FINAL REPORT ON THE
48-HOUR PUMPING TESTS
INDIAN SPRING WELLS RW-1 AND RW-4
PRUDENCE ISLAND UTILITIES CORPORATION
PRUDENCE ISLAND, RHODE ISLAND

D.L. Maher Co.
July, 1995

TABLE OF CONTENTS

Introduction

This report presents the results of a 48-hour pumping test involving the Indian Spring Rock Wells RW-1 and RW-4 on Prudence Island, Rhode Island. This work was undertaken for the Prudence Island Utilities Corporation and involved pump testing two 6 inch diameter bedrock wells to establish potential yields and the water quality of each.

The wells were constructed in October of 1994 by the D.L. Maher Co. as part of the ground water development program. The wells were drilled on PIUC property known as the Indian Spring Site. The results of the test drilling and initial water chemistry proved favorable and warranted further evaluation.[1] In April of 1995, The D.L. Maher Co. was directed by the PIUC to perform a prolonged pumping test at the Indian Spring Site. In May of 1995 this test work was undertaken.

Well Construction

Construction of the six inch diameter bedrock wells were started on October 13, 1994 and completed October 28, 1994.[2] Each well has been constructed to meet the State of Rhode Island DOH approval.

Construction of RW-1 was started by drilling a 12 inch borehole to a depth of 33.5 feet below grade. Six inch diameter steel casing was set and pressure grouted within the bedrock. The depth to ledge here is 12 feet. At 16 feet the bedrock became competent. The steel casing is grouted 21.5 feet into bedrock.

After allowing the grout to set, a six inch diameter borehole was drilled to a depth of 464 feet. The driller reported encountering several water producing zones at the following depths;

Depth	GPM	Total
103-123	3	3
203-223	12	15
283-303	5	20
423-443	10+	30+

---

[1]. D.L. Maher Correspondence and Preliminary Water Chemistry. (Appendix A)

[2]. Well Logs RW-1 & RW-4. (Appendix A).

RW-4 is approximately 53 feet west of RW-1 and was constructed similar to RW-1. A 12 inch borehole was drilled to a depth of 464 feet. The depth to bedrock was 12 feet. The rock was soft and broken to 22 feet. Casing was advanced to a depth of 40 feet where it was pressure-grouted to the bedrock. The driller reported the following yields at the following depths;

Depth	GPM	Total
62-83	10	10
83-103	5	15
103-123	5	20
163-183	5	25
203-223	10	35
443-463	10+	45+

In the two well constructions, casing was set greater than fifteen feet into competent bedrock and a 3 inch annulus grout seal was installed.

Pump Test Set Up

The pumping test was run using temporary test pumps set at depths of 200 feet. The pumps were powered by a portable diesel generator. Flow was measured using a combination of 2 "x 1.5" orifice weir, propeller meter and bucket. To prevent recirculation, the pumped water was conveyed 200 feet downgradient and discharged into Mill Creek. Water levels were measured at specific intervals using an electronic water level indicator inside 1 inch diameter black-poly stilling wells.

Pump test procedures

Prior to the 48 hour pump test, two separate pumping tests were performed on the wells. From this we were able to observe the interference between the two wells and establish the pumping rates for the 48 hour pump test.

RW-4 was pumped at 30 gpm for thirty minutes then at 43 gpm for 60 minutes. A third rate of 50 gpm was maintained for 6.5 hours. Unfortunately this was most the test pump could deliver. Drawdown in RW-4 and RW-1 was 37.68 feet and 21.01 feet respectively.

RW-1 was pumped at the pumps' full capacity. A rate of 21 gpm was maintained for 8 hours. Drawdown in RW-1 was 36.21 feet. RW-4 had 11.93 feet of drawdown.

In order to maximize the information generated, the wells were pumped simultaneously so as to provide data on the potential interference between the two wells during high demand situations.

A pumping rate of 44 gpm was selected for RW-4 and 14 gpm for RW-1 for a combined rate of 58 gpm.

In order to assess the impact of pumping had on the adjacent Mill Creek a piezometer was driven below the creek bed. An additional rock well located 476 feet to the south was also observed as was a dug well located 350 feet to the east. See enclosure 1 for locations.

The test was started on May 22, 1995 at 0915 hours. Well RW-4 pump was turned on and readings were taken at RW-4 every minute for the first ten minutes and then collected in both as frequently as possible. At 0945 the pump in RW-1 was turned on. Again the wells were simultaneously monitored at the previously described frequency. After 48 hours of continuous pumping both wells were shut off. Recovery readings were then taken at specific intervals. The recovery period was short lived due to the time restraints due to the ferry service schedule. However within this time frame the wells had recovered 90 % of the recorded drawdowns.[3]

Pump Test Analysis

The effect of pumping on water levels throughout the test is shown on the semilog plot of time vs. drawdown for wells RW-1, RW-4 and RW-3 (figure 1). As this plot shows, water levels declined at a more or less regular rate throughout the test, with one apparent break. The break appears at 30 minutes reflects RW-1 being turned on. At this moment the pumping rate increased from 44 gpm to a combined rate of 58 gpm. One other fluctuation observed in RW-1 occurred about 1440 minutes and reflects an increase in the pumping rate to accommodate the "Micro-Particulate Analysis" apparatus. Later in the test, past 2000 minutes, it appears that flattening of the drawdown curve had occurred, and that water levels approached stabilization. Drawdown in RW-3 was 18 feet.

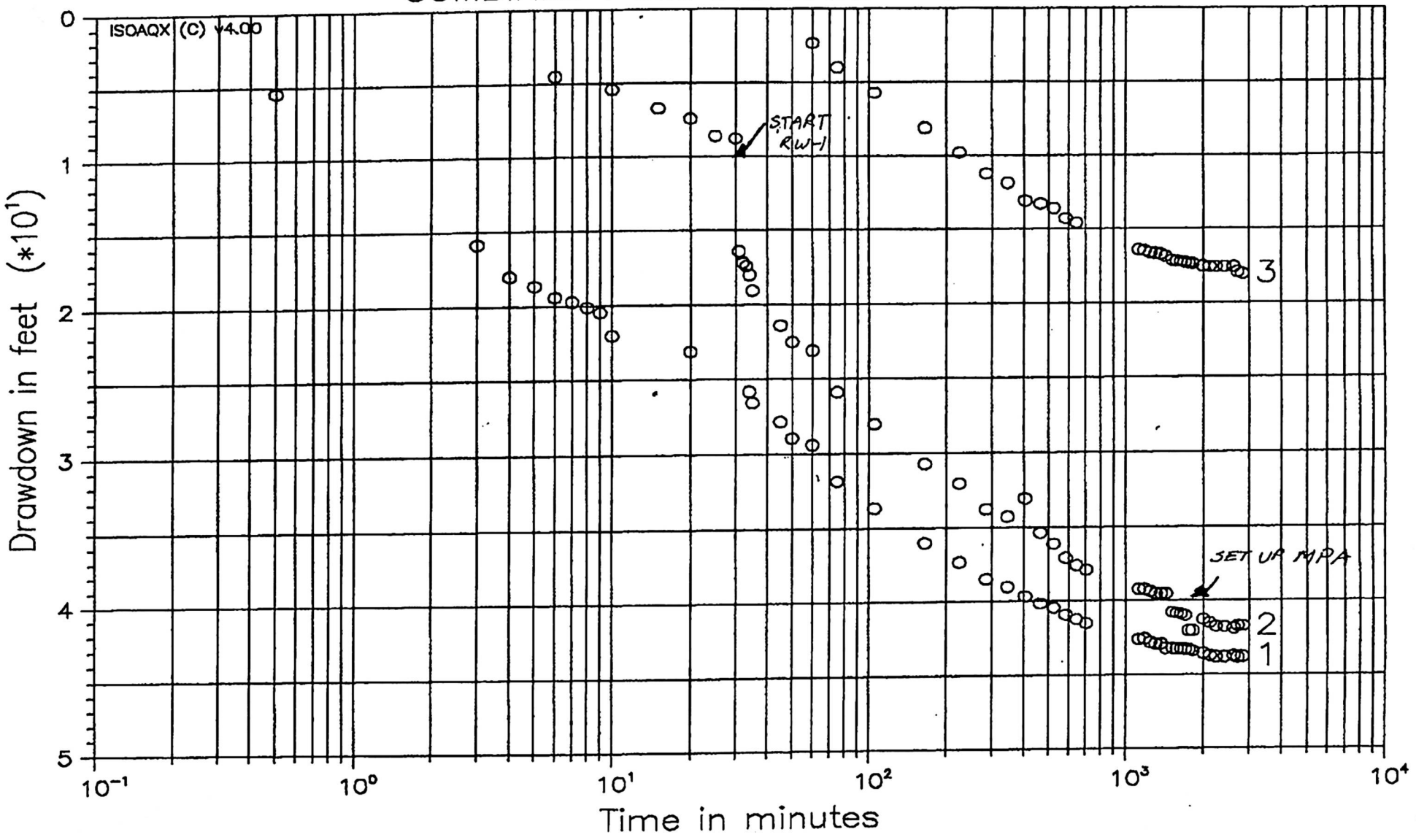
To ascertain on site impacts, a piezometer (P1), located approximately 10 feet away within the creek, and the dug well were measured. As the pump test records show, the water level in these wells remained constant throughout the test. This suggests that the amount of recharge derived from the creek and the unconsolidated deposits in the vicinity of the well is minimal or none.

Residual drawdown are plotted in figures 2 and 3 for wells RW-1 and RW-4. The residual plots shows that $T/T' > 1.0$ which indicates that recharge equals or exceeds the average pumping rate for each well. This recharge is most likely attributed to

---

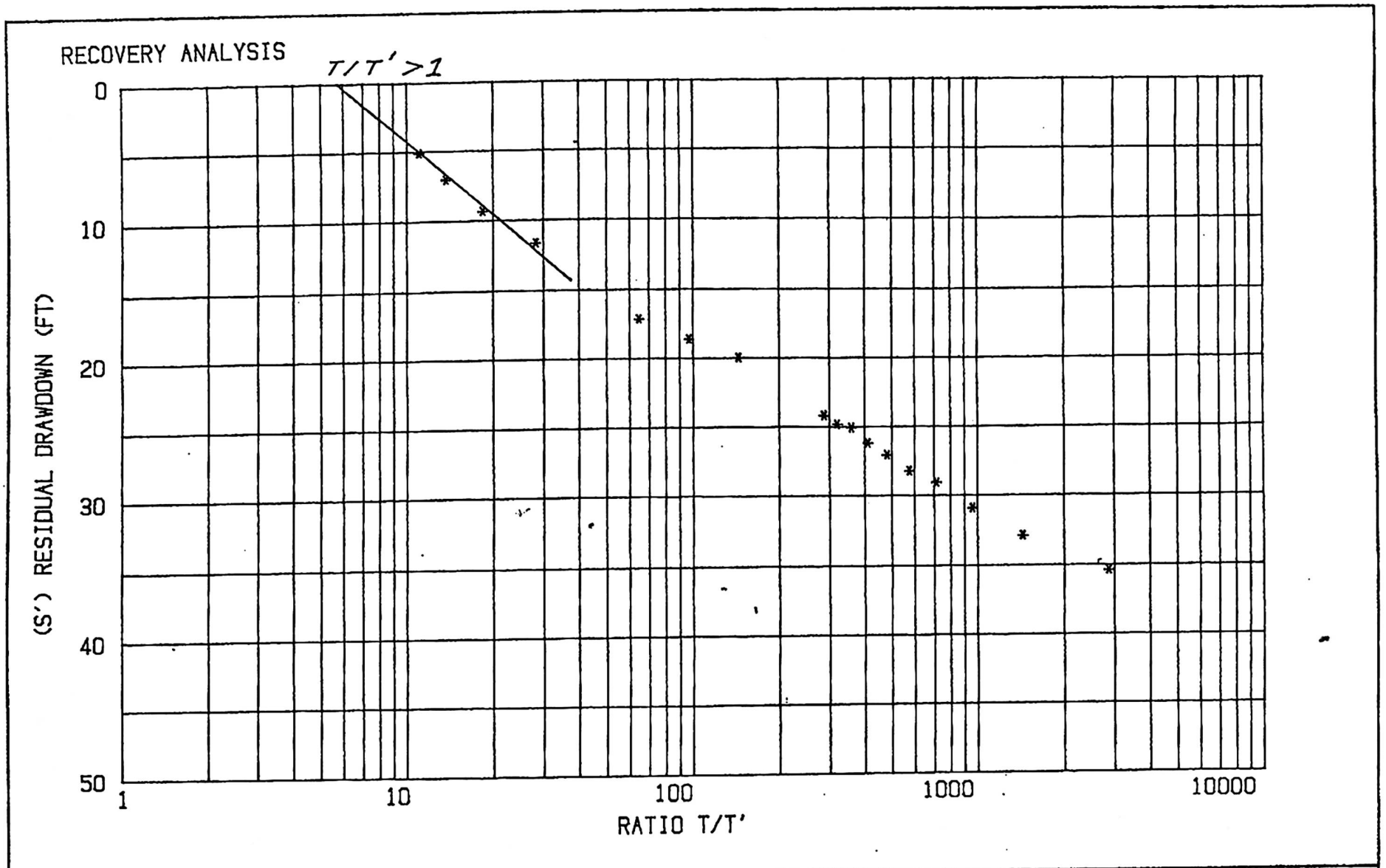
[3]. Pump Test Records. (Appendix C).

PRUDENCE ISLAND 48–HOUR PUMP TEST
INDIAN SPRING WELL SITE WELLS RW1 & RW4
COMBINED PUMPING RATE = 58 GPM



1 = RW-4 2 = RW-1 3 = RW-3

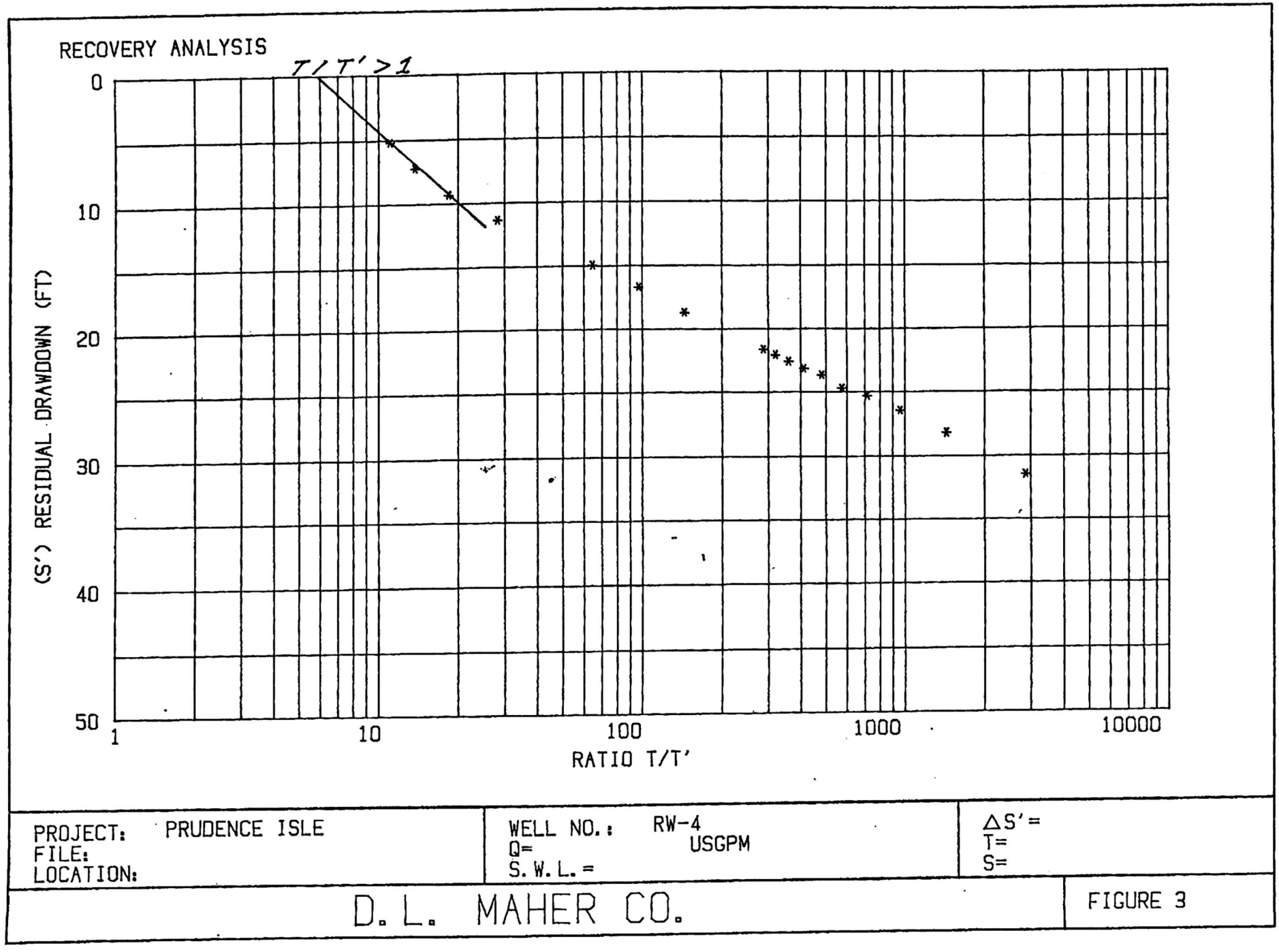
Figure 1



PROJECT: PRUDENCE ISLE FILE: LOCATION:	WELL NO.: RW-1 Q= 58 USGPM S. W. L. =	ΔS' = T= S=

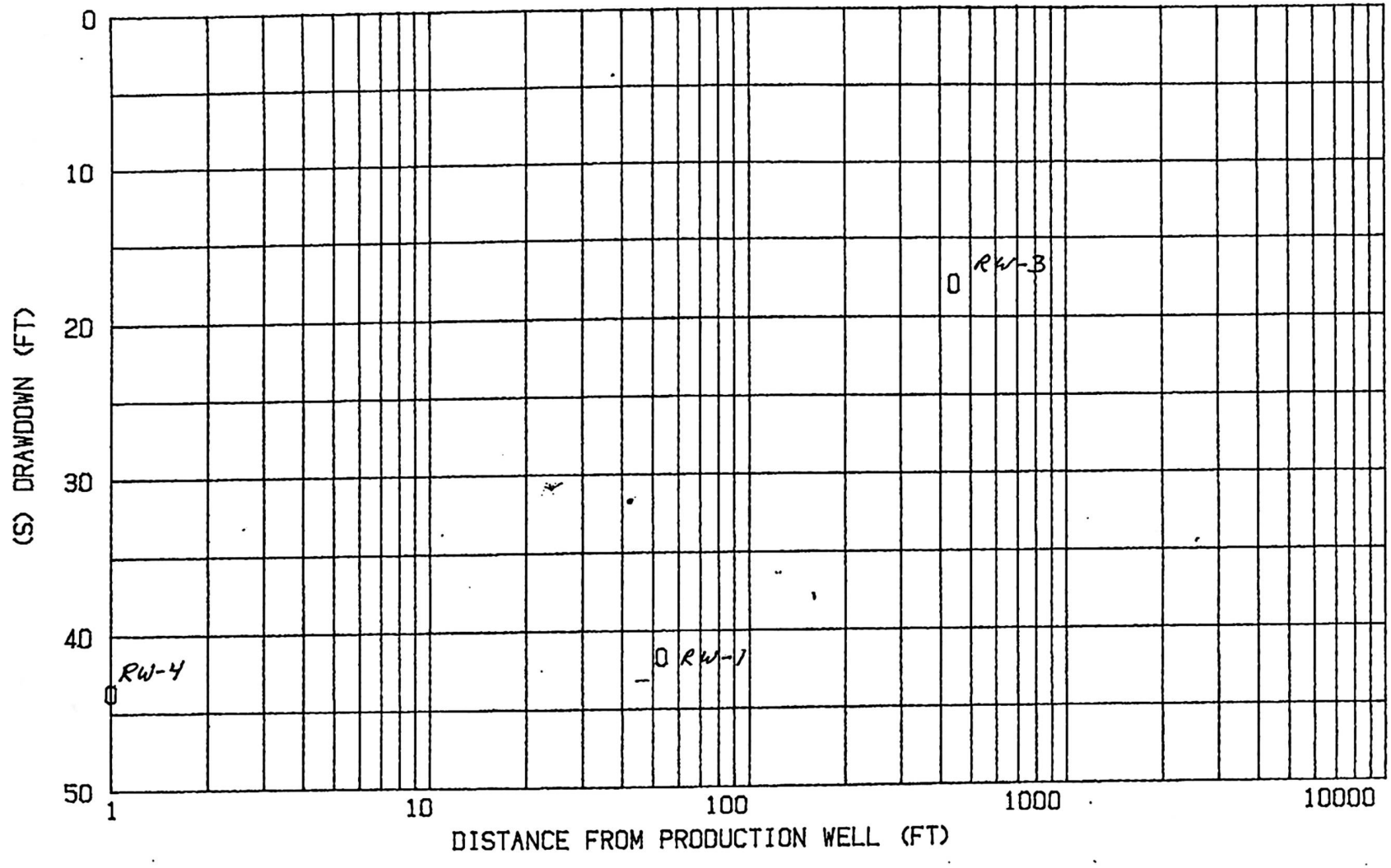
D. L. MAHER CO.

FIGURE 2


RECOVERY ANALYSIS
T/T' > 1
0
10
20
30
40
50
(S') RESIDUAL DRAWDOWN (FT)
1
10
100
1000
10000
RATIO T/T'
PROJECT: PRUDENCE ISLE
FILE:
LOCATION:
WELL NO.: RW-4
Q= USGPM
S. W. L. =
ΔS' =
T=
S=
D. L. MAHER CO.
FIGURE 3

Time = 2880 minutes

PUMPING TEST ANALYSIS STRAIGHT LINE APPROXIMATION METHOD



PROJECT: PRUDENCE ISLE FILE: LOCATION:	PUMPING RATE FOR PRODUCTION WELL RW-4 = 58 USGPM	ΔS= T= S=
D. L. MAHER CO.		FIGURE 4

the presence of a high density fracture zone in the immediate proximity of the two wells. The distance drawdown plot (figure 4) shows how the drawdowns are distributed within the bedrock. It is apparent that RW-3 lies at some distance from the major fracture zone. It also shows that the adjacent bedrock is contributing from storage and that recharge to the wells will not come solely ground water within the major fracture.

Water Quality

Prior to shut down, at each well, water samples were collected and taken to the Rhode Island Department of Health Testing Laboratory in Providence, Rhode Island for analysis. The state laboratory conducted the quantification of various compounds in accordance with those practices used for public water supplies. Water samples taken during the pump test are specified below:

Every 12 hours
Field Tests - pH, conductance, temperature

48 hours
Sanitary Microbiology
Total coliform Bacteria - SM36-MPN

Trace Organics
Volatile Organic Compounds - TO12-VQVOC(524)

Water Chemistry
Drinking Water Metals - WLF-Heavy Metals
General Chemistry - WLA-C+
Free Ammonia - WL15
Nitrate/Nitrite - WL16

Radiation Chemistry
Gross Alpha - RA1
Gross Beta - RA2

The analytical results [4] which show that water quality is generally good, are discussed below.

Sanitary Microbiology - All samples taken showed 0 coliform/100 ml, indicating that bacteriological contamination is not a problem.

Trace Organics - Samples were collected prior to shutdown to be analyzed for volatile organics using EPA Schedule 524. None of the constituents analyzed under this schedule were present at detectable levels.

Water Chemistry - No metals were detected. The routine water

---

[4]. Analytical results. (Appendix D).

chemistry for both wells meets all of the parameters now in effect with the exception of iron, manganese and turbidity.

Radiation Chemistry - The gross alpha and gross beta particle levels in both wells are within the current drinking water guidelines.

Field Tests - Field tests were done at 12 hour intervals for pH, temperature and specific conductance. The results were almost identical. The results are summarized below:

Well	Date/Time	pH	Spec. Cond.	Temp.
RW-1	5/22 1000	7.4	230 mohs/cm	53 F
RW-4	"	7.4	220 mohs/cm	52 F
RW-1	5/22 2200	7.4	240 mohs/cm	53 F
RW-4	"	7.4	200 mohs/cm	52 F
RW-1	5/23 1000	7.4	220 mohs/cm	54 F
RW-4	"	7.4	200 mohs/cm	52 F
RW-1	5/23 2200	7.4	220 mohs/cm	54 F
RW-4	"	7.4	200 mohs/cm	52 F
RW-1	5/24 0900	7.4	220 mohs/cm	53 F
RW-4	"	7.4	200 mohs/cm	52 F
Spring	"	5.5	85 mohs/cm	49 F
Creek	"	6.0	67 mohs/cm	53 F

Micro-Particulate Analysis

The Surface Water Treatment Rule (SWTR), an amendment to the Safe Drinking Water Act (SWDA), requires groundwater sources which are located within 200 feet of a surface water body be examined so as to determine if the source is under direct influence of said surface water body and are at risk to waterborne diseases such as giardiasis.

Particulate analysis provides the most conclusive evidence regarding the occurrence of pathogen migration from surface water features into the aquifer. The particulate parameters recommended by EPA for analysis are diatoms and certain other algae, rotifers, cocoidia, giardia, and insect parts. The EPA consensus method was utilized for particulate analysis and collection. Environmental Associates LTD., Bradford, PA. provided the laboratory interpretation.

RW-1 , located approximately 60 feet from the creek was assigned a moderate risk whereas RW-4, located 12 feet away was assigned a low risk[5]. Based on the construction, depth of fractures and

---

[5]. MPA results. (Appendix E).

tightness of the creek bed, we feel that the risk potential is low from surface water contamination.

Conclusions and Recommendations

Based on the pump test conducted and the available water quality, we believe that the wells can be used to upgrade the present system. Overall RW-4 shows the best potential, having a specific capacity 2.3 times greater than RW-1. We believe RW-4 can be pumped at a rate of 60 GPM intermittently. RW-1 should be used as a backup to RW-4 and be pumped at a reduced rate of 25 gpm. The wells should never be pumped simultaneously at these rates nor should they be allowed to run for extended periods without monitoring the water levels. We also recommend recovery periods for each well should be similar to the time in which each well is pumped. This schedule may be altered once the pumping and recovery behavior of each well has been more thoroughly observed. We also believe that the possibility of saline intrusion extremely unlikely based on all available data. Further recommendations follow:

- o Upon receipt of approval of wells RW-1 and RW-4 as public water supplies, PIUC should seek the aid of a qualified engineer to upgrade the present distribution system.
- o Pumps should be installed to a depth of 150 feet in RW-4 and 175 feet in RW-1.
- o Water levels, pumping rates, and chemistry should be monitored to determine the long term pumping capacities of each well and to insure that the sources due not degrade with protracted use.

Respectfully submitted,

Reidar W. Bomengen

Reidar W. Bomengen
Staff Hydrogeologist

Reviewed by:

J. Theodore Morine
Senior Hydrogeologist

APPENDIX A

December 15, 1994

Control Engineering Inc.
190 Doty Circle
West Springfield, Ma. 01089
Attn: Mr. Mark Kimball

Re: Wells 1 & 4
Prudence Island

Dear Mark,

Please excuse our delay in sending this information. This letter serves to update the utility on the results of October, 1994 Drilling Program and to make known our recommendations and concerns about the completed wells. We understand that the utility desires to get these wells approved as public water supplies as soon as possible and that any suggestions from us will help direct your decisions.

The wells to be discussed are RW-1 and RW-4. The Drilling Program commenced in October of 1994. Each well is situated on PIUC land and has been constructed to meet the State of Rhode Island DOH approval. Attached is a representative as-built showing the type of casing and sanitary seal used in constructing each well. Well RW-1 was drilled initially to 363 feet and was later deepened to 464 feet. Bedrock was encountered at a depth of 12 feet. A total of 33.5 feet of six inch casing was set and cement grouted to the rock. The driller reported encountering several water producing zones at the following depths;

Depth	GPM	Total
103-123	3	3
203-223	12	15
283-303	5	20
423-443	10+	30+

RW-4 is approximately 60 feet west from RW-1. This well was also drilled to 464 feet. The depth to bedrock was 12 feet. The rock was soft and broken to 22 feet. Casing was advanced to a depth of 40 feet where it was pressure-grouted to the bedrock. The driller reported the following yields at the following depths;

Depth	GPM	Total
62-83	10	10
83-103	5	15
103-123	5	20
163-183	5	25
203-223	10	35
443-463	10+	45

Throughout the drilling of RW-4, RW-1 was periodically checked for interference. The driller observed a maximum drawdown of approximately 18 feet in RW-1. This amount is not great given the wells' proximity to RW-4.

Water samples were taken from each well. The results show the water chemistry to have elevated levels of manganese. We feel that this metal may not be a problem given the water is buffered by hardness and alkalinity. It is possible that this water chemistry will tend to prevent the manganese and iron from precipitating out. Of more concern to the utility, is the potential of salt water intrusion during protracted dry spells. At the time of the drilling, there was no evidence via the water chemistry, of such an occurance. It should be monitored over long term use.

The next step which needs to be addressed is the sizing of the pumps. Once this has been determined and the pumps installed, separate 48 hour pump tests should be conducted at each well and water samples taken to a state approved lab. The results of this work must then be submitted to the DOH for final approval. Once approved, the wells then can be used to service the system. However, as actual hydraulic data is not available for the determination of the operating TDH (total dynamic head), we must make assumptions regarding the range of drawdown that can be expected in each of the wells and the potential friction losses attributed to the distribution system when determining the operating pressure. The determination of TDH, by this method. can result in the oversizing of these pumps. The appropriate method would entail setting temporary pumps, running pump tests and evaluating the existing distribution system, i.e., mapping, measuring capacity, and pressure testing. This work would be costly and a hardship to the utility.

From the information provided, our understanding of the current water system's design and operation consists of two 20,000 gallon surface storage tanks being recharged by a number of low yielding wells. These storage tanks feed the distribution system of which the majority consists of 1.5 inch diameter lines. The system's maximum demand is about 40 GPM. At times of high demand, the system is plagued with low pressure. Assuming the following conditions, drawdown of 200 feet in each well when pumping 30 - 40 GPM, 1500 feet of 1.5 inch main from the well head to the tanks,

and surface elevations of 50 feet at the wells and 100 feet at the storage tanks, the operating TDH would be equivalent to 377 feet @ 30 GPM and 453 feet @ 40 GPM. We have selected a pump, which will under the current system's configuation and the expected TDH, may only be capable of pumping 20 gpm. With improvements to the system, the TDH will decrease thus the performance of the selected pumps will increase. Consequently, when the utility choses to upgrade the existing 1.5 inch mains, these pumps can be utilized. If, in the course of operation, it is found that excess pressures are occuring, we recommend that pneumatic storage tanks or pressure control valves be installed to alleviate this problem. The installation of a pressure relief valve may in our opinion cause additional problems such as water quality and plugging of the wells.

We are attaching all pertinent records. If you need additional information or have any questions, please contact this office. Thank you for the opportunity to be of service to the Prudence Island Utilities Corporation.

Very Truly Yours,

D.L. MAHER CO.

Reidar Bomengen
Staff Hydrogeologist

RWB0095