June 11, 2008

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, WY 82002

ATTN: Chris Abernathy, Project Manager

RE: Star Valley Ranch Groundwater Level II Study – Test Borings Results

Dear Mr. Abernathy:

Thomas Drilling has recently completed the drilling, logging, and plugging of the three test borings. This letter provides a summary of the findings of the test boring program, criteria for aiding in deciding which site to select for exploration well drilling, and recommendations.

WELL SITING CRITERIA

As part of the Star Valley Ranch Level I Water Supply Study, Weston Engineering, Inc. (WESTON) prepared a well siting study that identified four test well sites. The sites were identified using a number of criteria, including geologic setting, water quality, potential for interference, and wellhead protection, as well as other criteria. The geologic setting is the most important criteria for successfully locating an exploration well site and our understanding of the setting has been significantly increased as a result of the test boring program. The geologic setting will be discussed in the individual test boring site discussions. The following sections summarize applicable well siting criteria as they apply to selection of an exploration well site for this project.

Land Ownership and Access

Land ownership is important to the selection of a potential well site because of access issues. An access agreement and right-of-way agreement must be established for a well site and transmission conveyance on privately owned properties. Preference should be given for well sites on properties owned by Star Valley Ranch or whose landowners are willing to work favorably with the Town of Star Valley Ranch (TSVR) and the Wyoming Water Development Commission (WWDC). Additionally, consideration must be given to physical constraints that may limit the ability to move equipment onto a site and to potential costs that may be incurred to prepare a site for drilling activities.

Water Quality

When considering target aquifers, the quality of the water from the aquifers must be compared to the intended uses. A public water supply source well must yield water that meets the primary drinking water standards and should also exceed the secondary standards, as established by the U.S. Environmental Protection Agency (EPA). Although the existence of water quality data for each of the EPA regulated constituents are rare for many aquifers in Wyoming, the total dissolved solids (TDS) concentration is one water quality parameter that is regulated by the EPA that can serve as an indicator of overall water quality and is a commonly measured constituent. The EPA primary drinking water standard for TDS for public water systems is 500 milligrams per liter (mg/L), with a secondary standard of 1,000 mg/L for water systems that cannot obtain better quality water. In most aquifers, the longer the residence time of the groundwater the poorer the

water quality. This trend is the result of the groundwater dissolving constituents of the rock it is passing though. Generally, the closer the point of withdrawal or well is to the recharge area, the lower the TDS. Water quality data are available for a number of wells in the study area. In general, the water quality from wells completed in the study area is good and appears to meet all the requirements of the EPA for a public water supply source.

Because the SVR community currently utilizes individual septic systems for wastewater disposal, there is some concern that wells located downgradient of the community may be at risk of being contaminated from the wastewater effluent. However, none of the deeper wells completed in the Salt Lake Formation or underlying Paleozoic limestones indicate the presence of elevated levels of nitrates, which would be expected in the water from the wells if they were influenced by septic waste. Nevertheless, if a potential well site is selected west of the SVR community, the potential for influence from septic effluent can be addressed by drilling deeper wells that are sufficiently sealed from shallow groundwater.

Water quality in the Paleozoic aquifer system is excellent as indicated by the water quality reports for the springs. A well completed in the Paleozoic Aquifer System should eliminate concern regarding influence from surface water that is a concern with the springs.

Proximity to Existing Infrastructure

Because a successful well will have to be tied into the TSVR water system, locating the well near existing or proposed storage tanks will reduce the cost of connecting the well to the system. With all other factors being equal, preference should be given to the site that is closest to current or proposed infrastructure. The northern part of the system has the potential to experience water shortages more frequently than the southern part of the system. Additionally, the differences in elevation across the town result in six different pressure zones. The approximate locations of the six pressure zones are presented on Figure 1. The pressure zones to the north have higher pressures while the zones to the south have lower pressures. Water can be transferred by gravity from the north, but installation of transfer pumps will be required to move water from the south to the north.

It is preferable to tie a well into a water storage tank to provide more even system pressures, prevent hammer to distribution lines, provide for consistent pump operational cycles, and to facilitate isolation of the system in the event of contamination. Because the TSVR is facing the potential for significant changes to the water transmission and distribution systems and the costs associated with these changes, WESTON recommends that a well at any of the three sites under consideration be tied into the system at the nearest 6- or 8-inch PVC pipeline. Connecting to the nearest 6- or 8-inch PVC pipeline will minimize the potential for head losses and will minimize costs for connecting the well. In the future plans should be made to connect the well directly to a water storage tank.

Additional consideration must be given to the distance to 3-phase power service. The initial infrastructure investment for electrical service can be significant. Furthermore, longer service lines increase the potential for interruptions in the event of foul weather.

Well and Spring Interference Issues

It is WESTON's goal to identify a site that will minimize the possibility for impacts to surface water resources and to the existing area wells. Locating new wells at a distance from existing wells or completing a new well across different geologic intervals will minimize the potential for interference. Trihydro (1993) observed water levels in an irrigation well located approximately 1,860 feet from the Freedom Well No. 2. Both of the wells are completed in the Salt Lake Formation. When the Freedom Well No. 2 was pump tested at a rate of 650 gpm for 8 days, the maximum drawdown observed in the irrigation well was 0.85 feet. These results indicate that the potential for interference in the Salt Lake Formation will be minimal unless wells are in close

proximity to one another. No data are available to indicate the potential for interference between wells completed in the Madison Limestone, but few wells are completed in this geologic unit.

Wellhead Protection Concerns

The Wyoming Wellhead Protection Program Guidance Document, Version 3.0 (Wyoming Department of Environmental Quality – Water Quality Division, 1997) recommends considering potential sources of contamination when siting new municipal wells. For this study the areas around each of the three sites were visited or reviewed from aerial photographs to determine potential contaminant sources in the vicinity of the wells. The most likely source of potential contamination to the Salt Lake Aquifer is effluent from individual septic systems. In order to alleviate any potential for contamination of the aquifer, the well will be designed to minimize the potential for contamination.

Site Specific Concerns

Because each well site is unique there may be site-specific issues that do not conform with the other well siting criteria. These issues are identified and evaluated on a site-by-site basis.

GEOLOGIC SETTING

The three test borings drilled at the Town of Star Valley Ranch were completed at the locations indicated on Figure 1. The sites were chosen from a desire to investigate the subsurface formations and potential to develop groundwater at wide-ranging locations within the Town and the ability to negotiate access with property owners. The locations of the test borings are provided on Figure 1.

Each of the three test borings were advanced to a depth of approximately 750 feet, the lithlogic samples from drill cuttings were described by the on-site geologist, and geophysical logs were run on each borehole. The test borings were plugged and abandoned after the geophysical logs were run. Table 1 provides data for each of the three boreholes.

The Wyoming Department of Environmental Quality – Water Quality Division (DEQ) and the State Engineers Office prohibit completing production wells (including exploration wells that have the potential to be used as production wells) across more than one aquifer. This results in the need to clearly define the boundaries between the aquifers, which are the saturated parts of formations. The lithologic and geophysical logs were used to determine the contacts between the units penetrated by the test borings.

Quaternary alluvial materials, the underlying Tertiary Salt Lake Formation, and the Paleozoic limestones beneath the Salt Lake Formation were encountered in all three test borings. The alluvial materials are between 92 and 142 feet thick at the three sites. The contact between the alluvium and the Salt Lake Formation is set at the first yellowish-orange clay. The contact is observed both in the drill cuttings and as an elevated gamma ray response on the geophysical logs. The saturated permeable deposits in the Salt Lake Formation are composed of variably cemented conglomerates. Minor claystone lenses in the Salt Lake Formation are impermeable. The Salt Lake Formation has a variable geophysical response in all three of the test borings, with the permeable deposits having low gamma ray (left trend), low spontaneous potential (left trend), and high resisitivity (right trend). The Salt Lake Formation is between 230 and 392 feet thick at the three sites.

The Paleozoic formation beneath the Salt Lake Formation is interpreted by WESTON as the Madison Limestone. At Star Valley Ranch the Madison Limestone is comprised of limestone with siltstone and claystone. The limestone intervals are indicated on the geophysical logs by low gamma ray, low spontaneous potential, high resistivity, and high density. Low density signals across limestone intervals may indicate fractures or voids. The claystone and siltstone intervals

have a geophysical signal characterized by high gamma, high spontaneous potential, low density, and low resistivity.

TABLE 1
TEST BORING SUMMARY

	SITE 1	**SITE 2**	**SITE 3**
Location	SE NE Sec 6, T34N, R118W	NW NW Sec 31, T35N, R118W	SE SW Sec 30, T35N, R118W
Site Ownership	Bureau of Land Management	Star Valley Ranch Association	Izatt
Production Potential	Very Good	Moderate	Questionable
Total Depth	753 feet	753 feet	755 feet
Alluvium	0 – 100 feet	0 – 142 feet	0 – 92 feet
Salt Lake Fm.	100 – 492 feet	142 – 372 feet	92 - 406 feet
Madison Limestone	492 - 753 feet	372 - 753 feet	406 - 755 feet
Static Water Level	190 feet	175 feet^	200 - 270 feet
Target Formation	Salt Lake Fm.	Madison Limestone	Salt Lake Fm.
Well Design	Screens 340 – 480 feet	Screens 375 – 405 feet 418 – 433 feet Open Hole 450 – 520 feet	Screens 272 – 312 feet 320 – 335 feet
Est. Well Cost	$256,050	$231,650	-
Access Potential	Ready	Negotiate with SVRA	Negotiate with Izatt
Interference Potential	Low	Moderate – Airstrip Well	Low- Freedom No. 2 Hokanson Well
Pressure Zone	Zone 1	Zone 2	Zone 4
Distance to Pipeline	220 feet to 6-inch PVC line on Hardman Road 1,600 feet to Zone 2	200 feet to 8-inch PVC line on Vista Drive	3,670 feet to 6-inch PVC line at N. Forest Drive and Muddy String Road
Distance to 3 Phase Power	7,500 feet	200 feet	1,800 feet $7,000

^Estimated from Airstrip No. 1

Test Boring Results

The contacts between the geologic formations penetrated by the three test borings are presented in Table 1. Based on the geophysical logs, lithologic logs, and drilling characteristics, it is WESTON's opinion that the best target aquifer at Sites 1 and 3 is the Salt Lake Formation, while the best target aquifer at Site 2 is the Madison Limestone. The following sections provide a summary of our findings for each site.

Site 1. The production potential from the Salt Lake Formation at Site 1 is estimated to be very good based on indications from the geophysical log and a brief airlifting test. The airlifting test suggested that the test boring could yield over 200 gallons per minute (gpm) with little to no drawdown. Analysis of the airlifting test is complicated by the fact that the entire borehole was open during airlifting and some water may have been contributed by the Madison Limestone. Thomas Drilling staff indicated that the geology of the materials penetrated by the test boring is similar to those found at highly prolific well sites in the Thayne area.

WESTON's review of the lithologic and geophysical logs from the test boring at Site 1 indicates that the Salt Lake Aquifer could yield large quantities of water to well if screens are installed from depths of 340 to 480 feet. The anticipated static water level in a well at Site 1 is 190 feet, which

was measured during drilling of the test boring. A preliminary well design diagram for an exploration well at Site 1 is provided on Figure 2. A cost estimate for drilling, constructing, developing, and testing an exploration well at Site 1 is provided in Table 2.

The potential for a new well at Site 1 interfering with existing water wells is estimated to be low. The nearest well to Site 1 that is completed across the same interval is over 4,500 feet away. This distance, coupled with the high tranmissivity of the Salt Lake Aquifer makes the potential for interference very low.

Site 1 is located in the lowest pressure zone in the SVR water system. This limits the potential for having water from the well serve the majority of the Town without running a dedicated transmission line to tie the well into a pipeline or tank in the northern part of the Town. A pipeline from Site 1 to the Prater Canyon Tank would be prohibitively expensive at the present time. Connecting a well at Site 1 into an 8-inch PVC pipeline Zone 2 would require installation of approximately 1,600 feet of new transmission line. Connecting a well at Site 1 with Zone 2 would significantly increase the number of homes that could be served by the well.

The nearest 3-phase power to Site 1 is approximately 7,500 feet away and it is estimated that the cost for bringing 3-phase service to the site will be approximately $28,500.

Site 2. The production potential from the Madison Limestone at Site 2 is estimated to be good based on indications from the geophysical log and the yield of the Airstrip No. 1 well. The Airstrip No. 1 well was pump tested at a rate of up to 690 gpm and had a drawdown of only 14 feet. The well cannot be pumped at a rate of more than 300 gpm because of the casing diameter limits the size of the pumping equipment. It is anticipated that a well drilled at Site 2 could have similar production capacity and with a 10 ¾-inch pump chamber could have a yield that is greater than the Airstrip No. 1 well.

WESTON's review of the lithologic and geophysical logs from the test boring at Site 2 indicates that the Madison Limestone could yield large quantities of water to well if the well is constructed as shown of Figure 3. The preliminary well design on Figure 3 includes stainless steel screens across limestone intervals that are believed to yield water, with shale baskets above and below each screened interval to prevent plugging of the screens from clays. The bottom of the well would have an open-hole completion across a limestone interval. The anticipated static water level in a well at Site 1 is approximately 175 feet, which is estimated from the Airstrip No. 1 well. A cost estimate for drilling, constructing, developing, and testing an exploration well at Site 2 is provided in Table 3.

The potential for a new well at Site 2 interfering with the Airstrip No. 1 well is moderate; however, the degree of interference is expected allow both wells to pump simultaneously and increase the overall water supply source capacity. It is not expected that a well at Site 2 will interfere with other area wells.

Site 2 is located in the Zone 2 pressure system. This limits the potential for having water from the well serve the majority of the Town without running a dedicated transmission line to tie the well into a pipeline or tank in the northern part of the Town. A pipeline from Site 2 to the Prater Canyon Tank would be prohibitively expensive at the present time. Connecting a well at Site 2 into an 8-inch PVC pipeline Zone 2 would require installation of as little as 200 feet of transmission line. The well could be directly connected to a water storage tank at a later date.

The nearest 3-phase power to Site 2 is located at the Airstrip No. 1 well, which is less than 200 feet from Site 2.

Site 3. The test boring at Site 3 penetrated the Salt Lake Formation between 92 and 406 feet. The first indication of water in the test boring was observed at a depth of 270 feet. A review of data from the domestic wells in the area reveals that static water levels in the area range from 343 to 460 feet below the ground surface. It appears that the static water level in the Salt Lake Formation could be as deep as 270 feet.

WESTON's review of the lithologic and geophysical logs from the test boring at Site 3 indicates permeable deposits in the Salt Lake Formation between 272 and 312 feet and between 320 and 335 feet could yield water to a well. However, the geophysical logs suggest that a well at Site 3 will not be as productive as a well at Site 1. Additionally, the apparently deep static water level could result in dewatering of the permeable interval between 272 and 312 feet. Drilling fluid losses were observed by the driller at 420 and 545 feet in the Madison Limestone, but there is no indication that the Madison Limestone will yield large quantities of water to a well at Site 3.

The lack of permeable materials and apparent deep static water level at Site 3 result in a recommendation that an exploration well not be considered by the WWDC and Town of Star Valley Ranch at that location.

CONCLUSIONS AND RECOMMENDATIONS

A new well at either Site 1 or Site 2 has the potential to increase the water supply source capacity of the Town of Star Valley Ranch. Site 1 appears to have very good potential for yielding large quantities of water, but without significant investment in transmission lines cannot serve a large part of the water system. Site 2 has good potential for development of a new water supply well and is located near 3-phase power and an 8-inch PVC transmission line.

If the Town of Star Valley Ranch wishes to maximize the production potential, then it is WESTON's opinion that a well should be drilled at Site 1; however, connecting a well at Site 1 could be more costly than connecting a well at Site 2. It is likely that adding one additional well to the Town's water system will not solve the long-term water supply problems and that funding should be pursued to drill and complete a well at the site not selected for this project.

WESTON will complete plans and specifications for a new exploration well at the site selected by the WWDC and the Town of Star Valley Ranch. We will work diligently in an effort to complete all the permitting and bidding so that the project can be completed in a timely fashion. If you have any questions or comments regarding this letter please feel free to call me.

Respectfully Submitted,

Ben J. Jordan, P.G.

Cc: Town of Star Valley Ranch
Jerry Hunt, P.E.
Clarence Kemp, P.E.

REFERENCES CITED

TriHydro, Inc., 1993, Freedom No. 2 Test Well Construction and Testing Report: Consultant's Report prepared for Forsgren and Associates for submittal to the Wyoming Water Development Commission.