# APPENDIX 7-57

# DETERMINATION OF RECHARGE LOCATION

# OF LITTLE BEAR SPRING (DYE TRACING)

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GENWAL Resources, Inc., Price, Utah

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**GENWAL Resources, Inc., Price, Utah**

**20 November 2001**

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# Determination of the Recharge Location Of Little Bear Spring by Means of Fluorescent Dye Tracing

## 1. Introduction

Little Bear Spring is located in the central Wasatch Plateau region, approximately 12 miles northwest of Huntington, Utah (Figure 1). Mayo and Associates (1999) suggested that Little Bear Spring is recharged through surface water and/or alluvial groundwater losses in Mill Fork Canyon, located approximately 1.5 miles southwest of the spring (Figure 2). Two recent investigations have been performed by Mayo and Associates (2001a, 2001b) regarding the recharge location for Little Bear Spring. These reports are entitled *Investigation of the Potential for Little Bear Spring Recharge in Mill Fork Canyon, Emery County, Utah (Mayo and Associates, 2001a)* and *Investigation of the Alluvial Groundwater System In Mill Fork Canyon with Implications for Recharge to Little Bear Spring* (Mayo and Associates, 2001b). It was the finding of both of these investigations that Little Bear Spring recharges in Mill Fork Canyon. Water Technology and Research (1999) performed an investigation using a proprietary geophysical technique that was in agreement with the finding that recharge to Little Bear Spring occurs in Mill Fork Canyon. To verify that Mill Fork Canyon is the recharge area for Little Bear Spring, a fluorescent dye tracing investigation was commenced by Mayo and Associates in December 2000. This document is the report of that dye tracing investigation.

Figure 1 Location map of the Little Bear Spring area.

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

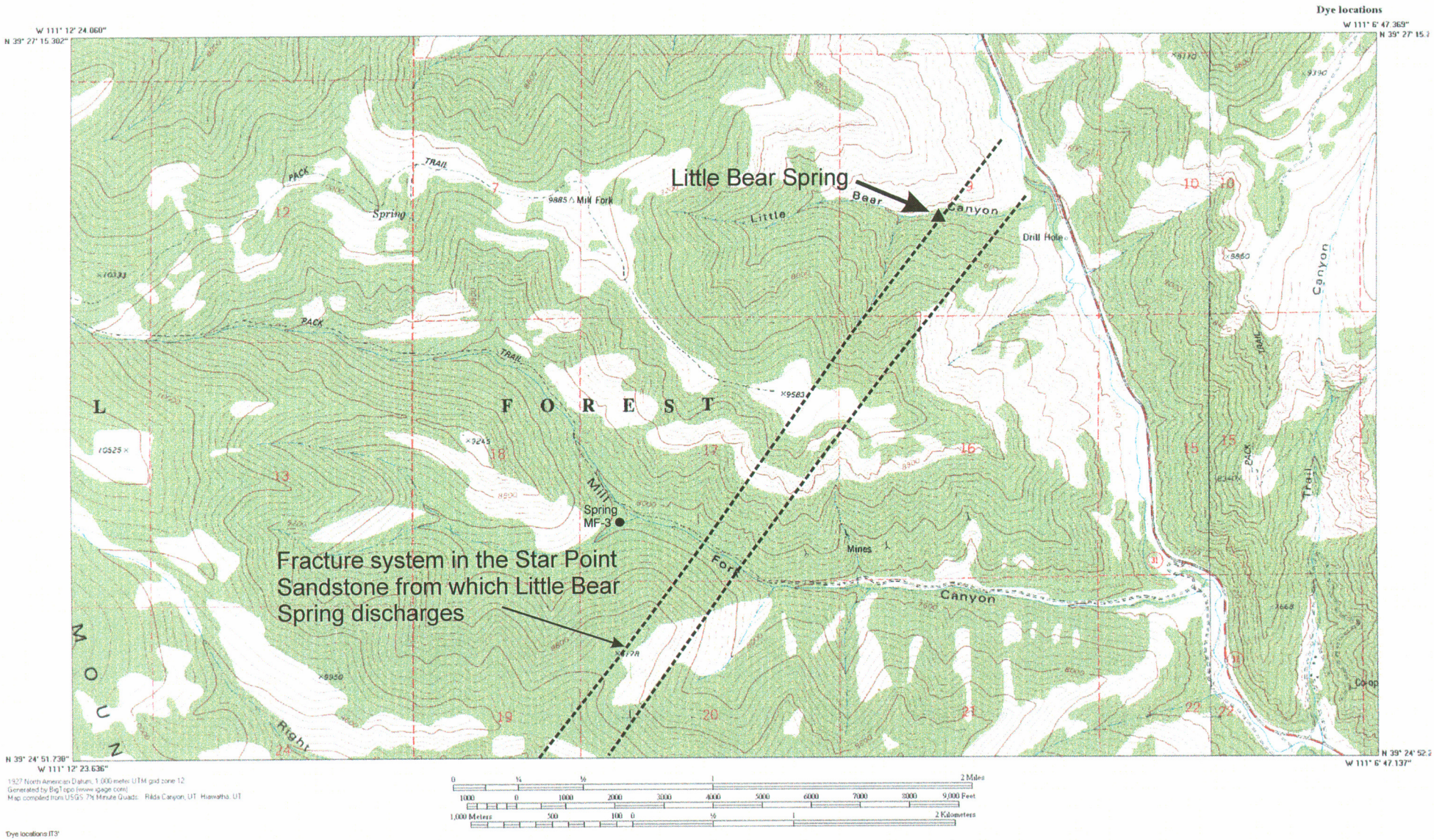


Figure 2 Location of Little Bear Spring and Mill Fork Canyon.

Including this introduction, this report contains the following sections:

1. Introduction
2. Methods of Study
3. Locations and Quantities of Dye Injections and Sampling Locations
4. Results
5. Conclusions
6. References Cited

## 2. Methods of study

*Fluorescent dye selection*

The fluorescent dye eosine was selected as the tracer for the Little Bear Spring study. Eosine dye was selected because 1) it has been determined to be safe for use in and around culinary water systems (Aley, 1999; Field and Others, 1995; Smart, 1984 ), 2) it is detectable in water samples at the laboratory at very low concentrations while it remains non-visible at concentrations higher than other commonly used fluorescent dyes, and 3) it is among the dyes most resistant to adsorption onto organic or clay particles which are thought to be present in the lower Mill Fork alluvial sediments. Eosine dye rapidly decomposes in the presence of sunlight (Aley, 1999).

*Dye detection*

Analysis for eosine dye was performed on activated carbon samplers by Ozark Underground Laboratory of Protem, Missouri. Activated carbon samplers continuously accumulate dye as long as they remain in the water, which allows for continuous, uninterrupted monitoring for fluorescent dye at the sampling locations. Very low laboratory detection limits are also

possible using activated carbon samplers. The determinations of the amounts of dye to be placed in Mill Fork Creek were based on the goal of achieving concentrations at the sampling locations that would be high enough to be detectable in the laboratory but sufficiently low so as not to be visible.

*Characterization of Background Fluorescence*

Prior to the placement of eosine dye into Mill Fork Creek, a survey of local hydrologic research institutions was conducted to determine whether any recent injections of fluorescent dye had occurred in the Huntington Canyon and surrounding area. After discussions with personnel from the Utah State University Water Research Laboratory, University of Utah, Brigham Young University, United States Geological Survey, United States Forest Service, State of Utah Divisions of Drinking Water and Water Quality, and local hydrologic consulting firms, there was no indication of recently placed dye in the area.

To check for either naturally occurring or human induced background fluorescence in the Mill Fork and Little Bear Spring areas, carbon samplers were placed in upper Mill Fork Creek, lower Mill Fork Creek, and Little Bear Spring approximately one week before the first placement of dye in Mill Fork Creek. Analysis of these samplers indicated no background fluorescence.

*Dye Injection Technique*

After receiving letters of consent from appropriate agencies (Utah Division of Water Quality, U.S. Forest Service, Castle Valley Special Service District) eosine dye was placed in Mill

Fork Creek. The dye was shipped from Ozark Underground Laboratory of Protem, Missouri in powdered form. The powdered dye was mixed with culinary water (or creek water) in 5-gallon plastic containers prior to being placed in the creek. The dye was transported and placed in the creek by an assistant. At no time did the person or vehicle of the person collecting the dye samples come into contact with the eosine dye.

*Sample collection procedures*

Carbon samplers were collected and placed in sealed plastic baggies and kept out of sunlight to prevent sample degradation. The person collecting the dye samples wore rubber gloves to minimize the potential for sample contamination. The individual samples were double bagged and shipped to the laboratory in new coolers on "blue ice" to maintain refrigeration. A 100 ml sample of water was also collected during each sampling event at each site for potential direct laboratory analysis. During each sampling event, new carbon samplers were placed in duplicate to accumulate dye until the next sampling. Duplicate samplers were placed in each sampling location to minimize the potential for data loss due to the loss of the carbon samplers. Samplers placed in creeks were located in inconspicuous, shady areas to minimize the potential for vandalism or dye degradation.

As is generally the practice in dye tracer studies, samples for analysis were collected more frequently in the early portion of the test, and less frequently in the latter portion.

## 3. Locations and Quantities of Dye Injections and Sampling Locations

*Phase 1, Dye placed December 2000*

Sampling locations for Phase 1 of the dye tracer study are shown on Figure 3. Quantities of dye placed and dye placement locations are also shown on Figure 3. For Phase 1, a total of 4 pounds of eosine dye was placed in three locations in the Mill Fork drainage. During December 2001, with the exception of the discharge from spring MF-3, the Mill Fork drainage above the fracture system was mostly dry and/or frozen for a distance of approximately 1¼ miles above the fracture system. The discharge from MF-3 at that time (approximately 12 gpm) persisted in the stream channel for only about 75 yards before it completely infiltrated into the subsurface. Approximately 1.3 pounds of eosine dye was placed in the MF-3 discharge at 10:00 a.m. on 8 December 2000.

As shown on Figure 3, eosine dye was placed in two additional locations the upper Mill Fork drainage on 8 December 2000 at about 11:30 a.m. Approximately 1.3 pounds of dye was placed at each location in the creek, which was flowing at about 40 gpm at the time.

The purpose of the dye tracer investigation was to determine whether Little Bear Spring is recharged in Mill Fork Canyon. Consequently, the primary dye monitoring location was Little Bear Spring. The entire discharge from Little Bear Spring is captured in a closed collection system and piped down Huntington Canyon. Carbon samplers were placed in a concrete control structure adjacent to the Highway 31 in Huntington Canyon (Figure 3). The control structure is part of the culinary water conveyance system and remained locked at all

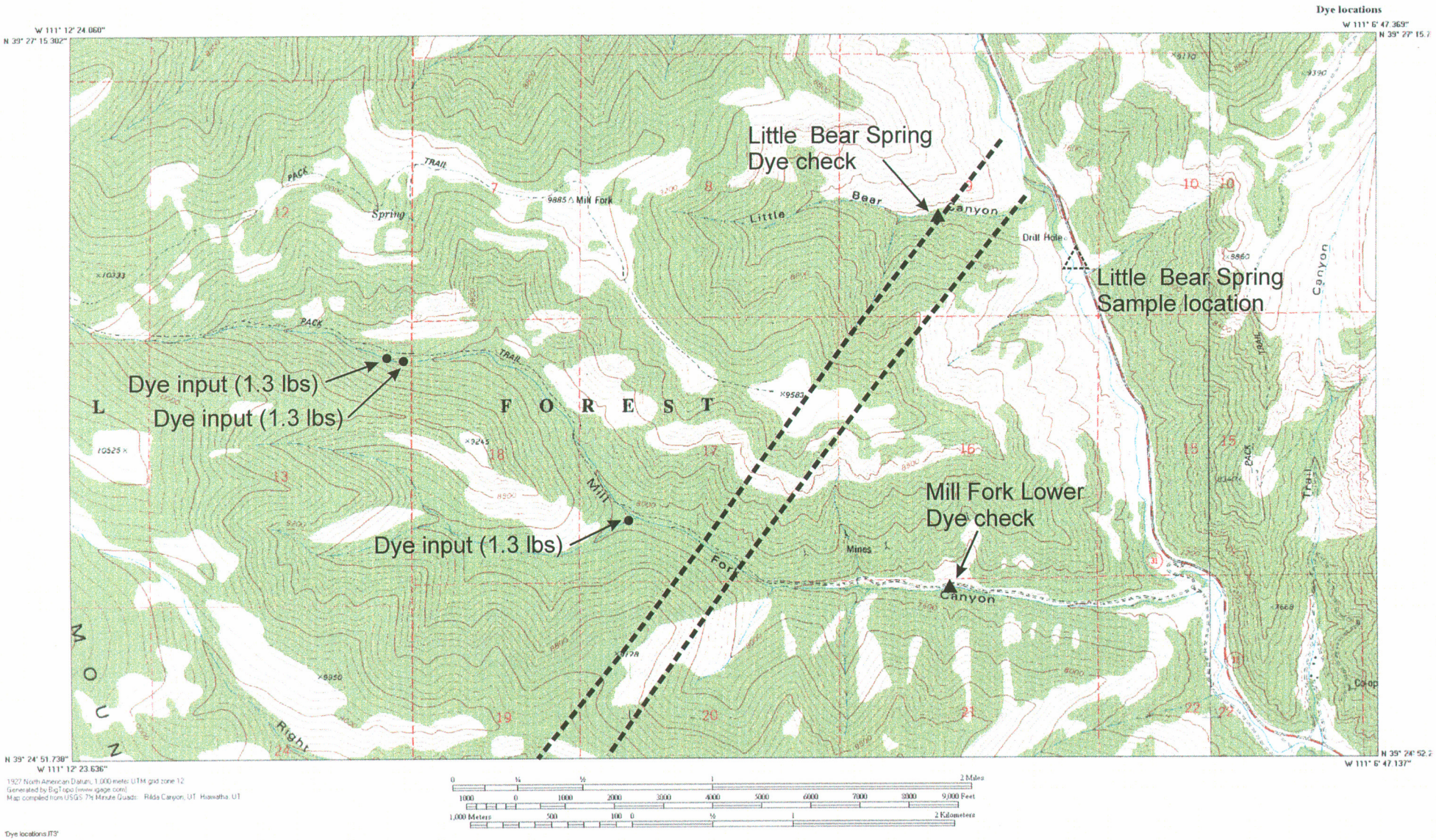


Figure 3 Dye input and monitoring locations, Phase 1. Eosine dye placed on 8 December 2001, 10:00 - 12:00.

times. Carbon samplers were also placed in the lower Mill Fork drainage where water first emerges in the drainage below the fracture system during most of the year (Figure 3). The purpose of monitoring at that location was to determine whether the groundwater that emerges there is hydraulically connected to surface waters in upper Mill Fork.

*Phase 2, Dye placed July 2001*

Sampling locations, dye placement locations, and dye quantities placed during Phase 2 of the dye tracer study are shown on Figure 4. Although there was appreciably more discharge in Mill Fork Creek during July 2001 than there was during December 2000, significant reaches of dry streambed were present during the Phase 2 dye placement. Six pounds of eosine dye was placed in upper Mill Fork Creek at the lower end of a flowing stream reach. Immediately below the dye placement location, the stream discharge entirely infiltrated into the subsurface. This location is situated approximately two-thirds of a mile above the fracture system from which Little Bear Spring discharges (Figure 4).

A meager discharge was present in the Mill Fork drainage during July 2001 below spring MF-3. The streambed in the Mill Fork drainage below MF-3 and above the fracture system contained water in some reaches and was dry in others. Discharge in the flowing reaches of the stream in these locations ranged from about 1 to 5 gpm. Dye was placed in three locations where surface water was present on 30 July 2001 from 19:00 to 20:30. The amounts of dye placed were 2 pounds at the upper location, 6 pounds in the middle location, and 6 pounds in the lower location (Figure 4).

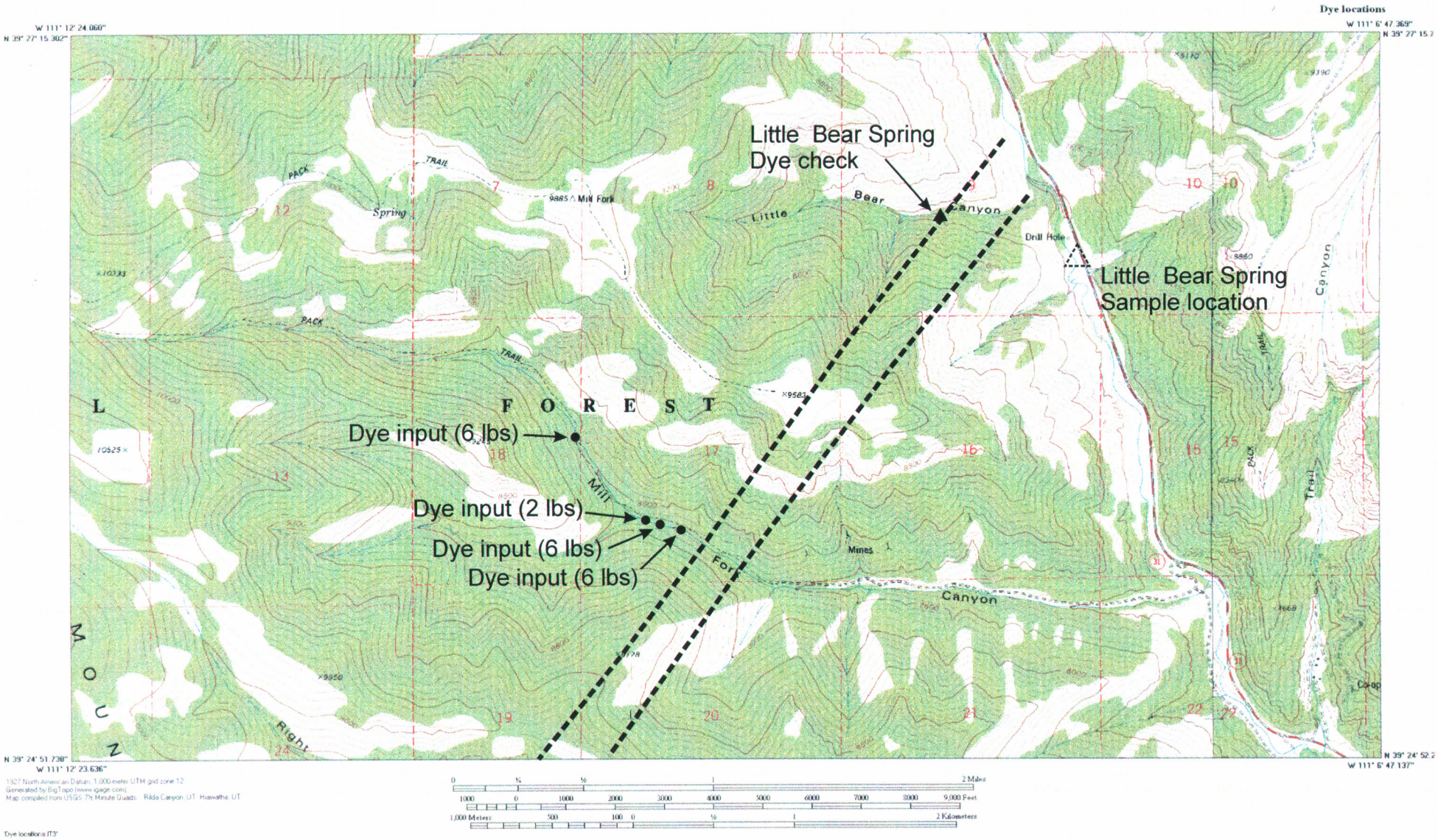


Figure 4 Dye input and monitoring locations, Phase 2. Eosine dye placed on 30 July 2001, 18:30-20:30.

In addition to the dye placed in the flowing reaches of Mill Fork Creek during Phase 2 of the dye tracer study, additional dye was placed in dry sets below the fracture system from which Little Bear Spring discharges. These locations are shown on Figure 5. On 30 July 2001 at 21:00, 2 pounds of eosine was placed in the upper dry set, 2 pounds placed in the middle dry set, and 1 pound placed in the lower dry set. The dry sets consisted of powdered eosine dye in open-topped plastic containers that were placed in the dry streambed and were to be activated when a significant amount of surface water was present in the drainage. When the dry sets were investigated on 28 October 2001, it was found that the dry sets had only partially activated and much or all of the powdered dye remained in the plastic containers. This is an indication that only relatively small surface water flows had occurred in the drainage. Approximately 1 pound of dye had been released from the upper set, approximately 0.25 pounds from the middle set, and approximately 0.25 pounds had been released from the lower set. The residual dye and the dry set containers were removed from the Mill Fork Drainage on 28 October 2001 and disposed of properly.

During Phase 2 of the investigation, monitoring of Little Bear Spring at the concrete control structure continued as during Phase 1. In the period immediately preceding the placement of dye for Phase 2, surface water had been flowing continuously at the surface from the dye placement areas to the confluence with Huntington Creek. Surface waters containing dye that could persist in the drainage from the dye placement area to the lower Mill Fork station would render any information about groundwater transport of dye to the lower Mill Fork station meaningless. Therefore, sampling at the lower Mill Fork site was discontinued for Phase 2 of the investigation.

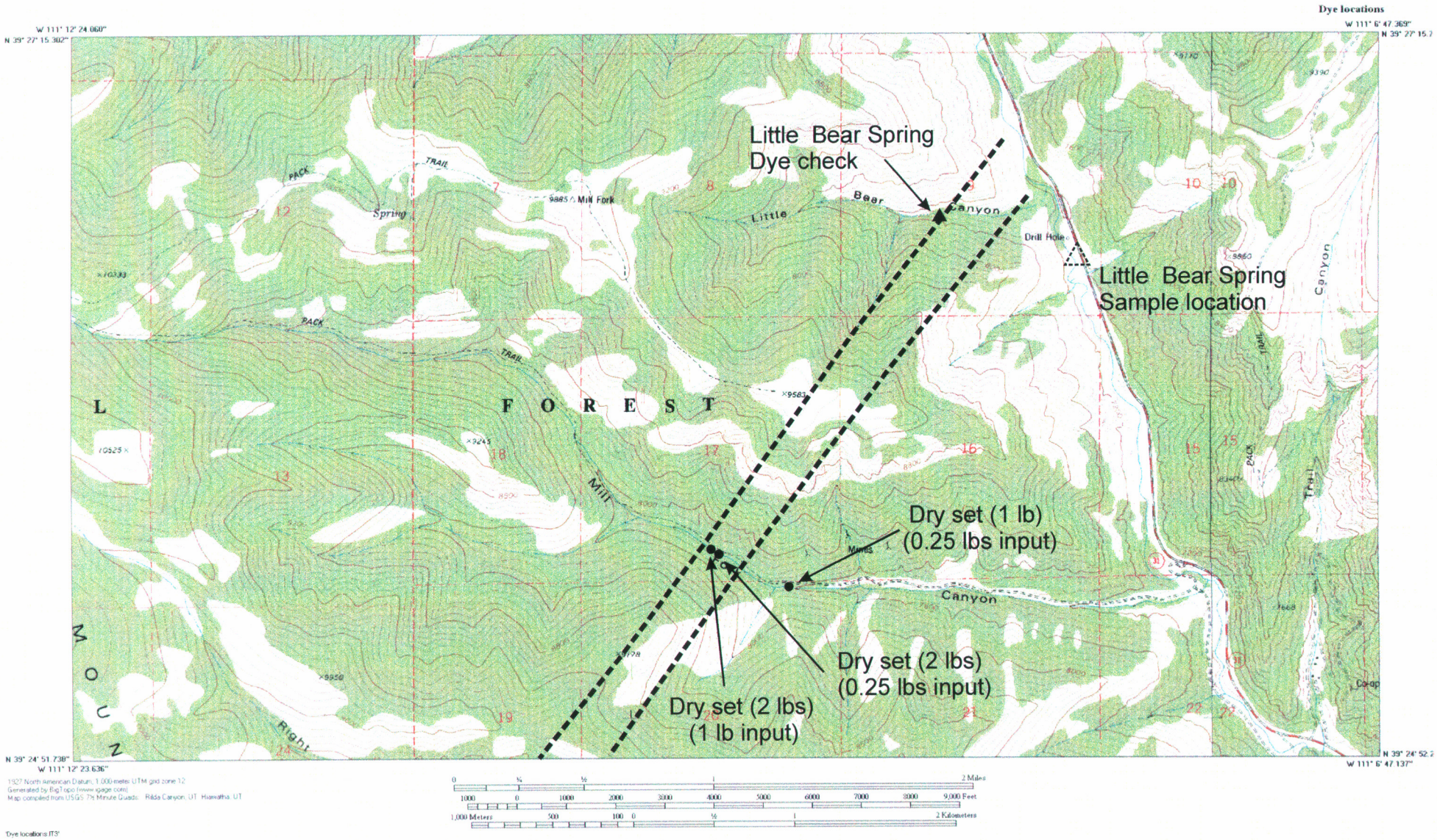


Figure 5 Dry set dye placements, Phase 2. Dry eosine powder placed in dry streambed on 20 July 2001, 21:00.

## 4. Results

*Phase 1*

The results of the dye detection analyses are listed in Table 1. Laboratory reporting sheets from Ozark Underground Laboratory are provided in the Appendix. As shown in Table 1, no eosine was detected in either monitoring location for a period of approximately 6 months. On 10 June 2001, a minor amount of eosine was detected at the lower Mill Fork site (Table 1). On the next monitoring event 13 days later, no eosine was detected at the lower Mill Fork site. Mayo and Associated (2001a) predicted that some of the alluvial groundwater in the upper Mill Fork drainage should eventually reach the lower Mill Fork monitoring site. However, the 10 June 2001 sampling event was the first sampling event after the first occurrence of continuous surface water flow in Mill Fork Creek from the headwater areas to below the lower Mill Fork monitoring site. Thus, there is the possibility that eosine dye held in the streambank sediments or shallow alluvial sediments beneath the shady, frozen drainage during the winter months could have been incorporated into the surface flow that reached the lower Mill Fork monitoring site. It is unknown whether the dye detected at the lower Mill Fork station was transported through the alluvial groundwater system in Mill Fork Canyon or whether the dye was transported by the surface water flow that had recently inundated the monitoring site. The latter of these two possibilities seems most likely.

**Table 1 Dye sample log and analytical results.**

| Sample name | Date retrieved from water | Time | Date put in water | Date sent for analysis | Result | Comments |
|---|---|---|---|---|---|---|
| Mill Fork Upper #1 | 27-Nov-00 | | | 29-Nov-00 | N.D. | Background check |
| Mill Fork Upper #2 | 27-Nov-00 | | | back-up | | Background check |
| Mill Fork Upper water samp | 27-Nov-00 | | | reserve | | Background check |
| Mill Fork Lower #1 | 29-Nov-00 | 11:00 | | 29-Nov-00 | N.D. | Background check |
| Mill Fork Lower #2 | 29-Nov-00 | 11:00 | | back-up | | Background check |
| Mill Fork Lower water samp | 29-Nov-00 | 11:00 | | reserve | | Background check |
| Little Bear #1 | 29-Nov-00 | 12:00 | | 29-Nov-00 | N.D. | Background check |
| Little Bear #2 | 29-Nov-00 (lost) | --- | | --- | | Background check |
| Little Bear water samp | 29-Nov-00 | 12:00 | | reserve | | Background check |
| **Phase 1** | | | | | | |
| **Eosine dye (4 lbs) added to Right and Left forks of Mill Fork (8 Dec 00, 10 am - 12 noon)** | | | | | | |
| Mill Fork Lower #1 | 9-Dec-00 | 15:40 | 29-Nov-00 | 15-Dec-00 | N.D. | |
| Mill Fork Lower #2 | 9-Dec-00 | 15:40 | 29-Nov-00 | back-up | | |
| Mill Fork Lower water samp | 9-Dec-00 | 15:40 | --- | reserve | | |
| Little Bear #1 | 9-Dec-00 | 15:10 | 29-Nov-00 | 15-Dec-00 | N.D. | |
| Little Bear #2 | 9-Dec-00 | 15:10 | 29-Nov-00 | back-up | | |
| Little Bear water samp | 9-Dec-00 | 15:10 | --- | reserve | | |
| Mill Fork Lower #1 | 11-Dec-00 | 14:45 | 9-Dec-00 | 15-Dec-00 | N.D. | |
| Mill Fork Lower #1 | 11-Dec-00 | 14:45 | 9-Dec-00 | back-up | | |
| Mill Fork Lower water samp | 11-Dec-00 | 14:45 | --- | reserve | | |
| Little Bear #1 | 11-Dec-00 | 14:10 | 9-Dec-00 | 15-Dec-00 | N.D. | |
| Little Bear #2 | 11-Dec-00 | 14:10 | 9-Dec-00 | back-up | | |
| Little Bear water samp | 11-Dec-00 | 14:10 | --- | reserve | | |
| Little Bear #1 | 14-Dec-00 | 14:00 | 11-Dec-00 | 15-Dec-00 | N.D. | Placed 3 carbon samplers in the spring box for emergency backup. |
| Little Bear #2 | 14-Dec-00 | 14:00 | 11-Dec-00 | back-up | | |
| Little Bear water samp | 14-Dec-00 | 14:00 | --- | reserve | | |
| Mill Fork Lower #1 | 14-Dec-00 | 15:00 | 11-Dec-00 | 15-Dec-00 | N.D. | |
| Mill Fork Lower #2 | 14-Dec-00 | 15:00 | 11-Dec-00 | back-up | | |
| Mill Fork Lower water samp | 14-Dec-00 | 15:00 | --- | reserve | | |
| Little Bear #1 | 26-Dec-00 | 17:00 | 14-Dec-00 | 27-Dec-00 | N.D. | |
| Little Bear #2 | 26-Dec-00 | 17:00 | 14-Dec-00 | back-up | | |
| Little Bear water samp | 26-Dec-00 | 17:00 | --- | reserve | | |
| Mill Fork Lower #1 | 26-Dec-00 | 18:00 | 14-Dec-00 | 27-Dec-00 | N.D. | |
| Mill Fork Lower #2 | 26-Dec-00 | 18:00 | 14-Dec-00 | back-up | | |
| Mill Fork Lower water samp | 26-Dec-00 | 18:00 | --- | reserve | | |
| Little Bear #1 | 12-Jan-01 | 15:00 | 26-Dec-00 | 15-Jan-01 | N.D. | |
| Little Bear #2 | 12-Jan-01 | 15:00 | 26-Dec-00 | back-up | | |
| Little Bear water samp | 12-Jan-01 | 15:00 | --- | reserve | | |
| Mill Fork Lower #1 | 12-Jan-01 | 16:00 | 26-Dec-00 | 15-Jan-01 | N.D. | |
| Mill Fork Lower #2 | 12-Jan-01 | 16:00 | 26-Dec-00 | back-up | | |
| Mill Fork Lower water samp | 12-Jan-01 | 16:00 | --- | reserve | | |
| Little Bear #1 | 24-Jan-01 | 17:00 | 12-Jan-01 | 26-Jan-01 | N.D. | |
| Little Bear #2 | 24-Jan-01 | 17:00 | 12-Jan-01 | back-up | | |
| Little Bear water samp | 24-Jan-01 | 17:00 | --- | reserve | | |
| Mill Fork Lower #1 | 24-Jan-01 | 18:00 | 12-Jan-01 | 26-Jan-01 | N.D. | |
| Mill Fork Lower #2 | 24-Jan-01 | 18:00 | 12-Jan-01 | back-up | | |
| Mill Fork Lower water samp | 24-Jan-01 | 18:00 | --- | reserve | | |
| Little Bear #1 | 2-Feb-01 | 16:00 | 24-Jan-01 | 7-Feb-01 | N.D. | |
| Little Bear #2 | 2-Feb-01 | 16:00 | 24-Jan-01 | back-up | | |
| Little Bear water samp | 2-Feb-01 | 16:00 | --- | reserve | | |
| Mill Fork Lower #1 | 2-Feb-01 | 17:00 | 24-Jan-01 | 7-Feb-01 | N.D. | |
| Mill Fork Lower #2 | 2-Feb-01 | 17:00 | 24-Jan-01 | back-up | | |
| Mill Fork Lower water samp | 2-Feb-01 | 17:00 | --- | reserve | | |
| Little Bear #1 | 17-Feb-01 | 13:30 | 2-Feb-01 | 23-Feb-01 | N.D. | |
| Little Bear #2 | 17-Feb-01 | 13:30 | 2-Feb-01 | back-up | | |
| Little Bear water samp | 17-Feb-01 | 13:30 | --- | reserve | | |
| Mill Fork Lower #1 | 17-Feb-01 | 16:30 | 2-Feb-01 | 23-Feb-01 | N.D. | |
| Mill Fork Lower #2 | 17-Feb-01 | 16:30 | 2-Feb-01 | back-up | | |
| Mill Fork Lower water samp | 17-Feb-01 | 16:30 | --- | reserve | | |
| Little Bear #1 | 14-Mar-01 | 12:30 | 17-Feb-01 | 16-Mar-01 | N.D. | |
| Little Bear #2 | 14-Mar-01 | 12:30 | 17-Feb-01 | back-up | | |
| Little Bear water samp | 14-Mar-01 | 12:30 | --- | reserve | | |
| Mill Fork Lower #1 | 14-Mar-01 | 13:30 | 17-Feb-01 | 16-Mar-01 | N.D. | |
| Mill Fork Lower #2 | 14-Mar-01 | 13:30 | 17-Feb-01 | back-up | | |
| Mill Fork Lower water samp | 14-Mar-01 | 13:30 | --- | reserve | | |
| Little Bear #1 | 1-Apr-01 | 13:30 | 14-Mar-01 | 3-Apr-01 | N.D. | |
| Little Bear #2 | 1-Apr-01 | 13:30 | 14-Mar-01 | back-up | | |
| Little Bear water samp | 1-Apr-01 | 13:30 | | reserve | | |
| Mill Fork Lower #1 | 1-Apr-01 | 13:45 | 14-Mar-01 | 3-Apr-01 | N.D. | |
| Mill Fork Lower #2 | 1-Apr-01 | 13:45 | 14-Mar-01 | back-up | | |
| Mill Fork Lower water samp | 1-Apr-01 | 13:45 | --- | reserve | | |
| Little Bear #1 | 27-Apr-01 | 17:15 | 1-Apr-01 | 30-Apr-01 | N.D. | |
| Little Bear #2 | 27-Apr-01 | 17:15 | 1-Apr-01 | back-up | | |
| Little Bear water samp | 27-Apr-01 | 17:15 | --- | reserve | | |
| Mill Fork Lower #1 | 27-Apr-01 | 17:45 | 1-Apr-01 | 30-Apr-01 | N.D. | |
| Mill Fork Lower #2 | 27-Apr-01 | 17:45 | 1-Apr-01 | back-up | | |
| Mill Fork Lower water samp | 27-Apr-01 | 17:45 | --- | reserve | | |
| Little Bear #1 | 13-May-01 | 16:45 | 27-Apr-01 | 21-May-01 | N.D. | |
| Little Bear #2 | 13-May-01 | 16:45 | 27-Apr-01 | back-up | | |
| Little Bear water samp | 13-May-01 | 16:45 | --- | reserve | | |
| Mill Fork Lower #1 | 13-May-01 | 17:15 | 27-Apr-01 | 21-May-01 | N.D. | |
| Mill Fork Lower #2 | (not collected) | | | | | |
| Mill Fork Lower water samp | 13-May-01 | 17:15 | --- | reserve | | |
| Little Bear #1 | 27-May-01 | 17:00 | 13-May-01 | 29-May-01 | N.D. | |
| Little Bear #2 | 27-May-01 | 17:00 | 13-May-01 | back-up | | |
| Little Bear water samp | 27-May-01 | 17:00 | --- | reserve | | |
| Mill Fork Lower #1 | 27-May-01 | 17:30 | 13-May-01 | 29-May-01 | N.D. | |
| Mill Fork Lower #2 | 27-May-01 | 17:30 | 27-Apr-01 | back-up | | |
| Mill Fork Lower water samp | 27-May-01 | 17:30 | --- | reserve | | |
| Little Bear #1 | 10-Jun-01 | 16:45 | 27-May-01 | 15-Jun-01 | N.D. | |
| Little Bear #2 | 10-Jun-01 | 16:45 | 27-May-01 | back-up | | |
| Little Bear water samp | 10-Jun-01 | 16:45 | --- | reserve | | |
| Mill Fork Lower #1 | 10-Jun-01 | 17:15 | 27-May-01 | 15-Jun-01 | | |
| Mill Fork Lower #2 | 10-Jun-01 | 17:15 | 27-May-01 | back-up | 1.26 ppb | |
| Mill Fork Lower water samp | 10-Jun-01 | 17:15 | --- | reserve | | |
| Little Bear #1 | 23-Jun-01 (damaged) | 20:00 | 10-Jun-01 | 25-Jun-01 | N.D. (possible) | About 2/3 of the carbon leaked out of the bag through a hole in the carbon sampler mesh |
| Little Bear #2 | 23-Jun-01 (lost) | 20:00 | 10-Jun-01 | --- | | Carbon sampler separated from the wire holder and was lost |
| Little Bear water samp | 23-Jun-01 | 20:00 | --- | reserve | | |
| Mill Fork Lower #1 | 23-Jun-01 | 20:30 | 10-Jun-01 | 25-Jun-01 | N.D. | |
| Mill Fork Lower #2 | 23-Jun-01 | 20:30 | 10-Jun-01 | back-up | | |
| Mill Fork Lower water samp | 23-Jun-01 | 20:30 | --- | reserve | | |
| Little Bear #1 | 27-Jun-01 | 13:30 | 23-Jun-01 | 9-Jul-01 | N.D. | |
| Little Bear #2 | 27-Jun-01 | 13:30 | 23-Jun-01 | back-up | | |
| Little Bear water samp | 27-Jun-01 | 13:30 | --- | reserve | | |
| Little Bear USFS | 27-Jun-01 | 13:30 | --- | 9-Jul-01 | N.D. | Sampler placed in spring box by Karl Boyer approximately 2 weeks earlier |
| Little Bear Backup #1 | 25-Jul-01 | 18:00 | 14-Dec-00 | 26-Jul-01 | N.D. | Installed 3 replacement backup samplers |
| Little Bear Backup #2 | 25-Jul-01 | 18:00 | 14-Dec-00 | back-up | | |
| Little Bear Backup #3 | 25-Jul-01 | 18:00 | 14-Dec-00 | back-up | | |
| Little Bear water samp | 25-Jul-01 | 18:00 | --- | reserve | | |
| **Phase 2** | | | | | | |
| **Eosine dye (20 lbs) placed in the Mill Fork Drainage above the fracture zone, 20 July 2001. Also 1.5 lbs released from dry sets below fracture.** | | | | | | |
| Little Bear #1 | 9-Sep-01 | 17:00 | 25-Jul-01 | 28-Sep-01 | 312 ppb | |
| Little Bear #2 | 9-Sep-01 | 17:00 | 25-Jul-01 | back-up | | |
| Little Bear #3 | 9-Sep-01 | 17:00 | 25-Jul-01 | back-up | | |
| Little Bear water samp | 9-Sep-01 | 17:00 | --- | reserve | | |
| Little Bear #1 | 26-Sep-01 | 17:00 | 9-Sep-01 | 28-Sep-01 | 496 ppb | |
| Little Bear #2 | 26-Sep-01 | 17:00 | 9-Sep-01 | back-up | | |
| Little Bear #3 | 26-Sep-01 | 17:00 | 9-Sep-01 | back-up | | |
| Little Bear water samp | 26-Sep-01 | 17:00 | --- | reserve | | |

**Phase 2**

No eosine was detected at Little Bear Spring during Phase 1 of the dye tracer investigation. As discussed previously, the amount of eosine placed in the Mill Fork drainage during Phase 1 of the investigation was minimized to mitigate the potential for visible coloration of the water in Little Bear Spring. After conversations with Mr. Tom Aley of the Ozark Underground Laboratory (Personnal Communication, Tom Aley, 2001) it was concluded that there was a reasonable possibility that insufficient eosine dye was placed during Phase 1. It has been estimated that commonly only approximately 1% of the dye injected in a tracer study in fractured, non-soluble rock is recovered at the sampling location (Ozark Underground Laboratory, 1999). This is because fluorescent dye is readily lost to adsorption on clay particles or organic material, or is lost to photo-degradation prior to infiltration. Mr. Aley recommended that for Phase 2 of the dye tracer study, approximately 4 times the amount of eosine dye used for Phase 1 be placed in the drainage. Consequently, a total of 20 pounds of eosine dye was placed in the Mill Fork drainage above the fracture system for Phase 2 of the dye tracer study.

It is not known when the approximately 1.5 pounds of eosine dye in the three dry sets discussed previously was released into the drainage. However, because all of the dry sets were located down gradient of the upper fracture from which Little Bear Spring discharges (Figure 5), it is unlikely that significant amounts of dye from the dry sets ever arrived at Little Bear Spring.

On 9 September 2001 during the first sampling event at Little Bear Spring subsequent to the introduction of dye for Phase 2 of the investigation, eosine dye was detected in the carbon sampler at a concentration of 312 ppb. On the following sampling event on 26 September 2001, dye was again detected at a concentration of 496 ppb.

## 5. Conclusions

Based on the positive detection of eosine dye in Little Bear Spring, it has been demonstrated that water in the Mill Fork Drainage recharges Little Bear Spring. The travel time from the streambed in Mill Fork Canyon to the spring is 40 days or less. These findings are in complete agreement with previous investigations of Little Bear Spring conducted by Mayo and Associates (2001a, 2001b).

## 6. References Cited

Aley, T., 1999, Ozark Underground Laboratory groundwater tracing handbook, Ozark Underground Laboratory, Protem, MO, 35 p.

Water Technology and Research, Inc, 1999, AquaTrack Survey, Little Bear Springs study, unpublished consulting report, 31 p.

Field, M.S., Wilhelm, J.F.Q., Quinlan, J.F., and Aley, T.J., 1995, An assessment of the potential adverse properties of fluorescent tracer dyes used for groundwater tracing, Environmental Monitoring and Assessment, 38: 75-96, Kluwer Academic Publishers

Mayo and Associates, 2001a, Investigation of the Potential for Little Bear Spring Recharge in Mill Fork Canyon, Emery County, Utah, unpublished consulting report for GENWAL Resources, Inc, Price, Utah.

Mayo and Associates, 2001b, Investigation of the Alluvial Groundwater System In Mill Fork Canyon with Implications for Recharge to Little Bear Spring, unpublished consulting report for GENWAL Resources, Inc, Price, Utah.

Mayo and Associates, 1999, Investigation of groundwater and surface-water systems in the vicinity of GENWAL's existing permit area and the Mill Fork Tract, Emery County, Utah, unpublished consulting report submitted to Genwal Resources, Inc., Huntington, Utah.

Smart, P.L., 1984, A review of the toxicity of twelve fluorescent dyes used for water tracing, NSS Bulletin 46: 21-33

# Appendix

## Laboratory Reporting Sheets

## Ozark Underground Laboratory

# Ozark Underground Laboratory for Mayo & Associates

**Date Samples Rec'd at OUL:** November 30, 2000
**Date Analyzed by OUL:** December 6, 2000

**Table 1. Results for charcoal background samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | Stn. # | Station Name | Date/Time Placed 2000 | Date/Time Collected 2000 | Fluorescein | | Eosine | | RWT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. | Peak | Conc. | Peak | Conc. |
| K6979 | 1 | Little Bear | NDT | 11/29 1200 | ND | | ND | | ND | |
| K6980 | [redacted] | | | | | | | | | |
| K6981 | 2 | Mill Fork Upper | NDT | 11/28 1600 | ND | | ND | | ND | |
| K6982 | 3 | Mill Fork Lower | NDT | 11/29 1130 | ND | | ND | | ND | |

**FOOTNOTES:**

NDT = No date or time given

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** Little Bear Springs
**Samples collected by:** Erik C. Petersen
**Samples shipped on:** December 15, 2000
**Date samples rec'd at OUL:** December 18, 2000
**Date analyzed by OUL:** December 20, 2000

**Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | Stn. # | Station Name | Date/Time Placed 2000 | Date/Time Collected 2000 | Fluorescein | | Eosine | | RWT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. | Peak | Conc. | Peak | Conc. |
| K7367 | 3 | Mill Fork Lower # 1 | NDT | 12/9 1540 | ND | | ND | | ND | |
| K7368 | 1 | Little Bear # 1 | NDT | 12/9 1510 | ND | | ND | | ND | |
| K7369 | 3 | Mill Fork Lower # 1 | NDT | 12/11 1445 | ND | | ND | | ND | |
| K7370 | 1 | Little Bear # 1 | NDT | 12/11 1410 | ND | | ND | | ND | |
| K7371 | 3 | Mill Fork Lower # 1 | NDT | 12/14 1500 | ND | | ND | | ND | |
| K7372 | 1 | Little Bear # 1 | NDT | 12/14 1400 | ND | | ND | | ND | |

**FOOTNOTES:**

NDT = No date or time given

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** Crandall Canyon Mine Project
**Samples collected by:** Erik C. Petersen
**Samples shipped on:** December 27, 2000
**Date samples rec'd at OUL:** December 28, 2000
**Date analyzed by OUL:** January 4, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | Stn. # | Station Name | Date/Time Placed 2000 | Date/Time Collected 2000 | Fluorescein | | Eosine | | RWT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. | Peak | Conc. | Peak | Conc. |
| K7491 | 1 | Little Bear # 1 | NDT | 12/26 1700 | ND | | ND | | ND | |
| K7492 | 3 | Mill Fork Lower # 1 | NDT | 12/26 1800 | ND | | ND | | ND | |

**FOOTNOTES:**

NDT = No date or time given

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** Crandall Canyon Mine Project
**Samples collected by:** Erik C. Petersen
**Samples shipped on:** January 15, 2001
**Date samples rec'd at OUL:** January 17, 2001
**Date analyzed by OUL:** January 22, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed | Date/Time Collected 2001 | Fluorescein | | Eosine | | RWT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. | Peak | Conc. | Peak | Conc. |
| K7909 | 1 | Little Bear # 1 | NDT | 1/12 1500 | ND | | ND | | ND | |
| K7910 | 3 | Mill Fork Lower # 1 | NDT | 1/12 1600 | ND | | ND | | ND | |

**FOOTNOTES:**

NDT = No date or time given

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** January 26, 2001
**Date samples rec'd at OUL:** January 30, 2001
**Date analyzed by OUL:** January 31, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| K8072 | 3 | Mill Fork Lower # 1 | 1/12 1600 | 1/24 1700 | ND | |
| K8073 | 1 | Little Bear # 1 | 1/12 1500 | 1/24 1800 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** February 7, 2001
**Date samples rec'd at OUL:** February 9, 2001
**Date analyzed by OUL:** February 14, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| K8289 | 1 | Little Bear # 1 | 1/24 1700 | 2/2 1600 | ND | |
| K8290 | 3 | Mill Fork Lower # 1 | 1/24 1800 | 2/2 1700 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** February 23, 2001
**Date samples rec'd at OUL:** February 27, 2001
**Date analyzed by OUL:** March 1, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| K8479 | 1 | Little Bear # 1 | 2/2 1600 | 2/17 1330 | ND | |
| K8480 | Laboratory Control Charcoal Blank | | | | | |
| K8481 | 3 | Mill Fork Lower # 1 | 2/2 1700 | 2/17 1630 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL - Little Bear
**Samples collected by:** Erik Petersen
**Samples shipped on:** March 16, 2001
**Date samples rec'd at OUL:** March 20, 2001
**Date analyzed by OUL:** March 23, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| K8870 | 1 | Little Bear # 1 | 2/17 1330 | 3/14 1230 | ND | |
| K8871 | 3 | Mill Fork Lower # 1 | 2/17 1630 | 3/14 1330 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** April 3, 2001
**Date samples rec'd at OUL:** April 5, 2001
**Date analyzed by OUL:** April 6, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| K9049 | 1 | Little Bear # 1 | 3/14 1230 | 4/1 1330 | ND | |
| K9050 | 3 | Mill Fork Lower # 1 | 3/14 1330 | 4/1 1345 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** April 30, 2001
**Date samples rec'd at OUL:** May 2, 2001
**Date analyzed by OUL:** May 10, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| K9427 | 1 | Little Bear # 1 | 4/1 1330 | 4/27 1730 | ND | |
| K9428 | 3 | Mill Fork Lower # 1 | 4/1 1345 | 4/27 1745 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** May 21, 2001
**Date samples rec'd at OUL:** May 23, 2001
**Date analyzed by OUL:** May 31, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| L0107 | 1 | Little Bear # 1 | 4/27 1715 | 5/13 1645 | ND | |
| L0108 | 3 | Mill Fork Lower # 1 | 4/27 1745 | 5/13 1715 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** May 29, 2001
**Date samples rec'd at OUL:** May 31, 2001
**Date analyzed by OUL:** June 7, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| L0484 | 1 | Little Bear # 1 | 5/13 1645 | 5/27 1700 | ND | |
| L0485 | 3 | Mill Fork Lower # 1 | 5/13 1715 | 5/27 1730 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** June 15 and 25, 2001
**Date samples rec'd at OUL:** June 19 and 27, 2001
**Date analyzed by OUL:** June 27, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of eosine dye.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Eosine | |
|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. |
| L1055 | 1 | Little Bear # 1 | 5/27 1700 | 6/10 1645 | ND | |
| L1056 | 3 | Mill Fork Lower # 1 | 5/27 1730 | 6/10 1715 | 536.4 | 1.26 |
| L1290 | 1 | Little Bear # 1 | 6/10 1645 | 6/23 2000 | ND | |
| L1291 | 3 | Mill Fork Lower # 1 | 6/10 1715 | 6/23 2030 | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** July 9, 2001
**Date samples rec'd at OUL:** July 11, 2001
**Date analyzed by OUL:** July 13, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of fluorescein and eosine dyes.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2001 | Date/Time Collected 2001 | Fluorescein | | Eosine | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. | Peak | Conc. |
| L1658 | 1 | Little Bear #1 | 6/23 2000 | 6/27 1330 | ND | | ND | |
| L1659 | 4 | Little Bear USFS | NDT | 7/8 2000 | ND | | ND | |
| L1660 | Laboratory Control Charcoal Blank | | | | | | | |
| L1661 | 3 | Mill Fork Lower #1 | 6/23 2030 | 7/8 2030 | ND | | ND | |
| L1662 | 1 | Little Bear #1 | 6/23 2000 | 7/8 2000 | ND | | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Mayo & Associates

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** July 26, 2001
**Date samples rec'd at OUL:** July 30, 2001
**Date analyzed by OUL:** August 1, 2001

**Table 1. Results for charcoal sampler analyzed for the presence of fluorescein and eosine dyes.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2000 | Date/Time Collected 2001 | Fluorescein | | Eosine | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. | Peak | Conc. |
| L2030 | 1 | Little Bear Backup #1 | 12/14 1400 | 6/25 1800 | ND | | ND | |

**FOOTNOTES:**

ND = No dye detected

# Ozark Underground Laboratory for Petersen Hydrologic

**Project:** GENWAL
**Samples collected by:** Erik Petersen
**Samples shipped on:** September 28, 2001
**Date samples rec'd at OUL:** October 1, 2001
**Date analyzed by OUL:** October 5, 2001

**Table 1. Results for charcoal samplers analyzed for the presence of fluorescein and eosine dyes.** Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

| OUL Lab # | OUL Stn. # | Station Name | Date/Time Placed 2000 | Date/Time Collected 2001 | Fluorescein | | Eosine | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Peak | Conc. | Peak | Conc. |
| L3448 | 1 | Little Bear #1 | 7/25 1800 | 9/9 1700 | ND | | 538.7 | 312 |
| L3449 | 1 | Little Bear #1 | 9/9 1700 | 9/26 1700 | ND | | 538.8 | 496 |

**FOOTNOTES:**

ND = No dye detected