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Rawlins UCG Demonstration Project
Site Characterization Report
Volume II: Hydrological Characterization

Topical Report

April 1989

Work Performed Under Contract No.: DE-FC21-88MC24167

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Energy International, Inc.
Pittsburgh, Pennsylvania

DISCLAIMER

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135 William Pitt Way
Pittsburgh, Pennsylvania 15238

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SITE CHARACTERIZATION REPORT

VOLUME II: HYDROLOGIC CHARACTERIZATION

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RAWLINS UCG DEMONSTRATION PROJECT

SITE CHARACTERIZATION REPORT

SUMMARY

The Site Characterization Report consists of separate geological and hydrological volumes. These volumes identify the coal and water resources at Energy International's Rawlins UCG Demonstration Project site.

The primary coal deposits are the steeply dipping (60°) "G" and "I" seams of the Fort Union Formation. Coal quality and quantity have been determined from core holes and surface trenching. The coal seams and surrounding starta are tight and uniform without any major cross-cutting structures that might result in product gas migration. Coal quality parameters meet all criteria and were found to be consistently predictable based upon patterns of deposition and depth of burial. Calculated reserves for the "G" seam in Section 11 are sufficient for the project requirements.

The hydrologic investigation gathered and evaluated data on the ground water of the proposed UCG area for both environmental and industrial purposes. The characterization program involved drilling eighteen wells for sampling and monitoring. Extensive ground water baseline information has been compiled by incorporating data from the 1979 and 1981 test burns. Transmissivities of the coal seams and surrounding strata are extremely low which is consistent with the results measured in 1979 and 1981. Based upon the low transmissivities and lack of communication between the monitoring wells, it is more appropriate to identify the ground water resources as a series of aquitards rather than aquifers. The isolation of these aquitards by tight formations limit the possibility of invasion by product gas. Analysis of the ground water samples found very few wells suitable for any but industrial use because of high iron, manganese, sulfate and total dissolved solids concentrations. This baseline sampling confirmed the Class IV classification observed on the previous test burns which qualifies for industrial use.

The site characterization program describes a coal resource ideally suited for underground coal gasification with a ground water system with very low yield and no beneficial use. This information will be incorporated into the module configurations and placement for maximum burn efficiency and gas recovery.

I. INTRODUCTION

The United States Department of Energy and Energy International, Inc. have entered into a Cooperative Agreement to conduct a cost-shared UCG field test demonstrating the operation of commercial scale Underground Coal Gasification (UCG) on steeply dipping bed modules to provide synthesis gas for a small scale commercial ammonia plant. The field test and the commercial ammonia plant will be located at the North Knobs site near Rawlins, Wyoming (Figure 1). This site has had previous UCG test burns in 1979 and 1981. During this demonstration test, two or more UCG modules will be operated simultaneously until one module is completely consumed and an additional module is brought on line. During this period, the average coal gasification rate will be between 500 and 1,200 tons per day. A portion of the raw UCG product gas will be cleaned and converted into a synthesis gas, which will be used as feedstock to a 400-500 ton per day ammonia plant. The UCG facility will continue to operate subsequent to the test demonstration to provide feedstock for the commercial plant.

Objective

The objective of the hydrologic site characterization program is to provide an accurate representation of the hydrologic environment within the area to be gasified. This information will aid in the placement and operation of the process wells in relation to the ground water source.

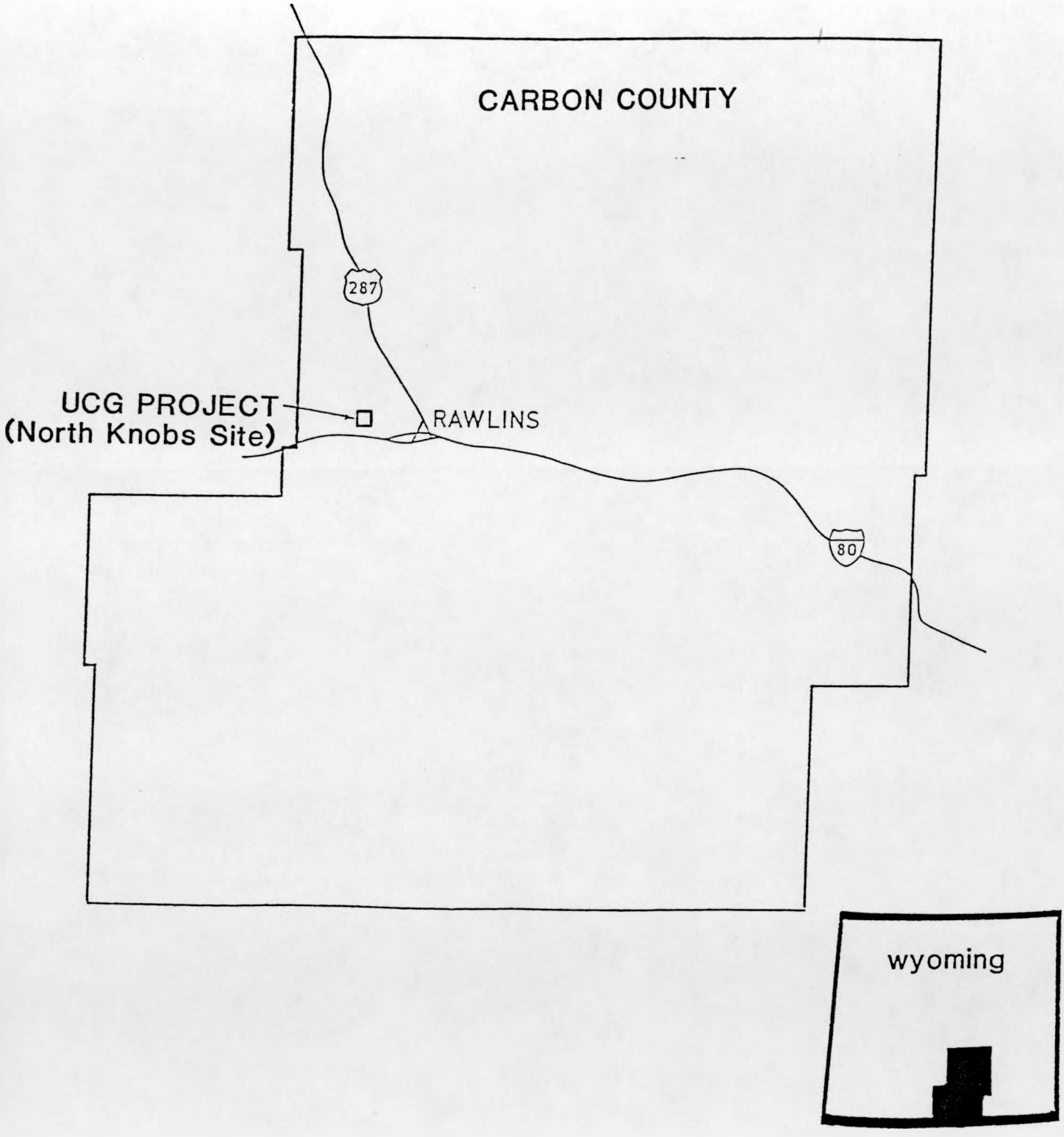
Background

The exploration and definition of the geologic characteristics of the proposed UCG site has been developed in Volume I of the Site Characterization Report. In conjunction with the geologic investigations, eighteen wells were drilled and completed for hydrologic sampling and monitoring of the ground water resource. This report includes sampling data acquired from these wells over a twelve-month period. In addition, hydrology information is included from the Gulf Research & Development Company test burns of 1979 and 1981. This data provides valuable insight to pre and post burn conditions on the coal resource at the North Knobs site.

II. GROUND WATER HYDROLOGY

The ground water hydrology of the permit area and adjacent area is evaluated for both environmental and industrial process purposes. Regulations of the Wyoming Department of Environmental Quality (WDEQ) require that the operator determine the depth, quantity and quality of ground water in geologic formations that may be affected by the proposed operations. This information serves as a measure of pre-operational (i.e. baseline) conditions from which operational and post-operational conditions can be compared to assess impact. Regulations of the WDEQ also require the operator to predict the expected impacts of the operation on water resources and water rights within the permit and adjacent areas. These predictions rely on baseline ground water information including hydraulic characteristics of the receiving strata, geologic interpretation and process details.

FIGURE 1: Project Location



Hydrogeologic Setting

The North Knobs site lies along the eastern limb of a major synclinal fold that is part of a flexure marking the boundary of the Red Desert Basin to the west and the Rawlins uplift to the east. The outcrops have eroded into a long parallel series of ridges called a hogback. These stratigraphic outcrops represent a complex relationship between the environment of deposition, the growth of the Rawlins uplift and the subsidence of the Red Desert Basin. The beds that form the hogback dip to the west, or basinward, at 60 degrees. These rocks consist of various sandstones, siltstones, shales and coal beds. The target coal resource is in this group and has been identified as the "G" seam.

The target G-seam is bounded above and below by a shale parting and thinner coal section (Figure 2). Post burn analysis of the 1979 and 1981 tests indicated minimal disturbance of the surrounding strata. As a result, the in-situ gasification process is only expected to affect the G-seam coal and adjacent formations.

Previous Hydrogeologic Testing and Evaluation

Monitoring wells completed for the previous UCG tests are shown on Plate 1. Figure 3 illustrates the location of these wells with respect to the two UCG test reactors. Test 1 took place between October 28, 1979 and December 5, 1979. Test 2 took place between August 22, 1981 and November 11, 1981. All of these wells have been plugged and abandoned for release of the reclamation bond. Information gathered from these wells has been used in this report.

Wells P-1, H-11, and H-13 were drilled during the site characterization program in 1978 and are discussed in detail in WDEQ LQD Permit 491. Well P-1 was a pump well used to withdraw water from the coal seam during pumpdown testing in 1978-1979. Well H-11 was completed in the sandstone above the coal seam. Well H-13 was completed in the shale below the coal seam. All of these wells were drilled with a 6-1/2 inch nominal diameter.

Wells H-16, H-17, and H-18 were the water sampling wells for Test 1. Well H-16 was first completed in the G-seam coal downdip from the Test 1 cavity, but in June of 1981 was plugged back and completed in the sandstone immediately above the G-seam. Well H-17 was completed in the coal seam downdip and down gradient from the Test 1 cavity. Well H-18 was the reference well completed in the G-seam updip and up the hydraulic gradient from the test reactor.

Wells H-19 through H-22 were the monitoring wells for Test 2. Wells H-19 and H-20 were completed in the G-seam coal downdip and down gradient from the Test 2 reactor. Well H-21 was completed in the G-seam updip and up the hydraulic gradient from the Test 2 reactor. Well H-22, downdip and down gradient of the Test 2 reactor, was first completed in the G-seam but was plugged back and completed in the sandstone above the coal in June 1981.

FIGURE 2: Target Coal Seam

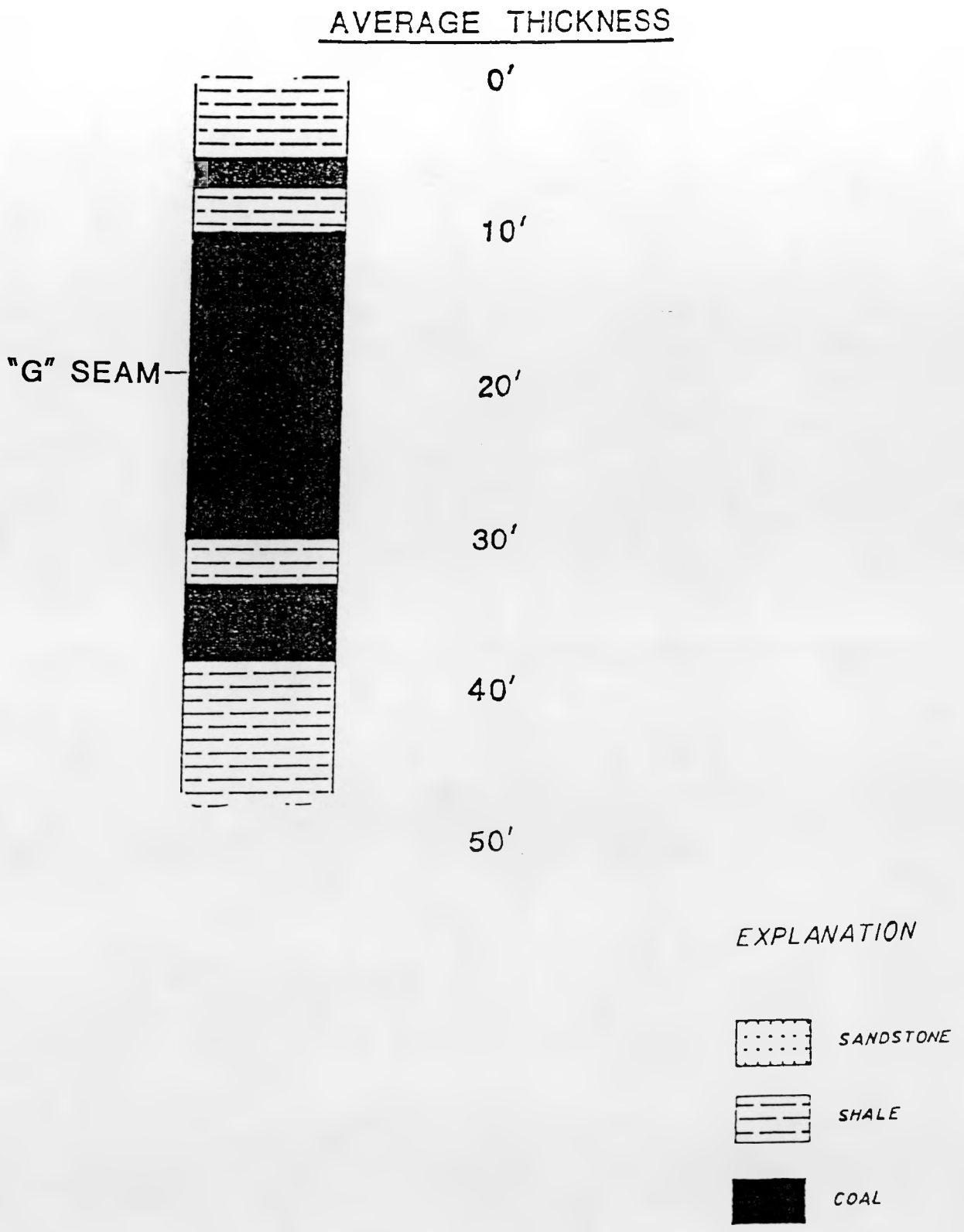
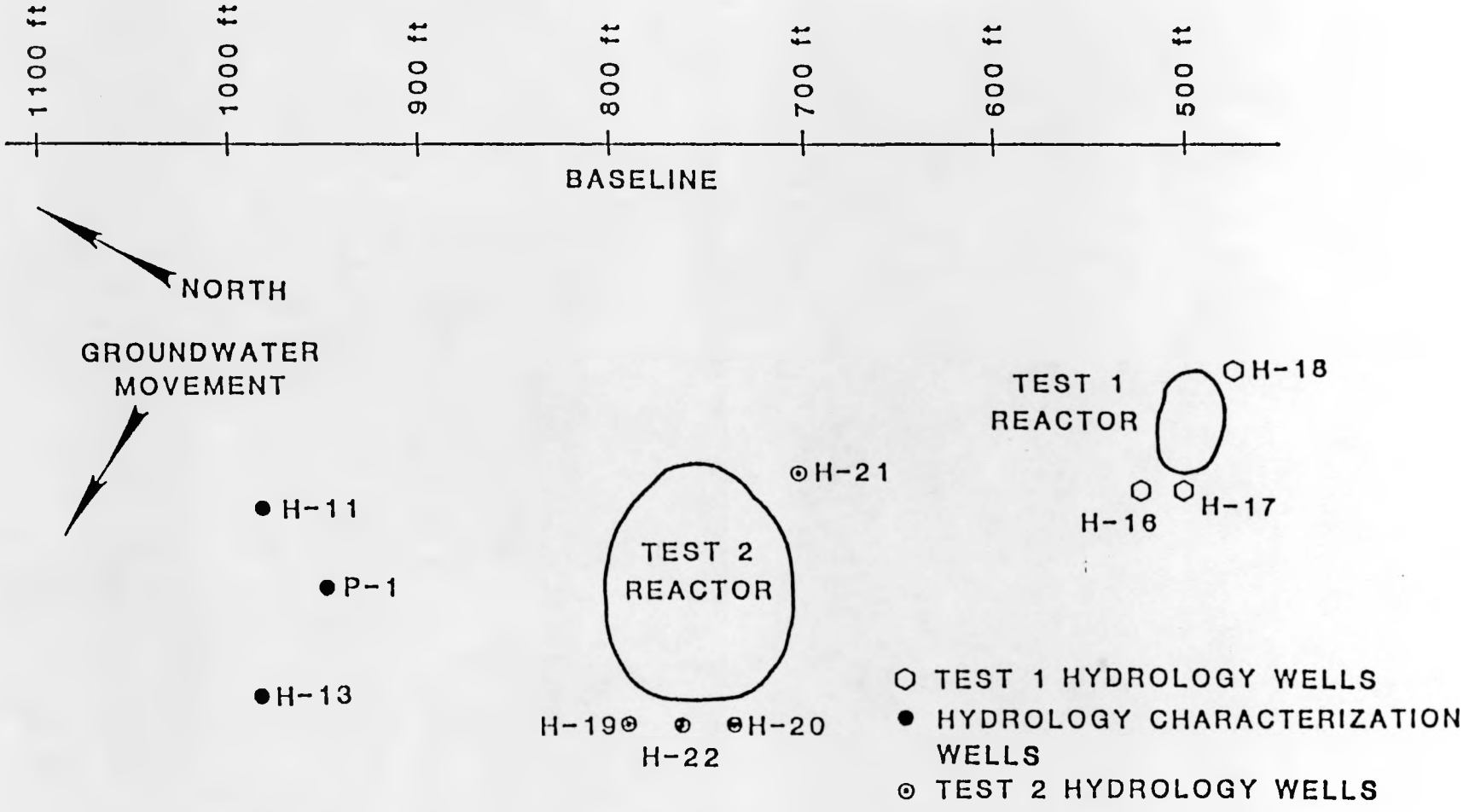


FIGURE 3 : Plan View of Hydrology Well Field



Water levels measured in G-seam monitoring wells prior to the two test burns were less than 100 feet below the surface near the subcrop. By means of ageostatistical analysis of the water level data, the potentiometric surface of the G-seam was projected to slope at about 0.1°/ft toward the west (in the direction of 268° azimuth).

The transmissivities of the G-seam coal, sand unit above the coal, and the shale immediately below the coal are apparently quite low. Recovery rates in coal wells dewatered during sampling and hydraulic testing varied from about 0.002 gallons per hour up to 1.6 gallons per hour making long-term pumping tests unrealistic. Single-well slug testing produced transmissivity estimates of about 0.008 gallons per day per foot (gpd/ft) for the G-seam at well P-1, 0.007 gpd/ft for the upper sandstone at well H-11, and 0.008 gpd/ft for the lower shale at well H-13. Laboratory testing of the G-seam coal provided an intrinsic permeability of 0.5 millidarcy.

Water samples drawn from the monitoring wells prior to, during, and following the previous two test burns indicated variable compositions that predicted correlations of water composition to particular strata. This was attributed to the extremely slow movement of ground water at the site (estimated to be on the order of 4×10^{-6} to 8×10^{-6} ft/day). This slow movement of ground water confounded interpretation of water quality data in that it took more than two years for the chemistry of the hydrologic characterization wells P-1, H-11, and H-13 (located outside of the range of chemical influence of the test burns) to stabilize following well drilling and completion. In part, this may be due to KCL additives in the drilling water. It is possible that the variability in water quality from well to well in each monitored stratum is a result of the ground water being in chemical equilibrium with its immediate matrix. The variation in water composition from well to well indicates that the mineral composition of the matrix around each well may vary significantly.

Aquifer Properties

Design of Ground Water Monitoring Program

Locations of the eighteen monitoring wells installed for the present UCG operation are illustrated on Plate 1. These locations were selected to provide hydrologic characterization of the ground water up and down gradient of the underground burn zone which will form in the target G-seam coal. With reference to Table I, wells have been completed in the G-seam coal (well designated by a G-prefix), the sand below the G-seam (well designated by an L-prefix), the sand above the G-seam (well designated by a U-prefix), and at site number seven a localized shallow sand unit (designated by an S-prefix).

Preliminary thoughts were that a possible joint or fracture zone existed in the bedrock, trending through the middle of the permit area in an east-northeast direction. The surface expression of this joint is an unnamed intermittent drainage tributary to Separation Creek. In consideration of the possibility of this joint acting as a conduit for excursions of degraded groundwater produced by the UCG process, monitoring well sites two, seven, and four are located between the reactor site and this joint. Monitoring well G-18 is located on the north side of the joint to characterize possible differences in ground water levels and water quality across the joint.

TABLE I : Well Completion Data

Well ID	Coordinates Feet East	Coordinates Feet North	Wellhead Elevation	(All Measurements In Feet Below Wellhead) Screened Interval Top	Screened Interval Bottom	4-Inch Casing	Total Depth	Top Of Packer	3/4-Inch Pipe	Completion Date	SEO Permit Number	Pressure Wellhead
U-1	478468.66	414332.00	6861.94	1119	1129	1125	1138	1051	1114	12/29/87	UW75847	No
G-1	478460.53	414353.47	6861.83	1190	1250	1188	1254	1101	1185	2/18/88	UW75846	Yes
L-1	478476.96	414317.45	6863.74	1283	1363	1279	1366	1194	1278	2/5/88	UW75849	Yes
U-2	478077.54	415210.57	6803.42	1116	1151	1118	1153	1048	1111	12/20/87	UW75851	No
G-2	478000.57	414148.47	6802.94	1315	1380	1322	1383	1226	1310	1/12/88	UW75848	No
L-2	477985.78	415188.00	6801.25	1523	1593	1518	1594	1433	1518	1/2/88	UW75852	No
U-3	479057.23	414687.59	6876.69	42	77	38	81	none	37	1/29/88	UW75856	Yes
G-3	479074.25	414650.94	6877.52	102	172	104	172	none	97	1/28/88	UW75850	Yes
L-3	479065.97	414669.04	6877.10	252	312	238	312	none	247	1/28/88	UW75858	Yes
U-4	478659.53	415442.34	6817.50	106	121	104	120	none	101	12/29/87	UW75857	Yes
G-4	478719.13	415485.92	6819.22	23	93	20	94	none	86	12/28/87	UW75853	Yes
L-4	478728.07	415469.23	6819.99	194	289	193	287	none	189	12/28/87	UW75859	Yes
U-5	478786.37	415025.83	6865.87	713	754	717	755	641	704	1/21/88	UW75854	No
U-7	478321.34	415285.14	6809.60	778	788	778	792	710	773	12/13/87	UW76345	No
G-7	478318.21	415310.82	6810.21	817	877	819	878	754	817	2/3/88	UW76342	Yes
L-7	478296.32	415322.72	6808.14	900	985	902	980	832	895	12/27/87	UW76344	No
S-7	478278.35	415314.57	6807.17	112	222	108	221	none	107	12/27/87	UW76346	Yes
G-8	478241.70	415459.88	6804.76	830	860	835	860	767	830	2/22/88	UW76343	Yes

Monitoring Well Description

Particulars of monitoring well construction are summarized in Table I. Figures 4 and 5 depict typical monitoring well construction. Completion of each well proceeded as follows:

- A pilot hole was drilled and cored to the depth indicated as "4-Inch Casing" in Table I.
- The pilot hole was reamed with a 7-7/8 inch drill bit to the top of the interval to be monitored.
- Threaded and coupled steel casing of 4-inch inside diameter was lowered to the bottom of the reamed hole and cemented into place.
- The interval to be monitored was drilled or cored with a 3-3/4 inch drill bit to the depth listed as "Total Depth" in Table I. A foam drilling fluid was used for this drilling operation.
- The hole was blown dry.
- The 2-inch diameter PVC well screen (usually topped with a five-foot length of blank PVC pipe) and neoprene packer was lowered at the end of the 3/4-inch steel pipe to or near the total depth of the well.
- The 3/4-inch pipe was detached from the well screen by use of a back-off-sub coupler and pulled back typically five feet from the top of the screen.
- If the well was deep, then an inflatable packer was set in the 4-inch casing typically 63 or 84 feet (3 or 4 pipe lengths) above the end of the 3/4-inch pipe. Affixed to the inflatable packer were a nylon tube for pressurizing the packer, and a second tube ending below the packer for pressurizing the well below the packer.
- The well was finished by installing a wellhead to which the 3/4-inch pipe and air lines are attached. Eleven of the eighteen wells have pressure wellheads which serve a double purpose of allowing the well to be pressurized below the wellhead for gas-driven water sampling and also to prevent the potential escape of gases to the atmosphere during and following the UCG burn.
- The well was purged via gas pressurization to remove, as best as possible, residual drilling fluids and other introduced substances.

All monitoring wells except U-4, S-7, and G-8 fully penetrate the stratum monitored. Wells U-4 and S-7 are completed at the bottom of the upper sandstone and a shallow sandstone, respectively. Well G-8 penetrates the upper half of the G-seam.

FIGURE 4 : Shallow Well Schematic

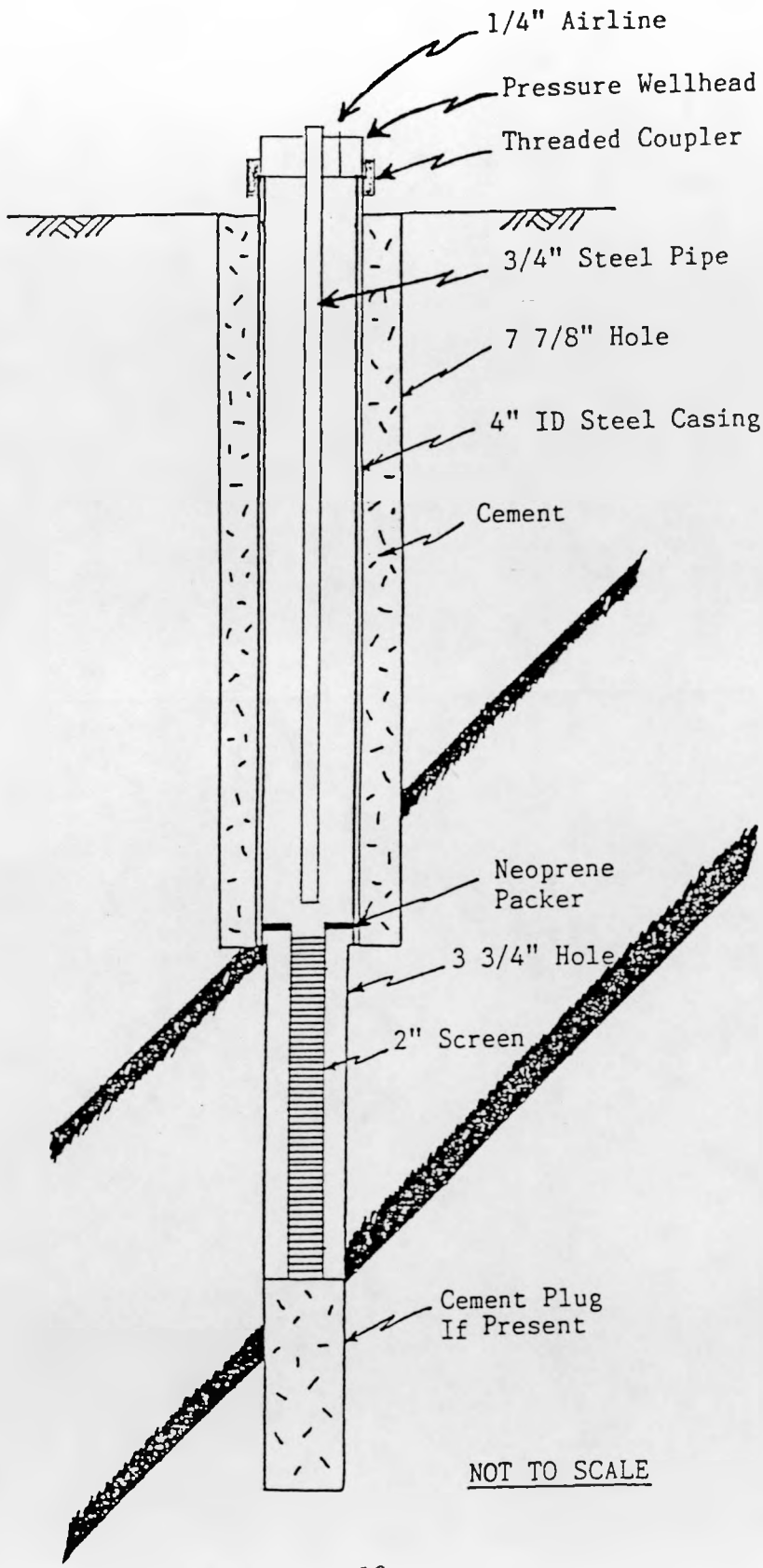
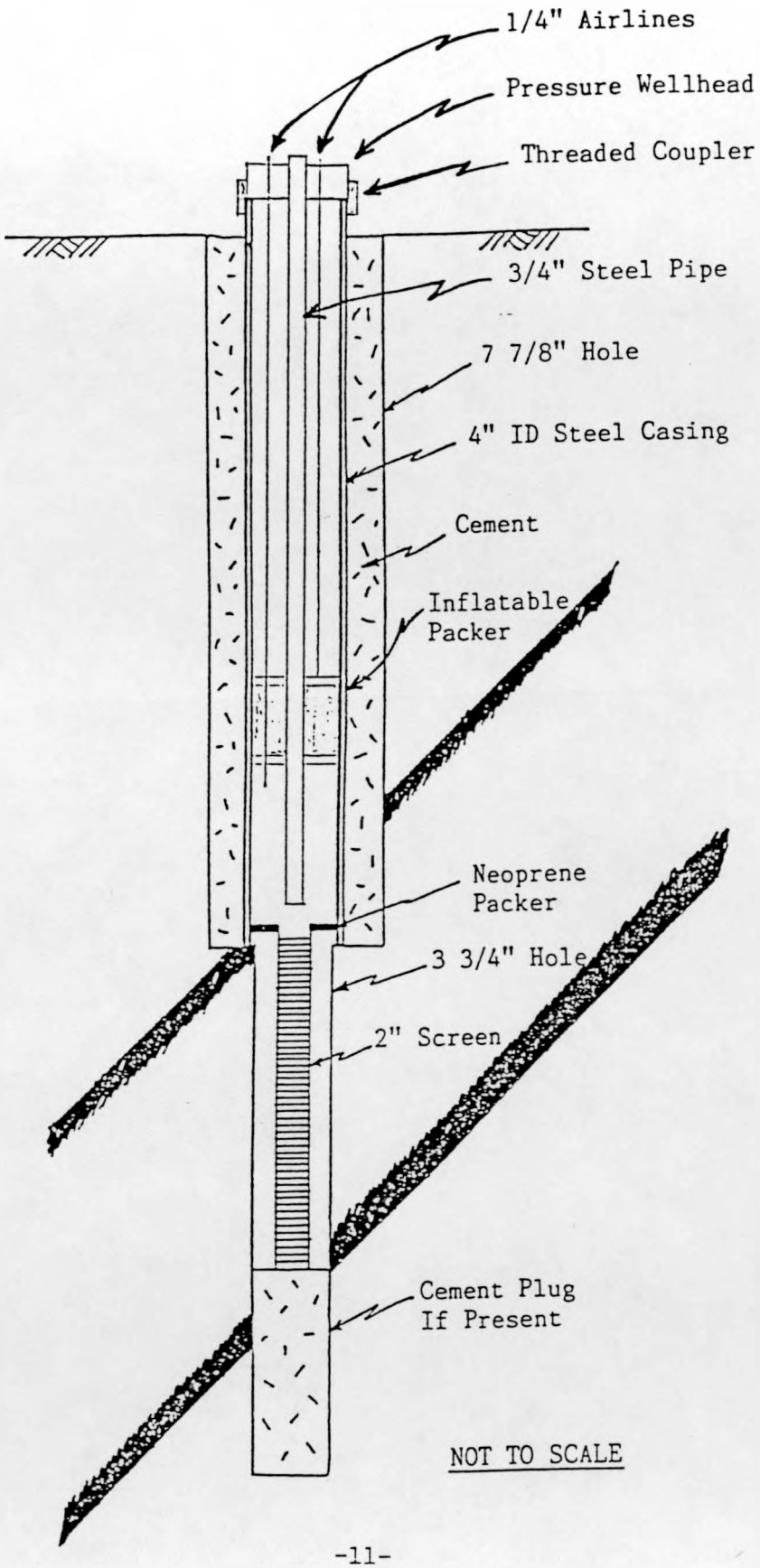


FIGURE 5 : Deep Well Schematic



Four of the wells, U-1 (drillhole RC-1), L-3, U-5 (drillhole RC-2), and G-8 (drillhole C-5) were completed in holes that were overdrilled and cemented back to the depth listed as 4-Inch Casing in Table I.

Potentiometric Levels and Interpretation

Water level measurements have been taken at the wells installed for monitoring during quarterly intervals. The initial water level measurements were taken at the end of 1987. Table II summarizes the data gathered to date. Hydrographs of the water level data have been grouped by site in Figures 6 through 12. Also illustrated on these figures are schematics of the monitoring well construction. Scrutiny of these figures reveals several observations. First, many of the hydrographs show dramatic rises and falls in water level elevations, as a result of purging and sampling efforts. Second, except at Site 4, the strata being monitored behave hydrologically independent of each other as evidenced by discrete water level elevations. At Site 4 the potentiometric surfaces of the G-seam and the upper sandstone are typically within one foot of each other. The potentiometric surface of the lower sandstone may eventually achieve approximately the same elevation as the G-seam and upper sandstone but has a distinctly different trend.

During aquifer testing of wells G-4 and U-4 (discussed in the following section), neither well showed a response when the other was pumped. The elevation of the potentiometric surface at all wells except G-1, L-3, U-4, G-4, S-7, and U-7 are above the top of the stratum monitored indicating confined conditions hydrologically. Water levels at wells G-1, L-3, and U-7 continued to rise slowly, thus the strata these wells monitor are likely confined also. The potentiometric surface at wells U-4, G-4, and S-7 have achieved equilibrium below the top of the strata monitored by these wells indicating unconfined conditions (i.e., a free water table surface) at these sites.

Plates 2 through 4 illustrate what is thought to be the equilibrium potentiometric surface of the upper sandstone, G-seam, and the lower sandstone. Water levels continue to rise in many of the deeper monitoring wells at the North Knobs site although considerable time has passed since the wells were completed and/or purged. Therefore, the potentiometric surfaces illustrated on Plates 2 through 4 are estimates based upon existing data and the knowledge gained from the previous two UCG tests. Obviously, much more time must pass for the water levels at many of the wells to equilibrate. The hydraulic gradient based on the potentiometric surface map is approximately 0.2 feet/foot to the west. A constraint upon an accurate definition of equilibrium potentiometric surfaces is the need for periodic water samples. Each sampling event resets the water level to the elevation of the bottom of the 3/4-inch pipe installed in the well sampled. Packer systems were installed in the deep wells in part to minimize well bore storage and reduce water level equilibrium time. It appears that yields in some wells are low enough to cause long equilibration time despite these efforts.

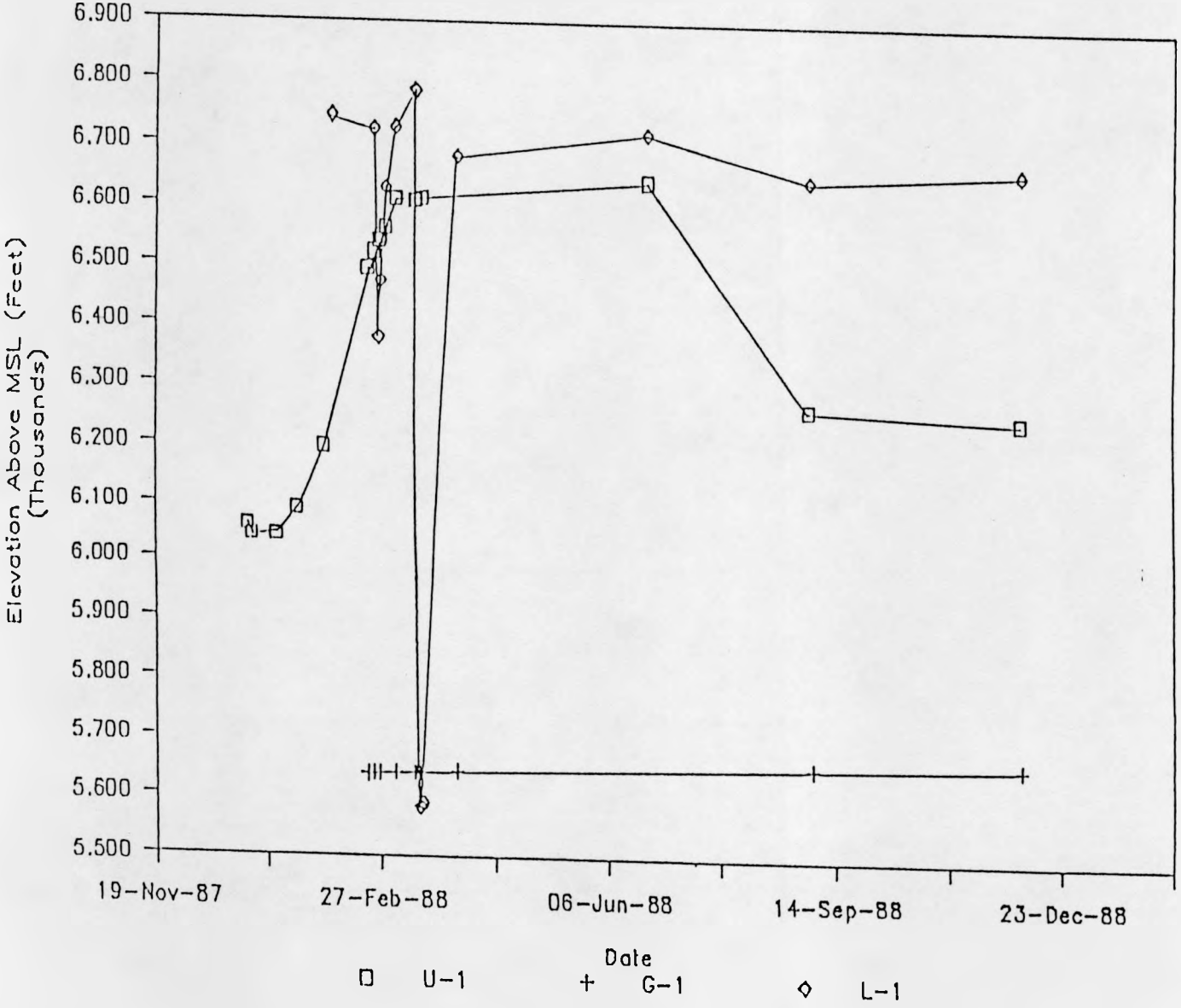
TABLE II : Water Level Data

WELL DESIGNATION

(All Measurements In Feet Below Measuring Point)

DATE	U-1	G-1	L-1	U-2	G-2	L-2	U-3	G-3	L-3	U-4	G-4	L-4	U-5	U-7	G-7	L-7	S-7	G-8
30-Dec-87	802			1074						40	42	173		784	504	851	46	
01-Jan-88	819			1113						43	42	157		784	493	816	46	
10-Jan-88														783	442	782	45	
12-Jan-88	819			1099		933				42	42	96						
21-Jan-88	772				1327	1134				39	42	73	579				44	
29-Jan-88							61	70										
02-Feb-88	666			1074	1321	1108	76	77		38	41	57	545	782	844	661	43	
05-Feb-88			120															
18-Feb-88										89	41	47						
21-Feb-88	367	1224	100	1063	1301	1010	DRY	77					696	781	236	590	42	360
22-Feb-88																		360
24-Feb-88	339	1223	140				DRY											
25-Feb-88										41	42	112			193		44	286
26-Feb-88	322	1223	484	1059	1294	733	DRY	78	289	41	42	107	637	781	179	825	44	281
27-Feb-88	315		390					79	288						176		44	
28-Feb-88								78	288	41	42	100						
29-Feb-88	301		235	1056	1291	595	DRY	78	287	41	42	95	634	781	163	816	43	250
01-Mar-88								78	285		42	92	633				43	183
02-Mar-88								78		41	42					697	43	
03-Mar-88													629		145			
04-Mar-88	252	1222	137															141
05-Mar-88										41	42	77						
06-Mar-88				1051	1282	424								781		839	43	
07-Mar-88							DRY	78										148
08-Mar-88																		44
09-Mar-88					1282					41	42	76		781				
12-Mar-88	256	1221	78							41								117
13-Mar-88	255	1222	80										634					
15-Mar-88	251	1222	1281	975	1274	374	DRY	78	279	41	42	68		781	72	481	43	291
16-Mar-88			1274										697					255
31-Mar-88		1219	182		1245	405	DRY	78	271	41	40	51	680	780	54	104	44	151
21-Jun-88										40	40	40					48	
22-Jun-88							DRY	76	227					775	32	46		156
23-Jun-88	219	<1100	143	668	907	492												
24-Jun-88													590					
01-Sep-88										41	41	42					43	
02-Sep-88							DRY	75	210					791	28	38		
03-Sep-88	595		216	950	1156	314												
04-Sep-88		1207											511					148
03-Dec-88										41	41	41			25	31	43	
04-Dec-88							DRY	75	201					791				155
05-Dec-88	609	1201	199										494					
06-Dec-88				844	1101	154												

FIGURE 6 : Water Level Elevations , Site 1



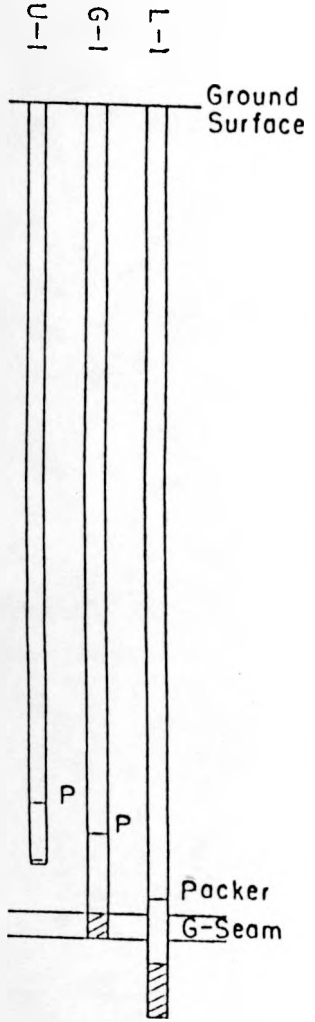
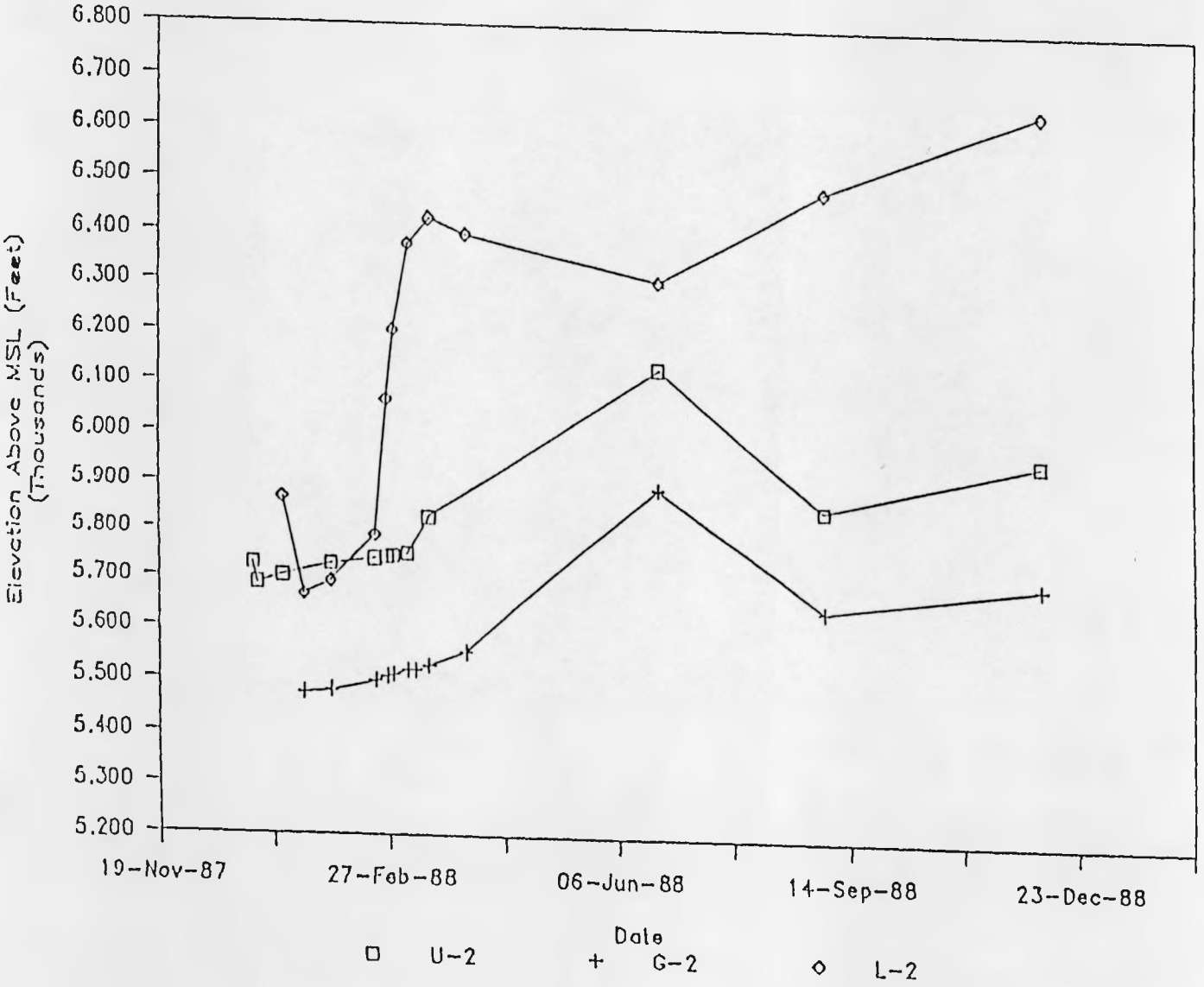


FIGURE 7 : Water Level Elevations , Site 2



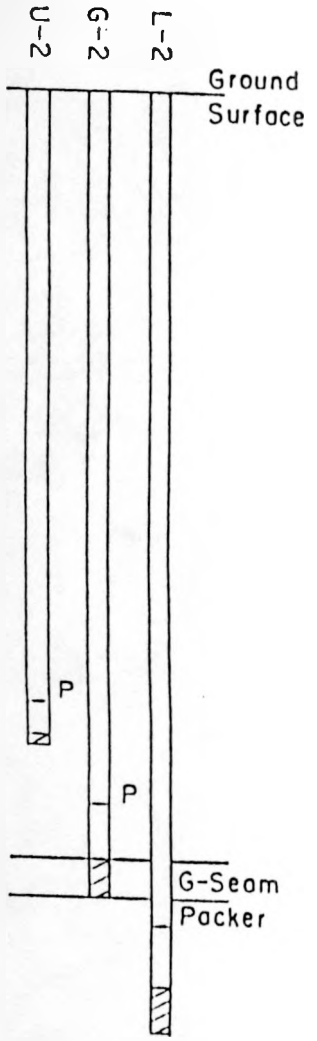
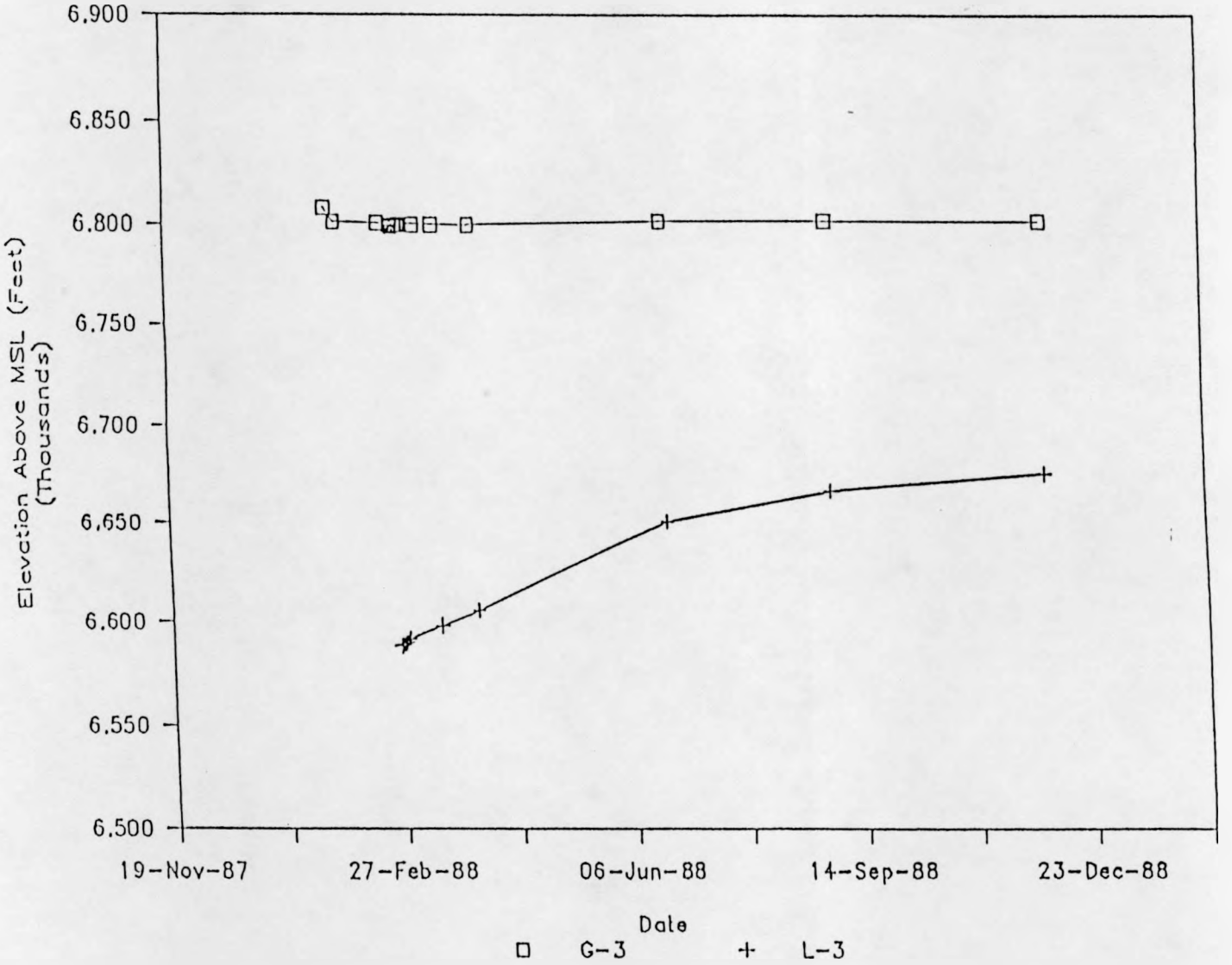


FIGURE 8 : Water Level Elevations , Site 3



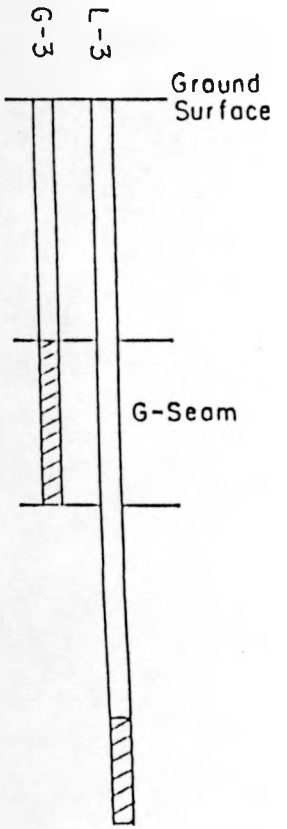
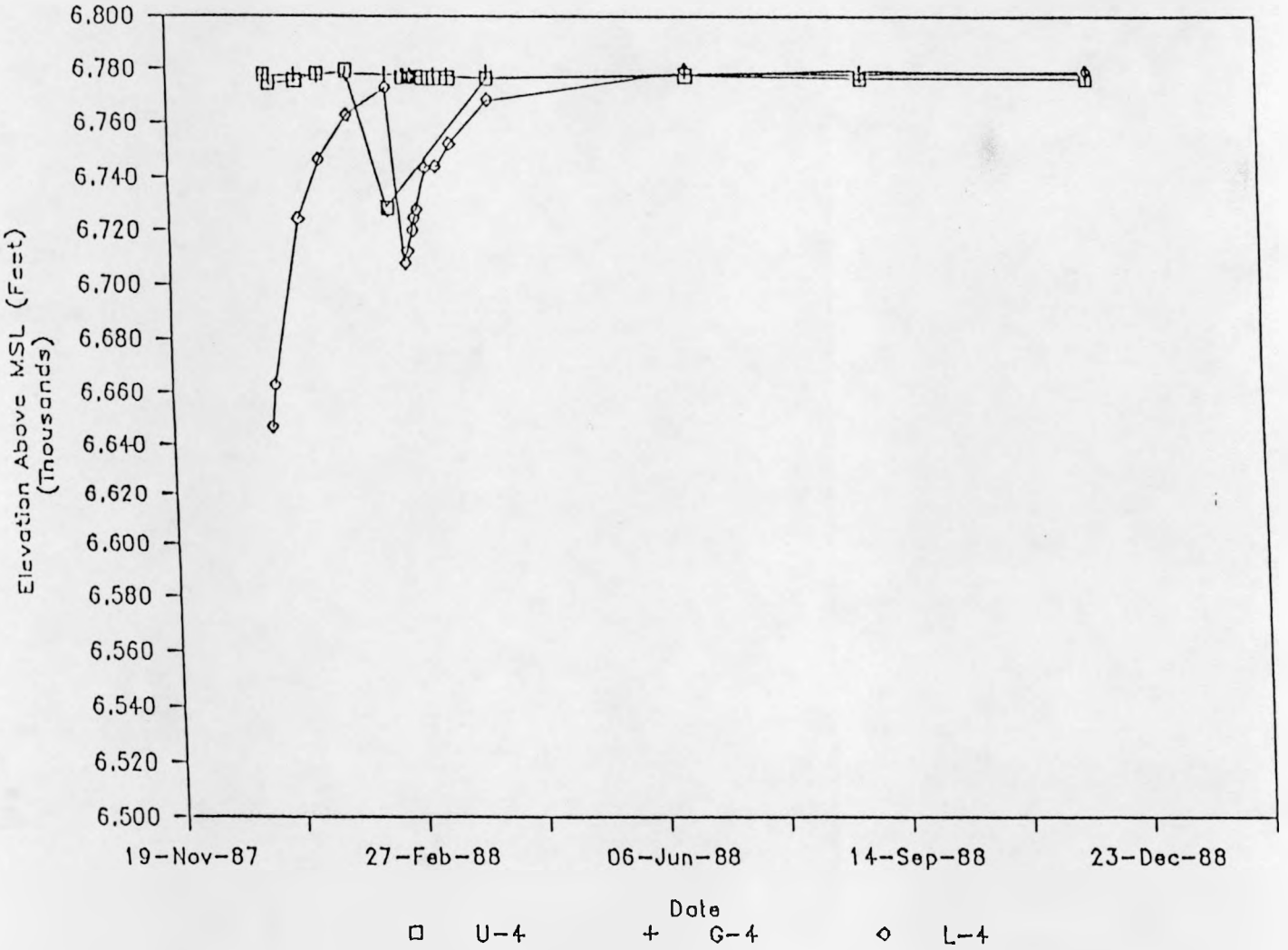


FIGURE 9 : Water Level Elevations , Site 4



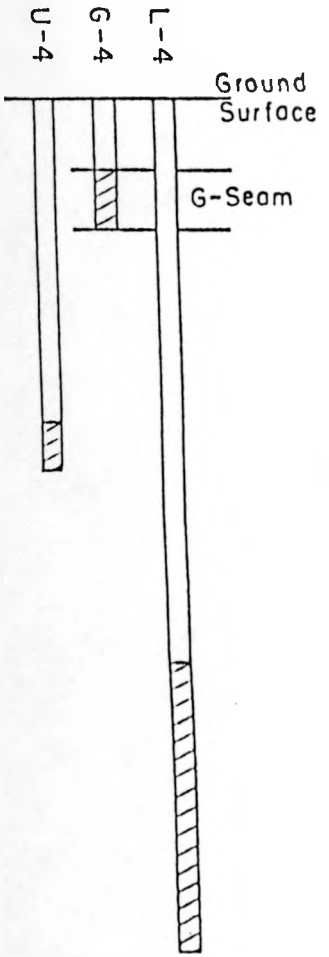


FIGURE 10 : Water Level Elevations , Site 5

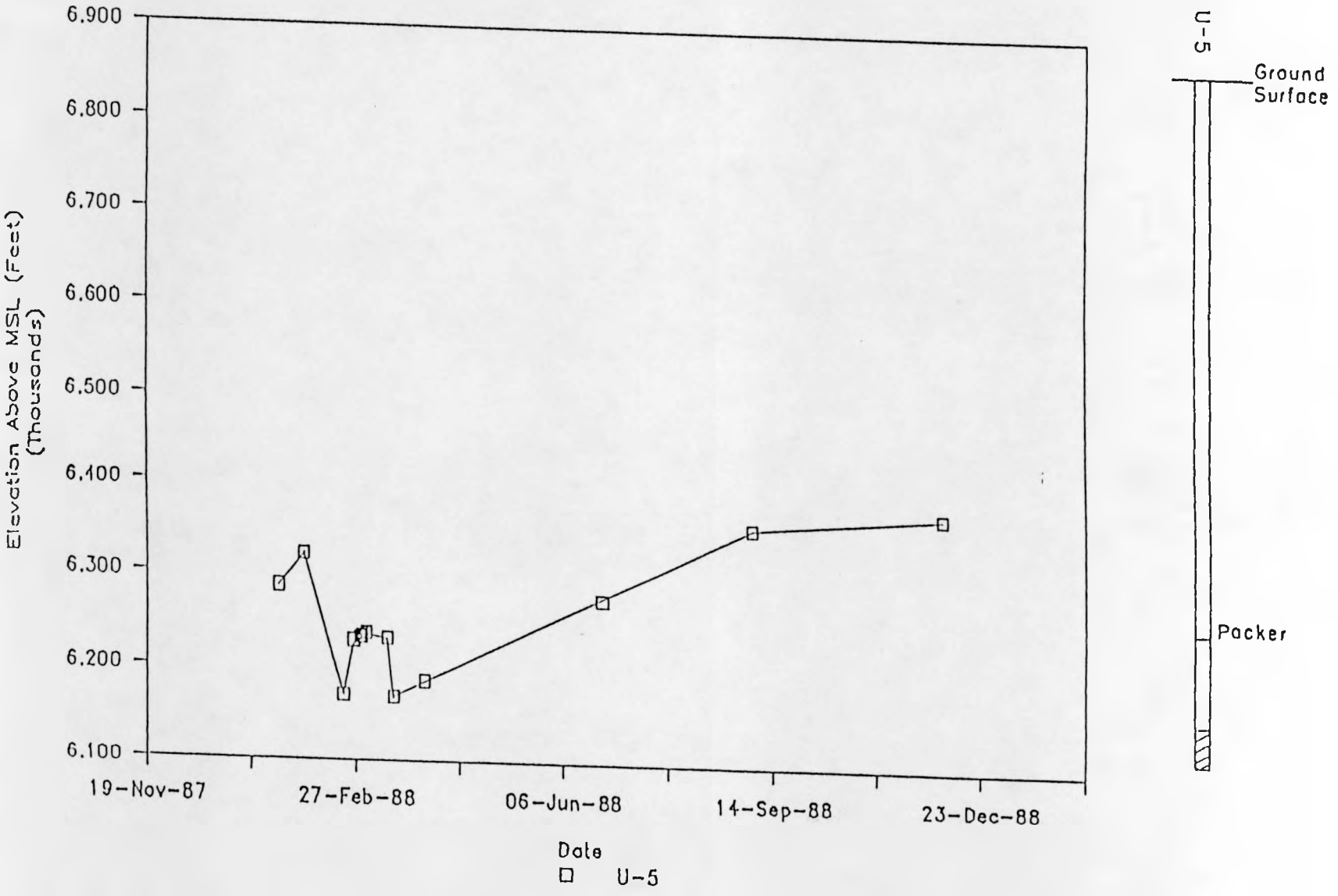
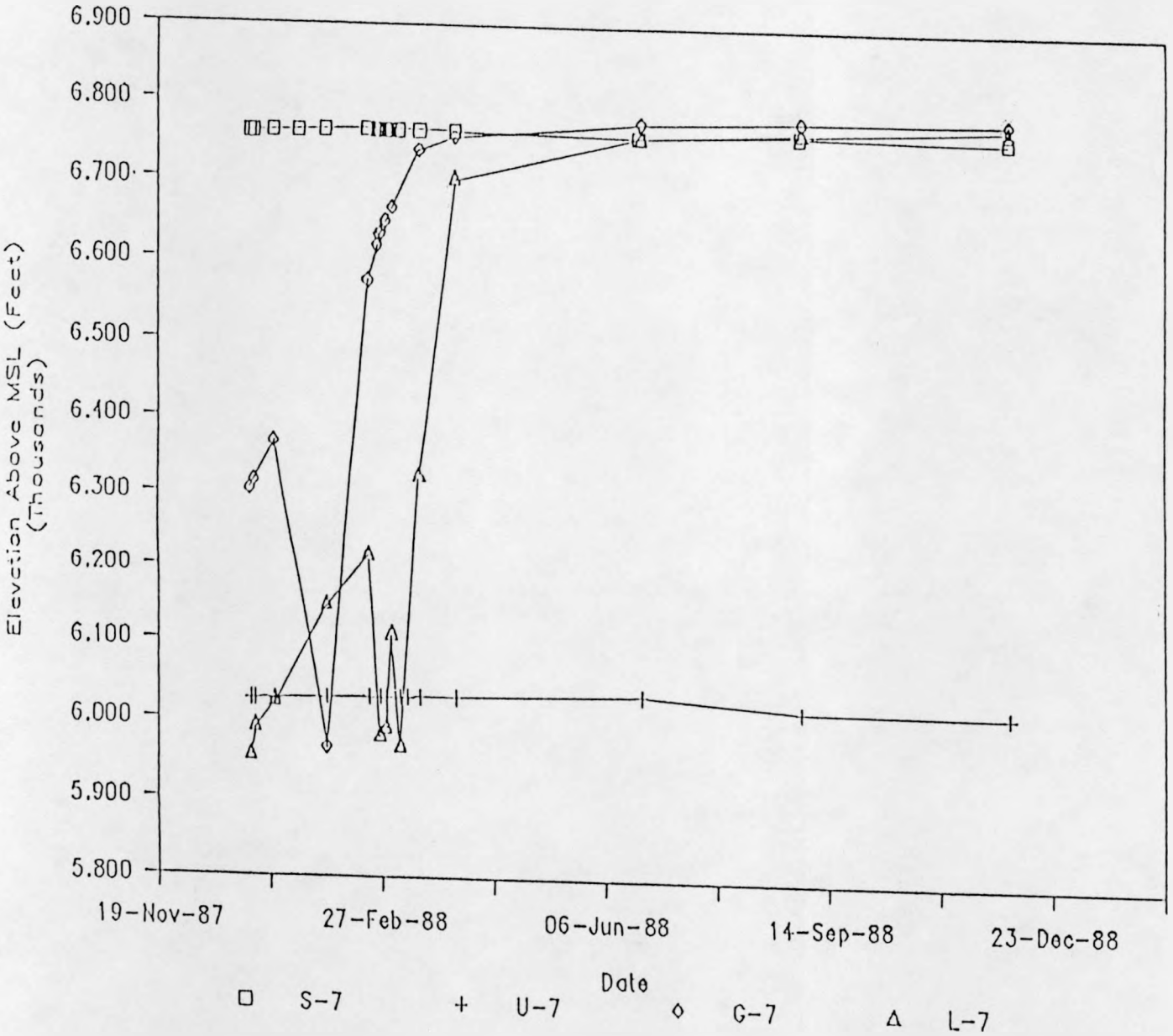


FIGURE 11 : Water Level Elevations , Site 7



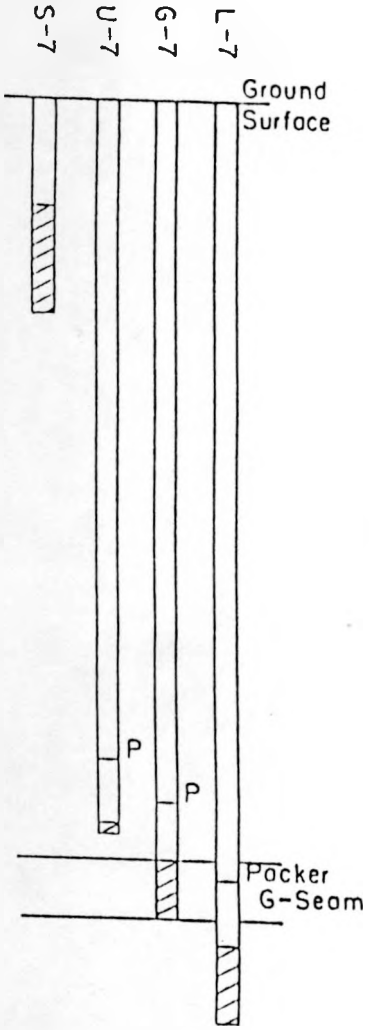
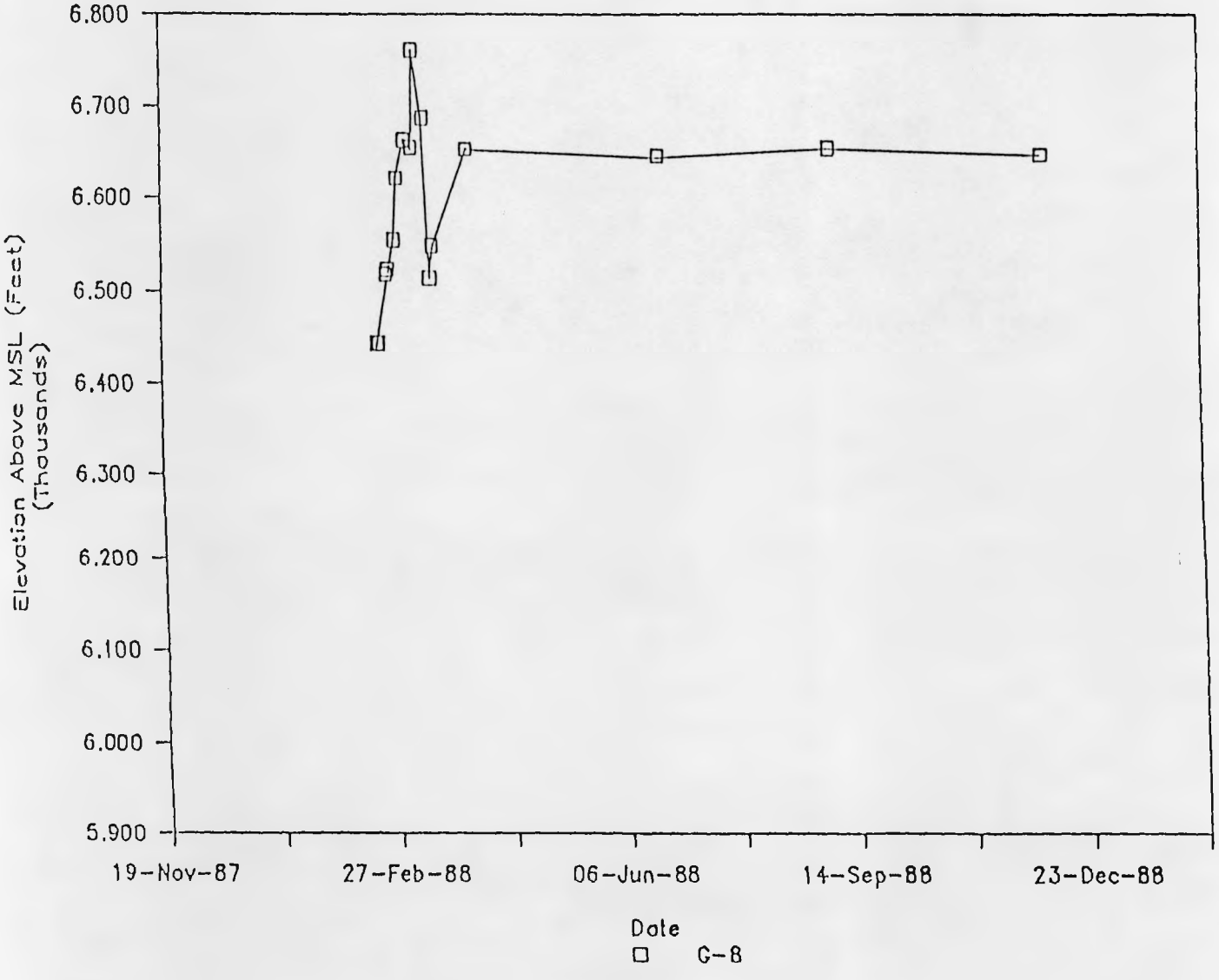


FIGURE 12 : Water Elevations , Site 8



Hydrogeologic Characteristics

All of the wells at the project site have been evaluated for transmissivity and hydraulic conductivity via single-well aquifer tests. Because of the nature of single-well tests, the storage coefficient of the monitored strata has not been evaluated. Aquifer test techniques are presented in available references such as Schafer (1980), Driscoll (1986), Freeze and Cherry (1979), Kruseman and De Ridder (1983), Lohman (1979), and Barrett (1980) et al. Table III summarizes the aquifer test data.

In the calculation of hydraulic conductivity from transmissivity (or vise versa if the analysis yielded a value of hydraulic conductivity), the penetrated thickness of the stratum was used as the aquifer thickness instead of the true thickness of the stratum since the zone of influence was centered about the well. This is in accordance with the test site geometry described by Krueseman and De Ridder (1983) for the evaluation of sloping aquifers. Unfortunately the methodology of Kruesman and De Ridder (1983) is not applicable here because the strata dip is more than 11 degrees. The aquifer test analyses employed here provide estimates of transmissivity and hydraulic conductivity rather than precise values. This is due to the steeply dipping nature of the strata which causes a deviation from the assumption of an aquifer of infinite areal extent. Because the analyses provide only estimates, no attempt was made to fine-tune the analyses for unconfined conditions (as per Stallman (1976) or partial penetration.

In the three drawdown-recovery tests performed no evidence of hydrologic boundaries is apparent in the trends of the data although it is possible that casing storage effects mask the boundary effects. The radius of influence of the slug tests was not likely great enough to be influenced by boundary conditions.

Mention should be made that some of the values of transmissivity and hydraulic conductivity derived from the Schafer (1980) analyses are best termed "tentative" because of the limited number of data points used in the evaluations. Also, the Schafer method appears to yield lower values than other more traditional methodologies.

A perusal of Table III reveals that except near the subcrop, the strata of the North Knobs site have very low values of transmissivity and hydraulic conductivity. This is consistent with findings in the previous two UCG tests. A physical manifestation of such low values of transmissivity and hydraulic conductivity is the very slow water level responses evident at most wells. Assuming a porosity of one percent at depth results in ground water velocities estimated to be on the order of 10^{-3} to 10^{-5} feet per day (0.4 to 0.004 feet per year). Assuming a higher porosity would result in slower estimates of ground water velocities.

TABLE III : Summary of Aquitard Test Data

Well	Well Diameter (in)	Type of Test[a]	Dates	Transmissivity (gpd/ft)	Transmissivity (ft^2/d)	Aquifer Thickness (ft)	Hydraulic Conductivity (gpd/ft^2)	Hydraulic Conductivity (ft/d)	Analysis[b]
U-1	4	R	1/1/88-3/15/88	$3x10^{-5}$	$4x10^{-6}$	10	$3x10^{-6}$	$4x10^{-7}$	4
G-1	4	R	2/21/88-3/12/8	$8x10^{-3}$	$1x10^{-3}$	60	$1x10^{-4}$	$2x10^{-5}$	4
L-1	4	R	2/26/88-3/12/8	$1x10^{-3}$	$2x10^{-4}$	80	$1x10^{-5}$	$2x10^{-6}$	4
U-2	4	R	1/1/88-3/15/88	$1x10^{-4}$	$2x10^{-5}$	35	$4x10^{-6}$	$5x10^{-7}$	4
G-2	4	R	1/21/88-3/15/8	$9x10^{-4}$	$1x10^{-4}$	65	$1x10^{-5}$	$2x10^{-6}$	4
L-2	4	R	2/21/88-3/15/8	$4x10^{-4}$	$6x10^{-5}$	70	$6x10^{-6}$	$8x10^{-7}$	4
G-3	4	S	2/26/88-2/28/8	6.7	0.9	70	$9.6x10^{-2}$	$1.3x10^{-2}$	3
G-3	4	R	2/26/88-2/28/8	1.1	0.1	70	$2x10^{-2}$	$2x10^{-3}$	4
L-3	4	R	2/26/88-3/15/8	$8x10^{-3}$	$1x10^{-3}$	60	$1x10^{-4}$	$2x10^{-5}$	4
U-4	4	S	2/28/88	112.2	15.0	15	7.5	1.0	1
U-4	4	D	3/9/88	54.6	7.3	15	3.6	0.5	2
U-4	4	R	3/9/88	26.9	3.6	15	1.8	0.2	5
G-4	4	S	2/28/88	2.9	0.4	15	0.2	$3x10^{-2}$	4
G-4	4	D	3/1/88-3/2/88	103.9	13.9	51.4	2.1	0.3	1
G-4	4	R	3/1/88-3/2/88	75.5	10.1	51.4	1.5	0.2	2
G-4	4	R	3/1/88	30.2	4.0	51.4	0.6	$7.9x10^{-2}$	5
L-4	4	R	2/25/88-3/15/8	1.9	0.3	51.4	$3.8x10^{-2}$	$5x10^{-3}$	4
U-5	4	R	2/21/88-3/3/88	$4x10^{-2}$	$6x10^{-3}$	95	$4x10^{-4}$	$6x10^{-5}$	4
U-7	4	R	12/30/88-3/15/8	$4x10^{-4}$	$6x10^{-5}$	41	$1x10^{-5}$	$2x10^{-6}$	4
G-7	4	R	2/2/88-3/3/88	$2x10^{-3}$	$2x10^{-4}$	10	$2x10^{-4}$	$2x10^{-5}$	4
L-7	4	R	12/30/88-2/21/8	$2x10^{-3}$	$3x10^{-4}$	60	$4x10^{-5}$	$5x10^{-6}$	4
				$4x10^{-5}$	$6x10^{-6}$	85	$5x10^{-7}$	$7x10^{-8}$	4

a - b See Footnotes at End of Table

TABLE III : Summary of Aquitard Test Data (Continued)

Well	Well Diameter (in)	Type of Test[a]	Dates	Transmissivity (gpd/ft)	Transmissivity (ft^2/d)	Aquifer Thickness (ft)	Hydraulic Conductivity (gpd/ft^2)	Hydraulic Conductivity (ft/d)	Analysis[b]
S-7	4	S	2/27/88	712.8	95.7	110	6.5	0.9	1
S-7	4	R	3/8/88-3/9/88	132.7	17.7	110	1.2	0.2	5
S-7	4	R	3/8/88	1.7	0.2	110	$2x10^{-2}$	$2x10^{-3}$	4
G-8	4	R	3/12/88-3/16/88	$2x10^{-2}$	$2x10^{-3}$	70	$2x10^{-4}$	$3x10^{-5}$	4

a D = Drawdown
R = Recovery
S = Slug

b 1 = Barrett and Others (1980)
2 = Cooper and Jacob (1946)
3 = Cooper and Others (1967)
4 = Schafer (1980)
5 = Theis (1935)

With reference to the well potential scheme developed by the United States Department of the Interior (1981) presented here as Figure 13, the strata at the North Knobs site at any depth from the subcrop have infeasible well potential. Near the subcrop, the shallow sandstone monitored by well S-7, the upper sandstone monitored by well U-4, and the G-seam coal monitored by well G-4 have fair well potential. The values of hydraulic conductivity observed at the North Knobs site at depth are typical of well-cemented and unjointed sandstones, shales, and fractured crystalline rocks. (Driscoll, 1986; Freeze and Cherry, 1979). At depth from the subcrop it is appropriate to refer to the strata as aquitards rather than as aquifers. These aquitards are confined by less permeable strata.

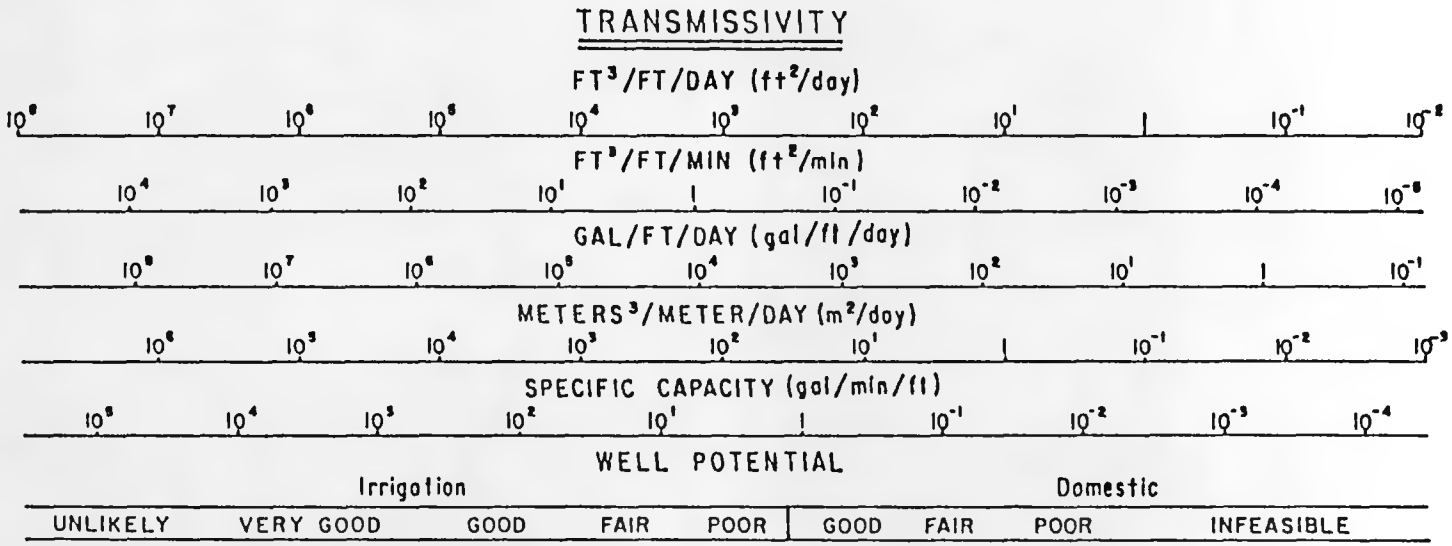
Recharge to the strata of the North Knobs site likely occurs at the subcrop beneath colluvium. The rate of recharge is unquantified; the rate is probably a very small percentage of the annual 8.9 inches per year of precipitation.

Baseline Water Quality Conditions

Results of chemical analyses of ground water sampled during the previous two UCG tests are presented in Appendix 1. The record spans late 1978 through early 1986. Figure 3 and Plate 1 depict the locations of the wells sampled. Scrutiny of the data reveals a wide range of analytical values for the samples drawn from each particular well regardless of whether the well was up or down gradient of the test burns or (as for hydrologic characterization wells P-1, H-11, and H-13) isolated from the test burns. It is likely that in part this variation is a result of using three different laboratories. Also evident, particularly in the data for conductivity and total dissolved solids concentrations, is the water quality as many of the wells took years to stabilize. Variability in water chemistry for wells completed in the same stratum and located up gradient of or beyond the test burns (e.g., wells P-1, H-18, and H-21 monitoring the G-seam; wells H-11 and H-16 monitoring the upper sandstone) is also evident in the data.

Ground water samples have been collected via methods consistent with those described by the U.S. EPA (1974) and Wyoming DEQ LQD Guideline Number 8 (1980). Specifically, when the well yielded sufficient water to allow purging, then at least three casing volumes were pumped prior to sampling. This was the circumstance for wells G-4, U-4, and S-7. All other wells yielded too little water to permit purging more than one casing volume. The sampling strategy for the low-yield wells was thus to use nitrogen gas to pressurize the four-inch casing in order to force water out of the 3/4-inch pipe set inside the four-inch casing. (The reader is referred to Figures 4 and 5 for illustrations of monitoring well construction.) The sample of ground water from the low-yield wells was collected after a volume of water at least equal to the storage within the 3/4-inch pipe had flowed. After collection of the sample, gas pressurization of the well was continued until all possible water was forced from the well so as to purge the well for future sampling.

FIGURE 13 : Well Potential Related to Transmissivity



NOTES: Transmissivity (T) = KM where
K = Permeability
M = Saturated thickness of the aquifer
Specific capacity values based on pumping period of approximately 8-hours but are otherwise generalized.

Source: U.S. Department of the Interior, Bureau of Reclamation (1977)

A portion of each sample was used to measure temperature, conductivity (corrected to 25°C), and pH. Prior to measuring these parameters, the necessary field equipment including bottled pH buffer solution was immersed in another portion of the sampled water so that the sensors and bottled buffer solution were equilibrated with respect to temperature. Filtering of the samples was performed at the time of sampling using a barrel filter outfitted with 0.45 micron membrane filters. The barrel filter and other necessary buckets were thoroughly rinsed with sample water prior to use.

Each sample set consisted of seven bottles. The first was a 750 milliliter plastic bottle containing filtered water with no chemical preservative. From this bottle the analyses for alkalinity, boron, bromide, chloride, fluoride, nitrate, and sulfate were performed. The second 750 milliliter plastic bottle contained a filtered sample and nitric acid preservative. From this bottle analyses for dissolved metals were performed. The third 250 milliliter glass bottle contained a filtered sample and sulfuric acid preservative. From this bottle, analyses for ammonia, chemical oxygen demand, dissolved organic carbon, and phenols were performed. The fourth 350 milliliter plastic bottle contained an unfiltered sample and sodium hydroxide preservative for the analyses of cyanides and thiocyanates. The fifth 250 milliliter plastic bottle contained an unfiltered sample and zinc acetate preservative the analysis of sulfide. Finally, two one-liter glass bottles containing an unfiltered sample and no preservatives were used for the analyses of heterocyclics and polynuclear aromatics; this portion of the total sample was collected directly from the well head so not to contact any plastics. Other portions of the total sample were taken from pre-rinsed three-gallon plastic buckets used to carry the sampled water from the well head to the field equipment and sample bottles.

The sample bottles were placed in ice chests, cooled with ice, and shipped via Greyhound Bus from Rawlins, Wyoming to ACZ Inc., Laboratory Division, in Steamboat Springs, Colorado for analyses. The samples arrived at the lab well within the holding times specified by the U.S. EPA (1979). ACZ Inc., Laboratory Division is certified by the U.S. EPA.

The records of field sampling and the results of chemical analyses are presented in Appendix 2. It should be noted that the mean pH values listed in Appendix 2 were calculated by converting the pH values to hydrogen ion activities (i.e., concentrations) prior to averaging; the mean hydrogen ion activity for all samples at a well was subsequently converted to a negative logarithm to obtain the mean pH value. This manipulation avoids questionable results produced by merely averaging the logarithmic pH values. Also contained in Appendix 2 is a listing of the detection limits and analytical techniques employed by ACZ Inc., Laboratory Division. In an effort to relate these data to those gathered during the previous permit, Table IV is presented here to compare analytical results by monitored stratum. In developing this table, only data gathered from wells up gradient or isolated from the test burns were used so as not to be influenced by the UCG reactors; this presumes that any plume of contaminants resulting from the test burns would move down the hydraulic gradient. Only the analyses of ground water

sampled from the G-seam and the upper sandstone can be compared because the lower sandstone was not monitored during the previous permit. The shale immediately below the G-seam was monitored. Perusal of Table IV reveals that the ranges of the parameter values for the ground water sampled for this permit fall within the ranges observed in ground water sampled for the previous permit except for the range of temperatures of the G-seam ground water and the pH observed at upper sandstone well U-4, both having lower values than previously observed.

Organic compounds were present in the samples drawn from wells L-1, G-3, G-4, G-7, and L-7. Among the primary organic compounds of interest only naphthalene (a polynuclear aromatic) was definitively detected. Several organic compounds were tentatively detected, the highest concentration of which were normal hydrocarbons (C_{20} - C_{28}) in well G-3 at 1.57 milligrams per liter.

Comparison of the analyses presented in Appendix 2 and the "Classification System for Groundwaters of Wyoming" (WDEQ WQD, 1980) indicates that the water sampled at well U-4 is only suitable for industrial use because iron, manganese, sulfate, and total dissolved solids (TDS) concentrations exclude domestic or agricultural use. The water sampled at well G-3 is only suitable for industrial use because chloride and TDS concentrations exclude other uses. The water sampled at well G-4 is suitable for livestock use but not agriculture or domestic use. The water sampled at wells G-7 and L-1 is suitable for agricultural use and is generally suitable for livestock except for the pH values of 8.64 and 8.98, respectively, which exceeds the standard of pH 8.5. The water sample at well L-7 is suitable for industrial use and possibly for agricultural use except that the chloride concentration of 109 mg/l exceeds the standard by 9 mg/l. The water sampled at well S-7 is suitable for livestock use but not domestic or agricultural use. Of course such uses presume that water would be available in quantities that would support the possible uses. Wells U-4, G-4, and S-7 are the only monitoring wells at the North Knobs site which produced enough water to provide for limited stock or domestic use.

Presently there are no Wyoming or Federal quality criteria for the organic compounds detected in the ground water samples.

Quality Assurance

Quality control and quality assurance for the analyses of ground water samples will be effected in each quarterly sampling effort via the collection of two duplicate and two split samples for analyses by laboratories certified by the U.S. EPA. The analyses of sample splits and duplicates will be reported with the routine analyses. Once per year a spiked sample will be sent to the primary laboratory for analysis.

TABLE IV : Comparison of Groundwater Concentrations (Prior Tests vs. Current Sampling Efforts)

Parameter	Wells P-1 H-18 H-21 Ranges	Wells G-3 G-4 G-7 Ranges
pH (units)	7.7 - 12.1	7.37 - 9.55
Conductivity (umhos/cm at 25°C)	2105 - 28500	1230 - 8900
T (°C)	7.2 - 12.0	6.0 - 12.0
Eh (mv)	-275 - +400	+120 - +313
Alkalinity as $CaCO_3$ (mg/l)	42 - 2320	694 - 1264
Ammonia as Nitrogen (mg/l)	0.1 - 2.22	0.32 - 5.7
Cyanide, Total (mg/l)	0.00001 - 0.004	<0.002 - 0.002
Phenol (mg/l)	0.006 - 1.2	<0.01 - 0.02
Solids, Total Dissolved (mg/l)	530 - 28400	1130 - 8550
Organic Carbon (mg/l)	1 - 967	20 - 163

TABLE IV : Comparison of Groundwater Concentrations

(Continued)

Parameter	Wells H-11 H-16 Ranges	Wells U-4 U-5 Ranges
pH (units)	8.08 - 11.9	7.35 - 10.6
Conductivity (umhos/cm at 25°C)	1700 - 50000	3470 - 4300
T (°C)	6.1 - 11.1	6.5 - 12.0
Eh (mv)	-390 - +310	+60 - +318
Alkalinity as $CaCO_3$ (mg/l)	203 - 1160	693 - 765
Ammonia as Nitrogen (mg/l)	0.1 - 3.3	2.4 - 4.41
Cyanide, Total (mg/l)	0.00001 - 0.046	<0.002
Phenol (mg/l)	0.001 - 3	<0.01 - 0.19
Solids, Total Dissolved (mg/l)	400 - 7580	2500 - 5170
Organic Carbon (mg/l)	1 - 130	<1 - 211

III. SURFACE WATER HYDROLOGY

Physiography

The proposed UCG area is on the west side of the Rawlins anticline on a hill slope approximately 1.5 miles east of Separation Creek. According to the U.S. Geological Survey basin classification, the North Knobs site is included in the Green River Basin. The hydrologic unit including the North Knobs site is also known as the Great Divide Basin. Low-lying dissected planes and basins are characteristic of the area surrounding the North Knobs site. Elevations at the North Knobs site range between 6790 and 6950 feet above sea level.

Climate

From U.S. Weather Bureau records collected at Rawlins, about nine miles to the east, the North Knobs site can be characterized as having low precipitation, widely varying temperatures, and high evaporation rates enhanced by frequent windy conditions.

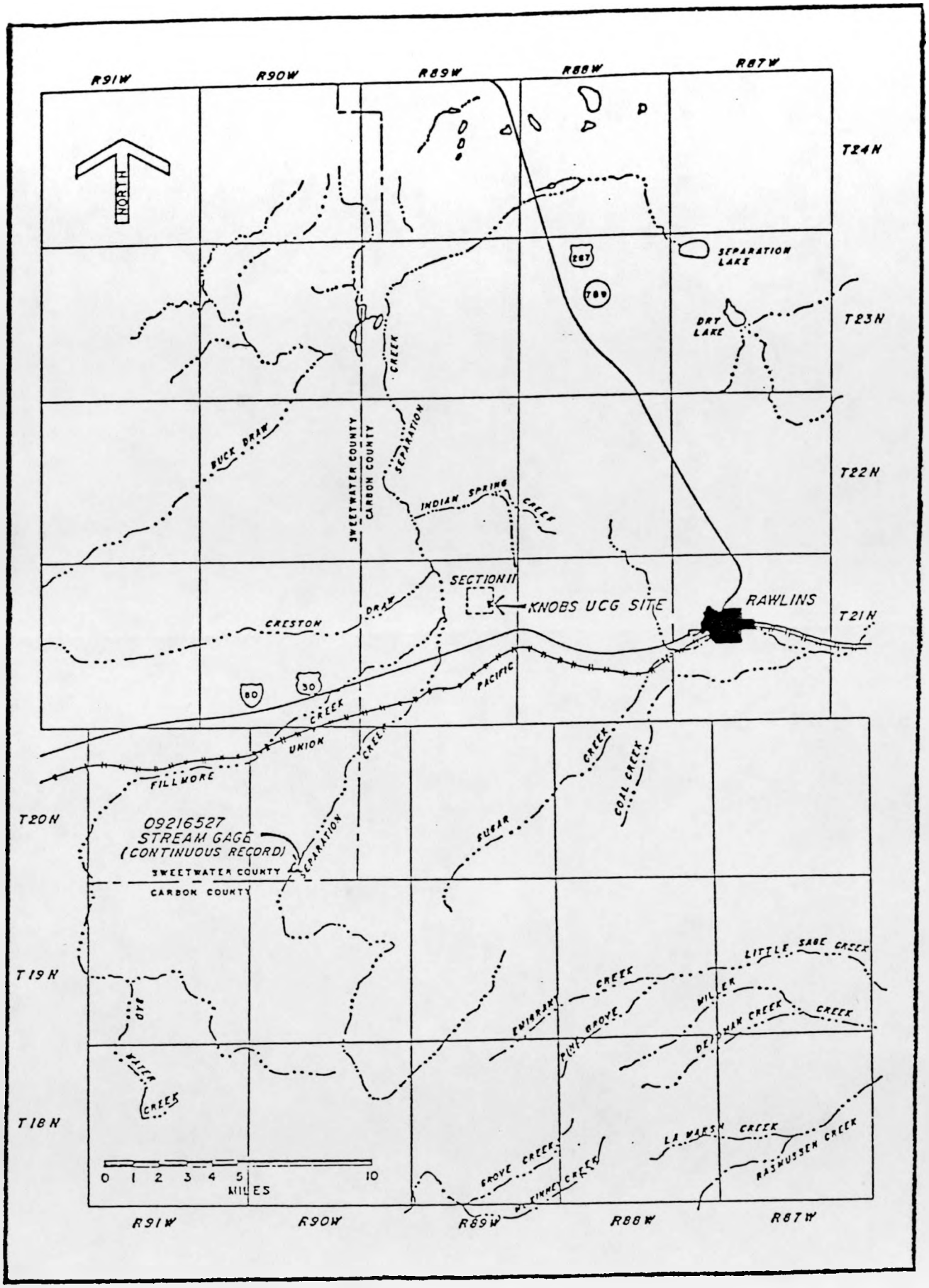
The normal precipitation is approximately 8.9 inches per year. The annual precipitation is highly variable as is typical of the arid and semi-arid west. The monthly distribution of precipitation is typical of south-central Wyoming with low precipitation in the winter months giving way to increasing precipitation through the spring until a peak in May. Winter snows are subject of redistribution by wind and also to large sublimation losses. Summer precipitation often occurs in localized small thundershowers which are rarely sufficient to generate local surface runoff. Often there is an increase in precipitation in September and October.

The average temperature at the Rawlins weather station is 43.5°F. The frost-free period is short, reaching from June to the early part of September. The mean monthly temperature in July approaches 68°F with the highest maximum temperature observed exceeding 100°F.

Watershed Description

Separation Creek originates on the southwest side of Separation Peak, approximately 13 miles to the southwest from Rawlins at an elevation of about 8400 feet. Figure 14 depicts the general surface drainage in the vicinity of the North Knobs UCG site. The original southwestern course of Separation Creek on the west side of the Atlantic Rim changes to a westerly course, then turns toward the north on the west side of Red Rim. After crossing the Union Pacific Railroad line and Interstate 80, Separation Creek continues in a general northern direction for about 18 miles passing to the west of the project site and proceeding to the west side of the Rawlins uplift. In Section 8, T23N, R89W, Separation Creek turns northeast for a distance of ten miles, then after short travel in a southeasterly direction, terminates in Separation Lake about 14 miles to the north of Rawlins at an elevation of about 6,400 feet.

FIGURE 14 : Surface Drainage Map



Separation Lake is a dry lake bed throughout most of the year and does not have a surface outflow from the basin. Surface drainage indicates Separation Lake as a sink hole, collecting runoff water at times of high spring runoff or heavy storms. A large part of the water collecting in Separation Lake is subject to evaporation; only a minor portion of the lake water recharges the unconfined alluvial aquifer surrounding the lake. Although there are no substantiating data, general geologic information for the area indicates that it is possible that the alluvium is connected to an alluvium tributary to the North Platte River where some of the underflow from the Separation Lake alluvial aquifer possibly joins the North Platte River. If this is the case, then the time required for water to percolate from Separation Creek to the North Platte River is likely on the magnitude of hundreds of years.

Separation Creek is intermittent near the test area and up to an elevation of about 7,000 feet. Above this elevation Separation Creek has perennial flow. The altitude of the channel of Separation Creek proximate to the permit area is about 6,640 feet.

Coursing through the permit area is an unnamed intermittent tributary to Separation Creek. This tributary has a drainage area of 1.13 square miles at the western permit boundary and 1.39 square miles at the eastern permit boundary (Plate 5). This drainage has a maximum relief of 560 feet as measured from the western permit boundary.

A small ephemeral tributary drainage to Separation Creek headwaters exists in the northern permit area beyond the area to be disturbed by the UCG operations. The extreme north and south ends of the permit area are parts of larger intermittent drainages. These drainage areas are depicted in Plate 5.

Surface Water Quantity and Quality

The runoff estimation technique of Craig and Rankl (1978) has been used to estimate maximum flood flow discharge rates and total flood volumes for floods of various recurrence intervals. The discharge rates and flood volumes were calculated for the two stream gauging sites depicted on Plate 5. Table V lists the regression equation, regression constants, and equation variables used in the calculations in addition to the results. This methodology is not applicable to very small drainages such as the ephemeral drainage headwatered in the northern permit area.

The North Knobs UCG site lies within the Great Divide Basin on an upland with snowmelt and storm runoff producing limited surface water flows. For this reason and because of the limited surface disturbances likely to result from the UCG project, continuous surface water monitoring is not thought to be necessary.

TABLE V : Discharge Estimates

Estimates Using Craig and Rankl (1978) Method at Stream Gaging Sites on the Permit Area Boundary.

Mathematical model

$$Q_n \text{ or } V_n = a A^{b_1} S_B^{b_2} R_m^{b_3} S_{10/85}^{b_4}$$

Flow characteristic	Regression constant (a)	b_1	b_2	b_3	b_4	Correlation coefficient	Average standard error of estimate (percent)
Q_2	34.06	1.134	1.216	−1.609	0.539	0.88	40
Q_5	30.77	1.105	1.135	−1.412	.588	.91	33
Q_{10}	32.99	1.094	1.080	−1.308	.603	.92	32
Q_{25}	37.73	1.086	1.012	−1.192	.613	.92	33
Q_{50}	43.88	1.084	.962	−1.118	.616	.91	34
Q_{100}	50.25	1.082	.914	−1.047	.615	.90	37
V_2	568	1.242	.898	−1.716	—	.91	37
V_5	529	1.190	.806	−1.490	—	.93	31
V_{10}	552	1.168	.750	−1.380	—	.93	30
V_{25}	584	1.142	.687	−1.260	—	.93	30
V_{50}	630	1.128	.641	−1.186	—	.92	31
V_{100}	666	1.115	.601	−1.119	—	.92	32

A Drainage area, in square miles.

R_m Maximum relief in basin, in feet; the difference in elevation between the channel at the gage and the highest point in the basin, determined from topographic maps.

S_B Basin slope, in feet per mile, obtained by measuring the lengths (in miles) of all contour lines within the drainage boundary, multiplying by the contour interval in feet, and dividing by the drainage area in square miles. Reasonable accuracy can be obtained on most topographic maps by measuring only the 100-foot contour lines.

$S_{10/85}$ Main-channel slope, in feet per mile, determined from elevations at points 10 and 85 percent of the distance along the channel from the gaging station to drainage-basin divide.

TABLE V : Discharge Estimates (Continued)

Estimates Using Craig and Rankl (1978) Method at Stream Gaging Sites on the Permit Area Boundary.

Parameter	Upstream Site	Downstream Site
A (mi^2)	1.13	1.39
S_B (ft/mi)	919.0	871.6
R_m(ft)	520	560
$S_{10/85}$(ft/mi)	236.1	219.6
Q_2 (cfs)	127.3	128.9
Q_5 (cfs)	295.5	301.9
Q_{10} (cfs)	452.1	465.3
Q_{25} (cfs)	708.7	736.5
Q_{50} (cfs)	945.9	990.5
Q_{100} (cfs)	1210.1	1276.7
V_2 (acre-feet)	6.6	7.2
V_5 (a-f)	13.4	14.7
V_{10} (a-f)	19.0	21.0
V_{25} (a-f)	27.6	30.7
V_{50} (a-f)	34.5	38.6
V_{100} (a-f)	42.1	47.3

IV. WATER RIGHTS

A listing of all active (i.e., not cancelled) water rights (adjudicated, and unadjudicated but in good standing) within three miles of the permit area is presented in Table VI and depicted on Plate 6.

As can be seen, the majority of ground water rights are for monitoring wells associated with the two previous UCG tests at the North Knobs site. The ground water right nearest the permit area that is not for a monitoring well is P11242W, Sandstone Separation #1, owned by the Sandstone Sheep Company of Rawlins, Wyoming. The right is for 17.5 gallons per minute from a depth of 420 to 452 feet. In consideration of the structural geology of the area, the Sandstone Separation #1 well is completed many hundreds of feet stratigraphically above the affected strata of the North Knobs site. Monitoring data gathered from the two previous UCG tests at the North Knobs site indicate that impacts to water levels will be localized within 100 to 200 feet of the UCG reactor and well within the proposed permit area. Other ground water rights lie at distances and stratigraphic positions beyond which might reasonably be expected to be impacted by the UCG operations.

There is only one active surface water right within three miles of the permit area. This is for the Larson Ditch, permit No. 1259, dated June, 1889, and located in the south half of the southeast quarter of Section 11, Township 21 North, Range 89 West (see Plate 6). The water right is for 0.3 cubic feet per second for livestock and irrigation use on 20 acres. A field search could not locate this ditch or any other man-made surface water feature in the listed quarter section. It is thought that this water right is listed in the wrong section or township or range. The limited surface disturbance caused by the North Knobs UCG project should have no effect on this water right.

V. ABANDONED DRILL HOLES

A listing of plugged and abandoned drill holes and monitoring wells is presented in the Geology Report of Volume I. The methodology of plugging and abandonment is also discussed.

VI. PROJECT IMPACTS

The North Knobs site does not have significant water resources. At the depth of the UCG reactor, affected strata are aquitards. Near their subcrop beneath the colluvium, the affected strata have fair potential for water production. The ground water, if available in sufficient quantities, is suitable for industrial use. Impacts to the surface water system should be localized because of the limited surface disturbance of the project. Use of alternative sediment controls will prevent changes in the prevailing hydrologic balance off site.

TABLE VI : Active Groundwater Rights

Water Rights Within Three Miles of the North KnobsUCG Site Permit Boundary.

LOCATION N TNSP	W RNG	SEC	1/4 OF 1/4	SEO PERMIT NO.	WELL DEPTH (FT)	SWL DEPTH (FT)	WELL YIELD (GPM)	SCREEN TOP (FT)	SCREEN BOT (FT)	USE	
21	88	19	SW NE	P7977W	305	40	4	260	305	DOM	
21	89	10	NE SE	P11242P	452	NA	17.5	420	446	STO	
21	89	11	NW NE	P40985W	600	91	NA	NA	NA	MIS	MON
21	89	11	SE SW	P40983W	520	106	NA	NA	NA	MIS	MON
21	89	11	NE SE	P40984W	580	116	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42590W	550	90	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42591W	570	65	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42592W	573	62	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42593W	596	80	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42598W	490	53	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42599W	550	450	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42600W	650	61	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42602W	550	67	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42603W	567	59	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42604W	800	84	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42605W	697	88	NA	NA	NA	MIS	MON
21	89	11	NE SE	P42608W	550	78	NA	NA	NA	MIS	MON
21	89	11	NE SE	P49792W	455	398	NA	NA	NA	MIS	MON
21	89	11	NE SE	P49793W	457	391	NA	NA	NA	MIS	MON
21	89	11	NE SE	P49794W	225	195	NA	NA	NA	MIS	MON
21	89	11	NE SE	P51836W	660	95.5	NA	NA	NA	MIS	MON
21	89	11	NE SE	P51837W	659	95	NA	NA	NA	MIS	MON
21	89	11	NE SE	P51838W	367	102.2	NA	NA	NA	MIS	MON
21	89	11	NE SE	P55287W	660	95.5	NA	NA	NA	MIS	MON
21	89	21	SW SW	P4421W	280	20	15	240	280	MIS	
21	89	22	NE NE	P11243P	252	NA	17.5	NA	NA	STO	
21	89	22	SE NE	P46864W	180	37	60	78	125	MIS	
21	89	22	SE NE	P71083W	180	37	75	78	125	MIS	
21	89	22	SW SW	P9773P	295	140	25	NA	NA	STO	
21	89	22	SW SW	P71359W	295	140	15	NA	NA	MIS	

NA Not Available

DOM Domestic
MIS Miscellaneous
MON Monitoring
STO Stock

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APPENDIX 1

GROUND WATER ANALYSES FROM
PRIOR UCG TESTS

Detection limits for the sample parameters were reported by Wyoming Analytical Labs and calculated for these specific samples according to the sampling methods. They are as follows:

Parameter	Limit
TDS	1 mg/L
Phenol	0.01 mg/L
Alkalinity	1 mg/L
Ammonia	0.2 mg/L
TOC	3 mg/L
Cyanide	0.1 ug/L

Baseline water analyses from December of 1978 are shown on the following table for wells H-13, P-1, and H-11. Analyses for all wells from first sample through January 1986 are shown on the following tables.

BASELINE DATA

December 7, 1978

Measured Parameter	Units	H-13	P-1	H-11
pH		11.0	12.1	11.9
Conductivity	micromhos	2300	27000	7000
Temperature	farenheit	49.1	47.0	47.0
Alkalinity (as $CaCO_3$)	mg/L	186	1320	696
Ammonia (as N)	mg/L	0.2	1.0	0.4
Cyanide	microgram/L	< 10	< 10	< 10
Phenols	microgram/L	14	9	< 1
TDS	mg/L	1840	23200	4680
TOC	mg/L	27	< 1	< 1

Water Analyses from Well P-1

Date	Lab	pH	Conductivity	Temperature Deg F	EH	Alkalynity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
12/7/78	WAL	12.1				1320	1.0	0.01	0.009	23200	1
4/5/79	GEOCO	11.4	31900	48				0.01	0.081	28400	240
6/27/79	GEOCO	11.5	28500	49		1510		0.01	0.15	23900	176
9/25/79	GEOCO	10.8	23500	48		1320		0.01	0.42	19670	144
2/17/82	WAL	8.1	4950	46	-20	1224	1.51	0.01	0.178	5010	406
4/27/82	WAL										280
6/3/82	WAL	8.8	4510	49	-275	1080	1	0.01	0.767	4820	412
10/2/82	WAL	8.8	4550	49	-260	844	0.553	0.01	0.704	4750	338
10/2/82	RMAL								0.014		8.5
1/19/83	WAL										
1/19/83	RMAL										
7/10/83	WAL	8.8	5200	10	-80	1070	1	0.5	0.663	4350	967
1/24/84	WAL	9.2	5770	11	+125	1190	1	0.5	1.2	4880	274
1/24/84	RMAL						0.6		0.52		300
7/25/84	WAL	9.75	7250	52		1230	<0.5	<0.5	0.55	4810	360
7/25/84	RMAL	9.75	7250	52		1230	0.9	0.6	0.23		340
1/08/85	WAL	9.85	6210	52	-245	1580	0.49		0.4	4480	
1/08/85	RMAL	9.85	6210	52	-245	1580	0.3	1.1	0.28		330
7/15/85	WAL	9.9	5460		-215	1530	0.26	2.4	0.3	4460	500
7/15/85	RMAL						0.1		0.5		360
1/26/86	WAL	10.2	4495	46	+10	1720	0.5	<0.1	0.17	4190	205

Water Analyses for Well H-11

Date	Lab	pH	Conductivity	Temperature Deg F	Eh	Alkalynity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
12/7/78	WAL	11.9				696	0.4	0.01	0.001	4680	1.0
4/5/79	GEOCO	11.7	50000	48				0.01	0.003		14
6/27/79	GEOCO	10.0	9500	50		602		0.01	0.022	7580	8
9/25/79	GEOCO	9.4	4520	51		925		0.01	0.018	400	15
8/11/81	WAL	9.6	3600			708	0.9	0.01	0.012	2400	7
2/17/82	WAL	11.2	5150	43	-45	809	1.25	0.01	0.012	3950	4
10/2/82	WAL	10.1	3550	49	+100	615	0.553	0.01	0.001	2360	37.7
10/2/82	RMAL										
1/19/83	WAL	10.15	3300	49	-115	629	0.553	0.8	0.001	2250	8.61
1/19/83	RMAL								0.0		12
7/10/83	WAL	10.25	3600	51.8	-80	777	1.18	1.5	0.01	2260	146
1/24/84	WAL					776	1	0.5	0.03	2450	25.2
1/24/84	RMAL						0.7		0.02		20
7/25/84	WAL	10.3	3950	52		708	1.0	<0.5	<0.01	2440	16
7/25/84	RMAL	10.3	3950	52			1.1		0.02		22
1/08/85	WAL	10.25	3940	52	-110	713	1.1	<0.1	0.05	2600	15
1/08/85	RMAL	10.25	3940	52	-110		1.6		0.01		11
7/15/85	WAL	10.2	4490		-140	648/667	1.4	2.4	<0.02	3150	11
7/15/85	RMAL	10.2	4490		-140		0.1		0.5		23
1/26/86	WAL	10.7	2905	47	+50	757	1.7	0.28	<0.01	2330	<3

Water Analyses for Well H-13

Date	Lab	pH	Conductivity	Temperature Deg F	EH	Alkalynity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
12/7/78	WAL	11.0				186	0.2	0.01	0.014	1840	27
4/5/79	GEOCO	10.9	>50000	48				0.01	0.011	65100	36
6/27/79	GEOCO	10.5	750000	50		2		0.01	0.057	63450	115
9/25/79	GEOCO	10.4	33000	49		320		0.01	0.024	29410	232
2/17/82	WAL	10.3	7700	49	-325	772	6.7	0.01	0.028	15800	123
4/27/82	WAL						7.23			12200	375
6/3/82	WAL	12.3	11050	54	-300	946	8.21	0.01	0.154	9260	292
10/2/82	WAL	12.2	11000	54	-240	717	6.2	0.01	0.14	9560	235
10/2/82	RMAL								0.13		200
1/24/84	WAL	11.5	11300	50	-125	868	10.4	0.5	1.15	6360	86.3
1/24/84	RMAL						11.0		0.46		100
7/25/84	WAL	12.0	12480	52		796	10.1	1.8	0.42	6380	150
7/25/84	RMAL	12.0	12480	52	-285	796	10.0		0.06		110
1/08/85	WAL	10.3	10255	52	-285	742	9.7	<0.1	0.36	5470	95
1/08/85	RMAL	10.3	10255	52	-180	742	11.0		0.18		100
7/15/85	WAL	11.2	10920			708	9.3	1.6	<0.02	7120	160
7/15/85	RMAL	11.2	10920				10		0.68		150
1/26/86	WAL	12.5	9200	46	-30	686	8.1	2.4	0.22	6180	68

Water Analyses for Well H-16

Date	Lab	pH	Conductivity	Temperature Deg F	Eh	Alkalynity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
8/29/79	GEOCO	11.2	1900	50		203		0.01	0.023	1530	13
9/12/79	GEOCO	10.2	7500	48		1030		0.01	0.22	4920	46
9/26/79	GEOCO	11.6	4800	49		1060		0.01	0.22	4510	57
11/07/79	GEOCO	11.8	1700	48		1160		0.01	0.53	4870	73
5/8/80	GEOCO					1120			0.068	4850	130
12/18/80	GEOCO	8.08	6750			124		0.01	3.0	4308	100
8/12/81	CDM	8.7	5200		+310	757	2.3	0.095	0.023	4020	10
2/17/82	WAL	8.9	3000	47	+310	955	1.85	0.016	0.006	3660	10
4/27/82	WAL						2.19	0.013			
6/3/82	WAL	9.5	3750	50	+95	745	2.02	0.021	0.137	3790	73
10/2/82	WAL	9.4	3650	49	+120	590	1.7	0.01	0.02	3860	16.6
10/2/82	RMAL						3.3	0.09			11
1/19/83	WAL	9.5	4200	49	-0.05	594	1.45	2.4	0.018	3630	12.1
1/19/83	RMAL								0.022		15
7/10/83	WAL	9.4	6100	10	-110	769	2.19	12.2	0.01	3680	109
1/21/84	WAL	9.6	4900	49	-60	786	1.98	0.5	0.446	3960	40.3
1/24/84	RMAL						2.4		0.01		12
7/25/84	WAL	9.7	5830	49		784	2.2	21.3	0.02	3960	13
7/25/84	RMAL	9.7	5830	49			2.2		0.02		15
1/08/85	WAL	8.5	5555	50	-155	872	2.2	19	<0.01	4010	15
1/08/85	RMAL	8.5	5555	50	-155		2.1		0.012		18
7/15/85	WAL	9.3	4850	46	-390	798	2.2	46	<0.02	4000	18
7/15/85	RMAL	9.3	4850	46	-390		2.1				30
1/26/86	WAL	9.7	4010	51	-100	803	2.3	37	<0.01	3800	<3

Water Analyses for Well H-17

Date	Lab	pH	Conductivity	Temperature Deg F	EH	Alkalynity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
8/29/79	GEOCO	12.2	13400	50		2730		0.1	0.09	9570	29
9/12/79	GEOCO	10.0	11800	49		830		0.1	0.31	9740	33
9/26/79	GEOCO	12.0	11200	50		2040		0.1	0.39	7140	31
11/07/79	GEOCO	12.0	11000	47		1950		0.1	0.66	7210	42
5/8/80	GEOCO					2640			1.5	7060	52
12/18/80	GEOCO	12.5	12600			2436		0.058	4.68	6840	
8/12/81	CDM	12	18000			2390	2.7	0.01	0.034	6530	45
2/17/82	WAL	12.8	7200	48	+250	2552	3.02	0.01	0.062	5540	41
6/3/82	WAL	12.8	7900	50	+80	2420	2.83	0.01	0.206	5830	51
10/2/82	WAL	12.8	8000	50	+100	1960	2.15	0.01	0.053	5960	40
10/2/82	RMAL						3.5		0.18		
1/19/83	WAL	12.6	11150	50	-200	2000	1.89	0.5	0.214	5230	32.2
1/19/83	RMAL								0.21		37
7/10/83	WAL	12.5	15200	52	-60	2370	3.66	0.5	0.01	5920	54
1/24/84	WAL	12.6	12500	48	-130	2300	2.53	0.5	0.138	5440	67.7
1/24/84	RMAL					2.7			2.1		54
7/25/84	WAL	12.6	14410	49		1140	3.0	0.58	0.25	5430	38
7/25/84	RMAL	12.6	14410	49		1140	2.3		0.14		41
1/08/85	WAL	12.1	13740	50	-375	2120	2.6	<0.1	0.22	5130	42
1/08/85	RMAL	12.1	13740	50	-375	2120	3.0		0.16		31
7/15/85	WAL	8.7	11100		-260	2060	3.2	0.7	0.19	5230	62
7/15/85	RMAL	8.7	11100		-260	2060	3.3		0.33		38
1/26/86	WAL	12.6	9980	50	-40	2270	2.8	<0.1		4790	6

Water Analyses for Well H-18

Date	Lab	pH	Conductivity	Temperature Deg F	EH	Alkalynity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
8/29/79	GEOCO	11.5	4700	50		580		0.01	0.14	3460	50
9/12/79	GEOCO	10.5	4500	47		2060		0.01	0.14	3600	47
9/26/79	GEOCO	10.9	4300	50		545		0.01	0.085	530	49
11/07/79	GEOCO	10.0	3190	47		848		0.01	0.069	3100	45
5/8/80	GEOCO					960			0.1	2640	51
12/18/80	GEOCO	10.0	3600			618		0.022	0.66	2316	
8/12/81	CDM	9.4	3400			1020	1.6	0.01	0.015	2080	35
2/17/82	WAL	10.0	3010	49	+400	567	1.91	0.01	0.006	1860	27
6/3/82	WAL	9.9	2500	51	+120	1060	1.91	0.01	0.032	2100	106
10/2/82	WAL	10.0	2700	50	+105	775	1.45	0.01	0.02	2010	58
10/2/82	RMAL						2.1		0.027		33
1/19/83	WAL	9.9	2800	50	-165	860	1.34	2.4	0.042	1890	26.9
1/19/83	RMAL								0.028		28
7/10/83	WAL	9.85	4000	53.6	-50	1130	2.22	0.5	0.013	1740	493
1/24/84	WAL	9.3	3100	50	+10	1150	2.01	0.5	0.1		
1/24/84	RMAL						1.9		0.16		23
7/25/84	WAL	10.05	3300	55		1120	1.2	1.5	0.02	1990	21
7/25/84	RMAL	10.05	3300	55		1120	2.3		0.02		26
1/08/85	WAL	10.1	3250	50	+55	1150	2.1	<0.1	0.03	1960	27
1/08/85	RMAL	10.1	3250	50	+55		2.3		<0.01		22
7/15/85	WAL	10.2	2850		-190	1220	2.8	4.0	<0.02	2030	11
7/15/85	RMAL	10.2	2850		-190		2.7		<0.02		55
1/26/86	WAL	10.6	2800	47	+20	1920	2.4	2.7	0.01	1960	13

Water Analyses from Well H-19

Date	Lab	pH	Conductivity	Temperature Deg F	EH	Alkalinity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
8/12/81	CDM	7.4	2100	47	-80	46	0.5	0.5	0.021	2100	13
2/17/82	WAL	6.5	2100	47	-80	1067	0.257	0.01	0.098	2840	52
4/27/82	WAL								1.06		
6/03/82	WAL	6.5	2400	49	-110	1050	1.0	0.01	0.437	2500	120
10/02/82	WAL	6.5	2400	49	-100	656	0.087	0.01	0.454	2090	47.5
10/02/82	RMAL								0.37		37.0
1/19/83	WAL	6.1	2300	50	-115	806	0.087	0.5	0.802	1600	34.1
1/19/83	RMAL								0.046		32
7/10/83	WAL	7.3	1950	52.7	+10	899	1.0	0.5	0.755	1110	123
1/24/84	WAL	9.1	1795	53.6	+104	717	<1.0	<0.5	0.313	1100	25.2
1/24/84	RMAL	9.1	1795	53.6							
7/25/84	WAL	9.1	1765	54		656	<0.5	1.8	0.05	1130	41
7/25/84	RMAL	9.1	1765	54			0.3		0.05		38
1/08/85	WAL	9.15	1995	54	-135	719	0.52	<0.1	0.06	1320	140
1/08/85	RMAL	9.15	1995	54	-135	719	0.7		0.04		120
7/15/85	WAL	9.3	2000	53	-210	720	0.75	1.1	0.13	1370	220
7/15/85	RMAL	9.3	2000	53	-210		0.9		0.19		160
1/26/86	WAL	9.9	1515	50	-10	814	0.5	0.98	0.12	1080	9

Water Analyses from Well H-20

Date	Lab	pH	Conductivity	Temperature Deg F	EH	Alkalinity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
8/12/81	CDM	7.3	2300	47	-50	35	0.7	0.01	0.017	3000	19
2/17/82	WAL	6.5	2300	49	-100	1820	0.493	0.01	0.18	3500	191
4/27/82	WAL										250
6/03/82	WAL	6.4	2400	51	-140	1070	1	0.01	0.751	3690	231
10/02/82	WAL	6.4	2450	51	-100	85	0.029	0.01	0.704	2920	167
10/02/82	RMAL								0.3		140
1/19/83	WAL	6.3	3000	51	-100	1300	0.058	0.5	1.28	2350	155
1/19/83	RMAL		3000						0.043		180
7/10/83	WAL	6.6	2700	48.2	-150	1290	2.19	0.5	2.93	1670	788
1/24/84	WAL	6.6	2200	56.3	-120	1070	1	0.5	1.0	1760	192
1/24/84	RMAL	6.6	2200	56.3	-120	1070					
7/25/84	WAL	8.25	2510	56		903	<0.5	2.1	0.12	1710	220
7/25/84	RMAL	8.25	2510	56			<0.1		0.07		200
1/08/85	WAL	8.3	2505	57	-135	928	0.2	<0.1	0.08	1300	210
1/08/85	RMAL	8.3	2505	57	-135		0.7		0.08		190
7/15/85	WAL	7.2	5980		-320	3520	0.72	2.4	<0.02	8180	2500
7/15/85	RMAL	7.2	5980		-320		9.5		0.61		230
1/26/86	WAL	7.7	4900	50	-105	3800	0.41	1.3	0.12	6480	1000

Water Analyses for Well H-21

Date	Lab	pH	Conductivity	Temperature Deg F	Eh	Alkalinity mg/l.	Ammonia mg/l.	Cyanide ug/L	Phenol mg/L	TDS mg/l.	TOC mg/l.
8/12/81	CDM		2800			42	0.8	0.01	0.005	2100	20
2/17/82	WAL	8.5	2250	45	-45	163	0.918	0.01	0.002		14
6/03/82	WAL	8.6	2300	49	+20	124	1.0	0.01	0.008	2070	43
10/02/82	WAL	8.7	2200	49	+20	98	0.581	0.01	0.001	1920	73.4
10/02/82	RMAL										
1/19/83	WAL	9.35	2300	49	-80	77	0.436	0.5	0.001	1750	15.8
1/19/83	RMAL								0.0		11
7/10/83	WAL					70.7	1	0.5	0.01	1620	40.8
1/24/84	WAL	7.7	2600	48.7	-210	2320		0.5	0.03	1930	61
1/24/84	RMAL						0.9		0.0		200
7/25/84	WAL	9.05	2830	50		1480	0.8	1.2	0.02	1680	23
7/25/84	RMAL	9.05	2830	50			0.8		0.01		20
1/08/85	WAL	9.5	2680	51	-260	1210	0.84	<0.1	<0.01	1640	29
1/08/85	RMAL	9.5	2680	51	-260	1210	1.4		<0.01		21
7/15/85	WAL	10.7	2410	51	-180	1180	1.0	4.0	<0.02	1690	36
7/15/85	RMAL	10.7					1.0				100
1/26/86	WAL	9.5	2105	47	-70	1211	0.96	0.98	<0.01	1630	<3

Water Analyses from Well H-22

Date	Lab	pH	Conductivity	Temperature Deg F	Eh	Alkalinity mg/L	Ammonia mg/L	Cyanide ug/L	Phenol mg/L	TDS mg/L	TOC mg/L
8/12/81	CDM	10.8	2750			579	5.4	0.852	0.344	1660	94
2/17/82	WAL	9.8	1825	49	-220	538	1.74	0.026	0.136	1300	67
4/27/82	WAL						2.44	0.01			
6/03/82	WAL	9.6	1700	55	+85	385	2.1	0.014	0.569	1210	69
10/02/82	WAL	9.6	1750	54	+100	264	0.64	0.01	0.387	1050	63
10/02/82	RMAL							0.02	0.14		29
1/19/83	WAL	9.4	1820	52	+65	855	2.94	22	0.978	1380	126
1/19/83	RMAL								0.44		140
7/10/83	WAL	10.8	2800	53.6	-55	593	6.61	0.5	0.517	1460	562
1/24/84	WAL	10.6	2500	52.7	-210	841	4.86	0.5	1.34	1800	167
1/24/84	RMAL						4.5		0.37		160
7/25/84	WAL	10.85	2610	53		787	7.5	8.3	0.57	1690	200
7/25/84	RMAL	10.85	2610	53			9.0		0.19		190
1/08/85	WAL	10.75	2505	54	-320	868	8.8	<0.1	0.62	1720	220
1/08/85	RMAL	10.75	2505	54	-320		10.0		0.35		110
7/15/85	WAL	9.95	1630		-415	832	8.3	25	<0.02	1770	300
7/15/85	RMAL	9.95	1630						0.03		1800
1/26/86	WAL	11.25	1600	56	-275	967	9.0	1.3	0.6	1720	57

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL G-3 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	02-Mar-88	21-Jun-88	02-Sep-88	04-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS								
Acenaphthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Acenaphthylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(b)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(k)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(g,h,i)Perylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Chrysene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Dibenzo(a,h)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluorene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Indeno(1,2,3-cd)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Naphthalene	3.988	<10	<10	<10	4	3.988	0.000	0.997
Phenanthrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000

TENTATIVELY IDENTIFIED COMPOUNDS	
Hexanoic Acid	85.5 (Estimated)
2-Ethyl Hexanoic Acid	50.2 (Estimated)
Normal Hydrocarbons (C20-C28)	1570 (Estimated)

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL G-4 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	02-Mar-88	21-Jun-88	01-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
Time	12:12	18:50	16:25	15:00				
Conductivity (U Mhos/Cm @ 25 Deg. C)	1900	2130	2650	2230	4	2650	1900	2227.500
pH (Units)	7.96	7.92	7.85	7.89	4	7.96	7.85	7.903
Temperature (Deg. C)	7	11	9.5	7.1	4	11	7	8.650
LABORATORY PARAMETERS								
Alkalinity as CaCO3		1185	1264	1244	3	1264	1185	1231.000
Bicarbonate as CaCO3	1316	1185	1264	1244	4	1316	1185	1252.250
Boron	<0.02	0.1	<0.02	<0.02	4	0.1	0	0.025
Bromide	0.23	0.28	0.22	0.11	4	0.28	0.11	0.210
Calcium	88	107	68	76	4	107	68	84.750
Carbon, Dissolved Organic	130	163	137	123	4	163	123	138.250
Carbonate as CaCO3	0	0	0	0	4	0	0	0.000
Chloride	33	32	31	30	4	33	30	31.500
COD	305	400	357	290	4	400	290	338.000
Cyanide, Total	0.002	<0.002	<0.002	<0.002	4	0.002	0	0.001
Fluoride	1	0.9	1	0.9	4	1	0.9	0.950
Hydroxide as CaCO3		0	0	0	3	0	0	0.000
Magnesium	37	47	39	37	4	47	37	40.000
Nitrogen, Ammonia	1.78	3.07	2.43	2.17	4	3.07	1.78	2.363
Nitrate as N	0.03	0.16	<0.01	<0.01	4	0.16	0	0.048
Nitrite as N	<0.01	0.01	<0.01	<0.01	4	0.01	0	0.003
Oxidation-Reduction Pot. (+mV)	241	160	313	248	4	313	160	240.500
Phenols	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Potassium	9	5	7	7	4	9	5	7.000
Sodium	648	6.24	662	659	4	662	6.24	493.810
Sulfate	381	473	354	317	4	473	317	381.250
Sulfide as S	0.2	0.2	0.08	0.2	4	0.2	0.08	0.170
Thiocyanate	0.9	2.1	0.6	0.8	4	2.1	0.6	1.100
Cations, Sum (meq/l)	36.18	36.79	35.91	36.01	4	36.79	35.91	36.223
Anions, Sum (meq/l)	35.25	34.53	33.58	32.38	4	35.25	32.38	33.935
Cation-Anion Balance (%)	1.3	3.17	3.35	5.31	4	5.31	1.3	3.282
Solids, Total Dissolved	2154	2264	2150	2114	4	2264	2114	2170.500
Aluminum	0.06	<0.05	0.08	<0.05	4	0.08	0	0.035
Arsenic	<0.001	0.095	0.042	0.011	4	0.095	0	0.037
Barium	0.32	0.27	0.27	0.25	4	0.32	0.25	0.278
Cadmium	<0.005	<0.005	<0.005	<0.005	4	0	0	0.000
Copper	<0.01	0.01	<0.01	<0.01	4	0.01	0	0.003
Chromium	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Iron	2.53	2.77	4.3	2.5	4	4.3	2.5	3.025
Lead	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Manganese	0.11	0.28	0.19	0.16	4	0.28	0.11	0.185
Mercury	<0.0002	<0.0001	<0.0001	<0.0001	4	0	0	0.0000
Molybdenum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Nickel	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Selenium	<0.001	<0.001	<0.001	<0.001	4	0	0	0.000
Zinc	0.01	0.04	0.01	<0.01	4	0.04	0	0.015

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL G-4 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	02-Mar-88	21-Jun-88	01-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS								
Acenaphthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Acenaphthylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(b)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(k)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(g,h,i)Perylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Chrysene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Dibenzo(a,h)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluorene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Indeno(1,2,3-cd)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Naphthalene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Phenanthrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
TENTATIVELY IDENTIFIED COMPOUNDS								
Sulfur (Mol. S8)	13.6 (Estimated)							

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL G-7 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	03-Mar-88	22-Jun-88	02-Sep-88	04-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS								
Acenaphthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Acenaphthylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(b)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(k)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(g,h,i)Perylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Chrysene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Dibenzo(a,h)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluorene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Indeno(1,2,3-cd)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Naphthalene	3.988	<10	<10	<10	4	3.988	0.000	0.997
Phenanthrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
TENTATIVELY IDENTIFIED COMPOUNDS								
Butanoic Acid	39.1 (Estimated)							

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL U-4 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	02-Mar-88	21-Jun-88	01-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
Time	14:11	13:15	14:00	12:45				
Conductivity (U Mhos/Cm @ 25 Deg. C)	3470	3985	3800	4000	4	4000	3470	3813.750
pH (Units)	7.63	7.35	7.5	7.52	4	7.63	7.35	7.488
Temperature (Deg. C)	6.5	10	10	7.9	4	10	6.5	8.600
LABORATORY PARAMETERS								
Alkalinity as CaCO3		933	922	930	3	933	922	928.333
Bicarbonate as CaCO3	996	933	922	930	4	996	922	945.250
Boron	0.08	0.12	0.08	0.06	4	0.12	0.06	0.085
Bromide	0.23	0.2	0.11	0.16	4	0.23	0.11	0.175
Calcium	453	503	389	498	4	503	389	460.750
Carbon, Dissolved Organic	23	16	93	<1	4	93	0	33.000
Carbonate as CaCO3	0	0	0	0	4	0	0	0.000
Chloride	13	21	25	31	4	31	13	22.500
COD	15	10	16	10	4	16	10	12.750
Cyanide, Total	<0.002	<0.002	<0.002	<0.002	4	0	0	0.000
Fluoride	0.2	0.2	0.1	0.2	4	0.2	0.1	0.175
Hydroxide as CaCO3		0	0	0	3	0	0	0.000
Magnesium	342	346	339	377	4	377	339	351.000
Nitrogen, Ammonia	2.64	2.4	2.44	2.49	4	2.64	2.4	2.493
Nitrate as N	0.04	<0.02	<0.01	<0.01	4	0.04	0	0.010
Nitrite as N	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Oxidation-Reduction Pot. (+mV)	309	240	318	268	4	318	240	283.750
Phenols	0.01	<0.01	<0.01	<0.01	4	0.01	0	0.003
Potassium	18	21	18	17	4	21	17	18.500
Sodium	620	558	645	642	4	645	558	616.250
Sulfate	2869	2782	2865	2850	4	2869	2782	2841.500
Sulfide as S	<0.2	<0.2	0.03	0.22	4	0.22	0	0.063
Thiocyanate	0.2	0.1	0.3	<0.1	4	0.3	0	0.150
Cations, Sum (meq/l)	78.44	78.62	76.1	84.5	4	84.5	76.1	79.415
Anions, Sum (meq/l)	80.53	77.67	79.3	79.32	4	80.53	77.67	79.205
Cation-Anion Balance (%)	-1.31	0.61	-2.06	3.16	4	3.16	-2.06	0.100
Solids, Total Dissolved	5092	5156	5074	5170	4	5170	5074	5123.000
Aluminum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Arsenic	<0.001	<0.001	0.002	<0.001	4	0.002	0	0.001
Barium	<0.01	0.01	<0.01	0.01	4	0.01	0	0.005
Cadmium	<0.005	<0.005	<0.005	<0.005	4	0	0	0.000
Copper	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Chromium	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Iron	7.1	4	2.94	3.05	4	7.1	2.94	4.273
Lead	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Manganese	0.61	0.72	0.6	0.59	4	0.72	0.59	0.630
Mercury	<0.0002	<0.0001	<0.0001	<0.0001	4	0	0	0.0000
Molybdenum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Nickel	0.02	<0.02	<0.02	<0.02	4	0.02	0	0.005
Selenium	<0.001	<0.001	<0.001	<0.001	4	0	0	0.000
Zinc	0.05	0.01	0.01	0.01	4	0.05	0.01	0.020

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL U-4 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	02-Mar-88	21-Jun-88	01-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS								
Acenaphthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Acenaphthylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(b)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(k)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(g,h,i)Perylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Chrysene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Dibenzo(a,h)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluorene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Indeno(1,2,3-cd)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Naphthalene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Phenanthrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL U-5 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	24-Jun-88	04-Sep-88	06-Dec-88	Count	Maximum	Minimum	Mean
Time	09:15	13:40	08:10				
Conductivity (U Mhos/Cm @ 25 Deg. C)	4300	4300	4010	3	4300	4010	4203.333
pH (Units)	10.6	10.08	9.94	3	10.6	9.94	10.129
Temperature (Deg. C)	12	9	7.2	3	12	7.2	9.400
LABORATORY PARAMETERS							
Alkalinity as CaCO3	693	765	720	3	765	693	726.000
Bicarbonate as CaCO3	224	427	548	3	548	224	399.667
Boron	0.07	0.04	<0.02	3	0.07	0	0.037
Bromide	0.74	0.39	0.57	3	0.74	0.39	0.567
Calcium	<1	2	3	3	3	0	1.667
Carbon, Dissolved Organic	211	210	202	3	211	202	207.667
Carbonate as CaCO3	469	338	172	3	469	172	326.333
Chloride	1123	998	840	3	1123	840	987.000
COD	665	597	1380	3	1380	597	880.667
Cyanide, Total	<0.002	<0.002	<0.002	3	0	0	0.000
Fluoride	2.1	2.1	2	3	2.1	2	2.067
Hydroxide as CaCO3	0	0	0	3	0	0	0.000
Magnesium	<1	1	3	3	3	0	1.333
Nitrogen, Ammonia	4.41	3.92	3.1	3	4.41	3.1	3.810
Nitrate as N	<0.03	<0.01	<0.01	3	0	0	0.000
Nitrite as N	0.01	<0.01	<0.01	3	0.01	0	0.003
Oxidation-Reduction Pot. (+mV)	60	158	179	3	179	60	132.333
Phenols	0.14	0.09	0.19	3	0.19	0.09	0.140
Potassium	335	300	185	3	335	185	273.333
Sodium	813	880	839	3	880	813	844.000
Sulfate	14	19	4	3	19	4	12.333
Sulfide as S	<0.2	0.02	0.4	3	0.4	0	0.140
Thiocyanate	0.8	0.4	0.2	3	0.8	0.2	0.467
Cations, Sum (meq/l)	44.35	46.7	42.12	3	46.7	42.12	44.390
Anions, Sum (meq/l)	45.6	43.64	38	3	45.6	38	42.413
Cation-Anion Balance (%)	-1.39	3.39	5.14	3	5.14	-1.39	2.380
Solids, Total Dissolved	3434	2850	2500	3	3434	2500	2928.000
Aluminum	1.15	0.06	<0.05	3	1.15	0	0.403
Arsenic	0.002	0.002	<0.001	3	0.002	0	0.001
Barium	0.13	0.18	0.17	3	0.18	0.13	0.160
Cadmium	<0.005	<0.005	<0.005	3	0	0	0.000
Copper	<0.01	<0.01	<0.01	3	0	0	0.000
Chromium	<0.01	<0.01	<0.01	3	0	0	0.000
Iron	<0.02	0.02	0.04	3	0.04	0	0.020
Lead	<0.02	<0.02	<0.02	3	0	0	0.000
Manganese	<0.01	<0.01	0.01	3	0.01	0	0.003
Mercury	<0.0001	<0.0001	0.0001	3	0.0001	0	0.0000
Molybdenum	<0.05	<0.05	<0.05	3	0	0	0.000
Nickel	<0.02	<0.02	<0.02	3	0	0	0.000
Selenium	<0.001	<0.001	<0.001	3	0	0	0.000
Zinc	0.01	<0.01	<0.01	3	0.01	0	0.003

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL U-5 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	24-Jun-88	04-Sep-88	06-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS							
Acenaphthene	<10	<10	<10	3	0.000	0.000	0.000
Acenaphthylene	<10	<10	<10	3	0.000	0.000	0.000
Anthracene	<10	<10	<10	3	0.000	0.000	0.000
Benzo(a)Anthracene	<10	<10	<10	3	0.000	0.000	0.000
Benzo(b)Fluoranthene	<10	<10	<10	3	0.000	0.000	0.000
Benzo(k)Fluoranthene	<10	<10	<10	3	0.000	0.000	0.000
Benzo(a)Pyrene	<10	<10	<10	3	0.000	0.000	0.000
Benzo(g,h,i)Perylene	<10	<10	<10	3	0.000	0.000	0.000
Chrysene	<10	<10	<10	3	0.000	0.000	0.000
Dibenzo(a,h)Anthracene	<10	<10	<10	3	0.000	0.000	0.000
Fluoranthene	<10	<10	<10	3	0.000	0.000	0.000
Fluorene	<10	<10	<10	3	0.000	0.000	0.000
Indeno(1,2,3-cd)Pyrene	<10	<10	<10	3	0.000	0.000	0.000
Naphthalene	6.316	11	10.5	3	11.000	6.316	9.272
Phenanthrene	<10	<10	<10	3	0.000	0.000	0.000
Pyrene	<10	<10	<10	3	0.000	0.000	0.000
TENTATIVELY IDENTIFIED COMPUNDS							
Benzothiazole (C7H5NS)	60 (Est.)		82				

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL S-7 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	02-Mar-88	21-Jun-88	01-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
Time	17:35	11:38	11:45	09:59				
Conductivity (U Mhos/Cm @ 25 Deg. C)	1810	2100	2630	2270	4	2630	1810	2202.500
pH (Units)	7.8	7.36	7.43	7.65	4	7.8	7.36	7.526
Temperature (Deg. C)	7	12	9.5	7.3	4	12	7	8.950
LABORATORY PARAMETERS								
Alkalinity as CaCO3		327	334	320	3	334	320	327.000
Bicarbonate as CaCO3	337	327	334	320	4	337	320	329.500
Boron	0.11	0.13	0.11	0.08	4	0.13	0.08	0.108
Bromide	0.15	0.11	0.08	0.16	4	0.16	0.08	0.125
Calcium	327	368	341	397	4	397	327	358.250
Carbon, Dissolved Organic	19	11	25	<1	4	25	0	13.750
Carbonate as CaCO3	0	0	0	0	4	0	0	0.000
Chloride	24	19	26	69	4	69	19	34.500
COD	45	5	14	5	4	45	5	17.250
Cyanide, Total	<0.002	<0.002	<0.002	<0.002	4	0	0	0.000
Fluoride	0.3	0.3	0.2	0.3	4	0.3	0.2	0.275
Hydroxide as CaCO3		0	0	0	3	0	0	0.000
Magnesium	189	171	202	228	4	228	171	197.500
Nitrogen, Ammonia	0.92	1.06	0.91	1	4	1.06	0.91	0.973
Nitrate as N	0.02	<0.02	<0.01	<0.01	4	0.02	0	0.005
Nitrite as N	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Oxidation-Reduction Pot. (+mV)	291	220	346	254	4	346	220	277.750
Phenols	0.01	<0.01	<0.01	<0.01	4	0.01	0	0.003
Potassium	8	6	8	6	4	8	6	7.000
Sodium	144	114	135	137	4	144	114	132.500
Sulfate	1414	1550	1638	1550	4	1638	1414	1538.000
Sulfide as S	0.2	<0.2	0.02	<0.01	4	0.2	0	0.055
Thiocyanate	0.1	<0.1	<0.1	0.1	4	0.1	0	0.050
Cations, Sum (meq/l)	38.39	37.59	39.76	44.73	4	44.73	37.59	40.118
Anions, Sum (meq/l)	37.11	39.62	41.81	40.88	4	41.81	37.11	39.855
Cation-Anion Balance (%)	1.7	-2.63	-2.51	4.5	4	4.5	-2.63	0.265
Solids, Total Dissolved	2482	2516	2472	2600	4	2600	2472	2517.500
Aluminum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Arsenic	<0.001	<0.001	<0.001	<0.001	4	0	0	0.000
Barium	0.01	0.01	0.01	0.02	4	0.02	0.01	0.013
Cadmium	<0.005	<0.005	<0.005	<0.005	4	0	0	0.000
Copper	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Chromium	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Iron	3.15	<0.02	1.78	1.83	4	3.15	0	1.690
Lead	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Manganese	0.05	0.04	0.04	0.04	4	0.05	0.04	0.043
Mercury	<0.0002	<0.0001	<0.0001	<0.0001	4	0	0	0.0000
Molybdenum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Nickel	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Selenium	<0.001	<0.001	<0.001	<0.001	4	0	0	0.000
Zinc	0.02	<0.01	0.02	0.01	4	0.02	0	0.013

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL S-7 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	02-Mar-88	21-Jun-88	01-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS								
Acenaphthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Acenaphthylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(b)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(k)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(g,h,i)Perylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Chrysene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Dibenzo(a,h)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluorene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Indeno(1,2,3-cd)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Naphthalene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Phenanthrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000

APPENDIX 2

CURRENT GROUNDWATER ANALYSIS

ACZ INC./LABORATORY DIVISION

WATER AND WASTEWATER ANALYTICAL METHODS

Parameter	Method *	Reportable * * Concentration mg/l
Acidity (as $CaCO_3$)	EPA 305.1 Titrimetric	1
Alkalinity (as $CaCO_3$)	EPA 310.1 Titrimetric	1
Aluminum	EPA 200.7 ICP	0.05
Aluminum (Low Level)	EPA 202.2 AA-Furance	0.002
Antimony	USGS I-1055-78 AA-Hydride	0.001
Arsenic	USGS I-2062-78 AA-Automated-Hydride	0.001
Barium	EPA 200.7 ICP	0.01
Barium (Low Level)	EPA 208.2 AA-Furnace	0.002
Beryllium	EPA 200.7 ICP	0.005
Beryllium (Low Level)	EPA 210.0 AA-Furnace	0.0002
Bicarbonate (as $CaCO_3$)	EPA 310.1 Titrimetric	1
BOD	EPA 405.1	1
Boron	EPA 200.7 ICP	0.02
Bromide	EPA 320.1 Titrimetric	2
Bromide	USGS I-1127-78 Colormetric	0.01
Cadmium	EPA 200.7 ICP	0.005
Cadmium (Low Level)	EPA 213.2 AA-Furnace	0.0001
Calcium	EPA 200.7 ICP	1
Calcium	EPA 215.1 AA-Flame	0.1
Carbonate (as $CaCO_3$)	EPA 310.1 Titrimetric	1
Chloride	EPA 325.2 Automated - Ferricyanide	1
Chromium	EPA 200.7 ICP	0.01
Chromium (Low Level)	EPA 218.2 AA-Furnace	0.001
Chromium, Hexavalent	Standard Methods 307 B Colorimetric	0.005
Cobalt	EPA 200.7 ICP	0.01
COD	EPA 4104 Ampule Method Colorimetric	5
Color	EPA 110.1 or 110.2 (units)	5
Conductivity	EPA 120.1 Meter (umhos/cm 25°)	1
Copper	EPA 200.7 ICP	0.01
Copper (Low Level)	EPA 220.2 AA-Furnace	0.001
Cyanide, Total	EPA 335.3 Automated UV or Manual Distillation	0.002
Fluoride	EPA 340.3 Automated - Complexone	0.02
Fluoride	EPA 340.2 Ion Select Electrode	0.1

* Note: Alternate Methods can be used upon client request.

* * Note: Alternate Methods (AA-Furnace, Celation-Extraction, Larger Sample Volume, etc.) can be used to obtain lower reporting limits for most parameters.

WATER AND WASTEWATER ANALYTICAL METHODS - Continued

Parameter	Method *	Reportable * * Concentration mg/l
Hardness, Total (as $CaCO_3$)	EPA 130.2 Calculation	1
Iodide	EPA 345.1 Titrimetric	2
Iron	EPA 200.7 ICP	0.02
Iron (Low Level)	EPA 236.2 AA-Furnace	0.001
Lead	EPA 239.1 AA-Flame	0.02
Lead (Low Level)	EPA 239.2 AA-Furnace	0.001
Lithium	EPA 200.7 ICP	0.1
Lithium	AA-Flame	0.01
Magnesium	EPA 200.7 ICP	1
Magnesium	EPA 243.1 AA-Flame	0.1
Manganese	EPA 200.7 ICP	0.01
Manganese (Low Level)	EPA 243.2 AA-Furnace	0.0002
Mercury	USGS I-2462-78 Automated Cold Vapor	0.0002
Molybdenum	EPA 200.7 ICP	0.05
Molybdenum (Low Level)	EPA 246.2 AA-Furnace	0.001
Nickel	EPA 200.7 ICP	0.02
Nickel (Low Level)	EPA 249.2 AA-Furnace	0.001
Nitrogen, Ammonia	USGS I-2552-78 - Salicylate Hypochlorite	0.02
Nitrogen, Nitrate	EPA 353.2 Automated - Cadmium Reduction	0.02
Nitrogen, Nitrate/Nitrite	EPA 353.2 Automated - Cadmium Reduction	0.02
Nitrogen, Nitrite	EPA 353.2 Automated	0.01
Nitrogen, Organic	Total - Ammonia	0.1
Nitrogen, Total (Kjeldahl)	USGS I-2552-78 BD40 Digestion,Colorimetric	0.1
Oil & Grease	EPA 413.1 Gravimetric	1
Organic Carbon	ASTM D 4129-82 Coulometric detection	1
pH	EPA 150.1 Meter	0.1
Phenols	EPA 420.2 Automated 4 - AAP or Manual Distillation	0.005
Phosphorus, Organic or Hydrolyzable	By Difference	0.02
Phosphorus, Ortho	EPA 365.1 Automated - Ascorbic Acid	0.02
Phosphorus, Total	EPA 365.1 Automated with Digestion	0.02
Potassium	EPA 200.7 ICP	1
Potassium	EPA 258.1 AA-Flame	0.1
SAR	Requires Ca, Mg, & Na (Calculation)	-

* Note: Alternate Methods can be used upon client request.

* * Note: Alternate Methods (AA-Furnace, Celation-Extraction, Larger Sample Volume, etc.) can be used to obtain lower reporting limits for most parameters.

WATER AND WASTEWATER ANALYTICAL METHODS - Continued

Parameter	Method *	Reportable * * Concentration mg/l
Selenium	USGS, (I-2667-81) AA-Automated Hydride	0.001
Silica	EPA 200.7 ICP	0.1
Silver	EPA 200.7 ICP	0.005
Silver (Low Level)	EPA 272.2 AA-Furnace	0.0001
Sodium	EPA 200.7 ICP	1
Sodium	EPA 273.1 AA-Flame	0.1
Solids, Dissolved	EPA 160.1 Gravimetric 180°C	2
Solids, Settleable	EPA 160.5 Volumetric (ml/l/hr)	0.1
Solids, Suspended	EPA 160.2 Gravimetric 105°C	2
Solids, Total	EPA 160.3 Gravimetric 105°C	2
Solids, Volatile	EPA 160.4 Gravimetric 550°C	2
Strontium	EPA 200.7 ICP	0.02
Sulfate	EPA 375.3 Gravimetric	4
Sulfide	EPA 376.1 Titrimetric	0.2
Sulfite	EPA 377.1 Titrimetric	2
Surfactants	EPA 425.1 Colorimetric	0.02
Thallium	EPA 279.2 AA-Furnace	0.002
Thiocyanate	ASTM D4193-82 Colorimetric	0.1
Tin	EPA 200.7 ICP	0.2
Titanium	EPA 200.7 ICP	0.005
Tungsten	EPA 200.7 ICP	0.1
Turbidity	EPA 180.1 Nephelometric (N.T.U.)	0.1
Vanadium	EPA 200.7 ICP	0.01
Vanadium (Low Level)	EPA 286.2 AA-Furnace	0.002
Zinc	EPA 200.7 ICP	0.01

* Note: Alternate Methods can be used upon client request.

* * Note: Alternate Methods (AA-Furnace, Celation-Extraction, Larger Sample Volume, etc.) can be used to obtain lower reporting limits for most parameters.

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

SURFACE WATER MONITORING

SITE	SWU	SWD	SWU	SWD	SWU	SWD	SWU	SWD
Date	02-Mar-88	02-Mar-88	21-Jun-88	21-Jun-88	01-Sep-88	01-Sep-88	03-Dec-88	03-Dec-88
Time	13:40	16:20	17:50	08:45	16:00	10:15	14:21	09:00
Flow (CFS)	0	0	0	0	0	0	0	0
Note	Frozen	Frozen	Dry	Dry	Dry	Dry	Frozen	Frozen

Site SWU is at the upstream permit area boundary on the unnamed drainage.
Site SWD is at the downstream permit area boundary on the unnamed drainage.

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-1 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	13-Mar-88	23-Jun-88	03-Sep-88	05-Dec-88	Count	Maximum	Minimum	Mean
Time	12:45	15:00	18:00	11:30				
Conductivity (U Mhos/Cm @ 25 Deg. C)	4500	5200	4550	4250	4	5200	4250	4625.000
pH (Units)	8.98	10.17	9.77	9.23	4	10.17	8.98	9.329
Temperature (Deg. C)	8	14	10	8	4	14	8	10.000
LABORATORY PARAMETERS								
Alkalinity as CaCO3		168	258	300	3	300	168	242.000
Bicarbonate as CaCO3	84	135	258	300	4	300	84	194.250
Boron	0.03	0.04	0.03	<0.02	4	0.04	0	0.025
Bromide	0.04	0.56	0.35	0.36	4	0.56	0.04	0.328
Calcium	39	166	91	50	4	166	39	86.500
Carbon, Dissolved Organic	20	193	294	346	4	346	20	213.250
Carbonate as CaCO3	0	33	0	0	4	33	0	8.250
Chloride	96	1803	1360	1140	4	1803	96	1099.750
COD	50	665	770	625	4	770	50	527.500
Cyanide, Total	0.005	<0.002	<0.002	<0.002	4	0.005	0	0.001
Fluoride	0.5	1.2	1.3	1.7	4	1.7	0.5	1.175
Hydroxide as CaCO3		0	0	0	3	0	0	0.000
Magnesium	3	4	6	8	4	8	3	5.250
Nitrogen, Ammonia	0.28	3.93	2.06	1.12	4	3.93	0.28	1.848
Nitrate as N	<0.02	<0.02	<0.01	<0.01	4	0	0	0.000
Nitrite as N	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Oxidation-Reduction Pot. (+mV)	203	120	171	198	4	203	120	173.000
Phenols	0.04	0.11	0.05	0.05	4	0.11	0.04	0.063
Potassium	10	59	38	23	4	59	10	32.500
Sodium	59	1060	938	980	4	1060	59	759.250
Sulfate	16	8	16	2	4	16	2	10.500
Sulfide as S	<0.2	0.2	0.06	0.2	4	0.2	0	0.115
Thiocyanate	0.1	<0.1	<0.1	<0.1	4	0.1	0	0.025
Cations, Sum (meq/l)	5.05	56.8	47.3	46.87	4	56.8	5.05	39.005
Anions, Sum (meq/l)	4.7	54.01	43.58	37.88	4	54.01	4.7	35.043
Cation-Anion Balance (%)	3.59	2.52	4.09	10.61	4	10.61	2.52	5.203
Solids, Total Dissolved	314	3904	3008	2900	4	3904	314	2531.500
Aluminum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Arsenic	<0.001	0.003	0.004	0.003	4	0.004	0	0.003
Barium	0.25	4.24	1.84	1.66	4	4.24	0.25	1.998
Cadmium	<0.005	<0.005	<0.005	0.005	4	0.005	0	0.001
Copper	0.01	<0.01	<0.01	0.01	4	0.01	0	0.005
Chromium	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Iron	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Lead	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Manganese	0.12	<0.01	0.01	0.04	4	0.12	0	0.042
Mercury	<0.0002	<0.0001	<0.0001	<0.0001	4	0	0	0.0000
Molybdenum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Nickel	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Selenium	<0.001	<0.001	<0.001	<0.001	4	0	0	0.000
Zinc	<0.01	0.01	<0.01	<0.01	4	0.01	0	0.003

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-1 GROUND WATER CHEMICAL ANALYSIS
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	13-Mar-88	23-Jun-88	03-Sep-88	05-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS								
Acenaphthene	0	<10	<10	<10	4	0	0	0
Acenaphthylene	0	<10	<10	<10	4	0	0	0
Anthracene	0	<10	<10	<10	4	0	0	0
Benzo(a)Anthracene	0	<10	<10	<10	4	0	0	0
Benzo(b)Fluoranthene	0	<10	<10	<10	4	0	0	0
Benzo(k)Fluoranthene	0	<10	<10	<10	4	0	0	0
Benzo(a)Pyrene	0	<10	<10	<10	4	0	0	0
Benzo(g,h,i)Perylene	0	<10	<10	<10	4	0	0	0
Chrysene	0	<10	<10	<10	4	0	0	0
Dibenzo(a,h)Anthracene	0	<10	<10	<10	4	0	0	0
Fluoranthene	0	<10	<10	<10	4	0	0	0
Fluorene	0	<10	<10	<10	4	0	0	0
Indeno(1,2,3-cd)Pyrene	0	<10	<10	<10	4	0	0	0
Naphthalene	9.73	6.421	10	8.7	4	10.0	6.421	8.713
Phenanthrene	0	<10	<10	<10	4	0	0	0
Pyrene	0	<10	<10	<10	4	0	0	0
TENTATIVELY IDENTIFIED COMPOUNDS								
2-Ethyl Hexanoic Acid	140.5 (Estimated)							

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-2 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	03-Sep-88
Time	12:00
Conductivity (U Mhos/Cm @ 25 Deg. C)	1800
pH (Units)	9.63
Temperature (Deg. C)	11
LABORATORY PARAMETERS	
Alkalinity as CaCO3	888
Bicarbonate as CaCO3	596
Boron	0.06
Bromide	0.1
Calcium	2
Carbon, Dissolved Organic	21
Carbonate as CaCO3	292
Chloride	53
COD	37
Cyanide, Total	<0.002
Fluoride	6.7
Hydroxide as CaCO3	0
Magnesium	<1
Nitrogen, Ammonia	0.42
Nitrate as N	<0.01
Nitrite as N	<0.01
Oxidation-Reduction Pot. (+mV)	228
Phenols	<0.01
Potassium	8
Sodium	481
Sulfate	4
Sulfide as S	0.04
Thiocyanate	<0.1
Cations, Sum (meq/l)	21.39
Anions, Sum (meq/l)	19.68
Cation-Anion Balance (%)	4.16
Solids, Total Dissolved	1076
Aluminum	<0.05
Arsenic	<0.001
Barium	0.04
Cadmium	<0.005
Copper	<0.01
Chromium	<0.01
Iron	0.49
Lead	0.04
Manganese	0.01
Mercury	<0.0001
Molybdenum	<0.05
Nickel	<0.02
Selenium	<0.001
Zinc	<0.01

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-1 CHEMICAL ANALYSES OF DUPLICATE SAMPLES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

LABORATORY PARAMETERS/DATE	L-1 Sample 23-Jun-88	Duplicate Sample 23-Jun-88	Difference from Sample L-1	L-1 Sample 03-Sep-88	Duplicate Sample 03-Sep-88	Difference from Sample L-1	L-1 Sample 05-Dec-88	Duplicate Sample 05-Dec-88	Difference from Sample L-1
Alkalinity as CaCO3	168	175	7	258	265	7	300	320	20
Bicarbonate as CaCO3	135	146	11	258	265	7	300	320	20
Boron	0.04	0.04	0	0.03	0.03	0	<0.02	<0.02	0
Bromide	0.56	0.53	-0.03	0.35	0.37	0.02	0.36	0.35	-0.01
Calcium	166	189	23	91	86	-5	50	49	-1
Carbon, Dissolved Organic	193	139	-54	294	263	-31	346	352	6
Carbonate as CaCO3	33	29	-4	0	0	0	0	0	0
Chloride	1803	1783	-20	1360	1377	17	1140	1100	-40
COD	665	690	25	770	762	-8	625	1100	475
Cyanide, Total	<0.002	<0.002	0	<0.002	<0.002	0	<0.002	<0.002	0
Fluoride	1.2	1.2	0	1.3	1.2	-0.1	1.7	1.8	0.1
Hydroxide as CaCO3	0	0	0	0	0	0	0	0	0
Magnesium	4	3	-1	6	8	2	8	8	0
Nitrogen, Ammonia	3.93	3.92	-0.01	2.06	2.04	-0.02	1.12	1.15	0.03
Nitrate as N	<0.02	<0.02	0	<0.01	<0.01	0	<0.01	<0.01	0
Nitrite as N	<0.01	<0.01	0	<0.01	<0.01	0	<0.01	<0.01	0
Oxidation-Reduction Pot. (+mV)	120	110	-10	171	171	0	198	190	-8
Phenols	0.11	0.12	0.01	0.05	0.07	0.02	0.05	0.1	0.05
Potassium	59	54	-5	38	44	6	23	23	0
Sodium	1060	848	-212	938	1030	92	980	955	-25
Sulfate	8	4	-4	16	2	-14	2	2	0
Sulfide as S	0.2	0.2	0	0.06	0.05	-0.01	0.2	0.16	-0.04
Thiocyanate	<0.1	<0.1	0	<0.1	<0.1	0	<0.1	<0.1	0
Cations, Sum (meq/l)	56.8	48.41	-8.39	47.3	51.42	4.12	46.87	45.72	-1.15
Anions, Sum (meq/l)	54.01	53.51	-0.5	43.58	43.9	0.32	37.88	37.16	-0.72
Cation-Anion Balance (%)	2.52	-5	-7.52	4.09	7.89	3.8	10.61	10.33	-0.28
Solids, Total Dissolved	3904	3908	4	3008	2944	-64	2900	2886	-14
Aluminum	<0.05	<0.05	0	<0.05	<0.05	0	<0.05	<0.05	0
Arsenic	0.003	<0.002	-0.001	0.004	0.003	-0.001	0.003	0.003	0
Barium	4.24	4.12	-0.12	1.84	2.04	0.2	1.66	1.82	0.16
Cadmium	<0.005	<0.005	1	<0.005	<0.005	0	0.005	<0.005	0
Copper	<0.01	<0.01	0	<0.01	<0.01	0	0.01	<0.01	0
Chromium	<0.01	<0.01	0	<0.01	<0.01	0	<0.01	<0.01	0
Iron	<0.02	<0.02	0	<0.02	<0.02	0	<0.02	<0.02	0
Lead	<0.02	<0.02	0	<0.02	<0.02	0	<0.02	<0.02	0
Manganese	<0.01	<0.01	0	0.01	0.01	0	0.04	0.04	0
Mercury	<0.0001	<0.0001	0	<0.0001	<0.0001	0	<0.0001	<0.0001	0
Molybdenum	<0.05	<0.05	0	<0.05	<0.05	0	<0.05	<0.05	0
Nickel	<0.02	<0.02	0	<0.02	<0.02	0	<0.02	<0.02	0
Selenium	<0.001	<0.001	0	<0.001	<0.001	0	<0.001	<0.001	0
Zinc	0.01	<0.02	0.01	<0.01	<0.01	0	<0.01	<0.01	0

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-1 CHEMICAL ANALYSES OF DUPLICATE SAMPLES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	L-1 Analysis 23-Jun-88	Duplicate Sample 23-Jun-88	Difference from Sample L-1	L-1 Analysis 03-Sep-88	Duplicate Sample 03-Sep-88	Difference from Sample L-1	L-1 Analysis 05-Dec-88	Duplicate Sample 05-Dec-88	Difference from Sample L-1
BASE/NEUTRALS									
Acenaphthene	<10	<10	0	<10	<10	0	<10	<10	0
Acenaphthylene	<10	<10	0	<10	<10	0	<10	<10	0
Anthracene	<10	<10	0	<10	<10	0	<10	<10	0
Benzo(a)Anthracene	<10	<10	0	<10	<10	0	<10	<10	0
Benzo(b)Fluoranthene	<10	<10	0	<10	<10	0	<10	<10	0
Benzo(k)Fluoranthene	<10	<10	0	<10	<10	0	<10	<10	0
Benzo(a)Pyrene	<10	<10	0	<10	<10	0	<10	<10	0
Benzo(g,h,i)Perylene	<10	<10	0	<10	<10	0	<10	<10	0
Chrysene	<10	<10	0	<10	<10	0	<10	<10	0
Dibenzo(a,h)Anthracene	<10	<10	0	<10	<10	0	<10	<10	0
Fluoranthene	<10	<10	0	<10	<10	0	<10	<10	0
Fluorene	<10	<10	0	<10	<10	0	<10	<10	0
Indeno(1,2,3-cd)Pyrene	<10	<10	0	<10	<10	0	<10	<10	0
Naphthalene	6.421	6.778	0.357	10.0	10.1	0.1	8.7	9.2	0.5
Phenanthrene	<10	<10	0	<10	<10	0	<10	<10	0
Pyrene	<10	<10	0	<10	<10	0	<10	<10	0

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-1 CHEMICAL ANALYSES OF SAMPLES SPIKED BY WYOMING ANALYTICAL LABORATORY, LARAMIE
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

LABORATORY PARAMETERS/DATE	L-1 Analysis 23-Jun-88	Field Spike Addition	Analysis of Spiked Sample	Difference from Sample L-1	L-1 Analysis 03-Sep-88	Field Spike Addition	Analysis of Spiked Sample	Difference from Sample L-1	L-1 Analysis 05-Dec-88	Field Spike Addition	Analysis of Spiked Sample	Difference from Sample L-1
Alkalinity as CaCO3	168		159	-9	258		240	-18	300		310	10
Bicarbonate as CaCO3	135		142	7	258		240	-18	300		310	10
Boron	0.04		0.05	0.01	0.03		0.03	0	<0.02		<0.02	0
Bromide	0.56	0.02	0.5	-0.06	0.35	0.02	0.51	0.16	0.36	0.02	0.35	-0.01
Calcium	166		110	-56	91		86	-5	50		47	-3
Carbon, Dissolved Organic	193		195	2	294		282	-12	346		336	-10
Carbonate as CaCO3	33		17	-16	0		0	0	0		0	0
Chloride	1803	96	1754	-49	1360	48	1570	210	1140	48	1110	-30
COD	665		630	-35	770		775	5	625		2100	1475
Cyanide, Total	<0.002	0.002	<0.002	0	<0.002	0.002	<0.002	0	<0.002	0.002	0.003	0.001
Fluoride	1.2		1.1	-0.1	1.3		1.1	-0.2	1.7		1.6	-0.1
Hydroxide as CaCO3	0		0	0	0		0	0	0		0	0
Magnesium	4		3	-1	6		6	0	8		7	-1
Nitrogen, Ammonia	3.93	0.1	3.98	0.05	2.06	0.1	2.48	0.42	1.12	0.1	1.3	0.18
Nitrate as N	<0.02		<0.02	0	<0.01		<0.01	0	<0.01		<0.01	0
Nitrite as N	<0.01		<0.01	0	<0.01		<0.01	0	<0.01		<0.01	0
Oxidation-Reduction Pot. (+mV)	120		110	-10	171		183	12	198		190	-8
Phenols	0.11	0.02	0.12	0.01	0.05	0.02	0.08	0.03	0.05	0.02	0.07	0.02
Potassium	59		52	-7	38		39	1	23		22	-1
Sodium	1060	30	1035	-25	938	30	959	21	980	30	934	-46
Sulfate	8		2	-6	16		16	0	2		2	0
Sulfide as S	0.2		0.2	0	0.06		0.07	0.01	0.2		0.26	0.06
Thiocyanate	<0.1		0.1	0	<0.1		<0.1	0	<0.1		0.1	0
Cations, Sum (meq/l)	56.8		52.64	-4.16	47.3		48	0.7	46.87		44.59	-2.28
Anions, Sum (meq/l)	54.01		52.33	-1.68	43.58		49.1	5.52	37.88		37.24	-0.64
Cation-Anion Balance (%)	2.52		0.3	-2.22	4.09		-1.13	-5.22	10.61		8.98	-1.63
Solids, Total Dissolved	3904		3686	-218	3008		2912	-96	2900		2806	-94
Aluminum	<0.05		0.09	0.04	<0.05		<0.05	0	<0.05		<0.05	0
Arsenic	0.003		0.003	0	0.004		0.003	-0.001	0.003		0.003	0
Barium	4.24	0.1	4.15	-0.09	1.84	0.1	2.04	0.2	1.66	0.2	1.76	0.1
Cadmium	<0.005		<0.005	0	<0.005		<0.005	0	0.005		<0.005	0
Copper	<0.01	0.005	<0.01	0	<0.01	0.005	<0.01	0	0.01	0.005	0.01	0
Chromium	<0.01		<0.01	0	<0.01		<0.01	0	<0.01		<0.01	0
Iron	<0.02		<0.02	0	<0.02		<0.02	0	<0.02		<0.02	0
Lead	<0.02		<0.02	0	<0.02		<0.02	0	<0.02		<0.02	0
Manganese	<0.01		<0.01	0	0.01		0.01	0	0.04		0.05	0.01
Mercury	<0.0001		0.0006	0.0005	<0.0001		<0.0001	0	<0.0001		0.0002	0.0001
Molybdenum	<0.05		<0.05	0	<0.05		<0.05	0	<0.05		<0.05	0
Nickel	<0.02		<0.02	0	<0.02		<0.02	0	<0.02		<0.02	0
Selenium	<0.001		<0.001	0	<0.001		<0.001	0	<0.001		<0.001	0
Zinc	0.01		0.02	0.01	<0.01		<0.01	0	<0.01		<0.01	0

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-1 CHEMICAL ANALYSES OF SAMPLES SPIKED BY WYOMING ANALYTICAL LABORATORY, LARAMIE
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	Sample L-1 23-Jun-88	Field Spike Addition	Analysis of Spiked Sample	Difference from Sample L-1	Sample L-1 29-Sep-88	Field Spike Addition	Analysis of Spiked Sample	Difference from Sample L-1	Sample L-1 13-Dec-88	Field Spike Addition	Analysis of Spiked Sample	Difference from Sample L-1
BASE/NEUTRALS												
Acenaphthene	<10		<10	0	<10		<10	0	<10		<10	0
Acenaphthylene	<10		<10	0	<10		<10	0	<10		<10	0
Anthracene	<10		<10	0	<10		<10	0	<10		<10	0
Benzo(a)Anthracene	<10		<10	0	<10		<10	0	<10		<10	0
Benzo(b)Fluoranthene	<10		<10	0	<10		<10	0	<10		<10	0
Benzo(k)Fluoranthene	<10		<10	0	<10		<10	0	<10		<10	0
Benzo(a)Pyrene	<10		<10	0	<10		<10	0	<10		<10	0
Benzo(g,h,i)Perylene	<10		<10	0	<10		<10	0	<10		<10	0
Chrysene	<10		<10	0	<10		<10	0	<10		<10	0
Dibenzo(a,h)Anthracene	<10		<10	0	<10		<10	0	<10		<10	0
Fluoranthene	<10		<10	0	<10		<10	0	<10		<10	0
Fluorene	<10		<10	0	<10		<10	0	<10		<10	0
Indeno(1,2,3-cd)Pyrene	<10		<10	0	<10		<10	0	<10		<10	0
Naphthalene	6.421	4	41.354	34.933	10.0	4	9.1	-0.9	8.7	4	9.3	0.6
Phenanthrene	<10		<10	0	<10		<10	0	<10		<10	0
Pyrene	<10		<10	0	<10		<10	0	<10		<10	0

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-1 CHEMICAL ANALYSES OF BLANK SAMPLES MADE UP AT THE WELL SITE FROM DEIONIZED WATER
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

LABORATORY PARAMETERS/DATE	23-Jun-88	03-Sep-88	05-Dec-88
Alkalinity as CaCO3	4	2	4
Bicarbonate as CaCO3	4	2	4
Boron	<0.02	<0.02	<0.02
Bromide	<0.01	0.02	0.02
Calcium	3	<1	1
Carbon, Dissolved Organic	4	14	1
Carbonate as CaCO3	0	0	0
Chloride	<1	<1	<1
COD	<5	<5	5
Cyanide, Total	<0.002	<0.002	<0.002
Fluoride	<0.1	<0.1	<0.1
Hydroxide as CaCO3	0	0	0
Magnesium	<1	<1	1
Nitrogen, Ammonia	<0.02	0.04	0.07
Nitrate as N	<0.02	<0.01	<0.01
Nitrite as N	<0.01	<0.01	<0.01
Oxidation-Reduction Pot. (+mV)	230	308	297
Phenols	0.03	<0.01	0.02
Potassium	1	1	1
Sodium	<1	<1	<1
Sulfate	2	<4	<2
Sulfide as S	0.5	0.01	<0.01
Thiocyanate	<0.1	<0.1	<0.1
Cations, Sum (meq/l)	0.05	<0.2	<0.2
Anions, Sum (meq/l)	<0.2	<0.2	<0.2
Cation-Anion Balance (%)	0	0	0
Solids, Total Dissolved	6	12	2
Aluminum	<0.05	<0.05	<0.05
Arsenic	<0.001	<0.001	<0.001
Barium	0.02	0.02	0.02
Cadmium	<0.005	<0.005	<0.005
Copper	<0.01	<0.01	<0.01
Chromium	<0.01	<0.01	<0.01
Iron	<0.02	<0.02	<0.02
Lead	<0.02	<0.02	<0.02
Manganese	<0.01	<0.01	<0.01
Mercury	<0.0001	<0.0001	<0.0001
Molybdenum	<0.05	<0.05	<0.05
Nickel	<0.02	<0.02	<0.02
Selenium	<0.001	<0.001	<0.001
Zinc	<0.01	<0.01	<0.01

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-1 CHEMICAL ANALYSES OF BLANK SAMPLES MADE UP AT THE SELL SITE FROM DEIONIZED WATER
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	23-Jun-88	03-Sep-88	05-Dec-88
BASE/NEUTRALS			
Acenaphthene	<10	<10	<10
Acenaphthylene	<10	<10	<10
Anthracene	<10	<10	<10
Benzo(a)Anthracene	<10	<10	<10
Benzo(b)Fluoranthene	<10	<10	<10
Benzo(k)Fluoranthene	<10	<10	<10
Benzo(a)Pyrene	<10	<10,	<10
Benzo(g,h,i)Perylene	<10	<10	<10
Chrysene	<10	<10	<10
Dibenzo(a,h)Anthracene	<10	<10	<10
Fluoranthene	<10	<10	<10
Fluorene	<10	<10	<10
Indeno(1,2,3-cd)Pyrene	<10	<10	<10
Naphthalene	<10	<10	<10
Phenanthrene	<10	<10	<10
Pyrene	<10	<10	<10

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-2 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	03-Sep-88
BASE/NEUTRALS	
Acenaphthene	<10
Acenaphthylene	<10
Anthracene	<10
Benzo(a)Anthracene	<10
Benzo(b)Fluoranthene	<10
Benzo(k)Fluoranthene	<10
Benzo(a)Pyrene	<10
Benzo(g,h,i)Perylene	<10
Chrysene	<10
Dibenzo(a,h)Anthracene	<10
Fluoranthene	<10
Fluorene	<10
Indeno(1,2,3-cd)Pyrene	<10
Naphthalene	<10
Phenanthrene	<10
Pyrene	<10

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-4 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	23-Jun-88	01-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
Time	19:40	17:42	16:00				
Conductivity (U Mhos/Cm @ 25 Deg. C)	1320	1800	1940	3	1940	1320	1686.667
pH (Units)	9.23	9.87	9.72	3	9.87	9.23	9.516
Temperature (Deg. C)	13	9	6	3	13	6	9.333
LABORATORY PARAMETERS							
Alkalinity as CaCO3	763	800	838	3	838	763	800.333
Bicarbonate as CaCO3	638	388	514	3	638	388	513.333
Boron	0.03	<0.02	<0.02	3	0.03	0	0.010
Bromide	0.22	0.12	0.2	3	0.22	0.12	0.180
Calcium	5	1	2	3	5	1	2.667
Carbon, Dissolved Organic	25	20	<1	3	25	0	15.0[illegible]
Carbonate as CaCO3	125	412	324	3	412	125	287.[illegible]
Chloride	53	56	50	3	56	50	53.000
COD	40	34	20	3	40	20	31.333
Cyanide, Total	<0.002	<0.002	<0.002	3	0	0	0.000
Fluoride	1.7	1.7	1.4	3	1.7	1.4	1.600
Hydroxide as CaCO3	0	0	0	3	0	0	0.000
Magnesium	1	<1	1	3	1	0	0.667
Nitrogen, Ammonia	0.51	0.58	0.7	3	0.7	0.51	0.597
Nitrate as N	<0.02	<0.01	<0.01	3	0	0	0.000
Nitrite as N	<0.01	<0.01	<0.01	3	0	0	0.000
Oxidation-Reduction Pot. (+mV)	120	213	220	3	220	120	184.333
Phenols	<0.01	0.01	<0.01	3	0.01	0	0.003
Potassium	8	8	6	3	8	6	7.333
Sodium	419	471	498	3	498	419	462.667
Sulfate	78	91	88	3	91	78	85.667
Sulfide as S	0.3	0.14	0.6	3	0.6	0.14	0.347
Thiocyanate	0.2	<0.1	0.1	3	0.2	0	0.100
Cations, Sum (meq/l)	18.98	20.9	22.25	3	22.25	18.98	20.710
Anions, Sum (meq/l)	18.38	19.48	20.08	3	20.08	18.38	19.313
Cation-Anion Balance (%)	1.61	3.52	5.13	3	5.13	1.61	3.420
Solids, Total Dissolved	1034	1070	1158	3	1158	1034	1087.333
Aluminum	<0.05	<0.05	<0.05	3	0	0	0.000
Arsenic	<0.001	<0.001	<0.001	3	0	0	0.000
Barium	0.01	0.01	<0.01	3	0.01	0	0.007
Cadmium	<0.005	<0.005	<0.005	3	0	0	0.000
Copper	<0.01	<0.01	<0.01	3	0	0	0.000
Chromium	<0.01	<0.01	<0.01	3	0	0	0.000
Iron	0.03	0.08	0.05	3	0.08	0.03	0.053
Lead	<0.02	<0.02	<0.02	3	0	0	0.000
Manganese	0.01	0.02	0.02	3	0.02	0.01	0.017
Mercury	<0.0001	<0.0001	<0.0001	3	0	0	0.0000
Molybdenum	<0.05	<0.05	<0.05	3	0	0	0.000
Nickel	<0.02	<0.02	<0.02	3	0	0	0.000
Selenium	<0.001	<0.001	<0.001	3	0	0	0.000
Zinc	<0.01	<0.01	<0.01	3	0	0	0.000

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-4 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	23-Jun-88	01-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS							
Acenaphthene	<10	<10	<10	3	0	0	0
Acenaphthylene	<10	<10	<10	3	0	0	0
Anthracene	<10	<10	<10	3	0	0	0
Benzo(a)Anthracene	<10	<10	<10	3	0	0	0
Benzo(b)Fluoranthene	<10	<10	<10	3	0	0	0
Benzo(k)Fluoranthene	<10	<10	<10	3	0	0	0
Benzo(a)Pyrene	<10	<10	<10	3	0	0	0
Benzo(g,h,i)Perylene	<10	<10	<10	3	0	0	0
Chrysene	<10	<10	<10	3	0	0	0
Dibenzo(a,h)Anthracene	<10	<10	<10	3	0	0	0
Fluoranthene	<10	<10	<10	3	0	0	0
Fluorene	<10	<10	<10	3	0	0	0
Indeno(1,2,3-cd)Pyrene	<10	<10	<10	3	0	0	0
Naphthalene	<10	26.2	<10	3	26.2	0	8.773
Phenanthrene	<10	<10	<10	3	0	0	0
Pyrene	<10	<10	<10	3	0	0	0

ENERGY INTERNATIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL L-7 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED UG/L)

ORGANIC PARAMETERS/DATE	03-Mar-88	22-Jun-88	02-Sep-88	04-Dec-88	Count	Maximum	Minimum	Mean
BASE/NEUTRALS								
Acenaphthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Acenaphthylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(b)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(k)Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(a)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Benzo(g,h,i)Perylene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Chrysene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Dibenzo(a,h)Anthracene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluoranthene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Fluorene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Indeno(1,2,3-cd)Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Naphthalene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Phenanthrene	0.000	<10	<10	<10	4	0.000	0.000	0.000
Pyrene	0.000	<10	<10	<10	4	0.000	0.000	0.000

TENTATIVELY IDENTIFIED COMPOUNDS	
1-Azido-2-Methylbenzene	31.3 (Estimated)
Normal Hydrocarbons (C20-C28)	55.1 (Estimated)

ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

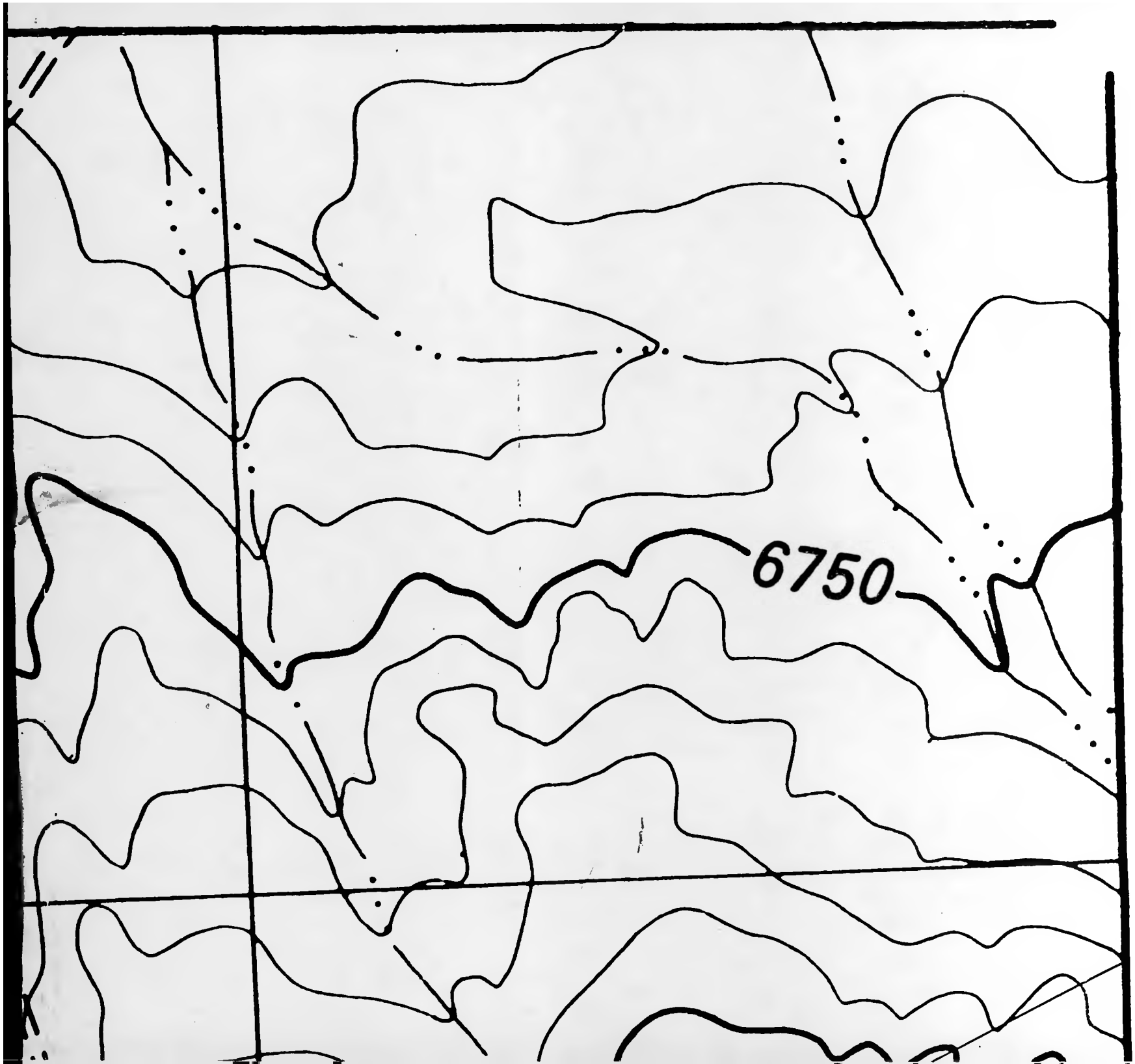
WELL L-7 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	02-Mar-88	22-Jun-88	02-Sep-88	03-Dec-88	Count	Maximum	Minimum	Mean
Time	18:35	18:27	17:45	14:24				
Conductivity (U Mhos/Cm @ 25 Deg. C)	1250	1220	1730	1850	4	1850	1220	1512.500
pH (Units)	9.04	9.27	9.2	9.24	4	9.27	9.04	9.178
Temperature (Deg. C)	6	11	11	9	4	11	6	9.250
LABORATORY PARAMETERS								
Alkalinity as CaCO3		779	772	630	3	779	630	727.000
Bicarbonate as CaCO3	737	658	672	590	4	737	590	664.250
Boron	0.06	0.05	0.03	<0.02	4	0.06	0	0.035
Bromide	0.29	0.17	0.12	0.15	4	0.29	0.12	0.183
Calcium	5	3	3	3	4	5	3	3.500
Carbon, Dissolved Organic	39	8	42	8	4	42	8	24.250
Carbonate as CaCO3	69	121	100	40	4	121	40	82.500
Chloride	109	74	66	63	4	109	63	78.000
COD	55	30	39	50	4	55	30	43.500
Cyanide, Total	<0.002	0.011	<0.002	<0.002	4	0.011	0	0.003
Fluoride	4.5	4.9	4.8	4.6	4	4.9	4.5	4.700
Hydroxide as CaCO3		0	0	0	3	0	0	0.000
Magnesium	2	1	1	1	4	2	1	1.250
Nitrogen, Ammonia	0.47	0.42	0.36	0.58	4	0.58	0.36	0.457
Nitrate as N	0.03	<0.02	<0.01	<0.01	4	0.03	0	0.008
Nitrite as N	<0.01	0.01	<0.01	<0.01	4	0.01	0	0.003
Oxidation-Reduction Pot. (+mV)	244	120	236	215	4	244	120	203.750
Phenols	0.03	0.02	0.05	0.01	4	0.05	0.01	0.028
Potassium	24	15	14	12	4	24	12	16.250
Sodium	437	401	419	413	4	437	401	417.500
Sulfate	39	<2	2	21	4	39	0	15.500
Sulfide as S	0.8	<0.2	0.03	0.18	4	0.8	0	0.253
Thiocyanate	0.3	0.2	<0.1	<0.1	4	0.3	0	0.125
Cations, Sum (meq/l)	20.27	18.27	19.03	18.72	4	20.27	18.27	19.073
Anions, Sum (meq/l)	19.99	17.61	17.33	14.81	4	19.99	14.81	17.435
Cation-Anion Balance (%)	0.7	1.84	4.68	11.66	4	11.66	0.7	4.720
Solids, Total Dissolved	1060	990	966	954	4	1060	954	992.500
Aluminum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Arsenic	0.001	0.002	<0.001	0.001	4	0.002	0	0.001
Barium	0.05	0.06	0.07	0.06	4	0.07	0.05	0.060
Cadmium	<0.005	<0.005	<0.005	<0.005	4	0	0	0.000
Copper	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Chromium	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Iron	0.19	0.16	0.56	0.39	4	0.56	0.16	0.325
Lead	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Manganese	0.05	0.01	0.02	0.01	4	0.05	0.01	0.023
Mercury	<0.0002	<0.0001	<0.0001	<0.0001	4	0	0	0.0000
Molybdenum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Nickel	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Selenium	<0.001	<0.001	<0.001	<0.001	4	0	0	0.000
Zinc	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000

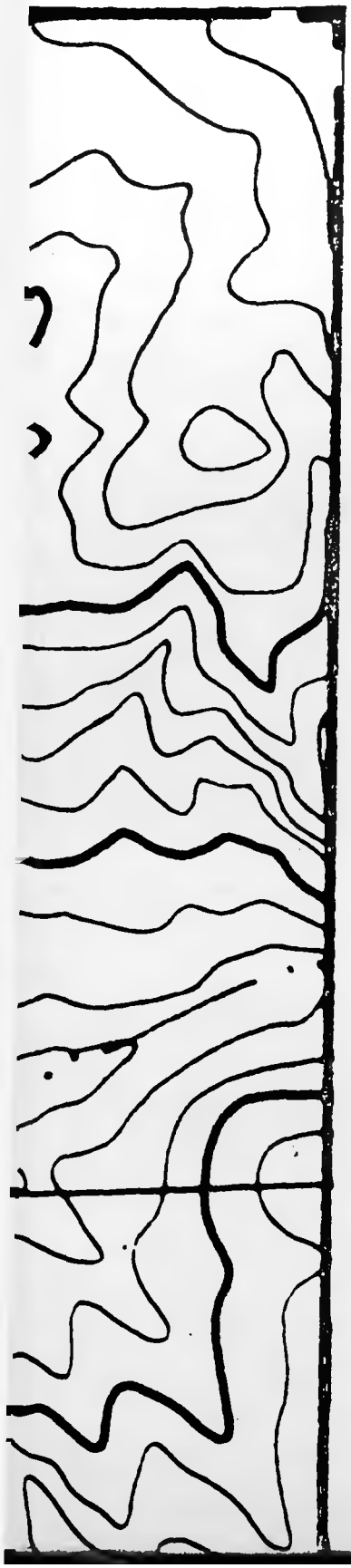
ENERGY INTERANTIONAL IN SITU COAL GASIFICATION PROJECT NORTH KNOBS SITE, CARBON COUNTY, WYOMING

WELL G-3 GROUND WATER CHEMICAL ANALYSES
(ALL PARAMETERS IN DISSOLVED MG/L UNLESS NOTED OTHERWISE)

FIELD PARAMETERS /DATE	02-Mar-88	21-Jun-88	02-Sep-88	04-Dec-88	Count	Maximum	Minimum	Mean
Time	14:55	20:30	08:42	08:25				
Conductivity (U Mhos/Cm @ 25 Deg. C)	8900	3550	2950	2210	4	8900	2210	4402.500
pH (Units)	7.5	7.37	7.7	7.73	4	7.73	7.37	7.550
Temperature (Deg. C)	6	8.5	8.5	7	4	8.5	6	7.500
LAB PARAMETERS								
Alkalinity as CaCO3		694	866	892	3	892	694	817.333
Bicarbonate as CaCO3	324	694	866	892	4	892	324	694.000
Boron	<0.02	<0.02	<0.02	0.03	4	0.03	0	0.008
Bromide	4.7	0.81	0.41	0.11	4	4.7	0.11	1.508
Calcium	411	100	51	35	4	411	35	149.250
Carbon, Dissolved Organic	43	91	101	76	4	101	43	77.750
Carbonate as CaCO3	0	0	0	0	4	0	0	0.000
Chloride	4360	1174	560	216	4	4360	216	1577.500
COD	200	430	207	175	4	430	175	253.000
Cyanide, Total	<0.002	<0.002	<0.002	<0.002	4	0	0	0.000
Fluoride	0.5	0.8	1	0.9	4	1	0.5	0.800
Hydroxide as CaCO3		0	0	0	3	0	0	0.000
Magnesium	168	50	25	17	4	168	17	65.000
Nitrogen, Ammonia	5.7	2.52	1.65	1.55	4	5.7	1.55	2.855
Nitrate as N	0.02	<0.02	<0.01	0.02	4	0.02	0	0.010
Nitrite as N	0.01	<0.01	<0.01	<0.01	4	0.01	0	0.003
Oxidation-Reduction Pot. (+mV)	237	210	201	272	4	272	201	230.000
Phenols	<0.05	0.02	<0.01	0.01	4	0.02	0	0.008
Potassium	1230	210	93	47	4	1230	47	395.000
Sodium	1530	748	574	486	4	1530	486	834.500
Sulfate	39	27	4	<2	4	39	0	17.500
Sulfide as S	<0.2	<0.2	0.09	0.8	4	0.8	0	0.223
Thiocyanate	0.3	0.7	0.6	0.6	4	0.7	0.3	0.550
Cations, Sum (meq/l)	133.63	47.47	32.27	25.75	4	133.63	25.75	59.780
Anions, Sum (meq/l)	129.38	47.32	33.08	23.85	4	129.38	23.85	58.408
Cation-Anion Balance (%)	1.62	0.16	-1.24	3.83	4	3.83	-1.24	1.093
Solids, Total Dissolved	8550	2910	1812	1488	4	8550	1488	3690.000
Aluminum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Arsenic	<0.001	<0.001	<0.001	<0.001	4	0	0	0.000
Barium	2.75	0.74	0.31	0.11	4	2.75	0.11	0.978
Cadmium	<0.005	<0.005	<0.005	<0.005	4	0	0	0.000
Copper	<0.01	<0.01	<0.01	<0.01	4	0	0	0.000
Chromium	<0.01	<0.01	<0.01	0.01	4	0.01	0	0.003
Iron	30.3	21.5	16	0.67	4	30.3	0.67	17.118
Lead	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Manganese	0.94	0.46	0.39	0.34	4	0.94	0.34	0.533
Mercury	<0.0002	0.0001	<0.0001	<0.0001	4	0.0001	0	0.0000
Molybdenum	<0.05	<0.05	<0.05	<0.05	4	0	0	0.000
Nickel	<0.02	<0.02	<0.02	<0.02	4	0	0	0.000
Selenium	<0.001	<0.001	<0.001	<0.001	4	0	0	0.000
Zinc	0.02	0.01	0.01	0.02	4	0.02	0.01	0.015


6750


40+00
BASELINE
35+00
30+00
PERMIT BOUNDARY
G—8
G—4
L—4
20+00
U—4
S—7
L—7
G—7
U—7
L—2
U—2
G—2



G= G—Seam Monitoring We

U= Sand Above G—Seam (

L= Sand Below G—Seam

S= Localized Shallow Sanc

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e G—Seam Coal

G—Seam

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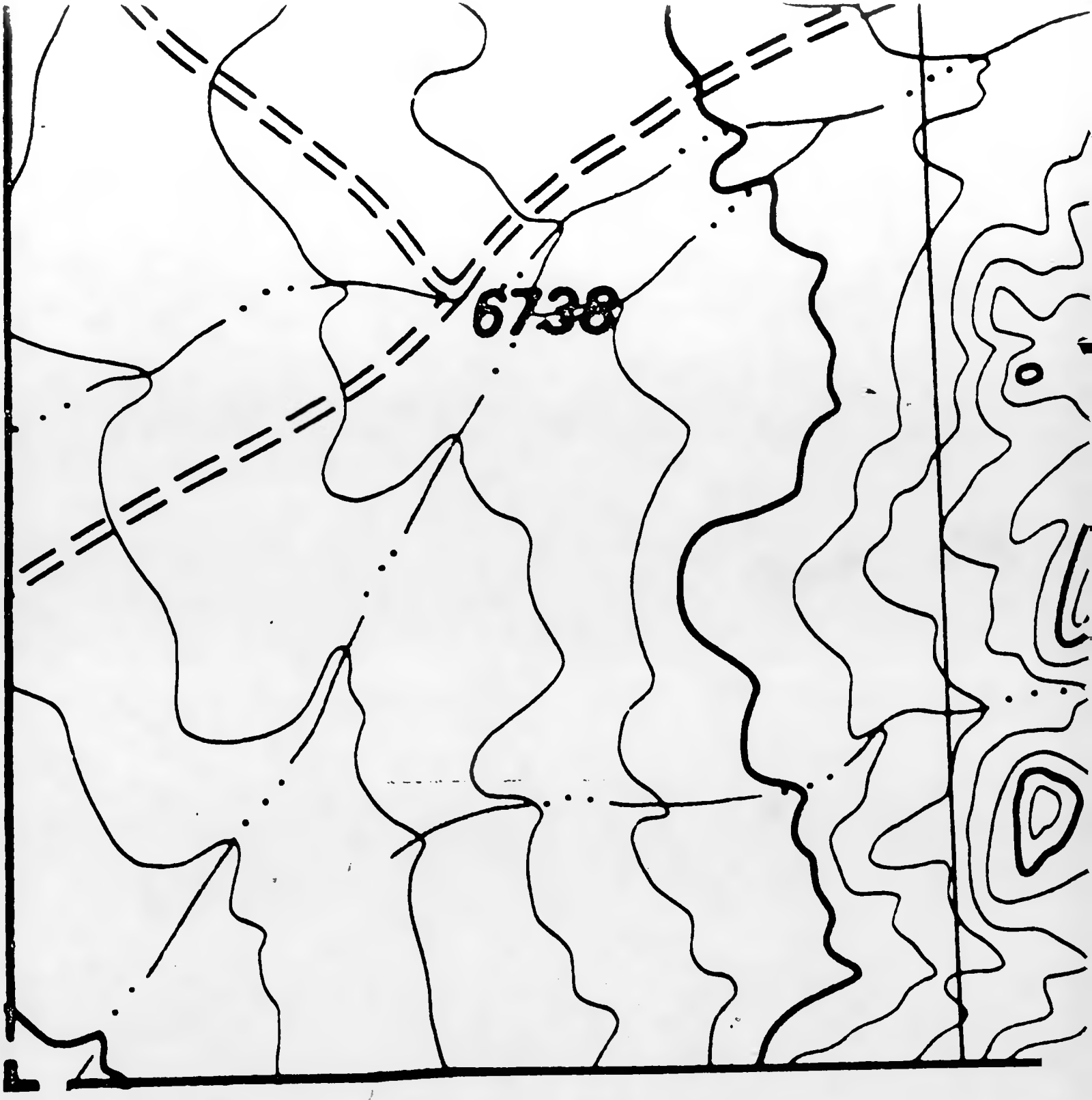
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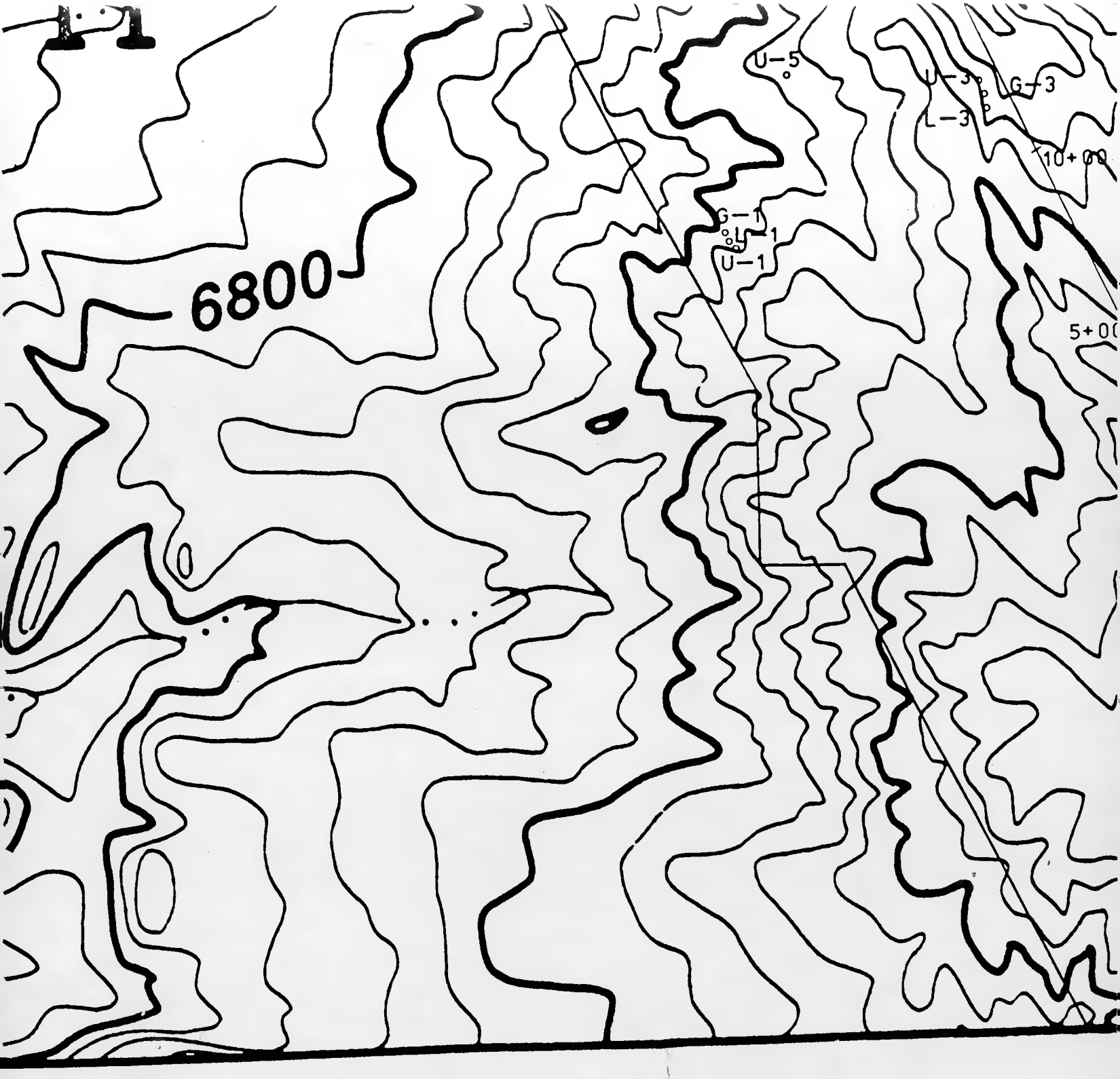
6800
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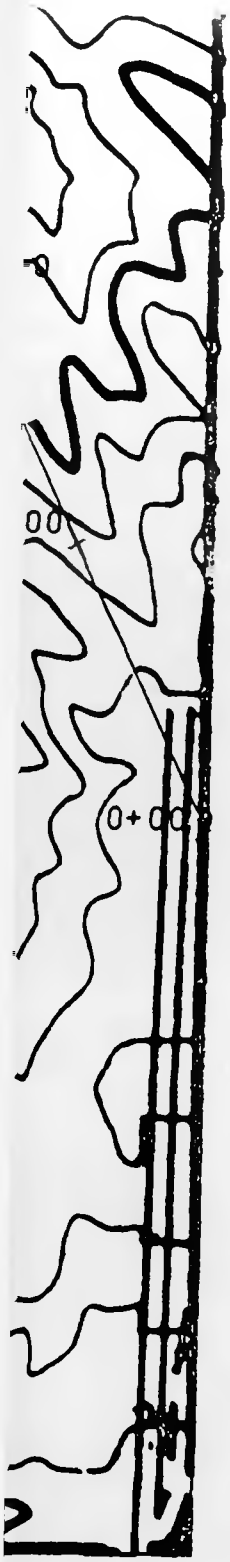
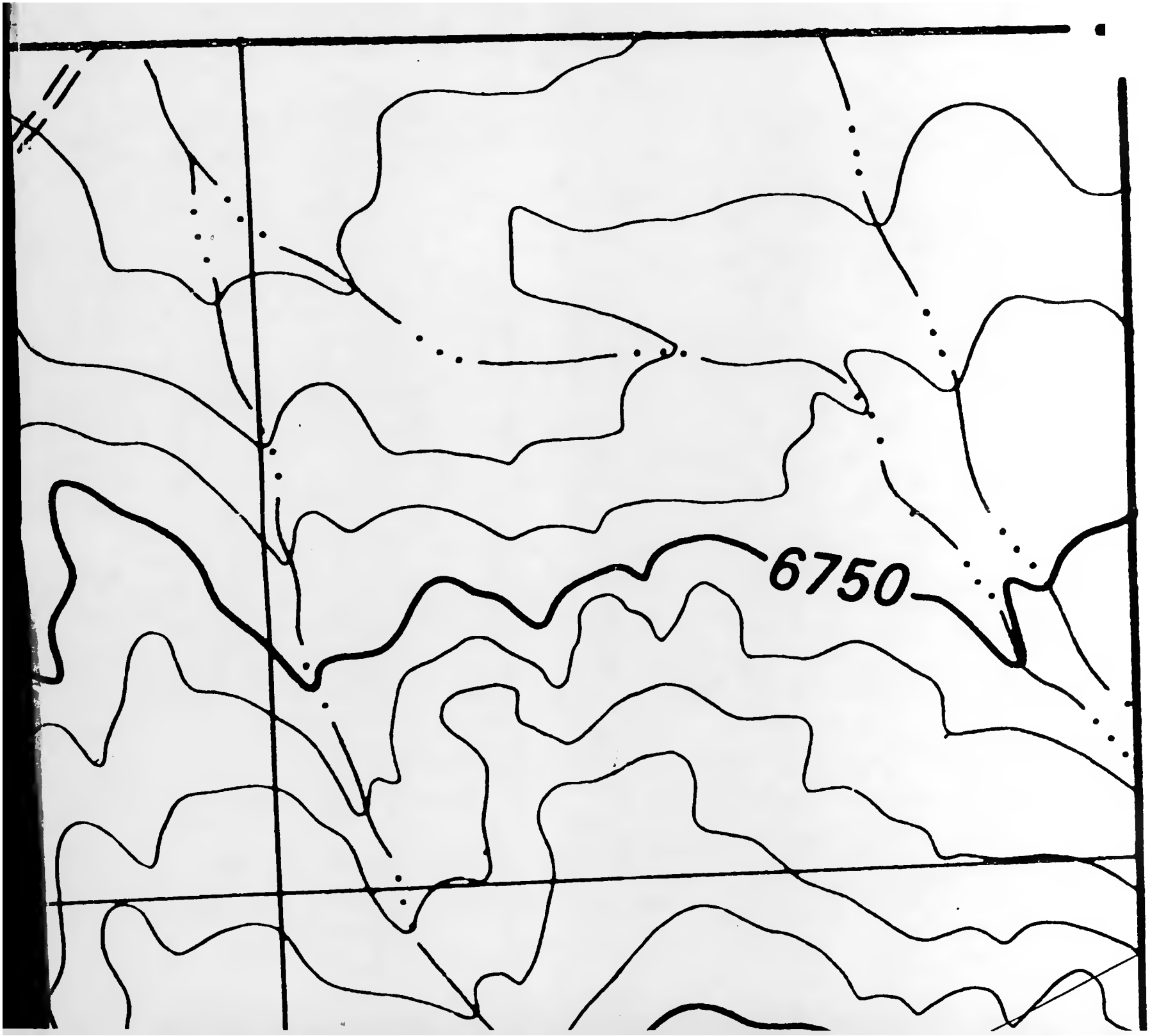


Project Name	Rawlins Underground Coal Gasifi
	Energy International In 135 William Pitt Way Pittsburgh, PA 15238 (412) 826–5350
Title	Locations of Monitoring Wells on Topo
Date	Drawn By

Underground Coal Gasification Company			Remarks
Energy International Inc. 135 William Pitt Way Pittsburgh, PA 15238 (412) 826—5350			
Monitoring Wells on Topographic Map.			Scale 1"=300'
	Drawn By	Approved By	Plate No. 1


6750


PERMIT BOUNDARY
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U-7
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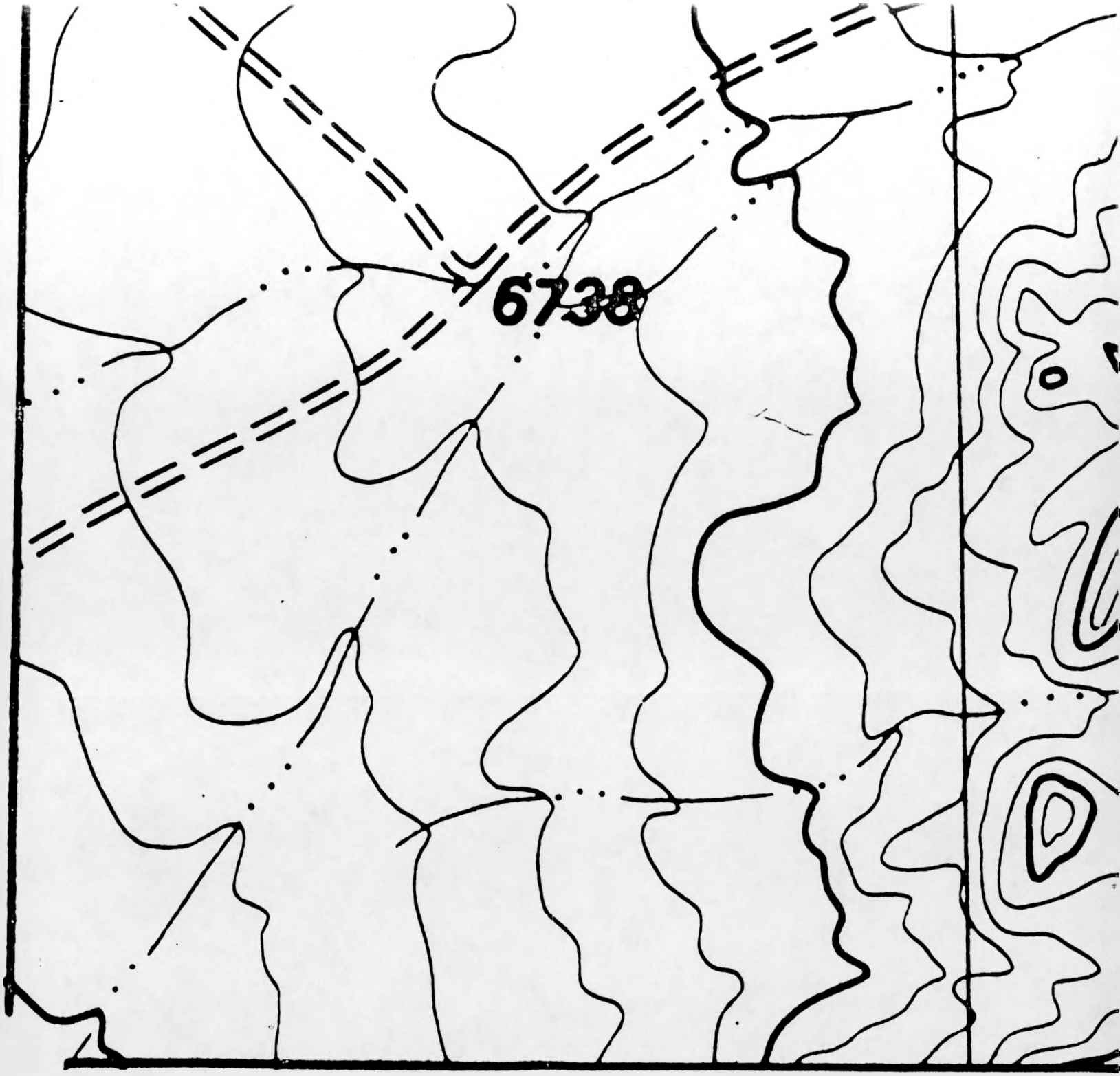
U-2
6135.5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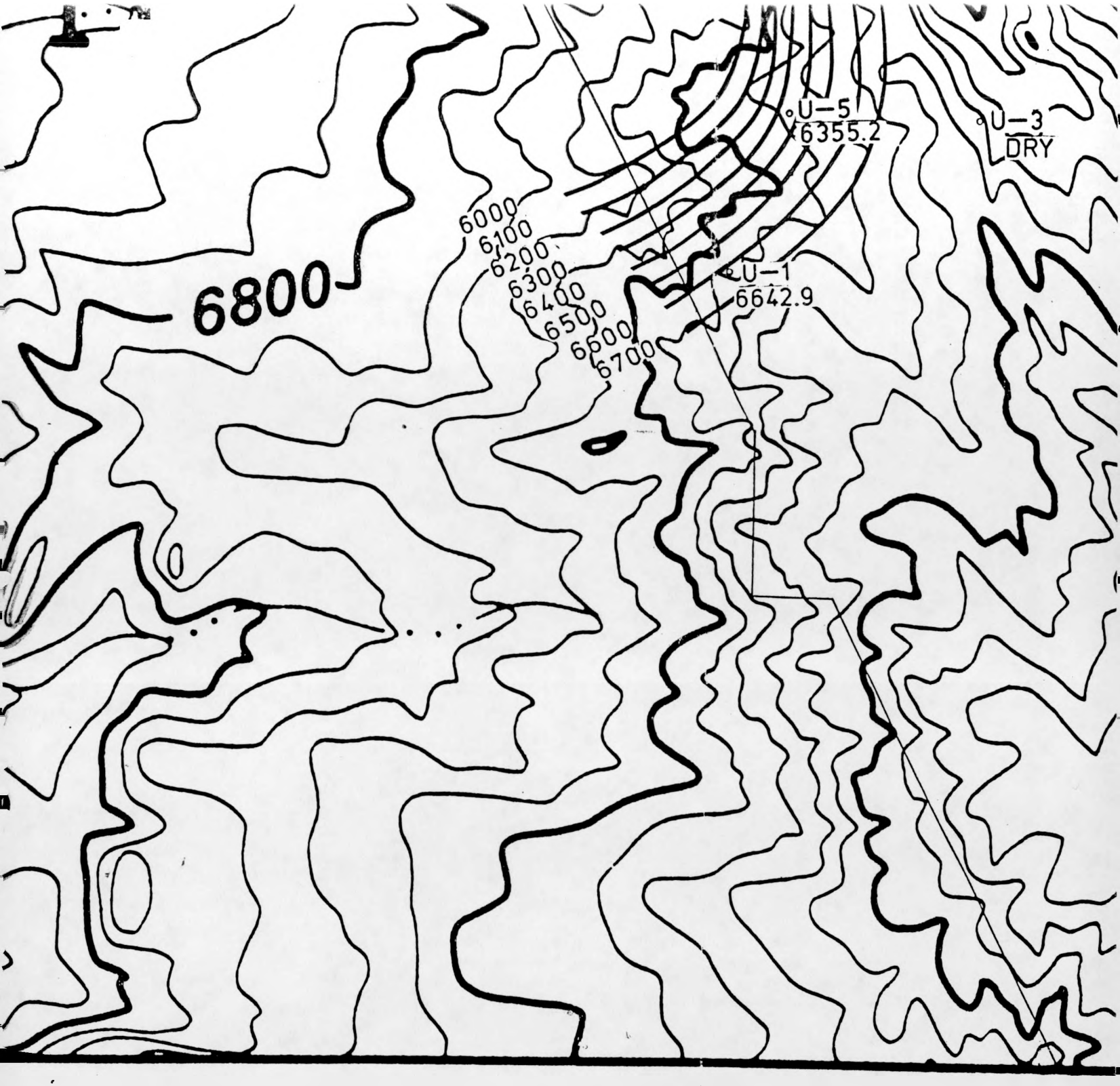
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Project Name	Rawlins Underground Coal Gas
	Energy International I 135 William Pitt Way Pittsburgh, PA 15238 (412) 826-5350
Title	Potentiometric Surface of Upper Sand
Date	Drawn By

d Coal Gasification Company	Remarks
ernational Inc. am Pitt Way h, PA 15238 26—5350	
Upper Sand.	Scale 1"=300'
Approved By	Plate No. 2


6750


PERMIT BOUNDARY
5600
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5800
5900
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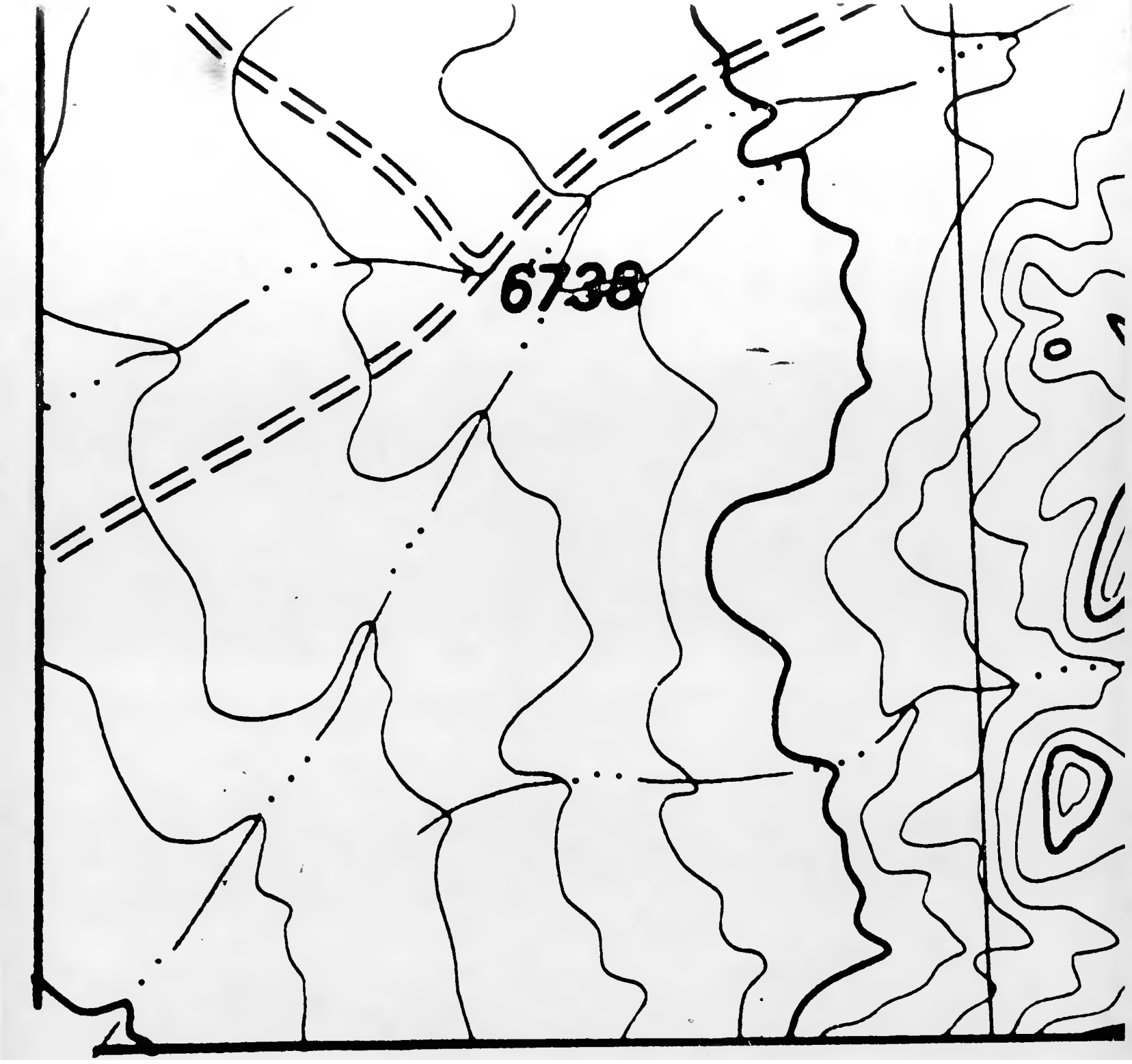
G-4
6778.8
G-7
6782.3
G-2
5896.1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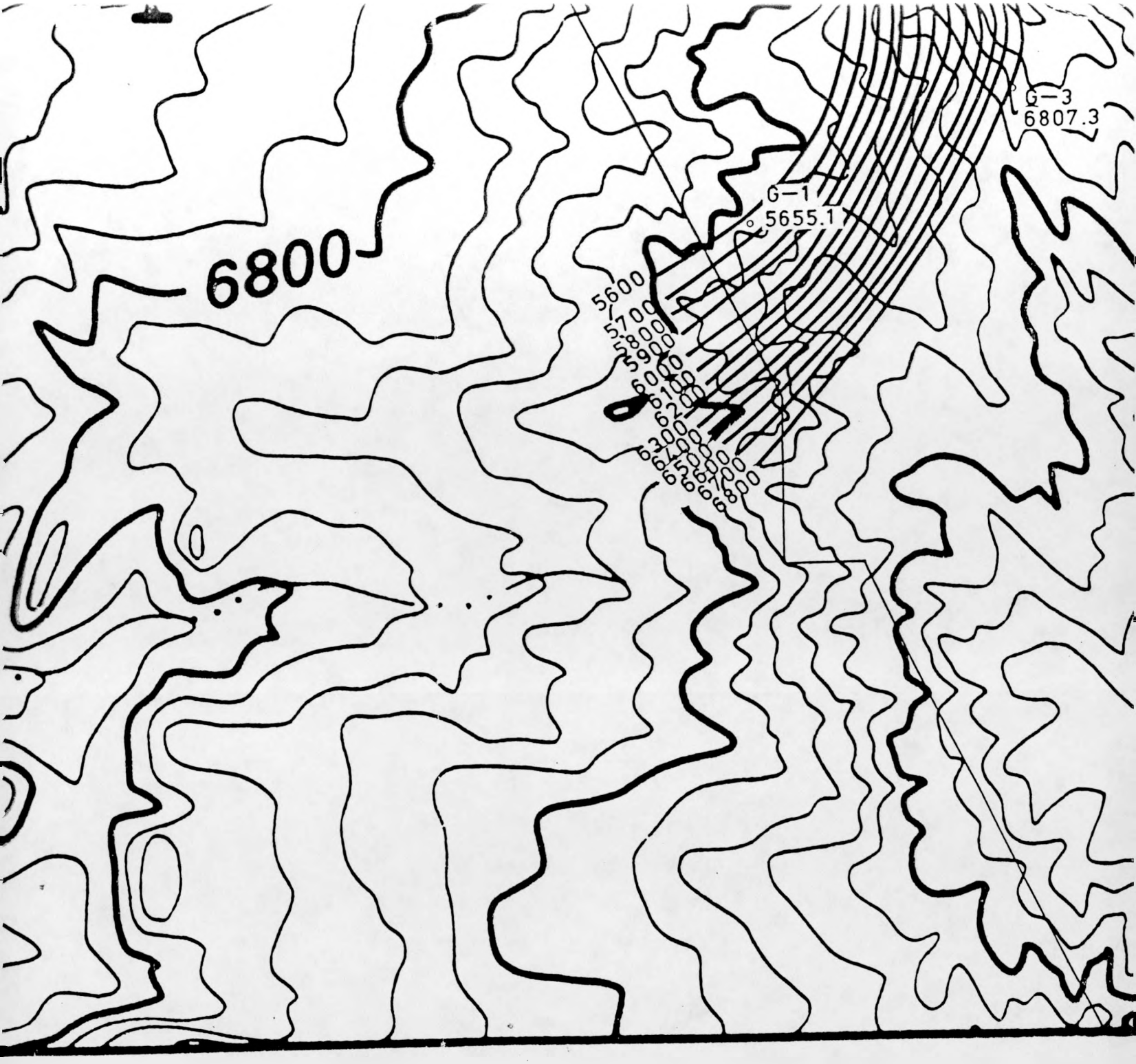
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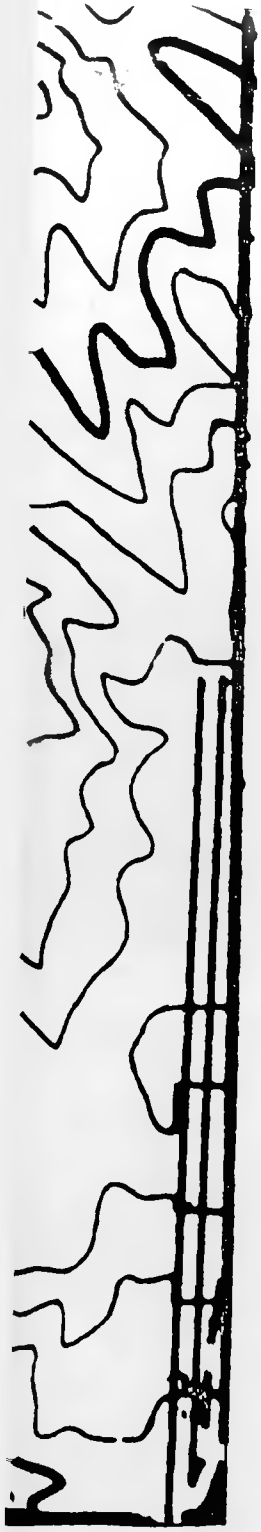
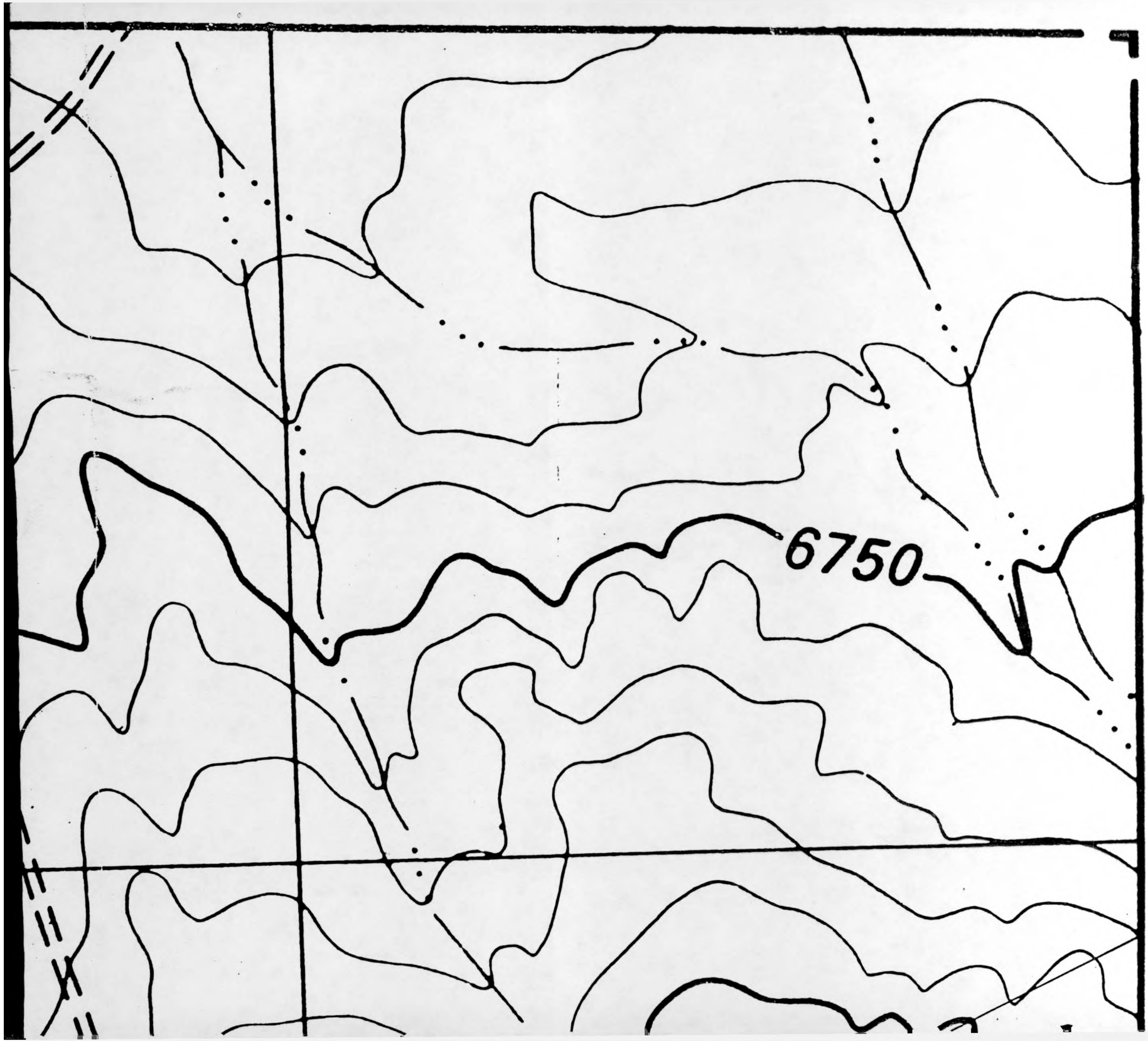
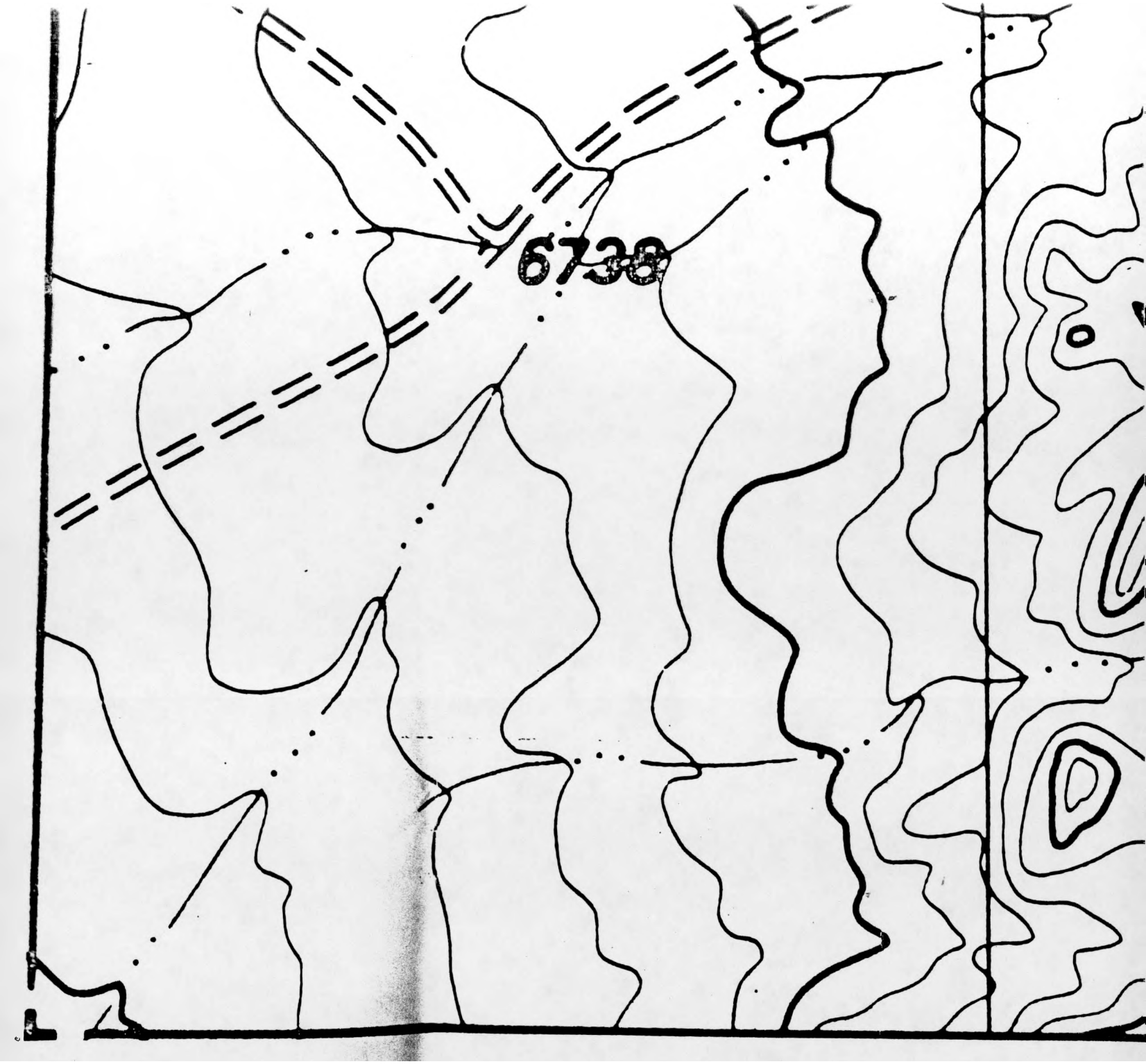


Project Name	Rawlins Underground Coal Gas
	Energy International 135 William Pitt Way Pittsburgh, PA 1523 (412) 826-5350
Title	Potentiometric Surface Map of G Se
Date	Drawn By

Name	Remarks
Rawlins Underground Coal Gasification Company	
Energy International Inc. 135 William Pitt Way Pittsburgh, PA 15238 (412) 826–5350	
Potentiometric Surface Map of G Seam.	Scale 1"=300'
Drawn By	Approved By	Plate No. 3


6750


PERMIT BOUNDARY
6400
6500
6600
6700
L-4
6779.7
6770.2
L-7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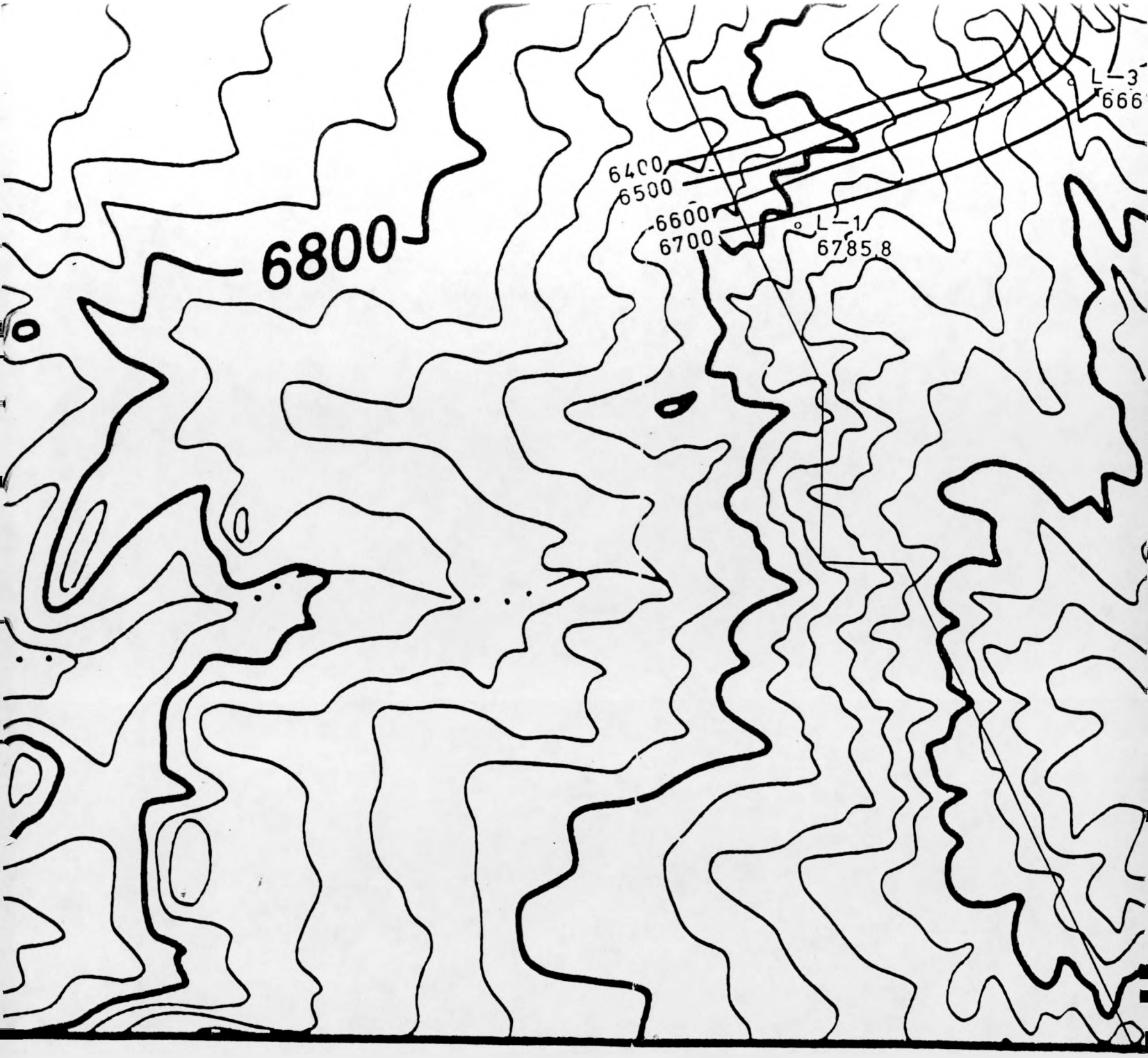
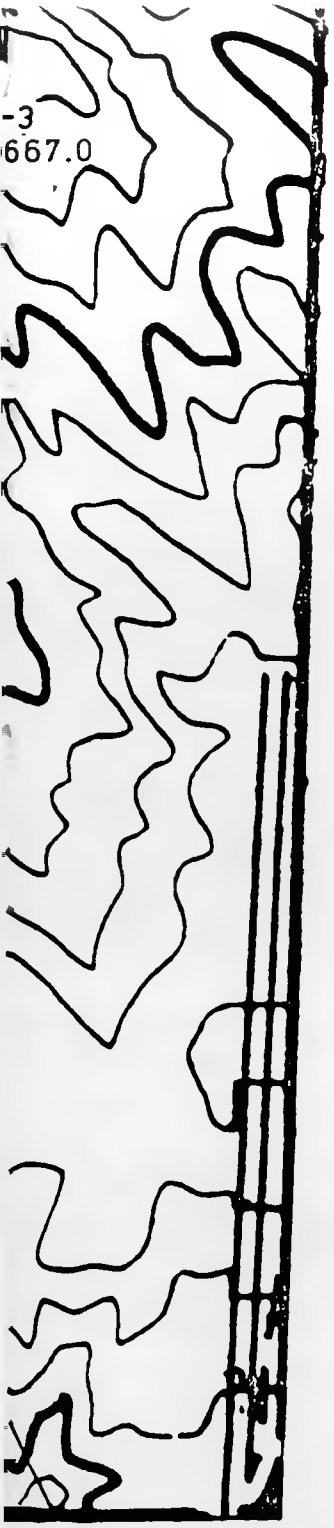
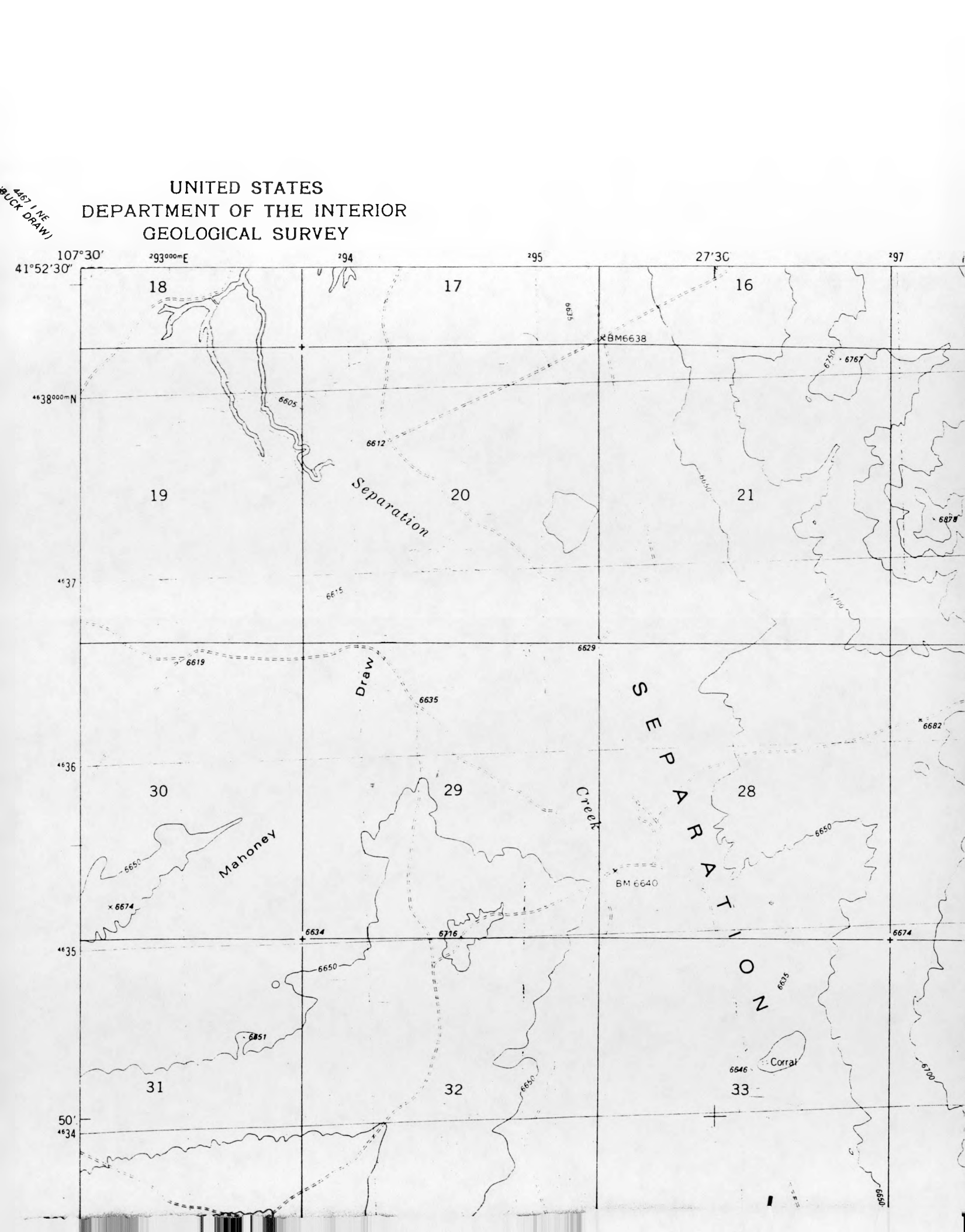

6800
6400
6500
6600
6700
L-1
6785.8
L-3
666



Project Name	Rawlins Underground Coal
	Energy Internatio 135 William Pitt Pittsburgh, PA 1 (412) 826—535
Title	Potentiometric Surface Map of L
Date	Drawn By

Rawlins Underground Coal Gasification Company	Remarks
Energy International Inc. 135 William Pitt Way Pittsburgh, PA 15238 (412) 826—5350	
ıtiometric Surface Map of Lower Sandstone.	Scale 1"=300'

	Drawn By	Approved By	Plate No. 4


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
4467 I NE
(BUCK DRAW)
107°30'
41°52'30"
293000mE
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27'30
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4638000mN
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50'
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6605
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6750
6767
Separation
6650
6878
6615
6629
6619
Draw
6635
SEPARATION
6682
Mahoney
6650
BM 6640
6674
6634
6716
Creek
6650
6635
6851
Corral
6646
6700
6650

RAWLINS PEAK SW QUADF
WYOMING–CARBON CO.
7.5 MINUTE SERIES (TOPOGR
SW 4 RAWLINS PEAK 15' QUADRANGLE

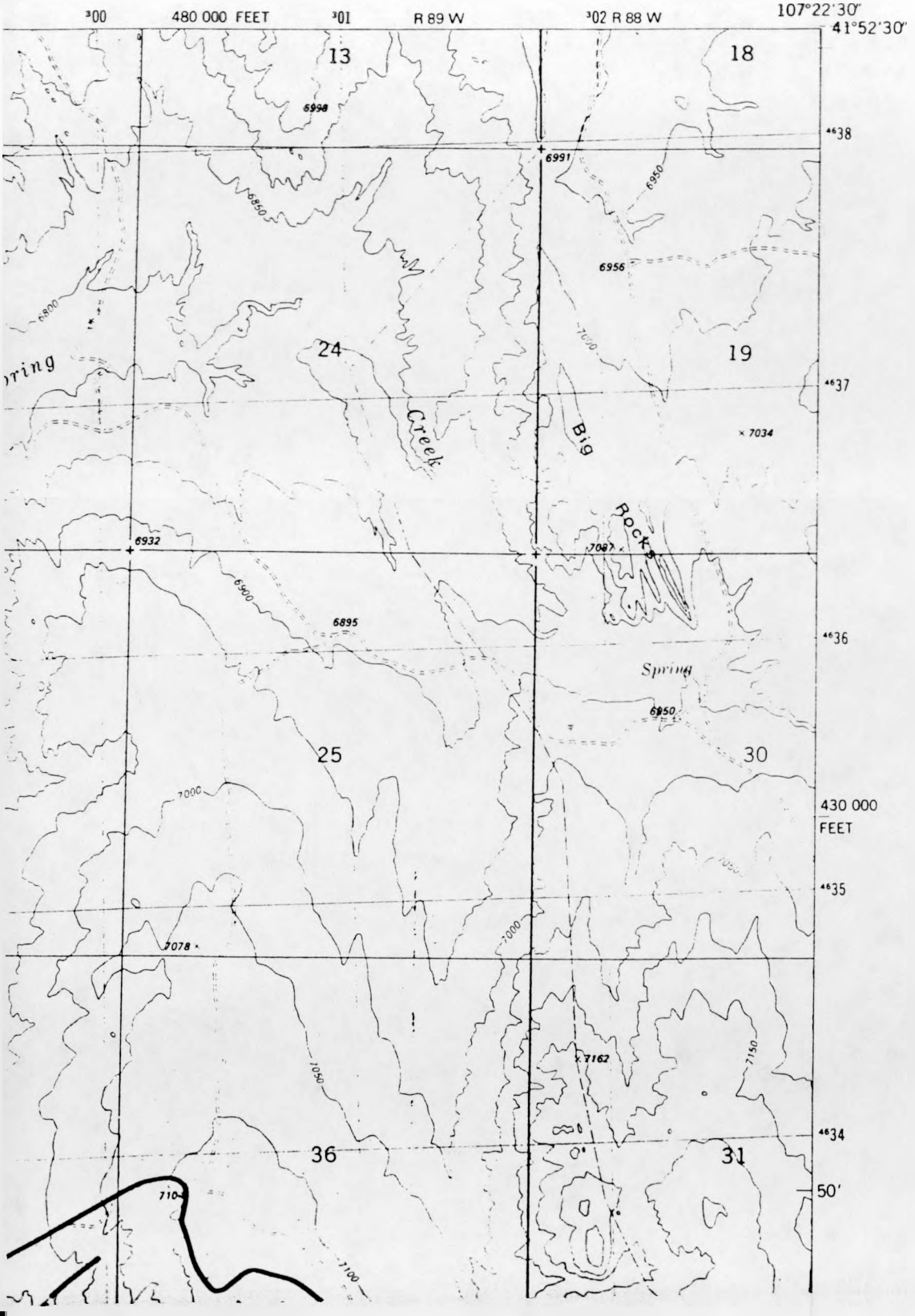
RAWLINS PEAK SW QUADRANGLE

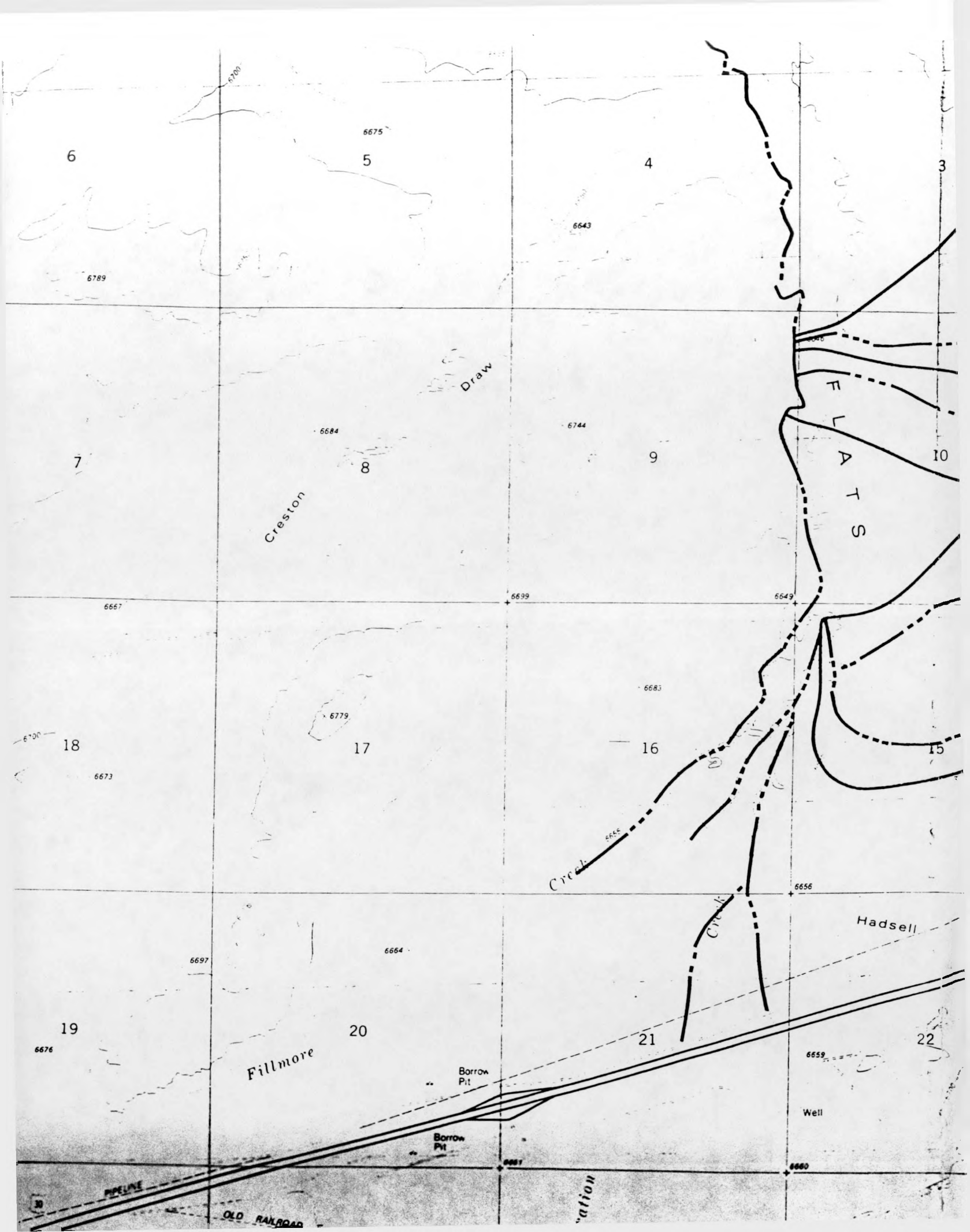
WYOMING–CARBON CO.

7.5 MINUTE SERIES (TOPOGRAPHIC)

SW/4 RAWLINS PEAK 15 QUADRANGLE

4567 IV NE (RENDLE HILL)




6
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Creston
Draw
FLATS
Hadsell
Fillmore
Borrow Pit
Borrow Pit
Well
PIPELINE
OLD RAILROAD
6700
6675
6643
6789
6684
6744
6667
6699
6649
6683
6779
6673
6656
6697
6664
6676
6659
6661
6660


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7269
7165
6724
6942
7141
8938
11
12
7
Drill
Holes
Well
6938
6691
6839
Prospect
7069
6850
PIPELINE
7045
6811
14
13
18
47'30"
4629
6814
RAILROAD
6894
GRADE
OLD
30
80
RAWLINS 7 MI
LARAMIE 99 MI
Draw
6811
4628
Hadsell
6767
23
Gravel
Pit
24
19
Hadsell
6991
BM 6662
4627
6774
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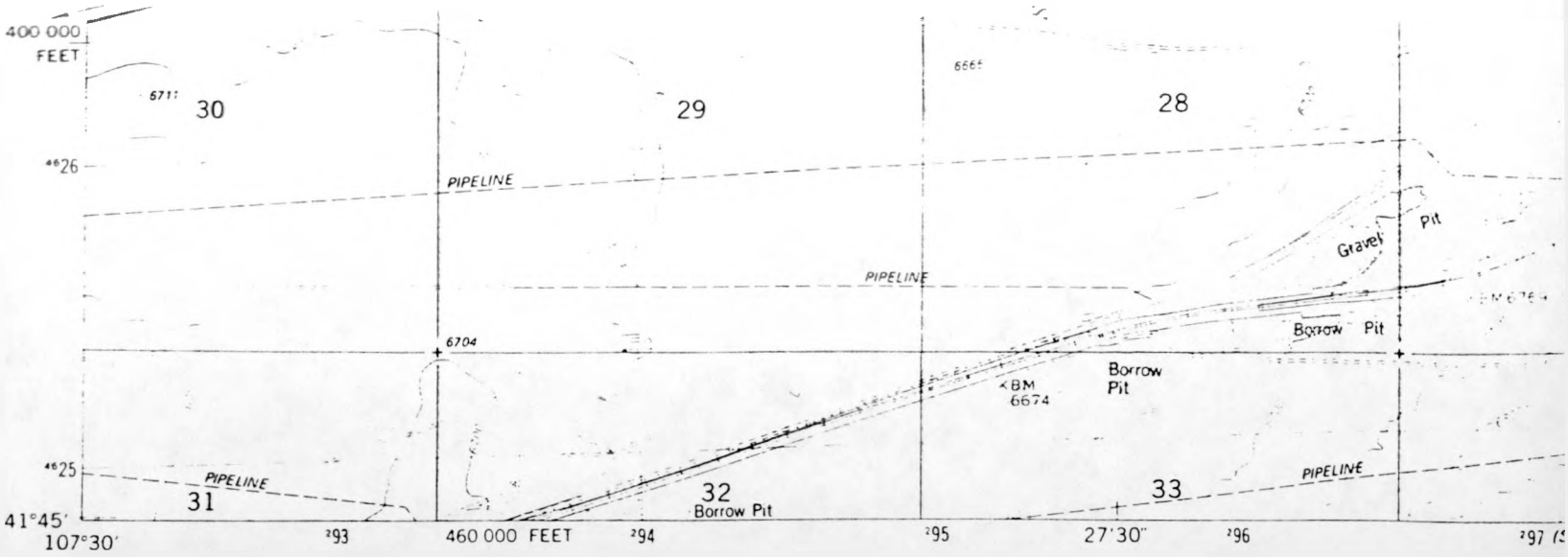


Mapped, edited, and published by the Geological Survey

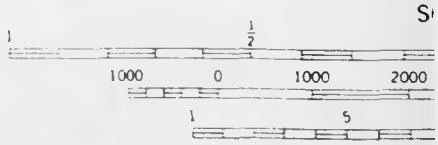
Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1975. Field checked 1978. Map edited 1983

Projection and 10,000-foot grid ticks: Wyoming coordinate system, east central zone (transverse Mercator)
1000-meter Universal Transverse Mercator grid, zone 13
1927 North American datum
To place on the predicted North American Datum 1983 move the projection lines 8 meters north and 52 meters east as shown by dashed corner ticks

Fine red dashed lines indicate selected fence lines

UTM GRID AND 1983 MAGNETIC NORTH DECLINATION AT CENTER OF MAP DIAGRAM IS APPROXIMATE



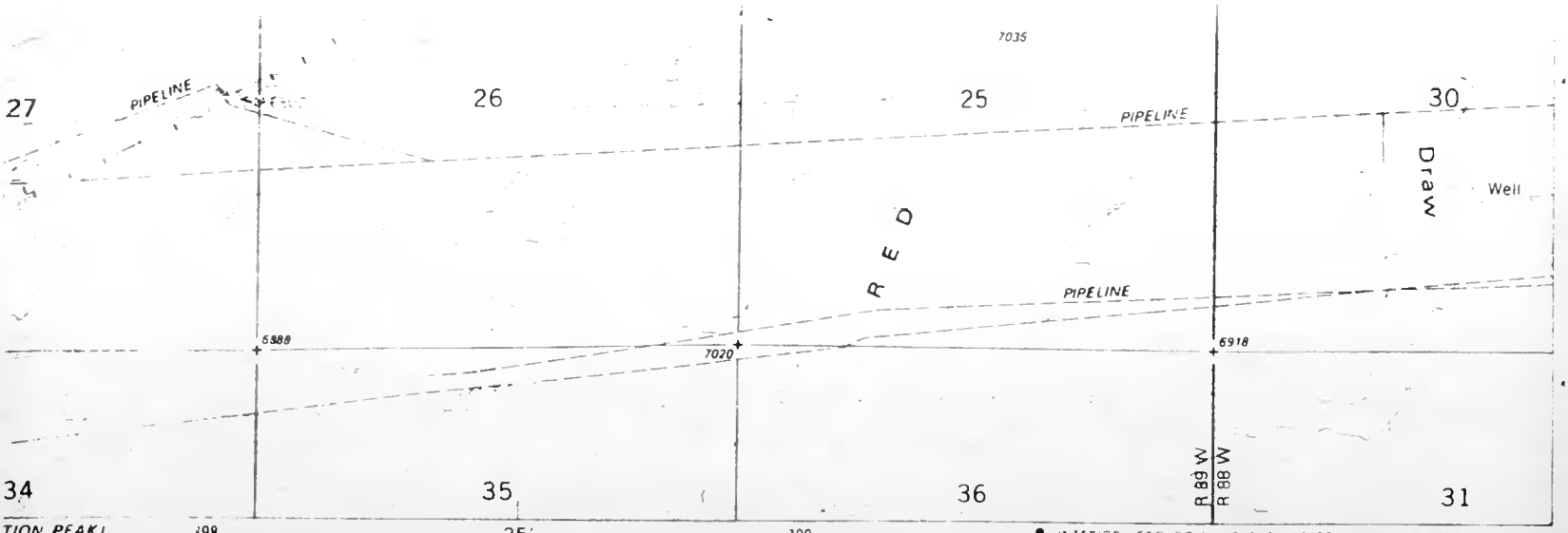
CONTOUR
DOTTED LINES R
NATIONAL GEODE

THIS MAP COMPLIES WITH
FOR SALE BY U. S. GEOLOGICAL SURVEY,
A FOLDER DESCRIBING TOPOGRAPHIC

LEGEND

Drainage Area Basin

Surface Water Monitoring Location



1:24 000

0 1 MILE

000 4000 5000 6000 7000 FEET

0 1 KILOMETER

RVAL 10 FEET
ENT 5-FOOT CONTOURS
RTICAL DATUM OF 1929

ROAD CLASSIFICATION

Primary highway hard surface

Light duty road hard or improved surface

Secondary highway hard surface

Unimproved road

Interstate Route U S Route State Route

QUADRANGLE LOCATION

NAL MAP ACCURACY STANDARDS
R, COLORADO 80225, OR RESTON, VIRGINIA 22092
AND SYMBOLS IS AVAILABLE ON REQUEST

RAWLINS PEAK SW, WYO.
SW/4 RAWLINS PEAK 15' QUADRANGLE
N4145-W10722.5/7.5

1983

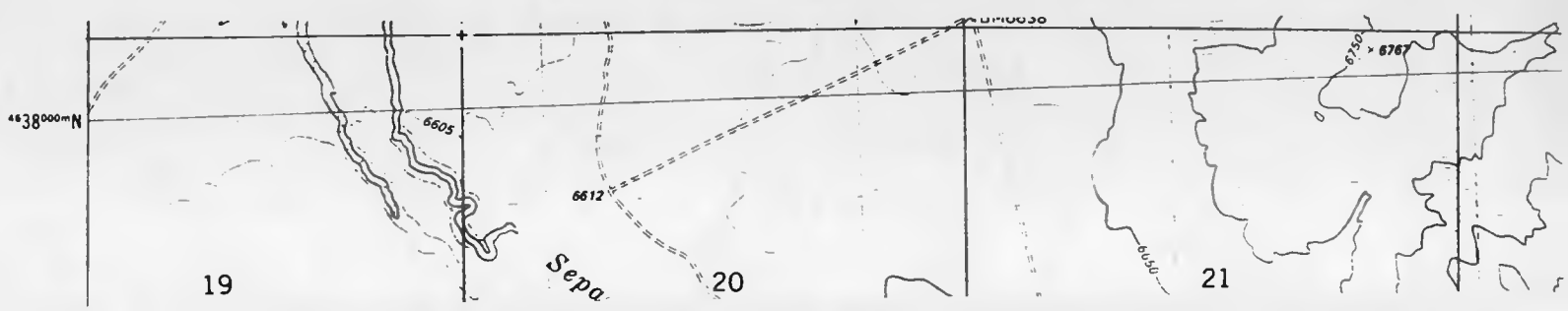
DMA 4567 IV SW-SERIES V874

Project Name	Remarks
Rawlins Underground Coal Gasification Company	
Energy International Inc. 135 William Pitt Way Pittsburgh, PA 15238 (412) 826—5350	
Title **Permit Area Drainage Basins**	

LEGEND

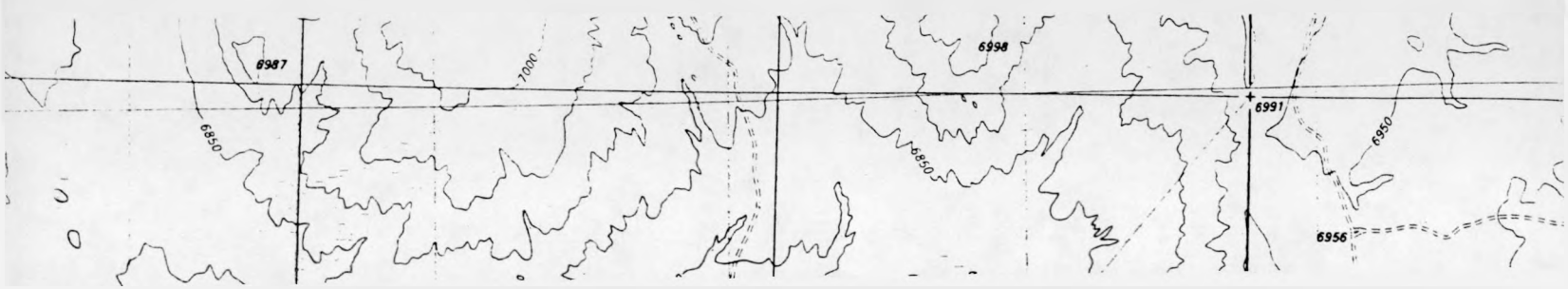
——— Drainage Area Basin

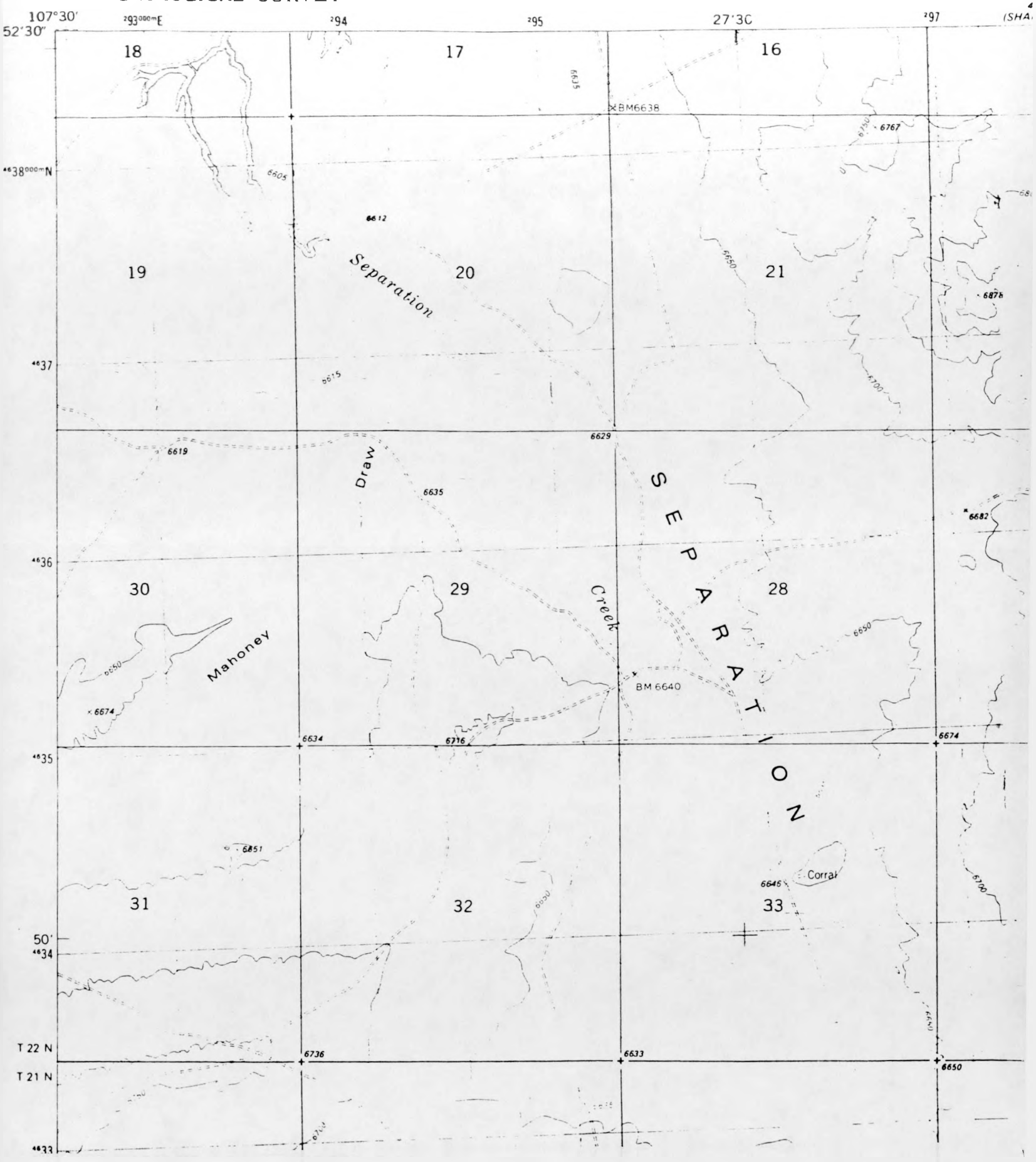
● Surface Water Monitoring Location



Project Name	Remarks
Rawlins Underground Coal Gasification Company	
Energy International Inc. 135 William Pitt Way Pittsburgh, PA 15238 (412) 826–5350	
Title Permit Area Drainage Basins.	Scale

Date	Drawn By	Approved By	Plate No.
			5




UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
107°30'
52'30"
293000mE
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27'30
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SEPARATION
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Creek
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Mahoney
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Corral
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50'
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T 22 N
T 21 N
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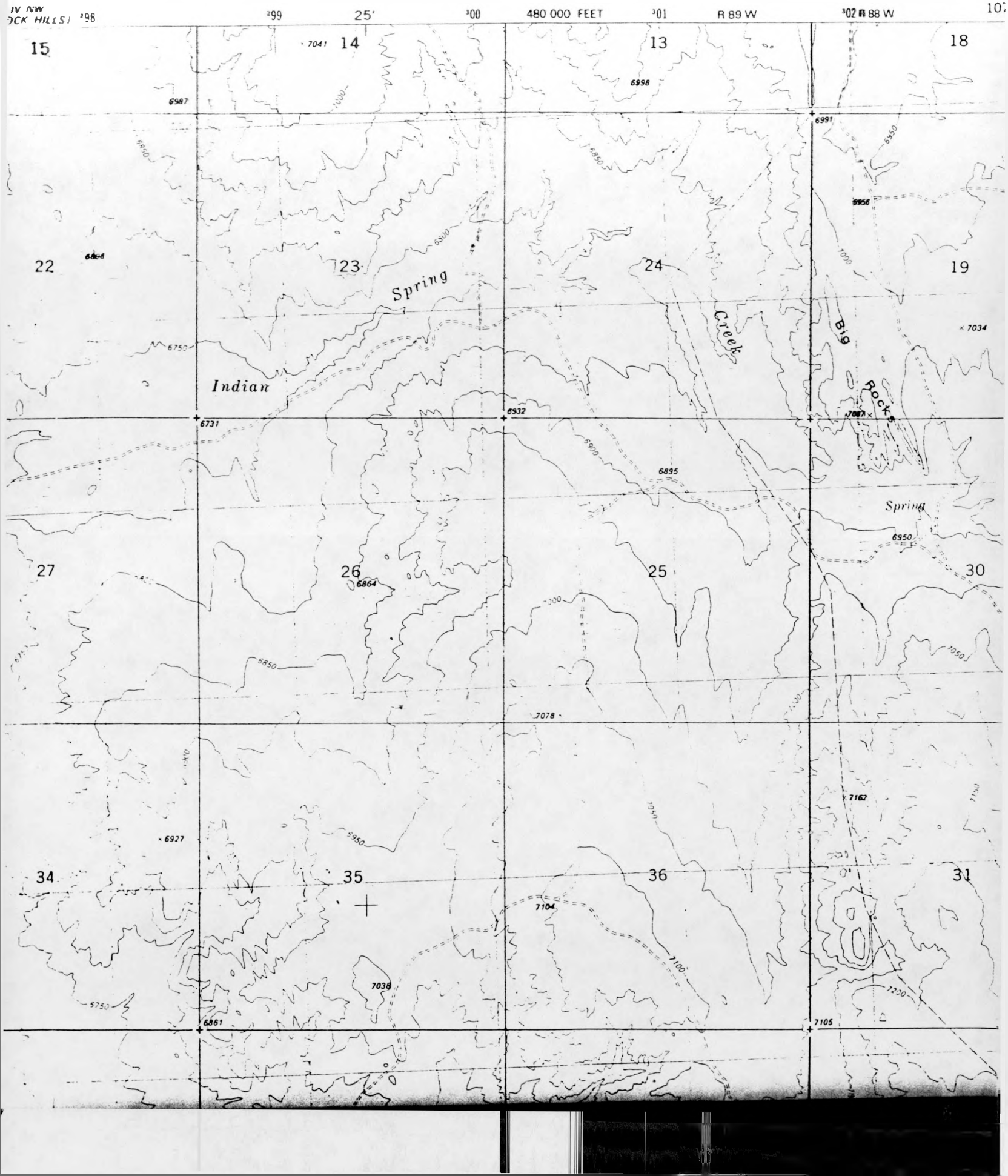
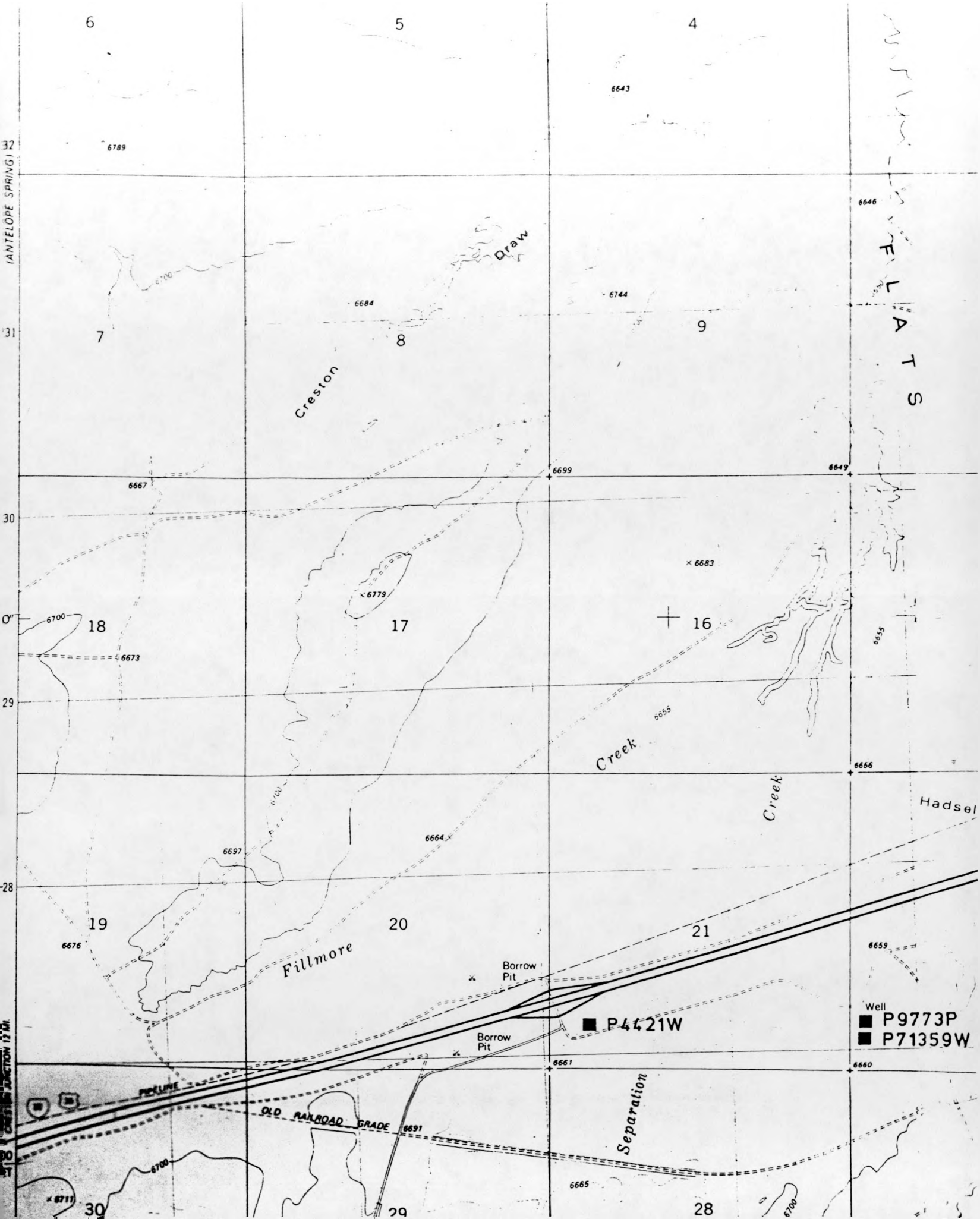
WYOMING–CARBON CO.

7.5 MINUTE SERIES (TOPOGRAPHIC)

SW/4 RAWLINS PEAK 15' QUADRANGLE

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21
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28
(ANTELOPE SPRING)
Draw
Creston
Creek
Creek
Fillmore
Hadsel
Separation
FLATS
Borrow Pit
Borrow Pit
Well
P4421W
P9773P
P71359W
PIPELINE
OLD RAILROAD GRADE
6789
6643
6646
6744
6684
6700
6699
6649
6667
6683
6779
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6655
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6697
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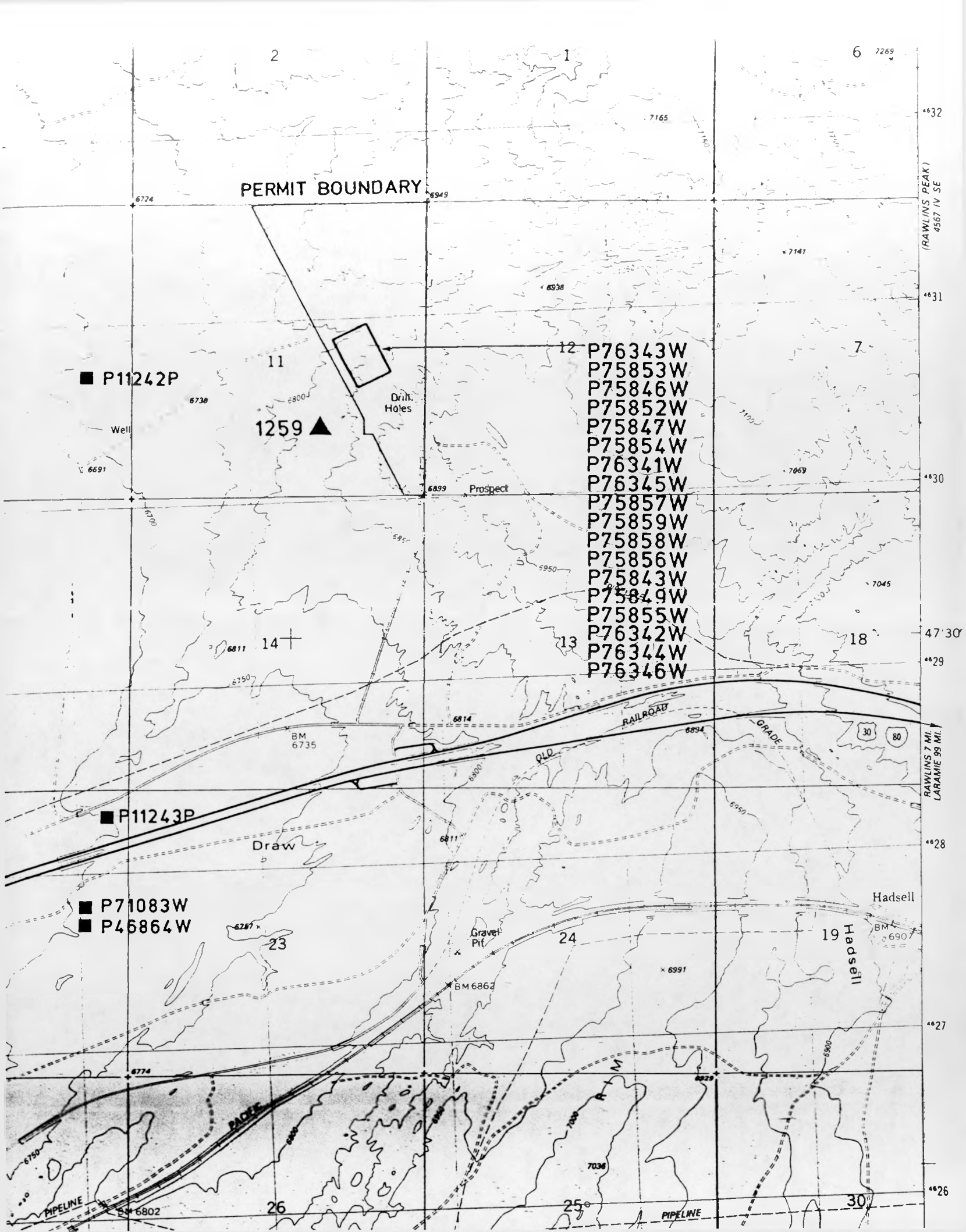
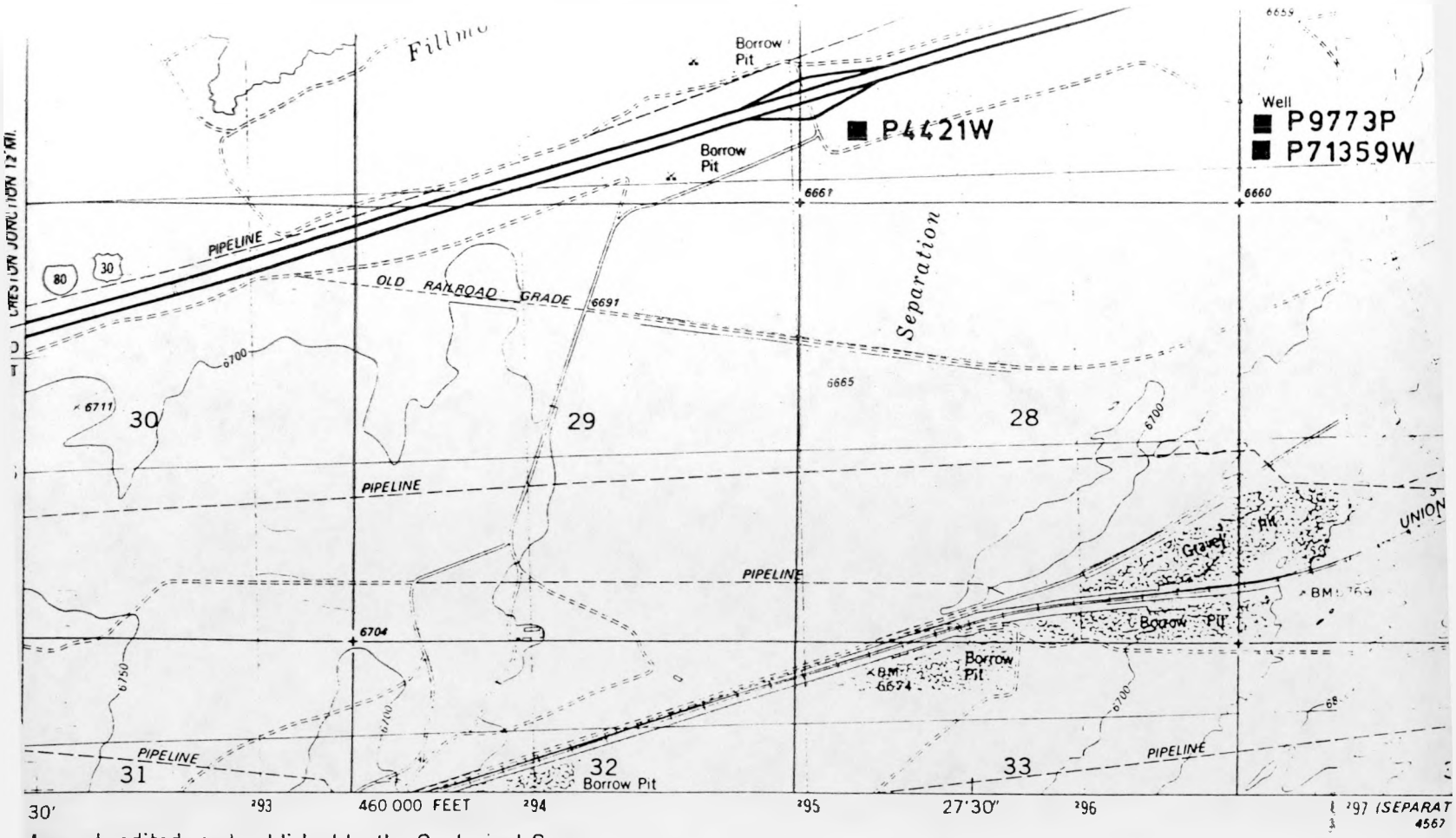
6691
6665
6711
6700


PERMIT BOUNDARY
P11242P
1259
Drill Holes
Well
Prospect
P76343W
P75853W
P75846W
P75852W
P75847W
P75854W
P76341W
P76345W
P75857W
P75859W
P75858W
P75856W
P75843W
P75849W
P75855W
P76342W
P76344W
P76346W
P11243P
Draw
P71083W
P46864W
Gravel Pit
BM 6735
BM 6862
BM 6802
Hadsell
RAILROAD GRADE
OLD
PACIFIC
PIPELINE
RAWLINS 7 MI.
LARAMIE 99 MI.
(RAWLINS PEAK) 4567 IV SE
47°30'



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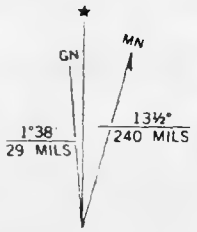
move the projection lines 8 meters north and
72 meters east as shown by dashed corner ticks

The red dashed lines indicate selected fence lines



UTM GRID AND 1983 MAGNETIC NORTH DECLINATION AT CENTER OF MAP DIAGRAM IS APPROXIMATE

SCALE 1

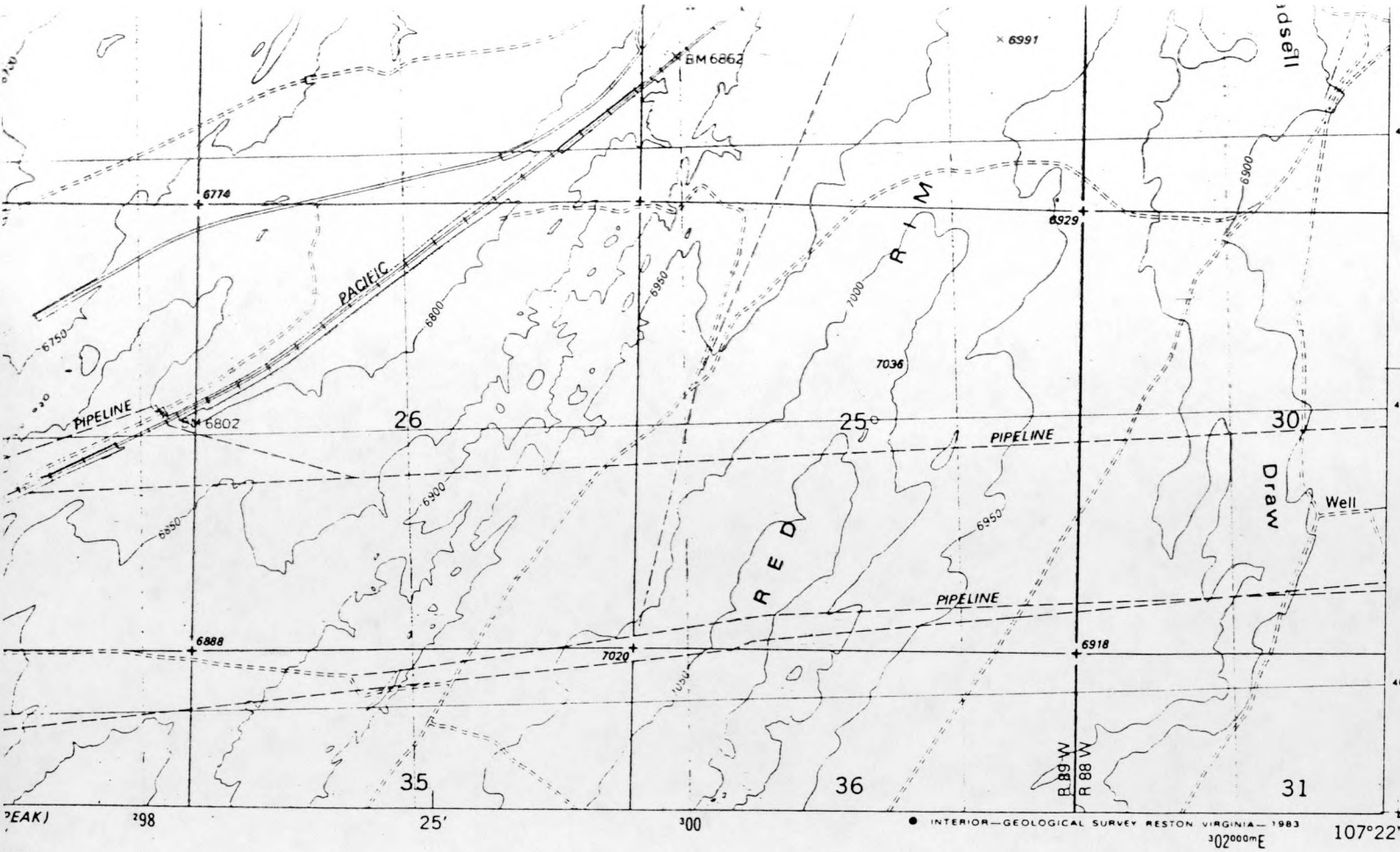
CONTOUR INTER
DOTTED LINES REPRESE
NATIONAL GEODETIC VER

THIS MAP COMPLIES WITH NATIONA
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER
A FOLDER DESCRIBING TOPOGRAPHIC MAPS

LEGEND

Ground Water Right

Surface Water Right



1 MILE

4000 5000 6000 7000 FEET

1 KILOMETER

. 10 FEET
-FOOT CONTOURS
L DATUM OF 1929

MAP ACCURACY STANDARDS
LORADO 80225, OR RESTON, VIRGINIA 22092
SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

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Secondary highway, hard surface

Light-duty road, hard or improved surface

Unimproved road

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RAWLINS PEAK SW, WYO.

SW/4 RAWLINS PEAK 15' QUADRANGLE
N4145-W10722.5/7.5

1983

DMA 4567 IV SW-SERIES V874

Project Name	Remarks
Rawlins Underground Coal Gasification Company	
Energy International Inc. 135 William Pitt Way Pittsburgh, PA 15238	

move the projection lines 6 meters north and
52 meters east as shown by dashed corner ticks

Fine red dashed lines indicate selected fence lines

DIAGRAM IS APPROXIMATE

LEGEND

■ Ground Water Right

▲ Surface Water Right

Project Name	Remarks
Rawlins Underground Coal Gasification Company	
Energy International Inc. 135 William Pitt Way Pittsburgh, PA 15238 (412) 826-5350	
Title Location of All Active Ground Water Rights.	Scale 1"=

Date	Drawn By	Approved By	Plate No.