WATER-RESOURCES RECONNAISSANCE OF PRINCE WILLIAM FOREST PARK, VIRGINIA

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ABSTRACT

The water resources of Prince William Forest Park are described and possible locations for additional supply wells and springs are identified. Specific-capacity tests at eight supply wells in 1982 indicate little change in yield since about 1970. At Goodwill Camp No. 3, an unused spring with a yield of approximately 7 gallons per minute is available to augment the present supply. At Park Headquarters, an unused well could contribute approximately 14 gallons per minute to the present supply.

All but two of the supply wells have been drilled along or near ridge tops. The water in these wells primarily comes from the overlying thick sections of saprolite or Cretaceous sediments that slowly release water to the underlying rocks.

Because the Park Service presently is using a decentralized system of wells and springs, it is economical and practical to continue to use ground water for new and additional supplies, although surface water could also be used for additional supplies if needed. Expansion of existing water-storage facilites could help alleviate possible future water shortages.

INTRODUCTION

Purpose and Scope

This report summarizes the water resources of the southern part of Prince William Forest Park. Increased use of the Park facilities, coupled with a drought beginning in the summer of 1980 and extending into the winter of 1982, has raised questions about the adequacy of eight wells and three springs that normally provide a reliable water supply.

A cooperative study between the National Park Service and the U.S. Geological Survey was begun in 1982 to determine the present yields of wells and springs, locate alternate sites for new wells, and measure unused springs with potential for augmenting the present supplies. Water-level measurements were made at 13 wells; specific-capacity tests of 1-hour duration were run at eight wells; and discharge measurements were made at five springs and 13 surface-water sites.

Description of Study Area

Prince William Forest Park is located in southern Prince William County, Virginia, about 32 miles south of Washington, D.C. (figure 1). The study area includes only the southern part of the Park where water from wells and springs

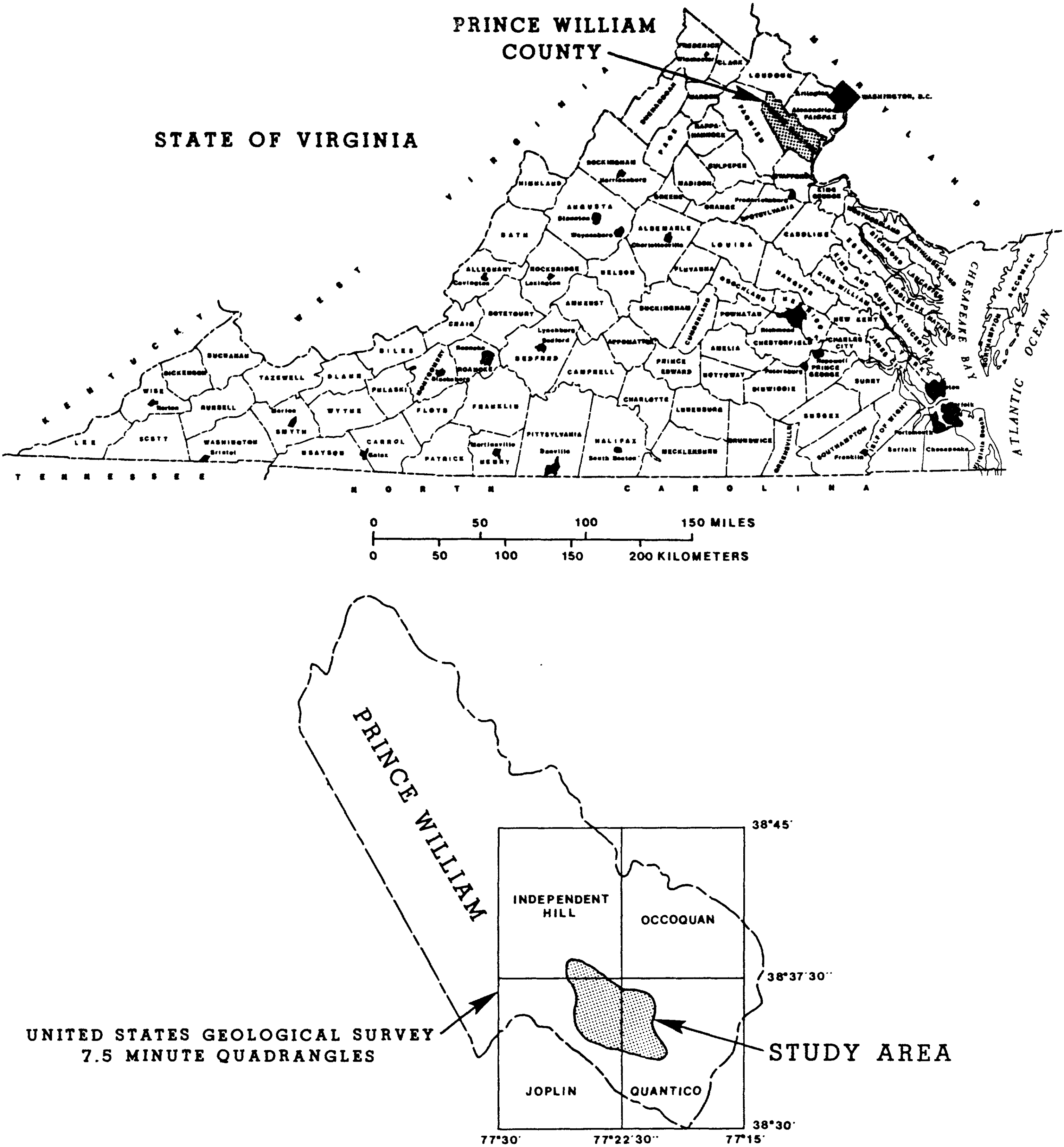

Figure 1.--Index map of Virginia showing location of Prince William Forest Park.

is used for supply. The area is bounded on the east by Interstate 95, on the south and west by State Highway 619, and on the north by Quantico Creek.

Well and Spring Numbering System

The well and spring numbering system used by the Geological Survey in Virginia is based on the Index to Topographic Maps of Virginia. The 7½-minute quadrangles are numbered 1 through 69 from west to east beginning at longitude 83°45' and are lettered A through Z (omitting letters I and O) from south to north, beginning at latitude 36°30'. Wells and springs are numbered serially within each 7½-minute quadrangle (an S precedes the serial number for each spring). For example, well 52S3 and spring 52SS1 are in the 7½-minute Quantico quadrangle. Well 52S3 was the third well inventoried and spring 52SS1 was the first spring inventoried in this quadrangle (see figure 2).

Previous Investigations

Background information for this study was taken from the files of the Geological Survey and National Park Service, and from a report by Brown (1981). Field work for Brown's report was completed in November 1975.

PHYSIOGRAPHIC AND GEOLOGIC SETTING

The study area straddles the Fall Line, which is the boundary between the Piedmont Province to the west and Coastal Plain Province to the east. The topography is undulating; with narrow ridge tops and relatively steep-sided valleys. The trend of the valleys and ridges is northwest-southeast.

The western three-fourths of the Park is in the Piedmont Province and is underlain by metamorphic rocks ranging in age from Precambrian and Early Cambrian to Late Ordovician. The rocks, which include gneiss, greenstone, phyllite, schist and slate, have been folded and faulted and now dip nearly vertically. Outcrops are found along the streambeds of South Fork Quantico Creek and some of its tributaries. Along the ridge tops and valley walls, the rocks are overlain by saprolite ranging in thickness from less than 5 feet to more than 150 feet. Saprolite is reported to be 150 feet thick at the supply well for Oak Ridge Campground (see pl.1). (Saprolite is thoroughly decomposed rock formed in place by chemical weathering of bedrock.) In the eastern third of the Park, younger Coastal Plain sediments consisting of sand, clay, silt and gravel of Cretaceous age unconformably overlie the saprolite and bedrock. A geologist's log indicates the Coastal Plain sediments are 140 feet thick at the supply well for the J.C. Williams Athletic Field near Park Headquarters. This thickness of sediments close to the Fall Line suggests a buried valley, a wave-cut beach along a former shoreline, folded and faulted bedrock, or a combination of one or more of these features. A detailed analysis of the cause(s) is beyond the scope of this report. Recent alluvial deposits are found along some of the streams throughout the Park.

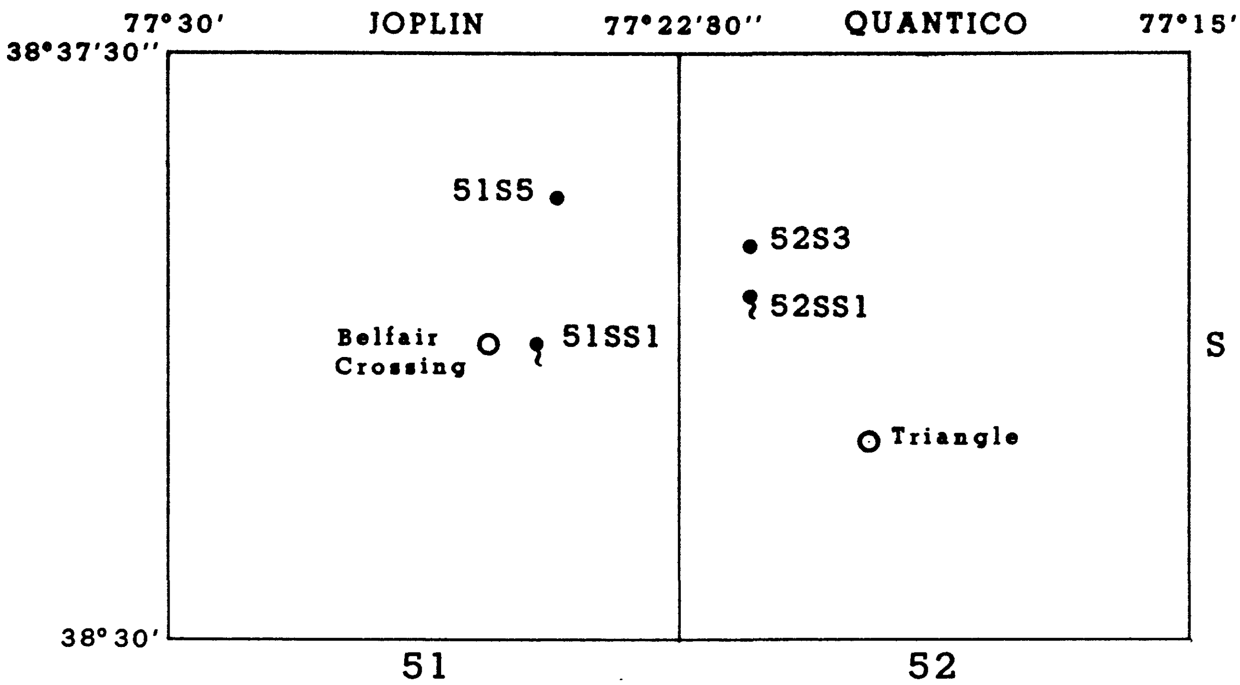

Figure 2.--Well and spring-numbering system in Joplin and Quantico quadrangles for wells and springs located within Prince William Forest Park, Virginia.

WATER RESOURCES

Precipitation

The average annual precipitation is about 38 inches. August is the wettest month and January is the driest month. Figure 3 shows the average monthly precipitation at Quantico, Virginia, for the period 1951-1980.

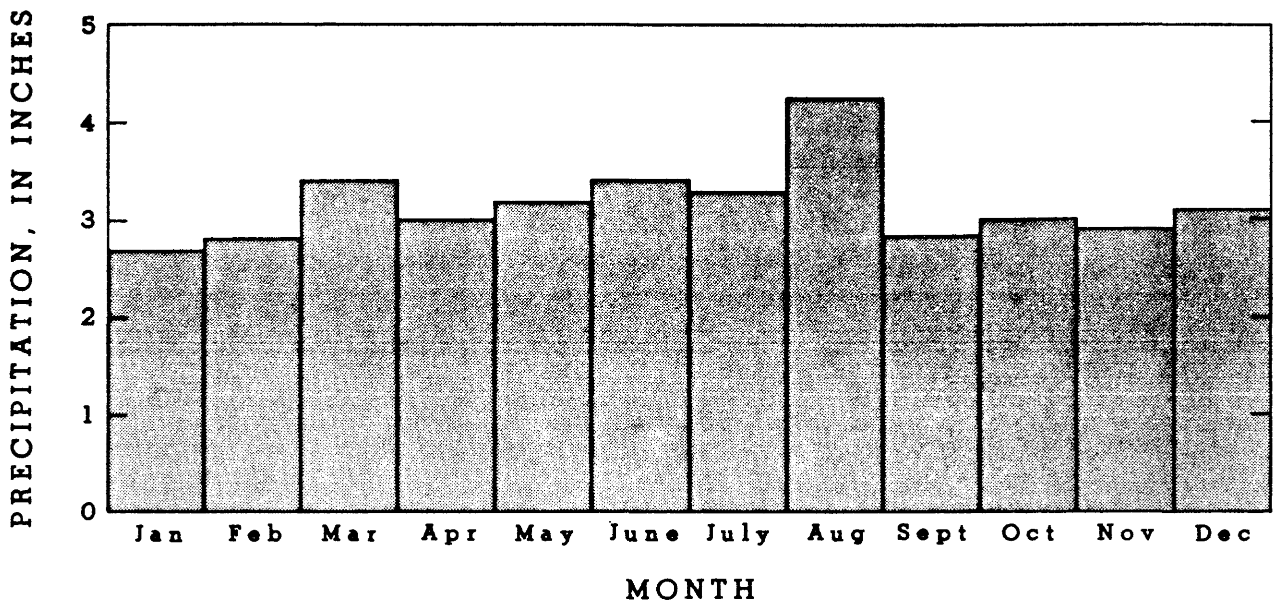

Figure 3.--Average monthly precipitation at Quantico, Virginia, for the period 1951-1980.

Ground Water

Ground water is found under water-table conditions. The water-table configuration reflects the local topography. Although the water table is highest beneath the ridges, the maximum depth to water occurs there. For example, the water level in the supply well on the ridge at Pine Grove picnic area near Park Headquarters was about 96 feet below land surface, in March of 1982. At the same time, the water level in the supply well in the valley between Mawavi Camp No. 2 and Happyland Camp No. 5 was only about 6 feet below land surface (see pl.1).

The direction of ground-water flow is from higher altitudes beneath the ridges to lower altitudes in the valleys. The valleys, in effect, act as collecting areas for ground water moving down the gradient and are generally considered the better areas for development of ground water. The supply well for Happyland Camp No. 5 (pl.1) is an example of a successful supply well drilled in a valley.

Storage of ground water within openings in the consolidated and unconsolidated rocks provides a source of water for streams and springs, as well as for withdrawal from wells. The term "storage" as used here refers to water in openings in the zone of saturation below the water table. There is some ground-water storage in the zone of aeration above the water table, but this water cannot be practically used for supply, and it is not discussed here.

In saprolite, ground-water storage occurs in interstitial openings between clay and silt particles. In unconsolidated Coastal Plain deposits, ground water is stored between clay, silt, sand, and gravel particles. In the clays and silts, interstitial openings may comprise as much as 45-60 percent of the volume of sediments, whereas in the sands and gravels these openings may comprise as much as 25-35 percent of the total sediment volume.

There is some storage in interstitial openings of the underlying bedrock but most storage occurs in openings along joint systems, bedding planes, faults and quartz veins. Openings along joint systems and bedding planes are generally about 3 percent of the volume of rock (Trainer and Watkins, 1975).

The maximum ground-water storage per volume of material occurs in the silts and clays of the Piedmont saprolite and Coastal Plain alluvium. Because of the very small size of these openings, the permeability and rate of movement of water may be several orders of magnitude less than in openings in sand and gravel or along joint systems and bedding planes in the bedrock. The high porosity and low permeability of the saprolite and clay provide for the storage of a large volume of water which is slowly released to the underlying rocks. The number of successful supply wells completed on ridge tops is due to this geologic condition. Examples are the wells near Park Headquarters on a ridge underlain by Cretaceous sediments as much as 140 feet thick. West of this area, at the supply well for Oak Ridge Campground (pl.1), saprolite is 150 feet thick.

The amount of ground water in storage changes with time. In the study area the source of ground-water recharge is precipitation. Losses from storage occur by evapotranspiration and ground-water discharge to streams and springs. Evapotranspiration losses are highest during the growing season. Ground-water discharge sustains streams and springs throughout the year.

The relationships among ground-water storage, streamflow, and precipitation for the period 1978 to 1982 are shown in figure 4. No spring-flow data were available for this period. The water levels were collected at Geological Survey observation well 51S7 near Happyland Camp No. 5 and streamflow data from the USGS gaging station on South Fork Quantico Creek near Independent Hill. Precipitation data are from the U.S. Marine Corps Air Station about 5 miles southeast of the Park. The average precipitation from which the departures were calculated is for the 30-year period 1951 to 1980.

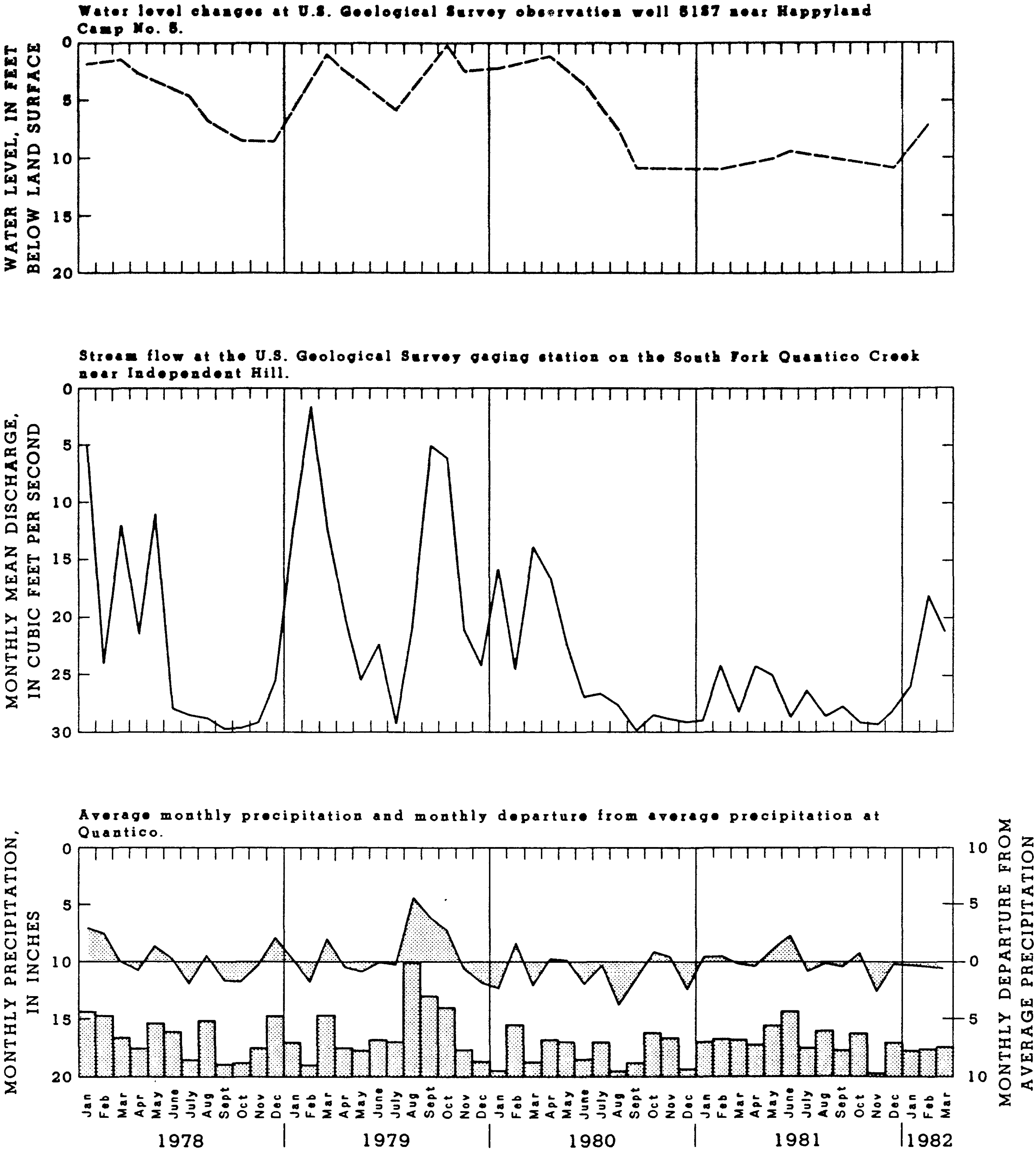

Figure 4.--Ground-water levels, surface water discharge and precipitation at Prince William Forest Park, for the period 1978 to 1982.

During the years 1978 to 1979, seasonal changes in ground-water levels and streamflow show a normal decline from late spring through fall when losses to evapotranspiration are a maximum. Increases in ground-water levels and streamflow occur during the winter to early spring when these losses are at a minimum. In the winter of 1980 and 1981, owing to below normal precipitation, there was no recovery of ground-water levels and streamflow was low.

As ground-water storage declines due to lessened precipitation and normal seasonal trends, there is less water available for wells, spring discharge and streamflow.

Streamflow

Streamflow measurements have been collected since May 1951, for South Fork Quantico Creek gaging station at the bridge on State Highway 619. The maximum discharge recorded was 3,940 ft^3/s (cubic feet per second) on June 21, 1972. The lowest flow recorded during the drought period June 1980 to December 1981 was 0.03 ft^3/s from September 6-15, 1980. No flow was recorded at times in 1954, 1957, and 1962-66.

Figure 5 shows the discharge measured at selected points along South Fork Quantico Creek and its tributaries on March 10 and 11, 1982. These points are located between the gaging station and the confluence with Quantico Creek.

Discharge measurements made along the mainstem of South Fork Quantico Creek in March of 1982, suggest that water may be lost between tributary 1 and tributary 3 (pl.1). It is possible this water is lost to bedrock along the stream channel. It is also possible that this decrease in measured stream flow is due to error in the streamflow measurements. More measurements are needed to confirm or deny this hypothesis.

PRESENT WATER USE

Peak demand for water during any given year occurs during the period May through September. The average per capita consumption at overnight facilities is about 35 gal/d (gallons per day) and at picnic areas and hiking trails, about 5 gal/d.

The number of people using the Park's facilities has increased from 24,400 in 1952 to about 500,000 in 1975. Since 1975 this number has fluctuated between 400,000 and just over 500,000. The greatest monthly total was 99,835 in May of 1979. More than 80 percent of use is in the southern part of the Park. Overnight accommodations at camps and campgrounds accomodate about 1,000 people.

Table 1 lists the number of vistors to the Park by annual and monthly totals for the period 1975-1981.

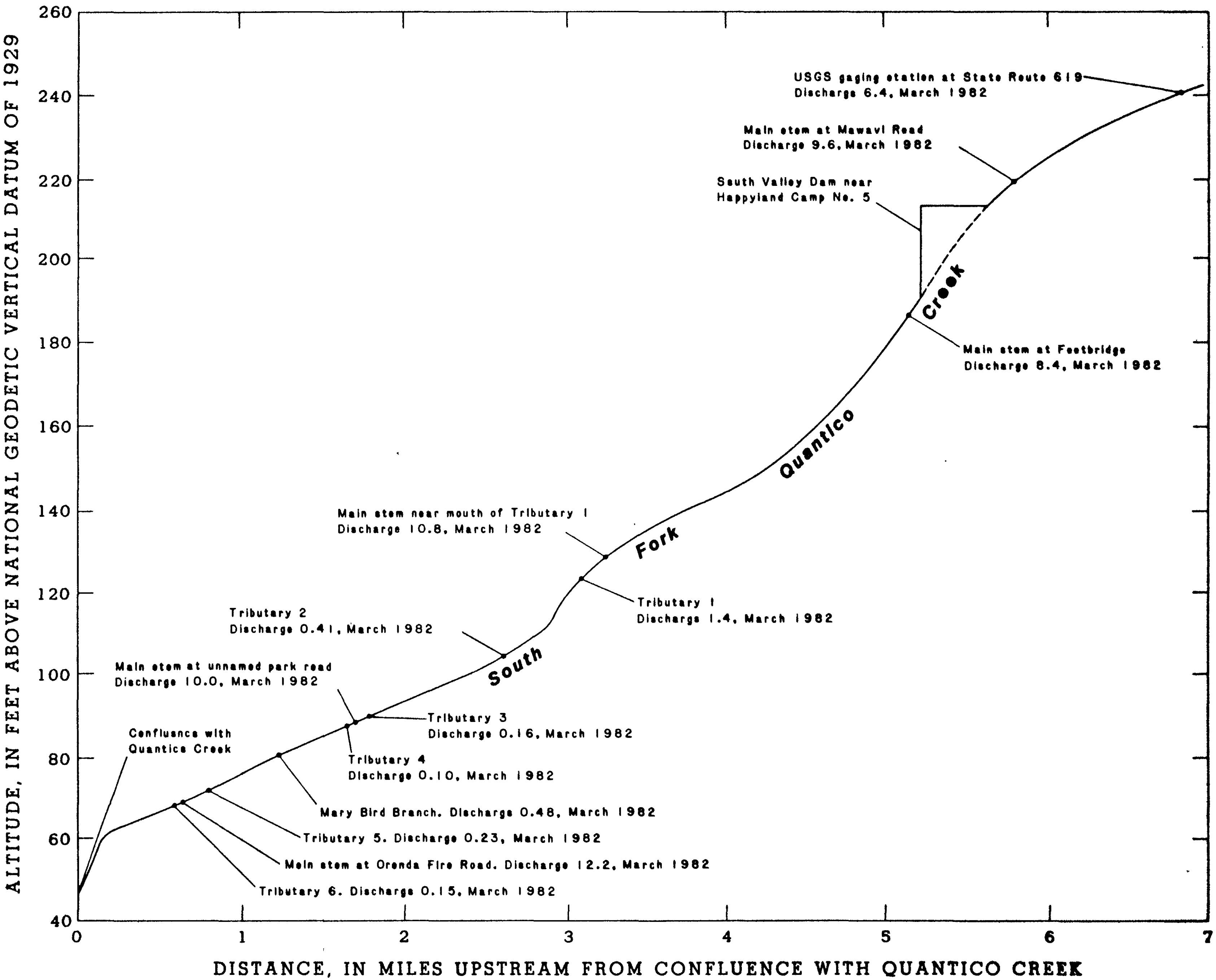

Figure 5.--Longitudinal profile of South Fork Quantico Creek. Discharge at sites shown are in cubic feet per second.

Table 1.-- Annual total and greatest monthly number of visitors at facilities for the period 1975-1981.

Year	Annual total	Month of greatest use	Number of visitors
1975	502,931	July	72,287
1976	415,639	July	82,501
1977	511,131	June	92,701
1978	521,532	September	87,325
1979	499,689	May	99,835
1980	404,838	July	58,270
1981	467,641	May	95,548

Use of the Park facilities is expected to increase because of its proximity to metropolitan areas to the north and south, and to a recently completed annex for Arlington National Cemetery just south of the Park.

PRESENT WATER SUPPLY

The present water supply for the study area is derived solely from ground water obtained from eight wells and three springs located at seven areas in the southern part of the Park. Peak demand for water occurs from May through September.

Well and Spring Yields

Historical and current data for individual wells and springs are given in table 2. Specific capacity is the yield in gallons per minute per foot of drawdown for a given period of time. All specific-capacity tests were of 1-hour duration except for the test (November 1973) at the maintenance area, well 52S14. Data from this test were taken from drillers' records which provided the yield and drawdown for a 5-hour period. Current data were collected by Geological Survey personnel during the period February-March 1982. Historical data were taken from files of the Geological Survey and drillers' records.

All wells listed in table 2 are similar in construction--finished open holes in bedrock. Well 52S30 near Park Headquarters (pl.1) also has screens set opposite sands of Cretaceous age, Potomac Group between 60 and 70 feet and 100 and 110 feet below land surface. Well 51S2 between Mawavi Camp No.2 and Happyland Camp No. 5 (pl.1) also has one screen set opposite partly weathered rock of the Precambrian or Lower Paleozoic Wissahickon Formation, from 39 to 49 feet below land surface.

In general, historical and current data are comparable. The well at the athletic field shows an increase in specific capacity. The yield in 1982 is

Table 2.--Historical and current yield data for wells and springs used for water supply in Prince William Forest Park.

		Historical Data					Current Data				
Local Number	Location	Water level in feet below land surface	Date	Specific capacity (gal/min/ft)	Yield (gal/min)	Date	Water level in feet below land surface	Date	Specific capacity (gal/min/ft)	Yield (gal/min)	Date
				Park Headquarters							
52S23	Well at Pine Grove Picnic area	--	--	ND	10*	--	96.27	03/05/82	.45	13.6	03/05/82
				Telegraph Road Picnic area							
52S30	Well at J.C. Williams Athletic Field	72.93	04/09/75	.35	7.1	04/09/75	58.52	03/04/82	1.62	11.5	03/04/82
		63.82	04/14/75								
52S24	Well at Telegraph Road Picnic area	65.60	10/25/72	ND	18	06/27/63	68.13	03/04/82	.87	14.3	03/04/82
				Goodwill Camp No. 3							
52S3	Well at Goodwill Camp No. 3	8.0*	06/26/68	ND	16	06/26/68	8.54	03/10/82	.45	13.6	03/10/82
52SS1	Spring at Goodwill Camp No. 3	--	--	ND	--	--	--	--	--	4.2	02/24/82
				Maintenance area							
52S14	Well at Park Maintenance area	30.0	11/00/73	.57*	.24*	11/00/73	35.52	03/04/82	.77	15.0	03/04/82
				Turkey Run Ridge Campground and Nature Center							
52S18	Well at Nature Center	27.59	10/26/72	ND	18*	--	27.03	03/03/82	.11	16.7	03/03/82
				Mawavi Camp No. 2 and Happyland Camp No. 5							
51S2	Well between Camps Nos. 2 and 5	6.0	06/19/68	.17*	10*	06/24/68	5.8	03/10/82	.11	10.9	03/10/82
51SS1	Spring between Camps Nos. 2 and 5	--	--	--	31**	06/08/73	--	--	--	16.5	02/25/82
51SS2	Spring between Camps Nos. 2 and 5	--	--	--			--	--	--	10.0	02/25/82
				Oak Ridge Campground							
51S5	Well at Oak Ridge Campground	31.71	10/26/72	ND	26*	06/24/63	38.86	03/03/82	.28	10.3	03/03/82

ND No previous specific capacity data available
* From drillers records
** Combined yield of both springs
R Reported

higher and the specific capacity is about five times that of 1975. This increase in specific capacity indicates that development of the well (by regular pumping) since completion and testing in 1975 has increased its productivity. The significant difference in yield for the well at Oak Ridge Campground (pl.1) in tests run in October 1972 and March 1982 is due to the use of two different size pumps during the tests. The yield shown for the springs supplying Mawavi Camp No. 2 and Happyland Camp No. 5 (pl.1) in June 1973, is the combined yield measured at the overflow from the underground reservoir. The yields shown for February 1982 were measured separately where the spring discharges enter the underground reservoirs.

Storage Facilities

Table 3 lists the amount of total storage available in elevated and underground reservoirs and shows yield data compiled from measurements made in February and March 1982. At all areas except Oak Ridge Campground, the combined potential daily yield of wells or springs, or both, exceeds the current storage capacity. At the athletic field near Park Headquarters, the potential daily yield of the well is about four times greater than the storage capacity of the elevated tank. At Turkey Run Ridge Campground (pl.1), the potential daily yield is about three times the storage capacity of the elevated tank. The potential daily yield of the two springs supplying Mawavi Camp No. 2 and Happyland Camp No. 5 (pl.1) is about twice the combined elevated and underground storage for these camps.

ALTERNATIVES FOR ADDITIONAL SUPPLIES

Ground Water

Additional supplies can be developed from surface- or ground-water sources. Of these potential sources, ground water is the easiest to develop at this time because it is available at or near each of the existing facilities. Several springs, in addition to those presently used for supply, were measured. Of these, only 52SS3 near Goodwill Camp No. 3 had a sufficient yield and is located close enough to existing supplies to be considered for development. A detailed inventory of springs in the Park, including quality-of-water analyses and discharge measurements, should be made to determine which springs are suitable for augmenting existing supplies.

Surface Water

There are sufficient streamflow and sediment data available for planning purposes for South Fork Quantico Creek. However, streamflow, sediment and water-quality data are not available for the tributaries. The collection, compilation and synthesis of these data would require additional studies.

CONCLUSIONS

There is sufficient water available from ground-water or surface-water sources to meet future needs of the Park within the study area. At the present time, with the existing decentralized water-supply system, it seems more practical to use ground water to develop additional supplies rather than surface water.

Table 3.--Comparison of potential yield and storage based on well yield and spring flow measured in February and March 1982 in Prince William Forest Park, Virginia.

Local number	Location	Potential yield (gallons per day)	Storage capacity*
	Park Headquarters		
52S23	Well at Pine Grove Picnic area	19,584	
52S30	Well at J.C. Williams Athletic Field	16,560	
	Total	36,144	20,000
	Telegraph Road Picnic Area		
52S24	Well at Telegraph Road Picnic Area	20,592	5,000
	Goodwill Camp No.3		
52S3	Well at Goodwill Camp No.3	19,584	
52SS1	Spring at Goodwill Camp No.3	6,048	
	Total	25,632	17,000
	Maintenance Area		
52S14	Well at Maintenance Area	21,600	20,000
	Turkey Run Ridge Campground and Nature Center		
52S18	Well at Nature Center	24,048	8,500
	Mawavi Camp No.2 and Happyland Camp No.5		
51S1	Well between Camps No. 2 and 5	16,969	
51SS1	Spring between Camps No. 2 and 5	23,760	
51SS2	Spring between Camps No. 2 and 5	14,400	
	Total	53,856	19,300
	Oak Ridge Campground		
51S5	Well at Oak Ridge Campground	14,832	20,000

* Storage is in above-ground and below-ground tanks.

In several areas of the Park, present supplies can be supplemented by increasing the capacity of storage facilities. Good records provide a history of streamflow, ground-water levels, well-yield and spring discharge, and are invaluable in evaluating changes with time.

The following are suggestions for placement of new well sites, springs that may be developed, and areas where storage may be increased, and for ways that record-keeping may be improved.

A. Park Headquarters:

1. The unused well (52S23) at Pine Grove picnic area can be cleaned out, redeveloped and put back on line. The yield of this well in March 1982, was 13.6 gal/min (gallons per minute).

2. Possible areas for new wells are in the valleys just to the north or west of well 52S23 at the picnic area.

B. J.C. Williams Athletic Field:

1. Possible site for a new well is in the valley just southwest of the supply well (52S30) at the ballfield.

C. Telegraph Road picnic area:

1. Possible site for a new well is off the access road just northwest of the supply well (52S24) at the picnic area.

D. Goodwill Camp Number 3:

1. Spring 52SS3, about 1,000 feet south-southeast of spring 52SS1 and well 52S3 (used to supply this area), can be developed and used to supplement the present supply for this camp. The discharge for this spring was approximately 7 gal/min in March 1982. Because it is at a higher altitude than spring 52SS1, it could feed the existing underground reservoir by gravity.

2. Possible areas for new wells:

   a. Along the valleys of South Fork Quantico Creek and its tributaries, such as the area near the bridge of Turkey Run Ridge Campground Road.

   b. North or South of the pond where the fire road crosses the tributary to South Fork Quantico Creek on the east side of Goodwill Camp No. 3.

3. Storage--The underground reservoir fed by gravity from spring 52SS1 and well 52S3 has a storage capacity of 11,500 gallons. The discharge from the spring measured at the overflow from the reservoir was approximately 4 gal/min and the yield of the well was approximately 14 gal/min in February 1982. There are

no previous discharge data available for the spring. Part of the overflow from the spring could be utilized by doubling the present reservoir capacity.

E. Maintenance area:

1. Possible areas for new wells are:

   a. At the end of the road running northeast toward the river from the supply well (52S14) for the area.

   b. In the valley north of well 52S14.

F. Mawavi Camp No. 2 and Happyland Camp No. 5:

1. Well 51S2 could probably be improved by pulling the screen and deepening this well from 102 to 300 feet. Water entering this well from the screen set in partly weathered rock is the source of the red coloring of the water.

2. Well 51S3 at Happyland Camp No. 5, open to a depth of 62 feet could be deepened to approximately 300 feet and tested as a possible supply well. There are no data on the original well construction or yield. However, the sounded depth of 62 feet in February 1982, was the same as when it was originally inventoried in November 1972.

3. Well 51S4 at Mawavi Camp No. 2 was sounded to 200 feet below land surface in November 1972, and reported to have been filled with debris to 18 feet below land surface in May 1974. It could be cleaned out and drilled to a depth of about 350 feet below land surface and tested as a possible supply well.

4. Possible areas for new wells are:

   a. Further down the valley from wells and springs used for supply at this area.

   b. Down the valley from well 51S7, the USGS observation well west of Happyland Camp No. 5.

   c. In the valley of the South Fork Quantico Creek where Mawavi Fire Road crosses the creek just north of Mawavi Camp No. 2.

5. Storage--The underground reservoirs which are fed by gravity from springs 51SS1 and 51SS2 have a combined storage of 13,800 gallons. Discharge from these springs measured at the overflow from the reservoirs was 31 gal/min in June 1972, and 26.5 gal/min in February 1982. Part of this overflow could be utilized by doubling the present storage capacity of these reservoirs and would provide ample water to meet peak demands.

G. Oak Ridge Campground:

1. Possible areas for new wells are:

a. In the valley south of Oak Ridge Campground and in the valley west of Oak Ridge Campground.

b. In the valley northeast of the supply well (51S5) for the area.

H. Turkey Run Ridge Campground and Nature Center:

1. Possible areas for new wells are:

a. In the valley of Mary Bird Branch just north or southeast of well 52S18.

b. In the valley of the tributary to South Fork Quantico Creek, just west of the Nature Center.

I. Records:

To provide up-to-date information on well construction, pump settings, changes in well depth, well yield and spring discharge, the maintenance of detailed records is required. Periodic discharge measurements should be made and recorded to determine seasonal changes and longterm trends for wells and springs. Non-pumping water-level measurements should be taken in the wells. Plotting these data provides a means for detecting changes with time. When pumps are pulled for routine maintenance, the well should be sounded to see if there has been any change in well depth due to silting or caving. Knowledge of the depth of pump setting is important in order to avoid drawing the water level below pump intakes.

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