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Groundwater Impact Assessment Report for the 400 Area Ponds

Geosciences
Westinghouse Hanford Company

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and Waste Management



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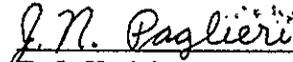
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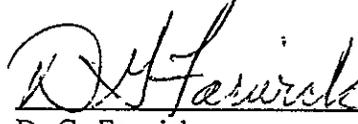
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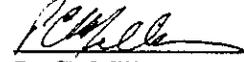
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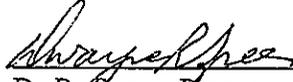
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EXECUTIVE SUMMARY

The 400 Area Secondary Cooling Water stream (informally designated the process sewer effluent) discharges to the 4608B and 4608C percolation ponds (informally designated the 400 Area ponds) located north of the 400 Area perimeter fence. This report satisfies one of the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-17-00B as agreed by the U.S. Department of Energy, Washington State Department of Ecology, and the U.S. Environmental Protection Agency. Tri-Party Agreement Milestone M-17-00B includes a requirement to assess impacts to groundwater from disposal of the process effluent to the 400 Area ponds.

The process sewer effluent is associated mainly with cooling towers for the Fast Flux Test Facility and the Fuels and Materials Examination Facility and air compressor condensate. The process sewer effluent does not contain chemical or radionuclide constituents above the guideline concentrations (DOE Order 5400.5 and WAC 173-200). Both tritium and nitrate originating from the 200 Areas are present in the upper portion of the unconfined aquifer in the vicinity of the 400 Areas. Nitrate concentrations are slightly elevated in the immediate vicinity of the sanitary sewer lagoon, located adjacent to the 400 Area ponds, likely due to disposal of sanitary sewage effluent. Tritium concentration in groundwater in the vicinity of the 400 Area ponds is lower than both up-gradient and down-gradient wells. This is probably due to dilution effects from discharge to the ponds and sanitary sewer lagoon. The process sewer effluent has substantially lower tritium concentrations than groundwater sampled from up-gradient and down-gradient monitoring wells, because it is derived from a water supply production well that draws from a deeper, less contaminated portion of the aquifer.

There are no significant hydrologic or contaminant impacts from the disposal of process sewer effluent in the 400 Area ponds. The monitoring well immediately down-gradient of the 400 Area ponds may be screened too deeply to representatively monitor the uppermost portion of the aquifer and hence the impact of the process sewer effluent on groundwater. Monitoring of the process sewer effluent directly should provide adequate monitoring for the level of impact from this site to the underlying groundwater.

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1.0 INTRODUCTION

Groundwater impact assessments are required for a number of liquid effluent receiving sites according to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestones M-17-00A and -00B, as agreed by the U.S. Department of Energy (DOE), Washington State Department of Ecology, and the U.S. Environmental Protection Agency (Ecology et al. 1991). This report assesses the impacts to groundwater from the disposal of the 400 Area Secondary Cooling Water stream to the 400 Area ponds.

The 400 Area ponds, formally known as the 4608B and 4608C percolation ponds, are located north of the 400 Area perimeter fence. For convenience, the 400 Area Secondary Cooling Water Stream is referred to as process sewer effluent in this report.

1.1 BACKGROUND

In response to public comments on the original Tri-Party Agreement, and at the request of the signatories on the Tri-Party Agreement, the DOE Richland Field Office (RL) conducted a study to assess the impact of liquid effluents discharged to the ground at the Hanford Site (WHC 1990a, 1990b). The EPA and Ecology expressed several concerns regarding uncertainties in the evaluations made by RL. Foremost among these concerns were the lack of site-specific data, the need to consider interactions with adjacent liquid discharge facilities, and the need for more rigorous models of contaminant transport. As a result of these concerns, the RL, Ecology, and EPA (the three parties) created a series of Tri-Party Agreement Milestones, including M-17-00A, M-17-00B, M-17-13, and M-17-13A, which pertain to groundwater impact assessments.

The Tri-Party Agreement Milestones M-17-00A and -00B require impact assessments for Phase I and II waste streams. Phase I and II waste streams are defined in Stordeur and Flyckt (1988). The 400 Area ponds receive a lower priority Phase II waste stream. Tri-Party Agreement Milestone M-17-13 required the development of a methodology for assessing the impact of liquid effluent discharge on groundwater, which resulted in the document *A Methodology for Assessing Impacts to Groundwater from Disposal of Liquid Effluent to the Soil at the Hanford Site* (WHC 1991a). Thirty days after regulatory approval of the methodology document, as required by Tri-Party Agreement Milestone M-17-13A, a schedule for performing the assessments at 13 receiving sites was completed. The 400 Area ponds are identified in the schedule as the first receiving site to undergo a groundwater impact assessment. This is because the groundwater impact assessment will also support the geohydrologic evaluation portion of a WAC 173-216 State waste discharge permit application to be submitted to Ecology in December 1992.

1.2 METHODOLOGY

The aforementioned methodology document (WHC 1991a) was followed in preparing the groundwater impact assessment for the 400 Area ponds. Included in that document is the categorization of each of the 13 receiving sites into 1 of 3 levels based on the amount of effort needed to perform the assessment. A level 1 receiving site groundwater impact assessment relies on available information. A groundwater impact assessment of a level 2 receiving site may require nonintrusive field work to verify the extent of existing contamination. A level 3 site may require intrusive field work. If through the course of performing a level 1 impact assessment, it is

discovered that existing information is inadequate, the assessment may be raised to a level 2 or 3 assessment.

The methodology document outlines several tasks to be conducted as part of the groundwater impact assessment for level 1 receiving sites:

- Prepare and present plan describing how the groundwater assessment will be conducted
- Characterize the liquid effluent stream
- Evaluate the site-specific hydrogeology
- Develop a site conceptual model
- Assess the hydrologic impact of the liquid effluent stream
- Assess the contaminant impact of the liquid effluent stream
- Evaluate the adequacy of the existing monitoring well network
- Prepare a written report of the results.

The tasks required for level 2 and 3 receiving sites are similar to those outlined above, but also include field work related activities. The 400 Area ponds were categorized as a level 1 receiving site, primarily on the basis of effluent characteristics.

Several key assumptions inherent to all groundwater impact assessments are explained in the methodology document and warrant summarizing here. For this impact assessment, the following assumptions are relevant.

- The expected level of impact from use of the receiving site determines how well the chemistry, geology, and hydrology need to be understood.
- Modeling sophistication is tailored to available information and the expected level of impact of the receiving site.
- Historical data are fully useable.

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2.0 400 AREA FACILITIES DESCRIPTION

2.1 LOCATION

The Hanford Site is a 1,434 km² (560-mi²) tract of land located in Benton, Franklin, and Grant Counties in the south-central portion of Washington State. The 400 Area is located in the south-central portion of the Hanford Site, approximately 18 km (11 mi) north of the city of Richland (Figure 2-1). The 400 Area ponds are located in the 600 Area, north-northeast of the 400 Area perimeter fence (Figure 2-2). Also depicted in Figure 2-2 is the sanitary sewage lagoon, located approximately 30 m (100 ft) west of the 400 Area ponds.

2.2 HISTORY

In 1943 the Hanford Site was chosen as a location for the Manhattan Project, to produce plutonium for use in nuclear weapons. By the mid-1960's non-defense activities began at the Hanford Site, and in 1967 Hanford was picked as the location for the Fast Flux Test Facility (FFTF). The FFTF is a 400 megawatt liquid-metal (sodium) cooled test reactor. Originally the FFTF was built to test fuels, materials, and components for advanced liquid-metal-cooled power plants; however, it has also been used for irradiation testing, space power system research, isotope production, and a variety of other domestic and international research programs.

Initial nuclear startup at the FFTF began in 1980, followed by scheduled operation in 1982. In 1979 when FFTF construction was nearing completion, the process sewer became active and the 400 Area ponds began receiving process sewer effluent. Although the DOE placed FFTF into standby mode on April 1, 1992, the process sewer still receives effluent from the FFTF and various other facilities.

2.3 FACILITIES

Four facilities contribute to the process sewer: the FFTF, the Fuels and Materials Examination Facility (FMEF), the Maintenance and Storage Facility (MASF), and the 481-A water pumphouse. Each facility has its own 6-in.- (15-cm) diameter underground pipeline through which liquid effluent flows to the 12-in.- (30-cm) diameter process sewer pipeline located in the central 400 Area. The process sewer pipeline extends north into the 600 Area to the 400 Area ponds where the liquid effluent is diverted into one of two unlined percolation ponds. The pipelines, 400 Area ponds, and the four contributors to the process sewer are shown in Figure 2-2.

The 4 contributing facilities contain 74 potential points of entry to the process sewer. Nine points of entry are routinely used and contribute approximately 99% of the total liquid effluent to the process sewer. Of these nine routine points of entry, five are associated with the FFTF and FMEF cooling towers, and none are located in areas of radioactivity. The location and effluent source and flow rate for each of the nine routine points of entry are summarized in Table 2-1. The 400 Area ponds and the four contributing facilities to the process sewer are discussed further below. The facility and process information used in this section is from the *400 Area Secondary Cooling Water Stream-Specific Report* (WHC 1990c) and the *400 Area Secondary Cooling Water Sampling and Analysis Plan* (Seamans 1992).

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Table 2-1. Points of Entry to the Process Sewer. (sheet 1 of 3)

Facility	Room	Entry Point	Source	Type		Discharge to Retention Liquid Waste System*	Flow Rate L/min (gal/min)	
				Routine	Infrequent		Average	Range
FFTF Cooling Tower on 483 Pad	611	Equipment drain	Cooling tower blowdown System	X		No	38 (10)	15-95 (4-25)b
FFTF Cooling Tower on 483 Pad	Pad	Equipment drain	Overflow and drains	X		No	4 (1)	4-19 (1-5)
FFTF Cooling Tower on 482 pad	611	Janitorial Sink	Personnel	X		No	<4 (<1)	<4 (<1)
FMEF Cooling Towers Area	North Yard	Equipment drain	Cooling Tower Drains	X		No	15 (4)b	0-38 (0-10)b
4862 Entry Wing	E215	Equipment drain	Computer room air conditioner cooling	X		No	<4 (<1)	0-11 (0-3)
FMEF Cooling Towers Area	North Yard	Janitorial Sink	Personnel	X		No	<4 (<1)	<4 (<1)
427 Mechanical Equipment Wing	352	Floor drain	Process water from pressure regulator relief	X		No	<4 (<1)	<4 (<1)
Equipment Room of 437 Building	Equipment Room	Equipment drain	Air compressor cooling water	X		No	8 (2)c	0-45 (0-12)
481-A Pump House	--	Equipment drain	Sanitary water pump packing leakage	X		No	<4 (<1)	<4 (<1)
427 Process Building	600	Electric water cooler	Personnel		X	Yes	--	--
427 Process Building	608	Electric water cooler	Personnel		X	Yes	--	--
427 Process Building	515	Electric water cooler	Personnel		X	Yes	--	--
427 Process Building	409	Electric water cooler	Personnel		X	Yes	--	--
427 Process Building	430	Electric water cooler	Personnel		X	Yes	--	--
427 Process Building	117	Electric water cooler	Personnel		X	Yes	--	--
427 Process Building	223	Electric water cooler	Personnel		X	Yes	--	--
4862 Fuel Assembly Area	E105	Electric water cooler	Personnel		X	Yes	--	--
427 Process Building	504	Janitorial Sink	Personnel		X	Yes	--	--
427 Process Building	408	Janitorial Sink	Personnel		X	Yes	--	--
427 Process Building	309	Janitorial Sink	Personnel		X	Yes	--	--
427 Process Building	149	Janitorial Sink	Personnel		X	Yes	--	--

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Table 2-1. Points of Entry to the Process Sewer. (Sheet 2 of 3)

Facility	Room	Entry Point	Source	Type		Discharge to Retention Liquid Waste System*	Flow Rate L/min (gal/min)	
				Routine	Infrequent		Average	Range
4862 Fuel Assembly Area	E278	Janitorial Sink	Personnel		X	Yes	--	--
427 Process Building	404	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	238	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	302	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	307	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	308	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	313	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	224	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	213	Floor drain (2)	Process water/condensate		X	Yes	--	--
427 Process Building	204	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	206	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	321	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	209	Floor drain	Process water/condensate		X	Yes	--	--
427 Process Building	300	Floor drain	Equipment/Vehicles		X	No	--	--
427 Mechanical Equipment Wing	352	Floor drain (19)	Process water/condensate		X	No	--	--
427 Emergency Equipment Wing	355	Floor drain (2)	--		X	No	--	--
4862 Fuel Assembly Area	E104	Floor drain (4)	--		X	Yes	--	--
4862 Fuel Assembly Area	E300	Floor drain	--		X	Yes	--	--
FMEF Cooling Towers Area	North Yard	Floor drain	Empty cooling towers chemical drum wash		X	No	--	--
427 Process Building	204	Equipment drain	--		X	Yes	--	--
427 Process Building	238	Equipment drain	--		X	No	--	--
FMEF Cooling Towers Area	North Yard	Equipment drain	--		X	No	--	--
High-bay Area of 437 Building	High Bay	Floor drain	Steam cleaner drain		X	No	--	--
High-bay Area of 437 Building	High Bay	Floor drain	--		X	No	--	--

Table 2-1. Points of Entry to the Process Sewer. (Sheet 3 of 3)

Facility	Room	Entry Point	Source	Type		Discharge to Retention Liquid Waste System ^a	Flow Rate L/min (gal/min)	
				Routine	Infrequent		Average	Range
Equipment Room of 437 Building	Equipment Room	Floor drain (2)	--		X	No	--	--
481-A Pump House	--	Floor drain	--		X	No	--	--
481-A Pump House	--	Equipment drain (2)	--		X	No	--	--
427 Process Building	--	Floor drain (2)	Overflow from T-21 & 22		X	Yes	--	--

^aEffluent wastewater collected and stored in FMEF retention liquid waste tanks.
Waste water is sampled prior to discharge to process sewer.
^bVariance results from ambient conditions (FMEF Cooling Tower have no flow for November through March).
^cFacility support system intermittent operation.
--dashes indicate data is not available
Source: Modified from Seamans 1992

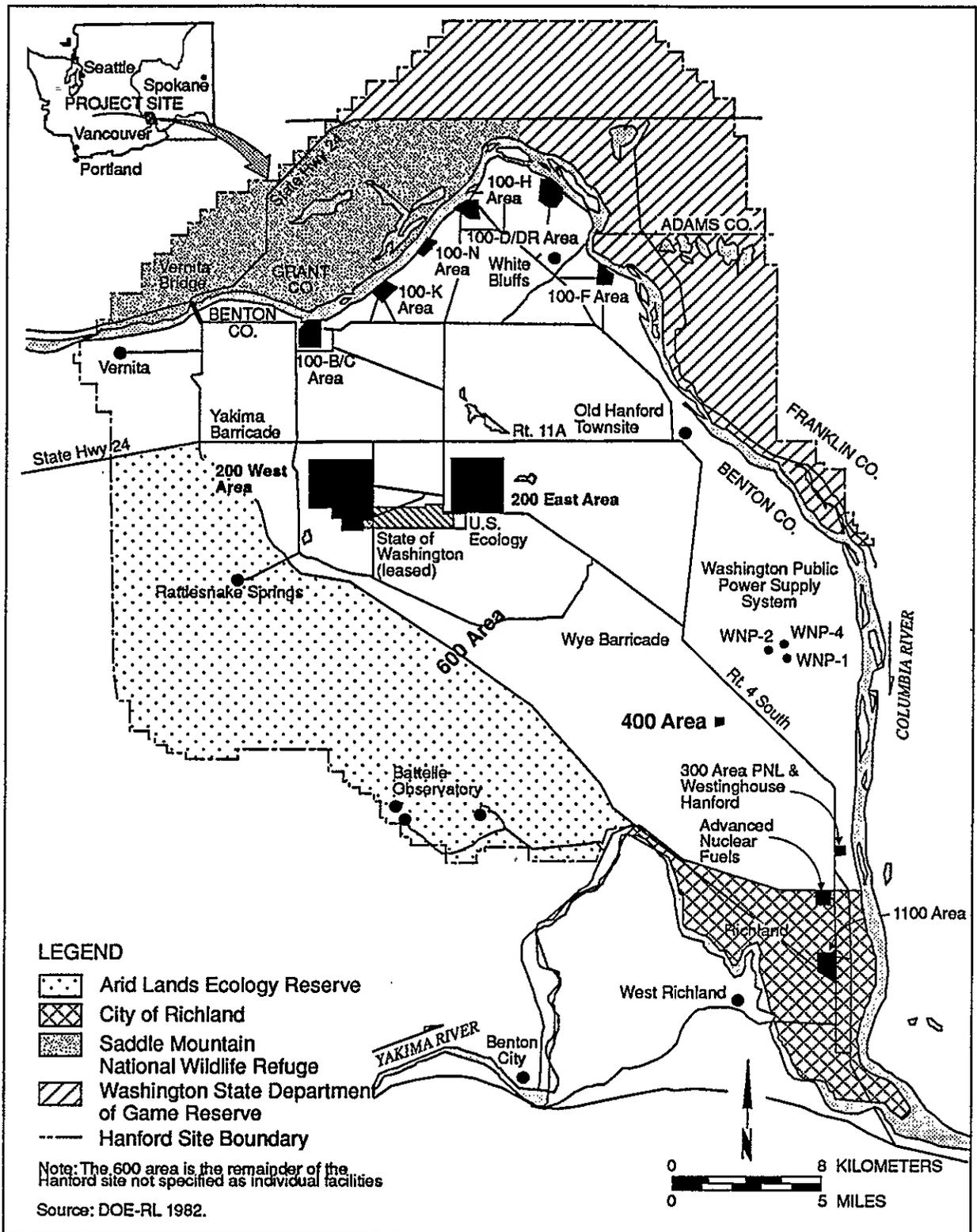
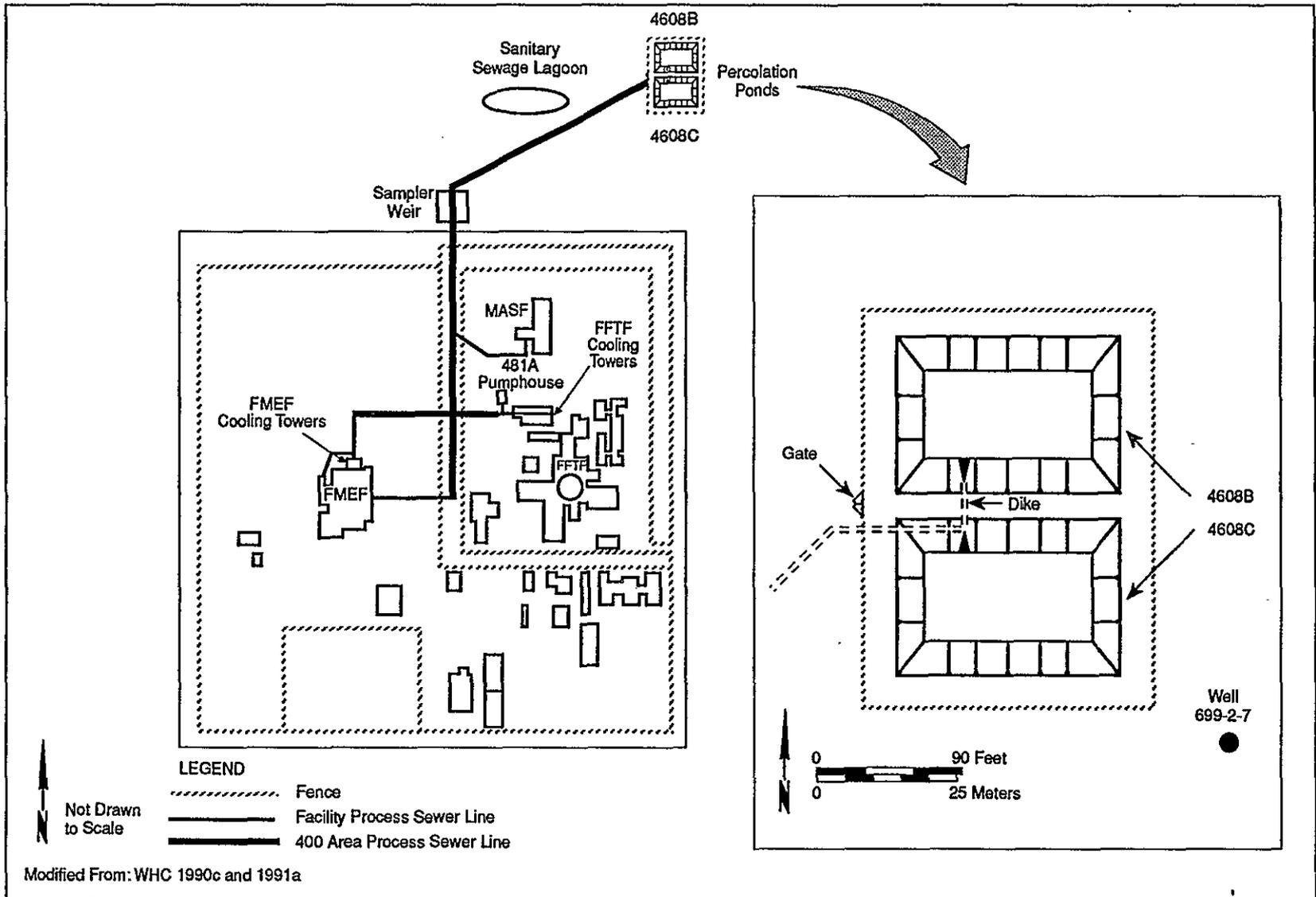


Figure 2-1. Hanford Site.

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Figure 2-2. 400 Area Process Sewer Contributing Facilities, Pipelines, and Ponds.

2.3.1 400 Area Ponds

Both of the 400 Area ponds are engineered unlined structures with the approximate dimensions of 50 x 100 ft (15 x 30 m) at base, and 4 ft (1 m) deep (Figure 2-2). The process sewer pipeline terminates in a diversion box built into the earthen wall separating the ponds. Manually operated slide gates located on opposite sides of the diversion box are used to direct flow to either pond. This design allows pond isolation in the event maintenance is required.

2.3.2 Fast Flux Test Facility

The FFTF consists of the reactor building and adjoining facilities, including eight cooling towers on a large concrete pad located northwest of the building (Figure 2-2). The cooling towers are used to remove heat generated by the reactor building's auxiliary systems such as the heating, ventilation, and air conditioning (HVAC) systems. Adjacent to and west of the cooling towers is the water treatment building, which contains treatment equipment, water quality monitoring instrumentation, and controls for the towers' blowdown valves.

The cooling towers consist of closed-loop coils of galvanized-steel pipe through which a 40% solution of ethylene glycol is circulated before returning to the auxiliary systems. Water is sprayed over the coils as fans blow air up the interior of the towers. The evaporation of the spray water cools the coils, which in turn cools the ethylene glycol solution. Each of the cooling towers has a sump capacity of approximately 7,570 L (2,000 gal).

The FFTF has three potential points of entry to the process sewer, all of which are associated with the cooling towers and are routinely used (Table 2-1). These points of entry are the equipment drain in the water treatment building that receives effluent from the blowdown valves; the drain trench on the north side of the cooling tower pad that receives tower overflow, drainage, and runoff from precipitation; and the sink in the water treatment building where personnel wash their hands, gloves, glassware, and other similar items as described in Section 3.1.

2.3.3 Fuels and Materials Examination Facility

The FMEF consists of two adjoined buildings, three auxiliary (e.g., HVAC) system cooling towers, and miscellaneous supporting facilities (Figure 2-2). The buildings have a total floor space of 20,233 m² (217,674 ft²), and are high-security, multi-storied structures designed to handle low- and high-level radioactive materials. Construction of the buildings and supporting facilities was completed in 1984. The original purpose of the FMEF was to fabricate FFTF experiments and re-process FFTF fuel, but program and funding changes prevented installation of most of the necessary specialized equipment. As a result, the FMEF has never received any radioactive material and is currently used only for personnel offices. In the future the FMEF may, however, be used for nuclear reactor fuel assembly and radioisotope power unit production.

There are 63 potential points of entry to the process sewer in the FMEF, 4 of which are routinely used and summarized in Table 2-1. Two of the routine points of entry are associated with the cooling towers, another receives cooling water from a computer room air-conditioning unit, and the fourth receives effluent from pressure release of the process sewer water supply system. The FMEF cooling towers have the same function as the FFTF cooling towers described in Section 2.3.2 and are of a similar design.

Because of its original intended use, those points of entry in areas of potential contamination within the FMEF are discharged to a retention liquid waste system (RLWS), which provides temporary storage for liquid effluent that would otherwise be discharged directly to the process sewer. The RLWS consists of two 22,700-L (6,000-gal) tanks that allow the effluent to be sampled for radioactivity and verified to meet acceptable discharge limits prior to release to the process sewer. Routine fire system tests, heating and ventilation systems, and electric water coolers are the only current sources of effluent to the RLWS. Due to the low volume of these sources, the tank's contents are released to the process sewer only once or twice a year.

2.3.4 Maintenance and Storage Facility

The MASF consists of a main building and a two-story service wing totaling approximately 3,022 m² (33,236 ft²) of ground-level floor space (Figure 2-2). Building construction was completed in 1984. The MASF provides storage, maintenance, and repair of radioactive and specialized equipment used in FFTF maintenance. None of the contaminated liquid waste generated in the MASF is discharged to the process sewer, but instead is collected in radioactive liquid waste tanks for disposal. The waste is then sent via rail tank car to the 200 Areas. There are four potential points of entry to the process sewer in the MASF. The only point of entry routinely used is an equipment drain that receives cooling water from the process equipment room air compressor (Table 2-1).

2.3.5 481-A Water Pumphouse

The 481-A water pumphouse is a single-story, concrete block building with 149 m² (1,608 ft²) of floor space (Figure 2-2). Construction of the structure was completed in 1984. The pumphouse contains a diesel-powered pump for fire fighting, a 1,136-L (300-gal) diesel fuel tank, and two electrical water-sealed pumps that supply all of the potable water to the 400 Area (including sanitary and process sewer water). The potable-water pumps draw from three deep wells located within the 400 Area and discharge to three 1,135,500-L (300,000-gal) storage tanks. Water is supplied to the facilities from the three storage tanks by a suction pump. Only well 499-S1-8J is pumped regularly, supplying 93% of the potable water in 1988.

The 481-A water pumphouse contains four potential points of entry to the process sewer, of which a floor drain is the only point of entry routinely used. There are two sources of liquid effluent to this floor drain: purge water from weekly operation of the diesel-powered pump to meet the requirements of the National Fire Protection Association (Seamans 1992) and leakage from the packings in the water supply pumps (WHC 1990c).

2.3.6 400 Area Water Supply

Groundwater pumped from onsite production wells completed at depths as great as 360 ft (110 m) is the sole source of water for the 400 Area sanitary water supply system. The primary water supply is well 499-S1-8J with backup wells 499-S0-8 and 499-S0-7. This system provides water for the 400 Area fire water supply system, sanitary water for uses such as drinking and washing, and process water for use in HVAC equipment, air compressors, other auxiliary equipment, and the FFTF and FMEF cooling towers.

Quality of the raw well water is monitored by the Hanford Environmental Health Foundation, and a summary of the monitoring results for 1988, 1989, and 1990 is presented in Table 2-2. The overall quality of the raw water is good enough to require only chlorination for its use in the sanitary water system. Chlorination is accomplished by adding 1 mg/L of sodium hypochlorite to the raw water as it is pumped to the water supply storage tanks. Water for use in the FFTF and FMEF cooling towers is treated with chemicals to prevent biological growth and scale formation in addition to the treatment with sodium hypochlorite. The chemicals used to prevent biological growth and scale formation and the method of introduction are discussed in Section 3.1.

2.3.7 400 Area Sanitary Sewer

2.3.7.1 Layout and System Operation. Two separate sanitary sewer systems have been utilized in the 400 Area. The original sanitary sewer system was abandoned in place and is presently covered by the 400 Area landfill and buildings. The first system operated in the early 1970's during a period of heavy construction. The increased demands placed on the original system by the number of personnel based in satellite offices were in excess of the design. Leakage was identified at sanitary sewer system manholes, and occasionally at the outfall. The decline in construction project personnel provided a natural stabilization of the system in late 1975 and early 1976. Backfill was used in all leakage areas, prior to installing black-top and pouring concrete in selected areas. Sampling of the soil to determine type and level of contaminants was not believed to have been done at the time of leakage, or prior to backfill activities, due to the type of spill. The original sanitary system piping and septic tanks were not removed after the new system was operational.

In 1983, a second sanitary sewer system was installed. Discharges were routed to a new septic tank that is located approximately 100 m (300 ft) north of the FFTF fenceline. The waste stream flows by gravity pressure to a drain field.

In 1986, the drain field clogged and failed, causing effluent to enter the sanitary sewer lagoon (percolation pond) via a ditch from an overflowing manhole. As a result, a diversion box was installed. The sanitary system was improved by deepening the sanitary sewer lagoon, constructing a berm around the lagoon, and backfilling the existing drainage ditch.

All sanitary effluent eventually discharges to a sewage lagoon located approximately 30 m (100 ft) west of the 400 Area ponds. The discharge is estimated to be 42,000 to 49,200 L/day (11,000 to 13,000 gal/day). Routine monitoring of the sanitary effluent for ammonia, chloride, phosphate, lead, zinc, cadmium, mercury, and pH began in 1980 and continues today.

Table 2-2. Summary Monitoring Results of the Raw Well Water for 1988, 1989, and 1990. (Sheet 1 of 2)

Constituents	1988 ^{a,d}	1989 ^{b,d}	1990 ^{a,e}		
			499-S1-8J Primary	499-S0-8 Backup	499-S0-7 Backup
Primary	Concentration (mg/L)				
Arsenic	<0.005	<0.002	<0.002	<0.002	0.003
Barium	0.16	0.13	<0.1	<0.1	<0.1
Cadmium	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Chromium	<0.005	<0.01	<0.002	<0.002	<0.002
Fluoride	0.33	0.33	0.4	0.4	0.4
Lead	<0.005	<0.005	<0.005	<0.005	<0.005
Mercury	<0.0005	<0.0004	<0.0004	0.0008	<0.0004
Nitrate (as N)	0.14	<0.05	0.15	1.0	0.91
Selenium	<0.005	<0.005	<0.002	<0.002	<0.002
Silver	<0.005	<0.005	<0.005	<0.005	0.0007
Sodium	29.0	30	32	28	24
Secondary	Concentration (mg/L)				
Color (unitless)	<5	<5	<5	<5	5
Chloride	11.9	11.9	8.3	9.7	10.8
Copper	0.11	<0.05	<0.05	<0.05	<0.05
Iron	<0.03	<0.03	<0.05	<.25 ¹	<0.05
Manganese	<0.01	0.04	0.01	0.27 ²	0.18 ³
Total dissolved solids	209	233	208	210	219
Sulfate	34	35	34	38	47
Zinc	<0.1	<0.1	<0.2	<0.2	<0.2

Table 2-2. Summary Monitoring Results of the Raw Well Water for 1988, 1989, and 1990. (Sheet 2 of 2)

Constituents	1988 ^{a,d}	1989 ^{b,d}	1990 ^{c,e}		
			499-S1-8J Primary	499-S0-8 Backup	499-S0-7 Backup
Radionuclides	Average Annual Concentration^f (pCi/L)				
Number of samples	4	9	13		
Gross Alpha	0.05 ± 0.12	0.12 ± 0.10	0.2 ± 0.2		
Gross Beta	7.2 ± 2.2	6.0 ± 0.5	11.2 ± 2.5		
Tritium	4,100 ± 2,400	8,280 ± 1,080	9,450 ± 2,080		
Iodine-131	ND	NA	-		
Strontium-90	0.01 ± 0.02	-0.008 ± 0.005	-0.004 ± 0.005		
Iodine-129	0.0046 ± 0.009	0.0055 ± 0.0008	0.0092 ± 0.008		
<p>^aValues obtained from Sommers 1989, WHC 1990c ^bValues obtained from Thurman 1990 ^cValues obtained from Thurman 1991 ^dSupply mixed: 93% from 499-S1-8J, 7% from 499-S0-7 ^eSupply mixed: 95% from 499-S1-8J, 5% from 499-S0-7 ^fAverage reported ± two standard error of the calculated mean. ¹Results of follow-up samples: 9/12/90 <0.05; 9/26/90 -0.06; 10/9/90 <0.05 Fe ²Results of follow-up samples: 9/12/90 <0.01; 9/26/90 <0.01; 10/9/90 -0.01 mg/L Mn ³Results of follow-up samples: 9/12/90 -0.04, 9/26/90 -0.04, 10/9/90 -0.18 mg/L Mn < = less than detection limit NA = Not analyzed ND = constituent not detected Blank denotes that data are not available Source: Sommers 1989, Thurman 1990, Thurman 1991, WHC 1990c</p>					

2.3.7.2 Effluent Characteristics. Although the 400 Area sanitary sewer system is not the subject of this report, review of sanitary sewer effluent characteristics assists in determining the impact of the 400 Area ponds. The overall approach to establishing the effluent constituents was to review all available documents for pertinent process and analytical data and to cross-check the data for redundancy. The analytical data were then tabulated as a function of time and constituent analytes. It was assumed that the data in the reviewed documents are valid. Data validation was limited to flagging of published or tabulated data anomalies. Information on liquid effluent characteristics was also obtained by review of appropriate documents. All data used in this report for the sanitary sewer were obtained from the HEHF Quarterly Data Reports (HEHF 1980a through 1992). Quality assurance related activities including validation of the sampling or test protocol and qualification of the reporting laboratories were not performed during the compilation of these data. Analytical data for the 400 Area sanitary sewer are provided in Appendix A, Table A-1. These data are presented by quarters from 1980 (second quarter) to 1992 (first quarter).

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3.0 PROCESS SEWER SYSTEM

3.1 LAYOUT AND OPERATION

Approximately 15% of the process water is used for equipment operation, and the remaining 85% is used for the cooling towers (Table 2-1). The majority of the process effluent is discharged to floor and equipment drains, and all of the process water not evaporated in the cooling towers eventually flows to the 400 Area ponds.

Water used in the FFTF and FMEF cooling towers requires treatment beyond the addition of sodium hypochlorite. In the past, sulfuric acid was added to the FFTF cooling tower to lower the pH of the water from a range of 8.4 to 9.0 to a range of 7.5 to 8.5, but this practice was stopped in 1986. Currently, chemicals are added to the FFTF and FMEF cooling-tower water to avoid biological growth and scale formation. Biological control is important for two reasons: certain species that thrive in a warm, moist environment can cause offensive odors and pose a health risk to maintenance personnel, and coating of the pipe coils with a growth would inhibit the transfer of heat between the evaporating spray water and the coils. Scale formation protection is necessary because of the increasing concentration of naturally occurring salts (typically calcium carbonate) resulting from the evaporation of the cooling-tower water.

Biological control is accomplished through the use of a biocide (Dearcide 702*) and a microbiocide (sodium hypochlorite). Until recently, the microbiocide Dearcide 717* was used instead of sodium hypochlorite, but incompatibilities with a new scale prohibitor (discussed below) necessitated its discontinuation. Dearcide 702 is maintained at the FFTF cooling towers at 25 mg/L by its addition to makeup water via a metering pump. The same concentration of Dearcide 702 is maintained at the FMEF cooling towers by its addition via a metering pump to the recirculated sump water. A concentration of 0.6 to 0.8 mg/L of sodium hypochlorite is maintained at the FMEF cooling towers using the same procedure as for the Dearcide 702. At the FFTF cooling towers the sodium hypochlorite is added at a concentration of 5 mg/L for "shock" when maintenance requires personnel to enter the tower for cleaning (normally during the spring and summer months).

Scale protection is accomplished in part by monitoring the electrical conductivity of the sump water. After about 2.5 cycles of the water through the cooling towers, the conductivity approaches 1200 μ mhos, which triggers automatic valves to open and discharge water to the process sewer. In response to the water discharge, the tower-sump water-level control system initiates the addition of makeup water. The discharge and addition of water continues until the conductivity drops to approximately 900 μ mhos. Note that a conductivity of 1200 μ mhos corresponds to a 3.5 to 4 fold increase in the nonvolatile constituents of the incoming well water.

Scale is also controlled by maintaining a concentration of 50 to 75 mg/L of Dearcide 878* in the cooling tower water. Until recently Dearcide 727* was used instead, but was replaced due to inadequate performance. At the FFTF cooling towers, Dearcide 878 is added via a metering pump to the makeup water at a concentration of 40 mg/L. This concentration increases to the required range as evaporation occurs. At the FMEF cooling towers, Dearcide 878 is added directly into the tower when the conductivity control system opens the valve that discharges the sump water.

*A trademark of Grace Dearborn Company.

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To ensure that the proper amount of scale inhibitor is being maintained, a field chemical analysis is periodically performed. The analysis involves the use of the following Dearborn chemicals: code 550 (sodium thiosulfate/borate solution), code 562 (xylenol orange indicator), code 595 (hydrochloric acid solution), code 899 (beryllium sulfate solution), and code 904 (thorium nitrate solution). Each analysis produces approximately 50 mL (0.01 gal) of solution with a beryllium content of 0.00095%. The washing of hands, gloves, glassware, and other chemical analysis equipment in conjunction with solution disposal results in small quantities of the aforementioned chemicals entering the process sewer via the sinks in both cooling tower buildings.

To confirm adequate microbicide (sodium hypochlorite) addition to the cooling tower water, a chemical analysis to measure the percent free chlorine is periodically performed. The test uses glacial acetic acid and methyl orange (amine, alkyl-aryl) and produces a solution of glacial acetic acid with an equivalent concentration of less than 0.01% (WHC 1992). Due to the low concentration of glacial acetic acid, the test solution is not designated as dangerous waste (WHC 1992) and is disposed of to the process sewer via the sinks in both cooling tower buildings.

3.2 DISCHARGE RATE

Although there are a number of estimates of the process sewer effluent volume (WHC 1992, Seamans 1992), no routine monitoring results or measured results are available. In mid-1992 an estimate of total water balance and use was made by 400 Area personnel. These estimates were prepared for submittal to Ecology in support of a WAC 173-216 state waste discharge permit. The estimates included average and maximum gallons per day discharged from the process and sanitary sewers. Figures 3-1 and 3-2 describe the results of this evaluation and provide the estimates of effluent volumes used in this document.

An unofficial measurement made in June 1992 by 400 Area personnel provided a value of 114 L/min (30 gal/min) or 164,000 L/day (43,200 gal/day), which is between the average value of 98,400 L/day (26,000 gal/day) and the maximum value of 306,500 L/day (81,000 gal/day).

3.3 EFFLUENT CHARACTERISTICS

3.3.1 Contaminant Sources

Past and present liquid effluent discharges to the 400 Area process sewer effluent receiving sites were reviewed for their chemical and physical characteristics. Data from 35 sources were included and the sources are referenced in the tabulated process sewer effluent data (Table A-2, Appendix A).

3.3.1.1 400 Area Production Water. The primary water supply for the 400 Area is well 499-S1-8J, and raw well water quality for 1988, 1989, and 1990 is presented in Table 2-2. Tritium concentrations are well below the 20,000 pCi/L drinking water standards and WAC 173-200 groundwater quality criteria for the period from 1988 - 1990. On one occasion in 1991, tritium concentration exceeded the criteria with a value of 29,700 pCi/L. This is two to three times greater than the results of seven other sampling events for that year and may be spurious data (Appendix D).

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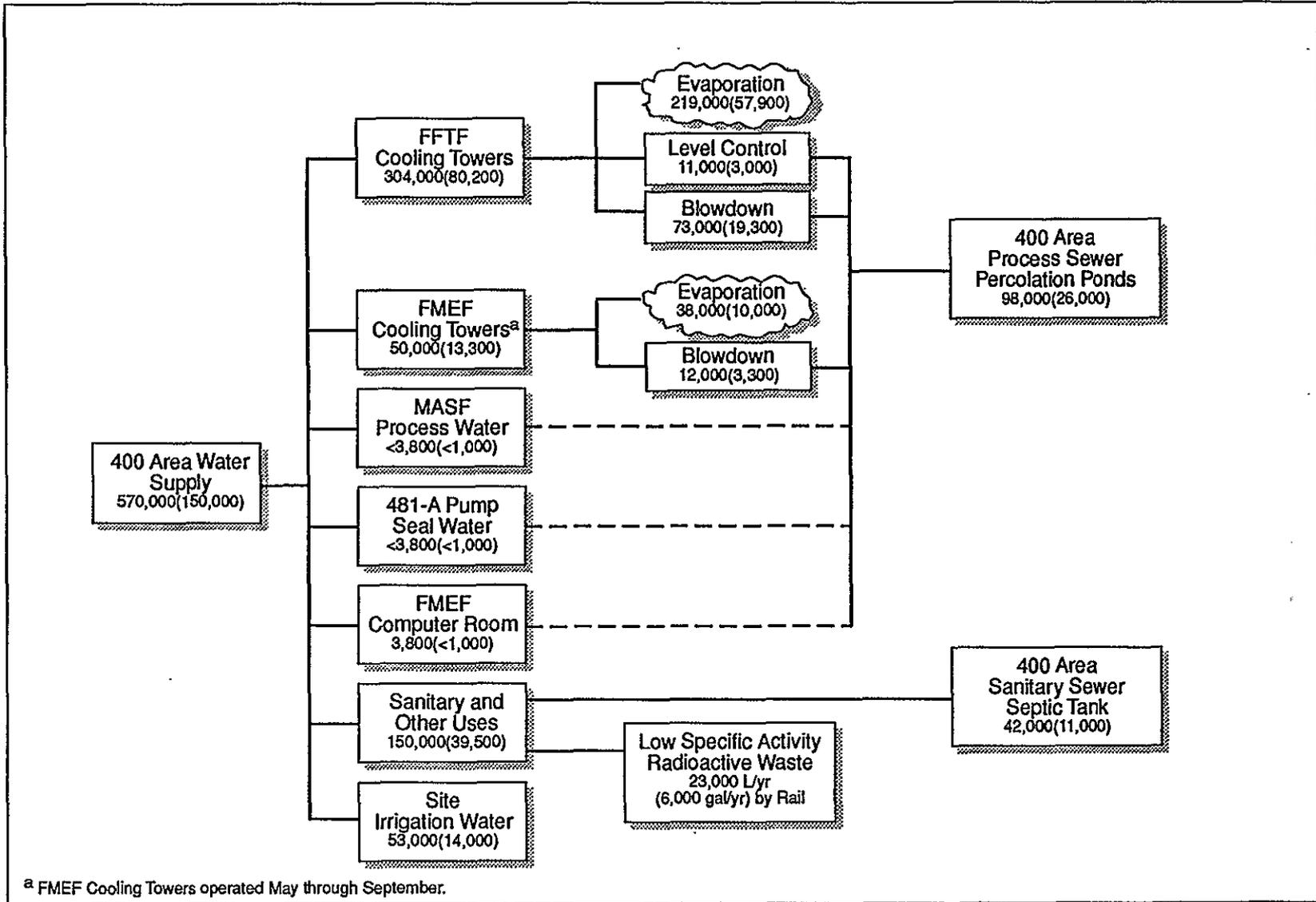


Figure 3-1. Average Annual Daily Flow Rates in L/d (gal/d).

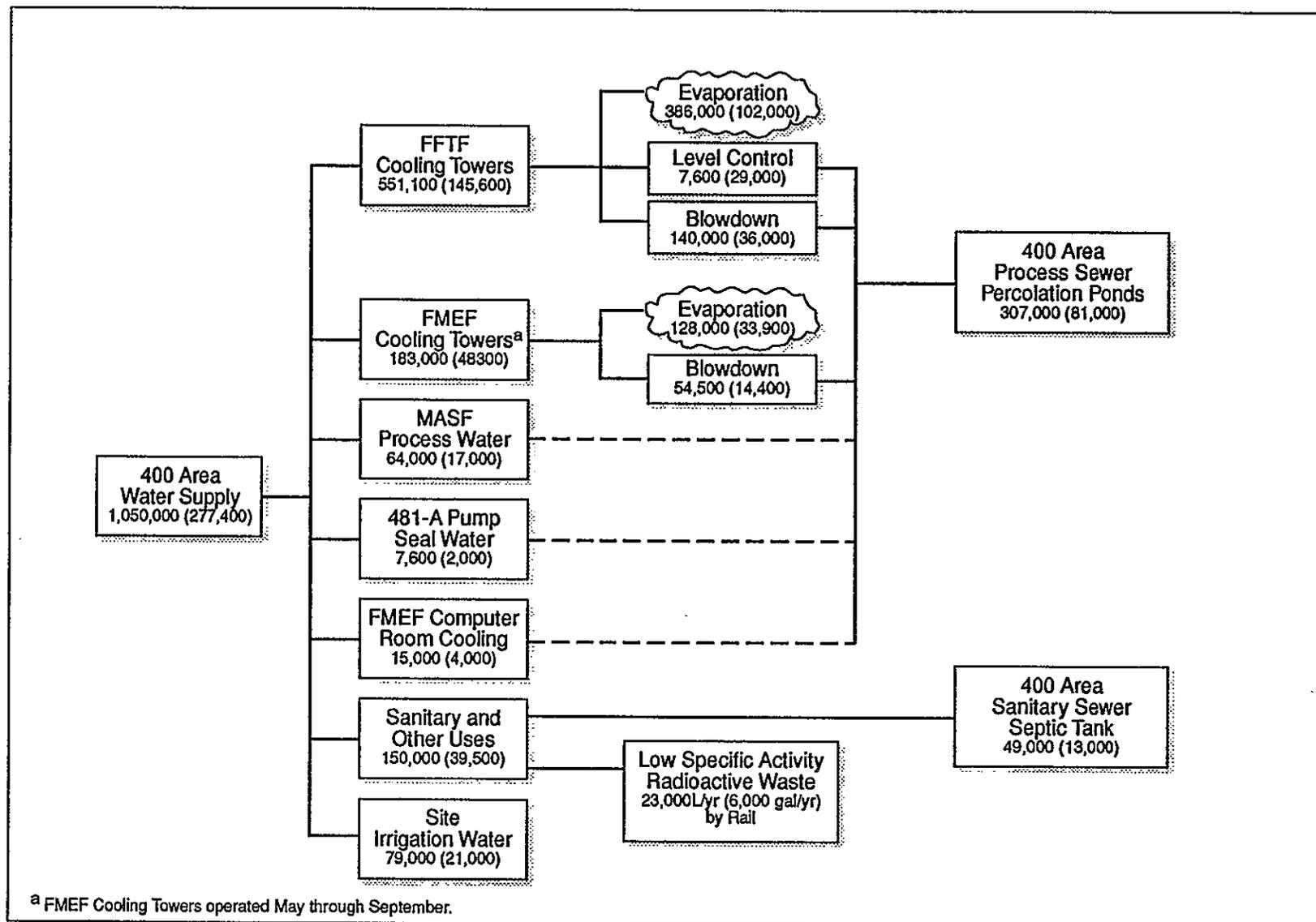


Figure 3-2. Peak Daily Flow Rates in L/d (gal/d).

3.3.1.2 Water Treatment Chemical Additives. The past and present operational activities were described in Section 3.1. Table 3-1 lists the chemicals discussed or mentioned in that section. Of the chemicals listed in Table 3-1, all the organics found in the microbiocide Dearborn 717, the biocide (Dearborn 702), and the scale inhibitor (Dearborn 727) were assessed in the 400 Area Secondary Cooling Water Stream Specific Report (WHC 1990a). An estimated upperbound for these constituents was established, and it was found that the effluent did not classify as a toxic dangerous waste per WAC 173-303. No analytical data were found for the new scale inhibitor (Dearborn 878) that replaced Dearborn 727 in 1990.

3.3.1.3 Chemical Analysis Reagents. Solutions with small concentrations of beryllium and glacial acetic acid are generated during the field analysis of cooling tower water to confirm that the proper concentrations of scale inhibitors and biocides are maintained. The solutions are disposed of in the process sewer via the sinks in the cooling tower buildings and are further discussed in Section 3.1.

3.3.1.4 Other Potential Contaminant Sources. Ethylene glycol (40%) is circulated in the closed loop of the evaporative towers serving FFTF and FMEF. The potential contaminant pathway and mitigation measures for the compound are discussed in Table 3-2. An ethylene glycol leakage would be reflected in the total organic carbon (TOC) analyses reported in Table A-2 (Appendix A). There was no significant increase in TOC during the monitoring period of 1987 through 1991, thus ethylene glycol was not considered further. Other potential sources of spills or leaks of contaminants, their locations, potential pathways, and proposed mitigation measures are also presented in Table 3-2.

3.3.2 Sampling Results

Routine monitoring of the process effluent for ammonia, chloride, phosphate, lead, zinc, cadmium, mercury, and pH began in 1980 and continues today. In 1989 the process sewer sampler weir (shown in Figure 2-2) was installed for continuous measurements of flow rate, pH, and conductivity, and is also used for the routine process effluent chemical monitoring. Currently none of the continuous measurement equipment is operating, and it is likely that the flow rate meter has never functioned properly. Monthly composite samples are collected from the sampler weir in a 1-gal container for chemical analysis. Radiological samples are collected directly from the process effluent.

Analytical data on the 400 Area process sewer effluent are provided in Appendix A, Table A-2. The data are presented by quarter from 1980 to 1992 (second quarter). Each table is arranged in groupings of primary and secondary drinking water standards and radionuclides. Additional groupings of "Other Inorganics," "Other Organics," and "Other Radionuclides" were added to the table for completeness.

The row labeled "Standard" contains the value of the particular analyte that represents the evaluation criteria from WHC 1991a which are regulatory levels from primary and secondary drinking water standards, WAC 173-200, or in the case of many of the radionuclides, 1/25 (4 mrem/year) of DOE Order 5400.5, *Derived Concentration Guides*.

Initial inspection of reported data revealed a very large number of reported "less than values" indicating that the tested analyte was not detected above a contractual reporting limit or

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Table 3-1. Process Water Chemical Additives.

Chemical/Constituents	Use	Entry Location
Sodium Hypochlorite	chlorination, microbiocide	Injected into raw water, added to cooling tower water
Sulfuric Acid	pH adjustment (discontinued in 1986)	Injected into FFTF cooling tower makeup water
Dearborn 702 MgCl ₂ Mg (NO ₃) ₂ isothiazolines	Biocide	Added to makeup water (FFTF) or the sump water (FMEF)
Dearborn 717 Alkyl Dimethyl Benzyl Ammonium Chloride, bis(Tri-n-Butylin) Oxide	Microbiocide (discontinued in 1986)	Added to makeup water (FFTF) or the sump water (FMEF)
Dearborn 727 potassium hydroxide other proprietary chemicals	Scale protection (discontinued in 1990)	Injected into FFTF, FMEF coolant tower water
Dearborn 878 Organophosphonic acid, potassium salt	Scale protection	Injected into FFTF, FMEF coolant tower water
Source: Seamans 1992		

Table 3-2. Potential Contaminant Pathways and Mitigation Measures of Potential Leaks and Spills into the 400 Area Process Sewer System. (Sheet 1 of 3)

FACILITY	ROOM/CELL	POTENTIAL CONTAMINANT	POTENTIAL PATHWAY	MITIGATION
481-A Water Pumphouse	Building 481A	Fuel Oil, Lube Oil	The floor in the Pump House is sloped towards the drain. The lube oil tank is mounted on a stand contained within the building. The pump is mounted on a pedestal. Lube oil and fuel oil have the potential of leaking and flowing to the drain. The drain is connected to the process sewer header.	A concrete berm is to be installed around the fuel oil storage tank and the diesel fire pump. The berm will contain the complete inventory of fuel oil and lube oil contained in Building 481A. The building main floor drain will be enclosed by a rubber dam/berm. The floor drain is located outside the berm.
FFTF	FFTF Cooling Towers	Ethylene glycol	A 40% solution of ethylene glycol is circulated within the Cooling Water System and the tubes of the cooling towers. If a tube leak were to occur, the ethylene glycol would contaminate the tower sump. Upon automatic or manual blowdown of the sump, the glycol would enter the process sewer through the tower pad trench or the blowdown trench in the Water Treatment Building. The trenches are connected to the process sewer header.	The cooling water system contains two expansion tanks. The level of the expansion tanks is monitored by instrumentation that triggers a low level alarm on a local control panel which then transmits an alarm to the FFTF Control Room. Any cooling tower tube leak will discolor the sump water (characteristic pink color). The sump automatic and manual blowdown lines discharge to trenches and are visible to the operator. With system design and operator monitoring, any ethylene glycol leak would be quickly discovered and mitigated by securing the effected tower.
MASF	Equipment Room	Lube Oil	A lube oil leak from the MASF air compressor has the potential to flow across the Equipment Room floor and enter a floor drain. The floor drain is connected to the Process Sewer header.	Rubber dams/berms are to be installed to enclose the Equipment Room floor drains. The dams are sized to contain the entire inventory of air compressor lube oil.
FMEF	Room 352	Ethylene Glycol and Oil	The floor drains are connected directly to the Process Sewer header.	Rubber dams/berms are to be installed to enclose four of the floor drains. The remaining drains in this room will be plugged.

Table 3-2. Potential Contaminant Pathways and Mitigation Measures of Potential Leaks and Spills into the 400 Area Process Sewer System. (Sheet 2 of 3)

FACILITY	ROOM/CELL	POTENTIAL CONTAMINANT	POTENTIAL PATHWAY	MITIGATION
FMEF	Room 307	Ethylene Glycol and Oil	The floor drain discharges to the FMEF Retention System. After sampling, the Retention System is discharged to the Process Sewer.	The floor drain will be plugged.
FMEF	Room 213	Ethylene Glycol and Oil	The floor drain discharges to the FMEF Retention System. After sampling, the Retention System is discharged to the Process Sewer.	A rubber dam/berm will be installed to enclose the floor drain.
FMEF	Room 206	Hydrochloric Acid	The floor drain discharges to the FMEF Retention System. After sampling, the Retention System is discharged to the Process Sewer.	The floor drain will be plugged.
FMEF	Room 204	Oil	The floor drain discharges to the FMEF Retention System. After sampling, the Retention System is discharged to the Process Sewer.	The floor drain will be plugged.
FMEF	Room 238	Oil	The floor drain discharges to the FMEF Retention System. After sampling, the Retention System is discharged to the Process Sewer.	A rubber dam/berm will be installed to enclose the floor drain.
FMEF	Room E124	Hydrochloric Acid	The floor drain discharges to the FMEF Retention System. After sampling, the Retention System is discharged to the Process Sewer.	The floor drain will be plugged.
FMEF	Room 355	Ethylene Glycol	The floor drain discharges to the FMEF Retention System. After sampling, the Retention System is discharged to the Process Sewer.	A rubber dam/berm will be installed to enclose the floor drain.
FMEF	Room E273	Ethylene Glycol	The floor drain discharges to the FMEF Retention System. After sampling, the Retention System is discharged to the Process Sewer.	A rubber dam/berm will be installed to enclose the floor drain.

Table 3-2. Potential Contaminant Pathways and Mitigation Measures of Potential Leaks and Spills into the 400 Area Process Sewer System. (Sheet 3 of 3)

FACILITY	ROOM/CELL	POTENTIAL CONTAMINANT	POTENTIAL PATHWAY	MITIGATION
FMEF	Cooling Tower	Ethylene Glycol	Ethylene glycol is circulated within the Cooling Tower tubes. If a tube leak were to occur, the ethylene glycol would contaminate the tower sump. Upon blowdown of the sump, the glycol would enter the process sewer through the tower line.	The cooling water system contains a compression tank. The level of the compression tank is monitored by instrumentation that triggers a low level alarm. Any cooling tower tube leak will discolor the sump water (characteristic pink color). With system design and operator monitoring, any ethylene glycol leak would be quickly discovered and mitigated by securing the effected tower.

an instrumental detection limit. In order to limit the size of the data tables and still include all pertinent data, the following conventions were followed.

- Data that indicated a "less than detection limit" were reported when the detection limit was lower than the regulatory limit (WAC 173-200 and DOE Order 5400.5).
- Data that indicated a "less than detection limit" were not reported when the detection limit was higher than the regulatory limit (WAC 173-200 and DOE Order 5400.5).
- Data that indicated a "less than detection limit" were not reported when no regulatory limit was listed in WAC 173-200 or DOE Order 5400.5.
- Radionuclides were reported as net activity. Negative numbers for these test results indicate a statistical variation in background counts where the background counts exceed the sample counts.

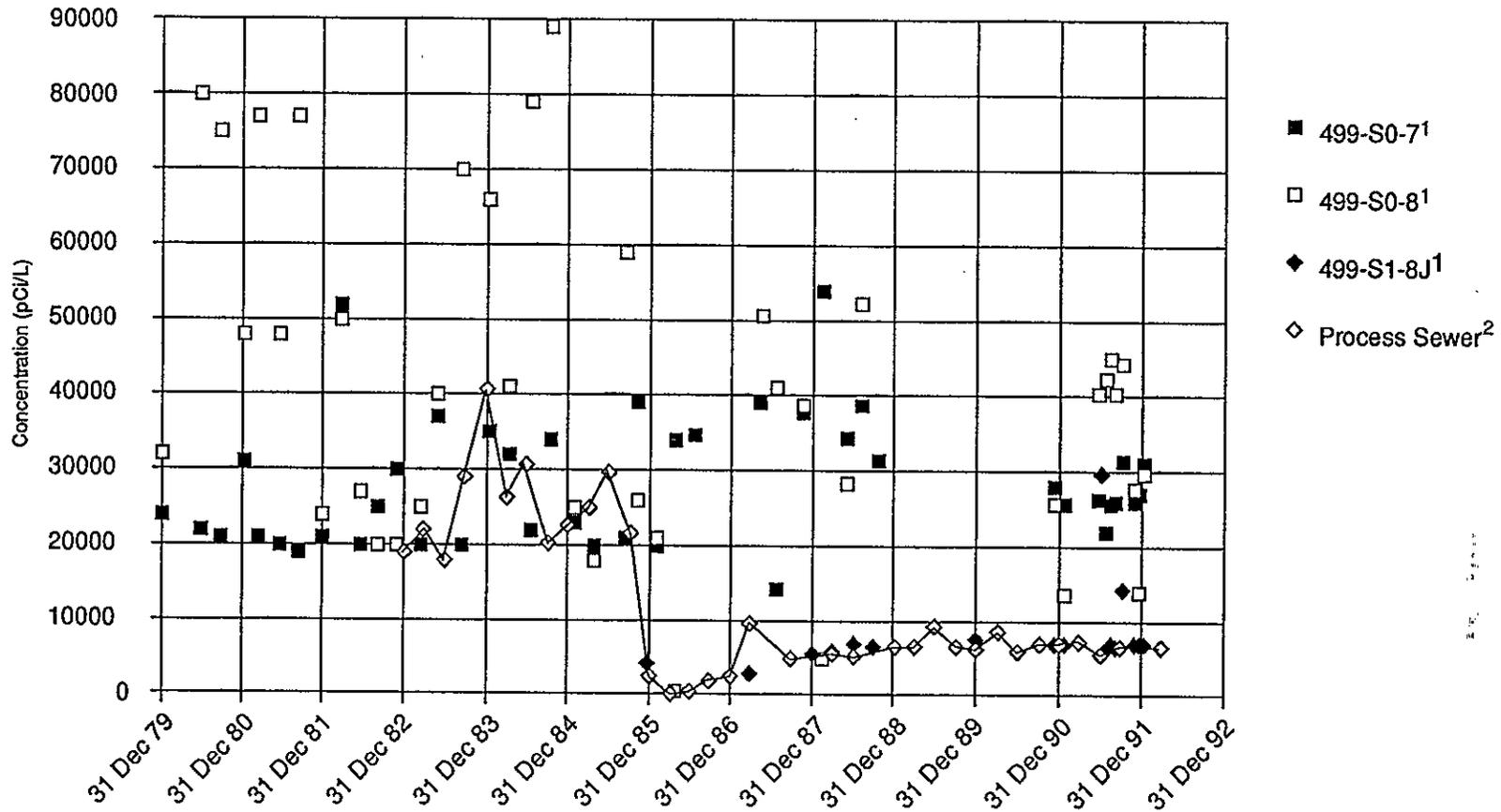
Determination of the validity of the sampling or test protocol, qualification of the reporting laboratories, and other quality assurance related activities were not performed during the compilation of these data.

3.3.3 Key Parameter

Comparison of the data obtained with groundwater quality criteria revealed that with one exception, only gross beta, pH, and tritium exceeded the evaluation criteria. The exception was a single positive result for mercury (0.0082 ppm) in the first quarter of 1985. This compares to a drinking water limit of 0.002 ppm. Quarterly data for 4 years prior to that date and 7 years after show no mercury above 0.002 ppm. Since data are available for 11 years surrounding the one positive mercury analysis, the positive analysis is considered anomalous and mercury is not considered further. The process sewer effluent analytical results are presented in Table A-2 (Appendix A).

Tritium levels in the process sewer effluent directly correspond with water source well concentrations. Figure 3-3 shows the dramatic drop in tritium levels when source well 499-S1-8J went into use in 1986. It is probable that the exceedance of groundwater quality criteria for tritium during the mid-1980's was not caused by any 400 Area operations, but instead is attributed to the concentration of tritium in the supply source water. Tritium was chosen as a key parameter because:

- Tritium levels in the process sewer in the past routinely exceeded groundwater quality criteria in WAC 173-200 (WHC 1991a).
- The current source water supply drawn from deeper in the aquifer has a significantly lower tritium concentration than the upper portion of the aquifer monitored by wells in the vicinity of the 400 Area ponds.
- Tritium is frequently sampled in wells in the vicinity of the 400 Area ponds and is a highly mobile constituent.



Source: Data points represent data taken from:
 1 Geosciences Groundwater Database, Westinghouse Hanford Company.
 2 PNL Yearly Summary reports (Jaquish and Bryce 1989, 1990, Jaquish and Mitchell 1988, PNL 1987, Price 1986, Price et al. 1984, and 1985, Sula et al. 1981, 1982, and 1983, Woodruff et al. 1991) with Supplementary Quarterly Radiological Testing Information (Surface Environmental Database, Pacific Northwest Laboratory).

Figure 3-3. Tritium Concentrations for Source Wells and Process Sewer.

Two samples (one in 1981 and a second in 1983) showed beta concentrations in the process sewer effluent that exceeded the groundwater quality criteria of 50 pCi/L. As with the source water data, these two datum are considered to be anomalous, with measurements preceding and following these spikes at a representative level. Gross beta was therefore not chosen as a key parameter.

All pH values for the source wells were within groundwater quality guidelines during 1989-1990, while all process sewer effluent pH values were greater than 8.5. The pH levels that exceed groundwater quality standards cannot be explained by excursions of pH from source wells. A pH excursion from 8.5 to 9.5 represents a very small change in equivalent OH^- concentration and can be explained by the lack of buffering capacity of the effluent water. Even a slight buffering action from the soil column is expected to return effluent pH to within guideline limits. Therefore, pH was not chosen as a key parameter.

In addition to gross beta and tritium discussed above, concentration of some additional analytes were tabulated in Table A-2 (Appendix A) for the period 1980 to 1991. These analytes were phosphate, ammonia, sulfate, nitrate, and chloride. These analytes are displayed because they would provide data on loading, potentially indicate process upsets, or serve as tracer constituents that could be measured in the groundwater and/or compared to the sanitary sewer and groundwater.

Table 3-3 compares the concentrations of selected constituents for source water and process effluent discharged to the 400 Area ponds. Evaporation of cooling water results in concentration of the naturally occurring salts and minerals in the process effluent when compared to the source water.

Table 3-3. Selected Process Sewer Analytes Compared to Source Water.

Analyte	Average Estimated Water Source Concentration ¹	Minimum Measured Concentration Above Detection Limit	Average of Measured Concentration Above Detection Limit	Maximum Measured Concentration
Nitrate	0.15 mg/L	0.59 mg/L	1.6 mg/L	3.2 mg/L
Chloride	8.3 mg/L	10.6 mg/L	28 mg/L	108 mg/L
Sulfate	34 mg/L	55 mg/L	74 mg/L	82 mg/L
Gross Beta	11.2 pCi/L	1.5 pCi/L	26 pCi/L	77 pCi/L
Tritium	9,450 pCi/L	232 pCi/L	12,200 pCi/L	40,500 pCi/L
Phosphate	1.00 mg/L	<0.05 mg/L	0.9 mg/L	12.6 mg/L
Ammonia as N	0.080 mg/L	<0.006 mg/L	0.3 mg/L	7.1 mg/L

¹ Average estimated water source concentration for nitrate, chloride, sulfate, gross beta, and tritium are from Table 2-2, Section 2.3.6. Values for nitrate, chloride, sulfate, gross beta, and tritium are for supply well 499-S1-8J in 1990. Estimated concentration for phosphate and ammonia are from Table 2-3, WHC (1992).

4.0 SITE DESCRIPTION AND CONCEPTUAL MODEL

4.1 GEOLOGY

4.1.1 Regional and Hanford Site Geology

The Hanford Site lies near the eastern limit of the Yakima Fold Belt in the Pasco Basin. The Pasco Basin is a structural depression divided by the Gable Mountain anticline into the Wahluke syncline to the north and the Cold Creek syncline to the south, and is underlain by Miocene-aged basalt of the Columbia River Basalt Group and late Miocene to Pleistocene suprabasalt sediments. The basalts and sediments thicken into the Pasco Basin and generally reach maximum thicknesses in the Cold Creek syncline. The suprabasalt sediments are up to 230 m (750 ft) thick in the west-central Cold Creek syncline, and pinch out against the anticlines of the Saddle Mountains, Gable Mountain/Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills. Pasco Basin sediments are divided into the stratigraphic units of the Ellensburg Formation, Ringold Formation, Hanford formation, Plio-Pleistocene unit, early "Palouse" soil, and the pre-Missoula gravels. A geologic cross section of the suprabasalt sediments north of the 400 Area is presented in Figure 4-1.

4.1.1.1 Columbia River Basalt Group. The Saddle Mountains Basalt is the youngest formation of the Columbia River Basalt Group and is present throughout the Hanford Site area. The Saddle Mountains Basalt is divided into seven members, which are from youngest to oldest, Ice Harbor, Elephant Mountain, Pomona, Esquatzel, Asotin, Wilbur Creek, and Umatilla. The Elephant Mountain Member is the uppermost basalt unit underneath most of the Hanford Site (Reidel and Hooper 1989).

4.1.1.2 Ellensburg Formation. The Ellensburg Formation consists of all sedimentary units situated between the basalt flows of the Columbia River Basalt Group. The three uppermost interbeds of the Ellensburg formation found at the Hanford Site are, from youngest to oldest, Levey, Rattlesnake Ridge, and Selah. The Levey interbed is found only in the vicinity of the 300 Area and lies between the Ice Harbor Member and the Elephant Mountain Member. The Rattlesnake Ridge interbed lies over the Pomona Member and under the Elephant Mountain Member, and the Selah interbed lies over the Esquatzel Member and under the Pomona Member (Smith 1988, Smith et al. 1989).

4.1.1.3 Ringold Formation. The lower half of the Ringold Formation contains five separate stratigraphic intervals dominated by fluvial gravels (Lindsey 1991; Lindsey et al. 1991, 1992). These gravels, designated units A, B, C, D, and E, are separated by intervals containing deposits typical of the overbank and lacustrine facies associations. The uppermost gravel grades upward into interbedded fluvial sand and overbank deposits, which are in turn overlain by intercalated fluvial sands and a second lacustrine interval. The lacustrine deposit and the underlying fluvial sand and overbank deposits compose the upper unit of the Ringold Formation as originally defined by Newcomb (1958).

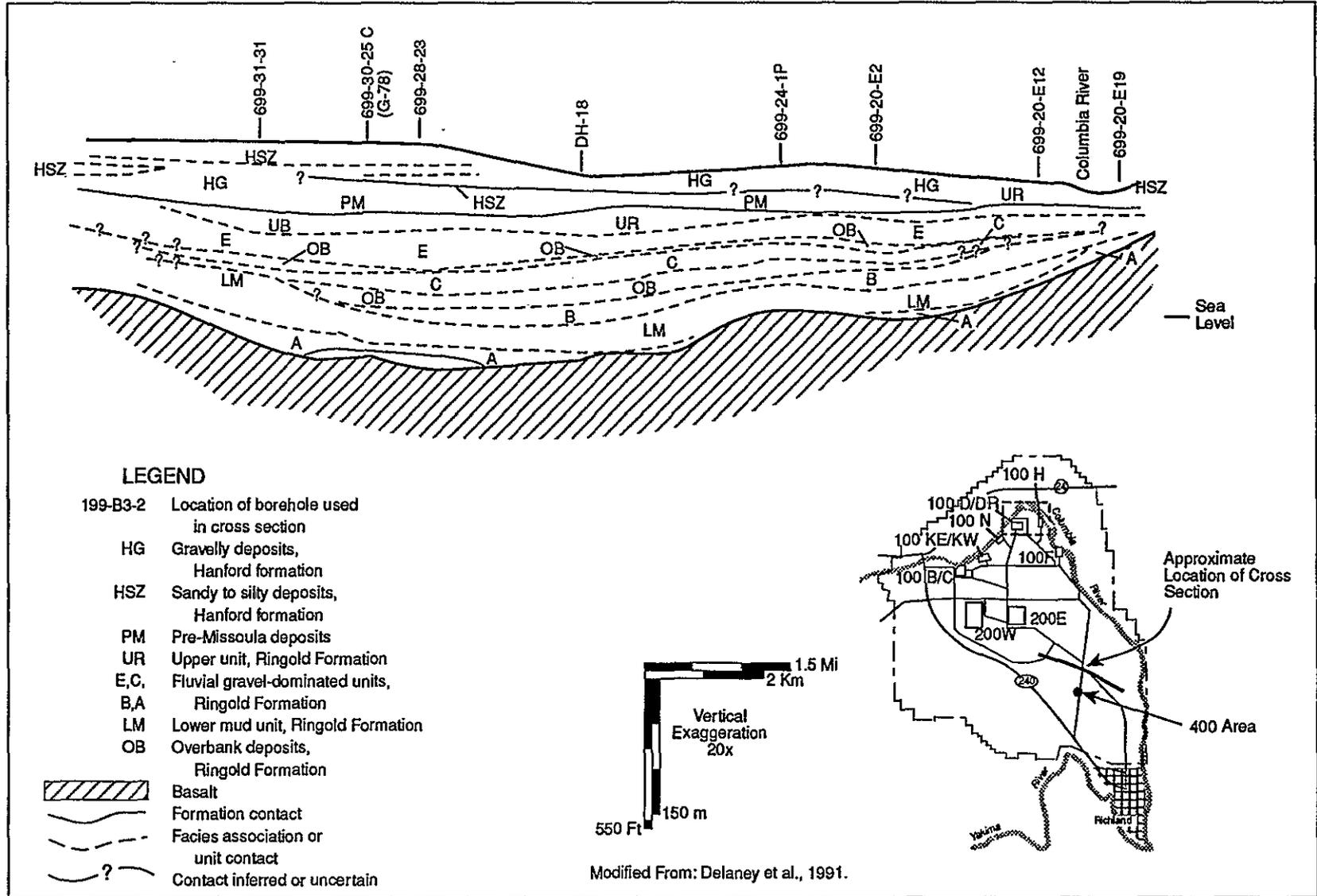


Figure 4-1. Hanford Site Geologic Cross Section.

4.1.1.4 Post-Ringold Pre-Hanford Deposits. Thin alluvial deposits located stratigraphically between the Ringold Formation and Hanford formation are found throughout the Pasco Basin. These deposits are referred to informally as the Plio-Pleistocene unit, the early "Palouse" soil, and the pre-Missoula gravels (Myers et al. 1979, Tallman et al. 1982, Delaney et al. 1991). The laterally discontinuous Plio-Pleistocene unit unconformably overlies the Ringold Formation in the western Cold Creek syncline. Overlying the Plio-Pleistocene unit is the early "Palouse" soil, which may grade up-section into the lower part of the Hanford formation. It is unclear whether the pre-Missoula gravels overlie or interfinger with the early "Palouse" soil and the Plio-Pleistocene unit.

4.1.1.5 Hanford Formation. The Hanford formation consists of pebble- to boulder-size gravel, fine- to coarse-grained sand, and silt. The gravel deposits range from well sorted to poorly sorted, and generally are informally referred to as the Pasco gravels (Brown 1975). The fine-grained deposits make up the most extensive and voluminous part of the Hanford formation and generally are informally known as the Touchet Beds (Flint 1938). The Touchet Beds are divided into two facies: plane-laminated sand and normally graded rhythmites (Baker et al. 1991).

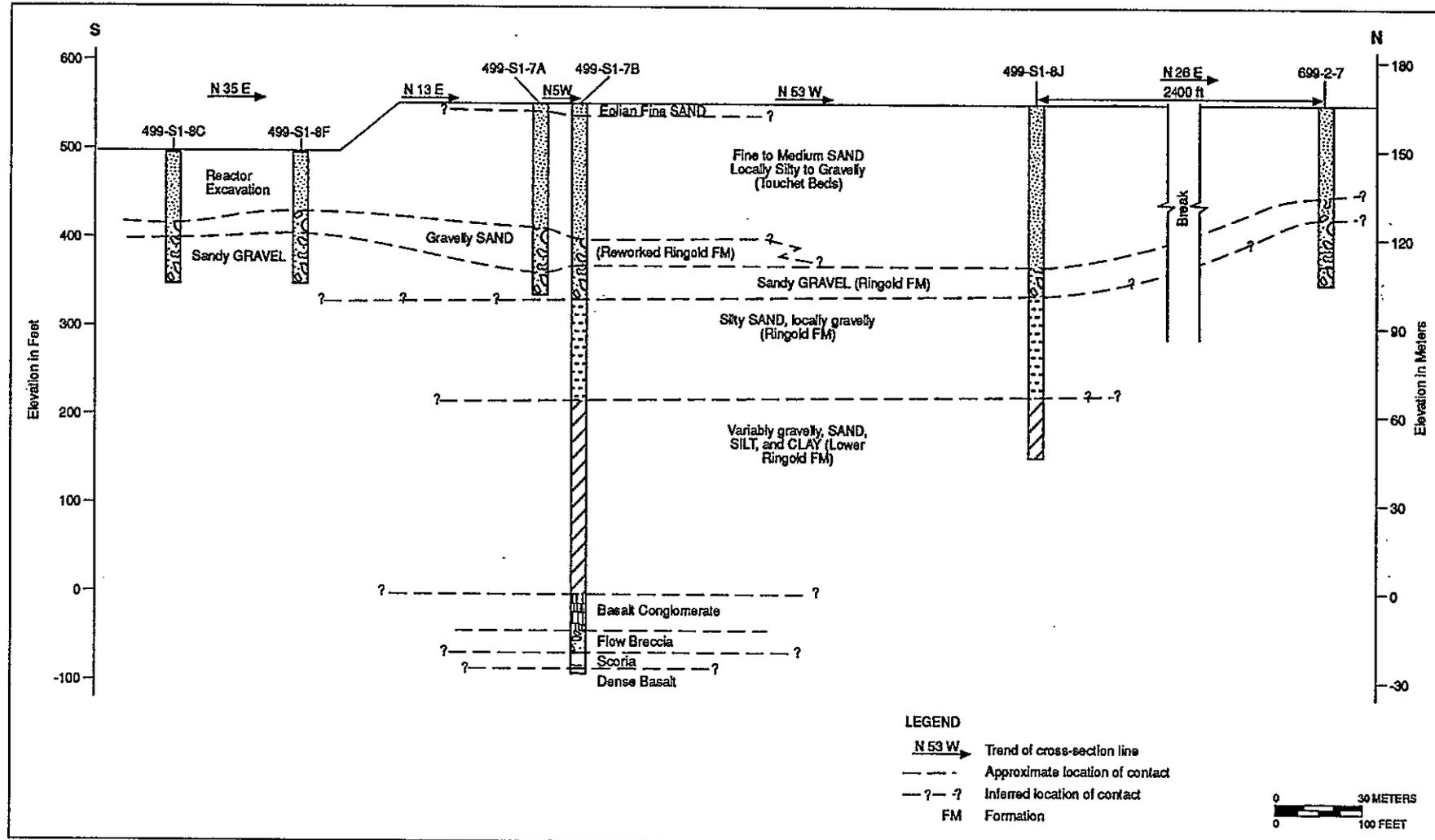
4.1.2 400 Area Geology

Information presented in this section was derived from reports of studies conducted to support siting and design of the FFTF (WHC 1975; HEDL 1975; John A. Blume & Associates 1970, 1971). Evaluations of soil lithology and geologic structure and stratigraphy conducted in these studies indicate that the three primary geologic units beneath the 400 Area are the Elephant Mountain Member of the Saddle Mountains Basalt Formation, the Ringold Formation, and the Touchet Beds of the Hanford formation. A geologic cross section extending from the FFTF to the 400 Area ponds is shown in Figure 4-2, and the location of the cross section is presented in Figure 4-3.

Borehole 499-S1-7B (Figure 4-2), drilled during a 1969 investigation, intersected what is believed to be the Elephant Mountain flow of the Elephant Mountain Member at 181 m (594 ft) below ground surface. The basalt consists of flow breccia from a depth of 181 to 191 m (594 to 626 ft), underlaid by scoria to a depth of 195 m (641 ft). Hard dense basalt extends downward from the scoria to the bottom of the hole at 198 m (649 ft). The dense basalt contains horizontal to subhorizontal flow structures and fractures dipping at 25 degrees.

The fluvial gravels and overbank and lacustrine silt and clay deposits of the lower portion of the Ringold Formation extend downward from 101 m (330 ft) below ground surface to the Elephant Mountain flow. The fine-grained, thinly bedded deposits are absent below a depth of approximately 168 m (550 ft). Intervals of well-cemented material often described in well logs as the Ringold conglomerate are found throughout the entire 81-m (264-ft) interval.

Overlying the lower portion of the Ringold Formation and extending upward to 67 m (220 ft) below ground surface are light brown and brown-gray silty sands that are both locally gravelly and locally clayey. Dense light gray-brown fluvial sandy gravels

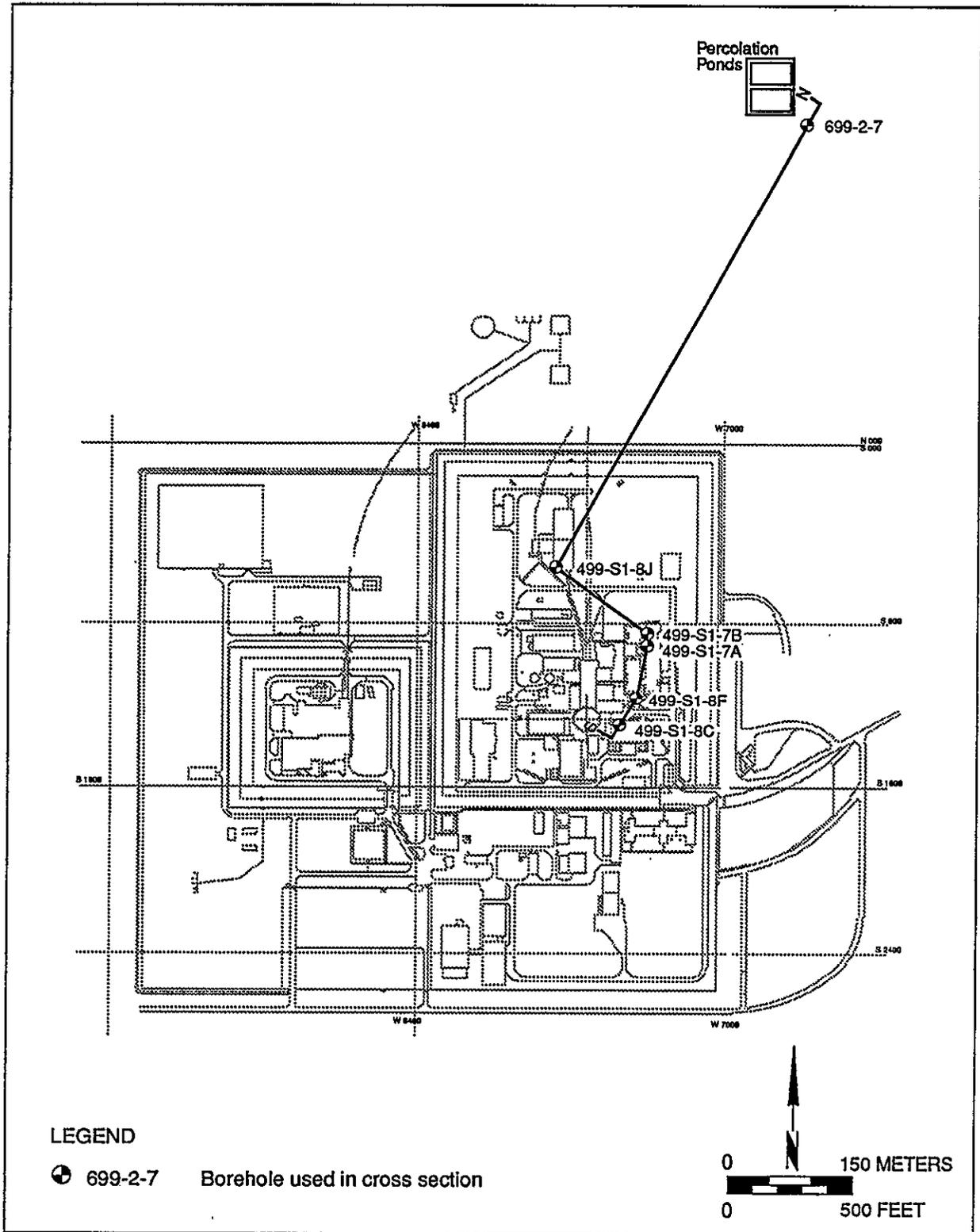


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Figure 4-2. 400 Area and Vicinity Geologic Cross Section.

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Figure 4-3. Location of the 400 Area and Vicinity Geologic Cross Section.

overlie the silty sands to a depth of approximately 55 to 46 m (180 to 150 ft). Overlying the sandy gravels between a depth of 37 to 58 m (120 and 190 ft) are dense well-graded gray gravelly sands consisting of light gray, fine to medium sand with some gravel. These gravelly sands may be a reworked surface of the Ringold Formation and are not continuous.

The Touchet Beds of the Hanford formation overlie the discontinuous gravelly sands. These horizontally stratified beds consist of late Pleistocene glaciofluvial dense sands that extend to approximately 37 to 55 m (120 to 180 ft) below ground surface. Individual bedding layers range from a fraction of an inch to several inches. The beds typically consist of gray-brown, poorly graded, fine- to medium-grained dense sands that are locally silty and locally gravelly. The sands grade downward to the dense gravelly sands (Baker et al. 1991).

Under the 400 Area the sands have unique structural features known as "sand" dikes or clastic dikes. These dikes were encountered in excavations created during construction of the FFTF facility and are apparently common in the Touchet Beds of this area. The dikes are composed of silt and sand in distinct bands (or beds) paralleling the dike walls and separated by a thin laminae of silty material. The width of the dikes ranges from several inches to six feet. The near-vertical deposits exhibit cross lamination and dewatering features. Vertical extent of the dikes is unknown. The dikes have been interpreted as non-tectonic structures related to rapid loading and unloading during cataclysmic flooding (Baker et al. 1991).

The Hanford formation is overlain by eolian deposits that blanket the ground surface of the 400 Area at an elevation of approximately 168 m (550 ft) above mean sea level (amsl). These deposits consist of 5 to 15 ft of eolian fine- to medium-grained sand dunes characterized by cross-bedding. The sand is derived from the top of the Hanford formation and is stabilized on the ground surface by growths of sagebrush and grass.

4.2 HYDROGEOLOGY

4.2.1 Regional and Hanford Site Hydrogeology

The hydrogeology of the Pasco Basin is characterized by a multi-aquifer system that consists of four hydrogeologic units that correspond to the upper three formations of the Columbia River Basalt Group (Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt) and the suprabasalt sediments. The basalt aquifers consist of the tholeiitic flood basalts of the Columbia River Basalt Group and relatively minor amounts of intercalated fluvial and volcaniclastic sediments of the Ellensburg Formation. Confined aquifers in the basalt are in the sedimentary interbeds and/or interflow zones that occur between dense basalt flows. The main water-bearing portions of the interflow zones are networks of interconnecting vesicles and fractures of the flow tops and bottoms (DOE 1988). The suprabasalt aquifer system consists of fluvial, lacustrine, and glaciofluvial sediments. This aquifer is regionally unconfined and is largely contained within the Ringold Formation and Hanford formation (Delaney et al. 1991). Hydraulic parameters for various water-bearing geologic units at the Hanford Site are presented in Table 4-1.

Table 4-1. Hydraulic Parameters for Geologic Units at Various Hanford Site Areas.

Geologic Unit	Area	Hydraulic conductivity (m/d)	Transmissivity (m ² /d)	Effective porosity	Data source
Selah interbed	Hanford Site	0.1 - 7	0.8 - 43	ND	Graham et al. (1981)
Rattlesnake Ridge interbed	100 Area	0 - 30	ND	< 10%	Gephart et al. (1979)
Rattlesnake Ridge interbed	200 Area	ND	3 - 93	ND	Graham et al. (1984)
Elephant Mountain interflow zone	200 East Area	ND	0.7 - 109	ND	Graham et al. (1984)
Levey interbed	300 Area	3×10^{-3} - 3×10^2	ND	ND	DOE-RL (1990)
Saddle Mountain Basalt flowtop	Hanford Site	3×10^{-7} - 3×10^{-3}	ND	5%	Cushing (1989)
Ringold Formation FSB/FSC	1100 Area	0.1 - 1.5	ND	ND	Lindberg and Bond (1979)
Ringold Formation overbank deposits	1100 Area	2.4×10^{-4} - 3.0×10^{-2}	ND	ND	Lindberg and Bond (1979)
Ringold Formation FSE	200 West Area	0.2 - 61	ND	ND	Last et al. (1989)
Ringold Formation FSE	100 Area	9 - 395	530 - 2,480	ND	Liikala et al. (1988)
Ringold Formation	300 Area	0.6 - 3,000	ND	ND	DOE-RL (1990)
Hanford formation	300 Area	3,400 - 15,000	ND	ND	DOE-RL (1990)
ND = No Data available.					

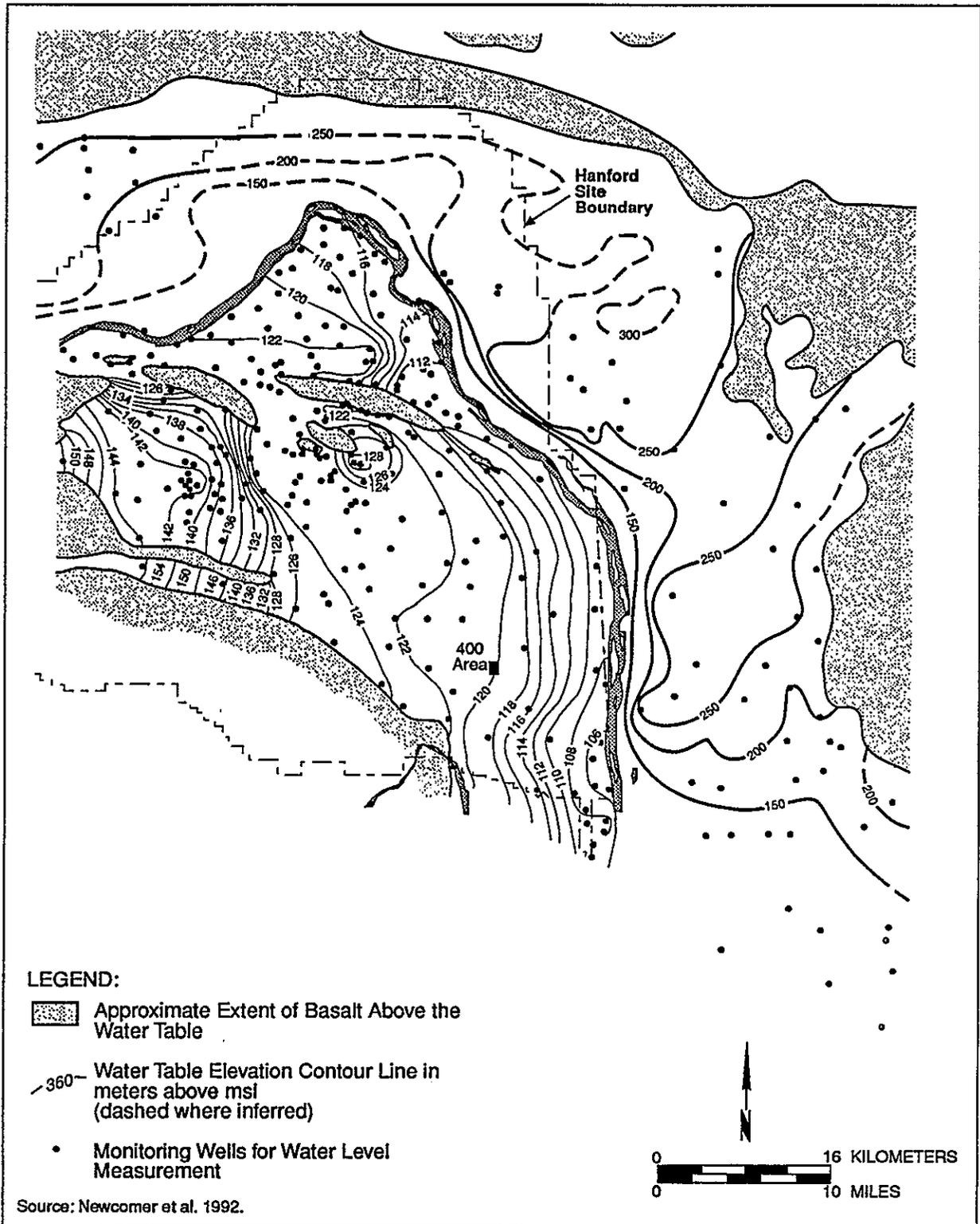
The shallow basalt aquifers are recharged from infiltration of precipitation and runoff along the margins of the Pasco Basin. Regional recharge of the deep basalt aquifers is inferred to result from interbasin groundwater movement originating northeast and northwest of the Pasco Basin in areas where the Wanapum and Grande Ronde Basalts crop out extensively (DOE 1988). The uppermost confined basalt aquifers are locally recharged from downward migrating groundwater only where the hydraulic head of the unconfined aquifer exceeds that of the confined aquifers. This can occur when artificial recharge creates mounding in the unconfined aquifer. Groundwater discharge from shallow basalt aquifers is probably to the overlying aquifers and to the Columbia River. The discharge area(s) for the deeper groundwater system is uncertain, but flow is inferred to be generally southeastward with discharge thought to be south of the Hanford Site (DOE 1988).

Erosional "windows" through dense basalt flow interiors allow direct interconnection between the unconfined aquifer system and underlying confined basalt aquifers. There are no known erosional windows in the vicinity of the 400 Area. Graham et al. (1984) reported that some contamination was present in the uppermost confined aquifer (Rattlesnake Ridge interbed) south and east of Gable Mountain Pond. Graham et al. (1984) evaluated the hydrologic relationships between the Rattlesnake Ridge interbed aquifer and the unconfined aquifer in this area and delineated a potential area of intercommunication beneath the northeast portion of the 200 East Area.

The uppermost aquifer system is regionally unconfined beneath the Hanford Site and lies at depths ranging from less than 1 ft below ground surface near West Lake and the Columbia and Yakima Rivers, to greater than 105 m (350 ft) in the central portion of the Cold Creek syncline. A water table map of the unconfined aquifer in the Hanford Site is presented in Figure 4-4. The position of the water table in the southwestern Pasco Basin is generally within Ringold fluvial gravels of unit E. In the northern and eastern Pasco Basin, the water table is generally within the Hanford formation. Hydraulic conductivities for the Hanford formation (600 to 3,000 m/day or 2,000 to 10,000 ft/day) are much greater than those of the gravel facies of the Ringold Formation (186 to 930 m/day or 610 to 3,050 ft/day) (Graham et al. 1981).

The base of the uppermost aquifer system is defined as the top of the uppermost basalt flow; however, fine-grained overbank and lacustrine deposits in the Ringold Formation locally form confining layers for Ringold fluvial gravels (units A, B, C, D, and E). The uppermost aquifer system is bordered laterally by anticlinal basalt ridges and has a saturated thickness of approximately 150 m (500 ft) thick near the center of the Pasco Basin (Delaney et al. 1991).

Average annual precipitation for the period 1956-1977 was 17.6 cm (6.95 in.) for the northern portion of the Hanford Site. Mean annual potential evapotranspiration has been estimated to be about 106.4 cm (41.89 in.). The actual annual evapotranspiration rate under current conditions is estimated to be about 17.1 cm (6.73 in.). Recharge infiltration is estimated to be about 0.74 cm (0.29 in.) under current conditions by Bauer and Vaccaro (1990), and in the range of 0 to 1.2 cm/year (0 to 0.47 in./year) by Gee (1987) and 2.5 to 7.6 cm/year (1 to 3 in./year) for grass-covered soils by Kirkham and Gee (1984). Kirkham and Gee (1984) estimate that recharge is 2.5 to 7.6 cm/year (1 to 3 in./year) for grass-covered soils. In areas covered with deep-rooted plants, little or no recharge occurs (Gee et al. 1989; Routson et al. 1988; Routson and Johnson 1990).



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Figure 4-4. Hanford Site Water Table Map for June through August, 1991.

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4.2.2 400 Area Hydrogeology

Borehole 499-SA-7B terminates in dense basalt at 198 m (649 ft) below ground surface and did not intersect any interflow zones or the sedimentary interbeds of the Ellensburg Formation (Figure 4-2). Hence, the shallowest of the confined basalt aquifers beneath the 400 Area must be at an even greater depth. John A. Blume & Associates (1971) tentatively identified the dense basalt penetrated by borehole 499-SA-7B as the Elephant Mountain flow of the Elephant Mountain Member. Assuming this identification is correct, the shallowest confined basalt aquifer is probably the Rattlesnake Ridge interbed.

Sediments overlying the Elephant Mountain flow total approximately 183 m (600 ft) in thickness. Approximately 134 m (440 ft) of the lower portion of these sediments is saturated and comprise what is probably a single unconfined aquifer. Locally confined or semiconfined conditions may, however, be present within this unconfined aquifer in areas where relatively impermeable cemented or fine-grained materials act as confining layers. The water table of the unconfined aquifer is located roughly at the contact between the Ringold Formation and the Hanford formation. This location corresponds to a depth of approximately 49 m (160 ft) and an elevation of about 119 m (390 ft) amsl.

Groundwater in the vicinity of the 400 Area moves in the unconfined aquifer to the southeast (Figures 4-5 and 4-6). Pumping of the production well 499-S1-8J at a depth of 110 to 119 m (360 to 390 ft) within the 400 Area may result in drawdown in close proximity to the well, but a noticeable cone of depression is not evident with the present water level data (Figures 4-5 and 4-6). Disposal of sanitary and process sewer effluent may have produced a small mound of groundwater beneath the sewage lagoon and the 400 Area ponds. The height of the groundwater mound is estimated to be on the order of a foot, based on water level data from wells in the vicinity of the 400 Area ponds.

4.3 GROUNDWATER QUALITY

4.3.1 Regional Hanford Site Groundwater Quality

Groundwater flows in the unconfined aquifer to the east and southeast beneath the central area of the Hanford Site (Figure 4-4). As a result, contaminants in the groundwater beneath the 200 Areas migrate as plumes towards and through the 400 Area. Two examples of this phenomenon are shown in Figures 4-7 and 4-8 for nitrate and tritium, respectively. Plume bifurcation in the 200 East Area results in contaminant movement to the north through Gable gap, but the bulk of the contaminant mass moves to the southeast (Figure 4-8).

4.3.2 400 Area Groundwater Quality

Groundwater concentration contours for nitrate and tritium in and around the 400 Area are presented in Figures 4-9 and 4-10, respectively.

499-S1-8J

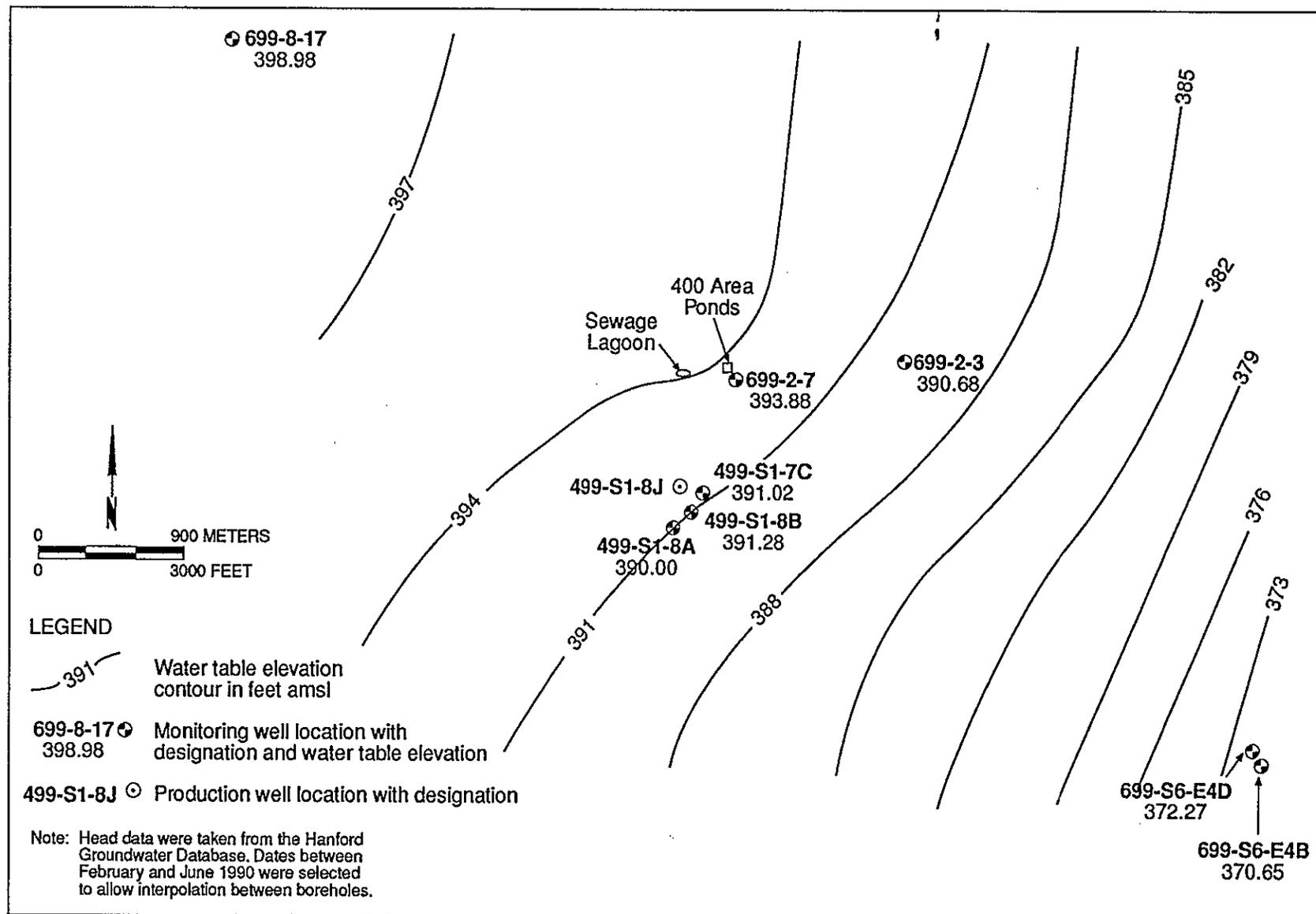
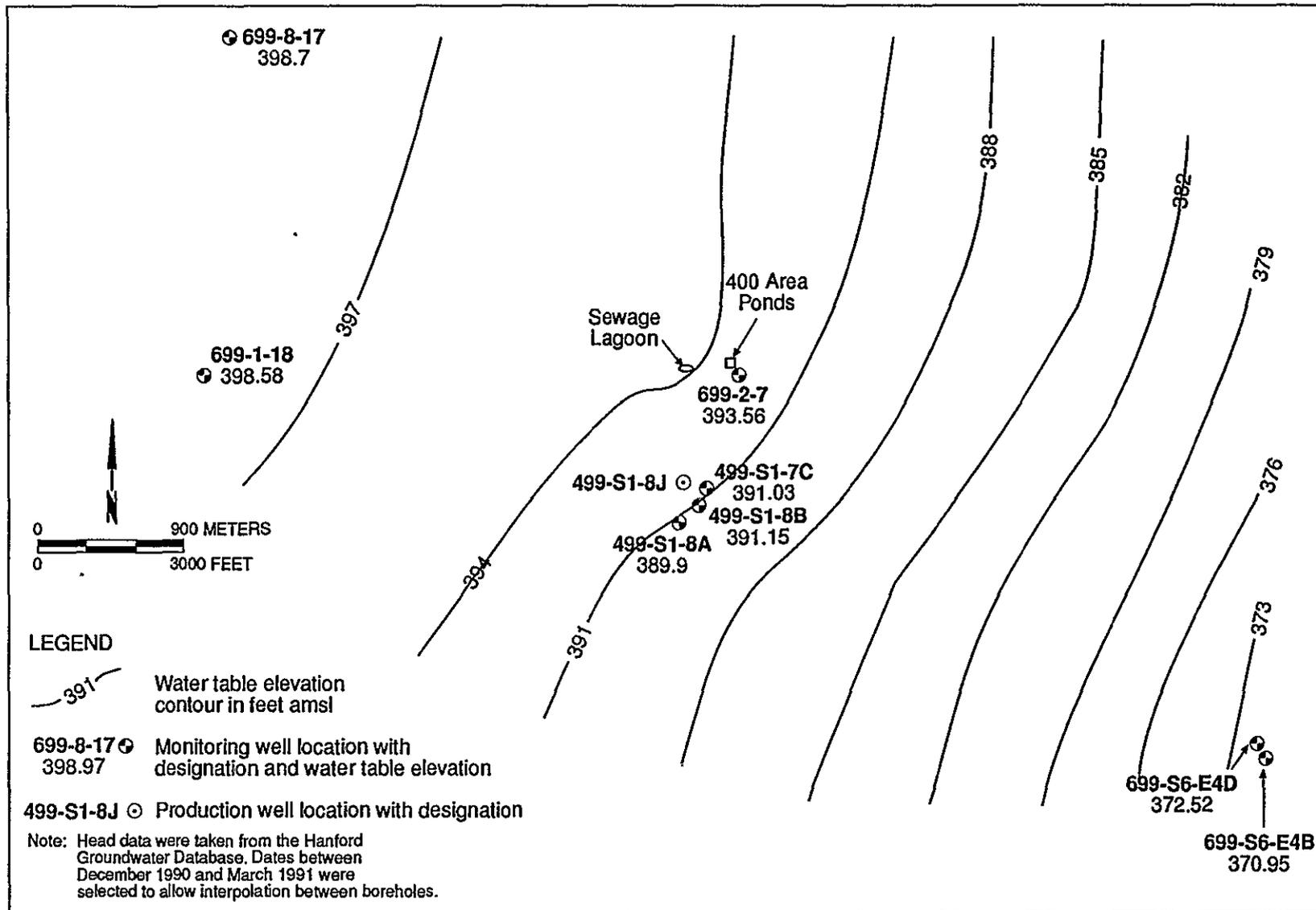


Figure 4-5. 400 Area and Vicinity Water Table Map for February Through June 1990.



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Figure 4-6. 400 Area and Vicinity Water Table Map for December 1990 Through March 1991.

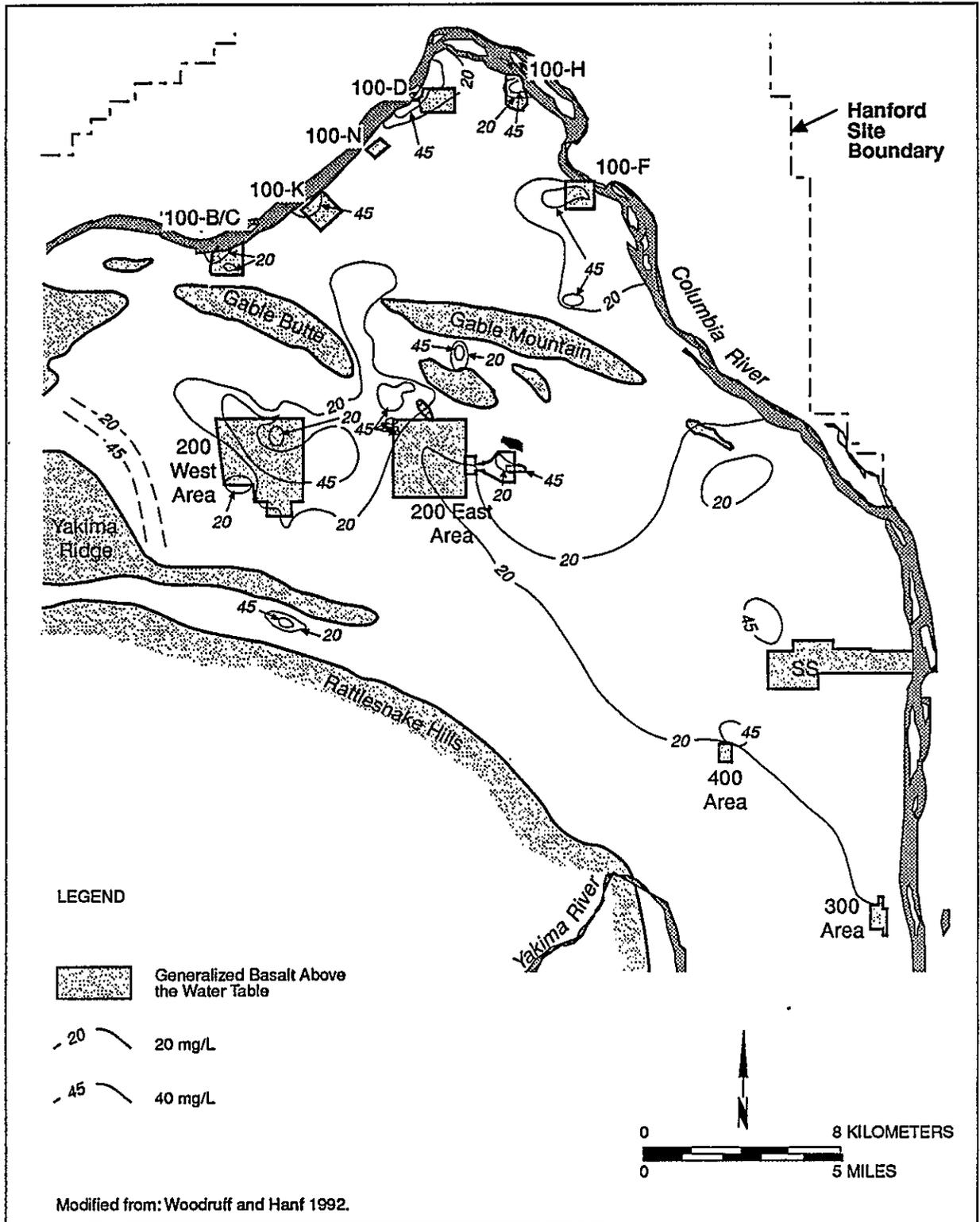
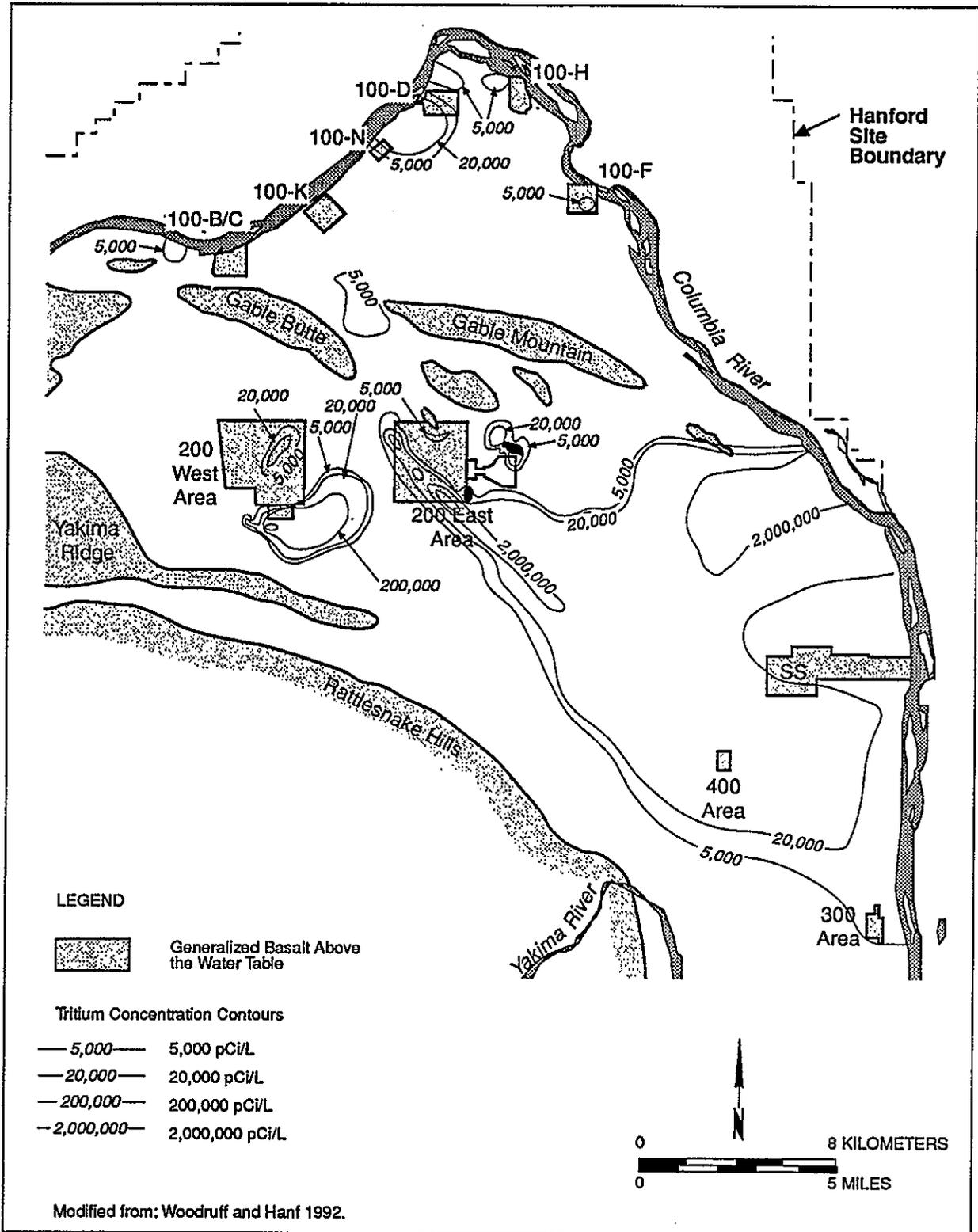


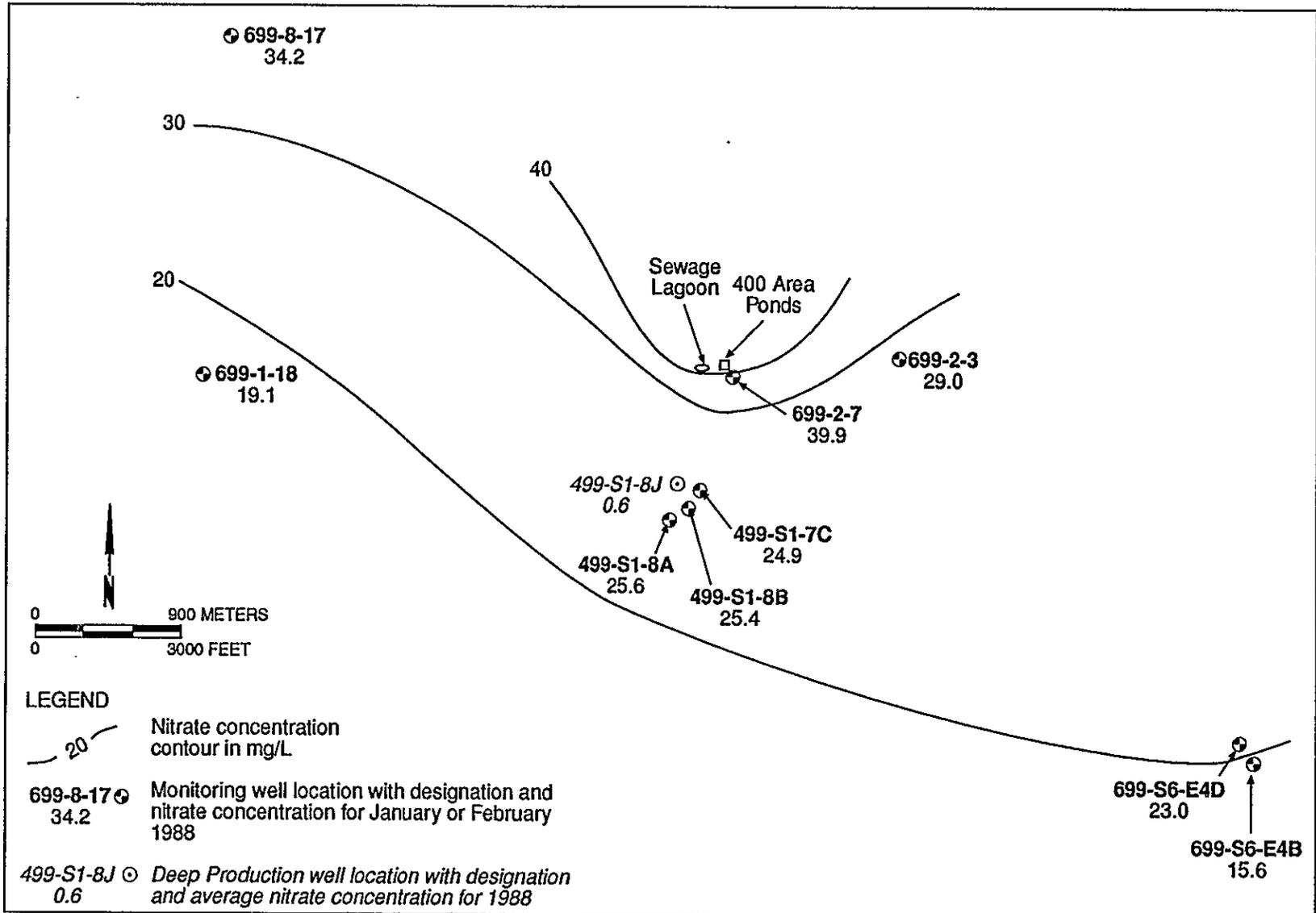
Figure 4-7. Hanford Site Nitrate Concentrations in the Unconfined Aquifer During 1991.

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Figure 4-8. Hanford Site Tritium Concentrations in the Unconfined Aquifer During 1991.



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Figure 4-9. 400 Area and Vicinity Nitrate Concentration Contours for 1988.

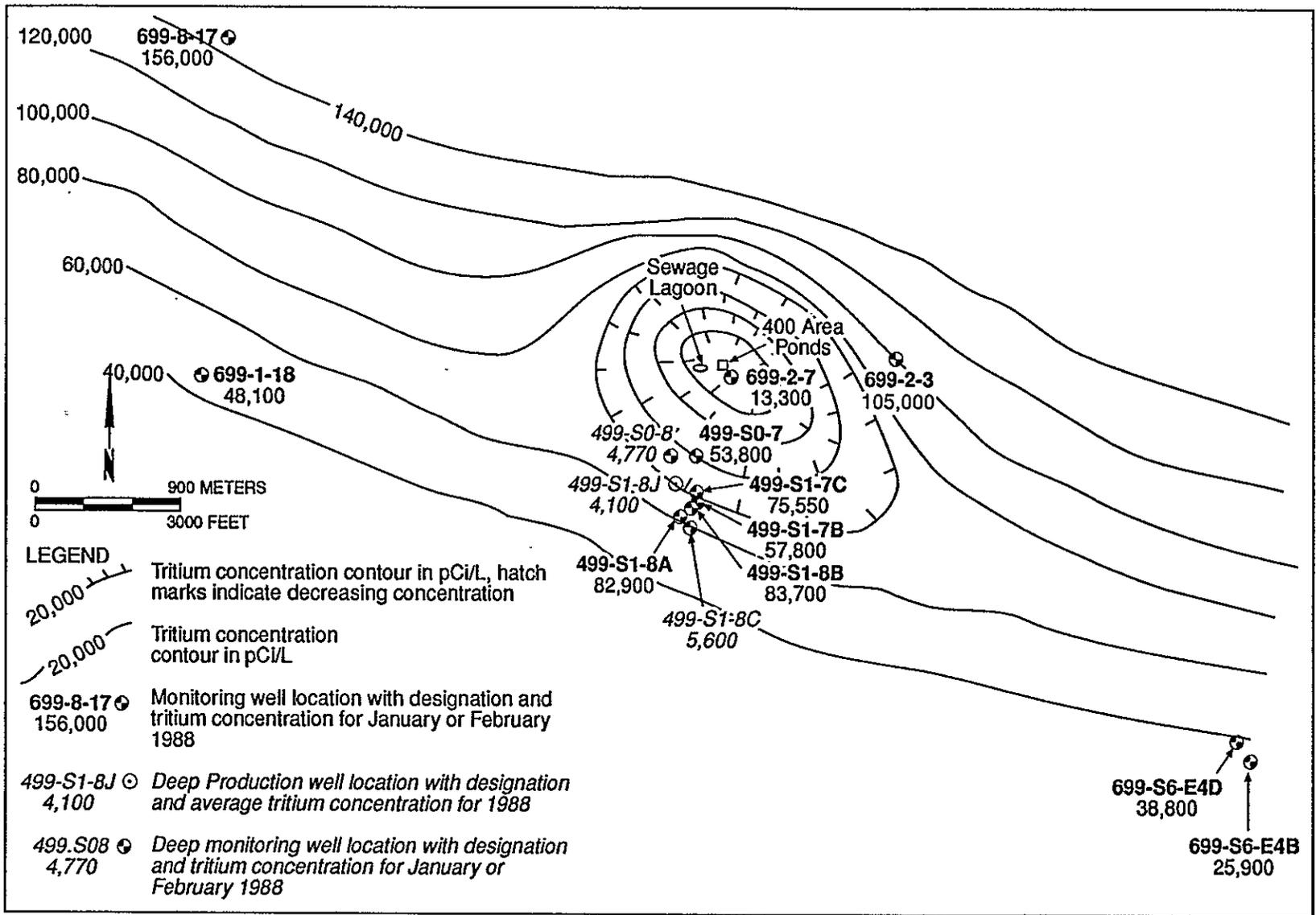


Figure 4-10. 400 Area and Vicinity Tritium Concentration Contours for 1988.

Nitrate concentrations are somewhat elevated in the area surrounding the sewage lagoon and 400 Area ponds. Elevated nitrate concentrations in this area can be attributed to the disposal of sanitary sewage effluent in the sewage lagoon. The current 400 Area primary water supply well (499-S1-8J) is screened deeper than other wells shown in Figure 4-9 and has a significantly lower concentration of nitrate. This lower concentration of nitrate in well 499-S1-8J is likely due to a vertical distribution of nitrate within the unconfined aquifer. The concentration of nitrate in well 499-S1-J5 has been shown in Figure 4-9 for information only and has not been used in the construction of the nitrate concentration contours because it represents nitrate concentrations deeper in the unconfined aquifer. Tritium concentrations in the vicinity of the 400 Area ponds appear to be lower than the surrounding areas, both up and down gradient of the 400 Area ponds (Figure 4-10). Tritium concentrations in deep wells 499-S0-8, 499-S1-8J, and 499-S1-8C are shown on Figure 4-10 for information only, but due to the vertical distribution of tritium within the unconfined aquifer the deeper wells were not considered in construction of the tritium concentration contours.

4.3.3 Potential Local Influences on Groundwater Quality

Nitrate concentrations in the upper portion of the unconfined aquifer in the vicinity of the 400 Area are due to the migration of nitrate originating from the 200 Areas (Figure 4-7). Additionally, nitrate levels in the unconfined aquifer are slightly elevated in the immediate vicinity of the sanitary sewer lagoon due to disposal of sanitary sewer effluent (Figure 4-9). Sanitary sewer effluent contains ammonium and other nitrogen compounds that are readily converted to nitrate in the soil column. Nitrate appears to have a vertical distribution within the unconfined aquifer, with the deeper portion of the aquifer considerably lower in nitrate concentration. Well 499-S1-8J is deeper than other wells presented in Figure 4-9 and has a significantly lower concentration of nitrate.

Tritium in the unconfined aquifer is the result of migration of tritium from the 200 Areas (Figure 4-8). Tritium concentrations in the unconfined aquifer in the vicinity of the 400 Area ponds are lower than the concentrations of tritium up-gradient and down-gradient of the ponds (Figure 4-10). The disposal of process sewer effluent in the 400 Area ponds appears to dilute the tritium concentration in the unconfined aquifer in the immediate vicinity of the ponds (Figure 4-10).

Tritium, like nitrate, appears to be vertically distributed within the unconfined aquifer, with significantly lower concentrations of tritium deeper in the unconfined aquifer. Measurements taken while drilling well 499-S1-8J indicate that the concentration of tritium at 79 m (260 ft) (38,000 pCi/L) is an order of magnitude greater than that at 122 m (400 ft) (3,200 pCi/L) (Meier Associates 1985). Construction details for the wells used in Figures 4-9 and 4-10 are listed in Table 4-2, and well construction logs are presented in Appendix B. Wells 499-S1-7B, 499-S1-7C, 499-S1-8A, 499-S1-8B, and 499-S1-8C are actually cased boreholes drilled around 1970 as part of the geologic investigation to support construction of the FFTF. Of these wells only 499-S1-7B and 499-S1-7C are perforated, and it is unlikely that any of the wells have an annular seal. Wells 499-S0-7 and 499-S0-8 were drilled for the purpose of 400 Area water supply, but because they were installed during 1972 it is not expected that they have annular seals either. Well 499-S1-8J was drilled in 1985 and is currently the primary production well for the 400 Area.

Table 4-2. Well Construction Data.

Well	Date Drilled	Hanford Coordinates Plant		Casing Elevation	Bottom Elevation (ft-amsl)	Casing Diameter (in)	Screen/Perforation Elevation (ft-amsl)		Notes
		East	North				Minimum	Maximum	
499-S0-7	3/72	-7470	-180	548.5	150	8	153	328	Perforated. Water supply well 2. Backup to water supply well 4.
499-S0-8	3/72	-7970	-180	546.90	253	8	267	359	Perforated. Water supply well 1. Not in service.
499-S1-7B	12/69	-7458	-1008	554.28	-95	8.0	274, 224, 174	324, 254, 199	Perforated. Cased to 14 ft amsl.
499-S1-7C	12/69	-7459.7	-760.1	549.52	343	8.0	350	375	Perforated.
499-S1-8A	12/71	-7820	-1258	547.50	420	Unknown	N/A	N/A	N/A.
499-S1-8B	12/71	-7573	-1108	547.50	422	Unknown	N/A	N/A	N/A.
499-S1-8C	12/71	-7605	-1440	497.50	349	Unknown	N/A	N/A	N/A.
499-S1-8J	4/85	-7880*	-692*	646.50*	247	10.0	257	287	Screened. Water supply well 4. Primary water supply well.
699-1-18	1/58	-17699	1452	537.65	370	8.0	273	429	Perforated. Six inch liner from 371 to 429 ft amsl. Elevation in doubt. End of boring 188 ft-amsl.
699-2-3	8/50	-3325	1900	477.14	330	8.0	354	392	Perforated.
699-2-7	3/78	-6824	1529	512.20	312	8.0	347	367	Screened.
699-8-17	5/50	-17125	8200	522.44	364	8.0	364	414	Screened. Plug at 364 ft amsl. End of boring 322 ft amsl.
699-S6-E4B	3/53	3982	-6098	421.36	335	8.0	344	372	Perforated. Cement plug at 335 ft amsl. End of boring 321 ft amsl.
699-S6-E4D	11/53	3767	-5734	430.47	288	8.0	290	397	Screened/perforated.

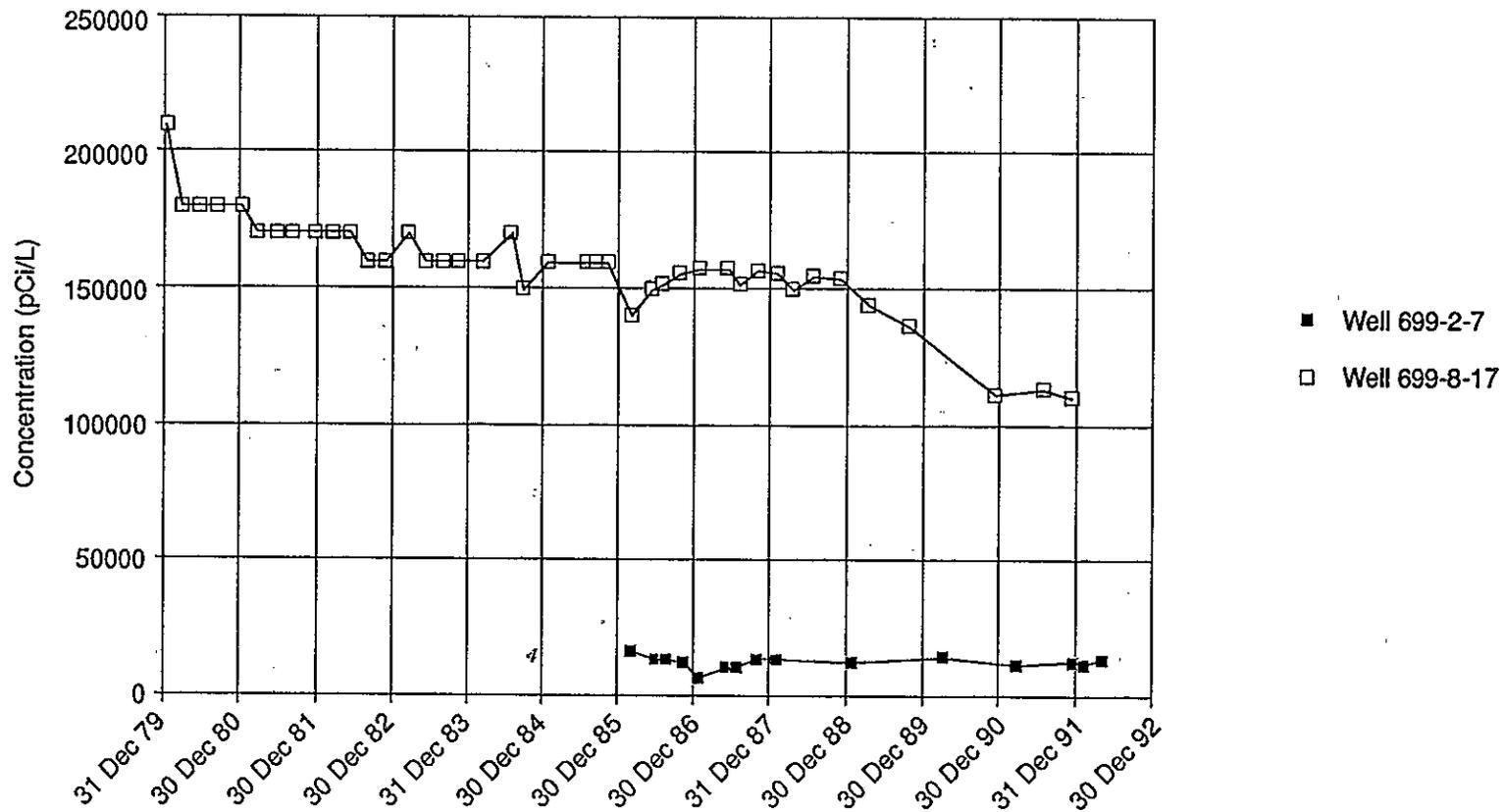
*Well 499-S1-8J has not been surveyed, but is reported to be 15 ft from well 499-S1-8H (Meier Associates 1985). The coordinates listed are for well 499-S1-8H.
N/A = Data not available.

Source: John A. Blume and Associates 1971, Golder Associates Inc. 1989a, Golder Associates Inc. 1989b, HEDL 1975, McGhan 1989, Meier Associates 1985, Newcomb 1972, Shannon & Wilson 1971, Summers and Schwaab 1977.

Wells 499-S1-8J, 499-SO-8, and 499-S1-8C are sampling groundwater at groundwater elevations lower than the remainder of the aforementioned wells, and they contain groundwater with a fraction of the contamination found in the other wells. This information supports the vertical distribution of tritium within the unconfined aquifer with significant lower concentrations of tritium deeper in the aquifer.

Tritium levels in the process sewer effluent directly correspond with the water supply concentrations from the production wells. Figure 3-3 shows the dramatic drop in tritium levels when production well 499-S1-8J went into use in 1986. It is probable that the exceedance of groundwater quality criteria for tritium in the 400 Area during the mid-1980's was not caused by 400 Area operations. Rather, the tritium was likely due to leaking of contaminated shallow groundwater deeper into the aquifer and into the 400 Area water supply. The cone of depression around the production wells may have aided the downward migration of contaminants along unsealed well casings.

Presently at the site, the extraction of groundwater with a cased and sealed production well results in a 400 Area water supply with significantly lower concentrations of tritium and nitrate than is present in the upper portion of the aquifer below the 400 Area (Figure 4-10), which is contaminated by tritium and nitrate plumes originating from the 200 Areas (Figures 4-7 and 4-8). The concentration of tritium in up-gradient well 699-8-17 versus the concentration in the down-gradient monitoring well 699-2-7 is presented in Figure 4-11 and shows that the concentration of tritium is significantly lower in the down-gradient monitoring well. During 1991 one groundwater sample from the current production well (499-S1-8J) exceeded the 20,000 pCi/L groundwater criteria for tritium (WAC 173-200), but the process sewer effluent did not increase in tritium concentrations. In subsequent sampling periods, the groundwater in production well 499-S1-8J was below the 20,000 pCi/L criteria (WAC 173-200) for tritium. The one sampling period in which the groundwater from production well 499-S1-8J exceeded the groundwater criteria for tritium (WAC 173-200) may have been anomalous, or could be due to leakage of groundwater with higher tritium concentrations from the upper portion of the aquifer deeper into the aquifer along unsealed well casings.



Source: Data points represent data taken from Geosciences Groundwater Database, Westinghouse Hanford Company.

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Figure 4-11. Tritium Concentrations for Well 699-2-7 and Well 699-8-17.

5.0 IMPACT ASSESSMENT

5.1 HYDROLOGIC IMPACTS

Travel times for liquid to reach the water table from the 400 Area ponds range from a low of 20 days based on the maximum estimated flow rate to a high of 37 days based on the minimum estimated flow rate (Table 5-1). The estimated average flow rate resulted in a calculated travel time of 22 days (Table 5-1). A discussion of the analytical model and assumptions for this analysis is presented in Appendix C. The calculated travel times are considerably shorter than those estimated with the same model in WHC 1990a for the 400 Area ponds. The differences result from classification of the soils into two layers of more permeable soils versus one layer of less-permeable soil in WHC 1990a and the calculated infiltration area. The previous study (WHC 1990a) calculated the infiltration area based on the total bottom area of both ponds versus the true infiltration area of approximately one-third of the bottom area of one pond. Because of the very short calculated travel times, a breakthrough of the initial process effluent is not likely to be visible in quarterly groundwater sampling results or water level readings of monitoring well 699-2-7.

It took approximately 1 month for the moisture front to reach the unconfined aquifer. Therefore, after approximately 12 years of effluent disposal at the ponds, it is reasonable to assume that a steady-state equilibrium has been reached. Water level data for well 699-2-7 were unavailable for years prior to 1990, so confirmation of steady-state conditions based on historical water level data for wells in the vicinity of the 400 Area ponds was not possible. The groundwater mound, on the order of 1 ft high, would be expected to remain about the same size unless the process sewer effluent discharge rate changes. Therefore, the hydrologic impact of the effluent disposal in the 400 Area ponds appears to be quite minimal.

5.2 CONTAMINANT IMPACTS

With the exception of tritium, process effluent constituents are consistently at concentrations below WAC 173-200 groundwater criteria and have a negligible impact on groundwater quality. Tritium was selected for assessment because in the past it exceeded groundwater criteria (WAC 173-200), it is monitored on a widespread basis, and it is highly mobile. Nitrate was also included in the transport analysis, but note that its presence in groundwater monitoring well 699-2-7 is attributed to the sanitary sewer lagoon, not from effluent disposed of in the 400 Area ponds.

Tritium is not absorbed and therefore moves with the moisture front. Table 5-2 presents the calculated travel times for tritium to move downward from the 400 Area ponds to the unconfined aquifer based on several process sewer effluent flow rates. Because of the very short calculated travel times, a breakthrough of the initial process effluent is not likely to be visible in quarterly groundwater sampling results of monitoring well 699-2-7. Discussion of the analytical model used to determine contaminant travel times is presented in Appendix C.

Because tritium moves at the same rate as the water, tritium flux should also have reached a steady-state equilibrium, and the concentration in the groundwater would not be expected to vary unless the concentration of tritium in the process sewer effluent varies. The extraction of groundwater from the current production well (499-S1-8J) with lower tritium concentrations than the up-gradient well (699-8-17), and subsequent disposal of the effluent in the 400 Area ponds,

Table 5-1. One-Dimensional Flow Assessment.

Rate L/min (gpm)	Area (m ²)	Infiltration Rate (cm/s)	Layer	Thick- ness (m)	Soil Type*	Saturated Moisture Content	Saturated Hydraulic Conductivity (cm/s)	Mois- ture State	Moisture Content (estimated)	Hydraulic Conductivity (cm/s)	Time (s)	Total (d)	Estimated Moisture Migration (cm/d)
Minimum 34 (19)	150	0.00038	upper	29	B	0.5	0.001	U	0.35	0.00038	2070000	31	
			lower					A				U	
Average 68 (18)	150	0.00076	upper	29	B	0.5	0.001	U	0.42	0.00076	1600000	18	160
			lower	7	A	0.5	0.005	U	0.34	0.00076	310000	4	
Maxi- mum 220 (59)	150	0.0025	upper	29	B	0.5	0.001	S	0.5	0.001	1400000	17	180
			lower					A				U	
U = unsaturated S = saturated													

*Soil types A and B in WHC 1990a are coarse sand, and gravel and sand, respectively.

Table 5-2. Transport Analysis.

Rate L/min (gal/min)	Constituent	Retardation Factor (RF)	Estimated Contaminant Migration (cm/day)	Contaminant Transport to Water Table (day)
Minimum 34 (9)	Tritium	1	97	37
	Nitrate	1	97	37
Average 68 (18)	Tritium	1	160	22
	Nitrate	1	160	22
Maximum 220 (59)	Tritium	1	180	20
	Nitrate	1	180	20

appears to locally decrease the tritium concentration in groundwater in the vicinity of the 400 Area ponds (Figure 4-10). The levels of tritium in the up-gradient well (699-8-17) and the down-gradient monitoring well (699-2-7) are compared in Figure 4-11 and confirm the lower tritium levels in groundwater in the vicinity of the 400 Area ponds in relation to the tritium level in groundwater up-gradient of the ponds.

Concentration of tritium in groundwater in the vicinity of the 400 Area ponds (Figure 4-10) is less than the 20,000 pCi/L criteria from WAC 173-200. Disposal of process effluent and sanitary sewage appears to dilute tritium concentrations in a small portion of the upper aquifer near the 400 Area ponds. Continued operation of the 400 Area ponds for disposal of similar effluent should pose no significant impacts to the groundwater quality in the vicinity.

5.3 EVALUATION OF MONITORING NETWORK ADEQUACY

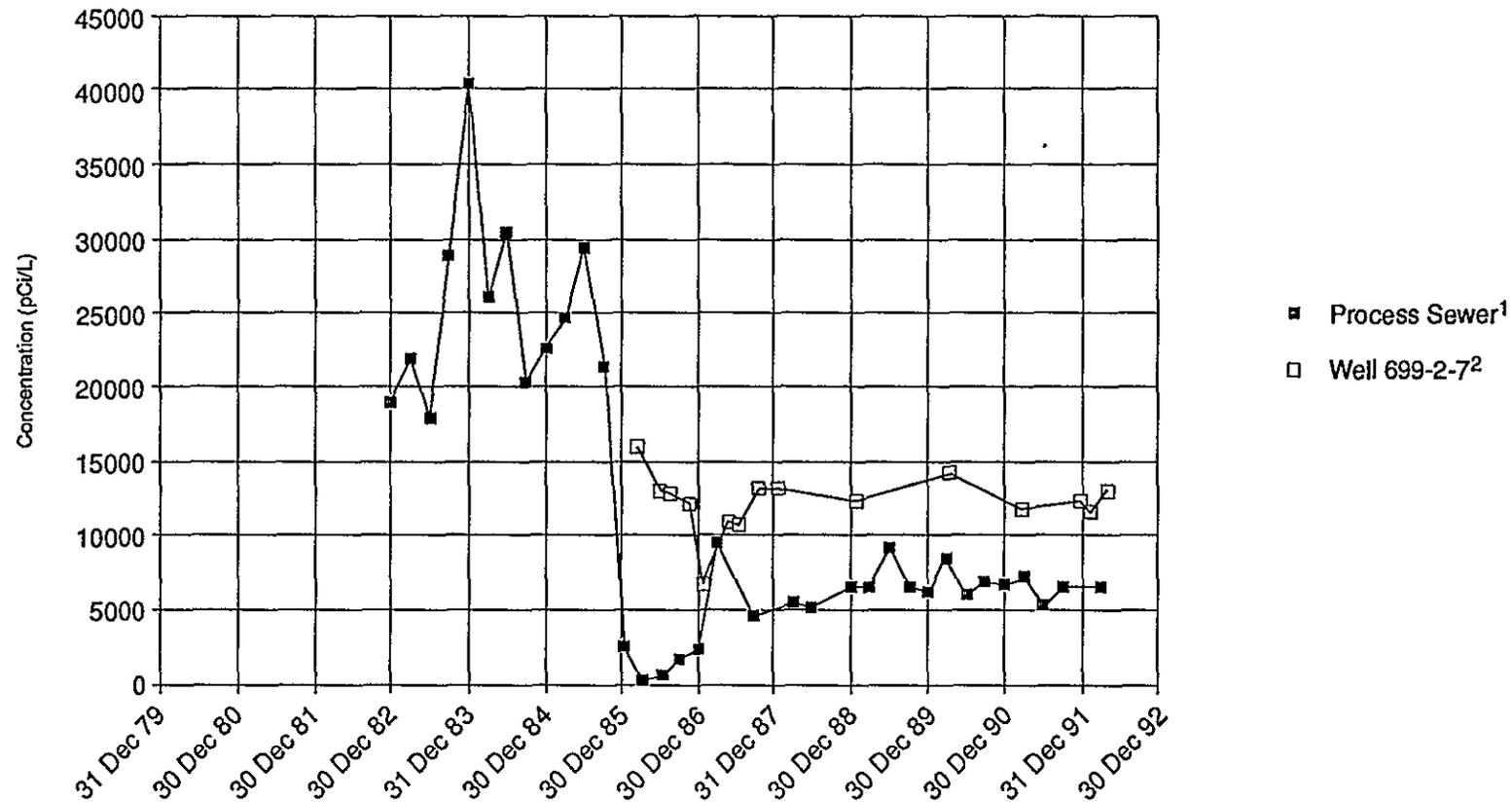
5.3.1 Groundwater Monitoring Well Placement

One monitoring well is presently installed adjacent and down-gradient of the 400 Area ponds to monitor groundwater quality down-gradient of the ponds (Figure 2-2). A well completion diagram for well 699-2-7 is presented in Appendix B, Figure B-11, and shows that the well is screened from a depth of 44 to 50 m (145 to 165 ft). The well may not be representatively monitoring the top of the aquifer because the top of the screen is more than 7 m (23 ft) below the water table.

Tritium concentration in the process sewer and the down-gradient monitoring well are compared in Figure 5-1, which shows that the monitoring well does generally correspond with the process sewer effluent. Figure 5-2 compares ammonium in the sanitary sewer and ammonium and nitrate in the process sewer with nitrate in the monitoring well. The concentrations of ammonium and nitrate in the process sewer are two to three orders of magnitude less than the concentration of ammonium in the sanitary sewer. The concentrations of nitrate in the monitoring well correspond well with the concentration of ammonium in the sanitary sewer. With the correspondence of nitrate concentrations in the sanitary sewer effluent and well 699-2-7, it appears that well 699-2-7 may be more influenced by the sanitary sewer effluent than the process sewer effluent. Nitrate concentrations would be expected to be somewhat diluted by the process sewer effluent if the well was intercepting the bulk of the process sewer effluent.

Well 699-2-7 appears to be monitoring the effluent from both the 400 Area ponds and the sanitary sewer lagoon that reaches the groundwater and may be mostly influenced by the sanitary sewer effluent. Although well 699-2-7 may be mostly influenced by effluent from the sanitary sewer lagoon, installation of a well more shallowly screened in the same area may not be needed due to the presence of wells further downgradient (Figure 4-6), sampling of the process sewer effluent, and the lack of constituents in the process sewer effluent that have a negative impact on the groundwater quality. One monitoring well in the vicinity of the 400 Area ponds is probably not sufficient to distinguish between constituents from the process sewer versus those from the sanitary sewer. However, comparison of the effluent sampling results from the process and sanitary sewer with the groundwater sampling results from the monitoring well should provide an

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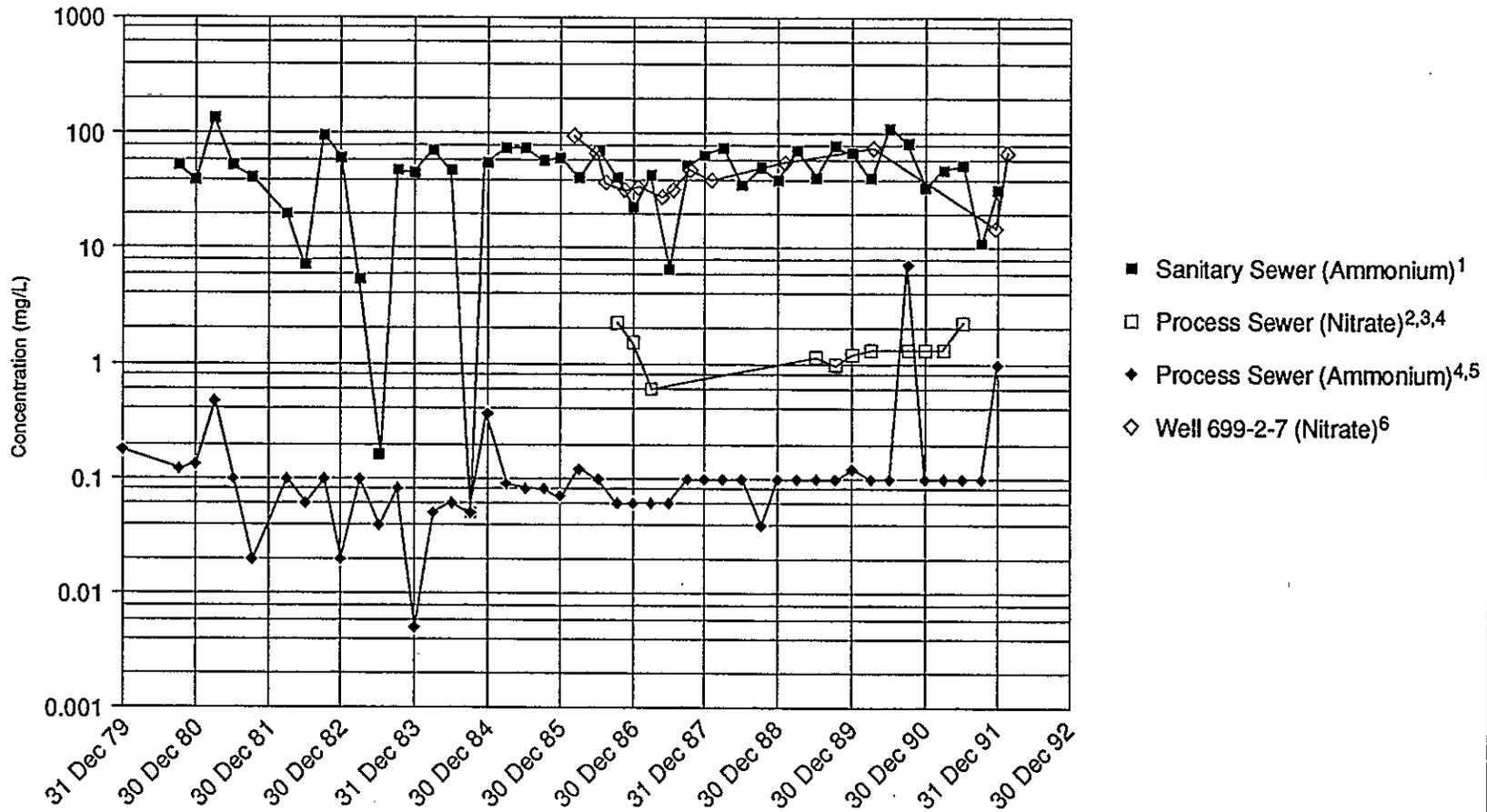
Source: Data points represent data taken from :

1 PNL Yearly summary reports (Jaquish and Bryce 1989, 1990, Jaquish and Mitchell 1988, PNL 1987, Price 1986, Price et al. 1984 and 1985, Sula et al. 1981, 1982, and 1983, Woodruff et al. 1991) with supplementary quarterly radiological testing information (Surface Environmental Database, Pacific Northwest Laboratory)

2 Geosciences Groundwater Database, Westinghouse Hanford Company.

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Figure 5-1. Tritium Concentrations for Process Sewer and Well 699-2-7.



- Sanitary Sewer (Ammonium)¹
- Process Sewer (Nitrate)^{2,3,4}
- ◆ Process Sewer (Ammonium)^{4,5}
- ◇ Well 699-2-7 (Nitrate)⁶

Source: Data points represent data taken from:

- 1 Hanford Groundwater Database, Pacific Northwest Laboratory
- 2 Preliminary evaluation of the Hanford Liquid Discharges to Ground (Jungfersch 1988)
- 3 WHC 300/400 Area surveillance data for environmental compliance, (McCarthy 1990, Manley 1992) and quarterly WHC 300/400 Area effluent monitoring reports, (WHC 1990d, WHC 1990e, WHC 1990f, WHC 1991b, WHC 1991c, WHC 1991d, WHC 1991e)
- 4 1989-1990 liquid effluent analytical data (WHC 1990g)
- 5 HEHF quarterly report of 400 Area process and sanitary sewers (HEHF 1980a through 1992)
- 6 Geosciences Groundwater Database, Westinghouse Hanford Company.

Figure 5-2. Nitrate and Ammonium Concentrations for the Process Sewer, Sanitary Sewer and Well 699-2-7.

adequate method of determining where constituents originate from if they are detected in the monitoring well. Background water quality data are provided by wells a considerable distance up-gradient from the 400 Area ponds, such as well 699-8-17 or well 699-1-18. Although samples taken from the up-gradient wells may not be truly representative of the groundwater directly up-gradient of the 400 Area ponds, they are adequate given the level of the impact of this site on the underlying groundwater.

5.3.2 Reporting of Monitoring Data

Environmental surveillance of the Hanford Site and surrounding areas is conducted by Pacific Northwest Laboratory for the DOE. Schedules for routine sample collection for the Ground-Water Monitoring Project are contained in the Environmental Surveillance Master Sampling Schedule (Bisping 1992). This schedule includes several wells in the 400 Area. Table 5-3 shows the parameters sampled and frequency for those wells listed. Annual reports are prepared by Pacific Northwest Laboratory.

Additional sampling for the drinking water supply system is conducted by the Hanford Environmental Health Foundation. Radionuclides are monitored monthly for tritium and quarterly for gross alpha, gross beta, gamma scan, and strontium-90. In addition, approximately 60 volatile organic compounds are monitored quarterly, and heavy metals, physical parameters, anions, and carbonate are monitored annually. Annual reports that summarize the collected data are prepared by the Hanford Environmental Health Foundation.

The Westinghouse Hanford Company Operational Groundwater Monitoring Program conducts RCRA, CERCLA, and other operational monitoring programs. Sampling is conducted in three wells surrounding the 400 Area. No CERCLA programs have been established in the vicinity of the 400 Area.

Table 5-3. Routine Groundwater Monitoring in the Vicinity of the 400 Area.

Analytical Parameters	Well Number								
	499-S1-8J	499-S0-7	499-S0-8	699-1-18	699-2-3	699-2-7	699-8-17	699-S6-E4B	699-S6-E4D
Gross Alpha	Q ²	Q ²	Q ²	Q ³	Q ³	Q ³			Q ¹
Gross Beta	Q ²	Q ²	Q ²	Q ³	Q ³	Q ³			Q ¹
Gamma Scan	Q ²	Q ²	Q ²						Q ¹
Tritium	M ¹ , M ²	M ¹ , M ²	M ¹ , M ²	Q ¹ , Q ³	Q ¹ , Q ³	Q ¹ , Q ³	SA ¹	SA ¹	Q ¹
Strontium-90	Q ²	Q ²	Q ²						
U-CHEM									Q ¹
Anions	M ¹ , A ²	M ¹ , A ²	M ¹ , A ²	Q ¹ , Q ³	Q ¹ , Q ³	Q ¹ , Q ³	SA ¹	SA ¹	Q ¹
Metals	A ²	A ²	A ²	Q ³	Q ³	Q ³			
Physical	A ²	A ²	A ²						
VOC	Q ²	Q ²	Q ²						
TOC				Q ³	Q ³	Q ³			
TOX				Q ³	Q ³	Q ³			
Coliform						Q ³			
Pesticide (Carbonate)	A ²	A ²	A ²						

Wells 499-S1-7B, 499-S1-7C, 499-S1-8A, 499-S1-8B, and 499-S1-8C are not sampled.

M = Monthly
Q = Quarterly
SA = Semi-Annually
A = Annually

Blank denotes that the well is not sampled for that analytical parameter.
¹Sampling by PNL, annually reported by PNL.
²Sampling by HEHF, annually reported by PNL, samples obtained from the drinking water supply system.
³Sampling by Environmental Protection Group, quarterly reported by WHC.

Source: ¹Bisping 1992

6.0 SUMMARY AND CONCLUSIONS

Disposal of process sewer effluent in the 400 Area ponds has negligible effect on the groundwater in the vicinity of the 400 Area. The results of this study can be summarized as follows.

- The hydrologic impacts are minimal and consist of a groundwater mound on the order of 1 ft (Figures 4-5 and 4-6) that should not change in size, unless the process sewer effluent discharge rate changes.
- There are no significant contaminant impacts. The process sewer effluent and the down-gradient monitoring well (699-2-7) both have lower concentrations of tritium than the up-gradient background wells (699-8-17 and 699-1-18) (Figure 4-10).
- While the well immediately down-gradient of the 400 Area ponds (699-2-7) may be screened too deep to monitor the groundwater influenced by disposal of the process sewer effluent in the ponds, lack of significant constituents in the process sewer effluent and monitoring of the process sewer effluent should be adequate for providing checks on effluent impacts to groundwater. The remainder of the monitoring wells are adequate for the level of the impact of this site on the underlying groundwater.

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APPENDIX A
EFFLUENT SAMPLING RESULTS

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Table A-1. Quarterly Inorganic Analytical Results for 400 Area Sanitary Sewer Effluent Quality
Second Quarter 1980 Through First Quarter 1992. (Sheet 1 of 3)

Sampling Quarter/Year	PRIMARY CONSTITUENTS			SECONDARY CONSTITUENTS			OTHER ANALYTES	
	Cadmium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Zinc (mg/L)	Chloride (mg/L)	pH	Phosphate (mg/L)	Ammonia (mg/L)
	Drinking Water Quality Standard*							
	0.01	0.05	0.002	5.0	250	6.5-8.5
Q2/80	NR	NR	NR	NR	NR	NR	NR	NR
Q3/80	NR	NR	NR	NR	NR	NR	NR	NR
Q4/80	<0.001	<0.005	<0.0003	0.03	48	7.53	1.4	52
Q1/81	<0.001	<0.005	<0.0005	<0.05	42	7.5	4.8	40
Q2/81	<0.001	<0.005	<0.0005	0.1	45	7.1	3.5	133
Q3/81	<0.001	<0.005	0.0009	0.06	46	7.1	2.6	52
Q4/81	0.001	<0.005	<0.0005	0.07	42	7.1	1.7	41
Q1/82	NR	NR	NR	NR	NR	NR	NR	NR
Q2/82	<0.001	<0.005	<0.0005	<0.03	25	6.7	1.2	20
Q3/82	<0.001	<0.005	<0.0005	0.05	60	7.1	1.8	7.1
Q4/82	<0.001	<0.005	<0.0005	0.09	63	7.1	3.5	95
Q1/83	<0.001	<0.005	<0.0005	0.14	57.8	7.1	3.5	61.2
Q2/83	<0.001	<0.005	<0.0005	0.05	42	7.3	1.4	5.4
Q3/83	<0.0005	<0.005	<0.0005	0.09	21	7.05	1	0.16
Q4/83	<0.001	<0.005	<0.0005	<0.05	45	7.2	2.9	49
Q1/84	<0.001	<0.005	<0.0005	<0.02	38	7.3	5.3	46
Q2/84	<0.0005	<0.005	<0.0005	0.08	48	7.1	6.5	71
Q3/84	<0.0005	<0.002	<0.0005	0.06	36	7	4.6	48
Q4/84	<0.001	<0.001	<0.0005	0.13	44.8	8.2	0.63	<0.05

Table A-1. Quarterly Inorganic Analytical Results for 400 Area Sanitary Sewer Effluent Quality
 Second Quarter 1980 Through First Quarter 1992. (Sheet 2 of 3)

Sampling Quarter/Year	PRIMARY CONSTITUENTS			SECONDARY CONSTITUENTS			OTHER ANALYTES	
	Cadmium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Zinc (mg/L)	Chloride (mg/L)	pH	Phosphate (mg/L)	Ammonia (mg/L)
	Drinking Water Quality Standard*							
	0.01	0.05	0.002	5.0	250	6.5-8.5	--	--
Q1/85	<0.0005	<0.002	<0.0005	0.21	52	8.7	20	57
Q2/85	<0.0005	0.005	<0.0005	0.23	59	7.8	11	74
Q3/85	<0.0005	<0.002	0.0007	0.07	52	8.5	3.4	76
Q4/85	0.0005	<0.002	<0.0005	0.21	66	8.5	1	59
Q1/86	<0.0005	<0.002	<0.0005	0.29	100	8.2	2.9	63
Q2/86	<0.0005	<0.005	<0.0005	0.78	66	8.2	4.8	42
Q3/86	0.0035	0.006	<0.0005	0.3	51	NR	62	70
Q4/86	0.002	0.018	0.0005	0.42	44	7.3	27	42
Q1/87	<0.0005	0.013	<0.0004	0.2	29	8.1	10.5	23.4
Q2/87	<0.0005	<0.005	<0.0004	0.48	84	7.9	15	44
Q3/87	<0.0007	<0.003	<0.0004	0.1	48	8.9	16	6.5
Q4/87	<0.0005	<0.005	<0.0004	<0.05	51	8.6	10.4	52
Q1/88	<0.0005	<0.005	<0.0004	0.37	4.72	8.5	19.2	64
Q2/88	<0.0005	<0.005	<0.0004	0.41	47	8.8	28	74
Q3/88	<0.0005	<0.005	<0.0004	<0.1	32	7.6	12	36
Q4/88	<0.0005	<0.005	<0.0004	<0.1	55	8.7	3.8	51
Q1/89	0.0006	<0.005	<0.0003	0.39	27	8.3	<5.0	39
Q2/89	<0.0005	<0.005	<0.0003	<0.05	42	8.8	18	73
Q3/89	<0.0005	<0.005	<0.0003	<0.1	49	8.7	27	42

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Table A-1. Quarterly Inorganic Analytical Results for 400 Area Sanitary Sewer Effluent Quality
 Second Quarter 1980 Through First Quarter 1992. (Sheet 3 of 3)

Sampling Quarter/Year	PRIMARY CONSTITUENTS			SECONDARY CONSTITUENTS			OTHER ANALYTES	
	Cadmium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Zinc (mg/L)	Chloride (mg/L)	pH	Phosphate (mg/L)	Ammonia (mg/L)
	Drinking Water Quality Standard*							
	0.01	0.05	0.002	5.0	250	6.5-8.5	--	--
Q4/89	<0.0005	<0.005	0.0004	<0.1	57	8.7	16.4	77
Q1/90	0.0006	<0.005	<0.0003	0.14	49	8.7	11.4	68
Q2/90	<0.001	<0.003	<0.0003	0.195	45.6	7.3	14.4	41.5
Q3/90	<0.0005	0.008	0.0005	<0.1	36.2	8.42	15.2	110
Q4/90	0.0007	0.003	<0.0003	0.21	53	7.2	19	83
Q1/91	<0.0002	<0.002	<0.0003	<0.1	34	8.7	6.9	34
Q2/91	0.0008	<0.005	<0.0003	0.3	42	8.5	17	49
Q3/91	<0.0005	<0.005	<0.0007	0.2	45	NR	6.5	54
Q4/91	<0.0005	<0.005	<0.0007	0.1	19	8	<5.0	11
Q1/92	<0.0005	<0.005	<0.0007	0.3	42	8.3	12	33

*Dash indicates no drinking water quality standard.
 NR = Not reported.
 < = less than analytical detection limit
 Source: Hanford Groundwater Database, Pacific Northwest Laboratory

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Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
First Quarter 1980 Through Second Quarter 1992 (Sheet 1 of 15)

Sampling Quarter/Year	PRIMARY CONSTITUENTS								
	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Selenium (mg/L)	Silver (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)
	Drinking Water Quality Standard								
	1.0	0.01	0.05	0.05	0.002	0.01	5.00	4.0	10.0
Q1/80		<0.001 ¹		<0.005 ¹	0.0005 ¹				
Q2/80		NR ¹		NR ¹	NR ¹				
Q3/80		NR ¹		NR ¹	NR ¹				
Q4/80		<0.001 ¹		<0.005 ¹	0.0003 ¹				
Q1/81		<0.001 ¹		<0.005 ¹	<0.0005 ¹				
Q2/81		<0.001 ¹		<0.005 ¹	<0.0005 ¹				
Q3/81		<0.001 ¹		<0.005 ¹	0.0005 ¹				
Q4/81		0.002 ¹		0.008 ¹	<0.0005 ¹				
Q2/82		NR ¹		NR ¹	NR ¹				
Q3/82		<0.001 ¹		<0.005 ¹	<0.0005 ¹				
Q4/82		<0.001 ¹		<0.005 ¹	<0.0005 ¹				
Q1/83		<0.001 ¹		<0.005 ¹	<0.0005 ¹				
Q2/83		<0.001 ¹		<0.005 ¹	<0.0005 ¹				
Q3/83		<0.0005 ¹		<0.005 ¹	<0.0005 ¹				
Q4/83		<0.001 ¹		<0.005 ¹	<0.0005 ¹				
Q1/84		<0.001 ¹		<0.005 ¹	<0.0005 ¹				

Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
First Quarter 1980 Through Second Quarter 1992 (Sheet 2 of 15)

Sampling Quarter/Year	PRIMARY CONSTITUENTS								
	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Selenium (mg/L)	Silver (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)
	Drinking Water Quality Standard								
	1.0	0.01	0.05	0.05	0.002	0.01	5.00	4.0	10.0
Q2/84		<0.0005 ¹		<0.005 ¹	<0.0005 ¹				
Q3/84		<0.0005 ¹		<0.002 ¹	<0.0005 ¹				
Q4/84		<0.001 ¹		<0.001 ¹	<0.0005 ¹				
Q1/85		0.002 ¹		0.012 ¹	0.0082 ¹				
Q2/85		<0.0005 ¹		0.006 ¹	<0.0005 ¹				
Q3/85		<0.0005 ¹		<0.002 ¹	<0.0005 ¹				
Q4/85		<0.0002 ¹		<0.002 ¹	<0.0005 ¹				
Q1/86		<0.0005 ¹		<0.002 ¹	<0.0005 ¹				
Q2/86		<0.0005 ¹		<0.005 ¹	<0.0005 ¹				
Q3/86		<0.0005 ¹		<0.005 ¹	<0.0005 ¹				
Q4/86		<0.0005 ¹		<0.005 ¹	<0.0005 ¹				
Q1/87	0.038 ³	<0.0005 ¹ <0.002 ³	<0.010 ³	<0.005 ¹ <0.005 ³	<0.0004 ¹ <0.010 ³		<0.01 0 ³	0.54 ³	2.2 ³
Q2/87	0.044 ³	<0.0005 ¹ <0.002 ³	<0.010 ³	<0.005 ¹ <0.005 ³	<0.0004 ¹ <0.010 ³		<0.01 0 ³	1.1 ³	1.5 ³
Q3/87	0.034 ³	<0.0003 ¹ <0.002 ³	<0.010 ³	<0.003 ¹ <0.005 ³	<0.0004 ¹ <0.010 ³		<0.01 0 ³	0.68 ³	0.59 ³

Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
First Quarter 1980 Through Second Quarter 1992 (Sheet 3 of 15)

Sampling Quarter/Year	PRIMARY CONSTITUENTS								
	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Selenium (mg/L)	Silver (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)
	Drinking Water Quality Standard								
	1.0	0.01	0.05	0.05	0.002	0.01	5.00	4.0	10.0
Q4/87		<0.0005 ¹		<0.005 ¹	<0.0004 ¹				
Q1/88		<0.0005 ¹		<0.005 ¹	<0.0004 ¹				
Q2/88		<0.0005 ¹		<0.005 ¹	<0.0004 ¹				
Q3/88		<0.0005 ¹		<0.005 ¹	<0.0005 ¹				
Q4/88		<0.0005 ¹		<0.005 ¹	<0.0004 ¹				
Q1/89		<0.0005 ¹		<0.005 ¹	<0.0003 ¹				
Q2/89		<0.0005 ¹		<0.005 ¹	<0.0003 ¹				
Q3/89		<0.0005 ¹		<0.005 ¹	<0.0003 ¹				
Q4/89	0.039 ⁴ 0.039 ⁵	<0.0005 ¹ <0.1 ⁵	<0.005 ⁴ <0.5 ⁵	<0.005 ¹ <0.001 ⁴ <0.02 ⁵	<0.0003 ¹ <0.001 ⁴ <0.02 ⁵	<0.005 ⁴ <0.5 ⁵	<0.00 5 ⁴ <0.5 ⁵	0.73 ⁴ 0.67 ⁵	2.8 ⁴ 1.15 ⁵
Q1/90	0.036 ⁴ 0.03 ⁵	0.0008 ¹ <.01 ⁵	<0.005 ⁴ <0.5 ⁵	<0.005 ¹ <0.001 ⁴ <0.05 ⁵	<0.003 ¹ <0.001 ⁴ <0.02 ⁵	<0.005 ⁴ 0.5 ⁵	<0.00 5 ⁴ <0.5 ⁵	0.71 ⁴ 0.68 ⁵	3.2 ⁴ 1 ⁵
Q2/90	0.04 ⁴	<.001 ¹	<0.005 ⁴	0.006 ¹ <0.001 ⁴	<0.003 ¹ <0.001 ⁴	<0.005 ⁴	<0.00 5 ⁴	0.8 ⁴	1.2 ⁴
Q3/90	0.04 ⁴	<0.0005 ¹	<0.005 ⁴	0.046 ¹ <0.001 ⁴	<0.0003 ¹ <0.001 ⁴	<0.005 ⁴	<0.00 5 ⁴	0.8 ⁴	1.3 ⁴

Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
First Quarter 1980 Through Second Quarter 1992 (Sheet 4 of 15)

Sampling Quarter/Year	PRIMARY CONSTITUENTS								
	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Lead (mg/L)	Mercury (mg/L)	Selenium (mg/L)	Silver (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)
	Drinking Water Quality Standard								
	1.0	0.01	0.05	0.05	0.002	0.01	5.00	4.0	10.0
Q4/90	NR ⁴	0.0002 ¹	NR ⁴	0.046 ¹ NR ⁴	<0.0003 ¹		NR ⁴	NR ⁴	NR ⁴
Q1/91		<0.0002 ¹	<0.005 ⁴	<0.002 ¹ <0.005 ⁴	<0.0003 ¹ <0.001 ⁴	<0.005 ⁴	<0.00 5 ⁴	0.8 ⁴	1.3 ⁴
Q2/91		<0.0005 ¹	<0.005 ⁴	0.008 ¹ <0.005 ⁴	<0.0003 ¹ <0.001 ⁴	<0.005 ⁴	<0.00 5 ⁴	1.1 ⁴	1.3 ⁴
Q3/91		>0.0005 ¹	<0.005 ⁴	<0.005 ¹ <0.005 ⁴	<0.0007 ¹ <0.001 ⁴	<0.005 ⁴	<0.00 5 ⁴	0.5 ⁴	1.3 ⁴
Q4/91		<0.0005 ¹	<0.005 ⁴	<0.005 ¹ <0.005 ⁴	<0.0007 ¹ <0.001 ⁴	<0.005 ⁴	<0.00 5 ⁴	0.7 ⁴	2.2 ⁴
Q1/92		<0.0005 ¹		<0.005 ¹	<0.0007 ¹				
Q2/92									

Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
First Quarter 1980 Through Second Quarter 1992 (Sheet 5 of 15)

Sampling Quarter and Year	SECONDARY CONSTITUENTS							
	Copper (mg/L)	Iron (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total dissolved solids (mg/L)	pH
	Drinking Water Quality Standard							
	1.0	0.30	0.05	5.0	250	250	500	6.5-8.5
Q1/80				0.37 ¹	37 ¹			8.8 ¹
Q4/80				0.36 ¹	50 ¹			8.86 ¹
Q1/81				<0.05 ¹	12 ¹			8.1 ¹
Q2/81				0.73 ¹	45 ¹			8.2 ¹
Q3/81				0.53 ¹	52 ¹			8.2 ¹
Q4/81				0.16 ¹	16 ¹			8.4 ¹
Q2/82				0.95 ¹	108 ¹			8.2 ¹
Q3/82				0.8 ¹	89 ¹			7.1 ¹
Q4/82				0.22 ¹	29 ¹			7.7 ¹
Q1/83				0.05 ¹	14.1 ¹			8.1 ¹
Q2/83				0.2 ¹	36 ¹			8.4 ¹
Q3/83				<0.05 ¹	13 ¹			8.4 ¹
Q4/83				0.35 ¹	44 ¹			8.4 ¹
Q1/84				<0.02 ¹	11.2 ¹			8 ¹
Q2/84				1.8 ¹	51 ¹			8.6 ¹

Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
First Quarter 1980 Through Second Quarter 1992 (Sheet 6 of 15)

Sampling Quarter and Year	SECONDARY CONSTITUENTS							
	Copper (mg/L)	Iron (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total dissolved solids (mg/L)	pH
	Drinking Water Quality Standard							
	1.0	0.30	0.05	5.0	250	250	500	6.5-8.5
Q3/84				0.08 ¹	13 ¹			8.3 ¹
Q4/84				0.13 ¹	44.2 ¹			8.3 ¹
Q1/85				0.23 ¹	15 ¹			8.1 ¹
Q2/85				1.07 ¹	45 ¹			6.8 ¹
Q3/85				<0.05 ¹	37 ¹			8.5 ¹
Q4/85				<0.05 ¹	20 ¹			8.6 ¹
Q1/86				0.03 ¹	17 ¹			8.4 ¹
Q2/86				<0.05 ¹	19 ¹			8.6 ¹
Q3/86				<0.1 ¹	19.8 ¹			— ¹
Q4/86				<0.1 ¹	33 ¹			8.6 ¹
Q1/87	0.02 ³	<0.050 ³	0.013 ³	<0.2 ¹ 0.073 ³	22.8 ¹ 26 ³	79 ³		8.6 ¹ 8.22 ³
Q2/87	0.022 ³	<0.050 ³	0.035 ³	0.06 ¹ 0.045 ³	10.6 ¹ 22 ³	82 ³		8.3 ¹ 8.13 ³
Q3/87	0.013 ³	<0.050 ³	0.022 ³	<0.05 ¹ 0.11 ³	28 ¹ 18 ³	55 ³		9.2 ¹ 7.6 ³

Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
First Quarter 1980 Through Second Quarter 1992 (Sheet 7 of 15)

Sampling Quarter and Year	SECONDARY CONSTITUENTS							
	Copper (mg/L)	Iron (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total dissolved solids (mg/L)	pH
	Drinking Water Quality Standard							
	1.0	0.30	0.05	5.0	250	250	500	6.5-8.5
Q4/87					19 ¹			8.7 ¹
Q1/88				0.07 ¹	22 ¹			8.3 ¹
Q2/88				0.104 ¹	24 ¹			8.9 ¹
Q3/88				<0.1 ¹	23 ¹			8.7 ¹
Q4/88				0.18 ¹	24 ¹			9 ¹
Q1/89				<0.1 ¹	21.7 ¹			8.9 ¹
Q2/89				<0.05 ¹	21.8 ¹			8.8 ¹
Q3/89				<0.1 ¹	27 ¹			8.9 ¹
Q4/89	0.006 ⁴ <0.01 ⁵	0.04 ⁵	0.014 ⁵	<0.1 ¹ 0.029 ⁵	19 ¹ 24 ⁴ 20.9 ⁵	74 ⁴ 61 ⁵	473 ⁵	8.9 ¹ 8.8 ⁴ 8.27 ⁵
Q1/90	<0.0005 ⁴ 0.011 ⁵	0.072 ⁵	0.012 ⁵	<0.1 ¹ 0.048 ⁵	23 ¹ 26 ⁴ 21 ⁵	77 ⁴ 71.9 ⁵	411 ⁵	8.7 ¹ 8.76 ⁴ 8.8 ⁵
Q2/90	0.022 ⁴			<0.1 ¹	20.7 ¹ 22 ⁴	80 ⁴		8.5 ¹ 8.6 ⁴
Q3/90	0.007 ⁴			<0.1 ¹	25.8 ¹ 25 ⁴	78 ⁴		8.97 ¹ 8.7 ⁴

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Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
 First Quarter 1980 Through Second Quarter 1992 (Sheet 8 of 15)

Sampling Quarter and Year	SECONDARY CONSTITUENTS							
	Copper (mg/L)	Iron (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total dissolved solids (mg/L)	pH
	Drinking Water Quality Standard							
	1.0	0.30	0.05	5.0	250	250	500	6.5-8.5
Q4/90	0.006 ⁴			<0.1 ¹	20 ¹ NR ⁴	NR ⁴		8.9 ¹ NR ⁴
Q1/91	0.005 ⁴			<0.1 ¹	25 ¹ 23 ⁴	80 ⁴		9 ¹ 8.6-8.8 ⁴
Q2/91	0.01 ⁴			<0.1 ¹	30 ¹ 24 ⁴	82 ⁴		8.8 ¹ 7.7-8.97 ⁴
Q3/91				<0.1 ¹	22 ¹ 24 ⁴	78 ⁴		8.8-9.1 ⁴
Q4/91				<0.1 ¹	24 ¹ 19 ⁴	58 ⁴		8.8 ¹ 8.5-8.6 ⁴
Q1/92				<0.1 ¹	20 ¹			8.6 ¹
Q2/92								

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Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
 First Quarter 1980 Through Second Quarter 1992 (Sheet 9 of 15)

Sampling Quarter and Year	OTHER INORGANICS												
	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Phosphate as PO4 (mg/L)	Potassium (mg/L)	Lithium (mg/L)	Silicon (mg/L)	Strontium (mg/L)	Ammonia as N (mg/L)	Boron (mg/L)	Conductivity (µS)	Alkalinity (mg/L)	Total carbon (mg/L)
	Drinking Water Quality Standard ^a												
Q1/80				0.4 ¹					0.18 ¹				
Q4/80				0.37 ¹					0.12 ¹				
Q1/81				<0.1 ¹					0.13 ¹				
Q2/81				0.73 ¹					0.48 ¹				
Q3/81				0.8 ¹					<0.1 ¹				
Q4/81				0.7 ¹					<0.02 ¹				
Q2/82				0.3 ¹					0.1 ¹				
Q3/82				0.19 ¹					0.06 ¹				
Q4/82				0.38 ¹					<0.1 ¹				
Q1/83				<0.2 ¹					<0.02 ¹				
Q2/83				0.22 ¹					0.1 ¹				
Q3/83				<0.08 ¹					<0.04 ¹				
Q4/83				1.1 ¹					0.08 ¹				
Q1/84				<0.2 ¹					<0.006 ¹				
Q2/84				0.46 ¹					0.05 ¹				
Q3/84				<0.1 ¹					<0.06 ¹				
Q4/84				1.29 ¹					<0.05 ¹				
Q1/85				0.92 ¹					0.37 ¹				

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Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
 First Quarter 1980 Through Second Quarter 1992 (Sheet 10 of 15)

Sampling Quarter and Year	OTHER INORGANICS												
	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Phosphate as PO4 (mg/L)	Potassium (mg/L)	Lithium (mg/L)	Silicon (mg/L)	Strontium (mg/L)	Ammonia as N (mg/L)	Boron (mg/L)	Conductivity (µS)	Alkalinity (mg/L)	Total carbon (mg/L)
	Drinking Water Quality Standard*												
Q2/85				2.5 ¹					0.09 ¹				
Q3/85				0.64 ¹					<0.08 ¹				
Q4/85				<0.1 ¹					<0.08 ¹				
Q1/86				0.16 ¹					0.07 ¹				
Q2/86				2.5 ¹					<0.12 ¹				
Q3/86				<0.5 ¹					<0.1 ¹				
Q4/86				<0.5 ¹					<0.06 ¹				
Q1/87	84 ³	72 ³	20 ³	<0.5 ¹	23 ³			0.34 ³	<0.06 ¹		630 ³		
Q2/87	96 ³	79 ³	24 ³	<0.5 ¹	25 ³			0.38 ³	<0.06 ¹		435 ³		
Q3/87	58 ³	42 ³	15 ³	<0.05 ¹	14 ³			<0.30 ³	<0.06 ¹		530 ³		
Q4/87				<0.5 ¹					<0.1 ¹				
Q1/88				<0.5 ¹					<0.1 ¹				
Q2/88				<0.5 ¹					<0.1 ¹				
Q3/88				<0.5 ¹					<0.1 ¹				
Q4/88				<0.2 ¹					0.04 ¹				
Q1/89				12.6 ¹					<0.1 ¹				
Q2/89				<0.5 ¹					<0.1 ¹				
Q3/89				<0.5 ¹					<0.1 ¹				

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Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
 First Quarter 1980 Through Second Quarter 1992 (Sheet 11 of 15)

Sampling Quarter and Year	OTHER INORGANICS												
	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Phosphate as PO ₄ (mg/L)	Potassium (mg/L)	Lithium (mg/L)	Silicon (mg/L)	Strontium (mg/L)	Ammonia as N (mg/L)	Boron (mg/L)	Conductivity (μ S)	Alkalinity (mg/L)	Total carbon (mg/L)
	Drinking Water Quality Standard*												
Q4/89	88 ⁴ 64.6 ⁵	52.8 ⁵	16 ⁵		17 ⁵	0.03 ⁵			0.17 ¹ 0.1 ⁵	0.047 ⁵	655 ⁵	275 ⁵	64.1 ⁵
Q1/90	75 ⁴ 55.8 ⁵	48.8 ⁵	13.8 ⁵	<0.5 ¹	14.1 ⁵	0.26 ⁵	32.1 ⁵	0.25 ⁵	<0.1 ¹ 0.12 ⁵	0.041 ⁵	698 ⁵	286 ⁵	51.4 ⁵
Q2/90	68 ⁴			<0.5 ¹					<0.1 ¹				
Q3/90	69 ⁴			<0.5 ¹					<0.1 ¹				
Q4/90	NR ⁴			<0.5 ¹					7.1 ¹				
Q1/91	81 ⁴			<5 ¹					<0.1 ¹				
Q2/91	74 ⁴			<0.5 ¹					<0.1 ¹				
Q3/91	70 ⁴			<0.3 ¹					<0.1 ¹				
Q4/91	53 ⁴			<0.5 ¹					0.1 ¹				
Q1/92				<0.5 ¹					<1 ¹				
Q2/92													

Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
 First Quarter 1980 Through Second Quarter 1992 (Sheet 12 of 15)

Sampling Quarter and Year	RADIONUCLIDES (pCi/L)						OTHER RADIONUCLIDES (pCi/L)					
	Gross alpha	Gross beta	Tritium	Strontium -90	Radium -226, -228	Radium -226	Cesium -137	Uranium	Sodium -22	Chromium -51	Cobalt -60	Zinc -65
	Drinking Water Quality Standard											
	15	50	20,000	8.0	5.0	3.0	120	24	400	40,000	200	360
Q2/80	0.49 ²	45 ²					1.2 ²		1.4 ²	-0.32 ²		1.2 ²
Q3/80	0.56 ²	21 ²					0.38 ²		0.52 ²	-2.2 ²		2.8 ²
Q4/80	0.09 ²	19 ²					-0.14 ²		-0.66 ²	13 ²		2.7 ²
Q1/81	0.47 ²	23 ²					2 ²		3.5 ²	8.8 ²		
Q2/81	0.23 ²	27 ²					-0.15 ²		1.2 ²	7.7 ²		
Q3/81	0.16 ²	57 ²					-0.12 ²		-0.18 ²	2.5 ²		
Q4/81	0.07 ²	22 ²					19 ²		8.2 ²	-46 ²		
Q1/82	0.04 ²	19 ²					-0.006 ²		0.15 ²			
Q2/82	-0.04 ²						0.13 ²		0.28 ²			
Q3/82	0.02 ²	6.7 ²					0.33 ²		0.2 ²			
Q4/82	0.22 ²	14 ²					-0.18 ²		0.1 ²			
Q1/83	0.38 ²	20 ²	19,000 ²				-0.92 ²					
Q2/83	-0.36 ²	77 ²	22,000 ²				1 ²					
Q3/83	1.2 ²	42 ²	18,000 ²				-0.22 ²					
Q4/83	1.6 ²	40 ²	29,000 ²				0.15 ²					
Q1/84	0.124 ²	20.1 ²	40,500 ²				0.388 ²		1.53 ²			
Q2/84	-0.125 ²	10.1 ²	26,200 ²				-0.622 ²		-2.57 ²			

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Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
 First Quarter 1980 Through Second Quarter 1992 (Sheet 13 of 15)

Sampling Quarter and Year	RADIONUCLIDES (pCi/L)						OTHER RADIONUCLIDES (pCi/L)					
	Gross alpha	Gross beta	Tritium	Strontium -90	Radium -226, -228	Radium -226	Cesium -137	Uranium	Sodium -22	Chromium -51	Cobalt -60	Zinc -65
	Drinking Water Quality Standard											
	15	50	20,000	8.0	5.0	3.0	120	24	400	40,000	200	360
Q3/84	-0.025 ²	41 ²	30,500 ²				1.33 ²		-2.8 ²			
Q4/84	-0.249 ²	3.48 ²	20,300 ²				-1 ²		2.9 ²			
Q1/85	10.8 ²	28.4 ²	22,700 ²				0.606 ²		1.6 ²			
Q2/85	1.48 ²	31.2 ²	24,800 ²				0.817 ²		0.929 ²			
Q3/85	0 ²	32.6 ²	29,400 ²				0.919 ²		-0.154 ²			
Q4/85	-4.92 ²	36.5 ²	21,400 ²				0.568 ²		2.79 ²			
Q1/86	0.49 ²	45.4 ²	2,530 ²				-0.189 ²		-0.83 ²			
Q2/86	0.763 ²	26.7 ²	232 ²				-1.38 ²		0.136 ²			
Q3/86	1.52 ²	25.8 ²	659 ²				2.5 ²		-1.77 ²			
Q4/86	0.0968 ²	19.6 ²	1,790 ²				1.03 ²		-0.151 ²			
Q1/87	1.26 ² 0.52 ³	17.2 ² 21 ²	2,410 ²				1.14 ²	0.057 ³	1.5 ²			
Q2/87	0.106 ² <0.92 ²	13.2 ² 31 ³	9,510 ²				0.362 ²	0.627 ³	0.818 ²			
Q3/87	NR ² <0.32 ³	NR ² 22 ³	NR ²				NR ²	0.158 ³	NR ²			
Q4/87	0.104 ²	17.9 ²	4,750 ²				-0.27 ²		-0.547 ²			
Q1/88	NR ²	NR ²	NR ²				NR ²		NR ²			
Q2/88	-0.158 ²	16.4 ²	5,550 ²				-0.152 ²		0.181 ²			

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Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
 First Quarter 1980 Through Second Quarter 1992 (Sheet 14 of 15)

Sampling Quarter and Year	RADIONUCLIDES (pCi/L)						OTHER RADIONUCLIDES (pCi/L)					
	Gross alpha	Gross beta	Tritium	Strontium -90	Radium -226, -228	Radium -226	Cesium -137	Uranium	Sodium -22	Chromium -51	Cobalt -60	Zinc -65
	Drinking Water Quality Standard											
	15	50	20,000	8.0	5.0	3.0	120	24	400	40,000	200	360
Q3/88	0.0697 ²	21.4 ²	5,200 ²				1.02 ²		-0.155 ²			
Q4/88	NR ²	NR ²	NR ²				NR ²		NR ²			
Q1/89	0.154 ²	11 ²	6,680 ²				0.862 ²		-1 ²			
Q2/89	-0.336 ²	16.6 ²	6,640 ²				-0.924 ²		0.553 ²			
Q3/89	0.548 ²	14.1 ²	9,200 ²				-0.817 ²		0.719 ²			
Q4/89	0.0068 ²	25.2 ² 45 ⁴ 21.2 ⁵	7,440 ² 6,620 ²		0.176 ⁵		-1.35 ² 94.8 ²	0.5 ⁵	-0.53 ²		91.6 ⁵	
Q1/90	1.26 ²	20.4 ² <40 ⁴ 12.5 ⁵	7,200 ² 6,310 ⁵		<0.074 ⁵		0.236 ²		0.684 ²			
Q2/90	-0.439 ²	13.7 ² <40 ⁴	8,480 ²				1.42 ²		-1.15 ²			
Q3/90	0.78 ²	15.1 ² <40 ⁴	6,010 ²				-0.198 ²		NR ²			
Q4/90	0.432 ²	14.5 ² NR ⁴	6,860 ²				0 ²		NR ²			
Q1/91	1.26 ²	6.91 ² 50 ⁴	6,810 ²				0.814 ²					
Q2/91	-0.306 ²	1.52 ² 50 ⁴	7,330 ²				0.213 ²					
Q3/91	0.691 ²	11 ² 50 ⁴	5,390 ²				1.97 ²					

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Table A-2. Quarterly Inorganic and Radionuclide Analytical Results for 400 Area Process Sewer Effluent Quality.
First Quarter 1980 Through Second Quarter 1992 (Sheet 15 of 15)

Sampling Quarter and Year	RADIONUCLIDES (pCi/L)						OTHER RADIONUCLIDES (pCi/L)					
	Gross alpha	Gross beta	Tritium	Strontium -90	Radium -226, -228	Radium -226	Cesium -137	Uranium	Sodium -22	Chromium -51	Cobalt -60	Zinc -65
	Drinking Water Quality Standard											
	15	50	20,000	8.0	5.0	3.0	120	24	400	40,000	200	360
Q4/91	-0.173 ²	7.13 ² 60 ⁴	6,570 ²				0.206 ²					
Q1/92	1.16 ²	12 ²					-0.369 ²					
Q2/92	0.183 ²	8.91 ²	6,580 ²				-1.64 ²					

Blank denotes that data are not available.
NR analyte result was not reported, not analyzed or considered invalid.
< = less than analytical detection limit

Annual results are tabulated in the last quarter of the year. Infrequent results are tabulated in the quarter in which the analytical results were reported. Averages are tabulated when multiple results from a source were reported within a quarter.

*Dash indicates no Drinking Water Quality Standard

Sources:
¹HEHF quarterly report of 400 Area process and sanitary sewers (HEHF 1980a through 1992)
²PNL yearly summary reports (Jaquish and Bryce 1990, 1989, Jaquish and Mitchell 1988, PNL 1987, Price 1986, Price et al. 1985, 1984, Sula et al. 1983, 1982, 1981, Woodruff et al. 1991) with supplementary quarterly radiological testing information (Surface Environmental Database, Pacific Northwest Laboratory)
³Preliminary evaluation of the Hanford Liquid Discharges to Ground (Jungflersch 1988)
⁴WHC 300/400 Area surveillance data for environmental compliance (McCarthy 1990, Manley 1992) and quarterly WHC 300/400 Area effluent monitoring reports (WHC 1990d, WHC 1990e, WHC 1990f, WHC 1991g, WHC 1991c, WHC 1991d, WHC 1991e)
⁵1989-1990 liquid effluent analytical data (WHC 1990g)

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APPENDIX B
WELL CONSTRUCTION LOGS

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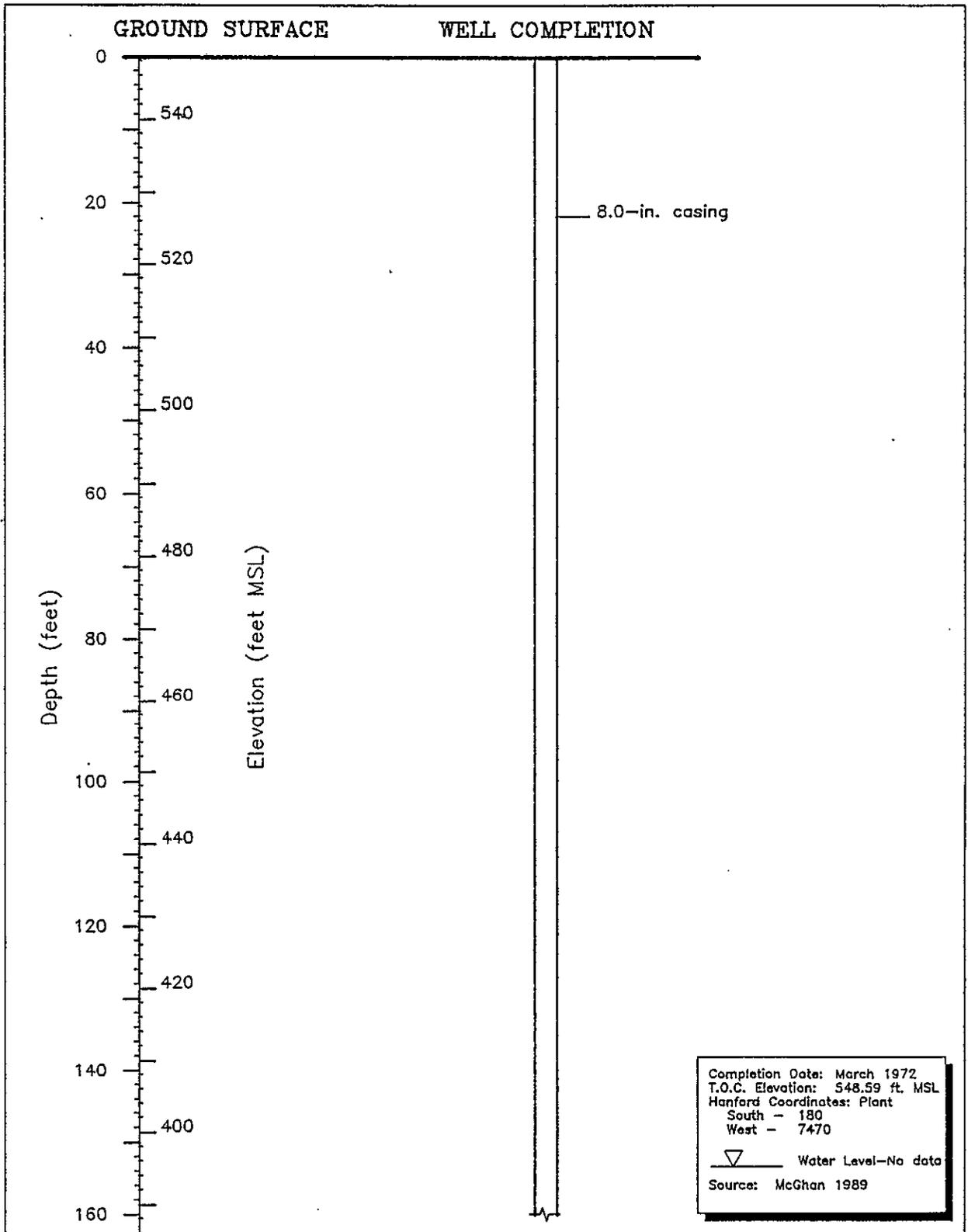
NOTES FOR WELL CONSTRUCTION LOG DATA

Well construction information was obtained from several sources to provide the most complete information for each well. Deficiencies are common in records for all wells evaluated, including those constructed during the 1980's. Although most wells have been constructed in accordance with acceptable standards and practices that were established at the time of installation, many of these wells do not satisfy current Washington Administrative Code requirements. Wells were not field checked to document condition, surface completion, locations, and construction.

- 1) Surface completion is unknown for the wells.
- 2) Top of casing is assumed and shown to be at the ground surface. Actual casing elevation may be different.
- 3) Coordinates are designated as Hanford Plant coordinates. For certain wells, the coordinates have been estimated.
- 4) The depth of the well is reported as determined at the time the well was completed.
- 5) The depth to the water table is shown as determined from recent measurements. In some cases the water level is below the construction depth of the well, indicating the original well construction logs may be inaccurate.
- 6) The diameter of the casing used in the construction of the well is given in inches. Data for initial borehole diameter or casings of more than one size required for construction are shown when information is available.
- 7) The most recent measurement of the bottom depth of the well is shown. Some wells are partially filled with sediments or have been plugged.
- 8) Wells were generally constructed with perforated casings. Several wells have well screens. Well screens or perforated liners were installed in several wells to recondition those wells.
- 9) Information regarding filter packs is not available for most of the wells.
- 10) Information regarding well seals is not available for the wells. According to an evaluation of borehole data and determinations for well fitness for wells in other areas of the Hanford Site (GAI 1989), a majority of the wells drilled prior to the 1980's and a limited number of wells drilled since 1980 do not have surface and annular seals that satisfy Washington Administrative Code or Resource Conservation Recovery Act groundwater monitoring requirements.
- 10) Other deficiencies may include inadequate documentation of 1) cleaning procedures for the field equipment, 2) use of potable water for seal hydration and decontamination, 3) handling procedures for cutting and well development fluids, and 4) installation of cement plugs and use of bleach during well remediation actions.

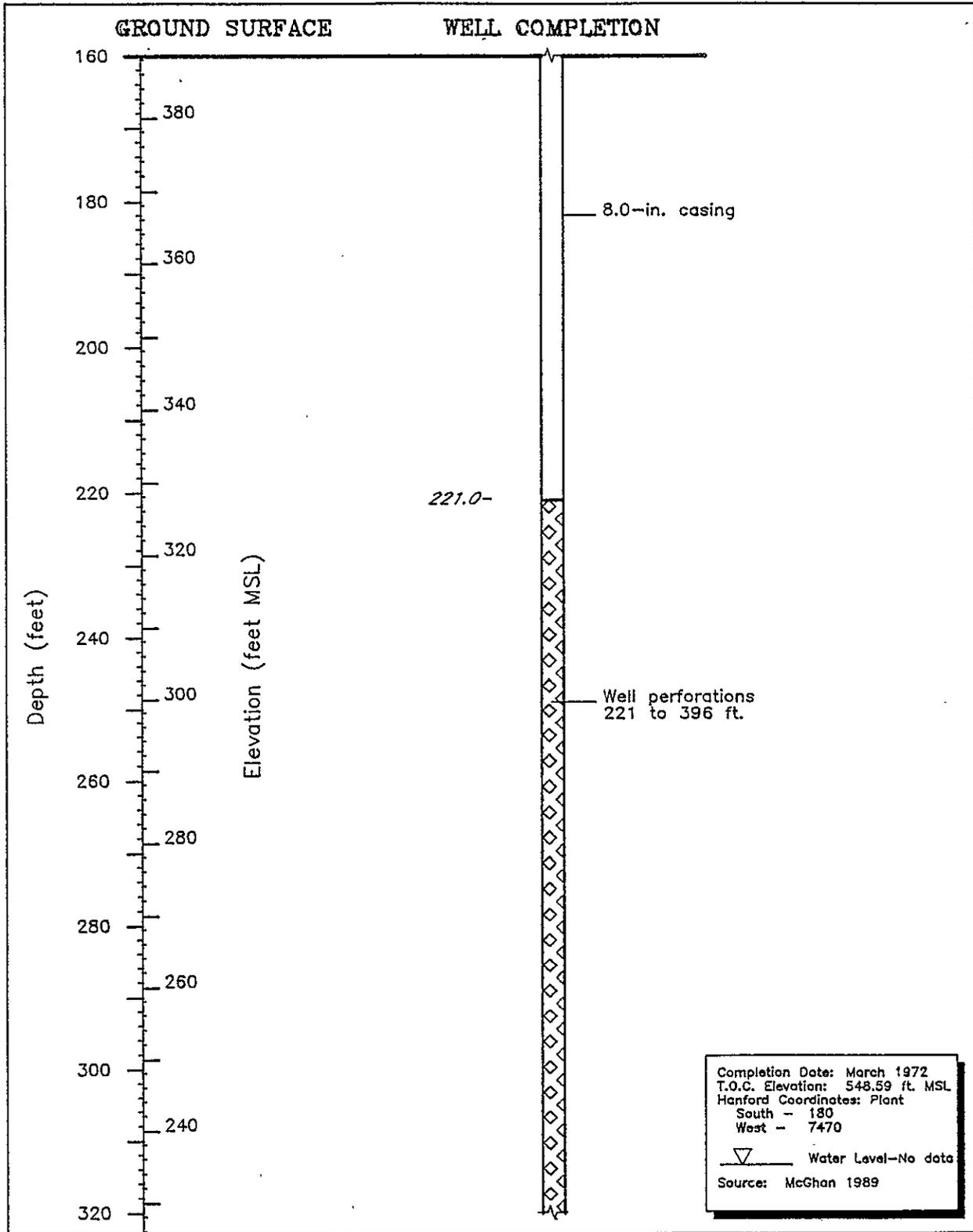
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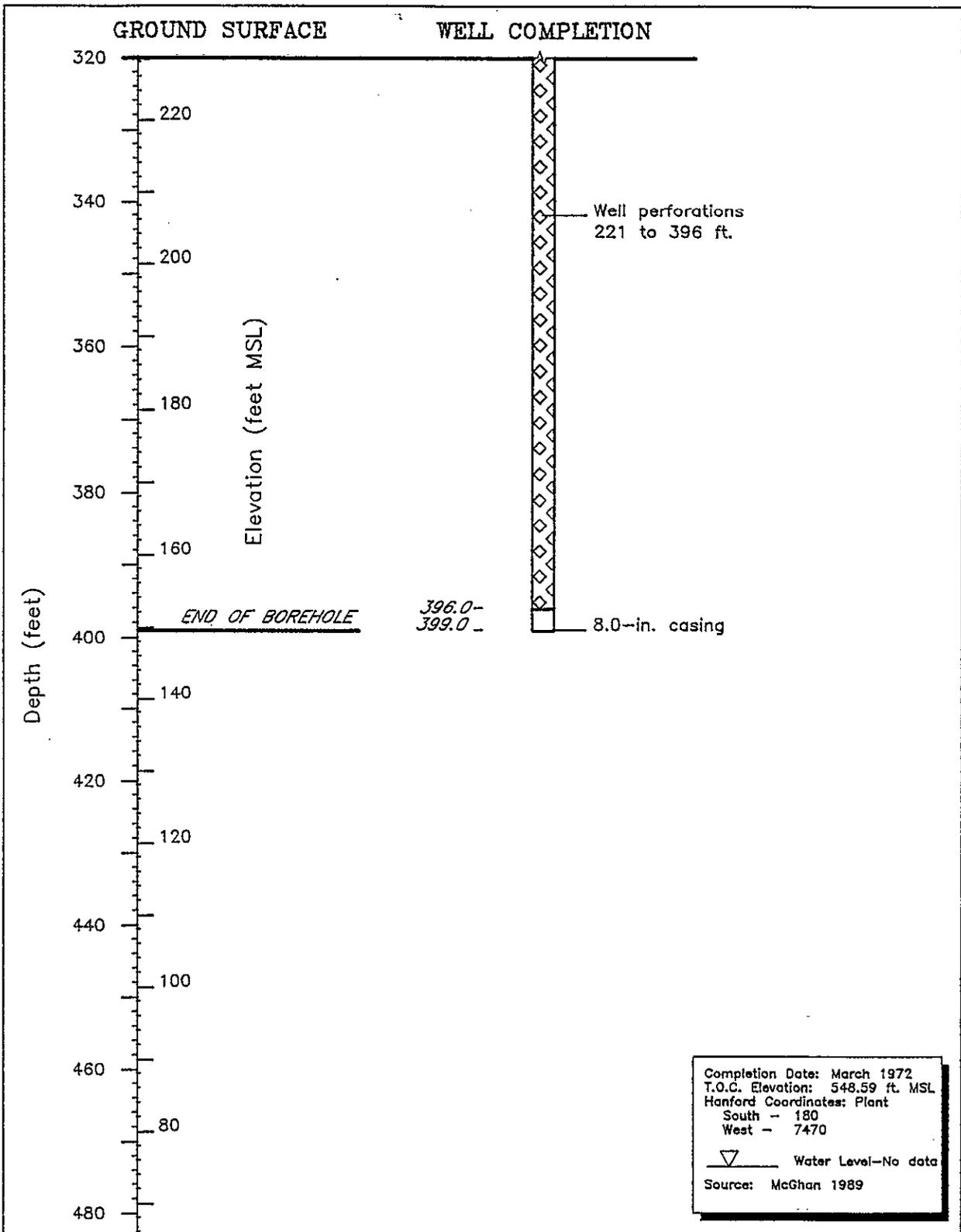
9131728\42132 9-18-92

Figure B-1a. Well Completion Log 499-S0-7
(Sheet 1 of 3).



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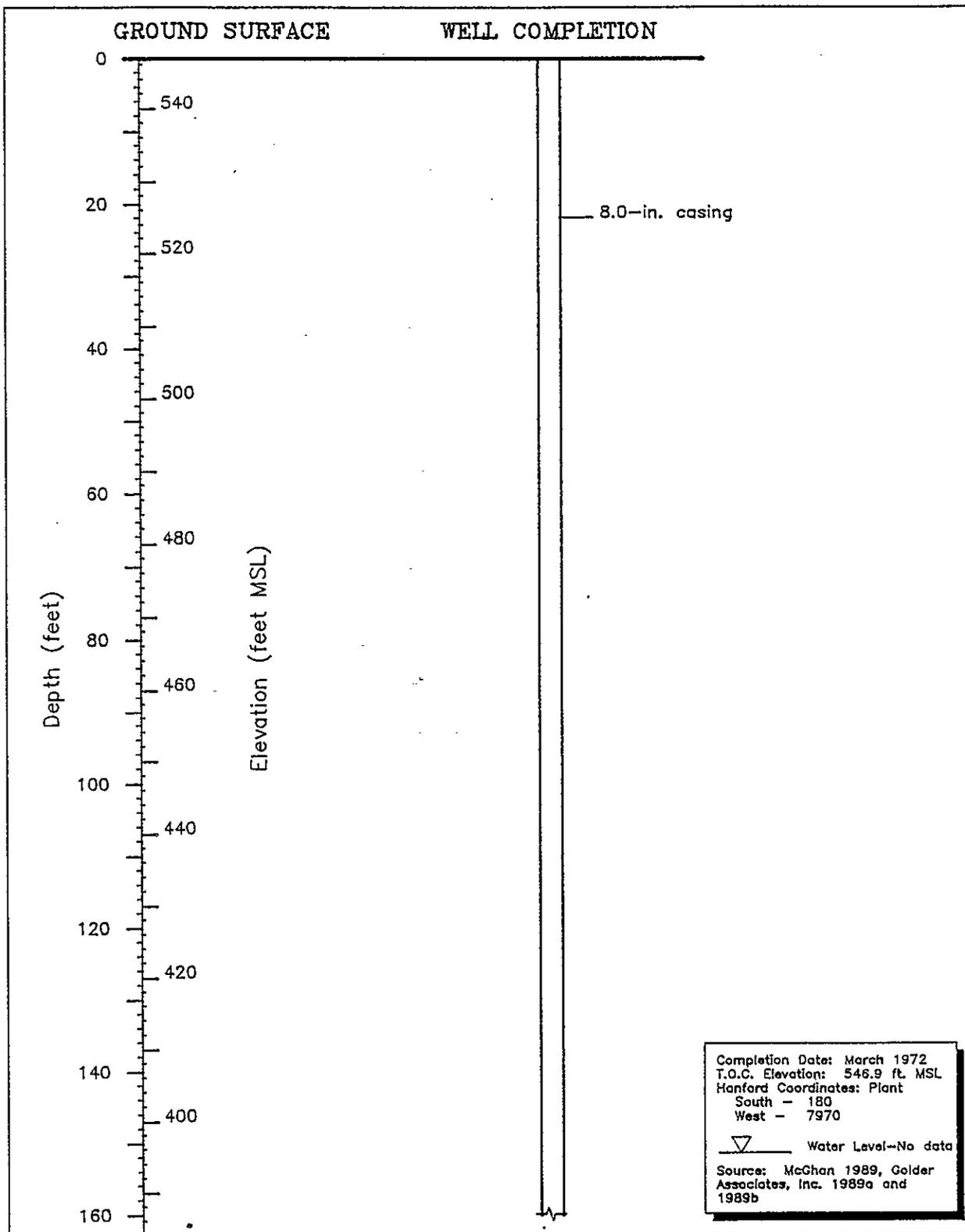
Figure B-1b. Well Completion Log 499-S0-7
(Sheet 2 of 3).



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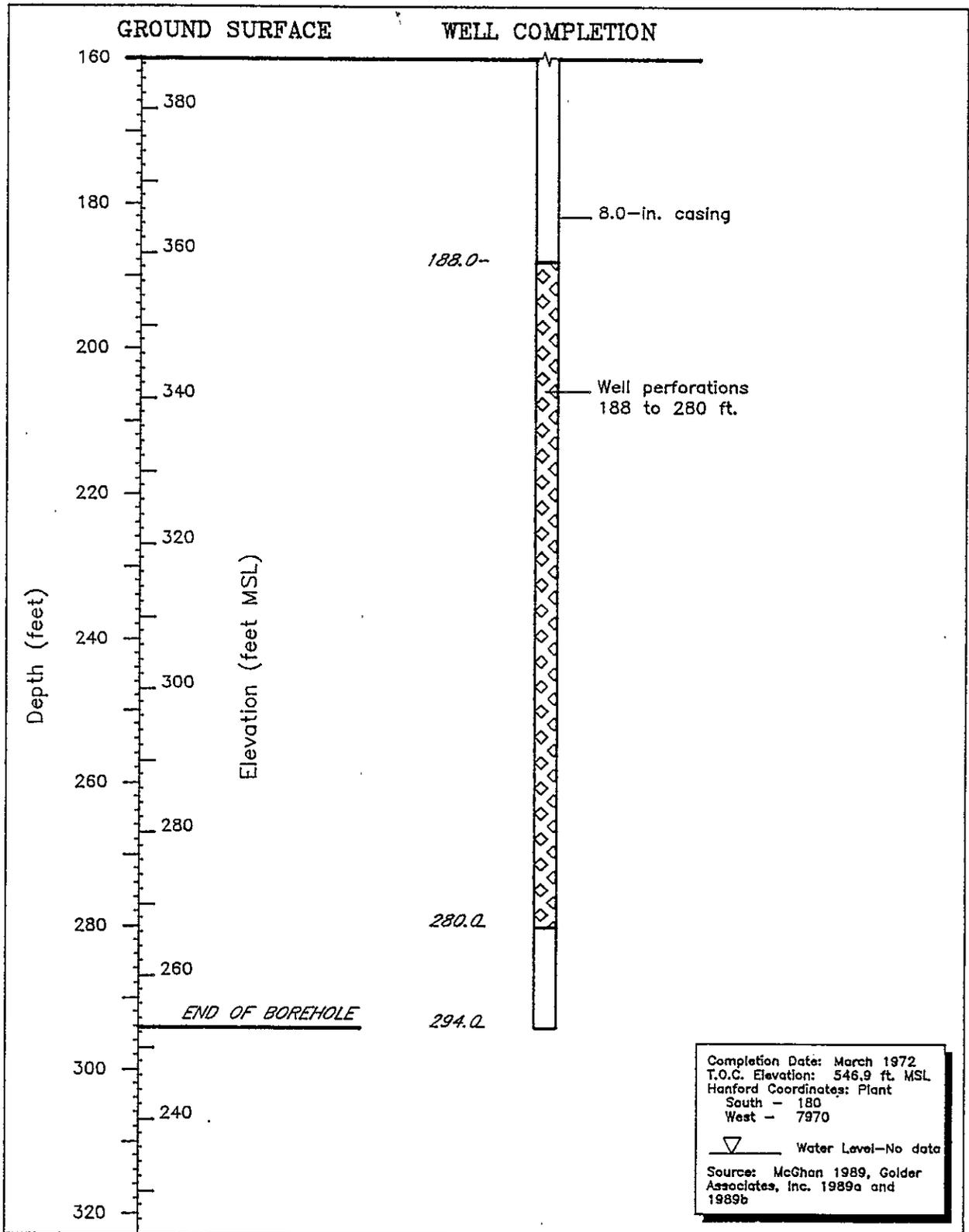
Figure B-1c. Well Completion Log 499-S0-7
(Sheet 3 of 3).

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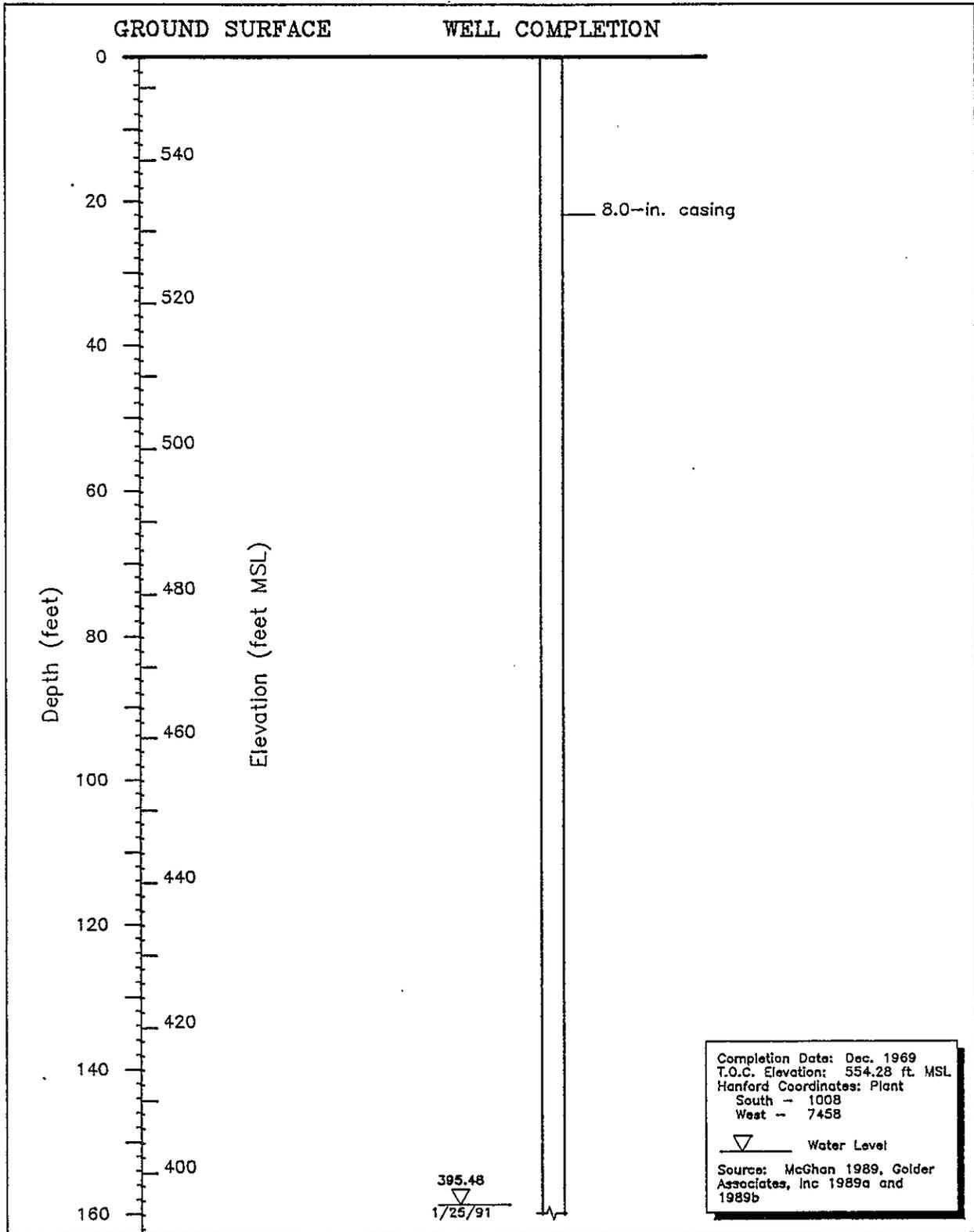
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Figure B-2a. Well Completion Log 499-S0-8 (Sheet 1 of 2).



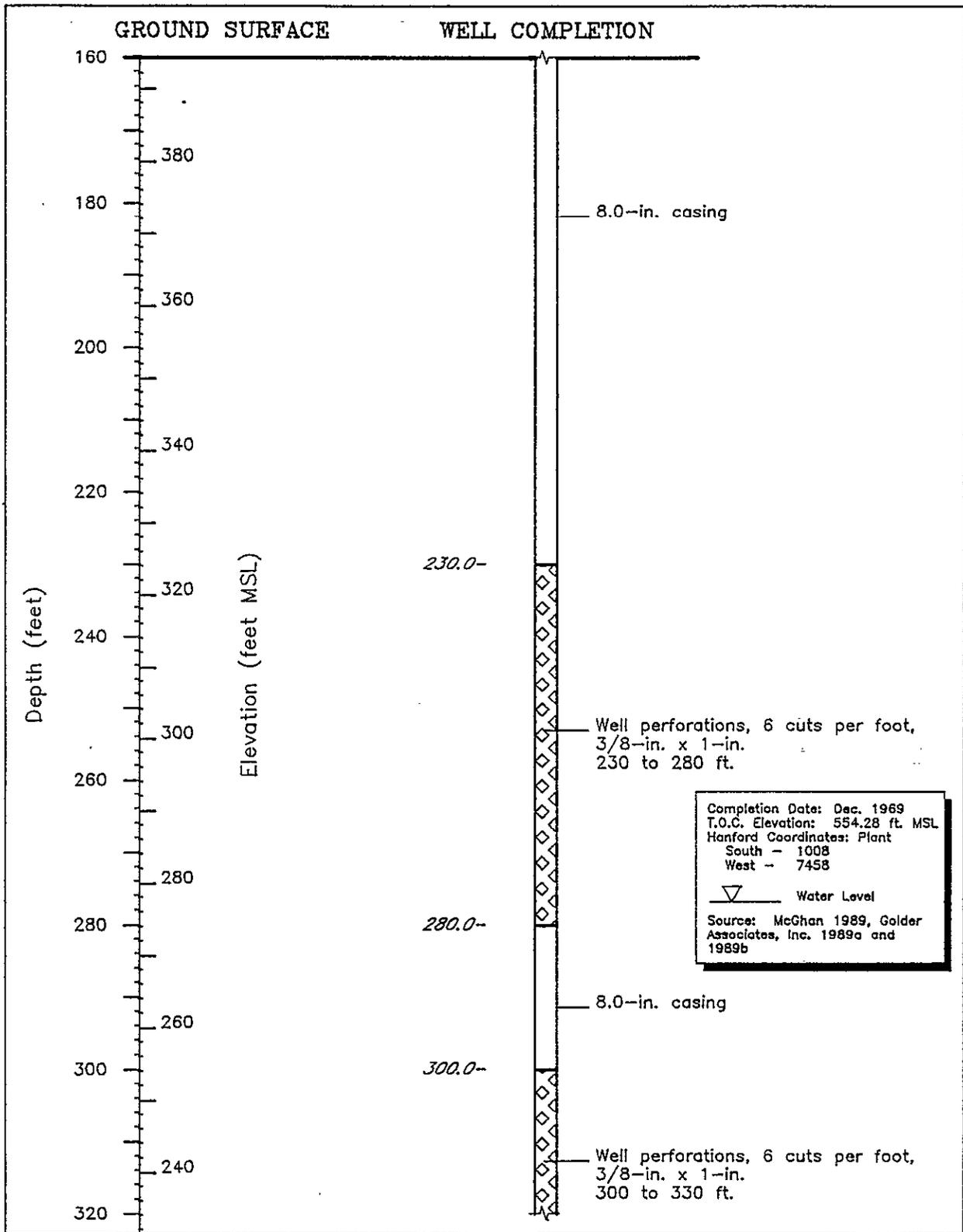
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Figure B-2b. Well Completion Log 499-S0-8
(Sheet 2 of 2).



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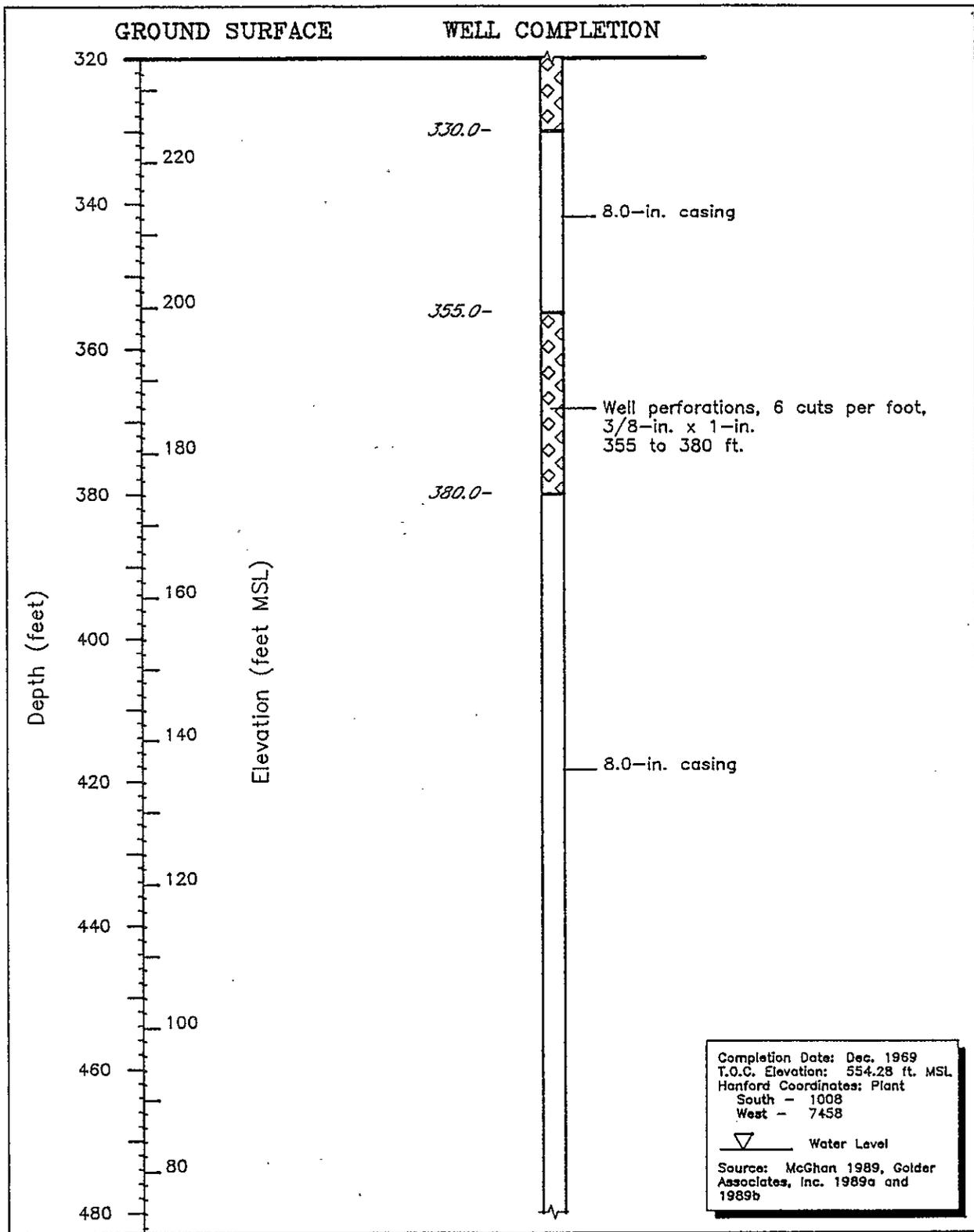
Figure B-3a. Well Completion Log 499-S1-7B
(Sheet 1 of 4).



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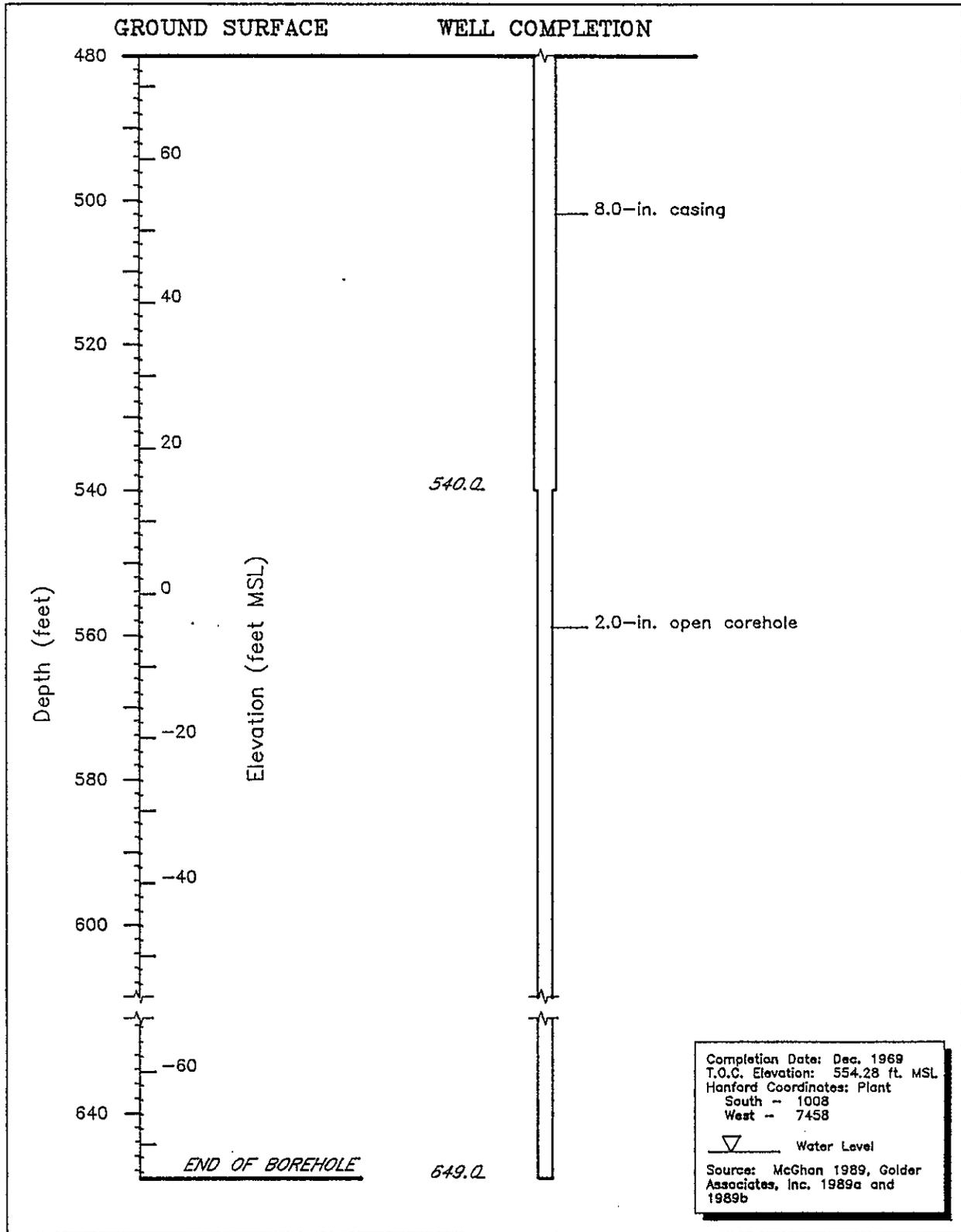
Figure B-3b. Well Completion Log 499-S1-7B
(Sheet 2 of 4).

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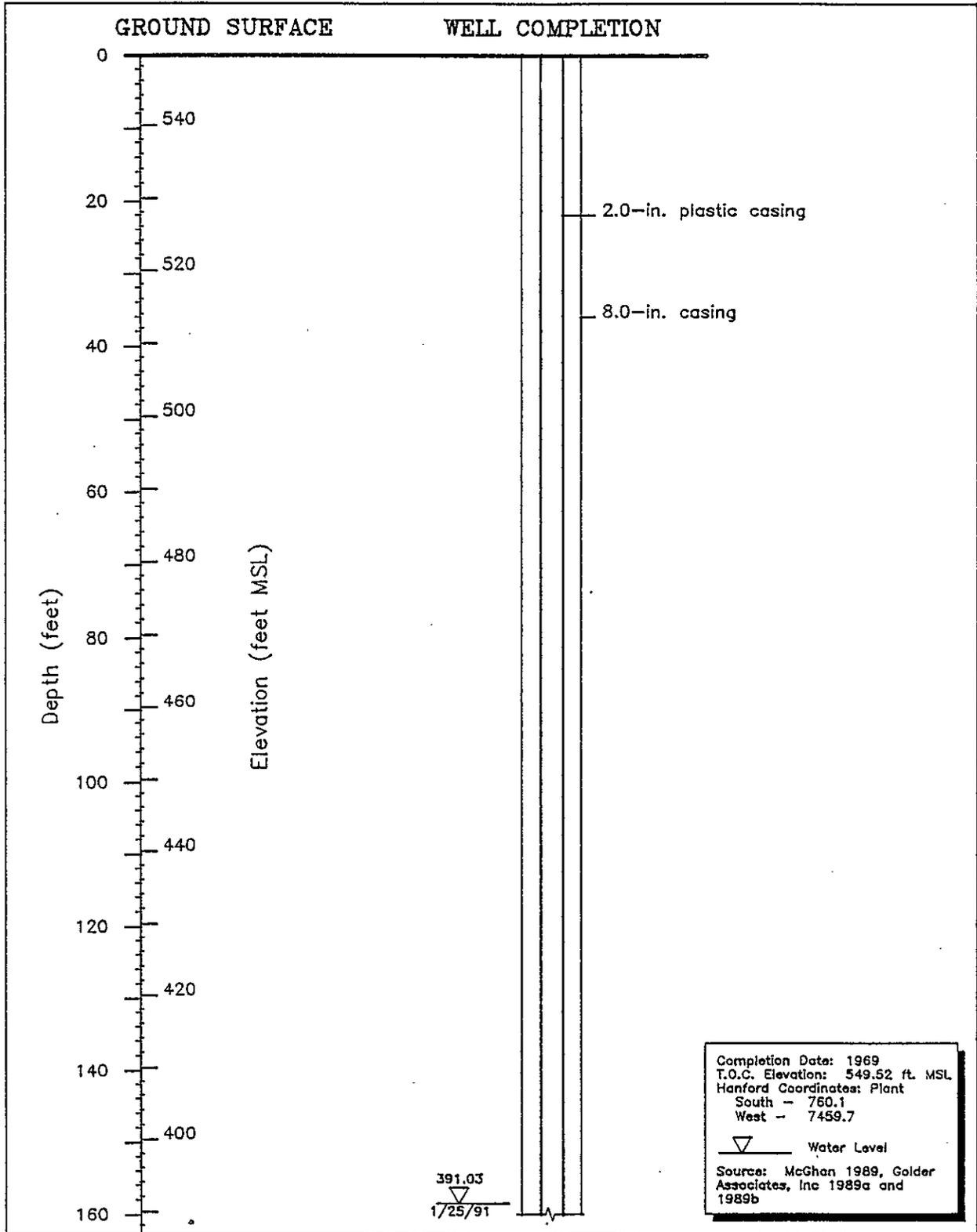
Figure B-3c. Well Completion Log 499-S1-7B
(Sheet 3 of 4).



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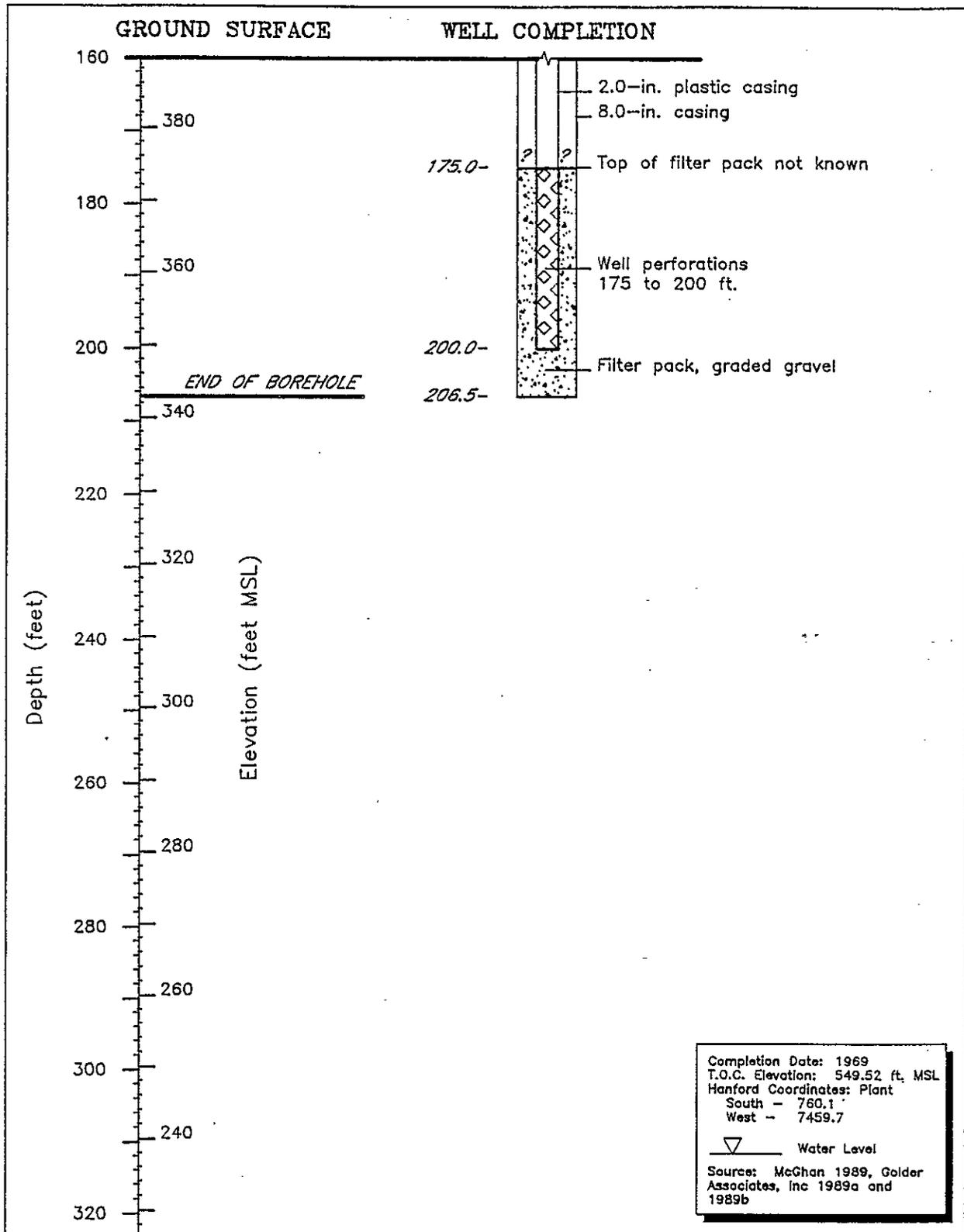
Figure 8-3d. Well Completion Log 499-S1-7B (Sheet 4 of 4).

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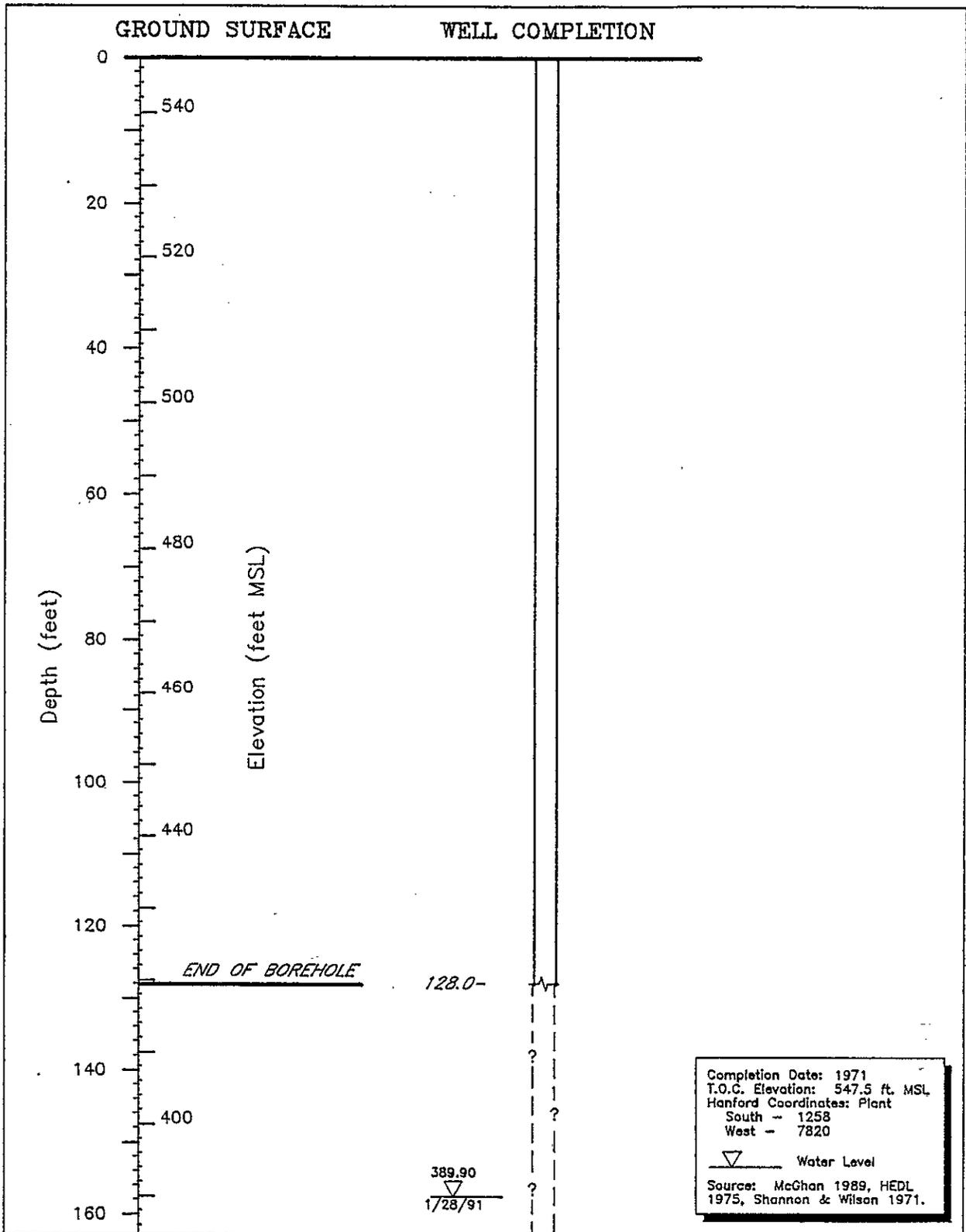
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Figure B-4a. Well Completion Log 499-S1-7C
(Sheet 1 of 2).



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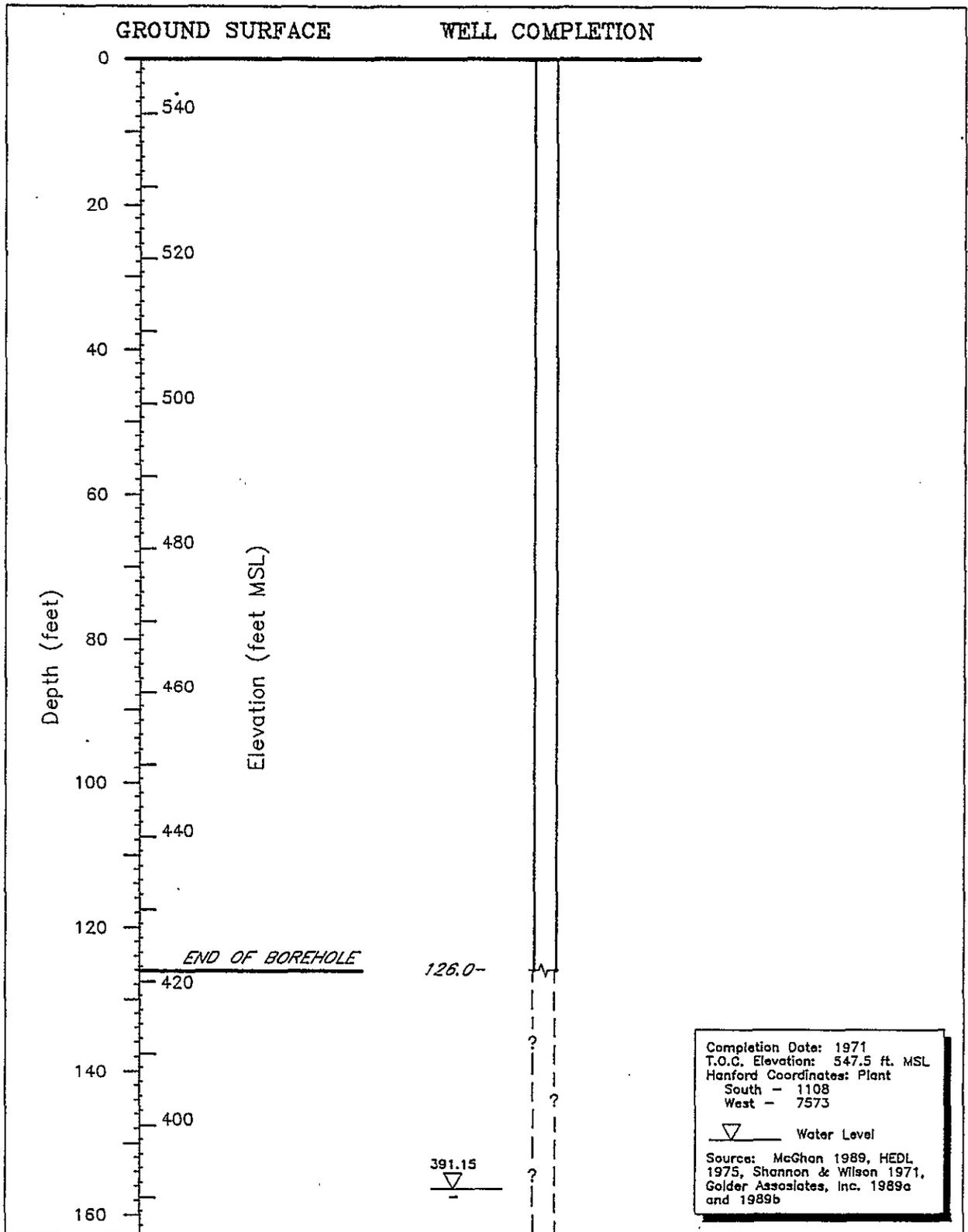
Figure B-4b. Well Completion Log 499-S1-7C (Sheet 2 of 2).



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Figure B-5. Well Completion Log 499-S1-8A
 (Sheet 1 of 1).

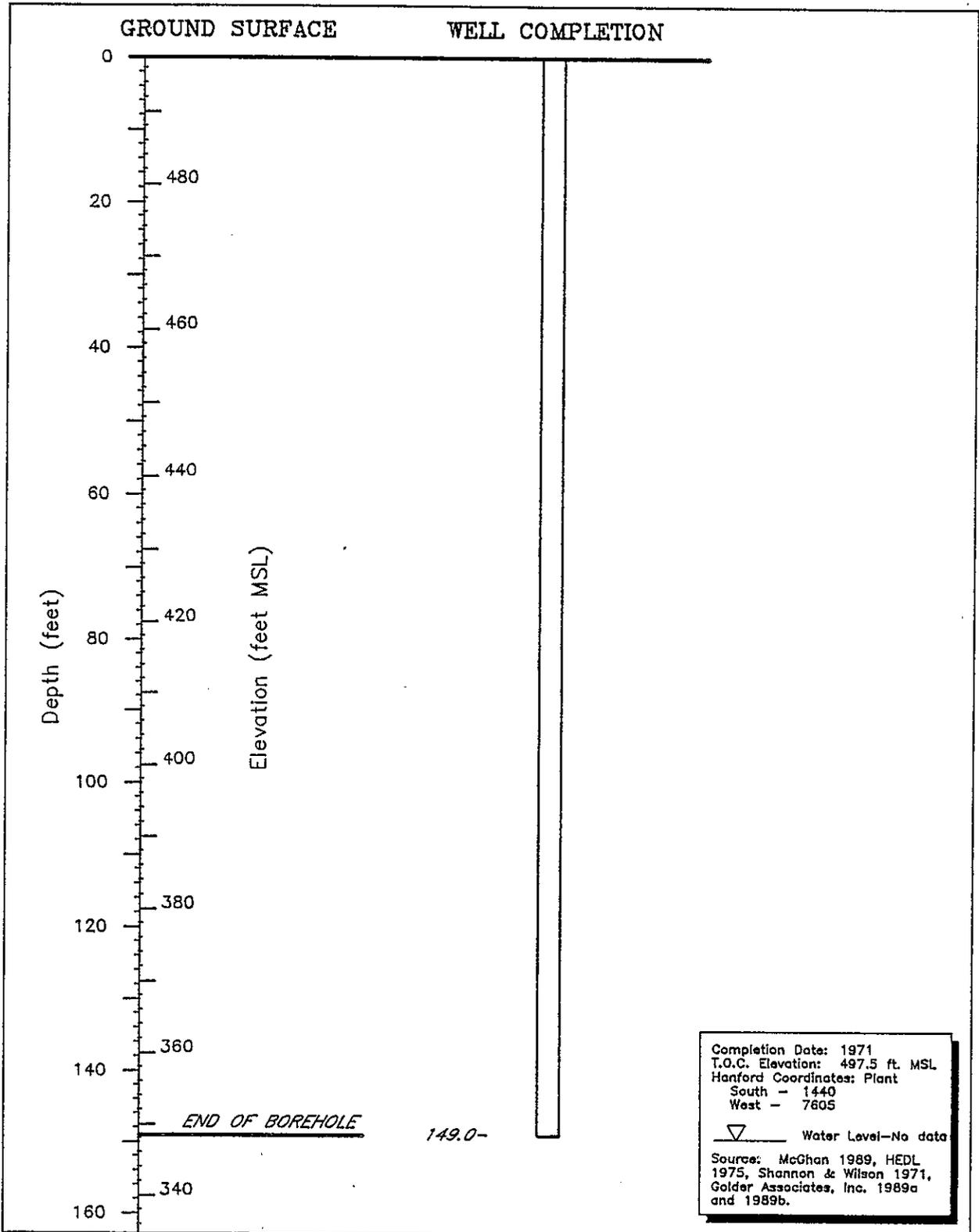
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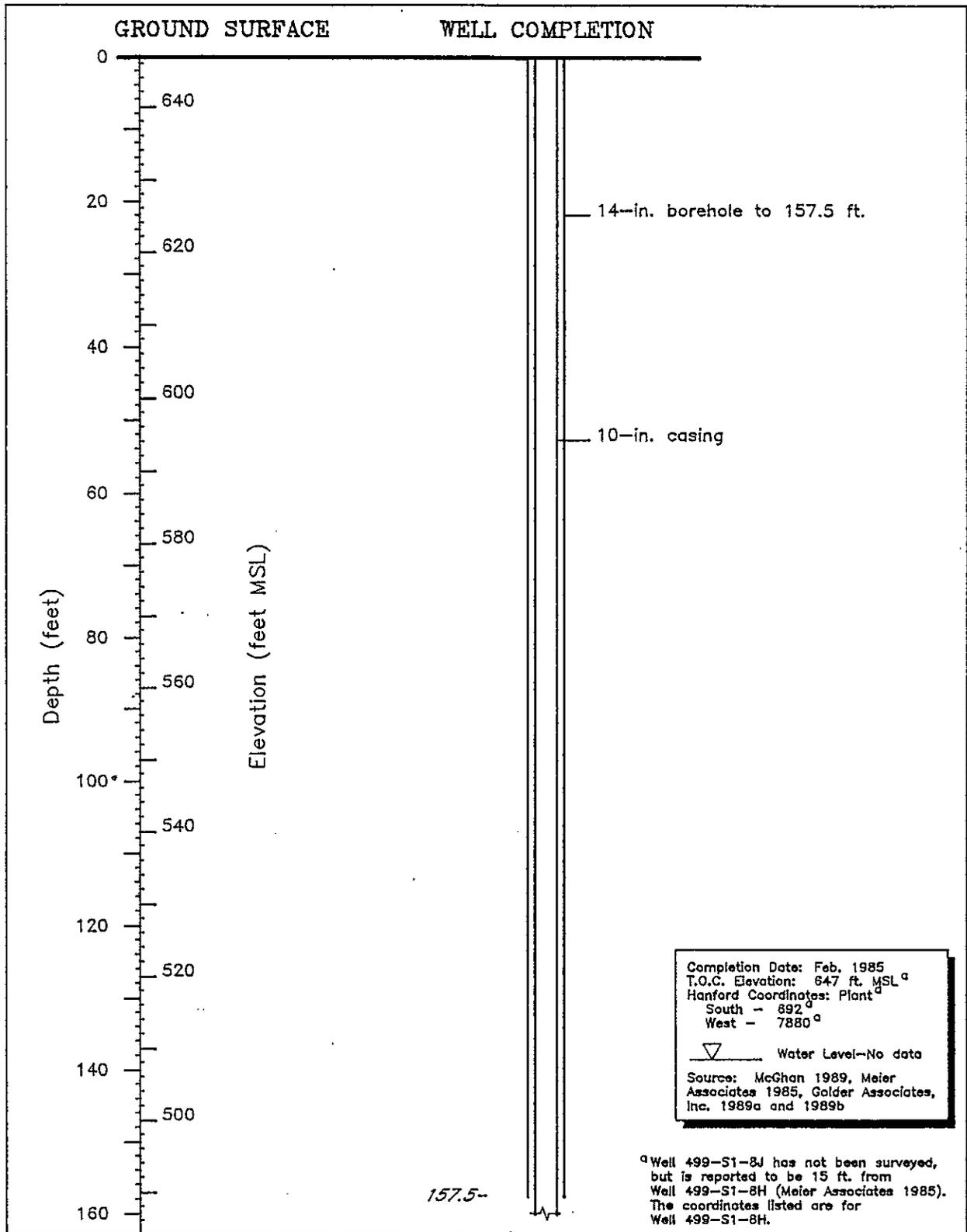
Figure B-6. Well Completion Log 499-S1-8B (Sheet 1 of 1).

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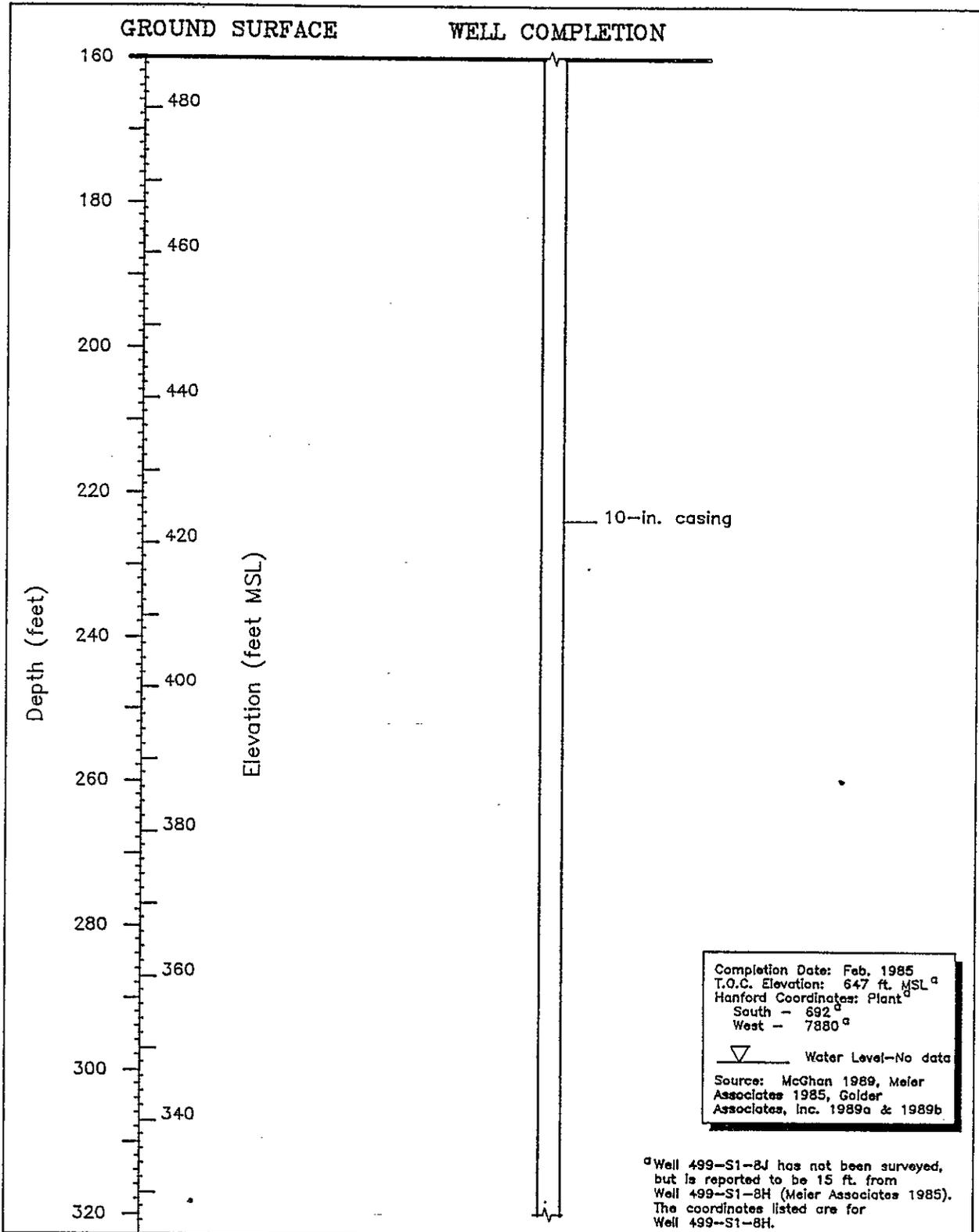
Figure B-7. Well Completion Log 499-S1-8C (Sheet 1 of 1).



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Figure B-8a. Well Completion Log 499-S1-8J
(Sheet 1 of 3).

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Figure B-8b. Well Completion Log 499-S1-8J
(Sheet 2 of 3).

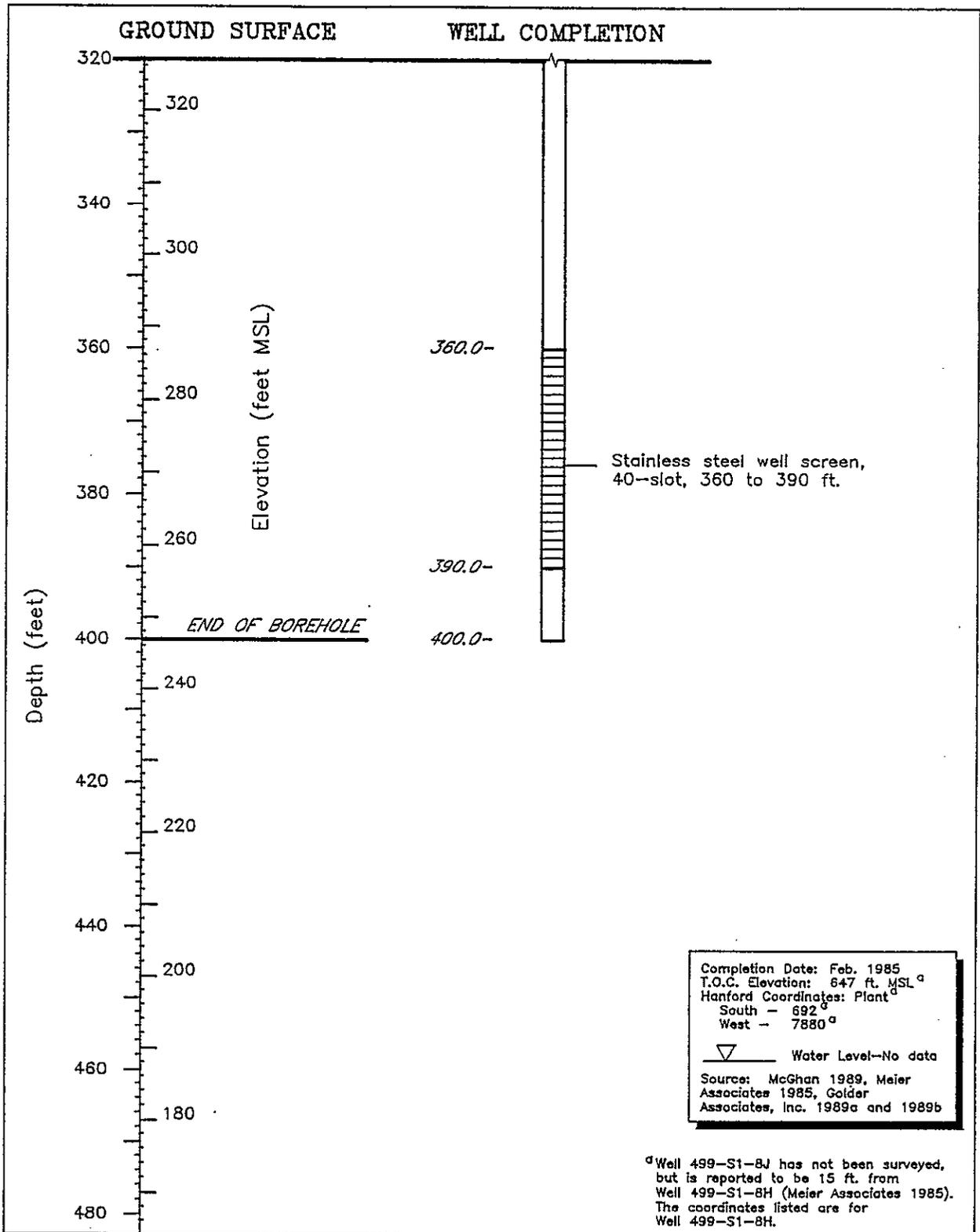
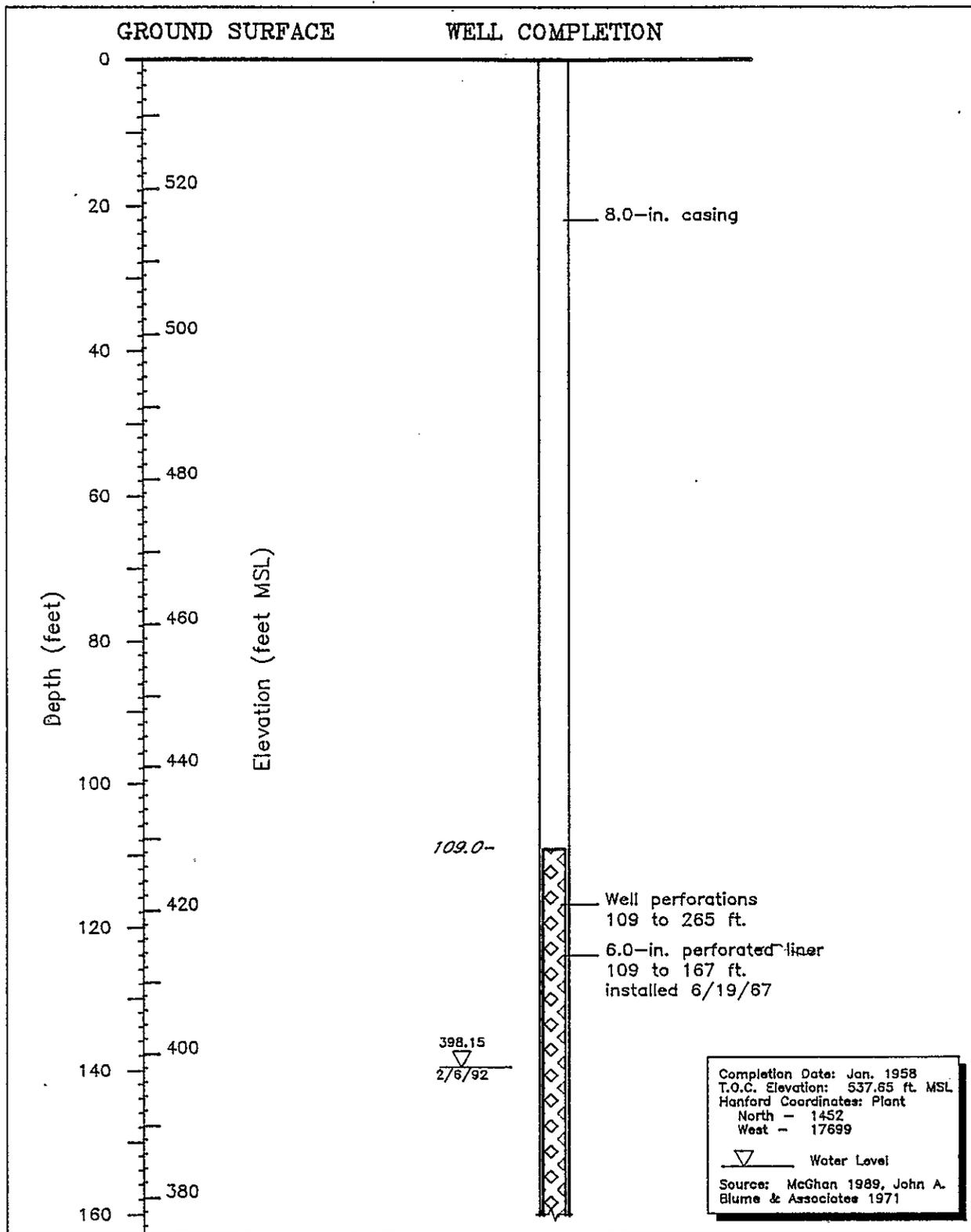
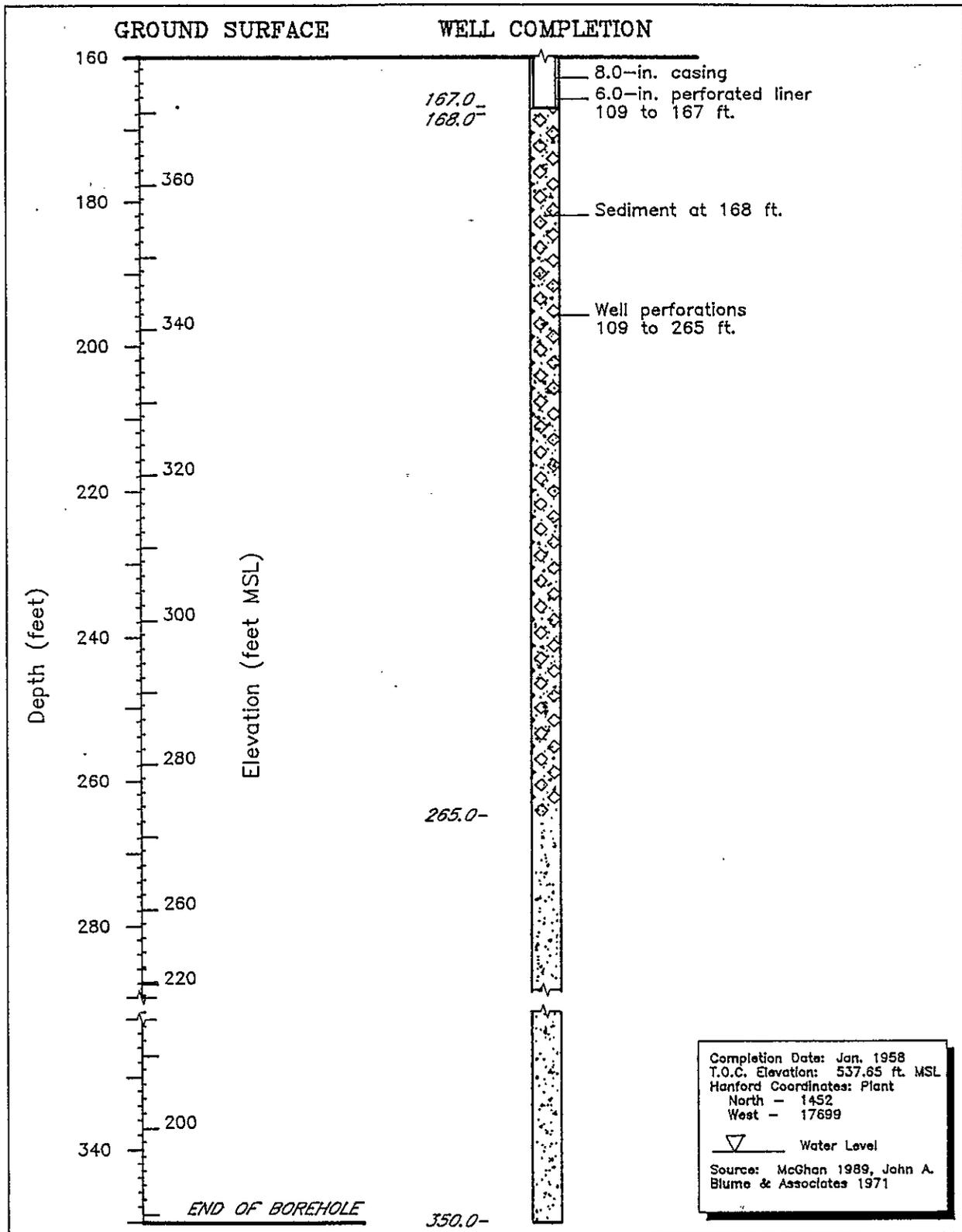


Figure B-8c. Well Completion Log 499-S1-8J (Sheet 3 of 3).



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Figure B-9a. Well Completion Log 699-1-18 (Sheet 1 of 2).

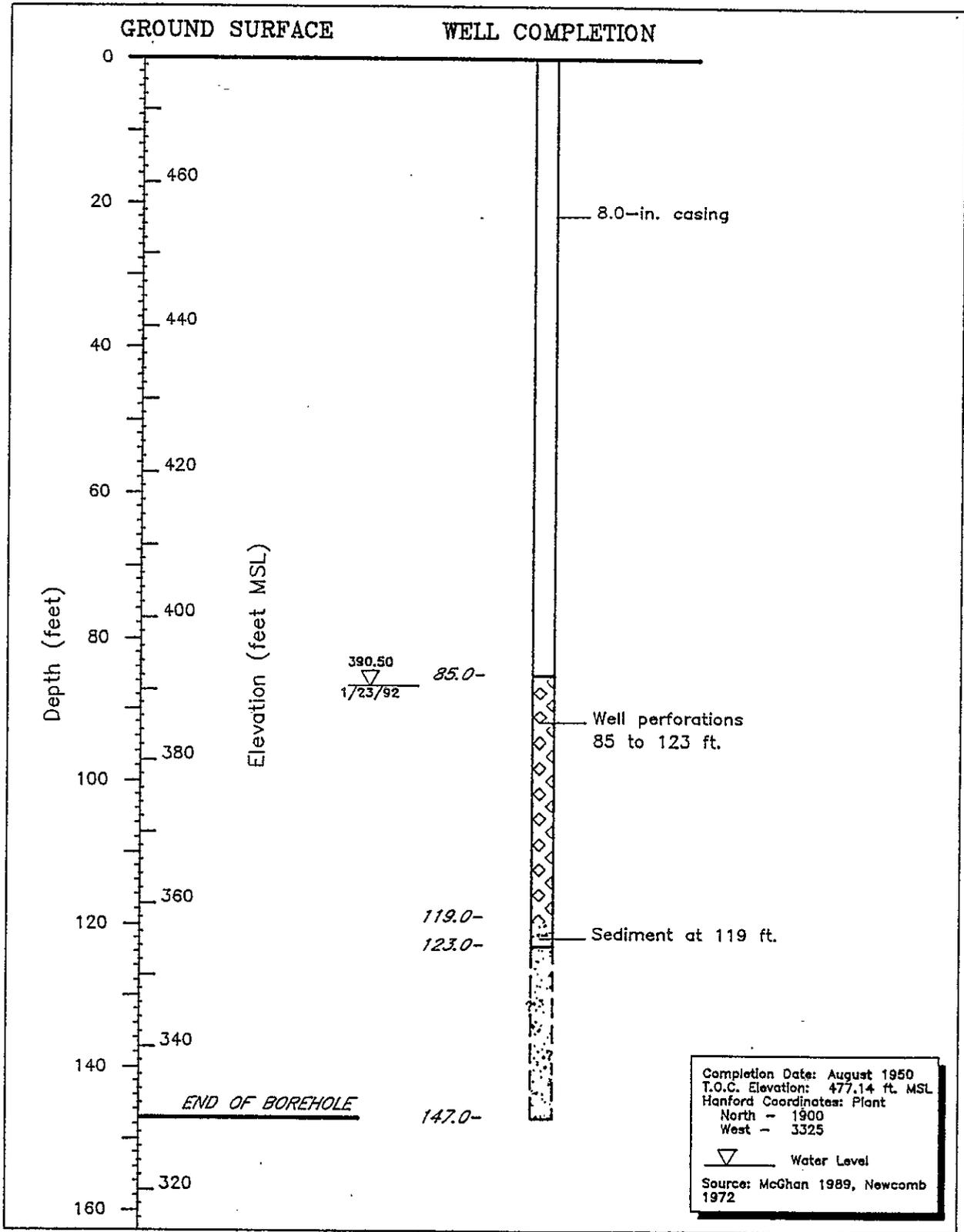


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Figure B-9b. Well Completion Log 699-1-18 (Sheet 2 of 2).

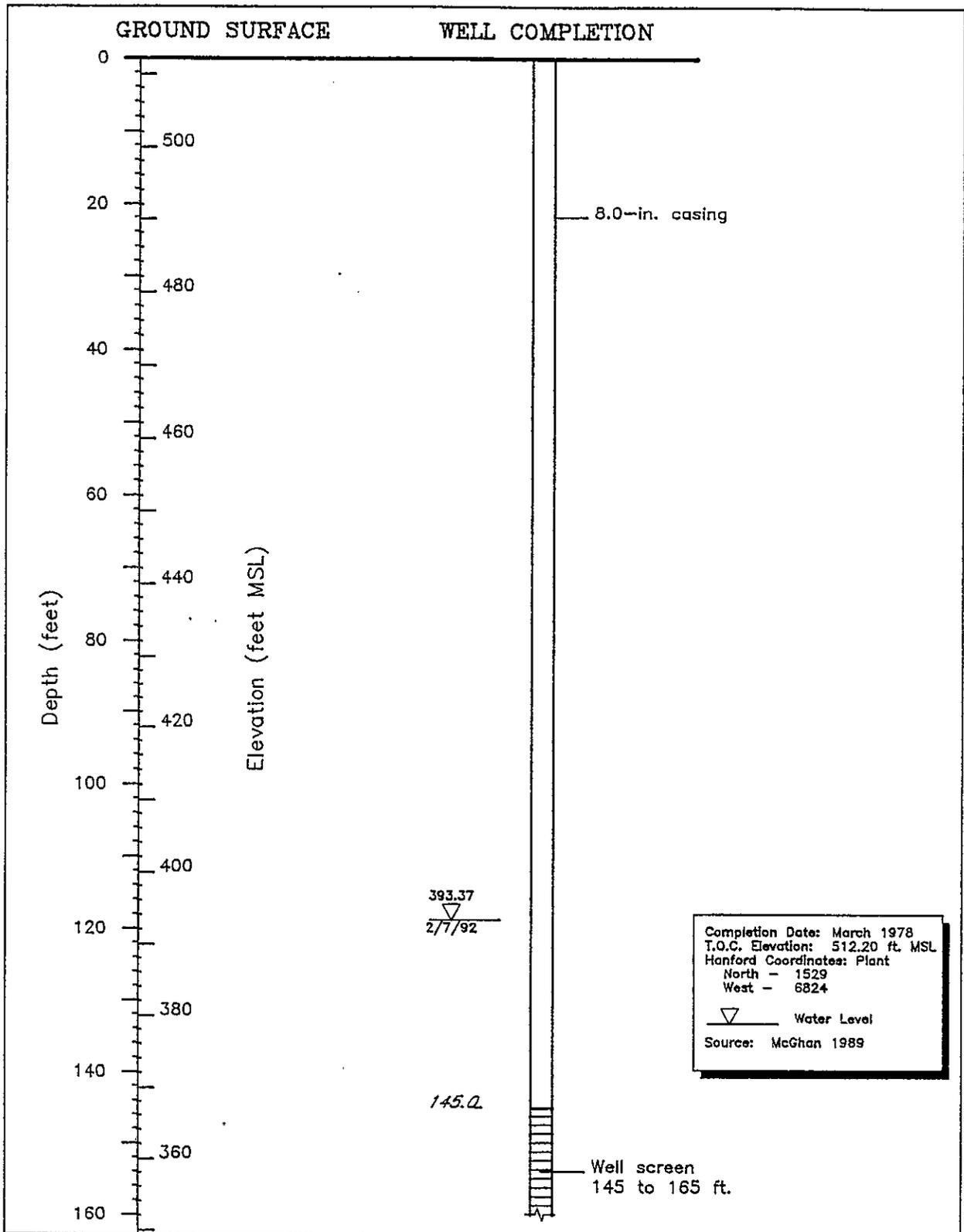
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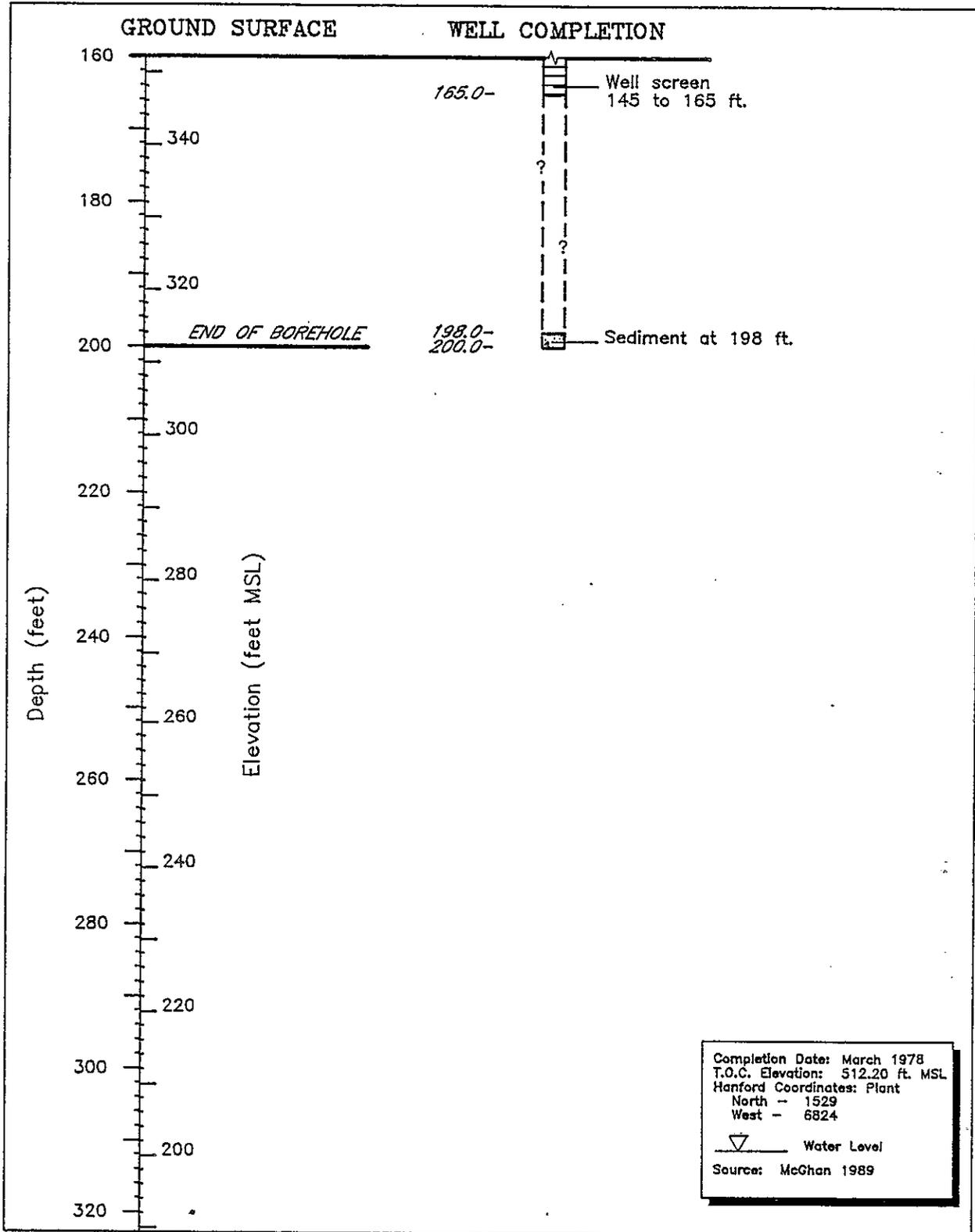
9131728\42141 9-18-92

Figure B-10. Well Completion Log 699-2-3
 (Sheet 1 of 1).



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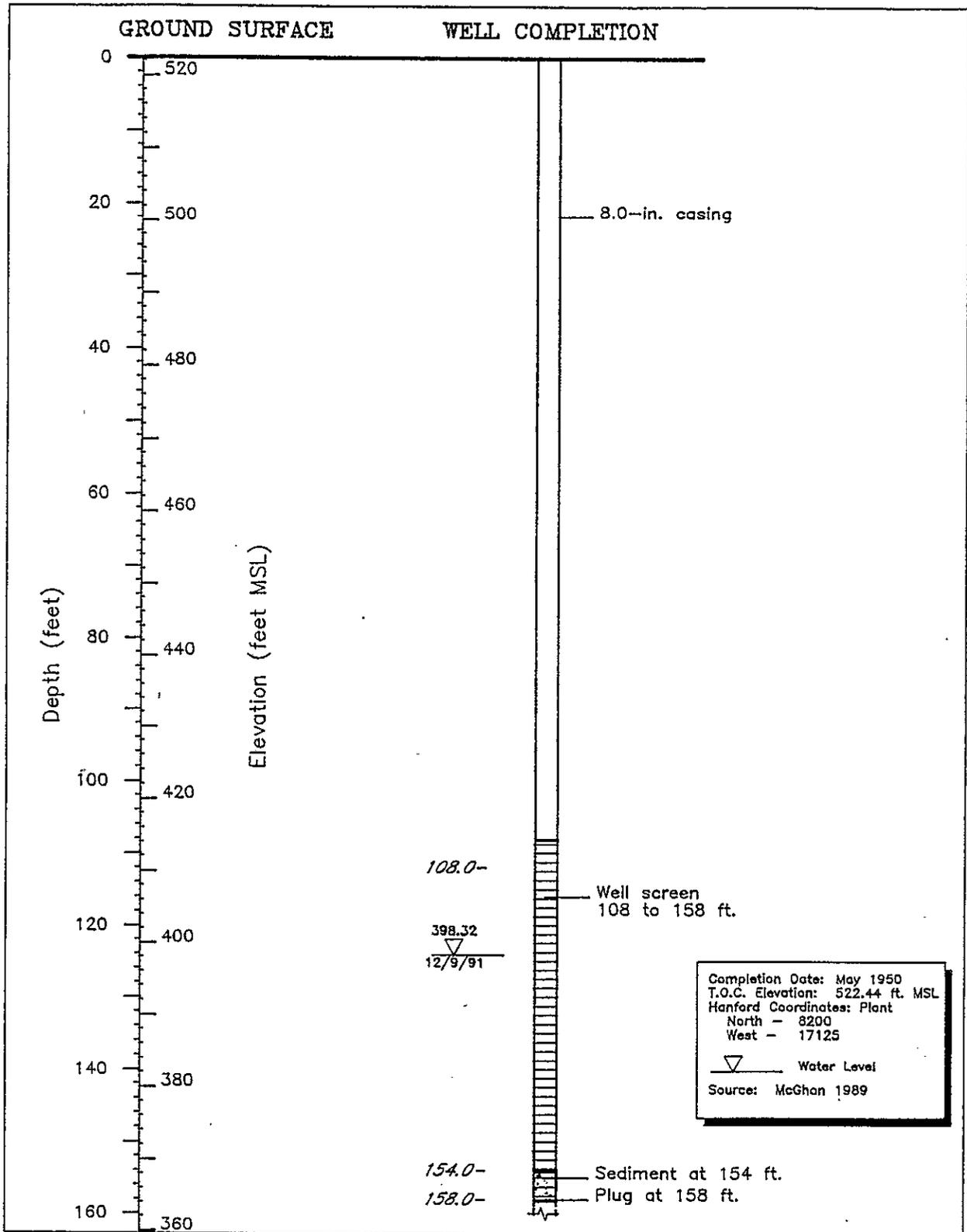
Figure B-11a. Well Completion Log 699-2-7
 (Sheet 1 of 2).



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Figure B-11b. Well Completion Log 699-2-7
(Sheet 2 of 2).

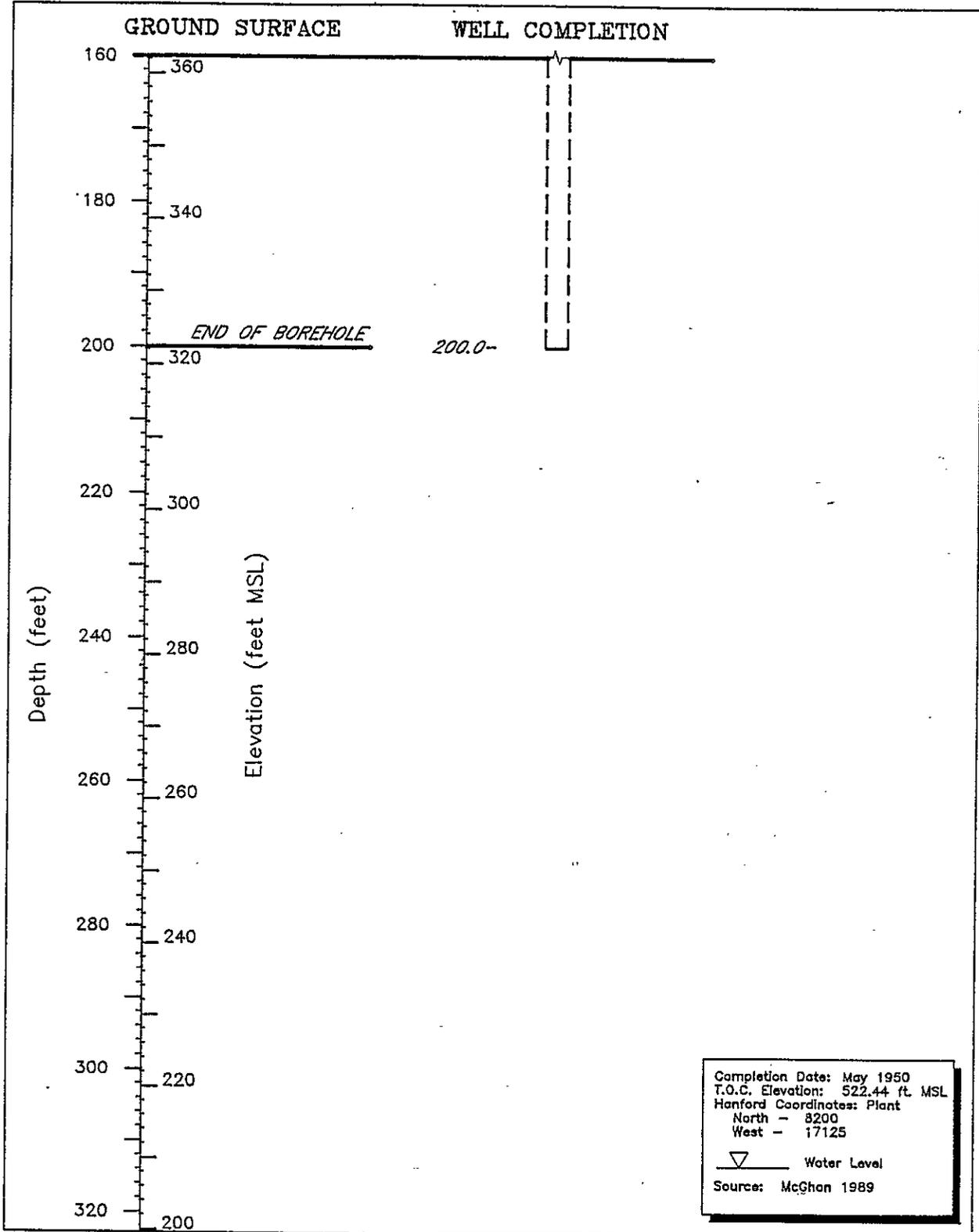


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Figure B-12a. Well Completion Log 699-8-17
(Sheet 1 of 2).

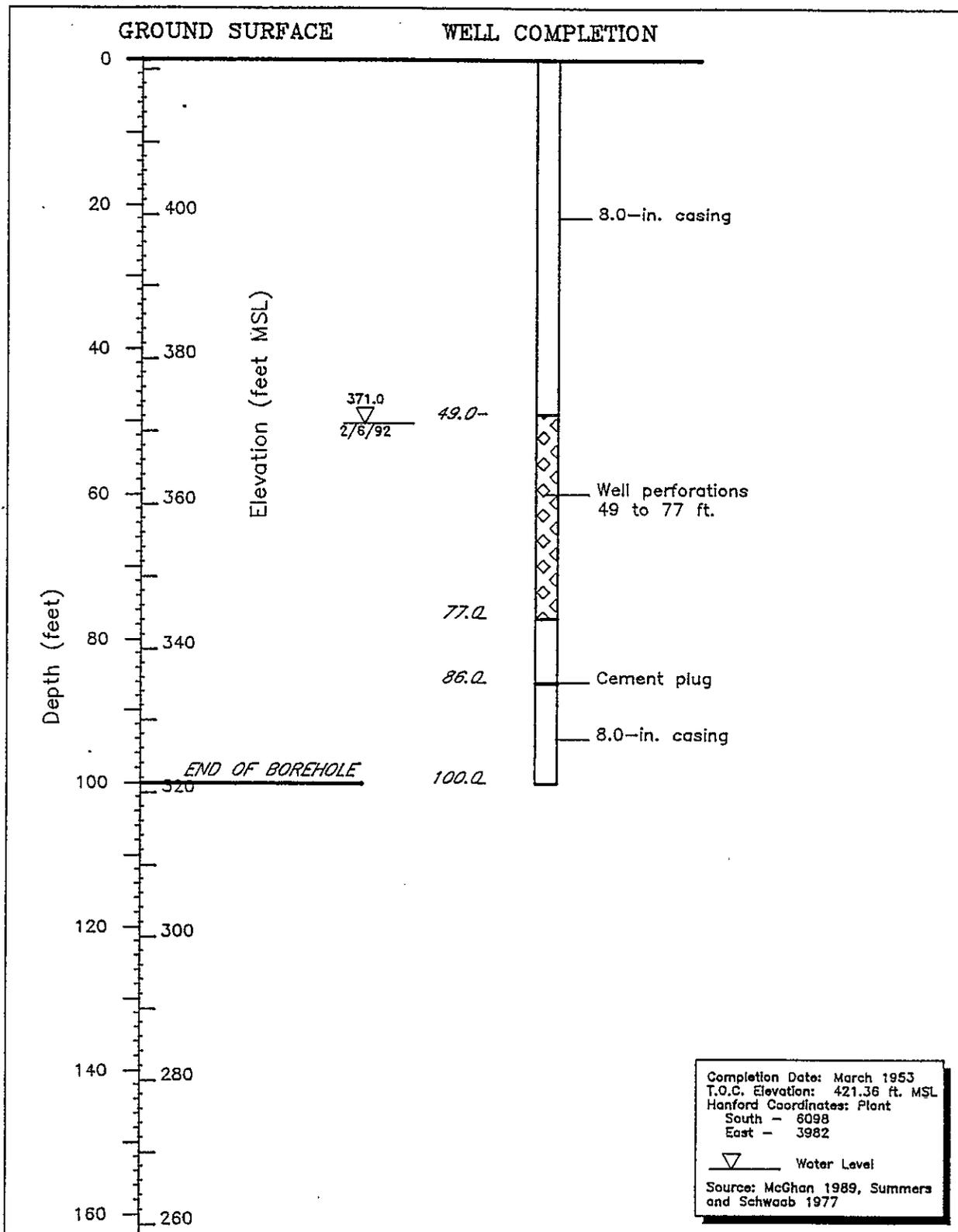
931304-0123

42140-92



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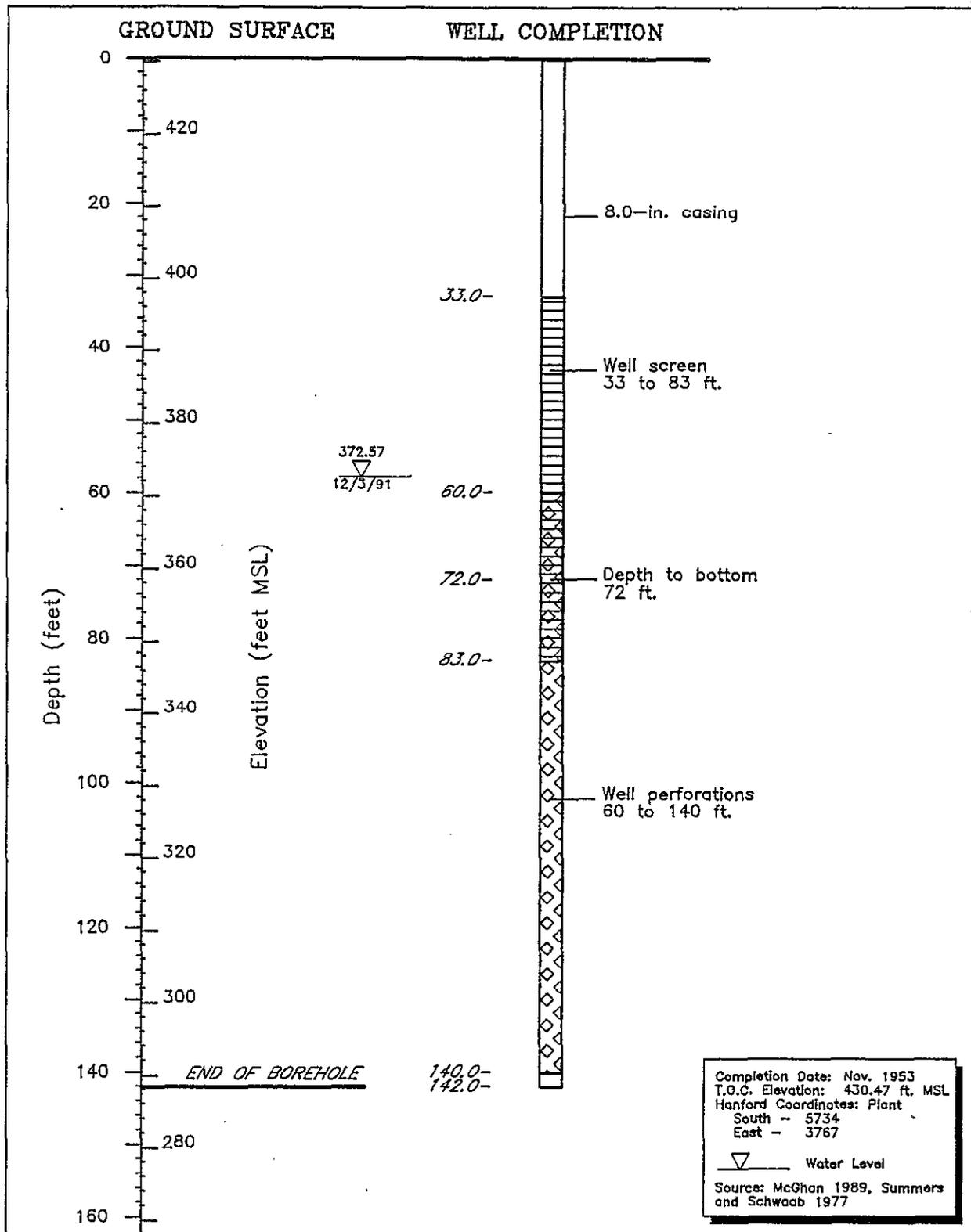
Figure B-12b. Well Completion Log 699-8-17 (Sheet 2 of 2).



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Figure B-13. Well Completion Log 699-S6-E4B
(Sheet 1 of 1).

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Figure B-14. Well Completion Log 699-S6-E4D
(Sheet 1 of 1).

APPENDIX C

DESCRIPTION OF HYDROLOGIC AND CONTAMINANT TRANSPORT MODEL

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1.0 HYDROLOGIC ASSESSMENT MODEL

A one-dimensional analytical model was selected for evaluating the time required for moisture to travel downward from the 400 Area ponds and into the aquifer.

The selected model was applied in the final environmental impact statement for Hanford Site defense wastes and is described in Appendixes O and Q of that document (DOE 1987). The model only considers flow in the vertical direction and does not allow for lateral migration, and therefore is expected to provide an estimated travel time that is faster than would actually occur in the subsurface environment.

The model addresses steady-state flow in the unsaturated zone and assumes a unit hydraulic gradient. The basic equation for any layer is:

$$t = L \times O/q$$

where:

t = time of travel through layer, sec

L = thickness of layer, cm

O = moisture content of sediment, computed as a function of hydraulic conductivity

q = Darcy velocity or moisture flux in layer, cm/sec.

The total travel time, T, is determined as the summation of the travel times for each of the layers. Based on driller's logs for wells in the area and specifically the log for Well 699-2-7 (Appendix B) located near the ponds to the southeast, two layers were determined for the disposal site. The upper and lower layers were estimated to be 29 m (95 ft) of coarse sand (soil type B in WHC 1990a) and 7 m (23 ft) of gravel and sand (soil type A in WHC 1990a), respectively.

The relationship between hydraulic conductivity, K, and moisture content, O, is described graphically in Figure B-1 of WHC, 1990a. These curves were derived empirically from laboratory tests on over 20 different Hanford Site sediment types and were used to establish five major sediment types, as noted in the figure of which coarse sand, and gravel and sand are shown. For unsaturated conditions, the flux is equal to the infiltration rate and O is read from the figure for the value of hydraulic conductivity equal to the flux.

In saturated cases, the steady-state Darcy velocity or water flux is described by the Green-Ampt equation (Bouwer, 1978), which results in the flux, q, being equal to the saturated hydraulic conductivity, K. When moving stratigraphically down from an unsaturated layer to a saturated layer with a resulting greater q, an implicit assumption is that the moisture plume expands to preserve continuity. In the reverse situation, when moving stratigraphically down from a saturated layer to an unsaturated layer, q in the unsaturated layer is taken to be equal to q in the saturated layer.

The infiltration rate is estimated on the basis of the effluent discharge rate (rate of inflow to the ponds) divided by the area of the infiltration area. The minimum, average, and maximum estimated flows into the ponds presented in Table 5-1 were used for the assessment. The average flow rate of 68 L/min (18 gal/min) is representative of the effluent discharge rate for 1979 to 1990, which was calculated from a total of 400 million liters (105,700 gal) (WHC, 1990). Current

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average annual effluent discharge rate is expected to be 34 L/min (9 gal/min) or less due to the reduction in operations at the FFTF. The estimated infiltration area of approximately 150 m² (1614 ft²) is based on the wetted coverage of approximately one third of the pond bottom, which measures about 15 by 30 m (49 by 98 ft). The estimated infiltration area was used for the assessment at the three flow rates.

The infiltration rate based on the minimum and average effluent flow rates did not exceed the saturated hydraulic conductivity. Therefore, the layers were unsaturated and the hydraulic conductivity was taken to be equal to the infiltration rate corresponding to each effluent flow rate. The moisture content at each of the infiltration rates was determined from the moisture curve for each of the layers.

At the maximum effluent discharge rate the infiltration rate exceeded the saturated hydraulic conductivity for the upper layer. Therefore, the upper layer was saturated and the saturated hydraulic conductivity and the corresponding moisture content were used. The lower layer was unsaturated since the saturated hydraulic conductivity for the upper layer was less than saturated hydraulic conductivity for the lower layer. The hydraulic conductivity for the lower layer was taken to be equal to that of the upper layer and the corresponding moisture content was determined from the moisture curve.

This model neglects lateral spreading and therefore the rates of moisture and contaminant migration are expected to be conservative approximations that are higher than would be observed. In addition, this model uses generalized moisture curves from the Hanford Site that are not specific to any individual site. However, they should be useful to obtain an appropriate estimate of soil moisture versus hydraulic conductivity.

Travel times for each of the soil layers and a total travel time were calculated for each of the effluent rates. The average rate of moisture migration through all the layers is obtained by dividing the depth of the vadose zone by the total travel time. Results of the assessment are presented below.

2.0 CONTAMINANT IMPACT ASSESSMENT MODEL

Contaminant migration rates were calculated by dividing the moisture migration rate by the appropriate retardation factor (Rf) for a contaminant/waste stream combination. The Rf for each constituent is estimated from the following equation: $Rf = (1 + 5Rd)$, an approximation for Hanford Site soils using Rd values summarized in Appendix C of WHC 1990. The migration rate for tritium is the same as the travel time of water, since it has a Rf of 1.

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APPENDIX D

GROUNDWATER SAMPLING RESULTS

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APPENDIX D

GROUNDWATER SAMPLING RESULTS

SOURCE OF DATA PRESENTED IN THIS APPENDIX

The groundwater chemistry and water levels data used in this appendix are contained in the Geosciences database, which is maintained by Westinghouse Hanford Company. This database is an interim storage location, which will be used until the formal database, the Hanford Environmental Information System, is ready to receive data. Data are either manually entered from field records or electronically loaded from computer diskettes provided by the analytical laboratories.

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DATE	ANALYTE	CODE	VALUE	UNITS
Well 499-SO-7				
08-Jan-80	Tritium		24000	PCI/L
25-Jun-80	Tritium		22000	PCI/L
17-Sep-80	Tritium		21000	PCI/L
05-Jan-81	Tritium		31000	PCI/L
17-Mar-81	Tritium		21000	PCI/L
17-Jun-81	Tritium		20000	PCI/L
16-Sep-81	Tritium		19000	PCI/L
05-Jan-82	Tritium		21000	PCI/L
29-Mar-82	Tritium		52000	PCI/L
17-Jun-82	Tritium		20000	PCI/L
07-Sep-82	Tritium		25000	PCI/L
30-Nov-82	Tritium		30000	PCI/L
23-Mar-83	Tritium		20000	PCI/L
08-Jun-83	Tritium		37000	PCI/L
19-Sep-83	Tritium		2000	PCI/L
11-Jan-84	Tritium		35000	PCI/L
12-Apr-84	Tritium		32000	PCI/L
23-Jul-84	Tritium		22000	PCI/L
16-Oct-84	Tritium		34000	PCI/L
29-Jan-85	Tritium		23000	PCI/L
24-Apr-85	Tritium		20000	PCI/L
12-Sep-85	Tritium		21000	PCI/L
05-Nov-85	Tritium		39000	PCI/L
03-Feb-86	Tritium		20000	PCI/L
29-Apr-86	Tritium		34000	PCI/L
23-Jul-86	Tritium		34500	PCI/L
15-May-87	Tritium		39000	PCI/L
28-Jul-87	Tritium		141000	PCI/L
20-Nov-87	Tritium		37600	PCI/L
17-Feb-88	Tritium		53800	PCI/L
07-Jun-88	Tritium		34100	PCI/L
02-Aug-88	Tritium		38700	PCI/L
19-Oct-88	Tritium		31400	PCI/L

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DATE	ANALYTE	CODE	VALUE	UNITS
06-Dec-90	Tritium		28000	PCI/L
18-Jan-91	Tritium		25500	PCI/L
24-Jun-91	Tritium		26300	PCI/L
29-Jul-91	Tritium		21900	PCI/L
15-Aug-91	Tritium		255000	PCI/L
09-Sep-91	Tritium		25800	PCI/L
10-Oct-91	Tritium		31300	PCI/L
27-Nov-91	Tritium		25900	PCI/L
23-Dec-91	Tritium		26800	PCI/L
16-Jan-92	Tritium		31000	PCI/L
Well 499-SO-8				
08-Jan-80	Tritium		32000	PCI/L
25-Jun-80	Tritium		80000	PCI/L
17-Sep-80	Tritium		75000	PCI/L
05-Jan-81	Tritium		48000	PCI/L
17-Mar-81	Tritium		77000	PCI/L
17-Jun-81	Tritium		48000	PCI/L
16-Sep-81	Tritium		77000	PCI/L
05-Jan-82	Tritium		24000	PCI/L
29-Mar-82	Tritium		50000	PCI/L
17-Jun-82	Tritium		27000	PCI/L
07-Sep-82	Tritium		20000	PCI/L
30-Nov-82	Tritium		20000	PCI/L
23-Mar-83	Tritium		25000	PCI/L
08-Jun-83	Tritium		40000	PCI/L
19-Sep-83	Tritium		70000	PCI/L
11-Jan-84	Tritium		66000	PCI/L
12-Apr-84	Tritium		41000	PCI/L
23-Jul-84	Tritium		79000	PCI/L
16-Oct-84	Tritium		89000	PCI/L
29-Jan-85	Tritium		25000	PCI/L
24-Apr-85	Tritium		18000	PCI/L
12-Sep-85	Tritium		59000	PCI/L
05-Nov-85	Tritium		26000	PCI/L

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DATE	ANALYTE	CODE	VALUE	UNITS
Well 499-SO-7				
08-Jan-80	Tritium		24000	PCI/L
25-Jun-80	Tritium		22000	PCI/L
17-Sep-80	Tritium		21000	PCI/L
05-Jan-81	Tritium		31000	PCI/L
17-Mar-81	Tritium		21000	PCI/L
17-Jun-81	Tritium		20000	PCI/L
16-Sep-81	Tritium		19000	PCI/L
05-Jan-82	Tritium		21000	PCI/L
29-Mar-82	Tritium		52000	PCI/L
17-Jun-82	Tritium		20000	PCI/L
07-Sep-82	Tritium		25000	PCI/L
30-Nov-82	Tritium		30000	PCI/L
23-Mar-83	Tritium		20000	PCI/L
08-Jun-83	Tritium		37000	PCI/L
19-Sep-83	Tritium		2000	PCI/L
11-Jan-84	Tritium		35000	PCI/L
12-Apr-84	Tritium		32000	PCI/L
23-Jul-84	Tritium		22000	PCI/L
16-Oct-84	Tritium		34000	PCI/L
29-Jan-85	Tritium		23000	PCI/L
24-Apr-85	Tritium		20000	PCI/L
12-Sep-85	Tritium		21000	PCI/L
05-Nov-85	Tritium		39000	PCI/L
03-Feb-86	Tritium		20000	PCI/L
29-Apr-86	Tritium		34000	PCI/L
23-Jul-86	Tritium		34500	PCI/L
15-May-87	Tritium		39000	PCI/L
28-Jul-87	Tritium		141000	PCI/L
20-Nov-87	Tritium		37600	PCI/L
17-Feb-88	Tritium		53800	PCI/L
07-Jun-88	Tritium		34100	PCI/L
02-Aug-88	Tritium		38700	PCI/L
19-Oct-88	Tritium		31400	PCI/L

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24-Jun-91	Tritium		26300	PCI/L
29-Jul-91	Tritium		21900	PCI/L
15-Aug-91	Tritium		255000	PCI/L
09-Sep-91	Tritium		25800	PCI/L
10-Oct-91	Tritium		31300	PCI/L
27-Nov-91	Tritium		25900	PCI/L
23-Dec-91	Tritium		26800	PCI/L
16-Jan-92	Tritium		31000	PCI/L
Well 499-SO-8				
08-Jan-80	Tritium		32000	PCI/L
25-Jun-80	Tritium		80000	PCI/L
17-Sep-80	Tritium		75000	PCI/L
05-Jan-81	Tritium		48000	PCI/L
17-Mar-81	Tritium		77000	PCI/L
17-Jun-81	Tritium		48000	PCI/L
16-Sep-81	Tritium		77000	PCI/L
05-Jan-82	Tritium		24000	PCI/L
29-Mar-82	Tritium		50000	PCI/L
17-Jun-82	Tritium		27000	PCI/L
07-Sep-82	Tritium		20000	PCI/L
30-Nov-82	Tritium		20000	PCI/L
23-Mar-83	Tritium		25000	PCI/L
08-Jun-83	Tritium		40000	PCI/L
19-Sep-83	Tritium		70000	PCI/L
11-Jan-84	Tritium		66000	PCI/L
12-Apr-84	Tritium		41000	PCI/L
23-Jul-84	Tritium		79000	PCI/L
16-Oct-84	Tritium		89000	PCI/L
29-Jan-85	Tritium		25000	PCI/L
24-Apr-85	Tritium		18000	PCI/L
12-Sep-85	Tritium		59000	PCI/L
05-Nov-85	Tritium		26000	PCI/L

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29-Apr-86	Tritium		390	PCI/L
22-May-87	Tritium		50600	PCI/L
28-Jul-87	Tritium		41000	PCI/L
20-Nov-87	Tritium		38600	PCI/L
17-Feb-88	Tritium		4770	PCI/L
07-Jun-88	Tritium		28200	PCI/L
02-Aug-88	Tritium		52300	PCI/L
06-Dec-90	Tritium		25400	PCI/L
18-Jan-81	Tritium		13600	PCI/L
24-Jun-91	Tritium		40400	PCI/L
29-Jul-91	Tritium		42400	PCI/L
15-Aug-91	Tritium		44900	PCI/L
09-Sep-91	Tritium		40400	PCI/L
10-Oct-91	Tritium		44400	PCI/L
27-Nov-91	Tritium		27700	PCI/L
23-Dec-91	Tritium		13700	PCI/L
16-Jan-92	Tritium		29500	PCI/L
Well 499-S1-7B				
17-Feb-88	Tritium		57800	PCI/L
Well 499-S1-7C				
17-Feb-88	Nitrate, High Detection Level		24900	PPB
17-Feb-88	Tritium		76100	PCI/L
17-Feb-88	Tritium		75000	PCI/L
Well 499-S1-8A				
17-Feb-88	Nitrate, High Detection Level		25600	PPB
17-Feb-88	Tritium		82900	PCI/L
Well 499-SI-8B				
17-Feb-88	Nitrate, High Detection Level		25400	PPB
17-Feb-88	Tritium		83700	PCI/L
Well 499-SI-8J				
01-Oct-85	Tritium		4200	PCI/L
01-Apr-87	Tritium		2740	PCI/L

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01-Apr-88	Tritium		5740	PCI/L
01-Jul-88	Tritium		6730	PCI/L
01-Oct-88	Tritium		6400	PCI/L
01-Jan-90	Tritium		7680	PCI/L
01-Jan-91	Tritium		6820	PCI/L
Well 699-1-18				
21-Jan-88	Nitrate, High Detection Level		19100	PPB
21-Jan-88	Tritium		48100	PCI/L
Well 699-2-3				
22-Jan-88	Nitrate, High Detection Level		29000	PPB
22-Jan-88	Tritium		104000	PCI/L
Well 699-2-7				
13-Aug-86	Nitrate		37200	PPB
07-Nov-86	Nitrate		33400	PPB
26-Jan-87	Nitrate		34300	PPB
31-May-87	Nitrate		28300	PPB
13-Apr-90	Nitrate		73400	PPB
18-Dec-91	Nitrate		15000	PPB
02-Feb-92	Nitrate		69000	PPB
24-Jul-87	Nitrate, High Detection Level		32900	PPB
21-Oct-87	Nitrate, High Detection Level		48600	PPB
27-Jan-88	Nitrate, High Detection Level		39900	PPB
30-Jan-89	Nitrate, High Detection Level		55500	PPB
03-Mar-86	Nitrate-ion		96	MG/L
24-Jun-86	Nitrate-ion		69	MG/L
13-Apr-90	Nitrate	<	1000	PPB
18-Dec-91	Nitrate	U	200	PPB
07-Feb-92	Nitrate	U	200	PPB
03-Mar-86	Tritium		16000	PCI/L
24-Jun-86	Tritium	<	13000	PCI/L

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26-Jan-87	Tritium		6790	PCI/L
31-May-87	Tritium		10900	PCI/L
24-Jul-87	Tritium		10700	PCI/L
21-Oct-87	Tritium		13300	PCI/L
27-Jan-88	Tritium		13300	PCI/L
30-Jan-89	Tritium		12300	PCI/L
13-Apr-90	Tritium		14300	PCI/L
21-Mar-91	Tritium		11900	PCI/L
18-Dec-91	Tritium		12300	PCI/L
07-Feb-92	Tritium		11700	PCI/L
30-Apr-92	Tritium		13100	PCI/L
Well 699-8-17				
27-Jan-88	Nitrate, High Detection Level		34200	PPB
04-Jan-80	Tritium		210000	PCI/L
17-Mar-80	Tritium		180000	PCI/L
10-Jun-80	Tritium		180000	PCI/L
03-Sep-80	Tritium		180000	PCI/L
06-Jan-81	Tritium		180000	PCI/L
19-Mar-81	Tritium		170000	PCI/L
24-Jun-81	Tritium		170000	PCI/L
01-Sep-81	Tritium		170000	PCI/L
30-Dec-81	Tritium		170000	PCI/L
22-Mar-82	Tritium		160000	PCI/L
16-Jun-82	Tritium		160000	PCI/L
03-Sep-82	Tritium		170000	PCI/L
30-Nov-82	Tritium		160000	PCI/L
16-Mar-83	Tritium		160000	PCI/L
06-Jun-83	Tritium		160000	PCI/L
31-Aug-83	Tritium		160000	PCI/L
19-Nov-83	Tritium		160000	PCI/L
17-Mar-84	Tritium		170000	PCI/L
19-Mar-84	Tritium		150000	PCI/L

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28-Sep-84	Tritium		160000	PCI/L
29-Jan-85	Tritium		160000	PCI/L
18-Jul-85	Tritium		160000	PCI/L
10-Sep-85	Tritium		140000	PCI/L
10-Nov-85	Tritium		150000	PCI/L
24-Feb-86	Tritium		152000	PCI/L
30-May-86	Tritium		156000	PCI/L
28-Jul-86	Tritium		158000	PCI/L
10-Oct-86	Tritium		158000	PCI/L
26-Jan-87	Tritium		152000	PCI/L
31-May-87	Tritium		157000	PCI/L
29-Jul-87	Tritium		156000	PCI/L
25-Oct-87	Tritium		150000	PCI/L
27-Jan-88	Tritium		155000	PCI/L
07-Apr-88	Tritium		154000	PCI/L
14-Jul-88	Tritium		144000	PCI/L
29-Nov-88	Tritium		136000	PCI/L
07-Apr-89	Tritium		111000	PCI/L
19-Oct-89	Tritium		113000	PCI/L
05-Dec-89	Tritium		110000	PCI/L
Well 699-S6-E4B				
19-Feb-88	Nitrate, High Detection Level		15600	PPB
19-Feb-88	Tritium		25900	PCI/L
Well 699-S6-E4D				
19-Feb-88	Nitrate, High Detection Level		23000	PPB
19-Feb-88	Tritium		38700	PCI/L
19-Feb-88	Tritium		389000	PCI/L

Source: Geosciences Groundwater Database

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10/27/92 DS

INFORMATION RELEASE REQUEST

Reference:

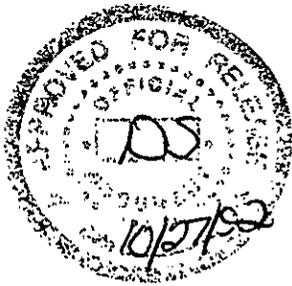
WHC-CM-3-4

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