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ST. JAMES' EXPLORATORY DRILLING

October - December 1993

WASHOE COUNTY

DEPARTMENT OF PUBLIC WORKS

UTILITY DIVISION

P.O. BOX 11130 RENO, NEVADA 89520



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Department of Public Works

Utility Division

1195-B Corporate Blvd.

P.O. Box 11130

Reno, Nevada 89520

by

Michael C. Widmer
Hydrogeologist

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EXECUTIVE SUMMARY

During the autumn of 1993, the Washoe County Utility Division conducted an exploratory drilling program in order to locate potential sites for production wells and to assess ground water supply for the St. James' Village Subdivision. Fredrick Pump and Well Drilling was awarded the low bid, drilling contract. Washoe County personnel supervised the drilling, geophysical logging and lithologic logging.

Air rotary drilling methods were mostly employed. The drilling encountered competent and fractured andesite as well as andesitic sands and gravels. Production zones appeared to be confined to the sands and gravels or lahars. Four test wells were constructed to depths of between 360 and 788 feet.

William E. Nork, Inc. was contracted to conduct short term pumping tests in order to assess the potential for production well sites. All four sites appear to have the long term potential to produce at least 300 gpm. There does not appear to be any water quality concerns.

It is recommended that three wells be constructed to provide service to the subdivision. These wells should be equipped at 300 gpm each. Drilling methods and well construction design recommendations are made. These production wells should be pump tested for a minimum of ten days each.

INTRODUCTION

The St. James's Village Tentative Map was approved in 1992 by the Washoe County Board of County Commissioners. One condition of the project was to verify the long term water supply. The Washoe County Utility Division conducted an exploratory drilling program in order to locate potential sites for production wells. Figure 1 shows five locations targeted for exploratory drilling. The drilling program's objectives were:

1. To drill approximately 500 feet per well and if warranted,
2. construct a four or six inch test well and,
3. conduct an air lift flow test to assess potential for a production well.
4. Make an assessment from the entire program as to the potential long term supply.

DRILLING OPERATIONS

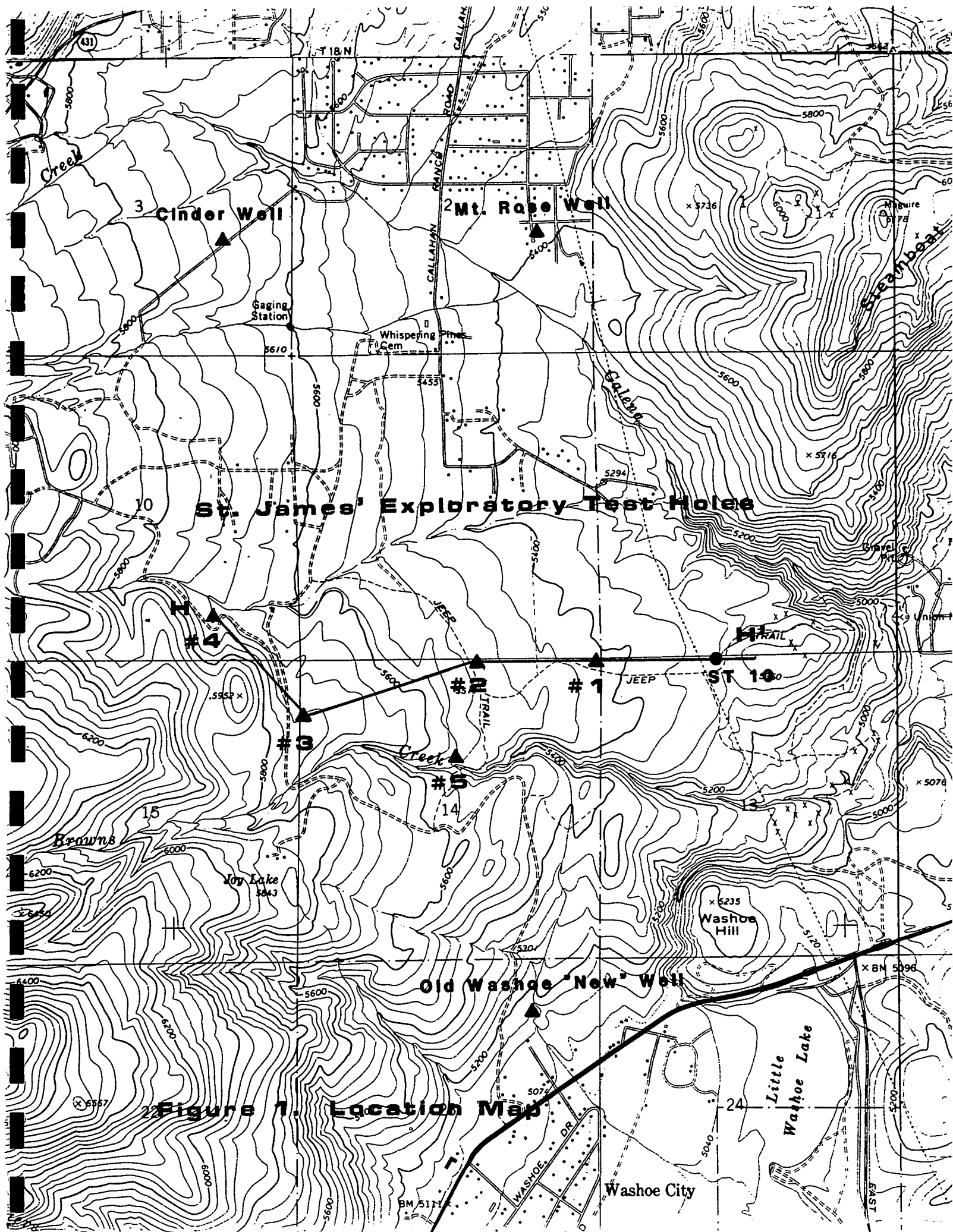
Through a low bid process, Fredrick Pump and Well Drilling was awarded the drilling contract. Two Ingorsall Rand TH-60 Top Head Drive drilling rigs were used for the project. Tricone bits were used to drill 10 inch nominal boreholes. The borehole depths ranged from 300 to 788 feet. Air rotary drilling methods were used on test holes 1, 3, 4. Air and mud rotary methods were used on test hole 2. The drilling fluid (mud) consisted of high yield bentonite clay with minor amounts of synthetic polymer additives.

Utility Division personnel supervised the drilling operations and performed the lithology sampling. Samples were collected throughout the borehole and bagged at ten foot intervals. Borehole geophysical logs (electric, caliper, and gamma) were run by Welenco and Century.

The boreholes were then constructed as four or six inch diameter, steel cased test wells. Local 4 x 8 gravel was used for the gravel envelope. A fifty foot seal was installed. The wells were air lift developed until clean, then air lifted for production assessment. Table 1 lists the construction of each well. After pumping tests were completed, the wells were retrofitted as two inch diameter monitor wells.

Table 1
Test Well Construction

Test Hole	Casing Diameter (in)	Total Depth (ft)	Casing Depth (ft)	Slot Interval (ft)	Devel. Time (hrs)	Static Level (ft)
1	4	788	770	470-770	1.5	403
2	6	640	535	none	0.0	245
3	6	600	580	280-580	3.5	230
4	6	360	360	240-360	4.5	190



DESCRIPTION OF LITHOLOGY

A general description for each borehole follows with the complete lithology described in Appendix 1. Appendix 2 contains the geophysical logs for each borehole.

Test Hole 1

Mixed, unconsolidated colluvium was encountered to a depth of 260 feet. Andesitic extrusives were encountered from 260 to 290 feet, 370 to 390 feet, 570 to 601 feet, 670 to 705 feet and 772 to 788 feet where the drilling ceased. Sand and gravel deposits were mostly encountered between these fractured rock formations.

Electric and caliper geophysical logs were run. A sonic log was attempted, but the Welenco operator had no confidence in the results. Borehole fill prevented the logging tools from getting below 710 feet. The resistivity log shows a general resistivity of 50 ohm-m except between 570 and 600 feet where the resistivity is approximately 100 ohm-m.

Water production zones were mostly below 540 feet and continued to the hole bottom. At best, water production from normal air drilling operations was approximately 200 gpm. The static water level was 403 feet after development.

Test Hole 2

Mixed, unconsolidated colluvium was encountered to a depth of 260 feet. Hard and competent andesite was then drilled to a depth of 530 feet where lost circulation problems occurred. The borehole was then geophysically logged, cased with 6" blank casing, and sealed to 50 feet. A six inch hammer bit was then used to drill to 560 feet when copious amounts of water "flooded out" the hammer. The borehole was then tricone drilled to 640 feet in gravels. There was no discharge or drill cutting returns below 560 feet.

Geophysical logging consisted of caliper, guarded focus resistivity and natural gamma (Century Geophysical, Inc.). The gamma and caliper logs confirm the competency of the andesite from 260 to 520 feet. The resistivity jumps remarkably from approximately 70 ohm-m to approximately 250 ohm-m below the andesite at 530 feet. Borehole fill limited the tools to a depth of 605 feet.

An unconfined aquifer exists from about 230 to 260 feet with limited production (air lifted at approximately 20 gpm). From 260 to 525 feet, hard, competent andesite probably has limited production from fractures. The zone of interest then, lies below 525 feet. Air lift production was well in excess of 100 gpm at a depth of 560 feet and probably increased with depth below 600 feet.

Test Hole 3

Mixed, unconsolidated colluvium was encountered to a depth of 188 feet. Andesite was drilled from 188 to 280 feet, then rounded to angular, mixed volcanic sediments to 346 feet. From there a dark blue, volcanic formation was encountered mixed with red cinder (?) to 460 feet. This unit drilled relatively fast, but is probably competent material. From this depth to 500 feet there was poor return of cuttings. At 500 feet the cuttings were multi-colored volcanics to a depth of 540 feet where poor returns continued to 600 feet. From 573 to 600 feet the drilling penetration rate decreased indicating a more competent volcanic unit.

Geophysical logs run were caliper, natural gamma, and guarded focus resistivities (Century Geophysical, Inc.). A zone of relatively high resistivity (100 - 200 ohm-m) exists between 340 and 440 feet.

Water production zones began at 280 feet such that at 400 feet, approximately 60 gpm was being airlifted. Production picked up remarkably from 500 to 600 feet so that about 150 gpm was produced. Returns were intermittent and surged from 540 to 600 feet. An air lift flow test was run for two hours at approximately 120 gpm in the completed well.

Test Hole 4

This borehole encountered unconsolidated silt, sand and gravel to a depth of 180 feet. Lost circulation was encountered to a depth of 300 feet. Cuttings from 300 to 360 feet were a dark blue to purplish andesite, angular and coarse with minor amounts of rounded to semi-rounded gravels. Lost circulation problems occurred such that mud rotary methods were employed below 360 feet, but with no success. In order to preserve borehole stability, drilling ceased.

Century Geophysical, Inc. ran natural gamma, guarded focus resistivity and caliper logs. The results are unremarkable and may show signs of mud invasion below 340 feet. Water production zones began at 290 feet and increased with depth to 360 feet. An air lift flow test was conducted for 90 minutes at 90 gpm in the completed well.

Test Hole 5

The drilling of this exploratory test hole was not pursued.

WATER QUALITY

Water samples were taken from all test wells. The analysis indicates that these waters meet state and federal drinking water standards. This ground water can be classified as calcium-

bicarbonate. Table 2 lists some of the constituents for these wells. The full analysis' can be found in the appendix.

Within the South Truckee Meadows ground water system, calcium bicarbonate waters are indicative of recently recharged ground water (Widmer, 1990). These waters are characterized with low values of total dissolved solids, chloride, sodium and sulfate. The sampled waters are also low in iron and manganese. Domestic wells within the area do have iron and manganese values that exceed drinking water standards based on Nevada State Health Lab reports.

Table 2
Water Quality Summary
(ppm)

<u>Well</u>	<u>TDS</u>	<u>Fe</u>	<u>Mn</u>	<u>As</u>	<u>CaCO3</u>	<u>Ca</u>	<u>Na</u>	<u>Cl</u>	<u>SO4</u>
SJ 1	210	0.04	0.05	<0.005	127	21	17	6	5
SJ 2	213	0.03	<0.01	<0.005	124	20	12	4	3
SJ 3	172	0.07	<0.01	<0.005	112	20	8	9	3
SJ 4	185	0.06	<0.01	<0.005	238	24	11	6	8

PUMPING TESTS

William E. Nork was contracted by Sierra Reflections Corporation to conduct pumping tests on test wells 2, 3 and 4. The report "St. James Village Exploration Wells SJ-3, SJ-4 and SJ-2 Testing Results" details the step-drawdown and constant discharge pumping tests. Table 3 summarizes the results.

Table 3
Pumping Test Results

Well	Discharge (gpm)	Drawdown (feet)	Duration (hrs)	Transmissivity* (gpd/ft)	Conductivity (ft/day)
SJ-2	140	46.33	42.5	3900	7.5
3	152	45.23	27.0	3900	1.7
4	152	31.01	41.7	16500	18.4

* As calculated by Nork, 1994

HYDROGEOLOGY

Figure 2 is a cross section of the test holes drilled and the Gulf Mineral's "Strat Hole 10" (Campbell, 1982) as shown in figure 1. The study area can be characterized somewhat as a volcanic pediment overlain with an alluvial veneer. Between volcanic flows, rubble zones of sand and gravel and lahar formations exist. During the drill cuttings inspection, many of these sands and gravels could also have been described as well fractured and broken andesite given their coarse and angular nature. Several north

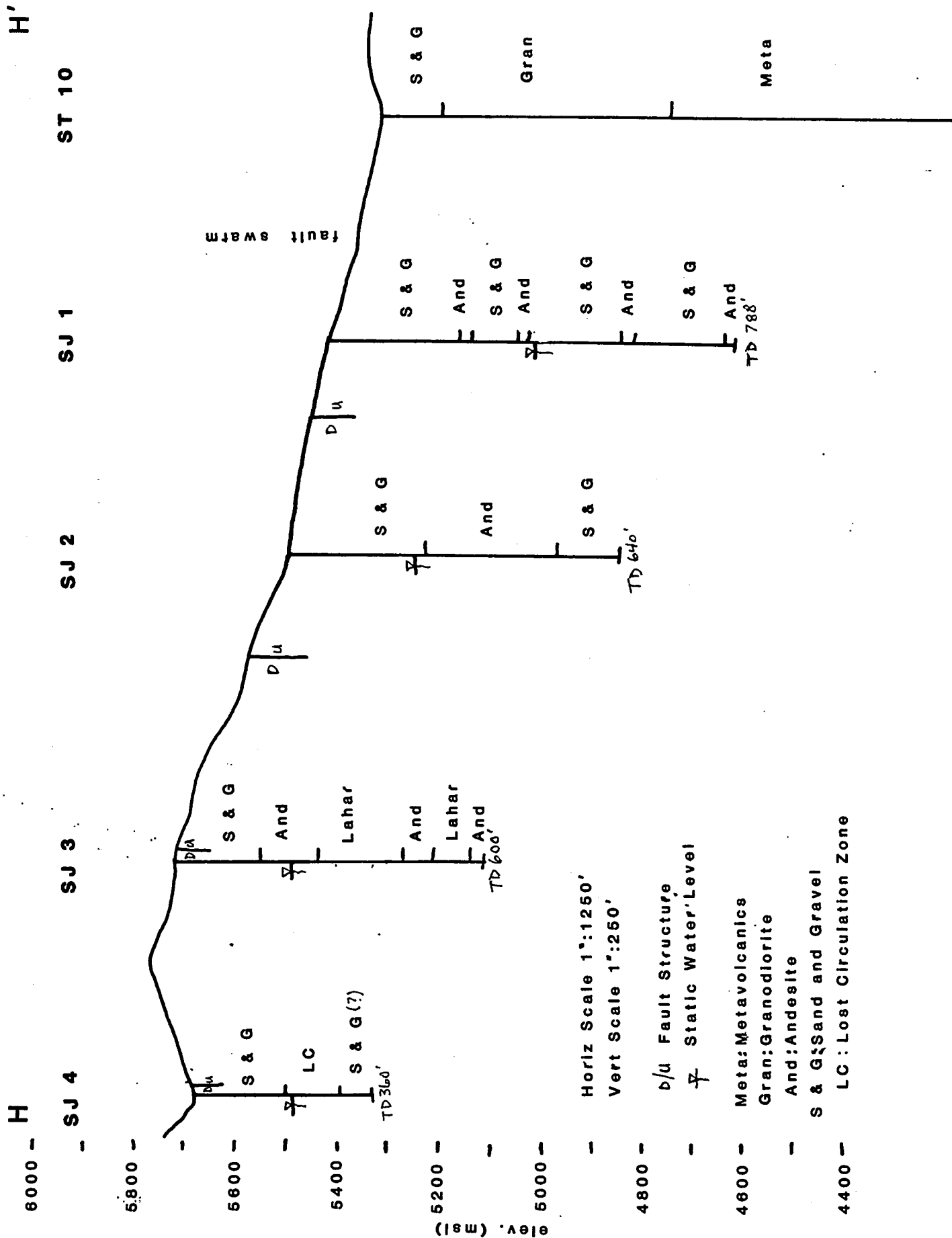


Figure . Cross Section of St. James' Test Holes

trending faults appear to offset the andesite such that individual flows are discontinuous from east to west; this structure may also be a result of the paleo-depositional and erosional environment. Based on this and other drilling programs, the "pediment" extends south to Washoe Valley, west to the Carson Range, east to the Steamboat Hills and north to the Callahan Ranch area where an apparent east-west fault scarp .

The west to east piezometric gradient appears to be consistent with water levels located in alluvium on the Galena Fan to the north (HydroSearch, 1991). This may indicate that there is good hydraulic communication between the pediment and the alluvial fan. It was not determined if the faulting acts as a barrier to ground water movement. Hydraulic conductivities appear to range from poor to good. Qualitatively speaking, it appears that there is sufficient ground water movement, and thus supply, to satisfy the needs of this 540 home subdivision.

Water production was noted mostly in the sands and gravels (or well fractured and broken andesite). All four sites have the potential to produce at least 300 gpm from properly constructed production wells based on the pumping tests conducted. Unless production wells are constructed deeper, maximum production per well is probably on the order of 500 gpm, specifically at sites 2 and 4. While test well 1 was not pumped, test well 4 proved to have the best potential for ground water exploitation. Because test wells 3 and 4 are located close to the mountain front and in faulted areas, production may be limited due to impermeable boundary conditions which, to date, have not been documented.

RECOMMENDATIONS

Average and peak day demands for this proposed subdivision are approximately 300 gpm and 800 gpm, respectively. Three wells equipped to pump 300 gpm each are sufficient to service this subdivision. Production wells should be located sequentially at sites 4, 3 and 2. This spacing should eliminate well interference effects and, more importantly, allow for more efficient ground water capture. Limiting production at site 4 will lessen the effects of drawdown on domestic wells located in the immediate area.

At site 4, the test hole encountered lost circulation zones, was only drilled to 360 feet and the completed well was highly inefficient. The production borehole should be drilled to a depth of 600 feet to further explore the aquifer potential. This should be drilled with the dual tube reverse method in order to overcome the lost circulation problems. Using the previous pumping test data and a more efficient well design, the pumping level should be between 240 and 260 feet at a pumping rate of 300 gpm. The well should be screened from 300 to 600 feet. Ten inch casing should be used. Please note that nothing is known of the aquifer below 360 feet.

At site 3, the test well's maximum production is 150 gpm based on locating the pump above the slotted portion of the well, a common practice for the Washoe County Utility Division. Nork, (1994) suggests that the test well is highly efficient. Therefore, constructing a production well at this site may yield less than 300 gpm if the same depths and screen intervals are used. The production well borehole should explore below 600 feet and ultimately be completed to at least 600 feet. The top of the screen should be located at 350 feet below land surface in order to allow adequate pumping drawdown. Ten inch casing is also recommended.

At site 2, the production zone is below 530 feet. The production well borehole should be drilled to 700 feet. The screened interval should be from 530 to 700 feet. This well design will accomodate 300 gpm production and allow for adequate long term drawdown. Ten inch casing is also recommended.

Drilling methods should employ the dual tube reverse method in order to eliminate lost circulation and borehole stability problems. At site 2, air hammer techniques should be used from 260 to 530 feet. After well completion and development, ten day pumping test should be run at all sites. Given the nature of the aquifer materials, this time frame will assure that adequate data is collected to: 1) assess possible aquifer boundaries, 2) determine effects on domestic wells and 3) ensure that water quality standards are met.

REFERENCES

Campbell, Glen E., 1982. Letter to John M. Collins, dated April 7, 1982. Gulf Mineral Resources Co., Denver, Colorado

Hydro Geo Chem, Inc., 1988. Well Hydraulics Interpretation Program. Hydro Geo Chem, Inc., Tucson, Ariz.

HydroSearch, Inc., 1991. South Truckee Meadows Ground-Water Flow and Transport Model. HydroSearch, Inc., Reno, Nevada

Nork, William E., 1994. St. James Village Exploration Wells SJ-3, SJ-4 and SJ-2 Testing Results. William E. Nork, Inc., Reno, Nevada

Widmer, Michael C., 1990. Notebook on the Hydrogeology of the South Truckee Meadows. Washoe County Department of Public Works, Utility Division, Reno, Nevada

APPENDIX

1. Lithology Logs
2. Geophysical Logs
3. Well Drillers Reports
4. Water Quality Reports
5. Pumping Test Data
6. Bid Proposal

LITHOLOGY

Footage Description

TEST HOLE 1

000-048 silty sand with cobbles
 048-105 cobbles with silty sand
 105-162 silty sand with cobbles
 162-260 silty, coarse sand w/occasional cobbles, minor water
 260-290 andesite
 290-310 andesitic gravel and sand
 310-370 sand and gravel
 370-390 andesite
 390-570 volcanic sand and gravel, water production zone 545 ft
 570-601 andesite
 601-666 silty sand
 666-670 silty, tan clay
 670-705 andesite
 705-772 gravelly, silty sand
 772-788 andesite

TEST HOLE 2

000-038 mixed clay, silt and sand
 038-264 andesitic and granitic sands and gravels, minor water
 264-524 hard andesite
 524-640 sands and gravels, lost circulation zone, good water production

TEST HOLE 3

000-060 clayey, silty sand with gravels and cobbles
 060-082 granitic and volcanic sand and gravels
 082-091 granodiorite boulder
 091-170 volcanic gravels and granitic/volcanic sands
 170-280 andesite
 280-300 andesitic welded tuff (?), broken and water bearing
 300-346 multi-colored volcanic sands and gravels
 346-421 med. to coarse, black, volcanic sand mixed with multi-colored volcanics
 421-437 red and dark, blue andesitic cuttings; poor returns
 437-500 coarse, dark blue andesitic cuttings; poor returns
 500-573 multi-colored, volcanic dans cuttings; good water production zone, poor returns.
 573-600 poor returns, harder drilling: some light green volcanic cuttings; caving problems at 580-600 feet.

TEST HOLE 4

000-080 sandy silt
 080-120 sandy gravel
 120-150 sandy silt with minor gravael
 180-295 lost circulation zone, no returns
 295-360 dark blue, andesitic sand and gravels, lost circulation at 360 ft; good water production zone

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

Log No.
Permit No.
Basin.

NOTICE OF INTENT NO.

1. OWNER <u>Washoe County</u>	ADDRESS AT WELL LOCATION <u>St. Jame's Village - well #1</u>
MAILING ADDRESS <u>P.O. Box 11130</u>	
<u>Reno, Nev. 89520</u>	

2. LOCATION NE 1/4 NE 1/4 Sec. 14 T. 17N N/S R. 19 E. Washoe County
 PERMIT NO. 59632 46-060-03 St. James Village
Issued by Water Resources Parcel No. Subdivision Name

3.	WORK PERFORMED	4.	PROPOSED USE	5.	WELL TYPE
<input checked="" type="checkbox"/> New Well	<input type="checkbox"/> Replace	<input type="checkbox"/> Domestic	<input type="checkbox"/> Irrigation	<input type="checkbox"/> Cable	<input type="checkbox"/> Rotary
<input checked="" type="checkbox"/> Deepen	<input type="checkbox"/> Abandon	<input type="checkbox"/> Municipal/Industrial	<input checked="" type="checkbox"/> Monitor	<input checked="" type="checkbox"/> Air	<input checked="" type="checkbox"/> Other fluid
	<input type="checkbox"/> Recondition		<input type="checkbox"/> Test		<input type="checkbox"/> RVC
	<input type="checkbox"/> Other _____		<input type="checkbox"/> Stock		

6. LITHOLOGIC LOG

[illegible]

8. WELL CONSTRUCTION

Depth Drilled 788 Feet Depth Cased 770 Feet

HOLE DIAMETER (BIT SIZE)

		From	To	
10	Inches	0	Feet	788
	Inches		Feet	
	Inches		Feet	

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
4.50		.188	0	770
2 3/8		sch 40	0	42

Perforations:

Type perforation. Mill slot
Size perforation. 3/32 x 3"

From	<u>470</u>	feet to	<u>770</u>	feet
From		feet to		feet
From		feet to		feet
From		feet to		feet
From		feet to		feet

Surface Seal: ☒ Yes ☐ No Seal Type:
 Depth of Seal: 50' ☐ Neat Cement
 Placement Method: ☐ Pumped ☐ Cement Grout
☒ Poured ☒ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 770 feet

9. WATER LEVEL

Static water level. 403' _____ feet below land surface
Artesian flow _____ G.P.M. _____ P.S.I.
Water temperature _____ °F Quality _____

10. DRILLER'S CERTIFICATION

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

Name Mark Fredrick pump & Well Drilling
Contractor

Address P.O. Box 335
Contractor
Jackson, CA 95642

Nevada contractor's license number
issued by the State Contractor's Board 0036313

Nevada driller's license number issued by the
Division of Water Resources, the on-site driller. 1476

Signed [Signature]
By driller performing actual drilling on site or contractor

Date 1-11-94

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

[illegible]

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

Log No.
Permit No.
Basin.....

NOTICE OF INTENT NO. _____

1. OWNER <u>Washoe County</u>		ADDRESS AT WELL LOCATION <u>St. Jame's village - well #4</u>	
MAILING ADDRESS <u>P.O. Box 21130</u> <u>Reno, Nev. 89520</u>			
2. LOCATION <u>SE 1/4 SE 1/4 Sec. 14</u> <u>T. 17N</u> <u>N/S R. 19</u> <u>E.</u> <u>Washoe</u> County			
PERMIT NO. <u>59230</u>	Issued by <u>Water Resources</u>	<u>47-010-04</u> Parcel No.	<u>St. Jame's Village</u> Subdivision Name

3.	WORK PERFORMED	4.	PROPOSED USE	5.	WELL TYPE
<input checked="" type="checkbox"/> New Well	<input type="checkbox"/> Replace	<input type="checkbox"/> Domestic	<input type="checkbox"/> Irrigation	<input type="checkbox"/> Cable	<input type="checkbox"/> Rotary
<input type="checkbox"/> Deepen	<input type="checkbox"/> Abandon	<input type="checkbox"/> Municipal/Industrial	<input checked="" type="checkbox"/> Monitor	<input checked="" type="checkbox"/> Air	<input checked="" type="checkbox"/> Other fluid
	<input type="checkbox"/> Recondition		<input type="checkbox"/> Test		<input type="checkbox"/> RVC
	<input type="checkbox"/> Other.....		<input type="checkbox"/> Stock		

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thick- ness
silt, sand, gravel		000	295	
volcanics		295	360	

8. WELL CONSTRUCTION
Depth Drilled 360 Feet Depth Cased 360 Feet

HOLE DIAMETER (BIT SIZE)

	From	To
10 Inches	0 Feet	360 Feet
Inches	Feet	Feet
Inches	Feet	Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 5/8		.188	0	360
2 3/8		sch 40	0	42

Perforations:

Type perforation mill slot

Size perforation 3/32 x 3"

From	240	feet to	360	feet
From		feet to		feet
From		feet to		feet
From		feet to		feet
From		feet to		feet

Surface Seal: ☒ Yes ☐ No

Depth of Seal 75

Placement Method: ☐ Pumped☒ PouredGravel Packed: ☒ Yes ☐ No

From 75 feet to 360 feet

9. WATER LEVEL

Static water level 190 feet below land surface

Artesian flow _____ G.P.M. _____ P.S.I. _____

Water temperature _____ °F Quality _____

10. DRILLER'S CERTIFICATION

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

Name Fredrick Pump & Well Drilling

Contractor

Address P.O. Box 335

Contractor

~~Jackson, CA 95642~~

Nevada contractor's license number
issued by the State Contractor's Board 0036313

Nevada driller's license number issued by the
Division of Water Resources, the on-site driller: 2476

Signed 1/1/12 F. W. B.
By driller performing actual drilling on site or contractor

Date 1-11-94

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☒ Pump ☐ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
--------	----------------------------------	--------------

	152	31	47
--	-----	----	----

	22	22	22
--	----	----	----

Sierra Environmental Monitoring, Inc.

47 Glen Carran Circle
Sparks, NV 89431
(702) 356-3868

Laboratory Analysis Report



Date : 12/09/93
Report : 9527
Client : WAS-314 PO#: 2137
Taken by : WASHOE COUNTY UTIL-M. WIDMER
Name : WASHOE COUNTY UTILITY DIV.
Address : P.O. BOX 11130
City/St/Zip: RENO NV 89520

Page: 1

Sample	Collected		ALKALINITY	COLOR	PH	TOTAL DISSOL.	NITRATE-N	ARSENIC
	Date	Time	MG/L CaCO3	C.U.	S.U.	SOLIDS MG/L	MG/L	MG/L
JAM 1	11/19/93	10:30	127B	5	8.01	210	0.6N	<0.005
Sample	Collected		BARIUM	CALCIUM	COPPER	IRON	MAGNESIUM	MANGANESE
	Date	Time	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
JAM 1	11/19/93	10:30	0.03	21	<0.02	0.04	9.2	0.05
Sample	Collected		POTASSIUM	SODIUM	ZINC	CHLORIDE	FLUORIDE	SULFATE
	Date	Time	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
JAM 1	11/19/93	10:30	6.3	17	0.69	6	0.2	5
Sample	Collected		MBAS					
	Date	Time	MG/L					
JAM 1	11/19/93	10:30	<0.05					

Approved By: 

This report is applicable only to the sample received by the laboratory. The liability of the laboratory is limited to the amount paid for this report. This report is for the exclusive use of the client to whom it is addressed and upon the condition that the client assumes all liability for the further distribution of the report or its contents.

St. James's Village Test Well #1



Laboratory
Analysis Report

Sierra
Environmental
Monitoring, Inc.

WILLIAM E. NORK, INC.
WILLIAM E. NORK
1026 WEST FIRST STREET
RENO NV 89520

Date : 1/26/94
Client : NOR-042
Taken by: W.E. NORK-D. BUGENIG
Report : 9765
PO# : W.E.NORK

Page: 1

Sample	Collected		ALKALINITY	COLOR	PH	TOTAL DISSOL.	NITRATE-N	ARSENIC
	Date	Time	MG/L CAC03	C.U.	S.U.	SOLIDS MG/L	MG/L	MG/L
SJ-2 WELL	1/05/94	11:45	1248	<5	7.57	213	0.2N	<0.005
Sample	Collected		BARIUM	CALCIUM	COPPER	IRON	MAGNESIUM	MANGANESE
	Date	Time	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
SJ-2 WELL	1/05/94	11:45	0.07	20	<0.02	0.03	12	<0.01
Sample	Collected		POTASSIUM	SODIUM	ZINC	CHLORIDE	FLUORIDE	SULFATE
	Date	Time	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
SJ-2 WELL	1/05/94	11:45	5.2	12	0.02	4	0.1	<3
Sample	Collected		MBAS					
	Date	Time	MG/L					
SJ-2 WELL	1/05/94	11:45	<0.05					

Approved By: 

This report is applicable only to the sample received by the laboratory. The liability of the laboratory is limited to the amount paid for this report. This report is for the exclusive use of the client to whom it is addressed and upon the condition that the client assumes all liability for the further distribution of the report or its contents.

William F. Pillsbury
President

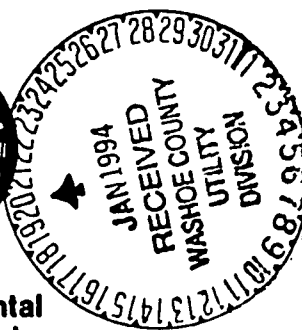
47 Glen Carran Circle
Sparks, Nevada 89431
Phone (702) 356-3868
FAX (702) 356-8037

John C. Seher
Chemist

Laboratory Analysis Report



**Sierra
Environmental
Monitoring, Inc.**



**WASHOE COUNTY UTILITY DIV.
DAN DRAGAN
P.O. BOX 11130
RENO NV 89520**

**Date : 1/19/94
Client : WAS-314
Taken by: WILLIAM NORK
Report : 9695
PO# : 002142**

Page: 1

Sample	Collected Date Time	ALKALINITY MG/L CAC03	COLOR C.U.	PH S.U.	TOTAL DISSOL. SOLIDS MG/L	NITRATE-N MG/L	ARSENIC MG/L
#93-539-01 - SJ-3	12/18/93 :	1128	<5	6.91	172	<0.1N*	<0.005
Sample	Collected Date Time	BARIUM MG/L	CALCIUM MG/L	COPPER MG/L	IRON MG/L	MAGNESIUM MG/L	MANGANESE MG/L
#93-539-01 - SJ-3	12/18/93 :	0.08	20	<0.02	0.07	11	<0.01
Sample	Collected Date Time	POTASSIUM MG/L	SODIUM MG/L	ZINC MG/L	CHLORIDE MG/L	FLUORIDE MG/L	SULFATE MG/L
#93-539-01 - SJ-3	12/18/93 :	4.0	8.0	0.08	9	0.1	<3
Sample	Collected Date Time	MBAS MG/L					
#93-539-01 - SJ-3	12/18/93 :	<0.05					

Approved By: 

This report is applicable only to the sample received by the laboratory. The liability of the laboratory is limited to the amount paid for this report. This report is for the exclusive use of the client to whom it is addressed and upon the condition that the client assumes all liability for the further distribution of the report or its contents.

**William F. Pillsbury
President**

**47 Glen Carran Circle
Sparks, Nevada 89431
Phone (702) 356-3868
FAX (702) 356-8037**

**John C. Seher
Chemist**



Laboratory
Analysis Report



Sierra
Environmental
Monitoring, Inc.

WASHOE COUNTY UTILITY DIV.
DAN DRAGAN
P.O. BOX 11130
RENO NV 89520

Date : 1/28/94
Client : WAS-314
Taken by: WASHOE CTY UTIL-R.V.H.
Report : 9721
PO# : 002145

Page: 1

Sample	Collected Date Time	ALKALINITY MG/L CAC03	COLOR C.U.	PH S.U.	TOTAL DISSOL. SOLIDS MG/L	NITRATE-N MG/L	ARSENIC MG/L
ST. JAMES #4	12/23/93 :	2388	<5	7.24	185	0.5N	<0.005
Sample	Collected Date Time	BARIUM MG/L	CALCIUM MG/L	COPPER MG/L	IRON MG/L	MAGNESIUM MG/L	MANGANESE MG/L
ST. JAMES #4	12/23/93 :	0.11	24	<0.02	0.06	15	<0.01
Sample	Collected Date Time	POTASSIUM MG/L	SODIUM MG/L	ZINC MG/L	CHLORIDE MG/L	FLUORIDE MG/L	SULFATE MG/L
ST. JAMES #4	12/23/93 :	6.2	11	0.06	6	0.1	8
Sample	Collected Date Time	MBAS MG/L					
ST. JAMES #4	12/23/93 :	<0.05					

Approved By: 

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William F. Pillsbury
President

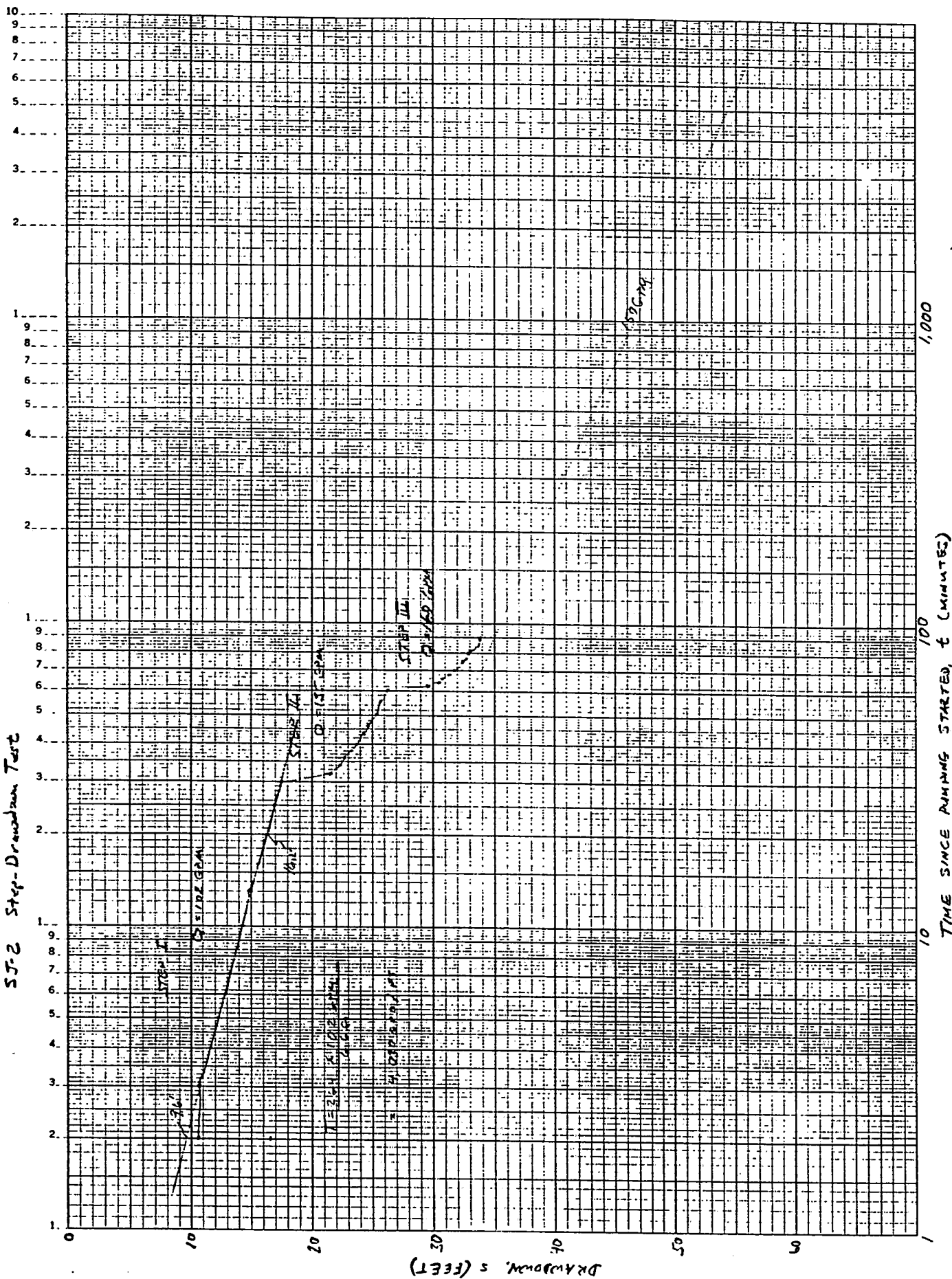
47 Glen Carran Circle
Sparks, Nevada 89431
Phone (702) 356-3868
FAX (702) 356-8037

John C. Seher
Chemist

94-539 ST. JAMES VILLAGE
 SEMI-LOGARITHMIC CYCLES X 70 DIVISIONS
 K-E KEUFFEL & ESSER CO. MADE IN U.S.A.

55-2 Step-Drawdown Test

Pump on: 1000 hrs 11/1/54
 Pump off: 1530 hrs 1/5/54
 46 6010



WILLIAM E. NORK, INC.
 1026 West First Street
 RENO, NEVADA 89503
 (702) 322-2604

JOB 94-539

SHEET NO. 1

OF

CALCULATED BY DCB

DATE 1/3/84

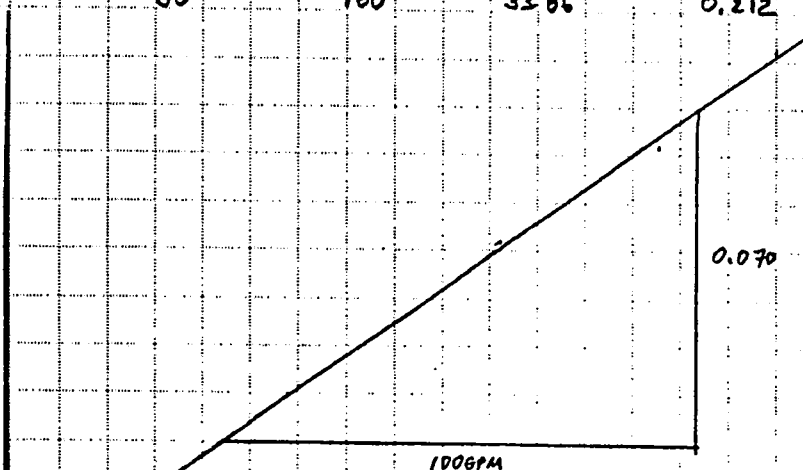
CHECKED BY

DATE

SCALE

SJ-2

STEP	DURATION ± (MINUTES)	PUMPING RATE Q (GPM)	DRAWDOWN S (FEET)	$\frac{S}{Q}$
I	30	102	17.42	0.171
II	30	136	26.17	0.192
III	30	160	33.86	0.212



$$C = 0.0007$$

$$B = 0.098$$

$$S = BQ + CQ^2$$

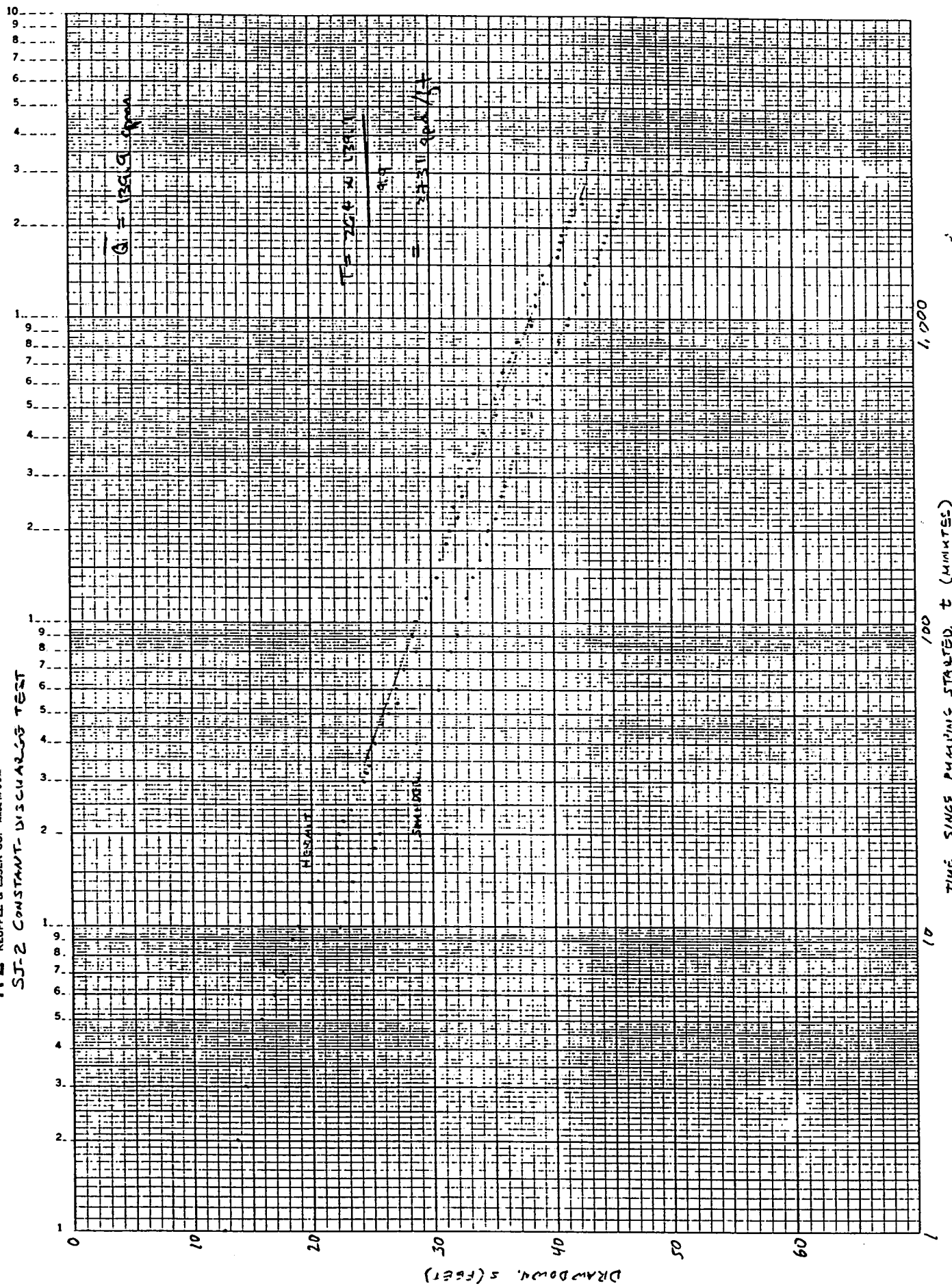
$$= 0.098Q + 0.0007Q^2$$

Q	BQ	CQ ²	S	EFF %
102	10.0	7.28	17.28	57.9
136	13.32	12.95	26.27	50.7
160	15.68	17.92	33.60	46.7

94-539 3T JAMES VILLAGE
 KEUFEEL & ESSER CO. MADE IN USA

SJ-2 CONSTANT-DISCHARGE TEST

PUMP ON: 1730 HRS 1/2/93
 PUMP OFF: 1200 HRS 1/5/93
 46 6010



TIME SINCE PUMPING STARTED, t (MINUTES)

SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 6010

ST-2 CONST Q TEST

ST-JANES VILLAGE

PUMP ON 1730 1/31/64

PUMP OFF 1/5/64 + 1200 hrs

$Q = 139.9 \text{ gpm}$

$T = 26.4 \times 139.9$

10

$= 3693.96$

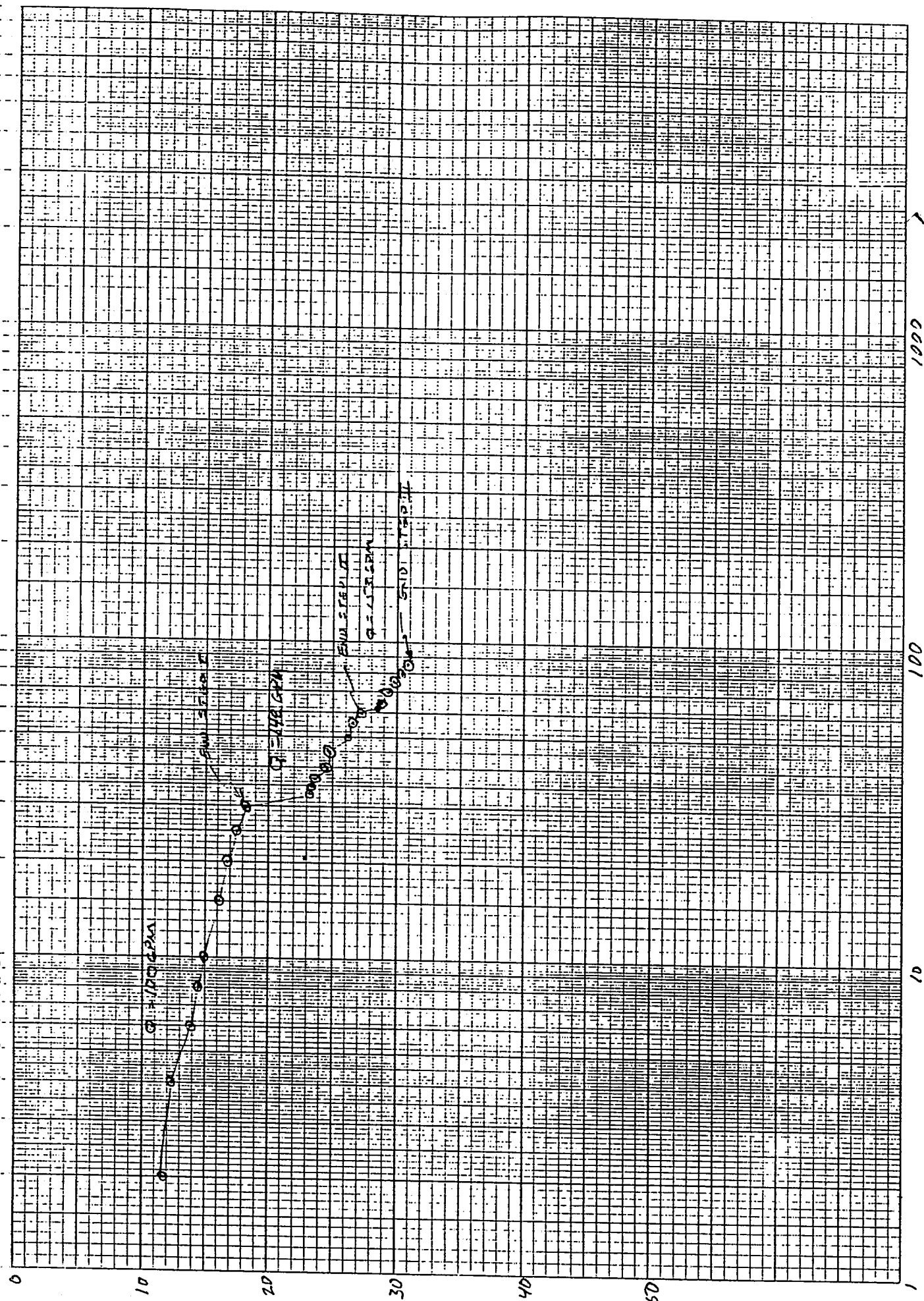
10

100

1000

10000

SJ-3 STEP-DRAWDOWN TEST

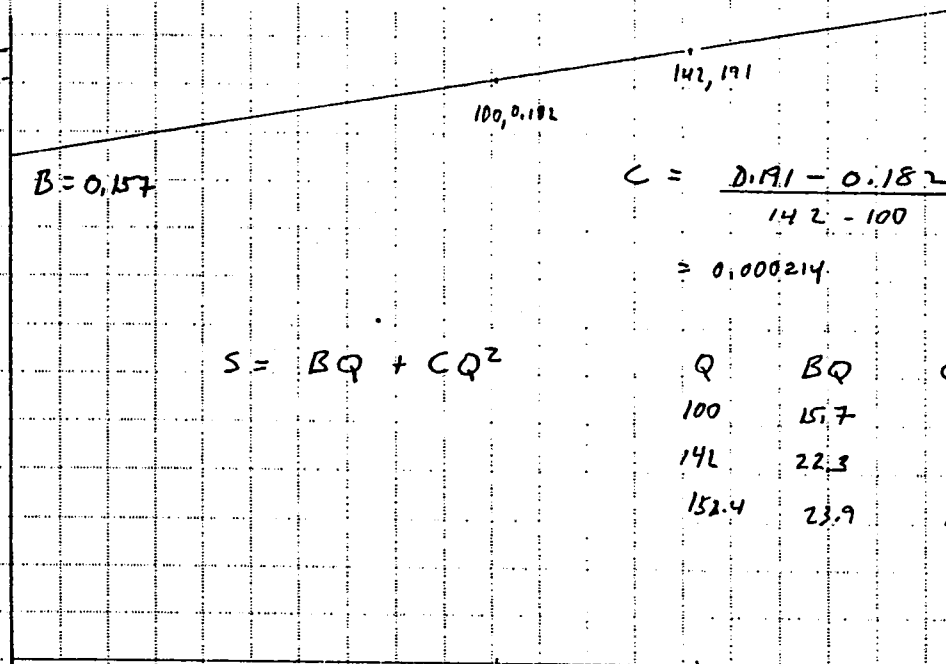


WILLIAM E. NORK, INC.
 1026 West First Street
 RENO, NEVADA 89503
 (702) 322-2604

JOB 93-539
 SHEET NO. 1 OF
 CALCULATED BY DCB DATE 12/12/93
 CHECKED BY DATE
 SCALE

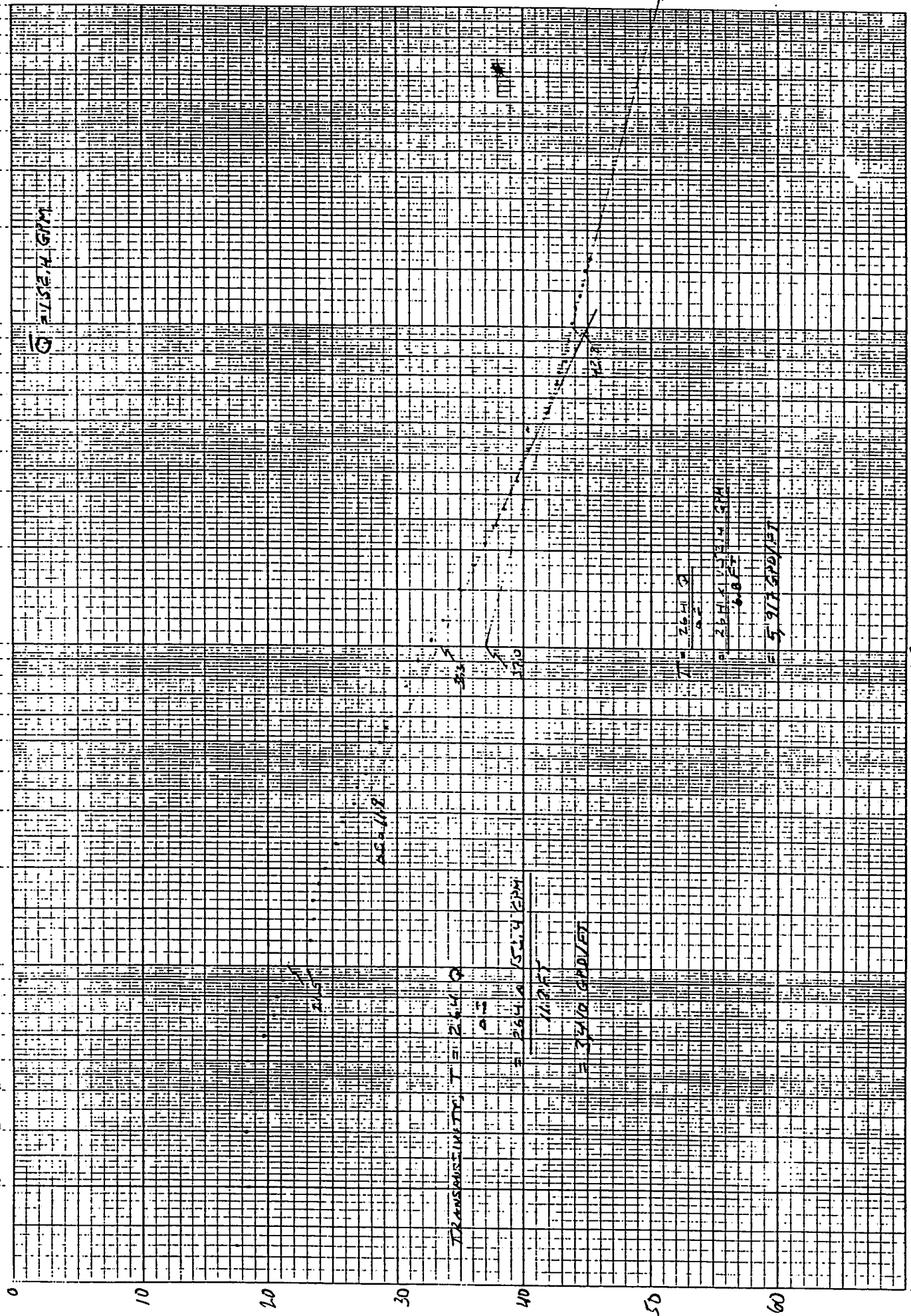
S T. JAMES TEST WELL SJ-3

STEP	DISCHARGE RATE, Q (GPM)	DRAWDOWN S (FEET)	S/Q
I	100	18.15	0.1815
II	142	27.11	0.1909



Q	BQ	CQ ²	S	(BQ + CQ ²) EFF.
100	15.7	2.14	17.8	88
142	22.3	4.3	26.6	84
152.4	23.9	5.0	28.9	83

55-3 CONSTANT DENSITY TEST



1,000

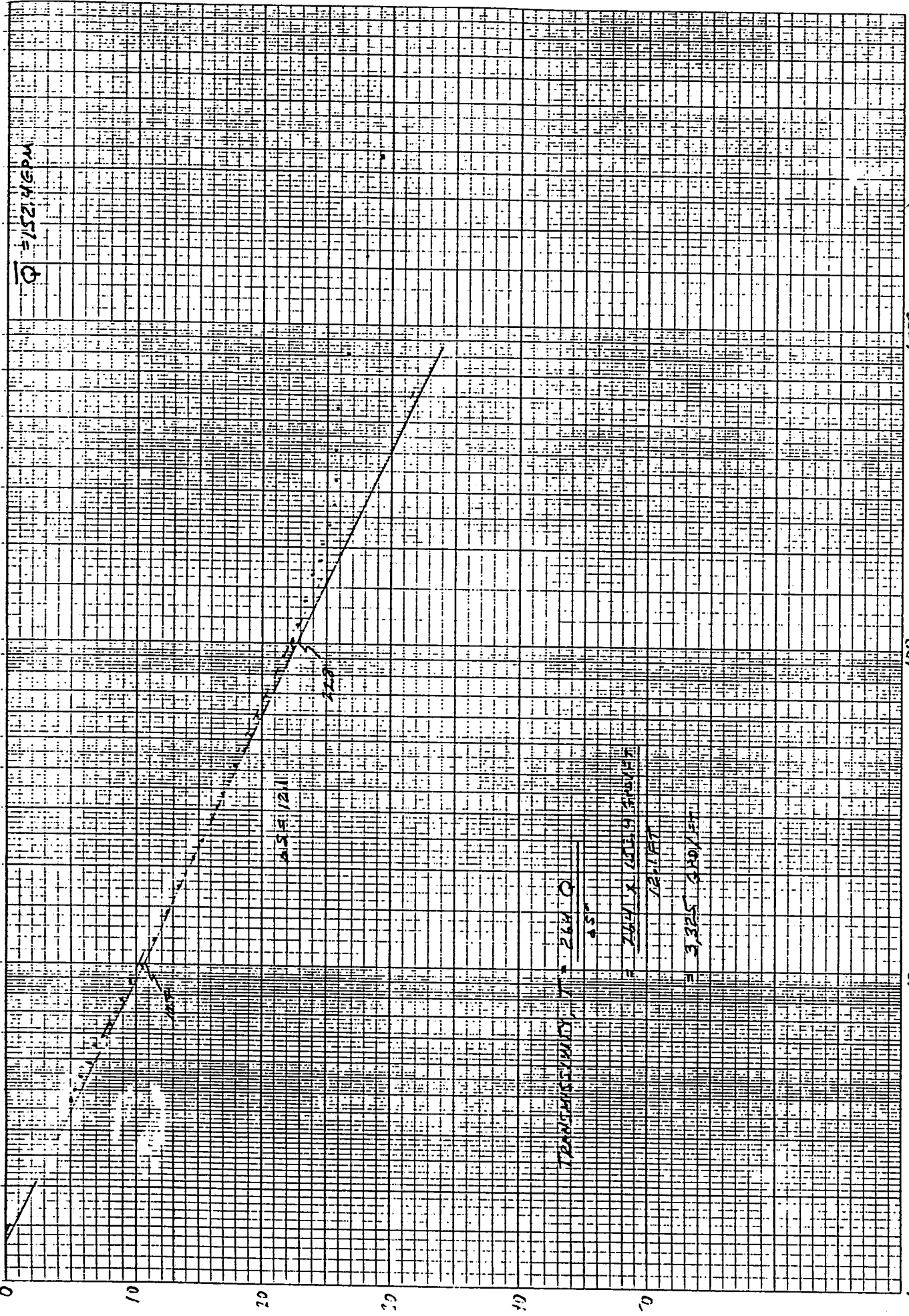
100

01

TIME \rightarrow INCREASING STAGES, 2 MINUTES

K-3
 SEMI-LOGARITHMIC CYCLES X 10 DIVISIONS
 KEUFFEL & ESSER CO. MADE IN U.S.A.
 SJ-3 CONSTANT-DISCARDAGE TEST

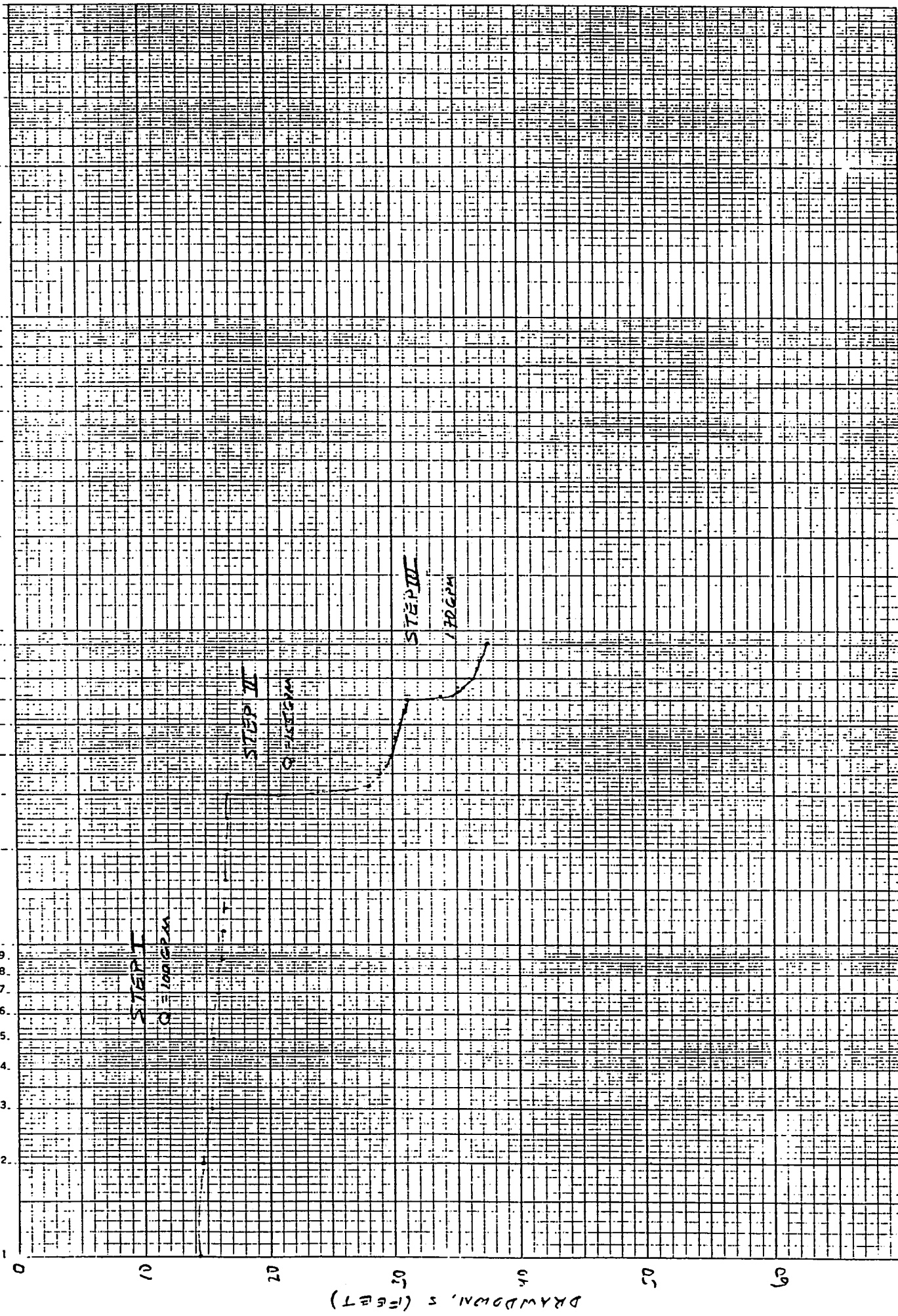
3/1/30
 46 6010



46 6010

SEMI-LOGARITHMIC CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

STEP-DRAWDOWN TEST

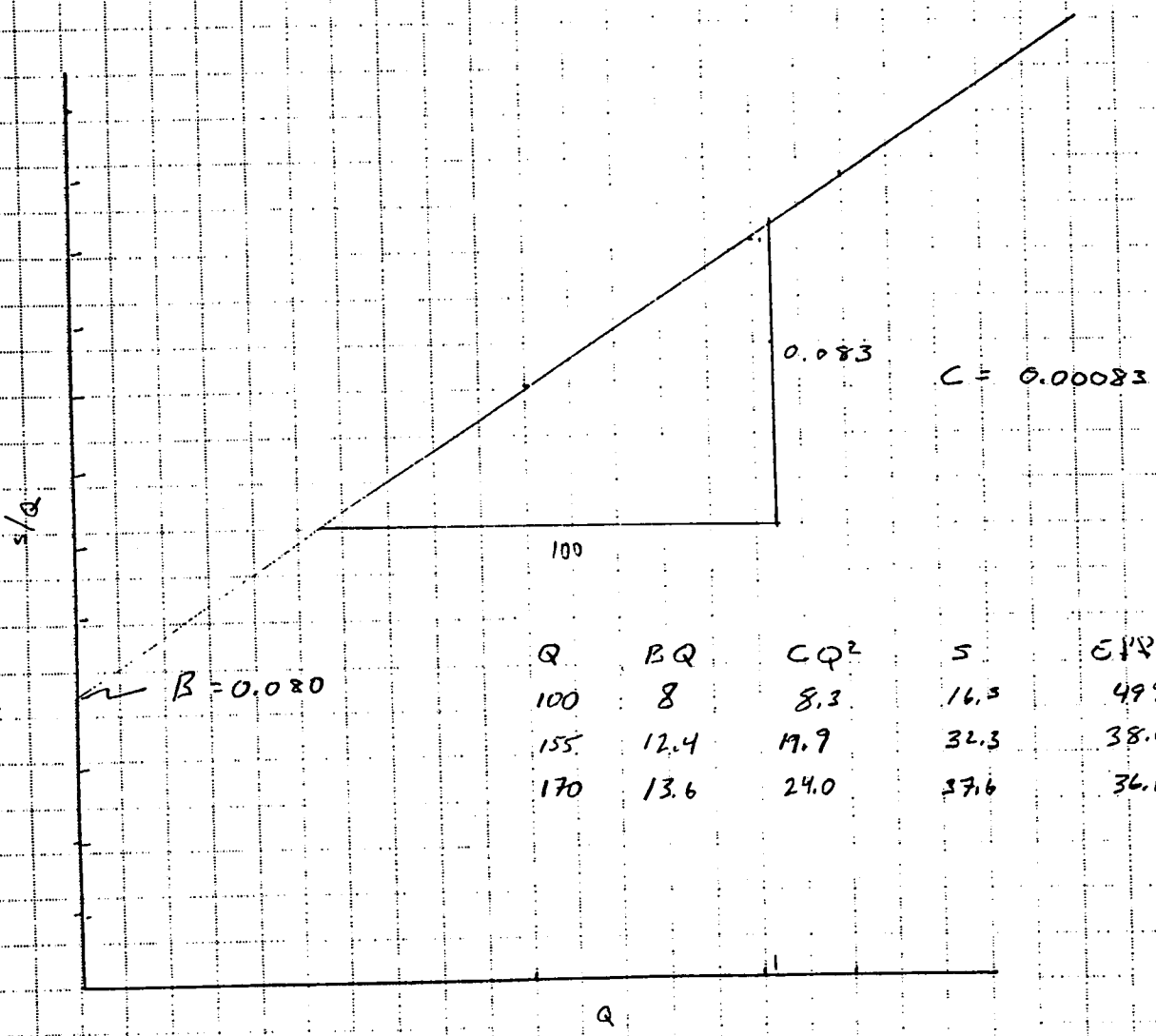


10 TIME SINCE PUMPING STARTED, t (MINUTES)

WILLIAM E. NORK, INC.
 1026 West First Street
 RENO, NEVADA 89503
 (702) 322-2604

JOB 93-539
 SHEET NO. 1 OF
 CALCULATED BY D.C.B. DATE 12/21/83
 CHECKED BY DATE
 SCALE

Step	Duration	Pumping Rate (GPM)	Drawdown s (feet)	s/q
I		100	16.28	0.163
II		155	31.09	0.201
III		170	37.41	0.210



Q	BQ	CQ ²	s	EFF (BQ ÷ s)
100	8	8.3	16.3	49%
155	12.4	17.9	32.3	38.4%
170	13.6	24.0	37.6	36.1%

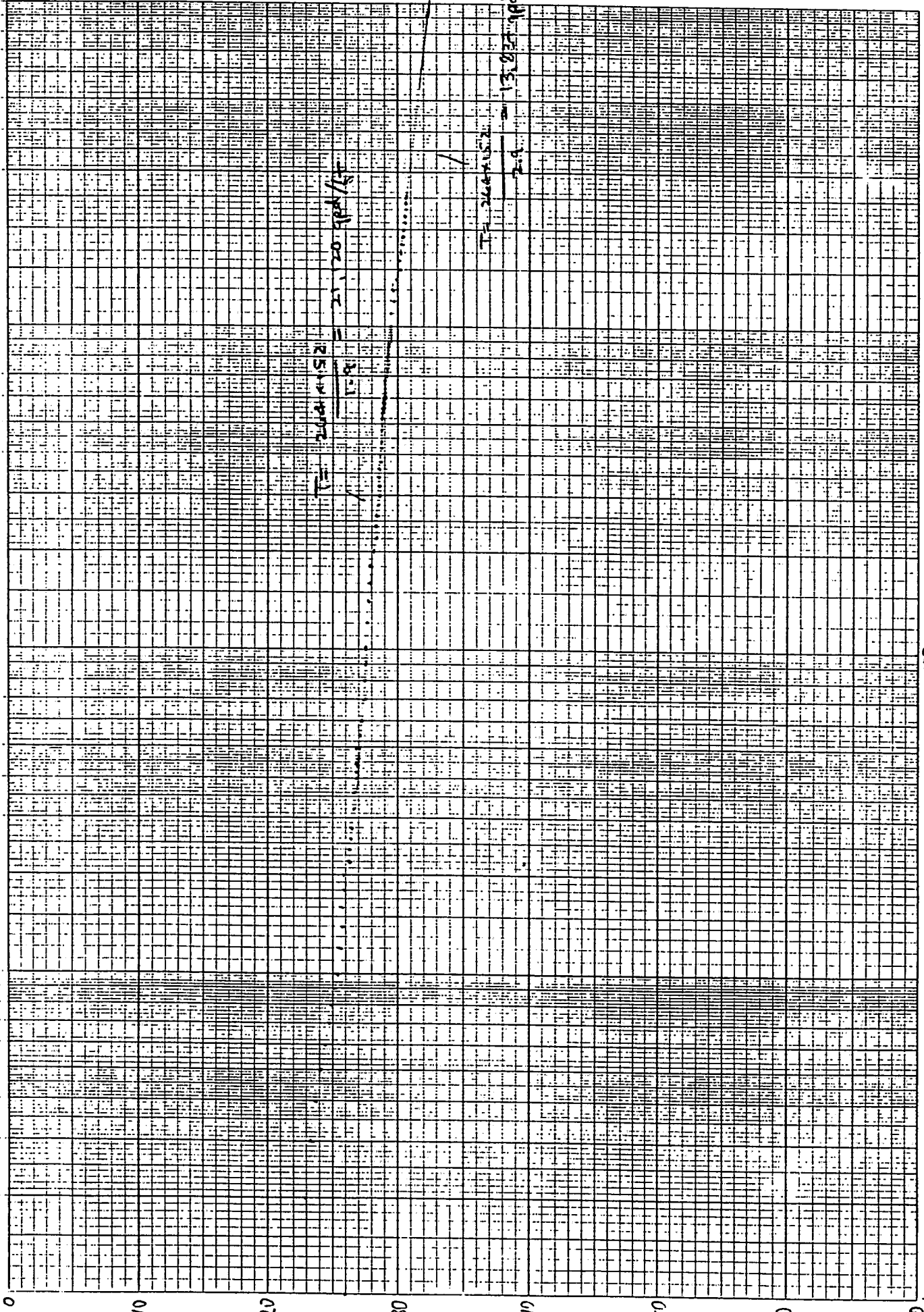
14MP 5.1.1

MIL-LOG THERMISTOR DIVISION
SUFFOLK COUNTY, MASS. U.S.A.

46 0

CONSTANT-DISCHARGE TEST

9
8
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TIME SINCE PUMPING STARTED, t (MINUTES)

SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

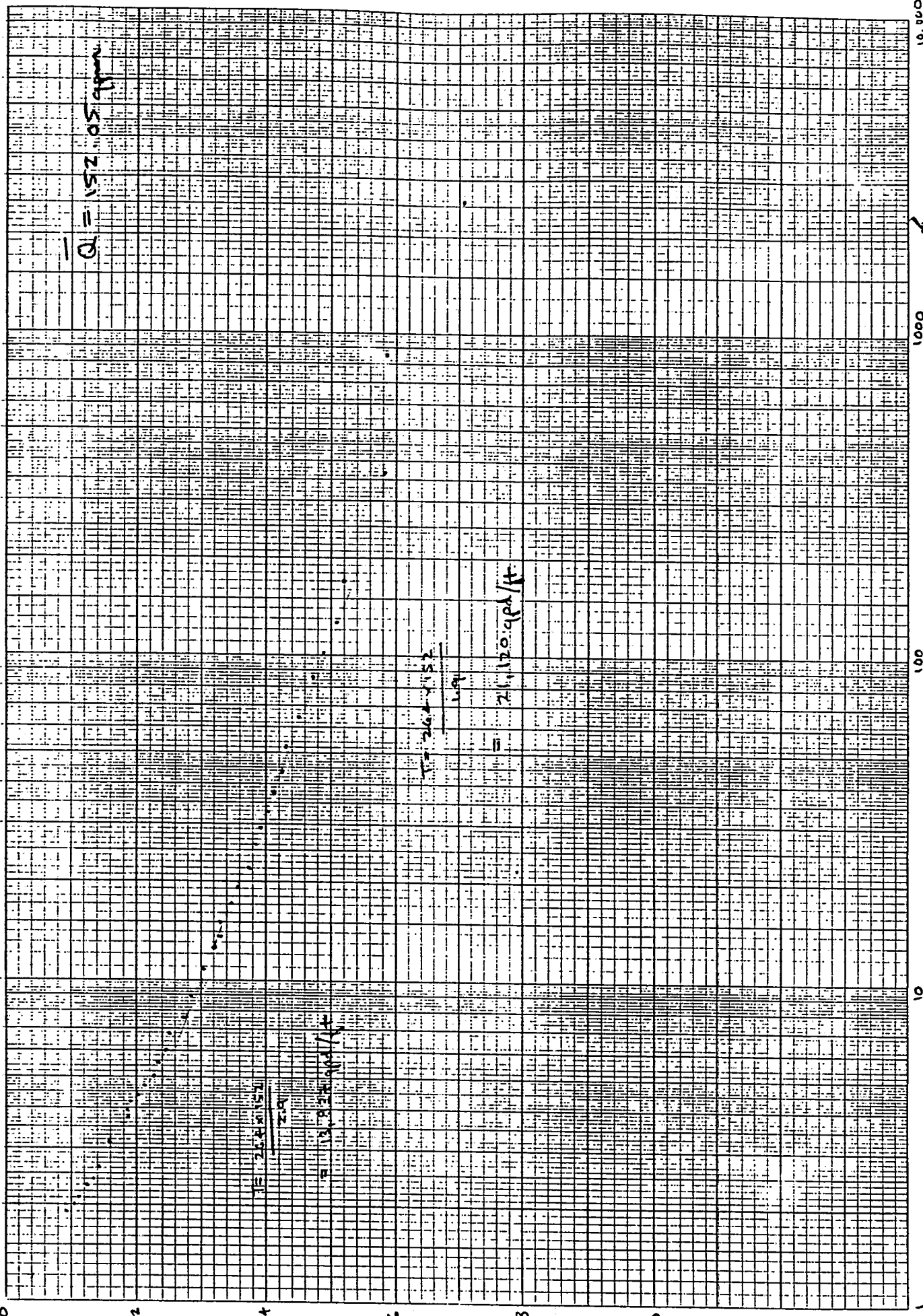
93-534 ST. JAMES, VILLAGES

554 0 1500 1000

46 6010

030 1730

Pump off 1130 12/23/93


$$t/t' \text{ (TIME SINCE PUMP STARTED) } \div \text{ TIME SINCE PUMP STOPPED}$$

Contract Documents and Specifications for St. James Exploratory Well Drilling

WELL SPECIFICATIONS

1. Scope of Work

The work to be performed includes the furnishing of all labor, materials, transportation, tools, supplies, plant equipment and appurtenances, unless hereinafter specifically excepted, necessary to complete and satisfactory construct, develop and test six (6), 4-inch diameter steel test wells.

2. Location and Access

The test wells are located south of the Mount Rose Highway (see attachment map) in T17N, R19E, sections 10, 14 and 23. The sites are on undeveloped land with easy access. The Contractor shall familiarize himself with the conditions within the drill site prior to bidding.

3. Equipment and Operating Requirements

Drilling shall be with the air rotary method. The equipment to be furnished shall be approved by the Owner and have excess capacity to construct the wells as specified herein. At least one (1) drill collar will be used for added weight during early stages of drilling.

4. Test Well Construction Development and Testing

- a. Borehole - The boreholes for the test wells shall be drilled to the depth specified by the Owner. The anticipated total depth for the bores are 500 feet. The diameter of the well bore shall not be less than 8-inches. Formation samples shall be taken at 10-foot intervals or at each change in formation. Samples shall be stored in Ziploc freezer bags or approved equal. Upon completion of the borehole, the contractor shall employ a commercial logging service such as Welenco, Geo-Hydro-Data or approved equal. The commercial logging service shall run standard electric, sonic and caliper logs.
- b. Casing Installation - The test well shall be constructed using new steel pipe and shall have an outside diameter of 4-inches and an inside diameter of not less than 3.72-inches. Wall thickness shall not be less than 0.134-inches. Perforated pipe shall be of the same material

Contract Documents and Specifications for St. James Exploratory Well Drilling

with vertical mill cut slots approximately 3-inches long by 3/32-inches wide. There shall be a minimum of four (4) slots per foot. Mill slots shall be clean and smooth with no burrs, filings or other obstructions on the inside or outside of the casing. The 4-inch pipe shall be completed with a threaded end, and cap. The casing shall be installed using methods approved by the Owner. The casing shall be suspended above the bottom of the hole and shall be firmly secured at the surface until the gravel and grout seal installation, including 24-hour set up for grout, is complete.

Welders required for field assembly of well casing shall be qualified in accordance with the latest revision of the section titled, "Welding Procedures" of the AWA Standard Qualification Procedure. All sections shall be joined by a watertight continuous, full fillet weld.

- c. Gravel Pack - The annular space between the borehole wall and the 4-inch casing from the bottom of the hole to a depth specified by the Owner (estimated at approximately 450 feet) shall be filled with a well-rounded siliceous 1/8 by 1/4 inch gravel. The selected gravel shall be approved by the Owner prior to installation. Gravel shall be installed to the specified depth through a tremmie pipe and "sounding" of the gravel depth shall be made and approved by the Owner prior to installation of the grout seal. Placement of gravel by end-dumping with a loader or shoveling directly into the hole will not be allowed. The Contractor shall be responsible for placing the gravel in the annulus without bridging. If the gravel bridges, the Contractor shall correct the problem with no damage to the well or drill a new well, complete, at his expense. If the Contractor chooses to drill a new well, he shall be responsible for all costs associated with properly abandoning the existing well. Bridging of gravel pack shall be assumed if gravel packing does not utilize at least 90% of the calculated annular space volume.
- d. Grout Seal - the annular space between the borehole wall and the 4-inch casing from the top of the gravel to the ground surface (estimated to be from 0 to 50 feet) shall be filled with neat cement grout. The grout shall be installed through a tremmie pipe from the bottom up. The

Contract Documents and Specifications for St. James Exploratory
Well Drilling

cement shall be left undisturbed for a minimum of twenty-four (24) hours before air-development begins. No standby time shall be paid during this period.

- e. Development - After the 24 hour allotted time for the grout seal to set-up, development and testing by air-lift may begin. Air lifting shall be accomplished by high pressure air pumped through an air line extending to within twenty (20) feet of the bottom of the well. Development shall continue until is the opinion of the Owner that development is complete.

After development, the contractor shall perform an air lift flow test in order to determine the hard rock aquifer's production potential. This test will be conducted for approximately four hours. The Contractor shall provide an adequate air compressor for development and flow testing. The Contractor shall also provide adequate material to ensure total discharge capture, during flow testing, for reliable measurements. This material and set-up must be approved by the geologist. The contractor shall make every effort to maintain a continuous ground water discharge from the well.

?
Draw
Down
Measure

Payment for development and testing by air lift shall be at the hourly rate specified in the bid sheet and shall include all fuels and other emergency sources necessary for completion of work as specified. The hourly rate does not include the time spent for equipment installation and removal.

5. Plumbness and Alignment

The Contractor shall guarantee that the well when completed, shall be sufficiently straight and plumb to permit the free installation and operation of a submersible pump regularly recommended to be installed in a 4-inch diameter well casing. The Contractor shall utilize a plumbness test approved by the Owner and the test shall be performed in the presence of the Owner.

Run a pump in the hole

When it becomes necessary to add clays or chemicals to the drilling fluid, it must be borne in mind that it is desirable to maintain a mud system containing a minimum of clay and fine sand and to deposit a thin, easily removable filter cake on the face of the borehole. If there should be a conflict between the mud requirements for ease in drilling and the mud requirements for protection of the aquifers, then the ruling requirements shall be those for aquifer protection.

The Contractor shall retain the services of a qualified mud engineer to plan and monitor the use of drilling fluid, additives and mud. The mud engineer shall outline the drilling fluid properties required, keeping in mind the goals of aquifer protection including those required to prevent bacterial contamination of the well. Drilling fluid additives used to stop lost circulation shall be as recommended by the manufacturer for that particular use and under the supervision of the mud engineer. The cost of drilling fluid and additives shall be included in the unit price per foot of drilling the borehole.

The Contractor shall monitor and maintain the fluid properties as outlined by the mud engineer. In the event that the Contractor cannot attain these properties, the mud shall be replaced. Contractor shall pay for additional drilling fluids up to a sum of \$500.00. Above \$500.00 the Owner shall pay the Contractor for additional drilling fluids at Contractor's cost plus fifteen percent (15%).

The mud engineer, before drilling begins, shall provide the geologist with his outline for drilling fluid properties and recommendations for monitoring those properties. The mud engineer shall include in his outline of drilling fluid properties, the recommended mud properties before and during the introduction of gravel. The Contractor shall obtain the equipment necessary to monitor drilling fluid properties and shall follow the mud engineer's recommendations for frequency of monitoring.

Section 12. . Monitoring Well Construction

Monitoring wells will be constructed using new, A.S.T.M. standard weight, galvanized, steel pipe, Grade B or better and shall have an inside diameter of 2.067 inches. Wall thickness shall be a minimum of 0.154 inch. Perforated pipe shall be of the same material with 3/32 inch vertical mill cut slots approximately 3 inches long. There shall be a minimum of four slots per foot. The 2 inch pipe shall extend 2 feet above ground surface and be completed with an approved vandal resistant locking cap.

ITEM APPROX. NO. QUANTITY	DESCRIPTION OF ITEM WITH UNIT UNIT PRICE WRITTEN IN WORDS	UNIT PRICE	TOTAL P R I C E
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SCHEDULE OF ITEMS AND PRICES

1.	1 Ea.	Mobilization and Demobilization including all materials, labor, equipment for completion of six expl. test wells as described in Specifications for the sum price of <u>eighteen hundred dollars</u> for all six wells (\$300.00 EA).	<u>1800.00</u>	<u>1800.00</u> /
2.	40 Hrs	Standby hours specifically at the request of the Owner. At the rate of <u>eighty-five</u> dollars. <u>per hour.</u>	<u>85.00</u>	<u>3400.00</u> /
3.	3000 LF	Drill six (6) minimum 8-inch diameter boreholes, to a depth of approximately 500 ft. at <u>fifteen dollars</u> <u>per lineal foot.</u>	<u>15.00</u>	<u>45,000.00</u> /
4.	6 ea.	Geophysical log of borehole estimated at lump sum price of <u>one thousand five hundred fifty</u> <u>each.</u>	<u>1550.00</u>	<u>9300.00</u> /
5.	1800 ft.	Furnish and install 4-inch diameter slotted steel pipe, estimated 300 feet per well at <u>seven dollars</u> <u>per lineal foot.</u>	<u>7.00</u>	<u>12,600.00</u> /
6.	1200 ft.	Furnish and install 4-inch diameter steel pipe, estimated 200 feet per well at <u>five</u> <u>dollars</u> <u>per lineal foot.</u>	<u>5.00</u>	<u>6000.00</u> /
7.	30 yds ³	Furnish and install gravel pack estimated 5 yds ³ per well at <u>fifty-two dollars</u> <u>per yd3</u>	<u>52.00</u>	<u>3600.00</u> /

1560

ITEM NO.	APPROX. QUANTITY	DESCRIPTION OF ITEM WITH UNIT UNIT PRICE WRITTEN IN WORDS	UNIT PRICE	TOTAL P R I C E
8.	6 ea.	Furnish and install grout sanitary seal estimated at 50 feet per well at <u>three hundred</u> per well.	<u>300.00</u>	<u>1800.00</u> ✓
9.	40 Hours	Furnish, install, operate & remove necessary equipment for air lift flow test at <u>one hundred eighty-five</u> dollars per hour.	<u>185.00</u>	<u>7400.00</u> ✓
10.	6 Each	Well disinfection & capping at <u>one hundred dollars</u> per well.	<u>100.00</u>	<u>600.00</u> ✓

PROPOSAL- TOTAL BID \$91,500.00

TOTAL BID WRITTEN IN WORDS

ninety-one thousand, five hundred dollars

89,460

The estimate of quantities of the various items of work and materials, as set forth in the Proposal Form, is approximate only and given solely to be used as a uniform basis for the comparison of proposals.

The unit prices above shall be the basis for determining the amount paid for the completed project including any increased or decreased quantities authorized by the Geologist.

If the undersigned is notified of the acceptance of his proposal, he agrees to execute the agreement for the work covered in his proposal for the above stated prices as full compensation for furnishing all materials and labor, and doing all of the work, in strict accordance with the Contract Documents, to the satisfaction of the Geologist.

The undersigned agrees, upon being notified of the acceptance of his proposal, that he shall execute the above agreement within ten (10) calendar days and commence work within seven (7) calendar days following the date of the Notice to Proceed. The undersigned