REPORT

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Prepared for:

RESOLUTION COPPER

Surface Water Baseline Addendum: Upper Queen Creek, Devils Canyon, and Mineral Creek Watersheds

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RESOLUTION COPPER MINING LLC, PINAL COUNTY, ARIZONA

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1 EXECUTIVE SUMMARY

1.1 Introduction

At the request of Resolution Copper (RC), Montgomery & Associates (M&A) has prepared this surface water baseline report to support ongoing National Environmental Policy Act (NEPA) review process for the Resolution Project near Superior, Arizona. This report is an addendum to the Surface Water Baseline Report prepared by M&A (2013) that includes detailed analysis and discussion of surface water monitoring results in the Resolution Project study area; Devils Canyon, Queen Creek, and Mineral Creek. The study area covered by this report encompasses:

- The Devils Canyon watershed
- The western part of the upper Mineral Creek watershed from the confluence with Devils Canyon upstream to the Government Springs Ranch and including Lyons Fork
- The Upper Queen Creek watershed from the Town of Superior upstream to the headwaters

The principal objectives of surface water monitoring program are to:

- Evaluate the magnitude and character of streamflow and base flow within the study area
- Identify locations where discharge from the regional groundwater system(s) supports surface water features
- Develop a baseline data set against which future potential impacts from mining may be measured

The Surface Water Baseline Report (M&A, 2013) provided analysis and discussion of surface water data for the period from Q1 2003 through Q1 2013. Data presented and discussed in this addendum include all data collected previously, as well as additional data collected from the Q1 2013 through Q1 2016. In addition to updating the analyses presented in the Surface Water Baseline Report (M&A, 2013), this report presents new analyses of base flow separation within the study area.

This report also differs from the original surface water baseline assessment (M&A, 2013) because it uses the Arizona Department of Environmental Quality (ADEQ) definition of *perennial* versus the U.S. Army Corps of Engineers (USACE) definition. This change was made because the United States Forest Service (USFS) and ADEQ will be the governing agencies concerning the Mine Plan of Operations. The USFS defines perennial streams as "streams that flow throughout the year and from source to mouth" (USFS, 1976). This definition is not considered appropriate for Arizona because very few Arizona streams flow continuously from source to mouth. In contrast, ADEQ defines perennial as a stream with continuous flow, allowing for the possibility of perennial reaches interrupted by intermittent or ephemeral reaches, as frequently occurs in Arizona. Because the ADEQ definition is based on the flow of water, occurrence surveys, which only identify the presence of water, are not used to determine whether a reach is perennial. This differs from the original surface water baseline report (M&A, 2013) which identified reaches as perennial based on occurrence surveys.

1.2 Results

Surface water in the Resolution Project study area is present in numerous springs and streams. Waters reporting to the streams and springs are understood to derive from three primary sources:

- Precipitation and snowmelt driven runoff resulting in event driven surface water flows.
- Discharge from shallow, perched, alluvial aquifers of limited areal extent. These aquifers may exist seasonally acting as a source of water to springs and streams over weeks or months following precipitation events.
- Discharge from the regional Apache Leap Tuff (ALT) aquifer. The ALT is present at the surface along portions of Upper Queen Creek, Devils Canyon, and Mineral Creek and supports perennial surface water flow in Devils Canyon and Mineral Creek.

1.2.1 Queen Creek Watershed

Surface water flow in the Upper Queen Creek watershed between the headwaters and the Superior Waste Water Treatment Plant is currently proposed to be reclassified by ADEQ from ephemeral to intermittent. Periods of sustained winter streamflow, observed in the Upper Carbonate data sonde record, occur generally beginning in November and lasting through April. Base flow separation analyses classify periods of sustained winter streamflow as base flow, persisting long after surface runoff events. Winter base flow at Upper Carbonate is interpreted to derive from local capture and storage of runoff water in surficial alluvial deposits and joint sets within the watershed which slowly release water into the Queen Creek drainage.

1.2.2 Devils Canyon Watershed

Ephemeral and/or intermittent streamflows in Devils Canyon are supported by precipitation and snowmelt driven runoff events and seasonal discharge from surface veneer alluvial aquifers. Downstream, three continuously saturated reaches have been identified in Devils Canyon and have been determined to be sourced quite differently. The furthest upstream continuously saturated reach, occurring from approximately DC 11.0 to DC 10.6, has been determined to be primarily supported by the local, shallow groundwater system and is recharged by precipitation-driven runoff (M&A 2010a, 2012, 2013, 2016). Further downstream, water is consistently present in or near the reaches from DC 9 to 7 and from DC 6 to 5. Hydrochemistry data, groundwater levels in the ALT aquifer, and base flow separation analyses indicate that base flow in these reaches is predominantly supported by discharge from the ALT aquifer (M&A 2010a, 2012, 2013, 2016). The end of the lowest continuously saturated reach near DC 5.4 coincides closely with the stream's transition onto the Whitetail Conglomerate (Tw) where the canyon opens up and a large deposit of floodplain alluvium is present. No continuously saturated reaches are known to exist in Devils Canyon below this point.

1.2.3 Mineral Creek Watershed

Mineral Creek and its tributary, Lyon's Fork, were added to the surface water monitoring program in 2008. Surface water was understood to be continuously present in the Mineral Creek stream channel between approximately MC 8.4 and MC 7.8 (M&A, 2013), where Mineral Creek briefly encounters a surface expression of the ALT. However, recent surveys from 2014 have demonstrated that this reach of Mineral Creek is not continuously saturated. Further, hydrochemical analyses of waters from this reach suggest that this reach is primarily supported by recently recharged surface water runoff. A long continuously saturated reach does occur, however, as Mineral Creek flows over the ALT between approximately MC 6.9 and MC 1.6. Hydrochemical and base flow analyses of waters in this section support the interpretation that this water is primarily derived from the regional ALT aquifer. Lyon's Fork was understood to be continuously saturated from approximately LF 0.16 to LF 0.09 (M&A, 2013). However, data from 2014 have led to this reach being reclassified as discontinuously saturated.

1.2.4 Summary

The streamflow characteristics of Upper Queen Creek, Devils Canyon, and Mineral Creek show some similarities while also differing in some important ways. In most cases base flows are highest in the winter and lowest in the summer in all streams, with median winter flows as much as 95 times larger than summer flows. The median annual streamflow of Upper Queen Creek is zero, indicating that flow does not occur most of the time. Median winter base flows at Devils Canyon surface water stations are all less than 0.5 cfs, while median winter base flows at Mineral Creek surface water stations are all less than 1.7 cfs. In general, Upper Queen Creek has the lowest flows while Mineral Creek has the highest.

2 INTRODUCTION

At the request of Resolution Copper (RC), Montgomery & Associates (M&A) has prepared this surface water baseline report to support ongoing National Environmental Policy Act (NEPA) review process for the Resolution Project near Superior, Arizona. This report is an addendum to the Surface Water Baseline Report prepared by M&A (2013) that includes detailed analysis and discussion of surface water monitoring results for Upper Queen Creek, Devils Canyon, and Mineral Creek. The study area covered by this report encompasses:

- The Devils Canyon watershed
- The western part of the upper Mineral Creek watershed from the confluence with Devils Canyon upstream to the Government Springs Ranch and including Lyons Fork
- The Upper Queen Creek watershed from the Town of Superior upstream to the headwaters

The study area is a subset of the overall Resolution Project study area; location for the study area is shown on **Figure 1**.

The surface water monitoring program in the study area was initiated in 2003 in conjunction with preliminary studies related to development of a large-scale copper mine east of Superior, Arizona. RC has proposed to develop a new mine that targets the Resolution orebody using the block-cave mining method. The overall goal of the surface water monitoring program is to identify springs and surface water resources that could potentially be impacted by proposed block-cave mining operations.

Specific objectives of the surface water monitoring program are to:

- Evaluate the magnitude and character of streamflow and base flow within the study area
- Identify locations where discharge from the regional groundwater system(s) supports surface water features
- Develop a baseline data set against which future potential impacts from mining may be measured

Details of the execution of the surface water program can be found in the Surface Water Baseline Report (M&A, 2013) which provided analysis and discussion of surface water data for the period from Q1 2003 through Q1 2013. Data presented and discussed in this addendum include all data collected previously by RC and Golder Associates, as well as additional data collected by RC from Q1 2013 through Q1 2016, with special emphasis placed on interpretation of results collected since 2013.

This report also differs from the original surface water baseline assessment (M&A, 2013) because it uses the Arizona Department of Environmental Quality (ADEQ) definition of *perennial* versus the U.S. Army Corps of Engineers (USACE) definition. This change was made because the United States Forest Service (USFS) and ADEQ will be the governing agencies concerning the Mine Plan of Operations. The USFS defines perennial streams as “streams that flow throughout the year and from source to mouth” (USFS, 1976). This definition is not considered appropriate for Arizona because very few Arizona streams flow continuously from source to mouth. In contrast, ADEQ defines perennial as a stream with continuous flow, allowing for the possibility of perennial reaches interrupted by intermittent or ephemeral reaches, as frequently occurs in Arizona. Because the ADEQ definition is based on the flow of water, occurrence surveys, which only identify the presence of water, are not used to determine whether a reach is perennial. This differs from the original surface water baseline report (M&A, 2013) which identified reaches as perennial based on occurrence surveys.

Although there are numerous surficial water features such as seasonal springs and seeps that discharge from shallow alluvial deposits and veneers, the principal focus of the surface water monitoring program as described in this report has been to identify groundwater discharge points for the Apache Leap Tuff (ALT) aquifer. The shallow surficial features, capture, store, and slowly release stormwater runoff, especially during the winter rainy season and snowmelt periods, but are not connected to the regional aquifer system within the Apache Leap Tuff (ALT) and are therefore not discussed in detail in this report. However, RC has indicated that some of these features are considered to be culturally meaningful and/or support ecosystem functions. For this reason, ongoing research and characterization of these features will be discussed in a separate technical memorandum to be issued in 2017.

2.1 Climate

Climate in the project area is generally arid to semi-arid. Precipitation typically occurs as high-intensity, short-duration storms during the months of July through September, and longer-duration storms of more moderate intensity that occur during the months of November through March. Although several meteorological stations have been, and are currently, maintained in the study area there is no one data set that is complete for the period covered in this report (2003 through 2016). As described in previous reports (M&A 2012, 2013, 2016), M&A has chosen to use the PRISM precipitation data set (Oregon State University, 2016). PRISM data are interpolated from gage data for the entire United States using the Parameter-elevation Regressions on Independent Slopes Model.

Average annual precipitation over the period of record (1895 to 2015) in the vicinity of Oak Flat (33.3005°N, 111.0573°W) as reported in the PRISM data set is 23.6 inches. Precipitation varies considerably over the project area which incorporates elevations ranging from 5,500 feet above mean sea level at Kings Crown in the Queen Creek headwaters to 2,400 feet above mean sea level near the confluence of Devils Canyon and Mineral Creek and is therefore subject to substantial orographic variability.

2.2 Hydrogeologic Context

The geology of the three watersheds is distinct (**Figure 2**). The Upper Queen Creek watershed is characterized by diverse geology, including Precambrian sedimentary and intrusive rocks, Paleozoic carbonates, Tertiary Apache Leap Tuff (Tal) and older volcanic rocks, and floodplain alluvium. The headwaters of Queen Creek host a marble quarry that operates sporadically (OMYA Quarry), and the presence of this quarry likely results in some alteration of the natural surface water flow regime. Location of the quarry is shown on **Figure 2**.

Geology in the Devils Canyon watershed is dominated by the Tal outcrop belt across most of the basin. Small outcrop belts of older volcanic rocks and intrusive rock occur along the north and east margins of the watershed. Unconsolidated alluvial deposits occur across the Apache Leap Tuff outcrop belt ranging from thin localized veneers in the Oak Flat area to deposits that approach several tens of feet in thickness and encompass several hundred acres such as the alluvial deposits at Top of the World (**Figure 2**).

The Mineral Creek watershed is composed of Precambrian and younger Precambrian schist, granites, and volcanics in the northeastern portion of the watershed, and Tal and other Tertiary volcanics along the western margin of the watershed; basin fill deposits and floodplain alluvium occur in the central to south portion of the watershed.

Based on results of hydrogeologic characterization conducted by M&A on behalf of RC (M&A 2010a, 2012, 2016), three principal groundwater systems have been identified in the study area including:

- Perched shallow groundwater systems hosted in disconnected, unevenly distributed unconsolidated alluvial sediments of limited areal extent,
- The ALT aquifer hosted in fractured Tal that extends across much of the study area, and
- A deep groundwater system hosted in a variety of older rock units.

For a detailed description of these hydrogeologic units see M&A (2016).

The deep groundwater system does not discharge to the surface in the study area. Discharge points for the ALT aquifer and the shallow groundwater system have been identified as springs and seeps that directly support surface water features in the study area (M&A 2012, 2013, 2016).

2.3 Surface Water and Springs

Surface water monitoring is conducted in three principal watersheds within the study area: Upper Queen Creek, Devils Canyon, and Mineral Creek. Queen Creek, a tributary of the Gila River, drains the northwestern part of the study area, and runs generally to the west-southwest through Superior. The central part of the study area is drained by Devils Canyon, which is a major tributary of Mineral Creek. Devils Canyon flows from north to south to the confluence with Mineral Creek in the southern part of the study area. The southeastern and eastern parts of the study area are drained by Mineral Creek, which is a tributary of the Gila River.

Monitoring of springs and surface waters within the study area began in 2003, and now includes:

- One data sonde and one stream gage in Queen Creek Watershed
- Eight data sondes and one stream gage in Devils Canyon Watershed
- Two data sondes in Mineral Creek Watershed

2.3.1 Watersheds and Monitoring Station Identifiers

For most surface water sampling stations, station identifiers consist of one or two letters identifying the watershed or sub-watershed, a numerical value that identifies the number of kilometers along the stream channel upstream from a defined confluence or major hydrographic feature, and a single letter related to the position of the station relative to the streambed. The station prefixes that identify each watershed or sub-watershed and the datum from which upstream distance is measured are designated as follows:

Watershed/Sub-watershed	Station Identifier Prefix	Distance upstream from
Queen Creek	QC	Whitlow Ranch Dam
Devils Canyon	DC	Confluence with Mineral Creek
• Iron Canyon	IC	Confluence with Devils Canyon
• Rancho Rio Canyon	RR	Confluence with Devils Canyon
• Hackberry Canyon	H	Confluence with Devils Canyon
Mineral Creek	MC	Confluence with Devils Canyon
• Lyons Fork	LF	Confluence with Mineral Creek

Location relative to the streambed is indicated by the following letters:

- Main stream channel = C
- Spring to the west of the main stream channel = W
- Spring to the east of the main stream channel = E

Another component of the surface water monitoring program includes detailed documentation of flowing reaches (occurrence surveys), and mapping of springs and seeps within the three watersheds.

Occurrence survey extents are shown on **Figure 2**, and the surveyed reaches are listed in **Table 1** and summarized by quarter in **Table 2**. For each surveyed reach, the lengths of the flowing sections are summarized by quarter in **Table 3**. Data sonde locations are shown on **Figure 2**, and summarized in **Table 4**. Spring locations are shown on **Figure 2** and listed in **Table 5**. The data are presented and interpreted in the following sections.

3 OCCURRENCE SURVEYS

The focus of the occurrence surveys is on identifying the continuous presence of water or saturation. Surface water occurrence surveys have been conducted periodically for the three principal surface water drainages in the study area since 2003. The results of the occurrence surveys provide a record of the location, persistence, and variability of surface water features along these drainages within the Resolution Project area over the last decade. Procedures for determining locations for either flowing or saturated stream reaches are described in M&A (2013). The following terms are used to describe the given stream reaches within a watershed based on the persistence of surface water.

- Continuously Saturated: Either flowing water or saturation is consistently present across seasons and over years.
- Discontinuously Saturated: Water is not consistently present across seasons and over years.

Figure 2 shows a map of the maximum survey extents. The actual survey extents have varied through the years as program goals have developed; **Table 1** summarizes quarter-specific survey extents, some of which are subsets of the maximum extents shown on **Figure 2**. Reaches included in each of the quarterly surveys are summarized in **Table 2,** and the length of each section is listed by quarter in **Table 3**. Continuously saturated stream reaches for Devils Canyon and Mineral Creek, as determined previously, are shown on **Figure 2**. No continuously saturated stream reaches have been identified in Queen Creek upstream from the Town of Superior.

Figures 3 through 9 show the reaches in which surface flow or saturation was observed in each of the quarterly occurrence surveys in the principal watersheds and sub-basins. Monthly precipitation estimated by PRISM is also shown on **Figures 3 through 9** to allow qualitative assessment of the relationship between precipitation and runoff response in the project area watersheds.

It should be recognized that field occurrence surveys are inherently subjective; results should be considered to be qualitative and used as general indicators of surface water distribution and persistence. Occurrence survey results shown on **Figures 3 through 9** document saturated stream reaches.

A discussion of principal observations of the occurrence surveys in each of the principal watersheds is provided in the following sections.

3.1 Upper Queen Creek

Occurrence surveys indicate that Upper Queen Creek from the town of Superior to the headwaters flows chiefly in response to winter precipitation events **(Figure 3)**. Sustained seasonal flow is often observed in the spring when slow release of surface water runoff and snowmelt is captured in shallow alluvial deposits and veneers, colluvium, and extensive shallow joint sets in the Tal outcrop belt drains into Queen Creek after the winter rainy season. These shallow, seasonal groundwater systems are perched above the regional ALT aquifer. The only continuously saturated reach along the main stem of Queen Creek is located downstream of the Town of Superior at the Superior Waste Water Treatment Plant and the Harborlite perlite mine, where discharges from these two facilities maintain perennial flow in Queen Creek down to the Boyce Thompson Arboretum (approximately QC 17.39 to 15.55). Currently the Arizona Department of Environmental Quality classifies this reach as being effluent-dependent. This reach is shown on **Figure 1**.

Two springs, Pump Station Spring and Boulder Hole, with some degree of persistence have been identified in the Upper Queen Creek drainage between the headwaters and the town of Superior. Pump Station Spring (QC 30.7 C) is located in the Queen Creek channel downstream of the OMYA marble quarry **(Figure 2)**. The spring discharges from shallow alluvial deposits that cover an area of more than 20 acres. Shallow groundwater stored in these alluvial deposits is the principal source of water to this spring. It has been reported that pumped water from dewatering of the OMYA quarry during runoff events is occasionally discharged to the Queen Creek channel above Pump Station Spring where it is available to recharge shallow groundwater hosted in the alluvial deposits.

Pump Station Spring was observed to flow consistently (at rates generally <0.03 cfs) until Q4 2010 when RC and Golder field staff reported that the sampling location was dry. Since Q4 2010 the Pump Station Spring has been reported as a stagnant pool with no associated flow. It is not clear whether these observations reflect changes in dewatering operations at the OMYA quarry, or whether it is related to ongoing drought conditions, or a combination of both factors.

Boulder Hole (QC 23.6 C) is located in boulder alluvium in the channel of Queen Creek below the Apache Leap Tuff outcrop belt (**Figure 2**). It is generally a stagnant pool (i.e. no visible flow exiting the pool) although subflow in the boulder alluvium may occur. Boulder Hole has never been reported to be dry, and estimates of stored water volumes range widely. Although the source of water at Boulder Hole is not well understood, it may reflect local storage and release of seasonal runoff from the upper part of Queen Creek canyon. Storage could be in the boulder alluvium where it rests on the poorly permeable Whitetail Conglomerate and Naco Limestone. The interpretation that water at Boulder Hole derives from seasonal runoff is supported by observed variability in total dissolved solids (TDS), with the lowest levels of TDS occurring during January-March when there is much runoff (M&A, 2016).

3.2 Devils Canyon

Occurrence surveys indicate that surface water is consistently present in three reaches of Devils Canyon **(Figures 1, 2, and 4)**. Hydrochemistry data indicate that base flow in the upper reach (DC 11.0 to 10.6) is likely supported by a perched, shallow groundwater system that is recharged by precipitation-driven runoff and has relatively short residence times (M&A, 2016). Further downstream, hydrochemistry data and groundwater levels in the ALT aquifer indicate that base flow for the two lower reaches (DC 9.1 to 7.5 and DC 6.1 to 5.4) is supported predominantly by discharge from the ALT aquifer (M&A 2010a, 2012, 2013, 2016). The lower two reaches historically have been classified by agencies and non-governmental agencies as perennial.

Three Devils Canyon tributaries, Iron Canyon, Rancho Rio Canyon, and Hackberry Canyon, are included in surface water occurrence surveys (**Figures 5 through 7**). Iron Canyon was added to the occurrence survey program in 2008 (**Figure 2**). Iron Canyon drains west from the Top of the World area, where a large deposit (>200 acres) of alluvial deposits and colluvium is located. Water in Iron Canyon is relatively persistent, but it is not continuously saturated (**Figure 5**). It appears that Iron Canyon in response to seasonal discharge from the shallow groundwater system hosted in the alluvial deposits in the Top of the World area, and slow discharge of winter precipitation-driven runoff stored in stream channel alluvium, both of which support low-volume discharge for a relatively long period after winter precipitation has ceased. Rancho Rio and Hackberry Canyon have been surveyed since the beginning of the program (**Figures 6 and 7**). No continuously saturated reaches have been identified in either tributary. However, in both tributaries there are a number of large pools that are rarely, if ever, dry. Data collected since 2013 are consistent with previous observations.

For the reach of Devils Canyon from DC 9.1 to DC 4.1, numerous small springs and seeps have been identified within the Devils Canyon corridor, nearly all of them associated with the two lower continuously saturated reaches that are predominantly supported by groundwater discharge from the ALT aquifer. Flow rates have been measured at four of these springs: DC 8.2 W, DC 6.1 E, DC 4.1 E and DC 6.6 W (**Table 5**). Saturation has been present during all field surveys at all four of these springs, however flow has not always been present. Measured flows have always been less than 0.1 cfs. Hydrochemical data indicate that these springs issue from the ALT aquifer (M&A 2010a, 2012a, 2013, 2016). Flow rates are summarized in **Appendix A**.

3.3 Mineral Creek

Mineral Creek and its tributary, Lyons Fork, were added to the occurrence survey program in 2008. Initial investigations led investigators to believe that Mineral Creek was continuously saturated between approximately MC 8.4 and MC 7.8 (M&A, 2013). However, additional surveys indicate either an ongoing change in conditions or that the original assessment of this reach was based on unusually wet conditions. Dry conditions have been documented in this reach in recent years (**Figure 8**). A continuously saturated reach occurs between approximately MC 6.9 and MC 1.6. Lyons Fork was interpreted to be continuously saturated from approximately LF 0.16 to LF 0.09 (M&A, 2013). However, data from the 2014 surveys have led to this reach being reclassified as discontinuously saturated (**Figure 9**). Streamflow rates are discussed in section 5.3.

Hydrochemical data indicate that base flow in upper Mineral Creek and Lyons Fork is supported by discharge of groundwater from the upper Mineral Creek drainage that is dominated by relatively recently recharged surface water runoff (M&A 2013, 2016). In the lower reaches of Mineral Creek hydrochemical data indicate that base flow is supported by a mixture of local, perched groundwater from the Mineral Creek drainage and regional groundwater from the ALT aquifer.

Two springs along Mineral Creek are regularly monitored. Government Springs discharges from a brecciated zone of Apache Leap Tuff via a concrete vault near the house at Government Springs Ranch. Instantaneous flow rates from this spring have been estimated to range from zero to approximately 0.007 cfs.

Spring MC 3.4 W has been observed to flow in all surveys that have been conducted in Mineral Creek. Hydrochemical data indicate that MC 3.4 W is a discharge location for the ALT aquifer (M&A, 2012a, 2013, 2016). The highest measured flow rate of 0.3 cfs was observed on only one occasion and represents an outlier. This higher flow rate is judged to represent a mixture of spring flow and surface water runoff. All other measured flows have been much lower.

4 DATA SONDES

Data sondes were installed at selected locations in Devils Canyon, Mineral Creek, and Queen Creek (**Figure 2**) in order to provide a more continuous record of water depth and water quality parameters to augment the occurrence survey dataset presented in Section 3. Because access to the monitoring stations in these canyons is quite difficult, installation of engineered surface water flow monitoring structures is not feasible, and maintenance of these small-scale installations is challenging. However, these sondes provide a very useful record of water depth and water quality parameters and provide valuable data for characterizing surface water flow in these drainages.

Data from the sondes are used to: (1) assess base flow conditions; (2) observe runoff events; (3) support the development of streamflow hydrographs, as discussed in Section 5; (4) determine the relationship between surface water flow and water quality; and, (5) provide context for the results of quarterly hydrochemical sampling. Data collected since 2013 support the conclusions published in M&A (2013).

Twelve sondes have been installed in two rounds; ten are still functional and two have been discontinued (**Table 4**). The first six data sondes were installed by Golder in Devils Canyon in 2003 (Golder, 2006). The sonde at DC 8.2 W was discontinued in 2005 when the flow path of spring discharge changed and the sonde was no longer submerged. In 2011 two new sondes were established, one at DC 8.1 C, and the other along Rancho Rio (RR 1.5 C), a tributary to Devils Canyon. Four additional data sondes were installed by RC in late 2010/early 2011 in order to collect continuous flow and water quality data in the Queen Creek and Mineral Creek watersheds. Two sondes were installed in Mineral Creek watershed, and two in Queen Creek watershed; however, only one of the Queen Creek sondes remains in use. In 2013, a vented pressure transducer was installed along Devils Canyon at the Highway 60 Bridge (DC SW1, J.E. Fuller, 2016). An additional stream gage operated by Pinal County is located on Queen Creek at Magma Avenue in Superior, AZ (QC Magma Ave). This stream gage is used to provide flood warning data for downstream areas along Queen Creek. Data collected at the ten functioning sonde locations, at discontinued sonde location DC 8.2 W, and at stream gages DC SW1 and QC Magma Ave are shown on **Figures 10 through 22**.

Parameters collected at the data sonde locations may include water depth, temperature, specific conductance, and pH. Depth of water is calculated based on pressure readings at the probe corrected for barometric pressure and converted to depth of water in feet (J.E. Fuller, 2016). Differences in water levels between sonde locations are a function of stream channel geometry and do not reflect relative flow volumes. For example at DC 8.8 C the sonde is located in an open, braided section of the stream channel so water depths for a given flow rate will be lower than at DC 7.1 C where streamflow is constrained by a bedrock narrows.

The presence of water over the data sonde sensor does not necessarily indicate the presence of flow. This is the case for data sondes installed in pools for which a given depth of water must accumulate before spilling over the lip of a pool. Base flow analyses discussed in **Section 5** are based on site-specific rating curves (J.E. Fuller, 2016) that account for this phenomenon.

Temperature data are collected at all ten sonde locations. Temperature data shown on **Figures 10, and 13 through 22** are raw data downloaded from the data sondes. Presented temperature data have not been post-processed beyond checking that the measurement units (°C) are correct and consistent.

Specific conductance (SC) is measured at all ten sonde locations and pH is measured at locations DC 8.8 C, DC 8.1 C, DC 7.1 C, and DC 5.5 C. Sonde water quality data are generally consistent with water quality parameters measured manually during sample collection (**Figures 10 and 13 through 22)**. Data collected up until 2008 were audited by Golder and any rejected data were removed from the data set. Some data were not rejected but were qualified—these data are included on **Figures 10 and 13 through 22**. Reasons for qualification include extremely low SC values and drifting or unreasonable pH values. A summary of the qualification status of sonde data collected up until 2008 is provided in M&A (2010b). Data collected since 2008 have not been screened for accuracy.

4.1 Upper Queen Creek

Two data sondes were installed along Upper Queen Creek, one at an upstream site, referred to as “Upper Carbonate,” and a second at a downstream site referred to as “Lower Carbonate” (**Figure 2**). The Lower Carbonate data sonde and data were lost in 2013; however, a radar gage (QC Magma Ave) was installed in early 2015, and streamflow records are available from 2015 through present at this site.

Data from the Upper Carbonate data sonde are shown on **Figure 20**. Inspection of **Figure 20** shows inconsistent presence of water, highly volatile diurnal temperature data, and specific conductance data with frequent zero values. Like ephemeral sites in the upper reaches of Devils Canyon, spikes in specific conductance correspond with precipitation events. These data are consistent with current understanding that Upper Queen Creek is ephemeral and that flow is generated by precipitation events (M&A 2013, 2016).

Data collected at stream gage QC Magma Ave are shown on **Figure 11.** Inconsistent presence of water indicates that streamflow at this site is ephemeral.

4.2 Devils Canyon

Depth of water above the sonde, specific conductivity, and temperature all provide information regarding the degree to which flowing water is perennial, intermittent, or ephemeral at each of the data sondes. **Figures 12 through 20** show data collected from the data sondes in Devils Canyon. Periods of no flow over a probe coincide with zero conductivity readings (because the conductivity probe dried out) and with markedly increased fluctuation in temperature (because the sonde is dry and changes in temperature are no longer attenuated by overlying water).

At DC SW1 (**Figure 12**) and DC 13.5 (**Figure 13**) In the upper reaches of Devils Canyon there are dry periods for which little or no surface water is present. Water level data from Station DC SW1 (**Figure 12**) shows extensive periods with surface water present. At the DC 13.5 C sonde, very dry periods (when the data sonde is completely dry) are characterized by large temperature departures, generally in the summer prior to onset of monsoon precipitation (May – June), accompanied by increased diurnal temperature variability (**Figure 13**). These observations are consistent with current understanding that streamflow at DC SW1 and DC13.5 in upper Devils Canyon is ephemeral (M&A 2013).

Flowing surface water is more persistent further downstream in Devils Canyon. Location DC 10.9 C was understood to be ephemeral when the data sonde was first installed (Golder, 2006). This initial expectation was likely based on results of the Q4 2002 occurrence survey which showed the site to be dry (**Figure 4**). This is consistent with the fact that 2002 was an extremely low-precipitation year and area conditions were very dry (in 2002 the total annual precipitation reported by PRISM for the Superior area (33.294°N, 111.1°W) was 5.8 inches compared with an annual average (1920 to 2015) of 23.6 inches). However, inspection of time-series plots on **Figure 14** shows that some minimum depth of water (on the order of 0.3 feet) has been present continuously at this site since 2009. Temperature and specific conductance data also support the water level data in indicating that water level has not dropped to zero at this site since 2009 (**Figure 14**). Therefore, station DC10.9 C has been reclassified as intermittent. Data collected at sonde location RR 1.5 C in Rancho Rio, a tributary to Devils Canyon, are shown on **Figure 15**. Inconsistent presence of water, highly volatile diurnal temperature data, and conductivity data with frequent zero values indicate that this site is ephemeral.

Inspection of **Figure 16** shows that water is consistently present at data sonde location DC 8.8 C. Diurnal fluctuations in temperature at DC 8.8 C are relatively small and there are no large departures that would suggest dry conditions. These data are consistent with current understanding of the presence of a continuously saturated reach in this part of Devils Canyon (M&A 2013, 2016).

A data sonde was initially installed to measure flow from the spring at DC 8.2 W. This sonde was left dry when a large runoff event changed the routing of surface flow from the spring. A new data sonde was located in a pool just downstream from this spring (DC 8.1 C) in 2011. Although the data sonde at DC 8.2 W only yielded approximately eight months of useable data, it is clear that the temperature and water level at this location are very stable compared with the diurnal and seasonal fluctuations observed at surface water sites (**Figure 17**). This is consistent with current understanding that the spring at DC 8.2 W is a discharge point from the ALT aquifer.

Data collected at sonde location DC 8.1 C are plotted on **Figure 18**. Water is intermittently present at this location. Extended dry conditions occurred during 2011-2012, and shorter duration dry conditions occurred during the summer in 2013 and 2014. However, subsurface flow in the boulder alluvium beneath the channel at this site was likely to be occurring. Inspection of **Figure 19** shows that water is relatively persistent at DC 7.1 C although water level does drop to zero or very low levels for short periods in the summer months. This is consistent with results of occurrence surveys that suggest that surface water flow in this reach is intermittent (M&A 2013).

Data collected from the sonde at location DC 5.5 C are provided on **Figure 20**. DC 5.5 C is located toward the bottom end of a continuously saturated reach identified based on results of occurrence surveys (M&A 2013) as well as survey conducted in 2014. Both depth of water and temperature data indicate that this location dries up periodically (**Figure 20**); however, when water is present, diurnal temperature fluctuations are similar in magnitude to those observed at sites where perennial flow is present. Large diurnal temperature fluctuations normally occur during the middle of the year when temperatures and evapotranspirative demands are at their highest. This signal is somewhat overprinted by the contribution of surface water runoff to streamflow; however, the data generally suggest that the reach represented by location DC 5.5 C is intermittent rather than ephemeral (i.e., that the reach is supported by groundwater discharge and that times of little or no surface flow are linked to increased evapotranspirative demand rather than lack of surface water runoff).

Figures 12 through 20 indicate that all locations in Devils Canyon respond to rainfall events with increased flow. High-intensity convective storms occurring during the summer months, coupled with low-permeability land surfaces, sparse vegetation, and steep topographic gradients produce rapid increases in streamflow in response to rainfall. Winter precipitation tends to produce runoff events of longer duration and with higher maximum flows than summer rains.

The relatively prolonged duration of streamflow is associated with several factors. First, winter precipitation generally occurs in association with frontal storms, and therefore falls over longer periods of time. Some winter precipitation occurs as snowfall, with snowmelt then providing a relatively steady source of moisture reporting to the main channel and tributaries of Devils Canyon. Finally, evapotranspiration is substantially less during the winter months than during the summer months. As a consequence of these three factors, wetter antecedent moisture conditions prevail in the winter months. These wetter conditions mean that there is less storage capacity in the near-surface in the winter and a larger proportion of any given rain event runs off rather than infiltrating (M&A 2013).

pH data are collected at five locations: DC 8.8 C, DC 8.2 W, DC 8.1 C, DC 7.1 C, and DC 5.5 C (**Figures 16 through 20**). Values are generally on the order of 7.5 to 8.5 standard units (s.u.) with diurnal fluctuations on the order of 0.5 s.u. Daily fluctuations are likely due to impact from biological activity (microbial respiration and photosynthesis by riparian vegetation) which changes the partial pressure of carbon dioxide and, as a result, imposes a control on pH (Jones et al. 2004). At DC 8.1 C pH values on the order of 16 s.u. were observed during 2013 and 2014 (**Figure 18**), and at DC 7.1 C negative pH values were observed during

2006 and 2007 (**Figure 19**). These values are erroneous (pH ranges from zero to 14 s.u.) and are likely the result of sensor drift. These erroneous measurements may an indication that measurements from these sensors are not reliable, even during periods when measurements seem plausible.

Several trends in specific conductance (SC) can be observed; these vary between sites dominated by surface runoff and those supported by groundwater discharge as discussed below.

At sites supported primarily by runoff (DC 13.5 C and RR 1.5 C; **Figures 13 and 15**) or shallow ground-water where flow rates are low (DC 10.9 C; **Figure 14**), the following conditions are observed:

- On the trailing edge of a runoff event when water levels decrease and evapoconcentration occurs, the SC increases.
- On the leading edge of a runoff event when antecedent conditions are dry, a spike in SC values is often observed. This is due to remobilization of salts that were precipitated in the stream channel or concentrated in small stagnant ponds as the previous runoff event dried up.
- During substantial runoff events, when the initial flush has passed through, SC values reflect the very dilute composition of rain water and SC values reach a minimum.

At locations where base flow is predominantly supported by ALT aquifer groundwater (DC 8.8 C, DC 8.1 C, DC 7.1 C, and DC 5.5 C; **Figures 16, 18 through 20**):

- SC of the base flow reflects the generally higher SC values of groundwater (on the order of 200-300 microSiemens per centimeter (µS/cm)).
- Input from runoff events tends to decrease SC values at these locations. Impact from flushing events is attenuated at these sites due to the diluting effects of base flow.

At spring DC 8.2 W, SC is relatively constant (for the short period of record available) at approximately 250-300 µS/cm (**Figure 17**) which is consistent with current understanding that spring DC 8.2 W is supported by discharge from the

ALT aquifer with little or no input from surface water runoff (M&A 2010a, 2012a, 2013, 2016).

4.3 Mineral Creek

Two data sondes were installed along Mineral Creek, one at an upstream site, referred to as “Upper Mineral,” and a second at a downstream site referred to as “Lower Mineral” (**Figure 2**). The Upper Mineral data sonde is located downstream of the confluence between Mineral Creek and Lyons Fork; data for the Upper Mineral data sonde is plotted on **Figure 21**. The pressure transducer at this site was noted to have significant drift from July 2014 through January 2015, and from July 2015 through January 2016 the transducer drifted to such an extent that the data was deemed unusable (J.E. Fuller, 2016).

Occurrence surveys during Q3 and Q4 2014 identified the presence of streamflow during time periods for which the Upper Mineral data sonde recorded zero water depth. This indicates that water depths at this site during Q3 and Q4 2014 cannot be used to infer the presence or absence of water. This is corroborated by relatively small diurnal fluctuations in temperature indicating the presence of flowing water was likely present at the site both during and surrounding the Q3 and Q4 2014 occurrence surveys. The specific conductance data at the Upper Mineral data sonde are higher and more variable than those observed in Devils Canyon. Dramatic peaks in specific conductance coincide with runoff events, possibly due to high turbidity resulting from storm runoff and erosion. The Lower Mineral data sonde is collocated with sampling site MC 3.3 C; data from this site is shown on **Figure 22**. Inspection of **Figure 22** shows that water is consistently present at the Lower Mineral data sonde location. Diurnal fluctuations in temperature are relatively small and there are no large departures that would suggest dry conditions. The record of specific conductance at this site is intermittent due to instrument failure. However, the available data suggest that specific conductance at this site is more stable than the data observed at Upper Mineral. These data are consistent with current understanding of the presence of a continuously saturated reach in this part of Mineral Creek (M&A 2013, 2016).

5 BASE FLOW ANALYSIS

Base flow is the sustained minimum flow of a stream in the absence of direct runoff; the source of base flow is groundwater inflow to the channel. Base flow in streams is sometimes used to estimate regional groundwater discharge. However, it is important to recognize that not all base flow in the study area originates as regional groundwater discharge, and furthermore, that not all groundwater discharge ultimately manifests as base flow.

In the Devils Canyon, Mineral Creek, and Upper Queen Creek watersheds, base flow includes regional groundwater discharge, and both snowmelt and floodwaters that have entered streambank storage before slowly draining into the main channel. Temporal variability in base flow is minimal compared with temporal variability of surface runoff; however, the magnitude of base flow is generally not constant. Base flow variability in the Devils Canyon, Mineral Creek and Upper Queen Creek watersheds is associated partly with the residence times of water that has entered into bank storage, and partly with the timing of consumptive water use by riparian vegetation. Surface water data – including continuous records of water depth and temperature and occurrence surveys – documented in this report have been analyzed to quantify the magnitude of base flow at various points along the main stream channels of the Devils Canyon, Mineral Creek, and Upper Queen Creek watersheds.

The base flow analysis procedure comprised three main phases. First, daily streamflow values were calculated from continuous stage records on the basis of rating curves developed for nine stream gaging stations along Devils Canyon and Mineral Creek (J.E. Fuller, 2016). Second, summary statistics of the long-term streamflow hydrograph were calculated to quantify the permanence of flow and to provide screening-level estimates of base flow. Furthermore, daily streamflow hydrographs were analyzed by hydrograph separation techniques to produce daily base flow time-series over the period of record. In the third and final phase, statistical summaries and hydrograph separation results were synthesized with flow occurrence surveys and hydrochemical analyses (M&A, 2016) to provide an interpretation of estimated base flow at each station. In particular, the relative importance of regional groundwater discharge toward sustaining base flow, the presence of seasonal trends, and the presence of long-term trends were qualitatively evaluated at each station.

Streamflow persistence at each of the nine stream gaging stations has been classified as perennial, intermittent, or ephemeral according to definitions specified by ADEQ Water Quality Standards (Arizona Administrative Code, Title 18, Ch. 11). These definitions are as follows:

- Perennial: Surface water that flows continuously throughout the year
- Intermittent: A stream or reach that flows continuously only at certain times of the year, such as when it receives water from a spring or melting snow
- Ephemeral: Surface water that has a channel that is at all times above the water table and flows only in direct response to precipitation

Perennial streamflow is present at DC 8.8 in the Devils Canyon watershed and Lower Mineral Creek (LMC) in the Mineral Creek watershed. Intermittent streamflow is present at DC 10.9, DC 8.1, DC 7.1 and DC 5.5 in the Devils Canyon watershed, and at Upper Mineral Creek (UMC) in the Mineral Creek watershed. Ephemeral streamflow is present at DC 13.5 and RR 1.5 in the Devils Canyon watershed, and at Upper Carbonate (UC) in the Queen Creek watershed.

5.1 Methods of Base Flow Analysis

For each station, several statistics have been calculated to quantify base flow during calendar years for which sufficient data are available, and over the entire period of record. Two of the statistics – the November 7-day low streamflow and the median annual streamflow – are calculated on the basis of the daily streamflow hydrograph. The remaining statistics – median annual base flow, median summer base flow, and median winter base flow – are calculated from daily base flow time series derived by streamflow hydrograph separation.

5.1.1 Annual Streamflow Statistics

The November 7-day low flow statistic is calculated as the minimum of the 7-day moving average streamflow, calculated during November. Previous base flow studies on the Verde River in northern Arizona (McGavock, 2015) have shown good agreement between this and other quantitative measures of mean annual base flow. This statistic is intuitively appealing, as November streamflow is minimally influenced by riparian evapotranspiration (ET) and winter storm flows. The median annual streamflow is a second basic metric used to quantify annual base flow, and is a more suitable base flow metric than mean annual streamflow, being less influenced than the latter by high-magnitude storm flows.

5.1.2 Hydrograph Separation

Daily streamflow hydrographs from each stream gaging station were separated into stormflow and base flow components using two methods: the local-minimum method (Sloto and Crouse, 1996) and the delta-filter method (Kennedy and Gungle, 2010). The local-minimum method is implemented in the computer program HYSEP (Sloto and Crouse, 1996), and is widely used in a variety of hydrologic settings. The local minimum method determines the approximate duration of surface water runoff and stormflow based on the upstream drainage area. **Table 6** lists the upstream drainage areas for each of the surface water stations considered in this analysis.

The delta-filter method was developed specifically for base flow estimation on the Upper San Pedro River, southeastern Arizona. The hydrogeologic setting of Devils Canyon and Mineral Creek differs considerably from that of the Upper San Pedro River; however, climatic conditions in the Devils Canyon and Mineral Creek watersheds are similar to those occurring in the Upper San Pedro River watershed. The delta-filter method requires as input a daily streamflow difference to be defined, which serves as a threshold value to delineate periods of base flow and stormflow. For all stations considered in this analysis, daily streamflow difference value of 0.1 cfs was found to produce acceptable results and was adopted in this analysis. Periods during which visual inspection of streamflow hydrographs indicated the presence of storm flows, but for which the magnitude of streamflow was less than the 0.1 cfs, were identified as base flow. Consequently, a manual secondary correction was undertaken to identify periods of apparent stormflow – based on the timing of the streamflow hydrograph and daily precipitation records, where available – and those periods were removed from the calculated daily base flow hydrograph.

For ease of comparison against the annual streamflow statistics defined in **Section 5.1.1**, the daily base flow hydrographs have been summarized to provide comparable statistics. Specifically, median daily base flow is calculated as the median of all available daily base flow values within a given period of time. For example, the median daily base flow for a given year is calculated by tabulating all of the daily base flow values within that year, and calculating the median. Similarly, seasonal variations in the median daily base flow can be determined by tabulating all of the base flow values within a given season – for example, winter months – and calculating the median of those values. In this report, the term "median daily base flow" refers to this calculation procedure.

Annual streamflow statistics for Upper Queen Creek, Devils Canyon, and Mineral Creek drainages are provided in **Tables 7, 8, and 9**, respectively. **Table 10** provides station summaries for all three drainages including: (1) classification of streamflow persistence; (2) streamflow and base flow statistics, and (3) groundwater sources contributing to base flow as determined by hydrochemical and base flow analyses, and comparison with groundwater level elevations in adjacent aquifers.

5.2 Upper Queen Creek

The period of record at the Upper Carbonate (UC) surface water station extends from late 2010 through present. The UC station is located in a reach of Upper Queen Creek where periods of sustained winter streamflow occur generally beginning in November and lasting through April. Median annual streamflow was not calculated for any year over the period of record due to either extended periods during which streamflow was absent, or data were missing from the station. During years with complete or nearly complete (with fewer than 30 days of missing records) streamflow records, the total number of dry days ranged from 165 days in 2011 to 255 days in 2015 (**Table 7**). **Figure 23** illustrates that periods of no streamflow at UC generally occur during the summer into the early fall (May through October).

Hydrograph separation analyses (**Figure 23**) classify periods of sustained winter streamflow as base flow, persisting long after surface runoff events. The median daily base flow during winter months is calculated to be 0.025 cfs (**Table 10**). The DF algorithm classifies certain instances of summer streamflow as base flow, but this is erroneous as these instances are clearly event-driven. Consequently, median daily base flow was not calculated during summer months because streamflow at this time is not representative of base flow.

The ephemeral nature and timing of streamflow at this station suggests that regional groundwater discharge is insignificant as a component of winter base flow. Instead, winter base flow at UC is interpreted to derive from local accumulation and storage of water in streambank alluvium which slowly seeps into the main channel.

5.3 Devils Canyon

Four of the seven surface water stations – DC 10.9 C, DC 8.8 C, DC 8.1 C, and DC 5.5 C – are located within continuously saturated reaches of Devils Canyon. Stations DC 13.5 C, DC 7.1 C, and RR 1.5 C are located in discontinuously saturated reaches. It should be noted that records from both stations located in discontinuously saturated reaches indicate periods of time with persistent streamflow, primarily during the spring months and associated with snowmelt. Nonetheless, summary statistics and streamflow hydrograph separation analyses show distinctively different characteristics between stations in the continuously and discontinuously saturated reaches.

Annual streamflow statistics for DC 13.5 C, DC 10.9 C, RR 1.5 C, DC 8.8 C, DC 8.1 C, and DC 5.5 C are compiled in **Table 8**. Sensor drift affected pressure transducer readings from the DC 7.1 C data sonde (J.E. Fuller, 2016). Consequently, time-series records of water depth for this station are useful for qualitative interpretation as demonstrated in Section 4 of this report, but could not be used to generate a reliable streamflow hydrograph (J.E. Fuller, 2016).

Statistics included in **Table 8** include the total number of days for which streamflow was not present, the total number of days for which streamflow could not be calculated, the number of days in November for which streamflow was calculated, the minimum 7-day moving average streamflow during the month of November, and the median annual streamflow.

At each station, median annual streamflow was not calculated during certain years for two reasons. Median annual streamflow was not calculated for years with more than 30 days of missing data, defined as days for which streamflow was not calculated. Periods of missing data are associated with either data gaps from sensors installed in the stream channel, or instances of sensor drift. At DC 13.5 C, for several of the years – specifically 2005, 2010, and 2012-2014 – the record was either complete or nearly complete, but streamflow was not present for at least 100 days. For these instances, the median annual streamflow would not be representative of base flow, as these years indicate years with minimal flow persistence; accordingly the median annual streamflow is not presented.

The minimum November 7-day average streamflow was not calculated during certain years. For some years, daily streamflow data during November were either not available, or not sufficiently continuous to reliably calculate the November 7-day low flow. For several stations, November streamflow was not present during some years. Both cases are flagged in **Table 8**.

Figures 24-29 show the available streamflow data, identifying separately days for which streamflow was not present (i.e. streamflow was zero cfs) from those days for which streamflow was not calculated (J.E. Fuller, 2016). Each plot also shows the daily streamflow hydrograph for periods when streamflow was present, and daily base flow determined by HYSEP local minimum (HLM) and delta-filter (DF) hydrograph separation algorithms. Finally, long-term median values have been calculated for the daily base flow hydrographs derived by the DF algorithm. These plots also include the median daily base flow calculated over the entire year, the median daily base flow calculated only during summer months, and the median daily base flow calculated only during winter months. Summer months are defined as June through September, and winter months are defined as November through February. These long-term median values are presented to illustrate the presence of seasonal variability in base flow at some of the stations.

Due to the length of the records (2003-2015) shown in **Figures 24-29** and corresponding temporal plotting resolution, periods of time with flowing conditions persisting for 2 days or less are not readily apparent. This phenomenon is illustrated in the inset boxes of **Figures 24, 25, and 29**.

5.3.1 DC 13.5 C

Annual statistics have been calculated for DC 13.5 C; however, these statistics do not adequately represent the streamflow regime, largely due to the ephemeral nature of streamflow at the site. Years for which the record is either complete or mostly complete – specifically, 2005, 2009-2010, and 2012-2014 – include extended periods for which streamflow was not present. Dry periods occur primarily during the late fall after the conclusion of the summer monsoon season but before the arrival of winter precipitation.

Sensor error – primarily for water depth less than 2 ft. – was detected for the DC 13.5 C data sonde. The onset of sensor error is not known, but a conservative approach would be to assume that sensor error has affected calculated low flows over the entire period of record. Consequently, streamflow data from this station are interpreted qualitatively only.

Peak flows occur during the spring and are associated with snowmelt and winter rain (**Figure 24**). Streamflow persists from weeks to months after peak flow events, and is sustained by the slow release of water from bank storage into the main channel. Hydrograph separation by both HLM and DF algorithms identify periods of base flow predominantly during the rising and falling limb of the hydrograph during these springtime events.

Several characteristics of the site should be considered when interpreting the meaning of base flow at DC 13.5 C. First, groundwater levels recorded at wells HRES-15 and Oak Flat Well indicated that the streambed of DC 13.5 C is located several hundred feet above the ALT aquifer water table. Specifically, November 2015 groundwater levels at wells HRES-15 and Oak Flat Well are approximately 3,668 and 3,782 feet above mean sea level (ft amsl) respectively, and the streambed at DC 13.5 C is at 3,900 ft amsl. Second, water quality characteristics of surface water samples collected at DC 13.5 – specifically, the ionic and stable isotopic composition (M&A, 2016) – indicate streamflow derived from local precipitation. These data support the interpretation that periods of sustained streamflow – classified in this report as base flow – are not supported by regional groundwater discharge. Instead, base flow originates exclusively as the slow drainage of surface runoff from storage in locally fractured bedrock and streambank alluvium where present.

5.3.2 DC 10.9 C

The period of record at DC 10.9 C extends from 2003-present, but the years 2003-2005 and 2006-2008 contained numerous days for which streamflow was not calculated. The streamflow record is complete from 2009-2015 with no missing data over this period (**Table 8**). During these more recent years, only 2012 and 2013 included periods of time for which streamflow was not present. The median annual streamflow during 2009-2015 varied from 0.006 cfs (2013) to 0.105 cfs (2015). The November 7-day low flows were generally lower than the median annual streamflow and ranged from zero (2003-2005 and 2012) to 0.214 (2009) (**Table 10**).

Hydrograph separation analyses (HLM and DF) for the record at DC 10.9 C produced similar results, with the exception that HLM identified as base flow periods of the record during 2005, 2009 and 2010 associated with daily streamflow in excess of 1 cfs (**Figure 25**). These periods are judged to represent surface runoff rather than base flow. The median daily base flow over the entire period of record, based on the DF analysis, was 0.037 cfs. The median daily base flow during summer and winter months calculated during 2009-2015, and based on the DF analysis, were 0.034 and 0.033 cfs, respectively (**Table 10**). This result indicates minimal seasonal variability in base flow at DC 10.9. In contrast, at the stations located in the continuously saturated reaches downstream, median winter base flow is discernably higher than median summer base flow. The distinction between seasonal base flow variability in this stream reach and lower reaches likely reflects differences in depth to the water table and associated density and extent of phreatophytes.

Groundwater level data from well A-06 indicate that the streambed elevation at DC 10.9 C is located above the regional water table. Specifically, November 2015 the groundwater level at well A-06 was approximately 3,643 ft amsl, whereas the streambed at DC 10.9 C is at 3,730 ft amsl. Furthermore, water quality characteristics – specifically the total dissolved solids and stable isotopic composition – of surface water samples collected at DC 10.9 C indicate that streamflow is dominated by local precipitation rather than regional groundwater discharge (M&A, 2016), even during periods with negligible surface runoff. Together, the hydrochemistry data, occurrence surveys, and base flow analyses suggest that base flow at DC 10.9 C is supported by snowmelt and/or floodwaters that have entered streambank storage before slowly draining into the main channel.

5.3.3 RR 1.5 C

The period of record for the streamflow hydrograph at RR 1.5 C is from mid-2011 through mid-2014. During this time, the record is punctuated by several periods of missing data, along with several periods for which streamflow was not present (**Figure 26**). Annual statistics were not calculated for this station due to the lack of data, and only rudimentary qualitative interpretation can be made on the basis of the streamflow hydrograph in **Figure 26**. Similar to DC 13.5 C, the hydrograph at RR 1.5 C indicates the persistence of winter to springtime streamflow over a period of months, but of very minor magnitude.

Hydrograph separation has been undertaken for the record at RR 1.5 C, and indicates that the falling limb of the springtime hydrograph may be classified as base flow due to the relatively minor changes in the magnitude of streamflow. Streamflow generally ceases prior to or during the early summer months. Median annual, winter, and summer base flow have not been calculated for this site due to the short and discontinuous nature of the streamflow hydrograph.

5.3.4 DC 8.8 C

Station DC 8.8 C is located in a continuously saturated reach of Devils Canyon. The period of record at this station extends from 2003-present, but includes numerous instances of missing data for most of those years. Median annual streamflow was calculated for 2005-2006, 2013, and 2015 (**Table 8**). Data were sufficiently continuous to calculate the November 7-day low flow for 2004-2006 and 2012-2015, and the value ranged from 0.024 cfs (2014) to 0.688 cfs (2006).

Daily base flow derived from hydrograph separation analyses exhibits clear seasonal oscillations, with minimum base flow occurring during the summer and maximum base flow occurring during the winter. The median daily base flow – calculated by the DF algorithm – over the entire period of record was 0.264 cfs. The median daily base flow during summer and winter months were 0.082 and 0.462 cfs, respectively (**Table 10**).

The pattern of seasonal base flow fluctuation illustrated in **Figure 27** is attributed primarily to two distinct physical processes: riparian evapotranspiration (ET) and delayed release – from bank storage in stream alluvial sediments – of precipitation from winter storms. The continuously saturated reach in which DC 8.8 is located features galleries of riparian vegetation. During the summer growing season, ET from the riparian canopy consumptively uses shallow groundwater in the continuously saturated reaches that otherwise would have discharged to surface water. For this reason, daily summer base flow – as calculated by hydrograph separation techniques – is consistently less than winter base flow.

The streamflow hydrograph shown in **Figure 27** shows periods of stormflow associated with winter storms. A portion of winter precipitation that does not immediately leave DC as surface runoff is likely stored temporarily in the thin veneer of unconsolidated alluvial sediments along major drainages, and in local, perched flow systems in the ALT aquifer adjacent to major drainages. The slow release of stored winter precipitation back to the main channel constitutes a second source of base flow, distinct from regional groundwater discharge from the ALT aquifer. The influence of water released from bank storage, combined with riparian ET during the growing season, accounts for seasonal fluctuation in base flow observed at DC 8.8 C and other stations in the continuously saturated reaches of Devils Canyon.

On the basis of groundwater levels recorded at wells HRES-07 and MJ-11, the streambed elevation at DC 8.8 C is estimated to coincide approximately with the regional water table elevation. Specifically, November 2015 groundwater levels at HRES-07 and MJ-11 were approximately 3,633 ft amsl and 3,615 ft amsl respectively, and the streambed at DC 8.8 C is at 3,520 ft amsl. Furthermore, the ionic and isotopic composition of surface water samples collected at DC 8.8 C resembles that of groundwater samples collected from the ALT aquifer, and also reflects the influence of local precipitation (M&A, 2016). These data support the conclusion that base flow at DC 8.8 is supported predominantly by regional groundwater discharge, but is supplemented seasonally by delayed release of water held locally in bank storage back into the stream channel.

5.3.5 DC 8.1 C

The period of record at DC 8.1 C extends from early 2011 through present. Several periods of missing data occur during the period of record, notably during winter 2011-2012 and winter 2012-2013. This site differs from DC 8.8 C in that streamflow is not present for certain parts of the record. This occurs primarily during the summer, for example during 2011-2014 (**Figure 28**). Continuity of the record was adequate during 2014-2015 for calculation of median annual streamflow, with values of 0.054 and 0.026 cfs for 2014 and 2015, respectively (**Table 8**). The November 7-day low flow varied from as low as 0.002 cfs (2012) to as high as 0.051 cfs (2014) (**Table 10**).

The daily streamflow and base flow hydrographs shown in **Figure 28** exhibit seasonal oscillation in base flow similar to DC 8.8 C, with elevated base flow occurring during the winter and minimal base flow or dry conditions occurring during the summer. The physical processes responsible for seasonal base flow oscillation at DC 8.8 C also influence seasonal base flow oscillation at DC 8.1.

The median daily base flow over the entire period of record was 0.040 cfs, and the median daily summer and winter base flow values were 0.008 and 0.145 cfs respectively. These values are all lower than the equivalent median statistics calculated for DC 8.8 C; however, these differences should not be interpreted as a decrease in base flow between the two stations. Instead, the higher median base flow at DC 8.8 C is due to the longer period of record at this station. Specifically, winter base flow at DC 8.8 C ranged from 0.498 cfs (2008) to 0.903 cfs (2007) during 2004-2008, and from 0.157 cfs (2015) to 0.415 cfs (2013) during 2011-2013 (**Table 10**). Therefore, the difference in median base flow statistics between DC 8.8 C and DC 8.1 C is due simply to differences in the length of the period of record.

The ionic and isotopic composition of surface water samples collected at DC 8.1 C coincides with that of groundwater samples from the ALT aquifer. This pronounced similarity is attributed to the influence of groundwater discharge, including spring discharge at station DC 8.2 W (M&A 2016). The isotopic composition of surface water samples reveal a minor degree of seasonal variation associated with the influence of winter precipitation stored locally in zones of perched groundwater. These seasonal variations are consistent with the conceptual model of base flow at the lower continuously saturated reach of Devils Canyon, described in the previous section.

5.3.6 DC 5.5 C

The period of record at DC 5.5 C extends from late 2003 through present. The streamflow hydrograph shown in **Figure 29** shows generally good continuity during the early part of the record, followed by several periods of missing data during 2008, 2010, and 2011-2012. These periods of missing data are associated with gaps in the recorded water depth at the data sonde. Median annual streamflow values calculated from 2004-2007 ranged from 0.153 cfs (2004) to 0.329 cfs (2007). The November 7-day low flow ranged from zero (2013) to 0.204 cfs (2010) (**Table 10**). This statistic was not calculated for 2013 due to dry conditions during the first half of November 2013.

Streamflow and base flow hydrographs shown in **Figure 29** exhibit a seasonal oscillation similar to the patterns present in the DC 8.8 C and DC 8.1 C hydrographs (**Figures 27 and 28**), and attributed to similar physical processes. Median daily base flow calculated at DC 5.5 C over the entire period of record was 0.088 cfs. Median daily base flow values calculated over the summer and winter months were 0.003 and 0.287 cfs, respectively. The length of the record used to calculate median daily base flow is comparable between DC 5.5 C and DC 8.8 C.

Comparison of median daily base flow values calculated at DC 8.8 C and DC 5.5 C indicates a difference between these two stations, which is attributed to differences in regional groundwater discharge and in contribution to bank storage from surface runoff in tributary side canyons. The ionic composition of surface water samples collected at DC 5.5 C fall within the field occupied by ALT groundwater samples.

5.4 Mineral Creek

Both the Upper Mineral Creek (UMC) and Lower Mineral Creek (LMC, MC 3.3 C) surface water stations occur in a continuously saturated reach of Mineral Creek. UMC was not given an official numeric station identifier, but is approximately 6.7 kilometers upstream from the confluence with Devils Canyon. The spatial distribution of regional groundwater levels suggests that Mineral Creek acts as a discharge point for the regional groundwater system hosted in the ALT aquifer. This inference is supported by the presence of intermittent and perennial streamflow at UMC and LMC respectively, and by the persistence of streamflow along nearly the entire length of a continuously saturated reach including and above LMC.

Both stations were established during late 2010, and the complete records are available beginning in 2011. Annual streamflow statistics for both stations are presented in **Table 9**. At LMC, streamflow was present over the entire period of record; on the other hand, at UMC streamflow was not present for at least 30 days during 2013-2015. Median annual streamflow and the November 7-day low flow have been calculated by year for each station, for years with adequate data (**Table 10**).

Figures 30 and 31 show hydrographs of daily streamflow and base flow for UMC and LMC. Periods during which streamflow records are not complete, and periods during which streamflow records are complete but streamflow was not present, have been distinctively noted.

5.4.1 Upper Mineral Creek (UMC)

Median annual streamflow was calculated at UMC over the period 2011-2013, and ranges from 0.059 cfs in 2013 to 0.128 cfs in 2011 (**Table 9**). These statistics correlate with the total number of dry days, with 65 dry days in 2013 compared with no dry days in 2011. The November 7-day low flow varied from dry conditions in 2014 to 0.020 cfs in 2012 (**Table 10**).

The period of record at UMC is short relative to other surface water stations in the Devils Canyon watershed. The streamflow hydrograph (**Figure 30**) shows a pattern of seasonal variability similar to the patterns observed at stations in continuously saturated reaches of Devils Canyon. Streamflow records during the second half of 2014 were affected by sensor drift; specifically, the sensor indicated dry conditions (zero water depth) during occurrence surveys during which flowing water was noted. Consequently, this period of time has been flagged in **Figure 30** and should not be interpreted as a period during which streamflow was not present.

The streambed elevation at UMC is inferred to coincide with the regional water table on the basis of groundwater level data from wells HRES-11 and HRES-10. Specifically the November 2015 groundwater levels at wells HRES-11 and HRES-10 were 2,825 ft amsl and 2,858 ft amsl respectively, and the streambed at UMC is at 2,788 ft amsl. Furthermore, the ionic and isotopic composition of surface water samples collected near UMC bear close resemblance to groundwater sampled from wells completed in the ALT aquifer (M&A, 2016). Base flow hydrographs, coupled with the hydrogeologic setting at UMC and water quality data indicate that base flow at UMC is sustained in large part by regional groundwater discharge from the ALT aquifer with seasonal contributions associated with local winter precipitation.

5.4.2 Lower Mineral Creek (LMC)

Median annual streamflow was calculated for 2014-2015, and the November 7-day low flow was calculated from 2011-2015 (**Table 9**). The median annual streamflow during 2015, and the November 7-day low flow during 2011 and 2015 are in excess of 3 cfs, which seems unusually high. However, the daily streamflow hydrograph from LMC (**Figure 31**) does not indicate that these relatively high streamflow values represent surface runoff, but rather are indicative of broad seasonal to interannual variability in base flow.

The contrast between 2014 and 2015 provides insight into streamflow dynamics at the LMC surface water station. Winter and spring of 2014 were unusually dry, with several months receiving no precipitation. Baseflow at LMC declined nearly continuously from January 2014 through fall 2014 despite a series of large summer stormflow events. While the summer precipitation events introduced a large amount of water to the watershed, they generated stormflow runoff and did not lead to a meaningful increase in baseflow. Beginning in late 2014 and continuing through 2015, baseflows rose sharply. This increase in sustained baseflows likely occurred in response to the presence of continuous, but modest precipitation throughout 2015. While monthly precipitation totals were often smaller in magnitude in 2015 than 2014, the presence of precipitation in every month may have allowed the sources that supply baseflow to continue releasing water throughout the year.

The general pattern of seasonal streamflow fluctuation at LMC is similar to the pattern observed for other stations located in continuously saturated reaches of Devils Canyon and Mineral Creek. Specifically, streamflow is elevated in the winter, and reaches annual minimum flows during the summer growing season. Hydrograph separation indicates that these oscillatory fluctuations reflect variability in base flow. The median daily base flow over the entire period of record at LMC was 1.33 cfs. The median daily base flow during summer and winter months were calculated to be 0.467 and 1.66 cfs, respectively (**Table 10**).

The presence of a flowing spring – MC 3.4 W – near LMC and the groundwater level elevation at HRES-11, nearly 300 ft higher than the streambed at LMC, indicate that the regional water table intersects the streambed at LMC. Specifically, the November 2015 groundwater level at HRES-11 was 2,825 ft amsl and the LMC streambed is at 2,516 ft amsl. Combining this information with the ionic and isotopic composition of surface water samples from LMC collected at surface water sampling station MC 3.3 C indicates that regional groundwater discharge is the predominant source of base flow at LMC. This is consistent with current conceptual understanding that Mineral Creek is a groundwater discharge point for the ALT aquifer (M&A 2016a, 2016b).

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7 ACRONYMS & ABBREVIATIONS

amsl ....above mean sea level
bgs ....below ground surface
cfs ....cubic feet per second
GIS ....geographic information systems
GPS ....global positioning system
mg/L ....milligrams per liter
NEPA ....National Environmental Policy Act
ºF ....degrees Fahrenheit
PRISM...........Parameter-elevation Regressions on Independent Slopes Model
TDS ....total dissolved solids
USGS............U.S. Geological Survey
µS/cm ....micro-Siemens per centimeter

8 GLOSSARY

The following list is a glossary for selected technical terms used in this report.

Alluvium: Clay, silt, sand, gravel, or other sediments that have been deposited by a stream or other body of flowing water in a streambed, on a flood plain, on a delta, or at the base of a mountain.

Aquifer: A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield usable quantities of water to wells or springs. *See also: Aquifer (Confined), Aquifer (Unconfined)*

Base Flow: The sustained minimum flow of a stream in the absence of direct runoff; the source of base flow is groundwater inflow to the channel. *See also:* Runoff

Bedrock: The consolidated, low-permeability rock formation(s) commonly underlying or forming the lateral boundaries of an aquifer. *See also: Aquifer Boundary*

Confluence: The flowing together of two or more streams; the place where a tributary joins the main stream.

Continuously Saturated: Either flowing water or saturation is consistently present across seasons and over years.

Discharge: The release or extraction of water from an aquifer by natural means (evapotranspiration, flow to springs and surface water bodies), by gravity-driven flow to artificial drains, or by pumping of wells. *See also: Recharge*

Discontinuously Saturated: Water is not consistently present across seasons and over years.

Effluent: Water or liquid waste that flows from a particular source, such as from a factory or wastewater treatment plant.

Electrical Conductivity [EC]: A measure of the ability of a liquid to conduct an electrical current. *See also: Specific Electrical Conductance*

Ephemeral Stream: Surface water that has a channel that is at all times above the water table and flows only in direct response to precipitation. *See also: Perennial Stream, Intermittent Stream*

Evapotranspiration [ET]: The process by which water is discharged to the atmosphere as a result of evaporation from soil and ponded water surfaces and transpiration by plants. *See also: Phreatophyte*

Flood Plain: A flat geographic zone bordering a stream channel that is at times inundated with flood waters. A flood plain is typically underlain by alluvium deposited during floods. *See also: Alluvium*

Gaining Stream: A stream or stream reach in which flow is increased by the inflow of groundwater to the channel. *See also: Losing Stream*

Groundwater: Subsurface water that occurs under saturated or unsaturated conditions in soils

Hydrogeologic Unit: Any soil or rock unit that has a distinct influence on the storage or movement of groundwater.

Infiltration: The downward movement of water from land surface into and through soil or porous rock. *See also: Seepage*

Intermittent Stream: A stream or reach that flows continuously only at certain times of the year, as when it receives water from a spring or from another surface source, such as melting snow. *See also: Ephemeral Stream, Perennial Stream*

Losing Stream: A stream or stream reach in which water flows from the stream bed into the ground.

Perennial Stream: Surface water that flows continuously throughout the year. *See also: Ephemeral Stream, Intermittent Stream*

pH: A measure of the acidity or alkalinity of water or a solution on a scale from 0 to 14, where values of less than 7 are acidic, values greater than 7 are alkaline (basic), and a value of 7 is neutral.

Phreatophyte: A plant that obtains much or most of its water supply from groundwater, either directly from the saturated zone or indirectly from the capillary fringe. *See also: Evapotranspiration*

Real-Time Data: Data that is collected using automated instrumentation, telemetered, and analyzed quickly enough to influence a decision that affects the monitored system.

Runoff: The fraction of precipitation or snowmelt that appears in stream channels or surface water bodies. *See also: Base Flow*

Seepage: The slow movement of water through small cracks, pores, interstices, etc., of a material into or out of a body of surface or subsurface water. *See also: Infiltration*

Specific Electrical Conductance [SC]: The electrical conductivity of a unit volume of the liquid at a specific temperature (typically 25ºC). *See also: Electrical Conductivity*

Spring: A discrete location where groundwater flows naturally to land surface or into a surface water body from a geologic formation or soil.

Streamflow: The total discharge of water in a natural drainage channel.

Surface Water: Water that occurs above ground in an open body such as a stream, lake, river, or reservoir. *See also: Groundwater*

Total Dissolved Solids [TDS]: The total concentration of dissolved chemical constituents in a solution, usually expressed in mg/L.

Tributary: A smaller river or stream that flows into a larger river or stream.

Watershed: The land area that drains water to a particular stream, river, or lake. A watershed is commonly delineated by tracing a line along the highest land elevations between adjoining drainage areas on a map.

Water Table: The upper surface of the saturated zone at which the pore water pressure equals atmospheric pressure. *See also: Piezometric Surface, Aquifer (Unconfined).*

TABLE 1. OCCURRENCE SURVEY EXTENTS BY YEAR
RESOLUTION PROJECT

WATERSHED/SUB-BASIN	SURVEY PERIOD	SURVEYED REACH (MILES)	SURVEYED REACH (KILOMETERS)
QUEEN CREEK WATERSHED			
Queen Creek	2002 - 2004	0 to 19.1	0 to 30.7
	2005 - 2014	13.5 to 19.7	21.8 to 30.7
DEVILS CANYON WATERSHED			
Devils Canyon	2002, 2003	0 to 9.1	0 to 14.7
	2004	3.8 to 9.1	6.1 to 14.7
	2005	3.8 to 9.4	6.1 to 15.2
	2008 - 2011	3.3 to 11.6	5.3 to 18.6
	2014	0.3 to 10.9	0.5 to 17.6
Iron Canyon	2008 - 2011	0 to 1.5	0 to 2.52
	2014	0 to 0.6	0 to 1.0
Rancho Rio	2003 -2005	0 to 1.5	0 to 2.4
	2008 -2014	0 to 0.9	0 to 1.5
Hackberry Canyon	2002 - 2014	0 to 0.9	0 to 1.5
MINERAL CREEK WATERSHED			
Mineral Creek	2008 - 2014	0.1 to 5.2	0.2 to 8.4
Lyons Fork	2008 - 2014	0.0 to 0.1	0.0 to 0.2

TABLE 2. SUMMARY OF SURVEYED REACHES
RESOLUTION PROJECT

SURVEY QUARTER	REACH								
	UPPER QUEEN CREEK	UPPER DEVILS CANYON	DEVILS CANYON FROM HWY 60 BRIDGE TO BELOW CRATER TANKS	LOWER DEVILS CANYON	IRON CANYON	RANCHO RIO	HACKBERRY CREEK	MINERAL CREEK	LYONS FORK
2002 Q4	X		X	X			X		
2003 Q2	X		X	X		X	X		
2003 Q3	X		X	X		X	X		
2004 Q1	X		X	X		X	X		
2004 Q2	X		X			X	X		
2004 Q3	X		X			X	X		
2004 Q4	X		X			X	X		
2005 Q1	X		X			X	X		
2005 Q2	X		X				X		
2005 Q3	X		X			X	X		
2008 Q3		X	X		X	X	X	X	X
2008 Q4		X	X		X		X	X	X
2009 Q1		X	X		X	X	X	X	X
2009 Q3	X	X	X		X		X	X	X
2010 Q1	X	X	X		X	X		X	X
2010 Q2	X	X	X		X	X	X	X	X
2010 Q4	X	X	X		X	X	X	X	X
2011 Q1	X	X	X		X	X	X	X	X
2011 Q2	X	X	X		X	X	X	X	X
2014 Q1	X	X	X	X	X	X	X	X	X
2014 Q2	X	X	X	X	X	X	X	X	X
2014 Q3	X	X	X	X	X	X	X	X	X
2014 Q4	X	X	X	X		X	X	X	X

TABLE 3. CUMULATIVE LENGTH OF SATURATED REACHES FROM OCCURRENCE SURVEYS RESOLUTION PROJECT

SURVEY QUARTER	TOTAL SATURATED LENGTH (MILES)		
	QUEEN CREEK	DEVILS CANYON	MINERAL CREEK
2002 Q4	1.51	2.35	---
2003 Q2	1.14	3.39	---
2003 Q3	1.14	2.77	---
2004 Q1	4.37	8.05	---
2004 Q2	0	1.69	---
2004 Q3	0	1.95	---
2004 Q4	0.10	2.51	---
2005 Q1	5.54	5.63	---
2005 Q2	0.66	2.21	---
2005 Q3	0.19	2.48	---
2008 Q3	---	7.33	4.08
2008 Q4	---	3.69	4.07
2009 Q1	---	8.23	4.72
2009 Q3	0	5.31	3.08
2010 Q1	4.60	7.60	5.11
2010 Q2	0	3.99	5.10
2010 Q4	0	3.57	4.57
2011 Q1	1.04	6.25	4.82
2011 Q2	0.01	3.65	3.98
2014 Q1	7.00	9.81	6.41
2014 Q2	0	2.74	4.58
2014 Q3	0.65	4.60	4.92
2014 Q4	0.37	6.03	4.89

--- = Not applicable

TABLE 4. DETAILS OF SONDE AND GAGE INSTALLATIONS
RESOLUTION PROJECT

WATERSHED	SONDE IDENTIFIER	AZSPC COORDINATES[a] EASTING (FEET)	NORTHING (FEET)	APPROXIMATE ELEVATION IN FEET	LOCATION	CO-LOCATED SAMPLE LOCATION	PERIOD OF RECORD[b]	PARAMETERS MEASURED[c]	GEOLOGIC UNIT[d]	STATUS
Queen Creek	Upper Carbonate (UC)	955,551	838,645	3,175	Channel; Stn[e] 23.4	None	Nov 2010 to present	W, C, T	Tal	Working
	Lower Carbonate (LC)	950,985	835,007	2,805	Channel	None	Nov 2010 to Feb 2011	W, C, T	Pz	Stolen--not replaced
	QC Magma Ave	950,585	835,762	2,804	Channel; near QC 21.7 C	QC 21.7 C	Feb 2015 to present	W	Pz	Working
Devils Canyon	DC SW1	969,854	847,857	3,990	Channel	None	Dec 2013 to present	W	Tal	Working
	DC 13.5 C	969,512	843,687	3,900	Channel	DC 13.5 C	May 2003 to present	W, C, T	Tal	Working
	DC 10.9 C	970,077	835,812	3,730	Channel	DC 10.9 C	Sep 2003 to present	W, C, T	Tal	Working
	DC 8.8 C	971,555	829,401	3,580	Channel	DC 8.8 C	Jul 2003 to present	W, C, T, pH	Tal	Working
	DC 8.2 W	971,887	827,474	3,540	Spring above main channel on west bank	DC 8.2 W	Jul 2003 to Sep 2004	W, C, T, pH	Tal	Discontinued: course of spring flow changed
	DC 8.1 C	971,969	827,403	3,520	Pool downstream of DC 8.2 W	DC 8.1 C	Installed April 2011; damaged; re-installed May 2012	W, T	Tal	Working
	DC 7.1 C	973,199	824,584	3,390	Channel	DC 7.1 C	Sep 2003 to present	W, C, T, pH	Tal	Working
	DC 5.5 C	974,406	820,866	2,960	Channel	DC 5.5 C	Oct 2003 to present	W, C, T, pH	Tw	Working
	RR 1.5 C	967,005	832,381	3,881	Channel	RR 1.5 C	Feb 2011 to present	W, C, T	Tal	Working
Mineral Creek	Upper Mineral (UMC)	988,636	823,794	2,790	Channel; Stn 6.84	None	Nov 2010 to present	W, C, T	Tal	Working
	Lower Mineral (MC 3.3 C)	984,176	816,176	2,515	Channel; MC 3.3 C	MC 3.3 C	Feb 2011 to present	W, C, T	Tal	Working

NOTES:

[a] Datum NAD83 (Epoch NA2011), Arizona State Plane Coordinates (AZSPC), Zone 0202 - NAVD88 (Geoid12A), in feet.

[b] Period of record is the period over which data are available; it does not imply that the data set is continuous for this period.

[c] W = depth of overlying water (inches)
C = electrical conductivity (µS/cm - microSiemens per centimeter)
T = temperature (°C - Degrees Celcius)
pH = pH (standard units)

[d] Tal = Apache Leap Tuff
Pz = Paleozoic carbonates
Tw = Whitetail Conglomerate

[e] Stn = Station

TABLE 5. SPRING LOCATIONS
RESOLUTION PROJECT

STATION IDENTIFIER	AZSPC COORDINATES[a]		APPROXIMATE ELEVATION (feet, amsl)[b]	TYPE	LOCATION
	EASTING (feet)	NORTHING (feet)			
QUEEN CREEK WATERSHED					
Pump Station Spring (QC 30.7 C)	960384	852426	4,390	Spring	Spring in Queen Creek channel
Boulder Hole (QC 23.6 C)	954577	838359	3,061	Seep	Channel
DEVILS CANYON WATERSHED					
DC 8.2 W	971881	827486	3,540	Spring	Spring above main channel on west bank
DC 6.6 W (DCT 6.6 W)	971650	823181	3,520	Spring	Spring ~ 200 yards up un-named tributary to Devils Canyon
DC 6.1 E	973865	822088	3,159	Spring	Spring discharging from east wall of Devils Canyon
DC 4.1 E	977648	818511	2,720	Spring	Spring discharging from east wall of Devils Canyon
MINERAL CREEK WATERSHED					
Government Springs	994863	821153	2,972	Spring	Largest spring discharging from concrete vault behind ranch house; discharges from a brecciated zone of the Apache Leap Tuff
MC 3.4 W (Wet Leg Spring)	984205	816684	2,579	Spring	Largest spring emanating from river right; discharges from shallow colluvium overlying Apache Leap Tuff

[a] Datum NAD83 (Epoch NA2011), Arizona State Plane Coordinates (AZSPC), Zone 0202 - NAVD88 (Geoid12A), in feet.
[b]amsl = above mean sea level

TABLE 6. CONTRIBUTING DRAINAGE AREA BY SURFACE WATER STATION, RESOLUTION PROJECT

WATERSHED	STATION	CONTRIBUTING DRAINAGE AREA (SQUARE MILES)
Upper Queen Creek	Upper Carbonate	9.1
Devils Canyon	DC 10.9 C	13.6
Devils Canyon	RR 1.5 C	1.9
Devils Canyon	DC 8.8 C	16.7
Devils Canyon	DC 8.1 C	18.9
Devils Canyon	DC 5.5 C	20.9
Mineral Creek	Upper Mineral Creek	47.9
Mineral Creek	MC 3.3 C	51.3

TABLE 7. ANNUAL STREAMFLOW STATISTICS CALCULATED FOR SURFACE WATER STATIONS IN UPPER QUEEN CREEK WATERSHED, RESOLUTION PROJECT

STATION NAME	YEAR	DRY CONDITIONS (DAYS)	MISSING RECORDS (DAYS)	NOVEMBER RECORDS (DAYS)	MINIMUM OF NOVEMBER 7-DAY AVERAGE STREAMFLOW (CFS[a])	MEDIAN DAILY STREAMFLOW (CFS[a])
Upper Carbonate (UC)	2010	2	304	30	0.002	NC[b]
	2011	165	0	30	DRY[c]	DRY
	2012	111	96	4	NC	DRY
	2013	168	0	30	DRY	DRY
	2014	52	142	0	NC	NC
	2015	255	25	30	DRY	DRY

NOTES:

[a] cfs - cubic feet per second

[b] NC - Not calculated

[c] DRY - Statistics affected by excessive number of days with no flow

TABLE 8. ANNUAL STREAMFLOW STATISTICS CALCULATED FOR SURFACE WATER STATIONS IN DEVILS CANYON WATERSHED, RESOLUTION PROJECT

STATION NAME	YEAR	DRY CONDITIONS (DAYS)	MISSING RECORDS (DAYS)	NOVEMBER RECORDS (DAYS)	MINIMUM OF NOVEMBER 7-DAY AVERAGE STREAMFLOW (CFS[a])	MEDIAN DAILY STREAMFLOW (CFS)
DC[b] 13.5 C	2003	120	227	0	NC[c]	NC
	2004	198	86	30	DRY[d]	NC
	2005	202	0	30	DRY	DRY
	2006	132	156	0	NC	NC
	2007	0	ALL	0	NC	NC
	2008	14	272	30	0.001	NC
	2009	144	0	30	DRY	DRY
	2010	85	0	30	DRY	0.063
	2011	137	30	30	DRY	DRY
	2012	145	14	30	DRY	DRY
	2013	125	10	30	DRY	DRY
	2014	22	21	30	0.035	0.045
	2015	54	39	14	0.024	NC
DC 10.9 C	2003	84	260	30	DRY	NC
	2004	285	3	30	DRY	DRY
	2005	145	50	30	DRY	NC
	2006	83	27	30	0.083	0.048
	2007	9	38	23	0.070	NC
	2008	1	106	30	0.030	NC
	2009	0	0	30	0.214	0.097
	2010	0	0	30	0.007	0.049
	2011	0	0	30	0.010	0.047
	2012	12	0	30	0.012	0.025
	2013	55	0	30	DRY	0.006
	2014	0	0	30	0.010	0.021
	2015	0	0	30	0.065	0.105
RR[e] 1.5 C	2011	132	78	30	DRY	NC
	2012	66	123	19	DRY	NC
	2013	90	73	0	NC	NC
	2014	7	259	0	NC	NC
	2015	0	ALL	0	NC	NC
DC 8.8 C	2003	0	ALL		NC	NC
	2004	0	90	30	0.488	NC
	2005	0	18	30	0.331	0.360
	2006	0	0	30	0.688	0.647
	2007	0	225	0	NC	NC
	2008	0	337	0	NC	NC
	2009	0	ALL	0	NC	NC
	2010	0	ALL	0	NC	NC
	2011	0	87	1	NC	NC
	2012	0	61	30	0.082	NC
	2013	0	17	22	0.282	0.306
	2014	0	99	30	0.024	NC
	2015	0	0	30	0.041	0.044

TABLE 8. ANNUAL STREAMFLOW STATISTICS CALCULATED FOR SURFACE WATER STATIONS IN DEVILS CANYON WATERSHED, RESOLUTION PROJECT

STATION NAME	YEAR	DRY CONDITIONS (DAYS)	MISSING RECORDS (DAYS)	NOVEMBER RECORDS (DAYS)	MINIMUM OF NOVEMBER 7-DAY AVERAGE STREAMFLOW (CFS[a])	MEDIAN DAILY STREAMFLOW (CFS)
DC 8.1 C	2011	145	120	30	0.006	NC
	2012	139	157	26	0.002	NC
	2013	37	41	30	0.031	NC
	2014	33	0	30	0.051	0.054
	2015	17	30	30	0.010	0.026
DC 5.5 C	2003	11	294	30	0.002	NC
	2004	84	8	30	0.201	0.153
	2005	69	5	30	0.056	0.154
	2006	10	5	30	0.197	0.312
	2007	0	5	30	0.038	0.329
	2008	2	109	30	0.007	NC
	2009	51	5	30	0.011	0.056
	2010	1	176	30	0.204	NC
	2011	0	209	0	NC	NC
	2012	60	287	15	NC	NC
	2013	176	43	30	DRY	NC
	2014	57	99	30	0.038	NC
	2015	201	0	30	0.002	DRY

NOTES:

[a] cfs - cubic feet per second

[b] DC - Devils Canyon

[c] NC - Not calculated

[d] DRY - Statistics affected by excessive number of days with no flow

[e] RR - Rancho Rio

TABLE 9. ANNUAL STREAMFLOW STATISTICS CALCULATED FOR SURFACE WATER STATIONS IN MINERAL CREEK WATERSHED, RESOLUTION PROJECT

STATION NAME	YEAR	DRY CONDITIONS (DAYS)	MISSING RECORDS (DAYS)	NOVEMBER RECORDS (DAYS)	MINIMUM OF NOVEMBER 7-DAY AVERAGE STREAMFLOW (CFS[a])	MEDIAN DAILY STREAMFLOW (CFS)
Upper Mineral Creek (UMC)	2011	0	0	30	0.003	0.128
	2012	14	0	30	0.020	0.060
	2013	65	23	30	0.002	0.059
	2014	183[b]	9	30	DRY[c]	NC[d]
	2015	40	184	0	ND[e]	NC
Lower Mineral (MC 3.3 C)	2011	0	77	30	4.01	NC
	2012	0	67	30	0.47	NC
	2013	0	64	30	0.97	NC
	2014	0	0	30	0.05	0.71
	2015	0	0	30	3.03	4.00

NOTES:

[a] cfs - cubic feet per second

[b] Estimated number of dry days affected by sensor drift during second half of 2014

[c] DRY - Statistics affected by excessive number of days with no flow

[d] NC - Not calculated

[e] ND - No data

TABLE 10. SUMMARY OF STREAMFLOW PERSISTENCE, STREAMFLOW STATISTICS, BASE FLOW STATISTICS, AND SOURCES OF BASE FLOW BY SURFACE WATER STATION, RESOLUTION PROJECT

WATERSHED	STATION NAME	PERSISTENCE OF STREAMFLOW	ANNUAL STREAMFLOW, RANGE: MINIMUM OF NOVEMBER 7-DAY AVERAGE STREAMFLOW (CFS[a])	ANNUAL STREAMFLOW, RANGE: MEDIAN DAILY STREAMFLOW (CFS[a])	MEDIAN DAILY BASE FLOW (CFS[a]), DELTA-FILTER: ANNUAL	MEDIAN DAILY BASE FLOW (CFS[a]), DELTA-FILTER: WINTER	MEDIAN DAILY BASE FLOW (CFS[a]), DELTA-FILTER: SUMMER	SOURCE(S) CONTRIBUTING TO BASE FLOW
Upper Queen Creek Watershed	Upper Carbonate (UC)	Ephemeral	Dry[b] to 0.002	Dry[b]	0.019	0.025	0.006	PERCHED GROUNDWATER
Devil's Canyon	DC 13.5 C	Ephemeral	Dry[b] to 0.035	Dry[b] to 0.063	0.065	0.082	0.008	PERCHED GROUNDWATER
	DC 10.9 C	Intermittent	Dry[b] to 0.214	Dry[b] to 0.105	0.037	0.033	0.034	PERCHED GROUNDWATER
	RR 1.5 C	Ephemeral	Dry[b]	NC[c]	NC[c]	NC[c]	NC[c]	PERCHED GROUNDWATER
	DC 8.8 C	Perennial	0.024 to 0.688	0.044 to 0.647	0.264	0.462	0.082	REGIONAL (ALT[d]) GROUNDWATER AND PERCHED GROUNDWATER
	DC 8.1 C	Intermittent	0.002 to 0.051	0.026 to 0.054	0.04	0.145	0.008	REGIONAL (ALT[d]) GROUNDWATER AND PERCHED GROUNDWATER
	DC 5.5 C	Intermittent	Dry[b] to 0.204	Dry[b] to 0.329	0.088	0.287	0.003	REGIONAL (ALT[d]) GROUNDWATER AND PERCHED GROUNDWATER
Mineral Creek	Upper Mineral Creek (UMC)	Intermittent	Dry[b] to 0.020	0.059 to 0.128	0.061	0.148	0.028	REGIONAL (ALT[d]) GROUNDWATER AND PERCHED GROUNDWATER
	Lower Mineral Creek (LMC)	Perennial	0.05 to 4.01	0.71 to 4.00	1.327	1.659	0.457	REGIONAL (ALT[d]) GROUNDWATER AND PERCHED GROUNDWATER

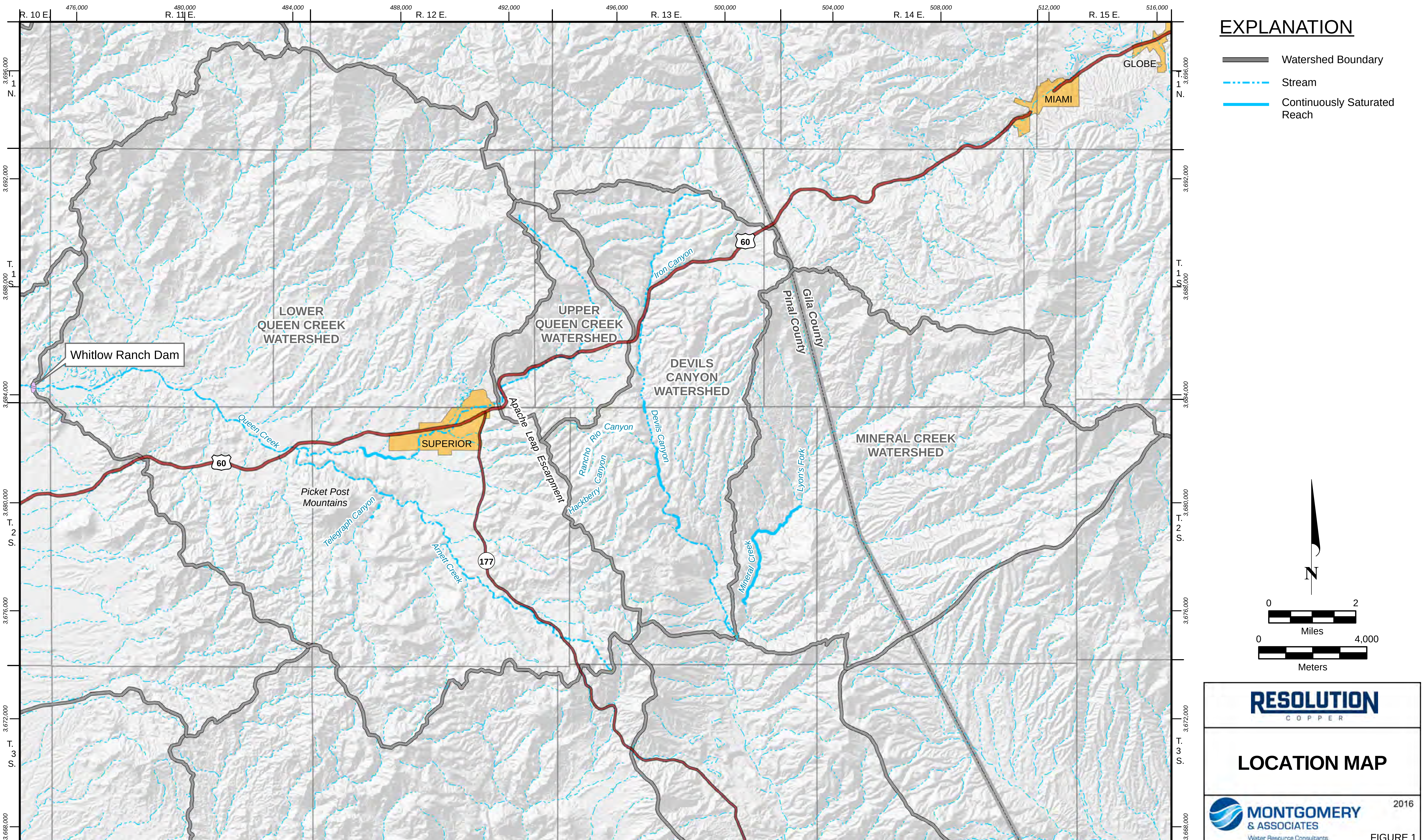
NOTES:

[a] cfs - cubic feet per second

[b] Statistic affected by excessive number of days with no streamflow

[c] NC - Not calculated

[d] ALT - Apache Leap Tuff

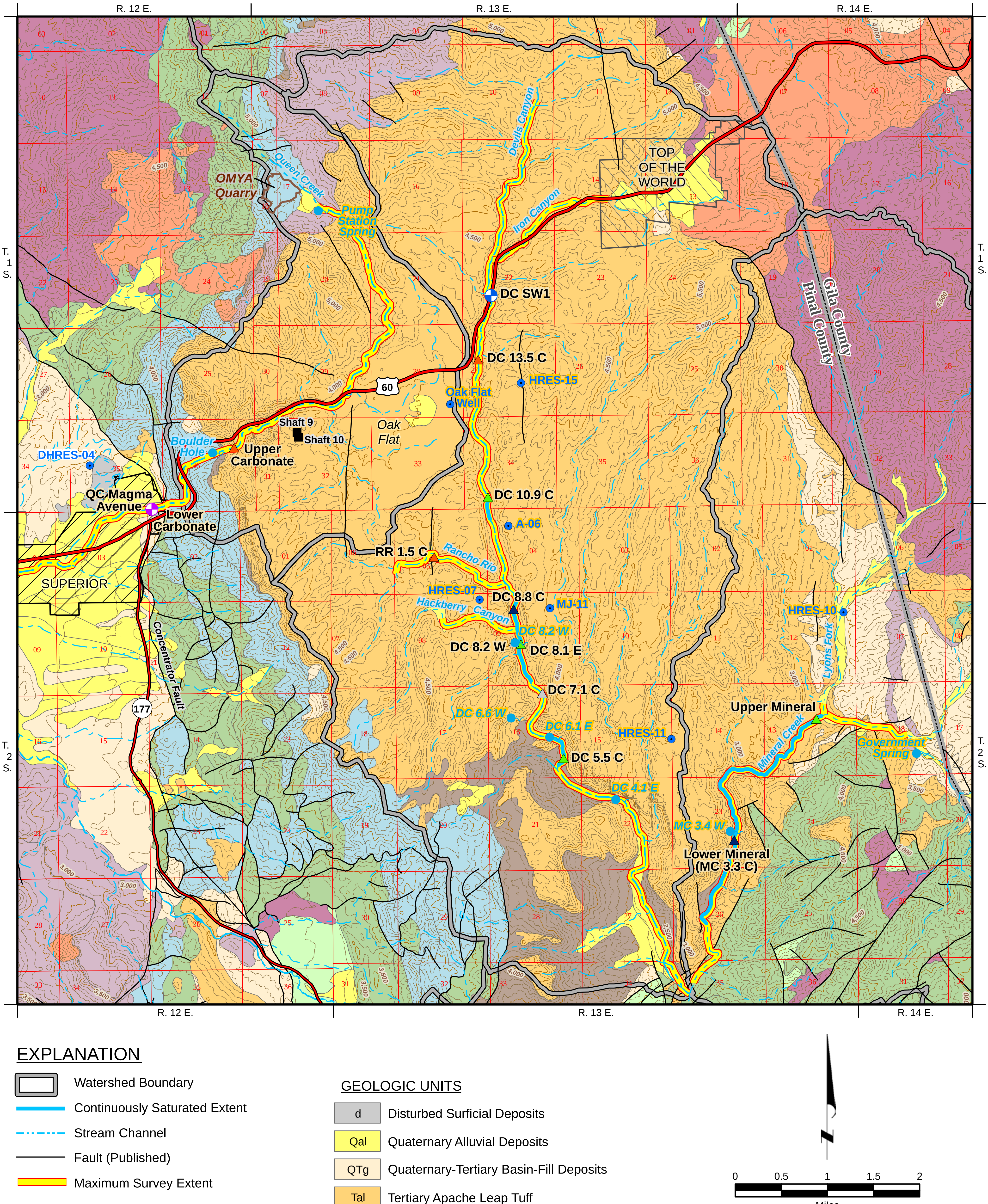


LOCATION MAP

2016

FIGURE 1

GIS-Tuc\Projects\605\605.1504\FinalReport\LocationMap2.mxd\08Sept2016



EXPLANATION

- Watershed Boundary
- Continuously Saturated Extent
- Stream Channel
- Fault (Published)
- Maximum Survey Extent
- Apache Leap Tuff Well
- Spring

DATA SONDE CATEGORIES

- Data Sonde Location, Not Analyzed
- Data Sonde Location, Ephemeral
- Data Sonde Location, Intermittent
- Data Sonde Location, Perennial

STREAM GAGE CATEGORIES

- Stream Gage Location, Established 2013
- Stream Gage Location, Pinal County, Established 2015

GEOLOGIC UNITS

d	Disturbed Surficial Deposits
Qal	Quaternary Alluvial Deposits
QTg	Quaternary-Tertiary Basin-Fill Deposits
Tal	Tertiary Apache Leap Tuff
Tvu	Tertiary Volcanic Rocks, undifferentiated
Tw	Tertiary Whitetail Conglomerate
TKg	Cretaceous and Tertiary Intrusive Rocks
Pz	Paleozoic Sedimentary Rocks
p€y	Younger Precambrian Sedimentary Rocks, Basalt, and Diabase
p€gu	Undifferentiated Precambrian Intrusive Rocks
p€pi	Older Precambrian Pinal Schist

0 0.5 1 1.5 2
Miles

0 1,000 2,000 3,000 4,000
Meters

Topographic Contour Interval: 500 Feet

RESOLUTION COPPER

DATA SONDE LOCATIONS AND MAXIMUM OCCURRENCE SURVEY EXTENTS

MONTGOMERY & ASSOCIATES
Water Resource Consultants

2016

FIGURE 2

\GIS-Tuc\Projects\605\605.1504\FinalReport\Geo_SondeLocations_MaxOccurrenceSurveyExtents_Ledger\10Jan2017

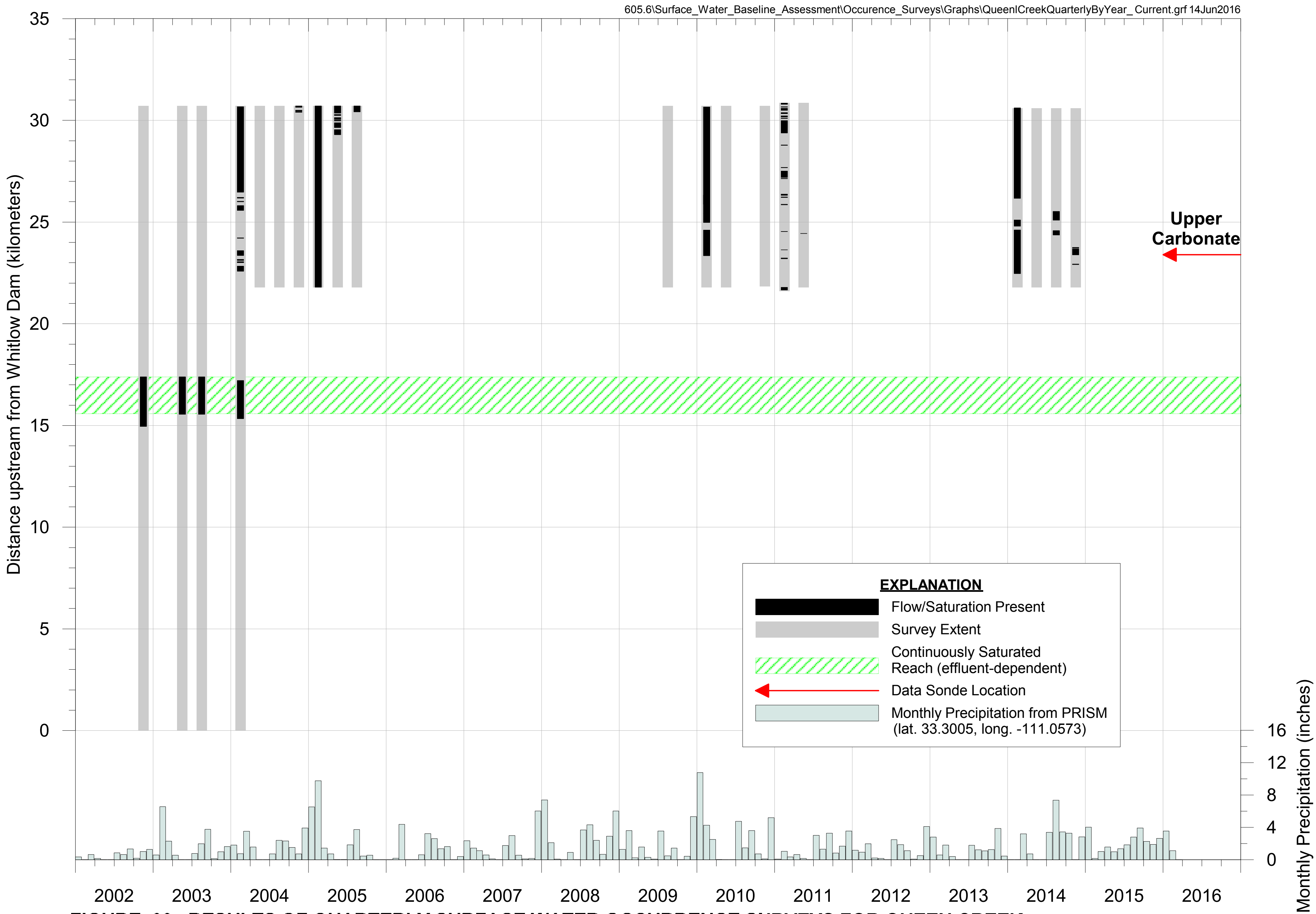


FIGURE 03. RESULTS OF QUARTERLY SURFACE WATER OCCURRENCE SURVEYS FOR QUEEN CREEK

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

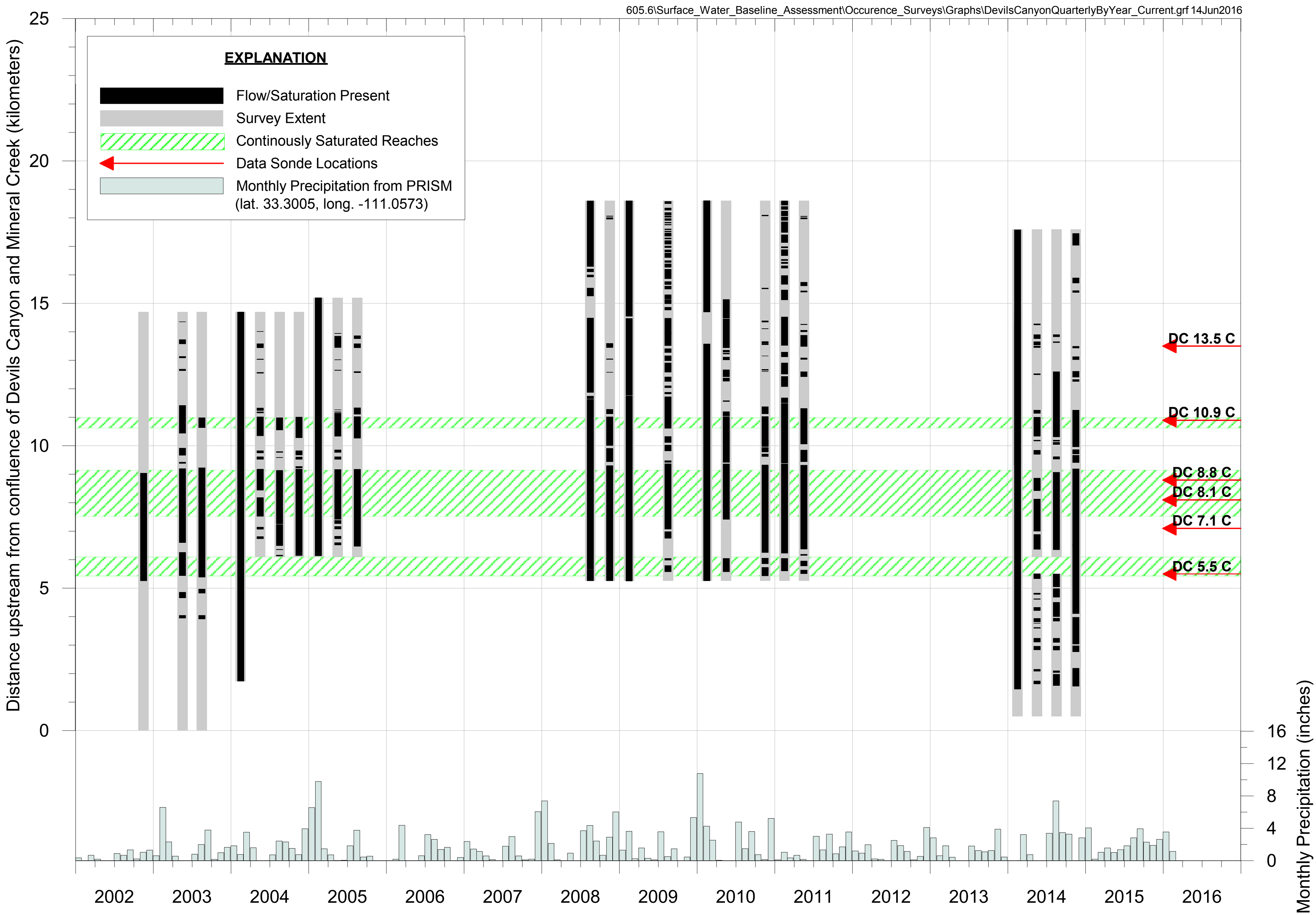


FIGURE 04. RESULTS OF QUARTERLY SURFACE WATER OCCURRENCE SURVEYS FOR DEVILS CANYON

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

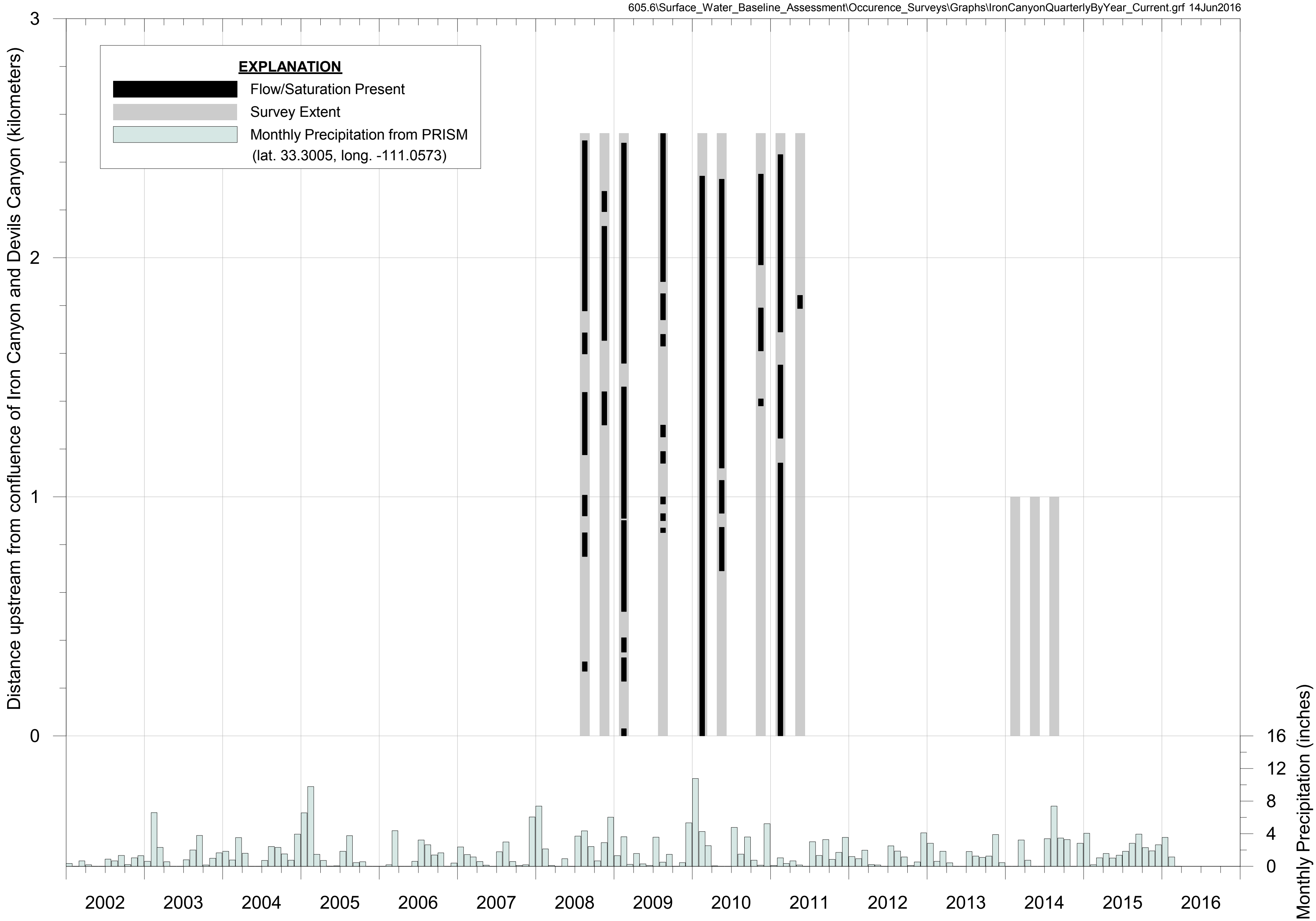


FIGURE 05. RESULTS OF QUARTERLY SURFACE WATER OCCURRENCE SURVEYS FOR IRON CANYON DEVILS CANYON WATERSHED

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

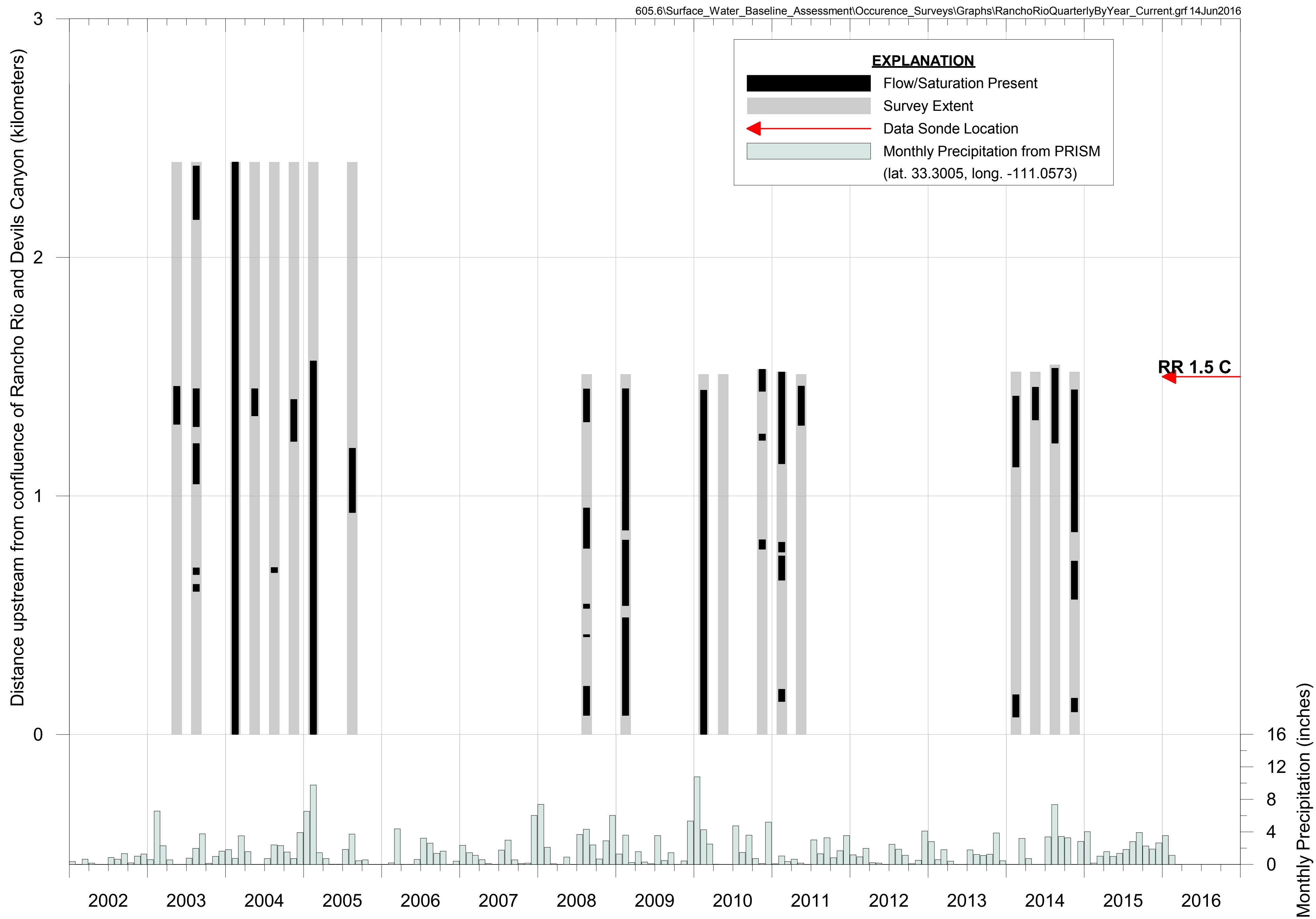


FIGURE 06. RESULTS OF QUARTERLY SURFACE WATER OCCURRENCE SURVEYS FOR RANCHO RIO DEVILS CANYON WATERSHED

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

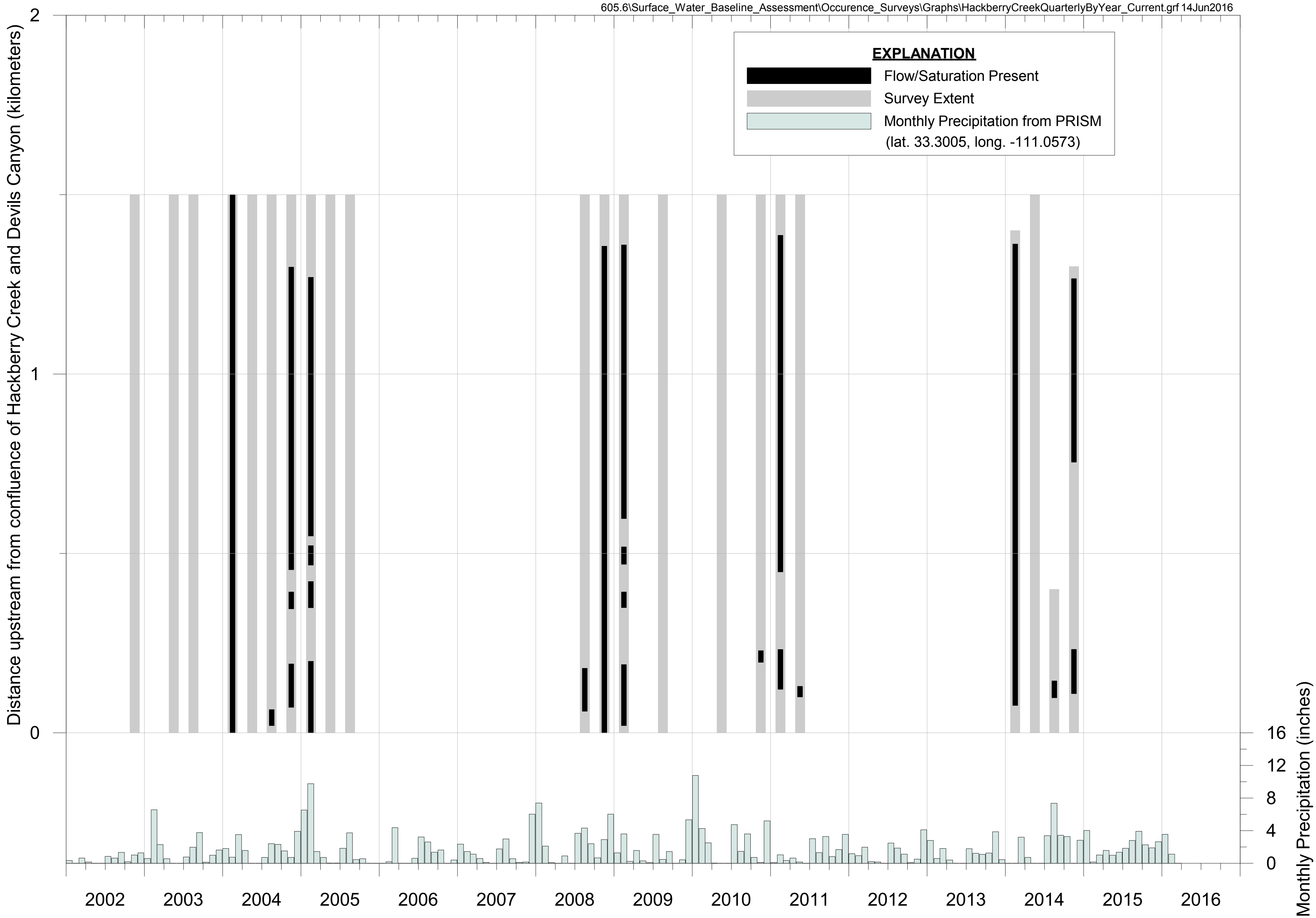


FIGURE 07. RESULTS OF QUARTERLY SURFACE WATER OCCURRENCE SURVEYS FOR HACKBERRY CANYON DEVILS CANYON WATERSHED

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

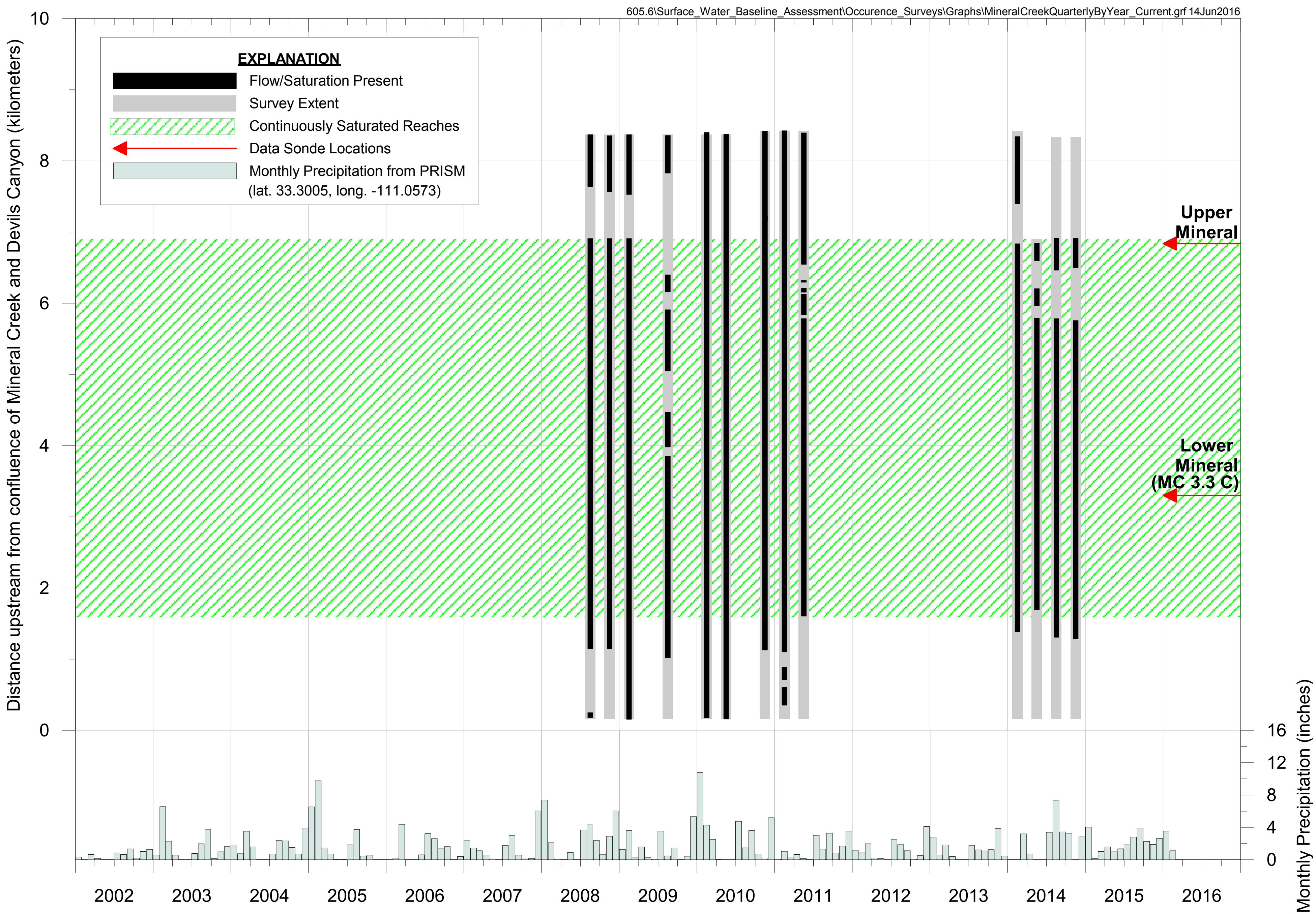


FIGURE 08. RESULTS OF QUARTERLY SURFACE WATER OCCURRENCE SURVEYS FOR MINERAL CREEK

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

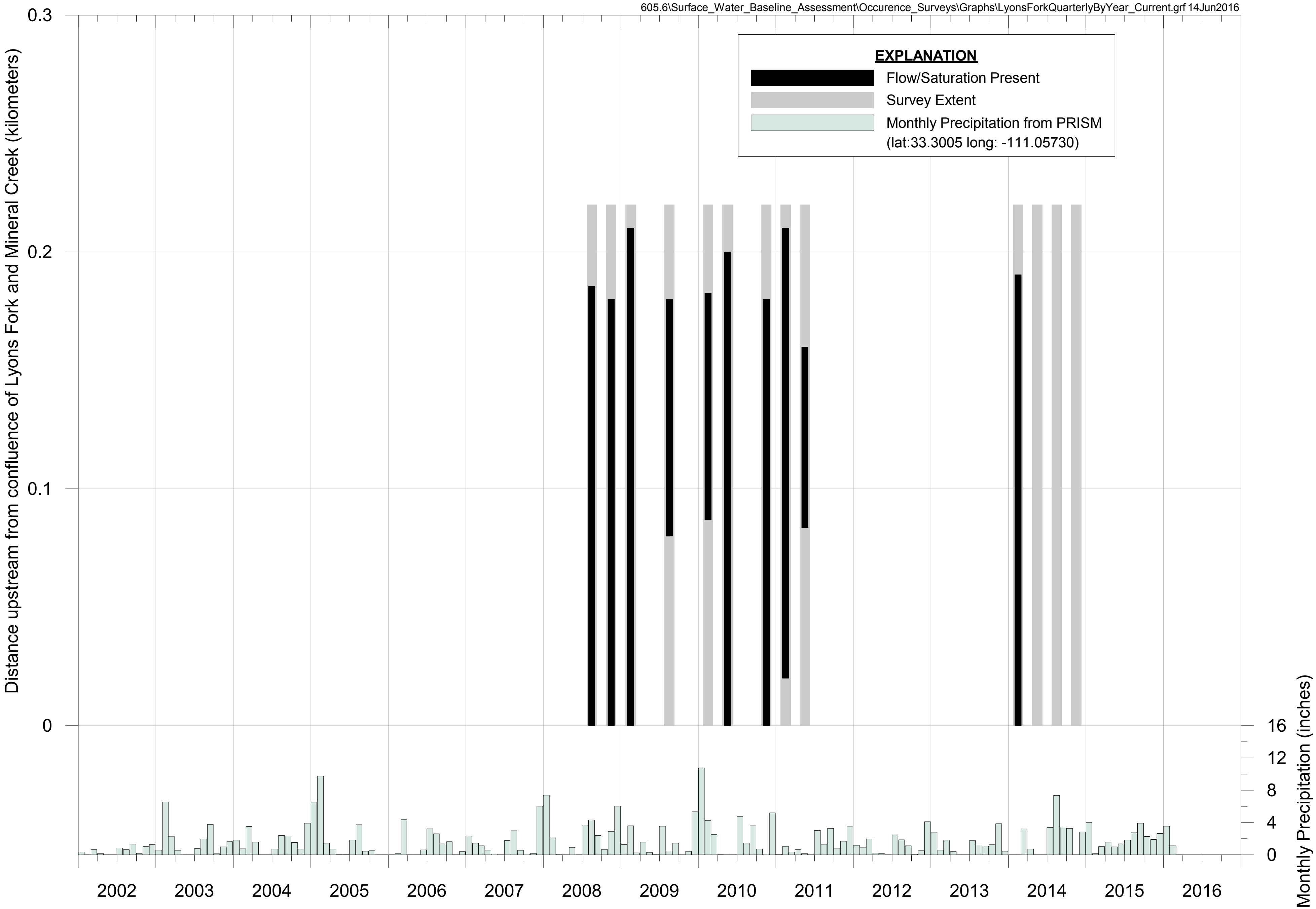


FIGURE 09. RESULTS OF QUARTERLY SURFACE WATER OCCURRENCE SURVEYS FOR LYONS FORK MINERAL CREEK WATERSHED

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

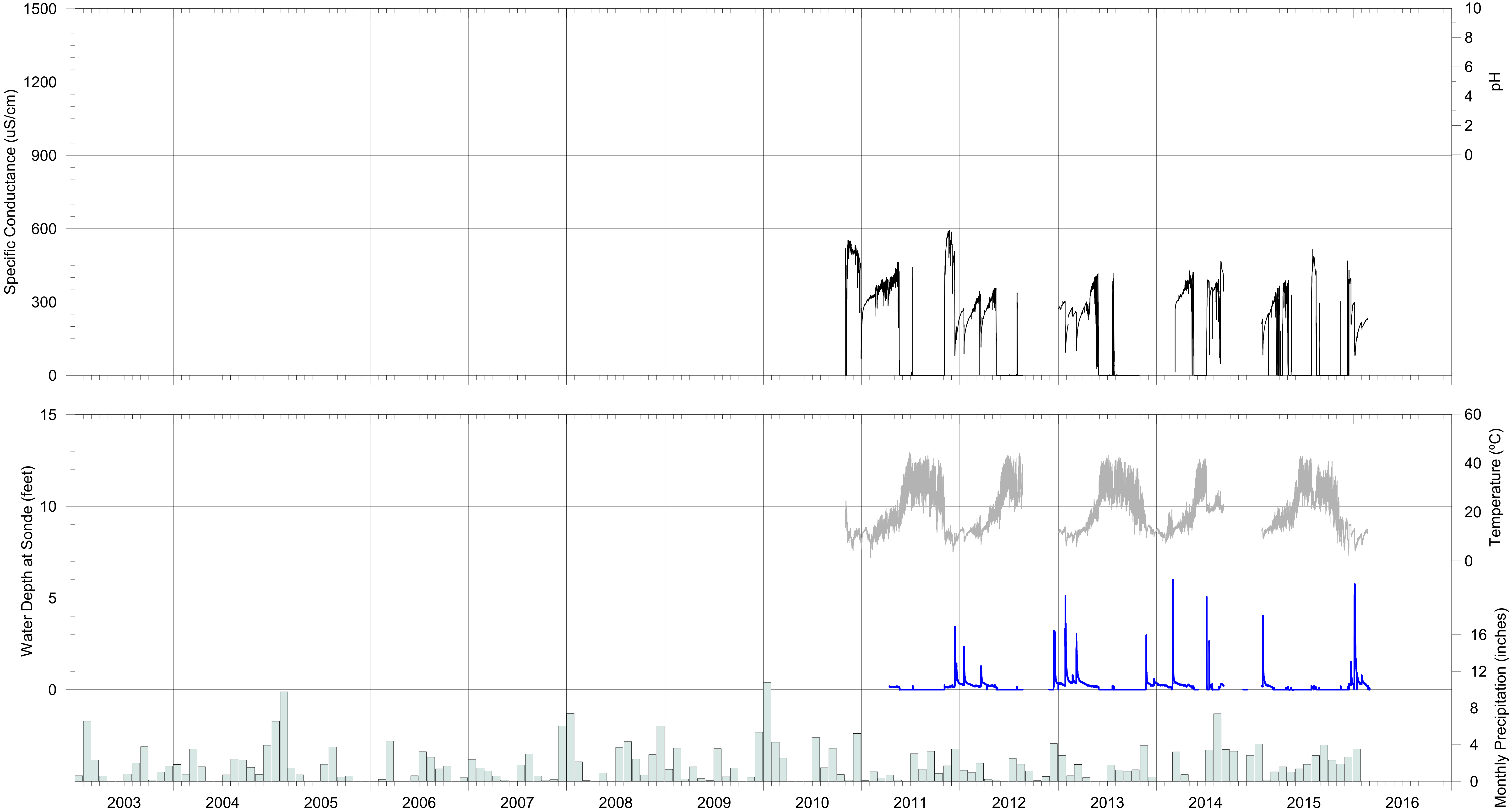
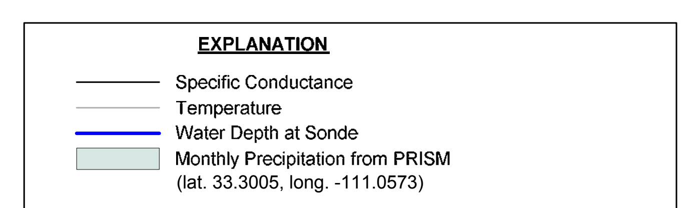


FIGURE 10. QUEEN CREEK DATA SONDE LOCATION "UPPER CARBONATE"



RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

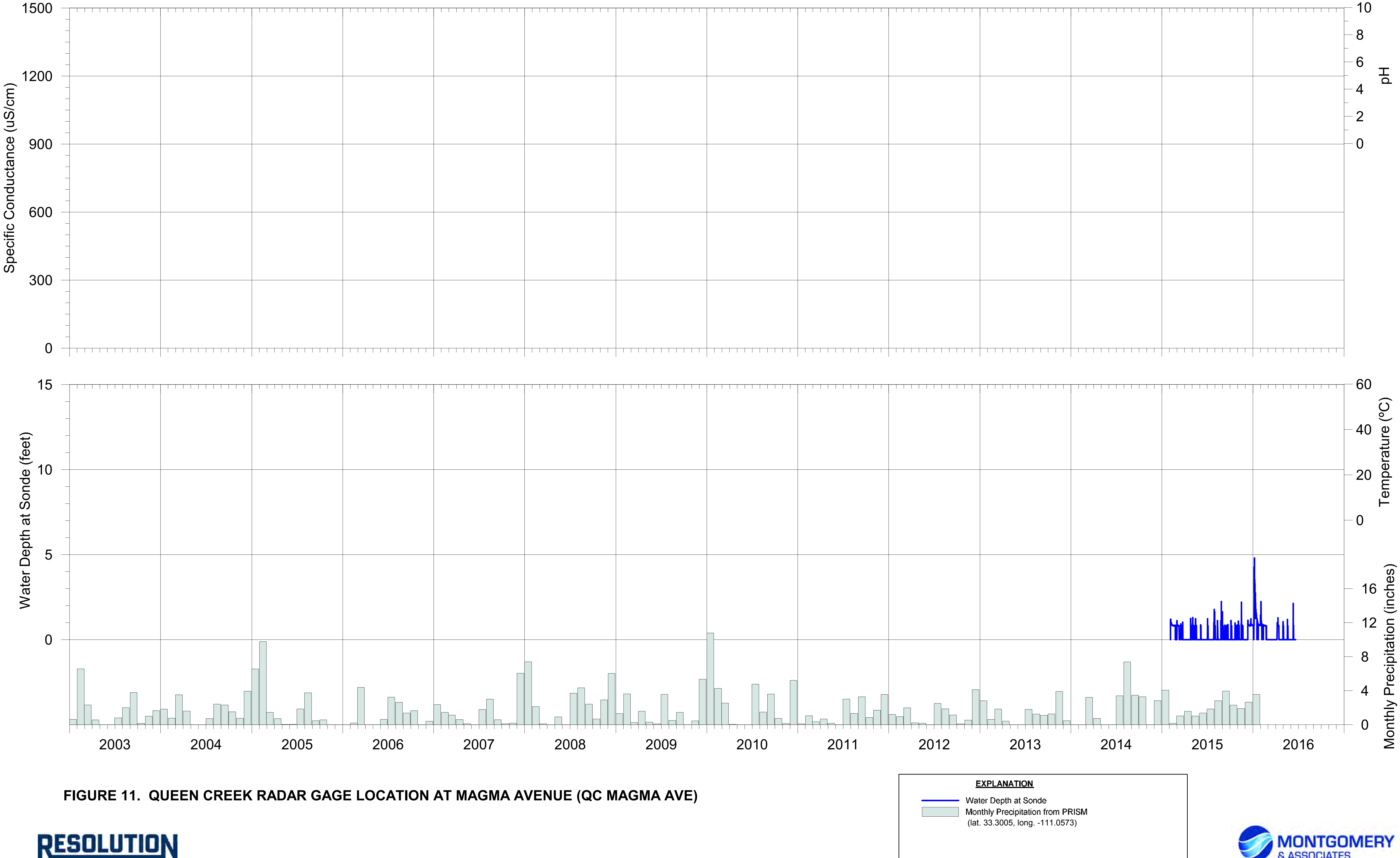


FIGURE 11. QUEEN CREEK RADAR GAGE LOCATION AT MAGMA AVENUE (QC MAGMA AVE)

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

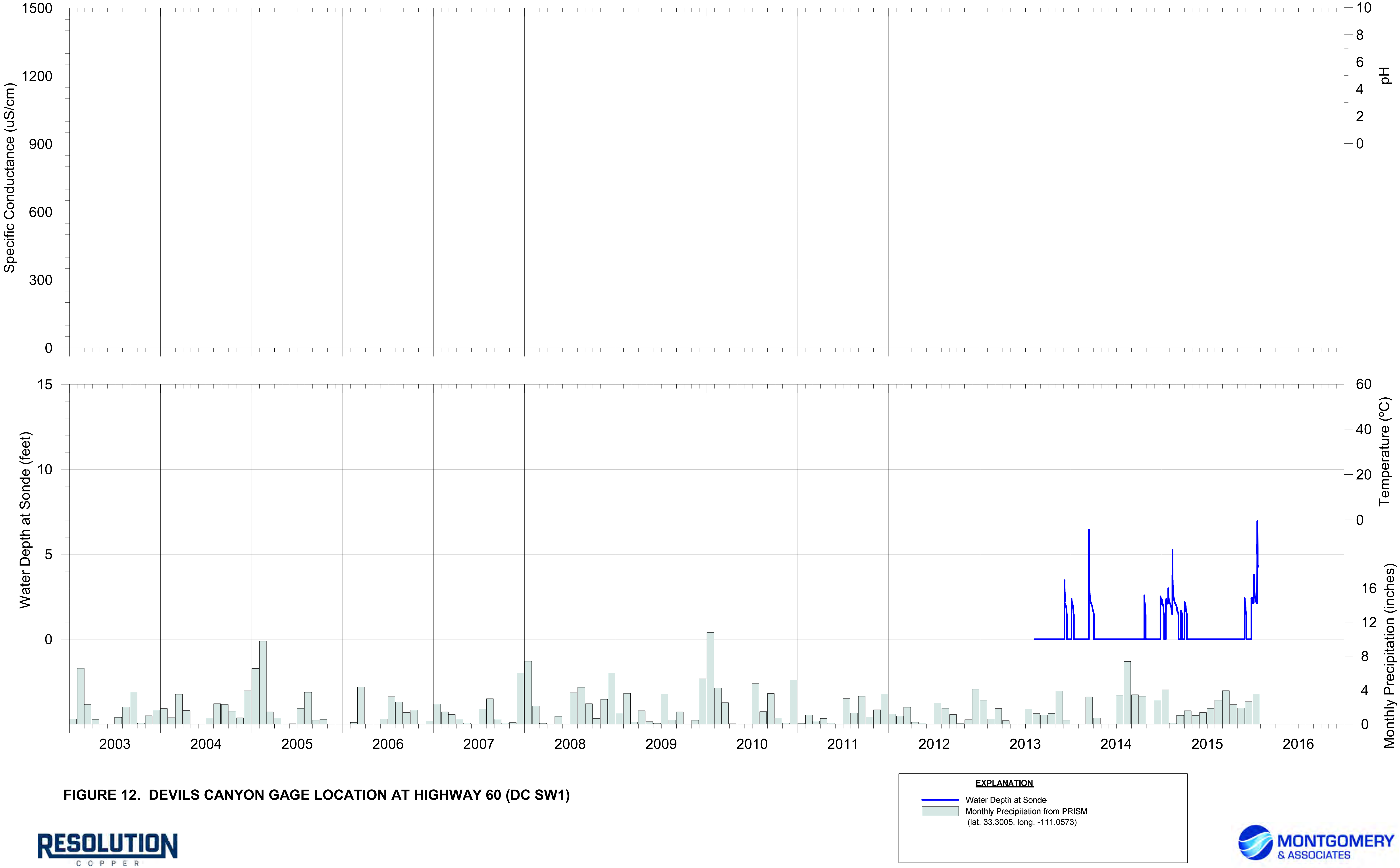


FIGURE 12. DEVILS CANYON GAGE LOCATION AT HIGHWAY 60 (DC SW1)

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

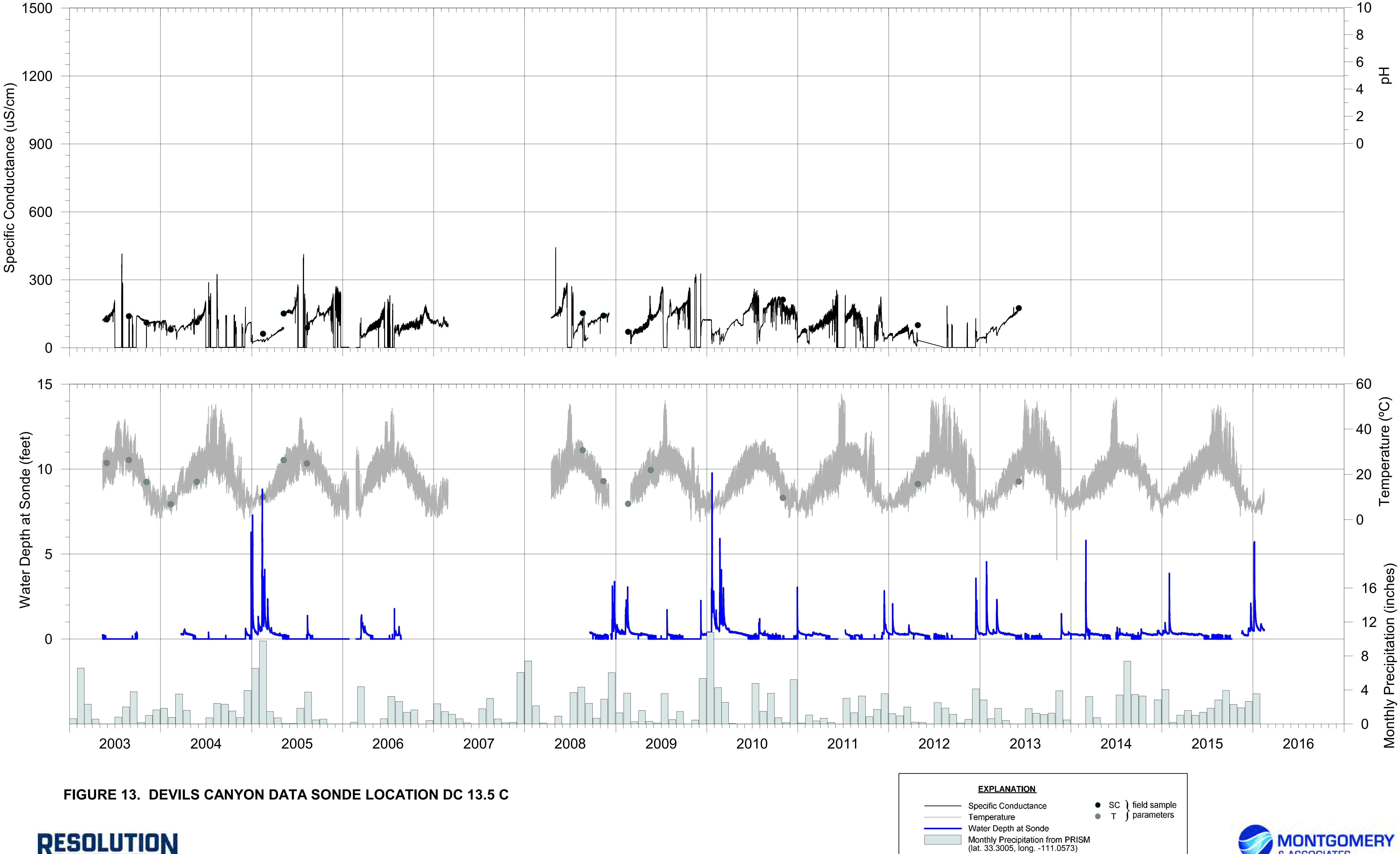


FIGURE 13. DEVILS CANYON DATA SONDE LOCATION DC 13.5 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

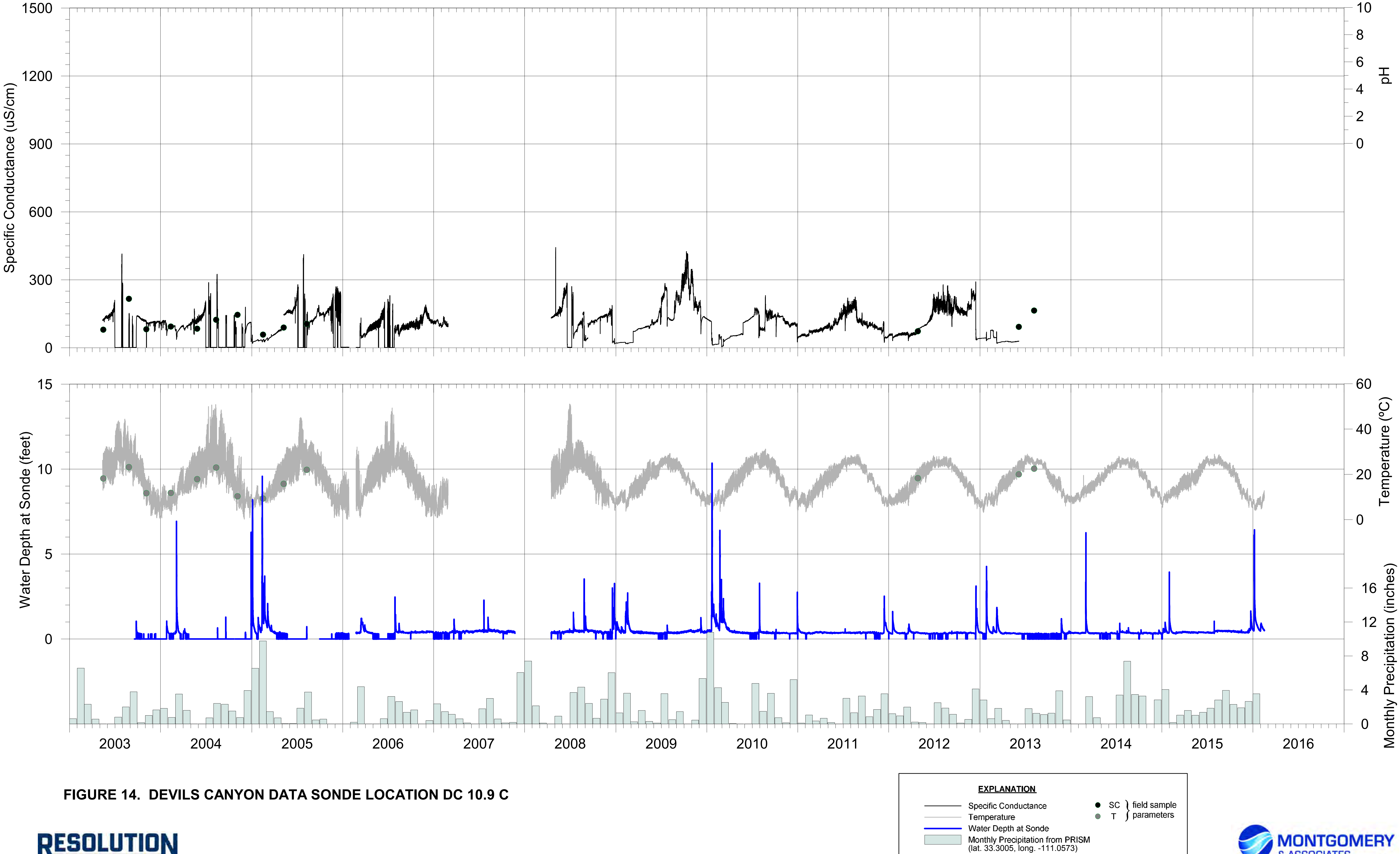


FIGURE 14. DEVILS CANYON DATA SONDE LOCATION DC 10.9 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

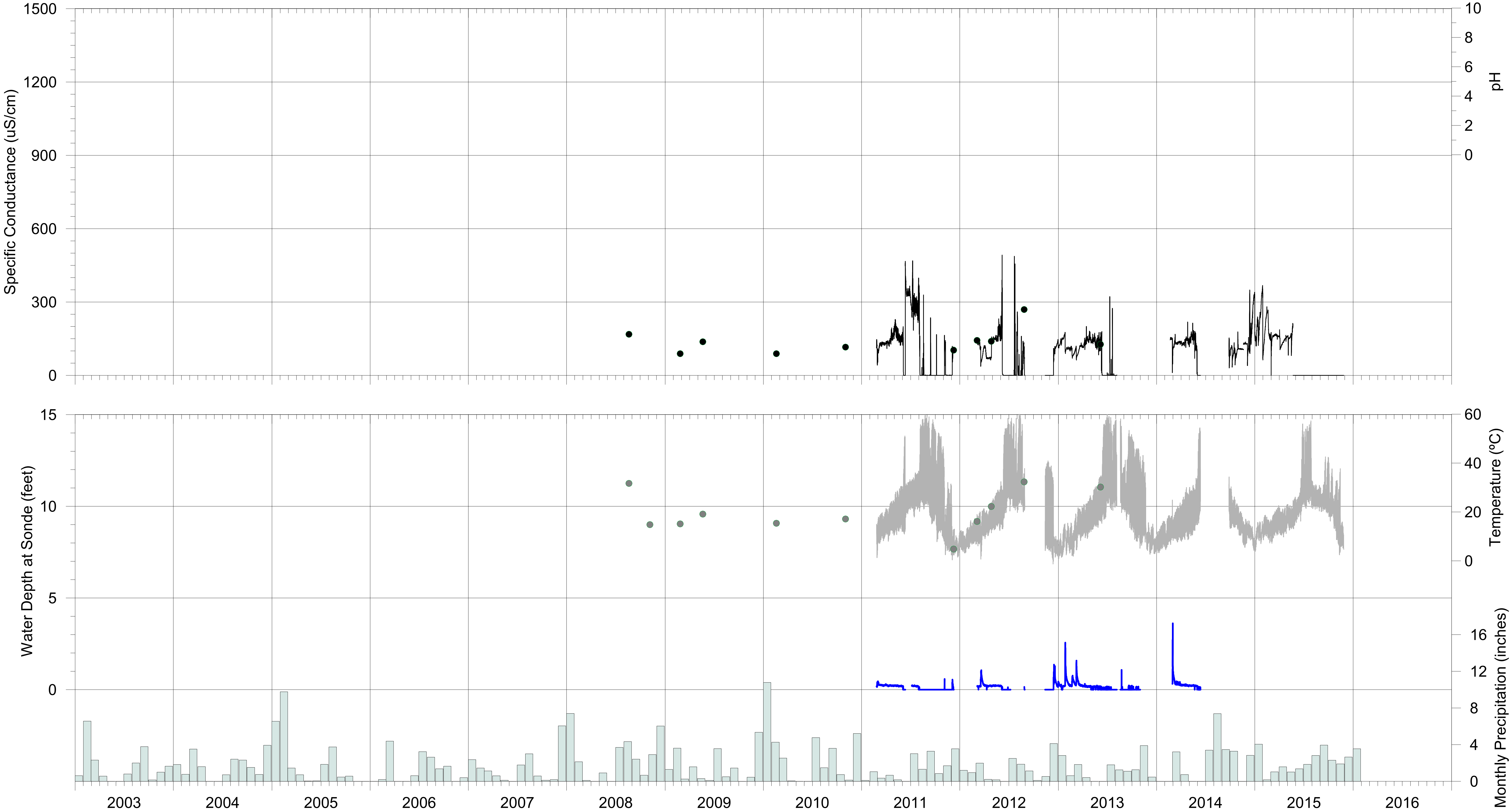


FIGURE 15. DEVILS CANYON DATA SONDE LOCATION RR 1.5 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

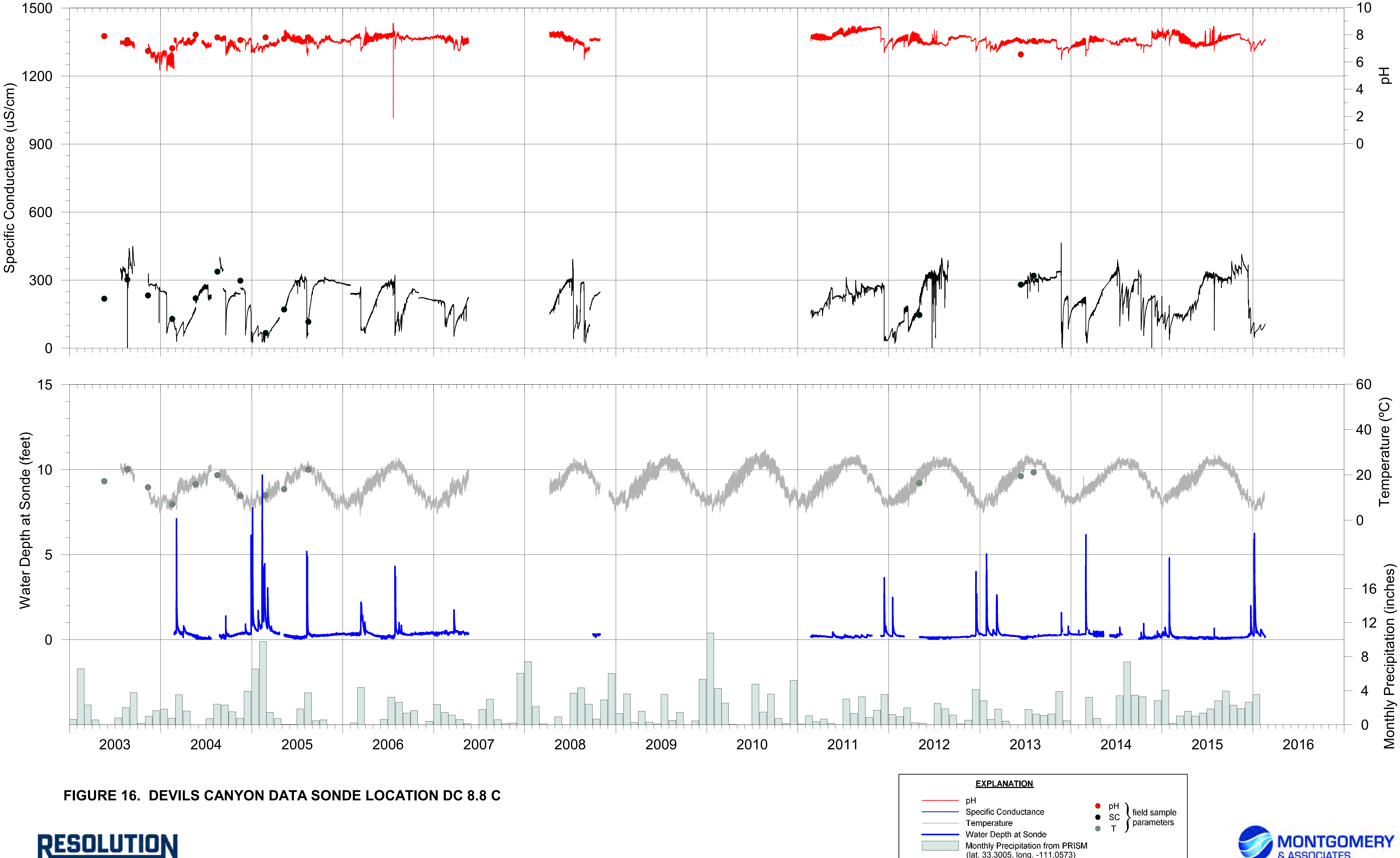


FIGURE 16. DEVILS CANYON DATA SONDE LOCATION DC 8.8 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

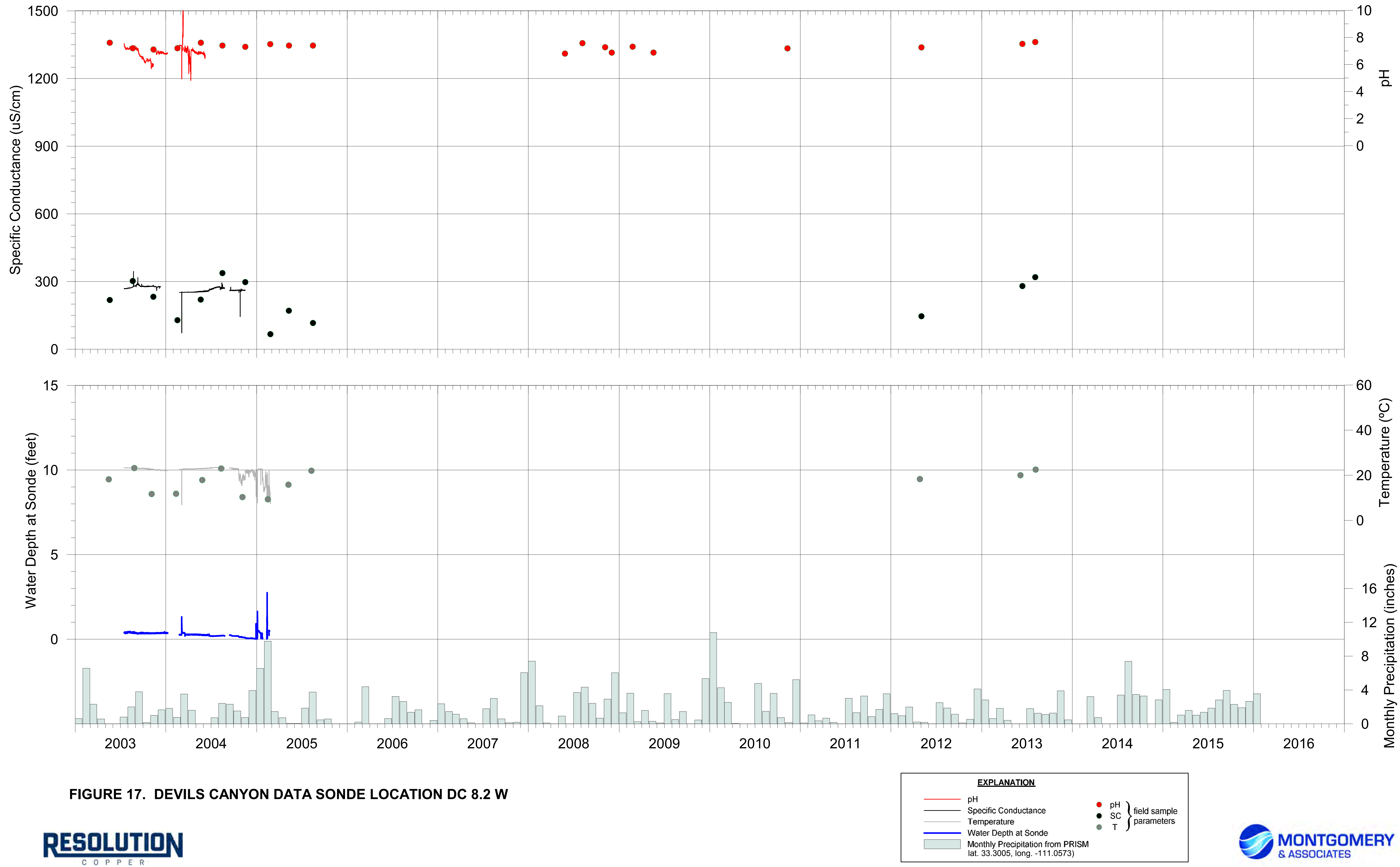


FIGURE 17. DEVILS CANYON DATA SONDE LOCATION DC 8.2 W

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

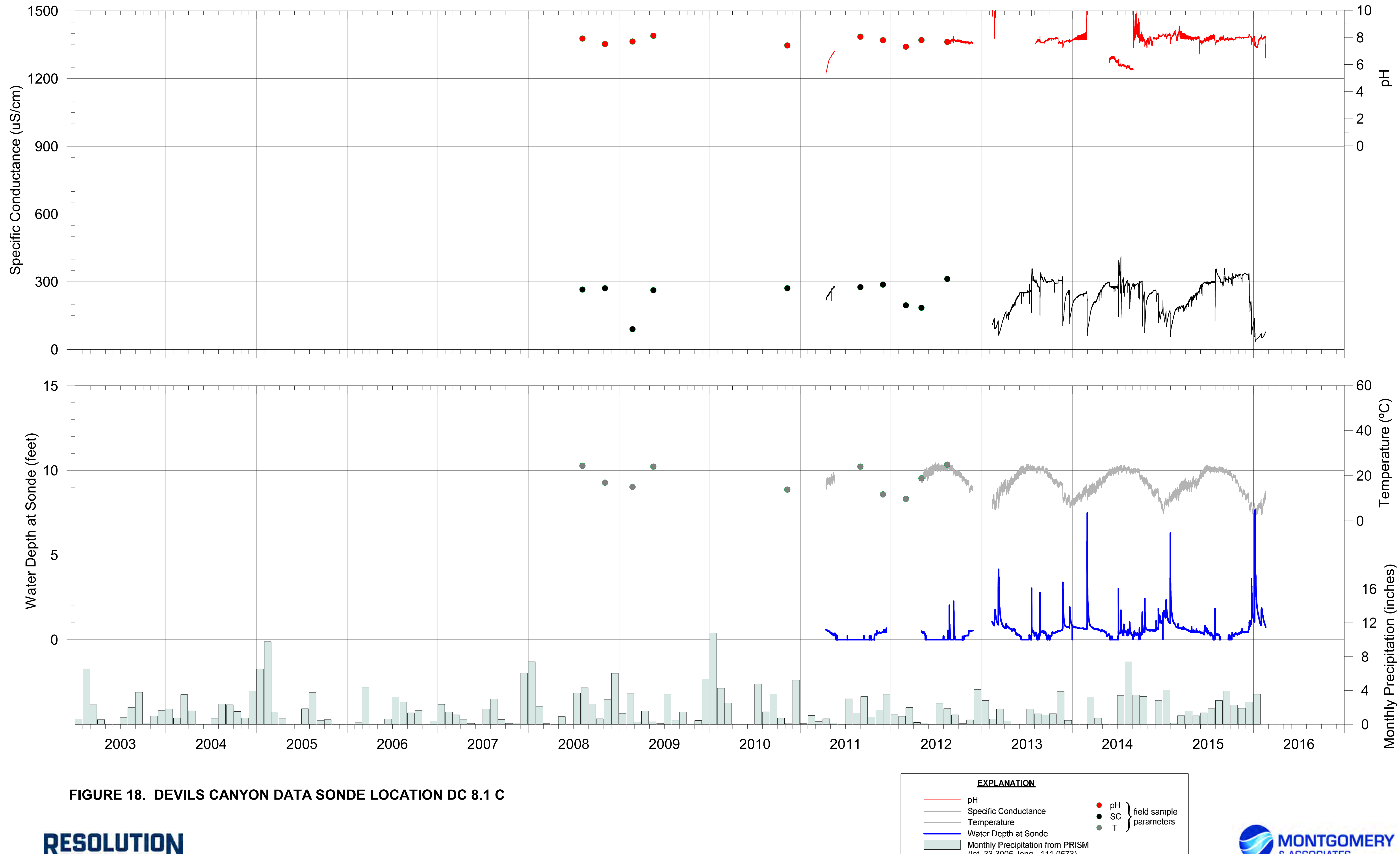


FIGURE 18. DEVILS CANYON DATA SONDE LOCATION DC 8.1 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

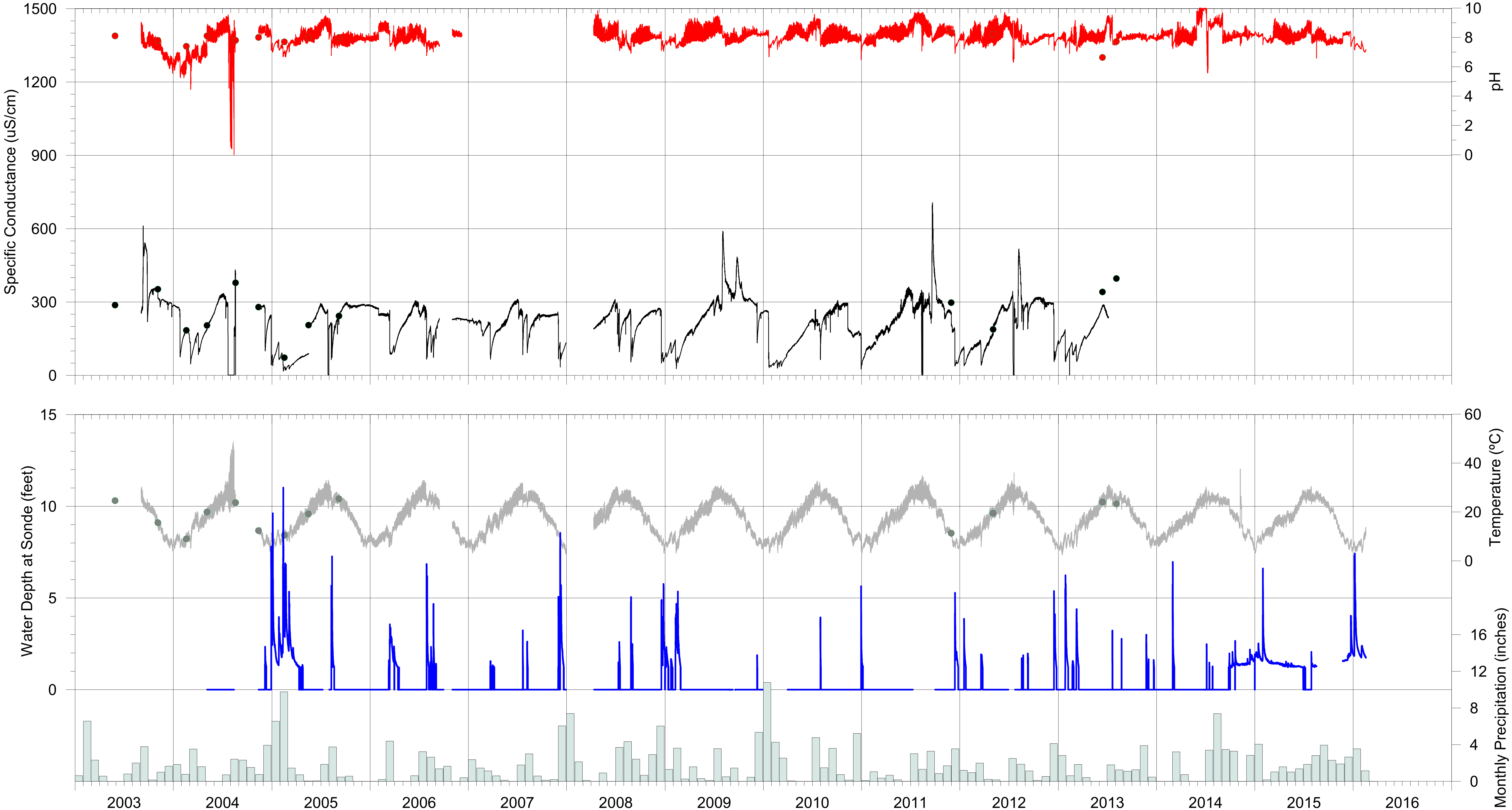


FIGURE 19. DEVILS CANYON DATA SONDE LOCATION DC 7.1 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

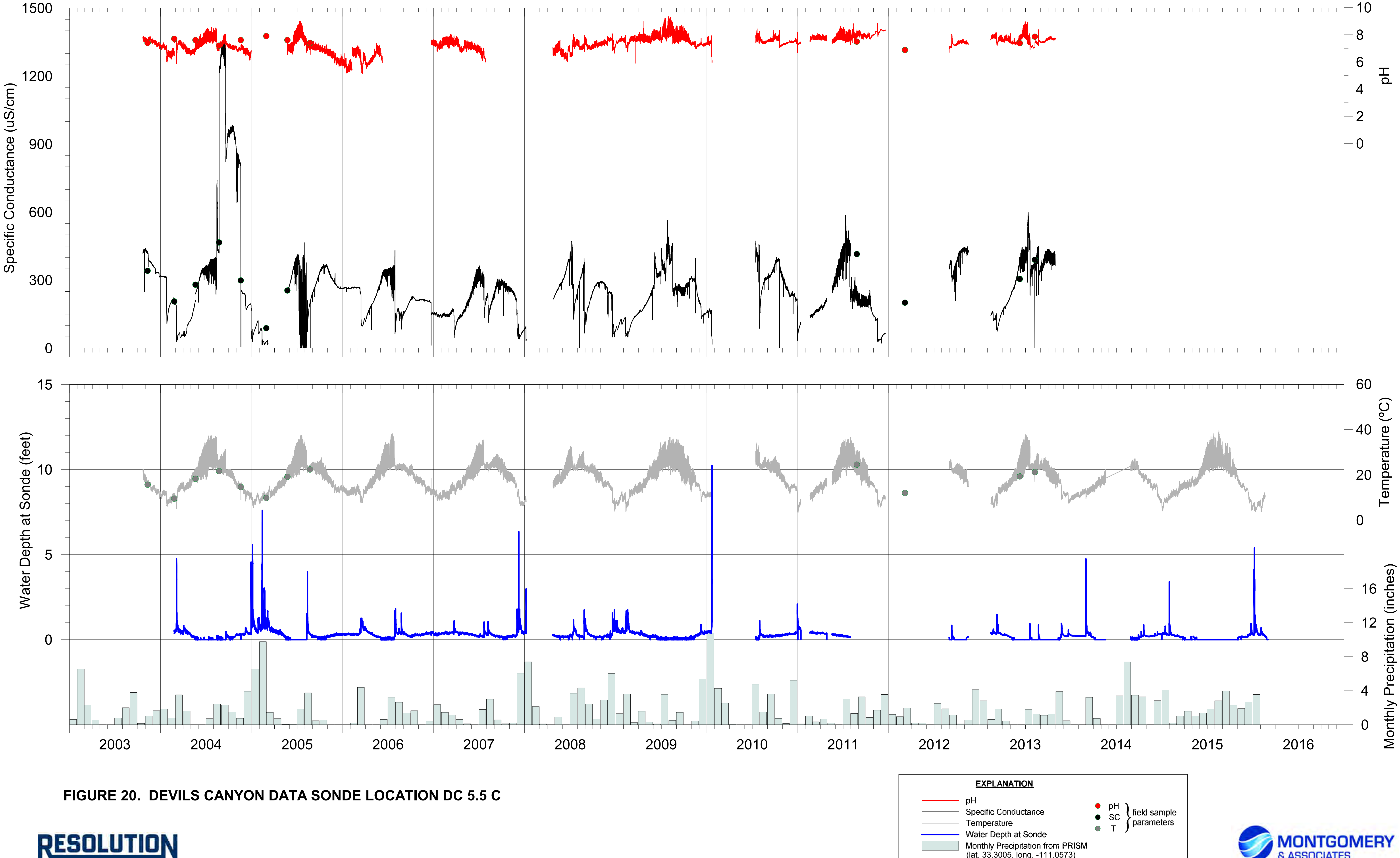


FIGURE 20. DEVILS CANYON DATA SONDE LOCATION DC 5.5 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

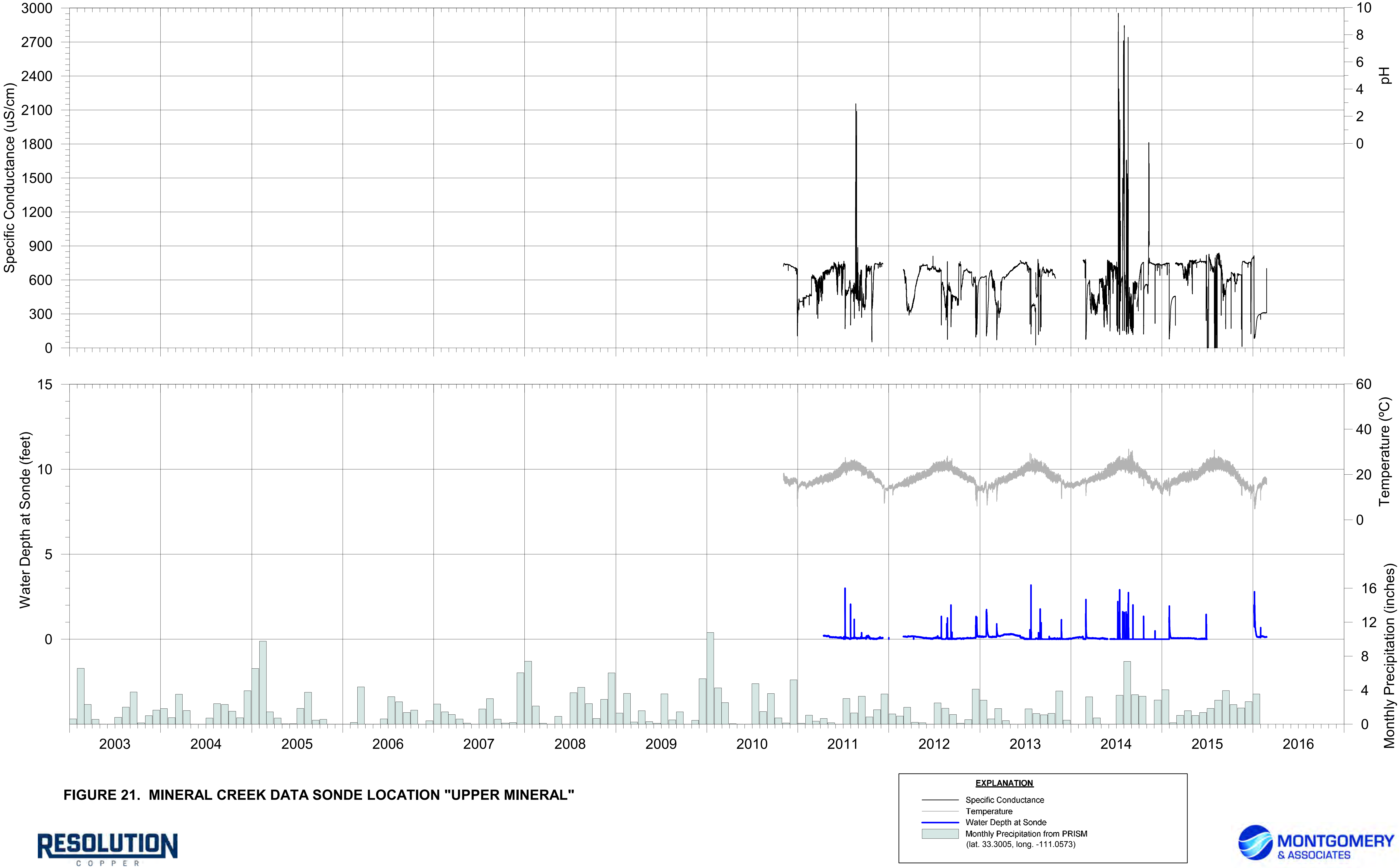


FIGURE 21. MINERAL CREEK DATA SONDE LOCATION "UPPER MINERAL"

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

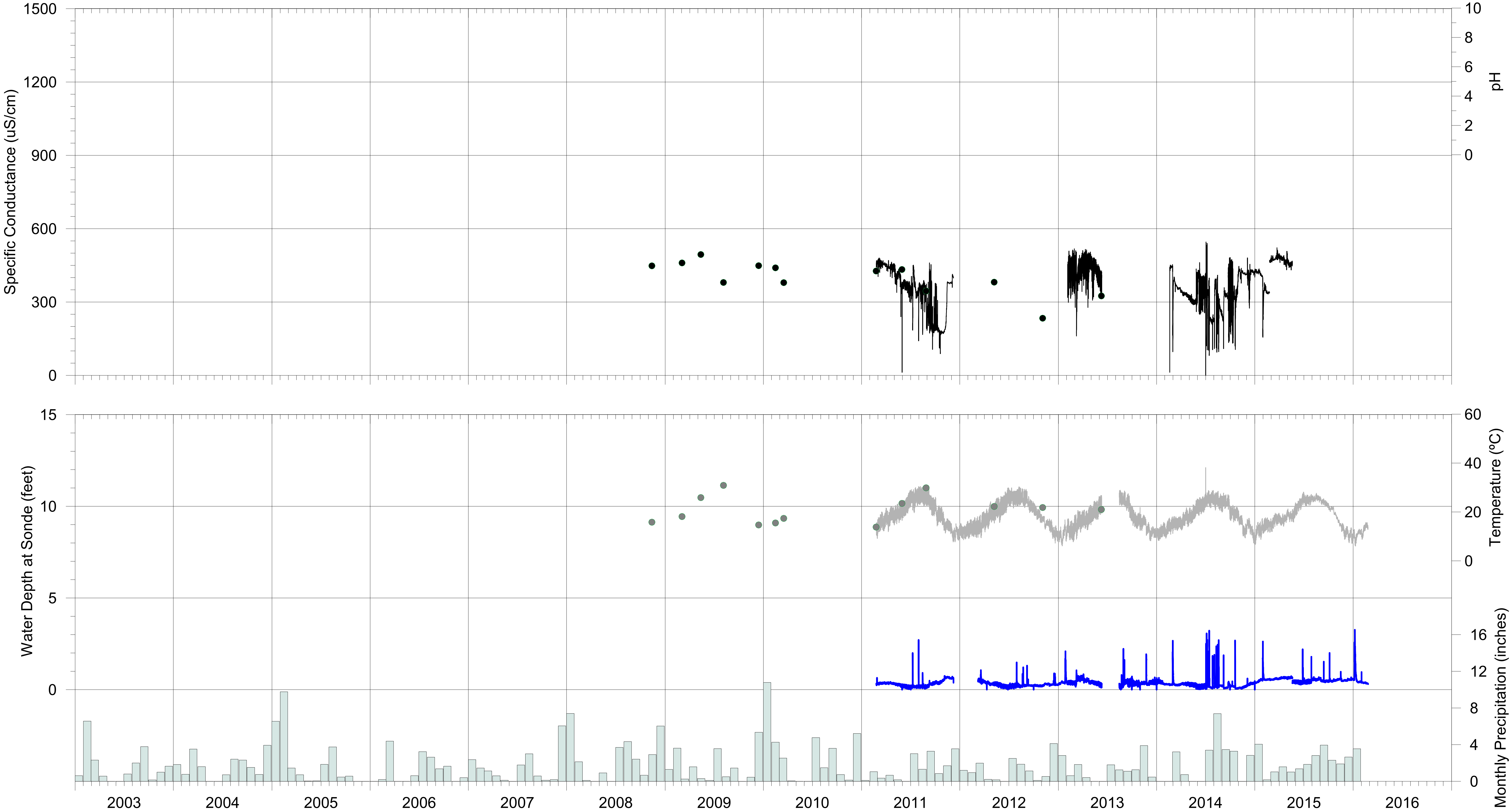


FIGURE 22. MINERAL CREEK DATA SONDE LOCATION "LOWER MINERAL" (MC 3.3 C)

EXPLANATION

- Specific Conductance
- Temperature
- Water Depth at Sonde
- Monthly Precipitation from PRISM (lat. 33.3005, long. -111.0573)
- SC, T } field sample parameters

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

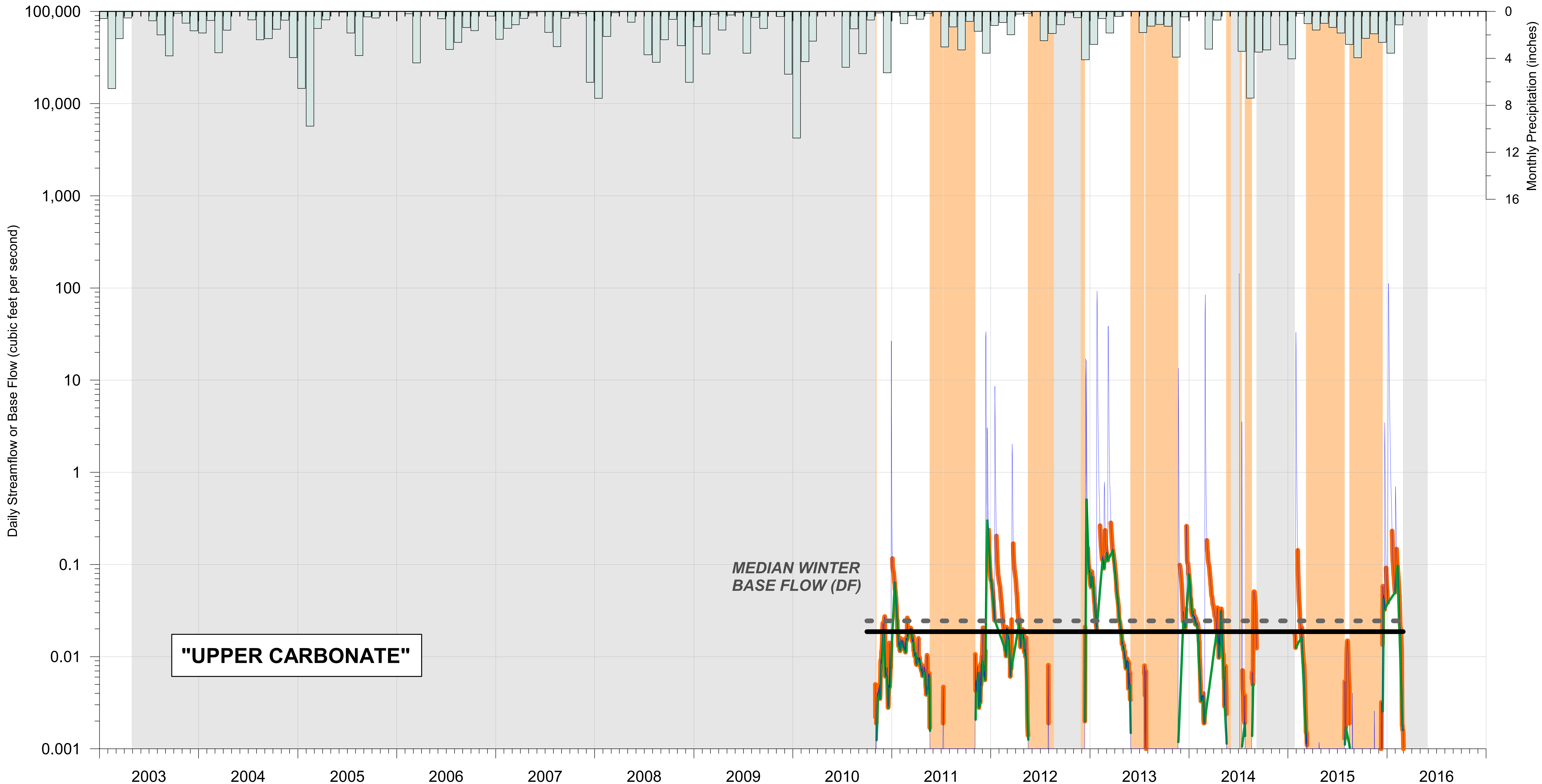


FIGURE 23. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, SURFACE WATER STATION "UPPER CARBONATE"

EXPLANATION

- Daily Streamflow at Upper Carbonate
- Daily Base Flow - HLM
- Daily Base Flow - DF
- Median Daily Base Flow, Entire Year
- Median Daily Base Flow by Season
- Streamflow Not Present
- Streamflow Not Calculated
- Monthly Precipitation from PRISM (lat 33.2992, long. -111.1052)

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

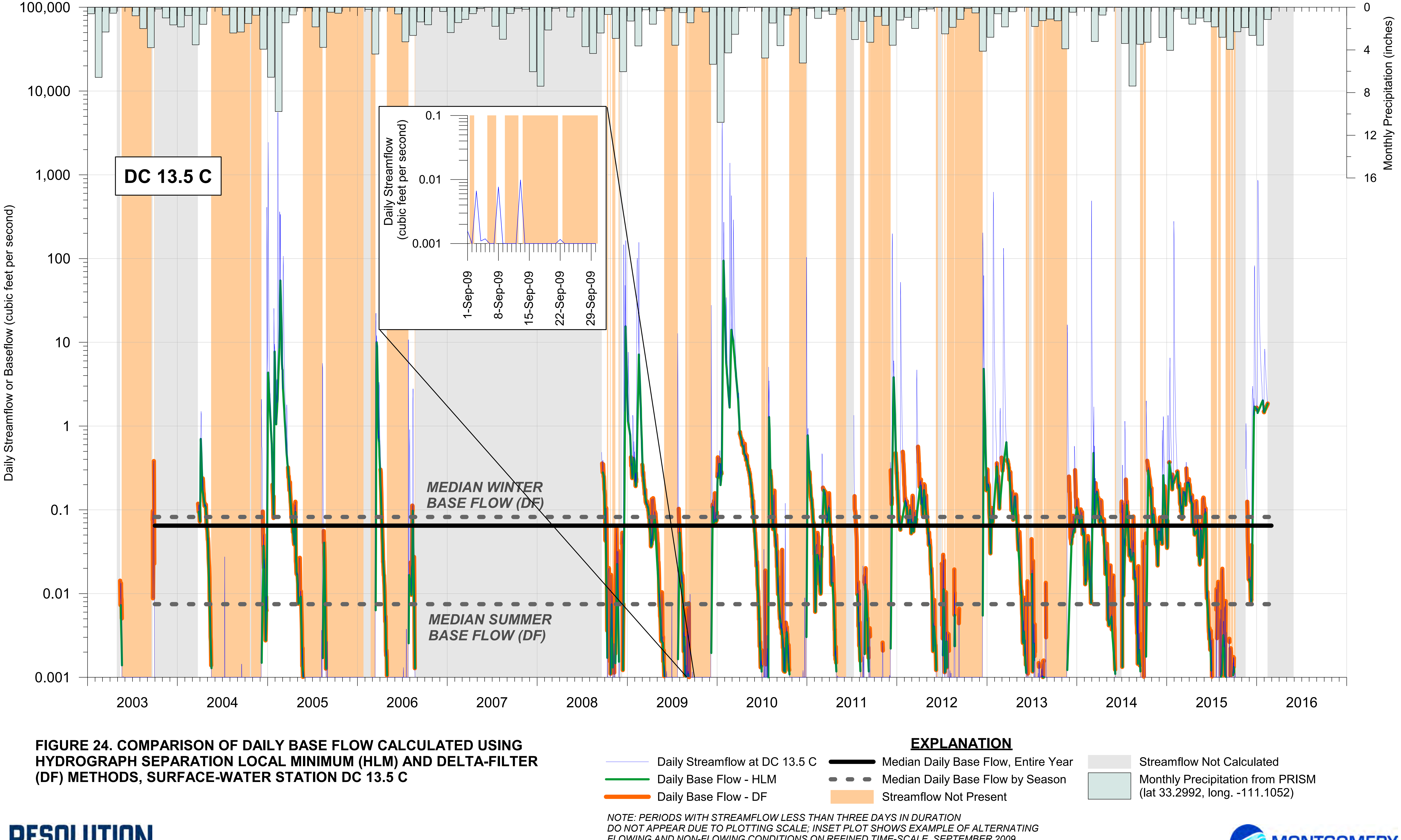


FIGURE 24. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, SURFACE-WATER STATION DC 13.5 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

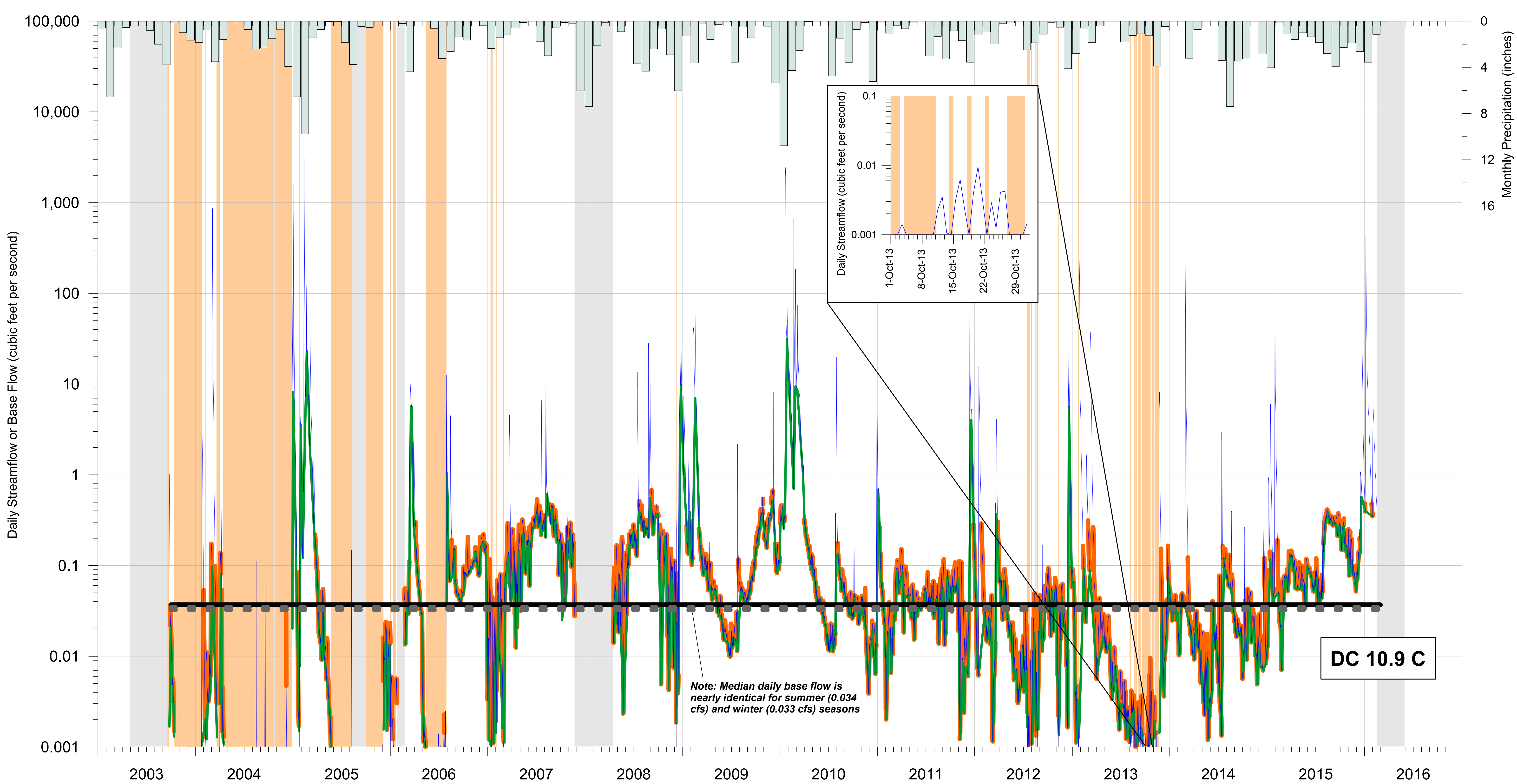


FIGURE 25. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, SURFACE-WATER STATION DC 10.9 C.

EXPLANATION

- Daily Streamflow at DC 10.9 C
- Daily Base Flow - HLM
- Daily Base Flow - DF
- Median Daily Base Flow, Entire Year
- Median Daily Base Flow by Season
- Streamflow Not Present
- Streamflow Not Calculated
- Monthly Precipitation from PRISM (lat. 33.2992, long. -111.1052)

NOTE: PERIODS WITH STREAMFLOW LESS THAN THREE DAYS IN DURATION DO NOT APPEAR DUE TO PLOTTING SCALE; INSET PLOT SHOWS EXAMPLE OF ALTERNATING FLOWING AND NON-FLOWING CONDITIONS ON REFINED TIME-SCALE, OCTOBER 2013

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

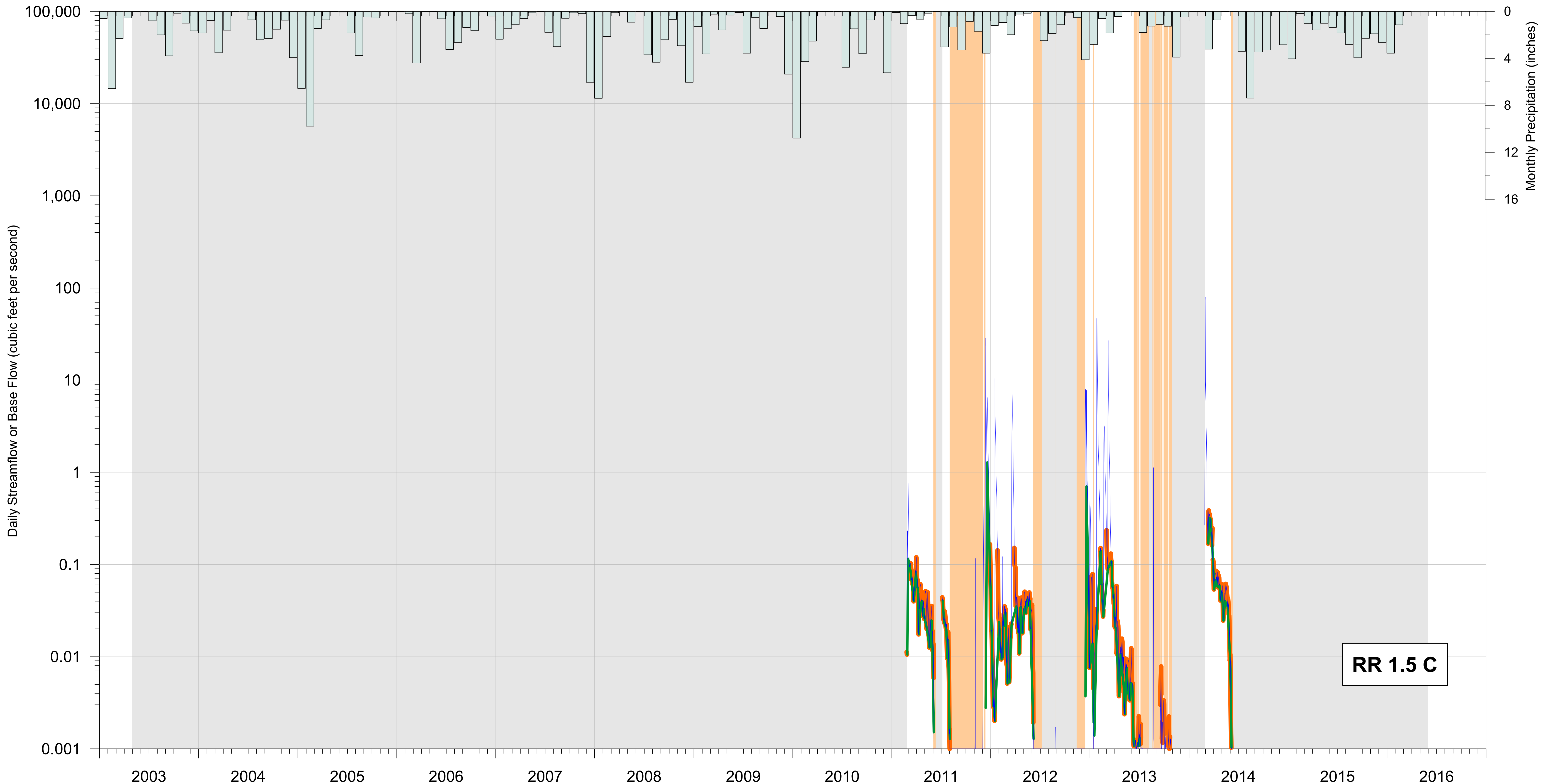


FIGURE 26. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, SURFACE-WATER STATION RR 1.5 C

EXPLANATION

- Daily Streamflow at RR 1.5 C
- Daily Base Flow - HLM
- Daily Base Flow - DF
- Streamflow Not Present
- Streamflow Not Calculated
- Monthly Precipitation from PRISM (lat. 33.2992, long. -111.1052)

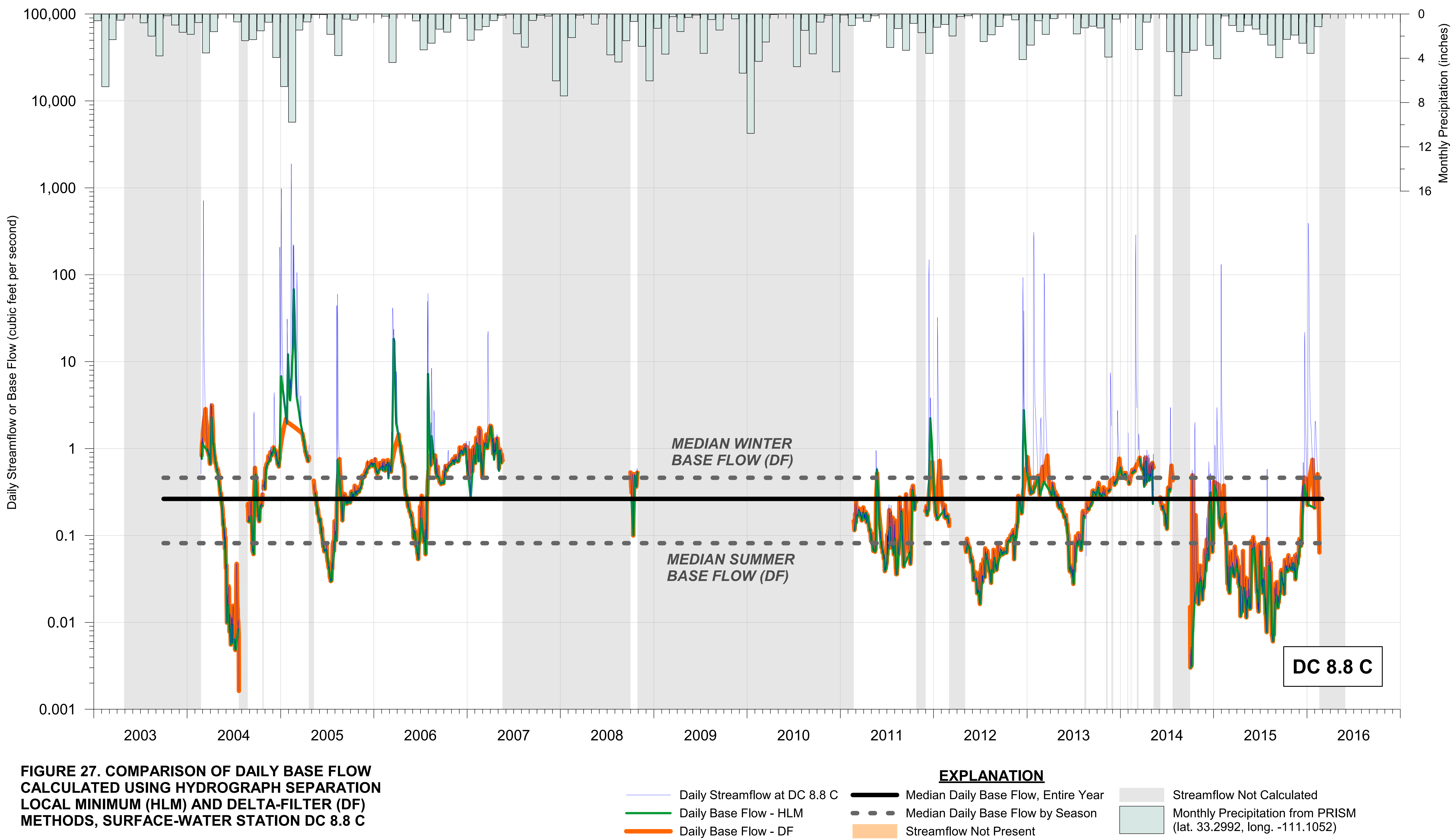


FIGURE 27. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, SURFACE-WATER STATION DC 8.8 C

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

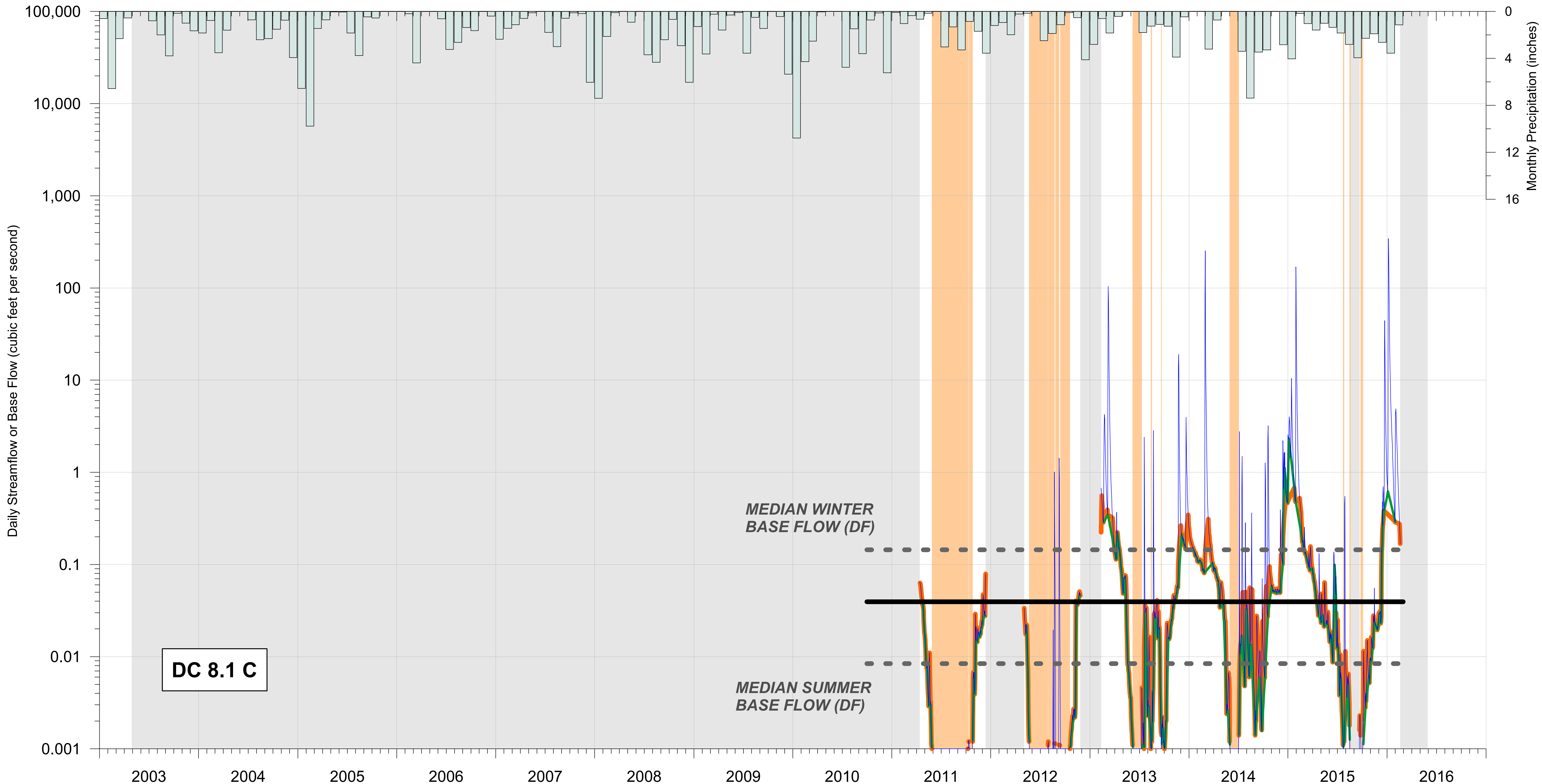


FIGURE 28. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, SURFACE-WATER STATION DC 8.1 C

EXPLANATION

- Daily Streamflow at DC 8.1 C
- Daily Base Flow - HLM
- Daily Base Flow - DF
- Median Daily Base Flow, Entire Year
- Median Daily Base Flow by Season
- Streamflow Not Present
- Streamflow Not Calculated
- Monthly Precipitation from PRISM (lat 33.2992, long. -111.1052)

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

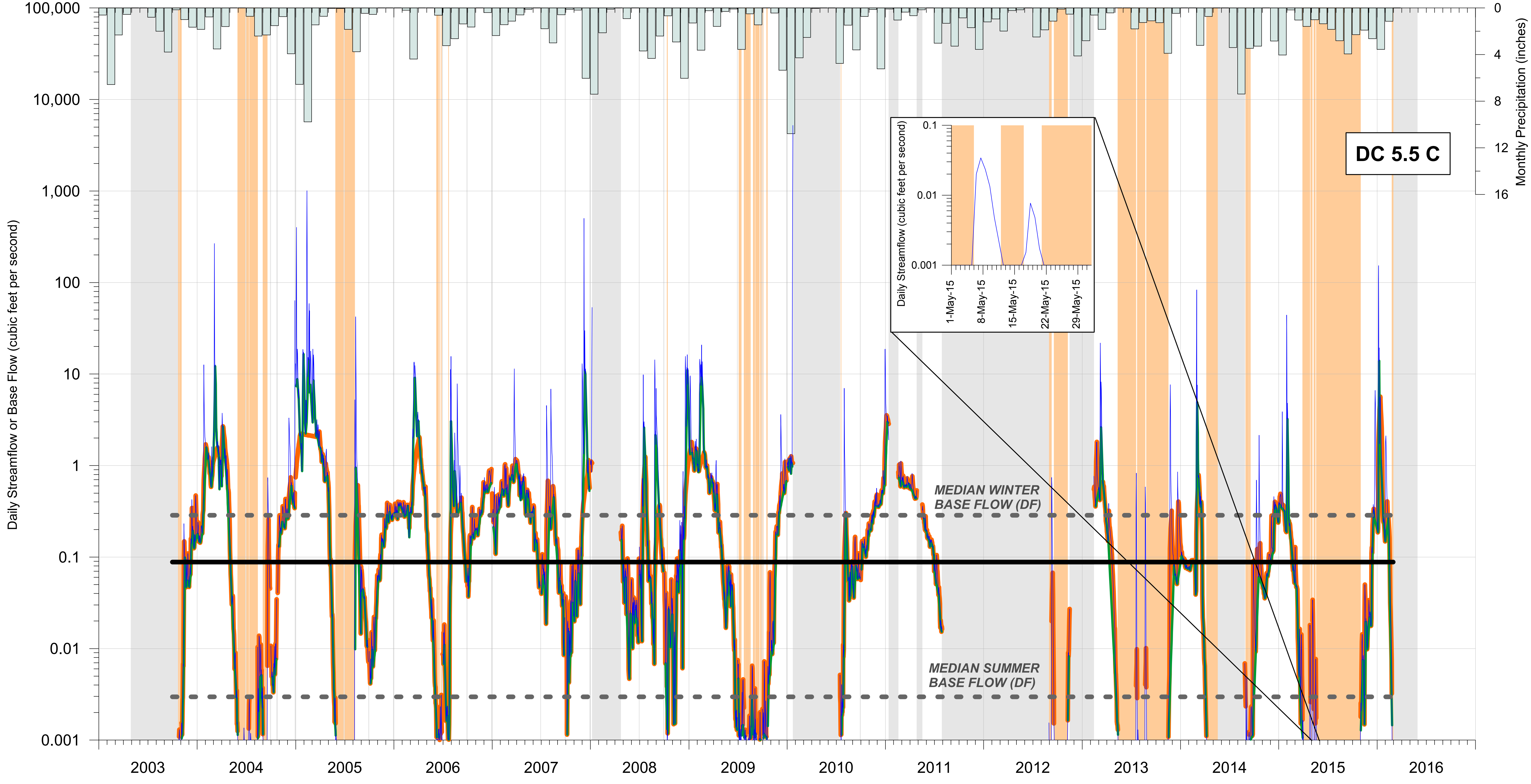


FIGURE 29. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, SURFACE-WATER STATION DC 5.5 C

EXPLANATION

Daily Streamflow at DC 5.5 C
Daily Base Flow - HLM
Daily Base Flow - DF
Median Daily Base Flow, Entire Year
Median Daily Base Flow by Season
Streamflow Not Present
Streamflow Not Calculated
Monthly Precipitation from PRISM (lat 33.2992, long -111.1052)

NOTE: PERIODS WITH STREAMFLOW LESS THAN THREE DAYS IN DURATION DO NOT APPEAR DUE TO PLOTTING SCALE; INSET PLOT SHOWS EXAMPLE OF ALTERNATING FLOWING AND NON-FLOWING CONDITIONS ON REFINED TIME-SCALE, MAY 2015

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

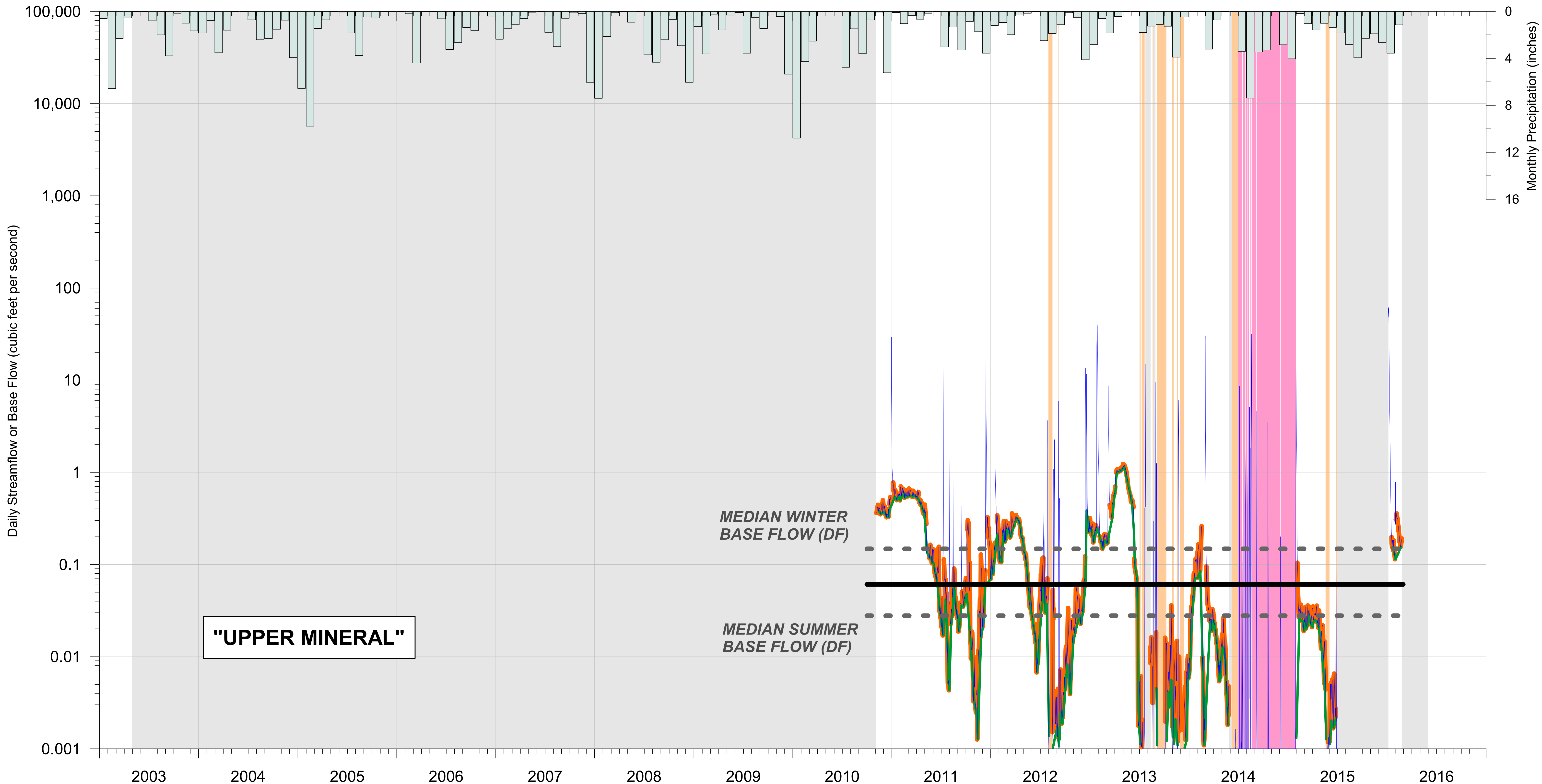


FIGURE 30. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, SUFACE WATER STATION "UPPER MINERAL"

EXPLANATION

- Daily Streamflow at Upper Mineral Creek
- Daily Base Flow - HLM
- Daily Base Flow - DF
- Median Daily Base Flow, Entire Year
- Median Daily Base Flow by Season
- Streamflow Not Present
- Streamflow Not Calculated
- Sensor Drift in Record
- Monthly Precipitation from PRISM (lat. 33.2992, long. -111.1052)

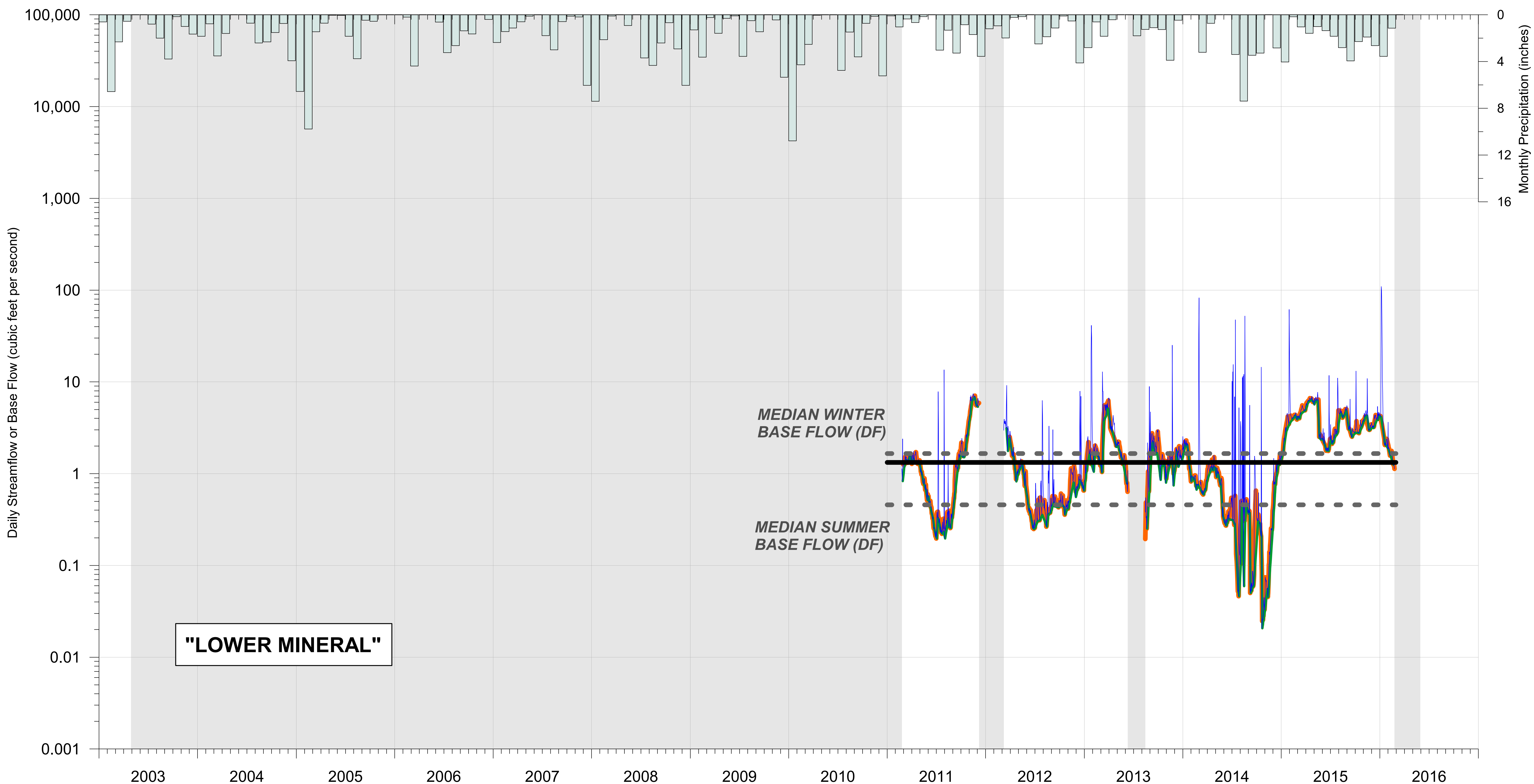


FIGURE 31. COMPARISON OF DAILY BASE FLOW CALCULATED USING HYDROGRAPH SEPARATION LOCAL MINIMUM (HLM) AND DELTA-FILTER (DF) METHODS, "LOWER MINERAL" (MC 3.3 C)

EXPLANATION

- Daily Streamflow at MC 3.3 C
- Daily Base Flow - HLM
- Daily Base Flow - DF
- Median Daily Base Flow, Entire Year
- Median Daily Base Flow by Season
- Streamflow Not Calculated
- Monthly Precipitation from PRISM (lat. 33.2992, long. -111.1052)

RESOLUTION COPPER

MONTGOMERY & ASSOCIATES

Appendix A

Surface Water and Spring Flow Rates, Resolution Project

APPENDIX A-1. SURFACE WATER AND SPRING FLOW RATES
RESOLUTION PROJECT

Station Name	Station Type	Date	Measured Flow Rate: Flow (gpm)[c]	Measured Flow Rate: Flow (cfs)[d]	Measured Flow Rate: Notes	Estimated Flow Rate: Flow (gpm)[c]	Estimated Flow Rate: Flow (cfs)[d]	Estimated Flow Rate: Notes
QUEEN CREEK WATERSHED								
Pump Station Spring	Spring	15-May-03	3	0.01	Cutthroat Flume			
		4-Sep-03				1	0.002	Unknown
		3-Nov-03				1	0.003	Visual Estimate
		9-Feb-04				1	0.003	Visual Estimate
		25-May-04				1	0.002	Visual Estimate
		3-Aug-04				<1.6	<0.004	Visual Estimate
		3-Nov-04				0	0.001	Visual Estimate
		8-Feb-05	46	0.10	Cutthroat Flume			
		4-May-05	20	0.05	Cutthroat Flume			
		8-Aug-05				5	0.011	Visual Estimate
		5-Aug-08				<1.6	<0.004	Visual Estimate
		4-Nov-08				<1.6	<0.004	Visual Estimate
		17-Feb-09	2,800	6.25	Pygmy Meter			
		12-May-09				1	0.002	Visual Estimate
		11-Aug-09	0	0	est. 3 gal (stagnant)			
		16-Feb-10				15	0.033	Unknown
		15-Jul-10	10	0.02	Cutthroat Flume			
		3-Nov-10	0	0	Dry at sample station			
		16-May-11	0	0	est. 26 gal (stagnant)			
		9-May-12	0	0	est. 21 gal (stagnant)			
		3-Mar-14			After large storm event	45	0.100	Visual Estimate
		14-May-14	0	0	Dry			
		26-Aug-14	0	0	Dry			
		17-Nov-14	0	0	Dry			
QC 27.3 C	Channel	8-Feb-05	73	0.16	Cutthroat Flume			
		4-May-05	8	0.02	Cutthroat Flume			
		5-Aug-08	0	0	Observation			
		4-Nov-08				<1.6	<0.004	Visual Estimate
		17-Feb-09	5,300	11.83	Pygmy Meter			
		7-May-09	0	0	Observation			
		3-Nov-10	0	0	est. 1,000 gal (stagnant)			
		16-May-11	0	0	est. 4,500 gal (stagnant)			
		19-Aug-11				5	0.011	Visual Estimate
		1-Dec-11	0	0	Observation			
		29-Feb-12	0	0	Observation			
		9-May-12	0	0	est. 3,200 gal (stagnant)			
		9-Jun-14	0	0	Dry			
		26-Aug-14	0	0	Dry			
		17-Nov-14	0	0	Dry			
Oak Flat Tributary	Tributary	27-Aug-08	1,500	3.35	Pygmy Meter			
		26-Feb-09	20	0.05	Cutthroat Flume			
		5-May-09	0	0	Observation			
		4-Aug-09	0	0	Dry			
		13-Feb-10				30	0.067	Visual Estimate
		19-Aug-11				3	0.007	Visual Estimate
		9-Dec-11	0	0	Observation			
		29-Feb-12				4	0.009	Visual Estimate
		1-Mar-12				4	0.009	Visual Estimate
		9-Jun-14	0	0	Dry			
		18-Aug-14	0	0	Dry			
		17-Nov-14	0	0	Dry			
Number 9 Tributary	Tributary	28-Aug-08	530	1.18	Pygmy Meter			
		12-Nov-08	0	0	Observation			
		19-Feb-09	1,000	2.23	Pygmy Meter			
		5-May-09				<1.6	<0.004	Visual Estimate
		13-Feb-10				35	0.078	Visual Estimate
		14-Jul-10	0	0	est. 100 gal (stagnant)			
		1-Nov-10				0.1	0.000	Visual Estimate
		3-Nov-10	0	0	est. 240 gal (stagnant)			
		21-Feb-11				1	0.002	Visual Estimate
		16-May-11	0	0	est. 2,000 gal (upper pool), 3,000 gal (lower pool) both stagnant			
		19-Aug-11				0.1	0.000	Visual Estimate
		1-Dec-11	0	0	Observation			
		29-Feb-12				3	0.007	Visual Estimate
		9-May-12	0	0	est. 500 gal (stagnant)			
		18-Aug-14				2	0.004	Visual Estimate

APPENDIX A-1. SURFACE WATER AND SPRING FLOW RATES
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Station Name	Station Type	Date	Measured Flow Rate: Flow (gpm)[c]	Measured Flow Rate: Flow (cfs)[d]	Measured Flow Rate: Notes	Estimated Flow Rate: Flow (gpm)[c]	Estimated Flow Rate: Flow (cfs)[d]	Estimated Flow Rate: Notes
QUEEN CREEK WATERSHED								
Upper Carbonate	Channel	4-Aug-09	0	0	est. 240 gal (stagnant)			
		14-Jul-10	0	0	est. 2,000 gal (stagnant)			
		1-Nov-10				1	0.002	Visual Estimate
		21-Feb-11				3	0.007	Visual Estimate
		23-Aug-11	0	0	Stagnant pool upstream from transducer			
		10-Mar-14			After large storm event	100	0.223	Visual Estimate
		5-Jun-14			Stagnant pool upstream from transducer	0.0	0.000	Visual Estimate
		21-Aug-14				<1	<0.003	Visual Estimate
		3-Nov-14				30	0.067	Visual Estimate
Boulder Hole	Spring	22-May-03	0	0	Observation			
		4-Sep-03	0	0	Observation			
		3-Nov-03	0	0	Observation			
		9-Feb-04	16	0.04	Container/Stopwatch			
		24-May-04	0	0	Observation			
		3-Aug-04	0	0	Observation			
		3-Nov-04	0	0	Observation			
		8-Feb-05				95	0.212	Visual Estimate
		4-May-05	0	0	Observation			
		6-Aug-08	0	0	Observation			
		6-Nov-08				<1.6	<0.004	Visual Estimate
		19-Feb-09	3,400	7.59	Pygmy Meter			
		7-May-09	0	0	Observation			
		4-Aug-09	0	0	est. <10 gal (stagnant)			
		13-Feb-10				45	0.100	Visual Estimate
		1-Nov-10	0	0	est. 35 gal (stagnant)			
		21-Feb-11	0	0	est. 1,000 gal (stagnant)			
		2-May-12	0	0	est. 400 gal (stagnant)			
		3-Mar-14			After large storm event	100	0.223	Visual Estimate
		5-Jun-14	0	0	Dry			
		21-Aug-14	0	0	Dry			
		3-Nov-14				15	0.033	Visual Estimate
QC 22.6 E	Spring	8-Feb-05	29	0.07	Cutthroat Flume			
		28-Aug-08	31	0.07	Cutthroat Flume			
		11-Feb-09	50	0.11	Cutthroat Flume			
		13-Feb-10				10	0.022	Visual Estimate
		27-Feb-12				3	0.007	Visual Estimate
		4-Mar-14			After large storm event	<1	<0.001	Visual Estimate
		5-Jun-14	0	0	Dry			
		21-Aug-14	0	0	Dry			
		3-Nov-14	0	0	Dry			
QC 21.7 C	Channel	28-Aug-08	1,700	3.79	Pygmy Meter			
		4-Nov-08				<1.6	<0.004	Visual Estimate
		11-Feb-09	25,000	55.80	Pygmy Meter			
		7-May-09	0	0	Observation			
		4-Aug-09	0	0	Dry			
		13-Feb-10	0	0	NA			
		19-Aug-11				0.1	0	Visual Estimate
		28-Nov-11	0	0	est. 240 gal (stagnant)			
		27-Feb-12	0	0	Observation			
		2-May-12	0	0	est. 740 gal (stagnant)			
		14-Aug-12	0	0	Observation			
		9-Jun-14	0	0	Dry			
		21-Aug-14	0	0	Dry			
		3-Nov-14	0	0	Dry			
QC 19.7 C	Channel	28-Aug-08	410	0.92	Pygmy Meter			
		11-Feb-09				10,800	24.062	Unknown
		4-Aug-09	0	0	Dry			
		14-Dec-11				8,500	18.938	Visual Estimate
		3-Mar-14			After large storm event	450	1.003	Visual Estimate
		9-Jun-14	0	0	Dry			
		15-Aug-14	0	0	Dry			
		9-Oct-14				200	0.446	Visual Estimate

APPENDIX A-1. SURFACE WATER AND SPRING FLOW RATES
RESOLUTION PROJECT

Station Name	Station Type	Date	Measured Flow Rate: Flow (gpm)[c]	Measured Flow Rate: Flow (cfs)[d]	Measured Flow Rate: Notes	Estimated Flow Rate: Flow (gpm)[c]	Estimated Flow Rate: Flow (cfs)[d]	Estimated Flow Rate: Notes
DEVILS CANYON WATERSHED								
IC 1.0 C	Tributary	28-Aug-08	4	0.01	Cutthroat Flume			
		17-Feb-09	6,500	14.51	Pygmy Meter			
		12-May-09				0.1	0	Visual Estimate
		7-Aug-09				<1.6	<0.004	Visual Estimate
		17-Feb-10				30	0.067	Unknown
		9-Dec-11	0	0.00	Observation			
		1-Mar-12				5	0.011	Visual Estimate
		21-Feb-14	0	0	Dry	0	0.000	Visual Estimate
		23-May-14	0	0	Dry			
		15-Aug-14	0	0	Dry			
		14-Nov-14	0	0	Dry			
DC 15.5 C	Channel	5-Aug-08	4	0.01	Cutthroat Flume			
		12-Nov-08	0	0	Observation			
		26-Feb-09	490	1.09	Pygmy Meter			
		5-May-09	2	0.00	Cutthroat Flume			
		8-Nov-10	0	0	est. 3,000 gal (stagnant)			
		22-Aug-11	0	0	est. 15,000 gal (stagnant)			
		29-Nov-11	0	0	est. 7,400 gal (stagnant)			
		1-Mar-12				15	0.033	Visual Estimate
		9-May-12	0	0	est. 10,000 gal (stagnant)			
		7-Mar-14			After large storm event	75	0.167	Visual Estimate
		3-Jun-14			Stagnant pool	0	0	Visual Estimate
		11-Aug-14			Stagnant pool	0	0	Visual Estimate
		14-Nov-14			Stagnant pool	0	0	Visual Estimate
DC 15.2 C	Channel	9-May-05	7	0.02	Cutthroat Flume			
		10-Aug-05	0	0	Observation			
		7-Mar-14			After large storm event	25	0.056	Visual Estimate
		3-Jun-14	0	0	Dry			
		11-Aug-14	0	0	Dry			
		14-Nov-14	0	0	Dry			
DC 14.7 C	Channel	5-Mar-04				>950	>2.117	Visual Estimate
		9-Mar-04	6,600	14.73	Pygmy Meter			
		27-Aug-08	3,200	7.14	Pygmy Meter			
		17-Feb-10				77	0.173	Unknown
		3-Mar-14			After large storm event	500	1.114	Visual Estimate
		3-Jun-14	0	0	Dry			
		15-Aug-14	0	0	Dry			
		14-Nov-14	0	0	Dry			
DC 13.5 C	Channel	30-May-03				2	0.005	Visual Estimate
		27-Aug-03				0	0.001	Unknown
		5-Nov-03				2	0.006	Visual Estimate
		11-Feb-04	50	0.11	Cutthroat Flume			
		24-Mar-04	450	1.00	Pygmy Meter			
		6-Apr-04	2,800	6.25	Pygmy Meter			
		26-May-04	3	0.01	Cutthroat Flume			
		15-Feb-05	27,000	60.27	Pygmy Meter			
		9-May-05	6	0.01	Cutthroat Flume			
		10-Aug-05				35	0.078	Visual Estimate
		21-Aug-08	1	0.00	Cutthroat Flume			
		12-Nov-08	1	0.00	Container/Stopwatch			
		19-Feb-09	7,000	15.63	Pygmy Meter			
		21-May-09				3	0.007	Visual Estimate
		17-Feb-10	75	0.17	Pygmy Meter			
		26-May-10	20	0.05	Cutthroat Flume			
		15-Aug-10	31	0.07	Cutthroat Flume			
		2-Nov-10	1	0.00	Container/Stopwatch			
		12-May-11	10	0.02	Cutthroat Flume			
		22-Aug-11				5	0.011	Visual Estimate
		27-Apr-12				50	0.111	Visual Estimate
		21-Feb-14				2	0.003	Visual Estimate
		16-May-14				7	0.016	Visual Estimate
		27-Aug-14				5	0.011	Visual Estimate
		13-Nov-14				7	0.016	Visual Estimate

APPENDIX A-1. SURFACE WATER AND SPRING FLOW RATES
RESOLUTION PROJECT

Station Name	Station Type	Date	Measured Flow Rate: Flow (gpm)[c]	Measured Flow Rate: Flow (cfs)[d]	Measured Flow Rate: Notes	Estimated Flow Rate: Flow (gpm)[c]	Estimated Flow Rate: Flow (cfs)[d]	Estimated Flow Rate: Notes
DEVILS CANYON WATERSHED								
DC 10.9 C	Channel	16-May-03	23	0.05	Cutthroat Flume			
		27-Aug-03				1	0.002	Visual Estimate
		5-Nov-03	18	0.04	Cutthroat Flume			
		11-Feb-04	29	0.07	Cutthroat Flume			
		9-Mar-04	8,000	17.86	Pygmy Meter			
		27-May-04	13	0.03	Cutthroat Flume			
		11-Aug-04				1	0.002	Unknown
		5-Nov-04	3	0.01	Cutthroat Flume			
		15-Feb-05	32,000	71.43	Pygmy Meter			
		9-May-05	15	0.03	Cutthroat Flume			
		2-Nov-10				5	0.011	Visual Estimate
		27-Apr-12				48	0.107	Visual Estimate
		20-Feb-14				20	0.045	Visual Estimate
		16-May-14				13	0.029	Visual Estimate
		27-Aug-14				10	0.022	Visual Estimate
		13-Nov-14				15	0.033	Visual Estimate
RR 1.5 C	Tributary	19-Aug-08				<1.6	<0.004	Visual Estimate
		5-Nov-08				0.1	0	Visual Estimate
		26-Feb-09	29	0.07	Cutthroat Flume			
		21-May-09				3	0.007	Unknown
		18-Feb-10	8	0.02	Cutthroat Flume			
		2-Nov-10				0	0	Visual Estimate
		28-Jun-11	4	0.01	Cutthroat Flume			
		9-Dec-11				2	0.006	Visual Estimate
		5-Mar-12	2	0.01	Cutthroat Flume			
		27-Apr-12				5	0.011	Visual Estimate
		27-Aug-12				0.1	0	Visual Estimate
		20-Feb-14				<1	<0.003	Visual Estimate
		22-May-14				2	0.003	Visual Estimate
		26-Sep-14				1	0.002	Visual Estimate
		5-Nov-14				3	0.007	Visual Estimate
DC 8.8 C	Channel	20-May-03	13	0.03	Cutthroat Flume			
		21-Aug-03				3	0.007	Unknown
		12-Nov-03	24	0.05	Cutthroat Flume			
		17-Feb-04	84	0.19	Cutthroat Flume			
		6-Apr-04	3,000	6.70	Pygmy Meter			
		21-May-04	13	0.03	Cutthroat Flume			
		16-Aug-04	5	0.01	Cutthroat Flume			
		16-Nov-04	17	0.04	Cutthroat Flume			
		25-Feb-05	33,000	73.66	Pygmy Meter			
		11-May-05	20	0.05	Cutthroat Flume			
		16-Aug-05	1	0.00	Container/Stopwatch			
		24-Feb-09	1,400	3.13	Pygmy Meter			
		3-May-12				40	0.089	Visual Estimate
		13-Mar-14			Flowing but rate not measured			
		6-Jun-14			Flowing but rate not measured			
		19-Sep-14				20	0.045	Visual Estimate
		21-Nov-14				15	0.033	Visual Estimate
H 0.1 C	Tributary	19-Aug-08				<1.6	<0.004	Visual Estimate
		5-Nov-08				<1.6	<0.004	Visual Estimate
		24-Feb-09	60	0.13	Cutthroat Flume			
		19-May-09	0	0	Observation			
		12-Aug-09				0.1	0	Visual Estimate
		10-Nov-10				0.1	0	Visual Estimate
		31-Aug-11				<1.6	<0.004	Visual Estimate
		30-Nov-11	0	0	Observation			
		2-Mar-12				3	0.007	Visual Estimate
		15-Aug-12	0	0	Observation			
		27-Feb-14				1	0.001	Visual Estimate
		29-May-14	0	0	Stagnant pool	0	0	Visual Estimate
		3-Sep-14	0	0	Stagnant pool	0	0	Visual Estimate
		21-Nov-14				1	0.001	Visual Estimate

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Station Name	Station Type	Date	Measured Flow Rate: Flow (gpm)[c]	Measured Flow Rate: Flow (cfs)[d]	Measured Flow Rate: Notes	Estimated Flow Rate: Flow (gpm)[c]	Estimated Flow Rate: Flow (cfs)[d]	Estimated Flow Rate: Notes
DEVILS CANYON WATERSHED								
DC 8.2 W	Spring	20-May-03	11	0.02	Cutthroat Flume			
		21-Aug-03				11	0.024	Unknown
		12-Nov-03	8	0.02	Cutthroat Flume			
		17-Feb-04	11	0.02	Cutthroat Flume			
		21-May-04	12	0.03	Cutthroat Flume			
		16-Aug-04	9	0.02	Cutthroat Flume			
		16-Nov-04	2	0.00	Cutthroat Flume			
		25-Feb-05				3	0.007	Visual Estimate
		11-May-05				10	0.022	Visual Estimate
		16-Aug-05				1	0.002	Visual Estimate
		5-Nov-08				1	0.002	Visual Estimate
		19-May-09				10	0.022	Unknown
		10-Nov-10				<1	<0.003	Visual Estimate
		3-May-12				5	0.011	Visual Estimate
		27-Feb-14				2	0.004	Visual Estimate
		29-May-14				2	0.004	Visual Estimate
		3-Sep-14				5	0.011	Visual Estimate
		21-Nov-14				5	0.011	Visual Estimate
DC 8.1 C	Channel	6-Aug-08	22	0.05	Cutthroat Flume			
		5-Nov-08				28	0.061	Unknown
		24-Feb-09	1,900	4	Pygmy Meter			
		19-May-09	13	0.03	Cutthroat Flume			
		10-Nov-10				60	0.134	Visual Estimate
		31-Aug-11				30	0.067	Visual Estimate
		30-Nov-11				35	0.078	Visual Estimate
		2-Mar-12				200	0.446	Visual Estimate
		3-May-12				50	0.111	Visual Estimate
		15-Aug-12				10	0.022	Visual Estimate
		27-Feb-14				25	0.056	Visual Estimate
		29-May-14	0	0	Flowing but rate not measured			
		3-Sep-14				17	0.038	Visual Estimate
		21-Nov-14				17	0.038	Visual Estimate
DC 7.1 C	Channel	29-May-03	4	0.01	Cutthroat Flume			
		4-Nov-03	15	0.03	Cutthroat Flume			
		18-Feb-04	100	0.22	Cutthroat Flume			
		5-May-04	30	0.07	Cutthroat Flume			
		19-Aug-04	31	0.07	Cutthroat Flume			
		12-Nov-04	50	0.11	Cutthroat Flume			
		16-Feb-05	30,000	67	Pygmy Meter			
		17-May-05	11	0.02	Cutthroat Flume			
		7-Sep-05	3	0.01	Cutthroat Flume			
		30-Nov-11				32	0.072	Visual Estimate
		4-May-12				75	0.167	Visual Estimate
		27-Feb-14				100	0.223	Visual Estimate
		29-May-14				1	0.002	Visual Estimate
		3-Sep-14				10	0.022	Visual Estimate
		7-Nov-14	0	0	Flow rate not estimated			
DC 6.6 W (DCT 6.6 W)	Spring in tributary	29-May-03				0	0.001	Unknown
		3-Sep-03				0	0.001	Unknown
		4-Nov-03				1	0.003	Visual Estimate
		18-Feb-04	1	0.00	Container/Stopwatch			
		5-May-04				0	0.001	Visual Estimate
		19-Aug-04	0	0	Container/Stopwatch			
		12-Nov-04	1	0.00	Container/Stopwatch			
		16-Feb-05	32	0.07	Cutthroat Flume; flow likely includes surface water runoff following large precipitation event			
		17-May-05				0	0.001	Visual Estimate
		7-Sep-05	0	0	Observation			
		4-May-12				2	0.004	Visual Estimate
		27-Feb-14				1	0.001	Visual Estimate
		25-Sep-14				0.1	0.000	Visual Estimate
		7-Nov-14				1	0.002	Visual Estimate

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Station Name	Station Type	Date	Measured Flow Rate: Flow (gpm)[c]	Measured Flow Rate: Flow (cfs)[d]	Measured Flow Rate: Notes	Estimated Flow Rate: Flow (gpm)[c]	Estimated Flow Rate: Flow (cfs)[d]	Estimated Flow Rate: Notes
DEVILS CANYON WATERSHED								
DC 6.14 C	Channel	20-Aug-08				3	0.007	Visual Estimate
		12-Nov-08	22	0.05	Cutthroat Flume; 90% capture			
		18-Feb-09	24,000	54	Pygmy Meter			
		6-May-09	3	0.01	Cutthroat Flume; 75% capture			
		12-Aug-09	0	0	No flow into Upper Crater Tank			
		30-Nov-11				40	0.089	Visual Estimate
		2-Mar-12				110	0.245	Visual Estimate
		4-May-12				70	0.156	Visual Estimate
		27-Feb-14				100	0.223	Visual Estimate
		29-May-14				7	0.016	Visual Estimate
		25-Sep-14				17	0.038	Visual Estimate
		7-Nov-14				55	0.123	Visual Estimate
DC 6.1 E	Spring	20-May-04				2	0.004	Visual Estimate
		23-Aug-04	1	0.00	Container/Stopwatch			
		18-Nov-04				2	0.004	Visual Estimate
		28-Feb-05	0	0	Observation			
		24-May-05				0	0.001	Visual Estimate
		23-Aug-05	0	0	Observation			
		7-Aug-08				1	0.002	Visual Estimate
		6-Nov-08	0	0	Observation			
		20-May-09				3	0.007	Unknown
		19-Mar-10				1	0.003	Unknown
		19-Oct-10				5	0.011	Visual Estimate
		10-Nov-10				80	0.178	Visual Estimate
		15-Aug-12	0	0	Observation			
DC 5.5 C	Channel	10-Nov-03	22	0.05	Cutthroat Flume			
		25-Feb-04	500	1.12	Pygmy Meter			
		20-May-04	11	0.03	Cutthroat Flume			
		23-Aug-04	9	0.02	Cutthroat Flume			
		18-Nov-04	60	0.13	Cutthroat Flume			
		28-Feb-05	10,500	23.44	Pygmy Meter			
		24-May-05	18	0.04	Cutthroat Flume			
		23-Aug-05	40	0.09	Cutthroat Flume			
		25-Feb-09	1,400	3.13	Pygmy Meter			
		19-Mar-10	1,600	3.57	Pygmy Meter			
		16-Jul-10				10	0.022	Visual Estimate
		19-Oct-10				7	0.016	Visual Estimate
		26-Aug-11				5	0.011	Visual Estimate
		6-Mar-12				160	0.356	Visual Estimate
		25-Feb-14				75	0.167	Visual Estimate
		20-May-14				6	0.013	Visual Estimate
		28-Aug-14				15	0.033	Visual Estimate
		25-Nov-14				35	0.078	Visual Estimate
DC 4.1 E	Spring	21-May-03	0	0	Observation			
		26-Aug-03	0	0	Observation			
		11-Nov-03	0	0	Observation			
		10-Feb-04				1	0.003	Visual Estimate
		20-May-14				2	0.004	Visual Estimate
		28-Aug-14				3	0.007	Visual Estimate
		25-Nov-14				2	0.003	Visual Estimate
MINERAL CREEK WATERSHED								
Government Springs	Spring	18-Mar-10				3	0.007	Visual Estimate
		8-Dec-11	0	0	Observation			
		28-Feb-12	0	0	Observation			
		23-Sep-14	0	0	Observation			
		11-Nov-14	0	0	No visible flow			
MC 8.4 C	Channel	13-Nov-08	18	0.04	Cutthroat Flume			
		5-Mar-09	60	0.13	Cutthroat Flume			
		14-May-09	200	0.45	Cutthroat Flume; 95% capture			
		6-Aug-09				1	0.002	Visual Estimate
		15-Dec-09	3	0.01	Cutthroat Flume			
		15-Feb-10	400	0.89	Cutthroat Flume; 70% capture			
		18-Mar-10	2,000	4.46	Pygmy Meter			
		19-Jul-10	200	0.45	Cutthroat Flume			
		4-Nov-10	32	0.07	Cutthroat Flume; 95% capture			
		24-Feb-11	21	0.05	Cutthroat Flume; 95% capture			
		31-May-11				1	0.002	Visual Estimate
		8-Dec-11				0	0.001	Visual Estimate
		8-May-12				10	0.022	Visual Estimate
		18-Feb-14	0	0	Dry	0	0	Visual Estimate
		27-May-14	0	0	Dry			
		23-Sep-14	0	0	Dry			
		11-Nov-14	0	0	Dry			

APPENDIX A-1. SURFACE WATER AND SPRING FLOW RATES
RESOLUTION PROJECT

Station Name	Station Type	Date	Measured Flow Rate: Flow (gpm)[c]	Flow (cfs)[d]	Notes	Estimated Flow Rate: Flow (gpm)[c]	Flow (cfs)[d]	Notes
MINERAL CREEK WATERSHED								
LF 0.2 C	Channel	13-Nov-08	16	0.04	Cutthroat Flume			
		5-Mar-09	300	0.67	Pygmy Meter			
		14-May-09	26	0.06	Cutthroat Flume; 90% capture			
		6-Aug-09	0	0.00	Confluence dry			
		15-Dec-09	0	0.00	Observation			
		15-Feb-10	46	0.10	Cutthroat Flume			
		18-Mar-10	1,900	4.24	Pygmy Meter			
		19-Jul-10	78	0.17	Cutthroat Flume			
		4-Nov-10	38	0.08	Cutthroat Flume			
		24-Feb-11				5	0.011	Visual Estimate
		31-May-11				5	0.011	Visual Estimate
		29-Aug-11				15	0.033	Visual Estimate
		8-May-12				5	0.011	Visual Estimate
		23-Sep-14	0	0	Dry			
		11-Nov-14	0	0	Dry			
Upper Mineral Transducer	Channel	24-Feb-11	200	0.45	Cutthroat Flume			
		31-May-11	49	0.11	Cutthroat Flume			
		28-Feb-12	78	0.17	Cutthroat Flume			
		8-May-12	63	0.14	Cutthroat Flume			
		18-Feb-14	49	0.11	Flume			
		27-May-14				20	0.045	Visual Estimate
		23-Sep-14				20	0.045	Visual Estimate
		11-Nov-14				30	0.067	Visual Estimate
MC 5.2 C	Channel	31-May-11	68	0.15	Cutthroat Flume			
		29-Aug-11	68	0.15	Cutthroat Flume			
		8-Dec-11	90	0.20	Cutthroat Flume			
		28-Feb-12	160	0.36	Cutthroat Flume			
		8-May-12	100	0.22	Cutthroat Flume			
		22-Aug-12				180	0.401	Visual Estimate
		18-Feb-14				90	0.200	Visual Estimate
		27-May-14				20	0.045	Visual Estimate
		23-Sep-14				25	0.056	Visual Estimate
		11-Nov-14				30	0.067	Visual Estimate
MC 3.4 W	Spring	13-Nov-08				1	0.003	Visual Estimate
		5-Mar-09	3	0.01	Container/Stopwatch			
		14-May-09	2	0.00	Observation			
		6-Aug-09				2	0.004	Visual Estimate
		15-Feb-10				1	0.002	Visual Estimate
		18-Mar-10				5	0.011	Visual Estimate
		4-Nov-10	135	0.30	Pygmy Meter			
		24-Feb-11	5	0.01	Observation			
		31-May-11	5	0.01	Observation			
		29-Aug-11	2	0.00	Observation			
		8-May-12	5	0.01	Observation			
		18-Feb-14				1	0.001	Visual Estimate
		27-May-14				<1	<0.003	Visual Estimate
		23-Sep-14				<1	<0.003	Visual Estimate
		11-Nov-14				2	0.004	Visual Estimate
MC 3.3 C	Channel	13-Nov-08	150	0.33	Cutthroat Flume			
		5-Mar-09	660	1.47	Pygmy Meter			
		14-May-09	170	0.38	Cutthroat Flume			
		6-Aug-09	22	0.05	Cutthroat Flume			
		15-Dec-09	48	0.11	Cutthroat Flume			
		15-Feb-10	500	1.11	Cutthroat Flume			
		18-Mar-10	5,300	11.81	Pygmy Meter			
		19-Jul-10				300	0.668	Visual Estimate
		4-Nov-10				5	0.012	Visual Estimate
		24-Feb-11	300	0.67	Pygmy Meter			
		31-May-11	58	0.13	Cutthroat Flume			
		29-Aug-11	37	0.08	Cutthroat Flume			
		28-Feb-12	290	0.65	Cutthroat Flume			
		8-May-12	84	0.19	Cutthroat Flume			
		18-Feb-14	200	0.45	Flume			
		27-May-14			Flow rate not estimated			
		23-Sep-14				33	0.074	Visual Estimate
		11-Nov-14				45	0.100	Visual Estimate

[a] Measured Flow Rate: Flow measured by container/stopwatch, Cutthroat flume, or Pygmy meter
[b] Estimated Flow Rate: Flow estimated based on visual inspection (or measurement method unknown); data should be used as a general indication of flow only
[c] gpm = gallons per minute
[d] cfs = cubic feet per second