

FINAL

**SAMPLING AND MONITORING PROGRAM
FOR THE MAGENTA DRAIN TUNNEL
AT THE EMPIRE MINE STATE HISTORIC PARK
GRASS VALLEY, CALIFORNIA**

JULY 2006

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1.0 INTRODUCTION

This document has been prepared by MFG, Inc. (MFG) for Newmont Mining Corporation and California Department of Parks and Recreation (CDPR) to present a proposed monitoring program for characterizing the water quality and flow from the Magenta Drainage Tunnel located at the Empire Mine State Historic Park (SHP). This monitoring program also includes the collection of sediment samples from the drainage ditch and creek downstream of the Magenta Drain Tunnel portal and the measurement of groundwater levels representative of the Empire Shaft mine workings. The Empire Mine SHP is located east of Grass Valley, California. The objectives of the proposed monitoring program are to collect data to characterize the:

- geochemical and hydrologic variability of the water flowing from the Magenta Drain Tunnel portal;
- concentrations of sediment in the drainage ditch and creek downstream of the Magenta Drain Tunnel portal; and
- variability of groundwater levels within the Empire Shaft.

The portal of the Magenta Drain Tunnel is located east of Highway 174 adjacent to the Happy Dale residential subdivision. Flow from the portal drains to a channel (drainage ditch). Several hundred yards downstream from the portal, the drainage ditch flows to an unnamed creek, historically referred to as Woodpecker Ravine, which flows through a rural residential area and the City of Grass Valley Memorial Park. Woodpecker Ravine (the Creek) is a tributary to the South Fork of Wolf Creek. The portal of the Magenta Drain Tunnel and portions of the drainage ditch and Woodpecker Ravine downstream of the portal are located on California Department of Parks and Recreation (CDPR) property.

The flow from the Magenta Drain Tunnel occurs year-round. However, the flow is responsive to storm events (CDPR, 2005a). The tunnel is believed to drain groundwater associated with historic underground mine workings and intercepts shallow groundwater flow along its length. The lower reach of the Magenta Drain Tunnel may intercept shallow groundwater recharge from Woodpecker Ravine. Historical and recent monitoring data of the tunnel flow are summarized by Tetra Tech EM Inc. (TTEMI, 2005). Based on limited measurements, flows from the tunnel at or near the portal have ranged from 623 to 982 gpm. The limited data set identifies that arsenic, iron, manganese, and thallium concentrations in the water from the Magenta Drain Tunnel at the portal and in the drainage ditch and creek downstream from the portal may exceed current water quality criteria (TTEMI, 2005). As described in Section 2.0, monitoring will be performed to characterize the quality and flow of the Magenta Drain Tunnel water.

Sediment samples were collected at two locations by Tetra Tech EM Inc. (TTEMI, 2005): from the drainage ditch at the Magenta Drain Tunnel portal and from the creek just upstream of Memorial Park. The arsenic concentrations of both samples exceeded the state soluble threshold limit concentration (STLC) criteria. As described in Section 3.0, additional sediment samples will be collected during a one-time sampling event in the drainage ditch downstream of the Magenta Drain Tunnel portal and the creek above and within Memorial Park. The sediment samples will be analyzed for arsenic, iron, manganese, and thallium total threshold limit concentrations (TTLC) and STLC to verify the results of the previous samples and provide data to evaluate the distribution of these concentrations in the drainage ditch and creek.

Flows from the tunnel are expected to be responsive to storm events and vary according to seasonal precipitation. As described in Section 4.0, groundwater levels representative of the Empire Shaft mine workings will be monitored to provide data to evaluate the variability in groundwater levels and the relationship between groundwater levels and tunnel flows. The groundwater levels will be monitored at an existing groundwater well that intersects the Empire Shaft.

2.0 MAGENTA DRAIN WATER QUALITY AND FLOW

2.1 Sampling Station Location and Instrumentation

Equipment will be installed at a monitoring station in the drainage ditch located immediately downstream of the portal for continuous measurement and recording of the flow and other field parameters (flow, pH, electrical conductivity, and temperature) and to allow both manually-collected and automatically-collected water quality samples to be obtained from the Magenta Drain Tunnel. The monitoring station will be located in the drainage ditch at or near the residential footbridge, approximately 150 feet downstream from the portal (see Photo 1). Channel and vegetation conditions of the drainage ditch are not conducive for installing the monitoring station equipment at a location closer to the portal, and no other surface flows have been observed entering the drainage ditch between the residential footbridge and the portal. However, the exact location of the monitoring station will be determined in the field based upon the stream geomorphology and property ownership limitations. Station installation has been authorized by the Army Corps of Engineers (USACE) under Nationwide Permit No. 5.

Instrumentation to be installed at the monitoring station will include a Parshall (or equivalent) flume, a pressure transducer to monitor the flow stage in the flume, probes to monitor pH, conductivity, and temperature, a portable automatic water sampler, and a continuous-recording data logger equipped with a water sampler control program. A tipping bucket rainfall intensity gauge will also be installed at the station to record precipitation depth and duration. Power will be supplied with a 12-volt sealed battery

that is charged by a 10W solar panel. The automatic sampler, data loggers, and power supply will be housed in a protective steel enclosure box adjacent to the station.

Based on existing flow data, a 9-inch Parshall flume will be installed in the drainage ditch. The data logger will continuously record the flow at a prescribed time interval (anticipated to be every 15 minutes) based on the measured stage and the known stage-discharge relationship for the flume. The pH, conductivity, temperature, and precipitation data will also be continuously recorded by the data logger at a prescribed time interval (anticipated to be every 15 minutes). Once sufficient baseline data are collected, the water sampler control program will be used to trigger the collection of event-based water quality samples by the automatic sampler based on a pre-programmed change in flow. The operation of the instrumentation will be verified and maintenance will be routinely performed (e.g., cleaning of the pH and conductivity probes), and the continuously recorded data will be downloaded on a periodic basis. Instrument replacement will be performed as necessary.

2.2 Monitoring Data Collection

2.2.1 Schedule

Monitoring of the flow and water quality of the drainage from the Magenta Drain Tunnel will be collected according to the following schedule:

1. For first two months of the monitoring program, regardless of when monitoring is initiated, water quality samples will be manually collected at the sample station every two weeks and analyzed for the constituents shown in Table 1 (routine parameter list) to provide data for initial review. Continuous monitoring of flow, pH, conductivity, temperature, and precipitation data will be initiated upon equipment installation and the recorded data will be retrieved at each water sampling event.
2. During the low-flow period (approximately April through October), water quality samples will be manually collected every month and analyzed for the constituents shown in Table 1 (routine parameter list). The continuously monitored flow, pH, conductivity, temperature, and precipitation data will be retrieved at each water sampling event.
3. During the high-flow period (approximately November through March), water quality samples will be manually collected at the sample station every two weeks and analyzed for the constituents shown in Table 1 (routine parameter list). The automated sampler will be programmed to automatically collect event-based water samples if a significant change in flow is observed as a result of precipitation events (assumes that sufficient period of baseline data collection has been performed to allow the automated sampler to be programmed). The event-based samples will be analyzed for the constituents identified in Table 2 (event-based parameter list).
4. During the first year, samples will be collected quarterly and analyzed for the constituents listed in Table 3 (Quarterly Parameter List). In addition, samples will be collected twice during the first year and analyzed for the constituents listed in Table 4 (Semi-Annual

Parameter List). The semi-annual samples will be collected once during the low-flow period and once during the high-flow period.

The monitoring program will be modified as necessary based on ongoing review of the data. Specifically, the sampling results will be evaluated on an ongoing basis to determine if the frequency of sampling and the list of parameters shown in Table 1, Table 2, Table 3, and Table 4 are appropriate for future analyses.

2.2.2 Data Collection Procedures

Sample collection, sampling handling, analytical, and QA/QC procedures will be conducted consistent with generally accepted practices and EPA guidance, as presented in the attached Field Sampling Plan (Attachment 1). As specified in the Field Sampling Plan, the laboratory analysis methods and detection limits are based on the CVRWQCB criterion quantitation limits. These procedures and methods will be reviewed to ensure that they are appropriate for the water quality of the Magenta Drain Tunnel. Any modification to these procedures and methods will be documented. The samples will be submitted for analysis to a laboratory that is accredited (NELAP) by the California Department of Health Services.

2.3 Proposed Monitoring Timeline, Data Management and Reporting

The manual collection of water quality samples and field parameter measurements will be initiated as soon as possible following approval of this proposed monitoring program. It is estimated that a minimum of 2 to 4 weeks will be required to install the automated monitoring and sampling equipment.

The period of monitoring will depend on the time of year when monitoring is initiated, but it is anticipated that this monitoring program will be conducted for a one-year period to evaluate the flow and water quality characteristics of the flow from the Magenta Drain Tunnel over an entire hydrologic season. The collection of monitoring data from the sampling station may be continued beyond the proposed one-year period as determined necessary and appropriate depending on the observed variability in flow and water chemistry.

The monitoring data (laboratory analytical results and continuous flow and field parameter data) will be compiled, validated, and managed in an electronic database. A quarterly data transmittal report that summarizes data collected during the preceding quarter will be prepared and submitted to the CVRWQCB.

3.0 MAGENTA DRAIN SEDIMENT SAMPLE COLLECTION

Sediment samples will be collected at seven locations in the drainage ditch and the creek downstream of the Magenta Drain Tunnel portal during one sampling event. Samples will be collected at the following

seven locations: at the portal, the residential footbridge, upstream of the roadway culvert above Memorial Park, and at four approximately evenly spaced intervals along the creek within Memorial Park. The exact sample locations will be determined in the field based on channel conditions and sediment occurrence. Samples will be collected in accordance with the Field Sampling Plan (Attachment 1) and analyzed for TLLC and STLC (California Waste Extraction Test) arsenic, iron, manganese, and thallium (Table 5).

4.0 EMPIRE SHAFT GROUNDWATER LEVELS

Two groundwater wells exist at the SHP that intercept the Empire Shaft. Groundwater is pumped from one of the wells to supply water for seasonal irrigation within the SHP; the other well is not currently used. A transducer and data logger will be installed in the unused well (Well #1) in accordance with the Field Sampling Plan (Attachment 1). Groundwater levels measured by the transducer will be recorded every hour.

5.0 REFERENCES

California State Department of Parks and Recreation, 2005a. Draft Preliminary Industrial Stormwater Pollution Prevention Plan, Empire Mine State Historical Park. October.

California State Department of Parks and Recreation, 2005b. Application/Report of Waste Discharge, General Information Form for Waste Discharge requirements or NPDES Permits. Submitted by California State Department of Parks and Recreation to State of California, Central Valley Region Water Quality Control Board. September 23.

Tetra Tech EM, Inc., 2005. Source Assessment and Evaluation of Remediation Measures for Metals in Surface Water, Magenta Drain Area, Empire Mine State Historic Park, Nevada County, California, prepared for California Department of Parks and Recreation, Gold Mines Sector, 10556 East Empire Street, Grass Valley, California 95945. March.

Table 1 Routine Parameter List (Monthly)

Analyte	
Inorganic Metals (total recoverable, except as indicated, and dissolved)	Aluminum (total), Antimony, Arsenic, Barium, Cadmium, Chromium, Hexavalent Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Nickel, Thallium, Vanadium, and Zinc
Inorganic Chemistry	Dissolved Oxygen, Temperature, pH, Conductivity, Sulfate, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Settleable Solids, Turbidity, Hardness (as CaCO ₃), and Color

Table 2 Event-Based Parameter List

Analyte
Arsenic (total recoverable and dissolved)
Iron (total recoverable and dissolved)
Manganese (total recoverable and dissolved)
Thallium (total recoverable and dissolved)
Total Suspended Solids (TSS)
Total Dissolved Solids (TDS)

Table 3 Quarterly Sampling List

Analyte	
Volatile Organics	1,1-Dichloroethane, 1,1-Dichloroethene, 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,2-Dichlorobenzene, 1,2-Dichloroethane, cis-1,2-Dichloroethene, 1,2-Dichloropropane, 1,2,4-Trichlorobenzene, 1,3-Dichlorobenzene, 1,3-Dichloropropene, 1,4-Dichlorobenzene, Acrolein, Acrylonitrile, Benzene, Bromoform, Bromomethane, Carbon tetrachloride, Chlorobenzene (mono chlorobenzene), Chloroethane, 2- Chloroethyl vinyl ether, Chloroform, Chloromethane, Dibromochloromethane, Dichlorobromomethane Dichloromethane, Ethylbenzene, Hexachlorobenzene, Hexachlorobutadiene, Hexachloroethane, Naphthalene, Tetrachloroethene, Toluene, trans-1,2-Dichloroethylene, Trichloroethene, Vinyl chloride, Methyl-tert-butyl ether (MTBE), Trichlorofluoromethane, 1,1,2-Trichloro-1,2,2-Trifluoroethane, Styrene, Xylenes
Semi-Volatile Organics	1,2-Benzanthracene, 1,2-Diphenylhydrazine, 2-Chlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 2,4,6-Trichlorophenol 2,6-Dinitrotoluene, 2-Nitrophenol, 2-Chloronaphthalene, 3,3'-Dichlorobenzidine, 3,4-Benzofluoranthene, 4-Chloro-3-methylphenol, 4,6-Dinitro-2-methylphenol, 4-Nitrophenol, 4-Bromophenyl phenyl ether, 4-Chlorophenyl phenyl ether, Acenaphthene, Acenaphthylene, Anthracene, Benzidine, Benzo(a)pyrene (3,4-Benzopyrene), Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Bis(2-chloroethoxy) methane, Bis(2-chloroethyl) ether, Bis(2-chloroisopropyl) ether, Bis(2-ethylhexyl) phthalate, Butyl benzyl phthalate, Chrysene, Di-n-butylphthalate, Di-n-octylphthalate, Dibenzo(a,h)-anthracene, Diethyl phthalate, Dimethyl phthalate, Fluoranthene, Fluorene, Hexachlorocyclopentadiene, Indeno(1,2,3-c,d)pyrene, Isophorone, N-Nitrosodiphenylamine, N-Nitrosodimethylamine, N-Nitrosodi-n-propylamine, Nitrobenzene, Pentachlorophenol, Phenanthrene, Phenol, Pyrene
Inorganics	Aluminum, Antimony, Arsenic, Asbestos, Barium, Beryllium, Beryllium, Cadmium, Chromium (total), Chromium (VI), Copper, Cyanide, Fluoride, Iron, Lead, Mercury, Methylmercury, Manganese, Molybdenum, Nickel, Selenium, Silver, Thallium, Tributyltin, Zinc
Pesticides and PCB's	4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-Endosulfan, alpha-Hexachlorocyclohexane(BHC), Alachlor, Aldrin, beta-Endosulfan, beta-Hexachlorocyclohexane, Chlordane, delta-Hexachlorocyclohexane, Dieldrin, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, Lindane (gamma-Hexachlorocyclohexane), PCB-1016, PCB-1221, PCB-1232, PCB-1242, PCB-1248, PCB-1254, PCB-1260, Toxaphene, Atrazine, Bentazon, Carbofuran, 2,4-D, Dalapon, 1,2-Dibromo-3-chloropropane (DBCP), Di(2-ethylhexyl)adipate, Dinoseb, Diquat, Endothal, Ethylene Dibromide, Glyphosate, Methoxychlor, Molinate (Ordram), Oxamyl, Picloram, Simazine (Princep), Thiobencarb, 2,3,7,8-TCDD (Dioxin), 2,4,5-TP (Silvex)
Other Constituents	Ammonia (as N), Chloride, Hardness (as CaCO ₃), Foaming Agents (MBAS), Nitrate (as N), Nitrite (as N), pH, Total Phosphorus (as P), Specific conductance (EC), Sulfate, Sulfide (as S), Sulfite (as SO ₃), Temperature, Total Dissolved Solids (TDS)

Table 4 Semi-Annual Parameter List

Analyte	
Dioxins	2,3,7,8 TetraCDD, 1,2,3,7,8-PentaCDD, 1,2,3,4,7,8-HexaCDD, 1,2,3,6,7,8-HexaCDD, 1,2,3,7,8,9-HexaCDD, 1,2,3,4,6,7,8-HeptaCDD, OctaCDD, 2,3,7,8-TetraCDF, 1,2,3,7,8-PentaCDF, 2,3,4,7,8-PentaCDF, 1,2,3,4,7,8-HexaCDF, 1,2,3,6,7,8-HexaCDF, 1,2,3,7,8,9-HexaCDF, 2,3,4,6,7,8-HexaCDF, 1,2,3,4,6,7,8-HeptaCDF, 1,2,3,4,7,8,9-HeptaCDF, OctaCDF

Table 5 Sediment Sample Parameters

Sample Media	Analyte
Sediment	Arsenic, TTLC and STLC by WET
	Iron, TTLC and STLC by WET
	Manganese, TTLC and STLC by WET
	Thallium, TTLC and STLC by WET



Photograph 1 Magenta Drain Proposed Monitoring Station at Residential Footbridge

ATTACHMENT 1
FIELD SAMPLING PLAN

**FIELD SAMPLING PLAN
FOR THE MAGENTA DRAIN TUNNEL
AT THE EMPIRE MINE STATE HISTORIC PARK
GRASS VALLEY, CALIFORNIA**

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ATTACHMENTS

SOP No. 1	Sample Collection
SOP No. 2	Sample Handling, Documentation, and Analysis
SOP No. 3	Flow Measurement
SOP No. 4	Sediment Sample Collection

1.0 FIELD SAMPLING PLAN

This Field Sampling Plan (FSP) is provided as an attachment to the Sampling and Monitoring Program for the Magenta Drain Tunnel at the Empire Mine State Historic Park in Grass Valley, California (Monitoring Program) (MFG, 2005). The Magenta Drainage Tunnel is located within the Empire Mine State Historic Park (SHP). The tunnel is believed to drain groundwater associated with historic underground mine workings and intercepts shallow groundwater flow along its length. The portal of the Magenta Drain Tunnel is located east of Highway 174 adjacent to the Happy Dale residential subdivision. Flow from the portal drains to a drainage ditch. Several hundred yards downstream from the portal, the drainage ditch joins an unnamed creek, historically referred to as Woodpecker Ravine, which flows through a rural residential area and the City of Grass Valley Memorial Park. Woodpecker Ravine is a tributary to the South Fork of Wolf Creek. The portal and portions of the drainage ditch and Woodpecker Ravine downstream of the portal are located on property owned by the California Department of Parks and Recreation (CDPR).

Based on limited historical and recent monitoring data summarized by Tetra Tech EM Inc. (TTEMI, 2005), arsenic, iron, manganese, and thallium concentrations in the water from the Magenta Drain Tunnel and in the drainage ditch and creek downstream from the tunnel portal may exceed current water quality criteria. Sediment samples were collected at two locations by Tetra Tech EM Inc. (TTEMI, 2005): from the drainage ditch at the Magenta Drain Tunnel portal and from the creek just upstream of Memorial Park. The arsenic concentrations of both samples exceeded the soluble threshold limit concentration (STLC) criteria.

As further described in the Monitoring Program, the objectives of this monitoring program are to characterize the quality and flow of water draining from the Magenta Drain Tunnel portal; collect additional sediment samples from the drainage ditch and creek downstream of the portal for total threshold limit concentration (TTLC) and STLC analysis (arsenic, iron, manganese, and thallium); and to monitor groundwater levels representative of the Empire Shaft mine workings. This FSP describes water and sediment sampling field activities, laboratory analyses, data validation, and data management. As described in Section 2, water quality data collection undertaken as part of this FSP includes water sampling, field parameter measurement, and flow measurement. Water sampling and data collection procedures include both manual and automated water sample collection. Sediment sampling and analysis methods are described in Section 3. Section 4 describes the groundwater level monitoring procedures.

2.0 MAGENTA DRAIN WATER QUALITY AND FLOW

2.1 Standard Operating Procedures

All data collection activities will be conducted according to the following Standard Operating Procedures (SOPs) pertaining to water quality sampling and hydrologic measurements:

SOP No. 1	Water Sample Collection
SOP No. 2	Sample Handling, Documentation, and Analysis
SOP No. 3	Flow Measurement

These SOPs are attached to this FSP. Procedures for automated water sampling and data collection have been developed specifically for this FSP and are provided in Section 4.2.

2.2 Sampling Location, Frequency, and Analysis

2.2.1 Sample Location

The monitoring station will be established in the drainage ditch at or near an existing residential footbridge, located approximately 150 feet downstream from the portal of the Magenta Drain Tunnel. Instrumentation to be installed at the monitoring station will include a Parshall (or equivalent) flume, a pressure transducer to monitor the flow stage in the flume, probes to monitor pH, conductivity, and temperature, a portable automatic water sampler, and a continuous-recording data logger equipped with a water sampler control program. A tipping bucket rainfall intensity gauge will also be installed at the station to record precipitation depth and duration. Power will be supplied with a 12-volt sealed battery that is charged by a 10W solar panel. The automatic sampler, data loggers, and power supply will be housed in a protective steel enclosure box adjacent to the station. On April 21, 2006, the Army Corps of Engineers (USACE) approved the installation of the flume in the channel under Nationwide Permit No.5.

Based on existing flow data, a 9-inch Parshall flume will be installed in the drainage ditch. The data logger will continuously record the flow at a prescribed time interval (anticipated to be every 15 minutes) based on the measured stage and the known stage-discharge relationship for the flume. The pH, conductivity, temperature, and precipitation data will also be continuously recorded by the data logger at a prescribed time interval (anticipated to be every 15 minutes). Once sufficient baseline data are collected, the water sampler control program will be used to trigger the collection of event-based water quality samples by the automatic sampler based on a pre-programmed change in flow.

2.2.2 Sample Frequency

The frequency of sampling is based on the presumed seasonal variability in flows and quality of the water draining from the Magenta Drain Tunnel. Flow occurs year-round from the Magenta Drain Tunnel. It is

anticipated, however, that flows from Magenta Drain Tunnel are responsive to storm events and vary according to precipitation with higher flows occurring during the winter period (approximately November through March). Based on limited flow measurements (TTEMI, 2005), flow from the tunnel at or near the portal has ranged from 623 to 982 gpm.

The quality of the water draining from the Magenta Drain Tunnel is expected to be flow dependent. Water quality is expected to be relatively stable during summer and fall except for variations caused by significant precipitation events. Based on previous sampling, dissolved metals concentrations during low flow conditions were higher than during high flow conditions, suggesting dilution of groundwater intercepted by the tunnel during storm events (TTEMI, 2005). However, it is expected that the total metals concentrations may be higher relative to dissolved concentrations during high flow conditions caused by storm events due to an increase in particulate (suspended solids) content.

Based on the presumed seasonal variability in flows and water quality, Table 1 provides the sampling frequency. The sample collection frequency may be modified during the monitoring period depending upon the results of the water chemistry data or continuous field parameter data. Upon installation of the automated monitoring instrumentation, continuous flow, pH, conductivity and temperature data will be recorded. The continuous data will be downloaded at each water sampling event and evaluated. Flow and field parameter measurements will also be performed at the time of water quality sample collection.

For the initial two-month period of monitoring regardless of when monitoring is initiated, water quality samples will be manually collected at the station every two weeks and analyzed for the constituents shown in Table 2 (routine parameter list) to provide data for initial review. Field measurements will be collected for flow, pH, conductivity, and temperature. The continuous flow, pH, and conductivity data collected during the initial two-month period will be used to initially program the automated sampler to collect event-based samples based on significant changes in flow.

During the low-flow period (approximately April-October), discrete samples will be manually collected every month and analyzed for the constituents shown in Table 2 (routine parameter list). In addition, the automated sampler will be programmed to collect event-based water samples if a significant change is observed in flow during the low-flow period. The event-based samples will be analyzed for constituents identified in Table 3 (event-based parameter list).

During the high-flow period (approximately November-March), discrete samples will be manually collected every two weeks and analyzed for the constituents shown in Table 2 (routine parameter list). In addition, the automated sampler will be programmed to collect event-based water samples if a significant

change is observed in flow during the high-flow period. The event-based samples will be analyzed for constituents identified in Table 3 (event-based parameter list).

During the first year of monitoring, the samples collected every quarter will also be analyzed for the constituents listed in Table 4 (quarterly parameter list). In addition, the samples will also be analyzed twice a year during the first year of monitoring for the additional parameters listed in Table 5 (semi-annual parameter list). The semi-annual samples will be collected during the high-flow and low-flow periods.

2.2.3 Sample Analysis

Table 2 (routine parameter list) identifies the parameters that will be analyzed by the laboratory for the water samples collected on a routine basis. Table 3 (event-based parameter list) identifies the parameters that will be analyzed by the laboratory for the event-based water samples. Table 4 (quarterly sampling parameter list) identifies the parameters that will be analyzed by the laboratory for the water samples collected every quarter. Table 5 (semi-annual sampling parameter list) lists the additional parameters that will be analyzed by the laboratory for the water samples collected twice a year. The need for analysis of additional samples for the parameters shown in Table 4 and Table 5 will be determined based on the analytical results for samples collected during the first year.

Table 2, Table 3, Table 4, and Table 5 also specify the laboratory analysis test methods and detection limits. Table 6 specifies the sample containers, preservatives, and holding times. The laboratory test methods and detection limits are based on the California Regional Water Quality Control Board (RWQCB) criterion quantitation limits pursuant to SIP 13267 (September 10, 2001, as revised December 27, 2001).

As shown in Table 2 and Table 4 low-level mercury analysis is specified by EPA Method 1631e. The analysis method requires the collection of water samples according to Method 1669: Sampling for Trace Metals at EPA Water Quality Criteria Levels (EPA, 1996). Procedures for collection and handling of water samples according to Method 1669 for low-level mercury analysis are provided in SOP No. 1 - Water Sample Collection and SOP No. 2 - Sample Handling, Documentation, and Analysis. During the initial two-month monitoring period, mercury samples will be collected according to Method 1669 and analyzed by the analytical laboratory according to Method 1631e. The need for continued Method 1669 sample collection and Method 1631e laboratory analysis will be determined based on evaluation of the mercury results.

The samples will be hand-delivered or shipped to the analytical laboratory under chain-of-custody procedures. The laboratory will be accredited (NELAP) by the California Department of Health Services.

2.3 Water Quality Data Collection

This water monitoring program has been organized into two components: (1) manual water sampling and (2) automatic water sampling.

2.3.1 Manual Monitoring

Water quality samples and associated field parameter measurements will be manually collected at the station. Manual samples will be collected according to SOP No. 1 - Water Sample Collection. Flow, pH, conductivity, temperature, dissolved oxygen, turbidity, and iron speciation (Fe^{+2} and Fe^{+3}) will be measured in the field at the time of sample collection. Procedures for manual flow measurement (flume or volumetric methods) are specified in SOP No. 3 – Flow Measurement. Procedures for field parameter measurement are described in SOP No. 1 – Water Sample Collection.

2.3.2 Automatic Water Quality Monitoring

The following describes the automated monitoring instrumentation, installation, water sample collection, QA/QC procedures, and continuous flow, pH, conductivity, and temperature measurements. Samples collected by the automatic sampler will be retrieved according to the procedures described in SOP No. 1 - Water Sample Collection.

2.3.3 Automatic Monitoring Equipment

The sampling station will include a 9-inch Parshall (or equivalent) flume, a stage height transducer sensor for the flume, pH and conductivity/temperature probes for continuous measurement, a continuous-recording data logger equipped with a water sampler control program, and an ISCO 6712 or American Sigma 900 portable automatic sampler (or equivalent). A tipping bucket rainfall intensity gauge will also be installed at the station.

2.3.4 Automatic Monitoring Equipment Installation

The automated monitoring equipment will be installed in accordance with manufacturer's specifications. The data logger and automatic sampler will be housed in an enclosure for protection against the elements. The stage height transducer sensor will be installed at the flume sidewall. The intake tubing of the sampler will be installed inside a PVC pipe for protection. The PVC pipe will be routed to the flume and terminated in flowing water at approximately mid-depth. A Teflon/stainless steel strainer will be installed at the end of the intake tubing to prevent clogging by debris. The PVC pipe will be anchored at multiple

locations and sensor cables are routed and attached along the pipe. The pH and conductivity/temperature sensors will be placed in flowing water near the end of the pipe.

The manufacturer's instructions will be followed for instrument testing and calibration of the electronic sensors including pH, conductivity, and temperature. These sensors will be calibrated prior to installation and tested against standard buffer solutions to determine accuracy. Following installation, the sensor accuracy will be compared against portable field instruments that are also tested against standard buffer solutions. If the remote sensors are out of calibration, the probes will be cleaned, recalibrated, and tested against standard buffer solutions. If necessary, adjustments will be made to the water sampler control program instruction values to acquire accurate readings. All calibration readings will be recorded on field forms. The operation of the instrumentation will be verified and maintenance will be routinely performed (e.g., cleaning of the pH and conductivity probes), and the continuously recorded data will be downloaded on a periodic basis. Instrument replacement will be performed as necessary.

The tipping bucket rainfall intensity gage will be mounted on the enclosure box. The gage will be leveled and field-tested with a calibrated water volume.

2.3.5 Continuous Field Parameters Measurement

Upon installation of automated monitoring equipment, flow, pH, conductivity, temperature, and precipitation will be continuously monitored. The programmable data logger will be configured to record sensor values at 15-minute intervals. The pressure transducer will be used to measure stage height to an accuracy of 0.01 feet and the corresponding flow will be recorded by the data logger based on the flume rating. The field parameter data will be downloaded whenever the station is visited for water sampling. The continuous data measured during the initial two-month monitoring period will be evaluated to define the normal range in flow, pH, conductivity, and temperature values. The automated sampler will be programmed to collect event-based water samples during the low-flow and high-flow monitoring periods if a significant change is observed in the normal range of a selected field parameter.

2.3.6 Automatic Water Sample Collection

The automatic sampler will be equipped with 24 1-liter capacity polyethylene sample bottles. The water sampler control program will be used to activate the automatic samplers at a pre-determined time during the day or based on flow/pH/conductivity for event-based sampling. An adequate volume of sample will be automatically collected over a discrete time interval to provide the sample volume required for laboratory analysis. At least one intake rinse cycle will be used before sample collection.

The automatic monitoring equipment allows water samples to be collected based on rapid changes in flow, pH, or conductivity. During the low-flow and high-flow monitoring periods, the automatic sampler will be activated if the flow, pH, or conductivity exceeds pre-defined threshold values over a specified time interval.

2.3.7 Automatic Water Sample Retrieval Procedures

Procedures for retrieving the water samples from the automated sampler are specified in SOP No. 1 - Water Sample Collection. Data will be downloaded from the data logger/water sampler control using a laptop or handheld computer and reviewed to evaluate sampling conditions and sample times. The automatic sampler will be maintained regularly and inspected when water samples are retrieved.

Observations and data taken during sample collection, any field measurements, and sample processing notes will be recorded on the field form as specified in SOP No. 1 - Water Sample Collection. Items not applicable to the sampling will be labeled as “not applicable” (NA). The information on the field form will include the following:

- Sample identification number and location
- Date and time of sampling
- Persons performing sampling
- If not already measured; conductivity, temperature, and pH
- If unusual; color, odor, and cloudiness of the water
- Number of samples taken, analytes, and processing/preservation methods
- Identification numbers of any QC samples
- Any irregularities or problems that may affect sampling quality.

Water samples for analysis will be transferred from the discrete sample bottles directly into the sample containers provided by the analytical laboratory. If sample filtration is specified, the samples will be filtered in the field using a disposable 0.45 µm membrane in-line filter and peristaltic pump. The analytical laboratory will provide sample containers with preservatives added or preservatives may be added in the field. Sample bottles will be labeled according to the station, date, time of collection, preservatives added, if any, and if filtered or not filtered.

2.3.8 Quality Assurance/Quality Control Samples

Quality assurance/quality control (QA/QC) samples will be collected during water sampling as described in SOP No. 1 - Water Sample Collection. For the automated sample collection program, field QA/QC

samples will consist of a field blank, rinsate blank, and duplicate sample collected at a rate of one per ten primary samples.

2.4 Sample Handling, Documentation, and Analysis

Procedures for sample handling and shipping, as well as proper sample containers to be used, are presented in SOP No. 2 - Sample Handling, Documentation and Analysis.

3.0 SEDIMENT SAMPLING

3.1 Standard Operating Procedures

Sediment samples will be collected and handled according to the procedures described in the following SOP:

SOP No. 4 Sediment Sample Collection

This SOP is attached to this FSP.

3.1.1 Sample Location

A total of 7 sediment samples will be collected from the drainage ditch and creek downstream of the Magenta Drain portal at the following locations: immediately downstream of the portal, at the residential footbridge, up-stream of the roadway culvert above Memorial Park, and at four samples approximately evenly spaced along the creek within Memorial Park. The sample locations will be documented in a field log and noted on a map.

3.2 Frequency

Sediment samples will be collected on one occasion.

3.3 Sample Analysis

The arsenic, iron, manganese, and thallium concentrations of the sediment samples will analyzed for TTLC and STLC following the procedures in Title 22 of the California Code of Regulations (Table 7). Table 8 specifies the sample containers, preservatives, and holding times. The samples will be hand-delivered or shipped to the analytical laboratory under chain-of-custody procedures. The laboratory will be accredited (NELAP) by the California Department of Health Services.

4.0 EMPIRE SHAFT GROUNDWATER LEVELS

A water level transducer (manufactured by In-Situ Inc. or equivalent) will be installed in the unused irrigation well (Well #1), which intersects the Empire Shaft. The transducer will be used to monitor groundwater levels in the well to provide data to evaluate the variability in groundwater levels and the possible relationship between groundwater levels at the Empire Shaft and Magenta Drain Tunnel flows. The measured groundwater levels will be converted to groundwater elevations based on the surveyed elevation of the well head. A survey will also be performed of the groundwater elevation in the Empire Shaft to confirm that the groundwater levels measured at the well are representative of the Empire Shaft water levels and to provide correlation of the well and Empire Shaft groundwater elevations. The elevations of the Empire Shaft collar and the Magenta Drain tunnel connection with the Empire Shaft will also be surveyed.

The transducer will be placed in the well at depth of approximately 30 feet below the groundwater level. If necessary, the transducer depth will be adjusted to compensate for groundwater level changes. The transducer cable and data logger will be secured at the well head. The transducer and data logger will be initially configured to record groundwater levels every hour. The recording frequency may be adjusted based on the observed fluctuation in groundwater levels. The depth to groundwater will be manually measured at the time of transducer installation and every time that data are downloaded from the data logger. The manual water level measurements will be used to configure the data logger to record the transducer pressure readings in terms of depth to groundwater, and to verify the accuracy of the transducer measurements. Water level data will be downloaded from the data logger at least every three months. The data will be maintained in a database.

5.0 QUALITY ASSURANCE PROJECT PLAN

5.1 Project Organization

All sampling activities will be conducted under the supervision of qualified personnel.

5.2 Laboratory

Chemical analyses will be performed by the laboratory (to be selected) according to the methods presented in Table 2, Table 3, Table 4, Table 5, and Table 7. The laboratory responsibilities, procedures, and QA/QC requirements will conform to the laboratory's quality assurance plan. The analytical results of the water samples will be validated as described in Section 5.3 and verified as to accuracy and precision.

5.3 Data Validation for Water Samples

Data validation will be used to assess the data quality using information such as sample holding times, and laboratory and field quality assurance. The data validation process takes the data from laboratory delivery to entry into a computerized data management system. The validation process will provide qualification of data based on the results of 1) a comparison of total and dissolved concentrations, 2) holding times, 3) field duplicate analysis, and 4) field blank and rinsate blank analysis. Additionally, laboratory quality control reports will be reviewed for each sample delivery group.

PRELIMINARY REVIEW AND COMPLETENESS CHECK. The purpose of this step is to assure that all requested analyses have been performed. Analyses requested on the chain-of-custody or analysis request document will be compared to the analyses performed. The final laboratory report is checked for transcription errors.

HOLDING TIMES. Holding times for all analytes are compared to the recommended holding times as shown in Table 6. If holding times are exceeded, the results are qualified as estimated.

COMPARISON OF TOTAL AND DISSOLVED CONCENTRATIONS. Samples in which both total and dissolved analyses were requested are reviewed to determine if dissolved concentrations exceed total concentrations. Theoretically, dissolved metal concentrations are less than total metal concentrations; however, dissolved metals concentration may slightly exceed the total metals concentrations. If dissolved concentrations exceed total concentrations, the laboratory may be requested to re-analyze the digestates and dissolved samples. The relative percent difference (RPD) is calculated if dissolved concentrations exceed total concentrations.

$$RPD = ((T-D) \times 100) / ((T+D)/2)$$

Where: T = total concentration (mg/L)
D = dissolved concentration (mg/L)

If the RPD is greater than 20 percent, both results are qualified as estimated.

FIELD DUPLICATE ANALYSES. Field duplicates are collected and analyzed as an indication of overall precision. These analyses measure both field and lab precision; therefore, the results may have more variability than lab duplicates that measure only lab performance. A comparison of primary and duplicate samples is conducted to determine the variance or RPD between the concentrations of each analyte. A target control limit of ± 20 percent for the RPD will be used for primary and duplicate samples greater than or equal to five times the detection level. A target control limit of \pm the detection level will be used when the primary and/or duplicate samples are less than five times the detection level. If the target control limit is exceeded, it will be noted in narrative comments accompanying the data validation report. As a possible indication of the source of the variance, the RPD's of associated laboratory duplicate analysis will be checked. If it appears that the source of the variance was not due to the laboratory analysis, then field procedures will be reviewed. If field procedures were a potential source of variance, it will be noted in the narrative report.

EVALUATION OF FIELD BLANK AND EQUIPMENT RINSATE ANALYSES If any analyte is detected in the equipment rinsate or field blank, field sample results within a factor of five times the concentration found in an associated blank are qualified as J/estimated.

LABORATORY QUALITY CONTROL REPORTS The analytical laboratory will review the results of their quality control analyses and provide a summary of this review with the laboratory analysis report. The summary will be evaluated, and the laboratory quality control results will be checked. If there was a significant problem with the laboratory quality control that may affect the quality of the data, the problem will be corrected. The problem and the possible impacts to the data will be discussed in the data transmittal report.

5.4 Data Management Plan

Data management activities consist of data entry and storage in a manner that maintains data validity and integrity. The data will be maintained in a Microsoft Access database and will be structured to maintain data integrity through the use of primary fields and indexes.

Monitoring performed pursuant to this FSP will generate both field and laboratory derived data that will be routinely added to the database. Data included in the database must be validated according to the

procedures in this FSP. At a minimum, the following data fields must be provided to allow data to be entered in to the site database:

- Site ID
- Sample Date
- Sample Time
- Sample Type (primary, duplicate, field blank, rinsate blank, other)
- Analyte (including a total or dissolved specifier)
- Result
- Lab Qualifier
- QA Qualifier
- Value Units

Other data fields such as detection limit and comments can also be provided and included in the database.

Similar restrictions will also be set-up in the database for sample types, analytes, lab qualifiers, QA qualifiers, and units. Only those values that are included in the linked tables can be added to the database. This maintains consistency within the database by making sure, for example, an analyte is always referred to by the same name or non-detect values are always referred to as 'U' and not '<' or some other variation.

6.0 REFERENCES

- California State Department of Parks and Recreation, 2005a. Draft Preliminary Industrial Stormwater Pollution Prevention Plan, Empire Mine State Historical Park. October.
- California State Department of Parks and Recreation, 2005b. Application/Report of Waste Discharge, General Information Form for Waste Discharge requirements or NPDES Permits. Submitted by California State Department of Parks and Recreation to State of California, Central Valley Region Water Quality Control Board. September 23.
- Tetra Tech EM, Inc., 2005. Source Assessment and Evaluation of Remediation Measures for Metals in Surface Water, Magenta Drain Area, Empire Mine State Historic Park, Nevada County, California, prepared for California Department of Parks and Recreation, Gold Mines Sector, 10556 East Empire Street, Grass Valley, California 95945. March.
- U.S. Environmental Protection Agency (EPA), 1994b. "U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganics Data Review." EPA-540/R-94-013. February.
- U.S. Environmental Protection Agency (EPA), 1996. "Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels." EPA-821/R-96-008. January.

Table 1 Water Quality Monitoring Frequency

Monitoring Period	Field Parameter Measurement Frequency	Water Quality Monitoring Frequency	
		Routine	Event-Based
Initial Two Month Period	Continuous flow, pH, conductivity, and temperature of the flow from the Magenta Drain Tunnel data and precipitation using automated instrumentation.	Bi-weekly sample collection, analyze for parameters shown in Table 2 (routine parameter list).	
Low-Flow Period (April – October)	Continuous flow, pH, conductivity, and temperature of the flow from the Magenta Drain Tunnel data and precipitation using automated instrumentation.	Monthly sample collection, analyze parameters shown in Table 2 (routine parameter list).	Automated sampler programmed to collect event-based water samples if significant change in selected field parameter is observed. Event-based samples analyzed for constituents identified in Table 3 (event-based parameter list).
High-Flow Period (November – March)	Continuous flow, pH, conductivity, and temperature of the flow from the Magenta Drain Tunnel data and precipitation using automated instrumentation.	Bi-weekly sample collection, analyze parameters shown in Table 2 (routine parameter list).	Automated sampler programmed to collect event-based water samples if significant change in selected field parameter is observed. Event-based samples analyzed for constituents identified in Table 3 (event-based parameter list).
Quarterly (during first year only)	See above.	Quarterly samples analyzed for parameters shown in Table 4 (quarterly sampling parameter list).	
Semi-Annual (during first year only)	See above.	Semi-annual samples analyzed for additional parameters shown in Table 5 (semi-annual sampling parameter list).	

Table 2 Routine Laboratory Parameter List

Parameter	EPA Method	Detection Limit (mg/L)
Aluminum, total and dissolved	M200.7 ICP	0.03
Antimony, total recoverable and dissolved	M200.8 ICP-MS	0.0002
Arsenic, total recoverable and dissolved	M200.8 ICP-MS	0.0001
Barium, total recoverable and dissolved	M200.8 ICP-MS	0.0001
Cadmium, total recoverable and dissolved	M200.8 ICP-MS	0.0001
Chromium, total recoverable and dissolved	M200.8 ICP-MS	0.0001
Chromium (VI), total recoverable and dissolved	M200.8 ICP-MS	0.0001
Cobalt, total recoverable and dissolved	M200.8 ICP-MS	0.00005
Copper, total recoverable and dissolved	M200.8 ICP-MS	0.0005
Iron, total recoverable and dissolved	M200.7 ICP	0.01
Lead, total recoverable and dissolved	M200.8 ICP-MS	0.0001
Manganese, total recoverable and dissolved	M200.8 ICP-MS	0.0001
Mercury, total and dissolved	M1631, Atomic Fluorescence	0.2 ng/L
Nickel, total recoverable and dissolved	M200.8 ICP-MS	0.0002
Thallium, total recoverable and dissolved	M200.8 ICP-MS	0.00005
Vanadium, total recoverable and dissolved	M200.8 ICP-MS	0.00005
Zinc, total recoverable and dissolved	M200.8 ICP-MS	0.002
Electrical Conductivity	M120.1 – Meter	1 umhos/cm
pH	M150.1 – Electrometric	0.1
Turbidity	SM214A	0.1 ntu
Sulfate	M375.3 – Gravimetric	10
Total Dissolved Solids	M160.1 – Gravimetric	10
Total Suspended Solids	M160.2	10
Settleable Solids	160.5 - Gravimetric	10
Hardness (as CaCO ₃)	M130.2	5

Table 3 Event-Based Laboratory Parameter List

Parameter	EPA Method	Detection Limit (mg/L)
Arsenic, total recoverable & dissolved	M200.8 ICP-MS	0.0001
Iron, total recoverable & dissolved	M200.7 ICP	0.01
Manganese, total recoverable & dissolved	M200.7 ICP	0.005
Thallium, total recoverable & dissolved	M200.8 ICP-MS	0.00005
Total Suspended Solids	M160.1 – Gravimetric	10
Total Dissolved Solids	M160.2	10

Table 4 Quarterly Sampling Parameter List

Parameter	EPA Method	Detection Limit (mg/L)
1,1-Dichloroethane	EPA 8260B	0.005
1,1-Dichloroethene	EPA 8260B	0.000057
1,1,1-Trichloroethane	EPA 8260B	0.2
1,1,2-Trichloroethane	EPA 8260B	0.0006
1,1,2,2-Tetrachloroethane	EPA 8260B	0.00017
1,2-Dichlorobenzene	EPA 8260B	0.01
1,2-Dichloroethane	EPA 8260B	0.00038
cis-1,2-Dichloroethene	EPA 8260B	0.006
1,2-Dichloropropane	EPA 8260B	0.00052
1,2,4-Trichlorobenzene	EPA 8260B	0.005
1,3-Dichlorobenzene	EPA 8260B	0.01
1,3-Dichloropropene	EPA 8260B	0.0005
1,4-Dichlorobenzene	EPA 8260B	0.005
Acrolein	EPA 8260B	0.021
Acrylonitrile	EPA 8260B	0.000059
Benzene	EPA 8260B	0.001
Bromoform	EPA 8260B	0.0043
Bromomethane	EPA 8260B	0.048
Carbon tetrachloride	EPA 8260B	0.00025
Chlorobenzene (monochlorobenzene)	EPA 8260B	0.05
Chloroethane	EPA 8260B	0.016
2-Chloroethyl vinyl ether	EPA 8260B	0.122
Chloroform	EPA 8260B	0.0011
Chloromethane	EPA 8260B	0.003
Dibromochloromethane	EPA 8260B	0.00041
Dichlorobromomethane	EPA 8260B	0.00056
Dichloromethane	EPA 8260B	0.0047
Ethylbenzene	EPA 8260B	0.029
Hexachlorobenzene	EPA 8260B	0.0000075
Hexachlorobutadiene	EPA 8260B	0.00044
Hexachloroethane	EPA 8260B	0.0019
Naphthalene	EPA 8260B	0.014
Tetrachloroethene	EPA 8260B	0.0008
Toluene	EPA 8260B	0.042
trans-1,2-Dichloroethylene	EPA 8260B	0.01
Trichloroethene	EPA 8260B	0.0027
Vinyl chloride	EPA 8260B	0.0005
Methyl-tert-butyl ether (MTBE)	EPA 8260B	0.005
Trichlorofluoromethane	EPA 8260B	0.15
1,1,2-Trichloro-1,2,2-Trifluoroethane	EPA 8260B	1.2
Styrene	EPA 8260B	0.011
Xylenes	EPA 8260B	0.017
1,2-Benzanthracene	EPA 8270C	0.0000044
1,2-Diphenylhydrazine	EPA 8270C	0.00004

Table 4 Quarterly Sampling Parameter List (continued)

Parameter	EPA Method	Detection Limit (mg/L)
2-Chlorophenol	EPA 8270C	0.0001
2,4-Dichlorophenol	EPA 8270C	0.0003
2,4-Dimethylphenol	EPA 8270C	0.54
2,4-Dinitrophenol	EPA 8270C	0.07
2,4-Dinitrotoluene	EPA 8270C	0.00011
2,4,6-Trichlorophenol	EPA 8270C	0.002
2,6-Dinitrotoluene	EPA 8270C	0.00005
2-Nitrophenol	EPA 8270C	0.15
2-Chloronaphthalene	EPA 8270C	1.6
3,3'-Dichlorobenzidine	EPA 8270C	0.00004
3,4-Benzofluoranthene	EPA 8270C	0.0000044
4-Chloro-3-methylphenol	EPA 8270C	0.03
4,6-Dinitro-2-methylphenol	EPA 8270C	0.0134
4-Nitrophenol	EPA 8270C	0.06
4-Bromophenyl phenyl ether	EPA 8270C	0.122
4-Chlorophenyl phenyl ether	EPA 8270C	0.122
Acenaphthene	EPA 8270C	0.02
Acenaphthylene	EPA 8270C	0.01
Anthracene	EPA 8270C	9.6
Benzidine	EPA 8270C	0.00000012
Benzo(a)pyrene		
(3,4-Benzopyrene)	EPA 8270C	0.0000044
Benzo(g,h,i)perylene	EPA 8270C	0.005
Benzo(k)fluoranthene	EPA 8270C	0.0000044
Bis(2-chloroethoxy) methane	EPA 8270C	0.005
Bis(2-chloroethyl) ether	EPA 8270C	0.000031
Bis(2-chloroisopropyl) ether	EPA 8270C	0.122
Bis(2-ethylhexyl) phthalate	EPA 8270C	0.0018
Butyl benzyl phthalate	EPA 8270C	0.003
Chrysene	EPA 8270C	0.0000044
Di-n-butylphthalate	EPA 8270C	0.003
Di-n-octylphthalate	EPA 8270C	0.003
Dibenzo(a,h)-anthracene	EPA 8270C	0.0000044
Diethyl phthalate	EPA 8270C	0.003
Dimethyl phthalate	EPA 8270C	0.003
Fluoranthene	EPA 8270C	0.3
Fluorene	EPA 8270C	1.3
Hexachlorocyclopentadiene	EPA 8270C	0.001
Indeno(1,2,3-c,d)pyrene	EPA 8270C	0.0000044
Isophorone	EPA 8270C	0.0084
N-Nitrosodiphenylamine	EPA 8270C	0.005
N-Nitrosodimethylamine	EPA 8270C	0.00000069
N-Nitrosodi-n-propylamine	EPA 8270C	0.000005
Nitrobenzene	EPA 8270C	0.017
Pentachlorophenol	EPA 8270C	0.00028
Phenanthrene	EPA 8270C	0
Phenol	EPA 8270C	0.005
Pyrene	EPA 8270C	0.96

Table 4 Quarterly Sampling Parameter List (continued)

Parameter	EPA Method	Detection Limit (mg/L)
Aluminum	EPA 6020/200.8	0.087
Antimony	EPA 6020/200.8	0.006
Arsenic	EPA 6020/Hydride	0.000018
Asbestos	EPA/600/R-93/116(PCM)	7 MFL
Barium	EPA 6020/200.8	0.1
Beryllium	EPA 6020/200.8	0.004
Cadmium	EPA 1638/200.8	0.00007
Chromium (total)	EPA 6020/200.8	0.05
Chromium (VI)	EPA 7199/ 1636	0.0002
Copper	EPA 6020/200.8	0.0041
Cyanide	EPA 9012A	0.0052
Fluoride	EPA 300	1
Iron	EPA 6020/200.8	0.3
Lead	EPA 1638	0.00092
Mercury	EPA 1669/1631	0.0000005
Methylmercury	EPA 1669/1630/1631	0.00000002
Manganese	EPA 6020/200.8	0.05
Nickel	EPA 6020/200.8	0.024
Selenium	EPA 6020/200.8	0.005
Silver	EPA 6020/200.8	0.00071
Thallium	EPA 6020/200.8	0.0017
Tributyltin	EV-024/025	0.000063
Zinc	EPA 6020/200.8	0.054
4,4'-DDD	EPA 8081A	0.00005
4,4'-DDE	EPA 8081A	0.00005
4,4'-DDT	EPA 8081A	0.00001
alpha-Endosulfan	EPA 8081A	0.00002
alpha-Hexachlorocyclohexane (BHC)	EPA 8081A	0.00001
Alachlor	EPA 8081A	0.0001
Aldrin	EPA 8081A	0.000005
beta-Endosulfan	EPA 8081A	0.00001
beta-Hexachlorocyclohexane	EPA 8081A	0.000005
Chlordane	EPA 8081A	0.0001
delta-Hexachlorocyclohexane	EPA 8081A	0.000005
Dieldrin	EPA 8081A	0.00001
Endosulfan sulfate	EPA 8081A	0.00005
Endrin	EPA 8081A	0.00001
Endrin Aldehyde	EPA 8081A	0.00001
Heptachlor	EPA 8081A	0.00001
Heptachlor Epoxide	EPA 8081A	0.00001
Lindane (gamma-Hexachlorocyclohexane)	EPA 8081A	0.00002
PCB-1016	EPA 8082	0.00000017
PCB-1221	EPA 8082	0.00000017
PCB-1232	EPA 8082	0.00000017

Table 4 Quarterly Sampling Parameter List (continued)

Parameter	EPA Method	Detection Limit (mg/L)
PCB-1242	EPA 8082	0.00000017
PCB-1248	EPA 8082	0.00000017
PCB-1254	EPA 8082	0.00000017
PCB-1260	EPA 8082	0.00000017
Toxaphene	EPA 8081A	0.0005
Atrazine	EPA 8141A	0.001
Bentazon	EPA 643/ 515.2	0.002
Carbofuran	EPA 8318	0.005
2,4-D	EPA 8151A	0.01
Dalapon	EPA 8151A	0.01
1,2-Dibromo-3-chloropropane (DBCP)	EPA 8260B	0.00001
Di(2-ethylhexyl)adipate	EPA 8270C	0.005
Dinoseb	EPA 8151A	0.002
Diquat	EPA 8340/ 549.1/HPLC	0.004
Endothal	EPA 548.1	0.045
Ethylene Dibromide	EPA 8260B/ 504	0.0002
Glyphosate	HPLC/ EPA 547	0.025
Methoxychlor	EPA 8081A	0.01
Molinate (Ordram)	EPA 634	0.002
Oxamyl	EPA 8318/ 632	0.02
Picloram	EPA 8151A	0.001
Simazine (Princep)	EPA 8141A	0.004
Thiobencarb	HPLC/ EPA 639	0.001
2,3,7,8-TCDD (Dioxin)	EPA 8290 (HRGC) MS	0.000000005
2,4,5-TP (Silvex)	EPA 8151A	0.001
Ammonia (as N)	EPA 350.1	1.5
Chloride	EPA 300.0	106
Hardness (as CaCO ₃)	EPA 130.2	5
Foaming Agents (MBAS)	SM5540C	0.5
Nitrate (as N)	EPA 300.0	10
Nitrite (as N)	EPA 300.0	1
pH	EPA 150.1	6.5-8.5
Phosphorus, Total (as P)	EPA 365.3	0.00014
Specific conductance (EC)	EPA 120.1	700 umhos/cm
Sulfate	EPA 300.0	250
Sulfide (as S)	EPA 376.2	0.000029
Sulfite (as SO ₃)	SM4500-SO3	
Total Dissolved Solids (TDS)	EPA 160.1	10

Table 5 Semi-Annual Parameter List

Parameter	Method	Detection Limit (mg/L)
2,3,7,8 TetraCDD	GCMS Method 8290	0.00000000425
1,2,3,7,8-PentaCDD	GCMS Method 8290	0.00000000274
1,2,3,4,7,8-HexaCDD	GCMS Method 8290	0.00000000462
1,2,3,6,7,8-HexaCDD	GCMS Method 8290	0.00000000316
1,2,3,7,8,9-HexaCDD	GCMS Method 8290	0.00000000496
1,2,3,4,6,7,8-HeptaCDD	GCMS Method 8290	0.00000000540
OctaCDD	GCMS Method 8290	0.00000000717
2,3,7,8-TetraCDF	GCMS Method 8290	0.00000000454
1,2,3,7,8-PentaCDF	GCMS Method 8290	0.00000000521
2,3,4,7,8-PentaCDF	GCMS Method 8290	0.00000000381
1,2,3,4,7,8-HexaCDF	GCMS Method 8290	0.00000000283
1,2,3,6,7,8-HexaCDF	GCMS Method 8290	0.00000000258
1,2,3,7,8,9-HexaCDF	GCMS Method 8290	0.00000000328
2,3,4,6,7,8-HexaCDF	GCMS Method 8290	0.00000000363
1,2,3,4,6,7,8-HeptaCDF	GCMS Method 8290	0.00000000237
1,2,3,4,7,8,9-HeptaCDF	GCMS Method 8290	0.00000000621
OctaCDF	GCMS Method 8290	0.00000000901

Table 6 Analytes, Sample Containers, Preservation and Holding Time Requirements for Water Samples

Analyte	Sampling Container	Filtration/Preservation	Holding Time
Field Analysis			
pH, Conductivity, Temperature, DO	Polyethylene	Unfiltered, Unpreserved	Analyze at time of sample collection
Ferrous Iron and Total Iron (Colorimetric Methods)	Polyethylene	Unfiltered, Unpreserved	Analyze at time of sample collection
Laboratory Analysis			
Total Metals (except mercury)	250 ml Polyethylene	Unfiltered, HNO ₃ , Cool to 4°C	180 days
Dissolved Metals (except mercury) and Dissolved Major Cations	125 ml Polyethylene	Filtered, HNO ₃ , Cool to 4°C	180 days
Total Mercury	250 ml pre-cleaned specialty	Unfiltered, Unpreserved, Cool to 4°C	48 hours
Major Anions	250 ml Polyethylene	Filtered, Unpreserved	28 days 48 hours (NO ₂ , NO ₃)
Alkalinity	500 ml Polyethylene	Unfiltered, Unpreserved, Cool to 4°C	14 days
Nitrogen, NO ₂ , NO ₃	250 ml Glass	Unfiltered, H ₂ SO ₄ , Cool to 4°C	28 days
Volatile Organics	Two 40 ml Glass	Unfiltered, 0.008% Na ₂ S ₂ O ₃ , Cool to 4°C	14 days w/ preservation 7 days if unpreserved
Semi-Volatile Organics	1 liter, 8 oz Glass	Unfiltered, 0.008% Na ₂ S ₂ O ₃ , Cool to 4°C	7 days until extraction 40 days after extraction
Pesticides-PCBs	1 liter, 8 oz Glass	Unfiltered, pH 5-9, cool to 4°C	7 days until extraction 40 days after extraction
Cyanide	500 ml/4 oz Polyethylene	Unfiltered, NaOH to pH>12, 0.6 g ascorbic acid	14 days
Chromium (VI)	500 ml/8 oz	Unfiltered, 4°C	24 hours
Phosphorus, Total (as P)	500 ml Polyethylene	Unfiltered, H ₂ SO ₄ pH<12, Cool to 4°C	28 days
Sulfide	500 ml Polyethylene	Unfiltered, NaOH to pH>9, add 2 ml of zinc acetate, Cool to 4 °C.	7 days.
Hardness	100 ml Polyethylene	Unfiltered, Unpreserved, Cool to 4°C	28 days
Foaming Agents	1000 ml Polyethylene	Unfiltered, Unpreserved, Cool to 4°C	48 hours
Dioxin and Furan Sampling	1000 ml, 8 oz Glass	Unfiltered, 0.008% Na ₂ S ₂ O ₃ , Cool to 4°C (dark)	30 days until extraction 45 days after extraction

Table 7 Sediment Sample Parameter List

Parameter	Method	TTLIC Detection Limit (mg/Kg)	STLC Detection Limit (mg/L)
Arsenic, TTLIC and STLC	CAL Title 22	4	0.04
Iron, TTLIC and STLC	TTLIC – EPA 3050b/EPA 6010	1	0.01
Manganese, TTLIC and STLC	STLC – Waste Extraction Test	0.5	0.005
Thallium, TTLIC and STLC	(WET) – EPA 6010	20	0.2

Table 8 Analyte, Sample Containers, Preservation and Holding Time Requirements for Sediment Samples

Analyte	Sampling Container	Filtration/Preservation	Holding Time
Arsenic Iron Manganese Thallium	8 oz Glass	Non-filtered/ Non-preserved	180 days

ATTACHMENTS

**MAGENTA DRAIN TUNNEL SAMPLING
EMPIRE MINE STATE HISTORIC PARK
GRASS VALLEY, CALIFORNIA**

**STANDARD OPERATING PROCEDURE NO. 1
WATER SAMPLE COLLECTION**

Version 1.0

**STANDARD OPERATING PROCEDURE NO. 1
WATER SAMPLE COLLECTION
Version 1.0**

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FIGURE

Figure 1 Water Sampling Data Sheet

1.0 PURPOSE AND SCOPE

The purpose of this document is to define the Standard Operating Procedure (SOP) for the collection of water samples from the Magenta Drain Tunnel located at Empire Mine State Historic Park (SHP). This SOP serves as a supplement to the Field Sampling Plan (FSP). This document describes sampling equipment, and specifies field sampling and quality assurance/quality control (QA/QC) procedures necessary for collecting water samples from the Magenta Drain Tunnel flow. The sample location and frequency of collection are described in the FSP.

2.0 RELATED STANDARD OPERATING PROCEDURES

This procedure is intended to be used with the following SOP:

- SOP No. 2 - Sample Handling, Documentation, and Analysis.

3.0 EQUIPMENT REQUIRED FOR WATER SAMPLING

3.1 General Equipment Requirements

The following general equipment may be required to collect water samples:

- Watch
- Backpack
- Field logbook
- Surface water data sheets (see Figure 1)
- Mobile telephone or radio
- Appropriate health and safety equipment
- Camera

The following equipment may be required for field parameter measurements:

- pH meter (with automatic temperature compensation)
- Electrical conductivity meter (with automatic temperature compensation)
- Ferrous iron meter
- Total iron meter
- Dissolved oxygen meter
- Plastic squeeze bottle filled with deionized or distilled water
- Polyethylene or glass containers (for field parameter measurements)
- Beakers

- Kimwipes® or equivalent
- Pipette and graduated cylinders (for dilution, if necessary)
- Calculator
- Field logbook
- Appropriate health and safety equipment.

The following equipment is required for collection and filtration of sample water:

- Pre-cleaned sample bottles obtained from the laboratory
- Beakers of assorted sizes
- Peristaltic pump and battery
- Tygon® or silicone tubing (fluoropolymer or styrene/ethylene/butylenes/silicone (SEBS) tubing required for collection of samples for low-level determination of metals (i.e. mercury)).
- Disposable latex gloves (non-talc)
- Disposable 0.45-micron filters (Gelman Supor 12175, or equivalent)

The following equipment is necessary for sample labeling, packing, shipping, documentation, and performing chain-of-custody procedures:

- Sample labels
- Appropriate preservatives
- Field logbook and surface water data sheets
- Chain-of-custody forms
- Disposable latex gloves (non-talc)
- Black permanent markers and waterproof pens
- Clear plastic tape
- Fiber tape
- Custody seals
- Large (30 gallon) trash bag
- Cooler
- Gallon Ziploc® freezer bags
- Ice
- Shipping documentation

4.0 WATER SAMPLING PROCEDURES

This section defines the step-by-step procedures for collecting water samples in the field. Procedures are provided for manual collection of water samples (Section 4.1.1), collection of water samples for low-level mercury determination (Section 4.1.2), and retrieving water samples from the automated samplers (Section 4.1.3). These procedures may be modified once the specific details of the monitoring station and associated instrumentation are installed. Observations made during sample collection shall be recorded in the field logbook and on the surface water data sheets (Figure 1).

4.1 Obtaining Water Samples

4.1.1 Manual Sample Collection

The following procedures apply to manual collection of water samples, except for collection of samples for low-level determination of mercury. Collect water samples as follows:

1. Obtain all necessary sample collection, filtering equipment, and laboratory supplied sample bottles.
2. Make sure that the sample labels have been filled out for the sampling location (if labels used). Place labels on the sample bottles and secure the labels with clear plastic tape.
3. All sampling personnel must put on and wear clean, disposable latex gloves before commencing and during sample collection activities.
4. Make sure that no activities are occurring or have recently occurred immediately upstream that would affect the integrity of the sample. Approach the sampling site from downstream and downwind if possible. To avoid disturbing stream sediments or otherwise contaminating samples, stand downstream of the location from which you collect the sample.
5. Triple rinse and fill the intermediate water collection container to be used for preparation of filtered samples by directly submerging the container in the water to be sampled. Filter the samples as described below in step #9. Sample bottles used as intermediate containers shall not be reused, but shall be discarded. If the collection container cannot be filled due to low water depth or other reasons, use the filtration system (peristaltic pump, tubing and 0.45 micron filter) to fill the laboratory-supplied sample bottles by pumping directly from the sample water into the sample bottles. Place the intake end of the tubing in the water to be sampled, being careful to minimize sediment, and follow the procedures specified in step #9.
6. Triple rinse and fill the unfiltered laboratory-supplied sample bottles directly by immersion in the water to be sampled. If unfiltered bottles cannot be filled due to low water depth or other reasons, use the peristaltic pump and tubing (no filter) to pump sample water into the unfiltered sample bottles or use a clean beaker to fill the unfiltered sample bottles, being careful to minimize sediment. If the sample location is not readily accessible, both unfiltered sample bottles and intermediate sample bottles can be filled at the sample site, transported back to the vehicle, and filtered from the intermediate bottles

into new sample bottles. Sample bottles used as intermediate containers shall not be reused, but shall be discarded.

7. The open end of the sample bottle or peristaltic tubing shall face upstream during sample collection.
8. Measure field parameters (e.g., pH, electrical conductivity, total iron, ferrous iron, and dissolved oxygen) from a separate aliquot of the unfiltered sample.
9. If the sample for preparation of filtered water samples is obtained in an intermediate collection container, filter the water samples as described below:
 1. Set up the filtration system consisting of the peristaltic pump, tubing, and a 0.45 micron filter.
 2. Remove the lid of the intermediate sampling container and place the intake end of the tubing in the container.
 3. Start the pump and pass approximately 100 to 200 mL of sample water through tubing/filter to rinse. Stop the pump and discard the rinse.
 4. Restart the pump and pass approximately 50 mL of sample water through the tubing/filter into the laboratory-supplied sample container. Stop the pump and rinse the sample container with the filtered water, discarding the rinse water.
 5. Restart the pump and pass sample water through the tubing/filter to fill the laboratory-supplied sample container.
10. Preserve the samples as specified in SOP No. 2 - Sample Handling, Documentation and Analysis.
11. Place the samples in Ziploc® freezer bags.
12. Place the samples on ice in a cooler.
13. Record the time of sampling.
14. Complete the field documentation and chain-of-custody form(s).

4.1.2 Sample Collection for Low-Level Mercury Analysis

Water samples collected for low-level mercury analysis will be performed in accordance with Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. Pre-cleaned and certified sample bottles for collection of low-level mercury samples will be provided in kit form by the laboratory. The kit will consist of double-bagged sample bottles, reagent water for field blank(s), gloves, and ice.

Collection of samples is performed using the “clean hands-dirty hands” technique (EPA Method 1669, Section 2.4). Bottles are sealed tightly and re-bagged using the opposite series of steps as were used to open them. Sample bottles will be shipped to the analytical laboratory via overnight courier for preservation and analysis (no filtering and no addition of a preservative to the sample bottles will be performed in the field). Ideally, at least two persons each wearing fresh cleanroom gloves (EPA Method

1669, Section 4.2.2.2) are required on a sampling crew. Cleanroom gloves should be worn at all times when handling samples or sampling equipment. The gloves should be changed between samples and whenever anything not known to be trace metal clean is touched.

The following procedures describe methods for collecting samples directly into the sample container. If other sampling methods (e.g. grab sampling device, sample collection container, or peristaltic pump) are required for sampling, procedures recommended in EPA Method 1669 should be followed. Collect water samples for mercury analysis as follows:

1. Obtain all necessary sample collection equipment.
2. Make sure that the sample labels have been filled out for the sampling location.
3. Obtain sample kit provided by laboratory.
4. All sampling personnel must put on clean latex gloves before commencing sample collection activities.
5. Make sure that no activities are occurring or have recently occurred immediately upstream that would affect the integrity of the sample. Approach the sampling site from downstream and downwind if possible. To avoid disturbing stream sediments or otherwise contaminating samples, stand downstream of the location from which you collect the sample.
6. “Dirty hands” removes a bagged bottle from the box or cooler, and opens the outer bag, avoiding touching the inside surface of that bag.
7. “Clean hands” reaches in, opens the inner bag, and removes the sample bottle. “Clean hands” should not touch anything but the outside surface of the sample bottle and cap, and the water being sampled. If anything other than the sample bottle, cap or water is touched, “clean hands” must change gloves.
8. “Clean hands” opens the sample bottle and holds the bottle in one hand and the cap in the other. If it is necessary to set the cap down, it should be placed in the inner bag from which the sample bottle was removed.

The person collecting the sample should be wary of disturbing the flow upstream of the sampling point. The insertion of the bottle into a flowing stream creates eddies (disturbances in the upstream flow) that can re-suspend solids near the sampling point. Entry of such re-suspended solids into the sample may produce a non-representative sample and could increase the mercury concentration.

9. “Clean hands” directly submerges the sample bottle in the water to be sampled. Rinse the sample bottle and inside surface of the cap three times with sample water. Then, fill the bottle to the top with sample until no more air bubbles appear, and while the bottle is still inverted so that the mouth of the bottle is underwater, “clean hands” replaces the cap of the bottle (Method 1669, Section 8.2.5.5). Tighten the cap securely.
10. Re-bag the bottle in the opposite order that it was removed using the “clean hands-dirty hands” technique.
11. Place the samples on ice in a cooler.

12. Record the time of sampling.
13. Complete the field documentation and chain-of-custody form(s).

EPA Method 1631 requires collection of a field blank with every 10 samples from a given site (Method 1631, Section 9.4.3.1). A sample bottle for the field blank will be provided by the laboratory as part of the sampling kit. A separate sample bottle as well as a bottle filled with reagent water are used to collect the field blank.

The following procedures are used to collect the field blank:

1. To collect the field blank, open an empty sample bottle using the “clean hands-dirty hands” techniques described above. Also open the bottle containing the reagent water.
2. Pour the reagent water into the empty sample bottle. This is now the field blank.
3. Re-bag the field blank in the opposite order that it was removed using the “clean hands-dirty hands” technique.

4.1.3 Automatic Water Sample Retrieval Procedures

The following procedures apply to the retrieval of water samples collected by the automated water sampling equipment. Collect water samples as follows:

1. Obtain all necessary sample collection bottles and filtering equipment.
2. Make sure that the sample labels have been filled out for the sampling location (if labels used). Place labels on the sample bottles and secure the labels with clear plastic tape.
3. All sampling personnel must put on and wear clean, disposable latex gloves before commencing and during sample collection activities.
4. For unfiltered samples, gently agitate the automatic sample bottle to re-suspend any particulates and then transfer water directly from the automatic sample bottle to the unfiltered laboratory supplied sample container. Water can also be transferred from the automatic sample bottle to the unfiltered laboratory supplied sample container using a peristaltic pump.
5. For filtered samples, gently agitate the automatic sample bottle to re-suspend any particulates and then place the tubing intake directly in the automatic sample bottle and pass approximately 100 to 200 mL of sample water through tubing/filter to rinse the tubing and filter, and discard the rinse. Then, pass approximately 50 mL of sample water through the tubing/filter to rinse the laboratory-supplied sample container, discarding the rinse water. Then, pass sample water through the tubing/filter to fill the laboratory-supplied sample container.
6. Measure field parameters (e.g., pH, electrical conductivity, and temperature) from remaining water contained in the automatic sample container.
7. Preserve the samples as specified in SOP No. 2 - Sample Handling, Documentation and Analysis.
8. Place the samples in Ziploc® freezer bags.
9. Place the samples on ice in a cooler.

10. Record the time of sample preparation.
11. Complete the field documentation and chain-of-custody form(s)
12. Discard any remaining water in the automatic sample bottles and decontaminate the bottles by triple rinsing with de-ionized water. Return the sample bottles to the automated sampler tray.

4.2 Flow Measurement

If flow will be measured, refer to SOP No. 3 - Flow Measurement (to be developed once flow measuring devices have been determined). Always collect the samples for chemical analysis before measuring discharge.

4.3 Quality Assurance/Quality Control (QA/QC) Procedures and Samples

Field QA/QC samples shall be collected in accordance with the following and shall include field equipment rinsate samples, field duplicate samples, and field blank samples. The field blank sample for low-level mercury analysis will be collected as described in Section 4.1.2.

4.3.1 Equipment Rinsate Samples

To check if decontamination procedures have been effective, equipment rinsate samples of decontaminated sampling equipment shall be collected if non-disposable, decontaminated sampling equipment is used in the collection of samples. A rinsate sample shall be collected from the decontaminated sampling equipment (e.g. beakers) before it is used to obtain a primary sample. Pour or pump deionized water into or through the decontaminated sampling equipment and transfer the water to the sample bottles. Assign the rinsate sample an appropriate identification number and follow SOP No. 2 - Sample Handling, Documentation and Analysis. Rinsate samples will be collected at a rate of one rinsate sample per 10 primary samples.

4.3.2 Duplicate Samples

To check for the natural sample variance and the consistency of field techniques and laboratory analysis, collect duplicate samples side-by-side with primary samples. After filling the primary sample bottles, immediately fill the duplicate sample bottles until all necessary sample bottles for both the primary and duplicate samples have been filled. For filtered water samples, use a different filter and tubing for the primary and duplicate samples. Handle the duplicate water sample in the same manner as the primary sample. Assign the duplicate samples an appropriate identification number and follow SOP No. 2 - Sample Handling, Documentation and Analysis. Duplicate samples will be collected at a rate of one duplicate sample per 10 primary samples.

4.3.3 Blank Samples

Collect field blanks by filling sample containers in the field with deionized water obtained from the laboratory. Assign the blank samples an appropriate identification number and follow SOP No. 2 - Sample Handling, Documentation and Analysis. Blank samples will be collected at a rate of one blank sample per 10 primary samples.

4.4 Sample Handling

Sample containers, labeling, parameter holding times, and preservatives are specified in SOP No. 2 - Sample Handling, Documentation and Analysis.

5.0 FIELD METER CALIBRATION AND MEASUREMENT

5.1 pH Meter

The pH meter shall be calibrated at least each day before taking any readings of samples. Calibration and operation of the pH meter shall be performed according to the manufacturer's specific instructions. In general, calibration is done by adjusting the meter with standard buffers that bracket the expected pH of the field water. Although the procedures described in this section are generic, they were generally written for Hach Company EC10 and EC20 pH meters.

5.1.1 Required pH Measurement Equipment

Use the following apparatus and supplies for measuring pH in the field:

- Portable pH meter
- Spare pH probe or electrolyte cartridge, as applicable
- pH electrode storage solution
- Extra batteries
- Beakers
- Buffer solutions of pH 4, 7, and 10
- Deionized or distilled water
- Wash bottle
- Kimwipes® or equivalent.

Determine the pH from a water sample as soon as possible after collecting it. Determine the pH by the electrometric method using standard buffer solutions. The electrometric method is the preferred method because of its greater accuracy and ease of measurement. Either a glass electrode and a reference

electrode, or a combination electrode, which combines the glass membrane electrode and the reference electrode, shall be used.

The pH meter shall automatically compensate for temperature and be capable of calibration with a two-point (using two buffers) slope adjustment method. The meter shall have a precision of at least 0.05 pH units.

5.1.2 pH Meter Calibration Procedures

Before collecting samples, calibrate the pH meter in accordance with the manufacturer's instructions using calibration solutions. Record all pH measurement data, including calibration dates and times, readings, the meter number, and sample temperatures on a surface water data sheet or in a field logbook.

Sampling personnel shall be familiar with the meter and shall follow the manufacturer's instructions for calibrating and using the meter. Calibrate the pH meter at least once per day, always at the start of each sampling day, and as needed during the day, especially when measuring waters with substantially different pH values. Check the pH calibration against a known standard three times daily. If the pH reading differs by more than 0.1 pH units from the check standard, the pH meter shall be recalibrated. Thoroughly document all calibrations, including the buffer readings and temperatures, in the field logbook or data sheets. Field sampling personnel shall do the following when calibrating the meter according to the manufacturer's procedures:

- Condition pH electrodes by soaking them for at least one hour in pH electrode storage solution. pH electrodes that have been properly stored in pH electrode storage solution do not need to be conditioned.
- One of the buffer solutions used for the slope adjustment should approximate the anticipated pH of the sample, and the other buffer should always have a pH of 7. Ensure that the buffer solutions are at the same temperature and are as close as practical to the temperature of the water to be measured. Use aliquots of the buffer solutions once and then discard the aliquots.
- Before immersing the probe(s) into the buffer or sample, rinse the probe with deionized or distilled water and blot it dry with clean Kimwipes® or equivalent. Protect the glass tip of the probe from abrasion and scratching.
- Calibrate the meter with two buffer solutions (two-point slope adjustment) at least once daily (or more often if specified by manufacturer).
- If the calibrated slope of the pH meter deviates significantly from its theoretical value, test for a potentially defective electrode or contaminated buffer solution.
- Always use the same electrode for measurements that was used for calibration.
- Recalibrate the meter if the electrode is replaced.

5.1.3 pH Measurement

The sampler shall measure pH as follows:

1. If the pH is measured in a container, rinse the sample container with deionized water and then rinse it three times with the sample water prior to measurement. Rinse the pH probe with deionized water and, if possible, blot the probe dry with clean Kimwipes® or equivalent. Be sure to protect the fragile glass bulb at the end of the probe from damage.
2. Immerse the electrode in the water, allow the pH reading to stabilize, and monitor the drift of the instrument. Do not immerse the electrode above the top of the pH probe. When the pH reading stabilizes (i.e., the meter beeps), record the temperature to the nearest 0.1 °C and the pH reading to the nearest 0.01 unit.
3. Between measurements, store the electrode in Hach pH electrode storage solution or equivalent solution, if possible, or put a cotton swab soaked in electrode solution in the protective cap of the electrode.
4. Measure the pH of samples within a short period of time after sampling and on a separate aliquot of the sample.
5. If using a Hach One pH meter, dispense electrolyte if the reading becomes unstable or erratic or if stabilization takes too long. An unstable reading may also indicate an air bubble in the reference line. Depress the dispenser button repeatedly until the bubble is expelled (5 to 10 clicks should be sufficient). Note that it is not necessary to refresh the electrolyte gel at the reference outlet between readings unless the reading does not stabilize within a reasonable period of time.
6. Store the electrode on a short-term basis (between measurements/up to one week) in the Hach pH electrode storage solution or place a cotton swab that has been soaked in pH electrode storage solution in the pH probe protective cap. Do not store the electrode in deionized water, as this will shorten the electrode life.
7. Avoid prolonged exposure of the pH meter and probe to sunlight.

5.2 Conductivity Meter

Electrical conductivity, or specific conductance, is the ability of water to conduct an electric current and depends on the concentration of ions in solution. The relationship between conductivity and the concentration of dissolved solids is approximately linear for most natural waters. Changes in this relationship indicate changes in the proportions of different salts and, therefore, changes in the sources of dissolved substances that enter the water body.

For measuring conductivity in the field, the meter shall have an automatic temperature compensator and shall display conductivity directly in units of microsiemens per centimeter ($\mu\text{S}/\text{cm}$) for samples with a conductivity less than 2,000 $\mu\text{S}/\text{cm}$ or in millisiemens per centimeter (mS/cm) for samples with a conductivity greater than 2.00 mS/cm , corrected to a temperature of 25 degrees C.

Electrical conductivity shall not be measured on a sample that was first used to measure pH. Potassium chloride that diffuses from the pH probe can alter the conductivity of the sample.

5.2.1 Required Conductivity Measurement Equipment

Use the following apparatus and supplies for measuring conductivity in the field:

- Conductivity meter
- Extra batteries
- Calibration solutions that bracket the expected range of measurements
- Deionized or distilled water
- Wash bottle
- Kimwipes® or equivalent
- Beakers.

5.2.2 Conductivity Meter Calibration

Before collecting samples, calibrate the conductivity meter using calibration solutions in accordance with the manufacturer's instructions. The sampler shall record all conductivity measurement data, including calibration dates, readings, the meter number, and sample temperatures on a surface water data sheet or in a field logbook.

Reagent-grade potassium chloride (KCl) or other equivalent solutions are universally used as reference solutions to calibrate conductivity equipment. The reference solutions are also used to check the accuracy of the meter. The conductivity of the reference solutions that are used to calibrate the meter should bracket the expected range of the conductivity of the water samples. Commercially prepared calibration standards are available from laboratory suppliers at many standard concentrations.

The sampler shall calibrate the meter as follows:

1. Calibrate the meter according to the manufacturer's instructions.
2. Prepare or obtain standard reference solutions of a known value at a known temperature. Adjust the meter or the calibration solution to the correct temperature.
3. Adjust the meter to read the reference conductivity. Rinse the probe with deionized water and blot the probe dry. Re-immers the probe in the reference solution and read the measured value to validate the corrected conductivity.

Check the calibration of the conductivity meter three times daily. If the conductivity meter reading differs by more than 10 percent from the check standard, the conductivity meter shall be recalibrated.

5.2.3 Conductivity Measurement

Measure conductivity immediately after a sample is collected. Record conductivity readings to the nearest 1 $\mu\text{S}/\text{cm}$ (for samples with conductivities less than 2,000 $\mu\text{S}/\text{cm}$) or 0.01 mS/cm (for samples with conductivities greater than 2.00 mS/cm), corrected to 25°C.

The sampler shall measure conductivity as follows:

1. Rinse the probe with deionized water and blot the probe dry with clean Kimwipes® or equivalent, without wiping the plating on the cell.
2. Insert the probe into the sample solution. Immerse the tip to or beyond the vent holes and agitate the probe vertically. Make sure that air bubbles are not trapped near the temperature sensor. Allow the reading to stabilize before recording measurements. Record the conductivity and temperature of the sample.
3. During normal use, rinse the probe thoroughly with deionized water between measurements to minimize the buildup of interfering substances on the probe element.
4. Avoid prolonged exposure of the probe to sunlight.

5.3 Total Iron Meter

The total iron concentration shall be measured at the time of sample collection. A Hach DR700 colorimeter and AccuVac ampoules (or equivalent) containing the appropriate reagents shall be used for field determination of total iron concentrations in the water samples. The total iron meter is factory calibrated and requires no field calibration. The factory calibration shall be confirmed before the total iron meter is sent to the field.

5.3.1 Required Total Iron Measurement Equipment

Use the following equipment and supplies for measuring total iron in the field:

- Portable total iron meter
- 50.01 filter module
- Extra batteries
- 50-mL beakers
- Rubber stoppers
- FerroVer AccuVac ampuls
- AccuVac holder
- 10-mL sample cell
- Deionized or distilled water

- Wash bottle
- Kimwipes® or equivalent.

5.3.2 Total Iron Measurement

The sampler shall perform the following procedures:

- Install model 50.01 in DR700 and power up the meter. The meter display will show 500 nanometers (nm) and module number 50.01. After two seconds, the display will show a program number, concentration units, decimal position, and the zero prompt. If necessary, press the UP ARROW key until the lower display shows program number 50.04.1. A ZERO prompt will be flashing on the display.
- Collect about 50-mL of sample in a 50-mL beaker and immediately fill a sample cell with 10-mL of the sample and a FerroVer AccuVac ampul with the sample. The ampul is filled with sample by breaking the narrow tip under water in the sample beaker. Keep the tip immersed while the ampul fills completely. When filled, quickly invert the ampul several times to mix. Wipe off any water and fingerprints, place a rubber stopper over the tip of the vial, and wait at least three minutes. An orange color will form if iron is present.
- Measurement of the total iron concentration shall be done within 30 minutes after the 3-minute period ends. To determine the concentration of iron in the sample, wipe off any water and fingerprints from the blank sample vial and place the vial in the cell holder. Close the cell compartment cover and press the ZERO key. The meter display will count down to zero and then show 0.000 mg/L and turn off.
- Open the compartment cover and remove the blank sample from the cell holder. Insert the AccuVac holder in the cell holder. Place the prepared sample ampul in the cell holder and close the compartment cover. Then press the READ key and the display will count down to zero. The display will show the concentration of total iron in mg/L.

If using a meter other than the DR700, refer to the instruction manual that came with the meter.

5.4 Ferrous Iron Meter

The ferrous iron concentration shall be measured at the time of sample collection. A Hach DR700 colorimeter and AccuVac samples containing the appropriate reagents shall be used for field determination of ferrous iron concentrations in the water samples. The ferrous iron meter is factory calibrated and requires no field calibration. The factory calibration shall be confirmed before the ferrous iron meter is sent to the field.

5.4.1 Required Ferrous Iron Measurement Equipment

- Portable ferrous iron meter
- 50.01 filter module
- Extra batteries

- 50-mL beakers
- Rubber stoppers
- Ferrous iron AccuVac ampuls
- AccuVac holder
- 10-mL sample cell
- Deionized or distilled water
- Wash bottle
- Kimwipes® or equivalent.

5.4.2 Ferrous Iron Measurement

The sampler shall perform the procedure outlined below:

- Install module 50.01 in DR700 and power up the meter. The meter display will show 500 nm and module number 50.01. After two seconds, the display will show a program number, concentration units, decimal position and the zero prompt. If necessary, press the UP ARROW key until the lower display shows program number 50.02.1. A ZERO prompt will be flashing on the display.
- Collect about 50 mL of sample in a 50-mL beaker and immediately fill a sample cell with 10-mL of sample water and a ferrous iron AccuVac ampul with the sample. The ampul is filled with sample by breaking the narrow tip under water in the sample beaker. Keep the tip immersed while the ampul fills completely. When filled, quickly invert the ampul several times to mix. Wipe off any water and fingerprints, place a rubber stopper over the tip of the ampul, and wait for at least three minutes. An orange color will develop if ferrous iron is present.
- During the 3-minute waiting period, fill a cell with 10 mL of blank sample. To determine the concentration of ferrous iron in the sample, wipe off any water and fingerprints and place the blank sample vial in the cell holder. Close the cell compartment cover and press the ZERO key. The meter display will count down to zero and the display will show 0.000 mg/L and then turn off.
- Open the compartment cover and remove the blank sample from the cell holder. Insert the AccuVac Vial holder in the cell holder. Place the ampul filled with the water sample in the cell holder and close the compartment cover. Press the READ key and the display will count down to zero. The display will show the concentration of ferrous iron in mg/L.

If using a meter other than the DR700, refer to the instruction manual that came with the meter.

5.5 Dissolved Oxygen Meter

The dissolved oxygen concentration shall be measured at the time of sample collection. A Hach DR700 colorimeter and AccuVac ampoules (or equivalent) containing the appropriate reagents shall be used for colorimetric determination of dissolved oxygen concentrations in the water. The dissolved oxygen meter

is factory calibrated and requires no field calibration. The factory calibration shall be confirmed before the dissolved oxygen meter is sent to the field.

5.5.1 Required Dissolved Oxygen Measurement Equipment

- Portable dissolved oxygen meter
- 60.01 and 52.01 filter modules
- Extra batteries
- 50-mL beakers
- Rubber stoppers
- Low and high range dissolved oxygen AccuVac ampuls
- AccuVac holder
- 10-mL sample cell
- Deionized or distilled water
- Wash bottle
- Kimwipes® or equivalent.

5.5.2 Dissolved Oxygen Measurement

The sampler shall perform the procedure outlined below:

- For low range dissolved oxygen readings (i.e., from 0 to 1 mg/L), install module 60.01 in a DR700 meter and power up the meter. The meter display will show 610 nm and module number 60.01. After two seconds, the display will show a program number, concentration units, decimal position, and a zero prompt. If necessary, press the UP ARROW key until the lower display shows program number 61.07.1. The ZERO prompt will be flashing on the display.
- For high range dissolved oxygen readings (i.e., from 0 to 14 mg/L), install module 52.01 in a DR700 meter and power up the meter. The meter display will show 525 nm and module number 52.01. After two seconds, the display will show a program number, concentration units, decimal position, and a zero prompt. If necessary press the UP ARROW key until the lower display shows program number 52.14.1. The ZERO prompt will be flashing on the display.
- Collect about 50 mL of sample in 50-mL beaker and immediately fill a sample cell with 10 mL of sample water and a low range or high range dissolved oxygen AccuVac ampul with the sample. The ampul is filled with sample by breaking the narrow tip under water in the sample beaker. Keep the tip immersed until the ampul fills completely. Without inverting the ampul, immediately place a rubber stopper over the tip of the ampul filled with the sample. Shake the ampul for approximately 30 seconds. The cap prevents contamination of the sample with atmospheric oxygen. Wipe off any water and fingerprints and wait for at least two minutes.

- During the 2-minute waiting period, fill a cell with 10 mL of blank sample. To determine the concentration of dissolved oxygen in the sample, wipe off any water and fingerprints and place the blank sample vial in the cell holder. Close the cell compartment cover and press the ZERO key. The meter display will count down to zero, and the display will show 0.000 mg/L and then turn off.
- Immediately after the 2-minute waiting period is up, open the compartment cover and remove the blank sample from the cell holder. Insert the AccuVac holder in the cell holder. Make sure that the module and the program conform with the specifications of the ampul used to prepare the sample (i.e., low or high range dissolved oxygen). Place the prepared sample in the cell holder and close the compartment cover. Then press the READ key and the display will count down to zero. The display will show the results in mg/L dissolved oxygen. If a low range analysis is indicated to be above 1.0 mg/L, re-analyze the sample using the high range method. If a high range analysis is less than 1.0 mg/L, re-analyze the sample using the low range method.

If using a meter other than a DR700, consult the operating instructions that came with the meter.

6.0 DOCUMENTATION

6.1 Water Data Sheet

Complete a water data sheet (Figure 1) for water samples at each sampling location. Be sure to completely fill in the data sheet. If items on the sheet do not apply to a specific location, label the item as not applicable (NA). The information on the data sheet includes the following:

- Sampling location
- Date and time of sampling
- Weather conditions
- Person(s) performing sampling
- Field parameters including conductivity, temperature, pH, total iron, ferrous iron, dissolved oxygen
- Field meters used and calibration information
- Sample identification number(s)
- QA/QC samples taken at the location
- Method of sample collection (e.g., poly dipper).

6.2 Field Notes

Keep field notes in a bound field logbook. Record the following information using waterproof ink (if not recorded in surface water data sheet):

- Names of personnel

- Weather conditions
- Date and time of sampling
- Sampling location
- Decontamination information
- Calculations
- Calibration information, sample methods used, or reference to the appropriate SOP
- Field parameters including conductivity, temperature, pH, total iron, ferrous iron, dissolved oxygen, date, and time
- Sample identification number.

Figure 1 Water Sampling Data Sheet

IDENTIFICATION

Sample Location _____ Date _____ Start Time _____ Stop Time _____ Page _____ of _____
 Sample Control Number _____ Samplers _____

WEATHER CONDITIONS

Ambient Air Temperature: _____ °C ? °F ? Measured ? Estimated ?
 Weather: Sunny ? Partly Cloudy ? Cloudy ? Rain ? Snow ? Heavy ? Moderate ? Light ?

INSTRUMENT CALIBRATION

pH Meter: Meter Make/Model Number _____
 Buffer _____ Measured Value _____ Temp. _____ °C ? °F ?
 Buffer _____ Measured Value _____ Temp. _____ °C ? °F ?
Conductivity Meter: Meter Make/Model Number _____
 Standard Value _____ μS/cm Measured Value _____ Temp. _____ °C ? °F ?
 Standard Value _____ μS/cm Measured Value _____ Temp. _____ °C ? °F ?

SAMPLE LOCATION DESCRIPTION

SAMPLE COLLECTION PROCEDURE

DISCHARGE MEASUREMENT

Method: _____
 Comments/Observations: _____

 Discharge: _____ Staff gauge: _____

FINAL SAMPLE PARAMETERS

Sample Date	Sample Time	Discharge (gpm)	pH	Cond. (mS/cm)	Temp (°C)	Total Iron (mg/L)	Ferrous Iron (Fe ²⁺) (mg/L)	Dissolved Oxygen (mg/L)

Was a duplicate sample collected (02) Yes ? No ? (Sample control number _____)
 Was a field blank sample collected (03) Yes ? No ? (Sample control number _____)
 Was a rinsate sample collected (04) Yes ? No ? (Sample control number _____)

Notes: _____

Sampler's Signature: _____

**MAGENTA DRAIN TUNNEL SAMPLING
EMPIRE MINE STATE HISTORIC PARK
GRASS VALLEY, CALIFORNIA**

**STANDARD OPERATING PROCEDURE NO. 2
SAMPLE HANDLING, DOCUMENTATION, AND ANALYSIS**

Version 1.0

**STANDARD OPERATING PROCEDURE NO. 2
SAMPLE HANDLING, DOCUMENTATION, AND ANALYSIS
Version 1.0**

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1.0 PURPOSE AND SCOPE

This document defines the standard operating procedure (SOP) for sample documentation, handling, packaging, and chain-of-custody (COC) procedures. The American Society for Testing and Materials (ASTM) Standard Practice for Sampling Chain-of-Custody Procedures (D 4840-99) was used to prepare this SOP. This SOP serves as a supplement to the Field Sampling Plan (FSP).

2.0 RELATED STANDARD OPERATING PROCEDURES

This SOP supplements and is referenced by other SOPs; however, it does not reference any other SOP.

3.0 NECESSARY EQUIPMENT

The following equipment may be used for sample labeling, packing, documentation, and COC procedures:

- Sample bottles
- Sample labels
- Appropriate preservatives
- Field book and data forms
- COC documents
- Black permanent markers, black pens, and pencils
- Clear plastic tape
- Fiber tape
- Custody seals
- Large trash bags
- Ziploc®-type freezer bags
- Ice
- Sample shipment containers (coolers)
- Shipping labels

4.0 SAMPLE HANDLING

4.1 Sample Identification

Assign unique sample identification numbers to the collected samples in order to identify the location and sample date for each sample. These numbers are required for tracking the handling, analysis, and verification or validation status of all samples collected during monitoring.

4.2 Sample Labeling

Label each sample that is collected in the field for future identification. Before collecting the sample, fill out sample labels as completely as possible with black waterproof ink. In most cases, sample labels need to be obtained from the analytical laboratory. Each label shall contain the following information, as appropriate:

- Sampler's company affiliation
- Unique sample identification number
- Sampling location
- Date and time of sample collection
- Method of preservation used (if any)
- Sampler's initials

After the label is completed and attached to the sample container, place clear plastic tape over the label to protect and secure it to the container. Attach and tape labels before filling the sample bottles, if possible.

4.3 Sample Containers, Preservatives, and Holding Times

4.3.1 Sample Containers

Observe proper sample handling practices (Section 4.5) to minimize sample contamination and potential repeat analyses due to anomalous analytical results. Before sampling, obtain commercially cleaned sample containers provided by the analytical laboratory. Keep all documentation regarding sample bottle decontamination. Label the bottles as described in Section 4.2. Sample bottles shall either be pre-preserved from the laboratory or preservatives shall be added in the field after sample collection. Sample container sizes and types (e.g., plastic or glass) are presented in Table 1. Sample bottles for mercury analysis will be provided by the laboratory in a kit form.

4.3.2 Sample Preservation

Water samples are preserved to prevent or minimize chemical changes that could occur during transit and storage. Preservation methods include placing samples on ice and adding certain chemicals. Preserve samples in the field immediately after collecting them to ensure that laboratory results are not compromised by improper coordination of preservation requirements and holding times. Store samples on ice in coolers before and during shipping. Specific preservation requirements for water samples are specified in Table 1 and should be discussed with the laboratory before performing the sampling episode.

4.3.3 Sample Holding Times and Analyses

Sample holding times are established to minimize chemical changes in a sample before analysis and/or extraction is performed. A holding time is defined as the maximum allowable time between sample collection and analysis and/or extraction, based on the nature of the analyte of interest, preservation method, and chemical stability factors. Holding times for water samples are specified in Table 1. Sample holding times should be discussed with the laboratory prior to sampling. All samples shall be shipped in time to ensure that holding times are not exceeded.

4.4 Sample Packaging and Shipping

Ship water samples in such a manner that holding times are not exceeded and required storage temperatures are maintained. Ship the samples in a sealed, ice-filled cooler of good quality. The field sampling technician shall pack water samples for shipment as follows:

1. Obtain an appropriately sized cooler of good quality in which to pack the samples.
2. Line the cooler with a large plastic trash bag.
3. Place each sample bottle in an appropriately sized Ziploc®-type plastic bag, and place the bottles upright in the large plastic trash bag lining the cooler.
4. Place sample bottles for mercury analysis in the original bags supplied by the laboratory.
5. Wrap glass sample bottles with bubble-type packing to prevent breakage during shipping.
6. If required, use absorbent packing material to fill voids in the cooler.
7. Verify that all samples in the cooler have been documented on the COC form. Record the number of the shipping document on the COC form. Sign and date the COC form and retain a copy of it. Place the COC form in a 1-gallon Ziploc®-type plastic bag and tape the COC form to the inside lid of the shipping cooler.
8. Seal the plastic trash bag liner with a signed custody seal. This will maintain the COC if the cooler is inadvertently opened during shipment.
9. Double-bag ice in 1-gallon freezer Ziploc®-type plastic bags. Use enough ice to keep the samples cool until they are received by the laboratory. Use more ice in the summer time.
10. Seal the cooler and drainhole with plastic or fiber tape and make sure the cooler has no leaks (shipping companies will not handle leaking coolers).
11. Attach signed custody seals across two sides of the cooler top.
12. Attach an address label with the laboratory address and phone number and with a return address and phone number.
13. Attach the shipping document and retain a copy of the shipping document with the COC form.

4.5 General Sample Handling Procedures

General sample handling procedures shall include the following:

- Always make field measurements on a separate sub-sample, not on the sample that is sent to the laboratory for analysis, and discard the sub-sample after the measurements have been made.
- Do not use containers that have been used in the laboratory to store concentrated reagents or have been previously used as sample containers. Use only new containers for samples that are certified clean by the manufacturer or laboratory.
- For water samples, do not allow the inner portion of sample containers and caps to come into contact with bare hands, gloves, or other objects.
- Keep sample containers in a clean environment away from dust, dirt, fumes, and grime.
- Field personnel shall wear disposable latex or nitrile gloves when collecting water samples.
- Do not let water, vegetation, or invertebrate samples stand in the sun. Store them in coolers with ice.

If temporary storage of collected water samples is required prior to shipment to a laboratory, the samples will be stored in a secure location.

5.0 SAMPLE DOCUMENTATION

Documentation of the conditions and procedures used to collect, treat, and handle samples and field data is one of the most important aspects of any monitoring program. Proper documentation provides sources to determine the integrity and applicability of the data. Carefully document all field activities in a field logbook or on data sheets. Field logbooks shall be bound with consecutively numbered pages and shall be written in with permanent black ink only. Record field activities in sufficient detail so that field activities can later be reconstructed from the notes. Any changes to the notes in the field logbook shall be made by drawing a single line through the incorrect material and initialing and dating the markout.

The following sections provide procedures and formats for documenting the field data and conditions at the time of sample collection, shipment to the laboratory, and laboratory analysis. While forms are provided in relevant SOPs to document specific tasks, the field sampling technician shall maintain a field logbook for recording all other events, conditions, and observations during sampling.

5.1 Field Notes

Documentation of observations and data acquired in the field provide information on sample acquisition, field conditions at the time of sampling, and a permanent record of field activities. Record field observations and data collected during routine monitoring activities with waterproof ink either in a permanently bound field logbook with consecutively numbered pages or on field data sheets.

Field logbook and data sheet entries will include the following information, as appropriate. Consult relevant sampling and decontamination SOPs to supplement this list.

- Project name
- Location of sample
- Weather conditions
- Sampler's printed name and signature
- Date and time of sample collection
- Sample identification number(s)
- Description of sample (matrix sampled)
- Sample depth (if applicable)
- Number and volume of samples
- Sample methods used, or reference to the appropriate SOP
- Sample handling, including filtration and preservation, as appropriate, for separate sample aliquots
- Field observations
- Results of any field measurements, such as depth to water, pH, temperature, electrical conductivity, discharge, and so forth
- Personnel present
- Decontamination procedures.

Strike out changes or deletions in the field book or on the data sheets with a single strike mark and be sure that the original information remains legible. All field logbooks shall be signed daily by the person who wrote the entries. Record enough information to allow the sampling event to be reconstructed from the notes alone.

Completely fill out field data sheets and do not leave blank lines. Write "Not Applicable" or "NA" on blank lines.

5.2 Chain-of-Custody Procedures

The custody of all samples shall be documented on the Chain-of-Custody (COC) forms. The COC forms document possession of the sample from collection through laboratory receipt.

Follow appropriate sample custody and documentation procedures precisely to preserve sample integrity and to ensure the validity of field and laboratory data. As a result, all sample data will be traceable from the time and location of sample collection through chemical analyses and to the time when data are used. Information on the custody, transfer, handling, and shipping of samples will be recorded on a COC form.

The objective of the custody identification and control system for the samples is to ensure, to the extent practicable, that the following occur:

- All samples scheduled for collection are uniquely identified.
- The correct samples are analyzed and are traceable to their records.
- Important sample characteristics are preserved.
- Samples are protected from loss or damage.
- Any alteration of samples (e.g., filtration, preservation, and dilution) is documented.
- A record of sample integrity is established.
- Legally traceable custody and possession records are maintained.

For this project, a sample is defined as being in an individual's custody if the following conditions occur:

- The sample is in that individual's actual physical possession.
- The sample is in that individual's view after being in their physical possession.
- The sample is in that individual's physical possession and then locked or otherwise sealed so that tampering would be evident.
- The sample is maintained in a secure area that is restricted to authorized personnel only.

General field custody procedures include the following:

- As few people as possible should handle samples.
- The field sampler is personally responsible for the care and custody of the samples collected until they are properly transferred.
- When transferring the samples, the individuals relinquishing and receiving the samples will document the transfer by signing, dating, and writing the time of transfer on the COC form.

- The person responsible for delivering the samples to the laboratory or to the shipping carrier will sign the COC form, retain the third copy of the form, document the method of shipment, and send the original and the second copy of the form with the samples.
- Custody seals shall be attached so that it is necessary to break the seal to open the shipping container. The person affixing the custody seal will sign and date the seal.

Observe general documentation rules, including the use of black ink. Make any changes to the COC form by drawing a single line through the incorrect material and initialing the markout. Put a line through and initial blank lines on the COC form.

Upon receiving the samples, the laboratory's representative shall do the following:

- Sign and keep copies of shipping documents.
- Sign the COC form and return the second copy to the Project Manager (may be included with the analysis results)
- Measure and document the temperature of the samples.
- Document the condition of the custody seals and of the samples.
- Notify the project manager if any breakage or improper preservation has occurred or if there is a discrepancy between the COC form, sample labels, and requested analyses.
- Provide copies of the above documentation to the project manager with the final laboratory data package.

6.0 REFERENCES

ASTM D-4840-99, Standard Practice for Sampling Chain-of-Custody Procedures, 1999 Annual Book of ASTM Standards, Vol. 04.08.

Table 1 Analytes, Sample Containers, Preservation, Filtering, and Holding Time Requirements for Water Samples

Analyte	Sampling Container	Filtration/Preservation	Holding Time
Field Analysis			
pH, Conductivity, Temperature, DO	Polyethylene	Unfiltered, Unpreserved	Analyze at time of sample collection
Ferrous Iron and Total Iron (Colorimetric Methods)	Polyethylene	Unfiltered, Unpreserved	Analyze at time of sample collection
Laboratory Analysis			
Total Metals (except mercury)	250 ml Polyethylene	Unfiltered, HNO ₃ , Cool to 4°C	180 days
Dissolved Metals (except mercury) and Dissolved Major Cations	125 ml Polyethylene	Filtered, HNO ₃ , Cool to 4°C	180 days
Total Mercury	250 ml pre-cleaned specialty	Unfiltered, Unpreserved, Cool to 4°C	48 hours
Major Anions	250 ml Polyethylene	Filtered, Unpreserved	28 days 48 hours (NO ₂ , NO ₃)
Alkalinity	500 ml Polyethylene	Unfiltered, Unpreserved, Cool to 4°C	14 days
Nitrogen, NO ₂ , NO ₃	250 ml Glass	Unfiltered, H ₂ SO ₄ , Cool to 4°C	28 days
Total Cyanide	500 ml Polyethylene	Unfiltered, NaOH, Cool to 4°C	14 days

**MAGENTA DRAIN TUNNEL SAMPLING
EMPIRE MINE STATE HISTORIC PARK
GRASS VALLEY, CALIFORNIA**

**STANDARD OPERATING PROCEDURE NO. 3
SURFACE WATER FLOW MEASUREMENT**

Version 1.0

**STANDARD OPERATING PROCEDURE NO. 3
WATER SAMPLE COLLECTION
Version 1.0**

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1.0 PURPOSE AND SCOPE

The purpose of this document is to define the Standard Operating Procedures (SOP) for measuring surface water flow. Flow will be expressed in cubic feet per second (cfs) or gallons per minute (gpm). A complete discussion of all available flow measurement techniques and the theory behind them is beyond the scope of this text (see USGS Water-Supply Paper 2175). This SOP outlines the three methods for measuring flow: (1) permanently installed or portable flumes, (2) the velocity-area method using Price AA, pygmy, or Marsh-McBirney meters, or (3) the volumetric method.

Because of the dynamic nature of surface water, flow measurement by the methods described in this document may, on occasion, be impossible at the site. If unmeasurable flow conditions exist at the surface water site, the field team will attempt to measure flow at a point upstream or downstream of the site and will note this point relative to the marked data collection point. Whether or not a measurement is made, the team will note the conditions that inhibited accurate flow measurement.

The discharge measurement method to be used at each site will be described in the field notes. Each of these methods will be presented in the following format:

- Method name
- Required measurement conditions
- Equipment
- Maintenance and calibration procedures
- Field procedures
- Flow calculations

2.0 RESPONSIBILITIES AND QUALIFICATIONS

The project manager or task leader is responsible for assigning project staff to measure flow at the Magenta Drain Tunnel. The project manager is also responsible for assuring that this and any other appropriate procedures are followed by all project personnel. The project staff assigned to measure discharge are responsible for completing their measurements according to this and other appropriate procedures.

Only qualified personnel will be allowed to perform these procedures. Qualifications are based on education, previous experience, and on-the-job training and supervision by another qualified person.

3.0 PROCEDURES

3.1 Methods

This section describes the three methods that will be used to measure discharge. If none of these three methods can be used to measure discharge at the sample location, then other methods may be selected and added as addenda to this SOP; or, the measurement point will be evaluated in terms of whether it can either be relocated to a point which permits discharge measurement or whether the point should be eliminated.

3.1.1 Velocity-Area Method

Surface flow in stream channels and ditches that lack permanent flumes can be measured using a current meter or velocity-area method.

Marsh-McBirney Velocity Meter

Portable Marsh-McBirney meters are a type of current meter that may be used in the velocity-area flow measurement. Either Model 201D or Model 2000 will be acceptable for the required gauging. The Marsh-McBirney meters measure flow velocity using the Faraday principle which states that as a conductor moves through and cuts the lines of a magnetic flux, a voltage is produced. The magnitude of the generated voltage is directly proportional to the velocity at which the conductor moves through the magnetic field.

The selector switch of the Model 201D has five positions, these positions are OFF, CAL, FT/SEC, M/SEC and KNOTS. To check for electronics failure or discharged batteries, the selector is first switched to the CAL position and the time constant switch to 2. If this is not the case, change the batteries and check CAL again. The time constant switch is used to help stabilize the velocity readings. General procedures are to begin with the smallest time constant and increase if the readout velocity does not stabilize.

The sensor on the Marsh-McBirney meter can be connected to the universal sensor mount on the top-setting wading rod and used to determine flows using either the six-tenths depth method or the two-tenths and eight-tenths depths method. The minimum flow depth at which an average velocity can be measured with the Marsh-McBirney meter set at six-tenths of total depth is approximately 0.18 feet. Velocities can be estimated in flows as shallow as 0.1 feet. The meter is capable of measuring velocities ranging from 0 to 20 feet per second.

Vertical Axis Current Meter

The vertical axis current meter is acceptable when using the velocity-area method for the following reasons:

- This meter operates in lower velocities than the horizontal-axis meter
- Bearings are well-protected from silty water
- Rotor can be repaired in the field without adversely affecting the measurement
- Single rotor serves for the entire range of velocities

A common type of vertical axis current meter is the price current meter, type AA or Marsh-McBirney.

In addition to the type AA meters, the U.S. Geological Survey and others use a Price pygmy meter in shallow depths. The pygmy meter is scaled two-fifths as large as the standard meter and has neither a tailpiece nor a pentagear. The contact chamber is an integral part of the yoke of the meter. The pygmy meter makes one contact per revolution. The predominant flow conditions in channelized streams indicate that either the pygmy meter or the Price AA meter may be needed at particular sites, depending on the amount of runoff contributing to stream flow at the time.

Theoretical Considerations

The volume rate of flow of water, which is commonly called discharge (Q), is the product of multiplying the average velocity (V) times the total cross-sectional area (A):

$$Q = VA$$

where Q is the total discharge, V is the average velocity for the entire cross section, and A is the total cross-sectional area.

Any current meter measures velocity at a point. The velocity-area method of making discharge measurements at a cross section requires measurement of the mean velocity in multiple portions of the cross section at each of the selected verticals. These are taken at subsections of the cross section. A complete discussion of velocity observation methods is found in United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Stream flow: Volume 1 - Measurement of Stage and Discharge, Chapter 5. These methods have been found to accurately measure average velocities.

By dividing the stream width into subsections, total discharge becomes the total of discharges measured in each subsection. Individual point velocity (v) is measured at each subsection, and discharge becomes the sum of the products of each point velocity and cross-sectional area (a) of each subsection:

$$Q = \sum_1^n va$$

where Q is total discharge, v is point velocity, and a is the area of the subsection. A cross section is defined by depths at verticals, 1, 2, 3, 4,... n . At each vertical, the average velocity is measured by a current meter.

The current meter measurements performed in channelized streams will be based on selecting subsections to contain approximately 10 percent or less of the total discharge. In general, depending on average depth and velocity distribution, a stream less than 2 feet wide will require no more than 8 to 10 subsections. A stream up to 4 feet wide will require about 10 to 12 subsections. Streams wider than 4 feet will require more subsections. Further, subsections need not be of identical width. For example, because velocities near banks are generally lower than velocities near the center of streams, these subsections may be wider than subsections near the center. Subsections will also be more closely spaced if a stream has an unusually deep portion in the cross section, or if velocities are higher than usual for the cross section. Velocity will be observed by current meter at each point for a period that ranges from 40 to 70 seconds.

The following table is to be used to guide the selection of the approximate number of subsections to be used based on stream width:

Table 1 Number of Subsections Based on Stream Width

Approximate Width (ft)	Approximate Number of Subsections	Approximate Distance between Subsections (ft)
<2	8-10	0.2-0.3
2-4	10-12	0.3-0.4
4-10	12-15	0.4-0.7
10 -20	15-20	0.7-1.0
>20	20-25	1.0-2.0

The stage of a stream is the height of the water surface above an established datum plane. The water-surface elevation referred to is some arbitrary gage datum is called the “gage height.” Stage or gage height is to be measured and recorded in feet and hundredths of a foot.

Required Measurement Condition

In order to make a velocity-area discharge measurement, the following conditions are required:

1. The stream must be channelized; that is, observable banks must channel the stream flow.
2. Depth must be greater than 0.2 foot across most of the cross section being measured.
3. The stream must have measurable velocity of at least 0.2 feet per second (fps) in most of the cross section, although the pygmy meter is capable of measuring velocity as low as 0.07 fps.

Conditions No. 2 and 3 can often be met in streams of very low discharge by conservatively modifying the stream channel to produce a narrower and slightly deeper cross section in order to meet measurement requirements. These modifications will include removal of aquatic growth or ice, moving large stones which impact velocity upstream or downstream of the cross section, and narrowing or deepening of the cross section. By rearranging small amounts of native rock or sand, the technician will produce a measurable cross section. When such modifications are made, great care will be exercised to avoid unnecessary movement of sediments. After clearing the cross section, allow the flow to stabilize before measurement begins.

Current meter measurements are best made by wading, if conditions permit. Wading measurements have a distinct advantage over measurements made from cableways or bridges in that it is usually possible to select the best of several available cross sections for the measurement. The type AA, Pygmy meter, or Marsh-McBirney is used for wading measurements. Table 2 lists the type of meter and velocity method to be used for wading measurements at various depths. A discussion of Table 2 follows the table.

Some departure from Table 2 is permissible. For example, if a type AA meter is being used in a measurement section that has most of its depth greater than 1.5 feet, the pygmy meter should not be substituted for a few depths that are less than 1.5 feet, or vice versa. The type AA meter should not typically be used in depths less than 1.25 feet. The Marsh-McBirney meter is appropriate for all depths deeper than 0.15 feet.

Table 2 Current Meter and Velocity Method for Various Depths (ft)

Depth (feet)	Meter*	Velocity Method (% of Depth)
1.5-2.5	Type AA	0.6
0.3-1.5	Pygmy	0.6
<0.3	Pygmy	0.5

* The Marsh-McBirney meter is appropriate for all depths deeper than 0.15 ft.

In the 0.6-depth, an observation of velocity made in the vertical at 0.6 of the depth below the surface is used as the mean velocity in the vertical. The 0.5-depth method will be used in very shallow stream conditions, with depths of less than 0.3 feet. This method requires that the meter be set at one-half the depth of water at the point, or at the lowest setting on the rod. For streams deeper than 2.5 feet, the two point measurement method (i.e., velocity measurement at 20% and 80% of the total stream depth) is recommended.

Vertical axis current meters do not register velocities accurately when placed close to a vertical wall. A Price meter held close to a right-bank vertical wall will under-register flow because the slower velocity near the wall strikes the effective (concave) face of the cups. The converse is true at a left-bank vertical wall. (The terms "left bank" and "right bank" designate direction from the center of a stream for an observer facing downstream.) The Price meter also under-registers when positioned close to the water surface or close to the streambed.

Equipment

Current meters, timers, depth and width measuring devices, and a means of counting meter revolutions are needed for measurement of discharge. The equipment includes:

- Depth-measuring device, the wading rod
- Current meter
- Width-measuring devices, either engineer's tape or tagline
- Headset
- Stop watch

Depth-Measuring Device. The depth-measuring device that will be used is the top-setting 1/2-inch-diameter hexagonal wading rod. The current meter is attached to the wading rod. The topsetting wading rod consists of a 1/2-inch hexagonal main rod for measuring depth and a 3/8-inch diameter round rod for setting the position of the current meter.

Current. A current meter is an instrument used to measure the velocity of flowing water. The principle of operation is based on the proportionality between the velocity of the water and the resulting angular velocity of the meter's rotor. By placing the current meter at a point in a stream and counting the number of revolutions of the rotor during a measured interval of time, the velocity of water at that point is determined.

The number of revolutions of the rotor is obtained by an electrical circuit through the contact chamber. Contact points in the chamber are designed to complete an electrical circuit at selected frequencies of revolution. The electrical impulse produces an audible click in a headphone. The intervals during which meter revolutions are counted are timed with a stopwatch.

Engineer's Tape or Tagline. Steel tapes, metallic tapes, or premarked taglines are used for width determinations during discharge measurements made by wading. Direct measurement of width using tapes or taglines can be accurate with proper precautions. Orientation normal to the flow pattern of the river and elimination of most of the sag, through support or tension, are recommended for improved accuracy.

Headset. A headset attaches to an electronic connection at the upper end of the wading rod. The hydrographer wears this headset to listen to audible clicking sounds which are produced when a rotating gear in the current meter makes contact with a thin wire ("cat's whisker") in the contact chamber. The rotating gear contacts the cat's whisker once each time the series of cups on the meter revolves one complete turn. The number of rotations are counted and timed. The first click is counted as zero. The relationship between rotations and time is the point velocity. Velocities as a function of time are listed on a velocity chart, which is kept in the current-meter carrying case.

SWU Watch. A stopwatch is used to measure time during which velocity is measured at each point in the cross section. Velocity at each point is measured for a period greater than or equal to 40 seconds and less than or equal to 70 seconds.

Staff Gage. Each location where the velocity-area method will be consistently applied may be equipped with a standard U.S. Geological Survey (USGS) vertical staff gages. The staff gages will be used to measure gage height to the nearest 0.02 of a foot.

Maintenance and Calibration Procedures

Prior to use of the current meter and following use of the meter, spin tests will be conducted to ensure that the unit performs acceptable. The spin test will be performed in an enclosed area, such as in the cab of a truck or in the enclosed rear of a truck, to prevent wind interference. The test is to be performed prior to attaching the current meter to the wading rod. While holding the meter steady in an area sheltered from breezes, the technician will spin the rotor and then press the start button on the stopwatch. The technician will observe the meter until the rotor ceases to spin.

The duration of the spin for the pygmy meter should be more than 40 seconds and for the Price AA meter should be more than 90 seconds. If the meter fails to meet the time-of-spin criteria, the meter will be cleaned and oiled before use. If the meter continues to spin well beyond these time limits, the record will indicate that the meter spun for 40+ seconds, in the case of the pygmy meter, or for 90+ seconds, in the case of the Price AA meter.

To ensure reliable observations of velocity, it is necessary that the current meter be kept in good condition. Before and after each discharge measurement, the meter cups or vanes, pivot and bearing, and shaft should be examined for damage, wear, or faulty alignment. During measurements, the meter will be observed periodically when it is out of the water to be sure that the rotor spins freely.

Meters will be cleaned and oiled daily when in use. If measurements are made in sediment-laden water, the meter will be cleaned immediately after each measurement. After oiling, the rotor will be spun to make sure that it operates freely. If the rotor stops abruptly, the cause of the trouble will be sought and corrected before using the meter.

In addition to meter maintenance, the entire unit, consisting of current meter, wading rod, digital counter, and headset, will be checked before departure to the field each day as follows:

- Attach the current meter and digital counter/headset to the wading rod.
- Test the headset by:
 - Spin the current meter to ensure that audible clicks occur.
 - If audible clicks do not occur, the following steps should correct the problem:
 - Check that electronic connections are tight.
 - Check that the cat's whisker lightly contacts the upper part of the shaft.
 - Spin again. If audible clicks still do not occur, check that the battery in the headset is properly aligned. Replace the battery, if necessary.

Field Procedures

Overview. Based on approximate depths, either the Price AA, Marsh-McBirney, or pygmy meter will be selected to perform a velocity-area measurement. Neither the Price AA nor pygmy meter should be used for measuring velocities slower than 0.1 fps unless absolutely necessary. If depths or velocities under natural conditions are too low for a dependable current meter measurement, the cross section will be

modified, if practical, to provide acceptable conditions. A shovel will be used to remove aquatic vegetation, ice, or rocks which may interfere with meter operation or discharge measurement.

Before velocity-area measurements are taken, use the staff gage to measure and record the gage height to the nearest 0.02 of a foot.

At each measurement point (or station) across the stream cross section, depth is measured prior to measurement of velocity. Therefore, it is recommended that the wading rod be set with the current meter suspended out of the water and above the tagline, which is used to measure width and to identify stations across the cross-section. Placement of the rod about 0.5 feet downstream from the tagline prevents contact between the tagline and the current meter when the meter is lowered into measuring position.

The wading rod will be placed in the stream so the base plate rests on the streambed, and the depth of water will then be read from the graduated main rod. The main rod is graduated into 0.1-foot increments: these increments are indicated by a single score in the metal. Half-foot increments are marked by two scores in the metal, and each foot is marked by three scores in the metal. A vernier scale on the upper handle of the rod corresponds to 0.1-foot increments. The top-setting rod, to which the meter is attached, has single scored marks which are aligned with values on the vernier scale.

The hydrographer reads water depth directly from the main rod. In high velocity areas, it is recommended that depth be read as the value between the depth on the upstream side of the rod and the depth on the downstream side of the rod. Depth is measured to the nearest 0.02 foot. This depth is used to set the vertical location on the current meter.

Next, the top-setting rod is adjusted downward so that the scored mark which corresponds to the range of depth in feet (e.g., if depth = 0.46, range in feet = 0; or if depth = 1.72, range in feet = 1) is aligned with the stream depth value transposed to the vernier scale. This automatically positions the meter for use in the 0.6 method as the meter is then six-tenths of the total depth from the surface of the water. If depths are less than 0.30 foot, the 0.5-method may be used. The observed depth will then be 0.5 of the total depth.

The hydrographer will stand in a position that least affects the velocity of the water passing the current meter. That position is obtained by facing upstream while holding the wading rod vertically and close to the tagline or measuring tape. The hydrographer stands at about a 45-degree angle downstream from the wading rod and at least 1.5 feet from the wading rod. This angle is an imaginary angle between the extended arm holding the wading rod and the tagline or measuring tape. The hydrographer should avoid

standing in the water if his or her feet and legs occupy a significantly large percentage of a narrow cross section. For narrow streams, it is often possible to stand astride the stream.

The wading rod should be held in a vertical position with the meter parallel to the direction of flow while the velocity is being observed. When measuring streams that have shifting beds, the soundings or velocities can be affected by the scoured depressions left by the hydrographer's feet. For such streams, the meter should be placed ahead of and upstream from the hydrographer's feet.

Once the velocity-area measurements have all been taken, measure and record the gage height from the staff gage to the nearest 0.02 foot again.

Steps to be Followed in Measuring Discharge. Water quality and bed material samples will be collected prior to making discharge measurements. The following steps are to be followed in discharge measurement:

- Use the staff gage to measure and record the gage height to the nearest 0.02 of a foot.
- Measurement notes should be recorded at each subsection of the cross section as the measurement is performed. If two people are performing the measurement, the hydrographer may state the stations, depths, counts, and number of seconds to a note keeper. The note keeper would then repeat each value stated by the hydrographer to ensure agreement between the value stated by the hydrographer and the value heard by the note keeper.
- Record on the field data collection form the following: distance from initial point, width, depth, observation depth, revolutions, time in seconds, velocity, area, discharge.
- Note the distance in feet in terms of stream direction that this cross section lies from the prescribed location. For example, the note may read "25 feet downstream" or "15 feet upstream." This is recorded in a manner similar to that on the front of the discharge measurement note.
- If the selected cross section contains aquatic growth, ice, boulders, or slack-water area that can either interfere with operation of the current meter or otherwise impede accurate measurement, use a shovel to remove minor flow impediments.
- Several measurement locations are required from one side of the stream to the other. Select the approximate number of subsections at which to take measurements as listed on Table 2. Position a tape (for small streams) or the tagline (for large streams) about one foot above the surface of the water. Secure the tape so that it remains taut and perpendicular to the channel.
- Select a starting point at either the left bank (left edge of water, LEW) or the right bank (right edge of water, REW), which is determined by facing downstream.
- Measure the width of the stream in feet. After selecting the Marsh-McBirney, the Price AA or pygmy meter (see Table 1), follow Table 2 to select the number of subsections in which to measure velocity. The goal in selection of measurement stations is to measure no more than ten percent of the total discharge in any given subsection. Subsections need not be identical in width. Use more observation points in deep areas or portions of the channel having higher velocities. Frequently, fewer observation points are needed near the shore than near the

center of the stream. Obvious breaks in streambed configuration are also proper locations at which to measure velocities.

- After determining the desired distance between stations, measurement can begin. Record the time and bank at which measurement starts on the discharge measurement note as "REW Start 0000", using REW or LEW, depending upon whether starting at the right or the left edge of the water. 24-hour clock time is used, and is recorded to the nearest five minutes.
- Note the distance to the beginning edge of water from the initial point. The initial point is an arbitrary point on the tape, preferably a whole number, which lies on the shore side of the stream. All subsequent station locations are recorded as distances from the initial point.
- Proceed to the first station. Record the distance from the initial point on the discharge note.
- Stand downstream of the tagline or tape and face upstream. Begin with the current meter on the wading rod well above the surface of the water.
- Measure stream depth at the measurement point on the wading rod. Individual lines on the wading rod indicate 0.10-foot increments; double lines indicate 0.50-foot increments, and triple lines indicate 1.00-foot increments. Record the stream depth to the nearest 0.02 feet: for example 0.32 feet or 1.54 feet.
- Lower the meter to the required depth and record the observation depth in the logbook. The observation depth as a fraction of total depth is usually 0.6, or 0.5 for subsections having depth of less than 0.3 feet.
- Stand downstream of the meter with the arm fully extended as you hold the wading rod. Position yourself so that the angle measured between the arm and the tagline is about 45 degrees. Stand as far away from the vertically held wading rod as possible.
- Start the stopwatch and begin counting clicks. The first click is counted as zero.
- After at least 40 but as much as 70 seconds have passed, stop the stopwatch. Record number of seconds and number of revolutions (clicks) on the same line of the note as the depth was recorded.
- Determine velocity as a function of elapsed time and number of revolutions from the velocity chart. Record velocity next to the other values for this station.
- Proceed to the next station. Record the distance from the initial point to the station. Repeat measurements of depth and velocity. Continue in this manner across the stream.
- After recording the distance measurement at the last station, record the time at which the ending edge of water is reached as "LEW (or REW) FINISH 1330."
- Note velocity and depth at the edge of water as zero.
- Following velocity-depth measurements, use the staff gage again to measure and record the gage height to the nearest 0.02 of a foot.
- Evaluate and record on the data collection note the following: Flow characteristics, weather, air temperature, water temperature, observer(s), type of meter, and remarks.
- For QA/QC purposes, each team should make repeat measurements at a station to document method precision. These measurements should be conducted at a minimum of one per every 20 flow measurements.

Discharge Calculations

A stream discharge is the summation of the products of the subsection areas of the stream cross section and their respective average velocities. The formula:

$$Q = \sum(av)$$

represents the computation, where Q is the total discharge, a is an individual subsection's area, and v is the corresponding mean velocity of flow normal to the subsection. The summation of the discharges for all the subsections is the total discharge for that stream cross section. The order for calculating discharge is:

- Use the distances, from initial point to compute width for each section. The first width is computed by subtracting the first distance from the second distance, and dividing this quantity by two. The second width is the difference between the third distance and the first distance, divided by two. For each subsequent width, subtract the distance on the line above the line you are calculating from the distance on the line below the line you are calculating, and divide this quantity by two. This procedure is carried out for each line until you reach the final width calculation. This is calculated as the difference between the final and the second-to-last distance, divided by two.
- Subsequent calculations will be performed as follows:
 - Calculate each discharge for each subsection by multiplying the width of the subsection times the depth times the velocity.
 - Sum the discharges for each subsection to arrive at total discharge for the entire cross section.
 - If the two-point measurement method was employed, average velocities to obtain a "mean" velocity for the partial section.
- Check your math by summing the subsection widths. Their total should equal the value obtained by taking the difference between the LEW and the REW station distances from initial point.
- Initial at the line "Comp. by" to identify yourself as the person responsible for performing the discharge calculation.

3.1.2 Flumes

Theoretical Considerations

Flumes are specially shaped open-channel flow devices that constrict channel area and change the slope to force the flow through critical depth. Typical flumes consist of three sections:

- A converging section to accelerate the approaching flow
- A throat section, whose width is used to designate flume size

- A diverging section, designed to ensure that the level downstream is lower than the level in the converging section

The hydraulic theory behind flume is based on a calibrated constriction placed to change the level of the water in or near the constriction. By knowing the dimensions of the constriction, the discharge through the constriction will be a function of the water level. A simple depth determination near the constriction provides a discharge measurement. Flumes are constructed so that a restriction in the channel causes the water to accelerate, producing a corresponding change (drop) in the water level. The head can then be related to discharge.

Required Measurement Conditions

The flow rate through a flume is determined by measuring the gage (flow depth) at a single point upstream from the throat. The gage height measurement determines the discharge only if critical flow is achieved in the throat of the flume. By definition, critical flow is when the ratio of force due to inertia to the force due to gravity (Froude number) is unity. Supercritical flow occurs when the Froude number exceeds unity. If the Froude number is less than one, subcritical flow occurs, commonly due to a condition referred to as submergence. If submergence exists, a second depth reading must be taken in the throat section to determine the flow rate. Additional information concerning the use of flumes under all flow conditions, including submergence, is found in USGS Water Supply Paper 2175, Volume 2, Chapter 10.

Equipment

For purposes of discharge measurements, existing flumes located at some of the surface water sites will be inspected and flow rates measured prior to sampling. Additional flumes may be permanently or temporarily installed at some sites.

Parshall Flume. The Parshall flume consists of a converging section with a level floor, a throat section with a downward sloping floor, and a diverging section with an upward sloping floor. The principal feature of the Parshall flume (developed by R. Parshall. in 1922) is an approach reach having converging sidewalls and a level floor of which the downstream end is a critical depth section. Critical flow is established at the throat due to a sharp downward break in the slope of the flume. The slope downstream from the level approach section is therefore supercritical. The primary gage height measurement is made in the approach reach at a standard distance upstream from the critical-depth cross section.

Portable Flume. A bed slope of less than one percent for a distance of four to six feet upstream of a portable cutthroat flume is necessary for proper operation for throat widths ranging from one to six

inches. Also, a flow width equal to at least two times the front width of the flume is recommended upstream of the flume. The flume must be installed level, plumb and square. All of the flow must be diverted into the flume inlet. After the flow has equilibrated, the up and downstream staff gages provided in the flume should be read and flow depths recorded. The flume should be installed so free-flow occurs, that is the flow through the flume reaches critical depth in the vicinity of minimum width in the flume. If free-flow conditions exist, only the upstream gage needs to be read. For submerged flow conditions both the upstream gage (head) and downstream gage needs to be read to determine discharge.

Maintenance and Calibration Procedures

All flumes will be inspected prior to measurement of discharge to determine that the flume is discharging freely. Any problems observed during the inspection will be noted and reported to the site supervisor.

Field Procedures

Overview. If the site is equipped with a permanent flume, then discharge will be measured as described below.

Steps to be Followed in Measuring Discharge from a Permanent Flume

- Remove any material that may have accumulated in the flume.
- Note any deterioration of the flume; report these conditions to the project technical consultant at the conclusion of daily data collection activities.
- Measure and record the throat width to the nearest 0.01 of a foot.
- Record the time and date of the site visit.
- Use the staff gage to measure and record the gage height to the nearest 0.02 of a foot.
- Calculate discharge using tables or equations suitable for the width and type of flume
- Record the calculated discharge (Should any leakage occur around the flume, the amount of leakage is estimated as a percent of the total measured flow and added to the calculated flow value).

Steps to be followed Measuring Discharge from a Portable Flume

- Remove any material that hinders ability to form a flat surface for flume to be level, plumb, and square. Use a leveling device to ensure the flume is level and plumb.
- Follow the steps measuring discharge from a permanent flume.

3.1.3 Volumetric Method

The volumetric method consists of capturing flow in a container and measuring the time required to fill the container. This may be accomplished by building a small earthen dike to divert the flow through a pipe, temporarily placed in the channel, into a container with a known calibrated volume. The container is placed below the discharge pipe, and the time required to fill the known volume is recorded with a stopwatch. The measurement is repeated at least three times and the resulting values averaged. If the variance between the time measurements exceeds ten percent, the measurement procedure is repeated. Should any leakage occur through or around the dike, the amount of leakage is estimated as a percent of the total measured flow and added to the calculated flow value.

Required Measurement Condition

The volumetric method of measurements is best used for measurement of small flows that are immeasurable by other methods, and can be diverted through a pipe. The flow has to be fully controlled through the pipe with no leakage through or around constructed dike.

Equipment necessary to measured discharge includes: smooth section pipe, graduated container or container of known volume, stopwatch.

Maintenance and Calibration Procedures

The pipe and container will be inspected for damage prior to use. If any cracks or holes exist in the pipe or container, the pipe shall be replaced. Only a pipe with a smooth surface shall be used. The volume of the container will be determined and documented.

SURFACE WATER DATA SHEET

IDENTIFICATION

Sample Location _____ Date _____ Time _____ Page ___ of ___
Sample Control Number _____ Samplers _____

WEATHER CONDITIONS

Ambient Air Temperature: _____ BC ~ BF ~ Not Measured? ~
Precipitation: None ~ Rain ~ Snow ~ Heavy ~ Moderate ~ Light ~ Sunny ~ Partly Cloudy ~

INSTRUMENT CALIBRATION

pH pH meter number: _____
Buffer _____ Measured Value _____ Temperature _____ BC ~ BF ~
Buffer _____ Measured Value _____ Temperature _____ BC ~ BF ~

Conductivity Motor Calibration/Measurement Meter number: _____
Standard Value _____ $\mu\text{S}/\text{cm}$ Measured Standard Value _____ $\mu\text{S}/\text{cm}$ Temperature _____ BC ~ BF
~
Standard Value _____ $\mu\text{S}/\text{cm}$ Measured Standard Value _____ $\mu\text{S}/\text{cm}$ Temperature _____ BC ~ BF
~

SAMPLE LOCATION DESCRIPTION

SAMPLE COLLECTION PROCEDURE

DISCHARGE MEASUREMENT

Method: _____
Meter Type/Model/Serial No.: _____
Comments/Observations: _____

Discharge _____ Staff gauge _____

Final Sample Parameters

Sample Date	Sample Time	Discharge	PH	Cond. ($\mu\text{S}/\text{cm}$)	Temp. BC ~ BF ~	Turbidity (Descriptive)

Was a duplicate sample collected? Yes ~ No ~ (sample control number _____)
Was a field blank collected? Yes ~ No ~ (sample control number _____)
Was a rinsate sample collected? Yes ~ No ~ (sample control number _____)

Notes _____

DISCHARGE MEASUREMENT NOTE

Sample Location: _____ Date: _____ Samplers: _____

Method: _____ Meter Type/Model/Serial No.: _____

Observations: _____

DIST FROM INIT POINT	WIDTH (FT)	DEPTH (FT)	OBSER DEPTH	REVS	TIME (SEC)	VELOCITY (F/S) AT POINT MEAN IN VERTICAL	AREA (FT)	DISCHARGE (CFS)
LEW or REW (circle one) at time = _____								
LEW or REW (circle one) at time = _____								

**MAGENTA DRAIN TUNNEL SAMPLING
EMPIRE MINE STATE HISTORIC PARK
GRASS VALLEY, CALIFORNIA**

**STANDARD OPERATING PROCEDURE NO. 4
SEDIMENT SAMPLING**

**STANDARD OPERATING PROCEDURE NO. 4
SEDIMENT SAMPLE COLLECTION
Version 1.0**

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1.0 PURPOSE AND SCOPE

The purpose of this document is to define the Standard Operating Procedures (SOP) for sediment sampling for physical or chemical analysis. The sediment is to be sampled from the Magenta Drain channel.

The sediment collection method to be used at each site will be described in the field notes. Each of these methods will be presented in the following format:

- Method name
- Measurement conditions
- Equipment
- Field procedures

2.0 RESPONSIBILITIES AND QUALIFICATIONS

The project manager or task leader is responsible for assigning project staff to collect sediment samples at the Magenta Drain Tunnel. The project manager is also responsible for assuring that this and any other appropriate procedures are followed by all project personnel. The project staff assigned to collect sediment samples are responsible for completing their sample collection according to this and other appropriate procedures.

Only qualified personnel will be allowed to perform these procedures. Qualifications are based on education, previous experience, and on-the-job training and supervision by another qualified person.

3.0 PROCEDURES

Sediment in a surface water course with little or no free water may be sampled by directly scooping the sample with a stainless steel or, as appropriate, plastic instrument (trowel, scoop). All sediments, including sediment submerged under water, may be sampled by the following method.

At each site, a sample will be collected from a depth of 0-4" in depth over an area approximately one-foot square, depending on sediment occurrence. Approximately 2 cups of sediment will be collected for each sample using a stainless steel or plastic trowel or large spoon.

Sampled material will consist of well-sorted, fine-grained, sediment within the stream channel. At sites where transported fine-grained sediment is not present, coarser streambed material will be collected. Organic material will be hand-removed from the sample (to the extent practical) during collection.

Sediment may be first collected in a stainless steel or plastic bowl for mixing and removing gravel and organic material before transferring to the sample container.

The sample shall be placed directly from the sampler into the prescribed sample container and labeled and preserved in a manner consistent with Section 4.0. All samplers shall wear clean latex gloves or equivalent during the sampling event.

4.0 QA/QC SAMPLING

Field duplicates will be collected and analyzed at a rate of one duplicate per 20 primary samples as an indication of overall precision. Duplicate samples will be collected simultaneously using identical procedures as with corresponding primary samples. For duplicate sampling, approximately four to six cups of sediment will be collected, homogenized in a mixing bowl, and split into the primary and duplicate sample containers. Duplicate and primary sample description and identification will be recorded in the field notes.

5.0 SAMPLE PRESERVATION

The soil or sediment sample will be quickly inspected for color, appearance, and composition, and then placed in the sample container. The samples shall be placed in clean containers provided the laboratory unless otherwise specified by the laboratory and/or project manager. The sample will be stored (in an ice-cooled, insulated chest, if necessary) until delivery to the laboratory.

6.0 SAMPLE LABELING AND SHIPPING

A MFG, Inc. chain of custody shall be filled and included in the shipping container for all samples sent to the laboratory. The sample container will be labeled with self-adhesive tags. Each sample will be labeled with the following information in waterproof ink:

- A. Project identification
- B. Sample identification
- C. Date and time sample was obtained
- D. Sample Depth Interval
- E. Initials of the sample collector

7.0 DOCUMENTATION AND RECORD MANAGEMENT

The following information will be recorded in a field notebook or analysis logbook:

- Date of sample collection
- Name sample collector
- Sample locations and identification numbers
- Time sample was collected
- Weather conditions
- General condition of sample
- General description of samples location, water turbidity, ease of sediment removal from the channel, and amount of flow
- Any problems encountered in sample collection

8.0 DECONTAMINATION

Equipment, including samplers and any other tools or equipment used in the sampling process shall be decontaminated before and after each use. Decontamination procedures will consist of wiping with a clean paper towel or dry brushing loose soil from each piece of equipment. Next, rinse and/or scrub equipment with a DI and Alconox mixture using a clean scrub brush. Rinse with DI or distilled water, and then wipe dry with clean paper towels or air dry. If air-drying is used, ensure the area is clean and away from areas where recontamination by air deposition is possible. Store equipment in plastic or other protective covering to keep clean.