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DEPARTMENT OF WATER AND NATURAL RESOURCES  
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DIVISION OF GEOLOGICAL SURVEY  
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Open-File Report 53-UR

INVESTIGATION OF PETROLEUM CONTAMINATION  
AT WASHINGTON HIGH SCHOOL,  
SIOUX FALLS, SOUTH DAKOTA

by

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## **INTRODUCTION**

### **Purpose and Scope**

The purpose of this investigation was to (1) determine if petroleum contamination was present in the soil and ground water on Washington High School property, Sioux Falls, South Dakota, and (2) if contamination was present, generally determine its type and direction of movement.

Work activities were limited to School property and City-owned right-of-way along Dakota Avenue. Potential sources of contamination and the extent of off-site contamination were not addressed.

### **Background Information**

Washington High School is located in downtown Sioux Falls, South Dakota, at 315 South Main Avenue (fig. 1).

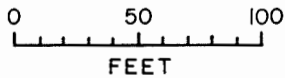
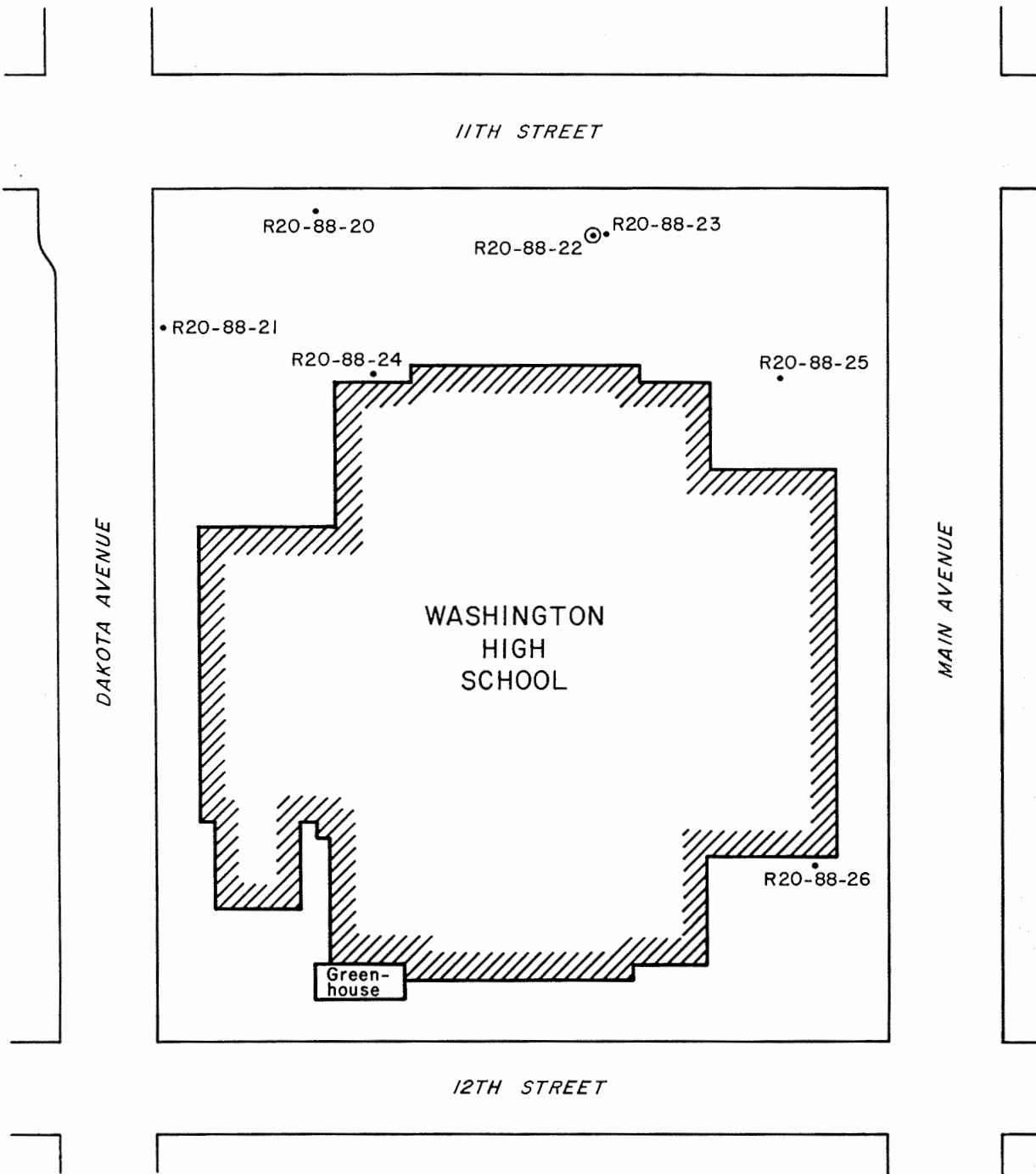
Petroleum contamination in the ground immediately across 11th Street to the north of Washington High School was first indicated in a report by Woodward-Clyde Consultants (1987). This contamination was subsequently identified as a gasoline type and was found to be present in the sediment and ground water (Twin City Testing Corporation, 1988).

As a result of the identification of petroleum contamination across the street from the School and because of concerns by the City regarding the future of the School, the City of Sioux Falls requested assistance from the South Dakota Department of Water and Natural Resources in assessing contamination on School property. The Division of Geological Survey, South Dakota Department of Water and Natural Resources, then proceeded to investigate possible petroleum contamination on School property.

### **Methods and Procedures**

#### **Drilling**

Drilling was performed with a Mobile B-61 hollowstem auger rig. The outer diameter of the hollow auger was 8.5 inches with a cutting head diameter of 11 inches. Split-barrel samples were taken continuously from land surface to completion depth of each test hole. The split-barrel sampler was 30 inches long with a 3 inch inner diameter. Representative samples of sediment from each pass of the split barrel were saved and will be stored at the Geological Survey in Vermillion until January 1, 1989.



- R20-88-25 • Monitoring well
  - R20-88-22 ⊙ Test hole
- } Number refers to test hole or monitoring well in Appendix A.

Figure 1. Locations of test hole and monitoring wells.

## SCREENING OF SEDIMENT SAMPLES FOR VOLATILE-ORGANIC VAPORS

Sediment recovered with the split-barrel sampler was scanned for volatile-organic vapors immediately after opening the sampler. The instrument used was an H\*NU Inc., model PI 101, photoionization detector which was calibrated to isobutylene, a substance with an ionization potential nearly the same as benzene. Results of this screening are included on the lithologic logs of the test holes (app. A).

## DECONTAMINATION

Prior to any drilling, the rear end of the drilling rig, auger flights, and other equipment which would come in contact with the test hole were cleaned with high pressure hot water. This process was repeated for all down-hole tools and equipment used on a given test hole prior to use on a subsequent test hole. This procedure was used to minimize the possibility of introducing contamination to a test hole.

The split-barrel sampler was disassembled after each sample collection event during the drilling process and was washed using a brush in a soap-water solution followed by a double rinse in clean water. Water used for this was from the Sioux Falls municipal supply. This procedure was used to limit the amount of possible contamination transfer from one depth to another in the test hole and to limit any carry-over of odor and vapors from sample to sample.

## Monitoring-well Installation

### DECONTAMINATION OF WELL MATERIALS

All well materials were cleaned and wrapped prior to transport to the site. Cleaning consisted of using high pressure hot water to minimize the amount of volatile-organic compounds which may or may not have been present on the materials from the factory. After cleaning, materials were wrapped in plastic and taped closed.

### WELL CONSTRUCTION

Monitoring wells were installed in two ways. One was to place the casing and screen through the center of the hollow auger and then remove all auger flights from the ground. The other method was to first remove all auger flights from the ground and then place the casing and screen into the open test hole.

After insertion of casing and screen into the ground, filter pack material was added to some level above the top of the screen and then a dry bentonite seal was placed above the filter pack.

The top of each well was completed by cementing in place a steel, protective, lockable cover over the casing. See appendix B for details of well construction.

### Surveying

Elevations of all wells were surveyed and are listed on the lithologic logs in appendix A. Surveying was done relative to mean sea level using, as a reference point, a Coast and Geodetic Survey bench mark with the following description: At Sioux Falls, Minnehaha County, on West Twelfth Street midway between South Main Street and South Dakota Avenue, at the south entrance to the high school, in the top of the concrete doorsill, near the south edge and 30 inches east of the west end.

This bench mark (designated G 5) is stamped with an elevation of 1441.733, however, this elevation was resurveyed in 1949 and the corrected elevation is 1441.687 feet.

### Water-level Measurement

Water levels were measured using a fiberglass tape graduated in 0.01-foot increments. The tape had a concave-shaped device on the end which created an audible sound upon impact with the fluid in the well.

Prior to any water-level measurement, the tape was washed in a soap-water solution followed by a rinse in clean water. This decontamination procedure was used to minimize the possibility of introduction of contamination into a well.

### Water Sampling

Water sampling was accomplished using laboratory cleaned, teflon bailers obtained from the South Dakota State Health Laboratory. A different bailer and lift rope were used for each well.

A minimum of 4.1 volumes of well water were evacuated from each well prior to sampling. Table 1 shows the volume of water removed from each well.

Samples were containerized in 40 milliliters purge and trap vials supplied by the South Dakota State Health Laboratory. Samples were then stored and shipped in a cooler containing ice to the State Health Laboratory for analysis. The chain of custody record may be obtained from the South Dakota State Health Laboratory.

Table 1. Records of water removal for sampling purposes.

Well	Volume of water in the well (gal)	Volume of water bailed from the well (gal)	Number of water volumes bailed
R20-88-20	0.76	5.0	6.6
R20-88-21	0.81	5.0	6.2
R20-88-23	0.18	4.0	22.2
R20-88-24	1.34	7.0	5.2
R20-88-25	0.23	2.8	12.2
R20-88-26	1.48	6.0	4.1

### Acknowledgements

Appreciation is expressed to Tom Olson, Director of the Sioux Falls Health Department, for his coordination of our work with the City of Sioux Falls. The efforts of Ray Merry, Sioux Falls Health Department, for his assistance in locating underground utilities, securing a permit to drill on City property, acquiring the assistance of the City Street Department, and for assisting in drilling activities by using the City's photoionization detector to scan sediment samples for possible contamination, is also acknowledged. Appreciation is also expressed to Rolland Rundell, Supervisor of Buildings and Grounds for the Sioux Falls School District, for providing information regarding Washington High School building plans and elevations.

### **RESULTS OF INVESTIGATION**

#### Sediment Contamination

A total of seven test holes were drilled (fig. 1) but results from only six of these holes will be discussed here. Because difficulties were encountered in drilling test hole R20-88-22 useful data regarding contamination are not available for this hole. However, another hole was drilled near the same location (test hole R20-88-23) from which data on contamination are available. Logs of all test holes are presented in appendix A.

Odor, visual, and organic-vapor evidence from the sediment samples indicate that petroleum contamination exists at four drill sites (test holes R20-88-20, R20-88-23, R20-88-24, and R20-88-25). The two locations which did not exhibit contamination in the sediment, using criteria listed above, were the drill sites of test holes R20-88-21 and R20-88-26. These two test holes are located near the northwest and southeast corners of School property (fig. 1).



Numbers from a photoionization detector, indicating the presence or absence of organic-vapor contamination are available for every test hole except R20-88-20. However, odor and visual evidence from R20-88-20 indicate that the sand layer beginning at 13.7 feet below land surface is contaminated by a petroleum product. The extent to which the sediments above and below this sand are contaminated in this hole cannot be assessed with available data. The contamination in the sand at 13.7 feet in test hole R20-88-20 corresponds with a contaminated sand found by Twin City Testing Corporation just northeast of the intersection of Dakota Avenue and 11th Street.

The other three locations at which sediment exhibited contamination (test holes R20-88-23, R20-88-24, and R20-88-25), according to the photoionization detector, showed the top of the organic-vapor contamination beginning anywhere from 16 to 18.5 feet below land surface and extending down to 19.8 to 27.5 feet (app. A). Vapor contamination was detected at lower elevations in an eastward direction. Meter readings from the photoionization detector were as high as 140 parts per million (test hole R20-88-25).

#### **Ground-water Contamination**

Monitoring wells were installed in six of the seven test holes drilled for this investigation. Well-construction information is presented in appendix B. Water from these wells was sampled, on July 19 and 20, 1988, and was analyzed for petroleum contamination by the South Dakota State Health Laboratory. Table 2 presents the results of these analyses.

Chemical analyses of ground water indicate petroleum contamination to be present in five of the six wells; the exception being R20-88-26 near the southeast corner of the School. This is in contrast to only four of the six well locations according to field evaluation of the sediment samples. The five wells with ground-water contamination showed a range from 0.142 parts per million (ppm) gasoline (well R20-88-20) to 161 ppm gasoline (well R20-88-25) (fig. 2). There was no evidence of free floating petroleum product in any of the six wells.

#### **Ground-water Movement**

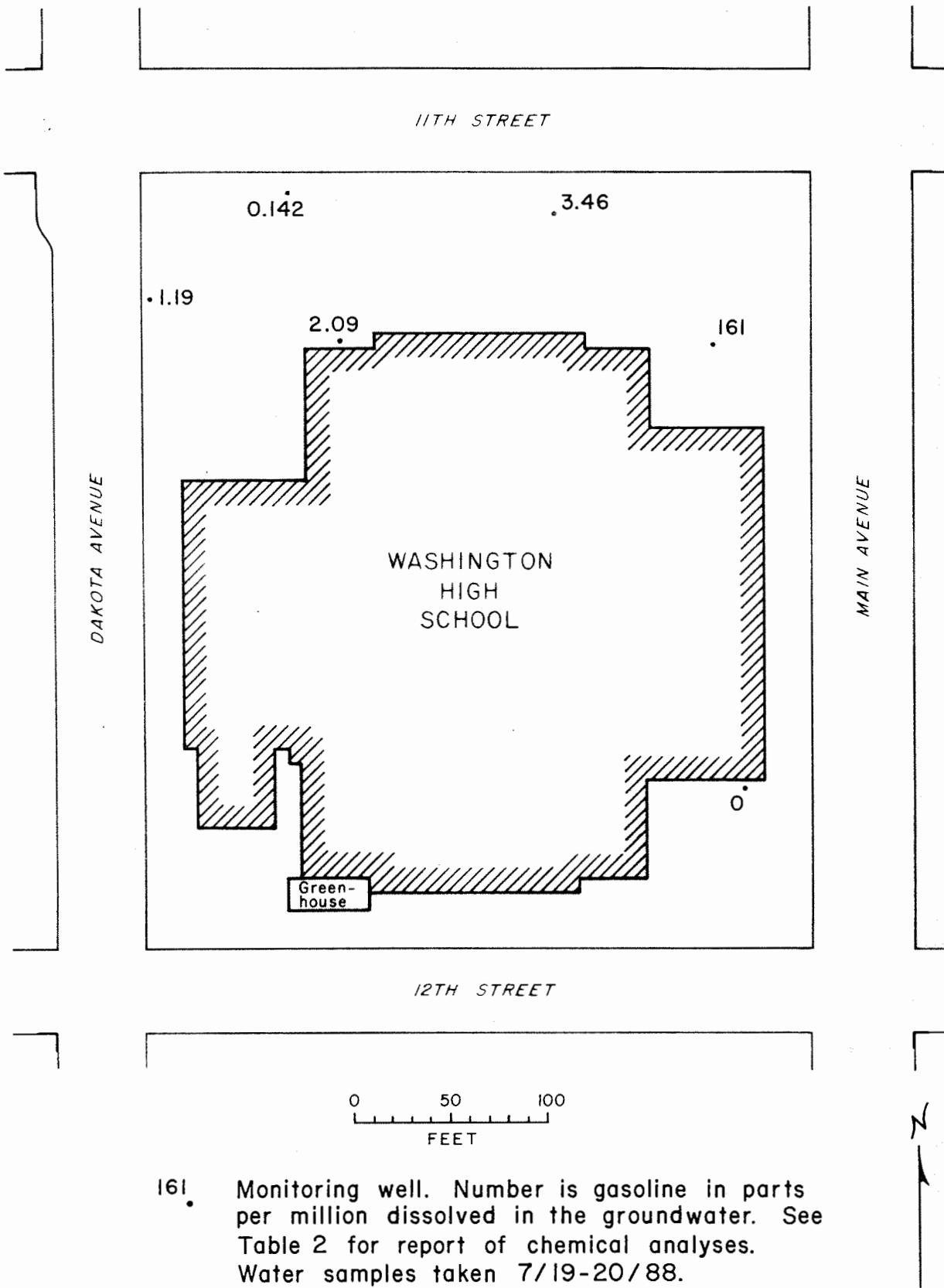
Figure 3 shows the general elevation of the water-table surface as indicated by measurements in the monitoring wells (table 3). An easterly or east-southeasterly direction of ground-water movement is indicated by the elevations. However, additional wells over a larger area, and a longer period of monitoring for all wells, are needed to better characterize the direction of ground-water movement.

Table 2. Results of chemical analyses.

<u>Well</u>	<u>Time and date collected</u>	<u>Lab Number</u>	<u>Results of analyses</u>
R20-88-20	11:59 a.m. 7-20-88	89X-67	0.142 ppm light ends of gasoline calculated against a gasoline standard
R20-88-21	11:15 a.m. 7-20-88	89X-65	1.19 ppm gasoline with a higher concentration of light compounds than expected
R20-88-23	1:55 p.m. 7-20-88	89X-68	3.46 ppm gasoline
R20-88-24	11:38 a.m. 7-20-88	89X-66	2.09 ppm gasoline with a slightly higher concentration of light compounds than expected
R20-88-25	4:05 p.m. 7-19-88	89X-64	161 ppm gasoline
R20-88-26	3:51 p.m. 7-19-88	89X-63	no petroleum found

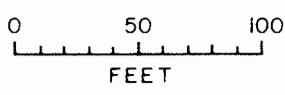
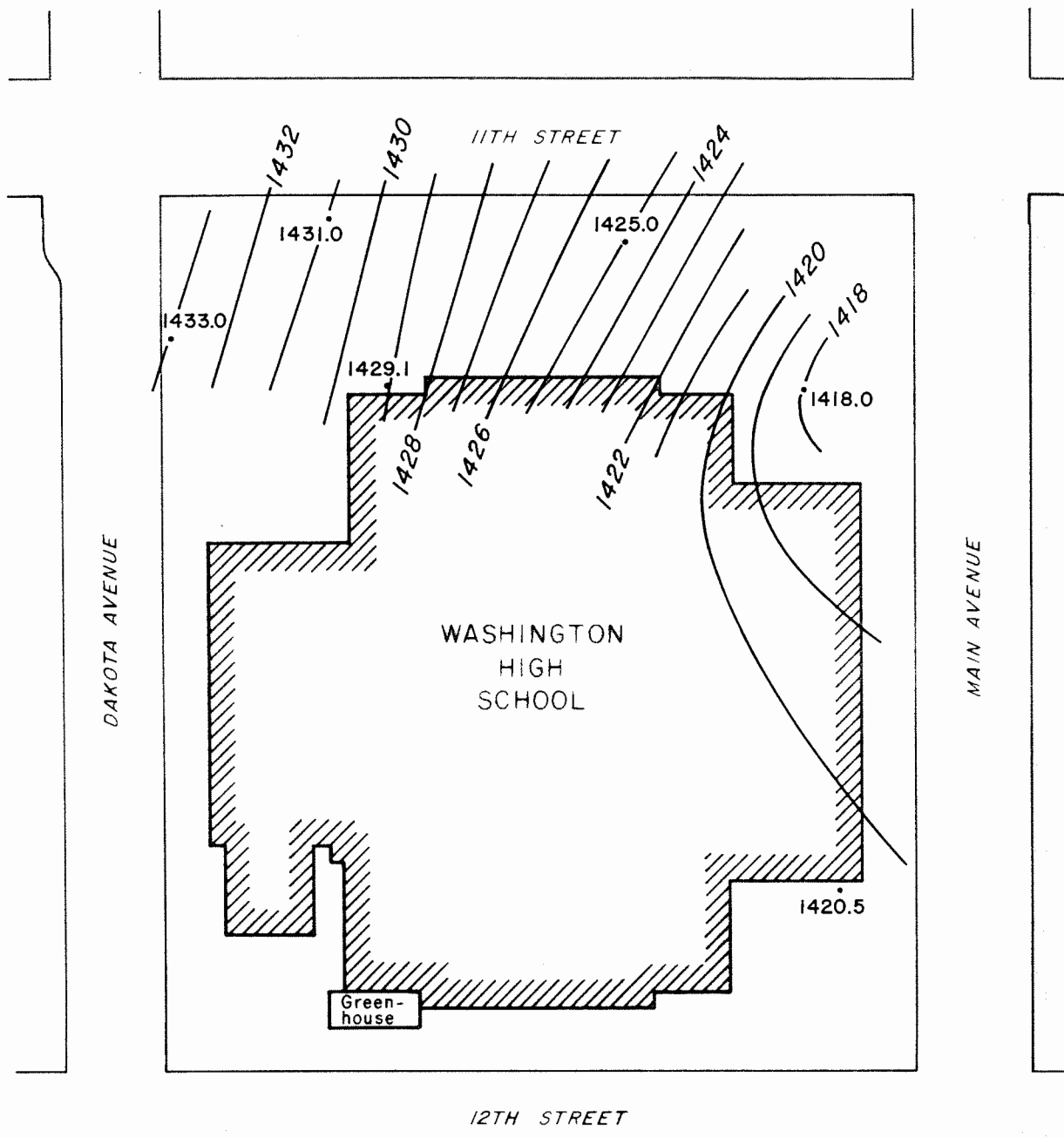
Information in this table is from a report of analyses from the South Dakota State Health Laboratory. Parts per million is abbreviated as ppm in this table.

The movement of ground water under the School may at times be altered by the building because of the depth of walls and footings underground which range from a low elevation of approximately 1,426 feet to a high of approximately 1,437 feet. However, at the time of water-level measurements shown in figure 3, the elevation of the ground-water surface along the northern and eastern edges of the School was found to be lower than walls and footings of the building along those same edges. Thus, ground water was able to move under the School in those areas at that time. However, during times of higher ground-water elevations, the water-table surface may be above the bottom of some footings and walls and thus force shallow contaminated water to flow around the School as well as perhaps under the School.



161. Monitoring well. Number is gasoline in parts per million dissolved in the groundwater. See Table 2 for report of chemical analyses. Water samples taken 7/19-20/88.

Figure 2. Distribution of petroleum contamination.



1429.1

Monitoring well. Number is elevation of water table in feet above mean sea level.

1424

Line connecting points of equal elevation on the water-table surface. Contour interval = 1 foot.

Figure 3. Water-table elevations; July 19, 1988.

Table 3. Water-level measurements.

Well	Casing top elevation (ft)	Depth to fluid from casing top, in feet, and date of measurement				
		6-29-88	6-30-88	7-6-88	7-13-88	7-19-88
R20-88-20	1443.85	12.81	12.80	12.75	12.76	12.84
R20-88-21	1445.75	12.50	12.51	12.53	12.61	12.75
R20-88-23	1441.41	---	15.85	16.00	16.12	16.42
R20-88-24	1445.59	---	16.45	16.41	16.43	16.54
R20-88-25	1441.32	---	dry	22.55	22.76	23.35
R20-88-26	1442.22	---	22.26	21.54	21.58	21.70

### SUMMARY AND CONCLUSIONS

This investigation has identified the presence of petroleum contamination on School property. It was detected as dissolved contamination in the ground water and as vapor in the sediment. In the wells which showed ground-water contamination, concentrations of gasoline ranged from 0.142 ppm to 161 ppm. Vapor concentrations in sediment samples from those same well locations ranged from nondetectable to 140 ppm.

The general direction of ground-water movement was determined to be in an easterly or east-southeasterly direction. This direction of ground-water movement indicates that the source of contamination is off-site to the northwest and/or west.

This investigation was not designed to assess any health risk which might be associated with the petroleum contamination. The intent of this investigation was only to generate reconnaissance-type data which could be used to guide further studies in this area, if necessary, and to provide some semi-permanent ground water monitoring points.

### REFERENCES CITED

- Twin City Testing Corporation, February 25, 1988, Preliminary contamination assessment, Home Federal Savings & Loan, 225 S. Main Avenue, Sioux Falls, South Dakota: Report Number 6600 88-0278.
- Woodward-Clyde Consultants, September 25, 1987, Soil and foundation investigation, Home Federal Savings and Loan Addition, Sioux Falls, South Dakota: Report Number 87MC151.

## APPENDIX A

### Logs of test holes and monitoring wells

#### LEGAL LOCATION and LOCATION

The logs are listed by smallest township number, then the smallest range number, the smallest section number, and then by quarter section: NE = A; NW = B; SW = C; SE = D. A comparison of LEGAL LOCATION and LOCATION is as follows. A LEGAL LOCATION of NW SE NE SW sec. 30, T. 99 N., R. 64 W. is the same as a LOCATION of 099N-64W-30CADB.

#### LATITUDE and LONGITUDE

The format is DD.MMSS where D is degrees, M is minutes, and S is seconds.

#### DRILLING COMPANY

SDGS is an abbreviation for South Dakota Geological Survey.

#### TOTAL DRILL HOLE DEPTH and SCREEN LENGTH

The numbers are presented in feet.

#### SCREEN TYPE and CASING TYPE

PVC is an abbreviation for polyvinylchloride. MFG. is an abbreviation for "manufactured" and indicates a product that is commercially available. SCH. is an abbreviation for "schedule" and refers to casing thickness.

#### CASING TOP ELEVATION and GROUND SURFACE ELEVATION

The numbers are presented in feet above mean sea level. I - the elevation was determined using a surveying instrument. The elevations were surveyed to the nearest 0.01 foot. T - the elevation was estimated from 7 1/2-minute series topographic map.

#### CASING DIAMETER

The numbers are presented in inches.



\* \* \* \*

COUNTY: MINNEHAHA LOCATION: 101N-49W-16CCCD 2  
LEGAL LOCATION: SE SW SW SW SEC. 16, T. 101 N., R. 49 W.  
LATITUDE: 43.3240 LONGITUDE: 96.4347  
LAND OWNER:  
PROJECT: LUST TRUST HOME FEDERAL  
DRILLING COMPANY: SDGS  
DRILLER: D. IVERSON DRILLER'S LOG:  
GEOLOGIST: D. ILES GEOLOGIST'S LOG: X  
DATE DRILLED: 06-28-1988 DRILLING METHOD: HOLLOWSTEM  
GROUND SURFACE ELEVATION: 1443.00 T  
TOTAL DRILL HOLE DEPTH: 20.0 TEST HOLE NUMBER: R20-88-21  
WATER RIGHTS WELL: SDGS WELL NAME: R20-88-21  
OTHER WELL NAME:  
BASIN: BIG SIOUX AQUIFER:  
MANAGEMENT UNIT:  
SCREEN TYPE: PVC, MFG., SCH. 40, 0.010 SLOT SCREEN LENGTH: 10.0  
CASING TYPE: PVC, SCH. 40 CASING DIAMETER: 2.0  
CASING TOP ELEVATION: 1445.75 I  
CASING STICK-UP: 2.30 TOTAL CASING AND SCREEN: 20.0  
WELL MAINTENANCE DATE:  
USGS HYDROLOGICAL UNIT CODE: 10170203  
ELECTRIC LOG INFORMATION:  
SPONTANEOUS POTENTIAL: SINGLE POINT RESISTIVITY:  
NATURAL GAMMA: EXTRA:  
SAMPLES:

SPLIT-BARREL SAMPLES WERE TAKEN CONTINUOUSLY FROM  
0 TO 20 FEET AND WERE SCANNED WITH AN HNU METER  
CALIBRATED TO ISOBUTYLENE. ALL SAMPLES DOWN TO  
COMPLETION DEPTH SHOWED NO DEFLECTION ON THE  
METER.

0	-	2.5	CLAY, GRAY TO BROWN, VERY SILTY; WITH A THIN LAYER OF BROWN, CLAYEY, SILTY SAND AT 1.3 FEET
2.5	-	9.0	CLAY, GRAY, REDDISH-BROWN, AND YELLOWISH-BROWN MOTTLED, SLIGHTLY SANDY, PEBBLY, AND SILTY
9.0	-	12.5	CLAY, GRAY, REDDISH-BROWN, AND YELLOWISH-BROWN MOTTLED, VERY SILTY AND SANDY, SLIGHTLY PEBBLY; THE SAND IS FINE TO MEDIUM, A VERTICAL SAND SEAM WAS OBSERVED, THERE WAS SOME FREE WATER AT ABOUT 12 FEET
12.5	-	13.7	SAND, YELLOWISH-BROWN WITH SOME GRAY, FINE, CLAYEY, SILTY
13.7	-	14.3	CLAY, YELLOWISH-BROWN WITH SOME GRAY, VERY SANDY AND SILTY
14.3	-	17.5	SAND, YELLOWISH-BROWN TO LIGHT-GRAY, FINE, CLAYEY; VERY WET BELOW 15 FEET, THERE WAS NO RECOVERY IN THE PASS FROM 15 TO 17.5 FEET



17.5 - 18.5 SILT, YELLOWISH-BROWN, SANDY, CLAYEY,  
SLIGHTLY PEBBLY; MORE MOIST THAN  
INTERVAL FROM 18.5 TO 20 FEET  
18.5 - 20.0 CLAY, YELLOWISH-BROWN, PEBBLY, SILTY,  
SLIGHTLY SANDY; APPEARS ALMOST DRY

\* \* \* \*

COUNTY: MINNEHAHA LOCATION: 101N-49W-16CCCD 3  
LEGAL LOCATION: SE SW SW SW SEC. 16, T. 101 N., R. 49 W.  
LATITUDE: 43.3240 LONGITUDE: 96.4344  
LAND OWNER:  
PROJECT: LUST TRUST HOME FEDERAL  
DRILLING COMPANY: SDGS  
DRILLER: D. IVERSON DRILLER'S LOG:  
GEOLOGIST: D. ILES GEOLOGIST'S LOG: X  
DATE DRILLED: 06-28-1988 DRILLING METHOD: HOLLOWSTEM  
GROUND SURFACE ELEVATION: 1439.00 T  
TOTAL DRILL HOLE DEPTH: 17.5 TEST HOLE NUMBER: R20-88-22  
USGS HYDROLOGICAL UNIT CODE: 10170203  
ELECTRIC LOG INFORMATION:  
SPONTANEOUS POTENTIAL: SINGLE POINT RESISTIVITY:  
NATURAL GAMMA: EXTRA:  
SAMPLES:

SPLIT-BARREL SAMPLES WERE TAKEN CONTINUOUSLY FROM  
0 TO 17.5 FEET AND WERE SCANNED WITH AN HNU  
METER CALIBRATED TO ISOBUTYLENE. ALL SAMPLES  
DOWN TO 10 FEET SHOWED NO DEFLECTION ON THE  
METER.

0 - 2.0 TOPSOIL, BLACK  
2.0 - 2.5 CLAY, GRAY TO YELLOWISH-GRAY, SLIGHTLY  
SILTY, PEBBLY  
2.5 - 10.0 CLAY, OLIVE-GREEN-GRAY AND BROWN MOTTLED,  
SLIGHTLY SILTY AND PEBBLY; SOME  
VERTICAL OXIDATION ZONES FROM 2.5 TO 5  
FEET, SLIGHTLY MOIST AT 6 FEET BECOMING  
MORE MOIST DOWNWARD, A WHITE CALCAREOUS  
NODULE AT 8 FEET  
10.0 - 17.5 UNKNOWN; POOR RECOVERY, THE LEAD AUGER  
BECAME PLUGGED, SEE THE LOG FOR A  
REDRILL OF THIS HOLE (R20-88-23) FOR  
FURTHER LITHOLOGIC DESCRIPTIONS

\* \* \* \*

COUNTY: MINNEHAHA LOCATION: 101N-49W-16CCCD 4  
LEGAL LOCATION: SE SW SW SW SEC. 16, T. 101 N., R. 49 W.  
LATITUDE: 43.3240 LONGITUDE: 96.4344  
LAND OWNER:  
PROJECT: LUST TRUST HOME FEDERAL  
DRILLING COMPANY: SDGS  
DRILLER: D. IVERSON DRILLER'S LOG:

GEOLOGIST: D. ILES  
 DATE DRILLED: 06-29-1988  
 GROUND SURFACE ELEVATION: 1439.00 T  
 TOTAL DRILL HOLE DEPTH: 22.5  
 WATER RIGHTS WELL:  
 OTHER WELL NAME:  
 BASIN: BIG SIOUX  
 MANAGEMENT UNIT:  
 SCREEN TYPE: PVC, MFG., SCH. 40, 0.010 SLOT SCREEN LENGTH: 10.0  
 CASING TYPE: PVC, SCH. 40 CASING DIAMETER: 2.0  
 CASING TOP ELEVATION: 1441.41 I  
 CASING STICK-UP: 2.50 TOTAL CASING AND SCREEN: 20.0  
 WELL MAINTENANCE DATE:  
 USGS HYDROLOGICAL UNIT CODE: 10170203  
 ELECTRIC LOG INFORMATION:  
 SPONTANEOUS POTENTIAL: SINGLE POINT RESISTIVITY:  
 NATURAL GAMMA: EXTRA:  
 SAMPLES:

SPLIT-BARREL SAMPLES WERE TAKEN CONTINUOUSLY FROM  
 0 TO 22.5 FEET AND WERE SCANNED WITH AN HNU  
 METER CALIBRATED TO ISOBUTYLENE. DEPTHS AND  
 METER READINGS ARE, RESPECTIVELY: ABOVE 16.0-0;  
 16.0-10; 16.2-85; 16.3-100; 16.8-45; 17.2-10;  
 18.3-40; 18.6-50; 19.0-60; 19.8-TRACE; BELOW  
 19.8-0.

0	-	1.5	TOPSOIL, BLACK
1.5	-	10.0	CLAY, OLIVE-GREEN-GRAY, BROWN, AND REDDISH-BROWN MOTTLED, SILTY, PEBBLY, SLIGHTLY SANDY; SOME VERTICAL OXIDIZED ZONES FROM 2 TO 5 FT, MANY BLACK SPECS LESS THAN 1 MM IN DIAMETER BELOW 2.5 FT, SOME WHITE CALCAREOUS NODULES 3 TO 7 MM IN DIAMETER FROM 7.5 TO 10 FT
10.0	-	11.5	CLAY, GRAY AND REDDISH-BROWN MOTTLED, VERY SILTY AND SANDY; THE SAND IS FINE GRAINED, MANY BLACK SPECS LESS THAN 1 MM IN DIAMETER
11.5	-	12.5	SAND, GRAY AND REDDISH-BROWN MOTTLED, FINE, VERY SILTY AND CLAYEY
12.5	-	15.0	CLAY, OLIVE-GREEN-GRAY, BROWN, AND REDDISH-BROWN MOTTLED, VERY SILTY; MANY BLACK SPECS LESS THAN 1 MM IN DIAMETER
15.0	-	16.3	CLAY, OLIVE-GREEN-GRAY WITH SOME REDDISH- BROWN, SILTY, SANDY, SLIGHTLY PEBBLY
16.3	-	16.9	SAND, OLIVE-GREEN-GRAY WITH SOME REDDISH- BROWN, FINE, CLAYEY
16.9	-	19.3	CLAY, OLIVE-GREEN TO BROWNISH-GREEN MOTTLED, VERY SANDY, SILTY, PEBBLY; THE SAND IS MOSTLY FINE WITH SOME MEDIUM
19.3	-	20.0	CLAY, BROWN TO LIGHT-BROWN, PEBBLY, SILTY, SLIGHTLY SANDY
20.0	-	22.5	CLAY, BROWN AND REDDISH-BROWN WITH SOME





SCREEN TYPE: PVC, MFG., SCH. 40, 0.010 SLOT SCREEN LENGTH: 10.0  
 CASING TYPE: PVC, SCH. 40 CASING DIAMETER: 2.0  
 CASING TOP ELEVATION: 1441.32 I  
 CASING STICK-UP: 2.50 TOTAL CASING AND SCREEN: 27.3  
 WELL MAINTENANCE DATE:  
 USGS HYDROLOGICAL UNIT CODE: 10170203  
 ELECTRIC LOG INFORMATION:  
 SPONTANEOUS POTENTIAL: SINGLE POINT RESISTIVITY:  
 NATURAL GAMMA: EXTRA:  
 SAMPLES:

SPLIT-BARREL SAMPLES WERE TAKEN CONTINUOUSLY FROM  
 0 TO 30 FEET AND WERE SCANNED WITH AN HNU METER  
 CALIBRATED TO ISOBUTYLENE. DEPTHS AND METER  
 READINGS ARE, RESPECTIVELY: ABOVE 18.5-0; 18.5-  
 4; 21.0-5; 22.5-140; 23.0-130; 23.5-17; 23.8-50;  
 24.1-100; 24.3-70; 24.5-110; 24-6-80; 25.9-50;  
 26.5-50; 27.0-12; 27.3-5; 27.5-TRACE; 28.3-0.

0	-	0.8	TOPSOIL, BLACK
0.8	-	2.5	CLAY, LIGHT-GRAY, SILTY, SANDY, PEBBLY; WITH WHITE AND RED CLASTS LESS THAN 1 MM IN DIAMETER
2.5	-	5.0	CLAY, GRAY, BROWN, AND REDDISH-BROWN MOTTLED, SILTY, SLIGHTLY SANDY AND PEBBLY
5.0	-	5.7	CLAY, DARK-BROWN, VERY SILTY AND PEBBLY, SLIGHTLY SANDY
5.7	-	7.5	SAND, LIGHT-BROWN WITH SOME REDDISH-BROWN VEINS, FINE, VERY SILTY AND CLAYEY
7.5	-	10.0	CLAY, OLIVE-GREEN-GRAY, LIGHT-GRAY, AND REDDISH-BROWN MOTTLED, VERY SANDY, SILTY, SLIGHTLY PEBBLY; MANY BLACK SPECS LESS THAN 1 MM IN DIAMETER, SOME WHITE CALCAREOUS CLASTS ABOUT 3 CM IN DIAMETER
10.0	-	11.5	CLAY, REDDISH-BROWN, BROWN, AND SOME GRAY MOTTLED, VERY SILTY, SLIGHTLY SANDY AND PEBBLY; MANY BLACK SPECS LESS THAN 1 MM IN DIAMETER, SOME WHITE CALCAREOUS CLASTS ABOUT 2 MM IN DIAMETER
11.5	-	12.2	SAND, GRAY WITH SOME BROWN, FINE, VERY CLAYEY, SILTY
12.2	-	12.5	CLAY, GRAY WITH SOME BROWN, SILTY, SLIGHTLY SANDY; SOME REDDISH-BROWN OXIDIZED VEINS, SOME FINE GRAINED, CLAYEY, SAND LENSES ABOUT 3 TO 5 MM THICK
12.5	-	15.0	CLAY, GRAY TO GREENISH-GRAY WITH SOME REDDISH-BROWN VEINS, SILTY, SLIGHTLY PEBBLY; MANY BLACK SPECS LESS THAN 1 MM IN DIAMETER, A FEW WHITE CALCAREOUS NODULES
15.0	-	17.3	CLAY, GRAY TO GREENISH-GRAY WITH

EXTENSIVE REDDISH-BROWN OXIDATION,  
 SILTY, PEBBLY; MANY BLACK SPECS LESS  
 THAN 1 MM IN DIAMETER, A FEW WHITE  
 CALCAREOUS NODULES

17.3 - 20.0 CLAY, REDDISH-ORANGE-BROWN WITH A LITTLE  
 GRAY, SILTY, VERY PEBBLY AND SANDY

20.0 - 22.5 CLAY, GREENISH-GRAY AND REDDISH-BROWN  
 MOTTLED, SILTY, VERY SANDY, SLIGHTLY  
 PEBBLY; A 4-INCH THICK CALCITE RICH  
 LAYER AT 21.5 FEET

22.5 - 25.0 CLAY, REDDISH-BROWN, GREENISH-GRAY, AND  
 LIGHT-GRAY MOTTLED, SILTY, SLIGHTLY  
 SANDY, VERY PEBBLY

25.0 - 27.5 CLAY, GREENISH-GRAY, REDDISH-BROWN, AND  
 LIGHT-GRAY MOTTLED, SILTY, SLIGHTLY  
 SANDY, PEBBLY; VERY REDDISH-BROWN  
 FROM 27.2 TO 27.5 FEET

27.5 - 30.0 CLAY, GREENISH-GRAY, REDDISH-BROWN, AND  
 BROWN MOTTLED, SILTY, SLIGHTLY SANDY,  
 VERY PEBBLY; MANY BLACK SPECS

\* \* \* \*

COUNTY: MINNEHAHA LOCATION: 101N-49W-21BBAB 1  
 LEGAL LOCATION: NW NE NW NW SEC. 21, T. 101 N., R. 49 W.  
 LATITUDE: 43.3237 LONGITUDE: 96.4342  
 LAND OWNER:  
 PROJECT: LUST TRUST HOME FEDERAL  
 DRILLING COMPANY: SDGS  
 DRILLER: D. IVERSON DRILLER'S LOG:  
 GEOLOGIST: D. ILES GEOLOGIST'S LOG: X  
 DATE DRILLED: 06-30-1988 DRILLING METHOD: HOLLOWSTEM  
 GROUND SURFACE ELEVATION: 1440.00 T  
 TOTAL DRILL HOLE DEPTH: 35.0 TEST HOLE NUMBER: R20-88-26  
 WATER RIGHTS WELL: SDGS WELL NAME: R20-88-26  
 OTHER WELL NAME:  
 BASIN: BIG SIOUX AQUIFER: TILL  
 MANAGEMENT UNIT:  
 SCREEN TYPE: PVC, MFG., SCH. 40, 0.010 SLOT SCREEN LENGTH: 10.0  
 CASING TYPE: PVC, SCH. 40 CASING DIAMETER: 2.0  
 CASING TOP ELEVATION: 1442.22 I  
 CASING STICK-UP: 2.50 TOTAL CASING AND SCREEN: 33.3  
 WELL MAINTENANCE DATE:  
 USGS HYDROLOGICAL UNIT CODE: 10170203  
 ELECTRIC LOG INFORMATION:  
 SPONTANEOUS POTENTIAL: SINGLE POINT RESISTIVITY:  
 NATURAL GAMMA: EXTRA:  
 SAMPLES:

SPLIT-BARREL SAMPLES WERE TAKEN CONTINUOUSLY FROM  
 0 TO 35 FEET AND WERE SCANNED WITH AN HNU METER  
 CALIBRATED TO ISOBUTYLENE. ALL SAMPLES DOWN TO  
 COMPLETION DEPTH SHOWED NO DEFLECTION ON THE  
 METER.

0	-	3.0	CLAY, DARK-BROWN TO BLACK, SILTY, SANDY, PEBBLY
3.0	-	6.3	CLAY, GREENISH-GRAY, REDDISH-BROWN, AND LIGHT-BROWN MOTTLED, PEBBLY, SLIGHTLY SILTY AND SANDY; SOME DARK-BROWN TO BLACK SPECS ABOUT 2 MM IN DIAMETER AND SOME WHITE CALCAREOUS NODULES ABOUT 5 MM IN DIAMETER BELOW 5 FEET
6.3	-	8.6	CLAY, VERY DARK-BROWN, SILTY, SLIGHTLY SANDY AND PEBBLY
8.6	-	12.0	CLAY, REDDISH-BROWN, BROWN, AND SOME GREENISH-GRAY MOTTLED, SILTY, SLIGHTLY SANDY, VERY PEBBLY; SOME WHITE CALCAREOUS NODULES
12.0	-	16.6	CLAY, LIGHT-GRAY WITH SOME REDDISH-BROWN VEINS, SILTY, SLIGHTLY PEBBLY; MANY BLACK SPECS LESS THAN 1 MM IN DIAMETER, SOME WHITE CALCAREOUS NODULES LESS THAN 1 MM IN DIAMETER
16.6	-	22.5	CLAY, REDDISH-BROWN, BROWN, AND SOME GRAY TO GREENISH-GRAY MOTTLED, SILTY, PEBBLY, SLIGHTLY SANDY; MANY WHITE CALCAREOUS NODULES AND VEINS
22.5	-	27.0	CLAY, REDDISH-BROWN, BROWN, AND SOME GREENISH-GRAY MOTTLED, SILTY, PEBBLY, SLIGHTLY SANDY; A FEW DARK-BROWN SPECS, A FEW WHITE CALCAREOUS NODULES
27.0	-	30.0	CLAY, GREENISH-GRAY AND REDDISH-BROWN MOTTLED, SILTY, PEBBLY, SLIGHTLY SANDY; A FEW WHITE CALCAREOUS NODULES, SOME GRAY COLORED VEINS
30.0	-	35.0	CLAY, GREENISH-GRAY, REDDISH-BROWN, AND BROWN MOTTLED, SILTY, SANDY, PEBBLY; SOME WHITE PEBBLES, SOME DARK-BROWN TO BLACK SPECS, SOME GRAY COLORED VEINS

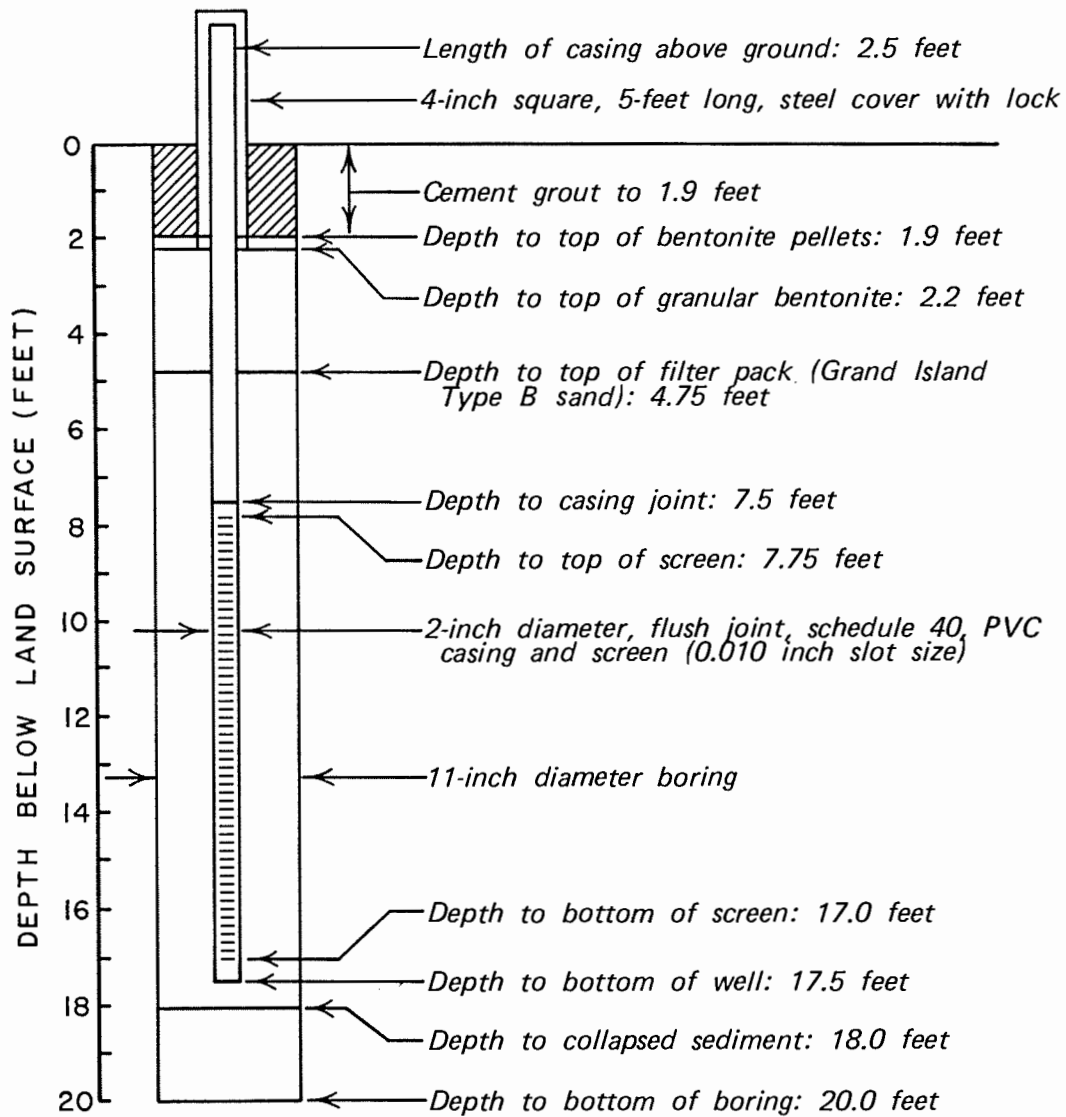
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**APPENDIX B**

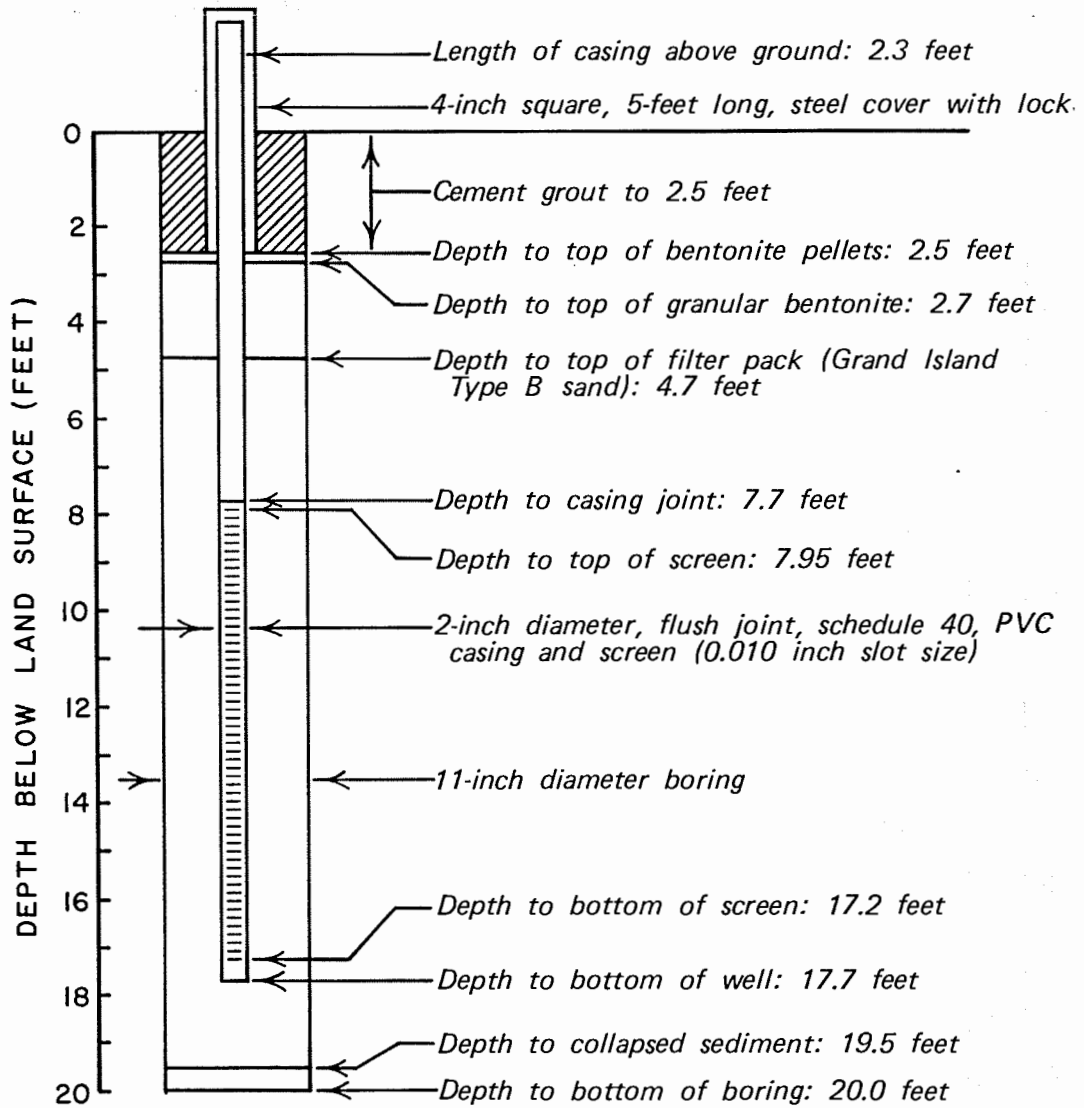
**Diagrams of well construction**



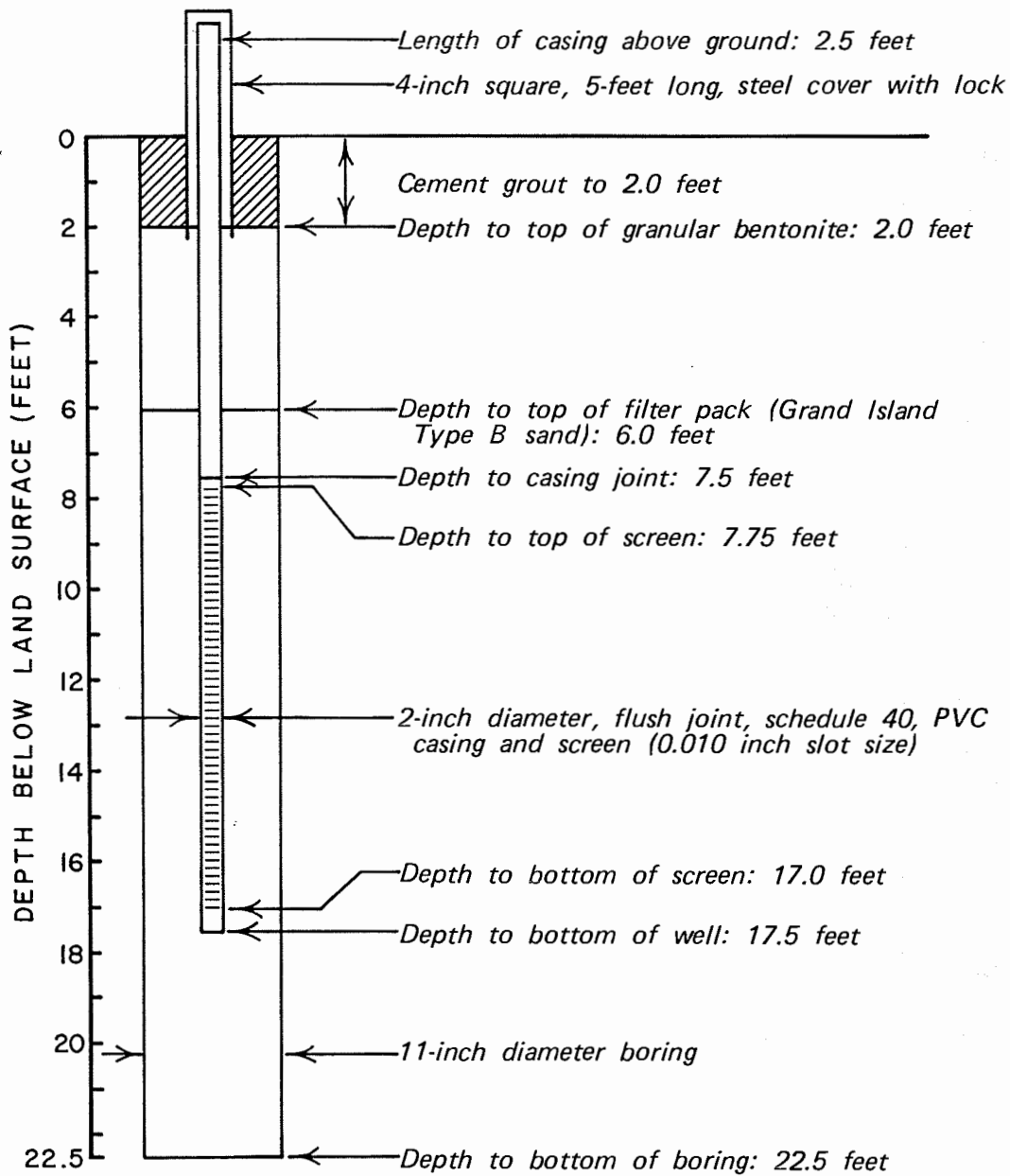
R20-88-20



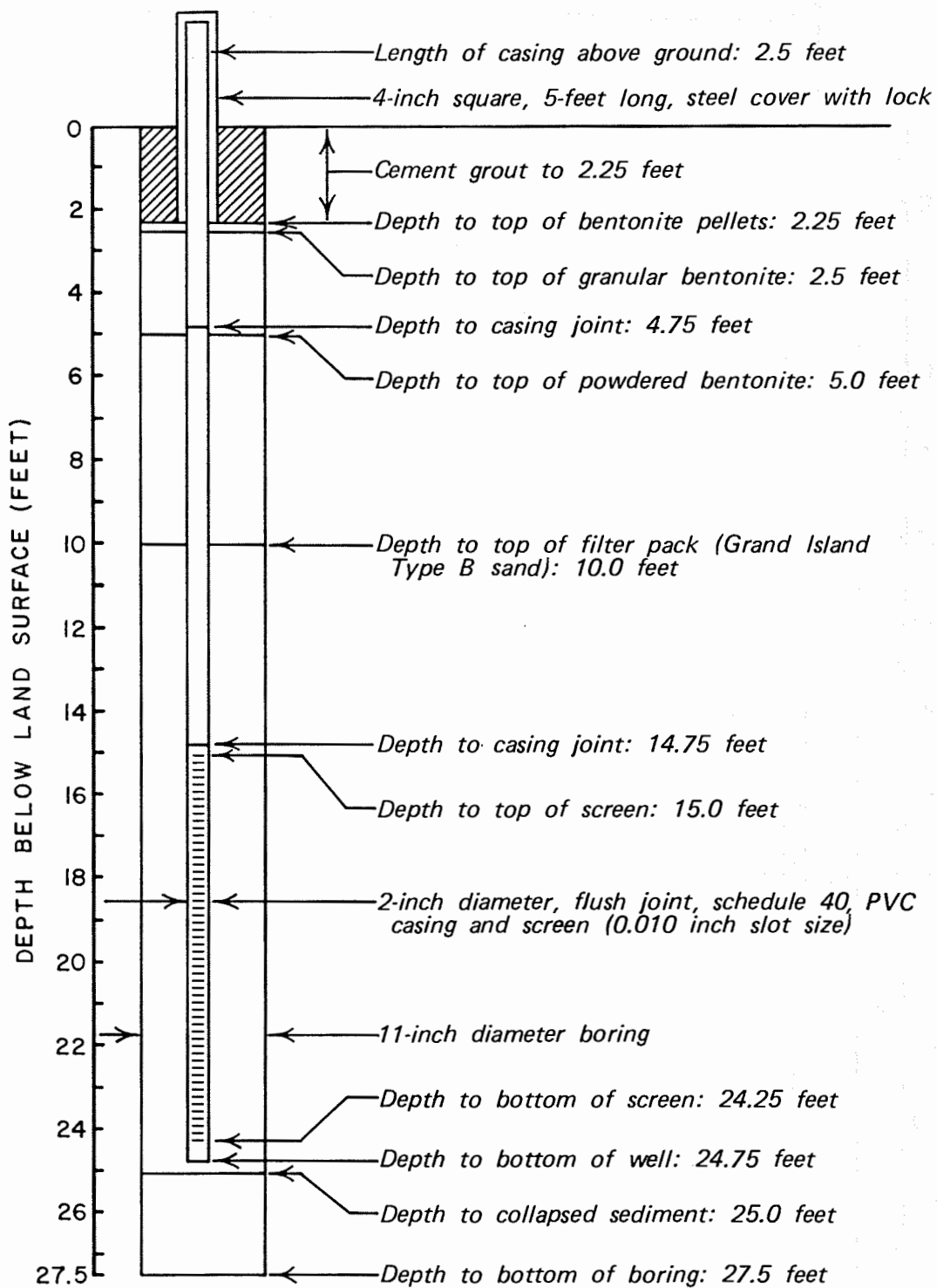
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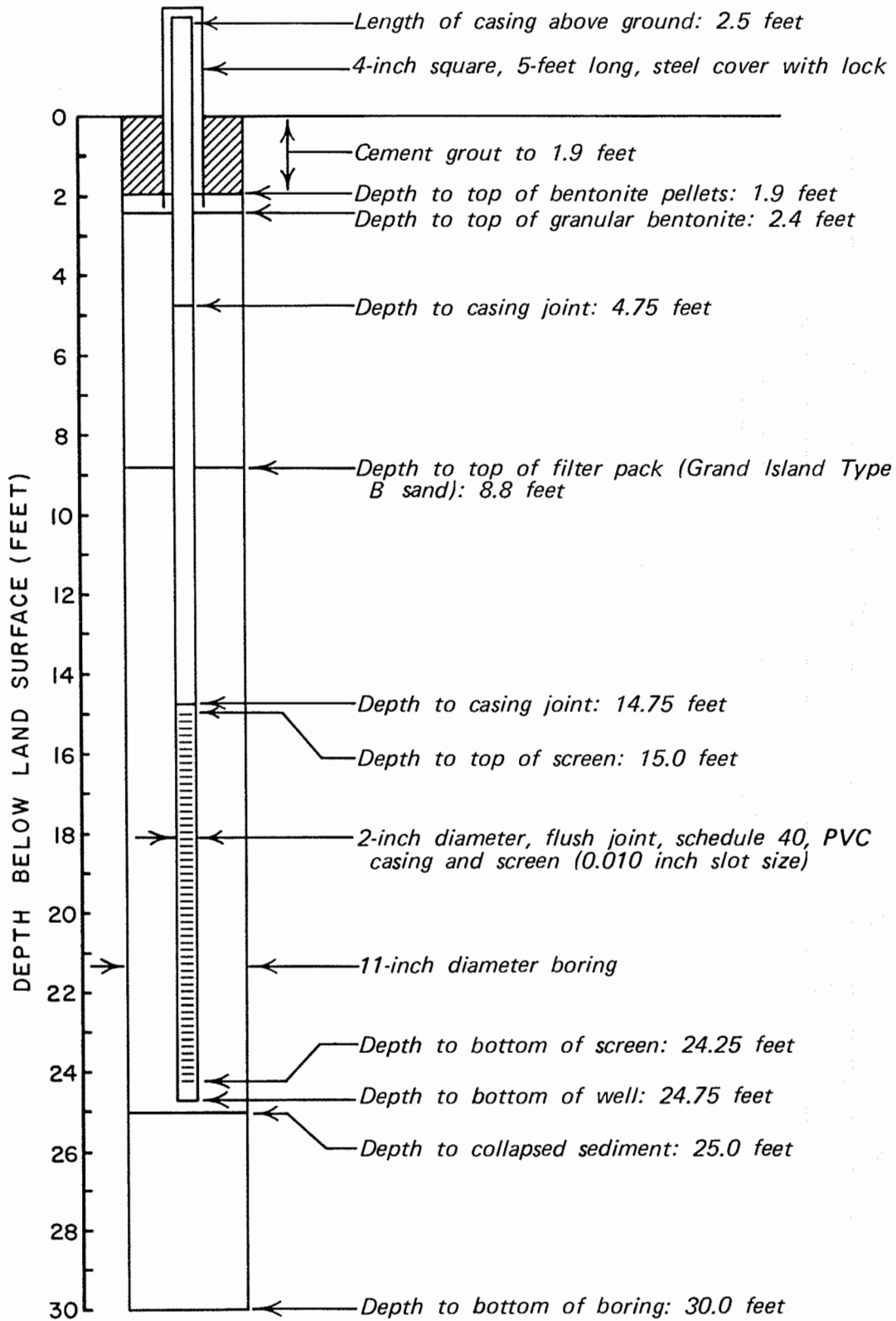
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# R20-88-25



R20-88-26

