ASSESSMENT OF HISTORY AND NATURE OF
ARROWHEAD SPRINGS
SAN BERNARDINO MOUNTAINS
SAN BERNARDINO COUNTY, CALIFORNIA

March 1999
by
Dames & Moore
10723 Bell Court
Rancho Cucamonga, California 91730
Job Number 36665-012-112

DAMES & MOORE
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EXECUTIVE SUMMARY

INTRODUCTION

This report has been prepared to document the identity and nature of springs and bore holes at the Arrowhead Springs in Strawberry Canyon, in the San Bernardino Mountains, San Bernardino County, California. The studies performed by Dames & Moore included review of historical information, published technical reports, and other existing records. Field testing was also conducted to document various hydrogeological and water quality parameters. These studies demonstrate that the spring water harvested from the bore holes at Arrowhead Springs meets the full requirements for "spring water" under both state and federal regulations.

LOCATION

The Arrowhead Springs are located southwest of the community of Rimforest, and south of State Highway 18, also known as Rim of the World Highway. The site is in Sections 30 and 31, Township 2 North, Range 3 West, San Bernardino Base and Meridian, in San Bernardino County, California.

SPRINGS AND BORE HOLES

There are seven natural springs which discharge water from the fractured granite. These are referred to as Springs No. 2, No. 3, No. 4, No. 7, No. 10, No. 11, and No. 12. The water from these springs was initially harvested for bottling purposes from Strawberry Creek in 1905. In 1930 tunnels were constructed to collect the water directly from these springs. Several years later, beginning in approximately 1950, ten bore holes were constructed from which spring water is harvested. These bore holes are referred to as Bore Holes No. 1, No. 1A, No. 7, No. 7A, No. 7B, No. 7C, No. 8, No. 10, No. 11, and No. 12. The bore holes have been constructed adjacent to or in the immediate vicinity of five of the springs. Springs No. 2 and No. 3 have no bore holes associated with them. The bore holes penetrate laterally into the granitic bedrock to intersect the fractures that supply groundwater to the springs. Spring water flows naturally by gravity from the springs and the bore holes. No pumping or other external force is used to collect spring water from the bore holes.

IDENTITY

The basis for establishing the *identity* of springs is set forth in the regulations established by the Food and Drug Administration (FDA) in 1995, Federal Register, Vol. 60, No. 218. For convenience, the pertinent section referring to identity is restated below.

> **The name of water derived from an underground formation from which water flows naturally to the surface of the earth may be "*spring water.*" Spring water shall be collected only at the spring or through a bore hole tapping the underground formation feeding the spring. There shall be a**

> **natural force causing the water to flow to the surface through a natural orifice. The location of the spring shall be identified.**

The FDA Regulations are applicable throughout the United States. These regulations provide sufficient detail to allow determination of the nature of spring sources with regard to the FDA identity requirements for bottling and labeling of spring water.

SPRING COMPLEXES

The Arrowhead Springs are grouped into two springs and three spring complexes for convenience in description.

- **Spring No. 2.**
- **Spring No. 3.**
- **Spring Complex No. 4** includes Spring No. 4, and Bore Holes No. 1, No. 1A, and No. 8. Spring No. 4 was not developed; therefore, the three associated bore holes are used for collection of the spring water that would otherwise be harvested from Spring No. 4.
- **Spring Complex No. 7** includes Spring No. 7, and Bore Holes No. 7, No. 7A, No. 7B, and No. 7C. Spring water is no longer harvested directly from Spring No. 7, but only from the four associated bore holes.
- **Lower Spring Complex** includes Springs No. 10, No. 11, and No. 12, and Bore Holes No. 10, No. 11, and No. 12. None of the springs have been developed; therefore, the spring water from these springs is harvested from Bore Holes No. 10, No. 11, and No. 12.

HISTORY

The Arrowhead Springs were first discovered by David Smith in 1857. The property was then sold to Seth Marshall who, in 1905, began to harvest the spring water from Strawberry Creek to sell at his hotel in Arrowhead. In 1909 the Arrowhead Springs Corporation began shipping the spring water to Los Angeles for bottling, and in 1930 began construction of tunnels for harvesting of the spring water directly from the springs. Construction of several bore holes began in 1950, and water has been harvested from either the springs or associated bore holes since that time.

TOPOGRAPHY

The Arrowhead Springs site is located along the south flank of the San Bernardino Mountains, and includes steep and rugged terrain along the southern slopes of the mountain. The property ranges in elevation from about 4,100 feet above msl in the lower elevation portion to about 5,300 feet above msl at the higher portion.

CLIMATE

In the San Bernardino Mountains, the climate varies depending on the local topography. In the valley area to the south and west the climate is semi-arid. The San Bernardino Mountains have more variation in temperature than the valley regions, with mean annual temperatures between 52 and 57 degrees Fahrenheit (°F). Mean annual rainfall ranges from 20 to 40 inches per year. Snow accumulates during winter in the higher elevations, and melts during the warmer seasons providing water for infiltration into the ground and recharge of the groundwater within the mountains.

GEOLOGY

The San Bernardino Mountains lie within the central portion of the Transverse Ranges. The San Andreas Fault Zone, the primary structural feature in the area, trends northwest-southeast dissecting the Transverse Ranges about seven miles east of the site.

Plutonic rock types predominate in the vicinity of Arrowhead Springs. The granitic and metaplutonic rocks in the area around the springs are of Jurassic or late Cretaceous age, and consist principally of quartz monzonite, known locally as the Cactus Granite.

GROUNDWATER

In the San Bernardino Mountains, groundwater generally occurs in the fractures and joints of the granitic bedrock. The intense fracturing associated with the San Andreas Fault Zone has produced an intricate system of intersecting fractures throughout the rock mass, which gives the rocks considerable secondary porosity and permeability.

The source of water to this fractured-rock aquifer system is infiltration of precipitation and snowmelt in the higher reaches of the mountains. This groundwater collects in the fractures forming a water-table aquifer, and slowly percolates laterally and downward to points of natural discharge to the surface through springs.

VEGETATION

Abundant rainfall on the slopes near the Arrowhead Springs supports a variety of forest vegetation. Seen near the springs are alders, sugar pine, yellow pine, incense cedar, oak, bay trees, and sycamore. Also present under the forest canopy along the creek channels are wild lilac, juncus grass, goldenrod, lupine, buttercups, poison ivy, and ferns. Near the springs, ferns and alders are especially prominent.

HYDRAULIC CONNECTION

To test the hydraulic connection, the flow of spring water from bore holes was shut off, and the rate of flow from the springs was monitored for any changes. The results of the hydraulic testing demonstrated that there is hydraulic connection between Spring No. 7 and its four associated bore holes. The hydraulic connection tests for Spring No. 4 and the three springs in the Lower Spring Complex were inconclusive due to both limitations in the flow rates and variability in flow measurements from the springs. Hydraulic connection in these two complexes is addressed using chemical similarities in spring water from the springs and associated bore holes.

WATER QUALITY

Samples of water were taken from the springs and bore holes for chemical analysis. Graphical techniques were used for evaluation and presentation of the chemical data from these samples. All chemical compounds with concentrations at or above the minimum detection level were included in the evaluation and compared to the federal maximum contaminant levels. The results of the comparison of chemical analyses between the springs and bore holes showed that the water from the bore holes is of the same chemical quality as the water from the springs.

Microscopic particulate analysis (MPA) samples were collected from the springs and bore holes that are used for harvesting spring water. The samples were evaluated for the presence of *Giardia* cysts, *Cryptosporidium* oocysts, Algae, Vegetative Debris, and other indicators that may result from direct influence of surface water. The findings were ranked, weighted, and combined to produce a score that identifies the level of risk. Based on the results of MPA analyses, the water from all of the springs and bore holes used to harvest spring water show no evidence of direct influence of surface water. Thus, these sources fully meet the FDA Regulations for groundwater.

CONCLUSIONS

- The Arrowhead Springs have been in existence for many years, and have been used as water supply sources since their discovery in 1894.
- All of the springs are classified as fracture-contact springs issuing from fractures in granitic and metaplutonic rocks of Jurassic or late Cretaceous age, located in the San Bernardino Mountains.

- The springs are subaerial, subvariable to variable, Fourth, Fifth, and Sixth Order Magnitude, nonthermal, perennial springs with low mineral content water.

- All springs and bore holes flow from fracture systems in granitic bedrock of the San Bernardino Mountains under the natural force of gravity.

- At the Arrowhead Springs, there are two springs and three spring complexes.

  Spring No. 2:

  Spring No. 3:

  Spring Complex No. 4:
  Including Spring No. 4, and Bore Holes No. 1, No. 1A, and No. 8.

  Spring Complex No. 7:
  Including Spring No. 7, and Bore Holes No. 7, No. 7A, No. 7B, and No. 7C.

  Lower Spring Complex:
  Including, Spring No. 10, No. 11, and No. 12, and Bore Holes No. 10, No. 11, and No. 12.

- Springs No. 4, No. 7, No. 10, No. 11, and No. 12 are not used for harvesting spring water.

- All of the bore holes produce water by gravity, alone. None of the bore holes are pumped.

- Hydraulic connection testing of the springs and associated bore holes demonstrated the following:

  Bore Holes No. 7, No. 7A, No. 7B, and No. 7C are hydraulically connected to **Spring No. 7**.

  The hydraulic connection tests for **Spring Complex No. 4** and the **Lower Spring Complex** were inconclusive due to limitations in the flow rates of these sources. Hydraulic connection was demonstrated through water chemistry.

  The tests for the hydraulic connection were inconclusive due to limitations in the flow rates of these sources. Hydraulic connection was demonstrated through water chemistry.

- Graphical evaluation of chemical quality data for springs and bore holes shows that the water from the bore holes in Spring Complexes No. 4, No. 7, and the Lower Spring Complex is the same quality water as from the associated springs.

- None of the compounds in the samples from either the springs or the bore holes exceeds the federal maximum contaminant levels.

- Microscopic particulate analysis of samples from **Bore Holes No. 1, No. 1A, No.7, No. 7A, No. 7B, No. 7C, No. 8, No 10, No. 11, and No. 12, and from Springs No. 2 and No. 3** show only **Low Risk**, the best relative risk that can be attained for any water source. **These tests confirm our conclusion that there is no direct influence of surface water on these spring water sources.**

- **Spring water harvested from Bore Holes No. 1, No. 1A, No. 7, No. 7A, No. 7B, No. 7C, No. 8, No. 10, No. 11, and No. 12 meets the FDA identity regulations for "*spring water*" sources.**

- **The term "*Mountain Spring Water*" is a correct and appropriate description for this spring water.**

SECTION 1

INTRODUCTION

This report has been prepared to document the identity and nature of springs and associated bore holes located in Strawberry Canyon, in the San Bernardino Mountains in San Bernardino, California. These have been historically referred to as the Arrowhead Springs. The studies performed by Dames & Moore as part of this documentation included review of historical information, published technical reports, existing data, and existing meteorological records. Appendix A presents a list of references used in this report.

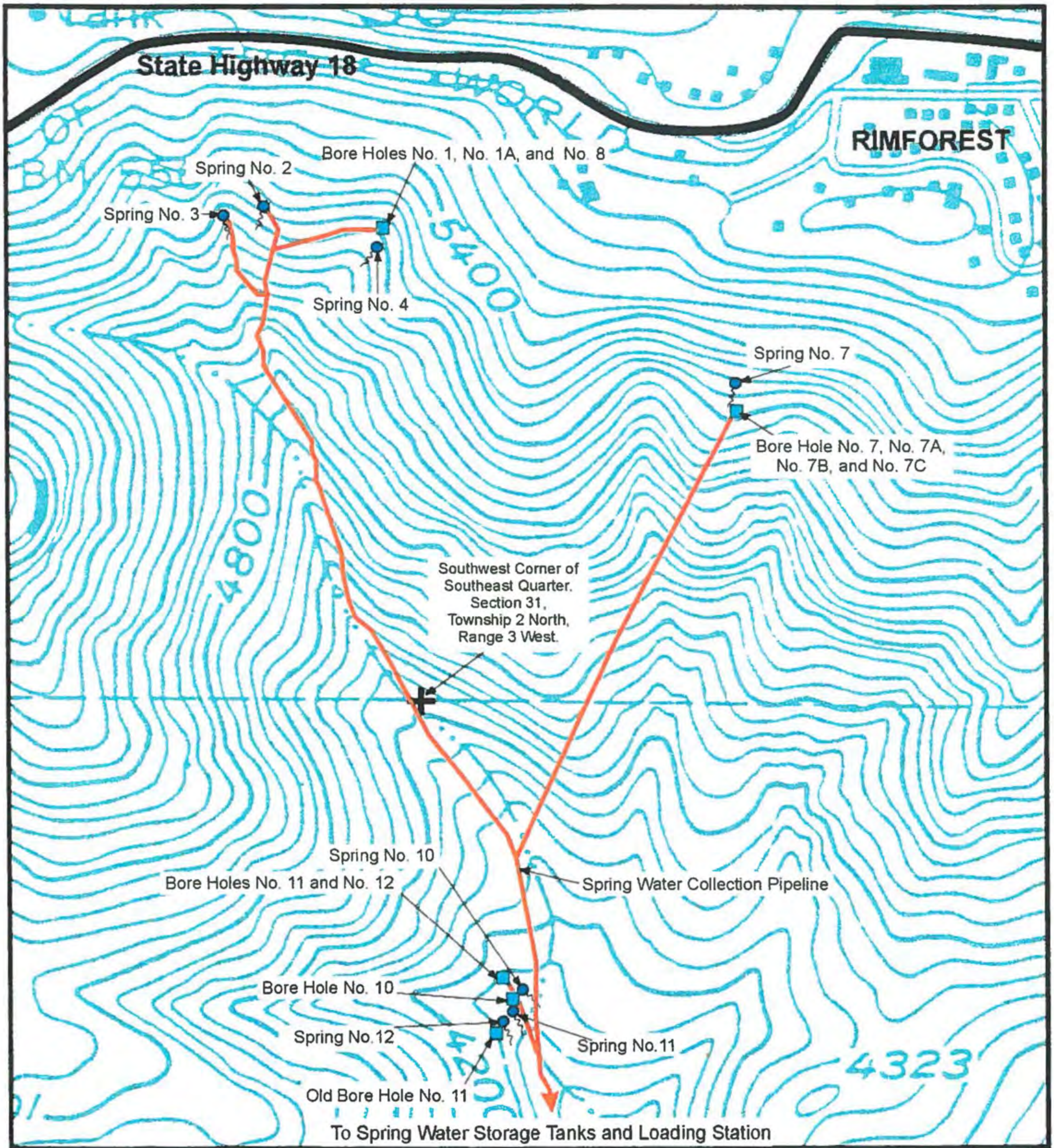
Field testing was also conducted to document various hydrogeological and water quality parameters. The results of these tests are presented later in the report. These studies have provided sufficient information to evaluate whether the Arrowhead Springs and associated bore holes, and the spring water harvested from those sources, meet the full requirements for "springs" and for "spring water" under both state and federal regulations.

LOCATION OF ARROWHEAD SPRINGS

The Arrowhead Springs are located in Sections 30 and 31, Township 2 North, Range 3 West, San Bernardino Base and Meridian, in San Bernardino County, California. They are southwest of the community of Rimforest, and south of State Highway 18, also known as Rim of the World Highway. They can be accessed by an improved wilderness path that is located at the extreme western end of the community of Rimforest and switches back along the mountainside, south of State Highway 18. The site is located on the steeply sloped southern face of the San Bernardino Mountains. The elevation of the springs ranges from about 5,280 feet above mean sea level (msl) at the uppermost spring, Spring No. 7, to about 4,140 feet above msl at the lowermost spring, Spring No. 11.

Figure 1-1 shows the locations of all of the springs and bore holes at this site, along with the roads, the collection pipeline, and the topography in the vicinity of the springs. The loading station and associated storage tanks are not shown on Figure 1-1. These facilities are several miles southeast of the Arrowhead Springs site. There are seven natural springs which discharge water from the fractured granite. These are referred to as Springs No. 2, No. 3, No. 4, No. 7, No. 10, No. 11, and No. 12. In addition to these springs, there are ten bore holes at the site from which spring water is harvested. The bore holes are referred to as Bore Holes No. 1, No. 1A, No. 7, No. 7A, No. 7B, No. 7C, No. 8, No. 10, No. 11, and No. 12. Appendix B presents the available bore hole logs for these bore holes.

Historically, there was an original spring, Spring No. 1, that was located in the vicinity of current Spring No. 4. Years ago, a horizontal bore hole was drilled at the location of Spring No. 1. This bore hole was later plugged by grouting, and today there is no flow from Spring No. 1.



Explanation

🟦 Bore Hole Surface Box

● Spring Orifice

N

0 500 1000

Approximate Scale in Feet

References: U. S. Geological Survey, 1988, Harrison Mountain, Calif., 7.5 Minute Quadrangle Maps, KCT Consultants Inc., 1997, Site Survey.
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Figure 1-1

Site Plan

Arrowhead Springs
San Bernardino Mountains, California

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Springs No. 5 and No. 6 are located east of the main spring area beyond the eastern edge of Figure 1-1. These two springs were partially developed in the 1930s, but were never completed. These springs are mentioned here to present a complete discussion of spring development in the area. Since spring water is not harvested from Springs No. 1, No. 5, and No. 6, they were not included in this study, and are not discussed further in this document.

Springs No. 2 and No. 3 have been developed by engineered collection facilities consisting of tunnels, and spring water is harvested directly from these springs. There are no bore holes associated with Springs No. 2 and No. 3.

Spring No. 7 was also developed by an engineered collection tunnel; however, this spring is no longer used for harvesting spring water. Instead, horizontal Bore Holes No. 7, No. 7A, No. 7B, and No. 7C are used to collect spring water that would otherwise flow out of Spring No. 7. This group of bore holes and Spring No. 7 is referred to as Spring Complex No. 7 in later portions of this report.

Spring No. 4 has not been developed, and is not used for harvesting spring water. Instead, bore Holes No. 1, No. 1A, and No 8 are used to harvest spring water from this source. This group of bore holes and the spring is referred to herein as Spring Complex No. 4.

Springs No. 10, No. 11, and No. 12 have not been developed. Spring water from these springs is harvested through Bore Holes No. 10, No. 11, and No. 12. A previously drilled bore hole, referred to as "Old Bore Hole 11," exists near Spring No. 12, as shown on Figure 1-1. This old bore hole is no longer used to harvest spring water, and is not discussed further in this report. Springs No. 10, No. 11, and No. 12, and Bore Holes No. 10, No. 11, and No. 12 are all located in the same general area, as shown on Figure 1-1. For convenience, this group of Springs and bore holes is referred to herein as the Lower Spring Complex.

The bore holes and tunnels penetrate laterally into the granitic bedrock to intersect the fracture systems that supply water to the springs. The bore holes and tunnels have been installed to protect the spring water from surface impacts. Collection piping has been installed to collect the water from the springs. Valves have been installed at the daylight point of the bore hole piping and along the supply pipeline to control the flow of spring water into the collection system. Spring water flows naturally by gravity alone from the springs and the bore holes, and through the connecting piping. No external force is used to collect the spring water.

IDENTITY OF SPRINGS AND SPRING WATER

The basis for establishing the *identity* of springs is set forth in the regulations established by the Food and Drug Administration (FDA) in 1995. The complete text of the FDA Preamble and the FDA Regulations are included in the Federal Register, Vol. 60, No. 218. For convenience, the pertinent section referring to identity is restated below.

> **The name of water derived from an underground formation from which water flows naturally to the surface of the earth may be "*spring water.*" Spring water shall be collected only at the spring or through a bore hole tapping the underground formation feeding the spring. There shall be a natural force causing the water to flow to the surface through a natural orifice. The location of the spring shall be identified. (FDA, 1995, p. 57124.)**

The FDA Regulations are applicable throughout the United States. These regulations provide sufficient detail to allow determination of the nature of spring sources with regard to the FDA requirements for bottling and labeling of spring water.

The following sections of this report provide information documenting the identity and nature of the springs, and the spring water harvested therefrom. Numerous references were reviewed as part of this study. Pertinent references are listed in Appendix A. Information has been selected from those references for summary in this report.

Figure 1-2. Spring No. 2 Portal

DESCRIPTIONS OF SPRINGS AND BORE HOLES

Table 1-1. Summary of Pertinent Spring Data

Spring No.	Tunnel Installation Date	Tunnel Length (Feet)
2	1947	27
3	1947	89
7	1933 (original) Approximately 1950 (upgraded)	30

The springs and bore holes, and our observations made during this study, are described in the paragraphs below. The springs are described in numerical order. Where bore holes have been installed adjacent to the springs, descriptions of the bore holes are presented immediately following the description of the associated springs. Bore hole logs are presented in Appendix B.

SPRING NO. 2

Spring No. 2 is a natural spring that has been improved by the installation of engineered collection facilities consisting of a hand dug tunnel and water collection piping. Figure 1-2 shows the portal entrance to the tunnel at Spring No. 2. The tunnel has concrete walls and gravel-lined floors to allow the spring water to enter the collection system from the fractures in the bedrock. Once through the portal, the tunnel advances straight back into the mountain side with no directional changes. Spring No. 2 issues from the steep granite hillside between Spring No. 4 and Spring No. 3, and is the northernmost spring at the site.

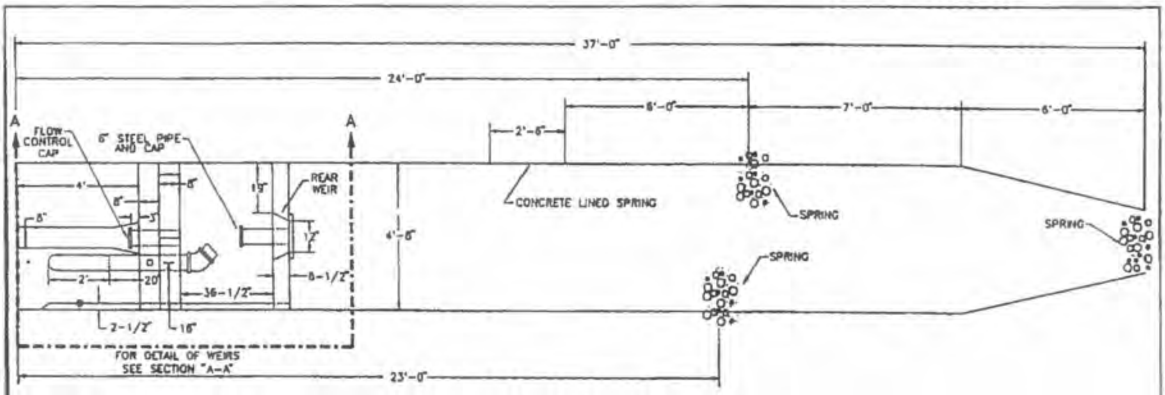


Figure 1-3. Spring No. 2 Collection Facilities

Figure 1-3 presents details of the engineered collection facility at this site. The spring is located at an elevation of approximately 5,260 feet above msl. Flow measurements from Spring No. 2 over the last decade showed a maximum flow of about 107 gallons per minute (gpm). A summary of the pertinent data for the springs is presented in Table 1-1.

SPRING NO. 3

Figure 1-4. Spring No. 3 Portal

Spring No. 3 is a natural spring that, like Spring No. 2, has been improved by the installation of engineered collection facilities. These include a hand dug tunnel, weirs, and water collection piping. Figure 1-4 shows the portal entrance to the Spring No. 3 tunnel. The entrance has been improved with stonework, comprised of native granite rocks, to blend into the mountainside environment. Figure 1-5 presents details of the engineered collection facility at this site. The tunnel has concrete walls and gravel-lined floors to allow the spring water to enter the collection system from the fractures in the bedrock. Unlike Spring No. 2, the tunnel into Spring No. 3 bends to the left (toward the north) about 16 feet beyond the tunnel portal, and makes two additional left-hand bends. The resulting tunnel alignment, therefore, curves toward the center of the mountain mass. Three gravel areas were installed to allow spring water to enter the collection facility from the granite hillside. Spring No. 3 is the westernmost spring at the site. The spring is located at an elevation of approximately 5,190 feet above msl. The flow from Spring No. 3 is approximately 95 gpm. A summary of the pertinent data for the springs is presented in Table 1-1.

SPRING COMPLEX NO. 4

Spring water in the vicinity of Spring No. 4 is harvested from three associated bore holes, Bore Holes No. 1, No. 1A, and No. 8. For convenience, this group of sources is referred to herein as Spring Complex No. 4. The descriptions of the spring and the associated bore holes are presented in the following paragraphs.

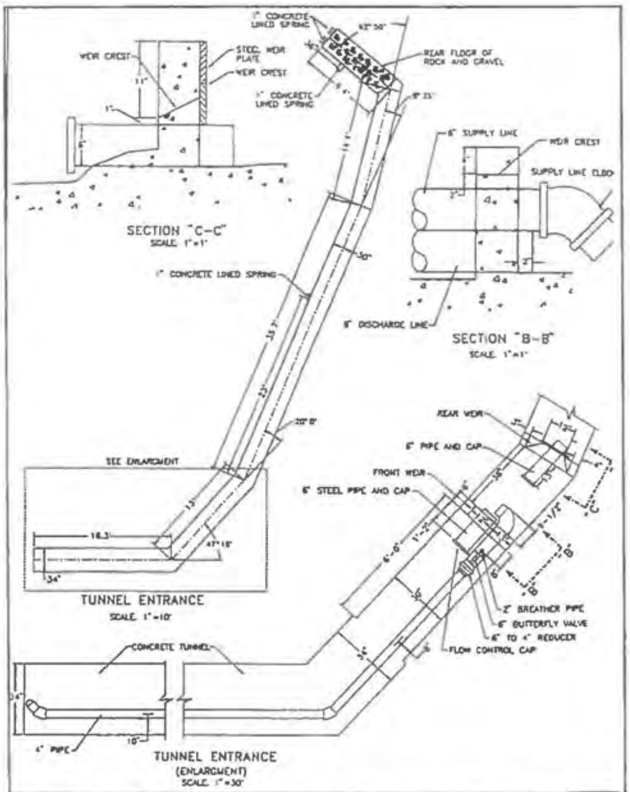


Figure 1-5. Spring No. 3 Collection Facilities

Spring No. 4

Spring No. 4, shown on Figure 1-6, issues from the steep granite hillside between Spring No. 2 and Spring Complex No. 7, at an elevation of approximately 5,190 feet above msl. Flow measurements from Spring No. 4 showed an average flow during monitoring of about 7 gpm. As noted earlier, Spring No. 4 has not been developed by installation of collection facilities, and spring water is not harvested directly from this spring. Spring water from this source is captured by three bore holes, Bore Holes No. 1, No. 1A, and No. 8, located approximately 60 feet north (up hill) from Spring No. 4.

Bore Holes No. 1, No. 1A, and No. 8

Groundwater discharging at Spring No. 4 is intercepted by Bore Holes No. 1, No. 1A, and No. 8. These three bore holes are protected inside a single concrete block enclosure, shown in Figure 1-7. Access to these bore holes is provided through a locking steel door. The bore holes, themselves, are constructed of slotted galvanized steel pipe. All three bore holes are horizontal. Pertinent data on the bore holes are summarized in Table 1-2. Bore Hole No. 1 is about 290 feet long, is oriented N25°E, and is constructed of 2-inch diameter galvanized steel pipe. Bore Hole No. 1A is approximately 130 feet long, is oriented N15°W, and is

Figure 1-6. Spring No. 4

constructed of 2-inch diameter galvanized steel pipe. Bore Hole No 8 is approximately 120 feet long, is oriented N44°W, and is constructed of 2-inch diameter galvanized steel pipe. A sampling port and totalizing flow meter are connected to the bore hole pipes where they extend to the surface. From the enclosure, water flows from the totalizing flow meter, through above-ground, ductile iron pipe to the storage tanks located near the loading station. Historic flow measurements indicate that the maximum flow from Bore Hole No. 1 is approximately 76 gpm, although this bore hole has recently averaged less than 20 gpm. The maximum flow from Bore Hole No. 1A is approximately 56 gpm. The maximum flow rate for Bore Hole No. 8 is about 50 gpm.

Table 1-2. Summary of Pertinent Bore Hole Data

Bore Hole No.	Date Installed	Bore Hole Length (Feet)	Seal Length (Feet)	Screen
1	6/14/76	290	126	Galv. Steel, Sch. 40
1A	8/9/93	130	66	Galv. Steel, Sch. 40
8	8/20/93	120	100	Galv. Steel, Sch. 40
7	9/27/92	290	126	Galv. Steel, Sch. 40
7A	9/6/92	230	95	Galv. Steel, Sch. 40
7B	9/10/92	397	121	Galv. Steel, Sch. 40
7C	7/18/93	300	167.6	Galv. Steel, Sch. 40
10	12/21/78	305	162	Galv. Steel, Sch. 40
11	5/20/94	310	67	Galv. Steel, Sch. 40
12	4/26/94	320	152	Galv. Steel, Sch. 40

SPRING COMPLEX NO. 7

Spring water in the vicinity of Spring No. 7 is harvested from four associated bore holes, Bore Holes No. 7, No. 7A, No. 7B and No. 7C. For convenience, this group of sources is referred to herein as Spring Complex No. 7. The descriptions of the spring and the associated bore holes are presented in the following paragraphs.

Spring No. 7

Figure 1-8 shows the portal of the tunnel at Spring No. 7. The components that make up Spring Complex No. 7 include Spring No. 7 and four bore holes referred to as Bore Holes No. 7, No. 7A, No. 7B, and No. 7C.

Figure 1-7. Bore Holes No. 1, No. 1A, and No. 8

Spring No. 7 is the easternmost spring at this site. It is a natural spring that has been improved by construction of an engineered collection facility, consisting of a short (30-foot) tunnel. Figure 1-9 presents a detailed drawing of the tunnel and associated collection facilities. The tunnel is concrete lined and has a gravel floor to allow the collection of spring water. Four horizontal bore holes, Bore Holes No. 7, No. 7A, No.

7B, and No. 7C, have been placed down slope of the spring to harvest spring water from this spring. Since their installation, these bore holes have been used for harvesting of spring water and conveying it into the water supply pipeline at the site, and spring water is no longer harvested directly from Spring No. 7. The Spring No. 7 tunnel advances straight back into the mountainside, terminating in a round room. A small rectangular room off the western side of the tunnel and the round room at the end have gravel-lined floors to allow spring water to enter the tunnel from the granite rock. The spring is located at an elevation of approximately 5,280 feet above msl.

Figure 1-8. Spring No. 7 Portal

Flow measurements from Spring No. 7, during recent monitoring by others, show a maximum flow during the monitoring period of about 20 gpm. A summary of the pertinent data for Spring No. 7 is presented in Table 1-1.

Bore Holes No. 7, No. 7A, No. 7B, and No. 7C

Groundwater discharging at Spring No. 7 is intercepted by Bore Holes No. 7, No. 7A, No. 7B, and No. 7C. Spring water collection in the area near Spring Complex No. 7 has undergone three separate phases of development. The tunnel was originally installed in the 1930s. A bore hole collection system was added in the early 1950s. The original bore holes, shown on Figure 1-9, were located closer to the spring than the existing four bore holes, also shown on that figure. The original bore holes have been grouted and recently

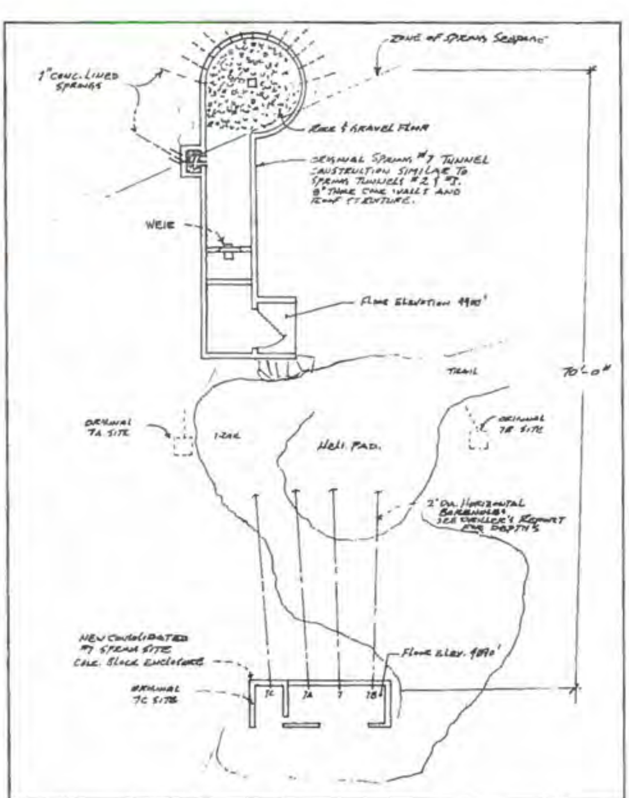
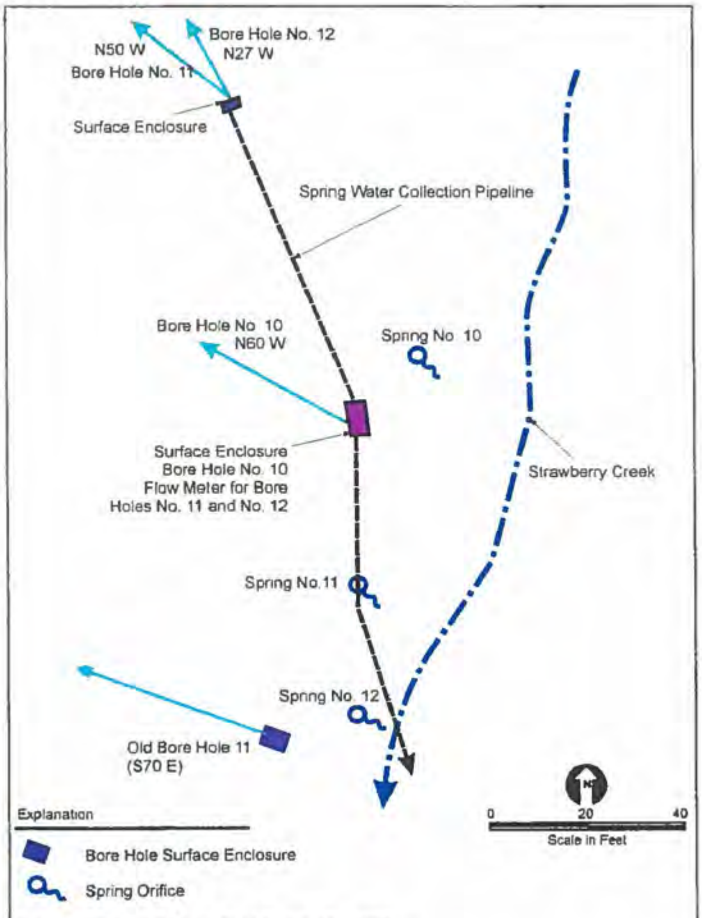


Figure 1-9. Spring No. 7 Collection Facilities

replaced by the current group of bore holes located near Spring No. 7. The locations of the four currently used horizontal bore holes are shown on Figure 1-9.

The bore holes are constructed of schedule 40 galvanized steel casing and schedule 40 galvanized steel screen at the end of each casing. Bore Holes No. 7, No. 7A, No. 7B, and No. 7C are protected inside a single concrete block enclosure shown in Figure 1-10.

Figure 1-10. Bore Hole Enclosure at Spring No. 7



Reference: Dames & Moore Field Sketch, May 1998
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Figure 1-11. Site Map of Lower Spring Complex

Access to the surface piping connected to these bore holes is provided through a locking steel door. Bore Hole No. 7 is about 290 feet long, and is oriented N23°E. Bore Hole No. 7A is approximately 230 feet long, and is oriented N19°W. Bore Hole No. 7B is approximately 397 feet long, and is oriented N37°E. Bore Hole No 7C is approximately 300 feet long, and is oriented N50°W. A sampling port and totalizing flow meter are connected to the bore hole pipes where they extend to the surface. From the enclosure, water flows from the totalizing flow meter, through above-ground, ductile iron pipe to the storage tanks located above the loading station. Pertinent data for the bore are presented in Table 1-2.

LOWER SPRING COMPLEX

The components that make up the Lower Spring Complex include Springs No. 10, No. 11, and No. 12, and Bore Holes No. 10, No. 11, and No. 12. Figure 1-11 shows the location of the springs in relation to the bore holes at this complex. The Lower Spring Complex is the southernmost complex at the site, and occurs at the lowest elevation of any of the spring areas. The springs and bore holes in the Lower Spring complex are described in the paragraphs below.

Figure 1-12. Spring No. 10

Figure 1-13. Spring No. 11

Springs No. 10, No. 11, and No. 12

Springs No. 10, No. 11, and No. 12 are natural springs that flow from the granitic hillside in the Lower Spring Complex. These springs are discussed as a group as they represent an area of measurable spring flow along this section of hillside. At an elevation between 4,140 and 4,160 feet above msl, these springs are at a lower elevation than the

Figure 1-14. Spring No. 12

Figure 1-15. Bore Hole No. 10

other springs at the site. The three springs issue forth in an area of dense phreatophyte foliation, common to spring sites in the San Bernardino Mountains. Figure 1-12 shows spring No. 10, and also shows the V-notch weir used for measurement of the flow from Spring No. 10. Figures 1-13 and 1-14 show Springs No. 11 and No. 12, respectively. Flow measurements were collected from each spring between June 18 and June 30, 1998. During our monitoring, flow from Spring No. 10 was approximately 26 gpm, Spring No. 11 flowed at about 10 gpm, and Spring No. 12 flowed at about 31 gpm.

Bore Holes No. 10, No. 11, and No. 12

Groundwater discharging from Springs No. 10, No. 11, and No. 12 is intercepted by Bore Holes No. 10, No. 11, and No. 12. Bore Hole No. 10 is located about 19 feet southwest of Spring No. 10, about 35 feet north of Spring No. 11, and approximately 60 feet north of Spring No. 12. Bore Holes No. 11 and No. 12 are located about 75 feet north-northwest of Spring No. 10. The concrete block enclosure for Bore Hole No. 10 is shown on Figure 1-15, while the enclosure for Bore Holes No. 11 and No. 12 is shown on Figure 1-16.

Bore Hole No. 10 is at an elevation of approximately 4,145 feet above msl, and Bore Holes No. 11 and No. 12 are at about 4,160 feet above msl. The construction of these three bore holes is similar to other bore holes at the site. The bore holes are all horizontal and are constructed of schedule 40 galvanized steel casing and has schedule 40 galvanized steel screen at the end of each casing.

Figure 1-16. Bore Holes No. 11 and No. 12

The construction of the surface boxes, however, varies slightly from other bore holes. The enclosures are made out of concrete block, but access is provided through a steel door attached to the top of each enclosure. Bore Hole No. 10, is located in a separate concrete enclosure that also contains the totalizing flow meter for the combined flow of Bore Holes No. 11 and No. 12 (see figure 1-15). A separate enclosure, located up-slope, houses Bore Holes No. 11 and No. 12 (see figure 1-16). A sampling port is located at the end of the piping for Bore Holes No. 11 and No. 12. The spring discharge pipes are then joined together and spring water flows through below-ground piping to the enclosure for Bore Hole No. 10. Pertinent data for Bore Holes No. 10, No. 11, and No. 12 are presented in Table 1-2.

HISTORY OF THE ARROWHEAD SPRINGS

In 1857, a young pioneer from Ohio named David Noble Smith came to southern California to the town of San Bernardino to prospect for gold. Smith, aided by a prominent local resident, Mr. John Brown, Sr., purchased land below the "Arrowhead" at the base of the San Bernardino Mountains. The "Arrowhead," shown in Figure 1-17, is a naturally-occurring image of an Indian arrowhead that is a well-known landmark in this area. Located in the southeast corner of Section 2, Township 1 North, Range 4 West, the "Arrowhead" is easily seen from State Highway 18 when driving past the entrance to the Arrowhead Springs area where the loading station and storage tanks are located, about 2 miles southeast of the spring site. Variations in geology and soil conditions in this part of the mountain side, and resultant variations in vegetation, have formed a near-perfect "Arrowhead" shape on the side of the San Bernardino Mountains. This natural image is the source of the name "Arrowhead" given to many of the developments in this area between Arrowhead Springs to the south and Lake Arrowhead, located farther northeast.

At the time that Smith first came to the area, there were abundant flowing springs in Strawberry Canyon. In 1858, Smith and Brown made an attempt to improve the springs in Strawberry Canyon, but abandoned the project due to the inaccessibility of the area.

In 1864, Smith opened a spa or "infirmary" next to Strawberry Creek near the naturally-occurring hot springs located about ½ mile south of the "Arrowhead." This area, commonly referred to today as the Arrowhead Hot Springs, became the first resort facility at this location. As noted above, this is also the current location for the storage tanks and loading station for spring water from the Arrowhead Springs farther up Strawberry Canyon. It reportedly was "Dr." Smith's vision to open a health resort. Smith had a vision that the climate and "curative" waters of the hot springs would be beneficial. The spa featured a large (100 foot by 75 foot) swimming pool fed by the hot springs on the property. The fresh water supply for the spa was Strawberry Creek, flowing down from the mountains and the abundant cold water springs located up the canyon.

Figure 1-17. "Arrowhead" in the Mountains

The spa was converted into a hotel and resort in 1885. The property was sold several times and was eventually acquired by a group of investors headed by Seth Marshall. By 1905, Marshall had built a new hotel on the property, and began selling water from the spring-fed Strawberry Creek soon after his hotel opened. The water was captured near the hotel and was bottled in the basement of the hotel in pint, quart, and gallon size bottles. The popularity of the water quickly spread. Marshall soon started bottling the water in 5-gallon containers. In 1909, the Arrowhead Springs Corporation began bottling operations at a plant in Los Angeles. Water was shipped from Arrowhead Springs to the plant by rail and stage. With new construction in the canyon, a way to protect the natural purity of the water was sought. Mr. Anthony Martins, the grounds superintendent for the hotel (beginning in 1914), located the springs near the 5,200 foot elevation of Strawberry Canyon. Consolidated Water Company was formed, and began development of the spring source in Strawberry Canyon in April 1930.

Water was collected from two of the springs (Spring No. 2 and No. 3) using engineered collection tunnels, excavated into the granite hillside. A pipeline was constructed from the springs through the rugged mountain terrain, down to the resort. The spring water was stored in reservoirs constructed at the resort before shipment to the bottling plant. The pipeline was approximately 37,300 feet long when first constructed. Spring No. 4 was partially developed during the installation of the pipeline; however, construction of the collection facilities at Spring No. 4 was never completed

Spring No. 1 was partially developed in 1932, and completed in 1948 by Mr. J. H. Hibner. This original development was abandoned and replaced by a horizontal bore hole in June 1976. Spring No. 8 was developed about 50 feet west of Spring No. 1 in 1950 and redeveloped in 1966. The original spring development was abandoned and a new bore hole, Bore Hole No. 8, was installed in August 1993. Bore Hole No. 1A was installed between Bore Holes No. 1 and No. 8 in August 1993.

Spring No. 3 was developed in 1931 by the installation of engineered collection facilities (or tunnels). Springs No. 5 and No. 6 are located in branches of Strawberry Canyon east of the main pipeline. These springs, located in very steep terrain, were partially developed in 1932 and 1935 respectively. They were never included in the spring water collection operation because of the high cost for full development.

An engineered collection tunnel at Spring No. 7 was begun in 1933 and completed in 1934. Horizontal bore holes (old Bore Holes No. 7A and No. 7B) were drilled at this spring in 1950. Harvesting of spring water from the engineered collection tunnel at Spring No. 7 was discontinued in 1961, about the same time that old Bore Hole No. 7C was completed. New bore holes replaced the original group installed at this spring. The new bore holes are the current Bore Holes No. 7, No. 7A, and No. 7B that were installed in 1992, and Bore Hole No. 7C that was installed in July 1993.

Bore Holes No. 10, No. 11, and No. 12 were originally installed in 1978 near a group of springs at about the 4,200 foot elevation along Strawberry Creek. Use of "Old Bore Hole 11" was discontinued, and a new bore hole, Bore Hole No. 11, was installed at a new location in May 1994 farther up the canyon, next to Bore Hole No. 12. Bore Holes No. 10 and No. 12 were reconstructed in June 1994.

Today, the Arrowhead Springs continue to be a major, well-known source of mountain spring water. Bottled Arrowhead Mountain Spring Water is widely distributed, and continues to be a popular source of drinking water.

SECTION 2

ENVIRONMENTAL SETTING

As part of our preliminary assessment, we have reviewed the topography, the climate, the geology, the groundwater, and the vegetation in the vicinity of these springs. This section presents a brief summary of this information.

TOPOGRAPHY

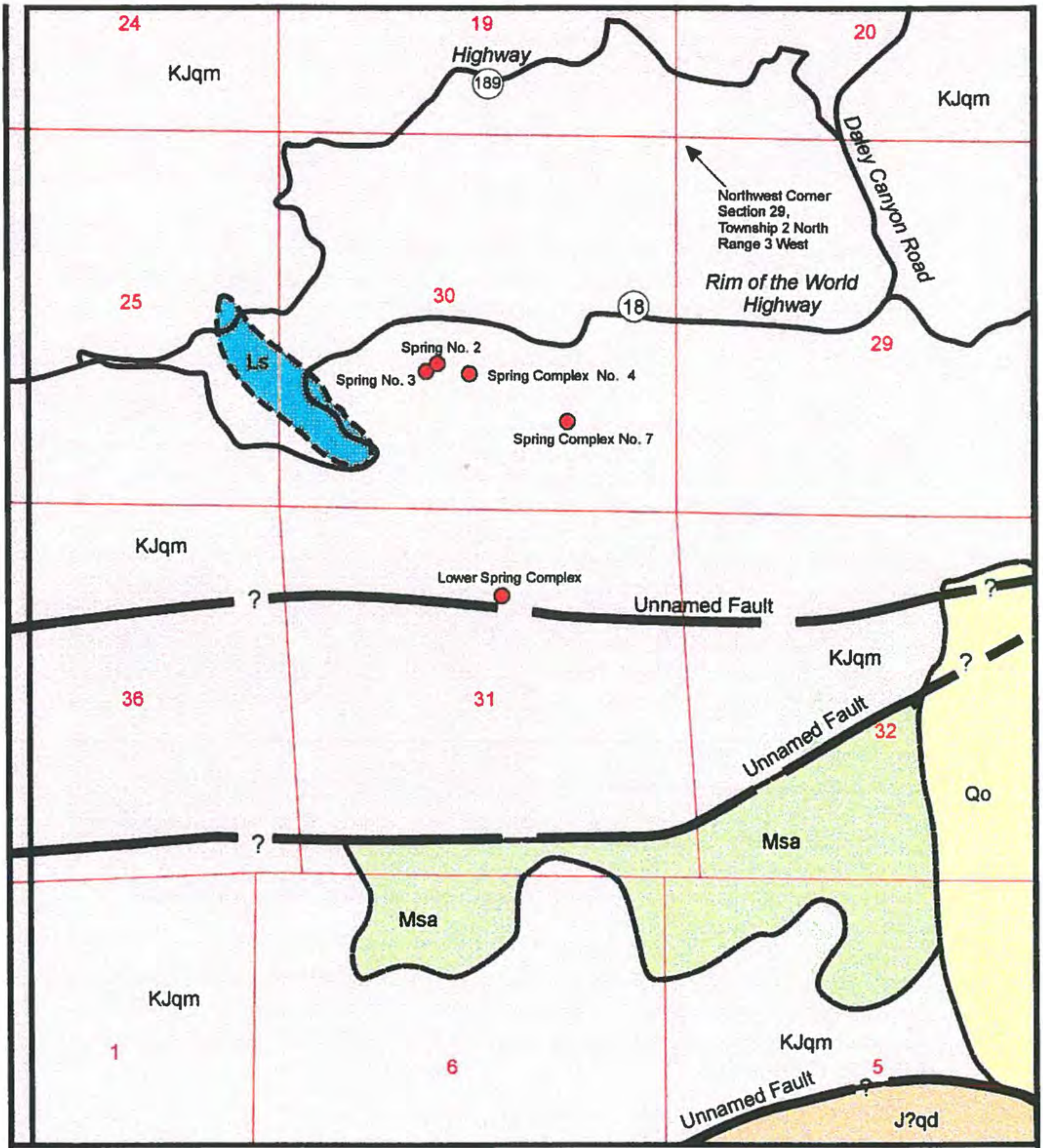
The Arrowhead Springs site is located along the south flank of the San Bernardino Mountains, and includes steep and rugged terrain along the southern slopes of the mountain. The Arrowhead Springs are located north of the city of San Bernardino, California, within the San Bernardino National Forest. Figure 1-1 in Section 1 shows the topography in the area of the springs. The Arrowhead Springs site ranges in elevation from about 4,100 feet above msl in the lower elevation portion to about 5,300 feet above msl at the higher portion. Figure 2-1 is a view of the southern slope of the San Bernardino Mountains in the area of the spring sites, showing the steep topography in the area.

Figure 2-1. Southern Slope of San Bernardino Mountains Near Arrowhead Springs

The hillsides in the vicinity of Arrowhead Springs generally slope at about a 50 percent grade (about 2,500 feet per mile) with steeper sections near stream channels. Individual slopes near the springs range from 20 to 65 percent or more, with stream channels eroding nearly-vertical granitic canyon walls in some locations. The Arrowhead Springs site is about midway up the mountain near the crest of the bedrock slopes. The mountains continue upward in elevation to the north, reaching heights in excess of 6,100 feet msl within ½ mile north of the site.

CLIMATE

In the San Bernardino Mountains, the climate varies depending on the local topography. In the valley area to the south and west the climate is semi-arid. San Bernardino County generally has hot, dry summers and mild winters. The Transverse Ranges of San Bernardino County, including the Arrowhead Springs area, have more variation in temperature than the valley regions, with mean annual temperatures between 52 and 57 degrees Fahrenheit (°F).



Explanation

Qo: Quaternary Older alluvium
Msa: Miocene Santa Ana Sandstone
KJqm: Cretaceous or Jurassic quartz monzonite
J?qd: Jurassic (?) Quartz diorite
Ls: Paleozoic Metasedimentary Rock

? Fault (approximate)
Formation Contact (approximate)
6 Section Lines and Numbers

References: Bortugno, E. J., and Spittler, T. E., 1986, Geologic Map of the San Bernardino Quadrangle, California. 1:250,000; U. S. Geological Survey, 1988, Harrison Mtn and San Bernardino North, Calif.,7.5 Minute Quadrangle Maps.

C jlg\corel\draw\figures\pga\esgeo cdr

N

0 2,000 4,000

Approximate Scale in Feet

Figure 2-2
Local Geology Map
Arrowhead Springs
San Bernardino Mountains, California

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Annual rainfall ranges from 20 to 40 inches per year, and is seasonal in this area. Most of the precipitation occurs in the cooler months of winter and early spring. Precipitation rates vary widely in these mountains. Most rainfall events are intense and irregularly distributed. At elevations above 4,000 feet msl, snow is the common form of precipitation in the winter months. Snow accumulates during winter in the higher elevations, and the snow-pack melts during the warmer seasons providing water for infiltration into the ground and recharge of the groundwater within the mountains.

GEOLOGY

The Arrowhead Springs are located on the large uplifted granitic rock mass that comprises the San Bernardino Mountains. Over time, these rocks have been fractured and sheared primarily by tectonic activity along the San Andreas Fault Zone. The fault zone is located along the base of the mountains, approximately two miles south of the study area. Fractures and joints have been subjected to water infiltration, causing the surrounding rock to weather and erode. However, the rate of erosion has not kept pace with the rate of uplift along the fault, and fresh to slightly weathered rock exposures are evident throughout the study area.

The San Bernardino Mountains lie within the central portion of the Transverse Ranges. The San Andreas Fault Zone, the primary structural feature in the area, trends northwest-southeast dissecting the Transverse Ranges about seven miles east of the site. Plutonic rock types predominate in the vicinity of Arrowhead Springs. Figure 2-2 is a geology map of the area in the vicinity of the springs showing the principal rock types, several unnamed faults that are structurally related to the San Andreas Fault Zone, and the locations of the Arrowhead Springs.

The granitic and metaplutonic rocks in the area around the springs are of Jurassic or late Cretaceous age and consist principally of quartz monzonite, known locally as the Cactus Granite (Norris & Webb, 1976). This rock crops out as weathered blocks and weathered-in-place boulders over most of the area. Its composition is chiefly quartz, orthoclase, plagioclase, and biotite, which results in a light-gray appearance. Although the host rock is generally medium-to-coarse grained, it shows an abundance of foliation, grading to a gneiss, and is intensely fractured. Many of the fractures show evidence of alteration along the fracture faces. Pegmatite dikes are common and intrude both the granites and the metasediments. The dikes typically contain large pink crystals of potassium feldspar and are also intensely fractured.

Soils in the area are generally rocky, coarse, sandy loam. The local soils have developed by weathering in place of the underlying granite bedrock. Thickness of soils ranges from zero to less than about 5 feet. Due to weathering in place, it is often difficult to distinguish between the base of the "soil" layer and the top of the "weathered granite," because this change is gradual. As a result of this condition, no distinct soil layers have been mapped in this area. Instead, the surface materials have been mapped as bedrock.

GROUNDWATER

In the San Bernardino Mountains, groundwater generally occurs in the fractures and joints of the granitic bedrock. The intense fracturing associated with the San Andreas Fault Zone has produced an intricate system of intersecting fractures throughout the rock mass, which gives the rocks considerable secondary porosity and permeability.

The source of water to this fractured-rock aquifer system is infiltration of precipitation and snowmelt in the higher reaches of the mountains. In the vicinity of the town of Rimforest, where the average annual rainfall is around 41 inches, there is considerable water available for infiltration into the rock, and percolation downward through the fractures.

Following infiltration, the groundwater collects in the fractures forming a water-table aquifer. The water then slowly percolates laterally and downward to points of natural discharge to the surface. At the face of the granite slopes of the mountain, groundwater discharges naturally to the surface through springs.

The springs are the surface expression of the water table in fractures in the granitic rocks, through which the groundwater flows to the surface. Certain fractures are larger than others, and the larger fractures provide higher rates of flow from the fractured-rock aquifer.

VEGETATION

As shown in Figure 2-3, the abundant rainfall on the mountain slopes near Arrowhead Springs supports a variety of forest vegetation. Near the springs are found alders, sugar pine, yellow pine, incense cedar, oak, and sycamore. Most of the taller trees occur in streamside woodlands in the lower portions of the canyons. Also present under the forest canopy along the creek channels are wild lilac, juncus grass, goldenrod, lupine, buttercups, poison ivy, and ferns. Near the springs, ferns and alders are especially prominent. The presence of ferns and alder trees is a common indicator of the existence of springs because these plants require a continual supply of shallow water that normally will occur only where there are springs.

Figure 2-3. Vegetation Near Arrowhead Springs

SECTION 3

HYDRAULIC CONNECTION

Springs may be developed with engineered collection facilities installed at the spring orifice, or they may be developed using bore holes that intercept the groundwater that normally flows through the natural orifices of the springs. Spring water may be collected either from the spring orifice or from the bore holes. It is important, however, for the source of the spring water, the underground source of the water, to be the same whether collected from a spring's natural orifice or from a bore hole.

FDA REGULATIONS

The Food and Drug Administration (FDA) discussed this issue in its 1995 Regulations:

> **"... water that is from an underground formation from which water flows to the surface, and that has the same physical properties, quality, and composition as the water that flows to the surface, is fairly and appropriately considered to be spring water even if it is extracted by use of a bore hole." (FDA, 1995, p. 57092.)**

The FDA Regulations discuss the appropriateness of testing to ensure that the water collected from the bore hole is the same as the water that flows naturally to the surface of the earth. (FDA, 1995, p. 57094.) According to FDA, there must be a

> **"... hydraulic connection between the bore hole and the natural spring ...."**
> **(FDA, 1995, p. 57094.)**

To address this issue, FDA modified its definition of "*spring water*" to require that

> **"... a measurable hydraulic connection, using a hydrogeologically valid method, between the bore hole and the natural spring, be established to show that the water is from the same underground stratum as the spring." (FDA, 1995, p. 57093.)**

The FDA further states that the water extracted from a bore hole must

> **"... be of the same composition and quality as the water that flows naturally to the surface of the earth. Water from a different underground stratum will have different properties and characteristics. Thus the water will not meet the definition of spring water unless it has the same properties and characteristics as the water that flows through the spring's natural orifice." (FDA, 1995, p. 57902.)**

In discussing the application of hydrogeological methods that may be used to demonstrate this, the FDA Regulations point out that

> **"... one or more hydrogeologically valid methods may be used as appropriate to determine hydraulic linkage. However, not all methods may be appropriate for different geologic regions or for the specific bore hole site. Therefore, the agency is not recommending or requiring any specific method or methods." (FDA, 1995, p. 57093.)**

FDA provided several examples of hydrogeologically valid methods for this purpose. Those example methods include: dye tracer tests, geophysical conductivity tests, hydraulic flow testing, and water analysis comparisons.

Where flows are sufficiently great, hydraulic connection can be demonstrated by hydraulic flow testing between bore holes and springs. If the natural flow of the spring decreases when a bore hole is allowed to drain water from the underground formation, this demonstrates a hydraulic linkage or connection between the bore hole and the spring. Similarly, if there is an increase in the natural flow from a spring when a bore hole that is discharging water to the surface is closed off, this also demonstrates hydraulic connection between the bore hole and spring.

In some instances hydraulic connection may not be demonstrable using flow testing due to the specific characteristics at a given spring or bore hole. In considering this issue, FDA has acknowledged that

> **"... if the withdrawal rate from the bore hole is small relative to the discharge rate of the spring, or if the spring is submerged, this decline may not be measurable."**
> **(FDA, 1995, p. 57092.)**

When hydraulic or geophysical methods are not applicable, water quality comparisons may be used for demonstrating the hydraulic connection between a bore hole and a spring. Several analytical techniques are available for comparing the water quality of a spring and an associated bore hole. The Stiff and Piper diagrams are two graphical methods mentioned in the FDA Regulations as examples of the variety of hydrogeologically valid graphical techniques available for comparison of water quality data. (FDA, 1995, p. 57902.) These methods, or other more appropriate graphical methods, may be used to demonstrate that the chemical and physical characteristics of the water from a bore hole correspond to those of the water from a natural spring orifice. Thus, water quality comparisons are valid methods to demonstrate that the water from the bore hole is the same as the water from the spring.

Results of chemical testing of the Arrowhead Springs and bore holes, and comparison of chemical data between springs and associated bore holes, are discussed in Section 4 of this report. The following paragraphs describe the hydraulic flow testing at Spring Complexes No. 4 and No. 7, and at the Lower Spring Complex. Springs No. 2 and No. 3 have been improved through the development of engineered collection facilities at the natural spring orifice, and spring water is harvested directly from these springs. There are no associated bore holes at Springs No. 2 and No. 3, and therefore, no need to demonstrate hydraulic connection at these locations.

HYDRAULIC TESTING

Testing for hydraulic connection was conducted by The Hydrodynamics Group for the bore holes adjacent to Spring No. 4 and Spring No. 7. Monitoring data from these tests are presented in Appendix C. Testing of Bore Holes No. 10, No. 11 and No.12 in the Lower Spring Complex was conducted by Dames & Moore. To test the hydraulic connection, the flow of spring water from bore holes near the springs was shut off, and the rate of flow from the springs was monitored for any changes. Changes in spring flow rates resulting from changes in bore hole flow rates would demonstrate hydraulic connection between the spring and the bore hole.

SPRING COMPLEX NO. 4

Bore Holes No. 1, No. 1A, and No. 8 were turned off on March 17, 1997, after the bore holes had been producing spring water for some time, and the flow rate issuing from Spring No. 4 was monitored for any changes. Changes were monitored using a ½-inch diameter Signet Flow Meter, and data were recorded on a Unidata Data Logger at intervals of 15 minutes. The flow from Spring No. 4 was relatively constant at about 6.7 gpm during the test period. The data collected show a diurnal dip in apparent flow amounting to about 1 percent of the total flow rate. This dip in spring flow occurred each day near the peak sunshine hours of the midday and afternoon. The apparent reduction of flow may be due to the effect of evapotranspiration through plants that have tapped into the saturated fracture system for their source of water, or due to temperature related changes to the data logging and collection equipment when that equipment was exposed to direct sunlight.

During a one day connection test with the bore holes closed, there was less than 1 percent increase in the flow rate from Spring No.4. When the bore holes were opened again on March 18, there was a less than 1 percent decrease in flow. The increase in flow occurred at the same time as the diurnal change that was observed each day. Thus, hydraulic connection test data collected from this spring were inconclusive in showing a hydraulic connection between these three bore holes and Spring No. 4.

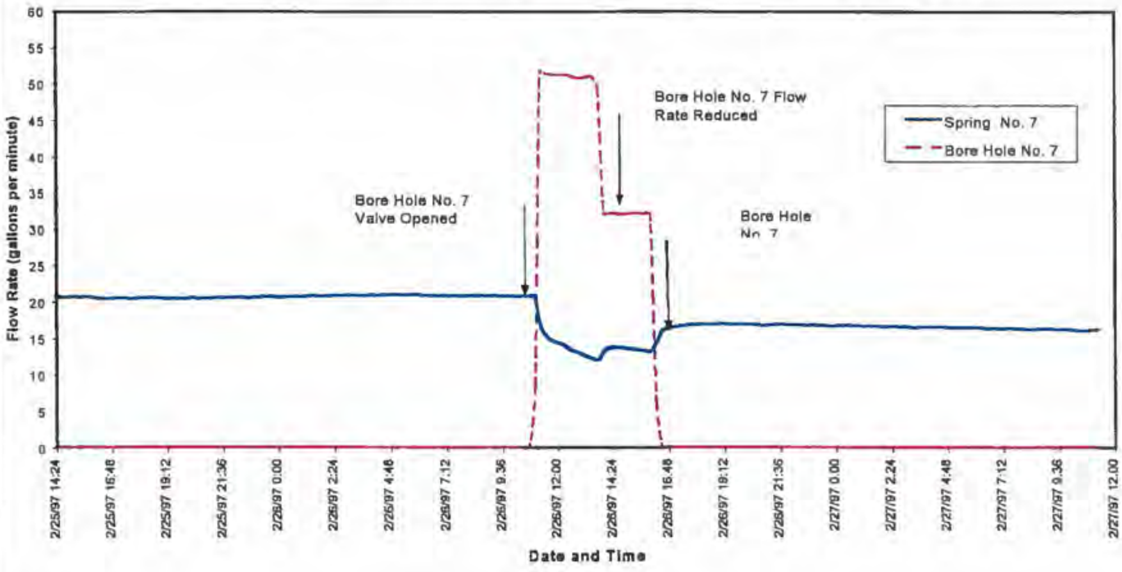
The fact that the spring is at a lower elevation than the bore holes, may provide an explanation for the inability to detect a change in flow. The hydrostatic head, and the flow rate from the spring resulting from the hydrostatic head, were not significantly affected by shutting off the flow from the three bore holes, because these bore holes are located above Spring No. 4. The small volume of spring water that is produced by gravity flow through each bore hole is not enough to affect the flow of Spring No. 4 a short distance away at a lower elevation. This is because each bore hole causes only a small depression in the piezometric surface, and this depression does not result in a significant change in the water table below the bore holes at the spring.

As noted above, the FDA Regulations anticipated situations in which ". . . the withdrawal rate from the bore hole is small relative to the discharge rate of the spring . . ." and acknowledged that other means for demonstrating hydraulic connection may be appropriate for these springs. Therefore, the chemical similarities between waters at this location is the most appropriate means to demonstrate a hydraulic connection. This assessment is presented in Section 4, later in this report.

SPRING COMPLEX NO. 7

The flows at Spring No. 7 and Bore Hole No. 7 were monitored from February 25 through April 15, 1997. Spring No. 7 was monitored using a ½-inch diameter Signet Flow Meter, and Bore Hole No. 7 was monitored using a 2-inch diameter Signet Flow Meter. Data were recorded at 15 minute intervals on a Unidata data logger. The flows for the other bore holes were monitored with totalizing flow meters installed at each bore hole. Figure 3-1 is a graph showing the flows from Bore Hole No. 7 and Spring No. 7 from February 25 to 27, 1997. As the figure shows, when the flow to Bore Hole No. 7 was turned on at a rate of about 50 gpm, the flow to Spring No. 7 decreased from 20 gpm to approximately 13 gpm.

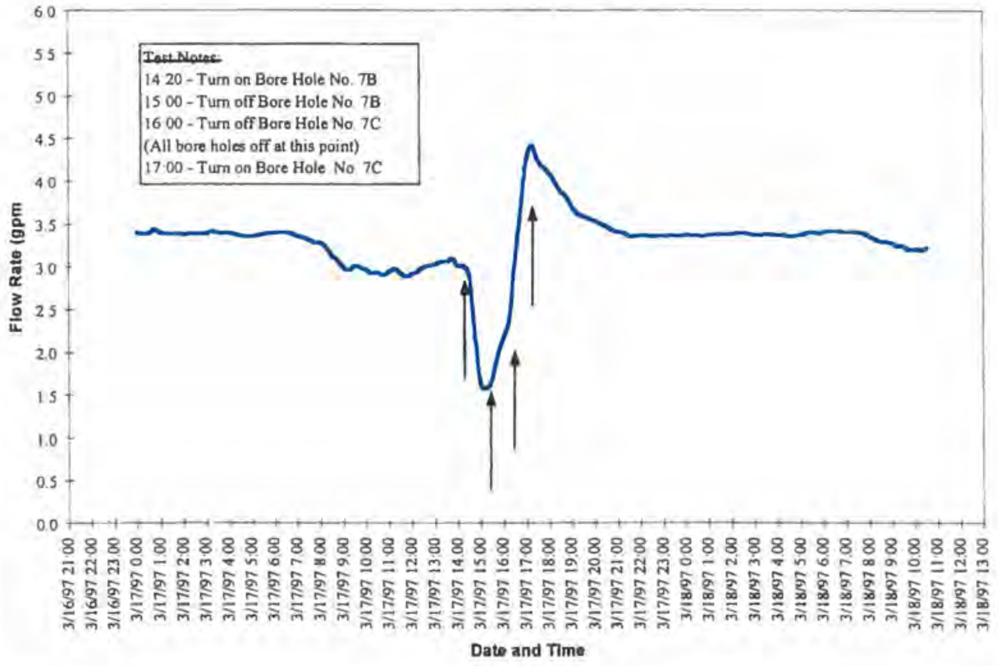
Figure 3-1. Hydraulic Connection Testing Bore Hole No. 7 and Spring No. 7



Hydraulic connection testing was also conducted at Spring No. 7 using Bore Holes No. 7B and No. 7C. During this test, conducted on March 17, 1997, Bore Holes No. 7 and No. 7A were off for the entire time of the test. This test consisted of monitoring the flow rate at Spring No. 7 while the rates of flow at Bore Holes No. 7B and No. 7C were varied.

Figure 3-2 shows a graph of the flow measured at Spring No. 7 during the test. Prior to 14:20 on March 17, 1997, Bore Hole No. 7C was allowed to flow at 45 gpm, while bore Hole No. 7B was shut off. When Bore Hole No. 7B was opened, at 14:20, there was a nearly immediate reduction in the flow rate for Spring No. 7 from about 3.5 gpm (with only Bore Hole No. 7C flowing) to about 1.5 gpm. At 15:00, while Bore Hole No. 7 continued flowing, the valve at Bore Hole No. 7B was closed. Closing the valve at Bore Hole No. 7B produced a nearly-immediate increase in flow in Spring No. 7, and the rate of increase tended to decline with time. At 16:00, the valve on Bore Hole No. 7C was

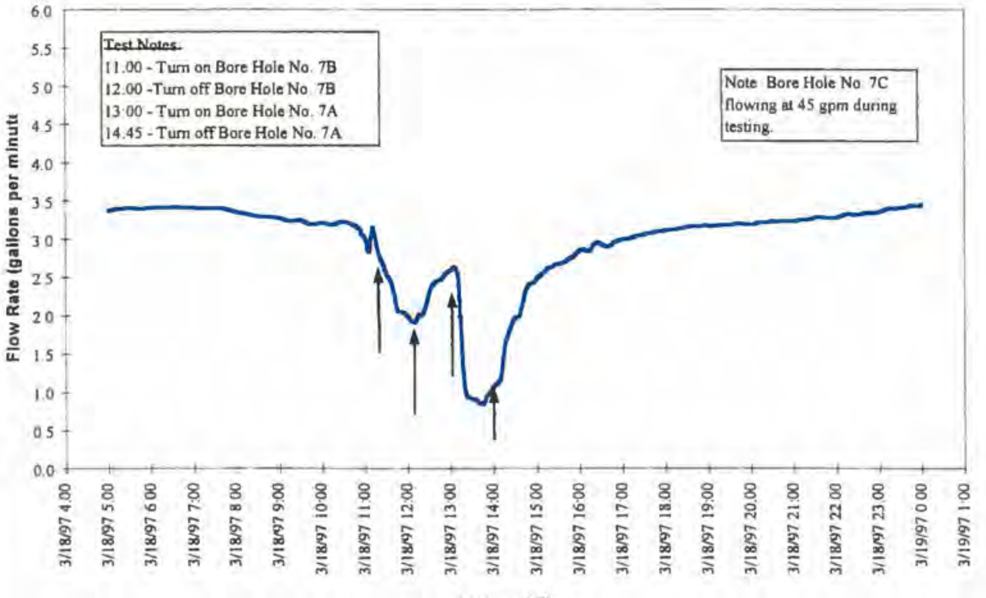
Figure 3-2. Hydraulic Connection Testing, Bore Holes No. 7B and 7C and Spring No. 7



closed, shutting off that 45 gpm flow. As Figure 3-2 shows, there was a nearly-immediate increase in the rate of change in flow at Spring No. 7. Between 15:00 and 17:00, the flow rate from Spring No. 7 increased from about 1.5 gpm to about 4.5 gpm as a result of closing both Bore Holes No. 7B and No. 7C. At 17:00, the valve at Bore Hole No. 7C was again opened, resulting in a reduction in flow from Spring No. 7 to about 3.5 gpm, similar to the flow rate at the beginning of the test.

A similar hydraulic connection test was conducted at Spring No. 7 using Bore Holes No. 7A and 7B on March 18, 1997. Figure 3-3 shows the graph of the flow measured at Spring No. 7 during this test. Throughout this test, the valve on Bore Hole No. 7C was open, and this bore hole flowed continuously at 45 gpm. The flow from spring No. 7, with Bore Hole No. 7C open, and Bore Holes No. 7A and No. 7B closed, was about 3.5 gpm, similar to the previous test. At 11:00, Bore Hole No. 7B was opened. This produced a decline in flow at Spring No. 7 to less than 2 gpm, similar to the previous test. For this test, Bore Hole No. 7B was closed at 12:00, and the flow rate from spring No. 7 began to increase. At 13:00, the valve on Bore Hole No. 7A was opened. This produced a nearly-immediate change in flow rate from spring No. 7, and the flow rate declined rapidly. At 14:45, when the flow rate at Spring No. 7 had declined to less than 1 gpm,

Figure 3-3. Hydraulic Connection Testing, Bore Holes No. 7A and No. 7B and Spring No. 7



the valve at Bore Hole No. 7A was closed. The flow rate at Spring No. 7 responded nearly immediately by increasing, rapidly at first, and slower with greater time. By the end of the day, the flow rate from Spring No. 7 had increased to its pre-test rate of about 3.5 gpm.

The results of hydraulic connection testing at Spring No. 7 confirmed that there is direct hydraulic connection between the bore holes and the spring. Each of the bore holes, Bore Holes No. 7, No. 7A, No. 7B, and No. 7C, have been shown to be hydraulically connected to Spring No. 7. The conclusion from this testing, therefore, is that these four bore holes are producing spring water, the same spring water that is flowing to the surface of the ground naturally through Spring No. 7.

LOWER SPRING COMPLEX

Dames & Moore conducted testing of Bore Holes No. 10, No. 11, and No. 12 in May and June 1998. The flows from Springs No. 10, No. 11, and No. 12 were diverted through temporary, plastic, V-Notch weirs. The weirs were installed to capture as much of the flow from each spring as possible. There is a direct relationship between the height of water flowing over a V-Notch weir and the rate of flow. This relationship is presented in the following equation.

$$\mathbf{Q = (C)(120)(L)(H)(2gH)^{1/2}}$$

where:

Q = flow of water, in gpm;
L = length of weir opening at a distance of **H** above apex, in feet;
H = height of water above the apex of the notch, in feet;
C = a constant varying with conditions, commonly 0.57; and
g = the acceleration due to gravity.

Figure 3-4. V-Notch Weir At Spring No. 12

Figure 3-4 shows the 60°-V-Notch weir used at Spring No. 12. The weir was constructed using a 5-gallon plastic bucket with a 60° angle, "V" shaped notch cut into the bottom. This type of construction was typical for each of the springs tested. Natural earth materials were used along with plastic sheeting to form the collection area from the spring to the weir, so that the maximum amount of spring flow could be measured. The flow from Spring No. 10 was between 22 and 26 gpm. Spring No. 11 flowed at a rate between 8.5 and 10 gpm. Flow from Spring No. 12 was between 22 and 31 gpm. The total flow from the three springs, while the bore holes were fully open, ranged from about 53 to 67 gpm, a range of variation of about 20 percent. Flows from Bore Holes No. 10, No. 11, and No. 12 were shut off and the springs were monitored for any increase in flow. The magnitude of the change in flow produced by shutting off the bore holes was not sufficient to cause a measurable change in spring flow. This was due to both the relatively low flow rates from the bore holes and to the range of variability in flow rates from the springs. The flows from bore Holes No. 10, No. 11, and No. 12 were about 37 gpm, 3 gpm, and 10 gpm, respectively. The total flow from these three bore holes was about 50 gpm.

The results of the hydraulic connection testing at the Lower Spring Complex did not show a significant increase in flow at these springs when the flow through the three bore holes was shut off. As noted above, and as described for the bore holes near Spring No. 4, the FDA Regulations anticipated situations in which the flow characteristics at specific springs and bore holes would not be adequate to demonstrate the hydraulic connection between the bore holes and the springs. For the bore holes in the Lower Spring Complex, therefore, chemical similarity is the most appropriate means to demonstrate the hydraulic connection.

SUMMARY OF HYDRAULIC CONNECTIVITY TESTING

Hydraulic connectivity testing was performed for all of the bore holes used to harvest spring water for bottling purposes. The testing consisted of modifying the flow from the bore holes adjacent to the springs, and monitoring changes in spring flow rates caused by changes in flow rates at the bore holes. Based on these tests, it was demonstrated that:

- Bore Hole No. 7 is hydraulically connected to Spring No. 7.
- Bore Hole No. 7A is hydraulically connected to Spring No. 7.
- Bore Hole No. 7B is hydraulically connected to Spring No. 7.
- Bore Hole No. 7C is hydraulically connected to Spring No. 7.

The tests for for hydraulic connection between Bore Holes No. 1, No. 1A, and No. 8, and Spring No. 4, were inconclusive due to limitations in the flow rates of these sources and diurnal changes in flows. Similarly, the tests in the Lower Spring Complex for hydraulic connection between Bore Holes No. 10, No. 11, and No. 12 and Springs No. 10, No. 11, and No. 12 were inconclusive due to both limitations in the flow rates and variability in flow measurements from the springs. Hydraulic connection in these two areas is addressed using chemical similarities in spring water from the springs and associated bore holes as described in the following section, Section 4.

SECTION 4

CHEMICAL ANALYSIS OF SPRINGS AND BORE HOLES

This section of the report presents the results of chemical analyses of water samples from the springs and bore holes at Arrowhead Springs, and provides a discussion of the results of those analyses. The paragraphs below first discuss methods of graphical analysis, followed by a discussion of the sampling and analytical procedures, then the results of analyses, and finally the results of chemical evaluation of water samples on a source-by-source basis.

GRAPHICAL ANALYSIS OF CHEMICAL DATA

There are numerous graphical analytical tools available for use in assessing the results of chemical analyses of water samples. Two of the more common techniques are the Piper diagram and the Stiff diagram. Both methods use a select group of compounds for comparison of water quality data. The Piper diagram, however, combines certain compounds and uses percentages instead of the actual concentrations. Neither method can appropriately address compounds such as silica (SiO_2) which is neither cationic nor anionic, or other parameters such as pH and electrical conductivity.

When the total dissolved solids (TDS) content of the water is sufficiently high, the Piper and Stiff Diagram methods can be effective tools for analysis of water chemistry data. For higher TDS samples the effect of other compounds such as SiO_2 is relatively low and can sometimes be ignored in assessing the data. However, when the TDS of the samples is low, these methods may not provide a fair and adequate assessment. The water samples from Arrowhead Springs are generally low in TDS. The range of TDS values for these samples is 91 milligrams per liter (mg/L) to 161 mg/L. The range of SiO_2 values is 23 mg/L to 49 mg/L, which amounts to a significant percent of the TDS for these samples. Thus, SiO_2 should not be ignored in assessing these data. Similarly, the other compounds, even in low concentrations, and the other parameters such as pH and electrical conductivity, should not be ignored in these assessments. Further discussions of the limitations of the Piper and Stiff diagrams, and the suitability of other graphical techniques are presented in Appendix D. For analysis of the chemical data for these samples, we have selected a "radar" diagram, as described below.

A radar diagram is a circular plotting technique that shows the magnitude of each parameter plotted on a radial scale. By connecting the plotted points with lines, the resulting plot produces a characteristic shape or pattern for each analysis. The patterns for multiple samples can be easily compared, visually, allowing assessment of the similarities or differences between samples. The radar diagram also allows plotting of a larger number of compounds for use in the assessment, and can address non-ionic species as well as all cations, anions, and other parameters. We have chosen to use a logarithmic scale for each of the parameters plotted. The units for each of the compounds and other parameters plotted are the same units shown on the laboratory reports in Appendix E, and on the tables of data presented in the text, below. We have included all compounds analyzed for each of the sources for which one or more of the analyses shows concentrations that are at, or above, the minimum detection level. For convenience in plotting, we have used the maximum detection level (MDL) for those compounds with concentrations below the MDL.

WATER SAMPLING

As part of this study, samples of water were taken for chemical analysis from each of the seven springs and from the ten associated bore holes. The sampling was conducted on several dates during the period 1996 through 1998. Samples were collected by Dames & Moore and by The Hydrodynamics Group. The water samples were stored in refrigerated containers for shipment to the laboratory and for subsequent analysis. Samples were analyzed by Arrowhead Quality Services Laboratory, later known as P.G.A. Quality Services Laboratory. This laboratory is certified by the State of California to perform the analyses requested. Results of the analyses were provided in laboratory reports signed by both the chemist conducting the analysis and by the laboratory manager. Copies of the laboratory reports are presented in Appendix E.

Table 4-1 shows the MDL and the federal maximum contaminant level (FEDMCL) for appropriate compounds or parameters. Results of chemical analyses for samples from the springs and the associated bore holes are shown in separate tables within the discussion sections below. The tables also show the units for each parameter. Although SiO_2 is listed as an anion on the tables, it does not normally exist in an ionic state in groundwater. All the springs and associated bore holes are currently used for harvesting spring water for bottling, except for Springs No. 4, No. 7, No. 10, No. 11, and No. 12. At the locations of these five springs, associated bore holes are used for harvesting the spring water.

Table 4-1. Minimum Detection Limits and MCLs

Constituents	Units	Minimum Detection Level	Fed Max Contam Level
ANIONS			
Bicarbonate	mg/L	1.	NR
Chloride	mg/L	.5	250.
Fluoride	mg/L	.1	2.4
Nitrate (as N)	mg/L	1.	10.
Phosphate (as P)	mg/L	.05	NR
Silica	mg/L	.5	NR
Sulfate	mg/L	.5	250.
Nitrite	mg/L	.1	1.
Bromide	mg/L	.1	NR
CATIONS			
Aluminum	mg/L	.01	.2
Arsenic	mg/L	.005	.05
Barium	mg/L	.01	2.
Cadmium	mg/L	.001	.005
Calcium	mg/L	.5	NR
Chromium	mg/L	.001	.1
Copper	mg/L	.005	1.
Iron	mg/L	.01	.3
Lead	mg/L	.001	.005
Magnesium	mg/L	.05	NR
Manganese	mg/L	.003	.05
Mercury	mg/L	.001	.002
Potassium	mg/L	.01	NR
Selenium	mg/L	.005	.01
Silver	mg/L	.005	.1
Sodium	mg/L	.1	NR
Zinc	mg/L	.025	5.
Beryllium	mg/L	.0005	.004
Antimony	mg/L	.001	.006
Nickel	mg/L	.001	.1
Thallium	mg/L	.0005	.002
SECONDARY FACTORS			
Conductivity	uS/cm	1.	NR
TDS, Evaporated	mg/L	.5	NR
Total Alkalinity	mg/L	1.	NR
Total Hardness	mg/L	.5	NR
Turbidity Source	ntu	.1	5.
Temperature	Deg. F	.01	NR
pH	pH	NR	NR

NR - None Required

In addition to the chemical analysis results, cation-anion balances were conducted for each of the samples. This technique involves calculating the milliequivalents per liter (meq/L) for each of the major cations and anions, and comparing the totals for both cations and anions. If there is no significant difference between the total meq/L for cations and anions, the laboratory analysis results are considered reasonable and reliable. For these samples, the differences were calculated as a percent of total meq/L. The cation-anion balance differences for all analyses ranged from .57 percent to 23.52 percent, but averaged 3.70 percent. Bore Hole No. 7B was at the maximum at 23.52 percent. This difference could be due to a variation in the bicarbonate value in the sample, which is significantly higher than all other samples from Spring No. 7 and the other associated bore holes. This high bicarbonate level could result from errors in sampling, sample handling, laboratory testing procedures, or laboratory analysis procedures. However the average of 3.7 percent is reasonable, and indicates that the laboratory analyses are sufficiently reliable for use in subsequent assessment of the springs and bore holes.

Table 4-2. Spring No. 2

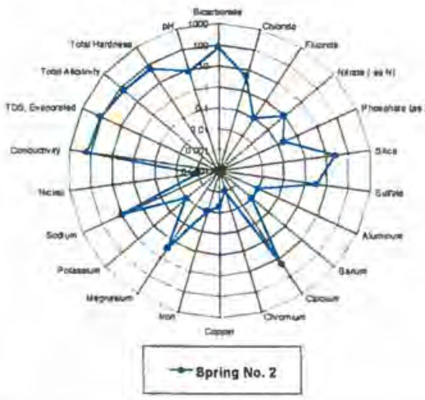
Constituents	Units	Spring 2
Sample Date		1/25/96
Collected by:		HD
ANIONS		
Bicarbonate	mg/L	76.86
Chloride	mg/L	5.07
Fluoride	mg/L	ND
Nitrate (as N)	mg/L	ND
Phosphate (as P)	mg/L	.2
Silica	mg/L	27.31
Sulfate	mg/L	3.34
Nitrite	mg/L	NA
Bromide	mg/L	ND
CATIONS		
Aluminum	mg/L	ND
Arsenic	mg/L	ND
Barium	mg/L	ND
Cadmium	mg/L	ND
Calcium	mg/L	19.22
Chromium	mg/L	ND
Copper	mg/L	ND
Iron	mg/L	ND
Lead	mg/L	ND
Magnesium	mg/L	2.5
Manganese	mg/L	ND
Mercury	mg/L	ND
Potassium	mg/L	ND
Selenium	mg/L	ND
Silver	mg/L	ND
Sodium	mg/L	9.05
Zinc	mg/L	ND
Beryllium	mg/L	ND
Antimony	mg/L	ND
Nickel	mg/L	ND
Thallium	mg/L	ND
SECONDARY FACTORS		
Conductivity	uS/cm	142.45
TDS, Evaporated	mg/L	103.
Total Alkalinity	mg/L	63.
Total Hardness	mg/L	58.3
Turbidity Source	ntu	ND
Temperature	Deg. F	50.
pH	pH	7.95

HD - HYDRODYNAMICS GROUP
ND - None Detected
NA - Not Analyzed

ASSESSMENT OF CHEMICAL DATA FOR SPRINGS AND BORE HOLES

The following paragraphs present a discussion of the results of chemical analyses for the seven springs and for the nine associated bore holes. For each discussion, we present the specific data, our assessment of the data, and a comparison of the chemical analyses of the spring and its associated bore holes. The paragraphs below first present the chemical data for Springs No. 2 and No. 3, the two springs without associated bore holes. Following those discussions, we have chosen to change the order of discussion somewhat from that used in previous sections of this report. Hydraulic connectivity testing at Spring No. 7 and its associated bore holes (referred to below as Spring Complex No. 7) conclusively demonstrated that the bore holes were hydraulically connected to the spring. Thus, the bore holes are producing the same groundwater as the water flowing naturally from Spring No. 7. It is appropriate, therefore, to assess the variations in chemistry among the bore holes and the spring at Spring Complex No. 7 to develop a basis for comparison of chemistry between other springs and their associated bore holes. This basis is then used for assessment of the bore holes associated with Spring No. 4, referred to below as Spring Complex No. 4, and the bore holes associated with Springs No. 10, No. 11, and No. 12, referred to herein as the Lower Spring Complex.

Figure 4-1
Radar Diagram for Spring No. 2



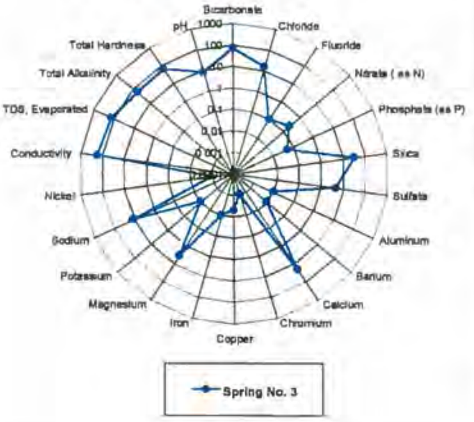
SPRING NO. 2

The location of Spring No. 2 is shown on Figure 1-1 in Section 1. Chemical analysis results of a water sample taken from the spring are shown on Table 4-2. None of the compounds in the water sample taken from Spring No. 2 exceeded the FEDMCLs.

The primary anions for these samples were bicarbonate (HCO_3), chloride (Cl), and sulfate (SO_4). The primary cations were calcium (Ca), magnesium (Mg), and sodium (Na). Based on the chemical analysis and the concentrations of major cations and anions, the water from this spring is of the calcium-bicarbonate type.

The TDS in water from Spring No. 2 was 142.45 mg/L. Under FDA Regulations, spring water with a TDS concentration less than 250 mg/L is considered water of "low mineral content." The pH was 7.95, which is slightly more alkaline than acidic, but within the normal range. The hardness was low at 58.3 mg/L. The data from Table 4-2 were plotted on a radar diagram, as shown in Figure 4-1, to allow a visual representation of the water chemistry of this spring. The pattern shown on the radar diagram can be used to compare the water from this spring with the water chemistry of

Figure 4-2
Radar Diagram for Spring No. 3



the other springs and bore holes. The pattern for water from this spring is typical for the groundwater that occurs in the fractured granite in this area. As shown in the following sections, this groundwater is all calcium-bicarbonate water of low mineral content.

SPRING NO. 3

The location of Spring No. 3 is shown on Figure 1-1 in Section 1. Chemical analysis results of a water sample taken from the spring is shown on Table 4-3. None of the compounds in the water sample taken from Spring No. 3 exceeded the FEDMCLs.

Table 4-3. Spring No. 3

Constituents	Units	Spring 3
Sample Date		1/25/96
Collected by:		HD
ANIONS		
Bicarbonate	mg/L	70.76
Carbonate	mg/L	ND
Chloride	mg/L	14.83
Fluoride	mg/L	ND
Nitrate (as N)	mg/L	.23
Phosphate (as P)	mg/L	ND
Silica	mg/L	33.81
Sulfate	mg/L	4.63
Nitrite	mg/L	NA
Bromide	mg/L	ND
CATIONS		
Aluminum	mg/L	ND
Arsenic	mg/L	ND
Barium	mg/L	ND
Cadmium	mg/L	ND
Calcium	mg/L	20.17
Chromium	mg/L	ND
Copper	mg/L	ND
Iron	mg/L	ND
Lead	mg/L	ND
Magnesium	mg/L	3.56
Manganese	mg/L	ND
Mercury	mg/L	ND
Potassium	mg/L	ND
Selenium	mg/L	ND
Silver	mg/L	ND
Sodium	mg/L	10.88
Zinc	mg/L	ND
Beryllium	mg/L	ND
Antimony	mg/L	ND
Nickel	mg/L	ND
Thallium	mg/L	ND
SECONDARY FACTORS		
Conductivity	uS/cm	174.58
TDS, Evaporated	mg/L	128.
Total Alkalinity	mg/L	58.
Total Hardness	mg/L	65.
Turbidity Source	ntu	ND
Temperature	Deg. F	50.
pH	pH	7.84

HD - HYDRODYNAMICS GROUP
ND - None Detected
NA - Not Analyzed

The primary anions for the sample taken were HCO_3, Cl, and SO_4. The primary cations were Ca, Mg, and Na. Based on the chemical analysis and the concentrations of major cations and anions, the water from this spring is of the calcium-bicarbonate type.

The TDS for Spring No. 3 was 174.58 mg/L. Under FDA Regulations, spring water with a TDS concentration less than 250 mg/L is considered water of "low mineral content." The pH was 7.84, which is slightly more alkaline than acidic, but within the normal range. The hardness was low at 65 mg/L.

The data from Table 4-3 were plotted on a radar diagram, as shown on Figure 4-2, to allow a visual representation of the water chemistry of this spring. The pattern shown on the radar diagram can be used to compare the water from this spring with the water chemistry of the other springs and bore holes. For example, the radar diagram for Spring No. 3, shown in Figure 4-2, can be visually compared with the radar diagram for Spring No. 2, shown in Figure 4-1. The comparison shows that the water chemistry for spring water from these two sources is nearly identical. Both figures show essentially the same pattern, indicating that the chemical composition of the water from both springs is the same. This, of course, is to be expected because both springs produce spring water from the same groundwater system within the same geologic horizon.

SPRING COMPLEX NO. 7

This spring complex has one spring, Spring No.7, and four associated bore holes, Bore Holes No. 7, No. 7A, No. 7B, and No. 7C. The locations of the spring and the four associated bore holes are shown on Figure 1-1 in Section 1. This spring and its associated bore holes are known to be hydraulically connected, based on the hydraulic connectivity testing described in Section 3. The results of chemical analyses of samples taken from the spring and its associated bore holes are shown on Table 4-4. None of the compounds in any of the samples from either the spring or the bore holes exceeded any of the FEDMCLs.

Table 4-4. Spring Complex No. 7

Constituents	**Units**	**Bore Hole 7**	**Bore Hole 7A**	**Bore Hole 7B**	**Bore Hole 7C**	**Spring 7**
Sample Date		3/21/96	3/21/96	3/21/96	3/21/96	2/19/97
Collected by:		HD	HD	HD	HD	HD
ANIONS						
Bicarbonate	mg/L	73.2	74.42	153.	92.72	76.86
Carbonate	mg/L	ND	ND	ND	ND	ND
Chloride	mg/L	20.8	17.78	22.27	22.54	16.22
Fluoride	mg/L	ND	ND	ND	ND	ND
Nitrate (as N)	mg/L	.58	.46	2.89	.43	.43
Phosphate (as P)	mg/L	ND	ND	ND	.14	ND
Silica	mg/L	34.05	34.6	35.22	32.83	34.
Sulfate	mg/L	3.73	3.64	4.1	3.92	3.3
Nitrite	mg/L	NA	NA	NA	NA	NA
Bromide	mg/L	ND	ND	ND	ND	ND
CATIONS						
Aluminum	mg/L	ND	ND	ND	ND	ND
Arsenic	mg/L	ND	ND	ND	ND	ND
Barium	mg/L	ND	ND	ND	ND	ND
Cadmium	mg/L	ND	ND	ND	ND	ND
Calcium	mg/L	22.99	22.04	21.73	24.54	21.4
Chromium	mg/L	ND	ND	ND	ND	ND
Copper	mg/L	ND	ND	ND	ND	ND
Iron	mg/L	ND	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND	ND
Magnesium	mg/L	4.11	4.2	3.53	3.92	3.9
Manganese	mg/L	ND	ND	ND	ND	ND
Mercury	mg/L	ND	ND	ND	ND	ND
Potassium	mg/L	1.67	1.61	1.66	1.68	1.6
Selenium	mg/L	ND	ND	ND	ND	ND
Silver	mg/L	ND	ND	ND	ND	ND
Sodium	mg/L	12.58	12.25	13.27	19.28	12.43
Zinc	mg/L	ND	ND	ND	ND	ND
Beryllium	mg/L	ND	ND	ND	ND	ND
Antimony	mg/L	ND	ND	ND	ND	ND
Nickel	mg/L	ND	ND	ND	ND	ND
Thallium	mg/L	ND	ND	ND	ND	ND
SECONDARY FACTORS						
Conductivity	uS/cm	213.62	205.2	210.27	252.72	NA
TDS, Evaporated	mg/L	150.	158.	153.	157.	128.
Total Alkalinity	mg/L	60.	61.	53.	76.	63.
Total Hardness	mg/L	74.3	72.3	68.8	77.4	69.5
Turbidity Source	ntu	ND	ND	ND	ND	ND
Temperature	Deg. F	50.	49.	49.	49.	49.
pH	pH	7.32	6.78	6.76	7.41	6.97

HD - HYDRODYNAMICS GROUP
ND - None Detected
NA - Not Analyzed

The primary anions for these samples were HCO_3, Cl, and SO_4. The primary cations were Ca, Mg, Potassium (K), and Na. Based on the chemical analysis and the concentrations of major cations and anions, the water from this spring and its associated bore holes is of the calcium-bicarbonate type.

The TDS in samples from the spring and the four associated bore holes ranged from 128 to 158 mg/L. Under FDA Regulations, spring water with a TDS concentration less than 250 mg/L is considered water of "low mineral content." The pH ranged from 6.76 to 7.41, with a pH of 7 indicating neutrality between acidity and alkalinity; therefore, the water pH is within the normal range. The hardness was low ranging from 68.8 to 77.4 mg/L.

Using a radar diagram, the data from Table 4-4 were plotted to allow comparison of the chemistry of Spring No. 7 with its associated bore holes. This plot is shown on Figure 4-3. As the radar diagram shows, there is an excellent correlation between the chemical analysis for Spring No. 7 and the analyses for the associated bore holes.

The laboratory report for Spring No. 7 did not present a value of conductivity for this sample. For waters of similar chemical composition, there is a direct relationship between the TDS and the electrical conductivity of the water. This relationship can be expressed by the following equation.

$$\mathbf{EC = (TDS)(F_{EC})}$$

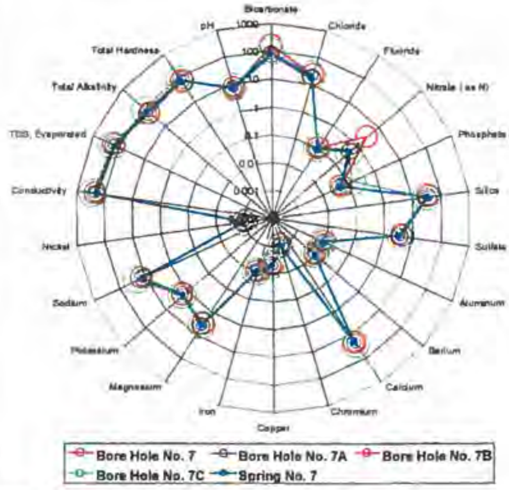
Where:

EC = electrical conductivity, in µS/cm;
TDS = total dissolved solids, in mg/L; and
F_{EC} = electrical conductivity factor, in mg/L per µS/cm.

The values of F_{EC} for the other spring water sources at Spring Complex No. 7 range from 1.30 to 1.61, and average 1.43. Applying this factor to the measured TDS for Spring No. 7, as reported by the laboratory, produces a calculated electrical conductivity of 183 µS/cm for the spring. For convenience in plotting, this calculated value was used on Figure 4-3.

The comparison of plots for Spring No. 7 and its four associated bore holes, as presented on Figure 4-3, shows an excellent similarity among the chemical characteristics of these samples. This similarity in water chemistry, by itself, would be sufficient to demonstrate that the water from the bore holes is the same as the water from the spring. As noted above, however, there was sufficient flow at Spring No. 7 to allow demonstration of the hydraulic connection between these sources by hydraulic means.

Figure 4-3
Radar Diagram For Spring Complex No. 7



Closer inspection of the chemical data for the sources at Spring Complex No. 7 shows some variations in concentration for the compounds tested. The compound with the highest variability was nitrate, with a range in concentration from 0.43 to 2.89 mg/L. This is a variability of over 600 percent. Due to the fact that the concentrations of nitrate are very low and well below the MCL of 10 mg/L for this compound, this range in concentration is of no consequence.

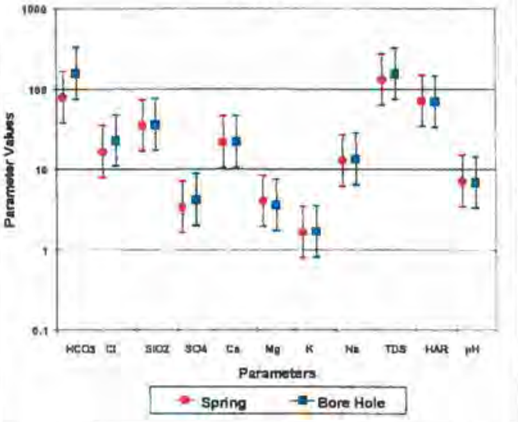
The compound with the next highest variation was HCO_3. Concentrations of HCO_3 ranged from a low of 73.2 mg/L at Bore Hole No. 7 to a high of 153 mg/L at Bore Hole No. 7B. This is a difference of 79.8 mg/L. There is no MCL for HCO_3 and therefore the magnitude of concentration and the differences in concentration for HCO_3 do not affect the overall suitability of this water for use. However, the variation in HCO_3, as shown by these data, can be an effective tool for use in assessing the similarity of water chemistry from other spring water sources.

Due to the results of hydraulic connectivity testing (Section 3), it is known that the water produced at Bore Hole No. 7B is the same spring water that is produced from Spring No. 7 and the other associated bore holes. Because the water from the bore holes is the same water as issues forth from the springs, the variation in HCO_3 is likely the result of variations in sampling, sample handling, or laboratory procedures, and it is not likely that this variation represents any true difference in the actual water chemistry. This same variation may occur for other samples taken from other springs and bore holes at this site. Thus, the range in variation of HCO_3 for this spring complex, as discussed above, is used to assess the degree of similarity between compound concentrations for samples from other sources. To determine the range of acceptability for variations in laboratory-reported concentrations from other sources, which may be due to sampling, sample handling, and laboratory differences, we calculated the percentage difference in HCO_3 from the sources at Spring Complex No. 7.

The maximum and minimum ranges were selected by reviewing the HCO_3 water chemistry data for Spring Complex No. 7, in which there is hydraulic connection between Spring No. 7 and associated bore holes. The concentration variation of HCO_3 among the spring and associated bore holes was used in this analyses. The HCO_3 variation was used because its variation represents the greatest actual variation in mg/L and the second greatest percentage range potential for any of the parameters. The percentage range of variability for K was greater than for HCO_3, however the low concentrations of K in the samples makes this compound unsuitable for this purpose. The upper limit factor was calculated by taking the deviation between the higher concentration and lowest concentration ranges of HCO_3 (79.8 mg/L difference) and dividing that number by the lower limit of the range of concentration (73.20 mg/L). This result (1.09) was then added to 1 in order to develop the factor for use as a multiplier ($1 + 1.09 = 2.09$). The same was done with the higher limit of the range of concentration (153 mg/L) to get a value for the lower limit range ($79.8/153 = 0.52$). This value was then subtracted from one to develop the factor for use as a multiplier for the lower limit of the range ($1 - 0.52 = 0.48$).

These factors for the upper and lower range of variability were then multiplied by the concentration data for each bore hole and spring from the laboratory data in Appendix E to produce the range of possible variability for each compound. The parameters that were used are only those for which there were measured concentrations. Compounds with concentrations below the MDL were not selected. The data for Spring No. 7 and Bore Hole No. 7B, and the calculated concentration ranges, were then plotted on an appropriate diagram to allow comparison of the data from the spring with data from the bore hole. Figure 4-4 shows the plot of these data. Bore Hole No. 7B was chosen for this comparison because its laboratory report showed that this sample had the greatest variation in HCO_3, in comparison with other samples from this spring complex.

Figure No. 4-4
Data for Spring No. 7 and Bore Hole No. 7B Showing Acceptable Data Variability Range



Eleven separate compounds or parameters are shown on Figure 4-4. These were selected because they represent compounds and parameters for which there were laboratory-reported values for each sample. The actual value for each compound or parameter is shown plotted using the symbols explained in the legend. The calculated range of variability for each compound, using the range of factors described above, are shown as a vertical line plotted through each point, with horizontal bars representing the upper and lower end of the range. The vertical scale for the diagram is logarithmic to allow plotting of all the various compounds and parameter values on the same diagram.

Using Figure 4-4, the data and the range of variability for the spring can be compared with the data and range of variability for the bore hole. Figure 4-4 shows the overlap between the ranges of variability for each compound from the bore hole and the corresponding ranges of variability for each compound from the spring. The laboratory-reported concentrations for bore hole compounds are not exactly the same as those reported for the spring water. Hydraulic connectivity testing has demonstrated, however, that the water from the bore hole is the same as that from the spring. Therefore, if the concentrations reported are within the range of variability shown in Figure 4-4, it is concluded that the compounds are sufficiently close in concentration to indicate that the water from the bore hole is the same spring water as the water that is flowing at the spring. This relationship is used below as the basis for assessing the similarity of water chemistry from other springs and associated bore holes at this site in instances where hydraulic testing is not possible.

SPRING COMPLEX NO. 4

This complex has one spring, Spring No. 4, and three associated bore holes, Bore Holes No. 1, No. 1A, and No. 8. The locations of the spring and three bore holes that comprise Spring Complex No. 4 are shown on Figure 1-1 in Section 1. Chemical analysis results of water samples taken from the spring and the associated bore holes are shown on Table 4-5. None of the compounds in the samples from either the spring or the bore holes exceeded the FEDMCLs.

The primary anions for these samples were HCO_3, Cl, and SO_4. The primary cations were Ca, Mg, K, and Na. Based on the chemical analysis and the concentrations of major cations and anions, the water from the spring and the associated bore holes is of the calcium-bicarbonate type.

The TDS ranged from 91 to 125 mg/L. Under FDA Regulations, spring water with a TDS of less than 250 mg/L is considered water of "low mineral content." The pH ranged from 6.0 to 7.4. The normal range of pH for groundwater is between 6 and 8.5; therefore, the pH of this water is within the normal range. The hardness ranged from 44 to 65 mg/L, which is relatively low.

Using a radar diagram, the data from Table 4-5 were plotted to allow visual comparison of the water chemistry of these three springs and the associated bore hole. This plot is presented as Figure 4-5. As the radar diagram shows, there is an excellent correlation between the chemical analyses for the spring and for the associated bore holes. Although several compounds show slight variations, there is an overall strong similarity among all the analyses.

Our assessment of the nature of the fractured granite rock aquifer supplying water to spring No. 4, the proximity of Bore Holes No. 1, No. 1A, and No. 8 to the spring, and the general hydrogeology of this area all indicate that the bore holes are producing the same spring water issuing forth from the spring. Hydraulic connection testing, water chemistry comparison, and other methods are available to confirm this assessment.

The hydraulic testing performed at Spring Complex No. 4, described in Section 3, was limited in its suitability for demonstrating hydraulic connection between Spring No. 4 and Bore Holes No. 1, No. 1A, and No. 8. As noted

Table 4-5. Spring Complex No. 4

Constituents	**Units**	**Bore Hole 1**	**Bore Hole 1A**	**Bore Hole 8**	**Spring 4**
Sample Date		10/8/97	10/8/97	10/8/97	3/17/97
Collected by:		HD	HD	HD	HD
ANIONS					
Bicarbonate	mg/L	70.	91.	76.	66.7
Carbonate	mg/L	ND	ND	ND	NA
Chloride	mg/L	18.	6.2	6.	5.2
Fluoride	mg/L	.1	.1	.1	.1
Nitrate (as N)	mg/L	.36	ND	ND	ND
Phosphate (as P)	mg/L	ND	ND	ND	ND
Silica	mg/L	33.	23.	23.	24.2
Sulfate	mg/L	1.4	2.6	3.4	2.6
Nitrite	mg/L	ND	ND	ND	ND
Bromide	mg/L	ND	ND	ND	ND
CATIONS					
Aluminum	mg/L	ND	ND	ND	ND
Arsenic	mg/L	ND	ND	ND	ND
Barium	mg/L	.01	ND	ND	ND
Cadmium	mg/L	ND	ND	ND	ND
Calcium	mg/L	16.	21.	17.	13.7
Chromium	mg/L	ND	ND	ND	ND
Copper	mg/L	06	ND	ND	ND
Iron	mg/L	ND	ND	ND	ND
Lead	mg/L	ND	ND	ND	ND
Magnesium	mg/L	5.	3.	2.	2.4
Manganese	mg/L	ND	ND	ND	ND
Mercury	mg/L	ND	ND	ND	ND
Potassium	mg/L	2.	2.	2.	1.2
Selenium	mg/L	ND	ND	ND	ND
Silver	mg/L	ND	ND	ND	ND
Sodium	mg/L	11.	8.	8.	7.3
Zinc	mg/L	ND	ND	ND	ND
Beryllium	mg/L	ND	ND	ND	ND
Antimony	mg/L	ND	ND	ND	ND
Nickel	mg/L	ND	ND	ND	ND
Thallium	mg/L	ND	ND	ND	ND
SECONDARY FACTORS					
Conductivity	uS/cm	182.	173.	150.	129.
TDS, Evaporated	mg/L	125.	111.	101.	91.
Total Alkalinity	mg/L	58	75.	62.	56.
Total Hardness	mg/L	58.	65.	51.	44
Turbidity Source	ntu	ND	ND	ND	ND
Temperature	Deg. F	50.	50.	49.	49.
pH	pH	6.	6.3	6.3	7.4

HD - HYDRODYNAMICS GROUP
ND - None Detected
NA - Not Analyzed

Figure 4-5
Radar Diagram for Spring Complex No. 4

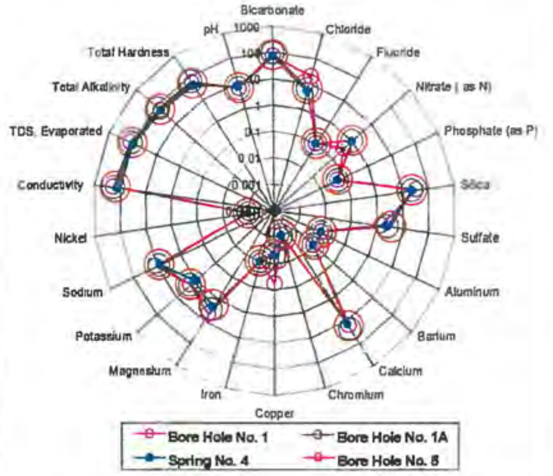


Figure No. 4-6
Data for Spring No. 4 and Bore Hole No. 1
Showing Acceptable Data Variability Range

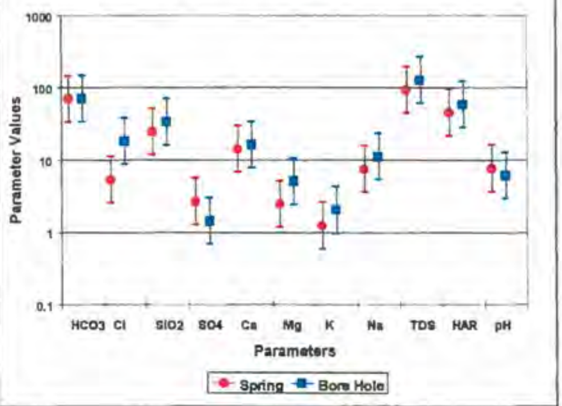


Figure No. 4-7
Data for Spring No. 4 and Bore Hole No. 1A
Showing Acceptable Data Variability Range

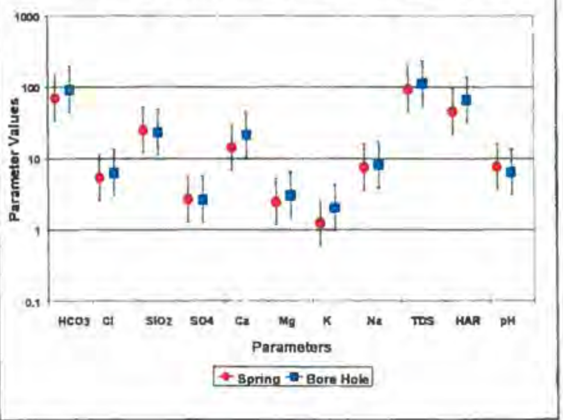
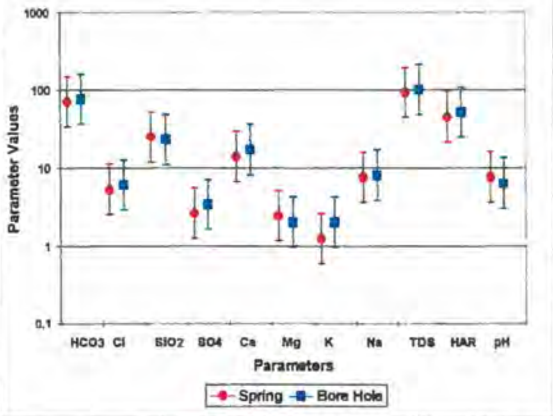


Figure No. 4-8
Data for Spring No. 4 and Bore Hole No. 8
Showing Acceptable Data Variability Range



earlier in this report, in these instances the FDA Regulations allow use of water chemistry comparisons for assessment of the hydraulic connection between springs and associated bore holes. The range of variability in water chemistry between the spring and associated bore holes described above for Spring Complex No. 7 can be used to assess whether or not the water from the bore holes in Spring Complex No. 4 is the same as the water from the spring. For this assessment, the variability range factors were multiplied by the concentrations shown in Table 4-5 for each of the compounds in samples from each of the bore holes in Spring Complex No. 4 to determine the range of acceptable variation in these compounds. Similarly, the concentrations for the sample from Spring No. 4 were also multiplied by the range of variability factors. The resulting data were then plotted, in a manner similar to that described above for Spring Complex No. 7, to allow assessment of the results. A separate plot was prepared for each bore hole, showing the data for Spring No. 4 compared with the data from each bore hole. These plots are shown on Figures 4-6, 4-7, and 4-8 for Bore Holes No. 1, No. 1A, and No. 8, respectively.

As can be seen by the diagrams, the percentage variations of each bore hole parameter in comparison to the spring are very close. In all cases, the ranges of variability in the concentrations for the bore holes fall within the ranges of variability for the spring. This indicates that the compound concentrations for the bore holes are sufficiently close to the concentrations for the springs to support the conclusion that the water from the bore holes is the same water as that from the spring. In fact, the actual concentration data points for each bore

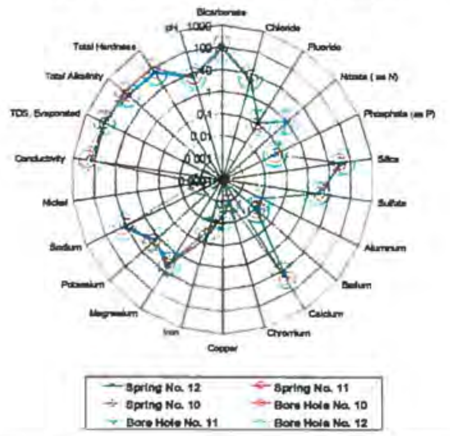
Table 4-6. Lower Spring Complex

Constituents	Units	Spring 10	Spring 11	Spring 12	Bore Hole 10	Bore Hole 10	Bore Hole 11	Bore Hole 12	Bore Hole 12
Sample Date		5/28/98	5/28/98	5/28/98	1/11/96	5/28/98	5/28/98	3/21/96	5/28/98
Collected by:		D&M	D&M	D&M	HD	D&M	D&M	HD	D&M
ANIONS									
Bicarbonate	mg/L	72.	103.	88	143.96	140.	81.	82.98	82.
Carbonate	mg/L	NA	NA	NA	ND	NA	NA	ND	NA
Chloride	mg/L	8.	4.5	4.3	4.69	5.1	6.	5.51	6.
Fluoride	mg/L	.1	.13	.13	.14	.12	.13	ND	.12
Nitrate (as N)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Phosphate (as P)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Silica	mg/L	31.	35.	40	23.8	27.	49.	39.98	48.
Sulfate	mg/L	3.4	4	4	3.81	5.1	3.	2.5	2.5
Nitrite	mg/L	ND	ND	ND	NA	ND	ND	NA	ND
Bromide	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
CATIONS									
Aluminum	mg/L	ND	ND	01	ND	ND	ND	.0335	ND
Arsenic	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Barium	mg/L	ND	.012	.012	ND	.013	.016	.0103	.013
Cadmium	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	18.	21.	17.	31.16	32.	14.	14.27	15.
Chromium	mg/L	ND	ND	ND	ND	.0014	ND	ND	ND
Copper	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Iron	mg/L	.015	.031	.056	ND	.062	.023	.0181	.025
Lead	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Magnesium	mg/L	3.	5	4.5	6.24	6.	4.	4.44	4.
Manganese	mg/L	ND	ND	ND	ND	ND	ND	.0032	ND
Mercury	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	mg/L	1.5	2.	1.5	ND	2.5	1.5	1.77	1.5
Selenium	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Silver	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/L	8.	11.6	11.	13.58	13.	13.	13.75	13.
Zinc	mg/L	ND	ND	ND	ND	ND	ND	.151	ND
Beryllium	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Antimony	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	mg/L	ND	ND	ND	.0012	.0015	ND	ND	ND
Thallium	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
SECONDARY FACTORS									
Conductivity	uS/cm	130.	170.	140.	243.08	220.	140.	165.56	140.
TDS, Evaporated	mg/L	100.	126.	115.	155.	161.	121.	119.	120.
Total Alkalinity	mg/L	59.	84.	70.	118.	115.	66.	68.	67.
Total Hardness	mg/L	57.	73.	61.	103.5	105.	51.	53.9	54
Turbidity Source	ntu	ND	ND	ND	,12	.26	ND	.25	15
Temperature	Deg. F	*	*	*	*	*	*	*	*
pH	pH	6.2	6.5	6.7	8.11	6.8	6.4	7.2	6.38

D&M - DAMES & MOORE
HD - HYDRODYNAMICS GROUP
ND - None Detected
NA - Not Analyzed

hole fall within the range of acceptable variation for Spring No. 4, with only one exception, that of Cl for Bore Hole No. 1. The difference between the concentration of Cl in this bore hole and the upper end of the range of acceptable variability in Cl for the spring is less than 3 mg/L. Since the data for the remaining parameters for Bore Hole No. 1 are within the variation range for Spring No. 4, the chloride variation cannot discount the fact that the data support the conclusion that the water from the bore hole is the same water as that from the spring. Thus, all of the comparisons of the chemical analyses between Spring No. 4 and the associated bore holes show that the water from of the associated bore holes is the same as that of the spring.

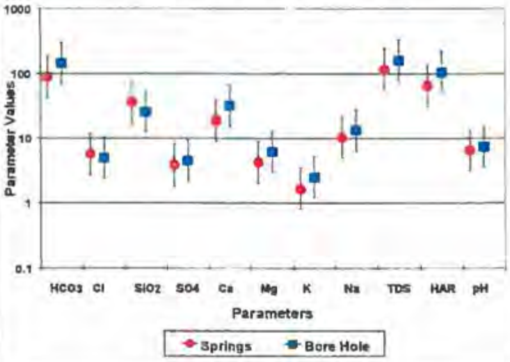
Figure 4-9
Radar Diagram for Lower Spring Complex



LOWER SPRING COMPLEX

This complex has three springs, Springs No. 110, No. 11, and No. 12, and three associated bore holes, Bore Holes No. 10, No. 11, and No. 12. The locations of the three springs and the three associated bore holes are shown on Figure 1-1 in Section 1. The results of chemical analyses of samples taken from the springs and their associated bore holes are shown on Table 4-6. None of the compounds in the samples from either the springs or the associated bore holes exceeded the FEDMCLs.

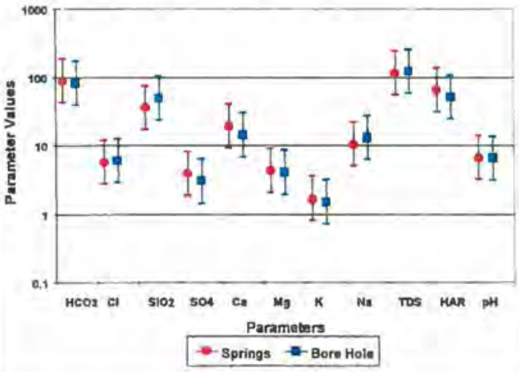
Figure No. 4-10
Averages of Data for Three Springs and Two Samples for Bore Hole No. 10 Showing Acceptable Data Variability Range



The primary anions for these samples were HCO_3, Cl, SO_4, and the primary cations were Ca, Mg, K, and Na. Based on the chemical analysis and the concentrations of major cations and anions, this water is of the calcium-bicarbonate type.

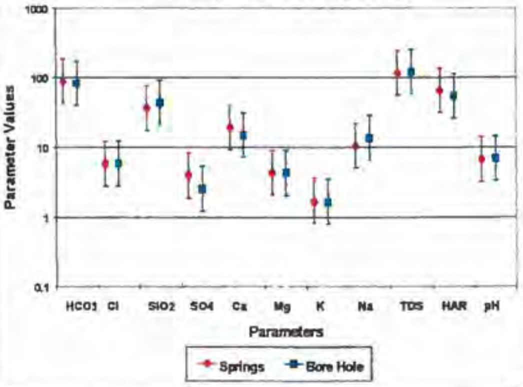
TDS ranged from 100 to 161 mg/L, which is less than the minimum amount set in the FDA Regulations of 250 mg/L for mineral water. Thus, this is water of low mineral content. The pH ranged from 6.2 to 8.11, with a pH of 7 indicating a neutrality between acidity and alkalinity; therefore, the pH of the water is within the normal range. The hardness ranged from 61 mg/L for Spring No. 12 to 105 mg/L for Bore Hole No. 10.

Figure No. 4-11
Average of Data for Three Springs and for Bore Hole No. 11 Showing Acceptable Data Variability Range



Using a radar diagram, the data from Table 4-6 were plotted to allow comparison of the chemistry of the springs and bore holes. This plot is shown on Figure 4-9. For convenience in plotting, data for the year 1996 for Bore Hole No. 10 were not included in the diagram. Although some compounds show slight variations, there is an overall strong similarity among all the analyses.

Figure No. 4-12
Average of Data for Three Springs and Two Samples for Bore Hole No. 12
Showing Data Accuracy Range



Our assessment of the nature of the fractured granite rock aquifer supplying water to springs No. 10, No. 11, and No. 12, the proximity of Bore Holes No. 10, No. 11, and No. 12 to the spring, and the general hydrogeology of this area all indicate that the bore holes are producing the same spring water issuing forth from these springs. Hydraulic connection testing, water chemistry comparison, and other methods are available to confirm this assessment.

The hydraulic testing performed at the Lower Spring Complex, described in Section 3, was limited in its suitability for demonstrating hydraulic connection between the springs and the bore holes. As noted earlier in this report, in these instances the FDA Regulations allow use of water chemistry comparisons for assessment of the hydraulic connection between springs and associated bore holes. The range of variability in water chemistry between Spring No. 7 and its associated bore holes is used to assess whether or not the water from the bore holes in the Lower Spring Complex is the same as the water from the springs.

For this assessment, the variability range factors were multiplied by the concentrations shown in Table 4-6 for each of the compounds in samples from the bore holes to determine the range of acceptable variation in these compounds. The resulting data were then plotted, in a manner similar to that described above for Spring Complex No. 7, to allow assessment of the results. A separate plot was prepared for each bore hole, showing the data for springs compared with the data from that bore hole. These plots are shown on Figures 4-10, 4-11, and 4-12 for Bore Holes No. 10, No. 11, and No. 12, respectively. For this purpose, the two samples from Bore Hole No. 10 were averaged. Similarly, the averages of the concentrations for samples from the three springs were multiplied by the variability factors.

As can be seen by the diagrams, the percentage variations of compounds for each bore hole, in comparison to the springs, is very close. In all cases, the range of variability in the concentrations for the bore holes falls within the range of acceptable variability for the springs. This indicates that the compound concentrations for the bore holes are sufficiently close to the concentrations for the springs to support the conclusion that the water from the bore holes is the same water as that from the springs. In fact, the actual concentration data points for each bore hole fall within the range of acceptable variation for the spring. Because the data for all the parameters for the three bore holes are within the variation range for the springs, the comparison of chemical analyses between the springs and the three associated bore holes shows that the water from all these sources is the same water.

SUMMARY OF WATER QUALITY COMPARISONS

The FDA Regulations indicate that groundwater from a bore hole located near a spring is considered "spring water" for identity purposes if the bore holes are hydraulically connected to the springs such that the bore holes produce the same water as that from the springs. If site conditions limit the ability to demonstrate hydraulic connectivity by hydraulic testing, the FDA Regulations provide for use of other hydrogeologically valid techniques including water quality comparisons. If the quality of the water from the bore hole is the same as the quality of water from the spring, this analysis supports the conclusion that the water from the bore hole is spring water for "identity" purposes. Based on the results of chemical analyses and comparison of water quality, we can make the following conclusions:

- The concentrations of chemical compounds in water from all of the seven springs and nine bore holes at the Arrowhead Springs site are below the federal maximum contaminant levels for all compounds tested.

- The groundwater from Bore Holes No. 7, No. 7A, No. 7B, and No. 7C in Spring Complex No. 7 is the same quality as the spring water from Spring No. 7. The water quality data confirm the conclusion from the hydraulic testing presented in Section 3 that the bore holes are hydraulically connected to the spring. Thus, the water from the bore holes is spring water under FDA Regulations.

- The groundwater from Bore Holes No. 1, No. 1A and No. 8 in Spring Complex No. 4 is the same quality as the spring water from Spring No. 4. Thus, the water from the bore holes is spring water under FDA Regulations.

- The groundwater from Bore Holes No. 10, No. 11, and No. 12, in the Lower Spring Complex is the same quality as the spring water from Springs No. 10, No. 11, and No. 12. Thus, the water from the bore holes is spring water under FDA Regulations.

SECTION 5

POTENTIAL FOR SURFACE WATER IMPACTS

As part of its definition of *spring water* for "Identity" purposes, FDA states that spring water is *groundwater* because it comes from an underground source. To be *groundwater*, the water must not be under the "direct influence of surface water" in accordance with the EPA definition of surface water impacts. EPA defines "groundwater under the direct influence of surface water" (40 CFR 141.2) as water beneath the surface of the ground with:

> **(1) Significant occurrence of insects or other microorganisms, Algae, or large diameter pathogens such as *Giardia lamblia*; or**
>
> **(2) Significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions.**

Consequently, as part of the evaluation of the Arrowhead Springs for purposes of documenting the identity of the harvested water as spring water under the FDA Regulations, an assessment of the potential for surface water impacts was conducted. This assessment involved sampling and testing for the presence of biological indicators of surface water at the bore holes from which spring water is harvested. Furthermore, an assessment was made of the water characteristics data, specifically turbidity and total dissolved solids versus precipitation, that are regularly monitored at Arrowhead Springs. The results of these assessments are presented in the sections below for the bore holes that are used for harvesting spring water.

MICROSCOPIC PARTICULATE ANALYSIS

Microscopic particulate analysis (MPA) samples were collected from Arrowhead Springs No. 2 and No. 3 and from Bore Holes No. 1, No.1A, No.8, No.7, No. 7A, No. 7B, No. 7C, No 10, No. 11, and No. 12. Samples were collected directly from the discharge piping through sample ports located within the bore hole housings or from the collection piping connected to the tunnel. The procedure for sample collection is described in detail in the U. S. Environmental Protection Agency document "Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis" (Vasconcelos and Harris, 1992). In summary, sampling consisted of drawing spring water through a filter at a rate of approximately 1 gpm for a period of about 24 hours.

The samples were evaluated for the presence of *Giardia* cysts, *Cryptosporidium* oocysts, and other indicator organisms that may result from contact with surface water. Other indicator organisms include Amorphous Debris, Rotifiers, Crustaceans, Insects or their body parts, Diatoms, Coccidian oocysts, chlorophyll-bearing Algae, and Cellular Plant Debris. The results are reported as particulate counts per 100 gallons of water filtered (#/100gal). The findings were ranked, weighted, and combined to produce a score that identifies the level of risk. Counts of indicators such as *Giardia*, if found, would be weighted more heavily than less harmful indicators such as Algae or Plant Debris.

Table 5-1. Summary of MPA Testing

PARAMETERS				Spring Complex No. 4			Spring Complex No. 7				Lower Spring Complex		
Constituents	Units	Spring 2	Spring 3	Bore Hole 1	Bore Hole 1A	Bore Hole 8	Bore Hole 7	Bore Hole 7A	Bore Hole 7B	Bore Hole 7C	Bore Hole 10	Bore Hole 11	Bore Hole 12
Sample Date	MDY	10/15/98	1/20/99	10/6/98	10/15/98	10/6/98	9/30/98	9/30/98	9/30/98	10/6/98	10/20/98	1020/98	10/20/98
Sample Data													
Sample Number	N/A	101398AHD	3011999AHD	10598AHS	101398AHD	10598AHS	92998AHS	92998AHS	92998AHS	10598AHS	AHD102098	AHD102098	AHD102098
Filter Color	N/A	White	White	White	White	White	White	White	White	White	Off White	White	Cream
Water Color	N/A	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Off White	Clear
Sediment Color	N/A	Brown	Light Gr.	Brown	Brown	Brown	Light Br.	Light Br.	Light Br.	Brown	Light Br.	Light Br.	Brown
Temperature	deg. C	12	10	11	12	11	10	11	10	13	13	2	15
pH	pH units	6.14	7.00	6.49	7.24	6.83	6.80	5.40	6.40	6.69	6.81	6.78	6.79
Volume Filtered	al	1,440	1,340	1,380	1,440	1,380	1,420	1,430	1,425	1,380	1,260	1,260	1,260
Pooled Sediment Vol.	uL	200	<100	500	200	500	500	500	500	500	500	500	300
Pooled Sediment Vol.	uL/100 gal	13.9	<7.5	36.2	13.8	36.2	35.2	34.9	35.8	36.2	39.7	39.7	23.8
Floatation Volume	uL	200	<100	500	200	500	500	500	500	500	500	500	300
Final Pellet Volume	uL	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
Indicator Analysis													
Giardia Cyst Confirmed	#/100 Gallons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Giardia Cyst Presumptive	#/100 Gallons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cryptosporidium Cyst Confirmed	#/100 Gallons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cryptosporidium Cyst Presumptive	#/100 Gallons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diatoms	#/100 Gallons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Algae	#/100 Gallons	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Protozoa	#/100 Gallons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Insects	#/100 Gallons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Insect Fragments	#/100 Gallons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vegetative Debris	#/100 Gallons	ND	17.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Large Amorphous Debris	#/100 Gallons	11,000	3,000	10,000	17,000	9,600	24,000	20,000	35,000	12,000	24,000	50,000	24,000
Fine Amorphous Debris	#/100 Gallons	33,000	20,000	45,000	30,000	30,000	72,000	66,000	110,000	36,000	75,000	125,000	52,000
Rotifers	#/100 Gallons	ND	ND	0	ND	ND	ND	ND	ND	ND	ND	ND	ND
Rotifer Eggs	#/100 Gallons	ND	ND	0	ND	ND	ND	ND	ND	ND	ND	ND	ND
Crustaceans	#/100 Gallons	ND	ND	0	ND	ND	ND	ND	ND	ND	ND	ND	ND
Crustacean Eggs	#/100 Gallons	ND	ND	0	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nematodes	#/100 Gallons	ND	ND	0	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nematode Eggs	#/100 Gallons	ND	ND	0	ND	ND	ND	ND	ND	ND	ND	ND	ND
Note: ND = Not Detected													
Risk Factor and Rating													
Risk Factor Score		0	4	0	0	0	0	0	0	0	0	0	0
Risk Rating		Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Direct Influence of Surface Water		No	No	No	No	No	No	No	No	No	No	No	No

As examples, a count of Algae totaling less than 1 is ranked as Not Significant; a count between 1 and 20 would be ranked as Rare; a count between 21 and 95 would be ranked as Moderate; a count between 96 and 299 would be ranked as Heavy; and a count of 300 or above would be ranked as Extremely Heavy. Each ranking category for each indicator receives a relative Risk Factor score that is again weighted against the more undesirable indicators. A Rare ranking for Algae would receive a relative Risk Factor score of 4.

The relative Risk Factor scores for all indicators are totaled and the total Risk Factor score is used to determine the Risk Rating of direct influence of surface water for a sample. A total Risk Factor score of 9 or less is considered Low Risk of direct influence of surface water. Thus, a Rare ranking for Algae with a relative Risk Factor score of 4 would be considered Low Risk, the same as a Risk Factor score of zero. Total Risk Factor scores of 10 to 19 are considered Moderate Risk. Total Risk Factor scores of 20 or greater are considered High Risk. Thus, Low Risk is the best Risk Rating that can be attained by any water source. Low Risk means no evidence of direct influence of surface water.

Samples from these twelve sources were collected between September 30, 1998, and January 20, 1999. Samples were shipped overnight to Morrell Associates Laboratory in

Marshfield, Massachusetts, under proper chain-of-custody following the protocols described in the sample shipment methods by the EPA.

The laboratory reports presenting the results of the MPAs for the samples are included in Appendix F. The results provide a Risk Factor and a Risk Range (Rating) for the waters tested. The data from the laboratory reports are summarized on Table 5-1. The data are organized by spring number or spring complex number, and then by the associated bore holes for each spring complex.

Water from all sources, except Spring No. 3, received a Risk Factor score of zero. Spring No. 3 received a Risk Factor score of 4 based on a result of 1.1 (#/100gal) algae, which is considered "rare" according to the EPA guidelines. All twelve sources were given a Risk Rating of Low Risk. Thus, it is concluded that the spring water from the groundwater sources feeding these bore holes is not under the direct influence of surface water, based on these tests.

WATER CHARACTERISTICS ANALYSIS

As part of the normal operating procedures for Arrowhead Springs, regular monitoring is conducted for various physical and chemical characteristics of the spring water. In particular, turbidity is monitored in the spring water from all the springs from which spring water is harvested. This monitoring is conducted at the point of entrance of the spring water into the main storage tanks. Turbidity of the spring water is measured on a regular basis and is reported daily. In addition to turbidity monitoring, total dissolved solids (TDS) is monitored and reported daily. Both turbidity data and TDS analyses can be used to assess the potential for direct influence of surface water on these spring-water sources.

As noted above, significant and relatively rapid shifts in water characteristics such as turbidity or TDS which closely correlate to climatological conditions such as precipitation can be indicators of direct influence of surface water. Since all such parameters vary somewhat with time, the key to the analysis is to determine if there are "significant and relatively rapid" variations that "closely correlate" with climatological conditions. To assess the data from the Arrowhead Springs, the turbidity and TDS data were compared with precipitation data as recorded by San Bernardino County at Twin Peaks, just north of the Arrowhead Springs. The turbidity data, TDS data, and precipitation data are shown in a table in Appendix F.

PRECIPITATION DATA

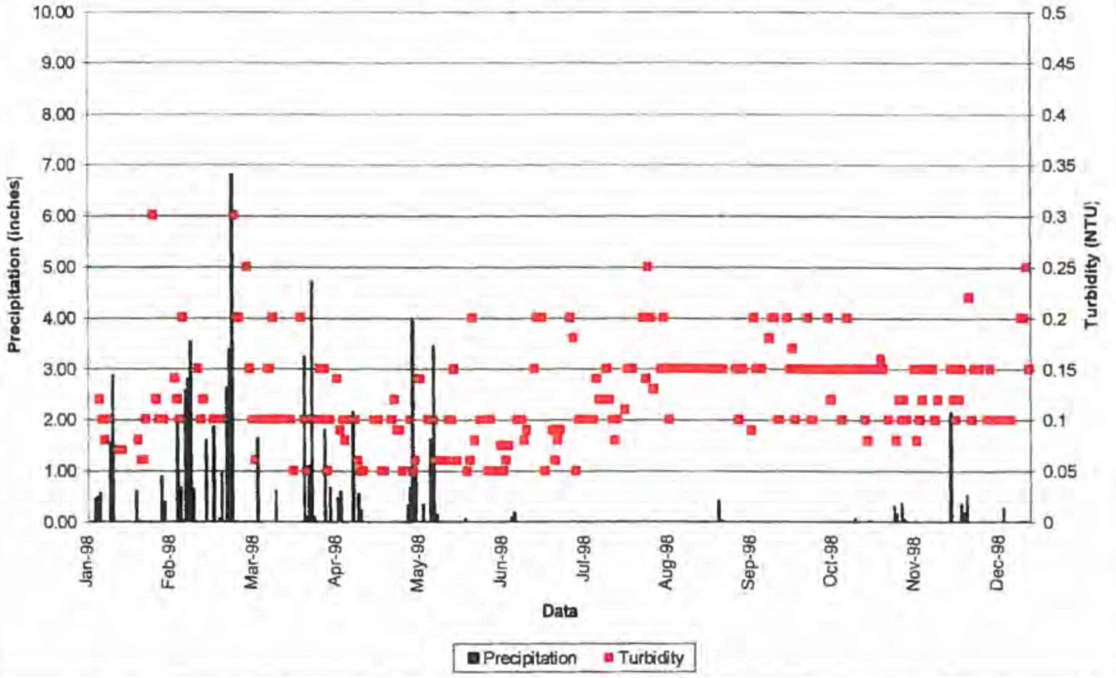
The seasonal nature of the precipitation is evident in the table in Appendix F. The rainy season is generally considered to be the period October through March, while the dry season is generally considered to be April through September. The 1998 rainy season was one of the heaviest on record, being coincident with the El Niño storms of 1998. The largest daily precipitation during 1998 was 6.80 inches, which occurred on February 24, 1998. There were six other storms that produced daily precipitation in excess of 3.00

inches that occurred during February through May 1998. The presence of these wide variations in precipitation suggested that, if there were direct influence of surface water on the spring-water sources, significant and relatively rapid shifts in turbidity and/or TDS should be evident.

TURBIDITY ANALYSIS

The recorded turbidity data for 1998 were compared to the precipitation data for the same period. Figure 5-1 shows a plot of turbidity data and precipitation for 1998. Again, the seasonal nature of the precipitation is evident in Figure 5-1. The turbidity data vary from 0.05 to 0.60 nephelometric turbidity units (NTU) and average about 0.125 NTU over the full year. There were no significant or relatively rapid shifts in turbidity that could be closely correlated with precipitation events over this period of record. The variations in turbidity do not appear to be related to precipitation, and are likely due simply to changes of flow of spring water within the connecting piping causing slight changes in turbidity.

Figure 5-1.
Turbidity and Precipitation Data For 1998

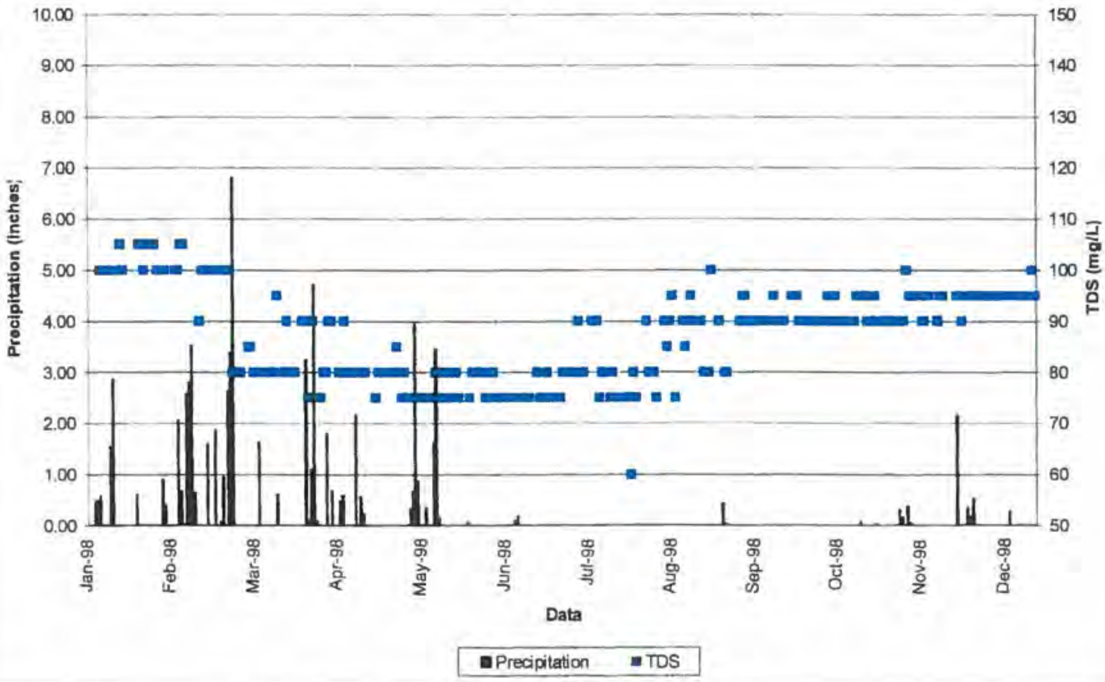


Considering the seasonal nature of precipitation, the turbidity data were assessed over the rainy season and the dry season. During October through March, the rainy season, turbidity varied from 0.05 to 0.60 NTU and averaged 0.132 NTU. The difference between the average value for the rainy season (0.132 NTU) and the average value for the entire year (0.125 NTU) was only 0.007 NTU. By comparison, during the dry season, April through September, turbidity varied from 0.05 to 0.25 NTU and averaged 0.117 NTU. The difference between the average value for the dry season (0.117 NTU) and the average value for the entire year (0.125 NTU) was only 0.008 NTU. These results do not show any significant or relatively rapid shifts in turbidity between the rainy season and the dry season.

TOTAL DISSOLVED SOLIDS ANALYSIS

The recorded TDS data for 1998 were compared to the precipitation data for the same period. Figure 5-2 shows a plot of TDS data and precipitation for 1998. Once again, the seasonal nature of the precipitation is evident in Figure 5-2. The TDS data vary from 60 to 105 mg/L and average about 88 mg/L over the full year. There were no significant or relatively rapid shifts in TDS that could be closely correlated with precipitation events over this period of record. The variations in TDS do not appear to be related to precipitation, and are likely due simply to seasonal changes in recharge to the groundwater system supplying the spring-water sources.

Figure 5-2.
TDS and Precipitation Data For 1998



To assess the TDS data in connection with the seasonal nature of precipitation, the TDS data were assessed over the rainy season and the dry season. During October through March, the rainy season, TDS varied from 75 to 105 mg/L and averaged 93 mg/L. The difference between the average value for the rainy season (93 mg/L) and the average value for the entire year (88 mg/L) was only 5 mg/L. By comparison, during the dry season, April through September, TDS varied from 60 to 100 mg/L and averaged 82 mg/L. The difference between the average value for the dry season (82 mg/L) and the average value for the entire year (88 mg/L) was only 6 mg/L. These results do not show any significant or relatively rapid shifts in TDS between the rainy season and the dry season.

DISCUSSION OF MPA AND WATER CHARACTERISTICS RESULTS

Based on the results of MPA analyses, the water from Arrowhead Springs Bore Holes No. 1, No.1A, No.8, No.7 No. 7A, No. 7B, No. 7C, No 10, No. 11, and No. 12, and from Springs No. 2 and No. 3 show no evidence of surface water impact. Assessment of turbidity versus precipitation and TDS versus precipitation showed no significant or relatively rapid shifts that could be correlated with climatological data. None of these data show any indication of direct influence of surface water. Thus, it is appropriate to consider these sources as "groundwater" under the FDA Regulations, and therefore this water can be considered "spring water" under those Regulations.

SECTION 6

CLASSIFICATION OF SPRINGS

The United States Geological Survey (USGS) established criteria for classifying springs in USGS Water Supply Paper 494, *Outline of Ground-Water Hydrology*, 1923. This document was written by Oscar E. Meinzer, long recognized as one of the foremost experts on groundwater. The USGS criteria provide an effective means for classifying springs according to the various parameters presented in that paper. Following are ten selected characteristic criteria.

- **Character of Openings**
- **Force Causing Discharge**
- **Lithology of the Aquifer**
- **Geologic Horizon**
- **Sphere of Discharge**
- **Quantity of Discharge**
- **Uniformity of Discharge**
- **Permanence of Discharge**
- **Water Quality**
- **Water Temperature**

CLASSIFICATION OF ARROWHEAD SPRINGS

Each of these classification criteria is discussed below, and applied to Arrowhead Springs No. 2, No. 3, No. 4, No. 7, No. 10, No. 11, and No. 12. The overall classification is summarized at the end of this section.

CHARACTER OF OPENINGS

There are three general classes of springs according to the character of discharge openings: *seepage* or *filtration* springs, *fracture* springs, and *tubular* springs. The term *seepage spring* is generally limited to springs with small discharge, while the term *filtration spring* is applied without limitation to discharge or yield. The term *fracture spring* is used where openings consist of joints or fractures in rock. The term *tubular spring* is generally used where the opening is more or less rounded.

The Arrowhead Springs are **fracture springs**. Water from the springs issues forth from fractures in granitic rock. These fractures are associated with the weathering and decomposition of the granite. The harvested water is collected in engineered collection facilities (tunnels) at Springs No. 2 and No. 3, and by bore holes at the other springs.

FORCE CAUSING DISCHARGE

Springs may be classified as *gravity* springs, *artesian* springs, or springs whose discharge is from *other forces*. A *gravity spring* occurs where groundwater discharges from an aquifer under the action of gravity due to an outcrop of the water table. An *artesian spring* is one whose water issues forth under artesian pressure. Discharge due to *other forces* includes thermal springs such as geysers, and other forces that originate deep in the earth's crust.

Figure 6-1. Spring No. 4 Flowing from Fractures in Granitic Bedrock

The Arrowhead Springs are **gravity springs** in which the flow issues forth from the fractures at the point where the saturated level of the fractured rock (water table) contacts the face of the granite slope. Therefore, these springs are **contact** springs, with gravity drainage from fractures at the face of the mountain. Figure 6-1 shows Spring No. 4, an undeveloped spring flowing from fractures in the granitic bedrock.

LITHOLOGY OF THE AQUIFER

The lithology of the aquifer supplying water to the springs provides an additional criterion for classifying springs. The aquifer may be in *limestone, sandstone, shale, conglomerate, granite, volcanic beds*, or any of a number of other geologic formations that are sufficiently permeable to transmit groundwater. The principal rock types can be further subdivided if appropriate.

The aquifer supplying water to the Arrowhead Springs is granitic rock composed principally of **quartz monzonite**. The rock texture is generally medium to coarse grained, and intensely fractured and altered along fracture faces.

GEOLOGIC HORIZON

Another geologic means of classifying springs is by the geologic horizon of the rocks supplying groundwater to the springs. The age and formation name of the aquifer materially assists in distinguishing among springs in a similar area.

The geologic horizon of the aquifer supplying the Arrowhead Springs is the "**Cactus Granite**" of the San Bernardino Mountains, part of the Transverse Ranges geomorphic province associated with the San Andreas Fault Zone to the south of the mountains. These rocks are early Cretaceous in age and plutonic in origin.

SPHERE OF DISCHARGE

Springs may be subdivided into two categories based on their sphere of discharge. The categories are *subaerial,* and *subaqueous*. The term *subaerial* refers to springs that discharge to the atmosphere above the level of standing or flowing surface water. The term *subaqueous* describes springs that discharge below the level of standing or flowing surface water.

The Arrowhead Springs are **subaerial springs**, discharging to the surface above the level of standing or flowing surface water. These springs discharge from fractures in the face of the slopes of the San Bernardino Mountains.

QUANTITY OF DISCHARGE

In earlier times, springs were sometimes classified as "strong" or "weak," or as "large" or "small." These terms, however, provided only a relative description as to discharge rate. To provide a more quantitative classification, Oscar E. Meinzer devised the following Quantitative Magnitude Classification (USGS WSP 494, 1923) for practical use in the United States. For convenience, we have converted the flow rates from cubic feet per second (cfs) to gallons per minute (gpm).

ORDER	DISCHARGE
First	**45,000 gpm (100 cfs) or more**
Second	**4,500 gpm – <45,000 gpm**
Third	**450 gpm – <4,500 gpm**
Fourth	**100 gpm – <450 gpm**
Fifth	**10 gpm – <100 gpm**
Sixth	**1 gpm – <10 gpm**
Seventh	**1/8 gpm – <1 gpm)**
Eighth	**<1/8 gpm (<1 pint/min.)**

The Arrowhead Springs were measured to determine the flow rates as part of the hydraulic testing described in Section 3 of this report. Based on those measurements and historical data, these springs can be classified according to their magnitude in the above Quantitative Magnitude Classification system. Monthly flow rate data are maintained by the site spring manager for Springs No. 2 and No. 3. The highest flow over the last decade of monitoring was 107 gpm for Spring No. 2, and 95 gpm for Spring No. 3. Flows of this magnitude would classify Spring No. 2 as a **Fourth Order Spring** and Spring No. 3 as a **Fifth Order Spring**. The flow from Spring No. 4 tested in March 1997 averaged approximately 7 gpm; therefore, it is a **Sixth Order Spring.** The flow rate for Spring No. 7 was tested in March 1997, and its rate was measured at 20 gpm when all the associated bore holes were shut off. Thus, Spring No. 7 is a **Fifth Order Spring**. Flow monitoring conducted by Dames & Moore measured the maximum flow at Spring No. 10 at about 26 gpm, Spring 11 at 10 gpm, and Spring 12 at 31 gpm. Therefore, Springs No. 10, No. 11 and No. 12 are all **Fifth Order Springs**

UNIFORMITY OF DISCHARGE

Springs may be further classified as to their *variability* of discharge. There are three categories of variability: *constant, subvariable,* and *variable*. Variability is quantitatively stated according to the ratio of its fluctuation to its average discharge (avg Q). The fluctuation is the difference between the maximum discharge (max Q) and the minimum discharge (min Q). Thus, variability (V) can be expressed as a percent by the following equation.

$$\mathbf{V = 100(max\ Q - min\ Q)/(avg.Q)}$$

A *constant spring* is one with a variability not more than 25 percent (V </= 25%). A *subvariable spring* is one with a variability greater than 25 percent but not more than 100 percent (25% < V </= 100%). Finally, a *variable* spring is one having a variability of more than 100 percent (V > 100%).

The studies performed did not permit direct measurement of variations in flow that would allow quantitative assessment of the springs. However, using our observations and the data collected by the Arrowhead Springs manager for the flows over time, Springs No. 2, No. 3, No. 4, No. 10, No. 11 and No. 12 would all be classified as **subvariable** to **variable** springs.

PERMANENCE OF DISCHARGE

Springs may be divided into *perennial* and *intermittent* springs. A *perennial spring* is one that discharges continuously, but may be constant, subvariable, or variable. An *intermittent spring* discharges during certain periods but may be dry or not flow as a spring at other times. All intermittent springs are variable.

Based on the historical information concerning Arrowhead Springs, there is no indication that these springs have ever stopped flowing, even during drought conditions, except when the flows are diverted by the associated bore holes. Thus these springs are classified as **perennial** springs.

WATER QUALITY

A wide variety of differences in water quality can be used to further classify springs. For example, springs can be classified according to the predominant mineral characteristics of the water (bromine and iodine springs, epsom springs, borax springs, etc.). These types of descriptions are qualitative, in that there is no standard against which the concentrations of these types of mineral characteristics may be compared.

As part of its 1995 Regulations, FDA defined the term *mineral water* as an identity term for bottled water. In this definition, *mineral water* is defined as water having 250 mg/L or more of total dissolved solids (TDS). This classification of water is a convenient system for use in classifying springs. Thus, a spring with *low mineral content* is one with less than 250 mg/L TDS

Based on the results of chemical analyses for springs and bore holes at Arrowhead Springs, we have TDS data available for making a determination of this classification criterion. All of the TDS results are less than 250 mg/L. Threfore, the spring water from all the springs and their associated bore holes is **low mineral content water**.

WATER TEMPERATURE

There are two categories of temperature used for classifying springs: *thermal,* and *nonthermal*. A *thermal spring* is one whose water has a temperature appreciably above the mean annual temperature of the atmosphere in the vicinity of the spring. Thermal springs are further subdivided as *hot springs*, if the water is higher than that of the human body (about 98°F), and *warm springs*, if the water is lower than about 98°F. Nonthermal springs whose water is appreciably below the mean annual air temperature may be referred to as *cold* springs.

The temperature of the water from springs and bore holes at Arrowhead Springs ranged between 47°F and 55°F. The mean annual air temperature is between 52°F and 57°F. Thus, the Arrowhead springs are classified as **nonthermal springs**.

SUMMARY OF SPRING CLASSIFICATION

Based on this analysis and assessment of the Arrowhead Mountain Springs, we can summarize the classification of these springs according to the selected criteria. The following is a summary of this classification.

• **Character of Openings**	**Fracture**
• **Force Causing Discharge**	**Gravity**
• **Lithology of the Aquifer**	**Quartz Monzonite**
• **Geologic Horizon**	**Cactus Granite**
• **Sphere of Discharge**	**Subaerial**
• **Quantity of Discharge**	**Fourth to Sixth Order**
• **Uniformity of Discharge**	**Variable**
• **Permanence of Discharge**	**Perennial**
• **Water Quality**	**Low Mineral Content**
• **Water Temperature**	**Nonthermal**

Due to the locations of these springs within the San Bernardino Mountains, the term "mountain springs" is appropriate for the Arrowhead Springs. Similarly, the spring water that is harvested from these springs is appropriately termed "mountain spring water."

SECTION 7

CONCLUSIONS AND LIMITATIONS

The results of Dames & Moore's assessment of the Arrowhead Springs allowed us to draw several conclusions. Listed below are the pertinent conclusions resulting from this study.

CONCLUSIONS

- Historical data indicate that the Arrowhead Springs have been in existence for many years and have been used as water supply sources for their entire history.
- Based on the USGS classification system devised by O. E. Meinzer, the Arrowhead Springs are classified as follows:

Character of Openings:	Fracture springs, with fractures associated with the San Andreas Fault Zone.
Force Causing Discharge:	Contact springs, with gravity drainage from fractures.
Lithology of the Aquifer:	Granitic rock consisting principally of Quartz Monzonite.
Geologic Horizon:	Early Cretaceous, "Cactus Granite" plutonic and metaplutonic rock of the central Transverse Ranges.
Sphere of Discharge:	Subaerial, discharge to the surface.
Quantity of Discharge:	Fourth to Sixth Order Springs.
Uniformity of Discharge:	Subvariable to variable.
Permanence of Discharge:	Perennial.
Water Quality:	Low Mineral Content.
Water Temperature:	Nonthermal.

- Springs No. 2 and No. 3 have been developed by construction of engineered collection facilities consisting of tunnels and piping that enhance the flow of spring water and provide protection to these sources.
- The other springs have been developed by construction of associated bore holes that enhance the flow of spring water and provide protection to the spring water sources.
- All springs and bore holes flow from fracture systems in quartz monzonite bedrock of the San Bernardino Mountains under the natural force of gravity.
- There are two separate springs and three spring complexes from which spring water is harvested for bottling. Each spring complex contains one or more springs and multiple bore holes.

Spring No. 2
includes Spring No. 2, only.

Spring No. 3
includes Spring No. 3, only.

Spring Complex No. 4
includes Spring No. 4, and
Bore Holes No. 1, No. 1A, and No. 8.

Spring Complex No. 7
includes Spring No. 7, and
Bore Holes No. 7, No. 7A, No. 7B, and No. 7C.

Lower Spring Complex
includes Springs No. 10, No. 11, and No. 12, and
Bore Holes No. 10, No. 11, and No. 12.

- All of the springs and bore holes produce water by gravity, alone. None of the springs or bore holes are pumped.

- Hydraulic connection testing between springs and associated bore holes shows a direct hydraulic connection between Bore Holes No. 7, No. 7A, No.7B and No. 7C and Spring No. 7.

- Due to the site limitations, hydraulic testing for connectivity at Spring Complex No. 4 and the Lower Spring Complex was inconclusive. Thus, in accordance with FDA Regulations, hydraulic connectivity at these complexes was demonstrated by water quality comparisons.

Bore holes No. 1, No. 1A, and No. 8
are hydraulically connected to Spring No. 4.

Bore Holes No. 7, No. 7A, No. 7B, and No. 7C
are hydraulically connected to Spring No. 7

Bore Holes No. 10, No. 11, and No. 12
are hydraulically connected to Springs No. 10, No. 11, and No. 12.

- Graphical analysis of chemical quality data for springs and bore holes shows that the water from the bore holes used to harvest spring water in Spring Complex No. 4, Spring Complex No. 7, and the Lower Spring Complex is the same quality water as from the associated springs.

Spring No. 2
None of the compounds in the sample from the spring exceeds the FEDMCLs.

Spring No. 3
None of the compounds in the sample from the spring exceeds the FEDMCLs.

Spring Complex No. 4
None of the compounds in the samples from either the springs or the bore holes exceeds the federal maximum contaminant levels (FEDMCLs).

Spring Complex No. 7
None of the compounds in the samples from either the springs or the bore holes exceeds the FEDMCLs.

Lower Spring Complex
None of the compounds in the samples from either the springs or the bore holes exceeds the FEDMCLs.

- Microscopic particulate analysis of samples from Bore Holes No. 1, No. 1A, No. 8, No. 7, No. 7A, No. 7B, No. 7C, No. 10, No. 11, and No. 12, and Springs No. 2 and No. 3 show only **Low Risk**. Low risk is the best relative risk that can be attained for any water source. Thus, **none of the MPA tests indicates direct influence of surface water to the springs or bore holes.**

- Water characteristics assessments comparing turbidity and total dissolved solids data with precipitation data for 1998 showed no correlation of turbidity or total dissolved solids to climatological conditions. The absence of significant variations and the absence of relatively rapid shifts in water characteristics are indicative of no direct influence of surface water on these spring sources. Thus, **none of the water characteristics assessments indicates direct influence of surface water to the springs or bore holes.**

- Based on this assessment, **water harvested** from Bore Holes No. 1, No. 1A, No. 7, No. 7A, No. 7B, No. 7C, No. 8, No. 10, No. 11, and No. 12, and Springs No. 2 and No. 3 **meets the "identity" criteria for "*spring water*" sources in the FDA Regulations.**

The spring water from springs and bore holes in Spring Complexes No. 4, No. 7, the Lower Spring Complex, and from the engineered collection facilities at Springs No. 2 and No. 3, issue forth from the San Bernardino Mountains. The water from Bore Holes No. 1, No. 1A, No. 8, No. 7, No. 7A, No. 7B, No. 7C, No. 10, No. 11, and No. 12 and Spring No. 2 and No. 3 meets the FDA and State of California regulatory requirements for "*spring water.*" Therefore, **the term "*Mountain Spring Water*" is a correct and appropriate description for this spring water.**

LIMITATIONS

The conclusions presented in this report are professional opinions based solely upon the data described in this report. They are intended exclusively for the purpose outlined herein and the site location and project indicated. This report is intended for the sole use of our client. The scope of services performed in execution of this investigation may not be appropriate to satisfy the needs of other users, and any use or reuse of this document or any findings, conclusions, or recommendations presented herein is at the sole risk of said user.

Opinions and recommendations presented herein apply to the site conditions existing at the time of our investigation and cannot necessarily apply to site changes of which Dames & Moore is not aware and has not had the opportunity to evaluate. Changes in the conditions of this property may occur with time due to natural processes or the works of man on the subject property or on adjacent properties.

Respectfully submitted,
DAMES & MOORE

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N. Thomas Sheahan
Principal Hydrogeologist
Vice President

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

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APPENDIX B

BORE HOLE LOGS

FEB-10-94 THU 05:20 PM SPRING WATER SYSTEMS

DUPLICATE
Driller's Copy
Page 1 of 1
Owner's Well No. New #1
Date Work Began 7/20/93, Ended 8/9/93
Local Permit Agency ~~08069201~~ San Bernardino Environmental Health
Permit No 08069201 Permit Date 8/3/93

1A #1A

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 485780

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) __ VERTICAL __ HORIZONTAL ✓ ANGLE __ (SPECIFY)
DEPTH TO FIRST WATER ____ (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	3	Loose Rk. Overburden
3	45	Alt. Med. & Hard Rk.
45	58	Soft & Clayey w/Fract. Rk
58	74	Alt. Med. & Med Hard Rk.
74	88	Hard Rk. w/cracks
88	130	Highly Fract. Med Hard & Hard Rk

TOTAL DEPTH OF BORING 130 (Feet)
TOTAL DEPTH OF COMPLETED WELL 130 (Feet)

WELL OWNER

Name Arrowhead Drinking Water Co.
Mailing Address [illegible] E. Potrero Grande Dr.
Monterey Park CA 91754
CITY STATE ZIP

WELL LOCATION

Address ½ mi. W Side of Rim Forest
City -
County San Bernardino
APN Book 0336 Page 031 Parcel 04
Township 2N Range 3W Section 30
Latitude 34 13 41 NORTH DEG. MIN. SEC. Longitude 117 14 09 WEST DEG. MIN. SEC.

LOCATION SKETCH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL
MODIFICATION/REPAIR
__ Deepen
__ Other (Specify)
__ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

__ MONITORING
WATER SUPPLY
__ Domestic
✓ Public
__ Irrigation
__ Industrial
__ "TEST WELL"
__ CATHODIC PROTECTION
__ OTHER (Specify)

DRILLING METHOD Rotary Core FLUID ____

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL N/A (Ft.) & DATE MEASURED N/A
ESTIMATED YIELD* 45 (GPM) & TEST TYPE Flow
TEST LENGTH ____ (Hrs.) TOTAL DRAWDOWN N/A (Ft.)
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	66	2½			✓		Stl galv	2	Sch 40	-
66	123	2		✓			Galv.	1 5/8	1/8"	3/4" holes
123	130	1 1/2		✓			Galv.	1 7/8	1/8"	3/4" holes

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	66	✓			Grout under Pressure

ATTACHMENTS (✓)

__ Geologic Log
__ Well Construction Diagram
__ Geophysical Log(s)
__ Soil/Water Chemical Analyses
__ Other ____
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Spring Water Systems
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

1828 Old Waterman Cyn. Rd. San Berdo. CA 92404
ADDRESS CITY STATE ZIP

Signed Gene P. Nelson 9/4/93 304075
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

New #1 9/93

DUPLICATE
Driller's Copy
Page 1 of 1
Owner's Well No. New #8
Date Work Began 8/2/93, Ended 8/20/93
Local Permit Agency San Bernardino Environmental Health
Permit No. 0806 9302 Permit Date 8/3/93

#8

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 485800

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER ______ (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	8	Hard Rk.
8	79	alt. Med. Hard & Hard Rk
79	80	Clay
80	100	alt. Soft & Med. Rk w/clay
100	114	alt. Hard & Very Hard Rk w/cracks
114	120	Highly Fract. Very Hard Rk.

TOTAL DEPTH OF BORING 120 (Feet)
TOTAL DEPTH OF COMPLETED WELL 120 (Feet)

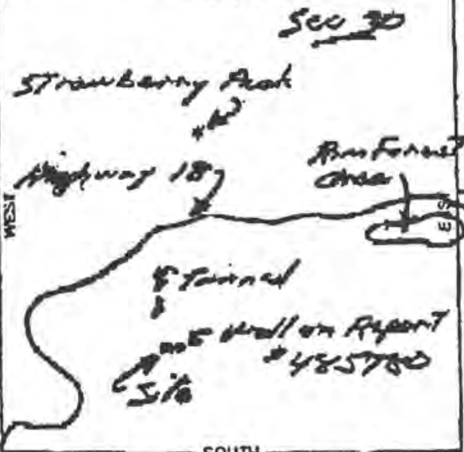
WELL OWNER

Name Arrowhead Drinking Water Co.
Mailing Address 6?? E Potrero Grande Dr.
Monterey Park CA 91754
CITY STATE ZIP

WELL LOCATION

Address 1/2 mi. WSW of Rim Forest
City —
County San Bernardino
APN Book 0336 Page 031 Parcel 04
Township 2N Range 3W Section 30
Latitude 34 13 41 NORTH Longitude 117 14 03 WEST
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
✓ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary Core FLUID —

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL N/A (Ft.) & DATE MEASURED N/A
ESTIMATED YIELD* 80 (GPM) & TEST TYPE Flow
TEST LENGTH 24 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	100	2 1/2			✓		Std. Steel	2	Sch. 40	—
100	120	2		✓			Galv.	1 1/2	1/8"	3/16 Holes

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	100	✓			Grout under pressure

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ______

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Spring Water Systems
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
1828 Old Waterman Cyn. Rd. San Berdo. CA 92404
ADDRESS CITY STATE ZIP
Signed Gene P. Nelson 9/4/93 304075
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

(New #8) 8/93

TRIPLICATE
Owner's Copy
Page 1 of 1

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 485773

Owner's Well No. New 7A #7A
Date Work Began 7/7/92, Ended 9/4/92
Local Permit Agency San Bernardino Co. Environmental Health
Permit No. 06259205 Permit Date 6/16/92

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE
LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ___ HORIZONTAL X ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER 96 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	30	Decomposed Granite
30	90	alt. Med. & Hard Rk.
90	96	Clayey Med. Rk. & Clay
96	110	Fractured Med. Rk.
110	139	Med. & Hard. Rk.
139	152	Hard Rd.
152	187	Alt. Med. & Hard Rk
		w/large Fracture @183'
187	230	Alt. Med. & Hard Rk (Fractured)

TOTAL DEPTH OF BORING 230 (Feet)
TOTAL DEPTH OF COMPLETED WELL 230 (Feet)

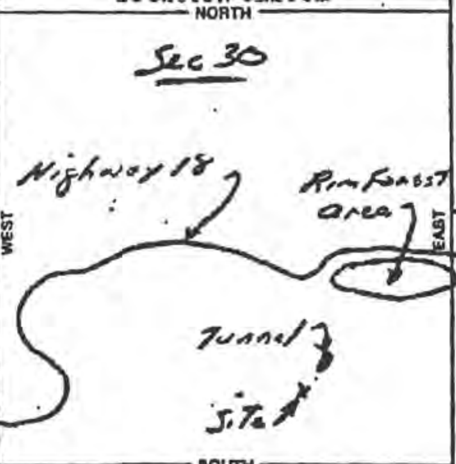
WELL OWNER

Name Arrowhead Drinking Water Co.
Mailing Address 601 E. Potrero Grande Dr
Monterey Park Ca. 91754
CITY STATE ZIP

WELL LOCATION

Address In SE 1/4 of Sec 30
City S. of Rim Forest
County San Bernardino
APN Book 0336 Page 031 Parcel 04
Township 2N Range 3W Section 30
Latitude 34 13 30 NORTH Longitude 117 13 30 WEST
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
X Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary Core FLUID

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL NA (Ft.) & DATE MEASURED NA
ESTIMATED YIELD* 100 (GPM) & TEST TYPE Flow
TEST LENGTH 500 (Hrs.) TOTAL DRAWDOWN NA (Ft.) 35 gpm.
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/ GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	95	2 7/8			✓		Std. Galv.	2	Std.	–
93.6	177.6	2		✓			Galv.	1½	Std.	1/16 Holes
177.6	230	2		✓			Galv.	1¼	1/16"	1/16" Holes

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	95	✓			Grout under
					pressure

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Spring Water Systems
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
1828 Old Waterman Cyn. Rd San Berdo, Ca. 92404
ADDRESS CITY STATE ZIP
Signed Gene P. Nelson 10/1/92 304075
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

FEB-10-94 THU 12:

TRIPLICATE
Owner's Copy
Page 1 of 1
Owner's Well No. New 7B
Date Work Began 7/21/92, Ended 8/19/92
Local Permit Agency San Bernardino Co. Environmental Health
Permit No. 08039201 Permit Date 7/21/92

#7B

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 485774

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE
LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ___ HORIZONTAL ✓ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 138 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	28	Decomposed Granite
28	120	Alt. Med. & Hard Rks
120	121	Clay
121	137	Sft. & Clayey Med. Rk.
137	150	Alt. soft & Med. Rk.
150	199	Alt. Med. & Hard Rk.
199	206	Very Hard Rk
206	214	Med. Rk.
214	245	Soft & Clayey Med. Rk.
245	340	Med. Rk.
340	350	Fractured Med. Rk.
350	397	Qtz

TOTAL DEPTH OF BORING 397 (Feet)
TOTAL DEPTH OF COMPLETED WELL 397 (Feet)

WELL OWNER

Name Arrowhead Drinking Water Co.
Mailing Address 601 E. Potrero Grande Dr.
Monterey Park Ca. 91754
CITY STATE ZIP

WELL LOCATION

Address In SE ¼ of Sec 30
City S. of Rim Forest
County San Bernardino
APN Book 336 Page 031 Parcel 04
Township 2N Range 3W Section 30
Latitude 34 13 30 NORTH Longitude 117 13 52 WEST
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)
X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)
___ MONITORING
WATER SUPPLY
___ Domestic
✓ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary Core FLUID

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL NA (Ft.) & DATE MEASURED NA
ESTIMATED YIELD* 45 (GPM) & TEST TYPE Flow
TEST LENGTH 72 (Hrs.) TOTAL DRAWDOWN NA (Ft.) 25 ft

* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	121	2 7/8			✓		Galv.	2"	Std.	—
119.8	252.8	2			✓		Galv	1½	Std	
252.8	397	1½		✓			Galv	1¼	1/16"	8 holes

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	121	✓			Grout under pressure

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Spring Water Systems
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
1828 Old Waterman Cyn. Rd. San Berdo Ca. 92404
ADDRESS CITY STATE ZIP
Signed
WELL DRILLER/AUTHORIZED REPRESENTATIVE
10/1/92 DATE SIGNED
304075 C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

NEW #7B 7/92

DUPLICATE
Driller's Copy
Page 1 of 1
Owner's Well No. 7C
Date Work Began 6/21/93, Ended 7/18/93
Local Permit Agency San Bernardino Environmental Health
Permit No. 26179301 Permit Date 6/18/93

#7C

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 485779

DWR USE ONLY – DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ✓ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 190 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	5	Overburden
5	34	Decomposed Granite
34	119	Med Hard Rk.
119	165.6	Alt. Med & Hard Rk.
165.6	166.6	Clay
166.6	190	Alt. Med. & Hard Rk
190	246	Med Hard & Hard Rk
246	251	Soft & Med Rk.
251	261	Hard Rk.
261	300	Alt. Med. Hard & Hard Rk

TOTAL DEPTH OF BORING 300 (Feet)
TOTAL DEPTH OF COMPLETED WELL 300 (Feet)

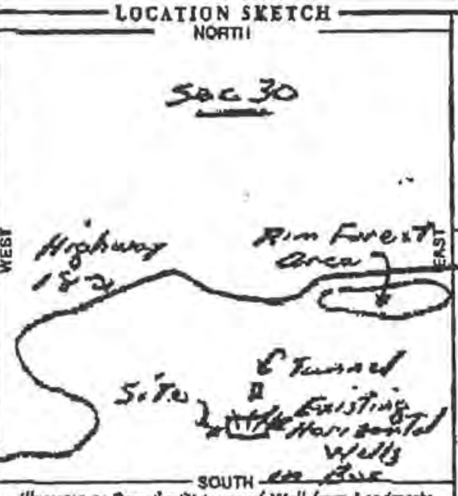
WELL OWNER

Name Arrowhead Drinking Water Co.
Mailing Address 6001 E. Potrero Grande Dr.
Monterey Park CITY Ca. STATE 91754 ZIP

WELL LOCATION

Address In SE 1/4 of Sec 30
City S. of Rim Forest
County San Bernardino
APN Book 0336 Page 031 Parcel 04
Township 2N Range 3W Section 30
Latitude 34 DEG. 13 MIN. 30 SEC. NORTH Longitude 117 DEG. 13 MIN. 53 SEC. WEST

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

☒ NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
☒ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary Core FLUID

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL n/a (Ft.) & DATE MEASURED n/a
ESTIMATED YIELD* 60 (GPM) & TEST TYPE Flow
TEST LENGTH 24 (Hrs.) TOTAL DRAWDOWN n/a (Ft.)
* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	167.6	2½			✓		Std. Galv.	2	Sch 40	—
167.6	240	2		✓			Galv.	1½	Sch 40	3/16" Holes
240	300	1½		✓			Galv.	1¼	Sch 40	3/16" Holes

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	167.6	✓			Grout under Pressure.

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Spring Water Systems (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
1822 Old Waterman Can. Rd. ADDRESS San Bernardino, CITY CA STATE 92408 ZIP
Signed Gene D. Nelson WELL DRILLER/AUTHORIZED REPRESENTATIVE 8/16/93 DATE SIGNED 304075 C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

DUPLICATE
Driller's Copy

#10

Notice of Intent No. 10580
Local Permit No. or Date 07287807

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

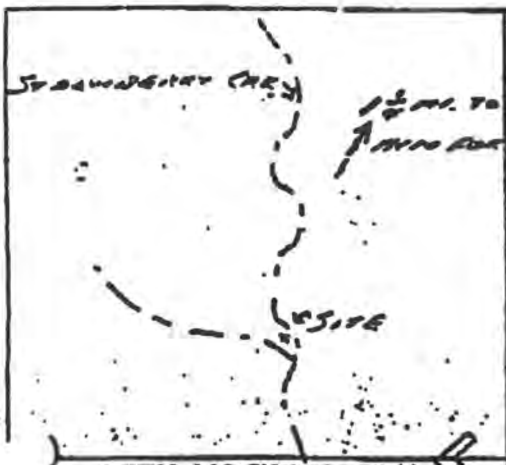
Do not fi

No. 04278

State Well No.
Other Well No.

(1) OWNER: Name Arrowhead Puritas Waters
Address 130 W. Fogg St.
City Colton Zip 92324

(2) LOCATION OF WELL (See instructions):
County San Berdo. Owner's Well Number #10
Well address if different from above
Township 2N. Range 3E Section 31
Distance from cities, roads, railroads, fences, etc. N.W. ¼ of S.E. ¼ Sec. 31 - In Strawberry Cyn. Approx. 1½ mi. S.S.W. of Rimforest.



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☒
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other Bottled ☒

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☐ No ☐ Size
Diameter of bore 2½" 0 to 162"
Packed from 2" 162 to 305'

(7) CASING INSTALLED:
Steel ☒ Plastic ☐ Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	162	2"	I.D.
		Std.	galv.

(8) PERFORATIONS:
Type of perforation or size of screen 1½" I.D. P.V.C.

From ft.	To ft.	Slot size
0	160	none
160	300	¼" drilled holes

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 162 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ft.
Method of sealing Grout under pressure

(10) WATER LEVELS: See Note - - - - - - -
Depth of first water, if known ft.
Standing level after well completion ft.

(11) WELL TESTS: See Note - - - - - - - -
Was well test made? Yes ☒ No ☐ If yes, by whom? Pierson Drilling
Type of test Flow Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ft. At end of test ft.
Discharge 50 gal/min after hours Water temperature 56
Chemical analysis made? Yes ☒ No ☐ If yes, by whom? Arrhd. Puritas
Was electric log made? Yes ☐ No ☐ If yes, attach copy to this report

(12) WELL LOG: Total depth 305 ft. Depth of completed well 305

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	23	black overburden
23	161	decomposed granite
161	162	clay
162	240	hard decomposed granite
240	270	med. hard rk.
270	290	alt. med. hard & hard rk.
290	305	hard rk.

*Water pick-ups (Initial Flows)

From	To	Flow
0	162	3 G.P.M. (sealed off)
162	190	10 G.P.M.
190	220	15 G.P.M.
220	260	16 G.P.M.
260	305	10 G.P.M.

Total initial flow - 50 G.P.M.

Note: When capped, well will store water underground until the pressure at collar level reaches 15 p.s.i.

After completion, well was allowed to flow unrestricted for periods of up to 8hrs. During this time initial flow dropped to 48 G.P.M. & seemed to be holding steady.

Work started 12/6 1978 Completed 12/21 197

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed (Well Driller)
NAME Pierson Drilling (Person, firm, or corporation) (Typed or printed)
Address P.O. Box 1028
City Crestline Zip 92325
License No. 304075 Date of this report 1/23/79

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

- Spring - 10

DUPLICATE
Driller's Copy "Old Bore Hole Null."

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

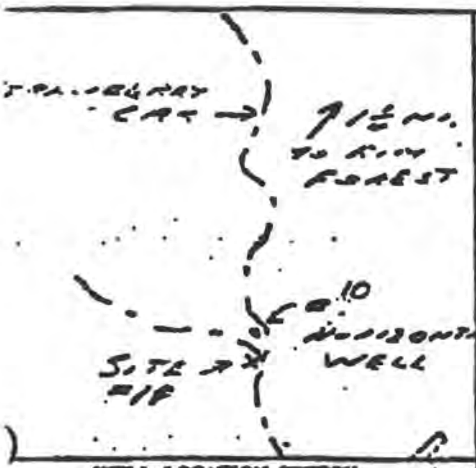
Do not fill
No. 04279

Notice of Intent No. 10581
Local Permit No. or Date 07287808

State Well No.
Other Well No.

(1) OWNER: Name Arrowhead Puritas Waters
Address 130 N. Pegg St.
City Colton Zip 92324

(2) LOCATION OF WELL (See instructions):
County San Berdo. Owner's Well Number ~~10~~ 11
Well address if different from above
Township 2N. Range 3E. Section 31
Distance from cities, roads, railroads, fences, etc. N.W. ¼ of S.E. ¼ Sec. 31 - In Strawberry Cyn. Approx. 1½ mi. S.S.W. of Rim Forest.



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☒
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other Bottled ☒

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) ~~GRAVEL PACK:~~
Yes ☐ No ☐ Size
Diameter of bore 2½" 0 to 164
2" 164 to 330
Packed from 1½" 330 to 495

(7) CASING INSTALLED:
Steel ☒ Plastic ☐ Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	164	3"	I.D.
		Std.	Galv.

(8) PERFORATIONS:
Type of perforation or size of screen None

From ft.	To ft.	Slot size

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 164 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ft.
Method of sealing Grout under pressure

(10) WATER LEVELS: See note - - - - - -
Depth of first water, if known ft.
Standing level after well completion ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ft. At end of test ft.
Discharge 20 gal/min after hours Water temperature 58
Chemical analysis made? Yes ☒ No ☐ If yes, by whom? Arrhd. Puritas
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 495 ft. Depth of completed well 495
from ft. to ft. Formation (Describe by color, character, size or material)

0 - 2 - rky. overburden
2 - 16 - decomposed granite
16 - 90 - med. hard rk.
90 - 163-8 - Alt. med. & hard rk.
163-8 - 164 - clay
164 - 289 - alt. med. & hard rk.
289 - 289-6 - clay.
289-6 - 356 - alt. med.hard & hard rk.
356 - 400 - alt.& med. rk.
400 - 495 - alt. med. & hard rk.

Water pick-ups (Initial Flows)

From	To	Flow
0	164	Trickle (sealed off)
164	250	1 G.P.M. "
250	400	1 G.P.M. "
400	440	16 G.P.M.
440	495	2 G.P.M.

Total Initial Flow - 20 G.P.M.

Note: When capped, well will store water under ground until the pressure at collar level reached 17 p.s.i.

Work started 12/27 1978 Completed 1/19 19

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
SIGNED (Well Driller)
NAME Pierson Drilling (Person, firm, or corporation) (Typed or printed)
Address P.O. Box 1028
City Crestline Zip 92325
License No. 304075 Date of this report 2/9/79

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Spring - 11

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 485788 #11

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO. / STATION NO.

LATITUDE / LONGITUDE

APN/TRS/OTHER

Owner's Well No. [illegible]

Date Work Began [illegible]/94 , Ended 6/10/94

Local Permit Agency San Bernardino Co Environmental Health

Permit No. 0[illegible]7701 Permit Date 5/20/94

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ___ HORIZONTAL ✓ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 85 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	8	Black overburden
8	40	Soft coarse decomposed Granite
40	160	Med. to chunky decomposed Granite
160	214	Med. rock
214	310	M. Smth. & Chunky Med. Rk

TOTAL DEPTH OF BORING 310 (Feet)

TOTAL DEPTH OF COMPLETED WELL 310 (Feet)

WELL OWNER

Name Arrowhead Drinking Water Co.

Mailing Address 601 Potrero Grande Dr.

Monterey Park CA 9175[illegible]
CITY STATE ZIP

WELL LOCATION

Address Near SE cor. of NE ¼ of NW ¼ Sec 31

City Sky of Rim Forest T2N, R3

County San Bernardino

APN Book 2345 Page 241 Parcel 03

or Township 2N Range 3W Section 31

or Latitude 34 13 05 NORTH Longitude 117 14 00 WE
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST EAST

SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL

MODIFICATION/REPAIR
- ___ Deepen
- ___ Other (Specify)

___ DESTROY (Describe Procedures and Mate Under "GEOLOGIC LC

PLANNED USE(

(✓)

___ MONITORING

WATER SUPPLY
- ___ Domestic
- ✓ Public
- ___ Irrigation
- ___ Industrial

___ "TEST WELL"

___ CATHODIC PROT TION

___ OTHER (Specify)

DRILLING METHOD Rotary Core FLUID —

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL N/A (Ft.) & DATE MEASURED N/A

ESTIMATED YIELD* 12 (GPM) & TEST TYPE Flow

TEST LENGTH 24 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)

*May not be representative of a well's long-term yield.

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	CASING(S) TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	67	3	✓				Galv	2½	1/16"	—
67	146	2½	✓				Std. Galv	2"	Sch 40	—
142	310	2¾		✓			Galv.	1¾	1/16"	3/16 Drilled holes

DEPTH FROM SURFACE Ft.	to Ft.	ANNULAR MATERIAL TYPE CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	67	✓			GrouT und Pressur

ATTACHMENTS (✓)

- ✓ Geologic Log
- ✓ Well Construction Diagram
- ✓ Geophysical Log(s)
- ✓ Soil/Water Chemical Analyses
- ✓ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belie

NAME Spring Water Systems
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

1828 Old Waterman Cyn. Rd San Bernardino CA 9240[illegible]
ADDRESS CITY STATE ZIP

Signed Gene P. Nelson 7/31/94 30457
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMB

DWR 188 REV 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 485787

Owner's Well No. [illegible] 72 #12

Date Work Began [illegible], Ended 8/9/94

Local Permit Agency San Bernardino Environmental Health

Permit No. 94264403 Permit Date 4/26/94

DWR USE ONLY — DO NOT FILL IN —

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ___ HORIZONTAL ✓ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 60 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	6	Black overburden,
6	90	Soft Decomposed Granite
90	100	Clayey DG.
100	130	alt. DG. & Med. Rk
130	160	Med. Rk.
160	230	Chunky Med. rk
230	237	Soft
237	320	Some short soft spts. but mostly chunky Med. rk

TOTAL DEPTH OF BORING 320 (Feet)

TOTAL DEPTH OF COMPLETED WELL 320 (Feet)

WELL OWNER

Name Arrowhead Drinking Water Co.

Mailing Address 601 Potrero Grande Dr.

Monterey Park CA 91754

CITY STATE ZIP

WELL LOCATION

Address Near SE Cor. of NE¼ of NW¼, Sec 31,

City SW of Rimforest T2N, R3W

County San Bernardino

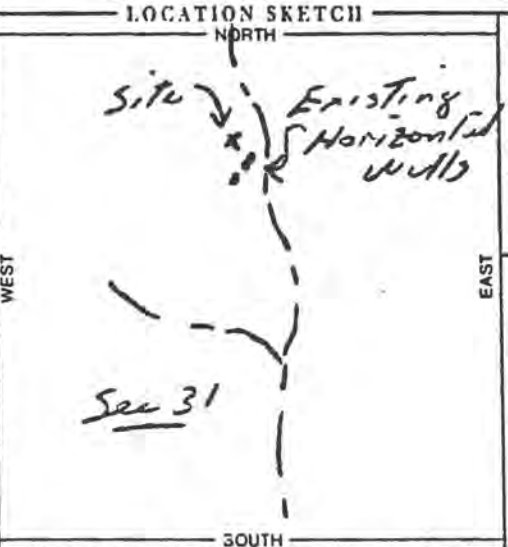
APN Book 0285 Page 241 Parcel 03

or Township 2N Range 3W Section 31

or Latitude 34 13 05 NORTH Longitude 117 14 00 WEST

DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

___ NEW WELL

MODIFICATION/REPAIR

___ Deepen

___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING

WATER SUPPLY

___ Domestic

✓ Public

___ Irrigation

___ Industrial

___ "TEST WELL"

___ CATHODIC PROTECTION

___ OTHER (Specify)

DRILLING METHOD Rotary Core FLUID —

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL N/A (Ft.) & DATE MEASURED N/A

ESTIMATED YIELD* 8 (GPM) & TEST TYPE Flow

TEST LENGTH 48 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)

*May not be representative of a well's long-term yield.

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CONDUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	95	2 7/8			✓		Std. Galv.	2"	sch 40	—
95	152	2			✓		Galv.	1½"	0.100	—
152	320	1½		✓			Galv	1 3/8	0.100	3/16 Drilled Holes

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	152	✓			Grout and Pressure

ATTACHMENTS (✓)

___ Geologic Log

___ Well Construction Diagram

___ Geophysical Log(s)

___ Soil/Water Chemical Analyses

___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Spring Water Systems

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

1828 Old Waterman Cyn Rd San Bernardino CA 92404

ADDRESS CITY STATE ZIP

Signed Gene P. Nelson 6/20/94 304075

WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

APPENDIX C

MONITORING DATA

Flow Rate at Spring 4, Arrowhead

Date/Time	gal/15 min	gpm
3/17/97 12:30	100.32	6.69
3/17/97 12:45	100.31	6.69
3/17/97 13:00	100.37	6.69
3/17/97 13:15	100.24	6.68
3/17/97 13:30	100.28	6.69
3/17/97 13:45	100.11	6.67
3/17/97 14:00	100.08	6.67
3/17/97 14:15	100.21	6.68
3/17/97 14:30	100.19	6.68
3/17/97 14:45	100.4	6.69
3/17/97 15:00	100.32	6.69
3/17/97 15:15	100.42	6.69
3/17/97 15:30	100.53	6.70
3/17/97 15:45	100.56	6.70
3/17/97 16:00	100.64	6.71
3/17/97 16:15	100.68	6.71
3/17/97 16:30	100.74	6.72
3/17/97 16:45	100.8	6.72
3/17/97 17:00	100.95	6.73
3/17/97 17:15	100.93	6.73
3/17/97 17:30	100.91	6.73
3/17/97 17:45	101.02	6.73
3/17/97 18:00	101.1	6.74
3/17/97 18:15	101.09	6.74
3/17/97 18:30	101	6.73
3/17/97 18:45	101.05	6.74
3/17/97 19:00	101.07	6.74
3/17/97 19:15	101.09	6.74
3/17/97 19:30	100.99	6.73
3/17/97 19:45	101.09	6.74
3/17/97 20:00	101.16	6.74
3/17/97 20:15	101.11	6.74
3/17/97 20:30	101.05	6.74
3/17/97 20:45	101.07	6.74
3/17/97 21:00	100.95	6.73
3/17/97 21:15	101.07	6.74
3/17/97 21:30	101.02	6.73
3/17/97 21:45	101	6.73
3/17/97 22:00	100.96	6.73
3/17/97 22:15	101	6.73
3/17/97 22:30	100.99	6.73
3/17/97 22:45	101.28	6.75
3/17/97 23:00	101.11	6.74
3/17/97 23:15	101	6.73
3/17/97 23:30	101.02	6.73
3/17/97 23:45	101.14	6.74
3/18/97 0:00	101.11	6.74

Flow Rate at Spring 4, Arrowhead

Date/Time	gal/15 min	gpm
3/18/97 0:15	101.07	6.74
3/18/97 0:30	101.13	6.74
3/18/97 0:45	100.81	6.72
3/18/97 1:00	100.95	6.73
3/18/97 1:15	101.01	6.73
3/18/97 1:30	100.96	6.73
3/18/97 1:45	101.06	6.74
3/18/97 2:00	101.08	6.74
3/18/97 2:15	101.08	6.74
3/18/97 2:30	101.11	6.74
3/18/97 2:45	101.08	6.74
3/18/97 3:00	101.19	6.75
3/18/97 3:15	100.81	6.72
3/18/97 3:30	101.15	6.74
3/18/97 3:45	101.05	6.74
3/18/97 4:00	101.07	6.74
3/18/97 4:15	101.09	6.74
3/18/97 4:30	101	6.73
3/18/97 4:45	101.12	6.74
3/18/97 5:00	101.03	6.74
3/18/97 5:15	101.17	6.74
3/18/97 5:30	100.88	6.73
3/18/97 5:45	100.97	6.73
3/18/97 6:00	101.02	6.73
3/18/97 6:15	101.07	6.74
3/18/97 6:30	101	6.73
3/18/97 6:45	100.93	6.73
3/18/97 7:00	100.85	6.72
3/18/97 7:15	100.91	6.73
3/18/97 7:30	100.83	6.72
3/18/97 7:45	100.92	6.73
3/18/97 8:00	100.93	6.73
3/18/97 8:15	100.85	6.72
3/18/97 8:30	100.93	6.73
3/18/97 8:45	100.9	6.73
3/18/97 9:00	100.99	6.73
3/18/97 9:15	100.83	6.72
3/18/97 9:30	101	6.73
3/18/97 9:45	100.95	6.73
3/18/97 10:00	100.91	6.73
3/18/97 10:15	100.53	6.70
3/18/97 10:30	100.42	6.69
3/18/97 10:45	100.31	6.69
3/18/97 11:00	100.26	6.68
3/18/97 11:15	100.15	6.68
3/18/97 11:30	100.26	6.68
3/18/97 11:45	100.07	6.67

Flow Rate at Spring 4, Arrowhead

Date/Time	gal/15 min	gpm
3/18/97 12:00	99.93	6.66
3/18/97 12:15	99.97	6.66
3/18/97 12:00	99.93	6.66
3/18/97 12:15	99.97	6.66
3/18/97 12:30	99.95	6.66
3/18/97 12:45	99.76	6.65
3/18/97 13:00	99.8	6.65
3/18/97 13:15	99.56	6.64
3/18/97 13:30	99.69	6.65
3/18/97 13:45	99.5	6.63
3/18/97 14:00	99.6	6.64
3/18/97 14:15	99.62	6.64
3/18/97 14:30	99.65	6.64
3/18/97 14:45	99.71	6.65
3/18/97 15:00	99.79	6.65
3/18/97 15:15	99.89	6.66
3/18/97 15:30	99.79	6.65
3/18/97 15:45	100	6.67
3/18/97 16:00	100.1	6.67
3/18/97 16:15	100.24	6.68
3/18/97 16:30	100.33	6.69
3/18/97 16:45	100.43	6.70
3/18/97 17:00	100.51	6.70
3/18/97 17:15	100.47	6.70
3/18/97 17:30	100.74	6.72
3/18/97 17:45	100.76	6.72
3/18/97 18:00	100.78	6.72
3/18/97 18:15	100.93	6.73
3/18/97 18:30	100.93	6.73
3/18/97 18:45	101.02	6.73
3/18/97 19:00	101.01	6.73
3/18/97 19:15	101.11	6.74
3/18/97 19:30	100.99	6.73
3/18/97 19:45	101.07	6.74
3/18/97 20:00	101	6.73
3/18/97 20:15	101.11	6.74
3/18/97 20:30	101.12	6.74
3/18/97 20:45	101.05	6.74
3/18/97 21:00	101.03	6.74
3/18/97 21:15	101.06	6.74
3/18/97 21:30	101.18	6.75
3/18/97 21:45	101.13	6.74
3/18/97 22:00	101.2	6.75
3/18/97 22:15	101.24	6.75
3/18/97 22:30	101.11	6.74
3/18/97 22:45	101.18	6.75
3/18/97 23:00	101.14	6.74
3/18/97 23:15	101.23	6.75
3/18/97 23:30	101.11	6.74
3/18/97 23:45	101.11	6.74
3/19/97 0:00	101.14	6.74

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
2/25/97 14:15	307.8	0.2
2/25/97 14:30	309.8	0.0
2/25/97 14:45	308.9	0.0
2/25/97 15:00	310.0	0.0
2/25/97 15:15	309.8	0.0
2/25/97 15:30	309.5	0.0
2/25/97 15:45	310.5	0.0
2/25/97 16:00	309.0	0.0
2/25/97 16:15	307.3	0.0
2/25/97 16:30	307.3	0.0
2/25/97 16:45	306.8	0.0
2/25/97 17:00	307.9	0.0
2/25/97 17:15	308.1	0.0
2/25/97 17:30	307.5	0.0
2/25/97 17:45	306.9	0.0
2/25/97 18:00	308.2	0.0
2/25/97 18:15	307.8	0.0
2/25/97 18:30	308.9	0.0
2/25/97 18:45	308.3	0.0
2/25/97 19:00	308.0	0.0
2/25/97 19:15	306.3	0.0
2/25/97 19:30	306.8	0.0
2/25/97 19:45	306.7	0.0
2/25/97 20:00	306.7	0.0
2/25/97 20:15	308.3	0.0
2/25/97 20:30	307.2	0.0
2/25/97 20:45	306.7	0.0
2/25/97 21:00	306.7	0.0
2/25/97 21:15	307.9	0.0
2/25/97 21:30	308.2	0.0
2/25/97 21:45	308.2	0.0
2/25/97 22:00	308.2	0.0
2/25/97 22:15	309.0	0.0
2/25/97 22:30	308.6	0.0
2/25/97 22:45	308.1	0.0
2/25/97 23:00	309.4	0.0
2/25/97 23:15	309.8	0.0
2/25/97 23:30	310.2	0.0
2/25/97 23:45	311.3	0.0
2/26/97 0:00	309.4	0.0
2/26/97 0:15	310.2	0.0
2/26/97 0:30	310.7	0.0
2/26/97 0:45	311.2	0.0
2/26/97 1:00	310.5	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
2/26/97 1:15	312.3	0.0
2/26/97 1:30	312.9	0.0
2/26/97 1:45	311.8	0.0
2/26/97 2:00	311.6	0.0
2/26/97 2:15	312.7	0.0
2/26/97 2:30	312.8	0.0
2/26/97 2:45	313.3	0.0
2/26/97 3:00	313.9	0.0
2/26/97 3:15	313.4	0.0
2/26/97 3:30	313.5	0.0
2/26/97 3:45	313.6	0.0
2/26/97 4:00	313.9	0.0
2/26/97 4:15	313.5	0.0
2/26/97 4:30	314.7	0.0
2/26/97 4:45	314.6	0.0
2/26/97 5:00	314.0	0.0
2/26/97 5:15	313.9	0.0
2/26/97 5:30	313.8	0.0
2/26/97 5:45	313.9	0.0
2/26/97 6:00	314.5	0.0
2/26/97 6:15	314.3	0.0
2/26/97 6:30	314.3	0.0
2/26/97 6:45	313.8	0.0
2/26/97 7:00	313.4	0.0
2/26/97 7:15	313.1	0.0
2/26/97 7:30	313.1	0.0
2/26/97 7:45	313.0	0.0
2/26/97 8:00	312.8	0.0
2/26/97 8:15	313.4	0.0
2/26/97 8:30	313.6	0.0
2/26/97 8:45	313.6	0.0
2/26/97 9:00	313.5	0.0
2/26/97 9:15	312.8	0.0
2/26/97 9:30	312.6	0.0
2/26/97 9:45	312.3	0.0
2/26/97 10:00	312.0	0.0
2/26/97 10:15	311.7	0.0
2/26/97 10:30	311.4	0.0
2/26/97 10:45	311.5	0.0
2/26/97 11:00	311.3	126.0
2/26/97 11:15	251.2	773.2
2/26/97 11:30	229.9	770.3
2/26/97 11:45	220.8	769.0
2/26/97 12:00	215.6	768.0
2/26/97 12:15	211.0	768.5

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
2/26/97 12:30	204.1	767.6
2/26/97 12:45	199.0	762.8
2/26/97 13:00	194.0	761.3
2/26/97 13:15	189.0	763.5
2/26/97 13:30	185.0	763.8
2/26/97 13:45	181.7	739.1
2/26/97 14:00	200.1	482.8
2/26/97 14:15	206.2	482.4
2/26/97 14:30	206.8	482.2
2/26/97 14:45	205.9	480.2
2/26/97 15:00	204.5	481.5
2/26/97 15:15	203.0	482.1
2/26/97 15:30	202.1	482.1
2/26/97 15:45	200.6	481.2
2/26/97 16:00	199.7	480.9
2/26/97 16:15	216.6	93.7
2/26/97 16:30	240.0	0.0
2/26/97 16:45	245.9	0.0
2/26/97 17:00	248.9	0.0
2/26/97 17:15	251.0	0.0
2/26/97 17:30	251.6	0.0
2/26/97 17:45	253.1	0.0
2/26/97 18:00	253.0	0.0
2/26/97 18:15	254.0	0.0
2/26/97 18:30	254.1	0.0
2/26/97 18:45	253.6	0.0
2/26/97 19:00	254.8	0.0
2/26/97 19:15	254.6	0.0
2/26/97 19:30	253.5	0.0
2/26/97 19:45	253.8	0.0
2/26/97 20:00	253.7	0.0
2/26/97 20:15	253.9	0.0
2/26/97 20:30	253.3	0.0
2/26/97 20:45	251.6	0.0
2/26/97 21:00	252.2	0.0
2/26/97 21:15	253.0	0.0
2/26/97 21:30	253.5	0.0
2/26/97 21:45	253.1	0.0
2/26/97 22:00	252.5	0.0
2/26/97 22:15	252.0	0.0
2/26/97 22:30	252.4	0.0
2/26/97 22:45	251.6	0.0
2/26/97 23:00	252.0	0.0
2/26/97 23:15	251.2	0.0
2/26/97 23:30	251.3	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
2/26/97 23:45	250.3	0.0
2/27/97 0:00	250.6	0.0
2/27/97 0:15	251.3	0.0
2/27/97 0:30	251.8	0.0
2/27/97 0:45	251.0	0.0
2/27/97 1:00	250.8	0.0
2/27/97 1:15	250.2	0.0
2/27/97 1:30	250.0	0.0
2/27/97 1:45	249.9	0.0
2/27/97 2:00	249.0	0.0
2/27/97 2:15	249.8	0.0
2/27/97 2:30	249.8	0.0
2/27/97 2:45	248.9	0.0
2/27/97 3:00	249.4	0.0
2/27/97 3:15	247.4	0.0
2/27/97 3:30	247.7	0.0
2/27/97 3:45	248.1	0.0
2/27/97 4:00	248.3	0.0
2/27/97 4:15	248.2	0.0
2/27/97 4:30	248.3	0.0
2/27/97 4:45	247.9	0.0
2/27/97 5:00	247.3	0.0
2/27/97 5:15	246.9	0.0
2/27/97 5:30	247.1	0.0
2/27/97 5:45	246.5	0.0
2/27/97 6:00	247.2	0.0
2/27/97 6:15	247.3	0.0
2/27/97 6:30	245.2	0.0
2/27/97 6:45	245.6	0.0
2/27/97 7:00	245.4	0.0
2/27/97 7:15	245.1	0.0
2/27/97 7:30	245.9	0.0
2/27/97 7:45	244.8	0.0
2/27/97 8:00	244.4	0.0
2/27/97 8:15	243.7	0.0
2/27/97 8:30	243.8	0.0
2/27/97 8:45	243.9	0.0
2/27/97 9:00	244.0	0.0
2/27/97 9:15	244.2	0.0
2/27/97 9:30	243.3	0.0
2/27/97 9:45	243.3	0.0
2/27/97 10:00	243.5	0.0
2/27/97 10:15	242.5	0.0
2/27/97 10:30	241.1	0.0
2/27/97 10:45	241.0	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
2/27/97 11:00	241.8	0.0
2/27/97 11:15	242.8	0.0
2/27/97 12:00	208.5	0.0
2/27/97 12:15	209.1	0.0
2/27/97 12:30	209.2	0.0
2/27/97 12:45	208.4	0.0
2/27/97 13:00	206.7	0.0
2/27/97 13:15	207.3	0.0
2/27/97 13:30	207.2	0.0
2/27/97 13:45	207.5	0.0
2/27/97 14:00	207.6	0.0
2/27/97 14:15	207.5	0.0
2/27/97 14:30	207.1	0.0
2/27/97 14:45	206.9	0.0
2/27/97 15:00	206.8	0.0
2/27/97 15:15	206.8	0.0
2/27/97 15:30	206.4	0.0
2/27/97 15:45	206.1	0.0
2/27/97 16:00	206.4	0.0
2/27/97 16:15	206.2	0.0
2/27/97 16:30	205.1	0.0
2/27/97 16:45	204.7	0.0
2/27/97 17:00	205.3	0.0
2/27/97 17:15	204.5	0.0
2/27/97 17:30	204.6	0.0
2/27/97 17:45	204.2	0.0
2/27/97 18:00	203.8	0.0
2/27/97 18:15	203.5	0.0
2/27/97 18:30	203.4	0.0
2/27/97 18:45	203.4	0.0
2/27/97 19:00	202.9	0.0
2/27/97 19:15	202.2	0.0
2/27/97 19:30	202.5	0.0
2/27/97 19:45	202.1	0.0
2/27/97 20:00	201.6	0.0
2/27/97 20:15	201.5	0.0
2/27/97 20:30	200.9	0.0
2/27/97 20:45	200.3	0.0
2/27/97 21:00	200.5	0.0
2/27/97 21:15	200.0	0.0
2/27/97 21:30	199.7	0.0
2/27/97 21:45	199.0	0.0
2/27/97 22:00	198.9	0.0
2/27/97 22:15	198.5	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
2/27/97 22:30	197.6	0.0
2/27/97 22:45	197.4	0.0
2/27/97 23:00	197.6	0.0
2/27/97 23:15	197.6	0.0
2/27/97 23:30	197.3	0.0
2/27/97 23:45	196.6	0.0
2/28/97 0:00	196.2	0.0
2/28/97 0:15	195.4	0.0
2/28/97 0:30	195.2	0.0
2/28/97 0:45	195.3	0.0
2/28/97 1:00	195.1	0.0
2/28/97 1:15	194.6	0.0
2/28/97 1:30	194.1	0.0
2/28/97 1:45	194.0	0.0
2/28/97 2:00	193.8	0.0
2/28/97 2:15	193.2	0.0
2/28/97 2:30	193.2	0.0
2/28/97 2:45	193.2	0.0
2/28/97 3:00	193.0	0.0
2/28/97 3:15	192.8	0.0
2/28/97 3:30	192.2	0.0
2/28/97 3:45	191.7	0.0
2/28/97 4:00	191.5	0.0
2/28/97 4:15	191.5	0.0
2/28/97 4:30	191.1	0.0
2/28/97 4:45	190.3	0.0
2/28/97 5:00	189.9	0.0
2/28/97 5:15	189.8	0.0
2/28/97 5:30	189.4	0.0
2/28/97 5:45	188.9	0.0
2/28/97 6:00	188.6	0.0
2/28/97 6:15	188.3	0.0
2/28/97 6:30	187.8	0.0
2/28/97 6:45	187.5	0.0
2/28/97 7:00	187.1	0.0
2/28/97 7:15	186.5	0.0
2/28/97 7:30	185.9	0.0
2/28/97 7:45	185.0	0.0
2/28/97 8:00	185.0	0.0
2/28/97 8:15	184.5	0.0
2/28/97 8:30	184.4	0.0
2/28/97 8:45	183.7	0.0
2/28/97 9:00	183.4	0.0
2/28/97 9:15	182.8	0.0
2/28/97 9:30	182.5	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
3/16/97 8:15	57.0	0.0
3/16/97 8:30	56.9	0.0
3/16/97 8:45	56.3	0.0
3/16/97 9:00	56.0	0.0
3/16/97 9:15	55.8	0.0
3/16/97 9:30	55.6	0.0
3/16/97 9:45	55.7	0.0
3/16/97 10:00	56.2	0.0
3/16/97 10:15	56.4	0.0
3/16/97 10:30	56.3	0.0
3/16/97 10:45	56.2	0.0
3/16/97 11:00	55.8	0.0
3/16/97 11:15	55.3	0.0
3/16/97 11:30	55.3	0.0
3/16/97 11:45	55.5	0.0
3/16/97 12:00	55.6	0.0
3/16/97 12:15	55.7	0.0
3/16/97 12:30	56.1	0.0
3/16/97 12:45	55.7	0.0
3/16/97 13:00	55.7	0.0
3/16/97 13:15	55.8	0.0
3/16/97 13:30	55.9	0.0
3/16/97 13:45	55.6	0.0
3/16/97 14:00	56.2	0.0
3/16/97 14:15	56.0	0.0
3/16/97 14:30	55.3	0.0
3/16/97 14:45	55.5	0.0
3/16/97 15:00	55.5	0.0
3/16/97 15:15	55.2	0.0
3/16/97 15:30	55.3	0.0
3/16/97 15:45	55.2	0.0
3/16/97 16:00	54.6	0.0
3/16/97 16:15	54.7	0.0
3/16/97 16:30	54.9	0.0
3/16/97 16:45	55.1	0.0
3/16/97 17:00	55.1	0.0
3/16/97 17:15	55.0	0.0
3/16/97 17:30	54.9	0.0
3/16/97 17:45	54.5	0.0
3/16/97 18:00	54.0	0.0
3/16/97 18:15	53.5	0.0
3/16/97 18:30	53.5	0.0
3/16/97 18:45	53.6	0.0
3/16/97 19:00	52.6	0.0
3/16/97 19:15	52.3	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
3/16/97 19:30	51.9	0.0
3/16/97 19:45	51.7	0.0
3/16/97 20:00	51.8	0.0
3/16/97 20:15	51.7	0.0
3/16/97 20:30	51.2	0.0
3/16/97 20:45	50.8	0.0
3/16/97 21:00	50.9	0.0
3/16/97 21:15	50.7	0.0
3/16/97 21:30	50.4	0.0
3/16/97 21:45	50.3	0.0
3/16/97 22:00	50.7	0.0
3/16/97 22:15	50.6	0.0
3/16/97 22:30	50.8	0.0
3/16/97 22:45	50.7	0.0
3/16/97 23:00	51.3	0.0
3/16/97 23:15	51.0	0.0
3/16/97 23:30	50.9	0.0
3/16/97 23:45	50.6	0.0
3/17/97 0:00	51.0	0.0
3/17/97 0:15	50.8	0.0
3/17/97 0:30	50.9	0.0
3/17/97 0:45	51.5	0.0
3/17/97 1:00	51.0	0.0
3/17/97 1:15	50.8	0.0
3/17/97 1:30	50.7	0.0
3/17/97 1:45	50.8	0.0
3/17/97 2:00	50.7	0.0
3/17/97 2:15	50.8	0.0
3/17/97 2:30	50.8	0.0
3/17/97 2:45	50.8	0.0
3/17/97 3:00	50.9	0.0
3/17/97 3:15	51.2	0.0
3/17/97 3:30	51.0	0.0
3/17/97 3:45	50.9	0.0
3/17/97 4:00	51.0	0.0
3/17/97 4:15	50.7	0.0
3/17/97 4:30	50.5	0.0
3/17/97 4:45	50.4	0.0
3/17/97 5:00	50.3	0.0
3/17/97 5:15	50.6	0.0
3/17/97 5:30	50.7	0.0
3/17/97 5:45	50.8	0.0
3/17/97 6:00	51.0	0.0
3/17/97 6:15	51.0	0.0
3/17/97 6:30	51.0	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
3/17/97 6:45	50.9	0.0
3/17/97 7:00	50.4	0.0
3/17/97 7:15	50.1	0.0
3/17/97 7:30	49.8	0.0
3/17/97 7:45	49.2	0.0
3/17/97 8:00	49.2	0.0
3/17/97 8:15	48.4	0.0
3/17/97 8:30	47.0	0.0
3/17/97 8:45	46.2	0.0
3/17/97 9:00	44.9	0.0
3/17/97 9:15	44.5	0.0
3/17/97 9:30	45.2	0.0
3/17/97 9:45	44.9	0.0
3/17/97 10:00	44.4	0.0
3/17/97 10:15	44.0	0.0
3/17/97 10:30	44.0	0.0
3/17/97 10:45	43.6	0.0
3/17/97 11:00	44.1	0.0
3/17/97 11:15	44.7	0.0
3/17/97 11:30	43.9	0.0
3/17/97 11:45	43.3	0.0
3/17/97 12:00	43.7	0.0
3/17/97 12:15	44.3	0.0
3/17/97 12:30	44.9	0.0
3/17/97 12:45	45.3	0.0
3/17/97 13:00	45.5	0.0
3/17/97 13:15	45.9	0.0
3/17/97 13:30	46.0	0.0
3/17/97 13:45	46.4	0.0
3/17/97 14:00	45.2	0.0
3/17/97 14:15	45.1	0.0
3/17/97 14:30	43.6	0.1
3/17/97 14:45	32.6	0.0
3/17/97 15:00	24.3	0.0
3/17/97 15:15	23.7	0.0
3/17/97 15:30	25.4	0.0
3/17/97 15:45	29.9	0.0
3/17/97 16:00	32.8	0.0
3/17/97 16:15	35.9	0.0
3/17/97 16:30	46.1	0.0
3/17/97 16:45	55.4	0.0
3/17/97 17:00	64.0	0.0
3/17/97 17:15	66.3	0.0
3/17/97 17:30	63.6	0.0
3/17/97 17:45	62.5	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
3/17/97 18:00	61.5	0.0
3/17/97 18:15	59.8	0.0
3/17/97 18:30	58.2	0.0
3/17/97 18:45	57.2	0.0
3/17/97 19:00	55.5	0.0
3/17/97 19:15	54.3	0.0
3/17/97 19:30	53.9	0.0
3/17/97 19:45	53.4	0.0
3/17/97 20:00	53.1	0.0
3/17/97 20:15	52.5	0.0
3/17/97 20:30	52.1	0.0
3/17/97 20:45	51.5	0.0
3/17/97 21:00	51.1	0.0
3/17/97 21:15	51.0	0.0
3/17/97 21:30	50.4	0.0
3/17/97 21:45	50.5	0.0
3/17/97 22:00	50.5	0.0
3/17/97 22:15	50.5	0.0
3/17/97 22:30	50.3	0.0
3/17/97 22:45	50.5	0.0
3/17/97 23:00	50.4	0.0
3/17/97 23:15	50.5	0.0
3/17/97 23:30	50.4	0.0
3/17/97 23:45	50.4	0.0
3/18/97 0:00	50.6	0.0
3/18/97 0:15	50.5	0.0
3/18/97 0:30	50.5	0.0
3/18/97 0:45	50.4	0.0
3/18/97 1:00	50.6	0.0
3/18/97 1:15	50.6	0.0
3/18/97 1:30	50.7	0.0
3/18/97 1:45	50.6	0.0
3/18/97 2:00	50.8	0.0
3/18/97 2:15	50.8	0.0
3/18/97 2:30	50.9	0.0
3/18/97 2:45	50.7	0.0
3/18/97 3:00	50.6	0.0
3/18/97 3:15	50.6	0.0
3/18/97 3:30	50.6	0.0
3/18/97 3:45	50.6	0.0
3/18/97 4:00	50.5	0.0
3/18/97 4:15	50.6	0.0
3/18/97 4:30	50.3	0.0
3/18/97 4:45	50.5	0.0
3/18/97 5:00	50.6	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
3/18/97 20:15	16.1	0.0
3/18/97 20:20	16.1	0.0
3/18/97 20:25	16.1	0.0
3/18/97 20:30	16.2	0.0
3/18/97 20:35	16.1	0.0
3/18/97 20:40	16.2	0.0
3/18/97 20:45	16.2	0.0
3/18/97 20:50	16.2	0.0
3/18/97 20:55	16.2	0.0
3/18/97 21:00	16.2	0.0
3/18/97 21:05	16.2	0.0
3/18/97 21:10	16.3	0.0
3/18/97 21:15	16.3	0.0
3/18/97 21:20	16.3	0.0
3/18/97 21:25	16.3	0.0
3/18/97 21:30	16.4	0.0
3/18/97 21:35	16.5	0.0
3/18/97 21:40	16.4	0.0
3/18/97 21:45	16.4	0.0
3/18/97 21:50	16.4	0.0
3/18/97 21:55	16.4	0.0
3/18/97 22:00	16.4	0.0
3/18/97 22:05	16.5	0.0
3/18/97 22:10	16.6	0.0
3/18/97 22:15	16.6	0.0
3/18/97 22:20	16.6	0.0
3/18/97 22:25	16.6	0.0
3/18/97 22:30	16.6	0.0
3/18/97 22:35	16.7	0.0
3/18/97 22:40	16.7	0.0
3/18/97 22:45	16.7	0.0
3/18/97 22:50	16.7	0.0
3/18/97 22:55	16.7	0.0
3/18/97 23:00	16.8	0.0
3/18/97 23:05	16.9	0.0
3/18/97 23:10	17.0	0.0
3/18/97 23:15	17.0	0.0
3/18/97 23:20	17.0	0.0
3/18/97 23:25	17.1	0.0
3/18/97 23:30	17.1	0.0
3/18/97 23:35	17.1	0.0
3/18/97 23:40	17.1	0.0
3/18/97 23:45	17.2	0.0
3/18/97 23:50	17.2	0.0
3/18/97 23:55	17.2	0.0

Complex 7

Date/time	Tunnel Flow (gallons per log interval)	Borehole 7 Flow (gallons per log interval)
3/19/97 0.00	17.3	0.0
3/19/97 0.05	17.3	0.0
3/19/97 0.10	17.4	0.0
3/19/97 0.15	17.6	0.0
3/19/97 0.20	17.6	0.0
3/19/97 0.25	17.6	0.0
3/19/97 0.30	17.6	0.0
3/19/97 0.35	17.6	0.0
3/19/97 0.40	17.7	0.0
3/19/97 0.45	17.7	0.0
3/19/97 0.50	17.8	0.0
3/19/97 0.55	17.8	0.0
3/19/97 1.00	17.9	0.0
3/19/97 1.05	17.9	0.0
3/19/97 1.10	17.9	0.0
3/19/97 1.15	17.9	0.0
3/19/97 1.20	18.0	0.0
3/19/97 1.25	18.0	0.0
3/19/97 1.30	18.1	0.0
3/19/97 1.35	18.3	0.0
3/19/97 1.40	18.3	0.0
3/19/97 1.45	18.4	0.0
3/19/97 1.50	18.4	0.0
3/19/97 1.55	18.4	0.0
3/19/97 2.00	18.5	0.0
3/19/97 2.05	18.6	0.0
3/19/97 2.10	18.7	0.0
3/19/97 2.15	18.8	0.0
3/19/97 2.20	18.8	0.0
3/19/97 2.25	19.0	0.0
3/19/97 2.30	19.0	0.0
3/19/97 2.35	19.1	0.0
3/19/97 2.40	19.2	0.0
3/19/97 2.45	19.3	0.0
3/19/97 2.50	19.3	0.0
3/19/97 2.55	19.3	0.0
3/19/97 3.00	19.4	0.0
3/19/97 3.05	19.4	0.0
3/19/97 3.10	19.4	0.0
3/19/97 3.15	19.4	0.0
3/19/97 3.20	19.4	0.0
3/19/97 3.25	19.5	0.0
3/19/97 3.30	19.5	0.0
3/19/97 3.35	19.5	0.0

APPENDIX D

SELECTING APPROPRIATE TECHNIQUES FOR COMPARISON OF WATER QUALITY DATA

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SELECTING APPROPRIATE TECHNIQUES FOR COMPARISON OF WATER QUALITY DATA

It is important to select appropriate analytical techniques to demonstrate hydraulic connection of bore holes and springs using chemical quality data. Each technique has a certain purpose, and consequentially certain limitations. Thus, not all techniques are appropriate for adequately demonstrating similarities between chemical analyses of water samples. The following subsections discuss several of the various techniques that are available and the basis for selection of appropriate techniques for different purposes.

ANALYSIS TECHNIQUES FOR COMPARING WATER QUALITY DATA

Over the years, a large number of techniques have been proposed and utilized for representation and analysis of water quality data. Concentrations of various compounds, ion species, and other parameters are commonly reported in units of milligrams per liter (mg/L). Numerous presentation and analysis methods have been described in the literature. These include: line plots, x-y plots, time-concentration plots x-y-z plots (isoconcentration maps), vertical and horizontal bar graphs, 3-dimensional bar or ribbon diagrams, radiating vectors (radar diagrams), pie diagrams, polygonal-shaped plots, kite diagrams, homographs, cumulative concentration plots, and tri-linear diagrams. Each of the graphical techniques has been devised to focus on one or more of a variety of purposes (Hem, 1989, p. 173). Some techniques help detect and identify trends in water quality composition (e.g., the time-concentration plot). Others identify chemical processes that may take place such as mixing of waters (e.g., the Piper diagram). Certain techniques allow chemical quality data to be shown on maps for purposes of displaying geographical differences in water quality data (e.g., the Stiff diagram). Most graphical methods present a number of solute concentrations simultaneously and show the proportions assigned to each species or group of species. Some techniques emphasize differences in water quality, while others emphasize similarities.

Two graphical techniques that are commonly used are the Piper diagram and Stiff diagram. One reason for their widespread use is the availability of computer programs such as HYDROCHEM by Rockware that make these methods readily available to investigators. Both of these diagrams plot charged solute species, cations and anions, on opposing scales or opposing diagrams. Although commonly used, these types of diagrams have limitations depending upon the particular purpose and the particular chemistry of the water being analyzed. For example, these diagrams normally use milliequivalents per liter (meq/L) or percentages of meq/L for plotting purposes. Because meq/L cannot be used for uncharged solute species or species whose form in solution is not specifically known, these diagrams cannot be used to represent all of the major chemical parameters from a given water analysis. Other limitations include the manner in which these diagrams may exaggerate small differences in chemical analyses that may not be truly representative of differences between types of water. In the following paragraphs, we discuss these and other limitations in Piper and Stiff diagrams as methods for comparison of water quality between bore holes and springs.

PIPER DIAGRAMS

If one considers only the major dissolved ionic constituents, a tri-linear plotting system similar to the Piper diagram can be used for graphical analysis of data (Hem, 1989, p. 176). Tri-linear plots commonly use two equilateral triangles, one for anions and one for cations. Each vertex of each triangle represents 100 percent of a particular ion or group of ions. A form of tri-linear diagram developed by Hill (1940) organizes the two triangles at the lower left and lower right of the diagram with the bases of the triangles aligned vertically and the vertices pointing toward each other. The upper central portion of the diagram is a diamond shape. This allows the plotted points to be extended into the central plotting diamond by projecting them along lines parallel to the upper edges of the diamond-shaped central field (Hem, 1989, p. 178). Piper (1944) suggested a modification to the Hill diagram which aligns the bases of the triangles horizontally and includes circles plotted in the central field that have areas proportional to the total dissolved solids (TDS) concentration. The Piper diagram has become commonly used for samples representing mixing of waters of different chemical quality.

Due to their ease of use through available computer programs, Piper diagrams have been used to compare water quality from bore holes and springs. However, there are a number of limitations to using the Piper diagram for comparison of waters for this particular purpose. The first limitation is that there are only three axes on each of the cation and anion triangles. Thus, to incorporate all of the charged ionic species, it is necessary to group compounds together. For example, sodium (Na) and potassium (K) are commonly grouped together along a single vertex of the cation plot, while calcium (Ca) and magnesium (Mg) each occupy separate vertices. Similarly, chloride (Cl), nitrate (N as NO3), and fluoride (F) are grouped on one vertex of the anion plot, while carbonate (CO3) and bicarbonate (HCO3) are grouped on another anion vertex. Sulfate (SO4) occupies its own anion vertex. By grouping ionic species in this manner, differences in the individual species that are grouped together cannot be discerned in the diagram.

Although the Piper diagram can incorporate a circle whose radius is proportional to the TDS concentration, it does not allow plotting of other non-ionic parameters. Specifically, it does not allow plotting of non-charged species such as silica (Si as SiO2). Furthermore, other important parameters such as temperature, pH, electrical conductivity (EC), dissolved oxygen (O2), and compounds such as iron (Fe) and manganese (Mn), the other metals, and other compounds cannot be shown on the Piper diagram.

An important limitation to using Piper diagrams for comparison of chemical quality has to do with the fact that the plots are in percentages of total meq/L. Commonly, it is expected that there will be a balance between the total meq/L of cations and the total for anions. Due to variations of laboratory procedures, as well as possible variations in sample collection and handling procedures, there may be slight variations in the chemical analyses between different samples from the same identical source. In addition, there are charged (e.g., Fe and Mn) and non-charged ionic species which may affect the cation-anion balance but which do not show on the Piper diagram. For samples of lower TDS, where concentrations of Fe and/or Mn may be important percentages of the TDS, the Piper diagram fails to provide a representative analysis.

Another limitation has to do with certain chemical species whose form in solution is not specifically known. For example, silica may occur in various solute species (e.g., SiO2). It may act as a cation, an anion, or in an uncharged state. In fact, silica may exist in all three states in solution in the water sample. In some waters, especially water with lower TDS concentration, the silica content of the water may be a significant percentage of the TDS. By not being able to represent silica graphically, the Piper diagram fails to allow comparison of waters where silica is one of the important constituents.

Piper diagrams have sometimes been used to compare water analyses from different samples. By plotting the major cations and anions for each sample on the Piper tri-linear plot, and comparing the location of the plotted points, the diagram has been used to attempt to show similarities or differences in water quality. If all of the samples plot at the same point or within a small circle (commonly within a radius of 10 to 20 percent), the samples are commonly considered identical or nearly identical. Plotted points that are not in close proximity (within 10 to 20 percent) of each other may be interpreted as demonstrating differences in water quality between the samples. Unfortunately, the TDS concentration may cause this comparison to produce an erroneous conclusion.

Although the Piper diagram allows plotting of the TDS concentration as a circle, it does not appropriately account for variations in TDS concentrations between groups of samples used for comparison. For example, when comparing samples whose TDS concentrations are relatively high, a variation of only a few mg/L of any one ionic species between samples would represent only a small percentage of the TDS. Conversely, the same variation in mg/L of that compound in samples whose TDS concentrations are relatively low would represent a much higher percentage.

Spring water samples are typically low in TDS. When using the Piper diagram for comparison of water quality of samples with relatively low TDS, the limitations of this diagram are important to consider. Small variations in mg/L of any given compound, as reported by the laboratory, may be due to laboratory analysis variations, sampling techniques, or sample handling. These small concentration differences may show up as significant differences in percentages when plotted in the Piper diagram. Thus, the Piper diagram tends to exaggerate the differences between samples for low TDS waters. This limitation can be demonstrated by comparing two hypothetical water compositions as shown by the Piper diagram. Table D-1 shows the hypothetical concentrations for a "Higher TDS Water" and a "Lower TDS Water". The higher TDS water has dissolved solids of about 250 mg/L. This value is consistent with the upper range of waters described in the FDA Guidelines as "*low mineral content*" waters. The lower TDS

Water has dissolved solids of about 50 mg/L, which is typical of spring water commonly found in granitic rocks. For both the higher TDS and the lower TDS samples, the proportions of each of the ionic species, cations and anions, are the same between the two samples. Thus, if those samples are plotted on a Piper diagram, they will plot at the exact same location, even though the TDS concentration varies by a factor of five between the samples. If there were a slight variation in laboratory analysis in one or more of the compounds, the slight variation would not be discernable on a Piper Diagram between samples of the higher TDS water. However, a slight variation in concentrations produces a significant difference in locations of these data points for the lower TDS water when plotted on a Piper diagram.

Table D-1, EXAMPLE OF HI-TDS VS. LO-TDS WATER DIFFERENCES

Compound or Parameter	Abbr.	Concentrations In Units Shown				
		Units	Higher TDS Water	Higher TDS +NaHCO3 - CaCl	Lower TDS Water	Lower TDS +NaHCO3 - CaCl
Sodium	Na	Mg/L	17.27	20.72	3.45	6.90
Potassium	K	Mg/L	1.55	1.55	0.31	0.31
Calcium	Ca	Mg/L	31.69	28.69	6.34	3.33
Magnesium	Mg	Mg/L	18.24	18.24	3.65	3.65
Chloride	Cl	Mg/L	56.08	50.76	11.22	5.90
Bicarbonate	HCO3	Mg/L	45.83	54.98	9.17	18.32
Carbonate	CO3	Mg/L	2.41	2.41	0.48	0.48
Sulfate	SO4	Mg/L	72.05	72.05	14.41	14.41
TDS Sum	TDS Sum	Mg/L	245.11	249.39	49.02	53.30

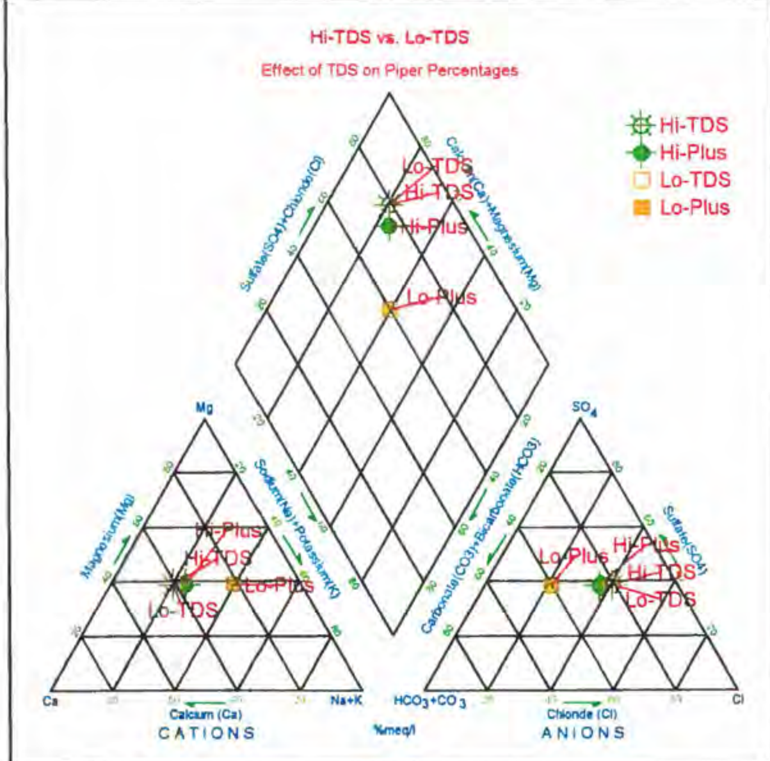

Figure D-1, PIPER DIAGRAM EXAMPLE

To demonstrate this, we have assumed that there is a variation in laboratory analyses of two identical samples with these two different TDS concentrations. Under this assumption, the Na concentration in increased by 3.45 mg/L and the Ca concentration is decreased by 3.01 mg/L for both the higher TDS and the lower TDS samples. To maintain a proper cation-anion balance, we have also assumed that HCO3 would be increased by an appropriate amount (9.15 mg/L) and Cl would be decreased by an appropriate amount (5.32 mg/L). In other words, we show a slight increase in NaHCO3 and a slight decrease in CaCl. These assumptions are shown in Table D-1. These hypothetical data are shown plotted in the Piper diagram in Figure D-1. The higher- and lower-TDS data are designated Hi-TDS and Lo-TDS, respectively, on the Piper diagram in Figure D-1. Similarly, the two data sets with slight modifications to certain cations and anions are referred to as Hi-Plus and Lo-Plus on the figure.

The slight differences in concentrations for the higher TDS water results in less than 4 percent difference in percent total meq/L for the higher TDS water. For the lower TDS water, however, the same slight difference in concentration is nearly 20 percent of total meq/L. In other words, the same slight variation in laboratory analysis, when plotted on a Piper diagram, would indicate that the two identical water samples of lower TDS concentration are significantly different. The two identical water samples of higher TDS concentration, however, would appear to be the same.

As shown in the Piper diagram for the lower TDS samples, the difference is even greater in the diamond-shaped central field where the data from the cation and anion triangles are projected. These apparent differences can result in erroneous conclusions, even when the actual differences are small. Thus, even though Piper diagrams are easily created and commonly used by hydrogeologists for depicting and analyzing water quality data, in the special instance of use in comparison of waters with relatively low TDS, the Piper diagram is not always appropriate.

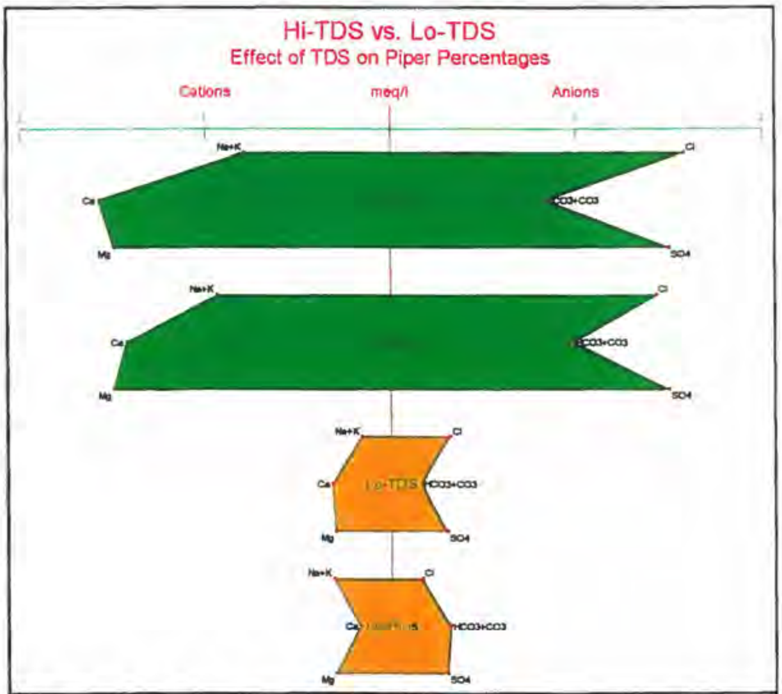

Figure D-2, STIFF DIAGRAM EXAMPLES

STIFF DIAGRAMS

Another commonly used plotting technique is the Stiff diagram. The Stiff diagram has been extensively used in recent years because of its convenience for showing distinctive patterns on maps. The Stiff diagram consists of a series of parallel horizontal axes extending on each side of a vertical zero axis. Concentrations of each of the cations, in meq/L, can be plotted, one on each axis to the left of zero. Likewise concentrations of each of the anions, in meq/L, can be plotted, one on each axis to the right of zero. By connecting the plotted points, a polygon shape is produced which can be compared from sample to sample to demonstrate similarities or differences between the samples. The Stiff diagram has an advantage over the Piper diagram in that more than three vectors can be used thus allowing plotting of more than three cations and three anions, or cation-anion groups, on the diagram. The scales used are normally constant among the various ions plotted. Units of mg/L, meq/L, or percent meq/L are common parameters plotted on Stiff diagrams.

Although the Stiff diagram provides some improvement over the Piper diagram for purposes of comparing water qualities, there are still serious limitations. When plotting analyses using meq/L as the scale, as is commonly done with the computer software available, other parameters such as temperature, EC, pH, TDS, etc., cannot be shown on the diagram. Also, waters of higher TDS, although proportionately the same in composition as lower TDS water, would show polygons of greatly varying size and shape. Figure D-2shows the data from Table D-1 plotted as Stiff diagrams.

The same limitation of small concentration variations in low TDS water occurs with the Stiff diagram as was described for the Piper diagram. With low TDS water, the Stiff diagram would tend to exaggerate small differences in composition by showing significant differences in shape of the polygon. If percent meq/L are used for the scale, the difference in TDS concentration is removed, and the samples can be compared based on proportionate amounts of the plotted compounds. However, the differences in polygon shape can still produce erroneous conclusions. As Figure D-2 shows, the two higher-TDS polygons appear reasonably similar in shape, one to another, supporting the conclusion that the two higher TDS samples are the same water quality. On the other hand, the two lower-TDS polygons appear to be significantly different. In fact, the two samples show polygons that are nearly mirror images of each other. This variation is due to the effects that small variations in concentrations have on lower TDS waters such as spring waters. Thus, for use in comparison of waters with relatively low TDS, the Stiff diagram is not always appropriate.

OTHER TYPES OF DIAGRAMS

The principal limitation of Piper and Stiff diagrams, the two plotting techniques described above, is their inability to show the wide variety of water quality parameters that are available in chemical analyses. For comparison of waters from different samples, it is important to select a method which allows plotting of all of the parameters, or a significant number of the parameters, to better demonstrate similarities and differences between the samples. In comparison of waters, it is also important to consider those compounds with low concentrations or non-detect concentrations, as well. For example, similar low concentrations of Fe and Mn in two samples being compared may be an important consideration in assessing the similarities of the two waters. Similarly, the concentrations of SiO2 may be important distinguishing characteristics. Thus, a method that allows plotting of a large number of parameters, even with differing units, gives the analyst a better tool for comparison of water quality among samples. Selecting a plotting technique that can show meaningful similarities (or differences) in overall proportionate concentrations, even with variations in TDS, is also important. In this way, samples of similar water quality but differences in TDS can be more easily compared to demonstrate the similarities (or differences) in composition between the waters. Finally, selecting a graphical presentation method that provides a distinctive shape for different combinations of water quality parameters is also an important consideration. Distinctive shapes are easily compared, visually, and can also be used to plot characteristic water qualities on maps.

Our review of most of the other graphical techniques (line plots, x-y plots, time-concentration plots, isoconcentration maps, vertical and horizontal bar graphs, 3-dimensional bar or ribbon diagrams, pie diagrams, kite diagrams, homographs, and cumulative concentration plots) indicated that none of these provided a suitable tool for presentation and analysis purposes. Most of these are relatively simple to employ using standard spreadsheet graphics (e.g., Excel). Each of the methods provides some insight into the analysis of data. Furthermore, each method has limitations, similar to those described for the Piper and Stiff diagrams, which may result in erroneous conclusions. However, none of these methods, in our opinion, provides all or the best combination of analysis and presentation tools for purposes of comparing water samples.

RADAR DIAGRAMS

Another graphical technique that has become more popular in recent years is the radial vector diagram. This type of diagram, commonly referred to as a "radar diagram," consists of a group of radial vectors or spokes each of which represent one of a number of chemical species, compounds, or other water quality parameters. The vector is scaled and the position of the plotted point on the radial vector is proportional to the concentration or parameter measurement for each of the parameters. The resulting plot produces a polygonal shape that is convenient for comparison of analyses, one to another, and for plotting on maps to demonstrate similarities or differences in chemical quality at various locations.

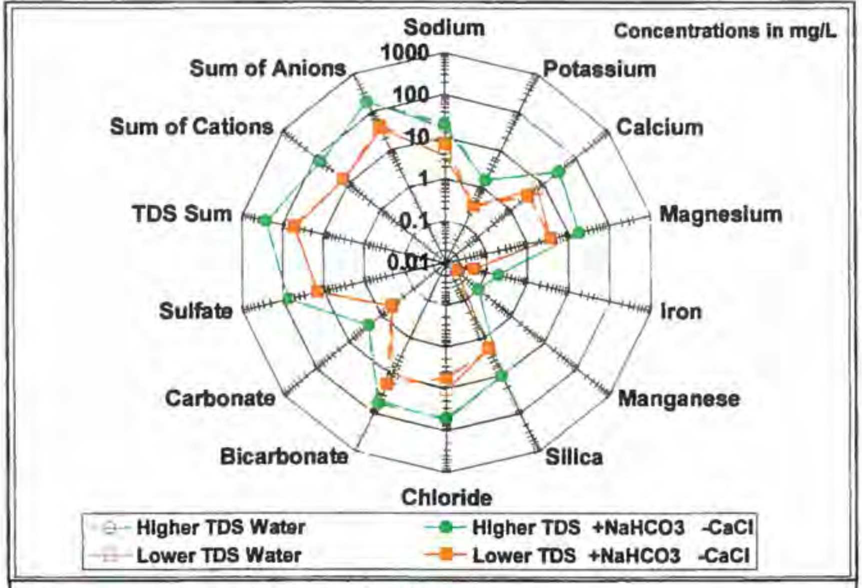

Figure D-3, RADAR DIAGRAM EXAMPLE

Use of logarithmic scales for the vectors can also enhance the presentation of water quality data. Wide variations in magnitude of different parameters can be conveniently represented on the same diagram using logarithmic scales, although the units for each of the radials may be different. For example, electrical conductivity measured in micromhos per centimeter can be plotted on one radial while TDS in mg/L can be plotted on a separate radial. The individual concentrations or measured values for these parameters can easily be plotted on the logarithmic scale even when there is a wide range among the various values. Differences in TDS between samples can be taken into consideration by plotting each of the values individually or as a percentage of the TDS concentration of the sample. This can be done for parameters such as total hardness, SiO2, alkalinity, and other parameters that are measured in mg/L but are not ionic species and do not fit within the groups of cations or anions. Values of electrical conductivity, although measured in micromhos per centimeter, can also be plotted separately. Each individual parameter, therefore, can be appropriately addressed, including parameters such as pH and temperature.

Figure D-3 shows an example of a radar diagram using the data from Table D-1. Also included, to demonstrate the flexibility of this type of diagram, are values for several other parameters. These include Fe, Mn, SiO2, TDS, Total Cations, and Total Anions. All of the parameters shown in the example are in mg/L, however, other parameters could be included with other units. Similarly, these values could have been plotted as percentages of TDS.

As Figure D-3 shows, there is a strong similarity between the Hi-TDS and Hi-Plus samples. Furthermore, there is also an obvious similarity between the Lo-TDS and Lo-Plus samples. As discussed above, both the Piper and Stiff diagrams exaggerated the slight variations between the two lower TDS samples. The radial vector plot, however, does not create this exaggeration, but clearly shows the slight variations. In addition, the figure shows the similarity between the polygonal shapes for the Hi-TDS and the Lo-TDS samples. Since these samples are nearly identical in proportional concentrations of the various compounds, the two sets of polygons should appear similar. The higher TDS samples simply cover a larger area than the lower TDS set.

The polygonal shapes produced by the plotted points for all of the water quality parameters for each sample could be conveniently shown as polygons on maps for comparison of water quality from one area to another. Similarly, these shapes can be easily compared, visually, to demonstrate similarities or differences in water quality. Variations that can be caused by slight differences in laboratory analyses for low TDS waters, as described above, may still show as more identifiable variations for the lower TDS water than for the higher TDS water. By plotting more of the chemical parameters, however, these small differences can be appropriately accounted for in comparison of the plots for similar water samples.

SELECTION OF APPROPRIATE GRAPHICAL ANALYSIS METHODS

Based on our review of all available graphical techniques, it appears that the radar diagram offers the greatest advantages for graphical comparison of water quality. Furthermore, we have selected the technique of plotting numerous individual parameters with a variety of units. Parameters such as pH and temperature are plotted in those individual units. We have also elected to use a wide variety of parameters, including parameters which are non-detect or low concentrations in the water samples. As a result, we believe the plotted analyses provide a better representation of each of the waters being analyzed and allow more definitive comparison of these samples for similarities or differences. We have chosen to use a logarithmic scale for each of the radials, radiating out from a value of 0.0001 to 1,000. This range allows plotting all of the variables of interest in comparing water qualities.

APPENDIX E

WATER QUALITY LABORATORY REPORTS

C O N F I D E N T I A L

ysis Id : 12642 1405 Arrowhead Spring # 2
stigation: QUARTERLY (SPRING)
sampled : 01-25-96 2 1gal, 2 4oz, 2 VOC vials
ition : Blue Ice pack.
ived by : Fatima
ived Dt : 01-26-96 Due Date Page 1

tituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
2				
ene	.0400	5.0000	ND	ug/l
obenzene	.1000	NR	ND	ug/l
ochloromethane	.1000	NR	ND	ug/l
odichloromethane	.0800	100.0000	ND	ug/l
oform	.1200	100.0000	ND	ug/l
omethane	.1000	NR	ND	ug/l
tylbenzene	.1000	NR	ND	ug/l
Butylbenzene	.1000	NR	ND	ug/l
-Butylbenzene	.1000	NR	ND	ug/l
on Tetrachloride	.2100	5.0000	ND	ug/l
robenzene	.1000	NR	ND	ug/l
roethane	.1000	NR	ND	ug/l
roform	.0300	100.0000	ND	ug/l
romethane	.1000	NR	ND	ug/l
lorotoluene	.1000	NR	ND	ug/l
lorotoluene	.1000	NR	ND	ug/l
omochloromethane	.0500	100.0000	ND	ug/l
omochloropropane (DBCP)	.0200	.2000	ND	ug/l
Dibromoethane	.0100	.0500	ND	ug/l
omomethane	.1000	NR	ND	ug/l
Dichlorobenzene (o-DCB)	.1000	600.0000	ND	ug/l
Dichlorobenzene (m-DCB)	.1000	600.0000	ND	ug/l
Dichlorobenzene (p-DCB)	.0300	75.0000	ND	ug/l
lorodifluoromethane	.1000	NR	ND	ug/l
Dichloroethane (1,1-DCA)	.1000	NR	ND	ug/l
ichloroethane (1,2-DCA)	.0600	5.0000	ND	ug/l
ichloroethene	.1000	7.0000	ND	ug/l
1,2-Dichloroethene	.1000	70.0000	ND	ug/l
s-1,2-Dichloroethene	.1000	100.0000	ND	ug/l
ichloropropane	.1000	5.0000	ND	ug/l
ichloropropane	.1000	NR	ND	ug/l
ichloropropane	.1000	NR	ND	ug/l
ichloropropene	.1000	NR	ND	ug/l
ichloropropene Total	.1000	NR	ND	ug/l
lbenzene	.1000	700.0000	ND	ug/l
hlorobutadiene	.1000	NR	ND	ug/l
opylbenzene	.1000	NR	ND	ug/l
opropyltoluene	.1000	NR	ND	ug/l
lene chloride	.1000	5.0000	ND	ug/l
halene	.1000	NR	ND	ug/l
opylbenzene	.1000	NR	ND	ug/l
ne	.1000	100.0000	ND	ug/l
,2-Tetrachloroethane	.1000	NR	ND	ug/l
,2-Tetrachloroethane	.1000	NR	ND	ug/l

None Detected NR - None Required NA - Not Analyzed

lysis Id : 12642 1405 Arrowhead Spring # 2
estigation: QUARTERLY (SPRING)
e sampled : 01-25-96 2 1gal, 2 4oz, 2 VOC vials
dition   : Blue Ice pack
ived by   : Fatima
eived Dt : 01-26-96   Due Date   Page 2

stituents.................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
,2,2-Tetrachloroethane	.1000	NR	ND	ug/l
rachloroethene	.1000	5.0000	ND	ug/l
uene	.1100	1000.0000	ND	ug/l
al Trihalomethanes*	.1000	100.0000	ND	ug/l
,3-Trichlorobenzene	.1000	NR	ND	ug/l
,4-Trichlorobenzene	.1000	9.0000	ND	ug/l
,1-Trichloroethane 1,1-TCA)	.1000	200.0000	ND	ug/l
,2-Trichloroethane 1,2-TCA)	.1000	5.0000	ND	ug/l
chloroethene (TCE)	.1000	5.0000	ND	ug/l
chlorofluoromethane (Freon	.1000	150.0000	ND	ug/l
,3-Trichloropropane	.1000	NR	ND	ug/l
,4-Trimethylbenzene	.1000	NR	ND	ug/l
,5-Trimethylbenzene	.1000	NR	ND	ug/l
yl Chloride (VC)	.1000	2.0000	ND	ug/l
enes, Total (m,p & O)	.1000	0000.0000	ND	ug/l
)1,3-Dichloropropene	.1000	NR	ND	ug/l
ns-1,3-Dichloropropene	.1000	NR	ND	ug/l
ONS				
arbonate	1.0000	NR	76.8600	mg/l
bonate	1.0000	NR	ND	mg/l
oride	.5000	250.0000	5.0700	mg/l
oride	.1000	2.4000	ND	mg/l
oride (Added)	.1000	1.7000		mg/l
rate (N03-N)	1.0000	10.0000	ND	mg/l
sphate (P04-P)	.0500	NR	.2000	mg/l
ica	.5000	NR	27.3100	mg/l
fate	.5000	250.0000	3.3400	mg/l
rite	.1000	1.0000	ND	mg/l
mide	.1000	NR	ND	mg/L
IONS				
minum	.0100	.2000	ND	mg/l
enic	.0050	.0500	ND	mg/l
ium	.0100	2.0000	ND	mg/l
mium	.0010	.0050	ND	mg/l
cium	.5000	NR	19.2200	mg/l
omium	.0010	.1000	ND	mg/l
per	.0050	1.0000	ND	mg/l
n	.0100	.3000	ND	mg/l
d	.0020	.0050	ND	mg/l
nesium	.0500	NR	2.5000	mg/l
'anese	.0030	.0500	ND	mg/l

- None Detected   NR - None Required   NA - Not Analyzed

-

CONFIDENTIAL

ysis Id : 12642 1405 Arrowhead Spring # 2
stigation: QUARTERLY (SPRING)
sampled : 01-25-96 2 1gal, 2 4oz, 2 VOC vials
ition : Blue Ice pack
ived by : Fatima
ived Dt : 01-26-96 Due Date Page 3

tituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
enium	.0050	.0100	ND	mg/l
ver	.0050	.1000	ND	mg/l
ium	.1000	NR	9.0500	mg/l
	.0500	5.0000	ND	mg/l
llium	.0005	.0040	ND	mg/L
imony	.0010	.0060	ND	mg/L
el	.0010	.1000	ND	mg/L
llium	.0005	.0020	ND	mg/L
NDARY QUALITY FACTORS				
iforms	1.0000	2.2000	ND	c/100
or	5.0000	15.0000	ND	units
ductivity	1.0000	NR	142.4500	uS/cm
	1.0000	3.0000	ND	T.O.N
olphthalein	1.0000	NR	ND	mg/l
Product	1.0000	NR		C/ML
Source	1.0000	NR	ND	C/ML
,Evaporated	.5000	NR	103.0000	mg/l
al Alkalinity	1.0000	NR	63.0000	mg/l
l Hardness	.5000	NR	58.3000	mg/l
idity Product	.1000	5.0000		ntu
idity Source	.1000	5.0000	ND	ntu
	.0000	NR	7.9500	pH
Rate	NR	NR		gal/m
AE	NR	NR	ND	units
ST	1.0000	NR	ND	CFU/M
D	1.0000	NR	ND	CFU/M
udomonas aeruginosa	1.0000	NR	ND	MPN

owhead Quality Services Laboratory

mist

Laboratory Manager

CONFIDENTIAL

ysis Id : 12643 1406 Arrowhead Spring # 3
stigation: QUARTERLY (SPRING)
sampled : 01-25-96 2 1gal, 2 4oz, 2 VOC vials
ition : Blue Ice pack
ived by : Fatima
ived Dt : 01-26-96 Due Date Page 1

tituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
2				
ene	.0400	5.0000	ND	ug/l
obenzene	.1000	NR	ND	ug/l
ochloromethane	.1000	NR	ND	ug/l
odichloromethane	.0800	100.0000	ND	ug/l
oform	.1200	100.0000	ND	ug/l
omethane	.1000	NR	ND	ug/l
ylbenzene	.1000	NR	ND	ug/l
Butylbenzene	.1000	NR	ND	ug/l
-Butylbenzene	.1000	NR	ND	ug/l
on Tetrachloride	.2100	5.0000	ND	ug/l
robenzene	.1000	NR	ND	ug/l
roethane	.1000	NR	ND	ug/l
roform	.0300	100.0000	ND	ug/l
romethane	.1000	NR	ND	ug/l
lorotoluene	.1000	NR	ND	ug/l
lorotoluene	.1000	NR	ND	ug/l
omochloromethane	.0500	100.0000	ND	ug/l
omochloropropane (DBCP)	.0200	.2000	ND	ug/l
Dibromoethane	.0100	.0500	ND	ug/l
omomethane	.1000	NR	ND	ug/l
Dichlorobenzene (o-DCB)	.1000	600.0000	ND	ug/l
Dichlorobenzene (m-DCB)	.1000	600.0000	ND	ug/l
Dichlorobenzene (p-DCB)	.0300	75.0000	ND	ug/l
lorodifluoromethane	.1000	NR	ND	ug/l
Dichloroethane (1,1-DCA)	.1000	NR	ND	ug/l
Dichloroethane (1,2-DCA)	.0600	5.0000	ND	ug/l
Dichloroethene	.1000	7.0000	ND	ug/l
1,2-Dichloroethene	.1000	70.0000	ND	ug/l
s-1,2-Dichloroethene	.1000	100.0000	ND	ug/l
Dichloropropane	.1000	5.0000	ND	ug/l
Dichloropropane	.1000	NR	ND	ug/l
Dichloropropane	.1000	NR	ND	ug/l
Dichloropropene	.1000	NR	ND	ug/l
Dichloropropene Total	.1000	NR	ND	ug/l
lbenzene	.1000	700.0000	.1200	ug/l
chlorobutadiene	.1000	NR	ND	ug/l
ropylbenzene	.1000	NR	ND	ug/l
opropyltoluene	.1000	NR	ND	ug/l
ylene chloride	.1000	5.0000	ND	ug/l
thalene	.1000	NR	ND	ug/l
opylbenzene	.1000	NR	ND	ug/l
ene	.1000	100.0000	ND	ug/l
1,2-Tetrachloroethane	.1000	NR	ND	ug/l
2,2-Tetrachloroethane	.1000	NR	ND	ug/l

None Detected NR - None Required NA - Not Analyzed

ysis Id : 12643 1406 Arrowhead Spring # 3
stigation: QUARTERLY (SPRING)
sampled : 01-25-96 2 1gal, 2 4oz, 2 VOC vials
.tion : Blue Ice pack
.ved by : Fatima
.ved Dt : 01-26-96 Due Date Page 2

:ituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
2,2-Tetrachloroethane	.1000	NR	ND	ug/l
achloroethene	.1000	5.0000	ND	ug/l
ene	.1100	1000.0000	.1400	ug/l
l Trihalomethanes*	.1000	100.0000	ND	ug/l
3-Trichlorobenzene	.1000	NR	ND	ug/l
4-Trichlorobenzene	.1000	9.0000	ND	ug/l
1-Trichloroethane ,1-TCA)	.1000	200.0000	ND	ug/l
2-Trichloroethane ,2-TCA)	.1000	5.0000	ND	ug/l
hloroethene (TCE)	.1000	5.0000	ND	ug/l
hlorofluoromethane (Freon	.1000	150.0000	ND	ug/l
3-Trichloropropane	.1000	NR	ND	ug/l
4-Trimethylbenzene	.1000	NR	ND	ug/l
5-Trimethylbenzene	.1000	NR	ND	ug/l
l Chloride (VC)	.1000	2.0000	ND	ug/l
nes, Total (m,p & O)	.1000	0000.0000	ND	ug/l
1,3-Dichloropropene	.1000	NR	ND	ug/l
s-1,3-Dichloropropene	.1000	NR	ND	ug/l
NS				
rbonate	1.0000	NR	70.7600	mg/l
onate	1.0000	NR	ND	mg/l
ride	.5000	250.0000	14.8300	mg/l
ride	.1000	2.4000	ND	mg/l
ride (Added)	.1000	1.7000		mg/l
ate (N03-N)	1.0000	10.0000	1.0300	mg/l
phate (P04-P)	.0500	NR	ND	mg/l
ca	.5000	NR	33.8100	mg/l
ate	.5000	250.0000	4.6300	mg/l
ite	.1000	1.0000	ND	mg/l
ide	.1000	NR	ND	mg/L
ONS				
inum	.0100	.2000	ND	mg/l
nic	.0050	.0500	ND	mg/l
um	.0100	2.0000	ND	mg/l
ium	.0010	.0050	ND	mg/l
ium	.5000	NR	20.1700	mg/l
mium	.0010	.1000	ND	mg/l
er	.0050	1.0000	ND	mg/l
	.0100	.3000	ND	mg/l
l	.0020	.0050	ND	mg/l
esium	.0500	NR	3.5600	mg/l
anese	.0030	.0500	ND	mg/l

· None Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

ysis Id : 12643 1406 Arrowhead Spring # 3
stigation: QUARTERLY (SPRING)
sampled : 01-25-96 2 1gal, 2 4oz, 2 VOC vials
ition : Blue Ice pack
ived by : Fatima
ived Dt : 01-26-96 Due Date Page 3

tituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
nium	.0050	.0100	ND	mg/l
er	.0050	.1000	ND	mg/l
um	.1000	NR	10.8800	mg/l
	.0500	5.0000	ND	mg/l
llium	.0005	.0040	ND	mg/L
mony	.0010	.0060	ND	mg/L
el	.0010	.1000	ND	mg/L
lium	.0005	.0020	ND	mg/L
NDARY QUALITY FACTORS				
forms	1.0000	2.2000	ND	c/100
r	5.0000	15.0000	ND	units
uctivity	1.0000	NR	174.5800	uS/cm
	1.0000	3.0000	ND	T.O.N
olphthalein	1.0000	NR	ND	mg/l
Product	1.0000	NR		C/ML
Source	1.0000	NR	ND	C/ML
Evaporated	.5000	NR	128.0000	mg/l
l Alkalinity	1.0000	NR	58.0000	mg/l
l Hardness	.5000	NR	65.0000	mg/l
idity Product	.1000	5.0000		ntu
idity Source	.1000	5.0000	ND	ntu
	.0000	NR	7.8400	pH
Rate	NR	NR		gal/m
E	NR	NR	ND	units
T	1.0000	NR	ND	CFU/M
	1.0000	NR	ND	CFU/M
domonas aeruginosa	1.0000	NR	ND	MPN

whead Quality Services Laboratory

nist

Laboratory Manager

C O N F I D E N T I A L

sis Id : 12647 1422 Arrowhead 7 (New)
igation: QUARTERLY (SPRING) Bore Hole
ampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
ion : Blue Ice pack
ed by : Bill
ed Dt : 03-22-96 Due Date Page 1

tuents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
e	.0400	5.0000	ND	ug/l
enzene	.1000	NR	ND	ug/l
hloromethane	.1000	NR	.1100	ug/l
ichloromethane	.0800	100.0000	1.5100	ug/l
orm	.1200	100.0000	ND	ug/l
ethane	.1000	NR	ND	ug/l
lbenzene	.1000	NR	ND	ug/l
tylbenzene	.1000	NR	ND	ug/l
utylbenzene	.1000	NR	ND	ug/l
Tetrachloride	.2100	5.0000	ND	ug/l
benzene	.1000	NR	ND	ug/l
ethane	.1000	NR	ND	ug/l
form	.0300	100.0000	1.0100	ug/l
methane	.1000	NR	ND	ug/l
rotoluene	.1000	NR	ND	ug/l
rotoluene	.1000	NR	ND	ug/l
ochloromethane	.0500	100.0000	1.0200	ug/l
ochloropropane (DBCP)	.0200	.2000	ND	ug/l
bromoethane	.0100	.0500	ND	ug/l
omethane	.1000	NR	ND	ug/l
chlorobenzene (o-DCB)	.1000	600.0000	ND	ug/l
chlorobenzene (m-DCB)	.1000	600.0000	ND	ug/l
chlorobenzene (p-DCB)	.0300	75.0000	ND	ug/l
rodifluoromethane	.1000	NR	ND	ug/l
chloroethane (1,1-DCA)	.1000	NR	ND	ug/l
chloroethane (1,2-DCA)	.0600	5.0000	ND	ug/l
chloroethene	.1000	7.0000	ND	ug/l
2-Dichloroethene	.1000	70.0000	ND	ug/l
1,2-Dichloroethene	.1000	100.0000	ND	ug/l
chloropropane	.1000	5.0000	ND	ug/l
chloropropane	.1000	NR	ND	ug/l
chloropropane	.1000	NR	ND	ug/l
chloropropene	.1000	NR	ND	ug/l
chloropropene Total	.1000	NR	ND	ug/l
enzene	.1000	700.0000	ND	ug/l
lorobutadiene	.1000	NR	ND	ug/l
pylbenzene	.1000	NR	ND	ug/l
ropyltoluene	.1000	NR	ND	ug/l
ene chloride	.1000	5.0000	ND	ug/l
alene	.1000	NR	ND	ug/l
ylbenzene	.1000	NR	ND	ug/l
e	.1000	100.0000	ND	ug/l
2-Tetrachloroethane	.1000	NR	ND	ug/l
2-Tetrachloroethane	.1000	NR	ND	ug/l

one Detected NR - None Required NA - Not Analyzed

C O N F I D E N T I A L

is Id : 12647 1422 Arrowhead 7 (New)
igation: QUARTERLY (SPRING) Bore Hole
ampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
ion : Blue Ice pack
ed by : Bill
ed Dt : 03-22-96 Due Date Page 2

tuents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
hloroethene	.1000	5.0000	ND	ug/l
e	.1100	1000.0000	ND	ug/l
Trihalomethanes*	.1000	100.0000	3.5400	ug/l
Trichlorobenzene	.1000	NR	ND	ug/l
Trichlorobenzene	.1000	9.0000	ND	ug/l
Trichloroethane -TCA)	.1000	200.0000	.3700	ug/l
Trichloroethane -TCA)	.1000	5.0000	ND	ug/l
oroethene (TCE)	.1000	5.0000	ND	ug/l
orofluoromethane (Freon	.1000	150.0000	ND	ug/l
Trichloropropane	.1000	NR	ND	ug/l
Trimethylbenzene	.1000	NR	ND	ug/l
Trimethylbenzene	.1000	NR	ND	ug/l
Chloride (VC)	.1000	2.0000	ND	ug/l
s, Total (m,p & O)	.1000	0000.0000	ND	ug/l
3-Dichloropropene	.1000	NR	ND	ug/l
1,3-Dichloropropene	.1000	NR	ND	ug/l
onate	1.0000	NR	73.2000	mg/l
ate	1.0000	NR	ND	mg/l
de	.5000	250.0000	20.2800	mg/l
de	.1000	2.4000	ND	mg/l
de (Added)	.1000	1.7000		mg/l
e (N03-N)	1.0000	10.0000	2.6300	mg/l
ate (P04-P)	.0500	NR	ND	mg/l
.	.5000	NR	34.0500	mg/l
e	.5000	250.0000	3.7300	mg/l
e	.1000	1.0000	ND	mg/l
ie	.1000	NR	ND	mg/L
IS				
ium	.0100	.2000	ND	mg/l
c	.0050	.0500	ND	mg/l
i	.0100	2.0000	ND	mg/l
im	.0010	.0050	ND	mg/l
im	.5000	NR	22.9900	mg/l
um	.0010	.1000	ND	mg/l
	.0050	1.0000	ND	mg/l
	.0100	.3000	ND	mg/l
	.0020	.0050	ND	mg/l
sium	.0500	NR	4.1100	mg/l
iese	.0030	.0500	ND	mg/l
ry	.0010	.0020	ND	mg/l
sium	.0100	NR	1.6700	mg/l

lone Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

.s Id : 12647 1422 Arrowhead 7 (New)
.gation: QUARTERLY (SPRING) Bore Hole
ımpled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
.on : Blue Ice pack
ꞏd by : Bill
ꞏd Dt : 03-22-96 Due Date Page 3

:uents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ım	.0050	.0100	ND	mg/l
	.0050	.1000	ND	mg/l
	.1000	NR	12.5800	mg/l
	.0500	5.0000	ND	mg/l
.um	.0005	.0040	ND	mg/L
ıy	.0010	.0060	ND	mg/L
	.0010	.1000	ND	mg/L
ım	.0005	.0020	ND	mg/L
ARY QUALITY FACTORS				
:ms	1.0000	2.2000	ND	c/100
	5.0000	15.0000	ND	units
:ivity	1.0000	NR	213.6200	uS/cm
	1.0000	3.0000	ND	T.O.N
ɔhthalein	1.0000	NR	ND	mg/l
ɔduct	1.0000	NR		C/ML
ırce	1.0000	NR	ND	C/ML
ıporated	.5000	NR	150.0000	mg/l
Alkalinity	1.0000	NR	60.0000	mg/l
Hardness	.5000	NR	74.3000	mg/l
ity Product	.1000	5.0000		ntu
ity Source	.1000	5.0000	ND	ntu
	.0000	NR	7.3200	pH
ıte	NR	NR		gal/m
	NR	NR	ND	units
	1.0000	NR	ND	CFU/M
	1.0000	NR	ND	CFU/M
ɔonas aeruginosa	1.0000	NR	ND	MPN

ꞏad Quality Services Laboratory

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Laboratory Manager

CONFIDENTIAL

sis Id : 12645 1420 Arrowhead Spring 7-A (New)
tigation: QUARTERLY (SPRING)
sampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
tion : Blue Ice pack
ved by : Bill
ved Dt : 03-22-96 Due Date Page 1

ituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ne	.0400	5.0000	ND	ug/l
benzene	.1000	NR	ND	ug/l
chloromethane	.1000	NR	.1000	ug/l
dichloromethane	.0800	100.0000	1.4800	ug/l
form	.1200	100.0000	1.1300	ug/l
methane	.1000	NR	ND	ug/l
ylbenzene	.1000	NR	ND	ug/l
utylbenzene	.1000	NR	ND	ug/l
Butylbenzene	.1000	NR	ND	ug/l
n Tetrachloride	.2100	5.0000	ND	ug/l
obenzene	.1000	NR	ND	ug/l
oethane	.1000	NR	ND	ug/l
oform	.0300	100.0000	1.0800	ug/l
omethane	.1000	NR	ND	ug/l
orotoluene	.1000	NR	ND	ug/l
orotoluene	.1000	NR	ND	ug/l
mochloromethane	.0500	100.0000	1.1300	ug/l
mochloropropane (DBCP)	.0200	.2000	ND	ug/l
ibromoethane	.0100	.0500	ND	ug/l
momethane	.1000	NR	ND	ug/l
ichlorobenzene (o-DCB)	.1000	600.0000	ND	ug/l
ichlorobenzene (m-DCB)	.1000	600.0000	ND	ug/l
ichlorobenzene (p-DCB)	.0300	75.0000	ND	ug/l
orodifluoromethane	.1000	NR	ND	ug/l
ichloroethane (1,1-DCA)	.1000	NR	ND	ug/l
ichloroethane (1,2-DCA)	.0600	5.0000	ND	ug/l
ichloroethene	.1000	7.0000	ND	ug/l
,2-Dichloroethene	.1000	70.0000	ND	ug/l
-1,2-Dichloroethene	.1000	100.0000	ND	ug/l
ichloropropane	.1000	5.0000	ND	ug/l
ichloropropane	.1000	NR	ND	ug/l
ichloropropane	.1000	NR	ND	ug/l
ichloropropene	.1000	NR	ND	ug/l
ichloropropene Total	.1000	NR	ND	ug/l
benzene	.1000	700.0000	ND	ug/l
hlorobutadiene	.1000	NR	ND	ug/l
opylbenzene	.1000	NR	ND	ug/l
propyltoluene	.1000	NR	ND	ug/l
lene chloride	.1000	5.0000	ND	ug/l
halene	.1000	NR	ND	ug/l
pylbenzene	.1000	NR	ND	ug/l
ne	.1000	100.0000	ND	ug/l
,2-Tetrachloroethane	.1000	NR	ND	ug/l
,2-Tetrachloroethane	.1000	NR	ND	ug/l

None Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

/sis Id : 12645 1420 Arrowhead Spring 7-A (New)
stigation: QUARTERLY (SPRING)
sampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
ition : Blue Ice pack
ived by : Bill
ived Dt : 03-22-96 Due Date Page 2

:ituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
achloroethene	.1000	5.0000	.1000	ug/l
ene	.1100	1000.0000	ND	ug/l
l Trihalomethanes*	.1000	100.0000	4.8200	ug/l
3-Trichlorobenzene	.1000	NR	ND	ug/l
4-Trichlorobenzene	.1000	9.0000	ND	ug/l
l-Trichloroethane ,1-TCA)	.1000	200.0000	ND	ug/l
2-Trichloroethane ,2-TCA)	.1000	5.0000	ND	ug/l
aloroethene (TCE)	.1000	5.0000	ND	ug/l
hlorofluoromethane (Freon	.1000	150.0000	ND	ug/l
3-Trichloropropane	.1000	NR	ND	ug/l
4-Trimethylbenzene	.1000	NR	ND	ug/l
5-Trimethylbenzene	.1000	NR	ND	ug/l
l Chloride (VC)	.1000	2.0000	ND	ug/l
nes, Total (m,p & O)	.1000	0000.0000	ND	ug/l
l,3-Dichloropropene	.1000	NR	ND	ug/l
s-1,3-Dichloropropene	.1000	NR	ND	ug/l
NS				
rbonate	1.0000	NR	74.4200	mg/l
onate	1.0000	NR	ND	mg/l
ride	.5000	250.0000	17.7800	mg/l
ride	.1000	2.4000	ND	mg/l
ride (Added)	.1000	1.7000		mg/l
ate (N03-N)	1.0000	10.0000	2.0800	mg/l
phate (P04-P)	.0500	NR	ND	mg/l
a	.5000	NR	34.6000	mg/l
ite	.5000	250.0000	3.6400	mg/l
ite	.1000	1.0000	ND	mg/l
ide	.1000	NR	ND	mg/L
ONS				
inum	.0100	.2000	ND	mg/l
nic	.0050	.0500	ND	mg/l
um	.0100	2.0000	ND	mg/l
ium	.0010	.0050	ND	mg/l
ium	.5000	NR	22.0400	mg/l
mium	.0010	.1000	ND	mg/l
er	.0050	1.0000	ND	mg/l
	.0100	.3000	ND	mg/l
	.0020	.0050	ND	mg/l
esium	.0500	NR	4.2000	mg/l
anese	.0030	.0500	ND	mg/l
ury	.0010	.0020	ND	mg/l
ssium	.0100	NR	1.6100	mg/l

None Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

sis Id : 12645 1420 Arrowhead Spring 7-A (New)
tigation: QUARTERLY (SPRING)
sampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
tion : Blue Ice pack
ved by : Bill
ved Dt : 03-22-96 Due Date Page 3

ituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ium	.0050	.0100	ND	mg/l
r	.0050	.1000	ND	mg/l
m	.1000	NR	12.2500	mg/l
	.0500	5.0000	ND	mg/l
lium	.0005	.0040	ND	mg/L
ony	.0010	.0060	ND	mg/L
l	.0010	.1000	ND	mg/L
ium	.0005	.0020	ND	mg/L
DARY QUALITY FACTORS				
orms	1.0000	2.2000	ND	c/100
	5.0000	15.0000	ND	units
ctivity	1.0000	NR	205.2000	uS/cm
	1.0000	3.0000	ND	T.O.N
lphthalein	1.0000	NR	ND	mg/l
roduct	1.0000	NR		C/ML
ource	1.0000	NR	ND	C/ML
vaporated	.5000	NR	158.0000	mg/l
Alkalinity	1.0000	NR	61.0000	mg/l
Hardness	.5000	NR	72.3000	mg/l
dity Product	.1000	5.0000		ntu
dity Source	.1000	5.0000	ND	ntu
	.0000	NR	6.7800	pH
Rate	NR	NR		gal/m
	NR	NR	ND	units
	1.0000	NR	ND	CFU/M
	1.0000	NR	ND	CFU/M
omonas aeruginosa	1.0000	NR	ND	MPN

head Quality Services Laboratory

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Laboratory Manager

CONFIDENTIAL

ysis Id : 12646 1421 Arrowhead Spring 7-B (New)
stigation: QUARTERLY (SPRING)
sampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
ition : Blue Ice pack
ived by : Bill
ived Dt : 03-22-96 Due Date Page 1

tituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
2				
ene	.0400	5.0000	ND	ug/l
obenzene	.1000	NR	ND	ug/l
ochloromethane	.1000	NR	ND	ug/l
odichloromethane	.0800	100.0000	1.3500	ug/l
oform	.1200	100.0000	ND	ug/l
omethane	.1000	NR	ND	ug/l
tylbenzene	.1000	NR	ND	ug/l
Butylbenzene	.1000	NR	ND	ug/l
-Butylbenzene	.1000	NR	ND	ug/l
on Tetrachloride	.2100	5.0000	ND	ug/l
robenzene	.1000	NR	ND	ug/l
roethane	.1000	NR	ND	ug/l
roform	.0300	100.0000	.9200	ug/l
romethane	.1000	NR	ND	ug/l
lorotoluene	.1000	NR	ND	ug/l
lorotoluene	.1000	NR	ND	ug/l
omochloromethane	.0500	100.0000	.8500	ug/l
omochloropropane (DBCP)	.0200	.2000	ND	ug/l
Dibromoethane	.0100	.0500	ND	ug/l
omomethane	.1000	NR	ND	ug/l
Dichlorobenzene (o-DCB)	.1000	600.0000	ND	ug/l
Dichlorobenzene (m-DCB)	.1000	600.0000	ND	ug/l
Dichlorobenzene (p-DCB)	.0300	75.0000	ND	ug/l
lorodifluoromethane	.1000	NR	ND	ug/l
Dichloroethane (1,1-DCA)	.1000	NR	ND	ug/l
Dichloroethane (1,2-DCA)	.0600	5.0000	ND	ug/l
Dichloroethene	.1000	7.0000	ND	ug/l
1,2-Dichloroethene	.1000	70.0000	ND	ug/l
s-1,2-Dichloroethene	.1000	100.0000	ND	ug/l
Dichloropropane	.1000	5.0000	ND	ug/l
Dichloropropane	.1000	NR	ND	ug/l
Dichloropropane	.1000	NR	ND	ug/l
Dichloropropene	.1000	NR	ND	ug/l
Dichloropropene Total	.1000	NR	ND	ug/l
lbenzene	.1000	700.0000	ND	ug/l
chlorobutadiene	.1000	NR	ND	ug/l
ropylbenzene	.1000	NR	ND	ug/l
propyltoluene	.1000	NR	ND	ug/l
ylene chloride	.1000	5.0000	ND	ug/l
thalene	.1000	NR	ND	ug/l
pylbenzene	.1000	NR	ND	ug/l
ene	.1000	100.0000	ND	ug/l
1,2-Tetrachloroethane	.1000	NR	ND	ug/l
2,2-Tetrachloroethane	.1000	NR	ND	ug/l

None Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

'sis Id : 12646 1421 Arrowhead Spring 7-B (New)
:tigation: QUARTERLY (SPRING)
sampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
.tion : Blue Ice pack
.ved by : Bill
.ved Dt : 03-22-96 Due Date Page 2

:ituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ıchloroethene	.1000	5.0000	ND	ug/l
:ne	.1100	1000.0000	ND	ug/l
. Trihalomethanes*	.1000	100.0000	3.1200	ug/l
‑Trichlorobenzene	.1000	NR	ND	ug/l
‑Trichlorobenzene	.1000	9.0000	ND	ug/l
.-Trichloroethane 1-TCA)	.1000	200.0000	.2600	ug/l
‑Trichloroethane 2-TCA)	.1000	5.0000	ND	ug/l
ıloroethene (TCE)	.1000	5.0000	ND	ug/l
ılorofluoromethane (Freon	.1000	150.0000	ND	ug/l
‑Trichloropropane	.1000	NR	ND	ug/l
‑Trimethylbenzene	.1000	NR	ND	ug/l
‑Trimethylbenzene	.1000	NR	ND	ug/l
Chloride (VC)	.1000	2.0000	ND	ug/l
ıes, Total (m,p & O)	.1000	0000.0000	ND	ug/l
,3-Dichloropropene	.1000	NR	ND	ug/l
‑1,3-Dichloropropene	.1000	NR	ND	ug/l
NS				
:bonate	1.0000	NR	153.0000	mg/l
onate	1.0000	NR	ND	mg/l
:ide	.5000	250.0000	22.2700	mg/l
:ide	.1000	2.4000	ND	mg/l
:ide (Added)	.1000	1.7000		mg/l
ate (NO3-N)	1.0000	10.0000	2.8900	mg/l
phate (PO4-P)	.0500	NR	ND	mg/l
:a	.5000	NR	35.2200	mg/l
ate	.5000	250.0000	4.1000	mg/l
ite	.1000	1.0000	ND	mg/l
ide	.1000	NR	ND	mg/L
ONS				
inum	.0100	.2000	ND	mg/l
ıic	.0050	.0500	ND	mg/l
ım	.0100	2.0000	ND	mg/l
ium	.0010	.0050	ND	mg/l
ium	.5000	NR	21.7300	mg/l
nium	.0010	.1000	ND	mg/l
er	.0050	1.0000	ND	mg/l
	.0100	.3000	ND	mg/l
	.0020	.0050	ND	mg/l
esium	.0500	NR	3.5300	mg/l
anese	.0030	.0500	ND	mg/l
ıry	.0010	.0020	ND	mg/l
ssium	.0100	NR	1.6600	mg/l

None Detected   NR - None Required   NA - Not Analyzed

CONFIDENTIAL

sis Id : 12646 1421 Arrowhead Spring 7-B (New)
tigation: QUARTERLY (SPRING)
sampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
tion : Blue Ice pack
ved by : Bill
ved Dt : 03-22-96 Due Date Page 3

ituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ium	.0050	.0100	ND	mg/l
r	.0050	.1000	ND	mg/l
m	.1000	NR	13.2700	mg/l
	.0500	5.0000	ND	mg/l
lium	.0005	.0040	ND	mg/L
ony	.0010	.0060	ND	mg/L
l	.0010	.1000	ND	mg/L
ium	.0005	.0020	ND	mg/L
DARY QUALITY FACTORS				
orms	1.0000	2.2000	ND	c/100
	5.0000	15.0000	ND	units
ctivity	1.0000	NR	210.1700	uS/cm
	1.0000	3.0000	ND	T.O.N
lphthalein	1.0000	NR	ND	mg/l
roduct	1.0000	NR		C/ML
ource	1.0000	NR	ND	C/ML
vaporated	.5000	NR	153.0000	mg/l
Alkalinity	1.0000	NR	53.0000	mg/l
Hardness	.5000	NR	68.8000	mg/l
dity Product	.1000	5.0000		ntu
dity Source	.1000	5.0000	ND	ntu
	.0000	NR	6.7600	pH
Rate	NR	NR		gal/m
	NR	NR	ND	units
	1.0000	NR	ND	CFU/M
	1.0000	NR	ND	CFU/M
omonas aeruginosa	1.0000	NR	ND	MPN

head Quality Services Laboratory

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Laboratory Manager

CONFIDENTIAL

sis Id : 12648 1424 Arrowhead Spring New 7C
:igation: QUARTERLY (SPRING)
sampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
:ion : Blue Ice pack
ved by : Bill
ved Dt : 03-22-96 Due Date Page 1

ituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ıe	.0400	5.0000	ND	ug/l
ɔenzene	.1000	NR	ND	ug/l
:hloromethane	.1000	NR	ND	ug/l
ìichloromethane	.0800	100.0000	.7100	ug/l
:form	.1200	100.0000	ND	ug/l
nethane	.1000	NR	ND	ug/l
ylbenzene	.1000	NR	ND	ug/l
ıtylbenzene	.1000	NR	ND	ug/l
3utylbenzene	.1000	NR	ND	ug/l
ı Tetrachloride	.2100	5.0000	ND	ug/l
ɔbenzene	.1000	NR	ND	ug/l
ɔethane	.1000	NR	ND	ug/l
ɔform	.0300	100.0000	.5700	ug/l
ɔmethane	.1000	NR	ND	ug/l
ɔrotoluene	.1000	NR	ND	ug/l
ɔrotoluene	.1000	NR	ND	ug/l
nochloromethane	.0500	100.0000	.4900	ug/l
nochloropropane (DBCP)	.0200	.2000	ND	ug/l
ıbromoethane	.0100	.0500	ND	ug/l
ıomethane	.1000	NR	ND	ug/l
.chlorobenzene (o-DCB)	.1000	600.0000	ND	ug/l
.chlorobenzene (m-DCB)	.1000	600.0000	ND	ug/l
.chlorobenzene (p-DCB)	.0300	75.0000	ND	ug/l
ɔrodifluoromethane	.1000	NR	ND	ug/l
.chloroethane (1,1-DCA)	.1000	NR	ND	ug/l
.chloroethane (1,2-DCA)	.0600	5.0000	ND	ug/l
.chloroethene	.1000	7.0000	ND	ug/l
2-Dichloroethene	.1000	70.0000	ND	ug/l
-1,2-Dichloroethene	.1000	100.0000	ND	ug/l
.chloropropane	.1000	5.0000	ND	ug/l
.chloropropane	.1000	NR	ND	ug/l
.chloropropane	.1000	NR	ND	ug/l
.chloropropene	.1000	NR	ND	ug/l
.chloropropene Total	.1000	NR	ND	ug/l
ɔenzene	.1000	700.0000	ND	ug/l
ılorobutadiene	.1000	NR	ND	ug/l
ɔpylbenzene	.1000	NR	ND	ug/l
ɔropyltoluene	.1000	NR	ND	ug/l
.ene chloride	.1000	5.0000	ND	ug/l
ıalene	.1000	NR	ND	ug/l
ɔylbenzene	.1000	NR	ND	ug/l
ıe	.1000	100.0000	ND	ug/l
2-Tetrachloroethane	.1000	NR	ND	ug/l
2-Tetrachloroethane	.1000	NR	ND	ug/l

Ione Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

is Id : 12648 1424 Arrowhead Spring New 7C
igation: QUARTERLY (SPRING)
ampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
ion : Blue Ice pack
ed by : Bill
ed Dt : 03-22-96 Due Date Page 2

tuents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
hloroethene	.1000	5.0000	ND	ug/l
e	.1100	1000.0000	ND	ug/l
Trihalomethanes*	.1000	100.0000	1.7700	ug/l
Trichlorobenzene	.1000	NR	ND	ug/l
Trichlorobenzene	.1000	9.0000	ND	ug/l
Trichloroethane -TCA)	.1000	200.0000	.1300	ug/l
Trichloroethane -TCA)	.1000	5.0000	ND	ug/l
oroethene (TCE)	.1000	5.0000	ND	ug/l
orofluoromethane (Freon	.1000	150.0000	ND	ug/l
Trichloropropane	.1000	NR	ND	ug/l
Trimethylbenzene	.1000	NR	ND	ug/l
Trimethylbenzene	.1000	NR	ND	ug/l
Chloride (VC)	.1000	2.0000	ND	ug/l
s, Total (m,p & O)	.1000	0000.0000	ND	ug/l
3-Dichloropropene	.1000	NR	ND	ug/l
1,3-Dichloropropene	.1000	NR	ND	ug/l
onate	1.0000	NR	92.7200	mg/l
ate	1.0000	NR	ND	mg/l
de	.5000	250.0000	22.5400	mg/l
de	.1000	2.4000	.1000	mg/l
de (Added)	.1000	1.7000		mg/l
e (N03-N)	1.0000	10.0000	1.9200	mg/l
ate (P04-P)	.0500	NR	.1400	mg/l
	.5000	NR	32.8300	mg/l
e	.5000	250.0000	3.9200	mg/l
e	.1000	1.0000	ND	mg/l
e	.1000	NR	ND	mg/L
S				
um	.0100	.2000	ND	mg/l
c	.0050	.0500	ND	mg/l
	.0100	2.0000	ND	mg/l
m	.0010	.0050	ND	mg/l
m	.5000	NR	24.5400	mg/l
um	.0010	.1000	ND	mg/l
	.0050	1.0000	ND	mg/l
	.0100	.3000	ND	mg/l
	.0020	.0050	ND	mg/l
ium	.0500	NR	3.9200	mg/l
ese	.0030	.0500	ND	mg/l
y	.0010	.0020	ND	mg/l
ium	.0100	NR	1.6800	mg/l

one Detected NR - None Required NA - Not Analyzed

C O N F I D E N T I A L

sis Id : 12648 1424 Arrowhead Spring New 7C
tigation: QUARTERLY (SPRING)
sampled : 03-21-96 2 1gal, 2 4oz, 2 VOC vials
tion : Blue Ice pack
ved by : Bill
ved Dt : 03-22-96 Due Date Page 3

ituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ium	.0050	.0100	ND	mg/l
r	.0050	.1000	ND	mg/l
n	.1000	NR	19.2800	mg/l
	.0500	5.0000	ND	mg/l
lium	.0005	.0040	ND	mg/L
ony	.0010	.0060	ND	mg/L
l	.0010	.1000	ND	mg/L
ium	.0005	.0020	ND	mg/L
DARY QUALITY FACTORS				
orms	1.0000	2.2000	ND	c/100
	5.0000	15.0000	ND	units
ctivity	1.0000	NR	252.7200	uS/cm
	1.0000	3.0000	ND	T.O.N
lphthalein	1.0000	NR	ND	mg/l
roduct	1.0000	NR		C/ML
ource	1.0000	NR	ND	C/ML
vaporated	.5000	NR	157.0000	mg/l
Alkalinity	1.0000	NR	76.0000	mg/l
Hardness	.5000	NR	77.4000	mg/l
dity Product	.1000	5.0000		ntu
dity Source	.1000	5.0000	ND	ntu
	.0000	NR	7.4100	pH
Rate	NR	NR		gal/m
	NR	NR	ND	units
	1.0000	NR	ND	CFU/M
	1.0000	NR	ND	CFU/M
omonas aeruginosa	1.0000	NR	ND	MPN

head Quality Services Laboratory

st

Laboratory Manager

C O N F I D E N T I A L

nalysis Id : 16631 999
nvestigation: ARROWHEAD #7 TUNNEL
ate sampled : 02-19-97 1 1gal.
ondition : Room Temp.
eceived by : Pam
eceived Dt : 02-20-97 Due Date Page 1

onstituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
NIONS				
icarbonate	1.0000	NR	76.8600	mg/l
hloride	.5000	250.0000	16.2200	mg/l
luoride	.1000	2.4000	ND	mg/l
itrate (NO3-N)	1.0000	10.0000	1.9500	mg/l
hosphate (PO4-P)	.0500	NR	ND	mg/l
ilica	.5000	NR	34.0000	mg/l
ulfate	.5000	250.0000	3.3000	mg/l
itrite	.1000	1.0000	ND	mg/l
romide	.1000	NR	ND	mg/l
ATIONS				
luminum	.0100	.2000	ND	mg/l
rsenic	.0050	.0500	ND	mg/l
arium	.0100	2.0000	ND	mg/l
admium	.0010	.0050	ND	mg/l
alcium	.5000	NR	21.4000	mg/l
hromium	.0020	.1000	ND	mg/l
opper	.0050	1.0000	ND	mg/l
ron	.0100	.3000	ND	mg/l
ead	.0010	.0050	ND	mg/l
agnesium	.0500	NR	3.9000	mg/l
anganese	.0030	.0500	ND	mg/l
ercury	.0010	.0020	ND	mg/l
otassium	.0100	NR	1.6000	mg/l
elenium	.0050	.0100	ND	mg/l
ilver	.0050	.1000	ND	mg/l
odium	.1000	NR	12.4300	mg/l
inc	.0250	5.0000	ND	mg/l
eryllium	.0005	.0040	ND	mg/l
ntimony	.0010	.0060	ND	mg/l
ickel	.0010	.1000	ND	mg/l
hallium	.0005	.0020	ND	mg/l
ECONDARY QUALITY FACTORS				
DS, Evaporated	.5000	NR	128.0000	mg/l
otal Alkalinity	1.0000	NR	63.0000	mg/l
otal Hardness	.5000	NR	69.5000	mg/l
H	.0000	NR	6.9700	pH

rrowhead Quality Services Laboratory

Fatima L. Valeton
hemist

Laboratory Manager

CONFIDENTIAL

Analysis Id : 20512 1401 Arrowhead # 1
Investigation: QUARTERLY (SPRING) Bore Hole
Date sampled : 10-08-97 2 1gal, 2 4oz, 2 VOC vials
Condition : Blue Ice pack
Received by : Pam
Received Dt : 10-08-97 Due Date Page 1

Constituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
524.2				
Benzene	.0400	5.0000	ND	ug/l
Bromobenzene	.1000	NR	ND	ug/l
Bromochloromethane	.1000	NR	ND	ug/l
Bromodichloromethane	.0800	100.0000	.3300	ug/l
Bromoform	.1200	100.0000	ND	ug/l
Bromomethane	.1000	NR	ND	ug/l
n-Butylbenzene	.1000	NR	ND	ug/l
sec-Butylbenzene	.1000	NR	ND	ug/l
tert-Butylbenzene	.1000	NR	ND	ug/l
Carbon Tetrachloride	.2100	5.0000	ND	ug/l
Chlorobenzene	.1000	NR	ND	ug/l
Chloroethane	.1000	NR	ND	ug/l
Chloroform	.0300	100.0000	.2900	ug/l
Chloromethane	.1000	NR	ND	ug/l
2-Chlorotoluene	.1000	NR	ND	ug/l
4-Chlorotoluene	.1000	NR	ND	ug/l
Dibromochloromethane	.0500	100.0000	.1700	ug/l
Dibromochloropropane (DBCP)	.0200	.2000	ND	ug/l
1,2-Dibromoethane	.0100	.0500	ND	ug/l
Dibromomethane	.1000	NR	ND	ug/l
1,2-Dichlorobenzene (o-DCB)	.1000	600.0000	ND	ug/l
1,3-Dichlorobenzene (m-DCB)	.1000	600.0000	ND	ug/l
1,4-Dichlorobenzene (p-DCB)	.0300	75.0000	ND	ug/l
Dichlorodifluoromethane	.1000	NR	ND	ug/l
,1-Dichloroethane (1,1-DCA)	.1000	NR	ND	ug/l
,2-Dichloroethane (1,2-DCA)	.0600	5.0000	ND	ug/l
,1-Dichloroethene	.1000	7.0000	ND	ug/l
is-1,2-Dichloroethene	.1000	70.0000	ND	ug/l
rans-1,2-Dichloroethene	.1000	100.0000	ND	ug/l
,2-Dichloropropane	.1000	5.0000	ND	ug/l
,3-Dichloropropane	.1000	NR	ND	ug/l
,2-Dichloropropane	.1000	NR	ND	ug/l
,1-Dichloropropene	.1000	NR	ND	ug/l
,3-Dichloropropene Total	.1000	NR	ND	ug/l
thylbenzene	.1000	700.0000	ND	ug/l
exachlorobutadiene	.1000	NR	ND	ug/l
sopropylbenzene	.1000	NR	ND	ug/l
-Isopropyltoluene	.1000	NR	ND	ug/l
ethylene chloride	.1000	5.0000	ND	ug/l
aphthalene	.1000	NR	ND	ug/l
-Propylbenzene	.1000	NR	ND	ug/l
tyrene	.1000	100.0000	ND	ug/l
1,2-Tetrachloroethane	.1000	NR	ND	ug/l

D - None Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

Analysis Id : 20512 1401 Arrowhead # 1
Investigation: QUARTERLY (SPRING) Bore Hole
Date sampled : 10-08-97 2 1gal, 2 4oz, 2 VOC vials
Condition : Blue Ice pack
Received by : Pam
Received Dt : 10-08-97 Due Date Page 2

Constituents....................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
1,1,2,2-Tetrachloroethane	.1000	NR	ND	ug/l
Tetrachloroethene	.1000	5.0000	ND	ug/l
Toluene	.1100	1000.0000	ND	ug/l
Total Trihalomethanes*	.1000	100.0000	.7900	ug/l
,2,3-Trichlorobenzene	.1000	NR	ND	ug/l
,2,4-Trichlorobenzene	.1000	9.0000	ND	ug/l
,1,1-Trichloroethane 1,1,1-TCA)	.1000	200.0000	ND	ug/l
,1,2-Trichloroethane 1,1,2-TCA)	.1000	5.0000	ND	ug/l
richloroethene (TCE)	.1000	5.0000	.4900	ug/l
richlorofluoromethane (Freon 1)	.1000	150.0000	ND	ug/l
,2,3-Trichloropropane	.1000	NR	ND	ug/l
,2,4-Trimethylbenzene	.1000	NR	ND	ug/l
,3,5-Trimethylbenzene	.1000	NR	ND	ug/l
inyl Chloride (VC)	.1000	2.0000	ND	ug/l
ylenes, Total (m,p & O)	.1000	0000.0000	ND	ug/l
i ,3-Dichloropropene	.1000	NR	ND	ug/l
rans-1,3-Dichloropropene	.1000	NR	ND	ug/l
NIONS				
icarbonate	1.0000	NR	70.0000	mg/l
arbonate	1.0000	NR	ND	mg/l
loride	.5000	250.0000	18.0000	mg/l
luoride	.1000	2.4000	.1000	mg/l
itrate (N03-N)	1.0000	10.0000	1.6000	mg/l
osphate (P04-P)	.0500	NR	ND	mg/l
lica	.5000	NR	33.0000	mg/l
lfate	.5000	250.0000	1.4000	mg/l
trite	.1000	1.0000	ND	mg/l
omide	.1000	NR	ND	mg/l
TIONS				
uminum	.0100	.2000	ND	mg/l
senic	.0050	.0500	ND	mg/l
rium	.0100	2.0000	.0100	mg/l
dmium	.0010	.0050	ND	mg/l
lcium	.5000	NR	16.0000	mg/l
romium	.0020	.1000	ND	mg/l
pper	.0050	1.0000	.0600	mg/l
on	.0100	.3000	ND	mg/l
ad	.0010	.0050	ND	mg/l
gnesium	.0500	NR	5.0000	mg/l
nganese	.0030	.0500	ND	mg/l
rcury	.0010	.0020	ND	mg/l

- None Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

Analysis Id : 20512 1401 Arrowhead Spring # 1
Investigation: QUARTERLY (SPRING)
Date sampled : 10-08-97 2 1gal, 2 4oz, 2 VOC vials
Condition : Blue Ice pack
Received by : Pam
Received Dt : 10-08-97 Due Date Page 3

Constituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
Potassium	.0100	NR	2.0000	mg/l
Selenium	.0050	.0100	ND	mg/l
Silver	.0050	.1000	ND	mg/l
Sodium	1.0000	NR	11.0000	mg/l
Zinc	.0250	5.0000	ND	mg/l
Beryllium	.0005	.0040	ND	mg/l
Antimony	.0010	.0060	ND	mg/l
Nickel	.0010	.1000	ND	mg/l
Thallium	.0005	.0020	ND	mg/l
SECONDARY QUALITY FACTORS				
Color	5.0000	15.0000	ND	units
Conductivity	1.0000	NR	182.0000	uS/cm
Odor	1.0000	3.0000	ND	T.O.N
Phenolphthalein	1.0000	NR	ND	mg/l
TDS,Evaporated	.5000	NR	125.0000	mg/l
Total Alkalinity	1.0000	NR	58.0000	mg/l
Total Hardness	.5000	NR	58.0000	mg/l
Turbidity Source	.1000	5.0000	ND	ntu
P	.0000	NR	6.0000	pH
oliforms	1.0000	1.0000	ND	c/100
PC Source	1.0000	NR	ND	C/ML
LGAE	NR	NR	ND	units
EAST	1.0000	NR	ND	CFU/1
OLD	1.0000	NR	ND	CFU/1
seudomonas (SOURCE)	1.0000	NR	85.0000	C/10M *

rrowhead Quality Services Laboratory

Fatima L. Valenton
hemist

Laboratory Manager

16 April. 1998

Summary of chemical analyses for bore-holes 1, 1A, 8, and spring 4.

	Spring 1 **10/08/97**	**Spring 8** **10/08/97**	**Bore-hole 1A** **10/08/97**	**Spring 4** **03/17/97**
Bicarbonate	70.0 mg/l	76.0 mg/l	91.0 mg/l	68.7 mg/l
Carbonate	nd	nd	nd	-
Chloride	18.0	6.0	6.2	5.2
Fluoride	0.1	0.1	0.1	0.1
Nitrate	1.6	nd	nd	nd
Phosphate	nd	nd	nd	nd
Silica	33.0	23.0	23.0	24.2
Sulfate	1.4	3.4	2.6	2.6
Nitrite	nd	nd	nd	nd
Bromide	nd	nd	nd	nd
Aluminum	nd	nd	nd	nd
Arsenic	nd	nd	nd	nd
Barium	0.010	nd	nd	nd
Cadmium	nd	nd	nd	nd
Calcium	16.0	17.0	21.0	13.7
Chromium	nd	nd	nd	nd
Copper	0.060	nd	nd	nd
Iron	nd	nd	nd	nd
Lead	nd	nd	nd	nd
Magnesium	5.0	2.0	3.0	2.4
Manganese	nd	nd	nd	nd
Mercury	nd	nd	nd	nd
Potassium	2.0	2.0	2.0	1.2
Selenium	nd	nd	nd	nd
Silver	nd	nd	nd	nd
Sodium	11.0	8.0	8.0	7.3
Zinc	nd	nd	nd	nd
Beryllium	nd	nd	nd	nd
Antimony	nd	nd	nd	nd
Nickel	nd	nd	nd	nd
Thallium	nd	nd	nd	nd
Coliform	nd	nd	nd	-
Conductivity	182 uS/cm	150 uS/cm	173 uS/cm	129 uS/cm
TDS	125 mg/l	101 mg/l	111 mg/l	91 mg/l
Total Alkalinity	58	62	75	56
Total hardness	58	51	65	44
Turbidity	nd	nd	nd	nd
pH	6.0	6.3	6.3	7.4

Source!
The Hydrodynamics
Group

C O N F I D E N T I A L

ıalysis Id : 16807 999
ıvestigation: S-UPPER, 5/28/98 Spring No. 10
ıte sampled : 05-28-98 1 - 0.5 lr
ɔndition : Room Temp.
ɛceived by : Gowri
ɛceived Dt : 06-02-98 Due Date Page 1

ɔnstituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ıIONS				
.carbonate	1.0000	NR	72.0000	mg/l
ıloride	.5000	250.0000	8.0000	mg/l
.uoride	.1000	2.4000	.1000	mg/l
.trate (NO3-N)	1.0000	10.0000	ND	mg/l
ıosphate (PO4-P)	.0500	NR	ND	mg/l
.lica	.5000	NR	31.0000	mg/l
ılfate	.5000	250.0000	3.4000	mg/l
.trite	.1000	1.0000	ND	mg/l
:omide	.1000	NR	ND	mg/l
ıTIONS				
.uminum	.0100	.2000	ND	mg/l
:senic	.0050	.0500	ND	mg/l
ırium	.0100	2.0000	ND	mg/l
ıdmium	.0010	.0050	ND	mg/l
ılcium	.5000	NR	18.0000	mg/l
ıromium	.0010	.1000	ND	mg/l
ɔpper	.0050	1.0000	ND	mg/l
:on	.0100	.3000	.0150	mg/l
ɛad	.0010	.0050	ND	mg/l
ıgnesium	.0500	NR	3.0000	mg/l
ınganese	.0030	.0500	ND	mg/l
ɛrcury	.0010	.0020	ND	mg/l
ɔtassium	.0100	NR	1.5000	mg/l
ɛlenium	.0050	.0100	ND	mg/l
.lver	.0050	.1000	ND	mg/l
ɔdium	.1000	NR	8.0000	mg/l
.nc	.0250	5.0000	ND	mg/l
ɛryllium	.0005	.0040	ND	mg/l
ıtimony	.0010	.0060	ND	mg/l
.ckel	.0010	.1000	ND	mg/l
ıallium	.0005	.0020	ND	mg/l
ɛCONDARY QUALITY FACTORS				
ɔnductivity	1.0000	NR	130.0000	uS/cm
)S,Evaporated	.5000	NR	100.0000	mg/l
ɔtal Alkalinity	1.0000	NR	59.0000	mg/l
ɔtal Hardness	.5000	NR	57.0000	mg/l
ırbidity Source	.1000	5.0000	ND	ntu
I	.0000	NR	6.2000	pH

:rowhead Quality Services Laboratory

) - None Detected NR - None Required NA - Not Analyzed

C O N F I D E N T I A L

nalysis Id : 16807 999
nvestigation: S-UPPER, 5/28/98 Spring No. 10
ate sampled : 05-28-98 1 - 0.5 lr
ondition : Room Temp.
eceived by : Gowri
eceived Dt : 06-02-98 Due Date Page 2

onstituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit

Fatima L. Valenton
iemist

Laboratory Manager

C O N F I D E N T I A L

nalysis Id : 16808 999
nvestigation: S-L-1, 5/28/98
ate sampled : 05-28-98 1 - 0.5 lr Spring No. 11
ondition : Room Temp.
eceived by : Gowri
eceived Dt : 06-02-98 Due Date Page 1

onstituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit	
NIONS					
icarbonate	1.0000	NR	103.0000	mg/l	
hloride	.5000	250.0000	4.5000	mg/l	
luoride	.1000	2.4000	.1300	mg/l	
itrate (N03-N)	1.0000	10.0000	ND	mg/l	
hosphate (P04-P)	.0500	NR	ND	mg/l	
ilica	.5000	NR	35.0000	mg/l	
ulfate	.5000	250.0000	4.0000	mg/l	
itrite	.1000	1.0000	ND	mg/l	
romide	.1000	NR	ND	mg/l	
ATIONS					
luminum	.0100	.2000	ND	mg/l	
rsenic	.0050	.0500	ND	mg/l	
arium	.0100	2.0000	.0120	mg/l	
admium	.0010	.0050	ND	mg/l	
alcium	.5000	NR	21.0000	mg/l	
hromium	.0010	.1000	ND	mg/l	
opper	.0050	1.0000	ND	mg/l	
ron	.0100	.3000	.0310	mg/l	*
ead	.0010	.0050	ND	mg/l	
agnesium	.0500	NR	5.0000	mg/l	
anganese	.0030	.0500	ND	mg/l	
ercury	.0010	.0020	ND	mg/l	
otassium	.0100	NR	2.0000	mg/l	
elenium	.0050	.0100	ND	mg/l	
ilver	.0050	.1000	ND	mg/l	
odium	.1000	NR	11.6000	mg/l	
inc	.0250	5.0000	ND	mg/l	
eryllium	.0005	.0040	ND	mg/l	
ntimony	.0010	.0060	ND	mg/l	
ickel	.0010	.1000	ND	mg/l	
hallium	.0005	.0020	ND	mg/l	
ECONDARY QUALITY FACTORS					
onductivity	1.0000	NR	170.0000	uS/cm	
DS,Evaporated	.5000	NR	126.0000	mg/l	
otal Alkalinity	1.0000	NR	84.0000	mg/l	
otal Hardness	.5000	NR	73.0000	mg/l	
urbidity Source	.1000	5.0000	ND	ntu	
H	.0000	NR	6.5000	pH	

rrowhead Quality Services Laboratory

D - None Detected NR - None Required NA - Not Analyzed

CONFIDENTIAL

nalysis Id : 16808 999
nvestigation: S-L-1, 5/28/98
ate sampled : 05-28-98 1 - 0.5 lr

Spring No. 11

ondition : Room Temp.
eceived by : Gowri
eceived Dt : 06-02-98 Due Date Page 2

onstituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit

Fatima L. Valenton
hemist

Laboratory Manager

C O N F I D E N T I A L

nalysis Id : 16809 999
nvestigation: S-L-2, 5/28/98
ate sampled : 05-28-98 1 - 0.5 lr
ondition : Room Temp.
eceived by : Gowri
eceived Dt : 06-02-98 Due Date Page 1

Spring No. 12

onstituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit	
NIONS					
icarbonate	1.0000	NR	86.0000	mg/l	
hloride	.5000	250.0000	4.3000	mg/l	
luoride	.1000	2.4000	.1300	mg/l	
trate (NO3-N)	1.0000	10.0000	ND	mg/l	
osphate (PO4-P)	.0500	NR	ND	mg/l	
lica	.5000	NR	40.0000	mg/l	
ulfate	.5000	250.0000	4.0000	mg/l	
itrite	.1000	1.0000	ND	mg/l	
romide	.1000	NR	ND	mg/l	
ATIONS					
luminum	.0100	.2000	.0100	mg/l	
rsenic	.0050	.0500	ND	mg/l	
arium	.0100	2.0000	.0120	mg/l	
admium	.0010	.0050	ND	mg/l	
alcium	.5000	NR	17.0000	mg/l	
hromium	.0010	.1000	ND	mg/l	
opper	.0050	1.0000	ND	mg/l	
ron	.0100	.3000	.0560	mg/l	*
ad	.0010	.0050	ND	mg/l	
gnesium	.0500	NR	4.5000	mg/l	
anganese	.0030	.0500	ND	mg/l	
ercury	.0010	.0020	ND	mg/l	
otassium	.0100	NR	1.5000	mg/l	
elenium	.0050	.0100	ND	mg/l	
ilver	.0050	.1000	ND	mg/l	
odium	.1000	NR	11.0000	mg/l	
inc	.0250	5.0000	ND	mg/l	
eryllium	.0005	.0040	ND	mg/l	
ntimony	.0010	.0060	ND	mg/l	
ickel	.0010	.1000	ND	mg/l	
hallium	.0005	.0020	ND	mg/l	
ECONDARY QUALITY FACTORS					
onductivity	1.0000	NR	140.0000	uS/cm	
S,Evaporated	.5000	NR	115.0000	mg/l	
tal Alkalinity	1.0000	NR	70.0000	mg/l	
otal Hardness	.5000	NR	61.0000	mg/l	
urbidity Source	.1000	5.0000	ND	ntu	
H	.0000	NR	6.7000	pH	

rrowhead Quality Services Laboratory

D - None Detected NR - None Required NA - Not Analyzed

C O N F I D E N T I A L

alysis Id : 16809 999
vestigation: S-L-2, 5/28/98
te sampled : 05-28-98 1 - 0.5 lr   Spring No. 12
ndition : Room Temp.
ceived by : Gowri
ceived Dt : 06-02-98 Due Date Page 2

nstituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit

Katina L. Valenton
emist

Laboratory Manager

Lower Spring Complex 10, and 12
SUMMARY OF CHEMICAL ANALYSIS

Method of Analysis	Constituent	Federal Max Levels	Bore-Holes	
			10	12
			1/11/96	3/21/96
~~[illegible]~~	~~E.coli~~	~~2 MPN/100 ml~~	~~ND~~	~~ND~~
EPA 200.7	Aluminum	0.20	ND	0.0335
	Antimony		ND	ND
	Arsenic	0.05	ND	ND
	Barium	2.00	ND	0.0103
	Beryllium	0.00	ND	ND
	Cadmium	0.01	ND	ND
	Calcium	NR	31.16	14.27
	Chromium	0.10	ND	ND
	Copper	1.00	ND	ND
	Iron	0.30	ND	0.0181
	Lead	0.01	ND	ND
	Magnesium	NR	6.24	4.44
	Manganese	0.05	ND	0.0032
	Mercury	0.00	ND	ND
	Nickel	0.10	0.0012	ND
	Potassium	NR	ND	1.77
	Selenium		ND	ND
	Silver	0.10	ND	ND
	Sodium	NR	13.58	13.75
	Thallium	0.00	ND	ND
	Zinc	5.00	ND	0.1510
EPA Method 340.2	Fluoride	2.40	0.14	ND
EPA Method 310.1	Total Alkalinity	NR	118.00	68.00
	Bicarbonate Alkalinity	NR	143.96	82.96
	Carbonate Alkalinity		ND	ND
EPA Method 300	Bromide	NR	ND	ND
	Chloride	250.00	4.69	5.51
	Nitrate	45.00	ND	ND
	Phosphate		ND	ND
	Silica	NR	23.80	39.98
	Sulfate	250.00	3.81	2.50
EPA Method 150.1	pH	NR	8.11	7.20
EPA Method 120.1	Electric Conductivity	250 umhos/cm	243.08	165.56
EPA Method 130.2	Total Hardness	NR	103.50	53.90
EPA Method 160.1	Total Dissolved Solids	NR	155.00	119.00
EPA Method 110.2	Color	NR	ND	ND
EPA Method 140.1	Odor	NR	ND	ND
EPA Method 180.1	Turbidity	5.00	0.12	0.25

Concentrations reported in mg/L unless otherwise specified.

ND = concentration below detection limit for method of analysis

NR = no required standard

The HYDRODYNAMICS Group

Precision
Cat / Anion Balance

CONFIDENTIAL

lysis Id : 16811 999
estigation: B-10, 5/28/98
e sampled : 05-28-98 1 - 0.5 lr
ition : Room Temp.
eived by : Gowri
eived Dt : 06-02-98 Due Date Page 1

stituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ONS				
arbonate	1.0000	NR	140.0000	mg/l
oride	.5000	250.0000	5.1000	mg/l
oride	.1000	2.4000	.1200	mg/l
rate (NO3-N)	1.0000	10.0000	ND	mg/l
sphate (PO4-P)	.0500	NR	ND	mg/l
ica	.5000	NR	27.0000	mg/l
fate	.5000	250.0000	5.1000	mg/l
rite	.1000	1.0000	ND	mg/l
nide	.1000	NR	ND	mg/l
IONS				
inum	.0100	.2000	ND	mg/l
enic	.0050	.0500	ND	mg/l
ium	.0100	2.0000	.0130	mg/l
ium	.0010	.0050	ND	mg/l
ium	.5000	NR	32.0000	mg/l
mium	.0010	.1000	.0014	mg/l
er	.0050	1.0000	ND	mg/l
	.0100	.3000	.0620	mg/l
	.0010	.0050	ND	mg/l
esium	.0500	NR	6.0000	mg/l
anese	.0030	.0500	ND	mg/l
ury	.0010	.0020	ND	mg/l
ssium	.0100	NR	2.5000	mg/l
nium	.0050	.0100	ND	mg/l
er	.0050	.1000	ND	mg/l
um	.1000	NR	13.0000	mg/l
	.0250	5.0000	ND	mg/l
llium	.0005	.0040	ND	mg/l
mony	.0010	.0060	ND	mg/l
el	.0010	.1000	.0015	mg/l
lium	.0005	.0020	ND	mg/l
NDARY QUALITY FACTORS				
uctivity	1.0000	NR	220.0000	uS/cm
Evaporated	.5000	NR	161.0000	mg/l
l Alkalinity	1.0000	NR	115.0000	mg/l
l Hardness	.5000	NR	105.0000	mg/l
idity Source	.1000	5.0000	.2600	ntu
	.0000	NR	6.8000	pH

whead Quality Services Laboratory

None Detected NR - None Required NA - Not Analyzed

C O N F I D E N T I A L

lysis Id : 16811 999
estigation: B-10, 5/28/98
e sampled : 05-28-98 1 - 0.5 lr
lition : Room Temp.
eived by : Gowri
eived Dt : 06-02-98 Due Date Page 2

stituents..................	Minimum Detection Level	Fed Max Contam Level	Level Unit Found

tima L. Valenton
iist

Laboratory Manager

C O N F I D E N T I A L

lysis Id : 16812 999
estigation: B-11, 5/28/98
e sampled : 05-28-98 1 - 0.5 lr
lition : Room Temp.
eived by : Gowri
eived Dt : 06-02-98 Due Date Page 1

stituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ONS				
arbonate	1.0000	NR	81.0000	mg/l
oride	.5000	250.0000	6.0000	mg/l
oride	.1000	2.4000	.1300	mg/l
rate (NO3-N)	1.0000	10.0000	ND	mg/l
sphate (PO4-P)	.0500	NR	ND	mg/l
ica	.5000	NR	49.0000	mg/l
fate	.5000	250.0000	3.0000	mg/l
rite	.1000	1.0000	ND	mg/l
nide	.1000	NR	ND	mg/l
IONS				
minum	.0100	.2000	ND	mg/l
enic	.0050	.0500	ND	mg/l
ium	.0100	2.0000	.0160	mg/l
mium	.0010	.0050	ND	mg/l
cium	.5000	NR	14.0000	mg/l
omium	.0010	.1000	ND	mg/l
per	.0050	1.0000	ND	mg/l
n	.0100	.3000	.0230	mg/l
d	.0010	.0050	ND	mg/l
nesium	.0500	NR	4.0000	mg/l
ganese	.0030	.0500	ND	mg/l
cury	.0010	.0020	ND	mg/l
assium	.0100	NR	1.5000	mg/l
enium	.0050	.0100	ND	mg/l
ver	.0050	.1000	ND	mg/l
ium	.1000	NR	13.0000	mg/l
:	.0250	5.0000	ND	mg/l
yllium	.0005	.0040	ND	mg/l
mony	.0010	.0060	ND	mg/l
kel	.0010	.1000	ND	mg/l
llium	.0005	.0020	ND	mg/l
ONDARY QUALITY FACTORS				
luctivity	1.0000	NR	140.0000	uS/cm
Evaporated	.5000	NR	121.0000	mg/l
al Alkalinity	1.0000	NR	66.0000	mg/l
al Hardness	.5000	NR	51.0000	mg/l
bidity Source	.1000	5.0000	ND	ntu
	.0000	NR	6.4000	pH

owhead Quality Services Laboratory

- None Detected NR - None Required NA - Not Analyzed

C O N F I D E N T I A L

lysis Id : 16812 999
estigation: B-11, 5/28/98
e sampled : 05-28-98 1 - 0.5 lr
dition : Room Temp.
eived by : Gowri
eived Dt : 06-02-98 Due Date Page 2

stituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit

atima L. Valenton
mist

Laboratory Manager

CONFIDENTIAL

Analysis Id : 16813 999
Investigation: B-12, 5/28/98
Date sampled : 05-28-98 1 - 0.5 lr
Condition : Room Temp.
Received by : Gowri
Received Dt : 06-02-98 Due Date Page 1

Constituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit
ANIONS				
Bicarbonate	1.0000	NR	82.0000	mg/l
Chloride	.5000	250.0000	6.0000	mg/l
Fluoride	.1000	2.4000	.1200	mg/l
Nitrate (NO3-N)	1.0000	10.0000	ND	mg/l
Phosphate (PO4-P)	.0500	NR	ND	mg/l
Silica	.5000	NR	46.0000	mg/l
Sulfate	.5000	250.0000	2.5000	mg/l
Nitrite	.1000	1.0000	ND	mg/l
Bromide	.1000	NR	ND	mg/l
CATIONS				
Aluminum	.0100	.2000	ND	mg/l
Arsenic	.0050	.0500	ND	mg/l
Barium	.0100	2.0000	.0130	mg/l
Cadmium	.0010	.0050	ND	mg/l
Calcium	.5000	NR	15.0000	mg/l
Chromium	.0010	.1000	ND	mg/l
Copper	.0050	1.0000	ND	mg/l
Iron	.0100	.3000	.0250	mg/l
Lead	.0010	.0050	ND	mg/l
Magnesium	.0500	NR	4.0000	mg/l
Manganese	.0030	.0500	ND	mg/l
Mercury	.0010	.0020	ND	mg/l
Potassium	.0100	NR	1.5000	mg/l
Selenium	.0050	.0100	ND	mg/l
Silver	.0050	.1000	ND	mg/l
Sodium	.1000	NR	13.0000	mg/l
Zinc	.0250	5.0000	ND	mg/l
Beryllium	.0005	.0040	ND	mg/l
Antimony	.0010	.0060	ND	mg/l
Nickel	.0010	.1000	ND	mg/l
Thallium	.0005	.0020	ND	mg/l
SECONDARY QUALITY FACTORS				
Conductivity	1.0000	NR	140.0000	uS/cm
TDS,Evaporated	.5000	NR	120.0000	mg/l
Total Alkalinity	1.0000	NR	67.0000	mg/l
Total Hardness	.5000	NR	54.0000	mg/l
Turbidity Source	.1000	5.0000	.1500	ntu
pH	.0000	NR	6.3800	pH

Arrowhead Quality Services Laboratory

ND - None Detected NR - None Required NA - Not Analyzed

C O N F I D E N T I A L

lysis Id : 16813 999
estigation: B-12, 5/28/98
e sampled : 05-28-98 1 - 0.5 lr
dition : Room Temp.
eived by : Gowri
eived Dt : 06-02-98 Due Date Page 2

stituents..................	Minimum Detection Level	Fed Max Contam Level	Level Found	Unit

tima L. Valenton
nist

Laboratory Manager

APPENDIX F

MICROSCOPIC PARTICULATE ANALYSIS REPORTS

AND

TABLE OF TURBIDITY, TOTAL DISSOLVED SOLIDS, AND PRECIPITATION DATA

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client: Arrowhead/Perrier, Brea, CA
PWS ID #: NA
Sample #: 101398AHD#2
Sample Location: San Bern. Nat'l Forest
Sample Taken From: AHS Spring #2
Date Sampled: 10/15/98
Date Received: 10/16/98
Date Processed: 10/16/98
Chain of Custody: Arrowhead/Perrier
Courier: FedEx
Analyst: Randall Kenney
Water Type: Groundwater
Water Source ID: Spring
Well Depth: NA

Filter Type: Faber M39R10A 1 micron
Filter Color: White
Water Color: Clear
Sediment Color: Brown
Temperature: 12°C
pH: 6.14
T.Chlorine: NA
F.Chlorine: NA
Conductivity: NA
Volume Filtered: 1,440 gallons
Pooled Sediment Volume: 200 uL
Pooled SedimentVolume uL/100 Gallons: 13.9
Floatation Volume: 200 uL
Final Pellet Volume: Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed: ND
Giardia Cyst Presumptive: ND
Cryptosporidium Oocyst Confirmed: ND
Cryptosporidium Oocyst Presumptive: ND

Particulate Analysis: #/100 Gallons

Diatoms: ND
Algae: ND
Protozoa: ND
Insects: ND
Insect Fragments: ND
Vegetative Debris: ND
Large Amorphous Debris: 11,000
Fine Amorphous Debris: 33,000

Rotifers: ND
Rotifer Eggs: ND
Crustaceans: ND
Crustacean Eggs: ND
Nematodes: ND
Nematode Eggs: ND

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: J. C. Morrell

10/26/98
Date

MORRELL ASSOCIATES
1861 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client: Arrowhead/Perrier Group of America/Dames & Moore
PWS ID #: NA
Sample #: AHD#3011999
Sample Location: San Bernardino County
Sample Taken From: Spring #3
Date Sampled: 1/20/99
Date Received: 1/21/99
Date Processed: 1/21/99
Chain of Custody: J. Goyich, Dames & Moore
Courier: UPS
Analyst: Randall Kenney
Water Type: Groundwater
Water Source ID: Spring
Well Depth: NA

Filter Type: Faber M39R10A 1 micron
Filter Color: White
Water Color: Clear
Sediment Color: Light Gray
Temperature: 10°C
pH: 7.0
T.Chlorine: NA
F.Chlorine: NA
Conductivity: 130
Volume Filtered: 1,340 gallons
Pooled Sediment Volume: < 100 uL
Pooled SedimentVolume uL/100 Gallons: < 7.5
Floatation Volume: < 100 uL
Final Pellet Volume: Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed: ND
Giardia Cyst Presumptive: ND
Cryptosporidium Oocyst Confirmed: ND
Cryptosporidium Oocyst Presumptive: ND

Particulate Analysis: #/100 Gallons

Diatoms: ND
Algae: 1.1
Protozoa: ND
Insects: ND
Insect Fragments: ND
Vegetative Debris: 17.9
Large Amorphous Debris: 3,000
Fine Amorphous Debris: 20,000

Rotifers: ND
Rotifer Eggs: ND
Crustaceans: ND
Crustacean Eggs: ND
Nematodes: ND
Nematode Eggs: ND

Risk Factor Ratings: This sample received 4 Risk Factor Points due to a rare amount of Algae. This sample is in the Low Risk Range.

Comments: The Algae detected were Characium.
ND denotes None Detected. NA denotes None/Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: John Morrell 1/22/99
John E. Morrell, Ph.D., R.S., C.H.O., Laboratory Director / Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client: Arrowhead/Perrier, Brea, CA
PWS ID #: NA
Sample #: 10598AHS#1
Sample Location: San Bern. Nat'l Forest
Sample Taken From: AHS Bore Hole No. 1
Date Sampled: 10/6/98
Date Received: 10/7/98
Date Processed: 10/7/98
Chain of Custody: Arrowhead/Perrier
Courier: FedEx
Analyst: Randall Kenney
Water Type: Groundwater
Water Source ID: Spring
Well Depth: NA

Filter Type: Faber M39R10A 1 micron
Filter Color: White
Water Color: Clear
Sediment Color: Brown
Temperature: 11°C
pH: 6.49
T.Chlorine: NA
F.Chlorine: NA
Conductivity: NA
Volume Filtered: 1,380 gallons
Pooled Sediment Volume: 500 uL
Pooled Sediment Volume uL/100 Gallons: 36.2
Floatation Volume: 500 uL
Final Pellet Volume: Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed: ND
Giardia Cyst Presumptive: ND
Cryptosporidium Oocyst Confirmed: ND
Cryptosporidium Oocyst Presumptive: ND

Particulate Analysis: #/100 Gallons

Diatoms: ND
Algae: ND
Protozoa: ND
Insects: ND
Insect Fragments: ND
Vegetative Debris: ND
Large Amorphous Debris: 10,000
Fine Amorphous Debris: 45,000

Rotifers: ND
Rotifer Eggs: ND
Crustaceans: ND
Crustacean Eggs: ND
Nematodes: ND
Nematode Eggs: ND

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: Morrell

10/20/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client: Arrowhead/Perrier, Brea, CA
PWS ID #: NA
Sample #: 101398AHD#1A
Sample Location: San Bern. Nat'l Forest
Sample Taken From: AHS Bore Hole No 1A
Date Sampled: 10/15/98
Date Received: 10/16/98
Date Processed: 10/16/98
Chain of Custody: Arrowhead/Perrier
Courier: FedEx
Analyst: Randall Kenney
Water Type: Groundwater
Water Source ID: Spring
Well Depth: NA

Filter Type: Faber M39R10A 1 micron
Filter Color: White
Water Color: Clear
Sediment Color: Brown
Temperature: 12°C
pH: 7.24
T.Chlorine: NA
F.Chlorine: NA
Conductivity: NA
Volume Filtered: 1,440 gallons
Pooled Sediment Volume: 200 uL
Pooled SedimentVolume uL/100 Gallons: 13.8
Floatation Volume: 200 uL
Final Pellet Volume: Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed: ND
Giardia Cyst Presumptive: ND
Cryptosporidium Oocyst Confirmed: ND
Cryptosporidium Oocyst Presumptive: ND

Particulate Analysis: #/100 Gallons

Diatoms: ND
Algae: ND
Protozoa: ND
Insects: ND
Insect Fragments: ND
Vegetative Debris: ND
Large Amorphous Debris: 17,000
Fine Amorphous Debris: 30,000

Rotifers: ND
Rotifer Eggs: ND
Crustaceans: ND
Crustacean Eggs: ND
Nematodes: ND
Nematode Eggs: ND

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: John C Morrell

10/26/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client: Arrowhead/Perrier, Brea, CA
PWS ID #: NA
Sample #: 10598AHS#8
Sample Location: San Bern. Nat'l Forest
Sample Taken From: AHS Bore Hole No. 8
Date Sampled: 10/6/98
Date Received: 10/7/98
Date Processed: 10/7/98
Chain of Custody: Arrowhead/Perrier
Courier: FedEx
Analyst: Randall Kenney
Water Type: Groundwater
Water Source ID: Spring
Well Depth: NA

Filter Type: Faber M39R10A 1 micron
Filter Color: White
Water Color: Clear
Sediment Color: Brown
Temperature: 11°C
pH: 6.83
T.Chlorine: NA
F.Chlorine: NA
Conductivity: NA
Volume Filtered: 1,380 gallons
Pooled Sediment Volume: 500 uL
Pooled SedimentVolume uL/100 Gallons: 36.2
Floatation Volume: 500 uL
Final Pellet Volume: Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed: ND
Giardia Cyst Presumptive: ND
Cryptosporidium Oocyst Confirmed: ND
Cryptosporidium Oocyst Presumptive: ND

Particulate Analysis: #/100 Gallons

Diatoms: ND
Algae: ND
Protozoa: ND
Insects: ND
Insect Fragments: ND
Vegetative Debris: ND
Large Amorphous Debris: 9,600
Fine Amorphous Debris: 30,000

Rotifers: ND
Rotifer Eggs: ND
Crustaceans: ND
Crustacean Eggs: ND
Nematodes: ND
Nematode Eggs: ND

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: John E Morrell

10/20/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client: Arrowhead/Perrier, Brea, CA
PWS ID #: NA
Sample #: 92998AHS#7
Sample Location: San Bern. Nat'l Forest
Sample Taken From: AHS Bore Hole No 7
Date Sampled: 9/30/98
Date Received: 10/1/98
Date Processed: 10/2/98
Chain of Custody: Arrowhead/Perrier
Courier: FedEx
Analyst: Randall Kenney
Water Type: Groundwater
Water Source ID: Spring
Well Depth: NA

Filter Type: Faber M39R10A 1 micron
Filter Color: White
Water Color: Clear
Sediment Color: Light Brown
Temperature: 10°C
pH: 6.8
T.Chlorine: NA
F.Chlorine: NA
Conductivity: NA
Volume Filtered: 1,420 gallons
Pooled Sediment Volume: 500 uL
Pooled SedimentVolume uL/100 Gallons: 35.2
Floatation Volume: 500 uL
Final Pellet Volume: Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed: ND
Giardia Cyst Presumptive: ND
Cryptosporidium Oocyst Confirmed: ND
Cryptosporidium Oocyst Presumptive: ND

Particulate Analysis: #/100 Gallons

Diatoms: ND
Algae: ND
Protozoa: ND
Insects: ND
Insect Fragments: ND
Vegetative Debris: ND
Large Amorphous Debris: 24,000
Fine Amorphous Debris: 72,000

Rotifers: ND
Rotifer Eggs: ND
Crustaceans: ND
Crustacean Eggs: ND
Nematodes: ND
Nematode Eggs: ND

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: John E Morrell

10/28/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client:	Arrowhead/Perrier, Brea, CA	Filter Type:	Faber M39R10A 1 micron
PWS ID #:	NA	Filter Color:	White
Sample #:	92998AHS#7A	Water Color:	Clear
Sample Location:	San Bern. Nat'l Forest	Sediment Color:	Light Brown
Sample Taken From:	AHS Bore Hole No 7A	Temperature:	11°C
Date Sampled:	9/30/98	pH:	6.4
Date Received:	10/1/98	T.Chlorine:	NA
Date Processed:	10/2/98	F.Chlorine:	NA
Chain of Custody:	Arrowhead/Perrier	Conductivity:	NA
Courier:	FedEx	Volume Filtered:	1,430 gallons
Analyst:	Randall Kenney	Pooled Sediment Volume:	500 uL
Water Type:	Groundwater	Pooled SedimentVolume uL/100 Gallons:	34.9
Water Source ID:	Spring	Floatation Volume:	500 uL
Well Depth:	NA	Final Pellet Volume:	Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed:	ND
Giardia Cyst Presumptive:	ND
Cryptosporidium Oocyst Confirmed:	ND
Cryptosporidium Oocyst Presumptive:	ND

Particulate Analysis: #/100 Gallons

Diatoms:	ND	Rotifers:	ND
Algae:	ND	Rotifer Eggs:	ND
Protozoa:	ND	Crustaceans:	ND
Insects:	ND	Crustacean Eggs:	ND
Insect Fragments:	ND	Nematodes:	ND
Vegetative Debris:	ND	Nematode Eggs:	ND
Large Amorphous Debris:	20,000		
Fine Amorphous Debris:	66,000		

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: Jol E Morrell

10/20/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client: Arrowhead/Perrier, Brea, CA
PWS ID #: NA
Sample #: 92998AHS#7B
Sample Location: San Bern. Nat'l Forest
Sample Taken From: AHS Bore Hole No. 7B
Date Sampled: 9/30/98
Date Received: 10/1/98
Date Processed: 10/2/98
Chain of Custody: Arrowhead/Perrier
Courier: FedEx
Analyst: Randall Kenney
Water Type: Groundwater
Water Source ID: Spring
Well Depth: NA

Filter Type: Faber M39R10A 1 micron
Filter Color: White
Water Color: Clear
Sediment Color: Light Brown
Temperature: 10°C
pH: 6.4
T.Chlorine: NA
F.Chlorine: NA
Conductivity: NA
Volume Filtered: 1,425 gallons
Pooled Sediment Volume: 500 uL
Pooled SedimentVolume uL/100 Gallons: 35.8
Floatation Volume: 500 uL
Final Pellet Volume: Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed: ND
Giardia Cyst Presumptive: ND
Cryptosporidium Oocyst Confirmed: ND
Cryptosporidium Oocyst Presumptive: ND

Particulate Analysis: #/100 Gallons

Diatoms: ND
Algae: ND
Protozoa: ND
Insects: ND
Insect Fragments: ND
Vegetative Debris: ND
Large Amorphous Debris: 35,000
Fine Amorphous Debris: 110,000

Rotifers: ND
Rotifer Eggs: ND
Crustaceans: ND
Crustacean Eggs: ND
Nematodes: ND
Nematode Eggs: ND

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: John E Morrell

10/20/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client:	Arrowhead/Perrier, Brea, CA
PWS ID #:	NA
Sample #:	10598AHS#7C
Sample Location:	San Bern. Nat'l Forest
Sample Taken From:	AHS Bore Hole No. 7C
Date Sampled:	10/6/98
Date Received:	10/7/98
Date Processed:	10/7/98
Chain of Custody:	Arrowhead/Perrier
Courier:	FedEx
Analyst:	Randall Kenney
Water Type:	Groundwater
Water Source ID:	Spring
Well Depth:	NA

Filter Type:	Faber M39R10A 1 micron
Filter Color:	White
Water Color:	Clear
Sediment Color:	Brown
Temperature:	13°C
pH:	6.69
T.Chlorine:	NA
F.Chlorine:	NA
Conductivity:	NA
Volume Filtered:	1,380 gallons
Pooled Sediment Volume:	500 uL
Pooled SedimentVolume uL/100 Gallons:	36.2
Floatation Volume:	500 uL
Final Pellet Volume:	Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed:	ND
Giardia Cyst Presumptive:	ND
Cryptosporidium Oocyst Confirmed:	ND
Cryptosporidium Oocyst Presumptive:	ND

Particulate Analysis: #/100 Gallons

Diatoms:	ND
Algae:	ND
Protozoa:	ND
Insects:	ND
Insect Fragments:	ND
Vegetative Debris:	ND
Large Amorphous Debris:	12,000
Fine Amorphous Debris:	36,000

Rotifers:	ND
Rotifer Eggs:	ND
Crustaceans:	ND
Crustacean Eggs:	ND
Nematodes:	ND
Nematode Eggs:	ND

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: John E Morrell

10/20/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client:	Arrowhead/Perrier, Brea, CA	Filter Type:	Faber M39R10A 1 micron
PWS ID #:	NA	Filter Color:	Off White
Sample #:	AHD102098#10	Water Color:	Clear
Sample Location:	San Bern. Nat'l Forest	Sediment Color:	Light Brown
Sample Taken From:	AHS Bore Hole No. 10	Temperature:	13°C
Date Sampled:	10/20/98	pH:	6.81
Date Received:	10/21/98	T.Chlorine:	NA
Date Processed:	10/21/98	F.Chlorine:	NA
Chain of Custody:	Arrowhead/Perrier	Conductivity:	NA
Courier:	FedEx	Volume Filtered:	1,260 gallons
Analyst:	Randall Kenney	Pooled Sediment Volume:	500 uL
Water Type:	Groundwater	Pooled SedimentVolume uL/100 Gallons:	39.7
Water Source ID:	Spring	Floatation Volume:	500 uL
Well Depth:	NA	Final Pellet Volume:	Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed:	ND
Giardia Cyst Presumptive:	ND
Cryptosporidium Oocyst Confirmed:	ND
Cryptosporidium Oocyst Presumptive:	ND

Particulate Analysis: #/100 Gallons

Diatoms:	ND	Rotifers:	ND
Algae:	ND	Rotifer Eggs:	ND
Protozoa:	ND	Crustaceans:	ND
Insects:	ND	Crustacean Eggs:	ND
Insect Fragments:	ND	Nematodes:	ND
Vegetative Debris:	ND	Nematode Eggs:	ND
Large Amorphous Debris:	24,000		
Fine Amorphous Debris:	75,000		

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: John E Morrell

10/26/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client:	Arrowhead/Perrier, Brea, CA	Filter Type:	Faber M39R10A 1 micron
PWS ID #:	NA	Filter Color:	White
Sample #:	AHD102098#11	Water Color:	Off White
Sample Location:	San Bern. Nat'l Forest	Sediment Color:	Light Brown
Sample Taken From:	AHS Bore Hole No. 11	Temperature:	2°C
Date Sampled:	10/20/98	pH:	6.78
Date Received:	10/21/98	T.Chlorine:	NA
Date Processed:	10/21/98	F.Chlorine:	NA
Chain of Custody:	Arrowhead/Perrier	Conductivity:	NA
Courier:	FedEx	Volume Filtered:	1,260 gallons
Analyst:	Randall Kenney	Pooled Sediment Volume:	500 uL
Water Type:	Groundwater	Pooled SedimentVolume uL/100 Gallons:	39.7
Water Source ID:	Spring	Floatation Volume:	500 uL
Well Depth:	NA	Final Pellet Volume:	Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed:	ND
Giardia Cyst Presumptive:	ND
Cryptosporidium Oocyst Confirmed:	ND
Cryptosporidium Oocyst Presumptive:	ND

Particulate Analysis: #/100 Gallons

Diatoms:	ND	Rotifers:	ND
Algae:	ND	Rotifer Eggs:	ND
Protozoa:	ND	Crustaceans:	ND
Insects:	ND	Crustacean Eggs:	ND
Insect Fragments:	ND	Nematodes:	ND
Vegetative Debris:	ND	Nematode Eggs:	ND
Large Amorphous Debris:	50,000		
Fine Amorphous Debris:	125,000		

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: ______________________

10/26/98
Date

MORRELL ASSOCIATES
1661 OCEAN STREET / P.O. BOX 268
MARSHFIELD, MA 02050
(781) 837-1395

Microscopic Particulate Analysis Report: Giardia, Cryptosporidium, & Particulates

Sample Data:

Client: Arrowhead/Perrier, Brea, CA
PWS ID #: NA
Sample #: AHD102098#12
Sample Location: San Bern. Nat'l Forest
Sample Taken From: AHS Bore Hole No. 12
Date Sampled: 10/20/98
Date Received: 10/21/98
Date Processed: 10/21/98
Chain of Custody: Arrowhead/Perrier
Courier: FedEx
Analyst: Randall Kenney
Water Type: Groundwater
Water Source ID: Spring
Well Depth: NA

Filter Type: Faber M39R10A 1 micron
Filter Color: Cream
Water Color: Clear
Sediment Color: Brown
Temperature: 15°C
pH: 6.79
T.Chlorine: NA
F.Chlorine: NA
Conductivity: NA
Volume Filtered: 1,260 gallons
Pooled Sediment Volume: 300 uL
Pooled SedimentVolume uL/100 Gallons: 23.8
Floatation Volume: 300 uL
Final Pellet Volume: Trace

Giardia / Cryptosporidium Analysis: #/100 Gallons

Giardia Cyst Confirmed: ND
Giardia Cyst Presumptive: ND
Cryptosporidium Oocyst Confirmed: ND
Cryptosporidium Oocyst Presumptive: ND

Particulate Analysis: #/100 Gallons

Diatoms: ND
Algae: ND
Protozoa: ND
Insects: ND
Insect Fragments: ND
Vegetative Debris: ND
Large Amorphous Debris: 24,000
Fine Amorphous Debris: 52,000

Rotifers: ND
Rotifer Eggs: ND
Crustaceans: ND
Crustacean Eggs: ND
Nematodes: ND
Nematode Eggs: ND

Risk Factor Ratings: This sample received Zero Risk Factor Points. This sample is in the Low Risk Range.

Comments: ND denotes None Detected. NA denotes Not Available.

Methodology: Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) and Immunofluorescent Antibody (IFA).

To the best of my knowledge, the information contained in this report is a true and accurate statement.

Analysis Reviewed By: John E Morrell

10/26/98
Date

Date	TDS	Turbidity	Precipitation
	(mg/L)	(NTU)	(inches)
01/01/98			0.00
01/02/98			0.00
01/03/98			0.46
01/04/98			0.50
01/05/98	100	0.12	0.57
01/06/98	100	0.1	0.00
01/07/98	100	0.08	0.00
01/08/98	100	0.1	0.00
01/09/98			1.55
01/10/98			2.87
01/11/98			0.00
01/12/98	100	0.07	0.00
01/13/98	105	0.07	0.00
01/14/98	100	0.07	0.00
01/15/98			0.00
01/16/98			0.00
01/17/98			0.00
01/18/98			0.00
01/19/98			0.62
01/20/98	105	0.08	0.02
01/21/98	105	0.06	0.00
01/22/98	100	0.06	0.00
01/23/98	105	0.1	0.00
01/24/98			0.00
01/25/98			0.00
01/26/98	105	0.3	0.00
01/27/98	100	0.12	0.00
01/28/98	100	0.1	0.00
01/29/98	100	0.1	0.90
01/30/98	100	0.1	0.40
01/29/98			0.00
01/30/98			0.00
02/01/98			0.00
02/02/98	100	0.14	0.00
02/03/98	100	0.12	2.07
02/04/98	105	0.1	0.68
02/05/98	105	0.2	0.04
02/06/98			2.57
02/07/98			2.80
02/08/98			3.53
02/09/98			0.65
02/10/98			0.00
02/11/98	90	0.15	0.00
02/12/98	100	0.1	0.00
02/13/98	100	0.12	0.00
02/14/98			1.61
02/15/98			0.00

Date	TDS (mg/L)	Turbidity (NTU)	Precipitation (inches)
02/16/98			0.00
02/17/98	100	0.1	1.86
02/18/98	100	0.1	0.00
02/19/98	100	0.1	0.08
02/20/98	100	0.1	0.95
02/21/98			0.00
02/22/98			2.64
02/23/98	100		3.38
02/24/98	80	0.6	6.80
02/25/98	80	0.3	0.00
02/26/98	80	0.2	0.00
02/27/98	80	0.2	0.00
02/28/98			0.00
03/01/98			0.00
03/02/98	85	0.25	0.00
03/03/98	85	0.15	0.00
03/04/98	80	0.1	0.00
03/05/98	80	0.06	0.00
03/06/98	80	0.1	1.64
03/07/98			0.00
03/08/98			0.00
03/09/98	80	0.1	0.00
03/10/98	80	0.15	0.00
03/11/98	80	0.15	0.00
03/12/98	80	0.2	0.00
03/13/98	95	0.1	0.61
03/14/98			0.00
03/15/98			0.00
03/16/98	80	0.1	0.00
03/17/98	90	0.1	0.00
03/18/98	80	0.1	0.00
03/19/98	80	0.1	0.00
03/20/98	80	0.05	0.00
03/21/98			0.00
03/22/98			0.00
03/23/98	90	0.2	0.00
03/24/98	90	0.1	3.25
03/25/98	75	0.05	0.11
03/26/98	90	0.1	1.10
03/27/98	90	0.1	4.70
03/28/98			0.10
03/29/98			0.00
03/30/98	75	0.15	0.00
03/31/98	80	0.1	0.00
04/01/98	80	0.15	1.80
04/02/98	90	0.05	0.00
04/03/98	90	0.1	0.69
4/498			0.00
04/05/98			0.00

Date	TDS	Turbidity	Precipitation
	(mg/L)	(NTU)	(inches)
04/06/98	80	0.14	0.48
04/07/98	80	0.09	0.60
04/08/98	90	0.1	0.00
04/09/98	80	0.08	0.00
04/10/98	80	0.1	0.00
04/11/98			0.00
04/12/98			2.16
04/13/98	80	0.1	0.00
04/14/98	80	0.06	0.56
04/15/98	80	0.05	0.24
04/16/98	80	0.05	0.00
04/17/98			0.00
04/18/98			0.00
04/19/98			0.00
04/20/98	75	0.1	0.00
04/21/98	80	0.1	0.00
04/22/98	80	0.1	0.00
04/23/98	80	0.05	0.00
424/98	80	0.05	0.00
04/25/98			0.00
04/26/98			0.00
04/27/98	80	0.1	0.00
04/28/98	85	0.12	0.00
04/29/98	80	0.09	0.00
04/30/98	75	0.09	0.00
05/01/98	80	0.05	0.00
05/02/98			0.00
05/03/98			0.34
05/04/98	75	0.1	0.67
05/05/98	75	0.05	3.94
05/06/98	75	0.06	0.87
05/07/98	75	0.14	0.00
05/08/98	75	0.14	0.00
05/09/98			0.35
05/10/98			0.00
05/11/98	75	0.1	0.00
05/12/98	75	0.1	1.62
05/13/98	80	0.1	3.45
05/14/98	80	0.06	0.16
05/15/98	75	0.06	0.00
05/16/98			0.00
05/17/98			0.00
05/18/98	80	0.06	0.00
05/19/98	75	0.1	0.00
05/20/98	80	0.1	0.00
05/21/98	80	0.15	0.00
05/22/98	75	0.06	0.00
05/23/98			0.00
05/24/98			0.00

Date	TDS	Turbidity	Precipitation
	(mg/L)	(NTU)	(inches)
05/25/98			0.07
05/26/98	75	0.05	0.00
05/27/98	80	0.06	0.00
05/28/98	80	0.2	0.00
05/29/98	80	0.08	0.00
05/30/98			0.00
06/01/98	80	0.1	0.00
06/02/98	75	0.1	0.00
06/03/98	75	0.1	0.00
06/04/98	75	0.05	0.00
06/05/98	80	0.1	0.00
06/06/98			0.00
06/07/98			0.00
06/08/98	75	0.05	0.00
06/09/98	75	0.075	0.00
06/10/98	75	0.05	0.00
06/11/98	75	0.06	0.00
06/12/98	75	0.075	0.00
06/13/98			0.10
06/14/98			0.19
06/15/98	75	0.1	0.00
06/16/98	75	0.1	0.00
06/17/98	75	0.1	0.00
06/18/98	75	0.08	0.00
06/19/98	75	0.09	0.00
06/20/98			0.00
06/21/98			0.00
06/22/98	80	0.15	0.00
06/23/98	75	0.2	0.00
06/24/98	75	0.2	0.00
06/25/98	75	0.2	0.00
06/26/98	80	0.05	0.00
06/27/98			0.00
06/28/98			0.00
06/29/98	75	0.09	0.00
06/30/98	75	0.06	0.00
07/01/98	75	0.08	0.00
07/02/98	80	0.09	0.00
07/03/98			0.00
07/04/98			0.00
07/05/98			0.00
07/06/98	80	0.2	0.00
07/07/98	80	0.18	0.00
07/08/98	90	0.05	0.00
07/09/98	80	0.1	0.00
07/10/98	80	0.1	0.00
07/11/98			0.00
07/12/98			0.00
07/13/98	90	0.1	0.00

Date	TDS	Turbidity	Precipitation
	(mg/L)	(NTU)	(inches)
07/14/98	90	0.1	0.00
07/15/98	90	0.1	0.00
07/16/98	75	0.14	0.00
07/17/98	80	0.12	0.00
07/18/98			0.00
07/19/98			0.00
07/20/98	75	0.15	0.00
07/21/98	80	0.12	0.00
07/22/98	75	0.1	0.00
07/23/98	75	0.08	0.00
07/24/98	75	0.1	0.00
07/25/98			0.00
07/26/98			0.00
07/27/98	75	0.11	0.00
07/28/98	60	0.15	0.00
07/29/98	80	0.15	0.00
07/30/98	75	0.15	0.00
07/31/98			0.00
08/01/98			0.00
08/02/98			0.00
08/03/98	90	0.2	0.00
08/04/98	80	0.14	0.00
08/05/98	80	0.25	0.00
08/06/98	80	0.2	0.00
08/07/98	75	0.13	0.00
08/08/98			0.00
08/09/98			0.00
08/10/98	90	0.15	0.00
08/11/98	85	0.2	0.00
08/12/98	90	0.15	0.00
08/13/98	95	0.1	0.00
08/14/98	75	0.15	0.00
08/15/98			0.00
08/16/98			0.00
8/1798	90	0.15	0.00
08/18/98	85	0.15	0.00
08/19/98	90	0.15	0.00
08/20/98	95	0.15	0.00
08/21/98	90	0.15	0.00
08/22/98			0.00
08/23/98			0.00
08/24/98	90	0.15	0.00
08/25/98	80	0.15	0.00
08/26/98	80	0.15	0.00
08/27/98	80	0.15	0.00
08/28/98	100	0.15	0.00
08/29/98			0.00
08/30/98			0.00
08/31/98	90	0.15	0.00

Date	TDS	Turbidity	Precipitation
	(mg/L)	(NTU)	(inches)
09/01/98			0.44
09/02/98	80	0.15	0.03
09/03/98	80	0.15	0.02
09/04/98			0.00
09/05/98			0.00
09/06/98			0.00
09/07/98			0.00
09/08/98	90	0.15	0.00
09/09/98	95	0.1	0.00
09/10/98	95	0.15	0.00
09/11/98	90	0.15	0.00
09/12/98			0.00
09/13/98			0.00
09/14/98	90	0.09	0.00
09/15/98	90	0.2	0.00
09/16/98	90	0.15	0.00
09/17/98	90	0.15	0.00
09/18/98	90	0.15	0.00
09/19/98			0.00
09/20/98			0.00
09/21/98	95	0.18	0.00
09/22/98	90	0.2	0.00
09/23/98	90	0.2	0.00
09/24/98	90	0.1	0.00
09/25/98	90	0.1	0.00
09/26/98			0.00
09/27/98			0.00
09/28/98	95	0.2	0.00
09/29/98	95	0.15	0.00
09/30/98	95	0.17	0.00
10/01/98	90	0.1	0.00
10/02/98	90	0.15	0.00
10/03/98			0.00
10/04/98			0.00
10/05/98	90	0.15	0.00
10/06/98	90	0.2	0.00
10/07/98	90	0.1	0.00
10/08/98	90	0.1	0.00
10/09/98	90	0.15	0.00
10/10/98			0.00
10/11/98			0.00
10/12/98	95	0.15	0.00
10/13/98	90	0.15	0.00
1014/98	95	0.2	0.00
10/15/98	95	0.12	0.00
10/16/98	90	0.15	0.00
10/17/98			0.00
10/18/98			0.00
1019/98	90	0.1	0.00

Date	TDS (mg/L)	Turbidity (NTU)	Precipitation (inches)
10/20/98	90	0.15	0.00
10/21/98	90	0.2	0.00
10/22/98	90	0.15	0.00
10/23/98	95	0.15	0.00
10/24/98			0.08
10/25/98			0.00
10/26/98	95	0.15	0.00
10/27/98	90	0.15	0.00
10/28/98	90	0.1	0.00
10/29/98	90	0.08	0.00
10/30/98	95	0.15	0.04
10/31/98			0.00
11/01/98			0.00
11/02/98	90	0.15	0.00
11/03/98	90	0.16	0.00
11/04/98	90	0.15	0.00
11/05/98			0.00
11/06/98	90	0.1	0.00
11/07/98			0.00
11/08/98			0.32
11/09/98	90	0.08	0.17
11/10/98	90	0.12	0.00
11/11/98	100	0.1	0.38
11/12/98	95	0.12	0.06
11/13/98	95	0.1	0.00
11/14/98			0.00
11/15/98			0.00
11/16/98	95	0.15	0.00
11/17/98	90	0.08	0.00
11/18/98	90	0.1	0.00
11/19/98	95	0.12	0.00
11/20/98	95	0.15	0.00
11/21/98			0.00
11/22/98			0.00
11/23/98	90	0.15	0.00
11/24/98	95	0.1	0.00
11/25/98	95	0.12	0.00
11/26/98			0.00
11/27/98			0.00
11/28/98			0.00
11/29/98			0.00
11/30/98	95	0.15	2.15
12/01/98	95	0.12	0.00
12/02/98	90	0.1	0.00
12/03/98	95	0.12	0.00
12/04/98	95	0.15	0.35
12/05/98			0.18
12/06/98			0.52
12/07/98	95	0.22	0.00

Date	TDS	Turbidity	Precipitation
	(mg/L)	(NTU)	(inches)
12/08/98	95	0.1	0.00
12/09/98	95	0.15	0.00
12/10/98	95	0.15	0.00
12/11/98	95	0.15	0.00
12/12/98			0.00
12/13/98			0.00
12/14/98	95	0.1	0.00
12/15/98	95	0.15	0.00
12/16/98	95	0.1	0.00
12/17/98	95	0.1	0.00
12/19/98	95	0.1	0.00
12/20/98			0.00
12/21/98	95	0.1	0.28
12/22/98	95	0.1	0.00
12/23/98	95	0.1	0.00
12/24/98	95	0.1	0.00
12/25/98			0.00
12/26/98			0.00
12/27/98			0.00
12/28/98	95	0.2	0.00
12/29/98	95	0.2	0.00
12/30/98	100	0.25	0.00
12/31/98	95	0.15	0.00