VII - UNDERGROUND GAS STORAGE

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New York State Natural Gas Corporation is a wholesale gas supplier to 21 major gas distributing companies in Pennsylvania, Ohio and New York. With the exception of the New York City district its market area includes virtually all of the state of New York.

During the last 15 years underground storage of gas in previously depleted gas field sands has become an important phase of gas company operations. The Harrison Field is one of the storage fields operated by New York State Natural.

State regulations limit the number of a utility's domestic gas consumers to the number that the utility can supply with an adequate, uninterrupted supply of gas. This in effect means that the number of domestic consumers is limited to the number the utility can supply on an extremely cold day. Industrial customers of a utility obtain lower gas rates but their supply is interruptible.

Therefore a utility can expand the number of its domestic gas consumers only if it does one of two things: (1) Cuts off or reduces the gas to its industrial customers during very cold weather and diverts that gas to its domestic consumers; (2) Increases the flow of gas to its domestic consumers during very cold days (called peak days in the gas business) by obtaining more gas from the wholesale gas supplier.

Since the first alternate usually results in a financial loss to the industrial customer the expanding utility increases the amount of its gas supply on peak days.

Quite a few of the utilities which New York State Natural supplies with gas have a contract which states that N.Y.S.N. will supply them with all the natural gas they require at any time they require it. This puts a tremendous strain on the N.Y.S.N. gas supply during cold weather, since its supply does not fluctuate very much. To meet this winter demand the company has developed 6 storage fields. Some are jointly financed. One of these is the largest storage field in the world in terms of amount of gas stored and horsepower used in storage operations. The Harrison field is financed jointly with Tennessee Gas Transmission Co.

Gas requirements of the domestic gas consumer fall into two types:

1. Fixed load. This consists of the gas used to run cooking stoves, gas refrigerators, water heaters, gas clothes dryers, etc. This load does not fluctuate much from summer to winter.

2. Space heating. Gas used in heating stoves, furnaces, etc. This load fluctuates tremendously and is the direct cause of having to use underground gas storage.

Since underground storage requirements are directly related to space heating load it follows that the underground storage requirements are also directly related to the temperature of the market area.

Studies of gas consumption in relation to U. S. Weather Bureau reports of the market area show that the average domestic gas consumer starts to use gas for space heating any time the average daily temperature drops below 65°. He uses 30 cubic feet of gas per day for every degree below 65°. If the daily temperature is 64° he will use 30 cubic feet. A one degree deficiency (below 65°) in the average daily temperature is called a degree day deficiency. In other words, if the average daily temperature for one day is 64° you have a 1 degree day deficiency. If the average temperature for a day is 35° you have 30 degree day deficiencies.

It is thus possible by calculating the number of degree day deficiencies during an average winter to anticipate what the demands for space heating gas will be. This is done simply by multiplying the number of degree day deficiencies per winter by 30 cubic feet by number of customers using space heating.

Records for the Pittsburgh, Pennsylvania area show that there are 5614 degree day deficiencies in the average winter. So the average space heating requirement per customer for an average winter's heat in that area is 5614 times 30 cubic feet or 168,420 cubic feet.

Utilities usually also calculate a requirement based on the coldest and warmest winter in their market area. There is a variation of about 20% from the average figure for gas requirements during the coldest or warmest winter. In that way the utility can figure what its average, maximum and minimum requirements for the winter may be. These estimates of requirements are usually furnished to the wholesale gas supplier several years in advance so he can adjust his amount of gas in storage accordingly.

Amount of gas actually in storage usually represents a smaller figure than the largest amount of gas possibly required to meet all the demands (domestic and industrial) of all the utilities for the coldest winter likely to occur.

Desirable characteristics of a storage field include: large open flow wells (so gas can be injected and withdrawn from the sand quickly); location close to market area (so gas can be delivered quickly); high total gas capacity; and well defined limits (so that no gas migration is likely to occur).

The Oriskany sand gas pools of this region provide ideal storage areas. They are all former gas pools from which the original gas was withdrawn in the 1930-1950 period.

DESCRIPTION OF ORISKANY SANDSTONE

The Oriskany sandstone is generally a medium grained, dark to light gray quartzitic sandstone. Porosity is relatively low, averaging only 9 per cent. Productivity of the sand, however, is greatly increased because of fracturing, which is in part associated with the faulting present in each productive area. An additional factor of productivity seems to be the increased permeability associated with structural highs. It is probable that slight folding took place during deposition, causing the reworking of the sand deposits along the present structural highs and thereby causing increased porosity and permeability. (1)

The Oriskany pools of northern Pennsylvania and southern New York are large capacity and high productivity pools with well defined limits. These factors are the essential characteristics of ideal storage pools and are indicative of the utility of the Harrison field as an underground stroage pool.

HARRISON FIELD

NATURAL CONDITIONS

The Harrison field is located in Bingham and Harrison Townships, Potter County, Pennsylvania and the Towns of West Union and Troupsburg, Steuben County, New York. The field is made up of three separate productive areas, the Harrison East End, Harrison West End, and the Brookfield pools. The latter is separated by a fault from the main producing area and has produced only a negligible amount of gas; it is not under con-

(1) F. H. Finn, "Geology and Occurrence of Natural Gas in Oriskany Sandstone in Pennsylvania and New York" Bulletin of the American Association of Petroleum Geologists, Vol. 33, No. 3 March 1949, p 314.

sideration for underground storage at this time. (2)

The Harrison East End Pool was discovered on June 10, 1934 with the completion by New York State Natural, of Well N-24 which had an open flow of 18 million cubic feet of gas and an original rock pressure of 2140 pounds. The Harrison West End Pool was not discovered until September 25, 1935, and it is estimated that the original pressure equalled the discovery pressure found in the East End Harrison area.

During active development, New York State Natural drilled eight productive wells in the East End Area and one well in the West End Pool. Outside operators were also active, drilling fourteen productive wells in the East End and five wells in the West End Pool. The original open flows encountered were somewhat lighter than those typical of Oriskany pools. They ranged from 505,000 cubic feet to 22.5 million cubic feet of gas per day in the East End Pool and 7.6 million to 20 million in the West End pool with the exception of one well in the East End Pool completed in 1943 with an open flow of 128,000 cubic feet, and a rock pressure of only 187 psig. It should be noted that several of the lighter open flow wells were drilled late in the productive period at a time when pressures were relatively low. Such wells would naturally have had a higher open flow at original reservoir pressures.

The Harrison field is located at the junction of the Harrison and Hebron Anticlines and covers an approximate area of 10,800 acres. The merging of the anticlines has caused the structural aspects of this pool to differ somewhat from a typical Oriskany pool found in this region. Faulting has caused the pool to be separated into two production areas; each of which has a vertical closure of approximately 125 feet. The faulting undoubtedly took place in early Devonian time, a fact made evident by the relatively minor evidence of faulting apparent in the shallower Dunkirk Sandstone, found near the surface. (3) See map no. 4 for subsurface structure.

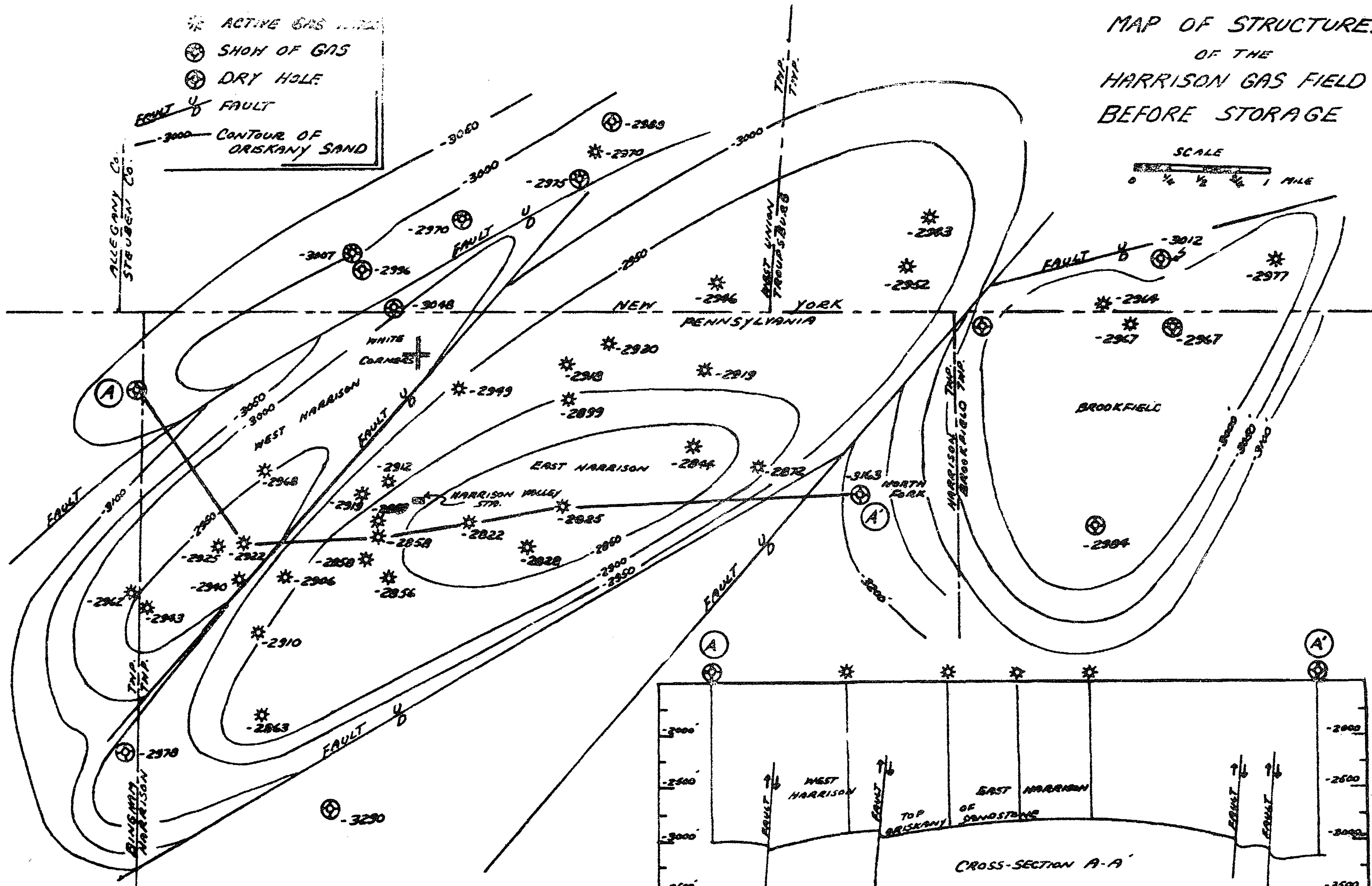
The Oriskany Sand is found at a depth of about 5,000 feet. The thickness averages approximately 32 feet, with the pay zone varying from one to nineteen feet, and with an average pay of six feet for the entire pool. The sand is medium grained and light gray with an average porosity of 9 percent. These characteristics indicate that the productive horizon is harder and somewhat less porous than that typical of gas pools in the immediate area. The more prolific wells are found higher on the structure indicating a direct relationship between structure and porosity. The probable reason for this is that folding took place during deposition, causing greater reworking of the sand at the top of the structure. The relatively tight sand and lesser pay thickness in this pool is the reason for its smaller reserve per acre (about 3½ million cubic feet) in comparison with other fields of the region which vary between 4½ and 10 million cubic feet per acre.

The Harrison pool has all the required characteristics of an ideal storage pool in that it has a high deliverability, is definitely limited by nonproductive wells and has a large capacity. The East End Pool, because of its larger capacity, may be used on a steady load basis, while the West End Pool, with its smaller capacity, may be held at high pressures, thus furnishing high deliverability for periods of short peak requirements. This condition of operation affords a flexibility which is found in very few storage pools of the Appalachian Area.

USE AS STORAGE POOL

After the decision has been made to use a pool for storage it is necessary to obtain storage rights from the lease owners or land owners. Some wells still have production "strings" of casing in them. These wells usually don't cost too much to recondition, since about all that is necessary is to put on fittings at the top of the well

(2) From Federal Power Commission report written by R. J. Murdy, Chief Geologist, New York State Natural Gas Corporation, and T. A. Kuhn.
(3) See footnote (1). P330.



MAP OF STRUCTURES
OF THE
HARRISON GAS FIELD
BEFORE STORAGE
SCALE
0 1/4 1/2 3/4 1 MILE
ACTIVE GAS WELL
SHOW OF GAS
DRY HOLE
FAULT
CONTOUR OF ORISKANY SAND
ALLEGANY CO.
STEUBEN CO.
NEW YORK
PENNSYLVANIA
WHITE CORNERS
WEST HARRISON
EAST HARRISON
HARRISON VALLEY
NORTH FORK
BROOKFIELD
CROSS-SECTION A-A'
TOP ORISKANY SANDSTONE

which will be safe for the pressure used to inject gas into the well. There have been 11 wells reconditioned in the Harrison field at an average cost of about $10,000 apiece.

Most of the wells have had the production string of casing ripped, and the casing pulled out of the hole. In redrilling operations attempts are made to clean out the well to bottom and run smaller casing inside the short length of casing at the bottom of the well. There have been 17 wells in the Harrison field redrilled at an average cost of $24,000 apiece.

To completely fill the storage pool in the summer time and get the gas out quickly in the winter time it is usually necessary to drill additional wells. There were originally 28 wells in the Harrison field. To obtain the delivery of gas which we required we drilled 31 additional wells. These have cost an average of about $50,000 apiece.

Maximum pressure in the Harrison field is expected to reach 2000#. At that pressure, the pool is expected to hold 33½ billion cubic feet of gas (roughly 23 million dollars worth at 70 cents per thousand - approximate local retail price). Maximum storage pressure will be about 140 pounds less than the original rock pressure of the field. At peak capacity the pool has a theoretical deliverability of about 300 million cubic feet of gas per day.

It has cost approximately 8 million dollars to fix up this field for storage. This includes cost of drilling and reconditioning wells, constructing compressor station, laying pipelines etc.

The productive portion of the field is about 6 miles long by 3 miles wide.

The pool is designed to:

1. Turn over 60% of its maximum capacity every year (i.e., about 20 billion cubic feet).

2. Have an average withdrawal rate of 133 million cubic feet per day.

3. Have a potential deliverability of 153 million cubic feet of gas per day at the end of the gas withdrawal period when the average pool pressure is 800#.

Topographic elevations in the field range from 1800 to 2223 above sea level. Within the field is a watershed divide between the Great Lakes - St. Lawrence River waters and the Susquehanna River drainage. A few miles to the west there is a three way continental divide between the Great Lakes - St. Lawrence River, Atlantic Ocean, and Gulf of Mexico drainage.

HARRISON VALLEY STATION

Compressors used consist of 5 large engines of 2000 horsepower each. Each of these weighs 93 tons and costs $186,000 apiece. One smaller engine is used which develops 1100 horsepower. It weighs 75 tons and costs $100,000.

It took about 5 months to build the station. It was completed in January of 1956.

Total cost of entire plant and equipment was about 4 million dollars.

The station operates 24 hours per day. Three men are on duty at all times.

The piping set-up at the station is actually more flexibile in operation than the simplified diagram indicates (See Fig 5 with road log for trips B1-B2). In practice gas can be taken from or discharged into either or both of the New York State Natural and Tennessee Gas Transmission Company lines.

The sketch below shows the relation of the Harrison Valley gas field and station to the area and may be of assistance to those departing for home from trip B2.