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WASHINGTON GEOLOGIC NEWSLETTER

Entry to the Newcastle mine near Bellevue. This mine was the leading producer of coal in Washington from approximately 1870 to 1900.

STATE OF WASHINGTON
BRIAN J. BOYLE
COMMISSIONER OF PUBLIC LANDS

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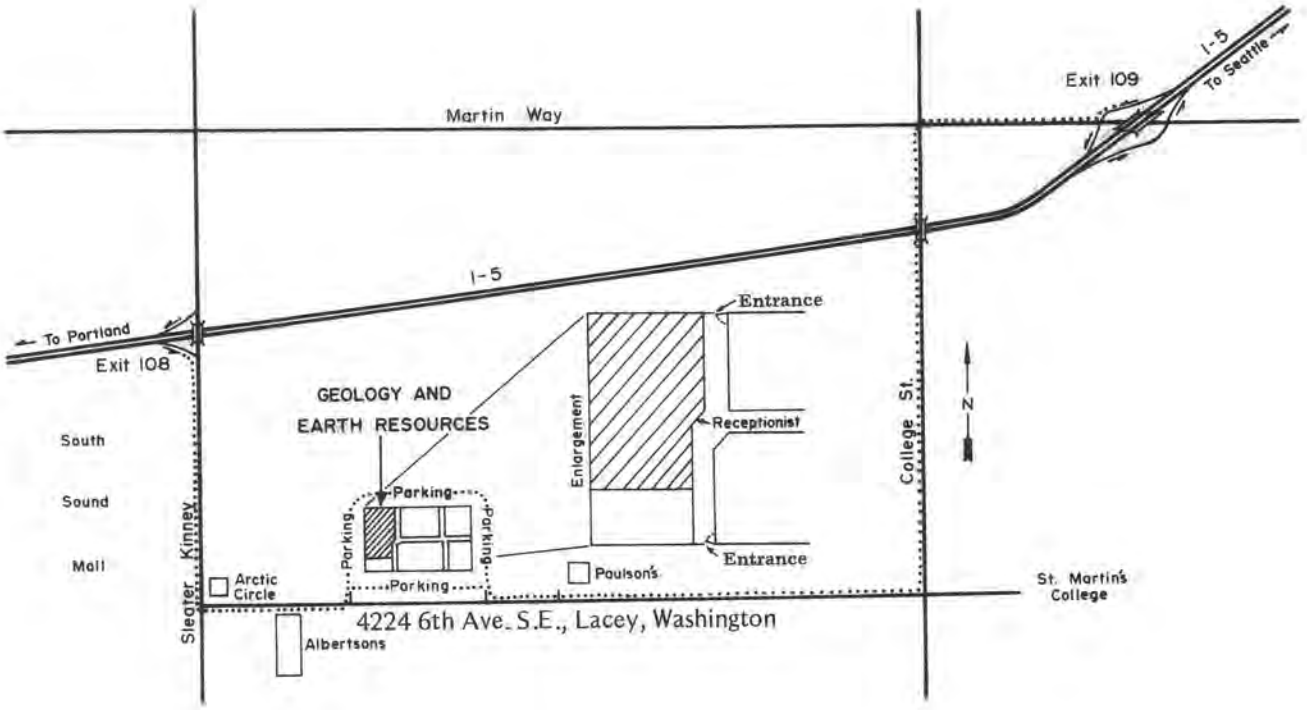
DEPARTMENT OF NATURAL RESOURCES

RAYMOND LASMANIS, State Geologist
DIVISION OF GEOLOGY AND EARTH RESOURCES



MAILING ADDRESS:

Department of Natural Resources
Division of Geology and Earth Resources
Olympia, WA 98504
(206) 459-6372

Field office address:

Department of Natural Resources
Division of Geology and Earth Resources
Spokane County Agricultural Center
N. 222 Havana
Spokane, WA 99202
(509) 456-3255

Laura Bray, Editor

The Washington Geologic Newsletter, a quarterly report of geologic articles, is published by the Division of Geology and Earth Resources, Department of Natural Resources. The newsletter is free upon request.

The division also publishes bulletins, information circulars, and geologic maps. A list of these publications will be sent upon request.

ABANDONED COAL MINE INVENTORY

by

Timothy J. Walsh and Frank V. La Salata *

Taylor coal mine in King County. Geologists in the foreground are inspecting the shaft which was the main entry.

In 1977, Congress passed the Surface Mining Control and Reclamation Act (SMCRA) to ameliorate adverse effects of past coal mining and to regulate subsequent coal mining. SMCRA provided for a tax on current coal mines at a rate of 35 cents/ton for surface mines, 15 cents/ton for underground mines (or 10 percent of the value at the mine), and 10 cents/ton for lignite mines (or 2 percent of the value at the mine). The revenue from this tax is deposited in the Abandoned Mine Reclamation Fund. SMCRA also created the Office of Surface Mining (OSM) to administer the provisions of the act. OSM oversees state regulatory agencies which administer the act, or as in the case of Washington, directly regulates the coal mining industry of a state. In addition, OSM performs reclamation and provides technical assistance to state reclamation agencies. Washington has no reclamation agency, so reclamation here is performed directly by OSM. The Abandoned Mine Reclamation Fund provides revenue for these functions, and also provides for direct payments to state regulatory and reclamation agencies. The act provided that at least 50 percent of the proceeds should be used for these purposes in the state of origin when there is sufficient need for reclamation. As of the end of fiscal year 1983, more than $9 million had been collected from the Washington Irrigation and Development Company (WIDCO), and Palmer Coking Coal Company, operators of Washington's two active mines.

To determine the reclamation needs of the states, OSM contracted for a national inventory of abandoned mines. The inventory for the State of Washington identified 10 problem areas, four of which are in the vicinity of Roslyn and Cle Elum in central Washington. The other

* Division of Geology and Earth Resources Geologists.

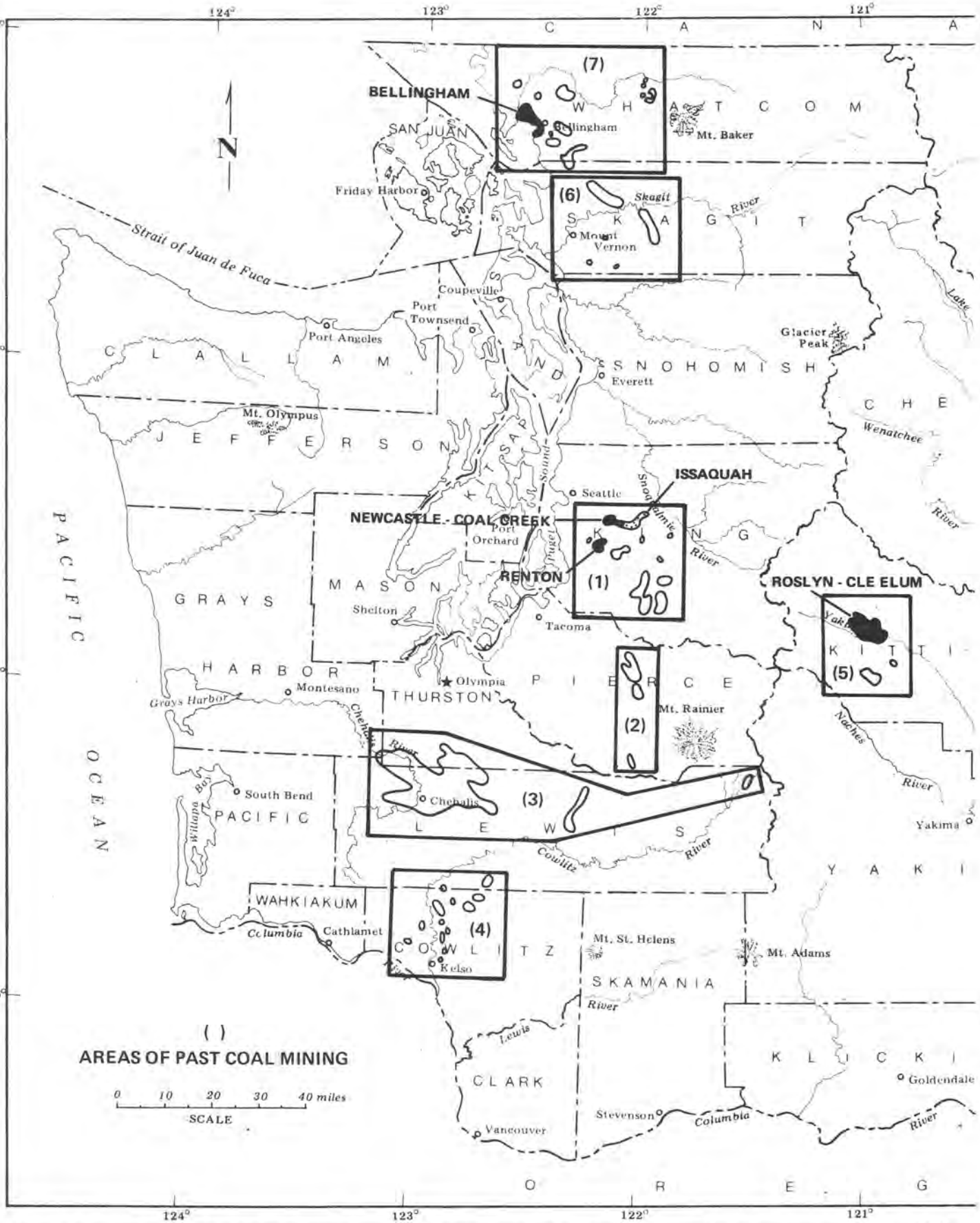


Figure 1. — Study areas for abandoned coal mine inventory in western and central Washington (from Beikman and others, 1961).

six problem areas were located near Centralia (two areas), Bellingham, Black Diamond, Newcastle, and Wilkeson.

By the end of fiscal year 1983, OSM had undertaken 11 emergency reclamation projects in Washington, only one of which was in an area included on the national inventory (these emergency projects cost OSM less than $150,000). Reference to figure 1 shows that the inventory was inadequate for dealing with the potential mine problems because the extent of coal mining in western and central Washington far exceeded that recognized in the inventory. One result of the sparseness of the inventory was that OSM transferred more than $3 million from Washington's 50 percent share of the coal production tax to other parts of the country, citing insufficient reclamation needs for the funds here.

In January of 1984 a cooperative agreement was signed between the Department of Natural Resources, Division of Geology and Earth Resources (DGER), and OSM. This agreement was the culmination of efforts by the Department of Natural Resources to rectify the inadequacies of the original inventory. The agreement called for the State of Washington to conduct an inventory of all abandoned coal mine lands within the state, and provide OSM with a final report along with site-specific descriptions and maps of the areas investigated. The final report will summarize the results of the inventory, by county, quadrangle, and severity of hazard.

Seven broad regions of interest, based on past coal mining activities, were defined for the study. These were (1) King County (Black Diamond, Issaquah, Renton, and the Green River coal mining area), (2) Pierce County (Wilkeson, Carbonado, Fairfax, and Ashford), (3) Lewis County (Centralia, Chehalis, Toledo, Morton, and Packwood), (4) Cowlitz County (Kelso and Castle Rock), (5) Kittitas County (Roslyn, Cle Elum, and Manastash), (6) Skagit County (Hamilton and Cokedale), and (7) Whatcom County (Bellingham, Glen Echo, Van Zandt, Blue Canyon, and Glacier) (fig. 1). An average of 3 weeks was allotted for each of these broad study areas.

The study had three objectives: First, to inventory abandoned-coal-mine-related problems affecting the health, safety, and general welfare of the public at large. Second, to categorize these problems by severity, accessibility, and proximity to population. Finally, to recommend to OSM the priority in which these problems should be corrected (based on their detriment to the general public). To date DGER has identified 76 problem areas, with 6 weeks remaining for the study.

In addition, five areas within the seven broad regions were targeted for more detailed inventories. These areas were Roslyn-Cle Elum, Issaquah, Newcastle-Coal Creek, Renton, and Bellingham. Each of these areas was selected because of the intensity of previous coal mining activities, the lack of detailed descriptions of the problems as they currently exist, and the presence of extensive residential or recreational development. Each of these areas was selected by OSM in conjunction with DGER. The Office of Surface Mining (OSM) awarded contracts to consulting companies for the detailed inventories.

These contracted inventories proceed from office compilation of mine map data held by the Division of Geology and Earth Resources (Schasse and others, 1983) and all available historical data, to field location of hazardous mines, followed by surveying and title searches of properties requiring reclamation. If necessary, drilling may be done to verify the existence of underground workings as shown on mine maps or to probe for mine voids in areas lacking mine maps. Finally the contractors will make recommendations for reclamation and will rank the severity of problem areas in consultation with OSM.

The contractors retained by OSM are listed below:

(1) Roslyn-Cle Elum: George Maddox and Associates, Spokane, Washington. OSM budgeted $75,000 in fiscal year 1983 for the Roslyn area inventory (fig. 1) which is nearly completed. At least 26 mines were operated in this area (Schasse and others, 1983), and more than 80 mine openings and subsidence areas have been located; 12 have been targeted for reclamation, and OSM anticipates design and construction expenditures of approximately $150,000.

(2) Issaquah: Goodson and Associates, Denver, Colorado. OSM has budgeted $75,000 for the Issaquah area inventory which consists of lands east of state highway 900 and south of interstate highway 90. At least five mines have been operated in this area. Field work to date has shown that most of the surface expressions of mine openings and subsidence have been modified by urban development. Investigations are continuing.

(3) Newcastle-Coal Creek: Skelly and Loy, Lexington, Kentucky. Field investigations have not yet begun in the Newcastle-Coal Creek area but at least 19 mines have been operated in the area (Walsh, 1983) and extensive areas are still known to be open. OSM reclaimed entries to the old Newcastle mine in 1983.

(4) Renton: Morrison-Knudsen, Boise, Idaho. At least 18 mines have been operated in Renton (Livingston, 1971). Investigations to date have uncovered at least three areas of probable mine subsidence. OSM has already reclaimed one area of subsidence in Renton as an emergency problem. Field investigations are continuing as of this writing.

(5) Bellingham: Tetra Tech, Englewood, Colorado. Two large mines and several smaller ones have been operated in Bellingham. Subsidence is known to have occurred

and one entry is reported to be at least partially open. Field investigations have just begun and are expected to be completed soon.

When completed, DGER will combine the information produced by contractors with our own data and produce an overall inventory that we estimate will include virtually all of the potential abandoned-mine-land-problem areas in the state. Reclamation priorities will be recommended to OSM and the report will be made available to the public as a DGER open-file-report. An appendix containing 2 inch by 2 inch photographic color slides of all the sites inventoried by DGER will be on file in the DGER library. The target date for completion of the report is October 1984. While we intend this report to be used principally for establishing reclamation needs and priorities, it is also expected to be used for planning in the affected communities. It may be useful for historical purposes as well.

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Livingston, V. E., Jr., 1971, Geology and mineral resources of King County, Washington: Washington Division of Mines and Geology Bulletin 63, 200 p.

Schasse, H. W.; Koler, M. L.; Herman, N. E., 1983, Directory and user's guide to the Washington State coal mine map collection: Washington Division of Geology and Earth Resources Open-File Report 83-8, 110 p.

Walsh, T. J., 1983, Map of coal mine workings in part of King County, Washington: Washington Division of Geology and Earth Resources Open-File Report 83-17, 1 map, 4 p.

Partial Seam CRIP* Underground Coal Gasification Field Test at Centralia Coal Mine

by

Henry W. Schasse **

A partial seam CRIP Underground Coal Gasification (UCG) field experiment was carried out at the Washington Irrigation and Development Company (WIDCO) coal mine near Centralia, Washington, in the fall of 1983. The test was performed near the earlier large block tests which were conducted during the early part of 1982 (Hill and Thorsness, 1982). The primary goals of the partial seam experiment were to test the CRIP concept and to further evaluate the test site for its potential for future development of UCG.

The process of underground (in-situ) coal gasification is a fairly simple concept. Two wells drilled into a coal seam some distance apart are connected by constructing a flow channel through the coal. The coal at the bottom of one of the wells is ignited and air or oxygen is pumped down this well from the surface to support the combustion. The gases produced by the burning coal escape through the flow channel and are removed through the other well. In a commercial-size system, many such well pairs would act simultaneously.

In practice, the process is complicated because as the burn proceeds the reacting volume is constantly changing geometry. In the early stages of the burn, the cavity is empty and totally within the coal. Later, roof collapse partially fills the cavity with rubble, which changes the flow patterns and the subsequent burn geometry.

The CRIP system is designed to keep the injection point on the bottom of the coal seam and to move it away from the collapse zone into fresh, solid coal. The principle of controlled retraction allows the operator to choose the optimum time and distance to move the injection point and consequently the burn zone to get optimum performance from the gasifier. The CRIP system is particularly well suited to thick coal seams where the cavity grows by coal collapse as well as combustion. A simplified design of the CRIP system is illustrated in figure 1.

The CRIP concept adds one more parameter (position of the injection point) to the other three control parameters in UCG (flow rate, injection gas composition, and operating pressure of the system). The CRIP maneuver is used when the product gas heating value declines to an unacceptable level. This characteristically occurs as a result of the growth of the burn cavity into the overburden and thus bringing inert material into contact with

* Controlled Retracting Injection Point System.

** Division of Geology and Earth Resources geologist.

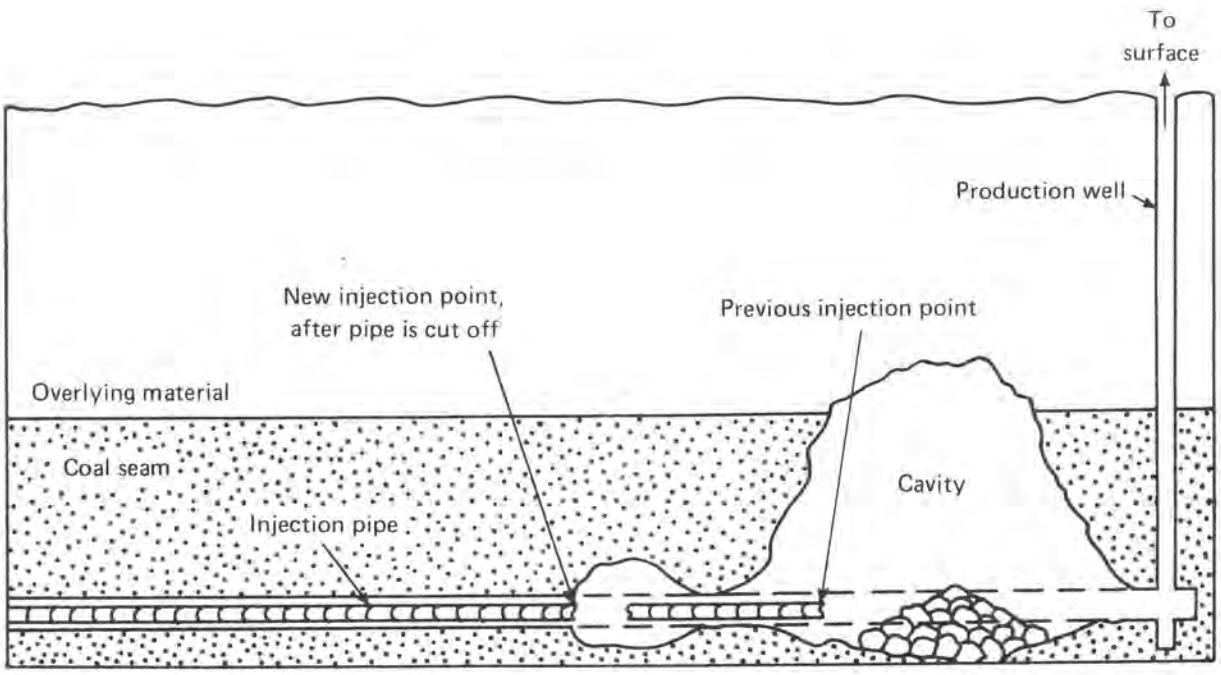

Figure 1. — Basic design of the controlled retracting injection point (CRIP) system. As the cavity burns toward the left, the injection point is moved to the left also, step by step, by cutting off or perforating the injection pipe, which can be done remotely from the surface. Thus the injectant gas is always being fed to a zone of the coal seam where unburned coal remains to be gasified (after Hill and Shannon, 1981).

burning coal. When this occurs, the injection point is retracted upstream along a horizontal to near-horizontal well into a region of fresh coal where the new burn is initiated (Cena and others, 1984). The process is then repeated as needed until the entire useful length of the injection well is used up.

The Centralia CRIP test lasted for 30 days, during which time 2,000 tons of coal were affected. Steam and oxygen were used primarily as the injected reactants. A single inclined injection well was drilled 900 ft along the bottom of the upper 18 ft of the Big Dirty coal seam. This was done because it would allow significant interaction with the roof to occur within the 30-day limit placed on the experiment by budgetary constraints. This high-ash subbituminous coal seam dips 14 degrees from the horizontal in the test site area.

The injection well was installed by directional drilling from the surface. Because of drilling problems encountered in its construction (the drill hole deviated from the coal seam into the underlying strata for part of its length), the five CRIP retractions planned originally were reduced to one.

Two production wells were constructed, one vertical and the other inclined. Gas was produced from the vertical production well for the first 12 days of the test while the inclined production well was used for the last 18 days of the test (see fig. 2).

Three distinct periods of gasification were observed during the test. During the initial period, a typical dry gas with a heating value of 248 Btu/scf (scf = standard cubic foot) was measured at the vertical production well. With the CRIP maneuver and switch to the inclined production well, a considerably higher gas quality (296 Btu/scf) was measured. The final period began with a large underground roof fall causing the typical dry gas heating value to drop to 220 Btu/scf.

The tests were conducted jointly by Lawrence Livermore National Laboratory and WIDCO. Sandia National Laboratory and Radian Corporation were involved in certain aspects of data collection. Sponsors of the test included the U.S. Department of Energy (with a support level of $30 million), the Gas Research Institute ($1 million), WIDCO ($200,000), and the Electrical Power Research Institute ($50,000). Meridian Land and Mineral Co., owner of the mineral rights to the coal seam, donated the coal resources utilized for the test.

Major conclusions drawn by Lawrence Livermore scientists (Cena and others, 1984) as a result of the CRIP field test were as follows:

- The Big Dirty coal seam is satisfactory for in-situ UCG.
- The burn cavity growth was consistent with that determined in the earlier large block tests.

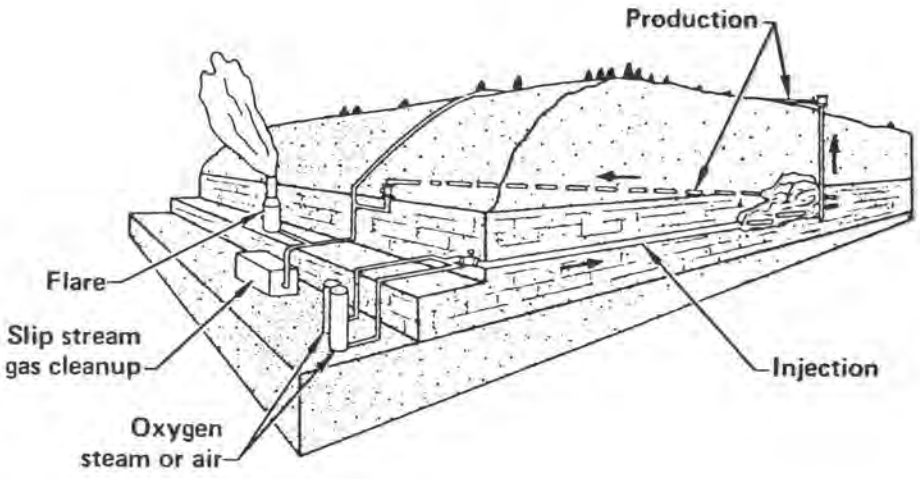

Figure 2. — Stylized version of the partial seam CRIP underground coal gasification field test illustrating CRIP geometry (Cena and others, 1984).

The inclined production well worked satisfactorily. Although pressure drops were higher with the inclined production well, they were, however, localized to the area near the injection point. There were no long-term changes in pressure drop and flow performance.

The CRIP system worked well and provided a valuable control mechanism. Two distinct levels of gas quality were observed: (1) a relatively high-level after the CRIP manuever; (2) lower levels during the first cavity burn and after the large-scale roof collapse.

Changes in steam/oxygen ratio, pressure, or flow rate did not have any lasting major effect on gas quality.

Particulate production was occasionally heavy, but was low during steady operation. The largest amounts of particulate produced were associated with periods of increasing flow rates.

The underground system was very forgiving and will apparently tolerate frequent upsets. Several power losses and boiler problems occurred during the operation of the test without any apparent long-term negative effects.

Plans are now underway for a 90-day commercial-scale test. Test plan objectives and cost estimates are currently being made and sponsors for the test are being solicited. The 90-day test will involve two simultaneous UCG modules growing together. This test will be used in making an economic analysis of such factors as the end use of product gases and optimum spacing of wells. Roger Paul, Manager of Business Development at WIDCO, believes that a commercial UCG operation is possible by the early 1990's.

For further and more detailed information on the partial seam CRIP test at Centralia, the reader is referred to the report by Cena and others (1984).

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Hill, R. W.; Thorsness, C. B., 1982, Summary report on large block experiments in underground coal gasification, Tono basin, Washington — Experimental description and data analysis: Lawrence Livermore National Laboratory, Livermore, Calif., UCRL-55305, v. 1.

FORMER WASHINGTON STATE GEOLOGIST DIES

Vaughn Edward (Ted) Livingston, State Geologist and supervisor of the Division of Geology and Earth Resources from November 1971 until January 1982, died on July 9, 1984, following an extended illness.

Ted was born on February 6, 1928, in Hayward, California. Part of his early years were spent in the Entiat Valley of north-central Washington. He attended Brigham Young University and received a bachelor of science degree in geology in 1954, followed by a master of science degree, also in geology, from the same university in 1955. He began his service with the old Division of Mines and Geology in the State Department of Conservation (later to become the Divison of Geology and Earth Resources in the Department of Natural Resources) as a geologist II in June 1956. He was promoted to geologist III in July 1959, and to geologist IV and Assistant State Geologist in May 1963. Following his service as State Geologist, Ted worked briefly for the Lands Division of the Department of Natural Resources before his retirement in May 1982.

During Ted's tenure as State Geologist, the geologic staff more than doubled, with the addition of an Environmental Geology section and broadened work on geothermal and coal resources. He was an active member of the Association of American State Geologists and the American Association of Petroleum Geologists. Throughout his state career, he took great interest in exploration for oil and gas in Washington, serving for many years as leader of the Division's regulatory program in oil and gas, either as Oil and Gas Supervisor or Deputy Oil and Gas Supervisor.

Ted's academic training and major interests as a professional geologist were in "soft-rock" geology — more specifically, paleontology and stratigraphy. Early contributions include a bulletin on the geology and mineral resources of the Kelso-Cathlamet area, much reconnaissance geologic mapping and compilation in southwestern Washington for the 1961 state geologic map, and the first "dry hole" map of the state ("Oil and Gas Exploration in Washington, 1900-1957"). Ted was also very much interested in educating lay persons about Washington's geology and resources. Publications on fossils in Washington, and geologic history and rocks and minerals of Washington were expressions of this interest.

As Assistant State Geologist, Ted was responsible for the day-to-day direction of the geologic staff and also for the direction of the Division's publication staff. In the area of publications, Ted became a reliable and frequently used source of practical knowledge on the preparation and printing of geologic maps and reports. He may be remembered by some as a pretty tough customer when it came to the correct use of stratigraphic names in geologic maps and reports.

As State Geologist, Ted still loved to get into the field when he could. Most often this was in the form of a 1-day visit to one of the staff geologist's field area. A sure-fire way to send him away happy was to show him your knottiest stratigraphic correlation problem; or better yet, take him to a fossil locality that he hadn't visited before.

Ted was long on patience, slow to anger, and will be remembered by many of us at the Division not only as our former boss, but also as a friend. Ted is survived by his wife, Nancy, and by four grown children — Leann, Jay, Robert, and David.

DIVISION OF GEOLOGY AND EARTH RESOURCES RELEASES OPEN-FILE REPORTS

The following open-file reports may be purchased from the Department of Natural Resources, Division of Geology and Earth Resources, Olympia, WA 98504; they are also available for inspection in our Division library.

Please send $1 to cover our Handling and Distribution charge for your total publication order.

Korosec, M. A., 1984, Chemical analyses for thermal and mineral springs examined in 1982-1983: Washington Division of Geology and Earth Resources Open-File Report 84-1, 8 p. Price $1.00.

Korosec, M. A., 1984, Summary of geothermal exploration activity in the State of Washington from 1978 to 1984 (Final program report to the U.S. Department of Energy): Washington Division of Geology and Earth Resources Open-File Report 84-2, 42 p. Price $1.25.

Phillips, W. M., 1984, Compilation geologic map of the Green River coal district, King County, Washington: Washington Division of Geology and Earth Resources Open-File Report 84-4, 1 plate, scale 1:24,000. Price $1.50.

Walsh, T. J., 1983, Map of coal mine workings in part of King County, Washington: Washington Division of Geology and Earth Resources Open-File Report 83-17, 4 p., 1 plate, scale 1:24,000. Price $1.00.

NEW 1:250,000-SCALE GRAVITY MAPS RELEASED

A new set of gravity maps for Washington has been released by the U.S. Geological Survey (USGS). Compiled from 29,733 gravity stations, the maps cover all of Wash-

ington and adjacent Oregon, Idaho, and offshore areas at a scale of 1:250,000. The maps consist of contoured free-air anomalies for offshore areas, and complete Bouguer anomalies (reduction density = 2.67 g/cm^3) for onshore. The contour interval is 2 mgals. Gravity station locations are also plotted.

Each of the maps is designed to overlay a standard USGS 1° by 2° topographic quadrangle. Longitude and latitude tick marks are provided at 15-minute intervals to ensure a good fit. Paper stretching or shrinkage of both base map or overlay can cause a slight distortion that should not present problems in routine use. There are 18 individual maps in the set.

The maps greatly improve the published gravity coverage of Washington and should prove useful in many geological applications. A set of the maps plotted on transparent acetate is available for use at the Division of Geology and Earth Resource's library in Lacey. The title of the map and the address where it can be purchased are listed below:

Finn, Carol; Phillips, W. M.; Williams, D. L., 1984, Gravity maps of the State of Washington and adjacent areas: U.S. Geological Survey Open-File Report 84-416, 18 map sheets, scale 1:250,000.

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THESES ADDED TO DIVISION OF GEOLOGY AND EARTH RESOURCES LIBRARY

The following theses were recently added to our division library where they are now available for reference work:

Harrison, W. J., 1984, Paleomagnetism of four Late Cretaceous plutons, north Cascades, Washington: Western Washington University Master of Science thesis, 106 p.

Johnson, M. J., 1981, Tectonic transport of the Newport allochthon, northeastern Washington and northern Idaho: University of Montana Master of Science thesis, 86 p.

Jones, T. D., 1977, Analysis of a gravity traverse south of Portland, Oregon: Portland State University Bachelor of Science thesis, 114 p.

Kachel, N. B., 1980, A time dependent model of sediment transport and strata formation on a continental shelf: University of Washington Doctor of Philosophy thesis, 123 p.

Lewellen, D. G., 1983, The structure and depositional environment of the Manastash Formation, Kittitas County, Washington: Eastern Washington University Master of Science thesis, 107 p., 2 plates.

Lewis, R. D., 1984, Geochemical investigations of the Yellow Pine, Idaho, and Republic, Washington, mining districts: Purdue University Doctor of Philosophy thesis, 204 p.

MacQueen, J. D., 1982, Linear inversion of gravity data with geological and geophysical constraints: University of Washington Doctor of Philosophy thesis, 137 p.

Sans, J. R., 1983, Mafic mineral chemistry and oxygen isotope composition of the Cloudy Pass batholith, Washington: University of Chicago Doctor of Philosophy thesis, 376 p.

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The following U.S. Geological Survey Open-File Reports are now available for inspection in our Division of Geology and Earth Resources library. If you wish to purchase any of these reports, please write or call:

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Booth, D. B., 1984, Surficial geology of the west half of the Skykomish River quadrangle, Snohomish and King Counties, Washington: U.S. Geological Survey Open-File Report 84-213, 36 p., 1 plate, scale 1:50,000.

Chrzastowski, Michael, 1983, Historical changes to Lake Washington and route of the Lake Washington Ship Canal, King County, Washington: U.S. Geological Survey Water Resources Investigations Open-File Report 81-1182, 9 p., 1 sheet, scale 1:24,000.

Church, S. E.; Mosier, E. L.; Frisken, J. G., 1983, Contour maps of analytical results for stream sediments and panned concentrates from stream sediments, and plots of the mineralogy of the nonmagnetic, heavy-mineral concentrates from stream sediments from the Glacier Peak Wilderness study area, Washington: U.S. Geological Survey Open-File Report 83-366, 37 p.

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Dvorak, J. J.; Okamura, A. T.; Johnston, M. J. S.; Mortensen, Carl; Mueller, R. J.; Furukawa, Bruce, 1984, Tiltmeter and magnetometer measurements at Mount St. Helens, Washington – 1980-1981: U.S. Geological Survey Open-File Report 84-164, 47 p.

Dzurisin, Daniel; Johnson, D. J.; Symonds, R. B., 1983, Dry tilt network at Mount Rainier, Washington: U.S. Geological Survey Open-File Report 83-277, 18 p.

Evarts, R. C.; Mosier, E. L.; Church, S. E.; Barnes, D. J., 1983, Mineral resource potential of the Glacier View roadless area, Pierce County, Washington: U.S. Geological Survey Open-File Report 83-501, 17 p.

Finn, Carol; Williams, D. L., 1982, Principal facts for one-hundred-six gravity stations near the Goat Rocks Wilderness area, Washington: U.S. Geological Survey Open-File Report 83-176, 6 p.

Fuste, L. A.; Packard, F. A.; Fretwell, M. O.; Garland, D. P., 1983, Data supplement to – Quality of coal mine drainage in Washington, 1975-1977: U.S. Geological Survey Open-File Report 83-205, 61 p.

Gilliom, R. L., 1983, Lake-water quality and land-use relationships for selected lakes in the Port Townsend quadrangle, Puget Sound region, Washington: U.S. Geological Survey Water Resources Investigations Open-File Report 82-684, 1 sheet, scale 1:100,000.

Hildreth, Wes; Fierstein, Judy; Miller, M. S., 1983, Mineral and geothermal resource potential of the Mount Adams Wilderness and contiguous roadless areas, Skamania and Yakima Counties, Washington: U.S. Geological Survey Open-File Report 83-474, 36 p.

Meyer, William; Carpenter, P. J., 1983, Filling of Spirit Lake, Washington, May 18, 1980, to July 31, 1982: U.S. Geological Survey Open-File Report 82-771, 19 p.

Robbins, S. L.; Kunk, J. R.; Clutsom, F. G., 1983, Principle facts and density estimates for borehole gravity stations and boreholes RRL-3, -4, -5, -6B, -7, -8, and -9 at the Hanford Site, Benton County, Washington: U.S. Geological Survey Open-File Report 83-386, 42 p.

Snavely, P. D., Jr.; Wells, R. E., 1984, Tertiary volcanic and intrusive rocks on the Oregon and Washington continental shelf: U.S. Geological Survey Open-File Report 84-282, 17 p., 3 plates.

U.S. Geological Survey, 1984, Aeromagnetic map of southwest Washington and northwest Oregon: U.S. Geological Survey Open-File Report 84-205, 1 sheet, scale 1:250,000.

RECENT GEOLOGIC REPORTS ADDED TO OUR LIBRARY

The following U.S. Geological Survey reports have recently been acquired by the Division of Geology and Earth Resources and are now available for reference work in the library:

Church, S. E.; Tabor, R. W.; Johnson, F. L., 1983, Mineral resource potential of the Eagle Rock roadless area, Snohomish and King Counties, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1380-B, 15 p., 1 plate, scale 1:50,000.

Drost, B. W., 1983, Impact of changes in land use on the ground-water system in the Sequim-Dungeness Peninsula, Clallam County, Washington: U.S. Geological Survey Water Resources Investigations 83-4094, 61 p.

Gilliom, R. J., 1983, Estimation of nonpoint source loadings of phosphorus for lakes in the Puget Sound region, Washington: U.S. Geological Survey Water Supply Paper 2240, 24 p.

Keefer, D. K.; Johnson, A. M., 1983, Earth flows — Morphology, mobilization, and movement: U.S. Geological Survey Professional Paper 1264, 56 p., 3 plates.

Luedke, R. G.; Smith, R. L.; Russell-Robinson, S. L., 1983, Map showing distribution, composition, and age of late Cenozoic volcanoes and volcanic rocks of the Cascade Range and vicinity, Northwestern United States: U.S. Geological Survey Miscellaneous Investigations Series Map I-1507, 1 sheet, scale 1:500,000.

Minard, J. P., 1983, Geologic map of the Edmonds East and part of the Edmonds West quadrangles, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1541, 1 sheet, scale 1:24,000.

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A PROGRESS REPORT ON THE GRADUATE STUDENT MAPPING PROJECT, STATE GEOLOGIC MAP PROGRAM

As previously reported in our Geologic Newsletter (January 1984), the Division of Geology and Earth Resources has begun a project to support graduate student thesis mapping. This project will provide geologic source maps for use in our compilation and revision of the state geologic map, form closer working relationships with the graduate students and faculties of the Pacific Northwest universities, and provide motivation and monetary support for graduate student geologic thesis mapping.

We distributed a "Request for Proposal" in October 1983, which called for submission of proposals by January 13, 1984. We received only three proposals. The low response seemed to be due to the holiday season and the fact that many students were not prepared to select a thesis area that early in the academic year. Therefore, we reissued the "Request for Proposal" with a cutoff date of April 30, 1984. This time, 13 proposals were received.

Of the 16 proposals submitted under both annoucements, 14 were selected for support. Twelve of these are master's thesis projects, one is an extension of a master's thesis (Jeffrey Jones), and one is being conducted by a professor (Robert Miller). Together, these projects will provide about 550 square miles of new geologic mapping for a total contracted price of just over $26,000.

The following table lists the name and university of each investigator, the state geologic map quadrant where the project is located, the date by which the project will be finished, and the project's title.

GRADUATE STUDENT MAPPING — PROJECTS FOR FISCAL YEAR 1985
(July 1, 1984 through June 30, 1985)

Investigator	University	State Map quad.	Completion date	Title
Brad Carkin	Western Wash. University	Southwest	1-1-85	Chemistry, stratigraphy, and paleomagnetism of the Fifes Peak Formation in the Cliffdell area, Kittitas and Yakima Counties, Washington.
Robert Goodfellow	University of Oregon	Northwest	6-30-85	Conodonts from Paleozoic and early Mesozoic limestones, northwestern Washington.
Louis Groffman	Washington State Univ.	Northeast	12-31-84	Geology of the Gypsy Peak area, Pend Oreille County, Washington.
Charles Gulick	Eastern Wash. University	Northeast	6-1-85	Geology of the southwest quarter of the Aeneas Valley quadrangle, Okanogan County, Washington.

GRADUATE STUDENT MAPPING – PROJECTS FOR FISCAL YEAR 1985
(July 1, 1984 through June 30, 1985) - Continued

Investigator	University	State Map quad.	Completion date	Title
Randy Hagen	University of Oregon	Southwest	3-30-85	Geologic map of the northern part of the Morton 15-minute quadrangle, Lewis County, Washington.
Jeffrey Jones	Western Wash. University	Northwest	12-31-84	Geology of the western portion of the Canyon Creek-Church Mountain area, Whatcom County, Washington.
Kevin Lindsey	Washington State Univ.	Northeast	5-31-85	Geologic mapping of parts of the Addy, Gypsy, and Three Sisters Formations near Chewelah and Metaline Falls, northeastern Washington.
John Link	Washington State Univ.	Southwest	12-31-84	Copper and gold mineralization in the McCoy Creek district, Skamania County, Washington
Krista McGowan	Portland State Univ.	Southwest	12-31-84	Regional geologic setting of the Wind River gold prospect, Skamania County, Washington
Robert Miller	Clark College	Southwest	12-31-84	Geologic map of the pre-Cenozoic rocks in the Bumping Lake-Rimrock Lake-Tieton River area, southern Cascades, Washington.
Kristin Orr	University of Washington	Northeast	3-31-85	Structural features along the margins of Kettle and Okanogan domes, northeastern Washington.
Gregory Reller	Western Wash. University	Northwest	6-20-85	Geology of the Deer Peak area, Skagit County, Washington.
Patricia White	University of Washington	Northeast	6-30-85	Geology of the Island Mountain area, Okanogan County, Washington.
Glenn Wiedenhoeft	Washington State Univ.	Northeast	12-31-84	Structural geology of the southern Metaline district, Pend Oreille County, Washington.

RECENT PERMITS FOR OIL AND GAS DRILLING

Operator	Permit no.	County	Well name	Location	Ground elevation (feet)	Estimated total depth (feet)	Spud date	Date permit issued
Oil and Gas Exploratory Wells								
Shell Oil Co.	340	Grant	BN 1-9	965 ft FWL and 1,869 ft FNL* sec. 9 (15-25E)	2,400	20,000	12-21-82	5-22-81
AMOCO Prod. Co.	354	King	Enumclaw Mill No. 1-34	1,430 ft FNL and 1,370 ft FWL sec. 34 (20-7E)	1,447	2,500	5-16-83	5-16-83
AMOCO Prod. Co.	386	Grays Harbor	Amoco-Weyerhaeuser No. 1-29	2,601 ft FWL and 2,377 ft FSL sec. 29 (19-8W)	390	12,000	6-26-84	5-31-84
Shell Western E & P Inc.	387	Grant	Maughan et al No. 1-5	1,398 ft FSL and 1,822 ft FEL sec. 5 (15-25E)	1,937	15,000		7-11-84
Oil and Gas Stratigraphic Tests								
AMOCO Prod. Co.	356	Pierce	Buckley No. 1	1,990 ft FWL and 2,033 ft FSL sec. 11 (19-6E)	755	1,800		7-26-83
AMOCO Prod. Co.**	360	King	Fall City Twin No. 1	1,217 ft FNL and 925 ft FEL sec. 7 (24-8E)	975	1,500	10-1-83	7-26-83
AMOCO Prod. Co.**	361	Pierce	National No. 1	968 ft FSL and 2,228 ft FEL sec. 28 (15-6E)	1,610	2,000	11-23-83	7-26-83
AMOCO Prod. Co.	362	King	Snoqualmie Mill Offset No. 1	1,489 ft FNL and 1,297 ft FWL sec. 25 (24-7E)	842	1,500		7-26-83
AMOCO Prod. Co.	363	King	Snoqualmie Mill Twin No. 1	1,779 ft FWL and 601 ft FSL sec. 19 (23-8E)	2,190	1,500		7-26-83
AMOCO Prod. Co.	364	Lewis	Storm King Twin No. 1	2,005 ft FSL and 2,569 ft FEL sec. 23 (14-5E)	1,835	1,500		7-26-83
AMOCO Prod. Co.	365	Lewis	WC-83-12	488 ft FWL and 2,212 ft FSL sec. 7 (14-5E)	1,515	2,000		12-15-83
AMOCO Prod. Co.	366	Pierce	WC-83-11	347 ft FSL and 330 ft FWL sec. 11 (19-6E)	752	2,000		12-29-83
AMOCO Prod. Co.	367	Pierce	WC-83-13	964 ft FNL and 1,015 ft FWL sec. 10 (15-6E)	3,260	2,000		12-29-83
AMOCO Prod. Co.**	369	King	WC-83-15	1,104 ft FSL and 704 ft FWL sec. 35 (25-7E)	310	2,000	4-1-84	12-29-83
AMOCO Prod. Co.	371	King	WC-83-31	114 ft FSL and 1,194 ft FEL sec. 15 (25-8E)	1,125	2,000		2-2-84
AMOCO Prod. Co.	372	King	WC-83-32	739 ft FNL and 2,032 ft FEL sec. 26 (26-7E)	620	2,000		2-2-84
AMOCO Prod. Co.	373	Pierce	WC-83-26	40 ft FSL and 609 ft FEL sec. 17 (16-4E)	725	2,000		2-2-84
AMOCO Prod. Co.	374	King	WC-83-17	847 ft FSL and 1,460 ft FWL sec. 13 (22-6E)	645	2,000		2-2-84
AMOCO Prod. Co.	375	King	WC-83-16	2,254 ft FNL and 562 ft FEL sec. 4 (20-7E)	1,246	2,000		2-2-84
AMOCO Prod. Co.	377	King	WC-83-20	696 ft FSL and 123 ft FWL sec. 1 (24-6E)	435	2,000		2-22-84
AMOCO Prod. Co.	378	King	WC-83-21	216 ft FSL and 1,131 ft FEL sec. 33 (21-6E)	675	2,000		2-15-84
AMOCO Prod. Co.	379	Pierce	WC-83-23	1,073 ft FSL and 1,130 ft FEL sec. 24 (19-5E)	820	2,000		2-15-84
AMOCO Prod. Co.	380	Lewis	WC-83-24	2,244 ft FSL and 2,356 ft FWL sec. 1 (14-4E)	1,635	2,000		2-15-84
AMOCO Prod. Co.	381	Lewis	WC-83-25	1,023 ft FNL and 752 ft FEL sec. 29 (13-4E)	1,540	2,000		2-15-84
AMOCO Prod. Co.	382	Pierce	WC-83-28	2,335 ft FNL and 661 ft FEL sec. 19 (19-6E)	520	2,000		2-15-84
AMOCO Prod. Co.**	383	Pierce	WC-83-29	1,144 ft FNL and 1,183 ft FEL sec. 32 (18-6E)	1,695	2,000	4-13-84	2-15-84
AMOCO Prod. Co.	384	Lewis	WC-83-33	1,107 ft FNL and 1,243 ft FEL sec. 33 (13-4E)	1,355	2,000		2-15-84
AMOCO Prod. Co.	385	Pierce	WC-83-34	700 ft FNL and 2,346 ft FEL sec. 25 (16-3E)	725	2,000		2-15-84

* Land description indicates that the location is 965 ft from the west line and 1,869 ft from the north line of sec. 9, township 15 north, range 25 east, Willamette meridian.

** Plugged and abandoned.

Department of Natural Resources
Division of Geology and Earth Resources
Olympia, WA 98504

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Permit 263