WORKPLAN (REVISION 2)

SITE GROUNDWATER CHARACTERIZATION AND DETECTION MONITORING PROGRAM

Lehigh Southwest Cement Company
Permanente Plant and Quarry
24001 Stevens Creek Boulevard
Cupertino, California

Submitted To: San Francisco Bay Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612

Submitted By: Golder Associates Inc.
425 Lakeside Drive
Sunnyvale, CA 94085

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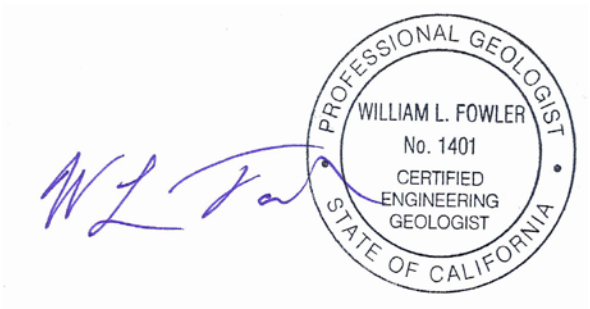
This Workplan has been prepared by and under the direction of:



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1.0 INTRODUCTION

Golder Associates Inc. (Golder) on behalf of Lehigh Southwest Cement Company (Lehigh) has prepared this revised Workplan to conduct an investigation of the site hydrogeology underlying the Lehigh Permanente Cement Plant and Quarry (Site) located at 24001 Stevens Creek Boulevard in Santa Clara County, California (Figure 1), inform the development of and implement a detection monitoring program, and ultimately evaluate any potential impacts to groundwater from the overburden and any other materials contained in the Eastern Materials Storage Area (EMSA) and Western Materials Storage Area (WMSA). The requirement for the investigation was included in a letter from the San Francisco Bay Regional Water Quality Control Board (RWQCB) to Lehigh dated June 26, 2013, providing conditional concurrence for a previous submittal, "*Workplan for Characterization of the Eastern and Western Materials Storage Area,"* and requesting additional associated technical work and reports. The requirement was included as Additional Investigation Technical Report Item 1:

> *"1. **Groundwater Investigation Workplan, Implementation, and Reporting:** A characterization of site hydrogeology is necessary to inform the development of a detection monitoring program in accordance with title 27. In addition, it is necessary to evaluate potential impacts to groundwater from the waste piles, and identify if surface water or groundwater that discharges to drinking water aquifers have been or could be impacted from on-site sources.*
>
> *We require that you submit and implement a workplan to install a groundwater monitoring well network to achieve both objectives. The network must be sufficient to characterize the hydrogeology of the site, including the interaction between site groundwater and adjacent surface waters including Permanente Creek and creeks to the north and west of the site. Given the reversal of groundwater flow direction caused by pumping in the quarry (indicated by the disappearance of Permanente Creek flow in the stretch adjacent to the quarry), it is expected that the hydrogeology of the site is complicated, necessitating that a qualified and experienced team of hydrogeologists perform the investigation. In order to adequately evaluate potential groundwater contamination, the COCs listed above must be monitored quarterly for a minimum of 2 years to obtain a robust dataset for evaluating impacts.*
>
> *A technical report must be submitted that presents and analyzes the results of the hydrogeologic and contaminant investigation. Graphics depicting the potentiometric surface of groundwater on site, including adjacent to Permanente Creek and creeks to the north and west of the site to demonstrate where the creeks are gaining and losing, must be included. In addition, groundwater contaminant data must be compared to the applicable water quality objectives for the protection of drinking water and aquatic habitat."*

1.1 Objectives

In accordance with the above, we have prepared this Workplan for review and concurrence by the RWQCB. The fundamental objectives of the proposed work are:

1. Characterize the site hydrogeologic conditions in sufficient level of detail such that a groundwater detection monitoring program for the relevant area can be developed in accordance with CCR Title 27. The existing Conceptual Site Model (CSM) for the site (Section 1.3 below) will be updated and revised to describe in more detail and confirm the site hydrogeology.

2. Utilize the developed monitoring program to create a site-wide potentiometric groundwater map, monitor groundwater flow and geochemistry, and evaluate any potential impacts to groundwater and/or adjacent surface water[1] from the EMSA/WMSA.

3. Utilize the refined CSM and geochemistry data from the monitoring program to regularly update the potential for impacts to groundwater and/or adjacent surface water from the EMSA/WMSA.

The Workplan includes a narrative of the site historical background and the regional topographic and geologic setting. This is followed by the proposed scope of work and schedule for the investigation. We are proposing a phased investigation to (1) install exploratory borings and wells, (2) evaluate the resulting data, prepare, and update the CSM, (3) propose a monitoring well network adequate to characterize site hydrology and inform the development of detection monitoring under CCR Title 27, (4) implement a monitoring program to supply groundwater hydrology and chemistry data for the CSM, and (5) evaluate any potential impacts to groundwater and/or adjacent surface water.

1.2 Access Constraints

The study proposed in this Workplan has been designed to provide sufficient information to meet the stated objectives using the most appropriate available technical methods. The methods were chosen to provide high quality information in an expedient manner in consideration of the challenges presented by the site. These challenges are both physical and regulatory.

The study area is located in the narrow, steep-sided Permanente Creek canyon that currently has few access roads adjacent to the creek. Installation of new roads, for example, to install monitoring wells, is constrained by several physical, land use, geotechnical, and environmental constraints, including: a) the steep-slopes require high cutslopes and fill slopes to create roads which are unstable and are prone to slope failures and erosion when disturbed; b) the established boundary of land disturbance activities imposed by the Reclamation Plan issued by Santa Clara County limits where grading activities are currently allowed; and c) potential habitat restrictions to protect the United States and California listed endangered California Red Legged Frog (CRLF). While construction of roads in the creek canyon may ultimately be technically feasible, the associated permitting and mitigation efforts would likely require many months, and possibly years, to obtain approval.

Given the constraints, the proposed Workplan has been prepared to gather the appropriate information utilizing existing access along the creek, such that the work can be completed in a timely manner and without compromising the objectives of the investigation.

[1] The RWQCB already separately regulates point source discharges to surface waters that may originate from the EMSA and WMSA as a result of precipitation events via the NPDES permit program; those discharges are not the subject of this Workplan.

1.3 Conceptual Site Model and Project Approach

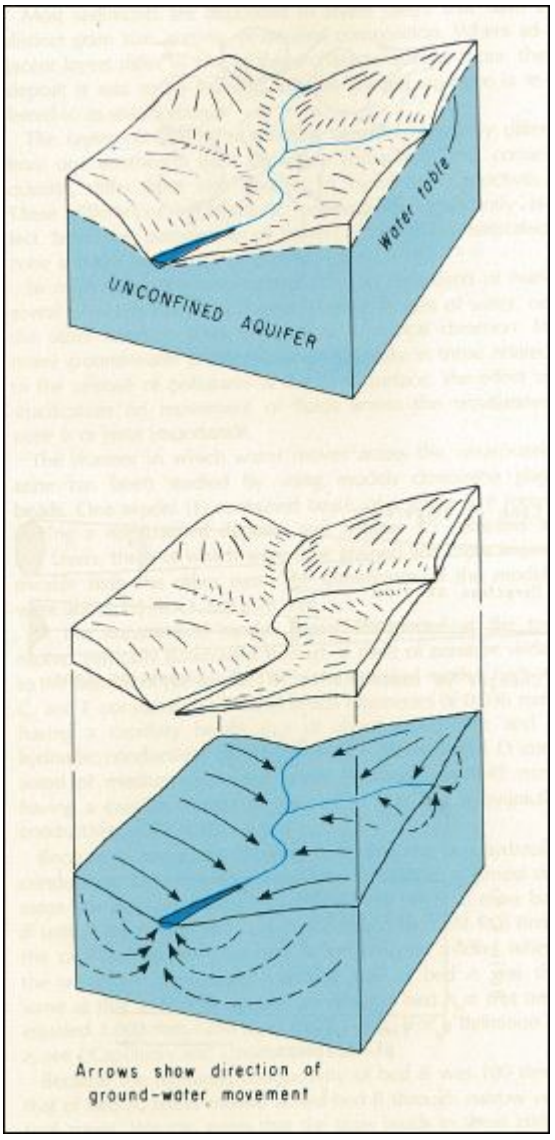
The Workplan details our current CSM and the additional data that will be collected to update the CSM and achieve the stated objectives. The CSM is intended to provide a current understanding of hydrogeologic and environmental conditions at the Site and is based, in part, on the available historical data for the Site. Review of historical data for a site is always part of a thorough CSM to adequately understand dynamic physical, chemical, and biological components involved, and is standard professional practice.[2,3] The CSM is a "living document" that is updated as additional data are collected. The CSM comprises a three dimensional understanding of the physical site setting of the area to be investigated and includes key hydrogeologic features and properties such as:

- The physical geologic and stratigraphic setting, including the known geologic and stratigraphic units of interest
- Hydrostratigraphic units, including aquifers of relevance and local and regional groundwater flow systems
- Groundwater elevation levels
- Physical and hydrogeologic boundaries that define the groundwater flow systems of interest, including recharge and discharge areas, boundaries or divides, and current conditions
- The location and character of potential on-site sources of impacts to groundwater
- Pathways for contaminate transport from potential source areas to potential receptors.

The current CSM was developed from reviewing existing data, historical reports, and our experience with hydrogeologic conditions with similar sites in the rugged terrain of the California Coast Ranges. Based on our current CSM, the field program was developed to characterize the WMSA and EMSA with respect to potential impacts to ground and/or adjacent surface waters from stored overburden and/or any other materials and potential pathways to these receptors. The results of this field program will provide the data necessary to broaden and provide more details regarding our current understanding of site conditions and to develop an appropriate detection monitoring program. Section 2 of this report provides site background information while Section 3 describes the regional physical geologic and stratigraphic setting. Section 4 discusses the known hydrogeologic conditions. Section 5 summarizes the CSM, discusses potential on-site sources, potential pathways, and provides the strategy for the proposed scope of work to be completed under this Workplan. Sections 6 and 7 describe the scope of work and how it will be implemented along with quality control procedures.

[2]ASTM. 2008. "Standard Guide for Developing Conceptual Site Models for Contaminated Sites" (E1689 – 95)
[3] New Jersey Department of Environmental Protection. 2011. "Technical Guidance for Preparation and Submission of a Conceptual Site Model"

The basic premise of our current CSM is that groundwater in rugged upland bedrock terrain, such as the Santa Cruz Mountains, typically flows from topographic highs, which act as groundwater divides, to topographic lows forming drainage basins or watersheds.[4] Perennial streams in mountainous terrain (absent a lake or snowpack in the headwaters), receive flow throughout the year because of baseflow from groundwater. In unconfined systems, groundwater flow typically follows a similar topographic pattern as surface water runoff.



Major drainage basins are typically comprised of smaller sub-basins. In mountainous terrain similar to the physical setting of the site, sub-basins are created from side canyons and smaller ridges trending opposite of the dominant ridges, and are typically drained by zero-order and first-order drainages. This is typically referred to as a trellis style drainage network. This drainage pattern is evident on topographic maps and aerial photographs of the undisturbed portion of the property south of Permanente Creek.

On the portion of the site underlain by the WMSA and EMSA, this drainage pattern is no longer evident, as the current topography has been significantly altered from the original topography to facilitate the storage of overburden and related materials. However, upon reviewing historical aerial photographs and USGS topographic maps, the sub-basins are evident in these areas of the site as well. The review of aerial photographs indicates that the ground surface was not altered (*i.e.,* mined or otherwise graded) in the WMSA prior to placement of overburden from the pit. In the EMSA, grading of roads and building pads occurred as part of the early industrial development of the area but the fundamental topography of the sub-basins in this area still remains. As the original ground surface was not significantly altered prior to creating the WMSA and EMSA, the sub-basin drainage pattern is inferred to still be the predominant geomorphic indicator as

[4] USGS. 1983. Basic Ground Water Hydrology, USGS Water-Supply Paper 2220, “Ground Water Movement and Topography”.

to how groundwater flows beneath the EMSA and WMSA prior to discharging into the larger basin comprising the upper Permanente Creek watershed.

Groundwater is anticipated to be present beneath the bedrock surface in the EMSA and WMSA at variable depths depending upon the geomorphic setting. Groundwater will be relatively deep along ridges, in the range of 100 to 200 feet, and can be shallow along the axis of first order drainages, even occurring as springs. During the wet season, perched conditions may exist between the base of the stored overburden material and the bedrock surface until the water is able to infiltrate. Based on regional and site-specific geologic mapping, the basement rock beneath the WMSA and EMSA is predominantly greenstone, sheared metabasalts and/or graywacke; therefore, we anticipate limited ability to transmit groundwater as discussed in more detail in Section 4. Additional hydraulic testing will be done to further evaluate and validate this assumption.

The site is separated from the Santa Clara Valley Groundwater Basin, the main groundwater basin to the north and east of the site, by several faults which comprise the Shannon-Monta Vista fault zone (Section 3.3). The fault zones are fundamental geologic and hydrogeologic boundaries between the basement bedrock units at the site and the much younger water-producing alluvial basin deposits located downgradient of the site. Natural recharge to the Santa Clara Valley Groundwater Basin occurs primarily as infiltration from streambeds (*i.e.,* losing streams) that exit the upland areas within the drainage basin and from direct percolation of precipitation that falls on the basin floor.[5]

Recharge to groundwater in the upland bedrock terrane at the site is from precipitation. As precipitation occurs in the uplands, a certain percentage of water will infiltrate through the ground surface to the subsurface, while the remainder will be lost to surface water runoff and some to evaporation.

For the EMSA and WMSA, precipitation must first infiltrate through the stored material and then the original ground surface. This process may lead to the addition of potential dissolved phase contaminants if present. While an extensive parameter list will be analyzed consistent with the RWQCB's June 26, 2013 request, metals are likely the primary constituents of concern at the site. Metal concentrations can be caused by a change in the redox conditions where sulfate containing minerals (*e.g.,* pyrite) undergo oxidation. It is hypothesized that this geochemical process may be more pronounced in the limestone materials (as opposed to graywacke, chert, and greenstone).[6] Further, the fresher exposed in situ rock and overburden materials, coupled with greater surface area per volume, are believed to have the greatest potential for oxidation and leaching (*i.e.,* freshly exposed limestone with a fine gradation would have a higher potential for leaching of metals). Conversely, non-limestone materials that have been exposed for many years or decades are believed to have a lower (though still existent) potential for

[5] Santa Clara Valley Groundwater Basin, San Francisco Bay Hydrologic Region. California's Groundwater Bulletin 118, Update 2/27/04.
[6] Golder 2011a. Hydrologic Investigation. Permanente Quarry Reclamation Plan Update, Santa Clara County, CA.

current leaching of metals. The results from the EMSA/WMSA characterization work[7] that is concurrently in progress will be reviewed as part of the implementation of this Workplan and will help to further refine this working hypothesis.

As described in more detail in Section 5, our CSM regarding occurrence and flow of groundwater, and our approach to evaluate potential geochemical affects to groundwater is to target the discharge points of the sub-basins to Permanente Creek that are now overlain by the EMSA and the WMSA. By targeting these locations with monitoring well installations, we will be able to ascertain the groundwater quality downgradient of the respective storage areas prior to groundwater leaving the sub-basin. The well locations within, and on the inferred upgradient sides of the storage areas, are being installed to better understand our inferred flow directions in the current CSM and to see if there is spatial variability in groundwater quality within the sub-basins, and between different sub-basins. Furthermore, if our current model of groundwater occurrence and flow is generally correct, the wells installed as part of our investigative program may be in locations suitable for on-going use as detection monitoring wells.

[7] SES. 2012. Workplan for Characterization of the Eastern and Western Materials Storage Area, Permanente Quarry, Santa Clara County.

2.0 SITE OVERVIEW

The Site mainly consists of a cement manufacturing plant, limestone quarry, and material (*e.g.,* overburden) storage areas (EMSA and WMSA) located in the unincorporated foothills of western Santa Clara County, approximately two miles west of the City of Cupertino (Figure 2). Additional structures located at the Site include a building that once housed an aluminum plant, wastewater treatment plant, aggregate rock plant, and laboratory. The Site occupies a portion of a 3,510-acre property owned by Hanson Permanente Cement, Inc., and is operated by Lehigh Southwest Cement Company (collectively, Lehigh).

The Site currently comprises approximately 570 acres of operational areas, which consist of surface mining excavations, overburden stockpiling, crushing and processing facilities, access roads, administrative offices and equipment storage. The Site also includes other predominantly undisturbed areas, either held in reserve or which buffer operations from adjacent land uses. The main operational areas of the Site are currently as follows:

- Quarry: The Quarry is where mineral extraction currently occurs and has historically taken place. The Quarry features a large mining pit with elevations that currently range from approximately 750 feet to 1,750 feet above mean sea level (amsl). Limestone and greenstone mined from the Quarry are crushed and either processed into aggregate products at Lehigh's on-site Rock plant or are used for cement manufacture at Lehigh's adjacent cement plant.
- East Materials Storage Area (EMSA): The EMSA is located to the east of the Quarry and is one of two main storage sites for overburden and related materials (rock plant fines). The EMSA partially overlies a former manufacturing area and associated historical waste repositories. Elevations at the EMSA range from 550 feet at the eastern end of the EMSA up to 1,270 feet amsl at the west end. The EMSA measures approximately 77 acres in plan area. At final completion, the EMSA will reach a maximum elevation of 910 feet amsl and a maximum thickness of approximately 150 feet.
- West Materials Storage Area (WMSA): The WMSA is the original historic overburden storage site, located west of the Quarry. Elevations in the WMSA range from 1,500 to 1,950 feet amsl. The WMSA has reached capacity and will be re-graded as part of the approved Reclamation plan for the Site.
- Rock Plant: The Rock Plant is located in the southeast portion of the site, on the south side of Permanente Creek, and processes mined material into aggregate products. The Rock Plant occupies gentle slopes from approximately 580 feet to 770 feet amsl.
- Cement Plant: The cement manufacturing plant lies adjacent to the Quarry on the east and is comprised of several main buildings, processes, and associated equipment. The Cement plant occupies a major north-south trending sub-canyon to Permanente Creek. The plant site includes a rail siding and coal storage area that runs from the east up Permanente Creek to the plant. Elevations in this area range from approximately 530 feet at the Creek up to about 1000 feet at the ridge top of the drainage basin.

3.0 REGIONAL SETTING

3.1 Topography

The Site is situated in the foothills of the rugged, northwest-trending Santa Cruz Mountains segment of the California Coast Ranges. The Site and its main areas are primarily situated on the north canyon wall of the east-flowing Permanente Creek (Figure 3). Topography in the area consists of moderately to steeply-sloped terrain with rounded ridges and drainages (Figure 3). Considerable earthwork has occurred over the 70 plus years of site mining, including the mining of the main pit, placement of overburden and related materials in the EMSA and WMSA areas, and also grading associated with development of the cement plant and quarry office areas.

Relief at the Quarry ranges from about 2,000 feet along the higher ridge crests to less than 500 feet amsl along the eastern portions of Permanente Creek. Average overall slope angles are typically around 25˚. The steepest natural slopes are on the order of 40˚ over smaller slope heights (100 to 200 feet) and generally correspond to limestone outcrops.

3.2 Geologic Setting

The majority of the Site is underlain by complexly deformed and faulted rocks of the Franciscan Assemblage (Figure 4). The eastern portion of the Site, including portions of the Cement Plant and the EMSA, are underlain by Plio-Pleistocene rocks of the Santa Clara Formation. Overlying the bedrock are modern alluvial deposits associated with Permanente Creek (restricted to the eastern portion of the property), and relatively shallow surficial deposits comprised of soil and colluvium. The geology of the area has been mapped in various levels of detail for published maps by the following:

- Rogers and Armstrong (1973)
- Sorg and McLaughlin (1975)
- Vanderhurst (1981)
- Mathieson (1982)
- Brabb, Graymer, and Jones (2000)

In addition, site-specific mapping at various scales, and utilizing both surface outcrop and subsurface drill core data, has also been completed by various geologists working for Lehigh. The following provides an overview of the primary geologic units at the Quarry.

3.2.1 Franciscan Assemblage

The following information regarding the Franciscan rocks as exposed in the Quarry has been excerpted from Foruria who performed detailed geologic mapping for the Quarry.[8]

Cement-grade limestone and aggregate are extracted from the intricately folded and faulted limestones and metabasalts (greenstones) in the Quarry. These rocks are part of the Permanente Terrane of the Jurassic-Cretaceous age Franciscan Assemblage. The Franciscan Assemblage represents a subduction zone assemblage of highly deformed, variably metamorphosed, marine sedimentary rocks with oceanic crust-related submarine basalt (greenstone), chert, and limestone. This limestone-metabasalt assemblage reaches a minimum total thickness of approximately 1,100 feet and dips to the southeast.

All major stratigraphic horizons within the Franciscan rocks as exposed in the Quarry are separated by low-angle faults forming a structurally imbricated thrust stack of layered and folded rock units. The deformed thrust stack is a gently folded, northeast-trending, southeast dipping sequence in the eastern area of the Quarry and transitions southwestward to a series of en-echelon, northwest-trending, southeast-plunging, anticlinal and synclinal folds in the western area. High angle, brittle faults crosscut the Franciscan rocks, dissecting the rocks along prominent north-south and northwest-southeast orientations. A major through-going regional fault, the northwest strand of the Berrocal fault, crosses through the western end of the Quarry.

3.2.2 Santa Clara Formation

The Santa Clara Formation overlies a portion of the Franciscan Assemblage rocks in the north-central portion of the property (Figure 4). The Santa Clara Formation is a continental fluvial and alluvial deposit that is composed of unconsolidated to slightly consolidated conglomerate, sandstone, siltstone, and claystone.[9] The age of the Santa Clara Formation ranges from late Tertiary to Pleistocene. Uplift of the Coast Ranges during this time resulted in increased erosion of the mountains and deposition of the Santa Clara Formation. The contact between the Franciscan rocks and Santa Clara Formation is considered to be unconformable, with the Santa Clara Formation deposited on an eroded Franciscan terrain.[10]

3.2.3 Surficial Deposits

3.2.3.1 Alluvium

Alluvium at the Site is limited to modern unconsolidated alluvial deposits along the active stream channel of Permanente Creek. These deposits are comprised of a poorly-sorted mixture of cobbles, gravels, sand, silt and clay. Deposits range from a few inches thick in the upper reaches of the watershed where

[8] Foruria, J., 2004. Geology of the Permanente Limestone and Aggregate Quarry, Santa Clara County, California: Report prepared for Hanson Permanente Cement, September 24, 2004.
[9] Vanderhurst, W., 1981. The Santa Clara Formation and Orogenesis of Monte Bello Ridge, 114 p.
[10] Rogers, T.H. and Armstrong, C.F., 1973. Environmental Geologic Analysis of the Monte Bello Ridge Mountain Study Area, Santa Clara County, California, California Division of Mines and Geology Preliminary Report 17.

erosion has cut the channel down into bedrock, to tens of feet thick where the channel widens and deepens as it approaches the flatter terrain of the Santa Clara Valley.

3.2.3.2 Colluvium

Colluvial deposits exist throughout the Site on natural slopes including areas underlying existing older overburden storage areas (*i.e.,* EMSA and WMSA). The natural slopes in general are overlain with approximately one to two feet of soil and colluvial materials, which thickens to several feet to perhaps tens of feet thick in the larger natural swales in the region.

Where colluvial materials were encountered in past exploratory activities, they were described as predominantly clayey sand with gravel to clayey gravel, with some gravelly clay.[11] Gravel size was up to 3-inches. In general, at the time of the investigations, the colluvium was dry and ranged from loose to very stiff or dense. During winter rainfall months, the colluvium likely becomes saturated from ephemeral runoff and infiltration.

3.3 Structural Setting

The San Andreas Fault Zone is located approximately two miles southwest of the Quarry. The Sargent-Berrocal Fault Zone (SBFZ), part of the Santa Cruz Mountains front-range thrust fault system, parallels the San Andreas to the east and forms the eastern-most structural boundary to the Permanente Terrain.

Near the Site, the SBFZ consists of two northwest-trending, sub-parallel faults, namely the northeastern-most Monta Vista Fault Zone and the southwestern-most Berrocal Fault Zone (Figure 4).[12] The Monta Vista Fault Zone is located approximately one mile to the northeast of the Quarry along the northeastern property boundary. A strand of the Berrocal Fault Zone lies beneath the adjacent cement plant area to the south of the EMSA, and extends west to other portions of the Site.[11,13]

The Monta Vista Fault Zone is located in a complex contractional system of generally northeastward vergent reverse faults that bound the northeastern side of the Santa Cruz Mountains.[14] The fault zone is predominately southwest-dipping with roots to the San Andreas Fault Zone. The fault zone forms the fundamental geologic and hydrogeologic boundary between the basement bedrock units at the Site and the much younger water-producing alluvial units downgradient of the site in the Santa Clara Valley.

[11] Golder 2007. Slope Stability Evaluation for Compliance with SMARA, West and East Materials Storage Areas, Permanente Quarry, Santa Clara County, California.
[12] Sorg, D.H., and McLaughlin, R.J., 1975. Geologic Map of the Sargent-Berrocal Fault Zone between Los Gatos and Los Altos Hills, Santa Clara County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-643, scale 1:24,000.
[13] Mathieson, E. L., 1982. Geology of the Permanente Property, Kaiser Corporation, Permanente, California, unpublished Kaiser Permanente Cement Company report, 34 p.
[14] Bryant, W.A., compiler, 2000, Fault number 56, Monte Vista-Shannon fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gove/hazards/qfaults.

4.0 SITE HYDROGEOLOGIC SETTING

4.1 Climate

The regional climate is Mediterranean with the majority of precipitation occurring between November and April. Average annual precipitation is about 22 inches, consistent with the intermediate altitudes of the Santa Clara Valley, and more than 50 inches in the surrounding mountains.[15]

The climate is also temporally variable with dryer and wetter seasons from year to year. Groundwater recharge is estimated to range from about 2 to 6 inches per year based on previous work and average precipitation rates.[16]

4.2 Surface Water Flow

Figure 5 depicts the surface water drainage catchment areas as defined by the GIS program ArcHydro. The predominant drainage for the Site is Permanente Creek, which drains the vast majority of the developed portions of the Site. Permanente Creek is situated just south of the existing Quarry and is entrenched in limestone where it lies adjacent to the Quarry. To the west and east of the Quarry, Permanente Creek is mostly underlain by greenstone, greywacke, and undifferentiated Melange. As discussed further below, Permanente Creek is generally dry adjacent to the Quarry during the dry season, though flow is restored via Pond 4A discharge and downstream gaining conditions.

Permanente Creek is a perennial stream that typically flows year-round both upstream of and downstream from the Quarry and is a gaining stream (*i.e.*, baseflow from groundwater in the Creek sustains the perennial stream). In upland bedrock terrain such as this, groundwater mimics the topography with recharge in the uplands and sideslopes, and discharge to drainage channels in the form of seeps, springs, and baseflow. At times of heavy rainfall and corresponding runoff, there can be short temporal intervals of recharge along channels, but by definition, perennial streams are gaining streams throughout most of year with baseflow sustained by groundwater discharge.[17] In contrast, where Permanente Creek debouches onto the relatively flat alluvial plain of the Santa Clara Valley, and in particular near the mountain front where the alluvium is coarse-grained, the Creek becomes a losing stream and serves to recharge the primary groundwater basins of the Valley.

To the north of the WMSA and Quarry is Wildcat Canyon Creek, which is a tributary to Permanente Creek. Wildcat Canyon Creek is a perennial creek that may receive diffuse overland runoff from the northern portion of the WMSA based on its current topography (Figure 5). Wildcat Canyon Creek runs

[15] Hanson, R.T., Li, Zhen, and Faunt C.C., 2004, Documentation of the Santa Clara Valley regional groundwater/surface-water flow model, Santa Clara County, California: U.S. Geological Survey Scientific Investigation Report 2004-5231.
[16] Golder 2011a.
[17] ***Perennial stream:*** A perennial stream has flowing water year-round during a typical year. The water table is located above the stream bed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow. (US Army Corp of Engineers, Part 330, Nationwide Permit Program, March 9, 2000)

parallel to Permanente Creek until it joins Permanente Creek approximately one mile downstream from where Permanente Creek leaves the Site at the eastern edge of the property. An unnamed tributary to Permanente Creek is just north of the EMSA, but south of Wildcat Canyon Creek, in the vicinity of the Gate of Heaven cemetery. The unnamed tributary joins Permanente Creek just north of the Site after Permanente Creek makes its sharp bend to the northwest.

4.3 Seeps

Seepage in the Quarry has been observed in the headscarp of a large landslide on the north highwall between elevations 1,400 and 1,600 feet, which then enters the northwestern part of the existing Quarry at elevation 750 feet. An additional seep at approximate elevation 850 feet exists along the southwest portion of the existing quarry. This seep is now hard-piped to a sump located on the 950 elevation bench (Figure 6). Seeps in the WMSA and EMSA are being investigated under a separate workplan.[18] Findings will be incorporated with the updated CSM.

4.4 Groundwater Occurrence

At depth, the occurrence of groundwater within the Franciscan bedrock is almost exclusively within secondary openings such as joints, fractures, shear zones and faults as opposed to primary porosity or pore spaces within the rock.[19] This is related to the tectonic genesis of the Franciscan bedrock along the subducting plate margin (*i.e.,* accretionary complex) and the resulting high- and low-grade metamorphism that is characteristic of most of the rocks contained in the assemblage. The structural complexity also locally creates perched and semi-confined conditions. Because of the limited amount of primary storage (pore spaces), and the relative lack of permeability, the Franciscan is considered “nonwater-bearing” with respect to production of usable quantities of water by the Department of Water Resources.[20]

In general, first-encountered groundwater at the Site occurs under unconfined conditions. Based on exposures in the quarry and previous work, the upper portion of the Franciscan bedrock is highly weathered. Because of this, flow of first-encountered groundwater is not necessarily fracture controlled but more like that of an equivalent porous media. Groundwater typically occurs at depths of 80 to 120 feet in the upland hillside terrain, and at shallower depths at lower elevations..[21]

Groundwater also occurs within the Santa Clara Formation that outcrops in the eastern portion of the Site. Groundwater occurs in both secondary openings (*i.e.,* fractures, joints, shears zones, and faults) and pore spaces within the more granular packages (*e.g*., sandstones and conglomerates) of the Santa Clara Formation. In general, the Santa Clara Formation rocks overlie the Franciscan Assemblage and the

[18] Golder Associates. October 2013. Workplan - EMSA and WMSA Seep and Runoff Sampling, Lehigh Southwest Cement Company, Permanente Plant and Quarry.
[19] Department of Water Resources. 1967. Evaluation of Ground Water Resources, South Bay, Bulletin No. 118-1, State of California.
[20] Ibid.
[21] Golder 2011a.

formations are in hydraulic communication. In some areas, the Santa Clara Formation is considered to be part of the alluvial valley deposits that make up the Santa Clara Valley Groundwater Basin. However, the portion of the Santa Clara Formation that is considered to be water-bearing is that which dips beneath the younger alluvial deposits in the large valley areas, northeast of the Monta Vista Fault and not that portion of the formation which is located west-southwest of the Monta Vista Fault Zone (Figure 4). For example, Stevens Creek Dam and Reservoir, which is founded on the same structural block of Santa Clara Formation southwest of the Monta Vista Fault Zone, has no discernable leakage through the formation.[22]

The primary groundwater basin near the site is the Santa Clara Valley Groundwater Basin. The site is located in upland bedrock terrain west of this basin. The boundary of the Santa Clara Valley Groundwater Basin is generally considered to be the contact of the alluvial valley deposits with the consolidated bedrock formations at the surface and beneath the alluvium.[23] As discussed above, the contact between the bedrock and the alluvium is a fundamental structural boundary formed by the Monta Vista Fault Zone which greatly limits hydraulic connection between the bedrock and the alluvial basins. At the site, this contact is located just northeast of the site property line.[24]

4.5 Groundwater Flow

The regional-scale direction of groundwater flow is interpreted to be from west to east, flowing from the topographic high at Black Mountain toward the Santa Clara Valley. In the area of the main Permanente Creek drainage basin, and based on fundamental hydrogeologic principles, groundwater flow is interpreted to flow toward the north from the steep groundwater divides/ridges separating Permanente Creek from Monte Bello Creek to the south, and to the south from the ridge separating Permanente Creek from Wildcat Canyon Creek to the north. In other words, groundwater flow is generally from the main ridge crests toward the primary drainages in the region, where it subsequently discharges.

Groundwater is also captured by the Quarry, which acts as a local sink due to the dewatering that has occurred over the years. The stretch of the Creek where its water is captured by the Quarry has been mapped and defined by as part of prior investigations associated with the Reclamation Plan.[25,26] Based on existing data, groundwater flow is preferentially within the more permeable limestone units; however, because the limestone units are of limited extent (a structural block truncated and surrounded by greenstone and graywacke), the overall basin-scale groundwater flow system is controlled by the lower permeability of the greenstone/graywacke units.

[22] Groundwater Committee of the California Regional Water Quality Control Board SF Bay Region, May 2003. A Comprehensive Groundwater Protection Evaluation for the South San Francisco Basins.
[23] Ibid.
[24] Ibid.
[25] Golder 2011a.
[26] WRA Environmental Consultants, May 2010. Permanente Aquatic Technical Report, Lehigh Permanente Quarry.

Recharge to the overall groundwater system is primarily by the infiltration of precipitation. The areas with flatter slopes or areas in topographic lows receive more uniform recharge, because runoff of rainfall is less than the runoff generated from the steeper slopes. Runoff from the steeper slopes can accumulate in topographically low spots, thereby focusing infiltration in these locations. Natural recharge to the Santa Clara Valley Groundwater Basin occurs primarily as infiltration from streambeds that exit the upland areas within the drainage basin and from direct percolation of precipitation that falls on the basin floor.[27]

4.6 Hydraulic Properties

The hydraulic properties of the Franciscan are highly variable. Most published values for hydraulic conductivity of the Franciscan are in the range of 1×10^{-5} to 1×10^{-6} cm/sec. Well yields are typically low, in the range of a few gallons per minute (gpm) to tens of gpm and are restricted to domestic use. Specific yields are very low — typically less than 3%.[28]

The hydraulic properties of the hydrogeologic units at the Quarry have been estimated from packer tests and constant rate pumping tests conducted in 2009 in several exploratory boreholes located south of Permanente Creek[29] and from constant-rate pumping tests performed in 2012 as part of the design of the Quarry dewatering system.[30] The following table summarizes the hydraulic conductivity values calculated from these hydraulic tests.

Table 1: Hydraulic Conductivity Summary

Location	Data Source	Lithology	Test Type	Hydraulic Conductivity (k)	
				ft/day	cm/s
HG-2	open borehole	Limestone	Packer	0.42	1.5×10^{-4}
HG-2	open borehole	Graywacke	Packer	2.51	8.9×10^{-4}
HG-3	open borehole	Greenstone	Packer	1.3	4.6×10^{-4}
HG-3	open borehole	Limestone	Packer	6.3	2.2×10^{-3}
HG-4	open borehole	Greenstone	Packer	0.2	8.3×10^{-5}
HG-5	open borehole	Greenstone	Packer	0.2	8.3×10^{-5}
HG-8	open borehole	Greenstone	Packer	1.8	6.6×10^{-4}
HG-9	open borehole	Weathered Graywacke	Packer	29.8	1.1×10^{-2}
HG-10s	pumping well	Limestone	CRP	6	2.1×10^{-3}
EW-7	pumping well	Limestone	CRP	3	1.1×10^{-3}

Note: CRP = constant rate pump test; average k values for lithologic unit per boring are shown

[27] Santa Clara Valley Groundwater Basin, San Francisco Bay Hydrologic Region. California's Groundwater Bulletin 118, Update 2/27/04.
[28] Department of Water Resources, 1975. Bulletin 118, California's Ground Water.
[29] Golder 2011a.
[30] Golder 2012, Quarry Dewatering Pilot Study - Draft, Lehigh Permanente Quarry

Hydraulic conductivities ranging from 8.3 x 10^{-5} to 6.6 x 10^{-4} cm/s (0.2 to 1.8 feet per day (ft/day)) for greenstones and 8.3 x 10^{-5} to 2.2 x 10^{-3} cm/s (0.2 to 6.3 ft/day) for limestones were measured in the packer testing. The results of constant rate discharge tests completed in limestone south of Permanente Creek in 2009, and within the Quarry in 2012, yielded hydraulic conductivities ranging from about 1.1 x 10^{-3} to 2.1 x 10^{-3} cm/sec (3 to 6 ft/day) for the limestone units.[31] A storativity (drainable porosity) of 0.004 (dimensionless) was calculated from the drawdown data from the 2012 pumping test. The results also indicated that groundwater flow is preferentially within the more permeable limestone units. However, as the limestone units are of limited extent (truncated by greenstone), the overall regional-scale groundwater flow system is assumed to be controlled by the lower permeability of the greenstone units which surround the limestone on all sides. The lower permeability of the greenstone also causes a higher potentiometric surface in the greenstone compared to the limestone because water drains less readily from the greenstone. This also leads to steeper hydraulic gradients in the greenstone compared to the limestone.

[31] Golder 2012.

5.0 STRATEGY AND RATIONALE FOR HYDROGEOLOGIC INVESTIGATION

The proposed hydrogeologic investigation is focused on a) defining the occurrence and flow direction of groundwater at the Site, particularly in the areas of the WMSA and EMSA, including the effect of quarry dewatering activities on groundwater flow direction and volume, b) identifying how site hydrogeology might influence whether pollutants, if any, from natural and anthropogenic materials stored at the EMSA/WMSA could impact groundwater and/or adjacent surface waters, and c) integrating this new information into an updated CSM for the Site, including the Permanente Creek drainage basin. The CSM will, in turn, provide the basis for the design and implementation of a groundwater detection monitoring program, likely comprised of a network of wells and seep monitoring (as applicable), that can determine if on and/or off-site groundwater impacts are occurring. Such impacts will be evaluated in relation to attainment of relevant beneficial uses. The CSM will be updated after each round of monitoring to ensure groundwater hydrogeology (*e.g.*, flow direction and volume) is understood for all hydrologic periods.

Review of historic USGS topographic maps for the Permanente Creek drainage basin show that the WMSA and EMSA are both in discrete hydrologic sub-basins (south-flowing side canyons to Permanente Creek). These sub-basins are separate and distinct from the sub-basin where the Quarry pit was excavated, and other sub-basins that exist at the Site. Because first encountered groundwater is unconfined, it is anticipated that groundwater levels and flow directions are controlled primarily by the terrain and geology of each sub-basin. This is not true for the segment of the Creek adjacent to the Quarry, where the influence of the Quarry dewatering, and the hydraulic connection between limestone exposed in the Creek and that in Quarry, has likely created an inward gradient to form in the immediate vicinity of the Quarry. Data from instrumentation installed in the quarry floor and pitwalls, in conjunction with monitoring of discharge from the Quarry and monitoring of flow in Permanente Creek, will inform the CSM regarding the influence of the Quarry.

It is possible that some influence from the Quarry may be observed in groundwater near the easternmost portion of the WMSA due to its proximity to the Quarry (*i.e.*, margin of the cone of depression); however, the EMSA is a sufficient distance away, and separated from the Quarry by intervening sub-basins such that there is clearly no influence in this area of the Site from the Quarry. This conclusion is supported by existing piezometric data in the eastern Quarry pitwall, which shows groundwater elevations over 500 feet higher than those historically observed at the EMSA. Development of a site-wide potentiometric map that illustrates piezometric head in the EMSA as compared to the Quarry will demonstrate that the EMSA is a distinct hydrogeologic regime.

In addition to defining the hydrogeology of the WMSA and EMSA sub-basins, and integrating this information with that of the Quarry, the investigation will provide new data on groundwater geochemistry from the newly installed wells to help define any potential impacts to underlying groundwater. Following

the initial investigation, on-going monitoring of the final detection monitoring well system will be conducted to provide additional geochemical data.

Generally, the proposed boring and well locations were selected with the following criteria in mind:

- Original (prior to overburden placement) topography of the sub-drainage basin
- Upgradient and downgradient monitoring locations with respect to overburden/material placement
- Areal distribution of data points
- Thickness of overburden/material
- Estimated depth to groundwater
- Detection monitoring capability at groundwater divide to the north of each area
- Detection monitoring capability downgradient of the storage areas and above Permanente Creek
- Accessibility of proposed drill locations
- Ability to compare piezometric head between groundwater and Permanente Creek to evaluate vertical gradients and assess areas of groundwater discharge

Boring and well locations for each area are discussed in more detail in the following sections and are shown on Figures 5 through 5d. Figure 5 provides a map of the entire site while Figures 5a through 5d show more detailed historical and current views of the EMSA and WMSA areas and the proposed exploratory program.

5.1.1 WMSA Boring/Well Locations and Seep Samples

The proposed exploratory boring and well locations for the WMSA are shown on a Google Earth image from 1951 (Figure 5a) and a 2011 aerial photograph (Figure 5b). On Figure 5a, the yellow line outlines the limits of the sub-drainage basin where the overburden from the Quarry was primarily placed to form the WMSA and the pink line outlines the WMSA limit as mapped on the 2011 image. The blue lines within the yellow outline show the main ephemeral and perennial drainages underlying the WMSA sub-drainage basin prior to filling. Permanente Creek is shown in blue along the southern margin of the figure. Ephemeral drainages flowing to the north to Wildcat Canyon Creek are shown along the upper margin of the figure.

While the currently exposed surface topography within the sub-basin has been altered by the placement of overburden at the WMSA, the estimated groundwater flow directions are anticipated to follow the natural geomorphology of the sub-basin as denoted by the blue arrows on Figure 5a. Based on the natural topography underlying the WMSA, groundwater in the WMSA sub-basin is assumed to generally flow to the southeast in the head of the basin, parallel to the main tributary of the sub-basin (which is a first-order stream). The eastern portion of the sub-basin shows a strong pattern of surface drainage to the south toward Permanente Creek. Where these two areas meet they merge to form a second-order

stream, and the combined groundwater is anticipated to flow to the south where it discharges in the main axis of Permanente Creek.

It is anticipated that any influence to groundwater from the placement of overburden at the WMSA will be limited to the south side of the ridge as opposed to flowing north toward Wildcat Canyon Creek. This assumes the groundwater drainage divide mimics the natural topographic divide and therefore any percolation through the overburden will be on the south side of the natural groundwater divide and will flow to the south towards Permanente Creek. To evaluate potential influence to groundwater flowing north from the drainage divide, we propose to sample the perennial zero- and first-order drainages that drain to the north toward Wildcat Canyon Creek as shown on Figures 5, 5a, and 5b (*i.e.,* Samples WC Seep A through D). Given the low rainfall to date, it is uncertain if seepage will be encountered at the proposed locations, but if seepage is present, it should be representative of groundwater daylighting in the side canyons flowing to the north toward Wildcat Canyon Creek.

With respect to surface water runoff from the WMSA, because the surface of the overburden storage pile extends higher than the ridge, and terminates at or near the ridgecrest, diffuse overland runoff from the north-facing slope of the WMSA could potentially flow to the north toward Wildcat Canyon Creek in certain limited locations (Figure 5b). Potential runoff from the WMSA and EMSA is being investigated as part of the *EMSA and WMSA Seep and Runoff Sampling Workplan* and the findings of the work will be incorporated in this investigation.[32]

The following summarize the purpose and expected data from each of the proposed boring/well/seep locations shown in Figures 5a and 5b.

- WMSA-DMW-1s and 1d (co-located vertical wells) and WMSA-DMW-4: These wells are located at the estimated groundwater divide between the WMSA and Wildcat Canyon Creek to the north. We will attempt to determine flow direction using geophysical survey methods (*i.e*., scanning colloidal borescope flowmeter (SCBFM) logging). A vertical pair of wells, 1s and 1d, separated by an approximate 30 to 40 feet vertical interval will be installed to evaluate vertical gradients along the ridge crest. The wells will also provide detection monitoring capability at the north margin of the WMSA.
- WMSA-DMW-1dg: This well will be installed if a) the data from the geophysical survey is inconclusive regarding the direction of groundwater flow or b) it is determined that groundwater flows from the WMSA materials and its quality could be monitored from this location. It is located about 300 feet north of the estimated drainage divide and 100 feet lower in elevation and should therefore encounter groundwater flowing to the north. Note, however, the proposed location would require brush removal and road building and would be outside of the existing Reclamation Plan Boundary. Therefore, an amendment to the approved Reclamation Plan would be required from the County of Santa Clara prior to performing this work.
- WMSA-DMW-5 and WMSA-DMW-6: These wells are situated along historical drainages within the WMSA sub-basin where groundwater is anticipated to be relatively shallow.

[32] Golder 2013.

The wells will assist with evaluating flow directions by providing depth to groundwater to develop potentiometric contours, and also provide chemistry for groundwater underneath the WMSA where seepage of percolate from the storage piles would be most likely encountered.

- WMSA-DMW-2,WMSA-DMW-3s and 3d, WMSA-DMW-7, WMSA-DMW-8s and 8d, and WMSA-DMW-11: These wells will provide data regarding groundwater elevations and flow directions at the downgradient edge of the WMSA. Two vertical pairs of wells, 3s/3d and 8s/8d, separated by an approximate 30 to 40 feet vertical interval will be installed to evaluate vertical gradients near Permanente Creek. A geophysical survey will also be conducted to evaluate potential vertical gradients in this location. The well locations were chosen to provide coverage along the downgradient portion of the WMSA in locations that are relatively accessible by existing roads.[33] WMSA-DMW-3s and 3d and WMSA-DMW-8s and 8d will also provide vertical gradient information when compared with the adjacent Permanente Creek elevation. This will provide information on the possible alteration of the potentiometric contours caused by quarry dewatering.
- Surface Water Samples WMSA-SW-A through E: For the WMSA wells located along Permanente Creek: WMSA-DMW-2, WMSA-DMW-3, WMSA-DMW-7, WMSA-DMW-8, and WMSA-DMW-11, a concurrent surface water sample will be collected from the Creek at the nearest point to the respective well to aid in determining groundwater influence and flux to surface water, if any.
- WC Seep A-D: Golder will sample seepage, if present at the end of rainy season, in the historical perennial drainages feeding Wildcat Canyon Creek. These seeps will provide geochemical data representative of groundwater flowing to the north toward Wildcat Canyon Creek.
- WMSA-DMW-9 and WMSA-DMW-10: These wells will provide data regarding groundwater elevation, chemistry, and flow directions along the southern ridgeline as shown on Figures 5a and 5b.
- One piezometer, WMSA-P6A, will be installed to provide additional groundwater elevation data along the southwestern limit of the WMSA. The piezometer will be used to supplement the groundwater elevation data at wells WMSA-DMW-6 and -9. Groundwater flow direction will be determined by triangulating groundwater elevations from the proposed piezometer and wells as shown on Figures 5a and 5b.

5.1.2 EMSA Boring/Well Locations and Seep Samples

The EMSA is located in the easternmost portion of the Permanente drainage basin just southwest of where east-trending Permanente Creek exits the rugged foothill terrain and turns sharply to the northwest due to the structural control exerted by the Monte Vista fault. As shown in the 1948 Google Earth image (Figure 5c), the area is bounded by a ridge to the north (shown in yellow) that separates it from an unnamed tributary to Permanente Creek just north of the site in the vicinity of the Gate of Heaven cemetery. The unnamed tributary joins Permanente Creek just north of the Site after Permanente Creek makes its sharp bend to the northwest. The southeast boundary is formed by the mostly channelized stretch of Permanente Creek that runs along the railroad siding built along the former Creek axis.

[33] Permits from several agencies may still be necessary for the installation of wells WMSA-DMW-3 and -8 because of the well locations with respect to the location of the Creek, potentially sensitive habitat, and/or national register of historic places. The procurement of any necessary permits may delay the installation of these wells.

The EMSA (limits defined by pink outline) sits astride two sub-drainage basins separated by a prominent north-south trending ridge (in yellow). The western portion of the EMSA is situated in the area of former prominent sidecanyon (former drainage shown in blue) with its head in the vicinity of the water tank situated along the ridge (historically known as Dry Canyon and shown in orange on Figure 5c). The area west of the main southeast-trending drainage axis of Dry Canyon is now extensively developed with the cement plant and ancillary facilities (Figure 5d). This area is not part of the current investigation plan.

The eastern portion of the EMSA is situated to the east of the north-south ridge in a separate subdrainage basin that drains to the east-southeast to Permanente Creek. The ridge and corresponding hillside were extensively developed with buildings related to the former Kaiser Aluminum Plant as shown on the 1948 image in Figure 5c. With the exception of the Aluminum Plant Building, the other buildings in this area have been demolished as seen on Figure 5d. The eastern subdrainage area has a well-developed drainage that extends from the ridgecrest down to Permanente Creek (shown in blue). The lower portions of the drainages were obscured along the lower portions of the hillside with activities associated with constructing the historic buildings and the main access road to the site.

As shown on Figure 5d, the EMSA was primarily placed east of the axis of the prominent drainage which runs through the cement plant area, although some overburden that was placed for construction of the mine haul road to the EMSA extends to the west of the drainage.

With respect to groundwater occurrence and flow, the EMSA is underlain by Santa Clara Formation rocks, which overlie Franciscan rocks at depth. Based on historical drilling and well information obtained by Golder, water generally occurs at shallower depths in the Santa Clara Formation than in the Franciscan Assemblage - typically at 25 to 90 feet below the original natural ground surface.[34, 35] Groundwater to the west of the north-south trending ridge flows toward the southwest into the Dry Canyon drainage, where, in turn it flows to the southeast toward Permanente Creek (see Figure 5c for historical groundwater contours from 1991).[36] It is also known that some groundwater surfaces as seepage in the cement plant area either in below grade structures (*e.g.,* basements below silos), or is intercepted by drainage trenches installed as part of the original site development of this prominent side-canyon. This groundwater seepage is collected and routed to the Cement Plant Reclaim Water System.

Groundwater to the east of the ridge flows to the south-southeast toward Permanente Creek as shown by the blue flow direction arrows and historical groundwater contours on Figure 5c.

[34] Golder 2007.
[35] Emcon Associates. 1993. Environmental Evaluation Report, Kaiser Aluminum & Chemical Corporation, Permanente Facility, Cupertino, CA.
[36] Ibid.

Wells and borings will be installed in the EMSA to develop information to attain the established goals of the hydrogeologic investigation as established above. In addition, we propose to sample the perennial drainage that lies to the north of the EMSA to evaluate potential influences from the overburden. The following summarize the purpose and expected data from these at each of the locations shown above.

- EMSA-DMW-1s and 1d EMSA-DMW-2s and 2d (co-located vertical wells), EMSA-DMW-8, and EMSA-DMW-9: These wells will provide data on groundwater elevations for potentiometric contour mapping and could serve as detection monitoring well locations between the downgradient edge of the EMSA and Permanente Creek. Vertical well pairs, 1s /1d and 2s/2d, separated by an approximate 30 to 40 feet vertical interval, will be installed to evaluate vertical gradients near the assumed groundwater discharge at Permanente Creek.
- EMSA-DMW-3: This well is located at the downgradient margin of the EMSA and will provide water quality and groundwater elevation data, and could also serve as a downgradient detection monitoring well location.
- EMSA-DMW-4s and 4d (co-located vertical wells) and EMSA-DMW-5: These wells are located at the estimated groundwater divide between the EMSA and the unnamed tributary to the north. The investigation will attempt to determine horizontal flow direction in these two locations using geophysical survey methods. The wells will also provide detection monitoring capability at the north margin of the EMSA. A vertical pair of wells, 4s and 4d, separated by an approximate 30 to 40 feet vertical interval will be installed to evaluate vertical gradients along the ridge crest.
- EMSA-DMW-4dg: This well will be installed if a) the data from the geophysical survey is inconclusive regarding the direction of groundwater flow or b) it is determined that groundwater flows from the EMSA materials and its quality could be monitored from this location. This well is located about 465 feet northeast of EMSA-DMW-4 and 50 feet lower in elevation, and should therefore encounter groundwater flowing to the north. Note, however, the proposed location would require road building and would be outside of the existing Reclamation Plan Boundary. Therefore, an amendment to the approved Reclamation Plan would be required from the County of Santa Clara prior to performing this work.
- EMSA-DMW-5, EMSA-DMW-6, and EMSA-DMW-7: These wells are in the western sub-drainage basin and will assist with evaluating potentiometric contours by providing depth to groundwater in this area. Well EMSA-DMW-7 will provide downgradient detection monitoring at the southeast margin of the Dry Canyon area and the overlying EMSA. Wells EMSA-DMW-5 and EMSA-DMW-6 will provide information on groundwater geochemistry above the EMSA, and also upgradient of historical site operations in the Dry Canyon area.
- Surface Water Samples EMSA-SW-A through C: For the EMSA wells located along Permanente Creek, EMSA-DMW-1, EMSA-DMW-2, and EMSA-DMW8, a concurrent surface water sample will be collected from the Creek at the nearest point to the respective well to aid in determining groundwater influence and flux to surface water, if any. The surface water sample associated with EMSA-DMW-2 will be collected at the confluence of Permanente Creek and Pond 21 drainage.
- GH Seep A and B: Golder will sample seepage, if present at the end of rainy season, in the perennial drainage located north of the EMSA. The seepage should be representative of groundwater geochemistry flowing to the north from the ridgecrest that bounds the EMSA on the north.

- Three piezometers, EMSA-P6A, EMSA-P7A, and EMSA-P8A, will be installed as shown on Figures 5c and 5d to provide additional groundwater elevation data. The piezometers will be used to supplement the groundwater elevation data from the proposed EMSA well network. Groundwater flow direction will be determined by triangulating groundwater elevations as shown on Figure 5c.

5.1.3 Background Well Locations

As shown on Figure 5, two background well locations, BKGD-1 and BKGD-2, are proposed to be installed as part of this investigation. The wells will be installed south of Permanente Creek in areas not affected by site operations. The two primary rock formations will be targeted: Franciscan (BKGD-1) and Santa Clara (BKGD-2) Formations.

5.1.4 Quarry Influence Investigative Tasks

The quarry is a known groundwater sink based on a variety of observations and measurements (see Figure 6 for instrumentation and well locations) conducted by Golder over the past six years:

1) The artificially maintained water level in the bottom of the quarry which is about 500 ft amsl compared to a Permanente Creek elevation of approximately 1000 amsl adjacent to the pit,
2) Instrumentation (vibrating wire transducers (VWTs)) installed in the bottom of the Quarry, and the north, east and south pit walls that provides data on water elevations behind the pit walls,
3) Observations and mapping by Golder and WRA staff from 2008 through 2011 of the loss of base flow in Permanente Creek roughly adjacent to the east-west limits of the Quarry, and,
4) Relationships between flow in Permanente Creek as measured over a two-year period associated with baseline studies conducted for the Reclamation Plan, quarry pumping, and response in instrumentation installed around the Quarry.

All of the above data demonstrates a closed groundwater depression with groundwater divides on the west, north and east sides of the Quarry that roughly coincide with the sub-basin that existed prior to mining of the quarry pit. The pit is flanked by a losing stream, *i.e.*, Permanente Creek, to the south that is likely captured by the steep gradient caused by the depth of the quarry and the dewatering operations. Captured flows quickly return to Permanente Creek via discharge from Pond 4A and downstream gaining conditions.

As depicted on Figure 6, Golder installed two monitoring stations, MS-1 and MS-2, in Permanente Creek as part of prior investigations associated with the Reclamation Plan.[37] The locations of the stations were selected based on a site reconnaissance by Golder in December 2008 to represent flow conditions upstream and downstream of the Quarry and discharge from Pond 4A, respectively.

[37] Golder 2011a.

Each monitoring station consists of a staff gauge and a stilling well equipped with a pressure transducer programmed to record stream height (or stage) at a frequency of every half hour. In addition, cross-sectional velocity measurements were made at designated areas by the stilling wells to determine discharge of the creeks and establish a relationship between gauge height and discharge rate. We will maintain these stations as part of the currently proposed investigation to provide additional data with regard to the relationship between flow in the creek, groundwater, and capture of groundwater by the Quarry.

To further characterize the relationship between the Creek, the Quarry and the surrounding terrain, Golder will prepare a potentiometric map based on the existing instrumentation, and pertinent new data from the adjacent WMSA investigation. The map will depict the potentiometric surface in the area of the Quarry, extending to the west to the WMSA, to the east to the area of the mine office, to the north ridge and to Permanente Creek to the south. This map should define the approximate limits of capture of groundwater by the Quarry as compared to the adjacent sub-basins and Wildcat Canyon Creek to the north.

Golder will also further outline and define the relationship between flow in Permanente Creek, groundwater movement and flow direction, groundwater levels in the Quarry pit, precipitation and run-on into the Quarry, and pumping of the Quarry and subsequent discharge to Permanente Creek.

6.0 SCOPE OF WORK

The following phased scope of work is proposed as follows:

- **Phase 1 – Field Hydrogeologic Investigation:** conduct a hydrogeologic investigation focused on the WMSA, Quarry, and EMSA using a series of exploratory borings which will be completed as groundwater monitoring wells, geophysical tests, hydraulic tests, and groundwater chemistry.
- **Phase 2 – Field Data Evaluation:** evaluate the data from the exploratory investigation and refine and update the CSM regarding the occurrence, flow and chemistry of groundwater at the Site.
- **Phase 3 – Interim Hydrogeologic Report and Iterative Results Discussion:** A report of the results from the Field Hydrogeologic Investigation will be discussed with RWQCB staff to obtain concurrence for any additional investigations needed or to proceed with the development of the proposed two-year monitoring program. This may require iterative discussions if further investigations are needed, approved, performed, and evaluated.
- **Phase 4 – Monitoring System Equipment Deployment:** Deploy all monitoring, data logging, and other equipment for the system, including installing additional wells for the proposed monitoring well network (if needed).
- **Phase 5 – Conduct Two Year Quarterly Monitoring Program:** Conduct two years (eight rounds) of quarterly monitoring and analysis and report the results.

Each of the above tasks is described in more detail in the following sections.

6.1 Phase 1 – Field Hydrogeologic Investigation

6.1.1 Phase 1 –Task 1: Pre-field Planning, Scheduling, and Coordination

Prior to commencement of drilling activities, Golder will complete the following pre-field activities:

- Schedule and contract subcontractors
- Develop access roads with assistance of Lehigh
- Obtain drilling permits from Santa Clara Valley Water District
- Coordinate and schedule with our subcontractor, Lehigh, and the RWQCB
- Prepare a site-specific site health and safety plan (HASP) in accordance to Occupational Safety and Health Administration (OSHA) requirements set forth in 29 CFR 1910.120
- Mark drill locations and notify Underground Service Alert (USA) 48 hours in advance of field work
- Perform additional utility locating using a private utility location contractor, if needed

6.1.2 Phase 1 - Task 2: Exploratory Borings

Depending on the boring location and subsurface materials present, we anticipate that multiple drilling techniques may be necessary. Borings that are in difficult locations not served by major haul roads will likely require use of a tracked, all-terrain type of drill rig - either a mini-rotosonic rig or a CME850 mud or air-rotary rig. Borings that are located over the EMSA or WMSA storage piles will likely be drilled with a truck-mounted, rotosonic rig as previous experience has shown good results with this technique. Prior to

selection of a drill rig, a site walk will be carried out with an experienced driller to evaluate subsurface conditions, logistics, and access-related issues.

During drilling activities, core and/or cuttings will be logged by a Golder geologist working under the direct supervision of a Professional Geologist. The logging will include a description of the formation materials with depths at which each change in materials occurs, and the penetration rate of each drill pipe section, drill bits used (type and size), and any notable events, such as loss of circulation, hole instability, voids, etc. Particular attention will be directed toward identification of any saturated zones within the storage piles (although none have been noted in the past), and the depth of overburden materials. Once native ground is encountered, drilling will proceed until groundwater is encountered, and each boring advanced an additional 20 to 40 feet into water.

6.1.3 Phase 1 - Task 3: Downhole Geophysical Testing

Golder will run a suite of downhole geophysical tools to evaluate where groundwater is flowing into the borehole, potential vertical gradients, and to determine primary horizontal flow directions. The proposed boreholes include those situated along the groundwater divide along the north ridge: WMSA-DMW-1 and -4, and EMSA-DMW-4 and -5. A scanning Colloidal Borescope Flow Meter (SCBFM) will be utilized to help in determining groundwater flow direction and velocity. The SCBFM is a downhole tool which measures horizontal flow and direction by measuring the velocity of colloidal sized particles moving advectively with the groundwater. The rate of movement and velocity are calculated using specialized image recognition software. The SCBFM may provide conclusive data on flow direction if there are relatively strong horizontal gradients and adequate velocity in this hydrogeologic environment; however, the effectiveness of the tool will need to be field-trialed. Additional geophysical tools including a caliper log, an optic and/or acoustic televiewer, and a heat-pulse flow meter may be used if conditions warrant.

6.1.4 Phase 1 - Task 4: Well and Piezometer Installations, Development and Hydraulic Testing

Depending on the well locations and subsurface materials present, multiple drilling techniques, such as air rotary, mud rotary, and rotosonic, may be necessary.

6.1.4.1 Well Installation

Table 2 lists the proposed boring and well details. Well casing installation will begin as soon as possible after the borehole total depth has been reached. Wells will be constructed with new, 2-inch diameter or 4-inch diameter, flush-threaded Schedule 40 PVC casing and well screens; screens will be 0.010-inch factory slots. The well casing will be suspended from the top and allowed to hang freely in the borehole at all times during well construction. Screen lengths will be selected based on hydraulic conditions. In general, borings will be advanced approximately 30 to 40 feet below first-encountered water in the bedrock to provide an adequate interval for geophysical testing and for construction of a monitoring well.

Assuming transmissive discontinuities are identified in the upper 20-foot saturated interval of the bedrock, we anticipate that wells will be constructed with 20-foot screen intervals so that the current water level is approximately 5 foot below the top of screen. As identified above, select well pairs will be installed to aid in characterizing vertical hydraulic gradients. Based on stratigraphy, we anticipate the deeper well will be advanced approximately an additional 30 to 50 feet and installed with a 10-foot screen section.

The filter pack, which will be placed from the base of the borehole to approximately 3 feet above the top of the screens, will consist of clean, graded silica sand. The filter pack sand will be installed through a tremie pipe into the annulus with clean water so that sand is released into the annular space with no more than ten feet of freefall below the tremie pipe tip. The filter pack placement will proceed without interruption until completion. The level of the filter pack will be checked and adjusted, if necessary.

A sanitary seal consisting of bentonite chips will be installed immediately above the filter pack. The bentonite chip seal will be a minimum of 1 foot thick. The bentonite chips will be allowed to hydrate for a minimum of 15 minutes before the bentonite-grout slurry is placed. The grout slurry will be mixed to manufacturer's specification and will be pumped through a tremie pipe fitted with a 90-degree elbow at the base. The grout will be discharged into the annulus no more than 3 feet above the bentonite chip seal. Grout will be added until remaining water is displaced and the grout reaches the surface.

The piezometers will be installed similarly to the above well installation procedure. The piezometers will be constructed of 1- or 2-inch diameter Schedule 40 PVC screened in the shallow groundwater zone. Further construction details are provided on Table 2.

6.1.4.2 Well Development

The wells will be developed by a combination of surging, bailing, and pumping techniques. Surging will be performed opposite the screened sections beginning with the shallowest section. Bailing or pumping will occur near the bottom of the casing. Well development will consist of cycles of surging and bailing or pumping until the discharged water is relatively clear. As water is removed from the wells, temperature, conductivity, pH, and turbidity will be recorded at regular intervals along with an estimate of the volume of water removed and the depth to the water surface.

6.1.4.3 Hydraulic Testing

Golder will perform falling-head and/or rising-head tests on a subset of the new wells installed for monitoring of the groundwater system. Two to three wells located in each study area will be tested to evaluate the approximate hydraulic conductivity of the monitored interval. The purpose of the testing is to expand the knowledge of hydraulic characteristics currently known. Wells showing anomalous hydraulic conductivity compared to surrounding wells might indicate areas of fault gouge or other anomalous zones

of hydraulic conductivity. Such results can lead to further investigations as warranted to better define the groundwater flow regime in the EMSA. Further investigations will be identified as needed.

6.1.5 Phase 1 — Task 5: Creek Instrumentation and Surveying

6.1.5.1 Well Survey

The completed well top-of-casing elevation and the horizontal position for each well will be surveyed by a licensed land surveyor. The elevation will be surveyed to the NGVD88 datum. The horizontal position will be surveyed to state plane coordinates. The survey results will be incorporated into the site's existing basemap and network of groundwater elevation monitoring points.

6.1.5.2 Creek Instrumentation and Survey

As depicted on Figure 6, Golder installed two monitoring stations, MS-1, MS-2 in Permanente Creek as part of prior investigations. The locations of the stations were selected based on a site reconnaissance by Golder in December 2008 to represent conditions upstream and downstream of the Quarry and discharge from Pond 4A, respectively.

Each monitoring station consists of a staff gauge and a stilling well equipped with a pressure transducer programmed to record stream height (or stage) at a frequency of every half hour. In addition, cross sectional velocity measurements were made at designated areas by the stilling wells to determine discharge of the creeks and establish a relationship between gauge height and discharge rate. We will maintain these stations as part of the currently proposed investigation to provide additional data with regard the relationship between flow in the creek, groundwater levels in the Quarry pit Sub-basin, pumping of the Quarry, and capture of groundwater by the Quarry.

6.1.6 Phase 1 – Task 6: Groundwater Sampling and Chemical Analyses

Following the hydraulic testing, Golder will conduct a full round of groundwater elevation measurements, including existing instrumentation at the Site to begin the generation of sequential potentiometric contour maps. All of the new wells in the investigation will be sampled to provide initial chemistry for each location.

6.1.6.1 Groundwater Elevation Survey

Table 3 contains a summary of the existing and proposed groundwater data points that will be monitored, including type of data point, location, and schedule. Four of the proposed well pairs will be instrumented with a pressure transducer programmed to record water elevations at a frequency of every six hours. The proposed groundwater data points include the extraction wells and observation piezometers in the quarry and several existing data points located south of Permanente Creek (Figure 6).

Groundwater elevations will be collected from the non-instrumented monitoring wells on a quarterly basis when the wells are sampled. The water level in each well will be measured with an electric sounder that has cable markings stamped at 0.01-foot increments. The water level is measured by lowering the sensor into the monitoring well. Depth to water is recorded to the nearest 0.01 foot on a water sample field data sheet. The groundwater elevation at the monitoring well is calculated by subtracting the measured depth to water from the datum mark at the top of the well casing.

6.1.6.2 Groundwater Monitoring Well Sampling

Groundwater samples will be collected using a low-flow groundwater sampling procedure as described below. The procedure is based on U.S. Environmental Protection Agency (EPA) technical publications from the Office of Solid Waste and Emergency Response.[38,39]

Low-flow groundwater sampling involves removal of water from the geologic formation immediately surrounding the screened interval of a monitoring well at discharge rates sufficiently low to minimize drawdown in the well. Minimizing drawdown minimizes mixing between the overlying stagnant casing water (or water that may be in direct contact with the atmosphere) and water near the pump intake interval, which is more likely to be representative of formation water. Before sampling, low-flow purging shall be conducted to obtain groundwater that is representative of formation water screened by the monitoring well. Purging is anticipated to be performed using dedicated bladder pumps. Pumps shall be capable of consistent flow rates less than 0.5 liters per minute (Lpm), and pumps shall be capable of consistent operation across low-flow pumping rates (*i.e.,* between 0.1 and 0.5 Lpm). Purge water will be discharged to the ground surface.

During purging, flow rates will be set according to the following requirements:

- Flow rates will be selected such that drawdown in the well is minimized (*i.e.,* observed drawdown is less than 0.1 meter [0.33 feet]), if feasible.
- Initial flow rates during purging will be no more than 0.5 Lpm, and will be adjusted downward as required to minimize drawdown.

Water levels will be measured at 3 to 5 minute intervals. Monitoring of field water-quality parameters using a flow-through cell will be performed. Stabilization of field water-quality parameters is indicative of the presence of formation water. Field measurements for pH, specific conductance, dissolved oxygen (DO), temperature, and turbidity are to be recorded during purging on field data sheets. In general, the order of stabilization is pH, temperature, and specific conductance, followed by DO and turbidity.

[38] Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (EPA-540/S-95/504, April 1996).
[39] Test Methods for Evaluating Solid Waste: Physical/Chemical Methods (EPA SW-846, Base Manual [3rd edition, November 1986], through Update III [June 1997]).

Stabilization should be considered complete when readings for all parameters have stabilized after three successive readings. The three successive stabilized readings should be within the following limits:

- Specific Conductivity: ± 3%
- pH: ± 0.2 standard unit
- Turbidity: ± 10% for values greater than 5 NTUs, or three readings below 5 NTUs
- DO: ± 10% for values greater than 0.5 mg/L, or three readings below 0.5 mg/L
- Temperature: ± 3%
- ORP: ± 10 millivolts

After field measurements stabilize, groundwater samples will be collected as outlined in Section 6.2. If there is no water in the well at the beginning of the sampling event, the well will be considered dry, a notation on the water sample field data sheet will be made, and no sample will be collected. If the well dries because of extremely low recharge rates before stabilization occurs, the well will be allowed to recharge up to 24-hours and samples will be collected when sufficient volume is available.

6.1.6.3 Seep and Surface Water Sampling

Golder will collect grab water samples directly into the appropriate sampling containers when possible. If the surface water flow is too low and does not allow for directly filling the sample containers, a clean transfer vessel may be used to assist with sample collection. Sample containers will be provided by the laboratory and will be certified pre-cleaned. For chemical analyses that require preserving acids, the bottles will also be pre-acidified so that the samples are immediately preserved. Field measurements for pH, specific conductance, DO, temperature, and turbidity will be recorded on field data sheets.

6.1.6.4 Laboratory Analyses

All samples will be submitted to a California-certified analytical laboratory for analysis of the parameters listed in Table 4. Table 4 also details the analytical method, sample collection requirements relating to container type, preservatives (if any), and holding times.

The constituents of concern (COC) to be analyzed will consist of the priority pollutants listed in Appendix 4 of the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* as requested in the RWQCB's June 26, 2013 letter.[40] The list includes the following parameters:

- Inorganics, including hexavalent chromium
- Volatile organic compounds (VOCs)

[40] RWQCB, 2013. Conditional Concurrence with the *Workplan for Characterization of the Eastern and Western Materials Storage Areas* and Requirement for Additional Technical Reports for WDR Development for the property located at 24001 Stevens Creek Boulevard, Cupertino, Santa Clara County

- Semi-volatile organic compounds (SVOCs) and
- Polychlorinated biphenyl compounds (PCBs) and pesticides (surface water only) [41]

Total petroleum hydrocarbons (TPH) as gasoline, diesel, and motor oil will also be analyzed. Analytical methods will be used capable of quantifying results at concentrations no higher than the minimum levels set in the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California.* Method detection limits (MDLs) and reporting limits (RLs) for the COCs are included as Appendix A. For TPH, 100 micrograms per Liter (µg/L) will be used as the minimum quantifying limit.

Table 4: Laboratory Analytical Summary

Parameter	Analytical Method	Preservative	Sample Bottle	Holding Time
VOCs	EPA 624 or 8260	None	4-40 milliliter VOAs	3 days
SVOCs	EPA 625 or 8270/SIM	None	2-1 Liter Amber	7 days
PCBs and Pesticides[1]	EPA 608 or 8081	None	2-1 Liter Amber	7 days
TPH as diesel and motor oil	EPA 8015	None	1-1 Liter Amber	14 days
TPH as gasoline	EPA 8015	HCL	2-40 millimeter VOAs	14 days
PP13 As, Cd, Cr, Pb, Se, Ag, Sb, Be, Cu, Zn, Ni, Tl (total and dissolved)	EPA 200.8	HNO_3	2-500 milliliter plastic	180 days
Mercury	EPA 1631	None	1-8 oz glass double bag	28 days
Hexavalent Chromium	SM3500	Ammonium Sulfate	1-250 milliliter poly	180 days

[1] = surface water samples only

6.2 *Phase* 2 – Field Data Evaluation

6.2.1 Phase 2 –Task 1: Data Analysis and Update of CSM

Following completion of the Phase 1 investigation, Golder will compile and review the newly obtained data and relevant historic data regarding the occurrence, flow, and chemistry of groundwater at the site to update the CSM for the Site. The newly acquired data collected as part of this workplan will be the primary data source to develop flow directions and gradients for groundwater underlying the EMSA and WMSA. The new data will also provide the initial baseline geochemistry for the new wells. Existing data sources will be used primarily to fill data gaps with respect to groundwater elevations in and around the Quarry, and to provide background data on groundwater geochemistry for comparison with new data.

[41] Ibid

Historical data from the EMSA will be reviewed to determine if depth to groundwater, flow directions and chemistry have changed over time.

The existing and historical data sources, and their relative applicability to the CSM are discussed below. There are four main groups of existing data available for the site that provide data regarding both current and historical depth to groundwater, groundwater flow directions, hydraulic properties, and groundwater geochemistry. The locations of the data sources described below are shown on Figure 6.

6.2.1.1 Quarry Data

There is a significant amount of recent data (2011-2014) associated with hydrogeologic investigations and dewatering of the Quarry. The data that we anticipate being useful and relevant to the site-wide hydrogeologic CSM include:

- Depth to groundwater in the pit slopes and quarry floor and vertical and horizontal gradients
- Aquifer properties (*i.e.*, hydraulic conductivity and transmissivity) of the main limestone ore body
- Geochemical data regarding the groundwater extraction and discharge from the Quarry and temporal and spatial variability of the data
- Observations and measurements of seepage into the Quarry and relationship with Permanente Creek
- A water balance model that estimates seepage into the Quarry and input from direct precipitation and surface water runoff and balances against Quarry pumping data

6.2.1.2 Permanente Creek Surface Flow

There is recent data from surface water monitoring stations MS-1 and MS-2 (2008-2011) relating to flow and temporal variations of flow in Permanente Creek. Newly acquired data will be added to the database and will provide a longer-term history (over several winter storm seasons) of perennial flow (baseflow) above the Quarry, and variability of flow downstream from the Quarry related to water management activities in the Quarry.

6.2.1.3 Historical EMSA Groundwater Data

Previous work associated with soil and groundwater investigations at the Kaiser Aluminum facility generated data regarding groundwater occurrence, flow, and chemistry from former monitoring well locations.[42] Historical groundwater contours from 1991 are shown on Figure 5c. With respect to the current proposed investigations, the historical data provides useful information regarding:

- Anticipated depth to groundwater

[42] Emcon Associates. 1993.

- Anticipated lithologies (*e.g.,* Santa Clara Formation versus Franciscan rocks) and hydraulic interaction between the two formations
- Historic direction of groundwater flow and gradient
- History, type, and location of waste disposal activities
- Locations of former buildings, storage areas, etc.
- Chemical characterization of potential contaminants in soils underlying the EMSA
- Chemical characterization of groundwater in the area and analyses of impacts related to groundwater associated with site activities (*i.e*., historical background data)

6.2.1.4 South Hillside Data

There is a significant amount of recent geologic and hydrogeologic data from an investigation of the hillside area south of Permanente Creek conducted in 2008-2010. The data that we believe is useful and relevant to the site-wide investigation includes:

- Depth to groundwater and variation in depth to groundwater in undisturbed native Franciscan bedrock, which informs us of likely drilling depths in the WMSA to encounter groundwater and helps for planning and equipment selection
- Hydraulic testing in this area provides significant data on the aquifer properties (*i.e.,* hydraulic conductivity and transmissivity) of Franciscan rocks encountered in the Permanente Creek drainage basin including greenstone, graywacke, and limestone
- Contouring of the data in the south hillside area informs us as to typical hydraulic gradients in undisturbed Franciscan rocks in terrain typical of that for the drainage basin
- Geochemical data from this area provides background geochemistry data for groundwater in Franciscan rocks

As discussed above, the relevant historical, recent and newly obtained data will be compiled to develop an updated CSM for the site that will be included in the Interim Hydrogeologic Report (Section 6.3). The CSM will concentrate on the occurrence of groundwater in various areas of the site, estimated flow directions, groundwater/surface water interaction, and potential influences to site groundwater from site material placement in the EMSA and the WMSA.

6.3 Phase 3: Interim Hydrogeologic Report and Iterative Results Discussion

Golder will prepare an Interim Hydrogeologic Report summarizing the work performed, and the findings and conclusions regarding the occurrence, flow, and chemistry of groundwater at the site after the completion of the initial sampling effort. The report will be written as a summary of findings with pertinent figures and tables, and will be supported by appendices documenting the details of the geologic, geophysical, and initial geochemistry tasks.

We propose to present the findings and recommendations of the initial hydrogeologic investigation in a meeting with the RWQCB to explain the preliminary findings of the investigation. If it is determined that further investigation is needed, a workplan for this investigative work will be prepared, submitted for

review, and implemented following RWQCB approval. Once it is determined that no further investigation is needed, the project will advance to Phase 4.

6.4 Phase 4 – Additional Well Installation and Monitoring System Equipment Deployment

If additional monitoring wells are needed beyond those installed as part of the initial phase of the hydrogeologic investigation, the wells will be installed and developed. All other necessary equipment for the monitoring system (*e.g.,* dedicated pumps, transducers, etc.) will be deployed and tested in the field in preparation for the commencement of monitoring.

6.5 Phase 5 – Task 1: Conduct Quarterly Monitoring

Golder will begin quarterly gauging and sampling in accordance with the standard procedures outlined in Section 6.1.6 above. Per the RWQCB's directive, eight quarterly monitoring events will be implemented over a two year period. The monitoring events will consist of sampling the newly installed wells and the Permanente Creek surface water sample locations specified in this Workplan. Annually, at the end of each rainy season, Golder will sample, if flow is present, the northern seep sample locations specified in this Workplan. Water elevation data will be collected as specified on Table 3.

6.5.1 Phase 5 – Task 2: Year One Annual Reporting

Upon the completion of four quarters of monitoring, an annual report will be submitted within 60 days of the end of the last quarter of the first year of monitoring that presents the results of the first year. The report will contain an evaluation of the monitoring program, including a summary of groundwater and surface water data and a comparison to the applicable water quality objectives.

6.5.2 Phase 5 – Task 3: Year Two Annual Reporting

Upon the completion of an additional four quarters of monitoring, an annual report will be submitted within sixty (60) days of the end of the last quarter of the second year of monitoring that presents the results of the program. Groundwater data will be evaluated and compared to the applicable water quality objectives. Based on the results of the two year monitoring program, a detection monitoring program will be proposed to the RWQCB.

7.0 DATA MANAGEMENT AND QUALITY CONTROL

Representative samples will be obtained through the use of generally accepted sampling procedures. Data comparability will be obtained through the use of standard operating procedures and through standard analytical methods used by the laboratory. Additionally, adherence to the procedures and Quality Control (QC) approach contained in this Workplan will provide for comparable data throughout the duration of this project.

7.1 Field Equipment Calibration and Maintenance

Field calibration requirements shall be in compliance with the technical procedure describing the instruments use and/or with the manufacturer's instructions issued with the equipment. Lease equipment shall require certifications or other documentation demonstrating acceptable calibration status for the entire period of use for this project. Daily records of calibration activities will be kept by field personnel.

7.2 Equipment Decontamination

Equipment that is in contact with potentially contaminated soil or water will be decontaminated prior to and after use. Decontamination consists of steam cleaning (high pressure, hot water rinse) or phosphate-free detergent wash and deionized (DI) or tap water rinse as appropriate. Rinse water will be disposed of to the ground designated areas at the Site.

7.3 Sample Handling

Sample containers will be provided by the laboratory and will be certified pre-cleaned. For chemical analyses that require preserving acids, the bottles will also be pre-acidified so that the samples are immediately preserved. Sampling for mercury will be conducted under EPA sampling procedure 1669 to the extent practicable. VOC sample bottles will be filled so there was no head space.

Water samples collected for dissolved metals analyses will be filtered prior to sample collection by filtering the samples through a disposable 0.45-micron acrylic copolymer filter before being placed into the pre-acidified, pre-cleaned containers. Each filter will be used once and discarded. While not anticipated to be necessary, as an alternative, the sample for dissolved metals may be collected in a non-preserved plastic bottle for the lab to filter, as long as the sample is submitted to the lab and filtered by the lab as soon as possible.

The sample containers for all parameters will be filled and labeled immediately following sample collection. Field data sheets documenting sampling collection date, time, location, personnel, weather conditions, sample identification, and measured field parameters will be completed for each sample. Water samples will be kept cool with ice to four degrees centigrade in insulated coolers or refrigerators until delivery to the laboratory. Each sample will be logged on a chain-of-custody record, which will accompany the samples through collection and delivery to the analytical laboratory.

7.4 Duplicates and Blanks

To assess the precision of field sampling procedures and the variability of the sample source, duplicates will be collected at a frequency of 1 in 20 samples. Each duplicate is to be collected after performing the decontamination and purging routines used for normal sample collection. When both sample results exceed the RDL (reporting detection limit) the RPD (relative percent difference) should be less than 25% or the current lab acceptance limit, whichever is lower.

Equipment blanks will be collected should non-dedicated equipment be used during sampling. Laboratory-supplied deionized water will be run through the decontaminated sampling equipment and into appropriate sample containers. Equipment blanks will be collected at a frequency of 1 per 20 samples per piece of non-dedicated field equipment and analyzed for the same parameters as the environmental sample collected immediately preceding the equipment blank. Trip blanks will not be submitted for this work based on the COCs.

7.5 Laboratory QA/QC

Standard laboratory QC procedures will be used by the analytical laboratory to document possible biases related to the analytical process. These QC procedures include the use of surrogate spikes, method blanks, matrix spikes, and matrix spike duplicates. Surrogate spiking compounds are added to every gas chromatography-mass spectrometry (GC/MS) surrogate spike sample. Method blanks are analyzed to assess possible effects of the laboratory environment on samples. Matrix spikes and matrix spike duplicates are analyzed by the laboratory to provide a quantitative measure of accuracy and precision, and to document effects that the sample matrix has on the analysis. As part of the data validation, the laboratory will provide a narrative summarizing the QC data on surrogate spikes, method blanks, and matrix spikes and if samples were analyzed within recommended holding times.

7.6 Field Reports

Accurate documentation of field activities is necessary for efficient completion of this investigation. Personnel will record daily activities on a daily field form and appropriate field data sheets. Documentation will include the following:

- weather conditions
- work activities and field observations
- description, date, and time of sample collection
- photographs of field activities and sample locations
- visitors to the Site
- calibration records
- deviations from the Workplan

- health and safety related issues or situations

7.7 Chain-of-Custody Procedures

The chain-of-custody procedures to be used during the investigation will be conducted as described below:

- The field sampler will have custody of the samples from the time they are collected until they are transferred to the laboratory courier.
- All bottles will be labeled with sample number and location by the sampler.
- The sample number, date, and collection time will be listed on the chain-of-custody form.
- When transferring possession of the samples, the individuals relinquishing and receiving will sign, date, and note the time on the COC form.
- Shipping containers will be secured with strapping tape and custody seals for shipment to the laboratory.

7.8 Laboratory Reports

Data reduction, review, and reporting will be performed under the contract laboratory's standard operating procedures. Data will be provided to data recipients within three weeks of receipt of the last sample for a sampling event and will be reported in the standard laboratory reporting format. This includes an analytical result, MDL, and RL. All analytical data packages submitted by the analytical laboratory shall include the following:

- Sample receipt, chain-of-custody and shipping documentation, including identification of field sampling personnel, shipping personnel (or organization)
- Analytical results for each sample containing the reduced results for all analytes/constituents requested in the chain of custody, request for analysis or purchase order
- Sample results will be available through LIMS or in an electronic version (Excel) of the hardcopy report

8.0 SCHEDULE

The schedule below summarizes the time frame for implementation of the proposed Workplan. Written approval is anticipated to be required prior to starting Phases 1, 4 and 5 and during Phase 3 for any further investigations.

Table 5: Schedule

Phase	Duration of Phase or Task (Days)	Cumulative Duration (Months)**
Phase 1 - Task 1: Pre-Field Activities	30	1
Phase 1 - Tasks 2 through 6: Field Program	120	5
Phase 2 - Data Evaluation	60	7
Phase 3 – Interim Hydrogeologic Report and Iterative Results Discussion	90*	10
Phase 4 – Additional Well Installation and Monitoring System Equipment Deployment	90	13
Phase 5 - Two Years of Quarterly Monitoring, Analysis, and Reporting		
Year 1 Report	1 year + 60 days	27
Year 2 Report (will include Year 1 historical data)	1 year + 60 days	41

* Estimated - actual time may vary due to the number of further investigations proposed or required

**Cumulative duration may change based on the time needed to secure RWQCB approvals.

TABLES

Table 2: Boring and Well Locations and Estimated Depths

Boring/Well Designation	General Location	Current Elevation (ft)	Original Ground (OG) (ft)	Depth to OG (ft)	Estimate Boring/Well Total Depth (ft bgs)	Purpose
WMSA-DMW-1s	WMSA	1865	1840	25	120-140	Groundwater divide to North with Wildcat Canyon Creek
WMSA-DMW-1d	WMSA	1865	1840	25	160-180	Groundwater divide to North with Wildcat Canyon Creek and to evaluate vertical gradient with WMSA-DMW-1s
WMSA-DMW-1dg	WMSA	1750	1750	0	120-140	Contingent, downgradient of WMSA-DMW-1 in Wildcat Canyon Creek Watershed
WMSA-DMW-2	WMSA	1650	1500	150	180-200	At confluence of second order streams in sub-basin
WMSA-DMW-3s	WMSA	1410	1410	0	30-50	Downgradient of sub-basin outlet at Permanente Creek
WMSA-DMW-3d	WMSA	1410	1410	0	70-90	Downgradient of sub-basin outlet at Permanente Creek; evaluate vertical gradient with DMW-3s
WMSA-DMW-4	WMSA	1885	1885	0	100-120	Groundwater divide to North with Wildcat Canyon Creek
WMSA-DMW-5	WMSA	1830	1600	230	280-300	Central portion of drainage basin/ first order ephemeral drainage
WMSA-DMW-6	WMSA	1935	1815	120	170-190	Northwest headwaters of sub-basin
WMSA-DMW-P6A (piezometer)	WMSA	1820	1790	30	120-140	Groundwater elevation data upgradient southwestern portion of WMSA
WMSA-DMW-7	WMSA	1620	1620	0	80-100	Southwestern extent of WMSA
WMSA-DMW-8s	WMSA	1380	1380	0	30-50	Downgradient of eastern extent of WMSA
WMSA-DMW-8d	WMSA	1380	1380	0	70-90	Downgradient of eastern extent of WMSA; evaluate vertical gradient with EMSA-DMW-8s
WMSA-DMW-9	WMSA	1770	1740	30	120-140	Southern extent of WMSA along southern ridgeline
WMSA-DMW-10	WMSA	1650	1630	20	100-120	Southern extent of WMSA along southern ridgeline
WMSA-DMW-11	WMSA	1470	1370	100	200-220	Southeastern extent of WMSA
EMSA-DMW-1s	EMSA	560	560	0	40-60	Junction of Dry Canyon with Permanente Creek
EMSA-DMW-1d	EMSA	560	560	0	80-100	Junction of Dry Canyon with Permanente Creek; evaluate vertical gradient with EMSA-DMW-1s
EMSA-DMW-2s	EMSA	560	550	10	60-80	Junction of zero order drainage from Northeast EMSA sub-basin
EMSA-DMW-2d	EMSA	560	550	10	100-120	Junction of zero order drainage from Northeast EMSA sub-basin and to evaluate vertical gradient
EMSA-DMW-3	EMSA	690	680	10	40-60	Southern downgradient edge of overburden storage
EMSA-DMW-4s	EMSA	750	750	0	60-80	Groundwater divide to North with Gate of Heaven Creek
EMSA-DMW-4d	EMSA	750	750	0	100-120	Groundwater divide to North with Gate of Heaven creek and to evaluate vertical gradient with DMW-4s
EMSA-DMW-4dg	EMSA	710	710	0	60-80	Contingent, downgradient of EMSA-DMW-4 in Gate of Heaven sub-basin

Boring/Well Designation	General Location	Current Elevation (ft)	Original Ground (OG) (ft)	Depth to OG (ft)	Estimate Boring/Well Total Depth (ft bgs)	Purpose
EMSA-DMW-5	EMSA	830	830	0	60-80	Groundwater divide to North with Gate of Heaven Creek/upgradient edge of overburden storage
EMSA-DMW-6	EMSA	885	875	10	60-80	Groundwater divide to North with Gate of Heaven Creek/ upgradient edge of overburden storage
EMSA-DMW-P6A (piezometer)	EMSA	860	850	10	60-80	Groundwater elevation data for upgradient southwestern portion of EMSA
EMSA-DMW-7	EMSA	700	700	0	40-60	Southwest downgradient margin of overburden storage/ Dry Canyon tributary junction
EMSA-DMW-P7A (piezometer)	EMSA	760	750	10	60-80	Groundwater elevation data along southern portion of central ridgeline
EMSA-DMW-8	EMSA	540	490	50	80-100	Eastern downgradient extent of EMSA
EMSA-DMW-P8A (piezometer)	EMSA	640	620	20	70-90	Groundwater elevation data within eastern subbasin of EMSA
EMSA-DMW-9	EMSA	520	520	0	20-40	Southern downgradient extent of EMSA
BKGD-1	Background	1220	1220	0	80-100	Background location within Franciscan Formation, south of Permanente Creek
BKGD-2	Background	240	240	0	60-80	Background location within Santa Clara Formation

Notes:
Boring and well depths are estimates and are based on historical borings at the site. Where concealed by fill, original ground depths are based on historical USGS topographic maps and should be considered very approximate.
All locations will be completed as monitoring wells unless designated as piezometer.

Table 3: Groundwater Elevation Monitoring Schedule

Boring/Well Designation	General Location	Existing or Proposed	Ground Elevation (ft amsl)	Type	Screen Interval or Depth (ft bgs)	Anticipated Groundwater Elevation Monitoring Frequency
WMSA-DMW-1s	WMSA	Proposed	1865	MW	TBD	Install pressure transducer and record data every 6 hours
WMSA-DMW-1d	WMSA	Proposed	1865	MW	TBD	Install pressure transducer and record data every 6 hours
WMSA-DMW-1dg	WMSA	Proposed	1750	MW	TBD	Quarterly (if installed)
WMSA-DMW-2	WMSA	Proposed	1650	MW	TBD	Quarterly
WMSA-DMW-3s	WMSA	Proposed	1410	MW	TBD	Install pressure transducer and record data every 6 hours
WMSA-DMW-3d	WMSA	Proposed	1410	MW	TBD	Install pressure transducer and record data every 6 hours
WMSA-DMW-4	WMSA	Proposed	1885	MW	TBD	Quarterly
WMSA-DMW-5	WMSA	Proposed	1830	MW	TBD	Quarterly
WMSA-DMW-6	WMSA	Proposed	1935	MW	TBD	Quarterly
WMSA-DMW-P6A	WMSA	Proposed	1820	PZ	TBD	Quarterly
WMSA-DMW-7	WMSA	Proposed	1620	MW	TBD	Quarterly
WMSA-DMW-8s	WMSA	Proposed	1380	MW	TBD	Quarterly
WMSA-DMW-8d	WMSA	Proposed	1380	MW	TBD	Quarterly
WMSA-DMW-9	WMSA	Proposed	1770	MW	TBD	Quarterly
WMSA-DMW-10	WMSA	Proposed	1650	MW	TBD	Quarterly
WMSA-DMW-11	WMSA	Proposed	1470	MW	TBD	Quarterly
EMSA-DMW-1s	EMSA	Proposed	560	MW	TBD	Quarterly
EMSA-DMW-1d	EMSA	Proposed	560	MW	TBD	Quarterly
EMSA-DMW-2s	EMSA	Proposed	560	MW	TBD	Install pressure transducer and record data every 6 hours
EMSA-DMW-2d	EMSA	Proposed	560	MW	TBD	Install pressure transducer to record data every 6 hours
EMSA-DMW-3	EMSA	Proposed	690	MW	TBD	Quarterly
EMSA-DMW-4s	EMSA	Proposed	750	MW	TBD	Install pressure transducer and record data every 6 hours
EMSA-DMW-4d	EMSA	Proposed	750	MW	TBD	Install pressure transducer to record data every 6 hours
EMSA-DMW-4dg	EMSA	Proposed	710	MW	TBD	Quarterly (if installed)
EMSA-DMW-5	EMSA	Proposed	830	MW	TBD	Quarterly
EMSA-DMW-6	EMSA	Proposed	885	MW	TBD	Quarterly
EMSA-DMW-P6A	EMSA	Proposed	860	PZ	TBD	Quarterly
EMSA-DMW-7	EMSA	Proposed	700	MW	TBD	Quarterly
EMSA-DMW-P7A	EMSA	Proposed	760	PZ	TBD	Quarterly
EMSA-DMW-8	EMSA	Proposed	540	MW	TBD	Quarterly
EMSA-DMW-P8A	EMSA	Proposed	640	PZ	TBD	Quarterly
EMSA-DMW-9	EMSA	Proposed	520	MW	TBD	Quarterly
BKGD-1	Background	Proposed	1220	MW	TBD	Quarterly

Table 3: Groundwater Elevation Monitoring Schedule

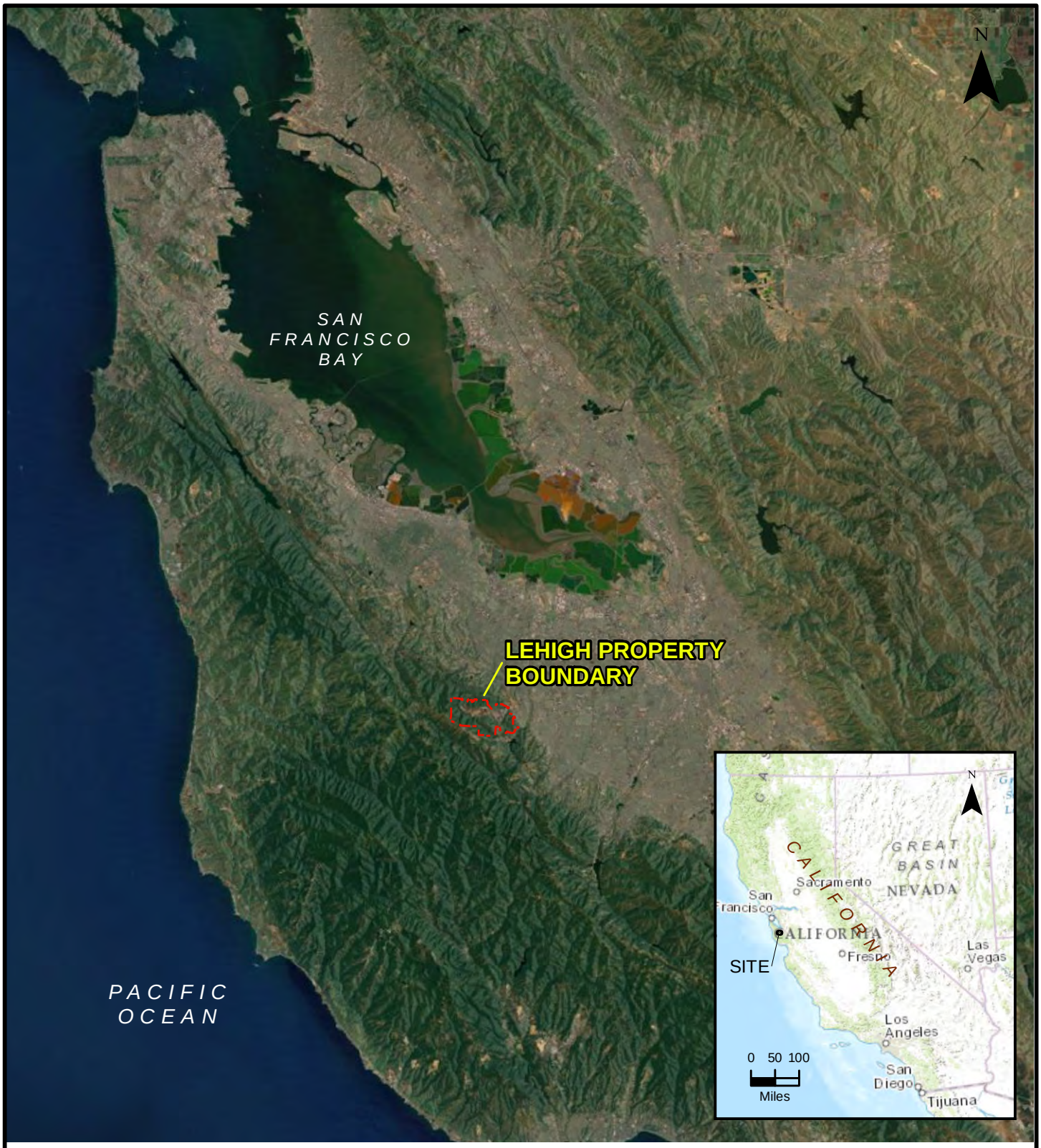
Boring/Well Designation	General Location	Existing or Proposed	Ground Elevation (ft amsl)	Type	Screen Interval or Depth (ft bgs)	Anticipated Groundwater Elevation Monitoring Frequency
BKGD-2	Background	Proposed	240	MW	TBD	Quarterly
WTP-03	Quarry	Existing	1354	VWT	237	Quarterly
GT1-4	Quarry	Existing	1119	VWT	168	Continue to collect data every 6 hours
EW-1	Quarry	Existing	872	EW	190-470	Quarterly[1]
EW-3	Quarry	Existing	742	EW	80-340	Quarterly[1]
EW-5	Quarry	Existing	748	EW	80-340	Quarterly[1]
EW-7	Quarry	Existing	856	EW	106-400	Quarterly[1]
EW-9	Quarry	Existing	949	EW	260-540	Quarterly[1]
EW-10	Quarry	Existing	954	EW	260-540	Quarterly[1]
MS-inc-1s, m, d	Quarry/ WMSA	Existing	1790	VWT	85, 280, 480	Quarterly
OW-1S	Quarry	Existing	854	VWT	146	Quarterly
OW-1D	Quarry	Existing	854	VWT	305	Continue to collect data every 6 hours
OW-2	Quarry	Existing	725	VWT	305	Continue to collect data every 6 hours
OW-3	Quarry	Existing	945	VWT	495	Quarterly
OW-4	Quarry	Existing	747	VWT	295	Continue to collect data every 6 hours
OW-5	Quarry	Existing	877	MW	160-370	Continue to collect data every 6 hours
OW-6	Quarry	Existing	725	VWT	295	To be destroyed in near term
GT2-7	S Perm Creek	Existing	1281	VWT	271	Quarterly[2]
GT3-4	S Perm Creek	Existing	1739	VWT	270	Quarterly[2]
GT4-25a	S Perm Creek	Existing	1671	VWT	277	Quarterly[2]

1 = minimum frequency will be quarterly; when pumps are supplied power, groundwater elevations will be recorded daily.

2 = groundwater elevations at existing data points south of Permanente Creek will attempted to be measured to aid in developing potentiometric map; pending accessibility different locations may be monitored.

MW = monitoring well; EW = extraction well; VWT = grouted in place vibrating wire transducer

FIGURES



0 2.5 5 10 15
Miles

REFERENCES

Spatial Reference:
NAD 1983 StatePlane California III FIPS 0403 feet

Base Maps
Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

PROJECT

WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CALIFORNIA

TITLE

REGIONAL LOCATION MAP

Golder Associates

PROJECT No.	063-7109-913		FILE No.	SiteLocMap
DESIGN	DLM	1/28/2010	SCALE: AS SHOWN	REV. 0
GIS	DLM/MM	10/31/2013		
CHECK	GW	10/31/2013	**FIGURE 1**	
REVIEW	BF	10/31/2013		

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LEGEND

- Stream
- Property Boundary
- Reclamation Plan Boundary

NOTES

1) Locations based on conversion from local coordinates or Google Earth placement.

REFERENCES

1)Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
2) Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

1,200 0 1,200
Feet

PROJECT
WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CALIFORNIA

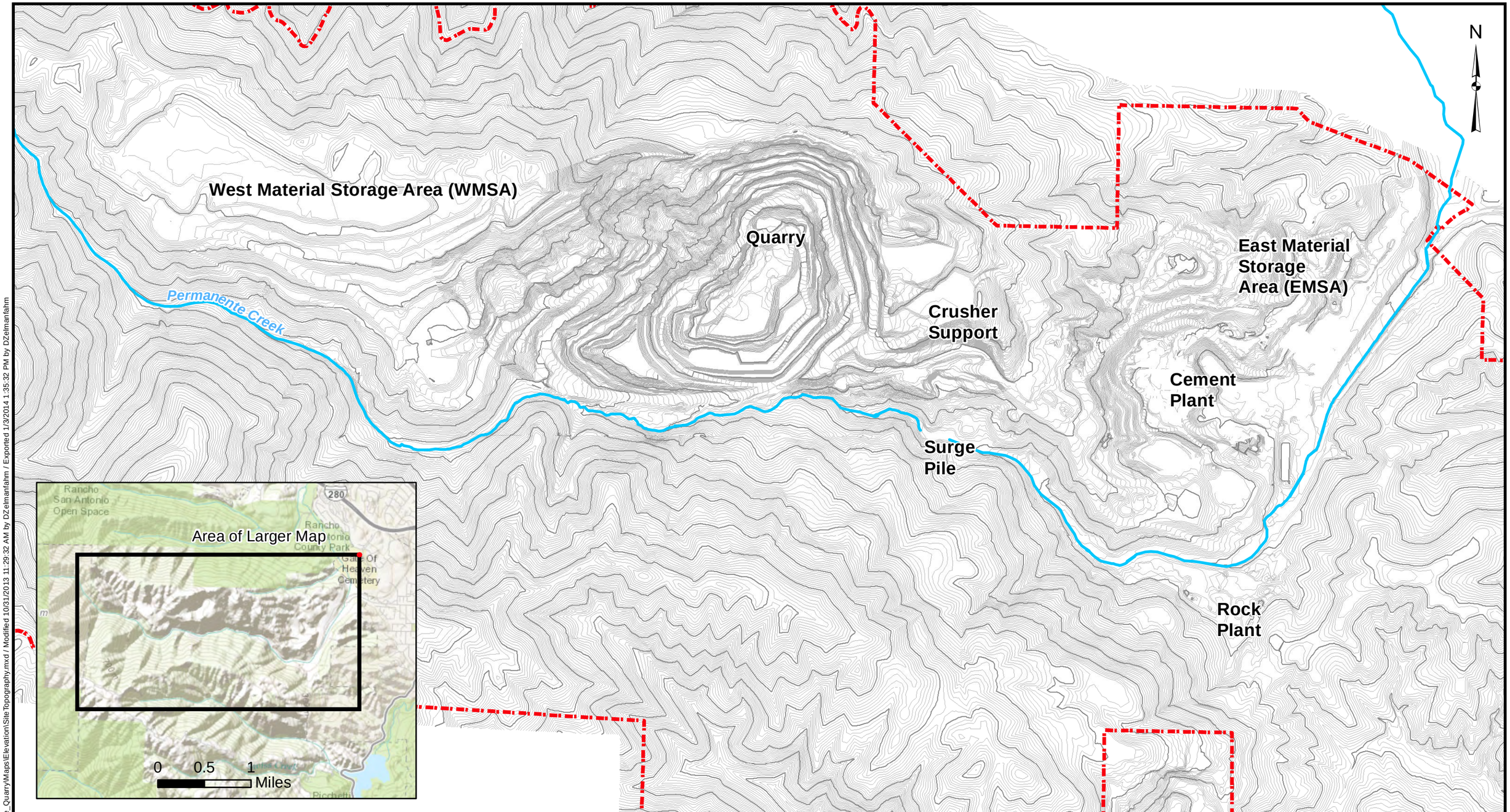
TITLE
SITE PLAN

Golder Associates

PROJECT No.		063-7109	FILE No.	SitePlan.mxd
DESIGN	DZF	10/31/2013	SCALE: AS SHOWN	REV. 0
GIS	DZF	1/3/2014		
CHECK	GW	1/3/2014		
REVIEW	GW	1/3/2014		

FIGURE 2

Map Document: G:\GIS\Sites\Lehigh_Permanente_Quarry\Maps\General\SitePlan.mxd / Modified 1/3/2014 4:03:32 PM by DZelmanfahm / Exported 5/6/2014 9:21:59 AM by DZelmanfahm



LEGEND

- Permanente Creek
- Property Boundary

April 2013 Topography

- 100 ft contour
- 10 ft contour

REFERENCES

1) Topography recieved from Lehigh April 2013.
2) Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

1,000 0 1,000 Feet

PROJECT
WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CALIFORNIA

TITLE
SITE TOPOGRAPHY

Golder Associates

PROJECT No.		063-7109-913	FILE No.	SiteTopography.mxd
DESIGN	MM	6/28/2013	SCALE: AS SHOWN	REV. 0
GIS	MM	10/31/2013		
CHECK	GW	10/31/2013	**FIGURE 3**	
REVIEW	WLF	10/31/2013		

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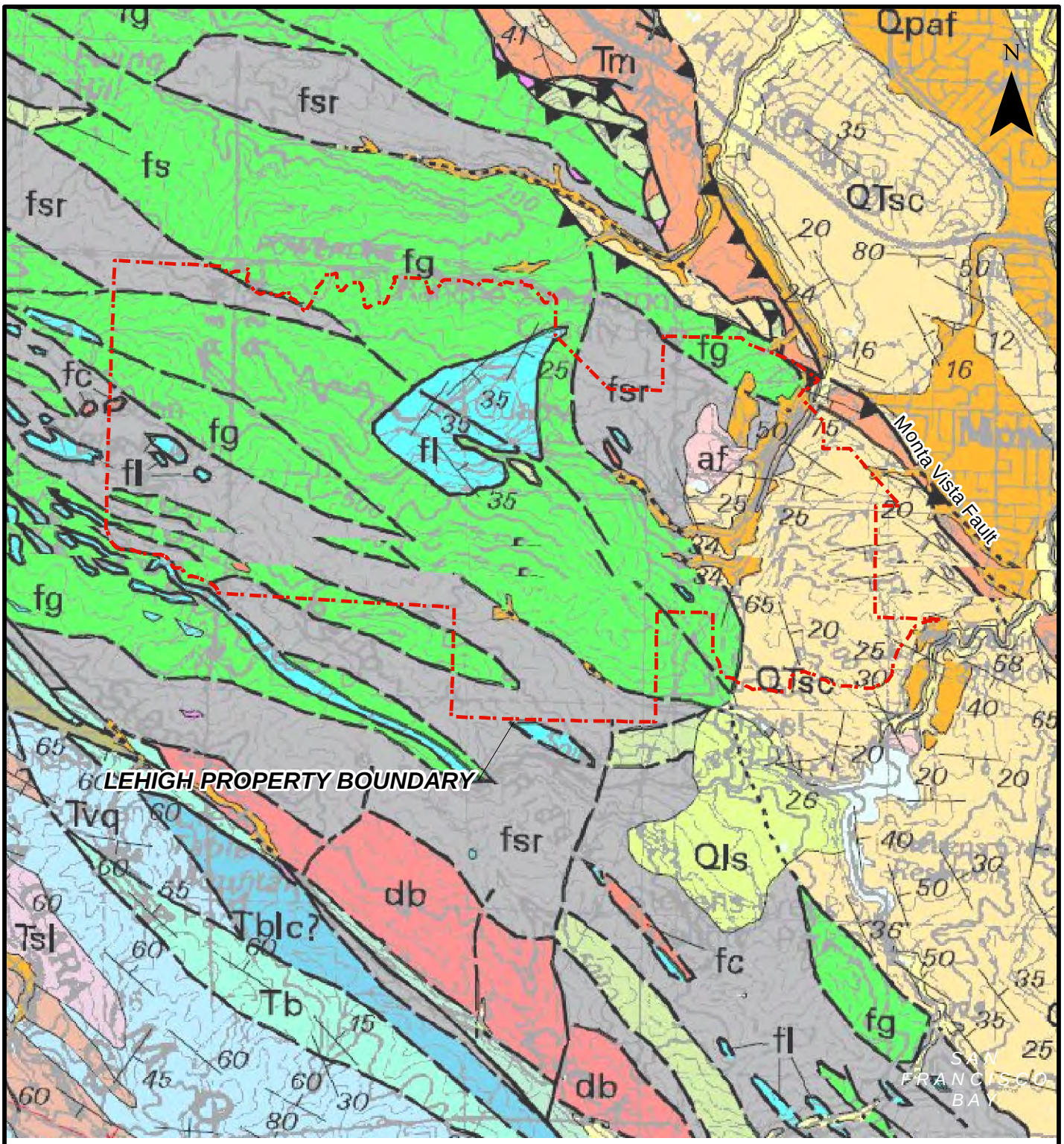

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REFERENCES

US Geological Survey, Geologic Map and Map Database of the Palo Alto 30' x 60' Quadrangle, California; Brabb, E.E., R.W.Graymer, and D.L., Jones, 2000. MF Studies Map MF-2332.
(http://pubs.usgs.gov/mf/2000/mf-2332/mf2332m.pdf)

PROJECT

WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CALIFORNIA

TITLE

REGIONAL GEOLOGIC MAP

Golder Associates

PROJECT No.		063-7109	FILE No.
DESIGN	DLM	1/28/2010	SCALE: AS SHOWN REV. 0
GIS	DLM	1/28/2010	
CHECK	GW	1/28/2010	FIGURE 4
REVIEW	WLF	1/28/2010	

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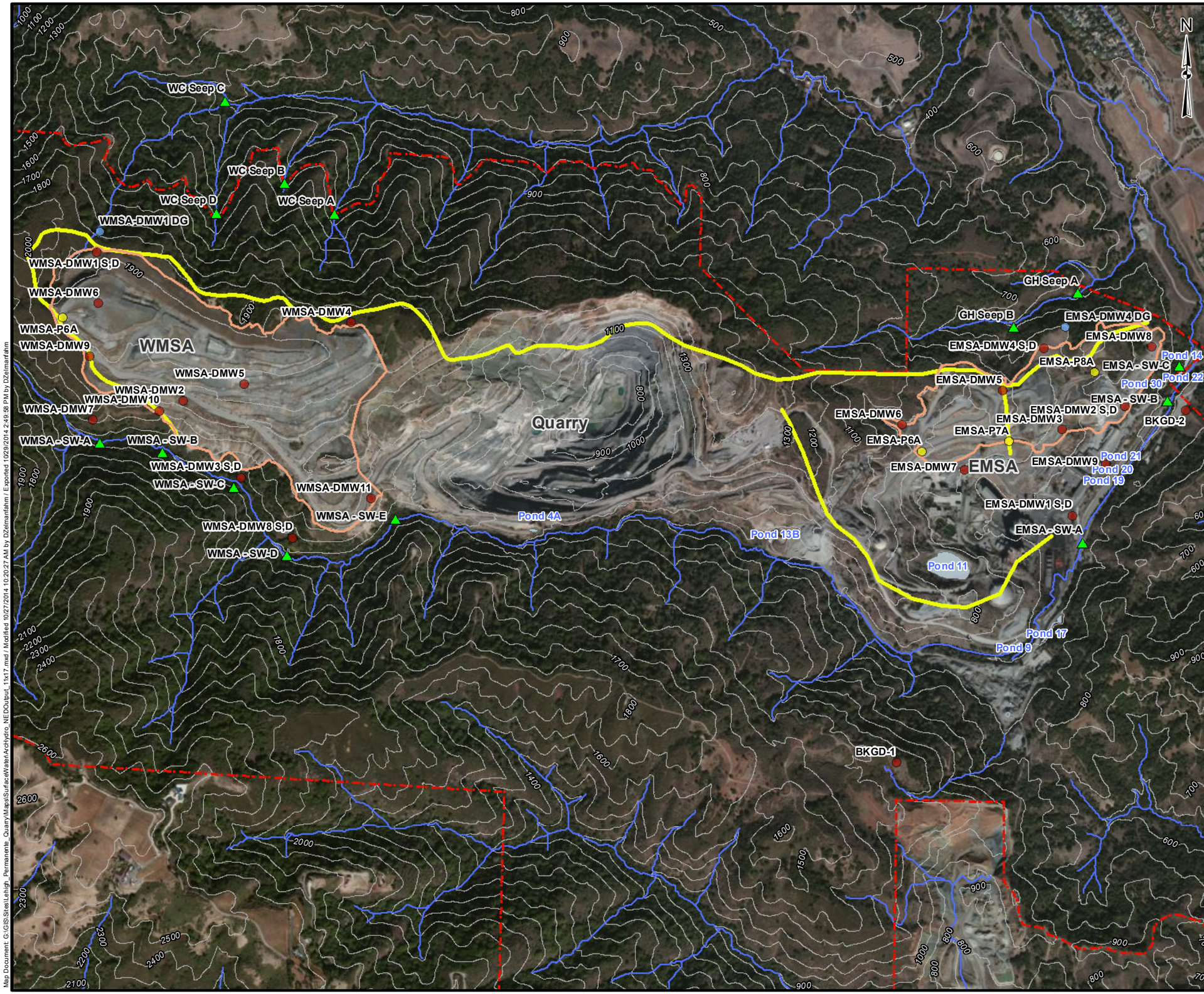

LEGEND

- Contingent Boring and Well Location
- Proposed Piezometer Location
- Proposed Boring and Well Location
- Proposed Seep and Surface Water Sample Location
- Former Ridgecrest
- Drainage Line (ArcHydro)
- Ponds
- Property Boundary
- 100 ft surface elevation contour
- EMSA/WMSA Rec Plan Boundary (Approximate)

NOTES

ArcHydro Modeling Notes:

1) 2006 LIDAR data processed by the USGS and available as 1/9th arc National Elevation Dataset (NED) was used for the ArcHydro modeling. Raw unclassified 2006 LIDAR data is available from the USGS Earth Explorer website, but the classified LIDAR data is not readily available as a LAS dataset. The unclassified data does not allow for the separation of ground surface LIDAR points from points representing the elevations of vegetation or noise. Therefore, the processed 1/9th arc National Elevation Dataset grid for this area generated using the ground surface points from the 2006 LIDAR data was used as the ArcHydro input data.

2) The NED data was projected into the NAD 1983 California State Plane III (FIPS 403) coordinate system with a 10 ft x 10 ft cell size.

3) Using the projected NED raster as the initial Digital Elevation Model (DEM), the Quarry Pit, Pond 9, Pond 13A/13B, and Pond 17 were defined as sinks. Ponds 19 and 20 were not defined as sinks.

4) The DEM was preprocessed using the Optimized Pit Removal Tool V1.5.1 developed by Stephen Jackson at the University of Texas at Austin Center for Research in Water Resources. The pits were removed using the method minimizing net change in the DEM.

5)The ArcHydro Tools for ArcGIS 10.1 released on 1/25/2013 were used to generate flow direction, flow accumulation, stream definition, stream segmentation, and catchment grids from the DEM following pit removal. The ArcHydro Tools were also used to produce catchment polygon and drainage line feature classes.

REFERENCES

1) USGS 1/9th Arc NED DEM based off of 2006 LIDAR Survey
2) Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
3) Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet
4) Former Ridgecrest created from 1952 Cupertino and 1955 Mindego Hills Quadrangle USGS Topographic Maps.

1,200 0 1,200 Feet
1 in = 1,200 feet

PROJECT WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CA

TITLE

PROPOSED BORING/WELL LOCATIONS AND DRAINAGE BASINS

Golder Associates

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GIS	MM	10/27/2014		
CHECK	GW	10/27/2014		
REVIEW	GW	10/27/2014		

FIGURE 5

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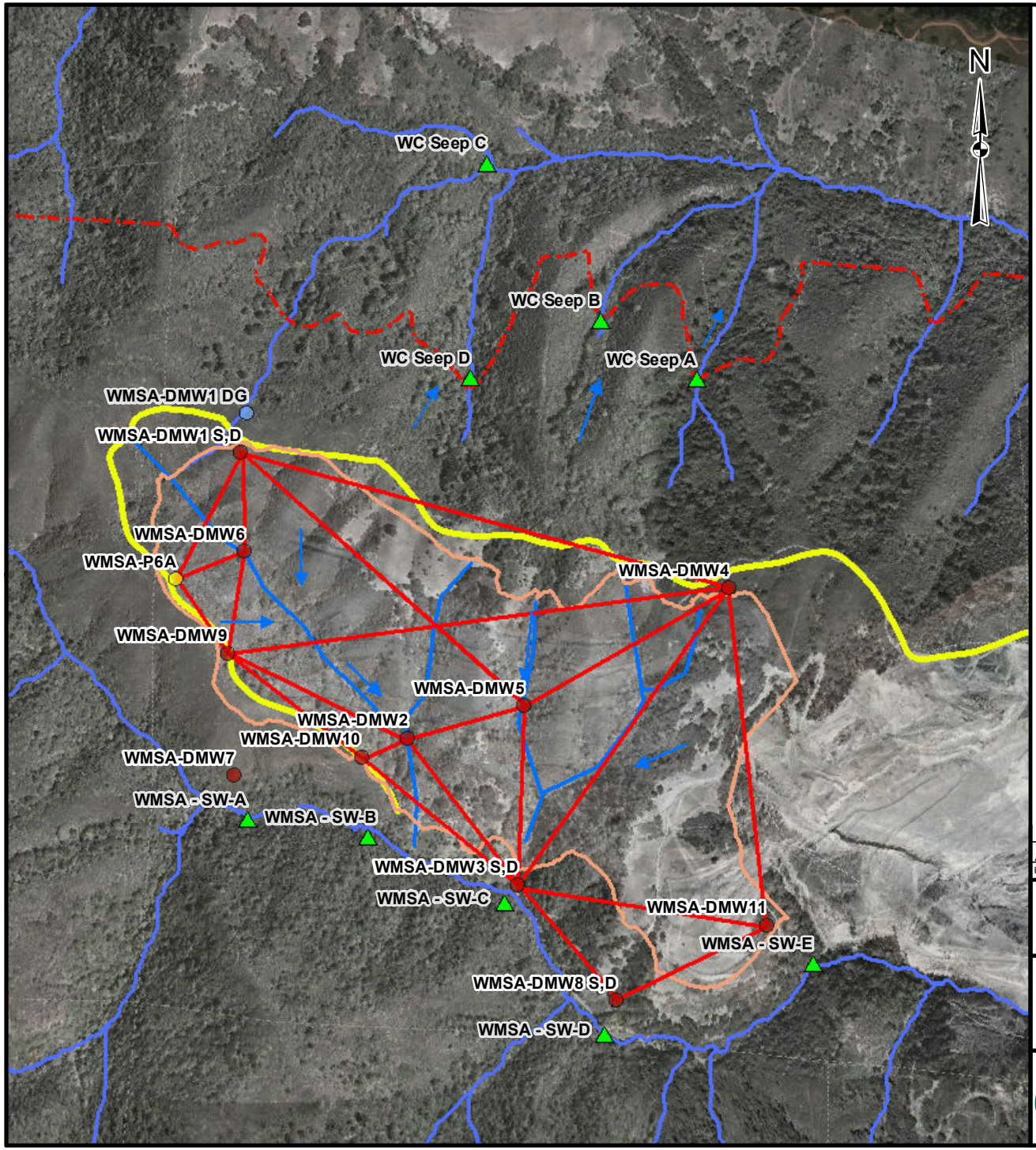
Map Document: G:\GIS\Sites\Lehigh_Permanente_Quarry\Maps\Wells\WMSA_WellsFlow.mxd / Modified 10/27/2014 10:12:11 AM by DZelmanfahm / Exported 10/29/2014 2:38:24 PM by DZelmanfahm



LEGEND

- Contingent Boring and Well Location
- Proposed Seep and Surface Water Sample Location
- Proposed Piezometer Location
- Proposed Boring and Well Location
- Groundwater Triangulation
- Inferred Groundwater Flow Direction
- EMSA/WMSA Rec Plan Boundary (Approximate)
- Former Ridgecrest
- Historical Drainages
- Property Boundary

NOTES

REFERENCES

1.) Service Layer Credits: "Permanente." Google Earth Pro. May, 1953.
September 4, 2014.
2.) USGS 1/9th Arc NED DEM based off of 2006 LIDAR Survey
Hills Quadrangle USGS Topographic Maps.
3.) Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet
4) Former Ridgecrest created from 1952 Cupertino and 1955 Mindego

1,000 0 1,000 Feet

1 inch = 1,000 feet

REV.	DATE	DES		REVISION DESCRIPTION	GIS	CHK	RVW
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PROJECT WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CA

TITLE
WMSA PROPOSED MONITORING LOCATIONS AND HISTORICAL AERIAL

Golder Associates

PROJECT No.		063-7109-914	FILE No.	WMSA_WellsFlow.mxd
DESIGN	DZF	8/21/2014	SCALE: AS SHOWN	REV. 0
GIS	DZF	10/27/2014		
CHECK	GW	10/27/2014		
REVIEW	GW	10/27/2014		

FIGURE 5A

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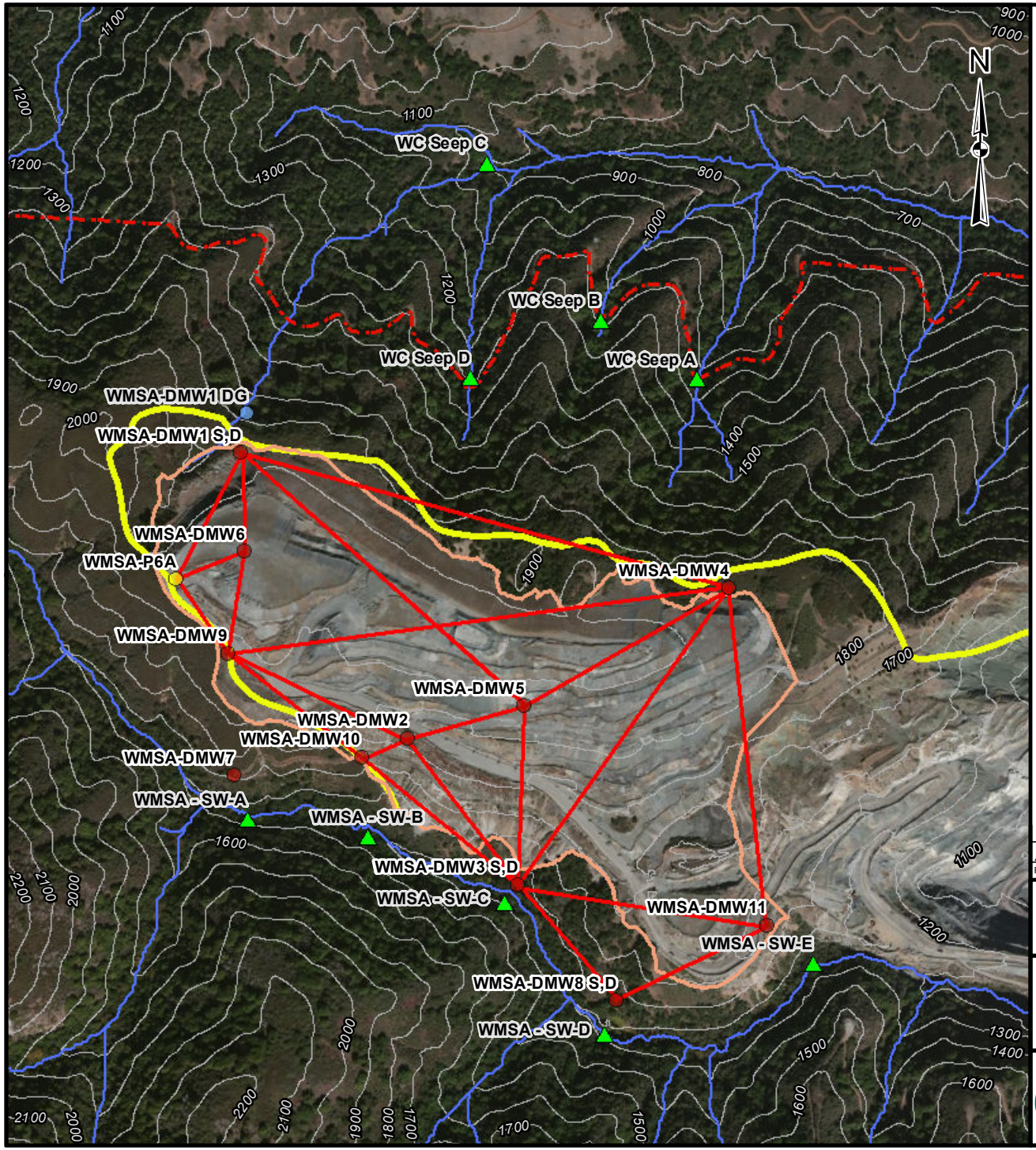

LEGEND

- Contingent Boring and Well Location
- Proposed Seep and Surface Water Sample Location
- Proposed Piezometer Location
- Proposed Boring and Well Location
- Groundwater Triangulation
- EMSA/WMSA Rec Plan Boundary (Approximate)
- Former Ridgecrest
- Property Boundary
- Drainage Line
- 100 ft surface elevation contour

NOTES

REFERENCES

1.) Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. 2011.
2.) USGS 1/9th Arc NED DEM based off of 2006 LIDAR Survey Hills Quadrangle USGS Topographic Maps.
3.) Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet
4) Former Ridgecrest created from 1952 Cupertino and 1955 Mindego

1,000 0 1,000 Feet

1 inch = 1,000 feet

REV.	DATE	DES		REVISION DESCRIPTION	GIS	CHK	RVW
0							

PROJECT WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CA

TITLE
WMSA PROPOSED MONITORING LOCATIONS AND 2011 AERIAL

Golder Associates

PROJECT No.		063-7109-914	FILE No.	WMSA_Wells.mxd
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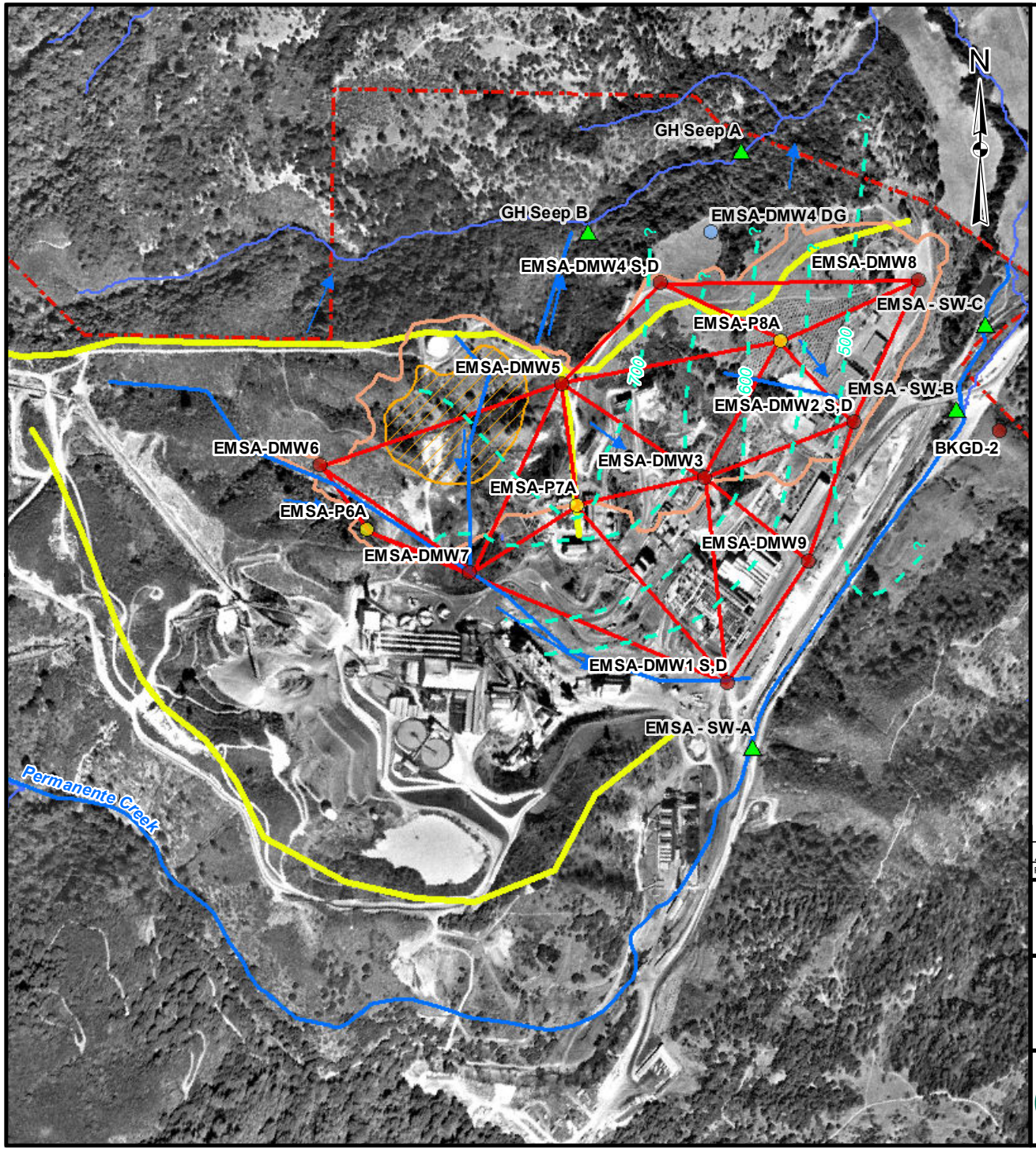
GIS	DZF	10/27/2014		
CHECK	GW	10/27/2014		
REVIEW	GW	10/27/2014		

FIGURE 5B

Map Document: G:\GIS\Sites\Lehigh_Permanente_Quarry\Maps\Wells\EMSA_WellsFlow.mxd / Modified 10/28/2014 12:49:34 PM by DZelmanfahm / Exported 10/29/2014 2:01:41 PM by DZelmanfahm



LEGEND

- Contingent Boring and Well Location
- Proposed Seep and Surface Water Sample Location
- Proposed Piezometer Location
- Proposed Boring and Well Location
- Groundwater Contours (ft, 1991)
- Historical Drainages
- Inferred Groundwater Flow Direction
- Groundwater Triangulation
- Dry Canyon Storage
- EMSA/WMSA Rec Plan Boundary (Approximate)
- Former Ridgecrest
- Property Boundary

NOTES

REFERENCES

1.) Service Layer Credits: "Permanente." Google Earth Pro. May, 1953. September 4, 2014.
2.) USGS 1/9th Arc NED DEM based off of 2006 LIDAR Survey Hills Quadrangle USGS Topographic Maps.
3.) Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet
4) Former Ridgecrest created from 1952 Cupertino and 1955 Mindego
5) Emcon Associates. 1991 Groundwater Contours, Supplemental Site Characterization, Kaiser Aluminum and Chemical Corp.

800 0 800 Feet

1 inch = 800 feet

REV.	DATE	DES		REVISION DESCRIPTION	GIS	CHK	RVW
0							

PROJECT WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CA

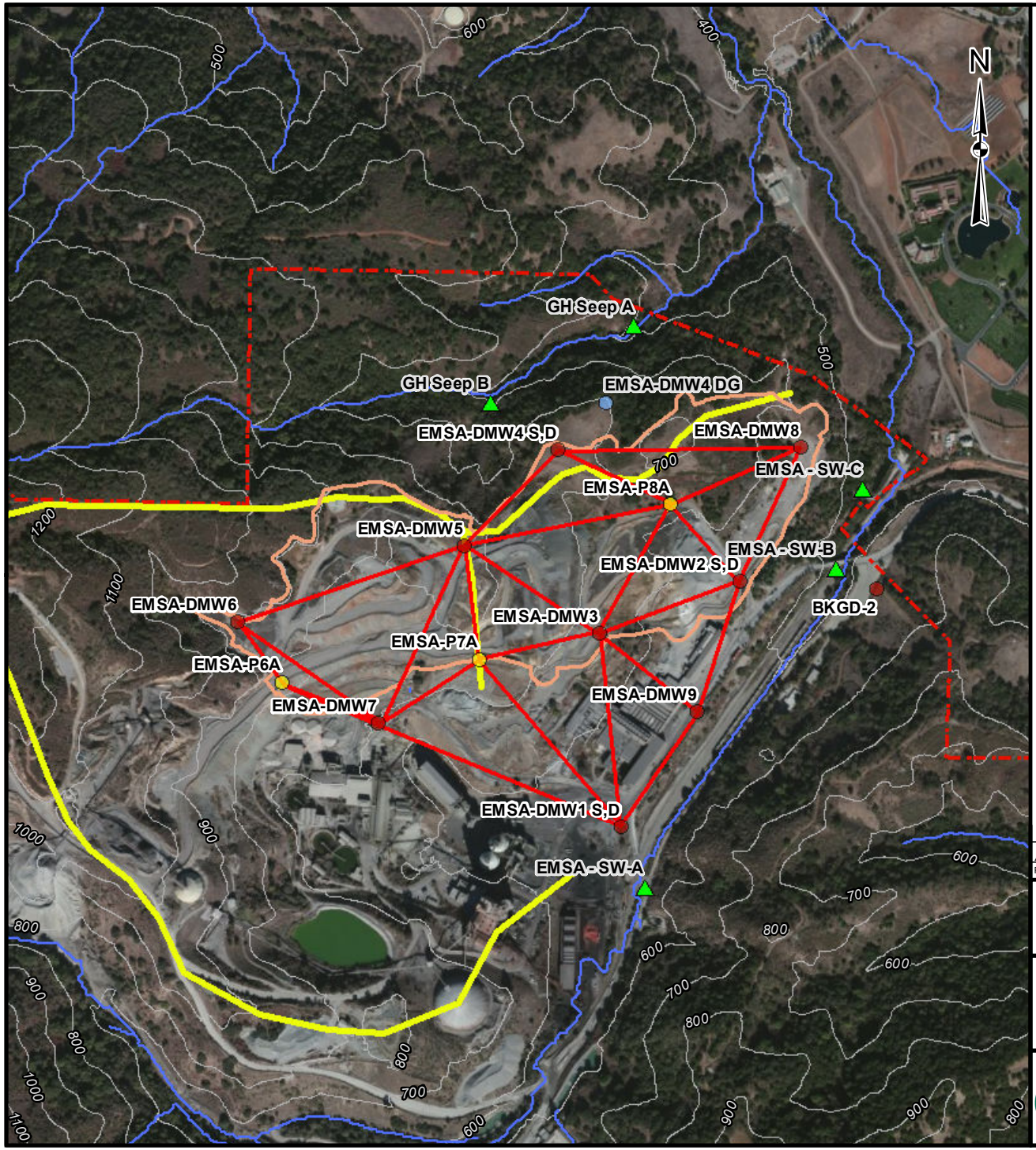
TITLE
EMSA PROPOSED MONITORING LOCATIONS AND HISTORICAL AERIAL

Golder Associates

PROJECT No.		063-7109-914	FILE No.	EMSA_WellsFlow.mxd
DESIGN	DZF	8/21/2014	SCALE: AS SHOWN	REV. 0
GIS	DZF	10/28/2014		
CHECK	GW	10/28/2014		
REVIEW	GW	10/28/2014		

FIGURE 5C

Map Document: G:\GIS\Sites\Lehigh_Permanente_Quarry\Maps\Wells\EMSA_Wells.mxd / Modified 10/28/2014 1:47:55 PM by DZelmanfahm / Exported 10/29/2014 1:53:09 PM by DZelmanfahm



LEGEND

- Contingent Boring and Well Location
- Proposed Seep and Surface Water Sample Location
- Proposed Piezometer Location
- Proposed Boring and Well Location
- Groundwater Triangulation
- EMSA/WMSA Rec Plan Boundary (Approximate)
- Former Ridgecrest
- Property Boundary
- Drainage Line
- 100 ft surface elevation contour

NOTES

REFERENCES

1.) Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. 2011.
2.) USGS 1/9th Arc NED DEM based off of 2006 LIDAR Survey Hills Quadrangle USGS Topographic Maps.
3.) Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet
4) Former Ridgecrest created from 1952 Cupertino and 1955 Mindego

800 0 800
Feet

REV.	DATE	DES		REVISION DESCRIPTION	GIS	CHK	RVW
0							

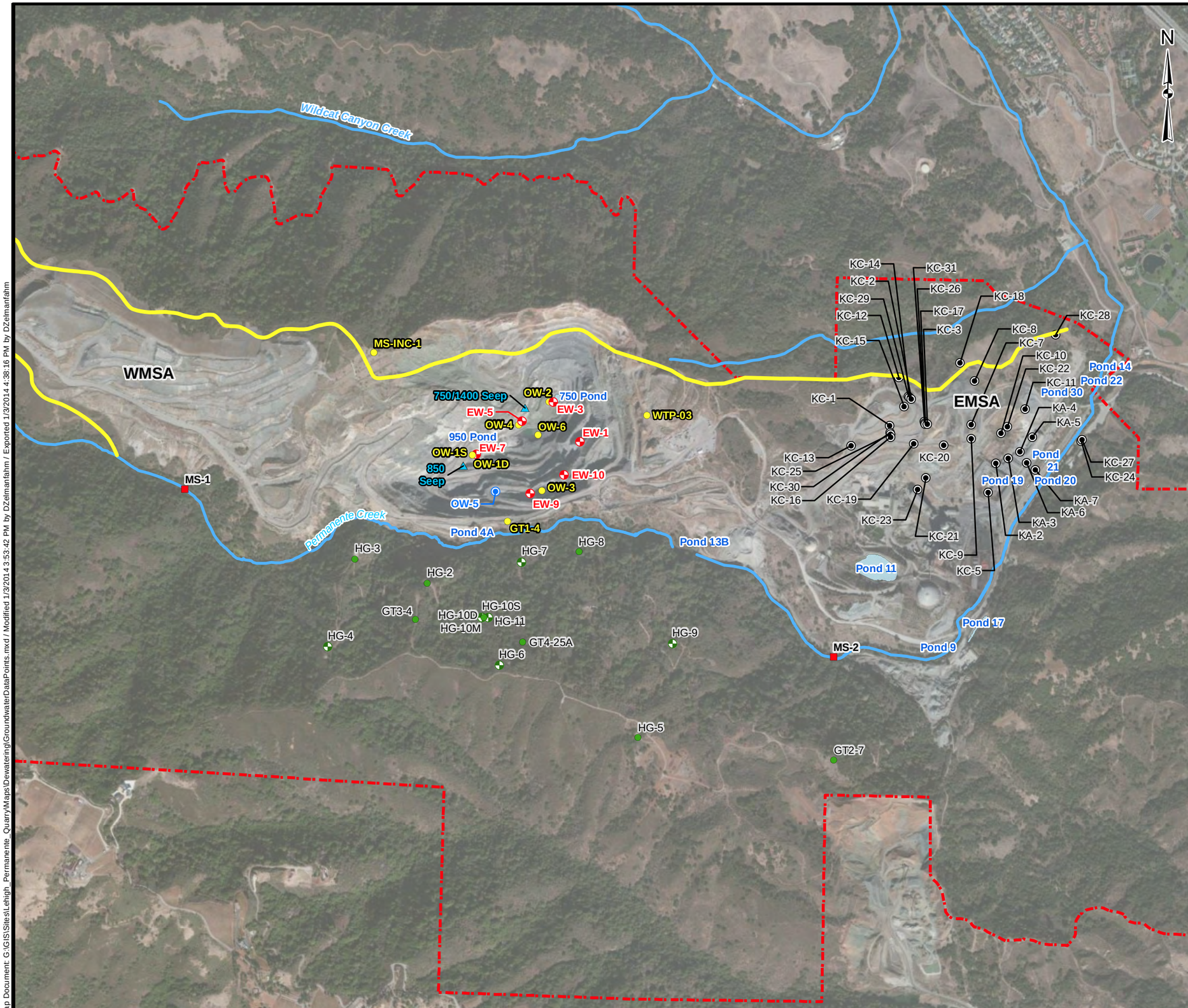
PROJECT WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CA

TITLE
EMSA PROPOSED MONITORING LOCATIONS WITH 2011 AERIAL

Golder Associates

PROJECT No.		063-7109-914	FILE No.	EMSA_Wells.mxd
DESIGN	DZF	8/21/2014	SCALE: AS SHOWN	REV. 0
GIS	DZF	10/28/2014		
CHECK	GW	10/28/2014		
REVIEW	GW	10/28/2014		

FIGURE 5D



LEGEND

- Historical EMSA Monitoring Well
- Southern Permanente Piezometer (VWT)
- Southern Permanente Well
- Piezometer (observation well)
- Extraction Well
- Piezometer (VWT)
- Seep
- Surface Water Station
- Stream
- Former Ridgecrest
- Property Boundary
- Pond

NOTES

1) Locations based on conversion from local coordinates or Google Earth placement.

REFERENCES

1)Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
2) Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet
3) Former Ridgecrest created from 1952 Cupertino and 1955 Mindego Hills Quadrangle USGS Topographic Maps.

1,200 0 1,200
Feet

PROJECT
WORKPLAN: SITE GROUNDWATER CHARACTERIZATION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CALIFORNIA

TITLE
EXISTING AND HISTORICAL DATA POINTS

Golder Associates

PROJECT No.		063-7109	FILE No.	GroundwaterDataPoints.mxd
DESIGN	MM	6/5/2013	SCALE: AS SHOWN	REV. 0
GIS	MM	1/3/2014		
CHECK	GW	1/3/2014		
REVIEW	GW	1/3/2014		

FIGURE 6

Map Document: G:\GIS\Sites\Lehigh_Permanente_Quarry\Maps\Dewatering\GroundwaterDataPoints.mxd / Modified 1/3/2014 3:53:42 PM by DZelmanfahm / Exported 1/3/2014 4:38:16 PM by DZelmanfahm

APPENDIX A

LABORATORY MDL AND RL SUMMARY

Alpha Analytical Laboratories Inc.

www.alpha-labs.com

Waters, Sediments, Solids

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Compound	CTR Number	Method	Hold Time	Matrix	Alpha's MDL	Alpha's RL	SWRCB Apx 4, ML
Purgeable Organic Compounds (4 x 40ml VOA Vial (unpreserved))							
Acrolein	17	EPA624	**3**	Final Effluent	.62ug/l	2ug/l	5ug/l
Acrylonitrile	18	EPA624	**3**	Final Effluent	0.21	2	2
Benzene	19	EPA624	7	Final Effluent	0.23	0.3	2
Bromoform	20	EPA624	7	Final Effluent	0.39	0.5	2
Carbon tetrachloride	21	EPA624	7	Final Effluent	0.3	0.5	2
Chlorobenzene	22	EPA624	7	Final Effluent	0.41	0.5	2
Chlorodibromomethane	23	EPA624	7	Final Effluent	0.47	0.5	2
Chloroethane	24	EPA624	7	Final Effluent	0.25	0.5	2
2-Chloroethyl vinyl ether	25	EPA624	7	Final Effluent	0.93	1	2
Chloroform	26	EPA624	7	Final Effluent	0.41	0.5	2
1,2-Dichlorobenzene	75	EPA624	7	Final Effluent	0.45	0.5	2
1,3-Dichlorobenzene	76	EPA624	7	Final Effluent	0.47	0.5	2
1,4-Dichlorobenzene	77	EPA624	7	Final Effluent	0.48	0.5	2
Dichlorobromomethane	27	EPA624	7	Final Effluent	0.48	0.5	2
1,1-Dichloroethane	28	EPA624	7	Final Effluent	0.43	0.5	1
1,2-Dichloroethane	29	EPA624	7	Final Effluent	0.42	0.5	2
1,1-Dichloroethylene	30	EPA624	7	Final Effluent	0.14	0.5	2
1,2-Dichloropropane	31	EPA624	7	Final Effluent	0.24	0.5	1
cis-1,3-Dichloropropylene	32	EPA624	7	Final Effluent	0.49	0.5	2
Ethylbenzene	33	EPA624	7	Final Effluent	0.44	0.5	2
Methyl bromide (Bromomethane)	34	EPA624	7	Final Effluent	0.27	0.5	2
Methyl chloride (Chloromethane)	35	EPA624	7	Final Effluent	0.45	0.5	2
Methylene chloride (Dichloromethane)	36	EPA624	7	Final Effluent	0.17	0.5	2
1,1,2,2-Tetrachloroethane	37	EPA624	7	Final Effluent	0.17	0.5	1
Tetrachloroethylene	38	EPA624	7	Final Effluent	0.33	0.5	2
Toluene	39	EPA624	7	Final Effluent	0.27	0.3	2
1,2-trans-dichloroethylene	40	EPA624	7	Final Effluent	0.48	0.5	1
1,1,1-Trichloroethane	41	EPA624	7	Final Effluent	0.36	0.5	2
1,1,2-Trichloroethane	42	EPA624	7	Final Effluent	0.49	0.5	2
Trichloroethylene	43	EPA624	7	Final Effluent	0.47	0.5	2
Vinyl Chloride	44	EPA624	7	Final Effluent	0.32	0.5	2

Compound	CTR Number	Method	Hold Time	Matrix	Alpha's MDL	Alpha's RL	SWRCB Apx 4, ML
Acid/Base Neutral Organic Compounds (2 x 1 Liter Amber Glass (unpreserved))							
2-Chlorophenol	45	EPA625	7	Final Effluent	0.66ug/l	5ug/l	5ug/l
2,4-Dichlorophenol	46	EPA625	7	Final Effluent	0.66	5	5
2,4-Dimethylphenol	47	EPA625	7	Final Effluent	1.2	2	2
4,6-Dinitro-o-cresol (2-methylphenol)	48	EPA625	7	Final Effluent	0.75	5	5
2,4-Dinitrophenol	49	EPA625	7	Final Effluent	1.3	5	5
2-Nitrophenol	50	EPA625	7	Final Effluent	0.9	10	10
4-Nitrophenol	51	EPA625	7	Final Effluent	0.99	10	10
4-Chloro-3-methylphenol	52	EPA625	7	Final Effluent	0.58	1	1
Pentachlorophenol	53	EPA625	7	Final Effluent	1.4	5	5
Phenol	54	EPA625	7	Final Effluent	0.46	1	1
2,4,6-Trichlorophenol	55	EPA625	7	Final Effluent	0.74	10	10
Acenaphthene	56	EPA625	7	Final Effluent	0.57	1	1
Acenaphthylene	57	625SIM	7	Final Effluent	0.2	0.2	10
Anthracene	58	625SIM	7	Final Effluent	0.2	0.2	10
Benzidine	59	EPA625	7	Final Effluent	3.4	5	5
Benzo(a)anthracene	60	625SIM	7	Final Effluent	0.2	0.2	5
Benzo(a)pyrene	61	625SIM	7	Final Effluent	0.2	0.2	2
3,4-Benzofluoranthene	62	625SIM	7	Final Effluent	0.2	0.2	10
Benzo(g,h,i)perylene	63	625SIM	7	Final Effluent	0.2	0.2	5
Benzo(k)fluoranthene	64	625SIM	7	Final Effluent	0.2	0.2	10
bis(2-Chloroethoxy)methane	65	EPA625	7	Final Effluent	0.81	5	5
bis(2-Chloroethyl)ether	66	EPA625	7	Final Effluent	0.14	1	1
bis(2-Chloroisopropyl)ether	67	EPA625	7	Final Effluent	0.41	2	2
bis(2-Ethylhexyl)phthalate	68	EPA625	7	Final Effluent	0.83	5	5
4-Bromophenyl phenyl ether	69	EPA625	7	Final Effluent	0.43	5	5
Butyl benzyl phthalate	70	EPA625	7	Final Effluent	0.64	10	10
2-Chloronaphthalene	71	EPA625	7	Final Effluent	0.57	10	10
4-Chlorophenyl phenyl ether	72	EPA625	7	Final Effluent	0.93	5	5
Chrysene	73	625SIM	7	Final Effluent	0.2	0.2	10
Dibenzo(a,h)anthracene	74	625SIM	7	Final Effluent	0.2	0.2	10
3,3'-Dichlorobenzidine	78	EPA625	7	Final Effluent	2	5	5
Diethyl phthalate	79	EPA625	7	Final Effluent	0.86	2	2
Dimethyl phthalate	80	EPA625	7	Final Effluent	0.68	2	2
Di-n-butyl phthalate	81	EPA625	7	Final Effluent	0.91	10	10
2,4-Dinitrotoluene	82	EPA625	7	Final Effluent	0.68	5	5
2,6-Dinitrotoluene	83	EPA625	7	Final Effluent	0.54	5	5
Di-n-octyl phthalate	84	EPA625	7	Final Effluent	0.65	10	10
1,2-Diphenylhydrazine	85	EPA625	7	Final Effluent	0.33	1	1
Fluoranthene	86	EPA625	7	Final Effluent	0.76	1	1
Fluorene	87	EPA625	7	Final Effluent	0.81	10	10
Hexachlorobenzene	88	EPA625	7	Final Effluent	0.89	1	1
Hexachlorobutadiene	89	EPA625	7	Final Effluent	0.84	1	1
Hexachlorocyclopentadiene	90	EPA625	7	Final Effluent	0.45	5	5
Hexachloroethane	91	EPA625	7	Final Effluent	0.58	1	1
Indeno(1,2,3-c,d)pyrene	92	625SIM	7	Final Effluent	0.2	0.2	10
Isophorone	93	EPA625	7	Final Effluent	0.81	1	1
Naphthalene	94	EPA625	7	Final Effluent	0.66	1	1

Compound	CTR Number	Method	Hold Time	Matrix	Alpha's MDL	Alpha's RL	SWRCB Apx 4, ML
Acid/Base Neutral Organic Compounds ~ Continued							
Nitrobenzene	95	EPA625	7	Final Effluent	0.74ug/l	1ug/l	1ug/l
N-Nitrosodimethylamine (NDMA)	96	EPA625	7	Final Effluent	1.1	5	5
N-Nitrosodi-n-propylamine	97	EPA625	7	Final Effluent	0.85	5	5
N-Nitrosodiphenylamine	98	EPA625	7	Final Effluent	0.9	1	1
Phenanthrene	99	625SIM	7	Final Effluent	0.2	0.2	5
Pyrene	100	625SIM	7	Final Effluent	0.2	0.2	10
1,2,4-Trichlorobenzene	101	EPA625	7	Final Effluent	0.59	5	5
Pesticide & Poly Chlorinated Biphenyl Compunds (2 x 1 Liter Amber Glass (unpreserved)]							
Aldrin	102	EPA608	7	Final Effluent	0.004	0.005	0.005
Alpha-BHC	103	EPA608	7	Final Effluent	0.002	0.01	0.01
Beta-BHC	104	EPA608	7	Final Effluent	0.002	0.005	0.005
Gamma-BHC	105	EPA608	7	Final Effluent	0.002	0.01	0.02
Delta-BHC	106	EPA608	7	Final Effluent	0.001	0.005	0.005
Chlordane	107	EPA608	7	Final Effluent	0.035	0.05	0.1
4,4'-DDT	108	EPA608	7	Final Effluent	0.005	0.01	0.01
4,4'-DDE	109	EPA608	7	Final Effluent	0.003	0.02	0.05
4,4'-DDD	110	EPA608	7	Final Effluent	0.002	0.02	0.05
Dieldrin	111	EPA608	7	Final Effluent	0.002	0.01	0.01
Endosulfan I	112	EPA608	7	Final Effluent	0.003	0.01	0.02
Endosulfan II	113	EPA608	7	Final Effluent	0.002	0.01	0.01
Endosulfan sulfate	114	EPA608	7	Final Effluent	0.002	0.05	0.05
Endrin	115	EPA608	7	Final Effluent	0.003	0.01	0.01
Endrin aldehyde	116	EPA608	7	Final Effluent	0.002	0.01	0.01
Heptachlor	117	EPA608	7	Final Effluent	0.002	0.01	0.01
Heptachlor epoxide	118	EPA608	7	Final Effluent	0.002	0.01	0.01
PCB Alochlors	119-125	EPA608	7	Final Effluent	0.05	0.5	0.5
Toxaphene	126	EPA608	7	Final Effluent	0.45	0.5	0.5
Metals (500ml Poly (HNO3)) + 250ml Poly (Ammonium Sulfate buffer)) + 8oz Glass Double Bag							
Arsenic	2	EPA200.8	180	Final Effluent	0.07	0.5	2
Cadmium	4	EPA200.8	180	Final Effluent	0.02	0.1	0.25
Chromium	5a	EPA200.8	180	Final Effluent	0.08	0.5	0.5
Hexavalent Chromium	5b	SM3500	180	Final Effluent	5	10	10
Lead	7	EPA200.8	180	Final Effluent	0.02	0.25	0.5
Mercury	8	EPA1631	28	Final Effluent	.2ng/l	0.5ng/l	0.5ng/l
Selenium	10	EPA200.8	180	Final Effluent	0.07ug/l	1ug/l	2ug/l
Silver	11	EPA200.8	180	Final Effluent	0.02	0.1	0.25
Antimony	1	EPA200.8	180	Final Effluent	0.02	0.5	0.5
Beryllium	3	EPA200.8	180	Final Effluent	0.02	0.1	1
Copper	6	EPA200.8	180	Final Effluent	0.04	0.5	0.5
Zinc	13	EPA200.8	180	Final Effluent	0.5	5	10
Nickel	9	EPA200.8	180	Final Effluent	0.06	0.5	5
Thallium	12	EPA200.8	180	Final Effluent	0.02	0.1	1
Misc. Analytical Requirements							
Cyanide	14	EPA335.2	14	Final Effluent	2ug/l	3ug/l	5ug/l