PRODUCTION HISTORY
FOR THE STATE OF IDAHO
CAPITOL MALL GEOTHERMAL SYSTEM
1983-1994

by

Kenneth W. Neely

Hydrogeologist

Idaho Department of Water Resources
Boise, Idaho

December, 1995

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The State of Idaho Capitol Mall geothermal system has operated in downtown Boise since 1982. The system supplies about ninety percent of the heat required for nine buildings, including the State Capitol. The primary components of the system are: 1) a production well, 2) heat exchangers, 3) underground delivery and collection pipes, and 4) an injection well. Production, temperature and system operation data have been recorded manually on Daily Logs since May, 1983. In 1991, the Department of Administration-Building Services made this data available through computer Trend Logs which capture information every six hours. The Idaho Department of Water Resources has compiled the Daily Logs and Trend Logs from 1983-1994.

Purpose and Scope

The purpose of this report is to publish a complete record to date of the geothermal production history for the State of Idaho Capitol Mall geothermal system. This report presents annual and monthly production totals, daily discharges, average monthly discharges, maximum monthly discharges and maximum monthly supply temperatures. The data in this report were compiled from the handwritten Daily Logs, the computer Trend Logs and previously published reports. Data are presented using Julian year dates.

The data in this report were used by the Idaho Department of Water Resources for the water right licensing of the State of Idaho geothermal production well in 1995.

Previous Studies

Several papers and reports describe either the development of the Capitol Mall geothermal system or document some of the production history (Mink, 1976; Anderson, 1981; Anderson and Kelly, 1981; Worbois, 1982; Berkeley Group Inc., 1990; Higginson, 1987; Waag and Wood, 1987; Boise Warms Springs Water District, 1989; Montgomery, 1992; Dansart and others, 1994; Montgomery Watson, 1994). Prior to this report, the most complete production history was presented in the Berkeley Group, Inc. (1990) report which contains records of annual production from 1982 through June 1989. The Montgomery (1992) and Montgomery Watson (1994) reports contain some production data for 1990 and 1991.

Well-Numbering System

The well-numbering system used in this report is identical to the system used by the U.S. Geological Survey (USGS) in Idaho (Figure 1). The system indicates the location of wells within the official rectangular subdivision of the Public Land Survey System (PLSS) with reference to the Boise baseline and meridian. The first two segments of the number designate the township and range. The third segment gives the section number followed by three or four letters and a number. The letters indicate the ¼ section (160 acre tract), ¼-¼ section (40 acre tract), ¼-¼-¼ section (10 acre tract), ¼-¼-¼-¼ section (2.5 acre tract), and the serial number of the well within the tract. Quarter sections are lettered A, B, C, and D in counterclockwise order beginning in the northeast quarter of the section. Successively smaller tracts are lettered in the same manner. For example, well 04N 01E 04CDA1 corresponds to the PLSS location: NE¼, SE¼, SW¼, Section 4, Township 4 North, Range 1 East, and it was the first well inventoried by the USGS in that tract.

Acknowledgements

The author would like to thank several people who helped compile the data for this report. Monty Leinberger and Bill Hudson, Idaho Department of Administration-Building Services and Tom Markland, Idaho Department of Lands, provided copies of the Daily Logs for the State Geothermal system. Cody Kinney, Idaho Department of Water Resources (IDWR), entered the data from the Daily Logs into computer spreadsheets. Wayne Haas, Hal Anderson, Paul Castelin and Steve Lester (all employees at IDWR) provided technical review for this report. I appreciate all of your efforts in this project.

GEOTHERMAL DEVELOPMENT IN BOISE

In late 1890, investors from the Boise Water Works Company decided to drill a hot water well in a swampy area about two and a half miles east of Boise. This tract of land was swampy because of seepage from natural geothermal springs. By early 1891, two geothermal wells (now known as Boise Warms Springs Water District (BWSWD) #1 and #2) had been successfully completed (Figure 2).

In May, 1892, the Boise Natatorium, a 15,000 square foot structure which included a 65 x 125 foot geothermal swimming pool, was open for business. In the same year, the Artesian Hot and Cold Water Company (which had purchased the Boise Water Works Company in 1891) began supplying geothermal water to private residences and businesses along Warm Springs Road. The Natatorium remained in business until 1934. From 1892 until the 1970's, there was no significant exploration for geothermal resources in the downtown Boise area.

In the early 1970's, the State of Idaho began expanding the Capitol Mall office complex. Rising heating costs prompted Governor Cecil Andrus to request a study of the Boise geothermal resources. The study, conducted by the U.S. Energy Research and Development Administration, recommended a pilot project. Consequently, the heating system for the State Health Laboratory on Penitentiary Road was converted to geothermal space heating in 1977. The State of Idaho realized the cost-saving benefits immediately. By 1979, the State was ready to take the next step in geothermal heating.

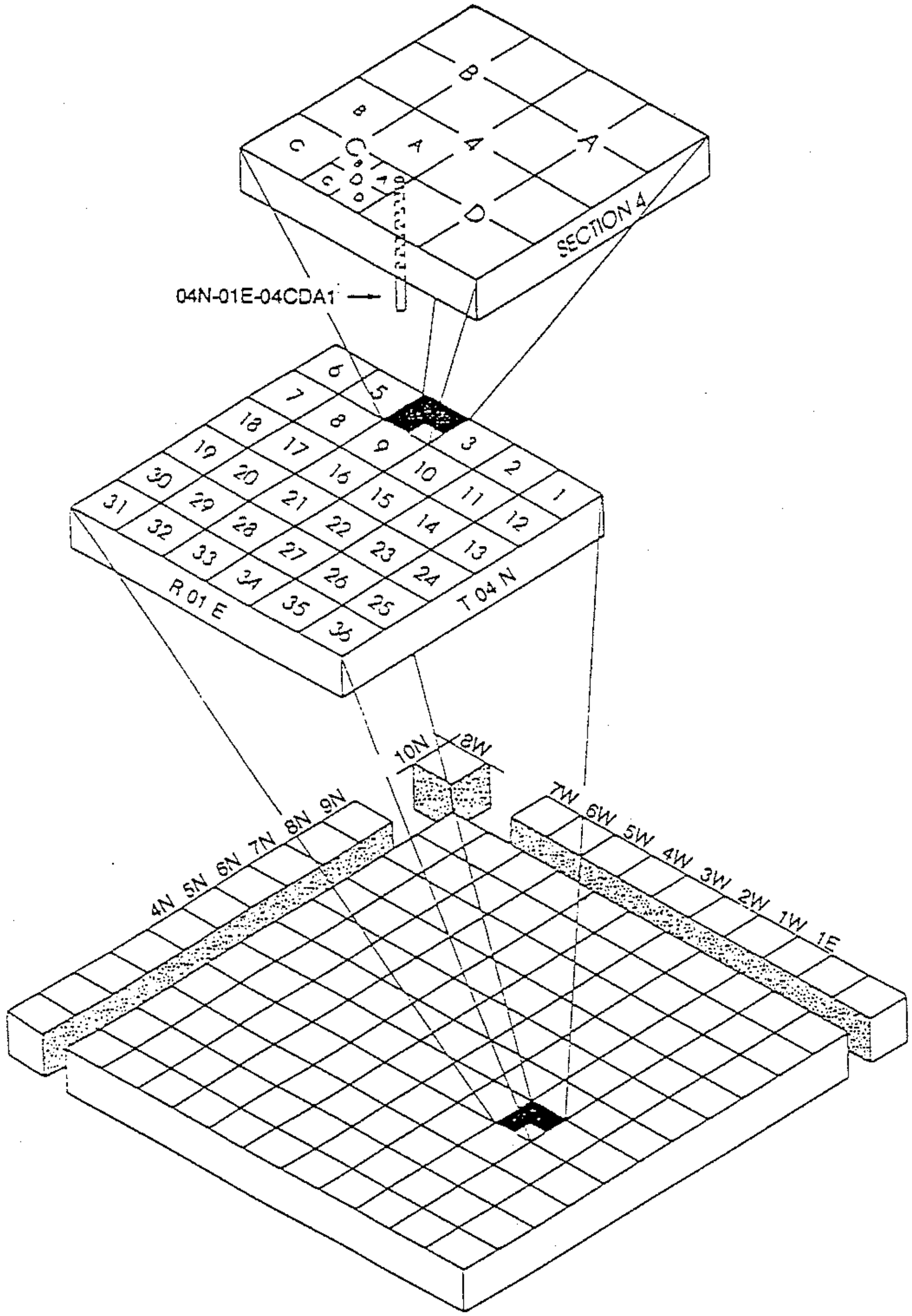

Figure 1. Well-numbering system.

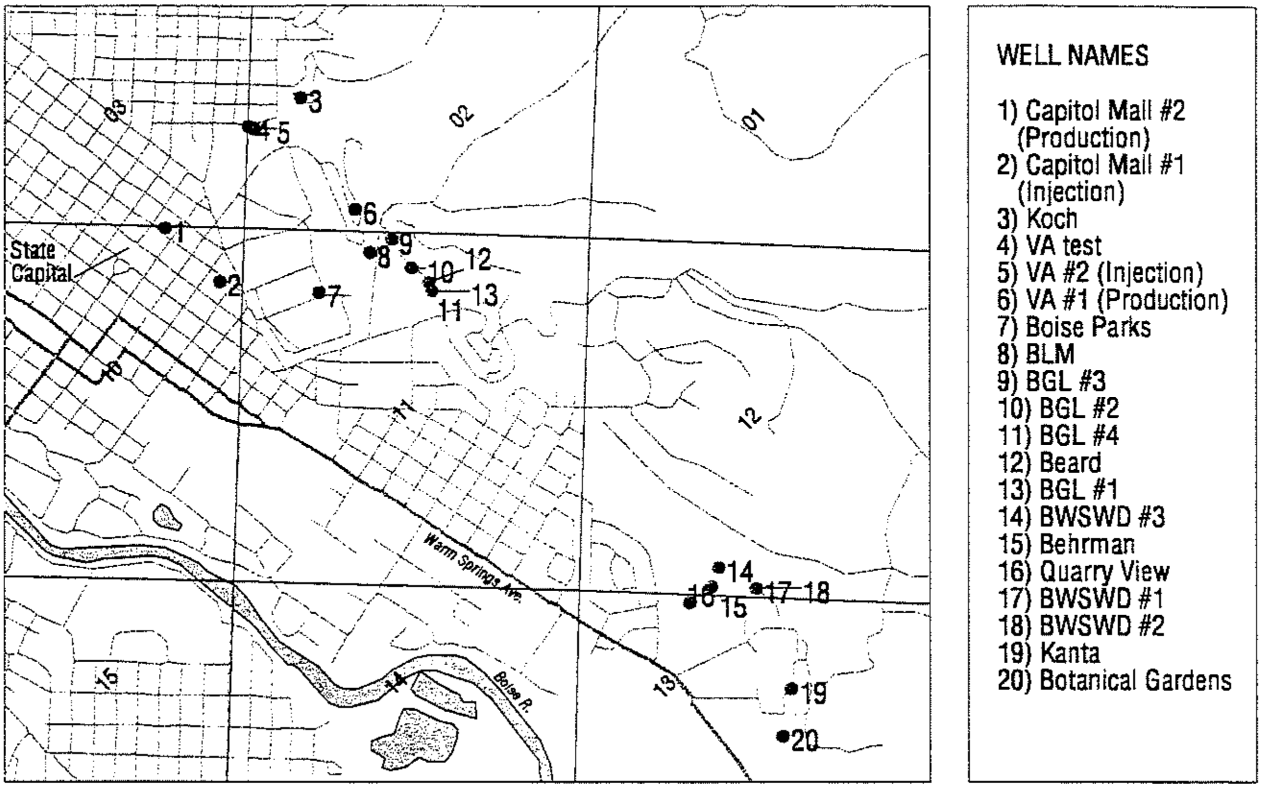

Figure 2. Location map of geothermal wells in the downtown Boise and Boise Warm Springs Water District areas. The map area is within Township 3 North, Range 2 East. The numbers appearing diagonally are the section numbers.

In 1981, the Capitol Mall #1 and #2 wells were completed to the east and northeast of the State Capitol, respectively (Figure 2). Capitol Mall #1 (03N 02E 10AADA1) is 2,152 feet deep and is used as the injection well. Capitol Mall #2 (03N 02E 11AABB1) is 3,030 feet deep and is the production well. Capitol Mall #2 is capable of flowing at over 900 gallons per minute. The original water temperature for Capitol Mall #2 was 160° Fahrenheit. By 1982, nine buildings in the Capitol Mall complex were being heated by the geothermal resource (Figure 3).

In the early 1980's, Boise Geothermal Limited drilled four production wells and the Veterans Administration drilled a test well followed by a production and an injection well (Figure 2). In 1988, the City of Boise purchased Boise Geothermal Limited.

In the mid 1980's, water levels in the Bureau of Land Management (BLM) observation well, located east of the Capitol Mall wells (Figure 4), began declining rapidly. In 1987, IDWR created the Boise Front Low Temperature Geothermal Resource Ground

Water Management Area because of the declining water levels. Further development of the geothermal resource was discontinued in the Management Area. Since 1987, water levels in the BLM well have ceased declining (Figure 4).

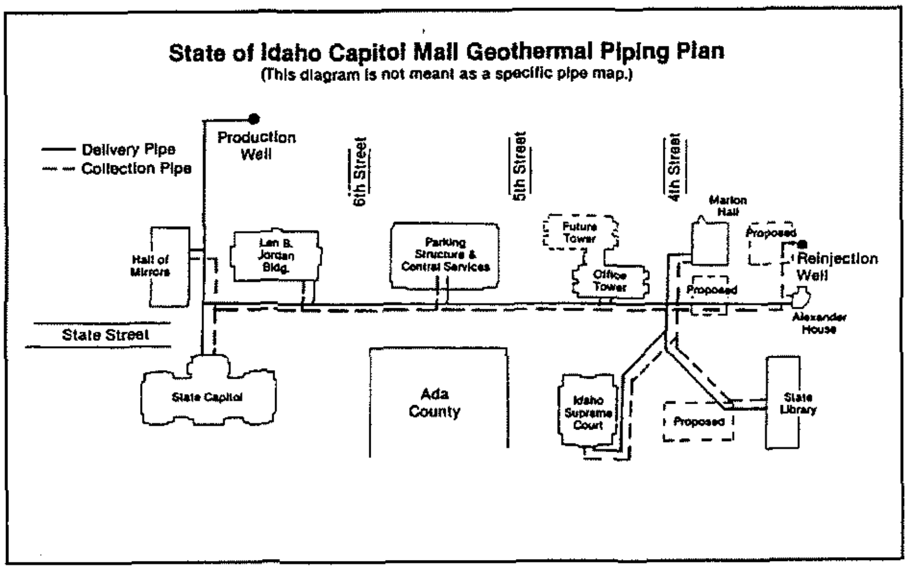

Figure 3. State of Idaho Capitol Mall geothermal piping plan (from Worbois, 1982).

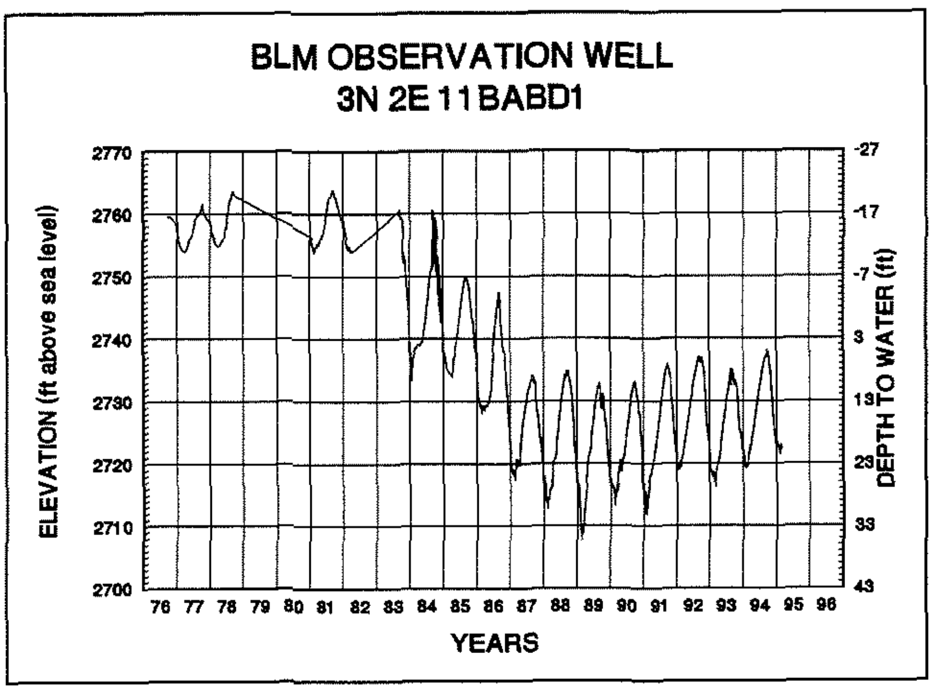

Figure 4. Hydrograph for the BLM observation well (03N 02E 11BABD1).

CAPITOL MALL DATA

Data are collected in two formats for the Capitol Mall system. The first format is handwritten Daily Logs on which discharge, temperature, pressure and other system operations are recorded. Data have been entered on Daily Logs since May, 1983. The Berkeley Group, Inc. (1990) report noted that the Daily Log data usually reflect higher than average discharges because the readings are taken during peak flow times (i.e. 5:00 - 8:00 a.m.). Data from the Daily Logs were entered into computer spreadsheet files at IDWR.

The second format is Trend Logs where data are recorded every six hours using a computer system. Data have been recorded on Trend Logs since 1991. Unfortunately, Trend Logs for 1991 and 1992 are incomplete primarily due to data capture mistakes by the author. Trend Log data for 1993 are considered to be complete. Trend Log data for 1994 are incomplete because the flowmeter was not working for several months.

The raw data from both the Daily Logs and the Trend Logs were used to calculate and graph annual and monthly production, daily and monthly discharges and average monthly supply temperatures.

Annual Production

Annual production for the State Geothermal system was obtained using three sources: 1) Berkeley Group Inc. (1990) report, 2) Daily Logs, and 3) Trend Logs. The Berkeley Group Inc. (1990) report used calculated average flowrates instead of the flowrates reported on the Daily Logs. In this study, the annual production totals using the Daily Logs (1983-1994) were calculated by multiplying each daily discharge reading (in gallons per minute) by 1,440 to obtain a daily volume, and summing the daily volumes. The annual production totals for the Trend Logs were calculated by computing an average discharge for each day, multiplying each average daily discharge by 1,440 to produce a daily volume, and summing the daily volumes. Table 1 lists the reported and calculated annual production totals for 1983-1994. Low values in 1983, 1990, 1991, 1992 and 1994 are caused by missing data. Figure 5 shows the range in annual production for 1983-1994.

Additional calculations were performed on the data for 1993 because of the differences between the annual production calculations from the Trend and Daily Logs (1993 was selected because the Trend Log data in that year was considered to be the more complete than the Trend Log data collected in 1991, 1992 and 1994). The maximum daily discharge was extracted from each set of four daily readings from the Trend Logs. The maximum daily discharge was multiplied by 1,440 to obtain a maximum daily volume. The sum of the maximum daily volumes was 240.4 million gallons essentially equal to the annual production calculated from the Daily Logs (240.2 million gallons). This result confirms the Berkeley Group Inc. (1990) assertion that the values from the Daily Logs are too high because they were recorded during peak production times.

Table 1. Annual production for the Capitol Mall geothermal system, 1983-1994 (in millions of gallons).

Year	Berkeley Group Inc. (1990)	Daily Logs	Trend Logs
1983	79.1	65.8	
1984	204.8	169.5	
1985	196.4	187.5	
1986	188.6	179.7	
1987	N/A	148.6	
1988	212.6[a]	122.7	
1989	106.3[a]	155.6	
1990		83.4	
1991		159.4	43.6
1992		136.3	75.3
1993		240.2	180.3
1994		167.9	96.3

[a] Estimated from Totalized value of 3.10 x 10 gallons for the period from January, 1988 through June, 1989 (Berkeley Group Inc. (1990)).

Monthly Production

Figure 6 shows the total monthly production for 1983 to 1994 as calculated from the Daily and Trend Logs. Monthly production ranged from 0 to 30.5 million gallons. Appendix A lists the monthly production data.

Daily Discharges

Figures 7 through 18 show the daily discharge readings from the Daily Logs for 1983-1994. The average daily discharge readings from the Trend Logs for 1991-1994 are included in Figures 15-18. The X axis for each figure is incremented by Julian days in the respective calendar year (Day 1 = January 1; Day 365 = December 31)

Daily discharges fluctuate from about 600 to 800 gallons per minute during the peak heating season (approximately days 1-90 and 300-365), to about 300-500 gallons per minute during the non-peak heating season (approximately days 91-180 and 240-299), to 0-300 gallons per minute during the summer (approximately days 181-239). Clearly, some years have more complete data than other years. Figures 9, 10, and 17 appear to be the most complete. Therefore, the annual production as calculated from the Daily and Trend Logs may be the most accurate for 1985, 1986 and 1993 (Table 1).

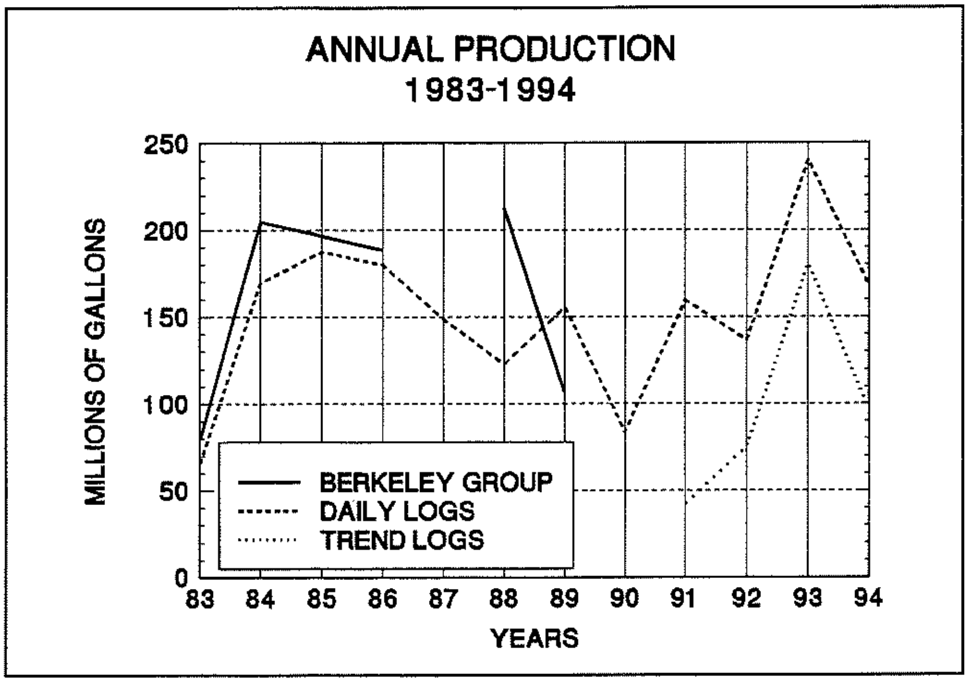

Figure 5. Annual production for the Capitol Mall geothermal system, 1983-1994.

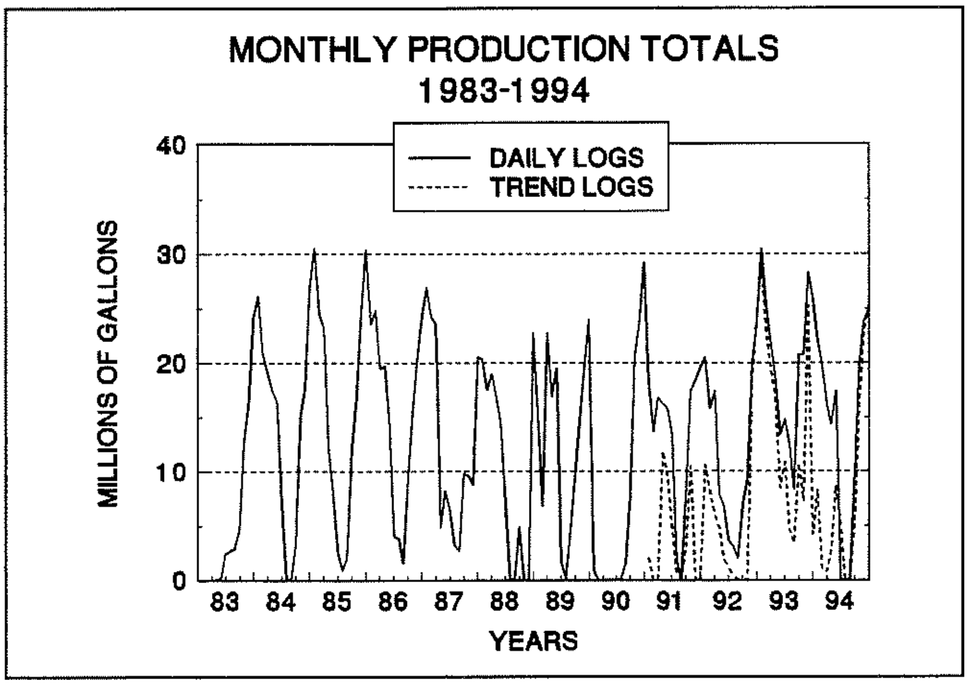

Figure 6. Monthly production for the Capitol Mall geothermal system, 1983-1994.

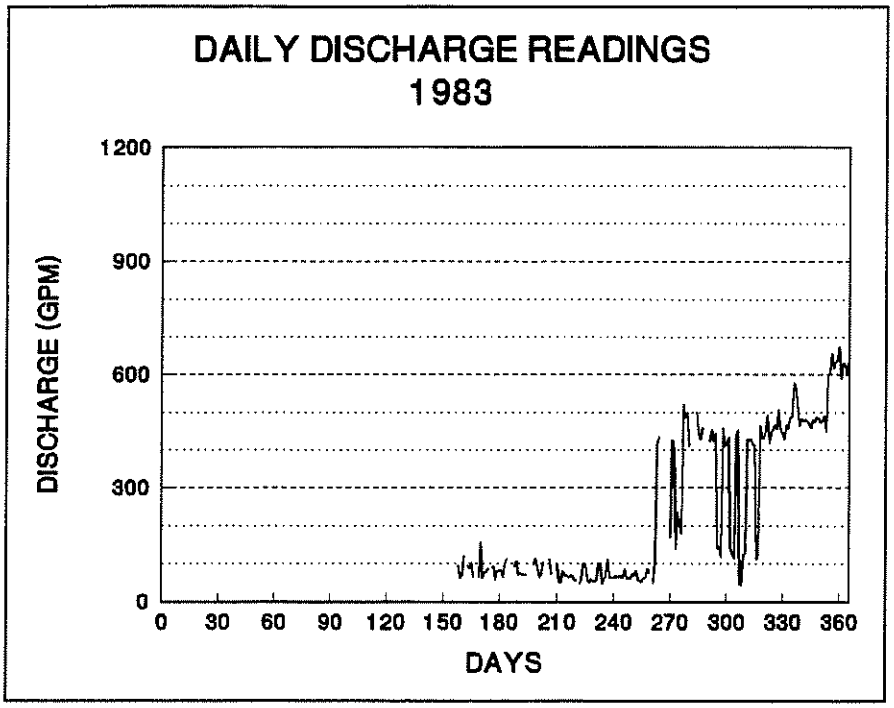

Figure 7. Daily discharge readings for the Capitol Mall geothermal system, 1983.

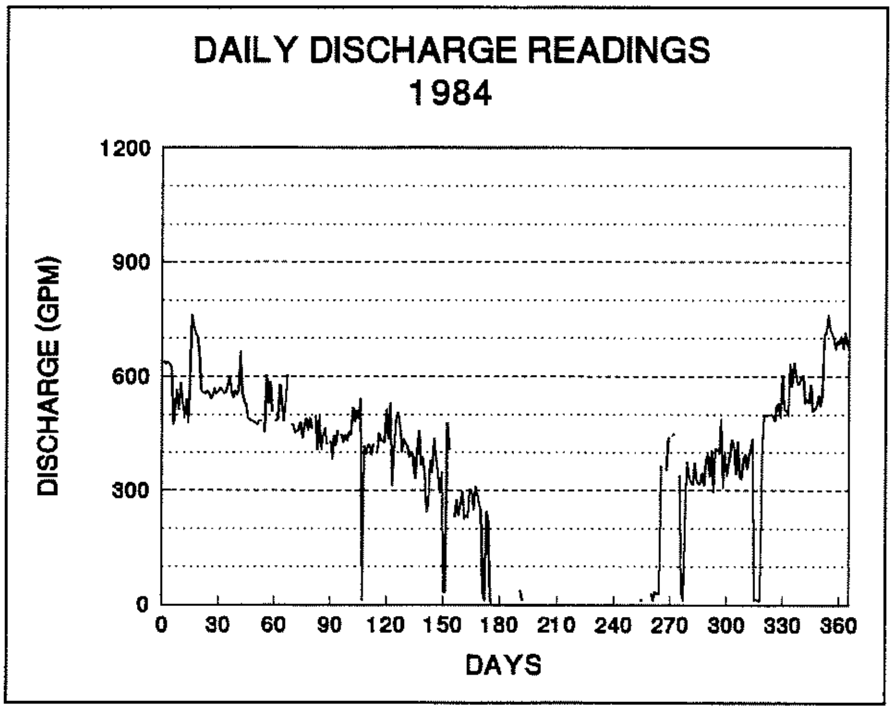

Figure 8. Daily discharge readings for the Capitol Mall geothermal system, 1984.

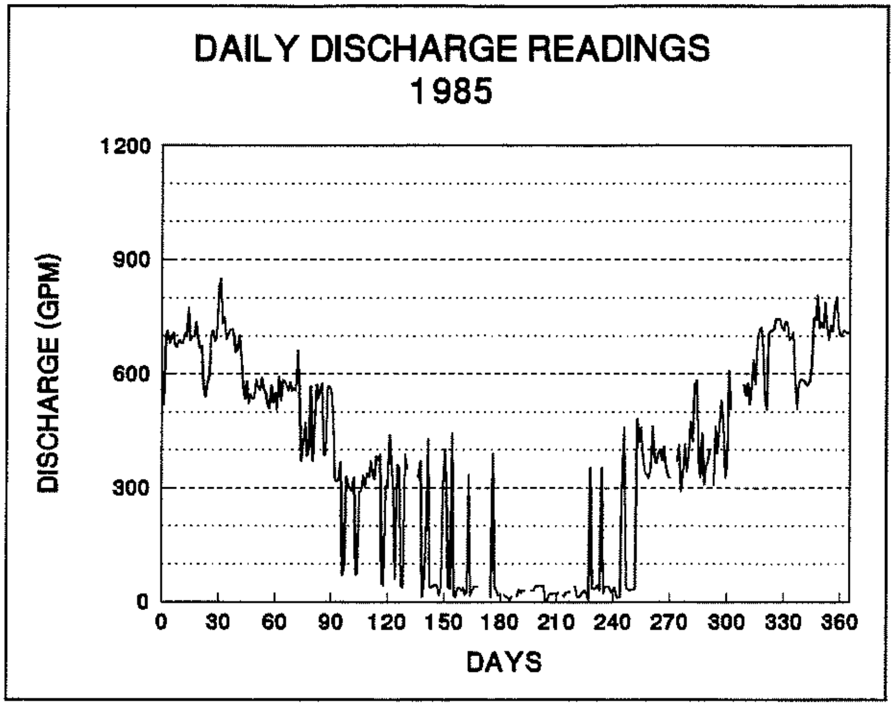

Figure 9. Daily discharge readings for the Capitol Mall geothermal system, 1985.

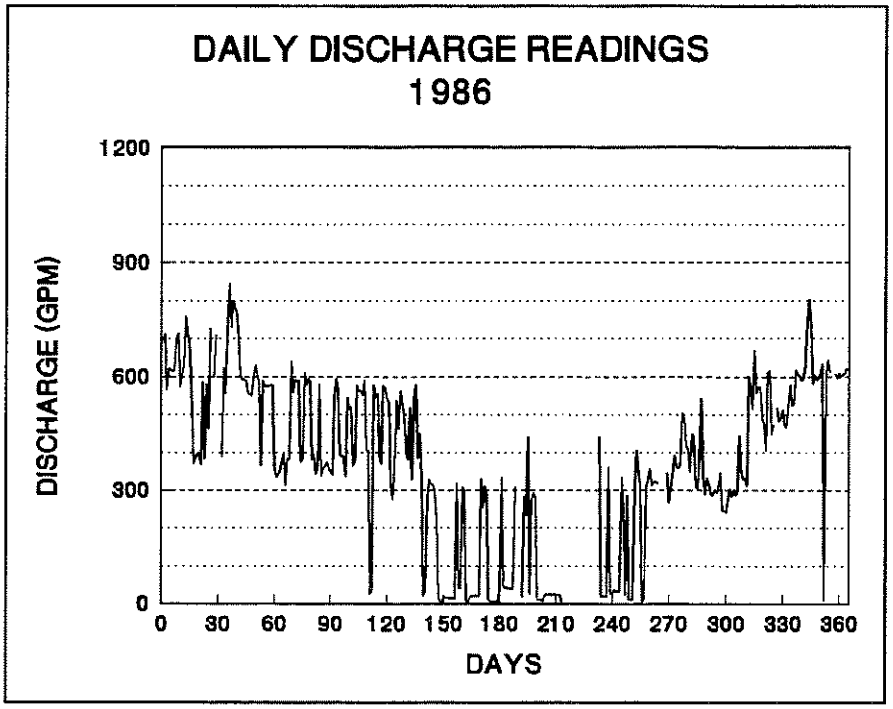

Figure 10. Daily discharge readings for the Capitol Mall geothermal system, 1986.

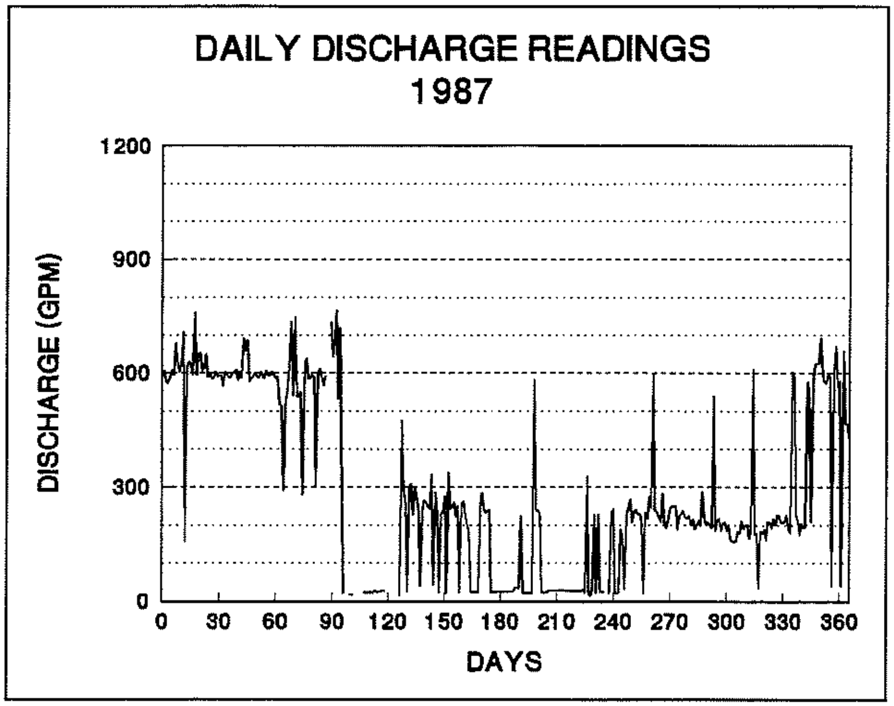

Figure 11. Daily discharge readings for the Capitol Mall geothermal system, 1987.

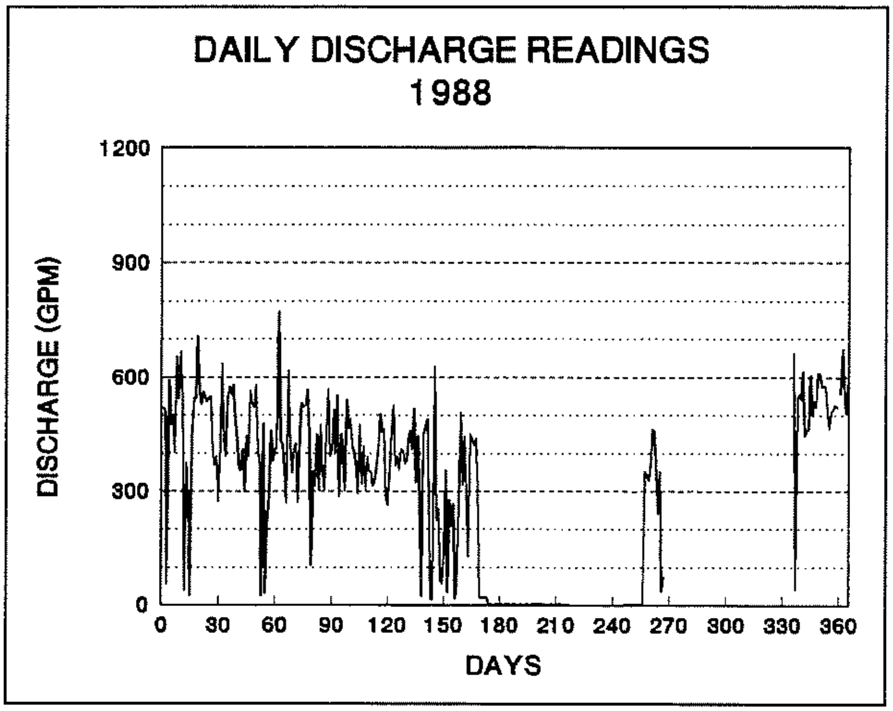

Figure 12. Daily discharge readings for the Capitol Mall geothermal system, 1988.

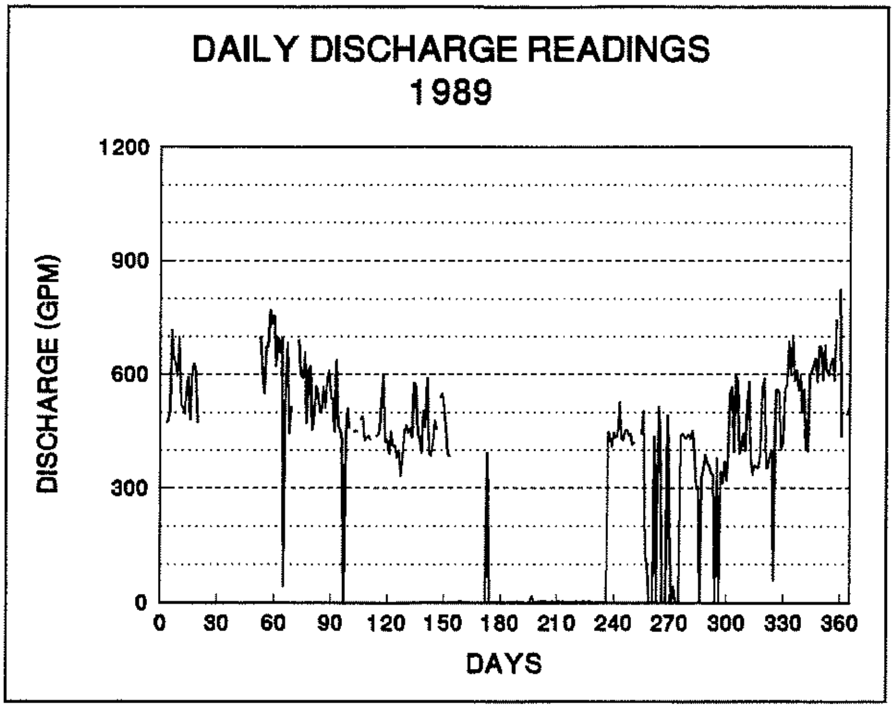

Figure 13. Daily discharge readings for the Capitol Mall geothermal system, 1989.

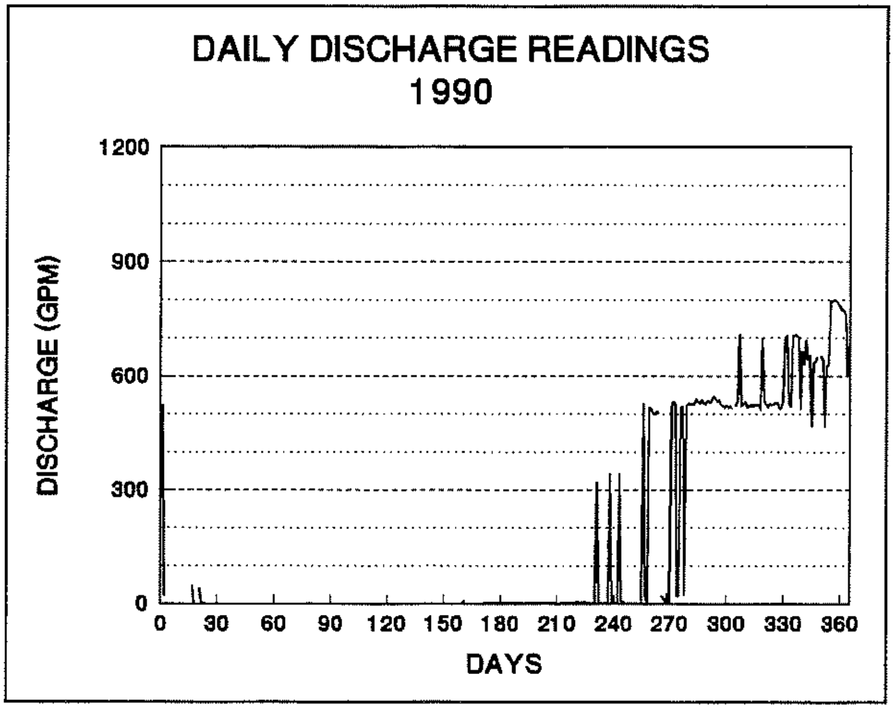

Figure 14. Daily discharge readings for the Capitol Mall geothermal system, 1990.

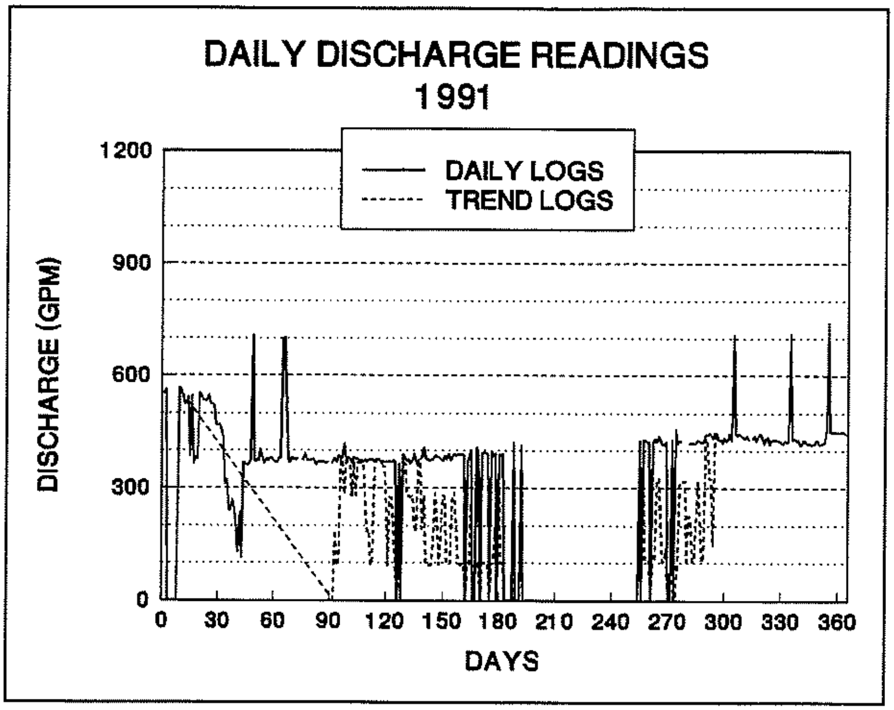

Figure 15. Daily discharge readings for the Capitol Mall geothermal system, 1991.

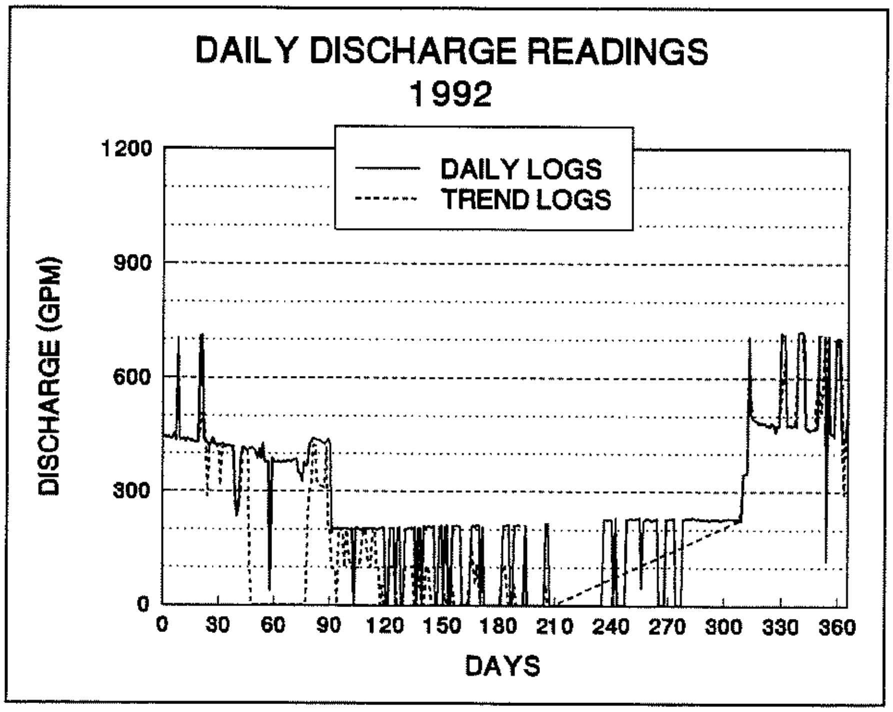

Figure 16. Daily discharge readings for the Capitol Mall geothermal system, 1992.

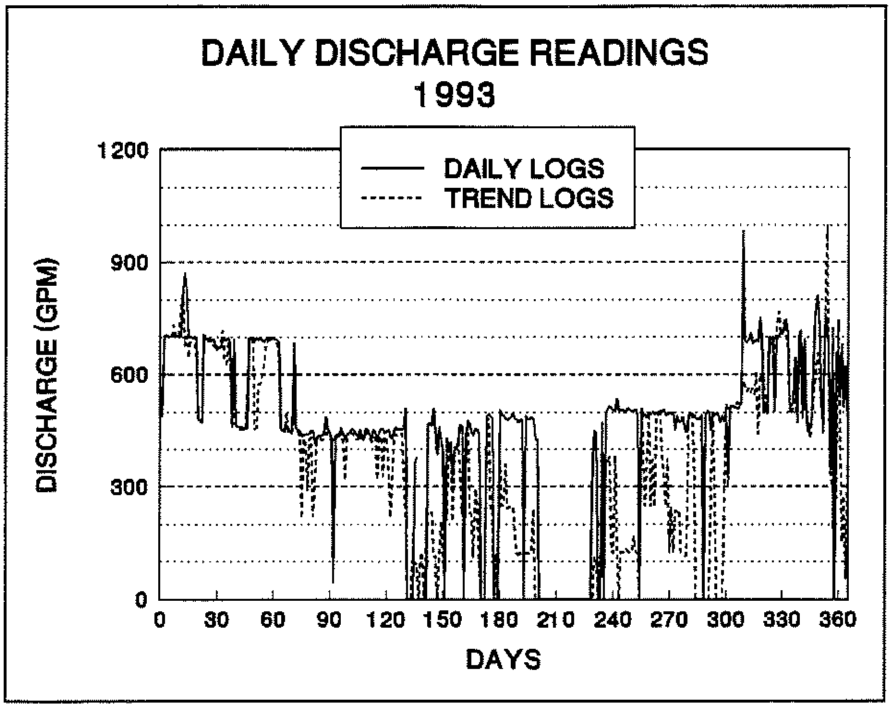

Figure 17. Daily discharge readings for the Capitol Mall geothermal system, 1993.

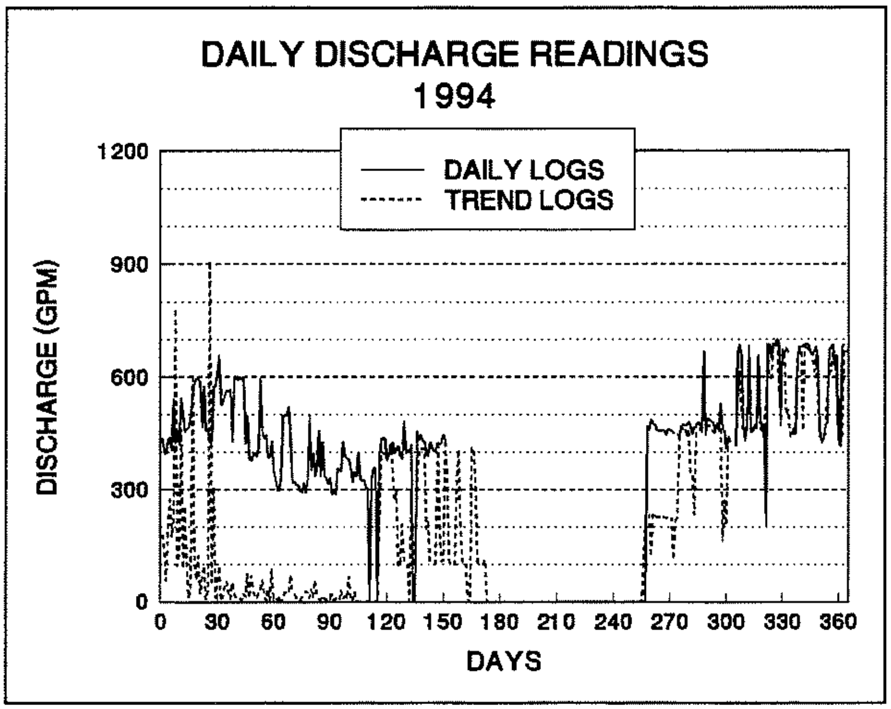

Figure 18. Daily discharge readings for the Capitol Mall geothermal system, 1994.

Monthly Discharges

The average monthly discharges ranged from 0 to 683 gallons per minute (Figure 19). Maximum monthly discharges were about 800-850 gallons per minute (Figure 20). The highest discharge rate was 982 gallons per minute in November, 1993.

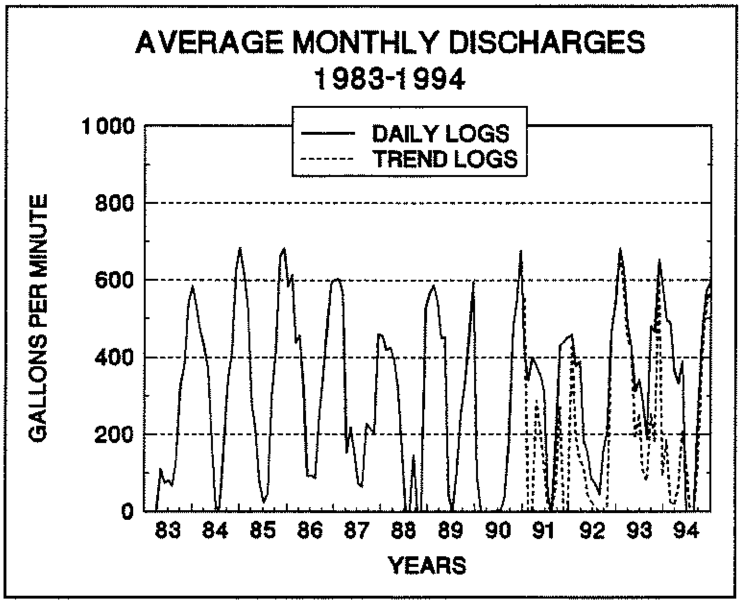

Figure 19. Average monthly discharges for the Capitol Mall geothermal system, 1983-1994.

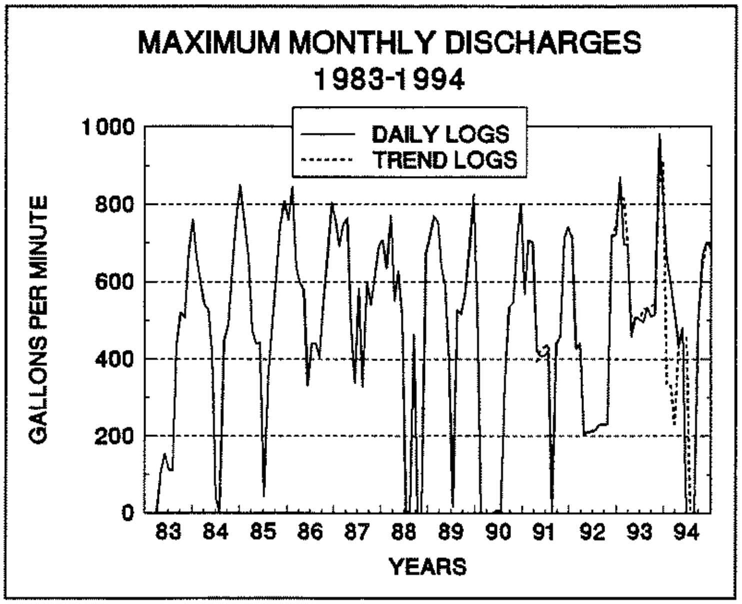

Figure 20. Maximum monthly discharges value for the Capitol Mall geothermal system, 1983-1994.

Supply Temperatures

Figure 21 shows a decline of about 5° Fahrenheit in the maximum monthly supply temperatures from 1983 to 1994. The decline may have been caused by a gradual thermal breakthrough related to nearby reinjection in Capitol Mall #1.

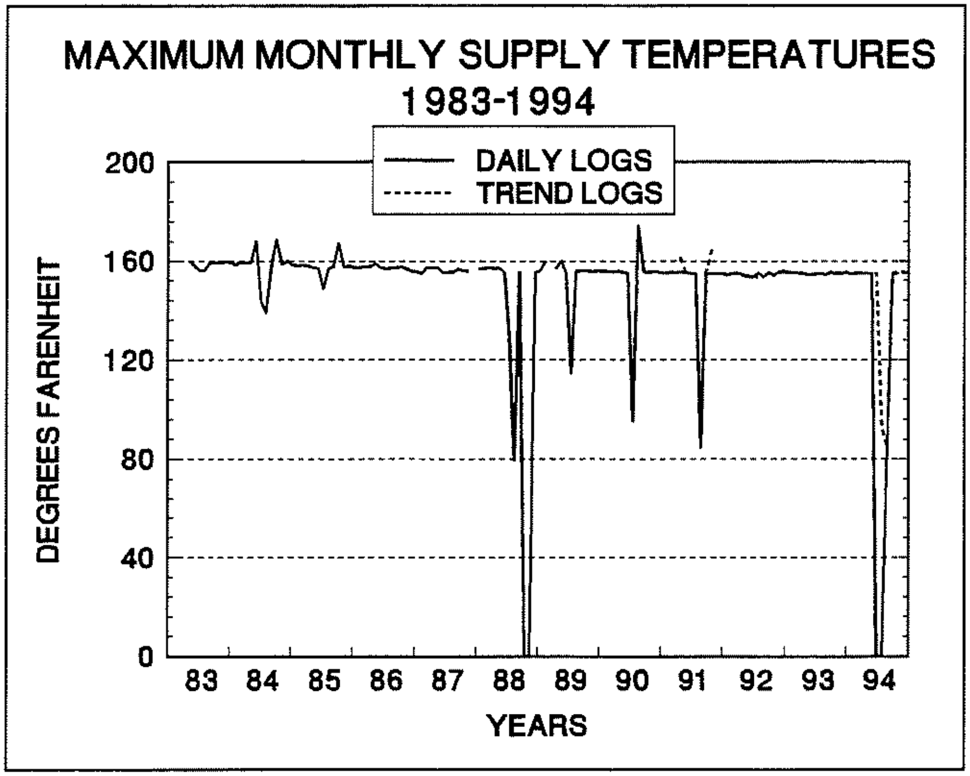

Figure 21. Maximum monthly supply temperatures for the Capitol Mall Geothermal system, 1983-1994.

CONCLUSIONS AND RECOMMENDATIONS

The State of Idaho Capitol Mall geothermal system heats nine buildings in the Capitol Mall complex. The system has been in operation since 1982. Annual production was computed to range from 65.8 to 240.2 million gallons during the time period from 1983 to 1994 (no records could be found for 1982). The computed value of 240.2 million gallons (1993 Daily Logs) is too high because the calculation is based on peak daily discharges as opposed to average daily discharges. The computed value of 65.8 (1983 Daily Logs) is too low because of missing data. Based on all of the data, the annual geothermal production for the Capitol Mall system probably ranged from 160 to 205 million gallons. A credible average annual production cannot be calculated because data records for several years are incomplete. The highest monthly production was 30.5 million gallons in January, 1985. The highest average monthly discharge rate was 683 gallons per minute in January, 1985. The maximum discharge rate was 982 gallons per minute in November, 1993. The maximum monthly supply temperature decreased about 5° Fahrenheit from 1983 to 1994.

Continued and improved monitoring is critical for the Capitol Mall system as well as for the other geothermal systems in the downtown Boise and Boise Warm Springs Water District areas. Efforts should be expanded to prevent data gaps caused by equipment failure and data capture mistakes.

REFERENCES

Anderson, J.E., 1981, Drilling and completion report Capitol Mall geothermal exploratory well #1: Idaho Department of Water Resources publication, 13 p.

Anderson & Kelly Consultants, 1981, Report on Capitol Mall geothermal Well #2: Prepared for CH2M Hill, 32 p.

Austin, J.C., 1978, A low temperature geothermal space heating demonstration project: Geothermal Resources Council, Transactions, Vol. 2, July, pp. 23-26.

Berkeley Group Inc., 1990, Boise geothermal aquifer study: Report to the Idaho Department of Water Resources, 118 p.

Boise Warms Springs Water District, 1989, Geothermal production, 1977-1989: Prepared by R.H. Griffiths, consultant.

Dansart, W.J., Kauffman, J.D., and Mink, L.L., 1994, Overview of geothermal investigations in Idaho, 1980-1993: Idaho Water Resources Research Institute, Research Technical Completion Report, 79 p.

Higginson, R.K., 1987, Investigation of the Boise Idaho geothermal system: Higginson-Barnett Consultants, Report to Boise State University, 20 p. plus appendices.

Mink, L.R., 1976, Geothermal testing of Statehouse well, final report: Boise State University, 7 p.

Montgomery, J.M., 1992, Boise geothermal aquifer study: James M. Montgomery, Consulting Engineers, Inc., Boise, Idaho and City of Boise and Boise Warm Springs Water District, 19 p. and appendices.

Montgomery Watson, 1994, Boise geothermal aquifer study, phase 2 report: Montgomery Watson and City of Boise and Boise Warm Springs Water District, Volumes 1 and 2.

Waag, C.J., and Wood, S.H., 1987, Geothermal investigations in Idaho-Evaluation of the Boise geothermal system: Final report to the Idaho Department of Water Resources, Boise, Idaho, 70 p.

Worbois, D., 1982, Glad to be in hot water-geothermal development in Boise, Idaho, 1890-1983: Parker Printing Company, 13 p.

APPENDIX A.

MONTHLY PRODUCTION FOR THE CAPITOL MALL GEOTHERMAL SYSTEM			
Year	Month	Production in gallons (Daily Logs)	Production in gallons (Trend Logs)
1983	January	NA	
	February	NA	
	March	NA	
	April	NA	
	May	158,400	
	June	2,441,952	
	July	2,688,192	
	August	2,914,128	
	September	4,604,400	
	October	12,642,192	
	November	16,281,360	
	December	24,102,864	
1984	January	26,069,904	
	February	20,765,808	
	March	19,024,992	
	April	17,335,728	
	May	16,408,368	
	June	6,986,448	
	July	97,488	
	August	NA	
	September	3,192,336	
	October	15,059,952	
	November	17,584,416	
	December	26,996,400	
1985	January	30,486,960	
	February	24,515,280	
	March	23,126,976	
	April	12,104,352	
	May	8,037,360	
	June	2,485,584	
	July	862,272	
	August	2,048,112	
	September	12,060,864	
	October	16,672,032	
	November	24,705,648	
	December	30,388,752	

MONTHLY PRODUCTION FOR THE CAPITOL MALL GEOTHERMAL SYSTEM			
Year	Month	Production in gallons (Daily Logs)	Production in gallons (Trend Logs)
1986	January	23,485,392	
	February	24,713,568	
	March	19,460,448	
	April	19,732,608	
	May	14,113,584	
	June	4,015,440	
	July	3,804,912	
	August	1,478,448	
	September	9,465,696	
	October	15,321,888	
	November	20,062,944	
	December	23,996,448	
1987	January	26,843,760	
	February	24,236,496	
	March	23,514,048	
	April	4,835,088	
	May	8,163,936	
	June	6,458,832	
	July	3,140,352	
	August	2,680,992	
	September	9,832,147	
	October	9,590,400	
	November	8,711,136	
	December	20,545,056	
1988	January	20,283,552	
	February	17,454,528	
	March	18,954,576	
	April	16,864,272	
	May	14,381,712	
	June	7,103,664	
	July	74,592	
	August	6,336	
	September	4,873,104	
	October	NA	
	November	NA	
	December	22,732,272	

MONTHLY PRODUCTION FOR THE CAPITOL MALL GEOTHERMAL SYSTEM			
Year	Month	Production in gallons (Daily Logs)	Production in gallons (Trend Logs)
1989	January	15,411,024	
	February	6,759,648	
	March	22,694,400	
	April	16,857,936	
	May	19,484,352	
	June	1,701,792	
	July	88,128	
	August	4,557,024	
	September	9,763,344	
	October	14,638,896	
	November	19,700,064	
	December	23,902,704	
1990	January	909,648	
	February	NA	
	March	NA	
	April	NA	
	May	NA	
	June	53,056	
	July	65,808	
	August	1,499,184	
	September	7,517,088	
	October	20,564,640	
	November	23,629,680	
	December	29,185,344	
1991	January	18,211,392	1,989,104
	February	13,621,968	NA
	March	16,704,288	NA
	April	16,199,136	11,787,606
	May	15,713,712	9,509,605
	June	13,411,872	4,903,862
	July	1,765,296	454,892
	August	NA	1,989,104
	September	8,554,608	3,061,955
	October	17,361,648	10,468,839
	November	18,400,752	NA
	December	19,489,824	NA

MONTHLY PRODUCTION FOR THE CAPITOL MALL GEOTHERMAL SYSTEM			
Year	Month	Production in gallons (Daily Logs)	Production in gallons (Trend Logs)
1992	January	20,499,696	10,557,900
	February	15,725,808	8,175,694
	March	17,325,360	5,995,368
	April	7,840,944	4,797,475
	May	6,790,896	1,874,974
	June	3,606,912	1,055,038
	July	3,049,776	381,575
	August	1,955,376	NA
	September	6,929,136	NA
	October	9,161,136	NA
	November	19,996,992	18,264,697
	December	23,412,816	24,173,503
1993	January	30,446,640	29,216,599
	February	25,213,968	22,915,361
	March	21,644,208	19,416,082
	April	18,493,589	16,610,861
	May	13,382,352	8,429,695
	June	14,780,160	10,848,560
	July	12,329,568	4,561,290
	August	8,352,144	3,359,905
	September	20,727,792	10,691,201
	October	20,737,296	7,234,027
	November	28,243,440	25,207,402
	December	25,850,160	21,795,714
1994	January	22,115,808	8,284,003
	February	19,691,136	1,007,734
	March	16,226,640	683,525
	April	14,303,952	2,681,849
	May	17,355,456	8,656,128
	June	NA	5,155,506
	July	NA	NA
	August	NA	NA
	September	9,947,088	5,374,422
	October	19,640,160	16,083,684
	November	23,774,112	23,009,472
	December	24,817,680	25,344,295