WELLS CREEK WATERSHED PARTNERSHIP

1999 MAINSTEM AND TRIBUTARY BASE FLOW DISCHARGE MEASUREMENTS

November 18, 1999

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INTRODUCTION

Early in the development of the Wells Creek Watershed Partnership, stream base flow was identified as an important metric for measuring the health of the watershed. In 1994, base flow discharge measurement of mainstem and some tributary streams were completed to quantify baseline conditions. In 1999, after 5 years of watershed management efforts, base flow discharge was once again measured for comparison to the 1994 study results.

BACKGROUND

Discharge measurements were completed by DNR interns at 13 locations using USGS methods on July 7 and 14, 1999. General field observations prior to the 1999 monitoring period determined that no significant surface water runoff was occurring. The mainstem and tributary streams appeared to be at base flow, although mainstem water was slightly turbid.

Rainfall events from June 15 to July 15, 1999 were numerous but generally less than 0.5 inches in magnitude (attachment 1). No precipitation occurred 4 days prior to the date of discharge measurements. Based on a temporary gaging station's measurements, the Wells Creek Watershed generally requires greater than 0.5 inches of rain to trigger a significant surface runoff event during the growing season. Following a runoff event, Wells Creek requires only 12 to 24 hours to fall back down to near base flow conditions.

A number of monitoring sites on the mainstem and tributary streams were remeasured for discharge in October of 1999 after a prolonged period without precipitation.

METHODS

Flow measurements were completed at 11 mainstem and 4 tributary streams using standard USGS methods (attachments 2 and 3). Flow velocities were generally measured at 0.6 feet depth at 20 - 30 points along a transect running from bank to bank and perpendicular to flow. A Marsh-McBirney 201D electronic flow meter and wading rod were used to complete the measurements. Field measurements were recorded in a field notebook. July field measurements were transferred to a computer spreadsheet to calculate discharges. October measurements were hand calculated and entered back into the field notebook.

FINDINGS

Longitudinal Groundwater Recharge Rates

Discharge measurements were calculated and plotted for the mainstem monitoring locations for the July 1999 measurements (attachments 4). Attachment 4 shows a large change in base flow discharge between Site 5 (Sonnen's) and Site 9 (just upstream of Clear Creek's confluence). Discharge measurements from 1994 (Johnson, 1994) were compared to the 1999 discharge measurements by plotting both sets of data on the same line graph (attachment 5). The 1994 and July 1999 data were comparable and suggest the same general trends. Two departures from the 1994 discharge data include Site 5 where discharge was greater in 1999 and at Site 1 where discharge was less in 1999. These departures are discussed in detail below.

The 1994 and July 1999 data suggests a high ground water recharge zone contributing to mainstem base flow between Site 5 and Site 9 as represented by the steepness of the line on the graph between these two points (attachment 5). The Goodhue County Geologic Atlas program mapped geologic structure and stratigraphy throughout the watershed (Minnesota Geological Survey, 1998). The potential high ground water recharge zone identified by the discharge measurements corresponds to a downthrown fault block (attachment 6). The location of the two faults and the relative vertical displacement of the downthrown fault block (between Sites 5 and 9) are depicted on the discharge measurement graph (attachment 5).

Geologic cross-section B-B' bisects the watershed perpendicular to the fault strike (attachment 6). The cross-section illustrates the downthrown fault block and the associated stratigraphy (attachment 7). The Shakopee Formation of the Prairie du Chien Group is the uppermost bedrock unit in the high ground water recharge zone. The Oneota Dolomite formation within the Prairie du Chein Group is more commonly the first bedrock unit within the watershed (attachment 8). The Shakopee Formation may facilitate greater recharge through its fractured, thinly bedded and solution widened dolomite compared to the Oneota Dolomite which is more crystalline, less fractured and massively bedded. In addition, the contact between the Shakopee Formation and the Oneota Dolomite has been observed to be a zone of high transmissivity which, if correctly positioned relative to the stream channel and water table elevations, could facilitate greater recharge rates to the stream (Green, 1999 pers. comm.).

The tributary with the highest base flow, Rock Creek, is contained within this downthrown fault block area. The largest spring (approximately 0.9 cfs) in the watershed, as well as two spring zones identified by DNR Fisheries (DNR, 1961), are also located within the downthrown fault block area. The Jordan Sandstone Formation below the Prairie du Chein Group may be saturated in this downthrown fault block since it is closer to the valley floor elevation. The Jordan Sandstone's high groundwater transmissivity is attributable to its high porosity and primary permeability which would facilitate recharge to the valley fill alluvium.

The other possible high recharge zone identified during the July 1999 base flow discharge measurements was between Sites 14 and 15 near the headwaters of the mainstem. The Geologic Atlas maps suggest that a second downthrown fault block, similar to the one described above, may be responsible for recharge to the headwaters of Clear Creek and unnamed creek on Stan Klair's property - both tributaries recently stocked with native brook trout because of their cold, steady base flows. To date, discharge in Klair's unnamed tributary has not been measured.

The water table contour map scheduled to be completed for Part B of the Geologic Atlas may add additional insight into the role geologic structure and stratigraphy play in recharge to Wells Creek and its tributaries. Additional well and boring logs are needed to better define the extent of the faulting in this area. In-stream mini-piezometer, seepage meter and water quality measurements may contribute additional information to better understand the observed higher ground water recharge rates in the downthrown fault block areas.

Site 5 Departure

In 1997, a data logger and pressure transducer was set up at Site 5 and a stage/discharge curve was developed. A comparison of Site 5 July 1999 data to the 1997 stage/discharge curve suggests water levels were 2 to 3 inches higher and approximately 14 cfs (56%) above base flows as measured in 1997 (attachment 9). Base flow measured at Site 5 in 1997 was comparable to base flow depicted by the 1994 data line of approximately 25 cfs (attachment 5). Water discharge in the nearby tributary stream (Site 6), with its confluence just above Site 5, was deemed too low in July of 1999 to be worth measuring (estimated at less than 1 cfs). Therefore, surface water runoff from this tributary was not suspected as being the source of the apparent increase in discharge at Site 5.

It was hypothesized that the increased flow at Site 5 (37.1 cfs in 1999 vs 25 cfs in 1997 and 1994) was attributable to increased infiltration due to the wet June and early July. Infiltrating water moving quickly through the downthrown fault block recharge zone and discharging as groundwater to the stream could result in a relatively short-lived enhancement of base flow conditions. After approximately 2 months of very dry weather, discharges were remeasured to further investigate the nature of the higher base flow first measured in July. Discharge at Site 5 on October 27, 1999 was measured at 34.39 cfs, nearly 10 cfs higher than the 1994/1997 base flow values and within 3 cfs of the July 1999 measurement.

Site 1 Departure

For all base flow measurements in both 1994 and 1999, discharge was less at the downstream location near Villa Maria (Site 1) compared to the Highway 61 (Site 2) and Territorial Bridge locations (Site 3). In the 1994 report, this had been attributed to the high porosity and primary permeability of the river terrace (Pleistocene) sands causing the stream to lose water thus becoming a "losing" stream. For the July 1999 data set, analysis of Lake Pepin water levels suggested part of the reduction in the measured discharge at Villa Maria (down approximately 22 cfs from the Territorial Bridge measurements) may be attributable to rising Lake Pepin water levels backing up and slowing down Wells Creek and the subsequent storage of water in streambanks, floodplain wetlands and Lake Frontenac (attachment 10). It was also suspected that a portion of the flow may have circumvented the historic monitoring location and not all discharge may have been measured.

On October 27, 1999, discharge was once again measured at the Villa Maria (Site 1) location. It was found that the stream channel has split into multiple channels with 2 channels exiting from under bridge. The July 1999 measurement represented discharge in only the old channel. On October 27, 1999, discharge was measured in both channels. The old channel had 11.4 cfs while the new channel contained 18.1 cfs for a total of 29.48 cfs. Discharge at Territorial Bridge was measured at 35.83 cfs. A loss of approximately 6 cfs occurred between Territorial Bridge and Villa Maria - likely due to percolation of water into the terrace sands and built up channel alluvium. It is believed that the new channels formed following the June 1998 flash flood.

Tributary Stream Discharge

Discharge measurements were made at the mouth of Clear Creek and Rock Creek in July of 1999. Additional measurements at four major tributary sites were made in October of 1999. A comparison of discharge measurements from 1994 to 1999 are shown in Table 1 below:

Table 1. Tributary discharges 1994 and 1999.

Date	Rock Creek-Site 8	Clear Creek-Site 10	Trib at Site 6	Trib at Site 13
July 1994	not measured	0.9 cfs	1.2 cfs	not measured
July 1994	not measured	0.9 cfs	1.1 cfs	not measured
Aug 1994	not measured	1.2 cfs	1.4 cfs	0.6 cfs
July 1999	4.6 cfs	0.4 cfs	not measured	not measured
Oct 1999	2.1 cfs	0.5 cfs	0.6 cfs	0.6 cfs

Rock Creek apparently was receiving some surface water runoff or short duration groundwater through-flow in July of 1999 because in October discharge had dropped more than 50 %. Never the less, discharge in Rock Creek is by far the highest of all tributaries measured. Clear Creek and tributary creek at Site 6 had base flow measurements about 50% less than 1994 values. Base flow in the tributary creek at Site 13 remained the same.

All tributary streams had reed canary grass growing along the banks and within the channel which made gaging difficult. This could result in a higher likelihood of measurement error. Some reduction in discharges could be attributed to losses due to evapo-transpiration by the grasses.

Long-Term Baseflow Trend

Base flow measurements at Villa Maria (Site 1) and Highway 61 (Site 2) from 1959 to 1999 were plotted from various sources suggesting a upward trend in base flow (attachment 11). The 1999 discharge measurement at Highway 61 (45.95 cfs) is consistent with the increasing base flow trend. A review of local precipitation records plotted as a running, monthly cumulative departure from normal reveals a similar upward trend from the early 1970s to 1999 (attachment 12)(DNR Waters Climatology Office, 1999 pers. comm.). This suggests that increasing base flows are attributable, in part, to increased precipitation. Improvements in land use and land cover are likely contributing to the increased base flow but at this time their contribution can not be quantified. It is interesting to note that between the late 1950s and late 1960s, there was a downward trend in precipitation as measured by monthly departures from normal.

CONCLUSIONS

The 1999 round of mainstem discharge measurements suggest the high base flow trend has been maintained. A comparison of long-term discharge measurements to local precipitation records suggest that base flows will likely continue to increase in the mainstem as long as precipitation trends continues to increase. Ground water recharge to the mainstem, tributaries and springs appears to be tied to geologic structure and related stratigraphy. Wells Creek has become a braided stream with multiple channels near its confluence with the Mississippi River's Lake Pepin.

REFERENCES

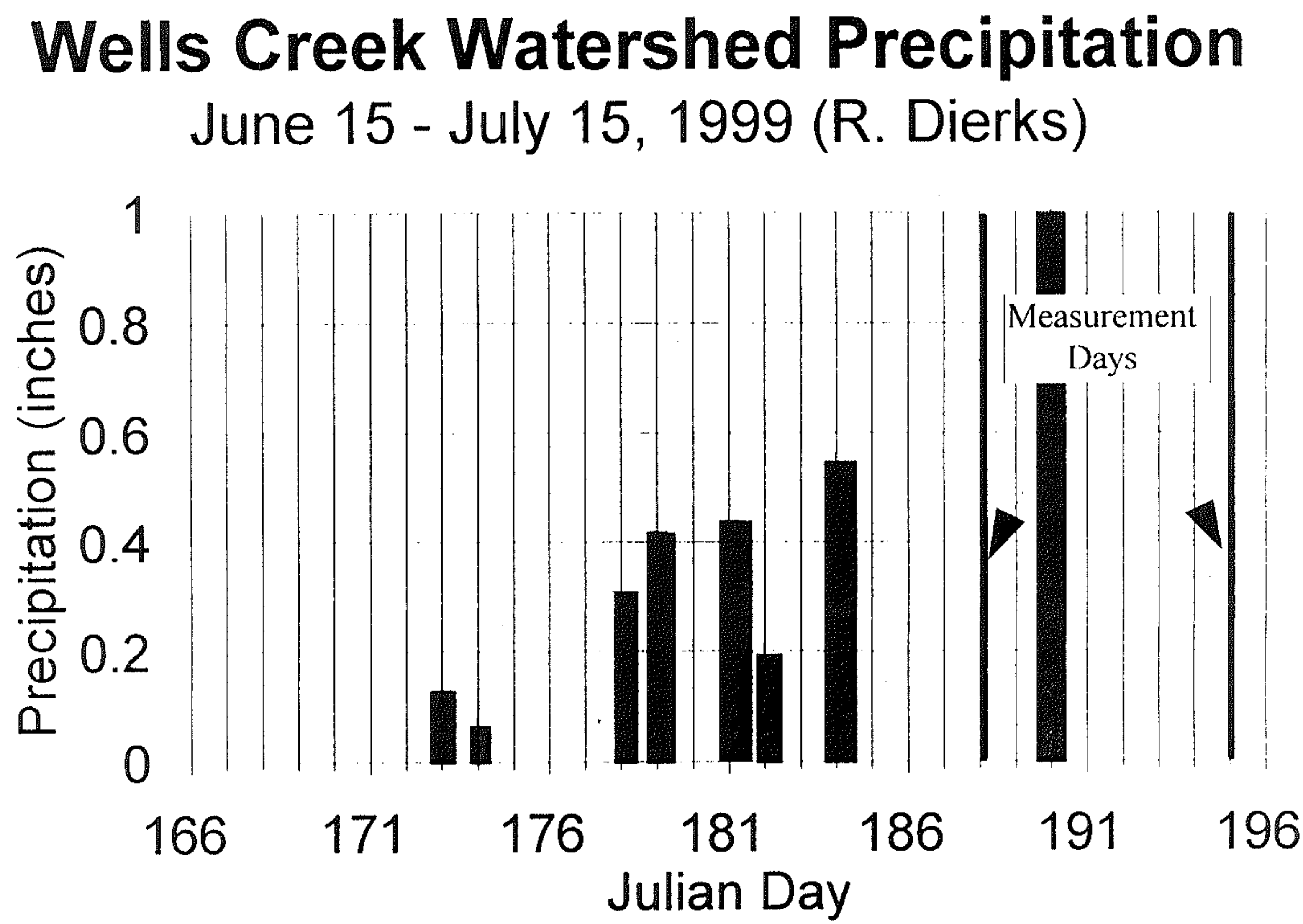
Department of Natural Resources - Division of Game and Fish, 1961, Stream Survey Data Summary Wells Creek M-43, Goodhue County, 14 pages.

DNR Waters' State Climatology Office, 1999, personal communication.

Green, J., 1999, DNR Waters Groundwater Specialist, personal communication.

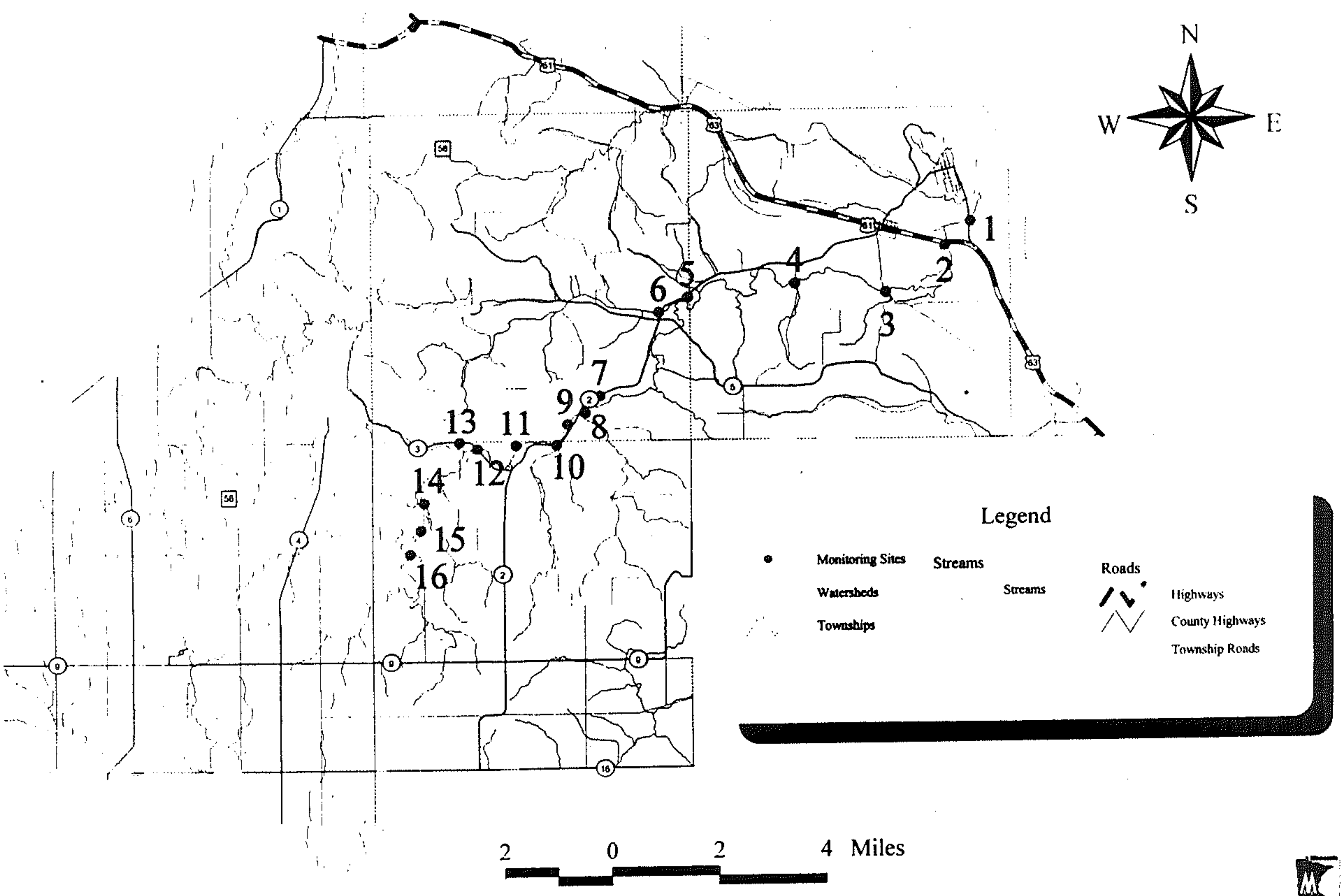
Johnson, S.B., 1994, 1994 Field Season Report and Analysis Mainstem and Tributary Base Flow Discharge, 3 pages plus attachments.

Minnesota Geologic Atlas, 1998, Geologic Atlas of Goodhue County, Minnesota, County Series Atlas Series C-12, Part A, 6 Plates, University of Minnesota, St. Paul.



Attachment 1. Precipitation in the Watershed from June 15 to July 15, 1999.

Wells Creek Stream Flow Monitoring Sites



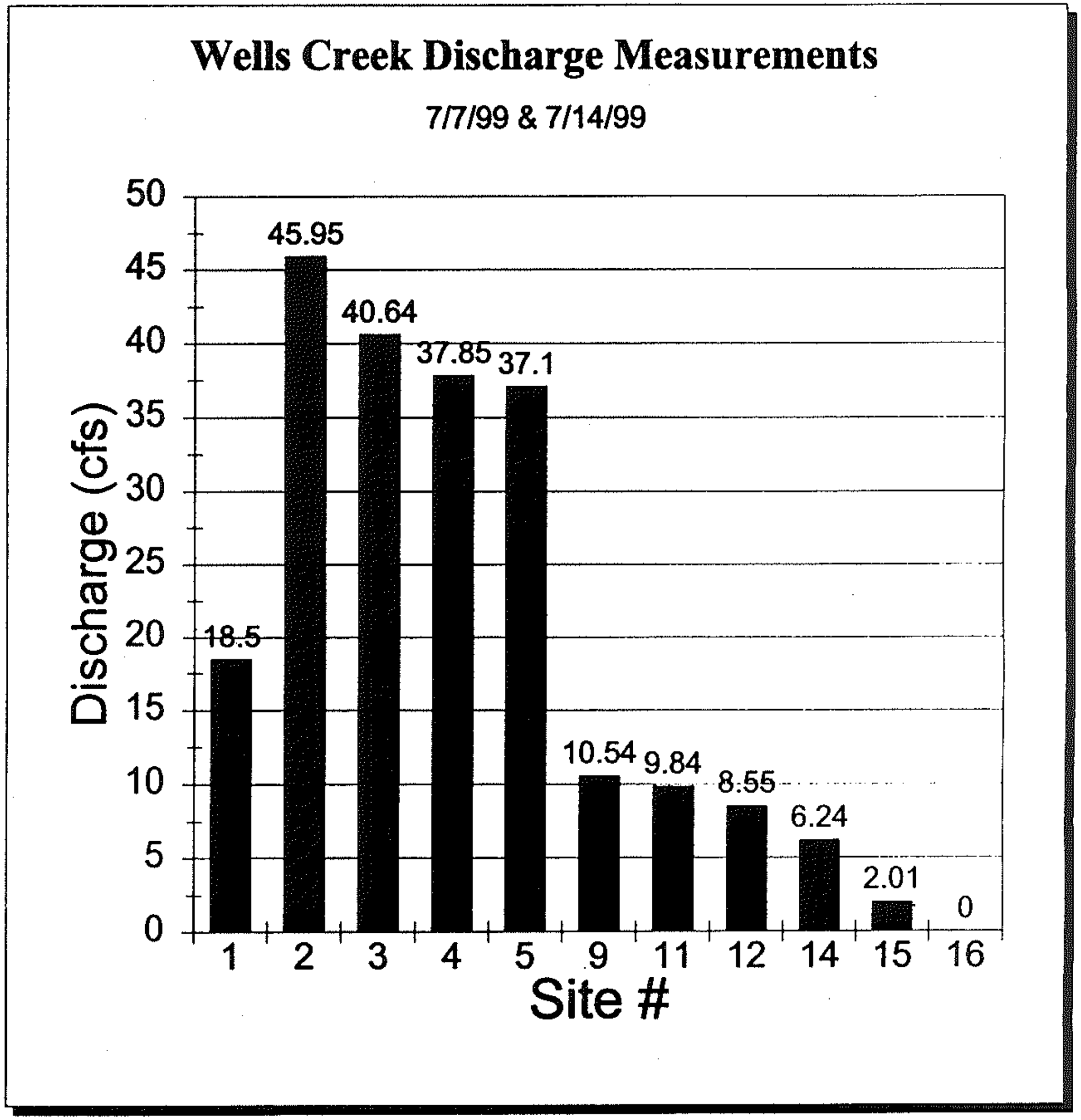
Attachment 2. Wells Creek Watershed 1999 discharge measurement locations.

Wells Creek Discharge Measurement Locations July 1999

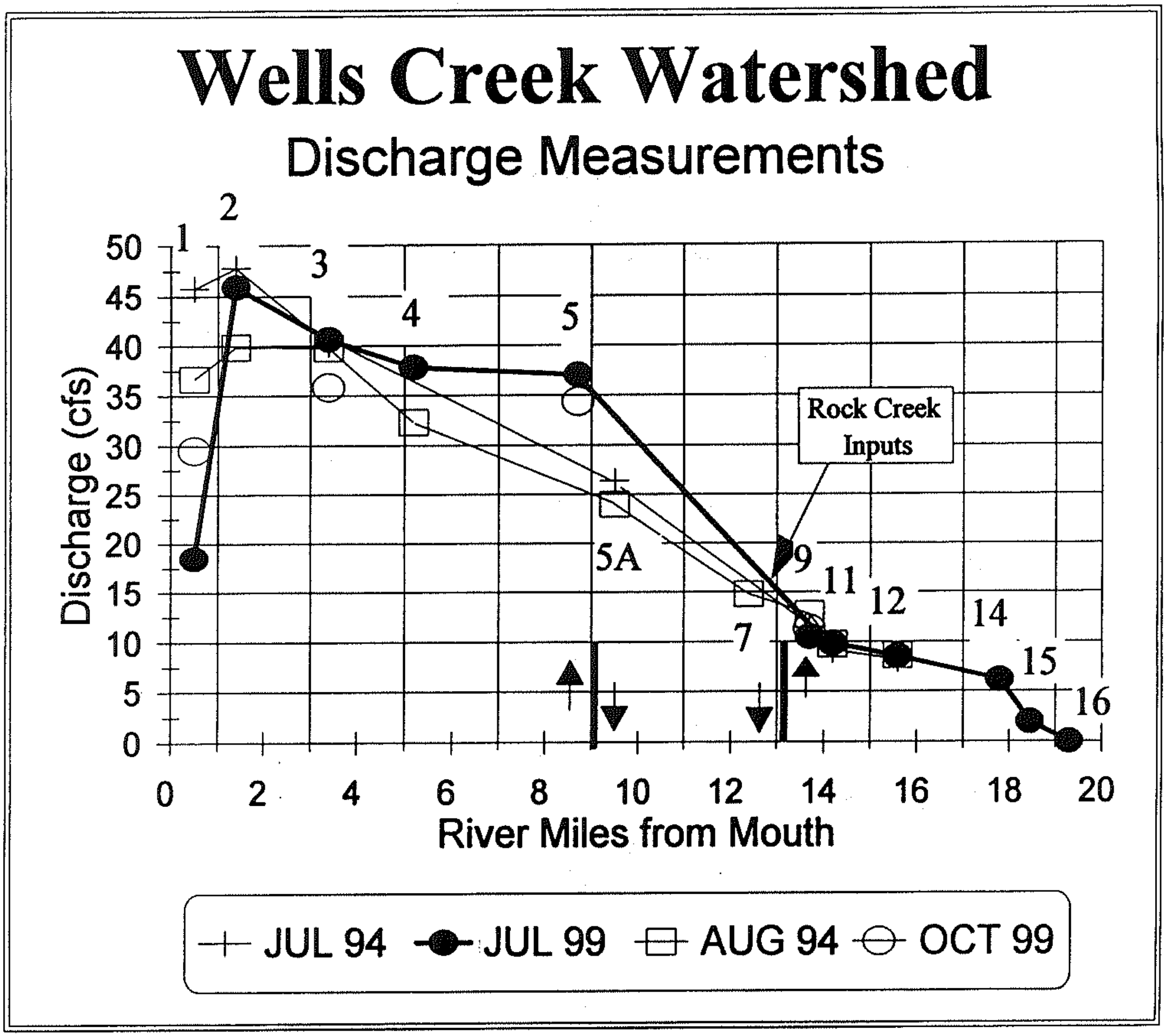
Old Site	New Site	River Mile	Locational Description	T	S	R
2	1	0.5	County Hwy 2 bridge. Villa Marie turnoff. 1st bridge	112N	13	13W
3	2	1.4	Hwy 61 bridge. Just north of Vila Marie turnoff	112N	22	13W
4	3	3.4	Territorial road bridge. Cty 2 west to territorial road. 1st bridge	112N	14	13W
4a	4	5.2	West Florence Trail Bridge. Cty 2 west to florence. 1st bridge	112N	21	13W
	5	8.7	Kiki Sonnen's place. Cty 2 west, west of Florence small sign that reads habitat plot near entrance	112N	24	14W
6	5A	9.5	County Hwy 5 Bridge	112N	24	14W
5	6		6133 acre sub-watershed. West on 2 past Sonnen's 1st bridge	112N	24	14W
6a	7	12.4	End of 284th Ave. Way	112N	35	14W
	8		Rock Creek. Follow 2 west to 45S, 1st bridge	112N	35	14W
8	9	13.7	Wells creek upstream confluence w/ Clear Creek 45N just off road	112N	34	14W
7	10		Cty 2 west, 1st bridge just west of 45N. Clear Creek	111N	3	14W
9	11	14.2	Between site 10 and cty 3. 341st Way bridge	111N	5	14W
11	12	15.6	Cty 3 bridge	111N	04/05	14W
10	13		3274 acre sub-watershed. Around curve west from site 12 small grassy driveway leading to stream	111N	5	14W
	14	17.8	county 3 west to hogsback trail. 1st bridge coming from cty3	111N	07/08	14W
	15	18.5	2nd bridge on hogsback coming from cty 3	111N	8	14W
	16	19.3	3rd bridge " "	111N	7	14W

Attachment 3. Listing and description of 1999 discharge measurement locations.

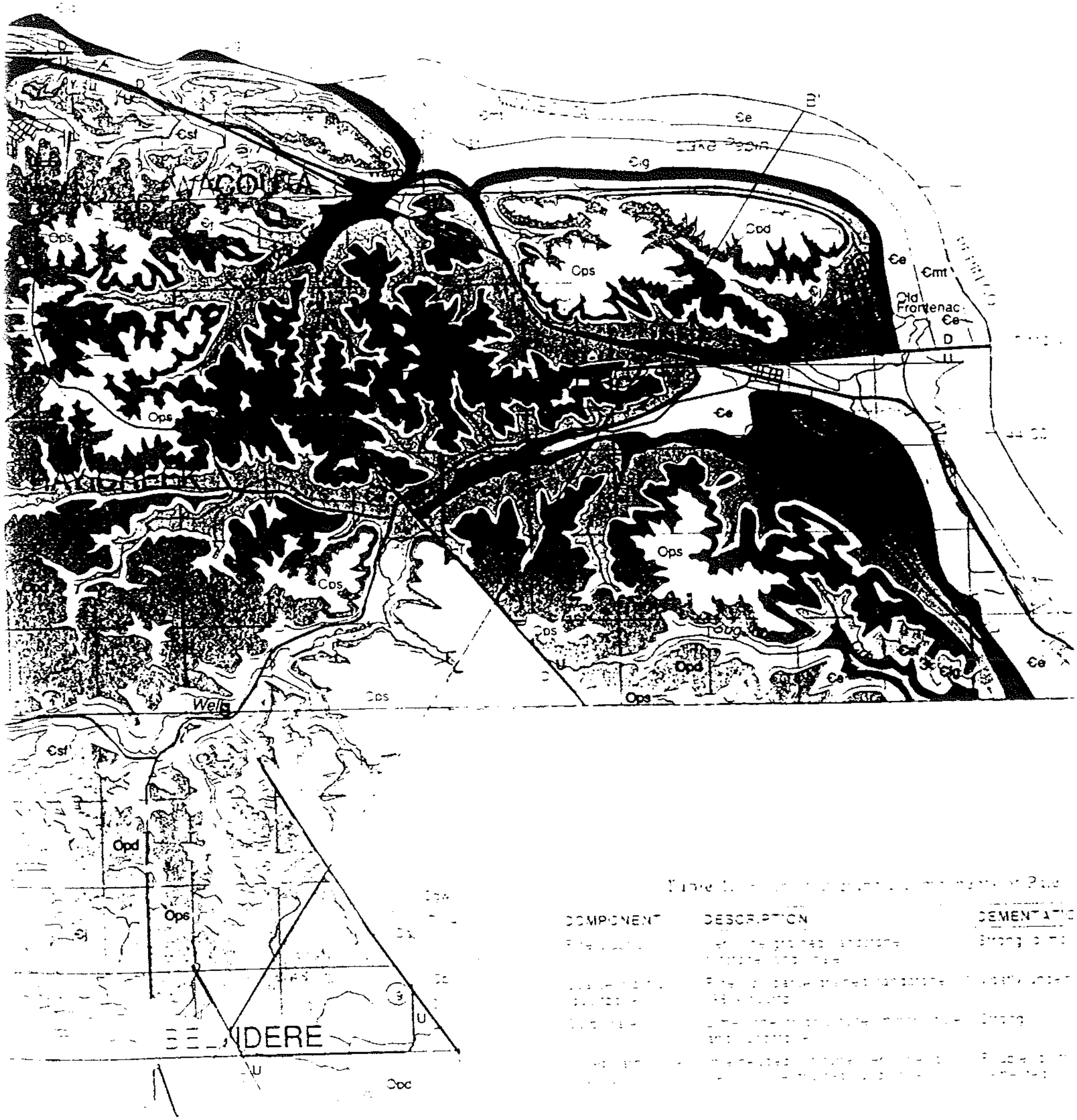
Site	Ave. Vel (ft/sec)	Discharge (cfs)
1	1.19	18.5
2	1.72	45.95
3	1.76	40.64
4	1.37	37.85
5	1.48	37.1
9	0.89	10.54
11	1.11	9.84
12	0.36	8.55
14	0.48	6.24
15	0.12	2.01
16	0	0



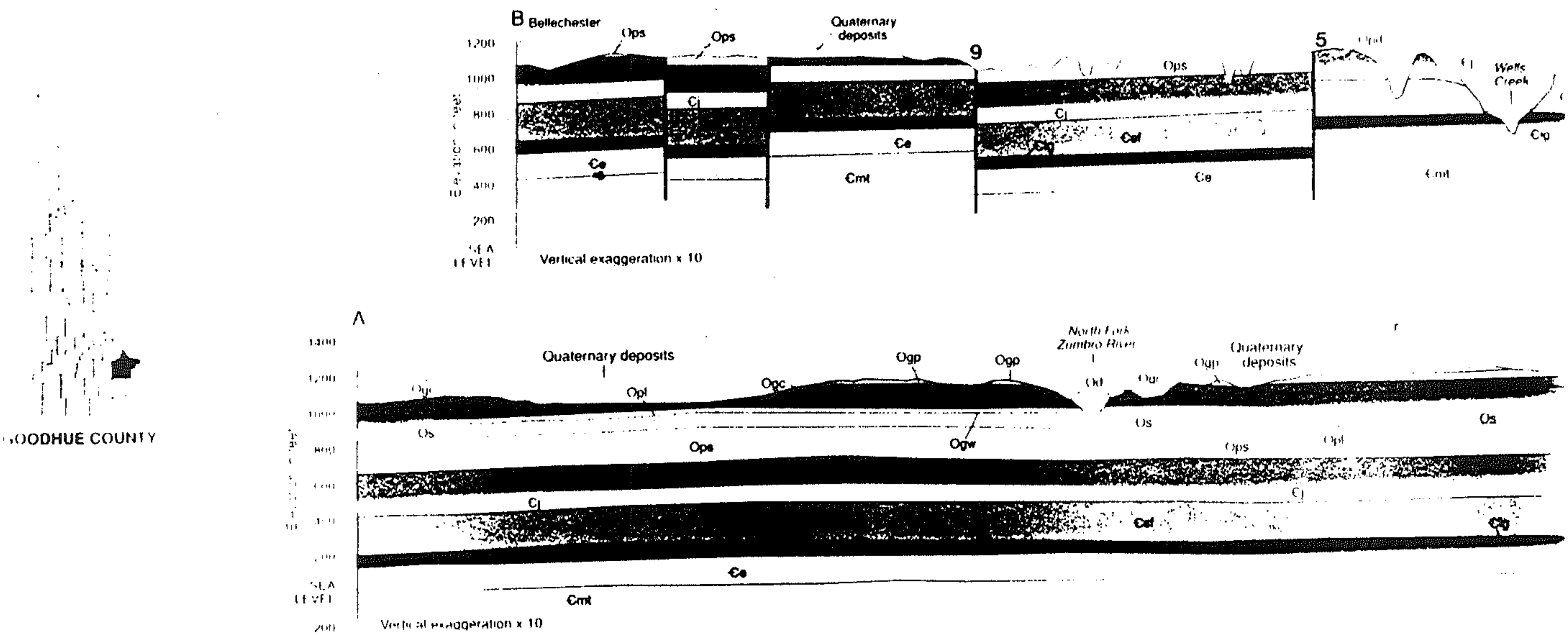
Attachment 4. July 1999 mainstem discharge measurements.



Attachment 5. Mainstem discharge measurement values for 1994 and 1999.

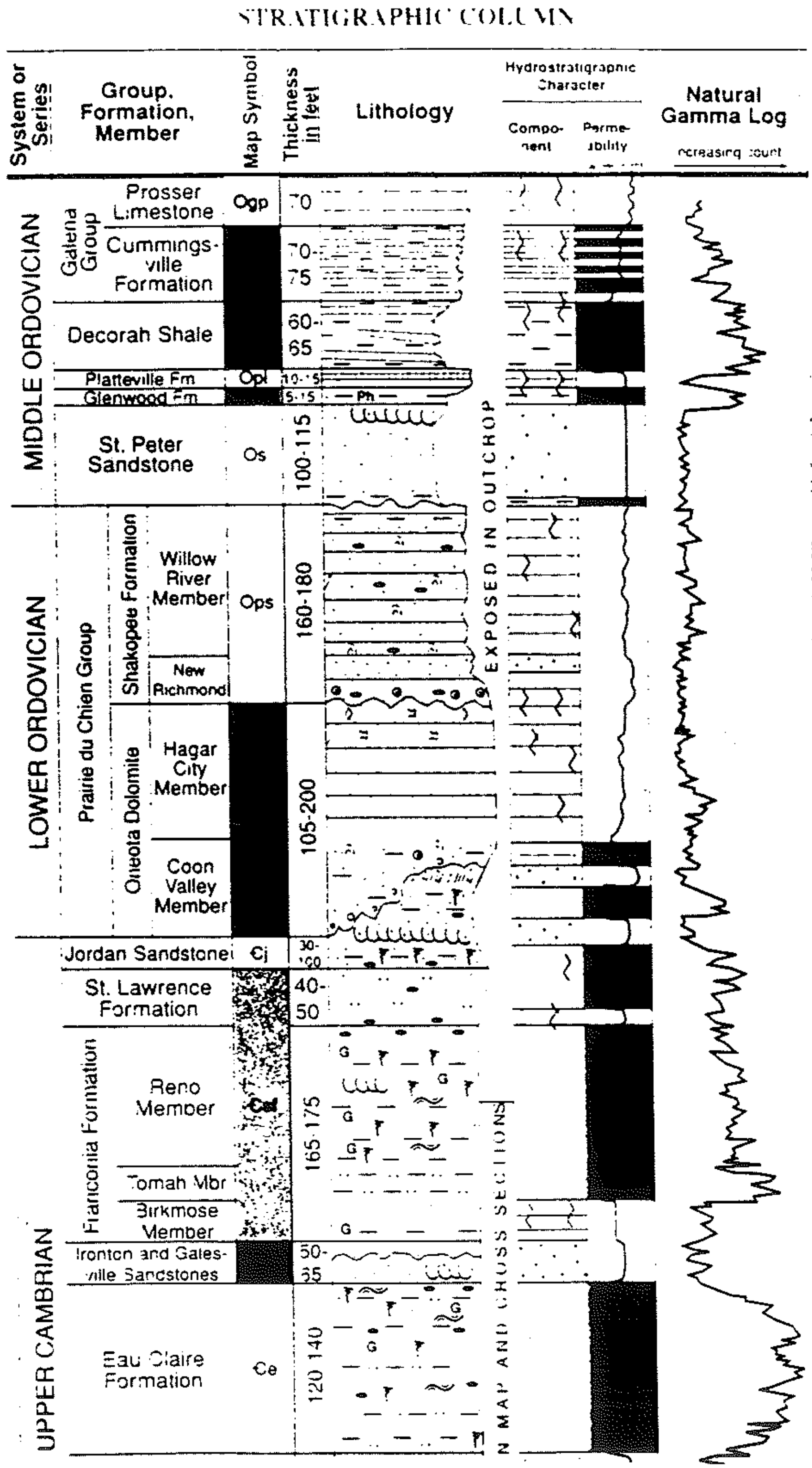


Attachment 6., Bedrock Geology Map from Goodhue County Geologic Atlas.

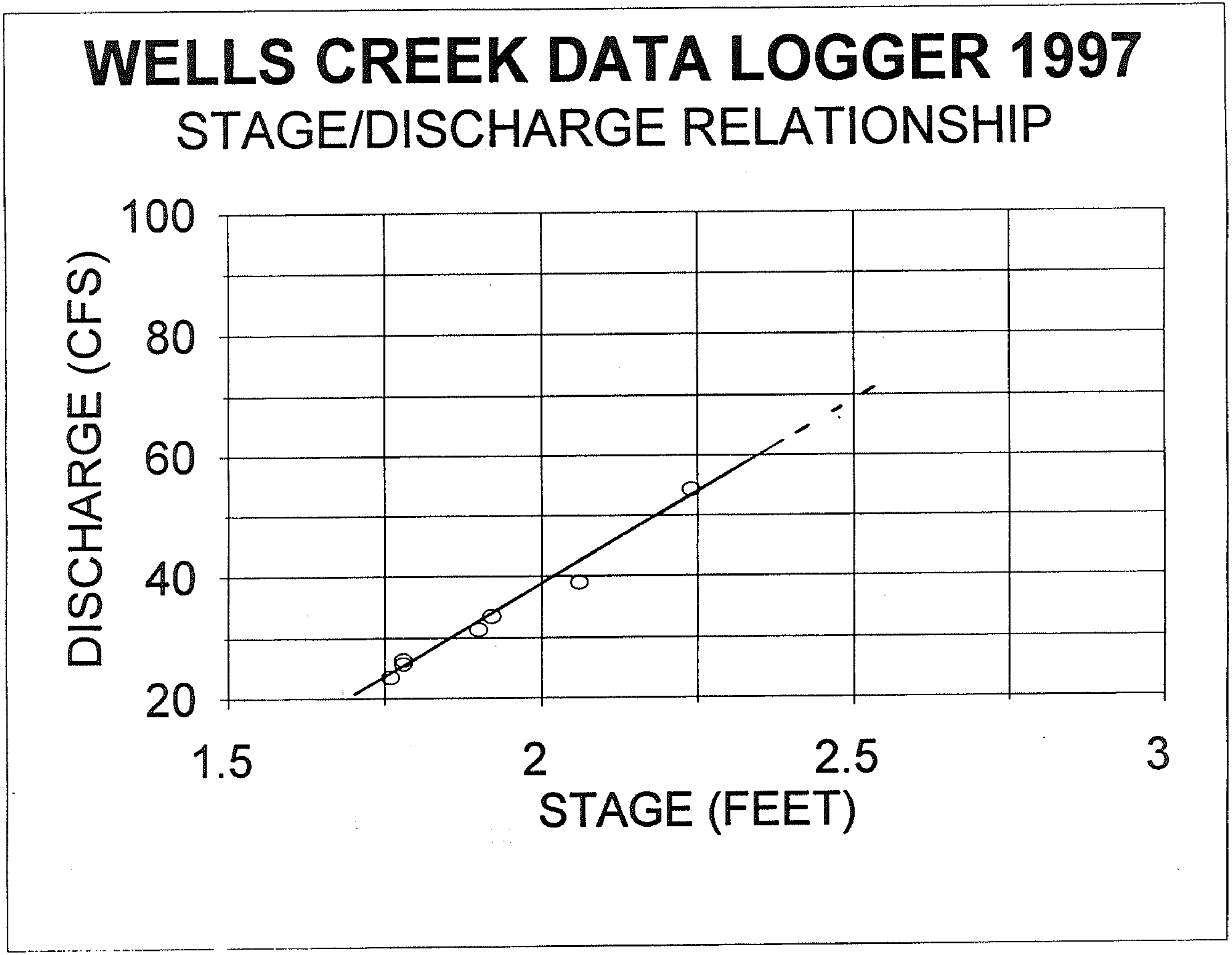


Attachment 7. Geologic Cross-Sections from Goodhue County Geologic Atlas.

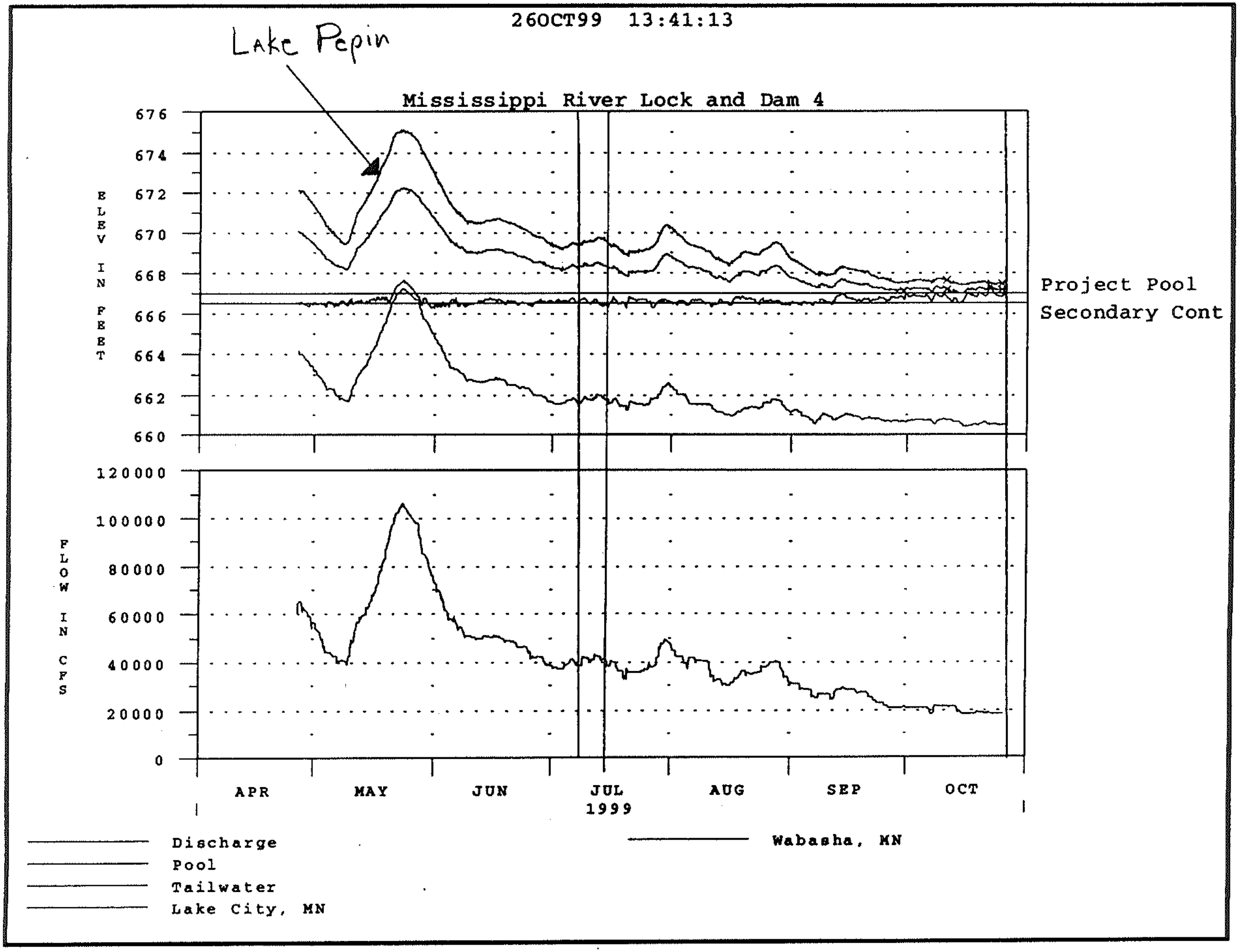
COUNTY ATLAS SERIES
ATLAS C-12, PART A
Plate 2—Bedrock Geology



Attachment 8. Geologic Stratigraphic Column from Goodhue County Geologic Atlas.



Attachment 9. Site 5 Stage/Discharge Relationship from 1997 measurements.



Attachment 10. Lake Pepin water levels for 1999.