Hydrologic Interpretation of Temporal Variation in Springs and Wells in the Thousand Springs Area, Idaho

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ABSTRACT

An understanding of the relationship of spring discharge to aquifer water level is fundamental to modeling and managing the Eastern Snake River Plain Aquifer. Previous work has suggested that these relationships appear nearly linear but frequently are inconsistent with field observations of spring elevation. The purpose of this report is to document recently collected spring discharge and nearby aquifer water-level data and further evaluate the relationship between these measurements.

Spring discharge is compared to aquifer water levels for 14 spring-well pairs. In most cases, the relationship between the spring discharge and well water level is approximately linear within the limited data range. In a few cases, either spring discharge or well water level exhibits atypical behavior and the linearity is diminished. This may be due to local recharge and discharge activities near either the spring or well. Extrapolation of the relationships consistently indicates that spring elevation should be higher than that observed in the field (the x-axis intercept). This implies that a non-linear relationship may exist below the data range observed, or that systematic errors were encountered in measurement of spring discharge or aquifer water level. Non-linearity at lower spring discharges could be due to unconfined aquifer conditions or other unknown phenomena.

Background

The Thousand Springs region is located in southern Idaho, along the reach of the Snake River between the Milner Dam and King Hill. The springs emanate from the wall of the Snake River Canyon that in places is 500 feet deep. Collective spring discharge in this area is normally more than 5000 cfs, making the area the main discharge reach for the Eastern Snake River Plain Aquifer. Since the 1950’s, declines in spring discharge (Figure 1) have resulted from a combination of drought, decreased recharge from surface water irrigation, and increased ground-water pumping. Understanding and modeling the impacts of these activities on spring discharge requires a sound conceptual understanding of temporal variations in discharge of individual springs and the relationship of those changes to variations in aquifer water level. In the Eastern Snake River Plain Aquifer model it is assumed that a linear relationship exists between spring discharge and aquifer water level. The work of Janczak (2001) and recent modeling efforts did not produce evidence of significant non-linearity, but did identify that spring discharge was often insufficiently sensitive to changes in aquifer water level when the observed spring elevation was applied in the linear relationship.

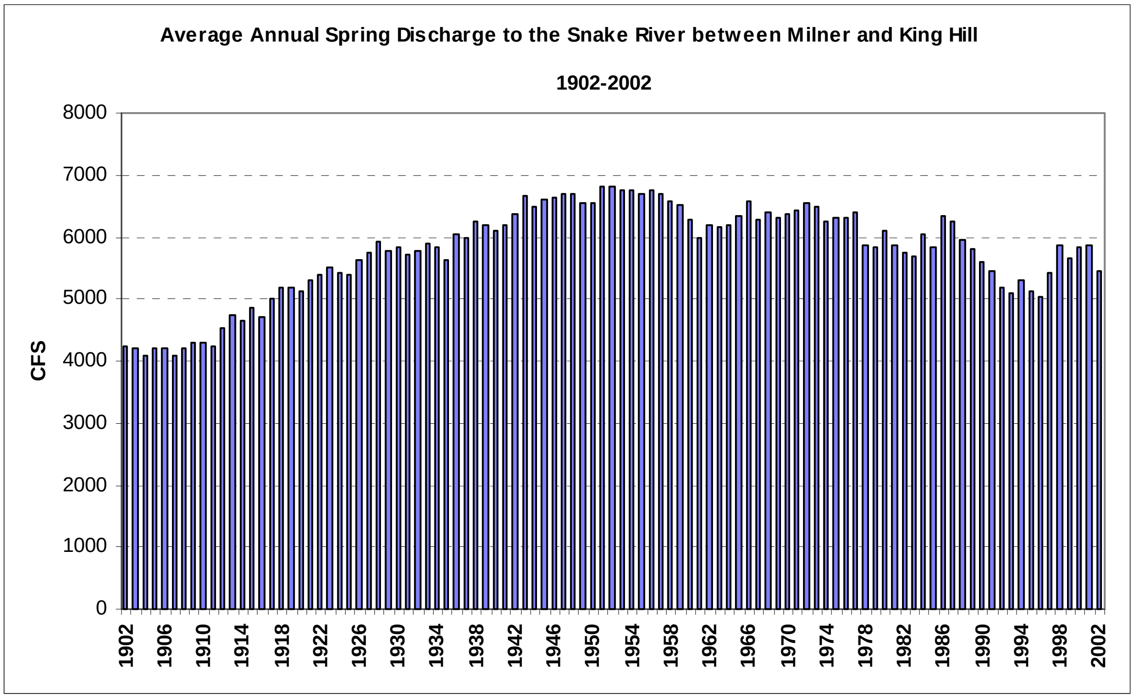

Figure 1: Average annual spring discharge to the Snake River between Milner and King Hill (modified using Kjelstrom method, 1995).

Purpose

This project has produced additional spring discharge and aquifer water level measurements since the Janczak (2001) analysis. The additional data extended over a larger data range than that evaluated by Janczak (2001) due to drought conditions since that analysis. The purpose of this report is to document data on spring discharges and water levels in wells that were collected by the Idaho Water Resources Research Institute (IWRRI) and evaluate the relationships between the aquifer water levels and the springs during this extended period. A comprehensive summary of past spring discharge data collected by IWRRI, the U.S. Geological Survey (USGS), the Idaho Department of Water Resources (IDWR) and private entities is available in a data report published by the

IWRRI (Johnson, et al., 2002). The data from this past publication plus updated data sets for some of the well and spring locations are used in this report.

Aquifer Water Level and Spring Discharge Measurements

Aquifer water-level measurements were taken by the IWRRI in five wells near the rim of the Snake River canyon (Figure 2). The frequency and duration of the measurements varied depending upon funding and usefulness of the measurements. The location, elevation, and the duration of measurements are identified in Table 1. The five wells were monitored using down-hole transducers and include the following locations T09S R16E Sec07DDD, T07S R14E Sec32AAA, T09S R14E Sec03AAB, T08S R14E Sec16CBB1, and T09S R18E Sec34DAC. The hydrographs for these five wells are provided in Figures 3 through 7.

Spring discharge was measured by the IWRRI in four springs: Crystal Spring, Blind Canyon Spring, and National Fish Hatchery Springs 10 and 15 (Figure 2). In each case, water level over a weir crest was measured using a pressure transducer. The frequency and duration of the measurements varied depending upon funding and usefulness of the measurements. The location, elevation, and the duration of measurements for the springs are identified in Table 1. The measurement sites were selected so that the measurement represents flow from the spring prior to any diversion or mixing with water from other sources. In some cases, accuracy of the discharge measurement may be affected by site conditions or instrument problems which will be discussed with each individual spring. The hydrographs for these springs are presented in figures 8 through 11. The black line represents results of hourly transducer observations and the red dots on the figures represent visual staff gage readings.

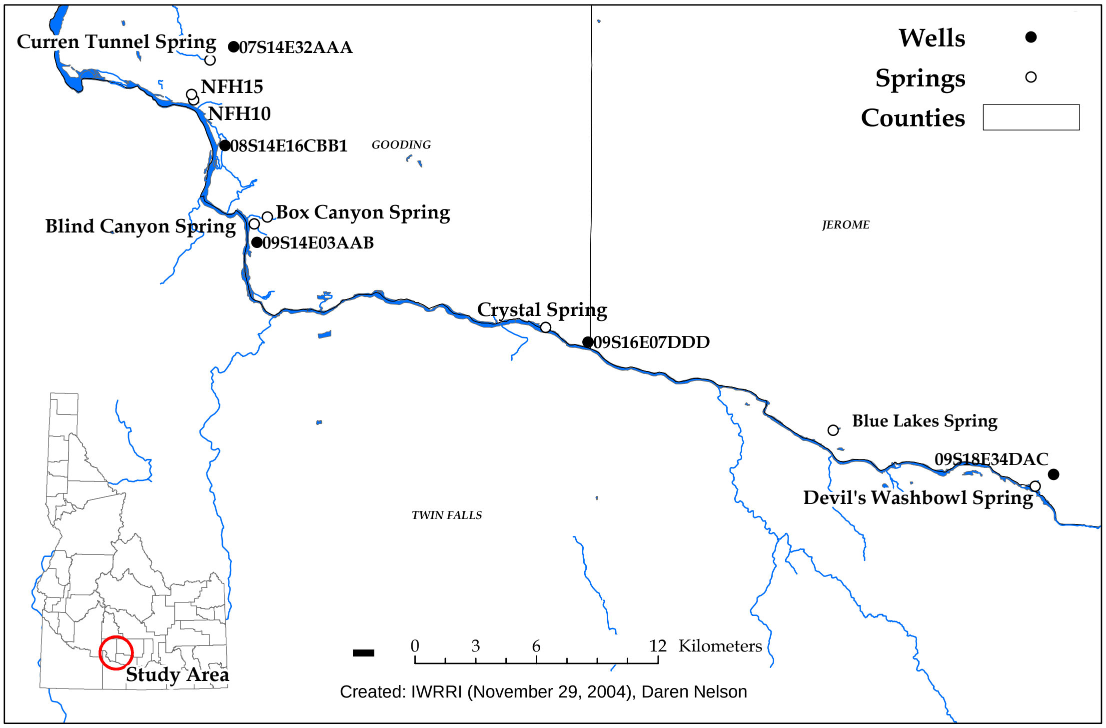

Figure 2: Spring and Well locations in the study area

Spring Name	Elevation	IDTM Northing	IDTM Easting	Duration of Measurements
Blind Canyon	3080	432950.3438	178492.9844	5/12/1999 – 9/29/2004
Box Canyon (USGS)	2950	433608.9375	178838.2969	1950 – Present
Crystal Springs	3031	447343.375	173369.4688	5/24/1999 – 4/5/2004
Devil's Washbowl (USGS)	3840	471542	165530.8125	1950 – 1959, 1985 – Present
National Fish Hatchery #10	2965	429969.625	184630.4844	5/27/1999 – 9/4/2003
National Fish Hatchery #15	3024	429859.1875	184905.5469	5/21/1999 – 12/20/2003
Curren Tunnel (IDWR)	3140	430766.43	186591.63	9/8/1993 – Present
Blue Lakes Spring (USGS)	3300	461560.37500	168280.9219	1950 – Present

Well Name	Elevation	IDTM Northing	IDTM Easting	Duration of Measurements
09S18E34DAC	3880	472444.125	166108.2813	3/6/2000 – 4/6/2004
09S16E07DDD	3428	449451.01	172659.03	6/6/1999 – 9/29/2004
09S14E03AAB	3190	433086.2188	177579.1875	3/26/1999 – 4/6/2004
08S14E16CBB1	3175	431514.4375	182375.4063	3/17/1999 – 9/28/2004
07S14E32AAA	3264	431941.39	187260.44	5/25/1999 – 9/28/2004

Table 1: Spring and well elevations, locations, and duration of measurements.

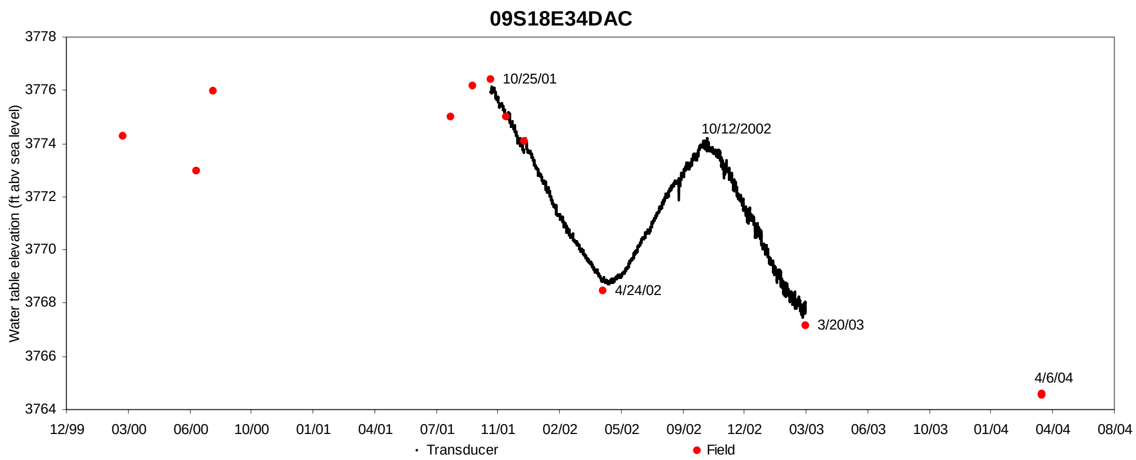

Figure 3: Hydrograph for 09S18E34DAC

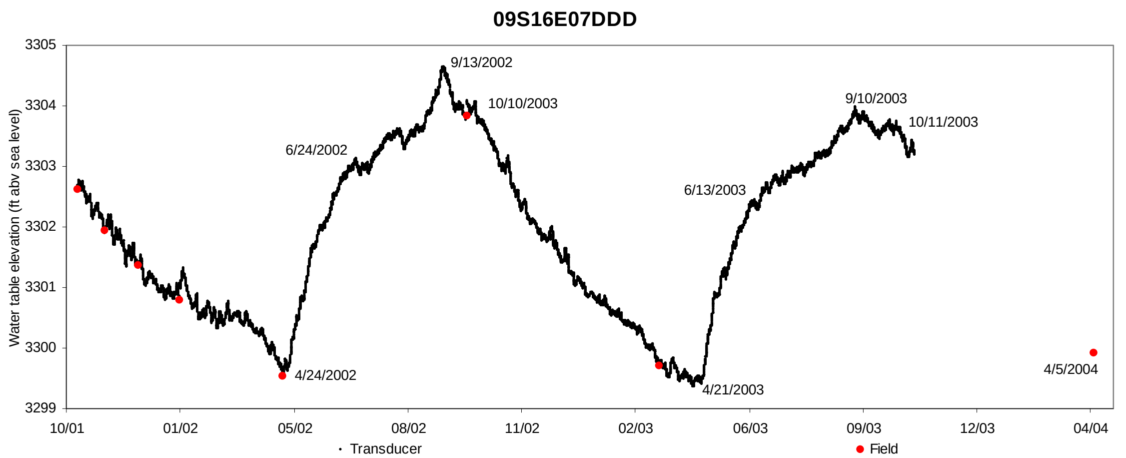

Figure 4: Hydrograph for 09S16E07DDD

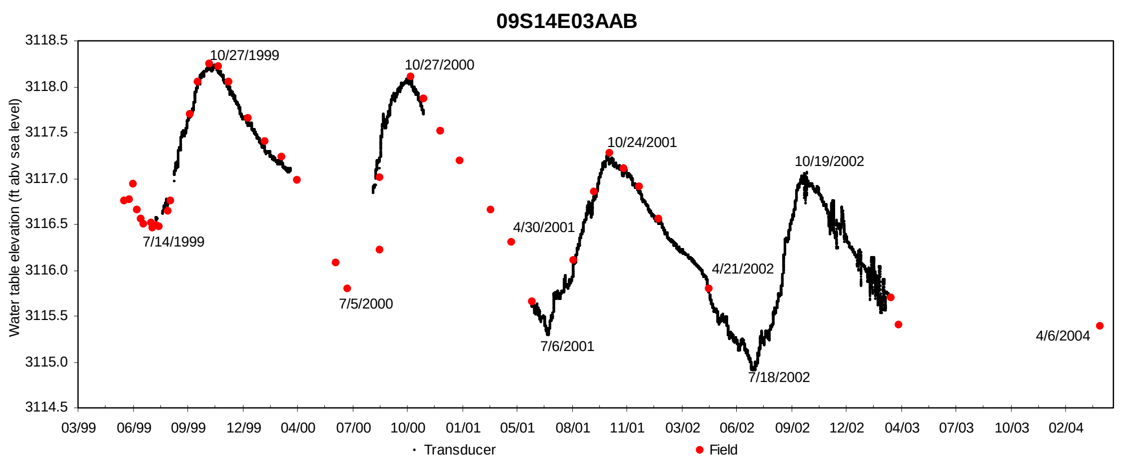

Figure 5: Hydrograph for 09S14E03AAB

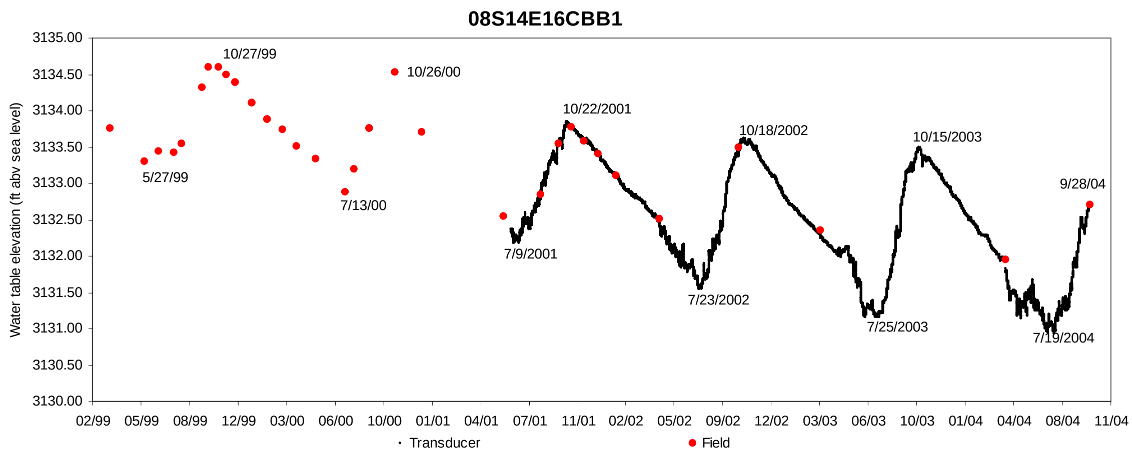

Figure 6: Hydrograph for 08S14E16CBB1

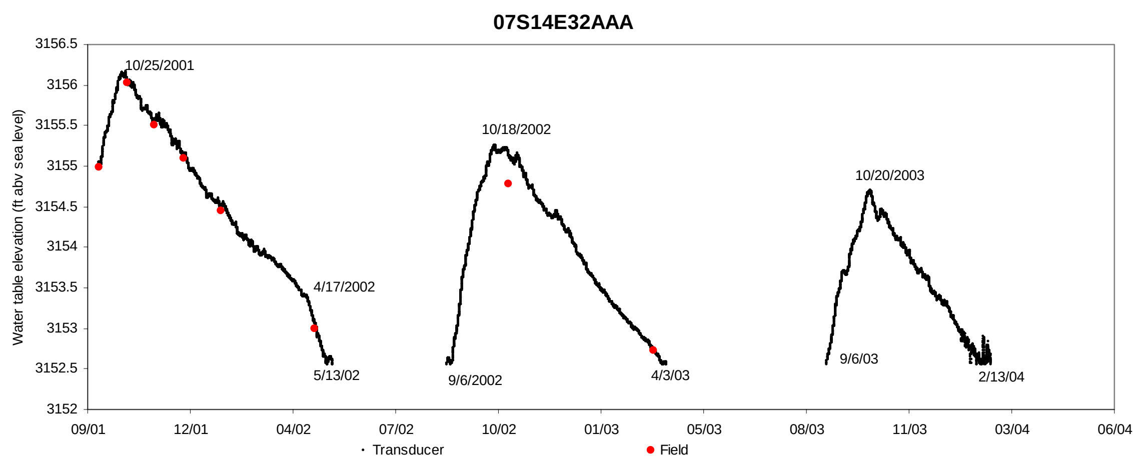

Figure 7: Hydrograph for 07S14E32AAA

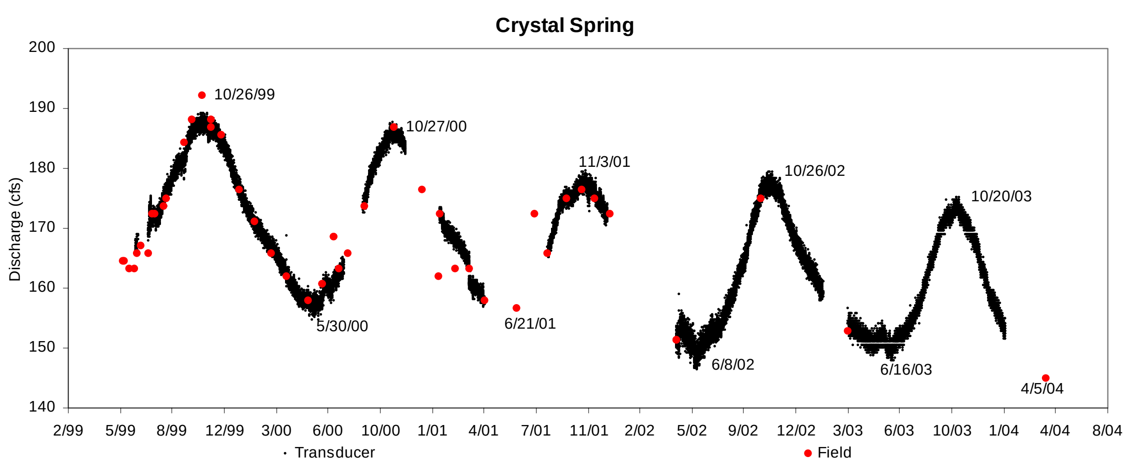

Figure 8: Hydrograph for Crystal Spring

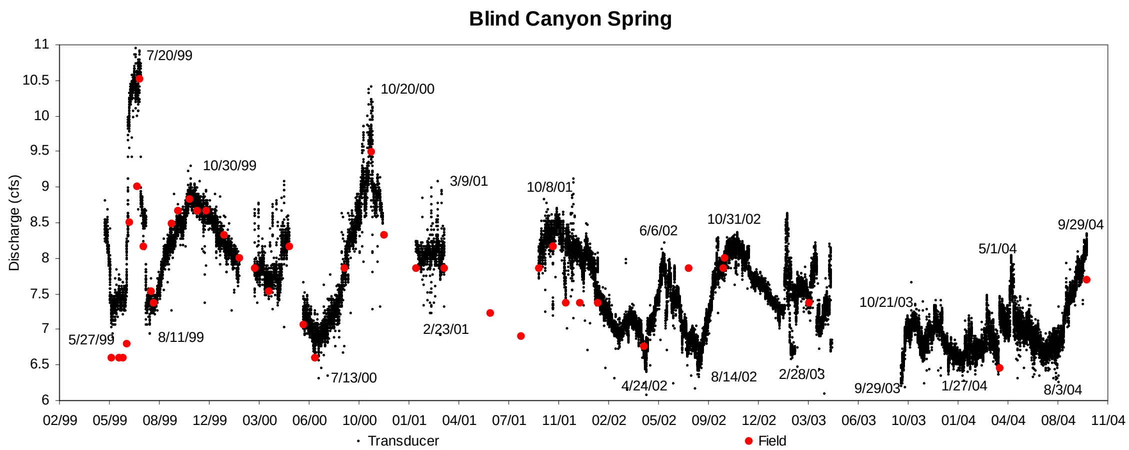

Figure 9: Hydrograph for Blind Canyon Spring

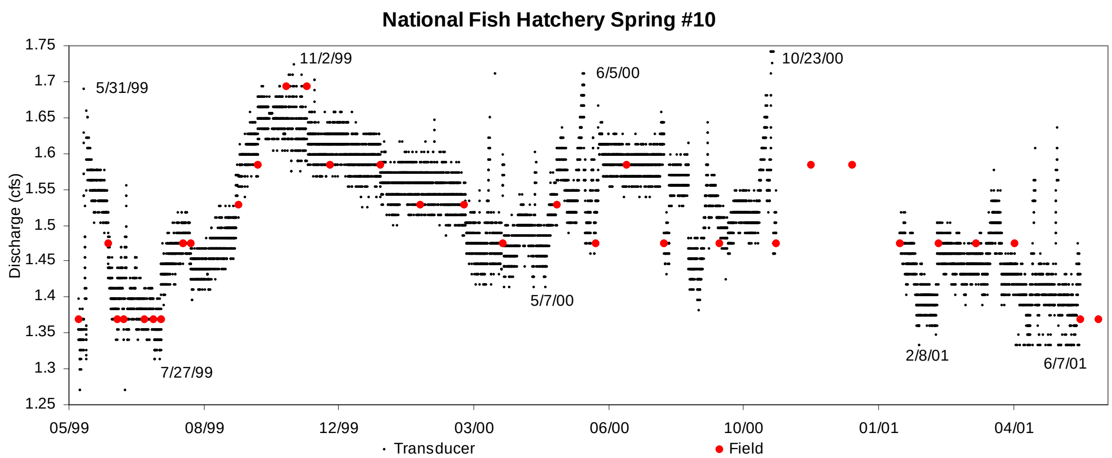

Figure 10: Hydrograph for National Fish Hatchery Spring #10

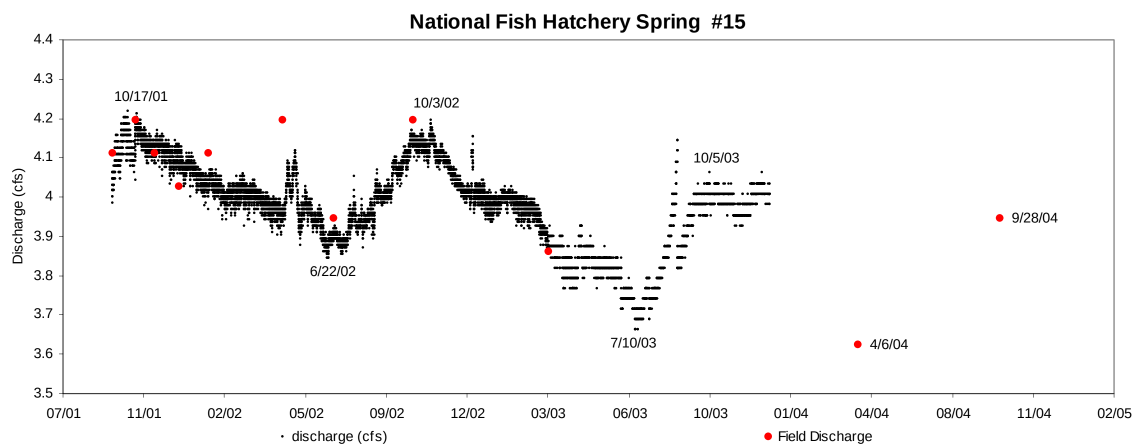

Figure 11: Hydrograph for National Fish Hatchery Spring #15

Spring discharge measurements collected in Blue Lakes Spring, Devils Washbowl Spring, and Box Canyon Spring were acquired from the USGS, and discharge measurements from Curren Tunnel Spring were acquired from the IDWR. The location and elevation of these springs can also be seen in Table 1 and are mapped in Figure 1. Hydrographs for these springs are presented in Figures 12 through 15. These springs are also compared to aquifer water-level measurements made by IWRRI in a subsequent section of this report.

Well 09S18E34DAC Water Levels

The well at location T09S R18E Sec34DAC has been manually monitored since March 6, 2000, and a transducer was installed to automatically measure water levels on an hourly basis on October 25, 2001. The well is approximately ¾ mile away from Devils Washbowl Spring and approximately 7 miles from Blue Lakes Spring. Figure 3 shows the cyclic pattern in the water levels, apparent after installation of the transducer. The minimum water level occurs in March-April and the maximum water level occurs during the period of October 12-25. The pattern from 10/25/2001 through 3/20/2003 shows a slight decline in water levels. However, it is not known how this pattern compares to longer-term conditions.

Well 09S16E07DDD Water Levels

The well at location T09S R16E Sec07DDD has been manually monitored since June 6, 1999, and a transducer was installed to automatically measure water levels on an hourly basis on October 25, 2001.

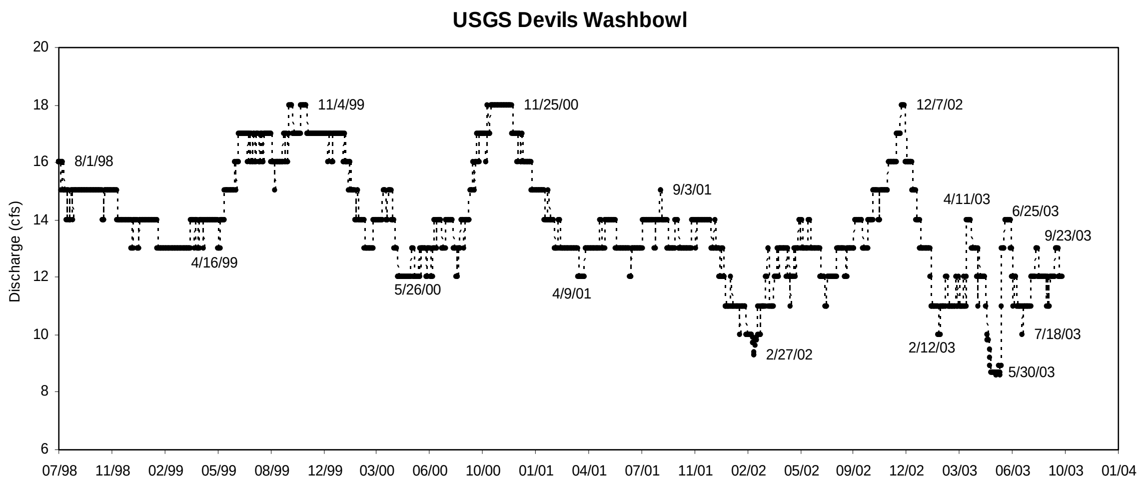

Figure 12: Hydrograph for USGS Devils Washbowl Spring

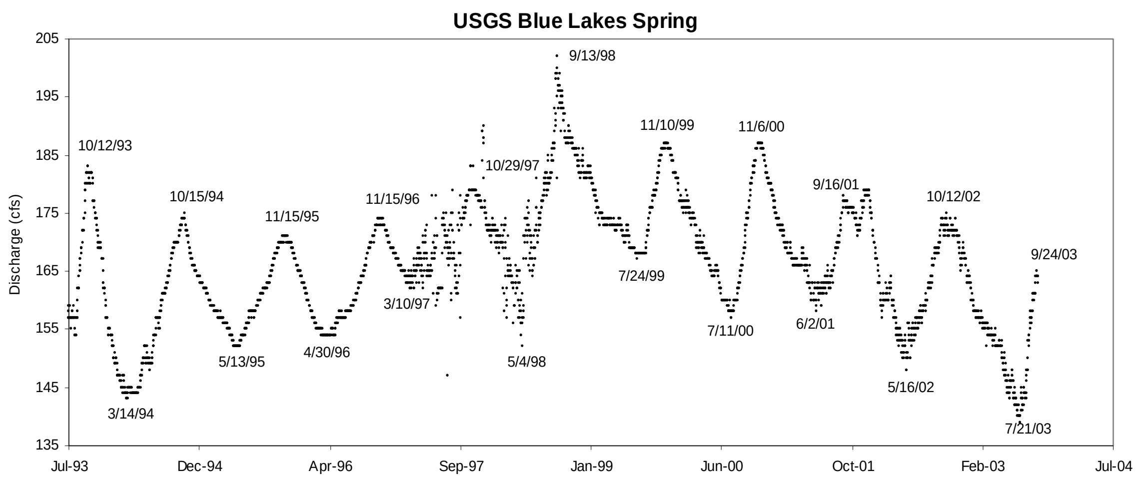

Figure 13: Hydrograph for USGS Blue Lakes Spring

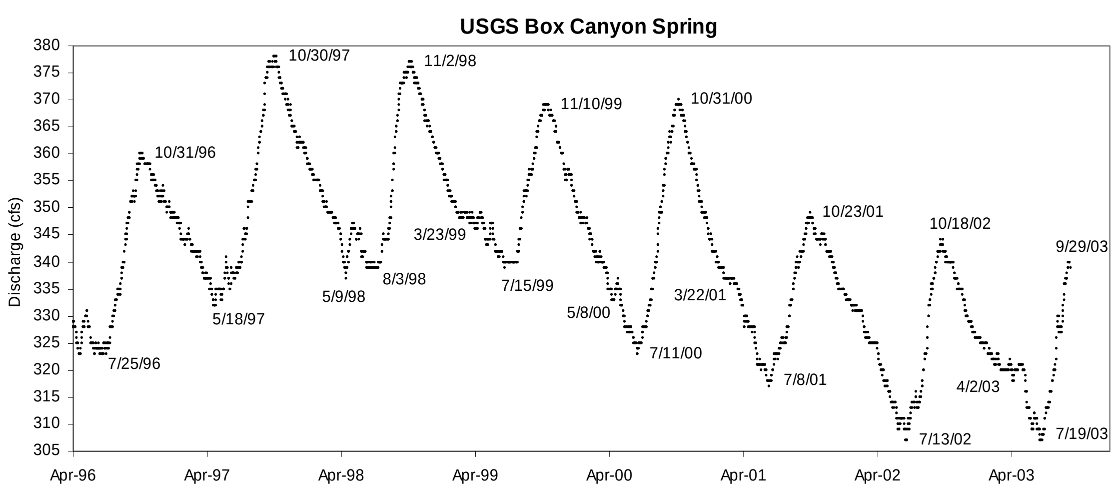

Figure 14: Hydrograph for USGS Box Canyon Spring

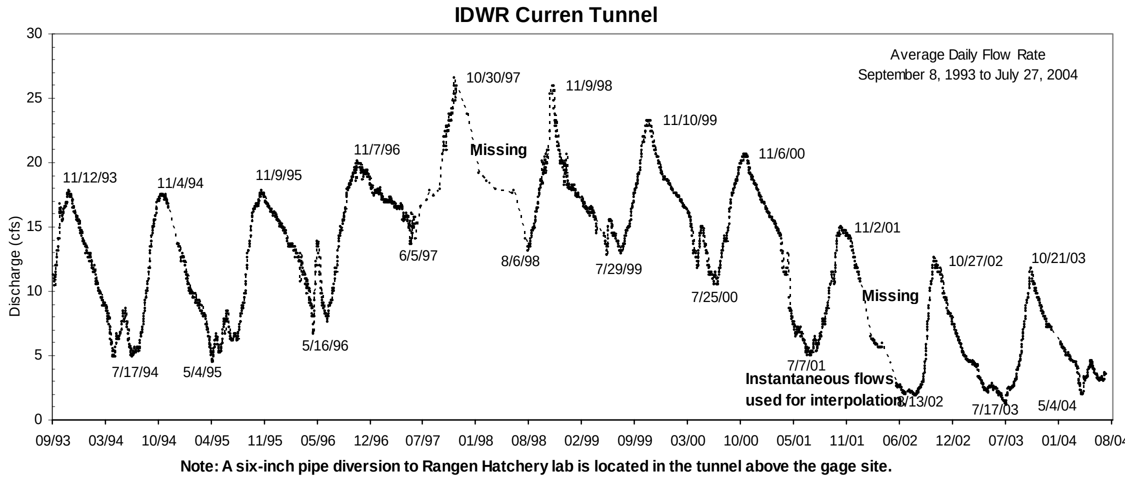

Figure 15: Hydrograph for IDWR Curren Tunnel Spring

The well is approximately 1 ½ miles from Crystal Spring and approximately 8 miles from Blue Lakes Spring. Figure 4 shows water levels have a cyclic seasonal pattern but do not exhibit a year-to-year decline during the period monitored. The minimum water levels occur in late April and then the water level abruptly rises. These minimum values correspond to timing of minimums in Well 09S18E34DAC and possibly in Crystal Spring with some time lag. The Well 09S16E07DDD hydrograph is unique from the other wells due to the concave nature of the recession limb and convex appearance of the increasing limb. In 2002 and 2003, the well also exhibited a spike in September for its maximum while other wells tend to reach a maximum in October. Near mid-June, the upward trend changes to a shallower slope.

Well 09S14E03AAB Water Levels

The well located at T09S R14E Sec03AAB has been manually monitored since March 26, 1999, and a transducer was installed to automatically measure water levels on an hourly basis on July 21, 1999. The well is approximately ½ mile away from Blind Canyon Spring, approximately 1 mile from Box Canyon Spring, and approximately 9 ¼ miles from Crystal Spring. Figure 5 shows that the water levels in the well display a seasonal cyclic pattern with a downward trend. The minimum water level value had declined by 1.48 feet from 7/14/1999 through 7/18/2002. The slope of the hydrograph abruptly changes at the maximum and minimum values in each year. The pattern is most similar to that of Well 08S14E16CBB1. The minimum values occur from July 5-18 and the maximum values occur from October 19 – 27. The increasing limb has a much steeper slope than most of the recession limb. Also, the recession limb of winter of 2002 exhibits high frequency variations while the rest of the graph does not. It appears that in spring, water levels begin to fall at an accelerated rate. This is most apparent from the transition on April 21, 2002. The change in slope is similar to that observed in Well 07S14E32AAA.

Well 08S14E16CBB1 Water Levels

The USGS has taken intermittent water-level measurements from Well 08S14E16CBB1 since 1955. IWRRI has manually monitored Well 08S14E16CBB1 since March 17, 1999, and installed a transducer on June 22, 2001 to automatically measure water levels on an hourly basis. The well is approximately 1 ¾ miles from National Fish Hatchery Spring #10, 2 miles from National Fish Hatchery Spring #15, 2 ½ miles from Box Canyon Spring, and 2 ½ miles away from Blind Canyon Spring. Figure 6 shows that the water levels in the well exhibit a cyclic seasonal pattern with a downward trend. The minimum water-level value had declined by 2.42 feet from

7/27/1999 through 7/19/2004. The maximum values of the pattern consistently occur in October, whereas the minimum values consistently occur in July. On April 24, 2002, May 4, 2003, and April 5, 2004 the slope of the recession limbs increase. This corresponds to changes in slope from Well 09S14E03AAB and Well 07S14E32AAA during the same time period.

Well 07S14E32AAA Water Levels

The well at location T07S R14E Sec32AAA has been manually monitored since May 25, 1999, and a transducer was installed to automatically measure water levels on an hourly basis on September 21, 2001. Figure 7 shows that the slope of the hydrograph abruptly changes in the fall and the maximum water level occurs in the period of October 18-25 each year. Since the well goes dry from spring until early September, it is not known what the minimum water level is in this well. The pattern seems to show a decline in water levels from year-to-year. The maximum values have declined by 0.9 ft from 2001-2002 and by 0.5 ft from 2002-2003. On April 17, 2002, the recession limb shows an increased rate of decline in water level. However, it cannot be determined if this trend continues on an annual basis since the well goes dry after this date over subsequent years.

Devils Washbowl Spring

Seasonal and longer term variation in discharge of Devils Washbowl Spring is presented in Figures 12 and 16. The USGS has recorded daily discharge measurements to the nearest 1 cfs from 1950 – 1959 and 1985 – present. Covington and Weaver (1990) indicate that the springs emerge from basalt cooling joints in the canyon wall. Altimeter measurements for the spring place the point of emergence at an elevation of approximately 3840 feet. Figure 16 presents daily discharge as a color coded scheme relative to average discharge of the spring for all measurements. The days of the year are shown on the horizontal axis and different years are plotted along the vertical axis. This color graphic shows that there has been a dramatic decrease in discharge between the long term measurements of 1950 – 1959 and 1985 – present. Average discharge from 1950 - 1959 and from 1985 – present was 22 and 13 cfs, respectively.

Blue Lakes Spring

Graphs of Blue Lakes Spring discharge are presented in Figures 13 and 17. The USGS recorded daily discharge measurements for the spring since 1950. Covington and Weaver (1990) indicate that the springs emerge at an elevation of approximately 3300 feet from beneath rubble on the alcove floor of the canyon that was deposited during the Bonneville Flood. Figure 17 shows a long-term decrease in spring discharge for the spring. From 1950 – 1960 the average discharge for the spring was 228 cfs whereas from 1990 – 2003 the average discharge was 166 cfs, a decline of 62 cfs. The degree of long term relative variation in Blue Lakes Spring (Figure 17) appears less than that of Devils Washbowl (Figure 16). The peak seasonal discharge values for the spring occur in October – November and the minimum seasonal discharge values occur in May – June. The seasonal variation is approximately 25-35 cfs. Figure 13 shows that from 1993 – 1997 the discharge in the springs increased, however, multiple years of drought have reversed these increases and have caused a decline in discharge.

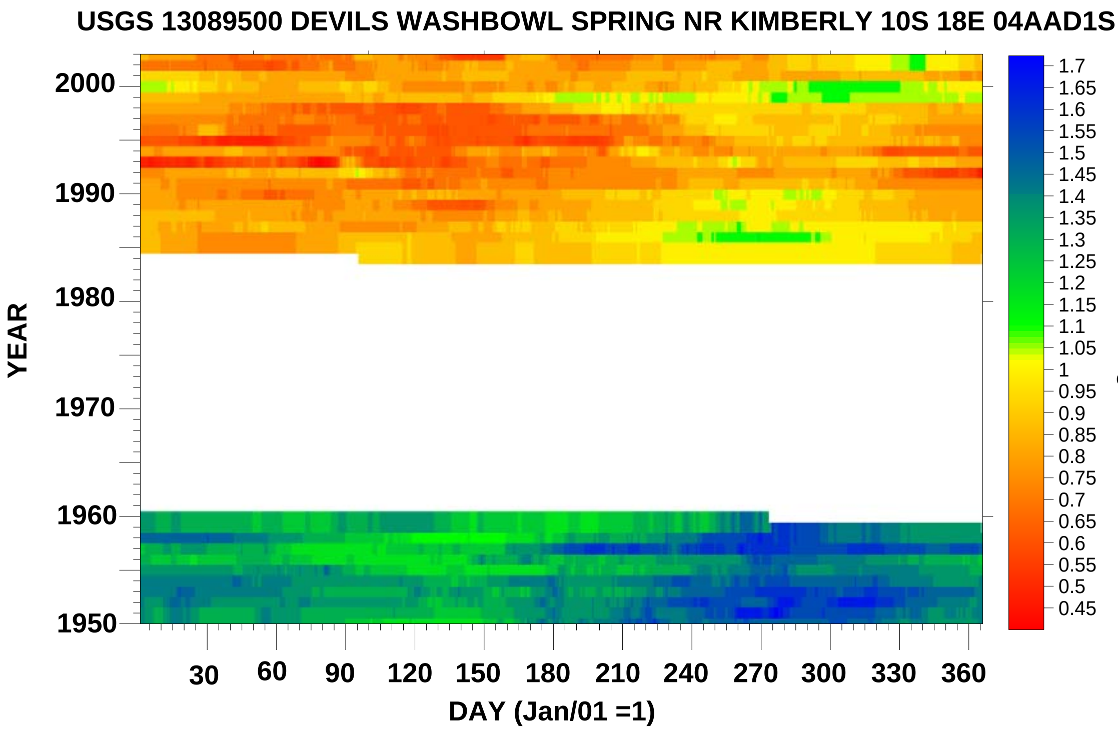

Figure 16. Color raster diagram of historic discharge from Devils Washbowl Spring.

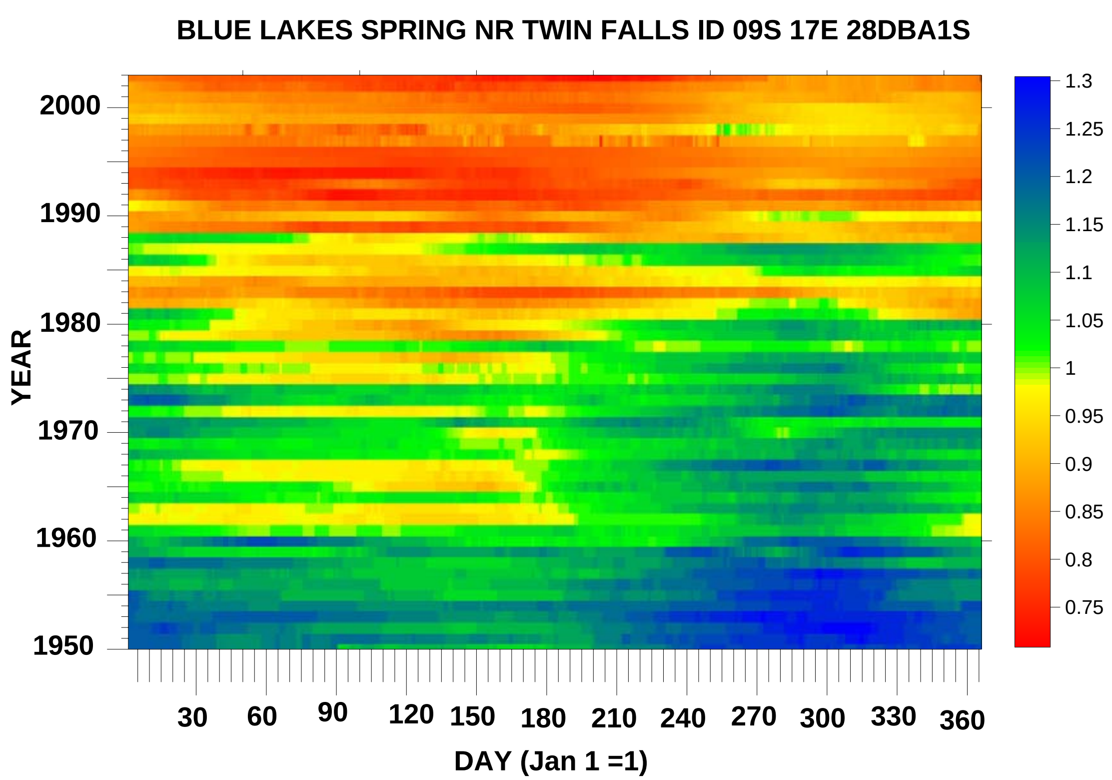

Figure 17. Color raster diagram of Blue Lakes Spring discharge.

Crystal Spring

The graphical description of the temporal variation in spring discharge for Crystal Spring can be seen in Figure 8. Measurements for the spring have been taken since May 24, 1999 and a transducer was installed and operating on July 20, 1999 to obtain hourly discharge measurements. Covington and Weaver (1990) indicate that the springs probably emerge from pillow facies of the Sand Springs basalt beneath a talus slope at an elevation of 3031. As seen in Figure 8, the spring has a very consistent seasonal pattern and a multi-year declining trend. The minimum discharge has declined by 18 cfs from 6/7/1999 through 4/5/2004. The maximum seasonal discharge occurs from October 20 – November 3 and the minimum seasonal discharge occurs from May 30 – June 21, with an average seasonal variation of approximately 30 cfs. These earlier minimum dates are consistent with the minimum water levels in both Well 09S16E07DDD and Well 09S18E34DAC, but differ from the other wells. The maximum dates are consistent with other measured springs and wells.

Blind Canyon Spring

The graphical description of temporal variation in discharge of Blind Canyon Spring is presented in Figure 9. Discharge measurements have been taken since May 12, 1999 and a transducer was installed and operating the same day. The spring emerges due to less permeable sedimentary materials beneath pillow basalts of the canyon wall at approximately 3080 feet elevation (Johnson et al., 2002). Blind Canyon is a relatively small spring with an average discharge of 7.6 cfs. The high frequency variation in discharge apparent in Figure 9 may be due to the fish hatchery operations located upstream from the measurement point. The peak seasonal discharge usually occurs in October and the minimum seasonal discharge usually occurs in July or August.

Box Canyon Spring

Discharge of Box Canyon Spring is graphically presented in Figures 14 and 18. Covington and Weaver (1990) indicate that the spring emerges from beneath a talus deposit of the Sand Springs basalt unit at an elevation of approximately 2950 feet. The USGS has recorded daily discharge measurements for the spring since 1950. Figure 18 shows that there has been a long term decline in spring discharge. Through 1950 - 1960 the average discharge is 416 cfs, whereas the average discharge through 1990 – 2003 is 340 cfs. In Figure 14, there seems to be an increase in the rate of seasonal decline in discharge after a flattening in late March. These patterns are very similar to wells in this area (08S14E16CBB1, 09S14E03AAB, and 07S14E32AAA), and could be caused by a combination of different recharge and pumping conditions.

National Fish Hatchery Spring #10

The discharge hydrograph for the NFH #10 spring is presented in Figure 10. The Hagerman National Fish Hatchery has measured the discharge of the spring in the past and IWRRI has taken manual and automatic discharge measurements for the spring since May 27, 1999 until September of 2004. However, in the summer of 2002, the weir was

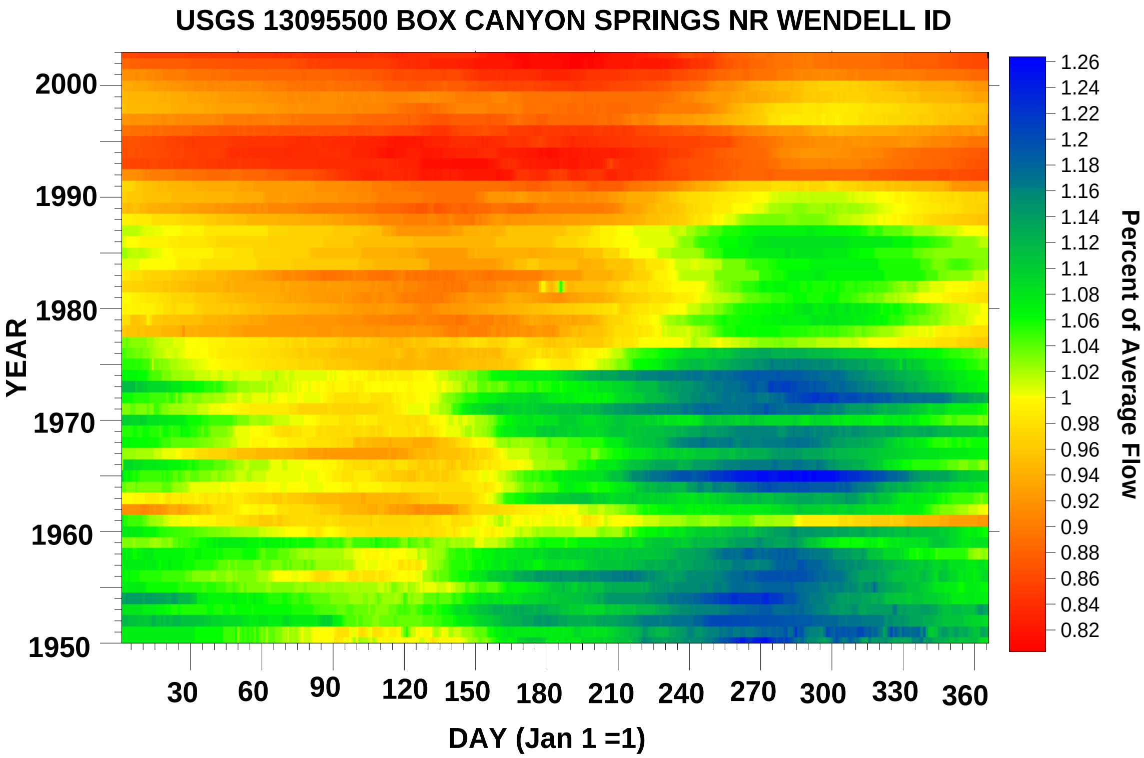

Figure 18: Long term temporal variations of Box Canyon spring discharge raster

reconstructed and subsequent observations were inconsistent. The spring emerges from beneath a talus deposit of the Thousand Springs basalt unit at an elevation of 2965 feet. Spring discharge appears relatively stable and there is no apparent seasonal pattern, possibly due to upstream hatchery operations.

National Fish Hatchery Spring #15

The discharge hydrograph for NFH #15 is presented in Figure 11. Manual measurements for the spring have been taken since May 21, 1999 and a transducer was installed and operating on July 22, 1999 to obtain hourly discharge measurements. The spring emerges at an elevation of approximately 3024 feet from beneath a talus deposit of the Thousand Springs Basalt unit. The discharge records indicate a small seasonal variation with a subtle multi-year declining trend. The maximum seasonal discharge occurs between early and mid-October and the minimum seasonal discharge occurs in late June or early July.

Curren Tunnel Spring

The discharge hydrograph for Curren Tunnel Spring is presented in Figure 15. The spring emerges from pillow basalt facies of the Malad Basalt at an elevation of 3140. The IDWR has measured Curren Tunnel with pressure transducer since 1992. The transducer is located near the tunnel outlet. However, a six-inch pipe diversion above the gage provides water for the Rangen Hatchery Lab and is not accounted for in the measurement. The seasonal variation of the discharge is approximately 14 cfs. The seasonal minimum discharge occurs from May – August but is usually during mid-July, and the peak seasonal discharge occurs during late October – early November.

Spring Discharge Relationship to Aquifer Water Levels

Janczak (2001) reported near linear relationships between spring discharge measurements and nearby measurements of aquifer water levels in the Thousand Springs area. In addition, Janczak (2001) found that the linear relationships were inconsistent with field observations of spring elevation. Subsequent modeling of springs in the Snake River Plain Aquifer Model found that simulations using field observations of spring elevations resulted in an insufficient sensitivity of spring discharge to variations in aquifer head. These simulations required increases in spring elevation, relative to field observations, in order to simulate the observed seasonal amplitude of variation in spring discharge.

This section describes the relationships and patterns between spring discharge and nearby aquifer water levels for individual well-spring pairs (Figures 19 – 32). The well-spring pairs that were analyzed were selected based on distances between spring and well locations and measurement frequency. In order to determine if the well-spring relationships change over time, each year was often divided into three periods of four months. The three periods included the winter (11/1 – 2/28), the spring (3/1 – 7/31), and the summer (8/1 – 10/31). A linear regression was performed for each well-spring pair.

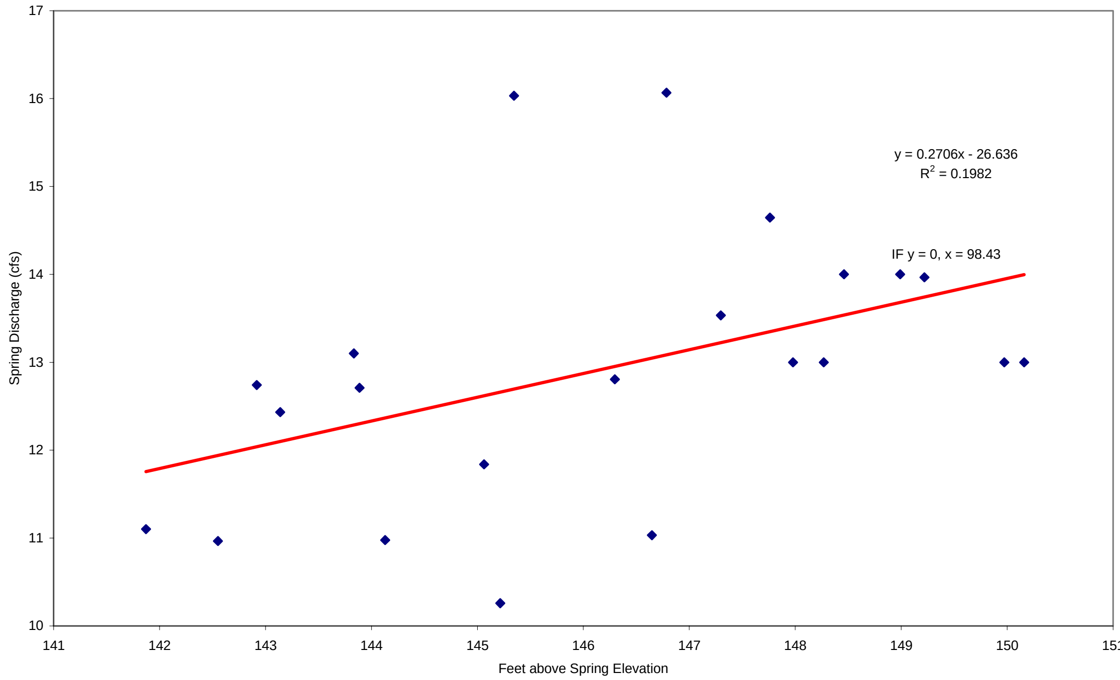

Figure 19. Linear regression of Devils Washbowl discharge and water level in Well 09S18E34DAC.

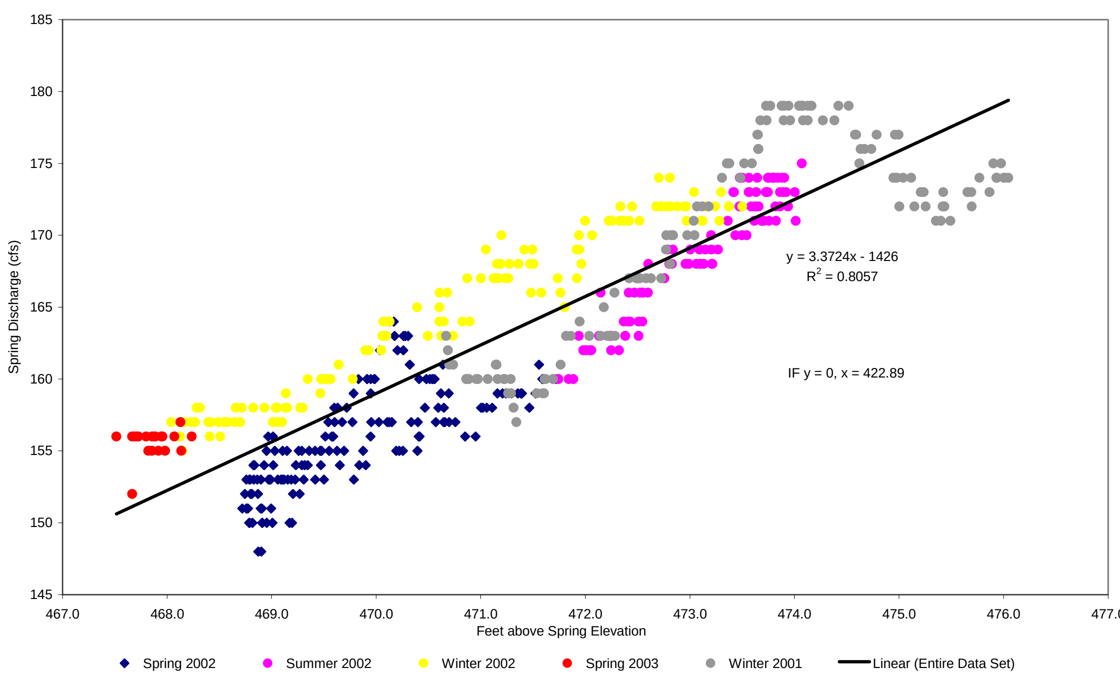

Figure 20. Linear regression of Blue Lakes Spring discharge and water level in Well 09S18E34DAC.

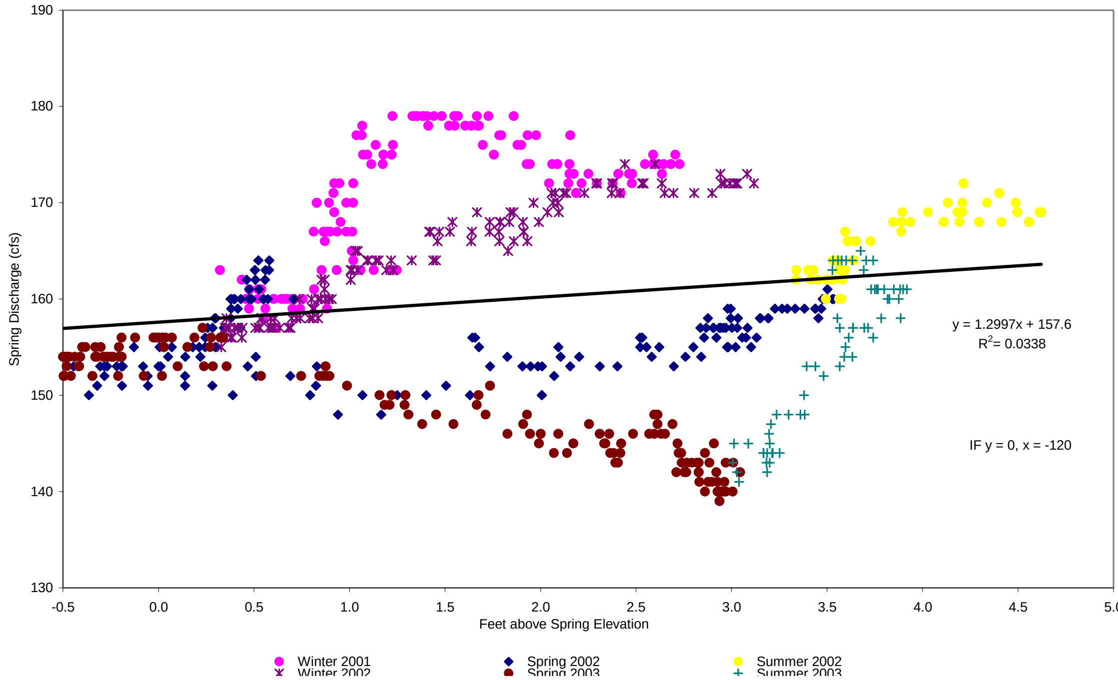

Figure 21. Regression of Blue Lakes Spring discharge and water level in Well 09S16E07DDD.

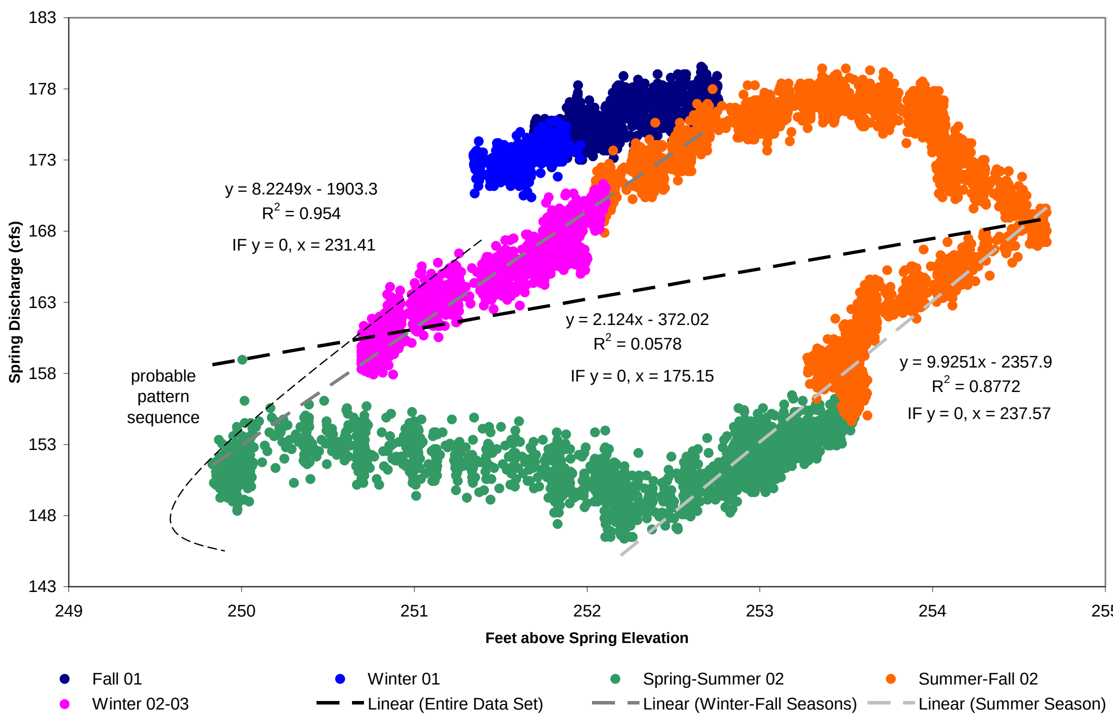

Figure 22. Regression of Crystal Spring discharge and water level in Well 09S16E07DDD.

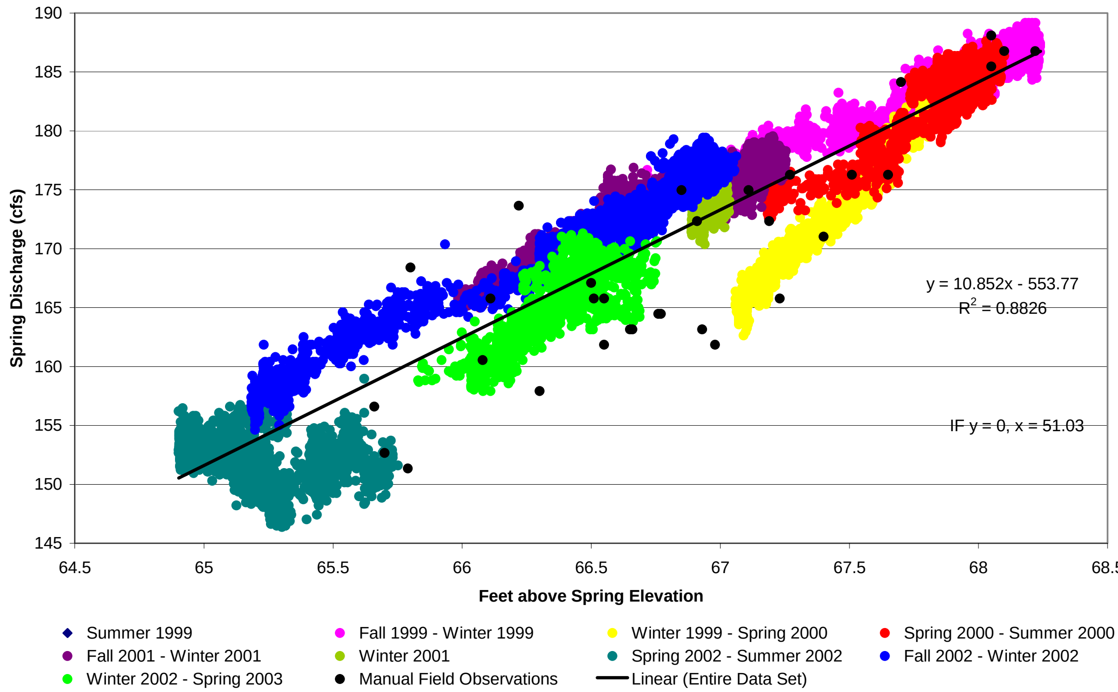

Figure 23. Regression of Crystal Spring discharge and water level in Well 09S14E03AAB.

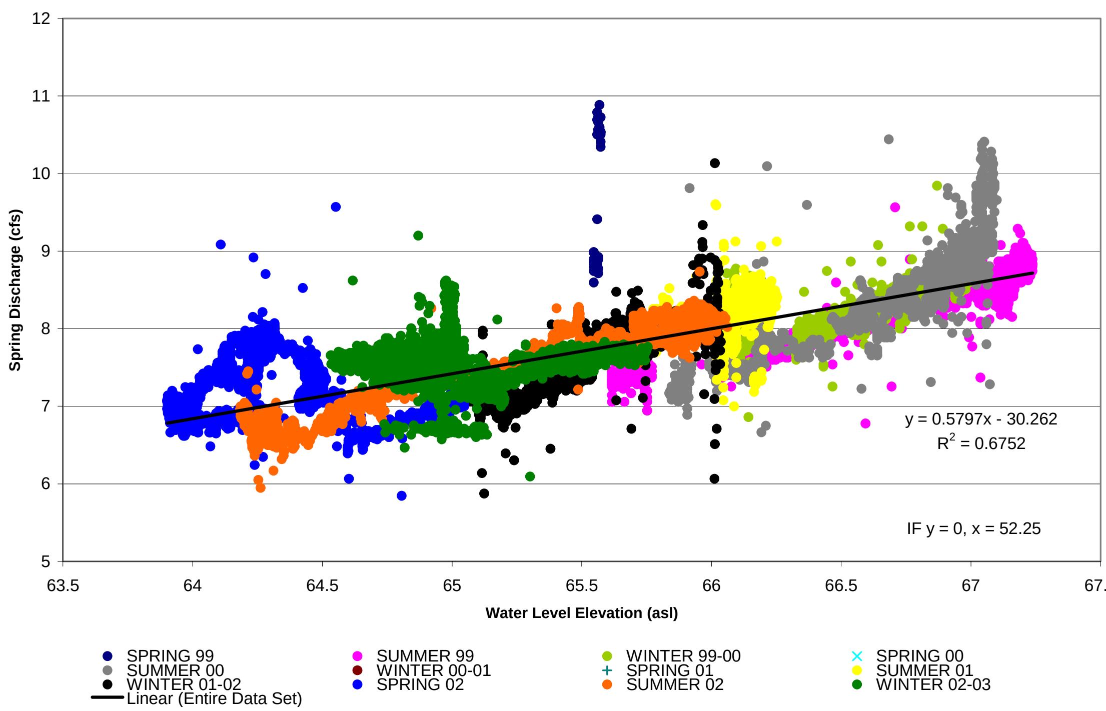

Figure 24. Regression of Blind Canyon discharge and water level in Well 09S14E03AAB.

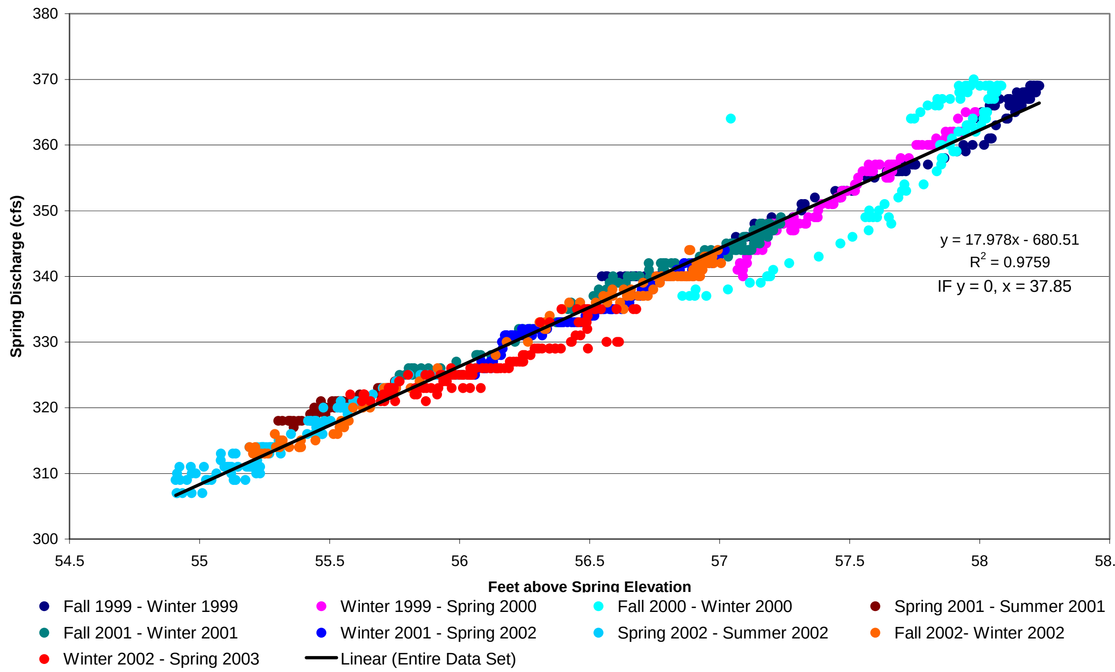

Figure 25. Regression of Box Canyon discharge and water level in Well 09S14E03AAB.

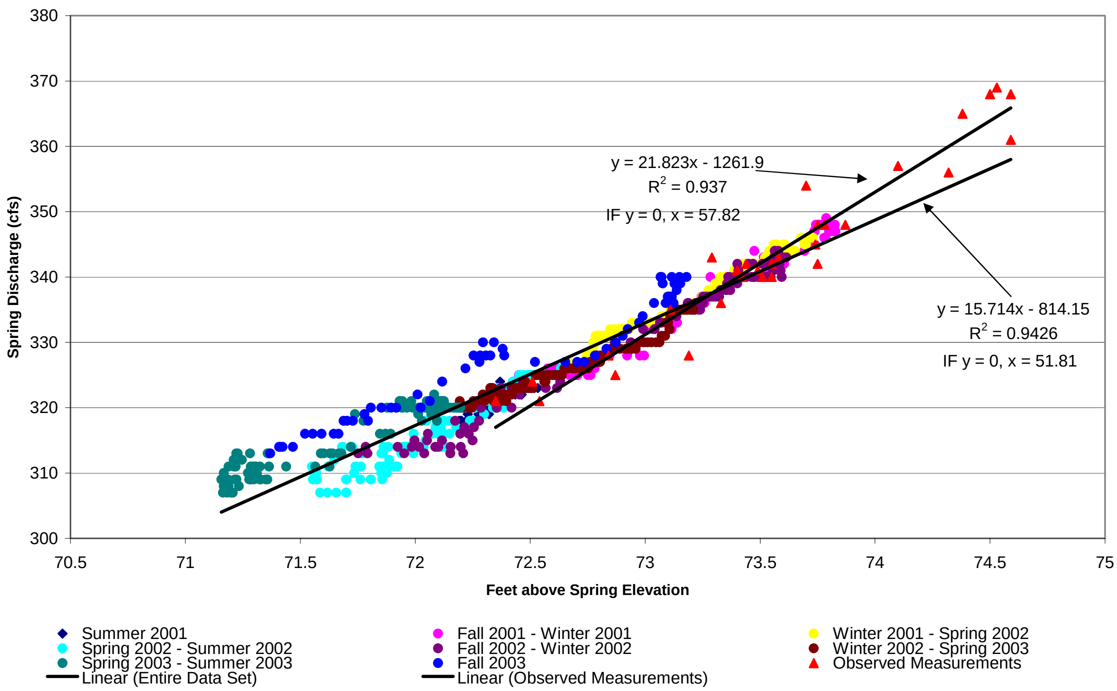

Figure 26. Regression of Box Canyon discharge and water level in Well 08S14E16CBB1.

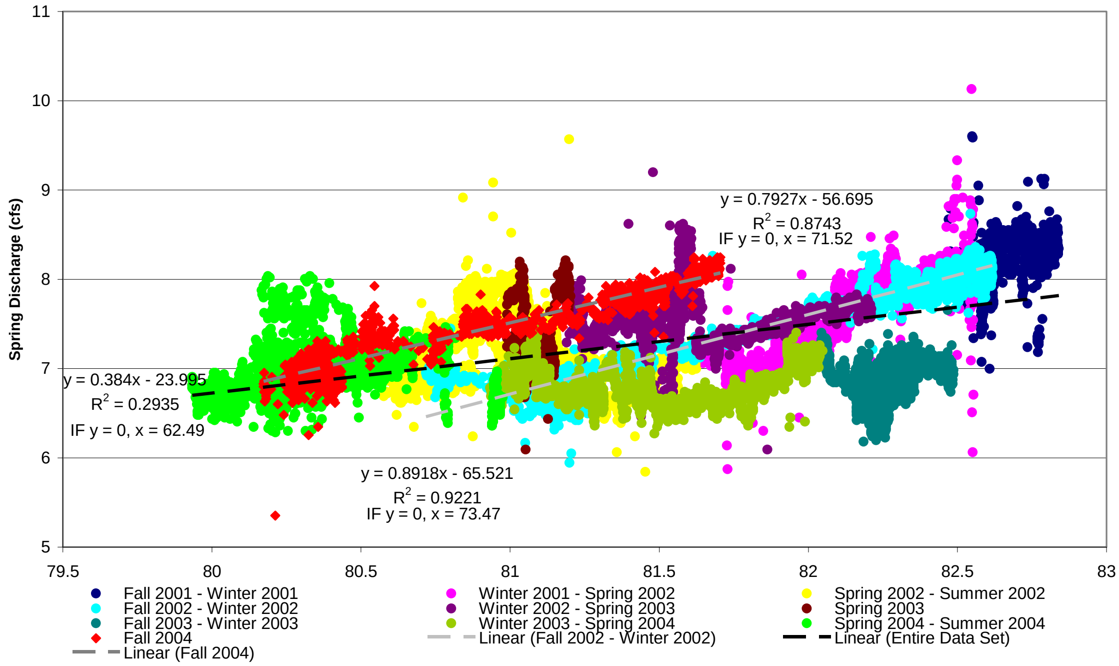

Figure 27. Regression of Blind Canyon Spring discharge and water level in Well 8S14E16CBB1.

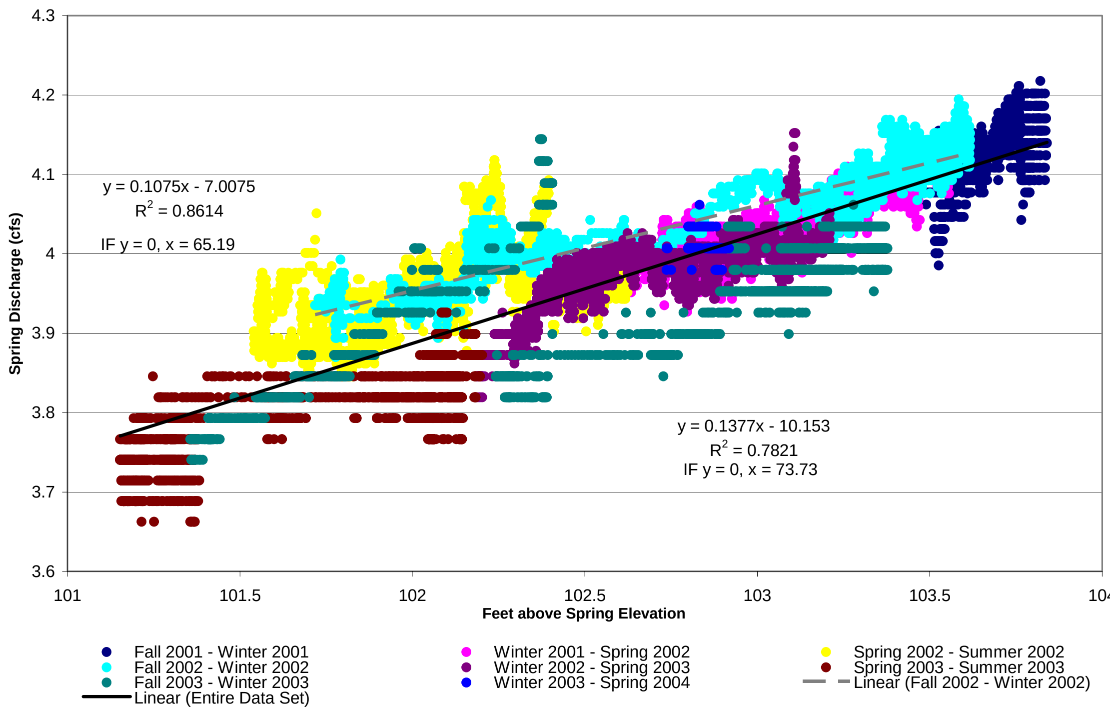

Figure 28. Regression of NFH15 spring discharge and water level in Well 08S14E16CBB1.

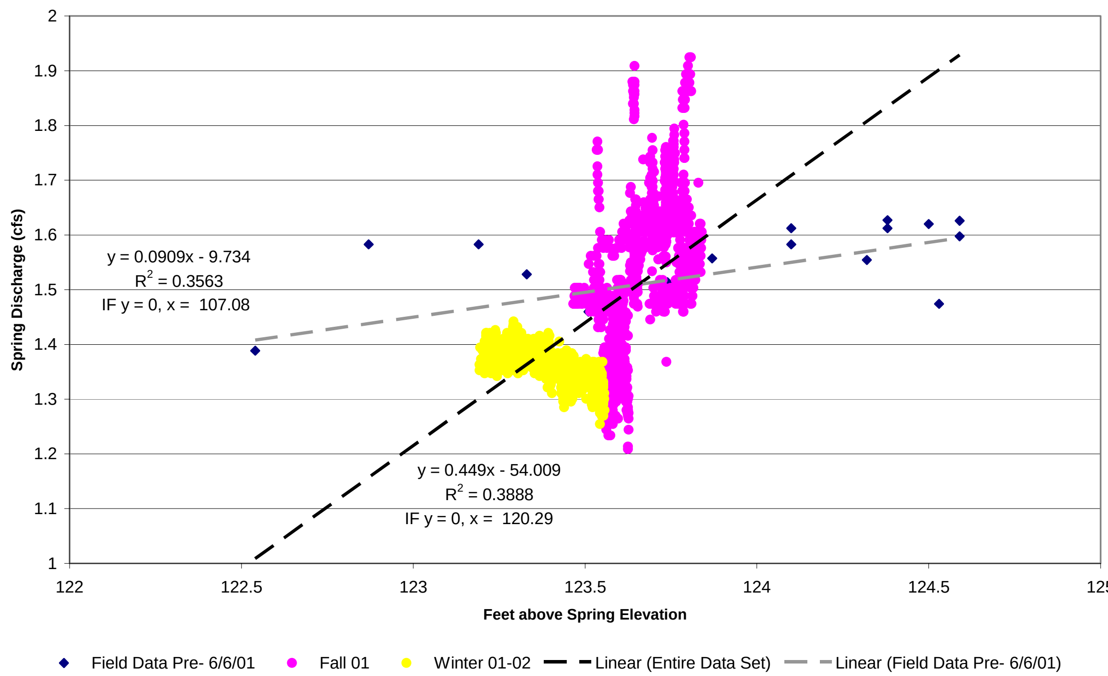

Figure 29. Regression of NFH10 spring discharge and water level in Well 08S14E16CBB1.

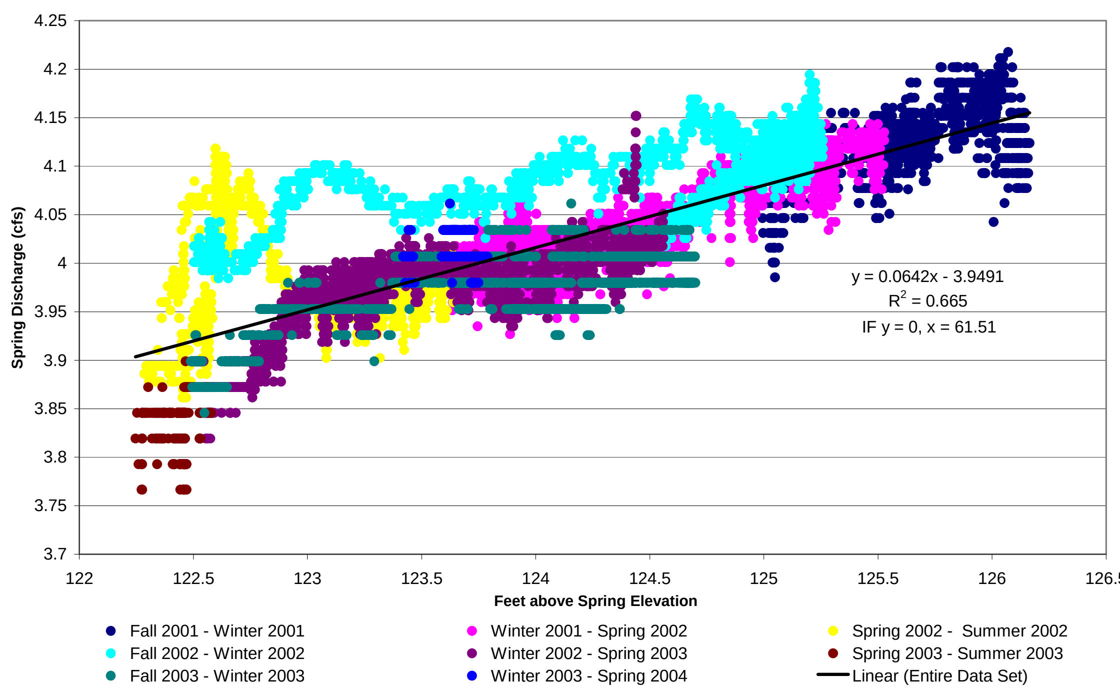

Figure 30. Regression of NFH15 spring discharge and water level in Well 07S14E32AAA.

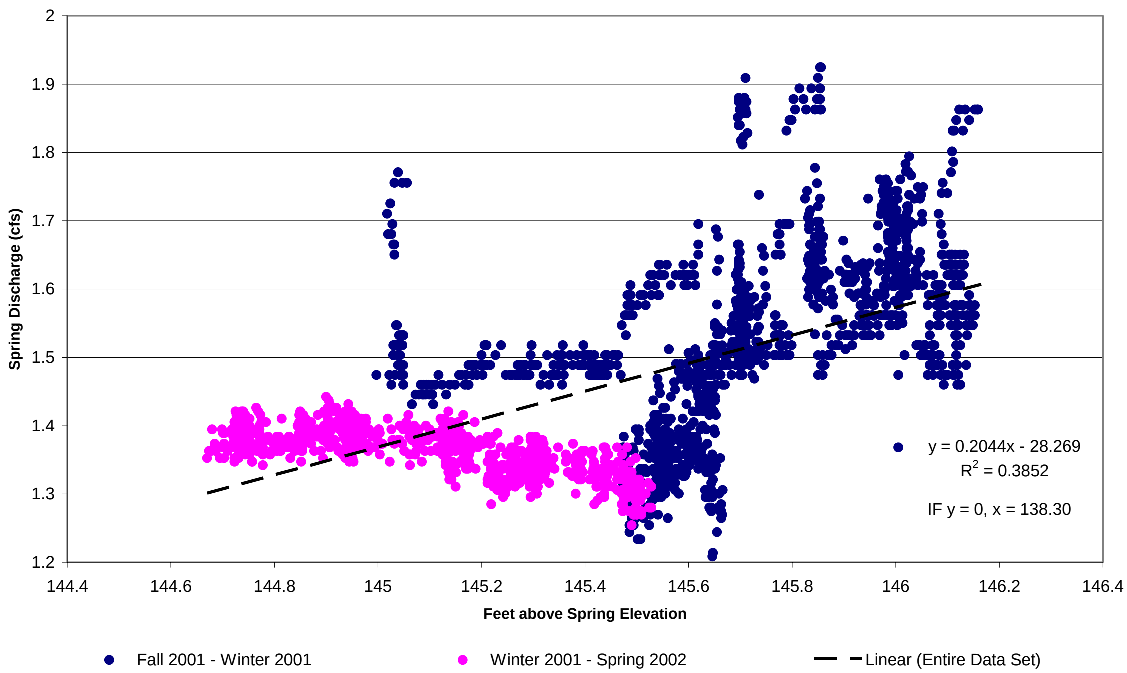

Figure 31. Regression of NFH10 spring discharge and water level in Well 07S14E32AAA.

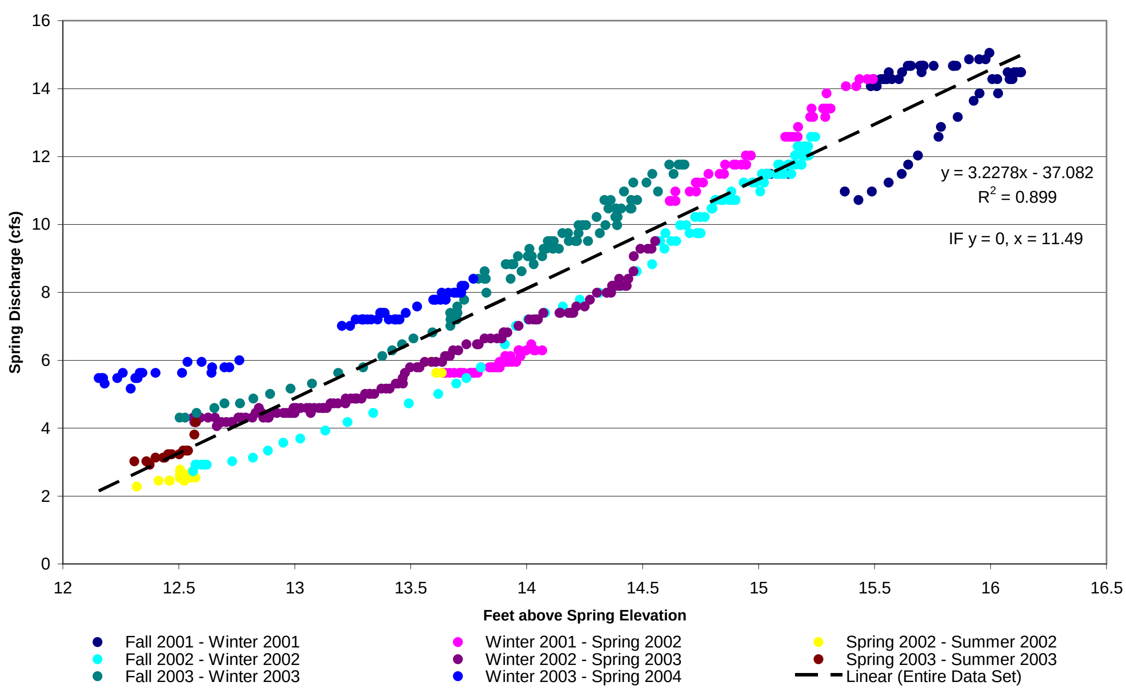

Figure 32. Regression of Curren Tunnel discharge and water level in Well 07S14E32AAA.

Devils Washbowl vs. 09S18E34DAC

Devils Washbowl Spring and 09S18E34DAC are approximately ¾ mile apart. There is a large degree of scatter in the relationship between spring discharge and well water level (plotted in feet above the spring elevation). However, this may be partially due to the USGS reporting measurements of discharge to the nearest cfs when spring discharge is only 10 to 20 cfs. To minimize the impacts of these errors, the average monthly discharges and water levels were plotted in Figure 19. The linear regression line for these average monthly discharges and head above the estimated spring elevation has a R^2 value of 0.20. The extrapolated regression line implies that the spring elevation is 98.42 feet higher than the observed value, however there is little confidence in the regression.

Blue Lakes Spring vs. 09S18E34DAC

Blue Lakes Spring and 09S18E34DAC are approximately 7 miles apart. The relationship of daily spring discharge and aquifer water level (head above the estimated spring elevation) is nearly linear over the range of observations (Figure 20). The linear regression line for these discharges and head have a R^2 value of 0.81, and the extrapolated regression line implies that the spring elevation is 422 feet higher than the observed value. This large elevation difference is due to the much higher land surface elevation at this upgradient well and potential effects of multiple recharge and discharge sources between the well and spring. There appears to be some variation of the relationship between spring discharge and well water level over time.

Blue Lakes Spring vs. 09S16E07DDD

Blue Lakes Spring is approximately 8 miles up-river from Well 09S16E07DDD. The graph of discharge vs. water level (Figure 21) shows a high degree of variability with season and a poor fit to linear regresseion (R^2=0.03). The seasonal variability of the relationship is probably due to two factors: 1) the effect of other recharge and discharge activities within the 8 miles separating the observation points, and 2) the unusual timing of maximums and minimums in Well 09S16E07DDD. The water level maximums and minimums in this well appear to precede those apparent in other wells and in spring discharges. Water level in this well may be influenced by more local recharge and discharge events.

Crystal Springs vs. 09S16E07DDD

Crystal Spring and 09S16E07DDD are approximately 1 ½ miles apart. Spring discharge plotted against well water level does not exhibit linear relationship, but displays a circular pattern showing seasonal effects (Figure 22). This is similar to the behavior described for Blue Lakes Spring when compared to this same well. The anomalous behavior of well water levels appear to be responsible for this pattern.

Crystal Springs vs. 09S14E03AAB

An approximately linear relationship appears to exist between Crystal Springs discharge and water level in Well 09S14E03AAB. The well is about 9 ¼ miles downstream of the spring (Figure 23). The linear regression line for the discharge and head has an R^2 value of 0.88. The extrapolated regression line implies that the spring elevation is approximately 51 feet higher than the estimated value, however the regression is probably impacted by the large distance and recharge and discharge activities between the spring and well.

Blind Canyon vs. 09S14E03AAB

Blind Canyon Spring and Well 09S14E03AAB are approximately 0.6 miles apart. Spring discharge displays a linear relationship to well water level with a rather large degree of scatter (Figure 24). Point scatter may be partially due to effects of upstream hatchery operations on discharge measurements. The linear regression of the data has a R^2 value of 0.67. The extrapolated regression line implies that the spring elevation is 52.25 feet higher than field observations. Somewhat different seasonal relationships are also evident in the plot.

Box Canyon vs. 09S14E03AAB

Box Canyon Spring and 09S14E03AAB are approximately 1 mile apart and exhibit an excellent linear relationship between spring discharge and water level above estimated spring elevation (Figure 25). The linear regression of the data has a R^2 value of 0.98, and the extrapolated regression line implies that the spring elevation is 38 feet higher than the field observation.

Box Canyon vs. 08S14E16CBB1

Box Canyon Spring and 08S14E16CBB1 are approximately 2 ½ miles apart and exhibit an strong linear relationship between spring discharge and water level above the estimated spring elevation (Figure 26). It appears there may be a slight upward curvature to the data. The linear regression of the entire data set has a R^2 value of 0.94, while the extrapolated regression line implies that the spring elevation is 51.81 feet higher than the estimated value.

Blind Canyon vs. 08S14E16CBB1

Blind Canyon Spring and Well 08S14E16CBB1 are approximately 2 ½ miles apart and do not exhibit a strong linear relationship (R^2=.29) between spring discharge and water level above the estimated spring elevation (Figure 27). However, linear relationships during smaller, four month periods of time, seem to exist. The extrapolated regression line implies that the spring elevation is 62.18 feet higher than the estimated value.

NFH15 vs. 08S14E16CBB1

National Fish Hatchery Spring #15 and Well 08S14E16CBB1 are approximately 2 miles apart and exhibit an approximate linear relationship between spring discharge and water level above the estimated spring elevation (Figure 28). The linear regression of the entire data set has a R^2 value of 0.78, while the extrapolated regression line implies that the spring elevation is 73.73 feet higher than the estimated value.

NFH#10 vs. 08S14E16CBB1

National Fish Hatchery Spring #10 and Well 08S14E16CBB1 are approximately 1 ¾ miles apart but do not display any apparent relationship between spring discharge and water level in the well above the estimated spring elevation (Figure 29). The lack of relationship may be due to discharge measurement error.

NFH#15 vs. 07S14E32AAA

National Fish Hatchery Spring #15 and Well 07S14E32AAA are approximately 2 miles apart and exhibit an approximate linear relationship between spring discharge and well water level above the estimated spring elevation (Figure 30). The linear regression has a R^2 value of 0.67. The extrapolated regression line implies that the spring elevation is 61.51 feet higher than the estimated value.

NFH10 vs. 07S14E32AAA

National Fish Hatchery Spring #10 and Well 07S14E32AAA are approximately 2 miles apart and do not exhibit a strong linear relationship between spring discharge and well water level above the estimated spring elevation (Figure 31). The slight circular pattern to the data suggest a difference in timing of the peak and minimum values. The extrapolated regression line implies that the spring elevation is 138.30 feet higher than the field observation.

Curren Tunnel vs. 07S14E32AAA

Curren Tunnel Spring and Well 07S14E32AAA are approximately 1 mile apart and exhibit an strong linear relationship between spring discharge and the well water level above the estimated spring elevation (Figure 32). The linear regression of the data has a R^2 value of 0.90, and the extrapolated regression line then implies that the spring elevation is 11.49 feet higher than the estimated value.

Summary/Conclusion

The hydrographs of most of the wells and springs are very similar. Most have minimum values in early to mid-summer and maximum values in October or November. The most notable exception is Well 9S16E07DDD which has a minimum in April and maximum in September. Well water levels appear to vary between 2.5 and 5 feet per year.

Spring discharge is approximately linearly related to well water level for most spring-well pairs over the limited range in which data were available. Greater linearity appears within single seasons than in the longer term. This may be the result of multiple signals imposed on the well and the spring data.

Spring elevations inferred from regression lines of the well-spring pair relationships are consistently higher than field observed values. This is consistent with the current Eastern Snake River Plain Aquifer Model calibration findings and the findings of Janczak (2001). The reason for the difference is unknown, however, there are several possible explanations including:

a) the aquifer is unconfined and non-linearity exists in the relationship when evaluated over a larger data range,

b) the discharge measurement is not capturing all the flow at the discharge sites, and

c) fracture flow is creating aberrations that we are unable to understand.

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