As a matter of proper business decorum, the Board of Directors respectfully request that all cell phones be turned off or placed on vibrate. To prevent any potential distraction of the proceeding, we request that side conversations be taken outside the meeting room.

AGENDA
SPECIAL BOARD MEETING
THREE VALLEYS MUNICIPAL WATER DISTRICT
1021 E. MIRAMAR AVENUE, CLAREMONT, CA 91711

Monday, February 24, 2020
8:00 a.m.

The mission of Three Valleys Municipal Water District is to supplement and enhance local water supplies to meet our region's needs in a reliable and cost-effective manner.

Item 1 – Call to Order — **Kuhn**

Item 2 – Pledge of Allegiance — **Kuhn**

Item 3 – Roll Call — **Executive Assistant**

Item 4 – Public Comment *(Government Code Section 54954.3* — **Kuhn**

Opportunity for members of the public to directly address the Board on items of public interest within its jurisdiction. The public may also address the Board on items being considered on this agenda. TVMWD requests that all public speakers complete a speaker's card and provide it to the Executive Assistant.

We request that remarks be limited to five minutes or less. Pursuant to Government Code Section 54954.3, if speaker is utilizing a translator, the total allotted time will be doubled.

Item 5 – Cadiz Valley Groundwater Conservation, Recovery, and Storage Project – [enc] — **Litchfield**

Discussion and possible action regarding study plan for investigation of hydrologic connection between Bonanza Spring and the Alluvial Aquifer in Fenner Valley.

Item 5: Board Action Required – Motion No. 20-02-5267

Staff Recommendation: Approve as presented

Item 6 – Future Agenda Items — **Kuhn**

Item 7 – Adjournment — **Kuhn**

The Board will adjourn to a Regular Board Meeting on Wednesday, March 4, 2020 at 8:00 a.m.

American Disabilities Act Compliance Statement

Government Code Section 54954.2(a)

Any request for disability-related modifications or accommodations (including auxiliary aids or services) sought to participate in the above public meeting should be directed to the TVMWD's Executive Assistant at (909) 621-5568 at least 24 hours prior to meeting.

Agenda items received after posting

Government Code Section 54957.5

Materials related to an item on this agenda submitted after distribution of the agenda packet are available for public review at the TVMWD office located at, 1021 East Miramar Avenue, Claremont, CA, 91711. The materials will also be posted on the TVMWD website at www.threevalleys.com.

Three Valleys MWD Board Meeting packets and agendas are available for review on its website at www.threevalleys.com.

Board of Directors
Staff Report

To:	TVMWD Board of Directors
From:	Matthew H. Litchfield, General Manager
Date:	February 24, 2020
Subject:	**Cadiz Valley Groundwater Conservation, Recovery, and Storage Project**

☒	**For Action**	☐	**Fiscal Impact**
☐	**Information Only**	☐	**Funds Budgeted:**

Staff Recommendation:

Staff is requesting direction and possible action to amend a professional services agreement with Aquilogic, Inc. to implement recommendations contained within the Scoping Plan – Bonanza Spring Study, February 2020.

Background:

An independent review of the Cadiz Project was completed in March 2019 and concluded that monitoring and mitigation measures for the Project are appropriate and protective of the surrounding ecosystem, as described in the Groundwater Management, Monitoring and Mitigation Plan ("GMMMP") adopted by the County of San Bernardino Board of Supervisors. The scientific evaluation was commissioned by Three Valleys Municipal Water District ("TVMWD") and Jurupa Community Services District ("JCSD"), which hold option agreements to participate in the Cadiz Water Project. Funding for the review was provided by Cadiz, Inc. The panel that conducted the review consisted of the following professionals:

Anthony Brown, Aquilogic
Mark Wildermuth, WEI
Dave Romero, Balleau Groundwater
Tim Parker, Parker Groundwater

The panel concluded in the report titled *"Report of the Independent Peer Review Panel, for the GMMMP"* ("Peer Review Panel Report") submitted on February 5, 2019 to TVMWD, that the GMMMP provides sufficient management and monitoring to identify any undesirable results that could occur in response to proposed groundwater pumping, as well as effective corrective measures. However, in an abundance of caution, the panel recommended several complementary additions that could be made to the GMMMP, where such additions are feasible to implement.

The results of the Peer Review Panel Report were presented to the TVMWD Board of Directors ("Board") at a special board meeting on March 13, 2019 to discuss the findings with project opponents and proponents in attendance. Subsequently, on June 11, 2019, Aquilogic submitted a proposal to TVMWD to implement certain recommendations contained within the Peer Review Panel Report. The proposed project team consists of the following professionals:

- Hydrology: Anthony Brown (Principal Hydrologist) and Brandon Eisen Principal Hydrogeologist/Project Manager, Aquilogic
- Geophysics: Paul Bauman (Senior Hydro-geophycist), Advisian
- Geochemistry: Dr. Anne Maest (Independent Geochemist)
- Ecology: Tamara Klug (Senior Ecologist), Cardno

The June 11th proposal was broken down into three phases as follows:

Phase 1: Development of a Study Plan
Phase 2: Implementation of the Study Program
Phase 3: Preparation of a Study Program Report

On June 19, 2019, the Board approved a professional services contract with Aquilogic to proceed with Phase 1 of the scope of work only. Phase 1 will define the Phase 2 and Phase 3 Study Program scope of work elements. On October 10, 2019, the stakeholders held a workshop at TVMWD to the discuss the Study Program and develop an outline for the Phase 2 and Phase 3 scope of work. The Phase 1 work has been completed and was submitted to TVMWD on February 12, 2020.

Discussion:

The Study Program titled *"Scoping Plan, Bonanza Spring Study, San Bernardino County, California"* ("Study Plan") is attached as **Exhibit A**. The Study Plan is the result of the culmination of work between the professionals listed above and is specifically tailored to address concerns related to a potential hydraulic connection between Bonanza Spring and groundwater in the alluvial aquifer in Fenner Valley.

The proposal and scope of work by the project team is attached as **Exhibit B**. The proposal outlines specific tasks and fees to complete Phase 2 and Phase 3 as follows:

Phase 2: $ 534,750.00
Phase 3: $ 270,250.00
Total: $ 805,000.00

The fees above include a 15% contingency. The Board has the following options for consideration regarding the Study Plan:

1. Approve Phase II scope of work only (Fee = $ 534,750.00)
2. Approve Phase II and Phase III scope of work (Fee = $ 805,000.00)
3. Take no action

Fiscal Impact:

Funding for the work will be placed on deposit with TVMWD by Cadiz, Inc. Therefore, there is no fiscal impact to TVMWD other than minor administrative costs.

Strategic Plan Objective(s):

1.3 Maintain diverse sources of water supplies and storage, and increase extractable water storage supplies to 10,000 AF

3.3 – Be accountable and transparent with major decisions

Attachment(s):

Exhibit A – Scoping Plan, Bonanza Spring Study, San Bernardino County, California

Exhibit B – Proposal to Conduct a Study Program to Evaluate the Hydrologic Connection Between Bonanza Spring and the Alluvial Aquifer in Fenner Valley

Meeting History:

Board of Directors Special Meeting – March 13, 2019 (Workshop)

Board of Directors Meeting – June 19, 2019

ML/NA

Item 5 - Exhibit A

aquilogic, Inc.
environment ● water ● strategy

245 Fischer Avenue, Suite D2
Costa Mesa, CA 92626
Tel. +1. 714.770.8040
Web: www.aquilogic.com

SCOPING PLAN

BONANZA SPRING STUDY

San Bernardino County, California

Prepared for:
Three Valleys Municipal Water District
1021 E. Miramar Avenue
Claremont, CA 91711-2052

Project No.: 052-02

February 2020

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ACRONYMS AND ABBREVIATIONS

%	percent
‰	per mille (per thousand)
°C	degrees Celsius
2-D	two-dimensional
316SS	Type 316 stainless steel
AF	acre-feet
AFY	acre-feet per year
BLM	Bureau of Land Management
^{12}C	carbon-12
^{14}C	carbon14
Cadiz Project	Cadiz Valley Water Conservation, Recovery and Storage Project
CF-IRMS	continuous flow isotope mass analyzer
CHg	Certified Hydrogeologist
CHM	conceptual hydrogeologic model
cm	centimeter
^{52}Cr	chromium-52
^{53}Cr	chromium-53
DC	direct current
δ	delta units
DEM	digital elevation model
DO	dissolved oxygen
DOT	US Department of Transportation
DSI or SiO_2	dissolved silica
DWR	California Department of Water Resources
EC	electric conductivity
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELAP	California Environmental Laboratory Accreditation Program
EM	electromagnetic
ERT	electrical resistivity tomography
ft	foot/feet
FVMWC	Fenner Valley Mutual Water Company
FVWA	Fenner Valley Water Authority
GIS	geographic information system
GMMMP	Groundwater Monitoring, Management and Mitigation Plan
gpm	gallons per minute
GPR	ground penetrating radar
GSSI	Groundwater Support Services, Inc.
^{2}H	deuterium
^{3}H	tritium
^{3}He	helium-3
IDW	investigation derived waste
in	inch

L	liter
K	hydraulic conductivity
LLNL	Lawrence Livermore National Laboratory
m	meter
m^3/s	cubic meters per second
mg	milligram
mi	mile
mi^2	square miles
mL	milliliter
mg/L	milligrams per Liter
MHZ	megahertz
MIT	Massachusetts Institute of Technology
MSL	mean sea level
MWD	Metropolitan Water District
MWL	meteoric water line
$Na\text{-}HCO_3$	sodium bicarbonate
NDVI	normalized difference vegetation index
NIR	near infrared
NMR	nuclear magnetic resonance
nT	nanotesla
^{16}O	oxygen-16
^{18}O	oxygen-18
ohm-m	ohmmeter
One Call	Underground Service Alert
ORP	oxidation-reduction potential
Panel	Independent Expert Panel
PE	Professional Engineer
PG	Professional Geologist
pCi/L	picocuries per Liter
pH	potential hydrogen ion concentration
pMC	percent modern carbon
ppt	parts per thousand
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RAWS	remote automated weather station
RGB	red, green, and blue
s	second
S	storativity
S/N	signal to noise
SB	senate bill
SM	Standard Methods
SMOW	standard mean ocean water
SMWD	Santa Margarita Water District
Study	third-party study
TDS	total dissolved solids
TOC	total organic carbon

UAV	unmanned aerial vehicle
UCI	University of California at Irvine
µmhos	micromhos
UNLV	University of Nevada at Las Vegas
µS	microsiemens
µS/cm	microSiemens per centimeter
UST	underground storage tank
USCS	Unified Soil Classification System
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
TU	tritium units
Three Valleys	Three Valleys Municipal Water District
VLF	very low frequency

1.0 INTRODUCTION

In late 2018, an Independent Expert Panel (Panel) was retained by Three Valleys Municipal Water District (Three Valleys) to conduct an independent review of the Groundwater Management, Monitoring and Mitigation Plan (GMMMP) for the Cadiz Valley Water Conservation, Recovery and Storage Project (Cadiz Project). The Panel consisted of the following professionals:

- Anthony Brown, **aquilogic**
- Mark Wildermuth, Wildermuth Environmental
- Dave Romero, Balleau Groundwater
- Tim Parker, Parker Groundwater

1.1 Panel Objectives

The focus of the Review was to evaluate whether the GMMMP (ESA, 2012a) was sufficient to ensure that the proposed pumping at the Cadiz Project would not result in Potential Significant Adverse Impacts to Critical Resources (Undesirable Results) that could not be effectively mitigated. The objectives of the Panel were to assess whether the GMMMP:

- Provided sufficient management and monitoring to identify any Undesirable Results that could occur in response to proposed groundwater pumping at the Cadiz Project
- Provided effective Corrective Measures (i.e., mitigation) to address any Undesirable Results that do occur

In addition, where deemed necessary, the Panel was to provide recommendations for management, monitoring, and mitigation procedures, and recommend additional work to improve the understanding of the hydrology of the Cadiz Project area.

1.2 Panel Conclusions

On February 5, 2019 the Panel submitted the "Report of the Independent Peer Review Panel, for the Groundwater Management, Monitoring, and Mitigation Plan (GMMMP) for the Cadiz Valley Groundwater Conservation, Recovery and Storage Project" to Three Valleys (the Peer Review Panel Report; aquilogic, 2019). On March 13, 2019, the findings within the Peer Review Panel Report were presented to the Board of Three Valleys.

The Review Panel concluded in the Peer Review Panel Report (aquilogic, 2019) that the GMMMP provides appropriate and sufficient management and monitoring to identify Undesirable Results that could occur in response to proposed pumping at the Cadiz Project. In addition, the GMMMP provides effective Corrective Measures to address any Undesirable Results in the long-term. The Panel also recommended a number of complementary additions that could be made to the GMMMP, where such additions are feasible to implement.

On June 11, 2019, **aquilogic** submitted a proposal to Three Valleys to implement certain recommendations contained within the Peer Review Panel Report related to Bonanza Spring. The focus of the proposal was to conduct an impartial, objective, third-party study (Study) of the nature of the hydraulic connection between the groundwater that supports Bonanza Spring and the aquifer in Fenner Valley below from which the Cadiz Project would withdraw groundwater.

1.3 Cadiz Project

The Cadiz Project is located at the confluence of the Fenner, Orange Blossom Wash, Bristol and Cadiz watersheds in eastern San Bernardino County (see **Figures 1 and 2**). Within this closed basin system, groundwater percolates and migrates downward from the higher elevations and eventually flows to Bristol and Cadiz dry lakes where it evaporates after mixing with the highly saline groundwater zone under the dry lakes. The portion that evaporates is lost from the groundwater basin and is unable to support beneficial uses. The fundamental purpose of the Cadiz Project is to conserve the substantial quantities of groundwater that are presently wasted and lost to evaporation to create a local water supply alternative for Southern California. Under the conservation and recovery component of the Cadiz Project, an average of 50,000 acre-feet per year (AFY) of groundwater would be pumped from the basin over a 50-year period.

1.4 Study Program Objectives

Many of the recommendations presented within the Review Panel Report (aquilogic, 2019) are focused on providing a better understanding of hydrologic conditions at, and in the vicinity of, Bonanza Spring (see **Figure 3**). Therefore, the objective of the Study Program is to implement a data collection and analysis program to provide this improved understanding. In particular, the goals of the Study Program are as follows:

- Answer definitively whether a hydrologic connection exists between the Cadiz Project and Bonanza Spring
- If a connection exists, determine whether the Cadiz Project can proceed in a manner protective of the spring
- If necessary, recommend amendments to the GMMMP to protect the spring.

Further, the Study Program will provide baseline monitoring (i.e., hydrologic and biological conditions) in the vicinity of Bonanza Spring prior to the proposed pumping at the Cadiz Project.

Since the submission of the Peer Review Report (aquilogic, 2019), State Senators Richard Roth, Anthony Portantino and Benjamin Allen, and Assembly Member Laura Friedman have sponsored Senate Bill (SB) 307. SB307 proposes to establish a new and added review of the Cadiz Project prior to the use of excess capacity in a publicly owned water conveyance facility to transfer water. Specifically, upon application by a transferor, the State Lands Commission will be asked to determine that the proposed transfer will not adversely affect the natural or cultural resources, including groundwater resources or habitat, of federal or state lands. The completion of this study is intended to be responsive to this evaluation.

1.5 Study Program Principles

The Study Program will adhere to the following principles:

- Transparent
- Inclusive
- Scientific
- Impartial
- Independent
- Honest
- Collaborative

1.6 Study Program Approach

aquilogic recommended that the Study Program be implemented in the following three phases:

I. Development of a Scoping Plan for the Study Program
II. Implementation of the Study Program
III. Preparation of a Study Program Report

The Study Program includes many of the recommendations provided in the Review Panel Report. However, the Review Panel Report does not provide details as to how the recommendations should be implemented. In addition, it was recognized that other parties may have ideas as to how the recommendations could be implemented, and the Study Program objectives satisfied. Therefore, **aquilogic** recommended that a workshop be conducted to define the scope of the Study Program.

1.7 Study Program Team

Given the objectives and goals of the Study Program, **aquilogic** assembled the following team of subject matter experts in various scientific disciplines to conduct the required field studies and data collection and analyze the data (see **Figure 4**):

- Hydrology – **aquilogic**, led by Anthony Brown (Principal Hydrologist) and Brandon Eisen (Senior Hydrogeologist and Project Manager)
- Geophysics – Advisian, led by Paul Bauman (Senior Hydro-geophysicist)

- Geochemistry – Dr. Anne Maest (Independent Geochemist)
- Ecology – Cardno, led by Tamara Klug (Senior Ecologist)

1.8 Study Program Peer Review

An expert panel will be established to provide peer review of the Study Program, its scope, data collection and analyses, study program findings, and the overall Study Program Report. The expert panel will consist of the following members:

- Geophysics – Professor Jascha Polet, CalPoly Pomona – invited
- Hydrology – Eric Reichard, PhD, United States Geological Survey (USGS) - invited
- Hydrogeology – Professor Charles Harvey, Massachusetts Institute of Technology (MIT)
- Geochemistry – Professor David Kreamer, University of Nevada at Las Vegas (UNLV)
- Ecology – Professor Travis Huxman, University of California at Irvine (UCI) - invited

1.9 Study Program Scoping Workshop

Over 80 representatives from environmental groups, non-profits, government agencies, water districts, and other stakeholders were invited to participate in a field visit to the Cadiz Project area and scoping workshop for the Study Program.

On October 9, 2019, Study Program team members visited Bonanza Spring, the Fenner Valley, and the Cadiz Project to gain an understanding of the project setting, including geographic location and scale, topography, climate, geology, hydrology, and ecology.

On October 10, 2019, 30 interested stakeholders convened at the offices of Three Valleys to discuss the Study Program and develop an outline for the Study Program scope (this document). In addition, the Study Program Team addressed technical questions from workshop participants regarding how the scope would provide data to help satisfy the Study Program goals and objectives.

1.10 Study Program Hypotheses

The Study Program will consider the following two hypotheses:

- The groundwater that supports flow at Bonanza Spring is hydrologically connected to the aquifer in Fenner Valley below from which the Cadiz Project will withdraw groundwater, and conversely
- The groundwater that supports flow at Bonanza Spring is hydrologically disconnected from the aquifer in Fenner Valley below.

Two conceptual hydrologic models were developed that illustrate these two hypotheses (see **Figures 5A and 5B**). For each conceptual hydrologic model, two alternatives were provided. The conceptual hydrologic model will be revised as data dictate.

The investigate the two hypotheses and associated conceptual hydrologic models, the Study Program will characterize geological, geophysical, hydrological, geochemical, and ecological conditions proximate to Bonanza Spring.

If the data collected and subsequent analysis support the first hypotheses, then the Study Program will evaluate whether the proposed pumping at the Cadiz Project will have significant and unreasonable adverse impact on flows at Bonanza Spring. If such impact will occur, then the Study Program will recommend amendments to the GMMMP, and possibly the overall Cadiz project, to protect the spring.

If the data collected and subsequent analysis support the second hypotheses, the Study Program will still recommend an ongoing hydrologic and ecological monitoring program to monitor conditions proximate to Bonanza Spring.

2.0 PROJECT SETTING

A description of the Cadiz Project, along with Project Setting and Hydrogeology, was presented in Appendix B to the Peer Review Report (aquilogic, 2019). Information from this document pertinent to Bonanza Spring is provided below.

2.1 Geographic Location

The spring closest to the proposed pumping at the Cadiz Project is Bonanza Spring. The spring is located in the Clipper Mountains (see **Figures 1 and 2**), one of a series of mountain ranges that surround the Fenner Valley that include (clockwise from the Clipper Mountains) the Providence, New York, Hacker, Castle, Piute, Old Woman, Ship, Marble, and Granite Mountains.

The Fenner Watershed encompasses approximately 1,100 square miles (mi^2). The topography of the watershed ranges in elevation from over 7,400 feet above mean sea level (MSL) in the New York Mountains to about 1,000 feet above MSL at the Fenner Gap. The Fenner Gap is located between the Ship and Marble Mountains just north of the current Cadiz Project land holdings. The Fenner Gap is the topographic low point at the southerly end of Fenner Valley, and all surface water and groundwater that drain the Fenner Watershed ultimately flows through the Fenner Gap. Bonanza Spring is approximately 11 miles north of the center of the Fenner Gap.

All springs within the Fenner Watershed, including Bonanza Spring, are located in crystalline bedrock formations and outcrop at much higher elevations than groundwater within the alluvial aquifer of the Fenner Valley. The elevation of Bonanza Spring is approximately 2,100 feet above MSL while the groundwater elevation within the alluvial aquifer Fenner Valley is approximately 1,090 feet above MSL, or a vertical separation between the spring and the water table of approximately 1,090 feet.

2.2 Regional Geology

Bonanza Spring is located in the Mojave Desert geomorphic province and Colorado River Hydrologic Region of eastern southern California. The spring marks the southern extent of a five to ten mi^2 swath of exposed bedrock on the southern flank of the Clipper Mountains.

There have been few studies describing the bedrock units and structures in the Clipper Mountains (Kenney, 2018 and Miller, 2007). The main bedrock units are described as sub-volcanic intrusive igneous bodies and were correlated with the rocks along the northern flanks of the Clipper Mountains (Kenney, 2018 and Miller, 2007). The majority of rocks were exhumed by Miocene crustal extension (Kenney, 2018).

Lithologies north of the Bonanza Spring are sub-volcanic, tabular intrusions intruded by steeply dipping and northwest-striking dikes with surface contacts trending parallel to their host rock units (Kenney, 2018). This area is also riddled with steeply dipping conjugate fracture and fault sets that generally strike either northeast or northwest, the orientation being strongly correlated with the unit that the structure deforms. The bedrock units are also deformed by several prominent fault zones; one whose trace trends northwest and is truncated by the other, whose trace trends northeast. According to Kenney (2018), the junction of these two fault sets is located at Bonanza Spring.

Bedrock of the Clipper Mountains is generally well-exposed north of the Bonanza Spring. The terrain south of the fault junction consists of the same rocks to the north, comprising a pediment (flat erosional bedrock plane) for one to two miles, covered by a thin layer of alluvium (Kenney, 2018). South of the pediment are fanglomerates, volcanic deposits, and stratigraphically highest alluvium filling the basin (**Figure 6** [from Kenney, 2018]). A cross-section showing the various geologic units and structural features proximate to Bonanza Spring is provided as **Figure 7** (from Kenney, 2018).

2.3 Regional Hydrogeology

2.3.1 Groundwater Basins

The California Department of Water Resources (DWR) laterally defines the Fenner Valley Groundwater Basin (No. 7-2) by the surficial expression of alluvial deposits and their contact crystalline bedrock in the surrounding mountain ranges. The Fenner Valley Basin covers a surface area of 454,000 acres (702 mi^2). The Lanfair Valley Groundwater Basin is located north of the Fenner Valley Basin, and groundwater within Lanfair Valley Basin likely flows into Fenner Valley. The Bristol Valley Groundwater Basin is located south of the Fenner Valley Basin, and groundwater within Fenner Valley flows through the Fenner Gap into the Bristol Valley Basin. Groundwater discharges from the Bristol Groundwater Basin via evaporation at the Bristol and Cadiz dry lakes or via pumping at agricultural and domestic water supply wells. Thus, the Fenner-Bristol Valleys form a closed groundwater system.

2.3.2 Hydro-Stratigraphy

<u>Fenner Valley</u>

Within the Fenner Valley Groundwater Basin, two main aquifers are recognized in the literature. The shallower aquifer reaches a thickness of up to 600 feet and is composed of Quaternary gravels and sands (DWR, 1967; MWD, 1999, 2000). A deeper aquifer is composed of Middle to Late Tertiary alluvium and may reach thicknesses of up to 1,800 feet (MWD, 2000). The deeper aquifer has comparatively more fine-grained sediments and lower permeability than the shallower aquifer (MWD, 2000). Discontinuous layers of silt and clay are observed, but neither aquifer is presumed to be confined (MWD, 2000).

Above Bonanza Spring

Immediately above Bonanza Spring, groundwater is present within the crystalline bedrock units. These bedrock units have very limited primary porosity, and most of the groundwater likely occurs within fracture networks (i.e., secondary porosity). This groundwater is sustained by recharge from precipitation that falls on the Clipper Mountains. Bonanza Spring is formed where the potentiometric surface of this groundwater intersects the land surface. Kenney (2018) suggests that the location of Bonanza Spring is fault controlled. The fault sets act as partial barriers to groundwater flow, with groundwater backed up behind the faults supporting flow at the spring. In simple terms, the fault zones act as a dam behind which the water builds up and over-tops the dam at a spring at ground surface.

Under this conceptual hydrologic model (see **Figure 5A**), the potentiometric surface of the groundwater above the spring is not contiguous with that below the spring. That is, there is no direct hydrologic connection between the groundwater that supports the spring and any groundwater in alluvial sediments south of the spring in Bonanza Wash, let alone with groundwater in the alluvial aquifers in the Fenner Valley below. Thus, changes in groundwater levels in Fenner Valley that result from pumping at the Cadiz Project would have no effect on the groundwater in crystalline bedrock that supports flows at Bonanza Spring and, thus, the spring flows.

An alternative interpretation (see **Figure 5B**) is that there is no barrier to groundwater flow. Under this conceptual hydrologic model, the potentiometric surface of groundwater above the spring is contiguous with that below the spring and with that in the alluvial aquifers of Fenner Valley. Bonanza Spring is simply formed at a location where the potentiometric surface contacts the land surface. Under this conceptual hydrologic model, changes in groundwater levels in Fenner Valley that result from pumping at the Cadiz Project may have an effect on the groundwater in crystalline bedrock that supports flows at Bonanza Spring and, thus, the spring flows.

Below Bonanza Spring

Irrespective of the presence or absence of barriers to groundwater flow at Bonanza Spring, flows at the spring discharge into upper Bonanza Wash. These flows then percolate into the underlying alluvial sediments within a few hundred yards south of the spring. However, during precipitation events, flows along Bonanza Wash can extend as far as Fenner Valley. The percolation of these surface flows would recharge the underlying groundwater.

The thickness of alluvial deposits along Bonanza Wash is not definitely known. Given observed bedrock outcrops along Bonanza Wash, Kenney (2018) interprets a shallow alluvial sequence over a pediment surface of crystalline rocks (see **Figures 5A and 7**). Under this conceptual hydrologic model, it is likely that ephemeral groundwater would be present in such thin alluvial sediments immediately after major precipitation events. The potentiometric surface of such ephemeral groundwater would not be contiguous with that of the alluvial aquifers in Fenner Valley. That is, there would not be a direct hydrologic connection between groundwater in the alluvial deposits along Bonanza Wash and the alluvial aquifers in Fenner Valley. Between precipitation events, ephemeral groundwater in the alluvial sediments would drain into the underlying bedrock. Under this conceptual hydrologic model, changes in groundwater levels in Fenner Valley that result from pumping at the Cadiz Project would have no effect on the groundwater in crystalline bedrock that supports flows at Bonanza Spring and, thus, the spring flows.

An alternative interpretation is that Bonanza Wash is a deeply incised subterranean canyon infilled with thicker alluvial deposits (see **Figure 5B**). These alluvial deposits, the groundwater within them, and the potentiometric surface are contiguous with those in Fenner Valley. Under this conceptual hydrologic model, changes in groundwater levels in Fenner Valley that result from pumping at the Cadiz Project may have an effect on the groundwater in crystalline bedrock that supports flows at Bonanza Spring and, thus, the spring flows.

Irrespective of the thickness of alluvial sediments within Bonanza Wash, groundwater is likely present in the fracture networks of the crystalline rocks that underlie Bonanza Wash at greater depth. Under one conceptual hydrologic model (see **Figure 5A**), the potentiometric surface of groundwater in the crystalline rocks is separate from that in the overlying alluvial sediments. Whereas, in an alternative conceptual hydrologic model (see **Figure 5B**), groundwater in the crystalline rocks and alluvial sediments is contiguous, the bedrock is fully saturated, and there is a single potentiometric surface present in the alluvial sediments.

2.3.3 Groundwater Flow

As noted, groundwater within the Lanfair-Fenner-Bristol Basins ultimately flows to the Bristol and Cadiz dry lakes, where it evaporates and is lost. In Orange Blossom Wash, groundwater flows to the southeast from the Granite Mountains through the wash, and then to the southwest into Bristol Dry Lake. In the Fenner Watershed, groundwater generally flows radially from the surrounding mountains to the center of the valley and thence southward. A groundwater divide exists within the watershed. Recharge from the Providence, Granite, Clipper and Marble mountains (the western portion of the watershed) eventually discharges through the Fenner Gap to the Bristol Dry Lake. Recharge from the New York, Old Women and Ship mountains (eastern portion) eventually discharges through the Fenner Gap to the Cadiz Dry Lake. It is likely that some groundwater from the Lanfair Valley flows into the eastern portion of the Fenner Watershed, and eventually discharges to Cadiz Dry Lake (groundwater in Lanfair Valley also supports flow at Piute Spring).

In the vicinity of Bonanza Spring, lateral groundwater flow is to the south. However, the degree of continuity in flow is dependent on the conceptual hydrologic model considered. Under one conceptual hydrologic model (see **Figure 5A**), groundwater in the crystalline bedrock above the spring is separated from groundwater below the spring by fault zones that act as partial barriers to flow. This groundwater does not flow across the fault zones into a contiguous groundwater system south of the fault zones, but rather overtops the faults and then re-percolates south of the fault zones. Further, the groundwater in a thin alluvial sequence in Bonanza Wash is ephemeral and perched above underlying crystalline rock. This groundwater drains into the fracture networks of the underlying crystalline bedrock, but the bedrock is not fully saturated. Thus, groundwater above the spring and groundwater in alluvial sediments along Bonanza Wash are not in direct hydrologic connection with groundwater in the alluvial aquifers in Fenner Valley. Groundwater in the crystalline bedrock beneath Bonanza Wash may or may not be in direct hydrologic connection with the groundwater in Fenner Valley.

Under the alternative conceptual hydrologic model (see **Figure 5B**), groundwater in the crystalline bedrock above the spring is contiguous with groundwater below the spring and groundwater flows unimpeded to the south. Further, groundwater south of the spring is present in a thicker alluvial sequence in Bonanza Wash and within the fracture networks of the underlying crystalline bedrock, and the bedrock is fully saturated. This groundwater continues to flow unimpeded to the south into the alluvial aquifers in Fenner Valley. Thus, groundwater above the spring and groundwater in alluvial sediments along Bonanza Wash are in direct hydrologic connection with groundwater in the alluvial aquifers in Fenner Valley.

2.4 Regional Surface Hydrology

There are no perennial streams within the watershed. Ephemeral runoff within the Fenner Watershed flows into the Schulyer Wash, the principal drainage feature, and then flows through Fenner Gap towards Bristol and Cadiz Dry Lakes. The only outlets for surface water are direct evaporation from intermittent surface water flow, transpiration by vegetation, and evaporation from the dry lakes.

The Bonanza Spring was recognized as a site of groundwater discharge more than 100 years ago. Mendenhall (1909) described use of the Bonanza Spring by prospectors, and Thompson (1929) reported a discharge value of approximately 10 gallons per minute (gpm). The water was sent through pipes to Danby to be used at the railroad. A former homestead is also located down-stream of Bonanza Spring. Water was transmitted from Bonanza Spring to the homestead. Old intake structures for surface water flow (i.e., drums cut in half connected to pipes extending down the gullies) are present above the current location of Bonanza Spring. In addition, a tunnel was excavated at a gully above Bonanza Spring at a location where the spring may have historically daylighted. These features suggest that, in the past, Bonanza Spring emerged from the bedrock at higher elevations that its current location.

2.5 Groundwater Use

There is no known current usage of groundwater in the immediate vicinity of Bonanza Spring. Within the Fenner Gap area and further downgradient at Bristol and Cadiz Dry Lakes, groundwater extraction supports agricultural and salt mining operations.

Between 1994 and 2007, approximately 5,000 to 6,000 AFY of groundwater was being used to support agricultural operations at the Cadiz land holdings (**Figure 2**). Starting in 2007, this annual usage was reduced in connection with the removal of approximately 500 acres of vineyard. Based on the recent crop mix, the agricultural operations are using approximately 1,800 AFY to 1,900 AFY (ESA, 2012b).

Two existing salt mining operations exist at the Bristol and Cadiz dry lakes. These operations excavate trenches down to the hyper-saline groundwater or pump hyper-saline groundwater into impounds. The groundwater then evaporates form the trenches/impounds and the precipitated salts are recovered. One operation uses approximately 500 AFY of the hyper-saline groundwater based upon recorded water extractions, while the other operation uses approximately 250 AFY, for a total of 750 AFY (ESA, 2012b).

In general, wells in the Fenner Valley Basin yield as much as 200 gpm; however, wells in the Fenner Gap area completed in the same aquifers yield 1,000 gpm to 3,000 gpm (MWD, 1999).

2.6 Groundwater Quality

Groundwater in the Fenner Valley Basin is primarily calcium-bicarbonate type near the western mountain ranges and sodium-bicarbonate ($Na\text{-}HCO_3$) type near the center of the basin. The total dissolved solids (TDS) concentrations of groundwater within the basin ranges between 173 milligrams per liter (mg/L) to 2,260 mg/L (averages 515 mg/L) (Friewald 1984). Near the Fenner Gap area, TDS concentrations typically range from 300 to 350 mg/L (MWD 1999). Groundwater discharged at Bonanza Spring is reportedly a sodium-bicarbonate ($Na\text{-}HCO_3$) type water, consistent with prior studies (Zdon, 2018).

3.0 SUMMARY OF PRIOR ASSESSMENTS

3.1 Davisson and Rose (2000)

Davisson and Rose (2000) used a calibrated Maxey-Eakin method to estimate recharge in the Fenner Basin. They concluded an annual groundwater replenishment rate range between 7,864 acre-feet (AF) and 29,185 AF.

3.2 Environmental Impact Report (2001)

The Metropolitan Water District of Southern California (MWD), in partnership with Cadiz, Inc., proposed a project that would include a 35-mile long pipeline for water conveyance. MWD published a draft Environmental Impact Report (EIR)/ Environmental Impact Statement (EIS) in 1999, followed by a 104-day public review period (MWD, 2000). Of principal concern to commenters was groundwater management issues. The EIR was finalized in September 2001.

3.3 Assessment of Effects of the Cadiz Project on Springs (2011)

The vulnerability of springs to the lowering of groundwater by pumping at the Cadiz Project was evaluated by reviewing the results of groundwater flow modeling (CH2M Hill, 2011 and GSSI, 2011). Two conceptual models were developed for the Bonanza Spring area. One model assumed no hydraulic connection between the regional groundwater table of the alluvial aquifer in Fenner Valley and the springs, and the other assumed a connection. In the model that considered a connection, if pumping maintained 10 feet (ft) of drawdown in alluvium at the edge of Fenner Valley most proximate to Bonanza Spring, there would be 1-ft of drawdown at the spring.

3.4 EIR (2012)

As the managing member of the Fenner Valley Water Authority (FVWA), a joint powers authority with the Fenner Valley Mutual Water Company (FVMWC), Santa Margarita Water District (SMWD) prepared an EIR for the Cadiz Project (ESA, 2012b). The Final EIR was certified in July 2012. The Cadiz Project included construction of groundwater extraction wells, a 43-mile long pipeline for water transport, and monitoring and safety features.

3.5 GMMMP, September (2012)

A GMMMP was prepared to guide the FVMWC and SMWD in their implementation of the Cadiz Project in compliance with the exclusion provisions of the San Bernardino County's Desert Groundwater Management Ordinance (ESA, 2012a). The plan outlined a Phase I for initial extraction of groundwater not exceeding an average of 50,000 AFY with a maximum of 75,000 AFY.

3.6 Review of the Groundwater Hydrology of the Cadiz Project (2013)

aquilogic (2013) conducted an impartial, objective, third-party review of the groundwater hydrology of the Cadiz Project to support settlement of litigation brought by Laborers' International Union of North America Local Union No. 783 against SMWD. The review focused on an evaluation of possible adverse impacts identified in the Final EIR (ESA, 2012b). The review concluded that, based on the currently available data, significant and unreasonable adverse impacts would not result from the pumping at the Cadiz Project.

3.7 Zdon and Associates (2016)

A survey of the springs of the Mojave Desert identifying 436 unique springs, including Bonanza Spring, was published (Zdon, 2016).

3.8 Lawrence Livermore National Laboratory (2017)

The Lawrence Livermore National Laboratory (LLNL) published data from 2000 on water collected in the Eastern Mojave Desert, including water sampled at Bonanza Spring (Rose, 2017). These data included 0.003 m^3/s spring discharge, a temperature of 26.5 degrees Celsius (°C), $\delta^{13}C = -9.2‰$, $\delta^{2}H = -83.1‰$, $\delta^{18}O = -10.65‰$, and a tritium measurement of 0.1 ^{3}H picocuries per Liter (pCi/L).

3.9 Zdon, et al. (2018)

A study was completed that analyzed major element and oxygen and hydrogen isotope geochemistry, and plotted their data relative to previously published data from the Fenner Valley Basin and adjacent areas (Zdon, 2018).

3.10 Kraemer (2018)

Based upon the results of the geochemical analyses published by others (Zdon, 2018), Kraemer (2018) concluded that groundwater at Bonanza Spring is chemically different from groundwater collected from wells within the Fenner Valley Basin.

3.11 Love and Zdon (2018)

A study of the estimate of groundwater recharge in the southeastern Mojave Desert using radiocarbon dating was published (Love and Zdon, 2018).

3.12 Kenney (2018)

Kenney (2018) performed detailed geologic mapping of the Clipper Mountains including analysis of the lithology and structural geology. Two significant structural interpretations included (1) Bonanza Spring is situated at the junction of two steeply dipping fault zones that act as barriers to horizontal groundwater flow, causing upstream groundwater in the fractures and faults to mound up, and (2) the alluvium downstream of Bonanza Spring is thin (several to several tens of feet) for several miles, resting atop a pediment continuation of the Clipper Mountains.

3.13 Peer Review Panel (February 2019)

An Independent Peer Review Panel was retained by Three Valleys and Jurupa Community Services District to conduct an impartial, objective, third-party review of the GMMMP for the Cadiz Project (aquilogic, 2019). Overall, the panel concluded that the GMMMP was appropriate for identifying, monitoring and mitigating potential undesirable results, but provided 12 recommendations to improve the understanding of the hydrology of the Cadiz Project.

3.14 FVWA Final EIR Addendum (2019)

Following the 2012 Final EIR, revisions to the Cadiz Project plans were completed. An addendum to the 2012 Final EIR was prepared to incorporate these revisions. The revisions included minor redesign to the project pipeline and the proposal of a groundwater treatment facility. The addendum concluded that the modifications since the 2012 Final EIR would not result in changes to its findings.

4.0 STUDY PROGRAM SCOPE

The study program will be implemented in the following phases:

- Geophysical and Hydrological Assessments – First Quarter 2020
- Ecological and Hydrogeological Assessments (excluding aquifer pumping tests) – Second Quarter 2020
- Aquifer Pumping Tests and Geochemical Assessment – Third Quarter 2020
- Report Preparation – Fourth Quarter 2020

4.1 Geophysical Assessment

The geophysical survey has the following objectives:

- Map the top of bedrock surface and geological structure (e.g., faults, fracture zones) around Bonanza Spring
- Map the depth to groundwater immediately above and below Bonanza Spring, and
- Characterize geologic conditions and groundwater depth along Bonanza Wash between Bonanza Spring and Fenner Valley.

In order to achieve these objectives, of the following geophysical techniques will be used: (1) seismic refraction and reflection, (2) electrical resistivity tomography (ERT), (3) ground penetrating radar (GPR), (4) magnetics (unmanned aerial vehicle [UAV] and ground-based), and (5) an UAV survey to collect photogrammetry data (including multispectral imagery for vegetation mapping).

4.1.1 Permitting

Permits and/or approvals will be obtained from the United States Bureau of Land Management (BLM) to conduct the geophysical surveys in the vicinity of Bonanza Spring. The geophysical surveys are not intrusive and leave no permanent facility or even an indication that they have been performed. Photographs showing similar geophysical surveys are provided in **Figure 8**.

4.1.2 Ground Penetrating Radar (GPR)

GPR is a shallow, non-invasive, subsurface investigation technique capable of mapping interfaces in a cross-sectional format. GPR measures the propagation time of high frequency EM pulses that are reflected from interfaces between materials of different electrical properties. Typically, radar reflections occur with abrupt changes in moisture content, grain size, porosity, or soil texture, or from massive buried objects such as pipelines or underground storage tanks (USTs). GPR is analogous to the reflection seismic technique that uses the travel time of acoustic pulses to identify interfaces. GPR is best suited to investigations in coarse-grained materials, i.e., sand size or larger.

GPR investigations for geological applications are typically performed at frequencies ranging from 12.5 megahertz (MHz) to 500 MHz. Higher frequencies provide data of higher vertical resolution, while lower frequencies improve the depth of investigation. For example, 500 MHz would provide a resolution of approximately 4-inches and a depth of investigation of approximately 3 feet in a sandy soil. Conversely, 12.5 MHz antennas may provide a depth of investigation of 130 feet or greater with a resolution of 10 feet in a sandy soil.

GPR may be a valuable tool for mapping top of bedrock, as well as mapping the groundwater table at this site, as GPR data can be collected rapidly, allowing large areas to be covered in a relatively short period of time. However, if the electrical conductivity of the subsurface is relatively high (e.g. clay rich or saline groundwater), the GPR signal may rapidly attenuate with depth. Initially, a reconnaissance day of GPR surveying will be conducted to test whether GPR is able to provide useful information at the Bonanza Spring site.

Because regional faults are expected to have an approximately east-west orientation, we would begin with collecting long north-south oriented GPR lines, starting approximately 1,000 feet above the spring and terminating 3,000 feet south of the spring. The GPR data would then be processed in the field to ascertain the value of GPR for this location. If the results do not distinguish useful subsurface reflections (e.g., top of bedrock or water table), no further GPR surveys would be conducted. However, if the GPR data are useful, then a further day of GPR surveying would be conducted at the site, covering as much area as possible. The proposed potential area of investigation is shown in **Figure 9**. The focus of the GPR survey would be the area around Bonanza Spring (1,000 feet north of the spring to approximately 3,000 feet south); however, some longer north-south GPR lines extending down to Route 66 may also be collected. Data quality would continue to be monitored throughout the survey to ensure that GPR was meeting the proposed survey objectives. The ground based GPR survey would be carried out by two personnel, while a third team member conducts the UAV survey.

4.1.3 Unmanned Aerial Vehicle (UAV) Surveys

Advisian is a commercially licensed UAV operator and follows all applicable regulations to complete any aerial survey. Prior to the UAV flight, Advisian requires the written permission of the landowner (or lease operator) to comply with regulations. The permission can be in the form of an email or a hard copy letter. In advance of the survey, Advisian must coordinate UAV flights with local airport authorities and the local air safety jurisdiction, as required by regulations. There are no commercial or military airfields or low altitude flightpaths in the vicinity of Bonanza Spring. The closest private airfield is at the Cadiz, Inc. landholdings about 12 miles south of the UAV survey area. The proposed UAV survey area near Bonanza Spring covers the same area as the GPR survey and is presented in **Figure 9**.

4.1.4 Aerial Photogrammetry and Multispectral Imagery

Photogrammetry is the science of retrieving spatial information from photographic images. Aerial photogrammetry involves capturing overlapping aerial photographs and processing the images with a photogrammetric software package. Common points (tie points) in multiple images are identified and three-dimensional coordinates of each point are automatically calculated to produce a point cloud. Ground control points with known coordinates spread across the survey area increase the point cloud positional accuracy and give the data a real world (geographic or projected) coordinate system.

This process enables the production of a georeferenced digital elevation model (DEM) and an orthophoto mosaic. The DEM created using photogrammetric techniques includes elevation data that represents the visible surface. The underlying terrain below any vegetation (i.e. trees, shrubs, grasses, etc.) is not measured. An orthophoto mosaic is created through the process of orthorectification and image mosaicking. Orthorectification corrects for variations in scale and displacements caused by terrain relief and tilt of the camera. Distortions resulting from any lens aberrations are also corrected. The produced orthophoto has a constant scale throughout the image, which allows for direct measurements of positions, distances, and areas. Image mosaicking involves stitching the orthophotos seamlessly together into a single image.

Multispectral imagery and visible light photogrammetry (also called RGB or red, green, blue color model) can be collected from a Parrot Sequoia high-resolution multispectral camera mounted on a UAV. The Sequoia records four discrete spectral bands including green, red, red edge, and NIR (near infrared). Conventional photographs are also captured with the RGB visible light imager. A higher quality visible light camera (a 12.0-megapixel DJI Zenmeuse X3) can also be mounted on the UAV to improve the quality of the photogrammetry.

The multispectral imagery can be processed using aerial photogrammetry to produce the normalized difference vegetation index (NDVI) image of the Site. On the NDVI map, live vegetation is displayed as bright green colors (NDVI value close to 1), in response to the high reflectance in the near infrared spectrum and low reflectance in the red spectrum; surfaces without live vegetation (or less vegetation) or with stressed vegetation appear as orange to red colors (low NDVI) from higher reflectance in the red spectrum and lower reflectance in the near infrared spectrum.

Advisian will collect aerial photogrammetry and multispectral data in the area around Bonanza Spring in the same area as for the GPR survey (**Figure 9**). The photogrammetry survey deliverables will include a high resolution, georeferenced aerial photograph of the site, a DEM for the site, as well as a calculated NDVI image of the site from the multispectral results. The initial NDVI image will be used in conjunction with a vegetation survey of the area to set a baseline for vegetation health around Bonanza Spring.

The Study Team will identify a reference spring(s) around Fenner Valley more distant from the proposed pumping area for the Cadiz Project. The reference spring location will also be surveyed using the multispectral camera to provide baseline information for this area.

The aerial photogrammetry/multispectral survey at Bonanza Spring can be carried out by one Advisian professional and staff scientist from **aquilogic**, who will act as a secondary observer during the survey. The secondary observer is required by regulations governing commercial UAV flights. It will take two days to collect aerial photogrammetry in the vicinity of Bonanza Spring, and an additional day for a survey at the reference spring. The photogrammetry survey will be conducted at the same time as the GPR survey.

4.1.5 Magnetic Survey

A total field magnetometer measures the intensity of the earth's magnetic field in units of nanoteslas (nT). Ferromagnetic materials such as iron alloys, when placed in the earth's magnetic field, tend to alter the field. As a result, such materials can be recognized as total field anomalies. Bedrock within the survey area is expected to be igneous, which likely contains ferromagnetic materials. The magnetic response of those ferromagnetic materials will be altered depending on their distance from the magnetometer, making magnetic methods an ideal method for mapping bedrock topography. Additionally, mineralization along existing faults may produce a distinctive magnetic signature that can be measured for delineation.

Advisian will complete a UAV-based magnetic survey to map magnetic anomalies associated with bedrock structures, initially covering the same area as the aerial photogrammetry and multispectral survey (**Figure 9**). The GEM GSMP-35U is a potassium electron spin resonance magnetometer that has 0.0003 nT sensitivity combined with +/-0.1 nT absolute accuracy over its full operating range. The UAV approach allows a large area to be covered quickly, with zero impact to the ground vegetation. Survey results can then be used to target a land-based magnetic and VLF EM survey to more accurately map bedrock topography and faults in areas of interest. The UAV magnetic survey at Bonanza Spring will take approximately two days. The survey would be carried out by one Advisian professional and a staff scientist from **aquilogic**, who would act as a secondary observer. Depending on survey results for the area around Bonanza Spring, it may be beneficial to extend the survey further towards the south using a coarser grid spacing, in order to map bedrock topography towards Fenner Valley.

4.1.6 Seismic Refraction/Reflection

The seismic refraction method uses the propagation of compressional waves in the subsurface to determine the velocity structure of the lithologic and geologic strata. Seismic energy is produced by a source (e.g. sledgehammer, weight drop, or vibroseis vehicle), and spreads downwards and laterally through the earth. An array of receivers (geophones) measures the arrival of that energy at points on a line. Increasing vertical velocity gradients with depth will cause seismic energy to refract back to the surface. Decreasing vertical velocity gradients are rare but, where present, will bend rays away from the surface and create shadow zones that cannot be imaged. The travel path that the energy takes from each shot to each receiver can be represented by a curved ray path. Typically, seismic energy that has propagated through bedrock material will arrive with faster apparent velocities along the seismic array than seismic energy that has travelled through overburden (e.g., weathered regolith or alluvial deposits).

The picked travel times of the first-arriving energy can be used as input to seismic inversion software (e.g., Rayfract), which solves for the velocity model of the subsurface that best fits the observed travel times. The accuracy of each travel-time pick is determined by the frequency of the first-arriving energy and the signal-to-noise (S/N) ratio. Factors that can reduce the frequency and/or S/N ratios include soft or spongy soils, wind noise, traffic noise, and the distance between the shot and the receiver (signal strength will reduce proportionally with increasing length of the ray path). The maximum depth of investigation of a velocity model is determined by the deepest refracted ray path. As a general rule, the longer the horizontal offset between a shot and a receiver, the greater the depth of penetration.

The seismic reflection method measures the travel times and amplitudes of seismic waves reflecting off subsurface strata, geologic structures (e.g., faults), and groundwater table. For each layer, the reflections from different shot points are stacked together to produce a cross-section of the reflectivity of the earth. The method is used extensively in oil exploration where reflections from sedimentary layers down to depths of 15,000 feet show the strata and structure needed to locate potential exploration wells. Shallow, high-resolution seismic reflection surveys are conducted in a similar manner to conventional oil exploration reflection surveys, except that the geophones and shot points are spaced at smaller intervals, and higher frequency seismic signals are generated and recorded. Parameters that determine the quality of a seismic reflection include the thickness of the strata and the velocity and density contrasts between layers. The ability to detect individual stratum is dependent on the frequency content of the downward propagating energy. A rule of thumb is that seismic reflection methods can resolve an individual bed that has a thickness greater than one-quarter the wavelength of the seismic pulse. Therefore, higher frequency waves are capable of resolving smaller beds than lower frequency waves. The main limitation of a high frequency seismic energy source is that the depth of penetration is less than for lower frequencies.

Advisian will conduct four seismic lines in the area around Bonanza Spring, with an option for two additional seismic lines further to the south along Bonanza Wash (**Table 1 and Figure 10)**. The objectives of the seismic survey around Bonanza Spring include mapping top of bedrock both above and below the springs, as well as characterizing bedrock in the area (bedrock competency, fractures, faulting, etc.). The objective of the two optional seismic lines is to map the top of bedrock as it gets deeper towards Route 66 and the Fenner Valley, and to possibly image the edge of the bedrock block bordering Fenner Valley. The actual location of seismic lines 5 and 6 would be based on the results of the GPR survey and UAV magnetic survey.

All of the seismic data will be processed using the seismic refraction method, to map top of bedrock and to evaluate the competency of rock with depth (higher seismic velocities correlate with more competent bedrock). Seismic line 1 will also be processed using the seismic reflection method, which will provide a roughly north-south oriented cross-section that can be used for mapping faults and other interface zones within the rock that have an expected east-west orientation. If all of the proposed seismic lines are collected, the survey will take three professionals a total of four days, with five additional days required for the two optional southern seismic lines. However, the seismic data will be processed as quickly as possible during the field survey such that plans can be modified depending on the results.

Table 1 Proposed Seismic Survey Lines

Seismic Line	Line Length (feet)	Geophone Spacing (feet)	Depth of Investigation (feet)	Estimated Field Days
1	4724	16.4	246	2.5
2	771	16.4	98	0.5
3	771	16.4	197	0.5
4	771	16.4	164	0.5
5 (optional)	3,150	16.4	246	2
6 (optional)	3,543	16.4	246	3

4.1.7 Electrical Resistivity Tomography (ERT)

ERT is a technique for mapping the distribution of subsurface electrical resistivity (or its inverse conductivity) in a cross-sectional format. Resistivity data are collected through a linear array of 81 electrodes coupled to a direct current (DC) resistivity transmitter and receiver, and an electronic switching box. Data collection is carried out in a sequential and automated fashion that takes advantage of all possible combinations of current and measure electrodes. The data are downloaded to a computer for processing and analysis. The data are inverted using a two-dimensional (2-D) finite difference or finite element inversion routine. The final product is a 2-D cross-section plotting resistivity (in ohmmeter [ohm-m]) versus depth.

The objectives of the ERT survey include mapping the top of bedrock, imaging water-saturated zones, and possibly mapping faults. In order to achieve these objectives, Advisian will conduct three ERT lines in the area around Bonanza Spring, with an option for two additional ERT lines further south, co-located with the optional seismic lines (**Table 2 and Figure 11)**. The ERT survey will be completed in three days by three Advisian professionals, with two additional days if the two optional lines are collected.

Table 2: Proposed ERT Lines

ERT Line	Line Length (feet)	Electrode Spacing (feet)	Depth of Investigation (feet)
1	1,148	8.2	98
2	1,968	16.4	197
3 (optional)	2,624	16.4	197
4 (optional)	2,624	16.4	197

4.2 Hydrologic Assessment

4.2.1 Permitting

Permits and/or approvals will be obtained from BLM to install a stilling pipe with pressure transducer at Bonanza Spring, soil water moisture/temperature dataloggers along Bonanza Wash, and a weather station proximate to Bonanza Spring. Photographs showing a typical remote weather station and typical pressure transducers for spring monitoring are provided as **Figures 12 and 13**, respectively. A field sampling and analysis plan for water quality/quantity evaluations will be developed prior to the first water sampling event.

4.2.2 Spring Flow Measurement

Measurements of the depth of water at Bonanza Spring and a reference spring selected by the Study Team will be collected through periodic manual observations (i.e., a temporary staff gauge) and by a continuous measurement device (i.e., pressure transducers).

A stilling pipe will be installed to house the continuous recording pressure transducer. The stilling pipe will be constructed of 1-inch diameter Schedule 40 PVC or steel pipe with 1/8-inch diameter holes every 1-inch of length and a conical drive-point on the bottom. The stilling pipe will also function as a staff gauge as it will have a scale marked on it to manually record water height. The stilling pipe will be installed immediately below each spring where the water depth is sufficient to accommodate the stilling pipe. The top of the stilling pipe will be surveyed to provide horizontal (x, y) location and elevation (z) for each point as Universal Transverse Mercator (UTM) and State-planar coordinates, and feet above MSL.

A vented pressure transducer and data logger will be used as they automatically correct for barometric pressure changes and eliminate the need for a recording barometer. The transducer will be capable of measuring water levels to within 0.01 feet, temperature to 0.01 °C, and electrical conductivity to 10 microsiemens per centimeter (µS/cm). Data from the pressure transducer will be downloaded quarterly and manual measurements from the staff gauge recorded at the time of download.

In addition to water height, the velocity of flow at the spring will be measured using manual observations (e.g., float travel time) and a digital flowmeter. The cross-sectional profile immediately below each spring at the stilling pipe will be mapped to establish a relationship between water height and flow width. Assuming a constant flow velocity, the water height from the pressure transducer can be converted to a volumetric flow rate at the spring.

Soil moisture content thermistors and/or soil water temperature dataloggers will be placed in shallow soil (approximately 3-inches below surface) along Bonanza Wash to record when water flows in Bonanza Wash. Such devices will only indicate when water is flowing, not the water depth, velocity, or volumetric flow rate. These dataloggers will be excavated and downloaded quarterly.

4.2.3 Spring Water Sampling

Spring water samples will be collected at Bonanza Spring and the reference spring on a quarterly basis. Surface water samples will be collected in general accordance with American Society for Testing and Materials (ASTM) Method D5358–93 (Standard Practice for Sampling with a Dipper or Pond Sampler) (ASTM, 2019a). The water will then be filtered, as needed, and transferred to the sampling containers. Each sample container will be labeled individually, entered into the chain-of-custody, and placed on ice in a cooler pending delivery to an environmental testing laboratory certified under the California Environmental Laboratory Accreditation Program (ELAP) (see **Section 4.4**).

4.2.4 Climatological Assessment

To obtain climatological data representative of conditions at Bonanza Spring, a remote automated weather station (RAWS) will be installed. RAWS are self-contained, portable, solar-powered weather stations that provide local weather data, typically for fire management purposes. The BLM, and other governmental agencies, operate and maintain a nationwide network of RAWS systems; however, there are none in the vicinity of Bonanza Spring. The nearest RAWS to Bonanza Spring is the Mojave River Sink station (NWS ID 045122) located approximately 15 miles south of Baker, California and 45 miles northwest of Bonanza Spring.

At a minimum, the RAWS will include instrumentation for the measurement of precipitation, wind speed, barometric pressure, air temperature, and humidity. Measurements will be recorded with an integral datalogger for retrieval on a quarterly basis. Due to the remoteness of the project area, the RAWS will include a battery and solar charging system to operate the instrumentation and datalogger for extended periods of unattended operation.

4.3 Hydrogeologic Assessment

Up to the following four groundwater monitoring wells will be installed within the Bonanza Spring area as part of this study program (**Figure 14**):

- A single, 2-inch diameter monitoring well (MW-1) will be located immediately above Bonanza Spring in the bedrock catchment that supports flow at the spring (MW-1)
- Two 2-inch diameter monitoring wells (MW-2A; MW-2B) will be located below Bonanza Spring at the limits of dense vegetation (i.e., about 3,000 feet north of the graded, pipeline road and 1,000 feet south of Bonanza Spring) with screened intervals in the alluvial sediments (MW-2A) and underlying bedrock (MW-2B)
- A single 2-inch diameter monitoring wells (MW-3) will be located in Bonanza Wash about 3,000 feet south of the graded, pipeline road with screened intervals at the base of the alluvial sediments immediately above the bedrock contact
- A single 4-inch diameter monitoring wells (MW-4) will be located where Bonanza Wash crosses Highway-66 with screened intervals across the groundwater table in the Alluvial Aquifer in Fenner Valley

The exact locations and depths of each monitoring well, and the drilling technique to be used (e.g., hollow stem auger, cable-tool, sonic, air-rotary), will be based on the results of the geophysical surveys and vehicular access limitations.

4.3.1 Permitting

Permits and/or approvals will be obtained from BLM to install and periodically sample the monitoring wells proximate to Bonanza Spring, in Bonanza Wash, and where Bonanza Wash crosses Route-66 (see **Figure 15**). Well installation permits will also be obtained from the County of San Bernardino. In addition, well completion reports will be filed with the DWR. Photographs showing a typical drill rig used for well installation and the final surface completion for each monitoring wells are provided as **Figures 16 and 17**, respectively.

4.3.2 Biological Clearance

The monitoring well locations and any paths for vehicular access away from paved and unpaved roads will be subject to biological clearance. Cardno will inspect the monitoring well locations (see **Figure 14**) and access paths (see **Figure 15**) for the presence of sensitive plant or animal species. If a sensitive plant species is identified or there are indications of a sensitive animal species, then the locations of the monitoring well or access will be adjusted to avoid such areas.

4.3.3 Underground Utility Clearance

Monitoring wells are to be installed in areas where no underground utilities are likely present. However, California law requires that utility clearance activities be performed whenever subsurface construction work is planned. These clearance activities include notification of utility protection organizations (i.e., One Call), and performing a geophysical clearance survey at each monitoring well location.

As required by State law, Underground Service Alert (One Call) will be notified at least 96 hours prior to commencement of field activities. One Call will notify utilities with known subsurface lines in the area of investigation and request that they clearly mark utility locations proximate to the proposed monitoring well locations.

In addition to notifying One Call, the presence of utility lines proximate to the monitoring well locations will also be investigated using geophysical techniques. Geophysical instruments that may be used to perform this survey include, but may not be limited to, metal detectors, acoustic locators, and GPR. The geophysical clearance surveys will be performed by Advisian.

Even after One Call has been notified and the geophysical clearance survey completed, further precautions will be taken. Prior to drilling, in areas with alluvial cover, a hand auger or air knife will be used to initially excavate a 6-inch diameter boring to a depth of eight feet (or until auger refusal is met). Any soil generated during hand augering will be handled in the same manner as drill cuttings (see **Section 4.3.13**).

In the event that an underground utility line that prohibits well installation is identified by a utility company, geophysical survey, or hand augering, the proposed monitoring well will be relocated slightly to avoid the utility line.

4.3.4 Equipment Access

Monitoring well locations will be initially accessed via the graded, unpaved pipeline access road and, where needed, the ungraded, unpaved road to Bonanza Spring. However, for locations MW-1, MW-2, and MW-3, the drill rig will need to traverse areas where no graded roads exist (see **Figure 15**). The route to these locations will be inspected with drilling contractor prior to well installation and marked with flags. The route will then be subject to biological clearance (see **Section 4.3.2**).

4.3.5 Equipment Cleaning

Aside from sample containers provided by the laboratory and other disposable (e.g., polyethylene bailers) or single-use items (e.g., well casing), all drilling and sampling equipment that will come in contact with subsurface sediments, bedrock, and/or groundwater will be cleaned prior to use and between each drilling/sampling location. The non-disposable equipment will include, but may not be limited to, the following: drill rods, soil samplers, grout tremie pipes, submersible pumps, water level probes, pressure transducers, etc. A three-stage wash-rinse cycle, including soapy water, tap water, and a final rinse using purified water (distilled or de-ionized water) will be used. Any wash water generated during equipment cleaning activities will be handled as investigation derived waste (IDW) as detailed in **Section 4.3.13**.

4.3.6 Borehole Advancement

All field work associated with monitoring well installation will be conducted under the direct supervision of a California Professional Geologist (PG) or Professional Engineer (PE). The drilling technique will be selected based on access limitations and the results from the geophysical survey (see **Section 4.1**). However, given the nature of the sediments and need to drill in bedrock at locations MW-1 and MW-2, it is likely that an air-rotary and/or rotasonic drilling method will be used.

At each well location, a six-inch diameter borehole will be advanced to the total planned depth (based on the results of the geophysical surveys). Soil/rock coring and sampling will be conducted during the drilling of the borehole (see **Section 4.3.8**). For locations MW-1, MW-2A, MW-2B, and MW-3, a 2-inch diameter monitoring well will be installed (see **Section 4.3.9**). At location MW-4, the pilot borehole will be enlarged to a diameter of 8-inches to accommodate the installation of a 4-inch diameter monitoring well.

4.3.7 Borehole Log

During drilling of each borehole, the lithology will be recorded continuously on a geologic boring log using methods described in ASTM Method D2488 (Standard Practice for Description and Identification of Soils [Visual-Manual Procedures]) (ASTM, 2017). Sediments will be described using the Unified Soil Classification System (USCS) and bedrock described using standard geologic nomenclature (e.g., rock type, color, mineralogy, structure, weathering). For air-rotary or similar drilling, this logging will be based on visual observation of soil cuttings, depth-discrete disturbed grab samples collected at 5-foot intervals, and bulk samples collected at 10-foot intervals. For rotasonic drilling, the logging will also be based on the sediment or rock cores retrieved from inside the drill casing.

A photographic log of this sediments and bedrock will also be prepared and correlated with the final geologic boring log. Bulk samples will be collected in 10-inch by 10-inch, one-gallon sample bags. To confirm the field logging, each bulk sample will be independently logged by a PG proficient in the methods described in ASTM D2488.

4.3.8 Rock and Soil Core Sampling

For air-rotary or similar drilling method, discrete-depth sediment and rock samples will be collected. These samples will be collected within 2-inch diameter sample tubes of varying lengths placed within a sample collection device (e.g., California Modified Split-spoon Sampler). Selected depth-discrete sample tubes will be submitted to a geotechnical testing laboratory. The remainder of the sediment/rock in every other sample (i.e., every 10-feet) will be extruded into one-gallon plastic bulk sample bags.

For the rotasonic drilling, a continuous sediment/rock core from near surface to total depth will be generated. Soil core will be recovered in a tubular plastic sleeve as the soil is extruded from the core barrel. Selected sections of the core will be extracted and submitted to a geotechnical testing laboratory as a depth-discreet or bulk sample.

At each borehole, soil/rock samples immediately below groundwater, at the base of the boring, and between these two depths will be sent to the geotechnical testing laboratory.

Selected bulk soil samples will be tested for the following:

- Grain size distribution in accordance with the ASTM Method D422,
- Where fine-grained sediments are present (i.e., silts and clays), hydrometer testing in accordance with ASTM Method D422.

Discrete-depth soil samples will be tested for the following:

- Moisture content in accordance with ASTM Method D2216

- Bulk density in accordance with ASTM Method D2937
- Specific gravity in accordance with ASTM Method D2937
- Permeability (constant head in accordance with ASTM Method D2434, falling head in accordance with California Test Method 220)
- Porosity (mass volume relationship).

4.3.9 Monitoring Well Construction

Using the results from the geophysical surveys and field boring log, a PG or PE will develop the final monitoring well designs, including casing diameter, casing material, screen intervals, slot size, and filter pack size and gradation. Monitoring wells will be constructed in accordance with the guidelines of the California Well Standards Bulletin 74-90 (DWR, 1991), ASTM Methods D5092/D5092M (Standard Practice for Design and Installation of Groundwater Monitoring Wells) (ASTM, 2016), and requirements of the County of San Bernardino.

At locations MW-2A and MW-3, it is anticipated that each monitoring well riser will consist of 2-inch diameter, Schedule 40 poly-vinyl chloride (PVC), blank casing above a 2-inch diameter, 0.02-inch slotted, PVC well screen, and PVC bottom end-cap.

At locations MW-1 and MW-2B, each monitoring well will be completed in bedrock. At these locations, geothermally heated groundwater may be present. Therefore, it is anticipated that a 2-inch diameter, Schedule 40 PVC, blank casing will be installed above a 2-inch diameter, Type 316 stainless steel (316SS) casing with a 0.02-inch wire-wrapped screened interval, and a stainless-steel end cap.

At location MW-4, it is likely that the monitoring well will be completed to a greater depth within the Alluvial Aquifer of Fenner Valley. Given the depth, there is an increased possibility of the well casing to warp. Any such warping could restrict development and sample purging at this monitoring well. Therefore, it is anticipated that a 4-inch diameter, Schedule 40 PVC, blank casing will be installed above a 4-inch diameter, 0.02-inch slotted, PVC well screen, and PVC bottom end-cap.

Filter material will be placed around the installed screen extending at least 1-foot below and 2-feet above the top of the screen interval. The filter material will be well-graded, clean sand (generally less than two percent by weight passing a No. 200 sieve and less than five percent by weight of calcareous material). The filter material will be a standard sand gradation designed for a range of anticipated sediment types or a sand gradation specifically designed to fit the sediments collected from the anticipated well completion zone. In either case, the filler material will be selected to be compatible with the well screen opening size.

Following the initial emplacement of the filter pack, each well will be surged to settle the filter pack. If necessary, the filter pack will be topped off to ensure that at least 2-feet of filter pack extends above the screened interval. The annular space above the filter pack will be sealed with hydrated bentonite pellets or chips for a minimum thickness of 5-feet. Where necessary, the annular space above this can be sealed with either hydrated bentonite chips, cement-bentonite grout, or bentonite slurry grout to within 1-foot of the ground surface.

At each monitoring well, the riser casing will extend 2-feet above ground surface and a lockable expanding well plug will be installed. A monitoring well monument will be constructed at each monitoring well. The monument will consist of a 3-feet high, 8-inch diameter, steel pipe with a lockable steel cap, set within a 3-foot square, 6-inch thick, concrete apron. The steel pipe will be painted bright red to allow easy identification in the field. Photographs of a typical monitoring well monument are provided in **Figure 17**.

The top of each well casing, monument pipe, and the concrete surface at the monument will be surveyed after installation. The location (x, y) and elevation (z) for each point will be provided as UTM and State-planar coordinates, and feet above MSL.

4.3.10 Well Development

Approximately 48 hours after installation, the wells will be developed to remove fine-grained sediments from the well casing and filter pack to promote unrestricted flow of groundwater into the well.

Prior to development, depth-to-water and total depth measurements will be collected from the wells with a water-level indicator accurate to 0.01 feet. These measurements will be used to calculate the volume of standing water in the well casing. Each well will first be surged for approximately 20 minutes using a vented surge block to improve hydraulic communication between the well and the materials surrounding the well bore. Each well will then be purged using either a bailer or a submersible pump. While purging, groundwater will be monitored periodically for physio-chemical parameters including potential hydrogen ion concentration (pH), electric conductivity (EC), temperature, dissolved oxygen (DO), and turbidity. Groundwater will be removed from each well until, at a minimum, the following criteria have been met:

- Volume of water removed from each well is greater than the volume of fluid introduced during well installation, if any; and
- Physio-chemical parameters have stabilized.

Physio-chemical readings will be considered stable when consecutive readings of EC, temperature, and turbidity are within ten percent (%) and the pH changes are less than 0.1 between successive measurements.

4.3.11 Borehole Abandonment

In the event that a groundwater monitoring well cannot be constructed within a borehole, or if a borehole is unable to be completed at a particular location, the borehole will be abandoned. The well will be sealed with bentonite grout using a pressure grouting system that maintains grouting pressure and grout emplacement in the boring while withdrawing the drilling rods. Borehole sealing material shall be either mixed on site with potable water according to manufacturer's specifications or delivered to the site pre-mixed. The use of special cements or other admixtures used to reduce permeability, increase fluidity and/or control set time, and the resultant seal composition shall be in compliance with any regulatory requirements. The final grout elevation will extend to 18 inches below ground surface and native soil will be used to fill each boring to an appropriate depth for surface completion. The former borehole location will be repaired to match the existing surface and in compliance with any local requirements.

4.3.12 Investigation Derived Wastes

All IDW such as excess sediment and rock cuttings, decontamination wash water, and purged groundwater will be placed in US Department of Transportation (DOT) rated, 55-gallon, steel drums. At the end of each day, these drums will be transported to the Cadiz Inc. field office. Given the location of the monitoring wells, there is no reason to believe that the sediment/rock IDW will contain hazardous waste or other contamination. Therefore, the solid IDW will be transported to an appropriate disposal facility (likely a municipal landfill) or spread at the Cadiz, Inc. landholdings. Likewise, there is no reason to believe that the water IDW will contain hazardous waste or other contamination. Therefore, the liquid IDW will be used for irrigation at the Cadiz, Inc. landholdings.

4.3.13 Periodic Groundwater Monitoring

<u>Periodic Depth to Groundwater Measurements</u>

Periodic depth to groundwater measurements will be collected from all monitoring wells constructed during this study program in accordance with ASTM Method D4750(2001) - Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well) and ASTM WK23760 - Revision of D4750 - 87(2001) Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well) (ASTM, 1987 and ASTM, 2019b). The water level meter is lowered into the well until a "beep" is heard, indicating that the probe is submerged in water, or until the bottom of a dry well is reached. The depth to water is determined by reading the value off the measuring tape at the measuring point. Measurements are repeated until consecutive readings are within 0.01 feet. After completing the measurement, the well will be closed and locked.

<u>Continuous Depth to Groundwater Measurements</u>

Depth to groundwater measurements will be collected continuously at each monitoring well using vented pressure transducers. Vented pressure transducers and data loggers will be used as they automatically correct for barometric pressure changes and eliminate the need for a recording barometer. The transducer will be capable of measuring water levels to within 0.01 feet, temperature to 0.01 °C, and electrical conductivity to 10 µS/cm. Data from these pressure transducers will be downloaded quarterly, and manual groundwater level measurements will be taken at the time of download.

Groundwater Sampling

Groundwater samples will be collected from each monitoring well at least 72-hours after development and quarterly thereafter. A groundwater and spring water sampling and analysis plan will be developed prior to the first water sampling event. Prior to sample collection, the transducer will be removed and the depth to water and total well depth will be measured to calculate the volume of water in the casing. The well will then be purged of standing water using a bailer or submersible pump. While purging, groundwater will be monitored periodically for physio-chemical parameters including pH, EC, temperature, DO, and turbidity. Groundwater will be removed from each well until, at a minimum, the following criteria have been met:

- Three casing volumes of groundwater have been purged, or
- Physio-chemical parameters have stabilized.

Physio-chemical readings will be considered stable when consecutive readings of EC, temperature, DO, and turbidity are within 10% and the pH changes are less than 0.1 between successive measurements.

After purging, the transducer will be reinstalled to monitor water level recovery in the well. This water level recovery data can be used to provide initial estimates of hydraulic conductivity for the aquifer (i.e., a rising-head slug test). Once the well has recovered to within at least 80% of the groundwater level measured prior to purging or for a maximum period of two hours, a groundwater sample will be collected using disposable polyethylene bailers. Groundwater will then be transferred to the sampling containers. Each sample container will be labeled individually, entered into the chain-of-custody, and placed on ice in a cooler pending delivery to an ELAP certified environmental testing laboratory (see **Section 4.4**).

All purged groundwater will be handled as IDW in the manner described in **Section 4.3.13**.

Quality Assurance/Quality Control

A number of quality assurance and quality control (QA/QC) samples will be collected in the field during groundwater sampling. For each day of sampling, the following field QA/QC samples will be collected:

- One equipment blank
- One field blank
- One duplicate
- One laboratory provided trip blank per cooler containing samples transported to the analytical laboratory.

4.3.14 Aquifer Properties

Single Well (Slug) Hydraulic Testing

Slug testing will be completed in each monitoring well. The procedures to be used will be in general accordance with the procedures described in ASTM Method D4044/D4044M – 15 - Standard Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers (ASTM, 2015a). Slug tests are an in-situ hydraulic conductivity test method used to obtain approximate values of hydraulic conductivities in the immediate vicinity of the well screen. An almost instantaneous change in the water level in a well can be achieved by quickly removing a “slug” of water with a bailer (rising head) or by submerging an object (or slug) in the water (falling head) and later removing the slug (rising head). After addition or removal of the slug, the water level is monitored as it recovers to equilibrium. If the aquifer is very permeable, the water level in the well will recover very rapidly and, conversely, if the aquifer is less permeable, the water level in the well will recover slowly. The rate and pattern of recovery can be analyzed using the Bouwer and Rice (1976) method or equivalent to estimate the hydraulic conductivity of the aquifer material.

At each monitoring well, an initial water slug removal (rising head) test will be performed (see **Section 4.3.14.3**) during the initial sampling of the well. Immediately prior to the next sampling event, the groundwater level will be manually recorded, and a solid, inert slug will be lowered into each well. The pressure transducer will remain in the well and will be programmed to record the change in water level on a high frequency basis. Once the water level falls/recovers to more than 80% of the level prior to addition of the slug (falling head test), the slug will be removed, and the water level will instantaneously fall. The water level will then rise/recover again to that prior to the testing (rising head test). During the falling and rising head tests, the pressure transducer will record changes in groundwater level. Manual readings of groundwater levels will also be taken every ten minutes during the testing.

Aquifer Pumping Test

Shortly after the second groundwater sampling event, an aquifer pumping test will be performed at MW-2A (or MW-2B if MW-2A is dry or contains very little groundwater). Initially, the static groundwater levels will be manually measured. A 2-inch diameter submersible pump will then be lowered into the well. Based on the slug testing at the well, the sustainable pumping rate will be estimated. A step-pumping test will then be performed at the well to confirm the sustainable pumping rate, with each step lasting for two hours or until groundwater levels recover to more than 80% of the initial static level, whichever occurs first. Pumping at the well will be initiated at 25% of the estimated sustainable pumping rate for step 1, increased to 50% of the estimated sustainable pumping rate for step 2, then 75% for step 3, and then 100% for step 4. If groundwater levels in the pumping well stabilize when the pumping rate is 100% of the estimated sustainable pumping rate, a fifth step at 150% of the estimated pumping rate will be performed. Based on the performance of the step pumping test, the sustainable pumping rate for a longer-term, constant rate aquifer test will be confirmed.

After the step pumping test, groundwater levels will be allowed to recover for 36 hours before the constant rate test is initiated. Pumping at the confirmed sustainable pumping rate will continue for 96 hours or until the well is dry. The procedures to be used for the performance and analysis of the aquifer pumping test will be in general accordance with those described in ASTM Method D5269 – 15 - Standard Test Method for Determining Transmissivity of Nonleaky Confined Aquifers by the Theis Nonequilibrium Method) (ASTM, 2015b).

During both the step and constant-rate pumping tests, groundwater levels will be monitored at MW-1, MW-2A, MW-2B, MW-3, and Bonanza Spring at the following frequencies:

Table 3: Aquifer Test Depth to Water Measurement Frequency

Frequency (One Measurement Every):	Elapsed Time (Pumping Well)	Elapsed Time (Observation Wells/Spring)
5 seconds	0 -5 minutes	-
30 seconds	5 – 30 minutes	-
3 minutes	30 – 180 minutes	0 – 180 minutes
10 minutes	3 – 24 hours	3 – 24 hours
30 minutes	>24 hours	>24 hours

Manual water level measurements will also be made at each monitoring location every two hours during daylight hours and every four hours during darkness to cross-check the validity of the pressure transducer readings. The pressure transducers will record water level measurements in accordance with the schedule presented in **Table 3**. During the pumping tests, field measurements of the pH, temperature, EC, oxidation reduction potential (ORP), and DO in the discharged water from the pumping well will be monitored periodically. The discharged water will be discharged directly into Bonanza Wash.

Prior to the conclusion of the constant-rate aquifer test, a water sample will be collected from the discharge in appropriate sampling containers. Each sample container will be labeled individually, entered into the chain-of-custody, and placed on ice in a cooler pending delivery to an ELAP certified environmental testing laboratory (see **Section 4.4**).

In addition, immediately prior to the cessation of pumping for the constant rate aquifer test, the pressure transducers at all monitoring locations will be reprogrammed to record recovery at the same frequency outlined above. Reprogramming will start at the most distant location and finish at the pumping well when pumping for the constant rate test is terminated. Manual measurements will also be collected at the same interval as during the pumping tests. Recovery will be measured until water levels recover to more than 80% of the static levels recorded prior to the testing.

The rate and pattern of water levels change during pumping and recovery can be analyzed to calculate the hydraulic conductivity (K) of the aquifer materials surrounding each well and the storativity (S) of the materials surrounding the observation wells (but not the pumping well). The changes will also assist in evaluating the degree of hydraulic continuity between the groundwater at MW-2, located south of Bonanza Spring, spring flows themselves, and the groundwater at MW-1, located in the bedrock catchment that supports flow at Bonanza Spring.

4.3.15 Field Work Documentation

Field activities will be documented through field notes, electronic records, or photographic records. Field personnel will be responsible for maintaining daily field logs and more specific records for individual tasks being performed. All field documents will be scanned or photographed and sent via email to **aquilogic** at the end of each field day. Information recorded in the daily field log will include, but may not be limited to, the following:

- General description of field activities
- Personnel and companies represented on site
- Field and weather conditions
- Photographic records (including location, aspect, subject, and time)
- Field boring logs
- Water sampling forms
- Chain-of-custody forms
- Field survey forms
- IDW logs and waste manifests
- Calibration records
- Deviations from accepted work or sampling plans, accompanied by a justification for the deviation
- Description of any equipment problems
- Detailed description of any health and safety issues.

Entries to daily field logs and task-specific data forms will be made in indelible ink and signed and dated by the personnel making the entry. If changes to entries are necessary, the person making the change will cross out the item to be changed with a single line and initial and date the change. An explanation of the change should be recorded, if necessary. Photographs of field activities, events or conditions will be supplemented with written records of the subject, date and time of the photographs.

4.4 Geochemical Assessment

Several geochemical parameters could provide an indication of groundwater origin, flow path, age, and/or hydraulic connection. One of these parameters alone may not provide definitive information. However, consideration of multiple parameters could provide helpful insight in the overall evaluation of groundwater origin, flow path, age, and/or hydraulic connection. A geochemical "tracer" is any chemical constituent that provides an indication of the original source of, or geochemical influence on, the groundwater sample. Tracers fall into the three broad categories: general chemical parameters (i.e., major ions, TDS, pH, etc.), conservative trace elements (i.e., boron or dissolved silica), and isotopic analysis (for example, water isotopes, $^{53}Cr/^{52}Cr$, and potentially other isotopic measurements as appropriate). It is possible that multiple lines of evidence can be drawn from these parameters (in connection with geologic and hydraulic data) to indicate varying sources of groundwater.

The geochemical characteristics of water samples collected from the newly constructed monitoring wells and from spring water at Bonanza Spring will be evaluated through a review of existing studies and the following methodologies:

- General water quality analysis
- Conservative tracers (boron and dissolved silica)
- Isotopic analysis (hydrogen, oxygen, carbon, and other trace elements)

4.4.1 Existing Data Review

As part of the geochemical assessment, existing geochemical data for water samples collected at, and in the vicinity of, Bonanza Spring will be identified and reviewed. As appropriate, existing data will be incorporated into the Study Program.

4.4.2 Laboratory Water Quality Analyses

The general mineral "fingerprint" of groundwater can be used, when combined with other more specific tracers, to assess different origins and flow paths of waters. Data evaluation tools such as Piper and Stiff Diagrams can be used to assess the potential for distinct groundwater types, including mixing of groundwater from different recharge areas. The general water quality analyses include the following constituents:

- Common cations – calcium (Ca), iron (ferrous [Fe(II)] and ferric (Fe(III)]), magnesium (Mg), manganese (Mn), sodium (Na), and potassium (K)
- Common anions – chloride (Cl), sulfate (SO_4), nitrate (NO_3), nitrite (NO_2), phosphate (PO_4), and fluoride (F)
- Water quality parameters –TDS, alkalinity (total, bicarbonate, carbonate and hydroxide), DO, total organic carbon (TOC), hardness, and pH
- Trace Metals – Antimony (Sb), arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), titanium (Tl), and zinc (Zn).

4.4.3 Potential Conservative Tracers

4.4.3.1 Boron

Boron is a conservative element found in nearly all natural waters. Under normal pH range (up to pH 10), boron exists in solution as a neutral (uncharged) ion ($H_3BO_3^0$) and is not prone to adsorption like many charged species. With its high solubility, boron moves conservatively through groundwater systems, similar to oxygen-18 (^{18}O) and deuterium (^{2}H); therefore, its concentration can potentially be tied to water sources and potential water mixing.

4.4.3.2 Dissolved Silica

Dissolved silica (DSI or SiO_2) is a neutral (uncharged) ion over nearly the entire pH spectrum (as $H_4SiO_4^0$). Although not as soluble in groundwater as other conservative constituents (i.e., boron), silica can be useful in identifying and verifying different sources of water in mixed geologic systems, particularly in the evaluation of the mean residence times of recent groundwater (less than 100 years) at a regional scale.

4.4.4 Isotopic Analysis

Additional isotopic analysis, such as the use of ^{36}Cl for dating of older waters, may be used. Depending on results for total parameters in groundwater and other geochemical factors, certain isotopic measurements may be prioritized or eliminated at one or more groundwater sampling location.

4.4.4.1 Water Isotopes (^{18}O and ^{2}H)

Stable isotopes of oxygen (^{18}O) and hydrogen (^{2}H) together can prove valuable as a tracer for identifying waters by their historic flow paths (such as groundwater that has been subject to partial evaporation or that has longer residence times within the aquifer). Waters derived from different sources would have differing isotopic “signatures.” When combined with the conservative tracer and general water quality data, the isotopic results may help to distinguish water types.

Stable isotope ratios are affected by evaporation due to fractionation. Precipitation-based soil water in arid regions that has undergone partial evaporation prior to infiltration produces a unique isotopic signature that becomes a characteristic property of the subsurface water. These characteristics can be tracked to determine source and mixing of various groundwater sources (Healy, 2012).

The stable isotope ratio measurements of oxygen-18/oxygen-16 ($^{18}O/^{16}O$) and hydrogen-2 (deuterium) and hydrogen-1 ($^{2}H/^{1}H$;) of water samples are compared to the standard mean ocean water (SMOW) ratio. These ratios are presented as delta units (δ) per mil (‰, or per thousand) in relative difference to the SMOW. Except for evaporation before or during infiltration, the stable oxygen and hydrogen isotope ratios remain mostly unchanged as surface water percolates down to groundwater. Evaporation increases the oxygen and hydrogen isotope ratios of the residual fraction and this residual water no longer follows the trace of the meteoric water line (MWL). Among other factors affecting the isotope composition of precipitation are seasonal changes, altitude, latitude, amount of precipitation, etc.

4.4.4.2 Chromium Isotopes

Another isotopic ratio that can be utilized to evaluate sources of groundwater is that for chromium. A water sample is prepared and analyzed with a mass spectrometer to measure the ratio of $^{53}Cr/^{52}Cr$. The ratio of $^{53}Cr/^{52}Cr$ is compared to the ratio reported for a chromium standard, and the difference in the sample ratio from the standard is reported in parts per thousand (ppt, equivalent to a percent difference multiplied by 10) and expressed as $\delta^{53}Cr$. Natural chromium contained in solid mineral phases is in the form of trivalent chromium (Cr(III)), and has a $\delta^{53}Cr$ of around 0 ppt. When this chromium is released by weathering and oxidized to hexavalent chromium (Cr(VI)) in solution, the $\delta^{53}Cr$ remains 0 ppt. However, when the water containing Cr(VI) flows through a groundwater system, a portion of the Cr(VI) is reduced back to Cr(III). Because the ^{52}Cr is more easily reduced, the remaining Cr(VI) in the groundwater has a slightly greater concentration of ^{53}Cr. As the flow path in groundwater becomes longer (i.e., the residence time in the aquifer becomes greater) the $\delta^{53}Cr$ increases greater than 0 ppt. As such, differing sources of groundwater can be estimated based upon the ratio of $^{53}Cr/^{52}Cr$ and the resulting $\delta^{53}Cr$.

4.4.4.3 Tritium

Tritium (^{3}H) is a radioactive isotope of hydrogen (having two neutrons and one proton). Due to having a radioactive half-life of 12.43 years, tritium can be a good tracer for young (less than 30 years) groundwater flow. Tritium concentrations are measured in tritium units (TU) where 1 TU is defined as the presence of one tritium in 10^{18} atoms of hydrogen.

Prior to atmospheric nuclear testing in the 1950s, the natural average concentrations of ^{3}H ranged from approximately 2 to 8 TU. “Bomb tritium” increased tritium concentrations in precipitation up to approximately 1000 TU. Since cessation of atmospheric nuclear tests, tritium concentrations have decreased to between 12 and 15 TU, although small contributions from nuclear power plants occur. Tritium typically enters the hydrologic cycle in precipitation and eventually becomes concentrated in levels detectable in groundwater.

Tritium measurements alone cannot be used for dating groundwater reliably because of the uncertainty in what the original ^{3}H concentration was at the time of recharge. In more recent years, the decay product of ^{3}H, helium-3 (^{3}He), can be measured due to improvements in measurement instrumentation. However, age dating of groundwater using ^{3}H has a large uncertainty due to the extent of time that has passed since nuclear testing ended and the short half-life of tritium.

Because groundwater tritium concentrations reflect atmospheric tritium levels when the water was last in contact with the atmosphere, tritium can be used to date groundwater recharge. Given that TU values vary both spatially and temporally, it is important to establish the closest precipitation measurement point to provide a reference to estimate groundwater recharge and travel times. Groundwater age estimation using tritium only provides quantitative estimates that an aquifer is being recharged with water that originated within the last 30 to 40 years.

4.4.4.4 Carbon Isotopes

Similar to ^{3}H, carbon-14 (^{14}C) also is a naturally occurring radioactive isotope of carbon. However, it has a much greater half-life (5,730 years), providing an age-dating limit of approximately 30,000 years, and is therefore useful in dating older, regional groundwater systems. This half-life is considerably longer than the half-life of ^{3}H and will not measurably decrease due to radioactive decay in young groundwater (less than 100 years). Typically, the inorganic carbon in a groundwater less than 100 years old will contain anywhere from 10 to 50% carbon from ^{14}C-depleted sources, but usually averages around 15%.

The amount of ^{14}C activity (reported as percent modern carbon [pMC]) and ratios of stable carbon isotopes ($^{14}C/^{12}C$) of inorganic carbon dissolved in groundwater are used to estimate the age of groundwater within an aquifer. After approximately 1950, the atmosphere contained high amounts of ^{14}C due to nuclear testing and groundwater that infiltrated the subsurface after this time typically has ^{14}C abundances greater than 100 pMC.

4.4.5 Analytical Methods for Water Samples

A water sampling and analysis plan will be developed before the first water sampling event. All groundwater and surface water samples will be sent to an ELAP certified environmental testing laboratory (for non-radiological analyses) or specialty laboratory for radiological analyses. The anticipated analytical methods for groundwater and surface water samples collected during this assessment are summarized in **Table 4**, below:

Table 4: Proposed Water Sample Analytical Methods

Analysis	Reporting Units	Field Measurement	Laboratory Measurement	Proposed Analysis Method
Temperature	°C	•		Field Instrument
pH	SU	•		Field Instrument
Specific Conductance	µmhos/cm	•	•	Field Instrument and SM 2510B
DO	mg/L	•		Field Instrument
Total Organic Carbon (TOC)	mg/L		•	SM 5310
TDS	mg/L		•	SM 2540C
Alkalinity (bicarbonate, carbonate, and hydroxide)	mg/L as $CaCO_3$		•	SM 2320 B
Hardness (calculated from Ca and Mg concentrations)	mg/L as $CaCO_3$		•	SM 2340C
Nitrate & Nitrite (as Nitrogen)	mg/L as N		•	SM 4500 / EPA 300.0
Anions (carbonate, bicarbonate, chloride, sulfate, fluoride)	mg/L		•	SM 4500 / EPA 300.0
Cations (Ca, Mg, Na, K, Fe, Mn)	mg/L		•	EPA 6010B/C or 200.7
Trace Metals and minor elements (B, Si, P, Sb, As, Be, Cd, Cr(t), Cu, Pb, Hg, Ni, Se, Ag, Tl, Zn)	mg/L		•	EPA 200.7 & 245.1 or EPA 6010B/C & 7470A or 7471A or ICP-MS
Fe Speciation (Fe[II] and Fe[III])	mg/l	•		Colorimetric analysis
Isotope Ratios ($\delta^{53}Cr$, $\delta^{18}O$, $\delta^{2}H$, $^{3}H/^{3}He$, $^{14}C/^{12}C$)	‰		•	CF-IRMS (continuous flow isotope ratio mass spectrometer)

4.5 Ecological Assessment

To evaluate the presence of wetland and riparian vegetation at Bonanza Spring, and how that compares with the region in general, three drainages will be studied: (1) Bonanza Wash, including Bonanza Spring, (2) a n unnamed wash on the southwest side of the Clipper Mountains (the reference wash), and (3) a reference spring and associated wash selected by the Study Team. The ecological assessment will provide the following:

- Baseline ecological conditions at three study areas
- An assessment of the variation in vegetation between the three study areas and reasons for the variation

- An evaluation of the source of water sustaining the vegetation, for example - spring flow (permanent surface water), shallow (permanent) groundwater, shallow (intermittent) groundwater that persist after a precipitation event, or solely from (short-term) precipitation events and associated soil moisture

A team of botanists from Cardno will conduct a detailed survey of the three study areas. This will include detailed vegetation mapping of riparian and wetland vegetation present at the spring and in the wash. In general, areas containing wetland and/or riparian vegetation will be mapped along the wash as patches or individual plants as appropriate. Mapping will be conducted using a sub-meter global positioning system (GPS) to record the locations of individual trees and/or the boundary of patches of vegetation. For the area around Bonanza Spring, where substantial areas are inaccessible due to very dense vegetation, the vegetation mapping will be accomplished using high-resolution aerial photographs (**Section 4.1.4**). Vegetation will be digitized from the aerial photographs using geographic information system (GIS) software and combined with the field data.

A study plan describing the tasks to be completed as part of the ecological assessment of the Bonanza Spring is presented in **Appendix A**.

5.0 REPORTING

5.1 Study Program Report

After completion of the aquifer testing program, the data from the following will be compiled and analyzed:

- Existing hydrologic studies pertinent to Bonanza Spring
- The geophysical surveys, including assessment of subsurface stratigraphy, structure, and groundwater presence (**Section 4.1**)
- Water levels and flow at Bonanza Spring and the reference spring (**Section 4.2.2**)
- Water occurrence along Bonanza Wash (**Section 4.2.2**)
- Regional weather conditions
- Localized weather conditions in the bedrock watershed that supports flow at Bonanza Spring (**Section 4.2.4**)
- Soil borings and monitoring well installation (**Section 4.3**)
- Sediment/rock sampling (**Section 4.3.8**)
- Geophysical Well logging (**Section 4.3.10**)
- Groundwater level data (**Section 4.3.14**)
- Slug testing (**Section 4.3.15.1**)
- Aquifer pumping tests (**Section 4.3.15.2**)
- Water geochemistry at Bonanza Spring and reference spring (**Sections 4.2.3 and 4.4**)
- Groundwater geochemistry (**Sections 4.3.14.3 and 4.4**)
- Ecological conditions at the three study areas (**Section 4.5**)

The data, data analysis, data interpretation, and findings will be presented within Study Program Report. The report will include appendices that contain the raw data and other documentation, tables that summarize the data, figures that depict key data and analyses, and text that describe the program, data analyses, and findings. A draft report will be provided to Three Valleys and the Expert Panel for review and comment. Once these comments have been addressed, a final draft Study Program Report will be provided to key stakeholders (including those that attended the Study Plan Workshop – see **Section 1.9**) for review and comment. Once these comments have been addressed, a final Study Program Report will be posed for public review.

5.2 Conceptual Hydrogeologic Model

One key element of the Study Program Report will be the refinement of the conceptual hydrogeologic model (CHM) for Bonanza Spring, as described in the two hypotheses being evaluated by the Study Program (see **Section 1.10**). The CHM will detail in text and graphics the hydrology of Bonanza Spring, notably the degree of hydrologic connection between the groundwater that supports flow at Bonanza Spring and the alluvial aquifer in Fenner Valley.

6.0 SCHEDULE

A preliminary schedule for the Study Program through December 2020 is presented below (**Table 5**):

Table 5: Proposed Implementation Schedule

Task	Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	Study program contracting	•											
2	Permitting	•											
3	Field work coordination	•	•										
4	Geophysical surveys			•									
5	Surface water gauge installation			•									
6	Spring water sampling						•			•			•
7	Monitoring well installation					•							
8	Groundwater transducer installation					•							
9	Groundwater sampling						•			•			•
10	Aquifer testing								•				
11	Geochemical assessment								•				
12	Ecological assessment					•							
13	Data analyses				•			•		•	•	•	
14	Status updates	•			•			•			•		
11	Report										•	•	•

7.0 CLOSING

In preparing this scoping plan our services have been performed using that degree of care and skill ordinarily exercised under similar circumstances by reputable, qualified water resources consultants practicing in this or similar locations. No other warranty, either expressed or implied, is made as to the professional advice included in this plan. These services were performed consistent with our agreement with our client. Opinions and recommendations contained in this plan apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We do not warrant the accuracy of information supplied by others nor the use of segregated portions of this plan.

8.0 REFERENCES

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FIGURES

Item 5 - Exhibit A

Bonanza Spring
Watersheds
Dry Lakes
Railroad Lines

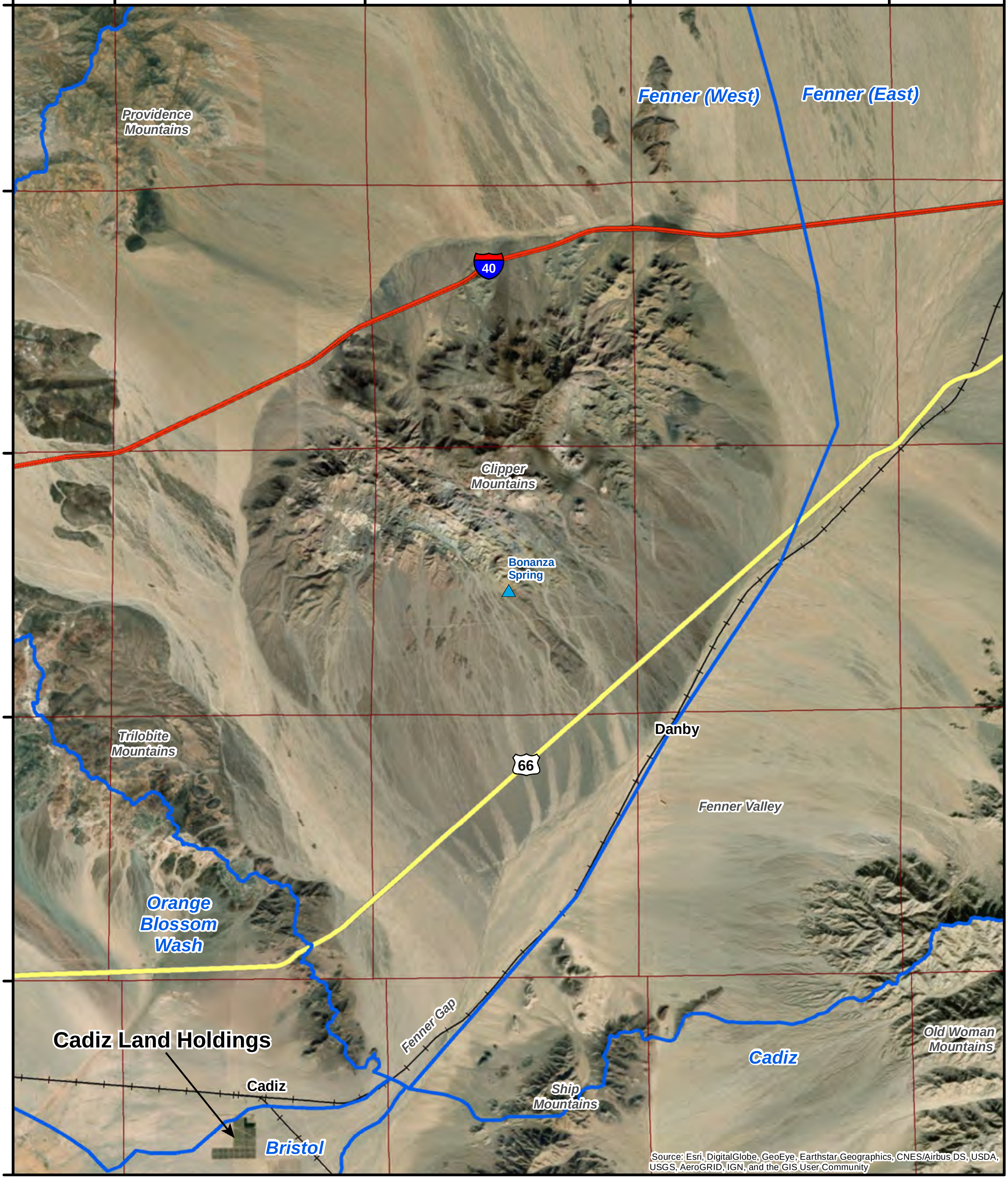
0 8
Miles

aquilogic, Inc.

TVMWD- Cadiz

General Project Area (Cadiz and Bristol Watersheds)

Date: 1/3/2020	Project #: 052-02	**Figure 1**



Bonanza Spring

Watersheds

Railroad Lines

0 3

Miles

aquilogic, Inc.

TVMWD- Cadiz

Local Project Area (Clipper Mountains)

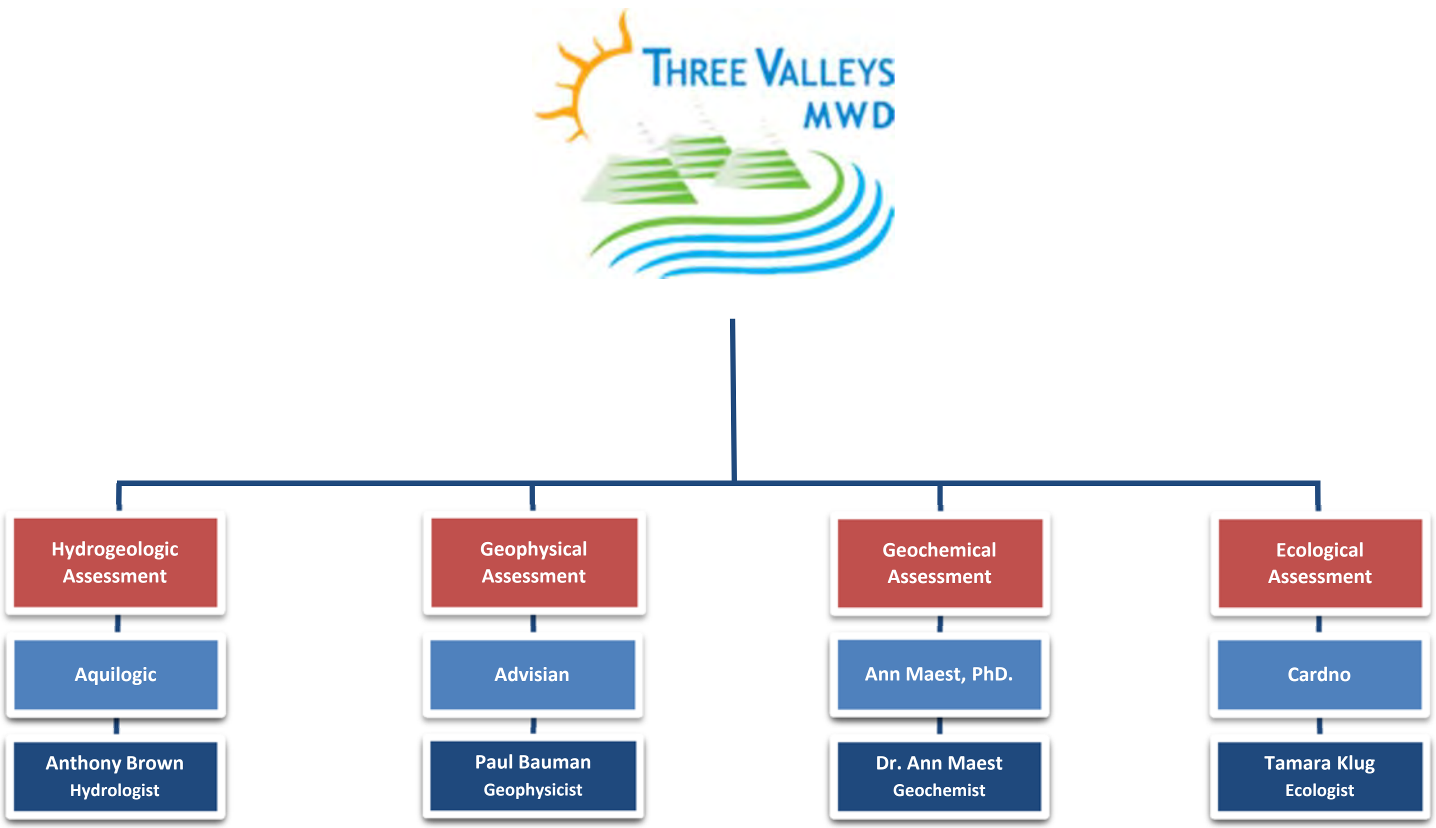
Date: 1/3/2020	Project #: 052-02	**Figure 2**

aquilogic, Inc.

TVMWD- Cadiz

Bonanza Spring Study Location

Date: 10/28/2019	Project #: 052-02	**Figure 3**

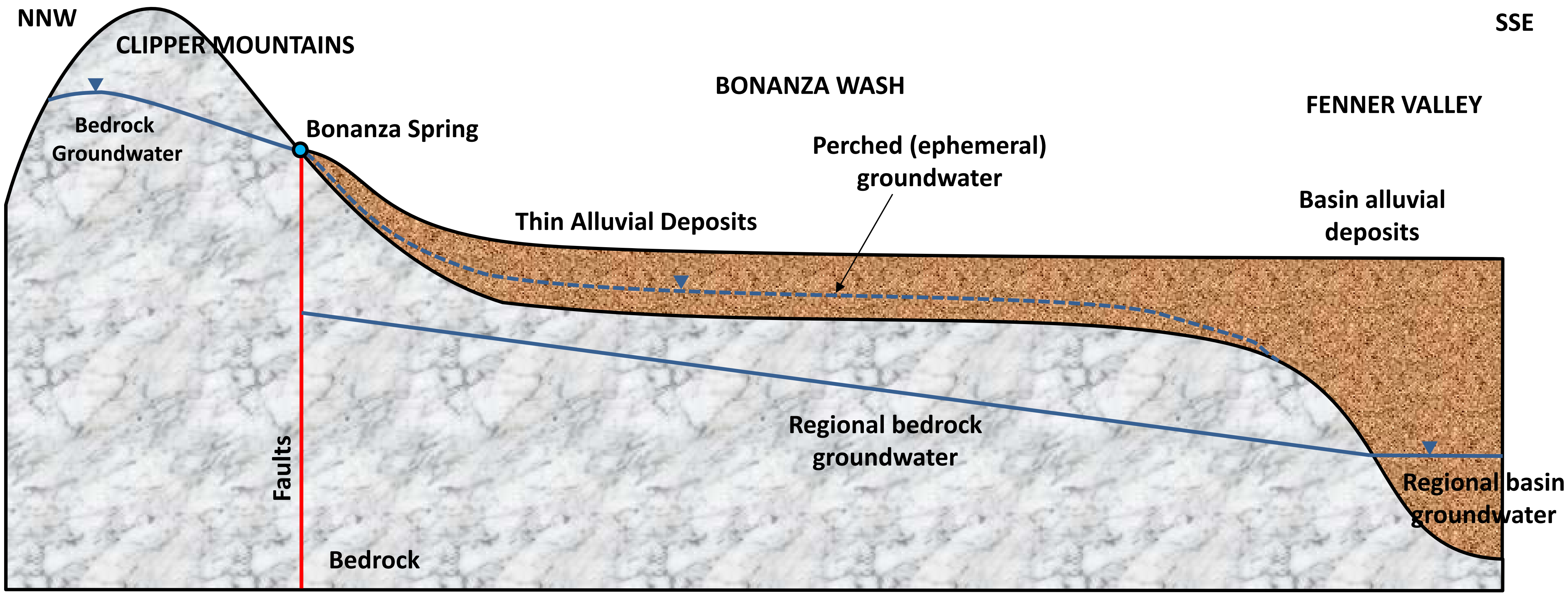


aquilogic, Inc.

TVMWD-Cadiz

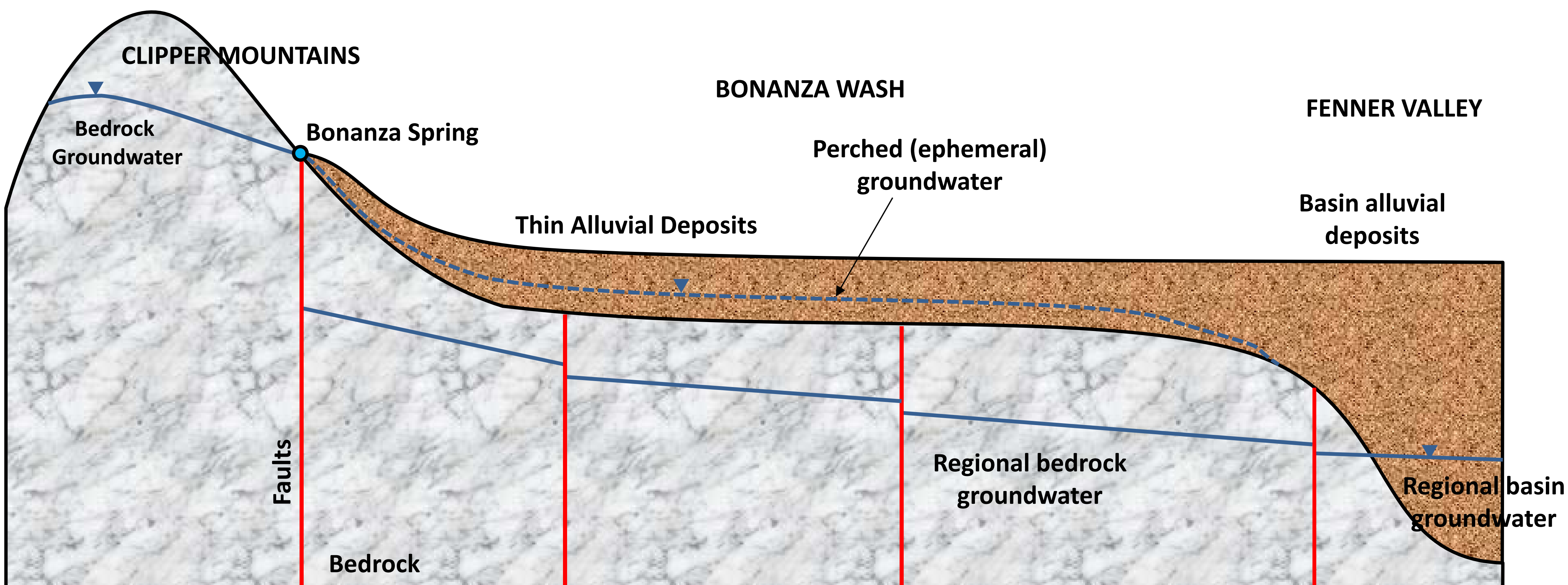
Project Team and Responsibilities

Date: 1/3/2020	Project #: 052-02	**Figure 4**



CONCEPTUAL MODEL A1:

Groundwater in bedrock above, and supporting, Bonanza Spring is isolated from regional groundwater in bedrock below the spring and in the alluvium in Fenner Valley. This results from a fault at the spring and a shallow bedrock pediment surface in Bonanza Wash below the spring. Therefore, groundwater levels in Fenner Valley may decline in response to pumping at the Cadiz Project; however, groundwater above the spring, and flows at the spring, will not be materially affected.



CONCEPTUAL MODEL A2:

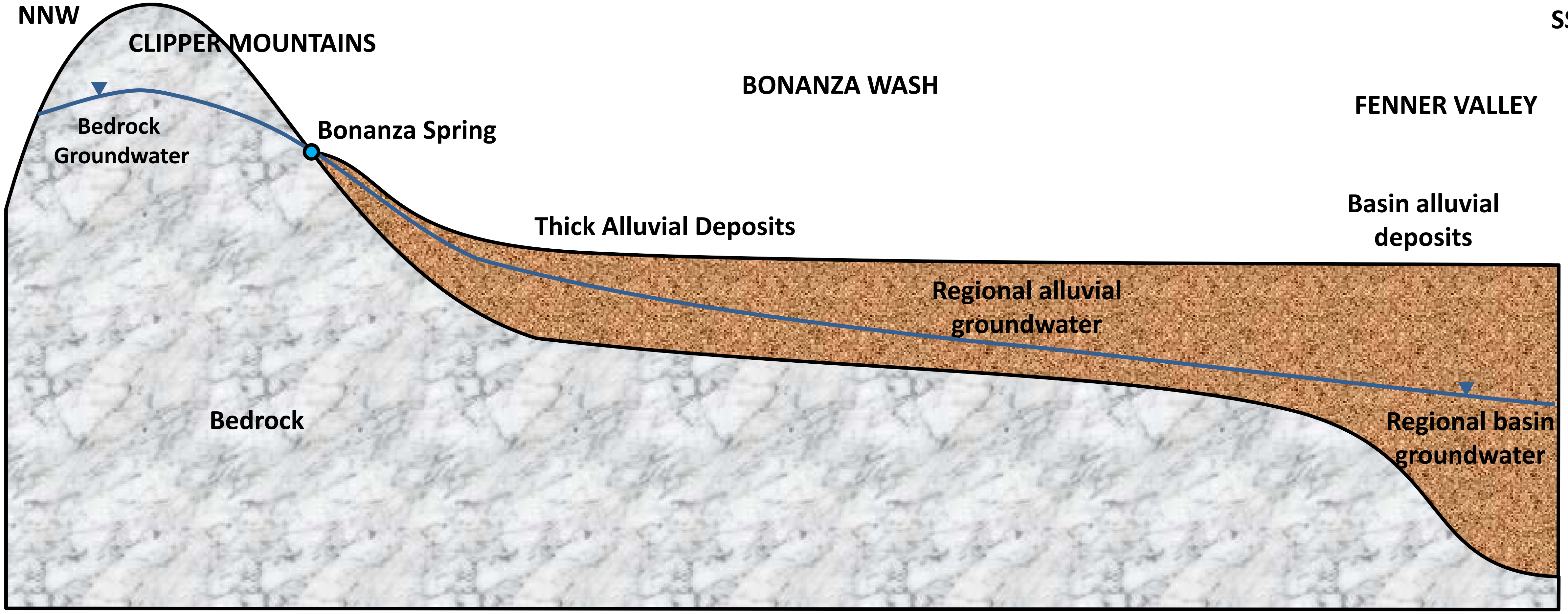
As Conceptual Model A1, but with further faulting below Bonanza Spring further isolating groundwater in bedrock that supports the spring from groundwater in the alluvium in Fenner Valley, and any pumping at the Cadiz project

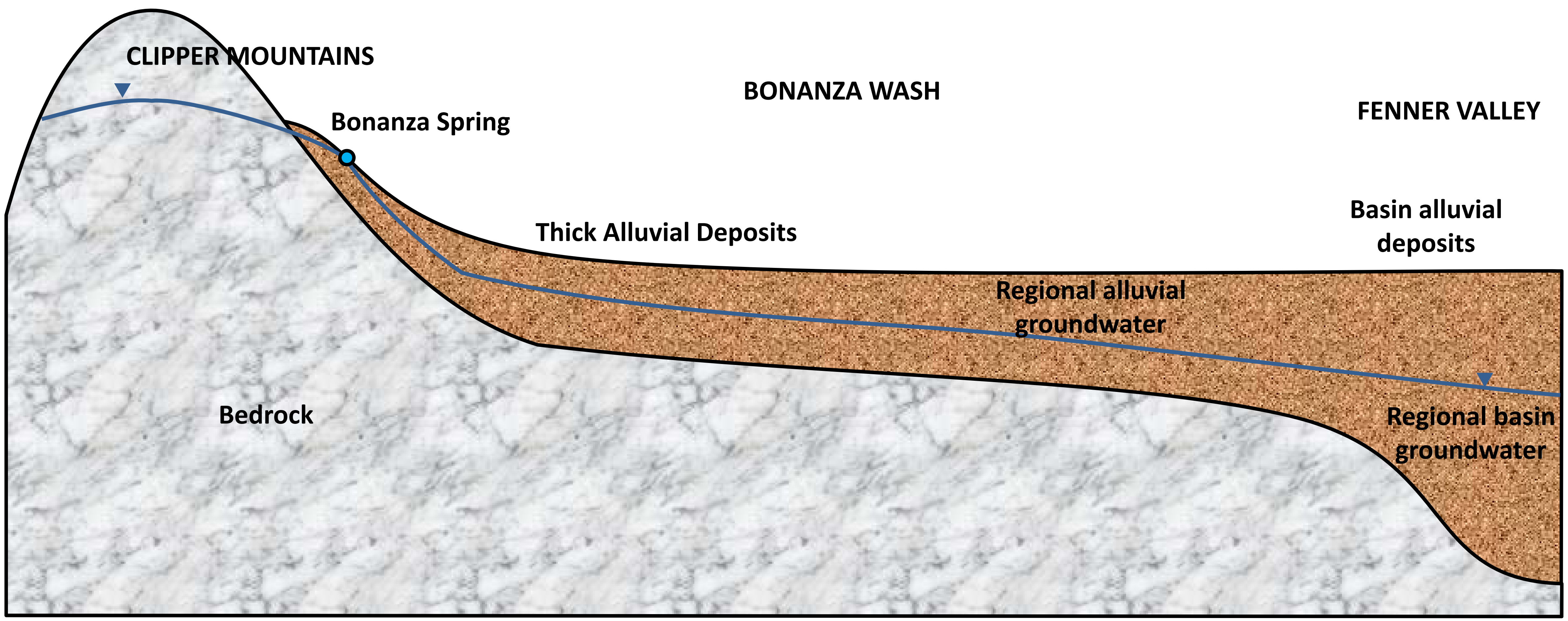
aquilogic, Inc.

TVMWD-Cadiz

Conceptual Hydrogeologic Models (A1 and A2)

Date: 1/5/2020	Project #: 052-02	Figure 5a





CONCEPTUAL MODEL B1:

Groundwater in bedrock above, and supporting, Bonanza Spring is in direct hydraulic communication with regional groundwater in alluvium below the spring and in Fenner Valley. This occurs as there are no isolating faults, the alluvium in Bonanza Wash is thicker, and groundwater from above the spring, within Bonanza Wash, and in Fenner Valley is a continuum. Therefore, any decline in groundwater levels in Fenner Valley in response to pumping at the Cadiz Project may propagate up Bonanza Wash to the spring and impact spring flows.

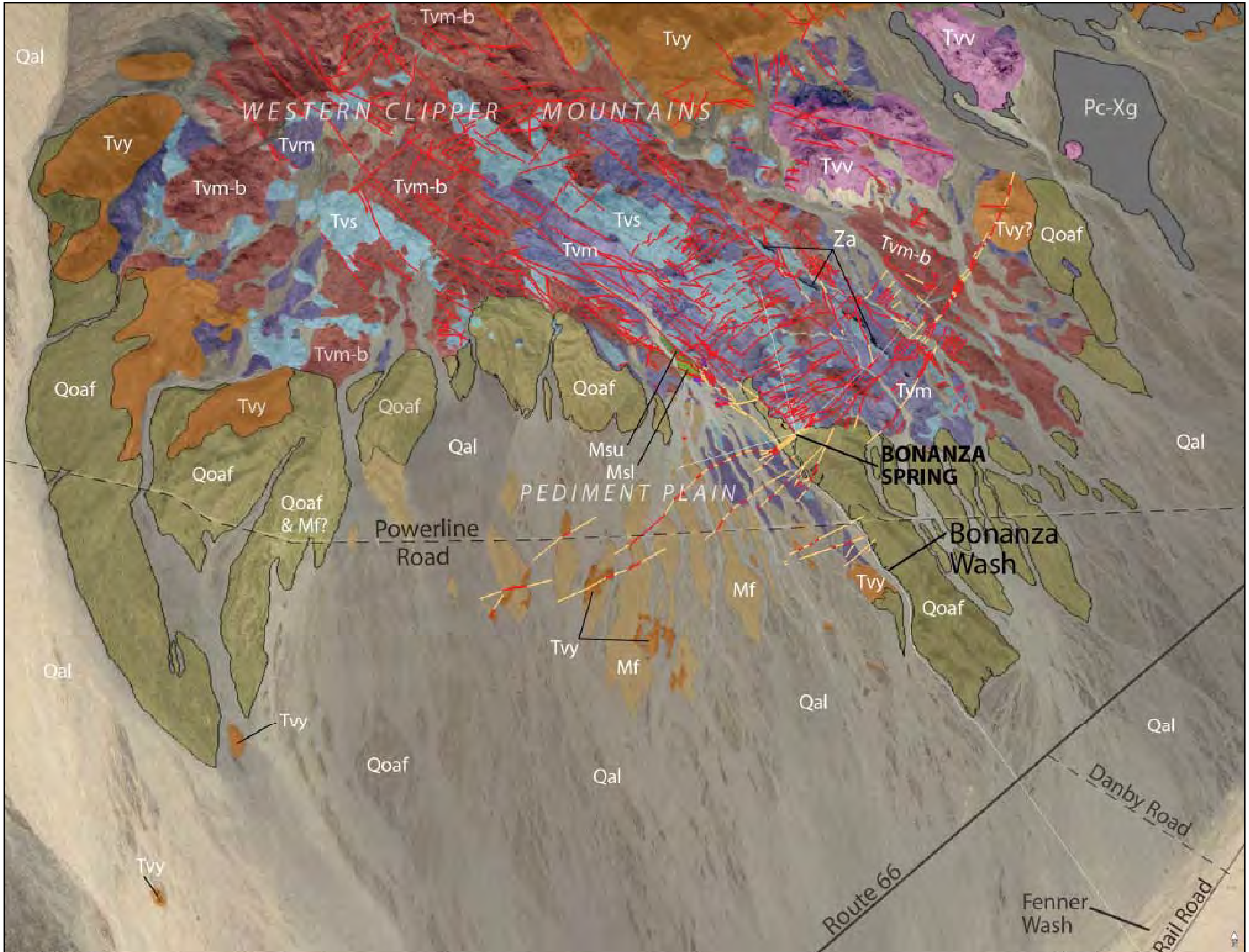
CONCEPTUAL MODEL B2:

As Conceptual Model B1, but Bonanza Spring occurs in the alluvium rather than at the alluvium-bedrock contact.

aquilogic, Inc. | TVMWD-Cadiz

Conceptual Hydrogeologic Models (B1 and B2)

Date: 1/5/2020	Project #: 052-02	**Figure 5b**



QUATERNARY SEDIMENTS

Qal	Late Pleistocene to Holocene alluvial sediments (not mapped)
Qoaf	Early Pleistocene (possibly late Pliocene) alluvial sediments

MIOCENE EXTRUSIVES - VOLCANIC - YOUNGER IGNEOUS SUITE

Tvy (Tal)	Tertiary igneous extrusive (volcanic) igneous rocks. Eroded away above the Western Clipper Igneous Intrusive Suite.
Mf (Ttb)	Miocene sedimentary deposits. Fanglomerates, lacustrine, reworked volcanics, interbedded igneous extrusives. Units generally dip toward the south approximately 25 to 35 degrees.

MIOCENE INTRUSIVES - WESTERN CLIPPER MOUNTAINS IGNEOUS INTRUSIVE SUITE

Tvv	Tertiary igneous shallow intrusives exhibiting vents (domes) of silicious dominated rocks. (>18.5 ma likely
Tvm-b	Tertiary igneous shallow intrusive rocks exhibiting generally mafic compositions (i.e. basaltic). Intrusions near vertical and trend northwest-southeast (>18.5 Ma). Some upper members of unit may be flows (extrusive) suggesting it is younger than units Tvs and Tvm.
Tvs (Tda)	Tertiary igneous shallow intrusive rocks exhibiting generally a silicic composition. Intrusions near vertical and trend northwest-southeast (>18.5 Ma).
Tvm (Tda)	Tertiary igneous shallow intrusive rocks exhibiting generally a silicic to mafic composition. Intrusions near vertical and trend northwest-southeast (>18.5 Ma).
Tvo	Tertiary igneous shallow intrusives or possibly extrusives. Abundant epidote secondary mineralizaion. Mostly mafic (>18.5 Ma).

EARLY MIOCENE SEDIMENTARY ROCKS

Msu	Sedimentary unit composed of well bedded thin members of siltstone and sandstones interbedded with massive volcanic breccias and volcanic silicic rocks. Siltstones and sandstones are likely from an ancient fluvial system with overbank deposits. Unit deposited during early phases of basin and range extensional tectonics and associated volcanism (>18.5 Ma).
Msl	Sedimentary unit composed of well bedded thin members of siltstone and sandstones similar to Msu however sandstone units contain some small gravels none of which were identified as volcanic suggesting deposition prior to regional volcanism and basin and range extensional tectonics (mountain building, >18.5 Ma).

EARLY PALEOZOIC (CAMBRIAN) ROCKS

Za	Zabriskie Quartize - altered. Clipper Mines associated with this unit (~500 Ma).
Pc-Xg	Proterozoic igneous and metamorphic suite (~1.7 billion years old).

Note: Possible correlating Miocence Igneous units Tal, Ttb, and Tda from USGS Bulletin 2160 with units from this study are shown.

Faults, joints/fractures

Projected faults, joints/fractures

~6000 feet
Scale

N

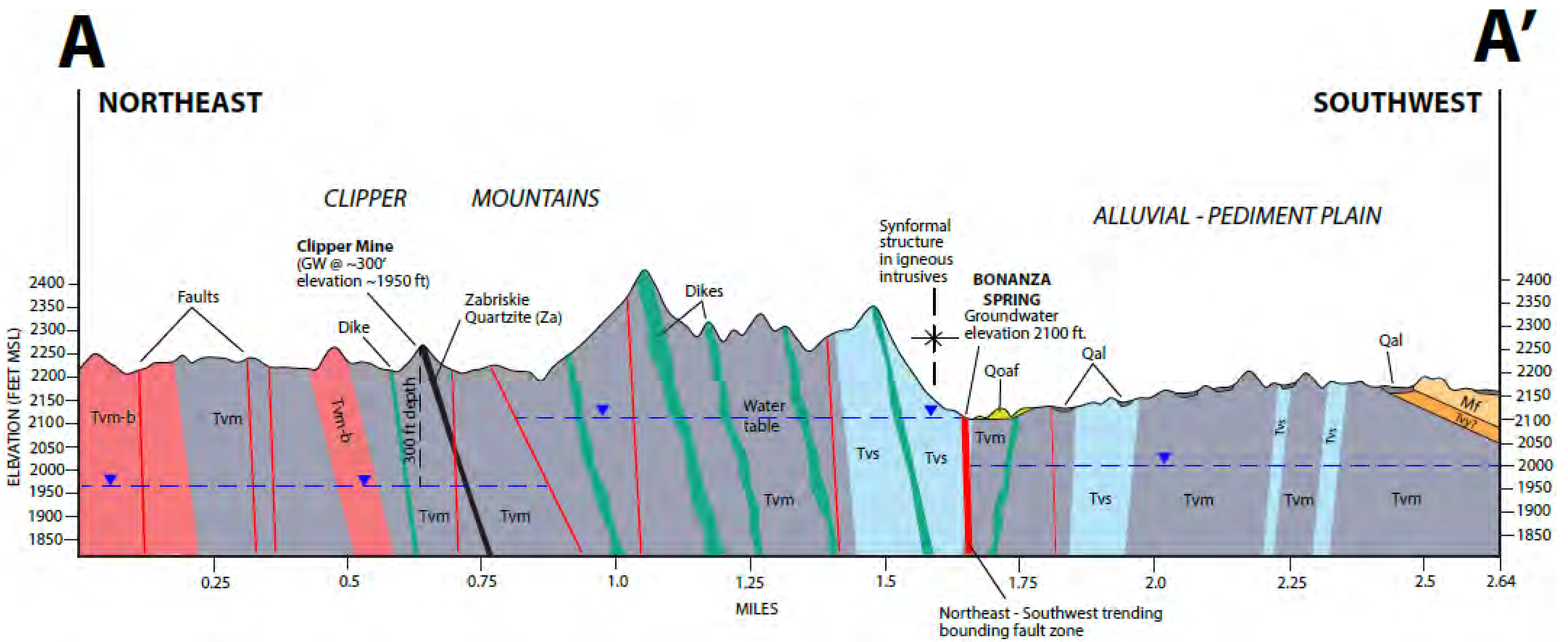
Source:
Kenney Geoscience and TLF Consulting. (2018). Updated Assessment of Cadiz Water Project's Potential Impacts to Bonanza Springs. January.

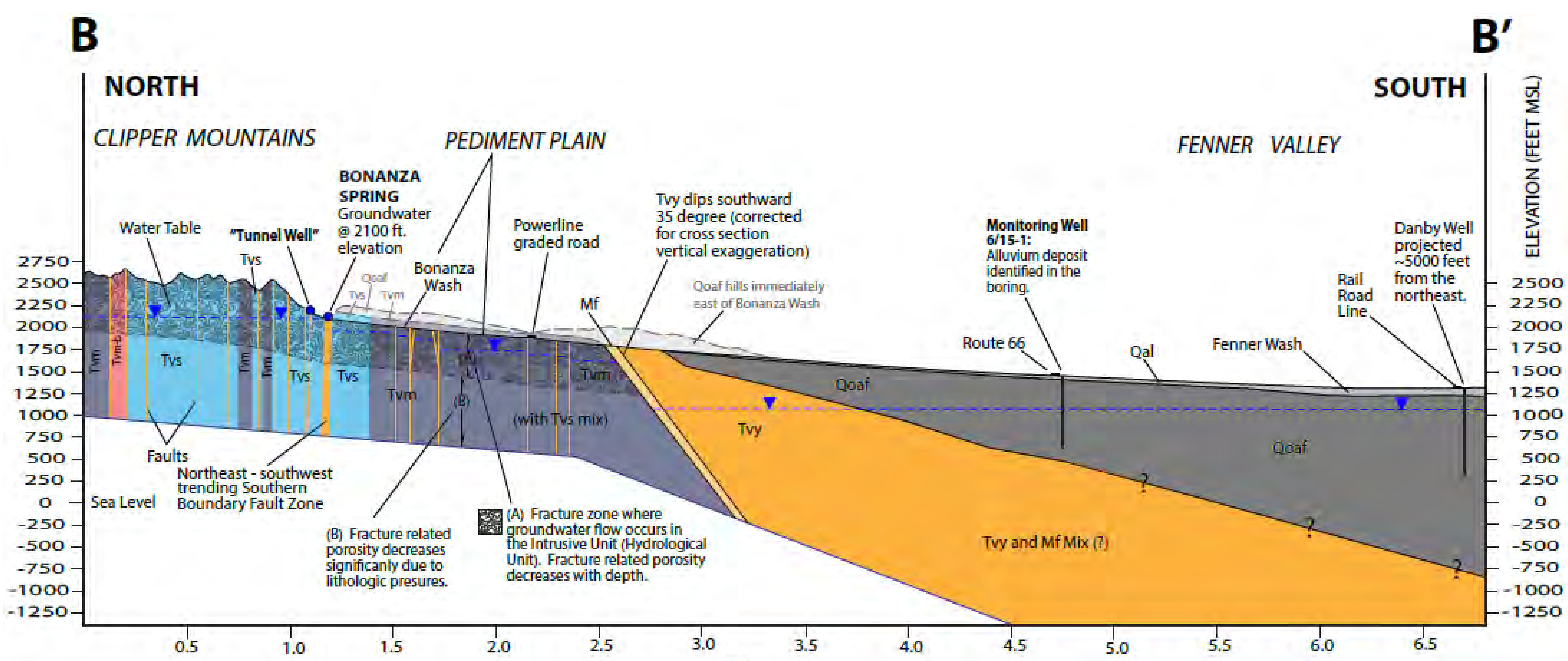
aquilogic, Inc.

TVMWD-Cadiz

Surficial Geology in the Vicinity of Bonanza Spring

Date: 1/5/2020	Project #: 052-02	**Figure 6**





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Tvv	Tertiary igneous shallow intrusives exhibiting vents (domes) of silicious dominated rocks. (>18.5 ma likely
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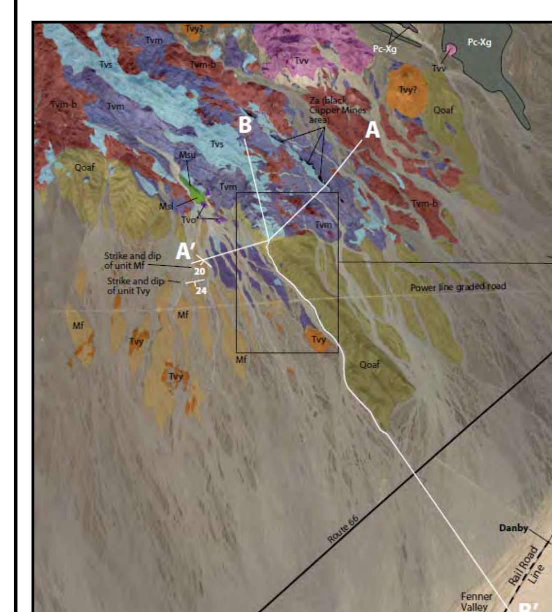


Source:
Kenney Geoscience and TLF Consulting. (2018). Updated Assessment of Cadiz Water Project's Potential Impacts to Bonanza Springs. January.

aquilogic, Inc.

TVMWD-Cadiz

Geologic Cross-Section Proximate to Bonanza Spring

Date: 1/5/2020	Project #: 052-02	Figure 7

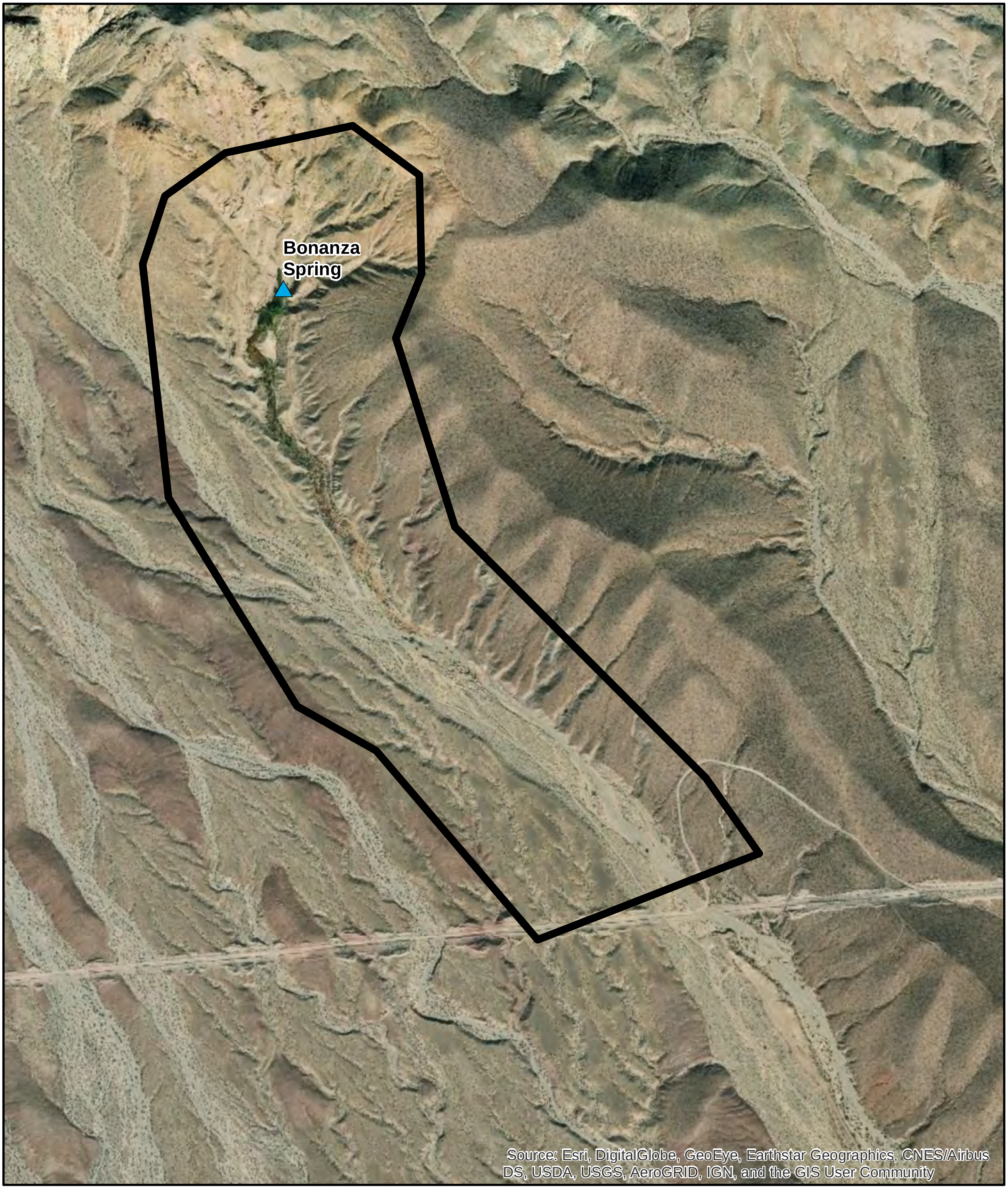
aquilogic, Inc.

TVMWD - Cadiz

Photographs of Similar Geophysical Surveys

Date 1/3/2020	Project #: 052-02	**Figure 8**

Item 5 - Exhibit A



Bonanza Spring

Proposed Unmanned Aerial Vehicle (UAV) and Ground Penetrating Radar (GPR) Survey Area

aquilogic, Inc.

TVMWD- Cadiz

Proposed Unmanned Aerial Vehicle (UAV) and Ground Penetrating Radar (GPR) Survey Area

Date: 10/28/2019	Project #: 052-02	**Figure 9**

Bonanza Spring

Proposed Seismic Survey Locations

0 1,750 Feet

aquilogic, Inc.

TVMWD- Cadiz

Proposed Seismic Survey Locations

Date: 10/28/2019	Project #: 052-0	**Figure 10**

Bonanza Spring

Proposed Electrical Resistivity Tomography (ERT) Survey Locations

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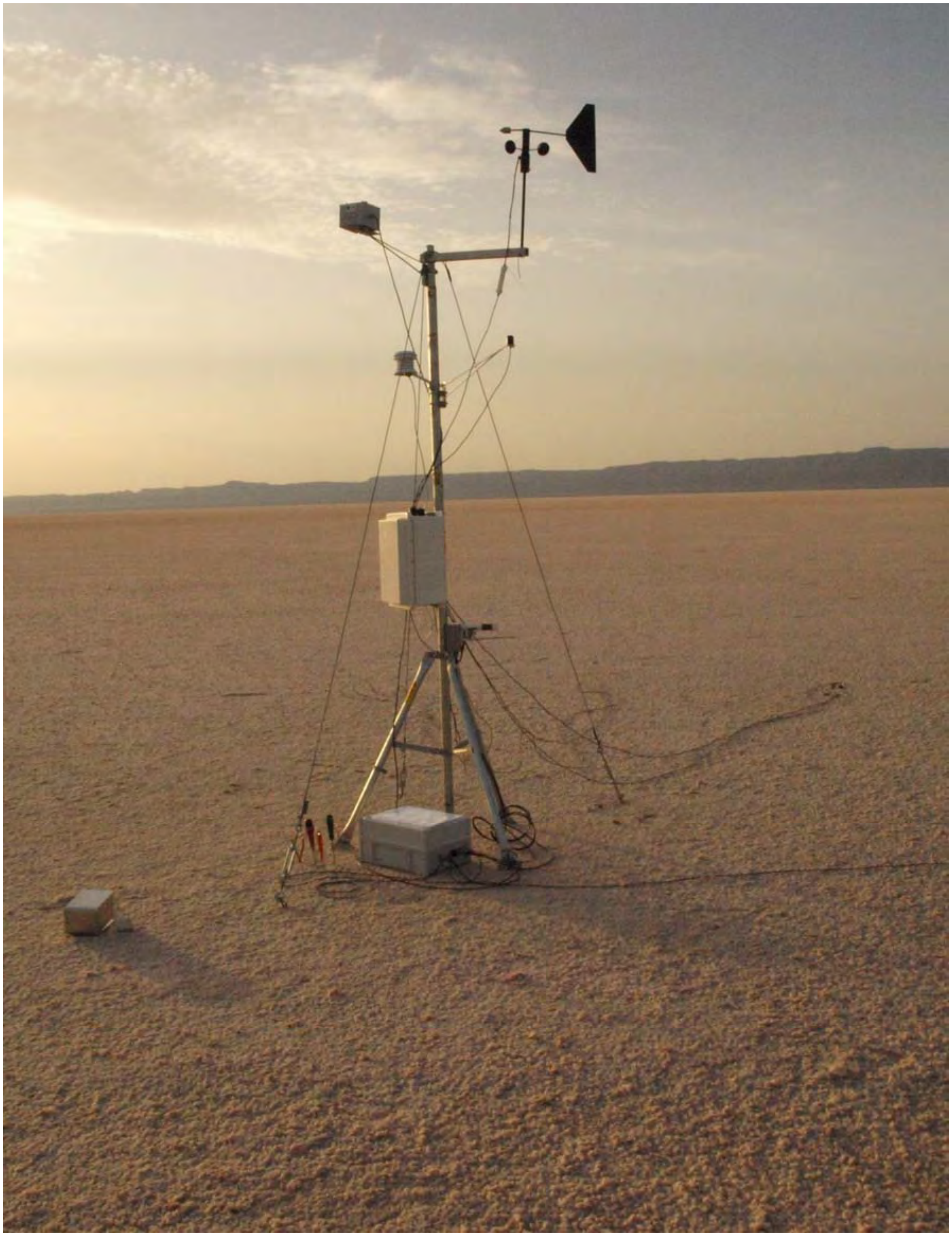
TVMWD- Cadiz

Proposed Electrical Resistivity Tomography (ERT) Survey Locations

Date: 10/28/2019	Project #: 052-02	**Figure 11**



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TVMWD - Cadiz

Photograph of Typical Remote Automated Weather Station

Date 2/12/2020	Project #: 052-02	**Figure 12**

aquilogic, Inc.

TVMWD - Cadiz

Photographs of Typical Pressure Transducer for Spring Monitoring

Date 1/3/2020	Project #: 052-02	**Figure 13**

Proposed Groundwater Monitoring Well Locations

Bonanza Spring

aquilogic, Inc.

TVMWD- Cadiz

Proposed Groundwater Monitoring Well Locations

Date: 10/28/2019	Project #: 052-02	**Figure 14**

Proposed Groundwater Monitoring Well Locations
Bonanza Spring
Access Road
Off-road truck route
Walking (geophysics)

0 2,500
Feet

aquilogic, Inc.

TVMWD- Cadiz

Proposed Groundwater Monitoring Well Access

Date: 10/28/2019	Project #: 052-02	**Figure 15**

aquilogic, Inc.

TVMWD - Cadiz

Photograph of Typical Monitoring Well Drill Rig

Date 2/10/2020	Project #: 052-02	**Figure 16**

aquilogic, Inc.

TVMWD - Cadiz

Photographs of Typical Monitoring Well Surface Completion

Date 2/10/2020	Project #: 052-02	**Figure 17**

APPENDICES

Item 5 - Exhibit A

Ecological Study Plan – Bonanza Spring

Cadiz Project

November 2019, Draft

Cardno

Document Information

Prepared for	Aquilogic Inc.
Project Name	Ecological Study Plan – Bonanza Spring Cadiz Project
Project Number	E319402000
Project Manager	Tamara Klug
Date	November 2019, Draft

Prepared for:

Aquilogic Inc.
245 Fischer Ave Suite D-2, Costa Mesa, CA 92626

Prepared by:

Cardno, Inc.
201 N. Calle Cesar Chavez, Suite 203 Santa Barbara, CA 93103

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Table of Contents

Appendices

Figures

Acronyms

CEQA	California Environmental Quality Act
EIR	Environmental Impact Report

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1 Assignment

The Cadiz Water Project is in San Bernardino County, approximately 100 miles east of Victorville. The Project entails pumping water from a subsurface aquifer to support various water needs in the region. The environmental planning process has been completed for the Cadiz Water Project (Project), and an Environmental Impact Report (EIR) was completed for the Project in 2012. In addition to review under the California Environmental Quality Act (CEQA), there have been a number of studies and peer review of those studies completed for the Project, which focus primarily on potential effects to natural springs that occur in the region. Various agencies and NGOs are concerned about the potential impacts to springs caused by groundwater pumping associated with the Project. Aquilogic, Inc. has brought together a team of scientists to study the nearest spring to the Project area to better understand the degree to which the springs could be affected by groundwater pumping by the Project.

The focus has been on Bonanza Spring, because it is the most robust and closest spring to the proposed location for the Project. Bonanza Spring is located approximately 11 miles from the Project area and is 1,000 feet higher in elevation. Four potential conceptual models to describe how the spring is supplied by water have been proposed (see Figures 1 through 4). These conceptual models are described in more detail in Figures 1 through 4.

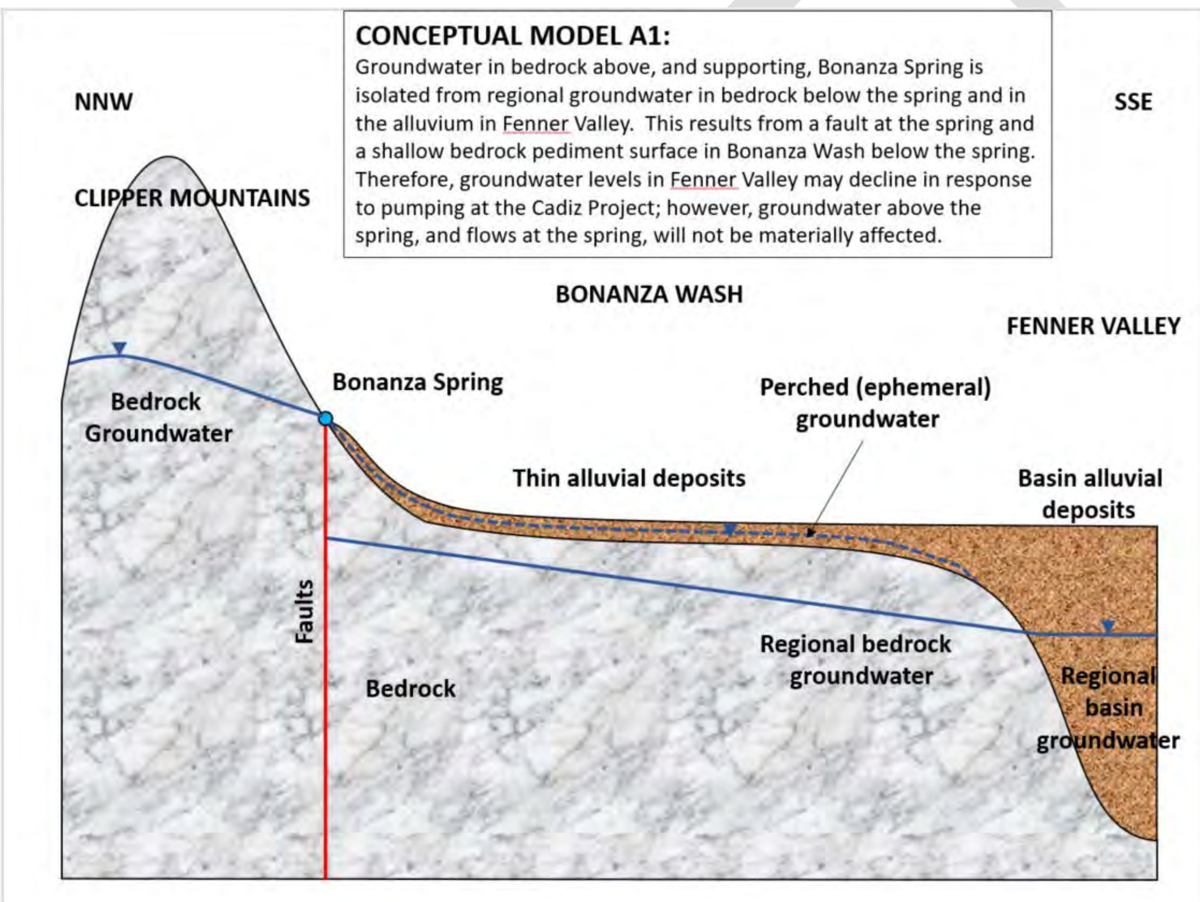

Figure 1 **Conceptual model A1 assumes a thin layer of alluvium in Bonanza Wash over a bedrock pediment surface with separate groundwater zones. Bonanza Wash is the drainage below the spring.**

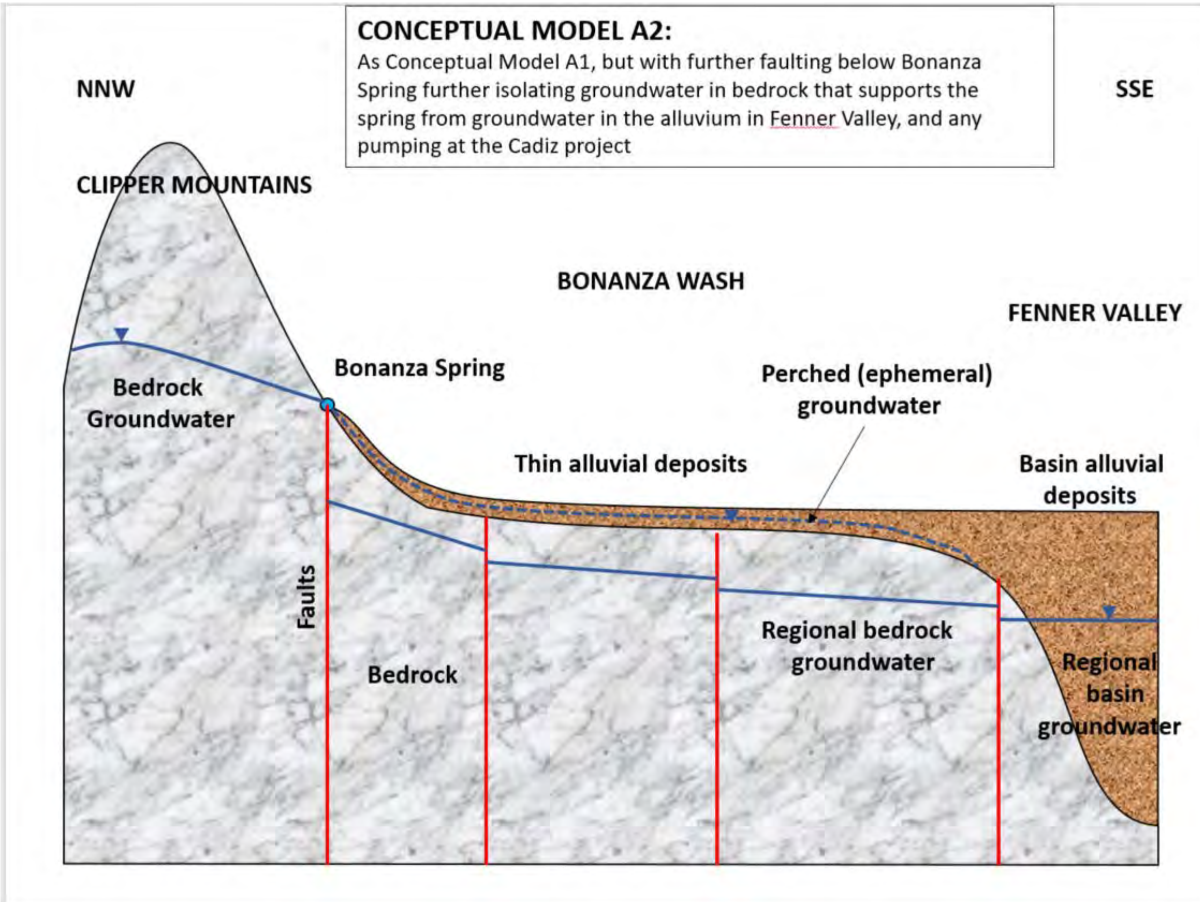

Figure 2 **Conceptual model A2 assumes a similar situation to conceptual model A1 but has multiple groundwater level offsets at faults.**

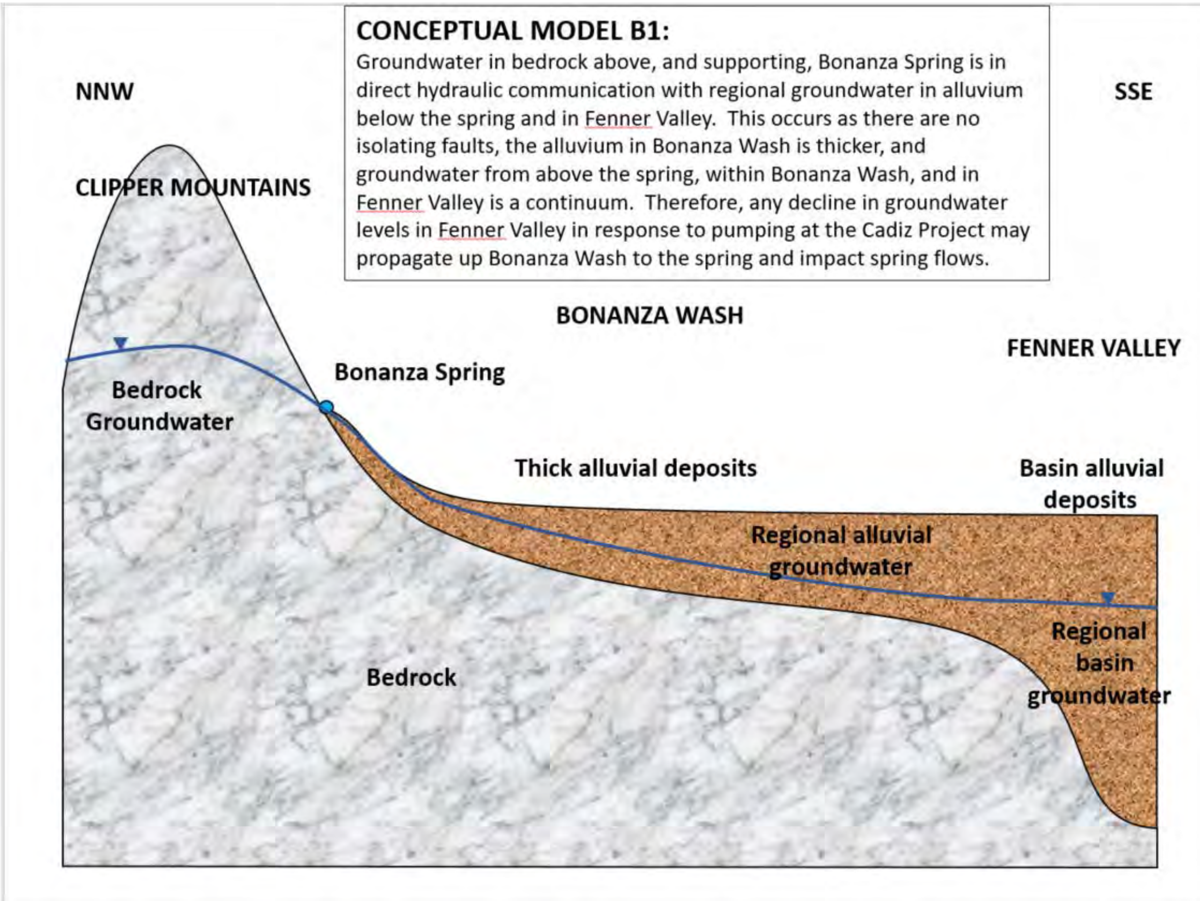

Figure 3 **Conceptual model B1 assumes a thicker alluvium than conceptual model A1 with the side-valley of Fenner Valley filled in with alluvium. Under this conceptual model, Bonanza Spring is at the alluvium/bedrock contact on Clipper Mountains.**

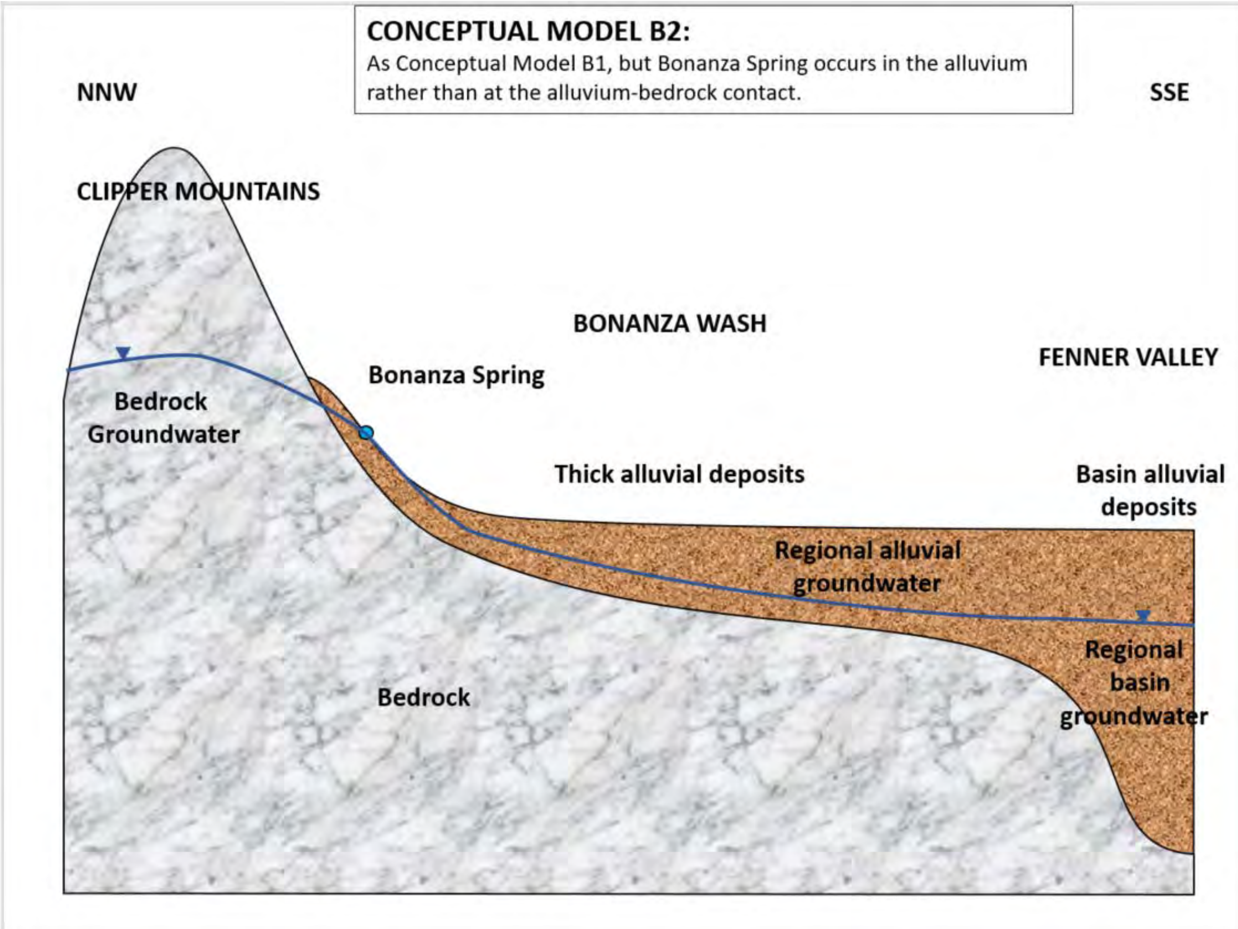

Figure 4 **Conceptual model B2 assumes a similar situation to conceptual model B1 with alluvium extending further up toward Bonanza Spring and Bonanza Spring is in the alluvium.**

Cardno was hired by Aquilogic, Inc. to develop a program that would do the following:

1. Determine if the biological evidence provides clarity regarding the accuracy of conceptual models A1, A2, B1, or B2.
2. Determine the amount of evapotranspiration that is being produced by vegetation at Bonanza Spring.
3. Develop a sampling plan to determine if vegetation changes are occurring to Bonanza Spring, and if so attribute them to a cause, if possible.

These three tasks are described in further detail in this Study Plan.

2 Conceptual Model Biological Evidence

The purpose of this task is to determine the relative water use of vegetation observed near the spring, and determine if the findings support any of the conceptual models. In particular, wetland and riparian vegetation that requires a greater amount of moisture would support models A1 and A2, which both assume a thin layer of alluvium. Models B1 and B2 assume subsurface water would be deeper in the alluvium and inaccessible to plant roots. Therefore, less consistent presence of wetland and riparian vegetation would be expected for either of these models. To determine the presence of wetland and riparian vegetation, and how that compares with the region in general, two drainages will be studied: Bonanza Wash and another nearby wash with similar characteristics. An unnamed wash on the southwest side of the Clipper Mountains will be the secondary reference drainage to Bonanza Spring.

A team of botanists will conduct a detailed survey of Bonanza Wash below Bonanza Spring as well as at the reference wash. This will include detailed vegetation mapping of riparian and wetland vegetation present in the wash. In general, areas containing wetland and/or riparian vegetation will be mapped along the wash as patches or individual plants as appropriate. Mapping will be conducted using a sub-meter GPS to record the locations of individual trees and/or the boundary of patches of vegetation. For the area around Bonanza Spring, where substantial areas are inaccessible due to very dense vegetation, the vegetation mapping will be accomplished using high-resolution aerial photographs. These aerial photographs are currently proposed as a separate part of this study. Vegetation will be digitized from the aerial photographs using GIS-software and combined with the field data.

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3 Evapotranspiration Estimates

Using the extent and species of vegetation mapped as described in Section 2, the amount of water transpired from the vegetation will be determined using the crop coefficient approach. We anticipate that species crop coefficient (Kc) data will be available for some species, but not for others. The Kc value for each native vegetation type incorporates canopy properties, ground cover, and water availability. For species lacking Kc data, a surrogate species will be identified and the Kc from the surrogate species will be used. Surrogate species will be of the same genus (if possible) or of a similar growth pattern and type.

In crop coefficient approach, the crop or vegetation evapotranspiration (ETc) is calculated by multiplying the reference ET (ET0) by a crop coefficient. The ET0 value is a function of climate conditions and can be solved for using the Penman-Monteith equation with data from local meteorological records. After ETc is calculated for each vegetation type, this value will be multiplied by the surface area occupied by each vegetation type to achieve the total ET for the study area.

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4 Baseline and Ongoing Vegetation Monitoring of Bonanza Wash

Vegetation type and extent will be monitored in Bonanza Wash and an off-site reference spring to detect changes in vegetation vigor or extent. The study will include a combination of methods, which have been specifically designed with the conditions at Bonanza Spring and wash in mind.

The purpose of the reference site is to understand the effects of regional changes that could be affecting the vegetation but would not be associated with pumping by the Project. Ideally, the reference site would be located nearby but would not be associated with the aquifer that would be used by the Project (the Fenner Aquifer). A review of potential reference springs was conducted using a survey of springs in the Mojave Desert (Zdon 2016) along with other data sources such as Google Earth. We attempted to identify springs of similar output, vegetation, and elevation. From this exercise, two potential springs were identified, Salt Spring (coordinates: 35.62614, -116.28089) and Sheep Creek Spring (coordinates: 35.58858, -116.36027). These springs will be investigated in the field to determine if they are suitable reference springs with consideration of the following factors: accessibility, dominant vegetation, and size.

4.1 Vegetation Transects

The primary method of vegetation study will be permanently-established transects that will be set up in accessible areas of the spring and associated wash and sampled annually in October or November.

4.1.1 Transect Locations

Transect locations will be set up at Bonanza and another reference spring and associated wash. Specific locations will be set up at regular intervals, dependent on the habitat type, with more frequent transects in more environmentally sensitive areas (i.e., areas supporting wetland plant species at the spring itself). Transects will be less frequent at locations further from the spring to encompass other areas that may be influenced by the spring. Transect sampling should include transects at 200-foot intervals in the area that is dominated by dense wetland and riparian vegetation (approximately 2,800 feet below the spring at Bonanza Spring). Transect sampling will continue downstream on Bonanza Wash for another 4,000 feet at 500-foot intervals.

4.1.2 Transect Sampling Methods

At each transect, a field measuring tape will be placed perpendicular to the channel. Transect ends will be marked with a large nail that can be removed for safety between visits. Detailed location information and GPS points will be recorded for transect ends, so they can be re-located. Beginning at one foot along the field tape, data will be recorded every foot, capturing dominant species for all vegetation strata (such as tree, shrub, or herb) directly above or below a given point along the field tape. For each vegetation stratum, datum is recorded as a "hit" (i.e., the stratum is present) or a miss (i.e., the stratum is not present). These data are then combined to calculate percent cover values.

One foot was selected as the spacing for the point intervals in order to account for the growth pattern of the primary species along the line. For example, rushes are 6 inches (more or less) in diameter. Vegetation strata that should be recorded are listed below. If two species of the same stratum (e.g., two different shrub species) are present at the same point, the taller or more dominant species should be recorded. In the event that understory species block the ability to observe the tallest species at a given sample point (e.g. a 6-foot bush obscures a 20-foot tree canopy), the tallest visible piece of vegetation will be recorded. Presence of saturated soil or depth of standing water will also be recorded. Photos of established transects will be taken during each sampling event from each end looking along the tape.

Vegetation Strata:

- > Herbaceous: non-woody plants of any height.
- > Vine: long-stemmed plants growing along the ground or climbing by tendrils.
- > Shrub: woody plants, less than 10-feet tall, which can include immature or low-stature trees.
- > Tree: woody plants, more than 10-feet tall.

4.2 Vegetation Mapping

Similarly as described above in Section 2, annual high-resolution aerial photography will be acquired of both Bonanza Spring and the reference spring. Detailed vegetation mapping of the springs will be digitized from the aerial photographs so changes in vegetation over the long-term can be tracked.

5 References

Zdon, Andy. 2016. Mojave Desert Springs and Waterholes: Results of the 2015-16 Mojave Desert Spring Survey Inyo, Kern, San Bernardino and Los Angeles Counties, California. Prepared for Transition Habitat Conservancy, The Bureau of Land Management, The Nature Conservancy. November 11, 2016.

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About Cardno

Cardno is an ASX-200 professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage, and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

Cardno Zero Harm

At Cardno, our primary concern is to develop and maintain safe and healthy conditions for anyone involved at our project worksites. We require full compliance with our Health and Safety Policy Manual and established work procedures and expect the same protocol from our subcontractors. We are committed to achieving our Zero Harm goal by continually improving our safety systems, education, and vigilance at the workplace and in the field. Safety is a Cardno core value and through strong leadership and active employee participation, we seek to implement and reinforce these leading actions on every job, every day.

aquilogic, Inc.
environment • water • strategy

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February 20, 2020

Matthew H. Litchfield, P.E.
General Manager
Three Valleys Municipal Water District
1021 E. Miramar Avenue
Claremont, CA 91711-2052

sent via email to:
mlitchfield@tvmwd.com

Re.: Proposal to Conduct a Study Program to Evaluate the Hydrologic Connection Between Bonanza Spring and the Alluvial Aquifer in Fenner Valley

Dear Mr. Litchfield:

Aquilogic is pleased to provide this proposal to Three Valleys Municipal Water District (Three Valleys) to conduct a study program to evaluate the hydrologic connection between Bonanza Spring and the Alluvial Aquifer in Fenner Valley (the Bonanza Spring Study).

On June 11, 2019, **aquilogic** submitted a proposal to implement certain recommendations contained within the Report of the Independent Peer Review Panel for the Groundwater Management, Monitoring, and Mitigation Plan (GMMMP) for the Cadiz Project. The June 2019 proposal provided a preliminary scope and budget for the entire Bonanza Spring Study. However, the proposal recommended that the Board of Three Valleys only approve the cooperative development of a Scoping Plan for the Bonanza Spring Study. A scope and budget for Scoping Plan preparation was provided in the June 2019 proposal and, on July 19, 2019, Three Valley authorized **aquilogic** to develop the Scoping Plan. Scoping Plan development has included the following:

- Building a team to prepare the Scoping Plan and implement the Bonanza Spring Study
- Holding a technical workshop with project stakeholders to develop the scope
- Convening an expert peer review panel to review the study program results
- Identifying permit requirements with the US Department of Interior, Bureau of Land Management (BLM) and County of San Bernardino
- Preparing the Scoping Plan document

These steps have been completed, and an initial draft Scoping Plan was provided to Three Valleys staff on January 7, 2020. We did receive some comments from several members of the Study Program Team and expert peer review panel. These have been addressed in an updated draft of the Scoping Plan (accompanying this proposal).

At this time, we are requesting that the Board of Three Valleys approve either: (1) the Bonanza Spring Study field program (Phase II), or (2) the field program (Phase II) and the data analyses and reporting (Phase III). An overall schedule and budget for the Bonanza Spring Study is provided in this proposal. However, the field program will be implemented in the following steps:

1. Geophysical (Task II.1) and hydrological (Task II.2) investigation
2. Hydrogeological (Task II.3) and ecological (Task II.4) investigation
3. Aquifer testing (Task II.3) and geochemical i(Task II.5) investigation

The scope of the field program (Phase II) is included in the updated draft Scoping Plan. However, it is recognized that some minor adjustments in scope for each step will be refined based on findings from prior steps. These adjustments can be accommodated within the contingency amount for each phase.

Phases II and III Bonanza Spring Study

As noted, the updated draft Scoping Plan provides the scope and schedule for the overall Bonanza Spring Study. The preliminary budget for the overall study provided in the June 2019 proposal has been updated below:

#	Phase/Task	Start	End	Budget	Remaining
I	**Phase I: Study Plan Preparation**	Jul-19	Jan-20	**$197,628**	$90,733
II	**Phase II: Field Program**				
II.1	Geophysical Investigation	Mar-20	Apr-20	$140,000	
II.2	Hydrological Investigation	Mar-20	Apr-20		
	Spring Monitoring	Mar-20	Mar-20	$35,000	
	Weather Station	Apr-20	Apr-20	$10,000	
II.3	Hydrogeological Investigation	Jun-20	Oct-20		
	Well Installation	Jun-20	Jul-20	$120,000	
	Aquifer Testing	Sep-20	Oct-20	$60,000	
II.4	Ecological Investigation	Jun-20	Dec-20	$45,000	
II.5	Geochemical Investigation	Sep-20	Dec-20		
	Surface Water Sampling	Sep-20	Dec-20	$20,000	
	Groundwater Sampling	Sep-20	Dec-20	$35,000	
	Phase II Sub-Total			**$465,000**	
	15% contingency			$69,750	
	Phase II Total			**$534,750**	
III	**Phase III: Data Analyses and Reporting**				
III.1	Updated Groundwater Flow Modeling	Jul-20	Jan-21	$70,000	
III.2	Data Analyses	Jul-20	Dec-20	$55,000	
III.3	Final Report	Dec-20	Feb-21	$40,000	
III.4	Board Presentation/Workshop	Feb-21	Mar-21	$40,000	

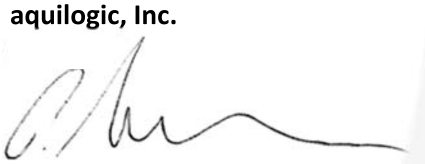
III.5	Alternative Mitigation Actions	Jan-21	Mar-21	$30,000
	Phase III Sub-Total			**$235,000**
	15% Contingency			$35,250
	Phase III Total			**$270,250**
	TOTAL (Phase II and III)			**$805,000**
	TOTAL (All Phases)			**$1,002,625**

All work will be billed on a time and materials basis according to the attached fee schedule, up to the total amount specified. It is understood that work on a particular task can exceed the budgeted amount. However, should supplemental budget be required to complete the entire scope, a change order will be provided for your approval. No such supplemental or additional work will be performed without prior authorization to proceed from the Client. Should you request that additional or supplemental work be performed, we will invoice you for this work on a time and materials basis. However, we will confirm your request via email prior to starting on such work.

Closing

We appreciate the opportunity to submit this proposal to Three Valleys. Should you have any questions, please do not hesitate to contact me at (949) 939-7160.

Sincerely,
aquilogic, Inc.



Anthony Brown
CEO and Principal Hydrologist

Encl. Fee Schedule
Updated Draft Scoping Plan

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environment ● water ● strategy

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2020 SCHEDULE OF FEES: CONSULTING SERVICES FOR PREFERRED CLIENTS

1. Technical Services

Technical Services performed by personnel of **aquilogic** for hours actually spent on project activity, including office, field and travel time, will be charged as follows (in U.S. Dollars):

Professional Personnel*		**Support Personnel**	
Corporate Executive	$400	Administrative Manager	$125
(Business) Principal-in-Charge	$320	Project Accountant	$110
(Technical) Principal Scientist/Engineer	$270	Project Assistant	$90
Senior Manager	$250	Senior Designer	$125
Project Manager	$220	Design Draftsperson	$105
Senior Technical	$220	Intern	$75
Project Technical	$170	Field Services Manager	$125
Staff Technical	$125	Field Technician	$85

*Includes all engineers, scientists and all other project professionals

Unless otherwise agreed to in writing, time will be billed in half hour increments.

All overtime (hourly or non-exempt support staff) will be billed at 1.25 times the above rates. Night, weekend or holiday work requested by the client (all staff) will be billed at 1.25 times the above rates. Specialist services (e.g. consulting boards, advisory panels or similar specialist consultation, declarations, deposition and trial preparation) will be billed at 1.5 times the above rates (with a four-hour minimum). Deposition and trial testimony will be billed at 2 times the above rates (with an eight-hour minimum).

This fee schedule is effective for the calendar year indicated at the top of this page. Should work extend beyond the calendar year into a subsequent year, then the hourly fees reflected hereon shall escalate at four percent (4%) on January 1 of that subsequent year, and four (4%) on January 1 of any subsequent year thereafter, unless an entirely new fee schedule is negotiated for any subsequent year.

2. Subsistence and Expenses

Living and travel expenses incurred by personnel of **aquilogic** associated with a project will be charged at cost plus twelve percent (12%). A fixed per diem can be negotiated for specific projects. All airline travel exceeding five hours airport gate to gate (on the most direct route) will be in business class.

3. Materials, Subcontracts, and Equipment Rental

Direct material, equipment, outside services, and other expenses contracted or incurred by **aquilogic** on behalf of a project will be charged at cost plus twelve percent (12%). These disbursements include but are not limited to: Field Equipment (e.g. field vehicles, etc.); subcontractor Services (e.g. laboratory analyses, etc.); materials and supplies (e.g. Sampling supplies, etc.); and other expenses (e.g. work permits, bonds, etc.). Postage, non-overnight shipping, telephone (office and cellular), office computing, facsimile, photocopying (excluding color), and miscellaneous office supplies will be billed as an administrative fee of four percent (4%) of project personnel billings.

4. Billings

Statements normally will be issued monthly, or at the completion of the project, and are payable upon receipt, unless otherwise agreed in writing by **aquilogic**. Interest, at the rate of one percent (1%) per month, not to exceed the maximum rate allowed by law, will be payable on any amounts not paid within thirty (30) days; payment thereafter to be applied first to accrued interest and then to the principal unpaid amount. Unless otherwise specified in other contract documents or project proposal, all work on a project will cease should any invoice remain unpaid 60 days after the invoice has been submitted to the client. Work will not recommence until the account has been made current; that is, all outstanding invoices (including accrued interest) have been paid.

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For projects where **aquilogic** experts are offering testimony at deposition, trial, and/or part of an administrative hearing, all outstanding invoices must be paid prior to such testimony.

5. Indemnity

aquilogic shall indemnify, defend and hold Client harmless from and against all claims, liabilities, suits, loss, cost, expense and damages for injury to or death of persons or damage to or destruction of property arising in connection with and to the extent of Consultant's negligence in the performance of the Services under this Agreement.

6. Warranty

aquilogic warrants that the Services shall be performed in accordance with the standards customarily provided by an experienced and competent professional engineering organization performing the same or similar Services. Consultant shall re-perform at its own expense any of said Services which were not performed in accordance with this standard, provided that Consultant is notified in writing of the nonconformity within twelve (12) months after the performance of the deficient Services, and provided further that the cost to Consultant of such remedial Services shall not exceed the amount paid to Consultant under this Agreement. The foregoing are Consultant's entire responsibilities and Client's exclusive remedies for Services performed or to be performed hereunder, and no other warranties, guarantees, liabilities or obligations are to be implied.

7. Consequential Damages

In no event shall **aquilogic** or its sub-consultants/sub-contractors or vendors of any tier be liable in contract, tort, strict liability, warranty, or otherwise for any special, indirect, incidental or consequential damages such as but not limited to loss of product, loss of use, non-operation or increased costs of operation of equipment or systems, loss of anticipated profits or revenue, costs of capital, or cost of purchased or replacement equipment or systems.

8. Limitation of Liability

In no event shall the total aggregate liability of **aquilogic** exceed the amount paid by Client for the Services performed.

9. Disputes

Any disputes between the Parties which arise out of this Agreement which cannot be settled amicably by the Parties shall be submitted to and settled under the arbitration rules of the American Arbitration Association with proceedings in Los Angeles, California. Such disputes shall be governed in accordance with the laws of the state of California, U.S.A.

10. Confidentiality

aquilogic and the Client agree to keep confidential all Information supplied by others and not to utilize, either directly or indirectly, any information for any purpose other than related to Services being performed, or to disclose it to anyone, including partners and affiliated companies, except on a "need to know" basis, without prior written consent from the party providing said confidential information. If required, **aquilogic** and the Client shall execute a non-disclosure or confidentiality agreement (NDA) that further defines the provision, use and disclosure of confidential information.

11. Termination

Client may at any time, by fifteen (15) days written notice to **aquilogic**, terminate all or any part of the unperformed Services under this Agreement. In such event, **aquilogic** shall be compensated for Services performed to the effective date of termination, plus the reasonable costs of demobilization and settlement of subcontracts, purchase orders, and other commitments incurred by **aquilogic** for performance of the Services.

12. Entire Agreement

In the absence of any other executed agreement, this schedule of fees and accompanying proposal constitute the entire agreement between the Client and **aquilogic** for the Services to be performed. No modification shall be effective unless it is in writing and executed by both Parties. This Agreement supersedes any and all other agreements between the Parties, whether written or oral, with respect to the subject matter hereof.