APPENDIX 7-55

INVESTIGATION OF ALLUVIAL GROUND WATER SYSTEM

IN MILL FORK CANYON

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Investigation of the Alluvial Groundwater System In Mill Fork Canyon with Implications for Recharge to Little Bear Spring

GENWAL Resources, Inc., Huntington, Utah

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Introduction

Little Bear Spring is located in the central Wasatch Plateau region, approximately 12 miles northwest of Huntington, Utah (Figure 1). The spring discharges from a northeast-southwest trending fracture system in the Star Point Sandstone. Discharge from the spring varies from about 200 gpm during periods of prolonged drought, to nearly 500 gpm during wetter climatic periods.

Recent hydrogeologic investigations of Little Bear Spring (Mayo and Associates 2001, 1999; WTR, 1999) have concluded that the spring is recharged from surface water and/or alluvial groundwater losses in Mill Fork Canyon, located about 1.5 miles southwest of the spring (Figure 2). Specifically, it has been found that recharge to the spring occurs where the Star Point Sandstone fracture system intersects the base of the alluvial deposits in Mill Fork Canyon.

The purpose of this investigation is 1) to verify that alluvial groundwater in Mill Fork Canyon is lost to the Star Point Sandstone fracture system that supports Little Bear Spring, and 2) to verify that alluvial groundwater loss in Mill Fork Canyon is of sufficient magnitude to sustain the baseflow discharge to Little Bear Spring.

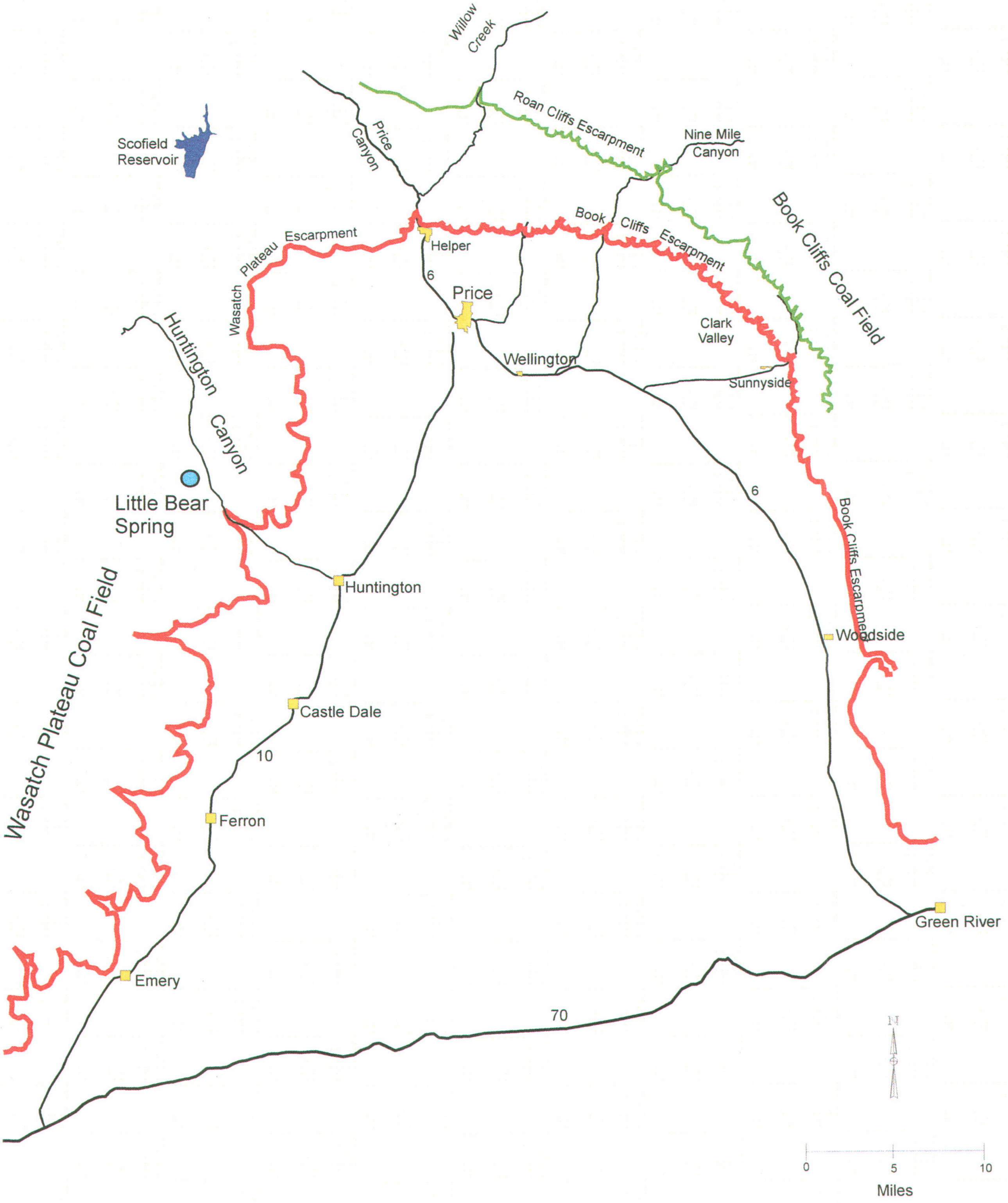

Figure 1 Location map of the Little Bear Spring area.

Mayo & Associates
Fig1 - Regional Map.cdr 13 Jul 99

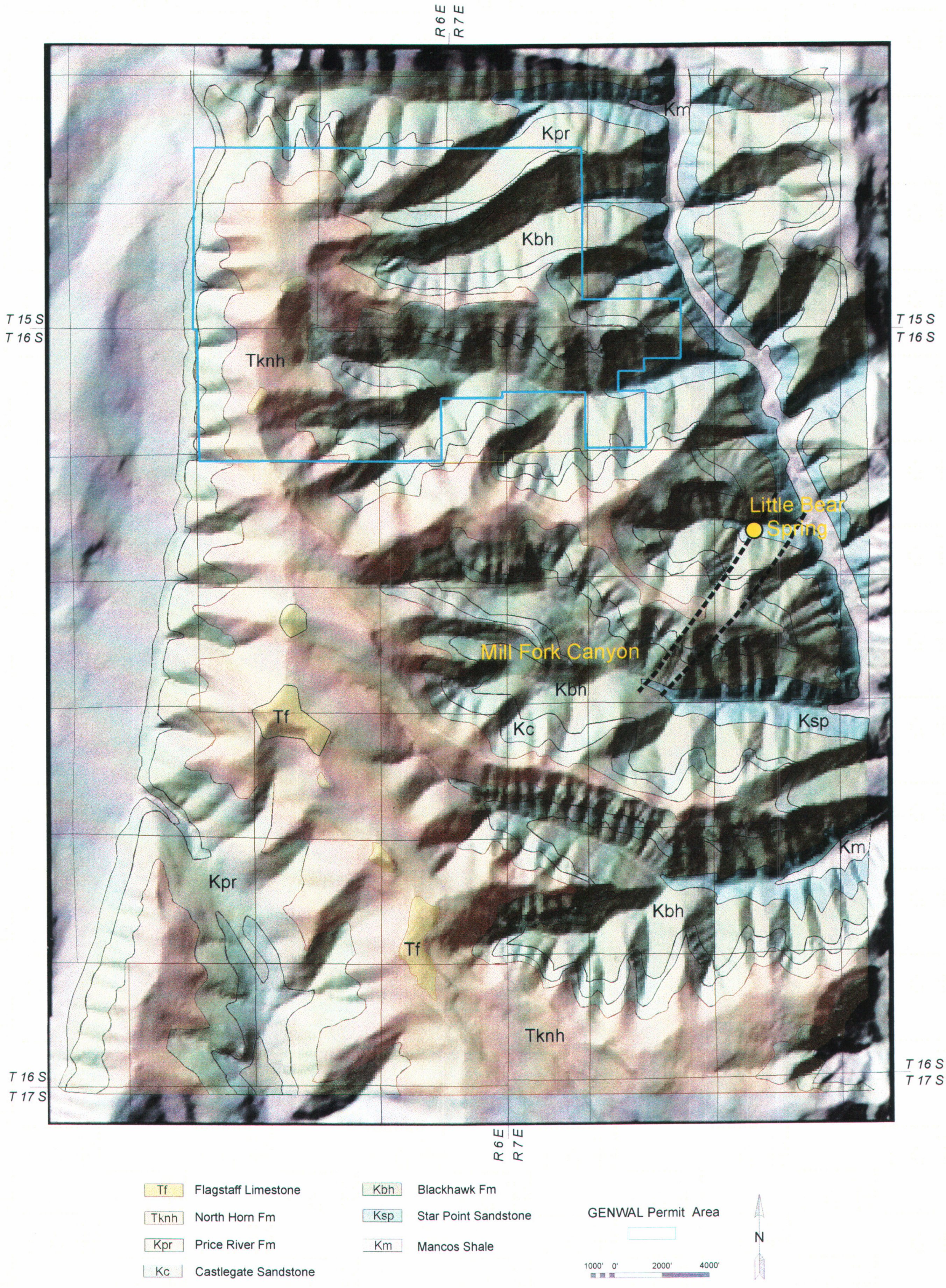

Figure 2 Relief map of the Little Bear Spring area.

Methodology

To verify that the alluvial deposits in Mill Fork Canyon recharge the fracture system from which Little Bear Spring discharges, it is necessary to determine the quantity of groundwater flowing through the Mill Fork alluvial deposits both above and below the fracture system. It is possible to determine the quantity of water flowing through a groundwater system using Darcy's Law, Q=KIA, where Q is the discharge rate, K is the hydraulic conductivity of the alluvial sediments, I is the hydraulic gradient, and A is the cross-sectional area of saturated alluvium. The determination of each of these parameters is discussed below.

Cross-sectional area of saturated alluvium

Sunrise Engineering of Draper, Utah performed a geophysical investigation of the alluvial sediments in Mill Fork Canyon during November 2000. This investigation included two electrical resistivity profiles. The upper profile was located just below the confluence of the upper right and left forks above the fracture zone from which Little Bear Spring discharges (Figure 3). The lower profile was located immediately below the fracture zone at the end of the Forest Service access road (Figure 3). Geophysical interpretations of the resistivity data were provided by Sunrise Engineering. The resistivity cross-sections shown in Figure 3 indicate the geometry of the bedrock/alluvium interface, the thickness of the alluvial deposits, and the cross-sectional area of saturated alluvium (Figure 3). Alluvial thickness measured at the upper profile ranged from 0 to 50 feet, while thicknesses ranged from 0 to 30 feet at the lower profile. The water table at both the upper and lower profiles is near the ground surface. The saturated alluvial thickness at the upper

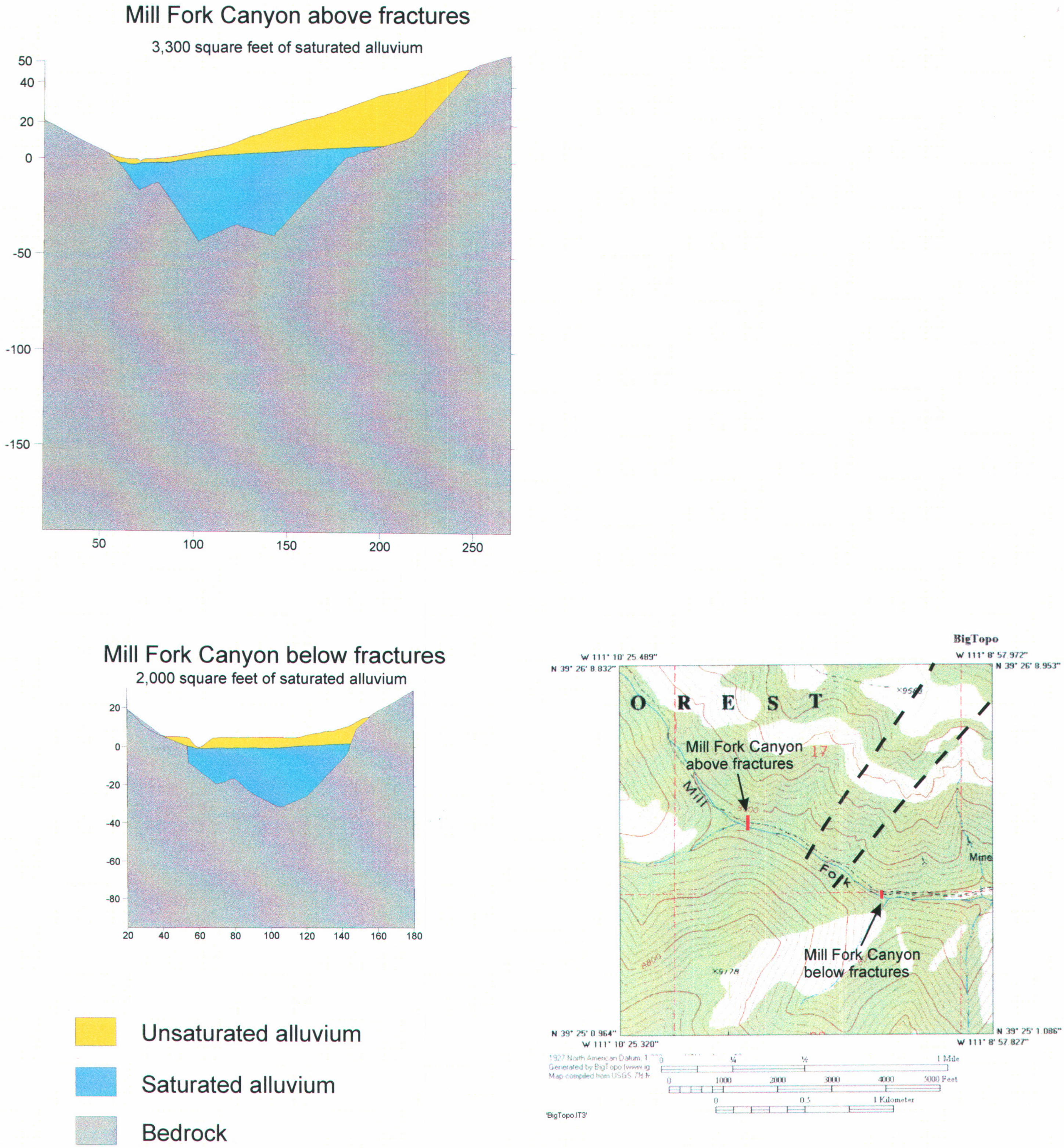

Figure 3 Cross-sections through alluvial sediments above (a) and below (b) the Star Point Sandstone fractures in Mill Fork Canyon. (Geophysical data and interpretation from Sunrise Engineering, 2001).

profile (3,300 square feet) is two-thirds greater than that at the lower profile (2,000 square feet)

Hydraulic Gradients

On 24 January 2001, topographic gradients in the vicinity of the lower resistivity profile were surveyed. Topographic gradients in the vicinity of the upper profile were surveyed on 17 February 2001. The surveys were performed using a hand transit. In this investigation the hydraulic gradient was assumed to be the same as local topographic gradient. This assumption, while not accurate in some geologic settings, is believed to be valid in this steep, mountainous terrain because topography constrains the geometry of the base of the alluvial deposits. Because the water table is essentially at the land surface at both profiles, it follows that the hydraulic gradient will be a reflection of the land surface. The gradient measured in the vicinity of the upper profile (0.132) is appreciably steeper than that at the lower profile (0.043).

Hydraulic conductivity of alluvial sediments

Because site-specific hydraulic conductivity data are not available for the alluvial sediments in upper Mill Fork Canyon it was necessary to estimate the hydraulic conductivity. During field activities in the upper Mill Fork Canyon area it was observed that the near-surface sediments in the stream channel consist primarily of clean sand with some gravel and boulders. There is an overall lack of fine-grained material observed in the stream channel. The makeup of the deeper alluvial sediments has not been investigated. Typical values of hydraulic conductivity for alluvial materials are given in Figure 4. The estimate used in this investigation for both the upper and lower profiles is 1.9×10^{-3} ft/sec, which is in the upper range of silty sand or the middle range of clean sand. The basis for this estimate is described below.

Flow Calculations

As discussed above, values for the saturated cross-sectional area of the alluvial sediments and the hydraulic gradient at both the upper and lower profiles were measured in the field. In order to calculate the flow rates across the upper and lower profiles, it is necessary to estimate the value for the third parameter in Darcy's Law, hydraulic conductivity.

One of the two purposes of this investigation is to verify that the losses from the alluvial groundwater system are on the order of 300 gpm (the baseflow discharge rate of Little Bear Spring). This is accomplished by using Darcy's Law to calculate the flow across the upper and lower profiles. The difference between the discharge in the upper and lower profiles represents the loss from the alluvial groundwater system between the two profiles. If it is assumed that the loss of alluvial water to the fracture system is 300 gpm, it is possible to reverse calculate the value of hydraulic conductivity that corresponds to this flow loss. Using this method, a value for hydraulic conductivity of 1.9×10^{-3} ft/sec is calculated. These calculations are presented in Table 1. As discussed previously, this value, which is consistent with the types of materials observed in Mill Fork Canyon, is reasonable.

Table 2.2 Range of Values of Hydraulic Conductivity and Permeability

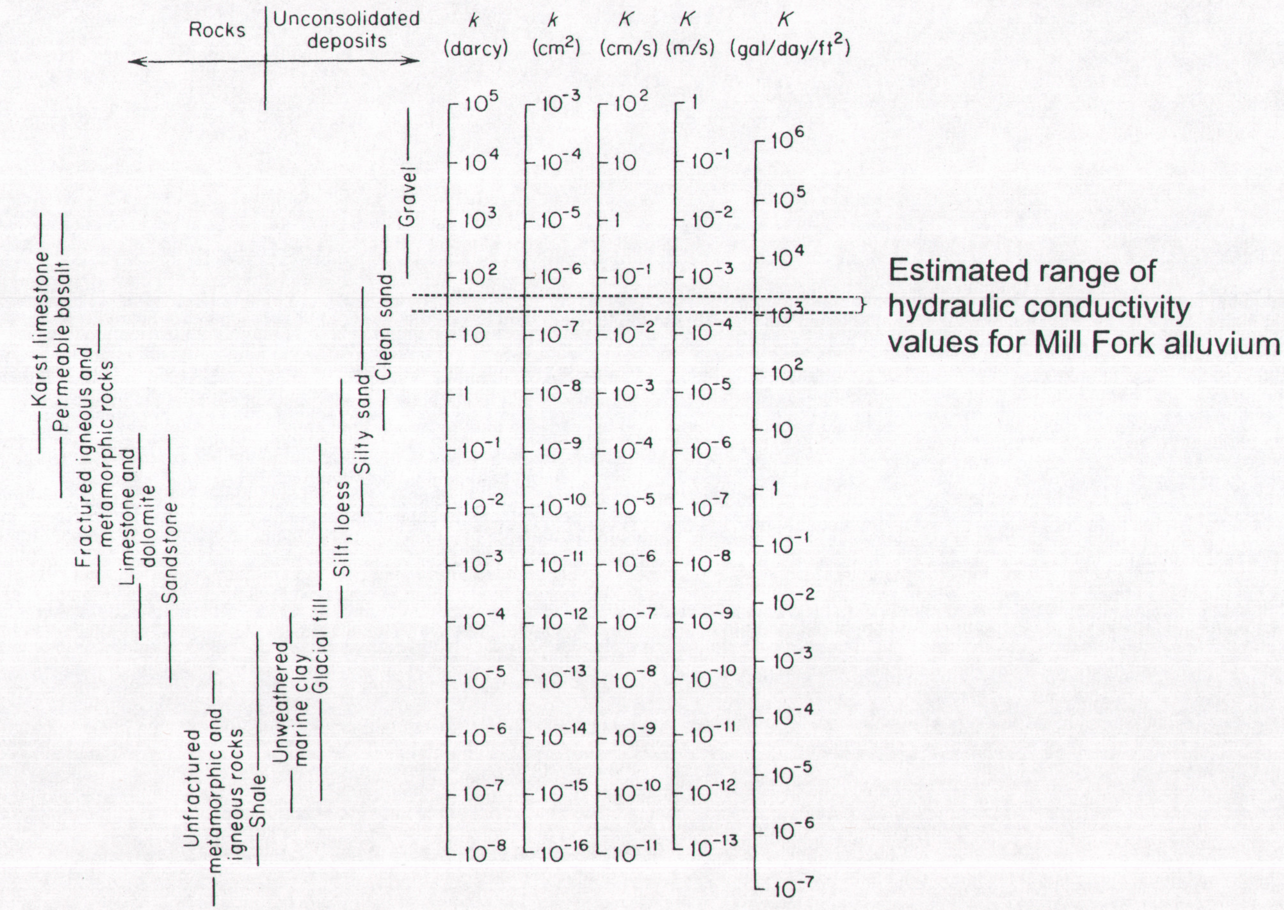

Figure 4 Estimated range of hydraulic conductivity for alluvial sediments in Mill Fork Canyon (Table of K values from Freeze and Cherry, 1979).

Table 1 Listing of parameters used in calculating alluvial groundwater loss in the vicinity of the fracture system from which Little Bear Spring discharges.

Upper cross-section		
K (ft/sec)	0.0019	(approximated)
I	0.132	(surveyed)
A (ft^2)	3300	(calculated from resistivity profile)
Q (cfs)	0.828	(calculated)
Lower cross-section		
K (ft/sec)	0.0019	(approximated)
I	0.043	(surveyed)
A (ft^2)	2000	(calculated from resistivity profile)
Q (cfs)	0.163	(calculated)
Flow difference (cfs)	**0.665**	
Flow difference (gpm)	**298**	

Consideration of three factors suggests that the value of hydraulic conductivity calculated above may be somewhat higher than the actual value. First, any groundwater entering the alluvial groundwater system from the canyon walls in the ½ mile reach between the upper and lower profiles (as suggested by the slope of the water table in both the upper and lower profiles; Figure 3) was not accounted for in the calculations. If this inflow were accounted for, a lower estimate of hydraulic conductivity of the Mill Fork alluvial sediments would result. Second, the alluvial sediments in the lower profile, where the stream gradients are more shallow than in the upper profile, are likely coarser than those in the less steep areas near the lower profile. Consequently, the hydraulic conductivity is likely greater near the upper profile than the lower profile. If the hydraulic conductivity estimate at the upper profile is increased, while the hydraulic conductivity at the lower profile is decreased, a significantly increased flow differential between the upper and lower profiles is calculated. Third, the flow calculations are based on a baseflow discharge rate from Little Bear Spring of 300 gpm. This assumption does not consider any contribution that may occur from delayed release of storage in the rocks between Mill Fork Canyon and the discharge location 1.5 miles distant in Little Bear Canyon (i.e. a gradual draining through the year of water that recharged during the high-flow period). Thus, it is possible that the actual recharge to the fracture system that occurs during the winter months may be significantly less than 300 gpm. The resistivity study was carried out during the driest period of the year when recharge contributions from Mill Fork Canyon are probably at their lowest.

Conclusions

The results of this investigation provide strong support for the idea that alluvial groundwater losses in upper Mill Fork Canyon provide recharge to Little Bear Spring through Star Point Sandstone fracture systems. The results of this investigation clearly indicate that there is more groundwater flowing through the alluvial sediments above the fracture system than below the fracture system. The large loss of water between the upper and lower resistivity profiles strongly support the idea of recharge to the Star Point Sandstone fracture system from the alluvial groundwater system in Mill Fork Canyon.

Although uncertainty regarding the hydraulic conductivity of the alluvial sediments precludes the precise determination of the magnitude of the recharge to Little Bear that occurs in Mill Fork Canyon, a recharge rate on the order of 300 gpm during low-flow conditions is reasonable.

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