CARLIN HIGH SCHOOL

GEOTHERMAL WELL

April 22, 1985

Project No. 85-325

Prepared for:

ELKO COUNTY SCHOOL DISTRICT

Prepared by:

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Reno, Nevada 89503

CARLIN HIGH SCHOOL
GEOTHERMAL WELL

Report dated April 22, 1985

CORRIGENDA

Page 3, first paragraph -

Limestone beds below a depth of 974 feet were...
Chert beds between 821 and 974 feet depth...

should read:

Limestone beds below a depth of 875 feet were...
Chert beds between 821 and 875 feet depth...

Page 3, third paragraph -

At the well site, however, they are either poorly sorted or of insufficiently...

should read:

At the well site, however, they are either poorly sorted or are insufficiently...

Page 4, Figure 1 -

See attached new figure showing WELL SITE

Page 5, 11/30/84 -

Drilling equipment were mobilized...

should read:

Drilling equipment was mobilized...

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Page 6, 4.2, third paragraph -

The discrepancy of these logs...

should read:

The discrepancy between these logs...

Page 12, first paragraph -

...results are summarized below and data [___] listed in...

should read:

...results are summarized below and data are listed in...

Page 18, 6.1, second paragraph -

Specifically. the water exceds the...

should read:

Specifically, the water exceeds the...

also,

...are discussed in Section 7.

should read:

...are discussed in Section 7.0.

Page 23, fourth paragraph -

...is the need for storage of the fluid [___] during the irrigation season...

should read:

...is the need for storage of the fluid for use during the irrigation season...

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

1.0 FINDINGS

1. The Carlin High School Geothermal Well was completed to a depth of 904 feet. The well derives ground water primarily from production zones in fractured limestone below a depth of approximately 875 feet.

2. The well is capable of sustaining a continuous pumping rate of 50 gpm necessary to meet the average daily demand of the heating system virtually indefinitely. The well is also capable of meeting the maximum peak demand of 200 gpm. Temperature of the water is $87^{\circ}F$.

3. The chemical quality of the ground water derived from the Carlin High School Well meets State and Federal Primary Drinking Water Standards. The ground water is chemically similar to the Carlin town water supplies.

4. Corrosion or incrustation of pipes and heat exchanger units is not anticipated.

5. The total dissolved solids (TDS) of the ground water derived from the well exceeds the Nevada Department of Environmental Protection standards for direct discharge into the Humboldt River. Alternate methods of disposal include injection back into the aquifer, utilizing the water for irrigation, discharge to evaporation/infiltration ponds, and blending with Carlin town water supplies.

2.0 INTRODUCTION

On the basis of the results of a 591 feet deep test hole drilled on the grounds of the Carlin High School in March and April 1984, a geothermal production well was drilled for space-heating purposes. Drilling operations commenced December 1, 1984. A 904 feet deep production well was completed March 3, 1985. Upon completion, the well was subjected to a series of pumping tests to determine the yield of the well and to assess the chemical quality of the ground water derived from the well. This report summarizes the data obtained from the drilling and testing program and discusses alternatives for the disposal of the heat-spent geothermal fluid.

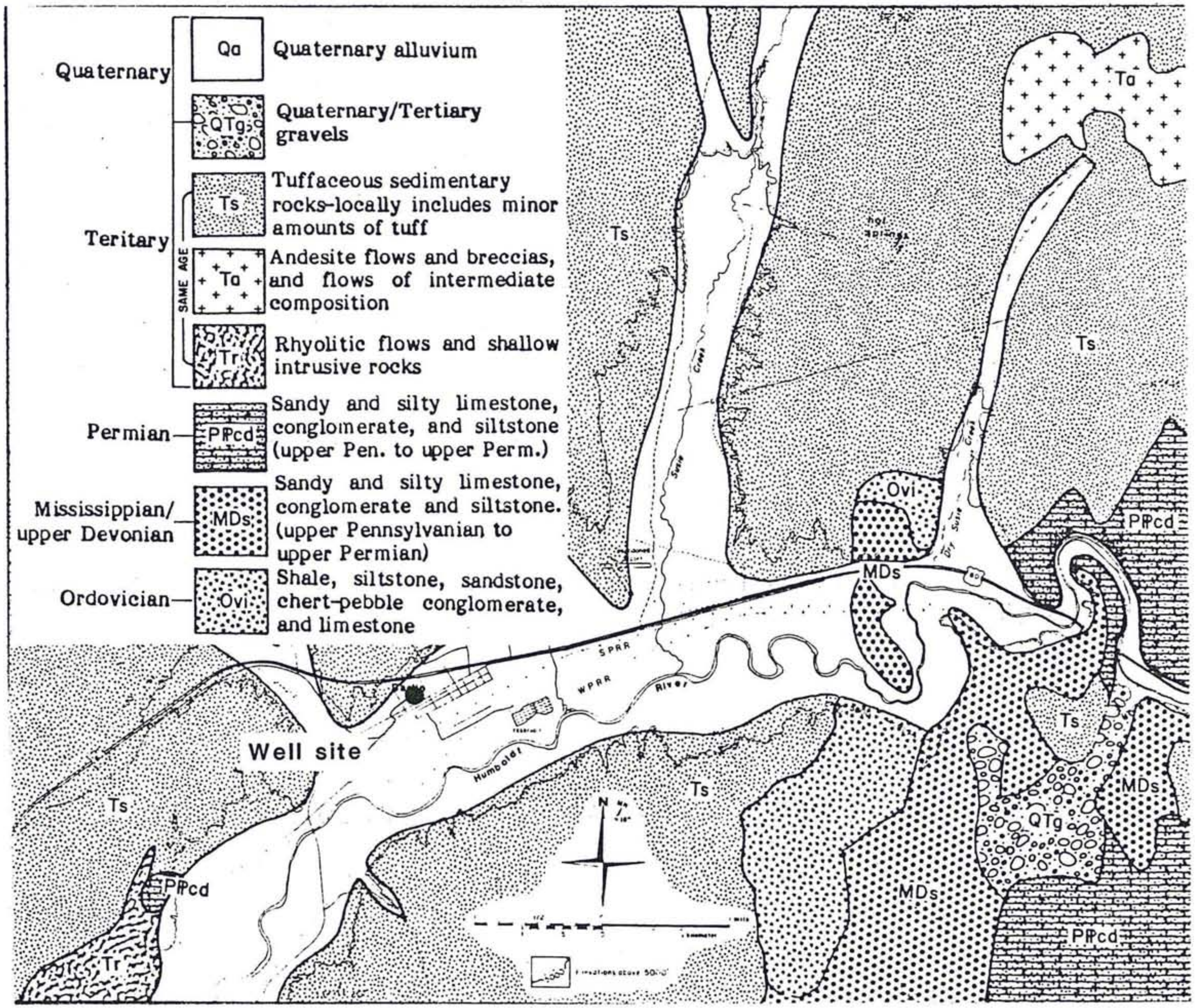
3.0 GEOLOGY

The geology in the vicinity of Carlin is summarized by Trexler, et. al. (1982). Geologic materials range from unconsolidated alluvial deposits to consolidated sedimentary rocks. The distribution of these various geologic units is given in Figure 1. Of the different units which crop out in the vicinity, only three were recognized as having been penetrated by the borehole. The oldest unit encountered in the borehole was the Vinnini Formation (Ovi). It comprises chert, shale, siltstone, and limestone and was penetrated below a depth of 821 feet. Limestone beds below a depth of 974 feet were highly fractured and yielded the bulk of the ground water derived from the well. Chert beds between of 821 and 974 feet depth also yielded ground water but in lesser amounts. Due to its wide distribution, this unit is a potentially significant geothermal aquifer in the vicinity of Carlin.

The Vinnini Formation is overlain by Carlin Formation (Ts) at the well site. The Carlin Formation comprises tuffaceaous sandstone, siltstone, conglomerate, tuff, ash, and limestone. A total of approximately 671 feet of this unit was penetrated by the well between depths of approximately 150 and 821 feet. These materials typically exhibit low permeability and serve to thermally and hydraulically isolate the warmer waters in the underlying Vinnini Formation from colder waters in the overlying alluvial deposits in this area.

Approximately 150 feet of unconsolidated alluvial deposits (Qa) comprising sandy clay and gravel overlie the Carlin Formation at the well site. Where saturated, these materials may constitute a suitable cold water alluvial aquifer. At the well site, however, they are either poorly sorted or of insufficiently thick to yield large amounts of ground water.

The low- to moderate-temperature geothermal resource in the vicinity of Carlin was assessed by Trexler (ibid.). This investigation suggested that sites with good potential for moderate- temperature geothermal resources existed at least three-fourths of a mile southwest of the high school. The school, however, is sufficiently close to the fringes of geochemical, geophysical, and thermal anomolies noted in the report to warrant drilling an exploration well on the premises.



(ref.: Trexler, et. al., 1982)

Figure 1. Geologic map, Carlin and vicinity.

4.0 WELL CONSTRUCTION SUMMARY

4.1 CHRONOLOGIC SUMMARY

Construction of the production geothermal well commenced December 1, 1984. Work was performed by Paul Williams and Sons, a Reno, Nevada-based drilling firm. A brief history of the drilling program is presented below.

11/30/84 Drilling equipment were mobilized to the well site.

12/01/84 Drilling of a 17 1/2-inch diameter borehole to a depth of 18 feet and installation of 16-inch diameter surface conductor casing was completed.

12/03/84 Drilling of a 14 3/4-inch diameter borehole commenced.

12/19/84 Drilling of a 14 3/4-inch diameter borehole to a depth of 625 feet was completed.

12/20/84 Drilling operations were suspended and equipment demobilized from the site for return to Elko.

1/08/85 Temperature survey of the borehole was performed.

2/11/85 Drilling equipment was remobilized to Carlin.

2/12/85 Drilling of a 9 7/8-inch diameter borehole below a depth of 625 feet commenced.

2/14/85 Drilling of a 9 7/8-inch diameter borehole to a depth 832 feet was completed; a second temperature survey of the borehole was performed; and reaming of the borehole to a diameter of 14 3/4 inches to a depth of 821 feet was completed.

2/17/85 Installation of blank 8 5/8-inch O.D. casing commenced.

2/20/85 Installation of blank 8 5/8-inch O.D. casing to a depth of 821 feet, sealing of the annulus with neat cement/bentonite slurry, and removal of the 16-inch diameter surface conductor casing was completed.

2/25/85 Drilling a 7 7/8-inch diameter borehole below a depth of 832 feet commenced.

3/01/85 Drilling the 7 7/8-inch diameter borehole to a depth of 904 feet was completed.

3/02/85 A total of 93 feet of 6 5/8-inch diameter perforated casing was installed in the well from a depth of 811 to 904 feet.

Upon completion of construction the well was air-lift pumped utilizing the drill-rig mounted air compressor. Yield of the well was estimated by the driller at approximately 300 gallons per minute (gpm). Test pumping equipment was installed in the well with the drill rig and support equipment was moved off the hole March 5, 1985.

4.2 TEMPERATURE SURVEYS

The production well was drilled on the premise that ground water with temperatures of approximately 100°F could be derived from Vinnini Formation below a depth of approximately 750 feet. This conclusion was based on results of a temperature survey of the test hole performed May 1, 1984.

The production well borehole was logged twice during the course of drilling. The first survey was conducted January 8, 1985 at which time the hole was 625 feet deep and temperature of fluid in the hole had been allowed to equilibrate with temperatures of the formation for 10 days. This log (Appendix A) yielded results different from that which were expected based on the log of the test hole. Compared to the log of the test hole, the production well borehole was virtually isothermal at 65°F between depths of 325 an 400 feet. It was obvious that the hole needed to be drilled deeper if a source of geothermal ground water was to be encountered.

The borehole was logged a second time on February 14, 1985 after the hole had been deepened to 800 feet. Results of this survey indicated a potential bottom-hole temperature of 82°F and indicated that temperatures approaching 110°F were not obtainable unless the well was drilled to depths approaching 1,500 feet or more. The discrepancy of these logs and the log of the test hole have yet to be resolved.

4.3 WELL-CONSTRUCTION DETAILS

The well was constructed so as to isolate the production zones from the shallow alluvial aquifer in the vicinity of Carlin. This was accomplished by installing blank well casing to a depth of 821 feet and sealing the annulus with a neat cement and bentonite slurry pumped under pressure from the bottom of the casing to land surface.

The major production zone is fractured limestone below a depth of 875 feet with secondary production zones between depths of 823 and 875 feet. Well construction details and a log of formation materials penetrated are illustrated in Figure 2. Additional construction information is listed below and Appendix B.

Casing Schedule

Depth interval (feet)	Remarks
+1-821	Blank 8 5/8-inch O.D. x 0.250-inch wall thickness steel well casing, specification ASTM A 53B.
811-904	6 5/8-inchO.D. x 0.250-inch wall thickness steel well casing, specification ASTM A 53B; quadruple 1/8" x 3" factory mill-slot perforations 823 to 904 feet.

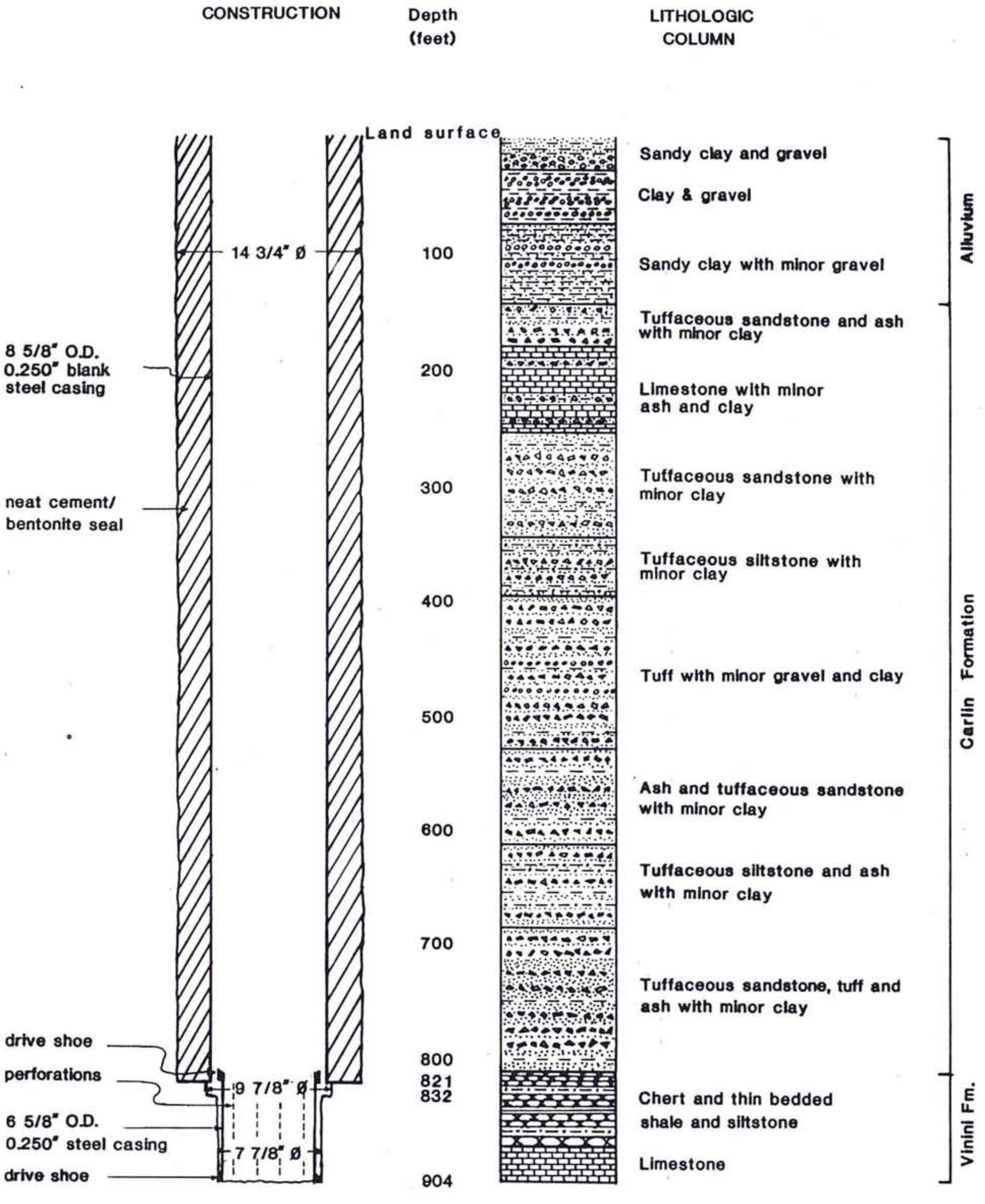


Figure 2. Carlin High School well construction and lithologic log.

5.0 AQUIFER TESTING

5.1 STEP-DRAWDOWN PUMPING TEST

A step-drawdown pumping test was conducted March 5, 1985 utilizing a turbine pump powered by a 30 horsepower submersible electric motor. Flow rates were measured by a four by three inch diameter pipe weir/orifice combination. The well was pumped at rates of 95, 200 and 298 gpm for a total of seven hours. Test data are plotted on Figure 3 and results summarized below.

> Static water level prior to pumping was 39.70 feet below the measuring point (M.P. = 2.0 feet above land surface). Testing commenced at 1530 hrs 3/5/85.

Step	Pumping rate Q (gpm)	Duration t (minutes)	Drawdown s (feet)	Specific Capacity Cs (gpm/ft)
I	95	60	30.66	3.10
II	200	150	77.90	2.57
III	298	180	173.86	1.69

> Testing was terminated at 2230 hrs 3/5/85. Water level in the well recovered 90 per cent within 12 hours following conclusion of pumping.

Specific capacity and drawdown data for each step are plotted on Figure 4 and suggest that the well was fully developed prior to the start of the pumping test.

The step-drawdown test data were analyzed to evaluate the efficiency of the well over a wide range of pumping rates. The results of this analysis are summarized below

Pumping rate (gpm)	Efficiency (per cent)
95	97
200	77
298	53

These results clearly illustrate that well efficiency decreases with increased pumping rate. Well losses are minimal at pumping rates up to 200 gpm but become large at 298 gpm. This is consistent with wells completed elsewhere in fractured rock where flow is linear toward a highly permeable fracture rather that radial toward a well and suggests that at the higher pumping rates flow in the fracture is turbulent.

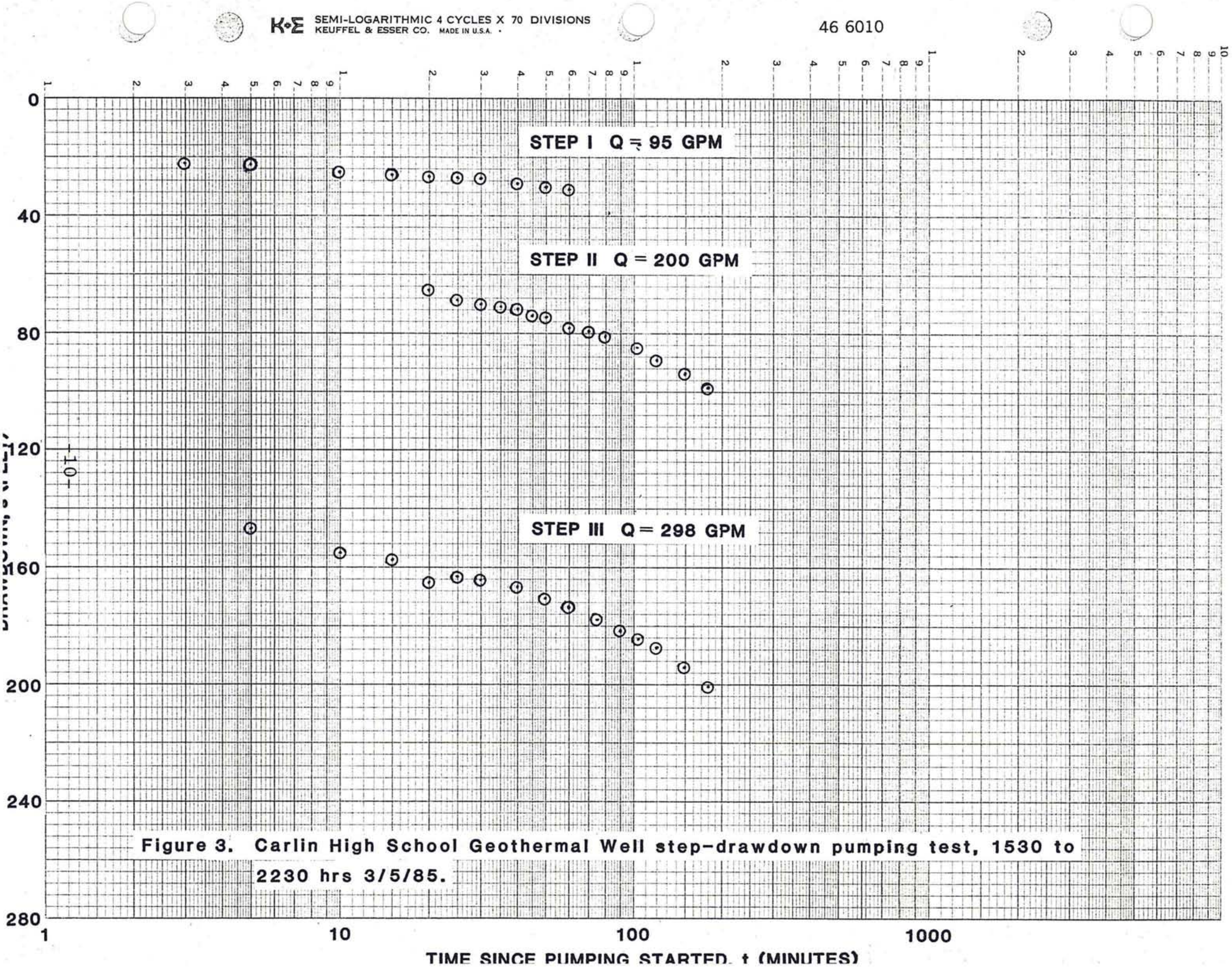


Figure 3. Carlin High School Geothermal Well step-drawdown pumping test, 1530 to 2230 hrs 3/5/85.

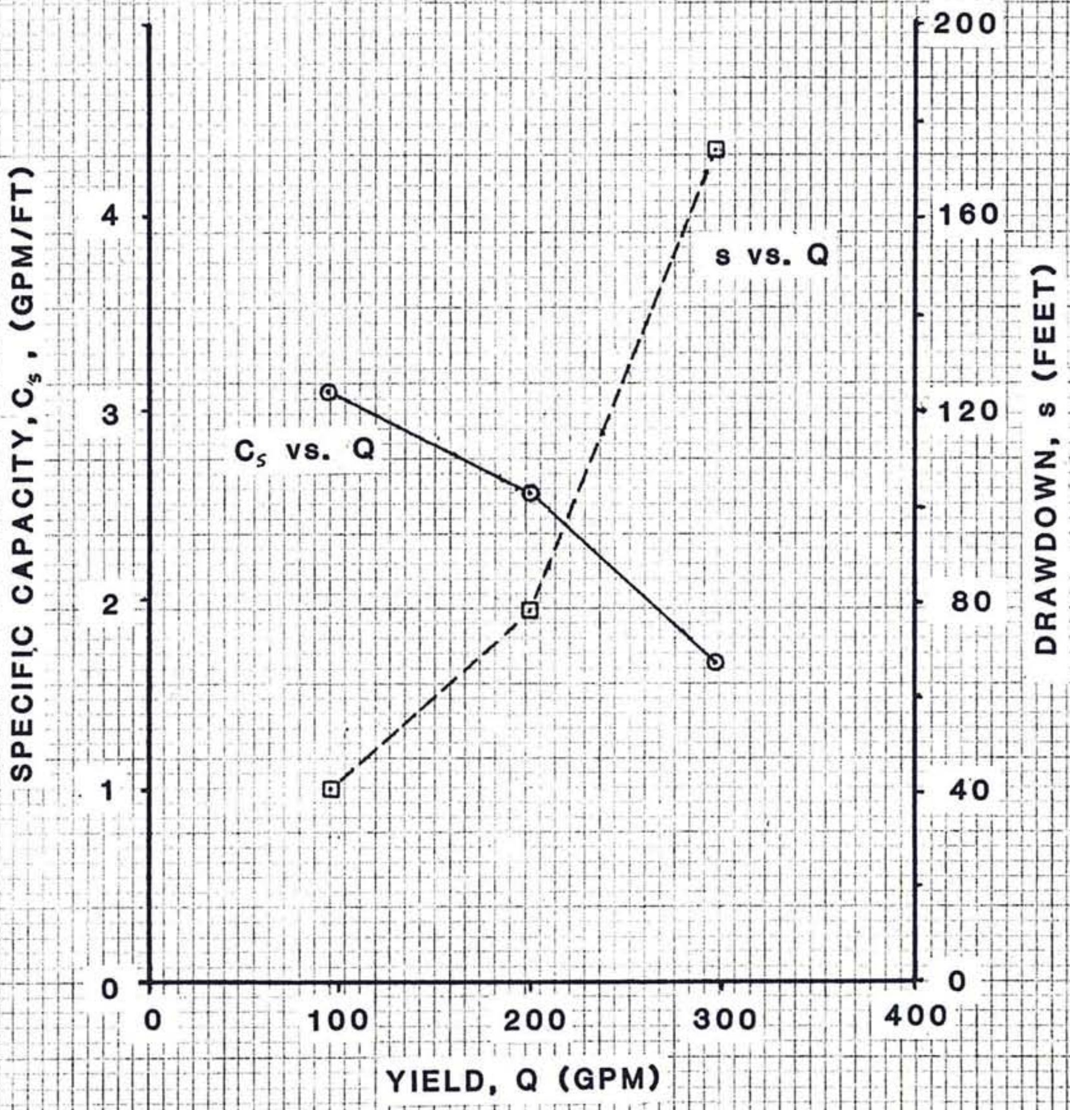


Figure 4. Specific capacity and drawdown versus yield, Carlin High School Geothermal Well.

5.2 CONSTANT-DISCHARGE PUMPING TEST

On the basis of the step-drawdown pumping test results, a pumping rate of 300 gpm was selected for the constant-discharge test. Testing results are summarized below and data listed in Appendix C.

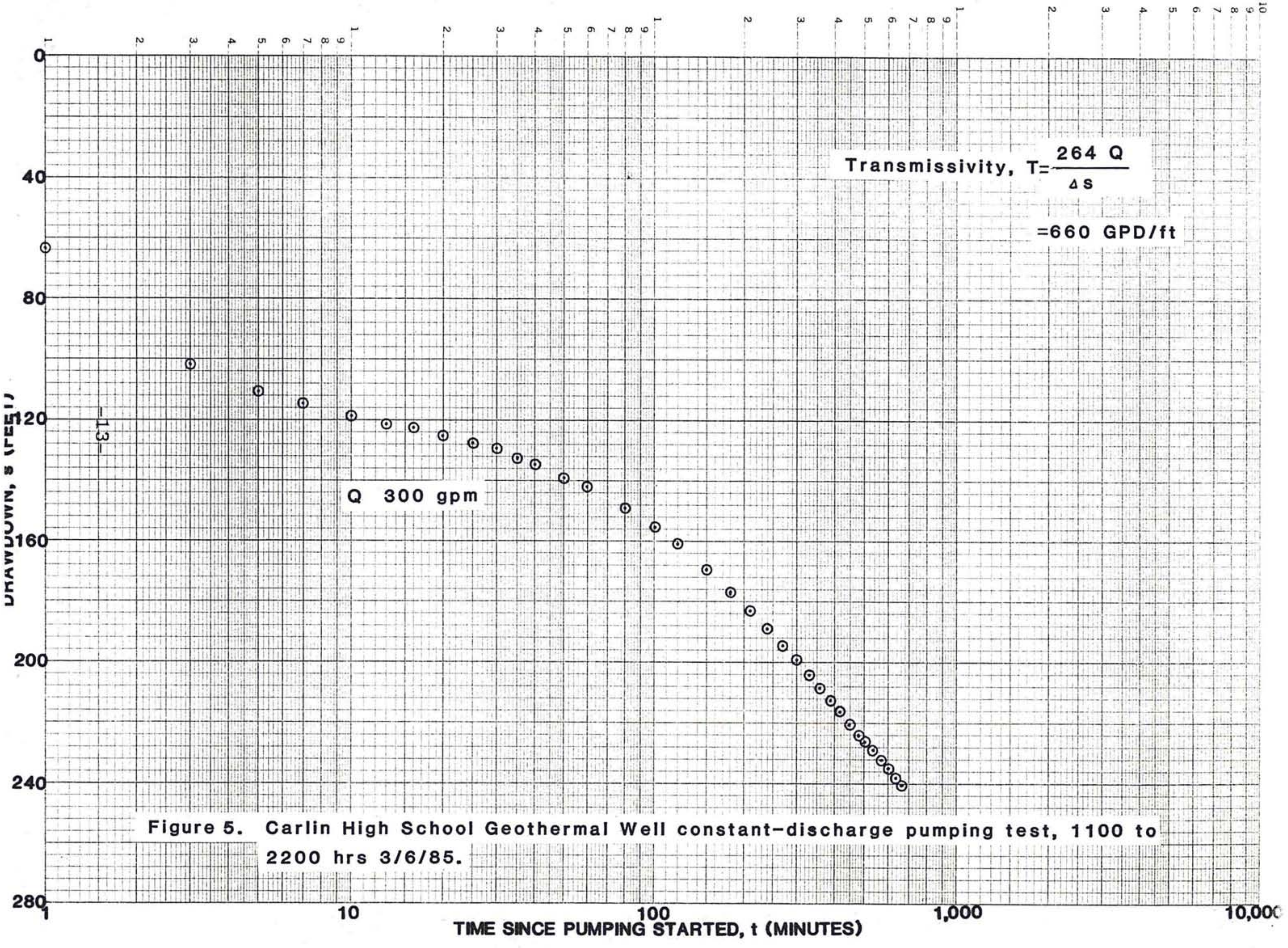
> Water level prior to the start of the test was 59.30 feet below M.P. Testing commenced at 1100 hrs 3/6/85. Pumping rate was held constant at 300 gpm. Testing was terminated after 11 hours. Drawdown at the conclusion of the test was 240.34 feet, a pumping water level of 299.64 feet.

Early-time test data plotted on Figures 5, 6, and 7 suggest a response indicative of fracture-dominated flow in the vicinity of the well bore where ground-water flow is linear toward a highly permeable fracture penetrated by the well (Jenkins and Prentice, 1982). Late-time data indicates a transition to radial-flow conditions after approximately 360 minutes. Equations which apply to radial-flow conditions were utilized to calculate aquifer characteristics. The aquifer transmissivity, the overall ability of the aquifer to transmit ground water, was calculated using Jacob's approximation of the the Theis equation and yielded a value of 660 gallons per day per foot (GPD/ft).

This value is indicative of low permeability materials. That the well is capable of discharge rates of up to 300 gallons per minute for as long as 11 hours is due in part to the presence of a relatively extensive fracture (or fracture system) penetrated by the well. Assuming that the aquifer is totally confined, the fracture could be as long as 1,500 feet or more (Appendix D).

5.3 LONG-TERM YIELD OF THE WELL

The design average demand the Carlin High School heating system will place on the well is estimated at 50 gpm of 87°F water (Petty, 1985). Under day to day use the well will probably be pumped at a rate of 150 gpm for short periods of time. Over the long run the response of the well to pumping 24 hours per day at a rate of 50 gallons per minute will be indistinguishable from pumping the well 8 hours per day at 150 gallons per minute. The well is capable of sustaining this pumping rate virtually indefinitely. Based on the operational history of the system at the Wells, Nevada elementary school, the average daily demand will probably be less. Maximum peak demand of the well is estimated at 200 gpm for a period of approximately three hours (Petty, 1985). It is highly unlikely that the



Transmissivity, $T = \frac{264\ Q}{\Delta s}$

$= 660$ GPD/ft

Figure 5. Carlin High School Geothermal Well constant-discharge pumping test, 1100 to 2200 hrs 3/6/85.

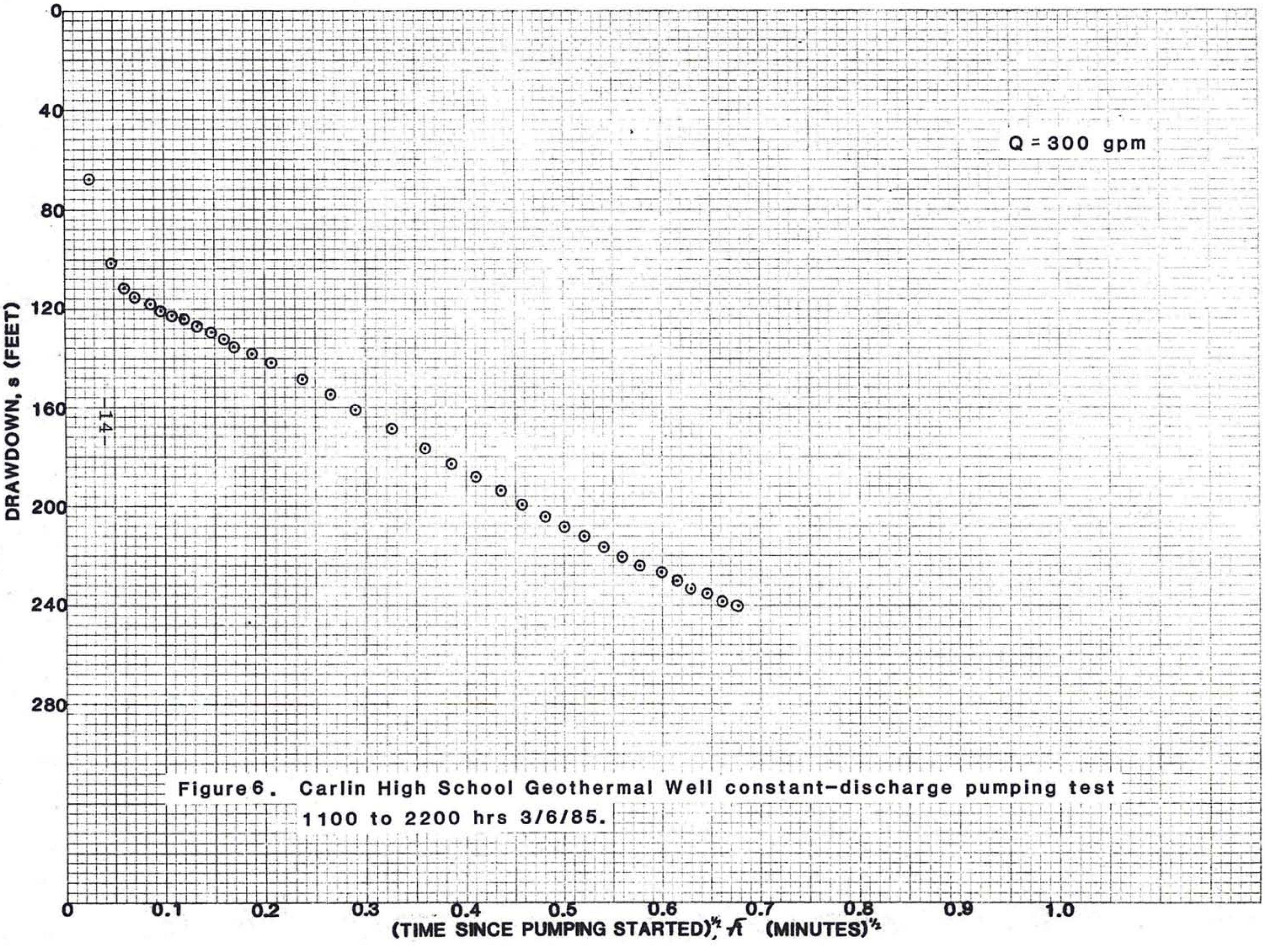


Figure 6. Carlin High School Geothermal Well constant-discharge pumping test 1100 to 2200 hrs 3/6/85.

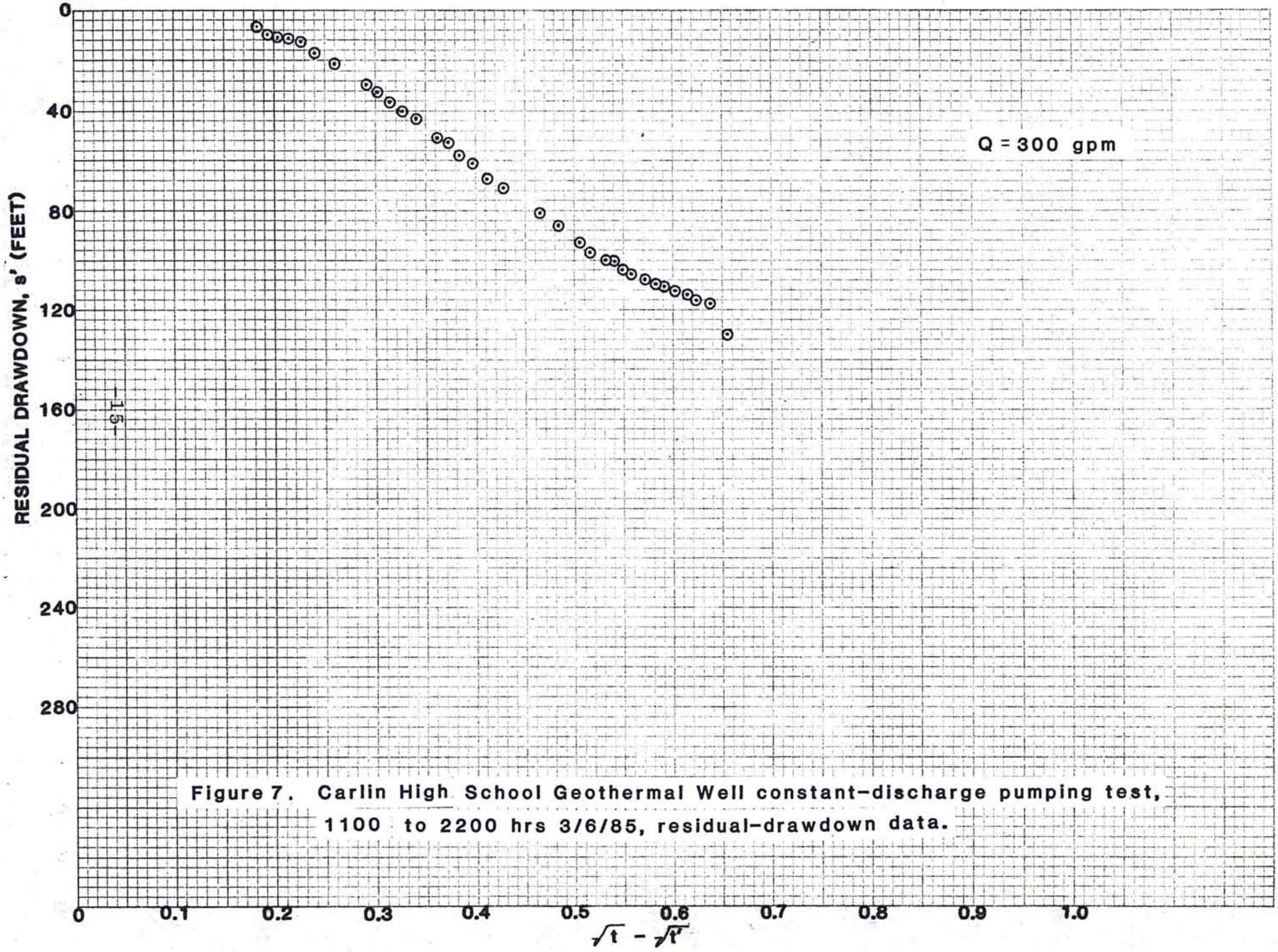


Figure 7. Carlin High School Geothermal Well constant-discharge pumping test, 1100 to 2200 hrs 3/6/85, residual-drawdown data.

well will ever be called upon to meet this demand. However, even in the unlikely event that this occurs toward the end of a six-month heating season when drawdown in the well will be at its maximum, the pumping water level in the well is not expected to drop below a depth of approximately 230 feet. Setting the production pump at a depth of 325 feet will provide a margin of safety of 95 feet of water above the pump under worst-case conditions.

Figure 8 illustrates the anticipated drawdown in the well due to continuous pumping at a rate of 50 gpm.

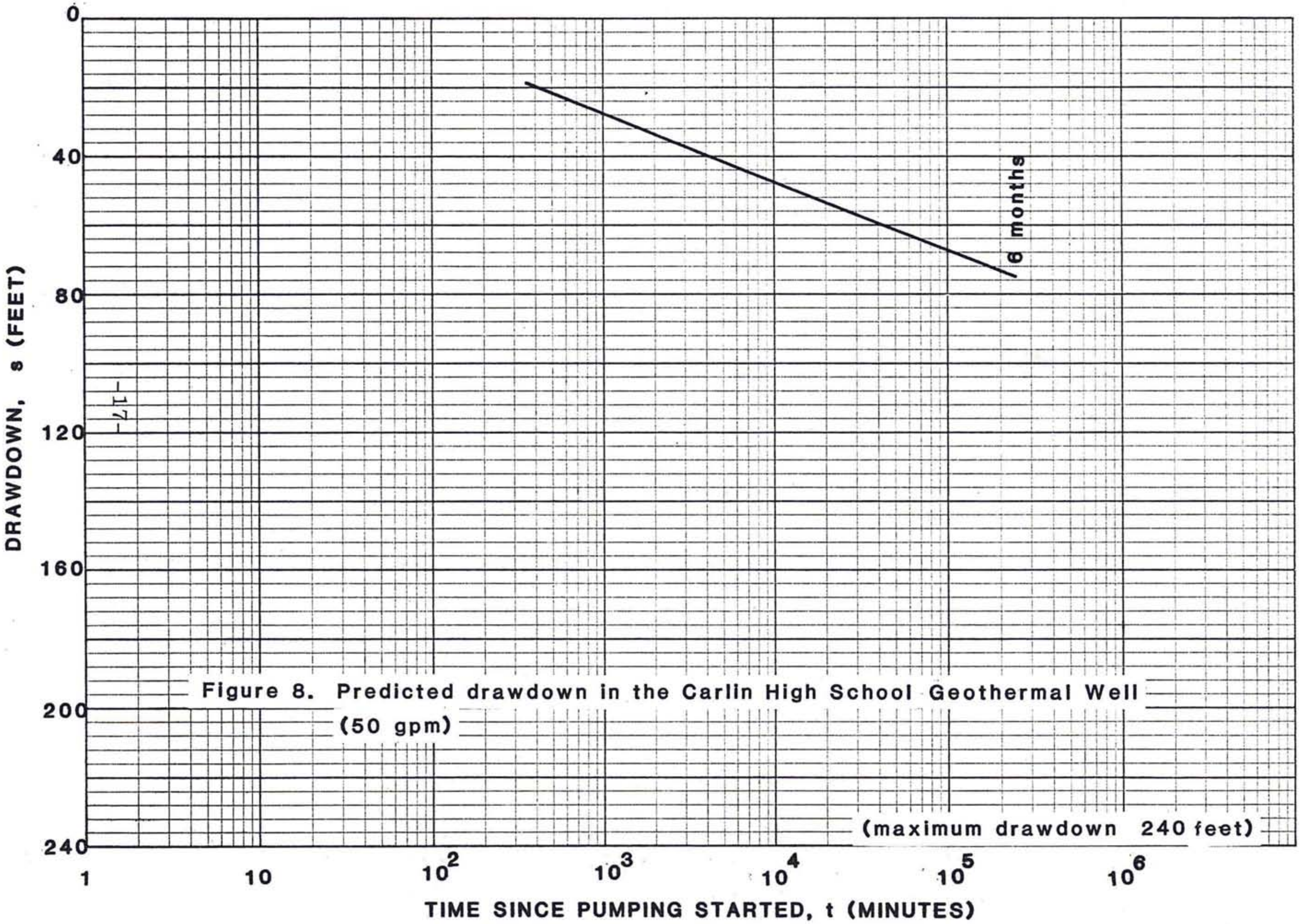


Figure 8. Predicted drawdown in the Carlin High School Geothermal Well (50 gpm)

6.0 WATER CHEMISTRY

6.1 WATER QUALITY

Water samples for chemical analysis were collected from the pump discharge after one and 10 and three-fourths hours of pumping during the constant-discharge pumping test. Results of the analyses are listed in Table 1. Examination of these data illustrates that, with the exception of iron, the water derived from the Carlin High School Geothermal Well meets State and Federal Drinking Water Standards. The level of iron dropped from 0.83 mg/l at the start of the test to 0.67 mg/l by the end of the test and may decrease below the standard after additional pumping. It should be noted that iron is a secondary standard and does not pose a health hazard. The gross chemistry of the water from the well is compared with the water from the City of Carlin water system in Figure 9. Examination of this figure clearly shows that the waters derived from the High School well and the springs are chemically similar.

The water does not meet the standards for direct discharge into the Humboldt River set by the Nevada Division of Environmental Protection (refer to Table 1). Specifically. the water exceds the standard for temperature, sodium, TDS, and DO, although it meets drinking water standards. Alternative methods of disposal are discussed in Section 7.

6.2 CORROSION AND INCRUSTATION POTENTIAL

The potential for carbonate mineral incrustation of pipes and heat exchanger units was examined. The water derived from the well is virtually at calcite saturation, indicating practically no scaling potential. Silicate scaling potential was not examined in detail due to a questionable value for dissolved silica analysis results. However, since the geothermal water is low temperature and chemically similar to city water, no silica scaling problems are anticipated.

The corrosion and incrustation potential of the water was also investigated using Ryznar's stability index (Ryznar, 1944). Values ranging between 6.6 and 6.9 indicate that the water is neither corrosive nor incrusting.

Mixing the geothermal and city water was analyzed using the PHREEQE computer program (INTERA, 1983). Since both the city and geothermal

Table 1. Water chemistry data, Carlin High School Geothermal well

Sample No.	325-1	325-2		Carlin	Drinking Water Standard	NEPA Discharge Standard
Date	3/06/85	3/06/85		7/19/84		
Time	1200	2145				
Lab	SEM	SEM	12/12/85	NDH		
Temp. ($^\circ$C)	30.5	30.5				10
pH	7.0	7.0	7.5	7.88		7-9
TDS	386	369	390	311	1,000^2	320
Suspended solids		1				80
BOD		<1				3
DO		<0.2				>5
Ca	57	56	63	48		
Mg	10.6	10.6	10.5	13	150^2	
Na	67	66	66	29		8
K	18	17	20	9		
Fe	0.83	0.67	1.7	0.08	0.60^2	
Mn	0.02	<0.02	0.03	0	0.1^2	
HCO_3	272	272	274	200		
SO_4	56	58	61	51	500^2	
Cl	11	11	12	16	400^2	18
NO_3 (as N)	0.1	<0.1	0.2	2.54	45^1	1.0
F	2.0	1.6	2.0	0.44	1.8^1	
PO_4		<0.1				0.35
As	0.016	0.016	0.013	0.005	0.05^1	
Ba		<0.04	=	0.14	1.0^1	
B		0.3	—	0		
Cd		<0.01	=	<0.001	0.01^1	
Cr		<0.02	=	<0.005	0.05^1	
Cu		<0.02	=	0.01	1.0^2	
Pb		<0.05	=	<0.005	0.05^1	
Hg		<0.0005	=	<0.005	0.002^1	
Se		<0.005	=	0.003	0.01^1	
Ag		<0.01	=	<0.005	0.05^1	
Zn		<0.01	=	0.23	5.0^2	
SiO_2		15	16	56		

1-USEPA Primary Drinking Water Standards

2-State of Nevada Secondary Drinking Water Standards

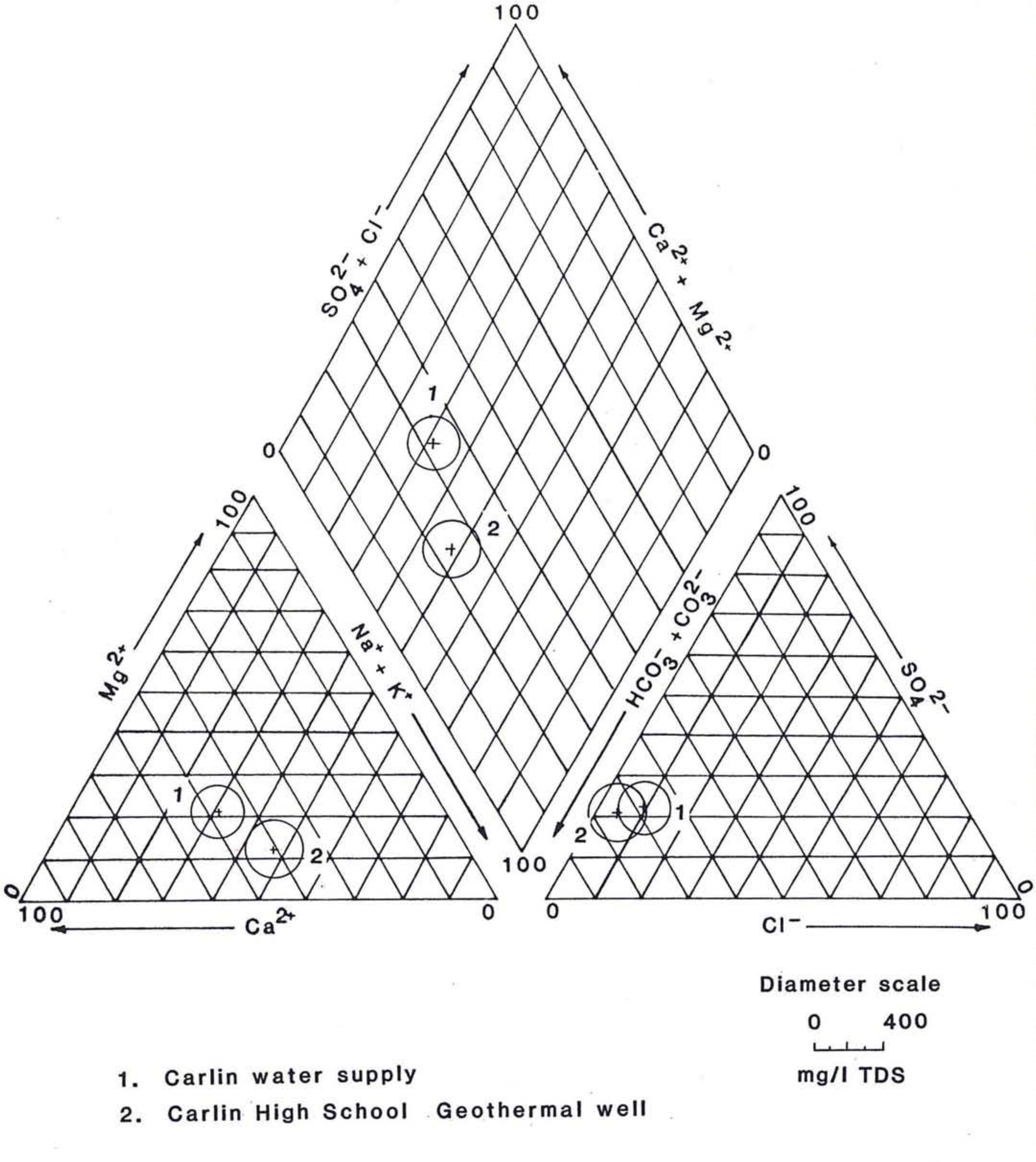


FIGURE 9. Trilinear diagram

waters are chemically very similar, mixing has little effect on the chemical properties of the waters. If the waters are mixed at discharge temperatures (31°C and 15°C for city and geothermal water, respectively) the blend is slightly oversaturated with respect to calcite (refer to Figure 10). However, scaling potential is minimal and for all practical purposes negligible. Heating mixtures of the water to 60°C increases carbonate saturation for all mixtures. However, scaling potential for the mixtures at this temperature is less than for city water, alone.

6.3 GEOTHERMOMETER EVALUATION

Because silica analysis results were suspect, only the cation geothermometers were evaluated. The Ca-Na-K geothermometer (Fournier, 1977) yielded a reservoir temperature of 89°C. Correcting for magnesium (Fournier and Potte, 1979) had little effect on the computed temperature, yielding a reservoir temperature of 85°C. These results suggest the water derived from the well is probably originally high temperature and cooled by conduction.

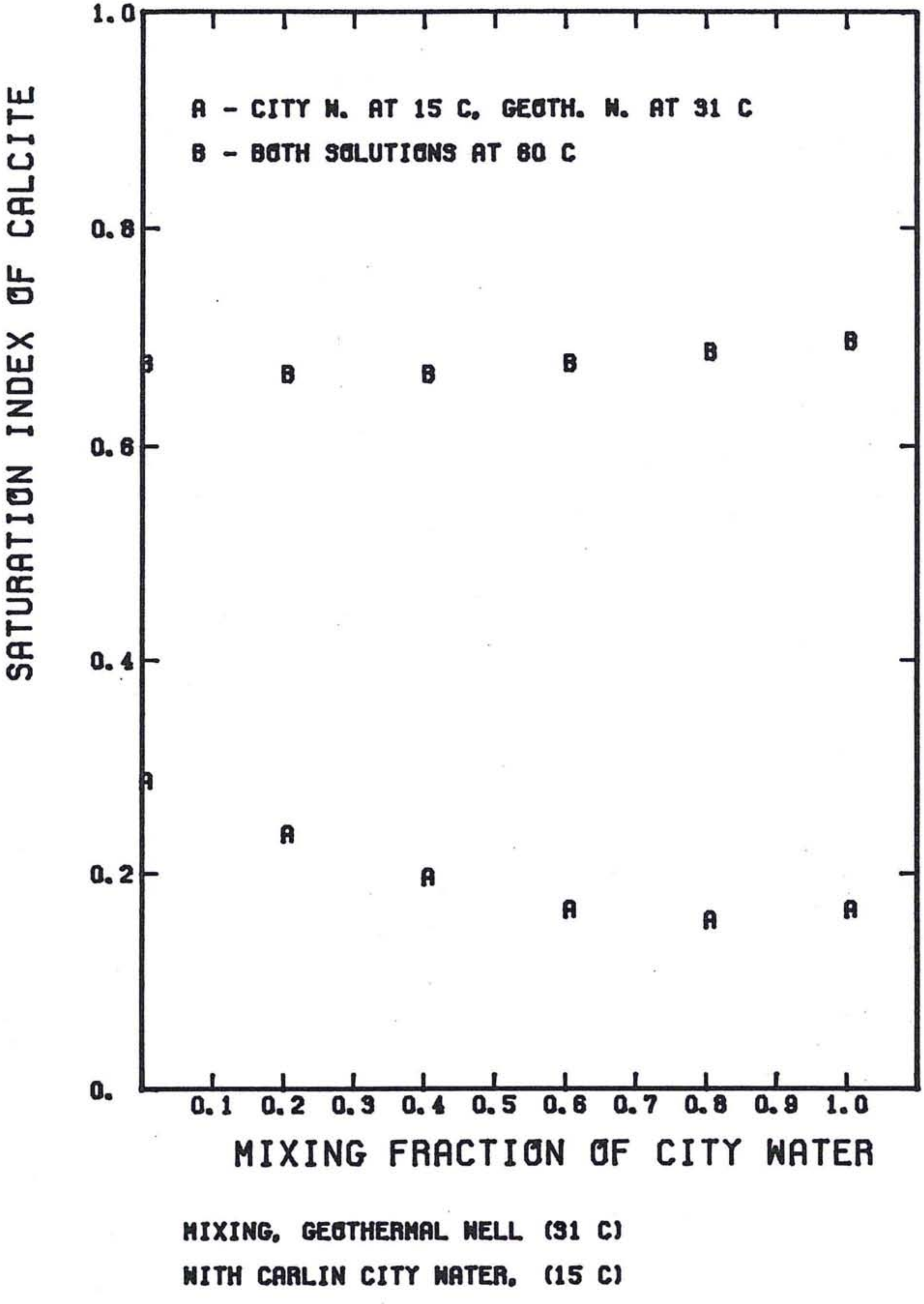


Figure 10. Calcite stability, blends of Carlin High School and City water

7.0 FLUID DISPOSAL ALTERNATIVES

There are at least five alternatives for disposal of the heat-spent water. These are:

1. Injection of the water back into the geothermal aquifer.
2. Discharge of the water directly into the Humboldt River.
3. Utilizing the water for irrigation purposes.
4. Disposal via infiltration ponds near the Humboldt River.
5. Mixing the geothermal waters with City water and augmenting the municipal water suppply.

The first alternative is undesireable due to high capital and operating costs. An injection well must dispose of the water in the same zone from which it was extracted in order to comply with Nevada DEP regulations. Such a well would cost approximately the same as the production well and a suitable injection well site must be located.

The second alternative is also unattractive. Since the water does not meet Nevada DEP standards for for direct discharge into the Humboldt River, costly advanced treatment such as reverse osmosis would be required to lower TDS and sodium concentration to acceptable levels. In addition, discharging even a small amount of water into the Humboldt River seems wasteful in a water-deficient state such as Nevada.

The third alternative is attractive since the water is available for an additional use - irrigation - after heat has been extracted. The water is suitable for irrigation use without any treatment. A disadvantage with this alternative is the need for storage of the fluid during the irrigation season which typically does not coincide with the heating season. The cost of a storage facility would have to be added to the cost of the system since no facility currently exists.

The fourth alternative is feasible although not attractive since the water is not put to any other beneficial use other than heating. The heat-spent water may be allowed to cool in ponds near the river and infiltrate the shallow alluvium where it will eventually enter the river. Because the water becomes a diffuse source, the Nevada DEP discharge standards are not applicable.

The fifth alternative is very attractive. The heat-spent geothermal water may be used to augment Carlin town water supplies. Since the water is chemically similar to City of Carlin water (refer to Section 6.2) no adverse consequences are anticipated. The effects of mixing the geothermal water with city water are summarized below.

1. Iron level. Iron concentration at the end of the pumping test only slightly exceeded the secondary standard and showed a general decrease with pumping. With increased pumping duration iron could well drop below the standard. Even if this does not occur mixing the geothermal water with city water will lower the iron concentration. Alternatively, chlorination of the water followed by filtration will easily remove iron from the water. An additional benefit of chlorination would be oxidation of hydrogen sulfide gas which was detected in the water and eliminate potential odor due to its presence.

2. Hardness. Both city and geothermal waters are classified as very hard. Blending the waters will have little affect on hardness.

3. Corrosion potential. Ryznar Indices for the city water and blends of city and geothermal water range between 6.6 and 6.9 and indicate that incrustation or corrosion potential of city water will not be changed by the addition of geothermal water into the drinking-water system.

4. Incrustaion potential. The incrustation potential of city and the geothermal water are similar. Mixtures of city and geothermal water will not be any more incrusting than the city water alone.

Preliminary discussion of the fifth alternative with Carlin City officials has met with tentative approval.

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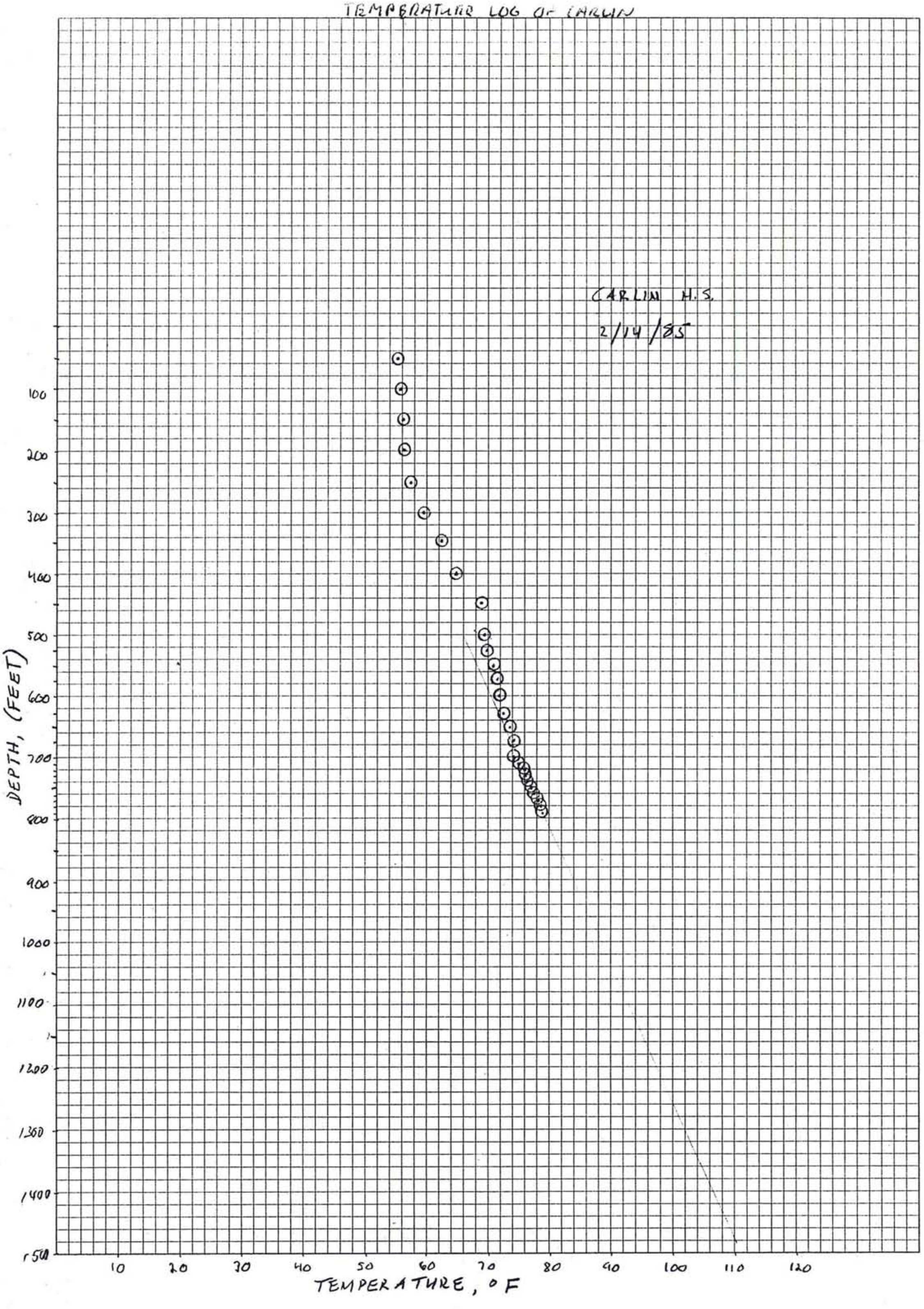
APPENDIX A

TEMPERATURE LOG

TEMPERATURE LOG OF CARLIN



GEO-HYDRO-DATA

INCORPORATED

ELECTRIC WELL LOG

COMPANY ELKO SCHOOLS
WELL CARLIN TEST HOLE
FIELD CARLIN
COUNTY ELKO
STATE NV

COMPANY ELKO SCHOOLS

WELL CARLIN TEST HOLE
FIELD CARLIN
COUNTY ELKO STATE NEVADA

LOCATION
no. side football field
Sec.____ Twp.____ Rge.____

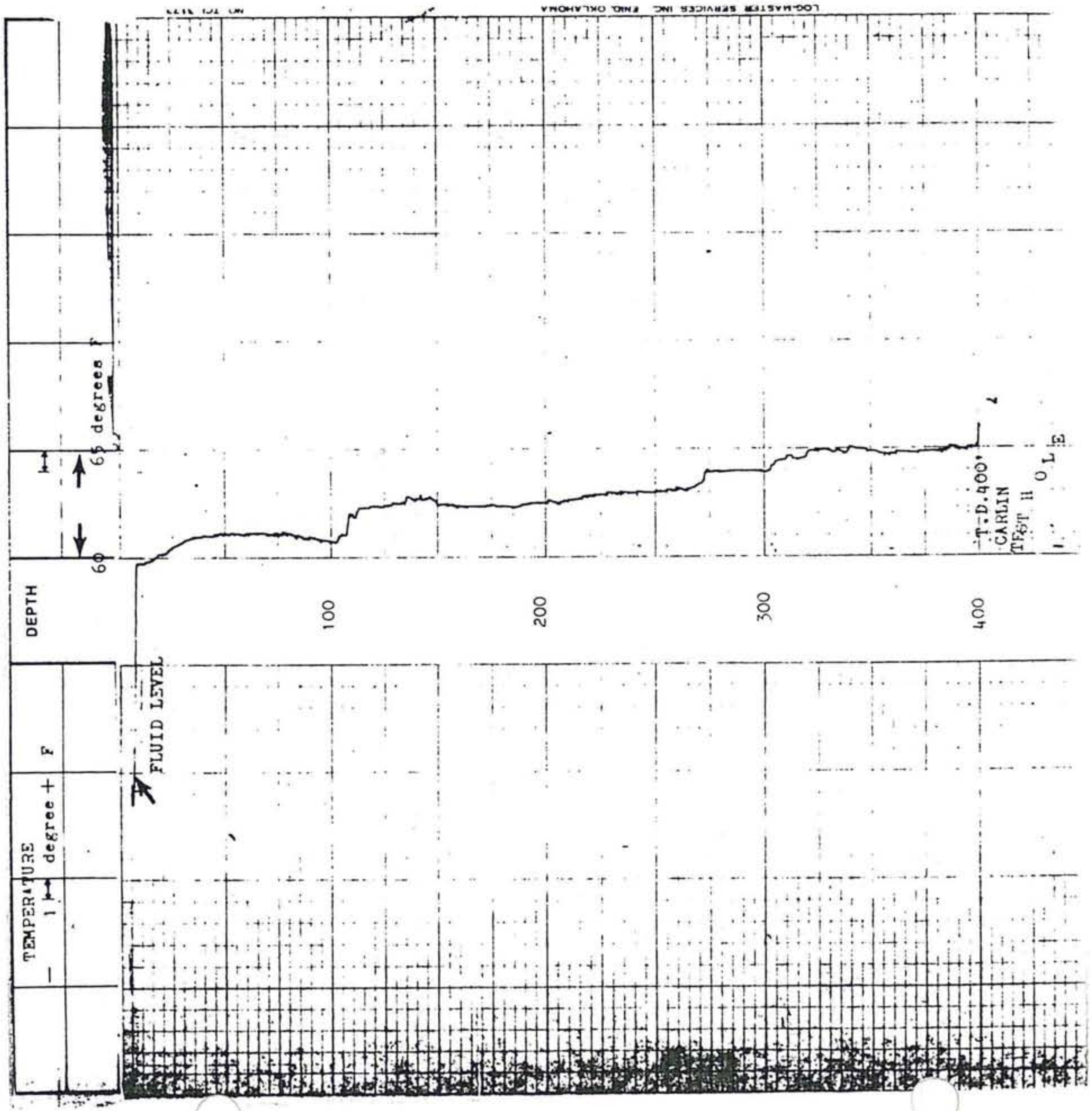
TYPE LOG
TEMP.

Permanent Datum GROUND LEVEL Elev.____
Log Measured From G.L. 0 Ft. Above Perm. Datum
Drilling Measured From G.L.

Elev.: K. B.____
D. F.____
G. L.____

Date	8 jan.85		
Run No.	ONE		
Depth — Driller	625 ft.	ft.	ft.
Depth — GHD	400 ft.	ft.	ft.
Btm. Log Inter.	400 ft.	ft.	ft.
Top Log Inter.	5 ft.	ft.	ft.
Casing — Driller	in. @ ft.	in. @ ft.	in. @ ft.
Casing — GHD	ft.	ft.	ft.
Bit Size	14 ½ in. to td ft.	in. to ft.	in. to ft.
Bit Size	in. to ft.	in. to ft.	in. to ft.
Bit Size	in. to ft.	in. to ft.	in. to ft.
Type Fluid in Hole	CLAY-GEL		
Source of Sample			
PPM TDS			
Fluid Level	6 ft.	ft.	ft.
Dens. | Visc.	|	|	|
pH | Fluid Loss	| ml	| ml	| ml
Rm @ Meas. Temp.	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F
Time Since Circ.	NA hr	hr	hr
Logging Speed	15 ft./min.	ft./min.	ft./min.
Tool Type and No.	TEMP.8		
Unit No.	2		
Location	STOCKTON,CA.		
Invoice No.	3783		
Recorded By	D.L. SHANHOLTZER (ASSOCIATE GEOLOGIST)		
Witnessed By	PAUL WILLIAMS JR. (DRILLER)		
other	GEORGE WILLIAMS (DRILLER)		

P. O. Box 418 Tehachapi, California 93561 (805) 832-4101



APPENDIX B

DRILLER'S REPORT

CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

Page 1 of 3

PRINT OR TYPE ONLY

DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

Log No.
Permit No.
Basin

NOTICE OF INTENT NO. 1540

1. OWNER Elko Co. School District
MAILING ADDRESS

ADDRESS AT WELL LOCATION Carlin School
Carlin Nevada

2. LOCATION N.W. ¼ S.W. ¼ Sec. 27 T. 33 N/S R. 52 E Elko County
PERMIT NO. 47234 (Issued by Water Resources)
Parcel No.
Subdivision Name

3. TYPE OF WORK
New Well ☒ Reconditlon ☐
Deepen ☐ Other ☐

4. Geoth. PROPOSED USE
Domestic ☐ Irrigation ☐ Test ☐
Municipal ☒ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Brown clay		0	2	2
Sandy Brown clay		2	14	12
sandy clay		14	16	2
large gravel		16	18	2
sandy gravel		18	28	10
gravel & brown clay		28	29	1
brown clay		29	33	4
brown clay & gravel		33	38	5
brown clay		38	39	1
gravel & brown clsy		39	43	4
gravel bed		43	45	2
brown clay& gravel		45	51	6
gravel		51	53	2
brown clay& gravel		53	54	1
gravel		54	57	3
brown clay& gravel		57	59	2
graevl		59	63	4
brown clay& gravel		63	71	8
brown clay		71	72	1
large gravel		72	73	1
brown clay& gravel		73	75	2
sandy brown clay		75	85	10
gravel bed		85	86	1
sandy brown clay		86	100	14
gravel bed		100	101	1
sandy brown clay		101	103	2
gravel& sandy brown clay		103	118	15

Date started November 30, 1984
Date completed March 15, 1985

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump

BAILER TEST

G.P.M. Draw down feet hours
G.P.M. Draw down feet hours
G.P.M. Draw down feet hours

8. WELL CONSTRUCTION

Diameter hole 14 3/4 inches Total depth 904 feet
Casing record
Weight per foot 28 lb. 18.97 Thickness .250

Diameter	From	To
8 5/8 inches	0 feet	821 feet
6 5/8 inches	811 feet	904 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type neat cement
Depth of seal 821 Betenite feet
Gravel packed: Yes ☐ No ☒
Gravel packed from feet to feet

Perforations:
Type perforation Factory Sawed
Size perforation 1/8x3x4 rows 6 5/8 o.d.
From feet to feet
From 823 feet to 904 feet
From feet to feet
From feet to feet
From feet to feet

9. WATER LEVEL

Static water level approx. 38' feet below land surface
Flow G.P.M. approx. 300
Water temperature 86 ° F. Quality unknown

10. DRILLERS CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Paul Williams & Sons (Contractor)
Address 22 South Patterson Place Sparks, Nevada (Contractor)
Nevada contractor's license number 14483
Nevada contractor's drillers number 957
Nevada driller's license number 957 (Actual Driller)
Signed Paul E. Williams (Contractor)
Date March 18, 1985

USE ADDITIONAL SHEETS IF NECESSARY

(Rev. 6-81) O-627 CR434

PINK—WELL DRILLER'S COPY

Page 2 of 3

PRINT OR TYPE ONLY

DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

Log No.

Permit No.

Basin

NOTICE OF INTENT NO. 1540

1. OWNER Elco Co. School District

MAILING ADDRESS

ADDRESS AT WELL LOCATION Carlin School
Carlin Nevada

2. LOCATION n.w. ¼ s.w. ¼ Sec. 27 T. 33 N/S R. 52 E Elko County

PERMIT NO. 47234

Issued by Water Resources

Parcel No.

Subdivision Name

3. TYPE OF WORK

New Well ☒ Recondition ☐

Deepen ☐ Other ☐

4. Geoth. PROPOSED USE

Domestic ☐ Irrigation ☐ Test ☐

Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL

Cable ☐ Rotary ☒

Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
sandy brown clay		118	143	25
white & red clay mix		143	153	10
white clay		153	158	5
gray clay		158	161	3
white& gray sandy clay mux		161	178	17
gray sandy clay		178	180	2
white clay& limestone		180	188	8
white clay		188	193	5
white limestone with white clay		193	253	60
gray sandstone layers and white clay		253	263	10
sandstone brown		263	303	39
brown sandstone & white clay		303	328	25
soft gray sandstone		328	340	12
hard gray sanestone		340	343	3
sandy gray clay		343	395	52
gray clay		395	420	25
gray clay with gravel		420	428	8
gray clay		428	450	22
gravel &gray clay		450	478	28
gray clay		478	482	4
gravel &gray clay		482	484	2
gray clay		484	496	12
gray hard clay		496	503	7

Date started November 30, 1984

Date completed March 15, 1985

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump

BAILER TEST

G.P.M. Draw down feet hours

G.P.M. Draw down feet hours

G.P.M. Draw down feet hours

8. WELL CONSTRUCTION

Diameter hole 14 3/4 inches Total depth 904 feet

Casing record

Weight per foot Thickness

Diameter	From	To
8 5/8 inches	0 feet	821 feet
6 5/8 inches	811 feet	904 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type neat cement +

Depth of seal 0-821 Bentenite feet

Gravel packed: Yes ☐ No ☒

Gravel packed from feet to feet

Perforations:

Type perforation Factory Sawed

Size perforation 1/8 x 3 x 4 rows 6 5/8 O.d.

From feet to feet

From 823 feet to 904 feet

From feet to feet

From feet to feet

From feet to feet

9. WATER LEVEL

Static water level approx. 38' feet below land surface

Flow G.P.M. P.S.I.

Water temperature 86 ° F. Quality unkown

10. DRILLERS CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Paul Williams & Sons
Contractor

Address 22 So. Patterson Pl. Sparks, Nev.
Contractor

Nevada contractor's license number 14483

Nevada contractor's drillers number 957

Nevada driller's license number 957
Actual Driller

Signed Paul E. Williams Sr.
Contractor

Date March 15, 1985

USE ADDITIONAL SHEETS IF NECESSARY

(Rev. 6-81) O-627 CR434

CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

Page 3of 3

PRINT OR TYPE ONLY

DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

Log No.
Permit No.
Basin

NOTICE OF INTENT NO. 1540

1. OWNER Elko Co. School District
MAILING ADDRESS

ADDRESS AT WELL LOCATION Carlin School
Carlin Nevada

2. LOCATION N. W. ¼ S.W. ¼ Sec. 27 T. 33 N/S R. 52 E Elko County
PERMIT NO. 47234 (Issued by Water Resources) | Parcel No. | Subdivision Name

3. TYPE OF WORK
New Well ☒ Reconditon ☐
Deepen ☐ Other ☐

4. Geoth. PROPOSED USE
Domestic ☐ Irrigation ☐ Test ☐
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thick-ness
gray clay		503	524	21
gravel & gray clay		524	526	2
gray clay		526	528	2
white sandy clay		528	560	32
white clay & hard sandy layers		560	578	18
white clay		578	591	3
gray sandy rock		591	612	21
white clay		612	620	8
gray clay		620	634	14
gray & white clay mix		634	653	19
hard gray clay		653	669	13
sandy gray clay		669	672	3
white & gray clay mix		672	686	14
tan clay		686	702	16
white chert		702	706	4
multi color clay		706	740	34
red white clay		740	758	18
red clay & white chert		758	762	4
pink clay		762	801	39
white chert ledge		801	802	1
pink clay		802	810	8
hard sands		810	812	2
multi color rock		812	832	20
multi color clay& rock		832	875	43
med hard brown lime-stone with fracture layer		875	904	29

Date started November 30, 1984
Date completed March 15, 1985

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump

BAILER TEST

G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION

Diameter hole .... inches Total depth .... feet
Casing record
Weight per foot .... Thickness

Diameter	From	To
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☐ No ☐ Type
Depth of seal .... feet
Gravel packed: Yes ☐ No ☐
Gravel packed from .... feet to .... feet

Perforations:
Type perforation
Size perforation
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL

Static water level .... feet below land surface
Flow .... G.P.M. .... P.S.I.
Water temperature .... ° F. Quality

10. DRILLERS CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Paul Williams & sons
Contractor

Address 22 So. Patterson Pl. Sparks, Nevada
Contractor

Nevada contractor's license number 14483

Nevada contractor's drillers number 957

Nevada driller's license number 957
Actual Driller

Signed Paul E. Williams Jr.
Contractor

Date March 18, 1985

USE ADDITIONAL SHEETS IF NECESSARY

APPENDIX C

FIELD DATA SHEETS

Project No. 85-325

PUMPING TEST DATA

Page 1 of 2

WELL NO. CARLIN HI SCHOOL

TYPE OF PUMPING TEST STEP-DD
[✓ PUMPING]/RECOVERY DATA
M.P. FOR WATER LEVELS TOP OF STILLING WELL
DISTANCE FROM PUMPING WELL —
LOCATION

[✓ PUMPING]/OBSERVATION WELL
OTHER OBSERVATION WELL(S)
NA
PUMP ON: DATE 3/5/85 TIME 1530
PUMP OFF: DATE TIME

CLOCK TIME	ELAPSED TIME (minutes)		t/t'	WATER LEVEL MEASUREMENT (feet)		PUMPING RATE (gpm)		REMARKS
	t	t'			(s) or s'	INCHES	Q	
1530	0			39.70	0			PUMP INTAKE @ 520 FT M.P. = 2.0 FT ABOVE LSD
1533	3			62.32	22.62	12¾	150	
1535	5			62.10	22.40	12½	149	T=76°F NOTE - Q MEASURED BY ORIFICE IN ERROR
1540	10			65.40	25.70	13	151	INCR Q @ 1537 T=79°F @ LOW RATES DUE TO VALVE-
1545	15			65.71	26.01	13¼	152.5	INDUCED TURBULENCE
1550	20			66.15	26.45	13¼	152.5	T=84°F
1555	25			66.82	27.12	13¼	152.5	T=79°F
1600	30			67.12	27.42	13¼	152.5	
1610	40			68.15	28.45	13¼	152.5	T=84.5°F
1620	50			69.32	29.62	13¼	152.5	T=85.5°F
1630	60			70.36	30.66	13	151	T=86°F
1645	15 / 75			82.2				0.2 CFS @ WEIR OPEN VALVE TO REDUCE TURBULENCE
1650	20 / 80			106.17	65.47	22¾	200	
1645	25 / 75			108.15	68.47	22¾	"	
1700	30 / 90			109.35	69.65	22¾	"	
1705	35 / 95			110.63	70.93	22¾	"	
1710	40 / 100			111.36	71.66	22¾	"	T=86.25°F
1715	45 / 105			113.12	73.42	22¾	"	
1720	50 / 110			114.49	74.79	22¾	"	
1730	60 / 120			117.60	77.90	22¾	"	T=86.5°F
1740	70 / 130			118.89	79.19	22¾	"	
1750	80 / 140			120.44	80.74	22¾	"	
1800	90 / 150			123.14	83.44	22¾	"	T=86.5°F
1815	105 / 175			124.59	84.89	22½	199	
1830	120 / 180			128.86	89.16	22¾	200	
1900	150 / 210			132.86	93.16	22¼	197	
1930	180 / 240			138.50	98.80	22¾	300	
1932	2			162.58	122.88	50	300	
1935	5 / 245			139.7 186.40	147.70	50	300	
1940	10 / 250			194.40	154.70	50	300	
1945	15 / 255			197.16	157.46	50	300	

WILLIAM E. NORK, INC.

Project No. 85-325

PUMPING TEST DATA

Page 2 of 3

WELL NO. CARLIN HI SCHOOL

TYPE OF PUMPING TEST STEP-DD
[✓ PUMPING]/[✓ RECOVERY] DATA
M.P. FOR WATER LEVELS TOP OF STILLING WELL
DISTANCE FROM PUMPING WELL —
LOCATION

[✓ PUMPING]/OBSERVATION WELL
OTHER OBSERVATION WELL(S)
NA
PUMP ON: DATE 3/5/85 TIME 1530
PUMP OFF: DATE 3/5/85 TIME 2030

CLOCK TIME	ELAPSED TIME (minutes)		t/t'	WATER LEVEL MEASUREMENT (feet)		PUMPING RATE (gpm)		REMARKS
	t	t'		39.70	Ⓢ or s'		Q	
1950	20 260			205.07	165.37	50	300	Δ CYCLES FROM 57 TO 60 Q WAS 7300
1955	25 265			202.27	162.57	50	300	
2000	30 270			203.90	164.20	50	300	T = 86.5°F
2010	40 280			207.07	167.37	50	300	
2020	50 290			210.61	170.91	50	300	
2030	60 300			213.56	173.86	50	300	
2045	75 315			216.70	177.00	49½	294	
2100	90 330			221.24	181.54	50	298	
2115	105 345			224.26	184.56	50	298	
2130	120 360			226.36	187.16	49½	294	
2200	150 390			234.14	194.44	50	298	
2330	180 420			239.79	200.09	50	298	
2331		1		139.52	99.82			
2333		3		125.48	85.78			
2335		5		123.84	84.14			
2337		7		122.45	82.75			
2240		10		120.93	81.23			
2243		13		119.38	79.68			
2246		16		118.32	78.62			
2250		20		116.86	77.16			
2255		25		114.95	75.25			
2300		30		113.31	73.61			
0820		590		62.83	23.13			
0900		630		61.97	22.27			3/6/85
0930		660		61.16	21.46			
1000		690		60.45	20.75			
1030		720		59.89	20.19			
1100								

720
90

WILLIAM E. NORK, INC.

Project No. 85-325

PUMPING TEST DATA

Page 1 of 2

WELL NO. GARLIN W.S.

TYPE OF PUMPING TEST CONSTANT Q
[✓ PUMPING]/RECOVERY DATA
M.P. FOR WATER LEVELS TOP OF STILLING WELL
DISTANCE FROM PUMPING WELL —
LOCATION

[✓ PUMPING]/OBSERVATION WELL
OTHER OBSERVATION WELL(S)
NA
PUMP ON: DATE 03/06/85 TIME 1100
PUMP OFF: DATE TIME

CLOCK TIME	ELAPSED TIME (minutes)		t/t'	WATER LEVEL MEASUREMENT (feet)		PUMPING RATE (gpm)		REMARKS
	t	√t DAYS			[✓ s] or s'	INCHES	Q	
1100	0	0.02		59.30		—	—	M.P. = 2.0' ABOVE L.S.D 3 x 4 PIPE WEIR
1101	1	0.026		126.85	67.55	51	300	FAINT H_2S ODOR Q RUSTY, CLEAR IN 30 SEC
1103	3	0.046		160.78	101.48	"	"	T=79°F
1105	5	0.059		169.85	110.55	"	"	T=81.5°F
1107	7	0.070		175.0	115.70	"	"	T=84.5°F
1110	10	0.083		177.97	118.67	"	"	T=86° F
1113	13	0.095		180.20	120.9	"	"	T=86,25°F
1116	16	0.105		181.65	122.35	"	"	
1120	20	0.118		184.05	124.75	"	"	
1125	25	0.132		186.61	127.31	"	"	
1130	30	0.144		188.12	128.82	"	"	
1135	35	0.156		191.45	132.15	"	"	
1140	40	0.167		194.29	134.99	"	"	
1150	50	0.186		197.61	138.31	"	"	
1200	60	0.204		201.03	141.73	"	"	E.C. = 660 μMHO/CM PH = 7.53 T = 86.5°F
1220	80	0.235		207.93	148.63	"	"	
1240	100	0.264		214.55	155.25	"	"	
1300	120	0.289		220.22	160.92	"	"	NOTE – Q ADJUSTED EVERY 10-15 MINUTES FROM HERE ON
1330	150	0.323		227.87	168.57	"	"	T=86.5°C
1400	180	0.354		235.70	176.40	"	"	
1430	210	0.382		242.46	183.16	"	"	T=87.0°F
1500	240	0.408		247.66	188.36	"	"	
1530	270	0.433		253.35	194.05	"	"	
1600	300	0.456		258.51	199.21	"	"	T = 87.0°F
1630	330	0.479		263.41	204.11	"	"	E.C. METER MALFUNCTION
1700	360	0.500		267.40	208.10	"	"	T=87.5°F
1730	390	0.520		271.41	212.11	"	"	
1800	420	0.540		275.00	215.70	"	"	
1830	450	0.559		279.33	220.03	"	"	
1900	480	0.577		283.23	223.93	"	"	
1930	540	0.[illegible]		286.12	226.82	"	"	

WILLIAM E. NORK, INC.

Project No. 85-323

PUMPING TEST DATA

Page 2 of 2

WELL NO. CALVIN #2

TYPE OF PUMPING TEST
[✓ PUMPING]/RECOVERY DATA
M.P. FOR WATER LEVELS TOP OF STILLING WELL
DISTANCE FROM PUMPING WELL —
LOCATION

[✓ PUMPING]/OBSERVATION WELL
OTHER OBSERVATION WELL(S)
NA
PUMP ON: DATE 3/6/85 TIME 1100
PUMP OFF: DATE TIME

CLOCK TIME	ELAPSED TIME (minutes)		t/t'	WATER LEVEL MEASUREMENT (feet)		PUMPING RATE (gpm)		REMARKS
	t	t'		59.30	[✓ S] or s'		Q	
2000	540	0.612		289.28	229.98	51	300	T=87°F
2030	570	0.629		292.17	232.87	51	"	
2100	600	0.646		294.83	235.53	51	"	
2130	630	0.661		297.20	237.90	50¾	299	
2200	660	0.677		299.64	240.34	51	300	VALVE WIDE OPEN

WILLIAM E. NORK, INC.

Project No. 85-325

PUMPING TEST DATA

Page 1 of 1

WELL NO. CARLIN H.S.

TYPE OF PUMPING TEST CONSTANT-Q
PUMPING/[✓ RECOVERY] DATA
M.P. FOR WATER LEVELS TOP OF STLLING WELL
DISTANCE FROM PUMPING WELL —
LOCATION

[✓ PUMPING]/OBSERVATION WELL
OTHER OBSERVATION WELL(S) NA
PUMP ON: DATE 3/6/85 TIME 1100
PUMP OFF: DATE 3/6/85 TIME 2200

CLOCK TIME	ELAPSED TIME (minutes)		~~t/t'~~ $\sqrt{t}-\sqrt{t'}$	WATER LEVEL MEASUREMENT (feet)		PUMPING RATE (gpm)		REMARKS
	t	t'		59.50	s or [✓ s']		Q	
2200	660	0		299.64	240.34			
2201	661	1	0.652	188.92	129.62			
2203	663	3	0.633	176.62	117.32			
2205	665	5	0.621	174.79	115.49			
2207	667	7	0.611	173.55	114.25			
2210	670	10	0.601	171.70	112.4			
2213	673	13	0.589	169.50	110.2			
2216	676	16	0.580	169.35	109.65			
2220	680	20	0.569	166.30	107.0			
2225	685	25	0.558	164.38	104.88			
2230	690	30	0.548	162.02	102.72			
2235	695	35	0.539	159.45	100.15			
2240	700	40	0.531	158.02	98.72			
2250	710	50	0.516	154.8	95.5			
2300	720	60	0.503	151.64	92.34			
2320	740	80	0.481	144.99	85.09			
2340	760	100	0.463	140.00	80.70			
2400	780	120	0.447					
0030	810	150	0.427	129.70	70.40			3/7/85
0100	840	180	0.410	122.0	62.7			
0130	870	210	0.395	119.61	60.31			
0200	900	240	0.382	115.68	56.38			
0230	930	270	0.371	111.21	51.91			
0300	960	300	0.360	109.00	49.70			
0330	990	330	0.350					
0400	1020	360	0.342	102.55	43.25			
0500	1080	420	0.325	98.70	39.40			
0600	1140	480	0.312	94.94	35.64			
0700	1200	540	0.301	91.37	32.07			
0800	1260	600	0.290	88.58	29.28			

WILLIAM E. NORK, INC.

Project No. 85-325

PUMPING TEST DATA

Page 1 of 2

WELL NO. CARLIN H.S.

TYPE OF PUMPING TEST CONSTANT-Q
PUMPING/[✓ RECOVERY] DATA
M.P. FOR WATER LEVELS TOP OF STILLING WELL
DISTANCE FROM PUMPING WELL —
LOCATION

[✓ PUMPING] OBSERVATION WELL
OTHER OBSERVATION WELL(S)
N/A
PUMP ON: DATE 3/6/85 TIME 1100
PUMP OFF: DATE 3/6/85 TIME 2200

CLOCK TIME	ELAPSED TIME (minutes)		t/t' $\sqrt{t}-\sqrt{t'}$	WATER LEVEL MEASUREMENT (feet)		PUMPING RATE (gpm)		REMARKS
	t	t'		59.30	s or [✓ s']		Q	
1200	1500	840	0.257	80.25	20.95			MEASURED BY P.W. CREW
1500	1680	1020	0.239	76.50	17.2			
1800	1860	1200	0.224	72.50	13.2			
2100	2040	1380	0.211	70.50	11.2			
2400	2220	1560	0.201	70.0	10.7			
0300	2400	1740	0.192	67.67	8.37			3/8/85
0600	2580	1920	0.184	65.30	6.0			

APPENDIX D

CALCULATIONS IN SUPPORT OF TEXT

$$\frac{s}{\sqrt{t}} = L\,\frac{Q}{\sqrt{\pi\ TS}} = 220\ \frac{\text{FT}}{\text{DAY}^{\frac{1}{2}}}$$ from 3/6/85 pumping test

Q = 300 GPM = 40.1 FT^2/MIN = 57754 FT^3/DAY

T = 660 GPD/FT = 88.2 FT^2 DAY

S = 0.0001 ASSUMED FOR ARTESIAN CONDITIONS

Fracture length, $L = \frac{Q}{\sqrt{\pi\ TS}}\ \frac{}{\frac{s}{\sqrt{t}}} = \frac{57754\ \text{FT}^3\ /\text{DAY}}{\sqrt{\pi}88.2\ \text{FT}^2/\text{DAY}\ .0001}\ \frac{1}{220}\ \frac{\text{DAY}^{\frac{1}{2}}}{\text{FT}}$

= 1577 FT

REF. Jenkins and Prentice, 1982