# 2005 Snowpack Sample Collection Event

Interim Report
**Mercury Assessment Project**
**Salmon Falls Creek Reservoir**

**A Summary Report**
**State Office of Technical Services**
**Idaho Department of Environmental Quality**
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# Executive Summary

This document constitutes the *Interim Report* required by the quality assurance plan for the mercury assessment project. The report serves as a single repository for all data and information obtained from a series of snowpack samples collected by the Idaho Department of Environmental Quality (DEQ) during the week of April 4, 2005. Primary objectives of the sampling event were to obtain representative samples from each site, using sample collection methodologies sufficient to satisfy analytical criteria, and to achieve a comparable data quality with similar data from other snowpack studies at sites throughout the western United States (US).

## Background

Salmon Falls Creek Reservoir (SFCR) is located in southern Idaho and, due to elevated mercury concentrations in fish tissue, is currently under a fish consumption advisory issued by the Idaho Department of Health. Sources of the mercury may include natural soils, geothermal hot springs, industrial sources, or the reservoir of global atmospheric mercury believed to contribute most of the atmospheric mercury in the western US.

## Data Collection Activities

The snowpack sampling effort is one of several coordinated studies implemented by DEQ to assess atmospheric inputs, identify sources, and define the associated source transport pathways contributing to elevated mercury levels in SFCR. Additional information about the mercury contamination issue, as well as a work plan for the mercury assessment project, is contained in *A Study of Mercury Contamination in Salmon Falls Reservoir and Jordan Creek* (DEQ 2005a, hereafter referred to as the *Master Work Plan*).

## Interim Findings

The sampling techniques and other field work conducted for the 2005 snowpack sampling event generally appear to have met relevant criteria needed to assure collection of representative snowpack samples from each site. Additionally, the magnitude of mercury concentration data from DEQ's sampling effort appears to be comparable with similar data from other studies.

At the present, based largely upon comparative assessments presented within this report, the snowpack data collected by DEQ does not appear to indicate

remarkably elevated mercury concentration(s) in snowpack at any of the 2005 sample-collection sites.

This apparent absence of any elevated mercury concentrations could be an indicator that wet atmospheric deposition of mercury in the winter snowpack is not a primary or solitary pathway for SFCR; however, it must be noted that a substantial volume of data required for the mercury assessment project has yet to be collected. Consequently, this interpretation of the snowpack data is very preliminary in the context of the overall mercury assessment project, and it may be altered when additional data has been collected and reviewed.

## Future Data Collection and Analysis

A second snowpack sampling event is currently scheduled for the spring of 2006; annual datasets from both snowpack sampling events will be collectively assessed in a final report slated for issuance in late summer of 2006.

The snowpack data will also be assessed with respect to data from other sampling events, conducted in compliance with the Master Work Plan, to develop conceptual and quantitative mathematical models describing mercury accumulation rates, sources, and pathways. Ultimately, the mercury assessment project is intended to assist with development of load allocations in support of a *Total Maximum Daily Load* (TMDL) for mercury in the Salmon Falls Creek watershed.

# 1. Introduction

Four reservoirs in southern Idaho, including the Salmon Falls Creek Reservoir (SFCR), with fish consumption advisory notices due to elevated concentrations of mercury in fish tissue samples. Tissue samples of fish taken from these reservoirs have exhibited mercury concentrations greater than the acceptable regulatory standard of 0.5 micrograms of mercury per gram (µg/g) of fish muscle tissue, wet weight.

A lack of information regarding the source of this mercury contamination, combined with anticipated regulatory changes regarding mercury, have led the Idaho Department of Environmental Quality (DEQ) to undertake additional studies—most specifically a study of mercury assessment in the winter snowpack.

## 1.1 Mercury Sources in the SFCR

No specific source(s) or transport pathway(s) have been conclusively identified as contributors to these elevated mercury concentrationsbut several potential sources and/or source pathways were identified as suitable candidates for further investigation. Tthese potential sources and/or source pathways include the following:

- loading from the global atmospheric reservoir
- geothermal hot spring sources
- surface soil sources
- forest and range fires
- atmospheric emissions from power generation and mineral processing facilities

Several of these sources can be hypothetically linked to the mercury issue at the Salmon Falls Creek watershed and/or are located in upwind directions from the reservoir.

## 1.2 Regulatory Issues Related to Mercury

There is a regulatory significance to these elevated mercury levels, stemming from a recently proposed water quality criterion for mercury (DEQ 2005b) that is based upon the concentration of mercury in fish tissue. In the event that this criterion should be promulgated as a final rule, the current level of mercury in fish

tissue from SFCR would likely necessitate development of Total Maximum Daily Loads (TMDLs) for the Salmon Falls Creek watershed.

The basic function of a TMDL is 1) to estimate current contaminant contributions from various sources releasing such contamination into the affected sub basin, and 2) to serve as a basis for allocation of allowable contaminant contributions from sources subject to regulation by the State of Idaho. To properly allocate source contributions for the TMDL, each source contributing regulated contaminants into the watershed, as well as the magnitude of such contributions, must be identified to the extent practical.

## 1.3 Why Additional Information Is Needed

Since information about mercury sources and relative contributions is presently unavailable for SFCR, DEQ has initiated a series of coordinated studies, sample collection efforts, and analytical assessments that are designed to evaluate the hypothetical air- and water-based transport pathways proposed for the Salmon Falls Creek watershed. Additional detail and discussion of these efforts is documented in the Master Work Plan and the quality assurance (QA) plan (DEQ 2005c) for the project.

The results from these studies are anticipated to allow estimation of current mercury contributions from various sources, and to support development of a TMDL for mercury for the Salmon Falls Creek watershed.

One of several potential transport pathways selected for further evaluation is wet atmospheric deposition that accumulates in the winter snowpack. To determine if this particular pathway, described further in the next section of this report, is a transport process contributing to elevated mercury levels at SFCR, snowpack samples were collected from select locations throughout southern Idaho and analyzed for the presence of mercury.

## 1.4 Assessment of Wet Deposition in Winter Snowpack

Most precipitation in the Great Basin area—a collection of watersheds in Nevada, Utah, California, Idaho, Oregon, and Wyoming—occurs in the winter and spring months. At higher elevations, such precipitation frequently accumulates as multiple layers of snow deposited over the localized terrain (i.e., *snowpack*). It is hypothesized that this snowpack could become mercury-enriched through atmospheric deposition processes of local, regional, or global mercury emissions. Subsequently, temperatures increase in the spring, mercury deposited in the snowpack could be transported into the local watershed (e.g., streams, reservoirs, etc.) by/within runoff from the snowmelt.

To assess the potential of this pathway for the Salmon Falls Creek watershed, DEQ collected a series of snowpack samples in the spring of 2005 and has also planned for a second round of snowpack sampling in the spring of 2006.

The 2005 samples were analyzed for total, trace mercury concentrations, as well as concentrations of select ion species thought to have potential for use as tracer species. Specifically, two sets of snowpack samples were collected from each site; one set to be analyzed for the presence of mercury and the second set intended to assess concentrations of sulfate, nitrate, and arsenic present in the snowpack.

## 1.5 Documentation for Sample Collection and the Interim Report Format

Collection of representative samples in the field is mandatory for proper assessment of mercury transport pathways. Consequently, prior to any field work, considerable time was devoted to development of the snowpack sampling plan and associated QA requirements for the collection event and analytical assessments.

Sampling procedures supplied to field personnel for the 2005 sampling event were documented in the *Snowpack Sampling and Analysis Plan (*SAP V.1.2*)*, dated April 2, 2005 (DEQ 2005d). The quality objectives and QA requirements for the sampling event were documented as *Snowpack, Surface Water, and Wet Deposition Monitoring Quality Assurance Project Plan (V.1.2)*, dated April 3, 2005 (QAPP).

## 1.6 Overview of the Remainder of the Report

The remainder of this report presents the following:

- Section 2 identifies analytical methods used for the sample collection effort.
- Section 3 contains actual, site-specific observations, data, and other information from the field.
- Quantitative sample results from analytical laboratories used for this collection effort are presented in Section 4.
- Section 5 assesses the quality of sample collection methods and field techniques used by DEQ personnel, as well as the results and data produced by this effort, with respect to requirements in the SAP and QAPP.
- In Section 6, the data collected from the 2005 sampling event is compared with similar snowpack data from the US Geological Survey (USGS) and other studies, in an initial attempt to determine whether enhanced mercury concentrations might exist in the Salmon Falls Creek watershed. This section of the report also identifies future assessments and other potential uses for the

2005 snowpack data, along with some suggested variations in the 2005 sample collection methodology, recommended for consideration/implementation in the 2006 snowpack sampling event.

- Section 7 provides literature citations and similar documentation used in the preparation of this report
- Appendix A contains actual sample data as reported by each analytical laboratory.
- Graphs of a preliminary confidence assessment for the mercury dataset and a comparison of DEQ's mercury dataset with data from other works are contained in Appendix B.

# 2. Sampling and Analytical Methods

Sampling and analytical methods used for this study addressed direct measurement of mercury as well as the measurement of select ionic species.

## 2.1 Mercury Concentrations

The analytical method selected for use in mercury analyses is a special method developed by Frontier Geosciences, specifically for trace measurement of mercury in water matrices, formally designated CALFED.C03 under the CALFED Mercury Project Quality Assurance Project Plan (March 2000). The associated sample collection *standard operating procedure* (SOP) for this method is a modified version of the US Environmental Protection Agency's (EPA's) Method 1669.

As specified in the Standard Operating Procedure (SOP) for CALFED.C03, Frontier Geosciences supplied pre-cleaned, 1-liter, Teflon®[1] sample bottles for use in the field, as well as pre-cleaned, Class 100 vinyl gloves (dust-free, clean room grade) for use in the sample collection work.

Additional requirements included preservation of the snow matrix by 1) immediately placing all snowpack samples on dry ice in an insulated cooler after collection to maintain the temperature at or below zero degrees Celsius ($0^{o}C$), and 2) expediently shipping snowpack samples to Frontier Geosciences as soon as all samples were collected.

## 2.2 Ionic Specie Concentrations

The following table contains analytical methods and associated requirements for sulfate, nitrate, and arsenic analyses; the sample collection methodology required is the same as that described in the previous section of this report (i.e., a modified version of EPA Method 1669).

**Table 2-1. Analytical Methods of Ionic Specie Analyses.**

| Parameter | Analytical Method | Holding Time | Preservation Method | Sample container |
|---|---|---|---|---|
| Sulfate | EPA Method 300.0 | 7 days | Cool to <0o C | 1-Liter plastic bottle |
| Nitrate | EPA Method 353.2 | 7 days | Cool to <0o C | 1-Liter plastic bottle |
| Arsenic | EPA Method 200.9 (GFAA)1 | 7 days | Cool to <0o C | 1-Liter plastic bottle |

[1]Graphite Furnace Atomic Absorption

[1] . *Teflon* is a registered trademark of DuPont.

Pre-cleaned, plastic sample containers were taken from DEQ's existing supply inventory. Pre-cleaned, Class 100 vinyl gloves used in sample collection work were supplied as described in the preceding section of this report.

# 3. Sample Collection Summary

Locations of the sites, a summary of the field work, and a snowpack stratigraphy assessment are presented in the following.

## 3.1 Sample Site Contour Maps

Snowpack samples were collected from four remote, high-elevation locations across southern Idaho during the week of April 4, 2005:

- Magic Mountain
- Pomerelle Mountain
- Jarbidge Mountain
- Galena Summit

Localized contour maps for each sample-collection site are presented in Figure 3-1 through Figure 3-4.

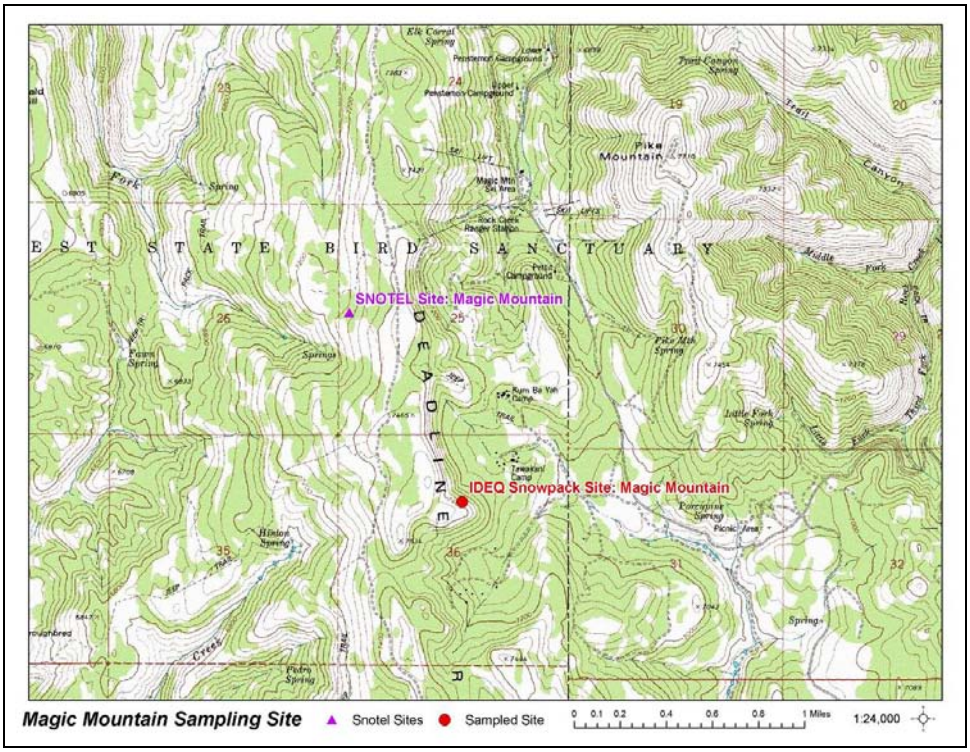



**Figure 3-1. Contour Map for Magic Mountain.**

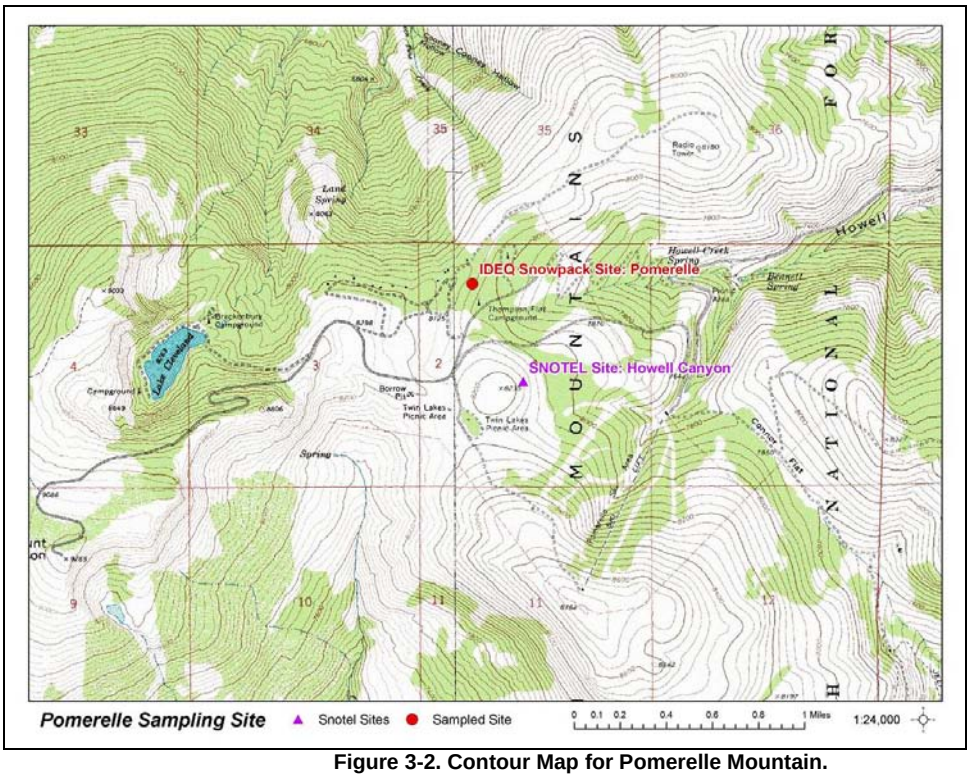



**Figure 3-2. Contour Map for Pomerelle Mountain.**

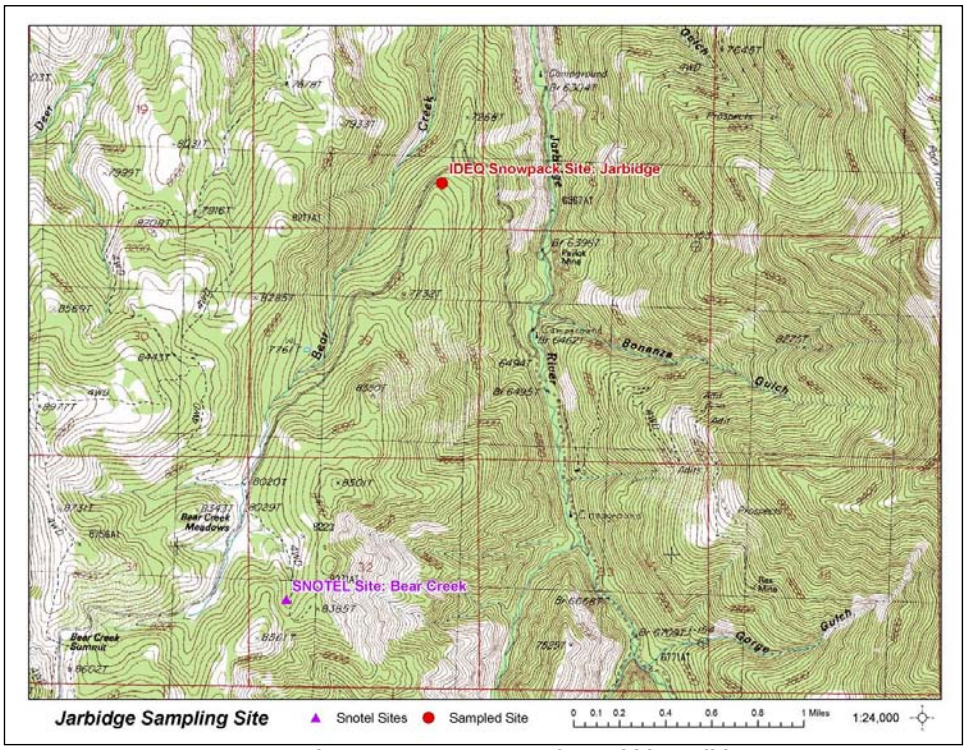



**Figure 3-3. Contour Map for Jarbidge Wilderness Area.**

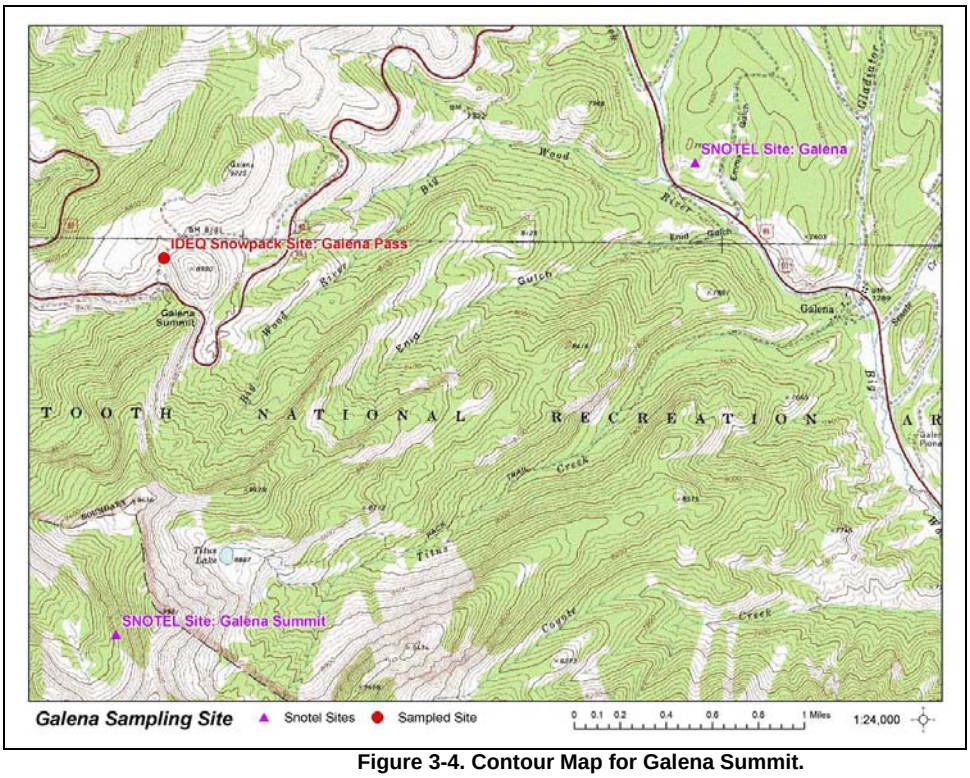



**Figure 3-4. Contour Map for Galena Summit.**

## 3.2 GPS Determination of Sampling Sites

All sample sites were recorded in the field with a Trimble Geo XM GPS. The recorded positions were later differentially corrected and post-processed with Trimble *GPS Pathfinder Office* software to improve site location accuracy. Site location coordinates are given in Table 3-1.

**Table 3-1. GPS Data for Each Sample Collection Site[1].**

| Site | UTM Northing (m) | UTM Easting (m) | Elevation (m) | Vertical Precision (m) | Horizontal Precision (m) | Standard Deviation |
|---|---|---|---|---|---|---|
| Magic Mountain | 4671996.45 | 723820.51 | 2236.26 | 2.40 | 1.30 | 1.05 |
| Pomerelle Mountain | 4691511.60 | 778151.72 | 2449.55 | 2.30 | 1.80 | 2.41 |
| Jarbidge Mountain | 4635015.63 | 629697.69 | 2246.82 | 1.80 | 1.40 | 0.64 |
| Galena Summit | 4860381.77 | 683497.39 | 2653.47 | 2.30 | 1.70 | 1.56 |

[1]Sample site locations reported in Universal Transverse Mercator (UTM) projection, Zone 11 North, North American Datum 1983.

## 3.3 Summary Report of Field Work

The following sections give a site-by-site accounting of the field work conducted in the 2005 collection effort.

### 3.3.1 Magic Mountain

On April 5, 2005, the field team arrived at the parking area for a snowmobile access site, located approximately one-half mile north of Magic Mountain ski area. From this location, the team used aerial photos and topographic maps to identify a potential target site (Photograph 3-1) for snowpack collection.

Using snowshoes and cross-country skis, the target site was reached at approximately 12:00PM MST. Although there was evidence of snowmobile activity in the general area, there was no such activity within a 100-yard radius of the target area. It was determined that the location would be suitable as a sampling site based on elevation, amount of snow present, lack of apparent avalanche danger, and lack of human activity.

**Photograph 3-1. South facing view of the sampling location at the Magic Mountain site prior to excavation of the pit.**

The sampling site was on an open, north-facing slope, inclined approximately 16$^{o}$ from horizontal, and approximately 100 yards below the crest of the ridge. The distance of the nearest visible vegetation was acceptable with the specifications of the SAP. The air temperature was 10.6$^{o}$C, with clear to slightly cloudy skies. The wind conditions were calm and no precipitation event occurred.

After the site was selected and weather conditions were recorded, the area of the pit was outlined on the slope and excavation of the pit commenced (Photograph 3-2). Care was taken not to approach the pit on the uphill side or to pile excavated

snow in areas where it could potentially re-enter the pit. The pit was oriented to the northeast, out of direct sunlight.

**Photograph 3-2. South facing view of the sampling pit excavated at the Magic Mountain site.**

After excavation was complete, each sampler dressed in a clean Tyvek®[2] suit and appropriate gloves (Photograph 3-3). The team designated a “clean hands” sampler, “dirty hands” sampler, and observer. The clean hands sampler entered the pit and exposed a clean sampling surface by scraping the face of the pit with a dedicated, plastic scraping device.

[2] *Tyvek* is a registered trademark of DuPont.

**Photograph 3-3. The clean hands sampler exposes a fresh surface for sample collection at the Magic Mountain site.**

Next, the clean hands sampler changed into a fresh pair of clean gloves and prepared to collect snowpack for mercury analysis. The container used to collect snowpack was double bagged in air-tight plastic bags. The dirty hands sampler only handled the outside of each plastic bag, and carefully opened the bags without touching the sampling container. The clean hands sampler then carefully retrieved the container from the bags without touching anything other than the container and the inside of the inner plastic bag (Photograph 3-4).

**Photograph 3-4. The dirty hands sampler passes a pre-cleaned sample container to the clean hands sampler.**

The sampling container was carefully opened and snowpack samples were collected by scraping the edge of the container against the freshly exposed surface in the pit. Numerous, evenly distributed strokes were repeated throughout the entire height of the sample wall to collect a sample representative of the entire snow column (Photograph 3-5); multiple passes were required to completely fill the sample container.

**Photograph 3-5. Snowpack sample collection at the Magic Mountain site.**

After the container was filled, the clean hands sampler placed the sample container back into the re-sealable plastic bags, held open by the dirty hands sampler. The exterior of the outer, sealed plastic bag was labeled with a unique identification number, and then the entire sample package was immediately placed on dry ice in a cooler to avoid any melting and/or chemical reactions within the sample. This completed collection of the snowpack sample for mercury analysis at the Magic Mountain site.

Next, additional snowpack samples to be analyzed for nitrate, sulfate, and arsenic were collected using procedures similar to those outlined above. All samples were labeled and immediately placed on dry ice in a cooler. Table 3-2 summarizes all samples collected at the Magic Mountain site:

**Table 3-2. Samples collected at the Magic Mountain site on April 5, 2005**

| Sample ID | Time of Collection | Parameter |
|---|---|---|
| SM1 | 12:40PM | Mercury |
| SN1 | 12:42PM | Nitrate |
| SS1 | 12:45PM | Sulfate |
| SA1 | 12:50PM | Arsenic |

After all samples were collected and on ice, protective clothing was discarded and the snow characterization process began (Photograph 3-6). The snow

characterization was recorded on prepared field sheets, and included measuring the height of the snow column, identifying and measuring each layer present in the column, measuring the temperature of the layers throughout the column, measuring snow particle size and shape, and evaluating the hardness of each layer. (Refer to Section 3.4 of this report for a description of field data collected.)

**Photograph 3-6. Snow characterization at the Magic Mountain site.**

After the characterization process was concluded, equipment was put away and the pit was refilled with snow to the extent practical (Photograph 3-7). After the site was returned to a condition similar to that in which it was found, the sampling team returned to the vehicle.

**Photograph 3-7. View of the sampling pit after the conclusion of the sampling event at the Magic Mountain site.**

### 3.3.2 Pomerelle Mountain

On April 6, 2005, the field team arrived at the parking area for the Pomerelle ski area at approximately 10:00AM MST. Topographic maps of the area were consulted to identify potential areas for use as a suitable sampling location. The sampling team used snowshoes and/or cross-country skis to access the upper boundary road on the southwestern border of the ski area.

Tree cover and evidence of human activity required the sampling team to investigate multiple sites to locate an adequate sampling location. Snowmobile tracks were visible in the area, greatly limiting the number of open slopes available for sample collection; consequently, the team transected to the west, into more vegetative cover.

At approximately 11:30AM MST, the sampling team identified a site that met the criteria outlined in the SAP. This site was located in a clearing surrounded by a grove of aspen and conifer trees on a relatively flat (~12%) slope (Photograph 3-8). The ridge was oriented in the north/northwest direction.

**Photograph 3-8. Sampling location at the Pomerelle Mountain site.**

For this sampling event/location, a digital camcorder was used to record and document the sampling event and techniques used onsite by field personnel. While the camcorder was set up, equipment was unloaded and excavation of the sampling pit commenced.

Care was taken not to approach the pit from the upslope side, and to prevent pile-up of excavated snow in areas where it could fall back into the pit (Photograph 3-9). Vegetation was found near the base of the pit, and numerous branches were removed during excavation. The sampling pit was oriented to the north/northwest.

**Photograph 3-9. Sampling pit at the Pomerelle Mountain site.**

When pit excavation was complete, sampling personnel followed the same sampling procedures described Magic Mountain, including the same clean hands/dirty hands procedure described for Magic Mountain.

Once suited in appropriate protective suits, a clean surface was exposed in the pit, using the dedicated plastic scraping device (Photograph 3-10). After a fresh sampling surface was exposed in the pit, the clean hands sampler changed into a fresh pair of gloves and prepared for the collection of snow for mercury analysis.

The snowpack sample was collected in several even strokes, using the open mouth of the sample container to simultaneously scrape the wall surface and catch dislodged snow without contacting any other surface (Photograph 3-11). Care was also taken to collect a sample representative of the entire snowpack profile during the collection process, without including any of the vegetation that was present in the pit. Multiple passes of the snowpack profile were required in order to completely fill the sample container.

**Photograph 3-10. View of the clean hands sampler exposing a clean surface in the sampling pit at the Pomerelle Mountain site prior to sample collection.**

**Photograph 3-11. Sample collection at the Pomerelle Mountain site.**

After the container was properly filled, the clean hands sampler placed the sample container back into the re-sealable plastic bags held open by the dirty hands sampler. The exterior of the outer, sealed plastic bag was labeled to identify the particular sample.

**Photograph 3-12. The dirty hands sampler labeling the exterior of the outer plastic bag used to preserve the mercury sampling container at the Pomerelle Mountain site.**

Snowpack samples for nitrate, sulfate, and arsenic were collected using similar procedures. All samples were labeled and immediately placed on dry ice in a cooler to avoid melting. Table 3-3 summarizes the samples collected at the Pomerelle Mountain site:

**Table 3-3. Samples collected at the Pomerelle Mountain site on. April 6, 2005**

| Sample ID | Time of Collection | Parameter |
|---|---|---|
| SM2 | 12:10PM | Mercury |
| SN2 | 12:15PM | Nitrate |
| SS2 | 12:13PM | Sulfate |
| SA2 | 12:20PM | Arsenic |

When all samples were collected and stored for transport from the site, the snowpack characterization process began (Photograph 3-13; Refer to Section 3.4 of this report for a description of field data collected.)

After characterization, equipment was put away, and the pit was refilled. The sampling site was returned to a similar condition to that in which it was found (Photograph 3-14), and the sampling team returned to the vehicle.

**Photograph 3-13. View of the snow characterization procedures conducted at the Pomerelle Mountain site.**

**Photograph 3-14. View of the sampling pit at the Pomerelle Mountain site after the sampling event concluded.**

### 3.3.3 Jarbidge Mountain

On April 7, 2005, a two-person field team traveled to the town of Jarbidge, Nevada, to access the mountain range south of the town. Due to deep snow conditions, the team could only drive approximately one mile past the town of Jarbidge, to the access road crossing the Jarbidge River. From this point, the sampling team hiked up the ridge to locate a suitable location for collection of the snowpack samples.

After hiking approximately one and a half miles, an open, north-facing slope was observed, and it appeared to be a suitable location for sampling. After reaching the open slope, it was determined that this particular location would fulfill sampling location requirements, based on snow accumulation, vegetative cover conditions, absence of avalanche danger, lack of human activity, and slope aspect. The sampling location was on a slope inclined approximately $16^{o}$ from horizontal, approximately 50 yards below the crest in the ridge. Visible vegetation was located at a distance acceptable to the SAP. The air temperature was $11^{o}$C, and partly cloudy skies were observed. The wind conditions were calm and no precipitation events occurred.

An outline of the area of the sample pit was delineated on the snow surface and excavation began. Care was taken not to approach the pit location from the uphill side and to prevent excavated snow from re-entering the pit. The pit was oriented to the north, out of direct sunlight.

**Photograph 3-15. View looking south of the sampling pit excavated for the sample collection at Jarbidge Mountain.**

Both members of the team donned Tyvek suits and appropriate gloves. A clean, uncontaminated surface was exposed by scraping the designated sampling face of the wall with the dedicated plastic scrapper. After exposing a fresh surface for sampling, the clean hands sampler changed into new gloves and took a mercury-sampling container from the dirty hands sampler using required protocols. This sample container was opened and placed in the corner of the sampling pit (Photograph 3-17) as a field blank sample. The field blank was a requirement outlined in the QAPP.

**Photograph 3-16. The clean hands sampler exposes a fresh surface at the Jarbidge Mountain site.**

**Photograph 3-17. The field blank sample from the Jarbidge Mountain site.**

With the field blank container open and exposed to ambient conditions within the pit, the clean hands sampler changed gloves once again, prior to collecting the snow samples.

Samples were collected in a manner consistent with procedures outlined in previous sections. Duplicate samples were collected at the site, as required by the QAPP. All samples were labeled and placed on dry ice immediately after collection in order to reduce any potential for snowmelt. Table 3-4 summarizes the samples collected at the Jarbidge Mountain site.

**Table 3-4. Samples collected at the Jarbidge Mountain site on April 7, 2005.**

| Sample ID | Time of Collection | Parameter |
|---|---|---|
| SM3 | 13:05 | Mercury |
| SN3 | 13:07 | Nitrate |
| SS3 | 13:09 | Sulfate |
| SA3 | 13:11 | Arsenic |
| DM3 | 13:13 | Mercury |
| DA3 | 13:15 | Arsenic |
| DS3 | 13:17 | Sulfate |
| DN3 | 13:19 | Nitrate |
| FB1 | 13:20 | Mercury |

After collecting all samples, duplicates, and the field blank from the site, the snow characterization procedures were initiated. After all characterization procedures, conducted in a manner similar to those described previously, were complete, the pit was backfilled with excavated snow (Photograph 3-18) and the sampling team descended from the mountain.

**Photograph 3-18. The sampling site after conclusion of sample collection at Jarbidge Mountain.**

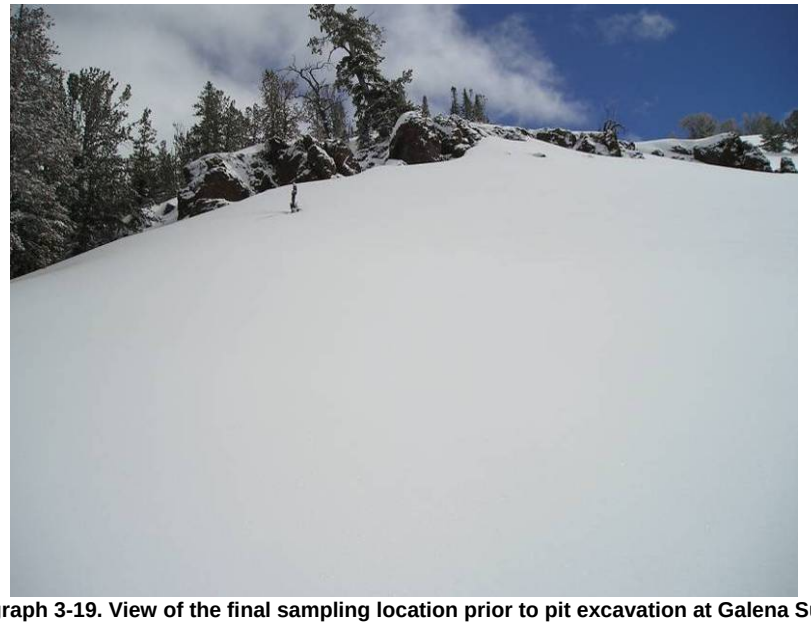
### 3.3.4 Galena Summit

On April 8, 2005, the field team arrived at the parking area for the winter recreation site located near Galena Lodge. Human activity (i.e., skiing and snowshoeing) was apparent at the site, adding considerable difficulty to location of an optimal sampling site. An open hillside was observed in an area with the least evidence of human disturbance. It was determined that this area would provide a suitable location for sampling.

Using procedures similar to those detailed previously, a sampling pit was excavated; however, after the sampling pit had been developed, the team determined that the depth of snowpack (<3 feet) was not representative of conditions surrounding the site. Therefore, this initial site was abandoned and the team moved to higher elevations to search for a new sample site.

As the sampling team climbed over Galena Summit, still attempting to locate a second sampling site, the wet condition of the snowpack, combined with steep terrain, made avalanche danger a serious concern. An optimal site was eventually located off of a main trailhead parking area, approximately one mile north of Galena Summit.

The sampling team arrived at the site at approximately 11:00AM MST, under cloudy skies with a slight breeze. The second sample location was situated on an east/west trending ridge with exposed rock outcroppings (Photograph 3-19). After assessing this site and unloading gear, the location of the pit was outlined on the slope and excavation commenced (Photograph 3-20). The pit was oriented to the northwest, out of direct sunlight.



**Photograph 3-19. View of the final sampling location prior to pit excavation at Galena Summit.**

**Photograph 3-20. The sampling pit excavated at the Galena Summit site.**

After excavation, designated personnel donned clean Tyvek suits and gloves, and a clean sampling wall within the pit was exposed using the dedicated scraper. Sample containers were handled as detailed previously, and samples were collected by scraping an even portion of the sample wall profile into each container, using the container to collect sample material.

This process was repeated until full samples were obtained in each container, such that representative samples of the snowpack were collected. Then the clean hands sampler returned each container into the re-sealable plastic bags, which were held

open by the dirty hands sampler (Photograph 3-21). The exterior of the outer bag around each sample container was then labeled in permanent ink, and the entire package was then placed on dry ice, as required to preserve the sample.

**Photograph 3-21. The clean hands sampler accepts the sample container from the dirty hands sampler at the Galena Summit site.**

**Photograph 3-22. Sample collection at the Galena Summit site.**

All remaining samples at this site were collected using procedures outlined in the preceding paragraph (Photograph 3-22). Duplicates samples were taken for each sample obtained at this site, for quality control purposes.

Table 3-5. Samples collected at the Galena Summit site on April 8, 2005. contains information for all samples collected at the Galena Summit site.

**Table 3-5. Samples collected at the Galena Summit site on April 8, 2005.**

| Sample ID | Time of collection | Parameter |
|---|---|---|
| SM4 | 12:05 | Mercury |
| SN4 | 12:09 | Nitrate |
| SS4 | 12:11 | Sulfate |
| SA4 | 12:13 | Arsenic |
| DM4 | 12:07 | Mercury |
| DN4 | 12:15 | Nitrate |
| DS4 | 12:17 | Sulfate |
| DA4 | 12:19 | Arsenic |

After all samples were collected, the snow characterization process was conducted (Photograph 3-23).

**Photograph 3-23. Characterizing snow particle shape and size as part of the snow characterization process at Galena Summit.**

At conclusion of the snow characterization process, the pit was returned to conditions similar to those at arrival (Photograph 3-24). After refilling the pit, the sampling team returned to the vehicle.

**Photograph 3-24. Sampling pit at the conclusion of the sampling event at Galena Summit site.**

## 3.4 Snowpack Stratigraphy

Snowpack assessments conducted during the 2005 sampling event, as well as the associated results obtained, are described in the following.

### 3.4.1 Field Methodology

The physical properties of the snowpack at each sample site were examined to determine the presence of snowmelt elution within the snowpack profile. Specifically, a series of tests was performed at each snow pit:

1. The height of the snow above the ground surface was measured with a metric tape.
2. Individual layers in the snowpack were identified by running a gloved finger down the face of the pit wall and noting changes in density, hardness, or texture; visual signs of stratification were also taken into account.
3. The break between each layer was measured and recorded as height above ground level.
4. Temperatures at ten-centimeter (10-cm) intervals throughout the profile were recorded with a calibrated thermistor.
5. Additional temperature measurements were taken within specific layers, as necessary.
6. Each layer in the profile was examined for hardness, moisture content, density, and grain type and size, as follows:

- Layer hardness was examined using the *hand resistance test* (Colbeck, 1990). This is a qualitative test designed to produce a relative value of hardness. Starting with a fist, objects of progressively smaller area are thrust into the snow with a penetration force of about 50 Newtons (N). The value assigned specifies the first object that does not penetrate the layer: fist, four fingers, one finger, pencil, or knife (i.e., “F”, “4F”, “1F”, “P”, or “K”, respectively).
- *Moisture content* was determined using the *squeeze test* (Cline, 2001, Colbeck, 1990). A fistful of snow from each layer is extracted and squeezed briefly with one gloved hand. The resulting adherence of the snow and the presence or absence of liquid water is then assessed and classified. A layer is determined to be *dry* when little or no adherence is observed. Snow is considered *moist* when the snow sticks together, but liquid water is not visible with a hand lens. Snow is *wet* when the squeeze test creates a perfect snowball and liquid water is visible between grains with a hand lens. Snow is *very wet* when water can be squeezed out with moderate pressure.
- The *density* of the snow was assessed by inserting a plastic cylinder of known weight and volume into each layer, filling it with snow, and recording the weight on a simple spring scale. Density was then calculated by subtracting the weight of the empty cylinder from the total weight and dividing by cylinder volume.
- *Snow grain size* and *shape* were classified with a hand lens and laminated black card printed with a millimeter grid. Crystals were collected from each

layer by scraping the wall with the card. After examination with the hand lens, grains were assigned a basic shape of *rounded*, *faceted*, or *mixed* (Cline, 2001). Size was assigned by measuring a number of grains and determining an average diameter against the measurement grid.

### 3.4.2 Results and Discussion of Field Assessments

The results of the snow pit tests are summarized in Figure 3- and Figure 3-:

- Figure 3- delineates the snowpack temperature profiles, in degrees Celsius for each site.
- Figure 3- describes the crystal type and size, moisture content, hardness, density, and stratigraphic structure of each site.

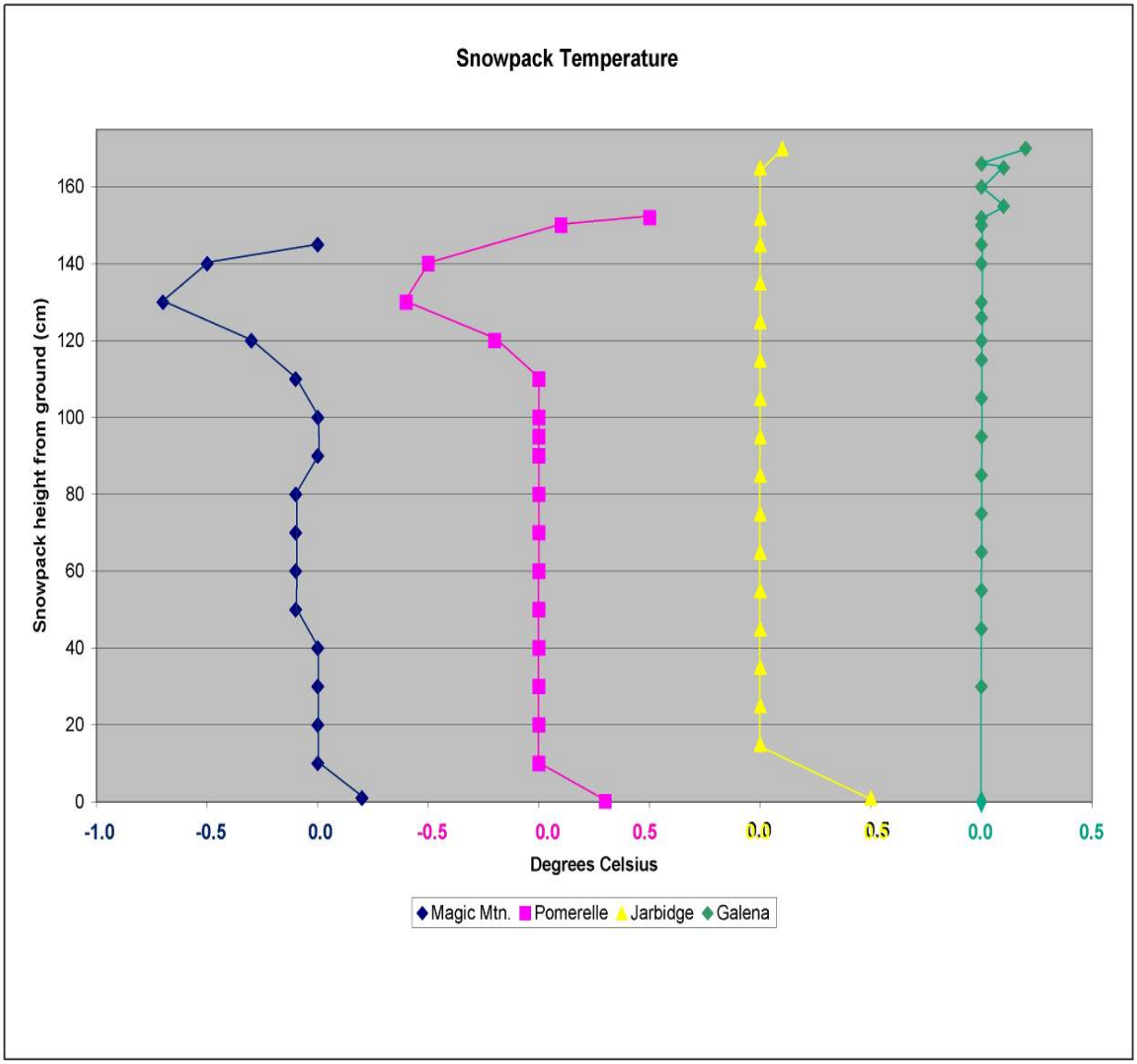



**Figure 3-5. Snowpack Temperature Profiles at Each Sample Collection Site.**

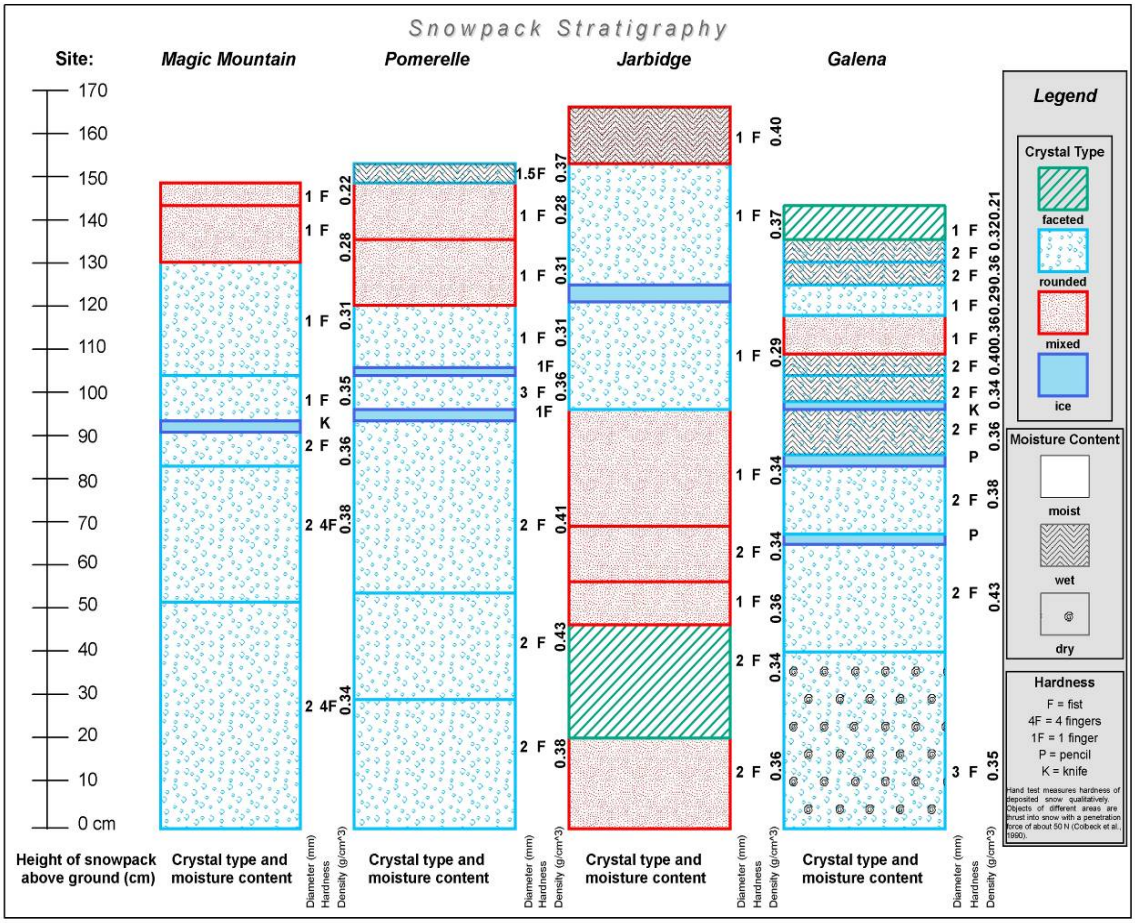



**Figure 3-6. Snowpack Stratigraphy of Each Sample Collection Site.**

Specific results include the following:

- The Magic Mountain and Pomerelle sites reflect similar temperature regimes: slightly warmer at the snow/ground interface, generally isothermal up to about 110 centimeters, and a warmer surface overlaying a colder layer. The Jarbidge and Galena sites exhibit a nearly total isothermal structure, with warmer layers near the surface.
- Jarbidge had the deepest snow, whereas Galena exhibited the largest number of individual layers and variety of crystal type and moisture content.
- All sites contained thicker and denser lower layers and, with the exception of Jarbidge, rounded, metamorphosed crystals comprised these lower layers.
- All sites had at least one ice layer in the top half of the profile, with Galena containing three.
- All sites except Magic Mountain had wet layers revealing some snowmelt in the upper portion of the snowpack.

- When examining the temperature profile and snowpack stratigraphy for evidence of snowmelt elution, a progression of melt development within the snowpack at each subsequent site is evident.
- The four sites were sampled during a four-day period, one a day, in the following order: Magic Mountain, Pomerelle Mountain, Jarbidge Mountain, and Galena Summit. The meteorological conditions in southern Idaho were generally calm and clear that week with air temperatures reaching 21°C.
- As the snowpack heated up throughout the week, the profiles showed signs of greater heat penetration and evidence of melting in the upper layers. The Magic Mountain site showed no signs of melting. Pomerelle had a 5-cm surface layer of wet snow, while Jarbidge had a larger (13-cm) surface layer of wet snow. The Galena site had the most melting, with multiple wet layers penetrating nearly halfway down the profile. One 5-cm layer, between 104 and 109 cm in the Galena profile, was completely saturated, exhibiting abundant liquid water when squeezed.

  This evidence indicates that the snowpacks were becoming isothermal and beginning to melt. However, at no site did meltwater penetrate the entire profile, so it is concluded that snowmelt elution sufficient to dilute and flush mercury present in the snow was not present. Furthermore, the presence of dense ice layers below the melt layers would serve to form a temporary barrier to the movement of meltwater further through the snowpack. The ice layers would cause the meltwater to pool until the ice warmed and metamorphosed enough to allow passage of the liquid.

# 4. Analytical Data from the 2005 Snowpack Sample Collection Event

Table 4-1 presents the results of all analytical work performed on snowpack samples collected in 2005.

**Note:** at the time this report was drafted, the final data review, including the required data-validation process, had not been conducted on any data/datasets presented herein. Formal data reviews and data validation assessment(s) are required as part of the final phases of the QA program implemented under the current QAPP for the mercury assessment project, and are to be initiated only after all data acquired for the entire mercury assessment project has been compiled.

**Table 4-1. Analytical Results and Data from the 2005 Snowpack Sample Collection Event[1].**

| Sample Site Location | Collection Date | Sample ID Number and Sample Type | Parameter | Analytical Results |
|---|---|---|---|---|
| Magic Mountain | 4/5/05 | SM1/req'd sample[2] | Mercury | 3.006 ng/L |
| | | SN1/req'd sample | Nitrate | 0.082 mg/L |
| | | SS1/req'd sample | Sulfate[4] | <2.00 mg/L |
| | | SA1/req'd sample | Arsenic[4] | <0.005 mg/L |
| Pomerelle Mountain | 4/6/05 | SM2/req'd sample | Mercury | 4.682 ng/L |
| | | SN2/req'd sample | Nitrate | 0.062 mg/L |
| | | SS2/req'd sample | Sulfate[4] | <2.00 mg/L |
| | | SA2/req'd sample | Arsenic[4] | <0.005 mg/L |
| Jarbidge Mountain | 4/7/05 | SM3/req'd sample | Mercury | 3.166 ng/L |
| | | SN3/req'd sample | Nitrate | 0.079 mg/L |
| | | SS3/req'd sample | Sulfate[4] | <2.00 mg/L |
| | | SA3/req'd sample | Arsenic[4] | <0.005 mg/L |
| | | DM3/duplicate | Mercury | 4.516 ng/L |
| | | DN3/duplicate | Nitrate | 0.073 mg/L |
| | | DS3/duplicate | Sulfate[4] | <2.00 mg/L |
| | | DA3/duplicate | Arsenic[4] | <0.005 mg/L |
| | | FB1/field blank | Mercury | 0.140 ng/L[3] |
| Galena Summit | 4/8/05 | SM4/req'd sample | Mercury | 3.469 ng/L |
| | | SN4/req'd sample | Nitrate | 0.069 mg/L |

| Sample Site Location | Collection Date | Sample ID Number and Sample Type | Parameter | Analytical Results |
|---|---|---|---|---|
| | | SS4/req'd sample | Sulfate[4] | <2.00 mg/L |
| | | SA4/req'd sample | Arsenic[4] | <0.005mg/L |
| | | DM4/duplicate | Mercury | 5.734 ng/L |
| | | DN4/duplicate | Nitrate | 0.111 mg/L |
| | | DS4/duplicate | Sulfate[4] | <2.00 mg/L |
| | | DA4/duplicate | Arsenic[4] | <0.005 mg/L |

[1]Revisions and/or alternate values may have been implemented or assigned to these datasets after issuance of this report.
[2]A 'required sample' must have been intended, at the time of the collection event, 1) to satisfy a collection requirement contained in the applicable QAPP or SAP revision governing such sampling work and 2) for sole use as a dedicated, representative sample collected for the express use of quantification of concentration of mercury or any other chemical specie delineated in the QAPP or SAP, and 3) designed to provide the bases for a parameter used in the overall assessment of associated sources and transport pathways discussed in the QAPP (i.e., as opposed to any sample intended to constitute a duplicate sample, a replacement samples mandated by developments in the field, or a required field or trip blank sample collected for QA purposes).
[b]Represents an average value from a single sample; the mercury blank was prepared and analyzed in three separate runs by the laboratory.
[4]All analytical results for sulfate and arsenic concentrations were reported as <2.00 mg/L and <0.005 mg/L, respectively (i.e., actual concentrations of these species in DEQ's snowpack samples were below detection limits of the methods).

# 5. Review of Field Methods, Analytical Data, and Quality Objectives

## 5.1 Seasonal Timing Requirements for Sample Collection

The samples collected during this event were intended to represent total, annual snowpack accumulation over the 2005 snowfall season. In theory, this requirement was met by delaying sample collection until all 2005 snowfall events have occurred. However, for purposes of the mercury assessment project, snowpack sample collection must also occur prior to snowmelt elution.

Snowmelt elution is a natural result of seasonal changes, induced by the increase in ambient air and snowpack temperatures. As snowpack temperatures increase above the freezing point, the potential for chemical reactions/transformations and evasion/leachate losses (i.e., due to snowmelt runoff) also increases. Consequently, premature or late sample collection could result in incorrect or skewed analytical results, creating uncertainty in the corresponding assessment of mercury deposition rates via snowpack.

To ensure that DEQ's snowpack samples included a majority of the seasonal snowfall events prior to onset of snowmelt elution, data trends for annual snowpack accumulation rates and snowmelt runoff rates (i.e., refer to http://www.wcc.nrcs.usda.gov/snow/snotel-geninfo.html) in 2005 were assessed daily, starting in March and continuing until an appropriate sampling period was identified. Based on visual observation of changing trends in these two rates, optimal sample collection times were predicted to exist during the final week of March or the first week of April.

## 5.2 Field Techniques and Sampling Methodology

The SAP contains several requirements for site selection and preparation; sample handling, collection, storage, and transport; collection of field data; log recordkeeping; chain-of-custody (COC) procedures; and quality control (QC) methodologies. Several of these SAP requirements specify documentation or records. In the following list, each of the SAP requirements is identified and used to assess the actual sample collection procedures used in the field.

a) Site Location Requirements: Criteria for location included: 1) clear, open areas, 2) north-facing slopes, 3) no human activity, animal activity, tree liter,

or other disturbances, 4) isolation distance equivalent to that of the highest trees in the local proximity, 5) no scoured/drifted snowscape, and 6) 500 feet of separation from plowed roadways.

The description of field work contained in Section 3.2 of this report (hereafter referred to as the *Field Report*) indicates that all sites used to collect samples generally met the SAP requirements. Therefore, it appears that SAP requirements for site locations were satisfied.

b) Site Preparation Requirements: Criteria for site preparation included: 1) appropriate area in pit for sample collection, 2) shade from direct exposure to sunlight, 3) no snowmelt elution visible, 4) exposure of a clean sampling surface on pit wall, and 5) restoration of site/pit to the original conditions.

The *Field Report* indicates that all sites were prepared as required and restored to original conditions, as practical. Records of the stratigraphy observed at Galena indicate "…heat penetration and evidence of melting in the upper layers…", though water from the snowmelt was determined insufficient to penetrate the entire snowpack profile (i.e., refer to the discussion of snow stratigraphy in the report in Section 3.3). Elevated temperatures in the upper snowpack layers would likely result in some mercury losses (e.g., mercury oxidation, ultraviolet vaporization effects, etc.) and could also have some effect on ionic species present (e.g., due to chemical interactions, chemical transformations, etc.); however, it does not appear that any leachate losses occurred prior to sample collection, and all snowpack temperatures remained below or, in the case of Galena Summit only, slightly above the freezing point. It is thought that these low temperatures should serve to 1) limit/minimize mercury losses from the snowpack and 2) inhibit or even prevent substantial chemical interaction from occurring between the target species. Therefore, the samples should provide evidence of any substantial levels of mercury within the snowpack (i.e., in the event that deposition in snowpack is a primary mercury pathway for SCFR, samples are expected to result in notably elevated mercury concentrations) and, consequently, are thought to be representative for the purposes of the QAPP.

With respect to the goal of representative sample collection, and based on the information in Section 3 of this report, site preparation requirements of the QAPP were satisfied by DEQ's field work.

c) Sample Handling/Collection/Storage/Transport Requirements: Criteria for sample handling, collection, and shipping included 1) use of "clean hands, dirty hands" protocols at all times until sample collection was complete, 2) designation and observation of specific roles during sample collection, 3) clean hands sampler to touch only sample bottle and the snow surface; conversely, the dirty hands sampler never to touch snow or bottle, 4) use of uniform passes of bottle to catch sample in bottle, 5) top five centimeters and bottom ten centimeters of wall excluded from sample, 6) volumetrically equal

sample profile of snowpack, 6) no container contact with any surface other than snow, 7) completely filled sample bottle, 8) bottle returned/sealed in bags, 9) outer bag labeled, 10) storage on dry ice in cooler, and 11) completed COC forms.

The *Field Report* indicates that all sample handling and collection requirements were followed. Generally, this appears to be an accurate assessment, although the *Field Report* does not address exclusion of the top five centimeters and bottom ten centimeters of the wall of the pit during sample collection. Although this particular SAP requirement was not explicitly addressed or documented in the field logbook or in reports from the field team, verbal communication indicates that such protocols were observed by the team while collecting snowpack samples. Consequently, it appears that SAP requirements for snowpack sample handling, collection, storage, and transport were satisfied by the field work.

d) Field Parameter Collection Requirements: Field parameters to be collected included 1) snowpack temperature profile, 2) snowpack stratigraphy, 3) depth of each layer, 4) free moisture present in each layer, 5) formation of each layer, 6) form of each layer, 7) density of each layer, and 8) the GPS coordinates of each site location.

Based on information contained in Section 3 of this report, all required data was collected; therefore, these SAP requirements were satisfied.

e) Logbook Recordkeeping Requirements: Information to be captured within the logbook included 1) purpose of event, 2) make/ model of equipment, 3) names of field crew, 4) identification of sampling site, 5) weather and time of arrival, 6) site description, snow conditions, and sample setup, 7) time of collection, 8) sample identification number, 9) field parameters, and 10) any other relevant observation.

The *Field Report* indicates that all sample handling and collection requirements were followed; however, a review of information recorded in the logbook indicates that the purpose of event and the makes/models of equipment used were not recorded.

DEQ notes that the purpose of the event has been well-documented in several locations and equipment make and models was obtained immediately after the sampling event was concluded.

Finally, although the field parameters were not recorded in the logbook as required, this data was collected on prepared field sheets, which is an alternative allowed by the SAP. Therefore, it appears that the intent of the logbook recordkeeping requirements was substantially met by the work of the field team.

f) Chain-of-custody Requirements: Criteria for COC included 1) all samples held in custody until delivered to shipping agent, 2) COC form properly completed and with samples, and 3) samples sealed in chest with COC form, signed at time of release.

The *Field Report* indicates that all COC requirements were collected as required. Based on the copy of the completed COC forms reviewed for this report, the associated SAP requirements were satisfied.

g) Quality Control Requirements: QC requirements within the SAP included 1) necessary sampling material (e.g., containers, gloves, etc.) supplied by analytical laboratories, 2) QA/QC report with continuing calibration checks in support of the data report from labs, 3) adherence to SAP requirements and documentation in logbook, 4) co-located field duplicates for 20% of the samples, or two duplicate field samples per method, 5) one trip blank per each sample shipment for mercury analysis, and 6) one field blank, if conditions allowed.

The *Field Report* indicates that all duplicates, as well as a field blank sample were taken during the event. All necessary sampling materials were supplied as requested by the laboratories, and the QA/QC reporting requirements were satisfied by the laboratory conducting analyses for total mercury content in the samples. With exception of a trip blank and a QA/QC report from the laboratory conducting analyses for ionic species, both discussed in the following paragraphs, all QC requirements in the SAP were satisfied.

A decision was made that a field blank would serve as both a field blank and a trip blank. Consequently, a trip blank was not collected in the 2005 sample collection event; however, the analysis of the field blank returned very low mercury concentrations, which satisfies the trip blank requirement.

The laboratory conducting analyses for levels of sulfate, nitrate, and arsenic within snowpack samples has not yet submitted a report demonstrating the use of ongoing QA/QC calibration checks during sample analyses. At this time, it is unclear if such QA/QC checks were conducted. This omission does not affect or invalidate results of the mercury analysis (i.e., considered a more critical parameter for the mercury assessment project); however, DEQ is currently investigating the actual QA/QC methodologies used by the laboratory and will report the findings of the investigation, if any, in an addendum to this report or in the final snowpack collection report. Should these findings relate to any aspect of the overall assessment project, these issues and any associated impact will be thoroughly documented in the final snowpack collection report to be drafted after the 2006 sampling event, as well as in the final report for the mercury assessment project.

Substantial fulfillment of SAP requirements was shown and documented by this interim report and other supporting records for the collection effort.

Although minor excursions from the SAP occurred, these issues appear to have been inconsequential in nature and did not constitute collection of non-representative samples. No other subsequent issue(s) indicating non-representativeness of the samples has been identified at the time of this report. Based on the preceding review and available records for the sampling event, it appears that the 2005 sampling event was substantially conducted in accordance with requirements of the SAP.

Although no trip blank was collected and QA/QC calibration checks used during analytical processing of samples for ionic species were not documented, these issues will be investigated further and should be addressed or corrected in the 2006 event. At this time, is believed that these issues are likely to be inconsequential with respect to the mercury assessment project.

## 5.3 Quality Assurance Objectives and Requirements

The draft QAPP contained four quality objectives and several other requirements for the snowpack sample collection event. Several of the QAPP requirements specify or relate to documentation or recordkeeping requirements in support of the quality objectives. In the following list, each of the QAPP objectives and requirements is identified and assessed against the 2005 sample collection effort for compliance with the QAPP.

a) Data Precision, Accuracy, Measurement Range: Table 5-1 contains requirements regarding the analytical precision, accuracy, and measurement ranges needed to satisfy the QAPP. Ranges specified for these parameters represent one of the four quality objectives required by the QAPP.

**Table 5-1. Analytical Precision, Accuracy, and Measurement Ranges Required for Results.**

| Parameter | Minimum Detection Limits | Accuracy (Acceptable Range of Recovery %) | Precision (Acceptable Range %) |
|---|---|---|---|
| Total mercury | 0.012 ng/L[a] | 80-110% | 10-30% |
| Sulfates | 0.1 µeq/L[b] | 80-110% | 10-30% |
| Nitrates | 0.1 µeq/L | 80-110% | 10-30% |
| Arsenic | 0.25 µg/L[c] | 80-110% | 10-30% |

[a]Nanograms per liter.
[b]Microequivalents per liter.
[c]Micrograms per liter.

These requirements have been satisfied for the analytical data pertaining to mercury concentrations (i.e., refer to the results of the QA/QC analyses reported by the laboratories in Appendix A of this report); however, as detailed in Section 5.2.g of this report, QA/QC information for sulfate, nitrate, and arsenic concentration data has not yet been submitted. Consequently, compliance with this quality objective cannot yet be assured. DEQ notes, however, that the analyses of these species does not affect the mercury data

reported; therefore, with respect to this dataset, it appears that the quality objective has been satisfied.

b) Data Representativeness: Data representativeness, a second quality objective in the QAPP, is assessed by proper selection of sampling locations, adherence with sample collection procedures, and collection of a sufficient number of samples. These requirements are generally satisfied by adherence to the SAP.

Since the SAP was substantially satisfied, this QAPP requirement is also satisfied.

c) Data Comparability: The third quality objective is data comparability and, as required for field aspects of this project, will be achieved by using standard methods of sample collection and handling and by analyzing mercury in all media in the same laboratory, selected for their nationwide recognition as experts in, and developers of, mercury analysis methods. Finally, data obtained from snow pack samples will be compared to the multi-year USGS snowpack data.

Frontier Geosciences, Inc. has completed successful laboratory inter-comparison studies with the USGS snow pack sampling program and reports good comparability with the data (Bob Burnette, Frontier Geosciences, personal communication). Additionally, refer to the discussion under Section 6 and the graphs in Appendix B of this report. Based on this information, the associated QAPP requirement has been satisfied at this point in the project.

d) Data Completeness: The fourth quality objective in the QAPP is data completeness, and is satisfied by meeting the requirements of Table 5-2 for the 2005 snowpack sampling event.

**Table 5-2. Data Completeness Requirements for 2005 Snowpack Sample Collection Event.**

| Parameter | No. Valid Samples Anticipated (Includes Blanks/Duplicates) | Percent Complete Goal |
|---|---|---|
| Snow Pack - Total Mercury | 7 in spring 2005 | 80% |
| Snow Pack - Sulfates | 7 in spring 2005 | 80% |
| Snow Pack - Nitrates | 7 in spring 2005 | 80% |
| Snow Pack - Arsenic | 2-7 in spring 2005 | 80% |

Seven samples of each type were collected and analyzed; therefore, this QAPP requirement has been satisfied at this point in the project.

e) Documentation and Record Requirements: The QAPP requires records to include all historical data, field notebooks, and field data sheets, which must be kept on file at DEQ's State Office. Documentation involves this report summarizing the sampling events and results, the SAP, and the QAPP.

With finalization of this report, all required tasks have been completed; therefore, this QAPP requirement has been satisfied at this point in the project.

f) Sample Logistics Requirements: Table 5.3 contains the QAPP requirements for logistics of samples.

**Table 5-3. Design Logistics for 2005 Snowpack Sample Collection Event.**

| Type of Sample/ Parameter | Number of Samples | Sampling Frequency | Sampling Period |
|---|---|---|---|
| Snowpack/Total mercury | 7/yr | Annual at minimum; subject to availability of snow pack | 3/05 – 5/06 |
| Snowpack/Sulfates | 7/yr | Annual at minimum; subject to availability of snow pack | 3/05 – 5/06 |
| Snowpack/Nitrates | 7/yr | Annual at minimum; subject to availability of snow pack | 3/05 – 5/06 |
| Snowpack/Arsenic | 7/yr | Annual at minimum; subject to availability of snow pack | 3/05 – 5/06 |

Seven samples of each type were collected and analyzed; this QAPP requirement has been satisfied by the 2005 snowpack sample collection event.

g) Sampling Method Requirements: The sampling method required use of a modified methodology of the USGS method for collection of snowpack samples, using pre-cleaned Teflon bottles for collection of snowpack.

Based on review of the records and reports from the field team, this QAPP requirement has been satisfied by the 2005 snowpack sample collection event.

h) Sample Handling and Custody Requirements: The QAPP required collection on site by DEQ personnel and direct transportation by vehicle to an express shipping provider located in Boise, Idaho, for shipment to Frontier Geosciences, located in Seattle, Washington, for mercury analysis. Samples taken for sulfate, nitrate, and arsenic analyses were to be delivered directly to the State Laboratory in Boise, Idaho by DEQ personnel. All proper chain of custody forms were required to be with samples throughout the duration of the shipping process.

Based on COC forms, the field logbook, and reports from the field team, this QAPP requirement has been satisfied by the 2005 snowpack sample collection event.

i) Analytical Method Requirements: The QAPP required pre-cleaned containers from the analytical laboratory for mercury samples. Other containers were to be supplied by the State Laboratory or, if acceptable, to be taken from DEQ's inventory. The samples were to be preserved on dry ice and maintained at $\leq 0^{o}$C, and were to be shipped after all annual samples were collected.

Based on COC forms, the field logbook, and reports from the field team, this QAPP requirement has been satisfied by the 2005 snowpack sample collection event.

j) Quality Control Requirements: QC requirements within the QAPP largely reflect the QC requirements of the SAP, and included 1) two duplicate

samples for each annual sampling event, or 20% of total samples if more than 10 samples were collected, 2) one trip blank per each annual sampling event, 3) adherence to SAP sample collection requirements, 4) a QA/QC report with continuing calibration checks in support of the data report from labs, and 5) a review of all data by QA Officer after all data is collected.

For a discussion of the first four requirements listed in the preceding paragraph, refer to Section 5.2.g of this report. It appears that these requirements, with the exceptions previously noted (i.e., the QA/QC report for analytical processing of samples for ionic species was not submitted), have largely been satisfied by the 2005 collection effort. DEQ notes that the QA Officer's review is pending conclusion of all sampling work and associated data collection, as required by the QAPP.

k) Equipment Testing, Inspection, and Maintenance Requirements: The QAPP required 1) calibration of all meters prior to use in the field and 2) visual inspection of Tyvek suits and vinyl gloves for cuts or tears prior to use.

The only meter used for this sampling event was a temperature probe. Documents from the 2005 sampling event include a calibration sheet, dated March 28, 2005, for the temperature probe used at each site. Verbal interviews with the Field Team Leader indicate that visual inspections of the suits and gloves used at each site were generally implemented prior to use. Consequently, these requirements were fulfilled by the 2005 collection effort.

l) Instrument Calibration and Frequency Requirements: The QAPP required calibration of 1) all field meters prior to use in the field and 2) the GPS unit by DEQ's Geological Information System staff as needed.

As indicated in the preceding section of this report, the temperature probe was the only meter required, and it was calibrated prior to use in the field. The GPS unit was obtained and assessed by the GIS staff as appropriate, prior to use in the field. Therefore, these QAPP requirements have been satisfied.

m) Inspection/Acceptance Requirements: The QAPP required that 1) all sampling equipment be obtained from DEQ's inventory, Frontier Geosciences, or the State Laboratory, and 2) that all equipment used be new, with the exception of the field meter(s) and the plastic snow shovel.

Based on the *Field Report* in Section 3 of this report, these requirements were satisfied.

n) Data Acquisition Requirements: The QAPP specified that all data relevant to the snowpack study be documented within the required reports. Additionally, meteorological data for the winter season prior to each sampling event is to be acquired and documented in the project records.

Upon finalization, this report will serve as the repository for all relevant data for the 2005 sampling event. Meteorological data for the 2004-2005 winter

season is readily available from several online sources and will be compiled and documented within the project records prior to finalization of the Final Snowpack Report required in the current revision of the QAPP. These requirements will not be satisfied, in total, until the entire snowpack sampling study has been completed.

o) Data Management Requirements: The QAPP required that all hard copies be kept on record at the DEQ State Office, 2) storage of information in source files, and 3) electronic copies of all reports to be available for review upon request.

At the current time, these requirements have been satisfied to the extent practical; however, compliance with these requirements will not be satisfied, in total, until the entire snowpack sampling study has been completed.

p) Assessment Requirements and Response Actions: Requirements related to QAPP assessments are to be performed by reviewing field notes and comments on a quarterly basis.

At the current time, the snowpack data presented in this report is the only data to be collected in conjunction with the mercury assessment project. This report constitutes the required review of this dataset, and it demonstrates compliance with the QAPP requirement at the present time. Final compliance with the requirement is pending conclusion of all related mercury assessment work, and it cannot be assessed at the current time.

q) Report Requirements: The QAPP requires interim and final reports for all sampling efforts for the mercury assessment project.

Upon finalization, this report will satisfy the applicable QAPP requirement; final compliance with the QAPP requirement is pending completion of final sampling reports for the project.

r) Data Review, Validation, and Verification Requirements: The QAPP requires that all data collected be reviewed by the Project Manager, Field Leader, and QA Officer.

This requirement is pending collection of all data for the snowpack sampling effort.

s) Requirement for Reconciliation with Data Quality Objectives: The relevant QAPP requirements for this issue are pending completion of the entire snowpack sampling effort. Consequently, compliance is pending completion of the final reports required under the QAPP and cannot be assessed at this time.

Based on the preceding review and available records for the sampling event, it appears that the 2005 sample collection event was substantially conducted in accordance with requirements of the QAPP. DEQ acknowledges that several QAPP requirements cannot be completely assessed at the present time and are

pending completion of future data collection efforts and development of final reports addressing such datasets; however, at the present time, applicable QAPP requirements appear to have been generally satisfied by the 2005 sample collection event. There is no indication that collection of non-representative samples may have occurred, nor any other subsequent issue to indicate non-representativeness in sample collection.

# 6. Preliminary Observations and Recommendations

Observations presented in this section should not be interpreted as the final assessment or determination for the mercury assessment project at SFCR:

- These initial assessments are preliminary and based largely on data and information collected to date.
- It is also important to recognize the limits and contextual impacts of the small sample population of the 2005 snow sample collection event.

Formal validation and verification assessments of all the snowpack data, as well as more intensive evaluations for trends, comparability, and related data-evaluation analyses, will be conducted after data is obtained from the 2006 sampling event. All observations and recommendations will be redressed, as necessary, and clarified, to the extent practical, in the final reports for 1) the snowpack sampling effort and 2) the mercury assessment project.

## 6.1 Relevant Snowpack Work/Studies

A primary goal of DEQ's snowpack sampling event was to generate analytical data that could be compared with similar data from other snowpack studies in the western US. Sources of comparability data for mercury concentrations include 1) 2002 data from an ongoing USGS snowpack study of sites throughout the Rocky Mountain range in the US (Ingersoll, 2004), and 2) informal data from the Idaho National Laboratory (Mike Abbott, personal communication, 2005). The comparability datasets presented for sulfate and nitrate concentrations are all taken from the USGS snowpack study, and also encompass sites throughout the Rocky Mountain region in the US (Ingersoll, 2004, 2003, and 2002). Although the comparability data for arsenic is also from the USGS snowpack chemistry database, this data is presented as site-specific averages of samples taken from Rocky Mountain regions in New Mexico and Colorado (Ingersoll, 2000).

The USGS, in cooperation with several other organizations, established a network of more than 50 snow-sampling sites in the Rocky Mountain region, generally located near the Continental Divide. Sites in the network have been sampled annually since 1993, and are located in areas deemed to have limited human, commercial, or industrial activities, to enable detection of regional emissions signals that may affect deposition hundreds of kilometers downwind. The intent of the work is to gain a better understanding of atmospheric deposition at high elevation in the Rocky Mountains, in an effort to assess the impact of airborne

contaminants (e.g., nitrogen, sulfur, mercury, etc.) to thin alpine and subalpine soils and dilute water bodies in mountain ecosystems.

Mike Abbott has provided ongoing assistance to DEQ personnel in regard to procedures and methodologies for real-time monitoring/sampling of atmospheric mercury concentrations (i.e., dry or vapor atmospheric mercury deposition). On May 27, 2005, Mr. Abbott presented findings from his mercury monitoring efforts at the Idaho National Laboratory, which included data collected from various regional sites by Abbott and/or Susong and others (Mike Abbott, personal communication, 2005). Results from these studies are only presented within this report for preliminary comparative purposes; formal citations for all datasets will be presented in the Final Report for DEQ's snowpack sampling efforts.

## 6.2 Mercury Data Obtained from 2005 Collection Event

Figures B-1 and B-2 in Appendix B of this report show 1) DEQ's mercury data with 90% confidence intervals for the Jarbidge and Galena sites, and 2) a graphical comparison of DEQ's mercury data with datasets from other selected studies, respectively. Confidence level intervals were not presented for the data collected from Magic Mountain or Pomerelle Mountain (i.e., these sites have single data point for each specie concentration; confidence level assessments typically require multiple data points).

Based on visual comparison of the datasets, it appears that DEQ's 2005 snowpack data is of a similar magnitude to that of data reported by the other studies. Moreover, DEQ notes that the average concentration from the 2005 snowpack data appears to approximate the average concentrations reported at other regional locations (i.e., Idaho National Laboratory, Snake River Plane, and the Teton Mountain range).

Based on Figure B.2, DEQ's mercury concentration data generally appears to show maximum values much less than the maximum values of the USGS dataset; in fact, only three datasets from two, relatively isolated regions (i.e., Teton Mountain range and Upper Fremont Glacier) have lower maximum-concentration values that are less than the maximum mercury-concentrations in DEQ's data.

Collectively, the graphs in Appendix B appear to indicate that the 2005 snowpack data should be relatively reliable for use in the mercury assessment project. The mercury concentrations generally reflect concentration ranges to similar to those for datasets from studies in the western US. It should be noted that additional information from the 2006 snowpack collection event should allow further assessment of reliability of DEQ's snowpack data, as well as additional insight into repeatability of the sampling results.

The apparent absence of any markedly elevated mercury concentrations in DEQ's dataset is a noteworthy trend that should be reassessed when the 2006 data is

reported. This observation could potentially be an indicator that atmospheric deposition of mercury in winter snowpack is not a primary or solitary transport pathway for the elevated mercury levels at SFCR (i.e., the presence of elevated mercury concentrations would typically be associated with downwind source(s) contributing mercury to SFCR through wet deposition processes in the winter season).

## 6.3 Ionic Specie Data Obtained from 2005 Collection Event

Figure B-3 in Appendix B of this report presents DEQ's nitrate data with 90% confidence intervals for the Jarbidge and Galena sites. Confidence level intervals were not presented for data collected from Magic Mountain or Pomerelle Mountain (i.e., these sites have single data point for each specie concentration; confidence level assessments typically require multiple data points). Additionally, no confidence level assessments were conducted for sulfate or arsenic concentration data because all reported values for each of these species were the same (i.e., <2.00 mg/L for sulfate and <0.005 mg/L for arsenic).

Table 6-1 shows DEQ's 2005 sulfate and nitrate concentration data with similar USGS datasets from 2002, 2001, and five-year averages from 1997 through 1993. For comparative purposes, DEQ's data was converted from milligrams per liter to microequivalents per liter (i.e., the units of the USGS datasets).

**Table 6-1. Comparison of Datasets for Sulfate and Nitrate Concentration in Snowpack.**

| Parameter | Value | DEQ 2005[1] | USGS 2002[2] | USGS 2001[2] | USGS 1997-93[2,3] |
|---|---|---|---|---|---|
| Sulfate (µeq/L) | Minimum | <41.7 | 1.8 | 4.1 | 2.5 |
| | Average | <41.7 | 5.9 | 7.6 | 6.5 |
| | Maximum | <41.7 | 15.5 | 14.3 | 11.4 |
| Nitrate (µeq/L) | Minimum | 1.0 | 2.7 | 5.3 | 2.3 |
| | Average | 1.3 | 11.8 | 12.2 | 7.9 |
| | Maximum | 1.8 | 24.5 | 23.0 | 15.1 |

[1]All analytical results for sulfate concentration in DEQ's samples were reported as <2.00 mg/L (i.e., <41.7 µeq/L).
This indicates that the actual sulfate concentration in each of DEQ's snowpack samples was below detection limit
of the analytical method.
[2]Taken from USGS Open File Report Nos. 2004-1027, 03-48, and 01-466 (refer to http://water.usgs.gov/pubs/of/).
[3]Five-year average values presented for all parameters (USGS Open File Report 01-466).

As noted in Table 6-1, values reported for sulfate concentration represent the minimum detection limit of the analytical method (i.e., actual sulfate concentrations in DEQ's snowpack samples were less than the value presented in Table 6-1). The sulfate concentrations reported by the USGS are significantly lower than the detection limit of the analytical method used for DEQ's samples, which appears to indicate that a more sensitive or precise methodology should be considered for the 2006 sampling event.

Nitrate concentrations reported for DEQ's samples were also consistently lower than the data contained in the USGS database, although this difference is not as apparent as the difference noted in the sulfate datasets. The range of the USGS concentration-data also appears to be much wider (i.e., from minimum to maximum value) than DEQ's data, although this effect is likely due to the greater number of samples and the wider expanse and range of sampling sites in the USGS work.

Table 6-2 shows DEQ's 2005 arsenic concentration data and average values of a similar USGS dataset for arsenic concentrations measured in the Rocky Mountain ranges of New Mexico and Colorado from 1993-2000. For comparative purposes, DEQ's arsenic data was converted from milligrams per liter to micrograms per liter (i.e., the units of the USGS datasets).

**Table 6-2. Comparison of Datasets for Arsenic Concentration in Snowpack.**

| Parameter | Value | DEQ 2005[1] | USGS 2000[2,3] | USGS 1999-93[2,3] |
|---|---|---|---|---|
| Arsenic (µg/L) | Minimum | <5.0 | <0.01 | 0.005 |
| | Average | <5.0 | 0.14 | 0.093 |
| | Maximum | <5.0 | 0.02 | 0.14 |

[1]All analytical results for arsenic concentrations in DEQ's samples were reported as <0.005 mg/L (i.e., <5.0 µg/L). This indicates that the actual arsenic concentration in each of DEQ's snowpack samples was below the detection limit of the analytical method.
[2]Taken from USGS Open File Report No. 00-394.
[3]Site-specific averages values were presented, averaged over entire time period shown in the table; average values shown here represent averages of all site-specific, averaged values in the USGS report. For each concentration reported as "<0.01", indicating that actual As concentrations were equal to or below the method detection limits, a value of 0.01 was assumed for averaging purposes. Actual As concentrations are equal to or below the values presented in Table 6.2.

While previous comparability datasets for mercury, sulfates, and nitrates utilized sampling sites throughout the US Rocky Mountain range and, in the case of the mercury data, include two sites in Idaho, the arsenic dataset(s) were limited to the mountain regions of New Mexico and Colorado. Additionally, many site-specific arsenic concentrations in the USGS study were reported as equal or less than the detection limit of the analytic method used to assess the amount of arsenic present in the samples; consequently, actual concentrations are equal to or less than the values presented in Table 6-2.

As noted in the discussion of sulfate concentrations, the arsenic concentrations reported by the USGS are significantly lower than the detection limit of the analytical method used for DEQ's samples. This appears to indicate a need for a more precise methodology for arsenic analysis in future snowpack sampling efforts. The quantitative limit in DEQ's dataset for arsenic concentration inhibits any significant observations and/or trend analyses with respect to the USGS data. However, it does appear that arsenic concentrations at the sites in DEQ's 2005 effort are relatively low (i.e., $\leq$5.0 ug/L).

Although more precise analytical methodologies would greatly assist in interpretation of the significance of DEQ's concentration data for ionic species present in the 2005 snowpack samples, it generally appears that significant amounts of sulfate, nitrate, and arsenic were not present. Allowing for the

uncertainties induced by the limited number of samples and the detection limits of the analytical methods employed, it may still be speculated that the general absence of any significant concentration may be due to an absence of deposition(s) from industrial sources, as these three species are typically associated with combustion processes used at such sources. Data from the 2006 sampling effort should allow a better assessment of this hypothesis, which is clearly preliminary at the present time.

## 6.4 Recommendations

The following section contains a list of potential investigations and/or assessments for future snowpack assessment work by DEQ or others. Recommendations for consideration/implementation in the pending 2006 snowpack sampling effort are also identified. The recommendations are largely based upon observations of the 2005 sampling event and may require some changes or re-evaluation as new data from other aspects of other studies and/or sampling efforts associated with the mercury assessment project become available or as new research or literature is produced outside of this project.

### 6.4.1 Potential Areas to Investigate in Future Work

a) Due to the limited nature of DEQ's 2005 snowpack data (i.e., small sample population), consideration has been given to methods of comparing this dataset with other datasets, including data from the National Atmospheric Deposition Program's *Mercury Deposition Network* (MDN) sites (refer to http://nadp.sws.uiuc.edu/mdn for additional information).

b) DEQ is also involved in ongoing efforts to identify predominant directions of the wind during 2005 snowfall events and/or seasonal average wind direction, as related to DEQ results. This information is intended to assist in determining and identifying storm source areas associated with the 2005 snowpack samples.

### 6.4.2 Potential Recommendations for Implementation in the 2006 Sample Collection Event

a) Deviations from the QAPP/SAP during the 2005 sampling event were noted in Section 5 of this report. Such deviations included 1) substitution of a field blank for a trip blank and 2) omission of a QA/QC report from the laboratory that conducting analyses for ionic specie concentrations. These deviations are not critical, but they should be addressed and/or corrected during the next sampling event. The procedures outlined in the QAPP and SAP should be revised as necessary and followed precisely to ensure representative samples are collected and appropriate analytical results are obtained.

b) Determine additional relevant snowpack datasets to use in comparability assessments of DEQ's data, including availability of 2003-2005 snowpack data from USGS.

c) Consider costs associated with implementation of collection and analyses of event-based wet deposition in snowpack. This might be implemented by use of 1) event-based transects of fresh snow samples, or b) horizontal sampling into the snowpack layer for certain targeted events, rather than sampling of entire, vertical snowpack profiles.

d) d) Investigate the method used to analyze sulfate and arsenic concentrations in the USGS snowpack samples/studies. It appears that the concentrations reported by the USGS are substantially lower than the minimum detection limits of the methods used for DEQ's data.

# References

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# A Appendix A: *Snowpack Data Reports from Analytical Laboratories*

**TABLE 1: Total Mercury in Snow**

| Lab Data Set ID | Lab Run # | Sample Volume | Sample ID | Concentration ng/L | Concentration Blank Cor ng/L |
|---|---|---|---|---|---|
| THG10-050422-1 | 1587 | 186.30 mL | SM-1 | 3.006 ng/L | 2.909 ng/L |
| THG10-050422-1 | 1591 | 368.60 mL | SM-2 | 4.682 ng/L | 4.585 ng/L |
| THG10-050422-1 | 1588 | 215.60 mL | SM-3 | 3.166 ng/L | 3.070 ng/L |
| THG10-050422-1 | 1589 | 401.60 mL | SM-4 | 3.469 ng/L | 3.372 ng/L |
| THG10-050422-1 | 1585 | 218.50 mL | DM-3 | 4.516 ng/L | 4.419 ng/L |
| THG10-050422-1 | 1586 | 207.20 mL | DM-4 | 5.734 ng/L | 5.638 ng/L |
| THG11-050503-1 | 21 | 0.00 mL | FB1-Rep1 | 0.143 ng/L | -0.024 ng/L |
| THG11-050503-1 | 22 | 0.00 mL | FB1-Rep2 | 0.135 ng/L | -0.032 ng/L |
| THG11-050503-1 | 23 | 0.00 mL | FB1-Rep3 | 0.143 ng/L | -0.024 ng/L |

**Field Blank = THg Conc - Prep Blk - Reagent Blk - MQ water**

**Figure A-1. Total Mercury in Snow.**

**TABLE 2: FRONTIER Preparation Blank Results**

| Lab Data Set ID | Lab Run # | Lab Prep Blank ID | ng/L |
|---|---|---|---|
| THG10-050422-1 | 1582 | BrCL 1 | 0.086 ng/L |
| THG10-050422-1 | 1583 | BrCL 2 | 0.072 ng/L |
| THG10-050422-1 | 1584 | BrCL 3 | 0.058 ng/L |
| THG11-050503-1 | 12 | BrCL 1 | 0.071 ng/L |
| THG11-050503-1 | 13 | BrCL 2 | 0.047 ng/L |
| THG11-050503-1 | 14 | BrCL 3 | 0.063 ng/L |
| | | **Average >** | **0.066** **ng/L** |
| | | **Standard Deviation >** | **0.013** **ng/L** |
| | | **Relative Standard Deviation >** | **20.1%** |
| | | **Minimum Detection Limit >** | **0.042** **ng/L** |

**MDL Calculated in the following manner:**

MDL = [ (Student t x SD of Standard Matrix (n=3) (ng/L)))

Student t value (n=3) = 3.182

EMDL = 0.042 ng/L

**Figure A-2. Frontier Preparation Blank Results.**

| TABLE 3: FRONTIER Reagent Blank Results | | | |
|---|---|---|---|
| **Lab Data Set ID** | **Lab Run #** | **Lab Reagent Blank ID** | **ng/L** |
| THG10-050422-1 | 1604 | REAGENT BLANK | 0.061 ng/L |
| THG10-050422-1 | 1605 | REAGENT BLANK | 0.044 ng/L |
| THG11-050503-1 | 18 | REAGENT BLANK | 0.008 ng/L |
| THG11-050503-1 | 19 | REAGENT BLANK | 0.032 ng/L |
| THG11-050503-1 | 20 | REAGENT BLANK | 0.008 ng/L |
| | | **Average >** | **0.031** |
| | | **Standard Deviation >** | **0.023** |
| | | **Relative Standard Deviation >** | **76.0%** |

**Figure A-3. Frontier Reagent Blank Results.**

| TABLE 4: FRONTIER MQ Water Results | | | |
|---|---|---|---|
| **Lab Data Set ID** | **Lab Run #** | **Lab MQ Water ID** | **ng/L** |
| THG11-050503-1 | 15 | MQ 1 | 0.070 ng/L |
| THG11-050503-1 | 16 | MQ 2 | 0.051 ng/L |
| THG11-050503-1 | 17 | MQ 3 | 0.089 ng/L |
| | | **Average >** | **0.070** |
| | | **Standard Deviation >** | **0.019** |
| | | **Relative Standard Deviation >** | **27.3%** |

**Figure A-4. Frontier MQ Water Results.**

**TABLE 5: ANALYSIS QA/QC PERFORMANCE SUMMARY - SRM Results**

| Lab Data Set ID | Lab Run # | QC Parameter | Observed Value (ng/L) | True Value (ng/L) | SRM % Recovery | QA/QC Range |
|---|---|---|---|---|---|---|
| THG10-050422-1 | 1577 | ICV/NIST 1641d | 1554557.082 ng/L | 1601000.00 | **97.1%** | **80%-120%** |
| THG11-050503-1 | 06 | ICV/NIST 1641d | 1603352.974 ng/L | 1601001.00 | **100.1%** | **80%-120%** |

**TABLE 6: ANALYTICAL SPIKE RECOVERY**

| Lab Data Set ID | Lab Run # | Site ID | Observed (ng/L) | Spike Level (ng/L) | Net (ng/L) | % Recovery | QA/QC Range |
|---|---|---|---|---|---|---|---|
| THG10-050422-1 | 1593 | SM-2 AS +10ng/L | 14.609 ng/L | 10.00 | 9.93 | **99.3%** | **75% - 125%** |

**TABLE 7: LAB REPLICATE RESULTS**

| Lab Data Set ID | Lab Run # | Site ID | Replicate #1 (ng/L) | Replicate #2 (ng/L) | Replicate #3 (ng/L) | RSD or RPD | QA/QC-Range |
|---|---|---|---|---|---|---|---|
| THG10-050422-1 | 1592 | SM-2 AD | 4.682 ng/L | 4.677 ng/L | na | **0.1%** | **0% - 25% RPD** |

**Figure A-5. Analysis of QA/QC Performance Summary, Analytical Spike Recovery, Lab Replicate Results.**

**TABLE 8: Initial Calibration Blank (ICB) and Continued Calibration Blanks (CCBs)**

| Lab Data Set ID | Lab Run # | CCB ID | ICB/CCB (ng Hg/Blank) | QA/QC Acceptance |
|---|---|---|---|---|
| THG10-050422-1 | 1578 | ICB/BB | 0.000 ng/L | < 0.25 |
| THG10-050422-1 | 1579 | CCB1 | 0.000 ng/L | < 0.25 |
| THG10-050422-1 | 1580 | CCB2 | 0.000 ng/L | < 0.25 |
| THG10-050422-1 | 1581 | CCB3 | 0.000 ng/L | < 0.25 |
| THG10-050422-1 | 1595 | CCB4 | 0.000 ng/L | < 0.25 |
| THG10-050422-1 | 1611 | CCB5 | 0.000 ng/L | < 0.25 |
| THG10-050422-1 | 1623 | CCB6 | 0.047 ng/L | < 0.25 |
| THG11-050503-1 | 07 | ICB/BB | 0.024 ng/L | < 0.25 |
| THG11-050503-1 | 08 | CCB1 | 0.039 ng/L | < 0.25 |
| THG11-050503-1 | 10 | CCB2 | 0.024 ng/L | < 0.25 |
| THG11-050503-1 | 11 | CCB3 | 0.055 ng/L | < 0.25 |
| THG11-050503-1 | 25 | CCB4 | 0.016 ng/L | < 0.25 |

**Figure A-6. Initial Calibration Blank (ICB) and Continued Calibration Blanks (CCBs).**

**TABLE 9: Continued Calibration Verification (CCVs)**

| Lab Data Set ID | Lab Run # | CCV ID | True Value | Measured | % Rec. | QA/QC Acceptance |
|---|---|---|---|---|---|---|
| THG10-050422-1 | 1594 | CCV1 | 20.000 ng/L | 19.761 ng/L | 98.8% | 80% - 120% |
| THG10-050422-1 | 1610 | CCV2 | 20.000 ng/L | 19.741 ng/L | 98.7% | 80% - 120% |
| THG10-050422-1 | 1622 | CCV3 | 20.000 ng/L | 19.488 ng/L | 97.4% | 80% - 120% |
| THG11-050503-1 | 26 | CCV1 | 20.000 ng/L | 19.184 ng/L | 95.9% | 80% - 120% |

**Figure A-7. Continued Calibration Verification (CCVs).**

| OrderID | SampleNumber | Test | Method | CustomerSampleNumber | Result | Units |
|---|---|---|---|---|---|---|
| 041305_02 | 0504 163 | Arsenic (GFAA) | EPA 200.9 | SA1 | <0.005 | mg/L |
| 041305_02 | 0504 163 | Turbidity, metals check | EPA 180.1 | SA1 | < 1 | NTU |
| 041305_02 | 0504 164 | Arsenic (GFAA) | EPA 200.9 | SA2 | <0.005 | mg/L |
| 041305_02 | 0504 164 | Metals Digestion | EPA 3005A | SA2 | Done | N/A |
| 041305_02 | 0504 164 | Turbidity, metals check | EPA 180.1 | SA2 | 1.64 | NTU |
| 041305_02 | 0504 165 | Arsenic (GFAA) | EPA 200.9 | SA3 | <0.005 | mg/L |
| 041305_02 | 0504 165 | Metals Digestion | EPA 3005A | SA3 | Done | N/A |
| 041305_02 | 0504 165 | Turbidity, metals check | EPA 180.1 | SA3 | 1.73 | NTU |
| 041305_02 | 0504 166 | Arsenic (GFAA) | EPA 200.9 | SA4 | <0.005 | mg/L |
| 041305_02 | 0504 166 | Turbidity, metals check | EPA 180.1 | SA4 | < 1 | NTU |
| 041305_02 | 0504 167 | Nitrate + Nitrite as N | EPA 353.2 | SN1 | 0.082 | mg/L |
| 041305_02 | 0504 168 | Nitrate + Nitrite as N | EPA 353.2 | SN2 | 0.062 | mg/L |
| 041305_02 | 0504 169 | Nitrate + Nitrite as N | EPA 353.2 | SN3 | 0.079 | mg/L |
| 041305_02 | 0504 170 | Nitrate + Nitrite as N | EPA 353.2 | SN4 | 0.069 | mg/L |
| 041305_02 | 0504 171 | Sulfate-IC | EPA 300.0 | SS1 | <2.00 | mg/L |
| 041305_02 | 0504 172 | Sulfate-IC | EPA 300.0 | SS2 | <2.00 | mg/L |
| 041305_02 | 0504 173 | Sulfate-IC | EPA 300.0 | SS3 | <2.00 | mg/L |
| 041305_02 | 0504 174 | Sulfate-IC | EPA 300.0 | SS4 | <2.00 | mg/L |
| 041305_02 | 0504 175 | Arsenic (GFAA) | EPA 200.9 | DA3 | <0.005 | mg/L |
| 041305_02 | 0504 175 | Metals Digestion | EPA 3005A | DA3 | Done | N/A |
| 041305_02 | 0504 175 | Turbidity, metals check | EPA 180.1 | DA3 | 3.93 | NTU |
| 041305_02 | 0504 176 | Nitrate + Nitrite as N | EPA 353.2 | DN3 | 0.073 | mg/L |
| 041305_02 | 0504 177 | Sulfate-IC | EPA 300.0 | DS3 | <2.00 | mg/L |
| 041305_02 | 0504 178 | Arsenic (GFAA) | EPA 200.9 | DA4 | <0.005 | mg/L |
| 041305_02 | 0504 178 | Metals Digestion | EPA 3005A | DA4 | Done | N/A |
| 041305_02 | 0504 178 | Turbidity, metals check | EPA 180.1 | DA4 | 1.51 | NTU |
| 041305_02 | 0504 179 | Nitrate + Nitrite as N | EPA 353.2 | DN4 | 0.111 | mg/L |
| 041305_02 | 0504 180 | Sulfate-IC | EPA 300.0 | DS4 | <2.00 | mg/L |

**Figure A-8. Preliminary Concentration Data for Ionic Species**

# B Appendix B: Selected Graphical Presentations

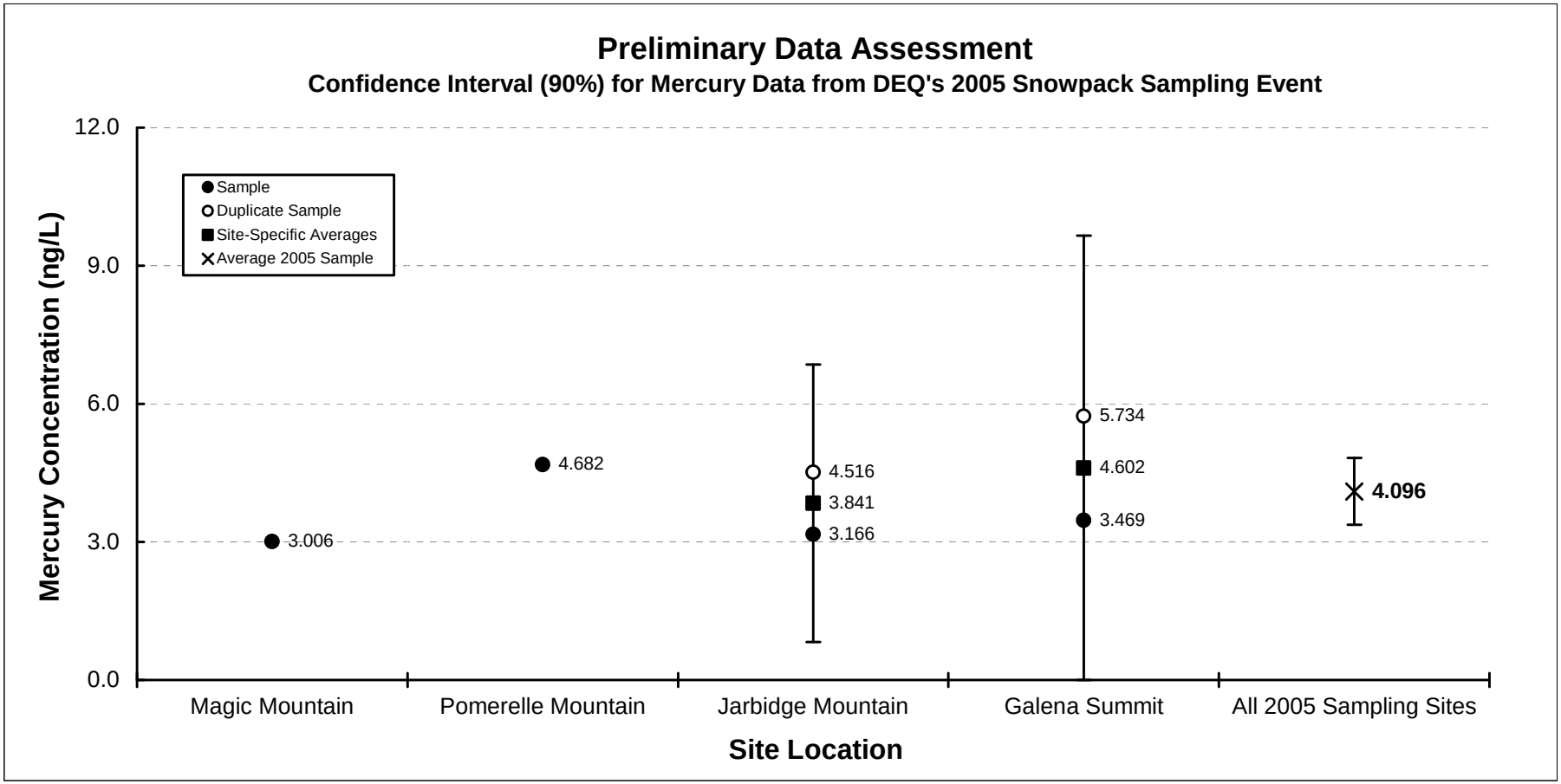


**Figure B-1. Preliminary Data Assessment of Mercury Data from DEQ's 2005 Sample Collection Event.**

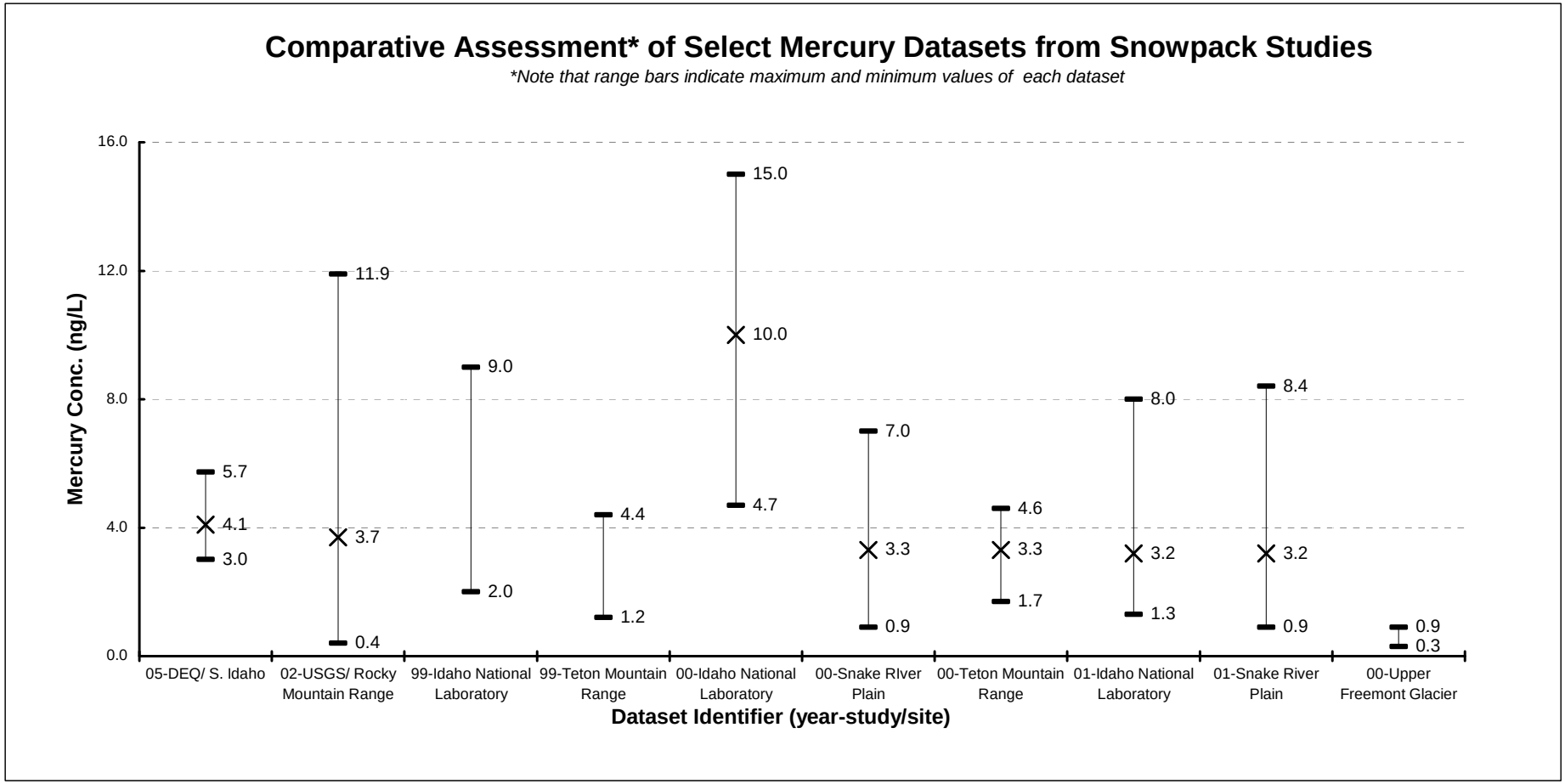


**Figure B-2. Comparative Assessment of Mercury Data from DEQ's 2005 Sample Collection Event.**

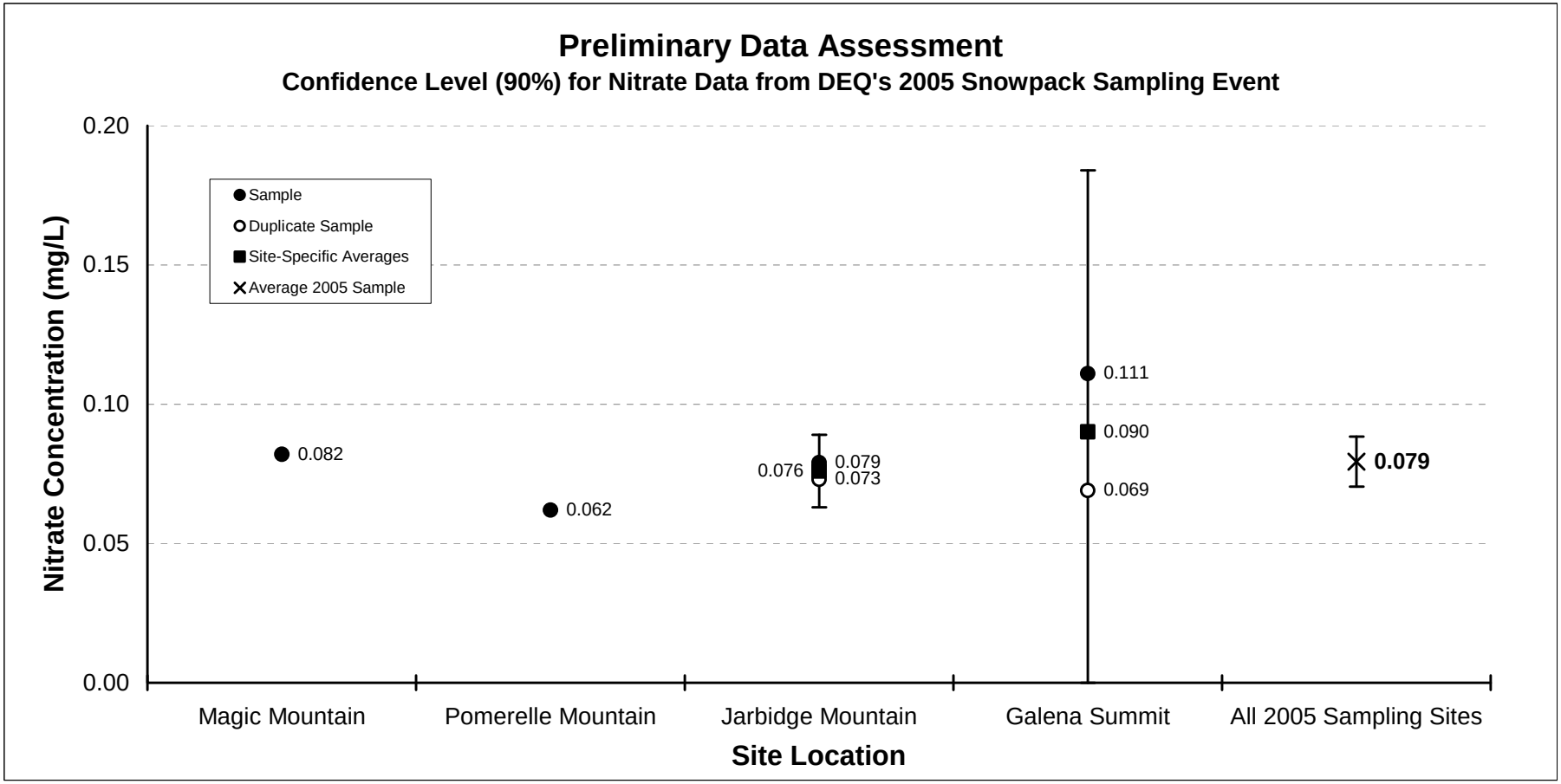


**Figure B-3. Preliminary Data Assessment of Nitrate Data from DEQ's 2005 Sample Collection Event.**

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