PRINCE WILLIAM COUNTY

Department of Public Works
Thomas Smith, Director

MEMORANDUM

November 22, 2021

TO: Board of County Supervisors

FROM: Thomas J. Smith
Director of Public Works

THRU: Christopher E. Martino
County Executive

RE: Groundwater Study Proposal

EXECUTIVE SUMMARY

The Board of County Supervisors directed staff to evaluate the need for a study to determine the potential impact of land use and impervious area changes on groundwater. Staff researched pertinent available studies and resources specific to Prince William County and discussed this with the United States Geological Survey (USGS), Occoquan Watershed Monitoring Lab of Virginia Tech (OWML), Virginia Department of Environmental Quality (DEQ), and the Virginia Department of Health (VDH).

For considerations by the Board of County Supervisors staff developed a proposed scope of work with USGS to develop a Soil-Water Balance Model (Model) for Prince William County. The Model helps in estimating the amount of groundwater recharge relative to land use changes. The cost of this Model is $320,000 and it would take approximately two years to complete. With a federal matching contribution of $50,000 from USGS, the net County cost for the Model will be $270,000. USGS will provide easily comprehensible findings on groundwater recharge for historic and projected changes in land use at the end of year two.

This Model will not address groundwater quality or consider future withdrawal rates.

The Virginia Department of Health has not reported any concerns regarding wells going dry or water quality in groundwater aquifers in the County. According to the Prince William County Service Authority, sufficient public water supply is available to serve the County's population to at least 2040. Extension of public water is allowed under current policy should any groundwater quality or quantity issues occur in the future.

BACKGROUND

Purpose of the Study – Residents and the Board of County Supervisors have expressed concerns on the potential impact of development on groundwater and the sustainability of groundwater as a water supply with future changes in land use.

Groundwater - The availability of groundwater as a drinking water source depends largely upon surface and subsurface geology as well as climate (precipitation). Water moves through an aquifer from areas of recharge to areas of discharge. Recharge of groundwater occurs from precipitation that infiltrates into soils or that seeps from the bottom of surface water bodies such as lakes and streams. In addition to geology and climate, groundwater supply is affected by impervious cover, seasonal evapotranspiration from trees, and pumping of groundwater. A simple depiction of the Hydrologic Cycle is shown in Figure 1.

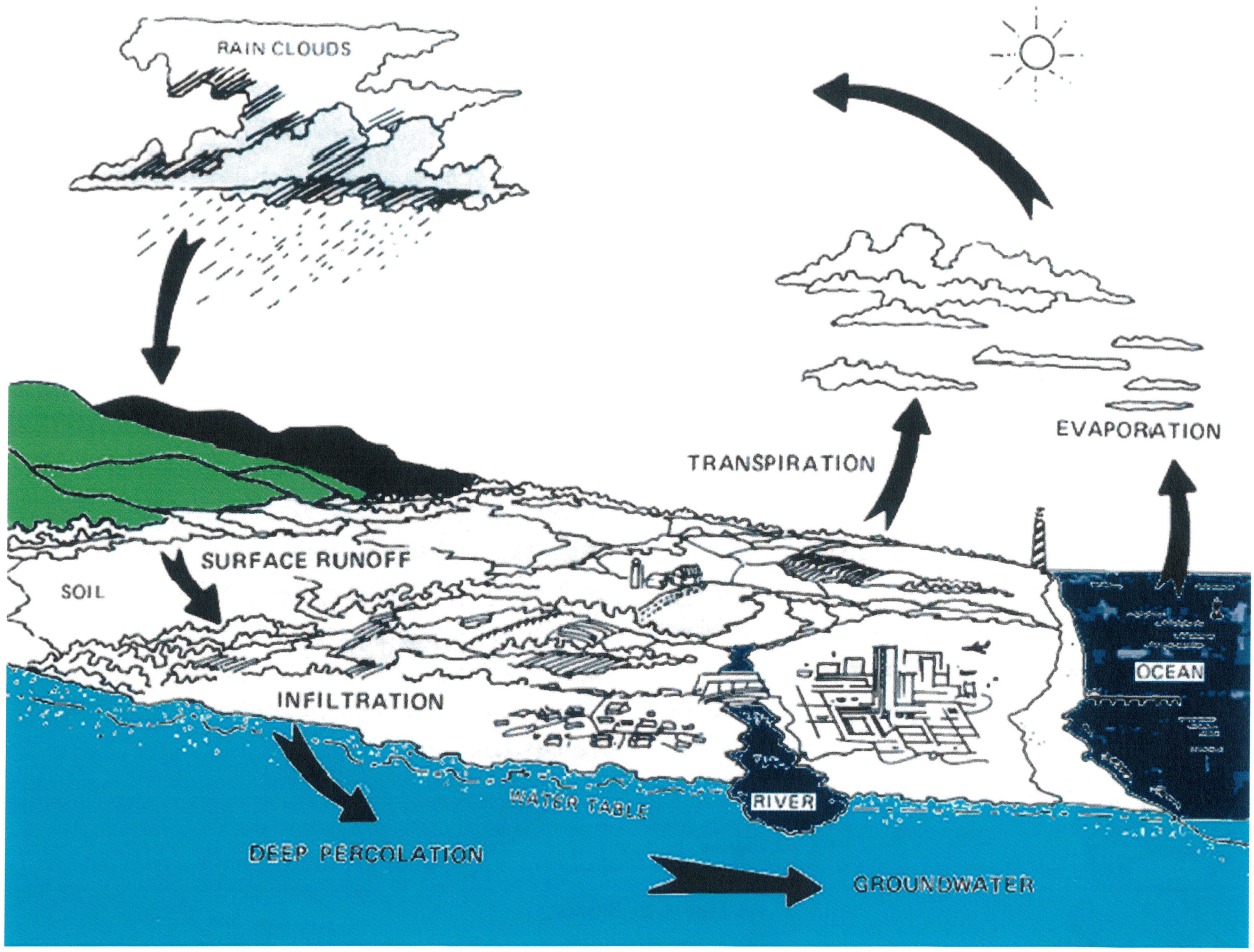

Figure 1 - Hydrologic Cycle

Culpeper Basin and Piedmont are the two major aquifers in the County. The groundwater systems are primarily recharged in elevated areas between stream valleys and discharged to streams and estuaries. Recharge occurs predominantly in colder months when plants are dormant, and evapotranspiration is not a factor. Figures 2 and 3 show the two aquifers in the County.

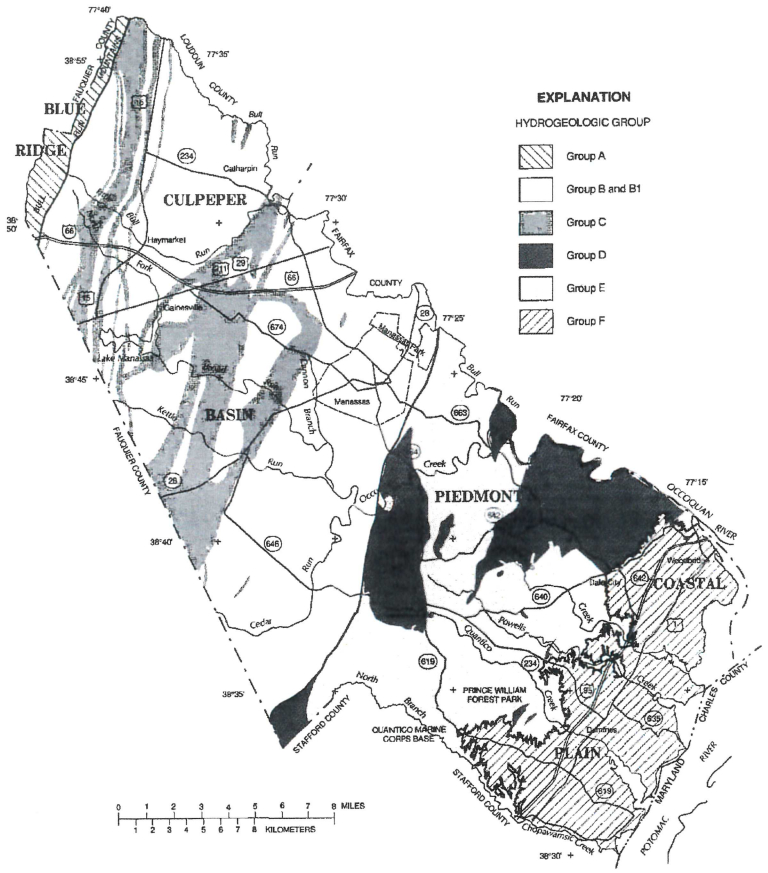

Figure 2 - Basins

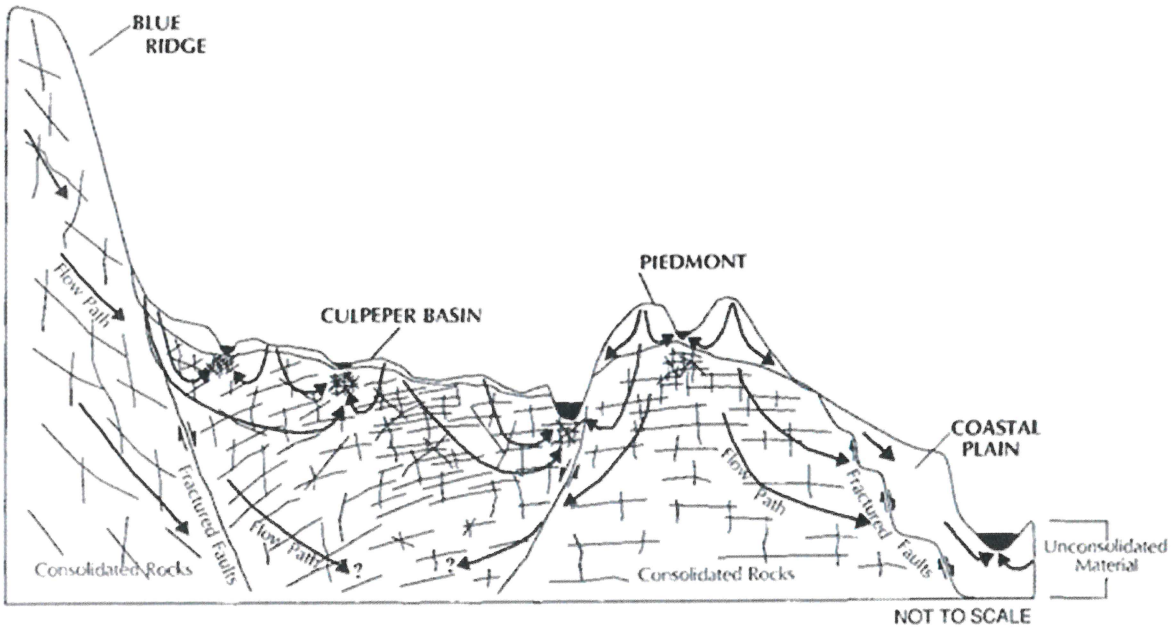

Figure 3 - Elevations

Previous Studies and Available information – USGS has been continuously monitoring water levels in two wells in the County for many years. One monitoring well is in Prince William Forest Park and the other in Bull Run Mountain area. Locations are shown in Figure 4. The water levels in the wells have remained relatively steady over the years, with seasonal and yearly fluctuations due to changes in weather and precipitation. Graph representations are shown in Figures 5 to 8.

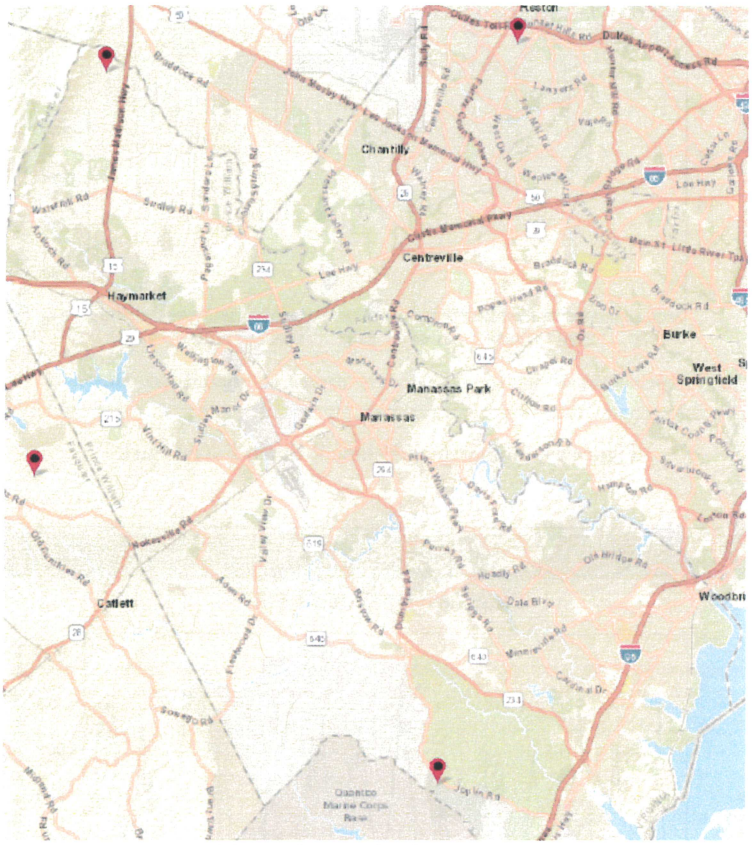

Figure 4 – Monitoring Wells

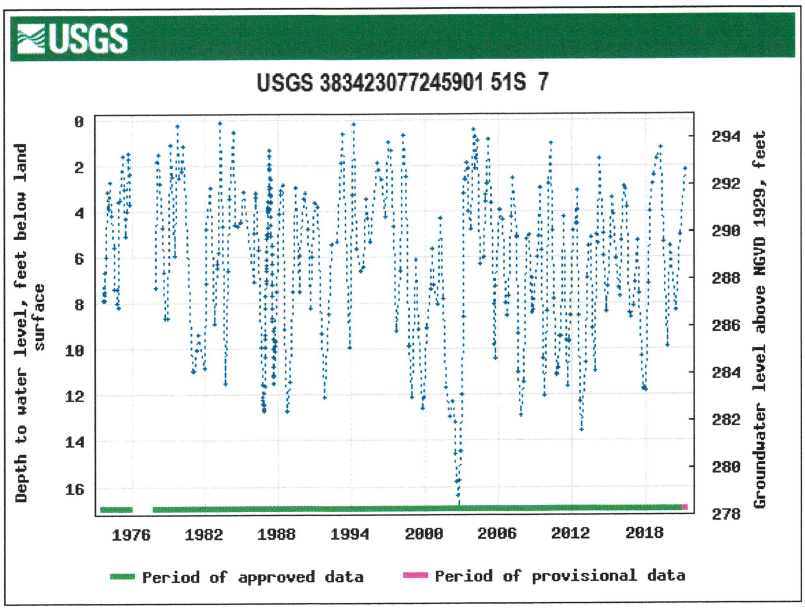

Figure 5 – Joplin Road/Prince William Forest Park

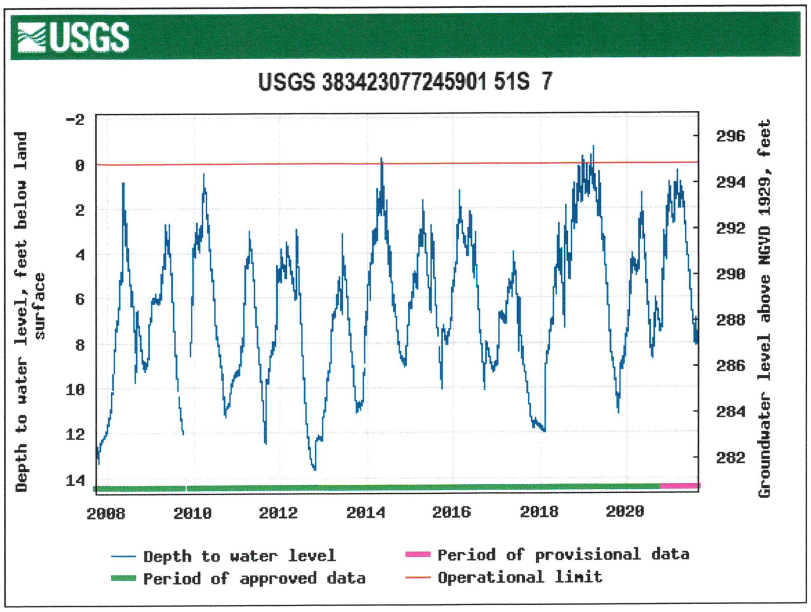

Figure 6 – Joplin/Prince William Forest Park

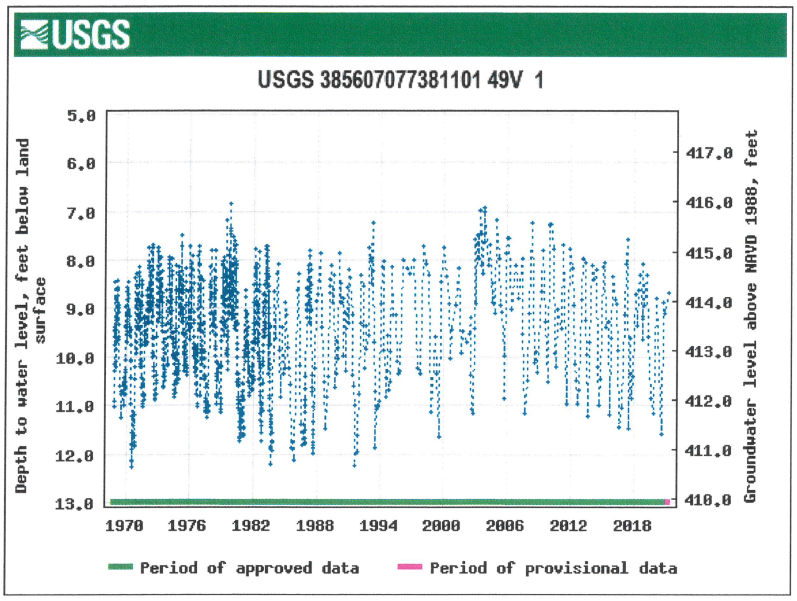

Figure 7 – Mountain Road/Loudoun Drive

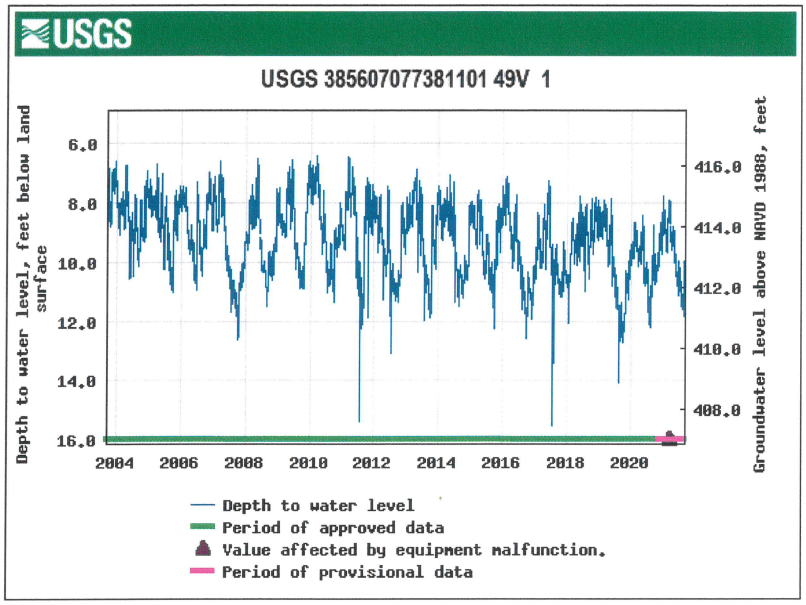

Figure 8 – Mountain Road/Loudoun Drive

The 1997 study published by USGS for Prince William County (Nelms and Brockman) indicated that the age of groundwater at the time of study was less than 45 years. Based on the study, the water levels are high during April and May and are the lowest during September/October, and the recharge is predominantly in colder months.

The study shows that the quality of groundwater varies across the County, and the primary concerns identified in the study were pH and Radon-222, and some other

concerns were on sulfate, chloride, total dissolved solids, iron, manganese, and zinc.

OWML has been continuously monitoring stream flows for some streams in the County for around 40 years. Computational methods can be used to extract the groundwater portion of inflow from the measured stream flows.

DEQ has some historic data on groundwater quality for some private individual wells in the County, in addition to reported water quality data from a few permitted industrial sites.

VDH has only very limited data on groundwater from individual private wells. Virginia Cooperative Extension Service provides limited assistance to residents in testing their water wells. The test results published can be found using this link: VAHWQP2012-19PrinceWilliamCounty | Piktochart Visual Editor

Discussion – Staff had several meetings and communications with USGS, OWML and DEQ. Our discussions centered on what data is available and how it can be used toward addressing the Board's concerns. USGS is currently conducting a groundwater study in Fauquier County, since groundwater is predominantly the source of municipal drinking water supply in Fauquier County. In response to our meetings, USGS proposed a Soil-Water Balance Model to analyze the impact of development on groundwater quantity. Input information to the Soil-Water Balance Model include precipitation, land use/land cover, soil hydrologic group, flow direction, and available water content. The Model estimates the amount of groundwater recharge available for water resource planning for projected changes in land use and land cover. Information from historic stream flow monitoring data from OWML will also be integrated into the Model. Based on County's request, USGS has provided a scope of work and cost proposal to develop the Model in two years (Attachment 1). USGS will provide easily comprehensible study findings on groundwater recharge at the end of year two.

These studies will not address any water quality issues or consider future withdrawal rates. The Virginia Department of Health has not reported any concerns regarding groundwater quality or wells going dry in the County. According to the Prince William County Service Authority, sufficient public water supply is available to serve the County's population to at least 2040. Extension of public water is allowed under current policy should any groundwater quality or quantity issues occur in the future.

There are no monitoring wells in the mid-county area. DEQ is considering adding additional wells in Virginia and will consider this area as a potential location. To add an additional monitoring well, it will cost $15,000 for the installation and additional $5,500 per year for monitoring.

Possible Action – Upon evaluation of all factors, the Board can consider the following options:

Option A: In response to the directive, the Board can take action to provide funding for a contract with USGS to develop a Soil-Water Balance Model to determine the effects of historic and future changes in land use on groundwater recharge. The total cost of the project is $320,000. USGS is proposing to provide a matching contribution of $50,000 toward the project, with the County cost being $270,000. The project will require two years to complete, and the projected County funding needs are $150,000 in year one, and the remaining $120,000 in year 2. Staff can prepare a Board resolution to fund and initiate this work if desired. Funding for a new monitoring well in mid-County can be considered later if DEQ does not provide funding.

Option B: The Board can take no action and not provide funding to perform the study. Staff will continue to monitor available groundwater data to determine if further studies or action is needed in the future.

STAFF CONTACT INFORMATION

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ATTACHMENTS

1. USGS Scope of Work Proposal
2. Enlarged images for Figures 1-8

USGS
science for a changing world

Projection and Retrospective Analysis of Land-Use Impacts to Groundwater Recharge in Prince William County, VA

Virginia and West Virginia Water Science Center

INTRODUCTION

Sustainability of groundwater resources in Prince William County, VA is a concern for citizens, water managers, and planners. Suburban and industrial development have added impervious surfaces that may reduce groundwater recharge in the rural portion of the County where residents rely more heavily on groundwater for domestic water supply. Urbanization and increases in impervious area are known to alter groundwater temperatures (Eggleston and McCoy, 2014), topography, vegetation, soil compaction, permeability fields, and recharge (Sharp, 2010).

In response to challenges to groundwater availability posed by historic and future land-use practices, the USGS was asked to propose an assessment of Prince William County aquifers that incorporates a hydrologic landscape approach to estimate all components of the hydrologic system: surface runoff, recharge, base flow from groundwater, and interaction with atmospheric water (precipitation and evapotranspiration). As urban and rural growth continues, water-resources management requires a long-term strategy founded on scientific assessment and characterization of the County's aquifer systems supported by long-term monitoring of aquifer and stream conditions. The U.S. Geological Survey (USGS) has assisted multiple Virginia counties facing similar issues through cooperative jointly-funded efforts.

This proposed assessment by the USGS is intended to complement Occoquan Watershed Monitoring Laboratory (OWML) investigations and provide foundational groundwater-related datasets to Prince William County decision makers. This proposal describes work to compile input datasets, build a model, and evaluate model output for historic and projected land-use changes.

The OWML has been measuring streamflow in Prince William County since the late 1970s, and the focus of data analysis has been on constraining HSPF simulations of streamflow and water quality within the Occoquan watershed (ex Solokian et al, 2020) and detailed analysis of climate and land-use drivers of water yield (runoff/precipitation) at the >50km2 basin scale (Kumar et al, 2018). Previous work by the USGS has focused on groundwater, yet explicit evaluation of recharge to aquifers in Prince William has been limited to long-term (decadal) estimates results extrapolated from nearby streamgages in similar terrains by (Sanford et al, 2011; Nelms et al, 1997) or steady-state simulations of regional-scale groundwater flow (Laczniak and Zenone, 1985). *Modern methods are available to model groundwater recharge at high spatial and temporal resolution utilizing existing remotely sensed and observational data to address causative factors of change.* Recharge estimates from the Soil-Water-Balance (SWB) model method, for example, can leverage both OWML streamflow data and available raster-based inputs to provide an evaluation of land-use effects on recharge.

OBJECTIVES

The specific objectives of the proposed effort are to:

1. Develop a Soil-Water Balance model for Prince William County;
2. Analyze the Soil-Water Balance model outputs to determine the effects of historic and forecasted land-use change on groundwater recharge; and
3. Publish all findings as peer-review, publicly-available, and citable resources.

APPROACH

The proposed SWB approach to begin developing the information needed to make informed decisions about groundwater resources in Prince William County relies on the development a regional-scale water-budget model that lends itself to assessing the impact of historic and forecasted land-use change (Sohl et al, 2018) on recharge to aquifers. The SWB model is a tool developed by the USGS and implemented in a variety of settings across the nation for computation of groundwater recharge (Westenbroek et al, 2021; McCoy and Ladd, 2019). The magnitude and distribution of water-budget components in Prince William County will be computed using regionally available spatial datasets and the SWB model. The SWB model calculates variations in groundwater recharge across space and time based on climatological data and soil and landscape properties. SWB is a deterministic model that uses gridded data and physically based parameters to apportion water derived from daily precipitation and snowmelt into surface runoff, evapotranspiration (ET), recharge, and water storage in the soil column. Model output consists of gridded distributions of water-budget components, such as surface flow leaving grid cells, actual ET, soil moisture, and recharge at a specified cell size within the study area. Computation of water-budget components relies on relations between surface runoff, land cover, and hydrologic soil group and estimated values of ET and temperature. Water storage in the soil column is estimated using a modified Thornwaite-Mather accounting method on a daily basis. A County-wide SWB model will be run using historic land use data from multiple points in time, and projected changes into the future (Sohl et al, 2018), to determine the effect of land-use development on aquifer recharge in Prince William County.

TIMELINE

The anticipated timeline for this effort is two years. The SWB model will be developed and run in the first year and a peer-reviewed, citable report, release of GIS datasets, and web-based delivery of easily comprehensible study findings will be produced in year two.

BUDGET

Total cost is $320,000.

The total cost for Prince William County for this effort will be approximately $150,000 in year 1 and $120,000 in year 2 (total $270,000). The USGS will contribute federal matching funds of $50,000 to the effort.

DELIVERABLES

The deliverables of this effort are:

1. Presentation of draft versions of the SWB data within 12 months of project initiation.
2. The SWB output datasets of recharge for a select historic, current, and projected years will be published at ≥100 square meter resolution and available in downloadable GIS format from ScienceBase (www.sciencebase.gov) within 24 months of project initiation. The actual years of

simulation will be determined by available climate data and land-use data at the time of project initiation.

3. An on-line USGS Scientific Investigations Report documenting the SWB model will be published within 2 years of project start.

BENEFITS

Results of this study will enable water-resource management efforts in Virginia to address changing trends in groundwater development by providing information on hydrologic conditions within aquifer systems of Virginia. At the end of the project, all data will be archived and made available to Prince William County, other public agencies, and the general public for evaluation of groundwater resources in the future.

REFERENCES

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CONTACTS

Questions or comments, please contact:

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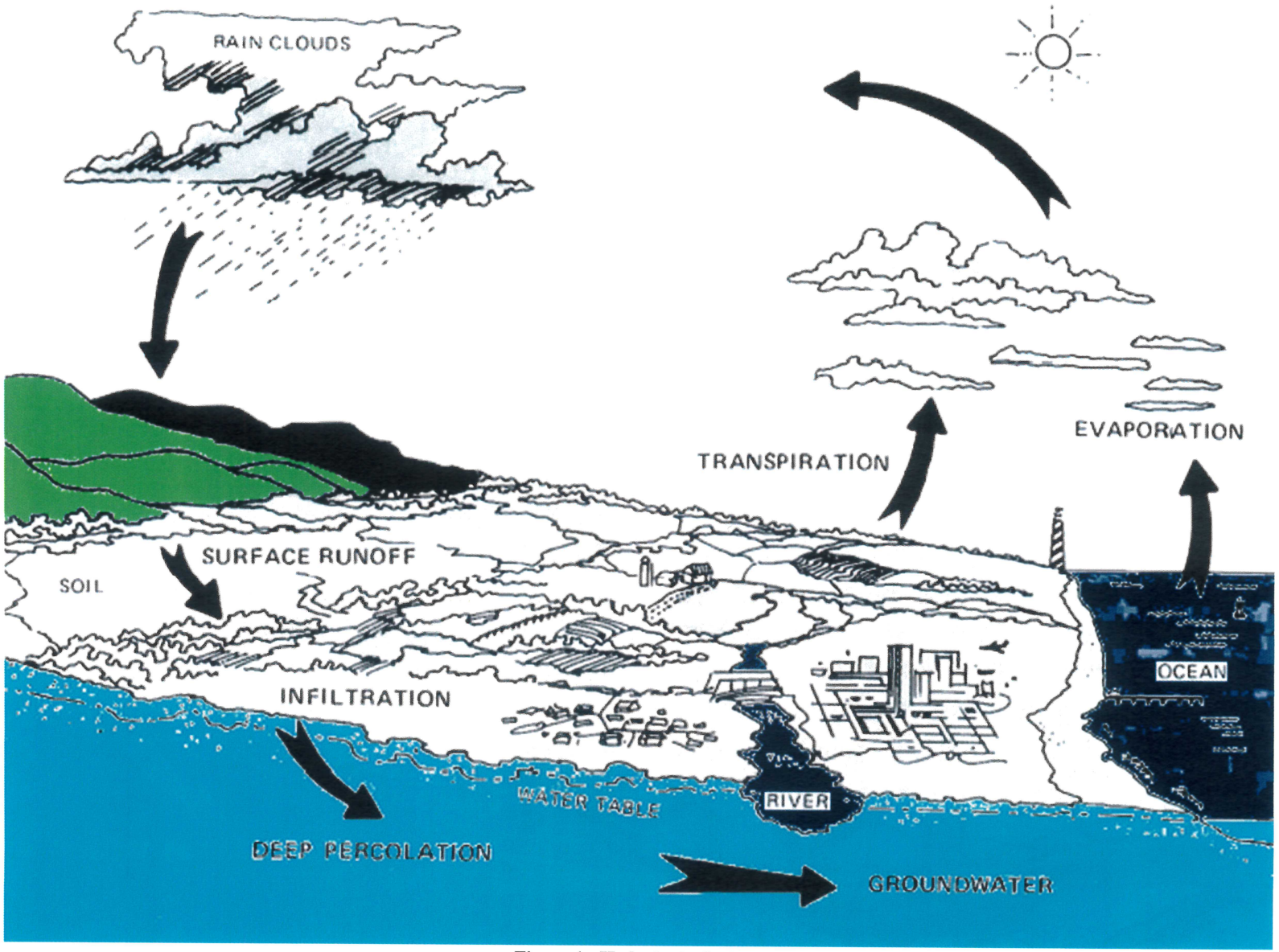


Figure 1 - Hydrologic Cycle

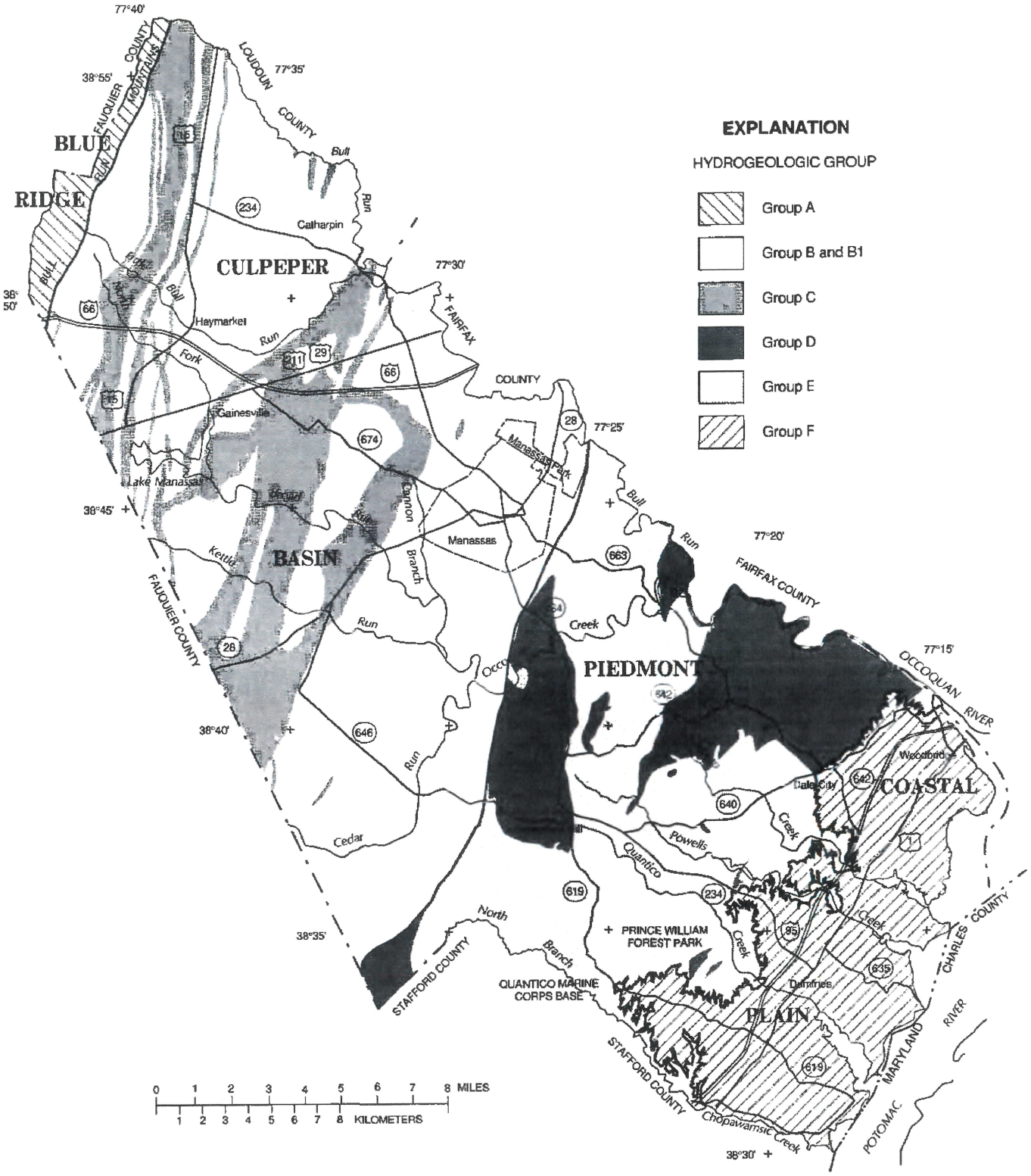


Figure 2 – Culpeper Basin and Piedmont

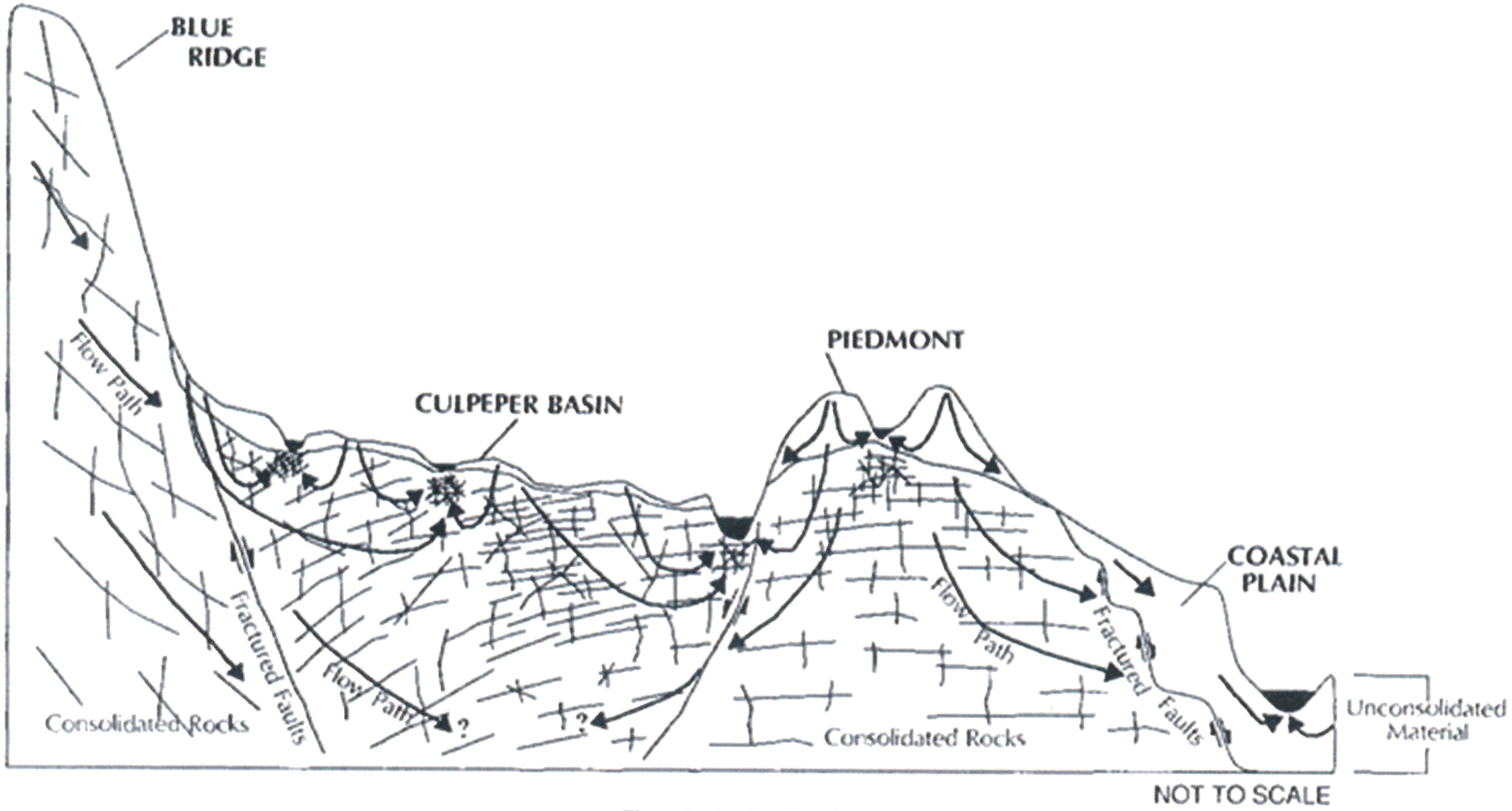


Figure 3 – Aquifer Elevation

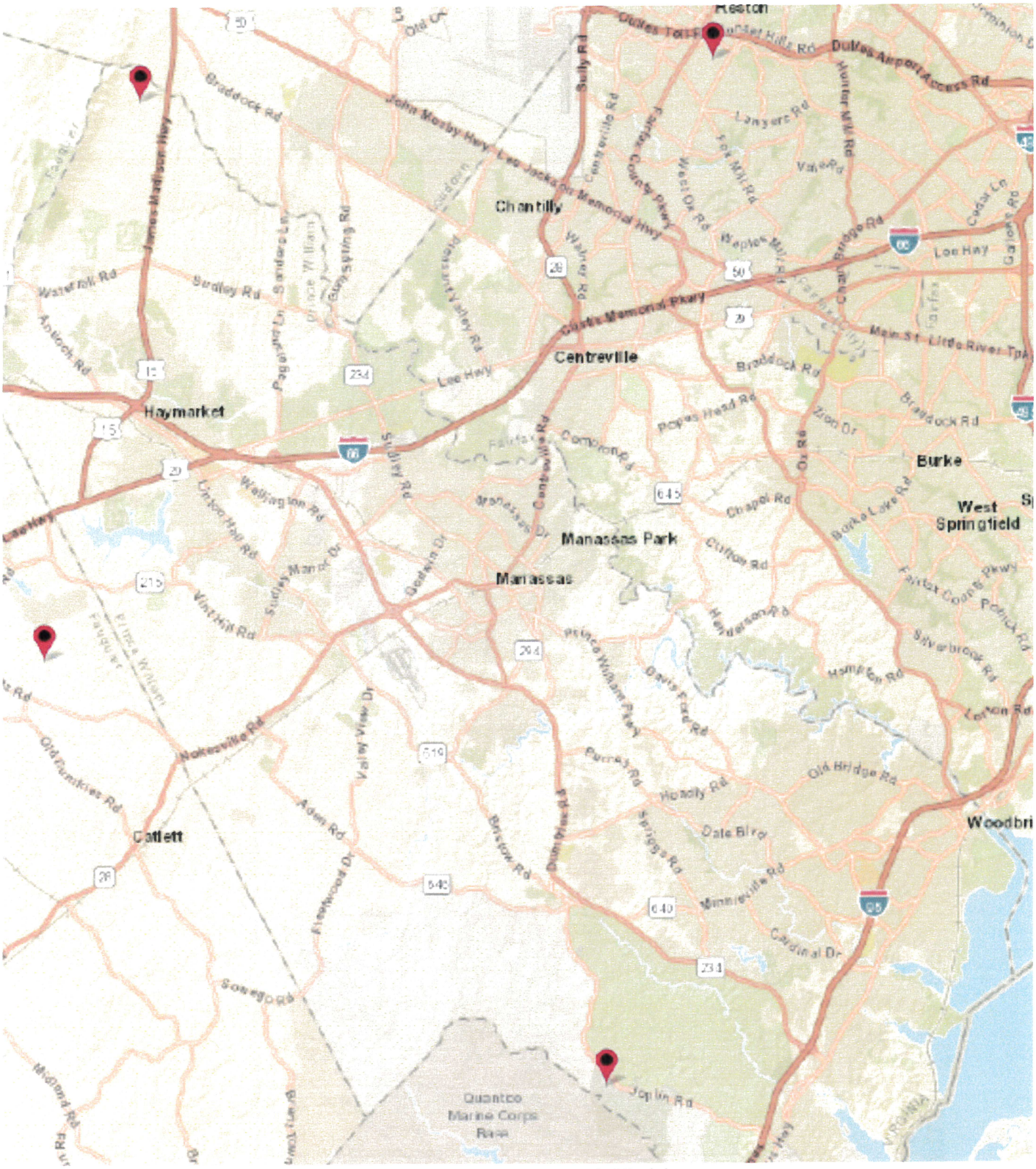
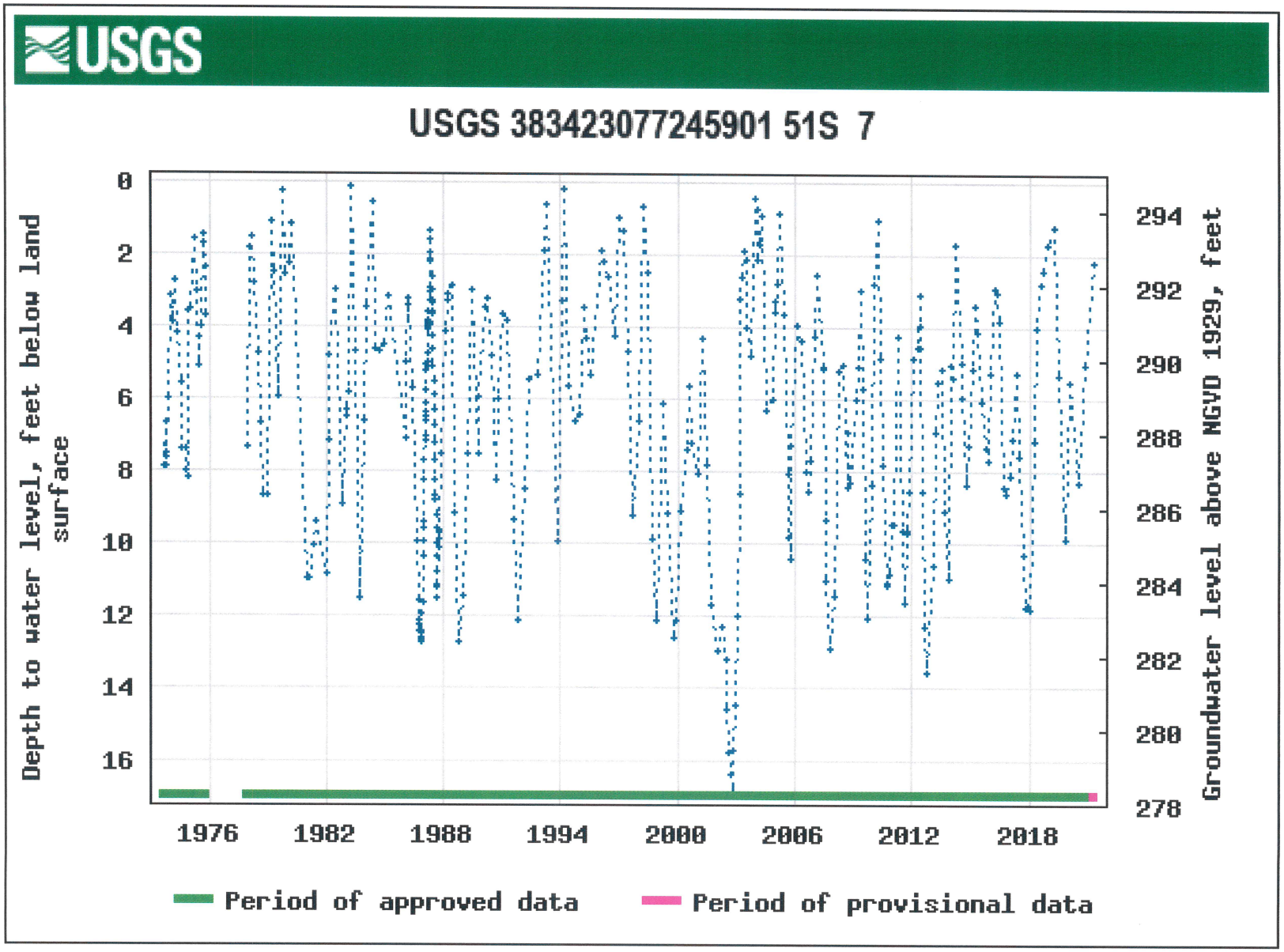


Figure 4 – USGS Monitoring Wells in Virginia



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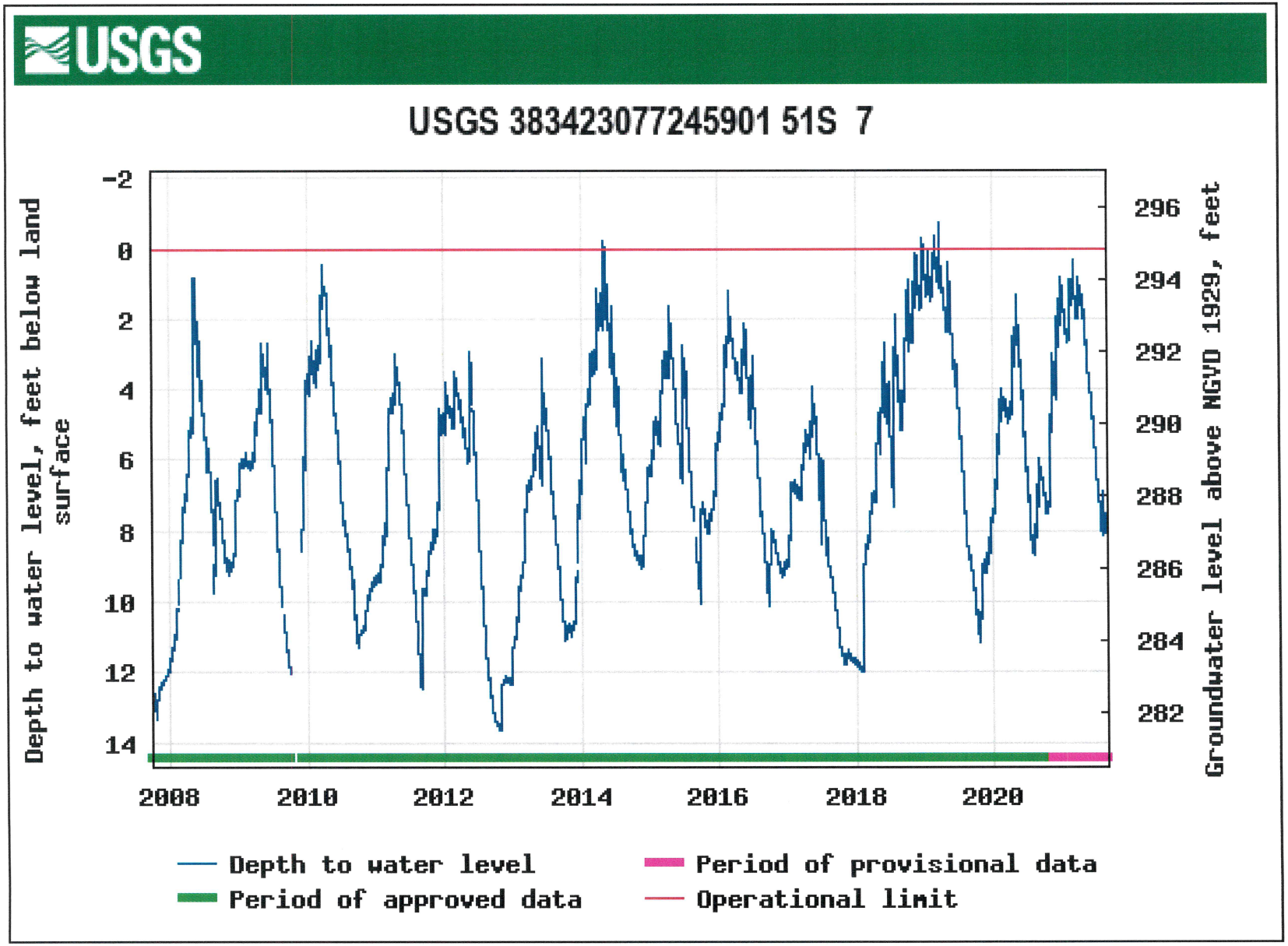
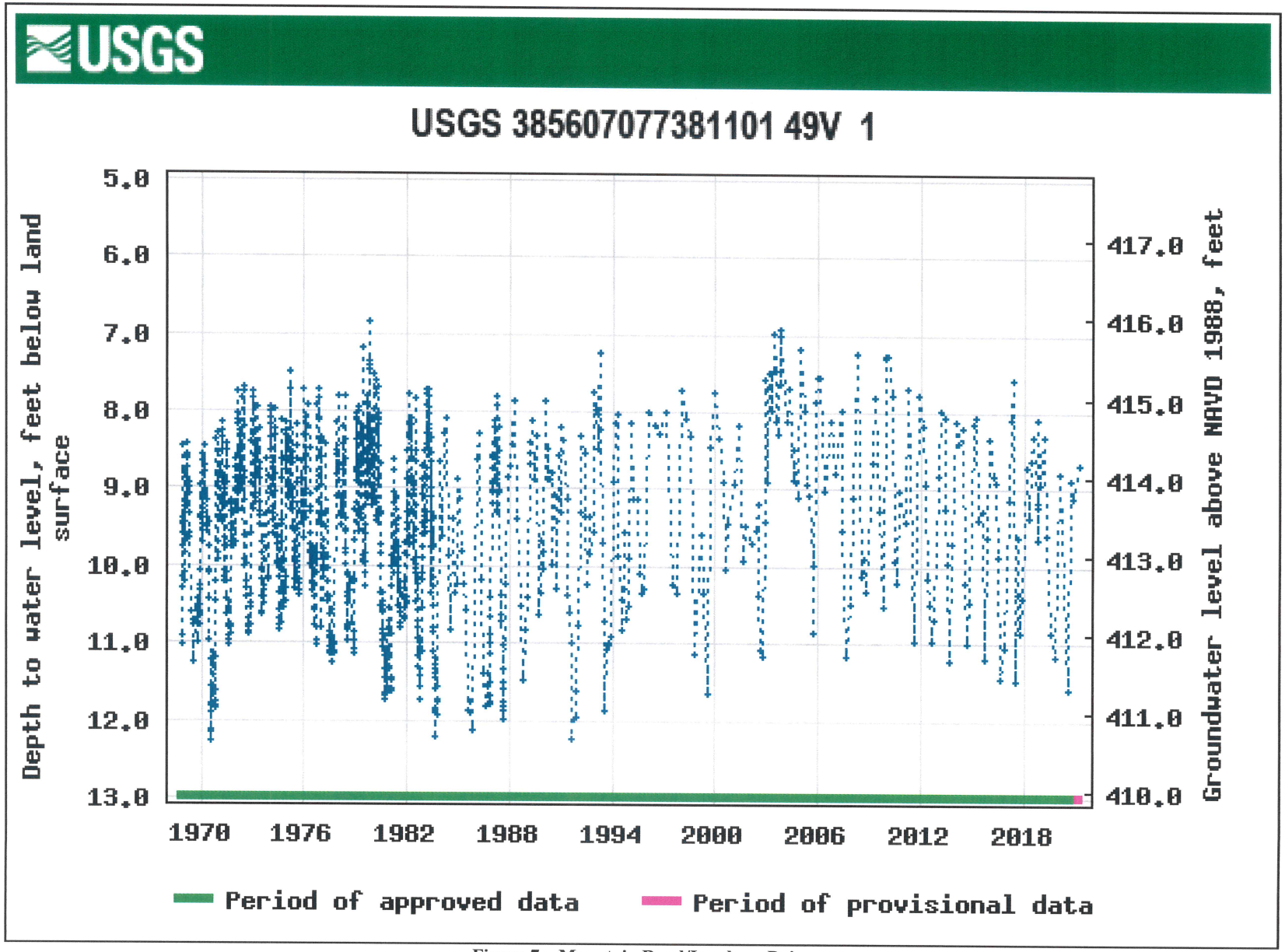


Figure 6 – Joplin Road/Prince William Forest Park



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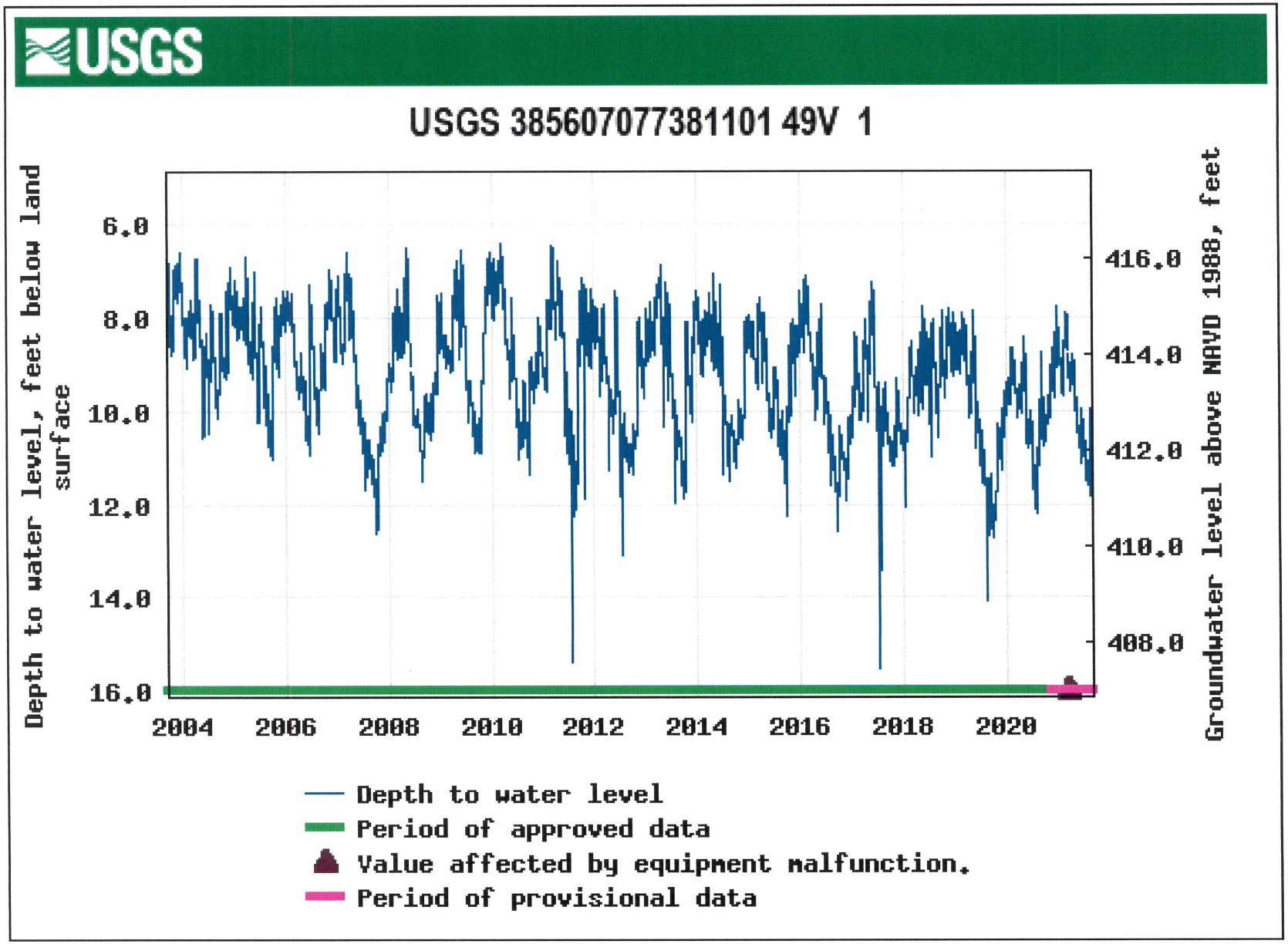

Figure 8 – Mountain Road/Loudon Drive