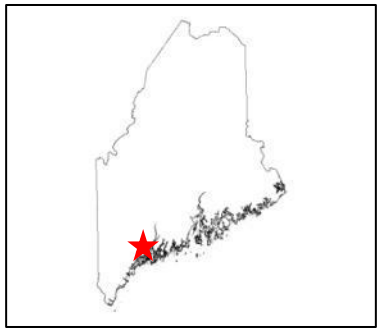
Geologic Site of the Month

May, 2010

The Freeport Basin Study: A Cooperative Investigation of Water Use



43 50‘ 30.69“ N, 70 13‘ 2.89“ W

Text by
Daniel B. Locke

Introduction

The Freeport Basin study is part of an ongoing effort to better understand water availability, use, and sustainability in Maine. Using drainage basins as a framework, areas of the State where cumulative water use was equal to or greater than 90 percent of mean annual runoff were identified (Figure 1).

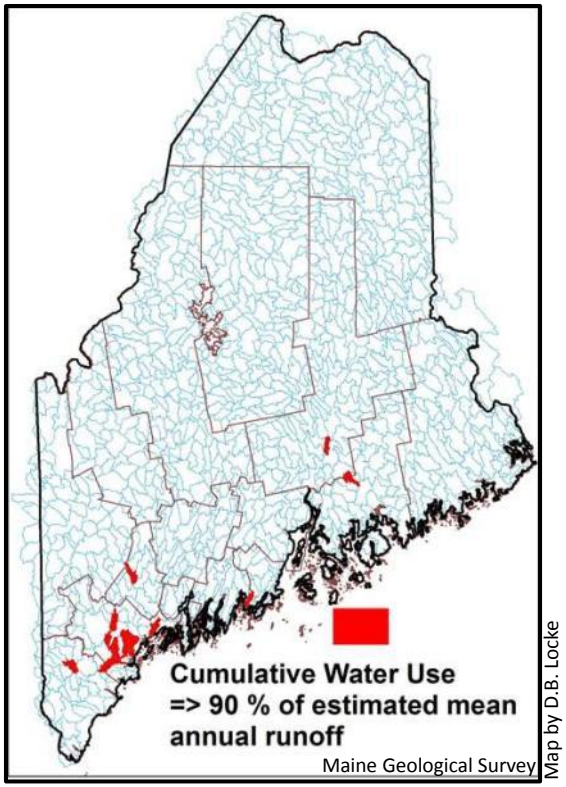


Figure 1. Map of Maine showing drainages and highlighting areas having greater than or equal to 90% of estimated mean annual runoff.

Freeport Basin Study

Based on this screening process, the Harvey Brook and Merrill Brook basins situated in Freeport and Pownal, Maine were selected for detailed study (Figure 2).

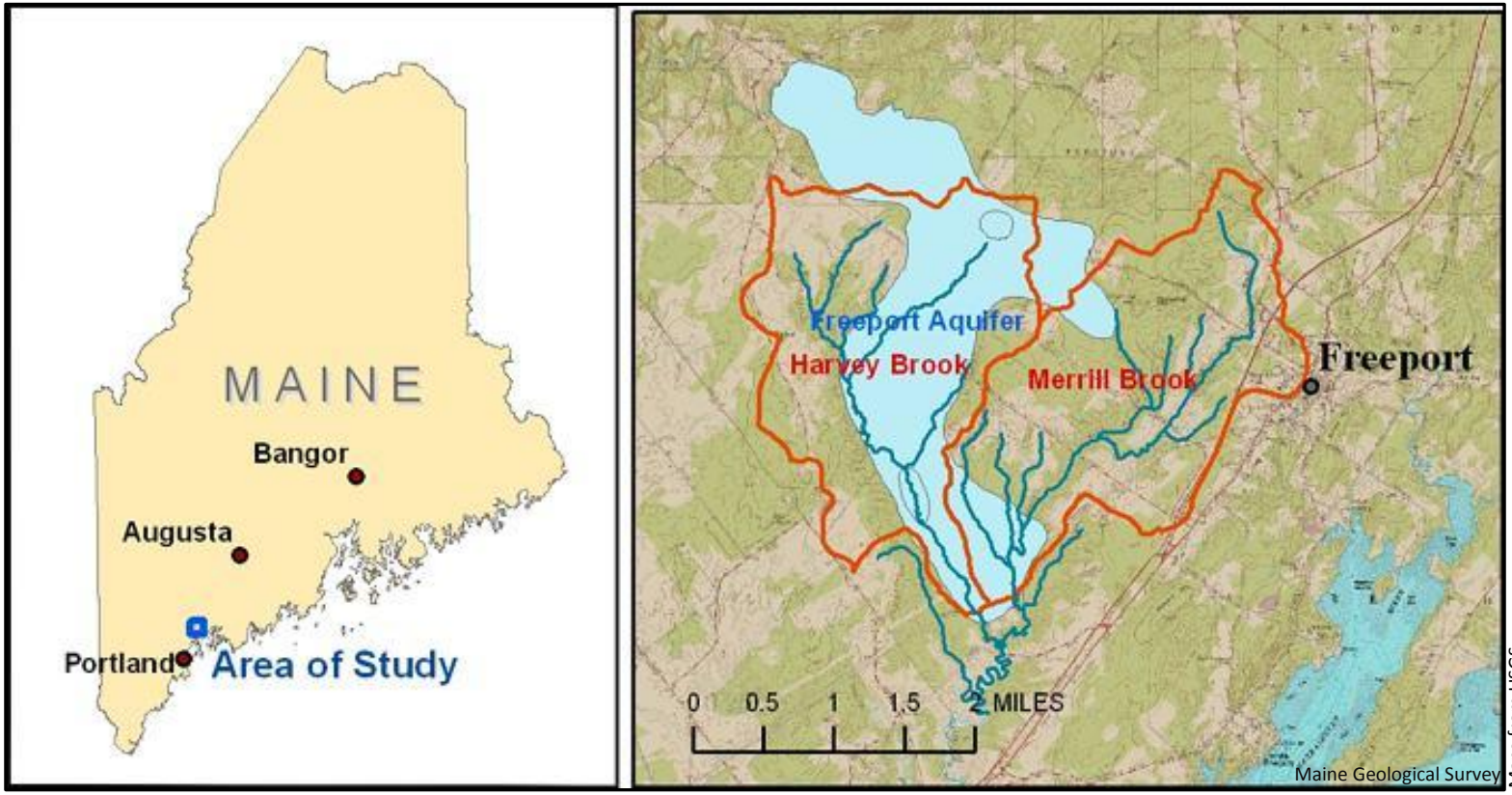


Figure 2. Map showing general area of study as well as a detailed map showing the Harvey Brook and Merrill Brook drainage basins (red outline) and the mapped sand and gravel aquifer extent (pale blue).

Freeport Basin Study

During 2008 and 2009, the Maine Geological Survey and the Maine Water Science Center (U.S. Geological Survey) cooperatively undertook an intensive water use investigation in this area. Data gathering involved reviewing earlier hydrogeologic investigations, conducting new 12-channel seismic refraction surveys, measuring surface water discharge, and drilling monitor wells. The accumulated data will ultimately be used to develop a detailed ground water model. Such a model will help identify the relationship between the sustainability of water use and recharge of the ground water system.

The primary water users within the watersheds are the Freeport Water District with two large capacity gravel pack wells and individual domestic water wells predominantly installed in fractured bedrock. Since the single largest water user is the Freeport Water District, the focus has been on the two municipal wells. A thorough review was conducted of existing data on Maine Geological Survey (MGS) maps, soil surveys, the MGS bedrock well database, and files containing hydrogeologic reports and data maintained by the Maine Department of Environmental Protection and Freeport Water District. A noted hydrogeologist with extensive expertise in the Freeport area was also interviewed and his privately held files were generously provided for review.

Freeport Basin Study

Existing MGS sand and gravel aquifer maps were examined to identify areas which contained sparse subsurface data. To fill these gaps in the ground-water data, seismic refraction surveys were completed in order to measure the depth to bedrock and the depth of the water table surface (Figure 3). Refer to the site on Seismic Refraction Profiling for more details concerning the use of 12-channel seismic refraction as a tool in sand and gravel aquifer mapping.

Figure 3. Photographs of 12-channed seismic refraction surveys run to define depth to bedrock and water table.

Discharge Measurements

To characterize surface runoff, five stream discharge measurement sites were selected (Figure 4). During 2009, weekly discharge measurements were taken at these sites (Figures 5-9).

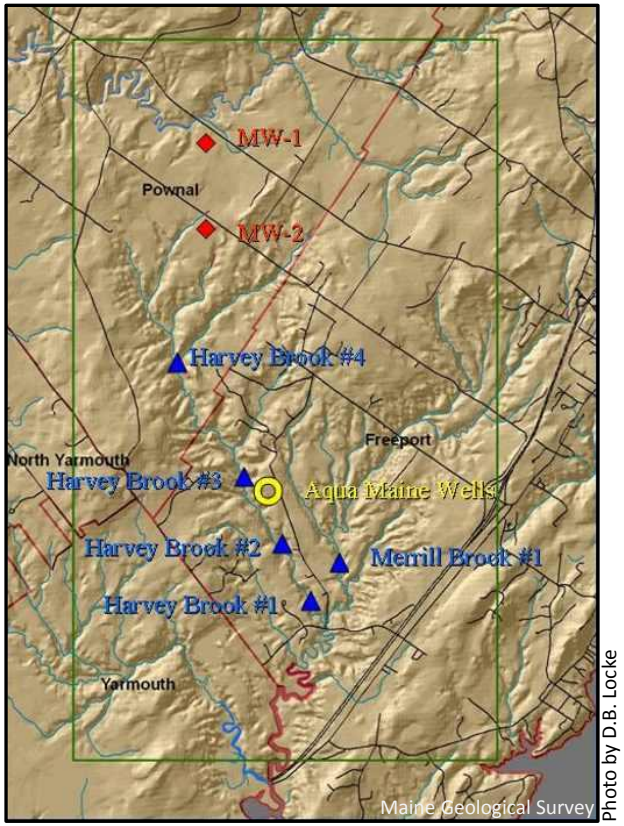


Figure 4. Shaded relief map showing locations of stream discharge measurement sites (blue triangles), locations of the Freeport Water District (Aqua Maine) supply wells, and locations of project monitoring well sites (red diamonds).

Discharge Measurements

Figures 5-9 are photographs of discharge measurement sites and details of the section and associated flow measurements taken on 9/23/2009.

Photo and figure by D.B. Locke

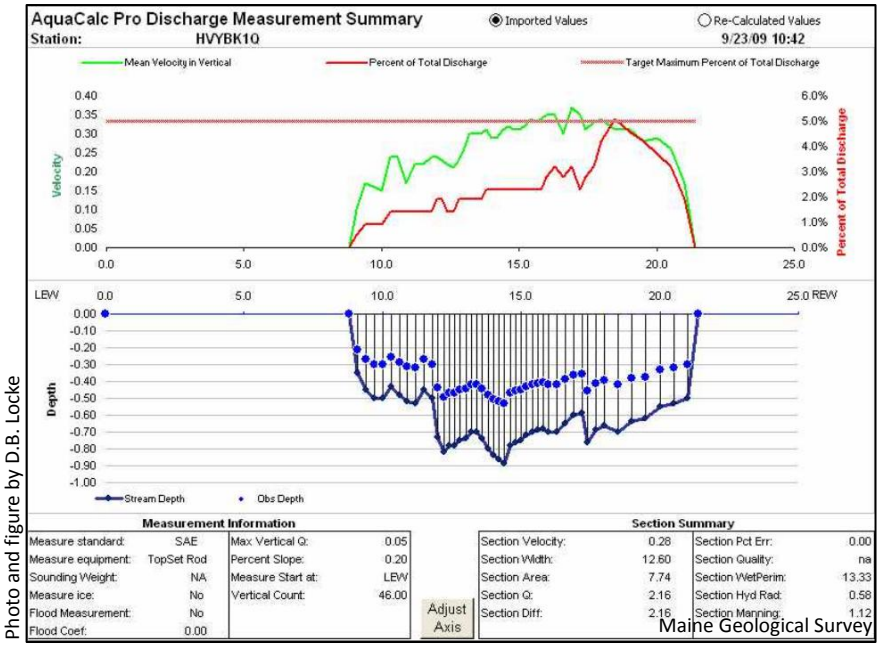


Figure 5. Harvey Brook #1.

Discharge Measurements

Photo and figure by D.B. Locke

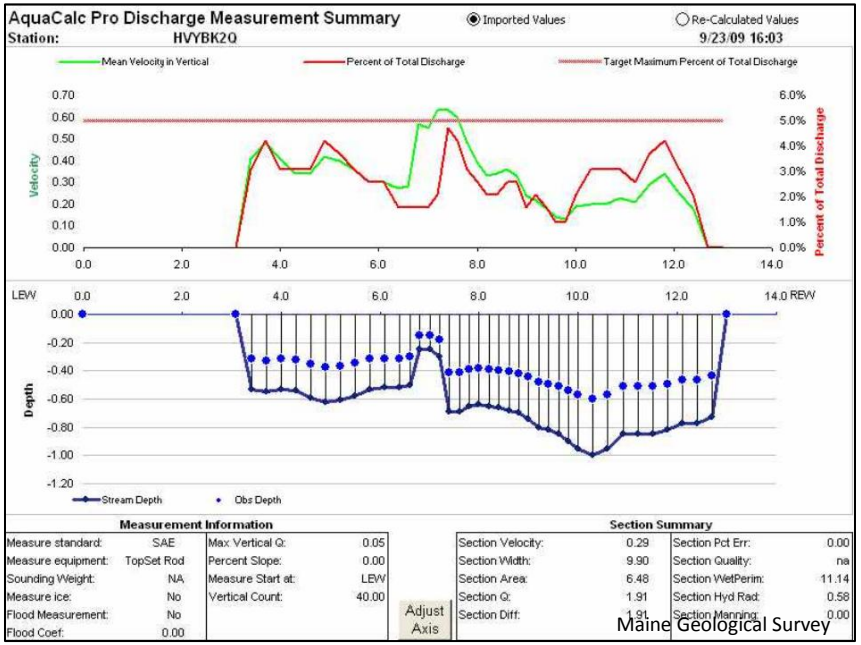


Figure 6. Harvey Brook #2.

Discharge Measurements

Photo and figure by D.B. Locke

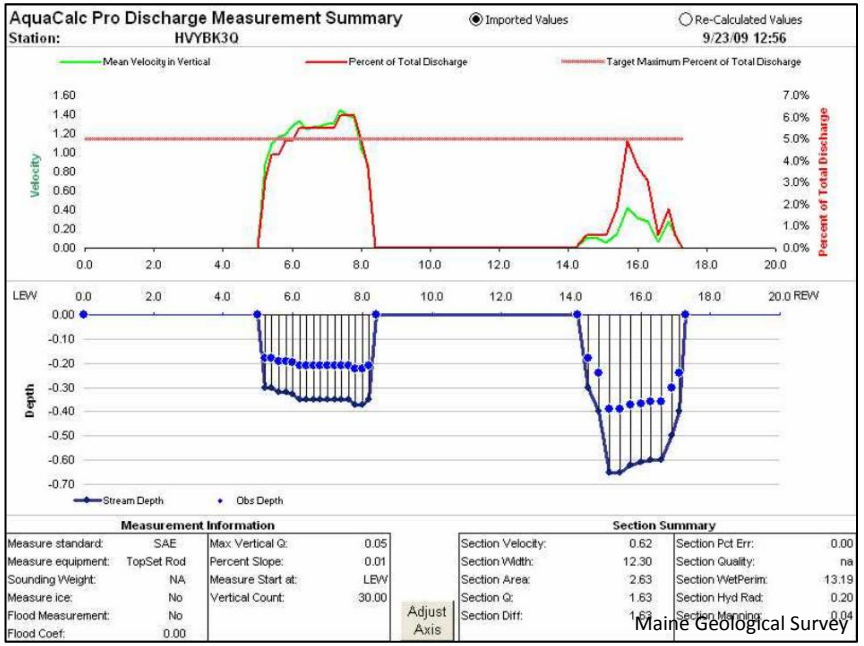


Figure 7. Harvey Brook #3.

Discharge Measurements

Photo and figure by D.B. Locke

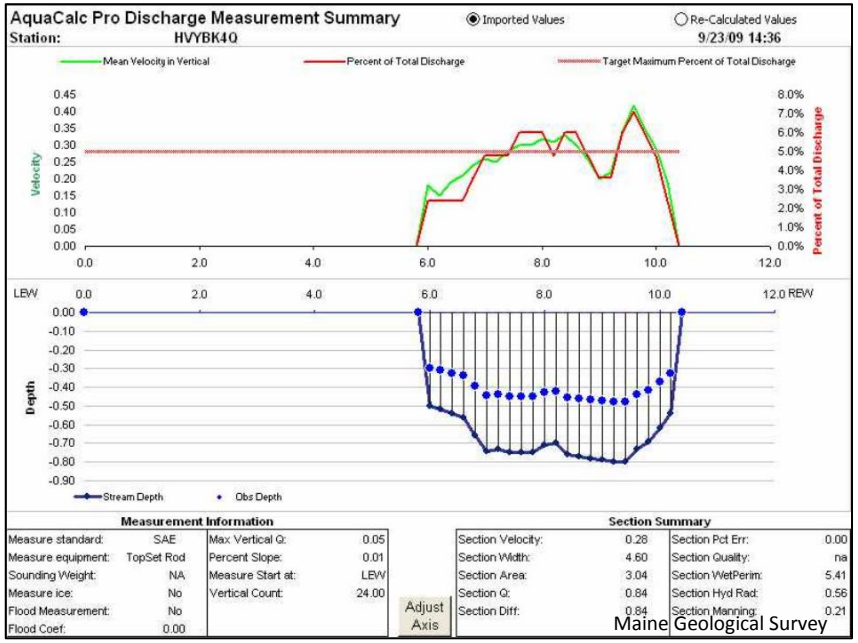


Figure 8. Harvey Brook #4.

Discharge Measurements

Photo and figure by D.B. Locke

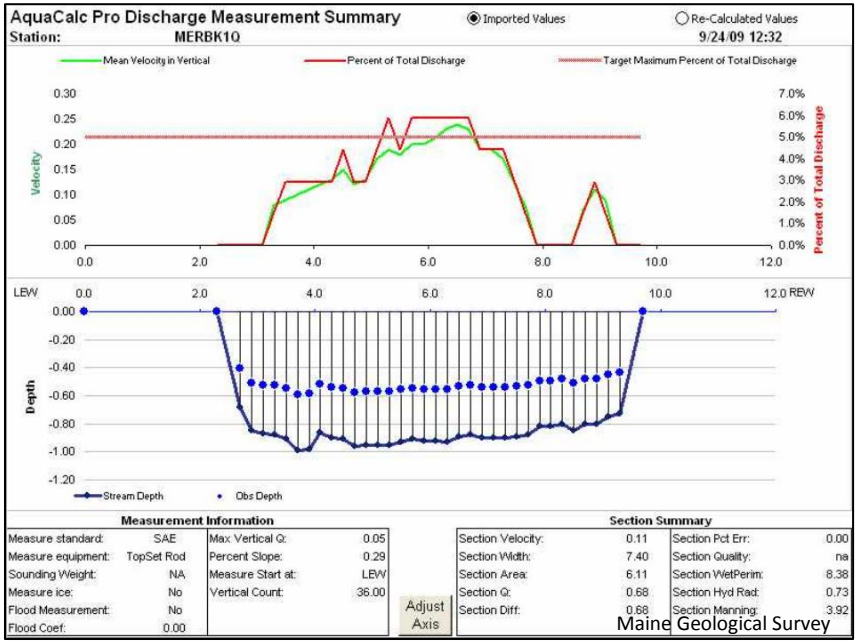


Figure 9. Merrill Brook #1.

Summary of Discharge Measurements

This work required sufficient measurements over a range of flows in order to determine monthly mean discharge (Figure 10 and Figure 11).

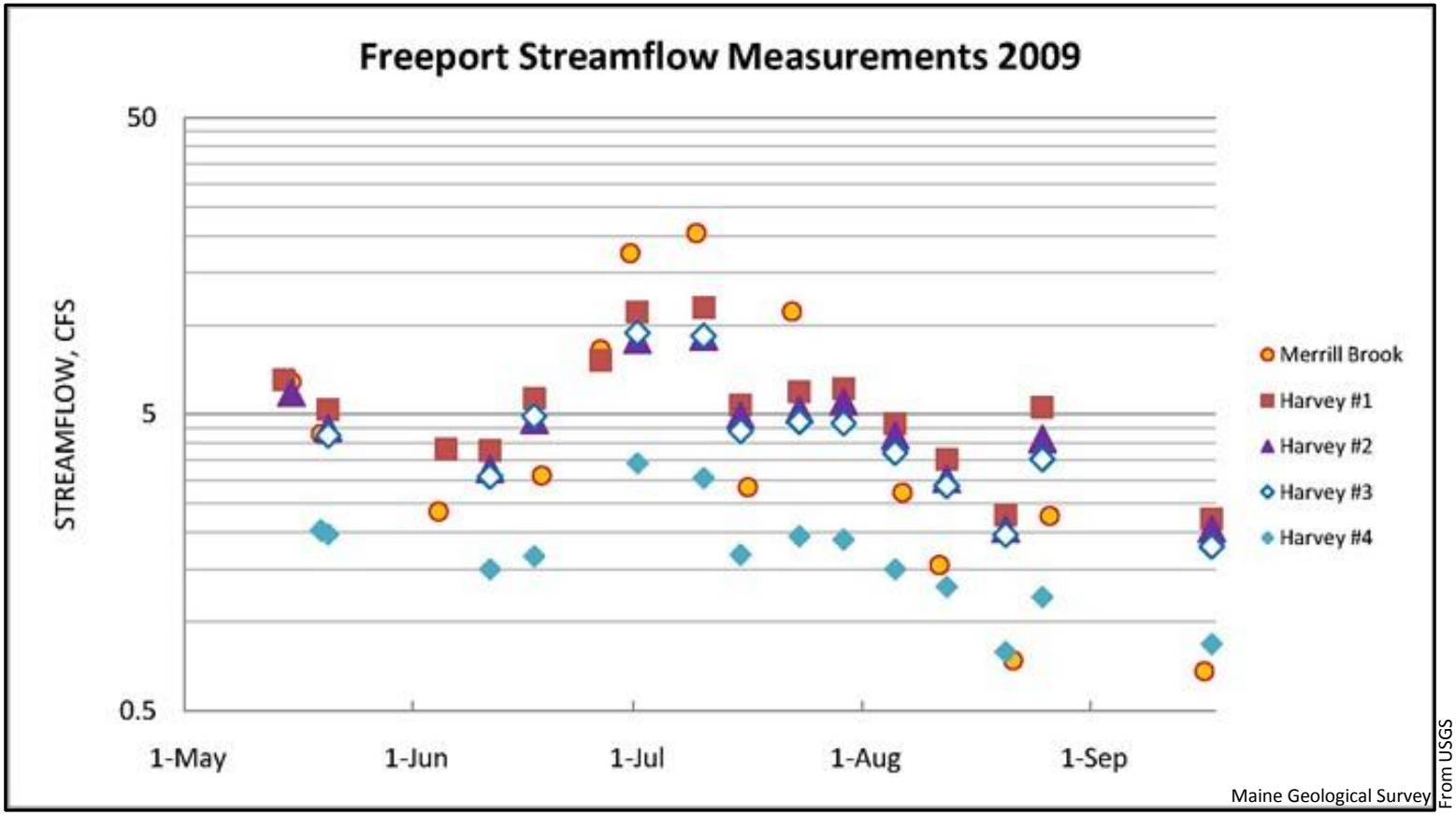


Figure 10. Plot summarizing discharge measurements at all five sites.

Summary of Discharge Measurements

Monthly mean discharge for the selected sites comprised a very important input into the ground water model and was determined through a record extension technique developed by the USGS.

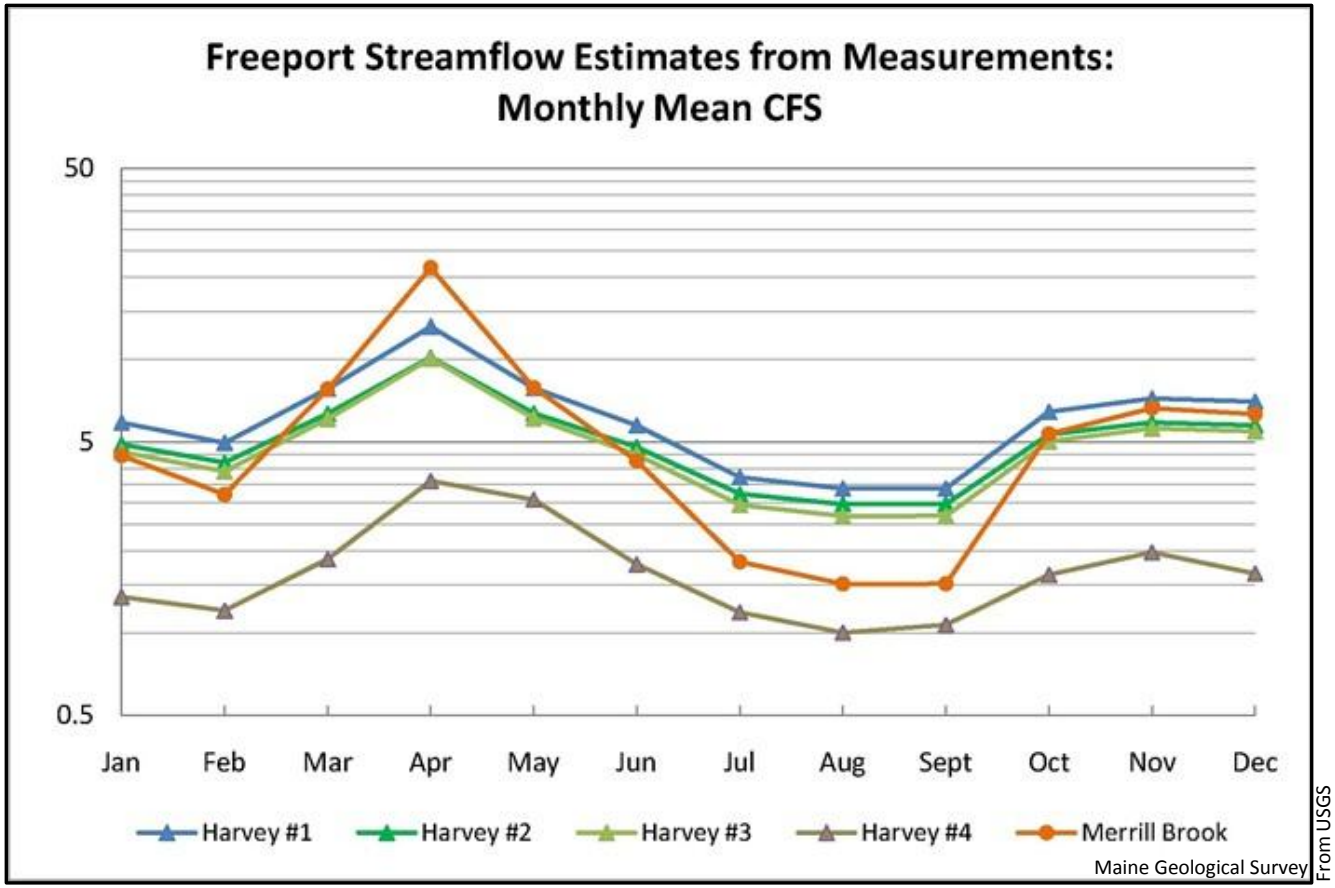


Figure 11. Graph depicting calculated monthly mean discharge for all five sites.

Test Drilling

Since there was very little hydraulic head data in the sand and gravel deposits along the northern boundary of the model, it was decided that test drilling and monitoring well installation were necessary. This exploratory work also helped to characterize subsurface materials as well as bedrock depth (Figure 12 and Figure 13).

Figure 12. Drilling at monitoring well MW-1.

Test Drilling

These two wells (MW-1 and MW-2, Figure 4) straddled a drainage divide to the north of the study area as well as the model boundary and helped to identify a possible hydraulic connection between the Harvey Brook aquifer and the East Branch of the Chandler River.

Figure 13. Drilling at monitoring well MW-2.

Conclusion

At this juncture, all field data has been collected. All available data was used in the development of a detailed three-dimensional ground water flow model developed by the U.S. Geological Survey (USGS). The USGS utilized the widely accepted model known as MODFLOW to simulate ground water flow within the drainages. Model simulations are currently being run for varying conditions and a report is being prepared with anticipated publication in 2011. The results of the modeling effort will likely appear as a follow-up Site of the Month, also in 2011.