WATER SUPPLY INVESTIGATION FOR OLD SETTLERS MEMORIAL PARK, NELSON COUNTY, NORTH DAKOTA

By
Jon C. Patch

North Dakota Ground-Water Studies
Number 99
North Dakota State Water Commission

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INTRODUCTION

In March, 1990, the Nelson County Water Resources District (WRD) requested assistance from the State Water Commission (SWC) to develop a new water supply for Old Settlers Memorial Park near Stump Lake in Nelson County (figure 1). A new water supply is necessary to meet the current needs of the park and the future needs of a golf course planned for the area.

The existing water supply for the park is from wells located on park property. The water from these wells is relatively high in total dissolved solids (TDS) concentration and is not suitable for irrigation and undesirable for most other uses. Water in the adjacent Stump Lake is highly saline with a TDS concentration about three times that of sea water. Test drilling done in and near the park property by private drilling companies did not indicate an adequate supply of ground water to meet the needs of the park.

PURPOSE

The primary purpose of this investigation is to find a suitable water supply both in quality and quantity. The park needs a well capacity of 200 to 400 gpm and water acceptable for golf course watering (low salinity and sodium hazard). Also, the water must be acceptable for human consumption at the park.

SCOPE

Available data in the study area suggests the best potential to meet the above needs is from the McVille aquifer. An area on the south end of Stump Lake was to be investigated if there was no indication of a suitable water supply at the Park. A cost sharing agreement between the Nelson County WRD and the State Water Commission was entered into in May, 1990 for the purpose of finding a suitable ground water supply for Old Settler's Memorial Park. The project consisted of five parts; preliminary planning, subsurface exploration, water quality

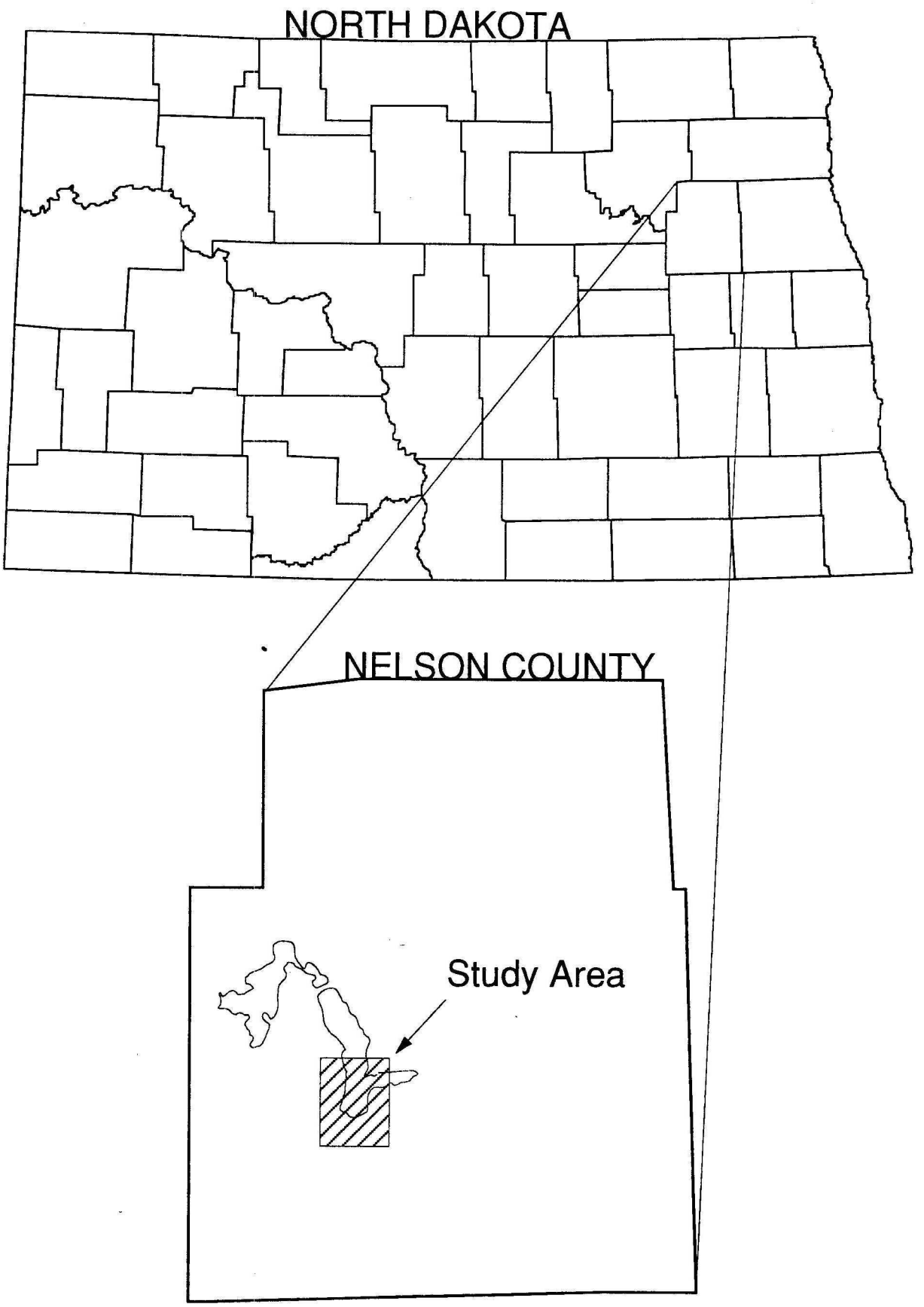


Figure 1 - Study area location

testing, surveying, and report preparation. Each of these phases of the project has been completed. This report will present the results of the study.

LOCATION NUMBERING SYSTEM

The description used to denote a well or test hole location is based upon the federal system of rectangular surveys of public land (figure 2). The first numeral denotes the township north of a base line, the second numeral denotes the range west of the fifth principal meridian, and the third numeral denotes the section in which the well is located. Letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section, quarter-quarter section, and quarter-quarter-quarter section (10 acre tract). For example, well 150-60-04ADD is in the SE1/4 SE1/4 NE1/4 Section 4, Township 150 North, Range 60 West (figure 2). Consecutive terminal numerals are added if more than one well is located in a 10-acre tract.

PREVIOUS INVESTIGATIONS

The geology of Nelson and Walsh counties were described by Bluemle (1973) as part of the county ground water studies program. Downey (1971, 1973) compiled the ground water data and described the ground water resources of Nelson and Walsh counties.

FIELD METHODS

In June , 1990, test holes were drilled using a forward mud-rotary rig at eight sites in the study area (figure 3). Drill cuttings were examined by an on-site geologist and a geologic log was completed for each test hole. Observation wells were installed at five of the eight drilling sites. The wells were constructed with 2-inch poly-vinyl chloride (PVC) casing and a 5-foot long 0.018 inch slot PVC screen. A check valve was attached to the bottom of the screen. After the casing screen and check valve assembly was inserted into the drill hole, the hole was back-washed with clean water through the casing, then blown with

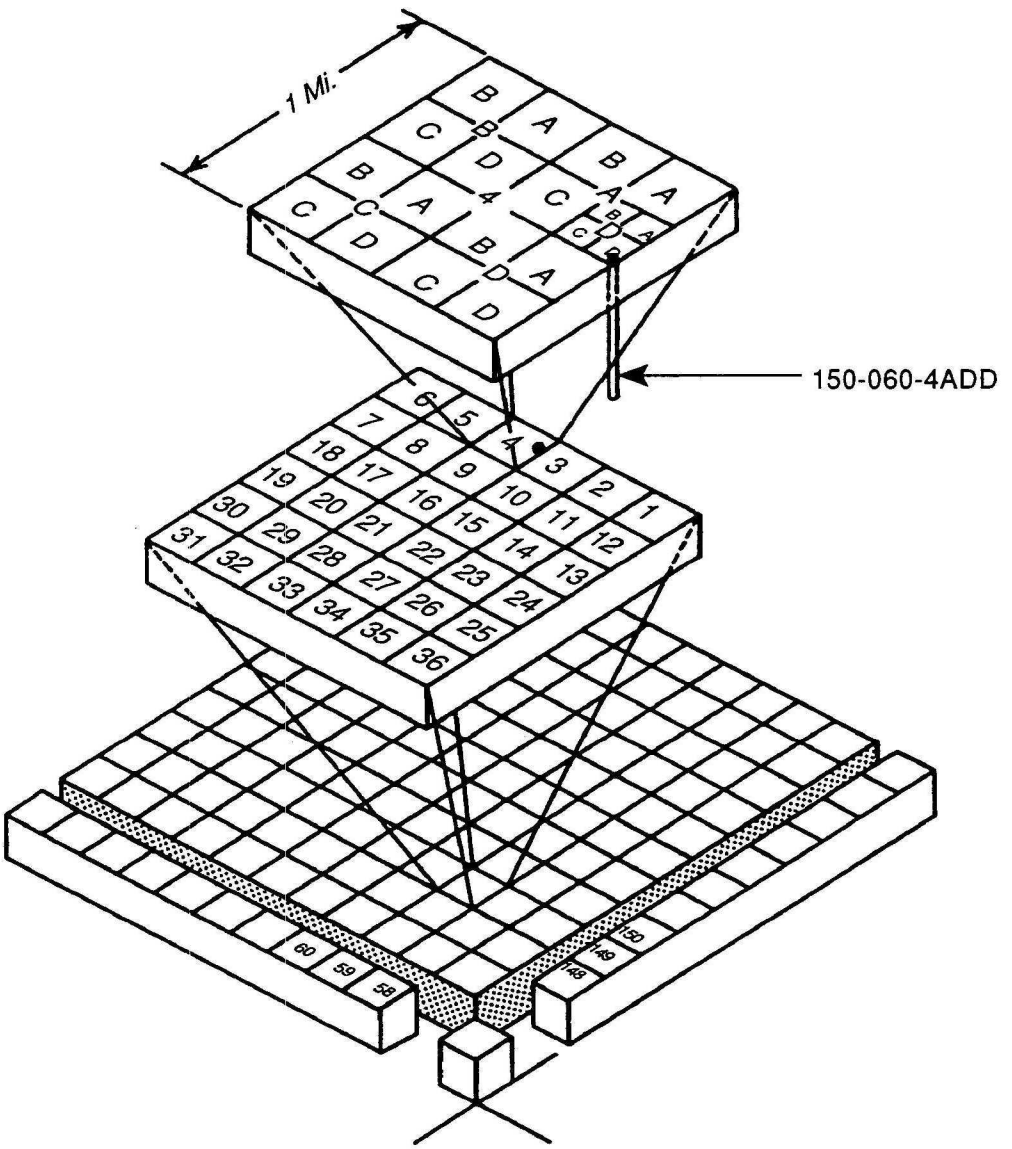
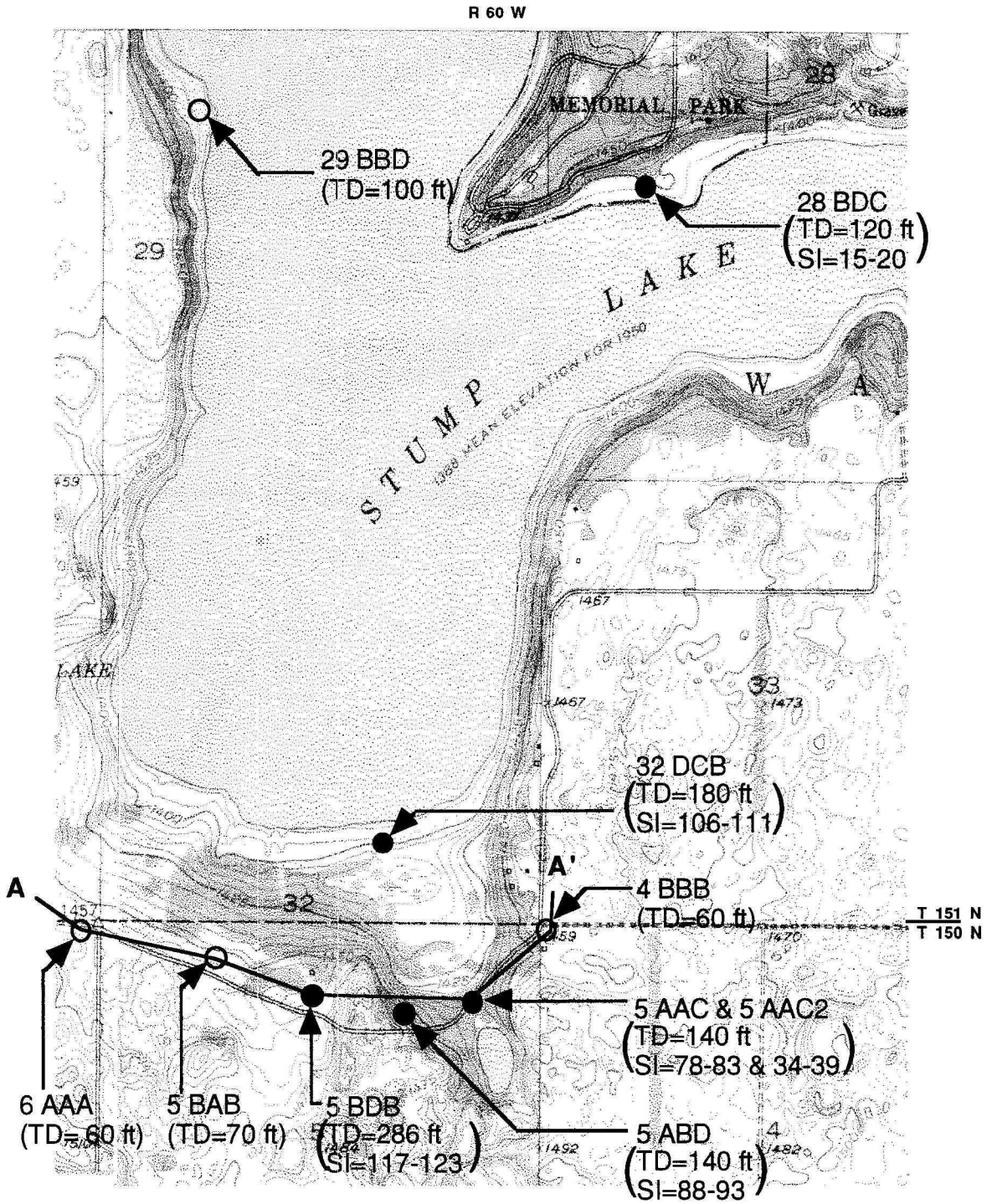


FIGURE 2. - Location numbering system



EXPLANATION

●	Observation Well
O	Test Hole
5 BDB (TD=286 ft SI=117-123)	Location description Total depth of test hloe Screened Interval

FIGURE 3 - Location of test holes and observation wells

compressed air causing the formation to collapse around the well screen. The annular space around the casing which remained open after collapsing the formation was sealed with a neat cement slurry to land surface. Upon completion, the wells were developed by pumping for several hours with the air lift method.

Water level measurements were made by inserting a chalked steel tape into the well and recording the water level to the nearest 1/100 foot. The exception to this was at one site where the water level was above the top of the well casing. Here, a pressure gage was connected to the top of the well and the shut-in pressure above the top of the measuring point was recorded and later converted to a water level.

The measuring point (MP) and land surface elevations relative to mean sea level were determined by differential leveling techniques. The level circuits were run with third-order accuracy and the elevations were recorded to the nearest 1/100 foot.

Water samples were collected from the wells for general water chemistry analysis. The wells were pumped with compressed air by inserting a small diameter rubber hose in the well to the top of the screen. Water was collected during evacuation from the well. The conductivity and temperature were recorded for each sample at the time of collection. Three samples were collected in plastic bottles for analysis in the laboratory:

1) Raw (500 mL)
2) Filtered (500 mL)
3) Filtered and acidified (500 mL)

A 2-mL ampule of concentrated nitric acid was added to sample 3 to prevent precipitation of carbonates and metal oxides. Specific conductance, pH, and concentration of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-})were measured in the lab using the raw sample. Concentrations of sulfate (SO_4^{2-}), chloride (Cl^-), fluoride (F^-), boron (B^{3+}), nitrate (NO_3^-), silica (SiO_2), and total dissolved solids were measured in the laboratory using the filtered (0.45 micron) sample. Concentrations of calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), iron (Fe^{2+}), and manganese (Mn^{2+}) were determined using the filtered and acidified sample.

DESCRIPTION OF STUDY AREA

The study area is limited to the vicinity of Old Settlers Memorial Park and the southern end of the east arm of Stump Lake in Nelson County (figure 1). The area is in the drift prairie region of the Central Lowland physiographic province. The area lies within the Devils Lake interior drainage basin. The topography is mainly hilly within the study area. The climate in the study area is subhumid with an average annual precipitation of about 18 inches.

GEOLOGY

The Pierre Formation of Cretaceous age unconformably underlies the Pleistocene deposits of the Coleharbor Group through most of the study area (figure 4). The Pierre Formation is composed of dark gray to black non-calcareous clay or shale and is believed to have been deposited in an offshore marine environment.

The Pleistocene Coleharbor Group is divided into three main textural facies: 1) till, 2) silt and clay, and 3) sand and gravel (Bluemle, 1975). Till is an unsorted mixture of material ranging in size from clay to boulders. The till was deposited in the form of moraines as glaciers advanced and receded over the area. The silt and clay facies was deposited in a glaciolacustine environment. The sand and gravel facies was deposited in a glaciofluvial environment.

Stump Lake (figure 5) originally formed as a proglacial lake which has persisted to this day although it has shrunk considerably in size (Bluemle, 1973). The depression in which Stump Lake formed may have originated as a result of a catastrophic erosional event such as the drainage of a glacial lake. The McVille trench was primarily cut into the easily erodible deposits of the Pierre Formation (figure 4). Bluemle (1973) states "This, the McVille trench, is deeply buried and has little or no surface expression throughout much of its length in Nelson County. It must have been cut as a diversion trench sometime prior to the Late Wisconsinian time". The saturated sand and gravel channel fill which now occupies the trench forms the McVille aquifer (figure 4). These deposits were formed as the trench became a regional drainageway.

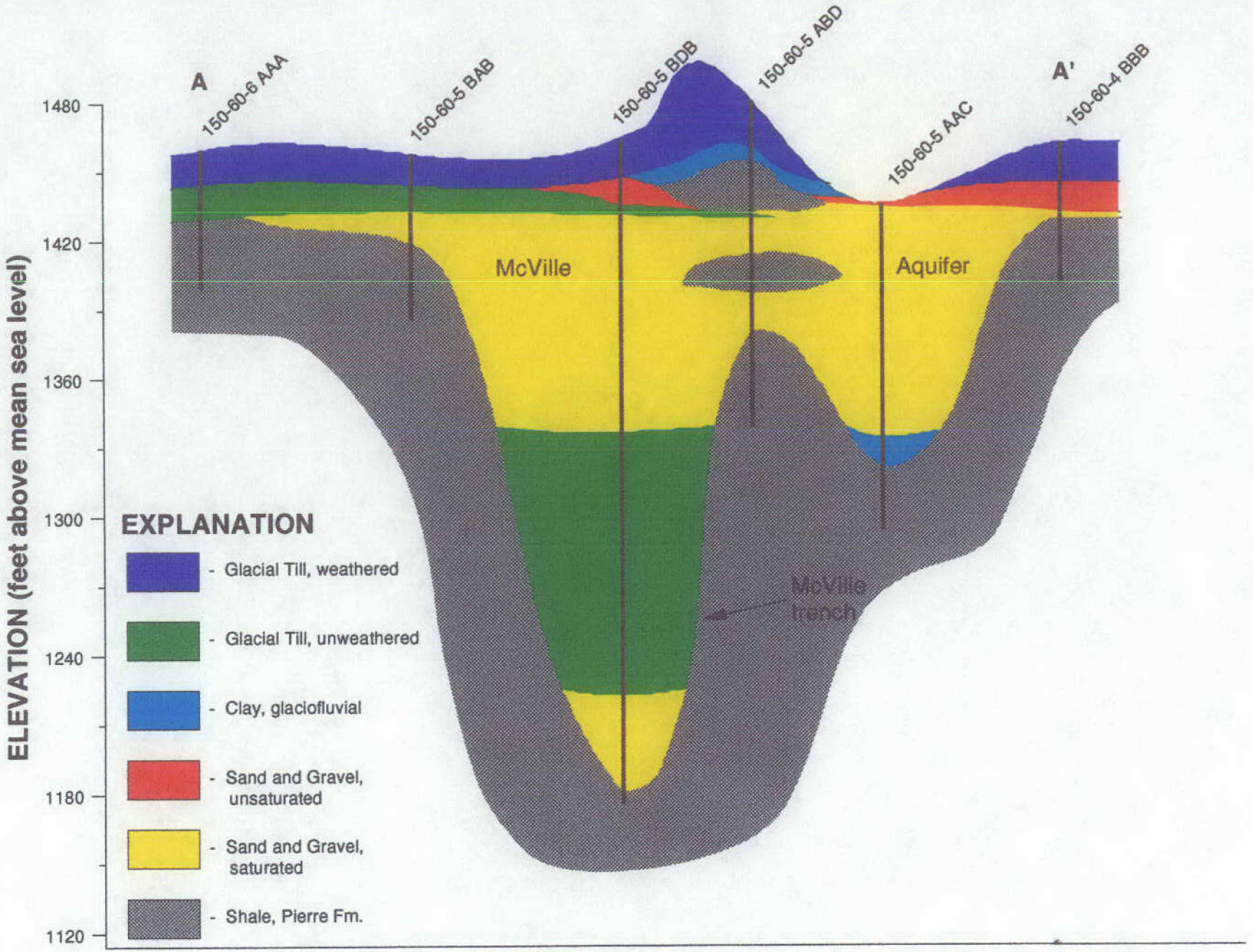
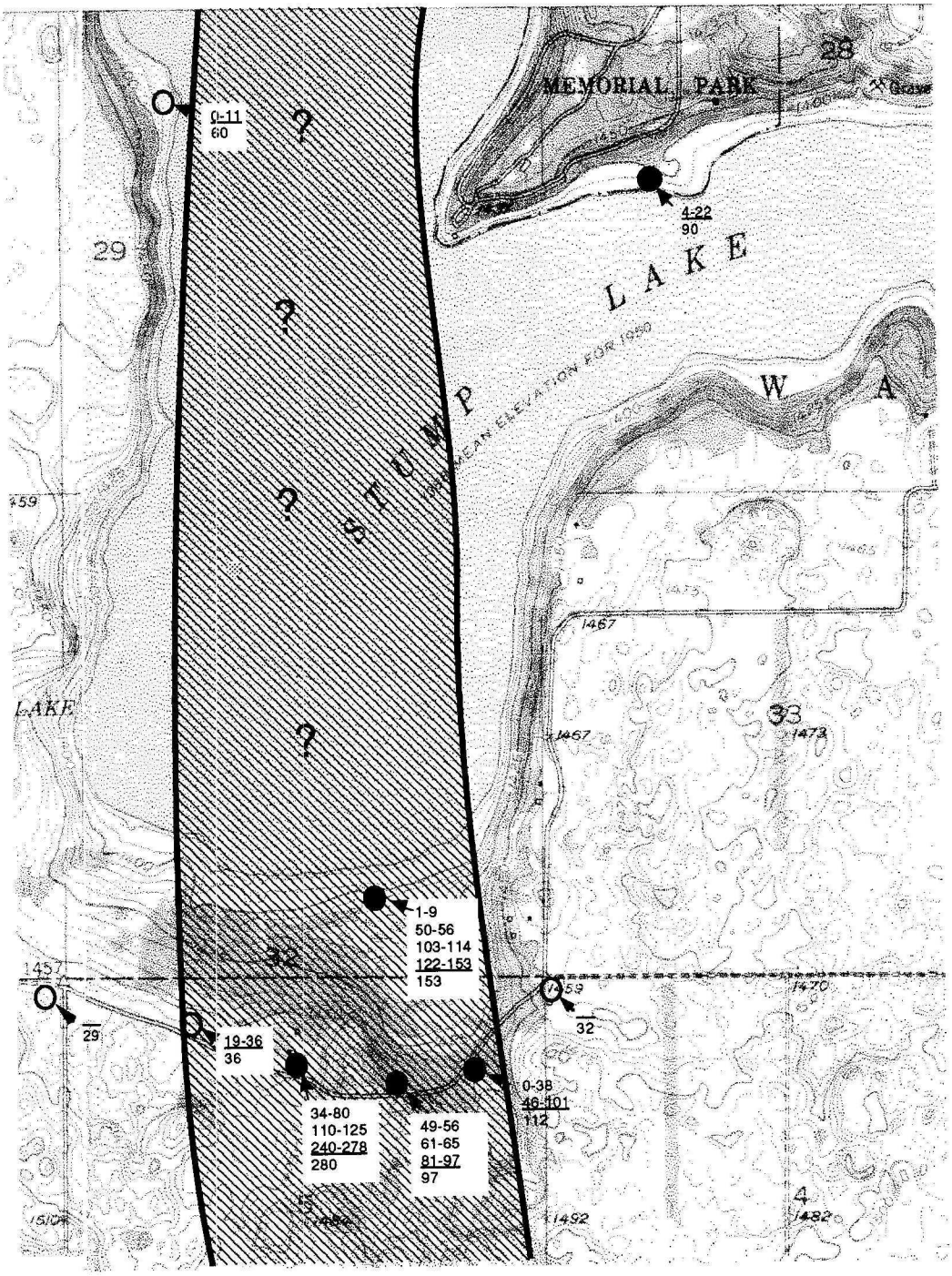


FIGURE 4 - Geologic Section A - A' shown on figure 2



EXPLANATION

McVille Aquifer

4-22
90

Above line is interval of sand and gravel
Below line is depth to bedrock

FIGURE 5 - Location of the McVille aquifer in the Study Area

Subsequent glacial advances covered portions of the channel with glacial till. It is possible that the depression which Stump Lake occupies may have formed as a result of glacial thrusting. This may have occurred where a southerly moving glacier overrode the saturated deposits in the McVille trench. The increased pore pressure within the aquifer as a result of the overriding ice may result in thrusting. This formation might be likened to popping the cork from a bottle of champagne (Bluemle, 1984) or a rolling pin across a tube of toothpaste. The glacial thrusting theory is supported by 1) the depression (Stump Lake) in the up gradient side of the glacial advance and the mound on the down gradient side 2) the "blocks" of Pierre shale which were logged in test hole 150-60-5 ABD (figure 4) 3) the apparent absence of sand and gravel in the trench adjacent to Old Settler's Memorial Park 4) other thrusting which has occurred in this region (Bluemle, 1981).

GROUND WATER HYDROLOGY

The McVille aquifer extends for about 70 miles beginning northwest of Stump Lake in Ramsey county and extending through Nelson, Griggs, Steele and into Barnes county. The aquifer is typically about 1/4 to 1/2 mile in width and averages several tens of feet thick. The aquifer is mainly composed of medium sand to fine gravel and is highly transmissive. The composition of the sand and gravel is about equal parts of silicate rock fragments, detrital shale, and detrital carbonate minerals. Within the study area, the aquifer ranged in thickness from 17 to 99 feet. Water levels measured in the wells completed in the aquifer indicate a northerly direction of flow toward Stump Lake.

Based on estimated average hydraulic conductivity (k) values of 500 to 750 ft/day for the McVille aquifer, the estimated transmissivity ranges from 5,700 to 49,500 ft^2/day. Specific capacities for a well completed in this type of material are typically 10 to 20 gpm per foot of drawdown. Using 1/2 of the total piezometric head (bottom of aquifer to water level) as the maximum available drawdown, well capacities ranging from 200 to 400 gpm are likely.

The aquifer is separated from the bottom of the lake by about 47 feet of glacial till (test hole 151-60-32 DCB). Test drilling indicates no direct hydraulic connection between the lake and the aquifer. The water level elevation at 151-60-32 DCB was 1443.1 feet and the lake level measured at same time was 1384.7 feet. The difference in water level elevation between the aquifer and the lake (58 feet) supports the available geological evidence that no direct hydraulic connection occurs between Stump Lake and the McVille aquifer. Several springs occur on the hillsides of the southern end of Stump Lake. The aquifer thins and may even be non-existent under Stump Lake.

WATER QUALITY

Water samples were collected for chemical analysis from the six observation wells completed in the study area (Table 1). All of the samples taken, with the exception of the sample from the well located at 151-60-28 BDC, are from the McVille aquifer (figure 6).

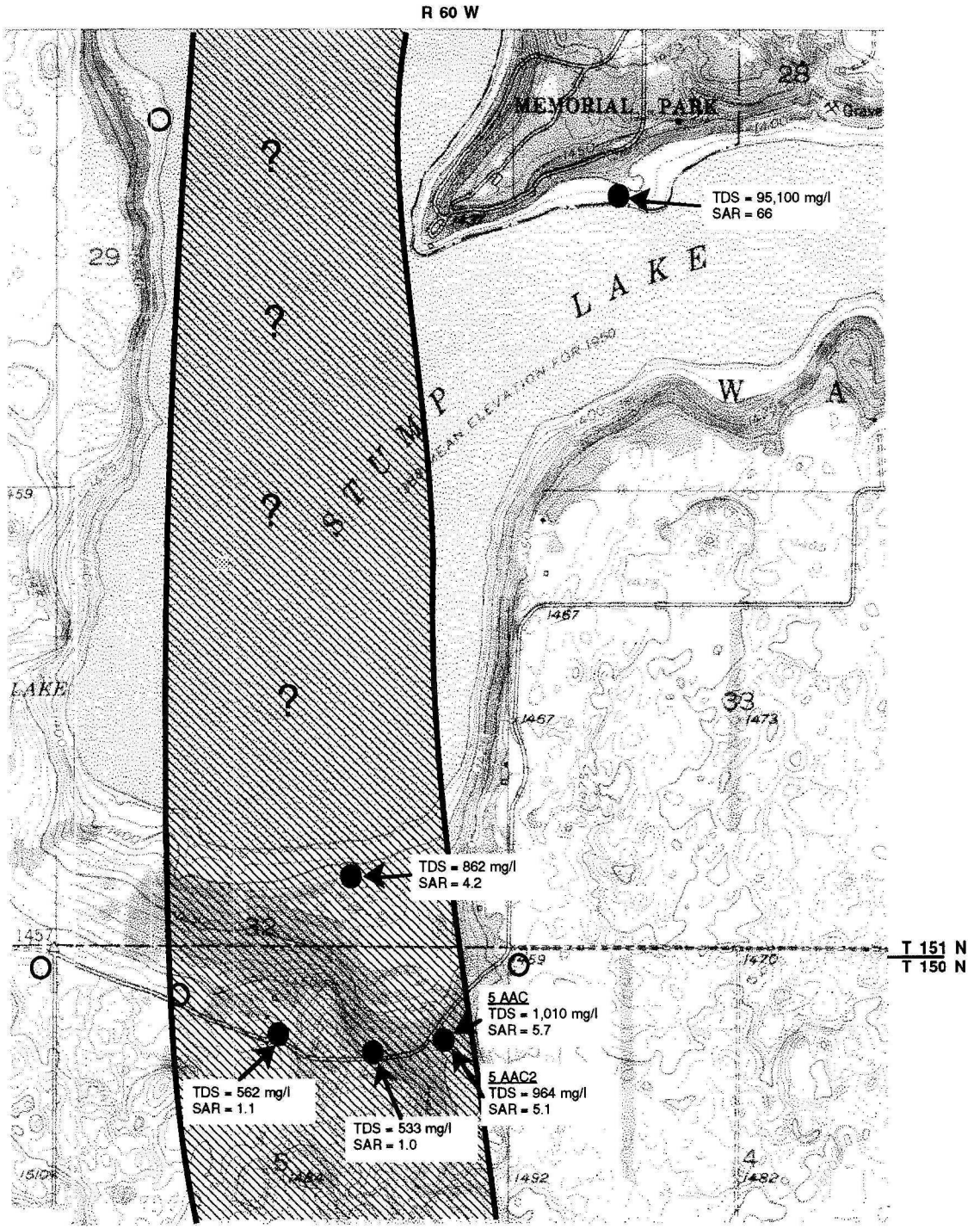
The suitability of water for irrigation application is evaluated using an irrigation classification system developed by the U.S. Department of Agriculture (1954). Classification is determined by comparing conductivity (salinity hazard) and the sodium adsorption ratio (sodium hazard). Figure 7 shows the six water quality analyses with respect to the USDA irrigation classification. The samples collected from & 150-060-05BDB are the most suitable for irrigation but do have a high salinity hazard. This water should only be used on soils of moderate to good permeability. Additional irrigation applications may be needed to induce leaching and prevent serious salt accumulation in the soil (NDSWC, 1972).

The EPA non mandatory guidelines for drinking and domestic use are as follows:

Iron	0.3
Manganese	0.05
Magnesium	125
Sulfate	250
Chloride	250
Fluoride	1.5
Nitrate	45
TDS	500

	150-060-05AAC	150-060-05AAC2	150-060-05ABD	150-060-05BDB	151-060-28BDC	151-060-32DCB
Date of Sample	06-20-90	06-21-90	06-01-90	06-21-90	06-20-90	06-21-90
Screened Interval	78-83	34-39	88-93	97-108	15-20	111-116
SiO_2 (mg/l)	25	26	27	26	16	27
Fe (mg/l)	0.08	0.58	0.16	0.31	18	0.58
Mn (mg/l)	0.62	0.53	0.92	0.94	15	0.88
Ca (mg/l)	82	76	97	100	330	100
Mg (mg/l)	30	32	28	26	5300	25
Na (mg/l)	240	210	43	50	23000	180
K (mg/l)	8	7	3	5	970	9
HCO_3(mg/l)	449	496	385	363	901	476
CO_3 (mg/l)	0	0	0	0	0	0
SO_4 (mg/l)	280	300	130	160	56000	270
Cl (mg/l)	120	66	12	14	9000	14
F (mg/l)	0.2	0.2	0.2	0.1	0.1	0.2
NO_3 (mg/l)	1	1	1	1	1	1
B (mg/l)	0.49	0.33	0.1	0.19	4.7	0.4
TDS (mg/l)	1010	964	533	562	95100	862
Hardness (mg/l)	330	320	360	360	23000	350
NCH (mg/l)	0	0	42	59	22000	0
% Na	61	58	21	23	68	52
SAR	5.7	5.1	1	1.1	66	4.2
Spec. Cond (µmho)	1660	1610	868	890	72700	1495
Temp (^{o}C)	7	7	7	8	6	8

TABLE 1 - Water Chemistry Analyses for the Wells in the Study Area



EXPLANATION

McVille Aquifer

TDS = 533 mg/l
SAR = 1.0

Total Dissolved Solids in milligrams per liter
Sodium Adsorption Ratio

FIGURE 6 - Map showing selected chemical analyses

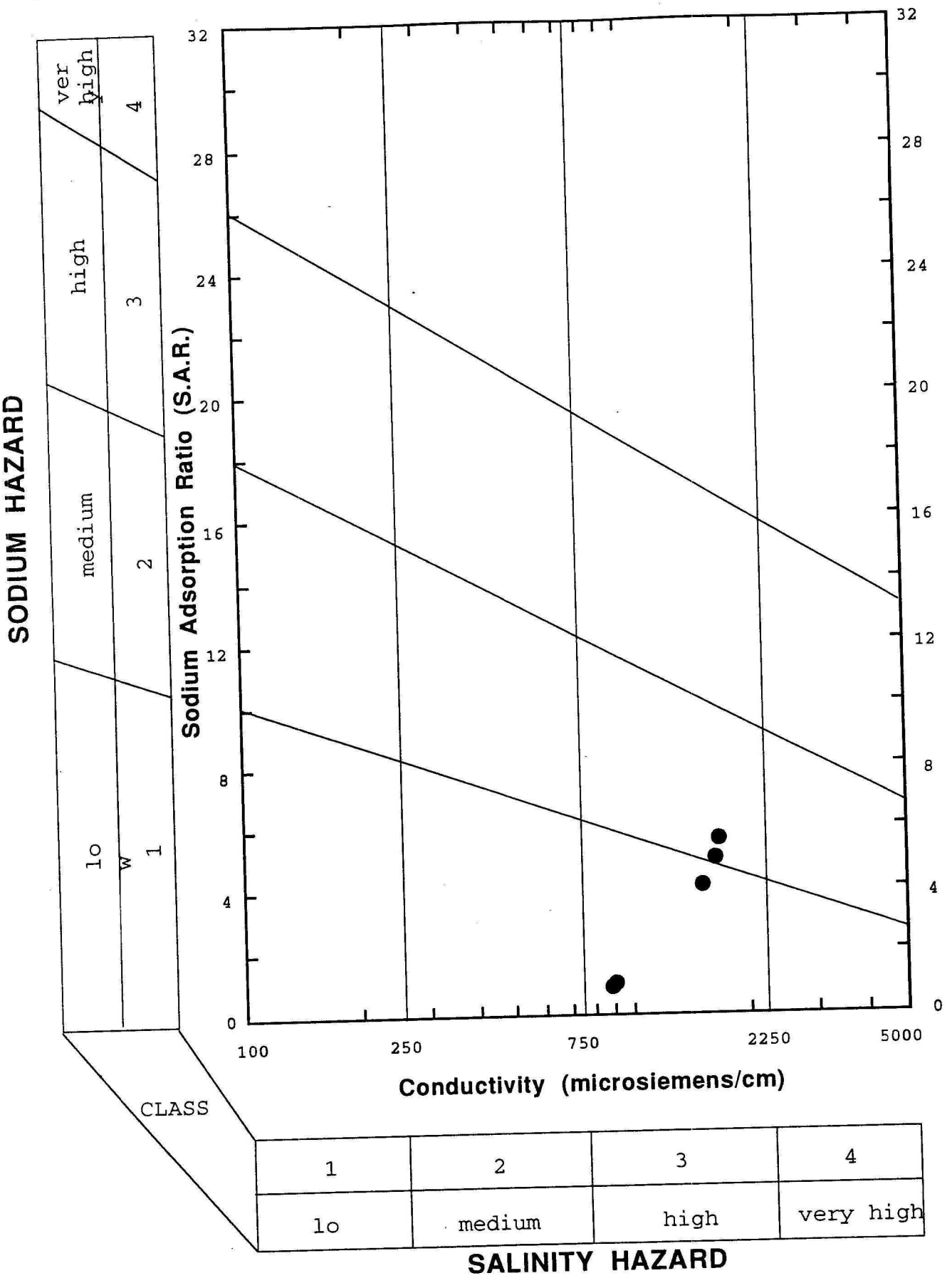


FIGURE 7 - Irrigation Classification Diagram (USDA, 1954)

Elevated nitrate concentrations in water can be harmful to infants because of the potential for methemoglobinemia, therefore, concentrations above 45 mg/l are not recommended for infants or nursing mothers. Slightly elevated concentrations of the other constituents listed are not harmful for human consumption. Elevated iron and manganese concentrations can cause staining of plumbing fixtures and clothes washed with this water. High magnesium, sulfate or chloride can have a laxative effect on those not accustomed to the water. Although there is no guideline, high sodium levels are not recommended for persons on a salt-restricted diet (NDSWC, 1978).

Of the samples collected, the water from wells 150-060-05ABD & 150-060-05BDB are the most suitable for human consumption. However, both of these samples have very high manganese concentrations which may cause staining.

SUMMARY

Results of the investigation to identify a suitable water supply for Old Settlers Memorial Park and a golf course are as follows:

1) The McVille aquifer occurs at the southern end of Stump Lake and does not occur within the Park.

2) The McVille aquifer consists of 17 to 99 feet of sand and gravel at the 6 sites it was encountered.

3) Estimated individual well yields range from 200 to 1000 gpm.

4) The water quality is suitable for irrigation under proper water management. Irrigation application in the fall may be required to induce leaching and flush the potential salt build-up in the soil profile.

5) The water quality is acceptable for human consumption even though the TDS is slightly higher than the EPA recommendations. Other than an elevated manganese concentration which may cause some staining of fixtures after prolonged use, the water meets the other EPA non-mandatory guidelines.

RECOMMENDATIONS

The site at 150-060-05ABD is the site recommended for the construction of a water supply well to serve the park and golf course. Although the test hole at this site does not show the thickness of the aquifer to be as great as some of the other test hole locations, the 16 foot interval of sand and gravel from 81 to 97 feet appears to be capable of meeting the desired capacity needed (200 to 400 gpm) for Old Settlers Memorial Park and golf course.

An alternative production well site is either 150-060-05BDB or 150-060-05AAC. The water quality at 05BDB is the similar water quality to 05ABD. A disadvantage is the added distance from the park. 150-060-05AAC is closer to the park but has the disadvantage of higher TDS concentrations and SAR. The water at 150-060-05AAC may be suitable for drinking and other domestic purposes, however, the SAR of 5.1 to 5.7 may adversely affect its suitability for irrigation.

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SUPPLEMENTAL DATA - TEST HOLE LOGS

150
~~151~~-060-04 BBB
NDSWC 12586

Date completed: 6/13/90
Depth drilled: 60 ft

Purpose: test hole
Source of data: SWC(jcp)
Land surface altitude (ft): 1458

Lithologic Log

Unit description	Depth (ft)
TOPSOIL	0-1
CLAY, pebbly, inclusions, oxidized, soft, (till)	1-18
SAND AND GRAVEL, very fine sand to 5mm gravel, poorly sorted, mainly medium to coarse sand, 30% shale, 30% carbonates, 30% quartz and igneous rock fragments, oxidized from 18-31, non-oxidized 31-32 feet	18-32
SHALE, dark gray to black, slightly to very brittle, white bentonitic zones, (Bedrock Pierre Formation)	32-60

150
~~151~~-060-05 AAC
NDSWC 12585

Date completed: 6/13/90
Depth drilled: 140 ft
Screened interval: 78-83
Casing Size: 2" PVC

Purpose: observation
Source of data: SWC(jcp)
Principal aquifer: McVille
Land surface altitude (ft): 1432.44

Lithologic Log

Unit description	Depth (ft)
SAND AND GRAVEL, fine sand to 15mm gravel, poorly sorted, very coarse and clean, predominantly very coarse sand to 3mm gravel, sub-round to sub-angular, 30% shale, 30% carbonates, 30-40% quartz and igneous rock fragments, drills very fast and easy, oxidized to about 8 feet	0-38
CLAY, medium gray, moderately soft to moderately firm, cohesive, (lacustrine)	38-46
SAND AND GRAVEL, as above, zones of very coarse large shale gravel interbedded with the other sand and gravel	46-101
CLAY, silty, medium gray, soft, no inclusions (lacustrine)	101-112
SHALE, dark gray to black, brittle to firm, slow firm drilling (Bedrock Pierre Formation)	112-140

150
~~151~~-060-05 AAC2
NDSWC 12590

Date completed: 6/14/90
Depth drilled: 50 ft
Screened interval: 34-39
Casing Size: 2" PVC

Purpose: observation
Source of data: SWC(jcp)
Principal aquifer: McVille
Land surface altitude (ft): 1432.32

see lithologic log for 150-60-05 AAC

150-060-05 ABD
NDSWC 12584

Date completed:	6/11/90	Purpose:	observation
Depth drilled:	140 ft	Source of data:	SWC(jcp)
Screened interval:	88-93	Principal aquifer:	McVille
Casing Size:	2" PVC	Land surface altitude (ft):	1476.28

Lithologic Log

Unit description	Depth (ft)
TOPSOIL	0-1
CLAY, silty, sandy, soft, oxidized, yellow	1-7
CLAY, silty, sandy, pebbly inclusions, yellow-brown (Till)	7-13
CLAY, slightly silty, oxidized, soft, cohesive	13-16
CLAY, slightly silty, unoxidized, medium gray, no inclusions, cohesive, (lacustrine)	16-21
CLAY, shaley, dark gray to black, greasy to brittle laminations (Bedrock Pierre Formation shove block))	21-46
CLAY, silty, sandy, pebbly, inclusions, moderately firm, medium gray, poor sample recovery, highly interbedded with gravel lenses, large rocks at 46-47, (till)	46-49
SAND AND GRAVEL, very fine sand to 15mm gravel, poorly sorted, mainly fine gravel, washing and taking water, 50% shale	49-56
CLAY, (Till), and lenses of sand and gravel, rock at 56-57	56-61
SAND AND GRAVEL, as above, cleaner, higher shale content	61-65
CLAY, dark gray to black, greasy to slightly brittle, interbedded with gravel lenses from 65-70,(Bedrock Pierre Formation shove block)	65-81
SAND AND GRAVEL, fine sand to 10-20mm gravel, poorly sorted, mainly 3mm gravel, clean coarse material, 30% shale, 30% carbonates, 30% quartz and igneous rock fragments, used much of drilling mud	81-97
SHALE, brittle to moderately firm, zones of bentonitic material, dark gray to black, slow firm drilling, (Bedrock Pierre Formation)	97-140

150-060-05 BAB
NDSWC 12588

Date completed: 6/13/90
Depth drilled: 70 ft

Purpose: test hole
Source of data: SWC(jcp)
Land surface altitude (ft): 1455

Lithologic Log

Unit description	Depth (ft)
TOPSOIL	0-1
CLAY, yellow buff, soft, oxidized	1-7
CLAY, silty, sandy, pebbly, inclusions, oxidized, light brown, soft (till)	7-10
CLAY, silty, sandy, pebbly, inclusions, moderately firm, medium gray (till)	10-19
SAND AND GRAVEL, fine sand to 30+mm gravel, poorly sorted, very large shale gravel, mainly very coarse sand and 2mm gravel, sub-angular to angular, mostly shale, carbonates, igneous type rock fragments and quartz grains	19-36
SHALE, clayey, brittle to moderately firm, dark gray to black, slow drilling (Bedrock Pierre Formation)	36-70

150-060-05 BDB
NDSWC 5351

Date completed:	July, 1969	Purpose:	observation
Depth drilled:	286 ft	Source of data:	SWC
Screened interval:	117-123	Principal aquifer:	McVille
Casing Size:	1" abs	Land surface altitude (ft):	1460.38

Lithologic Log

Unit description	Depth (ft)
TOPSOIL, clayey, silty, sandy, brownish-black	0-1
CLAY, silty, sandy, gravelly, yellow-brown, (till)	1-20
GRAVEL, sandy, fine to coarse	20-28
CLAY, silty, sandy, pebbly, olive-gray (till)	28-34
GRAVEL, sandy, fine to coarse	34-80
SAND, gravelly, fine to very coarse	80-90
CLAY, silty, sandy, olive-gray	90-110
SAND, very fine to very coarse	110-125
CLAY, sandy, silty, medium-dark-gray	125-170
CLAY, silty, sandy, pebbly, gravelly, olive-gray (till)	170-240
GRAVEL, sandy, clayey, fine to coarse	240-278
BOULDERS AND COBBLES	278-280
SHALE, siliceous, clayey, grayish black, (Bedrock Pierre Formation)	280-286

150-060-06 AAA
NDSWC 12587

Date completed: 6/13/90
Depth drilled: 60 ft

Purpose: test hole
Source of data: SWC(jcp)
Land surface altitude (ft): 1455

Lithologic Log

Unit description	Depth (ft)
TOPSOIL	0-1
CLAY, silty, soft, oxidized, yellow brown-buff, cohesive	1-9
CLAY, silty, sandy, pebbly, inclusions, oxidized, (till)	9-16
CLAY, silty, sandy, pebbly, inclusions, moderately firm, medium gray, rocks at 28-29 (till)	16-29
SHALE, dark gray to black, slightly to very brittle, (Bedrock Pierre Formation)	29-60

151-060-28 BDC
NDSWC 12591

Date completed:	6/14/90	Purpose:	observation
Depth drilled:	120 ft	Source of data:	SWC(jcp)
Screened interval:	15-20	Principal aquifer:	Unnamed
Casing Size:	2" PVC	Land surface altitude (ft):	1390

Lithologic Log

Unit description	Depth (ft)
TOPSOIL	0-1
CLAY, soft, oxidized, yellow brown	1-4
SAND AND GRAVEL, fine sand to 5mm gravel, poorly sorted, mainly very coarse sand and 2mm gravel, 40% igneous type rock fragments, 20% quartz, 20-30% shale, 20% carbonates	4-22
CLAY, slightly silty, light to medium gray, soft to moderately firm, fast drilling, (Lacustrine)	22-56
CLAY, silty, sandy, pebbly, inclusions, medium gray, moderately firm, (Till)	56-90
SHALE, clayey, brittle to firm, dark gray to black, (Bedrock Pierre Formation)	90-120

151-060-29 BBD
NDSWC 12583

Date completed: 6/11/90
Depth drilled: 100 ft

Purpose: test hole
Source of data: SWC(jcp)
Land surface altitude (ft): 1390

Lithologic Log

Unit description	Depth (ft)
SAND AND GRAVEL, very fine sand to 10mm gravel, poorly sorted, mainly very coarse sand and fine gravel, partially oxidized, mainly igneous type rock fragments, quartz, shale, and carbonates	0-9
SAND, very fine to medium, moderately sorted, mainly fine sand, dark, shaley	9-11
CLAY, light gray to black, laminated, strong H_2S odor, soft, sticky, cohesive, some dark brown carbonaceous lenses, (lacustrine)	11-33
CLAY, silty, sandy, pebbly inclusions, moderately firm, medium gray (till)	33-60
SHALE, clayey, brittle to firm, dark gray to black, slow firm drilling, white bentonitic lenses present (Bedrock Pierre Formation)	60-100

151-060-32 DCB
NDSWC 12589

Date completed:	6/13/90	Purpose:	observation
Depth drilled:	180 ft	Source of data:	SWC(jcp)
Screened interval:	106-111	Principal aquifer:	McVille
Casing Size:	2" PVC	Land surface altitude (ft):	1404.69

Lithologic Log

Unit description	Depth (ft)
TOPSOIL	0-1
SAND AND GRAVEL, poorly sorted, oxidized	1-3
CLAY, soft, oxidized, yellow brown	3-5
SAND, very fine to very coarse, poorly sorted, predominantly shale	5-9
CLAY, yellow to buff, oxidized	9-30
CLAY, slightly silty, unoxidized, medium gray, moderately soft, moderately cohesive, (lacustrine)	30-50
SAND, very fine to very coarse, poorly sorted, not much sample recovery, mostly shale sand	50-56
CLAY, silty, sandy, pebbly, inclusions, moderately firm, medium gray (till)	56-103
SAND AND GRAVEL, fine sand to 4-5mm gravel, poorly sorted, mainly very coarse sand and 2mm gravel, sub-angular to sub-round, 30% shale, 30% carbonates, 30-40% igneous type rock fragments and quartz grains	103-114
SHALE, clayey, brittle to moderately soft, dark gray to black, (Bedrock Pierre Formation)	114-122
SAND AND GRAVEL, very fine sand to 2mm gravel, moderately sorted, mainly medium sand, sub-angular to sub-round, 60% shale, 20% carbonates, 20% quartz grains, some lignite	122-153
SHALE, brittle to firm, dark gray to black, slow firm drilling (Bedrock Pierre Formation)	153-180