

Hydrogeological constraints on oil and gas drilling in the Galisteo Basin

Geological Background: Galisteo Basin

The most striking geologic characteristic of the Galisteo Basin is the extent to which, on both a regional and local scale, the basin is fractured and faulted.

Most importantly, the region is cut by the Tijeras-Canoncito (T-C) fault zone, a wide zone of structural disruption (faults, fractures, folding, upturned rocks) and igneous intrusions ([Figure 1](#); data for this map was compiled from: Bachman, 1975; Lisenbee, 199, 2000; Lisenbee and Maynard, 2001; Maynard and Lisenbee, 2001; Maynard et al, 2001; Shomaker, 1995). This map under-represents the actual number of faults because many of the traces of the faults are hidden by recent sedimentation.

The T-C fault zone is the main focus of interest for oil and gas exploration and the area in which all of the three wells for which Tecton Energy has filed applications to drill with the NM Oil Conservation Division are located. Faults and fractures are expected to enhance the deliverability of oil and gas. The Tecton State 16-1, for example, is located within 400 feet of a major fault.

Faults and fractures are intricately interconnected, in a vertical and horizontal sense. Faults and fractures are not simple planar features; they are more accurately depicted as a 3-D spiderweb-like network. There is ample evidence of this in the results of previous oil and gas drilling and of deep water wells in the area.

The hydrogeological properties of this fracture system and for many related faults in the region are much different than the properties of relatively unfaulted areas.

Published data from the T-C fault zone in the Ortiz Mountains and from similar fault and fracture zones indicate that these kind of hard bedrock faults appear to have high transmissivities and permeabilities relative to ground-water flow. These zones represent robust conduits for fluid flow.

Many faults have been mapped in the Galisteo Basin, and in at least one case, the hydraulic characteristics of the fault zone have been studied carefully. That is the Golden fault zone, a part of the regional Tijeras-Cañoncito fault zone, which was penetrated by the Carache Canyon Decline on the south side of the Ortiz Mountains on Lone Mountain Ranch. There, the fault zone, consisting of two parallel zones of fracturing, was a total of about 118 ft wide, and the fractures associated with it created a significant increase in permeability of the rocks, both vertically and along the trace (trend, or surface expression) of the fault.

The T-C fault system is also one of the principal recharge zones in the region. Precipitation and snow-melt run-off enter the ground-water system through faults and fractures that intersect the surface.

A. Protection of current and future water resources from contamination by drilling in faulted and fractured rock:

1). Establishment of baseline data and need for monitoring wells

Prior to operations, the oil and gas operator should be required:

a) to submit geologic information that specifically addresses the probability of the presence of a fault or fracture zone that might be near, or be intersected by, the proposed well;

b) to drill a test well (or wells) in support of its application in order to conduct an aquifer pumping test, or tests, of sufficient duration to be able to characterize the hydrogeology of the fault zone within one-half to one mile of the proposed drilling location;

Baseline data are notably lacking in the area of proposed drilling. Transmissivity data are absent from much of the area of intended drilling, according to County documents and it is likely that very few, if any, of the deeper water wells have been sources of data collection.

The need for baseline data is particularly important in those cases where the operator intends to utilize hydraulic fracturing to stimulate oil or gas production, in which fluid is pumped into the proposed producing zone to induce fracturing and thereby increase the permeability of the rock.

c) This initial aquifer test will collect data on direction of fluid flow, transmissivity of the fault zone and water quality of any encountered aquifer as well as water levels within a 1 mile radius. The specific test parameters should be determined by the County Hydrologist.

d) New monitor wells need to be drilled through the deepest known existing and potential aquifer to a depth at least 200 feet below the base of the deepest aquifer. This requirement is particularly important in areas of fractured rock

Drilling deep monitor wells is important in preventing contamination from oil and gas activities long after the well has been drilled.

It is unlikely that existing water wells can be used as reliable monitor wells. First, the NM OSE WATERS database for the area of proposed drilling includes only a few water wells drilled to depths greater than 1,000 feet, although existing and potential ground-water resources are found at greater depths.

Secondly, in many areas in the Galisteo Basin, there are not enough existing water wells that can be used to serve as monitor wells.

For example, the application by Tecton Energy to drill a 7,500 ft. well in section 16, T14N R9E is accompanied by a figure that shows four water wells within a 1 mile radius. Of these four, only one was actually drilled (one, RG 58769, is located in a distant township and range), according to the NM OSE WATERS database. The single drilled well, RG 83547, was drilled to a total depth of 485 feet and completed as a water

well in fractured rock. This well would not be a suitable monitoring well because of its relatively shallow depth and because the water-bearing zone is in fractured rock

d) The burden should be placed on the operator to demonstrate to the Santa Fe County hydrologist, or other designated authority, an understanding of where fluids used in oil and gas operations (e.g., drilling fluids, oil, gas, frac fluids) will go once they have left the borehole and entered into a fault and fracture network, and whether such fluids could be retrieved.

Hydraulic fracturing of deep zones in structurally complex subsurface environments must be closely monitored to the greatest depth possible because of the inevitable loss of hydraulic fracturing fluids into the fracture network. It is almost impossible to recover all of the load water by swabbing in a normal near-borehole environment, let alone where targeted zones are fractured and connected to other fractures

Although previous hydraulic fracturing jobs conducted by Tecton and other operators have been small, in the amount of water and proppant used, it is likely that deeper formations may require much larger amounts of frac fluids.

Gas-bearing zones have typically required very large fracs that inject massive amounts of water and proppant into the targeted interval.

e) If the operator can not provide evidence to confirm that the aquifer (or aquifers; current and potential) will not be contaminated, then such locations should be considered unsuitable for drilling.

2. Prohibition of injection of produced water into a) water-bearing zones of current or potential use whose water quality is less than 10,000 mg/L, total dissolved solids.; or b) into other layers that might be connected to such water-bearing zones by faults or fractures.

Water produced from oil and gas operations should be hauled away and not allowed to be discharged into evaporation ponds in order to prevent possible contamination of surface water and shallow ground water.

B. Depletion of ground-water resources

1) Impacts on ground-water resources must be evaluated as cumulative impacts. An oil and gas operator that proposes to undertake field development must provide the results of a ground water flow model that describes long-term withdrawal of groundwater during oil and gas operations over the expected life of oil and gas production.

a). Many of the geological formations that may contain hydrocarbons in the Galisteo Basin are also known aquifers, or may contain water not-yet-developed, but of significant future value.

b). Long-term pumping of a hydrocarbon-bearing formation that is hydraulically connected to water-bearing zones will eventually draw water away from wells.

The Hospah South field in McKinley County, which produces oil from the same kind of shallow reservoir as tested by Tecton in the Black Ferrill #1, has produced an estimated 30,000 acre-feet of water from approximately 100 wells over a 30 year period.

To recover the amount of oil or gas necessary for market-driven economic investment, it will be necessary to drill a very large number of wells. To recover 10 million barrels of oil may require 100-150 wells, depending on individual well recoveries. The high price of oil will make any well producing more than a few barrels of oil a successful investment and thus propel an extensive drilling program.

The discovery and concurrent exploitation of both oil and gas will increase the number of wells that are drilled because of the common practice of producing oil and gas wells separately. The deeper formations targeted by Tecton are gas zones and several previous wells have encountered indications of gas at the depths to be drilled by Tecton.

c). Deep artesian aquifers exist in the Galisteo Basin.

Two oil and gas wells encountered usable water in the Dakota Formation at locations near proposed drilling locations. Test data from the Eastland Oil McKee 1, drilled in 1974 in section 8, T13N R9E, indicated good to excellent fluid recovery and reservoir properties at a depth of approximately 2,000 feet. The second well, the Black Oil Cash 1, drilled in 1986 in section 5, T13E R9E, encountered sufficiently large water flows in the Dakota Formation at approximately 1,000 feet that the operator had to shut this water off by setting and cementing intermediate casing at 1500 feet.

Tecton Energy has announced its intent to test the sandstones of the Dakota formation for hydrocarbons near these two occurrences of water. If oil were to be found in the Dakota Formation, long-term and accelerated pumping of this formation from a large number of wells would cause water to be drawn into the producing field

2. Impacts of long term oil and gas development on recharge of ground water resources

a) Areas of ground-water recharge must be clearly designated on land use maps.

In most of Santa Fe County, ground-water recharge occurs primarily in drainages on the upper slopes adjacent to the mountain-fronts, in lower areas through the beds of the larger arroyos (defined as an arroyo with a bottom more than 10 ft wide), and in vertical fault and fracture zones open at the surface that allow recharge to lower ground water elevations.

b) Full field development should be prohibited within defined recharge areas.

[Figure 2](#) shows what full scale development would look like as far as surface damage is concerned. Such development would severely alter the recharge environment and cause changes in directions of surface runoff or in the amount of water available for recharge.

c) Setbacks should be established to protect recharge areas.

The danger of ground-water contamination due to a spill, which might then be forced downward toward the water table by later recharge, would be lessened by limiting oil and gas drilling to areas more than 1,000 ft from a significant arroyo, or to greater distances if indicated from hydrological studies and tests. The proposed Tecton State 16-1 and the Tecton Bruce Black 1-2 wells are located up-slope and less than 1,000 feet from major arroyos.

