HYDROGEOLOGIC REPORT OF HURRICANE BASIN

for

CREAMER & NÓBLE, INC.

Consulting Engineers

and

HURRICANE CITY

by

S. Bryce Montgomery

Geologist

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Introduction:

At the request of Creamer & Noble, Inc., Consulting Engineers for Hurricane City and city officials I have made a hydrogeologic study of the structural basin in which Hurricane City is located. The objective is to delineate the extent of the underlying groundwater reservoir, and determine the inter-relationships of the various water wells, sources of recharge, and direction of groundwater movement -- all to show the effect of changing the point of diversion of various water rights to a recently drilled test well for the City.

Besides prior, related visits and study of the area, the area was recently examined in further detail and research has been made of the following sources:

Cook, E. F. (1960), "Geologic Atlas of Utah," Bulletin 70, Utah Geological and Mineralogical Survey.

Cordova, R. M., et al, (1972), "Ground-Water Conditions in the Central Virgin River Basin, Utah," Technical Publication No. 40, Utah Division of Water Rights in Cooperation with U. S. Geological Survey.

Creamer & Noble, Inc., Consulting Engineers (1978), Personal Communication.

Hansen, V. and Associates (1978), "Hurricane Sewage Lagoon Dye Test," 208 Study.

State Engineer's Office (1978), Utah Division of Water Rights, Well log and water rights files.

Stoker, G. (1976), "Hurricane City Well Test," Memorandum Report of Pumping Test on Well in SW¼ Sec. 6, T 42 S, R 13 W.

Heylum, E. B. (1963), "Guidebook to the Geology of Southwestern Utah," Twelfth Annual Field Conference, Intermountain Association of Petroleum Geoiogists.

Utah Division of Oil & Gas and Mining (1978), files of oil and gas wells drilled.

U. S. Geological Survey (1954), Hurricane, Utah, 15-Minute Quadrangle, Topographic Map.

A hydrogeologic map has been prepared of the subject area and is included as a part of this report. Reference should be made to this map as the following information is read.

Geology and Hydrology:

The area of concern west and southwest of Hurricane City, within 4 - 10 miles distance is a topographic bench - valley which is butted against an abrupt and steep escarpment to the east, being the Hurricane Fault, and is bounded on the north and west by the Virgin River gorge and valley. To the south the bench - valley becomes low, sand covered mountains which produce a sharp and steep, southerly escarpment that bounds Warner Valley on its north side. The north end of the area has been pierced by volcanic eruptions and associated lava flows of various ages of basalt, cinders and clinkers, with at least three cones being well preserved.

The underlying sedimentary bedrock strata consists of the Jurassic age Navajo Sandstone, well known in southern Utah. This competent and massive, eolian derived sandstone has undergone downwarping to form a prominent synclinal basin beneath the area. This syncline is trending northeasterly and parallels the Virgin Anticline which is a few miles to the west with its axis being Purgatory Flats. The west limb of the Hurricane Syncline next to the Virgin Anticline is steeply dipping to the east causing the Navajo Sandstone to be bent upward here and truncated by erosion. The Navajo Sandstone is a fine grained, crossbedded sandstone, with subrounded to rounded grains being cemented with calcite and iron -oxide and in some places loosely cemented to friable. It is well jointed and fractured with most of the open joints and fractures trending northeasterly, parallel to the principal structure trend. Less prominent and fewer, open joints trend northwesterly and southwesterly and intersect the other joints. All of the joints dip steeply 54-84° easterly or southeasterly. The primary or intergranular porosity is estimated to be 15 - 20 percent with low permeability, but where fractured and jointed, the porosity and permeability is increased considerably, depending on the degree of structural deformation. From aquifer tests conducted by the U. S. Geological Survey (Cordova, 1972), by testing pumping wells completed in the fractured Navajo Sandstone near Leeds and Gunlock, the hydraulic conductivity is 15 - 20 feet/day and the specific yield is 30 percent. Although the total thickness of the Najajo Sandstone is near 2000 feet in southwestern Utah, within the study area erosion has removed an estimated fourth of it. Two wells drilled by Flora Tech in Section 7, T 42 S, R 13 W, cut apparently 1450 feet of Navajo Sandstone before penetrating the underlying Kayenta red shale and sandstone.

Underlying the Navajo Sandstone formation is the Triassic Kayenta formation is the Triassic Kayenta formation consisting of interbedded, brownish-red shale, siltsone and sandstone. It is about 600 feet thick and outcrops around the west and south edges of the Hurricane Basin as seen in the cliffs north of Warner Valley and the ledges east of the Virgin River and south of Berry Springs a few miles. The formation is tight of very low permeability except for some of the sandstone units near the top which are jointed and yield small quantities of water to springs such as Willow Spring, Sand Mountain Spring and Warner Valley Spring at the southwest edge of the Hurricane Basin. This spilling ground water apparently has leaked from the overlying Navajo Sandstone formation into joints within the upper sandstone units of the Kayenta formation. Because both the Navajo and Kayenta rock strata have been upwarped sharply at the west edge of the Hurricane Basin, the tight Kayenta formation creates a barrier to the movement of ground water from the Navajo Sandstone downward, and outward to the west, except for small flows as noted above which spill over the outcropping "lip" of the Kayenta formation.

Overlying the eroded surface of the Navajo Sandstone formation in the Hurricane Basin is the Quaternary - Tertiary age sequence of basalt lava flows. In the northern end of the basin northwest and southwest of Hurricane City are three prominent volcanic cones. Interbedded with the basalt are some clinker and cinder beds along with some ancient clay and gravel lenses. The main lava deposit northwest of Hurricaine and paralleling the Virgin River, apparently filled the original Virgin River channel, and being more resistant to erosion than adjacent formations, caused the Virgin River to be shifted north and northwestward into its present-day channel. The lava contracted during rapid cooling causing extensive fractures throughout, but the present-day porosity and permeability of the formation depends on the degree of filling of the fractures with clay from cinder alteration, interbedded cinder beds and intercalated, ancient alluvial deposits of clay, gravel and boulders.

At the east edge of the Hurricane Basin next to the Hurricane Fault and beneath Hurricane City, bedrock formations including some of the lava beds, are dropped down relative to the Hurricane Cliffs to the east. Here the lava flows are overlain and intercalated with Quaternary age and older alluvium, consisting of clay, silt, sand, gravel and boulders. Except in the alluvial fan deposits at the mouths of Gould Wash Canyon and Frog Hollow Canyon, the alluvial sediments are tight and yield only small quanities of water to wells. The Cannon well drilled to a total depth of 400 feet in alluvium, at the mouth of Frog Hollow Canyon in the N½ Section 15, T 42 S, R 13 W, is an exception which yielded a reported 1.5 cfs from gravel-sand beds, on a pump test.

Recharge source and direction of groundwater movement in the Hurricane Basin can be indicated by plotting existing wells and static water levels in relation to topography and geology, and contouring the piezometric groundwater surface as shown on the attached map. The arrows are attached to the contour lines to emphasize the actual direction of groundwater movement. Thus, it is seen that the two principal source areas of recharge are the east edge of the Hurricane Basin at and near the Hurricane Fault and the south end of the basin in the sand dunes area. The annual precipitation over the Hurricane Bench area averages only about 10 inches. Therefore, the groundwater recharge at the south end including the sand dunes is limited to this amount above water level elevation 2900 feet, less evapotranspiration losses. The east edge of the basin and the total basin below groundwater elevation 2900 feet is getting groundwater recharge benefit from the natural precipitation over that area, infiltration from irrigation water brought in from the Virgin River via the Hurricane Canal, the extensive drainages of Gould Wash and Frog Hollow which come off from the higher, Hurricane Cliffs area to the east, and apparently some seepage losses from the Virgin River where it passes over the outcropping Kaibab Limestone.

The Kaibab Limestone upper members outcrop in the bottom of the Virgin River Canyon in Sections 29 and 30, T 41 S, R 13 W, northeast of Hurricane. Here test drilling with associated water permeability tests were conducted into the Kaibab Limestone by the U. S. Bureau of Reclamation for the proposed Dixie Project storage dam. These tests showed the Kaibab Limestone to be highly permeable and for this reason the proposed damsite was abandoned. Visual examination of the Kaibab Limestone here and elsewhere along the Hurricane Cliffs show it to be well fractured and containing many solution channels. On the attached map it can be noted that the axis of the Hurricane Basin Syncline projects through the Hurricane Fault and directly through the Virgin River. Here, the Virgin River passes over the permeable, upper limestone units of the Kaibab Limestone. These limestone units are interbedded with tight shale beds which in the bottom of the compressed syncline axis, could function as a trough to convey infiltrating Virgin River water on an established gradient, southwestward to the Hurricane Fault about a mile or two south of Hurricane City. At this point where drainage water from Gould Wash and Frog Hollow have leached through the fault zone to increase its cross-permeability, the transported Virgin River water could be entering and helping to recharge the Hurricane Basin aquifer.

From a pumping test at a maximum rate of 556 gpm conducted in July 1976, the Hurricane City test well located in the NE¼ SW¼ Sec. 6, T 42 S, R 13 W, SLB & M, was shown to have little or no affect on nearby wells. The test was conducted under the direction of the State Engineer's, Area Engineer Gerald Stoker. Water level observations in four other wells at a distance of 2410 - 9120 feet away from the pumped well showed no drop during the 72 hour test period. The pumping rate was 556 gpm for the first 72 hours of pumping, creating a water level drawdown of 74 feet in the pumped well. The pump testing continued at higher rates of 768 and 1254 gpm for parts of two more days until the pump line shaft twisted off. After repairs, the well was pumped at a rate as high as 6 cfs, according to my understanding from the city officials. Thus, in this locality it is very apparent that the unconfined aquifer of the Navajo Sandstone is well jointed and fractured, has great storage of ground water, and rapid recharge to the Hurricane City test well.

It is obvious that the fractures and joints within the Navajo Sandstone and any injected basalt associated with it, are the main source of permeability or hydraulic conductivity, and of the high specific yield (water-yielding capacity in percentage of the total volume of rock occupied by the ultimate volume of water released from storage per unit decline of the water table). Thus, in drilling into these formations, no mud should be introduced under pressure such as is done with mud-rotary equipment. There are several examples of wells drilled into both the Navajo Sandstone and the basalt formations where the ground water was nearly or completely mudded-off due to mud injection and plugging of the formation joints and fractures. On the other hand, there are wells drilled without mud-injection by use of cable tools where the resultant groundwater yields were high, such as the Hurricane City test well and several other wells.

From a fluorescent, dye injection test conducted by Vaugh Hansen Associates, consulting engineers, under a federal 208 study, on the Hurricane City sewage lagoon effluent, further understanding of the groundwater movement in the area has been shown. This test conducted in September - November, 1976, showed a rapid movement of ground water from the sewage lagoon within the SW¼ Sec. 34, T 41 S, R 13 W, Northward, northwestward and westward. This shows the need to have the sewage effluent treated to a degree that it does not contaminate the groundwater aquifer with coloform bacteria, or else convey the effluent by pipeline directly to the Virgin River.

Summary, Conclusions and Recommendations:

The combination of data collected and analyzed shows that ground water is moving from the Hurricane Basin aquifer to the Virgin River, to the north, northwest and west, but restricted in its westward and northwestward movement by the upwarped beds of Kayenta Formation. Ground water is also moving from the aquifer to the southeast directly towards the Hurricane Fault zone at and near Section 33, T 42 S, R 13 W.

Thus, unless this "spillage" water from the groundwater aquifer is pumped and used, it will be lost from the groundwater reservoir into the Virgin River, and Hurricane Fault zone to the south. A total draft on the Hurricane Basin aquifer in excess of the recharge inflow will cause a declining water table. However, the total storage in the aquifer is large and Cordova, R. M. (1972), U. S. Geological Survey, estimated a recoverable volume of ground water from the Hurricane Bench of 10,000,000 acre-feet. Of course, in the use of the groundwater reservoir it would not be desirable to mine the water to this total volume, but wise use of the groundwater storage would allow a withdrawal and replenishment throughout each water year similar to the manner in which a surface-water reservoir is utilized.

Some adjustments in water distribution to satisfy water rights in order of priority would need to be made once peripheral springs decrease and shallow-completed wells experience water levels below their pump setting. However, this would not be necessary unless a continuous and very large draft of water from the reservoir is experienced. A 10,000,000 acre-foot reservoir must experience very large volume removals in order to cause much of an overall decline in the water level. The pumping test in the vicinity of the Hurricane City test well in Section 6, T 42 S, R 13 W, showed nil or very little effect of the pump well cone of depression on other wells, mainly because of the large groundwater storage in place.

It is apparent that all of the ground water within the Hurricane Basin is interconnected but with varying decrees of permeability due to the degree of open fracturing and jointing in the bedrock, and the nature of the alluvial sediments in the east side of the basin. One may compare the location of different well locations and aquifer discharge points to that of a surface river and lake system with its various water diversions. To change the point of diversion from the spilling part of the Hurricane Basin aquifer back to the center of the reservoir or near the recharge area would be similar to moving the point of diversion of the surface system from a downstream to a lake or upstream location. So long as there are no intervening water rights that would be unable to be satisfied through the change, there should be no difference on the total draft of the system. If such a change would cause an intervening right to be diminished in its allotted supply, then replacement of water would be necessary. To determine the interrelation affect of one right to another, water measurements could be made before and after the change on all involved water rights.. Although, this would require added effort and expense to what is presently being done, to more efficently use the existing groundwater resource, it could be justified.

To move a well water right from a less favorable part of the groundwater reservoir such as in or near Section 33, T 42 S, R 13 W, or along the very west or north edges of the Hurricane Basin, back into the deeper and central part of the basin would constitute an advantage over what was originally appropriated. However, it appears that the proposed change of the Graft water right from the SE¼ Sec. 32, T 42 S, R 13 W, to the City test well in the SW¼ Sec. 6, T 42 S, R 13 W, is moving from one spill point of the aquifer to another spill point. The proposal to change the Wilson well right from the southwest Corner of Sec. 15, T 42 S, R 13 W, in the alluvium of low permeability to the City test well in the SW¼ Sec. 6, T 42 S, R 13 W, is moving from the higher area of recharge in the aquifer to near the lower spilling edge of the aquifer.

So long as an operational system of diversion and distribution of all existing water rights in the aquifer is setup to satisfy each right, then changes that would constitute a better utilization of the available large resource of ground water, should be implemented.

Respectfully submitted,

S. Bryce Montgomery

S. Bryce Montgomery
Geologist

3512 South 100 East
Bountiful, Utah 84010

Telephone 295-8592

HYDROGEOLOGIC MAP OF HURRICANE BASIN

City of Hurricane

Waterbodies

0 0.5 1 2 Miles

GIS DEPARTMENT
HURRICANE CITY
UTAH