construction site adjacent to the University Football stadium (piles within 10-ft of stadium foundation). Involved test pile monitoring, recommendations for full scale construction and monitoring during construction. For Baugh Construction and Agra Foundations.

- SR 18 Slide Repairs: Responsible for establishing construction sequencing criteria based on vibrations form driven test piles, monitoring during construction, and final reporting of compliance with design criteria to owner. For Condon Johnson, Inc.
- Heritage Court Utility Trench/Vault Construction. Responsible for pre-blast property inspections, blast monitoring, blasting evaluation and reporting for blasting within 50-ft of $250,000 –to- $1,000,000 residential structures. Developed safe blasting criteria from monitoring data. For McCallum Rock Drilling and First Wellington Corporation.
- Interstate Rock, Washougal Quarry EIS. Responsible for oversight and final review of blast related EIS submittal for this large block quarry site.
- Cardai Hill Quarry. Responsible for preparing Blasting input to the EIS, including analyzing potential impacts on an adjacent gas pipeline, for this new rock quarry near Woodland, Washington. For Land Technologies Corporation.
- Goodwin Quarry: Responsible for developing the blasting input to the EIS and SEPA documentation for the Goodwin Quarry that will be constructed near an existing natural gas pipeline in Whatcom County. Designed and implemented a Test Blast as part of the EIS process that incorporated dynamic pore pressure measurements adjacent to the blast and at locations in the adjacent ancient landslide area. For Land Technologies and Trillium Corporation.
- Mats Mats Quarry. Responsible for analyzing two-years of blasting data, blast monitoring, blasting impact evaluation, presentation at public hearings, developing recommendations for flyrock prevention at this tidewater, rock quarry located near Port Ludlow, Washington on the Olympic Peninsula. For Lonestar Northwest, Inc.
- Stoneway, Black River Quarry. Provided expert testimony at public hearing of the first periodic review conducted by King County (the periodic review is a review of a quarry's compliance with SEPA and is held every five-years). Prepared reports covering blasting and air quality that were required by the Hearing Examiner. Responsible for third party monitoring of each blast at the site. For Stoneway Corporation.
- CADMAN, High Rock Quarry. Review and analyses blasting data and records from 1998 to 2000 against criteria provided by SubTerra in the 1996 EIS.
- Good Quarry. Responsible for reviewing blast monitoring data, preparing an evaluation of blasting practices and potential blasting impacts at this rock quarry near Napavine, Washington. For Good Construction Company.
- Good Quarry. Expert testimony at public hearing on SEPA appeal for the 30-acre Good Quarry. Hearing Examiner upheld the County's original SEPA decision and denied the appeal.
- Yucca Mountain near-field blast monitoring program. Responsible for the design of a near-field blast monitoring system designed to quantify criteria for minimizing rock damage at the periphery of the excavation. Accelerometers and geophones were located 3-ft and 10-ft from the final profile and monitored using standard Blast Monitors.
- Project manager for blast optimization studies for the San Manuel mine's block caving operations. Project involved underground blast monitoring of development, production and test blasts and re-design of the blast rounds to reduce blast damage, drilling and explosives costs. For Magma Copper Co., Arizona.

- Plymouth (UK) CSO. Blast monitoring for an 8 ft diameter tunnel being driven at a depth of approximately 60 feet beneath the City of Plymouth, UK.
- Superior Quarry. Responsible for monitoring large production blasts involving 80,000 lbs of explosives at this quarry located approximately 500-ft north of SR410, near Enumclaw. For Ashgrove Cement Company.
- Scatter Creek Quarry. Responsible for input to the mining plan and monitoring test blast and production blasts at this new silica quarry located east of Enumclaw, Washington. Involved in evaluating alternative crushing systems for 1/4-in minus silica rock production. For James Hardie Building Products, Inc.
- Duvall Quarry. Responsible for developing blasting criteria and blasting input to the SEPA documentation for this 80-acre quarry site located north of Duvall in King County, Washington. For Seattle General Corporation and Land Technologies, Inc.
- Lummi Island Quarry. Responsible for evaluating slope stability at this tidewater rock quarry located on Lummi Island, Washington. For Ace Rock Quarry, Inc.
- Littlerock Gravel Pit. Responsible for evaluating current permit issues prior to site purchase and subsequent SEPA permitting of a 150-acre pit expansion. For Quality Rock Company.
- High Rock Quarry DEIS/FEIS. Responsible for preparing blasting input to the EIS and FEIS (including responses to public questions) and attendance at public meetings for this large rock quarry near Monroe, Washington. For Cadman, Inc.
- High Rock Quarry Blast Engineering. Responsible for evaluating blasting practices and analyzing 3-years of daily blast production and monitoring data at this large rock quarry. Monitoring was carried out at the site boundary and at proximate residencies and used to develop a site law relating peak particle velocity to maximum charge weight per delay and distance. This law was incorporated into overall blasting recommendations for the project. For Cadman, Inc.
- Victor Industrial Minerals Oro Grande Quarry. Project involved an evaluation of the ore reserves and mining methods at the Oro Grande Silica quarry near Victorville, CA. Included an evaluation of impact crushing and vertical shaft impactor crushing of relatively wet materials to ¼-in minus. For James Hardie Building Products, Inc.
- Property Evaluation. Responsible for financial evaluation of a land parcel adjoining an aggregate mine near Cle Elum, Washington. For Plum Creek Timber Company
- Middlefork Prospect. Responsible for developing the mine plan, feasibility, cost estimate, and present value of 250-acre aggregate pit near Snoqualmie, Washington. For Weyerhaeuser Corporation.
- Black Diamond Aggregate Mine: Evaluation of site conditions and alternative methods for 100 ft long conveyor undercrossing of SR 169 south of Black Diamond, WA. Included preparation of site plan, construction method descriptions, cost estimates, and permit documents. For Cadman, Inc.
- Black River Quarry. Responsible for monitoring, evaluating, and reporting blasting at Stoneway, Inc.'s Black River Quarry in Renton. Blasting occurs within 400-ft of nearby apartments. Monitoring is carried out at the site fence and at the proximate structure. Provided expert blast and slope stability testimony at public hearings. For Stoneway Corporation.

- Preparation of feasibility study for taking operations at the San Rafael Quarry in San Francisco bay underground. The existing quarry was to be deepened and breached to provide a deep-water marina. Quarrying of the meta-sandstone would continue underground and the product would continue to be loaded to barges in the bay. For Dutra Corporation.
- Preparation of a Blast Monitoring and Optimization strategy to be used in conjunction with Drill and Blast construction in the ESF. Involved establishing criteria for monitoring compliance and blast monitoring strategy to limit rockwall damage during subsurface construction. A combination of near- and far-field monitoring was implemented. For Yucca Mountain Project, Test Coordination Office (LANL).
- Responsible for teaching Blast Engineering while an Assistant Professor in the Mining Department at Virginia Polytechnic Institute and State University.
- Lake Francis I Quarry. Responsible for permitting an initial 3-year mining phase at this existing 89-acre site. A Phase II expansion is in process and will be permitted under SEPA.
- 5-Mile Andesite Quarry. Responsible for evaluating feasibility for large andesite rock production from a new quarry located between Duvall and Monroe in Snohomish County, Washington. Project Manager for preparation of the SEPA and MC Zoning documentation and final designs for the quarry. For 5-Mile Quarry Company, Monroe, Washington.

PARTIAL LIST of PUBLICATIONS

- Breeds, C.D., Gonzalez, and Molvik, D., 2003. South Interceptor Tunnel Construction Using a Lovat EPBM, Proceedings, Rapid Excavation Tunneling Conference, New Orleans, LA, June, 2003.
- Breeds, C.D., Gonzalez, D., and Molvik, D., 2003. Tolt Pipeline Crossing of the Snoqualmie River, Proceedings, Rapid Excavation Tunneling Conference, New Orleans, LA, June, 2003.
- Breeds, C.D., 2003. Modern Advances in Tunneling Technology. Paper presented at the Annual TRB Conference, Washington, DC, January, 2003.
- Breeds, C.D., Johnston, K., and Fulton, O., 2003. Quarry Blast Permitting in the Urban Environment. Paper presented at the Annual ISEE Conference, Nashville, TN, Feb 2-5, 2003.
- Breeds, C.D., and Mills, R.M. Rockfall Hazard Risk Analysis and Mitigation in an Area of Coal Mine Subsidence. Proc. Pacific Rocks 2000, Seattle, WA
- Girard, Liebman, Breeds, and Doe. Editors: Pacific Rocks. Rock Around the Rim. Proceedings of the 2000 American Rock Mechanics Conference, Seattle, WA.
- Mills. R., Breeds, C.D., Archibeque, S., and Dowling, G. Subsidence Experience at Twentymile Coal Company. Paper presented at American Rock Mechanics Conference, Vail Colorado, June, 1999.
- Breeds, C.D. Developing TBM Performance Prediction Methodology for the Yucca Mountain Project. Paper presented at ASCE Annual Convention, GEO-CONGRESS 98, October 18-21, 1998.
- Dollinger, G.L., Handewith, H.J, and Breeds, C.D. Use of the Punch Test for Estimating TBM Performance. Paper presented at TAC 98, Vancouver, BC.
- Breeds, C.D., Mills, R. and Conway, J.J. Mine Subsidence and Rockfall Hazards: A Case Study from Northwest Colorado, Paper to be presented at the Annual AEG Conference, Portland, OR.
- Webb, R. and Breeds, C. D. Soft Ground EPBM Tunneling - The West Seattle, Alki Tunnel. Proceedings Tunneling 97, London, UK.
- Mayo, P.J., Breeds, C.D., and Goodale, B.G. Drift Mine Disposal of Low-Level and Greater Than Class C Radioactive Waste. Proceedings Waste Management .97, Tucson, Arizona.
- Breeds, C.D., et al., 1996. "Predicting Settlement for EPBM Driven Soft Ground Tunnels Using Probabilistic Methods." Keynote Paper, Conference on Tunnels and Deep Excavations, Jakarta, Indonesia, April, 1996.
- Sutherland, A, Goodale, B., and Breeds, C.D. "A detailed Comparative Evaluation of Six Low Level Radioactive Waste Disposal Methods". Paper presented at Waste Management, 96, Tucson, Arizona, 1996.

- Breeds, C.D., "Landfill Subsidence." Presented at the Colorado Environmental Health Association Annual Conference, Estes Park, Colorado, September, 1995.
- D. Baird, N. Chau, and Breeds, C.D., "Cost Estimates and Economic Evaluations for Conceptual LLRW Disposal Facility Designs." Presented at the 17th Annual DOE LLW Conference, Phoenix, Arizona, December, 1995.
- Breeds, C.D., "Developing the Mined Option for the New York Low Level Radioactive Waste Siting Commission." Presented at the 1995 Institute of Shaft Drilling Technology Annual Conference, Flamingo Hilton, Las Vegas, Nevada, April 25, 1995.
- Breeds C.D., and Talbot R.T., "Disposal of Low-Level Radioactive Waste in Underground Repositories". Paper presented at the North American Tunneling Conference, Boston, MA. October, 1992.
- Breeds C.D. and Schreiber S., "Evaluation of Potential Effects of Abandoned Coal Mines on Landfill Design and Construction". Paper to be presented at the 1992 Pacific Northwest Mining and Metals Conference, Bellevue, WA. April, 1992.
- Breeds C.D., Conway, J.J., "Rapid Excavation", SME Mining Engineers Handbook, 2nd edition, American Institution of Mining Engineers. Publication scheduled 1992.
- Conway, J.J., Breeds C.D., and Hammett, R.D., "Optimization of Underground Blasting". Intermountain Mining Symposium, Northwest Mining Association, Elko, Nevada. October, 1989.
- Breeds, C.D., Valencia, F.E., and Pye J.H. Final Report on Remote Shotcrete Lining System, prepared for the US Bureau of Mines, Carbondale, Illinois.
- Pye, J.H., and Breeds, C.D. Ground Support of Decline using Shotcrete, prepared for Donkin Morien project, 1982.
- Breeds, C.D., Valencia, F.E., and Pye J.H. The F.A.S.T. First Automatic Shotcrete Technique. Proc. Rapid Excavation and Tunneling Conference, San Francisco, CA, May 1981.
- Karmis, M. Haycocks, C., Breeds. C.D., and Topuz, E. Design of Coal Pillars from Drill Core Data. Proc. Coal Conference and Exposition V, Louisville, KY, 1979.
- Karmis, M., Haycocks, C., Breeds, C., and Lele, M. A study of Underground Convergence on Longwall Panels by In-Situ Measurements and Computer Simulation Techniques.
- Breeds, C.D. Subsidence, Prevention or Control. Proc. 1st Conference on Ground Control Problems in the Illinois Coal Basin, Carbondale, Illinois. Published by Illinois State University Mining Department, August, 1979.
- Haycocks, C., and Breeds, C.D. Ground Control Simulation over Longwall Workings", Annual APCOM Conference, Tucson, Arizona, September, 1979
- Breeds, C.D. and Haycocks, C. "Strata Control Simulation over Longwall Workings". Annual AIME Conference, New Orleans, LA, February, 1979.

- Breeds, C.D. and B.N. Whittaker. "A Critical Analysis of Contemporary Methods of Controlling Mine Subsidence Damage", 6th International School of Rock Mechanics, Kracow, Poland, February, 1979.
- Whittaker, B.N., and Breeds, C.D. "The Influence of Surface Geology on the Character of Mining Subsidence", Proc. Association Geotechnica Itiliana, Capri, Italy, 1977.