Appendix S

Fracture Trace Analysis

Technical Memorandum

Subject: Fracture Trace Analysis

To: Tim Miller, AICP

From: Sergio Smiriglio

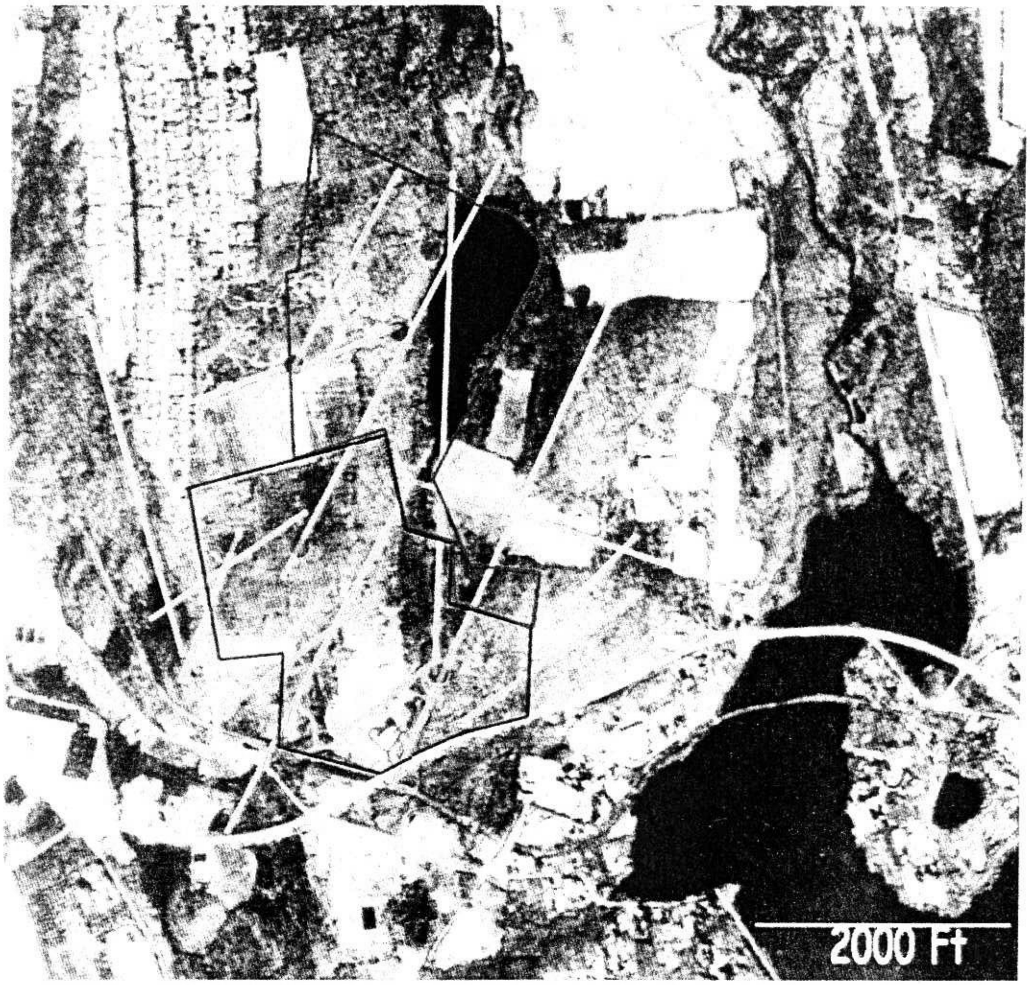
CC:

Date: December 23, 2004

Re: Gateway and Fairways

This memo provides a review of hydrogeological aspects of the subject project site in Carmel, New York. Several remote sensing techniques and a site traverse were used to assess the water production potential of the proposed Gateway and Fairways project sites. The property is located on the northeast side of The Middle Branch Reservoir, incorporating Mount Pisgah. The area is characterized topographically by moderately steep bedrock highlands composed of crystalline bedrock. The highlands are generally limited to several hundred feet of elevation. The area topography is primarily controlled by the existence of faults and the structure and resistance to erosion of the bedrock. The bedrock that is more resistant to erosion, due to the presence of fewer faults, form the highlands.

The area topography is a result of a combination of faulting and erosion from glaciation and more recent rain and wind erosion. The faulting in this area is due to several series of tectonic events that have compressed and sheared the rock causing folds and fractures. These structures are oriented according to the directions of the forces that caused them. These orientations make it possible to determine the locations of the bedrock fractures that may contain usable quantities of ground water. The primary [largest] faults in the area are thrust faults oriented in a northeast to southwest direction in response from compressive forces from the southeast. The thrust faults are characterized by large [measured in miles] slabs of rock overlying younger rock. The fault planes tend to be shallow, nearly horizontal, and highly compressed. The secondary shear faults, running through the project site, intersect the main thrust fault. Shear faults are caused by offset forces that produce a nearly vertical fault that is



generally oriented at about 30 to 60 degrees from the line of force. Typically, thrust faults of this type are associated with a high degree of bedrock fracturing. They also tend to release stress in the adjoining bedrock and, therefore, reduce the number of water bearing fractures. Additionally, thrust faults are compressional, which tend to squeeze and reduce the available volume for ground water in the fractures. The adjoining shear faults and fractures, however, may be water bearing and will be the target for the ground water exploration.

The bedrock unit that underlies the Carmel area is a combination of the Poughquag Quartzite and biotite gneis of uncertain origin, units that have poor primary permeability, with little to no extractable water found in the matrix of the rock. All usable water is found in the fractures and joints of these bedrock units (secondary permeability). The number and location of the bedrock fractures (fractures typically contain greater quantities of usable water than joints) is dependent on the degree of deformation that the bedrock has undergone through its formation. Typically the larger, more productive fractures tend to produce visible topographic traces. These traces can be found using stereoscopic aerial photography and digital terrain modeling.

Review of the high altitude infrared photography shows that the project area has several fracture traces trending from southeast to northwest. Regionally, most bedrock fractures tend to be oriented in a northeast to southwest direction, indicating that these are secondary fractures to the main thrust fault along Tilly Foster Road. These tend to be shear fractures formed due to uneven tectonic forces from the southeast, causing the rock to break in roughly the same plane as the force being applied. The intersection of the two types of faults, visible at the southern-most portion of the Gateway property, forms an angle of about 30 degrees, which is a typical angle between fractures in this type of bedrock.

Several tertiary fractures are visible within the property. The tertiary fractures have limited extent and, consequently, limited displacement. Typically for ground water exploration from bed rock aquifers, an air percussive drilling rig is mobilized and drilling continues until a sufficient amount of water is developed. Subsequently the successfully developed wells are tested to determine long-term yield and to determine if there is potential deleterious impacts on neighboring private wells.

The dots shown on the above photo indicate suggested drilling locations based on the intersection of potentially productive bedrock fractures.

Recharge

The Gateway/Fairways property is located on a hill side and adjoining valley which is surrounded by an extensive system of faults and fractures. A recharge analysis for the Gateway/Fairways property, assuming that the major fractures discussed above are tapped successfully, would involve having to include most of northern Westchester and southern Putnam counties. The faults and fractures which form the valleys surrounding the Gateway/Fairways property extend for miles and intercept additional fractures well beyond the property. Since precipitation falling anywhere within this area naturally drains towards the valleys from the highlands, the typical 25% of precipitation that becomes ground water through recharge will be available to wells tapping these interconnected fractures.

The primary limitation to the availability of all of the water in the system of fractures is the resistance to flow within the fractures. Since the bedrock fractures form planner channels which contain ground water, ground water can be drawn from considerable distances. However, the width of the fractures can vary considerably, ranging from several feet to places where the fracture walls are in contact with each other, limiting ground water flow. Additionally, rock type variability can cause portions of the fracture to fill with clay-like materials which can further limit the ground water transmissivity of the fracture. Ground water moves from high water levels to low water levels. Therefore, a quantitative analysis of the recharge potential for the project area can only be estimated based on various assumptions. Those assumptions are used in Table 1. The assumptions include an average monthly rainfall based on the Poughkeepsie rainfall data from the 10 year period ending in 2000. The recharge and evapotranspiration rates are based on a model from Keith Eggleston, a former senior climatologist at the

Northeast Regional Climate Center at Cornell University. The model prepared by Keith Eggleston estimates the amount of evapotranspiration, on a monthly basis, for forested land in the lower Hudson Valley. Forested land has a higher degree of evapotranspiration than does turf covered land (golf course, lawns) and represents a more conservative estimate for this project. Runoff was limited to 35% due to the nature of the rolling topography of the project site. A project area of 188.5 acres has been used for this analysis.

Recharge Calculation Limitied to property Boundries.

Table 1 - Recharge Calculations Monthly	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*
Acres	188.5	188.5	188.5	188.5	188.5	188.5
Square Feet	8211060	8211060	8211060	8211060	8211060	8211060
Rainfall (inches)	4.2	2.73	4.12	4.71	4.77	3.62
Rainfall (feet)	0.3499986	0.22749909	0.34333196	0.39249843	0.39749841	0.30166546
Cubic feet of precipitation per month	2873859.505	1868008.678	2819119.323	3222828.159	3263883.294	2476993.192
Gallons of precipitation per month	21497906.02	13973638.92	21088422.1	24108366.04	24415478.98	18529147.57
Amount lost to evapotranspiration in inches	0.37	0.8	1.487	1.37	1.193	1.5
Amount lost to evapotranspiration in feet	0.030833333	0.066666667	0.123916667	0.114166667	0.099416667	0.125
Amount lost to evapotranspiration in cubic feet	253174.35	547404	1017487.185	937429.35	816316.215	1026382.5
Amount lost to evapotranspiration in gallons	1893870.725	4094855.622	7611312.887	7012440.253	6106453.446	7677854.291
Amount lost to runoff (35%)	7524267.108	4890773.62	7380947.735	8437928.114	8545417.644	6485201.65
Amount lost to evapotranspiration and runoff	9418137.833	8985629.242	14992260.62	15450368.37	14651871.09	14163055.94
Amount, in gallons, available for recharge per month	12079768.19	4988009.673	6096161.477	8657997.674	9763607.893	4366091.631
Amount, in gallons, available for recharge per day	402618.6738	166250.3624	203185.062	288571.0625	325421.0511	145521.8341
Amount, in gallons, available for recharge per minute	279.5784071	115.4442516	141.0917071	200.3837458	225.9723779	101.0503616

	Jul	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Acres	188.5	188.5	188.5	188.5	188.5	188.5
Square Feet	8211060	8211060	8211060	8211060	8211060	8211060
Rainfall (inches)	4.06	4.17	3.91	4.23	4.51	3.77
Rainfall (feet)	0.33833198	0.34749861	0.32583203	0.35249859	0.37583183	0.31416541
Cubic feet of precipitation per month	2778064.188	2853331.937	2675426.348	2894387.072	3085977.706	2579631.031
Gallons of precipitation per month	20781309.16	21344349.55	20013526.8	21651462.5	23084656.23	19296929.93
Amount lost to evapotranspiration in inches	1.72	1.71	0.99	0.67	0.67	0.42
Amount lost to evapotranspiration in feet	0.143333333	0.1425	0.0825	0.055833333	0.055833333	0.035
Amount lost to evapotranspiration in cubic feet	1176918.6	1170076.05	677412.45	458450.85	458450.85	287387.1
Amount lost to evapotranspiration in gallons	8803939.587	8752753.892	5067383.832	3429441.583	3429441.583	2149799.202
Amount lost to runoff (35%)	7273458.205	7470522.343	7004734.379	7578011.873	8079629.681	6753925.476
Amount lost to evapotranspiration and runoff	16077397.79	16223276.24	12072118.21	11007453.46	11509071.26	8903724.677
Amount, in gallons, available for recharge per month	4703911.364	5121073.317	7941408.587	10644009.04	11575584.97	10393205.25
Amount, in gallons, available for recharge per day	156781.3658	170685.3736	264687.1482	354764.8213	385814.2469	346405.5311
Amount, in gallons, available for recharge per minute	108.8689804	118.5239235	183.7987557	246.3486919	267.9094131	240.5440008

Conclusion

The system of fractures that appear to exist within the subject properties have a the potential to produce supplemental water, assuming a sufficient number of successful test wells are drilled and developed.

ATTACHMENT TO APPENDIX S

The following table illustrates the availability of groundwater as water supply at Centennial Golf Club demonstrated in 1992. The two accompanying figures illustrate the locations of groundwater wells in the site vicinity.

New Wells

Location	Total Depth	Depth to Bedrock	Preliminary Yield [gpm]
Well 3	805	15	16
Well 4	815	115	25
Well 5	815	32	0.5
Well 6	815	24	35
Well 7	640	15	50
Subtotal	3890		126.5

Existing Wells

Location	Tested Well Yield [gpm]
Well 1	28
Fowler Well	40
Field Well	28
Subtotal	96

SUM Centennial Wells	**222.5 gpm**
	= 320,400 gallons per day

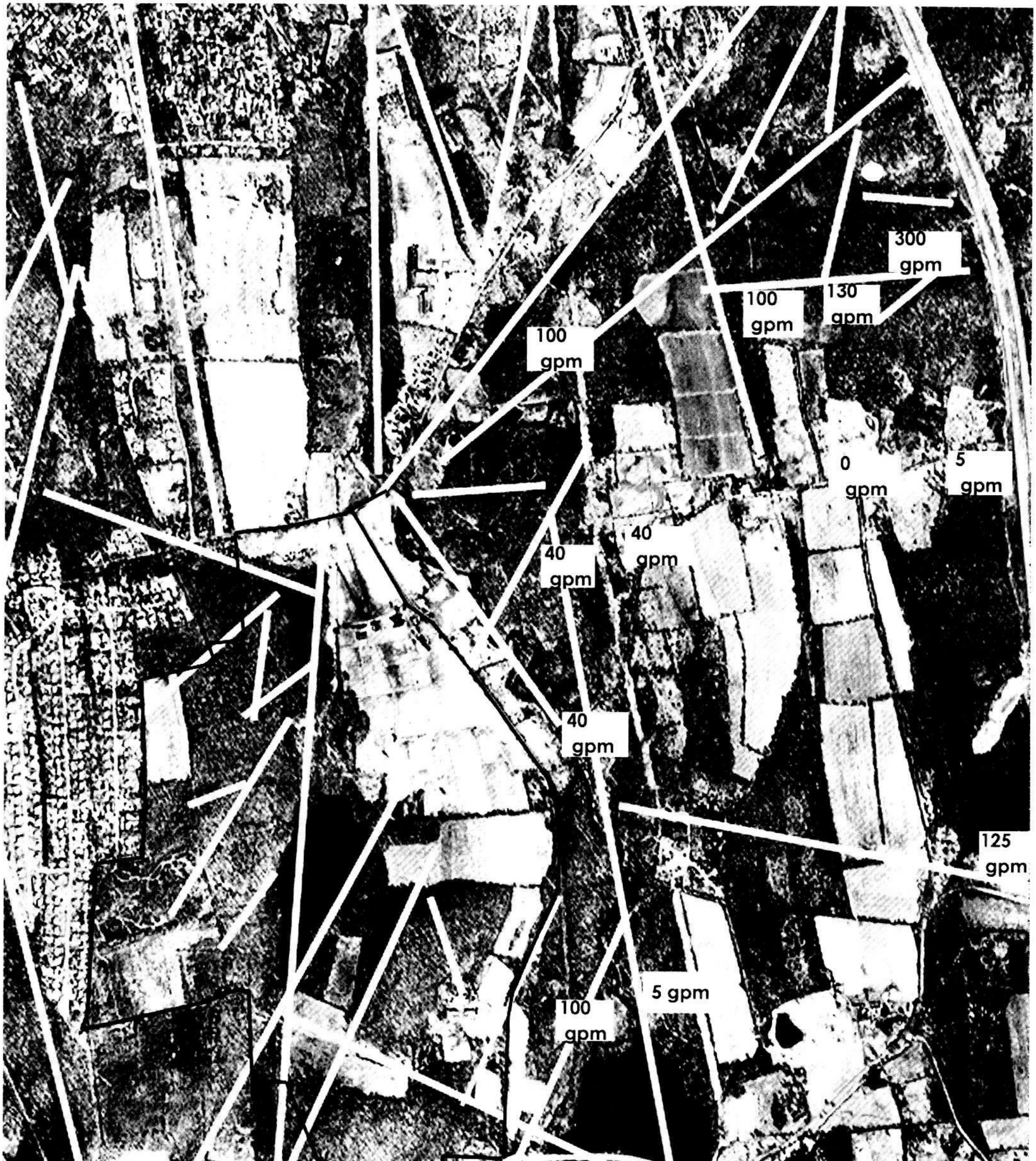


Figure Showing Existing Wells in Vicinity of Centennial Golf Club Property

Source: SSEC, Inc. (1992) for Centennial Golf Club

Scale: NTS

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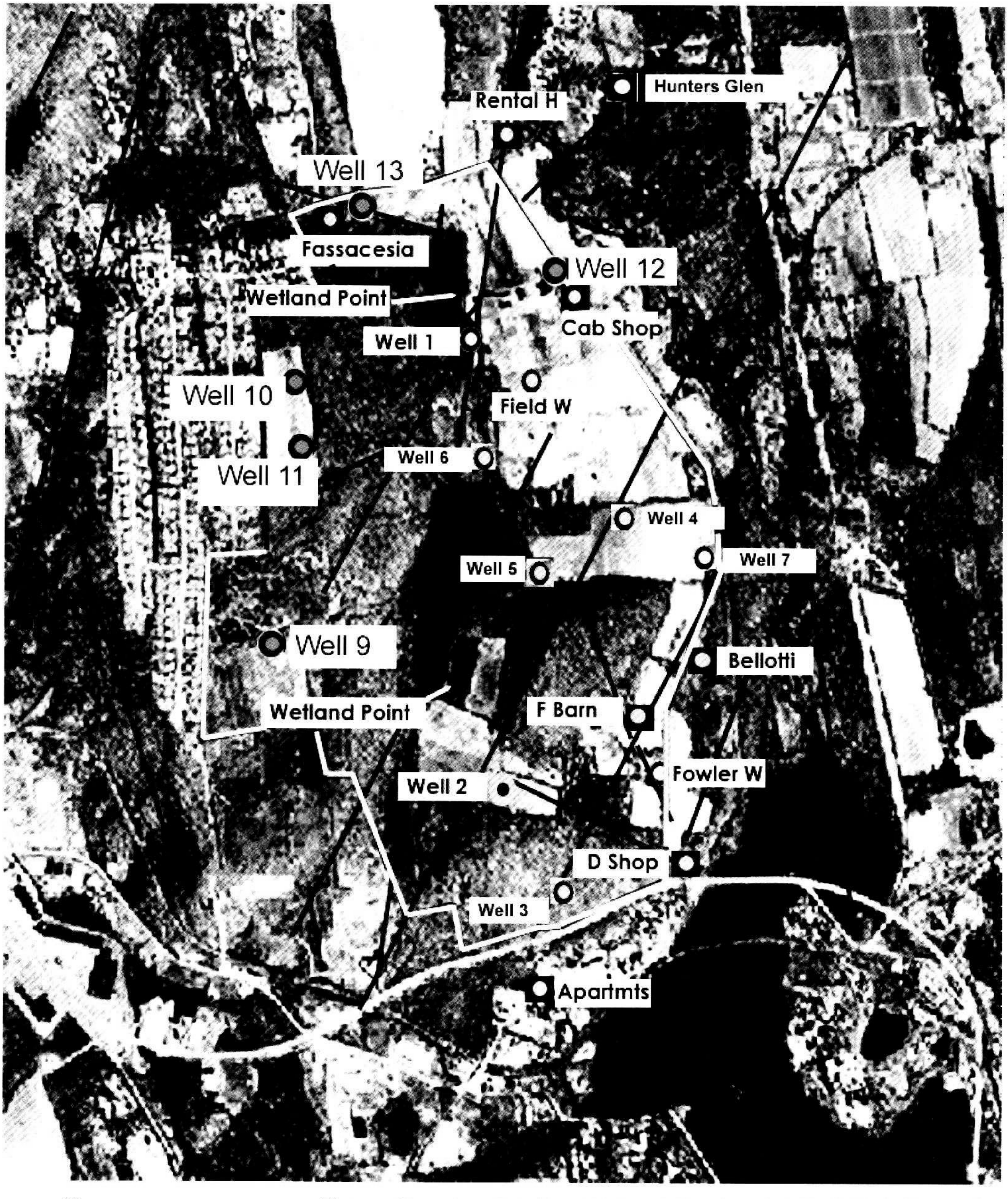

Figure Showing Existing Wells at Centennial Golf Club Property

Source: SSEC, Inc. (1992) for Centennial Golf Club

Scale: NTS

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