EPIC ENGINEERING, P.C.
Civil Municipal Project Management Water Resources

50 East 100 South
Heber City, Utah 84032

2880 West 4700 South, Suite D
West Valley City, Utah 84118

Wednesday, August 18, 2004

Mr. Jerry D. Olds, P.E.
Utah State Engineer
Department of Natural Resources
Division of Water Rights
1594 West North Temple, Suite 220
PO Box 146300
Salt Lake City, UT 84114-6300

RECEIVED
AUG 20 2004
WATER RIGHTS
SALT LAKE

SUBJECT: UGS CEDAR VALLEY COMMENTS

Dear Mr. Olds,

This memorandum provides clarification and an update of hydrogeologic study of the Cedar Valley area completed by Hurlow (2004) of the Utah Geological Survey. The principal sources of information used for this study include:

- the well drilling database maintained by the Utah Division of Water Rights,
- the Cedar Pass test well drilling program used to site Eagle Mountain Well No. 2 as summarized by Montgomery Watson (2000) and Hurlow (2004), and
- the report prepared by Lewis (1962) regarding the Collins Brothers Oil Co. Ward Well No. 1.

STATEMENT OF THE PROBLEM

Feltis (1967) completed a reconnaissance-level study of the hydrogeology of the Cedar Valley area which included estimates of the recharge to the alluvial and bedrock aquifers utilizing a hydrologic budgeting approach. While the hydrogeologic literature discounts the use of hydrologic budgeting to determine the size of development, the study completed by Hurlow (2004) promotes continued use of the hydrologic budgeting approach of Feltis (1967). Likewise, Hurlow (2004) continues to promote the interpretation that the alluvial and bedrock aquifers are in direct hydraulic communication as proffered by Feltis (1967) despite drilling and geochemical data collected since 1962 that indicates that there are several bedrock aquifers in the Cedar Valley area that are hydraulically separated from the shallow and deeper water bearing strata by low permeability rocks. No nested wells have been drilled in the alluvium and bedrock to confirm the conceptual hydrogeologic model that the alluvium and bedrock aquifers are in direct hydraulic communication.

Fax (435) 654-6622
Fax (801) 955-5618
EPICENG@EPICENGINEERINGPC.COM
Phone (435) 654-6600
Phone (801) 955-5605

The Collins Brothers Well

Wells (1962) summarized the hydrogeology of an oil exploration well located in the SE1/4, SE1/4 of Section 16, Township 5 South, Range 1 West in Utah County. These well reports, along with original geologic cross sections through this well, were supplied to the Utah Geological Survey by Eagle Mountain City during the course of the Hurlow (2004) study. The hydrogeologic significance of this well is manifold: (1) the well encountered groundwater stored in fractured limestones and dolomites; (2) the five principal water bearing zones were encountered at 398 feet, 1,300 feet, 1,500 feet, 2,300 feet, and 2,700 feet – these depths roughly correspond to the top of different rock layers; (3) "...there was an increase in temperature with depth above the normal temperature gradient..."; and (4) "...the water in the lower zone contained less solids...". While it could be argued that the increase in water production in depth was a function of increased submergence of the drill pipe used during direct air circulation while drilling through an water bearing strata as described by Doubek and Beale (1992), the change in water chemistry with depth indicates that the groundwater stored in the various rock layers are hydraulically isolated from shallower and deeper strata. Likewise, the reported increase in water temperature with depth is consistent with hydraulically isolated water bearing units; otherwise, isothermal conditions would be observed in areas where hydraulic communication between aquifers is occurring.

The Eagle Mountain Test Well Drilling Program

Four small diameter test wells were drilled in the Cedar Pass area of Cedar Valley in the late 1990s as part of a groundwater exploration program for Eagle Mountain City. On the basis of the local geology mapped by Moore (1973), coupled with the experience of Well (1962) and exploration and production wells in the different bedrock units in the Tooele and Oakley areas, two wells targeted the Oquirrh Formation, one well targeted the underlying Great Blue Limestone, and one well targeted the limestones in the deeper Humbug Formation. As summarized by Hurlow (2004), groundwater with total dissolved solids (TDS) ranging from 400 to 600 milligrams per liter (mg/l) was developed from the fractured quartzites and limestones of the Oquirrh Formation. The overlying alluvium at both locations targeting the Oquirrh Formation was either nonexistent or dry.

Groundwater developed from the limestones of the Great Blue Limestone yielded groundwater with TDS ranging from approximately 900 to 1,200 mg/l. Approximately 3 gallons per minute of groundwater was encountered in the nearly 200 feet of alluvium encountered at one of the test sites targeting the Great Blue Limestone. The electrical conductivity of the air-lifted water measured at Test Well No. 2 approached 4,400 umhos/cm yielding a calculated TDS approaching 3,000 mg/l. These data also indicate that the overlying alluvium was not in direct hydraulic communication with the underlying bedrock aquifers.

Test Well No. 3 targeted the Humbug Formation at 2,000 feet in depth. The groundwater stored in the Great Blue Limestone at 1,180 feet in depth was sampled before drilling deeper to the Humbug Formation; the TDS of this water approached 1,100 mg/l.

Fax (435) 654-6622
Fax (801) 955-5618
EPICENG@EPICENGINEERINGPC.COM
Phone (435) 654-6600
Phone (801) 955-5605

Groundwater air-lifted from the Humbug Formation encountered at 2,100 feet in depth had TDS approaching 1,200 mg/l with concentrations of sodium, calcium and sulfate that were different than the samples from the Great Blue Limestone. These data are consistent with the observations of differing water chemistries as drilling encountered deeper formations as reported by Wells (1962) for the Collins Brothers well located approximately one mile east of Test Well No. 3.

Geochemistry of Groundwater

Hurlow (2004) plotted the water quality data of the alluvial and bedrock aquifers tapped by wells and springs reported by Feltis (1967), as well as the water quality data from the Eagle Mountain Test Well Drilling Program that was provided by Eagle Mountain City, using a trilinear diagram to "type" the groundwaters in the Cedar Valley area. Figure 1 reproduces the trilinear diagram from Hurlow (2004), along with annotations to explain the data plotted in this figure. Examination of Figure 1 reveals that typical alluvial groundwater depicted by the population surrounded by a solid line are very different than the groundwaters developed by the Eagle Mountain Test Wells depicted by the population surrounded by a dashed line. These data suggest that the alluvial groundwaters are distinct from the groundwater stored in the bedrock aquifers.

A water sample was collected from the Test Well No. 3 by Mayo and Associates for analysis of enriched tritium to evaluate the relative age of the water produced from the well and the relative time required for water to travel from the recharge area to the test well. Tritium (3H) analysis is used to distinguish between water that entered an aquifer prior to 1953 ("pre-bomb water") and water that was in contact with the atmosphere after 1953. Although a small amount of tritium is produced by natural atmospheric processes, a far greater amount of tritium was released by atmospheric testing of thermonuclear weapons between 1953 and 1969. Prior to 1953, rainwater contained approximately 10 TU. Due to the 12.3-year half-life of tritium, pre-bomb groundwater today contains no tritium detectable by normal analytical procedures; post-1953 water contains approximately 50 TU (see Clark and Fritz, 1997).

The reported lack of tritium in the sample suggests that the water developed by Test Well No. 3 recharged the carbonate aquifers prior to 1953. Based on this result, the time-of-travel from the recharge area to the Test Well No. 3 is 44 years or more, substantiating the lack of hydraulic connection with shallow or surface water resources.

Fax (435) 654-6622
Fax (801) 955-5618
EPICENG@EPICENGINEERINGPC.COM
Phone (435) 654-6600
Phone (801) 955-5605

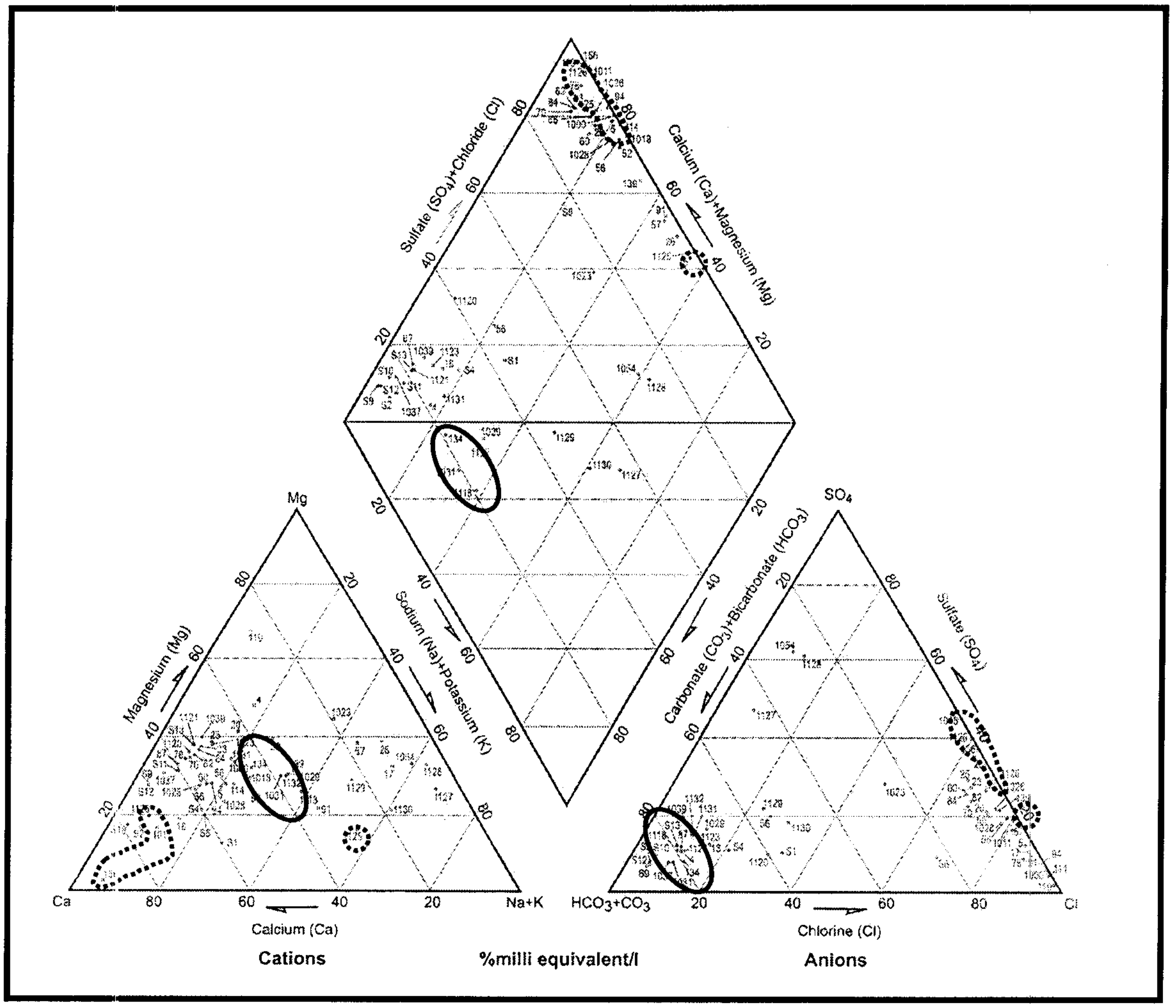

Figure 1. Trilinear diagram of water quality data of the Cedar Valley area. Adapted from Hurlow (2004). Plotted values represent various water sampling locations tabulated in Hurlow (2004). Sample locations nos. 156 = Great Blue Limestone tapped by Test Well No. 3; 1011 = Oquirrh Formation tapped by Test Well No. 1; 1125 = Great Blue Limestone tapped by Test Well No. 2; 1126 = Oquirrh Formation tapped by Test Well No. 4. Sample locations nos. 134, 1018, 1031, and 118 represent typical alluvial groundwater. The populations surrounded by dashed lines represent the bedrock aquifers tapped by the Eagle Mountain Test Well Program. The populations surrounded by the solid line represent a typical alluvial groundwater developed by Eagle Mountain City.

The Cedar Fort Test Well

The Town of Cedar Fort drilled a test well located in the SE1/4, SW1/4 of Section 30, Township 5 South, Range 2 West in 2004 to test the productivity of the Great Blue and Humbug formations in 2004. According to the well driller's report (attached), nearly 235 feet of alluvium at this site was unsaturated; the static water level was reportedly found at 235 feet. Deeper drilling into the limestone rocks encountered highly fractured limestone of the Oquirrh formation. Following drilling nearly 200 feet of black shale, the borehole

Fax (435) 654-6622
Fax (801) 955-5618
EPICENG@EPICENGINEERINGPC.COM
Phone (435) 654-6600
Phone (801) 955-5605

encountered the limestones of the Great Blue Limestone and the well reportedly flowed 200 gallons per minute (gpm). Prior to a flow test lasting 72 hours, the shut-in pressure was measured at 175 psi, indicating that the black shales serve as an effective confining layer between the bedrock aquifers and the overlying alluvium. The controlled flow test reportedly yielded 574 gpm. This well confirmed the observations of Wells (1962) and the conceptual hydrogeologic model derived from the Eagle Mountain Test Well Drilling Program that (1) significant quantities of groundwater are stored in the bedrock aquifers, and (2) the bedrock aquifers are not in direct hydraulic communication with the overlying alluvial aquifers.

CONCLUSIONS AND RECOMMENDATIONS

Feltis's conceptual hydrogeologic model that the Cedar Valley alluvial aquifers and bedrock aquifers constitute a hydraulically connected aquifer system has not withstood the test of time. Test well drilling and production wells drilled into the bedrock aquifers reveal that significant quantities of groundwater remain untapped in the Cedar Valley area. A series of nested wells with at least one shallow well dedicated to the alluvium and a deeper well dedicated to at least one of the deeper bedrock aquifers should be installed in areas of concern to better define the degree of hydraulic communication between the aquifer systems, if any.

Suggestions for further actions by groundwater users in the Cedar Valley area include the following:

- After new wells are equipped and connected to the water systems, the groundwater user should measure and record the shut-in pressure, pumping water level, flow rate, and total volume of the produced water. Monitoring well shut-in pressure, pumping water level, flow rate, and total production will be vital for: (1) trending pumping equipment behavior; (2) assessing the effect of long-term water withdrawals on the aquifer(s); and (3) recording length of time in service for scheduling preventive maintenance or repairs.

- After new wells are equipped and connected to the water systems, the groundwater user should measure and record the specific conductance of the produced water on a semi-annual basis. Monitoring well water specific conductance will be vital for: (1) trending changes in TDS; (2) assessing the effect of long-term water withdrawals on the water quality of the produced water; and (3) modifying the pumping rate, if necessary.

- After new wells are equipped and connected to the water system, the groundwater user should measure and record the tritium concentrations of the produced water on an annual basis. Monitoring well water tritium concentrations will be vital for assessing the effect of long-term water withdrawals on shallow aquifer and surface water capture.

Fax (435) 654-6622
Fax (801) 955-5618

EPICENG@EPICENGINEERINGPC.COM

Phone (435) 654-6600
Phone (801) 955-5605

The appendixes to this report have been attached. We respectfully request your comments and input.

Respectfully,
EPIC ENGINEERING, P.C.

Korey C. Walker, P.E.
Eagle Mountain City Engineer

CC: Jerry Kinghorn – Eagle Mountain City Attorney
Mayor Bailey – Eagle Mountain City Mayor
Mark Sovine – Eagle Mountain City Public Works Director
Chris Hillman – Eagle Mountain City Administrator

Attachments: References Cited (1 page)
Well Driller's Report (1 page)
Well Driller's Report Additional Data Form (2 pages)

Fax (435) 654-6622
Fax (801) 955-5618
EPICENG@EPICENGINEERINGPC.COM
Phone (435) 654-6600
Phone (801) 955-5605

REFERENCES CITED

Clark, I.D. and P. Fritz, 1997, Environmental Isotopes in Hydrogeology: Lewis Publishers, New York, 328 pp.

Doubek, G.R., and G. Beale, 1992, Groundwater Characteristics using Dual Tube Reverse Circulation Drilling: Society for Mining, Metallurgy, and Exploration, Inc. Pre-Print 92-133.

Feltis, R. D., 1967, Ground-Water Conditions in Cedar Valley, Utah County, Utah: prepared by U. S. Geological Survey in cooperation with The Utah State Engineer, Tech. Pub. No. 16.

Hurlow, H.A., 2004, The Geology of Cedar Valley, Utah County, Utah, and its relation to ground-water conditions: Utah Geological Survey Special Study 109.

Moore, W.J., 1973, Preliminary geologic map off western Traverse Mountains and northern Lake Mountains, Salt Lake and Utah Counties, Utah. U.S. Geol. Survey Miscellaneous Field Studies Map, MF-490

Wells, L.F., 1962, A geological report on Collins Brothers Oil Co. Ward Well No. 1: Consultant's report prepared for the Collins Brothers, 8 pp. with water quality data and geophysical logs.

Fax (435) 654-6622
Fax (801) 955-5618

EPICENG@EPICENGINEERINGPC.COM

Phone (435) 654-6600
Phone (801) 955-5605

RECEIVED
AUG 1 2 2004
WATER RIGHTS
~~SALT LAKE~~

WELL DRILLER'S REPORT

State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification

Non-Production Well: 0354605M00 WIN: 29442

Owner *Note any changes*

CEDAR FORT TOWN
2825 EAST COTTONWOOD PKWY
SALT LAKE CITY, UT 84121

Contact Person/Engineer: ____

Well Location *Note any changes*

N 8 7 E 3077 from the SW corner of section 30, Township 5S, Range 2W, SL B&M

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #)

Drillers Activity Start Date: 5 - 31 - 04 Completion Date: 7 - 16 - 04

Check all that apply: ☒ New ☐ Repair ☐ Deepen ☐ Clean ☐ Replace ☐ Public Nature of Use: ____

If a replacement well, provide location of new well. ____ feet north/south and ____ feet east/west of the existing well.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	320	12.75	DR Air	Foam
320	836	12	DR Rotary tri-cone	mud
836	1280	8"	Rotary tri-cone	mud

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE High	PERMEABLE Low	CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	ROCK TYPE	COLOR	DESCRIPTION AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition density, plasticity, shape, cementation, consistancy, water bearing, ordor, fracturing, minerology, texture, degree of weathering, hardness, water quality, etc.)
0	235					✓	✓	✓	✓	✓		Limestone, Quartzite, Volcanic	Brown	silty sand
235	241				✓	✓							Red	
241	251							✓						
251	296				✓			✓						
296	370										✓	Volcanics	Gray to Red	
370	402				✓	✓					✓	Limestone & volcanics		Very Broken, Silty Clay matrix
402	455										✓	Limestone	Gray to tan	Clay in fractures
455	480				✓						✓	Limestone		50% clay
480	628										✓	Limestone	Gray + tan	silty clay in fractures Brown [illegible]
628	641										✓	Limestone	Dark Gray	hard and Broken

Static Water Level

Date 7/16/04 Water Level N/A feet Flowing? ☑ Yes ☐ No

Method of Water Level Measurement ____ If Flowing, Capped Pressure 175 PSI

Point to Which Water Level Measurement was Referenced ____ Elevation ____

Height of Water Level reference point above ground surface ____ feet Temperature ____ degrees ☐C ☐F

Well Log

S:\PROJ\Eagle Mountain\WTR-General\Hydrology\Cedar Valley Hydro.doc

WELL DRILLER'S REPORT ADDTIONAL DATA FORM

State of Utah
Division of Water Rights

Page ____ of ____

Well Identification

Non-Production Well: 0354605M00

Owner *Note any changes*

CEDAR FORT TOWN
2825 EAST COTTONWOOD PKWY
SALT LAKE CITY, UT 84121

Contact Person/Engineer: ____________________

Well Location *Note any changes*

N 877 E 3077 from the SW corner of section 30, Township 5S, Range 2W, SL B&M

Location Description: (address, proximity to buildings, landmarks, ground elevation,local well #)

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE High	PERMEABLE Low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTION AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition density, plasticity, shape, cementation, consistancy, water bearing, ordor, fracturing, minerology, texture,degree of weathering, hardness, water quality, etc.)
641	660										✓	Limstone		silt in fracturing Broken
660	720										✓	Limestone		silty clay in fractures SWL 236 BGS
720	735										✓	Limstone Volcanics		
735	790	✓	✓									Shalen	Black	manning canyon Shale
790	830										✓	Shale	Black	Sticky
830	945	✓	✓								✓	Shale Limestone	Black	water Flowing aprox 200 gpm @ 945
945	1280	✓	✓								✓	Limestone	Gray to Black	

Well Log

Fax (435) 654-6622
Fax (801) 955-5618

EPICENG@EPICENGINEERINGPC.COM

Phone (435) 654-6600
Phone (801) 955-5605

Construction Information

DEPTH (feet) FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	DEPTH (feet) FROM	TO	SCREEN SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF
0	320	A53 B Steel	3"	12	818	1280	1/8"	3"	4620
+1.5	836	A53 B Steel		8"					
798	818	A53B Steel	.250	6"					
818	1280	A53B Steel perf	.250	6					
796	797	K Packer	.250	6					

☐SCREEN ☑PERFORATIONS ☐OPEN BOTTOM

Well Head Configuration: Valve (Flanged) Capped with Pressure Gauge Access Port Provided? ☐Yes ☑No

Casing Joint Type: welded Perforator Used: factory mill slot

Was a Surface Seal Installed? ☑Yes ☐No Depth of Surface Seal: 836 feet Drive Shoe? ☐Yes ☑No

Surface Seal Material Placement Method: Pump Down Between 12 and 8" flow up inside of 8" casing

DEPTH (feet) FROM	TO	SURFACE SEAL / INTERVAL SEAL / FILTER PACK / PACKER INFORMATION — SEAL MATERIAL, FILTER PACK and PACKER TYPE and DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal., # bag mix, gal./sack etc.)
0	836	50/50 Sand & Cement	13 yards	18.6 lbs/gal

Well Development and Well Yield Test Information

DATE	METHOD	YIELD	Units GPM	Units CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
7/12/04	Flow from 8" Discharge	574	✓		n/A	72 hrs

Pump (Permanent)

Pump Description: ______ Horsepower: ______ Pump Intake Depth: ______ feet

Approximate Maximum Pumping Rate: ______ Well Disinfected upon Completion? ☐Yes ☑No

Comments Description of construction activity, additional materials used, problems encountered, extraordinary Circumstances, abandonment procedures. *Use additional well data form for more space.*

(Did not Disinfect well flowing) K-packer on 6" Casing @ 796'

Well Driller Statement This well was drilled and constructed under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name ZIMMERMAN, MIKE WELL SERVICE LLC License No. 747

Signature [signature] Date 8/10/04

S:\PROJ\Eagle Mountain\WTR-General\Hydrology\Cedar Valley Hydro.doc