Surface Water Mitigation Plan

401 Certification ADEQ LTF No. 55425

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Prepared by:

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Monitoring and Reporting Schedule

Task Schedule	Purpose/Description/ Timing	Generic Year				
		C	Q	R	S	A
Collect precipitation samples	After rain event			X		
Collect stormwater samples	After rain event			X		
Spring monitoring	Surface water/groundwater interactions				X	
Record groundwater level on data logger	Pressure transducers	X				
Record temperature data on data logger	Temperature probes	X				
Collect groundwater samples	Water level measurement at each sampling event		X			
Download data from data logger	Inspect station during download		X			
Geomorphic monitoring (including pebble counts/gradation and vegetation monitoring)	Annually after monsoon season (every year for 5 years and every 5th year thereafter)					X
Surface Water Model	Update and run model, define and implement mitigation as needed					X
Reporting (data summaries)	To ADEQ		X			
Reporting (data and analysis)	To ADEQ					X

C = Continuously (pressure transducers); Q = Quarterly; R = As needed;
S = Semi-annually; A = Annually

Revision Log

Revision Number	***Revision Lead***	***Purpose of Revision***	***Revision Date***

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1.0 PLAN OBJECTIVE AND DESCRIPTION

This Surface Water Mitigation Plan (Plan) was prepared by Rosemont Copper Company (Rosemont) as a requirement of the 401 Certification to be issued by the Arizona Department of Environmental Quality (ADEQ) for the Rosemont Copper Project (Project). The need for a Plan prior to issuance of the 401 Certification was raised during public comment. Rosemont's draft 401 Certification for review was issued on February 21, 2014.

Rosemont anticipates no degradation to downstream water quality (compared to current water quality) due to Project construction, operation, and/or closure activities. Additionally, no degradation is anticipated to the water quality in the Outstanding Arizona Water (OAW) segment of Davidson Canyon Wash. This assessment is based on:

- Implementation of Best Available Demonstrated Control Technology (BADCT) design for the Project facilities and best management practices;
- Extensive stormwater management and erosion prevention controls, including pollution prevention and control measures;
- Development of a surface water model. To the extent that downstream water quality may be affected by water quantity changes, the model will serve as a predictive tool to quantify potential changes in surface water runoff from the Project site based on staged development. The model will correspondingly used as a tool to estimate runoff replacement quantities from off-site mitigation locations;
- Geochemical evaluations of waste rock;
- Numerous monitoring programs that will allow evaluation of trends in water quality and water quantity within the Davidson Canyon watershed, including monitoring that will specifically inform the surface water model; and
- A distance of about 12-miles between the downstream toe of the Project and the OAW segment of Davidson Canyon Wash.

1.1 PLAN OBJECTIVE

The objectives of this Surface Water Mitigation Plan are to:

- Provide details on the development and use of the surface water model planned for the Project site;
- Propose and describe mitigative measures that could be employed to offset and/or replace Project-related reductions in stormwater flow volume (per the surface water model) and sediment to Davidson Canyon Wash, should it occur;
- Ensure that any water used to mitigate (offset and/or replace) reduced stormwater flow volume meets applicable Arizona surface water quality standards; and
- Present and describe the various monitoring programs that will be conducted by Rosemont throughout the life of the Project that will be used to evaluate water quality and quantity as well as monitoring downstream resources.

The monitoring described in this Plan will be conducted during the pre-construction, construction, operational, and closure phases of the Project and this data will be used to develop and maintain the surface water model and also to monitor overall watershed conditions. Conditions in the watershed could change based on a variety of reasons such as potential impacts from the Project, natural climatic fluctuations, increased development in the area, and/or other non-Project related activities.

In addition to the Surface Water Mitigation Plan described herein, Rosemont has developed other plans, such as stormwater management plans, a spill prevention control and countermeasure plan, and various other water monitoring plans, specified by either ADEQ or the U.S. Forest Service (USFS), in order to monitor water resources in the Project area. Water resources include groundwater, stormwater, and springs. Appendix B of the Final Environmental Impact Statement (FEIS; USFS, 2013a) and draft Record of Decision (ROD; USFS, 2013b) lists the various mitigation and monitoring measures required by the USFS and by other agencies.

The monitoring programs described in this Plan will generate extensive data regarding stormwater and stream water quality, water quantity, stream erosion, groundwater/surface water interactions, and other related concerns. For example, Mitigation Measure FS-SR-05 requires monitoring of sediment transport in Barrel Canyon. Mitigation Measure FS-SSR-02 requires monitoring of springs that will yield data relevant to water quality. Mitigation Measure FS-BR-22 requires monitoring of stormwater and groundwater in Barrel and Davidson Canyon washes. Monitoring of vegetation (field inventory and description of existing conditions) in Barrel and Davidson Canyon will also be conducted. These specific plans are described and included herein for reference as they provide the majority of data gathering activities located down-gradient of the Project site. These and other plans specific to the USFS will require review by that agency prior to finalization. Any changes made to these USFS plans will be reviewed with ADEQ.

1.2 PLAN DESCRIPTION

This Surface Water Mitigation Plan includes the following components:

- General monitoring of stormwater, streamflow, springs, groundwater, precipitation, and stream geomorphology, including review and evaluation of this monitoring data;
- Monitoring and operational planning specifically related to the surface water model, including review and analysis of model inputs and results;
- Mitigation implementation; and
- Reporting.

Sections 1.2.1 through 1.2.5 provide a brief description of the components associated with this Plan while Sections 2.0 through 9.0 provide details. Section 10.0 provides a list of references.

1.2.1 General Monitoring Component

Although no monitoring is required under the 401 Certification to maintain compliance, Rosemont proposes to provide ADEQ with the results and analyses from various stormwater, groundwater, spring, geomorphology, and precipitation monitoring programs conducted under other agency requirements. Monitoring will provide both ADEQ and Rosemont with a better understanding of the normal variation of an ephemeral fluvial system, including changes in flow, sediment load/deposition, and water quality, and overall watershed conditions. The general monitoring program will only be used to monitor watershed conditions and to use that data to understand and monitor trends in the system. Section 2.0 of this Plan provides details on the general monitoring plan and the data that will be gathered. Section 3.0 provides a description of how that data will be presented.

In general, groundwater, stormwater, spring, and precipitation monitoring were initiated by Rosemont in 2006 to define pre-mining, or baseline, conditions. Additional monitoring locations have been added throughout the years and will continue to be added as required by the USFS and other agencies. Stormwater monitoring described in this Plan will consist of stormwater sampling and analysis and stream stage and discharge measurements in the ephemeral washes. Geomorphological (stream channel) and vegetation monitoring will also be performed. The geomorphological monitoring data will be used to evaluate ephemeral stream channel stability, sediment loading/deposition, and scour within the channels (Lower Barrel Canyon and Davidson Canyon). Vegetation monitoring data will determine if the existing vegetation shows symptoms of stress.

Monitoring discussed in this Plan is separated into two phases: Phase 1 and Phase 2.

- Phase 1 monitoring includes the time period from 2006 to the present and to the point when Project construction activities begin to affect stormwater flow and drainage. The installation of additional monitoring stations/locations (see Section 2.2.2 of this Plan) is assumed phased in during this period and is based on Rights of Way from the Arizona State Land Department (ASLD). This time period covers the baseline monitoring that was initiated in 2006. As a note, any trends, water quality changes, or other anomalies observed in the Phase 1 data are understood to be due to natural variations or other activities not associated with the Project; and
- Phase 2 monitoring will begin when major construction activities occur at the Project site, i.e., when larger-scale stormwater impoundments are constructed at the Project site and used to contain stormwater. Phase 2 monitoring will include that data collected during construction, operation, and closure phases. Additional monitoring stations/locations will have been installed prior to the beginning of this period or, again depending upon access by ASLD, during the first six (6) months of this period. Trends, water quality changes and anomalies observed in the Phase 2 monitoring will be evaluated to determine the potential cause(s). The Project will be monitored and required to maintain compliance with the permits as issued; however, the monitoring program can also be used to evaluate changes in the watershed that may not be associated with the Project.

Monitoring will be conducted from pre-mining through construction, operation, and closure. There will be no cessation or gaps of monitoring between Phase 1 and Phase 2. Only the designation of the monitoring phase will change. All water quality sampling, water level measurements, spring flow measurements, and other monitoring activities conducted for the USFS, ADEQ, and other regulatory agencies will be in accordance with the Rosemont's Water Programs Quality Assurance Project Plan (QAPP).

1.2.2 General Data Review and Evaluation Component

As monitoring data is obtained and compiled, Rosemont will review the analytical data for validity and representativeness, and evaluate the results for variations, trends, anomalies, etc. Review and evaluation of the data are discussed in Section 3.0 of this Plan.

1.2.3 Site Specific Data Review and Modeling Component

Section 4.0 of this Plan describes the surface water model to be developed for the Project. Monitoring data to be used in the development and maintenance of the model is also summarized in Section 4.0. A portion of the general monitoring data will be used as inputs to the surface water model. Additional data gathering requirements specific to the model are also specified.

1.2.4 Mitigation Component

The model will be used to quantify Project related changes in stormwater flow to Davison Canyon and then proactively mitigate or offset those changes, as needed. Potential storm water quantity mitigation approaches are described in Section 5.0. Section 5.0 also includes a discussion on offsetting changes to stormwater and to sediment loading from the Project site.

1.2.5 Schedule

Section 6.0 provides a schedule for the development of the surface water model.

1.2.6 Reporting Component

Data summaries will be prepared quarterly and provided to ADEQ as they are required for submittal to the Forest Service. The quarterly data will provide only the latest monitoring data generated during that period. Additionally, an Annual Summary Report will be prepared for ADEQ that provides current quarterly data along with the entire previous years' data. The annual report will also include analyses, statistical calculations, and updates summarizing any mitigation activities. Details on this report are provided in Section 7.0.

2.0 GENERAL MONITORING

2.1 PHASE 1 MONITORING

Phase 1 monitoring began on a voluntary basis by Rosemont in 2006 and will continue until major construction of the Project begins (i.e., start of Phase 2 monitoring). In addition to the continuation of the voluntary monitoring elements, certain portions of the monitoring required by the USFS and other regulatory agencies will be initiated during Phase 1. Data from the following monitoring programs will be provided to ADEQ in support of this Surface Water Mitigation Plan:

- Baseline stormwater quality data collected under Rosemont's voluntary Baseline Stormwater Sampling Program. This monitoring was initiated in 2010 and initially consisted of collecting stormwater samples at eight (8) Nalgene sampler locations in the ephemeral washes located within and outside of the Project footprint (see Figure 1). Two (2) automated monitoring stations, described in the third bullet, were added to this monitoring program in December 2012;
- Stormwater monitoring under the AZPDES MSGP. Stormwater monitoring under the AZPDES MSGP was implemented in conjunction with the Phase 1 Drilling Program. Baseline stormwater monitoring, as described above, will be occurring simultaneously;
- Surface water/groundwater monitoring under USFS Mitigation Measure FS-BR-22. Currently, there are two (2) automated surface water/groundwater monitoring stations (one in Barrel Canyon Wash and one in Davidson Canyon Wash) as shown on Figure 1. Monitoring parameters at these stations include: stream stage and discharge; stormwater quality; precipitation; shallow subsurface soil moisture, temperature, and conductivity; and groundwater quality and groundwater levels of bedrock and alluvial aquifers in Barrel and Davidson Canyon washes. Monitoring plans for these surface water/groundwater monitoring stations were previously reviewed by ADEQ and are provided in Appendix A of this Plan. The list of stormwater monitoring parameters initially proposed in the Water & Earth Technologies, Inc. (WET) 2012 *Davidson Canyon Conceptual Surface-Water Monitoring Plan* (provided in Appendix A) has been modified; the actual analyte list currently used for the baseline stormwater samples is listed below in Section 2.1.1. Mitigation Measure FS-BR-22 includes monitoring of these two (2) stations as well as several others, as practicable, in Barrel and Davidson Canyon washes, and in Cienega Creek. Appendix B provides a draft monitoring plan associated with Mitigation Measure FS-BR-22;
- Streamflow monitoring at United States Geological Survey (USGS) Gaging Station No. 09484580 in Barrel Canyon, just west of State Route 83 (SR 83);
- Stormwater and precipitation monitoring in unaffected washes. Rosemont proposes to install two (2) automated stormwater monitoring stations in the ephemeral washes (McCleary and Scholefield Canyons) located outside the Project footprint. These washes will not be directly affected by Project operations. Depending on location, installation of these stations will be subject Federal approval; and
- Spring monitoring of 25 springs and seeps in the vicinity of the Project under USFS Mitigation Measure FS-SSR-02. Under this monitoring program, Rosemont will monitor a suite of 25 springs and seeps, as shown on Figure 2, for presence/absence of water, and flow measurements, if possible, on a semi-annual basis.

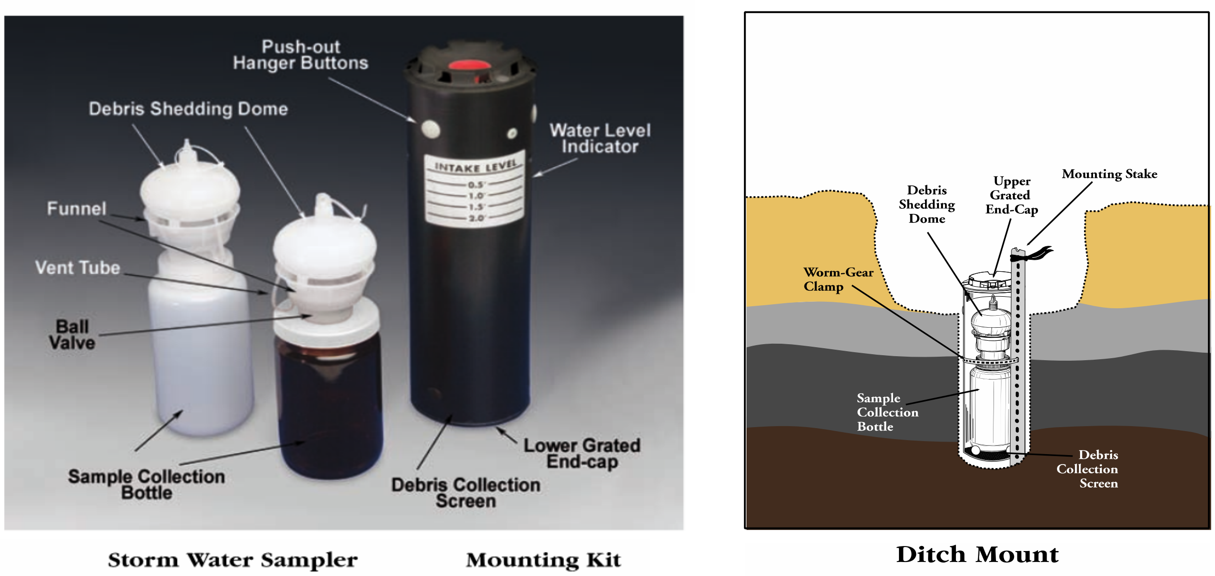
2.1.1 Baseline Stormwater Monitoring

Baseline (pre-mining) monitoring for stormwater quality in various on-site drainages was initiated in January 2010 and will continue into the initial stages of Project construction. There are currently ten (10) stormwater sampling locations (stations). These ten (10) stations consist of eight (8) locations where stormwater is collected using Nalgene sampler systems and two (2) locations where automated surface water/groundwater monitoring stations have been constructed. The ten (10) locations are either within the disturbance boundary of the Project or monitor washes that are likely to drain stormwater from the disturbance area.

Since inception of the voluntary Baseline Stormwater Monitoring Program, there have not been any significant site activities, only exploratory drilling and reclamation test plot construction. Therefore, the data collected to date characterize the quality of stormwater in the washes as baseline, or pre-mining, conditions.

Illustration 1 below is a picture of a typical first-flush Nalgene sampler used at eight (8) of the ten (10) current stormwater sampling locations. Section 6.3 of the Rosemont Copper Project Stormwater Pollution Prevention Plan (SWPPP) for the Arizona Pollutant Discharge Elimination System (AZPDES) General Permit for Stormwater Discharges Associated with Industrial Activity – Mineral Industry (AZMSG2010-003 [MSGP-2010]) describes the installation of the samplers and stormwater quality sample collection procedures. The other two (2) stormwater sampling points are located at the automated surface water/groundwater monitoring stations (described below in Section 2.1.2.

Illustration 1. Nalgene Sampler and Installation



The eight (8) monitoring locations that employ Nalgene stormwater mounting kits are located in the following washes:

- PSW-1, located in Upper Barrel Canyon Wash
- PSW-2, located in Wasp Canyon Wash
- PSW-3, located at Rosemont Junction, in Barrel Canyon Wash
- PSW-4, located in McCleary Canyon Wash

- PSW-5, located in Lower Barrel Canyon Wash
- PSW-6, located in Scholefield Canyon Wash
- PSW-7, located in Lower Barrel Canyon Wash at the USGS Gage, just upstream of SR 83
- PSW-8, located in Trail Creek

The two (2) automated monitoring stations were installed in December 2012 and are located in:

- Lower Barrel Canyon Wash, just upstream of SR 83 (BC-2); and
- Davidson Canyon Wash, downstream of the confluence with Barrel Canyon (DC-3).

Stormwater quality samples collected under the voluntary Baseline Stormwater Monitoring Program are submitted for the following parameters (as sample volumes allow):

Indicator Parameters and Major Ions	Total Metals	Dissolved Metals
pH – lab	Antimony	Arsenic
Specific conductance – lab	Arsenic	Cadmium
Temperature - lab	Barium	Chromium VI [2]
Total dissolved solids (TDS)	Beryllium	Copper
Total suspended solids (TSS)	Boron	Iron
Turbidity	Cadmium	Lead
Total alkalinity	Chromium, total [1]	Mercury
Carbonate	Copper	Nickel
Bicarbonate	Iron	Silver
Hydroxide	Lead	Zinc
Hardness	Manganese	
Chloride	Mercury	
Fluoride	Molybdenum	
Sulfate	Nickel	
Calcium	Selenium	
Magnesium	Silver	
Potassium	Thallium	
Sodium	Uranium	
Nitrate (as N)	Zinc	
Nitrate + Nitrite (as N)		
Total Nitrogen (calculation)		
Total Kjeldahl nitrogen (TKN)		

[1] – Analysis will be for Total Chromium, not Chromium III or Chromium VI.
[2] – Analysis will be for Chromium VI, the most stringent standard for chromium.

As practicable, Rosemont will continue collecting baseline stormwater quality samples on the Project site through completion of construction; however, as construction proceeds some of the sampling sites may need to be eliminated or relocated. Stormwater monitoring was also implemented under the AZPDES MSGP as associated with the Phase 1 Drilling Program. Stormwater monitoring sites will be located so that the requirements of the MSGP program are met. Stormwater samples collected under the AZPDES MSGP will be submitted for the parameters listed in Table 8.G-8.2 in the MSGP and in Section 2.2.1 of this Plan.

2.1.2 Surface Water/Groundwater Monitoring Under FS-BR-22

In December 2013, Rosemont installed two (2) surface water/groundwater monitoring stations. One of the monitoring stations (BC-2) is located approximately 1,600 feet upstream of the USGS gaging station (No. 09484580) in Barrel Canyon Wash. The other station (DC-3) is located approximately four (4) miles downstream of BC-2 in Davidson Canyon Wash. Figure 1 shows the locations of the two (2) existing monitoring stations. Both stations have co-located groundwater wells and surface water data collection systems for the purpose of evaluating potential surface water/groundwater interactions as well as to assist in the determination of hydrologic systems analysis, runoff, groundwater infiltration, effects of localized precipitation, soil moistures, and stormwater quality.

Each of the existing surface water/groundwater monitoring stations is equipped to monitor the following:

- Groundwater levels and water quality in the shallow, alluvial sediments (shallow well);
- Groundwater levels and water quality in the deeper, bedrock aquifer (deep well);
- Groundwater temperature, in both the shallow and deep water zones;
- Soil moisture at different depths, ranging from 1 to 6 feet beneath the wash channel;
- Soil temperature and conductivity at different depths in the wash channel;
- Stream level (stage);
- Stream discharge (in cubic feet per second);
- 15-minute and cumulative precipitation measurements; and
- Precipitation water quality (specifically stable isotopes).

Each monitoring station consists of two (2) groundwater wells (one shallow, one deep), three (3) to four (4) soil temperature probes, a standpipe housing, an instrumentation enclosure, and a foundation block at wash level. Each of the two (2) wells has a pressure transducer installed to monitor groundwater levels. A third pressure transducer is installed in a perforated pipe just below the surface of the wash to monitor the stream level. A data collection unit (DCU), located in a standpipe canister, is programmed to sample, store, and transmit all sensor data via a commercial satellite. Data are downloaded from the satellite data provider and stored in a database, which can be viewed over the internet. The DCU also activates a pump sampler when a stream level exceeding the trigger elevation is detected and confirmed by a float switch. The stormwater sampler is programmed to collect a 1-liter water sample every 5 minutes while the level in the stream is above the float switch activation level.

Precipitation is currently measured at four (4) stations: the USGS gaging station (No. 09484580) at SR 83 at Barrel Canyon; the Rosemont weather station located in the Open Pit area; and the two (2) surface water/groundwater monitoring stations discussed above (see Figure 3). Precipitation measurement stations are located at least one (1) mile from each other to quantify the spatial variability throughout the watershed. Additionally, the two (2) surface water/groundwater monitoring stations described above in Section 2.1.1 are equipped with precipitation collectors. The weather station located in the Open Pit area also has a precipitation collector and rain gage. Precipitation water samples are submitted to the University of Arizona laboratory for stable hydrogen/oxygen isotope analysis.

2.1.3 Streamflow Monitoring at USGS Gaging Station for Barrel Wash

As part of the most recent agreement between Rosemont and the USFS, and described in USFS Mitigation Measure RC-SW-01, Rosemont is required to fund the maintenance of the USGS gaging station (No. 09484580) through construction and operation and for at least five (5) years after operations cease. This agreement ensures that monitoring for streamflow will continue throughout the life of the Project.

The description of the USGS gage is:

- Latitude 31°51’42”N, Longitude 110°41’26”W, NAD27
- Pima County, Arizona
- Hydrologic Unit 15050302
- Drainage Area: 14.2 square miles
- Datum of the gage: 4,264 feet above NGVD29

The data available for the USGS gage includes:

- Current/historical observations from 23Jan2009 through present
- Daily discharge data in cubic feet per second (cfs) from 23Jan2009 to present
- Daily discharge statistics, in cfs from 23Jan2009 to present
- Monthly discharge statistics, in cfs from Jan2009 to present (prior month)
- Annual discharge statistics, in cfs from 2009 to present
- Peak streamflow, 1962 through 9Sept2013 (19 values available)
- Field measurements, 22Jan2010 through 11Sept2012 (7 visits)
- Annual water-data reports, 2010 through 2013 (see Appendix C for 2013 report)
- Precipitation data, data is stored only for 120 days by USGS

This USGS gaging station will play a key role in determining what, if any, potential mitigation measures will be implemented as part of this Plan. Along with other site specific monitoring data, the surface water model to be developed for the Project site will incorporate actual storm flow monitoring data recorded at this station as a basis of evaluating potential Project related impacts.

The previous estimate of average-annual runoff from the site was based on estimated or extrapolated values presented in a previously-developed hydrologic model (Tetra Tech, 2011). Rosemont understands that the average-annual runoff estimated by this model indicated an average-annual runoff of 1,407 acre-feet for the Barrel Canyon watershed at the USGS gaging station; however, no such average annual runoff has been measured since installation of the USGS gaging station on Barrel Canyon Wash at State Route 83. Total streamflow recorded by the USGS gaging station from 2010 to 2013 ranged from 41 acre-feet (0.058 cfs) to 185 acre-feet (0.26 cfs; see Appendix D).

2.1.4 Stormwater Monitoring for Unaffected Washes

As stormwater passes the measuring point at the USGS gaging station (No. 09484580), the aggregated flows at this point are made up of five (5) tributary drainages that all report to the SR 83 bridge along Lower Barrel Canyon:

- Upper Barrel Canyon Wash
- Wasp Canyon
- McCleary Canyon
- Scholefield Canyon

- “Trail Creek” (named for the Arizona Trail that currently passes through and along the drainage. The Arizona Trail will be moved out of Trail Creek as part of Project construction activities.)

While runoff from Upper Barrel Canyon Wash, Wasp Canyon Wash, and a portion of “Trail Creek”, will be affected by Project operations, McCleary Canyon Wash and Scholefield Wash are outside of the Project footprint, i.e., these drainages are considered unimpacted by Project activities.

At Rosemont’s request, Water and Earth Technologies (WET) recently prepared a plan to install two (2) surface water monitoring stations (one in McCleary Canyon Wash and one in Scholefield Canyon Wash) for the specific purpose of monitoring stormwater flows. WET’s proposal is provided in Appendix E. Depending on location, the installation of monitoring equipment in these drainages may require Federal permits.

2.1.5 Spring Monitoring

USFS Mitigation Measure FS-SSR-02 requires semi-annual monitoring of 25 springs/ seeps/ enhanced/constructed waters (springs) for presence/absence of water and measurement of flow, if possible. Rosemont has prepared a draft Plan (see Appendix F) to comply with this requirement. Rosemont has monitored 23 of the 25 springs for flow conditions since summer 2008. However, beginning in April 2014, all 25 springs have been monitored (see Figure 2).

2.1.6 Additional Stormwater Monitoring in Davidson Canyon

Other than the property that Rosemont already owns, such as the property on which the DC-3 automated station is located, legal access restrictions to other areas in and along Davidson Canyon Wash currently make monitoring baseline stormwater conditions impossible for Rosemont. Rosemont understands that baseline stormwater samples collected by other agencies (federal, state, or county) within the Davidson Canyon system may be made available to Rosemont for use in making the analysis required by this Plan.

Rosemont believes that due to the numerous activities that are on-going within Davidson Canyon drainage, i.e., vineyards, well drilling, septic systems, road crossings, agriculture uses, recreational uses of the washes as roads, and other residential household uses such as gardens, off-roading in the washes, maintenance of vehicles and houses, and other general rural land use, it will be necessary for ADEQ to take more than one (1) stormwater sample in Davidson Canyon. It is assumed that several sampling locations will be needed to monitor the tributary flows into Davidson Canyon to determine appropriate stormwater contaminant loading and assimilative capacities. There is no baseline that exists covering multiple tributary flows; however, as required by USFS Mitigation Measure FS-BR-22, Rosemont will install and maintain five (5) surface water/groundwater monitoring stations in Davidson Canyon Wash. If property access can be obtained, two (2) additional surface water/groundwater monitoring stations will be installed in Cienega Creek. One of the five (5) Davidson Canyon monitoring stations (DC-3) is already constructed and operating. Appendix A provides the WET report that selected and described the specific locations for the all of the surface water/groundwater monitoring stations. Note that field adjustments were made to the DC-3 and DC-4 stations as related to the WET (2012) report (see Figure 4 versus WET report in Appendix A). Although not in Davidson Canyon, the BC-1 monitoring location was also modified. Additionally, BC-1 is anticipated to be only a surface water monitoring station.

Rosemont is concerned that existing water quality data from the OAW segment of Davidson Canyon Wash consists of a limited suite of analysis - and no samples specifically related to stormwater. It is

Rosemont's anticipation that any baseline monitoring would include a suite of analytes similar to the suite in Section 2.1.1 prior to the initiation of Project construction.

2.2 PHASE 2 MONITORING

Within six (6) months of initiation of construction activities within the Project footprint, Phase 1 monitoring described will transition to Phase 2 monitoring. Construction will be defined by earthmoving activities rather than data gathering or mitigation work such as geotechnical drilling or archaeological mitigation. No gaps in monitoring will occur, only the designation of one phase (pre-construction) to another (construction/operations). In addition to continuing some of the monitoring described above in Section 2.1, Phase 2 monitoring will consist of the following components:

- Stormwater monitoring under the AZPDES MSGP. Stormwater monitoring under the AZPDES MSGP will continue. Additionally, baseline stormwater monitoring, as described above in Section 2.1.1, may be occurring simultaneously and will cease when each respective wash is disturbed due to Project construction. Additional discussion on this monitoring component is provided in Section 2.2.1;
- Continued monitoring at two (2) existing surface water/groundwater monitoring stations (one in Barrel Canyon Wash and one in Davidson Canyon Wash) under Mitigation Measure FS-BR-22 and as described in Section 2.1.2 and in Appendix B of this Plan;
- Additional surface water/groundwater monitoring as required under Mitigation Measure FS-BR-22. This will include construction of several other automated surface water and surface water/groundwater monitoring stations in Barrel and Davidson Canyon washes, and also in Cienega Creek depending upon property access. Monitoring parameters at these stations will include: stream stage and discharge; stormwater quality; precipitation; shallow subsurface soil moisture, temperature, and conductivity; groundwater quality and groundwater levels of bedrock and alluvial aquifers. Additional discussion on this monitoring component is provided in Section 2.2.2;
- Implementation of geomorphological monitoring under USFS Mitigation Measure FS-BR-22 at four (4) of the surface water/groundwater stations in Davidson Canyon Wash for channel stability, sedimentation, scour, and aggradation. Additional discussion on this monitoring component is provided in Section 2.2.3;
- Continued monitoring of streamflow at the USGS gaging station No. 09484580 in Barrel Canyon as described above in Section 2.1.3;
- Stormwater flow and water quality monitoring within McCleary and Scholefield Canyons as described in Section 2.1.4 (see Appendix E for proposal). These two (2) automated stormwater monitoring stations would measure precipitation and stream level, in addition to stormwater runoff;
- Continued semi-annual flow monitoring of 25 springs and seeps located downstream, but in the vicinity, of the Project area, as described above in Section 2.1.5 and as required by Mitigation Measure FS-SSR-02 (see Appendix F for plan);
- Implementation of sediment transport monitoring at two (2) locations in lower Barrel Canyon Wash to monitor stream channel stability, sediment deposition, and scour within the channel, as required by USFS Mitigation Measure FS-SR-05 (see Appendix G for plan). Additional discussion on this monitoring component is provided in Section 2.2.4. Monitoring under this program will begin prior to major site disturbance; and

- Addition of pebble counts and particle size analysis, and vegetation monitoring to the geomorphological monitoring requirements (FS-SR-05 and FS-BR-22) in Barrel and Davidson Canyon washes. Additional discussion on these monitoring components is provided in Sections 2.2.5 and 2.2.6, respectively.

2.2.1 MSGP Stormwater Monitoring

Upon implementation of the Phase 1 Drilling Program, Rosemont began stormwater monitoring under the AZPDES MSGP permit (AZMSG2010-003). Additional monitoring under Rosemont's voluntary Baseline Stormwater Monitoring Program also continues. The AZPDES MSGP stormwater monitoring and Rosemont's voluntary Baseline Stormwater Monitoring Program will overlap during the initial stages of construction. This will continue until such time that the individual drainages are disturbed and/or blocked off due to construction of stormwater impoundments within the Project area.

Outfall No. 1 (Sediment Control Structure No. 1) is proposed to be located in Lower Barrel Canyon Wash, just upstream of the confluence with McCleary Canyon Wash and just downstream from the northeast toe of the planned Dry Stack Tailings Facility. Outfall No. 2 (Sediment Control Structure No. 2) will be located south of Sediment Control Structure No. 1, at the upstream portion of Trail Creek, and downstream from the eastern edge of the planned Waste Rock Storage Area. Figure 5 shows the proposed locations of the two (2) AZPDES MSGP stormwater monitoring locations.

For the purposes of this Plan, Rosemont will evaluate the analytical results from the MSGP sampling to determine if changes or variabilities in those data can be correlated to sediment transport monitoring data, discussed below in Section 2.2.6. Data will also be evaluated to identify any water quality changes, possible cause(s) of the change, and any potential effects on assimilative capacities or pollutant loadings. Best stormwater management practices will be adjusted accordingly to ensure downstream water quality is not negatively affected.

Monitoring of the following analytical parameters is required under Permit AZMSG2010-003:

- Hardness (calculated from calcium and magnesium)
- pH
- Calcium
- Magnesium
- Antimony - analyzed as total recoverable (total)
- Arsenic - total
- Beryllium - total
- Cadmium - total and dissolved
- Copper - total and dissolved
- Iron - total and dissolved
- Lead - total and dissolved
- Mercury - total and dissolved
- Nickel - total and dissolved
- Selenium - total
- Silver - total and dissolved
- Zinc - total and dissolved

Because the receiving waters are ephemeral, monitoring of Total Suspended Solids (TSS) and Turbidity is not required under the MSGP. However, in an attempt to monitor suspended sediments in stormwater, TSS will be included as a monitoring parameter.

2.2.2 Additional Surface Water/Groundwater Monitoring Under FS-BR-22

Additional surface water and/or surface water/groundwater monitoring stations required under USFS Mitigation Measure FS-BR-22 will be constructed once property ownership/access issues and other factors are resolved. These monitoring stations will be equipped to monitor the same parameters as the existing two (2) stations currently monitored, and as listed above in Section 2.1.2.

In addition to a weather station, and excluding the installed stations BC-2 and DC-3, the original list of additional surface water/groundwater monitoring sites listed in FS-BR-22, contingent upon access agreements and restriction, included:

- BC-1 – to be located at the compliance point dam in Barrel Canyon;
- DC-1 – to be located in upper Davidson Canyon, below Questa Spring and above confluence with Barrel Canyon;
- DC-2 – to be located in Davidson Canyon, below the confluence with Barrel Canyon;
- DC-Dike – to be located in Davidson Canyon, near the hypothesized intrusive dike;
- DC-4 – to be located in Davidson Canyon, above the confluence with Cienega Creek, near downstream end of the OAW segment;
- CC-1 – to be located in Cienega Creek, upstream of the confluence with Davidson Canyon; and
- CC-2 – to be located in Cienega Creek, downstream of the confluence with Davidson Canyon.

The locations of the seven (7) additional surface water and surface water/groundwater monitoring stations, plus the existing two (2) stations, are shown on Figure 4. As noted in Section 2.1.6, the locations of BC-1, DC-3 and DC-4 have been modified from their original locations. Additionally, station BC-1 will only monitor surface water.

Each of the additional monitoring stations will be constructed to collect the same data as the existing surface water/groundwater monitoring stations (see Section 2.1.2).

2.2.3 Davidson Canyon Sediment Transport Monitoring

In addition to the surface water/groundwater monitoring, Mitigation Measure FS-BR-22 requires stream geomorphology monitoring at four (4) locations in Davidson Canyon Wash for channel stability, sedimentation, scour, and aggradation. These four locations will be established at specific points in Davidson Canyon Wash, ideally adjacent to or very near to the surface water/groundwater monitoring stations. Additional sediment monitoring locations can be added as needed.

Rosemont will conduct geomorphological monitoring (sediment transport and channel stability) at the established points every year for five (5) years. After five (5) consecutive annual geomorphological monitoring events, the frequency of geomorphological monitoring will be reduced to every fifth (5th) year as required in the Biological Opinion (BO) throughout the remaining operational and reclamation phases, plus one monitoring event in the closure phase of the Project, i.e., 5th year of closure. Monitoring will occur during the same month every monitoring event (for example, after the monsoon season in the October-November timeframe. The specific location across the wash will be selected following discussions with the USFS and ADEQ.

Rosemont has proposed using a ground-based LIDAR (Light Detection and Ranging) scanner to scan/map the stream channel at each of the Davidson Canyon Wash monitoring points/locations. The LIDAR scanner is an active remote sensing technology that uses light pulses to measure relative distance from the scanner, as well as other characteristics (texture, hardness, etc.) of terrain and objects. This generates a 3-dimensional point “cloud” of the area that also includes light intensities and RGB color values from a digital camera. (RGB stands for the three primary luminance or light colors: red, green and blue. Depending on the signal levels of each of these components, secondary colors, including black, white, or gray, can be produced on a viewing screen.)

It is anticipated that areas less than 100 feet x 100 feet will be scanned at each monitoring point, focusing on the stream channel. Details are included in Appendix B (Draft Barrel/Davidson Wash Monitoring Plan – FS-BR-22).

Geomorphological monitoring will be implemented once property access/right-of-way approvals are received and approval of methods and locations.

2.2.4 Barrel Canyon Sediment Transport Monitoring

Under USFS Mitigation Measure FS-SR-05, Rosemont will establish two (2) monitoring points/ locations in lower Barrel Canyon Wash to monitor and assess changes in stream geomorphology (see Appendix G for plan). The monitoring points/locations will be located as follows:

- Approximately 800 feet downstream of the proposed Sediment Control Structure No. 1; and
- Co-located with the BC-2 surface water/groundwater monitoring station – approximately 11,500 feet downstream of the proposed Sediment Control Structure No. 1.

Similar to the geomorphological monitoring in Davidson Canyon (Section 2.2.3), sediment transport monitoring in Barrel Canyon will be conducted initially every year for the first five (5) years. After five (5) consecutive annual monitoring events, the frequency of sediment transport monitoring will be reduced to once every fifth (5^{th}) year throughout the remaining operational and reclamation phases, plus one monitoring event in the closure phase, i.e., 5^{th} year of closure. The initial five (5) year annual monitoring period will begin in the pre-construction period.

2.2.5 Pebble Counts and Particle Analysis

In addition to the sediment transport measurements, Rosemont will perform pebble counts, particle size analysis, and field observations at the stream geomorphology monitoring points in Davidson and Barrel Canyons and at the same monitoring frequencies (see Section 2.2.3 and 2.2.4, respectively). The pebble count and particle analysis will be conducted in the same locations as the LIDAR survey.

Pebble counts and particle analyses will initially be conducted at the specific locations every year for five (5) years. After five (5) consecutive annual monitoring events, the frequency of pebble counts and particle analysis (as well as geomorphological monitoring) will be reduced to once every five (5) years throughout the remaining operational and reclamation phases, plus one event during the closure phase. Monitoring will occur during the same month every monitoring event.

2.2.6 Vegetation Monitoring

Rosemont proposes to conduct vegetation monitoring at the stream geomorphology monitoring locations in Davidson and Barrel Canyons and at the same monitoring frequencies (see Section 2.2.3 and 2.2.4, respectively). Vegetation monitoring will consist of a field assessment, consisting of descriptive and photographic documentation, of the existing vegetation at each monitoring point. Vegetation monitoring will document the volume, extensiveness, and overall health of the vegetation.

As a note, in previous field investigations, WestLand Resources assessed the riparian resources associated with the Project site and immediately downstream (WestLand, 2007; WestLand, 2010; WestLand, 2012). Most of the vegetation along Davidson Canyon wash currently consists of xeroriparian habitat. Estimates provided in Pima County mapping (that were used in development of the FEIS) were found to significantly overstate the riparian resources, average onsite measurements resulted in less than 40% of the anticipated riparian vegetation. This would result in an associated overstatement of impacts to a similar degree; therefore, Rosemont will use an actual measured baseline rather than the analysis in the FEIS.

3.0 GENERAL DATA REVIEW AND EVALUATION

The volume of data that will be collected and managed through the various monitoring programs described above will be quite substantial. As discussed above in Section 2.0, Rosemont will provide ADEQ with the following data on an on-going basis under this Surface Water Mitigation Plan:

- Precipitation volume;
- Streamflow stage, discharge, and peak;
- Stream channel stability, sedimentation, scour, and aggradation (geomorphology);
- Pebble count and particle analyses;
- Stable isotope analytical results for precipitation samples;
- Analytical results from stormwater quality samples;
- Shallow subsurface soil conductivity, temperature, and moisture;
- Shallow and bedrock aquifer water quality and water levels; and
- Spring flow conditions.

All field data collected through these monitoring programs, as well as all other monitoring programs conducted by Rosemont, will be entered into an electronic data management system.

Field data and laboratory analytical data will be reviewed upon receipt to ensure that the data are reliable, unbiased, accurate, and complete, and have full documentation. Personnel who have knowledge and expertise within the technical discipline of the specific monitoring activity will conduct a technical evaluation of the data within 90 days of receipt of data. The evaluation will consist of compiling and organizing the data; assessing potential trends and seasonal variability; and documenting findings. Graphs will be developed to illustrate any trends and outlier data points. Statistical tests may be used in combination with the graphs. Water quality data will be compared with applicable water quality standards.

Sections 3.1 through 3.3 provide a summary of some of the monitoring data collected at the Project site along with a brief analysis of that data.

3.1 RESULTS FROM CURRENT MONITORING DATA – STREAMFLOW

Streamflow data recorded in 2013 from the two (2) existing automated surface water/groundwater monitoring stations reveal 23 total days of measured streamflow in lower Barrel Canyon Wash compared to two (2) days of measured streamflow in Davidson Canyon Wash, just four (4) miles downstream (WET, 2014). This disparity is evidence of the huge volume of unsaturated fluvial sediments and assimilative capacity that exists in the ephemeral wash system between lower Barrel Canyon Wash and Davidson Canyon Wash just within four (4) miles. The conclusion that can be drawn from these data is that streamflow in lower Barrel Canyon Wash does not necessarily result in streamflow in Davidson Canyon Wash.

In addition to physical parameters, the surface water/groundwater monitoring stations also collect stormwater quality samples via an automated ISCO pump sampler system. Existing stormwater quality data (albeit limited) indicates that the quality of stormwater samples collected at the Davidson Canyon Wash station is similar to water quality in stormwater samples collected from the Barrel Canyon Wash station.

3.2 RESULTS FROM CURRENT DATA – STORMWATER QUALITY

Analysis of existing water quality data from the voluntary Baseline Stormwater Monitoring Program (discussed above in Section 2.1.1) indicate that existing water quality already exceeds the applicable surface water quality standard for lead. These concentrations could be an indication of impacts from leaded gasoline fuel used in vehicles for decades, lead bullets or shot from target shooting, or the inherent mineralization of the mining district within the national forest. Any or all of these may be having an effect on downstream surface water quality.

Removing or covering resources at the Project site will likely provide source control for various possible contaminants during construction and may very well improve downstream stormwater quality. In addition to this, the implementation of BADCT design for the Project facilities, best management practices, and the numerous monitoring programs, suggests no degradation to downstream water quality will occur due to Project construction, operation, and/or closure activities. Additionally, no degradation is anticipated to the water quality in the OAW segment of Davidson Canyon Wash due to Project construction, operation, and/or closure activities.

3.3 RESULTS FROM CURRENT DATA – PRECIPITATION

As mentioned above in Section 2.1.2, precipitation water samples are currently collected at three (3) stations on and downstream of the Project area: 1) the weather station located near the Open Pit; 2) the lower Barrel Canyon Wash automated surface water/groundwater monitoring station; and 3) the Davidson Canyon Wash automated surface water/groundwater monitoring station. Precipitation water samples are submitted to the University of Arizona laboratory for stable hydrogen/oxygen isotope analysis. Winter precipitation results range from -2.4/-4.0 ($^{18}O/^{2}H$) on January 25, 2013 to -13.2/-102.0 on January 28, 2013. Summer precipitation results range from -2.6/-31.0 on July 2, 2013 to -19.6/-149 on August 30, 2013. The only conclusion that can be made from the precipitation data is that there are more rainfall events (20 events) between July and September than there are between October and June (11 events).

4.0 SURFACE WATER MODEL

The development of a Surface Water Model (Model) is planned. As indicated in Section 1.0, this Model will be used as a predictive tool to quantify potential changes in surface water runoff from the Project site based on staged development. To the extent that these changes affect, or have the potential to affect, downstream water quality, ADEQ has requested mitigation for these changes.

In addition to serving as a tool to quantify potential flow reductions due to Project activities, the Model will be used to estimate runoff replacement quantities from off-site mitigation locations. Project effects will be based on existing and new monitoring points located throughout the watershed up-gradient of the USGS Gaging Station. The USGS station is located at the intersection of SR 83 and the Lower Barrel Canyon drainage.

Modeling will be performed with software such as KINEROS2 (a kinematic runoff and erosion model). This computerized distributive runoff model accommodates a spatial variation of rainfall, infiltration, runoff, and erosion parameters and can be used to determine the effects of development within a watershed such as the staged progression of the Rosemont Project.

Because of the variable nature of storms in the semi-arid environment encompassing Rosemont, the Model will need to be calibrated based upon the spatial and temporal distribution and intensity of recorded individual storm events before total yearly runoff volumes can reasonably be predicted. The outcome of the Model calibration is the development of rainfall-runoff relationships. The Model will be used to simulate two conditions: a ‘baseline’ condition (undisturbed watershed condition) that will be calibrated based on approximately two years of observed rainfall-runoff data; and ‘concurrent’ condition (disturbed watershed condition) that will continuously be updated to reflect development changes in the watershed and will be re-calibrated on a yearly basis. Using the same design precipitation input, the difference in calculated runoff volume between the two model conditions will be used to estimate potential impacts as a result of the Project (see Illustrations 2 and 3).

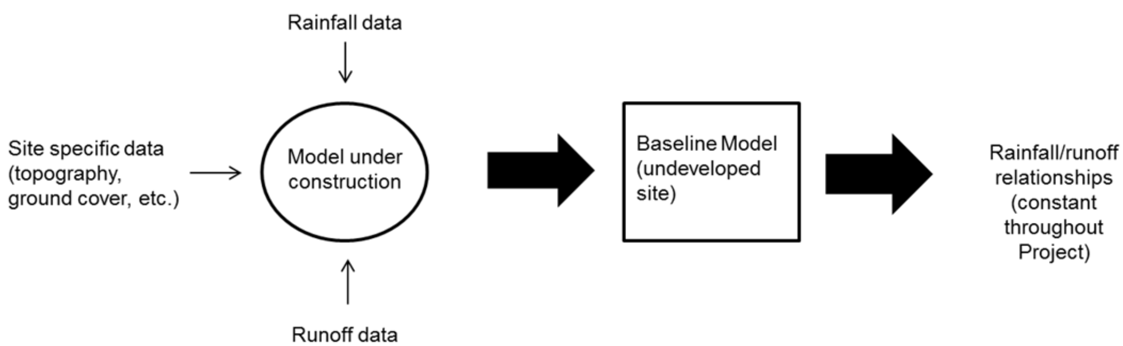


Illustration 2: Baseline Model

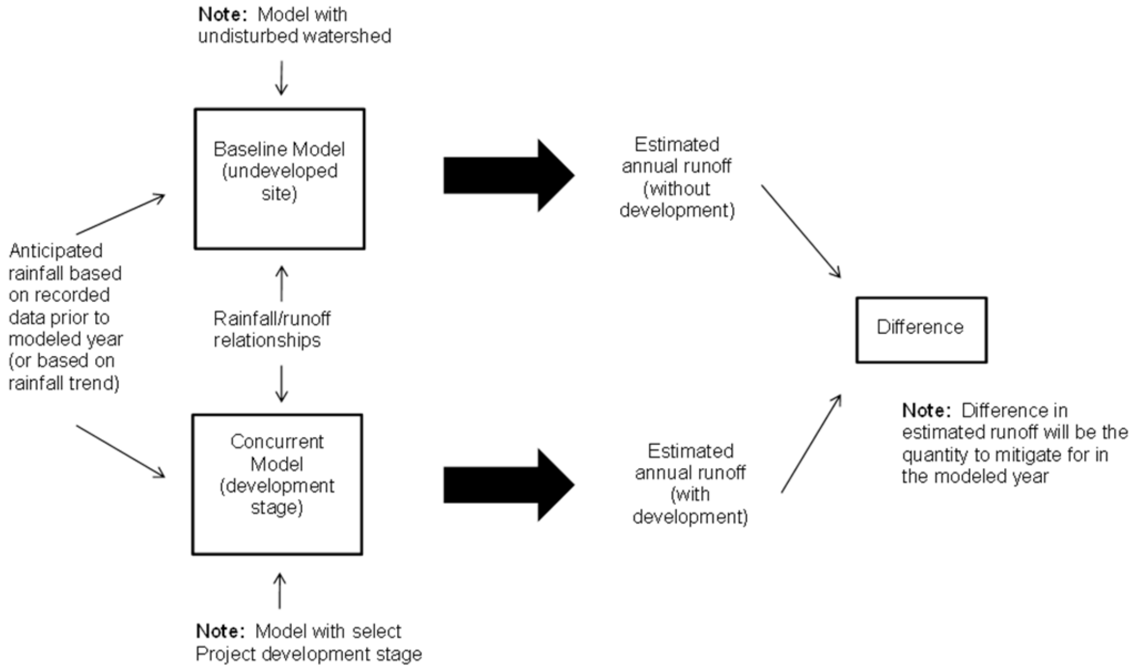


Illustration 3: Concurrent Model versus Baseline Model

Up until the point when major construction occurs, all watersheds within the Project area will be used for calibration of the ‘baseline’ Model. Once major construction starts, and stormwater flow paths become impacted by development, the ‘baseline’ Model will remain constant throughout the remainder of the Project. Other regionally instrumented watersheds, such as the Santa Rita Experimental Watershed, may also be used to help determine reasonable event-based, rainfall-runoff relationships.

The ‘concurrent’ Model will be used proactively. The estimated annual runoff will be calculated for the upcoming year based on mine development plans. Predicted runoff volume estimates (determined from the ‘concurrent’ Model) will be based on actual recorded precipitation events in the watershed from the previous year (or multiple years depending on rainfall trends). The summation of these individual recorded precipitation events will be input into the ‘concurrent’ Model to estimate the next year’s runoff totals. This same rainfall will be input into the ‘baseline’ model and the results compared to the ‘concurrent model. This comparison will result in a difference in stormwater volumes that will require mitigation (see Illustration 3).

The runoff volume estimates, as determined from the ‘concurrent’ Model, will then be compared against actual stream flow and precipitation measurements recorded during the year modeled. The projected surface runoff volume estimates from the ‘concurrent’ Model will then be reconciled against recorded streamflow data to determine the effect of Project development over that year (see Illustration 4).

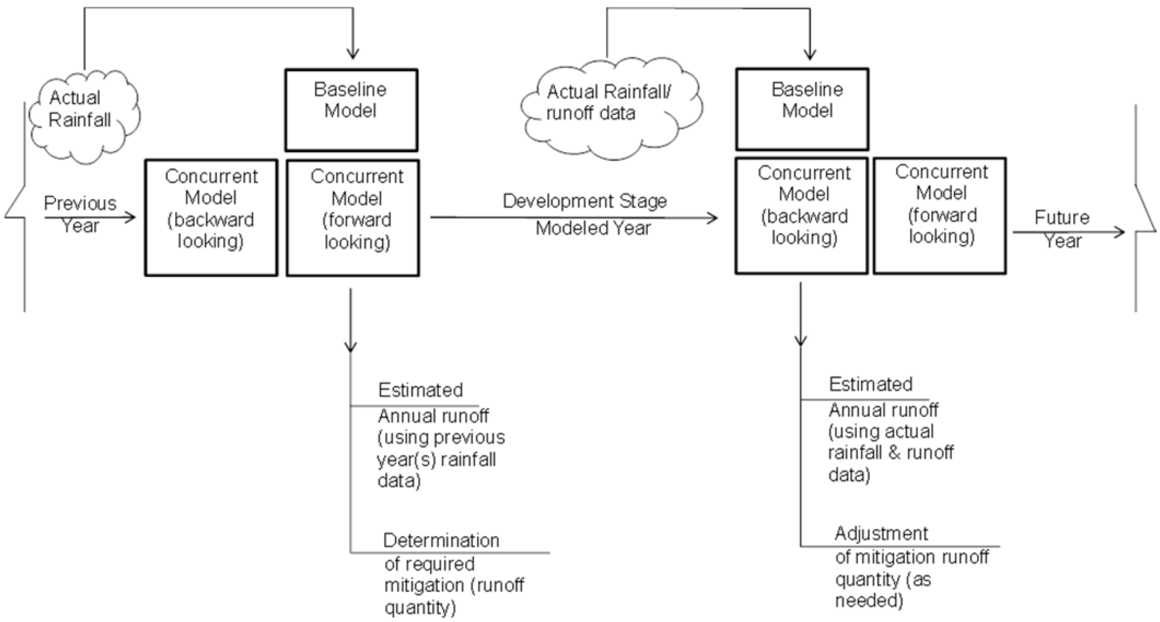


Illustration 4: Model Progression

Once mitigation requirements have been determined based on an estimated annual runoff deficiency, mitigation sites will be reviewed and runoff credits will be calculated. Since the calculation will be forward looking (assumed weather conditions), the updates will also look backward at the data to determine if additional credits are required based on actual data. The yearly analysis will produce a table summarizing the yearly runoff reductions and/or runoff additions, including adjustments. In terms of mitigation credit, the goal will be to balance the credits and impacts over the long-term.

In summary, at a minimum the table will include:

- Anticipated runoff reduction for upcoming year (onsite);
- Anticipated runoff credit for upcoming year (offsite);
- Adjustment of the previous year's reduction and/or credit based on actual monitoring data, i.e., adjustment to the annual runoff number; and
- Running total of mitigation sites and their yearly contribution

Development of the Model will include a review of all existing and planned monitoring stations and, as needed, a recommendation for additional instrumentation; i.e., rain gages and flow recording stations, that will assist in developing a more accurate accounting of rainfall (and infiltration) within the Project site.

As indicated in Section 2.0, existing monitoring points located within or downstream of the Project area include the following:

- USGS gage stream flow data;
- BC-2 monitoring station data;
- DC-3 monitoring station data; and
- Rainfall gage data (open pit station, BC-2/DC-3 monitoring stations, etc.).

Also indicated in Section 2.0, anticipated future instrumentation includes the following:

- BC-1 surface flow monitoring station in Lower Barrel Canyon (Sediment Control Structure No. 1 location);
- Additional Davidson Canyon and Cienega Creek surface flow monitoring stations similar to BC-2 and DC-3 stations;
- Additional rainfall gages;
- Surface flow monitoring stations in Scholefield and McCleary Canyons; and
- Weather station(s) associated with ADEQ’s Air Quality Permit and/or other Mitigation Measures listed in Appendix B of the FEIS.

5.0 MITIGATION

Rosemont does not anticipate any adverse changes to water quality or the stability of Davidson Canyon Wash or the OAW segment as a result of the Project activities. However, as a condition of the 401 Certification and as tied to potential water quality changes, mitigation measures are proposed that are related to the replacement of stormwater and sediment based on Project site activities. Replacement of stormwater will be based on the surface water modeling results described in Section 4.0. This section proposes and discusses, in general, a number of mitigation measures that could be employed to offset and/or replace reduced stormwater flow volume from the Project site if attributable to site activities. Stormwater Mitigation (Section 5.1) includes the following sections:

- Section 5.1.1 – On-site stormwater management
- Section 5.1.2 – Water rights assignment
- Sections 5.1.3, 5.1.4 and 5.1.5 – Closure of stock watering locations
- Section 5.1.6 – Additional Mitigation Opportunities
- Section 5.1.7 – Mitigation Selection Order

Section 5.2 covers sediment mitigation as well as providing a review of planned monitoring related to sediment loading/deposition.

The mitigation measures proposed and described below are in terms of a general concept. When it is determined that mitigation is required, and to what extent, a Mitigation Plan will be prepared by Rosemont that describes the specific and appropriate mitigation measure to be implemented, including the timeline for implementation and term of the activity.

Even though potential stormwater losses (and corresponding sediment losses) will be resolved based on mitigation sites, monitoring within the Davidson Canyon watershed will still take place. Should water quality conditions change at the OAW in Davidson Canyon, the general monitoring data will be used to help determine potential causes.

5.1 STORMWATER MITIGATION

5.1.1 On-Site Stormwater Management

During development of the Rosemont Project, a number of stormwater catchments and sediment traps (collectively referred to as “catchments”) are currently anticipated based on the Project development plans. Until actual field activities start, it is impossible to ascertain if all of the catchments will be required to ensure conformance with the MSGP. Where practicable, Rosemont has determined that the first mitigation efforts will be on-site flow diversion, installation of culverts, or management of activities to eliminate the need for impounding stormwater runoff waters onsite. This technique addresses both stormwater flow and sediment flow.

5.1.2 Water Rights Assessment

Rosemont has acquired an option to purchase a number of the highest priority surface water rights at Pantano Dam. These rights are currently used to provide irrigation water to a nearby golf course. As far as Rosemont has been able to determine, these priority rights have never been exercised to protect the water resources at the dam from upstream water users, or from other permitted consumptive uses. These uses affect downstream flows and ultimately the delivery of water to the system.

Rosemont proposes to sever and transfer the youngest of the water rights at the Pantano Dam (a 1935 right) and transfer it to ASLD, Arizona Game and Fish, or other State Agency allowed by law to hold a water right for the expressed right to protect the resources of the OAW segments in Davidson Canyon, i.e., eliminate upstream uses. This right is for 46 acre-feet and can be exercised to eliminate the rights that are newer than 1935. There are no rights that exist in the Davidson Canyon watershed that Rosemont is aware of that predate 1935 (other than Rosemont's own rights). It is anticipated that the State Agency and ADEQ will cooperatively work to examine opportunities for protection of the OAW in relation to this water right. It is noted that based on the flow information recorded in Lower Barrel Canyon Wash (as measured by the USGS gaging station No. 09484580 located at the SR 83 bridge; see Appendix D), this 46 acre-foot surface water right represents the entirety of the stormwater flow recorded at the USGS gage in 2013.

5.1.3 Closure of Stock Well in Davidson Canyon Wash

Rosemont currently owns a shallow, hand-dug well that is located on the northwest bank of Davidson Canyon Wash, approximately ½ mile upstream from the confluence with Barrel Canyon Wash. This well is part of the Rosemont grazing allotment and provides water to cattle while grazing on the east side of SR 83 highway. Water is pumped as needed for grazing. For the purposes of mitigation, Rosemont would propose to close this well along the stream channel.

ADEQ staff viewed the well during a field visit conducted with Rosemont in December 2013, which included areas within the Project site and down Davidson Canyon Wash to the confluence with Cienega Creek. Closing this well will provide a direct effect to the alluvial system of Davidson Canyon and provide a direct "wet water" replacement/offset for any potential Rosemont's impacts.

5.1.4 Cessation of Stock Watering at Questa Spring

One of Rosemont's properties in Upper Davidson Canyon includes a spring (Questa Spring), which currently has a well-developed cattle watering tank/system developed around it. This spring system reports to a tank rather than discharging to the ground, which increases the evaporation associated with the spring discharge and takes water from the natural system.

For the purpose of mitigation, Rosemont would propose to work with the appropriate agencies (i.e., Arizona Game and Fish, State Land, etc.) to eliminate the stock watering system associated with this spring and divert the discharge back into its natural channel. This return to a natural spring system will allow water to feed the Davidson Canyon system rather than be lost to evaporation.

5.1.5 Closure of Stock Ponds and Tanks

Rosemont owns the water rights to a number of stock ponds/tanks within or downstream of the Project area. While a number of those stock ponds will be directly impacted by the Project, a number of them are outside of the disturbance area. For the purpose of mitigation, Rosemont would propose to systematically close stock ponds and replace them with wells and stock drinkers, which overall would put storm flows back into the system. Removal of stock ponds would also put sediment currently trapped by the ponds back into the system, naturally offsetting any potential sediment losses to the system.

Because these stock ponds are part of on-going monitoring at Rosemont in relation to biological resources, any systems used to replace the ponds will need to be coordinated with the appropriate agency. The opportunities for potential replacement/elimination of the stock ponds are listed and described below. The biological descriptions, IDs, cadastral locations, and other information of the following stock ponds are cited from the draft FEIS (Table 88) and WestLand Resources annual ranid (frog) surveys conducted from 2008 through 2011 (WestLand 2009a, 2009b, 2011a, 2011b). Surveys of these stock pond locations, and associated watersheds, would be conducted by Rosemont as part of developing the mitigation site portion of the surface water model.

A survey of the stock tanks will be initiated in the pre-construction period to verify storage volumes and to determine the overall watershed condition up-gradient of the tanks.

5.1.5.1 Wasp Canyon Tank No. 38-70881

Tank ID: Surface water right no. 38-70881 / cadastral location (D-18-15) 25dd

This tank corresponds with the "South Upper Stock Tank (ID 10)", and is described as:

- Small stock tank (80 by 30 feet); appears to be recently developed. Westernmost of four tanks along FR 4501. Three site visits – August 25, August 26, and September 5, 2008. Tank supported 60-by-30-foot surface water in August and September 2009. Tank supported 20 m by 20 m of surface water in April 2011, was dry on August 16, 2011, and contained approximately 10 m by 5 m surface water on August 29, 2011.

The tank depth is unknown; therefore the actual volume is also unknown. However, based on the description, the tank holds at least 0.1 acre-feet of water.

5.1.5.2 Davidson Canyon No. 38-63384

Tank ID: Surface water right no. 38-63384 / cadastral location (D-17-17) 30ab / approximate UTMs: 533815, 3532715 / (ID 11)

There is no specific description on this tank; however, it has an assigned water right. Rosemont is in the process of determining the specifics contained in the water right and the actual capacity of the stock pond.

5.1.5.3 Davidson Canyon No. 38-66914

Tank ID: Surface water right no. 38-66914 / cadastral location (D-17-17) 30ab / approximate UTMs: 533815, 3532715 / (ID 11)

There is no specific description on this tank. Rosemont is in the process of determining the specifics contained in the water right and the actual capacity of the stock pond.

5.1.5.4 Davidson Canyon (D-17-16) 36a

Tank ID: Cadastral location (D-17-16) 36a / approximate UTMs: 532400, 3531350 / (ID 13)

There is no specific description on this tank. Rosemont is in the process of determining the specifics contained in the water right and the actual capacity of the stock pond.

5.1.5.5 Davidson Canyon (D-17-17) 07b

Tank ID: Cadastral location (D-17-17) 07b / approximate UTMs: 533031, 3537204 / corresponds with Davidson Canyon at diversion dam (ID 14)

The description from the 2011 ranid survey included:

- During the May 23, 2011 visit the pond was dry. On August 26, 2011 the surface water area was approximately 125 m by 50 m.

The pond depth is unknown; therefore the actual volume cannot be calculated. However, it is estimated that the pond holds at least 3 acre-feet of water.

5.1.5.6 McCleary Canyon (D-18-16) 19cc

Tank ID: Cadastral location (D-18-16) 19cc; corresponds McCleary Stock Tank (ID 20)

The description from the 2009 ranid survey included:

- This stock tank contained a 60-by-45-foot (20-by-15-m) area of surface water in August and September 2009.

The tank depth is unknown; therefore the actual volume is also unknown. However, based on the description, the tank holds at least 0.1 acre-feet of water

5.1.5.7 Barrel Canyon/East Dam Tank

Tank ID: Barrel Canyon / East Dam Tank; cadastral location (D-18-16) 128ac; corresponds to East Dam Tank (ID 21)

The description from the 2008 ranid survey included:

- Small wet area (25 by 10 feet [8 by 3 m]) in unnamed ephemeral tributary to Barrel Canyon, about 0.7 kilometers (km) south of USFS Road 231 (FR 231) during the September 12, 2008 site visit. Mud/silt and gravel substrate, extremely clear. Small wet area fed by water from East Dam. The stock pond is located on Coronado National Forest (CNF) land.

The stock tank depth is unknown; therefore the actual volume cannot be calculated. However, it is estimated that this large stock tank holds at least 5 acre-feet of water.

5.1.5.8 Davidson Canyon (D-18-16) 01ab

Tank ID: Cadastral location (D-18-16) 01ab / (ID 24)

There is no specific biological description on this tank. Rosemont is in the process of determining the number and specifics of the associated water right, including the capacity of the tank.

5.1.5.9 Summary

The stock ponds/tanks listed above have an aggregate storage capacity of at least 8.2 acre-feet. Assuming two fill periods, one during the monsoon flows and one during the winter rains, the volume of storage that could potentially be replaced in Davidson Canyon Wash could exceed 15 acre-feet per year. An assumption of three fills from storm events would approximate 25 acre-feet per year. Actual quantities will be determined via measurement and then modeling as described in Section 4.0.

Prior to closing any of the stock ponds, Rosemont proposes to evaluate the usefulness of each pond, ensure that the estimates of storage are appropriate and can be documented, and work with the Forest Service, State Lands, and the Arizona Game and Fish to ensure habitat for frogs and access to water for other wildlife are not adversely effected. Installing replacement drinkers with habitat features would also be considered for these sites, as appropriate.

Each stock tank closure would require a plan to breach the containment, manage the sediment, and salvage the riparian resources. It will also include a plan to stabilize the area with plantings or rip-rap as appropriate.

5.1.6 Additional Mitigation Opportunities

Several additional opportunities for mitigation exist for future consideration but are not preferable at this time. Those opportunities could be evaluated if the measures previously described do not bring about the desired mitigation effects and include:

- A change in the current design of the on-site Project stormwater management systems to provide mitigation to surface flows;
- Using pit dewatering water on an episodic basis to mitigate for temporal losses associated with stormwater reduction;
- Installing a well to provide water to the system on a regular basis to offset stormwater reductions; or
- Identifying off-site source control efforts in conjunction with ADEQ to eliminate pollutant loading within the Davidson Canyon drainage that is not associated with the Project. Such sources may be easily and inexpensively controlled at their source, and Rosemont could identify such solutions with funding.

5.1.7 Mitigation Selection Order

The following illustration (Illustration 5) provides a general order of selection of mitigation opportunities related to stormwater replacement, as needed, based on preserving surface water quality downstream of the Project. As noted, the initial course of action will be to delay, as long as practicable, the impoundment of stormwater once site development begins. Opportunities to reroute stormwater will be determined as part the annual Surface Water Model review. The closure of stock wells/tanks and the reassignment of water rights will be explored as initial mitigation options followed by the modification of earthen stock watering ponds. As noted, other options may be explored if needed. In any case, model results and calculated stormwater differences between the baseline and concurrent model will be reviewed with ADEQ prior to selecting and implementing stormwater mitigation options.

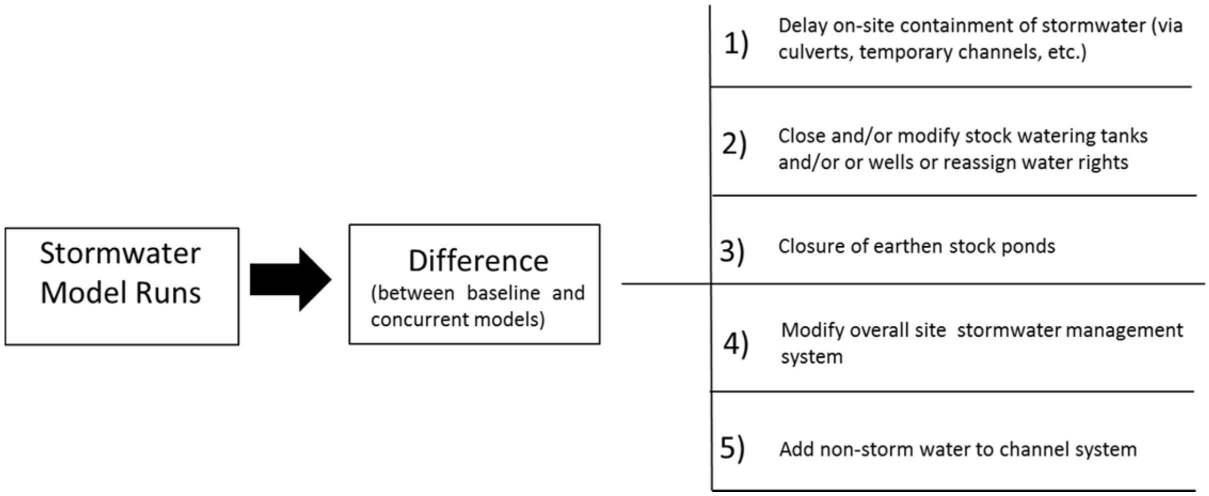


Illustration 5: General Surface Water Mitigation Selection Order

5.2 SEDIMENT MITIGATION

Replacement of sediment within the system will require ADEQ to balance the requirements of its varying permitting programs. The AZPDES MSGP program requires sediment control and specific best management practices to ensure sediments are not released in amounts that will effect water quality. Rosemont will consider adjustments to the MSGP requirements if ADEQ deems it necessary to increase sediment loading from the Project site.

In terms of mitigating for sediment loss, the removal of stock ponds/tanks will directly mitigate for sediment losses by allowing sediment currently being trapped to naturally enter the system. And as stated above and depending on water quality issues, the removal of the sediment control structures located down-gradient of the planned facilities may also be viewed in terms of functionally adding sediment back into the system.

As noted in previous sections of this Plan, locations along Lower Barrel Canyon Wash and along Davison Canyon Wash will be assessed for changes in geomorphology. The following will be monitored/assessed at these locations:

- Topographic surveys (using LIDAR). This will help determine whether the stream-bed at that specific location is aggrading or degrading, i.e., adding sediment or loosing sediment. Since changes within the stream-bed can be dramatic following flow events, this monitoring will be looking at long-term trends in sediment deposition. Photographic documentation will also take place along with the topographic surveys.
- Pebble counts and particle size analysis. This will help determine whether the characteristics of the flow events are changing in relation to carrying capacity. As with the topographic surveys, this data will be viewed in the context of a long-term trend analysis.

In addition to topographic surveys and pebble counts/particle size analysis, stormwater samples from surface water/groundwater monitoring stations, such as Station BC-2 and DC-3, will be analyzed for TSS. A trend analysis will be performed for TSS in an attempt to give an indication of the sediment load carried by the steam.

6.0 SCHEDULE

Illustration 6 provides a schedule for the planned development of the Surface Water Model (Model) as well as the installation of additional instrumentation, including the monitoring of stream-bed geomorphological changes. The following tasks are planned in support of the Model during the anticipated two-year timeframe available before major disturbance within the Project watershed takes place, and before the Model is implemented:

- Develop the Surface Water Model. This includes a review of existing monitoring equipment and the selection and installation of additional monitoring equipment/stations;
- Initiate stock pond surveys and other investigations as needed (i.e. water rights), related to potential storm water mitigation sites. Note that during the model development period, the refinement and quantification of available mitigation sites will be addressed, i.e., survey stock pond areas, quantify well/stock tank water flows, assess water rights, etc.; and
- Begin stream-bed geomorphological surveys.

Initiation of the activities outlined is dependent on acceptance of the Plan by ADEQ. Additionally, the installation of instrumentation is dependent on land access and weather; as a result instrumentation, or surveys, may be delayed. Several installation/survey campaigns are likely required.

In addition to the data required for the Model, other monitoring within the Davidson Canyon watershed, etc., is also dependent on access. This includes the installation of the surface/groundwater monitoring stations as well as geomorphological/sediment monitoring. These activities will commence once authorized by the Forest Service and/or other parties as needed.

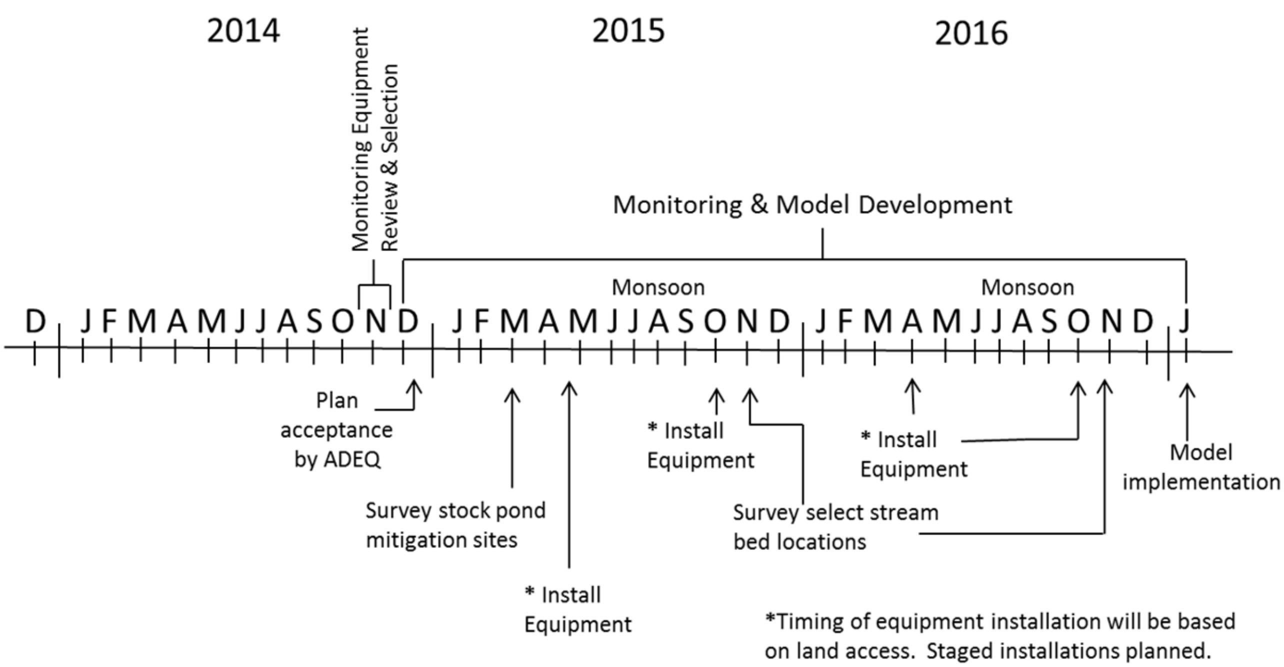


Illustration 6: Surface Water Model Development Timeline

7.0 REPORTING

Summaries of monitoring data will be prepared quarterly and provided to ADEQ as they are required for submittal to the Forest Service. The quarterly data will provide only the latest data gathered during that period.

An Annual Summary Report will be prepared for ADEQ that provides current quarterly data along with the entire previous years' data. The report will also include analyses, statistical calculations, and updates on the following:

- Precipitation reported from the various rain gages described in this Plan;
- Streamflow data from the USGS gaging station and the automated surface water/groundwater monitoring stations (as installed) in Barrel Canyon and Davidson Canyon washes;
- Soil moisture, conductivity, and temperature recorded from the automated surface water/groundwater monitoring stations (as installed);
- Groundwater level data for both alluvial and bedrock wells associated with the surface water/groundwater monitoring stations (as installed);
- Geomorphological (sediment transport and channel stability data) and vegetation monitoring data results;
- Summaries and graphs, if necessary, of stormwater quality data from the designated AZPDES outfall points as well as the surface water and surface water/groundwater monitoring stations in Barrel and Davidson Canyon washes and Cienega Creek (as installed). Analytical results will be tabulated and compared with applicable water quality standards;
- Graphs, hydrographs, statistical analysis, and tables, as needed, to illustrate and represent the above data;
- Information regarding the development and/or maintenance of the surface water model, including implementation of mitigative measures that may include, but not limited to, the following:
    - Status of the sever/transfer of water rights;
    - Plans for closure of stock tanks;
    - Storage capacity and sediment loading estimates with the stock pond/tank closures, including an analysis of the quality of the water in the ponds/tanks; and
    - Identification of other water rights and wells in the alluvium that have been eliminated from consumptive use and their associated measurements.

Additionally, all monitoring data and reports required by other agencies and/or programs will also be available to ADEQ upon request.

8.0 ADAPTIVE MANAGEMENT

Rosemont will incorporate the adaptive management process into the monitoring and analysis associated with this Surface Water Mitigation Plan. This process will ensure that the initial intent of the Plan is being met and that pertinent data is being collected and reported and that site conditions are accurately represented. The three key components of adaptive management are:

- Testing assumptions – collecting and using monitoring data to determine if current assumptions are valid;
- Adaptation – making changes to assumptions and monitoring program to respond to new or different information obtained through the monitoring data and project experience; and
- Learning – documenting the planning and implementation processes and its successes and failures for internal learning as well as the scientific community.

Elements that may be modified as part of the adaptive management process for this Plan include, but are not limited to, the following:

- Monitoring locations;
- Monitoring parameters;
- Monitoring frequencies;
- Assumptions associated with pollutant loading, runoff volume, and/or assimilative capacity;
- Modeling approach;
- Mitigation opportunities or requirements;
- Implementation process for mitigation; and
- Information provided and included in the quarterly data summaries and in the Annual Summary Report.

9.0 DATA MANAGEMENT

Data will be managed as specified in the various plans referenced herein. With regard to the 401 Certification, data that is specifically associated with reporting to ADEQ will be kept for ten (10) years following the submission of the information. Annual summary reports will be kept for ten (10) years after the expiration of the Certification or until facility closure, whichever date is sooner.

10.0 REFERENCES

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WET, 2014. *Scholefield and McCleary Canyon Surface-Water Monitoring Instrumentation Proposal*. Proposal prepared for Rosemont Copper Company. March 13, 2014.

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FIGURES

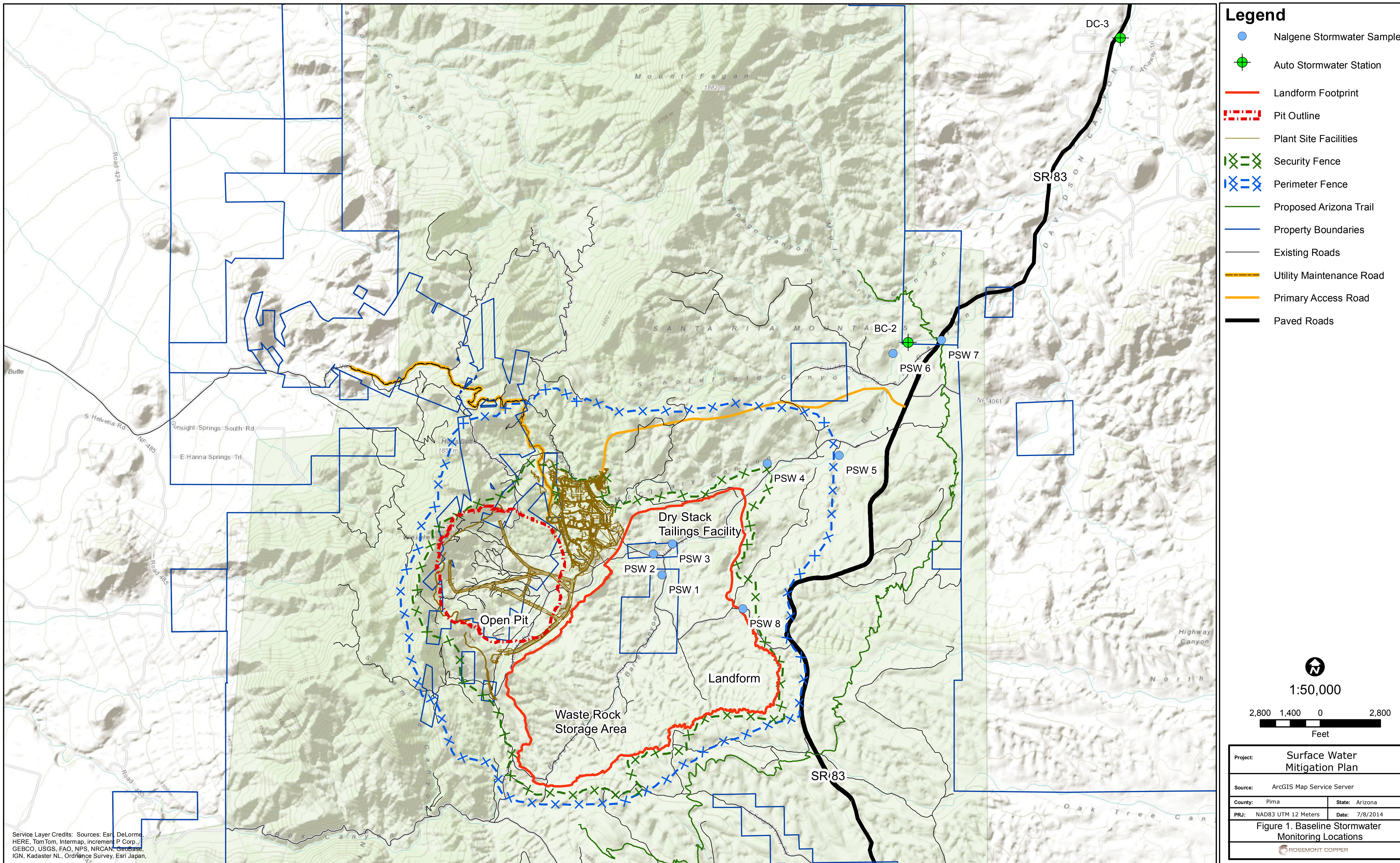


Figure 1. Baseline Stormwater Monitoring Locations

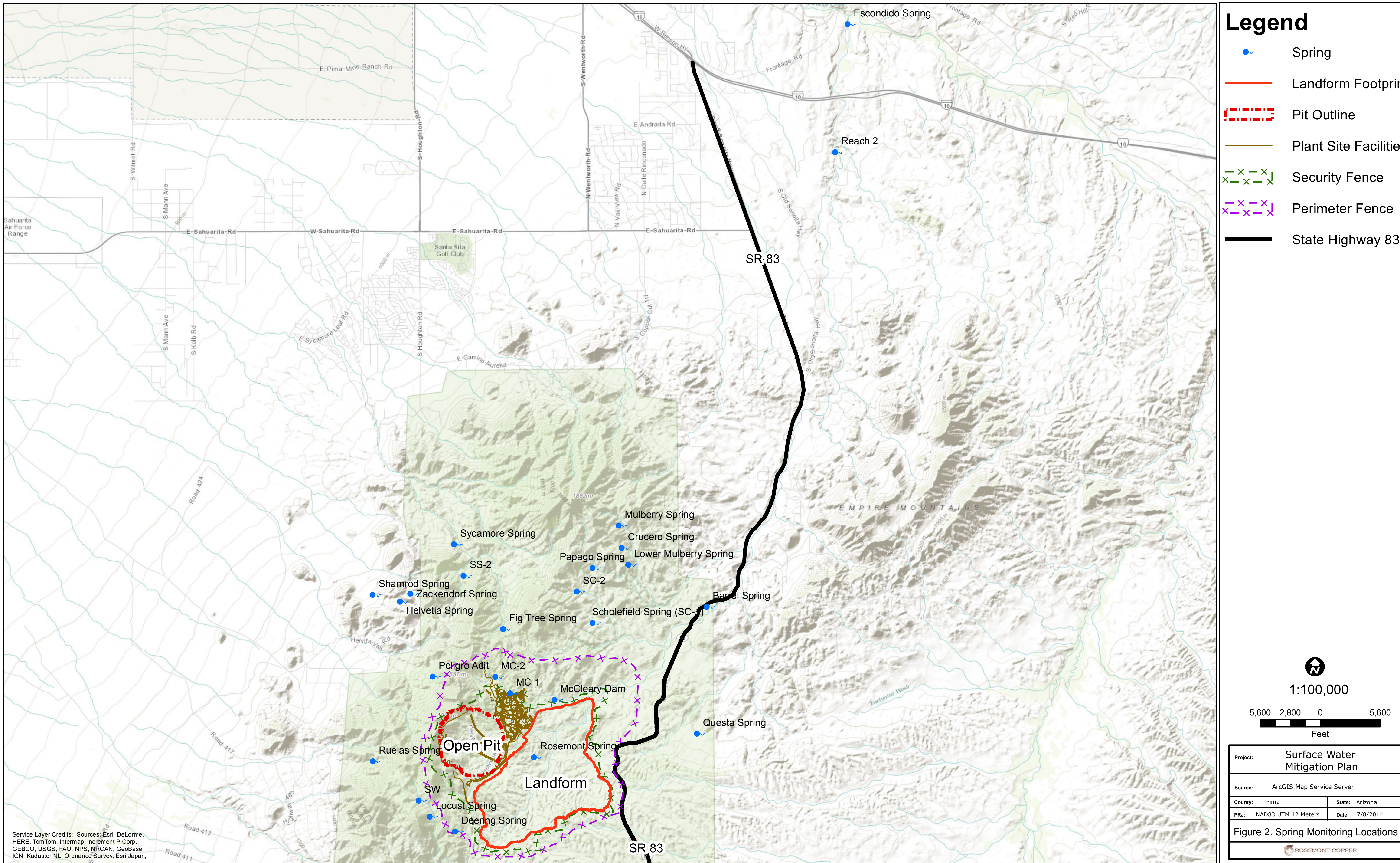


Figure 2. Spring Monitoring Locations

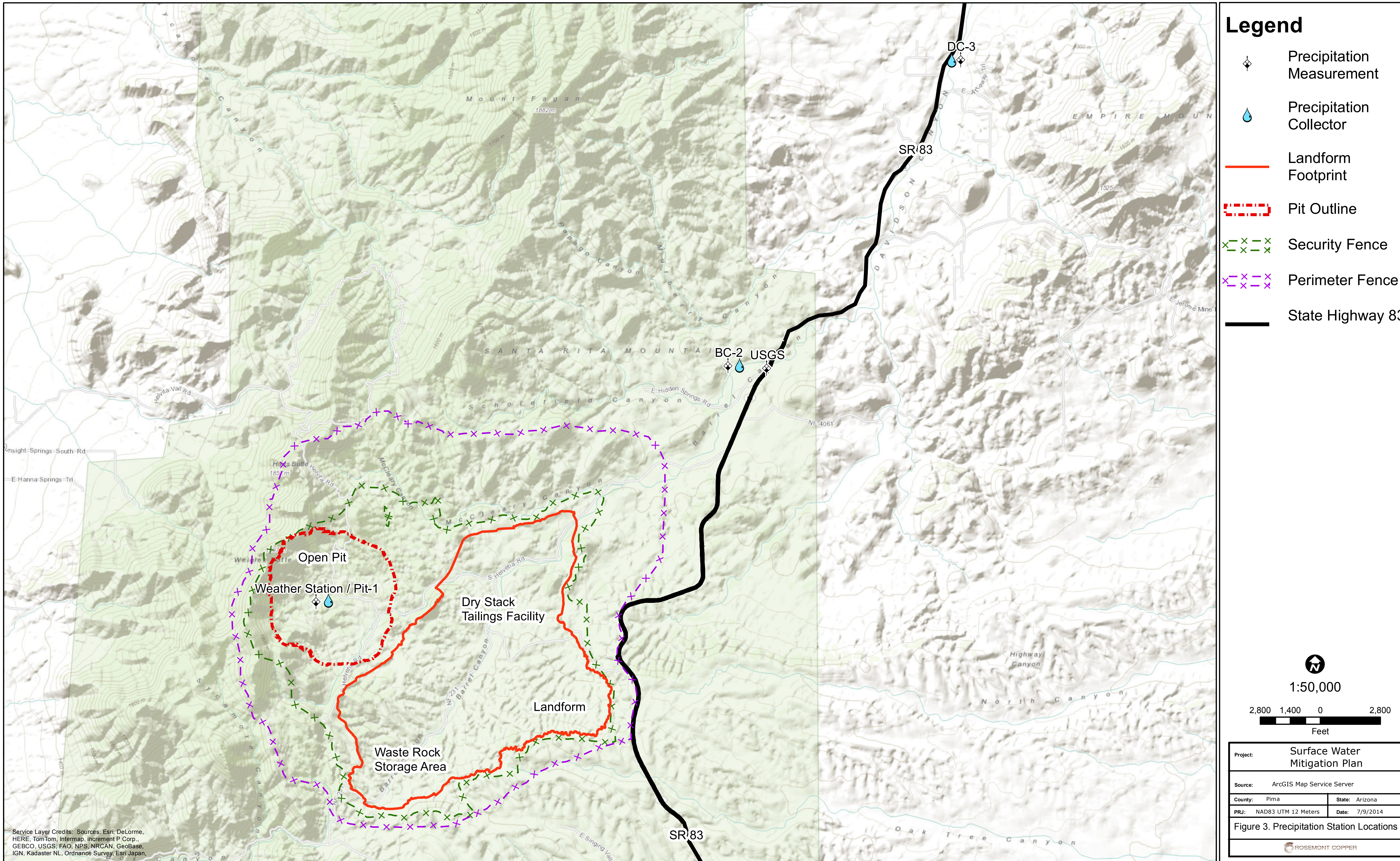
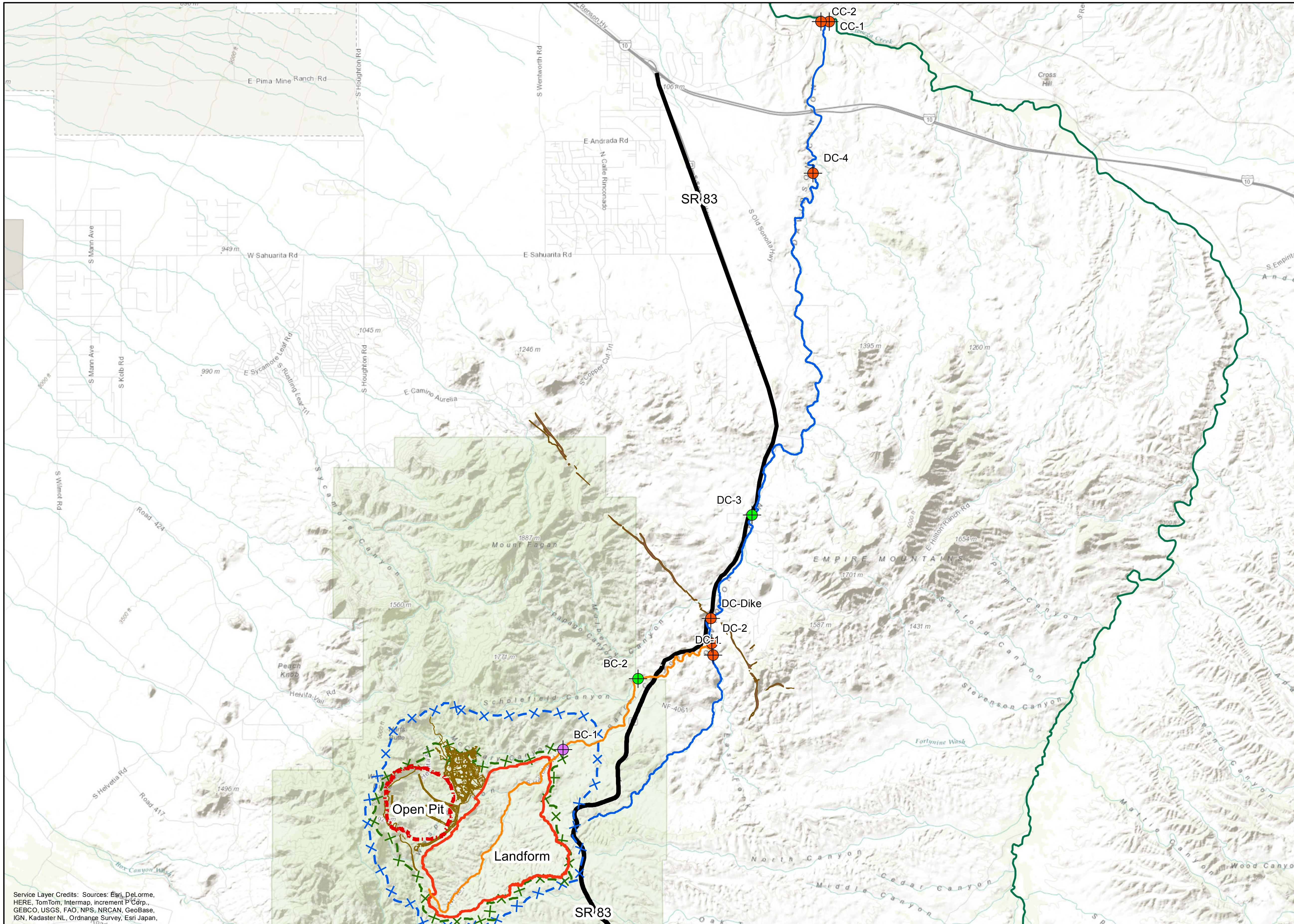


Figure 3. Precipitation Station Locations



Project:	Surface Water Mitigation Plan
Source:	ArcGIS Map Service Server
County: Pima	State: Arizona
PRJ: NAD83 UTM 12 Meters	Date: 11/17/2014

Figure 4. Automated SW/GW Monitoring Stations

ROSEMONT COPPER

APPENDIX A

WET and Engineering Analytics Monitoring Plans

Davidson Canyon

Conceptual Surface-Water Monitoring Plan

Prepared for:

Rosemont Copper Company

P.O. Box 35130

Tucson, AZ 85740-5130

Prepared by:

Water & Earth Technologies, Inc.

1225 Red Cedar Circle, Suite A

Fort Collins, CO 80524

March 2012

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List of Acronyms

ADEQ	Arizona Department of Environmental Quality
APP	Aquifer Protection Permit
AZPDES	Arizona Pollutant Discharge Elimination System
BLM	Bureau of Land Management
CNF	Coronado National Forest
EIS	Environmental Impact Statement
M&A	Montgomery & Associates
NEPA	National Environmental Policy Act
NWIS	USGS National Water Information System
OAW	Outstanding Arizona Waters
PAG	Pima Association of Governments
PCRFCD	Pima County Regional Flood Control District
USGS	United States Geological Survey

1. Introduction

This Conceptual Surface-Water Monitoring Plan (Plan) is submitted to Rosemont Copper Company (Rosemont) for support of the Rosemont Copper Project (Project). The Project includes an open pit mining and mineral processing operation on the east side of the Santa Rita Mountains, approximately 30 miles southeast of Tucson, Arizona in Pima County in the Santa Cruz watershed. The Project is currently going through the Environmental Impact Statement (EIS) process under the National Environmental Policy Act (NEPA), and also through a separate process to acquire an Aquifer Protection Permit (APP) with the Arizona Department of Environmental Quality (ADEQ). The Project is located on private land owned by Rosemont and federal land administered by the Coronado National Forest (CNF) and the Bureau of Land Management (BLM).

The proposed Project is located in the upper Davidson Canyon watershed, within a dendritic watershed tributary to the ephemeral Barrel Canyon channel (Figure 1). Depending upon the final configuration of Project facilities, the Project will potentially include development within three tributaries to the Barrel Canyon channel: upper Barrel Canyon, Wasp Canyon, and McCleary Canyon. Barrel Canyon's confluence with Davidson Canyon is approximately 4 miles downstream of the Project. Upper Davidson Canyon (above the confluence with Barrel Canyon) also drains the western flank of the Empire Mountains.

Below the confluence with Barrel Canyon, Davidson Canyon continues for approximately 12 miles to its confluence with Cienega Creek at an elevation of 3,325 feet above mean sea level (ft. amsl) (Tetra Tech, 2010b). Pima County's Cienega Creek Natural Preserve, an important recreational and habitat resource, encompasses the lower reaches of Davidson Canyon and adjacent reaches of Cienega Creek. A reach of Davidson Canyon and a reach in Cienega Creek have received an Outstanding Arizona Waters (OAW) designation from ADEQ (ADEQ, 2009).

All of the tributary channels, as well as the mainstem channel draining Davidson Canyon, are ephemeral except for reaches immediately adjacent to in-channel springs. The OAW reach in Davidson Canyon includes two sections below springs that flow throughout the year, separated by an ephemeral reach (ADEQ, 2009). However, both springs have been found without surface water expression during field visits documented by Rosemont and others, and provide seasonally maintained base flow only during periods of adequate precipitation. These springs lie within the channel and are obscured when surface flows are present.

This Plan is designed to supply data required to detect potential impacts from Project development on springs and on regional streams in and downstream of the Project area, particularly the reach designated as OAW in Davidson Canyon. The Plan describes a recommended monitoring network, including the location and instrumentation of monitoring stations, as well as the selection of water quality parameters and watershed health indicators for monitoring and a general discussion of sampling methods.

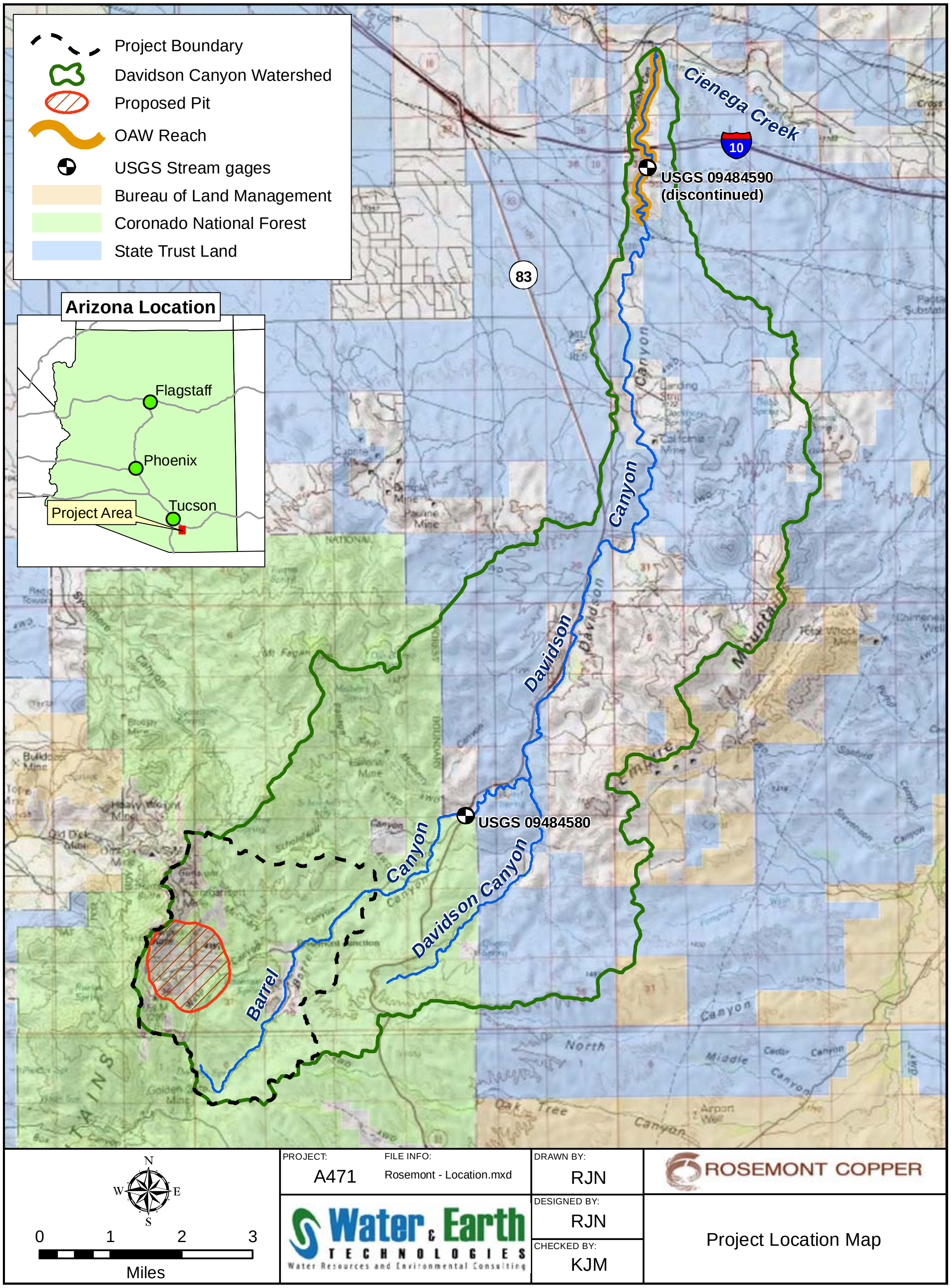

Figure 1. Project Location Map

1.1. Regulatory Framework for Monitoring

Water quality standards associated with an OAW designation are intended to protect designated waters from any water quality degradation. Tier 3 waters, including OAW waters, receive this highest level of protection. The detection, through routine monitoring, of any trend towards degraded water quality is significant in this regulatory environment. For anti-degradation purposes, these standards, described in detail in ADEQ (2008 and 2009) require water quality conditions to be maintained below numeric thresholds for a range of water quality constituents. This monitoring Plan is designed to provide data for comparison with the State of Arizona compliance criteria.

As indicated on the ADEQ website, (http://www.azdeq.gov/environ/water/standards/), the official version of the surface water quality standards document, effective January 31, 2009, is not available. The most current version of the standards document for the rules effective January 31, 2009 was used for the development of this monitoring Plan (ADEQ, 2009). Arizona surface water quality standards apply to four stream reaches in the Davidson Canyon Watershed (Table 1). Reach 1 encompasses the ephemeral headwaters and is not part of the OAW reach. The 3.2 mile-long OAW segment at the downstream end of Davidson Canyon is divided into three reaches, with different water use designations for the two intermittent or perennial warm water reaches that extend downstream from spring locations (Reaches 2 and 4) and the intervening ephemeral reach (Reach 3) (see Appendix B, page 22 of ADEQ, 2009). These reaches are described in terms of unnamed springs and tributaries. For this Plan, these landmarks are named Reach 2 Spring, Reach 3 Tributary, and Escondido (Reach 3) Spring, as described in Table 1.

Table 1. Water Quality Protection Designations for Davidson Canyon Stream Reaches

Reach Number	Reach Description	Protection Designation
1	Davidson Canyon headwaters downstream to unnamed spring at 31°59'00"/110°38'46" (NOT OAW) *Unnamed spring is Reach 2 Spring*	A&We - Aquatic and Wildlife (ephemeral) PBC - Partial-body contact AgL - Agricultural Livestock Watering
2	Unnamed spring downstream to confluence with unnamed tributary at 31°59'32.5"/110°38'43.5" (OAW) *Unnamed spring is Reach 2 Spring* *Unnamed tributary is Reach 3 Tributary*	A&Ww - Aquatic and Wildlife (warm water) FBC - Full-body contact FC - Fish consumption AgL - Agricultural Livestock Watering
3	From confluence with unnamed tributary downstream to unnamed spring at 32°00'54"/110°38'54 (OAW) *Unnamed tributary is Reach 3 Tributary* *Unnamed spring is Escondido (Reach 3) Spring*	A&We - Aquatic and Wildlife (ephemeral) PBC - Partial-body contact AgL - Agricultural Livestock Watering
4	From unnamed spring at 32°00'54"/110°38'54" downstream to confluence with Cienega Creek at 32°01'05"/110°38'32 (OAW) *Unnamed spring is Escondido (Reach 3) Spring*	A&Ww - Aquatic and Wildlife (warm water) FBC - Full-body contact FC - Fish consumption AgL - Agricultural Livestock Watering
Data source: ADEQ, 2009		

The numeric water quality standards applicable to the stream reach designations in Davidson Canyon are provided in Table 2. The lowest constant (limiting) numeric standard for dissolved and total recoverable constituent concentrations, if applicable, is noted in bold (ADEQ, 2009, Appendix A, page 1, Table 1).

Table 2. Numeric Water Quality Standards

Constituent	**FC (mg/L)**	**FBC (mg/L)**	**PBC (mg/L)**	**A&Ww Acute (mg/L)**	**A&Ww Chronic (mg/L)**	**A&We Acute (mg/L)**	**AgL (mg/L)**
Dissolved Oxygen (DO)[1]	**--**	**--**	**--**	**6.0**	**--**	**--**	**--**
pH min max	--	6.5 9.0	--	--	--	--	6.5 9.0
Suspended sediment [2]	--	--	--	--	**80**	--	--
Total Ammonia (NH_3)	--	--	--	F(pH)	F(pH)	F(pH)	--
Alpha Particles (Gross) radioactivity[3]	--	--	--	--	--	--	--
Antimony (Sb)	0.640 (T)	**0.0747 (T)**	**0.0747 (T)**	0.088 (D)	**0.030 (D)**	--	--
Arsenic (As)	0.080 (T)	**0.030 (T)**	0.280 (T)	0.340 (D)	**0.150 (D)**	0.440 (D)	0.200 (T)
Barium (Ba)	--	**98 (T)**	**98 (T)**	--	--	--	--
Beryllium (Be)	**0.084 (T)**	1.867 (T)	1.867 (T)	--	--	--	--
Boron (B)	--	**186.667 (T)**	**186.667 (T)**	--	--	--	--
Cadmium (Cd)	0.084 (T)	0.700 (T)	0.700 (T)	F(hardness) (D)	F(hardness) (D)	F(hardness) (D)	**0.050**
Chromium (Cr)	--	--	--	--	--	--	**1 (T)**
Copper (Cu)	--	**0.130 (T)**	**0.130 (T)**	F(hardness) (D)	F(hardness) (D)	F(hardness) (D)	0.500 (T)
Fluoride (F^-)	--	140	140	--	---	--	
Iron (Fe)	--	--	--	--	**1.000 (D)**	--	--
Lead (Pb)	--	**0.015 (T)**	**0.015 (T)**	F(hardness) (D)	F(hardness) (D)	F(hardness) (D)	0.1 (T)
Manganese (Mn)	--	**130.667**	**130.667**	--	--	--	--
Mercury (Hg)	--	0.280 (T)	0.280 (T)	0.0024 (D)	**0.00001 (D)**	0.005 (D)	**0.010 (T)**
Nickel (Ni)	**0.511 (T)**	28 (T)	28 (T)	F(hardness) (D)	F(hardness) (D)	F(hardness) (D)	--
Nitrate + Nitrite[4]	--	--	--	--	--	--	--
Selenium (Se)	0.667 (T)	4.667 (T)	4.667 (T)	--	**0.002 (T)**	0.033 (T)	0.05 (T)
Silver (Ag)	8 (T)	**4.667 (T)**	**4.667 (T)**	F(hardness) (D)	F(hardness) (D)	F(hardness) (D)	--
Thallium (Ti)	**0.001 (T)**	0.075 (T)	0.075 (T)	0.700 (D)	**0.150 (D)**	--	--
Zinc (Zn)	**5.106 (T)**	280 (T)	280 (T)	F(hardness) (D)	F(hardness) (D)	F(hardness) (D)	25 (T)

Table 2. (Continued)

A&Ww - Aquatic and Wildlife (warm water), A&We - Aquatic and Wildlife (ephemeral)

FBC - Full-body contact, PBC - Partial-body contact, FC - Fish consumption

AgL - Agricultural Livestock Watering

(T) – total recoverable

(D) – dissolved Note: surface water standards may not designate T or D for all constituents

F(pH) - standard value a function of pH

F(hardness) (D) - standard value a function of hardness for dissolved. Hardness is based on the hardness of the receiving water body from a sample taken at the same time that the sample for the metal is taken, except that the hardness may not exceed 400 mg/L $CaCO_3$.

[1]DO concentration is single sample minimum

[2]Suspended sediment concentration standard is median value determined from a minimum of four samples collected at least seven days apart. The Director shall not use the results of a suspended sediment concentration sample collected during or within 48 hours after a local storm event to determine the median value.

[3]The only standard designation for Alpha Particles (Gross) Radioactivity is a drinking water standard of 15 pCi/L

[4]The only standard designation for Nitrate + Nitrite is a drinking water standard of 10 mg/L

Data Source: ADEQ, 2009

ADEQ rules for obtaining sediment samples (See footnote 2 on Table 2) are not designed for sampling in ephemeral streams. The standard is designed to quantify general suspended sediment loads in perennial streams rather than the extremely high turbidity and suspended sediment concentrations typical of an ephemeral wash during a flow event.

1.2. Existing Water Quality Data

Although the ADEQ Water Quality Division currently monitors surface water quality in the perennial reach of Cienega Creek, no water quality monitoring data by ADEQ in Davidson Canyon have been found in the ADEQ water quality data repository STORET database.

In cooperation with Pima County, the Pima Association of Governments (PAG) conducts base flow water quality monitoring intended to characterize water in both Cienega Creek and in Davidson Canyon (PCRFCD, 2009) by measuring and sampling spring flow in Davidson Canyon and stream flow in Cienega Creek. However, no sampling of stormwater runoff in stream channels or washes directly following storm events is conducted by PAG.

Rosemont has sampled stormwater runoff in washes in Barrel Canyon as part of its Project Site Stormwater Monitoring program. Water quality of stormwater runoff is currently collected at seven (7) locations (Rosemont Copper, 2012c), shown in Table 3.

Table 3. Rosemont Stormwater Monitoring Program Sampling Locations

Station ID (old station IDs)	Easting (UTM NAD83 m)	Northing (UTM NAD83 m)	Location
PSW1	525262	3521826	Barrel Canyon
PSW2	525141	3522124	Wasp Canyon
PSW3 (Junction, Junction1, Factory125, ISCO125)	525413	3522269	Rosemont Junction
PSW4	526762	3523416	McCleary Canyon
PSW5 (RP2, ISCO219)	527790	3523594	RP2 Monitoring Well
PSW6	528552	3524980	Scholefield Canyon
PSW7	533454	3539776	Barrel Canyon USGS gage

Water-quality data presented in the Draft EIS (Chapter 3, Table 90, USDA, 2011 and Tetra Tech, 2010a) show that baseline stormwater samples taken at stations named: RP2, Factory 125 and Junction1 during in 2009, as part of the Project Site Stormwater Monitoring program, violate standards for Agricultural Livestock Watering and Aquatic Wildlife (ephemeral) acute exposure for the following constituents: dissolved copper and total recoverable copper, arsenic, cadmium, and lead. These data represent baseline conditions in the watershed.

Twenty four (24) springs within Davidson Canyon and its tributaries, shown in Table 4 and on Figure 2, are currently sampled by Rosemont on a monthly basis (Montgomery & Associates, 2012). Monitoring of flow and water quality from springs in the Project area has been performed since 2008 (M&A, 2012). Wells in Davidson Canyon are also currently sampled. Sampling plans describing methods for these activities are available (M&A, 2008a and 2008b). Routine flow measurement and sampling at these spring locations will continue in order to collect data on base flow surface water quality characteristics and potential surface water/groundwater interactions.

Table 4. Spring Sampling Stations

SEEP OR SPRING LOCATION	Latitude	Longitude	SEEP OR SPRING IDENTIFIER
(D-18-16)14cab	31° 52' 2.694" N	110° 40' 56.989" W	Barrel Spring
(D-18-16)9cbd	31° 52' 50.363" N	110° 42' 37.771" W	Crucero Spring
(D-19-15)1dbd	31° 48' 31.634" N	110° 45' 40.471" W	Deering Spring
N/A	31° 47' 15.674" N	110° 38' 21.270" W	Upper Empire Gulch Spring
(D-16-17)30abd	32° 0' 54.692" N	110° 38' 35.888" W	Escondido (Reach 3) Spring[1]
(D-18-16)19abb	31° 51' 37.989" N	110° 44' 47.645" W	Fig Tree Spring
(D-18-15)14dba	31° 52' 4.438" N	110° 46' 40.234" W	Helvetia Spring
(D-19-15)1bdb	31° 48' 45.738" N	110° 46' 8.493" W	Locust Spring
(D-18-16)9dbb	31° 52' 38.204" N	110° 42' 32.785" W	Lower Mulberry Spring
(D-18-16)30abc	31° 50' 40.071" N	110° 44' 46.261" W	MC-1 Spring
(D-18-16)19ccd	31° 50' 54.519" N	110° 44' 57.185" W	MC-2 Spring
(D-18-16)29bda	31° 50' 33.434" N	110° 43' 53.040" W	McCleary Dam[2]
(D-18-16)9abc	31° 53' 14.409" N	110° 42' 42.873" W	Mulberry Spring
(D-18-16)16bba	31° 52' 31.669" N	110° 43' 5.912" W	Papago Spring
(D-18-15)24dcc	31° 50' 55.227" N	110° 46' 4.974" W	Peligro Adit
(D-18-16)27ddd	31° 50' 0.943" N	110° 41' 18.495" W	Questa Spring
(D-17-17)6bdd	31° 58' 58.460" N	110° 38' 48.162" W	Reach 2 Spring
(D-18-16)32bbc	31° 49' 39.928" N	110° 44' 14.649" W	Rosemont Spring
(D-18-15)35bdc	31° 49' 36.536" N	110° 47' 9.231" W	Ruelas Spring
(D-18-16)17acc	31° 52' 12.699" N	110° 43' 42.019" W	SC-2 Spring
(D-18-16)16ccc	31° 51' 44.903" N	110° 43' 11.500" W	Scholefield Spring (SC-1)
(D-18-15)13aab	N/A	N/A	SS-2
(D-19-15)1bbb	31° 49' 1.274" N	110° 46' 20.432" W	SW
(D-18-15)12dba	31° 52' 55.598" N	110° 45' 37.184" W	Sycamore Spring

[1]Escondido (Reach 3) Spring is also currently sampled by Pima Association of Governments (PAG)

[2]Seepage from McCleary Dam; not a naturally occurring spring site

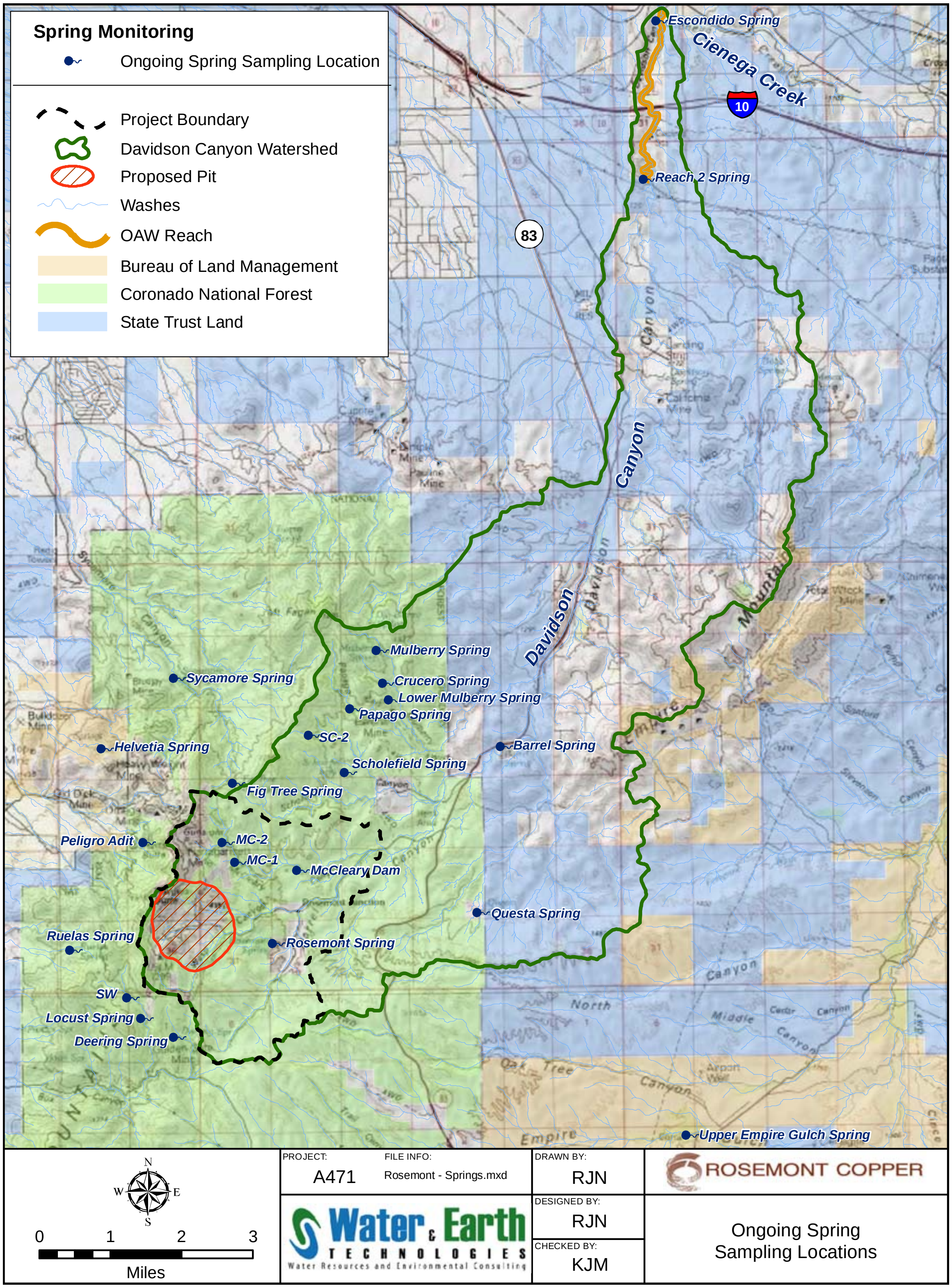

Figure 2. Ongoing Spring Sampling Locations

1.3. Existing Water Quantity Data

Measurements of spring discharge are included in the current monitoring programs conducted by PAG and Rosemont. PAG monitoring also includes measurement of baseflow in Cienega Creek using flowmeters during baseflow conditions (PAG, 2009). Various studies have been completed to determine diurnal and seasonal variations in flow, as well as to correlate precipitation and groundwater levels in wells with baseflow (PAG, 1998). In addition, a study has been completed using water chemistry and stable isotope analysis to estimate Davidson Canyon's contribution to baseflow quantity in Cienega Creek (PAG, 2003). Information included in previous studies indicates that flow from springs is highly variable (PAG, 1998).

Existing data also show that stormwater flows in the Davidson Canyon watershed have been temporally and spatially highly variable. Flow measurements at the recommended stormwater monitoring stations as part of this Plan are expected to follow this pattern, with discharges that span the entire length of Barrel and Davidson Canyons likely to occur only following substantial precipitation events. Discharge data for stormwater flows are available from United States Geological Survey (USGS) and Pima County Regional Flood Control District (PCRFCD) gages.

Two (2) USGS gages have measured stage in the regional stream monitoring area (shown on Figure 1). Historical peak flow measurements exist for both of these USGS gages. An historic USGS gage located in Davidson Canyon operated from 2/1/1968 to 9/30/1975. Data from this gage show the irregular nature of flow in Davidson Canyon, with only twenty-eight percent (28%) of days in the daily data record having non-zero daily average flows. This discontinued gage site was at the lower end of Davidson Canyon, upstream of the Interstate 10 bridges (09484590, Davidson Canyon Wash near Vail, Arizona:

http://nwis.waterdata.usgs.gov/az/nwis/dv/?site_no=09484590&agency_cd=USGS&referred_module=sw)

A new gage was installed in Barrel Canyon by the USGS with cooperative funding provided by Rosemont. This USGS gage measures stage in Barrel Canyon below the confluences with Wasp, McCleary, and Scholefield Canyons, and upstream of the confluence with Davidson Canyon. The gage is located at the State Route 83 (SR 83) highway bridge (Figure 3). Stage is measured by a pressure transducer (PT) mounted under the bridge and a sonic or radar sensor mounted to the upstream side of the double span bridge. A tipping bucket rain gage is installed in the instrument enclosure by the roadway. A cable installed just upstream of the bridge facilitates manual discharge measurement with a flowmeter without wading to measure the entire flowing width of the channel during high flow events, and a staff gage is mounted to the upstream bridge abutment.

Daily average flow data from this gage (09484580) demonstrate the irregular nature of flows in Barrel Canyon. This gage has operated daily since January 23, 2009, and roughly only two percent (2%) of days in the period of record show non-zero daily average flows. Although persistent surface water expression may occur farther downstream at in-channel springs within Barrel Canyon, hydrologic events generating non-zero gage flows are infrequent and of short duration. The SR 83 highway bridge gage in Barrel Canyon is maintained by the USGS Water Resources Division, Arizona District Office. Discharge estimates are reported on-line for the gage:

http://waterdata.usgs.gov/az/nwis/uv?cb_00060=on&cb_00065=on&cb_00045=on&format=html&period=7&site_no=09484580.

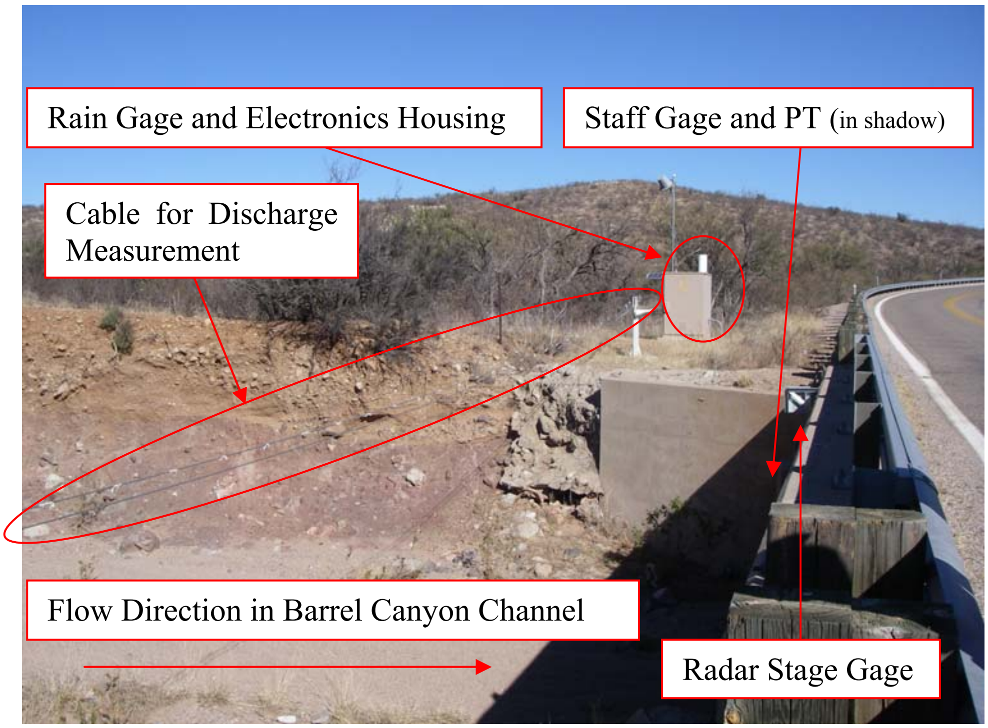

Figure 3. The USGS Gage on Barrel Canyon at SR 83 Highway Bridge (BC-2-SW)

The PCRFCD has real-time flow and precipitation stations throughout the county. Two stations are located within the Davidson Canyon area: Station 4310, Davidson Canyon at the I-10 Bridge is located at 3,448 ft amsl and measures precipitation and stage in Davidson Canyon. Station 4320 Empire Peak is located at 5,587 ft amsl and measures precipitation only. The flood control station data are online on the Arizona Flood Warning and Drought Monitoring website; however, data are real-time only.

http://data.afws.org/sui/siteDetail.aspx?dbNm=alert&statn_id=4310

http://data.afws.org/sui/siteDetail.aspx?dbNm=alert&statn_id=4320

Locations of stations 4310 and 4320 are presented on Figure 4 (PCRFCD, 2012, http://data.afws.org/sui/contentView.aspx?DT=2&KW=Precip_WS_SantaCruz_Pantano)

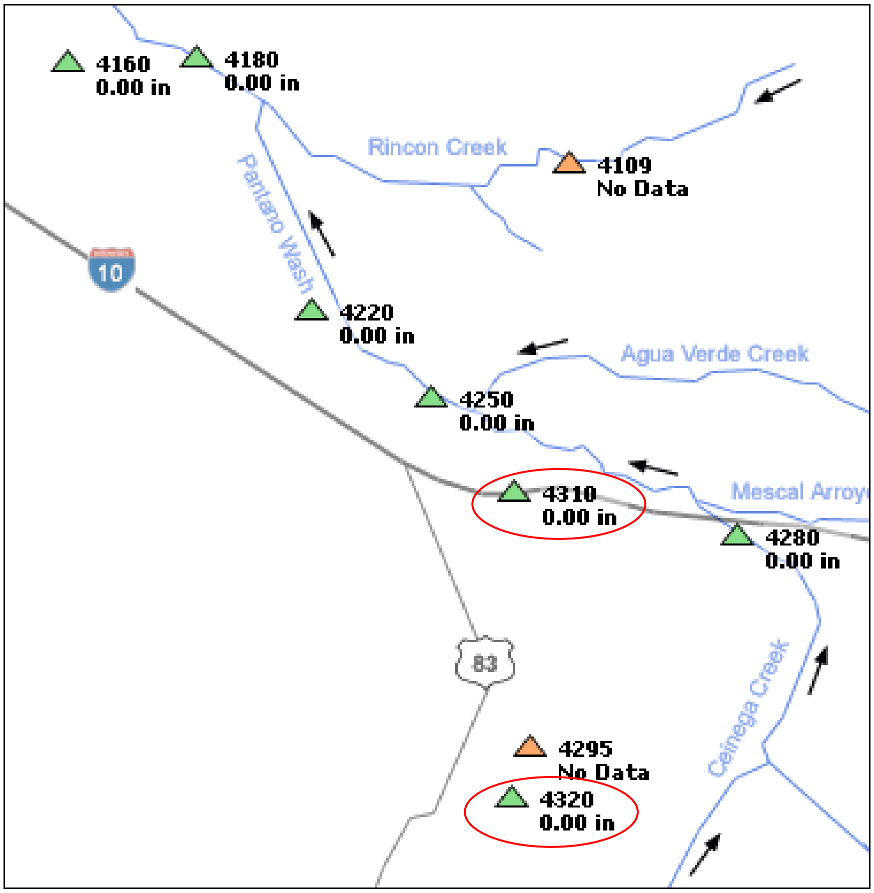

Figure 4. Location Map of PCRFCD Stations Measuring Flow and Precipitation in Davidson Canyon

A summary of current monitoring is presented in Table 5. A summary of data that were historically collected is presented in Table 6.

Table 5. Summary of Current Monitoring in Davidson Canyon Watershed Area

Location	What is Monitored	Responsible Agency
Pit Area	Precipitation, evaporation	Rosemont Copper
Empire Peak (near center of Davidson Canyon watershed)	Precipitation	PCRFCD
Davidson Canyon at I-10	Stage, precipitation	PCRFCD
24 stations within Davidson Canyon	Spring water quality	Rosemont Copper
7 Stations in Project area	Stormwater quality	Rosemont Copper
Barrel Canyon at SR 83 (USGS gage 09484580)	Real time and daily average discharge, precipitation	USGS
Davidson Canyon and Cienega Creek	Baseflow quantity and quality	PAG
Davidson Canyon and Cienega Creek	Spring flow quantity and quality	PAG

Table 6. Additional Historical Monitoring in Davidson Canyon Watershed

Location	What Was Monitored	Responsible Agency
Barrel Canyon at SR 83 (USGS gage 09484580)	Peak flow and daily average discharge	USGS
Near downstream end of Davison Canyon (discontinued USGS gage 09484590)	Peak flow and daily average discharge	USGS

2. Monitoring Purpose and Objective

The purpose of regional stream surface water monitoring by Rosemont is to credibly establish baseline watershed health and quantify water resource conditions throughout the Davidson Canyon watershed and, through continued monitoring, to detect potential impacts due to the Project and differentiate mine-related impacts from impacts associated with other activities in the watershed. Because watersheds encompass a broad ecosystem, including both upland and riparian habitats, their health is dependent upon complex dynamics. Watershed health is assessed using measurable attributes that are indicative of comprehensive watershed conditions. This Plan recommends monitoring of surface water hydrology, which includes water quality and water quantity, as well as indicators of watershed health for the Davidson Canyon watershed. Surface water monitoring under this Plan includes routine monitoring of spring discharges as well as the collection and analysis of samples captured during storm runoff events by samplers deployed in the ephemeral channels. Monitoring indicators of watershed health is also recommended to determine baseline values and detect changes in the health of riparian areas. Potential changes include: land use changes or development, hydrograph alteration, outfall discharges, water withdrawals, and channel alterations.

Evaluating potential surface water/groundwater interactions is integral to characterizing hydrologic conditions in Davidson Canyon watershed. Therefore, this Plan has been coordinated with a proposed Davidson Canyon Groundwater Monitoring Plan so that spring monitoring data are compatible with groundwater monitoring data. Rosemont and PAG already monitor regional springs. Ongoing routine monitoring of spring flow quantity and quality will provide data describing average (mean) values over time including seasonal variations, long-term trends, and correlations between related data variables. Analysis of concurrent precipitation and well monitoring data will allow relationships to be developed between rainfall, recharge, spring flow, and water quality.

This Plan has been coordinated with ongoing Project Site Stormwater Monitoring program conducted by Rosemont. The purpose of Project Site Stormwater Monitoring program is to supply data conducive to the assessment of compliance with regulatory requirements, including an Arizona Pollutant Discharge Elimination System (AZPDES) permit. Determining the requirements for Project Site Stormwater Monitoring program associated with an AZPDES permit is outside of the scope of this Plan. However, data associated with the location selected to represent the downstream extent of the Project disturbance will be important to the analysis of regional stormwater monitoring, and so a dual-purpose station is recommended at the Compliance Point Dam (C.P.D.) location that is already monitored by Rosemont. The physical location of the C.P.D may move as it is defined by the details of the final mine alternative, but the location of the C.P.D. will be directly below the disturbance area, above the influence of any other tributary wash inflows. This Plan expands stormwater monitoring to include monitoring locations downstream of the Project area to better characterize regional stormwater runoff quantity and quality. The recommended monitoring locations are on land owned by the Arizona State Trust or Pima County. No privately owned land must be accessed to implement this Plan. For surface water quality characterization, total recoverable metals will be monitored in addition to the parameters that are monitored for spring and well samples.

This Plan has also been developed in coordination with the Groundwater Monitoring Plan for the region (Engineering Analytics, 2012). Measurements of groundwater levels and groundwater quality are designed to be co-located at many of the surface water monitoring stations outlined in this Plan. Groundwater monitoring wells installed in the Davidson Canyon stream channel alluvium are intended to quantify the short-term water-level fluctuations due to storm-water runoff events. The combined continuous surface water and groundwater data collection will facilitate the quantification of surface and groundwater interaction mechanisms throughout the Davidson Canyon watershed. Analysis of these data can be used to quantify baseflow contribution to washes from the alluvial aquifer below the channel bed.

2.1. Precipitation Monitoring

Since the majority of the channels in the study area are typically without surface flow except at springs, scheduled surface water sampling is not feasible. Monitoring in response to flow events is recommended, with surface water samples captured by sample bottles deployed in the ephemeral channel. These samples will be available for laboratory analysis only when a flow event has occurred. Collection of the samples will be triggered by the detection of a precipitation or flow event of sufficient magnitude to potentially result in the capture of runoff samples. Precipitation monitoring is also a component of the Plan so that collection of stormwater samples can be triggered by the detection of a precipitation event.

Precipitation within the Barrel Canyon watershed is currently measured at two rain gages: at the USGS gage at SR 83 on Barrel Canyon, and at the Rosemont weather station in the Project area, at the upstream end of Barrel Canyon. The USGS gage in Barrel Canyon is instrumented to provide real-time precipitation data and is used currently to trigger event-driven sample collection. Real time, provisional, 15-minute tabular data for stage, discharge and precipitation are telemetered and available online from the USGS National Water Information System (NWIS) online. The NWIS webpage includes a Water Alert functionality, to send an email or text when a discharge event of a pre-defined magnitude is measured. A precipitation event alert is not available from the Water Alert function for this gage. Any personnel responding to storm events for sample collection must sign up for this Water Alert function for the Barrel Canyon gage. For Project Site Stormwater Sampling, the current sample collection trigger is 0.1 inches of precipitation captured by the USGS gage (Rosemont, 2012c). An event of this magnitude has been observed to cause enough flow in washes in the Project area to fill the lowest channel-bed mounted samplers, even though the Barrel Canyon gage may not register a change in stage. During office hours, Rosemont staff at the Project area can be called to confirm storm runoff. After hours, nights and weekends, the on-site security contractor can be called for runoff confirmation.

Data from the weather station in the Project area are currently saved on a data logger that must be downloaded by visiting the station. For real-time data access, this weather station would have to be upgraded with radio telemetry and a base station configuration, or with satellite telemetry via the internet. If the Project area weather station was equipped to provide real-time precipitation data, these data could be checked to confirm precipitation at the upstream end of the Barrel Canyon watershed. However, the USGS gage has historically been sufficient for triggering stormwater sample collection at the Project site.

The rainfall event of 0.1 inch of precipitation to trigger sample collection at the Barrel Canyon gage will be used as a starting point for predicting channel flow farther downstream in Davidson Canyon. Spatial variations in rainfall amounts are likely throughout Davidson Canyon. Observations of downstream flow events and correlation to other precipitation measurements throughout Davidson Canyon may be required to fine tune the initiation of sample collection. The PCRFCD stations in Davidson Canyon and Empire Peak (Figure 4) may provide real time precipitation data that can be used to trigger surface water sampling.

Because precipitation and runoff at a monitoring location can also be associated with a small, localized rainstorm, alerting monitoring personnel to mobilize for sample collection using only rainfall detection at select gage locations is prone to some error. Therefore, sampling personnel must check for samples even though a percentage of the trips to the site will find that no water sample was collected. In addition, it is important to check the sample bottles if flow data or visual evidence suggests that a runoff event occurred, even though the precipitation threshold triggering sample collection was not reached. If the bottles are filled during a first event and not replaced prior to a second event, then it is impossible to determine which event filled which bottles and water quality data will be compromised.

2.2. Water Quality Sampling

Surface water sampling will continue to determine the characteristics of water discharged from springs. Surface water sampling will also include characterization of the water quality of runoff from storm events in stream channels. Water quality will be characterized by field measurement of small set of constituents and samples will be collected for complete analysis at an analytical laboratory.

The measurements proposed for the aquifer protection permit are shown in Table 7 (from Draft Rosemont Aquifer Protection Permit P-106100, ADEQ, 2012). Although this document is under review, the list of constituents is not anticipated to change. Groundwater monitoring at Point of Compliance (POC) wells is proposed to be performed on a quarterly basis with a subset of constituents and on a biennial basis with the complete set of constituents. Currently spring and well sampling is performed on a monthly basis.

Table 7. Ambient Groundwater Monitoring Water-Quality Constituents for POC Wells

Depth to Water (feet)	Potassium [1]	Nickel [1]
Water Level Elevation (feet amsl)	Sodium [1]	Selenium [1]
Temperature – field (ºF)	Magnesium [1]	Thallium [1]
pH – Field & Lab (S.U.)	Aluminum [1]	Zinc [1]
Field Specific Conductance (µmhos/cm)	Antimony [1]	Molybdenum [1]
Total Dissolved Solids – Lab	Arsenic [1]	Gross Alpha Particle Activity (pCi/L) [2]
Total Alkalinity	Barium [1]	Radium 226 (pCi/L)
Bicarbonate	Beryllium [1]	Radium 228 (pCi/L)
Carbonate	Cadmium [1]	Uranium-Isotopes (pCi/L) [3]
Hydroxide	Chromium [1]	Carbon Disulfide
Sulfate	Cobalt [1]	Calcium [1]
Chloride	Copper [1]	Mercury [1]
Fluoride	Lead [1]	Uranium (total)
Nitrate + Nitrite	Manganese [1]	Iron (total)

Table 7. (Continued)

[1] Metals must be analyzed as dissolved metals, unless otherwise specified.
[2] The adjusted gross alpha particle activity is the gross alpha particle activity, including radium 226, and any other alpha emitters, if present in the water sample, minus radon and total uranium (the sum of uranium 238, uranium 235 and uranium 234 isotopes). The gross alpha analytical procedure (evaporation technique: EPA Method 900.0) drives off radon gas in the water samples. Therefore, the Adjusted Gross Alpha should be calculated using the following formula: (Laboratory Reported Gross Alpha MINUS Sum of the Uranium Isotopes).
[3] Uranium Isotope activity results must be used for calculating Adjusted Gross Alpha.
All concentrations are in milligrams per liter (mg/L), unless otherwise specified.

Data source: Draft Rosemont Aquifer Protection Permit P-106100, ADEQ, 2012

A proposed list of constituents for water-quality analysis of surface water is presented in Table 8. This list is consistent with the current Project Site Stormwater Monitoring program analysis currently underway by Rosemont (Rosemont, 2012b). The constituent list analyzed is consistent between groundwater wells (Engineering Analytics, 2012), springs and stream channels, except that for samples taken from streams and washes the analysis of dissolved and total recoverable constituents is required. For springs, only dissolved constituent analysis is required. Stream channel water quality also includes the measurement of sediment concentration and the calculation of sediment loading. The list of constituents to be measured includes indicator parameters and parameters for comparison with Arizona surface water-quality numeric standards. Every constituent for which there is a numeric standard applicable to the OAW reach in Davidson Canyon (Table 2) is included in the proposed constituent list for this Plan (Table 8).

Environmental isotope monitoring is recommended for springs and surface water for consistency with the regional groundwater monitoring (Engineering Analytics, 2012). Stable isotopes have the potential to identify similar waters, and hydraulic connection between the alluvium and stream-channel

Table 8. Proposed Constituent List for Measurement and Analysis for Streamflow

Constituent	Detection Limit Required	EPA Method for Analysis accepted by ADEQ (2004, Appendix C)
Field Measurements		
Field Water Temperature	0.1 °C	-
Field Specific Conductance	1 µS/cm	-
Field Turbidity	1 NTU	-
Field pH	0.1 units	-
Field Dissolved Oxygen (DO)	0.1 mg/L	-
Laboratory Analysis		
Temperature	0.1 °C	-
DO	0.1 mg/L	-
Biochemical Oxygen Demand (BOD)	1 mg/L	-
Carbonaceous Biochemical Oxygen Demand (CBOD)	1 mg/L	-
pH	0.1 units	-
Specific conductance at 25° C	1 µS/cm	-
Total Alkalinity	1 mg/L	EPA 305
Hardness as $CaCO_3$	1 mg/L	EPA 130.2
Turbidity	1 NTU	EPA 180.1
Alkalinity Bicarbonate (as $CaCO_3$)	20 mg/L	-
Alkalinity Carbonate (as $CaCO_3$)	20 mg/L	-
Alkalinity Hydroxide (as $CaCO_3$)	20 mg/L	-
Bicarbonate (dissolved)	20 mg/L	-
Carbonate (dissolved)	20 mg/L	-
Hydroxide (dissolved)	20 mg/L	-
Calcium (dissolved)	4 mg/L	EPA 200.7/215.1
Carbon Disulfide	-	-
Chloride (dissolved)	2.5 mg/L	EPA 325.2
Fluoride (dissolved)	0.5 mg/L	EPA 340.2
Potassium (total)	2 mg/L	EPA 258.1
Potassium (dissolved)	0.5 mg/L	EPA 258.1
Silica	0.5 mg/L	-
Sodium (total)	2 mg/L	EPA 200.7/273.1
Sodium (dissolved)	0.5 mg/L	EPA 200.7/273.1
Sulfate	3 mg/L	EPA 375.3
Sulfide	0.1 mg/L	EPA 375.4
Total Dissolved Solids	10 mg/L	-
Total Suspended Solids	10 mg/L	-
Total Settleable Solids	10 mg/L	BLS-256

Table 8. (Continued)

Constituent	Detection Limit Required	EPA Method for Analysis accepted by ADEQ (2004, Appendix C)
Nutrients		
Total Kjeldahl Nitrogen	0.1 mg/L	EPA 351.2
Nitrate-Nitrite (as N)	0.1 mg/L	EPA 353.2
Nitrate (as N)	0.1 mg/L	EPA 353.2T
Nitrogen Ammonia (as N)	0.1 mg/L	EPA 350.3
Metals		
Aluminum (total)	1 mg/L	EPA 202.1
Aluminum (dissolved)	0.1 mg/L	EPA 202.1
Antimony (total)	1 µg/L	EPA 204.2
Antimony (dissolved)	1 µg/L	EPA 204.2
Arsenic (total)	10 µg/L	EPA 206.2
Arsenic (dissolved)	10 µg/L	EPA 206.2
Barium (total)	0.1 mg/L	EPA 200.7/208.1
Barium (dissolved)	0.1 mg/L	EPA 200.7/208.1
Beryllium (total)	1 µg/L	EPA 210.2
Beryllium (dissolved)	1 µg/L	EPA 210.2
Boron (total)	50 µg/L	EPA 200.7/213.3
Boron (dissolved)	50 µg/L	EPA 200.7/213.3
Cadmium (total)	1 µg/L	EPA 213.2
Cadmium (dissolved)	0.25 µg/L	EPA 213.2
Total Chromium (total)	10 µg/L	EPA 218.2
Total Chromium (dissolved)	10 µg/L	EPA 218.2
Cobalt (total)	10 µg/L	EPA 219.2
Cobalt (dissolved)	10 µg/L	EPA 219.2
Copper (total)	10 µg/L	EPA 220.1
Copper (dissolved)	1 µg/L	EPA 220.1
Iron (total)	1 mg/L	EPA 200.7/236.1
Iron (dissolved)	0.1 mg/L	EPA 200.7/236.1
Lead (total)	10 µg/L	EPA 239.2
Lead (dissolved)	0.5 µg/L	EPA 239.2
Magnesium (total)	10 mg/L	EPA 200.7/242.1
Magnesium (dissolved)	10 µg/L	EPA 200.7/242.1
Manganese (total)	0.1 mg/L	EPA 200.7/243.1
Manganese (dissolved)	10 µg/L	EPA 200.7/243.1
Mercury (total)	1 µg/L	EPA 245.1
Mercury (dissolved)	0.01 µg/L	EPA 245.1
Molybdenum (total)	10 µg/L	EPA 246.2
Molybdenum (dissolved)	0.01 µg/L	EPA 246.2
Nickel (total)	10 µg/L	EPA 249.1
Nickel (dissolved)	10 µg/L	EPA 249.1
Selenium (total)	1 µg/L	EPA 200.9
Selenium (dissolved)	1 µg/L	EPA 200.9
Silver (total)	5 µg/L	EPA 272.2
Silver (dissolved)	0.5 µg/L	EPA 272.2
Strontium (dissolved)	0.5 mg/L	-
Thallium (total)	0.5 µg/L	EPA 279.2
Thallium (dissolved)	0.5 µg/L	EPA 279.2

Table 8. (Continued)

Constituent	Detection Limit Required	EPA Method for Analysis accepted by ADEQ (2004, Appendix C)
Titanium (total)	1 mg/L	-
Titanium (dissolved)	20 μg/L	-
Vanadium (total)	10 μg/L	EPA 289.1
Vanadium (dissolved)	10 μg/L	EPA 289.1
Zinc (total)	30 μg/L	EPA 289.1
Zinc (dissolved)	30 μg/L	EPA 289.1
Radiological Constituents		
Gross Alpha Particle Activity (pCi/L)	1 pCi/L	600-00 02, EPA 900.0
Radium 226 (pCi/L)	0.3 pCi/L	EPA 903.1
Radium 228 (pCi/L)	0.3 pCi/L	EPA 904
Uranium (total)	1 μg/L	00-07
Uranium-isotopes (pCi/L)	0.03 pCi/L	-
Isotopic Constituents		
Constituent	**Constituent Concentration Limit**	**Method of Analysis**
Nitrogen (^{15}N)	1 mg/L	Continuous-flow gas-ration mass spectrometer
Oxygen ($\delta^{18}O$)	N/A	Gas-source isotope ratio mass spectrometer
Deuterium (^{2}H or D)	N/A	Gas-source isotope ratio mass spectrometer
Carbon (^{13}C and ^{14}C)	10 mg/L	Liquid scintillation spectrophotometer
Sulfur (^{34}S)	100 mg/L	Continuous-flow gas-ratio mass spectrometer

Table 8 represents a complete list of analytical tests. The analysis methods indicated are methods recommended by the ADEQ to use where possible. Required detection limits indicated for each constituent are intended to detect any violations of the strictest applicable numeric standard. Many numeric standards are based on the hardness of the source water. Therefore, detection limits and corresponding analysis methods should be reviewed as data are collected and comparison made with standards. Analysis methods, detection and quantification limits are subject to change during monitoring. A complete analysis of samples should be performed in the initial stages of monitoring to provide a complete picture of background conditions. Based on the initial water quality results, the frequency of analysis of some constituents may be reduced. Toxins and process-specific chemicals may be added to the suite of constituents in the future.

Implementing this Plan will involve the development of a Sampling Analysis Plan (SAP) and of a Quality Assurance Plan (QAP) consistent with ADEQ (2004) guidelines. The details of these reports will be formatted to the specifications of ADEQ (2004). The SAP describes the overall sampling program design and description of why, where, when and what environmental measurements are to be made. Details of exact equipment used for monitoring is required in the SAP. ADEQ rules for obtaining sediment samples (See footnote 2 on Table 2) are not designed for sampling in ephemeral streams and are inconsistent with the sample collection methods recommended in this Plan. Otherwise, the field measurement and sampling procedures and laboratory analytical procedures described in the SAP will comply with ADEQ requirements to ensure the collection of credible data. These methods are consistent with those implemented by the Forest Service and Pima County. Procedures for filtering and preserving samples to be analyzed for dissolved concentrations will be outlined in the SAP.

The QAP discusses the details of the sampling protocol for field collection and laboratory analysis. Consistent labeling, documentation and chain-of-custody procedures for sample shipping will be specified. The inclusion of sample duplicates at a standard rate and blanks (provided by the analytical lab) is anticipated to comply with all quality assurance and quality control (QA/QC) requirements. Samples will be preserved as required for their intended analysis. A laboratory will be chosen for sample analysis that satisfies the acceptable criteria outlined by ADEQ. A laboratory list is presented in ADEQ (2004) Appendix F. The laboratory chosen for sample analysis will provide the laboratory QAP that will be incorporated into the Rosemont QAP. Standard QA/AC procedures, including calculating cation/anion balances for samples, will be specified.

This Plan has been developed to support the collection of data that can be assessed and interpreted with reasonable confidence in practice. However, natural variability in water quality data are likely and will be coupled with variability in sampling protocols that may be required to actually collect data in this ephemeral environment. Whether or not samples have been captured by the sampler bottles, it may be beneficial to sample any surface water that may be present when the sampling sites are visited to collect bottles. Surface water can sometimes be found throughout the stream network in residual pools that may persist after flow from a runoff event subsides. Water-quality sampling from these water sources may provide valuable data for analyzing the potential surface and groundwater system interactions in the watershed. Metadata relevant to each sample (when, where, and how it was collected) should be carefully recorded, especially when departures from standard sampling protocols are required to obtain data.

2.3. Water Quantity Monitoring

Instrumentation to measure the stream discharge during runoff events as well as the discharge associated with each water quality sample, is recommended at each water quality monitoring location. Water quantity measurements are co-located at water quality sampling stations to allow for the computation of constituent loads carried by stream flow and to correlate flow to water quality data. Water quantity data are vital given the potential impact to water quality resulting from changes in quantity, as well as the potential impact to riparian vegetation and habitat. Measurement of water quantity and quality at different stations along the length of Davidson Canyon is also valuable in understanding the mechanisms driving surface water hydrology and potential groundwater/surface water interactions. The flow data may be used to determine water balances between stations, providing insight into losing and gaining reaches and estimates of recharge. Therefore, stations are located where they can provide flow estimates as well as water quality sample data.

The SR 83 highway bridge is the only existing structure capable of facilitating flow quantification, and natural hydraulic controls are not typical of the area. All of the remaining recommended monitoring stations are located in natural channel reaches, and theoretical ratings for these sites can be developed based upon hydraulic modeling, using surveyed channel cross sections to characterize the stream reach at each monitored location. The historic, non-operational USGS gage near the downstream end of Davidson Canyon (09484590, Davidson Canyon Wash near Vail, Arizona) was also designed to measure flow in a natural channel.

2.4. Watershed Health Monitoring and Assessment

The natural characteristics and functions of channel and riparian areas are related to interdependent factors, including climate and hydrology, soils and vegetation, physiography and morphology. Natural variations including droughts and high discharge events can impact the physical characteristics of watersheds, channels and riparian areas. Human activities within the watershed can impact channel characteristics, potentially changing important attributes including connected floodplains, vegetation, habitat composition and connectivity, substrate and vegetation diversity, and geomorphic stability and sediment balance. These impacts occur as a result of land use changes (including disturbances, cultivation and development of impervious surfaces, vegetation management, exotic species, grazing) and changes to runoff hydrograph characteristics (including land use changes, water withdrawals, drainage network and channel alterations, and outfall discharges) (City of Portland, 2005).

Current land uses within the Davidson Canyon watershed include agricultural uses (orchard and winery), mining/quarries, ranching (grazing, stock ponds and corrals), homes, and recreation. Development activities including the Project and two quarry operations have been proposed. Existing development and future changes to upland areas of the watershed have the potential to impact not only water quantity and quality, but other desirable characteristics of riparian areas. In addition to water quantity and quality, watershed health monitoring will determine baseline values and detect changes in measurable attributes of regional channels that are “indicators” of the broader watershed health, providing a means to detect changes to desirable channel attributes caused by watershed alterations. Baseline monitoring data will describe the kinds of changes that occur in channel morphology and ecology under current conditions within the watershed given variations in precipitation and flow. Continued monitoring will determine if watershed impacts are exceeding the resilience of the channel system, resulting in deterioration of desirable channel characteristics.

Recommended monitoring includes the establishment of photo documentation points, vegetation monitoring and measurement of physical attributes of channel reaches that are indicators of watershed health, as shown in Table 9 (USDA, 1999). Some of the metrics for measuring watershed health developed for application to perennial streams will indicate that baseline watershed health in this ephemeral system is “poor” due to the harsh climate, in spite of the valuable characteristics and functions served by the riparian areas in this arid environment. The purpose of applying the metrics is to detect changes over time rather than to compare the Davidson Canyon values to optimal or desirable values for watersheds in wetter climates.

Table 9. Watershed Health Indicator Evaluation Matrix

Indicator	Excellent 0-0.1	Good 0.1-0.4	Fair 0.4-0.7	Poor 0.7-1.0
Substrate	>50% boulder, cobble or gravel substrate	25-50%	10-25%	<10%
Embeddedness	<25%	25-50%	>50-75%	>75%
Width/Depth	<7	8-15	16-25	>25
Bank Stability	>90% stable	70-90%	50-70%	<50%
Buffer Width	>18m	12-18m	6-12m	<6m
Vegetation Diversity	>10 species	5-10 species	3-5 species	<3 species
Structural Diversity	3 height classes	2 height classes	1 height class	Sparse 1 height
Percent Cover	>90%	70-90%	50-70%	<50%
Canopy Shading	Mixed sun/shade	Sparse canopy	Mostly sun	No shade
Data source: USDA, 1999				

Substrate. Substrate diversity ensures that void spaces necessary for macroinvertebrate habitat are available. The zig zag procedure (USDA, 1995) or the random walk method (USDA, 1999) for characterizing pebble counts are recommended to characterize the size and variability of material in channel bottoms and detect changes after storm events. Substrate composed of greater than 50% sand or smaller particles is considered "poor" habitat.

Embeddedness and Channel Width/Depth Ratio. Deeply embedded low flow channels disconnect the channel from its floodplain, resulting in perpetuating scour because runoff from storm events is concentrated in relatively deep, high velocity flows rather than shallow, slower overbank flow. Stable values for measurements of embeddedness and channel width/depth ratio are indicative of bed (longitudinal) stability and sediment transport balance. Routine watershed health monitoring will include channel cross section measurements at designated locations. At watershed health monitoring locations that are co-located with stormwater monitoring stations, channel cross section surveys are recommended for the development of hydraulic ratings. These surveys will provide 3 to 5 detailed representative cross sections in each reach that can be monitored over time to detect if cycles of aggradation and degradation maintain the fundamental physical integrity of the channel or if a trend towards undesirable changes in morphology is underway.

Bank Stability. Stable, low values for the percentage of the bank within a monitored reach that is vertical and unvegetated or visibly unstable and eroding are indicative of bank (lateral) channel stability and sediment transport balance.

Floodplain/Riparian Buffer Width and Inundation Frequency. Wide shallow floodplains hydraulically connected to the bankful channel provide habitat as well as opportunities for recharge as a result of overbank flow. Routine watershed health monitoring will include measurements of the floodplain and riparian buffer width. At watershed health monitoring locations that are co-located with stormwater monitoring stations, estimates of floodplain inundation frequency can be developed from peak discharge data.

Vegetation Diversity, Structural Diversity, Cover and Canopy. Vegetation diversity is determined by surveying the species occurring in the riparian zone, with excellent habitats exhibiting more than ten (10) species. Structural diversity is important for characterizing habitat values, and the presence of grasses, shrubs and trees (three height classes) is optimal. Vegetation cover percentage is estimated by walking floodplain transects and measuring the relative frequency of bare versus vegetated ground. Optimal canopy shading is a mix of sun and shade, while full sun is poor for habitat. Vegetation mapping at spring locations is possible to detect changes in the distribution or extent of wetland vegetation (sedges), as an indicator of the temporal and spatial extent of subsurface flow.

Evaluation indices, measurement methods and monitoring frequency are subject to change based on initial results. Implementing this Plan would involve the development of a Watershed Health Monitoring Plan, including a description of the monitoring program design and a description of how each environmental measurement will be made and details of the exact equipment used for monitoring, as well as quality control procedures.

3. Recommended Monitoring Network

The recommended monitoring network includes stations located throughout the Davidson Canyon watershed designed to monitor precipitation, stormwater in regional streams and watershed health indicators at stream and spring locations. The locations recommended for monitoring precipitation, stormwater quantity and quality, and those recommended for monitoring watershed health indicators, are described below. Instrumentation for these recommended stations is described in Section 4. Spring locations where baseflow quantity and quality are monitored were described in Section 1.

3.1. Stream Monitoring

Locations selected for monitoring surface water in streams and washes meet three criteria: they lie within the stream system at locations of interest for water quality data, they reside in reaches that are adequate for the development of a hydraulic rating to estimate discharge, and they can be accessed for event-driven sample collection. Eight (8) recommended stations, described in Table 10 and Table 11, are shown conceptually on Figure 5 and mapped on Figure 6. Surface water monitoring stations are indicated with –SW at the end of the station ID.

Table 10. Recommended Stream Station Identifiers and Descriptions

Station ID	Description	Measurements
BC-1-SW[1]	Upstream end of Barrel Canyon, directly below disturbance boundary, at or near the C.P.D.	Precipitation, Flow and Water Quality (Co-located with existing station currently sampled by Rosemont as PSW5)
BC-2-SW	At or near the existing USGS gage 09484580 BARREL CANYON NEAR SONOITA, AZ (SR 83 Highway Bridge)	Precipitation and Flow from USGS data, Water Quality added (Co-located with existing station currently sampled by Rosemont as PSW7)
DC-1-SW	Davidson Canyon flow upstream of Barrel Canyon inflow	Precipitation, Flow and Water Quality
DC-2-SW	Davidson Canyon downstream of Barrel Canyon inflow	Precipitation, Flow and Water Quality
DC-3-SW	Davidson Canyon just above the upstream end of the OAW reach (above Reach 2 Spring)	Precipitation, Flow and Water Quality
DC-4-SW[2]	Davidson Canyon above confluence with Cienega Creek (below Escondido (Reach 3) Spring)	Precipitation, Flow and Water Quality
CC-1-SW	Cienega Creek above confluence with Davidson Canyon	Flow and Water Quality
CC-2-SW	Cienega Creek below confluence with Davidson Canyon	Flow and Water Quality

[1]This location is subject to change depending upon the selected alternative

[2]The recommended station DC-4-SW will describe the downstream conditions in Davidson Canyon surface water designation Reach 4

Table 11. Recommended Stream Station Locations

Station ID	Latitude	Longitude	N UTM ft	E UTM ft
BC-1-SW[1]	31° 50' 47.039" N	110° 42' 27.381" W	11559844.73	1731178.22
BC-2-SW[2]	31° 51' 42.853" N	110° 41' 27.943" W	11565496.84	1736287.21
DC-1-SW	31° 52' 02.284" N	110° 40' 29.347" W	11567474.41	1741332.92
DC-2-SW	31° 52' 12.403" N	110° 40' 30.708" W	11568496.27	1741212.61
DC-3-SW	31° 58' 57.217" N	110° 38' 46.731" W	11609416.62	1750042.18
DC-4-SW	32° 01' 03.161" N	110° 38' 33.991" W	11622142.61	1751097.10
CC-1-SW	32° 01' 07.929" N	110° 38' 29.878" W	11622610.73	1751439.50
CC-2-SW	32° 01' 07.964" N	110° 38' 38.249" W	11622621.65	1750733.94
[1]Co-located with existing station currently sampled by Rosemont as PSW5 [2]Co-located with existing station currently sampled by Rosemont as PSW7				

Approximate locations desirable for precipitation measurement and event-driven surface water monitoring were determined throughout Davidson Canyon watershed (Figure 5). Monitoring locations were selected at specific points of interest or at the upstream and downstream ends of a reach of interest so that the influence of development or of spring or tributary inflows within that reach could be characterized. Precipitation measurement stations are located at least one mile from each other to quantify the spatial variable throughout the watershed. Monitoring is anticipated to detect changes in the flow and water quality associated with these specific points or reaches, and data can be compared to applicable criteria.

Stations are located along Barrel Canyon and along Davidson Canyon to quantify longitudinal changes in flow or water quality. Stations are located downstream of the Project disturbance area (BC-1-SW and BC-2-SW), at the downstream end of major washes (DC-1-SW and DC-4-SW), below confluences (BC-2-SW, DC-2-SW) and at important regulatory boundaries (BC-1-SW and DC-3-SW). Stations DC-3-SW and DC-4-SW are located to bound the OAW reach of Davidson Canyon and quantify water resource parameters in this protected reach. These data can also be used in conjunction with precipitation, spring and well data to evaluate potential surface water/groundwater interactions in Barrel and Davidson Canyons.

Field work was conducted to identify specific locations best suited for monitoring both water quality and water quantity. The recommended sampling stations are located in reaches that are conducive to the development of hydraulic ratings so that discharge can be estimated from measurements of stage. Recommended monitoring sites exhibit a consistent channel gradient, gradually varied channel cross section, and reasonably well-defined channel banks to facilitate the cross section survey and associated hydraulic modeling. Natural stream channels can change due to erosion and deposition during large flow events, and significant changes to the channel cross sectional geometry would require that the rating be revised. For this reason, locations exhibiting good channel stability were preferred, including locations with bedrock exposure.

Finally, station locations must be reasonably accessible for event-driven sample collection, so the road to the station must be passable during or immediately after wet weather. It is expected that these locations can be reached to retrieve sample bottles quickly after flow events. Access roads with few crossings of tributary washes were preferred.

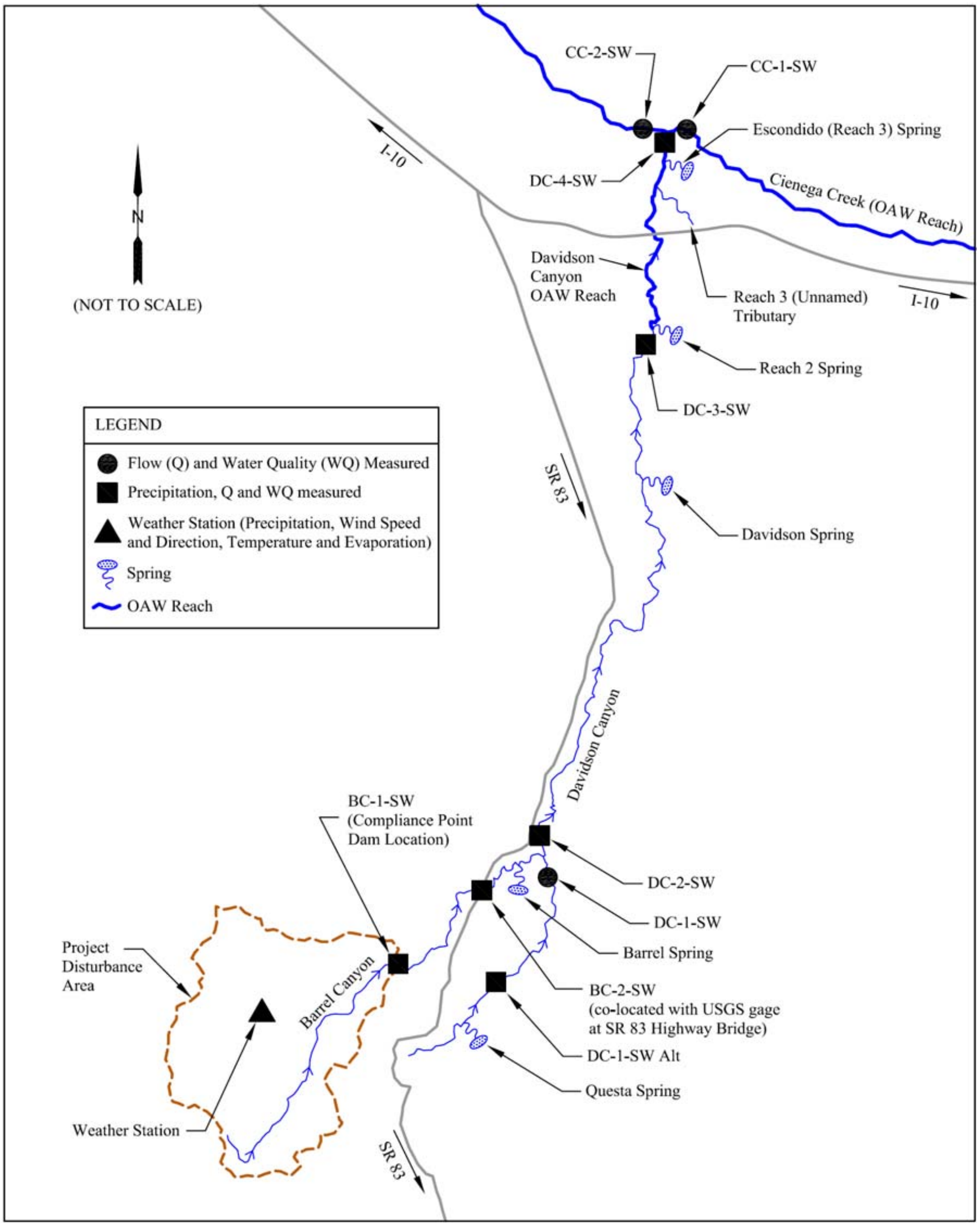

Figure 5. Schematic Showing Recommended Stream Sampling Locations

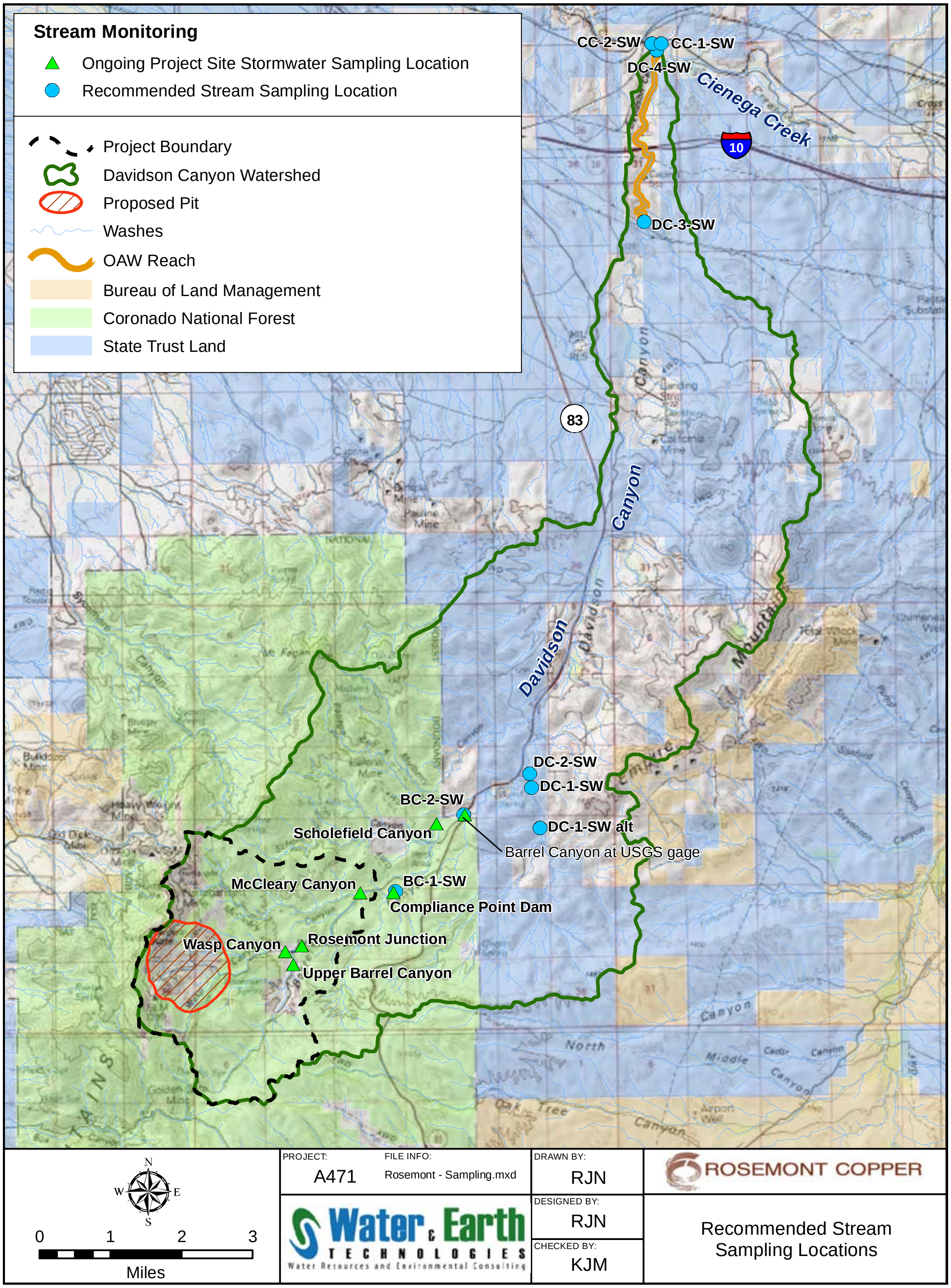

Figure 6. Recommended Stream Sampling Locations

Station BC-1-SW. Station BC-1-SW is sited to characterize precipitation, flow and water quality directly below the disturbance boundary and is co-located with Project Site Stormwater Monitoring Station PSW5 (historic data sampled at this site are indicated with the identifier RP-2) at the location of the C.P.D. During Project operations, this monitored location would provide early detection of any potential changes caused by the Project. When the C.P.D. structure is designed, it is recommended that a flow measurement weir be included directly below the structure to directly measure discharge. There is a road crossing the wash not far upstream of this monitoring site, and vehicle traffic on the road is a variable that could impact water quality samples collected at this location. Vehicle traffic is common in the washes throughout the Project site.

Station BC-2-SW. Recommended regional stream monitoring Station BC-2-SW is co-located with Rosemont Project Site Stormwater Monitoring station PSW7 and also co-located with the USGS gaging station at the SR 83 highway bridge over Barrel Canyon (09484580: Barrel Canyon near Sonoita, Arizona). This combined station characterizes water quality downstream of the Scholefield Canyon confluence with Barrel Canyon. Mounting sample collection bottles to the bridge at graduated stages is recommended at this site.

It is important to characterize water quantity and quality in each channel at the confluence of Upper Davidson and Barrel Canyons. Locating station BC-2-SW at the USGS gage makes use of the precipitation and continuous stage monitoring available there, and is recommended even though the gage lies some distance upstream of Barrel Canyon’s confluence with Upper Davidson Canyon. Discharge measurements at the USGS gage will exclude the inflow from a small portion of the Barrel Canyon watershed including one tributary that reports to the Barrel Canyon channel in the reach above the confluence but below the gage. Data from stations located in Davidson Canyon above Barrel Canyon and in Davidson Canyon below its confluence with Barrel Canyon could be analyzed, using the data from BC-2-SW for calibration and confidence, to quantify the discharge excluded from the measurements at BC-2-SW.

Station DC-1-SW. Two alternatives are suggested for monitoring Upper Davidson Canyon above its confluence with Barrel Canyon. These are described as DC-1-SW and DC-1-SW alt. The purpose of either station location is to characterize precipitation, flow and water quality for runoff from the headwaters area of Davidson Canyon, above the Barrel Canyon inflow. The best station location for this purpose would be as close as possible to the confluence with Barrel Canyon, especially if discharge estimates at this station are used to estimate the missing increment of discharge for station BC-2-SW. DC-1-SW is located immediately above the confluence, where it will monitor the full discharge from Upper Davidson Canyon. However, access and stability issues may prevent the use of this location. Therefore, an alternative location, DC-1-SW alt, was identified. Precipitation measurement instrumentation will only be required if the DC-1-SW alt location is chosen.

A road crossing coincides with the confluence and could aid access to DC-1-SW. However, Upper Davidson Canyon is on the far side of Barrel Canyon and collecting the sample bottle would require crossing the Barrel Canyon channel when accessing the site from SR 83. Depending upon how fast flows recede, this may be feasible. Also, DC-1-SW is not ideal for developing a stable hydraulic rating, because the channel banks at this location are shallow and entirely composed of sand. The cross section could be susceptible to changes from erosion and deposition during high flow events that would require the rating to be periodically adjusted.

Because of the challenges associated with monitoring at DC-1-SW, location DC-1-SW alt was explored. DC-1-SW alt lies upstream of two tributaries, which would not be included in the total contribution to both discharge and water quality characteristics from Upper Davidson Canyon to the confluence, thereby introducing some error into loading calculations. However, this may be easier to access and more stable for rating development.

Station DC-2-SW. Station DC-2-SW was selected to measure precipitation and characterize flow and water quality for the combined waters of upper Davidson Canyon and Barrel Canyon. This station will also provide data to describe flow and water quality above development and home sites, which are located between the Barrel Canyon confluence and the OAW section of Davidson Canyon. The sampling site is located downstream of the confluence to ensure complete mixing of flow from Barrel Canyon and upper Davidson Canyon. Precipitation for the Barrel and Davidson Canyon confluence area will be measured by the rain gage at DC-2-SW. Access to this station is via the road to the Davidson and Barrel Canyon confluence and a walk of less than 1000 ft along the left bank of Davidson Canyon.

Station DC-3-SW. Station DC-3-SW will characterize precipitation, flow and water quality in lower Davidson Canyon, below development. The site is upstream of the Reach 2 Spring. Data from this station will characterize stormwater conditions flowing into the OAW reach. Precipitation is measured here to quantify rainfall in lower Davidson Canyon. Access to this station is via a gravel road through the Cienega Creek Natural Preserve. A four wheel drive vehicle may be required to access the area near Davidson Canyon following a storm event. The walk of less than 1000 ft downstream along Davidson Canyon is required to access the station.

Station DC-4-SW. Station DC-4-SW is sited to provide precipitation, flow and water quality measurements at the downstream end of Davidson Canyon, immediately upstream of the confluence with Cienega Creek. Precipitation in the Davidson Canyon Cienega Creek confluence area is measured at DC-4-SW. A portion of the Arizona trail provides access from the Gabe Zimmerman trailhead to this site.

Station CC-1-SW. Station CC-1-SW is sited to provide flow and water quality measurements in Cienega Creek immediately upstream of the confluence with Davidson Canyon. This station is designed to characterize Cienega Creek flow and water quality upstream of the influence of Davidson Canyon. This station is located within ¼ mile of DC-4-SW. Access to this site is via the Arizona trail, or the Marsh Station Road Cienega Creek overlook.

Station CC-2-SW. Station CC-2-SW is sited to provide flow and water quality measurements in Cienega Creek immediately downstream of the confluence with Davidson Canyon. This station is located below the complete mixing of Davidson Canyon inflow with Cienega Creek waters, and is designed to characterize the flow and water quality in Cienega Creek downstream of the influence of Davidson Canyon. This station is located within ¼ mile of CC-1-SW and DC-4-SW. Access to this site is the same as for CC-1-SW.

3.2. Watershed Health Monitoring

To assess impacts to the overall health of the regional stream channel system, monitoring physical indicators of watershed health is recommended at eight (8) channel locations described in Table 12 and Table 13 and shown on Figure 7.

Watershed health water monitoring stations are indicated with –WH at the end of the station ID. Monitoring at these locations will establish baseline physical characteristics of the channel and detect changes over time to indicators of watershed health such as hydrologic floodplain connectivity, channel and floodplain geometry, bank erosion and channel substrate, and vegetation. Co-locating channel integrity monitoring with spring monitoring or recommended stormwater sampling stations is advantageous in that those locations will also have water quantity and quality data and will already be accessed for sampling. The cross sections surveyed during the development of hydraulic ratings at these locations will also represent detailed baseline channel geometry for integrity monitoring. Monitoring is recommended bi-annually in the fall, after the summer monsoon season, and in the spring.

Stations are located at springs [(BC-Barrel Spring, DC-Reach 2 Spring, and DC-Escondido (Reach 3) Spring)], at locations displaying evidence of recent or potential geomorphic instability (SC-1, DC-Reach 2 Spring), at a location with man-made channel alteration (DC-Stock Tank), and at locations that represent typical channel characteristics at important regulatory or watershed boundaries (DC-2-SW, DC-3-SW, DC-4-SW). Stations DC-3-SW and DC-4-SW are located to bound the OAW reach of Davidson Canyon and quantify watershed health indicators at the upstream and downstream ends of this protected reach.

Table 12. Recommended Watershed Health Monitoring Station Identifiers and Descriptions

Station ID	Description	Measurements
SC-1-WH	Downstream end of Scholefield Canyon, co-located with Rosemont PSW6	Flow and Water Quality Watershed Health Indicators
BC-Barrel Spring-WH	(D-18-16)14cab: Barrel Spring : Downstream of the SR83 Highway Bridge on Barrel Canyon (upstream of the Davidson Canyon Confluence.	Flow and Water Quality Watershed Health Indicators
DC-2-WH	Davidson Canyon downstream of Barrel Canyon inflow	Precipitation, Flow and Water Quality, Watershed Health Indicators
DC-Stock Tank-WH	Davidson Canyon upstream end of the OAW reach, at stock tank diversion	Diversion Structure Integrity
DC-3-WH	Davidson Canyon just above the upstream end of the OAW reach (above Reach 2 Spring)	Precipitation, Flow and Water Quality, Watershed Health Indicators
DC-Reach 2 Spring-WH	(D-17-17)6bdd: Reach 2 Spring at the Upstream end of the Davidson Canyon OAW reach	Flow and Water Quality Watershed Health Indicators
DC-Escondido (Reach 3) Spring-WH	(D-16-17)30abd: Escondido (Reach 3) Spring at the Downstream end of the Davidson Canyon OAW reach	Precipitation, Flow and Water Quality, Watershed Health Indicators
DC-4-WH[1]	Davidson Canyon above confluence with Cienega Creek	Precipitation, Flow and Water Quality
[1]The recommended station DC-4-WH will describe the downstream conditions in Davidson Canyon surface water designation Reach 4		

Table 13. Recommended Watershed Health Monitoring Station Locations

Station ID	Latitude	Longitude	N UTM ft	E UTM ft
SC-1-WH	31° 51' 36.497" N	110° 41' 51.334" W	11564849.12	173272.53
BC-Barrel Spring-WH	31° 52' 2.694" N	110° 40' 56.989" W	11567508.77	1738949.98
DC-2-WH	31° 52' 12.403" N	110° 40' 30.708" W	11568496.27	1741212.61
DC-Stock Tank-WH	31° 58' 12.113" N	110° 39' 4.732" W	11604855.40	1748507.00
DC-3-WH	31° 58' 57.217" N	110° 38' 46.731" W	11609416.62	1750042.18
DC-Reach 2 Spring-WH	31° 58' 58.460" N	110° 38' 48.162" W	11609541.77	1749918.57
DC-Escondido (Reach 3) Spring-WH	31° 00' 54.692" N	110° 38' 35.888" W	11621286.61	1750936.59
DC-4-WH	32° 01' 03.161" N	110° 38' 33.991" W	11622142.61	1751097.10

Station SC-1-WH. Scholefield Canyon. The terminal reach of the Scholefield Canyon wash and the short reach of Barrel Canyon immediately downstream of their confluence through to the SR 83 bridge displays characteristics consistent with relative geomorphic instability compared to wash reaches elsewhere in Barrel Canyon, including eroding vertical banks without vegetation. Ongoing bed and bank erosion in Scholefield Canyon provides a sediment supply to Barrel Canyon wash exceeding transport capacity at the confluence. Scholefield Canyon will be unimpacted by the Project, but geomorphic changes in response to natural high flow events would be expected in this location. Therefore, watershed health monitoring co-located with the Project Site Stormwater Monitoring program is recommended to provide data about storm events and discharges capable of initiating sediment movement and altering channel cross sections.

Station BC-Barrel Spring-WH Because of bedrock exposures in the vicinity of Barrel Spring, gross changes to channel morphology are unlikely. Wash integrity monitoring here will detect changes to channel substrate and vegetation in an area where shallow depths to groundwater are expected and the channel cross section is expected to remain relatively stable. Almost the entire watershed tributary to Barrel Canyon is upstream of this location.

Station DC-2-WH. Monitoring at stormwater monitoring Station DC-2-WH will include ongoing photo documentation and measurement of channel characteristics to characterize watershed health indicators downstream of the Project but upstream of most other development in Davidson Canyon. This reach is not substantially armored with bedrock, and cross section monitoring will help detect channel cross section changes that would impact the hydraulic rating for the site as well as providing data on watershed health indicators in a reach typical of much of the length of Davidson Canyon. Observations at this site will occur upstream and downstream within sight of the DC-2-SW station.

Station DC-Stock Tank-WH. During field work, an improvised diversion structure and related disturbance associated with the construction of a diversion channel supplying surface water to an off-channel stock tank was observed at this location. Monitoring the DC-Stock Tank location is recommended to assist in the interpretation of data from spring and stormwater monitoring stations located downstream. The diversion structure is expected to wash out during high flow events and to be periodically breached by ATV traffic, but may be routinely reconstructed after these events. Monitoring this location may be relevant to the enforcement of regulations for the County’s Cienega Creek Nature Preserve, and will provide an opportunity to assess the impact of ATV traffic and man-made channel alterations at the headwaters of the OAW reach of Davidson Canyon.

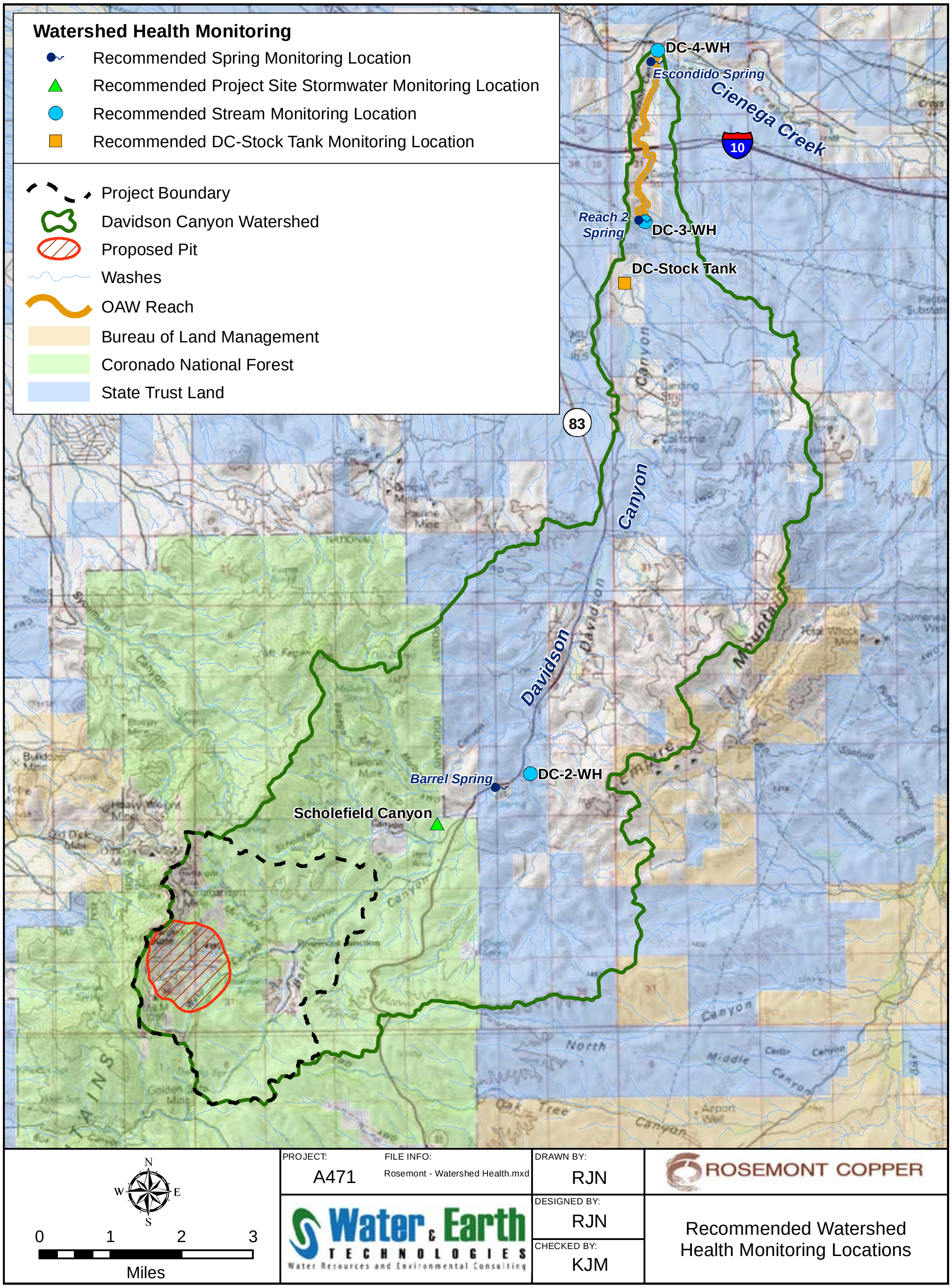

Figure 7. Recommended Watershed Health Monitoring Locations

Station DC-3-WH. Station DC-3-WH will characterize the channel integrity in lower Davidson Canyon, below development, but upstream of the Reach 2 Spring. Although this reach includes some exposed bedrock, it is representative of much of the length of Davidson Canyon. Observations at this site will occur upstream and downstream within sight of the DC-3-SW station.

Reach 2 Spring-WH. As a spring and as a location exhibiting evidence of recent changes to channel morphology, photo documentation and watershed health monitoring is recommended at the Reach 2 Spring location. Evidence of relatively recent changes to channel geometry was observed at this location during preliminary field work, including scour around established vegetation, some dislodging of willows and grass mats, areas of recently exposed cobbles and boulders, and a scoured pool and low flow channel immediately downstream of the spring.

Escondido (Reach 3) Spring-WH. Photo documentation and watershed health monitoring is recommended at the Reach 3 Spring, which is located at the downstream end of the OAW reach of Davidson Canyon. As observed during preliminary field work, this spring provides moisture for sensitive algal growth, riparian vegetation and several standing pools of water.

Station DC-4-WH Station DC-4-WH will characterize watershed health indicators in lower Davidson Canyon, immediately upstream of the confluence with Cienega Creek and downstream of Escondido (Reach 3) Spring. This reach is typical of the lower OAW reach of Davidson Canyon and its tributary area includes the entire Davidson Canyon watershed. Observations at this site will occur upstream and downstream within sight of the DC-4-SW station.

Watershed health monitoring is not recommended at CC-1-SW or CC-2-SW because Pima Association of Governments actively monitors watershed health in Cienega Creek Natural Preserve and provides annual reports of findings (e.g., PAG, 2009).

4. Recommended Instrumentation

The USGS gage in Barrel Canyon at the Highway 83 Bridge has real-time precipitation monitoring and can be used to trigger event-driven water quality sampling without further modification. Precipitation monitoring throughout Davidson Canyon is also recommended at continuous flow monitoring stations to better quantify variations in precipitations throughout the watershed.

For site BC-2-SW, channel flow will be estimated using continuous stage measurements at the USGS radar gage mounted on the SR 83 highway bridge. Continuous stage monitoring at all other regional stream locations is recommended to be added. Continuous stage monitoring captures the times series of stage during complete storm hydrographs when they occurs at a station. Discharge quantification is based on raw stream stage measurements and application of the stage – discharge rating at each site. Power, data logging and/or data telemetry equipment can be provided in one instrument enclosure at each site to support rainfall, surface water and groundwater monitoring at each station.

A pair of crest stage gages will also be installed at flow monitoring stations. Crest stage gages record the maximum water surface elevation that occurred during a runoff event. The peak discharge associated with that runoff event can then be calculated using the hydraulic rating developed for each station. The crest gages are read and reset after each flow event, when the sample bottles are collected. Crest gages offer a redundant, manual method of flow quantification that do not rely on technology for measurement.

Where single-stage sediment or water quality samplers are utilized, relatively permanent deployments are recommended so that the fill elevation does not change when the sample bottles are replaced. The fill elevation of each bottle can be established while cross sections are being surveyed for the development of hydraulic ratings, so that the discharge associated with each sample can be estimated from the rating. Deploying sample bottles in the channel bottom may be required to acquire samples for low-flow events, although these deployments tend to sample sediment bed load rather than suspended sediment. Additional sample collection bottles deployed to fill at higher stages are recommended, although sturdy installations are required given their exposure to flow. For the sandy channels typical of the area, deeply buried or concrete-encased T-posts that are also secured to an adjacent rock face or tree may be required to elevate sample bottles. Recommended instrumentation options are discussed in greater detail in Appendix A.

The recommended instrumentation for the stormwater monitoring stations includes the equipment shown in Table 14. The recommended instrumentation for the majority of the stations (except at station BC-2-SW, where no additional instrumentation is needed due to the USGS gage) includes the equipment specified in Appendix B. If automated samplers are preferred to single-stage sediment or water quality samplers, Isco samplers with housing boxes designed to avoid silting, prevent vandalism and exclude animals are recommended.

After each sample collection circuit is completed, the stations must be revisited to be inspected and reset for the next runoff event.

- All hoses and tubes are to be free of debris and insects. Sampler mounting should be solid.

- New empty sampler bottles are to be added to samplers.
- If automated samplers are installed at a station, testing of sample withdrawal for stage change trigger is to be performed.
- If applicable for each station, crest gage indicators should be uncapped, the measurement staff cleaned and cork added to the cup. Any sediment buildup needs to be removed from the crest gage pipe and intake holes need to be free of debris.
- If applicable for each station, testing of the stage recorder and satellite communication should be performed.
- Rain gages at the USGS gage and the Project area weather stations should be inspected and cleared of any debris and the screen replaced.

Table 14. Recommended Instrumentation Installations at Sampling Stations

Station	Flow Measurement	Water Quality	Watershed Health
SC-1-WH	Continuous stage monitoring, Crest gage pair[1]	Sediment or Stormwater Samplers[1]	Photo documentation and Data Collection
BC-1-SW	Continuous stage monitoring, Crest gage pair, weir to be installed below finished C.P.D.	Sediment or Stormwater Samplers	N/A
BC-2-SW	None to be added	Sediment or Stormwater Samplers mounted on bridge	N/A
BC-Barrel Spring-WH	None to be added	None to be added	Photo documentation and Data Collection
DC-1-SW	Continuous stage monitoring, Crest gage pair	Vandalism proof Sediment or Stormwater Samplers or automated sampler	N/A
DC-1-SW alt	Continuous stage monitoring, Crest gage pair	Sediment or Stormwater Samplers	N/A
DC-2-SW, DC-2-WH	Continuous stage monitoring, Crest gage pair	Sediment or Stormwater Samplers or automated sampler	Photo documentation and Data Collection
DC-Stock Tank-WH	None to be added	None to be added	Photo documentation and Data Collection
DC-3-SW, DC-3-WH	Continuous stage monitoring, Crest gage pair, possible staff gage	Sediment or Stormwater Samplers	Photo documentation and Data Collection
DC-Reach 2 Spring-WH	None to be added	None to be added	Photo documentation and Data Collection
DC-Escondido (Reach 3) Spring-WH	None to be added	None to be added	Photo documentation and Data Collection
DC-4-SW, DC-4-WH	Continuous stage monitoring, Crest gage pair, possible staff gage	Sediment or Stormwater Samplers	Photo documentation and Data Collection
CC-1-SW	Continuous stage measurement, Crest gage pair,	Sediment or Stormwater Samplers	N/A
CC-2-SW	Continuous stage measurement, Crest gage pair,	Sediment or Stormwater Samplers	N/A

[1] Performed by Rosemont Stormwater Monitoring Program

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6. Appendix A: Example Hardware Configuration Diagrams

The instrumentation and methods for precipitation, flow and water quality sampling are described briefly below.

6.1. Precipitation Measurement

Measurement of precipitation is accomplished through the use of a tipping bucket rage gage. Precipitation incident on the gage enters a funnel and causes one tip of the measurement bucket for each unit depth of rainfall, typically 0.01 inch. The time series data of tips are recorded and/or telemetered to quantify the timing and accumulation of rainfall in the area. A typical rain gage installation is shown on Figure 8. The instrument enclosure is a tall aluminum standpipe, which can withstand flooding. The standpipe is equipped with the rain gage at the top, telemetry antenna and solar panel. Data logging and radio equipment is kept cool through storage under ground level. This enclosure is capable of housing data logging hardware for several monitoring devices.

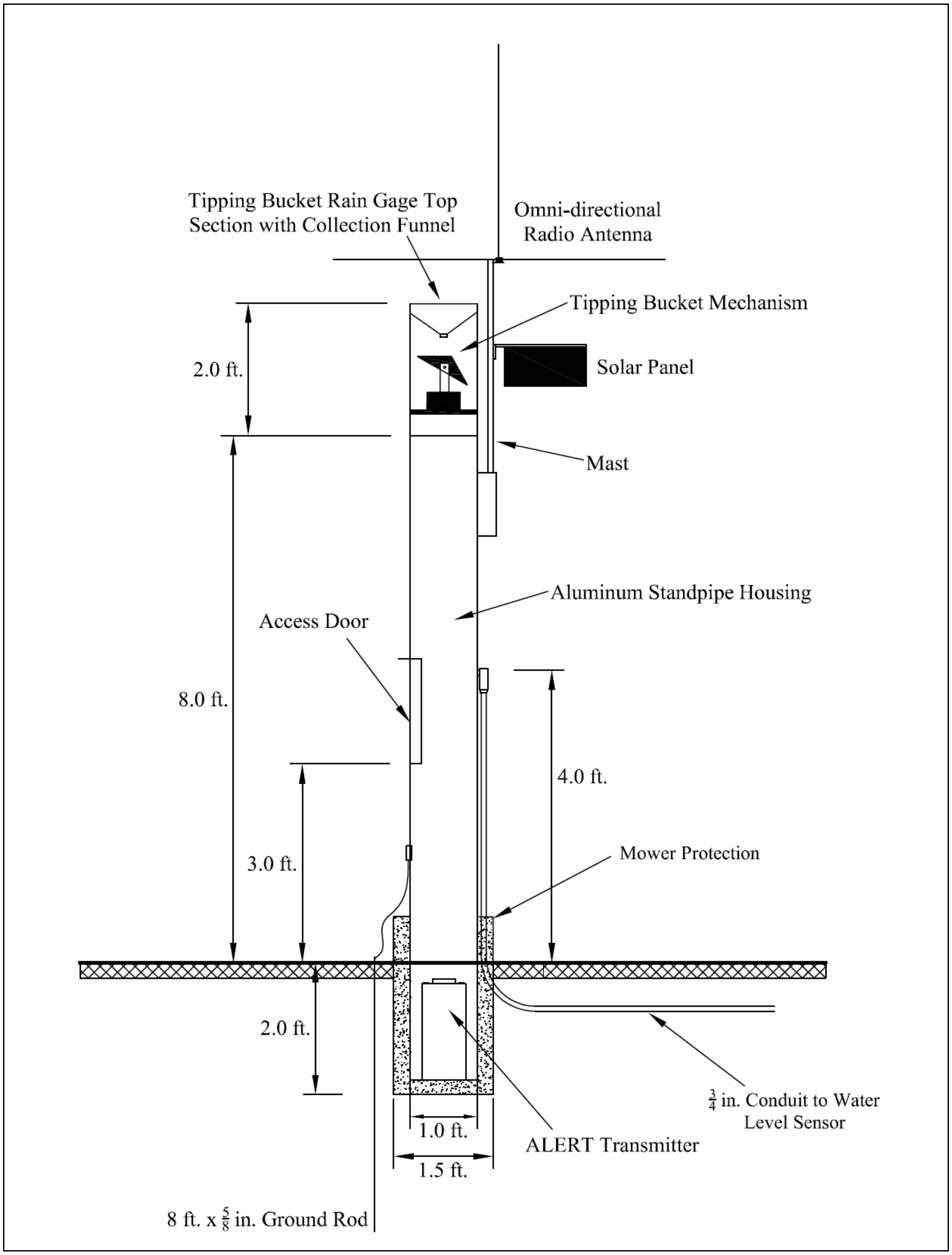


Figure 8. Example Installation Schematic for Tipping Bucket Rain Gage

6.1. Crest Gage Stage Measurement

The crest gage provides a simple, inexpensive method for obtaining stage data. The gage captures a record of the peak stage for the monitored reach during flow events. Crest gage pairs are installed a known distance apart along the channel profile and at known elevations relative to the channel invert. During a flow event, water enters the perforated pipe and floats cork particles placed in a perforated pipe. When the water recedes, the cork particles stick to a graduated rod inside the pipe, recording the maximum stage during the flow event. All of the vertical elevations, for both the crest gages and the sediment samplers, are determined relative to a local benchmark location adjacent to the stream channel, and no major surveying effort is required. A schematic drawing of a crest gage indicator is provided on Figure 9.

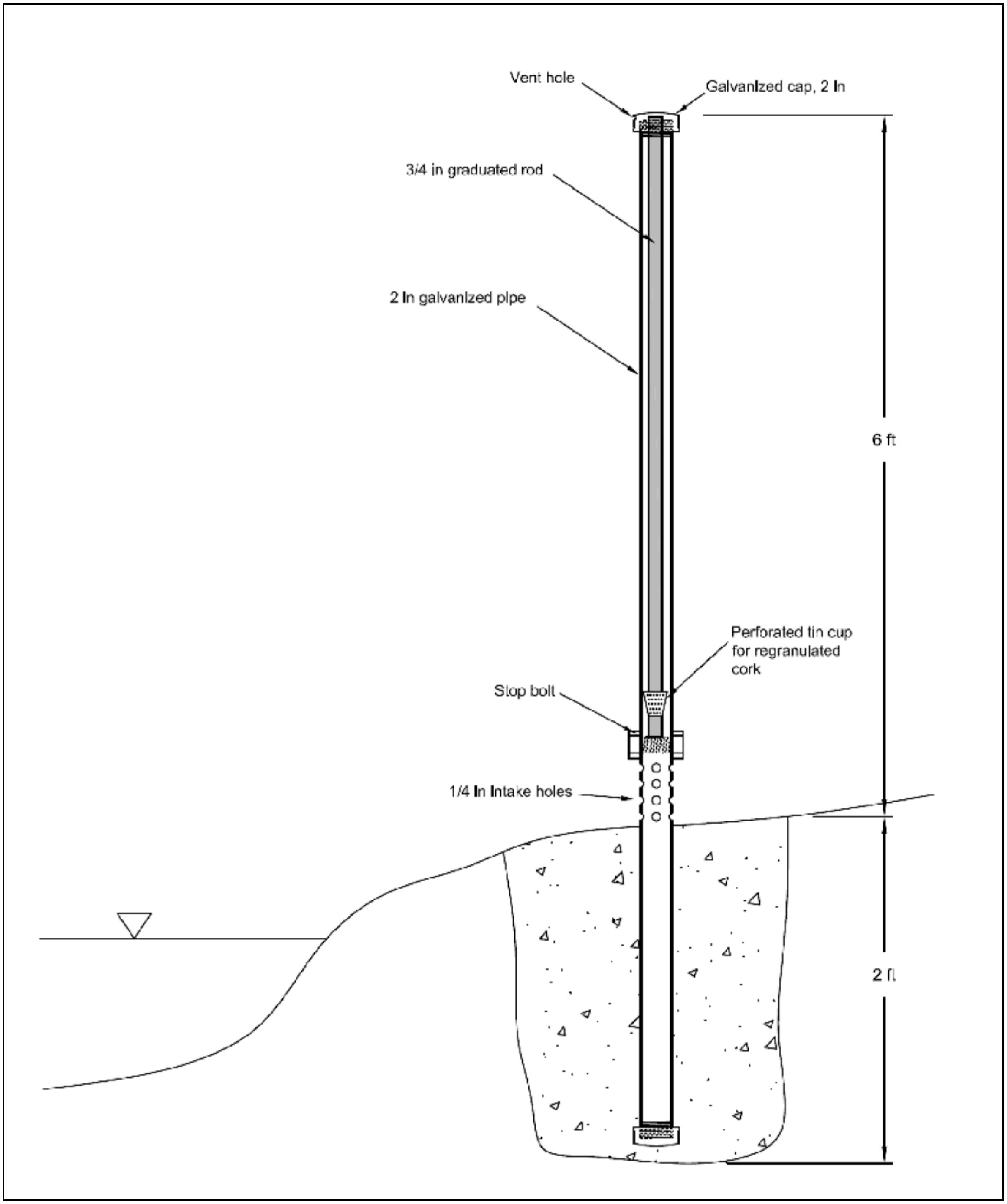


Figure 9. Example Installation Schematic for Crest Gage

6.2. Continuous Stage Measurement

Fully automated instrumentation measures stream stage at sampling stations. Sensors measure the depth of water in the stream channel above a measurement point at regular intervals in time.

A measurement frequency of 5-15 minutes is recommended. Thecurrent measurement interval at the Barrel Canyon USGS gage is 15 minutes. There are several options for the instrumentation at remote stations, both with respect to the water level sensor and for the collection of the data. Several instrumentation options are available for measuring stream stage, including pressure transducers, radar or sonar detection of the water surface elevation. As shown on Figure 10, water level sensors are typically installed near the channel thalwag to measure standing or flowing water in the channel. Pressure transducers can also be installed in porous material below the channel bottom elevation in order to measure very low flows.

Numerous data collection options exist. Data can be stored locally at the remote station and downloaded when samples are collected, or data can be automatically transmitted to a dedicated base station computer running a database designed to collect and analyze the data. Line-of-sight radio transmission of data is most common, but other methods, including cellular or wireless telephones or satellite telemetry can be used, to archive data and to trigger automated notifications for Grab-Sample collection, if desired.

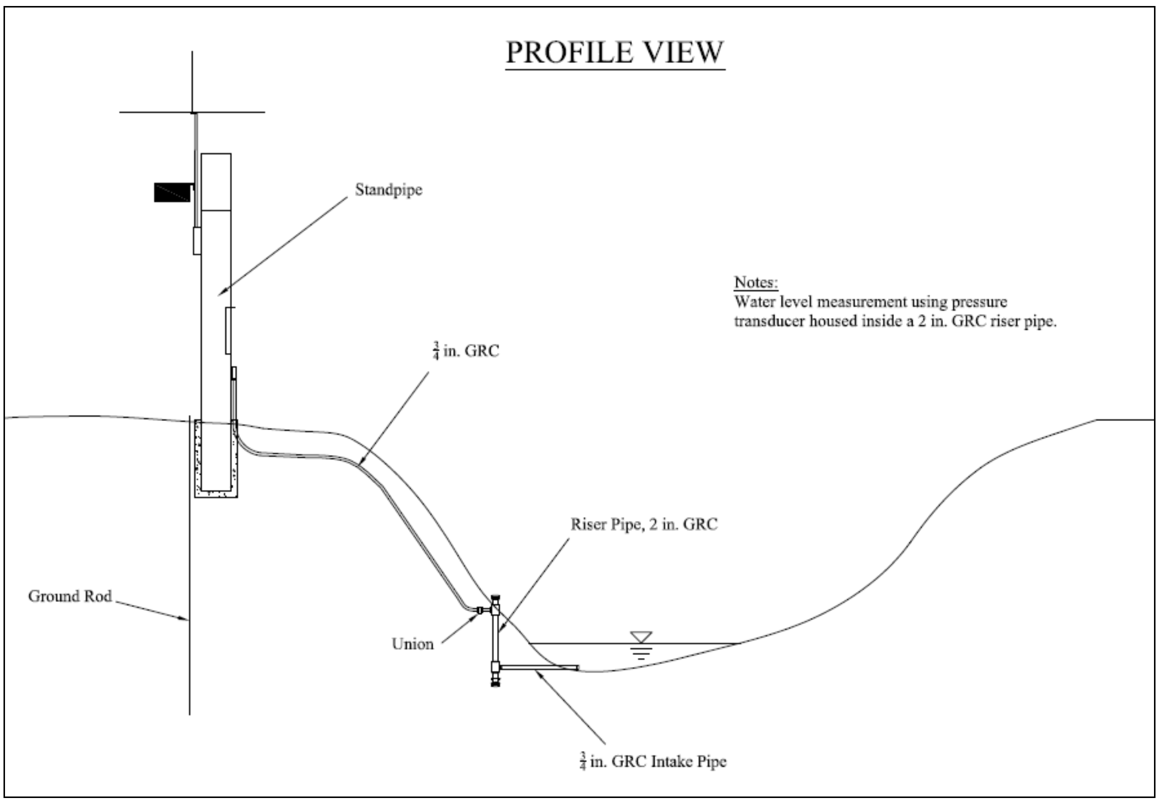


Figure 10. Example Installation Schematic for Continuous Stage Measurement

6.3. Single-Stage Samplers

The depth, flow and water quality of many streams can change very quickly in response to runoff from precipitation. Locally hired stream observers involved in water-data collection are often unable to reach streams quickly enough to observe or measure these rapid changes. A cost-effective alternative for automated sample collection is the use of single-stage sediment samplers or single-stage water quality samplers.

Single-stage samplers can be used to consistently collect samples at a predetermined water surface elevation (stream stage) corresponding to increased depth and flow. Since the samplers are relatively inexpensive to build, operate and maintain, they are cost effective to use at a large number of sites, or at a number of different rising stages at the same site.

Each single-stage sampler collects a water sample at only one stage, or depth of flow, but many single-stage sediment samplers can be installed within the monitored cross section, at various elevations, to capture samples associated with different flow depths during a large runoff event. This approach can provide cost-effective water samples as long as the bottles are collected with a timely response to precipitation/runoff events. As long as water samples remain unfiltered, continued dissolution of analytes from sediments within the sample bottles is expected. This dissolution is reduced by keeping samples cool. The maximum time between field sample collection and lab analysis will be specified in the SAP, but a typically maximum holding time is 24 hours.

It is recommended that at least three (3) samplers be installed at each monitoring site. They can be installed at three (3) different elevations in the flow path near the water's edge (Figure 11), or at different locations in the channel cross section on the channel bank. Sampler locations typically coincide with a lower stage experienced at the start of a runoff event, and a moderate and high stage for events that commonly occur within an average year.

Installation is relatively simple. A 6-ft T-post is driven at least 3 feet into the stream bed or channel bank with a post driver. Two 5- to 7-inch stainless steel marine clamps are used to attach the sampler to the T-post. The sampler can be moved up or down on the post to the desired vertical location. Sediment samplers are turned so that the intake and exhaust tubes point slightly downstream and away from the nearest bank. After installation, a hacksaw is used to cut the T-post just below the top of the sampler cap

A sturdy temporary bench mark should be established outside of the channel in the vicinity of the sampling location. The elevation of this mark is used as a reference to determine the stream depth (or elevation) at which each bottle will fill. When a rating relationship has been developed to relate stream stage to discharge, the depth at which each bottle fills can be related to a stream flow. Single-stage sample bottles are only filled on the rising limb of the runoff hydrograph.

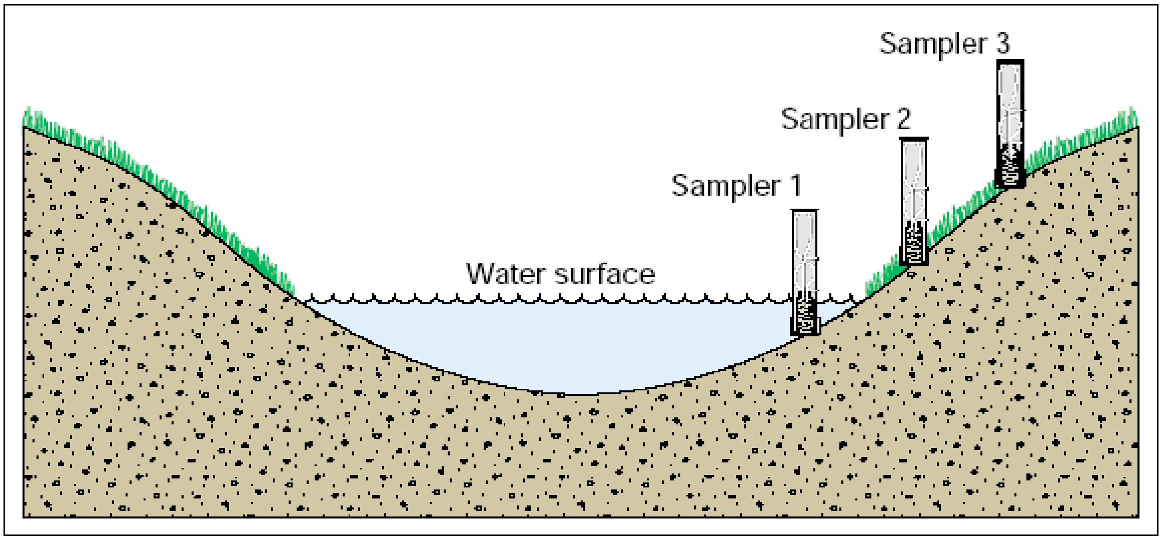


Figure 11. Example Installation Schematic for Single-Stage Samplers

6.3.1. Single-Stage Sediment Samplers

For sediment samplers, the threaded cap can be removed once the sampler is installed, so that the bottle and tubing for each sampler can be accessed (Figure 12). The lower protruding tube is the water intake. The upper tube is the air exhaust. As the water rises and the intake is inundated, water begins entering the tubing. When the water depth increases to the top of the loop in the intake line, a siphon is created and the bottle fills very quickly, as the air in the bottle exits through the upper exhaust tubing. Once the water fills the bottle to the end of the exhaust tubing located in the bottle, filling is complete, and no additional water will enter the bottle during the rising and falling stages of the runoff event. A surveyor's level is used to measure the elevation (stage) at which each bottle will fill, by carefully setting the survey rod on the top of the lower tubing loop inside the PVC pipe containing the bottle. The elevation of the top of the loop can now be referenced to the bench mark elevation. If a typical zero-flow elevation has been established for the channel cross section containing the samplers, the depth at which each sample bottle fills can easily be calculated by subtracting the zero-flow elevation from the elevation of the top of the intake loop.

When collecting a filled sample bottle, first remove the threaded cap. Insert your hand into the PVC housing and carefully pull the tubing from the holes in the side of the plastic housing. If the intake and exhaust ports are under water, use earplugs to plug the openings in the side of the housing as the tubing is removed to minimize the amount of water that enters the pipe housing. Lift the entire assembly (stoppered bottle and tubing) from the housing. Carefully remove the rubber stopper and replace it with a plastic lid to seal the water sample into the bottle. Place the bottle in a cooler of ice for subsequent shipment to the laboratory for analysis. Dry out the inside of the housing and re-install a clean bottle into the sampler.

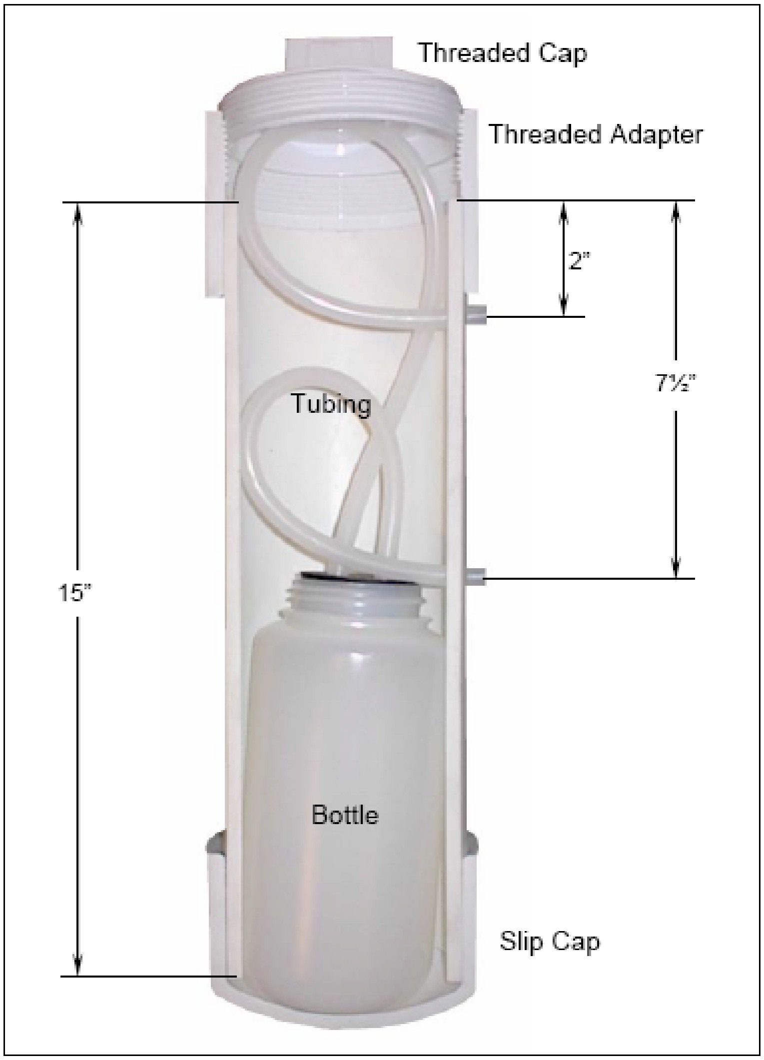
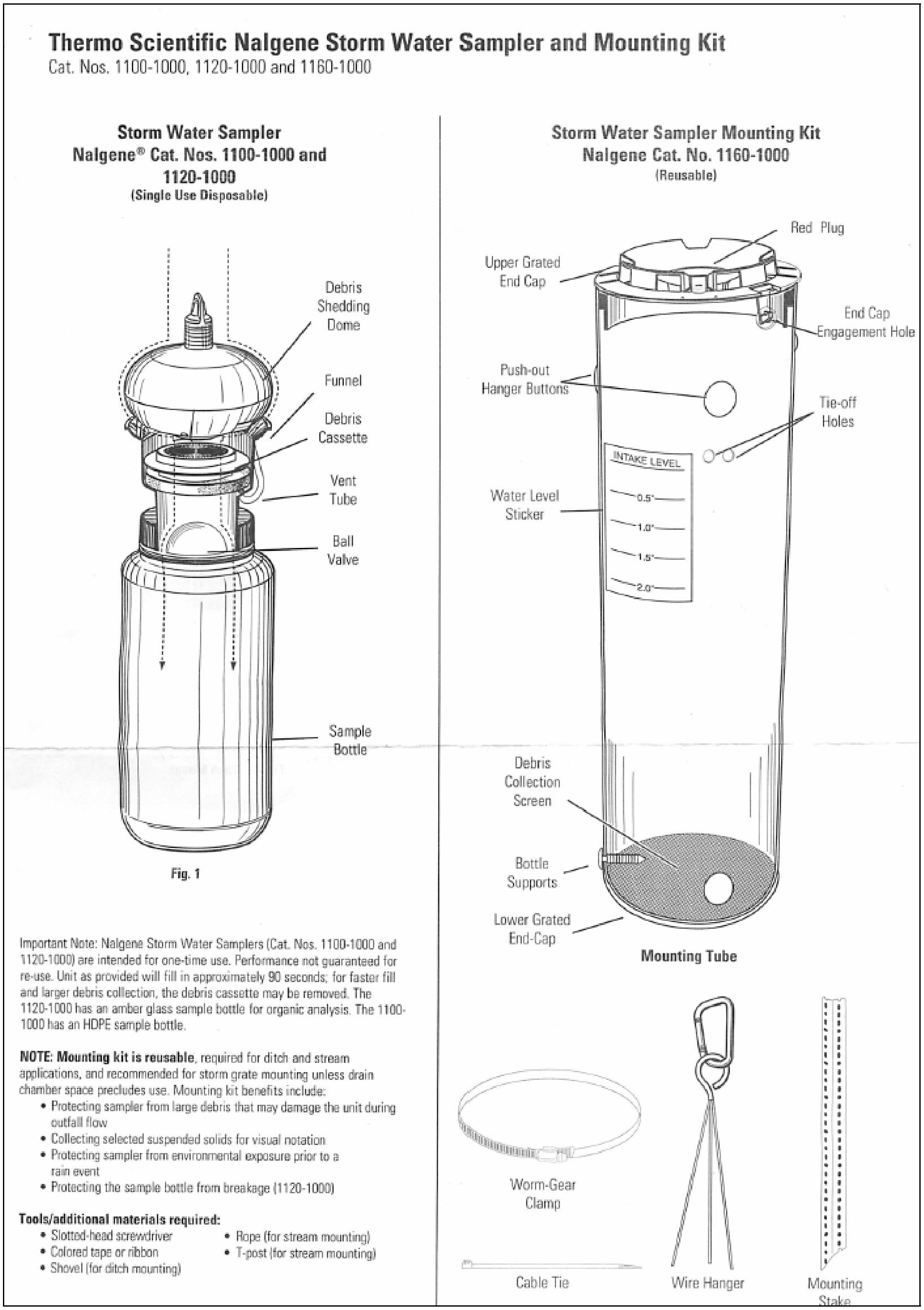


Figure 12. Cutaway Schematic of Single-Stage Sediment Sampler

6.3.2. Single-Stage Water Quality Samplers

Various commercially available stormwater samplers are designed to collect EPA-compliant grab samples, including the ***Nalgene® Stormwater Samplers*** Rosemont is currently using to collect baseline stormwater sample data (Figure 13). Sample bottles are deployed in reusable protective mounting tubes. Water flows through the collection funnel and into the sample bottle. After collecting a full liter of sample, the sampling mechanism closes to prevent cross-contamination with later water. When the bottle is full, a floating ball valve seals off the sample collection port. When samples are collected, the collection funnel is discarded and replaced with a standard Nalgene closure for leakproof transportation to a laboratory.



Thermo Scientific Nalgene Storm Water Sampler and Mounting Kit
Cat. Nos. 1100-1000, 1120-1000 and 1160-1000

Storm Water Sampler
Nalgene® Cat. Nos. 1100-1000 and 1120-1000
(Single Use Disposable)

Storm Water Sampler Mounting Kit
Nalgene Cat. No. 1160-1000
(Reusable)

Important Note: Nalgene Storm Water Samplers (Cat. Nos. 1100-1000 and 1120-1000) are intended for one-time use. Performance not guaranteed for re-use. Unit as provided will fill in approximately 90 seconds; for faster fill and larger debris collection, the debris cassette may be removed. The 1120-1000 has an amber glass sample bottle for organic analysis. The 1100-1000 has an HDPE sample bottle.

NOTE: Mounting kit is reusable, required for ditch and stream applications, and recommended for storm grate mounting unless drain chamber space precludes use. Mounting kit benefits include:

- Protecting sampler from large debris that may damage the unit during outfall flow
- Collecting selected suspended solids for visual notation
- Protecting sampler from environmental exposure prior to a rain event
- Protecting the sample bottle from breakage (1120-1000)

Tools/additional materials required:

- Slotted-head screwdriver
- Colored tape or ribbon
- Shovel (for ditch mounting)
- Rope (for stream mounting)
- T-post (for stream mounting)

Figure 13. ***Nalgene*® Single-Stage Water Quality Sampler**

(Thermo Scientific, 2010)

6.4. Automated Samplers

Fully automated instrumentation continuously measures stream flow and water samples are collected when stream channel flow is detected at each station. Automated sampling still requires field crews to label water samples and ship to analytical lab.

This installation option includes the construction of a streamside environmental monitoring station at each cross section of interest. Rainfall and/or water level in the channel are continuously monitored by sensors installed in the station. The site-specific precipitation and stage data collected at the station can be used to develop an empirical model of watershed response and to calibrate theoretical hydrologic modeling, allowing the relationship between rainfall and runoff to be more accurately determined.

As shown on Figure 14, this option involves using a float switch to trigger the collection of a water sample by pumping stream flow from an intake installed in the channel to a sample bottle secured in a housing box. Automated sampling can be accomplished using a rotating carousel of sample bottles that can be filled during both the rising and the falling limb of the hydrograph. Samples are associated with a specific stage measurement. Automated water sample collection reduces the uncertainty for estimates of discharge associated with samples from single-stage sediment or water quality samplers.

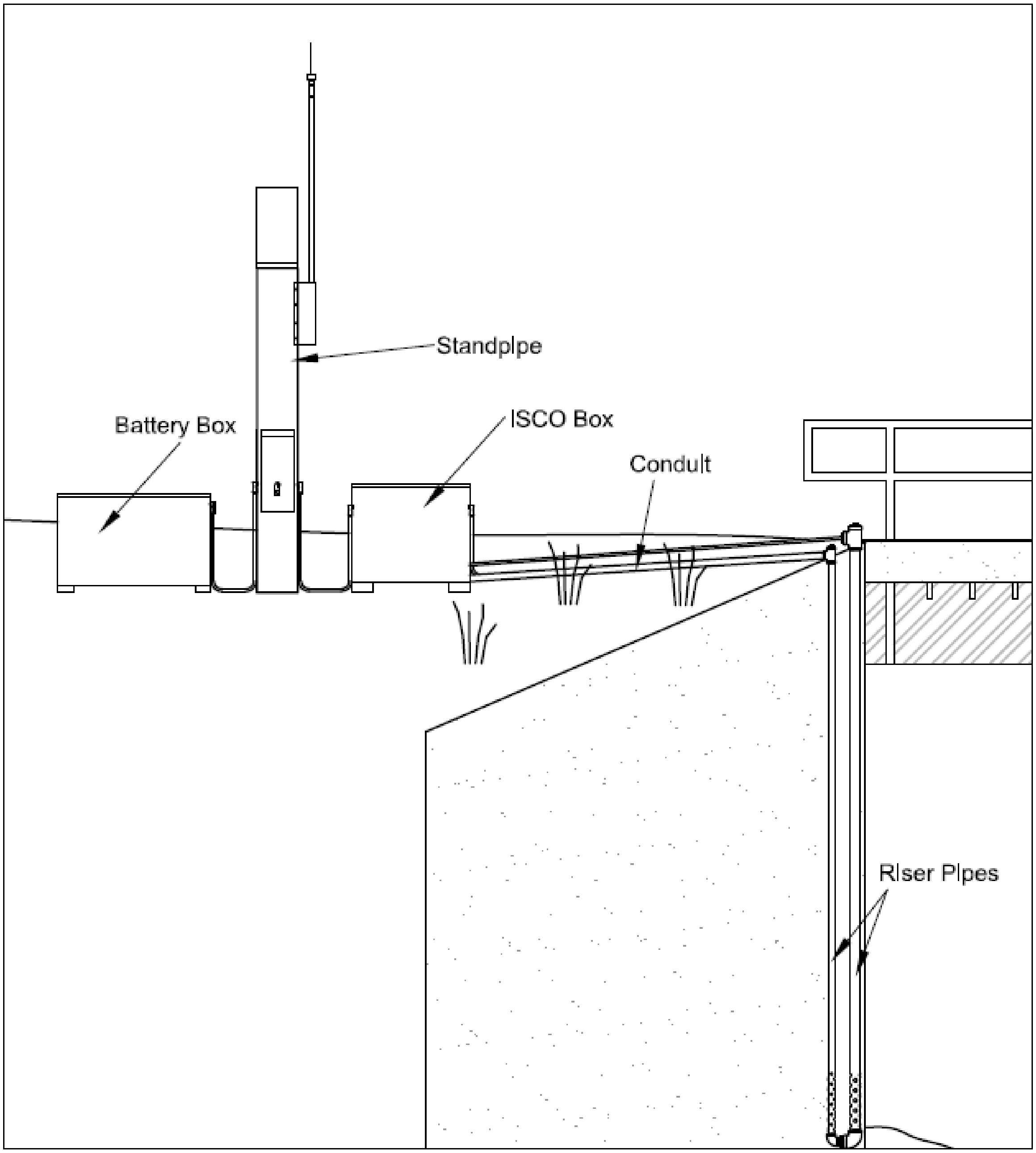


Figure 14. Example Installation Schematic for Automated Sampler

DAVIDSON CANYON
CONCEPTUAL GROUNDWATER
MONITORING PLAN

March 30, 2012

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Project No. 110195

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1.0 INTRODUCTION

The Rosemont Copper Project (Project) site is located in the Santa Rita Mountains southeast of Tucson. Peaks in the Santa Rita Mountains are over 6,000 feet above mean sea level (amsl) and the topography drops into the Cienega Creek and Davidson Canyon watersheds to the east and northeast. The elevation at the confluence of Davidson Canyon and Cienega Creek is 3,325 feet amsl. The proposed Rosemont Open Pit and the other main Project facilities are located in the upper Davidson Canyon watershed (Figure 1). The western flank of the Empire Mountains also drains into Davidson Canyon.

A reach of lower Davidson Canyon from an unnamed spring (referred to here as the Reach 2 Spring) to the confluence with Cienega Creek has been designated as an Outstanding Arizona Water (OAW; Figure 1). This designation provides a level of protection to assure the outstanding waters will not be degraded (PAG, 2005). Mining and other development activities, including the Rosemont Project, have been proposed or are currently in operation within the Davidson Canyon Watershed. Agriculture, ranching, domestic homes, and recreation are currently active land uses within the watershed. The current and future land uses may alter the groundwater quantity and quality in Davidson Canyon.

2.0 PURPOSE AND SCOPE

The purpose of this Davidson Canyon Conceptual Groundwater Monitoring Plan (Plan) is to recommend additional monitoring locations and data collection that can be used to assist in predicting and evaluating potential future groundwater quantity and quality changes to Davidson Canyon. Potential impacts include water-quality and water-level changes that could alter riparian vegetation and spring flow. This Plan recommends data collection that is intended to confirm and increase the current understanding of the natural hydrogeologic processes that contribute to groundwater and surface water interactions and watershed health.

Davidson Canyon's overall watershed health may depend to some degree on groundwater conditions. Riparian vegetation is important for several reasons, including maintaining bank stability and erosion control during storm-water runoff events. Storm-water infiltration into alluvial channel deposits is a source of water for vegetation. However, vegetation may also be supported to some degree by shallow groundwater. Interactions and changes in these water sources could potentially impact vegetation, spring flow, duration of ephemeral surface-water flows, and watershed health.

Baseline groundwater-level and groundwater-quality data are currently being collected by Rosemont in the Project area and by other entities (e.g. Pima Association of Governments (PAG) and Arizona Department of Environmental Quality (ADEQ)) in lower Davidson Canyon and in the Cienega Creek Natural Preserve. As required by the Aquifer Protection Permit (APP) program managed by the ADEQ, groundwater data will also be collected at point of compliance (POC) wells located along the periphery of project facilities.

The scope of this Plan is to provide additional, complementary hydrogeologic data in the Davidson Canyon watershed. Meteorological data are currently being collected by Rosemont near the proposed pit area and by various weather stations in the region. Additional meteorological data will not be collected as part of this Plan.

3.0 HYDROGEOLOGY

The bedrock forming the Santa Rita Mountains consists of a metamorphic core flanked by a metamorphic shell of Paleozoic and Mesozoic-aged sedimentary rock including carbonates, shales, and limestones (Wardrop, 2005). These and similar rocks across the watershed are collectively termed bedrock. Permeability in the bedrock is primarily due to secondary fractures since the bulk rock is typically metamorphosed or highly consolidated with minimal storage and permeability. This bedrock is typically covered by basin-fill deposits, recent alluvium, and unconsolidated deposits in the low lying storm-water drainage channels. These surficial deposits typically have higher storage and permeability with the capacity to transmit more water than the underlying bedrock (Tetra Tech, 2010a).

The bedrock topographic highs define the watershed boundary for Davidson Canyon (Figure 1). Due to the generally low permeability of the bedrock, and the focusing of water toward the interior of the watershed, it is assumed that the groundwater sub-basin follows the watershed boundary. Although groundwater inflows to the sub-basin are not believed to be occurring in significant amounts, there could be inflows in the upper-most reaches where the divides are less pronounced. Groundwater observed in Davidson Canyon is predominately the result of recharge occurring within the watershed (Tetra Tech, 2010a).

The configuration and properties of the bedrock and basin-fill deposits leads to a groundwater system with two (2) primary flow components. The bedrock forms a deeper flow system with limited storage and groundwater flows primarily through fractures. The basin-fill deposits form spatially limited, shallow flow systems with greater storage (per unit volume), and groundwater flow is primarily occurring through the unconsolidated sediments.

The Davidson Canyon fault zone consists of a western fault that is concealed by alluvium and an eastern fault that is partially exposed in the northern piedmont of the Empire Mountains (Ferguson and others, 2001). These faults are poorly understood (Ferguson and others, 2001), but their importance to groundwater flow has been demonstrated from groundwater flow modeling (Tetra Tech, 2010b; M&A, 2010). Water-level contours indicate that groundwater flow is focused toward the Davidson Canyon surface water drainage (M&A, 2010). The orientation of the Davidson Canyon fault zone is likely to be roughly parallel to the groundwater flow direction, suggesting that there is some degree of enhanced flow in the fault zone. The width of an enhanced flow zone due to faulting cannot be accurately determined based on the available information. Observed water levels suggest that the fault zone is permeable, is near the alluvial stream channel, and extends from near the confluence of Barrel and Davidson Canyons to the confluence of Davidson Canyon and Cienega Creek. A permeable fault zone would tend to focus bedrock groundwater flow towards the Davidson Canyon alluvial stream channel area.

Numerous quartz-porphyry dikes have formed in the Empire Mountains (Ferguson, 2009) and Mount Fagan areas (Ferguson et. al., 2001). There is the potential that these dikes may create barriers to groundwater flow due to their low permeability, relatively young geologic age that bisects older rocks, orientation transverse to flow, and the tendency to seal fractures in the surrounding bedrock. One of the longest, thickest, and most continuous dikes perpendicularly intersects Davidson Canyon downstream of the confluence with Barrel Canyon (Figure 1).

The regional groundwater flow system has been numerically modeled by Tetra Tech (2010b) and by Montgomery & Associates (2010). These groundwater flow models incorporated different conceptual models for Davidson Canyon. Tetra Tech (2010b) simulated the low-permeability dike and did not simulate a high-permeability fault zone. M&A (2010) did not simulate the dike, but did simulate the fault as a higher permeability zone. These different conceptual and numerical models demonstrated the influence of the dike and fault on the groundwater flow and predicted drawdown. These models predict that the leading edge of drawdown in Davidson Canyon will become focused near the dike in the alluvial stream channel. A low permeability dike would impede drawdown propagation into the lower reaches of Davidson Canyon, while a higher permeability fault zone would tend to allow drawdown propagation into the lower reaches.

4.0 CONCEPTUAL MODEL

Monitoring locations and data collection in this recommended Plan are guided by the conceptual model of groundwater recharge, occurrence, and flow in Davidson Canyon. Implementation of this Plan will confirm and update the conceptual model and the understanding of the groundwater flow system.

Nearly the entire length of Davidson Canyon consists of a variable width, alluvium-filled channel bounded by bedrock. In the OAW reach, steeply dipping geologic units, faulting, and other structures control the alluvium-bedrock channel geometry. Shallow depth to bedrock, infiltrating storm water, and narrowing of the channel likely causes groundwater levels to rise in the vicinity of the Reach 2 Spring. When the groundwater levels rise high enough to intersect the land surface, spring discharge results. In relatively wet periods and after storm-water runoff, flow may be occurring in the alluvium when no spring discharge and no surface flow are evident. This flow may be shallow groundwater, storm-water infiltration, water perched in the alluvium, or a mix of all. The subsurface bedrock geometry and topography largely determines where groundwater discharges, how far surface water flow is maintained, and the water volume stored in the alluvium. A schematic of how ephemeral and perennial springs occur due to storm-water infiltration and deep groundwater flow paths is presented in Figure 2.

In the upper reaches of Davidson Canyon, near the Rosemont Project area, the regional groundwater table is typically 20 feet to over 100 feet below the ground surface (bgs). The shallowest depth-to-water (DTW) tends to occur in the alluvial drainages. Water levels in the Project area typically, but not always, indicate downward gradients, which suggest that this is a recharge area. Recharge can occur due to precipitation infiltrating through the fractured bedrock to the saturated zone and also due to storm-water flow infiltrating into the stream channel deposits and ultimately reaching the underlying bedrock groundwater system. Stream-channel recharge is likely occurring through the alluvium that is present along the entire Davidson Canyon reach and its tributaries.

4.1 Hydraulic Connection

It is commonly understood and accepted that the bedrock permeability and storage in the Project area and in most of the region is due to fractures. A point of contention, however, is the degree of hydraulic connection between these fractures and the spatial extent of this connection. This is an important issue since the degree of hydraulic connection between the proposed Open Pit and down-gradient ecologically sensitive areas will determine the long-term groundwater inflow to the pit, the magnitude and timing of groundwater drawdown, and the hydrogeology related environmental impacts. Drawdown will preferentially propagate to areas with higher fracture permeability when there is a hydraulic connection over long distances. Conversely, if the hydraulic connection is limited in spatial extent, drawdown propagation will be limited, regardless of the permeability in disconnected fractures.

Large hydraulic gradients occur in areas with low permeability and gradients tend to decrease in areas with higher permeability. Measured water levels in the region are highest in the high elevation Project area and water levels decrease with decreasing elevation. Consistent with these water-level conditions is the presence of large hydraulic gradients in the Project area. Conversely, gradients in the lower reaches of Davidson Canyon are much smaller and indicate higher permeability.

Numerous 12- and 24-hour single well tests and a 30-day hydraulic test with five (5) pumping wells have been conducted by Montgomery & Associates (2009). The results indicated that there are zones within select wells that are permeable and capable of producing water. A 2-foot Water-level drawdown response to pumping was observed between wells PC-5 and PC-7, which are 3,541 feet apart in the proposed pit area. This was the greatest distance between a pumped well and an observed response in the 30-day test. The Flat Fault is a low angle fault that has been observed in several wells in the proposed pit area. This fault was interpreted as being the structure responsible for the hydraulic connection between PC-5 and PC-7 (M&A, 2010).

The permeability in several wells was quite low resulting in minimal groundwater flow to the well. This suggests that a limited set of fractures are hydraulically connected and this connection does not extend over large distances due to these low permeability zones. Groundwater flow to wells and the Open Pit will be predominately from fracture storage. As long-term pumping depletes the water stored in the fractures, flow to wells and the Open Pit will be controlled by the matrix material.

Hydraulic connection in the Project area is therefore considered to exist at a scale of less than 5,000 feet. At a scale of 10 to 100's of feet, it is possible to have hydraulic connections between permeable fractures. Poor hydraulic connection over 1,000's to 10,000's of feet would result in limited drawdown propagation away from Project area.

The hydraulic gradients within Davidson Canyon suggest that the fault zone has enhanced permeability. Numerical groundwater flow modeling by M&A (2010) achieved good water-level matches below the Barrel Canyon confluence with Davidson Canyon, simulating the fault is a higher-permeability zone. The question is whether this higher-permeability zone is hydraulically connected to the Project area. The high water levels and large hydraulic gradients suggest that the hydraulic connection is limited. Hydraulically connected fractures that allow groundwater flow over long distances would result in high discharge springs in lower Davidson Canyon. This hydraulic connection would tend to drain water from the Project area. The absence of large perennial springs in Davidson Canyon suggests that there is a limited hydraulic connection with the Project area. Additionally, low precipitation and low recharge rates in the Project area would not be able to sustain the high observed water levels if a good hydraulic connection existed.

The Davidson Canyon Dike (DC Dike) is an extensive, cross-cutting geologic feature with low permeability that may be limiting the hydraulic connection between Davidson Canyon and the Project area. The Tetra Tech (2010b) groundwater flow model simulated the low-permeability dike, while the M&A (2010) model did not. These different conceptual and numerical models demonstrated the influence of the dike on the groundwater flow. Even though there are insufficient water-level and hydraulic-test data in close proximity to the DC Dike to conclusively support or disprove its hydraulic properties and its impact on the flow system, the DC Dike's low permeability, relatively young geologic age (i.e. it bisects older rocks), orientation transverse to flow, thickness, and its tendency to seal fractures in the surrounding bedrock suggest that it restricts groundwater flow to some degree.

Based on the above evidence, the current conceptual model concludes that fractures are not hydraulically connected over large distances in the Project area. If there was a good hydraulic connection between the pit area and the confluence of Barrel and Davidson Canyons, water levels would be lower, gradients smaller, and significant spring flows would be observed in the lower reaches.

4.2 Groundwater Flow Paths

Conceptually there are three primary flow paths (deep, shallow, and alluvial stream channel) in the Davidson Canyon groundwater flow system (Figure 2). Deep flow paths likely originate in high-elevation, bedrock recharge areas in the Santa Rita Mountains. Infiltrating precipitation that reaches the saturated bedrock flows through fractures and fault zones. These waters tend to obtain geochemical characteristics that reflect water-rock interactions, long resident times, and long flow paths. Water being recharged at high elevation and in mineralized rocks also tends to obtain unique isotopic signatures compared to water recharged at low elevations and in non-mineralized rocks. Groundwater that circulates at greater depths also tends to be at higher temperature due to natural geothermal gradients.

Shallow groundwater flow paths tend to be shorter and can occur at any elevation. Precipitation infiltrating through bedrock or alluvium can reach the water table and then flows down gradient. If these waters stay near the water table they are considered to have shallow flow paths. These shallow flow paths can result in groundwater discharging at the ground surface, particularly in areas with steep topography (Figure 2). The water may also intersect alluvial filled stream channels that are incised into the bedrock, where the water may or may not discharge at the surface. Shorter flow paths, less residence time, and less water-rock interaction can result in different chemical constituent concentrations than water with deep flow paths.

Stream channel flow paths occur when storm-water runoff infiltrates into the alluvium. The magnitude, intensity, and duration of precipitation and runoff determine how deep the water infiltrates. The water may completely or partially saturate the alluvium and it will flow down gradient in the subsurface or discharge at the surface in the form of a spring. Low permeability bedrock obstructions and constrictions in the alluvium can contribute to forcing the groundwater to the surface (Figure 2). This water would tend to have the shortest residence time and shortest flow paths.

The deep, shallow, and stream-channel flow paths can have distinct geochemical properties. However, in practice these flow paths likely mix, which may reduce the distinction between the flow paths and water sources. A high degree of mixing can complicate the data interpretation. Deep and shallow groundwater that have mixed, however, are still likely to have different geochemical signatures than storm-water infiltration.

4.3 Groundwater and Surface-Water Interactions

Groundwater and surface-water interactions occur in alluvial stream channels where groundwater comes in contact with surface water, which in Davidson Canyon is the result of storm-water runoff. Streams either gain water from inflow of groundwater (gaining stream; Figure 3A) or lose water by outflow to groundwater (losing stream; Figure 3B). Losing streams can be connected to the groundwater system by a continuous saturated zone (Figure 3B) or can be disconnected from the groundwater system by an unsaturated zone (Figure 3C). An important feature of streams that are disconnected from groundwater is that groundwater pumping does not affect the flow of the stream (Winter and others, 1998). The connection between storm-water runoff and groundwater can also vary on a seasonal or annual basis depending on the overall climatic conditions.

At lower elevations in Davidson Canyon, the DTW in the alluvial stream channels is relatively shallow and larger magnitude storm-water flow is possible due to the majority of the watershed being up gradient. These conditions are the most favorable for groundwater and surface-water interactions. DTW has been persistently 7 to 15 feet below the stream channel in the OAW Reach (Figure 4) based on the Pima County well ((D-16-17)31dcb, Figure 8). Persistent DTW below the stream channel bottom, combined with ephemeral, short duration, low discharge, and limited surface-length expression of spring flow, indicates that the groundwater system is usually disconnected from the surface-water system.

A temporary connection between the groundwater and surface-water systems is possible during wet periods and long duration storm-water runoff events. Large volumes of infiltrating storm-water runoff can saturate the alluvium and connect to the shallow groundwater. Groundwater-levels that ultimately rise to the surface are expressed as spring discharge after the storm-water flow event has ended. Bedrock constrictions in the alluvial channels create the most favorable conditions for forcing this shallow, alluvial channel groundwater to the surface (Figure 2). The Reach 2 Spring and Escondido Spring in lower Davidson Canyon are examples of this type of disconnected groundwater and surface-water interaction with an occasional, temporary connection.

The Project area will result in a reduction in the Davidson Canyon watershed that contributes storm-water flow the OAW Reach. This decrease in watershed area is expected to reduce peak storm-water runoff to some degree. Infiltration estimates in Rillito Creek, a broad ephemeral alluvial channel in nearby Tucson, Arizona, indicated that the majority of infiltration occurred during long-duration, multiple day storm-water runoff events (Hoffmann and others, 2007). Infiltration in Davidson Canyon is also expected to depend largely on the duration of storm-water runoff and not the peak flow.

4.4 Potential Impacts

The Rosemont Project’s potential groundwater impacts to Davidson Canyon’s watershed health are largely related to water-level declines impacting vegetation and spring flow. These impacts depend on the hydraulic connection in the fractured rock, flow paths, and groundwater and surface-water interactions.

Existing geologic, groundwater-level, water-quality, and spring-flow data indicate that potential impacts to the OAW Reach will be limited. The hydraulic connection between the Open Pit and Davidson Canyon is limited by low permeability bedrock, disconnected fractures, and the DC Dike. Groundwater is disconnected from the alluvial stream channel and short-duration, temporary connections between groundwater and storm-water runoff may occur during infrequent, extended wet periods.

Vegetation and spring flow are most dependent on storm-water infiltration and groundwater storage within the alluvial channel sediments. The limited groundwater-level drawdown due to the Project and a reduction in peak storm-water runoff due to the decrease in contributing watershed area are not expected to significantly impact the volume of water stored in the alluvium. Project impacts will likely be indistinguishable from groundwater level and storm-water runoff variation due to natural climate changes.

5.0 CONCEPTUAL GROUNDWATER MONITORING PLAN

This recommended Conceptual Groundwater Monitoring Plan has been developed based on the observed hydrogeologic conditions and the resulting Davidson Canyon conceptual model. The data collected will validate, disprove, or result in modifications to the conceptual model. Prediction of impacts to the watershed health and mitigation measures will be improved as data are collected and analyzed.

Land ownership within the Davidson Canyon watershed consists of Arizona State Trust, Bureau of Land Management (BLM), Pima County, U.S. Forest Service, and private. All proposed field activities are on public land (State Trust, Pima County, and U.S. Forest Service). No privately owned land will be accessed during implementation of this recommended Plan. Existing roads and stream channels can be used to access the proposed monitoring locations.

5.1 Groundwater Monitoring Approach

The monitoring approach is designed to define groundwater flow paths, the nature of groundwater and surface-water interactions, and infiltration from storm-water runoff into the stream-channel alluvium. Groundwater conditions in the alluvial stream channel and the underlying bedrock, which are the two main groundwater system components (bedrock and alluvium) are recommended for monitoring. Distinguishing flow paths and natural processes, including groundwater mixing between the various flow paths, are anticipated to require multiple data types and several locations. Water levels, water quality, environmental isotopes, and subsurface temperature data are recommended to provide multiple lines of evidence to support conclusions.

Water-quality parameters proposed in this Plan are consistent with those currently used for storm-water monitoring (Water and Earth, 2012) and also for the draft APP program, with the exception of total concentrations being obtained for storm water. Environmental tracers (stable isotopes) will be analyzed to provide information on the source and age of the groundwater.

5.2 Monitoring Locations

Desirable monitoring locations provide data that are representative of flow paths, mixing zones, or aid in understanding natural features that will influence impacts and mitigation measures. Monitoring locations have therefore been selected along the following groundwater flow paths (Figure 5):

- Barrel Canyon down gradient of Project area

- Upper Davidson Canyon (above the confluence with Barrel Canyon)
- Davidson Canyon below confluence with Barrel Canyon
- Near the Reach 2 Spring
- Near the Davidson Canyon and Cienega Creek confluence

Important hydrogeologic features being monitored include the following:

- Davidson Canyon Dike
- Davidson Canyon Fault Zone
- Deep bedrock flow paths
- Shallow bedrock flow paths
- Alluvial stream-channel infiltration
- Groundwater conditions at surface-water monitoring locations

Co-locating groundwater and surface-water monitoring locations allows direct comparison of water quality and correlation of storm-water flows with groundwater levels, subsurface temperature profiles, and infiltration. Alluvial wells and temperature sensors are anticipated to be located in the active stream channel with bedrock wells located nearby, but out of the active channel. The wells and surface-water monitoring locations will be in close enough proximity so they can share instrumentation enclosures, data loggers, solar panels, data transmission, etc.

The following subsections describe each recommended monitoring location. Specific data collected at each location are discussed in subsequent sections. A summary of monitoring locations is provided in Table 1 and illustrated on Figure 6, Figure 7, and Figure 8.

Table 1. Summary of Recommended Monitoring Locations for the Davidson Canyon Conceptual Groundwater Monitoring Plan

Location	Well Name	Monitored Condition	Well Depth (feet)	Status	Land Owner
Rosemont Weather Station	--	Precipitation	--	--	Rosemont
Barrel Canyon	RP-2A[1]	Recent alluvium: Groundwater	30	Existing	U.S. Forest Service
	RP-2B[1]	Bedrock: Shallow groundwater	200	Existing	U.S. Forest Service
	RP-2C[1]	Bedrock: Deep groundwater	500	Existing	U.S. Forest Service
	BC-1A-GW[1,2]	Alluvium: Groundwater and surface-water interactions	<50	New	U.S. Forest Service
	BC-1B-GW[1,2]	Bedrock: Shallow groundwater	100-150	New	U.S. Forest Service
Upper Davidson Canyon	DC-1A-GW[1,2]	Alluvium: Groundwater and surface-water interactions	<50	New	AZ State Land Dept.
	DC-1B-GW[1,2]	Bedrock: Shallow groundwater	100-150	New	AZ State Land Dept.
	RP-9	Bedrock: Deep groundwater	250	Existing	Rosemont
Davidson-Barrel Confluence	DC-2A-GW[1,2]	Alluvium: Groundwater and surface-water interactions	<50	New	AZ State Land Dept.
	DC-2B-GW[1,2]	Bedrock: Shallow groundwater	100-150	New	AZ State Land Dept.
Davidson Canyon Dike (DC Dike)	DC-Dike-A-GW[2]	Alluvium: Groundwater and surface-water interactions	<50	New	AZ State Land Dept.
	DC-Dike-B-GW[2]	Bedrock: Shallow groundwater	100-150	New	AZ State Land Dept.
OAW Reach	DC-3A-GW[1,2]	Alluvium: Groundwater and surface-water interactions	<50	New	Pima County
	DC-3B-GW[1,2]	Bedrock: Shallow groundwater	100-150	New	Pima County
	DC-4A-GW[1,2]	Alluvium: Groundwater and surface-water interactions	<50	New	Pima County
	DC-4B-GW[1,2]	Bedrock: Shallow groundwater	100-150	New	Pima County
	(D-16-17)31dcb[2]	Alluvium: Groundwater and surface-water interactions	51	Existing	Pima County
	(D-17-17)06bdc[2]	Bedrock: Deep groundwater	495	Existing	Pima County

Table 1. Summary of Recommended Monitoring Locations for the Davidson Canyon Conceptual Groundwater Monitoring Plan - CONTINUED

Location	Well Name	Monitored Condition	Well Depth (feet)	Status	Land Owner
OAW Reach	CC-1A- GW[2,3]	Alluvium: Groundwater and surface-water interactions	<50	New	Pima County
	CC-1B- GW[2,3]	Bedrock: Shallow groundwater	100-150	New	Pima County
	CC-2A- GW[2,3]	Alluvium: Groundwater and surface-water interactions	<50	New	Pima County
	CC-2B- GW[2,3]	Bedrock: Shallow groundwater	100-150	New	Pima County

[1]This well is co-located or in close proximity to a proposed surface-water monitoring location (Water and Earth, 2012)
[2]Use and installation of this well requires permission from the land owner

5.2.1 Barrel Canyon

Existing wells RP-2A, RP-2B, and RP-2C are located in Barrel Canyon near the proposed Project facilities (Figure 6). RP-2A monitors the recent stream-channel alluvium and RP-2B and RP-2C monitor the bedrock at different depths. The three depth levels in RP-2A, RP-2B, and RP-2C allow characterization of alluvial groundwater, shallow bedrock water, and deeper bedrock water in the Project area. These groundwater sources may or may not be reaching the Reach 2 Spring and lower Davidson Canyon. Recharge in the upper most part of the groundwater system is likely represented by these waters. Similarities and differences in water quality and stable isotopes will provide information on groundwater mixing and the nature of groundwater flow paths from the Project area to the lower reaches of Davidson Canyon.

The existing RP-2 well cluster is currently being monitored for water levels and water quality in Rosemont's routine monitoring network. Additional water quality and environmental isotope data are recommended to be collected in these wells as part of this plan.

An alluvial channel well (BC-1A-GW) and a shallow bedrock groundwater (BC-1B-GW) well are recommended for installation in the stream channel in close proximity to surface-water monitoring location BC-1-SW (Figure 6) as proposed in the surface-water monitoring plan (Water and Earth, 2012). These wells will allow direct correlation with the storm-water monitoring data.

The Barrel Canyon monitoring locations provide data immediately below the Project facilities and represents Barrel Canyon's groundwater contribution to Davidson Canyon so that flow paths to down-gradient areas can be determined. Groundwater and surface-water interactions can also be monitored at this higher elevation.

5.2.2 Upper Davidson Canyon

The contribution of upper Davidson Canyon to the lower reaches can be determined by monitoring water levels, water quality, and isotopes up gradient of the confluence with Barrel Canyon. The recommended groundwater monitoring locations, DC-1A-GW and DC-1B-GW, are co-located with surface-water monitoring location DC-1-SW (Figure 7). A shallow, alluvial well and a well completed in bedrock are recommended near DC-1-SW. The exact location of DC-1-SW is not yet decided. Two locations are proposed in the surface-water monitoring plan (Water and Earth, 2012) (DC-1-SW and DC-1-SW alt, Figure 7). It is also recommended that deep groundwater conditions in upper Davidson Canyon be monitored in existing well RP-9 (Figure 1).

Existing well (D-18-16)14ddd is a potential location for shallow groundwater monitoring (Figure 7). This well is 115 feet deep, likely completed in bedrock, and potentially monitors shallow groundwater conditions. Well (D-18-16)14ddd is located on land controlled by the Arizona State Land Department and use of this well would require cooperation from this agency.

5.2.3 Davidson Canyon Dike

The recommended monitoring locations in the DC Dike area are illustrated on Figure 7. An alluvial well and a bedrock well are proposed immediately upstream of the mapped dike. The intent of this monitoring location is to determine the hydraulic significance of the DC Dike and the chemical characteristics of the groundwater. The dike is expected to limit groundwater flow and there is the potential for it to limit drawdown propagation into lower Davidson Canyon. Conversely, if this is a zone of higher permeability due to the fault zone then there is the potential for drawdown to be focused in this area. Since this location is potentially important as an early indicator of drawdown propagation, collecting background water-level data will define the range of natural fluctuations under the observed climate and storm-water runoff conditions.

Horizontal hydraulic gradients between the DC Dike area and recommended up gradient monitoring wells DC-2A and DC-2B will also provide information on whether the dike is a barrier to groundwater flow. A decrease in hydraulic gradient would occur up gradient from the dike if it restricts groundwater flow.

This location is down gradient of the confluence of Barrel and Davidson Canyons and groundwater represents a mixture of these flow paths. This may also be a potential mixing zone for storm-water infiltration with shallow and deep groundwater. Water chemistry and isotopic contributions to the lower reaches are recommended to be monitored at this location.

5.2.4 OAW Reach

The recommended monitoring well locations in the OAW Reach are illustrated on Figure 8. One shallow alluvial well and one bedrock well are recommended at both the upstream (DC-3A-GW and DC-3B-GW) and downstream (DC-4A-GW and DC-4B-GW) ends of the Davidson Canyon Wash OAW reach. One shallow alluvial well and one bedrock well are recommended upstream (CC-1A-GW and CC-1B-GW) and downstream (CC-2A-GW and CC-2B-GW) of the confluence of Cienega Creek and Davidson Canyon Wash. Locations of the wells within or in close proximity to the channel will be determined in the field and in consultation with PAG.

In Davidson Canyon Wash, the recommended upstream wells will be in close proximity to the Reach 2 Spring, which is surface-water monitoring location DC-3-SW (Water and Earth, 2012). Storm-water runoff and Reach 2 Spring interactions with alluvial and shallow groundwater will be monitored. The recommended downstream wells will assist in determining the groundwater flow and water-chemistry contribution of Davidson Canyon to Cienega Creek.

Existing bedrock well (D-17-17)06bdc is located within the PAG OAW designated parcel and is reported to be 495 feet deep. This well likely monitors the deep groundwater conditions in lower Davidson Canyon (Figure 8). The monitored depth interval in (D-17-17)06bdc is comparable to RP-2C. If a deep groundwater flow path exists between the Project area and the lower reaches it can potentially be identified using these two (2) well sites. The functionality of well (D-17-17)06bdc and access permission needs to be determined.

Existing alluvial well (D-16-17)31dcb is located within the OAW Reach (Figure 8). This well monitors the shallow alluvial groundwater conditions in lower Davidson Canyon and historical water level data are available. Continued and more frequent monitoring at this location will be beneficial. Permission to access this well site will need to be obtained.

In Cienega Creek, the recommended wells upstream of the confluence with Davidson Canyon Wash will be in close proximity to surface-water monitoring location CC-1-SW (Figure 8); the recommended wells downstream of the confluence will be in close proximity to surface-water monitoring location CC-2-SW (Water and Earth, 2012). The purpose of these wells is to determine the contribution of Cienega Creek and Davidson Canyon Wash to the combined channel downstream of the confluence.

5.3 Water-level Monitoring

Water levels will be monitored in wells completed in the stream-channel alluvium and in wells completed in the underlying bedrock. These data will provide information on the vertical and horizontal hydraulic gradients, hydraulic connection between the alluvium and bedrock, stream-channel recharge, and groundwater and surface-water interactions. These wells will also provide a baseline for the natural water-level fluctuations that are presently occurring under pre-mining conditions.

Rosemont has been monitoring wells and springs in the Project area since 2007 (M&A, 2009). Point of Compliance (POC) wells have been proposed by Rosemont in their Draft Aquifer Protection Permit (APP) application (NO. P-106100; ADEQ, 2012). The POC wells will monitor water levels and water quality near the Project facilities. Additional wells are proposed herein to augment existing wells, the proposed POC wells, and to monitor specific conditions within Davidson Canyon.

New wells installed in the Davidson Canyon stream channel alluvium are intended to monitor the short-term water-level fluctuations due to storm-water runoff events. Capturing groundwater and surface-water interactions and fluctuations will require wells equipped with pressure transducers. Transducers can measure water levels at high frequencies, but an hourly frequency is initially anticipated. When the timing of groundwater responses to storm-water events is adequately understood, the monitoring frequency at these wells could then be modified.

New bedrock wells are recommended in close proximity to the stream channel alluvial wells. The bedrock wells are intended to monitor the shallow groundwater that may be in contact, persistently or intermittently, with the stream-channel alluvium and storm-water flow. Consistent water-levels and fluctuations between the bedrock and alluvial wells will indicate a hydraulic connection. Transducers are recommended for monitoring water levels in the bedrock wells.

Existing, deeper bedrock wells are also recommended for monitoring. These wells are intended to provide information on the deeper flow paths and the vertical and horizontal hydraulic gradients. Upward gradients indicate that deeper groundwater is potentially a source for shallow groundwater, spring discharge, and surface-water flow. Downward gradients may suggest that the storm-water runoff is recharging the groundwater system.

Alluvial, stream-channel wells are likely to be less than 50 feet deep and bedrock wells will likely be 100 to 150 feet deep depending on their location (Figure 9). Depth-to-bedrock, however, is likely highly variable and exact well depths will be determined in the field. Alluvial wells will be completed with screens immediately above the bedrock contact. Bedrock wells will penetrate into competent bedrock until groundwater producing fractures are encountered. A schematic cross-sectional diagram of the well completions within the stream channel is provided in Figure 9. Bedrock wells are recommended to be 4-inch diameter PVC to allow for future aquifer testing if needed (Figure 9). Alluvial monitoring wells are recommended to be 4-inch diameter PVC, but deeper water levels may require larger diameters to facilitate water-quality sampling (Figure 11).

Monitoring well locations are illustrated on Figure 1, Figure 6, Figure 7, and Figure 8, and summarized in Table 1. Existing wells and recommended new wells on land owned by the Arizona State Land Department, Pima County, and the U.S. Forest Service will require access permission. Submersible pressure transducers measured at an hourly frequency are the recommended monitoring method for water level and water temperature. If water levels in the deeper wells do not respond to seasonal changes and have minimal variation then monthly monitoring with manual methods should be evaluated.

Groundwater monitoring will share shelters and instrumentation with the surface-water monitoring plan locations (Water and Earth, 2012). An example structure for the combined surface and ground water monitoring instrumentation is illustrated on Figure 12.

5.4 Water-Quality Monitoring

Water quality is recommended to be monitored in the wells identified in Table 2. These data will provide information on the water source, flow paths, hydraulic connection between the alluvium and bedrock, stream-channel recharge, and groundwater and surface-water interactions. Generally, waters with similar solute concentrations and ratios of concentrations likely originated in the same area and/or travel along similar flow paths. Conversely, waters with different solute concentrations likely did not originate in the same area, travel along the same flow paths, or have mixed with other waters. In this way, water-quality analyses can be used to identify similar waters and flow paths.

Water-quality monitoring parameters and detection limits in the proposed wells are recommended to be consistent with the full-suite of APP monitoring. This list of constituents is consistent with the surface-water monitoring plan with the exception of total recoverable concentrations are included in the surface-water suite (Water and Earth, 2012). Based on the initial water-quality results, the frequency of analysis and number of constituents may be reduced. Analytical tests, detection limits, and methods provided in Table 2 are subject to change if regulatory, water-quality, or laboratory conditions change.

APP parameters are provided in Table 3 for comparison. PAG monitoring in Davidson Canyon and Cienega Creek includes a very similar list of parameters. A complete analysis of samples should be performed in the initial stages of monitoring to provide a complete picture of background conditions.

Samples will be collected and analyzed quarterly for two years. The purpose of the quarterly sampling is to determine background conditions, and to determine which constituents are changing with time. It may also be advantageous to simultaneously collect groundwater and surface-water samples during longer duration storm-water flow events. The logistics and feasibility of simultaneous sampling can be further evaluated when sampling locations and instrumentation are finalized.

The water-quality constituents in Table 2 go beyond the APP constituent list and are consistent with the Davidson Canyon Surface-Water Monitoring Plan (Water and Earth, 2012). Non-detect and low concentration constituents may be removed from the analytical list after the initial sampling results have been evaluated. After the two year background period, the list of constituents will again be reviewed to determine if some constituents can be removed from the list, including a review of the monitoring frequency.

Table 2. Proposed Constituent List for Groundwater Measurement and Analysis

Constituent	Detection Limit Required	EPA Method for Analysis accepted by ADEQ (2004, appendix C)
Field Measurements		
Depth-to-Water	0.01 feet	--
Water-level Elevation	0.1 feet amsl	--
Field Water Temperature	0.1 °C	--
Field Specific Conductance	1 µS/cm	--
Field pH	0.1 units	--
Dissolved Oxygen (DO)	0.1 mg/L	--
Oxidation-Reduction Potential (ORP or Eh)	1 mV	--
Laboratory Analysis		
pH	0.1 units	--
Specific conductance at 25 C	1 uS/cm	--
Hardness as $CaCO_3$	1 mg/L	EPA 130.2
Total Alkalinity	1 mg/L	EPA 305
Alkalinity Bicarbonate	20 mg/L	--
Alkalinity Carbonate	20 mg/L	--
Alkalinity Hydroxide	20 mg/L	--
Calcium	4 mg/L	EPA 200.7/215.1
Carbon Disulfide	--	--
Chloride	2.5 mg/L	EPA 325.2
Fluoride	0.5 mg/L	EPA 340.2
Potassium	0.5 mg/L	EPA 258.1
Silica	0.5 mg/L	--
Sodium	0.5 mg/L	EPA 200.7/273.1
Sulfate	3 mg/L	EPA 375.3
Sulfide	0.1 mg/L	EPA375.4
Total Dissolved Solids	10 mg/L	--
Total Kjeldahl Nitrogen	0.1 mg/L	EPA 351.2
Nitrate-Nitrite (as N)	0.1 mg/L	EPA 353.2
Nitrate (as N)	0.1 mg/L	EPA 353.2T
Nitrogen Ammonia (as N)	0.1 mg/L	EPA 350.3

Table 2 Proposed Constituent List for Groundwater Measurement and Analysis - CONTINUED

Constituent	Detection Limit Required	EPA Method for Analysis accepted by ADEQ (2004, appendix C)
Metals[1]		
Aluminum	0.1 mg/L	EPA 202.1
Antimony	1 µg/L	EPA 204.2
Arsenic	10 µg/L	EPA 206.2
Barium	0.1 mg/L	EPA 200.7/208.1
Beryllium	1 µg/L	EPA 210.2
Boron	50 µg/L	EPA 200.7/213.3
Cadmium	0.25 µg/L	EPA 213.2
Chromium	10 µg/L	EPA 218.2
Cobalt	10 µg/L	EPA 219.2
Copper	1 µg/L	EPA 220.1
Iron	0.1 mg/L	EPA 200.7/236.1
Iron (Total)	1 mg/L	EPA 200.7/236.1
Lead	0.5 µg/L	EPA 239.2
Magnesium	10 µg/L	EPA 200.7/242.1
Manganese	10 µg/L	EPA 200.7/243.1
Mercury	0.01 µg/L	EPA 245.1
Molybdenum	0.01 µg/L	EPA 246.2
Nickel	10 µg/L	EPA 249.1
Silver	0.5 µg/L	EPA 272.2
Strontium	0.5 mg/L	--
Selenium	1 µg/L	EPA 200.9
Thallium	0.5 µg/L	EPA 279.2
Titanium	20 µg/L	--
Vanadium	10 µg/L	EPA 289.1
Zinc	30 µg/L	EPA 289.1

Table 2 Proposed Constituent List for Groundwater Measurement and Analysis - CONTINUED

Constituent	Detection Limit Required	EPA Method for Analysis accepted by ADEQ (2004, appendix C)
Radiological Constituents		
Gross Alpha Particle Activity (pCi/L)[2]	1 pCi/L	600-00 02
Radium 226 (pCi/L)	0.3 pCi/L	903.1
Radium 228 (pCi/L)	0.3 pCi/L	904
Uranium (total)[1]	1 µg/L	00-07
Uranium-isotopes (pCi/L)[3]	0.03 pCi/L	--
Isotopic Constituents		
Nitrogen (^{15}N)	1 mg/L	Continuous-flow gas-ration mass spectrometer
Oxygen ($\delta^{18}O$)	N/A	Gas-source isotope ratio mass spectrometer
Deuterium (^{2}H or D)	N/A	Gas-source isotope ratio mass spectrometer
Carbon (^{13}C and ^{14}C)	10 mg/L	Liquid scintillation spectrophotometer
Sulfur (^{34}S)	100 mg/L	Continuous-flow gas-ratio mass spectrometer

1 Metals must be analyzed as dissolved metals, unless otherwise specified.
2 The adjusted gross alpha particle activity is the gross alpha particle activity, including radium 226, and any other alpha emitters, if present in the water sample, minus radon and total uranium (the sum of uranium 238, uranium 235 and uranium 234 isotopes). The gross alpha analytical procedure (evaporation technique: EPA Method 900.0) drives off radon gas in the water samples. Therefore, the Adjusted Gross Alpha should be calculated using the following formula: (Laboratory Reported Gross Alpha MINUS Sum of the Uranium Isotopes).
3 Uranium Isotope activity results must be used for calculating Adjusted Gross Alpha.

Filtered water samples will be provided and analyzed by the laboratory for dissolved concentrations. Unfiltered water samples will also be provided and analyzed by the laboratory for total recoverable concentrations of iron and uranium. The same constituents, as dissolved and total concentrations, are analyzed in surface-water samples at co-located monitoring sites (Water and Earth, 2012). Samples will be preserved as required by analysis.

Table 3. Draft Aquifer Protection Permit Parameters for Ambient Groundwater Monitoring for POC Wells (APP NO. P-106100[4])

Depth to Water (feet)	Potassium[1]	Nickel[1]
Water Level Elevation (feet amsl)	Sodium[1]	Selenium[1]
Temperature – field (°F)	Magnesium[1]	Thallium[1]
pH – Field & Lab (S.U.)	Aluminum[1]	Zinc[1]
Field Specific Conductance (µmhos/cm)	Antimony[1]	Molybdenum[1]
Total Dissolved Solids – Lab	Arsenic[1]	Gross Alpha Particle Activity (pCi/L)[2]
Total Alkalinity	Barium[1]	Radium 226 (pCi/L)
Bicarbonate	Beryllium[1]	Radium 228 (pCi/L)
Carbonate	Cadmium[1]	Uranium-Isotopes (pCi/L)[3]
Hydroxide	Chromium[1]	Carbon Disulfide
Sulfate	Cobalt[1]	Calcium[1]
Chloride	Copper[1]	Mercury[1]
Fluoride	Lead[1]	Uranium (total)
Nitrate + Nitrite	Manganese[1]	Iron (total)

1 Metals must be analyzed as dissolved metals, unless otherwise specified.
2 The adjusted gross alpha particle activity is the gross alpha particle activity, including radium 226, and any other alpha emitters, if present in the water sample, minus radon and total uranium (the sum of uranium 238, uranium 235 and uranium 234 isotopes). The gross alpha analytical procedure (evaporation technique: EPA Method 900.0) drives off radon gas in the water samples. Therefore, the Adjusted Gross Alpha should be calculated using the following formula: (Laboratory Reported Gross Alpha minus Sum of the Uranium isotopes).
3 Uranium isotope activity results must be used for calculating Adjusted Gross Alpha.
4 Draft Rosemont Aquifer Protection Permit P-106100, ADEQ, 2012

5.5 Environmental Isotope Monitoring

Environmental isotope monitoring is recommended in the wells identified in Figure 1 and Table 1 and in springs monitored as part of the surface-water monitoring plan (Water and Earth, 2012). Stable isotopes have the potential to provide information on many processes that include recharge area, flow paths, groundwater age, hydraulic connection between the alluvium and bedrock, stream-channel recharge, and groundwater and surface-water interactions. In simplistic terms, waters with similar isotopic ratios and relationships with solute concentrations likely originated in the same area and/or travel along similar flow paths. In this way, isotope analyses can be used to identify similar waters, recharge areas, flow paths, and mixing of different water sources.

Nitrogen isotopes (^{15}N) are potentially important due to the wide range of water uses and development within Davidson Canyon. Sources of nitrogen from septic systems, manure, fertilizers, and explosives can be constrained with nitrogen isotopic analyses. In addition, stable isotopes of oxygen ($\delta^{18}O$), deuterium (^{2}H or D), carbon (^{13}C and ^{14}C), and sulfur (^{34}S) are also recommended for analyses (Table 2).

It is difficult to determine in advance which isotopes will be most useful in distinguishing the various water sources, flow paths, and mixing ratios. Several isotopes are recommended for screening until the most useful isotopes are identified. Previous oxygen and deuterium isotope analyses in the region have indicated that groundwater mixing is occurring and these isotopes alone have resulted in somewhat inconclusive findings (M&A, 2009). This is likely due to the mixture of high-altitude and low-altitude precipitation contributing to groundwater recharge. Additional isotopes in combination with water-quality solute concentrations provide other alternatives that may result in more conclusive results. For example, in Sonoita Creek, to the south of the Project area (Figure 1), sulfur isotopes and sulfate concentrations have been used to identify groundwater sources of base flow (Gu and others, 2008). Geologic and climate similarities between the Project area and Sonoita Creek suggest that sulfur isotopes may be helpful in distinguishing water sources in Davidson Canyon.

It is recommended that oxygen and deuterium isotopes be measured at the high-elevation (5,350 feet) Rosemont weather station (Figure 6). Precipitation isotopes from lower elevations in Davidson Canyon would also be helpful, but it is anticipated that existing isotope data from Tucson will be sufficient to distinguish the altitude effect on oxygen isotopes. These isotope data will provide site specific conditions that will aid interpretation of groundwater recharge sources and flow paths.

Background isotope analyses are most useful when they are obtained over a range of climate, seasons, elevations, depths, and distance from the Project area. Data from the recommended wells and springs will provide this variability. Quarterly monitoring is initially recommended and it may then be adjusted based on the results. Isotopes that are not useful or provide inconclusive results can be discontinued as appropriate.

5.6 Subsurface Temperature Monitoring

Infiltration rates and the infiltrating water’s interaction with groundwater can potentially be determined with temperature data collected at various depths and under a variety of hydrologic conditions. Subsurface temperature monitoring is recommended in the stream-channel alluvium at three water-level monitoring locations (Table 4).Temperature sensors installed over a range of depths (Figure 13) will provide information on groundwater and surface-water interactions and stream-channel recharge. Infiltrating storm water will likely have a different temperature than perched water, unsaturated sediments, and shallow groundwater. Water temperature will also be measured in wells equipped with pressure transducers (Table 4). A schematic diagram of temperature sensor placement in the alluvial channel is illustrated in Figure 13. If temperature data provide inconclusive results, additional measurement techniques can be recommended for evaluation.

Table 4. Summary of Recommended Data Collection for the Davidson Canyon Conceptual Groundwater Monitoring Plan

Location	Well Name	Monitored Condition	Water Level and Temperature[1]	Water Quality	Isotopes	Subsurface Temperature
Rosemont Weather Station	--	Precipitation			✓	
Barrel Canyon	RP-2A[2]	Recent alluvium: Groundwater	✓	✓	✓	
	RP-2B[2]	Bedrock: Shallow groundwater	✓	✓	✓	
	RP-2C[2]	Bedrock: Deep groundwater	✓	✓	✓	
	BC-1A-GW[2,3]	Alluvium: Groundwater and surface-water interactions	✓	✓		✓
	BC-1B-GW[2,3]	Bedrock: Shallow groundwater	✓	✓		
Upper Davidson Canyon	DC-1A-GW[2,3]	Alluvium: Groundwater and surface-water interactions	✓	✓	✓	
	DC-1B-GW[2,3]	Bedrock: Shallow groundwater	✓	✓	✓	
	RP-9	Bedrock: Deep groundwater	✓	✓	✓	
Davidson-Barrel Confluence	DC-2A-GW[2,3]	Alluvium: Groundwater and surface-water interactions	✓	✓	✓	✓
	DC-2B-GW[2,3]	Bedrock: Shallow groundwater	✓	✓	✓	
Davidson Canyon Dike (DC Dike)	DC-Dike-A-GW[3]	Alluvium: Groundwater and surface-water interactions	✓	✓	✓	
	DC-Dike-B-GW[3]	Bedrock: Shallow groundwater	✓	✓	✓	
OAW Reach	DC-3A-GW[2,3]	Alluvium: Groundwater and surface-water interactions	✓	✓	✓	
	DC-3B-GW[2,3]	Bedrock: Shallow groundwater	✓	✓	✓	✓
	DC-4A-GW[2,3]	Alluvium: Groundwater and surface-water interactions	✓	✓	✓	
	DC-4B-GW[2,3]	Bedrock: Shallow groundwater	✓	✓	✓	
	(D-16-17)31dcb[3]	Alluvium: Groundwater and surface-water interactions	✓	✓	✓	
	(D-17-17)06bdc[3]	Bedrock: Deep groundwater	✓	✓	✓	

Table 4. Summary of Recommended Data Collection for the Davidson Canyon Conceptual Groundwater Monitoring Plan - CONTINUED

Location	Well Name	Monitored Condition	Water Level and Temperature[1]	Water Quality	Isotopes	Subsurface Temperature
OAW Reach	CC-1A- GW[2,3]	Alluvium: Groundwater and surface-water interactions	✓	✓	✓	
	CC-1B- GW[2,3]	Bedrock: Shallow groundwater	✓	✓	✓	
	CC-2A- GW[2,3]	Alluvium: Groundwater and surface-water interactions	✓	✓	✓	
	CC-2B- GW[2,3]	Bedrock: Shallow groundwater	✓	✓	✓	

[1]Water level and temperature measured with submersible pressure transducers
[2]This well is co-located or in close proximity to a proposed surface-water monitoring location (Water and Earth, 2012)
[3]Use and installation of this well requires permission from the land owner (see Table 1)

6.0 POSSIBLE FUTURE CHARACTERIZATION ACTIVITIES

As discussed in the hydrogeology and conceptual model sections, the characteristics of the hydraulic connection between the Project area and Davidson Canyon, the DC Dike, and the DC fault zone will influence the impacts observed in Davidson Canyon. The recommended water-level, water-quality, isotope, and subsurface temperature data collection described in previous sections are designed to assist in further characterizing these features. It is possible, however, that the recommended data collection and subsequent analysis may need to be augmented.

It is recommended that this Plan be implemented for an appropriate period and then if necessary, other characterization methods can be evaluated. Potential future characterization could include the following:

- Hydraulic testing using high-capacity pumps in the proposed Open Pit area to assist in determining the degree of hydraulic connection of the Project area to lower Davidson Canyon
- Installing additional wells down gradient of the DC Dike and conducting hydraulic tests to provide direct information on the degree to which the dike restricts groundwater flow
- Hydraulic testing within the Davidson Canyon fault zone to explicitly determine its permeability and area of influence
- Geophysical surveys to locate and characterize the Davidson Canyon Dike, fault zone, and alluvial stream channel
- Additional subsurface temperature profiles and/or other methods for estimating storm-water infiltration rates and groundwater and surface-water interactions
- Refined grid and refined temporal discretization of groundwater flow models for predicting impacts in Davidson Canyon

Analysis and interpretation of data collected for this recommended Plan will provide additional insight into Davidson Canyon and the potential for Rosemont Project impacts. Additional characterization beyond that recommended in the Plan can be evaluated as needed.

7.0 DATA QUALITY

Detailed field-data collection and analysis activity notes will be maintained. Well locations and measuring point elevations will be determined by GPS or other adequately accurate method. Water-level data, water-quality samples, stable isotope samples, and temperature data will be collected and analyzed using standard operating procedures that are currently in-place or will be developed upon approval of this Plan. All field measurement, sampling procedures, and laboratory analytical procedures will comply with ADEQ requirements to ensure the collection of reliable and credible data. Consistent labeling, documentation, and chain-of-custody procedures for sample shipping will be followed. The inclusion of sample duplicates and blanks is anticipated to comply with all QA/QC requirements.

Following completion and approval of a final Davidson Canyon Monitoring Plan, a formalized Quality Assurance Plan (QAP) and Sampling Analysis Plan (SAP) that follow current ADEQ guidelines (ADEQ, 2004) may be required. The SAP will describe the overall sampling plan design and description of the environmental measurements. Details of equipment used for monitoring is also typically specified in a SAP.

The QAP discusses the details of the sampling and measurement protocols for field collection and laboratory analysis. The analytical laboratory QAPs will also be included into the Rosemont QAP. Sample analyses will meet the acceptable criteria outlined by ADEQ. An analytical laboratory list is presented in Appendix F of ADEQ (2004).

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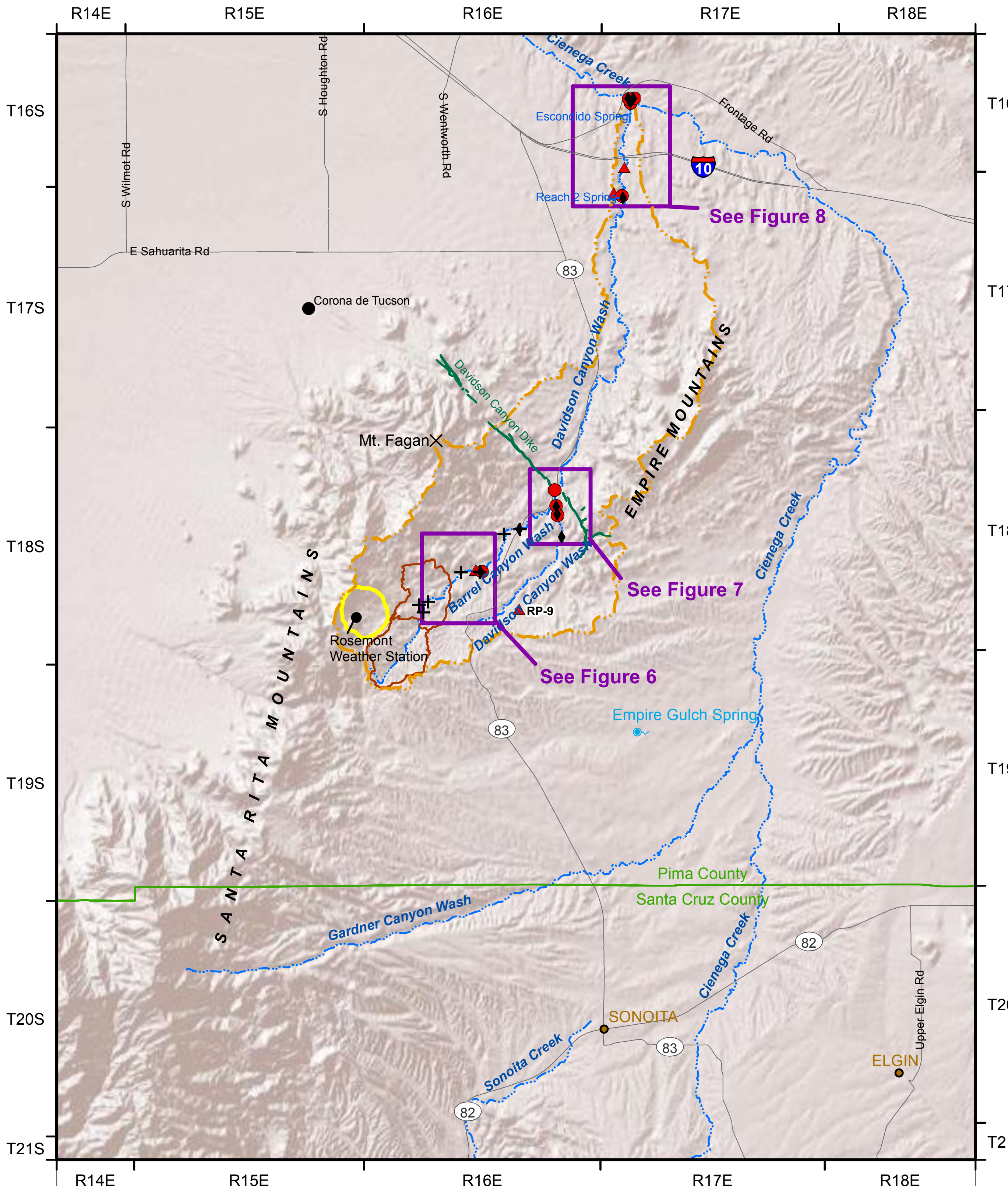

Explanation

- Detailed Map Area
- Extent of Ultimate Pit
- Davidson Canyon Dike
- Proposed Tailings and Waste Rock Facilities
- Davidson Canyon Watershed Boundary
- Ephemeral Streams

Monitor Locations

- RP-9 Existing Well Location Proposed for Monitoring
- Proposed New Monitoring Well
- Proposed Stormwater Sampling Location (Water and Earth, 2012)
- Proposed Surface-water Monitoring Location (Water and Earth, 2012)

N

0 1 2 3
Miles

Engineering Analytics, Inc.
ROSEMONT COPPER

Figure 1
Recommended Rosemont Monitoring Locations and Detailed Map Areas

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March 30, 2012

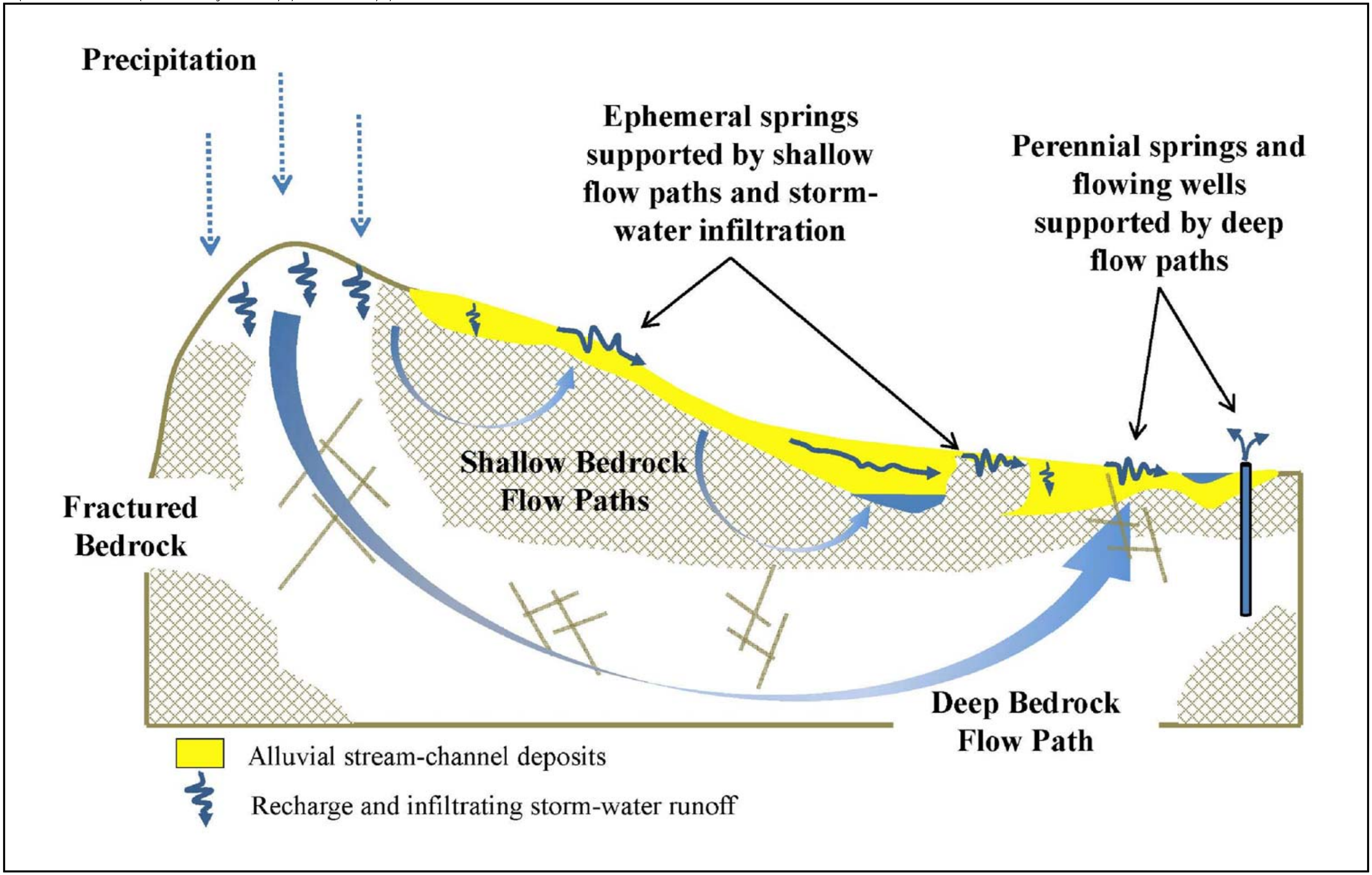

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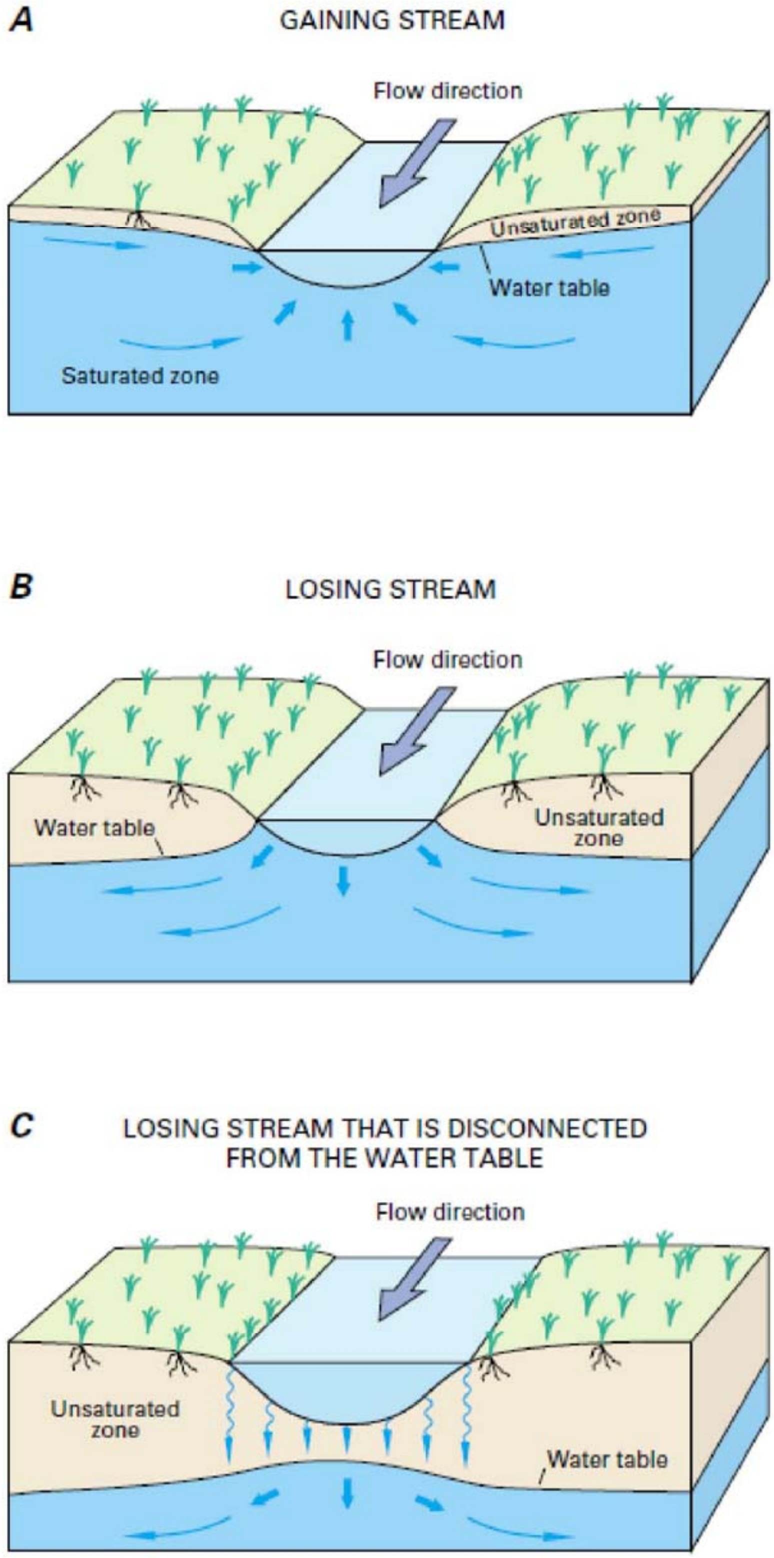
FIGURE 2
CONCEPTUAL MODEL OF GROUNDWATER FLOW PATHS, EPHEMERAL SPRINGS, AND PERENNIAL SPRINGS



T:\110195 Rosemont EIS\Streams.dwg SAVED: 3/5/12 PRINTED: 3/5/12

Project No. 110195

March 2012

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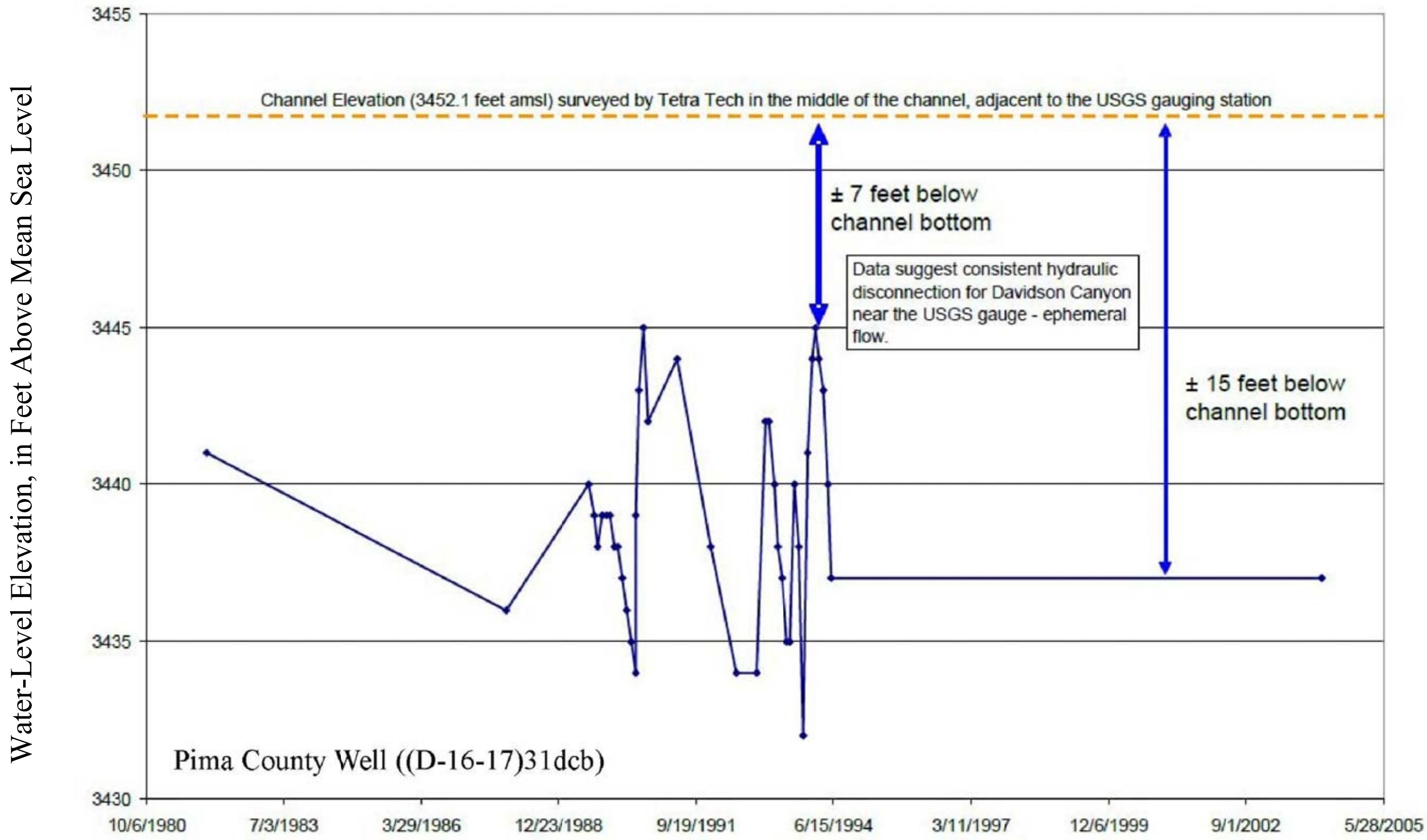
FIGURE 3
INTERACTIONS OF STREAMS AND GROUNDWATER
(MODIFIED FROM WINTER AND OTHERS, 1998)



Project No. 110195

Note: Data was compiled from the Davidson Canyon Unique Waters Nomination (PAG, 2005). (from Tetra Tech, 2010b)

March 2012

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FIGURE 4
GROUNDWATER DISCONNECTED FROM THE STREAM CHANNEL BOTTOM IN THE OAW REACH

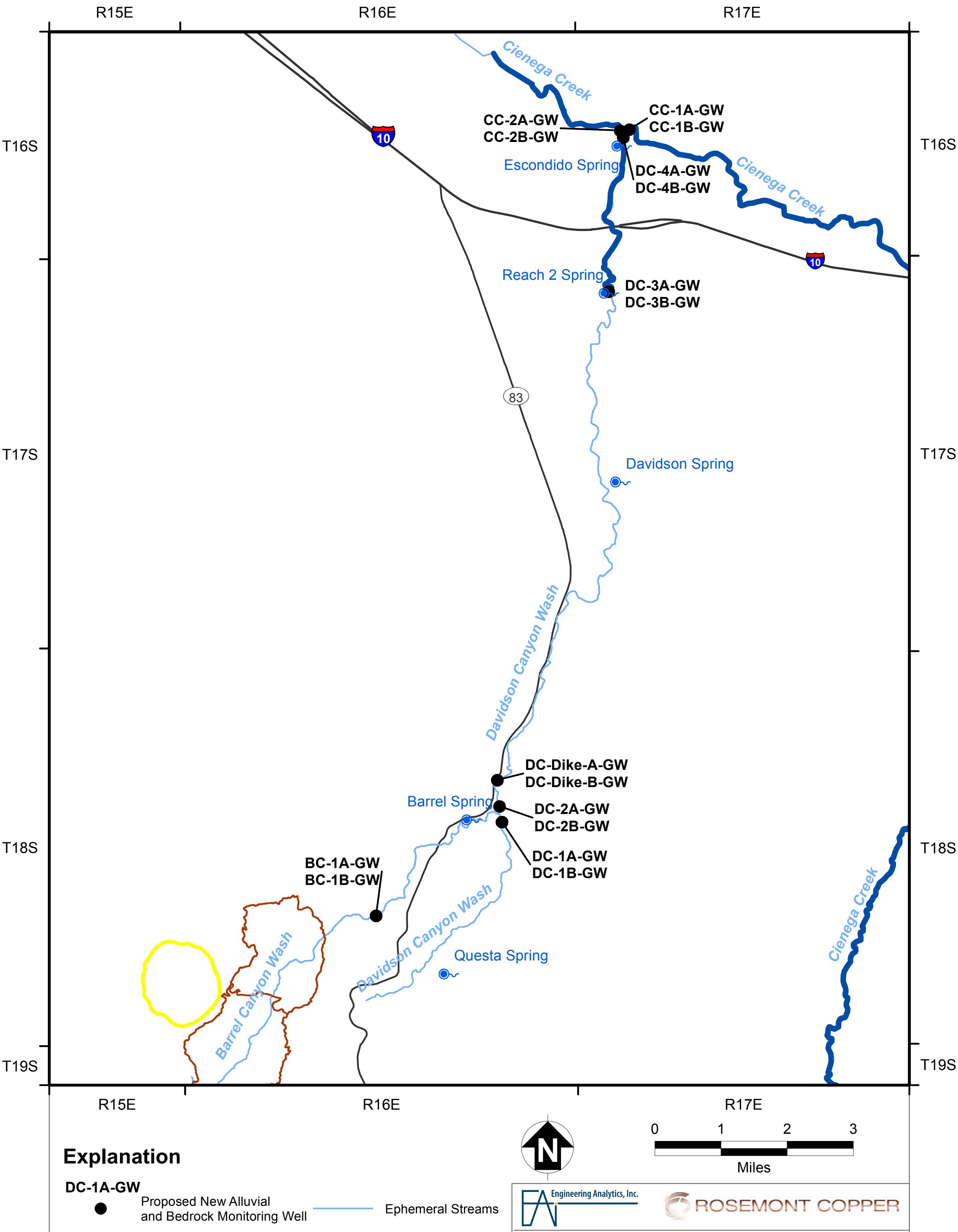
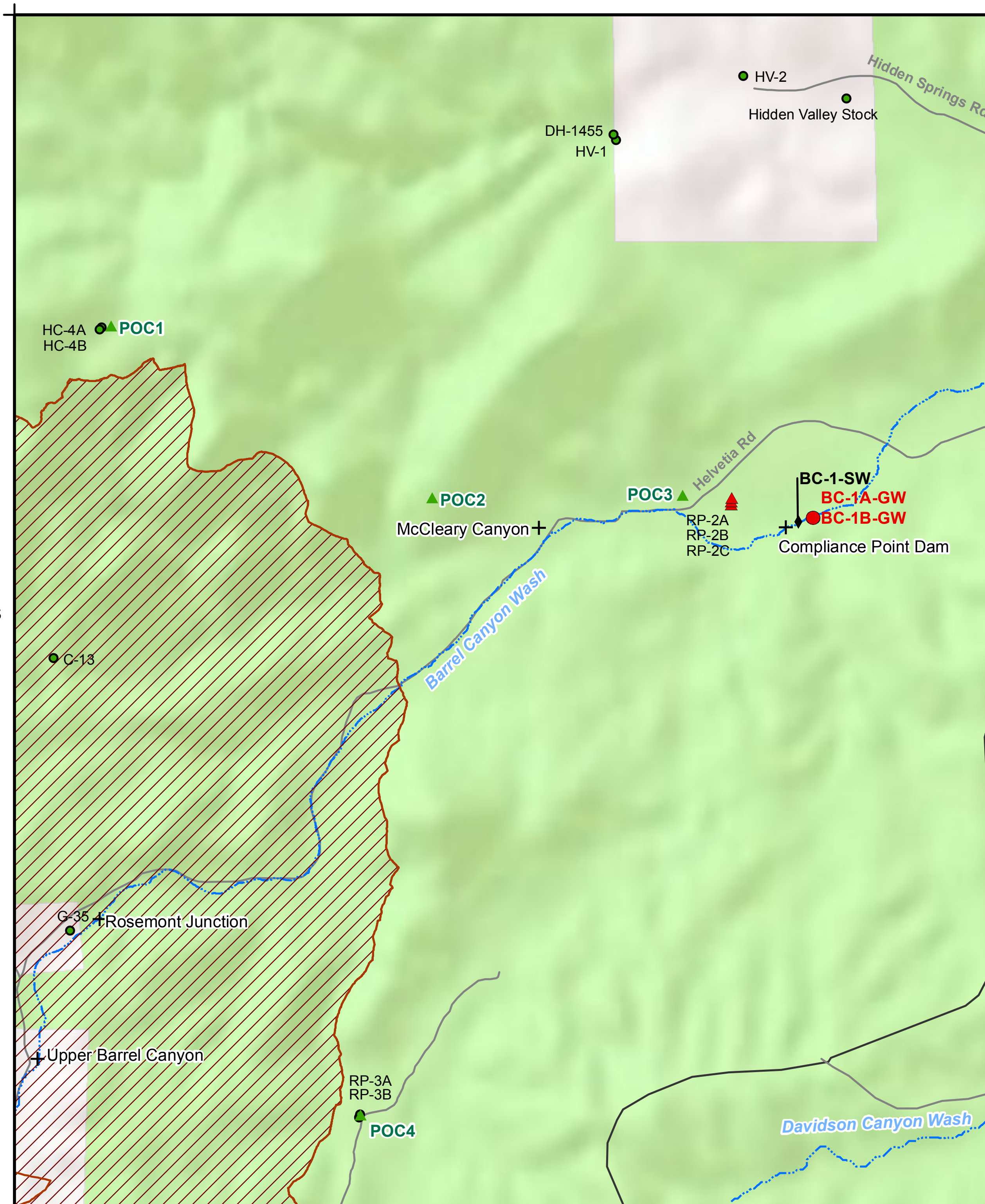


Figure 5
Overview of Recommended Rosemont Groundwater Monitoring Locations

File: T:\GIS\Projects\110195\Figures\DCMonitoring_Overview.mxd UTM NAD 83 Zone 12 N

March 30, 2012



Explanation

RP-3A	Existing Well Location and Identifier
RP-2A	Existing Well Location Proposed for Monitoring
BC-1A-GW	Proposed Bedrock and Alluvial Monitoring Wells
POC2	Point of Compliance Well and Identifier
	Ephemeral Streams
	Road
McCleary Canyon	Proposed Stormwater Sampling Location (Water and Earth, 2012)
BC-1	Proposed Surface-water Monitoring Location (Water and Earth, 2012)
	Proposed Tailings and Waste Rock Facilities

Land Ownership

- Coronado National Forest
- Private Land

0 1,500 3,000
Feet

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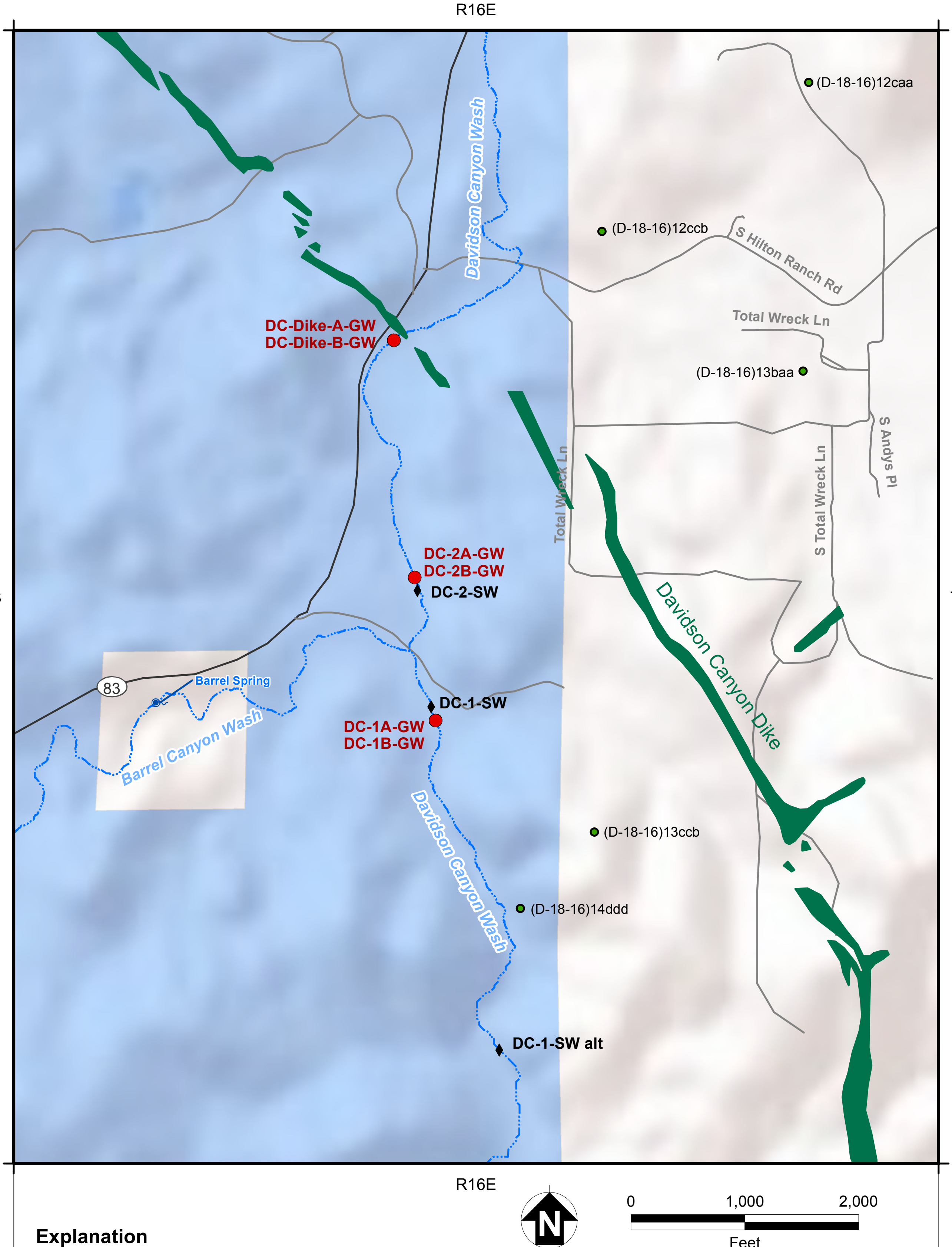
Figure 6
Barrel Canyon
Monitoring Locations

File: T:\GIS\Projects\110195\Figures\Monitoring_BarrelCanyon.mxd UTM NAD 83 Zone 12 N

March 20, 2012



Explanation

(D-18-16)14ddd — Existing Well Location and Identifier

DC-1-SW — Proposed Surface-water Monitoring Location (Water and Earth, 2012)

DC-1A-GW — Proposed Bedrock and Alluvial Monitoring Wells

Davidson Canyon Dike

Ephemeral Streams

Road

Land Ownership

Private Land

State Trust Land

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Figure 7
Upper Davidson Canyon Monitoring Locations

File: T:\GIS\Projects\110195\Figures\Monitoring_UpperDavidsonCanyon.mxd UTM NAD 83 Zone 12 N

March 20, 2012

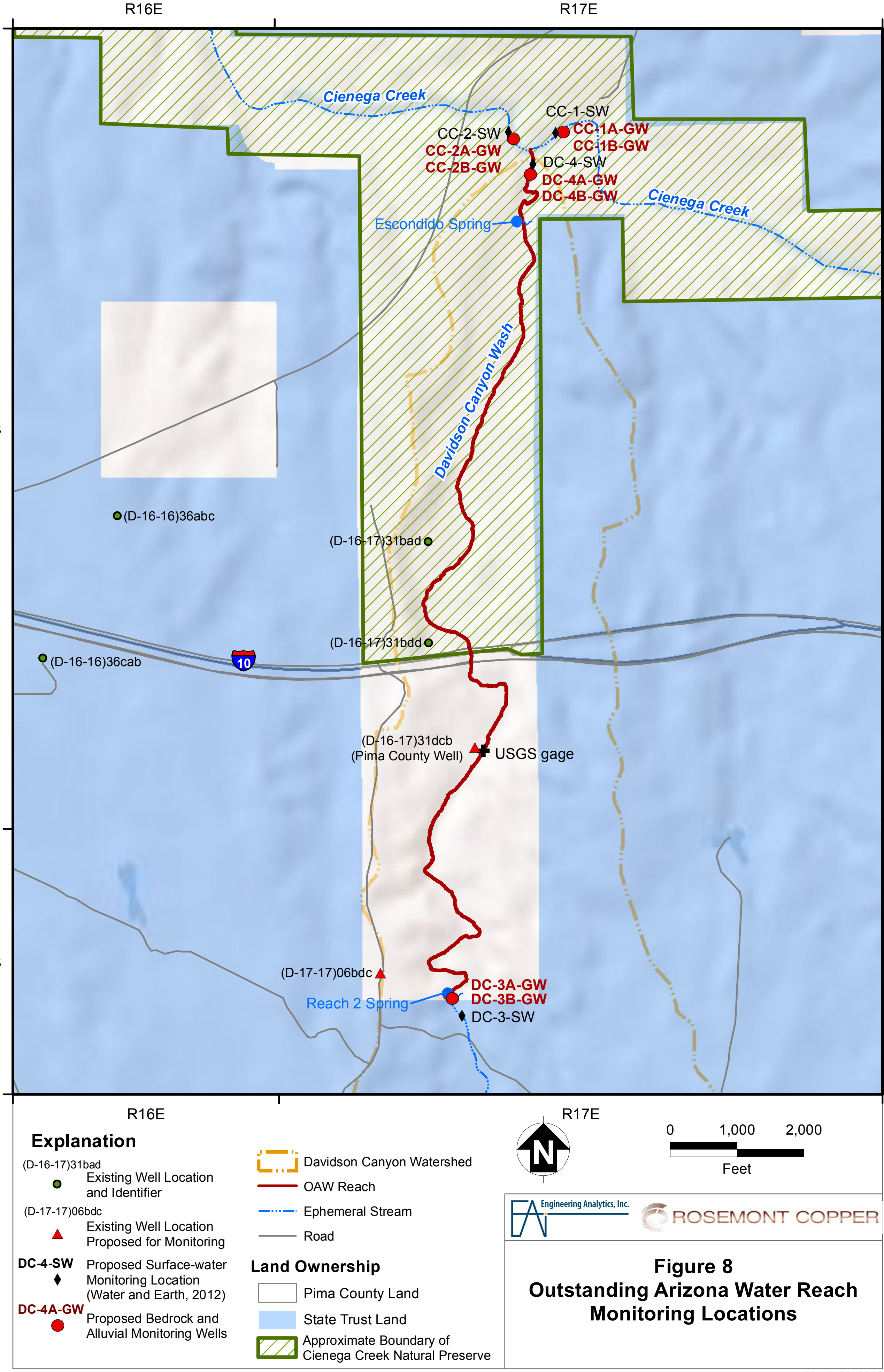

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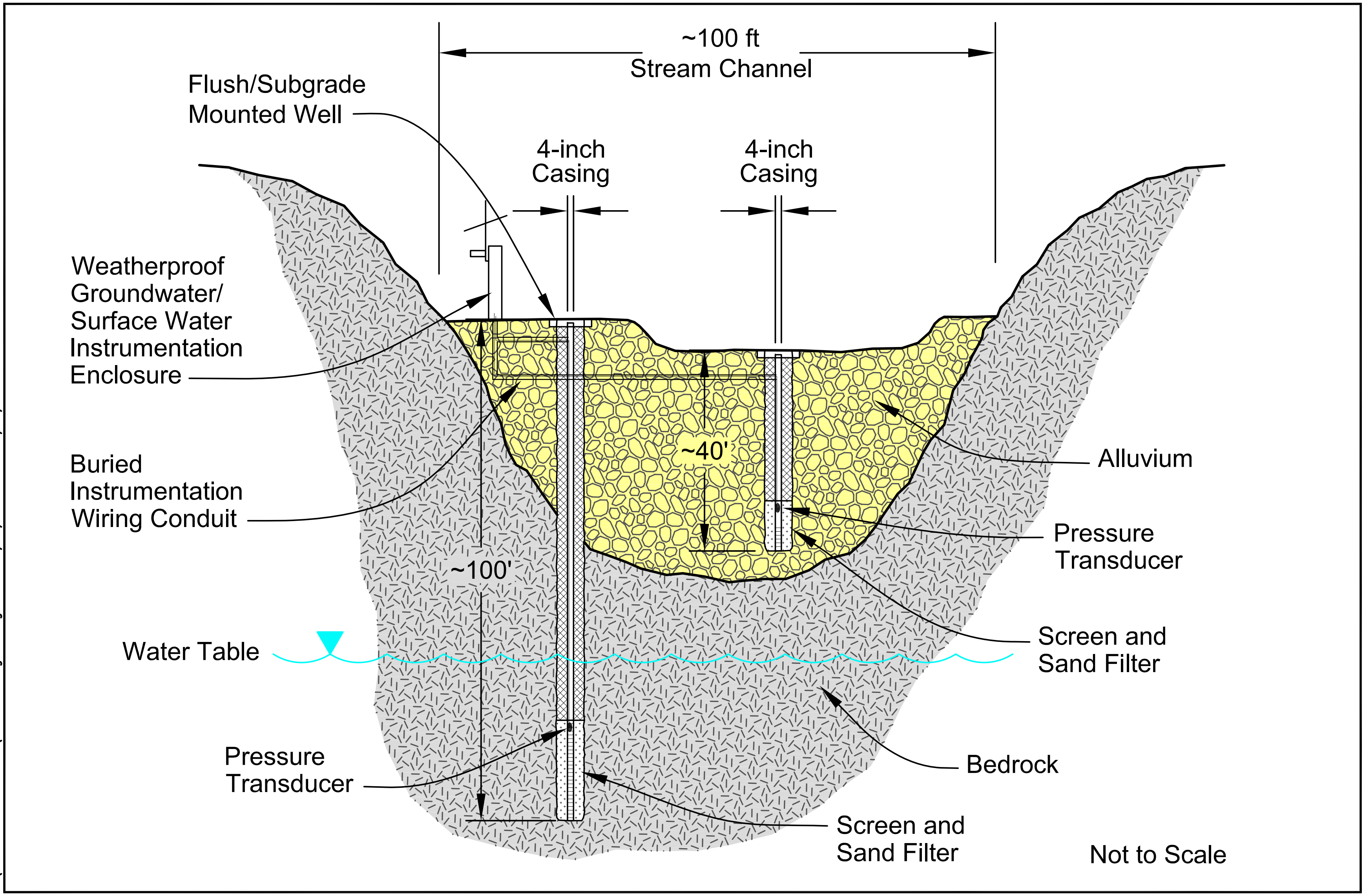
Figure 8
Outstanding Arizona Water Reach Monitoring Locations

File: T:\GIS\Projects\110195\Figures\Monitoring_OAW.mxd UTM NAD 83 Zone 12 N

March 20, 2012



Project No. 110195

March 2012

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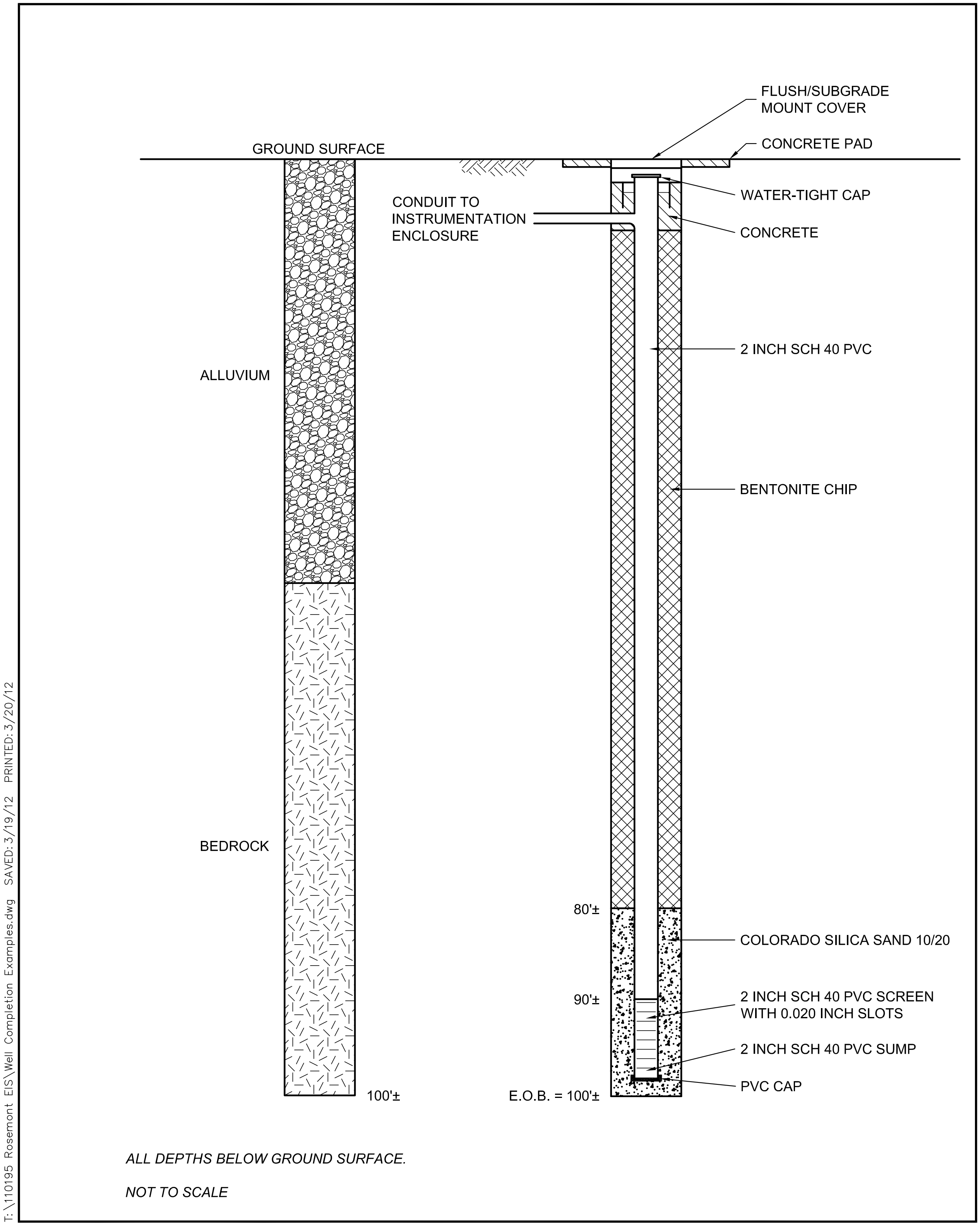
FIGURE 9
CONCEPTUAL CONFIGURATION OF BEDROCK AND ALLUVIAL MONITORING WELLS



Project No. 110195

March 2012

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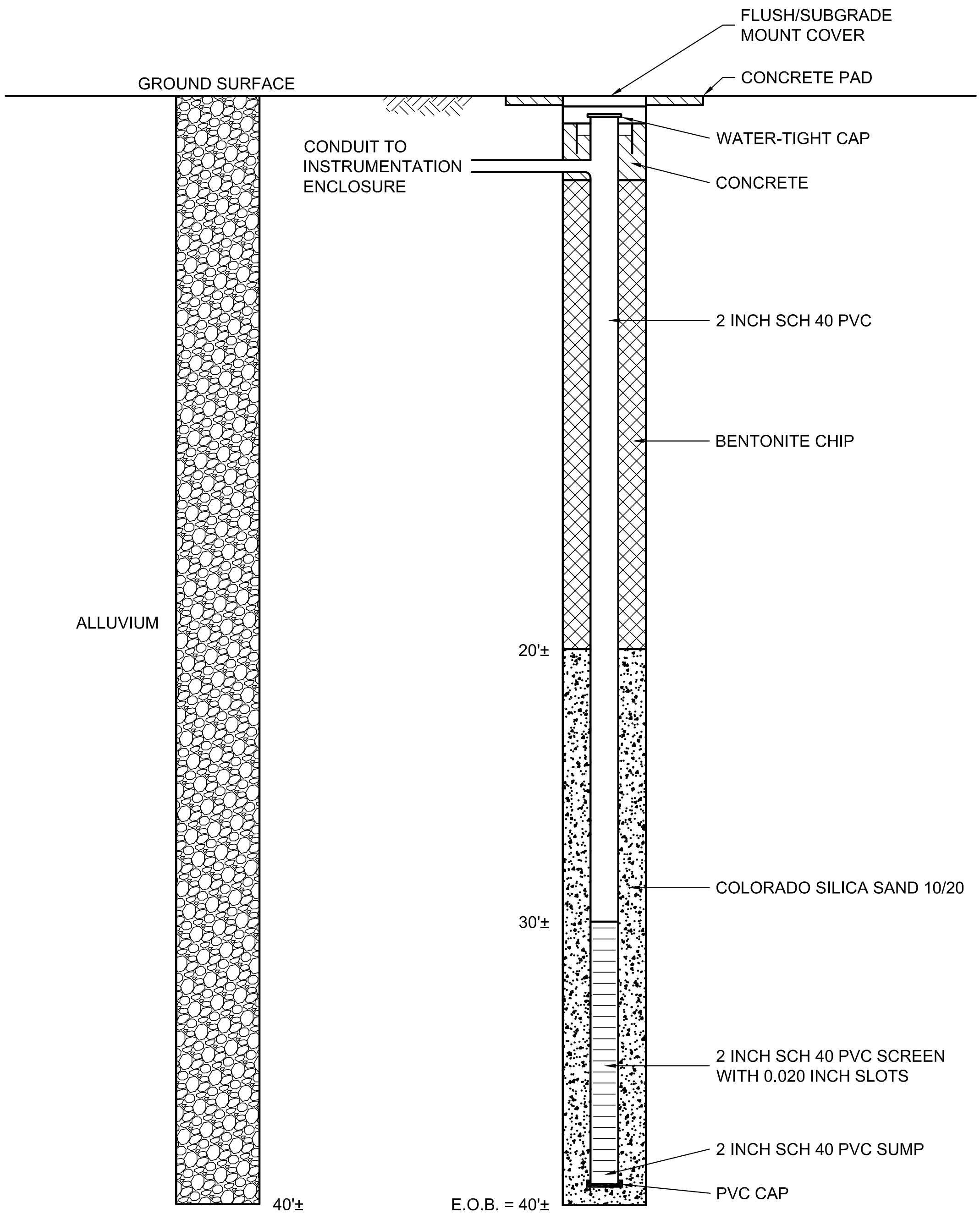
FIGURE 10
EXAMPLE BEDROCK WELL DESIGN



ALL DEPTHS BELOW GROUND SURFACE.

NOT TO SCALE

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Project No. 110195

March 2012

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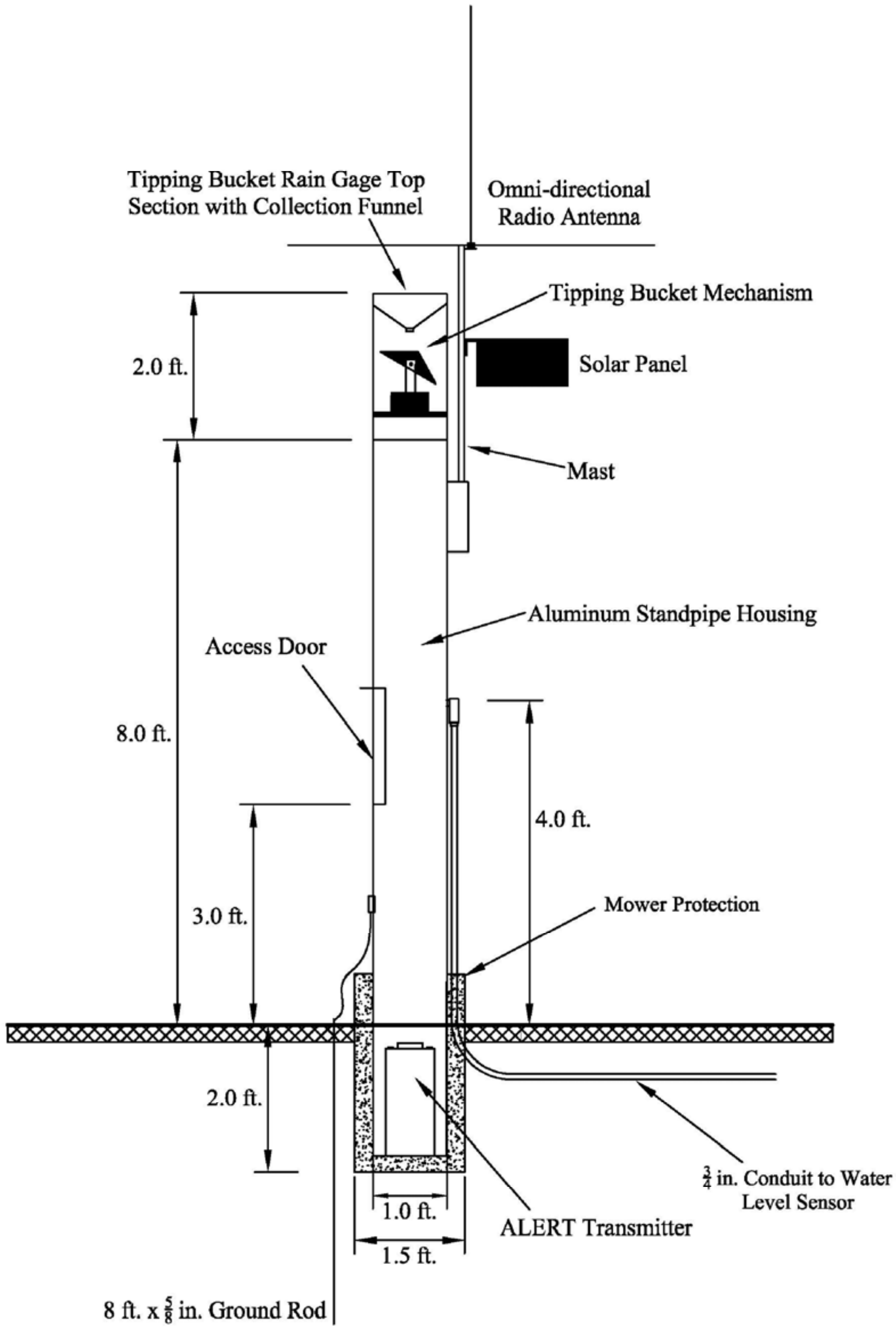
FIGURE 11
EXAMPLE ALLUVIAL CHANNEL WELL DESIGN



(FROM WATER & EARTH, 2012)

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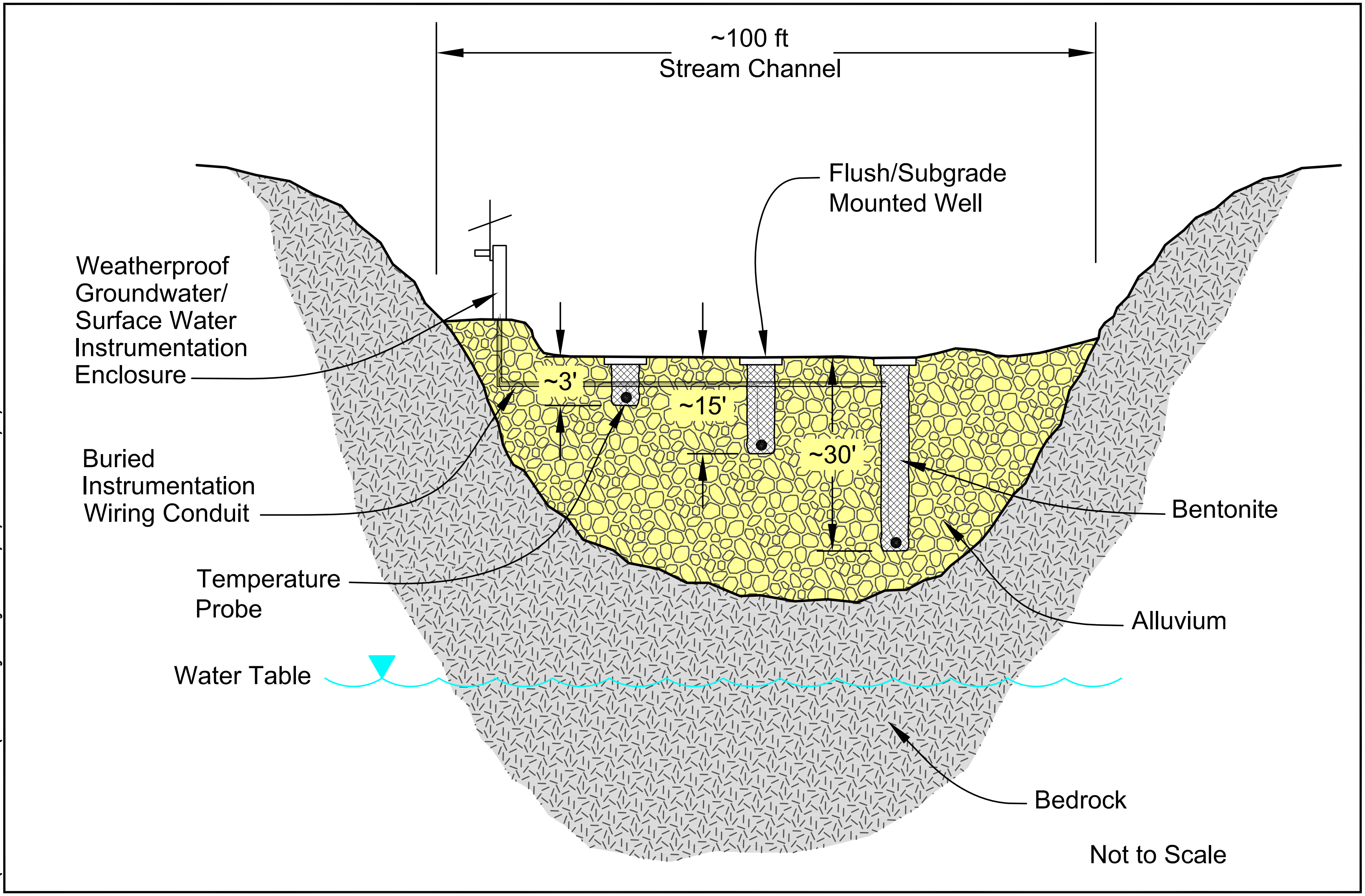
Project No. 110195 March 2012

Engineering Analytics, Inc.

FIGURE 12
TYPICAL STAGE AND RAIN MONITORING GAGE



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Project No. 110195

March 2012

Engineering Analytics, Inc.

FIGURE 13
CONCEPTUAL CONFIGURATION OF SUBSURFACE TEMPERATURE MONITORING

APPENDIX B

Draft Barrel / Davidson Canyon Wash Monitoring Plan (FS-BR-22)

Draft Barrel / Davidson Wash Monitoring Plan

As Required By:
Mitigation Measure FS-BR-22



November 2014

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REDEFINING MINING.

Monitoring and Reporting Schedule

Task Schedule	Purpose/Description	Generic Year			
		C	Q	R	A
Collect precipitation samples	After rain event			X	
Collect stormwater samples	After rain event			X	
Record groundwater level on data logger	Pressure transducers	X			
Record temperature data on data logger	Temperature probe	X			
Collect groundwater samples	Water level measurement at each sampling event		X		
Download Data from data logger	Inspect station during download		X		
Geomorphic monitoring	Every year for 5 years and every 5th year thereafter				X
Reporting (data summaries)	To Forest Service		X		
Reporting (data and analysis)	To Forest Service				X

C = continuously (pressure transducers); Q = quarterly; R = as needed; A = Annually

Revision Log

Revision Number	***Revision Lead***	***Purpose of Revision***	***Revision Date***

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1.0 PLAN OBJECTIVE AND DESCRIPTION

This monitoring plan (Plan) was developed in response to the mitigation and monitoring measure (Mitigation Measure) requirement of the U.S. Forest Service's (USFS) Coronado Forest (Coronado) Final Environmental Impact Statement (FEIS; USFS, 2013) for the Rosemont Copper Project (Project). The Mitigation Measure requirement is specified as "FS-BR-22: Monitoring to determine impacts from pit dewatering on downstream sites in Barrel and Davidson Canyons" on pages B-48 through B-50 in Appendix B of the FEIS. This Mitigation Measure is also mentioned on page 37 of the draft Record of Decision (ROD; USFS, 2013b).

Monitoring for Mitigation Measure FS-BR-22 will begin in the pre-mining phase of the Project and will continue into the closure phase. Portions of the Plan would be re-evaluated following two years of monitoring.

1.1 Plan Objective

The purpose of Mitigation Measure FS-BR-22 is to:

- Determine the existence and extent of impacts to groundwater drawdown to surface water features from pit dewatering; and
- Monitor geomorphic changes to Davidson Canyon.

The monitoring to be conducted under Mitigation Measure FS-BR-22 will be used to identify and evaluate changes and variability in the groundwater quality and levels, stormwater runoff (quantity and quality), and sediment transport to downstream washes over time and to determine if those changes and variability are due to natural or mining-related causes (i.e., de-watering in the mine pit), or other anthropogenic causes. Mitigation Measure FS-BR-22 is also designed to collect precipitation, surface water (i.e., stormwater) and groundwater data for the purpose of developing an understanding of the groundwater and surface-water interactions, infiltration from stormwater runoff into the stream channel alluvium (recharge), and groundwater flow paths.

Because all upstream stretches of both Barrel and Davidson Canyon washes, and their tributaries, are ephemeral, that is, they flow only in direct response to precipitation, reference to "surface water" monitoring under this Plan consists of only the measurements of stormwater flowing in the washes due to a significant storm event. There are no perennial or intermittent streams on or in the areas surrounding the Project.

Other USFS mitigation measures and/or other permits associated with monitoring groundwater and surface water changes (levels, flows/quantity, and quality) include:

- FS-GW-02: Water quality monitoring beyond point-of-compliance wells. This mitigation measure requires groundwater level and water quality monitoring at 14 existing wells and one new, proposed well. In addition, flow conditions and water quality sampling at 10 springs will be conducted under FS-GW-02. Monitoring for FS-GW-02 will be conducted on a quarterly basis (see pages B-17 and B-18 in Appendix B of the FEIS);
- FS-BR-05: Construction, management, and maintenance of water features to reduce potential impacts to wildlife and livestock from reduced flow in seeps, springs, surface water, and groundwater. This mitigation measure requires annual water level monitoring and managing/constructing water features, if needed, for Chiricahua leopard frog and

jaguar habitats (see page B-32 in Appendix B of the FEIS);

- FS-SSR-02: Spring, seep, and constructed/enhanced waters monitoring. This mitigation measure requires spring and seep flow/quantity monitoring at select springs located on and in surrounding areas of the Project site to measure the effects of groundwater drawdown and to determine if decreased water levels are due to mine activities (see pages B-26 and B-27 in Appendix B of the FEIS);

- FS-BR-27: Periodic validation and rerunning of groundwater model throughout life of mine. This mitigation measure also requires quarterly water level monitoring at well locations located on the Project site and in surrounding areas. A model validation report is due every 5 years and the installation of a new monitoring well is also required (see pages B-53 and B-54 in Appendix B of the FEIS);

- OA-GW-06: Groundwater quality and groundwater level monitoring required under the aquifer protection permit. This mitigation measure refers to monitoring requirements associated with point-of-compliance (POC) wells under Rosemont's aquifer protection permit (APP) No. P-106100 (see pages B-87 and B-88 in Appendix B of the FEIS); and

- The 401 certification requires a Surface Water Mitigation Plan that describes the monitoring and mitigation program Rosemont will conduct throughout the life of the Project. Monitoring results will be used to mitigate surface water flow volumes from the site and to track downstream conditions, i.e., sediment changes, water quality, etc.

Rosemont's Comprehensive Water Monitoring Plan summarizes the plans that are associated with water related issues. The Comprehensive Water Monitoring Plan includes a table listing the various monitoring programs and their associated wells, stations, points, and/or locations. The table was developed in an effort to eliminate duplication in data gathering.

1.2 Plan Description

This Plan includes the following components:

- Monitoring precipitation, surface water (i.e., stormwater runoff) and groundwater in Barrel and Davidson Canyon Washes, and in Cienega Creek depending on access. Each groundwater/surface water monitoring station, or surface water only station, will be equipped with an automated storm water sampler. Stations will be constructed as access to the sites is allowed;

- Geomorphological monitoring of changes (i.e., stream channel stability and sedimentation) in Davidson Canyon Wash at four (4) locations; and

- Construction of a weather station and relocation of the existing station at the Project site.

The following subsections describe the anticipated information to be gathered at the monitoring locations. These sub-sections include:

- Measurement Locations

- Monitoring Parameters

- Station/Instrumentation Design
- Data Transmission and Storage
- Station Monitoring Data
    - Precipitation Data
    - Surface Water Monitoring Data
    - Groundwater Monitoring Data
- Geomorphic Monitoring
    - Monitoring Points
    - LIDAR Scan
    - Photographs and Channel Observations
    - Initial Monitoring Event
    - Subsequent Monitoring Events
- Monitoring Frequency
- Analytical Parameters
- Water Quality Sampling Procedures
- Water Quality Thresholds

1.2.1 Measurement Locations

Rosemont has installed two (2) groundwater/surface water monitoring stations to date: one in Barrel Canyon wash (BC-2) and one in Davidson Canyon wash (DC-3). The locations of the two (2) monitoring stations are shown on Figure 1. The proposed locations for the additional groundwater/surface water and surface water only stations are shown on Figure 2. The following conceptual plans describe the station design:

- *Davidson Canyon Conceptual Surface-Water Monitoring Plan*, Water and Earth Technologies, Inc. (WET), March 2012; and
- Davidson Canyon Conceptual Groundwater Monitoring Plan, Engineering Analytics, Inc., March 2012.

Prior to constructing the remaining stations, Rosemont must resolve property ownership/access issues and other factors to determine a location's potential to obtain acceptable data. Table 1 shows the list of stations indicated in FEIS. Not all of the locations listed may be accessible to Rosemont.

1.2.2 Monitoring Parameters

In addition to automatic storm water sampling, each groundwater/surface water station will generally be equipped to monitor:

- Groundwater levels and water quality in the shallow, alluvial sediments;

- Groundwater levels and water quality in the deeper, bedrock aquifer;
- Groundwater temperature, in both the shallow and deep water zones;
- Soil moisture at different depths, ranging from 1 to 6 feet beneath the wash channel;
- Soil temperature and conductivity at different depths in the wash channel;
- Stream level (stage);
- Stream discharge (in cubic feet per second);
- 15-minute and cumulative precipitation measurements; and
- Precipitation water quality.

Mitigation Measure FS-BR-22 also includes geomorphological monitoring (i.e., stream channel stability and sedimentation) at four (4) locations in Davidson Canyon Wash.

Mitigation Measure FS-SR-05 ("Sediment Transport Monitoring" on page B-16 in Appendix B of the FEIS) requires geomorphological monitoring at two (2) locations in Lower Barrel Canyon Wash.

1.2.3 Station/Instrumentation Design

The general design components for each station are as follows:

- Two (2) groundwater wells (one shallow, one deep), each with a pressure transducer to automatically monitor groundwater levels (not applicable for surface water only station);
- One (1) pressure transducer installed in a perforated pipe just below the surface of the wash to monitor the stream level;
- ISCO stormwater sampler;
- Installation of multi-probe (temperature) sensors at different depths below wash level (not applicable for surface water only station);
- A standpipe housing; and
- An instrumentation enclosure. A data collection unit (DCU), located in a standpipe canister, is included and is programmed to sample, store, and transmit all sensor data via a commercial satellite.

Schematics showing the general layout of the instrument stations are shown on Illustrations 1 and 2. Each instrument station will be powered by a battery bank and solar panel. Illustration 1 shows the arrangement of the rain gage, water sampler and telemetry hardware installed in a 12-inch diameter, 10-foot tall aluminum standpipe housing. Illustration 2 shows hardware that is installed in the wash for measurement of stream stage, detection of flow and intake for the water sampler.

The automated sampler consists of a Teledyne ISCO (ISCO) pump sampler (Illustration 3), which is located in a waterproof equipment enclosure up out of the wash. Illustrations 4 and 5 show schematics of the two (2) installed stations, BC-2 and DC-3, respectively. Illustrations 6 and 7 provide photographs of these installed stations.

Two (2) redundant mechanical float switches in the wash trigger the automated collection of water samples during a flow event. Water samples are pumped from the intake in the wash to the ISCO sampler located in a weatherproof enclosure up on the wash bank. The sampler provides a purge cycle of the hose between samples to reduce any influence of sediment or debris inhibiting the pump.

1.2.4 Data Transmission and Storage

The Novastar 5 base station software is used to receive, process, manage, perform alarm and notification functions and archive data into a database. Novastar 5 is manufactured by HydroLynx Systems Inc. Data received from the monitoring stations can be accessed through a password-protected web site. Data can be queried in tabular or graphical format.

Data are logged on a 15-minute basis by the DCU and transmitted to the base station each hour. The base station archives a continuous record of 15-minute data. All data are stored on the DCU. The data communications between the remote stations and the NovaStar 5 base station will utilize a commercial low-earth-orbiting satellite network.

The DCU also activates a pump sampler when a stream level exceeding the trigger elevation is detected and confirmed by the float switch. The stormwater sampler is programmed to collect a 1-liter water sample every 5 minutes while the level in the stream is above the float switch activation level.

1.2.5 Station Monitoring Data

The following sub-sections provide details on the monitoring data that will be collected at each station:

- Precipitation Data
- Surface Water Data
- Groundwater Data

1.2.5.1 Precipitation Data

Baseline precipitation measurements are currently recorded at four (4) locations on and in the vicinity of the Project. The existing precipitation monitoring stations consist of the Rosemont Pit weather station, the USGS gage in Barrel Canyon (#09484580), and the two (2) surface-water/groundwater stations (BC-2 and DC-3) installed specifically for USFS Mitigation Measure FS-BR-22.

Precipitation at each of the current FS-BR-22 monitoring stations is measured by a 1-millimeter (mm) tipping bucket rain gage. These same devices will be installed at future stations. The existing weather station at the Project site is located in the center of the planned disturbance area. This station has been operating since 2006 and provides measurements of precipitation, evaporation, wind speed, wind direction and air temperature at 2 and 10 meters above the ground. This weather station will be moved to the Administration office location and a second Meteorological Monitoring Station will be installed as required by Mitigation Measure FS-BR-22 and also by Rosemont's Air Quality Control Permit No. 55223, the Arizona Department of Environmental Quality (ADEQ). Rosemont's air quality permit was issued on January 31, 2013

1.2.5.2 Surface Water Data

The surface water monitoring for Mitigation Measure FS-BR-22 is generally based on the monitoring proposed in the *Davidson Canyon Conceptual Surface-Water Monitoring Plan* (WET, 2012).

Stream stage and baseflow will be measured at water monitoring stations. Stream stage is a measure of the water surface elevation in the wash during a runoff event. Stream baseflow is a measure of the subsurface water level that occurs between stormwater events. An estimate of baseflow activity can be made from shallow subsurface water level in the stream channel. Stream stage and an estimate of baseflow measurements are made using one pressure transducer. The pressure transducer will be installed inside galvanized piping and anchored with concrete to the stream bank (see Illustration 2). During a storm event, the stage of water above the pressure transducer is measured frequently as the stream stage changes. Following the runoff event, the water level continues to be measured in order to describe changes in water level below the channel bed elevation providing stream baseflow.

Two (2) redundant mechanical float switches in the wash trigger the automated collection of water samples during a flow event. Water samples are pumped from the intake in the wash to the ISCO sampler located in a weatherproof enclosure up on the wash bank. The sampler provides a purge cycle of the hose between samples to reduce any influence of sediment or debris inhibiting the pump.

The measurement of stage at the station will be used to estimate the discharge of water at the station using a stage–discharge relationship developed specifically for the station. The stage–discharge relationship will be used in real time to estimate instantaneous discharge of water (in cubic feet per second) based on the stage (in feet) measured in the wash.

1.2.5.3 Groundwater Monitoring Data

The groundwater monitoring for Mitigation Measure FS-BR-22 is generally based on the monitoring proposed in the *Davidson Canyon Conceptual Groundwater Monitoring Plan* (Engineering Analytics, 2012).

Each water monitoring station will typically have one (1) well completed in the alluvial channel deposits, one (1) well completed in the bedrock, and soil (temperature) sensors installed in the shallow alluvium. A schematic of a typical well installation arrangement is shown on Illustration 8. Illustration 9 shows a schematic of the temperature sensors.

The groundwater levels, groundwater temperature, and soil parameter data obtained from these monitoring stations will assist in understanding the hydraulic connection between the alluvial drainage channels and the deeper bedrock groundwater system. Pressure transducers will be installed in each of the wells and will provide continuous groundwater level. The four (4) soil probes will provide data related to infiltration of stormwater into the drainage channel.

1.2.6 Geomorphic Monitoring

Mitigation Measure FS-SR-05 requires that Rosemont establish baseline channel bed morphology in lower Barrel Canyon Wash and then monitor the sediment transport and channel stability of the wash every five (5) years through the operational and closure phases of the Project. This schedule has been adjusted to include five (5) annual surveys starting in the pre-construction period and then every 5th year thereafter. Data obtained over time from the monitoring locations will be used to determine if significant erosion of sediment is occurring within the channel of Barrel Canyon Wash. The same approach will be used to monitor four (4) locations in Davidson Canyon under Mitigation Measure FS-BR-22. The use of ground based LIDAR (Light Detection and Ranging) scanner technology and photographs are proposed to document the physical changes over channel scour, degradation and aggradation, and geomorphological changes occurring within the stream channel at the monitoring locations.

The following subsections describe the anticipated information to be gathered at each monitoring location. These sub-sections include:

- Monitoring Points;
- LIDAR Scan;
- Photographs and Channel Observations;
- Initial Monitoring Event; and
- Subsequent Monitoring Events.

1.2.7 Monitoring Points

Rosemont will establish four (4) locations in Davidson Canyon Wash to monitor and assess any changes in stream geomorphology. These locations will need to be determined in conjunction with the Forest Service.

For each location, the following survey control will be added:

- Place and survey a minimum of four (4) control markers (elevation and horizontal) at each of the two monitoring points/locations; and
- Place permanent tags at each of the control points.

1.2.8 LIDAR Scan

As indicated, a ground-based LIDAR scanner will be used to map the stream channel at both Barrel Canyon Wash monitoring locations. The LIDAR scanner is an active remote sensing technology that uses light pulses to measure relative distance from the scanner, as well as other characteristics (texture, hardness, etc.) of terrain and objects. This generates a three-dimensional point “cloud” of the area that also includes light intensities and RGB color values from a digital camera. An area of approximately 100 feet x 100 feet will be scanned at each monitoring point depending on the stream channel width. The scanner will then create a high-resolution (down to 6 millimeters) digital elevation model of the stream channel. A GPS (Global Positioning System) receiver will be used to accurately determine the position of the LIDAR sensor and the environmental surface sensed with LIDAR.

Repeated LIDAR-derived data will then be used to detect and characterize changes over time that are occurring in the stream channel.

1.2.9 Photographs and Channel Observations

Photography will also be used to document stream points and channel observations. The LIDAR scanner is also equipped with a high-resolution camera. Photographs will focus on channel shape, channel bed and bank material, evidence of erosion or deposition, channel bank geometry, and vegetation. The photographs will be taken at the same location with the same angle facing the channel with the same level of magnification to ensure consistency.

At each monitoring event, photographs of each monitoring location will be taken from four (4) separate viewpoints: two (2) from upstream locations and two (2) from downstream locations).

1.2.10 Initial Monitoring Event

The following is a summary of the activities that will be conducted during the initial monitoring event:

- Locate and survey (elevation and horizontal) four control points at each monitoring location;
- Place permanent markers at each of the control points;
- Take photographs from each of the four (4) control points at set orientations (two (2) from upstream locations and two (2) from downstream locations);
- Record field notes describing channel conditions; and
- Take a three-dimensional cross-section topographic scan of the channel wash at each monitoring location. Create a topo (field) map of the monitoring location (area) and representative cross-sections showing the following (as appropriate): date/time, location of control points, direction of stream flow, North arrow, map scale, photopoint locations, and any other observations, i.e. trees, boulders, sand bars, etc.

1.2.11 Subsequent Monitoring Events

The following is a summary of the activities that will be conducted during subsequent monitoring events:

- Take photographs from each of the four (4) control points at set orientations (two (2) from upstream locations and two (2) from downstream locations);
- Record field notes describing channel conditions; and
- Take a three-dimensional cross-section topographic scan of the channel wash at each monitoring location. Create a topo (field) map of the same monitoring location (area) and same representative cross-sections showing the following (as appropriate): date/time, location of control points, direction of stream flow, North arrow, map scale, photopoint locations, and any other observations, i.e. trees, boulders, sand bars, etc.

Monitoring of all locations shall be done on the same day, including the locations associated with Mitigation Measure FS-SR-05.

1.3 Monitoring Frequency

Groundwater samples will be collected quarterly from all wells (alluvial and bedrock) associated with the water monitoring stations, if possible. The alluvial wells are typically dry and the bedrock wells tend to dewater quickly during pre-sampling purging.

Stormwater samples will be collected automatically by the water monitoring stations when washes are flowing. Stormwater runoff in the ephemeral washes on and near the Project site occurs only in response to significant precipitation events in the area. These storms are usually of short duration, i.e., less than 1 hour. However, during those short periods, the resulting flow can be of high intensity. The washes near the Project area demonstrate “flash flood” type of hydrologic response from storms. The bulk of the precipitation events annually occur during the thunderstorm-producing “monsoon” season in July and August and during multi-day precipitation events in December and January. Both of these meteorological patterns may produce storms over a short period of (consecutive) days. Short-duration runoff conditions, therefore, can occur daily for several days.

Stormwater samples collected under the FS-BR-22 monitoring program will be collected no less than three (3) days apart. The rationale for this frequency is that the water quality from back-to-back storm systems (i.e., those within 1 to 5 days from each other) is expected to be equivalent. Changes in water quality are more likely to occur seasonally rather than daily.

Precipitation at each of the FS-BR-22 monitoring stations will be measured by a 1-millimeter (mm) tipping bucket rain gage.

Geomorphological monitoring will occur annually at the established locations for five (5) years starting in the pre-construction period and then every 5th year thereafter.

1.4 Analytical Parameters

The specific procedures, methods, and considerations that are to be used when collecting groundwater samples and groundwater level measurements are described in the Rosemont Water Programs Quality Assurance Project Plan (Water Programs QAPP).

Stormwater samples collected from the Barrel/Davidson/Cienega monitoring stations will be submitted for the parameters listed in Table 2. Precipitation water samples will be submitted to the analytical laboratory for stable isotope (oxygen (^{18}O) and hydrogen (^{2}D) analysis. Groundwater samples collected from the wells (alluvial and bedrock) at the monitoring stations will be submitted to the analytical laboratory for the parameters listed in Table 3.

Only Arizona-certified laboratories will be used for water analysis.

1.5 Water Quality Sampling Procedures

The specific procedures, methods, and considerations that are to be used when collecting groundwater samples and groundwater level measurements are described in the Rosemont Water Programs QAPP.

In general, prior to collecting a water quality sample at each well, the static water level will first be measured and recorded with an electric water level sounder to confirm the pressure transducer reading. Data from the transducer datalogger will be downloaded quarterly. Wells will be purged and sampled in accordance with the Rosemont Water Programs QAPP.

Stormwater samples are collected automatically by the Teledyne ISCO (ISCO) pump sampler. Within 24 hours of a storm event, the ISCO sample bottles will be collected as well as the precipitation water samples and transported to an analytical laboratory.

1.6 Water Quality Thresholds

Water quality data received from the analytical laboratory undergo a data validation process, which will review and assess the sampling and analyses protocols to ensure that the samples and data are reliable, accurate, and representative.

Once the analytical data have been validated, the results will be compared to available background (pre-mining) data and applicable water quality standards, pursuant to Arizona Administrative Code (A.A.C.) Title 18, Chapter 11, Article I. Pre-mining data will include water quality results, obtained through Rosemont's Voluntary Baseline Stormwater Sampling Program, Voluntary Baseline Spring Monitoring Program, and Voluntary Baseline Groundwater Monitoring Programs.

Stormwater samples will be compared to Arizona surface water quality standards (SWQSs), which are based on designated uses. The applicable designated uses for the Barrel Canyon Wash, as well as other unnamed ephemeral washes, are:

- Aquatic and Wildlife (ephemeral) (A&We); and
- Partial Body Contact (PBC).

Reach 1 of Davidson Canyon Wash, which extends from the headwaters to the beginning of Reach 2 (the beginning of the Outstanding Arizona Waters (OAW) segment), is also classified as ephemeral but has an additional designated use of livestock watering. The applicable designated uses for Reach 1 of Davidson Canyon Wash are:

- A&We;
- PBC; and
- Agricultural Livestock Watering (AgL).

Reaches 2 and 4 of Davidson Canyon Wash, which are part of the OAW segment, are classified as perennial/intermittent and therefore, have the designated uses of:

- Aquatic and Wildlife, warm water (A&Ww);
- AgL;
- Fish Consumption (FC); and
- Full Body Contact (FBC).

Reach 3 of Davidson Canyon Wash, which is located between Reach 2 and Reach 4, and is also part of the OAW segment, is classified as ephemeral. Therefore, the applicable SWQSs for Reach 3 are the same as Reach 1. Figure 3 generally shows the four (4) reaches designated along Davidson Canyon wash.

Groundwater quality sample analytical data will be compared to the available background (pre-mining) data and the State numeric groundwater quality standards, i.e., the Aquifer Water Quality Standards (AWQSs), pursuant to A.A.C. R18-11-406. Although water quality data obtained under Mitigation Measure FS-BR-22 will be compared to pre-mining data and applicable water quality standards, this mitigation measure does not require the calculation and/or establishment of numeric standards, limits, thresholds, alert levels, or contingency actions for these monitoring stations. Water quality and water level data will be presented in appropriate hydrographs, charts, and/or trend analysis, which will reflect changes over time, whether seasonally or long-term. These hydrographs, charts, and trend analyses will be included in each FS-BR-22 annual summary report submitted to the USFS.

2.0 MONITORING AND REPORTING

Monitoring and reporting components for Mitigation Measure FS-BR-22 are listed below.

2.1 Monitoring

The following information will be collected quarterly from the surface water/groundwater monitoring stations:

- Data retrieval (water levels, rainfall temperature);
- Groundwater samples; and
- Manual groundwater level measurement.

The following will be collected, as practicable, after storm events:

- Stormwater samples; and
- Rainfall samples.

The following will be collected in annual increments for first 5 years and then every 5th year:

- Photographs of sediment monitoring locations; and
- LIDAR scan of sediment monitoring locations.

2.2 Reporting

Reports for Mitigation Measure FS-BR-22 will be provided to the Forest Service annually and include the following information:

- Tabulation, as appropriate, of current and accumulated precipitation, groundwater, surface water, and soil data;
- Summary of meteorological data from on-site or other selected weather stations;
- Development of appropriate charts, hydrographs, trend analyses; and
- Evaluation of the data will focus on surface water/groundwater interactions including the degree of vertical hydraulic connectivity between the washes and the shallow and deep aquifers, response time between storm events and recharge to the aquifer systems, storage properties, and changes in groundwater quality.

In addition to the annual reports, data from the surface water/groundwater monitoring stations will be downloaded and evaluated. Summary reports of this data will be provided to the USFS.

Included in the annual report will be the results of the geomorphological monitoring. Data will be collected and assessed every five (5) years and compared with previous years' data. The report is anticipated to include:

- Charts and trend analysis to graphically display the data;
- Comparative cross-sections prepared from the topographic scans;

- Volumetric differences between the scans;
- Photographs; and
- A discussion of the monitoring results.

3.0 ADAPTIVE MANAGEMENT

Rosemont will incorporate the adaptive management process into Mitigation Measure FS-BR-22. This process will ensure that the initial intent of the monitoring is being met and that pertinent data is being collected. The three key components of adaptive management are:

- Testing assumptions – collecting and using monitoring data to determine if current assumptions are valid;

- Adaptation – making changes to assumptions and monitoring program to respond to new or different information obtained through the monitoring data and project experience; and

- Learning – documenting the planning and implementation processes and its successes and failures for internal learning as well as the scientific community.

Elements that may be modified as part of the adaptive management process for this Plan include, but are not limited to, the following:

- Station locations;

- Monitoring parameters;

- Monitoring frequency; and

- Reporting schedule.

4.0 DATA MANAGEMENT

Records will either be taken in hardcopy format or electronically. These records will be used as a basis of reporting and compliance verification.

5.0 REFERENCES

ADEQ, 2013. Air Quality Class II Synthetic Minor Permit for the Rosemont Copper Project. January 2013

Engineering Analytics, Inc., 2012. Davidson Canyon Conceptual Groundwater Monitoring Plan. Consultant report prepared for Rosemont Copper Company. March 30, 2012.

Hydro-Logic, LLC, 2013. Groundwater Monitoring Well Installation, Barrel Canyon and Davidson Canyon: December 2012. Consultant report prepared for Rosemont Copper Company. February 8, 2013.

USFS, 2013a. Final Environmental Impact Statement for Rosemont Copper Project, Appendix B Mitigation and Monitoring Plan. November 2013.

USFS, 2013b. Draft Record of Decision and Finding of Nonsignificant Forest Plan Amendment for the Rosemont Copper Project. December 2013.

WET, 2012. Davidson Canyon Conceptual Surface-Water Monitoring Plan. Consultant report prepared for Rosemont Copper Company. Draft report dated March 2012.

WET, 2013. As-Built Report, Barrel and Davidson Canyons Surface-Water and Groundwater Monitoring Instrumentation Stations. Consultant report prepared for Rosemont Copper Company. January 25, 2013.

TABLES

Table 1. FS-BR-22 Monitoring Points and Required Parameters

Monitoring Station ID	Flow	Precipitation	Water Quality	Shallow Well	Deep Well	Water Level and Temperature	GW Quality	Isotopes	Subsurface Temperature
BC-1	X	X	X	X	X	X	X		X
BC-2	X	X	X	X	X	X	X		X
DC-1	X	X	X	X	X	X	X	X	
DC-2	X	X	X	X	X	X	X	X	X
DC-Dike				X	X	X	X	X	
DC-3	X	X	X	X	X	X	X	X	X
DC-4	X	X	X	X	X	X	X	X	
CC-1	X		X	X	X	X	X	X	
CC-2	X		X	X	X	X	X	X	

Note: Adjustments have been made to the original monitoring list shown. Field adjustments were made to DC-3 and DC-4 and BC-1 will be surface water only.

Table 2. FS-BR-22 Stormwater Monitoring Parameters

Parameter	SWQS	Units
pH – field	6.5 –	S.U.
Specific conductance - field	NS	µmhos/cm
Temperature - field	NS	° C
pH - lab	6.5 –	S.U.
Specific conductance - lab	NS	µmhos/cm
Temperature - lab	NS	° C
Total dissolved solids (TDS)	NS	mg/L
Total alkalinity	NS	mg/L
Carbonate	NS	mg/L
Bicarbonate	NS	mg/L
Hydroxide	NS	mg/L
Hardness	NS	mg/L
Chloride	NS	mg/L
Fluoride	140	mg/L
Sulfate	NS	mg/L
Calcium	NS	mg/L
Magnesium	NS	mg/L
Potassium	NS	mg/L
Sodium	NS	mg/L
Nitrate (as N)	3733.3	mg/L
Nitrate + Nitrite (as N)	NS	mg/L
Total Nitrogen (calculation)	NS	mg/L
Total Kjeldahl nitrogen	NS	mg/L
Cyanide	0.084	mg/L
Total Metals		
Antimony	0.747	mg/L
Arsenic	0.280	mg/L
Barium	98.0	mg/L
Beryllium	1.867	mg/L
Boron	186.6	mg/L
Cadmium	0.70	mg/L
Chromium - total	NS	mg/L
Copper	1.3	mg/L
Iron	NS	mg/L
Lead	0.015	mg/L
Manganese	130.7	mg/L
Mercury	0.280	mg/L
Molybdenum	NS	mg/L
Nickel	28.0	mg/L
Selenium	0.033	mg/L
Silver	4.667	mg/L
Thallium	0.075	mg/L
Uranium	2.8	mg/L
Zinc	280.0	mg/L

SWQS = Surface Water Quality Standard;

[1] : Actual SWQS based on hardness value. See tables in Appendix A of 18 A.A.C. 11, Article 1.

[2] : Standard of 0.034 mg/L is for Chromium IV, the most stringent of the chromium standards

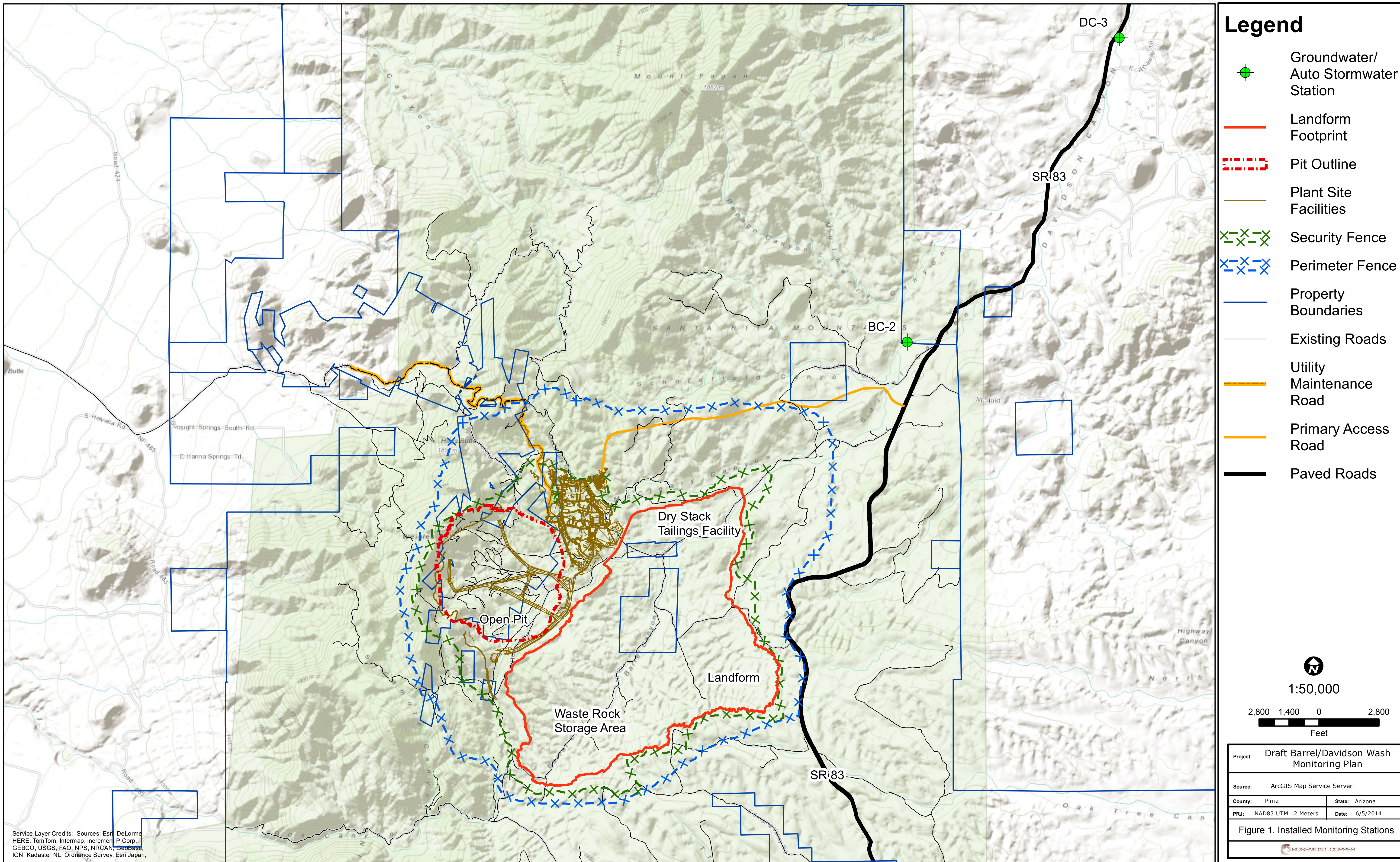
Table 3. FS-BR-22 Groundwater Monitoring Parameters

Parameter	Detection Limit Required	Arizona Aquifer Water Quality Standard (AWQS)
Depth to Water Level (feet)	0.01 feet	None
Water Level Elevation (feet)	0.1 feet amsl	None
Temperature - field	0.1 ° C	None
pH – field	0.1 S.U.	None
Specific conductance - field	1 µS/cm	None
pH – lab	0.1 S.U.	None
Total dissolved solids (TDS)	10 mg/L	None
Total alkalinity	2 mg/L	None
Carbonate	2 mg/L	None
Bicarbonate	2 mg/L	None
Hydroxide	2 mg/L	None
Calcium	4.0 mg/L	None
Magnesium	3.0 mg/L	None
Potassium	5.0 mg/L	None
Sodium	5.0 mg/L	None
Chloride	1 mg/L	None
Fluoride	0.50 mg/L	4.0 mg/L
Sulfate	5.0 mg/L	None
Nitrate + Nitrite	0.10 mg/L	10.0 mg/L
Nitrate, as N	1.0 mg/L	10.0 mg/L
Nitrite, as N	0.10 mg/L	1.0 mg/L
Cyanide (CN)	0.10 mg/L	0.20 mg/L
Dissolved Metals		
Antimony	0.0005 mg/L	None
Arsenic	0.04 mg/L	None
Beryllium	0.002 mg/L	None
Cadmium	0.002 mg/L	None
Chromium	0.005 mg/L	None
Copper	0.02 mg/L	None
Lead	0.04 mg/L	None
Mercury	0.001 mg/L	None
Nickel	0.05 mg/L	None
Selenium	0.01 mg/L	None
Thallium	0.0005 mg/L	None
Zinc	0.04 mg/L	None
Total Metals		
Antimony	0.0005 mg/L	0.006 mg/L
Arsenic	0.04 mg/L	0.05 mg/L
Barium	0.05 mg/L	2.0 mg/L
Beryllium	0.002 mg/L	0.004 mg/L
Boron	0.10 mg/L	None

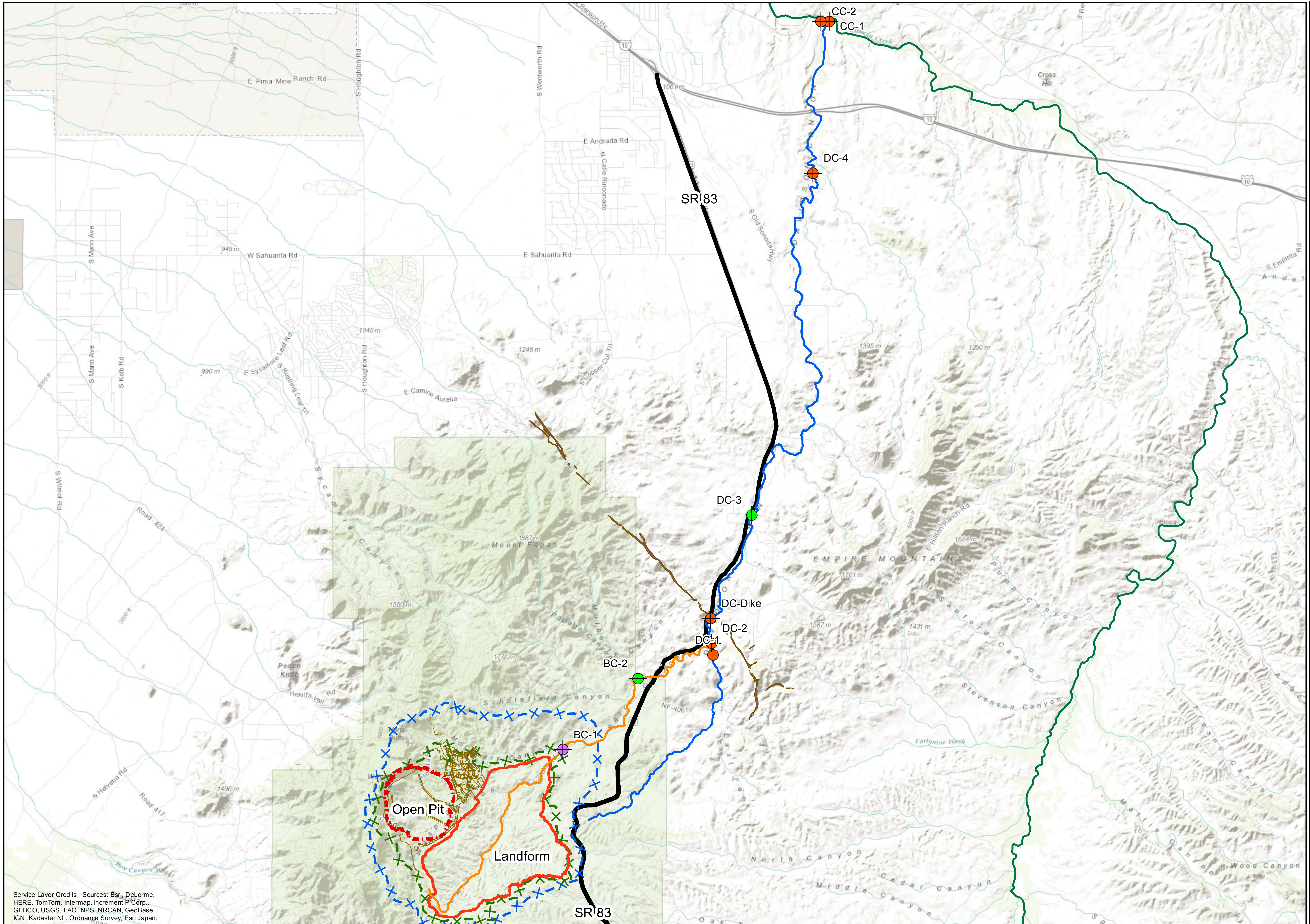
Parameter	Detection Limit Required	Arizona Aquifer Water Quality Standard (AWQS)
Cadmium	0.002 mg/L	0.005 mg/L
Chromium	0.003 mg/L	0.10 mg/L
Cobalt	0.10 mg/L	None
Copper	0.02 mg/L	None
Iron	0.30 mg/L	None
Lead	0.30 mg/L	0.05 mg/L
Manganese	0.02 mg/L	None
Mercury	0.001 mg/L	0.002 mg/L
Molybdenum	0.01 mg/L	None
Nickel	0.05 mg/L	0.10 mg/L
Selenium	0.0083 mg/L	0.05 mg/L
Silver	0.01 mg/L	None
Thallium	0.0005 mg/L	0.002 mg/L
Zinc	0.04 mg/L	None
Radiochemicals and Other Parameters		
Gross Alpha Particle	0.10 pCi/L	None
Adjusted Gross Alpha	1.0 pCi/L	15.0 pCi/L
Radium 226 + Radium 228	0.50 pCi/L	5.0 pCi/L
Radium 226	0.40 pCi/L	None
Radium 228	0.50 pCi/L	None
Uranium Activity	0.50 pCi/L	None
Uranium – isotopes	0.50 pCi/L	None
Oxygen (Delta ^{18}O)	N/A	None
Deuterium (^{2}H or D)	N/A	None

amsl = above mean sea level
° C = degrees Centrigrade
S.U. = Standard units
µS/cm = microSiemens per centimeter
mg/L = milligrams per liter
pCi/L = picoCuries per liter

FIGURES



Legend
Groundwater/ Auto Stormwater Station
Landform Footprint
Pit Outline
Plant Site Facilities
Security Fence
Perimeter Fence
Property Boundaries
Existing Roads
Utility Maintenance Road
Primary Access Road
Paved Roads
1:50,000
2,800 1,400 0 2,800
Feet
DC-3
BC-2
SR 83
Dry Stack Tailings Facility
Open Pit
Landform
Waste Rock Storage Area
Project: Draft Barrel/Davidson Wash Monitoring Plan
Source: ArcGIS Map Service Server
County: Pima
State: Arizona
PRJ: NAD83 UTM 12 Meters
Date: 6/5/2014
Figure 1. Installed Monitoring Stations
ROSEMONT COPPER
Service Layer Credits: Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan,



Project:	Draft Barrel/Davidson Wash Monitoring Plan
Source:	ArcGIS Map Service Server
County: Pima	State: Arizona
PRJ: NAD83 UTM 12 Meters	Date: 11/17/2014

Figure 2. Installed / Proposed Monitoring Stations

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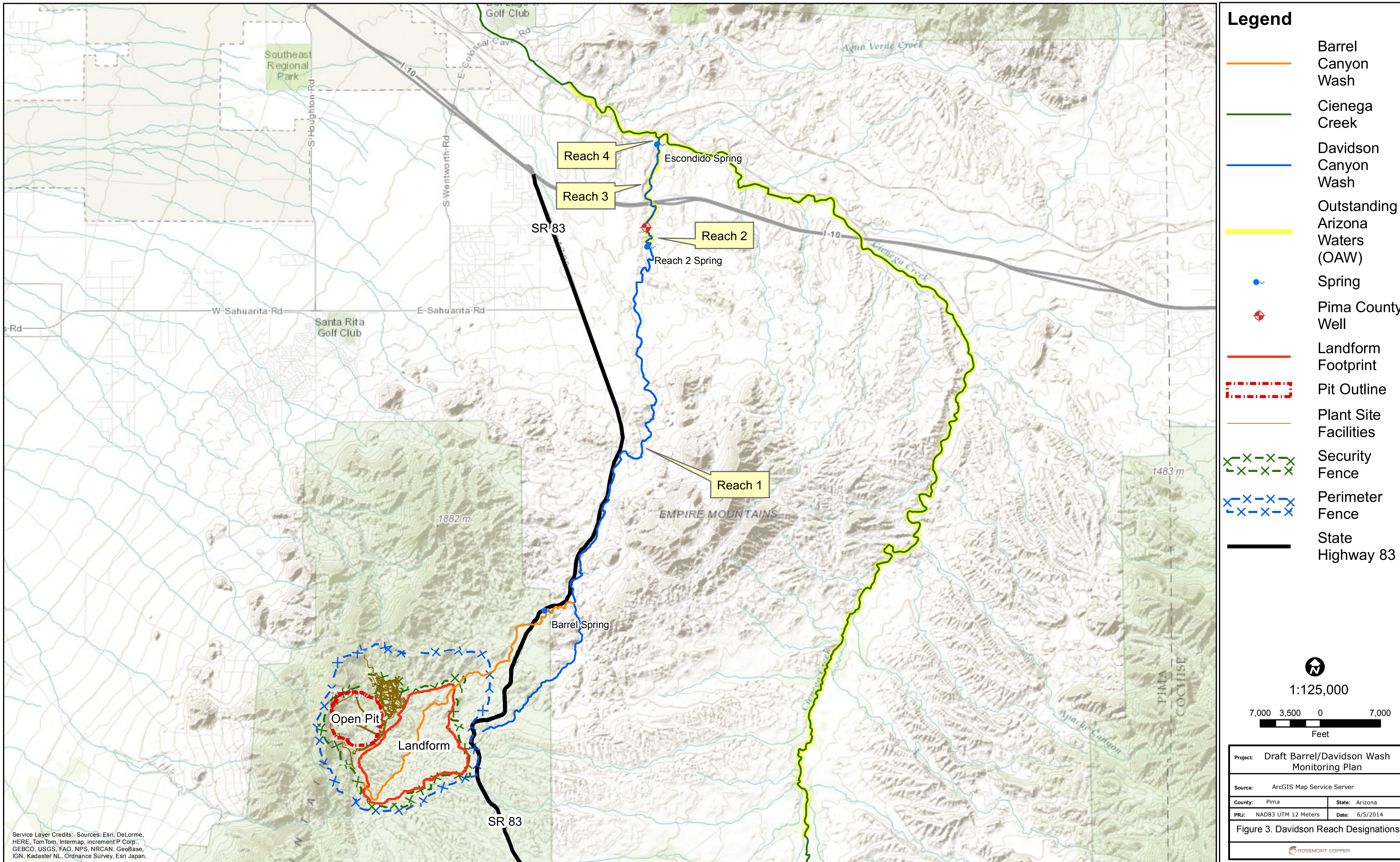


Figure 3. Davidson Reach Designations

ILLUSTRATIONS

Illustration 1. Schematic for Surface Water / Groundwater Monitoring Stations – Out of Wash

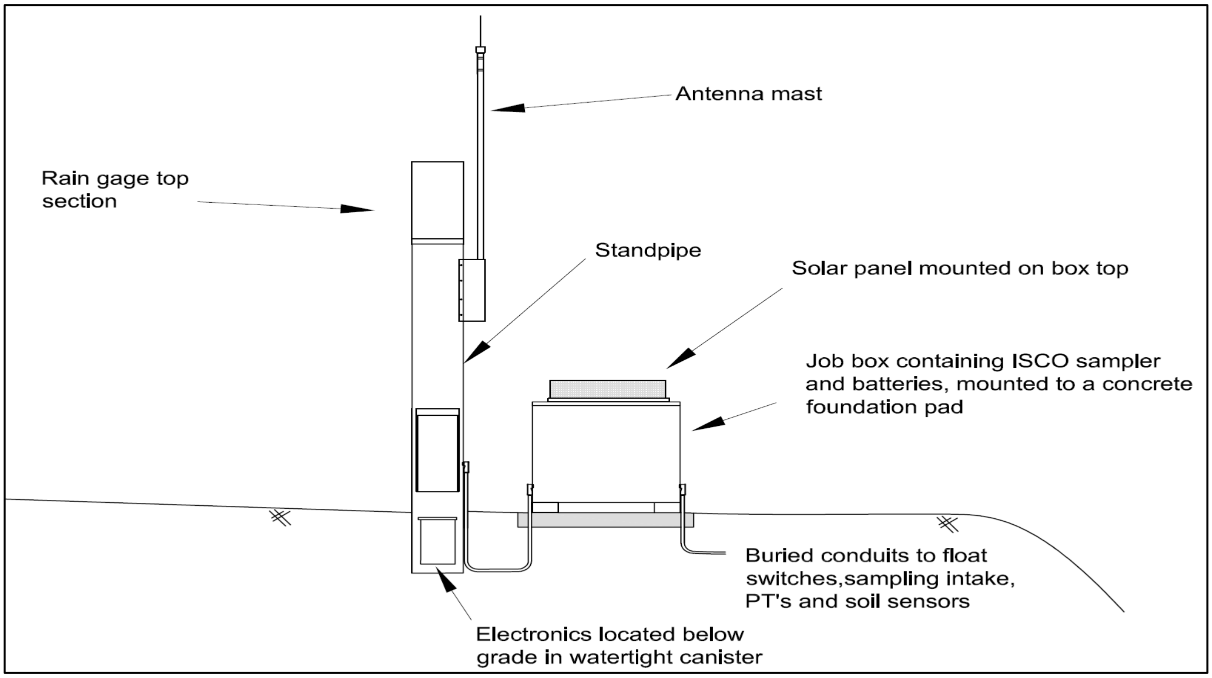


Illustration 2. Schematic for Surface Water / Groundwater Monitoring Stations – In Wash

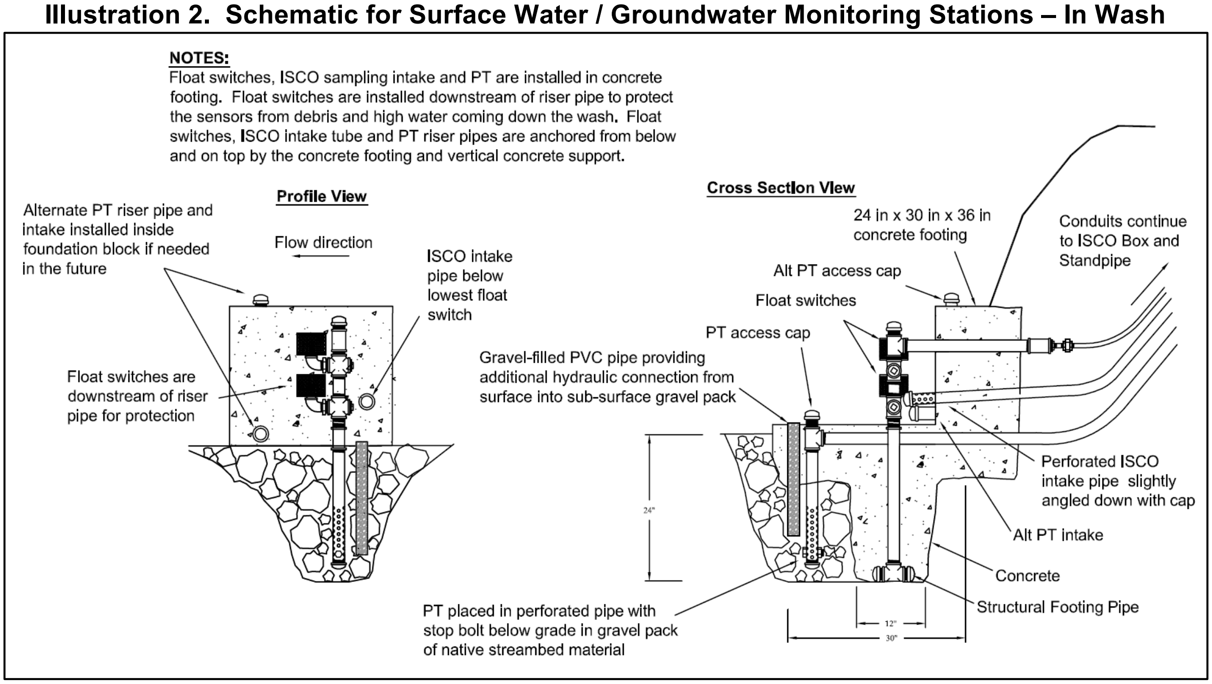


Illustration 3. ISCO 3700 Pump Sampler

Illustration 4. Barrel Canyon (BC-2) Monitoring Station– As-Built Schematic (Plan View)

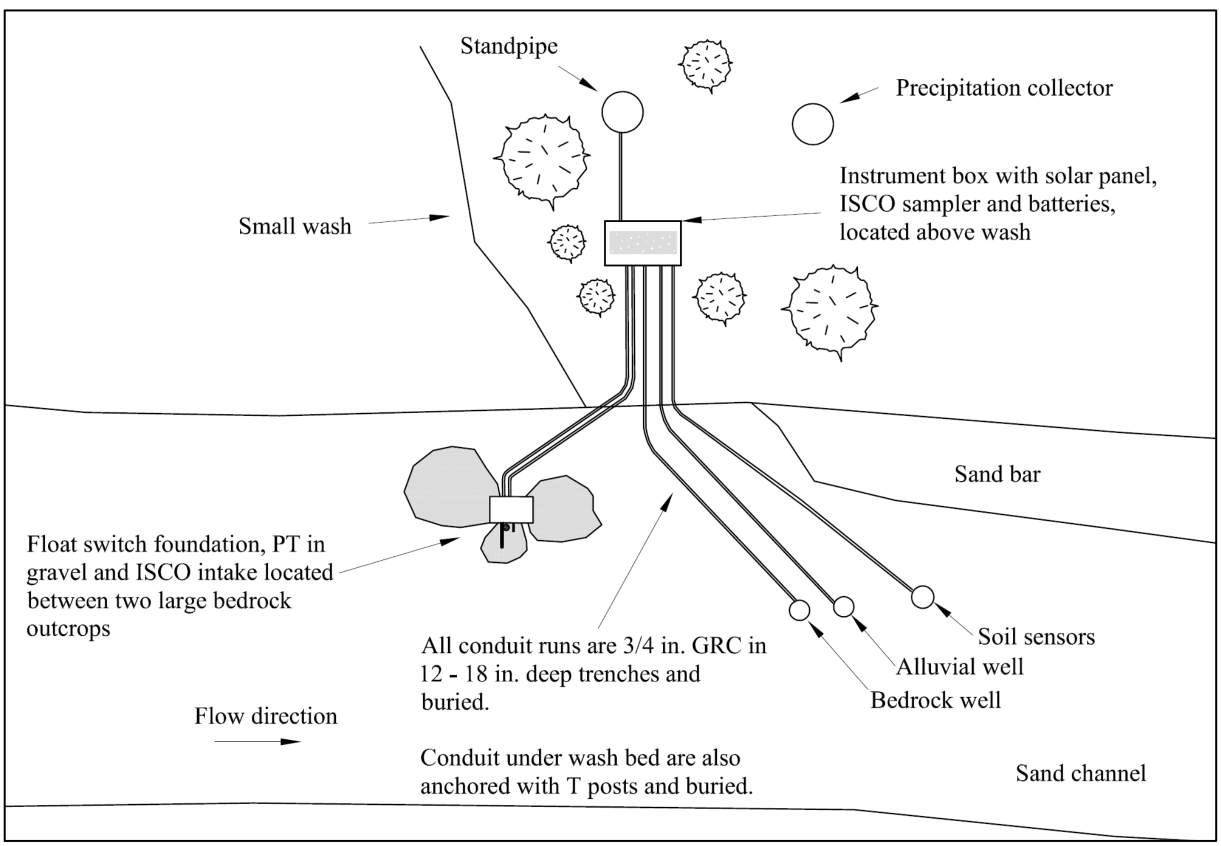


Illustration 5. Davidson Canyon (DC-3) Monitoring Station – As-Built Schematic (Plan View)

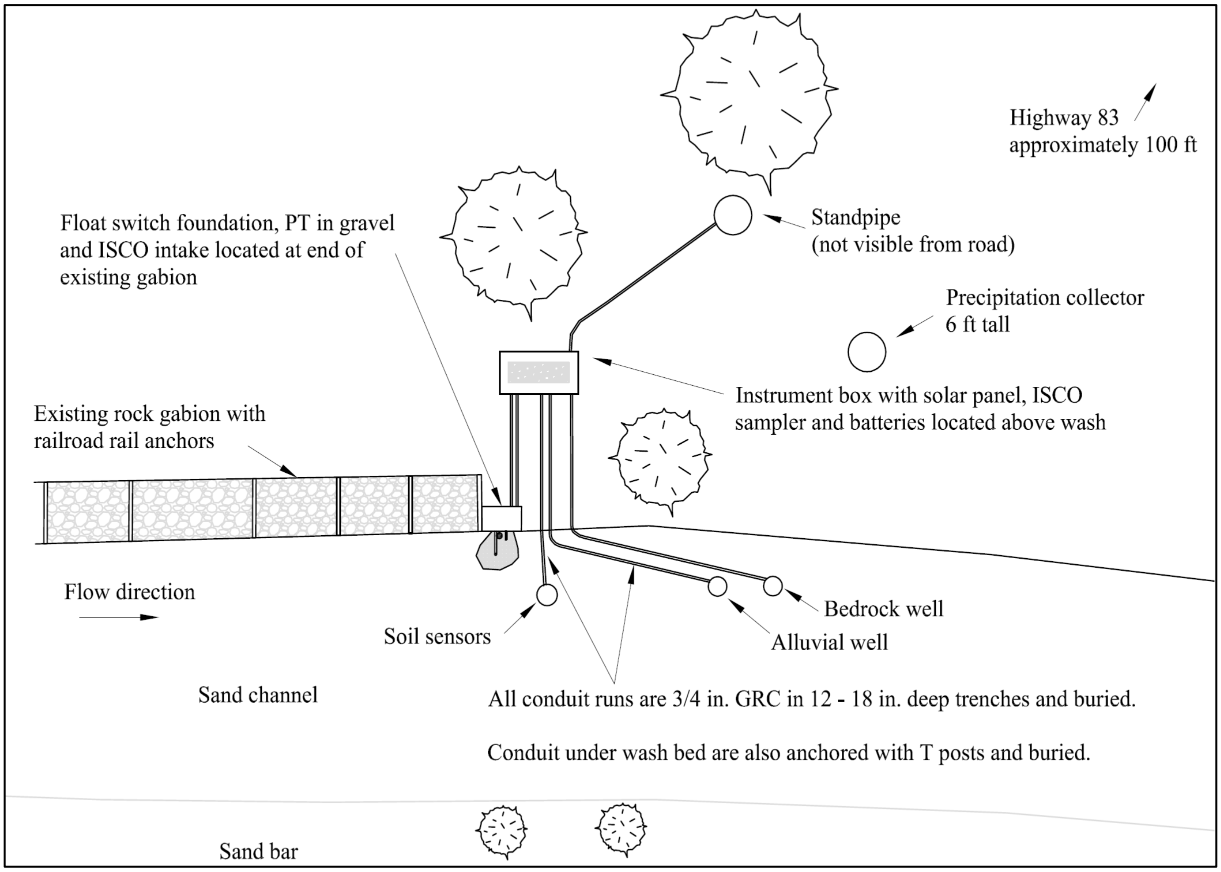


Illustration 6. Barrel Canyon (BC-2) Monitoring Station

Illustration 7. Davidson Canyon DC-3 Monitoring Station

Illustration 8. Schematic of Bedrock and Alluvial Groundwater Wells.

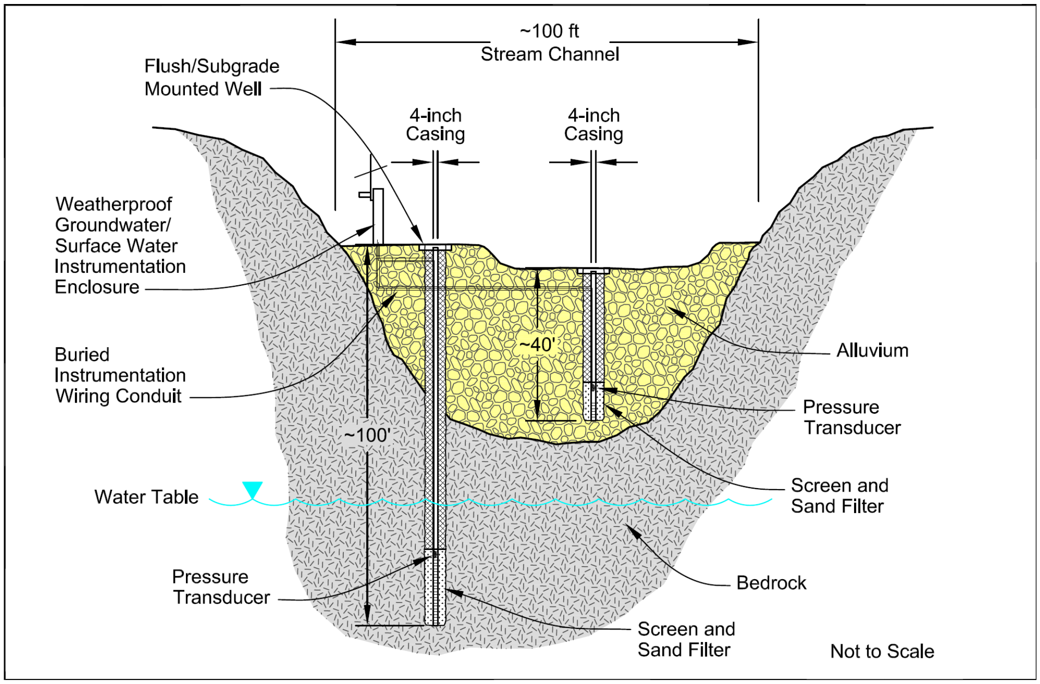
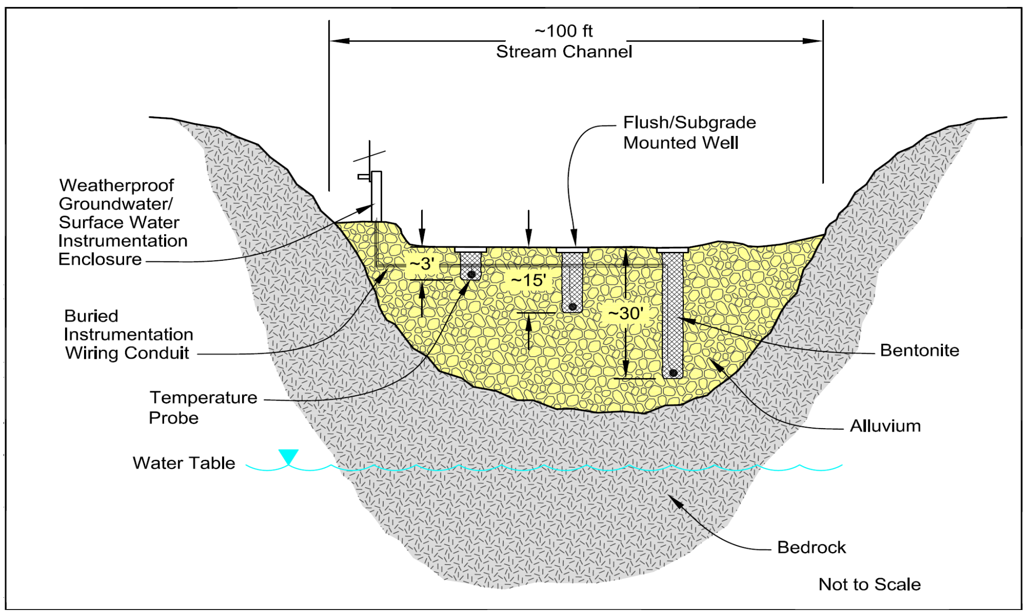


Illustration 9. Schematic of Subsurface Soil Probes.



APPENDIX C

USGS Annual Water-Data Report

09484580 BARREL CANYON NEAR SONOITA, ARIZ.

Santa Cruz Basin
Rillito Subbasin

LOCATION.--Lat 31°51′42″, long 110°41′26″ referenced to North American Datum of 1927, Pima County, AZ, Hydrologic Unit 15050302, north of Sonoita, AZ.

DRAINAGE AREA.--14.1 mi².

SURFACE-WATER RECORDS

PERIOD OF RECORD.--1962 to 1976 crest-stage, Jan. 2009 to current year.

GAGE.--Water-stage recorder. Elevation of gage is 4367 ft above sea level, from topographic map. Prior to 1977, nonrecording gage.

COOPERATION.--Department of Agriculture - Forest Service (Coronado National Forest)

REMARKS.--Records poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 1,780 ft³/s, Sept. 9, 2011 at 1820, gage height, 7.47 ft, from flood mark; minimum daily discharge, no flow for much of each year.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 350 ft³/s, Sept. 9, 2013 at 1715, gage height, 4.91 ft; minimum daily discharge, no flow for much of water year.

Suggested citation: U.S. Geological Survey, 2014, Water-resources data for the United States, Water Year 2013: U.S. Geological Survey Water-Data Report WDR-US-2013, site 09484580, accessed at http://wdr.water.usgs.gov/wy2013/pdfs/09484580.2013.pdf

09484580 BARREL CANYON NEAR SONOITA, ARIZ.—Continued

**DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES**

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.6
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.8
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.9	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.6	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	---	0.00	0.00	---	0.00	---	0.00	---	0.00	0.00	---
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	10.55	10.40
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.35
Max	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	5.6	8.8
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Med	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ac-ft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	21	21

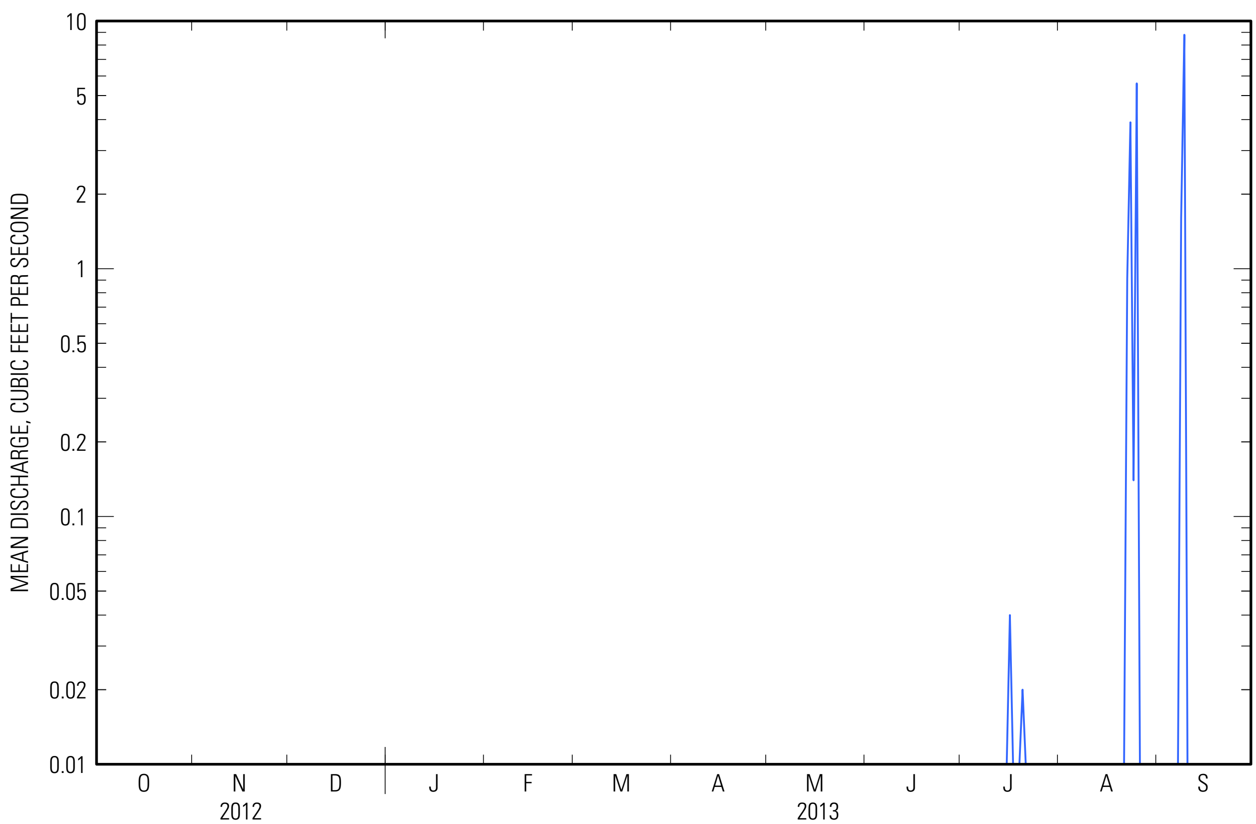
STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 2009 - 2013, BY WATER YEAR (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.05	0.22	0.18	0.95
Max	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.26	0.99	0.40	3.16
(WY)	(2010)	(2010)	(2010)	(2010)	(2009)	(2009)	(2009)	(2009)	(2009)	(2012)	(2010)	(2011)
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(WY)	(2010)	(2010)	(2010)	(2011)	(2009)	(2009)	(2009)	(2009)	(2010)	(2011)	(2009)	(2010)

09484580 BARREL CANYON NEAR SONOITA, ARIZ.—Continued

SUMMARY STATISTICS

	Calendar Year 2012		Water Year 2013		Water Years 2009 - 2013	
Annual total	66.91		21.02			
Annual mean	0.18		0.06		0.14	
Highest annual mean					0.26	2011
Lowest annual mean					0.06	2013
Highest daily mean	15	Jul 15	8.8	Sep 9	69	Sep 9, 2011
Lowest daily mean	0.00	Jan 1	0.00	Oct 1	0.00	Jan 23, 2009
Annual seven-day minimum	0.00	Jan 1	0.00	Oct 1	0.00	Jan 23, 2009
Annual runoff (ac-ft)	133		42		102	
10 percent exceeds	0.00		0.00		0.00	
50 percent exceeds	0.00		0.00		0.00	
90 percent exceeds	0.00		0.00		0.00	



APPENDIX D

USGS Annual Discharge Data 2010 – 2013

USGS Home
Contact USGS
Search USGS

National Water Information System: Web Interface

USGS Water Resources

Data Category: Surface Water
Geographic Area: United States
GO

Click to hideNews Bulletins

- Try our new Mobile-friendly water data site from your mobile device!
- Full News

USGS Surface-Water Annual Statistics for the Nation

The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications. The user is responsible for assessment and use of statistics from this site. For more details on why the statistics may not match, click here.

USGS 09484580 BARREL CANYON NEAR SONOITA, AZ

Available data for this site Time-series: Annual statistics GO

	Output formats
Pima County, Arizona Hydrologic Unit Code 15050302 Latitude 31°51'42", Longitude 110°41'26" NAD27 Drainage area 14.1 square miles Gage datum 4,364 feet above NGVD29	HTML table of all data Tab-separated data Reselect output format

Water Year	00060, Discharge, cubic feet per second
2010	0.062
2011	0.260
2012	0.183
2013	0.058

** No Incomplete data have been used for statistical calculation

APPENDIX E

WET McCleary and Scholefield Canyon Washes Monitoring Proposal

Scholefield and McCleary Canyon Surface-Water Monitoring Instrumentation Proposal

Prepared for:

Rosemont Copper Company

P.O. Box 35130

Tucson, AZ 85740-5130

Prepared by:

Water & Earth Technologies, Inc.

1225 Red Cedar Circle, Suite A

Fort Collins, CO 80524

March 13, 2014

Table of Contents

Contents

Introduction

Conceptual Surface-Water Monitoring Plan was submitted to Rosemont Copper Company (Rosemont) by Water & Earth Technologies, Inc. (WET) and Engineering Analytics, Inc. (EA) for support of the Rosemont Copper Project (Project). The Plans (WET 2012, EA 2012) outlined the locations and measurements to be performed as part of a comprehensive surface water and groundwater monitoring program.

During December 2012, Water and Earth Technologies, Inc. (WET) staff installed two combined groundwater and surface-water instrumentation stations. One station is located in Barrel Canyon just upstream of the SR 83 Bridge and one station is located in Davidson Canyon downstream of the Davidson Dike, downstream of the confluence with Barrel Canyon. The Davidson Canyon station was activated on December 20, 2012. The Barrel Canyon station was activated on December 21, 2012.

Two additional stations are proposed to characterize rainfall, runoff and runoff water quality in two undisturbed drainages: McCleary Canyon and Scholefield Canyon. These two, currently undisturbed watersheds are located near the planned Project disturbance area. During mine construction and production, these two watersheds will remain undisturbed. Rosemont currently collects runoff water samples for analysis at the mouths of both of these canyons. The proposed stations will automate the water sample collection effort and provide rainfall and stream stage measurements. The measurement of rainfall, runoff and collection of runoff water samples for water quality analysis will provide valuable data describing conditions in these watersheds.

This proposal outlines hardware and services WET will provide for the installation of two (2) new, solar-powered, surface-water monitoring stations equipped with satellite telemetry to monitor rainfall and stream level. Each site will include an automated ISCO pump water sampler to be triggered when water levels exceed a preset threshold.

The proposed work will be conducted in Colorado and Arizona. Two (2) trips to Arizona will be required to complete the design, planning, construction and integration of the new sites. The following scope presents an initial trip to conduct site investigations for station location and collect data relevant to the construction of each site, followed by a task to finalize the construction plans and order and bench test all equipment. The second trip to Arizona will be for construction and installation of the new sites and surveying of the channel for the development of a stage discharge relationship. Following installation, station data collection by the database will be verified and an as-built report will be developed.

Station Locations

The two proposed stations are shown on Figure 1. The exact locations of each station are to be determined during the site inspection field trip. Station siting will be based on watershed location, channel properties that suit stream stage measurement and water quality collection as well as rain gage location away from trees and canyon walls.

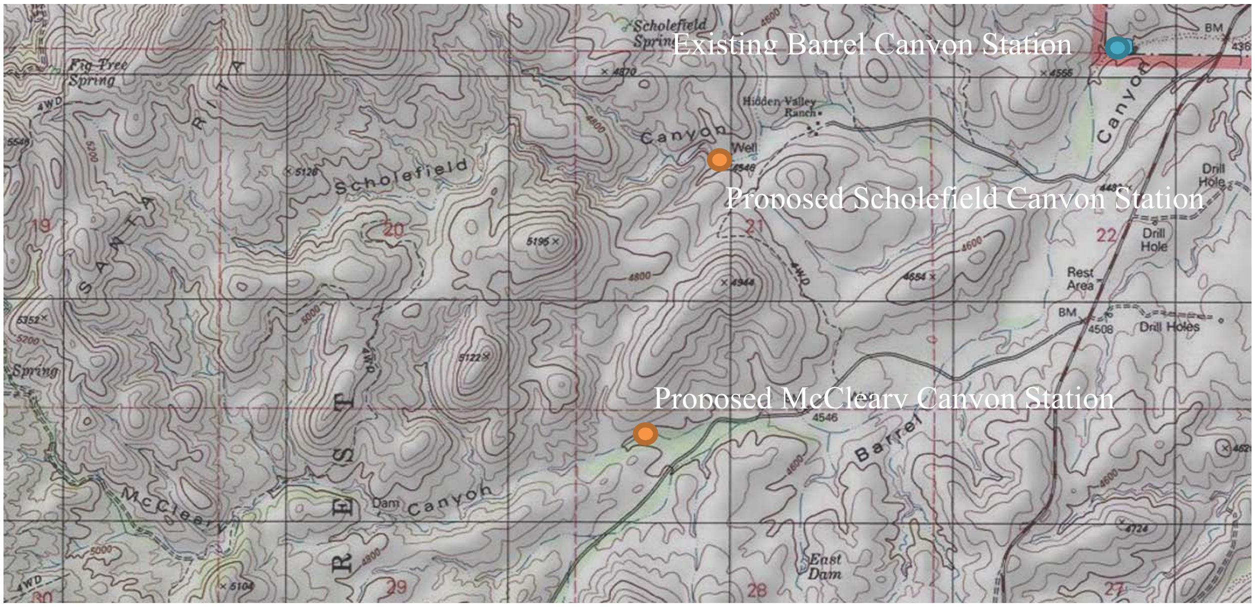


Figure 1. Proposed McCleary and Scholefield Stream Sampling Locations

Surface Water Measurement

Surface water monitoring includes measurements of precipitation, stream stage and automated water-quality sample collection when washes are flowing. Precipitation is measured by a tipping bucket rain gage installed at the station. Stream stage is a measure of the water surface elevation in the wash during a runoff event. Stream stage measurement is made using one pressure transducer (PT) installed either in a gravel-lined pit utilizing native materials in the channel of the wash, or in a perforated pipe located near the channel bed. Two alternate PT locations are pre-constructed at each station. The sub-surface installation is preferred, given that the PT is thermally insulated and remains moist, resulting in less noise in the resulting data. Intense heat can often yield variations in stage data measured when the wash is dry. If sedimentation during runoff events is high at the station, the above-channel PT installation location may be utilized. This location often provides better hydraulic connectivity to measure stage during storm events, but requires flushing and maintenance following storm events.

Automated Water Sample Collection

A Teledyne ISCO automated pump sampler will be installed at each station for automated water sample collection. The sampler will be triggered by a set of two redundant float switches in the channel. One liter water samples will be collected at 5-minute intervals during a runoff event. The sampler automatically purges the collection line with air prior to and following sample collection to ensure unique water collection at the time of sampling. Up to 24 1-liter samples can be collected. Following a collection event, bottles must be retrieved, sampler reset and samples packed and delivered to an analytical lab for water quality analysis. Sedimentation at the station may require flushing of the sampler intake line and clearing sediment from the float switches and intake pipe located near the channel bed.

Satellite Telemetry

The proposed stations will communicate measured precipitation, stream level, battery voltage and ISCO trigger information via satellite. Data will be received at the WET office and automatically imported into the NovaStar 5 database (as is currently performed for all data from the Barrel Canyon and Davidson Canyon stations). The satellite telemetry system proposed for these two new stations is different from the Barrel Canyon and Davidson Canyon stations. A lower-cost communication system, HughesNet, which supports satellite internet, has become available in the last year. Stations equipped with HughesNet satellite communication hardware are essentially connected to the internet. A Campbell Scientific CR800 data logger is used to drive the monitoring of the sensors and package the data for transfer over this specialized internet connection. This station configuration allows for more real-time data transfer (e.g., when rainfall causes the tipping bucket rain gage to tip, this tip is transmitted in real time, not on a 15-minute schedule as is performed for Barrel and Davidson Stations) at a lower monthly data transmission cost. This hardware setup also allows for two-way communication. Station software configuration files and currently-measured data can be viewed remotely over the internet. Station programming can also be updated over the internet. This hardware option provides greater functionality at a lower monthly cost.

It should be noted that the Barrel and Davidson Stations use the OrbComm satellite communication provider and a Hydrolynx 50385 data logger and transmit the sensor data package every 15 minutes. The data package size for the Barrel and Davidson Stations is quite large, given the larger set surface-water, ground water and soil sensors. These stations could be changed to the HughesNet/Campbell Scientific platform in the future, but the purchase of new hardware and custom datalogger programming would be required.

Instrumentation Summary

In general, each site will consist of a standpipe housing (i.e. an instrumentation enclosure) and an ISCO surface-water sampling enclosure. The standpipe housing is a 12-inch diameter, 10-foot tall aluminum tube that is set vertically in a concrete base (Figure 2 and Figure 3). The rain gage is included as the top section of the standpipe. Other monitoring and control electronics are housed in a water-tight enclosure that sits below grade inside the standpipe. A 1-mm tipping bucket rain gage with collection funnel completes the standpipe at the top along with a mast onto which the satellite antenna is mounted. Each standpipe will be constructed near the wash. Next to the standpipe will be constructed a water-tight, rodent-proof enclosure, which will house the ISCO automated pump sampler, solar panel and batteries. Power for the station and pump sampler is provided by batteries and solar panels (Figure 3). All hoses and wiring will be encased in steel conduit and buried where appropriate.

Each station will utilize one (1) pressure transducer installed to monitor the stream level. Additionally, two (2) float switches will be installed at critical elevations in the stream at each site to provide a redundant activation mechanism for the ISCO sampler. A large block foundation will be poured adjacent to the channel wash, which will anchor the float switches, ISCO intake pipe and the stream level pressure transducer (Figure 4 and Figure 5). The stream level PT will be installed in a native gravel-lined pit below the channel grade level. This installation protects the PT from dryness and reduces data drift from diurnal temperature fluctuations. A data collection unit (DCU) will be programmed to sample and store data, transmit data via a commercial satellite and to activate the ISCO pump sampler when a stream level exceeding the trigger elevation is detected and confirmed by the float switch.

Figure 2. Standpipe Housing with ISCO Enclosure (Davidson Canyon installation)

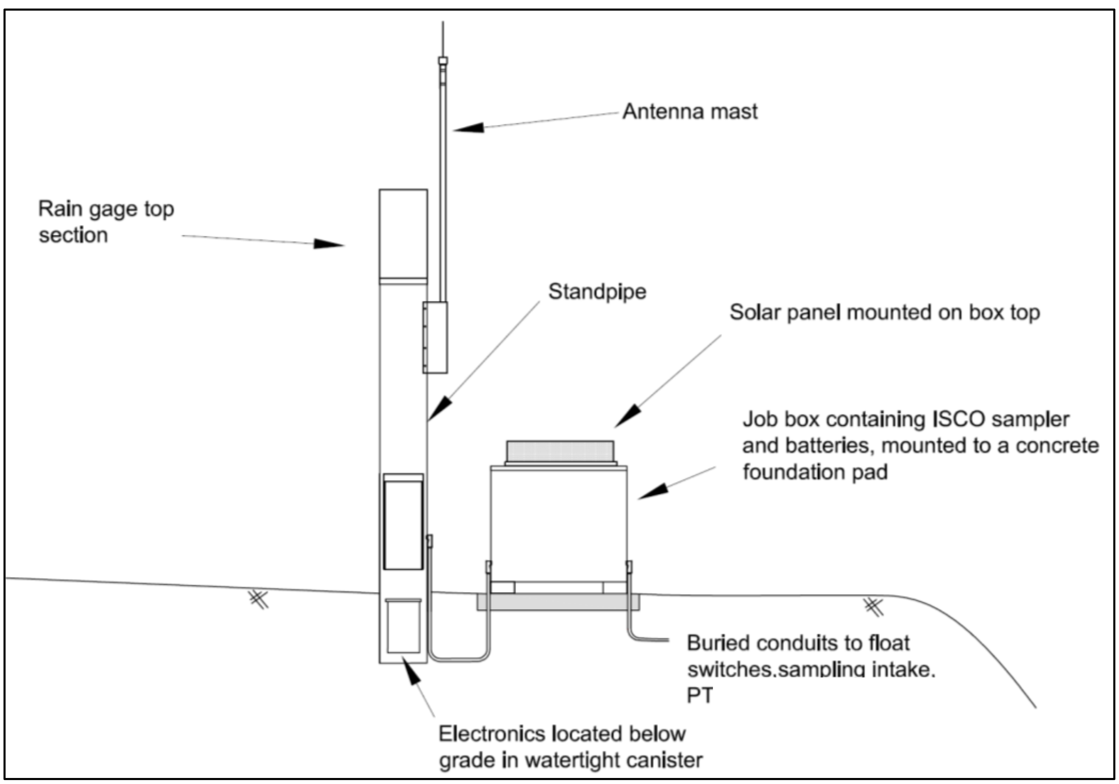


Figure 3. Station and Enclosure Schematic

Figure 4. Float Switch Foundation (Barrel Canyon installation)

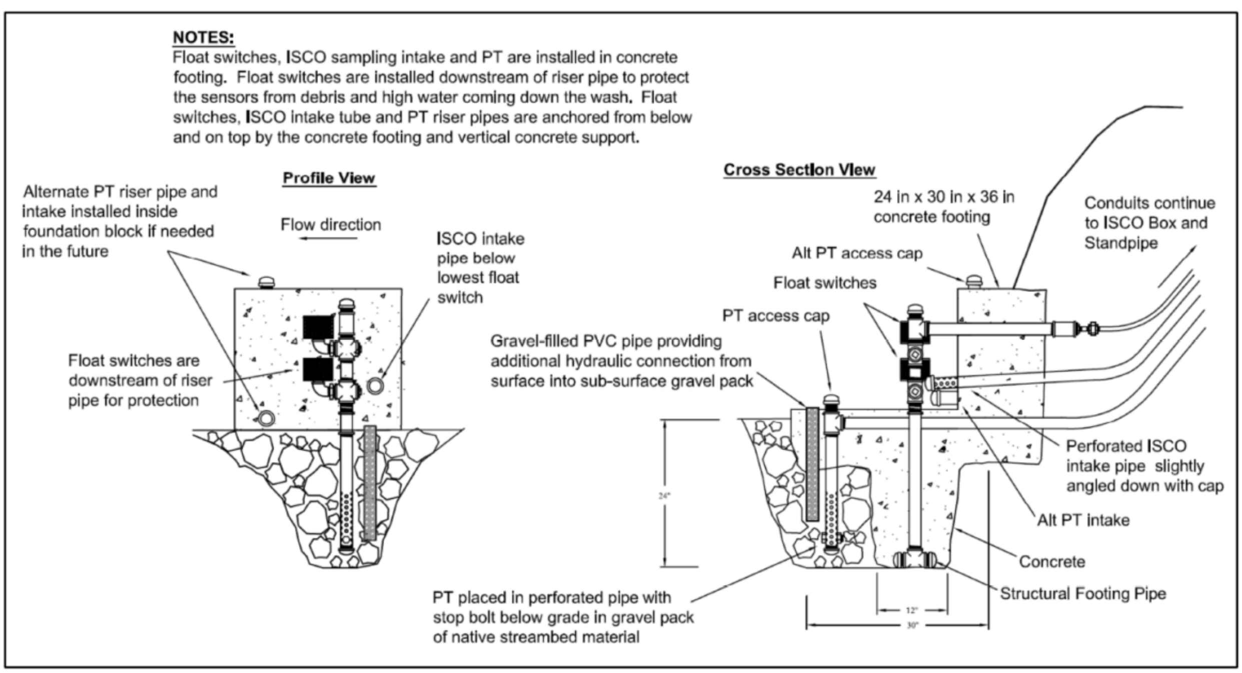


Figure 5. Float Switch, PT and ISCO Intake Schematic

A Campbell Scientific CR800 data logger will be used to sample data on a continuous basis including: stream level, rainfall, shallow and deep aquifer water level and thermistors in the channel sediments. The sampled data will be written to internal DCU memory for manual retrieval and it will be sent via commercial satellite to a dedicated base station operating at WET.

Surveying

Raw stage data are measured depths of water above the PT. The elevation of the PT will be surveyed in order to develop the water surface elevation of the water above the PT. Channel bed elevation will be surveyed so that the water surface elevation can be determined and a differentiation made between baseflow (water surface elevation below channel bottom) and flow in the wash (where the water surface is above the channel bottom).

Stage-Discharge Rating

The channel in the vicinity of the PT will be surveyed in order to develop a relationship between stage in the wash (in feet above the PT) and discharge in the wash (in cubic feet per second). Channel cross-sections are surveyed using a tape, level and rod. The set of channel cross-sections are used to develop a hydraulic model of the channel near the station using the Army Corps of Engineers, Hydrologic Engineering Center River Analysis System (HEC-RAS) software.

Stream stage will be measured by the instrumentation at each station. The stage-discharge rating will be applied by the base station software and the resulting output data of stage (in ft) and discharge (cubic feet per second) will be reported.

Data Transmission and Storage

WET utilizes the NovaStar 5 base station software to receive, process, manage, perform alarm and notification functions and archive data into a MySQL database. NovaStar 5 is an off-the-shelf software package manufactured by HydroLynx Systems Inc. Each station must be defined within the NovaStar 5 software along with the parameters being collected. An interface will be developed to receive the satellite data string from each station and to parse the data into the correct database tables. Alarm levels for stream stage will be defined along with a notification plan so that email and/or text pages can be disseminated to the proper individuals when alarm conditions for stormwater flow are met.

Rosemont staff will be able to access all data through a password protected web site. Data can be queried in tabular or graphical format. Example of web interface is shown along with a typical monthly discharge report in Figure 6 and Figure 7.

Data will be logged on a continuous basis by the DCU and transmitted to the base station each hour. The battery voltage, cumulative rainfall tip count and PT stage will be sent on a scheduled basis. During a precipitation event, each time the bucket tips, the tip count will be transmitted in real time. In the event of runoff, the times of float switch triggers and the status of the ISCO will also be transmitted in real time. The base station will archive a continuous record data. All data will also be stored on the DCU. The data communications between the remote stations and the NovaStar 5 base station will utilize a commercial low- earth-orbiting satellite network. The commercial satellite provider that will charge on a monthly basis based upon the total number of bytes of data communicated by each station.

WET will perform QA/QC of all received data and will generate monthly summary reports of rainfall and discharge. The data quality control protocol will consist of both automated data checks and manual checks. Data received from the satellite server will be processed and screened for outliers as well as for large differences between successive reports. Any large jumps in sequential data will be flagged as possibly erroneous. Each day, WET staff will review the incoming data, confirm proper station functioning and confirm accurate and erroneous data reports. End-of-month reporting will be based upon final data following QA/QC.

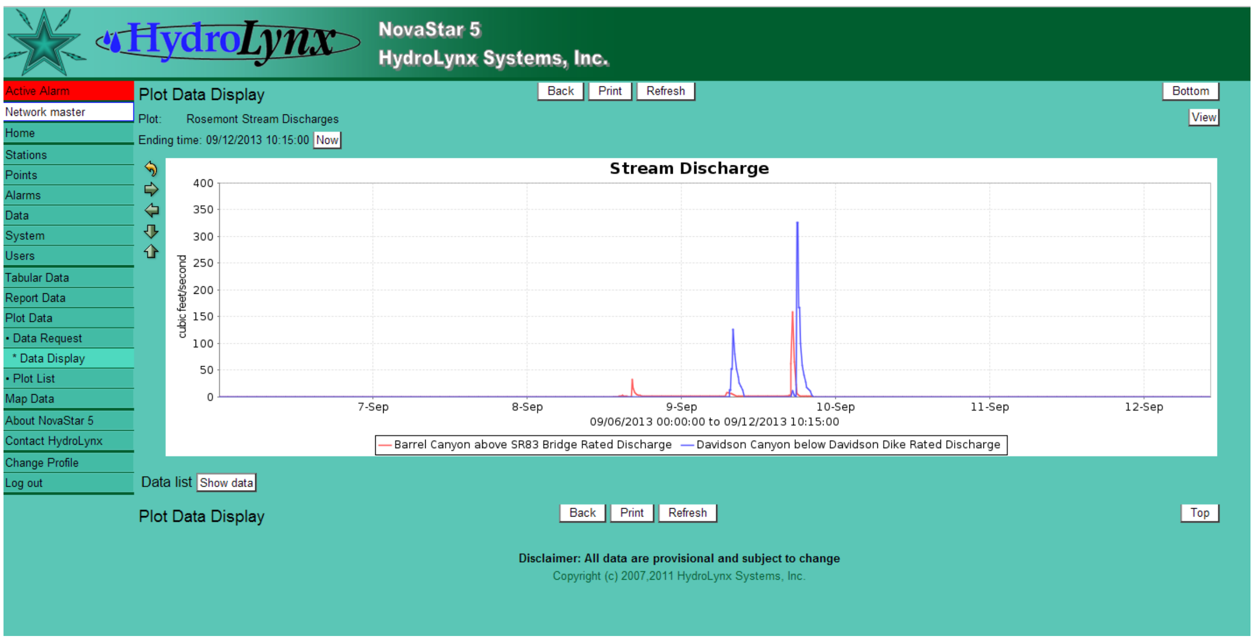


Figure 6. Example Data Plot

DISCHARGE REPORT

Station Number: 50000 Name: Barrel Canyon above SR83 Bridge

LOCATION.-- Lat 31.861622 Long -110.695900

DRAINAGE AREA.-- N/A

MEAN DAILY VALUES OF DISCHARGE, IN CFS, CALENDAR YEAR JANUARY 2013 TO DECEMBER 2013

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.06	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.01	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.54	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
29	0.00	---	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
30	0.00	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	---	0.00	---	0.00	---	0.00	0.00	---	0.00	---	0.00
MEAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.17	0.00	0.00	0.00
MAX	0.00	0.00	0.00	0.00	0.00	0.00	0.01	2.54	4.25	0.00	0.06	0.00
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CAL YR 2013 MEAN 0.03 MAX 4.25 MIN 0.00

INST MAX 158.66
INST MAX TIME 09/09/2013 17:15:00

Figure 7. Example Discharge Summary Report

Water Quality Sampling

Collection of stormwater samples will be automated and triggered by changes in stream stage. The ISCO sampler installed at each station will be triggered by the set of redundant float switches to start the collection of water samples via an intake tube and pump into a collection bottle. Twenty four (24) bottles are on a carousel, so that water samples can be taken throughout the storm hydrograph.

Sampling staff will retrieve surface-water samples and ship the sample bottles to the analytical lab shortly after a storm event.

Tasks

Task 1 –Pre-Construction Site Visit

A two-day trip to Arizona will be scheduled to collect site specific data relevant to the preparation of construction plans and to finalize station sensor locations and required hardware (conduit runs, concrete work, electronics housing locations etc.). WET will provide one engineer for this trip.

Task 2 - Construction Planning and Equipment Procurement, Configuration and Bench Testing

Upon completion of the pre-construction site visit, WET will finalize the site designs, develop construction plans, and determine final hardware specifications for each site. WET will procure all required hardware from the various vendors. All hardware will be ordered and received by WET in Fort Collins, Colorado where it will be set up and bench tested prior to installation. WET will fabricate custom piping parts for the foundation block. Hardware will be received a minimum of 30-days after ordering. Once all the hardware has been integrated and bench tested, and packed. WET will travel to Arizona to complete the installation.

Task 3 - Installation of Monitoring Stations

A two-week long trip will be scheduled to install the new monitoring stations. WET will drive to Arizona with all equipment using an enclosed 24-foot trailer.

WET will install the standpipe, ISCO enclosure, ISCO pump sampler, pressure transducer, Foundation block for two float switches and ISCO intake, tipping bucket rain gage, solar panel and DCU with satellite telemetry at each site. The NovaStar 5 database will be configured prior to the installation trip. Each site will be activated and data reception by the NovaStar5 base station will be confirmed. This will constitute the commissioning of each site.

Upon completion of the installation trip, WET will prepare a final as-built report documenting the installation of each site along with the final activation and commissioning of each site.

Task 5 - Surveying and Rating Development

During installation, WET will perform the channel survey for the two (2) monitoring stations. WET will perform rod and level surveys for the channel reach at each monitoring station. The survey will include elevation tie-in for the stream and well pressure transducers from the station local benchmark.

Following the field work, the survey notes will be reduced and the Army Corps of Engineers HEC-RAS modeling package will be used to develop a steady-state open-channel hydraulic model for each surveyed reach. Results from the modeling will be used to develop a stage - discharge relationship for each monitoring station.

The NovaStar 5 base station will be updated with each stage-discharge relationship.

Upon completion of the hydraulic modeling, WET will prepare a documentation spreadsheet describing the channel survey and hydraulic modeling summary.

Cost Estimate

A cost estimate is included at the end of this proposal. A summary of costs is shown in Table 1. A detailed Cost Worksheet is provided in the Appendix. These costs describe the hardware and labor costs for installation of the set of two (2) stations. A cost per station are included at the bottom of the Cost Worksheet.

The installation assumes that some additional labor will be provided by Rosemont, if needed for trenching and digging. It is also assumed that Rosemont will provide concrete, mixer and labor for pouring concrete. This labor was provided for the two previous station installations, which worked very well.

Table 1 includes a cost estimate for the equipment and installation for two (2) stations. Cost will be billed on time and materials basis. Note that a minimum of 30 days turnaround time is required for equipment ordering. An estimated additional 20 days required for setup, testing and custom fabrication of equipment following equipment delivery.

Note that this cost proposal DOES NOT include the cost of regional surveying, water sample collection, packaging, shipping to the analytical lab or analytical water quality data QA/QC, storage, display or analysis.

Table 1. Cost Summary For Two Stations

Work Item	Cost Estimate
Pre-Construction Site Visit	[redacted]
Equipment and Shipping	[redacted]
Hardware Setup, Testing Installation, Hydraulic Rating Labor and Travel Expenses	[redacted]
Initial Month Data Fees	[redacted]
Total	[redacted]

Monthly Data Analysis and Continued Station Maintenance

Costs for data collection, management and analysis are included in the Cost Worksheet, as specified under: Monthly Data Collection, Management, Reporting, Alarm and Notification. These are monthly costs for data collection, database maintenance, data QA/QC, analysis and reporting.

Stations also should be visited for inspection and maintenance on a quarterly basis to ensure proper functioning. Scheduled maintenance includes cleaning and calibration of the tipping bucket and PTs, testing of the solar panel and electrical system and testing of the satellite transceiver. Cost of this maintenance is not included in the Monthly Data line item. Annual estimated costs for labor and expenses for maintenance per station is [redacted].

References

Engineering Analytics, Inc. (EA), 2012, Davi dson Canyon Conceptual Gr oundwater Monitoring Plan.

Water and Earth Technologies, Inc. (WET), 2012, Davidson Canyon Conceptual Surface-Water Monitoring Plan, prepared for Rosemont Copper, April 2012.

APPENDIX F

Draft Springs Monitoring Plan
(FS-SSR-02)

Draft Spring Monitoring Plan

As Required By:
Mitigation Measure FS-SSR-02



November 2014

ROSEMONT COPPER
REDEFINING MINING.

Monitoring and Reporting Schedule

Task Schedule	Purpose/Description	Construction[1]		Operations		Closure[2]	
		SA	A	SA	A	SA	A
Monitor springs	Record flow conditions	X		X		X	
Reporting	To Forest Service		X		X		X

SA= semi-annually; A = Annually; [1]Includes pre-construction period; [2]Required 5-years into closure period.

Revision Log

Revision Number	*Revision Lead*	*Purpose of Revision*	*Revision Date*

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1.0 PLAN OBJECTIVE AND DESCRIPTION

This Spring Monitoring Plan (Plan) was developed in response to the mitigation and monitoring measure (Mitigation Measure) requirement of the U.S. Forest Service's (USFS) Coronado National Forest (Coronado) Final Environmental Impact Statement (FEIS; USFS, 2013a) for the Rosemont Copper Project (Project). The Mitigation Measure requirement is specified as "FS-SSR-02: Spring, seep, and constructed/enhanced waters monitoring" on pages B-26 and B-27 in Appendix B of the FEIS. This Mitigation Measure is also mentioned on page 36 of the draft Record of Decision (ROD; USFS, 2013b).

Monitoring for Mitigation Measure FS-SSR-02 will begin in the pre-mining phase of the Project and will continue five (5) years into the closure period.

1.1 Plan Objective

The purpose of Mitigation Measure FS-SSR-02 is to:

- Measure the effects of groundwater drawdown and to determine whether decreased water levels are due to mine activities.

Other USFS mitigation measures and/or permits associated with monitoring groundwater and surface water changes (levels, flows/quantity, quality) include:

- FS-GW-02: Water quality monitoring beyond point-of-compliance wells. This mitigation measure requires groundwater level and water quality monitoring at 14 existing wells and one new, proposed well, and flow conditions and water quality sampling at 10 springs. Monitoring for this mitigation measure will be conducted on a quarterly basis (see pages B-17 and B-18 in Appendix B of the FEIS);

- FS-BR-05: Construction, management, and maintenance of water features to reduce potential impacts to wildlife and livestock from reduced flow in seeps, springs, surface water, and groundwater. This mitigation measure requires annual water level monitoring and managing/constructing water features, if needed, for Chiricahua leopard frog and jaguar habitats (see page B-32 in Appendix B of the FEIS);

- FS-BR-22: Constructing and maintaining a weather station, plus automated surface water and groundwater/surface water monitoring stations in Barrel and Davidson Canyon washes, for the purpose of determining impacts from pit dewatering on downstream sites. This mitigation measure involves quarterly monitoring of groundwater in shallow and deep bedrock aquifers, precipitation measurements and sampling, as well as stormwater flow sampling. Monitoring of geomorphic changes is also required (see pages B-48 through B-50 in Appendix B of the FEIS);

- FS-BR-27: Periodic validation and rerunning of groundwater model throughout life of mine. This mitigation measure also requires quarterly water level monitoring at well locations located on the Project site and in surrounding areas. A model validation report is due every 5 years. The installation of a new monitoring well is also required (see pages B-53 and B-54 in Appendix B of the FEIS); and

- OA-GW-06: Groundwater quality and groundwater level monitoring required under the aquifer protection permit. This mitigation measure refers to monitoring requirements associated with point-of-compliance (POC) wells under Rosemont's aquifer protection permit (APP) No. P-106100 (see pages B-87 and B-88 in Appendix B of the FEIS).

- The 401 certification requires a Surface Water Mitigation Plan that describes the monitoring and mitigation program Rosemont will conduct throughout the life of the Project. Monitoring results will be used to mitigate surface water flow volumes from the site and to track downstream conditions, i.e., sediment changes, water quality, etc.

Rosemont's Comprehensive Water Monitoring Plan summarizes the plans that are associated with water related issues. The Comprehensive Water Monitoring Plan includes a table listing the various monitoring programs and their associated wells, stations, points, and/or locations. The table was developed in an effort to eliminate duplication in data gathering.

1.2 Plan Description

This Plan includes the following components:

- Monitoring flow conditions (presence/absence of water) semi-annually at select spring/ seep/constructed/enhanced water locations (springs).

An initial list of 25 springs was proposed by the USFS for Mitigation Measure FS-SSR-02 for flow conditions. The 25 springs are listed in Table 1; their locations are shown on Figure 1. The USFS selected the 25 springs based on their location relative to the Project area. Of the 25 springs proposed by the USFS, twenty-three (23) have been previously monitored by Rosemont. It is anticipated that additions/deletions to this list will occur over the life of the Project (see Section 3.0 – Adaptive Management).

In addition to the springs/seeps, Rosemont has committed to enhancing or replacing up to 30 water features, including stock ponds and retention ponds, to offset potential impacts to surface waters (see Mitigation Measure FS-BR-05 in Appendix B of the USFS FEIS (2013a). Mitigation Measure FS-SSR-02 will also include monitoring the performance and success of those "constructed" waters. It is expected that similar monitoring approaches would be used for both natural and constructed waters.

Springs/seeps/constructed/enhanced waters will be monitored semi-annually. It is anticipated that monitoring will be completed during the first (January through March) and third (July through September) quarters of each year. These quarters have shown the highest potential to record the presence of flows. Depending upon conditions and after data evaluation, automated equipment may be installed at Sycamore Spring, Questa Spring, and/or Deering Spring. This would allow for more frequent data collection.

The following subsections describe the anticipated information to be gathered at each monitoring location. These sub-sections include:

- Measurement Locations and Photopoints;

- Overall Condition of the Monitoring Location;

- Presence/Absence of Water;

- Riparian Vegetation; and
- Miscellaneous Site Information.

1.2.1 Measurement Locations and Photopoints

Each spring, seep, or constructed/enhanced water location selected for monitoring under this Plan will have a designated measurement location. The designated measurement location will be clearly described in a record, marked on a detailed map (i.e., a U.S. Geological Survey topographic map), photographed, and its coordinates surveyed with a global positioning system (GPS) unit. This will ensure consistent, reliable, and reproducible data. For locations with clearly visible flow conditions (i.e., spring discharge), measurement locations will be established without interfering with the spring function.

At least one photopoint (viewpoint) will be established for photographing the spring, seep, and constructed/enhanced water location. Each location will be marked (using a stake, flagging, or other identifying marks), and recorded (GPS coordinate). This photopoint will be used during subsequent monitoring events. Updated photographs will be taken at each monitoring event.

1.2.2 Overall Condition of the Monitoring Location

Discharge measurements will be obtained at the designated discharge measurement point. Should the designated discharge measurement point for a specific spring become inaccessible over time, Rosemont will clearly describe the current situation in the sample record, along with a description of the condition of the former discharge measurement point, photographs, and a description and photograph of the replacement discharge measurement point.

If the spring is not connected by pipe to a holding tank, a tape measure will be used to measure the distance from the spring source to the downstream limit of surface water, as well as the average width of the ponded water. For those springs that have ponded pools of water, the vertical distance from the bottom of the ponded area to the water surface (in centimeters) will be measured and recorded.

1.2.3 Presence/ Absence of Water

Based on previous monitoring, conditions recorded at the monitoring locations ranged from:

- Dry
- Moist soil
- Ponded water
- Flowing

These same descriptive terms will be used to define spring discharge under this Mitigation Measure. If flow is measureable – from a point source - an estimated flow rate will be provided in gallons per minute (gpm). If possible, discharge will be measured by recording the length of time required to fill a container of a known volume.

Automated flow monitoring equipment may be installed at the following locations if such equipment will not interfere with the functioning of the spring or its cultural significance:

- Sycamore Spring
- Questa Spring
- Deering Spring

A design for installing the automated equipment at these locations will be prepared once the feasibility of doing so is assessed. The proposed equipment and method for installation will be provided to the USFS for review and approval.

In addition to ponded or flowing water, evidence of sub-surface water will also be noted. Sub-surface water may be evidenced by damp soils or riparian vegetation.

1.2.4 Riparian Vegetation

An evaluation of the vegetation surrounding monitoring location will be conducted at each monitoring event. Changes in vegetation extent, density, diversity, and vitality could be indicators of changing groundwater discharge. Vegetation conditions near some of the selected springs were previously documented in WestLand Resources, Inc. (WestLand), (2012).

Vegetation monitoring will initially consist of preparing a detailed description of the existing vegetation along with photographs at each spring/seep/constructed/enhanced water location. The extent, density, diversity, and vitality of vegetation will be documented and mapped. Photopoint monitoring will be used to provide reliable and accurate record of the changes as they occur. It is noted, however, that vegetation will vary naturally throughout the year – not only in relation to the seasonal responses but also to other factors such cattle grazing, wildlife use, or drought

In addition to observed flow from the monitored springs, one of the primary criterion used for determining the presence of regional groundwater is the existence of extensive and well-established riparian vegetation in the immediate vicinity of a spring. Riparian vegetation requires groundwater to be within their maximum root depth and can persist when there is no visible discharge (e.g., dry surface conditions). The depth to groundwater influences the extent, density, diversity, and vitality of wetland and riparian vegetation.

1.2.5 Miscellaneous Site Information

Other information that will be collected and recorded at each monitoring location, as appropriate, includes:

- A description of the substrate composition, i.e., fines, sands, gravel, etc.;
- Land ownership, i.e., Coronado National Forest, private land, Rosemont private land, etc.; and
- Access to the spring/seep/constructed/enhanced water – the ease at which the public could visit a monitored location will be described and recorded, i.e., access only by cross-country hiking, site accessed by easy trail hike, site accessed by walking less than one (1) mile, or site is immediately adjacent to a road.

2.0 MONITORING AND REPORTING

Monitoring and reporting components for Mitigation Measure FS-SSR-02 are listed below.

2.1 Monitoring

The following data will be collected at each spring/seep/constructed/enhanced water location per monitoring event:

- Measurement location and photopoints;
- Overall condition of the monitoring location;
- Presence/absence of water;
- Riparian vegetation; and
- Miscellaneous site information.

2.2 Reporting

Reports for Mitigation Measure FS-SSR-02 will be provided to the Forest Service annually and include the following information:

- General discussion on previous year's monitoring/overall conditions;
- Flow measurements;
- Photographs;
- Historical/data trends; and
- Other pertinent information.

3.0 ADAPTIVE MANAGEMENT

Rosemont will incorporate the adaptive management process into Mitigation Measure FS-SSR-02. This process will ensure that the initial intent of the spring monitoring is being met and that pertinent data is being collected. The three key general components of adaptive management are:

- Testing assumptions – collecting and using monitoring data to determine if current assumptions are valid;
- Adaptation – making changes to assumptions and monitoring program to respond to new or different information obtained through the monitoring data and project experience; and
- Learning – documenting the planning and implementation processes and its successes and failures for internal learning as well as the scientific community.

Elements that may be modified as part of the adaptive management process for this Plan include, but are not limited to, the following:

- Spring monitoring locations;
- Monitoring frequency;
- Monitoring procedures; and
- Reporting schedule.

During the course of this monitoring program, the data collected by Rosemont will be assessed to determine if the Plan objectives are being met, including an assessment of which locations should be monitored.

Springs that exist solely due to precipitation events, that is, not connected to the regional aquifer or associated with a perched water zone, will not provide any useful data regarding regional groundwater drawdown. Only springs supported by the regional groundwater flow system will be useful for monitoring groundwater drawdown due to Open Pit dewatering. Therefore, after periodic assessments and discussions with the USFS, those springs that are determined to flow only in response to storm events or be connected to perched water zones may be dropped from the monitoring list associated with this Plan. Previous assessment work by WestLand (2012) and Tetra Tech (2010) will be used in the assessment. Accessibility of the monitoring locations will also be a factor that will be evaluated over the course of this monitoring program.

Recommendations on eliminating monitoring locations or other adjustments to the monitoring components would be made in the annual report and discussed with the USFS prior to implementing any changes.

4.0 DATA MANAGEMENT

Records will either be taken in hardcopy format or electronically. These records will be used as a basis of reporting and compliance verification.

5.0 REFERENCES

Tetra Tech, 2010. Davidson Canyon Hydrogeologic Conceptual Model and Assessment of Spring Impacts – Rosemont Copper Project. Consultant report prepared for Rosemont Copper Project, July 2010.

USFS, 2013a. Final Environmental Impact Statement for Rosemont Copper Project, Appendix B Mitigation and Monitoring Plan. November 2013.

USFS, 2013b. Draft Record of Decision and Finding of Nonsignificant Forest Plan Amendment for the Rosemont Copper Project. December 2013.

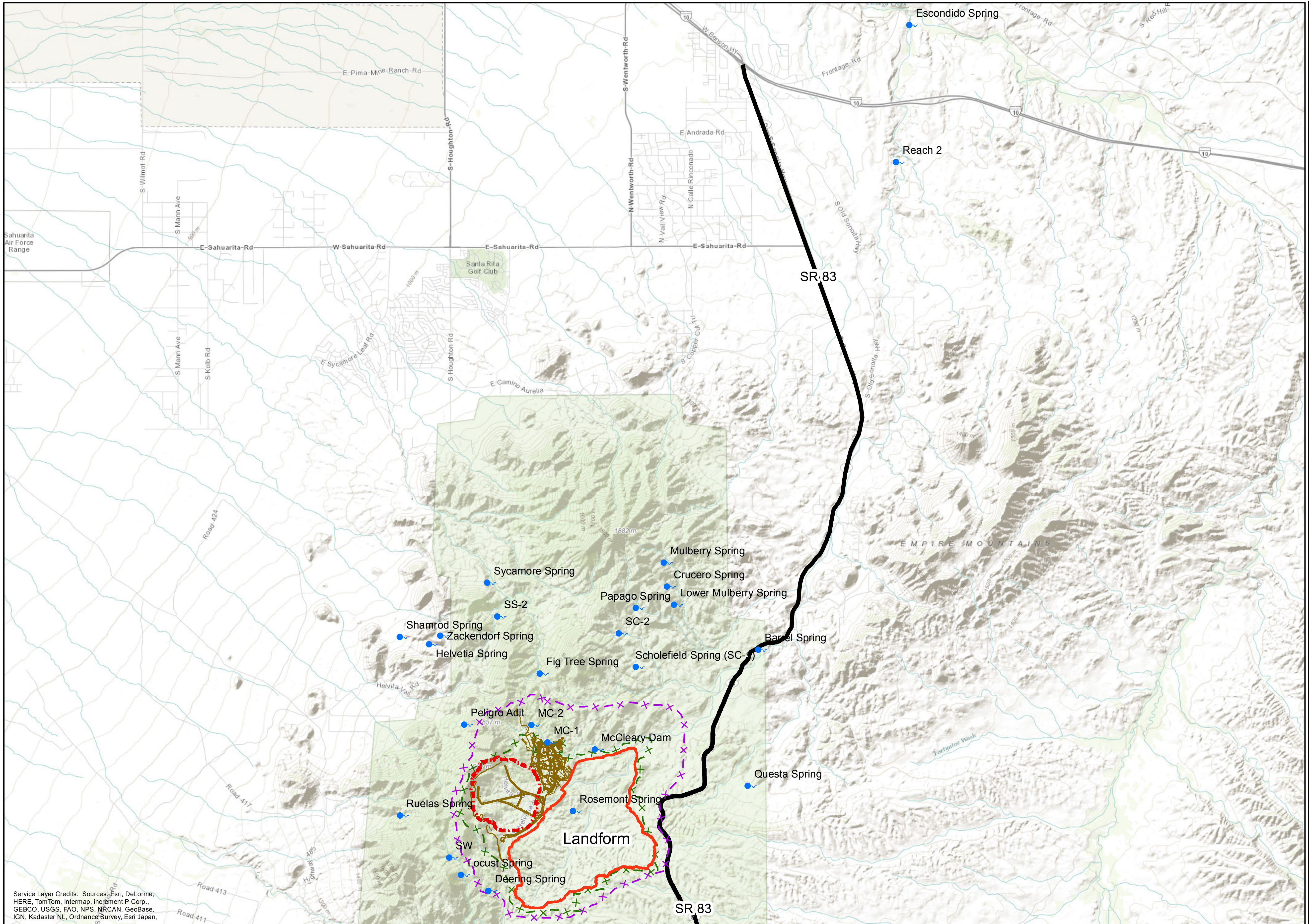
WestLand Resources, Inc. (WestLand), 2012. Rosemont Copper Project: Seeps and Springs Survey, 2011-2012. Consultant report prepared for Rosemont Copper Company. July 11, 2012.

TABLES

Table 1. List of Springs for FS-SSR-02 Monitoring

Spring ID	Cadastral Location
Deering Spring	(D-19-15) 01dbd
Locust Spring	(D-19-15) 01bdb
Rosemont Spring	(D-18-16) 32bbc
SW Spring	(D-19-15) 01bbb
Lower Mulberry Spring	(D-18-16) 09dbb
Crucero Spring	(D-18-16) 09cbd
Mulberry Spring	(D-18-16) 09abc
MC-1 Spring	(D-18-16) 30abc
McCleary Dam	(D-18-16) 29bda
Questa Spring	(D-18-16) 27ddd
MC-2 Spring	(D-18-16) 19ccd
Fig Tree Spring	(D-18-16) 19abb
Scholefield (SC-2)	(D-18-16) 17acc
Scholefield (SC-1)	(D-18-16) 16ccc
Papago Spring	(D-18-16) 16bba
Barrel Spring	(D-18-16) 14cab
Ruelas Spring	(D-18-15) 35bdc
Peligro Adit	(D-18-15) 24dcc
Helvetia Spring	(D-18-15) 14dba
SS-2	(D-18-15) 13aab
Sycamore Spring	(D-18-15) 12dba
Reach 2	(D-17-17) 06bdd
Escondido Spring	(D-16-17) 30abd
Shamrod Spring	(D-18-15) 14bcd
Zackendorf Spring	(D-18-15) 14ada

FIGURES



Legend

- Spring
- Landform Footprint
- Pit Outline
- Plant Site Facilities
- Security Fence
- Perimeter Fence
- State Highway 83

1:100,000

5,600 2,800 0 5,600

Feet

Project: Draft Spring Monitoring Plan	
Source: ArcGIS Map Service Server	
County: Pima	State: Arizona
PRJ: NAD83 UTM 12 Meters	Date: 6/5/2014

Figure 1. Spring Monitoring Locations

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APPENDIX G

Draft Barrel Canyon Sediment Transport Monitoring Plan (FS-SR-05)

Draft Barrel Canyon Sediment Transport Monitoring Plan

As Required By:
Mitigation Measure FS-SR-05



November 2014

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REDEFINING MINING.

Monitoring and Reporting Schedule

Task Schedule	Purpose/Description	Pre-Production	Operations	Closure[1]
		Initial "Baseline" Monitoring	**Every year for 5 years and every 5th year thereafter**	**Once after 5th year**
Establish Monitoring Points	Prior to mine construction	X		
Collect initial baseline geomorphological monitoring data	Prior to mine construction	X		
Collect subsequent monitoring data	Comparison with baseline and subsequent event		X	X
Reporting	To Forest Service	Submit in following annual report	Submit in following annual report	Submit in following annual report

[1]Assume one monitoring event in closure period.

Revision Log

Revision Number	*Revision Lead*	*Purpose of Revision*	*Revision Date*

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1.0 PLAN OBJECTIVE AND DESCRIPTION

This Barrel Canyon Sediment Transport Monitoring Plan (Plan) was developed in response to the mitigation and monitoring measure (Mitigation Measure) requirement of the U.S. Forest Service's (USFS) Coronado Forest (Coronado) Final Environmental Impact Statement (FEIS; USFS, 2013a) for the Rosemont Copper Project (Project). The Mitigation Measure requirement is specified as "FS-SR-05: Sediment Transport Monitoring" on page B-16 in Appendix B of the FEIS. This Mitigation Measure is also mentioned on page 34 of the draft Record of Decision (ROD; USFS, 2013b).

Monitoring for Mitigation Measure FS-SR-05 will begin in the pre-construction period and will continue through the reclamation and closure phase. Sediment transport monitoring in Barrel Canyon will be conducted every year for the first five (5) years. After five (5) consecutive annual monitoring events, the frequency of sediment transport monitoring in Barrel Canyon will be reduced to every five (5) years throughout the remaining operational. Data will be assessed and compared with previous years' data. Illustrations will be prepared as needed to graphically display the data.

1.1 Plan Objective

The purpose of Mitigation Measure FS-SR-05 is to:

- Determine whether erosion and downstream geomorphological changes are within the range of impacts described in the National Environmental Policy Act (NEPA) decision. As a result of the NEPA review process, it was determined that sediment load to Barrel Canyon and Davidson Canyon washes will decrease, but sediment concentrations would remain the same, compared with baseline (pre-mining conditions).

Other USFS mitigation measures and/or permits associated with monitoring changes in sediment transport include:

- FS-BR-22: Constructing and maintaining a weather station, plus automated surface water and groundwater/surface water monitoring stations in Barrel and Davidson Canyon washes, for the purpose of determining impacts from pit dewatering on downstream sites. This mitigation measure involves quarterly monitoring of groundwater in shallow and deep bedrock aquifers, precipitation measurements and sampling, as well as stormwater flow sampling. Monitoring of geomorphic changes is also required (see pages B-48 through B-50 in Appendix B of the FEIS);

1.2 Plan Description

This Plan includes the following components:

- Monitor stream channel stability, sediment deposition, and scour within the channel of lower Barrel Canyon Wash.

Compliance with Mitigation Measure FS-SR-05 requires that Rosemont establish baseline channel bed morphology in lower Barrel Canyon Wash and then monitor the sediment transport and channel stability of the wash periodically through the operational and closure phases of the Project. Data obtained over time from the monitoring locations will be used to determine if significant erosion of sediment is occurring within the channel of Barrel Canyon Wash.

Geomorphological monitoring for Mitigation Measure FS-SR-05 will consist of establishing two (2) monitoring locations in Barrel Canyon Wash between the Sediment Control Structure No. 1 and bridge at State Route 83. The use of ground based LIDAR (Light Detection and Ranging) scanner technology and photographs are proposed to document the physical changes over channel scour, degradation and aggradation, and geomorphological changes occurring within the stream channel at the monitoring locations.

The following subsections describe the anticipated information to be gathered at each monitoring location. These sub-sections include:

- Monitoring Points;
- LIDAR Scan;
- Photographs and Channel Observations;
- Initial Monitoring Event; and
- Subsequent Monitoring Events.

1.2.1 Monitoring Points

Rosemont will establish two (2) locations in lower Barrel Canyon Wash to monitor and assess any changes in stream geomorphology. Figure 1 shows the two (2) locations. In general, they are positioned as follows:

- Approximately 800 feet downstream of the proposed Sediment Control Structure No. 1; and
- Co-located with the BC-2 surface water/groundwater monitoring station – approximately 11,500 feet downstream of the proposed Sediment Control Structure No. 1.

For each location, the following survey control will be added:

- Place and survey a minimum of four (4) control markers (elevation and horizontal) at each of the two monitoring points/locations; and
- Place permanent tags at each of the control points.

1.2.2 LIDAR Scan

As indicated, a ground-based LIDAR (Light Detection and Ranging) scanner will be used to map the stream channel at both Barrel Canyon Wash monitoring locations. The LIDAR scanner is an active remote sensing technology that uses light pulses to measure relative distance from the scanner, as well as other characteristics (texture, hardness, etc.) of terrain and objects. This generates a three-dimensional point “cloud” of the area that also includes light intensities and RGB color values from a digital camera. An area of approximately 100 feet x 100 feet will be scanned at each monitoring point, focusing on the stream channel. The scanner will then create a high-resolution (down to 6 millimeters) digital elevation model of the stream channel. A GPS (Global Positioning System) receiver will be used to accurately determine the position of the LIDAR sensor and the environmental surface sensed with LIDAR. Repeated LIDAR-derived data will then be used to detect and characterize changes over time that are occurring in the stream channel.

1.2.3 Photographs and Channel Observations

Photography will also be used to document stream points and channel observations. The LIDAR scanner is also equipped with a high-resolution camera. Photographs will focus on channel shape, channel bed and bank material, evidence of erosion or deposition, channel bank geometry, and vegetation. The photographs will be taken at the same location with the same angle facing the channel with the same level of magnification to ensure consistency.

At each monitoring event, photographs of each monitoring location will be taken from four (4) separate viewpoints: two (2) from upstream locations and two (2) from downstream locations.

1.2.4 Initial Monitoring Event

The following is a summary of the activities that will be conducted during the initial monitoring event:

- Locate and survey (elevation and horizontal) four control points at each of the two (2) monitoring locations;
- Place permanent markers at each of the control points;
- Take photographs at each of the four (4) control points at set orientations (two (2) from upstream locations and two (2) from downstream locations);
- Record field notes describing channel conditions; and
- Take a three-dimensional cross-section topographic scan of the channel wash at each monitoring location. Create a topo (field) map of the monitoring location (area) and representative cross-sections showing the following (as appropriate): date/time, location of control points, direction of stream flow, North arrow, map scale, photopoint locations, and any other observations, i.e., trees, boulders, sand bars, etc.

1.2.5 Subsequent Monitoring Events

The following is a summary of the activities that will be conducted during subsequent monitoring events:

- Take photographs at each of the four (4) control points at set orientations (two (2) from upstream locations and two (2) from downstream locations);
- Record field notes describing channel conditions; and
- Take a three-dimensional cross-section topographic scan of the channel wash at each monitoring point/location. Create a topo (field) map of the same monitoring location (area) and same representative cross-sections showing the following (as appropriate): date/time, location of control points, direction of stream flow, North arrow, map scale, photopoint locations, and any other observations, i.e., trees, boulders, sand bars, etc.

2.0 MONITORING AND REPORTING

Monitoring and reporting components for Mitigation Measure FS-SR-05 are listed below.

2.1 Monitoring

The following data will be collected at each location per monitoring event:

- Photographs; and
- LIDAR survey.

Sediment transport monitoring in Barrel Canyon will be conducted every year for the first five (5) years. After five (5) consecutive annual monitoring events, the frequency of sediment transport monitoring in Barrel Canyon will be reduced to every five (5) years throughout the remaining operational period, with one (1) monitoring event in the closure period.

2.2 Reporting

Reporting on Mitigation Measure FS-SR-05 to the Forest Service will be completed annually after each monitoring event and will include the following information:

- Graphical or illustrative comparison with previous data (as appropriate) showing physical changes to the stream bed such as top of alluvium and location of main flow channel, etc.;
- Volumetric comparison with previous data (as appropriate); and
- Photographs.

Data collected from each monitoring event will be assessed and compared with conditions documented during the initial monitoring event and also to the previous event. The results will be described in a report prepared for the USFS. Changes to Barrel Canyon that are outside the range of anticipated impacts stated in Table 12, Chapter 2 of the FEIS (USFS, 2013a) will be noted. The anticipated impacts to Barrel Canyon Wash due to the Project include a decrease in sediment load compared with baseline (pre-mining) conditions; however, sediment concentrations are expected to remain the same. No change in geomorphology (scour/aggradation) is expected in Barrel Canyon or Davidson Canyon (FS-BR-22) owing to the change in sediment load.

3.0 ADAPTIVE MANAGEMENT

Rosemont will incorporate the adaptive management process into Mitigation Measure FS-BR-05. This process will ensure that the intent of the sediment transport monitoring is being met and that pertinent data is being collected and reported. The three key components of adaptive management are:

- Testing assumptions – collecting and using monitoring data to determine if current assumptions are valid;
- Adaptation – making changes to assumptions and monitoring program to respond to new or different information obtained through the monitoring data and project experience; and
- Learning – documenting the planning and implementation processes and its successes and failures for internal learning as well as the scientific community.

Elements that may be modified as part of the adaptive management process for this Plan include, but are not limited to, the following:

- Monitoring locations;
- Monitoring procedures (changes in technology, etc.);
- Information reported; and
- Monitoring frequency.

4.0 DATA MANAGEMENT

Field notes will either be taken in hardcopy format or electronically. Field notes, photos, and survey data will be used as a basis of reporting and compliance verification.

5.0 REFERENCES

USFS, 2013a. Final Environmental Impact Statement for Rosemont Copper Project, Appendix B Mitigation and Monitoring Plan. November 2013.

USFS, 2013b. Draft Record of Decision and Finding of Nonsignificant Forest Plan Amendment for the Rosemont Copper Project. December 2013.

FIGURES

Legend

- Sediment Control Structure
- Sediment Monitoring Area
- Control Point
- BC-2 Auto Stormwater / Groundwater Station
- Landform Footprint
- Security Fence
- Perimeter Fence
- State Highway 83

N

1:10,000

500 250 0 500

Feet

Project: Draft Barrel Canyon Sediment Transport Monitoring Plan	
Source: ArcGIS Map Service Server	
County: Pima	**State:** Arizona
PRJ: NAD83 UTM 12 Meters	**Date:** 11/17/2014
Figure 1. Sediment Transport Monitoring Locations	
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Legend

- Sediment Control Structure
- Sediment Monitoring Area
- Control Point
- Security Fence

1:1,500

100 50 0 100

Feet

Project:	Draft Barrel Canyon Sediment Transport Monitoring Plan
Source:	ArcGIS Map Service Server
County: Pima	**State:** Arizona
PRJ: NAD83 UTM 12 Meters	**Date:** 11/17/2014

Figure 2. Sediment Transport Monitoring Location #1

ROSEMONT COPPER

Legend

- Sediment Monitoring Area
- Control Point
- BC-2 Auto Stormwater/ Groundwater Station

1:1,500

100 50 0 100
Feet

Project: Draft Barrel Canyon Sediment Transport Monitoring Plan	
Source: ArcGIS Map Service Server	
County: Pima	**State:** Arizona
PRJ: NAD83 UTM 12 Meters	**Date:** 11/17/2014

Figure 3. Sediment Transport Monitoring Location #2

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