

Memorandum

To:	Chris Garrett, P.HGW.	Date:	August 8, 2012
Company:	SWCA	From:	John Kline, B.S., MAOM Michael York, B.A. Jan Rasmussen, Ph.D, R.G. Corolla Hoag, R.G.,
Copy to:	Dale Ortman, P.E.	Project #:	183100.020/Task 600
Subject:	Pt. 2 SWCA Questions 7, 8, and 10 – Professional Opinions on Miscellaneous Public Comments		

This review was undertaken and the Technical Memorandum prepared at the request of SWCA and the Coronado National Forest (CNF), in accordance with a Statement of Work (SOW) and Request for Cost Estimate from Mr. Chris Garrett, SWCA, dated June 14, 2012. The purpose of this memo is to provide professional opinions on three miscellaneous public comments that were submitted to CNF during the public comment period for the Draft Environmental Impact Statement (DEIS) for the proposed Rosemont Copper Company (Rosemont) operation.

This memorandum was prepared by the SRK personnel listed in Table 1. Opinions on SWCA Questions 1 through 3 on impacts to distant surface waters will be provided in a separate memorandum; opinions on SWCA Questions 4 through 6 were previously provided to CNF (SRK, 2012b). Opinions on SWCA Question 7, 8, and 10 are provided herein. References for the cited documents are provided in Section 4.

For clarity, the complete text of the SWCA questions are presented in blue italicized text and the original numbering scheme is retained. Selected text that is taken verbatim from a public comment provided in the SWCA SOW support documentation will be indicated with a citation.

Table 1 List of key personnel

SRK Team Member	Responsibilities for Each SWCA Question
John Kline, B.S., MAOM, Principal Associate Consultant (Metallurgy, Health & Safety)	Prepare response to Section 1 (Question 7)
Mike York, B.A., Senior Technician (Water Quality Sampling and Database Management)	Prepare response to Section 2 (Question 9)
Jan Rasmussen, Ph.D., R.G., Senior Associate Consultant (Geology)	Prepare response to Section 3 (Question 10)
Corolla Hoag, R.G., Principal Consultant (Geology)	Contributor to and technical reviewer of all responses.

1 SWCA Question 7 – Feasibility of Suspending Operations during Certain Environmental Conditions

Please provide additional information concerning the logistics and feasibility of suspending mine operations during certain environmental conditions, in response to the public comment received from the Center for Science in Public Participation (CSPP, 2012, page 8). [Note: text of public comment in its entirety is provided below including reference to a SRK 2010 report Alternatives Considered but Dismissed.]

CSPP Public Comment Text: This alternative considers suspending mining during certain environmental conditions such as high winds, extreme drought, or excellent visibility. The intent of this alternative is to reduce or eliminate fugitive dust created by mining and processing activities. The alternative also considered

day only-operations. The final determination to eliminate this alternative was based on the follow (sic) rationale:

SRK, 2010 Original Document Text: ‘It is not practically feasible to operate a mine on a 12-hour schedule. Mining and milling operations are continuous-flow processes that are not amenable to being shut down half of each day (12-hour scheduling).’ (SRK Consulting, 7 May 2012, p. 33)

CSPP: This response is misleading. It is practical to conduct mining operations on a 12-hour schedule, but the mill would need to operate on a 24-hour schedule. Again, this response appears to short circuit a more sincere evaluation of this alternative, which would be technically feasible. The ultimate viability of this alternative would be purely economic.

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CSPP Public Comment Text: *With regard to the potential for shutting down mine operations during dust events, it was concluded:*

SRK, 2010: ‘It is not practically feasible to suspend mining during high winds, in most instances.’ (SRK Consulting, 7 May 2010, p. 34)

*CSPP: It is feasible to suspend mining during high winds. In fact, on the next page of the SRK report it is explained:*

SRK, 2010: ‘It is practically feasible to suspend selected operations temporarily during high winds to comply with air quality permit requirements. This is a standard industry practice.’ (SRK Consulting, 7 May 2010, p. 35)

*CSPP: Making such contradictory statements does not lend credibility to these alternatives analyses. Mining operations will in fact be suspended if air quality permit conditions require it. The “suspend mining during high winds” variation conceivably would just make these suspensions more frequent, but the impact of requiring this was not evaluated in eliminating this alternative.*

## 1.1 SRK Response to Public Comment on Change in Scheduled Hours of Operation

In an evaluation report titled *Alternatives Considered but Dismissed*, SRK (2010, p. 33) had written: “It is technically feasible to operate a mine on a 12-hour schedule (day only or night only) or to suspend mining operations during periods of extreme weather conditions. It is not practically feasible to operate a mine on 12-hour schedule. Mining and milling operations are continuous-flow processes that are not amendable to being shut down half of each day (12-hour scheduling). For that reason it is an industry standard practice to operate an open pit mine and the associated processing facilities on a 24-hr-per-day schedule, 365 days per year.”

Rosemont has submitted a Base Case plan of operation for a mining rate that defines a range of overburden and ore tons to be mined and copper to be produced by milling the ore and producing copper concentrate and by producing copper through heap leaching. Peak mining rates of 318,000 short tons per day (tpd) would be realized in Year 1, but typical mining rates would be between 224,000-299,000 tpd including overburden and oxide and sulfide ore material. The volume and rate includes approximately 75,000 tpd of sulfide ore on an average annual basis for an anticipated mine life of approximately 20 years (M3, 2009).

In response to a comment provided by Center for Science in the Public Participation (CSPP, 2012, page 8), this memo clarifies select comments SRK made that addressed the feasibility of reducing potential environmental impacts by reducing the hours of operation (SRK, 2010). For completeness, we will address two alternative operational cases to the Base Case 24-hour operations schedule:

- Case 1 – 12-hr schedule with no change to the daily production rate or the expected mine life, and
- Case 2 – 12-hr schedule with half the daily production rate and double the expected mine life.

### 1.1.1 Case 1 – 12 Hr Operation with Same Production as Planned for a 24-Hr Operation and Same Mine Life

This analysis will examine the practical feasibility of operating the mining operations on a 12-hour basis. SRK writes the following comment assuming a given mine life, a given average annual tonnage rate, and that the answer is related to environmental impacts.

In order to remove the overburden (i.e. material with low or no copper mineralization) for waste disposal and the ore extraction, several impacts to the environment occur depending upon the “intensity” of operations and handling of the mined materials. Intensity refers to the activity level of material and equipment movement on

local highways, and the mine access roads, haul roads, associated storage yards, and in the mill ore storage facility.

To achieve the same production goals as in the Base Case, one 12-hour operating shift requires nearly twice as many hourly mine operating personnel traveling to and from work on public roads in 12 hours as would be required on a basis of two 12-hr work shifts. The number of personnel required to move the material in one shift simply doubles to accomplish the same task in 12 hours. Approximately the same number of total employees is involved—the intensity of activity just increases on the single 12-hour shift.

In the mine itself, blasting normally occurs only on one shift, but the drilling the blast holes to allow operators to install the blasting material can be done on two shifts. In any case the number of blast holes is the same whether the activity is spread over one or two shifts, but the dust load created per shift is increased if the drilling activity is compressed within a single 12-hour shift.

Haul trucks are used to transport the overburden to the waste rock storage area and the ore material to the Heap Leach Facility (oxide) or to the primary crusher (sulfide). The number of trucks and personnel required for haulage is a function of the size of the trucks and the shovel. Larger trucks require wider haul roads as documented in the specification manuals for the mobile haulage equipment as prepared by the manufacturer (i.e. Caterpillar, Komatsu, Liebherr Mining Equipment, etc.). Wider roads generate more surface area for potential fugitive dust emissions to occur and may require larger mobile water spraying equipment for dust suppression.

Dust loads used to calculate the air quality permit are based upon road conditions, miles traveled, the vehicle types (large mobile equipment, service trucks, light-duty pickups, etc.) and tire sizes used at the operation. Several impacts will occur by forcing all mine material movements to one shift assuming the same mining rate as proposed by Rosemont.

On a per hour basis, dust loads will be higher on single shift as the intensity of the number of trucks is greater. Loading the blasted materials into the trucks to maintain the same daily tonnage rate means additional large excavation and haulage equipment and thus potentially higher associated dust loads.

Safety concerns also become an issue with a compressed schedule. Haul truck speeds and distances between trucks are managed to ensure optimal performance and to provide minimum safe distance between vehicles. More vehicles on the mine road at any one time increase the probability of interactions between employees working on the ground (surveyors, blasting engineers, ore control, maintenance, and inspection personnel) in smaller vehicles, support vehicles, and re-fueling vehicles.

Rosemont has specified that it will use an enclosed ore facility building. This building will be fed by a truck dump and a covered conveyor system. The ore in the building is placed on top of ore feeders that underlie the ore stockpile. An ore pile looks like an inverted cone and only about one third of the pile can be used if ore is not fed to the pile continuously.

Operating on one shift only would require a much larger ore stockpile and associated ore stockpile building along with a near doubling in size of the conveyors that feed the stockpile. These would increase the potential for more dust and the need for larger air quality control equipment in SRK's opinion. If the ore stockpile and building were kept as presently designed, there would be insufficient ore over the feeders due to the limited space, and bulldozers and dozer operators would have to be used to push the remaining ore into the feeder to ensure continuous feed to the mill. This activity is expected to increase not only dust, but also substantially increase safety risk issues when working over active stockpile feeders.

Forcing all mine production into a 12-hour per day basis while maintaining the total planned production rate has several environmental, cost, and safety impacts. These are:

- Increasing the intensity of traffic on public and mine roads in one shift.
- Near doubling of the haul truck and ore/waste handling vehicles fleet with:
  - More haul trucks and ore handling equipment, and
  - More oil, lubricant, and maintenance wastes due to more equipment.
- More dust load from haul roads, dump pockets, and conveyors owing to operational intensity on the one shift.
- Larger dust suppression mobile equipment needed to address more fugitive dust exposed on wider haul roads.
- A larger ore storage facility with larger conveyor systems.

- Safety issues increase with the use of bulldozers to push ore into the ore feeders in the ore storage facility and increased mobile equipment operating simultaneously on the mine and haul roads.

SRK believes the Case 1 operation may be technically feasible with increased environmental impacts, safety risk, and capital costs. It is not practically feasible due to the negative environmental impacts owing to increased dust load per day as discussed in this response to the commenter.

### 1.1.2 Case 2 – 12 Hr Operation with Half the Production as Planned for a 24-Hr Operation and Double the Mine Life

This analysis will examine the practical feasibility of operating the mining operations on a 12-hour basis with half the daily production rate and twice the mine life planned in the proposed Base Case. SRK writes the following comment assuming a given mine life, a given average annual tonnage rate, and that the answer is related to environmental impacts.

CSPP (2012) states: *This response is misleading. It is practical to conduct mining operations on a 12-hour schedule, but the mill would need to operate on a 24-hour schedule. Again, this response appears to short circuit a more sincere evaluation of this alternative, which would be technically feasible. The ultimate viability of this alternative would be purely economic.*

CSPP recognizes the need to operate the mill on a 24-hour per days schedule. SRK's response will therefore address the full range of environmental impacts based upon the following assumptions:

1. The total mine life will approximately double in order to mine and process the same number of ore and waste tons with half the available time per day.
2. Staff levels for mine staff (i.e. planners, management, surveyors, safety staff, admin personnel, etc.) will be approximately the same in either Base Case or Case 2. The staff will be on site for twice as many years in Case 2.
3. Mill management, operating staff, and operating personnel will be approximately the same whether the mill operates at full tonnage per day (Base Case) or half tonnage per day (Case 2) because the size of the equipment will be smaller in than in the Base Case. Personnel will be required for twice as many years in Case 2 as in the Base Case.
4. Blasting load per ton will be the same in order to supply the right blast rock size.
5. Blasting could all be done on a single shift. The operators, however, may choose to blast enough material (mill ore, oxide leach, and waste rock tons) at one time for a two-week period rather than blasting one week of material at one time as is planned in Base Case.
6. Haul truck sizes would have to be either resized from the Rosemont Base Case or adjusted in order to move the tons to the mill on a single shift basis in order to feed the mill over a two-shift period.
7. The stockpile in the mill ore storage facility would have to accommodate feeding in a 24-hour period what is mined and moved in 12 hours.

The following environmental impacts would be realized in Case 2:

- Traffic from employees (Admin, Mine, Mill, Plant, Environmental, Safety), contractors, vendors, and other personnel would occur over a period that is twice the Base Case mine life at approximately the same rate per day as the Base Case, which means personal vehicle fuel consumption over the project life will be twice as great in Case 2 as it is in the Base Case.
- Blast dust is produced on a per ton basis. Blast explosive used for oxide, sulfide, and overburden is designed to produce a certain run-of-mine fragment size for moving and processing the material. Over the mine life, the dust produced is the same whether the mine life is doubled or not. If the blast occurs once every two weeks instead of once per week, the load on the day the shot is conducted for the two week supply will be as high as it is for the Base Case, although it would only occur once every two weeks.
- Mine support staff traffic would be marginally smaller for Case 2, but not half of Base Case. Safety, survey, management, and environmental staff would still tour and inspect the mine at the same level for Case 2 as for Base Case because their oversight responsibility occurs daily regardless of production. Dust loads on a daily basis for these staff activities would not significantly change for Base Case or Case 2. The dust loads would however, occur over twice as many years and roughly double the total load for life of mine. The same is true of non-Rosemont company personnel like safety and environmental inspectors,

service providers, and vendors. The intensity is nearly the same but occurs over twice the Base Case mine life.

- Mill shutdowns normally occur once per week for one shift to do preventative maintenance (PM) or planned repairs. The mill equipment size would be smaller for Case 2 than for the Base Case, but the PM requires basically the same staff and day shift maintenance crew sizes in either case. Thus, owing to the doubled mine life, the traffic load and fuel consumption for on-site and off-site for personnel will be approximately twice as high for Case 2 than for the Base Case.
- A “close-as-you-go” reclamation plan is proposed for Dry Stack Tailings such that tailings embankments will be covered and revegetated during the mine life instead of waiting until all tailings disposal is completed. Case 2 will double the mine life, thereby lengthening the process of concurrent reclamation and delaying the completion of final reclamation activities for the entire mine site.

In summary, environmental impacts for Case 2 are not halved as compared to the Base Case. In fact over the life of mine some impacts are greater due to cumulative requirements for staff and operating traffic, both on site and off site. Blast-produced dust is the same total load, but spread out over twice the period for Case 2 as seen in the Base Case. Final reclamation will require approximately 40 years rather than 20 years contributing to additional fugitive dust during the longer operations period. SRK believes the Case 2 alternative operation may be technically feasible with increased environmental impacts, safety risk, and capital/operating costs. It is not practically feasible due to the negative environmental impacts discussed in this response to the commenter.

## 1.2 SRK Response to Comments on the Impact of Wind and Rain on Operations

“Mining” in this response refers to blasting, truck haulage, and handling of ores that will be delivered to the mill and heap leach operations for treatment of the ores to recover copper.

With respect to cessation of mining operations owing to natural environmental factors (i.e. wind conditions), air quality permits typically specify compliance opacity percentage limits, which by extension dictate the allowable operations that can occur during high winds and resulting increase in high-opacity conditions. Air quality permit requires cessation when dust loads exceed an opacity compliance level regardless of whether or not there are “high” winds.

Wind velocity and opacity measured on the mine property may not be the same everywhere owing to the physical layout of facilities. Operations may continue in some locations whereas activities must be temporarily suspended in other areas. From a safety perspective, operators may deem it necessary to cease operations temporarily in a limited area of the mine despite the fact that the winds may occur at levels lower than will generate opacity that exceeds compliance limits. Safety factors are implied in the response, as driver visibility may be locally affected but the effect may not be mine-area wide.

For clarity, therefore, the following line from SRK’s 2010 report is amended from:

*“It is practically feasible to suspend selected operations temporarily during high winds to comply with air quality permit requirement. This is a standard industry practice.”*

to:

*“It is practically feasible to suspend selected operations temporarily during wind velocities or dust loads that exceed permit compliance conditions in order to comply with air quality permit requirement. This is a standard industry practice.”*

Other environmental factors may cause temporary cessation of mining operations from safety related conditions (not environmental-permit related). These include lightning and rainfall that cause unsafe outdoor work conditions or unsafe road conditions. Generally outdoor operations that expose mine operators in non-protected areas to lightning will cease when lightning is noted within a certain distance of the work area. Some mining companies and power companies have procedures that require operations to cease when lightning is within 7 miles of the facilities or work area. For example, ore and waste blasting operations, and operators who work in the open or on elevated platforms may have their work stopped until the area is deemed safe.

Rainfall may cause the unpaved mine roads to become too slick to drive on or be affected by wash outs. Safety conditions are continuously monitored, and operations cease temporarily when the mine management deems the conditions dangerous to men and equipment.

## 2 SWCA Question 8 – Review of Background Groundwater Samples Collected for DEIS – Organic Compound Analyses

*As described in the DEIS, groundwater samples were collected by Rosemont from 38 wells and six springs and analyzed for organic compounds. In 104 instances, an organic compound was detected in a groundwater sample by the analytical laboratory.*

- For 48 of these instances, similar compounds were detected in quality control samples.*
- For 39 of these instances, detections were below the limits considered practical for quantifying chemical constituents.*
- For 8 of these instances, dimethyl ketone (acetone), diethyl phthalate, or 2- butanone were identified, which can be common laboratory contaminants.*
- For 7 of these instances, toluene was identified.*
- For 2 of these instances, benzoic acid was identified.*

*Overall, public comments reflect an opinion that the above detections indicate that the laboratory analyses conducted on the groundwater samples should be invalidated and sampling should be conducted over. Please provide some context for these results in light of similar environmental sampling. Are such results unusual for a sampling program of similar size and scope? Do these results suggest that the laboratory analyses conducted are invalid or should be redone? Are there organic constituents observed that suggest groundwater contamination is present at the Rosemont site?*

### 2.1 Executive Summary

Water quality site characterization was performed at the Rosemont project area by two groundwater consulting firms and two laboratories from 2007 through 2010. A number of water quality samples detected volatile and semi-volatile organic compounds particularly in August and September 2008. Organic compounds, such as solvents, plasticizers, and fuel products, would not be expected to occur naturally in the groundwater in the Rosemont project area, so a field or laboratory origin is assumed. The results of the sampling program included a number of detections for BTEX<sup>1</sup> constituents, which are commonly found in gasoline and combustion fume exhaust. Two regulated constituents (toluene and total xylenes) were detected in a number of wells at low concentrations that did not exceed the applicable numeric groundwater standards. Results of follow-up sampling were similar in samples that were sent to a different laboratory. These contaminants could have been captured in the water sample or sample bottles during the sampling process.

Chemicals such as acetone and 2-butanone were noted in a number of samples; the contamination is assumed to have occurred during laboratory handling or analysis. One regulated constituent (bis(2-ethylhexyl) phthalate) exceeded the applicable groundwater standards in three monitor wells, but was acknowledged by the laboratory as having been contaminated during analyses. The contamination occurred during a limited time period in August 2008 and resulted from a reagent used in the extraction process; the source was confirmed by the supplying vendor. The constituent was not subsequently found in values exceeding standards in any other wells.

In SRK's opinion, it is not unexpected or unusual to see some contamination issues occurring in the field or laboratory during multi-year sampling programs of this scope. The overall sampling program was adequate to characterize the concentration of organic compounds, and the results (minus the samples that were contaminated) are a valid representation of site conditions.

### 2.2 Water Quality Sampling Program Overview

A hydrogeological characterization sampling and analysis program of local groundwater, seeps, and springs was conducted in the Rosemont project area from 2007 through 2010. A sampling and analysis program was implemented by groundwater consulting firms Montgomery & Associates (M&A) in 2007-2008 and the Verdad Group in 2009-2010. The results of the site hydrogeological characterization were submitted to the Arizona Department of Environmental Quality (ADEQ) in support of Rosemont's application for an Aquifer Protection Permit. The results were intended to establish the baseline, pre-mining hydrologic conditions, including groundwater levels, spring flow rates, potentiometric surface, and water chemistry.

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<sup>1</sup> BTEX is an acronym that stands for benzene, toluene, ethylbenzene, and xylenes. These compounds are some of the volatile organic compounds (VOCs) found in petroleum derivatives such as gasoline or diesel fuel.

Groundwater monitoring included historic and recently drilled wells under Rosemont's control, historic wells on property not controlled by Rosemont, and seeps and springs in the Santa Rita Mountains as well as in the Davidson Canyon and Cienega Creek areas. Sampling the groundwater wells required pumping a specified volume of water from the wells prior to sampling. The volumes pumped are typically a volume that is equivalent to three times the water that fills the borehole under static water conditions (diameter x length of borehole below the water table). The well purging was completed using a submersible electric pump that was suspended by PVC pipe into the well and powered by a portable generator that was transported to the sites by the samplers (J. Davis, M&A, pers. commun., 2012). Spring, seep, and creek samples were taken by hand with no pumping required. Constituents analyzed included common ions, major cations/anions, trace metals, organic compounds, and radiochemicals.

Public comments by Center for Science in Public Participation (CSPP, 2012, Item 4.2, p. 24) inquired about the apparent laboratory or other contamination evident in the organics sampling done during the 2008 baseline characterization. SRK reviewed both the results of the 2007-2008 sampling program and the follow-up analyses in 2009-2010 that were performed by a second laboratory. The 2006-2010 laboratory reports and electronic data deliverable results were provided to SRK by J. Davis, Montgomery & Associates. In the sections below, SRK will review the scope of the sampling program, summarize the compounds measured above detection and those exceeding groundwater quality standards, assess possible origins for the contaminants, and evaluate whether the results of the sampling program are valid.

Contamination can be caused by exposure of the sample stream to compounds in the immediate environment. This can include exposure to vapors, exposure via improper well construction or damaged wellhead, laboratory solvents, disinfectants, or residue from plastic containers. Off-site wells, creeks, seeps, and springs are not controlled by Rosemont, and therefore, their protection from contamination cannot be entirely assured. Groundwater impacts can occur from fuel spills in parking areas or roads, or from wildcat dumping and disposal of used motor oil or other products into an historic well. This type of contamination could enter groundwater. SRK believes, however, that potential historic impacts are not the most likely explanation of the compounds measured above detection. SRK assumes there are no known sources of current or historical potential industrial contamination at the sites sampled. It is not expected that waste from manufacturing plants, landfills, or waste water treatment plants, etc. would occur in natural groundwater. The sample contamination is therefore expected to be of an anthropogenic nature due to contamination in the field sampling or laboratory analysis.

## 2.3 Size and Scope of the Characterization Sampling Program

SRK has not had the opportunity to interview the field technicians responsible for taking the samples or review field log books. In both sample sets, the sampling is assumed to have been performed by trained and experienced water quality sampling technicians. All analysis methods were standard methods approved for environmental monitoring by the Arizona Department of Health Services.

The first set of organic compounds characterization samples (Sample Set 1) included those from 46 wells, springs, and creeks sampled between May 16, 2007 and October 23, 2008 as itemized in Attachment A Table 1. This set included historic stock wells and recently drilled wells installed by M&A for characterization and monitoring purposes. Thirteen of the sample points were sampled more than once, with a minimum of one month between sample events. The newly constructed HC-series and PC-series wells installed in 2007 and 2008 (HC-1A to HC-5B; PC-1 to PC-8) were sampled between one week and 4.5 months following installation, with the first sample generally being collected 48 to 75 days following well construction. The samples were analyzed for Volatile Organic Compounds (VOCs)<sup>2</sup> and Semi-Volatile Organic Compounds (SVOCs)<sup>3</sup> by ACZ Laboratories, Steamboat Springs, Colorado. ACZ is an Arizona-certified environmental water quality laboratory.

A subsequent sample set (Sample Set 2) was obtained from seven wells that were sampled between June 22, 2009 and May 28, 2010 (Attachment A Table 2). These samples were taken from the Rosemont Project characterization wells (designated by RP in the well name). The wells were sampled four to five times each with variable 2- to 6-month gaps between the sampling dates. The samples were analyzed for VOCs<sup>4</sup> by Columbia Analytical Services of Phoenix, which is also an Arizona-certified environmental laboratory.

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<sup>2</sup> Method M8260B GC/MS

<sup>3</sup> Method M8270C GC/MS

<sup>4</sup> Method EPA524.2 and SW8260B

For Sample Set 1, 124 samples were analyzed, including duplicates, trip blanks, and field blanks, with the result that 23 qualified measurements of organic compounds were above detection limits as shown in Attachment A Table 3. Additional detections of organic compounds occurred, but were designated as “estimated values” and assigned a “J” qualifier by ACZ. This designation indicates that the results were between the minimum detection limit and the practical quantitation limit according to protocols established by U.S. Environmental Protection Agency (EPA, 1994). The 23 qualified detections were 19 percent of the number of samples analyzed.

For Sample Set 2, 76 samples were analyzed, including duplicates, trip blanks, field blanks, and equipment blanks. This sampling program resulted in 29 qualified measurements of organic compounds that were above detection limits, which consisted of 38 percent of the number of samples (Attachment A Table 4).

## 2.4 Review of Analyses and Potential Avenues of Contaminant Entry into the Samples

Seven compounds were detected in one or more samples comprising Sample Set 1. These compounds included 2-butanone, acetone, benzoic acid, bis(2-ethylhexyl) phthalate, diethylphthalate, hexachlorobutadiene, and toluene (Attachment A Table 3). The common usages and potential entry points into the environment for these seven compounds are listed in Table 2 below. Two of the detected compounds (bis(2-ethylhexyl) phthalate and toluene) detected in Sample Set 1 have regulatory groundwater standards. In general, these organic compounds are found in additives in fuel, fuel exhaust/combustion products, solvents, and plasticizers in vinyl and polyvinyl chloride (PVC) products.

Sample Set 2 was analyzed by an alternative, approved laboratory method by a different laboratory. The list of VOC constituents measured was slightly different in the alternative analysis method, but contained similar families of compounds as were detected as measured in Sample Set 1. The samples contained one or more detections for nine compounds including 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 4-isopropyltoluene, bromoform, chloroethane, naphthalene, toluene, total trihalomethanes, total xylenes (Attachment A Table 4). The common usages of the compounds detected in Sample Set 2 are listed in Table 3. Two of the detected constituents in Sample Set 2 (toluene and total xylenes) have regulatory groundwater standards. In general, the compounds are found in additives in gasoline, fuel exhaust/combustion products, solvents, and disinfectants.

Two primary avenues of contamination could explain the entry of these compounds into the sample stream or sample vial—field sampling and handling procedures or laboratory handling procedures. Of the field conditions, potential avenues of contamination include the following:

- Fuel and exhaust fumes could have been present in the air in the immediate vicinity of the sampling area related to use of a portable generator over several hours to purge the wells and pump the groundwater while the sample was collected. Volatile compounds can contact water during sampling or remain in the sampling vials if the headspace is not completely filled with the sample;
- Fuel and exhaust fumes present in the air at a sampling site could have been related to a vehicle or piece of mobile equipment that may have been operating on a stationary basis or passing by at the time the sampling was performed;
- Plasticizer compounds could have been volatilizing from plastic or vinyl-based containers, products, or objects that inadvertently came into contact with the sample stream or sample bottle; and
- Disinfectants may have inadvertently contacted the inside of the lid, sample bottle, or sample as it was collected.

Of the laboratory conditions considered, the potential avenues of contamination include the following:

- Reagents provided by the laboratory’s supplier could have been contaminated;
- Solvents and disinfectants used at the laboratory may have inadvertently contacted the inside of the lid, bottle, or sample during the analysis process; and
- Plasticizer compounds volatilizing from plastic or vinyl-based containers, products, or other objects may have inadvertently come into contact with the sample stream or sample bottle.

A number of constituents detected in both sample sets fall within the BTEX suite of organic compounds (benzene, toluene, ethylene, and total xylenes) that are commonly associated with fuel, fuel combustion and exhaust, and related fuel-containing products. Solvents, such as acetone and bromoform, are also present in fuel as a thinning agent. The presence of trace concentrations of BTEX compounds, various similar derivatives, and benzoic acid is most likely related to the operation of a motorized vehicle or a portable diesel- or gasoline-powered electric generator in the immediate sampling area during purging and sampling activities.

Depending on the well diameter and water column height, purging can take 2-6 hours or more to complete. In remote areas outside the range of established electric infrastructure, the purging is typically completed by using a small, portable generator placed in the back of a pickup or a larger generator pulled from site to site via pickup or all-terrain vehicle. Small portable generators give off small quantities of fuel exhaust, perhaps barely noticeable to a particular technician, but which could potentially build up in the immediate well area unless they are removed by a moderate breeze. Based on the fuel-related compounds detected, one cannot eliminate the possibility that fuel-exhaust fumes may have been present in the air in the sampling area during the purging and sampling activities. The fumes could have been dissolved within the water stream or could have been present in the sample bottle if the sample bottle was not sufficiently filled to remove any gas remaining in the headspace below the sample vial lid.

Two types of phthalates and the solvents acetone and 2-butanone were noted in Sample Set 1. Of the 124 samples that were analyzed, only eight had qualified detections of these compounds. Solvents and numerous types of plastic bottles are commonly found in laboratory settings and could have come into contact with these particular samples. Phthalates are used in the production of PVC and vinyl chloride resins and are added to plastics to make them flexible. They are not added to PVC household plumbing or well casing products. Phthalates can enter the atmosphere and groundwater through volatilization of plastic and vinyl products, such as plastic water bottles, flexible plastic tubing and containers, or other plastic consumer object. It is conceivable that the sample stream or organics sample bottle inadvertently could have come into contact with phthalates and 2-butanone compounds that may have volatilized from a plastic sample container or water bottle in either the field or laboratory.

In the analysis report case narratives, however, ACZ acknowledged the responsibility for eleven bis(2-ethylhexyl) phthalate contaminations, which were attributed to a methylene chloride reagent used in the extraction process. This contamination was confirmed by the supplying vendor as noted on the analysis reports as detailed in Table . Three of the 11 contaminations were identified as being qualified measurements of the compound, while the remaining eight were identified as being estimated values. Samples that were affected by the contaminated reagent were analyzed between August 13 and September 5 in 2008. Analysis of samples outside of that time frame resulted in values that were estimated or not detected for these compounds.

An examination was conducted of the days the samples were analyzed during the 1.5-year sampling program. The investigation examined whether the detected compounds were all analyzed on the same day or within a short period of time; this would indicate a potential problem with procedures used by a particular analytical technician or that one or more samples may have been contaminated by compounds introduced in the laboratory at the same time. Of the seven compounds detected during Sample Set 1, only two samples were analyzed on the same day, not including a primary sample and its duplicate, which could have been contaminated in the field. This investigation indicated the detections were likely not related to a systematic error by a particular technician.

**Table 2 Sample Set 1 - Organic compounds measured above detection and common usage**

| <b>Compound</b>                    | <b>Common Usage</b>                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Potential Avenue of Contamination in General and in Sampling Program</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2-Butanone                         | Primarily used as a solvent in processes involving gums, resins, cellulose acetate, and cellulose nitrate. Methyl ethyl ketone is also used in the synthetic rubber industry, in the production of paraffin wax, and in household products such as lacquer and varnishes, paint remover, and glues.                                                                                                                                  | The release of 2-butanone to water or soil is not well documented. Release of 2-butanone to surface water may occur via industrial waste water emissions. 2-Butanone may also be released to soil or water from a spill. The leachate of landfills and hazardous waste sites may result in 2-butanone contamination of soil and groundwater.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Acetone                            | Common solvent                                                                                                                                                                                                                                                                                                                                                                                                                       | Acetone is emitted into the atmosphere both from natural and anthropogenic (man-made) sources. Natural sources of emission include plants and trees, forest fires, and insects and microbes. Acetone is also produced endogenously and is expired in human breath. Important anthropogenic sources of acetone in the air include <b>vehicular exhaust</b> , chemical manufacturing, tobacco smoke, wood burning and pulping, refuse and polyethylene combustion, petroleum production, certain landfill sites, and <b>solvent use</b> . Acetone is released into groundwater mainly as a result of leaching from municipal and industrial landfills. The principal sources of acetone in soil are municipal and industrial discharge in landfills. Acetone is released in soil from natural sources, such as disposed agricultural and food wastes and animal wastes. |
| Benzoic acid                       | Used regularly in food preservation, the treatment of bacterial infections, and combined with other chemicals to create products like repellants and perfumes.                                                                                                                                                                                                                                                                       | Benzoic acid may be released into the environment as emissions or, more commonly, in wastewater during its production and use as a chemical intermediate and additive. Benzoic acid and sodium benzoate are commonly added to food products as preservatives and as antimicrobial agents. <b>Formed in combustion processes, benzoic acid is found in automobile exhaust</b> , refuse combustion, and tobacco smoke. Benzoic acid is also widely distributed in nature and naturally occurs in food such as berries.                                                                                                                                                                                                                                                                                                                                                  |
| Bis(2-ethylhexyl) phthalate (DEHP) | Used in production of PVC and vinyl chloride resins, where it is added to plastics to make them flexible.                                                                                                                                                                                                                                                                                                                            | DEHP is a widely used chemical that enters the environment both through disposal of industrial and municipal wastes in landfills and <b>by leaching into consumer products stored in plastics</b> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Diethylphthalate                   | Used in applications that include building materials, clothing, cosmetics, perfumes, food packaging, toys, and vinyl products (e.g., flooring, shower curtains, and rain coats); and in medical applications that include blood transfusion bags and tubing, intravenous fluid bags and tubing, and other medical devices. Phthalates are also found in lubricating oils, solvents, and detergents.                                  | Diethyl phthalate may be released to the environment as a result of manufacturing processes, disposal in landfills, incomplete incineration, or <b>by leaching or volatilization from products in which it is used</b> . Releases are expected to be primarily to water or to soil as a result of leaching from landfills. <b>Diethyl phthalate may enter the atmosphere through combustion of plastics and, to a lesser degree, by volatilization</b> . Diethyl phthalate partitions to particulate matter in water or sediments, where it can be biodegraded either aerobically or anaerobically; other degradation processes are not significant. From soils with low organic matter content, diethyl phthalate may enter the underlying groundwater.                                                                                                              |
| Hexachlorobutadiene                | Used to make rubber, it is used as a solvent and to make lubricants, in gyroscopes, as a heat transfer liquid, and as a hydraulic fluid                                                                                                                                                                                                                                                                                              | Hexachlorobutadiene may be released to underground and surface waters through discharge from industrial facilities, by leaching from industrial discharges, by leaching from landfills or soils, or by urban runoff.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Toluene                            | Used as a mixture <b>added to gasoline</b> to improve octane ratings. Toluene is also used to produce benzene and as a solvent in paints, coatings, synthetic fragrances, adhesives, inks, and <b>cleaning agents</b> . Toluene is also used in the production of polymers used to make nylon, plastic soda bottles, and polyurethanes and for pharmaceuticals, dyes, cosmetic nail products, and the synthesis of organic chemicals | Toluene may be released to water from industrial discharges and urban wastes, or by spills and <b>leaks of gasoline</b> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

Source: Compiled by SRK from EPA and other internet sources, 2012

**Table 3 Sample Set 2 - Organic compounds measured above detection and common usage**

| Compound Name          | Common Usage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Potential Avenue of Contamination in General and in Sampling Program                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1,2,4-trimethylbenzene | <b>Gasoline additive</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Exposure to 1,2,4 trimethylbenzene can occur in the workplace or in the environment following releases to air, water, land, or groundwater. Exposure can also occur when people <b>use gasoline</b> or certain paints and cleaners.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 1,3,5-trimethylbenzene | <p>1,3,5-TMB is used in dyes, solvents, paint thinners and plastics. 1,3,5-TMB is emitted into the air by emissions from gasoline-powered vehicles, waste treatment plants and coal-fired power stations. 1,3,5-TMB occurs in petroleum and coal tar.</p> <p>1,3,5-TMB is found at low levels in air and in water, including drinking water. It is also found at low levels in food. Often, it is in beef and pork flavorings. 1,3,5-TMB is found in some automobile engine treatments and some epoxies for home use.</p>                                                                                                                                        | Breathing vapors when filling a tank with gasoline. Drinking small amounts of 1,3,5-TMB in drinking water, such as from groundwater near a waste site polluted with petroleum.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 4-isopropyltoluene     | Widely used as solvent, applied to synthetic resin, p-phthalic acid, cresylol and intermediate to dyestuff, perfume, medicine production as eliminating phlegm and preventing cough.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Released into the environment from natural sources such as volatile plant emissions. It is also released from anthropogenic sources such as <b>motor vehicle exhaust</b> , solvent evaporation, and industrial wastewaters                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Bromoform              | Bromoform is used as a fluid for mineral ore separation in geological tests, as a laboratory reagent, and in the electronics industry in quality assurance programs. Bromoform was formerly used as a solvent for waxes, greases, and oils, as an ingredient in fire-resistant chemicals and in fluid gauges. It has also been used as an intermediate in chemical synthesis, as a sedative, and as a cough suppression agent.                                                                                                                                                                                                                                   | The principal route of human exposure to bromoform is from drinking water that has been disinfected with chlorine, bromine, or bromine compounds. Bromoform has been detected in swimming pools that have been disinfected with bromine or bromine compounds; therefore, exposure to low levels could occur from inhalation of bromoform that has evaporated into the air or through the skin from bromoform in the water. Exposure could also occur from inhalation of ambient air near factories or laboratories that use bromoform. Another place for exposure is near a chemical waste site where bromoform leaked into water or soil.                                                                                                            |
| Chloroethane           | <p>Ethyl chloride is used in the production of ethyl cellulose, use as a solvent, refrigerant, and topical anesthetic, in the manufacture of dyes, chemicals, and pharmaceuticals, and as a medication to alleviate pain associated with insect burns and stings.</p> <p>In the past, ethyl chloride was used in the production of tetraethyl lead, an anti-knock additive to leaded gasoline. Government-mandated reduction in the amount of lead additives used in gasoline in the United States and a shift to the use of unleaded gasoline has caused a drastic reduction in the amount of ethyl chloride required for the production of tetraethyl lead</p> | <p>Sources of possible ethyl chloride exposure include the inhalation of contaminated air and ingestion of contaminated drinking water at very low levels.</p> <p>The general population can be exposed to ethyl chloride by skin contact with consumer products that contain ethyl chloride such as solvents and refrigerants.</p> <p>Occupational exposure by inhalation or dermal contact with ethyl chloride can occur in industries such as medical and health services; automotive dealers and service stations; wholesale trade, electric, gas, and sanitary services; machinery (except electrical) and special trade contractors; fabricated metal productions; printing and publishing; painting; rubber and plastic products; and food</p> |
| Naphthalene            | <p>The primary use for naphthalene is in the production of phthalic anhydride. However, o-xylene is replacing naphthalene as the preferred raw material for phthalic anhydride production.</p> <p>Other uses of naphthalene include carbamate insecticides, surface active agents and resins, as a dye intermediate, as a synthetic tanning agent, as a moth repellent, and in miscellaneous organic chemicals</p>                                                                                                                                                                                                                                               | Naphthalene is released to the air from the burning of coal and oil and from the use of mothballs. Coal tar production, wood preserving, and other industries release small amounts. Typical air concentrations of naphthalene in cities are about 0.18 parts per billion (ppb). Naphthalene has also been detected in tobacco smoke.                                                                                                                                                                                                                                                                                                                                                                                                                 |

**Table 3 Sample Set 2 - Organic compounds measured above detection and common usage (cont.)**

|                       |                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Toluene               | Same as Table 2 above                                                                                                                                                                                                                                                                   | Same as Table 2 above                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Total trihalomethanes | Trihalomethanes (THM) are a group of four chemicals that are formed along with other <b>disinfection byproducts</b> when chlorine or other disinfectants used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water. | Disinfection byproducts (DBPs) form when disinfectants used to treat drinking water react with naturally occurring materials in the water. <b>The predominant byproducts that result from use of chlorine as a disinfectant are trihalomethanes (chloroform, bromoform, bromodichloromethane, and dibromochloromethane) and haloacetic acids (monochloro-, dichloro-, trichloro-, monobromo-, dibromo-).</b> Trihalomethanes (THMs) and haloacetic acids (HAAs) form when chlorine reacts with organic and inorganic material in source water (which comes from decomposing plant material, pesticides, etc.). |
| Total xylene          | The greatest use of xylenes is as a solvent which is much safer than benzene. Other uses include: in <b>gasoline as part of the BTX component</b> (benzene-toluene-xylene); Xylene mixtures are used to make phthalate plasticizers, polyester fiber, film, and fabricated items.       | The major sources of xylenes in drinking water are discharge from petroleum factories; and discharge from chemical factories                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

Source: Compiled by SRK from EPA and other internet sources, 2012

## 2.5 Review of Results for Regulated Organic Constituents

The majority of the VOCs and SVOCs detected during the characterization program in trace concentrations were non-hazardous and non-regulated. Three regulated constituents with AWQS numeric limits were measured above detection including bis(2-ethylhexyl) phthalate (three samples), toluene (eight samples), and total xylenes (one sample) as shown in Table 4. Low level concentrations of regulated constituents toluene and total xylenes were detected but were below the applicable AWQS. Their use is ubiquitous so the source cannot be confirmed with 100 percent assurance.

At groundwater monitor wells RP-7, RP-8, and RP-9, three samples (one sample each, all in August 2008) exceeded the AWQS limit of 6 µg/L for the compound bis(2-ethylhexyl) phthalate. These particular samples, as well as other several other samples measured with concentrations below AWQS, were contaminated during laboratory analysis as confirmed by ACZ (see Attachment A Table 5).

**Table 4 Analysis results of organic compound with respect to applicable AWQS**

| Parameter<br>(µg/L)         | AWQS <sup>1</sup> | PC-4       | PC-3       | HC-4B      | HC-4B dup  |
|-----------------------------|-------------------|------------|------------|------------|------------|
|                             |                   | 05/18/2007 | 06/01/2007 | 07/17/2008 | 07/17/2008 |
| bis(2-ethylhexyl) phthalate | 6                 |            |            |            |            |
| toluene                     | 1000              | 46         | 34         | 92         | 87         |
| xylenes, total              | 10000             |            |            |            |            |
| Laboratory                  |                   | ACZ        | ACZ        | ACZ        | ACZ        |
| Laboratory ID               |                   | L62751-01  | L62992-01  | L70588-01  | L70588-02  |

| Parameter<br>(µg/L)         | AWQS <sup>1</sup> | RP-7 <sup>2</sup> | RP-8 <sup>2</sup> | RP-9 <sup>2</sup> | RP-2B      |
|-----------------------------|-------------------|-------------------|-------------------|-------------------|------------|
|                             |                   | 08/05/2008        | 08/07/2008        | 08/13/2008        | 08/26/2008 |
| bis(2-ethylhexyl) phthalate | 6                 | <u>42</u>         | <u>31</u>         | <u>21</u>         |            |
| toluene                     | 1000              | 36                |                   |                   | 10         |
| xylenes, total              | 10000             |                   |                   |                   |            |
| Laboratory                  |                   | ACZ               | ACZ               | ACZ               | ACZ        |
| Laboratory ID               |                   | L70986-01         | L71043-01         | L71193-01         | L71459-01  |

**Table 4 Analysis results of organic compounds with respect to applicable AWQS (cont.)**

| Parameter<br>(µg/L)         | AWQS <sup>1</sup> | RP-2A      | PC-5-1516-LP | RP-2C       | RP-4B       |
|-----------------------------|-------------------|------------|--------------|-------------|-------------|
|                             |                   | 08/28/2008 | 10/23/2008   | 6/24/2009   | 8/27/2009   |
| bis(2-ethylhexyl) phthalate | 6                 |            |              |             |             |
| toluene                     | 1000              | 141        | 59           | 0.5         |             |
| xylene, total               | 10000             |            |              |             | 0.7         |
| Laboratory                  |                   | ACZ        | ACZ          | Columbia    | Columbia    |
| Laboratory ID               |                   | L71524-01  | L72677-01    | 09060396-02 | 09080520-02 |

**Notes:**

1 AWQS = Arizona Department of Environmental Quality, Water Quality Standards, Title R18-11  
bold and underlined values exceed AWQS

2 ACZ Laboratories reported bis(2-ethylhexyl) phthalate was found in the prep blank above the reporting limit. It is attributable to methylene chloride reagent used in the extraction process and confirmed by the supplying vendor.

## 2.6 Summary and Conclusion

Trace concentrations of primarily non-hazardous, non-regulated organic compounds were detected in a number of water quality characterization samples taken at the Rosemont project site and surrounding area from 2007-2010. The samples included water pumped from groundwater wells and water sampled by hand from springs, seeps, and creeks. A number of other measurements were designated as “estimated” because their concentrations were so low they fell between the minimum detection limit and the practical quantitation limits according to EPA protocols. Of the qualified measurements above detection, the contaminants were primarily fuel and fuel-combustion related compounds, solvents, or plasticizers.

Detections of three hazardous, regulated organic compounds were detected in several groundwater wells in 2008-2009. The results from three groundwater monitor wells exceeded the AWQS limit for a plasticizer compound called bis(2-ethylhexyl) phthalate. The samples were confirmed to have been contaminated during laboratory handling owing to poor quality reagents as supplied by a chemical vendor.

No groundwater contamination associated with industrial activities is known to exist at the sites sampled. In SRK’s opinion, the trace detections for BTEX compounds are most likely related to the presence of fuel exhaust fumes from a nearby vehicle or from a generator that may have been present in the air at the moment the sample bottles were being filled. Owing to the low laboratory detection limits, the presence of fuel-related compounds can be measured at exceedingly low concentrations.

In SRK’s opinion, the number of qualified detections for organic compounds in the sampling results reported for these two sample sets in natural, unimpacted groundwater is not unusual for a multi-year groundwater monitoring program of this nature and scope. The results of the remaining analyses, as well as the overall organics sampling program, are valid and an extensive follow-up monitoring program is not recommended.

As a follow-up comment, SRK does not view VOCs and SVOCs to be meaningful parameters for routine groundwater monitoring at mining sites because they primarily occur below laboratory detection limits and are therefore unable to provide useful data on any trends in concentration. These types of samples can also, on occasion, be contaminated by compounds and chemicals that are ubiquitous and not reflective of actual groundwater conditions. The APP program does not include them in the routine compliance monitoring programs for mining sites. Field parameters (i.e. pH and electrical conductivity) and monitoring constituents such as sulfate and trace metals that are closely associated with the mineralization in the deposit and that are always or typically measured above detection are more relevant indicators of potential groundwater contamination related to the mining, processing, and waste disposal activities proposed for the site.

### 3 SWCA Question 10 – Potential for TENORM to be Present in Tailings Material

*Numerous public comments express concern over the potential for the concentration of radioactive materials through the mining process, or Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM). Please provide an analysis of the potential for TENORM to be present in the tailings. If so, please identify whether the potential for TENORM was adequately analyzed in the geochemical models for the tailings facility.*

TENORM is defined as any naturally occurring radioactive materials whose radionuclide concentrations or potential for human exposure has been increased above levels encountered in the natural state as a result of human activities (USEPA, 1999; NAS, 1999). In the discussion below, SRK will address the question of whether elevated concentrations or radioactive minerals are likely to be generated in significant amounts in the Dry Stack Tailings facility. This discussion will address the (1) ranges of uranium concentration generally found in crustal rock types, (2) general concentrations by rock type as related to the percentages of various rocks found in the Rosemont project area, (3) radionuclide analysis results for Rosemont tailings samples, and (4) uranium solubility at pH ranges expected in the tailings with reference on other Arizona deposits where information is readily available.

The discussion below cites data from a number of sources that use different units of measurement. Units of picoCuries per gram (pCi/g), milligrams per kilogram (mg/kg), and parts per million (ppm) refer to analyses performed on rock or soil solids. PicoCuries per Liter (pCi/L) and milligrams per Liter (mg/L) refer to analyses of liquids such as groundwater or extracts from geochemical testwork. Unit conversions are described in the notes under each table.

#### 3.1 Uranium Content of Crustal Rocks

Information about the characteristics of uranium in background concentrations in various rock types has been compiled by a number of researchers. The average background uranium concentration found in crustal rocks is 1.92 pCi/g or 2.78 parts per million (ppm) according to a compilation completed by the U.S. Environmental Protection Agency (USEPA, 1999). The values in the ranges and averages in two studies reviewed by SRK vary by rock type from a high in granite of 4.78 ppm to a low in sandstone of 0.5 ppm (USEPA, 1999; Hansen, 1975). Although the two sources of information used different populations, there is general congruence in the ranges and averages, such as high uranium values in granite and low values in basalt. The range of values presented in Table 5 for various crustal rock types establish background levels that can be used to evaluate the uranium concentrations measured in the tailings samples at Rosemont.

In general, uranium is found in accessory minerals in igneous rocks, such as zircon, monazite, sphene, apatite, and other minerals that are more common in the more silicic or felsic<sup>5</sup> rocks, such as granite and rhyolite. Mafic igneous rocks, such as basalt, have the lowest content of radioactive minerals. Generally, sedimentary rocks are low in radioactivity, with the exception of black, carbonaceous shale and arkosic sandstone. In sedimentary rocks, most of the radionuclides are in the detrital particles, such as feldspars that are rich in potassium. Uranium enrichment in black shale results from the tendency for uranium to precipitate from solution in reducing environments, such as in the presence of organic material, sulfide-bearing minerals, or hydrogen sulfide (Johnson, 1991).

The majority of the host rocks at Rosemont that will be placed on the Dry Stack Tailings consist of carbonate (limestone or dolomite) that is characterized by low concentrations of uranium (0.99 – 2.2 ppm) per research compiled on crustal rocks. The shale present at Rosemont is red oxidized siltstone or shale, which contains low amounts of uranium compared to the higher amounts of uranium in black shale, which enhances precipitation of uranium by the presence of organic material. The generally low concentration of uranium documented in carbonate rocks globally is important in establishing the natural low background concentration of uranium expected in the ore materials at Rosemont, which are primarily light-colored, non-organic limestone formations.

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<sup>5</sup> Silicic refers to a rock that is rich in silica. Felsic refers to a rock such as granite, rhyolite, or monzonite that is enriched in silica, oxygen, aluminum, potassium, and sodium and contains minerals such as quartz, muscovite, orthoclase, and sodium-rich plagioclase feldspars.

**Table 5 Average background levels of uranium in crustal rocks**

| Rock Type              | Uranium Range or Average (pCi/g) <sup>1</sup> | Uranium Range (converted to ppm) <sup>1</sup> | Uranium average (ppm) <sup>2</sup> |
|------------------------|-----------------------------------------------|-----------------------------------------------|------------------------------------|
| Mafic Basalt           | 0.34 – 0.61                                   | 0.49 – 0.88                                   |                                    |
| Salic Basalt           | 2.67 – 3.22                                   | 3.87 – 3.99                                   |                                    |
| Basalt                 |                                               |                                               | 1.0                                |
| Carbonate              | 0.68 – 1.37                                   | 0.99 – 1.99                                   | 2.2                                |
| Clean Sandstone        | 0.68 – 1.37                                   | 0.99 – 1.99                                   |                                    |
| Dirty Sandstone        | 1.38 – 2.06                                   | 2.00 – 2.99                                   |                                    |
| Sandstone              |                                               |                                               | 0.5                                |
| Granite                | 2.06 – 3.30                                   | 2.99 – 4.78                                   | 3.0                                |
| Soils average          | 1.23                                          | 1.78                                          |                                    |
| <b>Crustal average</b> | <b>1.92</b>                                   | <b>2.78</b>                                   |                                    |
| Shale                  | 2.20                                          | 3.19                                          | 3.7                                |
| Rhyolite               | 2.75                                          | 3.99                                          |                                    |

Note: pCi/g = picoCuries per gram; conversion from pCi/g to ppm: 1.0 part per million (ppm) = 0.69 pCi/g  
Sources: <sup>1</sup> = USEPA (October 1999, Table 6); <sup>2</sup> = Hansen (1975)

### 3.2 Percentages of Potentially Uranium-bearing Rock Units at Rosemont

The most frequent sources of natural uranium and residual radioactivity in the Arizona porphyry copper deposits are granitic rocks associated with Precambrian intrusive and metamorphic basement rocks and Laramide<sup>6</sup> intrusive igneous rocks (ADEQ, 1989; USEPA, 1999). The most common intrusive igneous rocks in these deposits include granite, quartz monzonite porphyry, quartz latite porphyry, and granodiorite porphyry.

As commented previously by SRK (2012), the volume of intrusive igneous rocks found in the ore types at Rosemont is low, in contrast to the amounts of intrusive igneous rock types that occur at nearby porphyry copper mines. Most of the other porphyry copper deposits contain significant percentages of Precambrian granite or Laramide quartz monzonite porphyry (Tqmp) that host the sulfide ore. For example, the amount of Tqmp found at the two closest analogs to the Rosemont deposit—Mission mine (active) and Twin Buttes mine (inactive)—is estimated to be 50 percent by volume. In contrast, igneous rocks at Rosemont containing the ore that will be processed through the mill during life of mine are less than 0.002% of the material to be placed in the Dry Stack Tailings (Table 6).

**Table 6 Summary of tonnages of sulfide rock types to be sent to the mill (and tailings)**

| Formation, rock type          | Tons material | % by weight of total |
|-------------------------------|---------------|----------------------|
| Horquilla Limestone (sulfide) | 246,897,000   | 45.191               |
| Horquilla Limestone (mixed)   | 12,360,000    | 2.262                |
| Earp Formation (sulfide)      | 91,053,000    | 16.666               |
| Colina Limestone (sulfide)    | 79,220,000    | 14.500               |
| Epitaph Dolomite (sulfide)    | 47,995,000    | 8.785                |
| Escabrosa Limestone (sulfide) | 19,810,000    | 3.626                |
| Sulfide other                 | 48,119,000    | 8.807                |
| Mixed other                   | 166,000       | 0.030                |
| Quartz Monzonite Porphyry     | 12,000        | 0.002                |
| Abrigo (mixed)                | 712,000       | 0.130                |
| Total Amounts                 | 546,344,000   | 100.000              |

Source: Geochemical Solutions, LLC (2012, Table 1 Rock types mined by year)

<sup>6</sup> Laramide refers to the period in which the Laramide Orogeny (mountain building event) occurred at the end of the Late Cretaceous to Early Tertiary time period approximately 75 Ma to 55 million years (Ma) before present.

### 3.3 Analyses Methods for Uranium and Radionuclides

Uranium content can be measured in groundwater, in solids, and in the fluid extracts derived from laboratory test work. There are regulatory standards for groundwater used for drinking water and for soil materials used for residential and non-residential purposes. The USEPA national Maximum Contaminant Level (MCL) for total uranium concentration in groundwater used for drinking purposes is 30 micrograms per Liter ( $\mu\text{g/L}$ ) (which can be converted to 30 parts per billion (ppb) or 0.03 ppm assuming 1 Liter of water has a mass of 1 kg). The mass of uranium in the water is needed to demonstrate compliance with this rule rather than just total uranium activity in pCi/L. Arizona has not adopted a numeric standard for uranium mass in groundwater as included in the Arizona Aquifer Water Quality Standards.

The Arizona non-residential soil remediation level (NRSRL) for uranium chemical toxicity is 200 mg/kg. Processed ore that is subsequently ground to rock-powder grit and placed in a tailings storage facility can contain trace amounts of uranium in the soil-sized particles. So although tailings are ground rock and not natural soil materials per se, they can be analyzed for total uranium content in units of mg/kg, and these results can be compared to the Arizona NRSRLs.

There are no regulatory standards for fluid extracts derived through laboratory test work, but the results can be compared to numeric water quality standards for reference purposes.

In addition to uranium concentration noted in units of mg/L or mg/kg, all uranium isotopes are radioactive. The three natural uranium isotopes found in the environment, U-234, U-235, and U-238, undergo radioactive decay by emission of an alpha particle accompanied by weak gamma radiation. The dominant isotope, U-238, forms a long series of decay products that includes the key radionuclides radium-226, and radon-222. The decay process of uranium continues until a stable, non-radioactive decay product is formed. Most of the naturally occurring radionuclides are alpha particle emitters (e.g., the uranium isotopes and radium-226), but naturally occurring beta particle emitters do occur (e.g., radium-228 and potassium-40).

Gross alpha radionuclides are radiological contaminants specifically identified by measuring the concentration of radionuclides that emit alpha particles, particularly the radioactivity from radium-224 and radium-226. The approved method is EPA Method 900.0.2.

The current Arizona Aquifer Water Quality Standards for activity are:

- 5 picoCuries per Liter (pCi/L) for combined radium 226/228;
- 15 pCi/L for gross alpha for all alpha emitters of (not including radon and uranium); and
- 4 millirem/year for combined beta emitters.

The gross alpha activity of a water sample is an estimate of the actual alpha activity of the water sample. If the gross alpha activity is greater than 5 pCi/L, but less than 15 pCi/L, an analysis is performed to determine the radium (Ra)-226 and Ra-228 activities of the water sample. If the combined activity of the radium isotopes exceeds 5 pCi/L, then the sample has a radium violation. If the gross alpha exceeds 15 pCi/L, then, in addition to the Ra-226 and Ra-228 activities, the total uranium activity is determined. The total uranium activity is subtracted from the gross alpha activity to obtain the adjusted gross alpha activity. If the adjusted gross alpha activity exceeds 15 pCi/L, then the water sample has a gross alpha violation, even if there is no radium violation.

Attempts to estimate the mass of uranium from total activity, or the total activity from mass, are prone to significant errors. Only laboratory methods that can measure the concentration of each individual isotope of uranium can provide the needed parameters accurately.

### 3.4 Results for Rosemont Geochemical and Tailings Test Work

Rosemont's geochemical consultants conducted uranium or radionuclide analyses on composite tailings samples consisting of more than one formation in proportions to be used in mining operations for particular production years. Limestone is not expected to contain any more than very low residual uranium (if present at all) based on analysis of rocks elsewhere in southern Arizona. Tetra Tech also focused their Tier II uranium and radionuclide investigation on specific rock types that were identified during the Tier I geochemical test phase to be potentially acid generating (PAG) or to have undetermined potential to generate acid such as Bolsa Quartzite, Willow Canyon Arkose, andesite, and quartz latite/quartz monzonite porphyry.

Although limited numbers of rock units at Rosemont were analyzed for uranium and radionuclides, the rock types that were analyzed (limestone, arkose, and andesite) will comprise the dominant volume of the mined materials (tailings, waste rock). The majority of the samples analyzed for radionuclides or uranium by Tetra

Tech (2007, 2010) returned results that were below the detection limits (designated by a < symbol). Only a few samples returned results that were slightly above detection (Table 7, Table 8, Table 9, and Table 10).

**Table 7 Summary of SPLP radionuclide testing data**

| Rock type | Sample No. | Gross Alpha | Adjusted Gross Alpha | Gross Beta | Gross Radium 226 | Radium 238 | Uranium |
|-----------|------------|-------------|----------------------|------------|------------------|------------|---------|
| Units     |            | pCi/L       | pCi/L                | pCi/L      | pCi/L            | pCi/L      | mg/kg   |
| Colina    | A830-01    | --          | --                   | --         | --               | --         | <0.0003 |
| Arkose    | AR2001-01  | <1.0        | <1.0                 | 2.7        | <0.02            | <1.0       | <0.0010 |
| Arkose    | AR2003-03  | <1.0        | <1.0                 | <2.0       | <0.2             | <1.0       | <0.0010 |
| Arkose    | AR2009-01  | <1.0        | <1.0                 | <2.0       | <0.2             | <1.0       | <0.0010 |
| Andesite  | AR2013-01  | 1.1         | 1.1                  | 8.3        | <0.2             | <1.0       | <0.0010 |

Source: Tetra Tech (September 2007, Geochemical Characterization Addendum 1, Table A.5)

SPLP = Synthetic Precipitation Leaching Procedure

-- = Not measured; 1 mg/kg = 1 part per million (ppm); pCi/L = picoCuries per Liter.

Maximum contaminant level (MCL) by USEPA for total uranium concentration in groundwater used for drinking water is 30 micrograms per Liter ( $\mu\text{g/L}$ ) (converted to 30 parts per billion (ppb) or 0.03 ppm, assuming 1 Liter of water has a mass of 1 kg)

The adjusted gross alpha particle activity is the gross alpha particle activity including radium 226, minus radon and total uranium (i.e. the sum of uranium 238, uranium 235, and uranium 234 isotopes) reported in pCi/L.

The rock units analyzed for radionuclides (gross alpha, adjusted gross alpha, gross beta, gross radium 226, radium 238, and uranium) were arkose (three samples), Colina Limestone (one sample), and andesite (one sample). These analyses were conducted on samples of fluids and solids derived from the Synthetic Precipitation Leaching Procedure (SPLP) testing (Tetra Tech, 2007). All of the samples, except the andesite and arkose, returned SPLP results that were below detection levels (Table 7).

Whole rock analyses were performed on the July 2008 tailings samples representing production years 1 to 3 and years 4 to 7. SPLP and Meteoric Water Mobility Procedure (MWMP) were performed on a mixed sample of Earp, Horquilla, and Escabrosa formations that represented the proportional amount of these rock types expected to be milled during the first 7 years. Year 1-3 sample contained uranium above the detection limit (2.89 mg/kg or 2.89 ppm) as shown in Table 8. The uranium contents of the Year 4-7 tailings composite containing Horquilla, Earp, Colina, and Epitaph was not measured, possibly because the previous result on the whole rock analysis was close to natural background of uranium in crustal rocks and the fluids derived from SPLP and MWMP testing were below detection limits (Tetra Tech, 2010).

**Table 8 Summary of uranium analyses from whole rock, SPLP, and MWMP tailings analyses**

| Date      | Rock Units                                                           | Test Type   | Result | Unit  |
|-----------|----------------------------------------------------------------------|-------------|--------|-------|
| July 2008 | 1-3 year composite (21.3% Earp, 72.9% Horquilla, 5.8% Escabrosa)     | Whole rock  | 2.89   | mg/kg |
| July 2008 | (1-3 year composite) 21.3% Earp, 72.9% Horquilla, 5.8% Escabrosa     | SPLP fluids | <0.002 | mg/L  |
| July 2008 | (1-3 year composite) 21.3% Earp, 72.9% Horquilla, 5.8% Escabrosa     | MWMP fluids | <0.001 | mg/L  |
| July 2008 | 4-7 year composite (50% Horquilla, 28% Earp, 18% Colina, 4% Epitaph) | Whole rock  | NM     | mg/kg |

Source: Tetra Tech (August 2010, Attachment D, Summary of Geochemical Data for Tailings Samples)

Note: SPLP = Synthetic Precipitation Leaching Procedure; MWMP = Meteoric Water Mobility Procedure; NM = Not measured; Conversion: 1 mg/kg = 1 part per million (ppm) assuming 1 Liter of water has a mass of 1 kg.

Uranium was also measured at low concentrations in the feed charge and fluid extracts from Humidity Cell tests performed by McClelland Laboratories, Inc. of Sparks, Nevada. Humidity Cell Tests were performed on rock units that were determined during preliminary geochemical test work (acid base accounting tests or ABA) as being potentially acid generating (PAG). Two PAG composite samples of Bolsa Quartzite material were prepared and analyzed (Tetra Tech, 2009). Sample A780-02 was a composite of samples having average sulfide-sulfur analyses based on the results of ABA test work. Sample A780-03 was composited from samples with high (worst case) sulfide-sulfur analyses. The uranium content in the feed charge for both samples (0.633 mg/kg for A780-02 and 0.795 mg/kg for A780-03) was measured in concentrations well below the average uranium crustal abundance of 2.78 ppm (2.78 mg/kg).

The fluid extracts from every fifth week of the Humidity Cell tests were analyzed from the two Bolsa composite samples. Most of the uranium analyses were below detection limits (McClelland, 2009). Sample

A780-02 measured uranium concentrations above detection in Week 0 and in the samples taken during Weeks 5 through 24. Sample A780-03 measured uranium concentrations above detection in Week 0 and Week 25 only.

**Table 9 Metals analysis results, Humidity Cell test fluid extracts on Bolsa Quartzite**

| Sample No.       | A780-02                                                       | A780-03                                                    |
|------------------|---------------------------------------------------------------|------------------------------------------------------------|
| Materials Type   | Bolsa Quartzite Composite with Average Sulfide-Sulfur Content | Bolsa Quartzite Composite with High Sulfide-Sulfur Content |
| Element Analyzed | Uranium (mg/L)                                                | Uranium (mg/L)                                             |
| Week 0           | 0.00440                                                       | 0.00137                                                    |
| Weeks 1-4        | <0.00100                                                      | <0.00100                                                   |
| Weeks 5-8        | <0.00100                                                      | <0.00100                                                   |
| Weeks 9-12       | <0.00100                                                      | <0.00100                                                   |
| Weeks 13-16      | 0.00105                                                       | <0.00100                                                   |
| Weeks 17-20      | 0.00176                                                       | <0.00100                                                   |
| Weeks 21-24      | 0.00165                                                       | <0.00100                                                   |
| Week 25          | <0.00100                                                      | 0.00132                                                    |

Note: 1 ppm = 1 mg/L, assuming 1 Liter of water has a mass of 1 kg  
Source : McClelland Laboratories, Inc. (August 17, 2009, Tables 7 and 8)

Cumulative metals mobility data from the Humidity Cell tests were calculated by McClelland Laboratories during the study. Inductively Coupled Plasma (ICP) metals analysis results (provided to McClelland by Tetra Tech) for the A780-02 sample (Bolsa Quartzite) and A780-03 (Composite) feed solids, extract volumes, and constituent concentrations from HC test extracts were used to calculate constituent mobility on a mass basis. These data were provided to place mobility potential in perspective with respect to the percentage of total contained metals actually mobilized during the Humidity Cell tests.

Constituent mobility was minimal from the two A780 solids-charges (McClelland, 2009). McClelland states that "Potential for metals mobility was minimal, and primary metals were not detected in Humidity Cell test extracts in concentration exceeding primary drinking water maximum contaminant levels (MCLs) after week 0" (McClelland, 2009). Results after the initial sample were generally below detection limits or were very low. For example, of the 0.633 ppm of uranium in the initial feed of the Humidity Cell test for the Bolsa Quartzite, only 1.58 percent was mobilized during the testing (Table 10) (McClelland, 2009). The 0.10 ppm of uranium that was mobilized was far below the average crustal abundance of uranium (2.78 ppm).

**Table 10 Cumulative metals mobility data, Humidity Cell Test**

| Sample No.                         | A780-02         | A780-03         |
|------------------------------------|-----------------|-----------------|
| Materials Type                     | Bolsa Quartzite | Composite       |
| Element Analyzed                   | Uranium (mg/kg) | Uranium (mg/kg) |
| Metals in feed                     | 0.633           | 0.795           |
| Metals mobilized                   | 0.10            | 0.002           |
| Percent of feed that was mobilized | 1.58            | 0.25            |

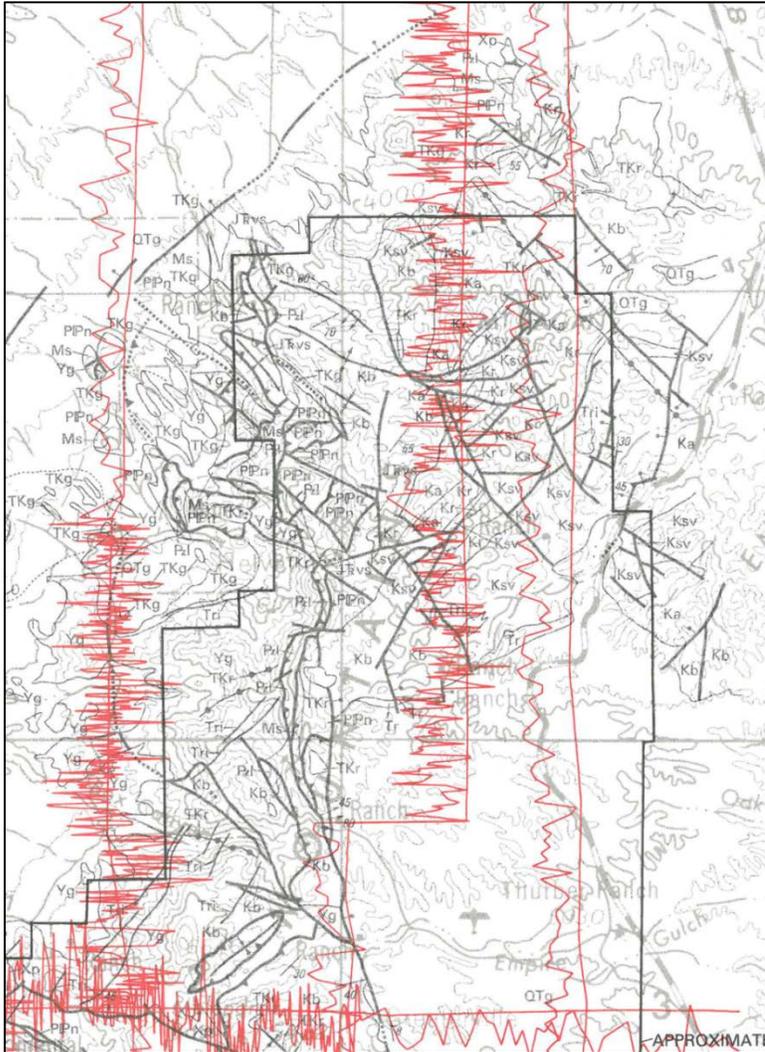
Source : McClelland Laboratories, Inc. (August 17, 2009, Table 9)

### 3.5 Analyses for Residual Uranium in Coronado National Forest

In a thorough study of the geophysics of the Coronado National Forest, Gettings (1996) analyzed the National Uranium Resource Evaluation (NURE) geophysical data to evaluate the gravity, magnetic, and gamma-ray spectrometric anomaly fields in the CNF units. The residual uranium NURE data consisted of gamma-ray total count; equivalent residual uranium, thorium, and potassium; and other data. The residual uranium values (Figure 1) are plotted as profiles along the flight lines projected onto maps at the scale of compilation of the geologic maps. For these plots, a base level was chosen for each area that approximates the average value of the data; base-level values are plotted in red on the flight-line location. Residual uranium values that are less

than the base level are plotted to the left of the North-South red line and values that are higher than the base level are plotted to the right.

The residual uranium values in the vicinity of the Rosemont deposit are primarily lower than the base level (Figure 1). The values for thorium and radioactive potassium are also primarily lower than the base level (Gettings, 1996). Gamma-ray emissions depicted by the radiometric profiles are produced by material in the upper few meters of the Earth's crust. The geologic formations shown on the figure indicate that the flight line was over the location of outcrops of Cretaceous Bisbee Group, Pennsylvanian-Permian Naco Group limestone, and Cretaceous volcanic and sedimentary rocks. Even in areas where the ground is mineralized at surface, these rock units contain very low amounts of uranium.



Source: Gettings in DuBray and others (1996, Plate 20)

Note: Red line is residual NURE radiometric-uranium values, with base value = 45 counts per second (CPS); deflections to the right of flight path are positive anomalies and deflections to the left are negative anomalies for North-South oriented lines. For East-West lines, positive and negative anomalies are shown above and below the line, respectively.

**Figure 1 Residual NURE radiometric uranium values at Rosemont**

### 3.6 Uranium Solubility

Groundwater in southern Arizona does not typically mobilize uranium in high concentrations although radionuclides such as uranium and gross alpha have been reported above detection in areas where groundwater wells are screened in 1.4 billion year old Precambrian basement rock such as the Oracle or Ruin Granite. Natural groundwater in southern Arizona generally falls between pH 7 to 9, which is the pH range where uranium is insoluble or has very low solubility.

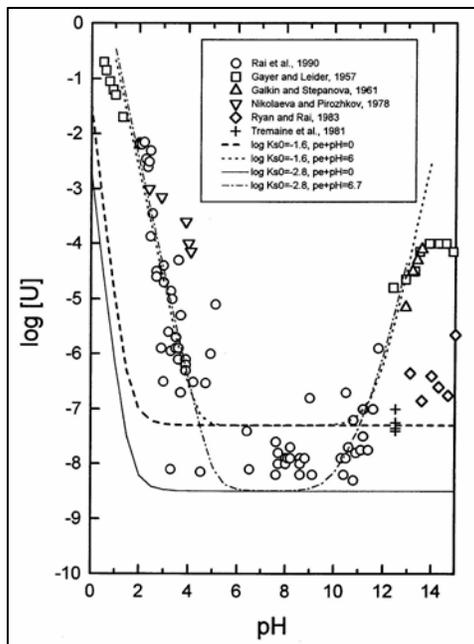
The solubility of uranium minerals and compounds is greatest in acidic, low pH conditions and in alkaline, high pH conditions. Uranium compounds have low solubility between approximately pH 6 through pH 11

(Figure 2). These characteristics of uranium solubility are the basis for the leaching and processing of uranium ores with either very acidic or very alkaline process solutions. In commercial uranium leaching operations, a low pH or high pH solution must be added to liberate the uranium in heap leach or in-situ leach operations. In Arizona, elevated uranium has been noted in groundwater at select porphyry copper mines where low-pH sulfuric acid process solution circulating in unlined rock leach dumps liberated uranium from the host rocks (EPA, 1999). At Twin Buttes, sufficient uranium was present in the deposit for Cyprus to commission a uranium extraction plant that operated in the 1980s. Elevated thorium-230 and uranium were detected in the Twin Buttes oxide tailings ponds in 1985 (EPA, 1999).

Based on the geochemical test work and fate and transport modeling completed to date for the Rosemont tailings facility, Tetra Tech modeled water quality for the starting solution for the tailings facilities and the resulting seepage water quality (Tetra Tech, 2010b). The starting solution is a mix of meteoric water and residual process water in contact with the tailings (called pore water). The pore water in contact with simulated Rosemont tailings materials (using composites of more than one formation and the testwork on Horquilla, Colina, Epitaph, and Earp formations) was estimated to have pH values ranging from a near-neutral 6.47 to an alkaline value of 8.1 depending on the specific rock type. This is the pH range in which uranium has very low solubility or is generally insoluble. The modeled tailings seepage chemistry was estimated to have a pH of slightly acidic pH of 5.87. Uranium concentration was not included in the model starting solutions owing to the fact it was not detected in the geochemical test work program so it was not relevant to include in the model simulations; uranium was therefore not generated in the seepage model results.

It may be useful to compare the Rosemont tailings seepage predictions with actual pH values and uranium concentrations from a closed tailings facility in southern Arizona (San Manuel). This conventional tailings facility contained a higher relative percentage of pore water to solids than the Rosemont Dry Stack Tailings will have during its operation and has a much higher proportion of intrusive igneous rocks than are found at Rosemont. The Precambrian Oracle Granite and Laramide granodiorite porphyry are the dominant host rocks at the San Manuel deposit and main component of the tailings facilities. As mentioned previously, uranium in Arizona porphyry deposits is typically associated with Precambrian and Laramide intrusive rocks.

The San Manuel tailings pore water measured in several locations in four tailings facilities ranged from a minimum pH of 5.1 to a maximum pH of 9.5; the majority of pH measurements ranged from 7.3 to 7.9. The tailings seepage water had a pH ranging from 7.7 to 7.9. Uranium in the tailings pore water ranged from <0.0001 to 0.00099 mg/L with the uranium concentration in the seepage water ranging from 0.0004 to 0.0104 mg/L (SRK, 2005). The individual tailings facilities operated for 30-50 years prior to decommissioning; the water quality measurements on the tailings were taken 5 to 27 years after the tailings were deactivated. The measurements for these actual tailings fluids were well below the national MCL of 0.03 mg/L uranium.



Note: Solubility data under nominally reducing conditions; log [U] is concentration

Source: Casas and others (1998, Figure 5)

**Figure 2 Uranium dioxide solubility versus pH**

### 3.1 Assessment of TENORM Potential in Dry Stack Tailings

In SRK's professional opinion, the potential for TENORM to be present in the Rosemont tailings was minimally, but adequately, evaluated in the geochemical model for tailings. This opinion is based upon the fact that uranium concentration in the major host rocks and tailings materials at Rosemont is expected to be very low or below average crustal abundance as documented by analysis of other limestone units in southern Arizona. Uranium results were below the detection limit in most of the samples analyzed. The concentration generated during geochemical testwork was primarily below detection so the fate and transport model or the facilities did not include uranium in the starting solution for water in contact with tailings. The total uranium content in solids is also well under the Arizona non-residential soil remediation limit of 200 mg/L for chemical toxicity.

Several factors contribute to the low potential for TENORM to be of concern at Rosemont. The primary reason for this conclusion is that the rocks that contribute the higher values of uranium (Precambrian granite and Laramide granite or quartz monzonite porphyry) are rare at Rosemont. The majority of the rock mass (91 percent) proposed to be mined at Rosemont is carbonate, which has very low background concentrations of uranium. Most of the analyses for radionuclides and uranium that were conducted on rocks from Rosemont confirm that the mineralized samples of carbonates are generally below detection limits (0.002 mg/kg or ppm) or are less than the average crustal abundance of uranium (1-3 ppm). The radioactivity of the tailings solids and the total uranium content during the life of mine are expected to be low. A trace uranium constituent may be present in extremely low amounts in the local host rocks and tailings solids, but the mobility of this uranium in contact with near-neutral to slightly alkaline pore water in the Dry Stack Tailings is expected to be *de minimus* based on mobility evaluations performed by McClelland Laboratories.

Routine compliance groundwater monitoring and reporting for radionuclides is specified in Rosemont's Aquifer Protection Permit No. P-106100 issued by the Arizona Department of Environmental Quality. Gross alpha particle activity (pCi/L), radium 226+Radium 228 (pCi/L), total uranium (mg/L), uranium isotopes (pCi/L) are all required on a biennial basis from the seven point of compliance wells.

In SRK's opinion, the unmineralized and mineralized rocks present at the Rosemont site will not generate detectable TENORM concentrations. Because of the very low concentration of uranium and radionuclides in the host rock, the concentration process that produces tailings will only technologically enhance the ratio of uranium and radionuclides by a very slight amount. The amount of technological enhancement is expected to be *de minimus*.

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Attachment A:  
Background Water Quality Analyses – Organic Compounds  
Sampling by Montgomery & Associates (2007-2008)  
Analyses by ACZ Laboratories, Inc. (2007-2008)

Sampling by Verdad Group (2009-2010)  
Analyses by Columbia Analytical Services (2009-2010)

**Table 1 Sampling points and dates, first sample set, 2007-2008**

| Sample Point        | Well Installation Date | Sample Point Description            | Sample Dates                                     | ACZ Lab ID                           |
|---------------------|------------------------|-------------------------------------|--------------------------------------------------|--------------------------------------|
| TTBH-08-08C         |                        | Piezometer well                     | 23-Jun-08                                        | L70179                               |
| Cienega Creek       | N/A                    | Creek                               | 24-Jun-08                                        | L70179                               |
| Upper Cienega Creek | N/A                    | Creek                               | 24-Jun-08                                        | L70179                               |
| Deering Spring      | N/A                    | Spring                              | 29-Apr-08<br>29-Jul-08                           | L68953<br>L70885                     |
| G-35                |                        | Historic well                       | 29-Apr-08<br>28-Jul-08                           | L68953<br>L70885                     |
| HC-1A               | 24-Jul-08              | Hydrogeologic characterization well | 9-Aug-08                                         | L71306                               |
| HC-1B               | 22-Jul-08              | Hydrogeologic characterization well | 15-Aug-08                                        | L71238                               |
| HC-2A               | 26-Jun-08              | Hydrogeologic characterization well | 03-Jul-08                                        | L70340                               |
| HC-2B               | 22-Jun-08              | Hydrogeologic characterization well | 08-Jul-08                                        | L70418                               |
| HC-3A               | 29-May-08              | Hydrogeologic characterization well | 11-Sep-08                                        | L71827                               |
| HC-3B               | 30-Apr-08              | Hydrogeologic characterization well | 04-Sep-08                                        | L71623                               |
| HC-3C               | 21-May-08              | Hydrogeologic characterization well | 02-Sep-08                                        | L71582                               |
| HC-4A               | 22-Jun-08              | Hydrogeologic characterization well | 22-Jul-08                                        | L70695                               |
| HC-4B               | 10-Jun-08              | Hydrogeologic characterization well | 17-Jul-08                                        | L70588                               |
| HC-5A               | 21-May-08              | Hydrogeologic characterization well | 18-Jun-08                                        | L70016                               |
| HC-5B               | 16-May-08              | Hydrogeologic characterization well | 24-Jun-08                                        | L70124                               |
| HV-1                |                        | Historic well                       | 18-Sep-07<br>24-Apr-08 24-Jul-08                 | L65117<br>L68913<br>L70755           |
| HV-2                |                        | Historic well                       | 18-Sep-07<br>24-Apr-08 24-Jul-08                 | L65117<br>L68913<br>L70755           |
| MC-1 Spring         | N/A                    | McCleary No. 1 Spring               | 23-Jul-08                                        | L70755                               |
| MC-2 Spring         | N/A                    | McCleary No. 2 Spring               | 22-Apr-08<br>23-Jul-08                           | L68853<br>L70755                     |
| PC-1                | 3-Apr-07               | Pit characterization well           | 25-May-07                                        | L62859                               |
| PC-2                | 25-Feb-07              | Pit characterization well           | 16-May-07<br>22-Apr-08<br>25-Jul-08              | L62687<br>L68853<br>L70755           |
| PC-3                | 25-Mar-07              | Pit characterization well           | 1-Jun-07                                         | L62992                               |
| PC-4                | 28-Apr-07              | Pit characterization well           | 18-May-07                                        | L62751                               |
| PC-5                | 16-Jun-08              | Pit characterization well           | 21-Oct-08<br>21-Oct-08<br>23-Oct-08              | L72632<br>L72639<br>L72677           |
| PC-6                | 31-Aug-08              | Pit characterization well           | 12-Oct-08<br>13-Oct-08<br>14-Oct-08<br>16-Oct-08 | L72438<br>L72463<br>L72496<br>L72561 |
| PC-7                | 13-Jul-08              | Pit characterization well           | 2-Oct-08<br>3-Oct-08<br>4-Oct-08<br>7-Oct-08     | L72215<br>L72248<br>L72247<br>L72329 |
| PC-8                | 14-May-08              | Pit characterization well           | 23-Sep-08<br>25-Sep-08<br>27-Sep-08              | L71996<br>L72069<br>L72094           |
| P-899               |                        | Pit characterization well           | 21-Apr-08<br>25-Jul-08                           | L68853<br>L70755                     |
| RP-2A               | 18-Jul-08              | Groundwater POC well                | 28-Aug-08                                        | L71524                               |
| RP-2B               | 14-Jul-08              | Groundwater POC well                | 26-Aug-08                                        | L71459                               |
| RP-2C               | 17-Jul-08              | Groundwater POC well                | 22-Aug-08                                        | L71404                               |
| RP-3A               | 30-Jun-08              | Groundwater POC well                | 15-Jul-08                                        | L70535                               |
| RP-3B               | 27-Jun-08              | Groundwater POC well                | 12-Jul-08                                        | L70472                               |
| RP-4A               | 6-Jun-08               | Groundwater POC well                | 01-Jul-08                                        | L70297                               |
| RP-4B               | 3-Jun-08               | Groundwater POC well                | 26-Jun-08                                        | L70195                               |
| RP-5                | 30-Jun-08              | Groundwater monitor well            | 24-Jul-08                                        | L70756                               |
| RP-6                | 2-Jul-08               | Groundwater monitor well            | 29-Jul-08                                        | L70855                               |
| RP-7                | 15-Jul-08              | Groundwater monitor well            | 05-Aug-08                                        | L70986                               |
| RP-8                | 11-Jul-08              | Groundwater monitor well            | 07-Aug-08<br>27-Aug-08                           | L71043<br>L71094                     |
| RP-9                | 13-Jul-08              | Groundwater monitor well            | 13-Aug-08                                        | L71193                               |
| Questa Spring       | N/A                    | Spring                              | 23-Apr-08<br>29-Jul-08                           | L68853<br>L70885                     |
| Rosemont Spring     | N/A                    | Spring                              | 23-Apr-08<br>29-Jul-08                           | L68853<br>L70885                     |

**Table 1 Sampling points and dates, first sample set, 2007-2008 (continued)**

| Sample Point    | Well Installation Date | Sample Point Description | Sample Dates           | ACZ Lab ID       |
|-----------------|------------------------|--------------------------|------------------------|------------------|
| Sycamore Spring | N/A                    | Spring                   | 30-Jul-08              | L70885           |
| (D-19-16)17ddd  | 1982                   | Historic well            | 25-Apr-08<br>24-Jul-08 | L68913<br>L70755 |
| (D-19-16)18ddb  | 1995                   | Historic well            | 25-Apr-08<br>24-Jul-08 | L68913<br>L70755 |

Source: Compiled by SRK, 2012 from records provided by Montgomery & Associates

**Table 2 Sampling points and dates, second sample set, 2009-2010**

| Sample point          | Sample Point Description | Sample Dates | Columbia Lab ID |
|-----------------------|--------------------------|--------------|-----------------|
| Trip Blank            | Groundwater monitor well | 22-Jun-09    | 09060364-01     |
| Equipment Blank RP-3B | Groundwater monitor well | 22-Jun-09    | 09060364-02     |
| RP-3B                 | Groundwater monitor well | 22-Jun-09    | 09060364-03     |
| Field Blank RP-3B     | Groundwater monitor well | 22-Jun-09    | 09060364-04     |
| Trip Blank            | Groundwater monitor well | 23-Jun-09    | 09060396-01     |
| RP-2C                 | Groundwater monitor well | 24-Jun-09    | 09060396-02     |
| RP-2B                 | Groundwater monitor well | 23-Jun-09    | 09060396-03     |
| RP-2B dup             | Groundwater monitor well | 23-Jun-09    | 09060396-04     |
| RP-3A                 | Groundwater monitor well | 24-Jun-09    | 09060396-05     |
| Trip Blank            | Groundwater monitor well | 25-Jun-09    | 09060423-01     |
| RP-4B                 | Groundwater monitor well | 25-Jun-09    | 09060423-02     |
| RP-4A                 | Groundwater monitor well | 25-Jun-09    | 09060423-03     |
| Trip Blank            | Groundwater monitor well | 24-Aug-09    | 09080453-01     |
| Equipment Blank RP-3A | Groundwater monitor well | 24-Aug-09    | 09080453-02     |
| RP-3A                 | Groundwater monitor well | 24-Aug-09    | 09080453-04     |
| Field Blank RP-3A     | Groundwater monitor well | 24-Aug-09    | 09060468-01     |
| RP-3A                 | Groundwater monitor well | 24-Jun-09    | 09060468-02     |
| Trip Blank            | Groundwater monitor well | 25-Aug-09    | 09080473-01     |
| RP-2B                 | Groundwater monitor well | 25-Aug-09    | 09080473-02     |
| Trip Blank            | Groundwater monitor well | 26-Aug-09    | 09080491-01     |
| RP-2C                 | Groundwater monitor well | 26-Aug-09    | 09080491-02     |
| RP-2B                 | Groundwater monitor well | 26-Aug-09    | 09080491-03     |
| Trip Blank            | Groundwater monitor well | 27-Aug-09    | 09080520-01     |
| RP-4B                 | Groundwater monitor well | 27-Aug-09    | 09080520-02     |
| RP-4A                 | Groundwater monitor well | 27-Aug-09    | 09080520-03     |
| Trip Blank            | Groundwater monitor well | 09-Sep-09    | 09090144-01     |
| Equipment Blank RP-3A | Groundwater monitor well | 09-Sep-09    | 09090144-02     |
| Field Blank RP-3A     | Groundwater monitor well | 09-Sep-09    | 09090144-03     |
| RP-3A                 | Groundwater monitor well | 09-Sep-09    | 09090144-04     |
| RP-3A dup             | Groundwater monitor well | 09-Sep-09    | 09090144-05     |
| Trip Blank            | Groundwater monitor well | 27-Oct-09    | 09090473-01     |
| RP-3A                 | Groundwater monitor well | 27-Oct-09    | 09090473-02     |
| RP-3B                 | Groundwater monitor well | 27-Oct-09    | 09090473-03     |
| Trip Blank            | Groundwater monitor well | 28-Oct-09    | 09100513-01     |
| RP-2C                 | Groundwater monitor well | 28-Oct-09    | 09100513-02     |
| RP-2B                 | Groundwater monitor well | 28-Oct-09    | 09100513-03     |
| Trip Blank            | Groundwater monitor well | 29-Oct-09    | 09100550-01     |
| RP-5                  | Groundwater monitor well | 29-Oct-09    | 09100550-02     |
| RP-4B                 | Groundwater monitor well | 29-Oct-09    | 09100550-03     |
| Trip Blank            | Groundwater monitor well | 10-Dec-09    | 09120195-01     |
| Equipment Blank RP-5  | Groundwater monitor well | 09-Dec-09    | 09120195-02     |

**Table 2 Sampling points and dates, second sample set, 2009-2010**

| Sample point          | Sample Point Description | Sample Dates | Columbia Lab ID |
|-----------------------|--------------------------|--------------|-----------------|
| Field Blank RP-5      | Groundwater monitor well | 09-Dec-09    | 09120195-03     |
| RP-5                  | Groundwater monitor well | 09-Dec-09    | 09120195-04     |
| Trip Blank            | Groundwater monitor well | 10-Dec-09    | 09120222-01     |
| RP-4A                 | Groundwater monitor well | 10-Dec-09    | 09120222-02     |
| Trip Blank            | Groundwater monitor well | 11-Dec-09    | 09120243-01     |
| RP-4B                 | Groundwater monitor well | 11-Dec-09    | 09120243-02     |
| RP-3B                 | Groundwater monitor well | 11-Dec-09    | 09120243-03     |
| RP-3A                 | Groundwater monitor well | 11-Dec-09    | 09120243-04     |
| Trip Blank            | Groundwater monitor well | 14-Dec-09    | 09120260-01     |
| RP-2C                 | Groundwater monitor well | 14-Dec-09    | 09120260-02     |
| RP-2B                 | Groundwater monitor well | 14-Dec-09    | 09120260-03     |
| Trip Blank            | Groundwater monitor well | 17-Feb-10    | 09120317-01     |
| Field Blank RP-5      | Groundwater monitor well | 17-Feb-10    | 09120317-02     |
| Equipment Blank RP-5  | Groundwater monitor well | 17-Feb-10    | 09120317-03     |
| RP-5                  | Groundwater monitor well | 17-Feb-10    | 09120317-04     |
| Trip Blank            | Groundwater monitor well | 18-Feb-10    | 09120345-01     |
| RP-3B                 | Groundwater monitor well | 18-Feb-10    | 09120345-02     |
| RP-3A                 | Groundwater monitor well | 18-Feb-10    | 09120345-03     |
| RP-4B                 | Groundwater monitor well | 18-Feb-10    | 09120345-04     |
| Trip Blank            | Groundwater monitor well | 19-Feb-10    | 09120349-01     |
| RP-2C                 | Groundwater monitor well | 19-Feb-10    | 09120349-02     |
| RP-2B                 | Groundwater monitor well | 19-Feb-10    | 09120349-03     |
| Equipment Blank RP-4A | Groundwater monitor well | 25-May-10    | 10050447-01     |
| Field Blank RP-4A     | Groundwater monitor well | 25-May-10    | 10050447-02     |
| RP-4A                 | Groundwater monitor well | 25-May-10    | 10050447-03     |
| RP-4A dup             | Groundwater monitor well | 25-May-10    | 10050447-04     |
| Trip Blank            | Groundwater monitor well | 26-May-10    | 10050482-01     |
| RP-4B                 | Groundwater monitor well | 26-May-10    | 10050482-02     |
| Trip Blank            | Groundwater monitor well | 27-May-10    | 10050516-01     |
| RP-2C                 | Groundwater monitor well | 27-May-10    | 10050516-02     |
| RP-2B                 | Groundwater monitor well | 27-May-10    | 10050516-03     |
| RP-5                  | Groundwater monitor well | 27-May-10    | 10050516-04     |
| Trip Blank            | Groundwater monitor well | 28-May-10    | 10050534-01     |
| RP-3B                 | Groundwater monitor well | 28-May-10    | 10050534-02     |
| RP-3A                 | Groundwater monitor well | 28-May-10    | 10050534-03     |

Source: Compiled by SRK, 2012 from records provided by Montgomery & Associates

**Table 3 Tabulation of water quality analysis for organic compounds – First sample set**

| Parameter<br>(µg/L)            | TTBH-08-08C | Upper<br>Cienega<br>Creek dup | HC-4B      | HC-4B dup  | HC-5B      | HC-5B<br>trip blank |
|--------------------------------|-------------|-------------------------------|------------|------------|------------|---------------------|
|                                | 06/23/2008  | 06/24/2008                    | 07/17/2008 | 07/17/2008 | 06/24/2008 | 06/24/2008          |
| 2-Butanone                     |             |                               |            |            |            |                     |
| Acetone                        | 50          | 30                            | 80         | 60         |            |                     |
| Benzoic acid                   |             |                               | 65         |            | 70         |                     |
| Bis(2-ethylhexyl)<br>phthalate |             |                               |            |            |            |                     |
| Diethylphthalate               |             |                               |            |            |            |                     |
| Hexachlorobutadiene            |             |                               |            |            | 12         | 14                  |
| Toluene                        |             |                               | 92         | 87         |            |                     |
| Laboratory                     | ACZ         | ACZ                           | ACZ        | ACZ        | ACZ        | ACZ                 |
| Laboratory ID                  | L70179-01   | L70179-04                     | L70588-01  | L70588-02  | L70124-01  | L70124-02           |

| Parameter<br>(µg/L)            | PC-2       | PC-2       | PC-3       | PC-4       | PC-5-TOTAL | PC-5-1516-<br>LP |
|--------------------------------|------------|------------|------------|------------|------------|------------------|
|                                | 04/22/2008 | 07/25/2008 | 06/01/2007 | 05/18/2007 | 10/21/2008 | 10/23/2008       |
| 2-Butanone                     | 60         |            |            |            |            |                  |
| Acetone                        |            | 60         | 60         |            |            |                  |
| Benzoic acid                   |            |            |            |            |            |                  |
| Bis(2-ethylhexyl)<br>phthalate |            |            |            |            |            |                  |
| Diethylphthalate               |            |            |            |            | 9          |                  |
| Hexachlorobutadiene            |            |            |            |            |            |                  |
| Toluene                        |            |            | 34         | 46         |            | 59               |
| Laboratory                     | ACZ        | ACZ        | ACZ        | ACZ        | ACZ        | ACZ              |
| Laboratory ID                  | L68853-02  | L70755-07  | L62992-01  | L62751-01  | L72632-01  | L72677-01        |

| Parameter<br>(µg/L)            | RP-2A      | RP-2B      | RP-7       | RP-8       | RP-9       |
|--------------------------------|------------|------------|------------|------------|------------|
|                                | 08/28/2008 | 08/26/2008 | 08/05/2008 | 08/07/2008 | 08/13/2008 |
| 2-Butanone                     |            |            |            |            |            |
| Acetone                        |            |            |            |            |            |
| Benzoic acid                   |            |            |            |            |            |
| Bis(2-ethylhexyl)<br>phthalate |            |            | 42         | 31         | 21         |
| Diethylphthalate               |            |            |            |            |            |
| Hexachlorobutadiene            |            |            |            |            |            |
| Toluene                        | 141        | 10         | 36         |            |            |
| Laboratory                     | ACZ        | ACZ        | ACZ        | ACZ        | ACZ        |
| Laboratory ID                  | L71524-01  | L71459-01  | L70986-01  | L71043-01  | L71193-01  |

Source: Compiled by SRK, 2012 from records provided by Montgomery & Associates

**Table 4 Tabulation of water quality analysis for organic compounds – Second sample set**

| Parameter<br>(µg/L)    | Equipment<br>Blank<br>RP-3B | Field Blank<br>RP-3B | Trip Blank  | RP-2C       | Trip Blank  | RP-4B       |
|------------------------|-----------------------------|----------------------|-------------|-------------|-------------|-------------|
|                        | 6/22/2009                   | 6/22/2009            | 6/23/2009   | 6/24/2009   | 6/25/2009   | 6/25/2009   |
| 1,2,4-trimethylbenzene |                             |                      |             |             |             |             |
| 1,3,5-trimethylbenzene |                             |                      |             |             |             |             |
| 4-isopropyltoluene     |                             | 16.6                 |             |             |             |             |
| bromoform              | 0.7                         | 0.6                  |             |             |             |             |
| chloroethane           |                             |                      |             |             |             |             |
| naphtalene             |                             |                      |             |             |             | 1.2         |
| toluene                |                             |                      | 0.6         | 0.5         | 0.5         |             |
| total trihalomethanes  | 0.7                         | 0.6                  |             |             |             |             |
| xylene, total          |                             |                      |             |             |             |             |
| Laboratory             | Columbia                    | Columbia             | Columbia    | Columbia    | Columbia    | Columbia    |
| Laboratory ID          | 09060364-02                 | 09060364-04          | 09060396-01 | 09060396-02 | 09060423-01 | 09060423-02 |

| Parameter<br>(µg/L)    | Field Blank<br>RP-3A | Equipment<br>Blank<br>RP-3A | RP-4B       | Equipment<br>Blank<br>RP-3A | Field Blank<br>RP-3A | RP-3B       |
|------------------------|----------------------|-----------------------------|-------------|-----------------------------|----------------------|-------------|
|                        | 8/24/2009            | 8/24/2009                   | 8/27/2009   | 9/9/2009                    | 9/9/2009             | 10/27/2009  |
| 1,2,4-trimethylbenzene |                      |                             | 0.5         |                             |                      |             |
| 1,3,5-trimethylbenzene |                      |                             | 0.5         |                             |                      |             |
| 4-isopropyltoluene     |                      |                             |             |                             |                      |             |
| bromoform              | 0.9                  | 0.6                         |             | 0.6                         | 0.6                  |             |
| chloroethane           |                      |                             |             |                             |                      | 0.6         |
| naphtalene             |                      |                             | 1.1         |                             |                      |             |
| toluene                |                      |                             |             |                             |                      |             |
| total trihalomethanes  |                      |                             |             | 0.6                         | 0.6                  |             |
| xylene, total          |                      | 0.6                         | 0.7         |                             |                      |             |
| Laboratory             | Columbia             | Columbia                    | Columbia    | Columbia                    | Columbia             | Columbia    |
| Laboratory ID          | 09060468-01          | 09080453-02                 | 09080520-02 | 09090144-02                 | 09090144-03          | 09090473-03 |

| Parameter<br>(µg/L)    | RP-4B       | Field Blank<br>RP-5 | Field Blank<br>RP-6 | Equipment<br>Blank<br>RP-5 | Equipment<br>Blank<br>RP-4A | Field Blank<br>RP-4A |
|------------------------|-------------|---------------------|---------------------|----------------------------|-----------------------------|----------------------|
|                        | 10/29/2009  | 12/9/2009           | 2/17/2010           | 2/17/2010                  | 5/25/2010                   | 5/25/2010            |
| 1,2,4-trimethylbenzene |             |                     |                     |                            |                             |                      |
| 1,3,5-trimethylbenzene |             |                     |                     |                            |                             |                      |
| 4-isopropyltoluene     |             |                     |                     |                            |                             |                      |
| bromoform              |             | 1.1                 | 2.8                 | 2.6                        | 1.9                         | 1.6                  |
| chloroethane           |             |                     |                     |                            |                             |                      |
| naphtalene             | 0.6         |                     |                     |                            |                             |                      |
| toluene                |             |                     |                     |                            |                             |                      |
| total trihalomethanes  |             |                     | 2.8                 | 2.6                        |                             |                      |
| xylene, total          |             |                     |                     |                            |                             |                      |
| Laboratory             | Columbia    | Columbia            | Columbia            | Columbia                   | Columbia                    | Columbia             |
| Laboratory ID          | 09100550-03 | 09120195-03         | 09120317-02         | 09120317-03                | 10050447-01                 | 10050447-02          |

Source: Compiled by SRK, 2012 from records provided by Montgomery & Associates

**Table 5 Analysis of bis(2-ethylhexyl) phthalate**

| Laboratory ID | Sample Identifier       | Sample Date | Date Parameter Analyzed | Value (µg/L) | Qualifier |
|---------------|-------------------------|-------------|-------------------------|--------------|-----------|
| L62687-01     | PC-2                    | 05/16/2007  | 05/30/2007              | < 4          | U         |
| L62751-01     | PC-4                    | 05/18/2007  | 05/31/2007              | < 4          | U         |
| L62859-01     | PC-1                    | 05/25/2007  | 06/12/2007              | < 4          | U         |
| L62992-01     | PC-3                    | 06/01/2007  | 06/13/2007              | < 4          | U         |
| L68853-01     | P-899                   | 04/21/2008  | 05/05/2008              | < 4          | U         |
| L68853-02     | PC-2                    | 04/22/2008  | 05/05/2008              | < 4          | U         |
| L68853-03     | MC-2 Spring             | 04/22/2008  | 05/05/2008              | < 4          | U         |
| L68853-04     | Questa Spring           | 04/23/2008  | 05/05/2008              | < 4          | U         |
| L68853-05     | Rosemont Spring         | 04/23/2008  | 05/05/2008              | < 4          | U         |
| L68913-01     | HV-2                    | 04/24/2008  | 06/04/2008              | < 4          | U         |
| L68913-02     | HV-1                    | 04/24/2008  | 06/04/2008              | < 4          | U         |
| L68913-03     | Field Blank for PC-3    | 04/24/2008  | 06/04/2008              | < 4          | U         |
| L68913-04     | HV-1 dup                | 04/24/2008  | 06/04/2008              | < 4          | U         |
| L68913-05     | (D-19-16)18ddb          | 04/25/2008  | 06/04/2008              | < 4          | U         |
| L68913-06     | (D-19-16)17ddd          | 04/25/2008  | 06/04/2008              | < 4          | U         |
| L68913-07     | (D-19-16)17ddd dup      | 04/25/2008  | 06/04/2008              | < 4          | U         |
| L68953-01     | Deering Spring          | 04/29/2008  | 06/04/2008              | < 4          | U         |
| L68953-02     | Field Blank for G-35    | 04/29/2008  | 06/04/2008              | < 4          | U         |
| L68953-03     | G-35                    | 04/29/2008  | 06/04/2008              | < 4          | U         |
| L70016-01     | HC-5A                   | 06/18/2008  | 07/21/2008              | < 4          | U         |
| L70124-01     | HC-5B                   | 06/24/2008  | 07/20/2008              | < 4          | U         |
| L70179-01     | C-13                    | 06/23/2008  | 07/21/2008              | < 4          | U         |
| L70179-03     | Upper Cienega Creek     | 06/24/2008  | 07/21/2008              | 6            | J         |
| L70179-04     | Upper Cienega Creek dup | 06/24/2008  | 07/21/2008              | < 4          | U         |
| L70179-05     | Field Blank             | 06/24/2008  | 07/21/2008              | < 4          | U         |
| L70195-01     | RP-4B                   | 06/26/2008  | 07/21/2008              | < 4          | U         |
| L70297-01     | RP-4A                   | 07/01/2008  | 07/20/2008              | < 4          | U         |
| L70340-01     | HC-2A                   | 07/03/2008  | 07/23/2008              | < 4          | U         |
| L70418-01     | HC-2B                   | 07/08/2008  | 07/21/2008              | < 4          | U         |
| L70472-01     | RP-3B                   | 07/12/2008  | 07/21/2008              | < 4          | U         |
| L70535-01     | RP-3A                   | 07/15/2008  | 08/01/2008              | < 4          | U         |
| L70588-01     | HC-4B                   | 07/17/2008  | 08/01/2008              | < 4          | U         |
| L70695-01     | HC-4A                   | 07/22/2008  | 08/04/2008              | < 4          | U         |
| L70755-01     | MC-1 Spring             | 07/23/2008  | 08/04/2008              | < 4          | U         |
| L70755-02     | MC-2 Spring             | 07/23/2008  | 08/05/2008              | < 4          | U         |
| L70755-03     | (D-19-16)18ddb          | 07/24/2008  | 08/05/2008              | < 4          | U         |
| L70755-04     | (D-19-16)17ddd          | 07/24/2008  | 08/05/2008              | < 4          | U         |
| L70755-05     | HV-2                    | 07/24/2008  | 08/05/2008              | < 4          | U         |
| L70755-06     | HV-1                    | 07/24/2008  | 08/05/2008              | 4            | J         |
| L70755-07     | PC-2                    | 07/25/2008  | 08/05/2008              | < 4          | U         |
| L70755-08     | P-899                   | 07/25/2008  | 08/08/2008              | < 4          | U         |
| L70755-09     | Field Blank             | 07/25/2008  | 08/08/2008              | < 4          | U         |
| L70756-01     | RP-5                    | 07/24/2008  | 08/08/2008              | < 4          | U         |
| L70855-01     | RP-6                    | 07/29/2008  | 08/13/2008              | 9            | J, B1     |
| L70885-01     | G-35                    | 07/28/2008  | 08/13/2008              | 10           | J, B1     |
| L70885-02     | G-36 dup                | 07/28/2008  | 08/13/2008              | 8            | J, B1     |
| L70885-03     | Deering Spring          | 07/29/2008  | 08/13/2008              | 12           | J, B1     |
| L70885-04     | Rosemont Spring         | 07/29/2008  | 08/13/2008              | 10           | J, B1     |
| L70885-05     | Questa Spring           | 07/29/2008  | 08/13/2008              | 11           | J, B1     |
| L70885-06     | Sycamore Spring         | 07/30/2008  | 08/15/2008              | 12           | J, B1     |
| L70885-07     | Sycamore Spring dup     | 07/30/2008  | 08/15/2008              | 14           | J, B1     |
| L70986-01     | RP-7                    | 08/05/2008  | 09/04/2008              | 42           | B1        |
| L71043-01     | RP-8                    | 08/07/2008  | 09/04/2008              | 31           | B1        |

**Table 5 Analysis of bis(2-ethylhexyl) phthalate (continued)**

| Laboratory ID | Sample Identifier | Sample Date | Date Parameter Analyzed | Value (µg/L) | Qualifier |
|---------------|-------------------|-------------|-------------------------|--------------|-----------|
| L71193-01     | RP-9              | 08/13/2008  | 09/05/2008              | 21           | B1        |
| L71238-01     | HC-1B             | 08/15/2008  | 09/15/2008              | 5            | J         |
| L71306-01     | HC-1A             | 08/19/2008  | 09/15/2008              | < 4          | U         |
| L71404-01     | RP-2C             | 08/22/2008  | 09/09/2008              | < 4          | U         |
| L71459-01     | RP-2B             | 08/26/2008  | 09/23/2008              | 13           | J         |
| L71524-01     | RP-2A             | 08/28/2008  | 09/23/2008              | < 4          | U         |
| L71582-01     | HC-3C             | 09/02/2008  | 09/23/2008              | < 4          | U         |
| L71623-01     | HC-3B             | 09/04/2008  | 09/23/2008              | < 4          | U         |
| L71827-01     | HC-3A             | 09/11/2008  | 09/22/2008              | < 4          | U         |
| L71996-01     | PC-8              | 09/23/2008  | 10/09/2008              | < 4          | U         |
| L72069-01     | PC-8-863          | 09/25/2008  | 10/27/2008              | < 4          | U         |
| L72094-01     | PC-8-1930         | 09/27/2008  | 10/08/2008              | < 4          | U         |
| L72215-01     | PC-7              | 10/02/2008  | 10/17/2008              | < 4          | U         |
| L72247-01     | PC-7-902-MP       | 10/04/2008  | 10/20/2008              | < 4          | U         |
| L72248-01     | PC-7-602-UP       | 10/03/2008  | 10/20/2008              | < 4          | U         |
| L72329-01     | PC-7-1422-LP      | 10/07/2008  | 10/23/2008              | < 4          | U         |
| L72438-01     | PC-6              | 10/12/2008  | 10/23/2008              | < 4          | U         |
| L72463-01     | PC-6-522-UP       | 10/13/2008  | 10/28/2008              | < 4          | U         |
| L72496-01     | PC-6-1002-MP      | 10/14/2008  | 10/28/2008              | < 4          | U         |
| L72561-01     | PC-6-1502-LP      | 10/16/2008  | 10/28/2008              | 10           | J         |
| L72632-01     | PC-5-TOTAL        | 10/21/2008  | 11/10/2008              | < 4          | U         |
| L72639-01     | PC-5-922-UP       | 10/21/2008  | 11/10/2008              | < 4          | U         |
| L72677-01     | PC-5-1516-LP      | 10/23/2008  | 11/10/2008              | < 4          | U         |

## Notes:

U = analyte was analyzed for but not detected at the indicated MDL

J = the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

B1 = Target analyte detected in prep / method blank at or above the method reporting limit. See case narrative. It is attributable to methylene chloride reagent used in the extraction process and was confirmed by the supplying vendor.