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REPORT ON
GROUND WATER OBSERVATION WELLS
LOS ALAMOS, NEW MEXICO

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI
1950

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REPORT ON GROUND WATER OBSERVATION WELLS

DESCRIPTION OF PROJECT. Surface drainage from the entire area occupied by the Los Alamos Community is discharged into Pueblo and Los Alamos Canyons, both of which head in the Jemez Mountain Range west of the Project, extend in an easterly direction through the Project to a confluence approximately two miles east of the easterly reservation boundary, below which junction Los Alamos Canyon continues eastwardly to the Rio Grande River, a distance of approximately five miles. The effluent from the existing sewage treatment plant serving the community and the TA-1 area, is now discharged into Pueblo Canyon. Effluent from the new sewage treatment plant now under construction to serve the Community and the new waste treatment plant which will receive the plant waste liquids from the TA-1 area, will be discharged into Pueblo Canyon. Sanitary sewage and plant waste liquids from the TA-21 area are discharged into Los Alamos Canyon above its junction with Pueblo Canyon. The effluent from the new sewage treatment plant serving the TA-3 area will be discharged into Sandia Canyon which discharges directly into the RIO GRANDE RIVER. The principal source of water supply for the Project is the group of six wells located in Los Alamos Canyon below the Pueblo Canyon confluence.

To facilitate a long-term study of the movement of contaminated waste liquids from the Project activities into and through the various aquifers underlying the project Site and possibly discharging into the main body of ground water from which the Los Alamos water supply is

taken, a construction project was set up ~~project was set up~~ providing for the construction of four groups of test wells, three of which would be located in Pueblo Canyon and one in Los Alamos Canyon. In selecting the general locations for these groups the governing consideration was that one group should be located as near as practicable to the confluence of Pueblo and Los Alamos Canyons; a second group should be located in Pueblo Canyon just below the point of discharge of the effluent from the existing sewage treatment plant; a third group in Los Alamos Canyon just below the TA-21 area, and a fourth group in Pueblo Canyon as near as practicable to the point of discharge of the effluent from the TA-1 acid waste sewer. In the case of the fourth group, difficulty of access to the Canyon floor for moving in the drilling equipment, as well as the presence at the selected site of a lava flow, prompted a decision to locate this group at a point on the south rim of the canyon and on the east rim of the smaller tributary canyon from the south which carries the discharge from the acid waste sewer. Each of the other groups were located on the canyon floor.

Each group of test wells was planned to include a main test hole, drilled with a cable-tool rig, of the depth required to penetrate the main ground water body, and one or more offset sampling holes, each drilled into an aquifer lying above the main ground water body if such an aquifer were **found** in the drilling of the main test hole. Thus if only one aquifer were found above the main ground water

body in the drilling of a main test hole, only one sampling well offsetting the main hole would be required in that group.

During the drilling of the main test hole in each group samples of the drill cuttings were taken by a representative of the U. S. Geological Survey at 5-foot depth intervals, and the location of each aquifer was determined. The samples of drill cuttings were classified and the results recorded in the form of geologists logs, copies of which are attached to this report.

Under Contract No. AT(29-1)-708, the Layne-Western Company, well construction contractor of Kansas City, Missouri, began the work of constructing and equipping the test wells and sampling wells on June 1, 1949, and the entire work, including the installation of the pumping equipment, was completed on June 12, 1950. The Contractor, or his sub-contractor, furnished all drilling equipment, tools, drilling crews, well screens, casing packers, fuel, lubricants and drilling mud, as well as the pumps and motors installed in the completed wells. The Government furnished all steel pipe required for casing the wells and for installation of the pumping equipment. Upon completion of the drilling, each test well and each sampling well was cased throughout its length to prevent caving and to seal off the flow from any aquifers located above that which the well was designed to tap. A 10-foot length of bronze wire-wrapped well screen was installed at the bottom of the casing string in each well. A sketch showing the physical dimensions, details of the casing and screen installation, and the classifications of the principal formations penetrated, for each well, is attached hereto.

DETAILS OF WELL CONSTRUCTION. Test Well No. 1 and sampling

Well No. O.S. 1-A are located on the floor of Pueblo Canyon at a site approximately 100 feet north of the Bayo Canyon Road, and 2500 feet northwest of the junction of State Route No. 4 and the Los Alamos main access road. At this site, the Layne-Western No. 24-L drilling rig was moved onto location designated as TA No. 1-A on June 1, 1949, and drilling began on June 8. On July 14 the hole was abandoned at a depth of 108 feet, since the lower 32 feet was crooked and could not be straightened with the available tools. The drilling rig was then shifted to a new location six feet ^{south} ~~west~~ of the abandoned hole, the new location being designated as TH No. 1-B, where drilling began on July 19. On August 23, the drilling of this hole was stopped at a depth of 140 feet, since repeated attempts, including the firing of three dynamite charges, had failed to straighten it.

TH-1
On November 27 the Jenkins Drilling Company No. 36-L drilling rig was moved onto a location, designated as TH No. 1-C, approximately 20 ^{west} ~~south~~ feet of TH No. 1-B, where drilling began on November 29. A flow of water was encountered at depth 210 feet, estimated at 18 gallons per minute, which rose in the hole to depth 188 feet. Drilling continued in open hole to depth 350 feet, and 12-inch casing was set to that depth in an unsuccessful attempt to seal off the water produced from the formation at 210-240 feet. The casing was then pulled back to depth 241 feet, and the hole below that depth was filled with sand, preparatory to cementing the casing. The cementing operation was performed by the Halliburton Oil Well

Cementing Company, on December 17, and was successful in sealing off the flow of water into the well. One hundred bags of portland cement were used in this operation. Drilling then continued through the 12 inch casing to depth 642 feet. A flow of water was encountered at depth 623 feet, the water rising in the hole to depth 584.9 feet. On January 3, 1950, this test well was completed, with 627 feet of 8-inch casing, 10 feet of 6-inch casing and 10 feet of 6-inch well screen, bottomed at 642 feet, in the hole. The lead packer between the 6-inch and 8-inch casing is at depth 622 feet. The geologist's log headed "Test Well No. 1" and the sketch titled "Log-Well No. 1", Figure 2, both attached to this report, pertain to this location TH No. 1-C.

The sampling well, offsetting Test Well No. 1, is on the location referred to above as TH No. 1-B. On January 4, 1950, the Jenkins No. 36-L drilling rig was set up over the TH No. 1-B hole, which had previously been drilled to depth 140 feet. Drilling began on January 5, and continued to depth 225 feet. A flow of water was encountered at depth 212 feet, the water rising in the hole to depth 188 feet. Apparently this is the same water bearing formation as that encountered in TH No. 1 at depth 210 feet. On January 10 and 11, 214 feet of 6-inch casing, with a 10 foot length of 6-inch well screen coupled to its lower end was set in this well and bottomed at depth 225 feet. This sampling well is designated on the sketch (Figure 3) attached hereto as Well No. O.S. 1-A.

Test Well No. 2 is located on the floor of Pueblo Canyon approximately three miles upstream from Test Well No. 1, one mile upstream from the easterly Project boundary, and one mile downstream from the point at which the effluent from the Community sewage treatment plant is discharged into this canyon. On August 25, 1949, the Layne-Western No. 24L drilling rig was set up on this location. Drilling began on August 29 and continued to a depth of 789 feet which was reached on November 3. A small flow of water, estimated at four gallons per minute, was encountered at depth 115 feet, the water rising in the hole to depth 93 feet. The geologists log for this well indicates that a second water zone was encountered at depth 165-170 feet, from which water rose in the hole to depth 108 feet. (No mention of a water zone at this depth is made in the driller's log.) Two holes subsequently drilled as offsets to TH No. 2 encountered no water bearing zone at or near the 165-170 foot depth. The main ground water zone was encountered at depth 767 feet, the water rising in the hole to depth 758.9 feet. The main casing string in this test well consists of 778 feet of 8-inch steel pipe, with approximately five feet of 6-inch steel pipe and a 10-foot length of 6-inch well screen at its lower end. The well screen is bottomed at depth 789 feet, and the lead packer between the 6-inch and 8-inch casing is at depth 774.5 feet. (Figure 4)

Sampling Well A, offsetting Test Well No. 2, and designated on the attached sketch (Figure 5) as Well O.S. 2-A, is located 50 feet west of Test Well No. 2. The purpose of this well was to

penetrate the water bearing zone encountered at depth 165 feet in Test Well No. 2. On January 30, 1950, Jenkins No. 36-L drilling rig was moved onto the location. Drilling began on February 2, and continued until February 5, when a depth of 155 feet was reached. The upper water bearing zone was encountered at depth 112 feet, and a string of 8-inch casing was set to a depth of 152 feet in an unsuccessful attempt to seal off the flow of water. It was then decided to complete the well in the upper water bearing zone. The casing string was lifted to depth 118 feet, the hole filled to depth 133 feet, and a 10-foot length of 6-inch well screen made on a 10-foot length of 6-inch steel pipe was set through the 8-inch casing, with the screen bottomed at depth 132.75 feet. The lead packer between the 6-inch and 8-inch casing is at depth 113 feet. This well was completed on February 7. 2A

In a second attempt to complete a sampling well penetrating the water bearing zone encountered at depth 165 feet in Test Well No. 2, the Jenkins drilling rig was moved onto a location 50 feet southeast of Test Well No. 2. Drilling began at this location on February 9 and continued until February 14 when a depth of 225 feet was reached. The upper water bearing zone was encountered at depth 104 feet. A string of 8-inch casing was set to depth 123.5 feet, which shut off the flow from the upper zone. The drilling continued through the 8-inch casing to depth 225 feet, but no water was found below the upper zone. The hole was ordered abandoned, the casing was pulled out and the hole filled with sand.

In the third attempt to complete a sampling well penetrating the water bearing zone encountered at depth 165 feet in Test Well No. 2, the Jenkins drilling rig was moved to a location 36 feet northwest of Test Well No. 2. Drilling began at this location on February 17, and continued until February 23, when a depth of 225 feet was reached. The upper water bearing zone was encountered at depth 103 feet, and 126.5 feet of 8-inch casing was set in the hole which shut off the flow from this zone. Drilling continued through the 8-inch casing string to depth 225 feet, but, again, no water was found below the upper zone. The hole was ordered abandoned. An attempt was made to pull and salvage the 8-inch casing, without success. The casing was capped one foot above ground line, and left in the hole.

Test Well No. 3 is located on the floor of Los Alamos Canyon approximately, 3000 feet west (upstream) from the easterly Project boundary. On October 6, 1949, the Jenkins No. 36-L drilling rig was moved onto this location where drilling began on October 7. On October 23, at depth 362 feet the drill stem broke in the wrench square. Fishing for the tools in the hole began at 12 30 on that date and continued without success until 2400 on October 30, at which time it was decided to abandon the hole. The drilling rig was shifted to a new location 8 feet west of the abandoned hole, where drilling began on November 1, and continued until November 20, when a depth of 815 feet had been reached. No water was encountered above depth 790, where the main ground water

zone was reached; the water rising in the hole to depth 743.3. The main casing string in this well is of 10-inch steel pipe extending to depth 811 feet. A 10-foot length of well screen with a 10-foot length of 6-inch steel pipe made on its upper end was set at depth 815 feet with the lead seal between the 6-inch pipe and the 10-inch casing at depth 795 feet. No sampling well was drilled offsetting this Test Well, since no water bearing zone above the main ground water body was penetrated in the drilling of Test Well No. 3. (See Figure 6)

Test Well No. 4 is located in Los Alamos at a point 221 feet north of Canyon Road and 293 feet northeast of the sewage lift station at 2610 Canyon Road. This site is on the easterly rim of the branch canyon into which the effluent from the new waste treatment plant is discharged, and approximately 1100 feet south of the southerly rim of Pueblo Canyon. On November 5, 1949, the Layno-Western No. 24L drilling rig was moved onto this location. Drilling began on November 10, and continued until March 8, 1950, when a depth of 1205 feet was reached. Water was encountered in the hole at depth 1184 feet, the water rising to depth 1170.8 feet. The main casing string is 6-inch steel pipe, which was set at depth 1195 feet. A 10-foot length of 4-inch well screen, with an 11-foot length of 4-inch steel pipe made on its upper end, was set with its lower end at depth 1205 feet. The lead seal between the 4-inch pipe and the 6-inch casing is at depth 1183 feet. Since no water bearing zone was penetrated above the 1184 foot depth, no sampling well offsetting the main hole was drilled. (See Figure 7)

PUMPING EQUIPMENT. The four Test Wells and the two sampling wells constructed under this project were equipped with electric motor driven Roda submergible deep well type centrifugal pumps. These pumps and motors were manufactured by the Roda Pump Company of Bartlesville, Oklahoma. In this type of pumping unit the motor and pump, bolted together to form a single unit, are lowered into the cased well to the desired depth on the end of a 1-1/2 inch steel pipe column, which after the installation serves as the pump discharge column. The power cable, entering the motor through a water-tight sealed gland, extends to the motor control box at the well head, and is anchored to the discharge column by means of stainless steel bands spaced at 5-foot intervals. The motor is completely enclosed in a water tight steel housing; is of the capacitor type, 220-volt, single phase, 2-pole, 3450 RPM at full load. The motor is of squirrel cage construction. The starter is mechanically bonded to the housing. The motor operating switch is a centrifugal switch located at the bottom of the motor shaft, which disconnects the starting winding when the motor reaches operating speed. The motor is filled with transformer oil at the factory, and needs no further addition of oil. A conical check valve in the head of the pump closes when the pump stops and prevents draining of the pump discharge column. In each installation, a small snifter hole was drilled in the discharge column five feet below the ground line to permit the column above this point to drain to prevent freezing. The arrangement of discharge column at the well head is indicated on the attached sketch, (Fig. 8).

The following tabulation indicates, as to each well, the pump model number, size of motor, depth of setting from ground level to center of water inlet, the pump and motor serial numbers and the approximate pumping rate for the pumping equipment installed therein:

Well No.	Pump Mod.No.	Motor H.P.	Depth of Setting	Pump Serial No.	Motor Serial No.	Discharge Rate GPM
1	60A-11	3	637 ²	6528	5-1050	8
O.S.-1A	19A-5	5/8	218	4504715	4506244	4
2	90A-5	3	784	6526	5-1047	8
O.S.-2A	19A-5	5/8	128	4506282	4504634	9
3	90A-5	3	810 ³	6524	5-1048	8
4	90A-5	3	1179	6525	5-1049	3

Upon completion of installation each pump was operated for a sufficient length of time to ascertain that it had been properly installed and connected, both electrically and mechanically, and that it would deliver water at the well head.

Geologists Log

TEST HOLE NO. 1

Pueblo Canyon

SW $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 17, T. 19 N., R. 7 E.

Altitude: 6,371 feet

Top Concrete Base-Elev.-6371.74

	<u>Depth</u> (feet)	
	From	To
Alluvial cover		
Soil zone	0	1.5
Sand, fine to medium, and silt.		
<p>The grains are angular to sub-angular. Materials are quartz, sanidine, and Bandelier tuff. A few small fragments of sub-angular to sub-rounded pumice are present.</p>		
Valley fill	1.5	50
Sand and gravel, with silty clay.		
<p>Sand and gravel composed of varying amounts of medium to coarse sand and medium gravel. In general sand is more abundant than gravel. The sand is composed of angular to sub-angular fragments of quartz, sanidine, and andesite and dacite derived from Chicoma volcanic rocks. Some of the sub-angular grains of quartz and sanidine show worn surfaces. The gravel consists of angular to almost sub-rounded fragments of welded Bandelier tuff, light gray, dense rhyolite, and Chicoma volcanic rocks, with the Chicoma rocks predominant. Pumice is present in very small amounts. Silty clay is present throughout the zone.</p>		

Test Hole No. 1 -- Continued

	<u>Depth</u> (feet)	
	From	To
White Rock Canyon basalt		
Upper flow or flows	50	173
<p>Very dark gray to black fine-grained basalt containing a few small phenocrysts of olivine. The basalt consists of alternate vesicular and non-vesicular zones as follows:</p> <p>50- 58 Vesicular basalt with oxidized fragments, and silty clay at top.</p> <p>58- 77 Non-vesicular, jointed basalt.</p> <p>77- 98 Vesicular basalt with red, silty clay-filled vesicles. Some oxidized fragments.</p> <p>98-117 Non-vesicular, jointed basalt.</p> <p>117-126 Vesicular basalt with red, silty clay-filling vesicles.</p> <p>126-138 Non-vesicular, jointed basalt.</p> <p>138-173 Vesicular basalt with red, silty clay-filling vesicles; large fragments of oxidized basalt also are present.</p> <p>It is possible that this sequence represents a series of three thin flows.</p>		
Interflow zone	173	176±
<p>This zone consists of angular fragments of vesicular and oxidized basalt; pinkish buff, silty clay; and a few small sub-angular to sub-rounded fragments of andesite and dacite derived from Chicoma volcanic rocks.</p>		
Middle flow	176±	210
<p>Medium gray to dark gray, fine-grained basalt which appears to contain a larger proportion of feldspar and olivine than the upper flow zone. The upper 4 feet of the flow is vesicular, the central part non-vesicular, and the lower 5 feet vesicular.</p>		

Test Hole No. 1 --Continued

	<u>Depth</u> (feet)	
	From	To
Interflow zone	210	215

This zone consists of angular fragments of basalt, and a little silty clay.

A perched water zone was encountered at 212 feet and the water rose to 184.90 feet below ground surface. The hole was bailed at the rate of 45 gallons per minute for 15 minutes and a drawdown of 15 feet resulted. Thirty minutes were required for a recovery of 14 feet and in 33 minutes the water stood at the same level as before bailing.

Lower flow	215	255
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This basalt appears to be identical with the middle flow rock but possibly contains more olivine. The top 7 feet is vesicular, the central part non-vesicular, and the lower 13 feet is vesicular and slightly reddened by oxidation.

Puye gravel

Gravel zone	255	410
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Sand and gravel; and clay, laminated.

Sand and gravel ranging from medium to coarse sand and fine to medium gravel. The zone is predominately angular to sub-rounded sand which is composed of quartz, quartzite, basalt, Chicoma rock, gray, dense rhyolite, gray, glassy rhyolite, and a trace of yellowish chalcedonic silica. Chicoma rocks predominate. The angular to sub-rounded gravel is composed chiefly of Chicoma rocks, basalt, and quartzite, but small amounts of gray, dense rhyolite, and pink rhyolite (?) are gravel size. Large amounts of clay are present at the following depths: 320 to 355 feet, 388 to 400 feet, and 405 to 415 feet. From 340 to 348, and 390 to 395 feet all clay is finely laminated and free of silt and sand.

Depth
(feet)
From To

White Rock Canyon basalt (?)

Indefinite zone 410 510

Black, very finely vesicular basalt, moderately rich in olivine, and containing a few tiny phenocrysts of plagioclase. Also present in small amounts are small sub-rounded to rounded pebbles of andesite and dacite derived from Chicoma volcanic rocks; and gray, dense rhyolite. It is believed that this zone represents a basalt flow or flows that incorporated some alluvial materials from the underlying Puyo gravel. One fragment of basalt was observed which contained a pebble of Chicoma andesite. The zone contains abundant thinly laminated, plastic clay between the following depths: 440 to 445 feet and 458 to 477 feet. This clay is buff colored and is free from sand and silt. It is not known if this clay represents interflow deposition or material incorporated in advancing basalt.

Puyo gravel

Gravel with some sand 510 605

The gravel is sub-angular to sub-rounded and is composed chiefly of Chicoma volcanic rocks that range up to 3/4-inch in diameter. Also present in small amounts are quartz; gray, dense rhyolite; gray, glassy rhyolite; and white, pumiceous glass (?). The zone apparently contains a little finely vesicular basalt at the top but this may be caving. The sand grains are angular to almost sub-round and range from medium to coarse and are composed of quartz, Chicoma rocks, gray dense rhyolite, gray glassy rhyolite, and white pumiceous glass (?).

255

605

Test Hole No. 1 - Continued

	<u>Depth</u> (feet)	
	From	To
Gravel and clay; some sand	605	642 (Bottom)

The gravel is sub-angular to sub-rounded and ranges up to 2 inches in diameter and is composed largely of Chicoma volcanic rocks. There is some quartzite; granite; gray dense rhyolite; and volcanic rocks foreign to the area. Clay is abundant and is grayish pink, in part silty, and contains soft, white material and flakes of biotite. It resembles the clay in the Santa Fe formation. The sub-angular to sub-rounded sand grains range from medium to coarse and are composed chiefly of quartz. Ground water was encountered at 623 feet and the water rose to 584.90 feet below ground surface. The hole was bailed at the rate of 15 gallons per minute for 30 minutes and a drawdown of 20 feet resulted, according to the driller. The time required for recovery was not observed.

Casing record:

- 16-inch ID casing set at 51 feet 8 inches.
- 12-inch ID casing with 13 7/8-inch drive shoe set at 241 feet.
- 8-inch ID casing was run to 627 feet.
- 10 feet of 6-inch Layne scree, with 10 feet of 6-inch ID casing, on top end, was set at 642 feet.
- Screen assembly extends up into 8-inch ID casing (to 622 feet below LSD - lower end of screen at 642 feet).

Total depth of hole 642 feet.

Geologists Log

TEST HOLE NO. 2

Pueblo Canyon

NW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 14, T. 19 N., R. 6 E.

Altitude: 6,646.4 feet

Top Concrete Base - Elev. 6647.63

Drilled by Layno-Western Co., Aug. 29-Nov. 4, 1949

	<u>Depth</u> (feet)	
	From	To
Alluvial cover		
Soil zone	0	1.5
<p>Sand, fine to medium, and silt. Grains are angular to sub-angular. Materials are quartz, sanidine, and Bandelier tuff. A few rounded pieces of pale pinkish-white pumice are present.</p>		
Valley fill.	1.5	11
<p>Sand and gravel. Sizes range from coarse sand to medium gravel. The sand is composed of angular to sub-angular grains of quartz and sanidine. Quartzoids are rare. The gravel is composed of angular fragments of welded Bandelier tuff, rhyolite, and Chicoma volcanic rocks.</p>		
Bandelier tuff		
Tent Rock member (?)	11	35
<p>Pumiceous tuff. Angular to sub-angular fragments of pumice ranging up to 3/4 inch in diameter embedded in light gray ashy tuff. The pumice is light gray to pale pinkish gray, silky, and carries phenocrysts of quartz and sanidine (?). From 30 to 35 feet are found a few fragments of light gray, dense rhyolite.</p>		
Santa Clara pumice member (?)	35	63
<p>Angular fragments of light gray to white pumice ranging up to 1/2 inch across, compose 80% of the zone. This pumice contains numerous phenocrysts of quartz (some of which are quartzoids). Other materials present are angular fragments of rhyolite and similar fragments of Chicoma volcanic rocks that range up to 1/4 inch across.</p>		

Test Hole No. 2 - Continued

	<u>Depth</u> (feet)	
	From	To
Puye gravel zone		
Upper gravel zone		
Gravel with some sand	63	103

The gravel, ranging to about 2 inches in diameter, is sub-angular to sub-rounded. It is composed chiefly of andesite and dacite derived from Chicoma volcanic rocks. Other materials present are light gray to pinkish gray, dense rhyolite and a little pumice which may be caving from other levels. The sand grains are angular to sub-angular and are composed of the same materials as the gravel. Also present, possibly in thin streaks, is a little clay.

Silty clay with some sand and gravel	103	110
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The zone is largely pinkish buff, silty clay which contains tiny areas of white powdery material, small flakes of biotite, and pieces of fine gravel. This clay is very plastic when wet. The gravel is sub-angular to sub-rounded and ranges up to 1/2 inch in diameter. It is composed chiefly of andesite and dacite derived from Chicoma rocks. Light gray, dense rhyolite is also present in small amounts. The sand present is composed of quartz and derivatives of Chicoma rocks. It is angular to sub-angular and ranges from medium to very coarse.

Gravel with some sand	110	125
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The gravel, ranging up to about 2-1/2 inches in diameter, is sub-angular to sub-rounded. It is composed chiefly of andesite and dacite derived from Chicoma volcanic rocks. Light gray, dense rhyolite and finely cellular, white pumice are present in small amounts. Silty clay is also present in very small amounts.

Perched water zone encountered between 112 and 115 feet. Water rose to 92.70 feet below ground surface. This zone apparently yielded approximately 4 gallons per minute per foot of drawdown (by bailing).

Test Hole No. 2 - Continued

	<u>Depth</u> (feet)
	From To
Sandy, silty clay with gravel	125 146

The clay in this zone is pinkish buff, sandy to silty and contains some fine gravel is sub-angular to sub-rounded and ranges up to 1/4 inch in diameter. It is composed chiefly of andesite and dacite derived from Chicoma volcanic rocks. Traces of light gray, dense rhyolite and white, finely cellular pumice are present. A thin zone of gravel and sand, with gravel predominating, occurs between 135 and 141 feet. This material is also composed of Chicoma volcanic rocks.

Gravel with a little sand; with clayey zones	146 335
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The sub-angular to sub-rounded gravel is essentially all derived from Chicoma volcanic rocks. There are only traces of light gray to pinkish-gray, dense rhyolite and gray, glassy rhyolite. Gravel sizes range up to 1/2 inch in diameter. The sand is composed of angular to sub-angular grains of quartz and Chicoma rocks. It ranges from medium to coarse. The zone is noticeably clayey between the following depths: 155 to 165, 175 to 180, and 195 to 200 feet, and the entire zone is apparently clayey. A zone of large, sub-rounded pebbles is present between 215 and 220 feet.

Encountered perched water zone between 165 and 170 feet. Water rose to 108.10 feet below ground surface.

Sand with a little gravel	335 340
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The sand ranges from fine to medium with the grains predominately angular but ranging to sub-angular. It is composed of quartz, Chicoma materials, and some gray, glassy rhyolite. The gravel is composed of sub-angular to sub-rounded pieces of Chicoma rocks that range to 1/2 inch in diameter.

Test Hole No. 2 - Continued

	<u>Depth</u> (feet)	
	From	To
Gravel with some sand; clayey zones	340	380
Same as 146 to 335 feet. Possibly a slight increase in amount of gray, glassy rhyolite.		
 Pumice zone		
Gravel with some sand . . . ,	380	700
Most of the gravel is less than 1/2 inch in diameter and ranges from angular to sub-angular. The gravel aggregate is composed chiefly of pumice and Chicoma volcanic rocks with the ratio of pumice to Chicoma materials varying through the zone. In general, the pumice is more abundant than the Chicoma rocks; however, Chicoma rocks equal or exceed the pumice at the following depths: 380 to 390, 475 to 500, 540 to 555, 585 to 598, 630 to 658, and 690 to 700 feet. The pumice in this zone ranges from white through light gray to pale pinkish-buff. It varies from a very finely cellular pumice to a dense, pumiceous glass. Phenocrysts of biotite, quartz, and glassy feldspar (at least some of which is plagioclase) are present but rare. Also present in small amounts are gray, dense rhyolite; gray, glassy rhyolite; and traces of pale gray, perlitic glass. The angular to sub-angular sand grains range from fine to coarse and consist of quartz and pumice.		
 Lower gravel zone (Lowermilk type gravel)		
Sand with gravel	700	789(bottom)
The sand, pinkish gray to grayish pink, ranges from fine to coarse and the grains are sub-angular to sub-rounded. The materials composing the sand are quartz, colorless to pinkish feldspar, and chalcedonic silica. The gravel ranges up to 2-1/2 inches in diameter and consists of sub-rounded to rounded pieces of quartz, quartzite, granite pegmatite, feldspar, and volcanic rocks. The volcanic rocks are rhyolitic to basaltic. Some clay is present through the zone and is most abundant		

Test Hole No. 2 - Continued

Depth
(feet)

From To

between 700 and 712 feet. Chicoma volcanic fragments are very rare. Ground water was encountered between 765 and 770 feet, and the water rose to 758.90 feet below ground surface. When the hole was bailed at the rate of 12 gallons per minute any drawdown that resulted could not be measured, according to the driller.

Casing record:

16" ID casing set at 57 feet.
12" ID casing first set at 141 feet but followed down hole
and finally set at 197 feet.
10" ID casing set at 519 feet.
8" set at 778 feet.
10' of 6" screen set at 789 feet.
Hole blew air at 270, 280, and 435 feet.

Geologist's Log

TEST HOLE NO. 3

Los Alamos Canyon

SE $\frac{1}{2}$ SW $\frac{1}{4}$ Sec.13, T. 19N., R. 6 E.

Altitude: 6,625 feet

Top Concrete Base - Elev. 6625.31

	<u>Depth</u> (feet)	
	From	To
Alluvial cover		
Soil zone	0	1.5
Sand, fine to medium and silt		
Grains are angular to sub-angular. Materials are quartz, sanidine, and Bandelier tuff. A few small fragments of sub-rounded to rounded, pale pinkish-white pumice are present.		
Valley fill	1.5	37±
Sand and gravel		
Sand and gravel composed of equal amounts of medium to coarse sand and medium gravel. The sand is composed of angular to sub-angular fragments of quartz and sanidine. Gravel consists of angular to sub-angular fragments of welded Bandelier tuff, light gray, dense rhyolite, and Chicoma volcanic rocks. A little silt is present through the zone.		
Bandelier tuff (?)		
Tent Rock member (?)	37±	175
Pumiceous tuff with fragments of volcanic rock		
Poorly consolidated, pinkish buff and gray tuffaceous material composed of quartz, sanidine, pumice, and ash. The materials present are chiefly angular fragments. The pumice varies from white to pale pinkish buff, and consists of fragments ranging up to 1/4 inch across. It varies from cellular, silky pumice to a pumiceous glass and carries phenocrysts of quartz (some of which are quartzoids),		

Test Hole No. 3 - Continued

	<u>Depth</u> (feet)	
	From	To
<p>and sanidine (?). The fragments of volcanic rock are chiefly andesite and dacite derived from Chicoma rocks, but small fragments of rhyolite also are present. This zone contains some fragments showing worn surfaces and it is possible that the material was at least in part deposited in water.</p>		
Gravel zone		
Gravel and some sand; with subordinate amounts of clay	175	266
<p>The sub-angular to sub-rounded gravel is essentially all derived from Chicoma volcanic rocks and ranges in size up to 1 inch in diameter. There are only traces of pumiceous glass; gray, dense rhyolite; and gray, glassy rhyolite. The sand, ranging from fine to coarse, is angular to sub-angular and is composed of the same materials as the gravel. The zone is noticeably clayey between the following depths: 190 to 197, 210 to 215, and 225 to 239 feet. The clay is brick red, very plastic when wet, and apparently occurs in thin beds.</p>		
White Rock Canyon basalt		
Basalt (upper flow)	266	327
<p>Very dark gray to black, fine-grained basalt containing a few tiny phenocrysts of olivine (?). The upper 6 feet of the flow is vesicular, the central part is non-vesicular and the lower 25 feet is highly vesicular and slightly reddened by oxidation.</p>		
Interflow zone	327	332
<p>This zone consists of angular fragments of vesicular and oxidized basalt, sub-rounded pebbles of andesite, and some clay.</p>		

Test Hole No. 3 - Continued

	<u>Depth</u> (feet)	
	From	To
Andesitic (?) basalt (lower flow)	332	388

Medium gray to medium dark gray, fine grained andesitic (?) basalt which appears to contain a high proportion of feldspar. This basalt is slightly coarser grained than the upper flow. The upper 11 feet of the flow is vesicular and reddened by oxidation, the central part is non-vesicular, and the lower 4 feet is vesicular and slightly reddened by oxidation.

Puyo gravel

Upper Gravel zone

<i>Conglomerate, sandy to slightly coarse, gray.</i>	142	
Gravel and sand; with some clay	388	530

The angular to sub-angular gravel ranges up to 1 inch in diameter and is composed chiefly of andesite and dacite ~~derived from Chicoma volcanic rocks.~~ Other materials present are light gray, dense rhyolite; gray glassy rhyolite; and a trace of pumiceous glass (?). The sand, medium to coarse, is composed of angular to sub-angular fragments of quartz, and the same materials as compose the gravel. ~~The gravel and sand immediately underlying the andesitic (?) basalt flow is brick red. The entire zone is slightly clayey.~~

Pumice zone

Gravel with some sand	530	620
---------------------------------	-----	-----

The gravel ranges from angular to sub-angular and most fragments are less than 1 inch in diameter. The materials composing the gravel are chiefly pumice and fragments of Chicoma volcanic rocks with the ratio of pumice to Chicoma fragments varying through the zone. In general, the pumice is more abundant than Chicoma fragments, but from 525 to 555 feet the Chicoma fragments equal or exceed the pumice. The pumice in this zone ranges from white through light gray to pale pinkish buff. It varies from a very finely cellular

Test Hole No. 3 - Continued

Depth
(feet)
From To

pumice to a pumiceous glass. Phenocrysts of quartz, and glassy feldspar (at least some of which is plagioclase) are rare. Also present in small amounts are gray dense rhyolite; gray glassy rhyolite; and traces of pale gray porlitic glass. The sand grains are angular to sub-angular, range from fine to coarse and consist of quartz, pumice, and Chicoma materials. The zone is very clayey between 595 and 612 feet.

Lower gravel zone (Lowdormilk type gravel)

Sand and gravel; clay, pink. 620 815 (bottom)

The sand is pinkish gray to grayish pink and ranges from fine to coarse and the grains are sub-angular to sub-rounded. The materials composing the sand are chiefly quartz, and colorless to pinkish feldspar. Some pink chalcedonic silica and volcanic rock fragments are also present. The gravel ranges up to 3 inches in diameter and consists chiefly of sub-rounded to rounded pieces of quartz, quartzite, granite pegmatite, feldspar, and volcanic rocks. The volcanic rocks are rhyolitic to basaltic with dark colors predominating. Chicoma rocks are rare. Some clay is present through the zone. At the top of the zone a few fragments of finely cellular, dense pumice are present. This material may be caving.

Encountered ground water at 790 feet and the water rose to 743.30 feet below the ground surface. The hole was bailed at the rate of 22 gallons per minute for 25 minutes with an apparent drawdown of 7 feet. Ten minutes were required for recover, according to the driller.

Casing records:

- 16-inch OD surface casing was set at 32 feet 10 inches.
- 10-inch ID casing was run to 811 feet.
- 10 feet of 6-inch Layne screen with 10 feet of 6-inch ID casing on top end was set at 815 feet. Screen assembly extends up into 10-inch ID casing to 795 feet below LSD. (Lower end of screen set at 815 feet)
- Total depth of hole 815 feet.

Geologist's Log

TEST HOLE NO. 4

Canyon Road

SE $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 9, T. 19 N., R. 6 E.

Altitude: 7,243 feet

Top Concrete Base - Elev. 7244.56

Drilled by Layne-Western Co.,

	<u>Depth</u> (feet)	
	From	To
Bandelier tuff		
Pinkish orange and gray tuff.	0	258
<p>Poorly consolidated tuff containing phenocrysts of quartz, sanidine, and hornblende (?). This tuff contains some gray and brown, very cellular pumice. Other materials present in traces are gray rhyolite containing phenocrysts of quartz, biotite, and hornblende; and minute fragments of dark gray, fine-grained rock which is possibly derived from the Chicoma.</p>		
Slightly pumiceous tuff.	258	285
<p>Slightly pumiceous, buff colored tuff containing numerous fragments of Chicoma rocks and some fragments of light gray rhyolite. The light gray to pale pinkish white pumice is finely cellular, and contains phenocrysts of quartz, sanidine, and biotite (?).</p>		
Pumiceous tuff.	285	368
<p>Pinkish buff pumiceous tuff containing some angular fragments of Chicoma rocks and rhyolite ranging up to 1/2 inch across. Between 330 and 340 feet, Chicoma fragments are abundant. The light gray to pale pinkish pumice is finely cellular and contains phenocrysts of quartz, sanidine, and biotite. The fragments of pumice range up to 1/4 inch across. Other materials present in traces are obsidian, perlitic glass, and pumiceous glass.</p>		

Test Hole No. 4 - Continued

	<u>Depth</u> (feet)	
	From	To
Pumice Zone	368	395

The zone is composed of light gray to almost white, finely cellular, silky pumice which contains numerous phenocrysts of quartz and sanidine.

Chicama volcanic formation

Dacite flows and flow breccia	395	805
---	-----	-----

Dull lavender-gray dacite porphyry containing phenocrysts of plagioclase, quartz, biotite, and hornblende. The plagioclase occurs both as dull, porcelainous and glassy phenocrysts. Some of these phenocrysts are 1/2 inch long. The quartz occurs as small sub-rounded phenocrysts which range to almost 1/4 inch long. The biotite and hornblende phenocrysts are oxidized to a brownish bronze color. The ground mass of this rock is extremely fine grained. Individual flows cannot be differentiated.

Dacite flows and flow breccia	805	1184
---	-----	------

Reddish brown dacite porphyry containing phenocrysts of plagioclase, quartz, biotite, and hornblende which compose about 25 percent of the total mass. Most of the plagioclase phenocrysts are glassy but some have a dull, porcelainous luster. The phenocrysts range up to 1/2 inch and are more numerous than in the preceding series of flows. The quartz occurs as small, sub-rounded phenocrysts which range to almost 1/4 inch across. The hornblende and biotite are somewhat oxidized and have a brownish tint. The ground mass of this rock has a slight granular appearance. Individual flows cannot be differentiated.

Test Hole No. 4 - Continued

	<u>Depth</u> (feet)	
	From	To
Dacitic sand and gravel or tuff breccia	1184	1195±

The zone is composed of angular fragments of reddish brown dacite ranging in size from very fine sand to fine gravel. This zone is unconsolidated and the water present caused the material to heave 5 to 10 feet up into the hole.

Ground water was encountered at 1184 feet and the water rose to 1170.8 feet below ground surface. The hole was bailed at the rate of 8 gallons per minute for 35 minutes. A drawdown of 2 feet resulted and 5 minutes were required for recovery, according to the driller.

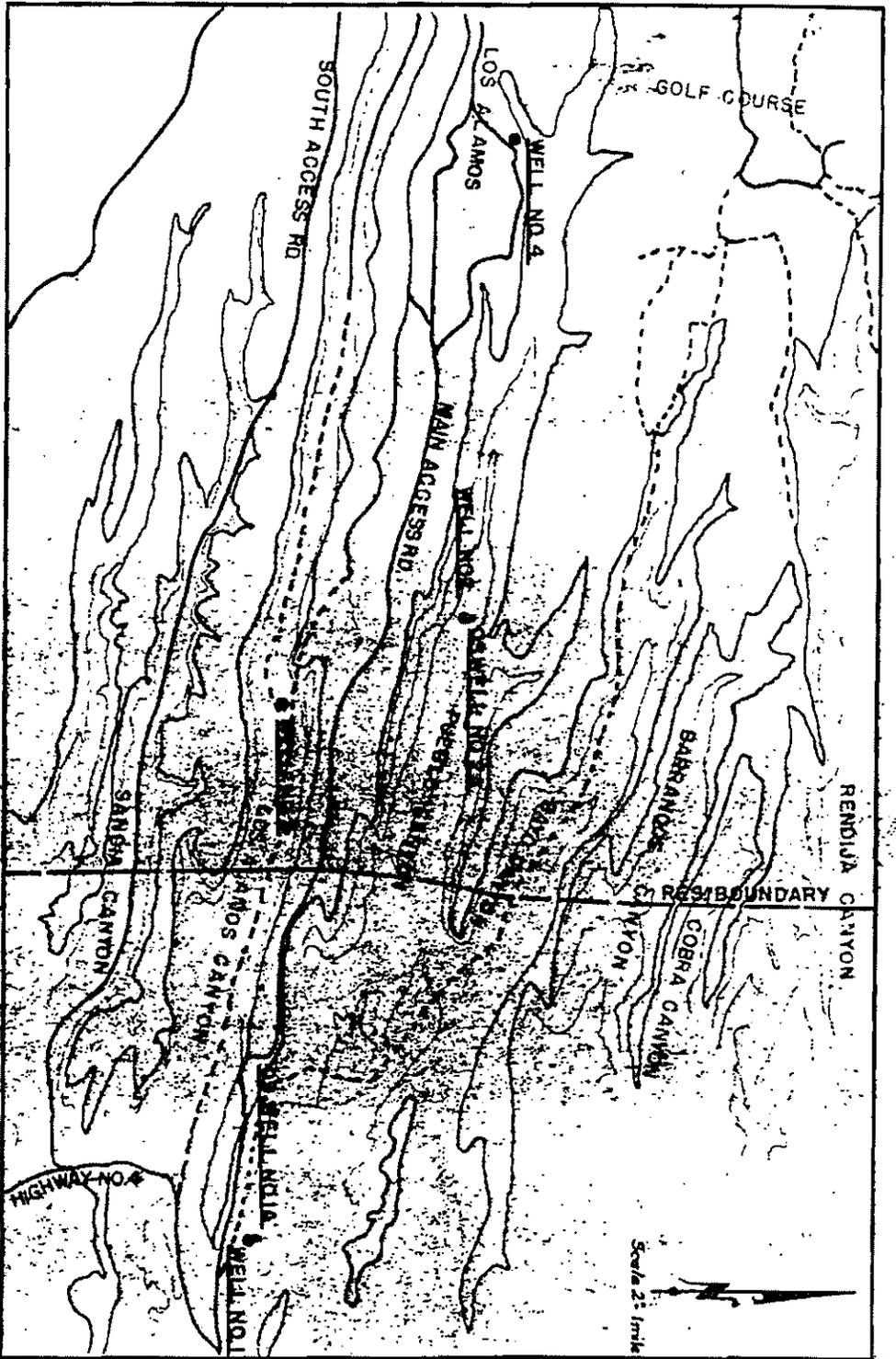
Dacite flows and flow breccia	1195±	1205(bot- tom)
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Same as 805 to 1184 feet.

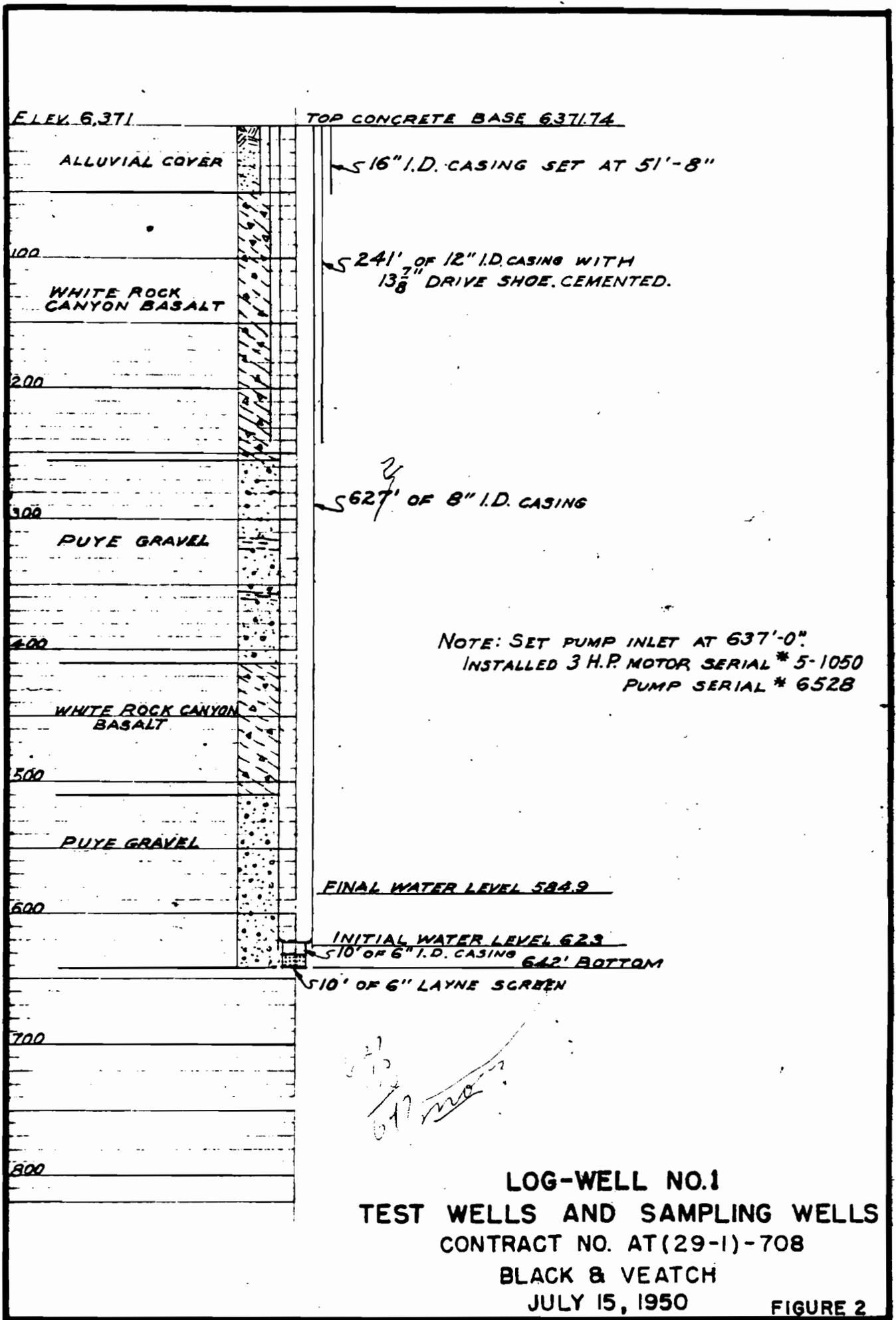
Casing record:

- 16-inch OD surface casing set at 109 feet.
- 12-inch ID casing with a 13 7/8-inch drive shoe on bottom end was run to 288 feet.
- 10-inch ID casing with a 11 1/2-inch drive shoe on bottom end was run to 1,195 feet.
- 6-inch ID casing was run to 1,195 feet.
- 10 feet of 4-inch Layne screen, with 11 feet of 4-inch ID casing on top end, was set at 1,205 feet. Screen assembly extends up into 6-inch ID casing to 1,184 feet below LSD. (Lower end of screen set at 1,205 feet).

Total depth of hole 1,205 feet.



LOCATION MAP
 TEST WELLS AND SAMPLING WELLS
 CONTRACT NO. AT (29-JI-708
 BLACK & VEATCH
 JULY 15, 1950
 FIGURE 1



ELEV. 6,371

TOP CONCRETE BASE 6371.74

ALLUVIAL COVER

5 16" I.D. CASING SET AT 51'-8"

100

WHITE ROCK CANYON BASALT

5 241' OF 12" I.D. CASING WITH 13 7/8" DRIVE SHOE. CEMENTED.

200

300

PUYE GRAVEL

2
5 627' OF 8" I.D. CASING

400

WHITE ROCK CANYON BASALT

NOTE: SET PUMP INLET AT 637'-0"
INSTALLED 3 H.P. MOTOR SERIAL * 5-1050
PUMP SERIAL * 6528

500

PUYE GRAVEL

FINAL WATER LEVEL 584.9

600

INITIAL WATER LEVEL 623

5 10' OF 6" I.D. CASING 642' BOTTOM

5 10' OF 6" LAYNE SCREEN

700

800

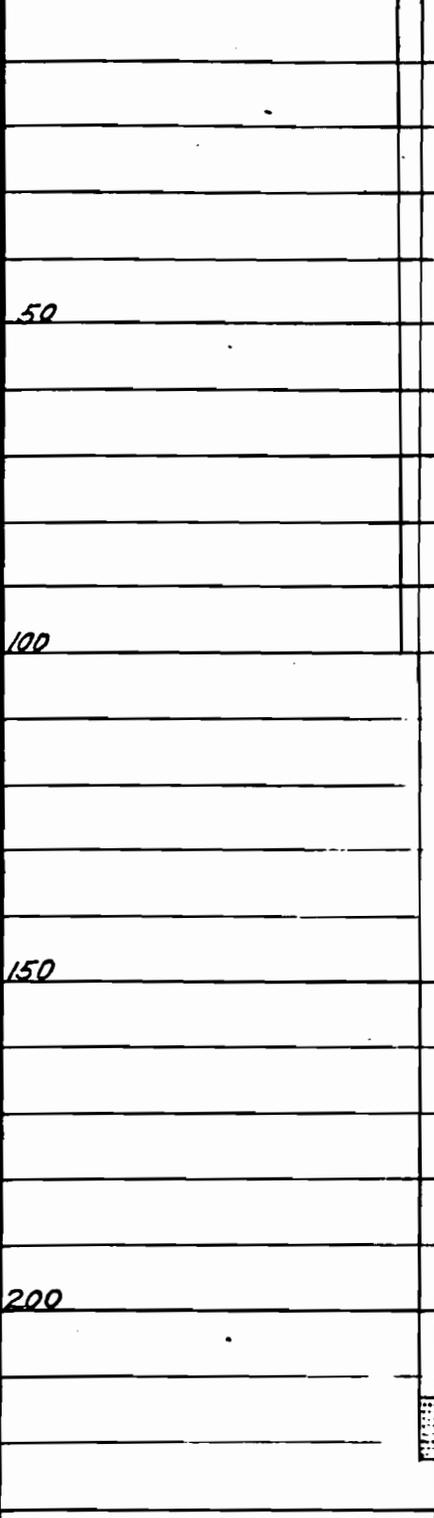
Handwritten notes:
617 mo

LOG-WELL NO. 1
TEST WELLS AND SAMPLING WELLS
CONTRACT NO. AT(29-1)-708
BLACK & VEATCH
JULY 15, 1950

FIGURE 2

ELEV. 6.371.00

TOP OF CONCRETE BASE 6371.77



50

← 100' OF 12" CASING

100

← 214' OF 6" CASING

150

NOTE: SET PUMP INLET AT 218'-1".
INSTALLED $\frac{5}{8}$ H.P. MOTOR SERIAL # 4506244
PUMP SERIAL # 4504715

200

188' FINIAL WATER LEVEL

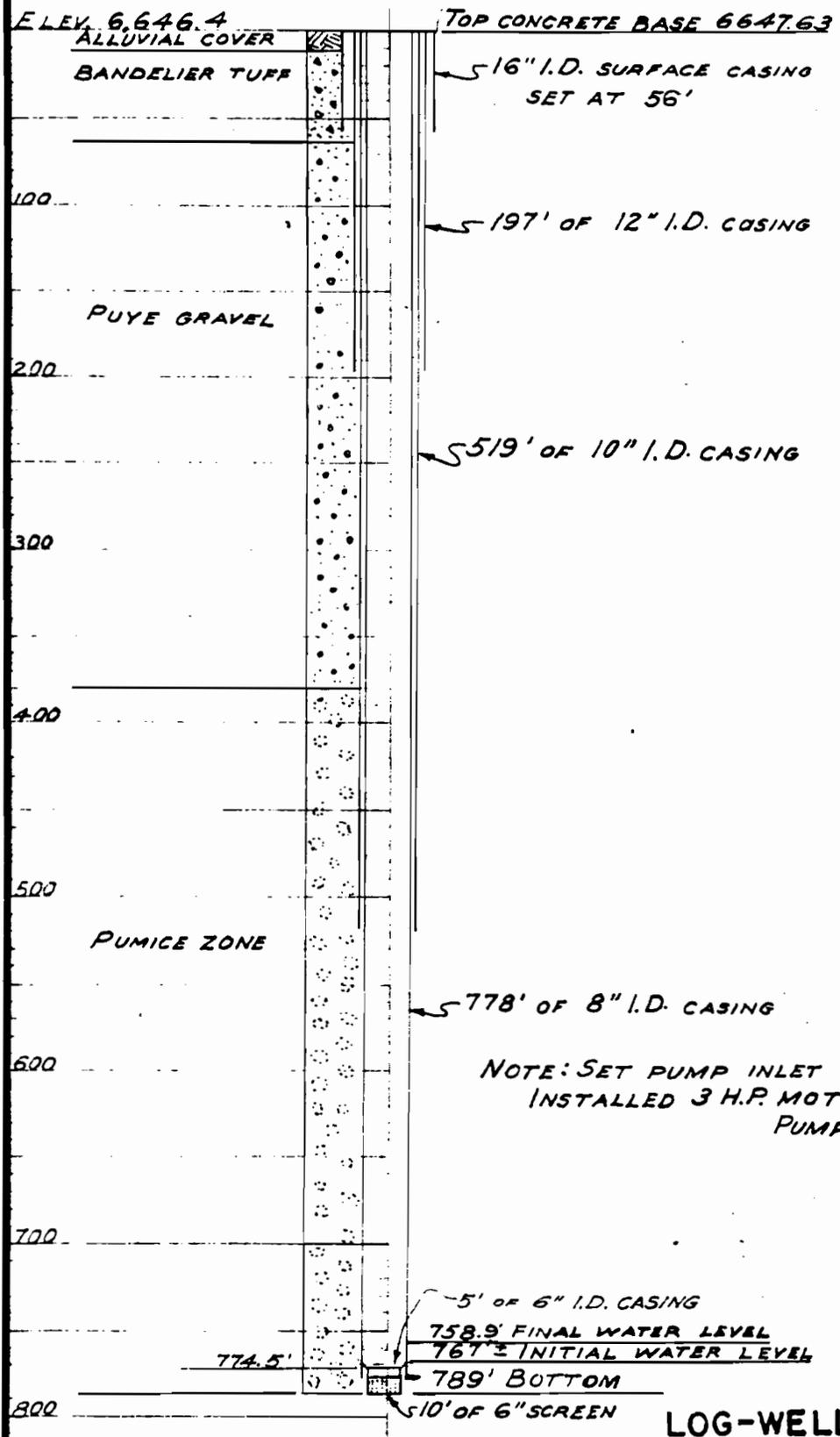
212' INITIAL WATER LEVEL

225' BOTTOM

← 10' OF 6" SCREEN

LOG-WELL NO. O.S. IA.
TEST WELLS AND SAMPLING WELLS
CONTRACT NO. AT(29-1)-708
BLACK & VEATCH
JULY 15, 1950

FIGURE 3



LOG-WELL NO. 2
 TEST WELLS AND SAMPLING WELLS
 CONTRACT NO. AT(29-1)-708
 BLACK & VEATCH
 JULY 15, 1950 FIGURE 4

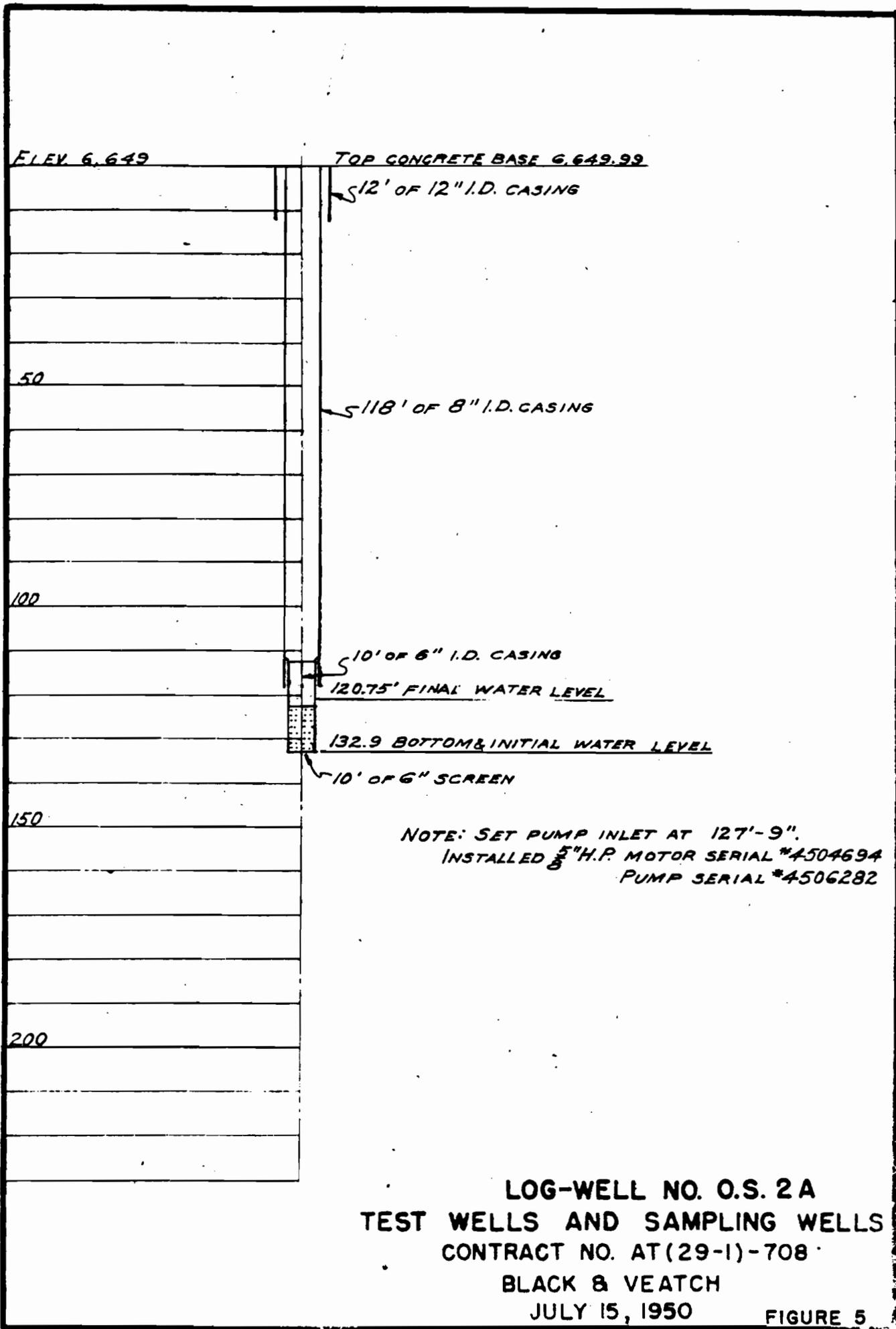
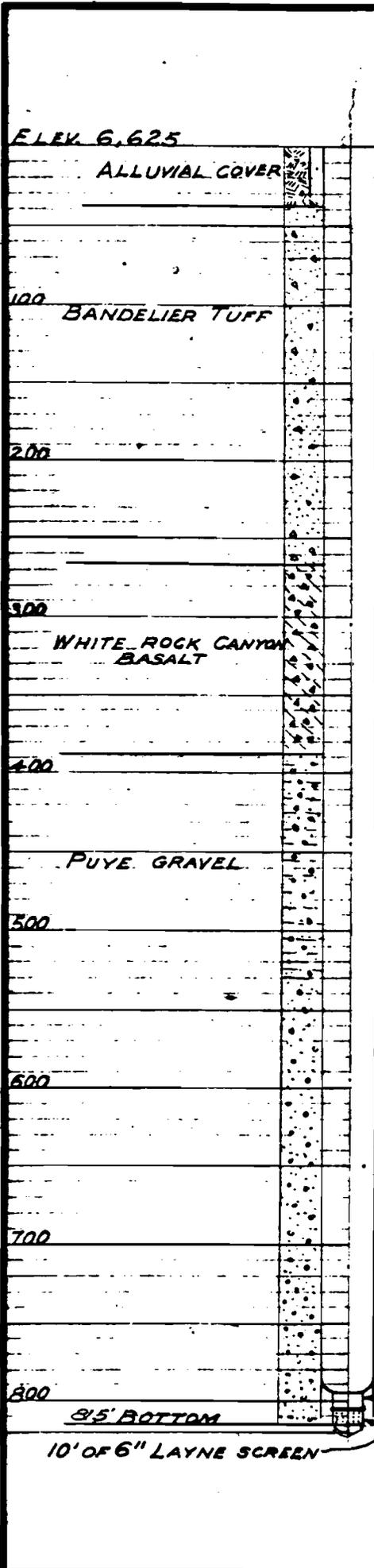


FIGURE 5



ELEV. 6,625

ALLUVIAL COVER

100

BANDELIER TUFF

200

300

WHITE ROCK CANYON
BASALT

400

PUYE GRAVEL

500

600

700

800

8'5" BOTTOM

10' OF 6" LAYNE SCREEN

TOP CONCRETE BASE

ELEV. 6,625.31

16" O.D. SURFACE CASING
SET AT 32.83'

581' OF 10" I.D. CASING

NOTE: SET PUMP INLET AT 810'
INSTALLED 3 H.P. MOTOR SERIAL #5-1048
PUMP SERIAL #6524

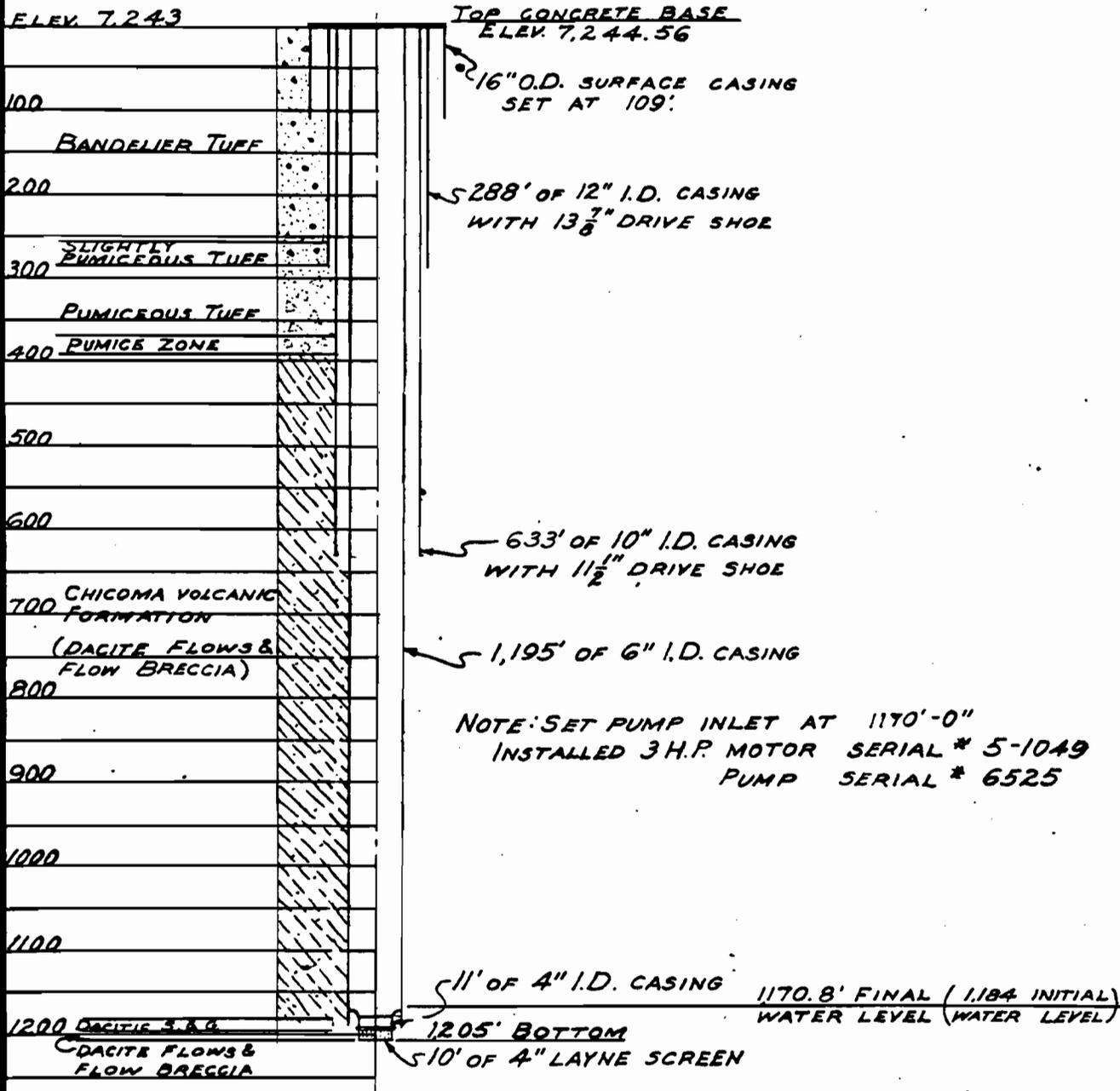
743.3' FINAL WATER LEVEL

10' OF 6" I.D. CASING

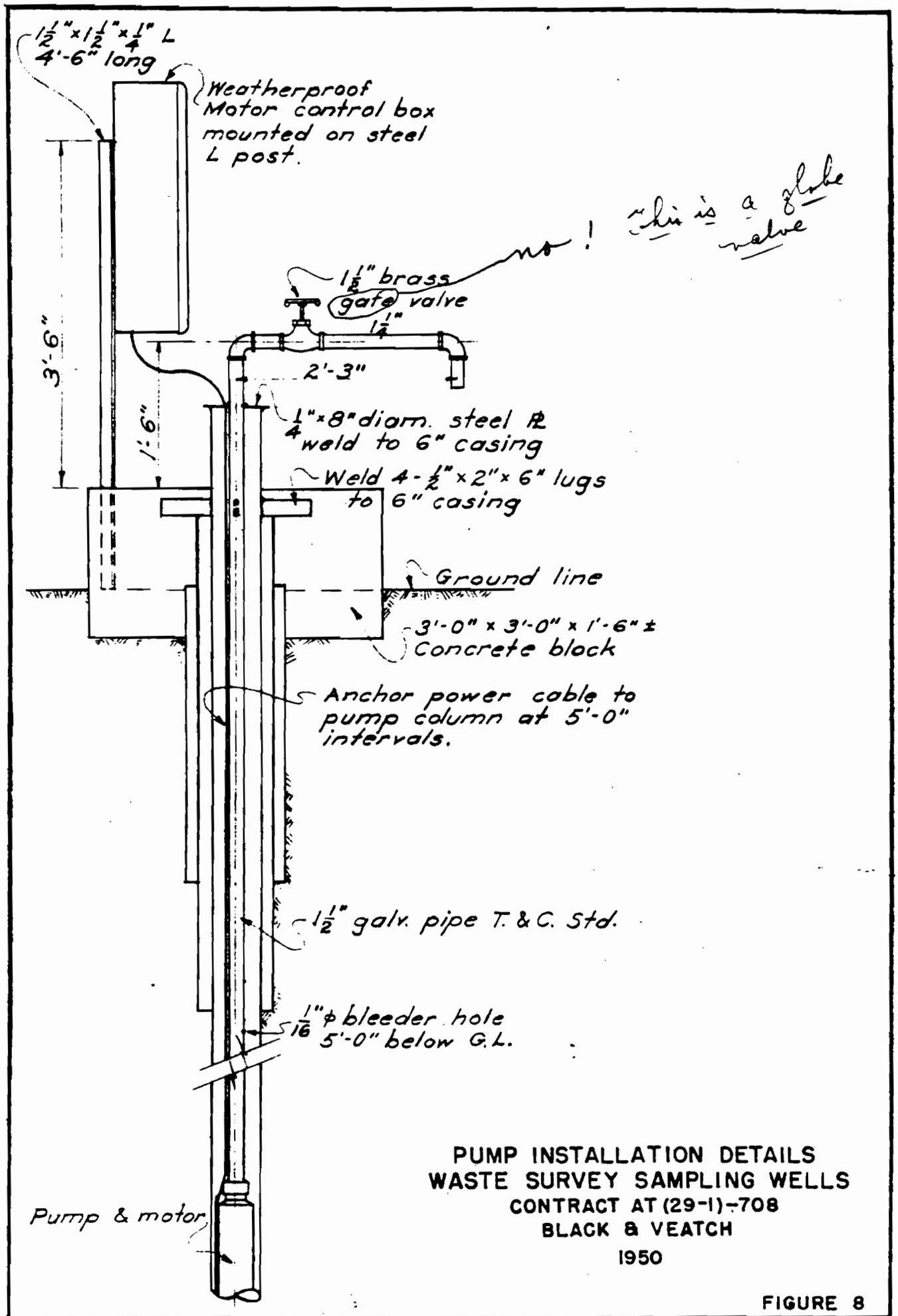
790' INITIAL WATER LEVEL

LOG-WELL NO. 3
TEST WELLS AND SAMPLING WELLS
CONTRACT NO. AT(29-1)-708
BLACK & VEATCH
JULY 15, 1950

FIGURE 6



LOG-WELL NO. 4
TEST WELLS AND SAMPLING WELLS
 CONTRACT NO. AT(29-1)-708
 BLACK & VEATCH
 JULY 15, 1950 FIGURE 7



PUMP INSTALLATION DETAILS
 WASTE SURVEY SAMPLING WELLS
 CONTRACT AT (29-1)-708
 BLACK & VEATCH
 1950

FIGURE 8