Source Water Availability
Town of Star Valley Ranch, Wyoming.

Robert C. Palmquist, PhD, LG (WA), LHG (WA), PG (WY)
September 13, 2006

INTRODUCTION

The Star Valley Ranch Association (Association) and the Town of Star Valley Ranch (Town) in cooperation with the Wyoming Water Development Commission (Commission) are in the first phase of a three phase study to assess the water needs of the Association and Town. The Interim Report on Water Supply and Demand Summary was released in July 2006 by Forsgren Associates, consultants to the Commission. This comment expand upon the water supply information and discussion contained in the interim report.

The interim report provides historical data on measurements of stream flow (discharge) on the two spring that provide irrigation water (Green Canyon Spring) and culinary water (Prater Canyon Spring) to the Town and Association. The duration of the record is short, extending from January 1987 to December 1991 for Green Canyon Spring and from October 1986 to December 1990 for Prater Canyon Spring with data gaps of one to two years within this short record. Additional sporadic monthly and daily measures are available for 2003 and 2006. The data to interpret the ground water resource available to the Association and Town are even more incomplete being limited to three water level measurements and two inadequate pumping tests.

The thrust of this comment is the proper and complete interpretation of these short records. The comment will therefore address the following questions:

1. Does the period of record represent normal conditions of annual precipitation or was the period of record unusually wet or dry?
2. Are the measured spring discharges indicative of those the Association and Town can anticipate under normal precipitation?
3. Are the spring discharges capable of meeting the peak demands of Star Valley Ranch?
4. Are the ground water levels measured in the two wells typical of normal precipitation conditions?

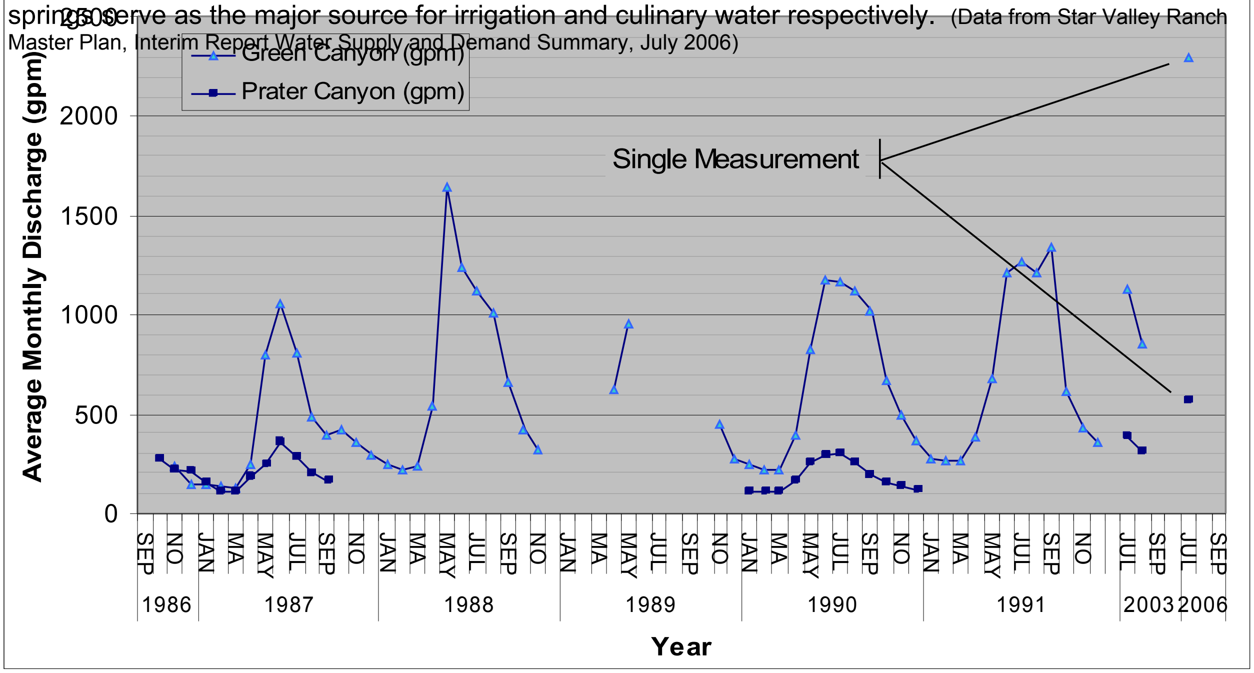
Many of the questions are intertwined about the first question. Without this answer the available data can not be properly interpreted and estimates of the water supply available to the Town and Association can not be assessed as to their values for planning for planning for the future needs of the Town and Association.

SPRING DISCHARGE RECORD

Figure 1 summarized the spring discharge data presented in tables 2 and 3 of the Interim Report. The graph shows the variation in the monthly average discharge for each spring. The discharge curve has several peaks separated by troughs that show the high discharge from the springs during and following snowmelt (May through August) followed by low discharges in January through March when snow is accumulating in Green and Prater Canyons and adjacent peaks.

The two obvious feature of the graph are the differences in the length of the flow records and the large difference in the amount of discharge between Prater Canyon Spring and Green Canyon Spring. The Prater Canyon record consists of two individual years of measurements separated

Figure 1. Average monthly discharges of Green Canyon and Prater Canyon Springs. These springs serve as the major source for irrigation and culinary water respectively. (Data from Star Valley Ranch Master Plan, Interim Report Water Supply and Demand Summary, July 2006)



by a two year gap. In contrast, The Green Canyon record includes four year of measurements with a partial one year gap. The spring in Green Canyon discharges approximately four times more water than the spring in Prater Canyon. Moreover Green Canyon Spring appears to be more irregular in the quantity of water discharged as shown by differences in the height of its peak discharges from year to year. The graph clearly shows that during some years more water is available than during other years.

STAR VALLEY PRECIPITATION RECORD

Volunteers for the University of Wyoming take daily weather observations at Bedford and Afton. The accuracy and completeness of these observations varies with the volunteers. The longest records are from Bedford where a continuous record of observations exists from 1901 through 1967 (Bedford SE 2), and from 1975 through 2006 (Bedford SE 3). The gap in the Bedford record was filled in by using data from Afton. The resulting composite precipitation record is 106 years long. **Figures 2 and 3** show the composite precipitation record for Bedford and Afton.

Figure 2 summarizes the annual precipitation record for the central Star Valley around Bedford. The record is characterized by peaks and troughs that tend to clump together as nearly decade-long sequences of wetter and drier years. Interpretation of this record is facilitated by establishing three datum for comparison – the median (50% value), the first quartile (25% value), and the third quartile (75% value). The median total annual precipitation for the record is 19.9 inches, which means that 50 percent of the years were wetter than 19.9 inches and 50 percent of the years were drier than 19.9 inches. The first quartile is 16.7 inches, which means that 25 percent of the years were drier than 16.7 inches. The third quartile is 22.7 inches per year, which means than 75 percent of the years were drier than 22.7 inches. The moving average shows the average annual precipitation for four consecutive years. It tends to smooth out the irregularities in the precipitation curve and emphasizes the tendency for wet and dry years to clump together. Most years since 1985 have been wetter than normal, that is, their annual precipitation exceeds that of 75 percent of the other years in the Bedford record. Also note that the drier years occurred in the early 1900s and the 1970s and these droughts were many years long.

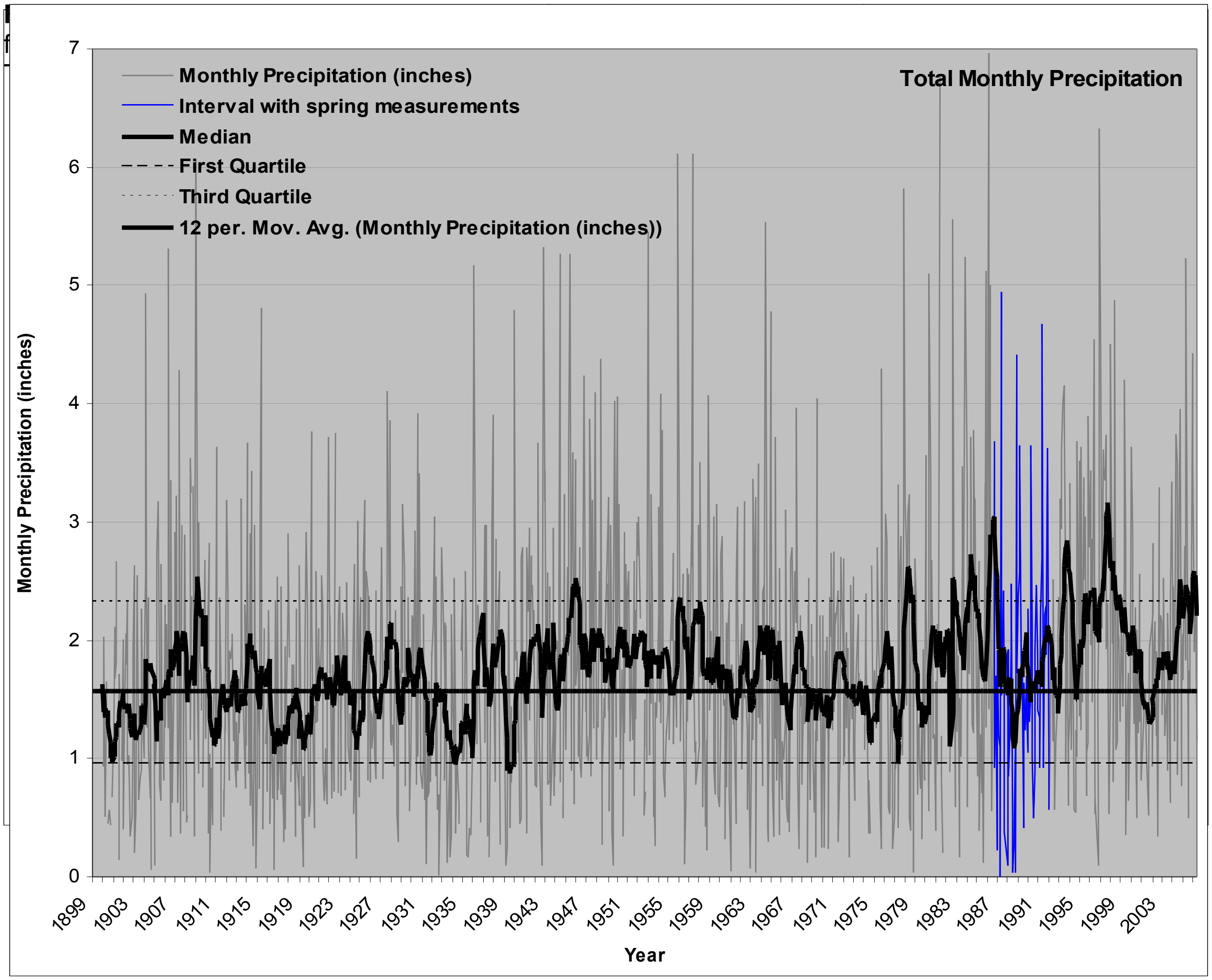
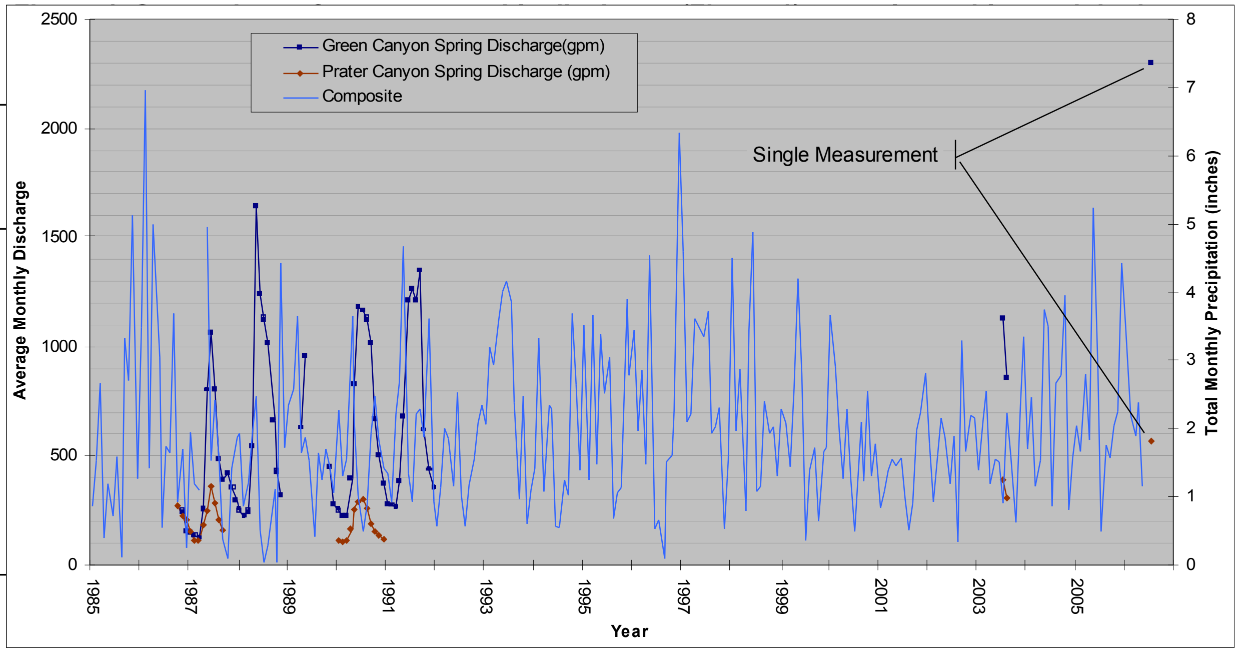


Figure 3. Total monthly precipitation in Central Star Valley, 1900 – 2006. The 12 month moving average indicates series of wetter and drier months. (data source same as Figure 1)

Also shown on **Figure 2** is the interval from 1986 through 1991 during which the spring discharges were measured. Note that this interval is during the recent wetter than normal precipitation grouping but includes a short excursion of slightly drier years. This observation answers the first important question -- Does the period of record represent normal conditions of precipitation and hence spring discharge or was the period of record unusually wet or dry? The answer is – the spring discharge measurements represent wetter than normal conditions. The significance of the drier years is discussed later.

Figure 3 shows the same data expressed as total monthly precipitation. The peaks and troughs are now much higher and lower and come with great frequency since the time frame is shorter. What the graph demonstrates is that some wet months are much wetter than other wet months and some dry months are drier than other dry months. The 12-month moving average again shows that wetter and drier months tend to group together. The importance of **Figure 3** is that the monthly variations in spring discharge shown in **Figure 1** probably result from the monthly variations in precipitation shown in **Figure 3**.



The monthly precipitation record for the interval during which spring discharges were measured (1986 through 1991) is incomplete and the total annual precipitation for these years is probably a minimal estimate (**Table 1**). The most complete year, 1990, has only 11 complete monthly records and the least complete year, 1987, has six complete months. The winter months, when snow measurements are difficult to make, are usually the incomplete months. These months have the greatest precipitation and several days without measurements could significantly lower the monthly total. The annual precipitation for the spring discharge observations therefore should be considered minimal estimates; that is, the years were all wetter than indicated on the graphs (**Figures 2 and 3**) and in **Table 1**. An important observation about **Table 1** is the relationship of the annual precipitation amounts to the datum discussed earlier. Four of the five years in **Table 1** are near to or exceed the third quartile value (22.7 inches) placing them in the wettest 25 percent of the years on record.

Comparison

Figure 4 compares the spring discharges in **Figure 1** with the monthly precipitation record in **Figure 3**. Note that peak discharges tend to either coincide with months of high precipitation or immediately follow such months. The winter precipitation is snow and it does not infiltrate into the aquifer until snowmelt occurs, which typically begins in April or May and peaks in June. Therefore spring discharge depends on the rain and snowfall during the previous year for the total quantity of water discharged and on the spring air temperature for the timing of the peak discharge. The general correspondence between peak winter precipitation, warmer springtime temperatures, and peak discharge from the springs is shown in **Figure 4**.

Table 2. Comparison of 12-month total precipitation to average summer (June – September) spring discharges. Precipitation record for each year extends from May (previous year) through June.

Year	Precipitation (inches)	Green Canyon (gpm)	Prater Canyon (gpm)
1987	21.6	686	253
1988	23.17	1,009	
1990	22.8	1,121	262
1991	25.34	1,257	

Table 2 addresses the issue of summer peak demand. The Interim Report indicates that the current (2006) summer peak demand is 1705 gpm

for both golf course (660 gpm) and residences (1045 gpm). **Table 2** shows the average summer (June through September) peak discharges from the springs and the total precipitation for the 12-months preceding them. The data in **Table 2** are interpreted to indicate that a 12-month precipitation of at least 22 inches is required to produce an average summer peak discharge in excess of 1,100 gpm for Green Canyon Spring and 250 gpm for the Prater Canyon Spring. Years that are drier or wetter than 21 inches will decrease or increase this estimated average peak discharge.
A more sophisticated statistical analysis was not attempted because of the short and incomplete data sets.

GROUND WATER DATA

The Association has two wells – the Airstrip Well and the Cedar No. 1 Well. The Airstrip Well was completed in 1993 and the measured water level (depth to water) was 187 feet. This well could produce in excess of 500 gpm with a larger pump. The Cedar No. 1 Well was completed in 1982 at which time the water level was 160 feet. In 1999 the water level had declined to 235 feet.

Ground water levels are a measure of the amount of water stored in the aquifer or aquifers being tapped by the wells. The closer the water level is to the ground surface, the more water that is in storage. Usually more water is in storage following wet years than during dry years because the aquifers continually drain into the Salt River and the amount of water in storage is the difference between inflow from precipitation and outflow to the Salt River. **Table 3** relates the observed groundwater levels to the total annual precipitation for the 12 months preceding the measurement.

Table 3. Relationship between observed ground water levels in Association wells and total precipitation for the previous 12 months. The date is the month and year that the ground water level was measured.

Year	Total 12-month Precipitation (inches)	Observed ground water level (well)
Jun-82	22.71	160 ft (Cedar No 1)
Mar-93	19.46	187 ft (Airstrip)
May-99	27.36	235 ft (Cedar No. 1)

The relationship of ground water level to 12-month precipitation shown in Table 3 is unclear. The two measurements for the Cedar No. 1 Well were both taken following years with a 12-month precipitation exceeding the third quartile value of 22. 7 inches but the water levels differ significantly. Since this well does not have significant usage, aquifer depletion does not appear to be a reasonable explanation for the water level decline. Perhaps one of the measurements is inaccurate. The water level for the Airstrip Well was measured during a short excursion of drier months during an otherwise wet sequence of years and the influence of previous wetter years on the amount of ground water storage in the aquifer cannot be assessed without additional data.

SUMMARY

The analysis of annual precipitation and source water availability presented in these comments should be considered preliminary but indicative of what can be determined with adequate data. The assessment indicates that the available water supply data were collected during wetter than normal years. The Interim Report therefore presents an optimistic assessment of the supply available to the Town and Association and overestimates the water availability during the 75 percent of the years when precipitation amounts are less. Perhaps using the spring discharges and ground water levels associated with the median precipitation (19.9 inches) would produce a more reasonable estimate of the available water resource.

An important point to make about the ground water assessment. A pumping test on any particular well only indicates the quantity of ground water that the well is capable of producing. It does not indicate the quantity of water that the aquifer is capable of producing on the long-term without being depleted. This "safe yield" is the quantity required to properly assess the source water availability to the Association and Town.

To summarize these comments, the answers to the initial four questions follow.

1. *Does the period of record represent normal conditions of annual precipitation or was the period of record unusually wet or dry?* **ANS.** Unusually wet
2. *Are the measured spring discharges indicative of those the Association and Town can anticipate under normal precipitation?* **ANS.** No. The measured discharges can be expected only during those years with precipitation exceeding 22.7 inches.
3. *Are the spring discharges capable of meeting the peak demands of Star Valley Ranch?* **ANS.** No. The measured discharges even during wetter than normal years, produce only 1,300 gpm during the summer peak which is less than the 1705 gpm currently required.
4. *Are the ground water levels measured in the two wells typical of normal precipitation conditions?* **ANS**. No. The water levels represent conditions during wetter than normal precipitation conditions.

RECOMMENDATIONS

The following recommendations are made with the goal of producing a set of data that be used to more accurately assess the water supply available to Star Valley Ranch.

1. Establish a meteorological station on the Ranch and begin collecting hourly meteorological data as soon as possible. Precipitation is the ultimate source of the Ranch's water supply and an accurate estimate is required. Automatic meteorological stations are available that would transmit data to a designated computer in Association/Town offices.
2. Establish gaging stations at both springs as soon as possible. A gaging station measures the discharge for the spring. The measurements can be automatic on an hourly basis and either can be transmitted to a computer or stored in a small computer at the site and collected monthly. These discharge data would provide both a better estimate of source water availability and data to be used to determine aquifer properties.
3. Establish a ground water monitoring program as soon as possible. The program should immediately begin by measuring water levels on a weekly basis in the two existing wells to assess the natural seasonal variations in ground water levels. Once the wells are being more pumped more frequently, their usefulness as monitoring wells decreases. At that time the development of new monitoring wells should be considered. The combination of pumping production wells and nearby monitoring wells would allow the determination of aquifer properties.
4. Using available well logs, field mapping of rock exposures, and perhaps supplementary geophysical data, determine the size and shape of the aquifer providing water to the springs and underlying the Ranch. This information would further allow the accurate determination of source water availability and is not as immediate a need as the monitoring programs described in recommendation 1 – 3.