OWENS VALLEY GROUNDWATER BASIN

Sampling and Analysis Plan (SAP)

Submitted to

OWENS VALLEY GROUNDWATER AUTHORITY

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Certification

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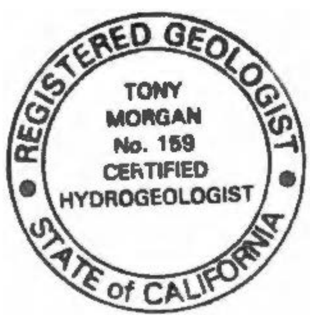

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List of Acronyms and Abbreviations

°C	degree(s) Celsius
ASTM	American Society of Testing and Materials
bgs	below ground surface
BMO	Basin Management Objective
BMP	Best Management Practices
DTW	depth-to-water
HCM	Hydrogeologic Conceptual Model
CASGEM	California Statewide Groundwater Elevation Monitoring
CDL	California Driver License
CCR	California Code of Regulations
CFR	Code of Federal Regulations
COC	chain of custody
DBS&A	Daniel B. Stephens & Associates, Inc.
DDW	SWRCB Division of Drinking Water
DO	dissolved oxygen
DQA	data quality assessment
DQO	data quality objective
DWR	California Department of Water Resources
EDD	electronic data deliverable
ELAP	California Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
GSP	Groundwater Sustainability Plan
HASP	health and safety plan
ICWD	Inyo County Water District
L	liter(s)
LADWP	Los Angeles Department of Water and Power
LCS	laboratory control sample
MD	matrix duplicate
MCL	maximum contaminant level
MDL	method detection limit
mL	milliliter(s)
MQO	measurement quality objective
MS	matrix spike

MSD	matrix spike duplicate
NAD	North American datum
NAVD	North American vertical datum
ORP	oxidation/reduction potential
OSHA	Occupational Safety and Health Administration
oz	ounce(s)
PARCC	precision, accuracy, representativeness, completeness, and comparability
PPE	personal protective equipment
QA	quality assurance
QC	quality control
PQL	practical quantitation limit
psi	pounds per square inch
RASA	regional aquifer-system analysis
RL	reporting limit
RP	reference point
RPD	relative percent difference
SAP	sampling and analysis plan
SOP	standard operating procedure
SVOC	semivolatile organic compound
SUM	summation
SWN	DWR state well number
SWRCB	California State Water Resources Control Board
TCLP	toxicity characteristic leaching procedure
TD	total depth
TDS	total dissolved solids
TFR	total filterable residue
TMDL	Total Maximum Daily Load
TVGMD	Tri-Valley Groundwater Management DistrictUSGS U.S. Geological Survey
VOC	volatile organic compound
WLE	water level elevation

1. Sampling and Analysis Plan Description and Management

Daniel B. Stephens & Associates, Inc. (DBS&A) has prepared this *Sampling and Analysis Plan (SAP)* for the Owens Valley Groundwater Authority (OVGA) and is under contract to prepare their Sustainable Groundwater Management Act (SGMA) of 2014 Groundwater Sustainability Plan (GSP or Plan). This SAP is intended to be included as an Appendix in the final GSP for the Owens Valley Groundwater Basin ((DWR basin ID: 6-12) and the Fish Slough subbasin (DWR basin ID: 6-12.02) (Figure 1-1)

1.1 Introduction, Problem Definition and Background

This section describes the purpose of the SAP and provides background information.

1.1.1 Purpose of the SAP

The purpose of this Sampling and Analysis Plan (SAP) is to establish SGMA compliant monitoring protocols and standard methods for water quality and groundwater level data collection in the Owens Valley Groundwater Basin. Water quality field sampling in the basins includes both groundwater and surface water. This SAP details:

- Water sample collection procedures;
- Analytical methods to be used;
- Groundwater level measurement protocol in water wells; and
- Data Quality Assurance (QA) and Quality Control (QC) procedures.

This SAP is not intended to impose specific schedules or monitoring wells and/or sampling locations on Inyo County Water Department (ICWD), City of Bishop, Mono County, or other entities. The SAP is intended to formalize field techniques and procedures that OVGA or other entities may already have in place for their respective existing long-standing monitoring programs. A brief summary of these monitoring networks are presented later in this SAP.

1.1.2 Background

DBS&A has developed this SGMA-focused Sampling and Analysis Plan (SAP) as a companion document to the Monitoring Plan and Data Gaps Analysis Technical Memorandum (Tech Memo) deliverable. The Tech Memo will provide recommendations on filling data gaps (temporal and spatial). SGMA requires aquifer-specific evaluation (DWR, 2016b) which will be a challenge in these basins (and in many basins across the State) as many existing monitoring points utilize privately owned agricultural wells or municipal wells potentially screened across multiple water-bearing units.

The Tech Memo is anticipated to include, but is not necessarily limited to, descriptions of the following:

- Available groundwater level and water quality data;
- Groundwater level and water quality monitoring networks;
- A trends analysis of groundwater level and groundwater quality constituents; and
- Recommendations on how refinement and expansion of the existing monitoring programs might minimize or eliminate data gaps, especially in critical areas.

1.1.3 Technical or Regulatory Guidelines and Guidance

DBS&A has developed this SAP in accordance with California Department of Water Resources' (DWR) SGMA inspired Best Management Practices (BMP). This SAP has been prepared in accordance with DWR's BMP #1 - M*onitoring Protocols, Standards, and Sites* (DWR, 2016a). Technical guidance documents considered in preparation of this SAP include, but are not limited to, the following documents:

- Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4 (EPA, 2006)
- Requirements for Quality Assurance Project Plans, EPA QA/R-5 (U.S. EPA, 2001)
- National Field Manual for the Collection of Water-Quality Data (USGS, individual Chapters published as separate documents)
- Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1 (USGS, 2011)

Much of the content contained in DWR's BMP #1 was directly applicable to the development of this SAP and BMP content has been liberally reproduced in this SAP. Links to complete documents, available online and cited in this SAP, are included in the References Section, where available.

This SAP has been prepared to satisfy criteria contained in 23 CCR § 352.2, § 352.4 and § 352.6. Monitoring protocols are to be reviewed and modified, as necessary, at least every five years as part of the periodic GSP evaluation (5-year updates).

1.1.4 SGMA Sustainability Indicators

Six sustainability indicators have been identified in the SGMA legislation that are effects caused by groundwater conditions occurring throughout a basin that, when significant and unreasonable, become undesirable results. The basin's GSP will establish sustainable management criteria that will provide metrics for evaluating undesirable results relative to the sustainability indicators. Data must be sufficient to limit uncertainty when used to assess the sustainability indicators. The essence of the six indicators are listed below:

- Groundwater Levels;
- Groundwater Storage;
- Seawater Intrusion;
- Water Quality;
- Land Subsidence; and
- Interconnected Surface Water

"GSP Regulations allow GSAs to use groundwater elevation as a proxy metric for any (or potentially all) of the sustainability indicators when setting minimum thresholds and measurable objectives, provided the GSP demonstrates that there is a significant correlation between groundwater levels and the other metrics" (DWR, 2017).

It is anticipated that groundwater levels will be used as a proxy for assessing other sustainability indicators in the basin in establishing basin-specific sustainable management criteria so it was determined that groundwater level measurement protocols should be included as a component of this SAP.

1.1.5 U.S. EPA Data Quality Objective Process

Data collected in accordance with this SAP will be of a standardized level of quality that provides decision makers with a sufficient level of confidence in the accuracy of the data on which they rely to inform their policy decisions. This SAP describes procedures to assure that the basin-specific Data Quality Objectives (DQOs) are met, and that the quality of data are known and documented.

The following excerpt from DWR's BMP #1 recommends:
"Establishing data collection protocols that are based on best available scientific methods is essential. Protocols that can be applied consistently across all basins will likely yield comparable data. Consistency of data collection methods reduces uncertainty in the comparison of data and facilitates more accurate communication within basins as well as between basins.

Basic minimum technical standards of accuracy lead to quality data that will better support implementation of GSPs....

It is suggested that each GSP incorporate the Data Quality Objective (DQO) process following the U.S. EPA Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA, 2006). Although strict adherence to this method is not required, it does provide a robust approach to consider and assures that data is collected with a specific purpose in mind, and efforts for monitoring are as efficient as possible to achieve the objectives of the GSP and compliance with the GSP Regulations" (DWR, 2016a).

DQOs are qualitative and quantitative statements developed through the seven-step DQO process (U.S. EPA, 2006). The DQOs clarify the study objectives, define the most appropriate data to collect and the conditions under which to collect the data, and specify acceptance criteria that will be used to evaluate whether the quantity and quality of data collected are sufficient to support decision making. The DQOs are used to develop a scientific and resource-effective design for data collection. Basins-specific DQOs are presented in Section 1.3.1 of this SAP.

1.1.6 QA/QC objectives

The overall QA/QC objectives are as follows:

- Obtain data of known quality to support goals set forth in the Owens Valley Groundwater Basin GSP
- Document all aspects of the quality program, including performance of the work and flexibility for changes to mitigate issues if they are discovered in the future
- Attain QC requirements for field measurements and analyses specified in this SAP

This SAP has been prepared with consideration of the EPA document, *Requirements for Quality Assurance Project Plans, EPA QA/R-5* (U.S. EPA, 2001). Table 1-1 provides a link between the

EPA's guidance and this SAP, and identifies the sections of this SAP that address the elements of QA/R-5.

EPA QA/R-5 QAPP Element	OVGA SAP
A1 Title and Approval Sheet	Title and Approval Sheet
A2 Table of Contents	Table of Contents
A3 Distribution List	Distribution List
A4 Project/Task Organization	1.0 SAP Description and Management
A5 Problem Definition/Background	1.1 Introduction, Problem Definition and Background
A6 Project/Task Description	1.2 SAP Description
A7 Quality Objectives and Criteria	1.3 Quality Objectives and Criteria
A8 Special Training/Certification	1.4 SOPs, Special Training and Certification
A9 Documents and Records	2.1 WQ Field Activity Documentation and Record Keeping 3.1 WL Field Documentation and Record Keeping
B1 Sampling Process Design	
B2 Sampling Methods	2.2 Sampling Methods and Field Activities
B3 Sample Handling and Custody	2.3 Sample Handling, Custody and Laboratory Coordination
B4 Analytical Methods	2.5 Analytical Methods
B5 Quality Control	2.6 WQ Assurance and Quality Control 3.5 WL Quality Assurance and Quality Control
B6 Instrument/Equipment Testing, Inspection, and Maintenance	2.7 WQ Instrument and Equipment Testing, Inspection, and Maintenance Requirements 3.3 WL Equipment Testing, Inspection, and Maintenance Requirements
B7 Instrument/Equipment Calibration and Frequency	2.8 Instrument Calibration and Frequency
B8 Inspection/Acceptance of Supplies and Consumables	4.0 Requirements for Inspection and Acceptance of Supplies and Consumables
B9 Non-Direct Measurements	5.0 Non-Direct Measurements)
D2 Validation and Verification Methods	7.2 Verification Methods
B10 Data Management	6.0 Data Management
C1 Assessment and Response Actions	7.1 Assessment and Response Actions
C2 Reports to Management	7.2 Reports to Management
D1 Data Review, Verification, and Validation	8.1 Data Review and Reduction Requirements
D3 Reconciliation with User Requirements	9.0 Reconciliation with Data Quality Objectives

Table 1-1. Summary of SAP cross-over with EPA QA/R-5 Requirements.

1.1.7 Geographic Description of the Basin

The geographic area covered by the SAP is shown in Figure 1-1. The basin is primarily an alluvial groundwater basin located along the Owens River in Inyo County and extends northward of the Inyo-Mono County boundary into Mono County.

The communities of Bishop, Independence, Big Pine, Lone Pine, as well as smaller communities such as Benton, Chalfant, Olancha, Keeler, and Cartago are located within the basin, but the predominant land use is agricultural or undeveloped/range land.

1.1.8 Physical Setting of the Basin

Owens Valley is located on the eastern side of the Sierra Nevada Mountains in California on the western edge the Basin and Range Province (Figure 1-2). The surrounding watershed is approximately 3,287 mi^2, extending from Long Valley and Benton Valley in the north to Haiwee Reservoir in the south. The Owens Valley groundwater basin is comprised of Owens Valley (6-012.01) and Fish Slough subbasins (6-012.02), which are about 1,032 mi^2 and 5 mi^2, respectively. Locally, the northern arm of the Owens Valley subbasin that contains Chalfant, Hammil, and Benton Valleys is referred to as “Tri-Valley.” For the purposes of this plan, this area is included when referring to the Owens Valley groundwater basin unless stated otherwise.

Elevations in the watershed range from 14,505 ft above mean sea level (amsl) at the summit of Mt. Whitney to 3,529 ft amsl in the Owens Dry Lake portion of the watershed. Topography can be broadly classified into three categories: mountain uplands, volcanic tablelands, and valley fill. The margins of the watershed are primarily composed of the steep, mountainous uplands. The western boundary is formed by the Sierra Nevada Mountains and the eastern boundary is formed by the White and Inyo Mountains, resulting in an elongated U-shaped watershed. The volcanic tablelands located to the north of Bishop are not nearly as prominent as the mountainous uplands but form a local topographic high. Valley fill makes up nearly a third of the total watershed area, formed by deposition from the Owens River, tributaries draining the surrounding mountains, and paleolakes.

The Owens River enters the northern portion of the groundwater basin near Bishop and then meanders southward through the valley towards Owens (dry) Lake (Figure 1-3). Numerous tributaries drain the Sierra Nevada and enter the western portion of the groundwater basin. A relatively high drainage density and large volume of annual runoff has caused the alluvial fans formed by these streams to coalesce and form a broad apron that extends eastward towards the center of the valley (Danskin, 1998). In contrast, there is relatively little runoff coming into the basin from the Inyo and White Mountains and alluvial fans on the east side of the valley are not nearly as prominent and more isolated compared those on the west. The Owens River generally flows on the east side of the valley as a result of this asymmetrical fan configuration.

The Owens Valley is a closed basin due to the Coso Range at the southern end of the watershed preventing groundwater and surface-water outflow since the end of the Pleistocene. Surface-water and groundwater flow east and then turn south toward to the , the natural terminus of the watershed. Prior to construction of the Los Angeles Aqueduct in the early 20th century inflows to the valley generally exceeded evapotranspiration rates and formed Owens Lake, which covered more than 100 mi^2 and had depths greater than 20 ft (Danskin, 1998). Diversion of surface-water for irrigation within the valley and exported south via the Los Angeles Aqueduct significantly altered the water budget and desiccated the lake by 1926 (Saint-Amand et al., 1986). With the exception of very wet years, Owens (dry) Lake is a playa and was one of the largest sources of dust pollution in the United States due to the combination of high winds and easily erodible sediments (Gill, 1996).

1.1.9 Historical and Current Groundwater Management in the Basin

*The discussion in this section comes from the **Owens Valley Groundwater Sustainability Plan – Monitoring Plan and Data Gaps Analysis Technical Memorandum***

Prior to SGMA, groundwater management for the Inyo County portion of Owens Valley was performed pursuant to the Long Term Water Agreement (LTWA). The overall goal of the LTWA is "to avoid certain described decreases and changes in vegetation and to cause no significant effect on the environment which cannot be acceptably mitigated while providing a reliable supply of water for export to Los Angeles and for use in Inyo County" [City of Los Angeles v. County of Inyo, 1991]. Implementation methods for these goals are described in the "Green Book," a technical appendix to the LTWA [County of Inyo and City of Los Angeles, 1990]. All lands owned by the City of Los Angeles in Inyo County are governed by the LTWA, and these lands are considered adjudicated and exempt for the purposes of SGMA.

In general, the primary goal of LTWA groundwater management for the LA-owned portion of the Owens Valley in Inyo County is to manage groundwater pumping to protect and sustain phreatophytic vegetation that depends on shallow groundwater as a primary water source. The primary goal is accomplished by a combination of monitoring, modeling, and forecasting of vegetation and hydrologic conditions on an annual basis. If pumping reduces, or is projected to reduce, soil moisture below a threshold that would cause irreversible damage to vegetation then pumping is decreased or stopped completely until water levels and soil water recover. Annual pumping plans provided by LADWP are prepared and analyzed using recent monitoring data and modeling. Since the vast majority of groundwater is pumped by the LADWP, the LTWA applies to most groundwater extraction in the Inyo County portion of Owens Valley.

In the Mono County portion of the Owens Valley, groundwater management is the responsibility of the Tri-Valley Groundwater Management District (TVGMD). According to the most recent General Plan Update [County of Mono, 2015], the TVGMD was formed in response to concern over possible exportation of groundwater from the area and implements an area-wide well-monitoring program. However, it is not clear that a comprehensive pumping or water level monitoring program exists as no groundwater data has been provided to the OVGA by the TVGMD to date. Furthermore, the TVGMD website appears to function primarily to host public announcements of monthly meetings, and does not contain groundwater management plans, or reporting and monitoring requirements. As noted by Langridge and others [2016], the TVGMD is a functioning public agency which holds periodic public meetings, but with no permanent staff and no employees on payroll (limited staff are provided by Mono County). The scope of the district's activities appear to be limited and primarily focused on preventing groundwater export from the area.

1.1.9.1 Summary of Existing Monitoring Networks

*The discussion in this section comes from the **Owens Valley Groundwater Sustainability Plan – Monitoring Plan and Data Gaps Analysis Technical Memorandum***

Multiple entities have established monitoring networks in the Owens Valley groundwater basin. The largest and most frequently measured monitoring well network is maintained by the LADWP and Inyo County Water Department. The U. S. Geological Survey (USGS) has historically conducted studies in the basin, but does not routinely monitor groundwater levels or water quality.

Several studies have included targeted data collection programs and have contributed to the available datasets in the basin.

Adequacy of the existing monitoring well network for evaluating groundwater level and quality spatially is discussed in the ***Monitoring Plan and Data Gaps Analysis Technical Memorandum***. This includes consideration of the number and distribution of wells screened discretely within in a single aquifer zone in the groundwater basin.

1.1.9.2 Groundwater Quality

*The discussion in this section comes from the **Owens Valley Groundwater Sustainability Plan – Monitoring Plan and Data Gaps Analysis Technical Memorandum***

Due to the generally high quality of water in the Owens Valley, no formal network has been established to measure and monitor groundwater quality in the basin. Monitoring is typically done on a well-specific basis according to the California Regulations Related to Drinking Water, or a site-specific basis according to the California State Water Resources Control Board in response to localized groundwater contamination (e.g., leaking underground storage tank). As a result, most groundwater quality observations are clustered around population centers in the basin. Further detail is contained in the ***Monitoring Plan and Data Gaps Analysis Technical Memorandum.***

1.1.9.3 Surface Water Quality

*The discussion in this section comes from the **Owens Valley Groundwater Sustainability Plan – Monitoring Plan and Data Gaps Analysis Technical Memorandum***

Surface-water runoff entering the Owens Valley is primarily sourced from Sierra Nevada snowmelt and is generally considered to be excellent in quality. As a result, limited surface-water quality data has been collected in the basin, typically consisting of a single sample for a given location. As it is impossible to determine water quality trends from a single data point, and the OVGA does not have any legal jurisdiction over surface-water, these data were not assimilated into the Owens Valley database. This may change if more surface-water quality data become available in the future.

1.1.9.4 Groundwater Level

> *The discussion in this section comes from the* ***Owens Valley Groundwater Sustainability Plan – Monitoring Plan and Data Gaps Analysis Technical Memorandum***

More than 535,000 water level measurements have been recorded in the Owens Valley at 1,314 wells between July 1924 and May 2020. Measurements are collected as a depth to water from a reference point, typically the top of the well casing. This value is then converted into a groundwater elevation using the elevation of the reference point. If the ground surface elevation is also known, a depth to water below ground surface (bgs) can be also be calculated. Groundwater level data assembled in the Owens Valley database were collected by multiple entities, and as such have varying degrees of data quality. Due to the sheer number of water level observations a complete review of quality of each datum prior to development of the GSP was not possible. Priority was given to checking data quality for representative monitoring points for which sustainable management criteria are based. It is anticipated that data quality issues will be addressed as they are discovered in the future.

The California Statewide Groundwater Elevation Monitoring (CASGEM) Program is a collaboration between local monitoring parties and DWR to collect statewide groundwater elevation measurements from wells in each basin throughout the State. Much of the water level data in the CASGEM database for Owen Valley basin was reported by ICWD, Mono County, TVGMD and LADWP.

1.1.10 Principal Decision Makers

The SAP principal decision maker is the OVGA Board of Directors. These decision makers will use data collected in accordance with this SAP in their basin management decision making process. Information regarding the Board composition, representation, formation and legal authority of the OVGA is included in other sections of the GSP.

1.2 SAP Description

This section describes the SAP data collection objectives and measurements for the basin.

This SAP addresses collection of water quality and groundwater level data indicative of the sustainability of human and environmental beneficial uses of groundwater in the basin. Additional analyses considerations may be necessary to address ecological receptors.

1.2.1 Basin Hydrogeologic Conceptual Model

The discussion in this section comes from the ***Owens Valley Groundwater Sustainability Plan – Hydrogeologic Conceptual Model Technical Memorandum***

The Owens Valley groundwater basin is large and complex hydrogeologic system consisting of an alluvial and fluvial aquifer interbedded with clays and volcanic flows. Confined to semi-confined conditions are generally found along the axis of the valley, with unconfined conditions present along the margin of the valley. Faults intersect the groundwater basin and act as both conduits for and barriers to groundwater flow depending on the location and orientation. Groundwater is primarily sourced from runoff that infiltrates into the alluvial fans along the margin of the valley as streams flow across them. Groundwater flow is generally from the margins towards the axis of the valley, and from the north towards the south. Naturally elevated solute concentrations are present either due to leaching of volcanic deposits or evaporative concentration in the Owens Lake area. Groundwater and surface-water in the basin are highly managed by the LADWP, with the majority of extracted groundwater exported out of the basin to the south for use in Los Angeles. Groundwater is used for a variety of purposes within the basin including agricultural, municipal, domestic, ecological, industrial, and recreational uses.

Further details on the hydrogeologic conceptual model for this basin are contained in the ***Hydrogeologic Conceptual Model Technical Memorandum*** included as an appendix to the GSP.

1.2.1.1 Analytes of Concern

Historically water quality data analytes (chemicals) of concern in the basin have generally included, but are not necessarily limited to, the following analytes:

- Arsenic;
- Nitrate;
- Total Dissolved Solids (TDS);
- Chloride; and
- Sodium

The discussion in this section comes from the ***Owens Valley Groundwater Sustainability Plan – Monitoring Plan and Data Gaps Analysis Technical Memorandum***

Both arsenic and nitrate have legally enforceable maximum contaminant levels (MCLs) of 10 micrograms per liter (µg/L) and 10 milligrams per liter as nitrogen (mg/L as N), respectively. Secondary, non-enforceable standards for TDS and chloride have been set at 500 mg/L and 250 mg/L, respectively. Sodium was included in the analysis because it is part of the conditional use permit issued by Inyo County for the Crystal Geyser Roxane water bottling plant expansion in the Owens Lake management area, although no state or federal standard has been set for it.

Further details on the analytes of concern for this basin are contained in the ***Monitoring Plan and Data Gaps Analysis Technical Memorandum*** included as an appendix to the GSP.

1.2.1.2 Historically Established Potential Sources of Groundwater Contamination

The landfills in basin have historically been identified as potential source of groundwater contamination. Each of these landfills have ongoing monitoring programs that are summarized below:

Bishop-Sunland Landfill

The Bishop-Sunland Landfill currently operates under an Evaluation Monitoring Program, indicating there has been a known release from the waste unit to groundwater. There is no significant off-site contamination at the landfill, however, contaminants have been detected in both upgradient and downgradient monitoring wells at levels generally ranging from below the laboratory Practical Quantitation Limit (PQL) to 5 µg/L. These contaminants include tetrachloroethene (PCE) and dichlorodifluoromethane (CFC-12) in downgradient wells MW-2 and MW-6, and 1,1-dichloroethane (1,1-DCA), trichloroethene (TCE), trichlorofluoromethane (CFC-11), PCE and CFC-12 in upgradient wells MW-1, MW-5. Off-site, dual-nested monitoring wells MW-8 and MW-9 are generally non-detect for all contaminants. A Corrective Action Plan has been implemented at the landfill, which includes the extraction of landfill gases from multiple sources on-site to help improve the groundwater quality.

Independence Landfill

The Independence Landfill currently operates under a Detection Monitoring Program, indicating there is no known release from the waste unit to groundwater. There is no significant off-site contamination at the landfill, however, CFC-11 and PCE have been detected intermittently in downgradient monitoring wells MW-2 and MW-3 at trace-to-low levels ranging from below the PQL to 1 µg/L. Inorganic monitoring parameters chloride, nitrate, sulfate, and TDS generally increase in concentration in all monitoring wells during drought years. Drought conditions can be further exacerbated by nearby groundwater pumping operations by the LADWP, which can run the landfill monitoring wells dry.

Lone Pine Landfill

The Lone Pine Landfill currently operates under an Evaluation Monitoring Program, indicating there has been a known release from the waste unit to groundwater. There is no significant off-site contamination at the landfill, however, 1,1-DCA, CFC-11 and PCE have been detected in downgradient monitoring wells MW-2 and MW-3 at trace-to-low levels ranging from below the PQL to 1 µg/L. There is no corrective action currently required at the Lone Pine Landfill.

Benton Landfill

The Benton Landfill currently operates under a Detection Monitoring Program, indicating there is no known release from the waste unit to groundwater. There is no significant off-site contamination at the landfill, and the groundwater monitoring wells are generally non-detect for volatile organic compounds.

Chalfant Landfill

The Chalfant Landfill currently operates under a Detection Monitoring Program, indicating there is no known release from the waste unit to groundwater. There is no significant off-site contamination at the landfill, however, CFC-11 and PCE have been detected in downgradient monitoring well MW-4 at levels generally ranging from below the PQL to 2 µg/L.

1.2.1.3 Groundwater Flow Paths and Potential Migration Pathways

Groundwater flow in the Owens Valley basin generally moves north-to-south through the alluvium. Groundwater recharge from tributary channels originating in the adjacent basin-bounding mountain ranges may locally impart an east-west groundwater flow path towards the more central portions of the basin where the flow paths evolve to the more general north-to-south orientation.

Site-specific flow paths in the basin and groundwater gradients are often influenced by localized and/or transient pumping depressions induced by well fields and individual wells pumped at high extraction rates.

The following are offered as general groundwater migration pathways of contaminates and are not specific to the Owens Valley basin. Groundwater contaminants may migrate by advection and dispersion, volatilize to soil gas, and ultimately disperse into the atmosphere, or may become adsorbed to aquifer soldis. Groundwater flow may redistribute contaminants within the shallow groundwater environment or transfer them to deeper aquifers.

1.2.1.4 Human Receptors

The predominant land use in the basin is for agricultural purposes or undeveloped rangeland/open space. Other land uses such as residential and commercial/industrial are generally limited to areas near cities, towns, or occasionally isolated commercial or industrial facilities. Potable groundwater produced for human use and consumption is monitored and regulated by the SWRCB Division of Drinking Water (large water systems) and the Inyo County Environmental Health Services (small water systems), and Mono County Environmental Health (small water systems).

1.2.2 Objectives

The primary objectives of this SAP are as follows:

- Describe water sample collection procedures;
- Analytical methods to be used;
- Groundwater level measurement protocol in water wells; and
- Data Quality Assurance (QA) and Quality Control (QC) procedures.

1.2.3 Tasks

SAP tasks include the following:

- Data collection planning and support;
- Management;
- Field acquisition of data; and
- Data review and validation.

Field activities should be conducted in accordance with this SAP to ensure proper sample management, including accurate chain of custody procedures for sample tracking, protective sample packaging techniques, and proper sample preservation techniques, as well as compliance with any applicable site-specific health and safety plans (HASP) (not included as part of this SAP).

1.3 Quality Objectives and Criteria

The following subsections present the DQOs and measurement quality objectives (MQOs) for the basin.

1.3.1 Data Quality Objectives

The seven steps of the DQO process for this SAP are presented in Table 1-2. Key to systematic planning is determining whether the problem to be solved requires a quantitative or qualitative answer (U.S. EPA, 2006).

Step 1: State the Problem
• Multiple entities collect water quality and water level data in the basin and basic minimum technical standards of accuracy are needed to ensure quality data are collected that will better support GSP implementation and OVGA policy decisions. Data must be sufficient to limit uncertainty when used to assess the sustainability indicators.
Step 2: Identify the Goal(s)
• Establish data collection protocols that are based on best available scientific methods. Protocols that can be applied consistently across the basin will likely yield comparable data. Consistency of data collection methods reduces uncertainty in the comparison of data and facilitates more accurate communication within as well as between basins.
Step 3: Identify the Inputs
• Groundwater Quality Sampling of Water Wells (dedicated monitor wells will be sampled where available) • Surface Water Quality Sampling • Groundwater Level Measuring in Water Wells (dedicated monitor wells will be sampled where available)
Step 4: Define the Boundaries of the Study
• The horizontal study boundaries are defined as the boundaries of the basin. • The vertical boundaries are defined as the base of groundwater below ground surface that is of a quality and quantity that it can be beneficially used. • There is no foreseeable temporal boundary as up-to-date water quality and water level data will continue to be necessary through GSP implementation and into the future to ensure sustainability in the basin is maintained once achieved.
Step 5: Develop an Analytical Approach
• Groundwater quality samples will be compared to the OVGA approved sustainable management criteria protective of water quality in the basin. • Groundwater levels will be compared to the OVGA approved sustainable management criteria protective of groundwater levels in the basin and any sustainability indicators in which water level is established as a viable proxy in the basins' GSP.
Step 6: Specify Performance or Acceptance Criteria
• Quality assurance samples will be collected during the sampling to evaluate sampling techniques and consistency. • Analytical results will be evaluated within their own tolerance limits and compared to appropriate screening levels. • Water quality samples will be analyzed using EPA methods that have been selected based on the reporting limits (RLs). RLs should be at a resolution that are sensitive enough to meet basins' DQOs.
Step 7: Develop a Plan for Obtaining Data
• It is not the purpose of this SAP to establish specific monitoring points but to equip the field data collecting entities active in the basins to collect data that is of a quality that will support sustainability monitoring in the basin. • The protocols established in this SAP will allow for consistently of data collection across the basin and will reduce uncertainty in data comparisons.

Table 1-2. Data Quality Objectives.

1.3.2 Measurement Quality Objectives

Analytical results of water quality samples should be evaluated in accordance with precision, accuracy, representativeness, completeness, and comparability (PARCC) and sensitivity parameters to document the quality of the data and to ensure that the data are of sufficient quality to meet the SAP objectives. Of these PARCC parameters, precision and accuracy should be evaluated quantitatively by collecting the QC samples listed in Table 1-3. The following subsections describe each of the PARCC parameters and how they will be assessed within this SAP.

Data Quality Indicator	QC Check Sample	Acceptance Criteria
Precision (RPD)	MS/MSD Field duplicates	35% RPD 50% RPD
Accuracy (Percent recovery)	MS and MSD Blanks [a]	50 to 150% recovery Less than MDL
Representativeness	The sampling methods and the analytical methods described in this SAP are designed to provide data that are representative of site conditions.	
Completeness	The objective for data completeness is 90%.	
Comparability	The use of standard published sampling and analytical methods, and the use of QC samples, will ensure data of known quality. These data can be compared to any other data of known quality.	
Sensitivity	Not applicable	RLs and laboratory RLs sensitive to basins' DQOs.

[a] May include method blanks, reagent blanks, instrument blanks, calibration blanks, and other blanks collected in the field (such as field blanks)

QC = Quality control
RPD = Relative percent difference
MDL = Method detection limit
MS = Matrix spike
MSD = Matrix spike duplicate

Table 1-3. Data Quality Indicators for Water Quality Sample Laboratory Analysis.

1.3.2.1 Precision

Precision is the degree of mutual agreement between individual measurements of the same chemical property under similar conditions. Usually, combined field and laboratory precision is evaluated by collecting and analyzing field duplicates and then calculating the variance between the samples, typically as a relative percent difference (RPD).

RPD is calculated as follows:

$$\text{RPD} = \frac{|A - B|}{(A + B)/2} \times 100\%$$

where A = First duplicate concentration
B = Second duplicate concentration

Field sampling precision can be evaluated by analyzing field duplicate samples. It is recommended that for every 10 samples collected, 1 blind duplicate sample should be collected. However, this may not be necessary for inorganic analytes with low risk of contamination during sampling and are analyzed by straight forward standardized laboratory methods.

Laboratory analytical precision is evaluated by analyzing laboratory duplicates or matrix spike (MS) and matrix spike duplicate (MSD) samples. For this SAP, MS/MSD samples should be generated for all analytes. The results of the analysis of each MS/MSD pair should be used to calculate the RPD as a measure of laboratory precision.

1.3.2.2 Accuracy

A program of sample spiking should be conducted to evaluate laboratory accuracy. This program includes analysis of the MS and MSD samples, laboratory control samples (LCSs) or blank spikes, surrogate standards, and method blanks. MS and MSD samples should be prepared and analyzed at a frequency of 5 percent. LCSs or blank spikes are also analyzed at a frequency of 5 percent. Surrogate standards, where available, are added to every sample analyzed for organic constituents. The results of the spiked samples are used to calculate the percent recovery for evaluating accuracy.

$$\text{Percent Recovery} = \frac{S - C}{T} \times 100\%$$

where S = Measured spike sample concentration
C = Sample concentration
T = True or actual concentration of the spike

1.3.2.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a population, variations in a parameter at a sampling point, or an environmental condition that they are intended to represent. For this SAP, representative data are anticipated to be obtained through careful selection of sampling locations and analytical parameters. Representative data will be obtained through proper collection and handling of samples to avoid interference and minimize contamination.

Representativeness of data can be ensured through the consistent application of established field and laboratory procedures. Field blanks (if appropriate) and laboratory blank samples should be evaluated for the presence of contaminants to aid in evaluating the representativeness of sample results. Data determined by comparison with existing data to be non-representative should be used only if accompanied by appropriate qualifiers and limits of uncertainty. However, this may not be necessary for inorganic analytes with low risk of contamination during sampling and are analyzed by straight forward standardized laboratory methods.

1.3.2.4 Completeness

Completeness is a measure of the percentage of basin-specific data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP, and when none of the QC criteria that affect data usability are exceeded.

When all data validation is completed, the percent completeness value should be calculated by dividing the number of usable sample results by the total number of sample results planned for this investigation.

Completeness should also be evaluated as part of the data quality assessment (DQA) process (U.S. EPA, 2000). This evaluation will help determine whether any limitations are associated with the decisions to be made based on the data collected.

1.3.2.5 Comparability

Comparability expresses the confidence with which one dataset can be compared with another. Comparability of data can be achieved by consistently following standard field and laboratory procedures and by using standard measurement units in reporting analytical data.

1.3.2.6 Detection and Quantitation Limits

The method detection limit (MDL) is the minimum concentration of an analyte that can be reliably distinguished from background noise for a specific analytical method. The MDL for each analyte should be listed as the detection limit in the laboratory's electronic data deliverable (EDD). The practical quantitation limit (PQL) represents the lowest concentration of an analyte that can be accurately and reproducibly quantified in a sample matrix by a specific method. Reporting limits (RL or RDL) may vary from lab-to-lab and are the lowest detection of an analyte from a sample after any sample dilution adjustments have been accounted for. Analyte concentrations below the RL are reported as not detectable. Sometimes laboratory results can be obtained for analytes below the PQL but these results should be reported as estimated values if concentrations are less than MDLs. For potable water samples, the U.S. EPA and many states have established water regulations for Maximum Contamination Levels (MCL) for primary and secondary contaminates. In California, state drinking water MCLs are often lower than the national regulations.

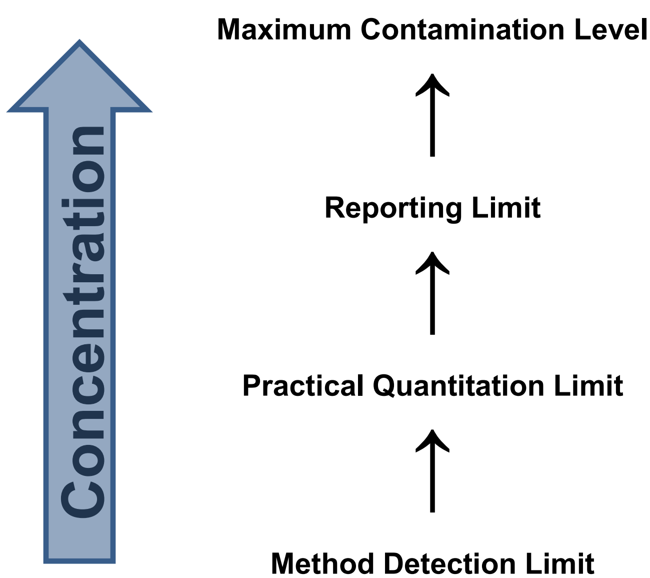

Figure 1-4. Laboratory water quality analysis detection and quantitation limits diagram.

1.4 SAP Personnel Organization

Personnel involved in SAP implementation are listed in Table 1-4, and shown as an organization chart in Figure 1-5.

Individual	Role in SAP	Organizational Affiliation	Contact Information
	Data Clearing House	ICWD	
	QA Officer	ICWD	
OVGA Executive Manager	SAP Manager	OVGA Executive Manager	
Board of Directors	Policy/Decision Maker	OVGA	
	Regulatory Agency	DWR	

Table 1-4. SAP Implementation Personnel

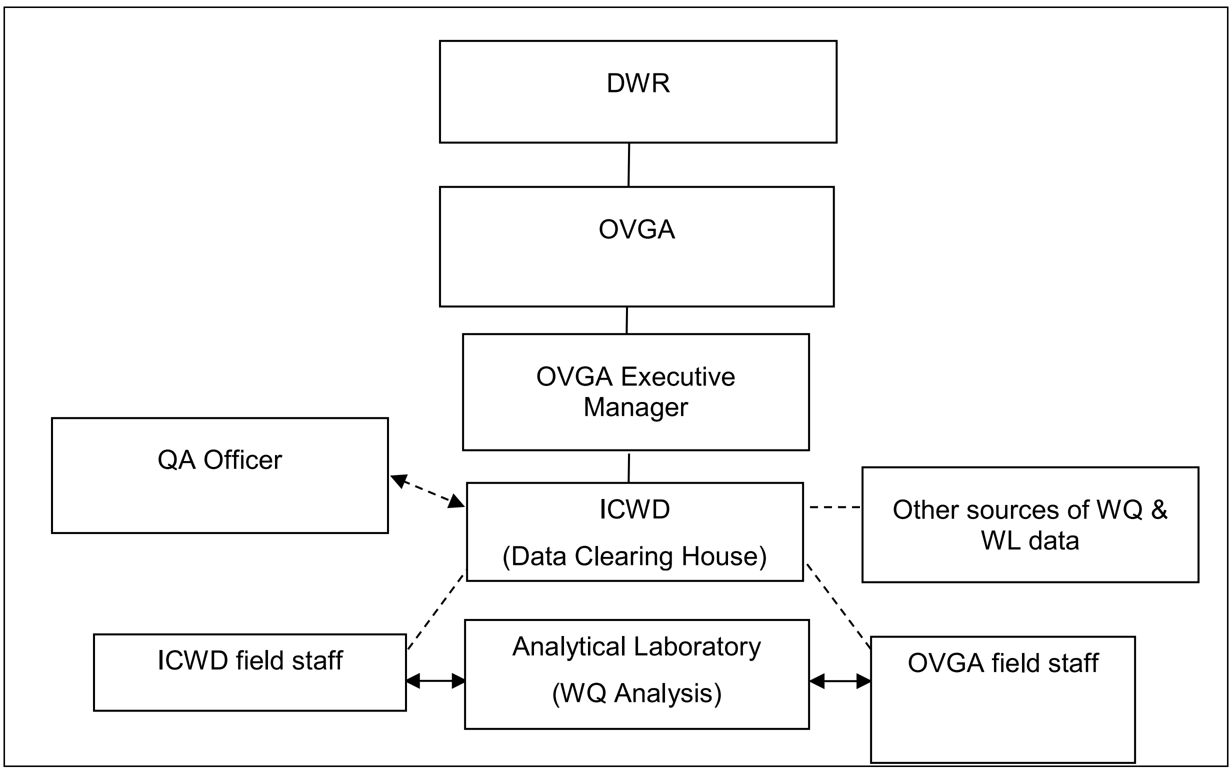

Figure 1-5: Organizational Chart

1.5 Standard Operating Procedures, Special Training and Certification

This section outlines potential Standard Operating Procedure development, field staff training, and certification requirements that may be necessary to complete the activities described in this SAP.

1.5.1 Standard Operating Procedures

It is recommended that individual monitoring entities develop and maintain Standard Operating Procedures for all field program activities. Table 1-5 lists recommended SOPs that should be developed (or updated as necessary) and implemented, if not currently in place, by monitoring entities in accordance with DWR's BMP #1 - *Monitoring Protocols, Standards, and Sites* (DWR, 2016a) and guidance from USGS reference documents cited in this SAP.

SOP Title
General Requirements
Equipment
Field Notes
Decontamination of Field Equipment
Water Sampling
Preparation for Water Sampling
Measurement of Field Parameters
Collection of Groundwater Samples
Collection of Surface Water Samples
Sample Preservation
Sample Filtration
Quality Assurance/Quality Control (QA/QC) Samples
Water Sampling
Measurement of Water Levels in Wells
Pressure Transducer & Data Logger: Deployment, Download, Maintenance and Troubleshooting
Quality Assurance/Quality Control (QA/QC) Water Levels

Table 1-5. List of potential Standard Operating Procedures

1.5.2 Equipment Operator Certifications and Licenses

Individual monitoring network managers and supervisors are responsible for ensuring that all field personnel are properly trained and certified in the activities they perform. Field sampling sometimes requires the use of specialized equipment that may require certification and training to safely operate.

1.5.3 Health and Safety Training

A basin-specific health and safety plan (HASP) is not included as part of this SAP. Agencies (e.g., Inyo, Mono County,) should have in place HASPs and ongoing field staff training programs that are specific to the field conditions and safety hazards encountered in field data collection activities.

It is not anticipated that field personnel working in the basin will necessitate access to sites that contain hazardous materials but personnel should be aware that OSHA training requirements are defined in 29 Code of Federal Regulations (CFR) 1910.120(e). However, if necessary, these requirements include (1) 40 hours of formal off-site instruction, (2) a minimum of 3 days of actual on-site field experience under the supervision of a trained and experienced field supervisor, and (3) 8 hours of annual refresher training. Field personnel who directly supervise employees engaged in hazardous waste operations also receive at least 8 additional hours of specialized supervisor training.

Copies of the field team's health and safety training records, including course completion certifications for the specialized supervisor training and the initial and refresher health and safety training, should be maintained and kept with site-specific files.

1.6 Monitoring Site Access Agreements

A signed access agreement should be procured prior to accessing all sites. The signed agreement should be on file and should be on hand in the field.

General agreement components should include, but are not necessarily limited to, the following:

- Monitoring site name (and any known alias), location and address;

- Property owner's name;
- Property contact information including property representative primary point of contact;
- Names of field staff, agency affiliations and contractors (if any) accessing the site as part of the monitoring program;
- Date and expiration (if any) of agreement;
- Prior notification requirements of intent to access property;
- Days of the week and time(s) of day property access is permitted; and
- Terms of agreement (e.g., liability considerations, data sharing considerations).

2. Water Quality Data Generation and Acquisition

A primary objective of this SAP is to describe groundwater and surface water sample collection procedures that will produce reliable basin-specific water quality data that can be used to evaluate sustainability in the basin with respect to the sustainability indicators set forth in the SGMA legislation. This section details activities associated with data collection, including field methods to be implemented, analytical requirements of the SAP, and steps that should be undertaken to ensure the adequacy of the data collection activities.

The following excerpt is from DWR's BMP 1 (DWR, 2016a):
Groundwater quality sampling protocols should ensure that:

- *Groundwater quality data are taken from the correct location*
- *Groundwater quality data are accurate and reproducible*
- *Groundwater quality data represent conditions that inform appropriate basin management and are consistent with the DQOs*
- *All salient information is recorded to normalize, if necessary, and compare data*
- *Data are handled in a way that ensures data integrity*

2.1 Water Quality Field Activity Documentation and Record Keeping

This Section discusses the requirements for documenting field activities and general record keeping. This documentation is imperative in preparing laboratory data packages (Section 2.3). Field personnel should follow the guidelines outlined in DWR's BMP #1 - *Monitoring Protocols, Standards, and Sites* (DWR, 2016a).

Field personnel should use monitoring network specifically prepared forms ("run sheets") or permanently bound field logbooks with sequentially numbered pages to record and document field activities. All paper field documentation should be scanned and archived by the monitoring entity.

General field-site documentation information should be on file with the monitoring agency that includes any access agreements (see Section 1.6) and associated property information. All field forms and logbooks should include and record at a minimum, the following information:

- Monitoring site name;

- Monitoring schedule event/list (e.g., fall water quality sampling run);Date and time (24-hour format) onsite;
- Name and affiliation of all on-site personnel including contractors or visitors;
- Weather conditions during the field activity;
- Summary of activities performed and significant events;
- Notes of conversations with coordinating officials;
- References to other field logbooks or forms that contain specific information;
- Discussions of problems encountered and their resolution;
- Discussions of deviations from the monitoring entity's field sampling plan or other governing documents; and
- Description of all photographs taken.

2.2 Sampling Methods and Field Activities

This Section describes the procedures for sample collection, including sampling methods and equipment, sample preservation requirements, and decontamination procedures. All samples collected should be analyzed by a laboratory certified under the Environmental Laboratory Accreditation Program (ELAP) (DWR, 2016a).

The USGS publishes the *National Field Manual for the Collection of Water Quality Data* (NFM). The NFM is comprised of standalone Chapters which are periodically updated by the USGS. DWR recommends that the NFM be used to guide the collection of reliable data (DWR, 2016a).

2.2.1 Groundwater Well Sampling Methodology

Groundwater samples should be collected from wells in the basin in accordance with the monitoring entities' SOPs that should adhere to the standard methods detailed in the USGS NFM. "*The specific sample collection procedure should reflect the type of analysis to be performed and DQOs"* (DWR, 2016a).

Before purging and sampling, groundwater level elevation should be measured in the well as described in the protocols in Section 3 of this SAP. The total depth (TD) of the well, depth-to-water (DTW) level measurement, and casing internal radius (in consistent units of feet) are needed to calculate the casing volume (V).

Casing volume in gallons is calculated as follows:

$$V = \pi r^2 h \ (7.48)$$

where V = casing volume (in gallons)

r = casing radius (feet)

h = TD – DTW (feet)

Each well, not equipped with low-flow or passive sampling equipment, should be purged of a minimum of three casing volumes (3 x V) prior to sampling to ensure that a representative groundwater sample is obtained. When purging by use of a pump or airlifting, a discharge rate should be estimated (if a flow meter is unavailable) so that field staff can estimate the time required to complete the purging process before sample collection. In the case of sampling with bailers, the volume of water extracted before sampling should be estimated.

"Professional judgment should be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected" (DWR, 2016a). If a well is purged dry, it should be documented and sampled when the well has recovered to within 90% of the original level prior to sampling. "*Professional judgment should be exercised as to whether the sample will meet the DQOs and adjusted as necessary" (DWR, 2016a).*

Means of extracting groundwater from a well for sampling include, but may not be limited to, the following industry standard methods:

- **Dedicated pump** - It is recommended that "samples should be collected at or near the wellhead. Samples should not be collected from storage tanks, at the end of long pipe runs, or after any water treatment" (DWR, 2016a).
- **Temporary pump** - See Section 2.2.3 for decontamination considerations between monitoring sites.
- **Bailer** - Dedicated or disposable polyethylene bailers are recommended. Bottom-emptying devices are recommended to transfer groundwater samples from bailers to unpreserved containers, to minimize volatilization and ensure sample integrity.

- **Airlifting** - Method not recommended when collecting samples for determination of analytes that are volatile or otherwise are affected by exposure to oxygen (USGS, 2018).
- **Low-Flow Sampling Equipment** - Requires additional special protocols. "In addition to the protocols listed above, sampling using low-flow sample equipment should adopt the following protocols derived from EPA's Low-flow (minimal drawdown) ground-water sampling procedures (Puls and Barcelona, 1996). These protocols apply to low-flow sampling equipment that generally pumps between 0.1 and 0.5 liters per minute. These protocols are not intended for bailers" (DWR, 2016a).
- **Passive Sampling Equipment** - Requires additional special protocols. "In addition to the protocols listed above, passive diffusion samplers should follow protocols set forth in *USGS Fact Sheet 088-00*" (DWR, 2016a).

If a pressure transducer and data logger is installed in a dedicated monitoring well, it should be removed before bailing, airlifting or installing any temporary sampling equipment (e.g., Grundfos Red-Flo2). See Section 3.3.3 for additional pressure transducer and data logger considerations.

The following minimum field parameters should be collected at the time of sampling:

- Specific Conductivity or Electrical Conductivity (EC);
- pH - "Measurements of pH should only be measured in the field, lab pH analysis are typically unachievable due to short hold times" (DWR, 2016a); and
- Temperature.

Additional field parameters "*may also be useful for meeting DQOs of GSP and assessing purge conditions. All field instruments should be calibrated daily and evaluated for drift throughout the day"* (DWR, 2106a). See Section 2.7.2 for Field Equipment and Instruments considerations. Additional field parameters may include, but are not limited to, the following:

- Dissolved Oxygen (DO) (in situ measurements preferable);
- Oxidation/Reduction Potential (ORP); and
- Turbidity.

Field parameters should be collected before, during and immediately after purging and should stabilize prior to sampling. "*Samples should be collected under laminar flow conditions. This may require reducing pumping rates prior to sample collection"* (DWR, 2016a). The water samples collected for dissolved metals should be mechanically filtered using a 0.45-micron filter, if necessary, to remove suspended particulates prior to the samples being placed in the appropriate containers for laboratory analyses.

"All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container" (DWR, 2016a).

Monitoring entities in the basin should have specific analytical programs adapted for their respective monitoring networks. Laboratory analytical methods are described in Section 2.5 of this SAP. Groundwater samples should be accompanied by full chain of custody documentation at all times (see Section 2.3.4).

2.2.2 Surface Water Sampling Methodology

Surface water samples should be collected from locations in the basin in accordance with the monitoring entities' SOPs that should adhere to the standard methods detailed in the USGS NFM. "*The specific sample collection procedure should reflect the type of analysis to be performed and DQOs"* (DWR, 2016a).

Similar methodologies should be used in sampling surface water as have been described above for sampling groundwater. Samples should be collected from flowing streams (not stagnate ponded water). Samples can be collected directly from the water source and so pumps and the purging process described above, is not necessary for collecting surface water samples.

Section 2.7.2 describes Field Equipment and Instruments considerations. The following minimum field parameters should be collected at the time of sampling:

- Specific Conductivity or Electrical Conductivity (EC);
- pH - "Measurements of pH should only be measured in the field, lab pH analysis are typically unachievable due to short hold times" (DWR, 2016a); and
- Temperature.

Additional field parameters may include, but are not limited to, the following:

- Dissolved Oxygen (DO) (in situ measurements preferable);
- Oxidation/Reduction Potential (ORP); and
- Turbidity.

If field conditions require filtering (e.g., such as with turbid surface water), the water samples should be mechanically filtered using a 0.45-micron filter to remove suspended particulates prior to the samples being placed in the appropriate containers for laboratory analyses. Field filtered samples shall be noted on the accompanying chain of custody and with reported results.

"All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container" (DWR, 2016a).

Monitoring entities in the basin should have specific analytical programs adapted for their respective monitoring networks. Laboratory analytical methods are described in Section 2.5 of this SAP. Surface water samples should be accompanied by full chain of custody documentation at all times (see Section 2.3.4).

2.2.3 Equipment Decontamination

Sampling decontamination between monitoring sites may be required, especially if a sampling site is known to contain transferable contaminants. If a site is known to be contaminated, dedicated or disposable sampling equipment should be used. Disposable gloves should be properly discarded between sampling sites.

The following excerpt is from DWR's BMP #1 (DWR, 2016a):
The sampler should clean the sampling port and/or sampling equipment and the sampling port and/or sampling equipment must be free of any contaminants. The sampler must decontaminate sampling equipment between sampling locations or wells to avoid cross-contamination between samples or wells.

Basin-specific examples include, but are not limited to, the following:

- Bailers used to sample shallow monitoring wells down-gradient from septic systems should not be used to sample any wells in the basin.
- Sampling pumps and the associated hardware (e.g., tubing) used in monitoring wells or other wells (e.g., abandoned production wells) should be matched to the analytes of concern for a particular well.

2.3 Sample Handling, Custody and Laboratory Coordination

Each sample collected by the field staff should be traceable from the point of collection through analysis and final disposition to ensure sample integrity. Sample integrity helps to ensure the legal defensibility of the analytical data and subsequent conclusions.

The following bullets are general guidance and standardized protocols recommended by DWR in BMP #1 (DWR, 2016a):

- *Prior to sampling, the sampler must contact the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.*
- *Each well used for groundwater quality monitoring must have a unique identifier. This identifier must appear on the well housing or the well casing to avoid confusion.*
- *Sample containers should be labeled prior to sample collection. The sample label must include: sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.*
- *Samples should be chilled and maintained at 4 °C to prevent degradation of the sample. The laboratory's Quality Assurance Management Plan should detail appropriate chilling and shipping requirements.*
- *Samples must be shipped under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.*
- *Instruct the laboratory to use reporting limits that are equal to or less than the applicable DQOs or regional water quality objectives/screening levels."*

2.3.1 Site and Sample Identification

Each sampling location (groundwater and surface water) should be identified as clearly as possible (e.g., Well #1 is not an acceptable site identifier). *"Each well used for groundwater quality* *monitoring must have a unique identifier. This identifier must appear on the well housing or the well casing to avoid confusion"* (DWR 2016a). All monitoring entities operating within the basin should use the same unique identifier scheme but where not practical (e.g., for historical network or other reasons), cross-over tables should be developed to identify monitoring sites within the basin. Blind duplicates should be clearly documented, with the actual well location listed in the logbook.

California Code of Regulations (23 CCR § 352.4) requires that the CASGEM Well Identification Number be used, if available, for identifying site locations. In addition, DWR identifies wells by State Well Number (SWN). SWNs are in an alphanumeric form (e.g., 04N18W20P01S) based on the public land grid (Township, Range and Section) which indicates geographic location of the well. In the SWN naming scheme, Sections are further subdivided into 1/16ths in which individual wells are numbered sequentially. The final letter in a SWN is the baseline and meridian of the public land grid in which the well lies. The following recommends naming conventions appropriate for different kinds of samples:

- **Groundwater samples.** CASGEM Well Identification Number and DWR State Well Numbers (SWN) are recommended for identifying well sampling sites in the basin.
- **Surface water samples.** A modified SWN format is recommended for identifying surface water sampling sites in the basin in the form: Township, Range and Section followed by "SW" and ending with individual sites within the section numbered sequentially (e.g., 04N17W29SW1)
- **Trip blanks, field blanks, and equipment blanks.** Samples should be designated TB, FB, and EB respectively.

2.3.2 Sample Labeling

A sample label should be affixed to each sample container. The label should be completed with the following information written in indelible ink:

- Sample location and identification number;
- Date and time of sample collection;
- Sample collector's initials;
- Preservation required; and
- Analysis required.

2.3.3 Sample Documentation

Documentation during sampling is essential to ensure proper sample identification. Field staff should adhere to the following general guidelines for maintaining field documentation:

- Documentation will be completed in permanent black or dark blue ink.
- All entries will be legible.
- Errors will be corrected by crossing out with a single line and then dating and initialing the lineout.
- Any serialized documents will be maintained by the monitoring entity and referenced in the site logbook.
- Unused portions of pages will be crossed out, and each page will be signed and dated.

The monitoring entity's supervisor is responsible for ensuring that sampling activities are properly documented.

2.3.4 Chain of Custody

Standard sample custody procedures should be used to maintain and document sample integrity during collection, transportation, storage, and analysis. A sample should be considered to be in custody if one of the following statements applies:

- It is in a person's physical possession or view.
- It is in a secure area with restricted access.
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal.

Chain of custody procedures provide an accurate written record that traces the possession of individual samples from the time of collection in the field to the time of acceptance at the laboratory. The chain of custody record should be used to document all samples collected and the analysis requested. Information that the field personnel should record on the chain of custody record includes the following:

- Sample location and identification number;
- Name and signature of sampler;
- Destination of samples (laboratory name);
- Date and time of collection;

- Analysis requested;
- Signatures of individuals involved in custody transfer, including the date and time of transfer;
- Airbill number (if applicable); and
- Monitoring entity supervisor's contact and phone number.

Unused lines on the chain of custody record should be crossed out. Field personnel should sign chain of custody records that are initiated in the field, and the airbill number should be recorded. The record should be placed in a waterproof plastic bag and taped to the inside of the shipping container used to transport the samples. Signed airbills serve as evidence of custody transfer between field personnel and the courier, and between the courier and the laboratory. Copies of the chain of custody record and the airbill should be retained and filed by field personnel before the containers are shipped.

2.3.5 Sample Shipment

The following procedures should be implemented if samples collected in accordance to this SAP are shipped:

- The shipping box should be filled with bubble wrap, sample bottles, and packing material. Sufficient packing material should be used to prevent sample containers from breaking during shipment.
- The chain of custody records should be placed inside a plastic bag. The bag should be sealed and taped to the inside of the cooler lid. The airbill, if required, should be filled out before the samples are handed over to the carrier. The laboratory should be notified if the sampler suspects that the sample contains any substance that would require laboratory personnel to take safety precautions.
- The shipping box should be closed and taped shut with strapping tape around both ends.
- Signed and dated custody seals should be placed on the front and side of each shipping box. Wide clear tape should be placed over the seals to prevent accidental breakage.
- The chain of custody record should be transported within the taped sealed shipping box. When the shipping box is received at the analytical laboratory, laboratory personnel should open the shipping box and sign the chain of custody record to document transfer of samples.

2.4 Sampling Containers and Holding Times

Confer with the ELAP certified analytical lab that will be receiving the samples for required containers for required sample volume, container type, preservation technique, and holding time for each analysis that is to be conducted on the groundwater samples collected. Required containers, preservation techniques, and holding times for field QC samples, such as field duplicates and MS/MSD samples (Section 2.6), should be the same as for field samples.

2.5 Analytical Methods

The source of analytical services to be provided will be determined by the individual entities conducting monitoring in the basin and should support the basin-specific DQOs presented in this SAP. EPA-approved methods for laboratory analyses of the samples should be used. Many of the general mineral, general physical and metals constituents (analytes or chemicals) listed in Table 1-6 are commonly sampled for in the basin by various entities. EPA-approved standard analytical methods are associated with each constituent listed in the table. As mentioned above, operators of potable water systems are required to sample for a variety of additional constituents including organic compounds.

Constituent	Analytical Method
General Mineral	
Aggressive Index	SM 4500HB
Bicarbonate as HCO3	EPA 2320B
Boron	EPA 200.7
Calcium	EPA 200.7
Carbonate as CO3	EPA 2320B
Chloride	EPA 300.0
Copper	EPA 200.7
Fluoride	EPA 300.0
Hydroxide as OH	EPA 2320B
Iron	EPA 200.7
Langlier Index (20°C)	SM 4500HB
Magnesium	EPA 200.7
Manganese	EPA 200.7
MBAS Screen (Foaming Agents)	SM 5540C
Nitrate + Nitrite as N	EPA 300.0
Nitrate as NO3	EPA 300.0
Nitrate Nitrogen	EPA 300.0
Nitrite as N	EPA 300.0
pH (Field)	-
Potassium	EPA 200.7
Sodium	EPA 200.7
Sodium Absorption Ratio (SAR)	EPA 200.7
Specific Conductivity	EPA 2510B
Sulfate	EPA 300.0
Total Alkalinity (as CACO3)	EPA 2320B
Total Anions	EPA 200.7
Total Cations	EPA 200.7
Total Dissolved Solids_SUM	EPA 200.7
Total Dissolved Solids_TFR	EPA 2540C
Total Hardness as CaCO3	EPA 200.7
Zinc	EPA 200.7
General Physical	
Color	SM 2120B
Odor	SM 2150B
Temperature (Field)	-
Turbidity	SM 2130B
Microbiology	
Total Coliform P/A	SM 9223B
Total Coliform (Enumeration)	SM 9223B

Constituent	Analytical Method
Inorganic Chemicals (IOC) - Metals	
Aluminum	EPA 200.8
Antimony	EPA 200.8
Arsenic	EPA 200.8
Barium	EPA 200.8
Beryllium	EPA 200.8
Cadmium	EPA 200.8
Chromium	EPA 200.8
Lead	EPA 200.8
Mercury	EPA 245.1
Nickel	EPA 200.8
Selenium	EPA 200.8
Silver	EPA 200.8
Thallium	EPA 200.8
Vanadium	EPA 200.8
1,2,3 - Trichloropropane	SRL 524M-TCP
Carbamates	EPA 531.1
Chlorinated Pesticides	EPA 505
Chromium VI	EPA 218.6
Diquat	EPA 549.2
EDB & DBCP	EPA 504.1
Endothall	EPA 548.1
Glyphosate	EPA 547
Gross Alpha	EPA 900.0
Haloacetic Acids	EPA 552.2
Herbicides	EPA 515.3
Nitrogen Phosphorus Pesticides	EPA 507
Radium-228	EPA Ra-05
Perchlorate	EPA 314.0
Total Alpha Emitting Radium-226	EPA 903.0
Total Cyanide (CN)	SM 4500-CN C,E
Trihalomethanes	EPA 551.1
Uranium	EPA 908.0
VOC's Full List	EPA 524.2
Asbestos	EPA 100.2
Dioxin (AQ/Solid) - 2,3,7,8, TCDD Only	EPA 1613
Organic Compounds in Drinking Water	EPA 525.2

Table 1-6. Laboratory Analytical Methods.

If an analytical system fails, the laboratory QA officer should be notified, and corrective action should be taken. In general, laboratory corrective actions should include stopping the analysis, examining instrument performance and sample preparation information, and determining the need to reprepare and/or reanalyze the samples.

TDS can be reported by either Total Filterable Residue (TFR) or by Summation (SUM), which is calculated by summing the mass of the major anions and cations in a water sample. TDS by Summation commonly yields a slightly higher value than the TDS by Total Filterable Residue. The wet chemistry evaporative method (TFR) is now the standard laboratory analysis for TDS and is recommended method for water sample analysis in the basin.

2.6 Water Quality Assurance and Quality Control

Various field and laboratory QC samples and measurements should be used to verify that analytical data meet the QA objectives. It is recommended that field QC samples and measurements be collected to assess the influence of sampling activities and measurements on data quality. Similarly, laboratory QC samples should be used to assess how the laboratory's analytical program influences data quality. This section describes the QC samples that are recommended to be analyzed during the site sampling activities. Table 1-3 shows the acceptance criteria for each type of QC sample. Table 1-7 specifies the recommended frequency of QC samples to be collected at the site.

Field Quality Control Sample	Frequency for Soil Matrix
Field duplicate	1 per 10 samples, rounded up
Equipment rinsate blank	1 per sampling event (run)
Matrix spike/matrix spike duplicate [a] (organics only)	1 per 20 samples
Matrix spike/matrix duplicate [b] (inorganics only)	1 per 20 samples
Trip blank	1 with each cooler containing aqueous samples for VOC analysis
Temperature blank	1 per cooler

[a] Matrix spike, matrix spike duplicate, and matrix duplicate analyses are technically not field quality control samples; however, they generally require that the field personnel collect additional volume of sample, and are therefore included on this table for easy reference.

Table 1-7. Frequency of Field Quality Control Samples.

All laboratories that perform analytical work under this SAP should adhere to a QA program that is used to monitor and control all laboratory QC activities. Each laboratory must have a written QA manual that describes the QA program in detail. The laboratory QA manager is responsible for ensuring that all laboratory internal QC checks are conducted in accordance with EPA methods and protocols, the laboratory's QA manual, and the requirements of this SAP.

Many of the laboratory QC procedures and requirements are described in EPA-approved analytical methods, laboratory method SOPs, and method guidance documents.

2.6.1 Field Quality Control Samples

Field QC samples should be collected and analyzed to assess the quality of data that are generated by sampling activities. These samples include laboratory QC samples collected in the field, field duplicates, equipment rinsates, MS/MSDs, and trip blanks. A temperature blank should be included. QC samples collected in the field for fixed laboratory analysis are presented in Table 1-7.

Field duplicates are independent samples that are collected as close as possible, in space and time, to the original investigative sample. Field duplicates can measure the influence of sampling and field procedures on the precision of an environmental measurement. They can also provide information on the heterogeneity of a sampling location. Field duplicates should be collected as listed in Table 1-7.

Equipment rinsate blanks are collected when non-dedicated or non-disposable sampling equipment is used to collect samples and put the samples into containers. One equipment blank should be collected per sampling event (run).

MS/MSDs are laboratory QC samples that are associated with analytical methods for organics. MSs are typically associated with analytical methods for inorganics. In the laboratory, MS/MSDs and MSs are split and spiked with known amounts of analytes. Analytical results for MS/MSDs and MSs and laboratory duplicate samples are used to measure the precision and accuracy of the laboratory's organic and inorganic analytical programs, respectively. Each of these QC samples should be collected and analyzed at a frequency of 1 for every 20 investigative samples or 1 method blank per batch if the batches consist of fewer than 20 samples.

Temperature blanks are containers of deionized or distilled water that are placed in each cooler shipped to the laboratory. Their purpose is to provide a container to test the temperature of the samples in the respective cooler.

2.6.2 Laboratory Quality Control Samples

EPA methods specify the preparation and analysis of QC samples. These samples may include, but are not limited to, the following types: (1) LCSs, (2) method blanks, (3) MS and MSD samples, (4) matrix duplicate (MD) samples, (5) surrogate spikes, and (6) standard reference materials or independent check standards. The following subsections discuss the QC checks that should be implemented.

2.6.2.1 Laboratory Control Samples

LCSs are thoroughly characterized, laboratory-generated samples that are used to monitor the laboratory's day-to-day performance of analytical methods. The results of LCS analyses are compared to well-defined laboratory control limits to determine whether the laboratory system is in control for the particular method. If the system is not in control, corrective action should be implemented. Appropriate laboratory corrective actions include (1) stopping the analysis, (2) examining instrument performance or sample preparation and analysis information, and (3) determining whether samples should be reprepared or reanalyzed.

2.6.2.2 Method Blanks

Method blanks, which are also known as preparation blanks, are analyzed to assess the level of background interference or contamination in the analytical system and the level that may lead to elevated concentration levels or false positive data. Method blanks should be required for all laboratory analyses and should be prepared and analyzed at a frequency of 1 method blank for every 20 samples, or 1 method blank per batch if the batch consists of fewer than 20 samples.

A method blank consists of reagents that are specific to the analytical method and are carried through every aspect of the analytical procedure, including sample preparation, cleanup, and analysis. The results of the method blank analysis should be evaluated in conjunction with other QC information to determine the acceptability of the data generated for that batch of samples. Ideally, the concentration of a target analyte in the method blank should be below the reporting limit for that analyte. For some common laboratory contaminants, a higher concentration may be allowed.

If the method blank for any analysis is beyond control limits, the source of contamination should be investigated, and appropriate corrective action should be taken and documented. This investigation includes an evaluation of the data to determine the extent of the contamination and its effect on sampling results. If a method blank is within control limits but analysis indicates a concentration of analytes that is above the reporting limit, an investigation should be conducted to determine whether any corrective action could eliminate an ongoing source of target analytes.

For organic and inorganic analyses, the concentration of target analytes in the method blank must be below the reporting limit for that analyte for the blank to be considered acceptable. An exception may be made for common laboratory contaminants (such as methylene chloride, acetone, 2-butanone, and phthalate esters) that may be present in the blank at up to five times the reporting limit. These compounds are frequently detected at low levels in method blanks from materials that are used to collect, prepare, and analyze samples for organic parameters.

2.6.2.3 Matrix Spikes and Matrix Spike Duplicates

MSs and MSDs are aliquots of an environmental sample to which known concentrations of target analytes and compounds have been added. The MS is used to evaluate the effect of the sample matrix on the accuracy of the analysis. If there are many target analytes, they should be divided into two to three spike standard solutions. Each spike standard solution should be used alternately. The MS, in addition to an unspiked aliquot, should be taken through the entire analytical procedure, and the recovery of the analytes should be calculated. Results should be expressed in terms of percent recoveries and RPD. The percent recoveries of the target analytes and compounds are calculated and used to determine the effects of the matrix on the precision and accuracy of the method. The RPD between the MS and MSD results is used to evaluate method precision.

The MS/MSD is divided into three separate aliquots, two of which are spiked with known concentrations of target analytes. The two spiked aliquots, in addition to an unspiked sample aliquot, are analyzed separately, and the results are compared to determine the effects of the matrix on the precision and accuracy of the analysis. Results should be expressed as RPD and percent recovery and compared to control limits that have been established for each analyte. If results fall outside control limits, corrective action should be performed.

2.6.2.4 Laboratory (Matrix) Duplicates

MDs, which are also called laboratory duplicates, are prepared and analyzed for inorganic analyses to assess method precision. Two aliquots of sample material are taken from the sample and processed simultaneously without adding spiking compounds. The MD and the original sample aliquot are taken through the entire analytical procedure, and the RPD of the duplicate result is calculated. Results are expressed as RPD and are compared to control limits that have been established for each analyte.

2.6.2.5 Surrogate Spikes

Surrogates are organic compounds that are similar to the analytes of interest in chemical properties but are not normally found in environmental samples. Surrogates are added to field and QC samples before the samples are extracted to assess the efficacy of the extraction procedure and to assess the bias that is introduced by the sample matrix. Results are reported in terms of percent recovery. Individual analytical methods may require sample reanalysis based on surrogate criteria.

The laboratory should use surrogate recoveries mainly to assess matrix effects on sample analysis. Obvious problems with sample preparation and analysis (such as evaporation to dryness or a leaking septum) that can lead to poor surrogate spike recoveries must be eliminated before low surrogate recoveries can be attributed to matrix effects.

2.6.3 Common Data Quality Indicators

This section describes how QA objectives for precision, accuracy, completeness, and sensitivity are measured, calculated, and reported.

2.6.3.1 Precision

Precision of many analyses is assessed by comparing analytical results of MS and MSD sample pairs for organic analyses, field duplicate samples, laboratory duplicate samples, MDs, and field replicate measurements. If precision is calculated from two measurements, it is normally measured as RPD. If precision is calculated from three or more replicates, it is measured as relative standard deviation.

2.6.3.2 Accuracy

The accuracy of many analytical methods is assessed by using the results of MS and MSD samples for organic analyses, MS samples for inorganic analyses, surrogate spike samples, LCSs, standard reference materials, independent check standards, and measurements of instrument responses against zero and span gases.

For measurements in which spikes are used, percent recovery should be calculated.

2.6.3.3 Completeness

Completeness is a measure of the percentage of basin-specific data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP, and when none of the QC criteria that affect data usability are exceeded.

When all data validation is completed, the percent completeness value should be calculated by dividing the number of usable results by the total number of sample results planned for this investigation.

Completeness should also be evaluated as part of the DQA process (U.S. EPA, 2000). This evaluation will help determine whether any limitations are associated with the decisions to be made based on the data collected.

2.6.3.4 Sensitivity

The achievement of MDLs depends on instrument sensitivity and matrix effects. Therefore, it is important to monitor the instrument sensitivity to ensure data quality and to ensure that analyses meet sensitivity requirements with respect to SAP QA objectives (Section 1.3.2).

2.7 Water Quality Instrument and Equipment Testing, Inspection, and Maintenance Requirements

This section outlines testing, inspection, and maintenance procedures for field equipment and instruments and for laboratory instruments.

2.7.1 General Requirements

Testing, inspection, and maintenance methods and frequency should be based on the following:

- The type of instrument;
- The instrument's stability characteristics;
- The required accuracy, sensitivity, and precision of the instrument;
- The instrument's intended use, considering basin-specific DQOs;
- Manufacturer's recommendations; and
- Other conditions that affect measurement or operational control.

For most instruments, preventive maintenance is performed in accordance with procedures and schedules recommended in (1) the instrument manufacturer's literature or operating manual or (2) SOPs associated with particular applications of the instrument.

In some cases, testing, inspection, and maintenance procedures and schedules will differ from the manufacturer's specifications or SOPs. This can occur when a field instrument is used to make critical measurements or when the analytical methods that are associated with a laboratory instrument require more frequent testing, inspection, and maintenance.

2.7.2 Field Equipment and Instruments

After the field equipment and instruments arrive in the field, they should be inspected for damage and the beginning and end of each day of use. Damaged equipment and instruments should be replaced or repaired immediately, if practicable. Battery-operated equipment (e.g., EC/pH meter) should be checked to ensure full operating capacity; if needed, batteries should be recharged or replaced.

Following use, field equipment should be properly decontaminated. Any equipment problems should be reported so that problems are not overlooked and any necessary equipment repairs are performed before the next use of the equipment.

2.7.3 Laboratory Instruments

All laboratories that analyze samples collected in accordance with this SAP must have a preventive maintenance program that addresses (1) testing, inspection, and maintenance procedures and (2) the maintenance schedule for each measurement system and required support activity. This program is usually documented by an SOP for each analytical instrument that is to be used. The program will typically be laboratory specific; however, it should follow requirements outlined in EPA-approved guidelines. Some of the basic requirements and components of such a program are as follows:

- As a part of its QA/QC program, each laboratory will conduct a routine preventive maintenance program to minimize instrument failure and other system malfunction.
- An internal group of qualified personnel will maintain and repair instruments, equipment, tools, and gauges. Alternatively, manufacturers' representatives may provide scheduled instrument maintenance and emergency repair under a repair and maintenance contract.
- The laboratory will perform instrument maintenance on a regularly scheduled basis. The scheduled service of critical items should minimize the downtime of the measurement system. The laboratory will prepare a list of critical spare parts for each instrument. The laboratory will request the spare parts from the manufacturer and will store the parts.

- Testing, inspection, and maintenance procedures described in laboratory SOPs will be performed in accordance with manufacturer's specifications and the requirements of the specific analytical methods that are used.
- All maintenance and service should be documented in service logbooks (or the site-specific logbook) to provide a history of maintenance records. A separate service logbook should be kept for each instrument. All maintenance records will be traceable to the specific instrument, equipment, tool, or gauge.
- The laboratory will maintain and file records that are produced as a result of tests, inspections, or maintenance of laboratory instruments. If necessary, these records will be available for review by internal and external laboratory system audits.

2.8 Instrument Calibration and Frequency

All laboratory equipment that is used to analyze samples collected in accordance with this SAP should be calibrated on the basis of written SOPs that are maintained by the laboratory. Calibration records (including the dates and times of calibration and the names of the personnel performing the calibration) should be filed at the location at which the analytical work was performed and maintained by the laboratory personnel who performed QC activities. The laboratory QA manager is responsible for ensuring that all laboratory instruments are calibrated in accordance with the requirements of this SAP

Subcontracted laboratories may conduct laboratory work if the primary laboratory is not ELAP certified to perform requested analysis or cannot meet requested turnaround times. Subcontracted laboratories are subject to the same requirements as the primary sample receiving laboratory.

The laboratories should follow the method specific calibration procedures and requirements for laboratory measurements. Calibration procedures and requirements should also be provided, as appropriate, for laboratory support equipment, such as balances, mercury thermometers, pH meters, and other equipment that is used to take chemical and physical measurements.

3. Groundwater Level Data Generation and Acquisition Protocol

An objective of this SAP is to describe groundwater data collection procedures that will produce reliable basin-specific water level data that can be used to evaluate sustainability in the basin with respect to the SGMA legislation sustainability indicators. This section details activities associated with measuring water levels in wells, including field methods to be implemented and steps that should be undertaken to ensure the adequacy of the data collection activities.

DWR's BMP #1 (DWR, 2016a) includes the following considerations for developing groundwater level protocols:

- Groundwater level data are taken from the correct location, well ID, and screen interval depth
- Groundwater level data are accurate and reproducible
- Groundwater level data represent conditions that inform appropriate basin management DQOs
- All salient information is recorded to correct, if necessary, and compare data
- Data are handled in a way that ensures data integrity

3.1 Groundwater Level Field Documentation and Record Keeping

This Section discusses the requirements for documenting water level measurement activities. Field personnel should follow the documentation guidelines outlined in DWR's BMP #1 - *Monitoring Protocols, Standards, and Sites* (DWR, 2016a).

Field personnel should use monitoring network specifically prepared forms ("run sheets") or permanently bound field logbooks with sequentially numbered pages to record and document field activities. Example water level data collection forms are included in *Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1* (USGS, 2011). All paper field documentation should be scanned and archived by the monitoring entity.

General field-site documentation information should be on file with the monitoring agency that includes any access agreements (see Section 1.6) and associated property information. All field forms and logbooks should include and record at a minimum, the following information:

- Well identifier - CASGEM Well Identification Number and CA DWR SWN are recommended (see Section 2.3.1 for a description of DWR's well identification convention);
- Monitoring schedule event/list (e.g., fall water level run);
- Date and time (24-hour format) of measurement; and
- Comments/ Notes field
    - Discussions of problems encountered and their resolution
    - Discussions of deviations from the monitoring entity's water level measuring SOP or other governing documents
    - Factors that may influence the depth to water readings (see Section 3.4.1).

Documentation of water level measurements is essential to ensure data integrity. Field staff should adhere to the following general guidelines for maintaining field documentation:

- Documentation will be completed in permanent black or dark blue ink.
- All entries will be legible.
- Errors will be corrected by crossing out with a single line and then dating and initialing the lineout.
- Any serialized documents will be maintained by the monitoring entity and referenced in the site logbook.
- Unused portions of pages will be crossed out, and each page will be signed and dated.

The monitoring entity's supervisor is responsible for ensuring that water level measurement activities are properly documented. The following subsections offer common "no measurement" obtained explanations and data qualifiers. It is important that monitoring entities maintain standardized lists of data qualifiers and all field staff understand the intended meaning (i.e., field conditions) of each qualifier so that they are applied in a standardized and consistent manner.

3.1.1 No Measurement Documentation

The following are common explanations for why a water level measurement was not obtained by field staff while accessing a well-site listed on a monitoring network schedule. Each of the bulleted explanations shown below can be assigned a unique number in a list maintained by a monitoring entity that allows field staff to quickly and efficiently document the field conditions that prohibited a water level measurement from being obtained. A list of commonly used qualifiers is included below. Documentation may include, but is not limited to, the following explanations:

- Measurement Discontinued;
- Pumping;
- Pump house locked;
- Tape hung up;
- Can't get tape in casing;
- Unable to locate well;
- Well has been destroyed;
- Special/Other (requires explanation in comments field);
- Casing leaking or wet;
- Temporarily inaccessible;
- Well dry; and
- Unmeasured flowing well.

If a water level is not obtained, the minimum site visit information, outlined above, should still be collected. Documenting well-site conditions can help inform future data collection efforts in the basin. For example, if a well is pumping multiple site visits in a row, it may warrant contacting the well owner or operator to schedule a time to measure the well when it will be off.

3.1.2 Water Level Measurement Qualifiers

The following are common water level measurement qualifiers that that can be assigned a unique number in a list maintained by a monitoring entity that allows field staff to quickly and efficiently document ancillary information associated with a water level measurement. Commonly used by qualifiers are included below.

- Caved or deepened;
- Pumping;
- Nearby pump operating;
- Casing leaking or wet;
- Pumped recently;
- Air or pressure gauge measurement;

- Special/Other (requires explanation in comments field);
- Recharge operation at or nearby well;
- Oil in Casing;
- Acoustic sounder;
- Measured flowing well; and
- Does not match transducer record.

3.2 Scheduling of Groundwater Level Monitoring Events

Groundwater levels in California basins are often at their highest annual levels during the spring of each year following winter precipitation. They are often at their lowest in the fall preceding the start of the winter rainy season with much of the annual precipitation falling from November through February in the basin. Temporal coordination of groundwater level collection activities across the State is important for comparison of water level measurements collected by different monitoring entities. DWR's BMP #2 specifies that *"Groundwater levels will be collected during the middle of October and March for comparative reporting purposes"* (DWR, 2016b)

The following excerpt is from DWR's BMP 1:
"Groundwater elevation data will form the basis of basin-wide water-table and piezometric maps, and should approximate conditions at a discrete period in time. Therefore, all groundwater levels in a basin should be collected within as short a time as possible, preferably within a 1 to 2 week period" (DWR, 2016a).

Likely water levels will be collected by Inyo County, Bishop, CSD's, and Mono County, as part of their established monitoring networks in the basin during other times of the year for various purposes, but as tight (small) a monitoring event window as reasonably possible should be scheduled around October and March of each year. These recommended spring-high water level measurement runs centering around April 1 and fall-low runs around October 1 are to conform to DWR's timing preference (mentioned above) for producing comparative state-wide record sets. Public water supply systems (e.g., City of Bishop) often have other sampling or measurement requirements (e.g., weekly water level measurements, quarterly or annual water quality sampling and analysis) as requirement of permits to serve potable water supplies.

3.3 Groundwater Level Equipment Testing, Inspection, and Maintenance Requirements

This section outlines testing, inspection, and maintenance procedures for field equipment and water level measurement devices.

3.3.1 General Requirements

Testing, inspection, and maintenance methods and frequency should be based on the following:

- The type of water level measurement device;
- The instrument's stability characteristics;
- The required accuracy, sensitivity, and precision of the equipment;
- The equipment's intended use, considering basin-specific DQOs;
- Manufacturer's recommendations; and
- Other conditions that affect measurement or operational control.

For most equipment, preventive maintenance is performed in accordance with procedures and schedules recommended in (1) the manufacturer's literature or operating manual or (2) SOPs associated with particular applications of the measurement device.

3.3.2 Manual Water Level Measurement Equipment

After field equipment and measurement devices are transported to the field, they should be inspected for damage at the beginning and end of each day of use. Damaged equipment should be replaced or repaired immediately, if practicable. Battery-operated equipment (e.g., electric sounder) should be checked to ensure full operating capacity; if needed, batteries should be replaced.

Following use, field equipment should be properly decontaminated. Any equipment problems should be reported so that problems are not overlooked and any necessary equipment repairs are performed before the next use of the equipment. Common water level measurement devices are listed below:

- Steel Surveyor's Measuring Tape;
- Electric Sounder (single wire and dual wire);

- Acoustic Sounder; and
- Permanently Installed Air Line.

For air line measurements, gauge reading is recorded after pressurizing with a pneumatic pump or compressed air tank. The depth of the bottom of the submerged tubing in the well open to the atmosphere must be known to calculate the water level in the well from the measured pressure.

3.3.3 Recording Water Level Devices - Pressure Transducer and Data Loggers

Pressure transducer and data logger monitoring networks are becoming commonplace in many groundwater basins. These devices can be used for recording water level measurements in wells on user defined or event based schedules.

The electronics components of the device are sealed in a housing that is installed below the water level surface in the well. They measure pressure (commonly in psi) above the sensor. For every 1 psi of pressure recorded by the gauge, there are 2.31 feet of potentiometric head above the sensor. A simple linear correction (coefficient) can be applied to adjust output readings to depth-to-water in the well or water level elevation referenced to mean sea level (given a RP elevation has been surveyed for the site). The devices can be downloaded during well-site visits or can be connected to telemetry systems to transmit data remotely.

The following excerpt is from DWR's BMP #1 (DWR, 2016a) and provides guidance on the use of pressure transducers and data loggers as a component of the monitoring plan for a basin:
When installing pressure transducers, care must be exercised to ensure that the data recorded by the transducers is confirmed with hand measurements.

The following general protocols must be followed when installing a pressure transducer in a monitoring well:

- *The sampler must use an electronic sounder or chalked steel tape and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in the monitoring well to properly program and reference the installation. It is recommended that transducers record measured groundwater level to conserve data capacity; groundwater elevations can be calculated at a later time after downloading.*
- *The sampler must note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.*

- *Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. Professional judgment should be exercised to ensure that the data being collected is meeting the DQO and that the instrument is capable. Consideration of the battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers should be included in the evaluation.*
- *The sampler must note whether the pressure transducer uses a vented or non-vented cable for barometric compensation. Vented cables are preferred, but non-vented units provide accurate data if properly corrected for natural barometric pressure changes. This requires the consistent logging of barometric pressures to coincide with measurement intervals.*
- *Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that DQOs are being met for the GSP.*
- *Secure the cable to the well head with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or an indelible marker. This will allow estimates of future cable slippage.*
- *The transducer data should periodically be checked against hand measured groundwater levels to monitor electronic drift or cable movement. This should happen during routine site visits, at least annually or as necessary to maintain data integrity.*
- *The data should be downloaded as necessary to ensure no data is lost and entered into the basin's DMS following the QA/QC program established for the GSP. Data collected with non-vented data logger cables should be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data should be deleted from the data logger to ensure that adequate data logger memory remains.*

3.4 Groundwater Level Measurements and Related Field Activities

Water level measurements from wells in the basin should be performed in accordance with the monitoring entities' SOPs that should adhere to the standard methods detailed in *Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1* (USGS, 2011). *"Well construction, anticipated groundwater level, groundwater* *level measuring equipment, field conditions, and well operations should be considered prior collection of the groundwater level measurement"* (DWR, 2016a).

3.4.1 Well-Site Conditions Assessment and Pre/Post-Measurement Activities

Upon arriving at a well-site, a basic site conditions assessment should be conducted. If the well being monitored is not a dedicated monitor well and is equipped with a pump, check to see if the pump is in operation or for other indicators that the pump was in operation recently (e.g., warm motor, wet adjacent irrigated fields or water around the well not associated with rain events). Do not measure the water level in the well if it is pumping unless instructed to do so by the monitoring entity's supervisor. Document *"factors that may influence the depth to water readings such as weather, nearby irrigation, flooding, potential for tidal influence [not applicable for the Owens Valley Groundwater Basin], or well condition*" (DWR, 2016a). Document any site conditions findings that do not result in a water level measurement according to Section 3.1.1, and qualify water level measurements, as appropriate, with qualifiers listed in Section 3.1.2.

The sampler should remove the appropriate cap, lid, or plug that covers the monitoring access point listening for pressure release. If a release is observed, the measurement should follow a period of time to allow the water level to equilibrate" (DWR, 2016a). *"If agricultural or municipal wells are used for monitoring, the wells must be screened across a single water-bearing unit, and care must be taken to ensure that pumping drawdown has sufficiently recovered before collecting data from a well"* (DWR, 2016b). After measuring the well, *"The sampler should replace any well caps or plugs, and lock any well buildings or covers"* (DWR, 2016a).

3.4.2 Reference Points and Surveying

If not previously measured and recorded for the site, or the former measurement is no longer valid (e.g., the surface casing was sheared off as the result of being run over by a truck), the reference point (RP) height in feet (above or below ground surface) should be measured. "*Depth to groundwater must be measured relative to an established Reference Point (RP) on the well casing. The RP is usually identified with a permanent marker, paint spot, or a notch in the lip of the well casing. By convention in open casing monitoring wells, the RP reference point is located on the north side of the well casing. If no mark is apparent, the person performing the measurement should measure the depth to groundwater from the north side of the top of the well casing"* (DWR, 2016a).

Ground elevation and top of casing elevation reference points should be measured to North American Vertical Datum 1988 (NAVD88) within 0.5 foot accuracy (23 CCR § 352.4) and a higher level of accuracy of 0.1 foot or less is preferred.

The locations of the monitoring wells on the land surface should be surveyed to North American Datum 1983 (NAD83) to an accuracy of 0.1 foot. DWR's standard horizontal projected coordinate system is California Teale Albers, NAD83. Feature class (location) data uploaded through the SGMA portal is required to be converted to this projected coordinate system for consistency across data sets. The OVGA's online database (www.owens.gladata.com) uses NAD 1983.

"*Survey grade global navigation satellite system (GNSS) global positioning system (GPS) equipment can achieve similar vertical accuracy when corrected. Guidance for use of GPS can be found at USGS http://water.usgs.gov/osw/gps/. Hand-held GPS units likely will not produce reliable vertical elevation measurement accurate enough for the casing elevation consistent with the DQOs and regulatory requirements"* (DWR, 2016a).

"Geographic locations shall be reported in GPS coordinates by latitude and longitude in decimal degree to five decimal places, to a minimum accuracy of 30 feet, relative to NAD83, or another national standard that is convertible to NAD83" (23 CCR § 352.4).

3.4.3 Measuring Groundwater Levels in Water Wells

Depth to groundwater should be measured to a minimum accuracy of 0.1 feet (23 CCR § 352.4) with a desired accuracy of 0.01 feet relative to the RP. "*Measure depth to water in the well using procedures appropriate for the measuring device. Equipment must be operated and maintained in accordance with manufacturer's instructions"* (DWR, 2016a). Measurements must be in consistent units. Recommended units are feet, partitioned into tenths of feet, and hundredths of feet. The use of feet and inches is not recommended. "*Air lines and acoustic sounders may not provide the required accuracy of 0.1 foot"* (DWR, 2016a).

Groundwater elevation is calculated as follows:

$$\mathrm{WLE} = \mathrm{RP} - D\mathrm{TW}$$

Where:

WLE = Groundwater Level Elevation

RP = Reference Point Elevation

DTW = Depth to Water

"For measuring wells that are under pressure, allow a period of time for the groundwater levels to stabilize. In these cases, multiple measurements should be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value should be appropriately qualified as a questionable measurement" (DWR, 2016a).

3.4.3.1 Flowing Wells

A special condition associated with confined aquifer systems (see Section 1.1.8) are naturally flowing wells (artesian) wells where the potentiometric head in the well rises above the land surface. If a monitored well is found to be flowing (i.e., naturally without the aid of a pump) after removal of the well cap, the condition should be documented. If appropriate and safe, the well should be measured. *"Site specific procedures should be developed to collect accurate information and be protective of safety conditions associated with a pressurized well. In many cases, an extension pipe may be adequate to stabilize head in the well. Record the dimension of the extension and document measurements and configuration"* (DWR, 2016a).

Two methods of measuring flowing wells are summarized below:

- Use of tubing or an extension pipe (appropriate for low artesian pressures). Water level under pressure from the flowing well rises in the tube/pipe to a height that is measured above the top of the well casing with respect to the established RP.
- Use of a pressure gauge (commonly applied where high artesian pressures make use of tubing/extension pipes impractical). For every 1 psi of pressure recorded by the gauge, there are 2.31 feet of potentiometric head above the gauge.

3.4.3.2 Periodically Dry Wells

If a well is dry, then document the total depth of the well (TD). If water level is measured near the TD of the well, professional judgment must be used to decide if the measurement is actually representative of the aquifer zone the well is completed in. Many wells have a sump (blank casing with a bottom cap) at the bottom of the well. Ten to 20-foot sumps are common in irrigation and production wells. Water level measurements that approach the TD of a well should be considered suspect unless the construction of the well is known and it has been determined that the water is not evaporation (condensation) water in the bottom of the well with the actual water level of the aquifer some distance below the bottom of the well.

3.4.4 Equipment Decontamination

"The water level meter should be decontaminated after measuring each well" (DWR, 2016a). Equipment decontamination is especially important if a monitoring well-site is known to contain transferable contaminants. If a site is known to be contaminated, dedicated equipment or thorough decontamination after each use may be necessary. Disposable gloves should be properly discarded between sampling sites.

3.5 Groundwater Level Quality Assurance and Quality Control

ICWD and Mono County have QA and QC measures in place to maintain the quality of the data collected by their individual monitoring networks. DWR recommends that *"All data should be entered into the GSA data management system (DMS) as soon as possible. Care should be taken to avoid data entry mistakes and the entries should be checked by a second person for compliance with the DQOs"* (DWR, 2016a).

As mentioned above, OVGA acts as the clearinghouse for water level data collected in the basin. This arrangement provides an additional QA/QC check for water level data collected in the basin by standardizing reference points and the use of data qualifiers associated with water level measurements. If any collected data are found to be suspect, OVGA can contact the originating source of the data (entity that collected the water level measurements) and resolves any apparent issues before upload to the State's database.

4. Requirements for Inspection and Acceptance of Supplies and Consumables

Individual monitoring network managers and supervisors are responsible for identifying the types and quantities of supplies and consumables that are needed for collecting the samples and groundwater level measurements described in this SAP. When supplies are received, field personnel should inspect the condition of all supplies before the supplies are accepted for use. If the supplies do not meet the monitoring entities acceptance criteria (e.g., non-expired field meter calibration standards), the supplies should be rejected.

5. Non-Direct Measurements

For this SAP, it is anticipated that Iinyo County, Bishop, or CSD's or their consultants will acquire data from non-direct measurements such as databases, spreadsheets, and literature files. In addition, these entities may acquire well owner verbally reported data (e.g., verbal water level measurement). Professional judgment and comparison to direct-measurements will be necessary in assessing the usefulness of non-direct measurements in GSP preparation.

6. Data Management

"Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin" (23 CCR § 352.6).

6.1 Water Quality Data

When appropriate, the data should be obtained from the analytical service provider in the form of an EDD, in addition to the required hard copy analytical data package. Formal verification of data should be conducted before associated results are presented or are used in subsequent activities.

Data tracking is essential to ensure timely, cost-effective, and high-quality results. Data tracking begins with sample chain of custody. When the analytical service provider receives custody of the samples, the provider should send a sample acknowledgment to the supervisor of the monitoring network entity. The sample acknowledgment confirm sample receipt, condition, and required analyses. The chain of custody forms should contain all pertinent information about each sample and can track the data at each phase of the process.

Data should be imported into the monitoring entities electronic database and shared with the OVGA clearing house for the agency's use annually at a minimum.

6.2 Water Level Data

Data should be imported into the monitoring entities electronic database and shared with the OVGA clearing house on a minimum frequency of once a year. Water level elevation data appropriately and all data qualifiers (Section 3.1.2) and associated water level measurements should be entered into the database along with any no measurement explanations (Section 3.1.1) documented in the field collection effort should be entered into the database along with the measured water levels.

7. Assessment, Response Actions, and Reports to Management

7.1 Assessment and Response Actions

The SAP QA Officer should conduct a readiness review immediately prior to major data collection tasks in the basin. The QA Officer should report findings to the OVGA Executive Manager, who should take corrective action (if necessary) before the data collection task begins. The OVGA Executive Manager and QA Officer should thoroughly debrief field staff a short time after beginning their respective implementation tasks if any emerging/unanticipated problems are reported and take corrective action, if necessary.

7.2 Reporting to Management

An annual report, after submittal of the basins' GSP, is required as a component of the SGMA legislation. The annual reports are intended to document monitoring and water use data to the DWR to gauge performance of the groundwater basin relative to the sustainability goal(s) identified in the basins' GSP. A component of the annual report could include SAP performance in meeting the sustainability monitoring requirements in the basin. Any limitations in the way the data can be reliably used should be described.

The OVGA Executive Manager could present an annual oral report to the OVGA Board of Directors during a regular monthly board meeting. The oral report should include:

- Readiness review findings (described above);
- Status of SAP related activities in the basin; and
- Identify whether any major QA problems were encountered (and if so, how they were handled).

8. Data Evaluation and Usability

This section describes the procedures that are planned to review and verify field and laboratory data, as well as procedures for verifying that the data are sufficient to meet DQOs and MQOs for the basin.

8.1 Data Review and Reduction Requirements

Data reduction (i.e., processing) and review are essential functions for preparing data that can be used effectively to support basin-specific policy decisions and DQOs. Data review includes all procedures that field or laboratory personnel conduct to ensure that measurement results are correct and acceptable in accordance with the QA objectives that are stated in this SAP. Field and laboratory measurement data reduction and review procedures and requirements are specified in previously discussed field and laboratory methods, and guidance documents.

Field personnel should record, in a field logbook and/or on the appropriate field form, all raw data from chemical and physical field measurements. Field staff should have the primary responsibility for (1) verifying that field measurements were made correctly, (2) confirming that sample collection and handling procedures specified in this basin-specific SAP were followed, and (3) ensuring that all field data reduction and review procedures requirements are followed. Field staff are also responsible for assessing preliminary data quality and for advising the data user of any potential QA/QC problems with field data. If field data are used in required basin reporting, data reduction methods should be fully documented.

The laboratory should complete data reduction for chemical and physical laboratory measurements and should complete an in-house review of all laboratory analytical results. The laboratory QA manager is responsible for ensuring that all laboratory data reduction and review procedures follow State and Federal requirements. The OVGA SAP QA manger is responsible for ensuring that these laboratory procedures are consistent with the requirements that are stated in this SAP. The laboratory QA manager should also be responsible for assessing data quality and for advising the OVGA SAP QA manager of possible QA/QC problems with laboratory data.

8.2 Verification Methods

All data that are used to support decision making must be adequate for their intended purposes. This section outlines the basic data verification procedures that should be followed for all field and laboratory measurements.

The usability of a dataset is determined by comparing the data with a predetermined set of QC limits. Inyo County, Bishop, and CSD's data reviewers should conduct a systematic review of the data for compliance with established QC limits (such as sensitivity, precision, and accuracy) on the basis of spike, duplicate, and blank sampling results that are provided by the laboratory. Data reviewers should evaluate laboratory data for compliance with the following information:

- Method- and basin-specific analytical service requests;
- Holding times;
- Initial and continuing calibration acceptance criteria;
- Field, trip, and method blank acceptance criteria;
- Surrogate recovery;
- Field duplicates and MS and MSD acceptance criteria;
- MD precision;
- LCS accuracy;
- Other laboratory QC criteria specified by the method or on the basin-specific analytical service request form;
- Compound identification and quantitation; and
- Overall assessment of data, in accordance with basin-specific objectives.

The most current EPA guidelines should be followed for completing data verification for all applicable test methods (U.S. EPA, 2002).

9. Reconciliation with Data Quality Objectives

After data have been collected, reviewed, and validated, the data should undergo a final evaluation to determine whether the DQOs specified in this SAP have been met. EPA's DQA process should be followed to verify that the type, quality, and quantity of data that are collected are appropriate for their intended use (U.S. EPA, 2000).

The DQA process involves (1) verifying that the data have met the assumptions under which the data collection design and DQOs were developed, (2) taking appropriate corrective action if the assumptions have not been met, and (3) evaluating the extent to which the data support the decision that must be made so that scientifically valid and meaningful conclusions can be drawn from the data. To the extent possible, DQA methods and procedures should be followed that have been outlined by the U.S. EPA (2000).

To the extent possible, DQA process should be followed to verify that the type, quality, and quantity of data collected are appropriate for their intended use (U.S. EPA, 2000). This assessment should include the following:

- A review of the sampling design and sampling methods to verify that these were implemented as planned and are adequate to support basins' objectives.
- A review of basin-specific data quality indicators for PARCC and quantitation limits to determine whether acceptance criteria have been met.
- A review of basin-specific DQOs to determine whether they have been achieved by the data collected.
- An evaluation of any limitations associated with the decisions to be made based on the data collected. For example, if data completeness is only 90 percent compared to a basin-specific completeness objective of 95 percent, the data may still be usable to support a decision, but at a lower level of confidence.

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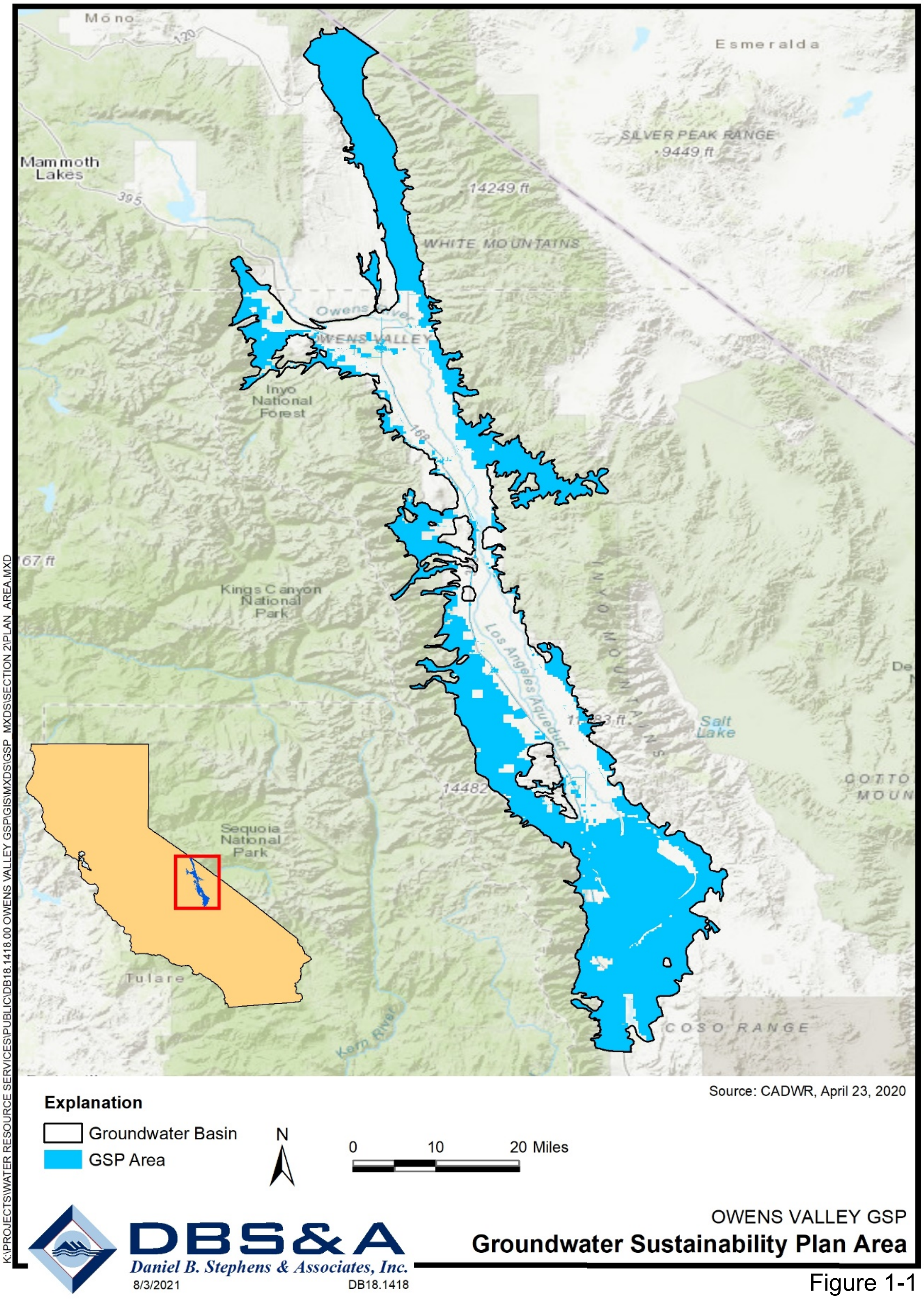
Figures


Mono
Esmeralda
Mammoth Lakes
SILVER PEAK RANGE
9449 ft
14249 ft
WHITE MOUNTAINS
Owens River
OWENS VALLEY
Inyo National Forest
Kings Canyon National Park
Los Angeles Aqueduct
INYO MOUNTAINS
Salt Lake
14482
Sequoia National Park
Tulare
Kern River
COSO RANGE
Source: CADWR, April 23, 2020
Explanation
Groundwater Basin
GSP Area
N
0
10
20 Miles
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8/3/2021
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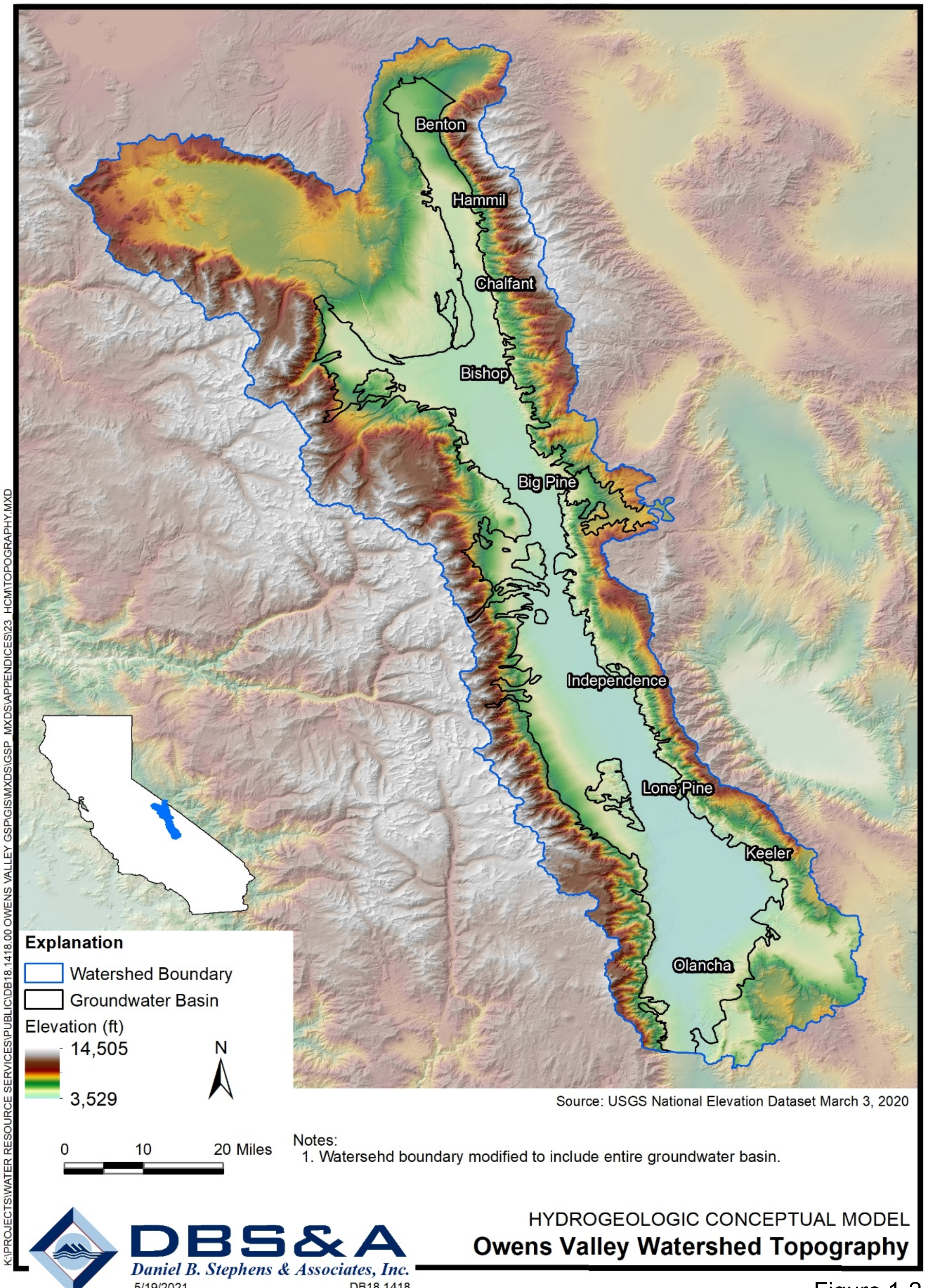
OWENS VALLEY GSP
Groundwater Sustainability Plan Area

Figure 1-1


Benton
Hammil
Chalfant
Bishop
Big Pine
Independence
Lone Pine
Keeler
Olancha
Explanation
Watershed Boundary
Groundwater Basin
Elevation (ft)
14,505
3,529
N
0
10
20 Miles
Source: USGS National Elevation Dataset March 3, 2020
Notes:
1. Watersehd boundary modified to include entire groundwater basin.
HYDROGEOLOGIC CONCEPTUAL MODEL
Owens Valley Watershed Topography
DBS&A
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5/19/2021
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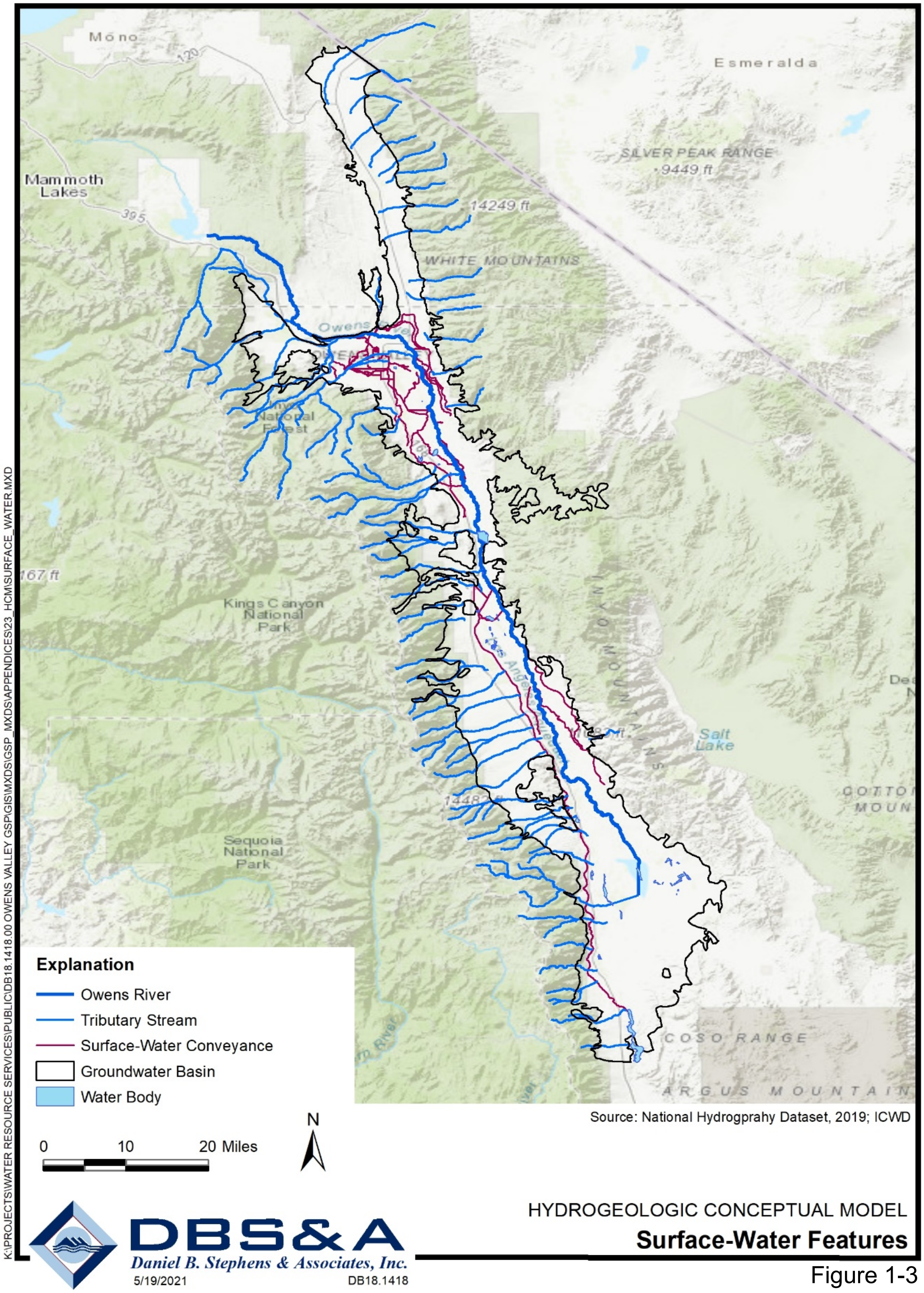
Figure 1-2


Mono
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WHITE MOUNTAINS
Kings Canyon National Park
INYO MOUNTAINS
Salt Lake
Sequoia National Park
COSO RANGE
ARGUS MOUNTAIN
Explanation
Owens River
Tributary Stream
Surface-Water Conveyance
Groundwater Basin
Water Body
0 10 20 Miles
N
Source: National Hydrogprahy Dataset, 2019; ICWD
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HYDROGEOLOGIC CONCEPTUAL MODEL
Surface-Water Features

Figure 1-3

Appendix A. Analytical Laboratory Information

To be supplied by the OVGA at a future date