A Look at Johnson's Up-On-Top

Introduction

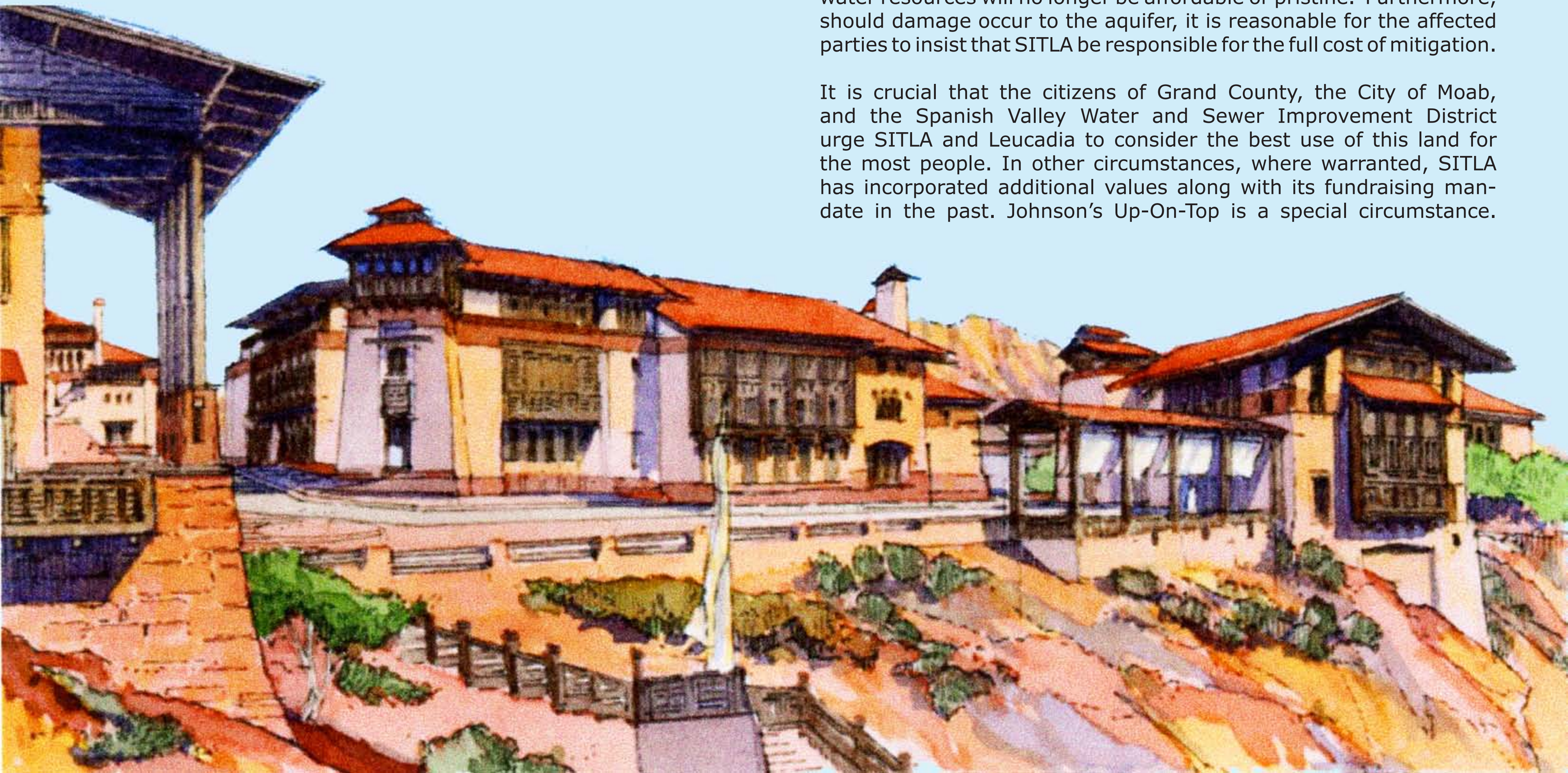
The scenic landscape we know as Johnson's Up-On-Top ("Johnson's") was once part of the Public Domain. Through exchanges that take place when Congress establishes a national monument, park, or recreation area, Johnson's was transferred to the State of Utah, specifically, the School and Institutional Trust Lands Administration (SITLA), which now acts as its trustee.

Johnson's Up-On-Top has many superlative qualities that are attractive to developers and buyers of real estate—hence the current development proposal by Leucadia National Corporation called Cloudrock. However, its most valuable attribute is the role it plays in the water we drink. Eighty percent of the drinking water for Moab and Spanish Valley residents and businesses is produced from springs and wells at the base of Johnson's. Although SITLA may own the land rights to Johnson's, the water rights beneath belong to us all. As you will read, the unique characteristics of the landscape that provides our abundant and cheap water makes development of Johnson's Up-On-Top an extreme and unnecessary risk for our community.

The groundwater that passes underneath Johnson's is "pristine and irreplaceable," a designation given by the Utah Division of Water Quality. The trustees of SITLA and Leucadia are aware of this designation. They also understand that if water pollution occurs (deliberately or accidentally), the risk of bringing harm to the residents and businesses in Moab and Spanish Valley is highly probable.

It is important that Grand County's citizens, Leucadia and SITLA clearly understand that if this water becomes damaged, our culinary water resources will no longer be affordable or pristine. Furthermore, should damage occur to the aquifer, it is reasonable for the affected parties to insist that SITLA be responsible for the full cost of mitigation.

It is crucial that the citizens of Grand County, the City of Moab, and the Spanish Valley Water and Sewer Improvement District urge SITLA and Leucadia to consider the best use of this land for the most people. In other circumstances, where warranted, SITLA has incorporated additional values along with its fundraising mandate in the past. Johnson's Up-On-Top is a special circumstance.



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Illustrations

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This booklet is available on the World Wide Web at:
http://www.livingrivers.org/pdfs/Johnsons.pdf

Reference materials are available at:
http://www.livingrivers.org/archives/article.cfm?NewsID=791

Summary

The Glen Canyon aquifer provides most of the drinking water for Moab and Spanish Valley residents and businesses. Nearly eighty percent of this drinking water is produced from springs and wells at the base of Johnson's Up-On-Top. This groundwater passes underneath Johnson's, flowing generally toward the west.

The groundwater comes from precipitation falling on the land between the peaks of the La Sal Mountains and the eastern escarpment of Moab-Spanish Valley and infiltrating into the underlying bedrock.

This aquifer has one of the highest transmissivity values of the bedrock units that underlie the Colorado Plateau, meaning water moves through the rock very quickly. Where these rocks are pervasively fractured, as is especially the case at Johnson's, the rate that fluids can pass through fractured sandstones can be as high as 88 feet per day. This is significant, because any other liquids spilled or leaking from a cracked underground pipe would pass through to the aquifer just as quickly, causing contamination.

In 2002, the aquifer was designated by the U.S. Environmental Protection Agency (EPA) to be the "sole source of drinking water for approximately 6,000 permanent residents within the City of Moab."

In 2005, the Utah Division of Water Quality (DWQ) classified the service area of this aquifer as Class 1a (pristine water) and Class 1b (irreplaceable water). The service area includes Johnson's.

It is worth noting that neither Spanish Valley Water and Sewer Improvement District nor Grand County have sought a designation from EPA for its water supply.

The EPA designation also states that "there is no unappropriated alternative drinking water source or combination of sources which could provide fifty percent or more of the drinking water to the designated area (Moab) nor is there any projected future alternative source capable of supplying the area's drinking water needs at an economical cost." *Federal Register,* Vol. 67, No 4, January 7, 2002, p. 737. **Online:** http://www.epa.gov/fedrgstr/EPA-WATER/2002/January/Day-07/w297.htm

The geologic setting of Moab is unique to the United States. Land use and building standards developed from experience in other areas, and codified for general use throughout the country, may not afford adequate protection for the specific problems that might arise as a result of developing Johnson's-Up-On-Top.

It is vital that SITLA, Leucadia, County, City, and Improvement District, demonstrate leadership in protecting our water resources and eliminate any and all risks to our pristine water supplies. Otherwise, the affordable water that we now enjoy with abundance could become scarce and expensive.

Moab's Glen Canyon Aquifer

The Setting

Geologically speaking, the Moab-Spanish Valley area of Grand County, Utah, is a very unusual place. Indeed, it is different from all other liveable places in the United States, because it is located along the crest of a collapsed salt anticline and surrounded by steep walls of bedrock that have very complex fault zones.

These walls of bedrock are mostly sandstones of the Glen Canyon Group (Navajo Sandstone, Kayenta Formation, and Wingate Sandstone). On most of the Colorado Plateau, these sandstones are impressively massive and generally uniform in structure. Contrarily, these same sandstones surrounding Moab (especially at Johnson's) have been severely fractured by the underground movement of salt and gypsum deposits, and the subsurface intrusion of igneous rocks that formed the La Sal Mountains.

Photo: Fractured Navajo Sandstone at Johnson's Up-On-Top.
Courtesy of John C. Dohrenwend.

This fracturing provides a useful conduit for the natural flow of reliable and pristine groundwater supplied to Moab and Spanish Valley, and explains why the springs flow so abundantly at the base of Johnson's. To have this gift of water in a harsh desert environment is truly remarkable.

Nearly eighty percent of the groundwater supplies for Moab and Spanish Valley flow through the sandstones underneath Johnson's. This flow of groundwater is intercepted by springs and wells at the base of Johnson's. The wells and springs are owned by the City of Moab, the Spanish Valley Water and Sewer Improvement District, and by private citizens.

Unfortunately, this fracturing can also serve as a major conduit for introducing pollution, whether accidental or intentional, from the land surface along the northeast margin of the valley. It is possible that residential and business activities at Johnson's could permanently pollute our clean water resources.

Photo: Aerial photo mosiac showing the fractured Navajo Sandstone surrounding Moab and Spanish Valley. National Agriculture Imagery Program.

Facts About Water Flow through Our Aquifer

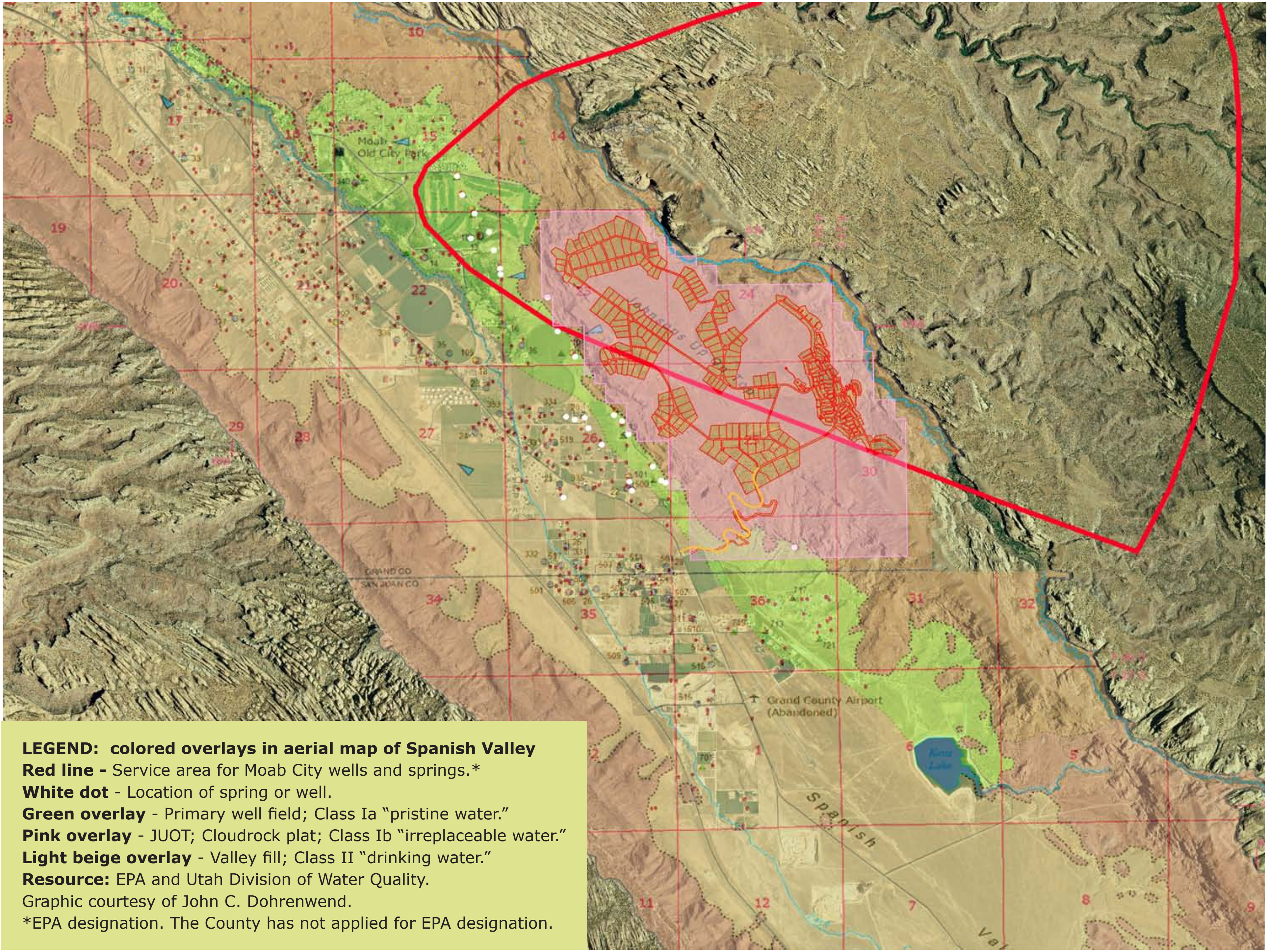
• The sandstones of the Glen Canyon Group on the Colorado Plateau are capable of transmitting large quantities of groundwater.

• The presence of pervasive fractures is the most important factor controlling the ability of the Glen Canyon aquifer to transmit water; the rate of recharge to the Glen Canyon aquifer is much higher where the sandstones are fractured and jointed. Fracturing provides primary control on aquifer characteristics of the Glen Canyon Group, altering hydraulic conductivity and effective porosity by several orders of magnitude.

• Hydraulic conductivity estimates derived from unfractured core samples range from 0.0037 to 5.1 feet/day, and values calculated from aquifer tests in Utah, Arizona, and Colorado are most commonly between 0.1 and 1 feet/day. However, based on oil well data, the hydraulic conductivity of an open 0.001 inch-wide fracture was calculated to be 132 ft/day.

• Bedrock cut by pervasive joint zones and other fractures may be, by several orders of magnitude, more permeable than unfractured bedrock (parallel to the predominant trend of the fractures).

• Wells completed in the Glen Canyon Group along the eastern margin of Moab-Spanish Valley intersecting joint zones are likely to have greatly increased hydraulic conductivity oriented northwest-southeast.



LEGEND: colored overlays in aerial map of Spanish Valley
Red line - Service area for Moab City wells and springs.*
White dot - Location of spring or well.
Green overlay - Primary well field; Class Ia "pristine water."
Pink overlay - JUOT; Cloudrock plat; Class Ib "irreplaceable water."
Light beige overlay - Valley fill; Class II "drinking water."
Resource: EPA and Utah Division of Water Quality.
Graphic courtesy of John C. Dohrenwend.
*EPA designation. The County has not applied for EPA designation.

What We Know About Our Water

• In 2005, the Utah Department of Environmental Quality/Division of Water Quality rated our Glen Canyon aquifer as Class 1a (pristine water) and Class 1b (irreplaceable water). **Online:** http://www.waterquality.utah.gov/images/maps/spanish_gwq.pdf

• In 2002, the Glen Canyon aquifer was designated by the EPA to be the "sole source of drinking water for approximately 6,000 permanent residents within the City of Moab."

• The EPA designation considers those areas where the aquifer is exposed at the surface to be "moderately to very vulnerable to possible contamination."

• The EPA designation also states that "there is no unappropriated alternative drinking water source or combination of sources which could provide fifty percent or more of the drinking water to the designated area (Moab) nor is there any projected future alternative source capable of supplying the area's drinking water needs at an economical cost." *Federal Register*, Vol. 67, No 4, January 7, 2002, p. 737. **Online:** http://www.epa.gov/fedrgstr/EPA-WATER/2002/January/Day-07/w297.htm

• To state it more clearly, the water in the Glen Canyon aquifer along the northeast side of Moab-Spanish Valley is ours and is relatively cheap. Other possible sources must be shared and would be expensive.

Groundwater Analysis to Date

Mathematical modeling of groundwater is based on assumptions of homogeneous, isotropic media. However, groundwater flow in the unsaturated zone is much more complex, and groundwater flow in pervasively fractured rocks is also very complex. Because of these complexities, estimating the rate of flow in the unsaturated zone of pervasively fractured rocks is very general at best. Therefore, we have only a rudimentary understanding of the potential risks of large-scale developments located in the recharge areas of the Glen Canyon aquifer in the Moab area.

While considerable knowledge concerning the hydrogeology of Grand County has been acquired in the last four decades, the Glen Canyon aquifer has not been comprehensively studied in the Moab area. Most of the studies that have been cited/referenced are either dated (up to 60 years old); very general and regional (the entire Colorado Plateau); or are extrapolations from studies in other regions. Most of the local studies have drawn heavily on these older regional reports.

Despite these limitations, we know that the Glen Canyon aquifer is a unique, complex water system that is vulnerable to possible contamination. It would be wise to have comprehensive knowledge about this system prior to taking any actions that might compromise it.

Congress has recently authorized funds to conduct a comprehensive hydrological study of Moab-Spanish Valley to specifically aid local government planning. Including the northeast escarpments of Moab-Spanish Valley in this study would answer many questions about the source and quality of the water, as well as the quantity.

The Solomon Report

There have been public misconceptions regarding the "Reconnaissance Study of Age and Recharge Temperature of Groundwater Near Moab, Utah," by Dr. Kip Solomon in 2001. The Solomon study was intended to better define the general nature of the groundwater flow system. Solomon notes that his investigation was a reconnaissance study that consisted of a very small number of samples that were analyzed for only a selected number of parameters. Although the analyses appears to be internally consistent, it is not possible to evaluate how representative the results are for the entire system.

Dr. Solomon concludes that most of the water he sampled, from the wells and springs along the northeast margin of Moab-Spanish Valley, is older than 40 years and derived from recharge at elevations between 6,500 and 8,200 feet along the northwest slope of the La Sal's (South Mesa). However, it is mixed with water that is much younger and derived from recharge in closer proximity to the Moab Valley (for example, Johnson's Up-On-Top).

While the study was not focused on evaluating the vulnerability of the groundwater system to contamination from other sources, the fact that older water and younger water is found mixed in this small sampling indicates that pollution in the recharge zone of the younger water would lead to contamination of the older water as well. The Solomon study does in fact suggest that: (a) the Glen Canyon aquifer is irreplaceable; and (b) that contamination from local sources is possible.

Other Water Studies

A brief summary of other hydrogeologic studies conducted between 1962 and 2007, is provided here. See also the summary compiled by Lowe, et al. (2007) and referenced at the end of this publication.

Jobin, 1962: "The Navajo sandstone, because it is uniformly thick and well sorted, has the largest transmissive capacity of all the hydrologic units of the Colorado Plateau." (Ref. 6, pg. 42.)

Blanchard, 1990: "The rate of recharge to the Navajo aquifer probably is much larger where the formation is fractured or jointed." (Ref. 1, pg. 40.)

"Recharge is enhanced where the depressions in the surface of the Navajo Sandstone contain thick, unconsolidated deposits. The deposits typically are erosional products of the formations of the Glen Canyon Group, are sandy, and are capable of holding water in storage for infiltration into the Navajo Sandstone." (Ref. 1, pg. 40.)

Eisinger and Lowe, 1999: "Secondary permeability due to fractures is still the most important factor controlling the ability of the formation to yield water. The hydraulic conductivity derived from unfractured core samples of the Navajo in Emery County ranges from 0.0037 to 5.1 feet/day. Based on oil well data, Hood and Patterson (1984) calculated that the hydraulic conductivity of an open 0.001 inch-wide fracture would be 132 ft/day. However, such a calculation overestimates the ability of a fractured rock aquifer to yield water. The highest hydraulic conductivity calculated by Freethey and Cordy (1991), from aquifer tests, was 88 feet/day for a 44 foot interval of fractured Navajo sandstone ... ." (Ref. 2, pg. 9.)

Lowe, Wallace, Kirby and Bishop, 2007: "Fracturing provides primary control on aquifer characteristics of the Glen Canyon Group, altering hydraulic conductivity and effective porosity by several orders of magnitude (Hood and Patterson, 1984; Freethey and Cordy, 1991). High values of hydraulic conductivity encountered in culinary wells along the eastern margin of Moab-Spanish Valley are attributed to fracturing of the bedrock aquifer (Eisinger and Lowe, 1999). Fracture characterization is therefore important in understanding the hydrogeology of the Glen Canyon Group in Moab-Spanish Valley." (Ref. 7, pg. 8.)

"Wells encountering joint zones may have permeability several orders of magnitude greater parallel to joint zone strike than wells that do not intercept joint zones…. Wells completed in the Glen Canyon Group along the eastern margin of Moab-Spanish Valley intersecting joint zones are likely to have greatly increased hydraulic conductivity … oriented to the northwest." (Ref. 7, pg. 11.)

Conclusion

The sandstones of the Glen Canyon Group are the premiere, permeable rock strata on the Colorado Plateau. When fractured by long, continuous joints, permeability is increased by several orders of magnitude. Johnson's is located in close proximity to the wells and springs that supply nearly 80% of Moab's water. This geologic setting is unique and may require more rigourous protection than the current land use standards that were developed elsewhere and codified for general use throughout the country.

Should an incident of pollution occur, it would cost untold millions of dollars to replace or purify this source of water that is currently in-hand and inexpensive. The geological setting at Johnson's Up-On-Top is about as close to a worse case scenario as one can imagine for possible contamination of a valuable bedrock aquifer.

This aquifer is afforded a maximum level of protection by both state and federal agencies—designated a sole source aquifer by the EPA and a Class 1a/Class 1b aquifer by the Utah DWQ.

The Moab area has never faced an environmental consequence of the magnitude that might occur if our drinking water becomes contaminated. The on-going cleanup of the Atlas Tailings Pile has taken years and the cost is exorbitant. The Atlas site affects water serving almost 25 million people. It's unlikely that our community of 8,000 people could find the necessary funding to clean up a contaminated aquifer.

It is appropriate for SITLA, Leucadia National Corporation, and our City, County, and Improvement District, to demonstrate leadership in protecting our pristine drinking water sources. The highest and best use of Johnson's Up-On-Top is the continuation of the role it plays today—safe, natural, and inexpensive filtering of our irreplaceable drinking water.

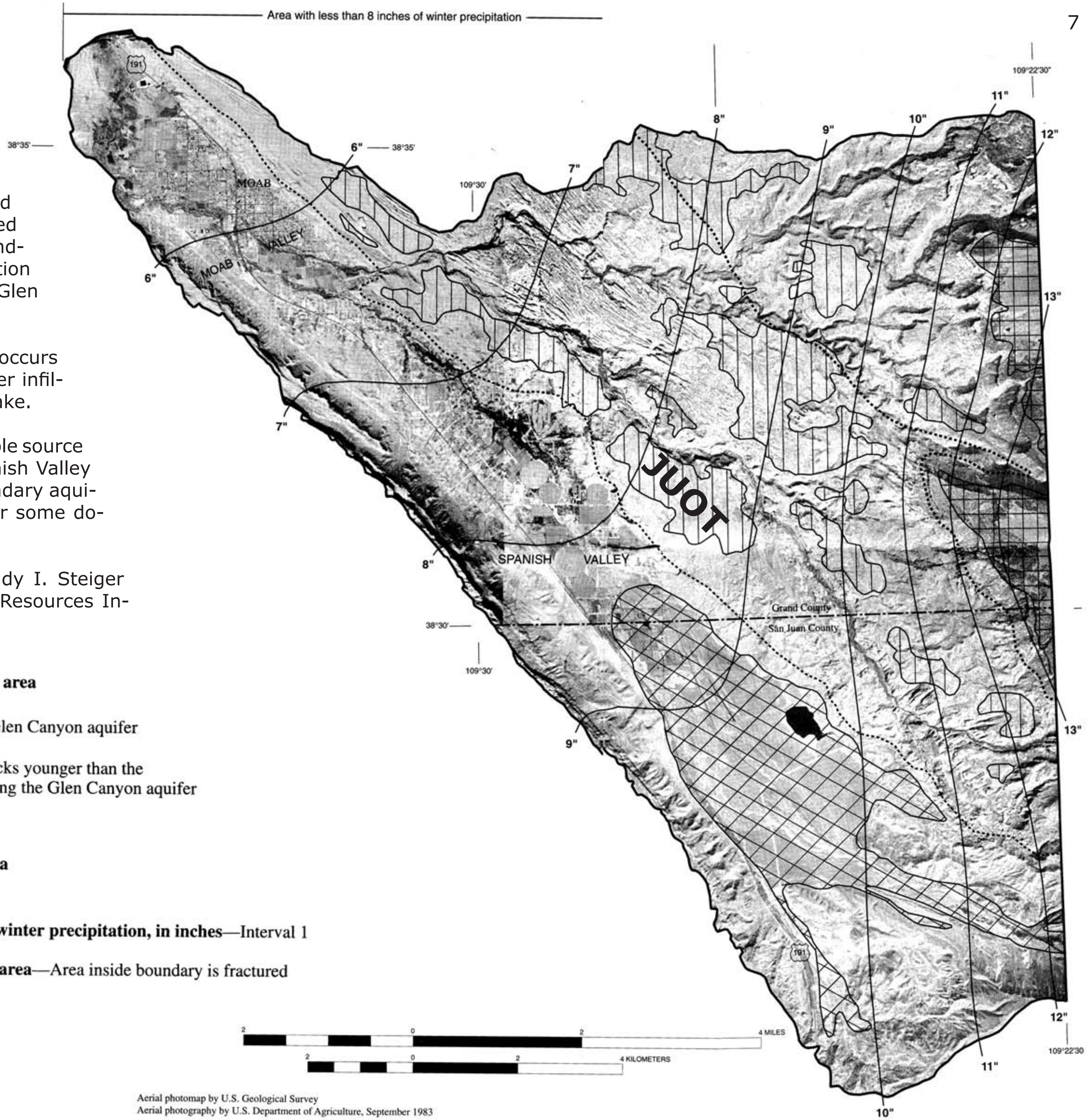
Map: The recharge areas for the Glen Canyon and valley-fill aquifers, and average annual winter precipitation for the Moab-Spanish Valley area. **JUOT** means Johnson's Up-On-Top.

The recharge areas are determined by consideration of the unconsolidated sediments covering the Navajo Sandstone as a means to store precipitation that will infiltrate down into the Glen Canyon aquifer.

Infiltration to the valley-fill aquifer occurs through direct precipitation and water infiltration from Pack Creek and Ken's Lake.

The Glen Canyon aquifer is the principle source of drinking water for the Moab-Spanish Valley area. The valley-fill aquifer is a secondary aquifer used mostly for irrigation and for some domestic water supply.

United States Geological Survey. Judy I. Steiger and David D. Susong, 1997. Water-Resources Investigations Report 97-4206.



Glen Canyon aquifer recharge area

Eolian deposits overlying the Glen Canyon aquifer

Upper mesas—Sedimentary rocks younger than the Navajo Sandstone and overlying the Glen Canyon aquifer

Valley-fill aquifer recharge area

—9"— **Line of equal average annual winter precipitation, in inches**—Interval 1

Boundary of highly fractured area—Area inside boundary is fractured

Boundary of study area

Aerial photomap by U.S. Geological Survey
Aerial photography by U.S. Department of Agriculture, September 1983

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Online: http://www.livingrivers.org/JUOT/2001Solomon.pdf

(10) Steiger, J.I., and Susong, D.D., 1997, Recharge areas and quality of groundwater for the Glen Canyon and valley-fill aquifers, Spanish Valley area, Grand and San Juan Counties, Utah: U.S. Geological Survey, Water-Resources Investigations Report 97-4206, 2 p.

Glossary

Aquifer - Saturated bedrock or sedimentary deposits that are sufficiently permeable to transmit water to wells and springs.

Homogenous - Similar or uniform structure or composition throughout.

Hydraulic Conductivity - The capacity of a porous medium to transmit water through a unit cross-sectional area. Hydraulic conductivity is dependent upon the physical properties of the porous medium and the viscosity of the water. It is expressed in units of length/time.

Isotropic - Having uniform properties in all directions.

Laccolith - An igneous intrusion that has been injected between layers of sedimentary rock (such as the La Sal Mountains). The pressure of the magma is high enough that the overlying strata are forced upward, giving the laccolith a dome or mushroom-like form with a generally planar base.

Permeability - The capacity of a porous rock for transmitting a fluid without changing the structure of the rock.

Porosity - A measure of the void or pore space within rocks and sediments to allow the passage of a liquid through rocks.

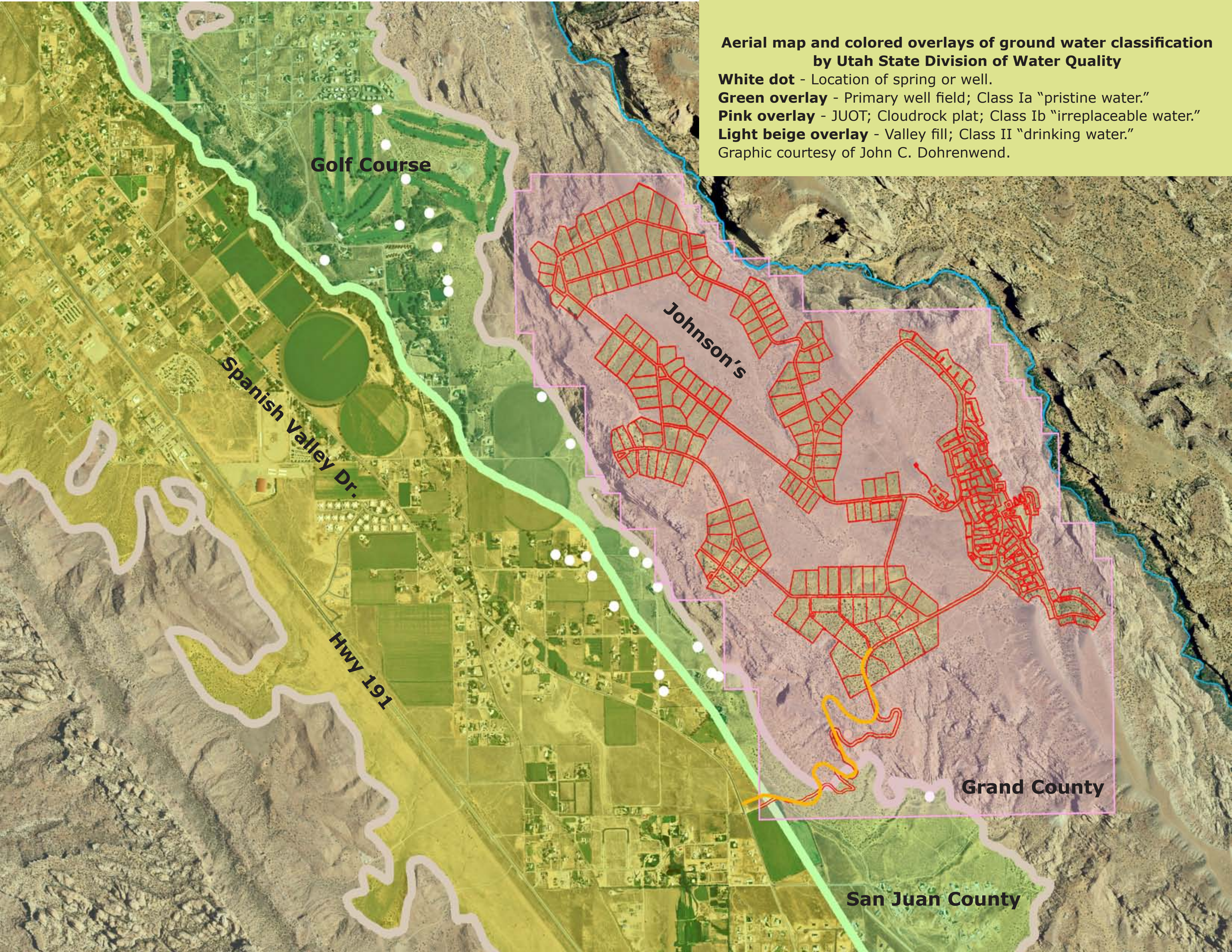
Recharge - Mechanisms of inflow to the aquifer, such as precipitation, applied irrigation water, underflow from tributary basins, and seepage from surface water bodies.

Salt Anticline - A subsurface upwelling of crystalline rock salt and the consequent deformity of the sedimentary rock above. A localized, upward fold in the earth's crust.

Photo: Moab-Spanish Valley looking southeast toward La Sal Mountains. Image courtesy of Google Earth (http://earth.google.com).

Transmissivity - The rate of flow of water through a vertical strip of aquifer that is one unit wide and extends the full saturated depth of the aquifer.

Unconsolidated - A formation composed of loose, earthen materials or particles, such as clay, silt, sand, gravel, or stones.


Aerial map and colored overlays of ground water classification
by Utah State Division of Water Quality
White dot - Location of spring or well.
Green overlay - Primary well field; Class Ia "pristine water."
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Graphic courtesy of John C. Dohrenwend.
Golf Course
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