Appendix F:
Thomas Harder Groundwater Consulting Letter

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Thomas Harder

Groundwater Consulting

May 1, 2009

Mr. Michael Perry
California Collaborative Solutions
P.O. Box 706
Big Bear City, California 92314

Re: Letter Addressing County of San Bernardino Comments Regarding Water Supply for the Moon Camp Development

Dear Michael,

As per your request, Thomas Harder Groundwater Consulting (THGC) has prepared this letter addressing comments from the County of San Bernardino (County) regarding water supply for the proposed Moon Camp Development near Fawnskin, California. The primary focus of the County's comments is a report by GEOSCIENCE Support Services, Inc. (GEOSCIENCE)[1] that describes the results of recent pumping tests conducted on the Moon Camp Tract's Well FP-2. However, the County's comments also discuss previous estimates of perennial yield for Tributary Subarea A and supplemental water to be supplied from the Moon Camp Tract's recently constructed Well FP-4.

This letter addresses the following specific issues raised by the County:

1. The range of perennial yield (including the low end or "minimum") that has previously been estimated for Subarea A, which is tributary to Well FP-2.
2. Potential impacts of pumping Well FP-2 on Big Bear Lake.
3. Potential impacts associated with the utilization of Well FP-4 as a supplemental water supply source for the development.

[1] GEOSCIENCE, 2008. Results of Rehabilitation and Aquifer Testing, Moon Camp Well FP-2. Prepared for California Collaborative Solutions; Dated August 7, 2008.

Perennial Yield Estimates

The majority of the proposed Moon Camp development is located within Tributary Subarea A of the North Shore Hydrologic Subunit within the Big Bear Lake Watershed. This subarea is the most westerly of the North Shore subareas and is adjacent to the Grout Creek Hydrologic Subunit (see Figure 1).

The perennial yield (i.e. groundwater available for municipal supply) for Subarea A has been estimated in the context of a range of possible natural recharge estimates for the area. GEOSCIENCE, 2003[2] estimated the natural recharge to range from 14 to 44 acre-ft/yr with a midpoint of 29 acre-ft/yr. They reported that the midpoint of the range (i.e. 29 acre-ft/yr) is considered a good estimate of the perennial yield for the subarea, based on available data.

Although recent testing has shown that the pumping capacity of Well FP-2 can easily meet and exceed the demands of the Moon Camp development, the well will be operated within the low end of the natural recharge estimate (14 acre-ft/yr) minus the estimated pumping of the existing homeowners in Subarea A (5 acre-ft/yr). This leaves 9 acre-ft/yr to be pumped from Well FP-2 for the Moon Camp Development. The low end of the range of natural recharge estimates for Subarea A (14 acre-ft/yr) is a conservative estimate of the perennial yield (i.e. available groundwater supply) for the subarea. This amount of recharge is only 2.5 percent of the long-term average annual precipitation for the subarea, which is approximately 28 in/yr based on the San Bernardino County Flood Control District isohyetal map for the area (see GEOSCIENCE, 2003; Figure 4). This amount of recharge is also below the range of accepted recharge estimates for other groundwater basins in southern California, which is generally 3 to 7 percent of precipitation (GEOSCIENCE, 2003). In some areas of southern California, groundwater recharge as a percent of precipitation has been reported to be greater than 10 percent (as an example, see Manghi, et al., 2009)[3]. Thus, until additional data can be collected to refine the perennial yield estimate of Subarea A, producing up to 14 acre-ft/yr of groundwater from this subarea for existing pumpers and the proposed Moon Camp development is a very conservative approach to developing the groundwater resources of the area.

[2] GEOSCIENCE, 2003. Focused Geohydrologic Evaluation of Maximum Perennial Yield for the North Shore and Grout Creek Hydrologic Subunits. Prepared for the City of Big Bear Lake Department of Water and Power. Dated December 2, 2003.

[3] Manghi, F., Mortazavi, B., Crother, C., and Hamdi, M., 2009. Estimating Regional Groundwater Recharge Using a Hydrological Budget Method. Springer Science and Business Media.

The data that has been collected since 2003, including the data from the FP-2 pumping test, is not adequate to refine the perennial yield estimate. One of the best ways to refine the current perennial yield estimate is to monitor groundwater pumping and groundwater level response within Subarea A over a long-term period. Long-term would be defined on the order of decades and would include monitoring and production over multiple "wet" and "dry" hydrologic cycles. Pumping Well FP-2 and other private wells in Subarea A at rates up to 14 acre-ft/yr is a prudent approach for developing the groundwater resources of the area and, in the context of a groundwater monitoring program, verifying the available perennial yield.

Potential Impacts of Pumping Well FP-2 on Big Bear Lake

The potential impact of pumping Well FP-2 on the surface water in Big Bear Lake would be minimal. Well FP-2 produces groundwater from an aquifer system that is deeper than the bottom of Big Bear Lake and is separated from the lake bottom by multiple silt and clay layers. The top of perforations for Well FP-2 occur approximately 60 ft below ground surface (bgs) at an elevation of approximately 6,686 ft above mean sea level (amsl). The high surface water elevation in the lake is 6,743 ft amsl and the average depth of the lake is 30 ft.[4] Thus, the elevation of the bottom of Big Bear Lake is approximately 27 ft above the top of perforations for Well FP-2. The geologic log for Well FP-2 shows multiple silt and clay layers between the land surface and top of perforations (see Attachment A). If the silt and clay layers extend beneath the lake, they would provide some hydraulic separation between the lake water and aquifer system. While it is possible that some vertical leakage could occur from the lake into the aquifer system of FP-2, the majority of groundwater produced by FP-2 would be from the aquifer underlying Subarea A.

Potential Impacts Associated with Pumping Well FP-4

Well FP-4 has recently been constructed in the northwestern corner of the proposed Moon Camp development to provide a supplemental source of water supply. This well is located within Subarea D of the Grout Creek Hydrologic Subunit, a separate drainage catchment from Tributary Subarea A of the North Shore Hydrologic Subunit (see Figure 1). A pumping test conducted upon completion of Well FP-4 indicates it is capable of producing up to 3.5 gallons per minute

[4] Big Bear Municipal Water District Website.

on a sustained basis. At this rate and assuming continuous operation, the well would produce approximately 5.6 acre-ft/yr.

GEOSCIENCE, 2003 reports the groundwater recharge for Subarea D to be between 32 and 99 acre-ft/yr with a midpoint of 66 acre-ft/yr. At present, the only groundwater production in this subarea is from private wells. There are eleven private wells shown on Figure 4 of GEOSCIENCE, 2003. Assuming an average per-household water demand of 250 gallons per day, annual groundwater production from private wells in Subarea D is estimated to be approximately 3 acre-ft/yr. Based on this, the additional 5.6 acre-ft/yr of pumping anticipated from Well FP-4 will not result in combined pumping in excess of the low end of recharge estimates (32 acre-ft/yr) for the Subarea and is not a significant impact to the long-term water supply of Subarea D.

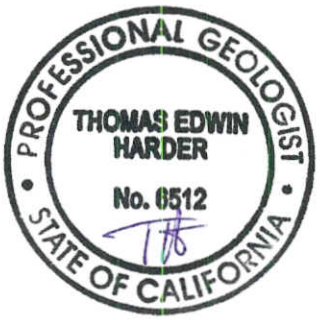
The only other potential impact of pumping Well FP-4 is interference with existing private wells. Pumping test data for Well FP-4 shows that pumping this well at a sustained rate of 3.5 gpm results in approximately 2 ft of drawdown in the nearest private well, which is approximately 250 ft from FP-4. The limited available data for the private well suggests that this well has available saturated thickness to accommodate the additional 2 ft of drawdown and pumping interference from Well FP-4 should not significantly impact the operation of the well.

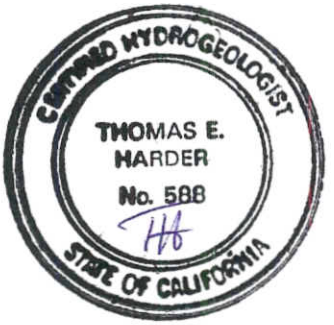
I appreciate the opportunity to assist in responding to the County's comments regarding the Moon Camp Development. If you have any questions, please call.

Sincerely,

Thomas Harder

Thomas Harder, P.G., C.HG.
Hydrogeologist





Attachment A

Well FP-2 Borehole Log

LITHLOGIC LOG

Well No. FP-2

Depth	Graphic Log		Description of Materials
		SOIL	Brown sandy silt with some gravel, roots
		GRAVEL & SAND	Multicolored, very fine to coarse sand and granule to cobble size gravel
10		SAND	Reddish brown, fine to coarse sand with some clay and fine gravel
20			Clayier
		SILT	Brown clayey silt with some fine sand
30		SAND	Multicolored silty sand with occasional fine to coarse gravel
		CLAY	Brown sandy clay with some silt and medium to coarse sand
40		SAND	Brown clayey sand with some gravel
		CLAY	Brown, medium to coarse sandy clay
50		SAND	Multicolored with a few fine gravels, medium to coarse loose sand
		CLAY	Brown sandy clay with considerable silt
60		SAND	Brown clayey sand with a few fine gravels, medium to coarse sand
		CLAY & SAND	Brown clay with local thin medium to coarse sand layers
70			
			Siltier

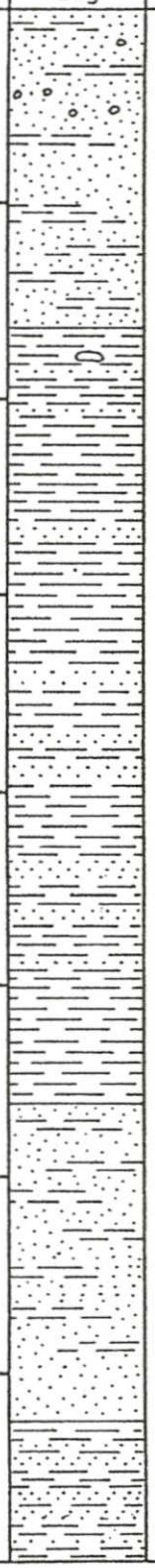
LITHLOGIC LOG

Well No. FP-2

Depth	Graphic Log		Description of Materials
			Clayier
90			
		SAND	Brown clayey sand with some silt, occasional fine gravel, fine to coarse sand
100			
			Clays decrease
			Clay
110			
			Gravel lens
120			
		CLAY	Brown silty clay with some sand
130		SAND	Brown clayey sand with some fine gravel, very fine to medium sand
140		CLAY & SAND	Brown clay and sand interbedded, occasional fine gravel, very fine to coarse sand
			Siltier
150			

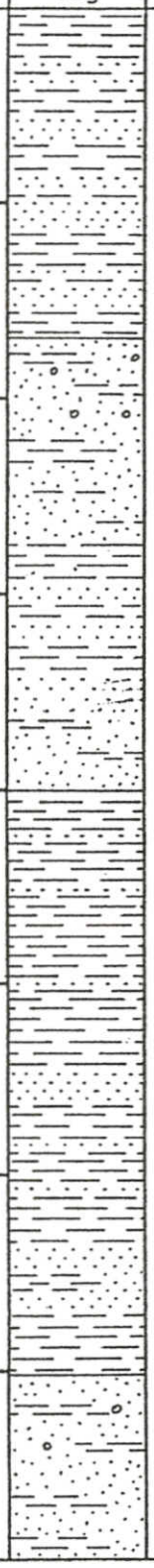
LITHLOGIC LOG

Well No. FP-2

Depth	Graphic Log	Description of Materials	
170		SAND	Brown clayey, very fine to fine sand with some silt and local fine gravel lens
180		CLAY	Reddish brown sandy clay with local sand lenses with occasional fine gravels
190			
200			
210			
220		SAND	Brown clayey very fine to medium sand, with some silts
230			
240		CLAY	Reddish brown sandy clay with occasional fine gravel and very fine to medium sand

LITHLOGIC LOG

Well No. FP-2

Depth	Graphic Log		Description of Materials
			Interbedded thin sand layers
250			
		SAND	Brown, clayey, fine to coarse sand with some fine gravel
260			
270			Clayier
280		CLAY	Reddish brown sandy clay with local thin beds of fine sand
290			
300			
310		SAND	Brown clayey medium to coarse sand with a few fine gravels

LITHLOGIC LOG

Well No. FP-2

Depth	Graphic Log		Description of Materials
			Clayier
330			
			White clays
340			
		CLAY	Reddish brown sandy clay with some silts and very fine to medium sand
350			
		SAND	Multicolored clayey very fine to coarse sand
360			
			Gravelly
370		CLAY	Reddish brown, medium to coarse sandy clay
380			
390			

LITHLOGIC LOG

Well No. FP-2

Depth	Graphic Log	Description of Materials
410		

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