Research Technical Completion Report

RECONNAISSANCE STUDY OF THE "RUSSELL" BASALT AQUIFER IN THE LEWISTON BASIN OF IDAHO AND WASHINGTON

by

Philip Leon Cohen
Graduate Student

and

Dale Ralston

College of Mines

and Earth Resources

Submitted to:
Idaho Department of Water Resources
and the
Idaho Department of Health & Welfare,
Division of Environment

IDAHO WATER RESOURCES RESEARCH INSTITUTE
University of Idaho
Moscow, Idaho

April, 1980

Research Technical Completion Report

RECONNAISSANCE STUDY OF THE "RUSSELL" BASALT AQUIFER IN THE LEWISTON BASIN OF IDAHO AND WASHINGTON

by

Philip Leon Cohen
Graduate Student

and

Dale Ralston
College of Mines and Earth Resources

Submitted to:

Idaho Department of Water Resources
and
Idaho Department of Health & Welfare,
Division of Environment

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

April, 1980

ACKNOWLEDGEMENTS

Support for this study was provided by a matching fund grant from the Idaho Department of Water Resources and Department of Health and Welfare. The grant was administered by the Idaho Water Resources Research Institute at the University of Idaho. The authors wish to thank the departments and Institute for making this study possible.

The authors also wish to thank and acknowledge the assistance given by persons, corporations, and government agencies providing access to field data and the loan of aquifer test equipment. Appreciation is extended to Paul A. Durand, Paul Castelin, John Busch, Thelon Winschell, Al Erickson, Ted Wright, and Harry Tanaka; Washington Water Power Company, Potlatch Corporation, and R.W. Engineering Company, Idaho Bureau of Mines and Geology, Washington State Department of Ecology, U.S. Army Corps of Engineers, Walla Walla District, and U.S. Geological Survey Water Resources Division of Spokane and Tacoma, Washington.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure | Page

Figure | Page

LIST OF PLATES

LIST OF TABLES

APPENDICES

ABSTRACT

The Lewiston Basin is a triangular-shaped bowl of approximately 400 mi.^{2} (1000 km^2) located in Northern Idaho and Eastern Washington. Within the basin, the two cities of Lewiston, Idaho, and Clarkston, Washington, have recently attained the status as a terminus for river barge traffic of the Columbia River. The purpose of this report is to investigate the ability of basalt aquifers beneath the two cities to sustain the present and anticipated future groundwater development.

The basalt artesian aquifers of the Grande Ronde Formation are the primary source of the groundwater withdrawn by the municipal and industrial wells in the Lewiston Basin. The Grande Ronde is the oldest formation of the Yakima Subgroup and second oldest of the formations comprising the plateau basalts of the Columbia River Group. Only the upper 800 feet (240 m) of basalt flows comprising the Grande Ronde Formation have been tapped for groundwater production. The author has grouped the aquifers of this vertical section into a single collective unit known as the "Russell" aquifer.

Post-Miocene tectonic deformation of the Columbia River Group created the majority of the faults and folds that form the hydrogeologic boundaries of the Lewiston Basin. The central feature of this basin is a broad, assymetrical syncline with a centrally plunging east-west axis. The difference in elevation from the basin center to the southern boundaries is over 4000 feet (1200 m). Tilted plateau basalts connect these two areas with dipslopes that vary from 2° to 4°. The central low forms a focal point for the majority of the stream and river channels of the basin.

Static water levels in the municipal and industrial wells indicates that the piezometric surface of the "Russell" aquifer is primarily controlled by the major streams of the basin, the Snake and Clearwater Rivers. Areas of river-aquifer interconnection occur where the Grande Ronde Formation crops out in the river channels or where faulting has provided a flow path for groundwater flow in the individual basalt contact zones to the surface.

Relatively high values of coefficient of transmissivity (5×10^5 gpd/ft (6200 m^2/day)) were determined for the "Russell" aquifer during a March 1979 aquifer test. Storage coefficient was calculated to be 5×10^{-5} from the same test. The overlaying aquifers of the Saddle Mountains and Wanapum Formations were determined to have lower values of hydraulic conductivity due to the presence of soil interbeds in their interflow contact zones.

Hydrographs constructed from municipal well water level records of the last nineteen years indicate no long term decline has occurred. The piezometric surface of the "Russell" aquifer has only shown seasonal decline caused by pumpage. Further groundwater development of this aquifer is possible. Such development should be augmented with additional aquifer tests and predictive computer modeling for optimal use.

Groundwater quality at the present is good and fairly typical of other basalt aquifers of the Columbia River group. The future supplies may be affected by changes in water quality in Lower Granite Reservoir, an artificial lake that recently covered potential recharge sites of the basalt aquifers.

The aquifer test of March 1979 located a barrier to groundwater flow that is believed to be a dike. The presence of such barriers would cause greater water level decline than would be anticipated if such barriers did not exist. Greater distances between wells would decrease the water level decline in the "Russell" aquifer caused by groundwater development near such barriers. Well spacing may also be a critical concern for groundwater development in areas that are located at a distance from the recharge sites of the Snake and Clearwater Rivers.

CHAPTER 1 INTRODUCTION

General Statement

Groundwater usage for industrial and municipal purposes is expected to increase in the Lewiston Basin of Lewiston, Idaho and Clarkston, Washington. This expected increase is based on the anticipated economic development resulting from the inclusion of the Lewiston-Clarkston area into the Snake and Columbia River barge navigation system as of 1975.

Historically, groundwater has been utilized to help meet the water needs of the two cities. Most of the groundwater has been obtained from deep wells located near the confluence of the Snake and Clearwater Rivers. The flow system in the basalt penetrated by these wells has only been examined in a cursory manner by previous investigators. Their reports have noted the following hydrologic evidence for such a connection:

(1) The static water levels of these wells are found approximately within the range and water level elevations of the Snake and Clearwater Rivers as they occur within the Basin.

(2) The water levels of these wells have not shown an appreciable amount of long term decline in spite of increased use of the wells.

(3) The water levels observed in municipal wells rose simultaneously with the filling of the Lower Granite Reservoir in February, 1975.

(4) A cessation of drawdown was observed during a 1957 specific capacity test of a municipal well (Mogg, 1958), indicating a source of surface water recharge.

This study will concentrate on delineating the groundwater flow system associated with the deep municipal and industrial wells in the

Lewiston-Clarkston area. Particular emphasis is placed on delineating a river-aquifer interconnection inferred by previous investigators.

The municipal and industrial wells penetrate as many as three of the four formations of the Columbia River Group of Basalts found in the Lewiston Basin. These wells obtain their major groundwater supply from aquifers within one of these formations. The author has grouped these aquifers into a single hydrogeologic unit called the "Russell" aquifer to commemorate Israel C. Russell, the geologist who first envisioned the existance of a major groundwater flow system in the Lewiston Basin (Russell, 1901).

Purpose and Objectives

The purpose of this study is to evaluate the hydrogeologic characteristics of the "Russell" aquifer in the Lewiston Basin as a source of municipal and industrial water supplies. Particular emphasis is placed on the river-aquifer interconnection as a potential limit to future resource development. The general objectives of this study are to delineate the characteristics of recharge, lateral flow, and discharge of the groundwater flow system identified as the "Russell" aquifer in the Lewiston-Clarkston area. The specific objectives are to:

(1) delineate the hydrogeologic framework of the basin with particular emphasis on the vertical and lateral extent of the "Russell" aquifer

(2) describe and interpret the water level data from existing municipal wells with respect to surface flow data in the Snake and Clearwater Rivers

(3) evaluate the several hypotheses of recharge for groundwater in the "Russell" aquifer in the Lewiston Basin

(4) determine coefficients of aquifer storage and transmissivity of the "Russell" aquifer

(5) describe the controls and limits for future well development

(6) report the findings in a manner useful to water-supply engineers and planners

Methods of Study

The methods of study in this report were:

(1) examine existing hydrologic and geologic reports to outline the hydrologic features that define and delineate the "Russell" aquifer.

(2) locate and compile existing hydrologic data for computer-aided interpretation of the flow system.

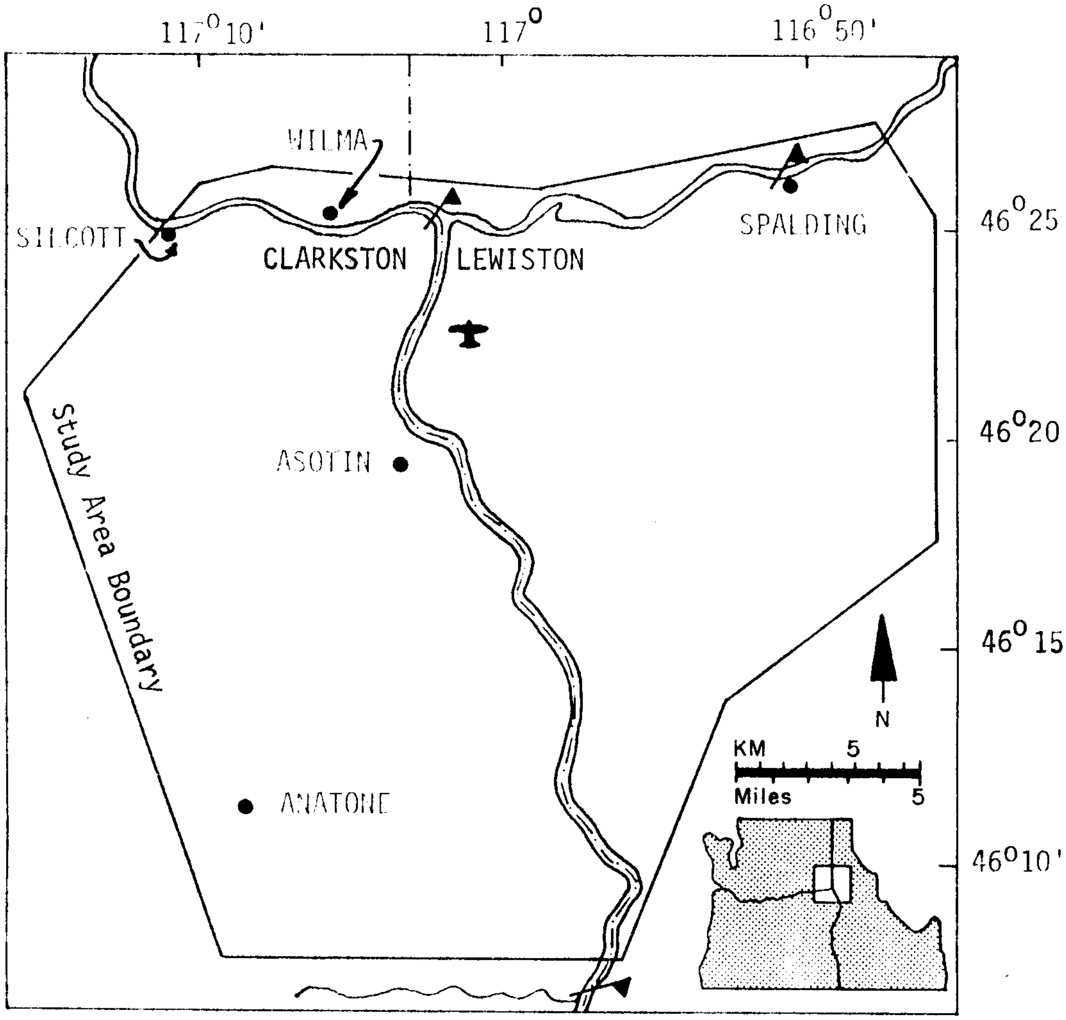
(3) conduct an aquifer test to obtain coefficients of transmissivity and storage.

(4) state and evaluate alternative hypothesis of recharge, lateral flow, and discharge for the "Russell" aquifer.

(5) communicate the findings in a written report.

Geographic and Geologic Location

The study area is located near the confluence of the Snake and Clearwater Rivers on the Idaho-Washington border at a latitude of 46°25' N. and longitude of 117°00' (Figure 1-1). The boundaries of the study area are approximately those of the topographic depression known



LEGEND

Streamflow Gaging Stations

Airport

Figure 1-1 Location of Study Area

regionally as the Lewiston Basin. This depression is a broad shallow syncline with an east-west axis that plunges toward the basin center. Parallel to the central axis, and truncating the northern flank of the syncline, is a multiple fault zone which forms the north wall. The Lewiston Basin is bounded on the southeast by Craig Mountain, a faulted monocline structure. The southwest and west boundary is a broad uplifted area known as the Blue Mountains.

The major physiographic features within and surrounding the Lewiston Basin are composed of the Miocene-Pliocene basalts of the Columbia River Group and later Pleistocene sediments (Swanson and others, 1977). The oldest formation is the Imnaha Basalt. It is overlain by the three formations of the Yakima Sub-group. The Grande Ronde is the oldest of these three. It is overlain by the Wanapum Formation. The youngest basalt flows of this Sub-group and in the Lewiston Basin are of the Saddle Mountains Formation. These last three names have replaced the Lower Yakima, Middle Yakima, and Upper Yakima.

The upper and lower limits of the "Russell" aquifer are tentatively defined from available well logs and geologic reports describing the basalt stratigraphy underlying the Lewiston-Clarkston area. Between the Grande Ronde and Wanapum Formations there exists a weathered basalt-clay horizon or saprolite. This marker unit is found extensively throughout the Columbia River Group (Camp, 1976 and Swanson and others, 1977) and is used in this report to denote the upper hydrogeologic boundary of the "Russell" aquifer as well as a time-stratigraphic boundary. Fortunately, the occurrence of interbeds is uncommon in the Grande Ronde Formation, so that this horizon of clay is generally the lowest unit of this type described in the deeper well logs. The saprolite layer is at an elevation of about 600 ft. (155 m) along the axis of the Lewiston syncline where it crosses the Snake River. Production zones in the deep wells extend to depths of -200 feet (-60 m) msl. Therefore, the total thickness of the "Russell" aquifer is approximately 800 feet (245 m) of basalt flows entirely within the Grande Ronde Formation.

It should be noted that the thickness of the "Russell" aquifer as defined does not preclude the possibility of additional production zones at greater depth. Such groundwater production zones would extend the lower limit of the "Russell" aquifer.

The lateral boundaries of the aquifer are formed by the geologic features which interrupt the continuity of the basalt section that comprises the aquifer. These features include the regional anticlines, faults, and deeply incised stream canyons of the Snake and Clearwater Rivers.

Climate

The Lewiston Climatological Station at the Lewiston-Nez Perce County Airport is the best source for daily precipitation and temperature data in the study area. The station is located at an elevation of 1,436 ft. (438 m) msl which is about 600 ft. (200 m) higher in elevation than the confluence of the Snake and Clearwater Rivers (Figure 1-1). For a thirty year record, the station reports an average temperature of 51.9° F. ; July is the warmest month of the year with an average temperature of 73.9°

F. with January being the coldest month with an average temperature of 31.4° F. Temperatures during the summer months of July and August may often exceed 100° F. Relative humidities for the above summer months average near 25 percent (Molnau, 1975).

The temperature and rainfall combine to give the central part of the Lewiston Basin a semi-arid climate. The higher elevations on the margins of the basin are subject to greater precipitation and cooler temperatures than the central areas. Winchester, Idaho located just south of the study area at an elevation of 4000 feet (1220 m), receives 25 inches (65cm) of precipitation (Molnau, 1975). The precipitation in the central part approximates 13 inches (33 cm) which includes 13 inches (33 cm) of snowfall (U.S. Army Corps of Engineers, 1972). Most of the precipitaion occurs during the fall, winter, and spring, with occasional thunderstorms providing more intense rainfall during the summer months.

Streamflow Information

Due to the emphasis given in this report to a river-aquifer interconnection, surface water records are provided for the reader. Table 1-1 gives a summary of stream flow data for the Snake and Clearwater Rivers and Asotin Creek. The U.S. Geological Survey Water Resources Division maintains these gaging stations with the exception of the gage near Clarkston which was dismantled in preparation for creating Lower Granite Reservoir in January of 1973. Its replacement has been the Army Corps of Engineer's stage recorder at the confluence of the two rivers. The " % of mean annual flow" data of Table 1-1 allows the reader to observe the seasonal variations of streamflow.

TABLE 1-1

MEAN MONTHLY STREAMFLOW DATA OF THE LEWISTON BASIN (MOLNAU, 1975)

GIVEN IN CFS-DAYS AND (CMS-DAYS) WHERE 1 FT^3 = 0.02832 M^3

	LOCATION AND MONTHLY % OF MEAN ANNUAL FLOW	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1.	Snake River near Clarkston, Wash.	858930	895178	1048991	1143947	1301060	1581182	2455434	3979721	3771352	1375800	710198	698263
		(24325)	(25351)	(29707)	(32397)	(36848)	(44779)	(69538)	(112705)	(106805)	(38963)	(20113)	(19775)
	% of mean annual flow.	4.3	4.5	5.3	5.8	6.6	8.0	12.4	20.1	19.0	6.9	3.6	3.5
2.	Snake River near Anatone, Wash.	711611	726063	835878	976694	996900	1151163	1435142	2046357	3214163	958500	566225	587586
		(2015 3)	(20562)	(24238)	(27660)	(28232)	(3261)	(40643)	(57953)	(91025)	(2790)	(16035)	(16640)
	% of mean annual flow.	5.3	5.5	6.3	7.3	7.5	8.7	10.8	15.4	17.4	7.2	4.3	4.4
3.	Clearwater River at Spalding, Idaho	148711	202607	267615	294802	339451	443897	851990	1524653	1281855	385288	134062	124815
		(4211)	(5738)	(7579)	(8349)	(9613)	(12571)	(24128)	(34178)	(36302)	(10911)	(3797)	(3535)
	% of mean annual flow.	2.5	3.4	4.5	4.9	5.7	7.4	14.2	25.4	21.4	6.4	2.2	2.1
4.	Asotin Crk below Kearney Gulch near Asotin, Wash.	1213	1403	1992	3114	2249	2879	3409	4570	3505	1541	1193	1126
		(34)	(40)	(56)	(88)	(64)	(82)	(97)	(129)	(99)	(44)	(34)	(32)
	% of annual flow.	4.3	5.0	7.1	11.0	8.0	10.2	12.1	16.2	12.4	5.5	4.2	4.0

MISCELLANEOUS NOTES (U.S. GEOLOGICAL SURVEY, 1972)

Snake River Near Clarkston, Wash.	Station Id. 13343500, Lat. 46°25'41", Long. 117°09'51", T.11N., R. 45 E., sec. 16, SE ¼ SE ¼, Whitman Co. Wash., datum of gage is 670 ft. (240 m.) above M.S.L.; period of record excellent until station removed in Jan., 1973.
Snake River near Anatone, Wash.	Station Id. 13334300, Lat. 46°05'50", Long. 116°58'36", in T. 7 N., R. 46 E., sec. 12, SE ¼ NE ¼, Asotin Co. Wash., datum of gage is 806.8 ft. (249.9 m.) above M.S.L.; period of record excellent, stage affected by upstream irrigation and hydropower generation.
Clearwater River at Spalding, Idaho	Station Id. 13342500, Lat. 46°26'55", Long. 116°49'35", in Indian allotment 198, T. 36 N. R. 4E., sec. 22 NE ¼ SW ¼, Nez Perce Co. Wash., datum of gage is 770.5 ft. (234.8 m.) above M.S.L.; period of record excellent, stage affected by upstream hydropower generation.
Asotin Creek below Kearney Gulch near Asotin, Wash.	Station Id. 13334700, Lat. 46°19'29", Long. 117°09'03", in T. 10 N., R. 45 E., sec. 22, SW ¼ SE ¼, Asotin Co. Wash., datum of gage is 1,090 ft. (332.2 m.) above M.S.L.; period of record good, stage affected by upstream irrigation.

Daily streamflow information for Lapwai Creek is available from 1974 to the present. During the 1975 water year, the month with the lowest daily mean flow was August with a mean discharge of 8.8 cfs (0.2 m^3/s). The month with the highest daily mean flow was May with a daily mean discharge of 292 cfs (8.3 m^3/s) (U.S. Geological Survey, 1975, p. 285).

Previous Investigations

The earliest known study of geology and hydrology was conducted by I.C. Russell in the summer of 1896. Russell led a reconnaissance expedition in noting the landforms, streamflows, regional geology, and structure in the Snake and Palouse River drainages in Washington and Idaho. In this report, he noted efforts by settlers in the Lewiston area to obtain water by stream diversion or well drilling (Russell, 1897). He returned four years later to prepare a more detailed report on the geology and hydrogeology of Nez Perce County, stating his interest ". . . with special reference to the possibilities of obtaining artesian water" (Russell, 1901, p. 11). Subsequent investigators use his observations as cornerstones in their geologic reports of the area.

The next contribution to the knowledge of groundwater in the area was provided inadvertently by Patrick Gibbons, a financier and geologist who organized the drilling of two exploratory oil wells in the Lewiston Basin in the 1920's (Lewiston Morning Tribune, March 9, 1927). These wells are in service today, providing water for municipal and irrigation uses. Kirkham in 1927 investigated the groundwater resources for the communities of Lapwai and Orofino (Kirkham, 1927). Lupher and Warren (1942) reported on two basalt flows unique to the Lewiston basin, which filled the ancestral valley of the Snake River. Graham (1949) studied the deformational structures in basalt flows in the Lewiston downwarp, located in the north-western part of the study area. Kinnison (1955) inventoried and described controls on the hydrogeology of the basin as part of a statewide survey. Hollenbaugh (1959) studied the eastern extensions and expression of the deformation studied by Graham as it appeared in Idaho and also presented a composite section of the basalt flows in Hatwai Canyon, just north of the study area. Almost, contemporaneously, the southern part of the study area along the Craig Mountain fault was mapped by Ferrians (1958) and Glerup (1960) in master's theses centering on the economic geology of the pre-Tertiary limestone exposures.

Bond (1963) provided the first stratigraphic interpretation of the basalt flows in the North-central Idaho area. He assigned formation and member status to the flows and interbeds of the Columbia River Group of Tertiary basalts in Idaho. Differentiation was based on outcrop appearance and petrographic analyses. His structural interpretations led to further refinements of the geologic history of the area, as exemplified by the Sweetwater Creek Interbed, which is only found in the Lewiston Basin area. Lynch (1976) was the first to use a portable magnetometer as a mapping tool in the study area. He found it significantly aided in the location and description of fault movement when poor outcrop exposure and undifferentiated basalt flows confronted the investigator.

Camp (1976) used the methods ascribed to Bond and Lynch in addition to major element analyses by X-ray spectrometry to further refine the stratigraphic knowledge in a doctoral thesis of the study area. Camp later mapped the Lewiston Basin more extensively in service to the U.S. Geological Survey (Swanson and others, 1977). Kehew (1977) reinterpreted some of Camp's earlier structural and stratigraphic history in his doctoral thesis of the environmental geology of the Idaho portion of the Lewiston Basin. Shallow to moderate depth subsurface drill exploration was performed by the Army Corps of Engineers (1963 and 1973) to delineate in-situ foundation conditions, necessary for dam and river levee design.

The late Joe L. Mogg analyzed the findings of aquifer tests performed with the Washington Water Power wells in Clarkston. Standard aquifer properties were obtained, and Mogg stated that well interference from simultaneous pumping would be minimal (Mogg, 1958). Castelin (1976) conducted a reconnaissance of the water resources of the Clearwater Plateau, an area which included Lewiston. His investigation focused on the use of ground and surface water for irrigation. One of his recommendations was to increase the scope of hydrogeologic knowledge in the Lewiston Orchards area to ascertain the potential for further groundwater development in that area. Salami (1978) performed a smaller scale reconnaissance, concentrating his study on the two aquifer systems that were delineated by Bond and Ralston (1977) in an unpublished consulting report on the construction of a deep well for use by the Lewiston Orchards Irrigation District.

CHAPTER 2 GENERALIZED GEOLOGY AND GEOLOGIC HISTORY

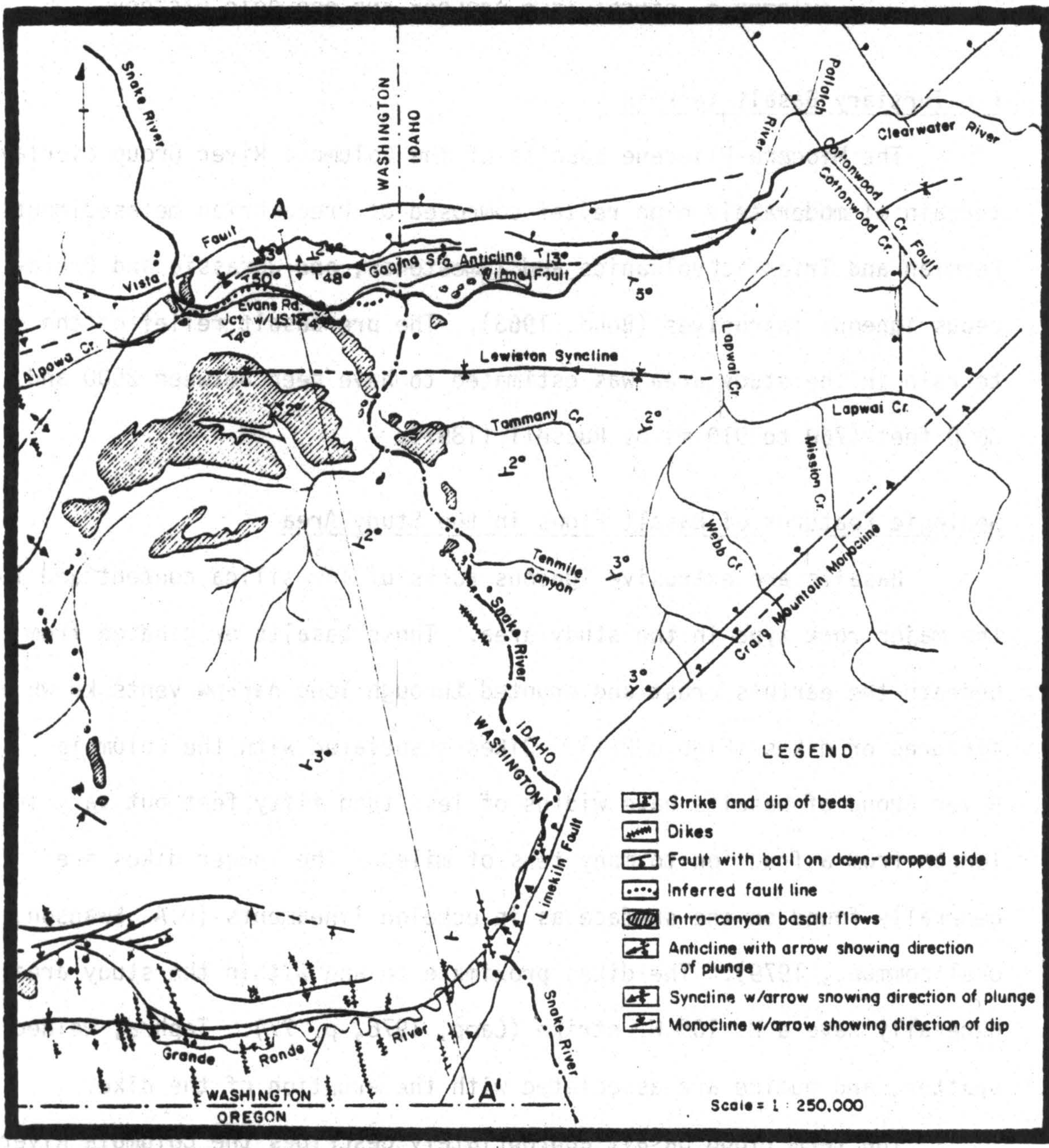
Pre-Tertiary Basalt Terrain

The Miocene-Pliocene basalts of the Columbia River Group overlay a terrain of moderately high relief composed of Precambrian metasediments, Permian and Triassic volcanics and limestones, and Jurassic and Cretaceous igneous intrusives (Bond, 1963). The pre-basalt relief of the terrain in the study area was estimated to have been between 2500 and 3000 feet (760 to 910 m) by Russell (1897).

Geologic Features of Basalt Flows in the Study Area

Basalts are extrusive igneous rocks of low silica content and form the major rock type in the study area. These basalts originated from beneath the earth's crust and erupted through long narrow vents known as fissures or dikes (Figure 2-1). Dikes associated with the Columbia River Group of basalts have widths of less than fifty feet but vary in length from a fraction to many tens of miles. The longer dikes are generally found on the surface as in echelon lineaments (D.A. Swanson, oral commun., 1979). The dikes proximate to and within the study area generally have a N. 10° W. strike (Camp, 1976, p. 77). Tephra, welded spatter, and pumice are associated with the eruption of the dike.

The term flood basalt appropriately describes the Columbia River Group, as their low viscosity permitted their widespread distribution. Average flow thickness is about one hundred feet (Longwell and others, 1969). The entire thickness of the basalts in the Lewiston Basin is more than three thousand feet (Figure 2-2).



(modified from Swanson and others, 1977; Camp, 1976 and 1978)

Figure 2-1 Geologic structure map of the Lewiston Basin

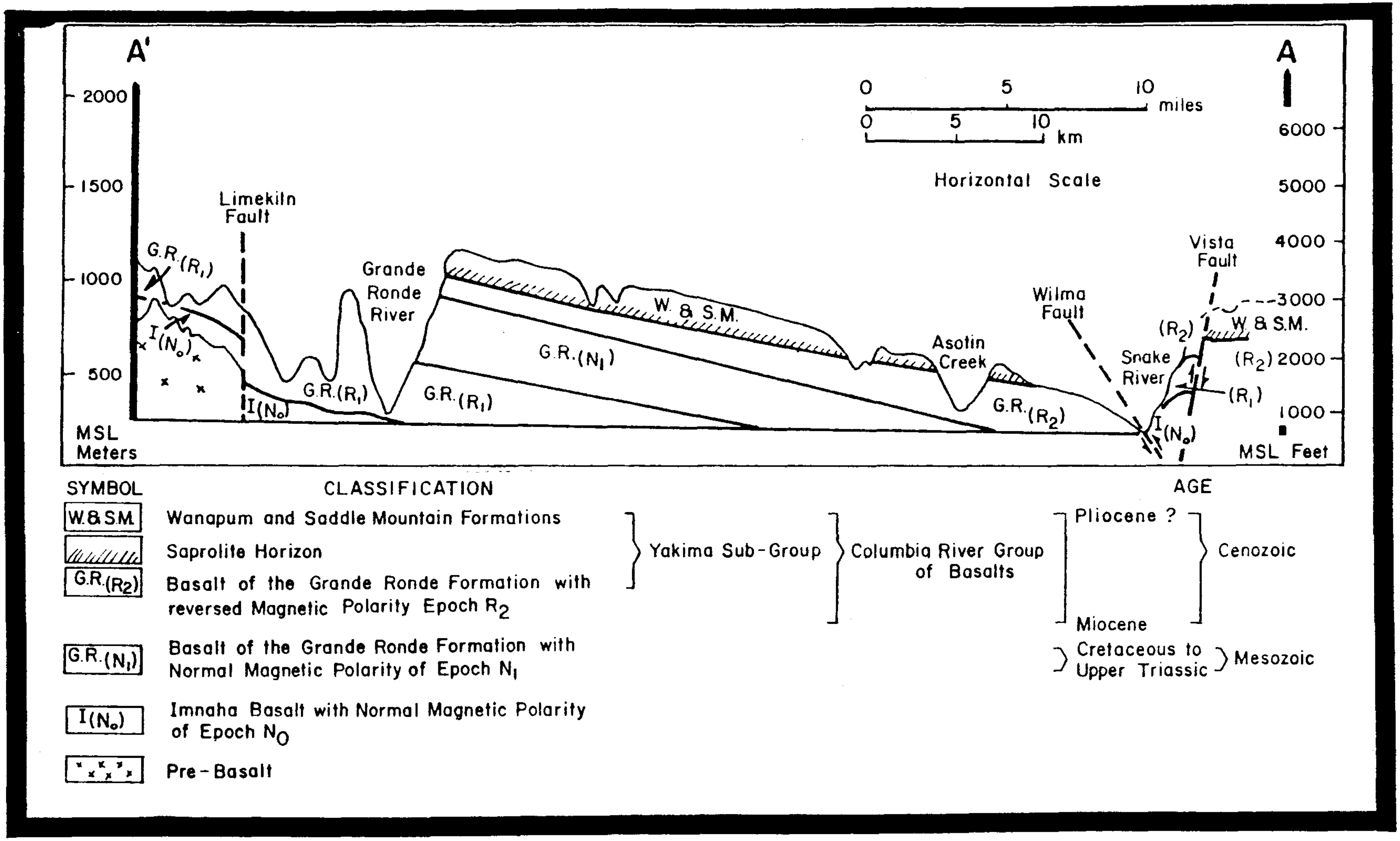


Figure 2-2 Geologic cross-section A-A' of the Lewiston Basin as illustrated in Figure 2-1.

As each flow is deposited, the geologic features associated with the pre-existing flow surface are preserved. If the time between successive flows is minimal, the flow will cover the porous upper surface of the earlier flow and form an interflow contact zone. Weathering of the flowtop will cause it to oxidize and turn red, and eventually an in-situ reddish-brown clay will form (Bond, 1963). The next flow will cover the deposit and create a soil interbed. The soil in the interbeds can be of assorted gradations, each one a reflection of the local depositional environment. Clays and silts indicate lacustrine deposits, while rounded sands and gravels are of a fluvial type. The clay formed from the weathering of the previous flow top may also be present. Slope wash and local stream deposits will increase the thickness of the interbeds near the edges of the flows in the basin or those lapping on pre-existing hillsides.

A majority of the basalts in the study area have no distinguishing characteristics in hand specimen appearance. However, the relatively high iron content of the basalt minerals is magnetically polarized at the time rock's deposition and cooling. A section of basalt flows deposited over several million years time can provide an index to reversals in the earth's magnetic poles. Magnetic data can thus be used for stratigraphic correlation of nearby flows. Figure 2-2 shows a composite of these correlations.

Imnaha Formation

The earliest Columbia River Group of basalt flows were extruded before 15 m.y.a. (million years ago); the most recent flows are dated at 6 m.y.a. (Ledgerwood and others, 1978). The Imnaha is the oldest of the four formations found in the Lewiston Basin. It has normal magnetic polarity and is found in the northwest corner of the study area as the core of the Gaging Station Anticline near the Snake River (Figure 2-1). Imnaha basalt, in hand specimen, appears dark brown in color and contains large plagioclase phenocrysts (Swanson and others, 1977).

Grande Ronde and Wanapum Formations

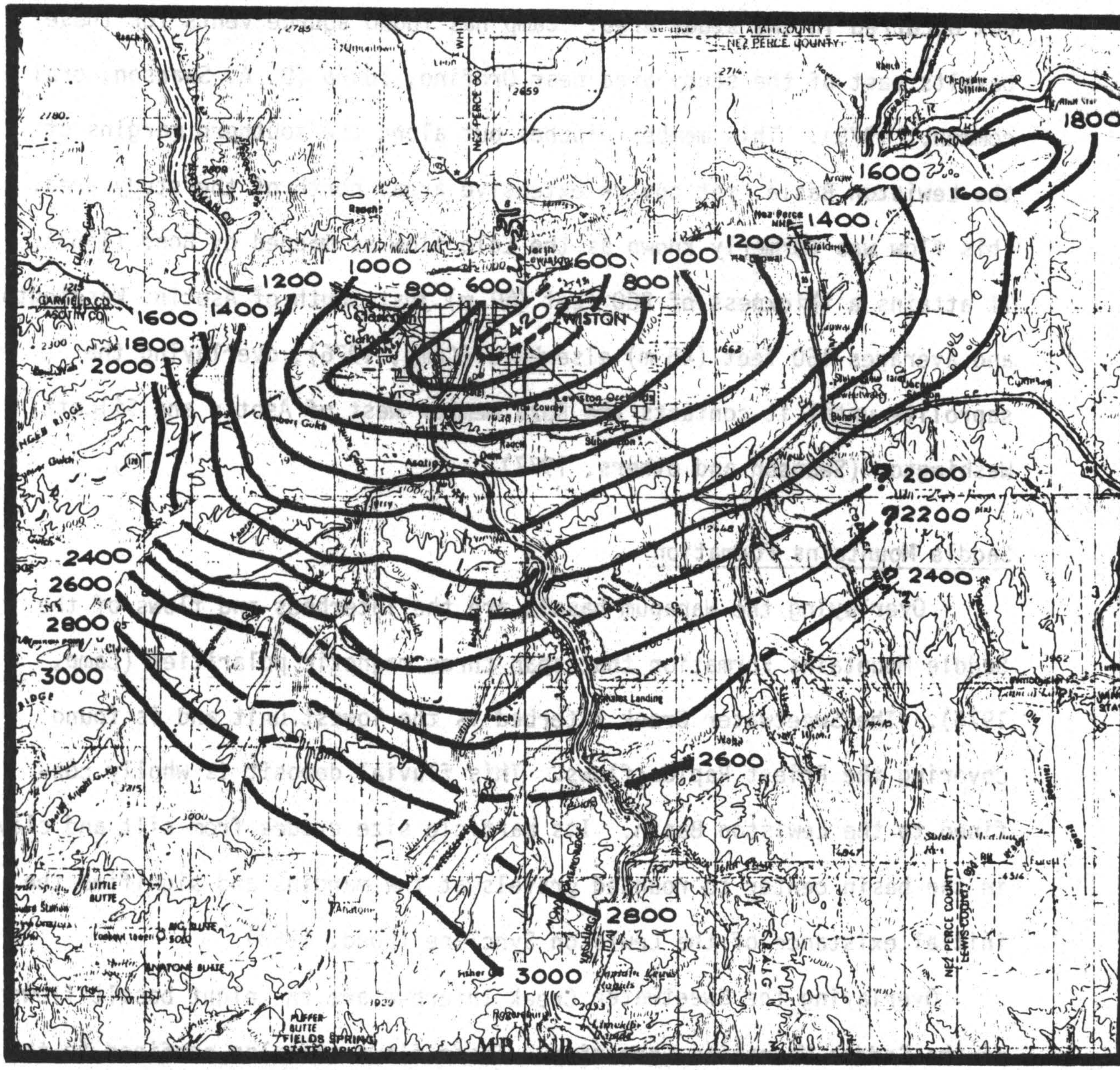
Overlaying the Inmaha basalt are flows of the Grande Ronde Formation. The "Russell" aquifer lies entirely within the upper section of this formation. The estimated total thickness of these flows in the Lewiston Basin is put at 2800 feet (850 m) in the southern part (Camp, 1976) to 2000 feet (610 m) in the northern part (Bond, 1963). The map rock-unit description given by Swanson and others (1977) is probably most apt:

> "Basalt flows, dikes, and minor deposits of tephra forming principal formation of the Blue Mountains and the entire Columbia Plateau Province. Consists chiefly of aphyric, fine-grained, petrographically nondistinct flows of Yakima chemical type, including its high Mg and Ti and low Mg subtypes (Wright and others, 1973). Locally, as along Grande Ronde River Valley and north of Snake River in Lewiston Basin, includes several plagioclase-phyric flows low in the section .... Single flows vary in thickness from less than 1 m to more than 50 m, and most probably cover several tens to several hundreds of km .... Feeder dikes of Yakima chemical type are distributed throughout the outcrop area of the Grande Ronde, and several vent areas were noted by the occurrence of welded spatter .... Correlation of some flows can be accomplished using chemistry, but there is no reliable field criterion based on flow appearance. The formation can be subdivided in the field into four magnetostratigraphic units on the basis of polarity determinations ...."

This formation generally lacks soil interbeds (V, E. Camp, oral commun., 1979). These flows were extruded prior to 14.5 m.y.a. (Ledgerwood and others, 1978) and before significant tectonic deformation occurred in the Lewiston Basin (V. E. Camp, oral commun., 1979). The close of this epoch of volcanism is marked by the in-situ formation of weathered basalt soil or saprolitic clay found extensively throughout the Columbia Plateau basalts. The saprolite is used as a marker bed to separate the Grande Ronde basalts below from the Wanapum basalt flows above (Swanson and others, 1977). The saprolite also serves as a near time boundary and is dated to approximately 14.5 m.y.a. (Ledgerwood and others, 1978). The paleoclimate at the time was similar to the present one in North Carolina (W. C. Rember, oral commun., 1979).

A structure-contour map of this soil horizon is presented in Figure 2-3. The amount of deformation which occurred in the study area during the volcanic hiatus marked by the saprolite is unknown. However, Camp (1976) suggests that initial uplift began in the Craig Mountain area during that time. He bases his conclusions on the absence of Wanapum basalt flows south of the Craig Mountain Anticline. Uplift appears to have occurred in the Blue Mountains of Washington and Oregon to the west and southwest during and after the lowermost basalt flows of the Wanapum Formation were extruded. The lowermost flow is the basalt of Dodge member which is found capping the Grande Ronde flows at all but the highest elevations in the Blue Mountains. However, the same flows are not found further east and north within the Lewiston Basin. Another Wanapum flow, the Roza Basalt, is one of the most extensive in the Columbia River Group. That flow extends over much of southeastern Washington but it pinches out about five miles west of Asotin, even though dikes of the Roza Basalt are found in a major vent system that passes through the western margin of the Lewiston Basin (Swanson and others, 1977).

The only member of the Wanapum Formation found extensively within the Lewiston Basin are two flows of the Priest Rapids member. The



(Compiled from Swanson and others,1977; Camp, 1978)

Figure 2-3 Structure-contour map of the Grande Ronde-Wanapum Formation contact: The saprolite used as marker unit for the top of the "Russell" Aquifer in the Lewiston Basin (Elevations given in feet msl) pattern of occurrence of this member indicates further plateau deformation has occurred in the study area. Camp has found source vents for these basalts east of the study area near Orofino, Idaho (D. A. Swanson, oral commun., 1979). This member pinches out along the southern margins of the Lewiston Basin, yet covers extensive areas north of the study area. This flow was formerly known as the Lolo flow as mapped by Bond (1963). It attains a thickness of 200 feet (60 m) just south of Asotin, Washington and averages 150 feet (45 m) elsewhere (Camp, 1976), overlaying the saprolite until it contacts the Roza member west of Asotin and Silcott, Washington (Swanson and others, 1977).

Saddle Mountains Formation

Overlaying the Wanapum basalt are the interbeds and flows of the Saddle Mountains Formation that span three magnetic polarities (Camp, 1976). The Sweetwater Creek Interbed is the lowest unit and is found covering the Priest Rapids flows. This fluvial deposit is wholly confined to the Lewiston Basin. Its particle size grades from silt and clay in the basin center to rounded gravels at the margins and signifies the initial existance of the Lewiston Syncline (Bond, 1963).

Overlaying the Sweetwater Creek Interbed are the eight basalt flows of the Saddle Mountains Formation. These flows are also confined to the Lewiston Basin with exception taken for four members of this formation known informally as the intra-canyon basalts. This informal name denotes the flood basalts that originated in the Lewiston Basin and followed the Snake River Channel downstream to the Pasco Basin in central Washington. These flows are formally known as the Intra-Canyon, Pomona, Elephant Mountain, and Lower Monumental members and are dated at post 13.6, 12.0, 10.5, and 6.0 m.y.a. respectively (Camp, 1976; Ledgerwood and others, 1978).

Within the Lewiston Basin, the intra-canyon basalts are found cropping out near the present Clearwater and Snake River Channels. They are seen as well formed columns and prominent cliffs along the Snake River indicating the former river channel location (Plate 2-1). This paleochannel of the Snake River trends north-northwest from Asotin to northwest of Clarkston, a distance of about seven miles. Geologic information from the U.S. Army Corps of Engineers (1963) indicate the channel had a width of 1800 feet (550 m). The canyon depth at Asotin was about 800 feet (240 m) of which 400 feet (120 m) was below the saprolite horizon. The channel was later bowed downward approximately 150 feet (45 m) where it crosses the Lewiston Syncline axis during post-volcanic deformation discussed hereinafter.

The Saddle Mountains basalts form an offlap sequence of parallel unconformities defined by interbeds of varying thicknesses and gradations. Basalt pillows were formed where the lava came into contact with bodies of water. A tephra deposit containing fossilized wood and overlain by pillows can be seen along Peaselee Avenue in Clarkston at T 11N R 46E S 32 SE NE (Plate 2-3). This exposure indicates a nearby dike of possible Pomona type. Drillers' logs of WWP (Washington Water Power) well nos. 5 and 7 (Table A-1, Appendix A) show a yellow clay interbed at about the same elevation of approximately 1000 feet (300 m) msl. A total of seven erosional unconformities have been found in the Wanapum and Saddle Mountains Formations (Swanson and others, 1977).

Later Pliocene and Pleistocene Geology

The major tectonic events occurred after the Lower Monumental flow of the early Pliocene. Deformation of the entire Columbia River Group

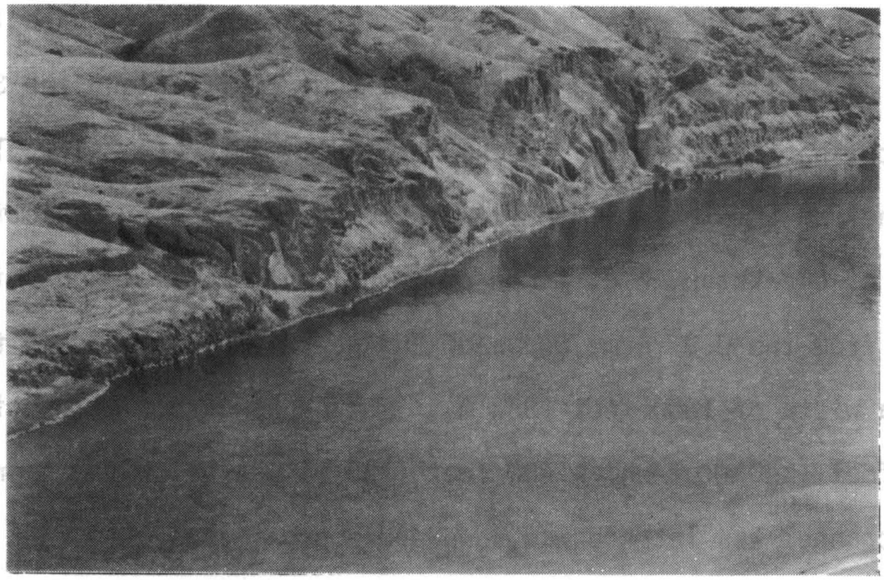


Plate 2-1 Intra-canyon basalts as viewed in Idaho. Photograph was taken near the saprolite horizon above Asotin, Washington. Snake River is in the foreground. Basalt flows of the Grande Ronde Formation are seen to the right and left of the younger basalt flows.

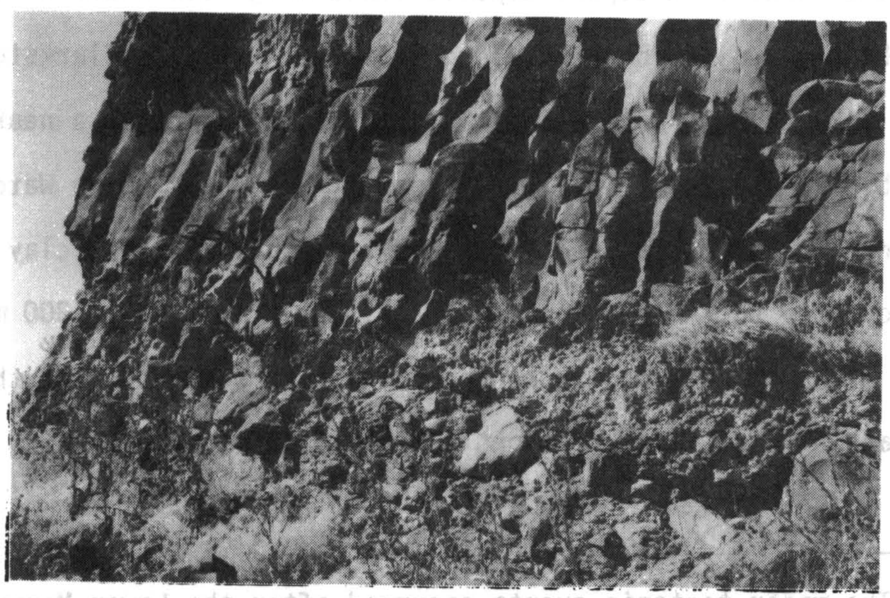


Plate 2-2 Close up view of intra-canyon basalt contact on paleo-channel alluvium. Photograph was taken at contact seen in lower left hand corner of Plate 2-1.

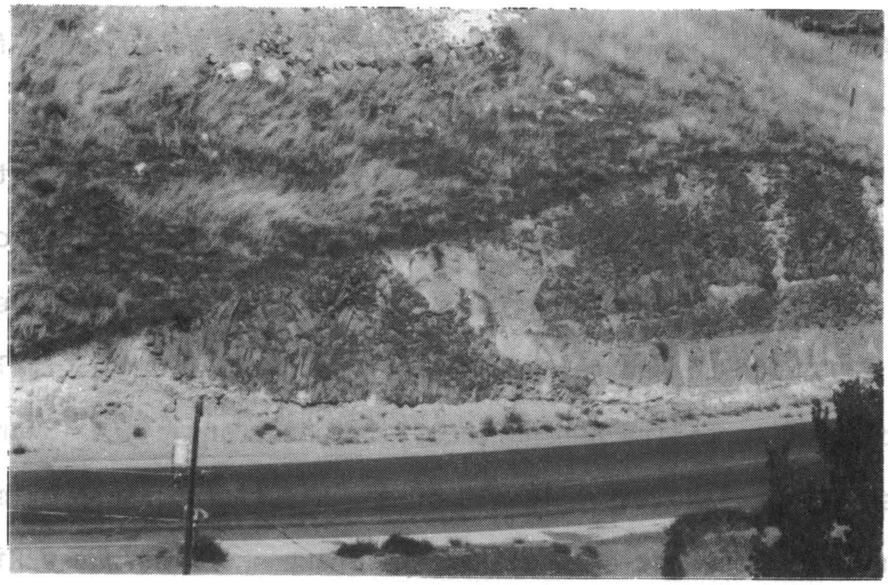


Plate 2-3 Tephra deposit with sill of Pomona(?) Basalt at Peaselee Avenue, Clarkston, Washington.

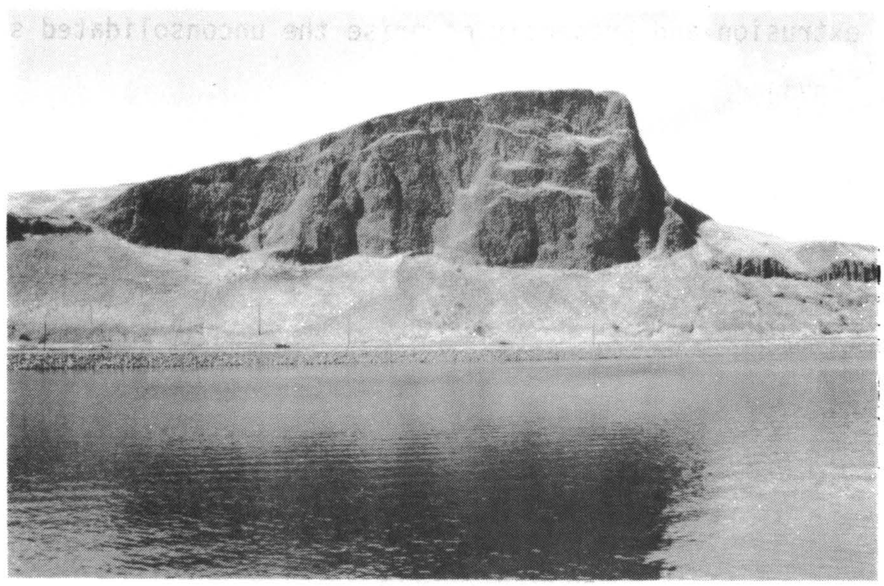


Plate 2-4 Reverse topography associated with the intra-canyon basalts of the Saddle Mountain Formation. View is Swallows' Nest Rock on Clarkston with Snake River in foreground. East side of paleo-Canyon is defined by the linear flow of Wanapum Basalt on the right.

of basalts in the Lewiston Basin has shaped the east-west centrally plunging Lewiston Syncline and caused massive faulting north of the synclinal axis (Figure 2-1). Inclusive in this fault zone, from south to north, are the Wilma Fault, Gaging Station Anticline, and the Vista Fault (Graham, 1949; Hollenbaugh, 1959). Camp (1976) suggested that these features formed an anticlinal horst block near Clarkston. He later mapped the eastern extension to Spalding, Idaho as an en echelon block fault (1978) and the western extension as a normal fault, a southeast dipping monocline and northeast trending anticline (Swanson and others, 1977). The total length of the structure is approximately 43 miles (70 km). The present channels of the Snake and Clearwater Rivers follow the base of the fault zone until leaving the Lewiston Basin at Silcott, Washington. The relative displacement of the intra-canyon basalts near the Wilma Fault is put at 1500 feet (460 m) by Graham (1949).

Flood gravels, alluvium and loess were deposited in the basin after basalt extrusion and presently comprise the unconsolidated sediments (Kehew, 1977).

CHAPTER 3 GEOHYDROLOGY OF THE LEWISTON BASIN

Basalt Aquifer Characteristics

The basalt flows in the study area are assummed to have the same general hydrogeologic characteristics attributed to the bulk of the Columbia River Group of basalts that lay west of the study area (Newcomb, 1959: Bond and Ralston, 1977). Two type zones of hydraulic conductivity exist within each individual flow. The flow center consists of jointed or cracked basalt with low hydraulic conductivity while the top and bottom of the basalt flow usually consists of cracked basalt with a greater fracture width that results in an increased hydraulic conductivity. The size and the number of the cracks is dependent upon the differential cooling rate within the basalt flow. Relatively high values of hydraulic conductivity are associated with the flow top, as cracking will interconnect the vesicular basalt in a zone 3 to 10 feet (1 to 3 m) thick (Newcomb, 1961). The hydraulic conductivity of the flow bottom is dependent upon the material encountered during the fluid stage of the lava flow; course grained detritus and breccia produces larger cracks (Newcomb, 1972) while fine grained surface deposits, such as clay, become vitrified and have low hydraulic conductivity (Mellott, 1973). Flows that invade lakes and streams develop a pillow-palagonite structure that has higher hydraulic conductivity due to the cracking associated with the rapid chilling of the contact zone. Thin flows, sandwiched between massive flows, may be fractured throughout and will then add their depth to the thickness of the water-bearing zone (Newcomb, 1961, 1972).

In a succession of lava flows, a layer-cake sequence of tabular zones is formed having widely differing values of hydraulic conductivity. Thus basalt flows form a stratified aquifer system that allows for both storage and flow of groundwater (Bond and Ralston, 1977). The continuity of these fracture zones is variable and dependent upon the pre-flow surface. Newcomb (1972, p. 9) states:

> "These permeable zones were discontinuously formed in a minor number of lava flows, their distribution is irregular both vertically and horizontally. Their probable presence within a given depth can be expressed as a statistical probability."

Lack of lateral continuity is one reason basalt aquifers may have low yield.

Surface water recharge to aquifer zones in horizontal basalt flows may occur by vertical infiltration along the cracks of thin flows. The upper basalt flows along an anticlinal ridge may also be a recharge site if tension cracks developed in the younger strata (Mellott, 1973). If basalt flows are tilted, recharge to the tabular aquifer zones is greatly enhanced since downslope drainage can occur and a greater recharge area is exposed. Streamflow that occurs over basalt flows tilted at a low angle (Figure 3-1C) provide the optimum geologic and hydrologic conditions for recharge.

Discharge of basalt aquifers can be artificial or natural. Artificial discharge is created by drilling and pumping wells in the water-bearing basalt interflow zones. Natural discharge occurs, as springs or seeps, when the lateral flowpath is interrupted as illustrated in Figure 3-2B. Belts of vegetation often delineate discharge sites in the semi-arid canyons of the study area (Plate 3-1).

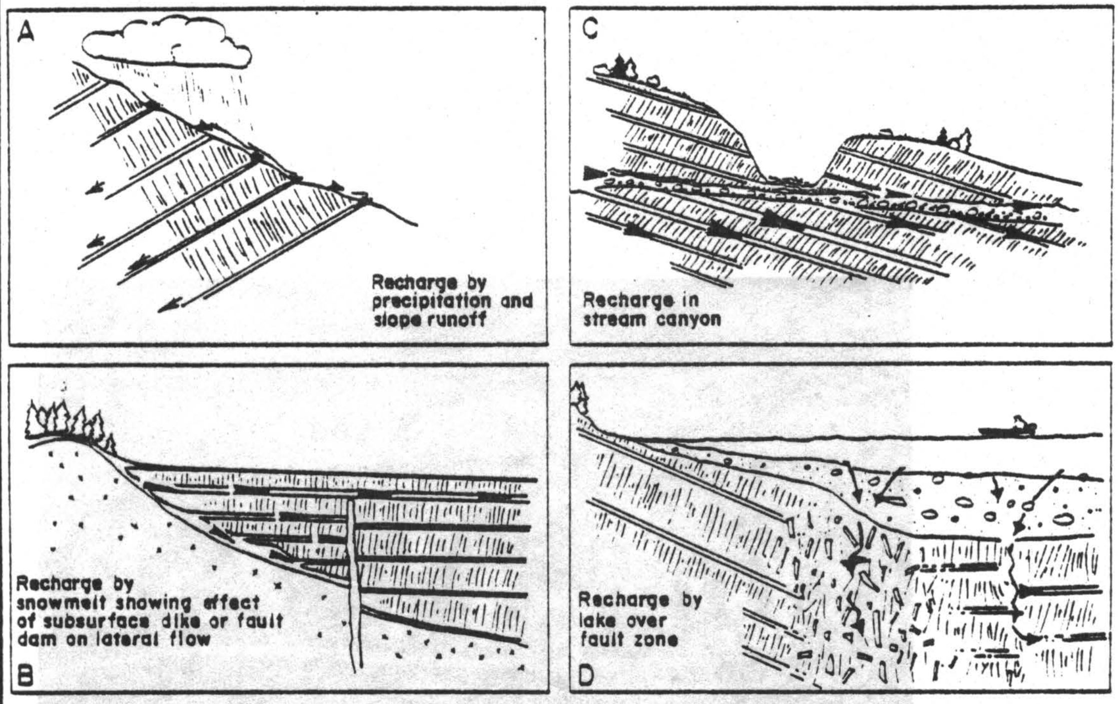


Figure 3-1 Schematic diagrams of recharge to basalt aquifers

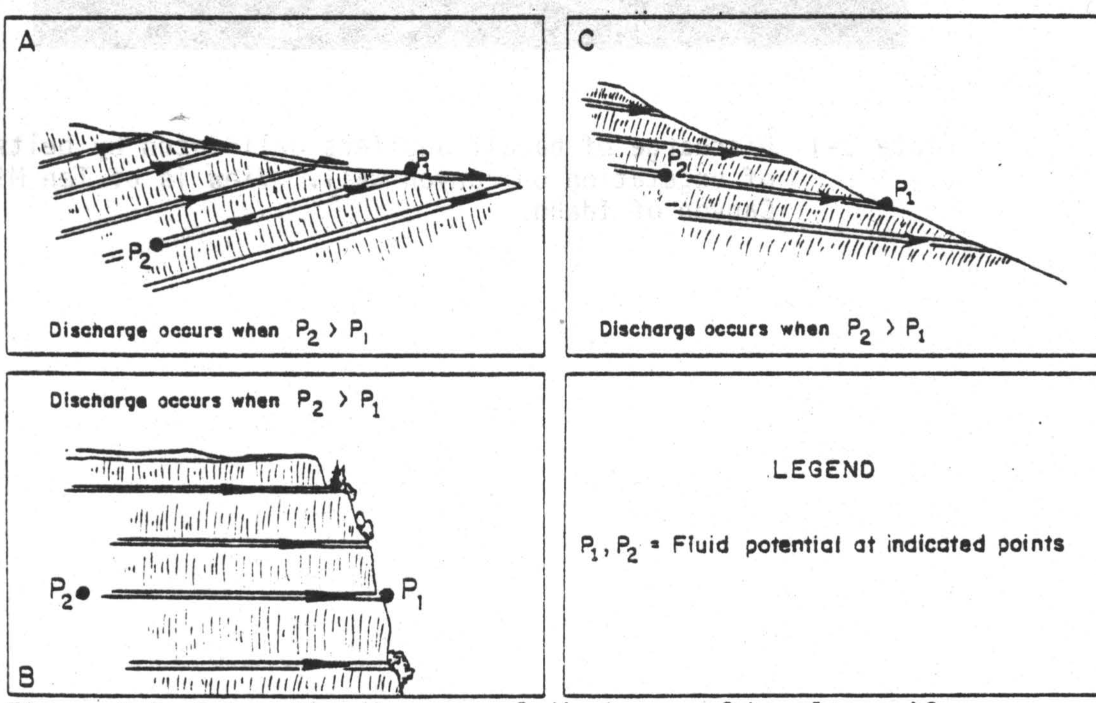


Figure 3-2 Schematic diagrams of discharge of basalt aquifers

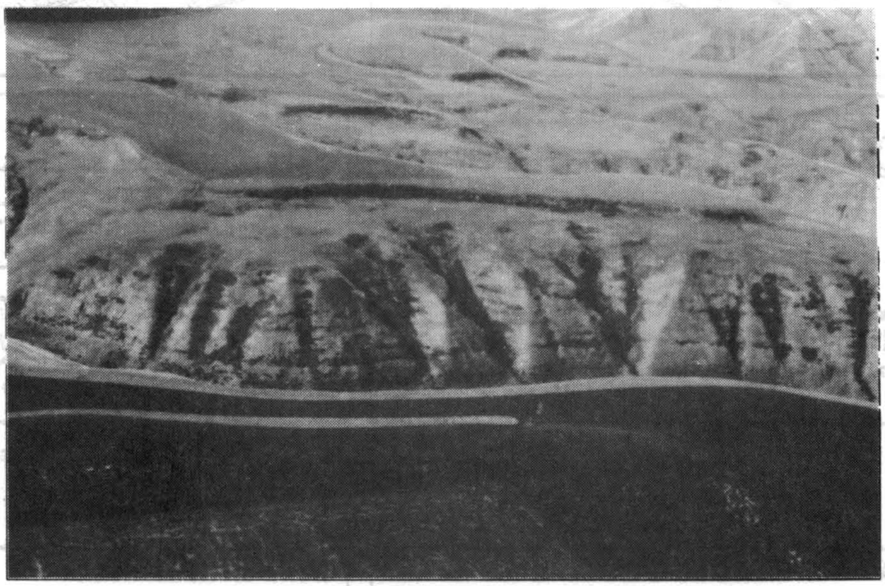


Plate 3-1 Discharge of basalt aquifers delineated by belts of vegetation on canyon wall. View is of Ten Mile Canyon of Idaho.

It is noteworthy to observe the stream gradient in relation to the dip of the basalt flows. If the dip of the basalt flows is greater than the stream gradient then aquifer recharge is likely. A comparison of Figure 3-1 to Figure 3-2 illustrates this relationship. A situation analagous to Figure 3-2C is the placement of shingles on a roof to prevent the inflow of precipitation. In the study area of this report, the relationship shown in Figure 3-1C prevails in the lower elevations of the Lewiston Basin, while the relationship shown in Figure 3-2C prevails in the upper elevations. If the stream gradient and dip of the basalt flows are not concurrent, as illustrated in Figures 3-1A and 3-2A, then the water pressure equations of Figure 3-2 provide insight to an aquifer-surface water relationship.

Basalt aquifer characteristics are often modified by structural or tectonic deformation events. The nature of the deformation is an important factor in determining these characteristics (Newcomb, 1961). Folds and faults are important features in the delineation of aquifer boundaries.

Folds are found in the study area as monoclines, anticlines and synclines. They share a common trait of directing groundwater flow along the dipslopes of their respective flanks. Within anticlines, the usual flow direction is away from the fold axis, while in synclines the usual flow direction is towards the fold axis, however, updip flow may be induced by artesian pressures. If major streams cross the tilted strata between the fold axes, the groundwater piezometric surface is found near the stream level, due to the optimal basalt aquifer recharge conditions mentioned earlier. Synclines act as groundwater flow collectors and basalt aquifers within synclinal basins have an artesian potentiometric surface associated with the groundwater drainage level of the basin (Newcomb, 1961).

Faults found in the study area are typical of the high angle normal faults found in other synclinal basins of the Columbia River Group of Basalts. This fault type disrupts the lateral continuity of the tabular basalt aquifers by creating gouge of low hydraulic conductivity and displacing the interflow zone aquifers next to flow centers. They may also increase recharge to the rocks by emplacing the basalt flows at the surface in potential recharge areas such as streams or snowfields. Lateral groundwater flow parallel to the fault plane is not affected. Vertical flow of a smaller quantity occurs if the fault plane is transverse to the lateral flow direction (Newcomb, 1961).

Another disruption to lateral continuity is found in sharp folds. Basalt flows near the fold's axial plane are crushed and the interflow contact may become incompetent beds of gouge and sheared breccia. Newcomb (1959) terms the above two disruptions to groundwater flow as "structural barriers". Dikes, if transverse to the direction of lateral flow, will also act as a groundwater flow barrier (Newcomb, 1961).

Hydrogeologic Boundaries of the Lewiston Basin

The hydrogeological boundaries of the Lewiston Basin are the faults and folds that form structural barriers to groundwater flow or dipslopes that influence the flow direction (Figures 2-1 and 2-2). These features surround the central syncline of the Basin so that groundwater flow inside the boundaries generally converges towards the Basin center.

The Lewiston hill forms the northern boundary and is a landmark in the Lewiston-Clarkston area (Plate 3-2). A structural barrier to

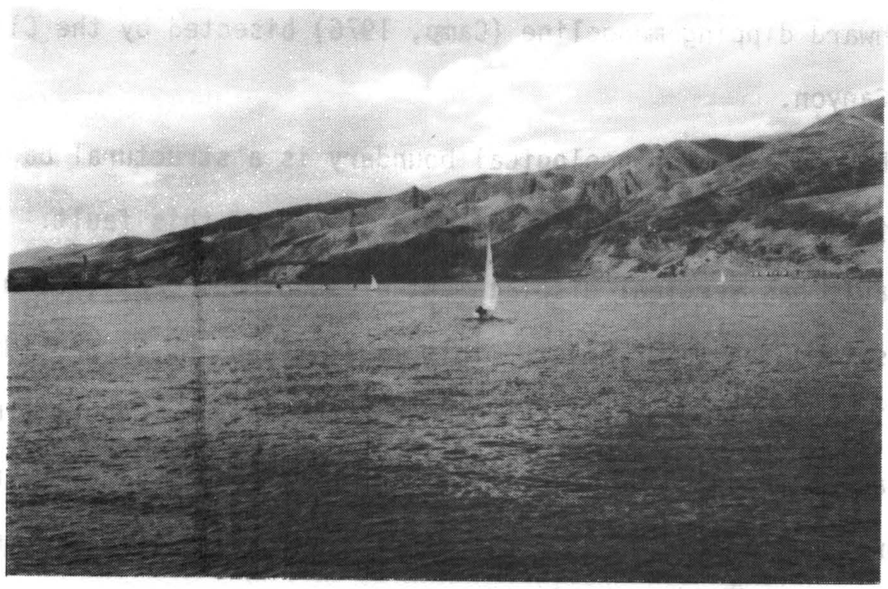


Plate 2-3 View of northern hydrogeologic boundary from southeast shore (Lewiston) of the Snake and Clearwater River confluence. Tilt of basalt flows of opposite dip show axis of Gaging Station Anticline.

groundwater flow is formed by the Wilma Fault, Gaging Station Anticline, and the Vista Fault. This boundary is defined as extending from Silcott, Washington east to the Cottonwood Fault (Figure 2-1). The Snake River exits the Lewiston Basin at Silcott after it has crossed the Wilma Fault and the Gaging Station Anticline. The north boundary becomes less complex towards the east as the fault-anticline-fault structure becomes a southward dipping monocline (Camp, 1976) bisected by the Clearwater River Canyon.

The eastern hydrogeological boundary is a structural barrier consisting of the Cottonwood Fault and a branch of this fault. The Cottonwood Fault has vertical displacement of about 600 feet (180 m) where it crosses the Clearwater River. This fault trends NW-SE providing structural control for erosion of the Cottonwood Creek canyon. About 4 miles (6 km) upstream of this canyon from its mouth, a normal fault of unknown displacement branches to the south for another 5 1/2 miles (9 km) (Camp, 1978).

In Idaho, the southern hydrogeological boundary is formed by the Craig Mountain Anticline and the Limekiln Fault. These features are an expression of a NE-SW trending downwarp of the original basalt plateau. At the base of the downwarp is a normal fault. The crest of the downwarp consists of the plateau basalts with a gentle southward dip. Displacement along the fold and fault increases in severity to the west, going from approximately 600 feet (200 m) in the east to 1600 feet (500 m) at the Snake River Canyon (Camp, 1978). Although streams that originate on the southern plateau cross the boundary, groundwater flow is assumed to be negligible across the basal fault, as it forms a structural barrier.

In Washington, the southern hydrogeological boundary is caused by the 2600 foot (800 m) depth of the Grande Ronde River canyon. This canyon interrupts the lateral continuity of all but the oldest formations of the Columbia River Group of basalts.

The southwestern boundary is the least distinct. It is defined by the forested northeastern culmination of the Blue Mountain anticlinorium. The area is dissected with streams canyons of neighboring drainage basins. A distinct groundwater divide is not defined, however the 6000 foot (1800 m) msl elevation of the crest probably indicates a groundwater divide occurs below.

The northwestern boundary is a structural barrier. It trends SW-NE from the Blue Mountain anticlinorium to Silcott, Washington and consists of an anticline, and eastward dipping monocline, and a normal fault, all sharing a common axial plane (Figure 2-1). The normal fault is uplifted on the Lewiston Basin side and extends into the Vista Fault (Swanson and others, 1977) of the northern hydrogeological boundary.

Basalt Aquifers of the Lewiston Basin

The Lewiston Syncline forms an artesian groundwater basin within the Columbia River Group of basalts. In some areas these basalts are overlain by unconsolidated sediments containing water-table aquifers. These aquifers are utilized by a fraction of the Basin's domestic wells. The remaining domestic wells, together with municipal, industrial and irrigation wells, obtain their water source from the basalt aquifers.

The basalt aquifers of the Lewiston Basin can be divided into two groups based upon three hydrogeological and geological distinctions. These groups are aquifers found in Wanapum and Saddle Mountains formations and aquifers found in the underlaying and older Grande Ronde formation. The three distinctions that have been noted are:

(1) The upper two formations contain many interbeds of low hydraulic conductivity.

(2) Except near the axis of the Lewiston syncline, the major streams and rivers have channels in the Grande Ronde Formation. These channels give this formation greater recharge potential.

(3) Only the deeper stream canyons of the Basin interrupt the lateral continuity of the older basalt aquifers.

Thus the Grande Formation appears to contain more aquifers of greater yield, recharge potential and lateral continuity.

Aquifers of the Wanapum and Saddle Mountain Formations

The majority of the irrigation and domestic wells within the Lewiston Basin are of moderate to shallow-depth and utilize the aquifers in the Wanapum and Saddle Mountains Formations. These wells are found to have varying depths-to-water and yields averaging 10 to 20 gpm (.05 to 0.10 m^3/min). In the following discussion, the term "upper aquifers" will be used to denote the aquifers within the basalts of the Wanapum and Saddle Mountains Formations. Exception is taken for the inter-canyon basalts that lay within the Grande Ronde Formation. These canyon-filling basalts are discussed thereinafter.

Recharge to the upper aquifer is believed to occur from irrigation and from precipitation. Recharge by irrigation may occur in Lewiston Orchards, Idaho (Salami, 1978) and Clarkston Heights, Washington. These communities are located proximate to the east-west axis of the Lewiston Syncline. There the basalt flows are horizontal and the surface drainage is poor. Vertical infiltration through the basalt flows is believed to occur. Discharge from the upper aquifers occurs as springs and seeps found on the valley slopes below these two communities and also domestic wells of shallow depth (Salami, 1978).

Precipitation is believed to be the source of recharge for the upper aquifers with the greatest amount of occurring at the higher elevations of the southern and western hydrogeological boundaries. These upper aquifers are believed to discharge along the lower reaches of the drainages of Lapwai Creek, the Clearwater River, and the Snake River, and where the basalt aquifers outcrop along the canyon walls. In Washington, lateral flow within the upper aquifers is truncated by the tributary stream canyons of Asotin Creek south and west of Clarkston (Swanson and others, 1977).

The aquifers of the Wanapum Basalts are found extensively below the level of the Clearwater River, north of the axis of the Lewiston Syncline. The City of Lewiston Well No. 4 and RPI (Potlatch Forests Inc.) Well Nos. 1 and 4 (Figure 3-3) appear to obtain water from these upper aquifers (Figure 3-5). Static water levels in these wells have declined during the last twenty years. Shallow drill cores taken in the area by the Army Corps of Engineers (1973) reveal the cementation of the sediments within and overlapping the basalts. Therefore in this area, it appears that recharge of river water to the Wanapum Formation aquifers is limited.

Aquifers of the Grande Ronde Formation

Most of the remaining municipal and industrial wells (Figure 3-3) have production zones in aquifers of the Grande Ronde Formation (Figures 3-4 and 3-5). In Figure 3-5, the City of Lewiston Well No. 2 appears

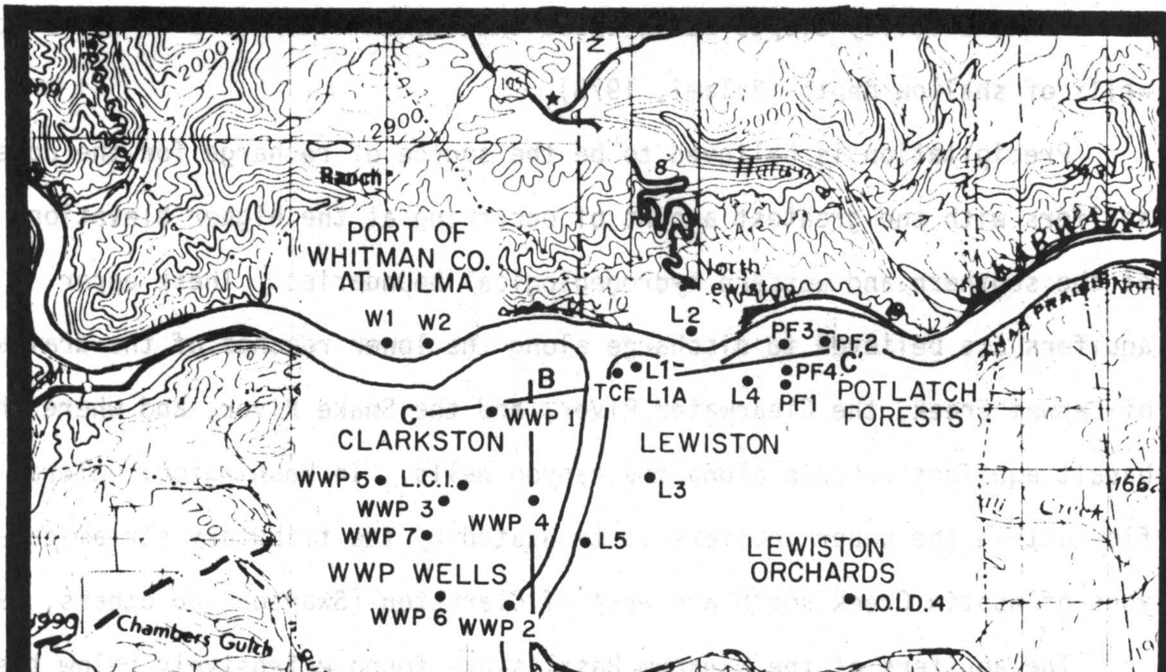


Figure 3-3 Site locations of municipal and industrial wells: Lewiston, Idaho; Asotin, Clarkston, and Wilma, Washington. Shown with locations of hydrogeologic cross sections B-B' and C-C'.

Notes: (1) Stratigraphy from Bond (oral commun., 1978), U.S. Army Corp of Engineers (1963), Swanson and others (1977), and lithologies of wells as shown.
(2) Production zones of wells are shown with solid verticle lines and are projected to match stratigraphy. Actual elevations are given in Appendix A, Table A-2.
(3) Production zone of WWP No. 2 estimated by Durand (1978).

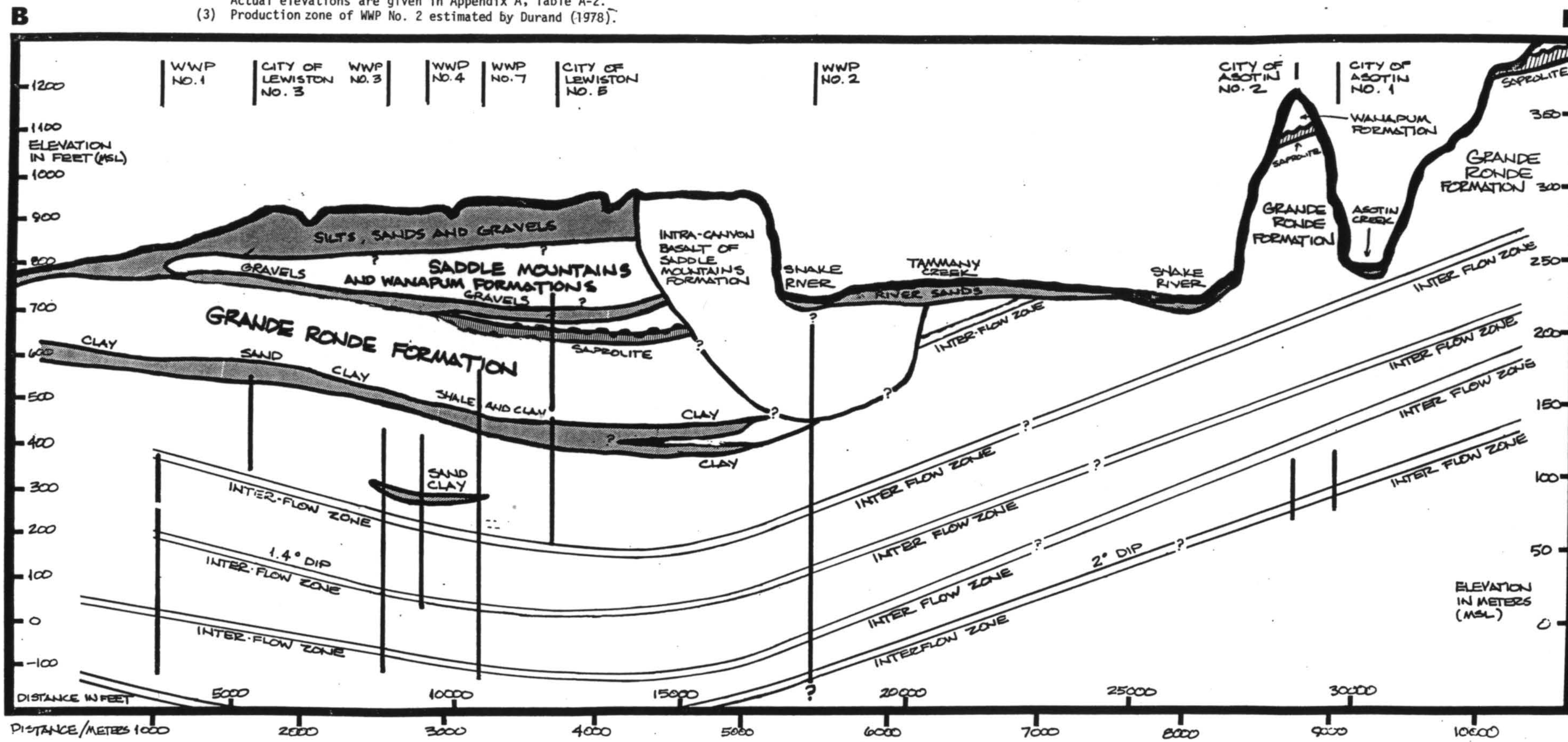


Figure 3-4 Diagramatic north-south cross section B - B' of the "Russell" aquifer in the Lewiston Basin showing the major stratigraphic horizons

Notes: (1) Stratigraphy from lithologies of wells as shown
(2) Production zones of wells are shown with solid verticle lines and are projected to match stratigraphy. Actual elevations are given in Appendix A, Table A-2.

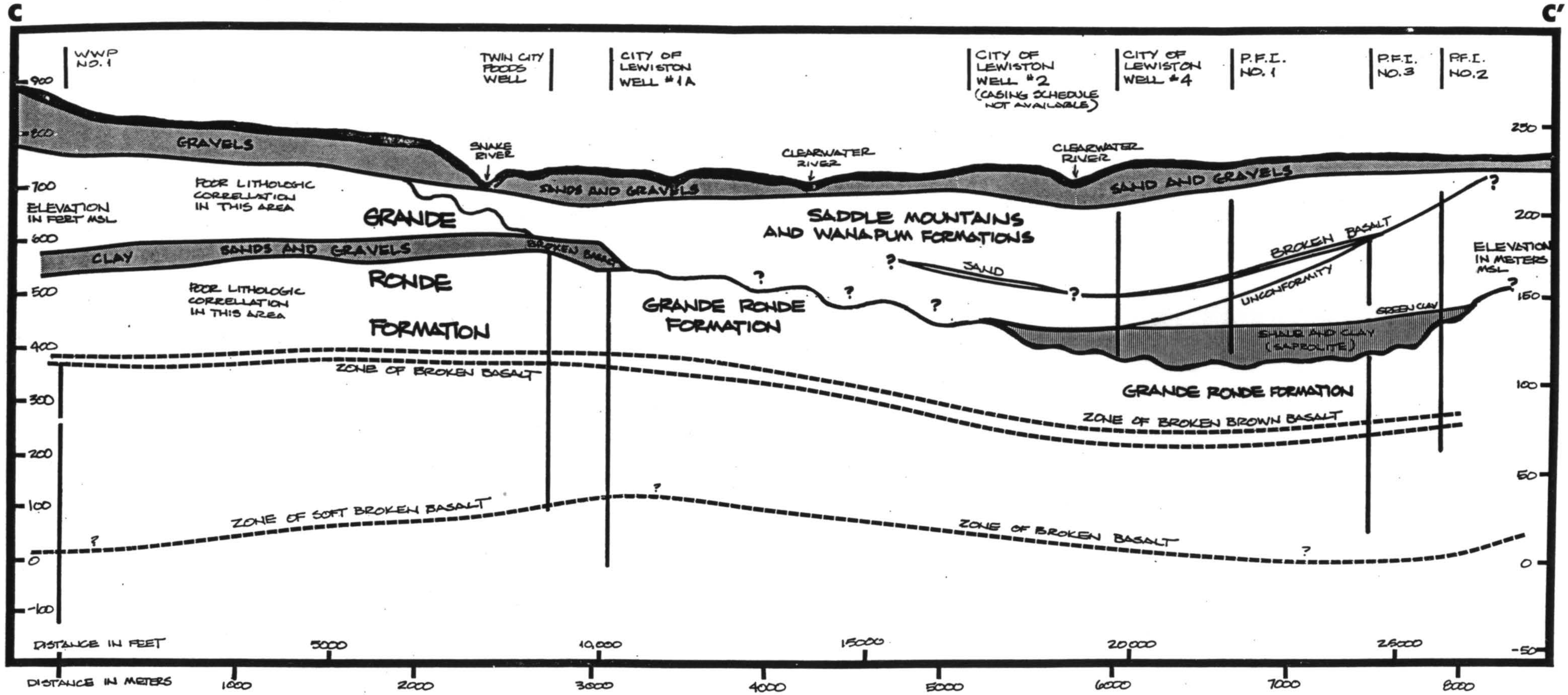


Figure 3-5 Diagramatic east-west cross section C - C' of the "Russell" aquifer in the Lewiston Basin showing the major stratigraphic horizons.

to be entirely within the same aquifer as the City of Lewiston no. 4 well. However, the historic response of the water levels in the no. 2 well (Presented in Chapter 4) suggests hydraulic connection to the underlaying aquifers found below the saprolite horizon (Figure 2-3) or a better hydraulic connection to the Clearwater River. As mentioned earlier, the author has grouped these developed aquifers of the Grande Ronde Formation into a single hydrogeological unit known as the "Russell" aquifer. The lower limit of the "Russell" aquifer is 800 feet (240 m) below the saprolite horizon. The best example of a well log lithology describing the saprolite is described by Stearns (1952) in the PFI no. 1 well (see Appendix A, Table 3A for well and reference) from a depth of 300 to 325 feet (90 to 100 m).

One of the attributes given for the "Russell" aquifer is the lack of interbeds of low hydraulic conductivity. The lithology of the L.O.I.D. no. 1 well (Appendix A, Table A-1) indicates the saprolite layer at the elevation 933 feet (284 m) msl. Above this horizon are the flows and interbeds of the Priest Rapids member. Some of the wells have occasional interbeds of sand and shale below the saprolite horizon (Figure 3-4 and 3-5). This horizon is not found in the well lithologies of the WWP well nos. 3 and 4 and the L.C.I. well (Appendix A, Table A-1) because of fluvial erosion prior to the emplacement of the intra-canyon basalts.

An indication of a specific aquifer location is found by examining the production zone elevations of the wells (Appendix A, Table A-2, col. 3) where perforations (P) or open hole (OH) construction is noted. Fractured, broken, soft, and porous are the usual adjectives used by the drillers to describe the discrete aquifer zones.

Recharge to the "Russell" aquifer can be from precipitation or streamflow. Areas favorable for recharge have been determined using the basalt stratigraphy of Camp (1976, 1978) in Idaho and Swanson and others (1977) in Washington. The primary evaluation factor has been the relationship between the dip of the basalt strata and the stream gradient or slope in the study area. The land surface slope was used in the southern highlands where the precipitation is the heaviest within the basin.

In Idaho, the plane of deformation associated with the Craig Mountain Anticline and the Limekiln Fault provides a pathway for precipitation to pass through the overlaying younger basalts and recharge the "Russell" aquifer. Other exposures of the "Russell" aquifer occur for recharge by precipitation in the Lapwai Creek drainage and Snake River Canyon. However, those sites have high evapotranspiration rates and low amounts of precipitation.

In Washington, the southwest hydrogeological boundary of the Blue Mountain anticlinorium provides a favorable area for direct recharge by precipitation to the younger basalt flows of the Grande Ronde Formation. It is stratigraphically possible that all the aquifers comprising the "Russell" aquifer are exposed to this type of recharge in the Blue Mountains area. However, two factors indicate that this mechanism for recharge is not important for the Lewiston-Clarkston wells.

(1) Numerous springs in this upland area form the baseflow of Asotin Creek and reduce the quantity of lateral groundwater flow towards the Basin center.

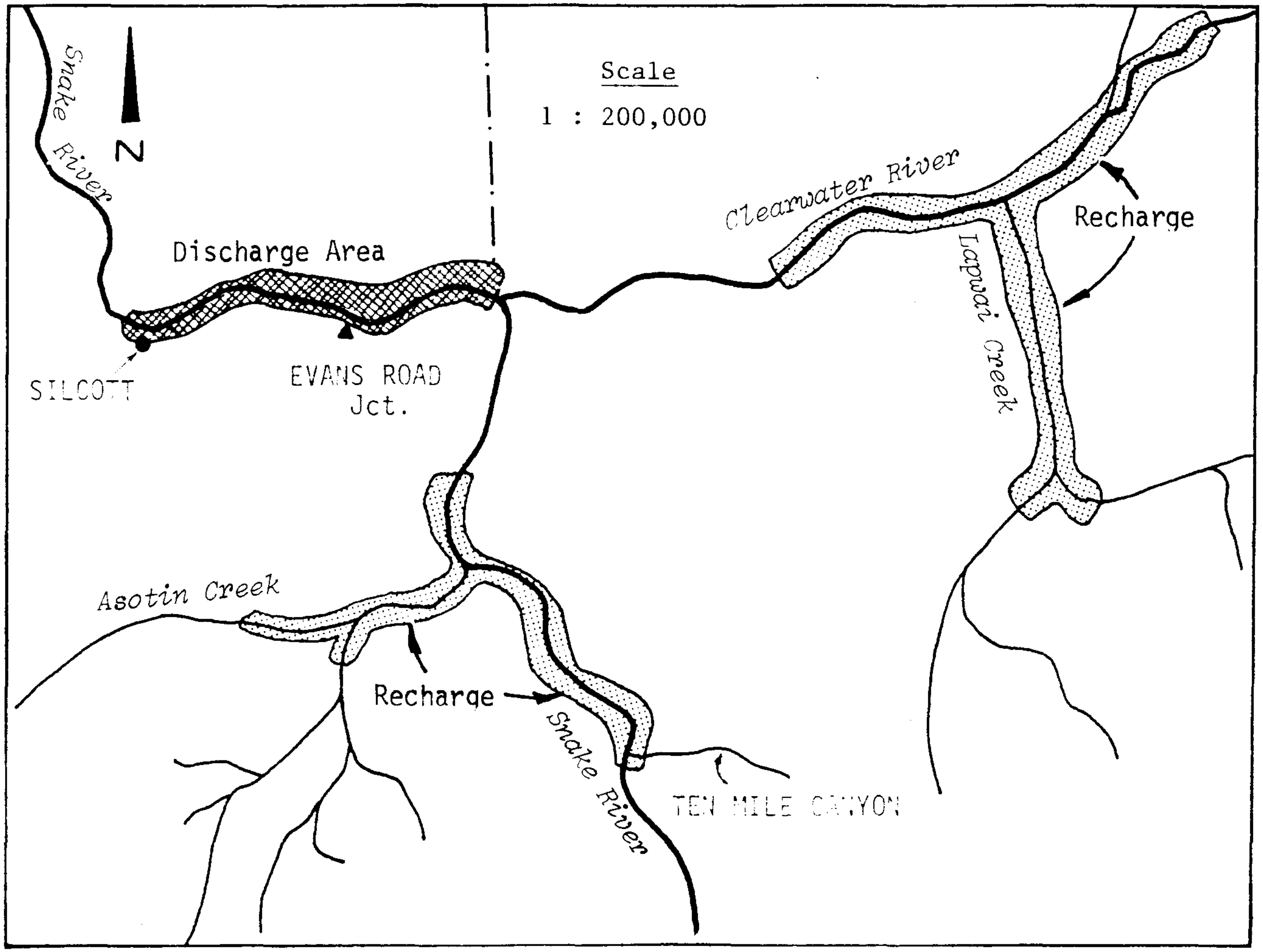
(2) The lateral continuity of the upper 400 feet (240 m) of the "Russell" aquifer is terminated by the main canyon of Asotin Creek.

These factors indicate that only the basalt aquifers comprising the lower half of the "Russell" aquifer are likely to be recharged by direct precipitation from the Blue Mountains area. Dikes in the area (Figure 2-1) may also limit groundwater flow from the potential recharge area to the vicinity of the municipal and industrial wells. As in Idaho, the remaining exposures of the Grande Ronde Formation in Washington are located at lower elevations. Here, low precipitation and high evapotranspiration rates discount significant aquifer recharge by precipitation.

Recharge to the basalt aquifers of the Grande Ronde Formation by streamflow is believed to occur where the concurrent dip of the stream is less than that of basalt aquifers (Figure 3-1C). These sites are shown in Figure 3-6 for the channels of the Snake and Clearwater Rivers and Asotin and Lapwai Creeks. Downstream of the confluence, aquifer recharge in the Snake River channel is believed to have been induced from the recent filling of the Lower Granite Reservior. This event is discussed later in Chapter 4.

The hydrogeologic setting for the upstream segment of the Snake River to recharge the "Russell" aquifer is illustrated in Figure 3-6 and Plate 3-3. On Plate 3-3 one can view the basalt flows dipping northward and coming into contact with the Snake River. The subsurface continuation of the interflow zones of breccia is illustrated in Figure 3-7. Approximately the top sixty percent of the "Russell" aquifer is shown in Figure 3-7. The dip of these basalt flows is 1.8° (± 0.2°) to the north and the average thickness of each aquifer or interflow zone is 18 feet (5.5 m).

The entire 800 foot section of the basalt flows comprising the "Russell" aquifer cropouts in the Snake River Channel from Swallow's



(modified from Bond and Ralston, 1977)

LEGEND

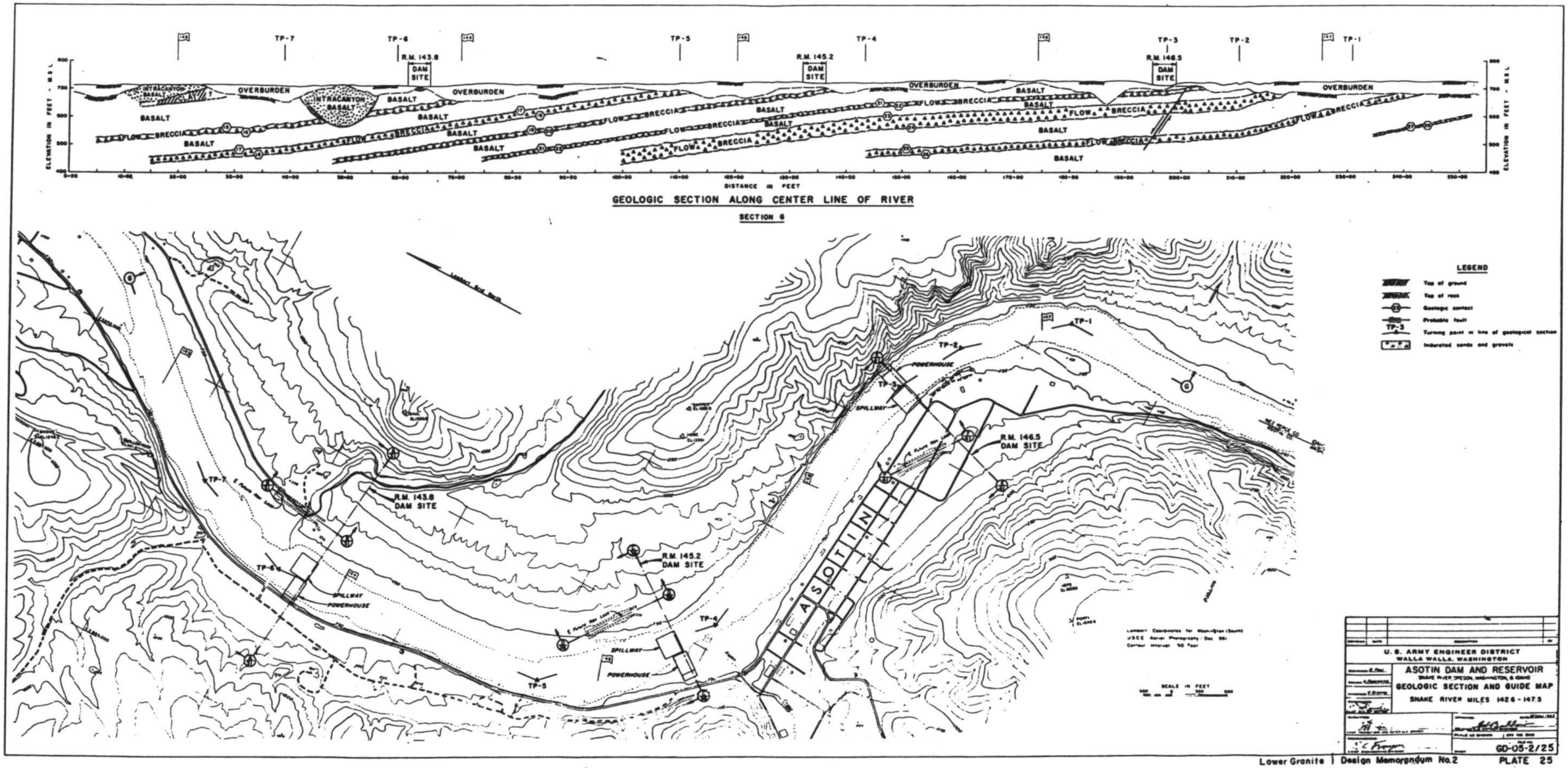
AREAS OF RIVER AQUIFER INTERCONNECTION

RECHARGE AREA

DICHARGE AREA

Figure 3-6 Location of recahrge and discharge areas of the "Russell" aquifer in the Lewiston Basin.

Plate 3-3 Basalt flows dipping north towards the Lewiston-Clarkston area. Snake River flows past alluvial deposit from Ten Mile Canyon of Idaho. Full section of the basalt flows comprising the "Russell" aquifer are exposed in the lower left corner. Asotin, Washington is located at fourth bend in river or about 5 miles (8 km) downstream of site.



(modified from U.S. Army Corp of Engineers, 1963)

Figure 3-7 Location of the basalt interflow zones comprising the upper sixty percent of the "Russell" aquifer in the Snake River Channel of the Lewiston Basin

Rock near Clarkston (T 10N, R 46E, S15, Asotin County) at Snake River Mile 143 south to Ten Mile Canyon in Nez Perce County, Idaho (T 34N, R 5W, S17) at Snake River Mile 152; approximately the same locations (Figure 3-6) suggested by Bond (J.G. Bond, oral commun., 1978). Interflow zones cropping out in the Snake River Channel at River Mile 152 (elevation of 750 feet (230 m) msl) are calculated to pass beneath the axis of the Lewiston Syncline at an elevation of -200 feet (-60 m) msl.

Recharge to the "Russell" aquifer from the Clearwater River is possible in the 9 miles (14 km) of river channel from Nez Perce Tractor Co. (T 36N, R 5W, S25, SE) upstream to an area approximately 3 miles (4.8 km) west of the Cottonwood Fault (T 36N, R 3W, S7, NE). The site near the Cottonwood Fault is where the entire 800 foot (245 m) stratigraphic section is above the river channel, whereas the Nez Perce Tractor Co. site (J.G. Bond, oral commun., 1978) is the locale where the saprolite dips below the Clearwater River. The straight line distance between these sites is about 8 miles (13 km) and the dipslope of the basalt flow is about 1.1°.

The amount of recharge originating from Lapwai and Asotin Creeks is unknown. Both streams appear to flow over the full stratigraphic section of "Russell" aquifer from their headwaters to their mouths. In the lower channels, the stream gradients and the dip of the basalt aquifers provide favorable sites for aquifer recharge. Streamflow data indicating gains or losses to the "Russell" aquifer were not obtained in this study. Both creeks have much less saturated thicknesses and widths of streambed sands and gravels than the major river channels of the Lewiston Basin. Therefore these streams have smaller potential recharge areas exposed to the interflow zones of the "Russell" aquifer.

Discharge of the Grande Ronde Formation aquifers occur where the water pressure relationships illustrated in Figure 3-2 are found at the edges of the basalt flows. Previous discussion of discharge sites has been concerned with local areas within the Lewiston Basin where the lateral continuity of the "Russell" aquifer has been terminated. The groundwater that does not discharge at these sites is assumed to flow down the aquifer dipslope towards the Basin center or axis of the Lewiston Syncline. Here the groundwater may be artificially discharged by the production wells within the "Russell" aquifer. Otherwise it seeks a natural discharge area at the drainage level of the Basin (Newcomb, 1961).

A discharge area is believed to exist in the Snake River Channel in the reach from the Snake and Clearwater River confluence to Silcott, Washington (Figure 3-6). In this area, the Snake River flows past the northern flank of the Lewiston Syncline (Figure 2-1). Since this syncline plunges to the east, multiple flows of basalt are exposed to the Snake River Channel; therefore a potential for river-aquifer interconnection exists in this area. This section of the river channel also comprises the regional topographic low of the Lewiston Basin. The elevation of the river surface at Silcott was 680 feet (207 m) msl prior to the damming of the Snake River by Lower Granite Dam (Plate 3-4).

Evidence exists for at least two discharge sites in the above described section of the Snake River Channel. One site is believed to exist at Silcott, Washington where Alpowa Creek joins the Snake River (T 11N, R 45E, S20, Asotin County, Washington). Here, Captain John Mullan (1863) reported a spring used for therapeutic purposes by the Nez Perce Indians.

Plate 3-4 Upstream view of Snake River from Silcott, Washington. Gaging station anticline is seen by tilted beds on left, north flank of Lewiston Syncline is on right side of river. View is towards the east.

Plate 3-5 Lower Granite Reservoir at Silcott, with overhead view of Alpowa Creek. Note the near vertical basalt flows rotated by Wilma Fault, U.S. Highway 12 runs past northeast-facing bluffs.

The other site location is based on evidence of an apparent temperature anomaly within the Snake River where Evans Road joins U.S. Highway 12 (T 11N, R 45E, NE SW). Gene Wilson (oral commun., 1979), a long time resident of the area, remembered instances of extreme cold and low flow where the river would remain ice-free downstream of the Evans Road junction. This temperature anomaly is believed to be caused by the discharge of groundwater at the Evans Road junction site.

Discharge at the Silcott site is believed to be caused by the presence of the Wilma Fault (Figure 2-1). Snake River Channel is believed to follow the fault line from the confluence to Silcott. At Silcott, the river channel swings abruptly north and the fault continues with a southwest trend into Alpowa Creek Canyon. Displacement along the fault extends into the pre-basalt basement (Camp, 1976, p. 101-103). The Wilma Fault is believed to be the major structural barrier that controls the groundwater discharge from the Lewiston Basin. Vertical groundwater flow is believed to occur along the fault plane so that an interconnection exists between basalt aquifers of the Grande Ronde Formation and the Snake River. Discharge at the Silcott site may also occur within the interflow zones of the basalt flows that have been rotated during tectonic deformation associated with the Gaging Station Anticline and Wilma Fault (Plate 3-5).

Discharge at the Evans Road junction site could be caused by two hydrogeologic features that converge in this area. One feature is a postulated basalt dike that may extend beneath the Snake River Channel near this site. (See Chapter 5, Figure 5-12). This dike strikes north-northwest and may form a structural barrier limiting east-west groundwater flow. The second hydrogeologic feature is formed by the paleo-channel alluvium

(Plate 2-2) associated with the intra-canyon basalts that crop out in the Snake River Canyon at this site (Figure 2-1). The alluvium may be of relatively high hydraulic conductivity and thus form a conduit to allow groundwater flow into the Snake River.

The postulated discharge areas were inundated by the creation of Lower Granite Reservoir in February, 1975, and are presently under 40 to 55 feet (12 to 17 m) of water. This flooding prevented site analysis of the Silcott and Evens roads junction sites.

Hydrogeologic Features of Interest within the "Russell" Aquifer

Several hydrogeologic features of interest are found within the "Russell" aquifer. These features are the intra-canyon basalts, a dike in Clarkston, Washington, and basalt interflow zones with above average hydraulic conductivity.

The intra-canyon basalts are found from Asotin to Clarkston, Washington (Figure 2-1) where they are estimated to penetrate the upper half of the "Russell" aquifer. These canyon-filling basalts are submerged at both ends where they outcrop in the present channel of the Snake River. They are believed to incorporate, as an outer surface, the coarse sediments deposited within the paleo-channel of the Snake River (Plates 2-1 and 2-2). This surface provides a conduit of relatively high hydraulic conductivity for groundwater to connect the laminated aquifer zones comprising the "Russell" aquifer (Bond and Ralston, 1977). This provides an additional avenue for recharge of river water to the upper half of the "Russell" aquifer. This surface also provides a site for vertical flow between the above mentioned laminated flows.

Explorations into the basalt-covered channel deposits (U.S. Army

Corps of Engineers, 1963, 1973) have revealed many of these stream deposits are cemented into a finer matrix and have a low hydraulic conductivity. However, the depth of exploration was shallow and stream channel deposits with less cementation and greater hydraulic conductivity may exist in the lower basalt flows.

The second feature of interest is a dike that was delineated during an aquifer test of March, 1979. Originally, the presence of this dike was inferred by Camp (1976) to extend northwest across the Lewiston Basin from the Ten Mile Canyon area to the Vista Fault, a distance of 16 miles (26 km). If the dike does extend this length, it would act as a hydrogeologic barrier and divert lateral groundwater flow within the "Russell" aquifer towards the Snake River Channel. Groundwater descending along the dipslope of the Blue Mountain and Asotin Creek drainage would be diverted west of the municipal and industrial wells with the exception of the WWP well nos. 5 and 6 (Figure 3-3).

The third feature is the possible existance of several interflow zones of hydraulic conductivity of significantly greater value than any of the interflow zones delineated by the U.S. Army Corps of Engineers (1963) (Figure 3-7). These zones are considered as the lowermost production units in the "Russell" aquifer and are found in depths from sea level to -160 feet (-50 m) msl as described in the WWP well lithologies (Table 3A). The reasons for this postulation are given below:

(1) the construction of the WWP wells stopped at depths ranging from -76 to -183 feet (-23.1 to -55.8 m) msl, indicating that contractors had met their specified production obligations.

(2) the City of Asotin wells have their production zones at depths

which stratigraphically correlate with these lowermost production zones. (See Figure 3-4 and Tables A-1 and A-2).

The recharge area for these zones of high hydraulic conductivity is in the Snake and Clearwater River channels at the same area given for the lower limits of the "Russell" aquifer. These areas are Ten Mile Canyon on the Snake River and in the Clearwater River three miles west of the Cottonwood Fault (Figures 2-1 and 3-6).

CHAPTER 4 HYDROLOGIC CHARACTERISTICS OF THE "RUSSELL" AQUIFER

Original Static Water Levels During and After Well Construction

During the construction of the municipal and industrial wells, the "Russell" aquifer was found to be artesian with the initial water level rising above the production zone as much as 420 feet (128 m) (see Appendix A, Table A-2, WWP Well No. 5, cols. 3 and 4). Some of these water levels also showed an additional increase in height as the well was drilled deeper. The City of Lewiston Well No. 5 had the largest increase of water level during construction, 34 ft (10.4 m). This well was drilled by the now-defunct drilling firm of A.A. Durand and Son of Walla Walla, Washington (Durand, 1978). Fortunately, the firm made a practice of recording the static water levels on the daily drillers' logs on this well and others constructed in the Lewiston Basin; the same trend is also noted in the WWP No. 3 and the P.F.I. No. 2 and 3 wells (Appendix A, Table 3-A). The rise in water level with increase in depth generally indicates that the wells are located near or in a discharge area of the aquifer system (Freeze and Witherspoon, 1967).

The original static water levels of the completed municipal and industrial wells in the "Russell" aquifer of the Lewiston Basin are shown in Figure 4-1. (A more complete listing is given in Appendix A, Table A-2, col. 4.) These water levels indicate that the piezometric surface of the "Russell" aquifer sloped to the north and west and thus suggesting a discharge site existed in the Snake River channel downstream of the confluence area.

An indication of a river-aquifer interconnection is apparent when one examines Figure 4-1 for the range of original static water levels in the wells. These values range from 688 to 741 feet (209.7 to 225.9 m) msl and are nested within the elevations of the postulated recharge and discharge

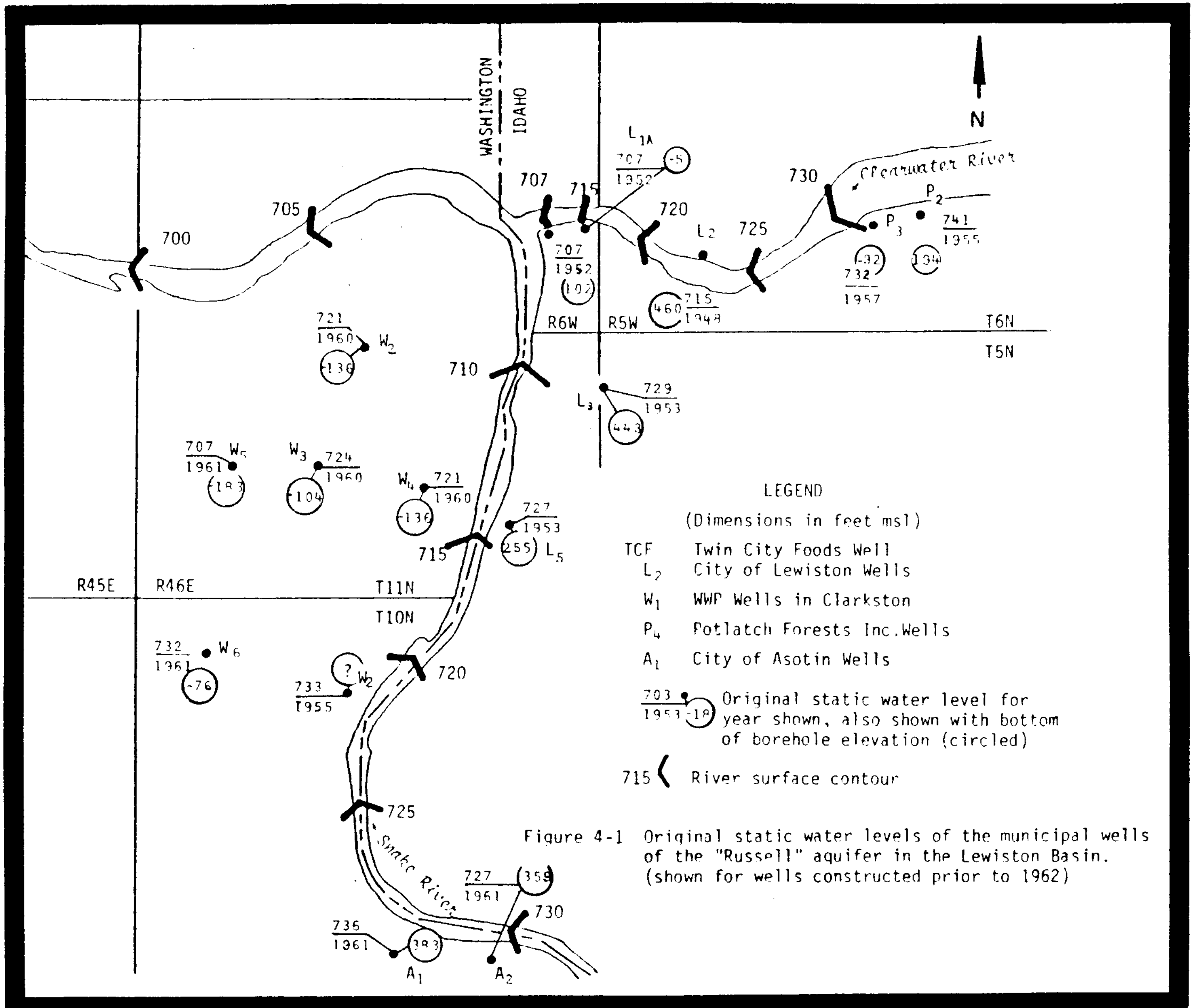


Figure 4-1 Original static water levels of the municipal wells of the "Russell" aquifer in the Lewiston Basin. (shown for wells constructed prior to 1962)

areas of the "Russell" aquifer as described in Chapter 3. The elevations for the recharge areas are 750 and 800 feet (229 and 244 m) msl for the Snake and Clearwater rivers, respectively. Surface water elevations at the discharge area was given as 680 feet (210 m) msl prior to the filling of the Lower Granite Reservoir. If the major source of recharge for the "Russell" aquifer originated in the southern highlands, then original static water levels of Figure 4-1 probably would have been greater in elevation.

Hydrographs of the Municipal Well Water Levels

Records of water levels of the municipal wells are available from 1961 to the present. The City of Lewiston measures these levels on a monthly schedule while the Clarkston municipal wells are measured on a weekly schedule by the WWP Co. (Washington Water Power Company). Shallow depth-to-water measurements are usually taken by direct (steel tape or m-scope) measurement, but most of the water levels are calculated from the borehole airline pressure. The latter method is prone to failure and is the major cause of the intermittent hydrograph record displayed in Figure 4-2. A compilation of the municipal well water levels taken from 1961 to 1978 are found in Appendix B, Table 1. The WWP No. 6 well has no record as its airline failed shortly after construction. A check on the accuracy of the WWP airline measurements was made using steel surveyor's tape in January, 1979 the airlines were found to differ 6 to 10 feet (1 to 3 m) from the taped measurements.

Hydrographs of the WWP No. 4 and the City of Lewiston No. 1-A wells were constructed to observe short- and long-term trends of the water levels (Figure 4-2). Both wells have an expected seasonal decline in water levels associated with pumpage in the summer months; however, no long-term decline is observed. An overall increase of water levels was observed on the hydrographs

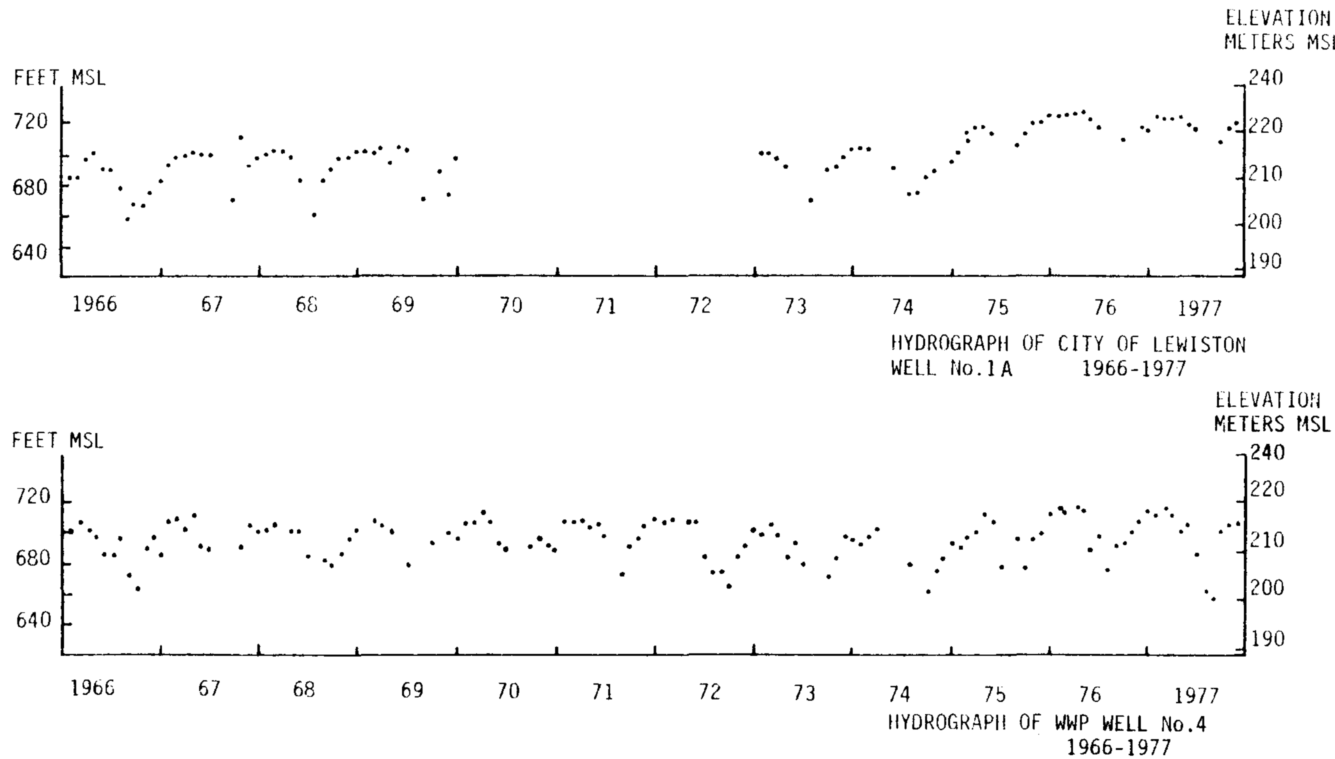


Figure 4-2 Hydrographs of two municipal wells in the "Russell" aquifer of the Lewiston Basin: City of Lewiston No. 1A and WWP No. 4

during 1975 and the water levels then appeared to stabilize at a new height. This change was noted by Bond and Ralston (1977) and attributed to the filling of the Lower Granite Reservoir during February 15-18, 1975. Static water level increases of 10 feet (3 m) were recorded in the WWP well Nos. 2, 4, and 5 within a month of filling the reservoir (Appendix B, Table B-1).

Computer Analysis of the Municipal Well Water Levels

A computer based statistical analysis of the municipal water levels was performed in the study for comparative purposes. The eighteen year record (1961 to 1978) of municipal well water levels (Appendix B) were coded and keypunched for computer statistical analysis. The analysis, performed with the University of Idaho IBM 370-145 computer using the SAS (Statistical Analysis System) (Barr and others, 1976) program, is summarized in Table 4-1. Two groups from the population of the municipal well water levels were defined. Group A consists of water levels taken prior to filling of the Lower Granite Reservoir and Group B consists of water levels taken after the reservoir filling of February 15, 1975.

The mean of each group for each well was obtained and is noted as maps of water levels of Figures 4-3 and 4-4. For each well with sufficient record, the mean of Group B was subtracted from the mean of Group A, with the difference shown in Figure 4-5. Also obtained were the standard deviation and range for each group (Table 4-2).

Most of the mean static water levels for the municipal wells in Figure 4-2 are less than the original ones of Figure 4-1. This decline is attributed to use of the wells. It is interesting to note that the mean static water level for the WWP No. 3 well is below the elevation of the postulated "Russell" aquifer discharge site at Silcott of 680 feet (207 m). This suggests

TABLE 4-1

SUMMARY OF MUNICIPAL WELL WATER LEVEL ANALYSES:* 1960 TO 1978
LEWISTON, IDAHO AND CLARKSTON, WASHINGTON

Well Name	Time Group	N	$\overline{X}$	$\overline{X}_B-\overline{X}_A$	σ	M	M_B-M_A	m	m_B-m_A	Range M_A-m_A M_B-m_B
Lewiston #1	A	59	692.1		11.9	707		654		53
	B									
Lewiston #1A	A	31	691.0	30.8	13.5	712	16	659	23	53
	B	26	721.8		5.6	728		709		19
Lewiston #2	A	63	716.4	4.5	3.5	724	- 1	701	15	23
	B	30	720.9		1.9	723		716		7
Lewiston #3	A	72	690.7		14.8	727		641		86
	B									
Lewiston #4	A	26	663.2	-43.1	13.6	693	-51	648	-77	45
	B	18	620.1		19.1	642		571		71
Lewiston #5	A	30	698.4	27.2	9.9	710	19	658	55	52
	B	23	725.6		4.4	729		713		16
WWP #1	A	134	689.2	17.4	15.8	742	-23	642	40	100
	B	109	706.6		7.5	719		682		37
WWP #2	A	218	712.0	9.3	7.2	723	6	677	19	46
	B	104	721.3		4.8	729		696		33
WWP #3	A	149	669.4		48.0	726		519		207
	B									
WWP #4	A	418	695.5	12.7	16.1	731	8	586	71	145
	B	145	708.2		14.7	739		657		82
WWP #5	A	288	687.2	23.8	18.8	702	20	547	65	155
	B	143	711.0		16.6	722		612		110

* Given in feet msl.

Legend: Time group A = water levels taken before February 14, 1975.
Time group B = water levels taken after February 14, 1975.

N = Number of observations.

$\overline{X}$ - mean water level; $\overline{X}_B-\overline{X}_A$ - difference of means, see Fig. 4-5.

σ - standard deviation of group.

M - maximum static water level; M_B-M_A - change of maximums.

m - minimum static water level; m_B-m_A - change of minimums.

M_A-m_A, M_B-m_B: range of group values

Source: City of Lewiston Water Dept., Wash. Water Power Co., Clarkston, Wa. Analysis by SAS (Barr and others, 1976) software, University of Idaho Computer Center, Moscow, Idaho.

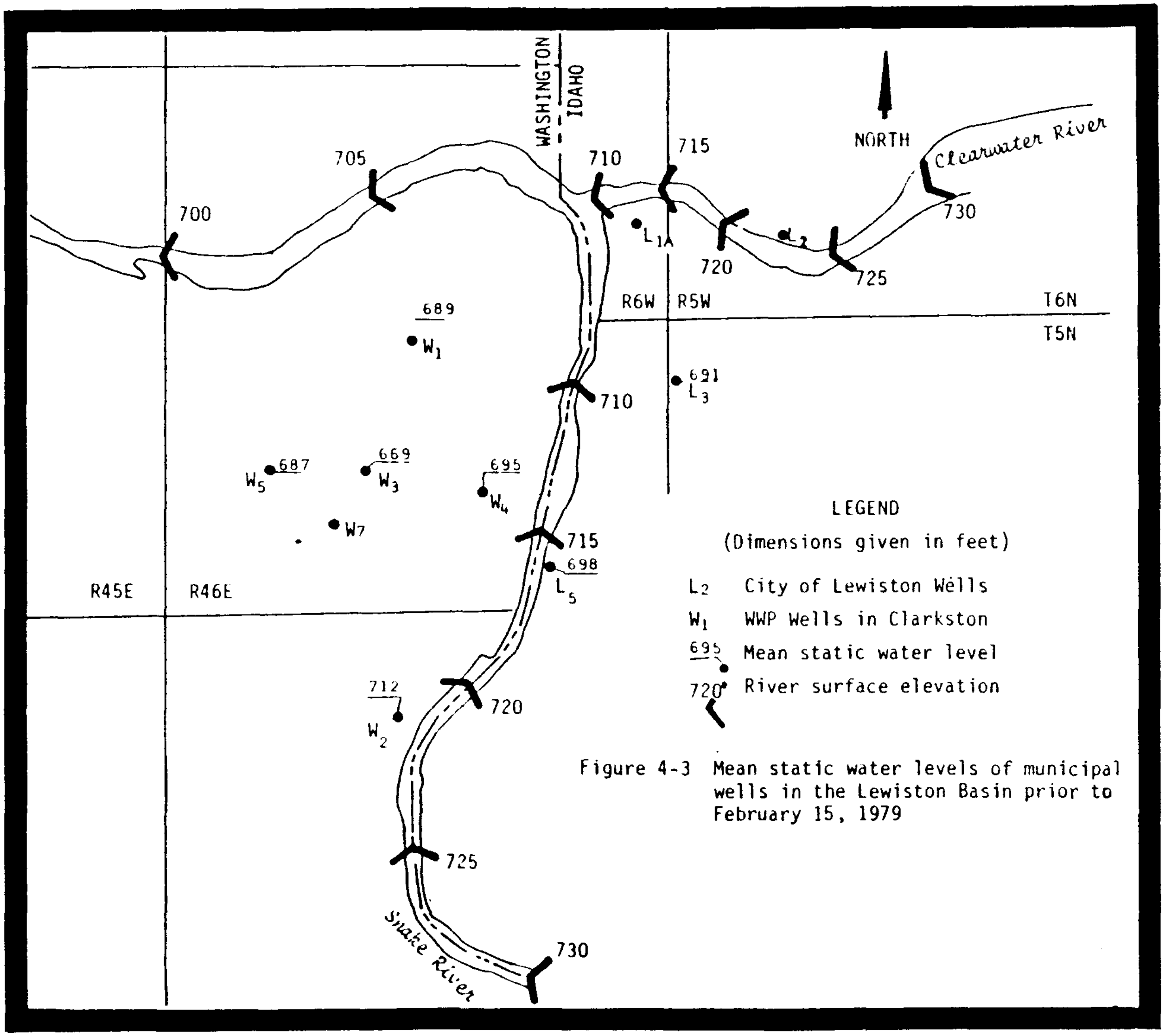


Figure 4-3 Mean static water levels of municipal wells in the Lewiston Basin prior to February 15, 1979

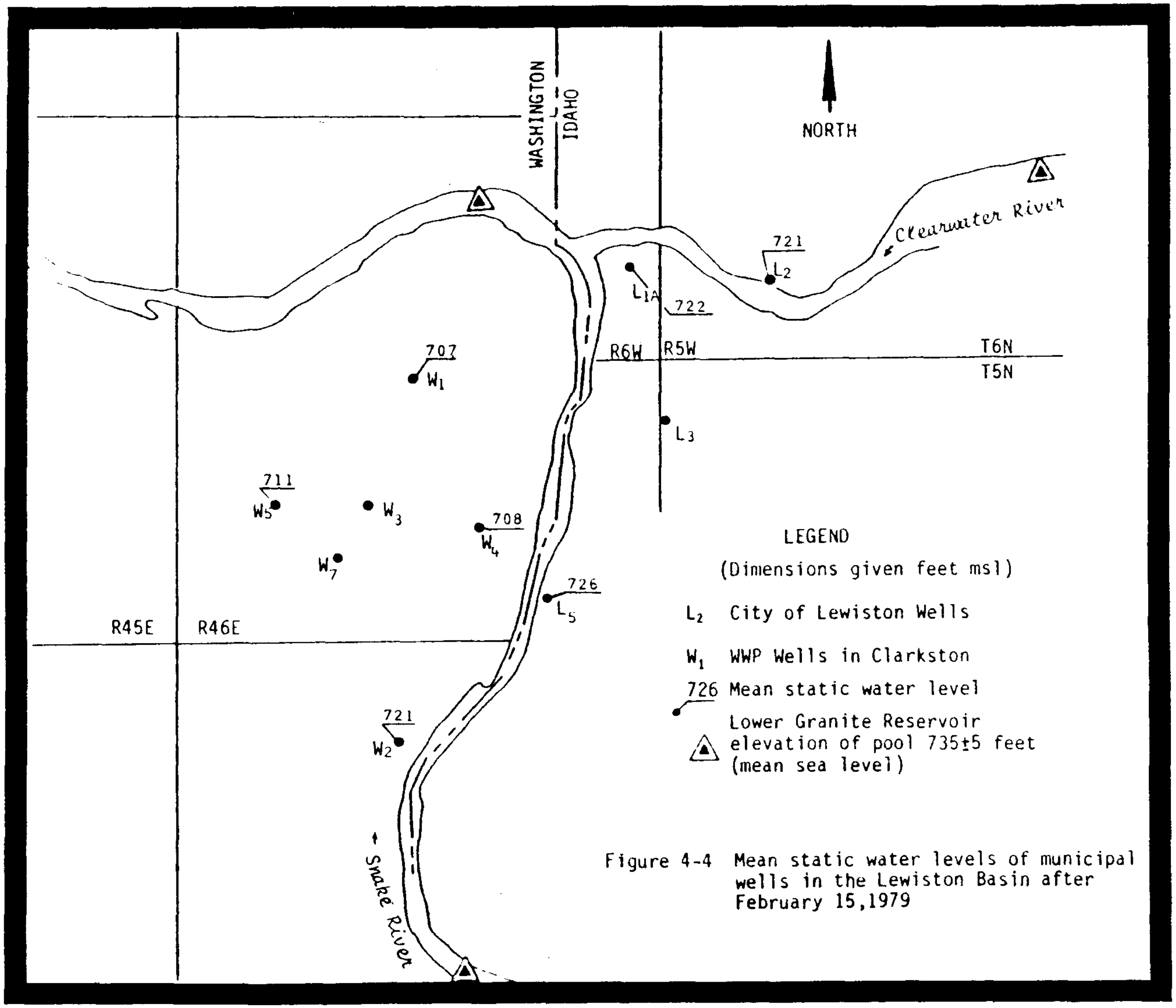


Figure 4-4 Mean static water levels of municipal wells in the Lewiston Basin after February 15,1979

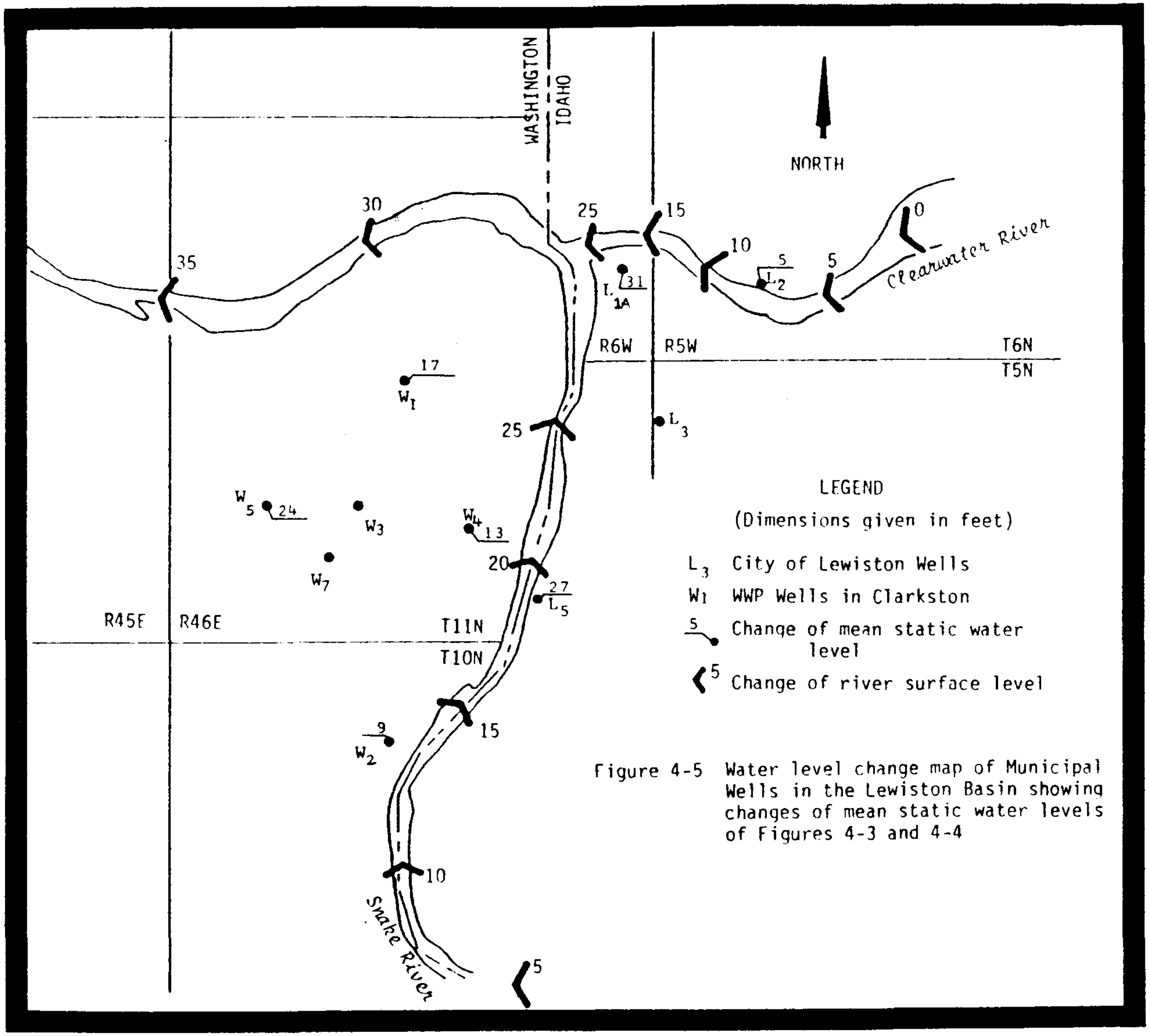


Figure 4-5 Water level change map of Municipal Wells in the Lewiston Basin showing changes of mean static water levels of Figures 4-3 and 4-4

a reversal of the ground water flow direction so that the original postulated discharge area has become a recharge site. The elimination of natural discharge from the "Russell" aquifer is more apparent in Figure 4-4. In this figure, all of the Group B mean water levels are lower than the surrounding water level of the Lower Granite Reservoir.

The well water and river surface elevation changes are shown by location in Figure 4-5. This figure illustrates the complex hydrogeology of the "Russell" aquifer. The City of Lewiston wells Nos. 1-A and 5 have water level changes that are greater than that found in the nearby reaches of the Snake and Clearwater rivers and are more similar to that found downstream of Clarkston in the Snake River. However, the WWP wells generally have water level changes that are similar to that found in the river near the well sites or upstream of the well sites.

CHAPTER 5 AQUIFER TESTS

Introduction

Five aquifer tests have been conducted in the "Russell" aquifer to date, using the non-equilibrium formula of Theis to estimate the aquifer coefficients of transmissivity and storage. Four tests were conducted in 1956-58 by the now defunct drilling firm of A.A. Durand and Son of Walla Walla, Washington. The field data of these tests were analyzed by G.F. Briggs and the late Joe Mogg of E.E. Johnson Co. (presently Johnson Div., UPO Inc.) of St. Paul, Minnesota. The fifth test was conducted in March, 1979, by researchers from the University of Idaho. For this test, use was made of a hydrograph taken from the WWP No. 7 well to determine the hydrologic factors that would affect time-drawdown data of the observation wells.

Well Development Tests

The first development testing of wells in the Lewiston Basin was conducted by Paul Durand of A.A. Durand and Son (Durand, 1978) during February 21-22, 1952, using the Sno-Crop (now Twin City Foods) well and the City of Lewiston No. 1 well (since abandoned (Figure 1-5)). The Sno-Crop well was pumped for a total of 31 1/2 hours at varying rates with water level observations taken in the City of Lewiston No. 1 well until 29 hours had elapsed. At this time the City of Lewiston No. 1 well was turned on and discharged at a rate of 484 gpm (1.83 m^3/min) for the remaining 2 1/2 hours. The Sno-Crop well had a specific capacity when pumped at 1,400 gpm (5.3 m^3/min) of 9.1 gpm/ft (0.11 m^2/min). When pumped at 1,700 gpm (6.3 m^3/min) the well had a specific capacity of 8.0 gpm/ft (0.10 m^2/min). Maximum interference observed in City of Lewiston No. 1 well was 10 feet (3.0 m) after 12 hours of pumping. These wells are located at a distance of 1,200 feet (365 m). Well interference in the Sno-Crop well from the city well pumping was not obtained. This Lewiston well was calculated to have a specific capacity of 3.16 gpm/ft (.04 m^2/min).

A second test conducted by Paul Durand occurred June 18-19, 1955, utilizing the P.F.I. (Potlatch Forests, Inc.) Nos. 2 and 3 wells (Kalz, 1979) which are located about 1,700 feet (518 m) apart. The No. 3 well was pumped at varying rates between 1,000 and 2,000 gpm (3.8 and 7.6 m^3/min). Maximum well interference in the No. 2 well was about 9.6 feet with a radial distance (r) of 1,700 feet (518 m). The pumped well had a specific capacity of 10 gpm/ft (0.12 m^2/min).

A third specific capacity test was conducted on the WWP No. 2 well. This well was pumped for 32 1/2 days at 1,275 gpm (4.8 m^3/min) in October and November of 1957. Drawdowns were observed in the pumped well only. After 3.8 days (5,500 min), the drawdown ceased at 703 feet (214 m) msl and held constant for the remaining 28 days (Mogg, 1958) (Figure 5-1). The significance of this stabilization was twofold. The test showed that a positive recharge boundary was present. It also showed that any well hydrologically interconnected with WWP No. 2 would also show a positive boundary if pumped long enough.

Aquifer Tests No. 1-4

Aquifer Tests Nos. 1-3 were conducted using the then newly constructed WWP No. 1 well for the pumped well and L.C.I. well (r = 4,720 feet (1,400 m)) and the "Swallows Nest" or WWP No. 2 well (r = 14,800 feet (4,500 m)) for the observation wells. WWP No. 1 well was deepened twice, approximately 100 feet (30 m) each time, following Aquifer Test Nos. 1 and 2. The third test was conducted to determine the effects of the second deepening, as the second

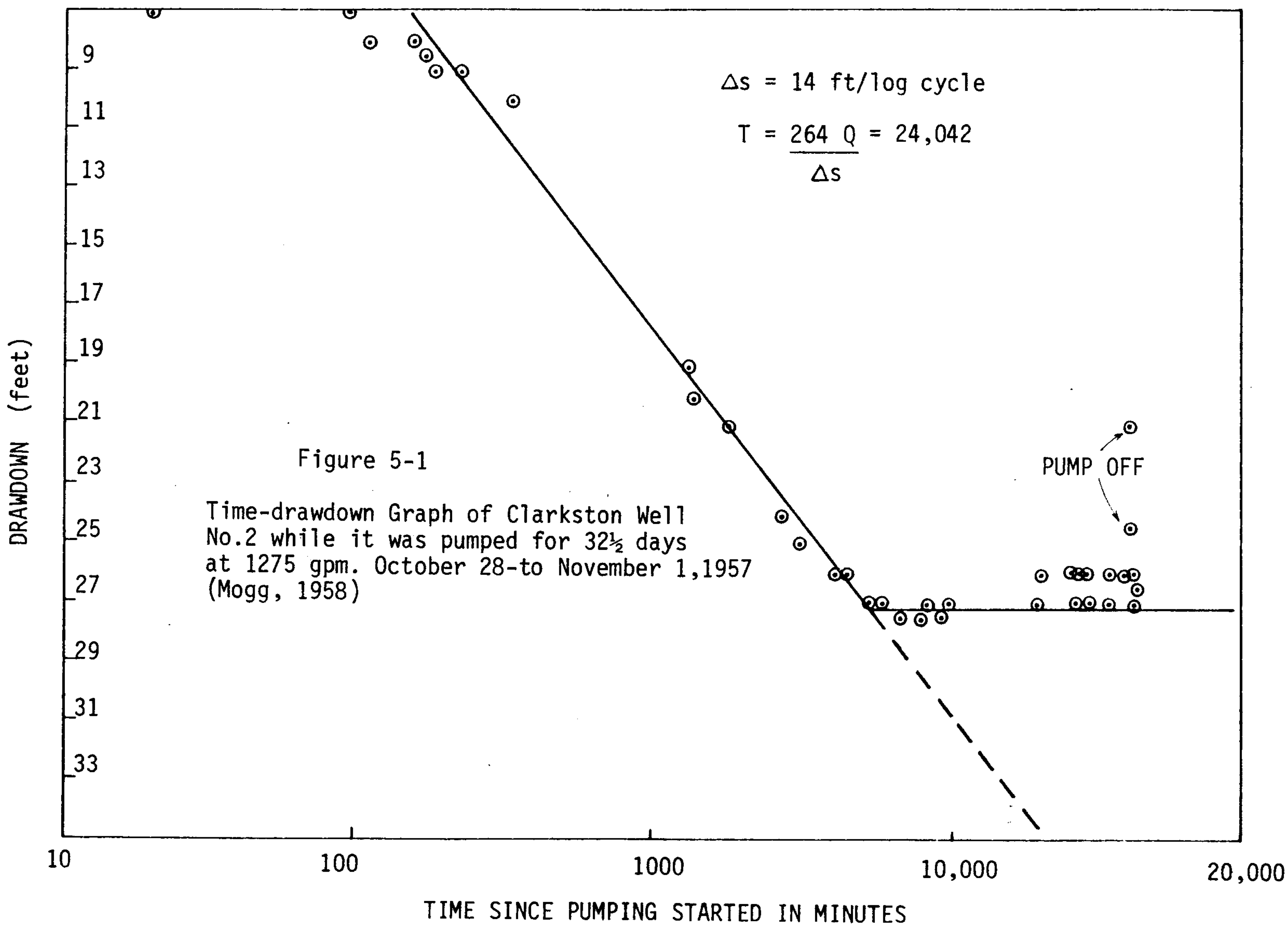


Figure 5-1

Time-drawdown Graph of Clarkston Well No.2 while it was pumped for 32½ days at 1275 gpm. October 28-to November 1,1957 (Mogg, 1958) test was conducted to determine the effects of the first deepening. Summaries of all the tests are given in Table 5-1.

Aquifer Test No. 1 commenced September 19, 1956, when the original borehole depth of the WWP No. 1 well was 767 feet (234 m) (Mogg, 1957). This well was pumped at 1,120 gpm (4.2 m^3/min) throughout the twenty-four hour test. The pumping of the WWP No. 1 well caused drawdowns in the L.C.I. and WWP No. 2 wells. Outside well interference from the pumping of the Twin City Foods and City of Lewiston Nos. 1 and 3 wells restricted drawdown analysis to the first 300 minutes of the test wells. (See Table 5-1.)

Aquifer Test No. 2 was conducted when the WWP No. 1 well was at the 869 foot (265 m) depth. The test lasted seven days, starting November 7, 1956, with the pumping rate held at 1,800 gpm (618 m^3/min) for the initial 123 hours (7,380 min) of the test and then varied. Drawdown in the pumped well appears to have stabilized after 5,880 minutes. Specific capacity at the time was 15.9 gpm/ft (0.20 m^2/min), an increase of 73 percent from the first test.

Observations of drawdowns were taken in the L.C.I. and the WWP No. 2 wells. Both wells had stabilized drawdowns after 7,200 minutes. Negative boundary conditions were observed near 1,200 minutes in the L.C.I. well and were interpreted by Mogg (1956) as the result of a nearby dike or fault. Negative boundary conditions were not observed in the data from the WWP No. 2 well. Outside well interference may have occurred from the pumping of the City of Lewiston No. 1 well at a rate of 480 gpm (1.8 m^3/min) prior to and during the test. Aquifer coefficients of transmissivity and storage were calculated from the observation wells and are given in Table 5-1.

Aquifer Test No. 3 was conducted and analyzed in a similar manner as the previous two tests. The WWP No. 1 well was deepened a second time, in

TABLE 5-1

Summary of Aquifer Tests, Clarkston, Washington

TEST NO. 1, September 19, 1956 (from Durand, 1978)

Pumped Well	Length of Test	Well Depth (feet)	Well Discharge (gpm)	Maximum Drawdown (feet)	Specific Capacity (gpm/ft dd)	Transmissivity (gpd/ft)
WWP No. 1	24 hours	767	1120	122	9.2	57,000

Observation Wells	Distance (feet)	Well Depth (feet)	Maximum Drawdown (feet)	Transmissivity (gpd/ft)	Storage	Boundary Conditions	Time of Occurrence (minutes)
L.C.I.	4,800	986	3.7	70,000		?	
WWP No. 2	14,600	?	1.5			?	

Comments: Outside well interference from the City of Lewiston well nos. 1 and 3 and Twin City Foods well prevented a good analysis of data and induced greater drawdowns in the monitored wells.

TEST NO. 2, November 7-14, 1956 (from Durand, 1978)

Pumped Well	Length of Test	Well Depth (feet)	Well Discharge (gpm)	Maximum Drawdown (feet)	Specific Capacity (gpm/ft dd)	Transmissivity (gpd/ft)
WWP No. 1	163.2 hours (9790 min.)	869	1800 0-7380 min. varied later	113	15.9	

Observation Wells	Distance (feet)	Well Depth (feet)	Maximum Drawdown (feet)	Transmissivity (gpd/ft)	Storage	Boundary Conditions	Time of Occurrence (minutes)
L.C.I.	4,800	986	12.4	63,000	2.11×10^{-4}	yes	1200
WWP No. 2	14,600	?	5.1	50,000	1.08×10^{-4}	no	

Comments: City of Lewiston well no. 1 pumped at 480 gpm starting 320 minutes prior to start of test. (Interwell distances given in Table C-1, Appendix C). Drawdowns in pumped well stabilized after 5880 minutes. Drawdowns in observation wells stabilized after 7200 minutes.

- continued -

TABLE 5-1 cont'd

TEST NO. 3, January 14-17, 1957 (from Durand, 1978)

Pumped Well	Length of Test	Well Depth (feet)	Well Discharge (gpm)	Maximum Drawdown (feet)	Specific Capacity (gpm/ft dd)	Transmissivity (gpd/ft)
WWP No. 1	(1) on 13 hours off 15 hours	970	1800	(1) 19	(1) 95	
	(2) on 48 hours		1800	(2) 25	(2) 72	

Observation Wells	Distance (feet)	Well Depth (feet)	Maximum Drawdown (feet)	Transmissivity (gpd/ft)	Storage	Boundary Conditions	Time of Occurrence (minutes)
L.C.I.	4,800	986	(1) 3.3 (2) 7.5	>200,000		yes	
WWP No. 2	14,600	?	(1) 0.7 (2) 2.5	>200,000		yes	

Comments: Pump wires burning out caused 15 hour delay of test. Transmissivity coefficient greater than values given above for observation wells. Increase of specific capacity and transmissivity due to additional 101 feet of depth in pumped well.

TEST NO. 4, February 4-7, 1958 (from Mogg, 1958)

Pumped Well	Length of Test	Well Depth (feet)	Well Discharge (gpm)	Maximum Drawdown (feet)	Specific Capacity (gpm/ft dd)	Transmissivity (gpd/ft)
WWP No. 1	0-4320 min.	970	2200	43.5	50.6	
WWP No. 2	(1) 2160-4320 min.	?	1200	22.8	52.6	

Observation Wells	Distance (feet)	Well Depth (feet)	Maximum Drawdown (feet)	Transmissivity (gpd/ft)	Storage	Boundary Conditions	Time of Occurrence (minutes)
L.C.I.	4,800 (1) 10,100	986	8.7 (1) 13.5	1.7×10^6	1.17×10^{-4}	yes	55; 260; 2350
WWP No. 2	14,600 (1) --	?	2.9				
Twin City Foods	10,300 (1) 21,100	630	0 (1) 0				
City of Lewiston No. 1	10,100 (1) 21,500	352	- 0.8 (1) 1.0				
No. 3	10,400 (1) 16,400	600	6 (1) 12				

Comments: Drawdown corrections made on WWP no. 1 and L.C.I. well from 4-day antecedent trends. Measurements in the Lewiston wells were taken by airline.

the interim, to its present depth of 970 feet (296 m). The L.C.I. and the WWP No. 2 well were used for observation wells. The test ran for forty-eight hours starting January 15, 1957. The City of Lewiston No. 1 well was the only outside well during the test. This well was turned at a rate of 450 gpm (1.7 m^3/min) on January 6 and continued pumping steadily throughout this period. The initial test started January 14 and continued for 778 minutes at which time the pump wires burned out. Discharge of the pumped well was given at 1,810 gpm (6.8 m^3/min). Recovery was monitored for the next 932 minutes whereupon the pumped well was again pumped at the same rate for the next 2,880 minutes.

The analysis of the drawdown data in all three wells of the early time data showed a coefficient of transmissivity greater than 200,000 gpd/ft (2,400 m^2/day). The specific capacity after 1,000 minutes of pumping was 95 gpm/ft (1.2 m^2/min) and decreased to 71 gpm/ft (0.9 m^2/min). The fourfold increase in specific capacity and transmissivity is attributed to deepening of WWP No. 1 well into basalt aquifers of above average hydraulic conductivity existing between -61 and -120 feet (-18.7 to -36.5 m) msl. A summary of this test is presented in Table 5-1.

Aquifer Test No. 4 was conducted about a year later during February 4-7, 1958. The WWP No. 1 well was pumped at 2,200 gpm (8.3 m^3/min) for the duration of the seventy-two hour test. Halfway through the test, WWP No. 2 was pumped at a 1,200 gpm (4.5 m^2/min) rate for the next thirty-six hours until 10 A.M. February 7. For four days previous to this test, water level measurements were obtained in the pumped wells and four observation wells which were the L.C.I., Sno-Crop, and City of Lewiston No. 1 and No. 3 wells. The City of Lewiston No. 3 well was the only one that had negligible antecedent fluctuations. As a result, corrections were made to the drawdowns in the WWP No. 1 and the L.C.I. well.

In the analysis of the pumped well drawdown, three changes of slope occurred on a semi-log plot of the drawdown versus time data. The first two, occurring at about 100 and 1,000 minutes, were the result of hydrogeologic boundaries and the third appeared shortly after WWP No. 2 started pumping. Observations of drawdowns in the L.C.I. well had slope changes at 55 and 260 minutes. The third slope change becomes apparent at 2,350 minutes, about 200 minutes after the WWP No. 2 well started discharging, as seen in a log-log of the L.C.I. observations of drawdown versus time (Durand, 1978). The initial coefficients of transmissivity and storage were calculated at 1.70×10^6 gpd/ft (2.1×10^4 m^2/day) and 1.47×10^{-4}, respectively, as noted in Table 5-1. This table also shows the maximum amount of drawdown observed in the Lewiston wells during Aquifer Test No. 4. It is felt by the author, based on the present understanding of the hydrogeologic system, that these measurements are of questionable accuracy and do not represent the response of the aquifer potentiometric surface in the Lewiston area to the pumping of the WWP wells.

Prediction of pumping interference in existing and future wells was the purpose of Aquifer Test No. 4. A compilation of the well interference is given in Table 5-2 as calculated by Mogg (1958). The positive boundary found during the 1957 specific capacity test of WWP No. 2 well was included in these calculations. Reviewing the data from the Aquifer Test No. 2, Mogg (1958) found indications of positive boundaries in all three wells between 6,000 and 7,000 minutes after the start of the test. To insure a factor of safety, Mogg (1958) used 8,000 minutes per pumped well as the time that drawdown would cease. In reviewing Table 5-2, it should be noted that WWP

TABLE 5-2

Ninety day drawdown and interference figures for Clarkston wells when six are pumping 2,500 gpm each and one well is pumping 1,200 gpm.

Well No.	Drawdown Caused By: Its own pumping	1	2	3	4	5	6	7	Extra*	Total Interference	Total Drawdown
1	51	--	4	13	11	13	13	14	15	83	134
2	30	9	--	10	12	10	8	8	15	72	102
3	51	13	5	--	13	13	12	11	15	82	133
4	51	11	6	13	--	13	10	9	15	77	128
5	51	13	5	13	13	--	10	11	15	78	129
6	51	13	4	12	10	10	--	14	15	76	127
7	51	14	4	11	9	11	14	--	15	78	129

Units given in FEET

*Extra --Pumping caused by Lewiston No. 1, No. 3, Snocrop, and others is assumed to be equal to 3,600 gpm for one well pumping 24 hours a day for 90 days and at a distance of 12,000 feet. This is a liberal allowance for the effects caused by these wells because it is doubtful that they will ever be pumping continuously for such a long period. (Table IV of Mogg, 1958)

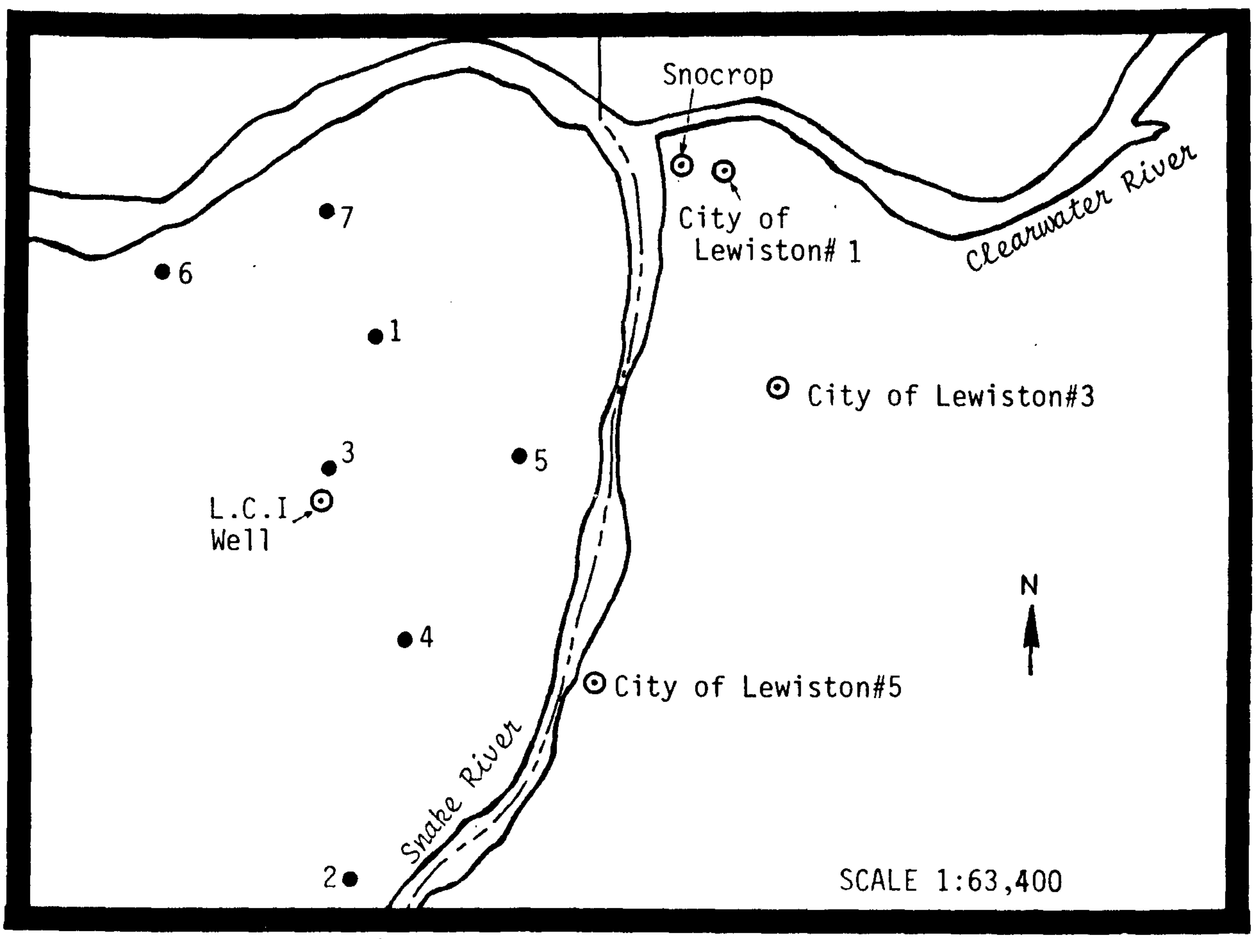


Figure 5-2 Well Location Map used by Mogg (1958) for calculating well interference on Table 5-2

Nos. 1 and 2 are the only Clarkston wells existing at the radii used to calculate the interference amounts. The other five Clarkston-WWP wells were constructed at different locations than those proposed to Mogg by A.A. Durand and Son (Figure 5-2).

Aquifer Test No. 5

Aquifer Tests Nos. 1-4 were performed in the late 1950's. The Washington Water Power Company has since constructed five additional deep wells to augment the municipal Clarkston water supply. These are WWP wells Nos. 3 through 7. The WWP well No. 7 was completed in 1977 after the other four were drilled in the early 1960's. All of these wells are completed in the Grand Ronde Formation and hence the "Russell" aquifer. A fifth test was conducted in early spring of 1979 and included all of the Washington Water Power wells.

A continuous record of static water levels from the WWP No. 7 well was obtained for a short period approximately six months prior to Aquifer Test No. 5. Four seven-day charts were obtained and used for pre-test analysis. Installation of the water level recorder occurred on August 14, 1978, prior to the installation of the pump bowls, column, and shaft (Plate 5-1). The static depth-to-water was established using a five hundred foot steel surveyor's tape. The initial depth-to-water was greater than 482 feet (147 m).

The traces from the time-water level cylindrical charts are reproduced in Figures 5-3 through 5-6. These figures show the water level response pumping of WWP No. 3 well at a rate of 4,200 gpm (15.9 m^3/min) at a radius of 2,750 feet (840 m), WWP No. 2 well at a rate of 1,280 gpm (4.8 m^3/min) at a radius of 7,900 feet (2,410 m), and WWP No. 5 well at a rate of 2,100 gpm (7.9 m^3/min) at a radius of 3,100 feet (940 m).

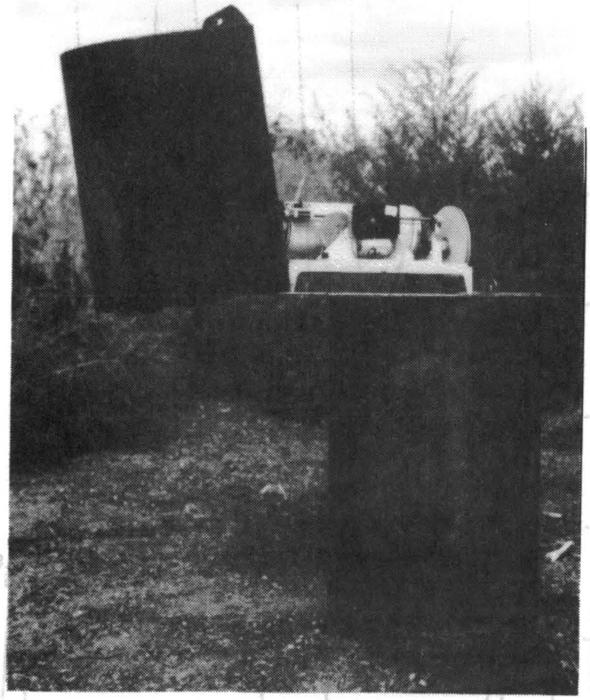


Plate 5-1 Leopold Stevens Type F Water Level Recorder installed on the WWP No. 7 well casing. Clockdrive (with seven day timing gears) obstructs view of cylindrical chart. Pulley, in center of casing, is reeved with a light cable and responds to water level float more than 450 feet below the water level recorder.

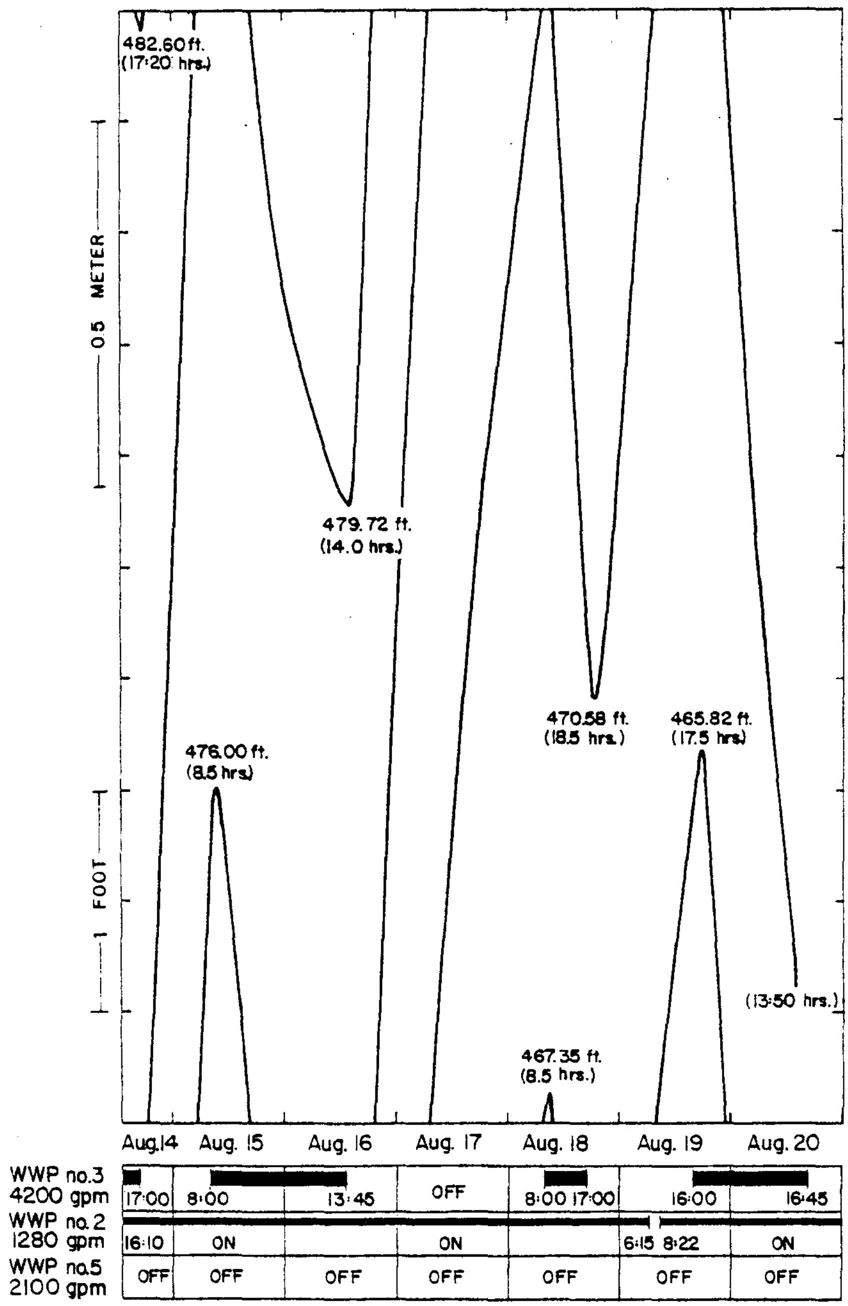


Figure 5-3 Hydrograph of WWP No.7 Well
August 14-20, 1978
Clarkston, Washington

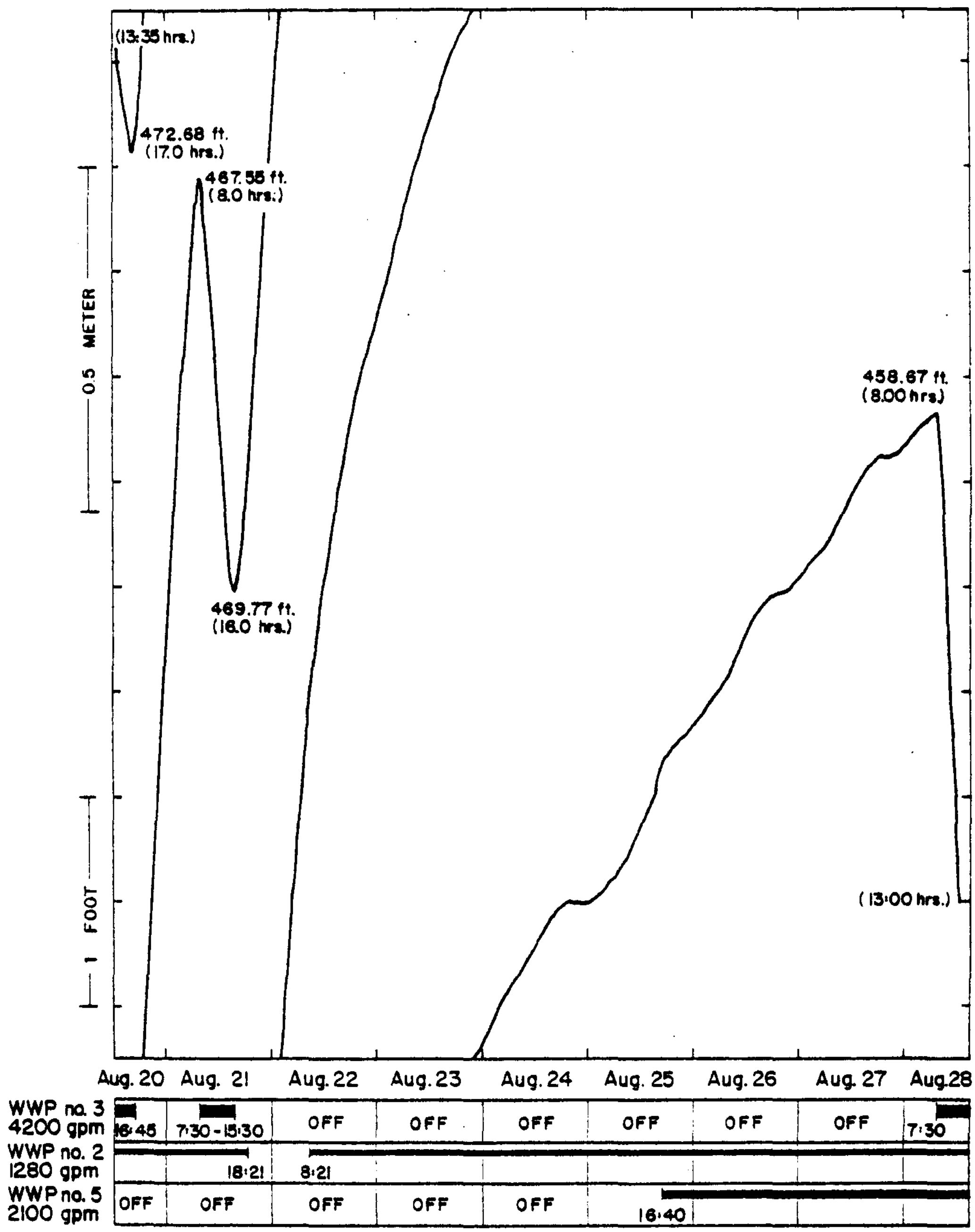


Figure 5-4 Hydrograph of WWP No.7 Well
August 20-28,1978
Clarkston, Washington

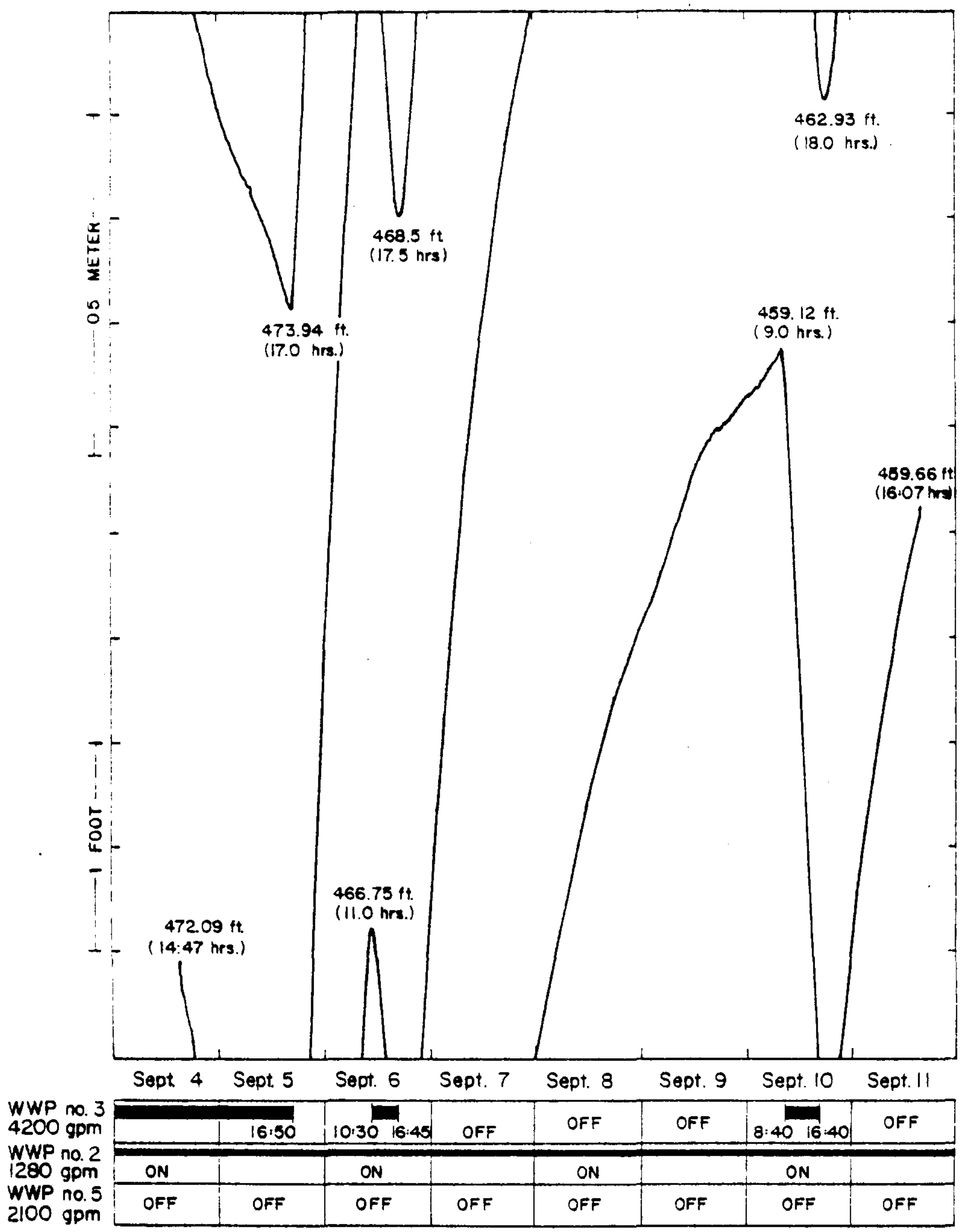


Figure 5-5 Hydrograph of WWP No.7 Well
September 4-11, 1978
Clarkston, Washington

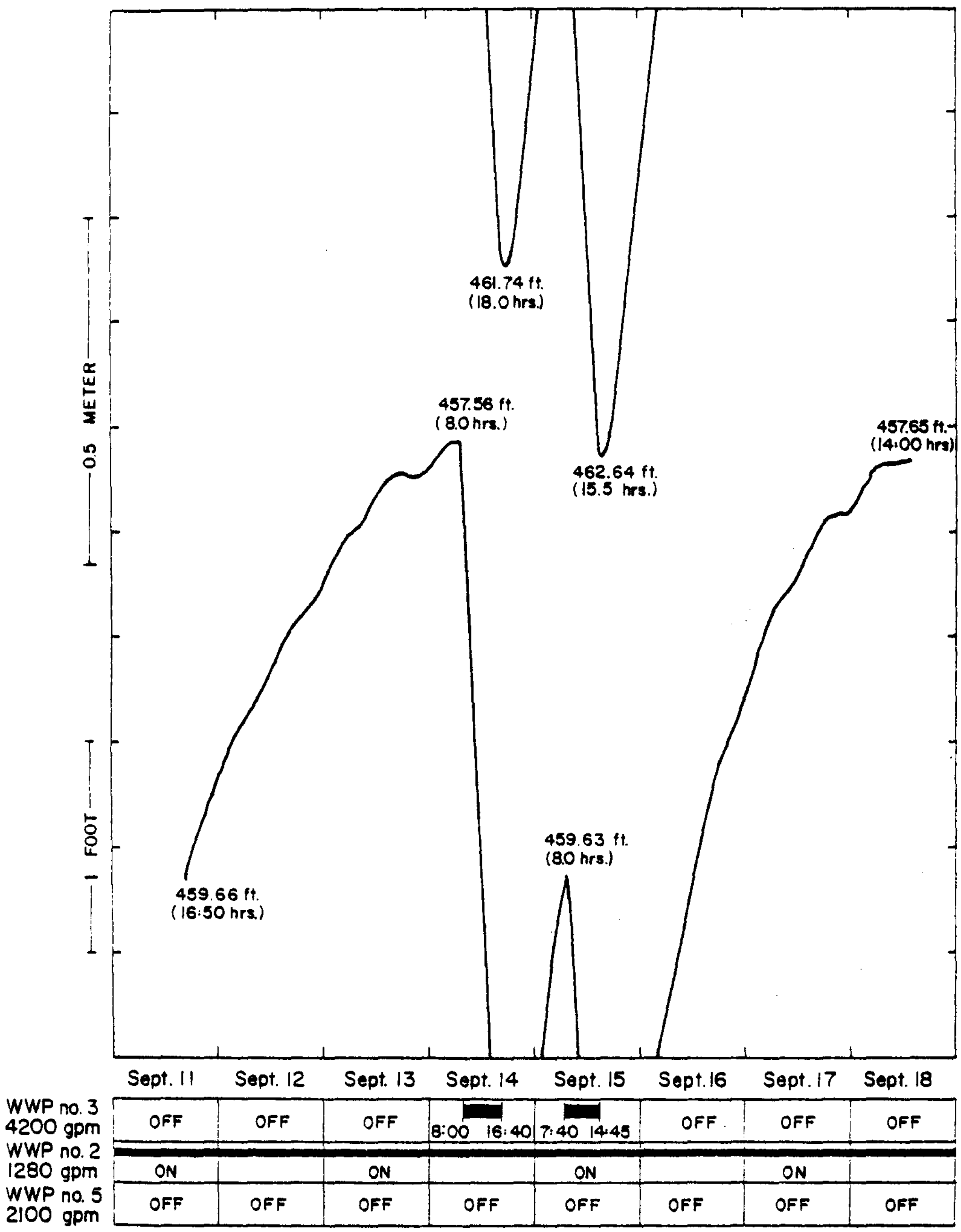


Figure 5-6 Hydrograph of WWP No.7 Well
September 11-18, 1978
Clarkston, Washington

The pumping of the WWP No. 3 well produced the only noticeable drawdown. Lack of noticeable well interference from the WWP Nos. 2 and 5 wells was attributed to poor inter-aquifer connection to the monitored No. 7 well. Low amplitude fluctuations were noted in the water level record during periods when the water level change caused by well pumpage was at a minimum (Figures 5-4 and 5-6). The fluctuations had a period of approximately twenty-four hours, and a maximum amplitude of 0.25 feet (7.6 cm). These fluctuations were believed to have been caused by changes in barometric pressure and possibly to changes in river stage where the river and aquifer are interconnected. Aquifer coefficients of transmissivity and storage were not calculated from the hydrograph data.

Aquifer Test No. 5 tested the response to pumping WWP No. 3 well in WWP well Nos. 1, 2, 4, 5, 6, and 7 and Port of Whitman well Nos. 1 and 2. These wells are located in Clarkston and Wilma, Washington (Figure 3-3). Access to the wells of Lewiston, Idaho, was limited to the L.O.I.D. (Lewiston Orchards Irrigation District) well No. 1. The City of Lewiston wells were not used as observation wells due to their either continuous or intermittent pumping schedules. Attempts to measure the depth-to-water in the L.O.I.D. well with an 850 (260 m) electric well sounder were unsuccessful due to repeated fouling of the wires in the borehole.

Electric water level measuring devices and steel tapes were used to collect water level measurements throughout the test. The Clarkston-WWP well Nos. 1, 4, 5, 6, and 7 were measured with a steel surveyor's tape attached to an electric tape so that an accuracy of 0.01 foot (3.05 mm) was obtained. Oil was noted on top of the water column in WWP wells Nos. 5 and 7. The depth-to-water was small enough in WWP No. 2 and the Port of

Whitman wells to use only a chalked steel surveyor's tape. No attempt was made to measure the depth-to-water in WWP No. 3 well due to its history of fouling water level sounding equipment.

The City of Lewiston used two of its wells intermittently during this test as shown in Table 5-3. City of Lewiston No. 5 well was pumped at 1,000 gpm (3.79 m^3/min) several months before and throughout the test.

The stage of the Snake River was obtained from two gaging stations throughout the test. The confluence and the Anatone gaging stations provided telemetric elevation at 15 minute intervals. Barometric pressure data were obtained from the National Oceanic and Atmospheric Administration weather station at the Lewiston Airport (Appendix C, Table C-2).

Monitoring of water levels began on March 4, 1979. The water levels in the wells were recovering from the previous pumping period that ended at 0800, Saturday, March 3, 1979. Discharge from WWP No. 3 well was approximately 4,200 gpm (15.90 m^3/min) during the previous pumping periods. Recovery data were collected hourly until 0832, Monday, March 5, when WWP No. 3 well was turned on for Aquifer Test No. 5. The remaining six WWP wells were not pumped during the entire test period. Depth-to-water measurements were collected with decreasing frequency until 1500 (3:00 P.M.), Tuesday, March 6, in the WWP well Nos. 1, 2, 4, 5, 6, and 7 and the two Port of Whitman wells (Appendix C, Table C-3). Discharge measurements of pumping well WWP No. 3 were obtained from flow meters inside and outside the pumphouse. Initially, the discharge was measured at about 4,200 gpm (15.90 m^3/min). Discharge had decreased to about 4,050 gpm (15.33 m^3/min) by the end of the test.

The Port of Whitman wells showed no response to the pumped well in Clarkston during the aquifer test. However, water level data for these wells

TABLE 5-3

DISCHARGE SCHEDULE OF CITY OF LEWISTON WELLS DURING AQUIFER TEST NO. 5, MARCH, 1979

WELL	SUNDAY MARCH 4	MONDAY MARCH 5	TUESDAY MARCH 6
No. 1A pumped at 1,600 gpm (6.1 m^3/min)			
Clock time	7:25 a.m. to 4:30 p.m.	7:50 a.m. to 8:30 p.m.	7:59 a.m. to 8:59 p.m.
Antecedent E.T. (min)	1,405 to 1,950	2,870 to 3,650	4,259 to 5,069
Pumping E.T. (min)		-42 to 717	1,347 to 2,157
No. 3 pumped at 1,000 gpm (3.8 m^3/min)			
Clock time		12:37 p.m. to 8:25 p.m.	8:04 a.m. to 1:14 p.m.
Antecedent E.T. (min)		3,157 to 3,624	4,324 to 4,634
Pumping E.T. (min)		245 to 712	1,412 to 1,722

Antecedent E.T. - Elapsed time in minutes since WWP No. 3 well stopped discharging 4,200 gpm (pump shut off at 8:00 a.m., March 3, 1979).

Pumping E.T. - Elapsed time in minutes since WWP No. 3 well started discharging 4,200 gpm (pump turned on at 8:32 a.m., March 5, 1979).

indicated a good hydraulic connection to the Snake River. Figure 5-7 shows the relationship between Port of Whitman Well No. 2 and river stage from the confluence gaging station. Data from Port of Whitman Well No. 1 shows a similar response to river stage.

Trends in water level changes in WWP wells Nos. 1, 2, 4, and 7 are somewhat similar during pretest recovery and the pumping period. These trends suggest that WWP Nos. 1, 2, 3, 4, and 7 are hydraulically connected. WWP well Nos. 5 and 6 showed no response to the pumping of WWP No. 3. During the test period, the water level changes in WWP wells Nos. 5 and 6 were similar and indicated a hydraulic connection exists between these wells and the Snake River. Figure 5-7 also shows the change in water level at WWP No. 5 well during the test period. This response appears to be lagged and subdued response to stage changes in the Snake River either below the confluence or upstream of Asotin, Washington, or possibly stage changes in both areas.

The following general observations may be stated based upon the analysis of the March, 1979 pump test data:

1) WWP well No. 7 showed a pretest recovery trend similar to WWP wells Nos. 1, 2, and 4.

2) Semi-log plots of pretest recovery data from WWP well Nos. 1, 2, 4, and 7 show changes in slope at approximately 2,100 and 2,700 minutes after the pump was shut off.

3) Barometric pressure remained steady during the test period.

4) WWP well Nos. 1, 2, and 4 all show a similar response to the pumping of No. 3.

5) WWP well Nos. 5 and 6 did not show a response to the pumping of WWP well No. 3.

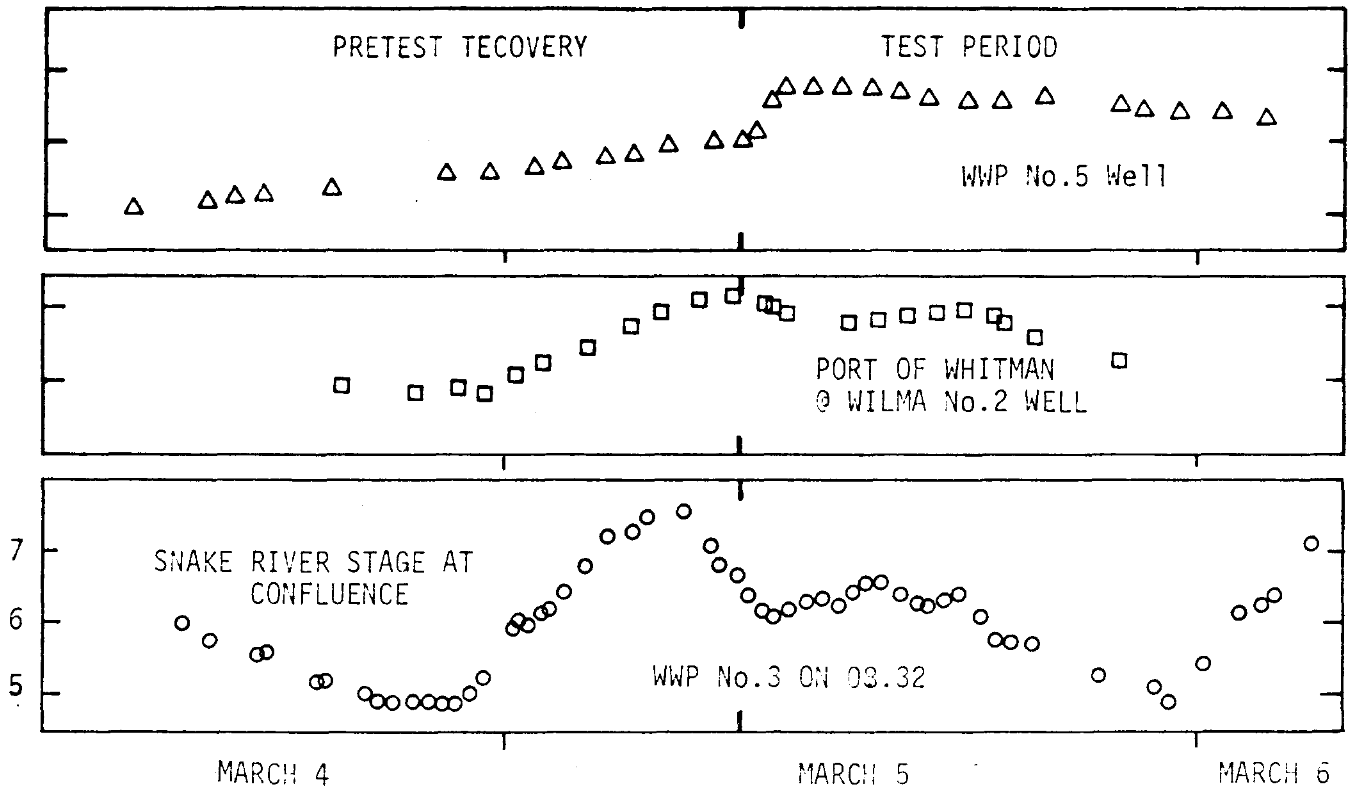


Figure 5-7 Plot of Water Levels in WWP No.5 and Port of Whitman No.2 Wells and Snake River Stage at confluence Gaging Station. Aquifer Test No.5 March 1979, Clarkston, Washington

6) WWP well No. 7 showed a delayed response to the pumping of WWP well No. 3, even though it is closer to WWP well Nos. 1, 2, and 4. Erratic early time drawdown measurements may be due to the oil in the borehole water column.

The initial data analysis was based upon plots of unadjusted drawdowns versus time on log-log and semi-log graph paper. Two general observations were made from these plots. First, the log-log plots did not readily fit the standard Theis non-equilibrium curve and second, the semi-log plots did not result in a straight line but displayed several changes in slope (Figure 5-8). Also, the pre-test recovery data were plotted versus time since the March 4 pumping ended in order to determine the antecedent water level trend. The same general observations were made concerning these data plots.

The drawdown data were adjusted using slopes established from a semi-log plot of the antecedent static water levels. Two trends were found within these slopes. Trend one is represented by the last clearly defined slope of recovery data. Trend two is the very last recovery data points. Figure 5-9 shows the plot and extrapolation of the water level recoveries in the WWP No. 1 well.

The drawdown data from WWP No. 1 well was selected to illustrate the determination of the aquifer coefficients of transmissivity and storage. Similar drawdowns were observed in WWP well Nos. 2, 4, and to some extent No. 7. In the initial analysis, the unadjusted log-log plot of the drawdown in WWP No. 1 displayed a fairly good fit to Theis type curve during the first 25 minutes (Figure 5-10). Adjustments to the drawdown data were made for both trend 1 and trend 2 (Appendix C, Table C-4) and plotted on log-log graph paper. Both plots did not fit the Theis type curve precisely. However, the

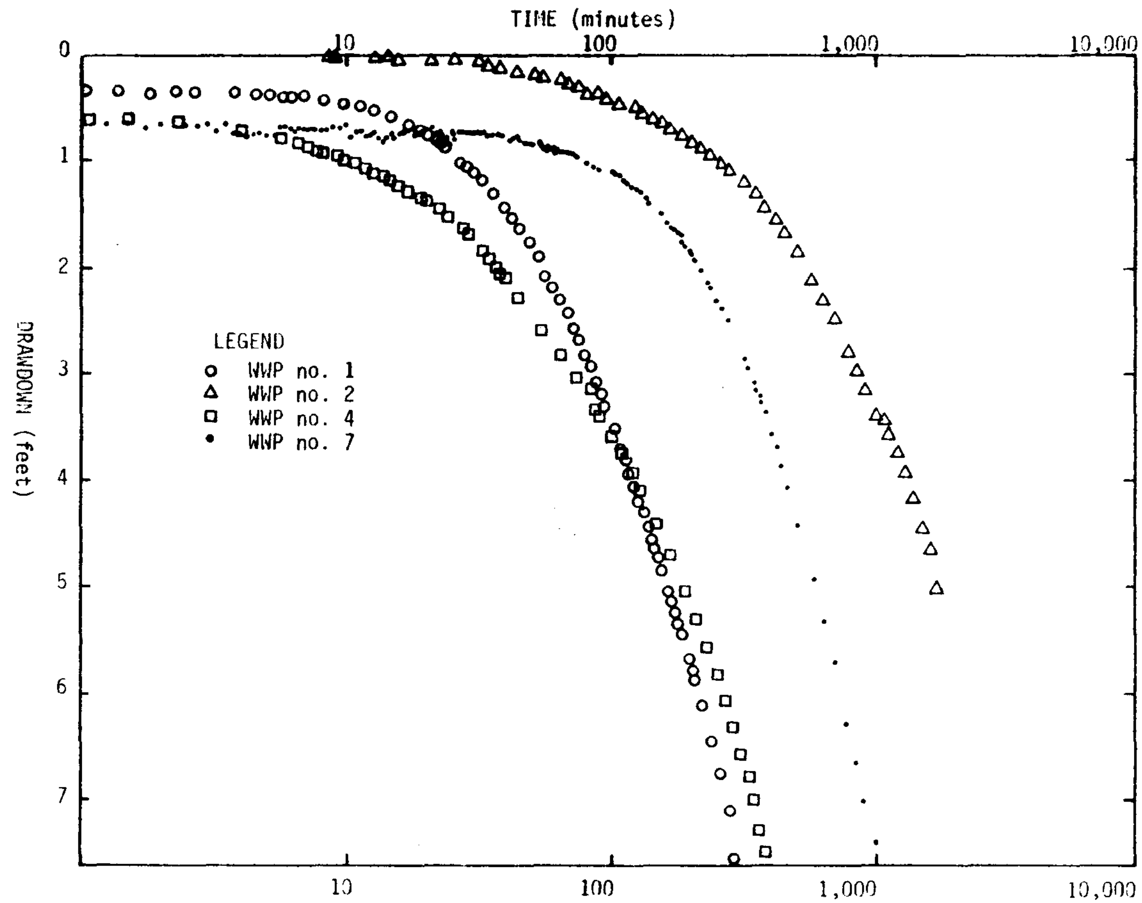


Figure 5-8 Semi-log plots of unadjusted time-drawdown data of WWP well nos. 1, 2, 4, and 7. Aquifer Test No. 5, March 5-6, 1979, Clarkston, Washington

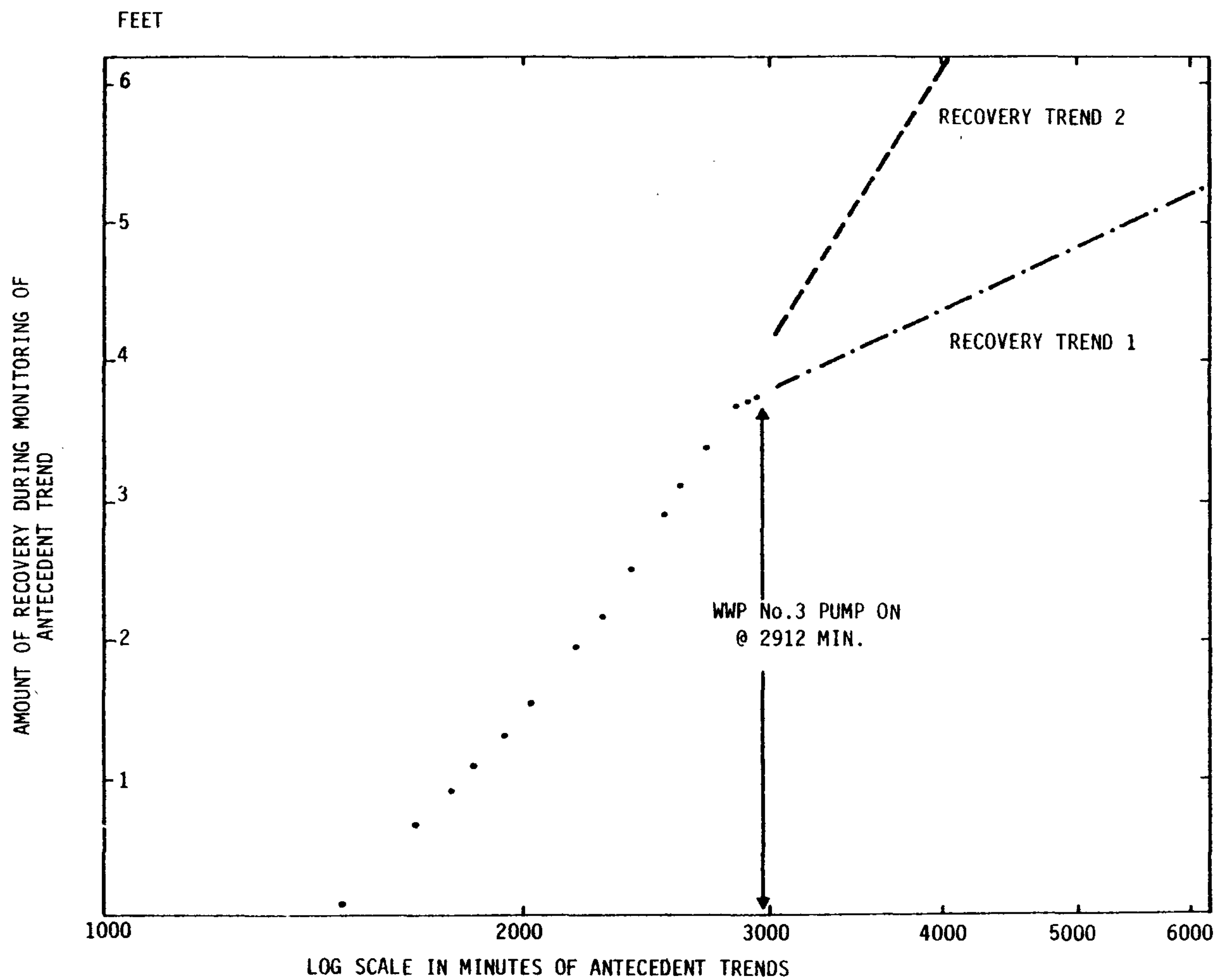


Figure 5-9 Antecedent Trends of WWP No.1 Well during Aquifer Test No.5, March 1979

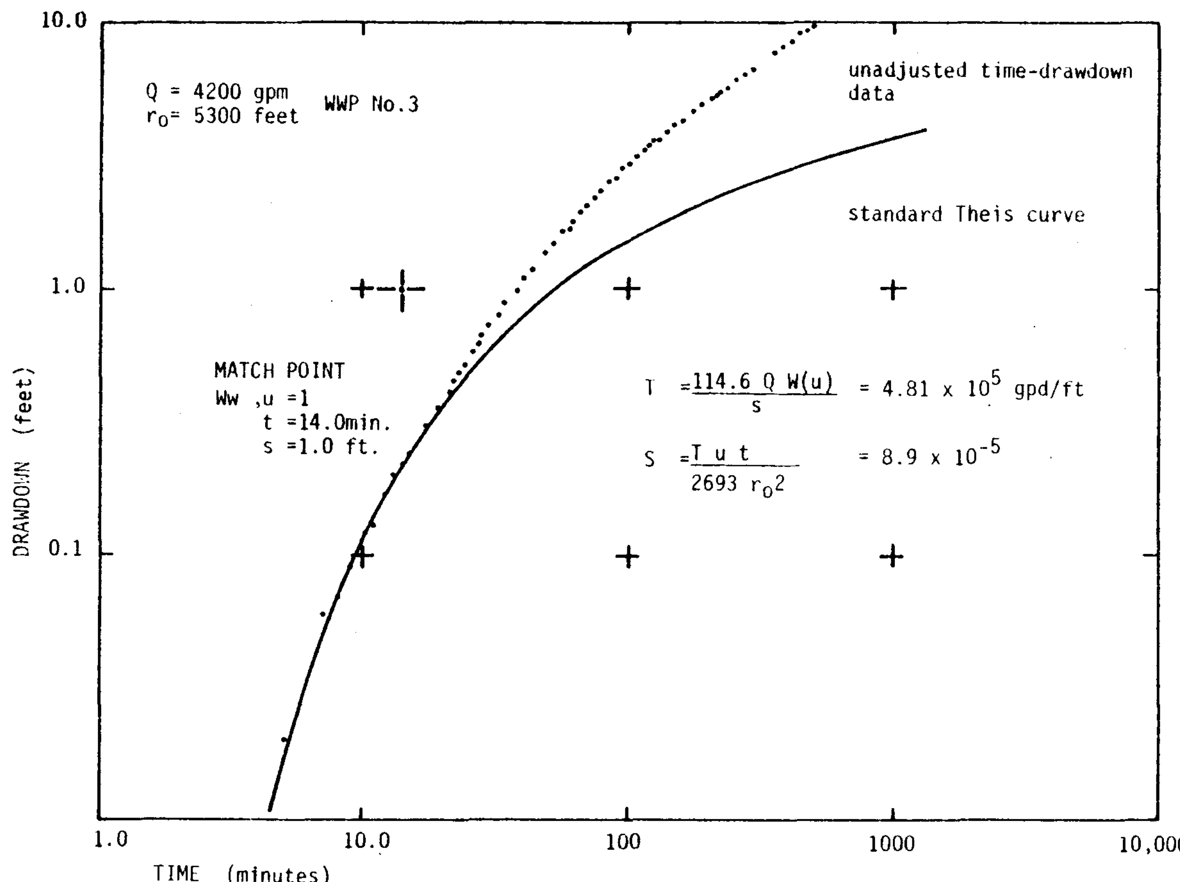


Figure 5-10 Log-Log plot of unadjusted Time-Drawdown data of observation well WWP No. 1, Aquifer test No. 5, March 1979 Clarkston, Washington

plot of trend 2 had the best fit and was selected to match with the Theis type curve (Figure 5-11).

The log-log plots of the adjusted and unadjusted data deviated from the Theis analytical solution (Figures 5-10 and 5-11). Five possible causes for the observed deviations from the Theis type curve were considered. These are:

1) barometric pressure change,

2) river stage fluctuations,

3) well interference,

4) hydrogeologic boundaries,

5) leaky artesian conditions with water derived from storage, or

6) any combination of the above reasons.

Barometric pressure changes and river stage were not considered to have a major effect on the overall drawdown trend in wells 1, 2, 4, and 7. Barometric pressure readings remained steady throughout the test and thus were eliminated as a possible cause of the deviation from the Theis solution. There were no definite correlations between river stage fluctuations and water level response that could be used to quantitatively analyze the data, even though some sort of relationship appears to exist. Therefore, well interference, hydrogeologic boundaries, and leaky artesian conditions with water derived from storage (Lohman, 1972, p. 32) were assumed to be the possible major causes of the observed deviations from the Theis analytical solution.

Interference from the pumping of the City of Lewiston wells is believed to have a major effect on the observed drawdown data plots on all the wells except WWP No. 2. However, the magnitude of this interference could not be

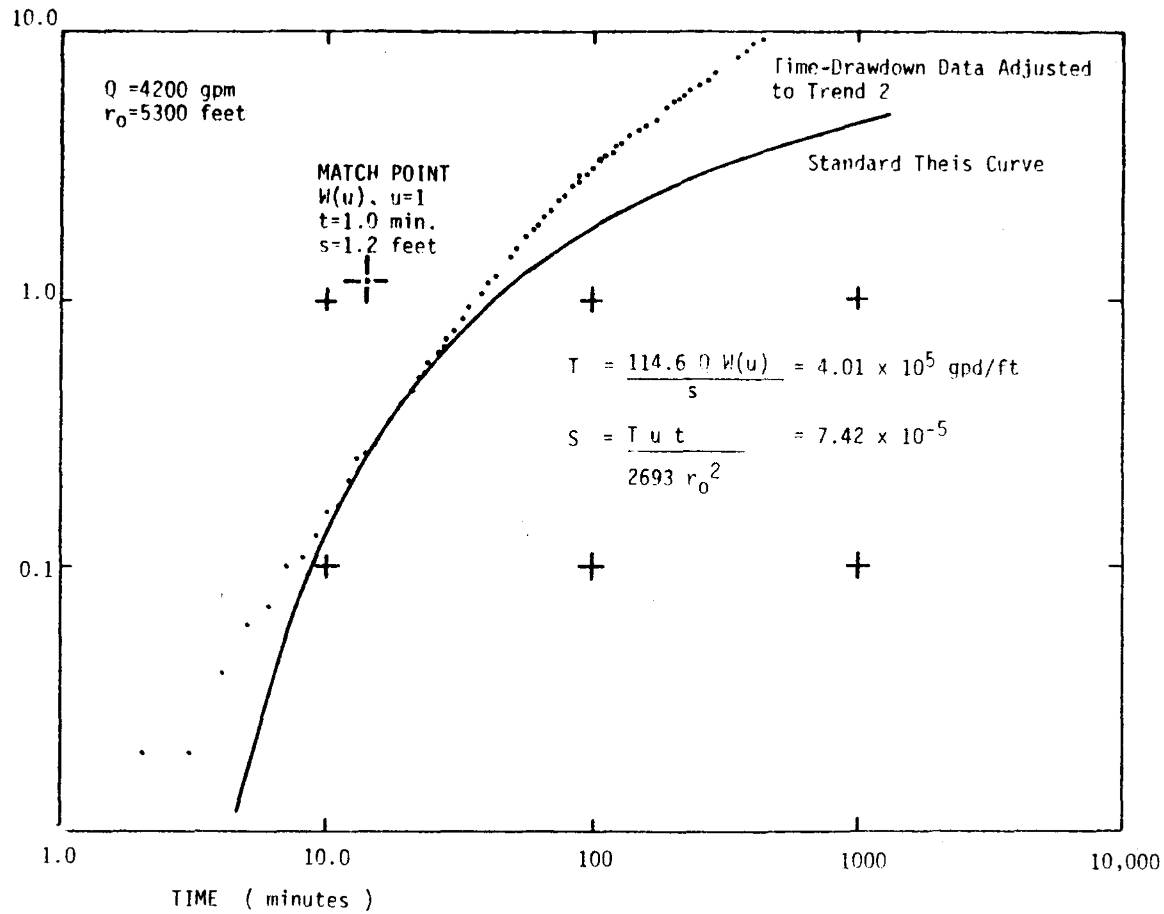


Figure 5-11 Log-Log plot of Time-Drawdown Data adjusted to Trend 2. Taken from Observation Well WWP No.1, Aquifer Test No.5, March,1979 Clarkston, Washington.

determined because of the lag-time effects necessary to adjust the drawdown data or discriminate this interference from the hydrogeologic boundaries mentioned in the earlier aquifer tests.

The "Russell" aquifer has both geologic boundaries or limits and a probable interface with the Snake and Clearwater rivers. These boundary conditions can range from "no flow" or negative boundaries formed by hydrogeologic discontinuities to positive or "constant head" boundaries formed by the close interconnection with the river.

It appears that the most pronounced negative boundary near these wells is the proximate dike mapped by Camp (1976) (Figure 5-12). Geologic evidence for this dike was mentioned in Chapter 2 (page 20) as the cause of the tephra deposits cropping out in the Peaslee Avenue roadcut. Hydrogeologic evidence is found in the lack of water level response in WWP well Nos. 5 and 6 to the discharge of WWP No. 3 well. The second negative boundary would logically be the Wilma Fault; however, this fault may actually provide the avenue for water movement from the Snake River to the aquifer and may thus act, at least in some areas, as a positive boundary.

The shape of the semi-log plots for the WWP wells Nos. 1, 2, 4, and 7 seem to indicate numerous hydrogeologic boundaries were encountered during the aquifer test. Matching the early drawdown data of the log-log plots (10-25 minutes) to the Theis type curve minimizes the effect of boundary conditions. Both unadjusted and adjusted curves were matched to the Theis type curve. The results are given in Table 5-4 for the aquifer coefficients of transmissivity and storage for using the standard Theis condition.

Another explanation for the shape of the log-log drawdown data plots is represented by leaky artesian conditions with water derived from storage.

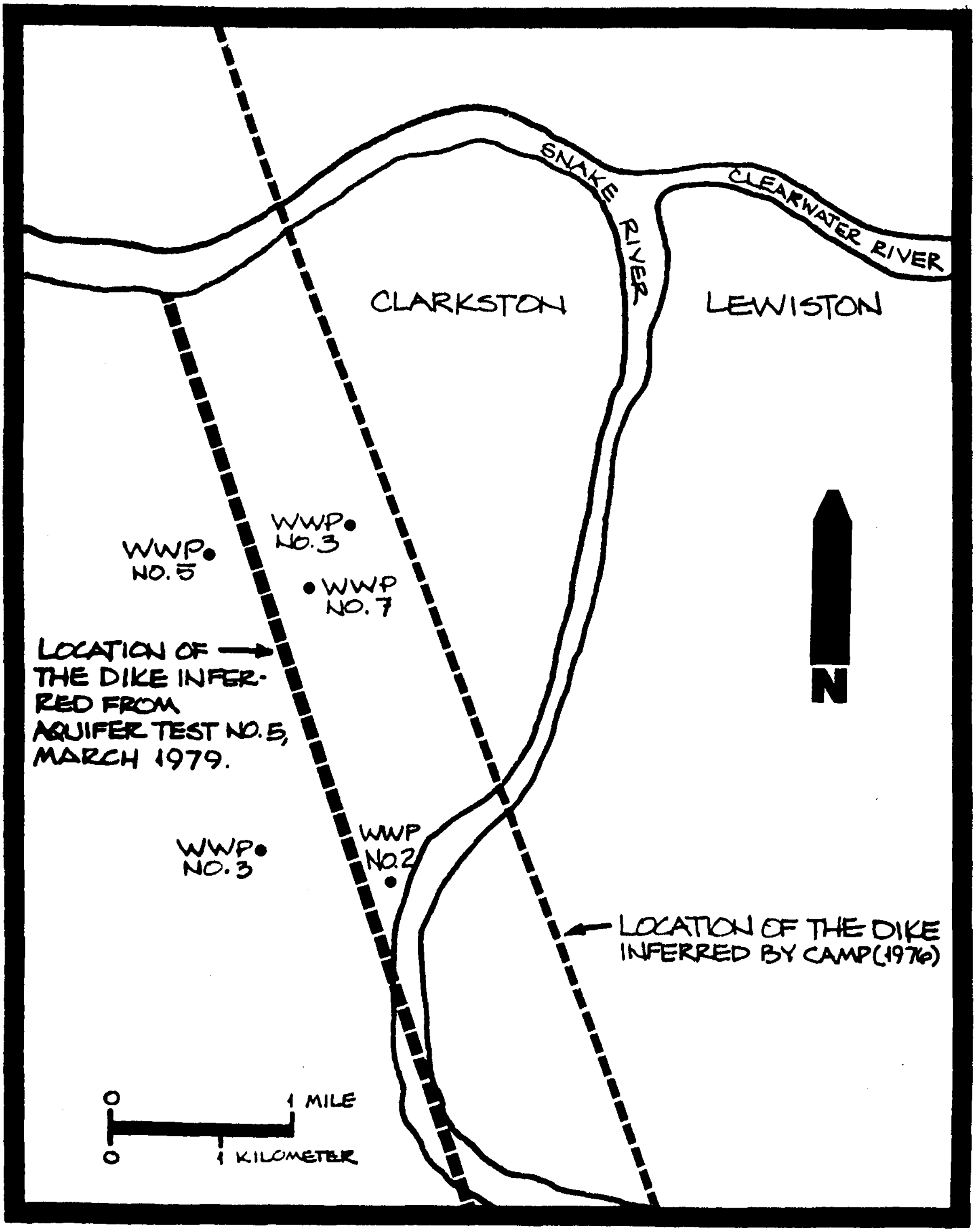


Figure 5-12 Inferred location of major dike in Clarkston, Washington

TABLE 5-4

AQUIFER TEST NO. 5: AQUIFER TRANSMISSIVITY AND STORAGE COEFFICIENTS FOR STANDARD THEIS AND LEAKY ARTESIAN CONDITIONS

WELL NO.	DATA	THEIS STANDARD SOLUTION T gpd/ft	THEIS STANDARD SOLUTION S	LEAKY ARTESIAN WITH WATER FROM STORAGE T gpd/ft	LEAKY ARTESIAN WITH WATER FROM STORAGE S
1	Unadjusted	4.8×10^{5}	8.9×10^{-5}	1.2×10^{4}	2.1×10^{-9}
	Adjusted			1.4×10^{4}*	4.7×10^{-10}*
	Adjusted	4.0×10^{5}**	6.6×10^{-5}**	1.2×10^{4}**	4.7×10^{-10}**
2	Unadjusted	1.1×10^{5}	1.4×10^{-5}	4.5×10^{3}	1.8×10^{-9}
4	Unadjusted	6.5×10^{5}	7.7×10^{-5}	3.3×10^{4}	6.6×10^{-10}
7	Unadjusted	5.5×10^{5}	1.4×10^{-3}	1.0×10^{4}	8.3×10^{-9}

*Adjusted using Trend 1.
**Adjusted using Trend 2.
Q = 4,200 gpm (discharge of pumping well - Clarkston No. 3).

r_1 = radius to observation well No. 1 from pumping well No. 3.

r_1 = 5,300 ft
r_2 = 9,650 ft
r_3 = 4,375 ft
r_4 = 2,750 ft

Water pumpage from the aquifer results in a decline of the piezometric head and is accompanied by a release of water from storage from the aquifer and aquiclude or aquicludes. A very good match to a curve from the family of leaky artesian type curves (Lohman, 1972, p. 32) was obtained for both unadjusted and adjusted drawdown plots. The match was for data points from 10 minutes to the end of the test (Appendix C, Table C-4).

The results obtained from use of the standard solution boundary conditions and leaky artesian conditions are markedly different. High values of transmissivity and moderately low values for storage coefficient are obtained by using the standard solution. These calculated aquifer coefficients represent the response of the physical system over a short pumpage period. These parameters would be useful in predicting the response of the system under various pumping schedules over a long time period if image well theory is applied to eliminate the effects of boundary conditions. (See Chapter 6.)

Leaky artesian conditions with water derived from storage show low transmissivity and extremely low storage coefficient values. It is believed that these values do not represent the actual physical system because of previous evidence given for negative boundaries. Also, the hydrogeologic nature of the "Russell" aquifer is not typified by the extremely low storage coefficient.

The conclusions of Aquifer Test No. 5 are as follows:

1) Two separate flow systems were found to exist in the "Russell" aquifer of the Lewiston Basin. These flow systems are separated by a hydrogeologic boundary that isolates the WWP 5 and 6 wells from the remaining WWP and Lewiston municipal and industrial wells.

2) The hydrogeologic boundary that separates WWP well Nos. 5 and 6 from WWP well Nos. 1, 2, 3, 4, and 7 appears to be a dike.

3) The recharge boundary of the river was not intersected with the cone of depression of pumped well WWP No. 3.

4) The slope changes in the semi-log plot of the drawdown curves can best be explained by the existence of negative boundaries and well interference.

5) The most representative value of transmissivity is 5×10^5 gpd/ft (6,200 m^2/day) and for storage is 5×10^{-5}. These aquifer coefficients may be used to project long-term drawdown only if image well theory is used to model the aquifer boundaries believed to be present.

CHAPTER 6 INTERSTATE WELL INTERFERENCE

Introduction

Predictions of well interference between wells of Lewiston, Idaho and Clarkston, Washington are presented in this section based on a simplified model of the "Russell" aquifer. Drawdown is calculated at a hypothetical observation well located on the Idaho-Washington state line. Pumpage in the two cities is represented by two hypothetical wells: one located in Clarkston and discharging at 10,000 gpm (37.9 m^3/min.) and the other located in Lewiston and discharging at 4,000 gpm (15.1 m^3/min.). These discharge rates are chosen to represent the extensive use of the Lewiston and Clarkston municipal wells during the summer months. Drawdown at the observation well was calculated for ten and one hundred day pumping periods. Two separate model configurations of the "Russell" aquifer were examined. One configuration assumes all the water in the aquifer is derived from storage while the other configuration introduces a nearby surface water source for aquifer recharge.

Image Well Theory

The presence of hydrogeological boundaries in the aquifer prevents the direct use of the Theis non-equilibrium formula for the calculation of drawdown in the hypothetical stateline observation well. The method of analysis used in this chapter is based on image well theory because of the mathematically based assumption of infinite areal extent of the aquifer. This type of theoretical analysis replaces the hydrogeological boundaries with imaginary wells. These wells induce the same effects as the boundaries (Ferris and others, 1962). The use of image well theory allows drawdown calculations to be made as if the aquifer were of infinite areal extent.

The effect of a hydrogeologic boundary is replicated by an image well located at the same distance, but on the opposite side of the boundary from the pumping well. The location of this image well is such that the hydrogeological boundary is the perpendicular bisector to a line drawn from the image well to the real well. If the boundary acts to recharge the aquifer, such as a stream or lake, then it is termed a "constant head" or positive boundary. The hydraulic action of a positive boundary is replaced by a recharging well that injects water into the aquifer at the same rate that the real well is discharged. If the boundary is a barrier to groundwater flow, then it is termed a negative or impermeable boundary (Figure 6-1). This negative boundary is replaced by an image well that is discharged at the same rate as the real well. The drawdown in an observation well can be found at any given time by applying the Theis non-equilibrium formula, using the radii from the observation to the real and image wells. The drawdowns in the observation well from the pumping well and image well(s) are then added algebraically (necessary to account for a recharging image well) to find the cumulative drawdown in the observation well.

If the aquifer contains more than one boundary, then an array of image wells is formed. In this respect, the boundaries "mirror" the real wells and other boundaries with their image wells. If two aquifer boundaries happen to be parallel, an infinite array of image wells results. Generally, only the nearby image wells are used to estimate the drawdown in a given observation well since the more distant image wells would not produce a significant water level change. The arrays of image wells in an aquifer with hydrological boundaries that are perpendicular and parallel are illustrated in Figures 6-2 and 6-3.

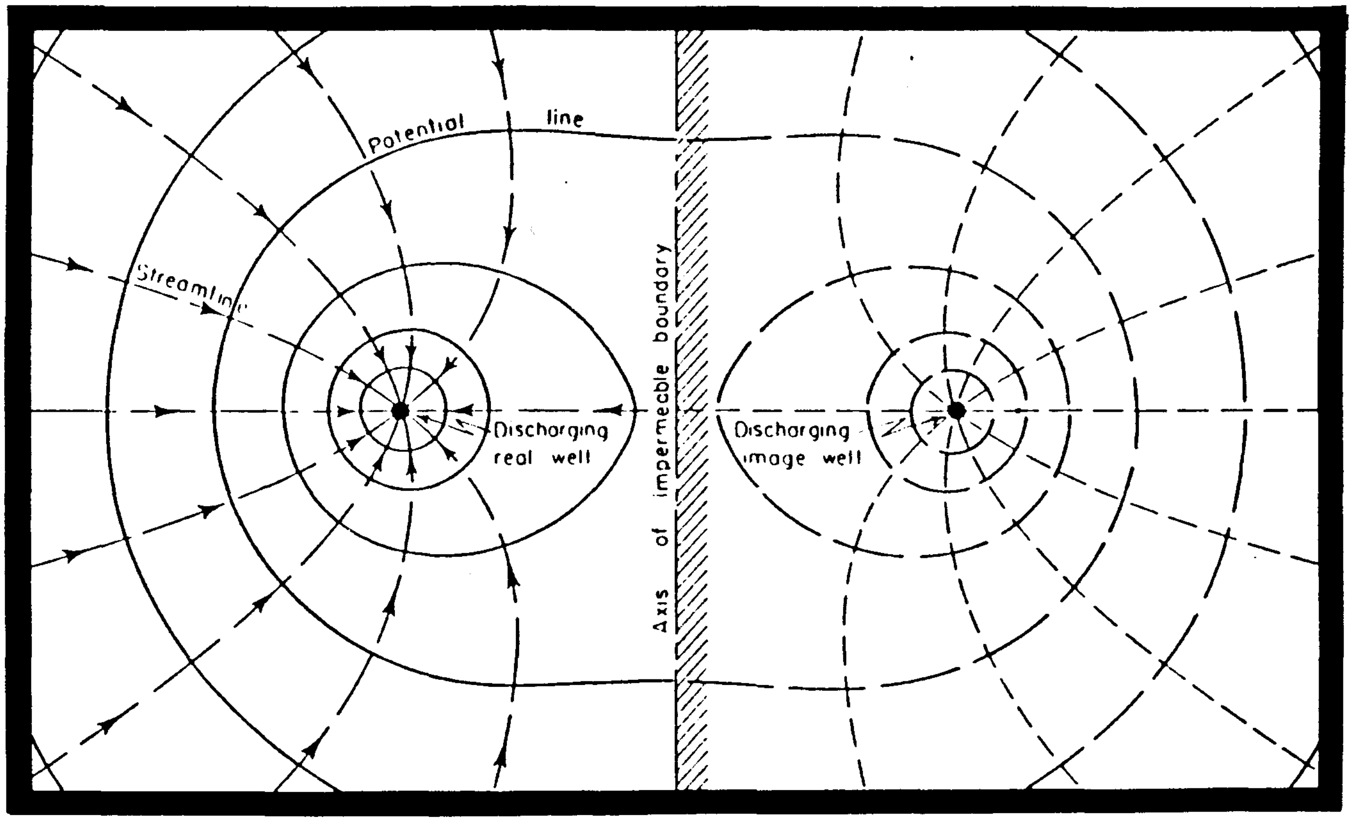


Figure 6-1 Generalized flow net showing stream lines and potential lines in the vicinity of a discharging well near an impermeable boundary.
(from Ferris and others, 1962)

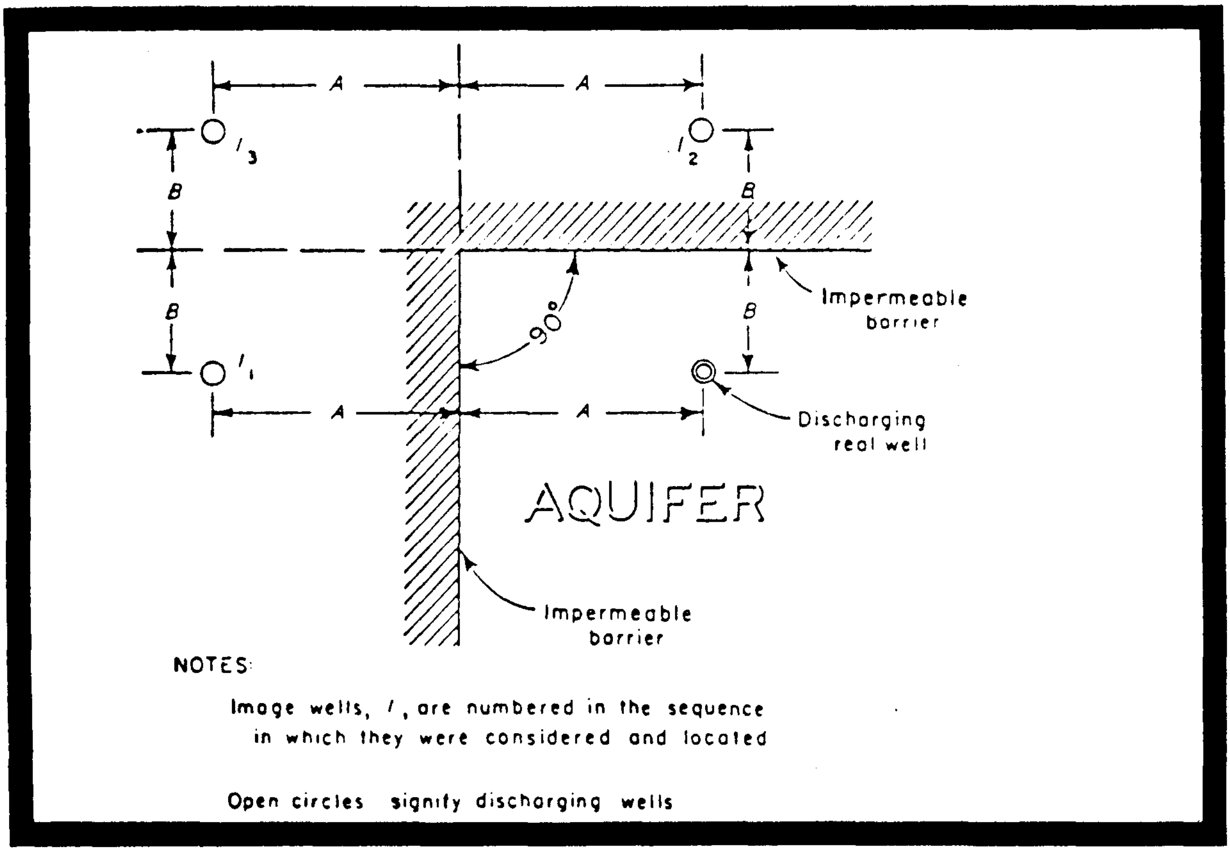


Figure 6-2 Plan of image well system for a discharging well in an aquifer bounded by two impermeable barriers intersecting at right angles. (from Ferris and others, 1962)

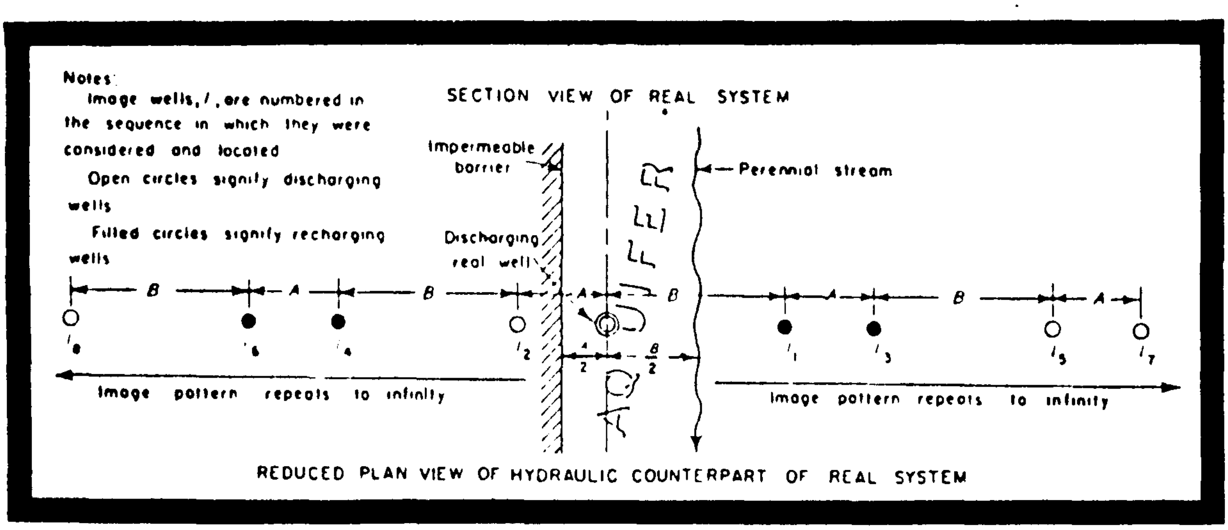


Figure 6-3 Image well system for a discharging well in an aquifer bounded by an impermeable barrier parallel to a perennial stream. (from Ferris and others, 1962)

Model Formulation

Two predictive model configurations were chosen for the drawdown calculations. The initial configuration is patterned after Figure 6-2. The impermeable barriers of Figure 6-2 are represented by the Wilma Fault and the dike believed present in Clarkston. For simplicity of the model, these negative hydrogeologic boundaries are assumed to intersect at right angles. The resulting model configuration and array of image wells is illustrated in Figure 6-4A. This model represents an aquifer where pumpage is largely derived by a depletion of groundwater in storage. This case is applicable to the "Russell" aquifer if it were recharged by precipitation from the distal southern highlands. In this respect, the groundwater flowpath length would be about 20 to 25 miles (32 to 40 km) from the southern hydrogeological boundaries of the study area to the discharging wells of the model.

The second configuration is a composite of Figures 6-2 and 6-3 as it introduces a third hydrogeologic boundary that is positive and parallel to the Wilma Fault (Figure 6-4B). This positive boundary is introduced to account for, in a simplified form, all of the river water recharge to the "Russell" aquifer. The placement of the boundary is put at Asotin, approximately 4 and 6 miles (6 and 10 km) from the two discharging wells of the model.

Both boundary types are assumed to (1) fully penetrate the "Russell" aquifer and (2) extend infinitely away from their points of intersection in order to comply with image well theory (Ferris and others, 1962, p. 144-161). It is felt that these assumptions can adequately replicate the hydrogeologic boundaries.

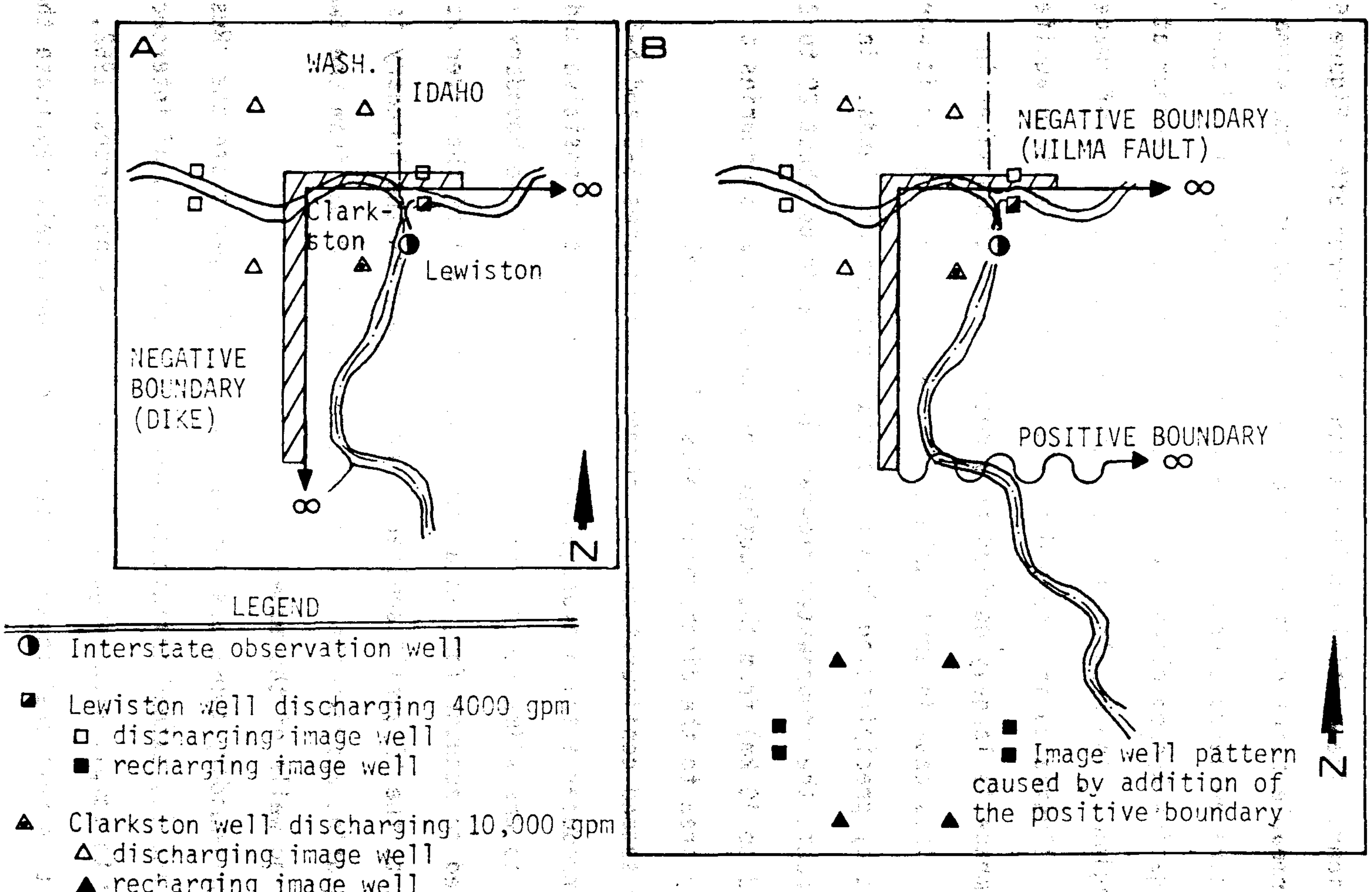


Figure 6-4 Real and image well locations and boundaries used for estimation of drawdown for the "Russell" aquifer
(A) Two impermeable boundaries.
(B) Two impermeable boundaries and a constant head boundary.

The dimensions and layout of the model with respect to the physical system are as follows. The northern boundary (Wilma Fault) is located about 6,000 feet (1,800 m) north of the line dividing Townships 35 and 36 N. in Idaho. The location of the negative boundary (the dike) is 1 mile (1.6 km) east of the dividing line for Ranges 46 and 47 E. in Washington and is based on the findings of Aquifer Test No. 5 (Figures 5-12 and 6-4A). The positive boundary is located about 32,000 feet (9,800 m) south of the northern negative boundary (Figure 6-4B). Only the first set of image wells resulting from the parallel boundaries were used in the calculations. This was done since the next nearest image wells would not have produced a significant water level charge.

The Washington Water Power Company wells are represented by one well in Clarkston discharging 10,000 gpm (37.8 m^3/min.) located 9,300 feet (2,830 m) south of the Wilma Fault and 6,500 feet (1,980 m) east of the dike. This locates the well near Twelfth and Highland Streets in Clarkston, Washington. The City of Lewiston and Twin City Foods wells are represented by one well discharging 4,000 gpm (15.1 m^3/min.), located 1,600 feet (490 m) south of the Wilma Fault and 13,000 (3,960 m) east of the dike. The location is analogous to a well halfway between the Twin City Foods well and the City of Lewiston well no. 1A. The observation is placed on the state-line 6,400 feet (1,950 m) south of the Wilma Fault and 11,500 feet (3,510 m) east of the dike.

All wells are assumed to fully penetrate the aquifer and be of infinitely small diameter. The aquifer is also assumed to be homogeneous, isotropic, and of infinite areal. These assumptions are necessary in order to use the Theis method of analysis for well interference calculations (Ferris and others, 1962, pp. 93-98).

The aquifer coefficients of transmissivity (5×10^5 gpd/ft (6200 m^2/day)) and storage (5×10^{-5}), used in the model, were obtained from Aquifer Test No. 5. Aquifer coefficients from Test No. 5 were selected because of (1) the greater number of observation wells and (2) the known quality of the collection and analysis of the field data.

Drawdown Predictions in the Hypothetical Interstate Well

Based on the assumptions given above for the model, three pairs of drawdown amounts in the hypothetical observation well were obtained for ten and one hundred day pumping periods. Drawdown values of 22 and 29 feet (6.7 and 8.8 m) were predicted in the model aquifer when it contained no boundaries and thus no image wells. With only negative boundaries, the drawdown increases to 65 and 96 feet (19.8 and 29.3 m) for the selected time periods. The introduction of the positive boundary reduces the drawdown to 36 and 37 feet (11.0 and 11.3 m). These numbers represent drawdowns found during and at the close of a summer pumping period.

A review of actual municipal well locations indicate that the WWP No. 4 well is reasonably close to the hypothetical observation well site. As such, its long term hydrograph can be used to examine the accuracy of the simple model (Figure 4-2). The original static water level in the WWP No. 4 well was 721 feet (219.7 m) (Appendix A, Table A-2). Most of the record shown in Figure 4-2 occurs prior to 1975 or the filling of the Lower Granite Reservoir. During this period, the water level appears to have stabilized near an elevation of 710 feet (216 m) msl during the non-pumping season. During the pumping season, the water level occasionally declines to 660 feet (201 m) msl but is usually in the range of 670 and 690 feet (204 and 210 m) msl. If one assumes that water levels below 670 feet

(204 m) msl are caused by the pumping of the WWP No. 4 well, then the seasonal well interference amounts to about 40 feet (12 m). This compares favorably with the amount of predicted drawdown in the hypothetical state-line well of 37 feet (11.3 m); the model thus appears to be a reasonable representation of the aquifer system.

It is felt by the author that the model is an over-simplification of the complexity of the real hydrogeologic system of the "Russell" aquifer and should only be used as the initial step in the construction of a more representative computer model. Future groundwater development and aquifer testing in the "Russell" aquifer will invariably aid and refine this predictive tool.

CHAPTER 7 WATER QUALITY CHARACTERISTICS OF THE RUSSELL AQUIFER

Existing Water Quality Conditions

The present water quality in the deep aquifer in the Lewiston Basin is excellent. This is shown by a water quality analyses from municipal wells in the Lewiston Basin presented in Table 7-1. The water generally has total dissolved solids levels less than 350 ppm (parts per million) with a slightly basic pH in the range of 7.1 to 8.0. Chemical analyses indicate that the principle cations are sodium, calcium and magnesium. Most of the sodium concentrations are in the range from 20 to 50 ppm. The water quality found in the deep aquifer in the Lewiston Basin is typical for that found in basalt synclinal valleys in the Washington-Idaho area. Table 7-2 gives a summary of basalt water quality for the Columbia River Group as compared to the range for the Lewiston Basin.

The temperature of ground water from the Russell Aquifer ranges from 60^{o}F (degrees Fahrenheit) to 74^{o}F. This is typical of a normal geothermal gradient of 2^{o}F per 100 feet of depth found in the Columbia River basalts.

It is important to note that the ground water quality from the lower aquifer in the Lewiston Basin is very similar to that found in the Snake and Clearwater rivers. Table 7-3 lists the range of concentrations of various elements of the Snake River near Anatone, Washington for the 1976 water year.

Potential for Aquifer Water Quality Degradation

This study has shown that the water in the Russell Aquifer in the Lewiston Basin is derived largely if not entirely from recharge from the

TABLE 7-1

WATER QUALITY ANALYSES FROM MUNICIPAL WELLS IN THE LEWISTON BASIN:

PART A - PHYSICAL PARAMETERS

PART B - CHEMICAL PARAMETERS

(Constituents given in ppm or mg/l unless otherwise noted)

PART A - PHYSICAL PARAMETERS

Well Name	Date Coll.	Temp. °F - °C	pH	Turb. J.T.U. [2]	T.S. [3]	T.D.S. [4]	Cond. [5]	Alk. $CaCO_3$	Hard $CaCO_3$	Color C.U.	Source	Comments
Lewiston #1	9- 2-55		7.9					128	68.0		C	
#1	9-25-64		8.0		220.0			57.0	48.0		A	
#1A	1-25-62	59.5°F		10.0 est.		210.0		115.0	120.0	18.0 est.	C	
#1A	7-28-69	22.0°C	7.8	<25.0				136.0	128.0	<5.0	B	
#1A	6-22-73		8.0	2.0				96.0	72.0		B	
#1A	7- 1-74		7.7	3.0	292.0	202.0		94.0	96.0	<5.0	B	
#1A	6-10-75		6.5	4.6		180.0		96.0	100.0	<5.0	B	
#2	9- 2-55		8.0					136.0	85.0		C	
#2	10-16-62		7.4		230.0			96.0	140.0		A	
#2	6-22-73		8.1		460.0			104.0	124.0		B	
#2	6-22-73		7.6	2.0	144.0			60.0	48.0		B	
#2	7- 1-74		7.4	2.0		175.0		18.0	22.0	<5.0	B	
#2	6-10-75		6.9	63.0		332.0		124.0	176.0	<5.0	B	
#3	7- 1-53	68.0°F	8.0		350.0			128.5	39.0		C	CO_2=2.6ppm
#3	9-12-55		8.2		253.4			133.0	41.0		C	CO_2=1.75ppm
#3	9-25-64		8.0		220.0			57.0	48.0		A	
#3	7- 1-74		8.1	2.0		101.0		34.0	38.0	<5.0	B	
#3	6-10-75		6.9	3.1	206.0			116.0	40.0	<5.0	B	
#4	7-28-69	18.0°C	7.5	<25.0		350.0		152.0	140.0	<5.0	B	
#4	11- 4-71		7.9	<1.0	312.0	272.0		148.0	136.0		B	
#4	6-22-73		7.9		380.0			136.0	116.0		B	
#4	7- 1-74		8.0	4.0		302.0		118.0	120.0	<5.0	B	
#4	6-10-75		7.1		2.8	230.0		120.0	112.0	<5.0	B	
#5	7-28-69	19.0°C	7.8	<25.0		290.0		148.0	120.0	<5.0	B	
#5	6-22-73		8.0	3.0	284.0			124.0	56.0		B	
#5	7- 1-74		3.1	2.0		280.0		124.0	64.0	<5.0	B	
#5	6-10-75		7.3	3.2		185.0		108.0	52.0	<5.0	B	
#5	7-11-78		7.45			55.0		16.0	26.0	5.0	B	
L.O.I.D.	4-26-78			.51		224.0		110.0	14.0	7.5	J	preserved with H_2SO_4 and HNO_3

TABLE 7-1 (Cont'd)

PART A - PHYSICAL PARAMETERS

Well Name	Date Coll.	Temp. °F - °C	pH	Turb. J.T.U.[2]	T.S.[3]	T.D.S.[4]	Cond.[5]	Alk. $CaCO_3$	Hard $CaCO_3$	Color C.U.	Source	Comments
Clarkston WWP #1	3- 7-58		7.9		221.0			63.0[9]	54.0		F	
WWP #2	3- 7-58		8.1		207.0			55.0[9]	16.0		F	
WWP #2	10-28-59	23.5°C	8.4			202.0	24.8	101.0		5	G	CO_2=.8
WWP #2	5-24-60	23.5°C	8.3			199.0	23.6	101.0			G	CO_2=.9
WWP #3	11- 6-63		8.6		220.0			2.0[8]	52.2		F	
WWP #3	6- 6-75		7.85		239.0		265.0	120.0	60.0		E	
WWP #3	2- 7-79								60.0	3.0	E	
WWP #5	12- 2-61		8.0		222.0	222.0		123.0[9]			F	
WWP #5	10-30-62	23.3°C	9.2			241.0	303.0		32.0		I	CO_2=1.3
Asotin #1	7-19-72		7.1	.8	178.0		204.0	88.0	88.0	5	D	
#2	12- 2-70	18.7°C	8.2		170.0	170.0	204.0	89.			H	CO_2=1.1
#2	5-19-71	18.3°C	8.2				241.0	98.			H	CO2=1.2
#2	7-19-72		7.7	1.5			200.0	162.0	136.0	5	D	
#2	1-11-78			.2			230.0		78.0	0	D	

TABLE 7-1 (Cont'd)

TABLE B - CHEMICAL PARAMETERS

Well Name	Date Coll.	Al	NH_3	AS	Ba	Cd	Ca	Cl	Cr	Cu	F	Fe	Pb
Lewiston #1	9- 2-55	0						10.0			0.4		
#1	9-25-64	0					15.0	15.0			1.03	0.02	
#1A	1-25-62	trace						16.0				0.1	
#1A	7-28-60						27.0	40.0			.2	.13	
#1A	6-22-73		0.2			.017	19.0	8.0		<.001	.67	.1	<.01
#1A	7- 1-74			< .01	< .1	<.001	18.0	9.0	<.01	<.001	.47	< .01	<.01
#1A	6-10-75		.15	< .01	< .1	<.001	26.0	6.0	<.01	.001	.34	.06	<.01
#2	9- 2-55							21.0			0.9	0.0	
#2	10-16-62						34.0	19.0			0.18	.08	
#2	6-22-73		0.3			.018	57.0	26.0		<.001	0.84	.23	<.01
#2	6-22-73		0.3			<.008	11.0	8.0		<.001		.14	<.01
#2	7- 1-74		0.03	0.01	<0.1	<.001	7.0	19.0	<.01	<.001	0.98	< .01	.01
#2	6-10-75		0.1	<0.01	<0.1	<.001	45.0	4.0	<.01	<.001	0.64	.64	<.01
#2	6-25-76							8.0				0.2	
#3	7- 1-53	10.0					26.5	23.0			1.2		
#3	9- 2-55						13.1	20.0			1.1	0.02	
#3	9-25-64						15.0	15.0			1.03	<0.01	
#3	7- 1-74			< .01	<0.1	<.001	12.0	10.0	<.01	<.003	1.18	.04	<.01
#3	6-10-75			< .01	<0.1	<.001	11.0	4.0	<.01	.001	1.12	.02	<.01
#3	6-25-76							10.5					
#4	7-28-69						29.0	44.0			.13	.17	
#4	11- 4-71		.1				24.0	24.0			.01	.1	
#4	6-22-73		.2			.006	24.0	26.0		<.001	.79	.22	<.01
#4	7- 1-74		.02	< .01	< .1	<.001	20.0	23.0	<.01	<.001	.26	.02	<.01
#4	6-10-75		.11	< .01	< .1	<.001	22.0	4.0	<.01	<.001	.36	.07	<.01
#5	7-28-69						16.0	46.0		.02	.85	.13	
#5	6-22-73		.1			.009	14.0	16.0		.001	.98	.24	<.01
#5	7- 1-74		.01	< .01	< .1	<.001	14.0	19.0	<.01	<.001	.98	< .01	<.01
#5	6-10-75		.05	< .01	< .1	<.001	16.0	2.0	<.01	<.001	1.02	.11	<.01
#5	7-11-78		.03	< .01	< .1	<.001	8.0	3.0	<.01	<.01	1.21	< .01	<.01
L.O.I.D.	4-26-78		.027	0.013	<0.1	<.001	4.0	14.0	<.01	<.01	0.03	0.06	<.01

TABLE 7-1 (Cont'd)

TABLE B - CHEMICAL PARAMETERS

Well Name	Date Coll.	Mg	Mn	Hg	NO_3	NO_2	PO_4 [6]	K	Se	SiO_2	SO_4 [7]	Na	Zn
Lewiston #1	9- 2-55										6.5		
#1	9-25-64	2.0			0.3						7.0		
#1A	1-25-62												
#1A	7-28-69	13.0	.01		6.4		0.03				17.0	17.0	
#1A	6-22-73	6.0	.02		3.8		0.04	2.7		13.6	6.0	40.0	.002
#1A	7- 1-74	12.7	< .01	<.001	4.4			5.0	< .01	59.3	8.0	17.0	.003
#1A	6-10-75	7.7	.01	<.005	7.06			4.1	< .01	10.5	18.0	14.2	.013
#2	9- 2-55										15.5		
#2	10-16-62	13.0			2.0						24.0	21.	
#2	6-22-73	8.0	.05		.8		0.05	4.8		9.7	62.0	76.	.009
#2	6-22-73	5.0	.01		1.9		0.02	1.0		4.1	6.0	12.	.002
#2	7- 1-74	2.2	< .01	<.001	.01			9.7	< .01	67.5	2.0	45.	.016
#2	6-10-75	14.6	.07	<.005	< .01			7.8	< .01	10.0	72.9	33.0	.008
#2	6-25-76				0.0					80.4	12.0	41.0	
#3	7- 1-53	12.5									3.0		
#3	9- 2-55										2.3		
#3	9-25-64	2.0			0.3					7.63	7.0		
#3	7- 1-74	4.7	< .01	<.001	1.04			1.9	< .01	26.3	8.0	7.0	.027
#3	6-10-75	3.1	.01	<.005	< .01			7.7	< .01	13.9	10.	42.7	.045
#3	6-25-76									58.8	5.6	36.6	
#4	7-28-69	16.	.01		2.8		.04				54.	60.0	
#4	11- 4-71	18.	.02		2.8		.1	5.6		26.8	21.	78.0	
#4	6-22-73	13.	.01		4.0		.08	4.1		14.1	44.	54.0	.005
#4	7- 1-74	18.0	.01	<.001	3.3			8.8	< .01	34.0	22.0	43.0	.006
#4	6-10-75	12.8	< .01	<.005	3.27			7.6	< .01	9.0	38.0	36.6	.015
#5	7-28-69	19.0	.01		1.8		.01				14.0	70.0	
5	6-22-73	5.0	.02		.1		.01	3.8		23.2	3.0	52.0	<.001
#5	7- 1-74	6.6	< .01	<.001	.01			8.7	< .01	67.5	2.0	44.0	.003
#5	6-10-75	3.5	.01	<.005	.05			7.9	< .01	18.3	10.0	37.3	.005
#5	7-11-78	.7	< .01	.0008	.03			.7	< .005	10.0	12.0	2.1	<.001
L.O.I.D.	4-26-78	.8	<0.01	<.0005	.01			9.0	< .01	67.3	9.0	51.2	.001

TABLE 7-1 (Cont'd)

TABLE B - CHEMICAL PARAMETERS

Well Name	Date Coll.	Al	NH_3	AS	Ba	Cd	Ca	Cl	Cr	Cu	F	Fe	Pb
WWP #1	3- 7-58						30.0	24.0			0.6		
#2	3- 7-58						9.0	11.0			1.0	0.1	
#2	10-28-59						6.5	7.8			1.1	40. UG/L	
#2	5-24-60												
#3	11- 6-63	11.0						26.5			0.6	0.2	
#3	6- 5-75						20.0	16.0			0.52		
#3	2- 7-79			<.01	<.02	.005		11.2	<.005		0.6	.01	.02
#5	12- 2-61							26.0			0.6		
#5	10-30-62	0.2					11.0	12.0			0.9	0.01	
Asotin #1	7-19-72						14.4	13.0			.35	.84	
#2	12- 2-70	<.010						5.9	<.030	<.050	.4	.03	
#2	5-19-71							7.4					
#2	7-19-72						15.2	8.0			.23	.16	
#2	1-11-78			<.01	<.25	<.005			<.01		.3	<.2	

TABLE 7-1 (Cont'd)

TABLE B - CHEMICAL PARAMETERS

Well Name	Date Coll.	Mg	Mn	Hg	NO_3	NO_2	PO_4 [6]	K	Se	SiO_2	SO_4 [7]	Na	Zn
WWP #1	3- 7-58							18.0		30.0	4.0	9.0	
#2	3- 7-58							56.0		33.0	10.0	10.0	
#2	10-28-59	0.2			.10			9.9		65.0	8.9	42.0	
#2	5-24-60												
#3	11- 6-63						2.0	18.5		25.0	9.25	65.0	
#3	6- 6-75	2.4			0.44		0.03	9.2		75.0	12.1	33.5	
#3	2- 7-79		<.003	<.0002	.1				<.002		17.2	39.0	
#5	12- 2-61							25.0		30.0	42.0	130.0	
#5	10-30-62	1.0						11.0		66 0	25 0	49.0	
Asotin #1	7-19-72	12.63	.009		.2	.074	.15	10.5		47.0	9.2	17.0	
#2	12- 2-70		<20.0 UG/L		.30		5.2	8.7		60.0		17.0	<10.0 UG/L
#2	5-19-71												
#2	7-19-72	238.1	.009		< .01	.049	.73	10.5		18.4	12.0	17.3	
#2	1-11-78		0.012	<.001	< .1				<.005				

FOOTNOTES

1. < means less than
2. Turbidity expressed as Jackson Turbidity Units
3. T.S. = Total Solids
4. T.D.S. = Total Dissolved Solids
5. Cond. = Specific Conductivity expressed a umohs/cm at 25 C.
6. PO_4 given as total phosphate
7. SO_4 given as total dissolved sulfates
8. Alkalinity in ppm $CaCO_3$ from phenolphthalein analysis
9. Alkalinity in ppm $CaCO_3$ from methlorange analysis

TABLE 7-1

WATER QUALITY ANALYSES FROM MUNICIPAL WELLS
IN THE LEWISTON BASIN

WATER QUALITY

SOURCES

A. Idaho Department of Health, Engineering, and Sanitation Division, January 1968, A Compilation of Chemical Analysis of Public Water Supplies in the State of Idaho, Boise, Idaho, p. 20.

B. Idaho Department of Health and Welfare, Division of Environment, January 1968-July 29, 1976, Region I, Chemical Analysis of Public Water Supplies in the State of Idaho, Boise, Idaho, pp. 19-20.

C. City of Lewiston, Water Treatment Plant Laboratory, Lewiston, Idaho: Obtained from P. A. Durand files, donated to the archives of Penrose Memorial Library, Whitman College, Walla Walla, Washington.

D. Washington Department of Social and Health Services, Health Services Division, Seattle, Washington.

E. ABC Testing Laboratories, Spokane, Washington: Data obtained from Washington Water Power Company, Spokane, Washington.

F. Washington Testing Laboratories, Inc., Spokane, Washington: Data obtained from Washington Water Power Company, Spokane, Washington.

G. U. S. Geological Survey, Water Quality Data, Water Year October 1959 to September 1960: Computer print-out of June 7, 1978 from U. S. Geological Survey, Water Resources Division, Tacoma, Washington.

H. ________, Water Quality Data, Water Year October 1970 to September 1971: Computer print-out of June 7, 1978 from U.S. Geological Survey, Water Resources Division, Tacoma, Washington.

I. U. S. Geological Survey, Water Analysis, October 30, 1962: Obtained from Washington Water Power Company, Spokane, Washington.

J. Idaho Department of Environmental and Community Services, 1978 Laboratories Section, Potable Water Quality Report of L.O.I.D. (Lewiston Orchards Irrigation District) Well, April 26, 1978, Boise, Idaho.

TABLE 7-2

SUMMARY OF BASALT WATER QUALITY: RANGE OF VALUES FOR DISSOLVED CONSTITUENTS IN AQUIFERS OF THE COLUMBIA RIVER GROUP AND AQUIFERS OF THE LEWISTON BASIN (GIVEN IN ppm or mg/l)

AREA	PRINCIPAL CATIONS Na	Ca	Mg	PRINCIPAL ANIONS Cl	SO_4	HCO_3	OTHER $Si(OH)_4$	Fe
Columbia River Group*	100-6	100-8	106-0	30-5	50-10	300-50	80-40	.30-.01
Lewiston Basin**	130-2	57-4	238-.2	46-2	62-4	162-2	80-4	.84-.01

*Common range of values for the Columbia River Group (from Newcomb, 1972).
**See Appendix D for the water quality and sources of information for the individual wells.

TABLE 7-3

WATER QUALITY FOR THE SNAKE RIVER NEAR ANATONE, WASHINGTON, FOR 1976*

DESCRIPTION	RANGE
Field specific conductance (micro-mhos)	106-263
Hardness (Ca, Mg) (mg/l)	51-140
Dissolved calcium (Ca) (mg/l)	14-35
Dissolved magnesium (Mg) (mg/l)	3.8-12
Dissolved sodium (Na) (mg/l)	6.8-25
Dissolved potassium (K) (mg/l)	1.4-3.5
Dissolved sulfate (SO_4) (mg/l)	11-43
Dissolved chloride (Cl) (mg/l)	3.9-18
Total nitrogen (NO_3) (mg/l)	.71-5.3
Total phosphorus (P) (mg/l)	.01-.09
Total arsenic (As) (ug/l)	2-38
Total iron (Fe) (ug/l)	80-1300

* Range of values during 1976 water year.

Snake and Clearwater rivers and their tributaries. As such, the quality of ground water in this aquifer will change as the water quality in these streams change. The river water quality is particularly important near the recharge areas shown on Figure 3-6. Potential sources of water quality degradation occurring from land use in these areas is also of major importance. Based upon available records, there has not apparently been any major change in water quality in the deep aquifer resulting from man's activities. However, the potential for such change exists and should be recognized.

A significant period of time is required for water to move through the aquifer from the identified recharge areas to the vicinity of the present municipal wells. A crude estimate of the rate of ground water movement may be obtained using Darcy's law and the following input characteristics: hydraulic conductivity of 1000 gpd/ft^2 from pump test No. 5, a gradient of 3.3 feet per mile based upon water level data, and an estimated porosity of 0.10. Using these input values, an average ground water flow velocity of 0.84 feet per day may be claculated. This shows that there would be a significant time lag between the recharge of poor quality water at the recharge areas and subsequent discharge from pumpage in the municipal wells.

The upper aquifer in the Lewiston Orchards area is not hydraulically interconnected with the Russell Aquifer. Significant movement of water from the upper aquifer to the Russell Aquifer will occur through improperly constructed wells. Care should be taken to insure that deep wells in the Lewiston Orchards area are cased and sealed throughout the upper aquifer.

CHAPTER 8. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary and Conclusions

Groundwater pumped from the municipal and industrial wells of the Lewiston Basin is derived from the basalt aquifers of the Grande Ronde, Wanapum, and Saddle Mountains Formations of the Columbia River Group. The Grande Ronde Formation is the oldest of the three and contains the most productive aquifers. Only the upper 800 feet (240 m) of the Grande Ronde Formation basalt are used for groundwater production. The aquifers within this vertical section have been grouped and named as the "Russell" aquifer. Overlaying the "Russell" aquifer are aquifers of the Wanapum and Saddle Formations. The high productivity of the "Russell" aquifer is attributed to a lack of soil interbeds in the interflow contact zones in contrast to the aquifers of the younger formations.

All of the formations of the Columbia River Group in the Lewiston Basin have been tectonically deformed by post-Miocene compression and faulting. The central feature of the basin is the Lewiston Syncline. Folds and faults on the margins of the synclinal basin were identified as the hydrogeologic barriers that define the lateral extent of the "Russell" aquifer and other groundwater flow systems of the Lewiston Basin.

The major amount of recharge and natural discharge is believed to occur where the lateral continuity of the "Russell" aquifer is breached by faults, folds, and stream or river canyons. Recharge to the aquifer by precipitation is believed to occur on the southern margin of the Lewiston Syncline. Most of the recharge to the "Russell" aquifer is believed to occur where the basalt flows dip at a concurrent angle greater than the stream and where the interflow zones of the basalt outcrop in the river channel. Such areas occurs in the Clearwater River Channel approximately 7 to 17 miles (11 and 27 km) upstream of its confluence with the Snake River and in the Snake River 3 to 9 miles (5 to 14 km) upstream of its confluence with the Clearwater River. Two discharge areas were identified in the Snake River Channel where it crosses the topographic low of the Lewiston Basin downstream of the confluence.

Two hydrologic features were delineated within the "Russell" aquifer. A groundwater flow barrier, believed to be a dike, was located during a 1979 aquifer test in an area south and west of Clarkston, Washington. A second feature was the presence of highly productive aquifers located at the lower limit of the "Russell" aquifer. Examination of well lithologies and specific capacity data provided this information.

Water level records from the "Russell" aquifer support the hypothesis of a river-aquifer interconnection. The original static water levels in the municipal and industrial wells were found to be nested within the range of elevations of the postulated areas of river recharge and discharge. The long term hydrographs of the municipal wells in the "Russell" aquifer do not show a steady decline. Finally, a rise in the water levels of the municipal wells coincides with the filling of the Lower Granite Reservoir. The mean static water levels in the municipal wells are lower than the surface water level at the Snake River Channel discharge site. It is postulated that pumping has reversed the groundwater flow direction; the former discharge area near Silcott, Washington is now a recharge area.

The quality of groundwater was found to be suitable for direct municipal use without treatment. The range of dissolved constituents is similar with that of groundwater in the other basalt aquifers of the Columbia River Group.

Five aquifer tests have been conducted using the Clarkston-WWP municipal wells. Four of the tests were conducted in the mid-1950's and used two observation wells. The fifth test was conducted in 1979 and had additional observation wells in use. Evidence for a river-aquifer interconnection was also found in an aquifer test and specific capacity test conducted on the Clarkston-WWP wells. These indicated a positive or recharge boundary to exist in time-drawdown data during a period of 5,500 to 7,000 minutes after pumping had commenced.

Aquifer coefficients of transmissivity and storage were found to vary from well to well. Transmissivity values were found to range from approximately 1.1×10^5 to 1.7×10^6 gpd/ft. (1,400 to 21,000 m^2/day). Storage coefficient was found to vary from 1.1×10^{-3} to 1.4×10^{-5}. The coefficients of transmissivity and storage calculated from Aquifer Test No. 5 of March, 1979, were 5×10^5 gpd/ft. (6200 m^2/day) and 5×10^{-5} respectively.

The potential for additional development of the "Russell" aquifer for municipal and industrial groundwater use exists. This conclusion is based on the analysis of municipal well hydrographs and aquifer tests. Recommendations for this development are given hereinafter.

Recommendations

1. Additional aquifer tests should be conducted in the "Russell" aquifer to better determine the location and extent of hydrogeologic boundaries and aquifer coefficients of transmissivity and storage. These values have yet to be obtained from any of the Lewiston area wells. Groundwater development of this area, at present, could only be planned on the aquifer coefficients gained from the five Clarkston-WWP tests. Information gained

from additional aquifer tests would benefit the predictive accuracy of a computer model.

2. A computer model of the "Russell" should be constructed. Such a model should contain positive and negative boundaries. This model could be used as a predictive tool for estimating drawdowns in areas where future groundwater development of the "Russell" aquifer is to take place.

3. Wells constructed in the "Russell" aquifer should include solid casing through the interval of the upper aquifers used by shallow wells. Such construction would eliminate the possibility of aquifer "thieving" or draining of an upper aquifer by a well borehole.

4. The present water quality may degrade due to upstream contamination of the Snake River. The presence of Lower Granite Reservoir may provide a site for additional concentration of dissolved constituents. Temporal plots of water quality should be constructed to monitor changes in concentrations of dissolved constituents from the individual wells. Water quality samples should be taken and analyzed on an annual basis for each of the wells.

BIBLIOGRAPHY

Baksi, A. K. and N. D. Watkins, 1973, Volcanic Production Rates: Comparison of Oceanic Ridges, Islands, and Columbia Plateau Basalts: Science, v. 180, pp. 493-496.

Barr, A. J. and others, 1976, A Users Guide to SAS: SAS Institute, Inc., Raleigh, North Carolina, 123 p.

Bond, J. G., 1962, Geology of the Clearwater Embayment in Idaho: Ph.D. dissertation, University of Washington, Seattle, Washington, 193 p.

________, 1963, Geology of the Clearwater Embayment: Pamphlet 128, Idaho Bureau of Mines and Geology, Moscow, Idaho, 83 p.

Bond, J. G. and D. R. Ralston, 1977, Lewiston Orchards Groundwater Potential and Well Site Location Study: Unpublished Consulting Report, Moscow, Idaho, 17 p.

Camp, V. E., 1976, Petrochemical Stratigraphy and Structure of the Columbia River Basalt, Lewiston Basin Area, Idaho-Washington: Ph.D. dissertation, Washington State University, Pullman, Washington, 201 p.

________, 1978, Geologic Map of the Columbia River Basalt Group of Western Idaho: Pullman Quadrangle, 1:250,000 AMS Series.

Castelin, P. M., 1976, A Reconnaissance of the Water Resources of the Clearwater Plateau, Nez Perce, Lewis and Northern Idaho Counties, Idaho: Water Information Bulletin No. 41, Idaho Department of Water Resources, Boise, Idaho, 46 p.

Durand, P. A., 1978, Data, notes, letters and files pertaining to well development in the Lewiston Basin: Records Obtained from Archives of Penrose Memorial Library, Walla Walla, Washington.

Ferrians, O. J., 1958, Geology of a Portion of the Mission Creek Area, Nez Perce-Lewis Counties, Idaho: M.S. thesis, State College of Washington, Pullman, Washington, 54 p.

Ferris, J. G. and others, 1962, Groundwater Hydraulics: U.S. Geological Survey Water Supply Paper 1536-E, U.S. Government Printing Office, Washington, D.C., pp. 92-97.

Freeze, R. A. and P. A. Witherspoon, 1967, Theoretical Analysis of Regional Groundwater Flow: Part 2, Effect of Water-Table Configuration and Subsurface Permeability Variation: Water Resources Research, v. 3, no. 2, pp. 623-633.

Garber, M. S. and F. C. Koopman, 1968, Techniques of Water-Resources Investigations of the U. S. Geological Survey: Methods of Measuring Water Levels in Deep Wells: U. S. Government Printing Office, Washington, D. C., v. 8, ch. 1.

Glerup, M. O., 1960, Economic Geology of the Lime Point Area, Nez Perce County, Idaho: M.S. thesis, University of Idaho, Moscow, Idaho, 40 p.

Graham, E. C., 1959, Structure of the Western Portion of the Lewiston Downwarp in Southwestern Washington: M.S. thesis, Washington State University, Pullman, Washington, 36 p.

Hollenbaugh, K. M., 1959, Geology of Lewiston and vicinity, Nez Perce County, Idaho: M.S. thesis, University of Idaho, Moscow, Idaho, 52 p.

Hooper, P. R. and T. L. Vallier, 1976, Geologic Guide to Hells Canyon, Snake River: Geologic Society of America, Field Guide No. 5, Cordilleran Section, 72nd Annual Meeting, Washington State University, Pullman, Washington, 38 p.

Johnson Division, United Oil Products, Inc., 1975, Groundwater and Wells: St. Paul, Minnesota, 4th printing, 109 p.

Kalz, E. M., 1979, Daily driller's logs and related information regarding Potlatch Forest Industries Wells No. 1, 2, 3, and 4: Potlatch Forests Corp., Engineering and Technical Services, Lewiston, Idaho.

Kehew, A., 1977, Environmental Geology of Lewiston and vicinity: Ph.D. dissertation, University of Idaho, Moscow, Idaho, 210 p.

Kinnison, P. I., 1955, A Survey of Groundwater in Idaho: M.S. thesis, University of Idaho, Moscow, Idaho, 63 p.

Kirkham, V. R. D., 1927, Underground Water Resources in the Vicinity of Orofino, Idaho and Lapwai, Idaho: Pamphlet 24, Idaho Bureau of Mines and Geology, Moscow, Idaho, 17 p.

Ledgerwood, R. K. and others, 1978, Pasco Basin Stratigraphic Nomenclature: Pamphlet RHO-BWI-LD-1, Rockwell Hanford Operations, Richland, Washington.

Lewiston Morning Tribune, Tribune Publishing Company, March 9, 1927, Lewiston, Idaho.

Lohman, S. W., 1972, Groundwater Hydraulics: U. S. Geological Survey Professional Paper 708, U. S. Government Printing Office, Washington, D. C., 32 p.

Longwell, C. R. and others, 1969, Physical Geology: John Wiley and Sons, New York, New York, 465 p.

Lupher, R. L. and W. C. Warren, 1942, The Asotin Stage of the Snake River Canyon near Lewiston, Idaho: Journal of Geology, v. 50, p. 866-881.

Lynch, M. B., 1976, Remnant Paleomagnetism in the Miocene Basalts of North Idaho: M.S. thesis, University of Idaho, Moscow, Idaho, 150 p.

McKee, E. H. and others, 1977, Duration and Volume of Columbia River Basalt Volcanism, Washington, Oregon, and Idaho: Geologic Society of America Abstracts with Programs, v. 3, p. 399.

Mellott, J. C., 1973, Preliminary Ground-water Flow System Analyses in the Columbia River Basalts: M.S. thesis, Washington State University, Pullman, Washington.

Mogg, J. L., 1956, Aquifer Tests: See Durand, P. A., 1978.

________, 1957, Engineering Report, Pumping Tests at Clarkston, Washington, 1956 and 1957: Consulting Report for Washington Water Power (see Durand, P. A., 1978).

________, 1958, Aquifer Test No. 4, Clarkston, Washington, January-February, 1958: Consulting Report for Washington Water Power (see Durand, P. A., 1978).

Molnau, Myron, 1975, A Guide to the Use of HISARS: A Hydrologic Information Storage and Retrieval System: College of Agriculture Misc. Public. Series No. 32, University of Idaho, Moscow, Idaho.

Mullen, Captain John, 1863, Construction of a Military Road From Fort Walla Walla to Fort Benton: U. S. Government Printing Office Report, Washington, D. C., p. 101.

National Oceanic and Atmospheric Administration, 1978, Environmental Data and Information Service, Climatological Data, Idaho: National Climatic Center, Asheville, North Carolina, p. 15.

Newcomb, R. C., 1959, Preliminary Notes on Groundwater in the Columbia River Basalts: Northwest Science, v. 33, no. 1, p. 1-18.

________, 1961, Storage of Groundwater Behind Subsurface Dams in the Columbia River Basalt, Washington, Oregon, and Idaho: U. S. Geological Survey Professional Paper 383-A, p. 15.

________, 1969, Effect of Tectonic Structure on the Occurrence of Groundwater in the Basalt of the Columbia River Group of The Dalles Area, Oregon and Washington: U. S. Geological Survey Professional Paper 383-C, p. 33.

________, 1972, Quality of Groundwater in the Basalt of the Columbia River Group, Washington, Oregon, and Idaho: U. S. Geological Survey Water Supply Paper 1999-N, p. 71.

Quevedo, E. B., 1972, Engineering Properties of Clay Interbeds in the Vicinity of Lewiston, Idaho: M.S. thesis, University of Idaho, Moscow, Idaho, 109 p.

Russell, I. C., 1897, A Reconnaissance in Southeastern Washington: U. S. Geological Survey Water Supply Paper, v. 4, p. 1-76.

________, 1901, Geology and Water Resources of Nez Perce County, Idaho: U. S. Geological Survey Water Supply Papers 53 and 54, Parts I and II, 141 p.

Salami, S. O., 1978, A Reconnaissance Study of the Groundwater of the Lewiston-Clarkston Area, Idaho-Washington: M.S. thesis, University of Idaho, Moscow, Idaho, 105 p.

Swanson, D. A. and others, 1977, Reconnaissance Geologic Map of the Columbia River Basalt Group, Pullman and Walla Walla with Quadrangles Southeast Washington and Adjacent Idaho: Open-File Report, U. S. Geological Survey Report 77-100.

________, 1978, Revisions in Stratigraphic Nomenclature of the Columbia River Basalt Group Contributions to Stratigraphy: U. S. Geological Survey Bulletin 1457, p. 46-47, 61.

U. S. Army Corp. of Engineers, 1963, Upper Pool Determination, Lower Granite Lock and Dam, Lower Snake River Project, Oregon, Washington, and Idaho: Design Memorandum, Walla Walla, Washington, no. 2.

________, 1972, West Lewiston Levee: Design Memorandum, Walla Walla, Washington, no. 29, p. 2.

________, 1973, Lower Lock and Dam, Snake River, Washington: Lewiston Levees Contract Plans, Walla Walla, Washington, v. 3.

U. S. Geological Survey, 1972, Water Resources Data for Idaho, Part I: Surface Water Records, Water Resources Division, Boise, Idaho.

________, 1975, Water Resources Data for Idaho, 1975: Water Resources Division, Boise, Idaho, p. 285.

Watkins, N. D. and A. K. Baksi, 1974, Magnetostratigraphy and Oreclinal Folding of the Columbia River, Steens, and Owyhee Basalts in Oregon, Washington, and Idaho: American Journal of Science, v. 24, p. 148-189.

APPENDIX A

WELL INFORMATION: LITHOLOGY, DIMENSIONS, AND HYDRAULICS

TABLE A-1 WELL LITHOLOGY

Elevations Given in Feet MSL
* Denotes Water
SWL @ : Static Water Level in Feet MSL

Well Name: City of Asotin Well #1 Date Completed: 2/14/61
Location: T10N-R46E-S21 NW NW Driller: Charles Jungman,
Asotin Co., Wash. Walla Walla, Wash.

Thickness	From	To	Lithology
10	800	790	brown, broken rock and boulders
14	790	776	cemented gravel
4	776	772	grey, broken basalt
11	772	761	black, medium, broken basalt
21	761	740	grey, hard basalt
12	740	728	brown, medium and grey, hard basalt
4	728	724	black, medium, broken basalt
4	724	720	brown, red, green, broken basalt
18	720	702	brown, soft, broken basalt
32	702	670	grey, medium, broken basalt
41	670	629	brown, soft, broken basalt
16	629	613	black, medium basalt
10	613	603	brown, medium basalt
2	603	601	brown, hard basalt
5	601	596	black, medium basalt
24	596	572	grey, hard basalt
17	572	555	black, medium basalt
11	555	544	black, hard basalt
8	544	536	brown, medium basalt
8	536	528	brown, hard basalt
3	528	525	brown, medium basalt
9	525	516	black, medium basalt
12	516	504	black, hard basalt
19	504	485	black, medium basalt
11	485	474	black, hard basalt
26	474	448	red, medium and hard basalt
25	448	423	black, medium and medium hard basalt
4	423	419	blue hard basalt
3	419	416	black hard basalt
13	416	403	red and black, medium basalt
3	403	400	brown, hard basalt
3	400	397	black, soft basalt
5	397	392	black, hard basalt
1	392	391	grey, hard basalt
1	391	390	red, hard basalt
1	390	389	grey and very hard basalt
10	389	379	black, hard and brown, hard broken basalt

City of Asotin Well #1 (con't.)

Thickness	From	To	Lithology
2	379	377	grey, fine sand
5	377	372	black, hard basalt
5	372	367	black, soft, porous basalt
19	367	348	black, medium hard basalt
28	348	320	grey, hard basalt
5	320	315	red, soft basalt
11	315	304	red, medium hard basalt
12	304	292	red, brown, black, medium hard basalt
11	292	281	black, medium hard, broken basalt
8	281	273	black, soft, medium hard, (some porous) basalt
12	273	261	grey, hard, broken and caving basalt

Well Name: City of Asotin, Well #2 Date Completed: 4/15/61
Location: T10N-R46E-S16 SE SW Driller: Charles Jungman
Asotin Co., Wash. Walla Walla, Wa.

Thickness	From	To	Lithology
33	760	727	over burden, boulders, sands and and gravels
2	727	725	black and soft basalt
4	725	721	grey hard basalt
16	721	705	blue, medium, basalt*
18	705	687	dark, medium, basalt
14	687	673	decomposed red and black, basalt
8	673	665	soft, blue, broken, basalt
2	665	663	dark, medium, hard, basalt
1	663	662	blue, hard, basalt
17	662	645	dark, medium, hard, basalt
15	645	630	dark, soft basalt
20	630	610	brown, medium, hard, basalt
15	610	595	grey, medium, hard, basalt
5	595	590	brown, medium, basalt
5	590	585	blue, hard, basalt
9	585	576	dark, hard, basalt
9	576	567	blue, hard, basalt

TABLE A-1 (Cont'd)

City of Asotin, Well #2 (con't.)

Thickness	From	To	Lithology
136	567	431	medium hard basalt
15	431	416	reddish, fractured, medium soft basalt
5	416	411	brown, medium soft basalt
26	411	385	medium hard basalt
21	385	364	medium soft basalt
37	364	327	dark hard basalt
42	327	285	black and brown, medium soft, basalt
19	285	266	dark, medium hard, basalt
4	266	262	brown medium soft basalt
18	262	244	black medium hard basalt
3	244	241	dark medium hard basalt
3	241	238	dark and hard basalt

Σ=522 ft.

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
* Denotes Water
SWL @ : Static Water Level in Feet MSL

Well Name: City of Lewiston #1A
Location: T36N-R6W-S36 NE SE
Nez Perce County, Idaho
Date Completed: 1/28/62
Driller: Midland Drilling Co.
Walla Walla, Wash.

Thickness	From	To	Lithology
15	730	715	topsoil, gravel
25	715	690	coarse gravel *
35	690	655	cemented gravel
63	655	592	dark and medium dark, broken basalt
29	592	563	light and medium hard sand
28	563	535	clay on shells, broken basalt
33	535	502	dark, medium hard, broken basalt
7	502	495	grey, hard basalt
10	495	485	dark, medium hard basalt
8	485	477	grey, hard basalt
17	477	460	grey, medium hard basalt
5	460	455	black, soft basalt
38	455	417	dark, broken basalt
18	417	399	grey,medium hard basalt
5	399	394	dark, medium hard basalt
18	394	376	brown, medium, broken basalt
19	376	357	dark, medium hard, broken basalt
35	357	322	dark and black, medium hard, broken basalt
5	322	317	grey, hard basalt
5	317	312	dark, medium hard basalt
16	312	296	grey, hard basalt
10	296	286	dark, medium hard, basalt
4	286	282	grey, medium hard basalt
15	282	267	grey, hard basalt
6	267	261	grey, medium to hard basalt
17	261	244	light brown, medium basalt
6	244	238	dark brown, hard basalt
13	238	225	brown, medium hard basalt (end of construction May 5, 1960)
16	225	209	hard, grey basalt
26	209	183	hard, dark basalt
51	183	132	brown, soft basalt
8	132	124	dark, hard basalt
40	124	84	grey, very hard basalt
33	84	51	dark, hard basalt
19	51	32	hard, grey basalt
34	32	-2	variegated basalt
3	-2	-5	hard, grey basalt
Σ=735 ft.			

Well Name: City of Lewiston Well #2
Location: T36N-R5W-S32 NW SW
Nez Perce County, Idaho
Date Completed: 9/24/48
Driller: A.A. Durand & Son
Walla Walla, Wash.

Thickness	From	To	Lithology
10	735	725	sand
7	725	718	fine gravel
3	718	715	coarse gravel
7	715	708	boulder (probably bedrock)
9	708	699	blue basalt
3	699	696	shattered basalt
9	696	687	very hard basalt
27	687	660	medium hard basalt
6	660	654	hard and medium hard basalt
10	654	644	broken basalt
25	644	619	medium hard basalt
17	619	602	hard basalt
3	602	599	soft basalt
10	599	589	basaltic conglomerate (gravel?)
13	589	576	basalt w/some clay
4	576	572	hard sandstone
31	572	541	basalt
3	541	538	sand
22	538	516	basalt with hard streaks
18	516	498	hard basalt
10	498	488	soft basalt
7	488	481	basalt
5	481	476	hard basalt * warm water with with 100°F. est. temp.
9	476	467	sandy broken basalt
7	467	460	gravel-cobbles up to 4"
Σ=275 ft.			

Well Name: City of Lewiston Well #3
Location: T39N-R5E-S6 SW NW
Nez Perce County, Idaho
Date Completed: 7/3/53
Driller: A.A. Durand & Son
Walla Walla, Wash.

Thickness	From	To	Lithology
28	837	809	silt, dirt and boulders
47	809	762	hardpan with broken basalt
8	762	754	medium hard grey gravel
20	754	734	grey clay hard pan
14	734	720	gravel * swl @ 725

TABLE A-1 (Cont'd)

City of Lewiston Well #3 (con't.)

Thickness	From	To	Lithology
5	720	715	hard pan
6	715	709	black sand
7	709	702	boulder gravel
11	702	691	grey, hard hard pan
44	691	647	gravel, cemented with clay
8	647	639	broken, black basalt
88	639	551	solid and fractured basalt
19	551	532	clay and basalt
12	532	520	hard black basalt
14	520	506	broken basalt with green clay
21	506	485	broken black basalt
15	485	470	very hard blue basalt swl @ 721
10	470	460	very hard basalt with crevices of green clay swl @ 722
4	460	456	very hard grey basalt
7	456	449	black sand and hard blue clay
45	449	404	soft green shale swl @ 722
16	404	388	hard black basalt swl @ 743
63	388	325	very hard, grey basalt swl @ 732-729
6	325	319	medium hard grey basalt
5	319	314	black, porous, soft basalt
15	314	299	medium hard blue basalt
8	299	291	soft blue black basalt
9	291	282	medium hard blue black basalt
26	282	256	very hard, blue black basalt
4	256	252	soft, blue black, basalt
15	252	237	very hard blue, black basalt; swl @ 729.5
Σ=600 ft.			

Well Name: City of Lewiston Well # 4 Date Completed: 8/31/51
Location: T36-N-R5W-S32 NE SW Driller: A.A. Durand & Son
Nez Perce County, Idaho Walla Walla, Wash.

Thickness	From	To	Lithology
10	743	733	cinder fill
55	733	678	sand, gravel, clay
3	678	675	sandy shale
2	675	673	broken basalt
3	673	670	sand
30	670	640	fractured basalt and hard basalt
53	640	587	hard basalt
94	587	493	hard, medium, and soft basalt
35	493	458	fractured black basalt *
3	458	455	soft green shale
2	455	453	hard grey basalt
57	453	396	green soft shale
11	396	385	fractured hard and medium black basalt
Σ=358 ft.			

Well Name: City of Lewiston Well #5 Date Completed: 11/14/53
Location: T35N-R6W S12 Driller: A.A. Durand & Son
Nez Perce County, Idaho Walla Walla, Wash.

Thickness	From	To	Lithology
8	855	847	black boulders and topsoil
14	847	833	black boulders
3	833	830	coarse, black, basalt gravel
8	830	822	yellow clay
7	822	815	pink clay
48	815	767	dark, dense, fine grained basalt
40	767	727	very hard, black basalt
17	727	710	brown clay interbed
60	710	650	medium hard, black basalt
12	650	638	broken black basalt (aquifer) * swl @ 685
44	638	594	very hard black basalt
39	594	555	medium and very hard black basalt *swl @ 695
10	555	545	soft blue clay
7	545	538	green soft clay
166	538	370	very hard black basalt
5	370	365	brown honeycomb basalt (aquifer) *swl @ 715
6	365	359	hard black basalt
4	359	355	soft black basalt (aquifer) *swl @ 725
35	355	320	dense hard black basalt swl @ 719
10	320	310	soft black basalt
9	310	301	broken black basalt
46	301	255	very hard to medium black basalt, intermittent aquifer zones caving
Σ=600 ft.			

Well Name: City of Lewiston Well # 1 (Abandoned) Date Completed: 7/20/46
Location: T36N-R6W-S36 NE Driller A.A. Durand & Son
Walla Walla, Wash.

Thickness	From	To	Lithology
15	730	715	sand
4	715	711	gravel
10	711	701	sand
54	701	647	gravel and boulders
6	647	641	broken rock
34	641	607	basalt
14	607	593	shattered basalt
10	593	583	white sand and river gravel
2	583	581	sand
7	581	574	burned (?) soft basalt

TABLE A-1 (Cont'd)

City of Lewiston Well # 1 (con't.)

Thickness	From	To	
3	574	571	fine gravel
10	571	561	shattered basalt
1	561	560	blue shale
4	560	556	grey sand and gravel
4	556	552	fine red sand *
4	552	548	coarse sand and gravel
60	548	488	basalt
14	488	474	basalt and grey shale
8	474	466	hard black basalt
19	466	447	soft brown basalt
32	447	415	black basalt
13	415	402	grey basalt
16	402	386	hard black basalt
5	386	381	red basalt *
3	381	378	brown basalt

$\Sigma = 352$ ft.

TABLE A-1 (Cont'd)

WELL LOG
LEWISTON-CLARKSTON IMPROVEMENT CO.
(Statement of Henry Adams)

Located in Lot 5 of Block LL Vineland, Clarkston, Wash. Sec. 29, SW¼ of SE¼, T 11N, R 46EWM, Asotin County, Wash. Ground surface elevation 978.05 well mouth.

LAYER	DEPTH-ft.	SOIL	WORK DESCRIPTION (1901)	LAYER THICK
1	1 to 25	SURFACE soil	and broken rock cut and blasted by hand	25
2	25 " 40	BASALT ROCK	lines and crossed with seams; drill would not work so this was cut and blasted by hand at first	15
3	40 " 70	HARD YELLOW CLAY	, easy work but not much of it	30
4	70 " 135	HONEYCOMB	, easy drilling; the 12" hole was carried to this front and abandoned as it could not be driven through; a little water was found but it did not rise much	65
5	135 " 175	YELLOW STICKY CLAY	. 9 5/8" casing put in as clay bound the tools, could drill 10-15 ft. per day	40
6	175 " 205	HARD BASALT	; just hard enough to hold the casing back so that it had to be abandoned and 9 5/8" hole drilled without it.	30
7	205 " 245	SOAPSTONE	, sticky, bound the bit so that no progress could be made for fear of sticking, easy drilling	40
8	245 " 233	HARD BASALT	. 10 ft. of rock held back the casing	10
9	233 " 265	SOAPTONE	; sticky, not deep enough to interfere	10
10	265 " 545	HARD BASALT	; hardest layer we had; at first we could barely make 7 ft. per day. Lost tools as the sinker bar broke; did not get them out till the following year. Cost of well $6758.92 Less Investm. 2245.00 Cost of hole 4513. 92 (8.30 per ft.)	
			(1902)	
11	545 to 575	HARD BASALT	, tools out, Jan. 10 drilling easy, 7 ft. per day; hole got crooked; much of day wasted; tool stuck several times; had to fish for it; a few bits of wood came up.	30
12	575 " 590	HARD BASALT	, very hard rock, could only do 4 ft. per day	15
13	590 " 685	HARD BASALT	, March 4, had a fine run of 60 ft; lost tools, smashed everything At the time of the smash we had the first of the very hard rock and could only do 2 ft. per day- expensive fishing job.	95
14	685 " 710	HARD BASALT	, Sept. 11, drilling again for ten days; could only make 2 ft. per day; then broke stem. McCarthy drilling, progress slow; rock hard; above 2 ft. per day.	25
15	710 " 755	SOFT-POROUS, ROCK	. Made above 45 ft. in 1 wk. but dangerous for caving.	45
16	755 " 760	HARD ROCK	, down to 2 - 1 foot per day	15
17	760 " 790	HARD ROCK	, end of year, hardest rock now, 3 ft. per week	30
			(1903)	
18	790 " 865	HARD ROCK	, Jan. 1, to depth of 865' the rock seemed harder than ever; tools kept continously breaking and causing delay in drilling	75
19	865 " 933	HARD ROCK	, had a soft red streak (May 4); changed all at once for the next 4 weeks. We did 25, 14, 9 and 6 ft.; then the rock again got hard and we could only do 1 ft. per day	68
20	933 " 940	HARD ROCK	, June 15, 1903, rock hard - 1 ft. per day June 19, 1903, " " " " July 31, 1903 lost the bit 3 times; it got stuck each time and much time spent fishing, spudding and changing the shape of tools. What drilling was done was intermittent.	7
	940 " 986.5		No rock units given	47

COPY FROM THE FILES OF A.A. DURAND & SON
(Durand, 1973)

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
* Denotes Water Indication By Mud Loss
SWL @ : Static Water Level in Feet MSL

Well Name: L.O.I.D. (Lewiston Orchards Irrigation District) Well #1
Location: T35N-R5W-S22 NW NE
Nez Perce County, Idaho

Date Completed: 2/3/78
Driller: E.E. Luhdorff, Moses Lake, Wash.

Thickness	From	To	Lithology
70	1553	1483	basalt
5	1483	1478	clay
10	1478	1468	basalt
5	1468	1463	clay
65	1463	1398	basalt
5	1398	1393	clay
115	1393	1278	basalt
175	1278	1103	clay
20	1103	1083	basalt
10	1083	1073	clay-basalt
40	1073	1033	basalt
15	1033	1018	clay
65	1018	953	basalt-clay
20	953	933	basalt
15	933	918	clay
15	918	903	basalt
20	903	883	basalt *
70	883	813	basalt
30	813	783	basalt *
55	783	728	basalt
45	728	683	basalt *
50	683	633	basalt
25	633	608	basalt *
15	608	593	basalt
40	593	553	basalt *
40	553	513	basalt
40	513	473	basalt *
80	473	393	basalt
40	393	353	basalt *
50	353	303	basalt
30	303	273	basalt *
95	273	178	basalt *
50	178	128	basalt *
75	128	53	basalt *
20	53	33	basalt

-1520 ft.

TABLE A-1 (Cont'd)

Megascopic log of samples from Potlatch Forests, Inc. (PFI) well.
By H.T. Stearns, Consulting Geologist, Hope, Idaho
November 15, 1952

Well drilled by Paul Durand and Sons, Walla Walla, Washington
Arner Dunlap, Driller

Samples deposited with USGS, Ground-Water Division, Idaho, Boise, Office.

Samples start at 49 feet.

(Addendum by P.L.C. August, 1979: Currently known as PFI well # 1; estimated elevation of wellhead is 741 feet above mean sea level.)

Depth (feet)	Description
49	Highly vesicular fine grained Columbia River basalt
55	Fine cuttings stuck together of various crystal grains. Could be from hard basalt, sample unwashed.
65	Same as at 55'
70	Same as at 55'
75	Similar to 55' but washed and with many more clear quartz grains. These could be coming down from above, from interbedded sand, or from amygdaloidal fillings. Hole is supposed to be effectively cased below alluvium; hence quartz grains probably are not from overburden.
80	Similar to sample at 75'
85	" " " " "
90	" " " " "
No samples from 90'-117	
117	Chips of fine grained hard basalt. Quartz grains not present.
134 & 137	Similar to 117' but quartz grains present again
143	" " 117' but with few quartz grains
145	Mixture of chips of dense hard basalt and vesicular fragments. Evidently passing into a vesicular phase.
151	Very fine cuttings, probably indicating very hard dense basalt some clear crystals are probably feldspar.
155	Similar to 151' - Tested grains of white crystal and many are unquestionably quartz.
No samples from 155' to 173'	
173 to 176	Similar to 151'
175 to 180	" " 151' But containing ½" pieces of creamy secondary mineral from cavaties, probably lime or one of the zeolites
180 to 185	Similar to 175-180' but containing fragments ½" to 4" across of highly vesicular basalt some containing white zeolites (the source of some of the clear white grains above). Also a few fragments of basaltic glass altered to palagonite along the surface and highly suggestive of a layer of pillow lava or a wet contact at time of lava extrusion. These fragments indicate a good aquifer.

TABLE A-1 (Cont'd)

(Log of P.F.I. well continued)

185 to 190	Chips of hard dense basalt mixed with chips of zeolites and palagonite.
190 to 195	Similar to 185-190'
195 to 200	" " 185-190'
200 to 205	Similar to 185-190' except 1-inch piece of palagonitized basalt.
210 to 215	Same as 205-210'
215 to 220	Same as 205-210'
220 to 225	Same as 205-210'
225 to 230	Similar to above but very coarse chips, some vesicular and some with amygdaloidal fillings indicating softer lava.
230	Similar to 225-230' but with fewer vesicular chips.
235	" " 230'
240	Chips of hard grey blue basalt.
245	Similar to 240'
250	" " 240'
255	" " 240'
260	" " 240'
265	" " 240'
270	" " 240'
275	" " 240'
280	Brown and green silty clay.
285	Pale green silty clay containing sufficient volcanic mineral grains to suggest an ashy sediment.
290	Similar to 285'
295	Similar to 285' but contains some fragments of pale green hard shale. This would make an excellent confining member for an artesian structure.
300	Similar to above but a 1-inch fragment of a soapy green clay mineral outlining what appears to be relict vesicles. If so, this could be a leached and weathered surface of a lava flow.
315	Similar to 310' but less weathered basalt.
320	" to 315' but still less weathered and with some hard fresh basalt chips.
325	Similar to 320'
330	" to 320' but fragments xx ¼" across are numerous and some are vesicular.
335	Chips of hard fresh gray basalt.
340	Same as 335'
342	" as 335'

Bottom of well, October 27, 1952

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
***Denotes Water**
SWL @ : Static Water Level in Feet MSL

Well Name: PFI (Potlatch Forests Inc.)
Well #2 East Levee
Location: T36N-R5W-S28 SW SE

Date Completed: 7/8/55
Driller: A.A. Durand & Son
Walla Walla, Wash.

Thickness	From	To	Lithology
17	746	729	hard gravel and boulders
5	729	724	hard grey basalt
4	724	720	hard black basalt
30	720	690	hard grey basalt
19	690	671	medium grey basalt
1	671	670	broken basalt and blue clay
4	670	666	medium grey basalt
15	666	651	broken basalt and brown clay
14	651	637	hard grey basalt
22	637	615	medium grey basalt *swl @ 736
45	615	570	hard grey basalt
2	570	568	medium blue clay
2	568	566	hard grey basalt
23	566	543	soft blue clay
6	543	537	soft yellow clay
11	537	526	medium grey basalt
9	526	517	medium grey sticky clay
8	517	509	medium grey basalt
39	509	470	hard grey basalt
10	470	460	soft green grey clay (very sticky)
2	460	458	hard grey basalt
14	458	444	soft grey clay
28	444	416	medium grey basalt
18	416	398	hard grey basalt
7	398	391	soft red clay
27	391	364	medium grey basalt *swl @ 738
5	364	359	medium brown basalt
23	359	336	hard grey basalt *swl @ 739
2	336	334	soft red clay (very sticky)
39	334	295	hard grey basalt
7	295	288	medium grey sand
33	288	255	hard grey basalt
5	255	250	medium red clay
13	250	237	medium brown clay
30	237	207	hard, grey basalt * swl @ 740
13	207	194	medium grey basalt * swl @ 741

Σ=552 ft.

Well Name: PFI (Potlatch Forests Inc.)
Well #3 West Levee

Date Completed: 7/27/57
Driller: A.A. Durand & Son
Walla Walla, Wa.

Thickness	From	To	Lithology
28	742	714	river channel alluvium
21	714	693	medium rock and sand
3	693	690	hard basalt
16	690	674	hard basalt * @682 ft: swl @ 725
9	674	665	hard sand and rock
9	665	656	hard basalt
14	656	642	medium brown basalt
25	642	617	soft grey and brown basalt-broken
33	617	584	medium grey basalt
28	584	556	hard grey basalt
27	556	529	sharp hard grey basalt
16	529	513	hard grey basalt
47	513	466	soft green clay (caving)
7	466	459	soft grey clay (caving)
7	459	452	soft red clay (caving)
2	452	450	hard grey basalt (caving)
9	450	441	soft grey clay
11	441	430	hard grey basalt * @ 436 ft.? swl @ 728
1	430	429	soft grey clay
84	429	345	hard grey basalt
6	345	339	soft yellow clay
20	339	319	medium grey basalt
4	319	315	hard grey basalt
9	315	306	soft blue clay (very sticky)
6	306	300	soft red clay (very sticky)
7	300	293	hard grey basalt
4	293	289	medium blue clay (very sticky)
11	289	278	blue shale
134	278	144	medium hard to hard grey basalt @ 195 ft: swl @ 731
12	144	132	hard brown basalt
10	132	122	hard black basalt with red rock
30	122	92	medium grey basalt

Σ=650 ft.

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
*Denotes Water
SWL @ : Static Water Level in Feet MSL

Well Name: PFI (Potlatch Forests Inc.) Well #4
Location: T36N-R5W-S32-NE SE
Nez Perce County, Idaho
Date Completed: 2/26/65
Driller: Charles Jungman, Walla Walla, Wa.

Thickness	From	To	Lithology
4	744	740	silt
12	740	728	cobbles and boulders *
9	728	719	cemented gravel
29	719	690	sand, clay
14	690	676	broken basalt
35	676	641	grey basalt
11	641	630	black basalt
14	630	616	grey hard basalt
17	616	599	dark basalt, brown basalt *
8	599	591	hard grey basalt
Σ=153 ft.			

Well Name: Twin City Foods (formerly Sno-Crop)
Location: T36-R6W-S36 NW SE
Nez Perce County, Idaho
Date Completed: April, 1951
Driller: A.A. Durand & Son Walla Walla, Wash.

Thickness	From	To	Litholgy
8	732	724	sand, gravel and topsoil
20	724	704	river gravel and boulders
18	704	686	gravel with some sand
57	686	629	gravel and seams of broken basalt, *swl @ 716 ft.
7	629	622	sandy clays and broken basalt
33	622	589	yellow clay, boulders, sand, some gravel
11	589	578	dark, hard basalt
2	578	576	broken basalt
8	576	568	dark medium basalt
9	568	559	hard grey basalt
12	559	547	dark basalt * (water level apparently fluctuates with river rise)
27	547	520	extremely hard grey basalt. Ball tested drawdown to 582 ft.
31	520	489	hard black basalt with intermittent crevices
16	489	473	solid black basalt

Twin City Foods (con't.)

Thickness	From	To	Litholgy
13	473	460	broken brown medium basalt *swl @ 711 ft.
59	460	401	hard black and grey basalt
15	401	386	broken brown basalt
55	386	331	hard grey basalt *swl @ 708 ft.
5	331	326	hard grey basalt, badly creviced
34	326	292	medium black and grey basalt *swl @ 707 ft.
6	292	286	grey basalt, creviced
5	286	281	grey basalt
22	281	259	fractured basalt, caving
9	259	250	dark grey basalt, bail tested @ 210 gpm 13 ft. drawdown for one hour
44	250	206	very hard black and grey basalt
17	206	189	broken red basalt
75	189	114	hard grey and black basalt
3	114	111	broken black and grey basalt
Σ=621 ft.			

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
***Denotes Water**
SWL @ : Static Water Level in Feet MSL

Well Name: WWP #1 Date Completed: July, 1957
Location: T11N-R46E-S29 NE NE Driller: A.A. Durand & Son
Asotin County, Wash. Walla Walla, Wash.

Thickness	From	To	Lithology
18	850	832	top soil and gravel
70	832	762	gravel and boulders
68	762	684	hard and medium grey basalt
96	684	588	hard, dark, basalt
8	588	580	sand * swl @ 708
46	580	534	clay
149	534	385	clay and shattered basalt
87	385	298	soft and medium, dark, basalt
46	298	252	soft porous, basalt
59	252	193	hard, dark, basalt
13	193	180	soft basalt
73	180	107	hard and medium, dark basalt
1	107	106	soft (clay?)
50	106	56	medium and soft dark basalt: 87 ft. msl: depth of original borehole, swl @ 708 9/17/56
40	56	16	medium and hard, dark, basalt
5	16	11	soft (clay?)
72	11	-61	medium and hard, dark, basalt; -19 ft. msl: depth of first deepening, swl @ 717 11/26/56
59	-61	-120	medium, dark, basalt; -120 ft. msl final depth, swl @ 720 1/14/57.

Σ=970 ft.

Well Name: WWP #3 Date Completed: June 1960
Location: T11N-R46E-S29 SW SE Driller: Zinkgraff Drilling Co.
Asotin County, Wash. Spokane, Wash.

Thickness	From	To	Lithology
25	999	974	mud and gravel
58	974	916	broken basalt (caving)
14	916	902	clay
16	902	886	broken basalt and clay

WWP #3 (con't.)

Thickness	From	To	Lithology
12	886	874	basalt
11	874	863	basalt and clay
25	863	838	shale and basalt boulders
106	838	782	hard grey basalt caving from above
9	782	741	green shale, caving and sticky
20	741	721	basalt and shale
26	721	695	hard grey basalt; @ 701 ft: swl @ 724
59	695	636	hard and soft basalt
25	636	611	hard basalt
44	611	567	soft basalt
23	567	544	hard basalt
20	544	524	soft basalt
11	524	513	hard basalt
8	513	505	crevice (caving)
21	505	484	soft basalt
11	484	473	hard basalt
35	473	438	soft grey basalt; @ 440 ft: swl @ 654
80	438	358	hard grey basalt
24	358	334	soft broken basalt
5	334	329	hard basalt
33	329	296	soft black basalt
43	296	253	hard grey basalt; @ 274 ft: swl @ 725
31	253	222	soft black basalt
35	222	187	hard brown caving basalt
75	187	112	hard and soft layers of black basalt
43	112	69	red caving basalt, drill cuttings lost
35	69	34	hard basalt
23	34	11	soft black and red basalt
27	11	-16	medium black basalt
30	-16	-46	soft brown caving basalt
45	-46	-91	medium and soft basalt
13	-91	-104	hard basalt

Σ=1103 ft.

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
*Denotes Water
SWL @ : Static Water Level in Feet MSL

Well Name: WWP #4 Date Completed: June, 1960
Location: T11N-R46E-S33 NW NE Driller: Holman Drilling Co.
Asotin County, Wash. Spokane, Wash.

Thickness	From	To	Lithology
26	876	850	gravel
84	850	766	broken basalt and gravel
63	766	703	soft basalt (caving)
17	703	686	hard basalt
16	686	670	soft basalt *
24	670	646	soft basalt
50	646	596	hard basalt
50	596	546	soft basalt
37	546	509	hard basalt
22	509	487	soft basalt
31	487	456	shale and clay, caving
33	456	423	soft basalt
77	423	346	hard basalt, caving from above
31	346	315	soft basalt
31	315	284	hard basalt
10	284	274	sand
57	274	217	soft basalt
98	217	119	hard basalt (caving)
21	119	98	soft basalt
8	98	90	hard basalt
9	90	81	red basalt
12	81	69	brown basalt (sticky)
42	69	27	very soft brown basalt **
37	27	-10	soft brown and black basalt
44	-10	-54	medium black basalt
38	-54	-92	medium and hard basalt
44	-92	-136	black and brown basalt
Σ=1012 ft.			

** hole caved in and filled to 36 ft. msl

Well Name: WWP #5 Date Completed: 1961
Location: T11N-R46E-S30 SE SW Driller: Jungman Drilling Co.
Asotin County, Wash. Walla Walla, Wash.

Thickness	From	To	Lithology
10	1147	1137	yellow clay

WWP # 5 (con't.)

Thickness	From	To	Lithology
44	1137	1093	sand and gravel
9	1093	1084	sand, clay, and gravel
11	1084	1073	clay
5	1073	1068	gravel
22	1068	1046	broken basalt
23	1046	1023	hard dark basalt
24	1023	999	broken dark basalt
12	999	987	dark basalt
19	987	968	clay
23	968	945	broken basalt
17	945	928	clay
11	928	917	basalt and clay
14	917	903	sticky blue clay (caving)
13	903	890	medium hard dark basalt
28	890	862	sticky clay (caving)
44	862	818	basalt and clay seams
33	818	685	medium hard basalt
1	685	684	shale
91	684	593	medium hard basalt
26	593	567	hard basalt with clay streaks
28	567	539	medium hard basalt with clay streaks
42	539	497	broken basalt
128	497	369	hard dark basalt
13	369	356	broken red brown basalt
8	356	348	medium hard broken basalt
147	348	201	medium hard dark basalt
12	201	189	hard dark basalt
32	189	157	medium hard dark basalt
14	157	143	medium soft brown basalt
6	143	137	medium hard dark basalt
17	137	120	medium soft dark basalt
8	120	112	medium dark basalt
32	112	80	medium brown basalt
4	80	76	medium hard dark basalt
24	76	52	medium hard dark basalt
2	52	50	medium hard brown basalt
63	50	-13	medium hard dark basalt
47	-13	-60	hard dark basalt

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
*Denotes Water
SWL @ : Static Water Level in Feet MSL

WWP # 5 (con't.)

Thickness	From	To	Lithology
4	-60	-64	medium soft dark basalt
6	-64	-70	soft brownish dark basalt
3	-70	-73	medium soft brownish dark basalt
40	-73	-113	medium hard basalt
15	-113	-128	hard dark basalt
8	-128	-136	medium hard dark basalt
17	-136	-153	hard dark basalt
3	-153	-156	medium hard brown basalt
5	-156	-161	medium soft brown basalt
7	-161	-168	medium dark basalt
15	-168	-183	hard dark basalt

Σ=1330 ft.

Well Name: WWP #6 Date Completed: June, 1961
Location: T10N-R46E-S6 SE NW Driller: Jungman Drilling Co.
Asotin County, Wash. Walla Walla, Wash.

Thickness	From	To	Lithology
5	993	988	topsoil
5	988	983	sand and gravel
89	983	894	gravel
14	894	880	cemented gravel
57	880	823	gravel
5	823	818	cemented gravel
36	818	782	hard dark basalt
9	782	773	clay
21	773	652	medium and hard basalt
10	652	642	hard basalt
11	642	631	dark porous basalt
11	631	620	medium and hard basalt
55	620	565	hard basalt
23	565	542	medium hard basalt
35	542	507	medium hard brown and black basalt
2	507	505	blue clay
59	505	446	medium hard basalt

WWP # 6 (con't.)

Thickness	From	To	Lithology
16	446	430	hard dark basalt
31	430	399	brown and black basalt
18	399	381	medium hard dark basalt
17	381	364	hard basalt
19	364	345	soft brown basalt
14	345	331	medium hard dark basalt
17	331	314	hard basalt
10	314	304	brown basalt and clay
11	304	293	medium and soft dark basalt
10	293	283	hard black basalt
6	283	277	hard black basalt with clay lenses
42	277	235	medium hard basalt
38	235	197	medium hard brown and grey basalt
36	197	161	hard dark basalt
19	161	142	medium hard and soft dark basalt
20	142	122	hard dark basalt
18	122	104	medium dark basalt
6	104	98	hard dark basalt (caving)
135	98	-37	medium hard basalt
17	-37	-54	soft dark basalt
22	-54	-76	dark hard basalt (caving)

Σ=1069 ft.

Well Name: WWP # 7 Date Completed: 2/4/77
Location: T11N-R46E-S32 NW SW Driller: Holman Drilling Co.
Asotin County, Wash. Spokane, Wash.

Thickness	From	To	Lithology
32	1180	1152	sandy topsoil
72	1152	1080	soft brown basalt
120	1080	960	hard black basalt
41	960	919	yellow clay
70	919	849	medium brown basalt *
22	849	827	medium black basalt

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
*Denotes Water
SWL @ : Static Water Level in Feet MSL

HWP # 7 (con't.)

Thickness	From	To	Lithology
107	827	720	hard black basalt
29	720	691	clay and brown basalt *
31	691	660	brown clay
54	660	606	medium black basalt
19	606	587	black basalt and grey clay
165	587	422	medium black basalt
37	422	385	medium fractured basalt *
19	385	366	soft red basalt *
53	366	313	medium black basalt
12	313	301	soft red basalt *
16	301	285	medium black basalt
15	285	270	soft red basalt *
90	270	180	hard black basalt
43	180	137	red soft basalt *
74	137	63	black medium basalt
24	63	39	medium red basalt *
38	39	1	medium black basalt
11	1	-10	soft red basalt *
25	-10	-35	medium black basalt
19	-35	-54	soft red basalt *
90	-54	-144	medium black basalt
7	-144	-151	medium red basalt *
9	-151	-160	hard black basalt
Σ=1340 ft.			

TABLE A-1 WELL LITHOLOGY (con't.)

Elevations Given in Feet MSL
***Denotes WATER**
SWL @ : Static Water Level in Feet MSL

Well Name: Port of Whitman County #2 — **Date Completed: 9/15/77**
Location: T11N-R46E-S19 — **Driller: Adcock Air Drilling**
Whitman County, Wash. — **Lewiston, Idaho**

Thickness	From	To	Lithology
25	760	735	brown silt
25	735	710	large gravel
17	710	693	cobblestone and large gravel
33	693	660	brown basalt
50	660	610	very porous rock
25	610	585	red and brown rock
95	585	490	grey basalt
89	490	401	brown basalt
24	401	377	grey basalt
2	377	375	porous rock
30	375	345	hard basalt
35	345	310	porous rock
72	310	238	red brown basalt
8	238	230	hard grey basalt
Σ=530 ft.			

Well Name: Port of Whitman County # 1 — Date Completed: 6/28/74
Location: T11N-R46-S19 — Driller: A and W Drilling Co.
Whitman County, Wash. — Lewiston, Idaho

Thickness	From	To	Lithology
78	760	682	river chanel sands and gravels
320	682	362	bedrock
8	362	354	pea gravel

TABLE A-2 WELL DATA

Well Name	Surface to Bottom (DIMENSIONS, given in feet msl)	Casing Schedule (DIMENSIONS, given in feet msl)	Production Zones P= perforations OH= open hole (DIMENSIONS, given in feet msl)	Orig. S.W.L. (feet msl) (HYDRUALICS)	Specific Capacity (gpm/ft dd) and dischg. (HYDRUALICS)	Date and Length of test (HYDRUALICS)	Data Source col. no. (COMMENTS)	Data Source foot note (COMMENTS)	COMMENTS
1		2	3	4	5				6
City of Asotin #1	800 to 261	12" 800 to 383	383 to 261 OH 12" dia.	736	66.7 @ 800 gpm	Feb., 1961 4 hrs.	1-5 6	E A	Chlorinator tube in top of casing prevented steel tape measurements of depth-to-water in 1978-79. Accuracy of airline unknown
City of Asotin #2	760 to 238	20" 760 to 725 16" 760 to 662 12" 760 to 359	359 to 238 OH 12" dia.	727	14.3 @ 599 gpm	5/18/61 4 hrs.	1-5 6	 A	same as above
City of Lewis. #1	730 to 378	20" 730 to 641 16" 730 to 560 12" 730 to 445	445 to 378 OH 15" dia.	705	2.9 @ 480 gpm	2/22/52 6½ hrs.	1-3 4,5 6	BCF B BD	First municipal well; abandoned due to "dog leg" at 200 ft depth breaking pump shaft.
City of Lewis. #1A	730 to -5	24" 730 to 642 20" 730 to 548 16" 563 to 225	540 to 227 P 227 to -5 OH 16" dia.	688	7.9 @ 1677 gpm	Jan., 1962 24 hrs.	1-6	E	Completed to 225 ft. elev. May, 1960. Spec. Capac. = 5.4 gpm/ft dd at 617 gpm. Well deepened in Nov., 1961.
City of Lewis. #2	735 to 460	(casing schedule not available)		715	3.7 @ 720 gpm	48 hrs.	1-6	F	Known as the "Pepsi Park" well. H_2S odor and 100°F. water found during construction but disappeared after pumping. Stratigraphy limited to top of "Russell" aquifer.
City of Lewis. #3	837 to 237	26" 837 to 715 16" 747 to 443	443 to 237 OH 15" dia.	729	22.6 @ 1200 gpm	7/03/53 8 hrs.	1-5 6	EF B	Known as the "Cemetery Well". Used as obs. well in Aquifer Test #4
City of Lewis. #4	743 to 385	16" 743 to 676 12" 743 to 609	609 to 384 OH 12" dia.	728	32.8 @ 295 gpm	8/28/51	1-3 4,5	G F	Known as the "Old C.P.R.R. Well". Decline in S.W.L. for period of record. Appears to lay in separate aquifer above the "Russell" aquifer and possibly influenced by P.F.I. #2 and #4 wells.
City of Lewis. #5	855 to 255	16" 855 to 815 10" 550 to 525	815 to 770 OH 15¼"dia. 770 to 550 OH 12" dia. 525 to 255 10" dia. OH	727	7.5 @ 805 gpm	11/13/53 12 hrs.	1-6	E	Formerly owned by Roy Huffman, 2100 Country Club Dr., Lewiston, Id.

TABLE A-2 WELL DATA (Con't.)

Well Name	Surface to Bottom	Casing Schedule	Production Zones P= perforations OH= open hole	Orig. S.W.L. (feet msl)	Specific Capacity (gpm/ft dd) and dischg.	Date and Length of test	Data Source col. no.	foot note	COMMENTS
	DIMENSIONS (given in feet msl)			HYDRAULICS					
	1	2	3	4	5				6
L.C.I. (Lewis Clark Impr. Company)	978 to -8	12" 978 to 908 19" 978 to 803 8" 978 to 803+	not available	730 (June 1955)	47.4 @ 450 gpm	June 1955 12 hrs.	1-5 6	B H	Probably first deep well in Lewiston Basin Drilled to procure a free flowing well. Investigated for water supply for WWP Co. by A.A. Durand & Son, May-June 1955. Used in Aquifer Tests #1-4. Presently paved over, filled with rock and used for gas line anode well by WWP Co.
L.O.I.D.#1 (Lew. Or. Irr. Dist.)	1553 to 33	24" 1553 to 1520 16" 1553 to 550 8" 559 to 33	559 to 33 P	730	3.8 @ 550 gpm	Feb. 1978 2.5 hrs.	1-5 6	E IK	Low spec. cap. due to installation of perf. casing before removal of drilling mud. Bore hole has geophysical log.
P.F.I. #2 (EAST LEVEE)	746 to 194	24" 746 to 728 20" 746 to 708 16" 746 to 203	234 to 203 P 203 to 194 OH 19" dia.		not available		1-3 6	B J	Industrial well. Original 19" open hole caved. Repaired by Jungman Drilling Co. with ext. gravel packed 16" casing, June-Aug. 1965
P.F.I #3 (WEST LEVEE)	742 to 92	28" 742 to 718 20" 742 to 666	666 to 540 OH 20"dia. 429 to 92 OH 15"	732	75.6 @ 208 gpm	6/04/55 10 min w/ bailer	1-6	BJ	Industrial well.
P.F.I. #4	744 to 591	12" 744 to 691 10" 794 to 674	674 to 591 OH 10"	692	80.0 @ 240 gpm	3/02/65 8 hrs	1-5	EJ	Stratigraphically above "Russell" aquifer water levels indicate aquifer connection to PFI #1 and City of Lewiston #4 wells.
TWIN CITY FOODS	732 to 102	24" 732 to 674 20" 732 to 580	580 to 102 OH 10" ?	707	8.0 @ 1700 gpm	2/21/52 3 hrs	1-3 4,5	F B	Previous name: "Sno-Crop #1." Known interconnection with WWP #1 and #2 and City of Lewiston #1 wells. Pumped 2000 gpm from July 1 to August 15 annually.
WWP #1	850 to-120	24" 850 to 768 20" 850 to 755 16" 850 to 369 12" 390 to 301 10" 327 to 258	299 to 292 P 290 to 265 P 258 to-120 OH 10" dia.	711	22.6 @ 2980 gpm	6/01/61 64 days	1-3,6 4,5	B H	Deepened twice for increase of yield Pump bowls set at 471 ft.msl.
WWP #2	793 to ?	12" 793 to 674	unknown	733 9/16/55	17.5 @1350 gpm	6/01/61 65 days	1,2,4,6 5	B H	Formerly known as "Swallows Nest Wildcat Oil Well". Specific capacity test showed no further drawdown after 5500 min. Small borehole dia. prevents larger pump bowl emplacement. Pump bowls set at 554 ft. msl.

TABLE A-I WELL DATA (con't.)

	DIMENSIONS			HYDRAULICS					COMMENTS
Well Name	Surface to Bottom (given in feet msl)	Casing Schedule	Production Zones P=perforations OH= open hole	Orig. S.W.L. (feet msl)	Specific Capacity (gpm/ft dd) and dischg.	Date and Length of test	Data Source col. no.	foot-note	
	1	2	3	4	5				6
WWP # 3	999 to -104	24' 999 to 974 20" 999 to 440	440 to -104 OH ? dia.	724	33.9 @ 4200 gpm	6/16/61 51 days	1-6	H	Principal well of WWP Co. water utility in Clarkston, Wash. Airline broken since 1974. Pump bowls set at 498 ft. msl.
WWP # 4	876 to -136	24" 870 to 734 20" 876 to 463 12" 475 to 425	425 to 36 OH ? dia.	721	10.3 @ 1600 gpm	8/02/61 8 days	1-6	H	Borehole cared and filled to 36 ft. msl. Pump bowls aet at 531 ft. msl.
WWP # 5	1147 to -183	30" 1147 to 1071 24" 1147 to 804 20" 1147 to 402 16" 420 to 60	287 to 257 P 217 to 77 P 60 to -183 OH 15" dai.	707	13.8 @ 2200 gpm	6/21/61 72 days	1-5	H	Aquifer Test #5 indicated hydrogeologic boundary separating this well from Clarkston and Lewiston wells within "Russell" aquifer. Pump bowls set at 499 ft. msl.
WWP # 6	993 to -76	30" 993 to 818 24" 993 to 752 20" 993 to 393 16" 403 to 91	245 to 230 P 208 to 178 P 91 to -76 OH 15" dia.	732	14.8 @2450 gpm	6/13/61 62 days	1-5	H	Response of water levels similar to WWP #5 during Aquifer Test #5. Pump bowls set at 494 ft. msl.
WWP #7	1180 to -160	20" 1180 to 1080 16" 1180 to 527	527 to -160 OH 15"dia.	730	38.8	1/20/78	1-3,5	E	Hydrograph record of Aug.-Sept. 1978 shows no connection to WWP#5. Geophysical log exists.
Port of Whitman #1 (@ Wilma)	760 to 354	10" 760 to 676	676 to 500 OH 10" dia. 500 to 354 OH 8" dia.	?	500 gpm	June 1974	1-5	J	Water levels monitored in 1979 showed response to river levels near confluence.
Port of Whitman #2 (@ Wilma)	760 to 230	14" 760 to 685 12" 685 to 480 8" 480 to 345	345 to 230 OH 8"dia.	735	400.0 @1320 gpm	Sept. 1977 24 hrs.	1-5	E	Response same as Port of Whitman #1 with respect to river stage at confluence.

TABLE A-2

WELL DATA SOURCES

A. From well logs in City Hall file as of December 1978. City of Asotin, Asotin County, Washington.

B. Paul A. Durand Files, 1978 Whitman College Archives, Walla Walla, Washington.

C. City of Lewiston, 1946, City Engineers' Annual Report, Lewiston, Idaho, p. 24.

D. ________, 1948, City Engineers' Annual Report, Lewiston, Idaho, p. 38.

E. Driller's well log from respective state agency.

F. City of Lewiston, 1959, Department of Engineering: Graphic Well Logs, File No. F-63 of March 20, Lewiston, Idaho.

G. Castelin, Paul, 1978, Department of Water Resources, Boise, Idaho, (personal letter of December 15).

H. Washington Water Power, 1978, Engineering Department: File No. PC-83-A and PC-83-B, Drilling Logs and Pump Data for Clarkston Wells No. 1-7, Spokane, Washington.

I. Ralston, D. R., 1978, Department of Geology, University of Idaho, Moscow, Idaho, (personal communication of August 8).

J. Kalz, E. M., 1979, Potlatch Corporation, Lewiston, Idaho (letter of January 31).

K. Geophysical log obtained from Department of Geological Engineering, Albrook Hydraulic Laboratory, Washington State University, Pullman, Washington.

L. Clegg, Robert, 1979, Manager-Port of Whitman, Colfax, Washington, (well log information via telephone call of July 13).

APPENDIX B

HISTORIC WATER LEVELS OF THE MUNICIPAL WELLS

TABLE B-1

MUNICIPAL WELL STATIC WATER LEVELS OF LEWISTON, IDAHO AND CLARKSTON, WASHINGTON, 1961 - 1978

DATE: GIVEN AS YEAR-MONTH-DAY

DEPTH: WATER LEVEL DEPTH (FEET)

ELEV.: WATER LEVEL ELEVATION (FEET MSL)

CITY OF LEWISTON NO. 1

DATE	DEPTH	ELEV.
64-12-03	48.6	681.4
65-01-04	43.6	686.4
65-02-01	34.9	695.1
65-03-02	27.0	703.0
65-04-05	25.0	705.0
65-05-04	23.0	707.0
65-06-02	41.0	689.0
65-08-01	55.0	675.0
65-09-01	47.0	683.0
65-10-04	51.0	679.0
65-11-01	49.0	681.0
65-12-03	45.6	684.4
66-01-01	44.6	685.4
66-02-01	44.0	686.0
66-03-01	32.5	697.5
66-04-04	29.0	701.0
66-07-05	72.0	658.0
66-11-01	54.0	676.0
66-12-01	46.6	683.4
67-01-03	34.0	696.0
67-02-01	30.3	699.7
67-03-01	29.0	701.0
67-04-03	28.8	701.2
67-05-01	28.5	701.5
67-06-01	29.0	701.0
67-07-05	66.0	664.0
67-08-31	76.5	653.5
67-11-01	36.0	694.0
67-12-01	32.0	698.0
70-01-02	31.5	698.5
70-02-02	29.5	700.5
70-03-03	30.0	700.0
70-04-01	30.0	700.0
70-05-08	30.0	700.0
70-06-03	36.0	694.0
70-07-01	49.0	681.0
70-08-01	49.0	681.0
70-08-31	53.0	677.0
70-10-05	41.0	689.0
70-11-04	36.0	694.0
70-12-01	31.0	699.0
71-01-04	31.0	699.0
71-02-02	28.0	702.0
71-03-01	27.0	703.0
71-04-09	25.0	705.0
71-05-01	27.0	703.0
71-06-01	27.0	703.0
71-09-01	53.0	677.0
71-10-04	37.0	693.0
71-11-22	33.0	697.0

CITY OF LEWISTON NO. 1

DATE	DEPTH	ELEV.
71-12-02	31.0	699.0
72-01-03	32.0	698.0
72-01-31	29.0	701.0
72-03-03	30.0	700.0
72-04-07	26.0	704.0
72-05-09	28.0	702.0
72-09-15	47.0	683.0
72-10-02	43.0	687.0
72-12-04	32.0	698.0

CITY OF LEWISTON NO. 1A

DATE	DEPTH	ELEV.
66-01-01	44.6	685.4
66-02-01	44.0	686.0
66-03-01	32.5	697.5
66-04-04	29.0	701.0
66-05-04	39.0	691.0
66-05-31	40.0	690.0
66-08-01	71.5	658.5
66-09-02	61.5	668.5
66-10-04	62.0	668.0
66-17-01	54.0	676.0
66-12-01	46.6	683.4
67-01-03	35.5	694.5
67-02-01	30.3	699.7
67-03-01	29.5	700.5
67-04-03	28.8	701.2
67-05-01	29.5	700.5
67-06-01	29.0	701.0
67-09-01	58.5	671.5
67-10-01	18.0	712.0
67-11-01	36.0	694.0
67-12-01	31.5	698.5
69-01-02	27.0	703.0
69-02-03	29.0	701.0
69-03-03	26.0	704.0
69-04-02	35.0	695.0
69-05-04	25.0	705.0
69-06-02	26.5	703.5
69-08-03	59.0	671.0
69-10-01	41.0	689.0
69-11-01	56.5	673.5
69-12-03	33.0	697.0
76-01-12	5.0	725.0
76-02-09	4.0	726.0
76-03-11	3.0	727.0

CITY OF LEWISTON NO. 1A

DATE	DEPTH	ELEV.
76-04-05	1.8	728.2
76-05-05	7.0	723.0
76-06-08	12.0	718.0
76-09-14	21.0	709.0
76-11-03	11.0	719.0
76-12-01	13.0	717.0
77-01-03	5.0	725.0
77-02-01	5.4	724.6
77-03-01	5.5	724.5
77-04-04	4.5	725.5
77-05-03	10.0	720.0
77-06-01	11.5	718.5
77-09-02	21.5	708.5
77-10-03	12.0	718.0
77-11-03	9.0	721.0
77-12-05	7.0	723.0
78-01-10	5.0	725.0
78-02-22	2.5	727.5
78-03-07	2.5	727.5
78-04-05	2.0	728.0
78-05-23	2.0	728.0
78-09-06	17.0	713.0
78-10-01	12.0	718.0

CITY OF LEWISTON NO. 2

DATE	DEPTH	ELEV.
64-11-04	20.4	714.6
64-12-03	20.0	715.0
65-01-04	18.4	716.6
65-02-01	18.2	716.8
65-03-02	15.6	719.4
65-04-05	15.0	720.0
65-05-04	14.0	721.0
65-06-02	18.0	717.0
65-09-01	27.0	708.0
65-10-04	22.0	713.0
65-11-01	21.0	714.0
65-12-03	19.8	715.2
66-01-01	19.0	716.0
66-02-01	19.0	716.0
66-03-01	18.0	717.0
66-04-04	17.5	717.5
66-05-04	19.0	716.0
66-05-31	19.0	716.0
66-07-05	16.0	719.0
66-10-04	24.0	711.0

TABLE B-1 (CON'T.)

CITY OF LEWISTON NO. 2

DATE	DEPTH	ELEV.
66-11-01	21.6	713.4
66-12-01	21.0	714.0
67-01-03	19.0	716.0
67-02-01	12.3	722.7
67-03-01	23.0	712.0
67-04-03	16.5	718.5
67-05-01	11.5	723.5
67-07-05	20.2	714.8
67-10-01	34.0	701.0
67-11-01	20.5	714.5
67-12-01	19.0	716.0
69-01-02	16.0	719.0
69-02-03	15.0	720.0
69-03-03	16.0	719.0
69-04-02	15.0	720.0
69-05-04	13.0	722.0
69-06-02	16.0	719.0
69-10-01	21.0	714.0
69-11-01	22.0	713.0
69-12-03	19.5	715.5
70-01-02	19.5	715.5
70-02-02	17.0	718.0
70-03-03	17.5	717.5
70-04-01	18.0	717.0
70-05-08	18.0	717.0
70-08-31	25.0	710.0
70-10-05	21.0	714.0
70-11-04	19.5	715.5
70-12-01	18.0	717.0
71-01-04	19.0	716.0
71-02-02	16.0	719.0
71-03-01	16.0	719.0
71-04-09	15.5	719.5
71-05-01	16.0	719.0
71-10-04	20.0	715.0
71-11-22	19.0	716.0
71-12-02	18.0	717.0
72-01-03	19.0	716.0
72-01-31	18.0	717.0
72-03-03	17.0	718.0
72-04-07	15.0	720.0
72-05-09	16.0	719.0
72-09-15	23.0	712.0
76-01-12	13.0	722.0
76-02-09	12.5	722.5
76-03-11	12.5	722.5
76-04-05	12.0	723.0
76-05-05	14.0	721.0
76-06-08	15.0	720.0
76-07-07	18.0	717.0
76-08-01	19.0	716.0
76-09-14	17.0	718.0
76-10-06	15.5	719.5
76-11-03	14.0	721.0
76-12-01	13.5	721.5
77-01-03	13.0	722.0
77-02-01	13.5	721.5
77-03-01	13.0	722.0
77-04-04	13.0	722.0
77-05-03	15.0	720.0
77-06-01	14.5	720.5

CITY OF LEWISTON NO. 2

DATE	DEPTH	ELEV.
77-09-02	16.0	719.0
77-10-03	14.0	721.0
77-11-03	14.0	721.0
77-12-05	13.5	721.5
78-01-10	12.0	723.0
78-02-22	12.0	723.0
78-03-07	12.0	723.0
78-04-05	12.5	722.5
78-05-23	12.0	723.0
78-08-16	17.0	718.0
78-09-06	15.0	720.0
78-10-01	14.0	721.0

CITY OF LEWISTON NO. 3

DATE	DEPTH	ELEV.
64-11-04	144.0	693.0
64-12-03	144.0	693.0
65-01-04	140.0	697.0
65-02-01	139.0	698.0
65-03-02	132.0	705.0
65-04-05	130.2	706.8
65-05-04	138.4	698.6
65-12-03	142.0	695.0
66-01-01	139.0	698.0
66-02-01	138.0	699.0
66-03-01	135.0	702.0
66-04-04	129.0	708.0
66-05-04	150.0	687.0
66-05-31	164.5	672.5
66-07-05	160.0	677.0
66-08-01	155.5	681.5
66-09-02	158.0	679.0
66-10-04	156.0	681.0
66-11-01	150.0	687.0
66-12-01	143.0	694.0
67-01-03	137.0	700.0
67-02-01	142.0	695.0
67-03-01	133.5	703.5
67-04-03	133.0	704.0
67-05-01	134.0	703.0
67-06-01	150.0	687.0
67-07-05	169.0	668.0
67-08-31	182.0	655.0
67-09-01	185.0	652.0
67-10-01	153.0	684.0
67-11-01	143.0	694.0
67-12-01	139.0	698.0
69-01-02	133.0	704.0
69-02-03	135.0	702.0
69-03-03	133.0	704.0
69-04-02	110.0	727.0
69-05-04	139.0	698.0
69-06-02	148.0	689.0
69-07-01	158.0	679.0
69-10-01	157.0	680.0
69-11-01	155.5	681.5
69-12-03	145.0	692.0
70-01-02	143.5	693.5

CITY OF LEWISTON NO. 3

DATE	DEPTH	ELEV.
70-02-02	138.0	699.0
70-03-03	136.0	701.0
70-04-01	135.0	702.0
70-05-08	134.5	702.5
70-06-03	175.0	662.0
70-07-01	156.0	681.0
70-08-01	165.0	672.0
70-08-31	181.0	656.0
70-10-05	158.0	679.0
70-11-04	146.0	691.0
70-12-01	139.0	698.0
71-01-04	137.0	700.0
71-03-01	135.0	702.0
71-04-09	134.0	703.0
71-05-01	145.0	692.0
71-06-01	140.0	697.0
71-07-02	141.0	696.0
71-08-03	196.0	641.0
71-09-01	172.0	665.0
71-10-04	147.0	690.0
71-11-22	139.0	698.0
71-12-02	141.0	696.0
72-01-03	139.0	698.0
72-01-31	143.0	694.0
72-03-03	143.0	694.0
72-04-07	136.0	701.0
72-05-09	140.0	697.0
72-10-02	161.0	676.0
72-12-04	138.0	699.0

CITY OF LEWISTON NO. 4

DATE	DEPTH	ELEV.
64-11-04	50.5	692.5
64-12-03	49.9	693.1
65-11-01	58.0	685.0
66-09-02	67.5	675.5
66-10-04	69.0	674.0
66-11-01	68.0	675.0
67-05-01	69.0	674.0
67-12-01	76.3	666.7
67-12-05	75.5	667.5
69-10-01	86.0	657.0
69-11-01	86.0	657.0
70-03-03	85.5	657.5
70-04-01	86.0	657.0
70-05-08	86.0	657.0
70-07-01	87.0	656.0
70-08-01	86.0	657.0
70-12-01	90.0	653.0
71-04-09	87.0	656.0
71-06-01	90.0	653.0
71-09-01	93.0	650.0
71-10-04	92.0	651.0
71-11-22	92.0	651.0
71-12-02	92.0	651.0
72-04-07	94.0	649.0
72-05-09	65.0	678.0
72-10-02	95.0	648.0

TABLE B-1 (CON'T.)

CITY OF LEWISTON NO. 4

DATE	DEPTH	ELEV.
76-01-12	102.0	641.0
76-02-09	110.0	633.0
76-04-05	111.0	632.0
76-05-05	101.0	642.0
76-12-01	116.0	627.0
77-01-03	115.0	628.0
77-02-01	115.0	628.0
77-03-01	114.0	629.0
77-05-03	117.0	626.0
77-09-02	122.0	621.0
77-10-03	169.0	574.0
77-11-03	122.0	621.0
77-12-05	122.0	621.0
78-01-10	122.0	621.0
78-02-22	121.0	622.0
78-08-16	129.5	613.5
78-09-06	172.0	571.0
78-10-01	132.0	611.0

CITY OF LEWISTON NO. 5

DATE	DEPTH	ELEV.
64-12-03	158.0	697.0
65-03-02	147.0	708.0
65-04-05	145.0	710.0
65-05-04	153.0	702.0
66-10-04	165.0	690.0
66-11-01	163.0	692.0
66-12-01	155.0	700.0
70-01-02	154.0	701.0
70-02-02	152.0	703.0
70-03-03	152.0	703.0
70-04-01	153.0	702.0
70-05-08	153.0	702.0
70-07-01	164.0	691.0
70-10-05	167.0	688.0
70-11-04	158.0	697.0
70-12-01	153.0	702.0
71-01-04	151.0	704.0
71-02-02	151.0	704.0
71-03-01	147.0	708.0
71-04-09	148.0	707.0
71-05-01	153.0	702.0
71-06-01	152.0	703.0
71-10-04	158.0	697.0
71-11-22	152.0	703.0
71-12-02	153.0	702.0
72-08-01	197.0	658.0
72-09-15	168.0	687.0
72-10-02	169.0	686.0
72-12-04	153.0	702.0
76-01-12	127.0	728.0
76-02-04	126.0	729.0
76-03-11	127.0	728.0
76-04-05	126.0	729.0
76-05-05	133.0	722.0
76-06-08	131.0	724.0
76-10-06	127.0	728.0
76-11-03	127.0	728.0
76-12-01	127.0	728.0

CITY OF LEWISTON NO. 5

DATE	DEPTH	ELEV.
77-01-03	127.0	728.0
77-02-01	127.5	727.5
77-03-01	127.0	728.0
77-04-04	127.7	727.3
77-05-03	127.0	728.0
77-06-01	127.0	728.0
77-09-02	128.0	727.0
77-10-03	128.0	727.0
77-11-03	127.0	728.0
77-12-05	128.0	727.0
78-01-10	142.0	713.0
78-02-22	138.0	717.0
78-04-05	135.5	719.5
78-05-23	136.0	719.0

WWP NO. 1

DATE	DEPTH	ELEV.
61-02-01	125.0	725.0
61-02-08	125.0	725.0
61-03-02	143.0	707.0
61-03-08	143.0	707.0
61-03-10	142.0	708.0
61-05-21	108.0	742.0
61-06-02	180.0	670.0
61-07-29	208.0	642.0
61-10-12	174.0	676.0
61-10-16	174.0	676.0
61-10-19	172.0	678.0
61-10-26	171.0	679.0
61-11-05	172.0	678.0
61-11-19	171.0	679.0
61-12-03	169.0	681.0
61-12-17	146.0	704.0
61-12-31	146.0	704.0
62-01-14	144.0	706.0
62-01-28	144.0	706.0
62-02-11	144.0	706.0
62-02-25	146.0	704.0
62-03-11	149.0	701.0
62-03-25	153.0	697.0
62-04-08	147.0	703.0
62-05-06	155.0	695.0
62-05-10	155.0	695.0
62-05-13	150.0	700.0
62-05-20	175.0	675.0
62-05-24	151.0	699.0
62-05-27	148.0	702.0
62-09-09	204.0	646.0
62-09-13	178.0	672.0
62-09-16	178.0	672.0
62-09-20	187.0	663.0
62-09-23	192.0	658.0
62-09-27	195.0	655.0
62-09-30	176.0	674.0
62-10-04	171.0	679.0
62-10-11	157.0	693.0
62-10-14	155.0	695.0
62-10-18	155.0	695.0
62-10-21	153.0	697.0

WWP NO. 1

DATE	DEPTH	ELEV.
62-10-25	153.0	697.0
62-11-01	172.0	678.0
62-11-04	157.0	693.0
62-11-08	155.0	695.0
62-11-23	156.0	694.0
62-12-09	162.0	688.0
62-12-23	148.0	702.0
63-01-06	148.0	702.0
63-01-22	148.0	702.0
63-02-03	153.0	697.0
63-02-28	150.0	700.0
63-03-10	150.0	700.0
63-03-24	153.0	697.0
63-04-21	169.0	681.0
63-04-27	171.0	679.0
63-06-05	167.0	683.0
63-06-09	160.0	690.0
63-06-13	174.0	676.0
63-09-22	185.0	665.0
63-09-26	190.0	660.0
63-10-03	198.0	652.0
63-10-06	192.0	658.0
63-10-20	185.0	665.0
63-11-03	164.0	686.0
63-11-17	156.0	694.0
63-12-01	155.0	695.0
63-12-15	157.0	693.0
63-12-22	160.0	690.0
63-12-29	155.0	695.0
64-01-05	157.0	693.0
64-01-19	152.0	698.0
64-02-02	150.0	700.0
64-02-11	150.0	700.0
64-03-01	150.0	700.0
64-03-15	150.0	700.0
64-03-29	181.0	669.0
64-04-12	174.0	676.0
64-04-26	181.0	669.0
64-05-03	162.0	688.0
64-06-07	164.0	686.0
64-09-06	178.0	672.0
64-09-13	185.0	665.0
64-09-20	169.0	681.0
64-10-04	164.0	686.0
64-10-16	169.0	681.0
64-10-28	160.0	690.0
64-11-16	167.0	683.0
64-11-27	171.0	679.0
64-12-16	167.0	683.0
64-12-31	155.0	695.0
65-01-12	150.0	700.0
65-01-27	157.0	693.0
65-02-11	155.0	695.0
65-02-18	160.0	690.0
65-02-24	146.0	704.0
65-03-09	144.0	706.0
65-03-23	144.0	706.0
65-04-12	144.0	706.0
65-04-27	148.0	702.0
65-05-03	150.0	700.0
65-05-21	164.0	686.0
65-07-22	176.0	674.0

TABLE B-1 (CON'T.)

WWP NO. 2

DATE	DEPTH	ELEV.
63-03-24	77.0	716.0
63-04-07	79.0	714.0
63-04-21	87.0	706.0
63-06-06	103.0	690.0
63-06-09	88.0	705.0
63-09-19	93.0	700.0
63-11-03	86.0	707.0
63-11-17	81.0	712.0
63-12-01	81.0	712.0
63-12-15	79.0	714.0
63-12-29	77.0	716.0
64-01-05	77.0	716.0
64-01-19	74.0	719.0
64-02-02	77.0	716.0
64-02-16	77.0	716.0
64-03-01	77.0	716.0
64-03-15	77.0	716.0
64-03-29	77.0	716.0
64-04-26	88.0	705.0
64-06-07	95.0	698.0
64-06-18	84.0	709.0
64-06-21	79.0	714.0
64-07-19	97.0	696.0
64-08-02	111.0	682.0
64-10-16	88.0	705.0
64-10-28	86.0	707.0
64-11-16	84.0	709.0
64-11-30	81.0	712.0
64-12-16	81.0	712.0
64-12-31	79.0	714.0
65-01-12	77.0	716.0
65-01-27	81.0	712.0
65-02-11	77.0	716.0
65-02-18	79.0	714.0
65-02-24	72.0	721.0
65-03-09	72.0	721.0
65-03-23	72.0	721.0
65-04-12	70.0	723.0
65-04-27	70.0	723.0
65-05-02	74.0	719.0
65-08-22	102.0	691.0
65-08-26	95.0	698.0
65-08-29	93.0	700.0
65-09-15	98.0	695.0
65-10-22	88.0	705.0
65-11-02	88.0	705.0
65-11-22	84.0	709.0
65-12-06	77.0	716.0
65-12-17	77.0	716.0
65-12-30	79.0	714.0
66-01-07	81.0	712.0
66-01-26	74.0	719.0
66-02-07	77.0	716.0
66-02-23	77.0	716.0
66-03-11	79.0	714.0
66-06-05	84.0	709.0
66-06-12	116.0	677.0
66-10-16	86.0	707.0
66-10-24	86.0	707.0
66-11-08	81.0	712.0
66-11-17	81.0	712.0
66-11-29	81.0	712.0

WWP NO. 2

DATE	DEPTH	ELEV.
66-12-09	88.0	705.0
66-12-27	77.0	716.0
67-01-03	77.0	716.0
67-01-24	74.0	719.0
67-02-07	74.0	719.0
67-02-27	77.0	716.0
67-03-08	74.0	719.0
67-03-21	81.0	712.0
67-11-09	79.0	714.0
67-11-30	77.0	716.0
67-12-20	78.0	715.0
67-12-29	74.0	719.0
68-01-02	74.0	719.0
68-01-16	74.0	719.0
68-01-26	74.0	719.0
68-02-13	74.0	719.0
68-02-26	74.0	719.0
68-03-09	77.0	716.0
68-03-22	79.0	714.0
68-10-30	81.0	712.0
68-11-07	81.0	712.0
68-11-19	77.0	716.0
68-12-09	74.0	719.0
68-12-20	77.0	716.0
69-01-02	77.0	716.0
69-01-15	74.0	719.0
69-01-29	74.0	719.0
69-02-11	74.0	719.0
69-02-24	72.0	721.0
69-03-11	74.0	719.0
69-03-26	72.0	721.0
69-04-03	77.0	716.0
69-04-14	72.0	721.0
69-04-29	74.0	719.0
69-10-27	86.0	707.0
69-11-04	86.0	707.0
69-11-18	79.0	714.0
69-12-01	77.0	716.0
69-12-12	79.0	714.0
69-12-26	88.0	705.0
70-01-04	81.0	712.0
70-01-23	79.0	714.0
70-02-04	77.0	716.0
70-02-17	77.0	716.0
70-02-27	77.0	716.0
70-03-12	79.0	714.0
70-03-26	74.0	719.0
70-04-03	77.0	716.0
72-02-07	76.0	717.0
72-02-17	78.0	715.0
72-02-24	78.0	715.0
72-03-03	79.0	714.0
72-03-10	78.0	715.0
72-03-17	78.0	715.0
72-03-24	77.0	716.0
72-03-31	77.0	716.0
72-04-11	76.0	717.0
72-04-20	76.0	717.0
72-04-26	77.0	716.0
72-05-13	80.0	713.0
72-10-20	85.0	706.0
72-10-27	85.0	708.0

WWP NO. 2

DATE	DEPTH	ELEV.
72-11-02	83.0	710.0
72-11-10	87.0	706.0
72-11-15	87.0	706.0
72-11-28	83.0	710.0
72-12-14	83.0	710.0
72-12-22	83.0	710.0
72-12-29	83.0	710.0
73-01-05	80.0	713.0
73-01-15	78.0	715.0
73-01-23	82.0	711.0
73-01-30	82.0	711.0
73-02-12	78.0	715.0
73-02-20	82.0	711.0
73-03-01	81.0	712.0
73-03-08	81.0	712.0
73-03-13	83.0	710.0
73-03-21	82.0	711.0
73-03-29	84.0	709.0
73-10-31	88.0	705.0
73-11-13	84.0	709.0
73-11-26	84.0	709.0
73-12-07	84.0	709.0
73-12-13	83.0	710.0
73-12-20	83.0	710.0
73-12-26	83.0	710.0
74-01-04	83.0	710.0
74-01-11	84.0	709.0
74-01-22	77.0	716.0
74-01-28	77.0	716.0
74-02-04	82.0	711.0
74-02-12	80.0	713.0
74-02-20	80.0	713.0
74-02-28	80.0	713.0
74-03-04	76.0	717.0
74-03-14	80.0	713.0
74-03-20	81.0	712.0
74-03-28	82.0	711.0
74-04-04	82.0	711.0
74-04-11	76.0	717.0
74-11-12	83.0	710.0
74-11-21	91.0	702.0
74-11-27	89.0	704.0
74-12-04	86.0	707.0
74-12-11	86.0	707.0
74-12-19	84.0	709.0
74-12-24	82.0	711.0
74-12-31	85.0	708.0
75-01-09	84.0	709.0
75-01-15	84.0	709.0
75-01-24	83.0	710.0
75-01-30	83.0	710.0
75-02-06	83.0	710.0
75-02-14	83.0	710.0
75-02-19	83.0	710.0
75-02-26	80.0	713.0
75-02-27	79.0	714.0
75-02-28	78.0	715.0
75-03-03	74.0	719.0
75-03-04	79.0	714.0
75-03-06	77.0	716.0
75-03-07	77.0	716.0
75-03-10	73.0	720.0

TABLE B-1 (CON'T.)

WWP NO. 1

DATE	DEPTH	ELEV.
65-08-26	178.0	672.0
65-08-29	178.0	672.0
65-09-05	173.0	677.0
65-09-15	171.0	679.0
65-09-24	178.0	672.0
65-10-06	171.0	679.0
65-10-22	167.0	683.0
65-11-03	160.0	690.0
65-11-22	150.0	700.0
65-12-06	148.0	702.0
65-12-17	155.0	695.0
65-12-30	155.0	695.0
66-01-07	162.0	688.0
66-01-26	146.0	704.0
66-02-07	155.0	695.0
66-02-23	144.0	706.0
66-03-11	155.0	695.0
66-03-30	144.0	706.0
66-04-08	162.0	688.0
66-04-19	150.0	700.0
66-04-30	167.0	683.0
66-05-08	169.0	681.0
66-05-15	153.0	697.0
66-06-05	155.0	695.0
66-06-12	167.0	683.0
66-07-03	164.0	686.0
66-07-10	181.0	669.0
75-03-04	137.0	713.0
75-03-07	142.0	708.0
75-03-14	143.0	707.0
75-03-21	140.0	710.0
75-03-24	133.0	717.0
75-04-05	136.0	714.0
75-04-08	131.0	719.0
75-04-11	140.0	710.0
75-04-14	140.0	710.0
75-04-18	142.0	708.0
75-04-21	136.0	714.0
75-04-25	136.0	714.0
75-04-28	137.0	713.0
75-05-02	144.0	706.0
75-05-07	142.0	708.0
75-05-10	143.0	707.0
75-05-13	140.0	710.0
75-05-16	139.0	711.0
75-05-19	155.0	695.0
75-05-24	153.0	697.0
75-05-27	168.0	682.0
75-08-31	162.0	688.0
75-10-04	162.0	688.0
75-10-14	150.0	700.0
75-10-21	155.0	695.0
75-10-28	154.0	696.0
75-11-06	144.0	706.0
75-11-12	146.0	704.0
75-11-19	157.0	693.0
75-11-26	146.0	704.0
75-12-05	144.0	706.0
75-12-11	144.0	706.0
75-12-17	144.0	706.0
75-12-31	142.0	708.0
76-01-08	134.0	716.0

WWP NO. 1

DATE	DEPTH	ELEV.
76-01-14	134.0	716.0
76-01-21	134.0	716.0
76-01-28	139.0	711.0
76-02-11	141.0	709.0
76-02-19	141.0	709.0
76-03-04	141.0	709.0
76-03-11	139.0	711.0
76-03-17	139.0	711.0
76-03-24	141.0	709.0
76-03-31	139.0	711.0
76-04-07	141.0	709.0
76-04-18	139.0	711.0
76-04-25	139.0	711.0
76-05-01	146.0	704.0
76-05-29	144.0	706.0
76-06-15	157.0	693.0
76-08-09	162.0	688.0
76-08-15	162.0	688.0
76-10-10	153.0	697.0
76-10-20	153.0	697.0
76-10-28	146.0	704.0
76-11-04	150.0	700.0
76-11-17	144.0	706.0
76-11-24	153.0	697.0
76-12-01	141.0	709.0
76-12-09	139.0	711.0
76-12-16	144.0	706.0
76-12-29	146.0	704.0
77-01-05	144.0	706.0
77-01-13	141.0	709.0
77-01-19	148.0	702.0
77-01-26	144.0	706.0
77-02-02	146.0	704.0
77-02-09	139.0	711.0
77-02-16	139.0	711.0
77-02-23	139.0	711.0
77-03-02	139.0	711.0
77-03-10	144.0	706.0
77-03-16	139.0	711.0
77-03-30	148.0	702.0
77-04-06	141.0	709.0
77-09-04	155.0	695.0
77-09-10	167.0	683.0
77-09-19	157.0	693.0
77-10-03	139.0	711.0
77-10-10	139.0	711.0
77-10-17	139.0	711.0
77-10-25	143.6	706.4
77-10-31	139.0	711.0
77-11-07	139.0	711.0
77-11-14	146.0	704.0
77-11-29	141.3	708.7
77-12-07	139.0	711.0
77-12-15	139.0	711.0
77-12-21	139.0	711.0
77-12-28	148.3	701.7
78-01-04	141.3	708.7
78-01-11	141.3	708.7
78-01-18	134.4	715.6
78-01-23	134.4	715.6
78-02-01	136.7	713.3
78-02-08	139.0	711.0

WWP NO. 1

DATE	DEPTH	ELEV.
78-02-15	143.6	706.4
78-02-22	139.0	711.0
78-03-01	139.0	711.0
78-03-08	136.7	713.3
78-03-15	141.3	708.7
78-03-22	143.6	706.4
78-03-29	143.6	706.4
78-04-05	134.0	716.0
78-04-12	139.0	711.0
78-04-19	139.0	711.0
78-04-26	139.0	711.0
78-05-03	137.4	712.6
78-05-11	139.0	711.0
78-05-21	139.0	711.0
78-05-28	139.0	711.0

WWP NO. 2

DATE	DEPTH	ELEV.
61-09-21	95.3	697.7
61-10-09	88.3	704.7
61-10-12	86.0	707.0
61-10-16	86.0	707.0
61-10-18	86.0	707.0
61-10-22	88.0	705.0
61-10-26	88.0	705.0
61-11-05	87.0	706.0
61-11-19	83.0	710.0
61-12-03	84.0	709.0
61-12-17	71.0	722.0
61-12-31	70.0	723.0
62-01-14	70.0	723.0
62-01-28	70.0	723.0
62-02-11	70.0	723.0
62-02-25	72.0	721.0
62-03-11	74.0	719.0
62-03-25	74.0	719.0
62-04-08	74.0	719.0
62-05-24	77.0	716.0
62-05-27	93.0	700.0
62-09-13	103.0	690.0
62-09-16	104.0	689.0
62-09-30	93.0	700.0
62-10-04	88.0	705.0
62-10-11	81.0	712.0
62-10-14	81.0	712.0
62-10-18	78.0	715.0
62-10-21	78.0	715.0
62-10-25	77.0	716.0
62-11-02	86.0	707.0
62-11-04	84.0	709.0
62-11-08	81.0	712.0
62-11-22	81.0	712.0
62-12-09	81.0	712.0
62-12-23	77.0	716.0
63-01-06	77.0	716.0
63-01-21	74.0	719.0
63-02-03	74.0	719.0
63-02-28	74.0	719.0
63-03-10	78.0	715.0

TABLE B-1 (CON'T.)

WWP NO. 2

DATE	DEPTH	ELEV.
75-03-11	77.0	716.0
75-03-12	76.0	717.0
75-03-13	75.0	718.0
75-03-14	76.0	717.0
75-03-17	72.0	721.0
75-03-21	74.0	719.0
75-03-24	71.0	722.0
75-03-28	75.0	718.0
75-03-31	76.0	717.0
75-04-04	74.0	719.0
75-04-07	69.0	724.0
75-04-11	73.0	720.0
75-04-14	76.0	717.0
75-04-18	73.0	720.0
75-04-19	73.0	720.0
75-04-20	73.0	720.0
75-04-21	72.0	721.0
75-04-25	73.0	720.0
75-04-28	72.0	721.0
75-10-14	86.0	707.0
75-10-21	78.0	715.0
75-10-28	76.0	717.0
75-11-06	71.0	722.0
75-11-12	73.0	720.0
75-11-19	80.0	713.0
75-11-26	73.0	720.0
75-12-05	72.0	721.0
75-12-11	70.0	723.0
75-12-17	71.0	722.0
75-12-22	68.0	725.0
75-12-30	70.0	723.0
76-01-08	70.0	723.0
76-01-14	68.0	725.0
76-01-21	68.0	725.0
76-01-28	68.0	725.0
76-02-04	70.0	723.0
76-02-11	71.0	722.0
76-02-18	70.0	723.0
76-03-04	67.0	726.0
76-03-11	68.0	725.0
76-03-17	67.0	726.0
76-03-24	67.0	726.0
76-03-31	66.0	727.0
76-04-18	67.0	726.0
76-10-28	78.0	715.0
76-11-04	74.0	719.0
76-11-17	71.0	722.0
76-11-24	77.0	716.0
76-12-01	71.0	722.0
76-12-09	69.0	724.0
76-12-17	75.0	718.0
76-12-29	70.0	723.0
77-01-05	71.0	722.0
77-01-13	69.0	724.0
77-01-19	71.0	722.0
77-01-26	69.0	724.0
77-02-02	69.0	724.0
77-02-09	68.0	725.0
77-02-16	68.0	725.0
77-02-23	68.0	725.0
77-03-02	69.0	724.0

WWP NO. 2

DATE	DEPTH	ELEV.
77-03-10	68.0	725.0
77-03-16	68.0	725.0
77-03-30	70.0	723.0
77-09-25	97.0	696.0
77-10-03	71.0	722.0
77-10-10	71.0	722.0
77-10-17	71.0	722.0
77-10-25	75.0	718.0
77-10-31	68.0	725.0
77-11-07	73.0	720.0
77-11-14	72.0	721.0
77-11-29	72.0	721.0
77-12-07	71.0	722.0
77-12-15	69.0	724.0
77-12-21	70.0	723.0
77-12-28	73.0	720.0
78-01-04	70.0	723.0
78-01-11	70.0	723.0
78-01-18	64.0	729.0
78-01-21	66.0	727.0
78-01-23	67.0	726.0
78-02-01	67.0	726.0
78-02-08	70.0	723.0
78-02-15	68.0	725.0
78-02-22	68.0	725.0
78-03-01	68.0	725.0
78-03-08	67.0	726.0
78-03-15	67.0	726.0
78-03-22	69.0	724.0
78-03-29	69.0	724.0
78-04-05	65.0	728.0
78-04-12	67.0	726.0
78-04-19	66.0	727.0
78-04-26	66.0	727.0

WWP NO. 3

DATE	DEPTH	ELEV.
61-01-04	288.0	711.0
61-01-11	289.0	710.0
61-01-18	289.0	710.0
61-01-25	288.0	711.0
61-02-17	288.0	711.0
61-02-20	289.0	710.0
61-03-01	289.0	710.0
61-06-03	313.0	686.0
61-08-25	350.0	649.0
61-08-31	332.0	667.0
61-09-05	312.0	687.0
61-09-07	323.0	676.0
61-09-21	318.0	681.0
61-09-28	319.0	680.0
61-10-02	316.0	683.0
61-10-05	316.0	683.0
61-10-09	312.0	687.0
61-12-17	289.0	710.0
61-12-31	289.0	710.0
62-01-14	288.0	711.0
62-01-28	286.0	713.0
62-02-11	286.0	713.0

WWP NO. 3

DATE	DEPTH	ELEV.
62-02-14	286.0	713.0
62-02-25	289.0	710.0
62-03-11	291.0	708.0
62-03-26	289.0	710.0
62-04-08	290.0	709.0
62-05-03	307.0	692.0
62-05-10	296.0	703.0
62-05-13	291.0	708.0
62-05-20	300.0	699.0
62-05-24	290.0	709.0
62-05-27	287.0	712.0
62-06-03	309.0	690.0
62-06-07	314.0	685.0
62-07-04	332.0	667.0
62-08-05	335.0	664.0
62-08-26	344.0	655.0
62-08-30	339.0	660.0
62-09-30	312.0	687.0
62-10-11	300.0	699.0
62-10-14	300.0	699.0
62-10-18	297.0	702.0
62-10-21	297.0	702.0
62-10-25	296.0	703.0
62-11-04	300.0	699.0
62-11-08	293.0	706.0
62-11-22	296.0	703.0
62-12-23	289.0	710.0
63-01-22	289.0	710.0
63-02-28	290.0	709.0
63-03-10	289.0	710.0
63-04-07	300.0	699.0
63-05-05	309.0	690.0
63-05-30	339.0	660.0
63-06-02	321.0	678.0
63-06-06	309.0	690.0
63-06-09	300.0	699.0
63-06-22	328.0	671.0
63-06-30	330.0	669.0
63-07-11	335.0	664.0
63-08-11	353.0	646.0
63-08-25	342.0	657.0
63-09-15	330.0	669.0
63-11-17	295.0	704.0
63-12-01	293.0	706.0
63-12-22	277.0	722.0
63-12-29	291.0	708.0
64-01-05	273.0	726.0
64-01-19	288.0	711.0
64-02-02	291.0	708.0
64-02-16	291.0	708.0
64-03-01	326.0	673.0
64-03-15	326.0	673.0
64-03-29	385.0	614.0
64-05-24	352.0	647.0
64-06-04	367.0	632.0
64-06-07	339.0	660.0
64-06-18	340.0	659.0
64-06-21	335.0	664.0
64-07-05	369.0	630.0
64-07-19	360.0	639.0
64-08-02	379.0	620.0
64-08-06	397.0	602.0

TABLE B-1 (CON'T.)

WWP NO. 3

DATE	DEPTH	ELEV.
64-08-16	404.0	595.0
64-09-20	365.0	634.0
64-10-04	365.0	634.0
65-07-25	388.0	611.0
65-08-15	390.0	609.0
65-08-22	381.0	618.0
68-05-05	369.0	630.0
68-05-26	355.0	644.0
71-11-23	294.0	705.0
72-01-05	301.0	698.0
72-01-06	294.0	705.0
72-01-07	297.0	702.0
72-01-13	292.0	707.0
72-01-19	290.0	709.0
72-01-31	300.0	699.0
72-02-07	289.0	710.0
72-02-16	293.0	706.0
72-02-24	290.0	709.0
72-03-10	298.0	701.0
72-04-12	294.0	705.0
72-04-26	296.0	703.0
72-05-06	303.0	696.0
72-05-13	282.0	717.0
72-05-21	296.0	703.0
72-05-27	306.0	693.0
72-06-03	323.0	676.0
72-06-11	305.0	694.0
72-06-18	328.0	671.0
72-06-24	312.0	687.0
72-06-25	307.0	692.0
72-07-09	330.0	669.0
72-08-20	330.0	669.0
72-09-03	344.0	655.0
72-09-10	328.0	671.0
72-09-16	312.0	687.0
72-10-06	307.0	692.0
72-10-20	296.0	703.0
72-11-02	296.0	703.0
72-11-28	296.0	703.0
73-02-20	298.0	701.0
73-04-15	309.0	690.0
73-04-22	309.0	690.0
73-05-06	314.0	685.0
73-05-26	307.0	692.0
73-06-03	384.0	615.0
73-06-13	425.0	574.0
73-06-14	423.0	576.0
73-06-15	420.0	579.0
73-06-16	419.0	580.0
73-06-17	411.0	588.0
73-06-18	413.0	586.0
73-06-19	415.0	584.0
73-06-20	416.0	583.0
73-06-24	430.0	569.0
73-06-25	425.0	574.0
73-06-26	425.0	574.0
73-07-01	448.0	551.0
73-07-06	441.0	558.0
73-07-07	435.0	564.0
73-07-23	435.0	564.0
73-07-29	480.0	519.0
73-08-12	441.0	558.0

WWP NO. 3

DATE	DEPTH	ELEV.
73-08-19	434.0	565.0
73-08-26	437.0	562.0
73-09-23	393.0	606.0

WWP NO. 4

DATE	DEPTH	ELEV.
61-07-02	218.0	658.0
61-08-21	228.0	648.0
61-08-25	226.0	650.0
61-08-30	221.0	655.0
61-09-05	191.0	685.0
61-09-21	194.0	682.0
61-09-26	196.0	680.0
61-09-28	194.0	682.0
61-10-02	201.0	675.0
61-10-09	184.0	692.0
61-10-12	194.0	682.0
61-10-16	194.0	682.0
61-10-19	191.0	685.0
61-10-22	191.0	685.0
61-10-26	190.0	686.0
61-11-05	191.0	685.0
61-11-19	189.0	687.0
61-12-03	189.0	687.0
61-12-16	168.0	708.0
61-12-31	166.0	710.0
62-01-14	166.0	710.0
62-01-28	164.0	712.0
62-02-11	164.0	712.0
62-02-25	167.0	709.0
62-03-11	168.0	708.0
62-03-25	167.0	709.0
62-04-08	166.0	710.0
62-04-19	198.0	678.0
62-05-03	183.0	693.0
62-05-06	173.0	703.0
62-05-10	173.0	703.0
62-05-13	167.0	709.0
62-05-17	187.0	689.0
62-05-24	171.0	705.0
62-05-27	163.0	713.0
62-05-31	194.0	682.0
62-06-03	185.0	691.0
62-06-07	176.0	700.0
62-06-10	188.0	688.0
62-06-14	203.0	673.0
62-07-19	227.0	649.0
62-07-22	225.0	651.0
62-08-05	208.0	668.0
62-08-13	219.0	657.0
62-10-10	189.0	687.0
62-10-11	175.0	701.0
62-10-14	173.0	703.0
62-10-18	172.0	704.0
62-10-21	171.0	705.0
62-10-25	171.0	705.0
62-11-02	191.0	685.0
62-11-04	177.0	699.0
62-11-08	171.0	705.0

WWP NO. 4

DATE	DEPTH	ELEV.
62-11-22	173.0	703.0
62-12-09	180.0	696.0
62-12-23	168.0	708.0
63-01-06	168.0	708.0
63-01-21	173.0	703.0
63-02-03	168.0	708.0
63-02-28	168.0	708.0
63-03-10	173.0	703.0
63-03-24	173.0	703.0
63-04-07	178.0	698.0
63-04-21	187.0	689.0
63-05-05	182.0	694.0
63-05-15	203.0	673.0
63-06-02	198.0	678.0
63-06-06	184.0	692.0
63-06-09	177.0	699.0
63-06-13	189.0	687.0
63-06-23	201.0	675.0
63-06-27	210.0	666.0
63-06-30	203.0	673.0
63-07-11	205.0	671.0
63-08-15	228.0	648.0
63-08-18	231.0	645.0
63-08-22	231.0	645.0
63-08-25	212.0	664.0
63-09-01	221.0	655.0
63-09-05	228.0	648.0
63-09-15	203.0	673.0
63-09-19	194.0	682.0
63-09-22	201.0	675.0
63-10-20	203.0	673.0
63-11-03	182.0	694.0
63-11-17	173.0	703.0
63-12-01	173.0	703.0
63-12-15	175.0	701.0
63-12-22	179.0	697.0
64-01-05	175.0	701.0
64-01-19	171.0	705.0
64-02-02	171.0	705.0
64-02-16	171.0	705.0
64-03-01	168.0	708.0
64-03-15	168.0	708.0
64-03-29	189.0	687.0
64-04-12	189.0	687.0
64-04-25	189.0	687.0
64-05-03	180.0	696.0
64-05-10	205.0	671.0
64-05-24	290.0	586.0
64-06-04	208.0	668.0
64-06-07	180.0	696.0
64-06-14	189.0	687.0
64-06-18	178.0	698.0
64-06-21	177.0	699.0
64-08-02	198.0	678.0
64-08-23	226.0	650.0
64-08-27	219.0	657.0
64-08-30	201.0	675.0
64-09-06	194.0	682.0
64-09-13	201.0	675.0
64-09-20	187.0	689.0
64-09-27	198.0	678.0
64-10-04	166.0	710.0

TABLE B-1 (CON'T.)

WWP NO. 4			WWP NO. 4			WWP NO. 4		
DATE	DEPTH	ELEV.	DATE	DEPTH	ELEV.	DATE	DEPTH	ELEV.
64-10-16	187.0	689.0	66-12-27	168.0	708.0	69-06-29	177.0	699.0
64-10-28	177.0	699.0	67-01-03	168.0	708.0	69-09-21	182.0	694.0
64-11-16	180.0	696.0	67-01-24	166.0	710.0	69-09-28	176.0	700.0
64-11-27	190.0	686.0	67-02-07	166.0	710.0	69-10-08	175.0	701.0
64-12-16	185.0	691.0	67-02-27	166.0	710.0	69-10-21	173.0	703.0
64-12-31	174.0	702.0	67-03-07	164.0	712.0	69-11-04	175.0	701.0
65-01-12	171.0	705.0	67-03-21	173.0	703.0	69-11-18	171.0	705.0
65-01-27	180.0	696.0	67-04-17	164.0	712.0	69-12-01	161.0	715.0
65-02-11	175.0	701.0	67-04-26	161.0	715.0	69-12-12	164.0	712.0
65-02-18	177.0	699.0	67-05-04	168.0	708.0	69-12-26	180.0	696.0
65-02-24	164.0	712.0	67-05-15	159.0	717.0	70-01-09	170.0	706.0
65-03-09	161.0	715.0	67-05-21	177.0	699.0	70-01-23	168.0	708.0
65-03-23	161.0	715.0	67-05-28	184.0	692.0	70-02-04	168.0	708.0
65-04-12	159.0	717.0	67-06-04	173.0	703.0	70-02-17	159.0	717.0
65-04-27	166.0	710.0	67-06-18	187.0	689.0	70-02-27	166.0	710.0
65-05-02	166.0	710.0	67-06-25	175.0	701.0	70-03-12	161.0	715.0
65-05-21	180.0	696.0	67-10-09	184.0	692.0	70-03-26	162.0	714.0
65-05-30	183.0	693.0	67-10-18	175.0	701.0	70-04-03	166.0	710.0
65-06-12	191.0	685.0	67-10-26	175.0	701.0	70-04-24	168.0	708.0
65-07-05	201.0	675.0	67-11-09	171.0	705.0	70-05-10	164.0	712.0
65-07-22	191.0	685.0	67-11-30	166.0	710.0	70-05-17	173.0	703.0
65-08-22	191.0	685.0	67-12-15	175.0	701.0	70-05-31	182.0	694.0
65-08-26	194.0	682.0	67-12-29	173.0	703.0	70-06-14	175.0	701.0
65-08-29	194.0	682.0	68-01-02	173.0	703.0	70-06-28	187.0	689.0
65-09-15	184.0	692.0	68-01-16	166.0	710.0	70-08-02	182.0	694.0
65-09-24	194.0	682.0	68-01-26	168.0	708.0	70-09-06	241.0	635.0
65-10-06	189.0	687.0	68-02-13	171.0	705.0	70-09-13	180.0	696.0
65-10-22	184.0	692.0	68-02-26	164.0	712.0	70-09-26	184.0	692.0
65-11-03	173.0	703.0	68-04-09	166.0	710.0	70-10-12	175.0	701.0
65-11-22	166.0	710.0	68-04-22	173.0	703.0	70-10-29	180.0	696.0
65-12-06	159.0	717.0	68-05-26	195.0	681.0	70-11-05	180.0	696.0
65-12-17	159.0	717.0	68-06-02	191.0	685.0	70-11-25	184.0	692.0
65-12-30	173.0	703.0	68-06-09	171.0	705.0	70-12-02	182.0	694.0
66-01-07	175.0	701.0	68-06-16	187.0	689.0	70-12-03	187.0	689.0
66-01-26	161.0	715.0	68-06-23	191.0	685.0	71-01-11	168.0	708.0
66-02-07	168.0	708.0	68-08-18	187.0	689.0	71-01-26	157.0	719.0
66-02-23	161.0	715.0	68-08-25	194.0	682.0	71-02-12	166.0	710.0
66-03-11	173.0	703.0	68-09-01	187.0	689.0	71-02-25	168.0	708.0
66-03-30	159.0	717.0	68-09-08	196.0	680.0	71-03-10	168.0	708.0
66-04-08	175.0	701.0	68-09-15	187.0	689.0	71-03-23	161.0	715.0
66-04-19	166.0	710.0	68-09-22	177.0	699.0	71-04-01	171.0	705.0
66-04-30	180.0	696.0	68-10-10	175.0	701.0	71-04-20	173.0	703.0
66-05-08	184.0	692.0	68-10-30	189.0	687.0	71-04-28	173.0	703.0
66-05-15	171.0	705.0	68-11-07	180.0	696.0	71-05-17	168.0	708.0
66-05-22	178.0	698.0	68-11-19	175.0	701.0	71-05-30	170.0	706.0
66-05-29	189.0	687.0	68-12-09	173.0	703.0	71-06-06	164.0	712.0
66-06-05	172.0	704.0	68-12-20	173.0	703.0	71-06-20	173.0	703.0
66-06-12	182.0	694.0	69-01-02	175.0	701.0	71-06-27	177.0	699.0
66-06-19	189.0	687.0	69-01-15	171.0	705.0	71-08-24	202.0	674.0
66-06-26	184.0	692.0	69-01-29	171.0	705.0	71-09-12	184.0	692.0
66-08-27	203.0	673.0	69-02-11	166.0	710.0	71-09-26	177.0	699.0
66-09-04	198.0	678.0	69-02-24	168.0	708.0	71-10-08	180.0	696.0
66-09-11	212.0	664.0	69-03-11	171.0	705.0	71-10-21	171.0	705.0
66-09-25	198.0	678.0	69-03-26	168.0	708.0	71-11-01	171.0	705.0
66-10-02	187.0	689.0	69-04-03	175.0	701.0	71-11-16	168.0	708.0
66-10-08	173.0	703.0	69-04-14	164.0	712.0	71-11-29	166.0	710.0
66-10-16	182.0	694.0	69-04-29	173.0	703.0	71-12-10	166.0	710.0
66-10-24	187.0	689.0	69-05-10	173.0	703.0	71-12-20	164.0	712.0
66-11-08	175.0	701.0	69-05-18	168.0	708.0	72-01-05	168.0	708.0
66-11-17	175.0	701.0	69-05-26	168.0	708.0	72-02-17	166.0	710.0
66-11-29	177.0	699.0	69-06-01	168.0	708.0	72-02-24	166.0	710.0
66-12-09	189.0	687.0	69-06-15	196.0	680.0	72-03-10	171.0	705.0

TABLE B-1 (CON'T.)

WWP NO. 4			WWP NO. 4			WWP NO. 4		
DATE	DEPTH	ELEV.	DATE	DEPTH	ELEV.	DATE	DEPTH	ELEV.
72-03-17	173.0	703.0	74-01-22	182.0	694.0	75-04-11	161.0	715.0
72-03-24	168.0	708.0	74-01-22	166.0	710.0	75-04-14	161.0	715.0
72-03-31	168.0	708.0	74-02-04	166.0	710.0	75-04-18	161.0	715.0
72-04-11	168.0	708.0	74-02-12	177.0	699.0	75-04-19	164.0	712.0
72-04-20	164.0	712.0	74-02-20	177.0	699.0	75-04-20	164.0	712.0
72-04-26	168.0	708.0	74-02-28	171.0	705.0	75-04-21	161.0	715.0
72-05-13	164.0	712.0	74-03-04	166.0	710.0	75-04-25	159.0	717.0
72-05-21	168.0	708.0	74-03-14	173.0	703.0	75-04-28	160.0	716.0
72-06-11	175.0	701.0	74-03-20	168.0	708.0	75-05-02	168.0	708.0
72-06-24	191.0	685.0	74-03-28	168.0	708.0	75-05-07	162.0	714.0
72-06-25	187.0	689.0	74-04-04	168.0	708.0	75-05-10	164.0	712.0
72-07-09	196.0	680.0	74-04-11	166.0	710.0	75-06-05	191.0	685.0
72-07-23	203.0	673.0	74-04-18	170.0	706.0	75-06-08	187.0	689.0
72-08-20	201.0	675.0	74-04-27	168.0	708.0	75-06-14	198.0	678.0
72-09-10	210.0	666.0	74-05-05	180.0	696.0	75-06-21	182.0	694.0
72-09-17	184.0	692.0	74-05-06	145.0	731.0	75-06-27	175.0	701.0
72-09-24	189.0	687.0	74-05-07	173.0	703.0	75-08-24	180.0	696.0
72-10-01	180.0	696.0	74-05-14	175.0	701.0	75-08-31	177.0	699.0
72-10-08	191.0	685.0	74-06-07	171.0	705.0	75-09-07	167.0	709.0
72-10-20	173.0	703.0	74-06-11	210.0	666.0	75-09-10	194.0	682.0
72-10-27	180.0	696.0	74-07-06	196.0	680.0	75-09-13	198.0	678.0
72-11-02	173.0	703.0	74-08-03	228.0	648.0	75-09-21	191.0	685.0
72-11-10	184.0	692.0	74-09-11	205.0	671.0	75-09-28	191.0	685.0
72-11-15	177.0	699.0	74-09-15	212.0	664.0	75-10-04	180.0	696.0
72-11-28	171.0	705.0	74-09-22	214.0	662.0	75-10-14	168.0	708.0
72-12-14	173.0	703.0	74-09-29	208.0	668.0	75-10-21	175.0	701.0
72-12-22	173.0	703.0	74-10-06	201.0	675.0	75-10-28	173.0	703.0
72-12-29	175.0	701.0	74-10-14	201.0	675.0	75-11-06	164.0	712.0
73-01-05	173.0	703.0	74-10-21	198.0	678.0	75-11-12	166.0	710.0
73-01-15	168.0	708.0	74-10-30	189.0	687.0	75-11-19	175.0	701.0
73-01-23	177.0	699.0	74-11-12	173.0	703.0	75-11-26	166.0	710.0
73-01-30	177.0	699.0	74-11-21	191.0	685.0	75-12-05	164.0	712.0
73-02-12	171.0	705.0	74-11-27	184.0	692.0	75-12-11	164.0	712.0
73-02-20	171.0	705.0	74-12-04	177.0	699.0	75-12-17	164.0	712.0
73-03-01	171.0	705.0	74-12-11	182.0	694.0	75-12-22	154.0	722.0
73-03-08	174.0	702.0	74-12-19	175.0	701.0	75-12-31	164.0	712.0
73-03-13	178.0	698.0	74-12-24	173.0	703.0	76-01-08	157.0	719.0
73-03-28	175.0	701.0	75-01-24	177.0	699.0	76-01-14	157.0	719.0
73-04-05	177.0	699.0	75-01-29	173.0	703.0	76-01-21	157.0	719.0
73-04-15	177.0	699.0	75-02-06	175.0	701.0	76-01-28	159.0	717.0
73-04-22	181.0	695.0	75-02-14	177.0	699.0	76-02-04	161.0	715.0
73-04-29	191.0	685.0	75-02-19	175.0	701.0	76-02-11	161.0	715.0
73-05-06	182.0	694.0	75-02-26	168.0	708.0	76-02-18	159.0	717.0
73-05-26	180.0	696.0	75-02-27	167.0	709.0	76-03-04	154.0	722.0
73-06-17	196.0	680.0	75-02-28	166.0	710.0	76-03-11	154.0	722.0
73-07-01	210.0	666.0	75-03-03	161.0	715.0	76-03-17	154.0	722.0
73-09-09	203.0	673.0	75-03-04	174.0	702.0	76-03-24	159.0	717.0
73-09-16	203.0	673.0	75-03-06	166.0	710.0	76-03-31	154.0	722.0
73-09-23	187.0	689.0	75-03-07	166.0	710.0	76-04-08	161.0	715.0
73-09-30	184.0	692.0	75-03-10	159.0	717.0	76-04-18	157.0	719.0
73-10-09	191.0	685.0	75-03-11	171.0	705.0	76-04-25	157.0	719.0
73-10-16	180.0	696.0	75-03-12	184.0	692.0	76-05-01	171.0	705.0
73-10-24	189.0	687.0	75-01-21	164.0	712.0	76-05-09	187.0	689.0
73-10-31	182.0	694.0	75-03-13	161.0	715.0	76-05-15	182.0	694.0
73-11-13	175.0	701.0	75-03-14	168.0	708.0	76-05-23	177.0	699.0
73-11-26	177.0	699.0	75-03-17	159.0	717.0	76-05-29	166.0	710.0
73-12-07	180.0	696.0	75-03-21	164.0	712.0	76-06-06	177.0	699.0
73-12-12	177.0	699.0	75-03-24	157.0	719.0	76-06-13	173.0	703.0
73-12-20	180.0	696.0	75-03-28	166.0	710.0	76-06-20	174.0	702.0
73-12-26	173.0	703.0	75-03-31	157.0	719.0	76-06-27	198.0	678.0
74-01-04	177.0	699.0	75-04-04	161.0	715.0	76-07-25	201.0	675.0
74-01-11	175.0	701.0	75-04-07	156.0	720.0	76-08-22	177.0	699.0

TABLE B-1 (CON'T.)

WWP NO. 4

DATE	DEPTH	ELEV.
76-08-29	184.0	692.0
76-09-12	182.0	694.0
76-08-19	182.0	694.0
76-09-26	182.0	694.0
76-10-03	195.0	681.0
76-10-10	173.0	703.0
76-10-20	168.0	708.0
76-10-28	161.0	715.0
76-11-04	168.0	708.0
76-11-17	161.0	715.0
76-11-24	168.0	708.0
76-12-01	161.0	715.0
76-12-09	154.0	722.0
76-12-16	164.0	712.0
76-12-29	161.0	715.0
77-01-05	163.7	712.3
77-01-13	159.1	716.9
77-01-19	163.7	712.3
77-01-26	161.4	714.6
77-02-02	159.1	716.9
77-02-09	154.4	721.6
77-02-16	156.8	719.2
77-02-23	159.1	716.9
77-03-02	157.0	719.0
77-03-10	159.0	717.0
77-03-16	159.0	717.0
77-03-30	164.0	712.0
77-04-06	154.0	722.0
77-04-13	175.0	701.0
77-04-20	171.0	705.0
77-07-10	194.7	681.3
77-07-17	198.3	677.7
77-07-24	214.5	661.5
77-07-31	210.0	666.0
77-08-07	212.0	664.0
77-08-14	219.0	657.0
77-08-21	205.0	671.0
77-08-28	187.5	688.5
77-09-04	171.0	705.0
77-09-10	175.0	701.0
77-09-19	173.0	703.0
77-09-25	171.0	705.0
77-10-03	156.7	719.3
77-10-10	156.7	719.3
77-10-17	161.4	714.6
77-10-25	170.6	705.4
77-10-31	154.5	721.5
77-11-07	168.3	707.7
77-11-14	161.4	714.6
77-11-29	168.6	707.4
77-12-07	159.1	716.9
77-12-15	159.1	716.9
77-12-21	156.8	719.2
77-12-28	159.1	716.9
78-01-04	159.1	716.9
78-01-11	159.1	716.9
78-01-18	149.8	726.2
78-01-21	152.1	723.9
78-01-23	152.1	723.9
78-02-01	152.1	723.9
78-02-08	156.7	719.3
78-02-15	161.4	714.6

WWP NO. 4

DATE	DEPTH	ELEV.
78-02-22	154.5	721.5
78-03-01	136.7	739.3
78-03-08	154.4	721.6
78-03-15	156.7	719.3
78-03-22	161.4	714.6
78-03-29	159.1	716.9
78-04-05	163.7	712.3
78-04-12	156.7	719.3
78-04-19	156.7	719.3
78-04-26	156.7	719.3
78-05-03	154.4	721.6
78-05-11	156.7	719.3
78-05-21	156.7	719.3
78-05-28	161.4	714.6

WWP NO. 5

DATE	DEPTH	ELEV.
61-08-09	573.0	574.0
61-08-10	557.0	590.0
61-08-16	554.0	587.0
61-08-19	558.0	589.0
61-08-22	553.0	594.0
61-08-24	545.0	602.0
61-09-05	452.0	695.0
65-06-12	490.0	657.0
65-06-20	480.0	667.0
65-08-05	530.0	617.0
65-08-15	510.0	637.0
65-08-22	480.0	667.0
65-08-26	475.0	672.0
65-08-29	475.0	672.0
65-09-05	478.0	669.0
65-09-15	475.0	672.0
65-09-22	510.0	637.0
65-09-24	455.0	692.0
65-10-06	455.0	692.0
65-10-22	455.0	692.0
65-11-03	460.0	687.0
65-11-22	460.0	687.0
65-12-06	457.0	690.0
65-12-17	455.0	692.0
65-12-30	455.0	692.0
66-01-07	455.0	692.0
66-01-26	450.0	697.0
66-02-07	455.0	692.0
66-02-23	455.0	692.0
66-03-11	455.0	692.0
66-03-30	450.0	697.0
66-04-08	450.0	697.0
66-04-19	450.0	697.0
66-04-30	450.0	697.0
66-05-08	450.0	697.0
66-05-15	450.0	697.0
66-05-22	470.0	677.0
66-06-05	450.0	697.0
66-06-12	450.0	697.0
66-09-04	455.0	692.0
66-09-11	458.0	689.0
66-09-25	458.0	689.0

WWP NO. 5

DATE	DEPTH	ELEV.
66-10-02	460.0	687.0
66-10-08	455.0	692.0
66-10-16	455.0	692.0
66-10-24	455.0	692.0
66-11-08	455.0	692.0
66-11-17	460.0	687.0
66-12-09	460.0	687.0
66-12-27	455.0	692.0
66-12-29	455.0	692.0
67-01-03	455.0	692.0
67-01-24	450.0	697.0
67-02-07	450.0	697.0
67-02-27	455.0	692.0
67-03-08	450.0	697.0
67-03-21	455.0	692.0
67-04-17	450.0	697.0
67-04-26	450.0	697.0
67-05-04	450.0	697.0
67-05-15	450.0	697.0
67-05-21	450.0	697.0
67-05-28	450.0	697.0
67-06-04	450.0	697.0
67-06-18	450.0	697.0
67-06-25	450.0	697.0
67-09-10	490.0	657.0
67-09-24	460.0	687.0
67-10-09	455.0	692.0
67-10-18	455.0	692.0
67-10-26	455.0	692.0
67-11-09	455.0	692.0
67-11-30	455.0	692.0
67-12-20	455.0	692.0
68-01-02	455.0	692.0
68-01-16	455.0	692.0
68-01-26	455.0	692.0
68-02-13	455.0	692.0
68-02-26	455.0	692.0
68-03-09	455.0	692.0
68-03-22	455.0	692.0
68-05-12	450.0	697.0
68-05-19	450.0	697.0
68-05-26	450.0	697.0
68-06-02	450.0	697.0
68-06-09	450.0	697.0
68-06-16	450.0	697.0
68-06-23	470.0	677.0
68-07-14	460.0	687.0
68-08-18	460.0	687.0
68-08-25	460.0	687.0
68-09-01	450.0	697.0
68-09-08	457.0	690.0
68-09-15	455.0	692.0
68-09-22	460.0	687.0
68-10-10	457.0	690.0
68-10-30	455.0	692.0
68-11-07	460.0	687.0
68-11-19	455.0	692.0
68-12-09	455.0	692.0
68-12-20	455.0	692.0
69-01-02	455.0	692.0
69-01-15	455.0	692.0
69-01-29	455.0	692.0

TABLE B-1 (CON'T.)

WWP NO. 5

DATE	DEPTH	ELEV.
69-02-11	455.0	692.0
69-02-24	455.0	692.0
69-03-11	455.0	692.0
69-03-26	450.0	697.0
69-04-03	450.0	697.0
69-04-15	450.0	697.0
69-04-29	450.0	697.0
69-05-10	450.0	697.0
69-05-18	450.0	697.0
69-05-25	450.0	697.0
69-06-01	450.0	697.0
69-06-08	450.0	697.0
69-06-15	450.0	697.0
69-06-22	490.0	657.0
69-06-29	450.0	697.0
69-07-07	450.0	697.0
69-09-08	465.0	682.0
69-09-14	460.0	687.0
69-09-21	460.0	687.0
69-09-28	460.0	687.0
69-10-08	460.0	687.0
69-10-27	460.0	687.0
69-11-04	460.0	687.0
69-11-16	460.0	687.0
69-12-01	457.0	690.0
69-12-12	455.0	692.0
69-12-26	460.0	687.0
70-01-09	455.0	692.0
70-01-23	457.0	691.0
70-02-04	555.0	592.0
70-02-17	455.0	692.0
70-02-27	455.0	692.0
70-03-12	455.0	692.0
70-03-26	455.0	692.0
70-04-03	455.0	692.0
70-04-24	452.0	695.0
70-05-10	460.0	687.0
70-05-17	460.0	687.0
70-05-24	450.0	697.0
70-05-31	450.0	697.0
70-06-14	450.0	697.0
70-06-21	450.0	697.0
70-06-28	470.0	677.0
70-08-02	460.0	687.0
70-09-13	455.0	692.0
70-09-26	455.0	692.0
70-10-12	455.0	692.0
70-10-29	455.0	692.0
70-11-05	455.0	692.0
70-11-25	455.0	692.0
70-12-02	455.0	692.0
70-12-23	455.0	692.0
71-01-11	450.0	697.0
71-01-26	450.0	697.0
71-02-12	450.0	697.0
71-02-25	450.0	697.0
71-03-10	450.0	697.0
71-03-23	450.0	697.0
71-04-20	450.0	697.0
71-04-28	450.0	697.0
71-05-09	450.0	697.0
71-05-17	445.0	702.0

WWP NO. 5

DATE	DEPTH	ELEV.
71-05-30	470.0	677.0
71-06-06	445.0	702.0
71-06-20	445.0	702.0
71-06-27	450.0	697.0
71-07-11	460.0	687.0
71-09-12	457.0	690.0
71-09-26	455.0	692.0
71-10-08	455.0	692.0
71-10-22	455.0	692.0
71-11-01	455.0	692.0
71-11-16	455.0	692.0
71-11-29	460.0	687.0
71-12-10	455.0	692.0
71-12-20	455.0	692.0
72-01-05	455.0	692.0
72-02-07	445.0	702.0
72-02-17	450.0	697.0
72-02-24	450.0	697.0
72-03-03	450.0	697.0
72-03-10	450.0	697.0
72-03-17	450.0	697.0
72-03-24	450.0	697.0
72-03-31	450.0	697.0
72-04-11	450.0	697.0
72-04-20	450.0	697.0
72-04-26	450.0	697.0
72-05-06	450.0	697.0
72-05-13	450.0	697.0
72-05-21	450.0	697.0
72-05-27	450.0	697.0
72-06-03	450.0	697.0
72-06-12	450.0	697.0
72-06-18	450.0	697.0
72-06-24	490.0	657.0
72-06-25	452.0	695.0
72-07-09	465.0	682.0
72-07-23	460.0	687.0
72-08-20	465.0	682.0
72-09-17	460.0	687.0
72-09-24	460.0	687.0
72-10-01	457.0	690.0
72-10-08	455.0	692.0
72-10-20	457.0	690.0
72-10-27	457.0	690.0
72-11-02	457.0	690.0
72-11-10	460.0	687.0
72-11-15	460.0	687.0
72-11-28	460.0	687.0
72-12-14	455.0	692.0
72-12-22	455.0	692.0
72-12-29	455.0	692.0
73-01-05	455.0	692.0
73-01-15	455.0	692.0
73-01-23	455.0	692.0
73-01-30	455.0	692.0
73-02-12	455.0	692.0
73-02-20	455.0	692.0
73-03-01	455.0	692.0
73-03-08	455.0	692.0
73-03-13	455.0	692.0
73-03-21	455.0	692.0
73-03-29	455.0	692.0

WWP NO. 5

DATE	DEPTH	ELEV.
73-04-05	455.0	692.0
73-04-15	455.0	692.0
73-04-22	455.0	692.0
73-04-29	455.0	692.0
73-05-06	455.0	692.0
73-05-13	455.0	692.0
73-05-26	465.0	682.0
73-06-03	470.0	677.0
73-06-24	540.0	607.0
73-09-09	485.0	662.0
73-09-23	470.0	677.0
73-09-30	460.0	687.0
73-10-09	455.0	692.0
73-10-16	460.0	687.0
73-10-24	460.0	687.0
73-10-31	460.0	687.0
73-11-13	460.0	687.0
73-11-26	460.0	687.0
73-12-07	460.0	687.0
73-12-12	460.0	687.0
73-12-20	460.0	687.0
73-12-26	460.0	687.0
74-01-04	460.0	687.0
74-01-11	460.0	687.0
74-01-22	460.0	687.0
74-01-28	457.0	690.0
74-02-04	457.0	690.0
74-02-12	460.0	687.0
74-02-20	458.0	689.0
74-02-28	457.0	690.0
74-03-04	455.0	692.0
74-03-14	457.0	690.0
74-03-20	457.0	690.0
74-03-28	453.0	694.0
74-04-04	460.0	687.0
74-04-11	450.0	697.0
74-04-19	450.0	697.0
74-04-27	450.0	697.0
74-06-12	450.0	697.0
74-07-06	475.0	672.0
74-09-15	465.0	682.0
74-09-29	470.0	677.0
74-10-06	460.0	687.0
74-10-14	460.0	687.0
74-10-27	460.0	687.0
74-10-30	460.0	687.0
74-11-12	457.0	690.0
74-11-21	460.0	687.0
74-11-27	460.0	687.0
74-12-04	460.0	687.0
74-12-11	460.0	687.0
74-12-19	460.0	687.0
74-12-24	460.0	687.0
74-12-31	460.0	687.0
75-01-09	457.0	690.0
75-01-15	457.0	690.0
75-01-24	457.0	690.0
75-01-30	460.0	687.0
75-02-07	457.0	690.0
75-02-14	460.0	687.0
75-02-19	457.0	690.0
75-02-26	445.0	702.0
75-02-27	445.0	702.0

TABLE B-I (CON'T.)

WWP NO. 5

DATE	DEPTH	ELEV.
75-02-28	443.0	704.0
75-03-03	440.0	707.0
75-03-04	440.0	707.0
75-03-06	450.0	697.0
75-03-07	440.0	707.0
75-03-10	440.0	707.0
75-03-11	440.0	707.0
75-03-12	437.0	710.0
75-03-14	440.0	707.0
75-03-17	435.0	712.0
75-03-21	440.0	707.0
75-03-24	435.0	712.0
75-03-28	435.0	712.0
75-03-31	435.0	712.0
75-04-04	430.0	717.0
75-04-07	430.0	717.0
75-04-11	430.0	717.0
75-04-14	432.0	715.0
75-04-18	430.0	717.0
75-04-19	430.0	717.0
75-04-20	430.0	717.0
75-04-21	430.0	717.0
75-04-25	430.0	717.0
75-04-28	430.0	717.0
75-05-02	430.0	717.0
75-05-07	430.0	717.0
75-05-10	430.0	717.0
75-05-13	430.0	717.0
75-05-16	430.0	717.0
75-05-19	430.0	717.0
75-05-24	430.0	717.0
75-06-14	480.0	667.0
75-06-21	440.0	707.0
75-06-27	480.0	667.0
75-08-17	510.0	637.0
75-08-24	480.0	667.0
75-08-31	430.0	717.0
75-09-21	435.0	712.0
75-10-04	450.0	697.0
75-10-14	430.0	717.0
75-10-21	430.0	717.0
75-10-28	430.0	717.0
75-11-06	430.0	717.0
75-11-12	430.0	717.0
75-11-19	430.0	717.0
75-11-26	430.0	717.0
75-12-05	430.0	717.0
75-12-11	430.0	717.0
75-12-17	430.0	717.0
75-12-22	430.0	717.0
75-12-31	430.0	717.0
76-01-08	430.0	717.0
76-01-14	430.0	717.0
76-01-21	430.0	717.0
76-01-28	430.0	717.0
76-02-04	430.0	717.0
76-02-11	430.0	717.0
76-02-18	430.0	717.0
76-03-04	430.0	717.0
76-03-11	430.0	717.0
76-03-17	430.0	717.0
76-03-24	430.0	717.0

WWP NO. 5

DATE	DEPTH	ELEV.
76-03-31	425.0	722.0
76-04-07	430.0	717.0
76-04-18	427.0	720.0
76-04-25	430.0	717.0
76-05-01	430.0	717.0
76-05-09	430.0	717.0
76-05-15	430.0	717.0
76-05-23	427.0	720.0
76-05-29	435.0	712.0
76-06-06	430.0	717.0
76-06-12	448.0	699.0
76-06-20	430.0	717.0
76-07-24	470.0	677.0
76-08-01	455.0	692.0
76-08-08	435.0	712.0
76-08-15	435.0	712.0
76-08-22	430.0	717.0
76-10-03	470.0	677.0
76-10-10	430.0	717.0
76-10-20	430.0	717.0
76-10-28	430.0	717.0
76-11-04	430.0	717.0
76-11-17	430.0	717.0
76-11-24	430.0	717.0
76-12-01	430.0	717.0
76-12-09	430.0	717.0
76-12-16	430.0	717.0
76-12-29	430.0	717.0
77-01-05	432.0	715.0
77-01-13	430.0	717.0
77-01-19	432.0	715.0
77-01-26	430.0	717.0
77-02-02	430.0	717.0
77-02-09	430.0	717.0
77-02-16	428.0	719.0
77-02-23	430.0	717.0
77-03-02	430.0	717.0
77-03-10	430.0	717.0
77-03-16	430.0	717.0
77-03-30	430.0	717.0
77-04-06	425.0	722.0
77-04-13	490.0	657.0
77-07-03	535.0	612.0
77-07-17	520.0	627.0
77-08-28	435.0	712.0
77-09-04	425.0	722.0
77-09-10	425.0	722.0
77-09-19	440.0	707.0
77-09-25	430.0	717.0
77-10-03	430.0	717.0
77-10-10	430.0	717.0
77-10-17	430.0	717.0
77-10-25	430.0	717.0
77-10-31	430.0	717.0
77-11-07	430.0	717.0
77-12-15	430.0	717.0
77-12-21	430.0	717.0
77-12-28	430.0	717.0
78-01-04	430.0	717.0
78-01-11	435.0	712.0
78-01-18	430.0	717.0
78-01-23	430.0	717.0

WWP NO. 5

DATE	DEPTH	ELEV.
78-02-01	430.0	717.0
78-02-08	435.0	712.0
78-02-22	435.0	712.0
78-03-01	430.0	717.0
78-03-08	430.0	717.0
78-03-15	430.0	717.0
78-03-22	435.0	712.0
78-03-29	430.0	717.0
78-04-05	430.0	717.0
78-04-12	430.0	717.0
78-04-19	435.0	712.0
78-04-26	430.0	717.0
78-05-03	430.0	717.0
78-05-11	430.0	717.0
78-05-21	430.0	717.0
78-05-28	430.0	717.0

APPENDIX C

AQUIFER INTERCONNECTION, INTERWELL DISTANCES, AND AQUIFER TEST NO. 5 DATA

TABLE C - 1

SUMMARY OF SELECTED MUNICIPAL AND INDUSTRIAL WELLS OF THE LEWISTON BASIN

A. AQUIFER INTERCONNECTION
B. INTERWELL DISTANCES

PART A. SUMMARY OF AQUIFER INTERCONNECTION

LEGEND: A - interconnection indicated from aquifer tests

B - interconnection indicated by basalt stratigraphy and/or historic water level response

C - separation indicated by hydrogeologic boundary

D - separation indicated by basalt stratigraphy

WELL NAME	L1A	L2	L3	L4	L5	LOID 1	TCF	C1	C2	C3	C4	C5	C6	C7	PW1	PW2	A2	PFI3
L1A		B	A	D	A	B	A	A	A	A	A	C	C	A	C	C	B	B
L2	6800		B	D	B	B	B	B	B	B	B	C	C	B	C	C	B	B
L3	7100	8000		D	A	B	A	A	A	A	A	C	C	A	C	C	B	B
L4	9400	2500	9900		D	D	D	D	D	D	D	C	C	D	C	C	D	D
L5	14,100	16,100	8200	18,500		B	A	A	A	A	A	C	C	A	C	C	B	B
LOID 1	—	22,400	21,700	—	22,800		B	B	B	B	B	B	C	C	C	C	B	B
TCF	1200	7800	7000	10,500	13,800	—		A	A	A	A	C	C	A	C	C	B	B
C1	10,100	15,900	10,400	18,500	10,500	—	10,300		A	A	A	C	C	A	C	C	B	B
C2	21,500	24,500	16,400	—	8300	—	21,100	14,600		A	A	C	C	A	C	C	B	B
C3	14,500	19,300	12,300	9900	8250	—	13,600	5300	9650		A	C	C	A	C	C	B	B
C4	12,400	16,100	8500	18,400	4300	—	11,800	6350	9200	4375		C	C	A	C	C	B	B
C5	17,600	23,400	16,200	—	11,800	—	16,700	7650	10,700	3900	8200		A	C	C	C	C	C
C6	22,800	—	18,700	—	11,700	—	21,900	14,100	4450	8775	10,400	8100		C	C	C	C	C
C7	16,900	21,600	14,200	24,300	8900	—	16,300	7700	7900	2750	5800	3100	6600		C	C	B	B
PW1	15,700	23,000	18,200	—	18,100	—	15,200	8000	17,500	10,500	13,700	9300	17,400	11,800		A	C	C
PW2	18,200	25,000	20,600	—	19,800	—	17,200	10,200	17,800	12,000	15,500	9700	17,900	12,900	2000		C	C
A2	—	—	24,200	—	15,600	—	—	—	11,700	21,300	19,600	22,600	15,200	19,800	—	—		B
PFI3	12,200	6200	15,000	4200	22,600	—	13,300	22,000	—	—	—	—	—	—	—	—	—	
WELL NAME	L1A	L2	L3	L4	L5	LOID 1	TCF	C1	C2	C3	C4	C5	C6	C7	PW1	PW2	A2	PFI3

PART B. SUMMARY OF INTERWELL DISTANCES (obtained from USGS 7½' series maps)

(distances are given in feet, blanks indicate that the interwell distance is greater than 25,000 feet)

WELL NAMES

Idaho

L1A - L5 City of Lewiston Well Nos. 1A-5

LOID 1 Lewiston Orchards Irrigation District Well No. 1

TCF Twin City Foods Well (formerly called " Sno-Crop Well No. 1")

PFI 3 Potlatch Forests Inc. Well No. 3 (West Levee)

Washington

C1-C7 WWP (Washington Water Power Co.) Well Nos. 1-7 of Clarkston

PW1,PW2 Port of Whitman (at Wilma) Wells Nos. 1 and 2

A2 City of Asotin Well No. 2

TABLE C-2

AQUIFER TEST NO. 5: BAROMETER AND RIVER STAGE DATA

Date	Time	Sta. Press.	R.S. @ Confl.	R.S. @ Anatone	R.S. @ Spldng.	Date	Time	Sta. Press.	R.S. @ Confl.	R.S. @ Anatone	R.S. @ Spldng.
4 March	08:00	28.69	6.68	6.62	4.08	5 March	:30		6.37	5.84	4.73
1979	:30			6.52	4.08		12:00	28.75	6.34	5.80	4.78
	09:00	.69	6.64	6.41	4.08		:30		6.41	5.80	4.83
	:30		6.48	6.31	4.08		13:00	.75	6.51	5.85	5.07
	10:00	.70	6.58	6.20	4.08		:30		6.54	5.93	5.28
	:30			6.10	4.08		14:00	.76	6.65	6.06	5.45
	11:00	.69	6.33	6.00	4.08		:30		6.42	6.21	5.56
	:30		6.18	5.91	4.08		15:00	.77	6.27	6.37	5.63
	12:00	.68	6.17	5.85	4.08		:30		6.29	6.52	5.67
	:30			5.81	4.08		16:00	.78	6.34	6.66	5.70
	13:00	.66	6.16	5.81	4.08		:30		6.40	6.77	5.73
	:30		6.07	5.87	4.08		17:00	.79	6.39	6.88	5.75
	14:00	.66	6.00	5.97	4.08		:30		5.85	6.98	5.79
	:30		5.82	6.11	4.08		18:00	.79	5.77	7.09	5.82
	15:00	.65	5.78	6.23	4.09		:30			7.17	5.85
	:30			6.44	4.09		19:00	.80	5.71	7.21	5.87
	16:00	.65	5.70	6.60	4.10		:30			7.21	5.90
	:30			6.77	4.12		20:00	.80	5.55	7.18	5.93
	17:00	.66	5.44	6.94	4.13		:30			7.11	5.96
	:30			7.11	4.15		21:00	.81	5.27	7.03	5.99
	18:00	.66	5.29	7.25	4.17		:30			6.94	6.01
	:30			7.36	4.19		22:00	.81	5.23	6.84	6.04
	19:00	.67	5.21	7.45	4.23		:30			6.76	6.07
	:30			7.52	4.25		23:00	.81	5.07	6.68	6.09
	20:00	.65	5.01	7.57	4.28		:30			6.62	6.12
	:30		4.93	7.58	4.30	6 March	24:00	28.81	4.05	6.58	6.15
	21:00	.65	4.91	7.59	4.32		:30			6.55	6.17
	:30		4.91	7.55	4.34		01:00	.81	5.47	6.54	6.20
	22:00	.66	4.91	7.51	4.35		:30			6.53	6.22
	:30		4.91	7.45	4.37		02:00	.82	6.10	6.55	6.23
	23:00	.66	4.90	7.41	4.39		:30			6.60	6.22
	:30		5.09	7.39	4.40		03:00	.81	6.30	6.70	6.16
5 March	24:00	28.66	5.22	7.37	4.41		:30			6.81	6.08
	:30			7.34	4.41		04:00	.82	6.87	6.90	5.99
	01:00	.67	5.96	7.31	4.42		:30		7.11	6.99	5.92
	:30		6.07	7.26	4.43		05:00	.83	7.29	7.03	5.87
	02:00	.68	6.20	7.21	4.44		:30			7.03	5.84
	:30			7.13	4.45		06:00	.84	7.46	6.99	5.83
	03:00	.68	6.59	7.06	4.46		:30			6.94	5.83
	:30		6.88	6.99	4.46		07:00	.85	7.45	6.86	5.85
	04:00	.68	7.09	6.92	4.47		:30		7.17	6.78	5.87
	:30			6.88	4.47		08:00	.86	7.09	6.69	5.89
	05:00	.66	7.36	6.83	4.48		:30			6.59	5.91
	:30		7.55	6.79	4.48		09:00	.86	6.90	6.49	5.92
	06:00	.69	7.80	6.76	4.49		:30		6.82	6.37	5.94
	:30			6.72	4.51		10:00	.86	6.76	6.27	5.95
	07:00	.71	7.60	6.67	4.52		:30			6.17	5.96
	:30			6.60	4.53		11:00	.84	6.53	6.07	5.99
	08:00	.73	6.85	6.52	4.55		:30			5.98	6.05
	:30			6.42	4.57		12:00	.87	6.35	5.91	6.17
	09:00	.73	6.60	6.32	4.59		:30		6.22	5.86	6.32
	:30		6.42	6.21	4.62		13:00	.79	6.17	5.84	6.47
	10:00	.73	6.12	6.10	4.64		:30			5.87	6.59
	:30		6.24	6.00	4.67		14:00	28.79	5.93	5.98	6.67
	11:00	28.75	6.22	5.91	4.69		:30			6.12	6.72

Notes: Station Pressure from Lewiston Airport WSO (Elev. 1438 ft msl) - inches of Hg ;
R.S. @ : River stages at the confluence, Anatone, Wa., and Spalding, Id. gauging stations given in feet above datum.

TABLE C-3

AQUIFER TEST NO. 5: TIME AND WATER LEVEL DATA OF 4-6 MARCH 1979

E.T. PUMP OFF: ELAPSED TIME OF RECOVERY FROM LAST PUMPING OF WWP NO. 3 (PUMP OFF AT 08:00, 3 MARCH 1979)

E.T. PUMP ON: ELAPSED TIME OF WWP NO. 3 PUMPING (PUMP ON AT 08:32, 5 MARCH 1979)

WATER LEVEL: READINGS FROM STEEL SURVEYOR'S TAPE ATTACHED TO ELECTRIC WATER LEVEL SOUNDER

WELL NAME	E.T. PUMP OFF (MIN.)	WATER LEVEL (FEET)
WWP 2	1710	72.95
WWP 2	1712	72.93
WWP 2	1715	72.86
WWP 2	1800	72.70
WWP 2	1805	72.68
WWP 2	1871	72.51
WWP 2	1874	72.51
WWP 2	1980	72.24
WWP 2	1987	72.25
WWP 2	2092	71.97
WWP 2	2094	71.97
WWP 2	2222	71.61
WWP 2	2160	71.61
WWP 2	2316	71.35
WWP 2	2258	71.33
WWP 2	2424	71.04
WWP 2	2460	70.15
WWP 2	2462	70.93
WWP 2	2463	70.90
WWP 2	2555	70.69
WWP 2	2556	70.67
WWP 2	2559	70.67
WWP 2	2640	70.43
WWP 2	2641	70.43
WWP 2	2736	70.19
WWP 2	2737	70.17
WWP 2	2867	69.98
WWP 2	2867	69.97
WWP 2	2810	69.97
WWP 2	2871	69.96
WWP 2	2872	69.96
WWP 2	2874	69.96
WWP 2	2875	69.96
WWP 2	2887	69.93
WWP 2	2890	69.93
WWP 2	2895	69.92
WWP 2	2900	69.91
WWP 2	2905	70.00
WWP 2	2910	69.89
WWP 2	2911	69.87

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 2	0	69.87
WWP 2	1	69.88
WWP 2	2	69.89
WWP 2	3	69.89
WWP 2	5	69.88
WWP 2	6	69.88
WWP 2	7	69.89
WWP 2	8.5	69.89
WWP 2	9.5	69.89
WWP 2	12	69.82
WWP 2	13	69.89
WWP 2	14	69.88
WWP 2	15	69.88
WWP 2	16	69.90
WWP 2	16.8	69.90
WWP 2	17.5	69.90
WWP 2	18.3	69.90
WWP 2	20.3	69.91
WWP 2	21.3	69.92
WWP 2	22.3	69.92
WWP 2	23	69.92
WWP 2	24	69.92
WWP 2	26	69.93
WWP 2	27	69.94
WWP 2	28.2	69.69
WWP 2	29	69.95
WWP 2	29.8	69.95
WWP 2	32	69.96
WWP 2	33	69.93
WWP 2	34	69.97
WWP 2	35	69.97
WWP 2	36	69.98
WWP 2	37	69.98
WWP 2	38	69.98
WWP 2	39	69.98
WWP 2	44.5	70.01
WWP 2	45.5	70.03
WWP 2	47.5	70.01
WWP 2	51	70.04
WWP 2	52	70.06
WWP 2	53.5	70.07
WWP 2	54.5	70.07
WWP 2	56.5	70.08
WWP 2	59.5	70.09
WWP 2	61.5	70.10

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 2	62.5	70.10
WWP 2	63.5	70.10
WWP 2	65	70.11
WWP 2	70	70.14
WWP 2	74	70.15
WWP 2	77	70.17
WWP 2	81	70.22
WWP 2	83.5	70.21
WWP 2	85	70.22
WWP 2	88	70.24
WWP 2	90	70.23
WWP 2	93	70.27
WWP 2	96	70.29
WWP 2	98	70.29
WWP 2	100	70.30
WWP 2	102	70.30
WWP 2	104	70.31
WWP 2	106	70.32
WWP 2	108	70.32
WWP 2	110	70.34
WWP 2	114	70.34
WWP 2	116	70.34
WWP 2	118	70.35
WWP 2	124	70.37
WWP 2	128	70.39
WWP 2	135	70.42
WWP 2	140	70.44
WWP 2	143	70.46
WWP 2	148	70.46
WWP 2	153	70.50
WWP 2	158	70.50
WWP 2	163	70.52
WWP 2	173	70.56
WWP 2	183	70.60
WWP 2	193	70.65
WWP 2	208	70.68
WWP 2	223	70.74
WWP 2	238	70.80
WWP 2	253	70.85
WWP 2	268	70.88
WWP 2	283	70.88
WWP 2	288	70.95
WWP 2	290	70.97
WWP 2	298	70.98
WWP 2	314	71.03

TABLE C-3 (CON'T.)

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 2	328	71.07
WWP 2	358	71.19
WWP 2	373	71.29
WWP 2	388	71.30
WWP 2	403	71.36
WWP 2	418	71.40
WWP 2	433	71.44
WWP 2	448	71.49
WWP 2	463	71.56
WWP 2	517	71.72
WWP 2	589	71.99
WWP 2	652	72.16
WWP 2	708	72.35
WWP 2	710	72.36
WWP 2	804	72.64
WWP 2	872	72.83
WWP 2	939	73.02
WWP 2	1024	73.15
WWP 2	1025	73.15
WWP 2	1083	73.29
WWP 2	1084	73.29
WWP 2	1152	73.42
WWP 2	1233	73.58
WWP 2	1306	73.77
WWP 2	1314	73.80
WWP 2	1317	73.80
WWP 2	1409	74.04
WWP 2	1411	74.03
WWP 2	1538	74.31
WWP 2	1541	74.35
WWP 2	1663	74.61
WWP 2	1664	74.62
WWP 2	1716	74.90

WELL NAME	E.T. PUMP OFF (MIN.)	WATER LEVEL (FEET)
WWP 4	1519	22.00
WWP 4	1523	21.99
WWP 4	1696	21.46
WWP 4	1699	21.45
WWP 4	1791	21.19
WWP 4	1862	21.03
WWP 4	1970	20.84
WWP 4	2081	20.52
WWP 4	2202	20.20
WWP 4	2303	19.92
WWP 4	2414	19.60
WWP 4	2445	19.50
WWP 4	2538	19.77
WWP 4	2623	19.01
WWP 4	2630	19.01
WWP 4	2727	18.65
WWP 4	2854	18.63
WWP 4	2872	18.63
WWP 4	2890	18.62
WWP 4	2905	18.60
WWP 4	2908	18.59
WWP 4	2909	18.59

WELL NAME	E.T. PUMP OFF (MIN.)	WATER LEVEL (FEET)
WWP 4	2910	18.59
WWP 4	2911	18.59

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 4	.4	18.59
WWP 4	.5	18.59
WWP 4	1.0	18.59
WWP 4	1.3	18.59
WWP 4	1.5	18.59
WWP 4	1.9	18.60
WWP 4	2.1	18.60
WWP 4	2.4	18.61
WWP 4	2.6	18.62
WWP 4	2.9	18.62
WWP 4	3.0	18.63
WWP 4	3.2	18.63
WWP 4	3.8	18.64
WWP 4	4.0	18.64
WWP 4	4.2	18.65
WWP 4	4.4	18.66
WWP 4	4.5	18.68
WWP 4	4.7	18.70
WWP 4	4.9	18.70
WWP 4	5.2	18.71
WWP 4	5.3	18.72
WWP 4	5.6	18.72
WWP 4	6.0	18.74
WWP 4	6.3	18.75
WWP 4	6.5	18.77
WWP 4	6.9	18.79
WWP 4	7.4	18.80
WWP 4	7.8	18.82
WWP 4	8.3	18.84
WWP 4	8.9	18.86
WWP 4	9.5	18.89
WWP 4	10.1	18.92
WWP 4	10.8	18.95
WWP 4	11.6	18.98
WWP 4	12.1	19.00
WWP 4	12.6	19.02
WWP 4	13.1	19.04
WWP 4	13.6	19.06
WWP 4	14.1	19.08
WWP 4	14.6	19.10
WWP 4	15.1	19.12
WWP 4	15.6	19.14
WWP 4	16.1	19.16
WWP 4	16.6	19.18
WWP 4	17.1	19.20
WWP 4	17.6	19.22
WWP 4	18	19.24
WWP 4	19	19.28
WWP 4	20	19.31
WWP 4	21	19.34
WWP 4	22	19.37
WWP 4	23	19.41
WWP 4	24	19.46
WWP 4	25	19.48

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 4	26	19.52
WWP 4	27	19.55
WWP 4	28	19.60
WWP 4	29	19.63
WWP 4	30.1	19.66
WWP 4	31	19.70
WWP 4	32	19.74
WWP 4	33	19.79
WWP 4	35	19.85
WWP 4	37	19.92
WWP 4	39	19.99
WWP 4	41	20.05
WWP 4	43	20.12
WWP 4	48	20.29
WWP 4	53	20.43
WWP 4	58	20.58
WWP 4	63	20.70
WWP 4	73	20.93
WWP 4	78	21.04
WWP 4	83	21.14
WWP 4	83	21.24
WWP 4	93	21.33
WWP 4	93	21.40
WWP 4	108	21.57
WWP 4	118	21.73
WWP 4	128	21.90
WWP 4	138	22.08
WWP 4	158	22.39
WWP 4	178	22.69
WWP 4	198	23.03
WWP 4	218	23.28
WWP 4	238	23.55
WWP 4	258	23.80
WWP 4	279	24.06
WWP 4	298	24.29
WWP 4	318	24.52
WWP 4	338	24.75
WWP 4	358	24.99
WWP 4	378	25.24
WWP 4	398	25.47
WWP 4	418	25.70
WWP 4	438	25.91
WWP 4	458	26.13
WWP 4	478	26.32
WWP 4	508	26.61
WWP 4	577	27.32
WWP 4	645	27.92
WWP 4	712	28.40
WWP 4	796	29.13
WWP 4	863	29.52
WWP 4	930	29.90
WWP 4	1013	30.17
WWP 4	1074	30.35
WWP 4	1144	30.62
WWP 4	1144	30.62
WWP 4	1221	30.32
WWP 4	1302	31.10
WWP 4	1407	31.55
WWP 4	1428	31.60
WWP 4	1428	31.60
WWP 4	1530	[illegible]

TABLE C-3 (CONT.)

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 4	1650	32.45
WWP 4	1762	32.91

WELL NAME	E.T. PUMP OFF (MIN.)	WATER LEVEL (FEET)
WWP 5	1587	3.98
WWP 5	1588	3.99
WWP 5	1754	3.85
WWP 5	1755	3.82
WWP 5	1831	3.79
WWP 5	1895	3.73
WWP 5	2020	3.68
WWP 5	2021	3.69
WWP 5	2141	3.63
WWP 5	2255	3.50
WWP 5	2345	3.46
WWP 5	2450	3.40
WWP 5	2498	3.36
WWP 5	2586	3.27
WWP 5	2587	3.27
WWP 5	2674	3.20
WWP 5	2675	3.19
WWP 5	2756	3.15
WWP 5	2856	3.02
WWP 5	2865	3.04
WWP 5	2880	3.03
WWP 5	2895	3.02
WWP 5	2900	3.02
WWP 5	2905	3.02
WWP 5	2910	3.02
WWP 5	2911	3.02

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 5	0	2.98
WWP 5	1	2.98
WWP 5	2	2.97
WWP 5	3	2.97
WWP 5	4.5	2.97
WWP 5	5.5	2.96
WWP 5	6	2.96
WWP 5	7	2.95
WWP 5	8	2.94
WWP 5	9	2.94
WWP 5	10	2.94
WWP 5	11	2.93
WWP 5	12	2.93
WWP 5	13	2.93
WWP 5	14	2.93
WWP 5	15	2.93
WWP 5	17	2.93
WWP 5	19	2.93
WWP 5	20	2.92
WWP 5	23	2.89
WWP 5	26	2.88
WWP 5	28	2.86
WWP 5	30	2.85
WWP 5	35	2.83
WWP 5	36	2.83
WWP 5	37	2.76
WWP 5	40	2.71
WWP 5	41	2.68
WWP 5	42	2.63
WWP 5	43	2.60
WWP 5	44	2.58
WWP 5	45	2.55
WWP 5	46	2.52
WWP 5	47	2.52
WWP 5	48	2.49
WWP 5	49	2.48
WWP 5	50	2.47
WWP 5	51	2.45
WWP 5	53	2.44
WWP 5	62	2.41
WWP 5	63	2.40
WWP 5	66	2.39
WWP 5	73	2.34
WWP 5	74	2.38
WWP 5	76	2.38
WWP 5	77	2.37
WWP 5	80	2.36
WWP 5	84	2.36
WWP 5	85	2.35
WWP 5	88	2.35
WWP 5	89	2.34
WWP 5	96	2.34
WWP 5	97	2.33
WWP 5	98	2.32
WWP 5	100	2.31
WWP 5	101	2.30
WWP 5	104	2.29
WWP 5	102	2.29
WWP 5	108	2.28
WWP 5	118	2.27
WWP 5	148	2.27
WWP 5	158	2.27
WWP 5	183	2.26
WWP 5	188	2.26
WWP 5	208	2.25
WWP 5	243	2.25
WWP 5	271	2.25
WWP 5	313	2.27
WWP 5	338	2.29
WWP 5	348	2.29
WWP 5	388	2.32
WWP 5	403	2.33
WWP 5	413	2.32
WWP 5	463	2.36
WWP 5	478	2.37
WWP 5	490	2.41
WWP 5	523	2.39
WWP 5	538	2.39
WWP 5	610	2.40
WWP 5	674	2.41
WWP 5	723	2.45
WWP 5	830	2.49
WWP 5	890	2.55
WWP 5	963	2.56
WWP 5	1048	2.60
WWP 5	1104	2.65
WWP 5	1178	2.67
WWP 5	1258	2.71
WWP 5	1326	2.78
WWP 5	1374	2.82
WWP 5	1558	2.87
WWP 5	1686	2.87
WWP 5	1808	2.93

WELL NAME	E.T. PUMP OFF (MIN.)	WATER LEVEL (FEET)
WWP 6	1557	3.97
WWP 6	1725	3.88
WWP 6	1816	3.78
WWP 6	1816	3.78
WWP 6	1881	3.71
WWP 6	1997	3.70
WWP 6	2115	3.55
WWP 6	2235	3.46
WWP 6	2320	3.42
WWP 6	2436	3.38
WWP 6	2475	3.36
WWP 6	2566	3.22
WWP 6	2568	3.22
WWP 6	2652	3.19
WWP 6	2654	3.19
WWP 6	2658	3.17
WWP 6	2744	3.12
WWP 6	2850	3.11
WWP 6	2658	3.17
WWP 6	2744	3.13
WWP 6	2850	3.11
WWP 6	2865	3.06
WWP 6	2880	3.28
WWP 6	2898	3.28
WWP 6	2895	3.27
WWP 6	2900	3.50
WWP 6	2903	3.50
WWP 6	2905	3.50
WWP 6	2905	3.27
WWP 6	2908	3.50
WWP 6	2910	3.50
WWP 6	2925	3.50
WWP 6	2911	3.50

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 6	0.0	3.50
WWP 6	1.0	3.50
WWP 6	2.0	3.52
WWP 6	3.0	3.52
WWP 6	4.0	3.53
WWP 6	5.0	3.52

TABLE C-3 (CON'T.)

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 6	6.0	3.52
WWP 6	7.0	3.52
WWP 6	8.0	3.52
WWP 6	9.0	3.52
WWP 6	10.0	3.52
WWP 6	11.0	3.52
WWP 6	12.0	3.52
WWP 6	13.0	3.52
WWP 6	14	3.52
WWP 6	15	3.52
WWP 6	16	3.52
WWP 6	17	3.52
WWP 6	18	3.52
WWP 6	19	3.52
WWP 6	20	3.52
WWP 6	25	3.52
WWP 6	30	3.52
WWP 6	40	3.52
WWP 6	46	3.52
WWP 6	53	3.52
WWP 6	58	3.52
WWP 6	73	3.52
WWP 6	89	3.52
WWP 6	92	3.52
WWP 6	103	3.22
WWP 6	118	3.52
WWP 6	118	3.22
WWP 6	113	3.52
WWP 6	133	3.22
WWP 6	138	3.52
WWP 6	148	3.21
WWP 6	178	3.20
WWP 6	208	3.19
WWP 6	223	3.18
WWP 6	238	3.18
WWP 6	253	3.17
WWP 6	268	3.18
WWP 6	298	3.18
WWP 6	328	3.18
WWP 6	348	3.18
WWP 6	358	3.18
WWP 6	388	3.19
WWP 6	408	3.20
WWP 6	418	3.20
WWP 6	433	3.20
WWP 6	448	3.20
WWP 6	464	3.21
WWP 6	473	3.22
WWP 6	524	3.23
WWP 6	597	3.23
WWP 6	659	3.24
WWP 6	707	3.25
WWP 6	813	3.27
WWP 6	878	3.27
WWP 6	947	3.31
WWP 6	1033	3.35
WWP 6	1092	3.35
WWP 6	1161	3.39
WWP 6	1242	3.44
WWP 6	1323	3.46
WWP 6	1393	3.51
WWP 6	1547	3.61
WWP 6	1648	3.56
WWP 6	1672	3.56
WWP 6	1784	3.59

WELL NAME	E.T. PUMP OFF (MIN.)	WATER LEVEL (FEET)
WWP 7	1572	11.65
WWP 7	1573	11.64
WWP 7	1737	11.05
WWP 7	1738	11.09
WWP 7	1739	11.10
WWP 7	1826	10.87
WWP 7	1890	10.72
WWP 7	1952	10.48
WWP 7	1954	10.46
WWP 7	2071	10.20
WWP 7	2179	9.96
WWP 7	2275	9.78
WWP 7	2382	9.58
WWP 7	2423	9.48
WWP 7	2513	9.32
WWP 7	2575	9.30
WWP 7	2578	9.28
WWP 7	2665	9.08
WWP 7	2666	7.07
WWP 7	2751	8.91
WWP 7	2847	8.74
WWP 7	2861	8.74
WWP 7	2867	8.66
WWP 7	2895	8.64
WWP 7	2909	8.63
WWP 7	2910	8.64
WWP 7	2910.5	8.64
WWP 7	2911	8.69
WWP 7	2911.5	8.70

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 7	0.0	8.69
WWP 7	0.5	8.65
WWP 7	1.0	8.64
WWP 7	1.3	8.64
WWP 7	1.5	8.64
WWP 7	1.8	8.67
WWP 7	2.0	8.65
WWP 7	2.5	8.65
WWP 7	2.8	8.66
WWP 7	3.0	8.66
WWP 7	3.2	8.70
WWP 7	3.5	8.65
WWP 7	3.7	8.72
WWP 7	4.0	8.72
WWP 7	4.2	8.73
WWP 7	4.5	8.73
WWP 7	4.7	8.73
WWP 7	5.0	8.74
WWP 7	5.2	8.74
WWP 7	5.5	8.74
WWP 7	5.8	8.67
WWP 7	6.0	8.67
WWP 7	6.3	8.69
WWP 7	6.5	8.69
WWP 7	6.8	8.69
WWP 7	7.0	8.69
WWP 7	7.3	8.69
WWP 7	7.5	8.69
WWP 7	7.8	8.69
WWP 7	8.0	8.70
WWP 7	8.3	8.75
WWP 7	8.5	8.69
WWP 7	8.8	8.69
WWP 7	9.0	8.67
WWP 7	10	8.65
WWP 7	11	8.70
WWP 7	12	8.73
WWP 7	13	8.73
WWP 7	14	8.73
WWP 7	15	8.73
WWP 7	16	8.74
WWP 7	17	8.71
WWP 7	18	8.74
WWP 7	19	8.75
WWP 7	20	8.74
WWP 7	21	8.72
WWP 7	22	8.72
WWP 7	23	8.75
WWP 7	24	8.75
WWP 7	25	8.71
WWP 7	26	8.78
WWP 7	27	8.71
WWP 7	28	8.81
WWP 7	29	8.71
WWP 7	30	8.71
WWP 7	31	8.71
WWP 7	32	8.71
WWP 7	33	8.72
WWP 7	34	8.72
WWP 7	35	8.74
WWP 7	36	8.73
WWP 7	37	8.74
WWP 7	38	8.74
WWP 7	39	8.74
WWP 7	40	8.76
WWP 7	41	8.77
WWP 7	42	8.77
WWP 7	43	8.77
WWP 7	44	8.78
WWP 7	45	8.78
WWP 7	46	8.81
WWP 7	47	8.83
WWP 7	48	8.81
WWP 7	49	8.81
WWP 7	50	8.81
WWP 7	51	8.82
WWP 7	52	8.91
WWP 7	53	8.85

TABLE C-3 (CON'T.)

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
WWP 7	54	8.82
WWP 7	55	8.82
WWP 7	56	8.83
WWP 7	57	8.85
WWP 7	58	8.86
WWP 7	59	8.84
WWP 7	60	8.86
WWP 7	61	8.85
WWP 7	62	8.88
WWP 7	64	8.89
WWP 7	66	8.90
WWP 7	68	8.90
WWP 7	70	8.90
WWP 7	72	8.91
WWP 7	74	8.92
WWP 7	76	8.95
WWP 7	78	8.95
WWP 7	83	9.00
WWP 7	88	9.02
WWP 7	93	9.05
WWP 7	105	9.09
WWP 7	103	9.12
WWP 7	111	9.13
WWP 7	113	9.15
WWP 7	118	9.19
WWP 7	123	9.22
WWP 7	128	9.25
WWP 7	133	9.29
WWP 7	138	9.33
WWP 7	143	9.38
WWP 7	153	9.45
WWP 7	158	9.47
WWP 7	163	9.50
WWP 7	168	9.56
WWP 7	173	9.60
WWP 7	178	9.62
WWP 7	183	9.65
WWP 7	188	9.69
WWP 7	193	9.73
WWP 7	198	9.78
WWP 7	203	9.81
WWP 7	208	9.85
WWP 7	213	9.90
WWP 7	218	9.93
WWP 7	223	9.99
WWP 7	228	10.02
WWP 7	238	10.10
WWP 7	248	10.16
WWP 7	258	10.27
WWP 7	263	10.34
WWP 7	283	10.46
WWP 7	328	10.82
WWP 7	343	10.93
WWP 7	358	11.06
WWP 7	366	11.11
WWP 7	375	11.19
WWP 7	382	11.22
WWP 7	393	11.32
WWP 7	418	11.53
WWP 7	436	11.65
WWP 7	458	11.84
WWP 7	482	12.03
WWP 7	531	12.37
WWP 7	604	12.88
WWP 7	667	13.29
WWP 7	723	13.66
WWP 7	823	14.25
WWP 7	884	14.60
WWP 7	957	14.97
WWP 7	1042	15.35
WWP 7	1100	15.38
WWP 7	1171	15.87
WWP 7	1250	16.15
WWP 7	1331	16.40
WWP 7	1382	16.54
WWP 7	1554	16.99
WWP 7	1798	17.62
WWP 7	1680	17.30

WELL NAME	E.T. PUMP OFF (MIN.)	WATER LEVEL (FEET)
POW 1	2055	25.55
POW 1	2057	25.02
POW 1	2064	25.02
POW 1	2114	24.93
POW 1	2115	24.93
POW 1	2345	24.92
POW 1	2401	24.92
POW 1	2405	24.92
POW 1	2406	24.92
POW 1	2412	24.85
POW 1	2519	24.77
POW 1	2605	24.61
POW 1	2700	24.38
POW 1	2874	24.07
POW 1	2909	24.05

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
POW 1	27	24.06
POW 1	35	24.04
POW 1	47	24.04
POW 1	60	24.06
POW 1	62	24.05
POW 1	64	24.05
POW 1	79	24.07
POW 1	80	24.08
POW 1	96	24.06
POW 1	93	24.08
POW 1	102	24.08
POW 1	114	24.09
POW 1	125	24.09
POW 1	137	24.11
POW 1	150	24.12
POW 1	153	24.10
POW 1	155	24.10
POW 1	165	24.11
POW 1	167	24.11
POW 1	178	24.12
POW 1	180	24.11
POW 1	191	24.12
POW 1	192	24.12
POW 1	203	24.13
POW 1	204	24.12
POW 1	229	24.12
POW 1	230	24.11
POW 1	290	24.11
POW 1	292	24.10
POW 1	322	24.10
POW 1	323	24.10
POW 1	352	24.10
POW 1	353	24.10
POW 1	384	24.11
POW 1	385	24.11
POW 1	405	24.12
POW 1	407	24.11
POW 1	542	24.12
POW 1	478	24.13
POW 1	480	24.13
POW 1	508	24.15
POW 1	509	24.15
POW 1	540	24.17
POW 1	542	24.19
POW 1	582	24.23
POW 1	754	24.44
POW 1	1467	23.94

WELL NAME	E.T. PUMP OFF (MIN.)	WATER LEVEL (FEET)
POW 2	2105	57.93
POW 2	2107	58.11
POW 2	2335	58.10
POW 2	2392	58.10
POW 2	2461	57.95
POW 2	2526	57.77
POW 2	2613	57.53
POW 2	2708	57.14
POW 2	2863	56.85
POW 2	2911	56.94

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
POW 2	13	56.86
POW 2	23	56.86
POW 2	38	56.87
POW 2	43	56.88
POW 2	48	56.90
POW 2	59	56.91
POW 2	64	56.93

TABLE C-3 (CON'T.)

WELL NAME	E.T. PUMP ON (MIN.)	WATER LEVEL (FEET)
POW 2	71	56.94
POW 2	76	56.95
POW 2	86	56.96
POW 2	93	56.97
POW 2	104	56.98
POW 2	212	57.13
POW 2	238	57.14
POW 2	263	57.14
POW 2	283	57.14
POW 2	313	57.12
POW 2	343	57.09
POW 2	373	57.04
POW 2	389	57.02
POW 2	419	57.06
POW 2	444	57.05
POW 2	483	57.09
POW 2	508	57.08
POW 2	538	57.12
POW 2	593	57.35
POW 2	763	57.69
POW 2	1454	56.99
POW 2	1456	56.99

TABLE C-4

AQUIFER TEST NO. 5: TIME, WATER LEVEL DATA, AND EXTRAPOLATED RECOVERY TRENDS OF WWP NO. 1 WELL*

*DATA GIVEN IN UNITS OF MINUTES AND FEET

E.T. PUMP OFF: ELAPSED TIME OF RECOVERY FROM LAST PUMPING OF WWP NO. 3 (PUMP OFF @ 08:00, 3 MARCH 1979)

E.T. PUMP ON: ELAPSED TIME OF WWP NO. 3 PUMPING (PUMP ON @ 08:32, 5 MARCH 1979)

WATER LEVEL: READINGS FROM STEEL SURVEYOR'S TAPE ATTACHED TO ELECTRIC WATER LEVEL SOUNDER

UNADJ. D.D.: UNADJUSTED DRAWDOWN - NET CHANGE OF WATER LEVEL SINCE PUMPING STARTED

TREND 1: WATER LEVELS AND DRAWDOWNS CALCULATED FROM THE LATE TIME ANTECEDENT TREND OF RECOVERY

TREND 2: WATER LEVELS AND DRAWDOWNS CALCULATED FROM THE EARLY ANTECEDENT TREND OF RECOVERY

	E.T. PUMP OFF	WATER LEVEL
WWP 1	1489	29.94
WWP 1	1490	29.93
WWP 1	1492	29.92
WWP 1	1493	29.90
WWP 1	1684	29.36
WWP 1	1685	29.36
WWP 1	1783	29.11
WWP 1	1855	28.94
WWP 1	1947	28.75
WWP 1	1950	28.73
WWP 1	1955	28.71
WWP 1	2042	28.50
WWP 1	2190	28.10
WWP 1	2286	27.83
WWP 1	2405	27.52
WWP 1	2435	27.40
WWP 1	2531	27.15
WWP 1	2620	26.91
WWP 1	2622	26.91
WWP 1	2721	26.66
WWP 1	2867	26.36
WWP 1	2884	26.34
WWP 1	2895	26.33
WWP 1	2898	26.32
WWP 1	2909	26.31
WWP 1	2910	26.31
WWP 1	2911	26.32

					TREND 1		TREND 2	
	E.T. PUMP OFF	E.T. PUMP ON	WATER LEVEL	UNADJ. D.D.	CALC. WATER LEVEL	CALC. D.D.	CALC. WATER LEVEL	CALC. D.D.
WWP 1	2912	0	26.32	0.00	26.25	0.07	26.30	0.02
WWP 1	2913	1	26.31	-0.01	26.25	0.06	26.30	0.01
WWP 1	2914	2	26.32	0.00	26.25	0.07	26.30	0.02

TABLE C-4(CON'T.)

	E.T. PUMP OFF	E.T. PUMP ON	WATER LEVEL	UNADJ. D.D.	TREND 1 CALC. WATER LEVEL	TREND 1 CALC. D.D.	TREND 2 CALC. WATER LEVEL	TREND 2 CALC. D.D.
WWP 1	2915	3	26.32	0.00	26.25	0.07	26.30	0.02
WWP 1	2916	4	26.32	0.00	26.24	0.08	26.28	0.04
WWP 1	2917	5	26.34	0.02	26.24	0.10	26.28	0.06
WWP 1	2918	6	26.35	0.03	26.24	0.11	26.28	0.07
WWP 1	2919	7	26.38	0.06	26.24	0.14	26.28	0.10
WWP 1	2920	8	26.39	0.07	26.23	0.16	26.28	0.11
WWP 1	2921	9	26.41	0.09	26.23	0.18	26.28	0.13
WWP 1	2922	10	26.44	0.12	26.22	0.22	26.28	0.16
WWP 1	2923	11	26.45	0.13	26.22	0.23	26.28	0.17
WWP 1	2924	12	26.49	0.17	26.22	0.27	26.28	0.21
WWP 1	2925	13	26.52	0.20	26.21	0.31	26.27	0.25
WWP 1	2926	14	26.54	0.22	26.21	0.33	26.27	0.27
WWP 1	2927	15	26.56	0.24	26.21	0.35	26.27	0.29
WWP 1	2929	17	26.63	0.31	26.21	0.42	26.27	0.36
WWP 1	2931	19	26.68	0.36	26.20	0.48	26.27	0.41
WWP 1	2933	21	26.73	0.41	26.20	0.53	26.27	0.46
WWP 1	2934	22	26.78	0.46	26.20	0.58	26.27	0.51
WWP 1	2935	23	26.81	0.49	26.19	0.62	26.27	0.54
WWP 1	2936	24	26.85	0.53	26.19	0.66	26.27	0.58
WWP 1	2938	26	26.91	0.59	26.18	0.73	26.27	0.64
WWP 1	2939	27	26.94	0.62	26.18	0.76	26.27	0.67
WWP 1	2940	28	26.99	0.67	26.17	0.82	26.27	0.72
WWP 1	2942	30	27.05	0.73	26.17	0.88	26.27	0.78
WWP 1	2944	32	27.12	0.80	26.17	0.95	26.27	0.85
WWP 1	2946	34	27.21	0.89	26.17	1.04	26.27	0.94
WWP 1	2950	38	27.31	0.99	26.15	1.16	26.25	1.06
WWP 1	2952	40	27.40	1.08	26.15	1.25	26.25	1.15
WWP 1	2955	43	27.50	1.18	26.14	1.36	26.25	1.25
WWP 1	2960	48	27.66	1.34	26.13	1.53	26.24	1.42
WWP 1	2964	52	27.81	1.49	26.13	1.68	26.24	1.57
WWP 1	2968	56	27.96	1.64	26.12	1.84	26.24	1.72
WWP 1	2972	60	28.08	1.71	26.10	1.98	26.24	1.84
WWP 1	2974	62	28.14	1.82	26.10	2.04	26.23	1.90
WWP 1	2978	66	28.28	1.96	26.08	2.20	26.23	2.04
WWP 1	2982	70	28.40	2.08	26.05	2.35	26.22	2.18
WWP 1	2986	74	28.53	2.22	26.05	2.48	26.22	2.31
WWP 1	2990	78	28.66	2.34	26.03	2.63	26.21	2.45
WWP 1	2996	84	28.85	2.53	26.03	2.82	26.21	2.64
WWP 1	3001	89	28.98	2.66	26.01	2.97	26.20	2.78
WWP 1	3007	95	29.16	2.84	26.01	3.15	26.20	2.96
WWP 1	3011	99	29.27	2.95	26.00	3.27	26.20	3.07
WWP 1	3019	107	29.49	3.17	26.00	3.49	26.18	3.31
WWP 1	3025	113	29.66	3.34	25.99	3.67	26.17	3.49
WWP 1	3030	118	29.77	3.45	25.97	3.80	26.17	3.60
WWP 1	3035	123	29.91	3.59	25.97	3.94	26.17	3.74
WWP 1	3040	128	30.01	3.69	25.95	4.06	26.16	3.85
WWP 1	3050	138	30.26	3.94	25.92	4.34	26.15	4.11
WWP 1	3060	148	30.50	4.18	25.90	4.60	26.14	4.36
WWP 1	3070	158	30.70	4.38	25.87	4.83	26.14	4.56
WWP 1	3085	173	31.00	4.68	25.85	5.15	26.13	4.87
WWP 1	3100	188	31.30	4.98	25.82	5.48	26.10	5.20
WWP 1	3115	203	31.57	5.25	25.77	5.80	26.08	5.49
WWP 1	3125	213	31.75	5.43	25.75	6.00	26.07	5.68
WWP 1	3130	218	31.84	5.52	25.75	6.09	26.07	5.77
WWP 1	3145	233	32.09	5.77	25.72	6.37	26.04	6.05
WWP 1	3165	253	32.40	6.08	25.67	6.73	26.04	6.36
WWP 1	3185	273	32.72	6.40	25.62	7.10	26.01	6.71
WWP 1	3205	293	33.06	6.74	25.59	7.47	26.00	7.06
WWP 1	3265	353	34.10	7.78	25.48	8.62	25.95	8.15
WWP 1	3295	383	34.53	8.21	25.41	9.12	25.90	8.65
WWP 1	3325	413	34.95	8.63	25.35	9.60	25.90	9.05

TABLE C-4 (CON'T.)

	E.T. PUMP OFF	E.T. PUMP ON	WATER LEVEL	UNADJ. D.D.	TREND 1 CALC. WATER LEVEL	TREND 1 CALC. D.D.	TREND 2 CALC. WATER LEVEL	TREND 2 CALC. D.D.
WWP 1	3355	443	35.40	9.08	25.29	10.11	25.87	9.53
WWP 1	3385	473	35.77	9.45	25.22	10.55	25.87	9.90
WWP 1	3415	503	36.14	9.82	25.19	10.95	25.80	10.34
WWP 1	3460	543	36.71	10.37	25.09	11.62	25.75	10.96
WWP 1	3530	618	37.40	11.08	24.95	12.45	25.67	11.73
WWP 1	3594	682	38.04	11.72	24.82	13.22	25.60	12.44
WWP 1	3643	736	38.57	12.25	24.72	13.85	25.56	13.01
WWP 1	3752	840	39.20	12.88	24.53	14.67	25.48	13.72
WWP 1	3815	903	39.44	13.12	24.44	15.00	25.42	14.02
WWP 1	3883	971	39.66	13.34	24.30	15.36	25.35	14.31
WWP 1	3920	1008	39.74	13.42	24.26	15.48	25.32	14.42
WWP 1	3980	1068	39.90	13.58	24.12	15.78	25.27	14.63
WWP 1	4040	1123	40.04	13.72	24.03	16.01	25.23	14.81
WWP 1	4121	1209	40.21	13.89	23.90	16.31	25.18	15.03
WWP 1	4207	1295	40.42	14.10	23.79	16.63	25.12	15.30
WWP 1	4274	1362	40.60	14.28	23.68	16.92	25.06	15.54
WWP 1	4312	1400	40.68	14.36	23.60	17.08	25.04	15.64
WWP 1	4436	1524	41.63	14.91	23.43	18.20	24.95	16.28
WWP 1	4572	1660	42.07	15.75	23.23	18.84	24.85	17.22
WWP 1	4606	1694	42.27	15.95	23.18	19.09	24.82	17.45
WWP 1	4733	1821	42.78	16.46	23.00	19.78	24.75	18.03