REGIONAL GROUND-WATER STUDY
TOWN OF HIGHLANDS
ORANGE COUNTY, NEW YORK

Prepared for

Orange County Water Authority

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EXECUTIVE SUMMARY

The Town of Highlands does not have a water district. The residents outside of the Village of Highland Falls are supplied by individual residential domestic wells. Unconsolidated deposits are scarce in Highlands, and almost all wells draw ground-water from the bedrock aquifer. Several subdivisions, including the proposed Corbin Hills and the existing Linden Manor subdivision in Fort Montgomery, utilize bedrock wells which reportedly yield up to 40 gpm (gallons per minute). High radon concentrations are commonly reported in the groundwater. Adequate water supply and demand data for the Town of Highlands are not available to evaluate future water deficits or surpluses. Based on a projected population curve and average per capita consumption it appears that by the year 2020 the town will have a demand of 1.26 mgd (million gallons per day).

The Village of Highland Falls is supplied by impounded surface water. Mr. James McDonald, treatment plant operator, estimates the Village's present and near future average water demand for the public system is about 0.45 mgd. The current reservoir maximum yield capacity of 0.53 mgd will meet the projected water demand in the year 2020 estimated to be 0.45 mgd.

INTRODUCTION

The Orange County Water Authority retained Lawler, Matusky and Skelly Engineers (LMS) to conduct a regional ground-water study for the Town of Highlands including the Village of Highland Falls and the hamlet of Fort Montgomery. The study primarily involved:

- an inventory of existing municipal surface water supplies;
- an evaluation of the adequacy of the supplies and their ability to meet present and future demands;
- a review of local geology, zoning and land use
- a review of existing and potential groundwater contamination problems within the Town which may effect ground-water quality.

There are no community water supply wells in the Town of Highlands or the Village of Highland Falls which satisfy the reporting criteria of producing at least 50,000 gpd. The hamlet of Fort Montgomery, which is located in Highlands, has several notable wells which are discussed below. The Town of Highlands which is supplied by private, individual domestic wells does not have a water district. The United States Military Academy (USMA), located in Highlands, is supplied by two surface water sources, the Stony Lonesome and Lusk systems. The Palisades Park Commission, which includes Harriman State Park, also contains a surface water supply. However, the USMA and Harriman State Park were not included as part of this investigation.

The Village of Highland Falls is supplied from a diversion dam on Highlands Brook. The water is stored by the Upper Bog Meadow Reservoir and Jim's Pond which feed the Lower Bog Meadow Reservoir and the diversion dam. The Highland Falls Village supply is the only municipal water supply in the Town of Highlands (Donofrio, 1993).

EXISTING WATER SUPPLY SYSTEMS

Highland Falls Village Supply

Surface Water Reservoir System

The source of the Highland Falls Water Supply is the Highland Brook; also known as Buttermilk Falls Brook. Watershed drainage area totals are 2.9 square miles at the intake. Two storage reservoirs in the upper reaches of the watershed impound runoff from less than one quarter of the total drainage area.

Flow is released from the reservoirs to augment stream flow at the intake as required for water supply. The releases and unregulated runoff from the remaining drainage area are intercepted by the main and the auxiliary intake basins. The auxiliary intake is upstream of the 2.5 million gallon (mg) main intake basin. The main intake channels the water to the treatment plant through a 12-inch pipe. The reservoirs are all located in former swampy areas and are designated Upper Bog Meadow, Jim's Pond, and Lower Bog Meadow. They have capacities of 100 mg, 20 mg, and 5 mg, respectively. Combined

usable storage, however, is reported to be about 85 million gallons.

Determination of the dependable yield of the Highland Falls system is complicated by the fact that flow from most of the drainage area is unregulated. In August 1965, the dependable yield was estimated to be about 0.53 mgd (McDonald, 1993).

The surface water treatment includes the following steps: aeration (Cascade); rapid mix; coagulation (alum); flocculation; sedimentation; three rapid sand filters with capacities of 0.38 mgd each; chlorine disinfection; flouridation; and corrosion control (soda ash) (Orange County Department of Health [OCDOH]).

Low Producing Wells in Service

The Orange County Department of Health water supply files indicate that six developments (subdivisions and trailer parks) are supplied by groundwater. The most notable well reported in the Town of Highlands supplies Lower Hudson View Terrace (Groundwater Inventory Map ["GIM"], Well HL-1) and presently yields 30 gpm. The bedrock well is completed in granite (as are most of the reported wells in Highlands) with an open rock interval from 20-240 feet in depth according to the Orange County Department of Health (OCDOH) single line inventory file.

Fort Montgomery Ground-Water Supply

The most notable well reported in the Fort Montgomery section of Highlands is the proposed Corbin Hills Well No. 3 (GIM, Well HL-4). The well is 245 feet deep, and its reported yield is 41 gpm (OCDOH single line inventory file). Drillers logs from Linden Manor, also located in Fort Montgomery (GIM, Wells HL-5 and HL-6), describe the bedrock as granite and "iron ore" overlain by five feet of overburden (Fullam, 1975).

PROPOSED COMMUNITY WATER SUPPLY SYSTEMS

Corbin Hills Subdivision

The Corbin Hills subdivision located in Fort Montgomery, has three proposed supply wells (GIM, Wells HL-2, HL-3 and HL-4) with yields ranging from 29 to 41 gpm. The well depths range from 205 to 273 feet, however there is no specific data regarding the geologic media. The wells are proposed to supply a proposed subdivision that is presently in bankruptcy (Livsey, 1993).

Schoonmacher Homes Subdivision

The Schoonmacher Homes Subdivision, located within the Town of Highlands, has two proposed supply wells. Information for these wells was not available.

WATER SUPPLY DEMAND

Highland Falls Village Supply

Mr. James McDonald, filtration plant operator, reported that the present supply meets the average daily water demands of about 0.45 mgd and the estimated maximum daily water demand of 0.6 mgd. The average maximum yield capacity of the reservoir system is estimated at 0.53 mgd.

Fort Montgomery Groundwater Supply

Detailed well production records were not available for the Corbin Hills and Linden Manor subdivisions. Water supply planning data for the Linden Manor development projected average daily water demand to be .016 mgd and maximum daily water demand to be about 0.02 mgd. The maximum yield capacity, based on yield test data is 0.07 mgd; which exceeds the maximum daily water supply demand for the Linden Manor development (Fullam, 1975).

Projected Water Demands

Table 4 indicates that existing and proposed reservoir capacity of the Highland Falls impoundment system will have a maximum capacity of up to 0.53 mgd. The current average water demand for the Village of Highland Falls is estimated to be about 0.45 mgd and the existing and proposed supply will also likely have a maximum yield capacity up to 0.5 mgd. The projected water demand was estimated using the population projections reported in the Orange County Comprehensive Sewerage Study (Hazen and Sawyer, 1991). The data indicates that by the year 2020, the Village will likely have a water supply surplus estimated to be about 0.08 mgd.

Population/Demand Analysis

Population growth or decline was analyzed for the Town of Highlands and Village of Highland Falls. Population projections were obtained from the Orange County Comprehensive Sewerage Study (Hazen and Sawyer, 1991) for these areas from the present to the year 2020. These points were plotted to determine the trends and predict population changes that would affect the water demand to the year 2030.

Predictions on population that would affect water demand were accomplished with a linear regression statistical analysis of the population data. The objectives of the linear regression method are:

- to determine a relationship between variables
- to describe the nature of the relationship, should one exist, in the form of a linear equation
- to assess the degree of accuracy of description or prediction achieved by the regression method (Kachigan, 1991).

Points of known population were graphed. The values for the points were calculated using the regression method, and a slope, y axis intercept, and correlation coefficient (r) were solved for. The correlation or regression coefficient is used to determine the accuracy of the line based on the control points. Using the equation of a line and the slope and y-intercept determined from the regression calculation, values for future population were calculated based on trends of the last 30 years and are listed below.

The projected future water demands were estimated by multiplying the projected population by an average per capita use factor of 100 gpd. Based on the data, the demand for the Town of Highlands is projected to be 1.26 mgd, and demand for the Village of Highland Falls is projected to be 0.45 in the year 2020. This demand, based on a declining population, is less than current demand.

2000		2010		2020		2030	
Persons	Water Demand[1]	Persons	Water Demand[1]	Persons	Water Demand[1]	Persons	Water Demand[1]
TOWN OF HIGHLANDS							
10,900	1.09	11,700	1.17	12,600	1.26	13,460	1.35
VILLAGE OF HIGHLAND FALLS							
4,200	0.42	4,400	0.44	4,500	0.45	4,640	0.46

[1] 100 gpd is the average daily use per person of water; water demand in mgd.
Source: Civil Engineering Reference Manual, 6th Edition, Michael R. Lindeburg, 1992 (pg. 7 - 16).

GEOLOGY

Unconsolidated Deposits

Unconsolidated deposits are relatively thin over the upland region of Highlands as compared with Central Orange County. Frimpter (1972) does not report sand and gravel deposits in the Town of Highlands. The unconsolidated deposits in the Fort Montgomery area are reported to be thin and patchy distribution of glacial till. The till is described as a poorly sorted mixture of boulders, pebbles, and finer grained sand, silt, and clay deposited directly from an overriding ice sheet. Due to its unsorted, fine grained nature, the till has low porosity and permeability and is generally a poor aquifer (Satterthwaite, 1986).

Bedrock Aquifer

The Town of Highlands is situated within the New England physiographic province consisting of upland topography with limited soil cover. The Geologic Map of Orange County (Fisher, 1970) indicates that the Town of Highlands is underlain by structurally complex, middle proterozoic, metamorphic granitic gneiss bedrock of uncertain age. The complex geologic structure of multiple lithologic contacts, anticlines, and synclines includes faults and a mapped fracture trace which are prospective targets for fault plane aquifers.

Bedrock is described in detail in a ground-water study of the Dodson property in Fort Montgomery by Walter B. Satterthwaite Associates, Inc. (Satterthwaite, 1986), as consisting of garnet-bearing gneiss and interlayed quartzite as well as amphibolite, pyroxennic amphiabolite and hornblende gneiss. Typical well yields in the bedrock are reported on the average as less than 10 gpm, however a series of seven to ten fracture traces and seven to ten lineaments were detected trending N30W to N13E, with associated water bearing capacities of as much as 190 gpm (Satterthwaite, 1986).

LAND USE

The land-use map indicates the following:

The majority of the land use in the Town of Highlands is open space associated with the U. S. Military Academy and Harriman State Park. Residential, commercial and industrial land uses are concentrated along the Hudson River in the Village of Highland Falls, the Hamlet of Fort Montgomery and the U. S. Military Academy campus. Existing surface water supplies are located in undeveloped areas; existing community groundwater supplies are located within residential land use areas; and several potential contamination sites are located within the vicinity of Fort Montgomery. The Town should consider the potential risk to the water supply from these sites (Space Track, 1993).

WATER QUALITY

Although only minimal data is available regarding water quality, several reports indicate the presence of naturally occurring compounds which affect the bedrock aquifer water quality. These are high concentrations of iron, manganese, and fluoride. High concentrations of sodium and lithium also have been reported.

Radon

Dr. Mike Kitto of the Wadsworth Center for Laboratories and Research represents the NYSDOH and indicated elevated levels of radon gas (the highest levels in New York state) have commonly been reported in wells located in the Village of Highland Falls, and Fort Montgomery. Concentrations greater than 110,000 pCi/L of radon have been detected in groundwater in these areas, located above the eastern extension of the Reading Prong. The Reading Pronge is a linear band of granitic bedrock which extends from Reading, Pennsylvania through Orange County, continuing up to Maine. Decay of the natural uranium in the granite produces radon gas.

Presently, no regulatory health based limits exist for waterborne radon. To place the measured concentrations in perspective, 1000 pCi/L of waterborne radon contributes about 0.1 pCi/L of indoor radon in the air of a home. The USEPA recommended limit for indoor air radon is 4 pCi/L. Thus, any concentrations in excess of 40,000 pCi/L will most likely exceed the USEPA indoor air limit (Kitto, 1993).

INVENTORY OF GROUND-WATER CONTAMINATION PROBLEMS

Existing Ground-Water Contamination Problems

LMS reviewed existing known ground-water contamination sites from a Freedom of Information Law (FOIL) New York State Department of Environmental Conservation (NYSDEC) file search. The FOIL search included NYSDEC inactive hazardous waste sites, active remediation projects at spill sites, spill sites, solid waste facilities, petroleum bulk storage sites and RCRA sites for the Town of Highlands and Village of Highland Falls. According to the file search there are no existing ground-water contamination sites in the Town of Highlands or Village of Highland Falls (NYSDEC 1993). Based on a discussion with an unidentified town clerk, the following sites were identified.

Spill Site

Spill located on Cherry Street in Fort Montgomery; gasoline contamination detected in residential water supply wells.

Spill Site

Spill located on Franklin Street in Fort Montgomery; fuel oil detected in a residential water supply well.

Potential Ground-Water Contamination Problems

Information about potential ground-water contamination sites was obtained from:

- FOIL request to NYSDEC (LMS, 1993); and
- Land use data from the Orange County, New York Real Property Tax Assessment data base (Space Track, 1993).

The following summarizes the potential ground-water contamination sites. Several potential sites are listed for West Point and will not be discussed.

Town Landfill

Craigston Sanitary Landfill is listed by the NYSDEC as being located in the Town of Highlands.

Spill Site

Highland Falls Middle School located at 40 Mountain Avenue in Highland Falls.

Town Salt Storage

Small salt storage facility in Fort Montgomery on Route 9W about 1 mile north of the Bear Mountain Bridge.

Town Salt Storage

Very small salt storage facility located in the Village of Highland Falls on Havens Road.

Each property in Orange County has a land use code number. Properties with land use code numbers associated with potential contamination of ground water were identified through analysis of the Real Property Tax Assessment data base by Space Track, Inc. The types of land uses in the potential contamination category include:

- industrial facilities;
- gas stations;
- dry cleaners, and
- auto repair facilities.

Where possible, approximate locations of these sites are shown as triangles on the GIM.

Petroleum Bulk Storage Facilities

The FOIL request from the NYSDEC inventoried the petroleum bulk storage facilities presented on Table 5.

The above sites are listed as potential ground-water contamination sites. Further investigations would be required to determine if contamination exists at the respective locations.

CONCLUSIONS

There are no water districts within the Town of Highlands. The residential population obtains its water supply from individual home owner bedrock wells. Several subdivisions are supplied by small community well systems, which yield less than the reporting criteria of 50,000 gpd. One notable subdivision is the proposed Corbin Hills development in Fort Montgomery which is capable of producing a combined yield from two wells of 0.07 mgd. This review indicates that the bedrock aquifer in Town is suitable for development of moderate yielding wells.

The Village of Highland Falls is supplied by impounded surface water and individual homeowner wells. High levels of radon have been detected in many of these wells. Data indicates that the current surface water supply is adequate to meet future demands.

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Hazen and Sawyer, 1991, Orange County, New York, Comprehensive Sewerage Study, September 1991.

Kitto, Michael, personal communication on October 28, 1993.

Supervisor Mervin Livsey, personal communication on December 21, 1993.

Mayor Joseph Donofrio personal communication on August 30, 1993.

McDonald, James, personal communication on November 1, 1993.

New York State Department of Environmental Conservation; Freedom of Information request.

Orange County Department of Health, single line inventory file.

Walter B. Satterthwaite Associates, Inc., 1986, Water Well Location Study, Dodson Property. Fort Montgomery, New York.

Space Track, Inc., 1993, "Orange County Landuse Maps."

TABLE 1

TOWN OF HIGHLANDS (Fort Montgomery)

Summary of Available Well Data

Well Water District	Tax Map Municipality Section Block Lot	Map Location I.D. #	Well Status	Reported Yield (gpm) Original Present	Depth of Well (feet)	Well Diameter (inches)	Length of Casing (feet)	Well Screen Length (feet) Setting Interval (feet)	Aquifer	Date Drilled	Comments
Well 3 Lower Hudson View Terrace	9 2 4	Highlands 1	In Service Active	NA 30	240	6	20		Granite	NA	
Well 1 Corbin Hills	11 1 38	Highlands 2	Inactive Not Equipped	29 NA	273	NA	NA		NA	1986	
Well 2 Corbin Hills	11 1 38	Highlands 3	Inactive Not Equipped	35 NA	205	N	NA		NA	1986	
Well 3 Corbin Hills	11 1 38	Highlands 4	Inactive Not Equipped	41 NA	245	NA	NA		NA	1986	
Well 1 Linden Manor	NA	Highlands 5	In Service Active	29 NA	135	6	20		Bedrock Granite	1973	Artesian
Well 2 Linden Manor	NA	Highlands 6	In Service Active	18 NA	107	6	20		Bedrock Granite	1973	Artesian

gpm - Gallons per minute.
NA - Not available.

Note: There are no water supply wells in the Town of Highlands which satisfy the groundwater criteria of 50,000 mgd.

TABLE 2A

TOWN OF HIGHLANDS

Summary of Well Yield Capacities
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Well ----- Water District	WSA No. ----- Permitted Yield (gpm)	Average Yield Capacity (gpm) ----- (gpd)	Maximum Yield Capacity (gpm) ----- (gpd)	Comments
TOTALS	**(Total Permitted Yield)**	**(Total Yield Capacity)**	**(Total Maximum Yield Capacity)**	

gpm - Gallons per minute. WSA No. - Water Supply Application Number.
gpd - Gallons per day.

Note: There are no water supply wells in the Town of Highlands which satisfy the groundwater criteria of 50,000 mgd.

TABLE 4

TOWN OF HIGHLANDS

Projected Water Demand
1993 - 2020
(mgd)

Water District	Current Maximum Yield Capacity (mgd)	Current and Proposed* Maximum Yield Capacity (mgd)	1993 Projected Water Demand ----- Water-Supply Adequacy**	2000 Projected Water Demand ----- Water-Supply Adequacy***	2010 Projected Water Demand ----- Water-Supply Adequacy***	2020 Projected Water Demand ----- Water-Supply Adequacy***
Town of Highlands	NA	NA	1.09 -------- NA	1.09 -------- NA	1.17 -------- NA	1.26 -------- NA
TOTAL	NA	NA	1.09 -------- NA	1.09 -------- NA	1.17 -------- NA	1.26 -------- NA

mgd - Million gallons per day.
* Combined yield capacity of both current and proposed water supply(s).
** Calculated by current maximum yield capacity minus projected water demands.
*** Calculated by current and proposed maximum yield capacity minus projected water demands.

\+ Surplus water supply, mgd.
\- Water supply deficiency (mgd).

COMMENTS:

Note: There are no community water supplies within the Town of Highlands as residents obtain water from individual homeowner wells. Current maximum yield capacity is unknown.

TABLE 3 (OPTION A)

MUNICIPALITY: Town of Chester (per Town, Village or City)

Summary of Water-Supply Source

[Short Summary]

Existing Source

	Water District	**Ground Water (mgd)**
Current Average Daily Water Demand		
Current Maximum Daily Water Demand		
Maximum Yield Capacity		
Average Yield Capacity		
Proposed Sources (Average Day)		
TOTAL MAXIMUM YIELD CAPACITY (MGD) = ---------- CURRENT MAXIMUM DAILY USE (MGD) =		----------

mgd - Million gallons per day.

COMMENTS

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OCWA.TBL/OCWADSK

TABLE 3

TOWN OF HIGHLANDS

Summary of Water-Supply Source

There are no community water supplies within the Town of Highlands as residents obtain water from individual homeowner wells.

Existing Source
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	Surface Water (mgd)	**Ground Water (mgd)**
Current Average Daily Water Demand		
Current Maximum Daily Water Demand		
Maximum Yield Capacity		
Average Yield Capacity		
Proposed Sources (Average Day)		
***TOTAL MAXIMUM YIELD CAPACITY (MGD) =** ---------- ***CURRENT MAXIMUM DAILY USE (MGD) =**		---------

mgd - Million gallons per day.
* Combine surface water and ground-water sources.

COMMENTS

TABLE 2B

VILLAGE OF HIGHLAND FALLS

Summary of Well Yield Capacities
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Well ----- Water District	WSA No. ----- Permitted Yield (gpm)	Average Yield Capacity (gpm) ----- (gpd)	Maximum Yield Capacity (gpm) ----- (gpd)	Comments
TOTALS	**(Total Permitted Yield)**	**(Total Yield Capacity)**	**(Total Maximum Yield Capacity)**	

gpm - Gallons per minute. WSA No. - Water Supply Application Number.
gpd - Gallons per day.

Note: There are no water supply wells in the Village of Highland Falls which satisfy the groundwater criteria of 50,000 mgd.

TABLE 4

VILLAGE OF HIGHLAND FALLS

Projected Water Demand
1993 - 2020
(mgd)

Water District	Current Maximum Yield Capacity (mgd)	Current and Proposed* Maximum Yield Capacity (mgd)	1993 Projected Water Demand ----- Water-Supply Adequacy**	2000 Projected Water Demand ----- Water-Supply Adequacy***	2010 Projected Water Demand ----- Water-Supply Adequacy***	2020 Projected Water Demand ----- Water-Supply Adequacy***
Reservoir	0.53	0.53	0.42 --------- + 0.11**	0.42 -------- + 0.11***	0.44 ------- + 0.09***	0.45 --------- + 0.08***
TOTAL	0.53	0.53	0.42 ---------- + 0.11**	0.42 ---------- + 0.11***	0.44 -------- + 0.09***	0.45 ---------- + 0.08***

mgd - Million gallons per day.+ Surplus water supply, mgd.
*Combined yield capacity of both current and proposed water supply(s).
**Calculated by current maximum yield capacity minus projected water demands.
***Calculated by current and proposed maximum yield capacity minus projected water demands.

COMMENTS:
! Future projected water demands are based on Orange County Sewerage Study (Hazens and Sawyer, 1991) Populations.

TABLE 3

VILLAGE OF HIGHLAND FALLS

Summary of Water-Supply Source

The source of Highland Falls water supply is Highland Falls Brook which is impounded in these reservoirs, located in former wetlands.

Existing Source

	Surface Water (mgd)	**Ground Water (mgd)**
Current Average Daily Water Demand	0.45	
Current Maximum Daily Water Demand	0.51	
Maximum Yield Capacity	0.53	
Average Yield Capacity	0.45	
Proposed Sources (Average Day)		
***TOTAL MAXIMUM YIELD CAPACITY (MGD) = ---------- *CURRENT MAXIMUM DAILY USE (MGD) =**		**0.53 --------- 0.51**

mgd - Million gallons per day.
* Combine surface water and ground-water sources.

COMMENTS

- Current maximum daily water demand of 0.6 mgd is an estimate.
- In September, 1993 the water system Phase II drought reservoirs were at 48%
- A dam repair at the Upper Bog Meadow is currently in the design stage.