DISCHARGE AND WATER WITHDRAWAL ASSESSMENT, MOUNTAIN FORK WATERSHED, MADISON COUNTY, ALABAMA

GEOLOGICAL SURVEY OF ALABAMA

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DISCHARGE AND WATER WITHDRAWAL ASSESSMENT, MOUNTAIN FORK WATERSHED, MADISON COUNTY, ALABAMA

OPEN-FILE REPORT 0527

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Tuscaloosa, Alabama
2005

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EXECUTIVE SUMMARY

In September 2004 Madison County and the Geological Survey of Alabama entered into an agreement to perform a hydrogeologic investigation for Mountain Fork Creek and Cress Spring. The project area was in and around the New Market community in northeast Madison County and included the Mountain Fork Creek watershed from the northern end of Mountain Fork Road to immediately downstream from the confluence with Hester Creek.

The purpose of the project was to document the discharge characteristics of Mountain Fork Creek and Cress Spring and to determine the influence, if any, of the Cress Well on the discharge of the creek and spring and to assess the general discharge character of the stream.

Pumping tests were performed by the GSA in October 2004 and May 2005. Also, discharge data were collected monthly for 12 sites to determine seasonal discharge variations and natural gain and loss of stream segments.

Results of the October 2004 and May 2005 pumping tests were similar and indicated that the Cress Well is hydraulically connected to Cress Spring and to Mountain Fork Creek. Upon initiation of pumping the Cress Well, Cress Spring responded immediately with decreasing spring discharge. Cress Spring discharge decreased approximately 93 percent at a Cress Well pumping rate of 3,075 gallons per minute (gpm). Evaluations of pumping test data indicate that Cress Spring discharge supplies less than 20 percent of the water withdrawn from the Cress Well. The remaining water produced by the Cress Well probably discharges to Mountain Fork Creek through fractures and joints that intersect the creek bed at multiple locations downstream from the well. This concept is supported by creek discharge measured during the pumping tests where much of this ground water discharges between sites 4B and 5. At a pumping rate of 4,100 gpm, creek discharge at site 5 indicated that 100 percent of water withdrawn by pumping was accounted for in decreased creek discharge.

Discharge response to pumping at site 5 in May 2005 was similar to the October 2004 test. At a pumping rate of 5,000 gpm, site 5 discharge decreased by 9.49 cfs (4,269 gpm) or 0.85 gallon of creek discharge per gallon of pumping. Therefore, both the October 2004 and May 2005 pumping tests indicate that water withdrawn by Cress Well

pumping is sourced from ground water that enters Mountain Fork Creek between sites 3 and 5 when the well is not pumping.

Discharge at 12 Mountain Fork Creek monitoring sites was measured monthly from September 2004 to September 2005 to determine seasonal fluctuations and to determine if monitored stream segments exhibited natural gains or losses in discharge related to the karst hydrogeology that characterizes the watershed. Peak discharge occurred in March 2005 and was 67.6 cfs (30,343 gpm) at site 3 and 145.4 cfs (65,264 gpm) at site 9B. Low flow occurred in September 2005 and was significantly less than the September 2004 low flow due to limited rainfall during summer and fall 2005. Site 3 low flow discharge was 1.9 cfs (853 gpm) at site 3 and 18.9 cfs (8,484 gpm) at site 10.

Effects of irrigation pumping by water cress growers were observed between sites 6 and 8 where more than 10 cfs may be withdrawn periodically. Other creek discharge losses include natural losses that are common in streams underlain by karst geology. Losses may occur in any segment of the stream but were documented between sites 9B and 10 where as much as 45 cfs may be lost to the subsurface during peak flow.

Several factors contributed to decreased discharge in Mountain Fork Creek, especially in summer and early fall. Pumping by Madison County and water cress growers, natural loss of stream segments, and limited rainfall all contributed to low discharge in the creek.

INTRODUCTION

In September 2004, Madison County and the Geological Survey of Alabama (GSA) entered into an agreement under which GSA would perform a hydrogeologic investigation to determine the discharge characteristics of Mountain Fork Creek, the discharge of Cress Spring, and determine what effects, if any, withdrawals from the Cress Well, a Madison County public water supply well, have on discharge of the creek and spring.

Currently, two major water users withdraw water from the Mountain Fork Creek watershed in the New Market area of northeastern Madison County (fig. 1). A conflict exists between Madison County and a downstream agricultural water user (water cress growing operation), who withdraws water directly from Mountain Fork Creek regarding the pumping rate of the Cress Well and its effect on creek flow and downstream users. The water cress producers contend that Madison County is impacting creek and spring discharge to an extent that limits their ability to grow water cress.

ACKNOWLEDGMENTS

The Geological Survey of Alabama acknowledges those individuals, agencies, and companies whose participation and cooperation made this assessment possible. The Madison County Commission, Mr. Fritz Muck and Mr. John Buxton (Madison County Water Department), were instrumental in providing financial and technical support. Mr. Jeff Rich (Madison County Attorney) provided technical assistance. Mr. Tony White and Mr. Barry Jones (Cress Well Water Treatment Plant) supplied data and assisted with field assessments. Mr. Bob Burgoon (B&W Growers) provided access for field data collection.

HYDROGEOLOGIC ASSESSMENT

PHYSIOGRAPHY AND GEOLOGY

Madison County, Alabama, is located in north-central Alabama in the Jackson County Mountains district of the Cumberland Plateau physiographic section and in the Tennessee Valley district of the Highland Rim physiographic section (fig. 2) (Sapp and Emplaincourt, 1975).

Figure 1.—Alabama map depicting the location of the Mountain Fork Creek watershed.

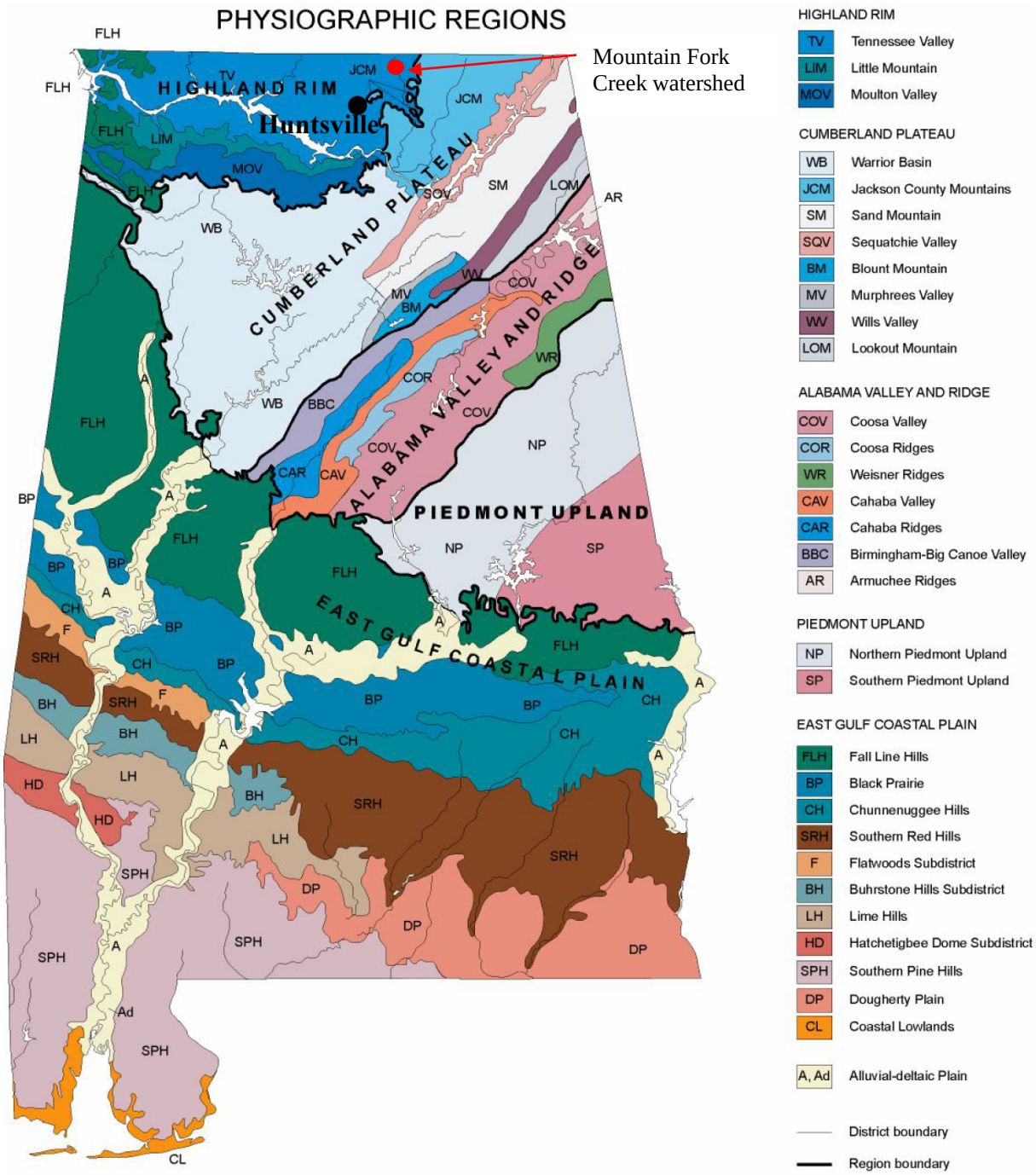


Figure 2.— Physiographic designation for the Mountain Fork Creek Watershed.

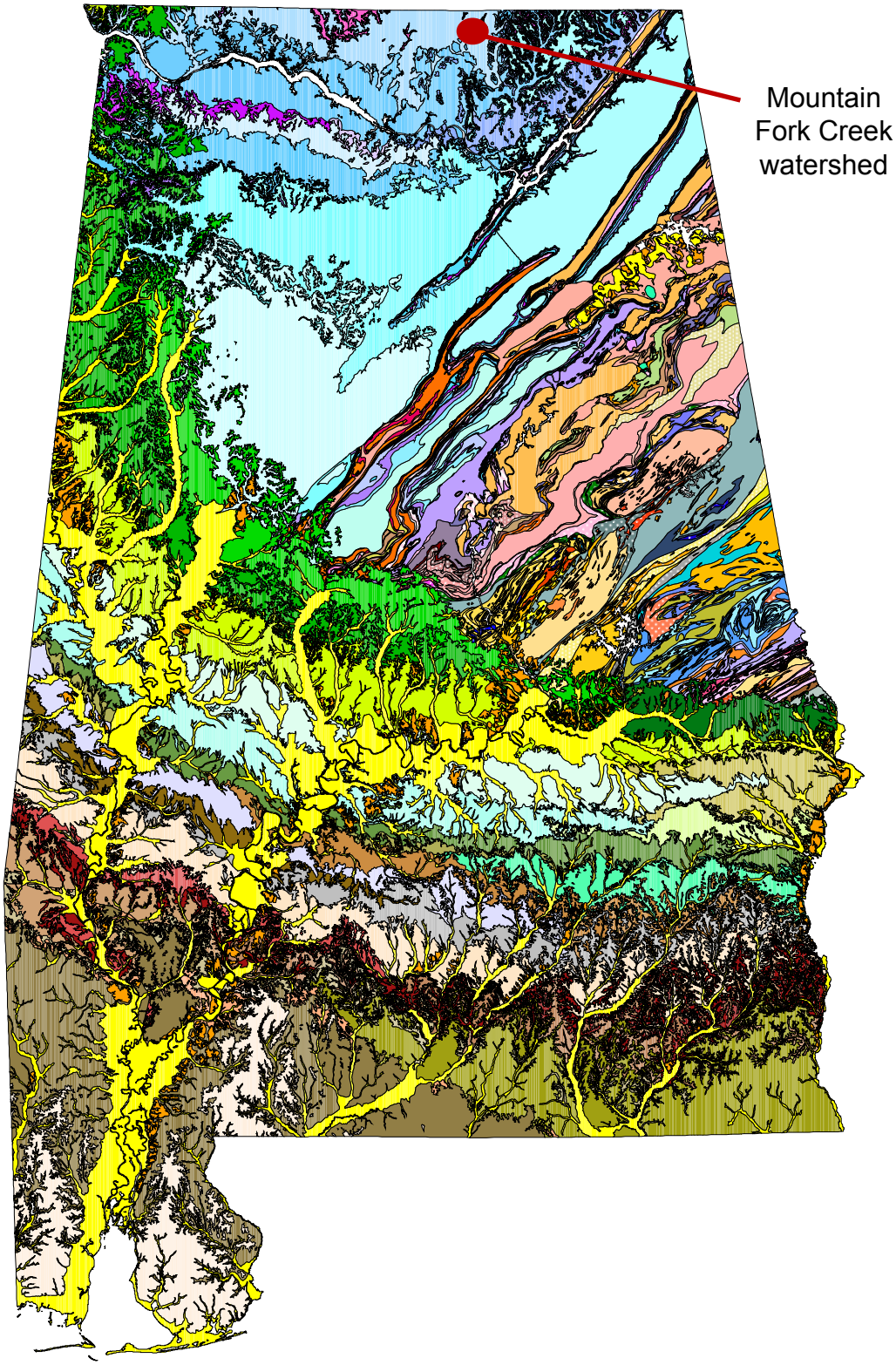


Figure3.--- Generalized geology of Alabama showing the location of Mountain Fork Creek watershed.

Rocks cropping out in Madison County and the Huntsville area include limestone, sandstone, shale, and dolomite of Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian ages as well as unconsolidated sand, clay and gravel of Quaternary age. Figure 3 is a generalized geologic map of Alabama. The Mountain Fork Creek watershed is underlain by rocks of Mississippian age. The creek valley floor is underlain by Tuscumbia Limestone in the headwaters and by the Fort Payne Chert in the middle and lower portions of the watershed. Areas of higher elevation along the valley flanks are underlain by Monteagle Limestone, Hartselle Sandstone, and Bangor Limestone (fig. 4). Solution features such as caves, sinkholes, springs, and sinking streams are common in the carbonate rocks of the area.

The surface area is primarily an unconsolidated layer of locally cherty clay and gravel (regolith) that includes flood plain deposits, material that has moved downslope under the influence of gravity, and material derived from weathering of the bedrock. Weathering includes the chemical decomposition and mechanical disintegration of rocks, followed by removal of water-soluble materials. The insoluble residue that remains above bedrock is termed regolith. Thickness of the regolith varies considerably, from a maximum of 102 feet in the carbonate lowlands to less than 20 feet on the mountains and hills.

Structurally, Madison County lies on the flank of the Nashville dome. Regional dip is to the south and southwest at about 20 feet per mile; however, minor folds modify the dip so that local dip amount and direction vary widely.

Joints are generally the result of compression or tension in sedimentary rocks. They are of particular interest in hydrogeological assessments because they provide fracture permeability for movement of ground water, especially in carbonate rocks. Joints may also influence surface-water flow when they are exposed in stream beds by allowing surface water to move downward into the subsurface (losing stream) or ground water to move upward to increase stream discharge (gaining stream). A study of joints in caves in Madison County revealed that east-west- and north-south-oriented joints are the dominant avenues for water movement (Baker and Raymond, 1994).

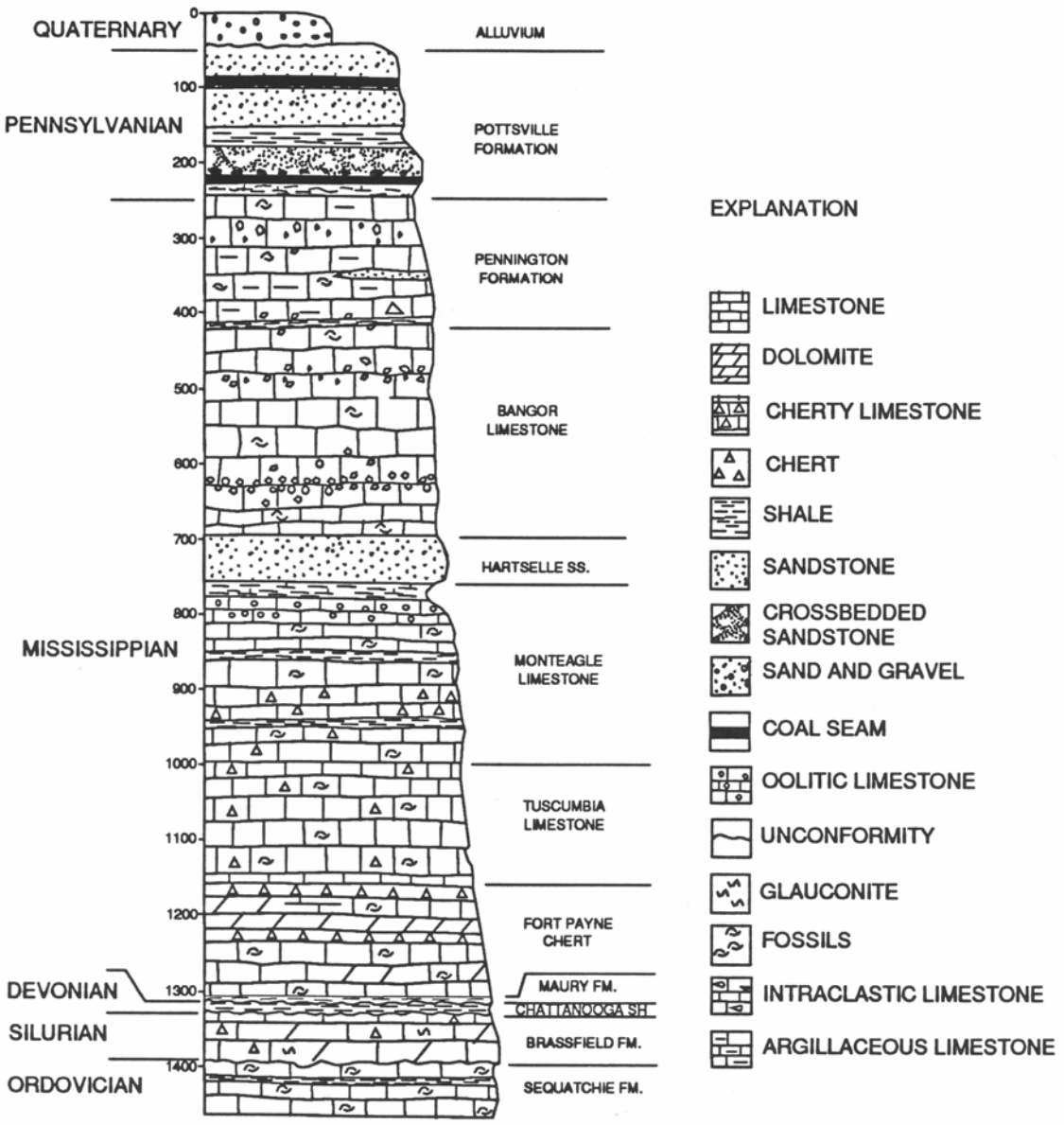


Figure 4.— Generalized stratigraphic column for Madison County, Alabama.

HYDROGEOLOGY

The northern Madison County area has undergone significant shallow, open, subsoil, karst development. The limestone bedrock is relatively flat lying and exhibits solutionally enlarged fractures, bedding planes, and joints and contains sinkholes and caves. The Mountain Fork Creek area is an open, subsoil karst area since it receives recharge directly from the regolith above and there are no lateral hydrogeologic barriers

to the flow of ground water. The limestone strata are of limited thickness, and impervious strata below have been exposed by erosion down to base level in some areas, such as Limestone Creek to the west and parts of Hester and Mountain Fork Creeks to the east.

Ground water in the northern Madison County area is contained primarily in the solution-enlarged fractures, bedding planes, and cavities in the limestone and in the regolith covering these strata. As water from precipitation percolates downward from the ground surface, the regolith serves as temporary storage for ground water and as a primary source of recharge of water to the underlying limestone aquifers. Fort Payne Chert and Tuscumbia Limestone are the principal water-bearing units in the county. The Tuscumbia-Fort Payne aquifer is basically composed of ramifying solution features, which constitute arteries for ground-water movement, bounded by large masses of dense, poorly permeable carbonate rock. Solution cavities in these formations supply water to all the major wells and springs in the county including the Cress Well and Cress Spring.

METHODOLOGY

The approach employed by the GSA was to document the discharge of Mountain Fork Creek from its headwaters to the downstream extent of water cress production, Cress Spring discharge, and Cress Well production. Discharge data were collected monthly from 12 monitoring stations established on Mountain Fork Creek (table 1, fig. 5, pl. 1). The monthly monitoring was designed to determine seasonal and climatic effects on creek discharge and water loss or gain within sections of Mountain Fork Creek as a result of natural ground-water inflow or surface-water outflow. Quantities of water withdrawn from the creek by the water cress producer were unknown and therefore were not considered in the assessment. Therefore, the impact of water usage by the water cress producer, particularly in areas that also may be affected by Cress Well production cannot be evaluated in this assessment. Cress Spring discharge was monitored continuously at 15 minute intervals, and Cress Well production rates were recorded daily. During October 2004 and May 2005, pump tests were performed to compare to selected production rates from the Cress Well with Mountain Fork Creek and Cress Spring discharge. During these tests, productions rates from the Cress Well varied from 0 to 5,000 gpm, while spring and creek discharge were monitored simultaneously. Creek monitoring stations 3, 4, 4A, 4B,

Table 1. Descriptions of Mountain Fork Creek monitoring stations.

Site No.	Site name	Location	Latitude/Longitude	Approximate drainage area (mi^2)	Remarks
1	Mountain Fork Creek	SW¼SE¼ sec. 13, T. 1 S., R. 2 E.	34. 57.01/86 21.94	16.82	Owned by Mr. Martin Hutchison, 1847 Mountain Fork Rd., New Market. Creek is mostly dry late spring through fall. 10-20 yards downstream of small bridge
2	Mountain Fork Creek	SW¼NW¼ sec. 26, T. 1 S., R. 2 E.	34 55.63/86 23.65	19.68	Owned by Howard Jones, 5276 Winchester Road, New Market. 20 yards upstream of 90° bend; 1 mi from Cress Well Road; turn left onto field road (Convict Drive); go 0.70 mi through locked gate (2741 lock) to site
3	Mountain Fork Creek	SE¼NE¼ sec. 27, T. 1 S., R. 2 E.	34 55.67/86 23.59	22.75	Twenty-five yards downstream of concrete bridge on Cress Well Rd. MP for tape down is on downstream side of bridge marked with orange paint elev. at 740.215 ft.
3A	Cress Spring discharge	sec. 27, T. 1 S., R. 2 E.	34 55.60/86 23.65	NA	Fifteen-inch Thelmar weir installed on 9/28/04.
4	Mountain Fork Creek	NE¼SE¼ sec. 27, T. 1 S., R. 2 E.	34 55.447/86 26.795	22.81	Near diversion flume discharge. Creek is measured upstream and downstream of flume discharge.
4B					Flume diversion to water cress ponds, near site 4.
4C					Pipe(s) discharge to water cress ponds.
5	Mountain Fork Creek	SW¼SE¼ sec. 27, T. 1 S., R. 2 E.	34 55.22/86 23.92	23.00	Upstream of wooden bridge on Cress Pond road. Measured below cress pond discharge. Tape down on downstream edge of bridge (nail cap) elev. 741.72 ft.
6	Mountain Fork Creek	NE¼NE¼ sec. 33, T. 1 S., R. 2 E.	34 54.89/86 24.77	25.75	Behind water cress growers office. Measured section upstream of pump.
7	Unnamed tributary to Mountain Fork Creek	NE¼NW¼ sec. 33, T. 1 S., R. 2 E.		5.39	On Mountain. Fork Road.
8	Mountain Fork Creek	NW¼NW¼ sec. 33, T. 1 S., R. 2 E.	34 54.62/86 26.26	32.15	At Winchester Road in New Market. Downstream side of bridge 40 yards.
9	Mountain Fork Creek and Hester Creek	SE¼NW¼ sec. 32, T. 1 S., R. 2 E	34 54.86/86 26.26	72.3	West of New Market 0.5 mile. Hester Creek (40.1 mi sq) upstream of confluence with Mountain. Fork Creek. Measured Mountain Fork downstream side of bridge 20 yards
10	Mountain Fork Creek	SW¼SW¼ sec. 32, T. 1 S., R. 2 E.	34 54.16/86 26.74	72.68	Approximately 1 mile SW of New Market. Turn south on dirt road before creek bridge on county paved road. Go through all water cress ponds 0.95 mile to last pumping station. Measured section is 50 ft downstream of old Ford sedan.

4C and 5 were monitored during the test (fig. 5). The time period for each production rate interval allowed for stabilization of spring discharge and downstream travel times to determine the effect of pumpage on spring and stream discharge.

Discharge was measured with a Price AA flow meter attached to a top set wading rod. The data were collected according to United States Geological Survey (USGS) flow measurement guidelines (Carter and Davidian, 1968). An in-stream flow measurement device (24-inch pipe with a 15-inch Thelmar weir) was installed and calibrated at the discharge point of Cress Spring (fig. 6). Continuous levels in the spring were recorded using an Insitu Mini Troll water level data logger (fig. 6). Water levels were calibrated with discharge from the Thelmar weir to determine spring discharge at 15-minute intervals during the assessment period.

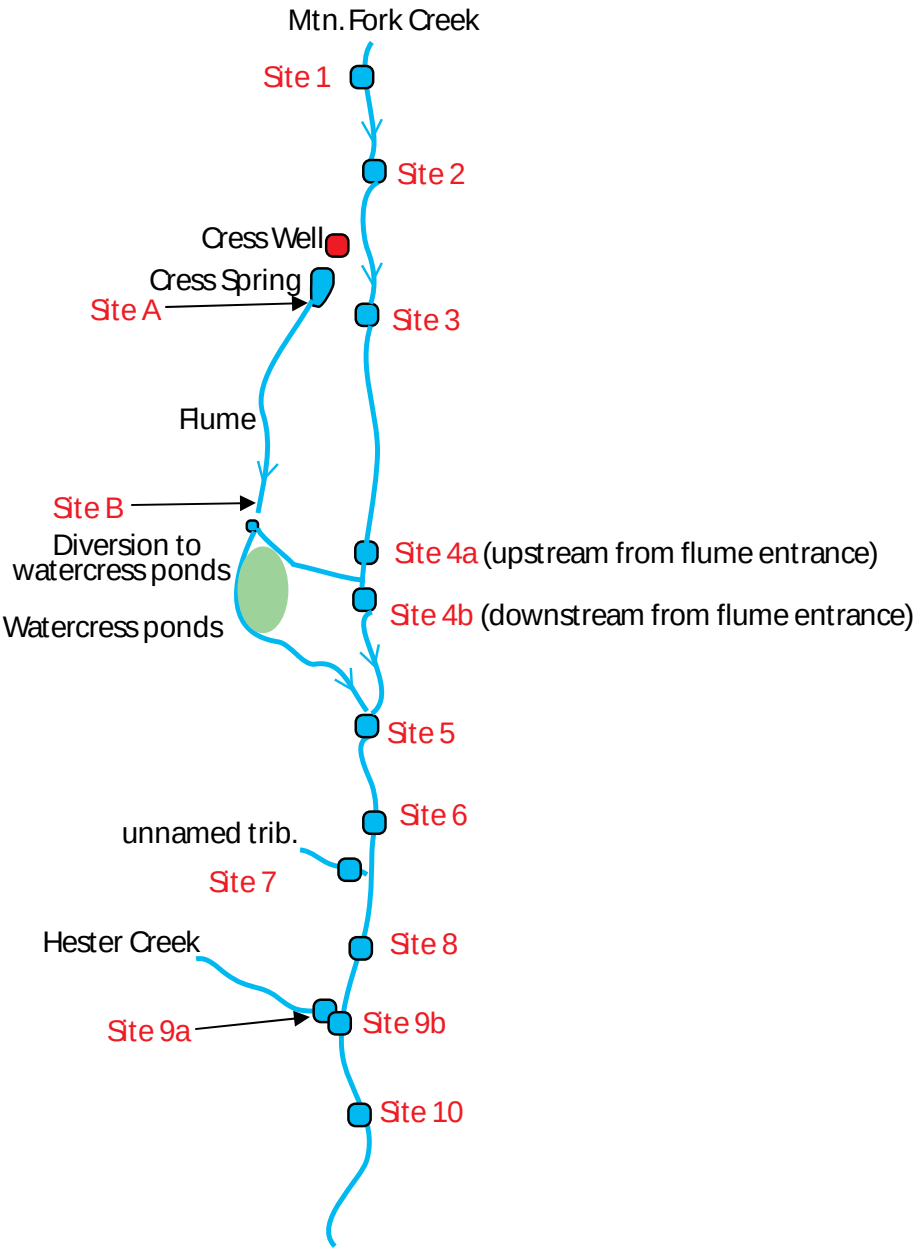


Figure 5.—Schematic of discharge measurement sites during the October 25-26, 2004, pumping test.

Figure 6.—Thelmar weir and mini troll water level monitor installed in Cress Spring discharge.

Figure 7.—GSA personnel measuring discharge on Mountain Fork Creek.

OCTOBER 2004 PUMPING TEST

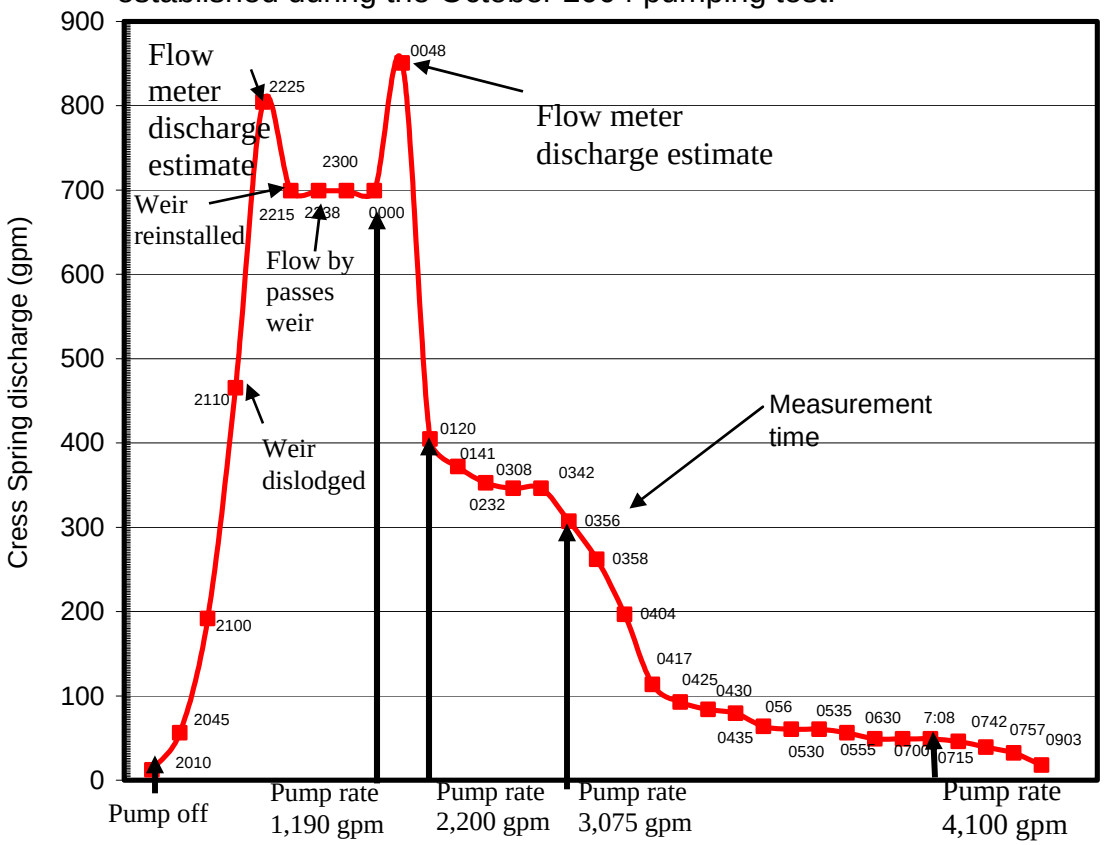
The first of two pump tests performed on the Cress Well were conducted on October 25-26, 2004. GSA personnel were positioned to measure discharge in Mountain Fork Creek and Cress Spring (fig. 7) and measured flow into and out of water cress fields in the vicinity of the Cress Well. Madison County personnel maintained Cress Well pumping rates in cooperation with GSA monitoring via radio communication. Spring discharge recovery began when the Cress Well pump was turned off at 2010 hours on October 25 (fig. 8). The Cress Spring discharge responded immediately, increasing from 12 to 465 gpm in one hour. Increasing pressure head dislodged the Thelmar weir at 2110 hours. Maximum stabilized spring discharge occurred at approximately 2225 hours. At this time spring discharge was estimated from a manual flow measurement at 804 gpm (fig. 8). Discharge measured from the weir was 699 gpm after reinstallation at 2215 hours. However, the weir discharge capacity was exceeded and discharge was observed bypassing the weir. Spring drawdown measurements began when pumping was resumed at 1,190 gpm at 0000 hours (fig. 8). A discharge estimate of 851 gpm was made by flow meter measurement at 0048 hours on October 26. Immediately after this measurement, spring discharge decreased in response to pumping. Discharge decreased to 405 gpm at 0120 hours (decrease of 446 gpm in 32 minutes) (fig. 8). Pumping was increased to 2,200 gpm at 0120 hours and spring discharge decreased to 307 gpm at 0356 hours (decrease of 98 gpm in 2 hours 36 minutes) (fig. 8). Pumping was increased to 3,075 gpm at 0356 hours. Spring discharge stabilized at approximately 0425 hours at 93 gpm (decrease of 214 gpm in 29 minutes) (fig. 8) but continued a slow decline to 49 gpm at 0708 hours (decrease of 44 gpm in 2 hours 43 minutes) (fig. 8). Pumping was increased to 4,100 gpm at 0708 hours. After monitoring at this rate for 2 hours spring discharge was 18 gpm, near the discharge rate measured at the beginning of the test prior to pumping cessation (fig. 8).

Interpretation of October 2004 pumping test data indicates that Cress Spring and Cress Well are hydraulically connected and that spring discharge responds to variations in pumping rates. However, Cress Spring discharge supplies approximately 20 percent of the water withdrawn from the Cress Well (fig. 8). These data illustrate the complexity of karst hydrogeologic systems and the conduits that transport ground water through

subsurface limestone aquifers. The remaining 80 percent of the water intercepted by the Cress Well probably discharges to Mountain Fork Creek through fractures and joints that intersect the creek bed at multiple locations downstream from the well. This concept is supported by creek discharge measured during the pumping test (fig. 9). Potentiometric surface mapping in the area indicates that the dominant direction of ground-water movement is toward Mountain Fork Creek (pl. 2). Lineaments in the Cress Spring area influence ground-water quantity and movement.

Figure 9 illustrates changes in creek discharge for variable pumping rates at five locations in the vicinity of Cress well during the test. With the Cress Well pump off, discharge between measurement sites 2 (approximately 100 yards upstream from the well) and 3 (adjacent to the well) is virtually equal. Creek discharge increased at an average rate of 5.2 cfs at each site downstream from the Cress Well (sites 4A, 4B, and 5) with the pump off (fig. 9).

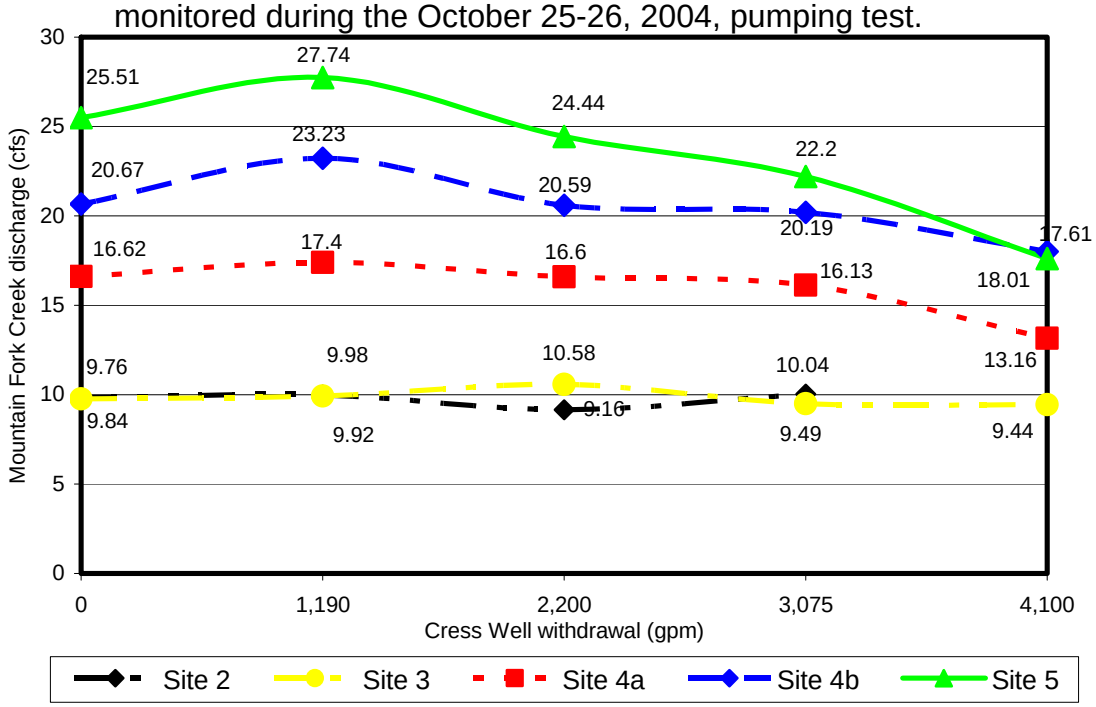
Figure 8.--Cress Spring and Cress Well discharge relationship established during the October 2004 pumping test.



An evaluation of elapsed pumping time intervals and discharge measured during the test indicated that stabilization of stream discharge was not attained for pumping rates of 1,190, 2,200, or 3,075 gpm. Stabilized discharge at sites 4A, 4B, and 5 for the 0 gpm pumping rate actually occurred during the 1,190 gpm pumping interval (fig. 9). At pumping rates of 2,200 and 3,075 gpm, discharge at site 5 decreased 1,481 and 2,490 gpm, respectively. However, the 4,100 gpm rate was continued for a sufficient period to observe stabilized discharge and to account for 100 percent of water withdrawn from the well between Mountain Fork Creek sites 3 and 5.

At the 4,100 gpm pumping rate, approximately 37 percent of creek discharge was lost between sites 3 and 5 during the test on October 26. The percentage of creek discharge lost to Cress Well withdrawal will vary depending on upstream creek flow and the amount of ground water available to the well.

Figure 9.--Measured discharge for Mountain Fork Creek sites monitored during the October 25-26, 2004, pumping test.



MAY 2005 PUMPING TEST

The second pumping test was performed on the Cress Well on May 3-4, 2005. GSA personnel were positioned to measure discharge in Mountain Fork Creek, Cress Spring, and flow into and out of water cress fields in the vicinity of the Cress Well. Madison County personnel maintained Cress Well pumping rates in cooperation with GSA monitoring via radio communication. Spring discharge recovery began when the Cress Well pump was turned off at 1745 hours on May 3 (fig. 10). The Cress Spring discharge responded immediately, increasing from 195 to 345 gpm in six minutes. Maximum weir capacity was exceeded at this point and discharge was observed bypassing the weir. In order to prevent dislodging of the weir due to increased pressure, discharge entering the pipe containing the weir was restricted at 1751 hours (fig. 10). No estimate was made of maximum spring discharge. Pumping was resumed (2,000 gpm) at 2123 hours (fig. 10). Spring discharge decreased immediately in response to pumping. Due to the weir flow restriction and discharge bypassing the weir, no absolute discharge was determined at the 2,000 gpm pumping rate. However, discharge decreased 15 percent during the 2,000 gpm pumping period. Pumping was increased to 3,000 gpm at 0100 hours and spring discharge decreased by an additional 9 percent (fig. 10). At 0121 hours the pressure head decreased sufficiently to remove the flow restriction and restore total flow (390 gpm) through the weir at 0136 hours (fig. 10). Discharge continued to decrease and stabilized at 288 gpm at 0335 hours (fig. 10). Pumping was increased to 4,000 gpm at 0335 hours. Spring discharge quickly decreased to 135 gpm and stabilized (fig. 10). Pumping was increased to 5,000 gpm at 0550 hours. After monitoring at this rate for 5 hours spring discharge stabilized at 58 gpm (fig. 10).

Although higher initial and ending discharges in May 2005 were higher than in October 2004, interpretation of the May 2005 pumping test data indicates a similar result as the October 2004 test. Cress Spring and Cress Well are hydraulically connected and spring discharge responds to variations in pumping rates. Also as previously determined, Cress Spring supplies only a small portion of the water withdrawn from the Cress Well (fig. 10).

Figure 11 compares creek discharge at sites 3 (nearest site to Cress Spring and Cress Well) and 5 with discharge from the Cress Spring diversion canal for variable

Cress Well pumping rates during the test. Unlike the October 2004 test, discharge at site 3 decreased with each Cress Well pumping rate. At pumping rates of 2,000 and 5,000 gpm, site 3 discharge decreased by 350 and 1,629 gpm, respectively (fig. 11). Discharge response to pumping at site 5 was similar to the October 2004 test (fig. 11). At a pumping rate of 5,000 gpm, site 5 discharge decreased by 9.49 cfs (4,269 gpm) or 0.85 gallon of creek discharge per gallon of pumpage.

Figure 12 illustrates decreased discharge at the terminus of the Cress Spring diversion canal in response to Cress Well pumping. Figure 12 also indicates that at a 0 pump rate, there is a large ground-water contribution to the diversion canal between the spring discharge and the terminus of the canal. Spring discharge was approximately 850 gpm, and discharge at the canal terminus was approximately 4,800 gpm.

Figure 10.--Measured Cress Spring and Cress Well discharge relationship determined during May 2005 pumping test.

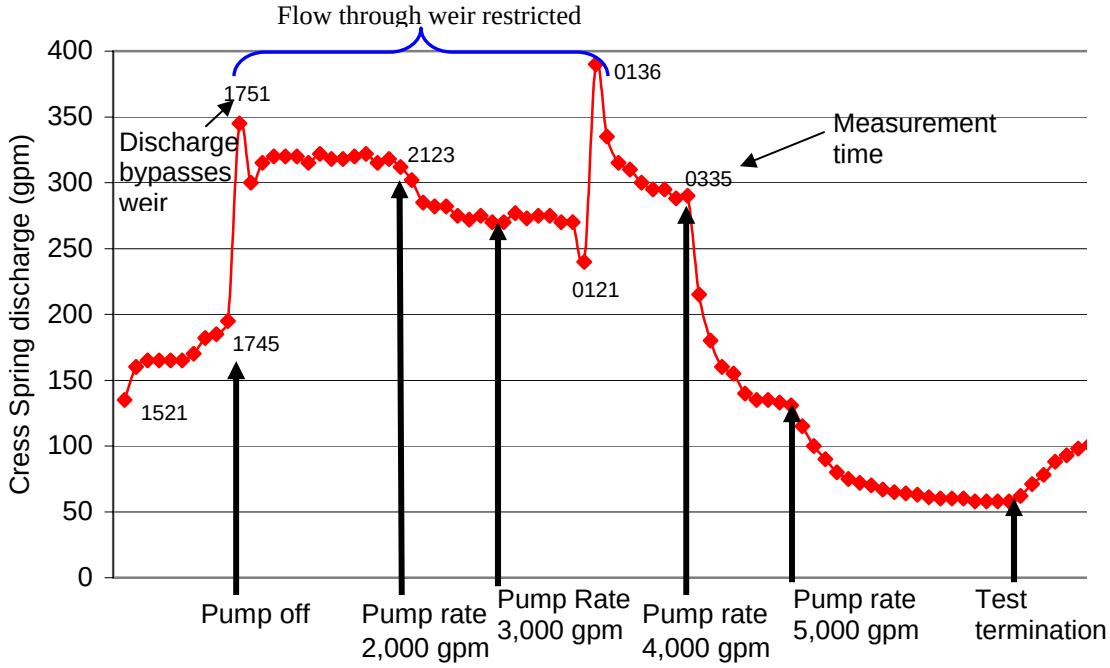


Figure 11.--Measured discharge at Mountain Fork Creek sites 3 and 5, downstream terminus of the Cress Spring diversion canal, and Cress Well withdrawal.

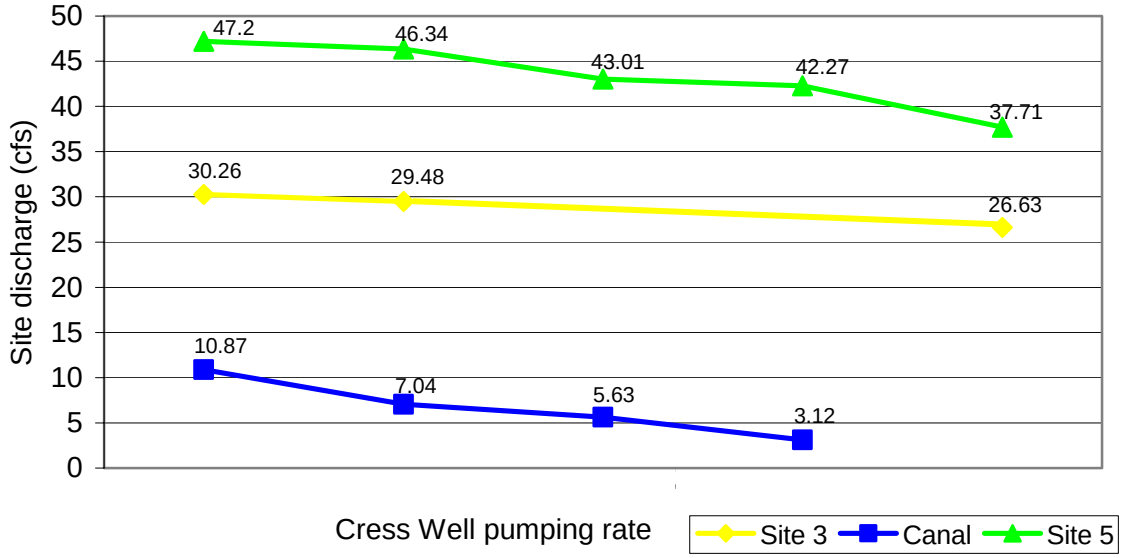
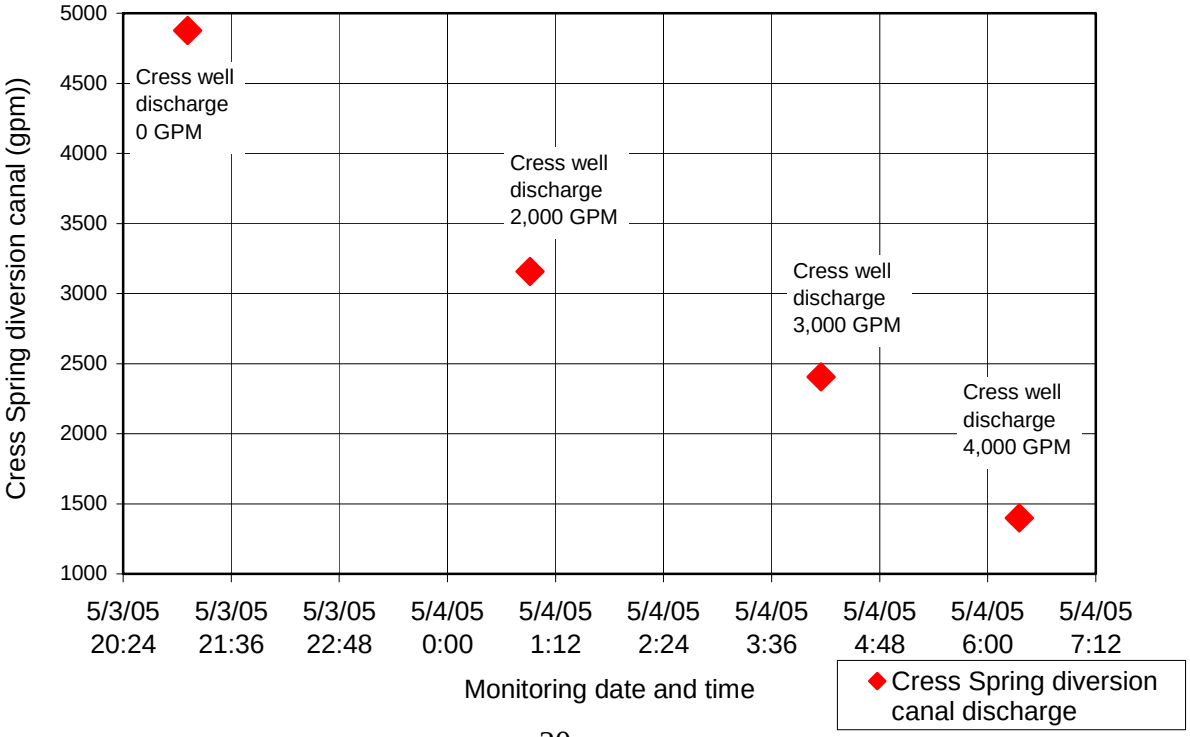


Figure 12.--Measured discharge from downstream terminus of the Cress Spring diversion canal discharge and Cress Well withdrawal.



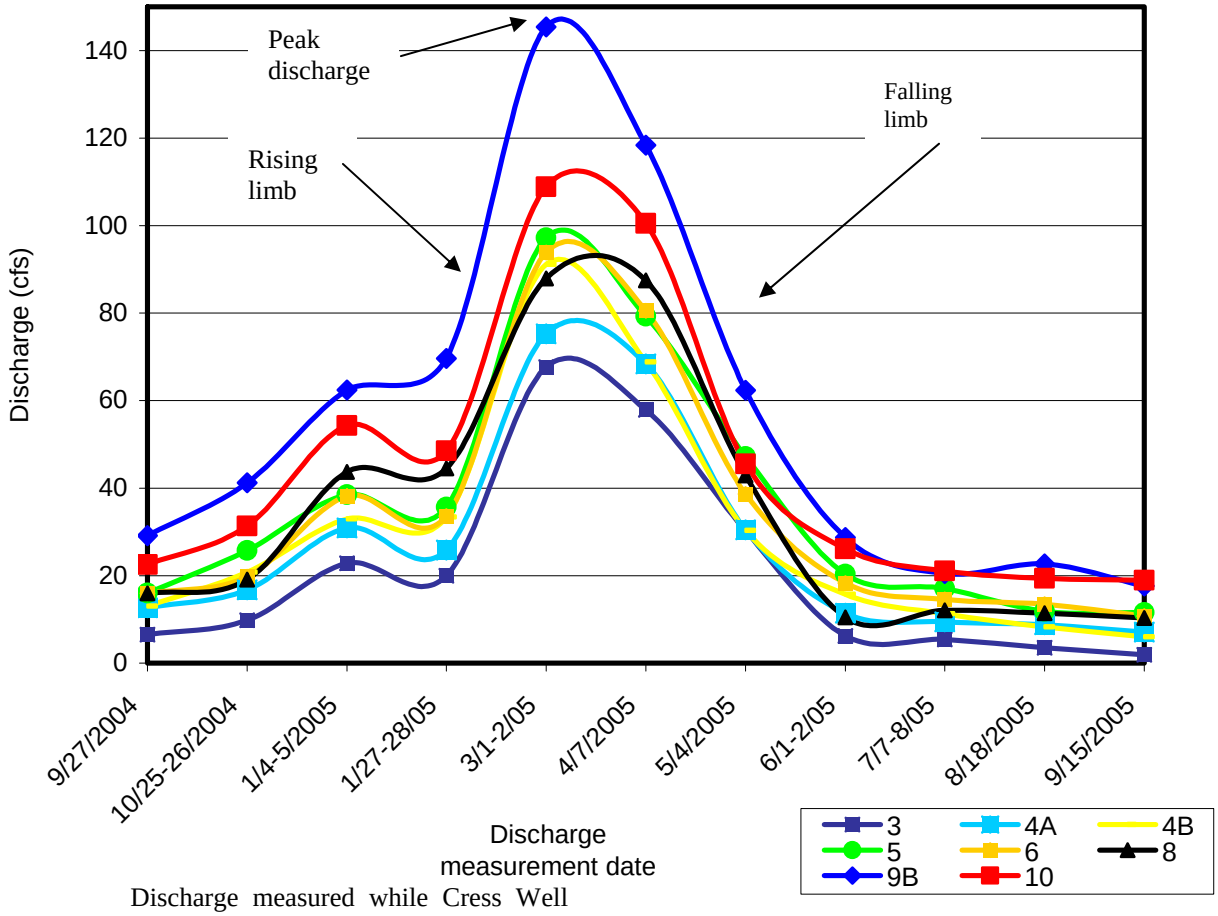
MONTHLY DISCHARGE MONITORING

Discharge at 12 Mountain Fork Creek monitoring sites was measured monthly from June 2004 to September 2005. The purpose of these measurements was to determine seasonal fluctuations in Mountain Fork Creek discharge and to determine if monitored stream segments exhibited natural gains or losses in discharge related to the karst hydrogeology that characterizes the watershed. Observation of withdrawals related to pumping at the Cress Well (year-round) and by the water cress growers, irrigation (during the growing season) were also anticipated although no locations, schedules, or rates of irrigation pumping were disclosed by the water cress growers. Figure 5 and plates 1 and 3 depict the locations of measurement sites, and figure 13 illustrates monthly discharge measurements at sites 3, 4A, 4B, 5, 6, 8, 9B, and 10. The location of Cress Spring and water cress production fields is shown on plate 3.

The curves on this graph represent a series of annual hydrographs for Mountain Fork Creek. The rising limb of the hydrograph occurs from September 2004 to March 2005 (fig. 13). The lowest flow during the rising limb period occurred in September. Site 3 discharge was 6.6 cfs and site 9B discharge was 29.2 cfs. Peak flow occurred in March 2005. Peak discharge at site 3 was 67.6 cfs (30,343 gpm) and site 9B discharge was 145.4 cfs (65,264 gpm). The falling limb of the hydrograph occurred from March 2005 to September 2005 (fig. 13). Base flow occurred in June 2005. Low flow occurred in September 2005 and was significantly less than the September 2004 low flow due to limited rainfall during summer and fall. Site 3 discharge was 1.9 cfs (853 gpm) and site 10 discharge was 18.9 cfs (8,484 gpm).

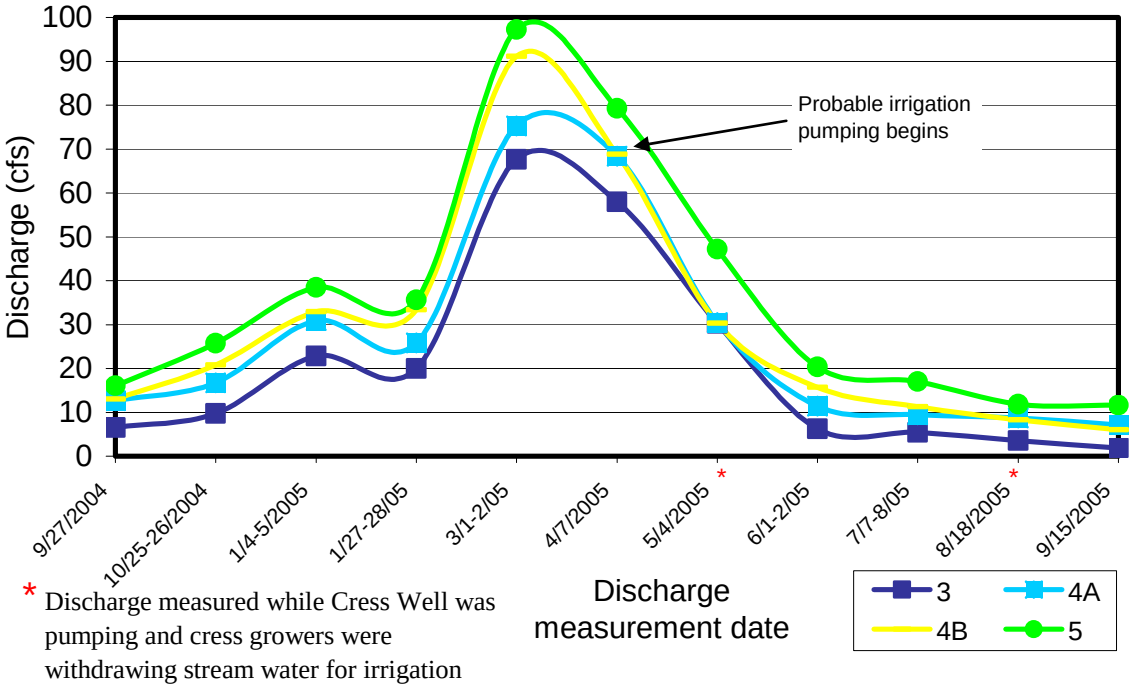
Figure 14 illustrates typical downstream increases in discharge from September 2004 to March 2005. Irrigation pumps installed by the water cress growers were observed in Mountain Fork Creek between sites 4A and 4B and immediately downstream from site 6 (fig. 5, pls. 1, 3). Discharge data collected in April 2005 indicated initiation of probable irrigation water withdrawals between sites 4A and 4B (fig. 13). These withdrawals were observed visually during May and August 2005 and were indicated by the discharge data each month from May to September (fig. 14).

Figure 13.--Discharge measured monthly at Mountain Fork Creek sites 3, 4A, 4B, 5, 6, 8, 9B, and 10.



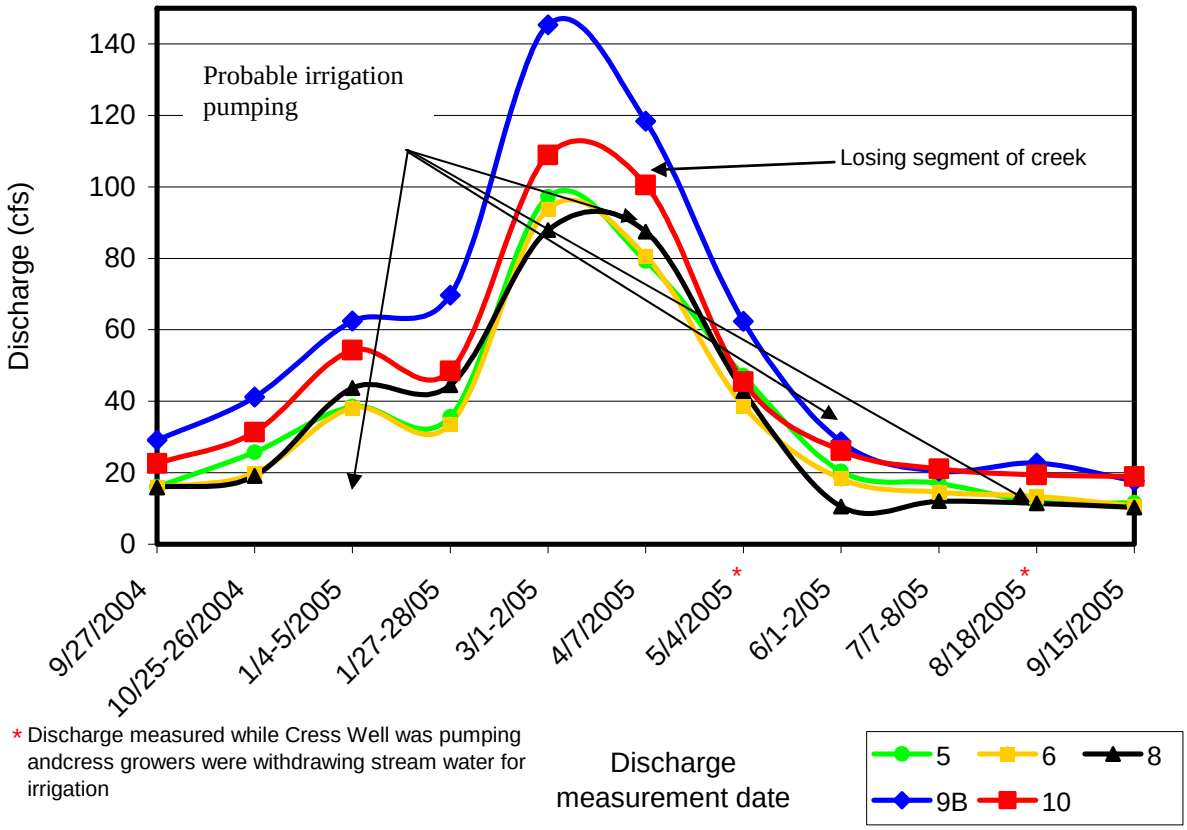
Discharge measured while Cress Well was pumping and cress growers were withdrawing stream water for irrigation

Figure 14.--Discharge measured monthly at Mountain Fork Creek sites 3, 4A, 4B and 5.



* Discharge measured while Cress Well was pumping and cress growers were withdrawing stream water for irrigation

Figure 15.--Discharge measured monthly at Mountain Fork Creek sites 5, 6, 8, 9B, and 10.



* Discharge measured while Cress Well was pumping andcress growers were withdrawing stream water for irrigation

Although site 10 is downstream from site 9B, site 10 had significantly less discharge from September 2004 to May 2005 (fig. 15). This is primarily attributed to natural loss of water from the creek into the subsurface (losing stream segment). This is common in karst terrains and may occur in other segments of Mountain Fork Creek. During several monthly measurements in the spring and summer, discharge at sites 6 and 8 were less than at site 5 (fig. 14). This is probably caused by irrigation pumping by the water cress growers. Affects of irrigation pumping by water cress growers were observed between sites 6 and 8 where more than 10 cfs may be withdrawn occasionally. However, a quantitative assessment of this pumping is difficult and no pumping rates were available for irrigation withdrawals.

MOUNTAIN FORK CREEK DISCHARGE RATING

Table 2 includes discharge data collected during pumping tests, monthly measurements, creek stage height, and water level elevations measured from a reference point established on the concrete bridge near Cress Spring. The table does not represent discharge values for water levels that overtop the concrete bridge.

SUMMARY AND CONCLUSIONS

The purpose of the discharge and water withdrawal assessment for Mountain Fork Creek was to determine the effects, if any, of pumping from the Madison County Cress Well on Cress Spring and Mountain Fork Creek. Pumping tests were performed by the GSA in October 2004 and May 2005. Also, discharge data were collected monthly from September 2004 to September 2005 for 12 sites to determine seasonal discharge variations and natural gaining and losing stream segments, if any.

October 2004 and May 2005 pumping test results were similar and indicated that the Cress Well is hydraulically connected to Cress Spring and to Mountain Fork Creek. Evaluations of pumping test data indicate that Cress Spring discharge accounts for approximately 20 percent of the water withdrawn from the Cress Well. The remaining 80 percent of the water intercepted by the Cress Well probably discharges to Mountain Fork

Table 2.-- Discharge rating table for Mountain Fork Creek near Cress Spring.

Stage height (feet)	Stage height (feet, inches)	Discharge (cfs)	Stage elevation (feet above mean sea level)	Stage height (feet)	Stage height (feet, inches)	Discharge (cfs)	Stage elevation (feet above mean sea level)
4	4' 0"	4.5	736.12	2	2' 0"	67	738.12
3.9	3' 11"	4.8	736.22	1.9	1' 11"	72	738.22
3.8	3' 10"	5	736.32	1.8	1' 10"	77	738.32
3.7	3' 8"	5.5	736.42	1.7	1' 8"	82	738.42
3.6	3' 7"	5.8	736.52	1.6	1' 7"	87	738.52
3.5	3' 6"	6	736.62	1.5	1' 6"	91	738.62
3.4	3' 5"	6.5	736.72	1.4	1' 5"	95	738.72
3.3	3' 4"	7	736.82	1.3	1' 4"	98	738.82
3.2	3' 2"	7.5	737.92	1.2	1' 2"	101	739.92
3.1	3' 1"	8	737.02	1.1	1' 1"	104	739.02
3	3' 0"	8.5	737.12	1	1' 0"	106	739.12
2.9	2' 11"	10.5	737.22	0.9	0' 11"	109	739.22
2.8	2' 10"	13	737.32	0.8	0' 10"	112	739.32
2.7	2' 8"	16	737.42	0.7	0' 8"	115	739.42
2.6	2' 7"	20	737.52	0.6	0' 7"	118	739.52
2.5	2' 6"	27	737.62	0.5	0' 6"	121	739.62
2.4	2' 5"	34	737.72	0.4	0' 5"	124	739.72
2.3	2' 4"	43	737.82	0.3	0' 4"	127	739.82
2.2	2' 2"	51	738.92	0.2	0' 2"	129	740.92
2.1	2' 1"	60	738.02	0.1	0' 1"	133	740.02

Creek through fractures and joints that intersect the creek bed at multiple locations downstream from the well. This concept is supported by creek discharge measured during the pumping tests. During the October 2004 test, pumping caused discharge at site 5 to decrease. At a pumping rate of 4,100 gpm, the total well withdrawal was measured in decreased creek discharge at site 5. This pumping rate on October 26, 2004, accounted for approximately 37 percent of total creek discharge. The percentage of creek discharge lost to Cress Well withdrawals varies with upstream stream flow and the amount of ground water available to the well.

During the May 2005 pumping test, creek discharge response to pumping at site 5 was similar to the October 2004 test. At a pumping rate of 5,000 gpm, site 5 discharge decreased by 9.49 cfs (4,269 gpm) or 0.85 gallon of creek discharge per gallon of pumping.

Discharges at 12 Mountain Fork Creek monitoring sites were measured monthly from June 2004 to September 2005 to determine seasonal fluctuations and to determine if monitored stream segments exhibited natural gains or losses in discharge related to the karst hydrogeology that characterizes the watershed. Peak discharge occurred in March 2005 and was 67.6 cfs (30,343 gpm) at site 3 and 145.4 cfs (65,264 gpm) at site 9B. Low flow occurred in September 2005 and was significantly less than the September 2004 low flow due to limited rainfall during summer and fall. Site 3 low flow discharge was 1.9 cfs (853 gpm) at site 3 and 18.9 cfs (8,484 gpm) at site 10.

Effects of irrigation pumping by water cress growers were observed between sites 6 and 8 where more than 10 cfs may be withdrawn at times. Natural discharge losses are common in streams underlain by karst geology. Losses may occur in any segment of the stream but were documented between sites 9B and 10 where as much as 45 cfs may be lost to the subsurface during peak flow.

Several factors contribute to decreased discharge in Mountain Fork Creek, especially in summer and early fall. Pumping by Madison County and water cress growers, natural losing stream segments, and limited rainfall all contribute to decreased discharge in the creek.

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