UNIVERSITY OF CONNECTICUT

WELLFIELD MANAGEMENT PLAN

MAY 2011

MMI #1958-31

Prepared for:

University of Connecticut
Facilities Management – Operations
25 Ledoyt Road, Unit 3252
Storrs, Connecticut 06269-3252
(860) 486-0041

Prepared by:

Milone & MacBroom, Inc.
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773
www.miloneandmacbroom.com

MILONE & MACBROOM®

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

SECTION 1.0
INTRODUCTION

1.0 INTRODUCTION

1.1 BACKGROUND

The University of Connecticut (the University) withdraws water from two stratified drift wellfields in the town of Mansfield, Connecticut. These are known as the Fenton River Wellfield located to the east of campus along the Fenton River, and the Willimantic River Wellfield located to the west of campus along the Willimantic River. The four Fenton River wells are registered with the Connecticut Department of Environmental Protection (DEP) for a maximum withdrawal rate of 0.8443 million gallons per day (mgd). The four Willimantic River Wellfield wells are registered with the DEP for a maximum withdrawal rate of 2.3077 mgd. Both wellfields are integral sources of supply for the University of Connecticut, which also provides water to portions of the town of Mansfield.

As a result of ongoing concern about the environmental impacts of withdrawing water from the Fenton River Wellfield and in conjunction with the Environmental Impact Evaluation of the North Campus Master Plan, the Fenton River and its stratified drift aquifer have been extensively studied. The University's "Fenton River Study" was published in March 2006 with the formal name *Long-Term Impact Analysis of the University of Connecticut's Fenton River Water Supply Wells on the Habitat of the Fenton River*. The study was conducted to determine whether and how water withdrawals from the Fenton River Wellfield affect the fisheries habitat of the Fenton River adjacent to the wellfield.

The Fenton River Study found that fisheries habitat became perceptibly reduced when the upstream flow in the Fenton River was flowing at less than 7.0 cubic feet per second (cfs) and the Fenton River Wellfield was operating. The amount of available habitat became significantly reduced by the pumping of the wellfield when the upstream flow was at 3.0 cfs. Thus, the primary recommendation of the Fenton River Study was to institute a series of successive reductions in the daily volume of pumping when the upstream flow in the

Fenton River dropped from 6.0 cfs to 3.0 cfs, with the wellfield being shut down when upstream flows dropped below 3.0 cfs.

With a better understanding of the aquifer processes in the Fenton River and the impacts of ground water withdrawals, attention then turned to the Willimantic River aquifer and associated wellfield. The University's "Willimantic River Study" was published in June 2010 with the formal name *Report of the Willimantic River Study: An Analysis of the Impact of the University of Connecticut Water Supply Wells on the Fisheries Habitat of the Willimantic River*. Similar to the Fenton River Study, the Willimantic River Study was conducted to determine whether and how water withdrawals from the Willimantic River Wellfield affect the fisheries habitat of the Willimantic River adjacent to the wellfield.

The Willimantic River Study found that the amount of available fisheries habitat in the Willimantic River is much greater than that in the Fenton River. For this reason, and the fact that the Willimantic River Wellfield is the University's only remaining source of supply after the Fenton River is shut off during low-flow periods, the Willimantic River Study recommended a progression of voluntary and mandatory water conservation measures as upstream flows in the Willimantic River dropped from approximately 19 cfs to approximately 8.0 cfs. The ability of the University to enact these water conservation measures was tested immediately following the completion of the study, as dry conditions prevailed in summer 2010 and low river flows occurred.

One of the primary recommendations of the Willimantic River Study was to develop the subject comprehensive Wellfield Management Plan to conjunctively manage the University's water supplies at the Fenton River Wellfield and the Willimantic River Wellfield. Adoption and execution of this plan would then enable the University to formally incorporate the results of the Fenton River Study and the Willimantic River Study into its various plans and procedures for operating the University water system.

1.2 PURPOSE

As discussed above, the primary purpose of this document (the University's initial *Wellfield Management Plan*) is to allow the University to formally incorporate the results of the Fenton River Study and the Willimantic River Study into the overall management of its water system. This document includes a review of both the Fenton River Study and the Willimantic River Study, a review of system operational history, and protocols for operating both wellfields throughout the year. As suggested by the Willimantic River Study, this document further includes:

- A determination for how the University will monitor USGS-measured upstream discharges at each wellfield and correlate pumping rates to the habitat threshold triggers determined in both the Fenton River Study and the Willimantic River Study.
- A formal update to the Drought Response Plan, including response timing and recovery guidelines.
- Recommendations for limited use of the Fenton Well D when the Fenton River Wellfield would otherwise be shut down. This may allow for brief decreases in pumping at the Willimantic River Wellfield to provide short periods of relief to the fish species in the Willimantic River, while also restoring the system margin of safety.

1.3 RELATIONSHIP TO WATER AND WASTEWATER MASTER PLAN

On September 26, 2005, the Connecticut Department of Public Health issued a consent order to the University of Connecticut to address what it characterized as deficiencies in the operation and management of its water supply system. As part of the consent order, the University agreed to develop a Water System Master Plan to identify and evaluate viable options for meeting the University's future drinking water needs. Additionally, the University voluntarily expanded this charge to include evaluation of its wastewater collection and treatment needs as well.

The Water and Wastewater Master Plan was published in June 2007. The document was designed to convey an understanding of the extent and condition of water and wastewater infrastructure owned and operated by the University of Connecticut; evaluate the capacity of the system to meet current and future water demands and wastewater treatment needs; estimate the value of water and wastewater assets owned by the University; assess management and ownership options for the water and wastewater systems; and develop recommendations relative to future management and operation of the water and wastewater systems.

Most of the recommendations of the Water and Wastewater Master Plan are more directly applicable to the Individual Water Supply Plan than to this Wellfield Management Plan. With regard to the two wellfields, the Water and Wastewater Master Plan recommended the following:

- Perform, as planned, the Willimantic River Study (completed in 2010);
- Continue to operate the Fenton River as outlined in the Fenton River Study (ongoing);
- Relocate Fenton Well A further from the river but within the distance available [250 feet] for a diversion permit exemption (pending additional study); and
- Provide emergency power to Well #2 and Well #4 at the Willimantic River Wellfield (completed in 2011).

As this document recommends a monthly-based operating strategy derived from the current understanding of the characteristics of the two wellfields and the associated rivers, this Wellfield Management Plan supersedes the hypothetical operating scenarios presented in the Water and Wastewater Master Plan.

1.4 RELATIONSHIP TO OTHER WATER SYSTEM PLANNING DOCUMENTS

This Wellfield Management Plan presents a review of historical operational procedures as well as a review of the recent environmental studies that presented recommendations for reducing or curtailing withdrawals during periods of low streamflow. In addition, this plan provides guidelines for the incorporation of wellfield management procedures into a variety of other University documents, including the Water Supply Plan, the draft Drought Response Plan, the Emergency Contingency Plan, and the Water Conservation Plan. As such, a large portion of this initial Wellfield Management Plan provides background information above and beyond the scope of a typical operational reference document. It is envisioned that future versions of this Wellfield Management Plan will be more streamlined to be used as operational reference guides.

1.4.1 Relationship to the Individual Water Supply Plan

Whereas the Individual Water Supply Plan is the University's comprehensive water system planning document, this Wellfield Management Plan is intended toward incorporating the operational recommendations of the two recent environmental studies into a comprehensive operations document. As such, this document is designed to be included as part of the Water Supply Plan but can also serve as a stand-alone document.

The monthly margin of safety projections prepared for the Water Supply Plan are influenced by the recommendations of this Wellfield Management Plan, particularly regarding the proposed operation of Well D during low-flow periods. It is envisioned that the University may choose to update or amend the Wellfield Management Plan concurrent with the Water Supply Plan in the future.

1.4.2 Relationship to the Drought Response Plan

Several months prior to the extreme dry period in 2007, the University prepared a draft "Drought Response Plan" to augment to the pre-existing Emergency Contingency Plan. A copy of this plan (revised through August 22, 2008) is included in Appendix A. Designed to serve as a set of protocols more than as a plan document, the Drought Response Plan establishes trigger levels, describes responses, lists conservation measures, and describes recovery from "emergency." The levels of response in the plan are denoted as follows:

- Stage IA – Water Conservation Alert
- Stage IB – Water Supply/Drought Advisory
- Stage II – Water Supply/Drought Watch
- Stage III – Water Supply/Drought Warning
- Stage IV – Water Supply/Drought Emergency

The University's protocols begin with an Alert stage, which is not specifically called for in the Connecticut Drought Preparedness and Response Plan published in August 2003. However, the terms Advisory, Watch, Warning, and Emergency are consistent with the Connecticut Drought Preparedness and Response Plan.

The University's draft Drought Response Plan links the projected available supply (including the available supply from the Fenton River Wellfield in accordance with the recommendations of the Fenton River Study) and High Head Reservoir levels to the trigger levels. An itemized list of response protocols was presented in the plan for each of the stages listed above to enable the University to respond according to each particular trigger level.

The Connecticut DPH reviewed the draft Drought Response Plan and offered the following comments by memorandum on September 9, 2008. Considerations related to these comments have been incorporated, where appropriate, into the Emergency Contingency Plan and this Wellfield Management Plan:

- *Initial Trigger Level:* Issue Stage IA when the flow in the Fenton River reaches 4.0 or 5.0 cfs instead of 3.0 cfs to allow additional time to prepare for implementing conservation measures.
- *Source-Based Trigger Levels:* It may be more appropriate to base trigger levels for Stage IB, Stage II, Stage III, and Stage IV on groundwater levels rather than levels in the High Head storage facility.
- *Water Audits:* Water audits of the system's largest users should be performed when demand reductions are not met at each response stage. Such water audits should be part of the water system's normal business practice.
- *System Recovery:* Recovery triggers should be based on groundwater levels and streamflows in addition to the High Head storage facility levels.
- *Term Clarification:* Clarification was recommended for what constitutes a projected available supply being "significantly less" than projected water usage, and what constitutes an "overall decrease in tank storage." These statements could be quantified in units or percentages.
- *Emergency Sources:* The plan should identify all potential sources of water supply within a reasonable proximity to its distribution system that could potentially be tapped during a Stage IV emergency. This would necessitate an emergency order that is unlike the one outlined in prior stages, and would require water boiling and possibly other public health precautions contingent on the quality of the emergency source.

The draft Drought Response Plan was considered during the Willimantic River Study to correlate its protocols to those recommended when the Willimantic River falls below the threshold streamflow triggers outlined in its environmental study. The protocols suggested in the Willimantic River study report were then followed during the dry summer of 2010.

This Wellfield Management Plan fully incorporates the University's Drought Response Plan. Because a dry spell or moderate drought is not necessarily a water supply emergency and therefore should not always be treated as such, this Wellfield Management Plan instead uses the guidelines from the two river studies to revise the five stages of water conservation triggers.

1.4.3 Relationship to the Emergency Contingency Plan

The purpose of the Emergency Contingency Plan is to outline protocols to follow when actual emergencies occur, such as failing wells, water main breaks, tank levels falling rapidly, contamination of water, or other disasters. It is understood that such events can curtail the University's ability to provide potable water, which may result in a threat to public health.

This Wellfield Management Plan does not consider the impact of such emergencies, but rather considers day-to-day operation of the wellfields under normal operating conditions and during periods of low river flows when wellfield operation could cause adverse environmental stress to the habitat of the rivers adjacent to each wellfield. Seasonal low streamflows are not considered an emergency situation for the University, but instead a situation that advises conservation and results in the utilization of response protocols.

On the other hand, it is understood that a sustained drought such as the drought of record in the 1960s could result in low groundwater levels that could in turn cause wells to go dry. This situation would be considered an emergency.

Currently, the draft Drought Response Plan offers reasonable response protocols for instituting water conservation measures when available supply is limited due to declines in available storage. These response protocols have been folded into the Emergency Contingency Plan as appropriate for the Water Supply Plan. Low groundwater levels were also added to the Emergency Contingency Plan as this scenario would represent an emergency situation. These modifications were necessary to provide a clear, workable set of emergency response protocols for the University and differentiate emergency response from typical drought response for the majority of low-flow events.

1.4.4 Relationship to the Water Conservation Plan

The purpose of the Water Conservation Plan is to describe *how* to accomplish University-wide water conservation measures both in the long-term and in the short-term when triggered by the Drought Response Plan, the Emergency Contingency Plan, or this Wellfield Management Plan. The protocols for water conservation are similar between the three documents, although the timing of water conservation initiatives may need to be expedited during emergency situations.

SECTION 2.0
REVIEW OF THE FENTON RIVER STUDY

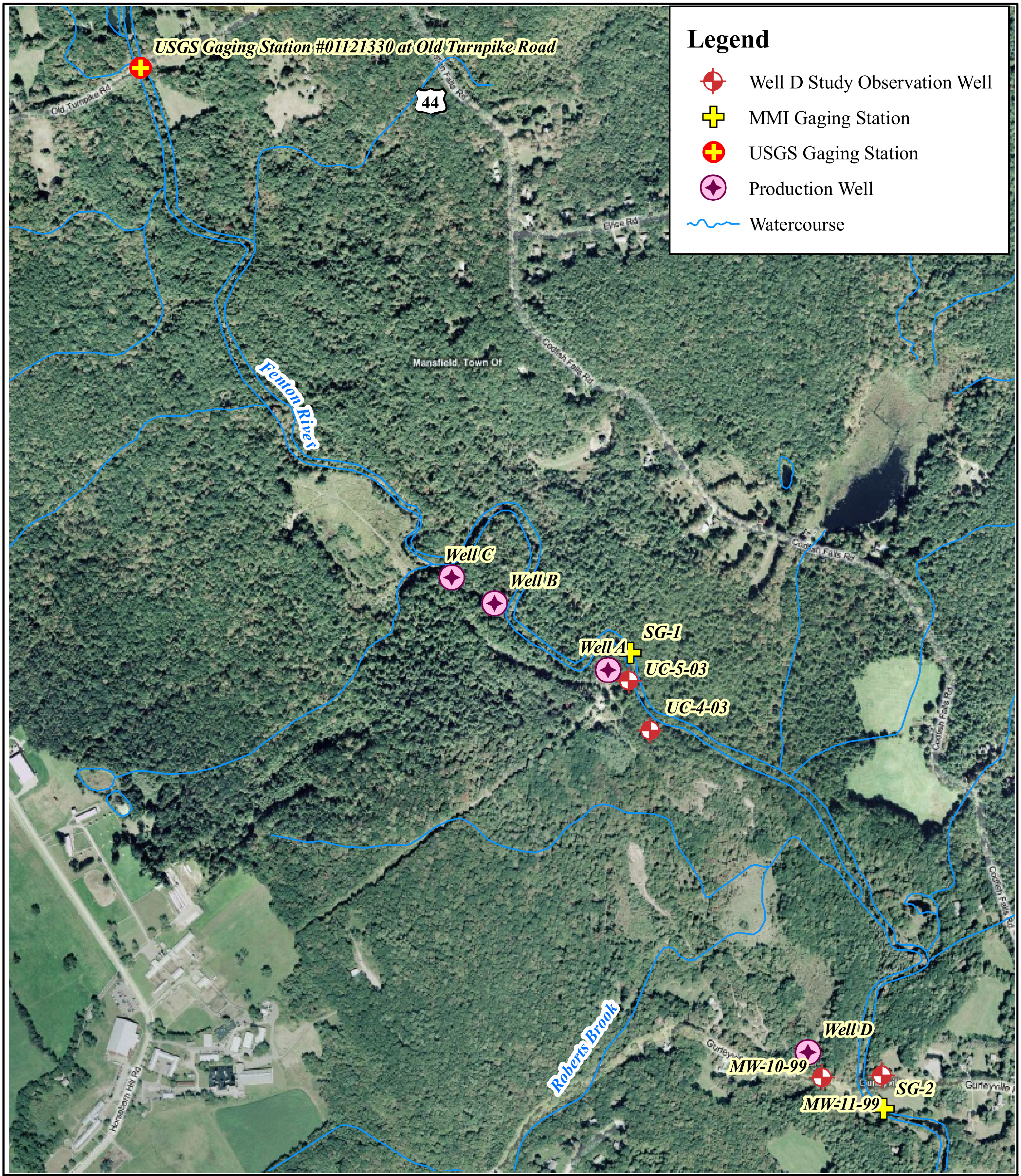
2.0 REVIEW OF FENTON RIVER STUDY

2.1 PURPOSE

The University's "Fenton River Study" was published in March 2006 with the formal name *Long-Term Impact Analysis of the University of Connecticut's Fenton River Water Supply Wells on the Habitat of the Fenton River*. The study was conducted to determine whether and how water withdrawals from the Fenton River Wellfield affect the fisheries habitat of the Fenton River adjacent to the wellfield. The Fenton River Study was conducted in conjunction with the Environmental Impact Evaluation of the North Campus Master Plan due to ongoing concern about the environmental impacts of withdrawing water from the Fenton River Wellfield. The Fenton River Wellfield is depicted on Figure 2-1.

The specific objectives of the Fenton River Study were to:

- Develop relationships between instream flow and habitat in the Fenton River for selected fish species;
- Derive the relation between the magnitude and timing of groundwater withdrawals on the stage and flow of water in the Fenton River principally from Old Turnpike Road to Stone Mill Road using existing data, new data collection, and mathematical simulation modeling; and,
- Mathematically model selected water-management scenarios to optimize water withdrawals while minimizing adverse impacts on stream flow and in-stream habitat.



Engineering, Landscape Architecture and Environmental Science

MILONE & MACBROOM®

99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

Fenton River Wellfield

LOCATION: **Mansfield, CT**

MMI#: 1958-31-3
MXD: P:\fenton.mxd
SOURCE: Microsoft

N

University of Connecticut Wellfield Management Plan

Map By: SJB
Date: 3/4/2011
Scale: 1:10,000

SHEET: **Figure 2-1**

2.2 FINDINGS

The Fenton River Study demonstrated that the Fenton River is a complex system in the vicinity of the Fenton River Wellfield. There are several gaining and losing reaches throughout the study area which can vary in response to precipitation patterns. The study found that in general, during non-pumping conditions the Fenton River tends to gain flow in the downstream direction including during times of prolonged dry weather.

As no long-term USGS gauging station was available on the Fenton River, determination of the long-term frequency of low flows was accomplished by correlating the limited available gauging data of the Fenton River with the long-term gauging data from the nearby Mount Hope River. The frequency analysis was effective at predicting low flow values on the Fenton River which correlated well to observed flows during the 2005 drought. The frequency analysis found that the Fenton River can naturally reach flows during dry periods that approach the magnitude of the registration rate of the Fenton River Wellfield (0.8443 mgd, or 1.31 cfs). Recession curve analysis (based on one summer of data) indicated that the Fenton River takes about six days to drop from 20 cfs to 6.5 cfs, and takes a little longer (about eight days) to drop from 6.5 cfs to 3.0 cfs.

Field data were measured and collected from 2003 through 2005. Hydrogeophysical investigations included soil borings, bedrock outcrop mapping, and the use of seismic and ground-penetrating radar techniques. Hydrologic data collection included rainfall data at the University's Agronomy Farm and at the Fenton River Wellfield, groundwater monitoring in nearby monitoring wells using dataloggers, and streamflow measurements during a series of aquifer tests.

Fisheries habitat investigations included field surveys to map mesohabitat reaches in the study area and to identify river segments most representative of major habitat conditions. Ten sub-reaches were identified for fish collections. Velocity, depth, substrate, cover, and water surface elevation were measured at transect points during three calibration flows (high, moderate, and low river flows) and bed elevations were surveyed. This information was used in the Physical Habitat Simulation System (PHABSIM) with the conceptual and analysis framework of the Instream Flow Incremental Methodology (IFIM) to model relationships between instream flow and fisheries habitat.

Target fish species included brown trout, brook trout, fallfish, and tessellated darter. Standard Weighted Usable Area (WUA) curves were produced for each species along with WUA curves by mesohabitat for each species. Uniform-Continuous Under Threshold (UCUT) curves were developed for each species to relate percentage of maximum WUA to the percentage of time that the Fenton River habitat for each species is below that percentage of maximum WUA. Results for the overall fish community are presented in Table 2-1.

TABLE 2-1
Percent of Maximum WUA, Discharge, and Persistent Duration of Common, Critical, and Rare Habitat Thresholds for Target Fish Community

Habitat Stressor Threshold	Parameter	Result
Common	Habitat (% Max WUA)	35%
	Discharge (cfs)	7.5
	Persistent Duration (days)	40
Critical	Habitat (% Max WUA)	15%
	Discharge (cfs)	2.5
	Persistent Duration (days)	15
Rare	Habitat (% Max WUA)	10%
	Discharge (cfs)	1.4
	Persistent Duration (days)	5

In modeling sub-reach 2 (the vicinity of Fenton Wells A and B), the Fenton River was found to be the most susceptible to the loss of fisheries habitat during low-flow periods. Results for the overall fish community in this sub-reach are presented in Table 2-2.

TABLE 2-2
Percent of Maximum WUA, Discharge, and Persistent Duration of Common, Critical, and Rare Habitat Thresholds for Target Fish Community in Modeling Sub-Reach 2

Habitat Stressor Threshold	Parameter	Result
Common	Habitat (% Max WUA) Discharge (cfs) Persistent Duration (days)	35% 11 40
Critical	Habitat (% Max WUA) Discharge (cfs) Persistent Duration (days)	15% 6 15
Rare	Habitat (% Max WUA) Discharge (cfs) Persistent Duration (days)	10% 5 5

The Fenton River Study verified earlier suppositions that operation of the wellfield causes reduced groundwater discharge to the river and induced infiltration from the river. The magnitude of reduced instream flow was estimated through three independent means: thermistors in the nested piezometers (0.17 to 0.58 ft/d), weir measurements (inconclusive), and streamflow loss observations (46% of the pumping rate). The field data found that the published results from the 1960s (0.22 ft/d) slightly underestimated the amount of induced infiltration. Analysis of 2004 data indicated that the ground water table near Well A can be as much as seven feet below the river bed when the river is flowing.

The field data were used to develop and calibrate a numerical model of ground water flow using MODFLOW 2000. The model was subsequently validated with previous investigations that occurred in the 1960s. The numerical model was used to simulate the effect of the Fenton River Wellfield on the stage and discharge in the Fenton River with several infrastructure improvements and under several management scenarios.

The four primary improvements and management options considered included: (1) increasing the capacity of Well D; (2) increasing the capacity of Well A and moving it farther from the Fenton River to a location with a greater thickness of stratified drift; (3) increasing the capacity of Well D and turn off Well A during periods of low river flow; and (4) reducing overall pumping from the wellfield as flows fall below 6.0 cfs. The model results indicate that a linear rate of daily streamflow loss exists as a function of total daily pumping. Additionally, pumping only Wells C and D (the two wells farthest apart at the Fenton River Wellfield) will mitigate drawdown impacts (and therefore habitat impacts) in the vicinity of Well A and Sub-Reach 2.

The best management scenarios with multiple wells pumping during periods of low streamflows suggested that the relocation of Well A to halfway between its existing location and Well D (an action requiring an individual diversion permit from the Connecticut DEP) or up to 250 feet to the south (no individual diversion permit required) could have moderate benefits to instream flow. However, relocating this well was not concluded to be cost-effective, as the reduction in streamflow loss was fairly minimal.

2.3 CONCLUSIONS

The Fenton River Study concluded that the timing and the rates of ground water withdrawals, with respect to: (1) periods of ground water recharge; and (2) periods that are critical for fish populations, can be managed to minimize impacts. The study notes that diminution of streamflow displays a delayed response to ground water withdrawals, and also notes that there is very little difference between scenarios that spread the same total pumping over longer durations during the day.

The habitat studies indicated that fisheries habitat impacts due to the operation of the Fenton River Wellfield were not discernable at upstream flows exceeding 10 cfs. Habitat begins to become perceptibly reduced when the wellfield is pumping and upstream flows drop below 7.0 cfs, and is significantly reduced by pumping when upstream flows fall below 3.0 cfs. The key conclusion was that during low-flow conditions with an approximate five-year recurrence interval, pumping the Fenton River Wellfield reduced flow in the Fenton River by approximately 0.8 cfs in the vicinity of Well A, with the potential to cause adverse impacts to fish.

Modeling Sub-Reach 2 in the vicinity of Wells A and B required the highest flows, on the order of 6.0 cfs, to maintain at least 15% of maximum WUA for brook trout and fallfish. As such, the UCUT results from this modeling sub-reach were utilized to set guidelines for the cessation of pumping at the Fenton River Wellfield.

Given the fact that the Fenton River can naturally reach flows lower than the registration rate of the Fenton River Wellfield, the Fenton River Study concluded that there will be times when no management scenario will mitigate an adverse pumping impact to fish habitat. As such, the Fenton River Study suggested a management scenario that institutes successive pumping limitations when the flow in the Fenton River upstream of the wellfield is between 6.0 cfs and 3.0 cfs, with the wellfield completely shut down when upstream flow falls below 3.0 cfs.

2.4 RECOMMENDATIONS

The Fenton River Study offered the following recommendations to protect fisheries habitat in the vicinity of the Fenton River Wellfield:

1. Install a continuously operating, telemetric streamflow gauging station on the Fenton River at Old Turnpike Road to manage pumping of the Fenton River Wellfield on a daily basis; this was completed.
2. Repair or replace Well D so that it can run continuously and pump at its maximum capacity; this was completed.
3. Replace Well A with a well of similar capacity farther from the river and in a deeper part of the stratified drift aquifer, such as halfway between existing Well A and Well D. This replacement is not believed to be cost-effective and therefore not yet completed; future studies will be completed by graduate students at the University.

4. Install modern electronic speed controls or duty-cycle controllers on all well motors; this was completed.
5. Upgrade motor controls to enable more flexible operation of each well and the entire wellfield; this was completed.
6. Calibrate and maintain flow meters on the discharge line of each well; this was completed.
7. Install a chemical disinfection system that follows best established practices to maintain the correct quantity of disinfectant over a wide range of pump flow rates from individual wells in order to add flexibility in pumping rates from each well and combination of wells; this was completed.
8. Reduce the daily volume of pumping to 0.633 mgd if the flow in the Fenton River as measured at Old Turnpike Road is less than 6.0 cfs.
9. Reduce the daily volume of pumping to 0.422 mgd if the flow in the Fenton River as measured at Old Turnpike Road is less than 5.0 cfs.
10. Reduce the daily volume of pumping to 0.211 mgd if the flow in the Fenton River as measured at Old Turnpike Road is less than 4.0 cfs.
11. Do not pump the Fenton River Wellfield is the flow in the Fenton River is less than 3.0 cfs.
12. Do not pump the Fenton River Wellfield is flow in the river is below 6.0 cfs for more than 15 consecutive days, or below 5.0 cfs for more than five consecutive days, regardless of the other thresholds. This will help to avoid increasing the frequency of occurrence of fish habitat reduction due to pumping.

Recommendations 8 through 12 were incorporated into the Fenton River Wellfield operating protocols. The Fenton River Study suggested that the decision for restarting pumping when flow increases above 6.0 cfs should be based on the amount of flow and the expected time of recession back to 6.0 cfs. A series of equations were provided on Page 83 of the Fenton River Study for the operator to use in assisting with this judgment.

The University has been following recommendations number 8 through 12 since completing the study. However, in practice, the operating rules are very close to one another requiring necessary operational changes as flows shift between 6.0 and 3.0 cfs. Thus, the University tends to shut down the wellfield when the upstream flow falls below 6.0 cfs in late spring or summer, and does not start it back up again until the autumn when flows can reasonably be expected to remain above 6.0 cfs.

SECTION 3.0
REVIEW OF THE WILLIMANTIC RIVER STUDY

3.0 REVIEW OF WILLIMANTIC RIVER STUDY

3.1 PURPOSE

The University's "Willimantic River Study" was published in June 2010 with the formal name *Report of the Willimantic River Study: An Analysis of the Impact of the University of Connecticut Water Supply Wells on the Fisheries Habitat of the Willimantic River*. Similar to the Fenton River Study, the Willimantic River Study was conducted to determine whether and, if so, how water withdrawals from the Willimantic River Wellfield affect the fisheries habitat of the Willimantic River in the vicinity of the wellfield. The Willimantic River Study was triggered by the November 6, 2006 *Memorandum of Agreement* with the Connecticut Water Planning Council in which the University agreed conduct a study for the Willimantic River Wellfield similar to that conducted for the Fenton River Wellfield. The Willimantic River Wellfield is depicted on Figure 3-1.

The specific objectives of the Willimantic River Study were to:

- Develop relationships between instream flow and habitat in the Willimantic River for selected fish species;
- Derive the relation between the magnitude and timing of groundwater withdrawals on the stage and flow of water in the Willimantic River from Merrow Road to Mansfield Depot using existing data, new data collection, and mathematical simulation modeling; and
- Numerically model selected water-management scenarios to optimize water withdrawals while minimizing adverse impacts on stream flow and instream habitat.

Engineering, Landscape Architecture and Environmental Science

MILONE & MACBROOM®

99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

Willimantic River Wellfield

LOCATION: **Mansfield, CT**

MMI#: 1958-31-3
MXD: P:\willimantic.mxd
SOURCE: Microsoft

N

University of Connecticut Wellfield Management Plan

Map By: SJB
Date: 3/4/2011
Scale: 1"=1,000'

SHEET: **Figure 3-1**

3.2 FINDINGS

The Willimantic River is a complex system in the vicinity of the Willimantic River Wellfield. There are several gaining and losing reaches throughout the study area that can vary in response to precipitation patterns and timing. In general, during non-pumping conditions the Willimantic River tends to gain flow in the downstream direction including during times of prolonged dry weather.

The Instream Flow Incremental Method (IFIM) was used to evaluate the potential effects of reductions in river flow associated with withdrawal of water at the Willimantic River Wellfield on the habitats of representative fish species in the Willimantic River. Target fish species included brook trout, brown trout, fallfish, and common shiner.

Simulation of river hydraulics and aquatic habitat was performed using computer models collectively known as Physical Habitat Simulation (PHABSIM). The hydraulic simulation models of PHABSIM are used to predict changes in depth, velocity, and wetted area at various river flows. The aquatic habitat simulation models generate a composite suitability function collectively referred to as Habitat Suitability Criteria (HSC) derived from curves representing the depth, velocity, and substrate preferences of selected target species/life stages. The aquatic habitat simulation models integrate the output of the hydraulic simulation models with the HSC to yield an estimate of habitat usability (WUA).

Field data collection for the IFIM spanned 2008 and 2009. Aquatic habitats were mapped to determine the percentage of all significant mesohabitat types in the study area. Nine representative reaches of the significant mesohabitats were selected based on the aquatic habitat mapping, with representative transects selected within those reaches. Velocity, depth, substrate, cover, bed elevations, and water surface elevations were surveyed at each transect during five calibration discharges.

The USGS has operated a long-term real-time gauging station on the Willimantic River (the "Coventry" gauge) since 1931. Flow statistics from this site have been published by the USGS. The 99% duration discharge of the Willimantic River (approximately equivalent to the 7Q10 discharge) is estimated to be 11 cfs. The published mean daily discharge values were modified to represent discharge at the Willimantic River Wellfield by correcting for water supply withdrawals, wastewater discharges, and drainage basin area. The lowest recorded mean daily discharge at the wellfield since 1958 is believed to be approximately 6.0 cfs in August 1999 during a prolonged dry period.

The PHABSIM output provided relationships between WUA and discharge for each target fish species. The mean daily streamflow dataset calculated for the wellfield and the WUA to discharge relationships for each target species were then used to perform habitat time-series and UCUT analyses. These analyses evaluated the magnitude, frequency, and duration of various discharge-related habitat events for the target species. The results of the UCUT analysis are summarized in Table 3-1.

A hydrogeologic study was performed to evaluate the effects of sustained pumping on the aquifer under various river discharges. The objective was to collect data during three different combinations of river flow regime (low to moderate, low to moderate, and low) and wellfield operation (low, moderate, and high). Each monitoring event consisted of a 72-hour constant-rate pumping test.

Data collection included water levels measured at existing monitoring wells and at 12 piezometers installed for the study as well as temperature monitoring at each piezometer and along the thalweg of the river. In addition, river flow was measured consistent with USGS methods at locations upstream of, downstream of, and at the USGS gauging station at the wellfield in order to determine if direct impacts to river discharge could be detected. Automatic dataloggers were used to assist with data collection and were installed in one monitoring well and in four of the piezometers.

TABLE 3-1
Percent of Maximum WUA, Discharge, and Persistent Duration of Common, Critical, Rare, and Extreme Habitat Thresholds for Target Fish Community

Habitat Stressor Threshold	Parameter	Result
Common (Upper Subregion)	Habitat (% Max WUA) Discharge (cfs) Persistent Duration (days)	44% 27 19
Common (Lower Subregion)	Habitat (% Max WUA) Discharge (cfs) Persistent Duration (days)	34% to 49% 19 19
Critical	Habitat (% Max WUA) Discharge (cfs) Persistent Duration (days)	28% 15 13
Rare	Habitat (% Max WUA) Discharge (cfs) Persistent Duration (days)	24% 12 12
Extreme	Habitat (% Max WUA) Discharge (cfs) Persistent Duration (days)	19% 7.8 7

The drawdown of ground water due to the Willimantic River wells can cause the ground water table in the vicinity of the river to fall below the river water surface and, in some locations, below the riverbed elevation. In these cases, water will infiltrate from the riverbed into the ground water system (i.e., induced infiltration). The piezometer and temperature data provided an estimate of the area of influence of the wellfield, which is believed to extend from slightly south of the wellfield and along the stratified drift aquifer to the northwest into Coventry.

A numerical model was originally constructed using the USGS program MODFLOW-2000 for the vicinity of the Willimantic River Wellfield during the Level A Aquifer Protection Area study. The Level A model was updated in this study to further characterize the Willimantic River and its interactions with the underlying aquifer. A pumping test conducted in 1999 and the three monitoring events performed during the 2008 hydrogeologic study were used to calibrate and verify the updated model.

The updated numerical model was used to simulate the timing and magnitude of pumping on the stage and discharge in the Willimantic River under various management scenarios. First, the four existing production wells and eight theoretical production well locations within the model area were simulated to determine the timing of pumping impacts. The model output suggests that the Willimantic River will have a slightly delayed response to pumping with reductions of discharge in the Willimantic River occurring as soon as nine hours after pumping begins for wells close to the river.

The existing wells and several of the theoretical wells were then simulated under 11 pumping management scenarios to determine if withdrawals can be managed to minimize adverse habitat impacts while meeting water supply demands. The model output for the management scenarios suggested that while there are combinations of wellfield withdrawals that will provide lower impact overall to instream flow through the model area, the difference in river flow reduction between the existing wellfield operation and the best modeled condition has a delta of only 0.31 cfs. It is believed that water conservation measures are more cost effective than constructing and permitting new water supply wells to achieve this very small incremental benefit.

3.3 CONCLUSIONS

The Willimantic River consistently conveys more water at the Willimantic River Wellfield than the Fenton River conveys at the Fenton River Wellfield. For this reason, it has historically been considered the more appropriate river for supporting public water supply withdrawals. The instream flow study portion of the Willimantic River Study resulted in some distinctive findings, especially when compared to the Fenton River Study:

- It is extremely unlikely that the Willimantic River Wellfield would be capable of running the Willimantic River dry, as the maximum legal withdrawal of 2.3077 mgd is equivalent to 3.6 cfs, and 3.6 cfs is approximately 60% of the value of the lowest instream flows believed to have occurred in the river near the wellfield.

- From the perspective of fish habitats, a very low flow may be "rare" on the Willimantic River but not especially rare on the Fenton River. As a result, the UCUT curves for the Willimantic River are shifted in comparison to the UCUT curves for the Fenton River, and differentiation of the common, critical, extreme, and rare thresholds is more challenging.
- The critical threshold for the Fenton River occurs around 15% of maximum WUA whereas the critical threshold for the Willimantic River occurs around 30% of maximum WUA.
- Fish species in the Willimantic River routinely experience a relatively lower loss of habitat than fish species in the Fenton River. In other words, fish "enjoy" a relatively greater amount of habitat in the Willimantic River.
- Nevertheless, a strict interpretation of the UCUT curves for the Willimantic River would tend to call for protection to a higher standard (maintaining a greater percent of maximum WUA for each species) than the interpretation of the UCUT curves for the Fenton River.
- If cutbacks in wellfield withdrawals were linked with the common, critical, extreme, and rare thresholds, the Willimantic River would be asked to protect a proportionally greater quantity of habitat than the Fenton River (nearly double for the critical flow) largely because it conveys more water.
- However, unlike the Fenton River where the common, critical, rare, and extreme habitat stress thresholds can be met in a matter of hours from one to the next, the Willimantic River may require several days to pass through these thresholds. This will allow for a more methodical response from the University.

The hydrogeologic study portion of the Willimantic River Study has resulted in an updated numerical model that works well under a variety of wellfield pumping scenarios. Some distinctive findings include the following:

- Effects of wellfield withdrawals are manifested in reduced ground water discharge and induced infiltration within nine to 16 hours for each existing well. In addition, the ratio of ground water withdrawals to reduced instream flow is nearly one-to-one in the short term and equal to one-to-one under continuous steady pumping conditions. Therefore, the relationship between wellfield withdrawals and reduced ground water discharge/induced infiltration is relatively immediate and direct.
- Minimal overall benefit can be gained by relocating wells. The time lag between pumping and impact to the river is difficult to increase by moving wells further away because the aquifer is narrow.
- A very minor (0.31 cfs) benefit to proximal riffle habitats can be gained by shifting some of the ground water withdrawals downstream, but the net effect will be the same at the downstream end of the study area over the long term.
- This low benefit to streamflow suggests that an investment in moving or replacing infrastructure to reduce the effect on instream flow will not be as cost effective as additional water conservation measures or development of new sources of supply.

3.4 RECOMMENDATIONS

The recommendations of the Willimantic River Study were aimed at reducing demand through the use of conservation measures rather than setting specific production cutbacks. The results of the UCUT analyses were correlated to the 2008 draft *Drought Response Plan of the University of Connecticut Water Supply Emergency Contingency Plan* as shown in Table 3-2. The time lapse between each trigger level was found historically to be approximately four to six days.

TABLE 3-2
Recommended Willimantic River Drought Trigger Levels and Corresponding Management Response

Response Stage	Willimantic River at Wellfield Trigger Discharge	Examples of Conservation Measures
Prepare for implementation of Stage IA	Discharge ≤ 27 cfs	None / Preparation for Stage IA
Stage IA (Two potential triggers)	Discharge < 27 cfs for 19 or more days	Voluntary: Shorter showers, condensed washing loads, elimination of nonessential consumption, raise thermostats on centrally chilled buildings
	Discharge < 19 cfs	
Stage IB	Discharge < 15 cfs	
Stage II (Two potential triggers)	Discharge < 15 cfs for 13 or more days	Voluntary items above become mandatory and include (but are not limited to) the following mandatory items: No flushing of hydrants, pipes, or sewer lines; no vehicle fleet washing; no use of water for street sweeping; reduce irrigation by 50%; reduce operation of research equipment cooled with domestic water; import water needed for construction dust control; no pool filling; raise thermostats of centrally chilled buildings
	Discharge < 12 cfs	
Stage III (Two potential triggers)	Discharge < 12 cfs for 12 or more days	
	Discharge < 7.8 cfs	
Stage IV	Discharge < 7.8 cfs for 7 or more days	

The formal recommendations of this study were divided into Demand-Based Water Conservation recommendations and Supply Management recommendations. Recommendations for Demand-Based Water Conservation include:

1. Incorporate the trigger discharges into the Drought Response Plan. Discharges measured by the USGS at the Merrow Road gauging station will be used to determine when triggers are met. The precise methodology that the University will use to activate and deactivate conservation measures and to formally link these trigger thresholds to appropriate response and recovery guidelines is discussed in Section 6.0

of this Wellfield Management Plan. These triggers should be revisited as appropriate when changes in supply occur.

2. Incorporate mandatory conservation measures for both on- and off-campus users, including residential, municipal, and commercial customers; and Connecticut Department of Corrections facilities. This process will continue using the Water Conservation Plan as a guide.

Recommendations for Supply Management include:

1. Develop a combined Willimantic River Wellfield – Fenton River Wellfield Management Plan to manage the University's water supplies, including a strategy of how the University will correlate upstream discharges to the discharge triggers for protection of fisheries habitat, a formal update to the Drought Response Plan, and authorization for limited but occasional use of the Fenton River Wellfield when it would otherwise be shut down. The subject document fulfills this recommendation.

2. Complete the design and construction of the Reclaimed Water Facility; this is currently underway.

3. After the Reclaimed Water Facility is operational, the University should ensure that the increment of water freed from non-potable usage (central utility plant and athletic fields) will be partially allocated to instream needs as well as new potable demands that may arise in the future in an equitable manner. This is an operational recommendation that will be worked into the management of the wellfield subsequent to the completion of the RWF.

4. Consider future ground water supplies downstream of the Willimantic River Wellfield in a location where instream flows would be higher than they are at the existing wellfield, and/or fish habitats would be less sensitive to flow reductions. The

Individual Water Supply Plan discusses the lower Willimantic River aquifer as a potential future supply.

5. Pursue interconnections with the Connecticut Water Company's Northern Region/Western System and Windham Water Works, which the University could utilize for supply during drought periods. The Individual Water Supply Plan also discusses these alternatives for potential future supply.

6. Consider provision of short-term or pulsed releases from the Staffordville Reservoir, Crystal Lake, and/or State Line Pond. This will require cooperation with the dam owners and the parties that control the impoundments and the dam outlet works. No plans are in place to move forward with this recommendation at the present time. It may be the next logical step if the University were eventually able to withdraw the full registered capacity of the Willimantic River Wellfield (2.3077 mgd) using the existing wells, because it would enable greater protection of the adjacent section of the river while the University utilized the wellfield to its full legal potential.

SECTION 4.0
SYSTEM OPERATIONAL HISTORY

4.0 SYSTEM OPERATIONAL HISTORY

Operation of the University's water system can be divided into five distinct operational periods based on source availability:

- Pre-Fenton River Wellfield (prior to 1926);
- Fenton River Wellfield as sole source of supply (1926 to 1972);
- Fenton River Wellfield and Willimantic River Wellfield (1969 to 2006);
- Subsequent to Fenton River Study (2006 to 2010); and
- Subsequent to Willimantic River Study (2010).

The Fenton River Wellfield provided 100% of the water to the University's Main Campus system from 1926 until 1972, at which point a 16-inch transmission line was installed from the Willimantic River Wellfield to the main campus. After that time, the Willimantic River Wellfield began to provide an increasing percentage of the overall supply. The operational periods subsequent to 1969 are therefore of most interest to this Wellfield Management Plan because both wellfields were available for the University. These three periods are discussed in detail below.

4.1 SYSTEM OPERATION PRIOR TO 2006

Pre-1990s

Limited records exist detailing the day-to-day operation of the Fenton River Wellfield in relation to the Willimantic River Wellfield prior to the 1990s. It is believed that neither of the two wellfields was shut down for more than a few days at the time. Anecdotal data collected during the Willimantic River Study suggested that during the 1970s the University would operate the Fenton River Wellfield and the Willimantic River Wellfield on alternate days during low-flow periods. However, it is more likely that the Fenton River Wellfield was pumped intermittently whereas the Willimantic River Wellfield pumped continually because the University still needed to provide Mansfield Training School with water, and only the Willimantic River Wellfield could provide that water.

Water demand increased throughout the 1980s and peaked in 1989, corresponding to the peak on-campus enrollment during that decade. The Willimantic River Wellfield provided approximately 70% of the water (an average of 1.65 mgd) used by the two University systems in 1989.

1990s-2006

The period 1989 through 1997 corresponded to a decline in overall water usage at the University. Total annual water usage was at its lowest in 1997 at 412 million gallons. Enrollment increased again in 1997 and 1998, and off-campus uses such as E.O. Smith High School increased enrollment, while during the same time period the Bergin Correctional Facility opened near the Depot Campus. The increase in the number of users at the end of the decade was counteracted by water conservation measures instituted by the UConn 2000 projects. In 1998, the University used an average of 1.15 mgd, with 83% of the water coming from the Willimantic River Wellfield; however, the Fenton River Wellfield remained an important supply.

As the UConn 2000 project and the 21st Century UConn initiative continued, the University expanded and water demands began to increase, though at a rate mitigated by the continued water conservation efforts. Total water usage was approximately 469 million gallons in 2003, an average rate of 1.29 mgd. The Willimantic River Wellfield continued to provide the majority (approximately 82%) of water produced, but the Fenton River Wellfield was still used year-round.

4.2 SYSTEM OPERATION SUSEQUENT TO FENTON RIVER STUDY

The findings and recommendations of the Fenton River Study placed restrictions on the amount of water production that could be contributed by the Fenton River Wellfield. Daily withdrawals at the wellfield were reduced during low-flow periods based on recommendations 8 through 12 listed in Section 2.4. The University has often shut down the Fenton River Wellfield completely after flow in the Fenton River reached 6.0 cfs if a prolonged dry period was predicted in order to avoid navigating through the particulars of the recommendations for pumping reduction. The University will occasionally operate the Fenton River Wellfield wells for maintenance purposes during the low-flow periods but typically does not produce more than 25,000 gpd from any well.

A second operational change that occurred was the hiring of the University's first contract operator of its water system, New England Water Utility Services (NEWUS), in August 2006. Prior to that time, the University water system had been operated by trained University personnel. NEWUS has helped to modernize many of the systems at the two wellfields.

The following case studies highlight the University's response to the last two severe dry periods. Graphics related to the dry periods are included in Appendix B.

Case Study: 2007 Low-Flow Period

The Fenton River Wellfield was shut down on July 26, 2007 in response to seasonal low flows in the Fenton River. The wellfield had been minimally used prior to that date due to system improvements (i.e., installation of a new booster pump with variable frequency drive and a rebuild of Well D). The dry period persisted through the end of the year, and the wellfield remained offline through January 2008. During this time, the Willimantic River Wellfield provided 100% of the system water needs, and the University implemented conservation measures to try and minimize the stress to the Willimantic River wells.

A Water Conservation Alert was issued on August 6, 2007 by the University in accordance with the Emergency Contingency Plan in effect at that time. System users were asked to voluntarily conserve water. The request for voluntary conservation was the first stage of the University's five-step Emergency Contingency Plan. The triggers for subsequent steps were based on a combination of operational factors including projected available supply, projected water usage, and tank storage levels.

As a result of the start of the fall semester on August 27, 2007, the water demand on the system increased from approximately 1.2 mgd to 1.7 mgd. System demand peaked at over 1.8 mgd for three consecutive days leading up to August 31. The University entered Stage IB of its Emergency Contingency Plan on September 4 and entered Stage II Watch on September 5, 2007.

The activation of the Stage II Watch caused the University to immediately initiate mandatory conservation measures, supplementing the voluntary conservation measures already in place. In addition to the mandatory conservation measures identified in the Emergency Contingency Plan, the University raised room temperatures by four degrees Fahrenheit and began serving breakfast and lunch on paper plates at dining halls. In mid-September, the control settings for the Bone Mill tank at the Depot Campus were changed to allow for the tank to refill on a daily basis (as opposed to every third day) to even out spikes in demand associated with the diversion of water to the Depot Campus system.

Following a period of sporadic precipitation and cooler temperatures that served to moderate the impact of the drought on the surface and ground water levels and further lessen demand, the University was able to lift its Stage II Watch on October 29, 2007. A Water Conservation Alert (voluntary conservation) remained in effect into November.

The Willimantic River Study estimated that these conservation measures reduced production by 10% (as compared with 2006 production data) over the five month period that the Fenton River Wellfield was offline. However, the drop in production may have also been influenced by other less tangible factors.

If the Willimantic River Study recommendations had been in place, the University would have entered the following stages of water conservation throughout the prolonged dry period in 2007:

- Stage IA/IB in mid-August;
- Stage II in late August;
- Stage III and Stage IV in early September; and
- Stage II for the remainder of September.

Note that the Willimantic River protocols would have caused an earlier onset of Stage IB and Stage II. Furthermore, Stage III and Stage IV would have occurred, whereas they were not triggered in 2007.

4.3 SYSTEM OPERATION SUBSEQUENT TO WILLIMANTIC RIVER STUDY

The Willimantic River Study was published in June 2010. The operational recommendations were aimed at reducing demand through the use of conservation measures rather than setting specific production cutbacks. The streamflow response triggers were correlated to the five stages of the 2008 draft Drought Response Plan in terms of the voluntary or mandatory conservation measures to be enacted.

Case Study: 2010 Low-Flow Period

The operational recommendations of the Willimantic River Study were quickly put into effect in the dry summer of 2010. The Fenton River Wellfield was taken offline on June 28, 2010 in response to low flows in the Fenton River, leaving the Willimantic River

Wellfield as the University's sole source of supply. As the draft Drought Response Plan was originally written to provide operational recommendations based on the amount of stored water available, and the University had no problems with storage or with wellfield hydraulics in 2010, it became apparent that environmental triggers would tend to override the operational triggers listed in the plan.

The University notified customers by letter dated July 6, 2010 of the need to conserve water (Stage IA) and requested that system users voluntarily limit their water use. This action, triggered by the onset of seasonally low surface water flows in both the Fenton and Willimantic Rivers, was consistent with the University's Water Supply Emergency Contingency Plan and the Willimantic River Study. The following water conservation measures were suggested:

- Take short showers and turn off the water flow when soaping and shampooing.
- Use the appropriate water level or load size selection on the washing machine.
- Use water only as needed when washing dishes, shaving, and brushing teeth. Don't let the faucet run unnecessarily.
- Run dishwashers only when completely full.
- Use of public water to wash building exteriors, driveways, sidewalks, or a vehicle is discouraged.
- Reconsider pouring water down the drain when there may be another use for it.
- Immediately report any leaky fixtures in UConn buildings to Facilities Operations.

On August 13, 2010, the University issued a Stage II Watch when flows in the Willimantic River hit triggers established in the Willimantic River Study. In addition to continuing the voluntary conservation measures requested beginning on July 6, the University implemented certain mandatory conservation restrictions including:

- Lawn watering for all University and non-University users was limited to four hours or less per day and only between the hours of 5 A.M. and 9 A.M. and 7 P.M. to 9 P.M. Athletic fields were allowed up to two hours of water per day during the same hours.
- Filling of public or private pools was only provided via water from a non-University source.
- Washing of motor vehicles was banned. The University's wash bay was closed.
- The use of ornamental or display fountains was banned.
- The use of water for washing and wetting down streets, sidewalks, driveways, or parking areas was banned unless required by the local health authority.
- The use of University water for dust control at construction sites was banned. Contractors were required to provide water for dust control from an outside source.
- The use of hydrant sprinkler caps was banned.
- Water main flushing was only allowed to be used to address acute water quality issues.

On September 13, 2010, the University issued a Stage III Warning as flows in the Willimantic River continued to recede and hit persistent low-flow triggers established in the Willimantic River Study. The Stage III request reinforced the need to conserve water and reiterated those restrictions identified during the prior advisory communication. In an effort to conserve additional water resources, on September 27, 2010 the Department of Dining Services began using paper plates and cups and plastic silverware in all eight residential dining halls. This activity was believed to save an additional 30,000 to 40,000 gallons of water per day.

System production during the first three weeks of September 2010 was 1.64 mgd, slightly higher than the production realized during 2008 and 2009 when system production in September was 1.58 mgd and 1.59 mgd, respectively. In spite of this slight increase, the 2010 figures compare favorably with these prior years when demands (especially those of the Central Utility Plant for cooling purposes) were depressed due to the relatively milder weather. While it is difficult to quantify the impact conservation measures had on water usage in 2010, the data suggest that the University's conservation efforts reduced water consumption below what would otherwise be expected for similar conditions.

The mandatory water conservation measures were lifted on October 25, 2010 due to rainfall increasing the amount of flow in the Willimantic River. The University remained on a Stage IA conservation notice until the Fenton River flow was deemed sustainable above 3.0 cfs on November 11, 2010.

The University is now in a unique position of gearing up for water conservation in any given year, and then requiring mandatory conservation during any year that is drier than normal. For example, conservation under current protocols would have been mandatory in 1999, 2001, and 2005, in addition to the two recent dry years in 2007 and 2010. Adjustments to wellfield operating protocols and drought responses are clearly necessary, should this pattern continue with dry years interspersed with normal or wet years.

SECTION 5.0
FENTON RIVER WELLFIELD WELL D STUDIES

5.0 FENTON RIVER WELLFIELD WELL D STUDIES

The adoption of the recommendations of the Fenton River Study by the University has caused the University to operate the Fenton River Wellfield based on environmental considerations instead of in response to system demand or operational constraints. Although it is generally understood that the University could legally reactivate the Fenton River Wellfield during a low-flow period, the University has elected to instead reserve this action for response to a public health emergency.

While the University supports the reduction and ultimate cessation of withdrawals as flows in the Fenton River fall from 6.0 cfs to 3.0 cfs and below to protect habitat, this operating strategy shifts the environmental strain to the Willimantic River and its habitat. In addition, this operating strategy leaves the University with a diminished capacity to safely supply water to its existing systems from the perspective of margin of safety.

Notably, the results of the Fenton River Study were focused on modeling Sub-Reach 2, namely the stretch of river from the vicinity of Well B to a point some 500 feet downstream of Well A. This was the stretch of river found to be at the highest risk of environmental impact due to operation of the Fenton River Wellfield. In addition, the Fenton River Study noted that flow in the Fenton River decreased between Old Turnpike Road and Well A, and thus pumping of the Fenton Wellfield would tend to exacerbate the loss of instream flow in this area. Operating protocols were likewise based on the findings from Sub-Reach 2.

Alternatively, the flow in the Fenton River was found to increase from Well A to Gurleyville Road (just downstream of Well D). This implies that the operation of Well D during low-flow periods could be managed "within" the natural amount of streamflow gain while avoiding the exacerbation of any loss of instream flow upstream near Well A.

Although it was beyond the scope of the Fenton River Study to focus on Well D in a more detailed manner, it was understood by the University that the potential use of Well D with certain restrictions may be feasible while mitigating impacts to the river. In response to the dry conditions that persisted from mid-2007 to the end of the year cutting off the use of the wellfield, the University commissioned a simulation study to more fully characterize the impacts of pumping Well D on the Fenton River. The results of the modeling effort (discussed below) were sufficiently favorable that the prospect of utilizing Well D during prolonged dry periods was included as early as Stage IB in the draft Drought Response Plan revised in 2008.

5.1 NUMERICAL MODELING ANALYSIS

The report *The Impact of Pumping Well D on the Fenton River Stream Flow during Drought Periods (Simulation Studies)* was presented to the University by Ph.D. candidate Farhad Nadim on May 29, 2008. A copy of the report is included in Appendix C. Four scenarios were investigated using the numerical model prepared for the Fenton River Study and assuming that conditions were similar to the drought year of 1966:

I. Well D was pumped for the entire year using a continuous pumping rate of 200 gpm (0.45 cfs).

II. Well D was pumped for the entire year using a continuous pumping rate of 300 gpm 0.67 cfs).

III. Well D was pumped for the entire year using a continuous pumping rate of 400 gpm (0.89 cfs).

IV. Well D was pumped for two weeks in late September 1966 at 200 gpm (0.45 cfs), then was off for two weeks, and then reactivated at 200 gpm for two additional weeks.

The results of the modeling in the first three scenarios indicated that by operating Well D throughout the year without operating Wells A, B, and C, the streamflow loss downstream of Well D ranged from 0.21 to 0.61 cfs, with the highest losses occurring from mid-August through mid-October of 1966.

- Under Scenario I, the average loss was about 0.21 cfs with the maximum streamflow loss being 0.30 cfs. The Fenton River was found to theoretically run dry for half of a day on September 3.

- Under Scenario II, the average streamflow loss was 0.32 cfs with the maximum streamflow loss being 0.45 cfs. The Fenton River was simulated as going dry near Well D from September 1 through September 3.

- Under Scenario III, the average streamflow loss was 0.43 cfs and the maximum loss was 0.61 cfs. The Fenton River was simulated as theoretically going dry near Well D from September 1 through September 3.

The results of the fourth scenario indicated that the average streamflow loss was 0.07 cfs and the maximum streamflow loss under that condition was 0.17 cfs, or a flow loss equivalent to 1.7% of the total streamflow during the period that the maximum flow loss took place.[1] The report concludes that Well D could be used as a backup well at 200 gpm during extended dry periods with an intermittent pumping schedule, provided that:

- A 30-day period of no pumping from the Fenton River Wellfield precedes the first two-week period of pumping from Well D;
- Fenton Wells A, B, and C are not operated during low-flow conditions;
- Well D is off for a two-week period between the two pumping periods; and
- The streamflow stays above 1.0 cfs during the intermittent pumping periods.

[1] Although it is beyond the scope of this review to offer varying interpretations of the Well D study, these figures would suggest that the flow in the Fenton River was approximately 10 cfs during the time of the maximum flow loss, which is higher than the threshold noted in the Fenton River Study where there was no discernable impact on streamflow (and subsequently, fisheries habitat) due to pumping. The 1.7% figure may have been reported in error instead of a flow loss of 17%, indicating that the Fenton River was flowing at 1.0 cfs for the simulation, which seems more appropriate for the drought period of 1966 and consistent with the first three scenarios.

The Well D report suggests the installation of additional monitoring wells to assist with determining when the ground water table falls below the streambed of the Fenton River near Well D. If the ground water table falls below the level of the streambed, the report suggests that pumping should be stopped. The report does not indicate the elevation of the streambed near Well D. The report also notes that field and simulation studies have indicated that if significant precipitation events occur during the two-week operational period, the high recharge rate of the aquifer will allow Well D to continue pumping without the resting period as long as the flow in the river remains above 1.0 cfs.

Page 3 of the Well D report explains that the 30 days of non-pumping was necessary in the Fenton River Study simulations for ground water to return to normal expected levels. This statement appears to contradict the finding on page 66 of the Fenton River Study that the aquifer near Well A recovered from nine feet below the river bed to three feet above the river bed (a total of twelve feet) in five days during the 2005 drought after the wellfield was shut down. The Fenton River Study concluded that the infilling processes of the cones of depression at the wellfield are on the order of days, not weeks. As such, it may be possible to begin the intermittent pumping of Well D sooner than the suggested 30 days of shutdown, or to continue it without the two weeks of shut-down in between the periods of operation.

Notably, the Well D study did not include simulations for higher pumping rates such as 300 gpm and 400 gpm at intermittent pumping over two-week periods. Instead, the simulation study limited the scope to a potential use of Well D at 200 gpm. Additionally, it remains unclear from the Well D simulation study report whether some of the author's statements about reductions from instream flow are relative to the amount of water in the stream, or the amount of water gained in the stretch of the stream downstream of Well A. And finally, it was beyond the scope and schedule of the Well D modeling study to include any field verification of the findings. Conditions would presumably need to be very dry to conduct a verification of the findings in the vicinity of Well D, given the very low flows discussed in the report.

With the development of very dry conditions and very low flows in the Fenton River in 2010, a unique opportunity was presented to investigate the results of operating Well D while the rest of the wellfield was shut down. This study is discussed below.

5.2 2010 PUMPING TEST

Milone & MacBroom, Inc. (with the assistance of NEWUS and the University) conducted a pumping test of Well D and study streamflows in the Fenton River in September 2010. The primary objective of the field study was to provide additional support for the use of Well D during periods of low flow in the river. Secondary objectives were to modify the recommendations of the Well D modeling study where possible relative to the pumping rates, duration of pumping, and ability to pump Well D when streamflow drops below 1.0 cfs.

Well D was activated on September 8, 2010 for seven days at an average rate of 0.348 mgd (0.54 cfs, or equivalent to 242 gpm) during a period when the Fenton River was flowing below 1.0 cfs. The water withdrawn from Well D was directed to the distribution system. Data collection included the following:

- Streamflows were monitored at the existing USGS gauging station at Old Turnpike Road as reported on the USGS website;
- Streamflows were measured at least once per day at a staff plate installed near Well A known as SG-1 and at a staff plate downstream of Gurleyville Road known as SG-2.
- Four observation wells (two near Well A, and two near Well D) were monitored to track changes in ground water levels occurring from natural drawdown and due to pumping.

Data collected during the Well D pumping test are included in Appendix C. The streamflow monitoring results are summarized in Table 5-1. Based on the streamflow measurements, the use of Well D appeared to have minimal adverse impact to instream flows during the seven days of pumping.

TABLE 5-1
Measured Streamflows During Well D Pumping Test

Date	Well D Pumping Rate, cfs	USGS Gauging Station at Old Turnpike Road, cfs	SG-1 (near Well A), cfs	SG-2 (downstream of Gurleyville Road), cfs	Gain, USGS to SG-1 (cfs)	Gain, SG-1 to SG-2 (cfs)
9/7/2010	Off	0.70	0.62	--[1]	-0.08	--
9/8/2010[2]	0.53	0.74	0.62	1.15	-0.12	0.53
9/9/2010	0.53	0.87	0.73	1.01	-0.14	0.28
9/10/2010	0.63	0.80	0.80	1.22	0.00	0.42
9/10/2010	0.63	0.74	0.80	1.28	0.06	0.48
9/11/2010	0.51	0.74	0.72	1.10	-0.02	0.38
9/12/2010	0.53	0.74	0.71	1.03	-0.03	0.32
9/13/2010	0.55	0.74	0.71	1.12	-0.03	0.41
9/14/2010	0.50	0.80	0.71	1.10	-0.09	0.39
9/15/2010	Off	0.60	0.63	0.89	0.03	0.26
9/16/2010	Off	0.63	0.58	0.81	-0.05	0.23

Notes: [1]Flow was not measured at this location on 9/7/10
[2]Test startup was approximately 12:30 P.M. The flow at SG-1 was measured just prior to test start up and the flow at SG-2 was measured just after test startup, but both are considered representative of pre-pumping conditions. The pumping rate was averaged through the following morning.

The 0.53 cfs gain in instream flow from SG-1 to SG-2 on the first day of pumping is considered the baseline increase between the two stations, as the pumping did not begin until 12:30 PM. Groundwater discharge to the river was responsible for the increase of 0.53 cfs. In contrast, the change in the instream flow between the USGS station and SG-1 was a loss of 0.12 cfs on that day. A slight loss of instream flow was measured from the USGS station to SG-1 on most of the days of the test, confirming previous conclusions that Sub-Reach 2 represents a section of the river with natural losing conditions.

A decrease in the gain from SG-1 to SG-2 then occurred during the remainder of the test, averaging an incremental loss 0.15 cfs. Because the average loss was only 0.15 cfs, it could not reverse the natural gain of 0.53 cfs, and an overall gain from SG-1 to SG-2 still occurred. This decrease in streamflow of 0.15 cfs is similar to the figure of 0.17 cfs discussed in the Well D modeling study and report, although it is believed that the author of that study was speaking of an absolute flow loss of 0.17 cfs and not a decrease in the gain near Well D.

An interpretation of the post-test streamflow data is complicated by the fact that the upstream flow at the USGS gauging station dropped sharply from 0.8 cfs to 0.6 cfs on the same day the test ended. The measured flow at SG-2 likewise dropped 0.2 cfs, and the gain from SG-1 to SG-2 dropped to 0.26 cfs.

The average ratio of groundwater withdrawals to instream flow diminution was 0.15 cfs/0.54 cfs, or roughly 0.3. If a one-to-one relationship between pumping and instream flow diminution had developed, then the withdrawal of 0.54 cfs would have completely offset the gain of 0.53 cfs between SG-1 and SG-2, and the resulting flow at SG-2 would have been the same as the flow at SG-1. This is an important point, because even a ratio of one-to-one could not have desiccated the river near Well D.

The water levels at monitoring wells UC-K-03 and UC-5-03 near Well A increased slightly over the course of the pumping test. They both dropped approximately 0.08 feet in the two days following the pumping test, corresponding to the drop in upstream river flow measured on September 15 and September 16. This implies that the aquifer at the upstream monitoring wells is well-connected to the Fenton River. With reference to the levels measured during the test and after the test, it is clear that the cone of depression of Well D does not extend upstream to the vicinity of Well A. There is no environmental impact to Sub-Reach 2 (the most susceptible section of the Fenton River) attributed to the operation of Well D.

The water level in the monitoring well on the east side of the Fenton River near Well D (MW-11-99) declined by 0.47 feet during the test, likely as a result of pumping. The water level declined an additional 0.10 feet following the pumping test, suggesting that this monitoring well is also well-connected to the stage of the Fenton River.

The water level in the monitoring well on the west side of the Fenton River near Well D (MW-10-99) declined by 3.01 feet during the test as a result of the nearby pumping. The water level continued to drop by an additional 0.73 feet following the pumping test. This suggests that groundwater response in the vicinity of Well D may be somewhat lagged behind the cessation of pumping. In turn, this implies that it could have taken a few days for the full gain between SG-1 and SG-2 to restore itself.

The Well D pumping test represents a very good surrogate for operation of Well D when the Fenton River decreases below 1.0 cfs at the USGS gauging station. Because the instream flow just below Well D will not be any lower than the instream flow near Well A, and in most cases will be higher, the operation of Well D should be allowed during low-flow conditions with fewer restrictions than those outlined in the Well D modeling study report. Specifically, operation for more than two two-week periods should be considered, and operation should be allowed when the river decreases below 1.0 cfs.

Nevertheless, the University recognizes that Well D is not sufficient for restoring the full capacity of the Fenton River Wellfield. Furthermore, use of Well D throughout the late spring and summer leading up to the typical driest month (September) is not a prudent use of water resources. Therefore, if the entire wellfield is cut back according to the Fenton River Study's operating protocols, the University proposes to use Well D only in September and October.

The attractiveness of this proposal is that it restores the University's margin of safety to greater than 1.0 *without actually requiring* the use of Well D every day. This is because Well D can be included in the margin of safety calculation as an available supply for two consecutive months, but storage can be used to sustain the system as desired, and the Willimantic River Wellfield can occasionally be operated more than 18 hours per day to supply nearly 2.0 mgd despite its safe yield of 1.48 mgd. If Well D were to be used, it would allow a respite for one well at the Willimantic River Wellfield.

Additional safeguards are recommended to facilitate the collective acceptability of using Well D during dry years. For example, additional monitoring wells could be observed when Well D is in operation, and streamflow could be monitored downstream of Well D. An acceptable level of monitoring could occur without the establishment of a USGS-supported gauging station.

5.3 RECOMMENDATIONS

The following recommendations are proposed for Well D. In all cases, the underlying assumption is that the entire Fenton River Wellfield has been shut down according to the Fenton River Study's operating protocols. If the conditions are sufficiently wet that the operating protocols have not been triggered, then the wellfield should be used according to its diversion registration.

- Well D can be operated with minimal impact to instream flows when the Fenton River is below 1.0 cfs at the USGS gauging station. For planning purposes, a rate of 0.348 mgd should be used, as it mirrors the rate used for the pumping test. This rate is less than the 360 gpm (0.518 mgd) rate sustained during the 1999 pumping test of the Fenton River Wellfield, which translates to a safe yield of 0.389 mgd. Thus, the 0.348 mgd figure should be considered representative of the available yield from Well D during low-flow conditions.

- The University should determine the elevation of the monitoring wells near Well D and the elevation of the streambed in order to continue developing a relationship between groundwater and river levels. Future activations of Well D during low-flow periods should include the use of dataloggers to monitor ground water levels in nearby monitoring wells in order to note the timing of groundwater recovery as compared to the timing of the well start-up and shut-down.

- The University should establish a staff gauge and develop a rating curve to monitor instream flow downstream of Well D while it is being used during dry conditions (i.e., while the Fenton River Wellfield operating protocols are otherwise in effect). A permanent staff gauge should be installed that can be reused from year to year.

- It is reasonable to follow the recommendation in the Well D simulation report that a waiting period should be considered for use of Well D during dry conditions that cause low instream flows. Use of the well should be postponed until September, which would allow the aquifer near Well D to remain as close as possible to natural levels during the spring and summer seasons.

- A two-month period of availability is recommended, from September through October. When possible, storage should be used to sustain the system and the Willimantic River Wellfield should be operated to its full potential to allow occasional periods of shut-down of Well D.

- Likewise, Well D should be used occasionally in September and October in order to allow periodic relaxation of pumping at the Willimantic River Wellfield.

SECTION 6.0
PROTOCOLS FOR CONJUNCTIVE USE OF SUPPLIES

6.0 PROTOCOLS FOR CONJUNCTIVE USE OF SUPPLIES

The following protocols are the guidelines by which the University shall manage its water system during normal and low-flow periods. Emergency situations are not considered – such situations and the appropriate response protocols are outlined in the Emergency Contingency Plan.

6.1 INTERPRETATION OF USGS GAUGING STATION DISCHARGE

The Fenton River Study and the Willimantic River Study both recommended utilizing an upstream USGS-maintained gauging station to determine the discharge that is approaching each wellfield. These two gauging stations are real-time USGS stations that can be monitored on the internet at the following world-wide web addresses:

- Fenton River gauge: http://waterdata.usgs.gov/nwis/uv?01121330
- Willimantic River gauge: http://waterdata.usgs.gov/nwis/uv?01119382

The Fenton River Study recommended using a direct reading of the Old Turnpike Road gauge to determine the amount of discharge in the Fenton River. This reading would allow the wellfield to be managed through the reductions and eventual cessation of withdrawals as upstream discharge fell from six cfs to three cfs and below.

The Willimantic River Study was different in that demand management (voluntary and mandatory conservation) was recommended as opposed to supply management (reductions or cessations in withdrawals). The environmental triggers are based on levels of flow downstream of the Willimantic River Wellfield in the study reach. Since the daily withdrawal typically varies from 1.2 to 1.9 mgd (1.85 to 2.94 cfs), an adjustment to the direct reading from the Merrow Road gauge is recommended based on the previous week's average pumping rate, as shown by the following equation:

- USGS discharge – [Previous week's average withdrawal rate from Willimantic River Wellfield (gallons) x 0.13368 / 24 / 60 / 60] = Discharge Downstream of the Wellfield

The University may utilize the above equation to correct the USGS discharge at Merrow Road to a representative discharge downstream of the Willimantic River Wellfield. It is this adjusted discharge that would be compared to the Willimantic River streamflow triggers discussed in Section 6.3.

6.2 NORMAL OPERATION PROCEDURES

Under normal environmental conditions, the University has sufficient available supplies to meet the current and future committed demands on its water system with minimal environmental impact. Withdrawals from the Fenton River Wellfield are limited to 0.844 mgd (diversion registration), and withdrawals from the Willimantic River Wellfield are limited to 1.97 mgd (current available water for peak days, or 1.48 mgd safe yield).

Assuming a long-term one-to-one ratio between aquifer pumping and streamflow loss, these values equate to a maximum loss of streamflow of 1.31 cfs downstream of the Fenton River Wellfield and 3.05 cfs downstream of the Willimantic River Wellfield. According to the Fenton River Study, when flows in the Fenton River (as measured at Old Turnpike Road) are greater than 10 cfs, there is no discernable environmental impact on the habitat of the Fenton River. Similarly, the Willimantic River Study indicated that there is no discernable environmental impact when the Willimantic River is flowing above 27 cfs. Thus, when flows in either river are above their respective values, the University is considered to be operating under "normal" conditions and the University has operational flexibility to pump one or both wellfields or a combination of wells at each wellfield to meet system demands.

During a typical year, the University withdraws approximately 80% of its water from the Willimantic River Wellfield. This proportion approaches 100% during the summer months during most years when the Fenton River Wellfield is offline based on the in-stream flow recommendations of the Fenton River Study. It is understood that the Willimantic River Wellfield cannot be shut down entirely as it is the sole source of supply for the Depot Campus. However, the University should strive to utilize the Fenton River Wellfield during the winter and spring months as much as possible to give the Willimantic River aquifer the ability to recharge and the wells a respite from pumping.

When the discharge in the Fenton River drops below 10 cfs as measured by the USGS at Old Turnpike Road, or the discharge in the Willimantic River drops below 27 cfs as measured by the USGS at Merrow Road (as modified for pumping rate as shown in Section 6.3), the University will activate its "Low-Flow Operation Procedures" described below.

6.3 LOW-FLOW OPERATION PROCEDURES

The University will utilize its Low-Flow Operation Procedures when discharges in the Fenton River drop below 10 cfs, and/or when discharges in the Willimantic River downstream of the Willimantic River Wellfield drop below 27cfs. In general, the Fenton River drops below 10 cfs nearly every year, while the Willimantic River drops below 27 cfs approximately every third year. Thus, the University must remain prepared to activate at least a portion of these Low-Flow Operation Procedures every single year.

The Fenton River Wellfield typically drops below 10 cfs before the Willimantic River drops below 27 cfs. As such, since 2006 the University has managed its water supply without the Fenton River Wellfield during the summer months. Thus, the discharge triggers for the Fenton River Wellfield presented in Table 6-1 are primarily operational (consistent with the Fenton River Study recommendations), while the discharge triggers for the Willimantic River Wellfield are based on the previous draft Drought Management Plan as informally amended in the Willimantic River Study.

TABLE 6-1
Low-Flow Operation Procedures

River / Wellfield	Discharge (Q)	Management Procedure
Fenton	Q < 10 cfs	Prepare for Stage IA
Willimantic	Q < 27 cfs	
Fenton River Wellfield Management – Upstream Discharge		
Fenton	5 cfs ≤ Q < 6 cfs	Reduce wellfield withdrawals to a maximum of 0.633 mgd, minimize withdrawals from Well A
Fenton	4 cfs ≤ Q < 5 cfs	Reduce wellfield withdrawals to a maximum of 0.422 mgd, minimize withdrawals from Wells A and B
Fenton	3 cfs ≤ Q < 4 cfs	Reduce wellfield withdrawals upstream of Well A to a maximum of 0.211 mgd, utilize Well C or D only
Fenton	Q < 3 cfs	Cease wellfield withdrawals. **Activate Stage IA**. **Exception:** During September and October, withdrawals are allowed from Well D (maximum of 0.348 mgd) – Refer to Section 5.3 for specific operating recommendations
Willimantic River Wellfield Management – Downstream (Adjusted) Discharge		
Willimantic	Q < 27 cfs for 19+ days, or Q < 19 cfs	**Activate Stage IA**[1]
Willimantic	Q < 15 cfs	**Activate Stage IB**
Willimantic	Q < 15 cfs for 13+ days, or Q < 12 cfs	**Activate Stage II**
Willimantic	Q < 12 cfs for 12+ days, or Q < 7.8 cfs	**Activate Stage III**
Willimantic	Q < 7.8 cfs for 7+ days	**Activate Stage IV**

[1]It is possible that localized dry conditions could occur in the Willimantic River watershed that could cause the University to enact various conservation measures while the Fenton River remained fully operational. Under this rare circumstance, the University should utilize the Fenton River Wellfield as much as possible to "rest" the Willimantic River Wellfield during the drought period, since it is likely that water levels in the Fenton River will soon recede as the localized drought regionalizes.

The Fenton River Wellfield management procedures call for supply management as the discharge in the Fenton River falls from 6 cfs to below 3 cfs. These recommendations came from the Fenton River Study, and were amended to exclude certain wells based on the discussion in Section 2.0 of this plan. In previous years, the University has simply shut the Fenton River Wellfield down when the upstream discharge falls below 6 cfs in order to avoid manually setting the reduced pumping rates. It is likely that this will continue in the future.

This Wellfield Management Plan amends the recommendations of the Fenton River Study based on the results of additional studies discussed in Section 5.0. Specifically, the use of Well D is recommended during the months of September and October up to a maximum withdrawal of 0.348 mgd as guided by the recommendations in Section 5.3.

The five Water Conservation triggers in Table 6-1 based on the 2008 draft Drought Response Plan are listed below. Note that this plan supports and recommends that the word "drought" be removed from the name for each stage, as they are correlated to streamflows and not a drought declaration:

1. When flow in the Fenton River drops below 3 cfs, or when flow in the Willimantic River drops below 19 cfs (or below 27 cfs for 19 or more days), the University issues a *Stage IA - Water Conservation Alert*.

2. When flow in the Willimantic River drops below 15 cfs, the University issues a *Stage IB - Water Supply Advisory*.

3. When flow in the Willimantic River drops below 12 cfs (or below 15 cfs for 13 or more days), the University issues a *Stage II - Water Supply Watch*.

4. When flow in the Willimantic River drops below 7.8 cfs (or below 12 cfs for 12 or more days), the University issues a *Stage III - Water Supply Warning*.

5. When flow in the Willimantic River drops below 7.8 cfs for seven or more days, the University issues a *Stage IV - Water Supply Emergency*.

The appropriate responses to each water conservation trigger are described below. Note that Well D will be considered an active source of supply during September and October upon approval of this plan, and thus its use as an emergency supply (or at the very least, a method of addressing prolonged dry periods or droughts) is no longer applicable in the staged responses outlined in Section 6.3.1 through 6.3.5.

6.3.1 Stage IA - Water Conservation Alert

- Issue request for voluntary water conservation measures (Section 6.3.6).
- Contact the DPH, DEP, and other state and local agencies (Department of Corrections, Town of Mansfield, town members of Water/Sewer Advisory Board) concerning the activation of the Alert.
- Evaluate operative status of system components and availability of supply.
- Monitor daily production, storage, and consumption to quantify any demand reductions. The goal is to reduce demand by at least 5% from normal conditions. The success of meeting this goal should be checked by reviewing daily wellfield production records and tank levels for the preceding five days.

6.3.2 Stage IB - Water Supply Advisory

- Re-issue request for voluntary water conservation measures.
- Review mandatory conservation measures and update if necessary (Section 6.3.6).
- Contact the DPH, DEP, and other state and local agencies concerning the activation of the Advisory.
- Evaluate operative status of system components and availability of supply. Evaluate and identify operating adjustments, emergency equipment, or other materials necessary to temporarily increase available supply. Ensure operating adjustments are in place to maximize available supplies.
- Monitor daily production, storage, and consumption to quantify any demand reductions. Investigate any deviance from normal patterns. The goal is to reduce demand by 10% from normal conditions. The success of meeting this goal should be

checked by reviewing daily wellfield production records and tank levels for the preceding five days.

- ❑ Review the Emergency Contingency Plan and update contact information or other sections if necessary, in case an actual drought is emerging.

6.3.3 Stage II - Water Supply Watch

- ❑ Re-issue request for voluntary water conservation measures.
- ❑ Issue mandatory conservation measures and water use restrictions.
- ❑ Contact the DPH, DEP, and other state and local agencies concerning the activation of the Watch.
- ❑ Evaluate operative status of system components and availability of supply. As required, schedule necessary in-house emergency equipment; order additional equipment or services from outside vendors following University purchasing procedures.
- ❑ Monitor daily production, storage, and consumption to quantify any demand reductions. Investigate any deviance from normal patterns. The goal is to reduce demand by 15% from normal conditions. The success of meeting this goal should be checked by reviewing daily wellfield production records and tank levels for the preceding five days.

6.3.4 Stage III - Water Supply Warning

- ❑ Re-issue request for voluntary water conservation measures.
- ❑ Re-issue mandatory conservation measures and water use restrictions.
- ❑ Contact the DPH, DEP, and other state and local agencies concerning the activation of the Warning.
- ❑ Evaluate operative status of system components, availability of supply, and effectiveness of demand reduction measures taken to date.

- Eliminate all unnecessary outdoor water usage and routinely monitor and enforce compliance with mandatory conservation measures.
- Review High Priority User list and update if necessary.
- Schedule necessary purchase of supplemental water, either bottled or by tanker, for critical areas.
- Monitor daily production, storage, and consumption to quantify any demand reductions. Investigate any deviance from normal patterns. The goal is to reduce demand by 20% from normal conditions. The success of meeting this goal should be checked by reviewing daily wellfield production records and tank levels for the preceding five days.
- Monitor ground water levels at each production well at least once per day. Refer to the drought section of the Emergency Contingency Plan and activate emergency procedures if an actual water supply emergency is imminent or occurring.

6.3.5 Stage IV - Water Supply Emergency

- Re-issue request for voluntary water conservation measures.
- Re-issue mandatory conservation measures and water use restrictions.
- Contact the DPH, DEP, and other state and local agencies concerning the activation of the Emergency.
- Evaluate operative status of system components, availability of supply, and effectiveness of demand reduction measures taken to date.
- Eliminate all unnecessary outdoor water usage and routinely monitor and enforce compliance with mandatory conservation measures.
- Make necessary adjustments and/or order supplemental water supplies to meet needs of high priority users.
- Monitor daily production, storage, and consumption to quantify any demand reductions. Investigate any deviance from normal patterns. The goal is to reduce demand by 25% from normal conditions. The success of meeting this goal should be

checked by reviewing daily wellfield production records and tank levels for the preceding five days.

- Continue to monitor ground water levels at each production well at least once per day. Refer to the drought section of the Emergency Contingency Plan and activate emergency procedures if an actual water supply emergency is imminent or occurring.

6.3.6 Water Conservation Measures

The request for voluntary water conservation measures is announced to the public when any of the discharge triggers are reached in Table 6-1 as explained in Section 6.3.1 through 6.3.5. The Office of Environmental Policy is responsible for monitoring instream flows and determining when a discharge trigger has been met. The announcements include letters to students, faculty, staff, and customers, as well as announcements on the University's local radio station and cable TV channel. Several departments are in charge of handling the media request:

1. Office of Environmental Policy: Draft water conservation request for voluntary conservation measures.
2. University Relations: Review and approve draft water conservation request.
3. Vice President / Chief Operating Officer: Issue water conservation request as UConn Announcement.
4. Facilities Operations / Contract Operator: Issue water conservation request to off-campus users; respond to reported leaks as high priority repairs; report relevant water demand changes to UConn water conservation communications team (Administration & Operations, Office of Environmental Policy, University Relations, Town of Mansfield).

The Director of Facilities Operations and/or his/her designee is responsible for notifying outside state and local agencies of the status of the University's water system at each trigger level. University Relations is responsible for notifying legislators and the governor of Connecticut, if needed.

Voluntary water conservation measures include:

- Take short showers; turn off the water flow while soaping or shampooing.
- Use the appropriate water level or load size selection on the washing machine.
- Use water only as needed when washing dishes, shaving, and brushing teeth. Do not let the faucet run unnecessarily.
- Run dishwashers only when completely full.
- Use of public water to wash building exteriors, driveways, sidewalks, or a vehicle is discouraged.
- Reduce or eliminate non-essential consumption of water, such as lawn or garden watering.
- Reconsider pouring water down the drain when there may be another use for it.
- Raise air conditioning thermostats for centrally-chilled buildings to 75 degrees Fahrenheit.
- Immediately report any leaky fixtures in UConn buildings to Facilities Operations at (860) 486-3113.

In addition to voluntary water conservation measures, mandatory water conservation measures are enforced when the University reaches the discharge triggers for Stage II, Stage III, or Stage IV (Section 6.3.3 through 6.3.5). Public announcements are made through the same protocols as the voluntary conservation measures, with the following additions:

1. Vice-President / Chief Operating Officer: Issue department-head directives applicable to UConn operations (Chief Operating Officer direct reports and Athletics).
2. Executive Vice President / Provost: Issue directives applicable to academic/research activities (Deans and Directors)

3. Facilities Operations / Contract Operator: Issue directives applicable to non-University and off-campus water system users; provide updated list of Central Utility Plant and centrally-cooled buildings; report relevant water production and demand changes to the University's water conservation communications team.

Mandatory water conservation measures for *Stage II - Water Supply Watch* include:

- Lawn watering for all users is limited to four hours or less per day and only between the hours of 5 A.M. to 9 A.M. and 7 P.M. to 9 P.M. Athletic fields will be allowed up to two hours of water per day during the same hours.
- Filling or public or private pools must be provided via water delivered from another source.
- Washing of motor vehicles is banned. The University's wash bay is closed until mandatory water conservation measures are lifted.
- The use of ornamental or display fountains is banned.
- The use of public water for washing and wetting down streets, sidewalks, driveways, or parking areas is banned unless required by the local public health authority.
- The use of University water for dust control at construction sites is banned. Contractors are required to provide water for dust control from an outside source.
- The use of hydrant sprinkler caps is banned.
- No routine maintenance flushing or hydrants, pipes, and sewer lines. Water main flushing will only be used to address water quality issues.
- Curtail running of lasers, autoclaves and other research lab devices that consume water for cooling (once-through cooling).
- Thermostats set at 78 degrees Fahrenheit for centrally-cooled buildings.

Additional measures enacted during a *Stage III - Water Supply Warning* include the use of paper plates and plastic silverware in any or all eight on-campus dining areas, depending on which dining areas provide the most conservation benefits. In general, the conservation methods employed Stage III and Stage IV are the same as those used during Stage II, with the expectation that the conservation goals of 20% and 25% from normal wellfield production would be met under Stage III and Stage IV, respectively.

6.3.7 Recovery from Conservation Measures

Defining a rigid regimen for recovering from the five water conservation stages is difficult due to the relatively rapid peaking and decline of river hydrographs from summer storms. Thus, the Office of Environmental Policy should exercise professional judgment in determining the exact timing of recovery. Potential recovery triggers are suggested as follows:

1. When flow in the Willimantic River rises above 7.8 cfs for seven consecutive days, and flow in the river appears to be stable or slowly increasing, the University may return to a *Stage III - Water Supply Warning*.

2. When flow in the Willimantic River rises above 12 cfs for seven consecutive days, and flow in the river appears to be stable or slowly increasing, the University may return to a *Stage II - Water Supply Watch*.

3. When flow in the Willimantic River rises above 15 cfs for seven consecutive days, and flow in the river appears to be stable or slowly increasing, the University may return to a *Stage IB - Water Supply Advisory*.

4. When flow in the Willimantic River rises above 19 cfs and flow in the river appears to be stable or slowly increasing, the University may return to a *Stage IA - Water Conservation Alert*.

5. When flow in the Willimantic River is stable or slowly increasing above 19 cfs, and flow in the Fenton River is generally sustainable above three cfs, the University may lift the *Stage IA - Water Conservation Alert* and continue to operating according to the Low-Flow Operation Procedures in Table 6-1 regarding the Fenton River withdrawals.

The University will re-issue appropriate water conservation notices as the water system recovers through the five water conservation stages in order to educate water users regarding system status and necessary conservation measures.

APPENDIX A
2008 DRAFT DROUGHT RESPONSE PLAN

DROUGHT RESPONSE PLAN

DRAFT 08-22-08

UCONN
Water Supply Emergency Contingency Plan

1. TRIGGER LEVELS:

Stage IA – Water Conservation Alert:

- Projected Available Supply[1] is forecast to be greater than or equal to the Projected Water Usage[2] for an extended period yet flow in the Fenton River is at 3.0 cfs or less.

Stage IB – Water Supply / Drought Advisory:

- Projected Available Supply[1] is forecast to be equal to or less than Projected Water Usage[2], or
- Continuous pumping at maximum available supply results in an overall decrease in tank storage, as expressed by water levels in the High Head Reservoir.

Stage II – Water Supply / Drought Watch:

- Projected Available Supply[1] is forecast to be significantly less than Projected Water Usage[2] for an extended period, or
- Three consecutive days of continuous pumping at maximum available supply results in an overall decrease in tank storage, as expressed by water levels in the High Head Reservoir.

Stage III – Water Supply / Drought Warning:

- If the High Head Reservoir fails to recover to two-thirds full (10' level) for three consecutive days.

Stage IV – Water Supply / Drought Emergency:

- If the High Head Reservoir fails to recover to 40% full (6' level) for four consecutive days.

---

[1] Projected Available Supply is the expected capacity of the system's sources operating concurrently, and adjusting for any losses due to well maintenance or repair; transmission or pumping limitations due to depressed groundwater levels at the Willimantic wells; anticipated reductions in Fenton well withdrawal based on flow recession equations developed in the Study Report; or other supply-reducing events.

[2] Projected Water Usage is the expected production for the particular time of year for which the assessment is made, and includes any reductions or increases in demand due to historical variation or known significant changes.

2. **RESPONSE:**

Stage IA – Water Conservation Alert:

- Implement Demand-Side Water Conservation Plan for voluntary conservation.
- Contact the Departments of Public Health and Environmental Protection and other state and local agencies, as outlined in the plan, concerning the initiation of an Alert.
- Maintain compliance with Fenton River Study flow management recommendations, including cessation of Fenton Well Field withdrawals when flow is less than 3 cfs, as measured at USGS gaging station 01121330.
- Evaluate the operative status of system components and availability of supply.
- Monitor daily production, storage and consumption to quantify any demand reductions.

Stage IB – Water Supply / Drought Advisory:

- Re-issue Demand-Side Water Conservation Plan for voluntary conservation.
- Contact the Departments of Public Health and Environmental Protection and other state and local agencies, as outlined in the plan, concerning the initiation of an Advisory.
- Maintain compliance with Fenton River Study flow management recommendations, including phased scaling back of Fenton Well Field withdrawals when flow is less than 6 cfs, as measured at USGS gaging station 01121330.
- Investigate any material deviation from normal consumption, production or storage patterns.
- Evaluate the operative status of system components and availability of supply. Evaluate and identify operating adjustments, emergency equipment, or other actions necessary to temporarily increase available supply.
- Contact DPH and DEP regarding the possible activation of Fenton Well D and/or issuance of temporary or emergency authorization allowing rebalancing of registered diversion rates to allow increased withdrawals from Willimantic Wells 1 and/or 3.
- Review Water Supply Plan Emergency Contingency Plan and update if necessary.
- Monitor daily on-campus, metered consumption, storage and metered production to ensure consumption and production reductions are met (10% from previous non-advisory average).
- Ensure all operating adjustments are made to increase available supply, with the exception of activating Fenton wells that are off-line or restricted due to low-flow conditions.

Stage II – Water Supply / Drought Watch:

- Re-issue Demand-Side Water Conservation request for voluntary conservation.
- Issue Demand-Side Water Conservation notice for water use restrictions.
- Contact the Departments of Public Health and Environmental Protection and other state and local agencies, as outlined in the plan, concerning the initiation of a Watch.
- Maintain compliance with Fenton River Study flow management recommendations, including phased scaling back of Fenton Well Field withdrawals when flow is less than 6 cfs, as measured at USGS gaging station 01121330.

Stage II – Water Supply / Drought Watch (continued):

- Continue investigation of any material deviation from normal production, consumption and storage patterns.
- Evaluate the operative status of system components and availability of supply. As required, schedule necessary in-house emergency equipment; order additional equipment or services from outside vendors following University purchasing procedures.
- Contact DPH/DEP regarding activation of Fenton Well D in accordance with recommended abbreviated pumping plan and/or issuance of temporary or emergency authorization allowing rebalancing of registered diversion rates to allow increased withdrawals from Willimantic Wells 1 and/or 3.
- Review Mandatory Conservation measures and update if necessary.
- Monitor daily on-campus, metered consumption and metered production to ensure consumption and production reductions are met (15% from previous non-advisory average).

Stage III – Water Supply / Drought Warning:

- Re-issue Demand-Side Water Conservation request for voluntary conservation.
- Re-issue Demand-Side Water Conservation Plan for mandatory conservation.
- Contact the Department of Public Health and other state and local agencies, as outlined in the plan, concerning the initiation of a Warning.
- Evaluate the operative status of system components, availability of supply, and the effect of demand reduction measures taken to date. Evaluate and prioritize reactivation of any Fenton wells off-line or throttled due to flow-imposed limits, including Fenton Well D.
- Eliminate all unnecessary outdoor water usage and routinely monitor and enforce compliance with mandatory conservation measures.
- Activate Fenton Well D in accordance with recommended abbreviated pumping plan, if feasible.
- During increasing severity of stage, and upon notification and consultation with appropriate state agencies, initiate limited Willimantic Well 1 and 3 well use to maintain level in the High Head Reservoir.
- Review High Priority User list and update if necessary.
- Schedule necessary purchase of supplemental water, either bottled or by tanker, for critical areas.
- Monitor daily on-campus, metered consumption, metered storage, and metered production to ensure consumption and production reductions are met (20% from previous non-advisory average).

Stage IV – Water Supply / Drought Emergency:

- Re-issue Demand-Side Water Conservation request for voluntary conservation.
- Re-issue Demand-Side Water Conservation notice for water use restrictions.
- Contact the Department of Public Health and other state and local agencies, as outlined in the plan, concerning the initiation of an Emergency.

Stage IV – Water Supply / Drought Emergency (continued):

- Eliminate all outside water usage, and enforce all mandatory conservation restrictions, as necessary.
- Evaluate the operative status of all system components, availability of supply, and the effect of demand reduction measures taken to date. Make necessary operating adjustments to meet needs of high priority users.
- During increasing severity of stage, and upon notification and consultation with appropriate state agencies, increase production at the Fenton Well Field to maintain level in the High Head Reservoir.
- Order supplemental water supplies for high priority users.
- Monitor daily on-campus, metered consumption and metered production to ensure consumption and production reductions are met (25% from previous non-advisory average).

3. CONSERVATION MEASURES:

Demand-Side Water Conservation Plan – Voluntary Measures

Water Conservation Measures	Departmental Responsibilities

Water Conservation Alert; Water Supply Advisory; Water Supply Watch: <u>Voluntary Measures</u>
• Reduce use
  o shorter showers
  o condense washing of loads (dishes and laundry)
• Be more conscious of use
  o Not letting water run to warm up or cool down
  o Not letting faucets run while brushing teeth, shaving, etc
• Eliminate non-essential consumption of water (lawn watering, garden watering at night only, car washing).
• Raise air conditioning thermostats for centrally-chilled buildings to 75 degrees
• Report leaks immediately
  o Facilities Operations (6-3113)
	OEP – draft WC request for voluntary conservation measures
	
	Univ Relations – review and approve draft WC request
	
	VP/COO – issue WC request as UConn Announcement
	
	FacOps/NEWUS – issue WC request to off-campus users
	
	FacOps/NEWUS – respond to reported leaks as high priority repairs
	
	FacOps/NEWUS – report relevant water demand changes to UConn WC communications team (A&O, OEP, Univ Relations, Town of Mansfield)
	
	--- 	
	
	The following communications responsibilities applicable to each step in this Plan:
	
	A&O - notify DPH, DEP, DOC, Town of Mansfield, and town members of Water/Sewer Advisory Board
	
	Univ Relations – notify legislators and governor, as needed

Demand-Side Water Conservation Plan – Mandatory Measures

Water Supply Warning; Water Supply Emergency: Mandatory Water <u>Conservation Measures</u> • No routine maintenance flushing of hydrants, pipes and sewer lines • No fleet vehicle washing • 50% reduction in irrigation of athletic fields, landscaping and research facilities, unless separate irrigation ponds or wells are used • Curtail running of lasers, autoclaves and other research lab devices that consume water for cooling (once-through cooling) • No use of UC water for construction site dust control or rinsing activities • No use of water for street sweeping • No pool filling • Thermostats set at 78 degrees for centrally-cooled buildings	*VP/COO – Issue department-head directives applicable to UConn operations (COO direct reports and Athletics) *EVP/Provost - Issue directives applicable to academic/research activities (Deans and Directors) *FacOps/NEWUS – Issue directives applicable to non-University and off-campus water system users FacOps provide updated list of CUP and centrally-cooled buildings FacOps – report relevant water production and demand changes to UConn Water Team --- *When warranted, these parties are also responsible for notifying same water system users about repeal of mandatory measures.

4. RECOVERY FROM EMERGENCY:

The method of recovery from a water emergency will vary according to the stage and responsible trigger. In general, once the emergency condition is rectified, the emergency can be considered over and normal system operating conditions can resume. Several non-drought emergencies may not result in formal activation of the stage response plan due to the short-term duration of the emergency. Therefore, the recovery can be quite rapid, compared to recovery from a drought.

The steps to be taken to step down from longer term and drought related emergencies are as follows:

Stage IV – Water Supply / Drought Emergency:

When the water level in the High Head Reservoir is maintained above 6 feet, 40% full, for three consecutive days with an overall trend showing an increase in tank storage, and continued recovery can be sustained without use of the Fenton wells, well use may be curtailed as flow management recommendations dictate. When water level in the High Head Reservoir can be maintained above 10 feet, two-thirds full, with an overall trend showing an increase in tank storage, Stage III can be re-implemented and mandatory restrictions eased.

Stage III – Water Supply / Drought Warning:

When response measures have resulted in the water level in the High Head Reservoir being maintained above 10 feet, two-thirds full, for three consecutive days with an overall trend showing an increase in tank storage, and continued recovery can be sustained without use of the Fenton wells, well use may be curtailed as flow management recommendations so dictate. Production from all sources is to be reviewed and if projected available supply is greater than the projected water usage, Stage II can be re-implemented and mandatory restrictions further eased.

Stage II – Water Supply / Drought Watch:

When response measures have resulted in the water level in the High Head Reservoir returning to normal, and when Projected Available Supply is greater than the Projected Water Usage, Stage I can be re-implemented and voluntary conservation maintained.

Stage IB – Water Supply / Drought Advisory:

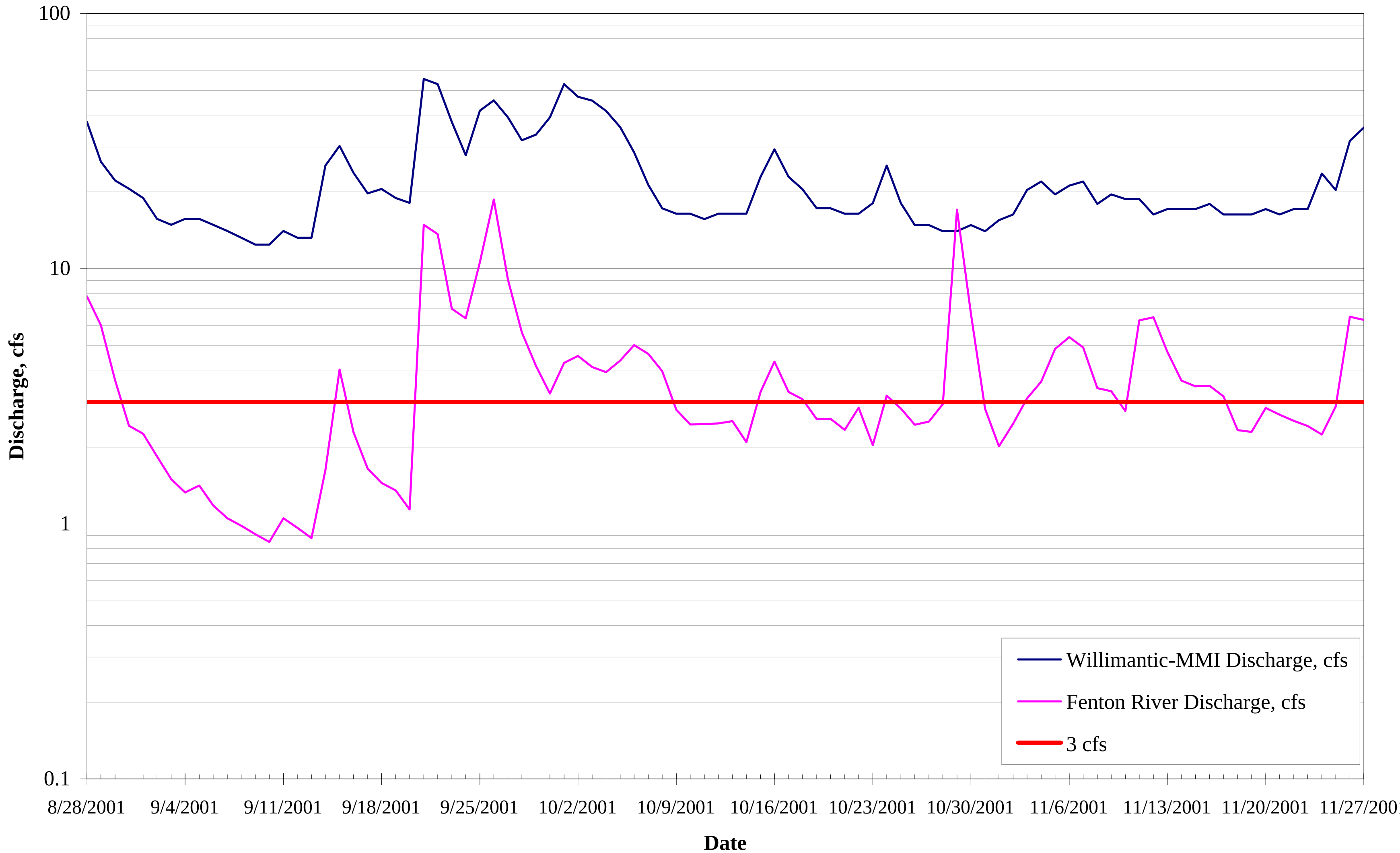
When response measures have resulted in the water level in the High Head Reservoir returning to normal for five consecutive days, and when Projected Available Supply is greater than the Projected Water Usage, the advisory can be lifted.

Stage IA – Water Conservation Alert:

When response measures have resulted in the water level in the High Head Reservoir returning to normal for five consecutive days, and when Projected Available Supply is greater than the Projected Water Usage, and when the flow in the Fenton River is greater than 3.0 cfs, the Alert can be lifted.

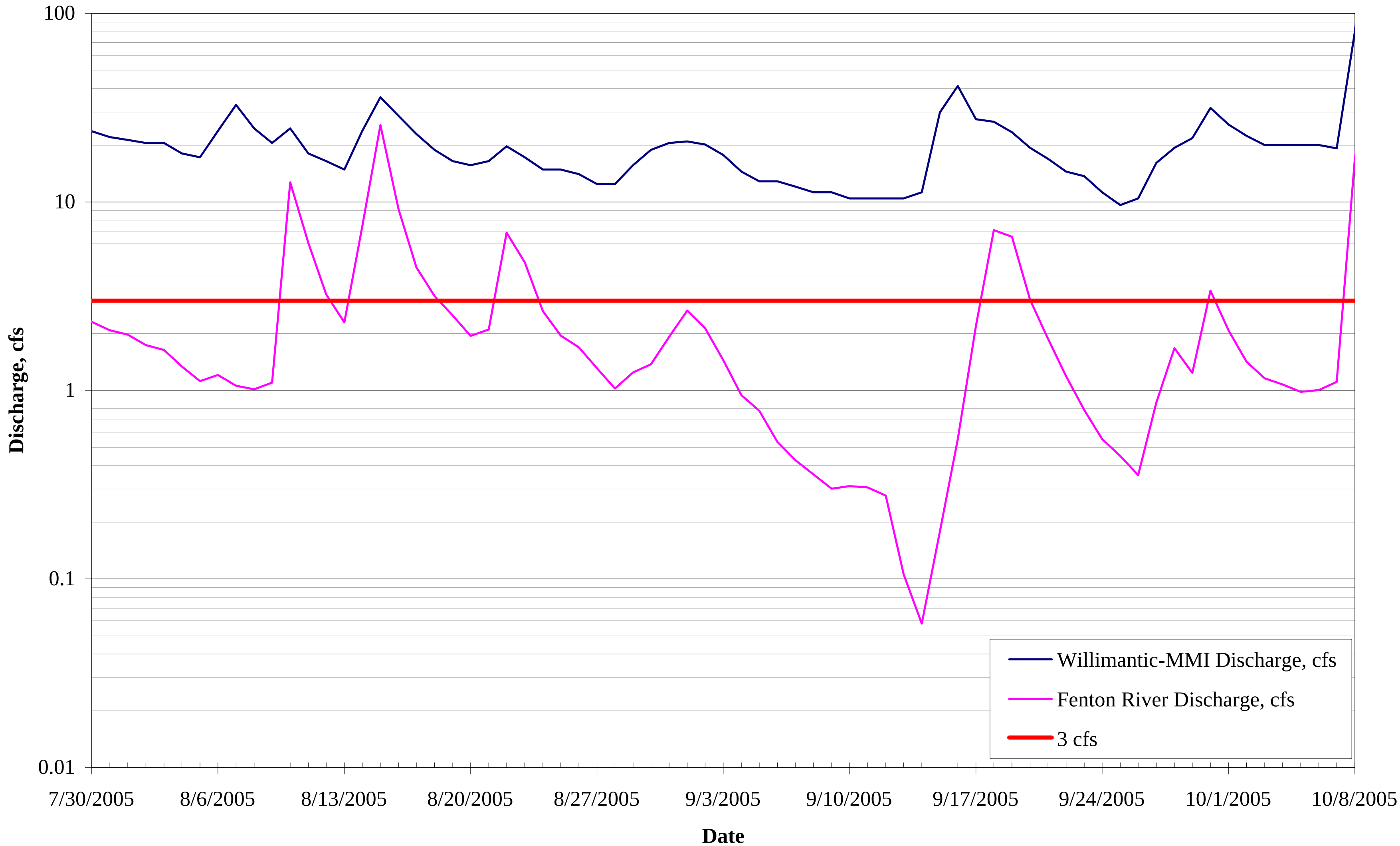
APPENDIX B
LOW-FLOW CASE STUDIES

Comparison of 2001 Discharges



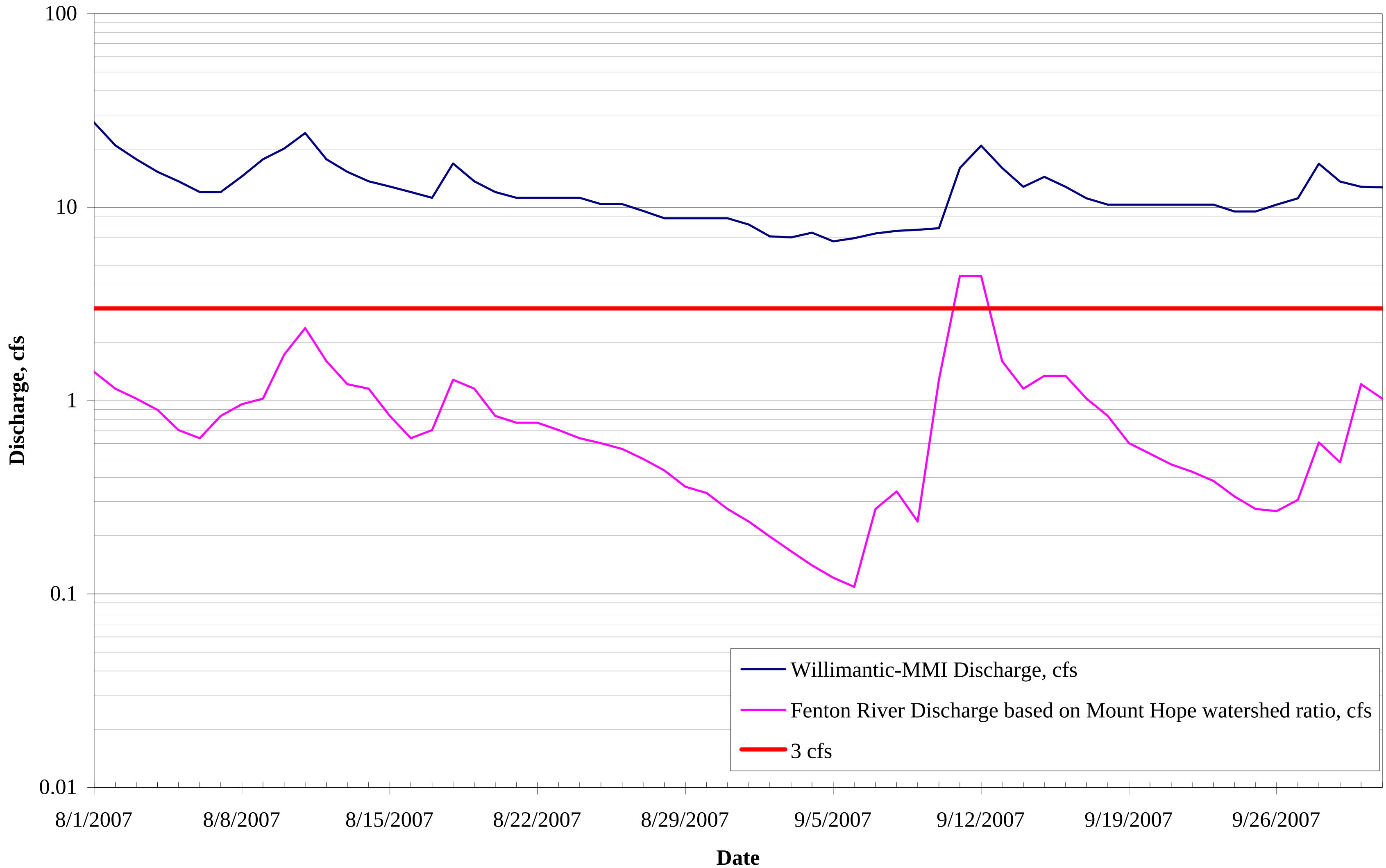
MILONE & MACBROOM®

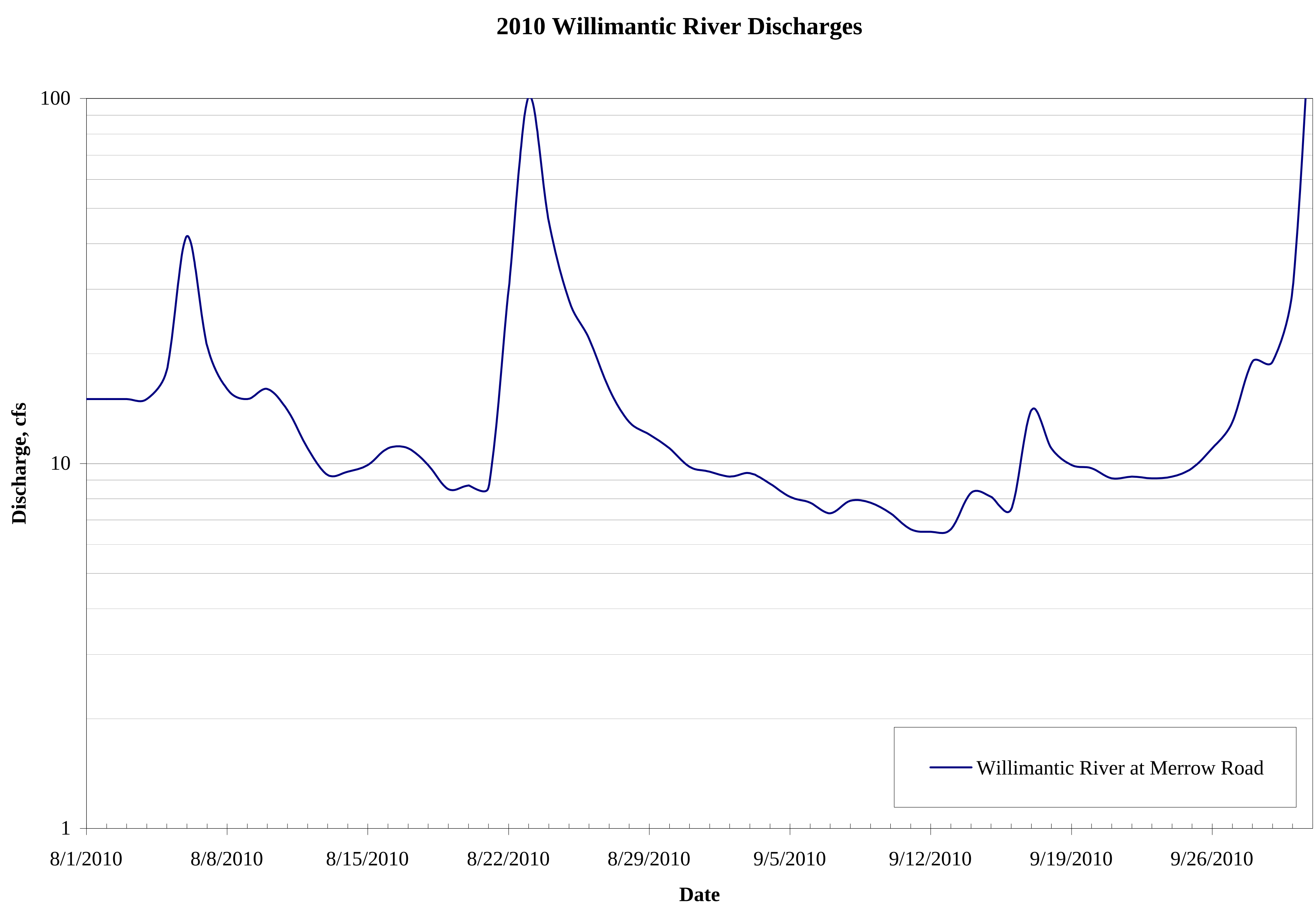
Comparison of 2005 Discharges



MILONE & MACBROOM®

Comparison of 2007 Discharges





MILONE & MACBROOM®

APPENDIX C
FENTON WELL D STUDY (2008) AND
WELL D PUMPING TEST DATA (2010)

The Impact of Pumping Well D on the Fenton River Stream Flow during Drought Periods (Simulation Studies)

May 29, 2008

Farhad Nadim (Ph. D.)

Executive Summary

The prospect of using Well D in the Fenton River well field as a back up source of water for the University of Connecticut during drought periods was investigated with the aid of a numerical code. Three continuous pumping rates of 200, 300, and 400 gpm (Scenarios I, II, and III) were chosen to study the impact on the stream flow in the vicinity of Well D. A fourth scenario (Scenario IV) was also chosen to test the impact on the stream flow due to short-term pumping from late September to early November. The hydrological conditions of 1966 (one of the driest years recorded in the state of Connecticut) were used to conduct the simulations.

Results from Scenarios I-III indicated that by pumping Well D throughout the year without pumping Wells A, B, and C, the stream loss ranged from 0.30 to 0.61 cfs. The maximum flow loss (0.61 cfs) is equivalent to about 43% of the total stream flow for the period that the maximum flow loss occurred. To examine the difference between continuously pumping Well D at 200 gpm versus pumping Well D at 267 gpm for 18 hour/days with no pumping for 6 hours/day, two different variations of Scenario I were run through the model. The results did not indicate any difference between the two simulated variations.

In Scenario IV, Well D was pumped for two weeks beginning in late September at 200 gpm, followed by a two-week period where pumping ceased and was then resumed for a second two week period at 200 gpm.. The maximum stream flow loss in the Fenton River was 0.17 cfs. This flow loss was the equivalent to only 1.7% of the total stream flow during the period that the maximum flow loss took place. Well D could be used as a back up well during drought periods with an intermittent pumping schedule, provided that:

a) A thirty-day period of no pumping from all Fenton wells precedes the first two-week period of pumping from Well D,
b) Fenton Wells A, B, and C are not operated during the low-flow conditions,
c) Well D is off for a two-week period between the two pumping periods, and
d) The stream flow stays above 1 cfs during the intermittent pumping periods (3 cfs > Q_R > 1 cfs).

Installation of monitoring wells measuring the groundwater elevation near Well D can assist in determining the periods when groundwater table falls below the streambed and causes the river to turn into a losing stream during which pumping can be stopped.

Background

The University of Connecticut (UConn) water supply is obtained from four wells located along the valley of the Fenton River and four wells located along the valley of the Willimantic River (about 2 miles east and west of the University campus, respectively). The Fenton River well field and locations of Wells A, B, C and D are shown in Figures 1 and 2.

In a detailed study conducted by the University of Connecticut in 2005, the long term impact of the Fenton River water supply wells on the habitat of the Fenton River was investigated. During the 2005 study, seventeen pumping scenarios were used to investigate the stream flow loss in the vicinity of Wells A, B, C, D, meadows, and Gurleyville Road. These scenarios ranged from different hours of pumping per day (14, 20, and 24 hours), to different total daily pumping (844,000, 633,000, 422,000, and 211,000 gpd), to different locations for a replacement of Well A, to imposing limits on the total daily pumping depending on the stream flow.

Based on water management schemes presented in the Fenton River well field study of 2005, the University of Connecticut implemented a drought response plan in which pumping water from the Fenton River well field ceases completely during low flow periods (i.e. $Q_R < 3$ cfs). During these periods, the University relies solely on the water available from the Willimantic well field within the registered diversion limits.

Study Objective and Scope of the Work

To determine the impact, if any, on the stream flow of the Fenton River and on local groundwater elevation, new simulations were conducted based on the existing mathematical model to study the affects of a) pumping Well D exclusively throughout the year at three different, constant pumping rates (200, 300, and 400 gpm) and b) pumping Well D at 200 gpm only during two separate two-week intervals during the expected drought period.

Methodology

The mathematical model used to achieve the study objectives was the same model that was developed for the Fenton River Well Field Study conducted in 2005. Detailed description of the numerical model and scenarios used for this study can be found in the final project report entitled, "Long-Term Impact Analysis of the University of Connecticut's Fenton River Water Supply Wells on the Habitat of the Fenton River," which was submitted to the University of Connecticut in March 2006.

To assess the potential affects of operating Well D throughout the year into a period of drought conditions, three pumping scenarios were simulated. In Scenarios I, II, and III, Well D was exclusively pumped (no pumping from Wells A, B, and C) at 200, 300, and 400 gallons per minute (gpm), respectively, during the entire year (January 1st through December 31st). All simulations were based on precipitation and evapotranspiration data from 1966 because that was one of the driest years recorded in the state of Connecticut. The pumping scenarios were based on the assumption that Well D was on for 18 hours and off for 6 hours during the 24 hour pumping period. To compensate for the period when the pump at Well D was off, the pumping rates were corrected and the values used during the simulations were 267, 400, and 533 gpm for Scenarios I, II, and III, respectively. The predicted effects on stream flow are at the location within the river nearest to Well D, shown as Point 1 on Figure 3.

In addition to the three model scenarios that evaluated year-long pumping, Scenario IV was conducted to investigate the impact on the stream flow loss if Well D were exclusively operated (no pumping from Wells A, B, and C) for two discreet two-week intervals of pumping separated by a two week of no pumping. In the Scenario IV simulation, all pumps were off from January 1st until September 21st. The simulated start of pumping at 200 gpm began on September 22nd and continued until October 5th. The Well D pump was simulated as "off" for two weeks from October 6th to October 20th, and pumping then resumed "on" from October 21st until November 7th. A summary of the four pumping scenarios is given in Table 1.

Although the Scenario IV simulation assumed that all wells are off during the period from January 1st until September 21st, thirty days of no pumping allows the stream flow and groundwater to recover to the normal levels expected if no previous pumping were to have occurred at all. This is based on the results from the earlier simulation studies conducted in 2005 to examine maximum withdrawal rate scenarios (Scenarios 1-3 of the 2005 study). As such, Scenario IV applies to all situations in which the Fenton well field is used within its registered diversion limits, so long as the wells were not used for a period of at least thirty days prior to an intermittent pumping period and the flow in the Fenton River remains higher than 1 cfs.

Table 1. Well D Pumping scenarios used in this study

Simulation Scenario	Pumping rate gpm (18 hr/day)	Equivalent Continuous Pumping Rate (gpm, 24 hr/day)	Duration
Scenario- I	267	200	Jan-1 to Dec. 31
Scenario-II	400	300	Jan-1 to Dec. 31
Scenario-III	533	400	Jan-1 to Dec. 31
Scenario-IV	267	200	Sep-22 to Oct-5 Oct 25th to Nov 7th

Model parameters (daily precipitation and recharge, hydraulic conductivity, specific storage, specific yield, etc.) used in this study were similar to the parameters used in the UConn-2005 Fenton River Well Field Study that was designed to simulate a dry year with prevailing drought conditions during summer and early fall.

Results and Discussion

a) Scenario I (Well D - 200 gpm)

Mean and maximum stream flow losses are summarized in Table 2. The simulation results indicated that during Scenario I (Well D on for 18 hours at 267 gpm and off for 6 hours) the average stream flow loss in the section of stream near Well D was about 0.21 cfs. The maximum flow loss was 0.30 cfs (Figure 4). The highest stream flow loss in the section of stream near Well D is predicted to occur from mid-August to mid-October.

During this pumping scenario, the section of stream near Well D becomes completely dry during part of day #246 (nearly ½ days of September 3). If there were no pumping during this time, flow in the stream in this vicinity of Well D is estimated to be 0.18 cfs.

A variation of Scenario I was also modeled to determine if a difference in stream flow loss could be expected if the total daily withdrawal was kept constant, but with a reduced, continuous pump rate of 200 gpm (rather pumping at 267 gpm with a 6-hour rest period). As shown on Figure 5, the plots for both modeling results overlap and there is no difference in the stream flow loss in the section of the Fenton River in the vicinity of Well D for the two pumping variations.

b) Scenario II (Well D pumped at 300 gpm)

During the Scenario II simulated pumping (Well D on for 18 hours at 400 gpm and off for 6 hours), the average stream flow loss in the section of stream near Well D during the entire year, was about 0.32 cfs (Figure 6). The maximum stream flow loss was 0.45 cfs. The highest stream flow loss in the section of stream near Well D occurred from mid-August until mid-October. Similar to Scenario I pumping, the section of stream in the vicinity of Well D becomes completely dry but for a longer period of time (from day #244 to day #246 - September 1 to September 3).

c) Scenario III (Well D pumped at 400 gpm)

During the Scenario III simulated pumping (Well D on for 18 hours at 533 gpm and off for 6 hours), the average stream flow loss in the section of stream near Well D during the entire year, was about 0.43 cfs (Figure 7). The maximum stream flow loss was 0.61 cfs. The highest stream flow loss in the section of stream near Well D occurred from mid-August to mid-October. Similar to Scenario II pumping, the section of stream near Well D becomes completely dry during the Scenario III pumping (day #244 to day #246 - September 1 to September 3).

d) Scenario IV. (Well D pumped at 200 gpm from September 22 to October 5 and from October 21st to November 7th)

Scenario IV simulated pumping from Well D for two two-week periods separated by with a two-week break, The results indicate that the maximum stream flow loss would be 0.14 for the first two-week pumping period and 0.17 cfs for the second two week pumping period (Scenario IV curve on Figure 8).

Results indicated that during the simulated intermittent pumping, maximum stream loss in the vicinity of this well was 0.17 cfs, which is the equivalent to only 1.7% of the total stream flow during the period that the maximum flow loss took place. Therefore, during dry periods when the stream flow is low but still greater than 1 cfs, Well D can be operated continuously (24 hr/day) for a two week period either continuously at 200 gpm or for 18 hr/day at 267 gpm. Then, if the wells are rested for two weeks, pumping can resume for another two-weeks.

Table 2: ΔQ (cfs) for Fenton River near Well D for four pumping scenarios

Simulation Scenario	Maximum ΔQ (cfs)	Mean ΔQ (cfs)
Scenario - I	0.30	0.21
Scenario - II	0.45	0.32
Scenario – III	0.61	0.43
Scenario - IV	0.17	0.07

The field and simulation studies also indicated that recharge to the Fenton River well field occurs rapidly during precipitation events. Thus, if significant rainfall occurs during the two weeks operational period, Well D can be allowed to be pumped without the resting period as long as the flow in Fenton River remains higher than 1 cfs.

In addition to estimating the actual amount of maximum stream flow reductions, the change in stream flow was estimated as a percent of total stream flow in the vicinity of Well D. The simulation results indicate that when the stream flow falls below 1 cfs, the ratio of Delta Q to total stream flow increases dramatically. The Delta Q in the vicinity of Well D during Scenario I simulation exceeded 20% of the total stream flow for only a short period (September 7th – September – 13th) and reached the maximum of about 40% (Figure 9). In Figure 10, the Delta Q relative to stream flow in the vicinity of Well D during Scenario I simulation is shown for the entire year. Comparatively, during the Scenario IV pumping period, Delta Q reached a maximum of 1.7% of the total stream flow (Figure 11).

The groundwater elevation was plotted for pumping Scenarios I, II, and III and the results indicated that when Well D is pumped at 200 gpm, the groundwater elevation remains above the streambed in the vicinity of Well D. When pumping is increased to 300 gpm, at certain time periods during the dry months (July, August and September) groundwater falls below the streambed elevation (Figures 12 and 13).

Conclusions

The three simulation scenarios conducted for Well D in the Fenton River well field indicated that if Well D was exclusively pumped at 200, 300, and 400 gpm continuously for the entire year, maximum flow loss occurring in section of the Fenton River near Well D would be 0.30, 0.45, and 0.61 cfs, respectively. Based on the simulation results, the highest flow loss occurs during the time period of mid-August to mid-October when the stream flow reaches its lowest levels. The simulation results also indicated that a section of stream near Well D could go dry from 0.5 to 3 days in early September.

Scenario IV indicates that operation of Well D for two (2) two-week periods during low flow conditions ($Q_R < 3$ cfs) either continuously (24 hr/day) at 200 gpm or for 18 hr/day at 267 gpm will result in a minimal impact to stream flow (0.17 cfs, or 1.7 % of the total expected stream flow), provided that:

a) A thirty-day period of no pumping from all Fenton wells precedes the first two-week period of pumping from Well D,
b) Fenton Wells A, B, and C are not operated during the low-flow conditions,
c) Well D is off for a two-week period between the two pumping periods, and
d) The stream flow stays above 1 cfs during the intermittent pumping periods (3 cfs $> Q_R >$ 1 cfs).

Field and simulation studies also indicated that recharge to the Fenton River well field is swift during precipitation events. Therefore, if significant rainfall occurs during the two weeks operational period, Well D can be pumped without the resting period as long as the flow in Fenton River remains higher than 1 cfs.

Recommendations

1. During drought periods, intermittent use of Well D is considered possible. Well D could be used as a back-up well during drought periods with intermittent pumping schedules. Well D can be operated for two (2) two-week periods at 200 gpm for 24 hr/day or at 267 gpm for 18 hr/day, provided that
    a. A thirty-day period of no pumping from all Fenton wells precedes the first two-week period of pumping from Well D,
    b. Fenton Wells A, B, and C are not operated during the low-flow conditions,
    c. Well D is off for a two-week period between the two pumping periods, and
    d. The stream flow stays above 1 cfs during the intermittent pumping periods (3 cfs > Q_R > 1 cfs).
2. If the decision is made to utilize Well D as a backup source of water for the UConn campus during dry periods, attention should be given to the amount of stream flow loss that occurs in the section of the Fenton River near this well.
3. Installation of monitoring wells measuring the groundwater elevation near Well D can assist in determining the periods when groundwater table falls below the streambed and causes the river to turn into a losing stream during which pumping can be stopped.

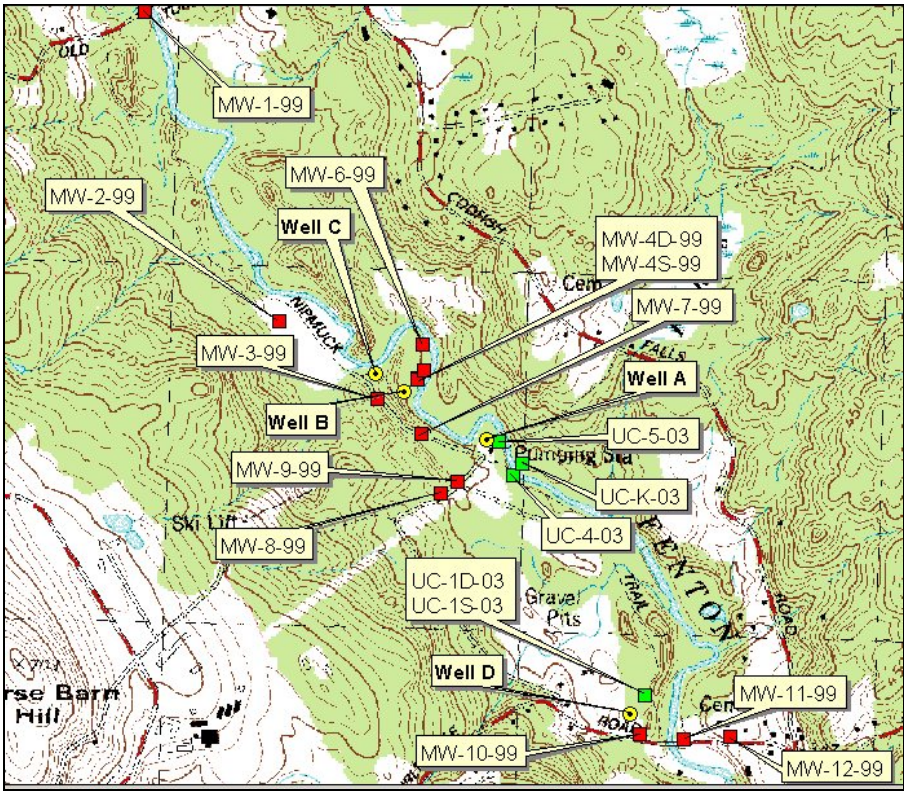


Figure 1. Map showing the Fenton River Well-Field with all pumping wells.

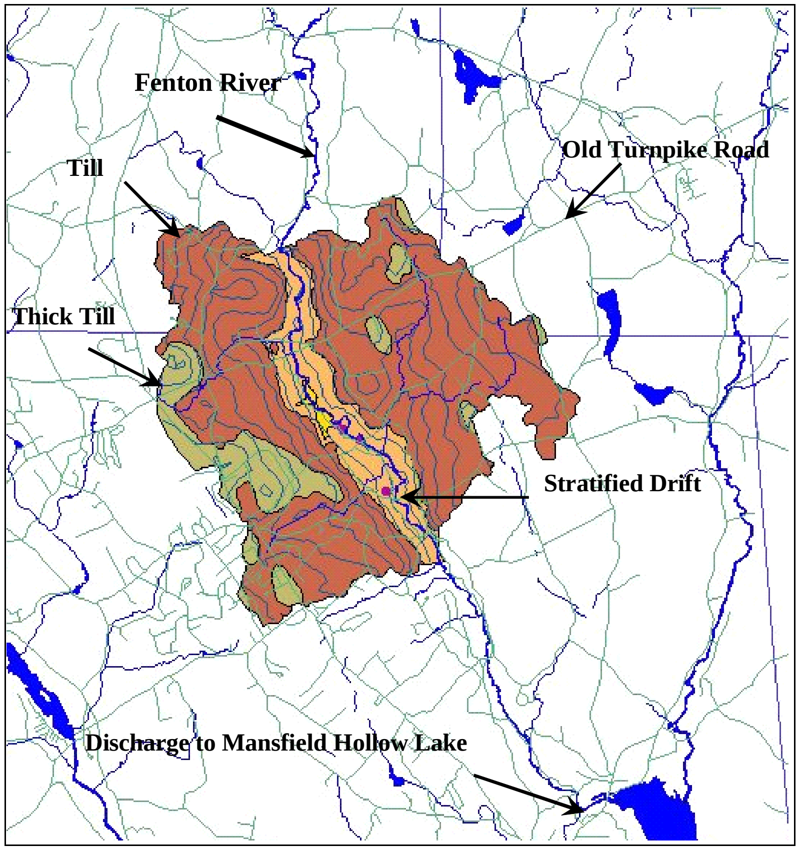


Figure 2. Simulation domain and geographical boundaries.

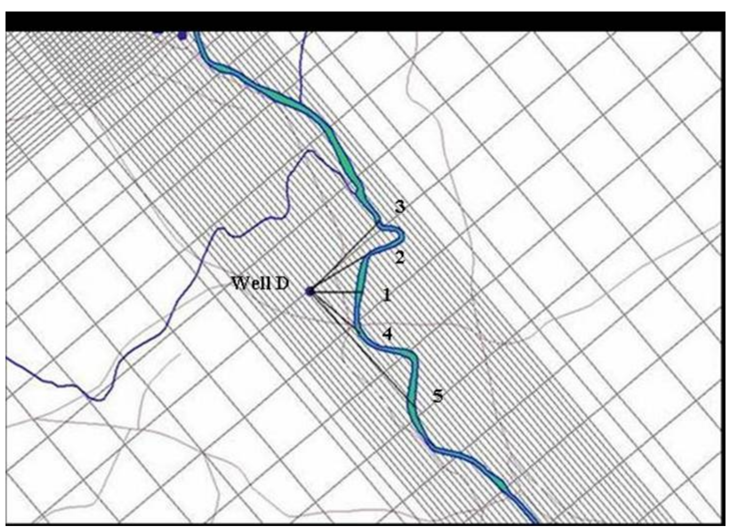


Figure 3. Location of Delta Q estimations at five points near Well D (1-vicinity, 2- 45° north, 3- 60° north, 4- 45° south, 5- 60° south).

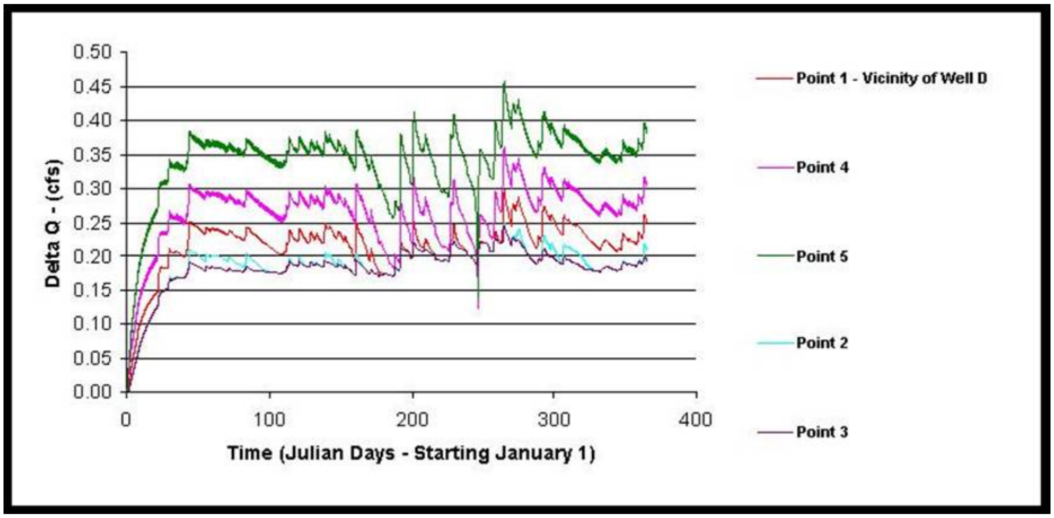


Figure 4. Delta Q at five points near Well D during simulation scenario I (pumping rate = 200 gpm)

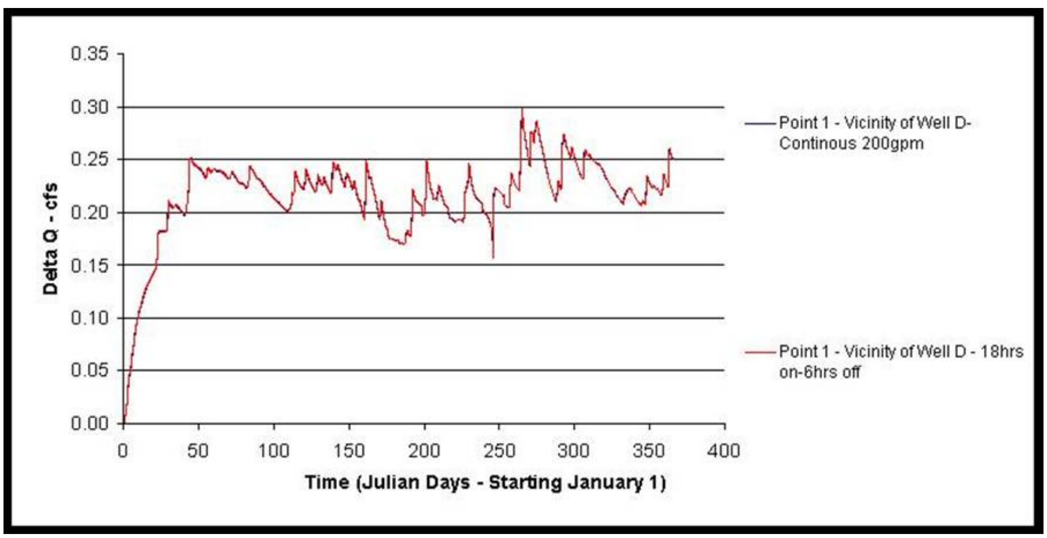


Figure 5. The difference between continuous pumping of Well D at 200 gpm or 18 hours at 267 gpm and 6 hours off. No difference was observed and data points correspond.

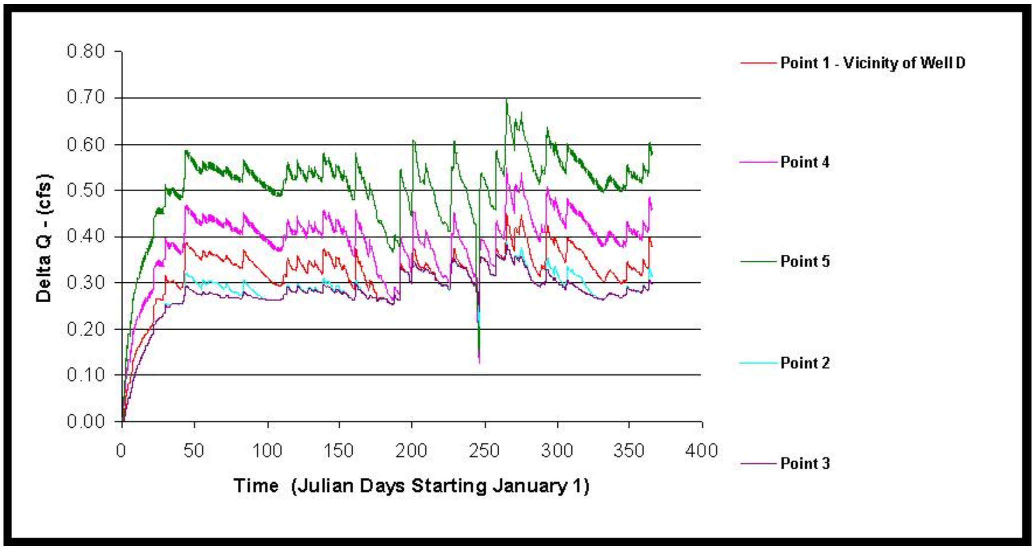


Figure 6. Delta Q at five points near Well D during simulation scenario II (pumping rate = 300 gpm).

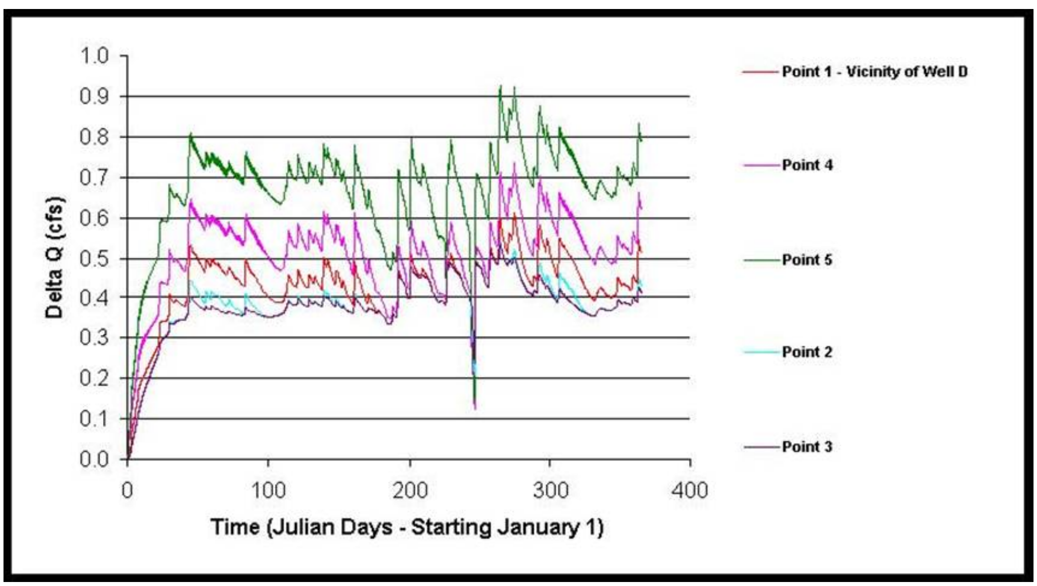


Figure 7. Delta Q at five points near Well D during simulation scenario III (pumping rate = 400 gpm).

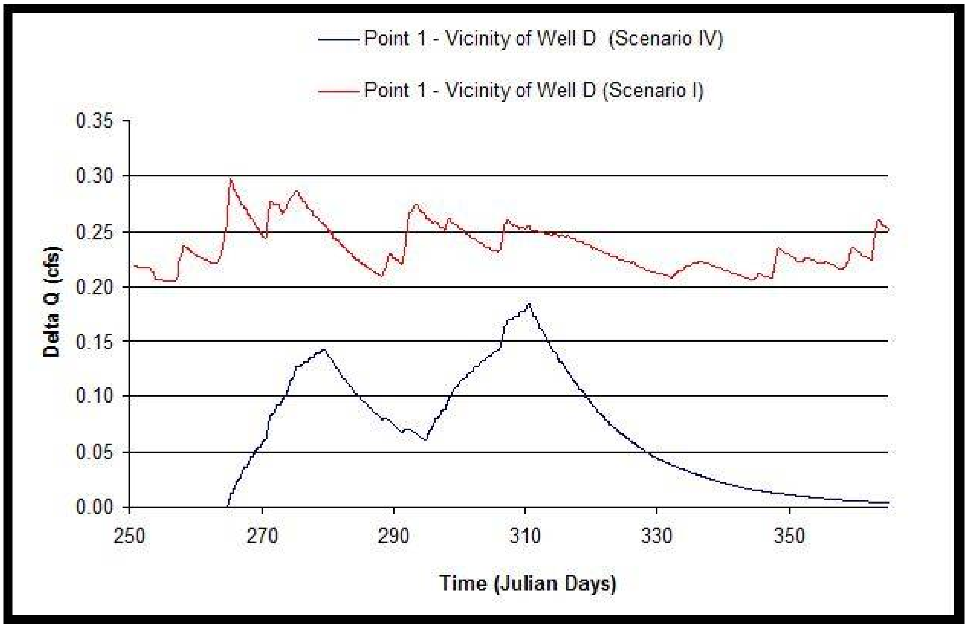


Figure 8. Delta Q in the vicinity of Well D (Point 1) during scenario IV simulation. All pumps are off from January 1st until Sep 21st. Well D is pumped at 200 gpm from Sep 22nd – Oct 5th and from Oct 21st – Nov 7th.

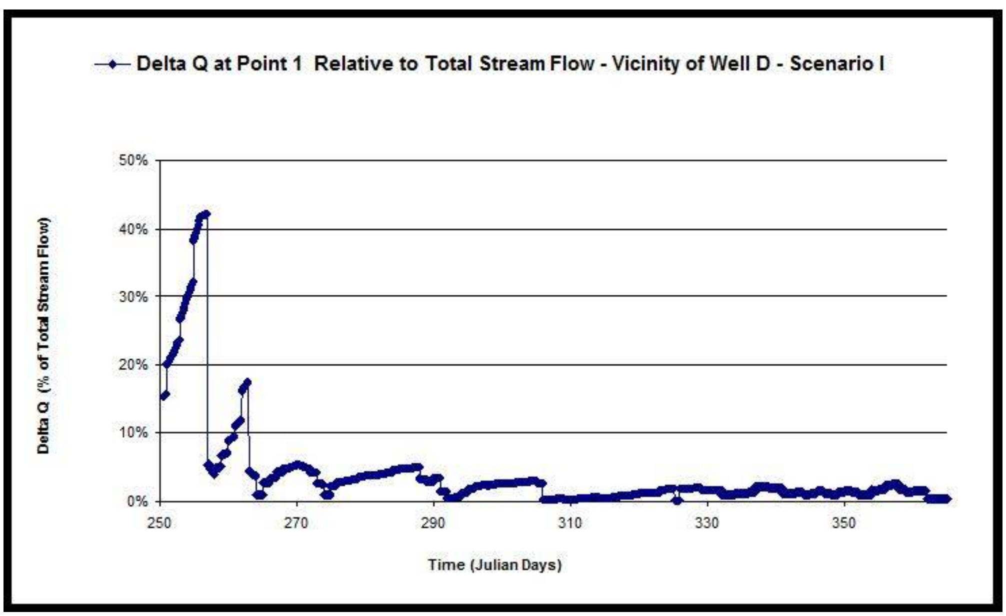


Figure 9. Delta Q relative to streamflow (%) in the vicinity of Well D (Point 1) during selected period (September 7th – December 31st, 1966) of Scenario I simulation. Well D is pumped continuously at 200 gpm.

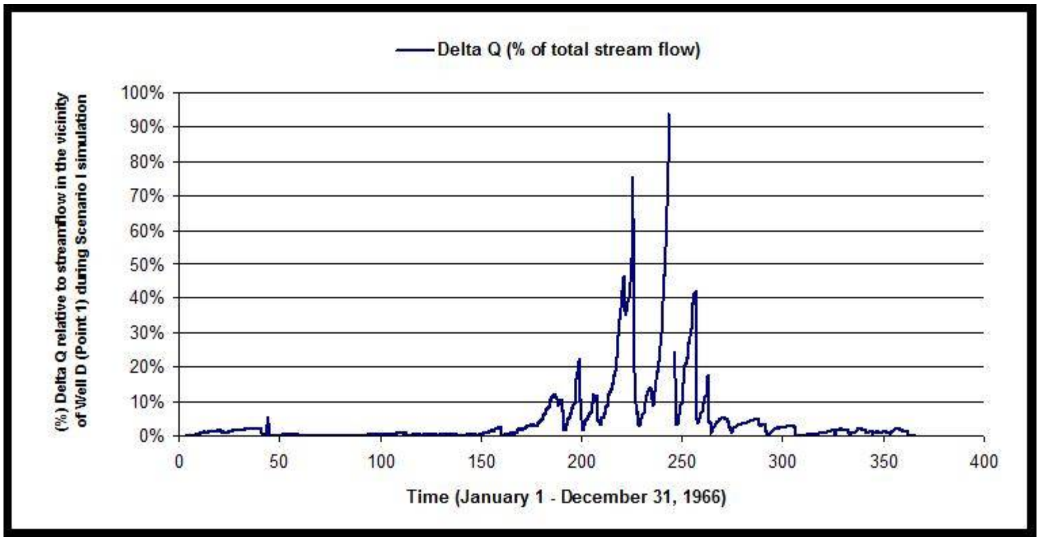


Figure10. Delta Q relative to streamflow (%) in the vicinity of Well D (Point 1) during the entire simulated year (January 1st – December 31st, 1966) of Scenario I simulation. Well D is pumped continuously at 200 gpm.

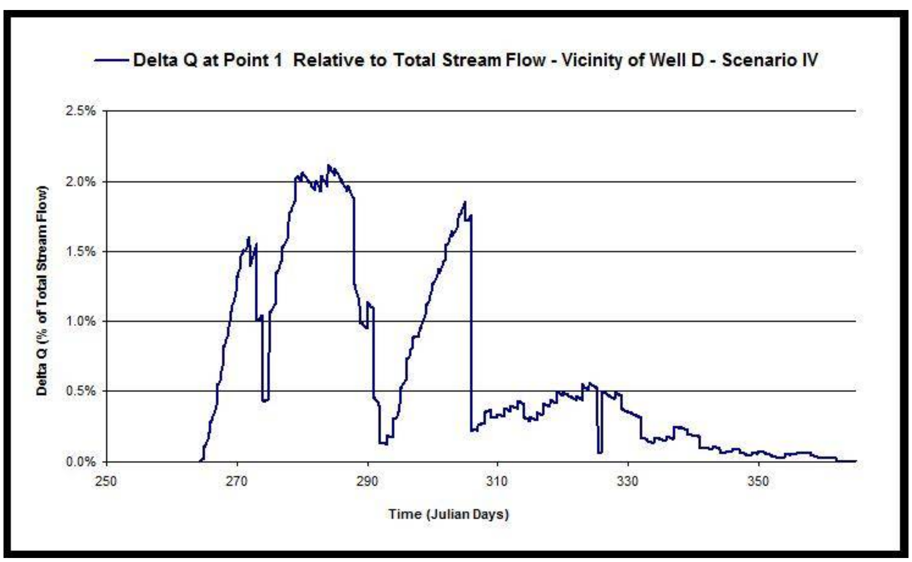


Figure 11. Delta Q relative to stream flow (%) in the vicinity of Well D (Point 1) during Scenario IV simulation. All pumps are off from January 1st until Sep 21st. Well D is pumped at 200 gpm from Sep 22nd – Oct 5th and from Oct 21st – Nov 7th.

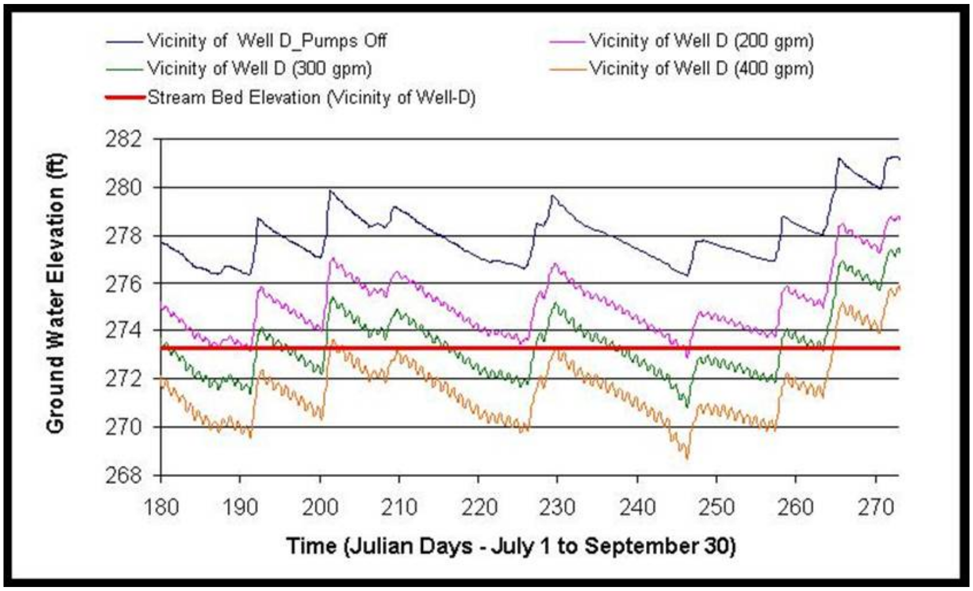


Figure 12. The impact of pumping Well D on the groundwater head near well D during the dry months (July 1 to September 30)

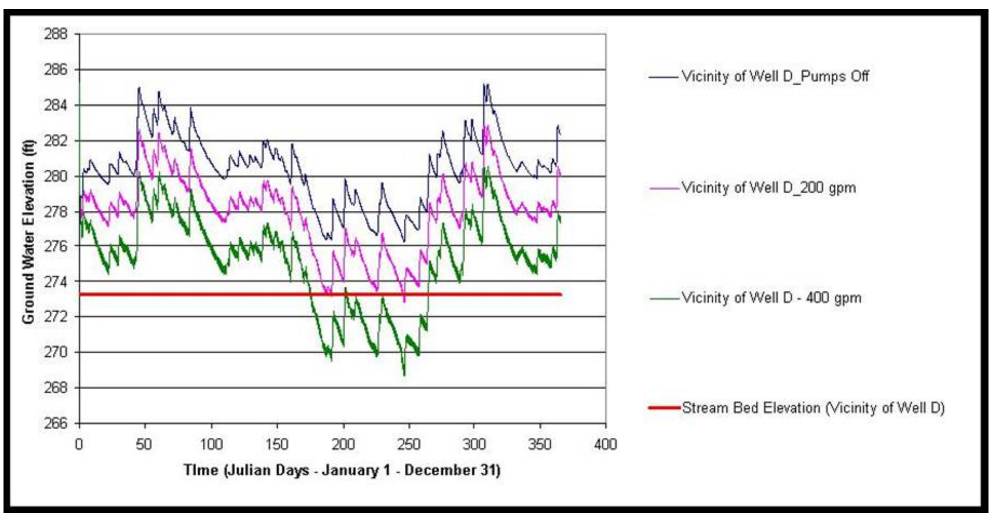


Figure 13. The impact of pumping Well D on the ground water head near well D during the entire simulated year (January 1 to December 31).

WELL D PUMPING TEST - SEPTEMBER 2010

MW-10-99 MP Elevation: 291.35

Date	Time	Water Level		Water Elevation
9/8/2010	11:16	11.89	ft	279.46
9/8/2010	13:26	11.90	ft	279.45
9/8/2010	15:09	11.92	ft	279.43
9/8/2010	16:19	11.93	ft	279.42
9/9/2010	9:46	12.21	ft	279.14
9/9/2010	12:04	12.26	ft	279.09
9/9/2010	14:19	12.33	ft	279.02
9/10/2010	8:55	12.84	ft	278.51
9/10/2010	12:02	12.92	ft	278.43
9/11/2010	12:01	13.53	ft	277.82
9/12/2010	10:46	14.02	ft	277.33
9/12/2010	13:10	14.04	ft	277.31
9/13/2010	9:39	14.44	ft	276.91
9/14/2010	8:55	14.90	ft	276.45
9/15/2010	14:08	15.45	ft	275.9
9/16/2010	14:25	15.63	ft	275.72
	DD	**3.01**		
	End Rec DD	**3.74**		

MW-11-99 MP Elevation: 285.79

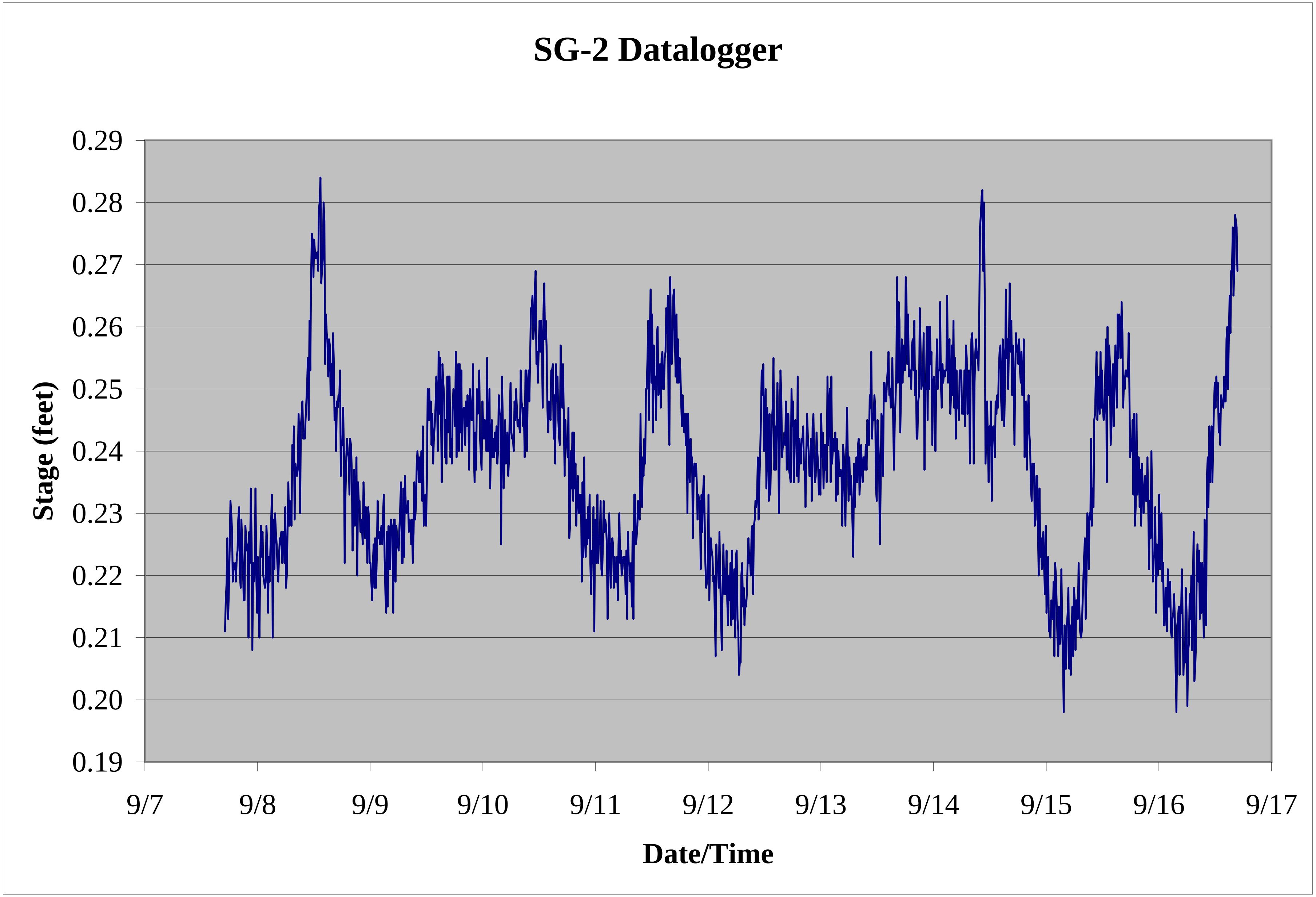
Date	Time	Water Level		Water Elevation
9/8/2010	11:11	6.06	ft	279.73
9/8/2010	13:21	6.08	ft	279.71
9/8/2010	15:14	6.09	ft	279.7
9/8/2010	16:24	6.09	ft	279.7
9/9/2010	9:50	6.12	ft	279.67
9/9/2010	12:08	6.13	ft	279.66
9/9/2010	14:23	6.14	ft	279.65
9/10/2010	9:01	6.19	ft	279.6
9/10/2010	12:06	6.20	ft	279.59
9/11/2010	11:05	6.29	ft	279.5
9/12/2010	10:42	6.38	ft	279.41
9/12/2010	13:06	6.39	ft	279.4
9/13/2010	9:30	6.46	ft	279.33
9/14/2010	8:51	6.53	ft	279.26
9/15/2010	14:03	6.61	ft	279.18
9/16/2010	14:29	6.63	ft	279.16
	DD	**0.47**		
	End Rec DD	**0.57**		

UC-K-03 MP Elevation: 296.30

Date	Time	Water Level		Water Elevation
9/7/2010	15:17	9.24	ft	287.06
9/8/2010	11:30	9.22	ft	287.08
9/8/2010	13:05	9.23	ft	287.07
9/8/2010	14:48	9.25	ft	287.05
9/8/2010	16:00	9.26	ft	287.04
9/9/2010	9:27	9.23	ft	287.07
9/9/2010	11:44	9.23	ft	287.07
9/9/2010	14:00	9.24	ft	287.06
9/10/2010	7:19	9.22	ft	287.08
9/10/2010	10:47	9.23	ft	287.07
9/11/2010	10:48	9.24	ft	287.06
9/12/2010	11:04	9.23	ft	287.07
9/12/2010	13:18	9.24	ft	287.06
9/13/2010	9:51	9.22	ft	287.08
9/14/2010	9:13	9.21	ft	287.09
9/15/2010	14:22	9.28	ft	287.02
9/16/2010	14:10	9.28	ft	287.02
	DD	**-0.01**		
	End Rec DD	**0.06**		

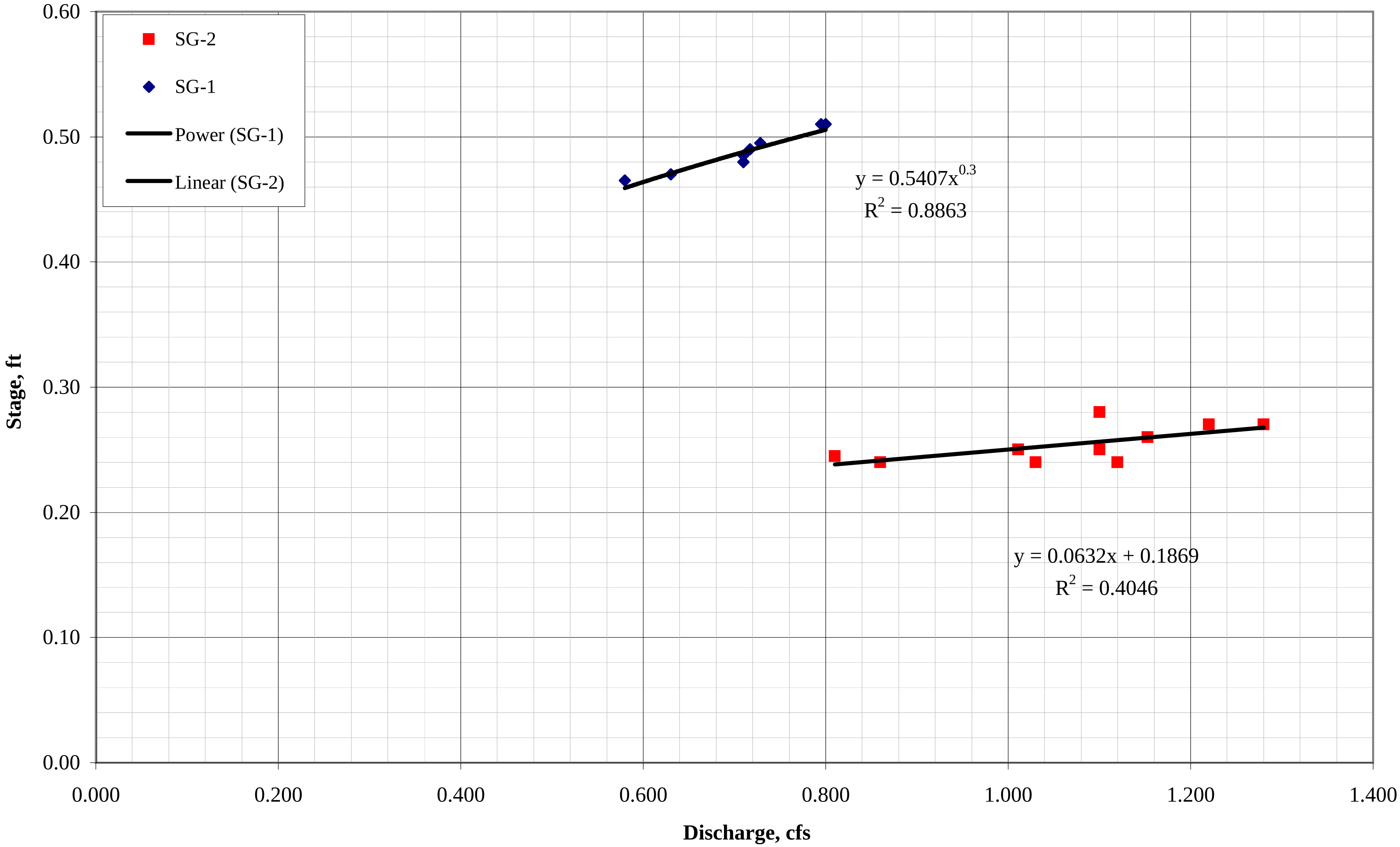
UC-5-03 MP Elevation: 297.30

Date	Time	Water Level		Water Elevation
9/8/2010	11:37	5.42	ft	291.88
9/8/2010	13:09	5.44	ft	291.86
9/8/2010	14:52	5.47	ft	291.83
9/8/2010	16:05	5.48	ft	291.82
9/9/2010	9:31	5.43	ft	291.87
9/9/2010	11:49	5.44	ft	291.86
9/9/2010	14:04	5.46	ft	291.84
9/10/2010	7:23	5.42	ft	291.88
9/10/2010	10:51	5.44	ft	291.86
9/11/2010	9:35	5.44	ft	291.86
9/12/2010	11:08	5.44	ft	291.86
9/12/2010	13:22	5.45	ft	291.85
9/13/2010	9:56	5.42	ft	291.88
9/14/2010	9:16	5.41	ft	291.89
9/15/2010	14:25	5.49	ft	291.81
9/16/2010	14:13	5.49	ft	291.81
	DD	**-0.01**		
	End Rec DD	**0.07**		



SG-2 Datalogger
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
Stage (feet)
9/7
9/8
9/9
9/10
9/11
9/12
9/13
9/14
9/15
9/16
9/17
Date/Time

Fenton River Rating Curves from Well D Pumping Test
Near Well A (SG-1) and Downstream of Gurleyville Road (SG-2)



MILONE & MACBROOM®

SG-1: FENTON RIVER NEAR WELL A

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/7/2010	LEW	10.00						Stage: 0.51' @ 15:46	
	1	10.25	0.38	0.07	0.01	0.00	0.00	Taken by DRM	0.0%
	2	10.50	0.25	0.60	0.15	-0.02	0.00	rock upstream	-0.5%
	3	10.75	0.25	0.65	0.16	-0.02	0.00	rock upstream	-0.5%
	4	11.00	0.25	0.76	0.19	-0.01	0.00	rock upstream	-0.3%
	5	11.25	0.25	0.79	0.20	0.03	0.01		1.0%
	6	11.50	0.25	0.83	0.21	0.04	0.01		1.3%
	7	11.75	0.25	0.86	0.22	0.10	0.02		3.5%
	8	12.00	0.25	0.88	0.22	0.19	0.04		6.8%
	9	12.25	0.25	0.83	0.21	0.22	0.05		7.4%
	10	12.50	0.25	0.97	0.24	0.17	0.04		6.7%
	11	12.75	0.25	0.99	0.25	0.11	0.03		4.4%
	12	13.00	0.25	0.99	0.25	0.12	0.03		4.8%
	13	13.25	0.25	1.02	0.26	0.16	0.04		6.6%
	14	13.50	0.25	0.93	0.23	0.16	0.04		6.0%
	15	13.75	0.25	0.96	0.24	0.19	0.05		7.4%
	16	14.00	0.25	0.95	0.24	0.16	0.04		6.1%
	17	14.25	0.38	0.91	0.34	0.17	0.06		9.4%
	18	14.75	0.38	0.88	0.33	0.18	0.06		9.6%
	19	15.00	0.25	0.91	0.23	0.19	0.04		7.0%
	20	15.25	0.25	0.89	0.22	0.17	0.04		6.1%
	21	15.50	0.25	0.69	0.17	0.17	0.03	on rock	4.7%
	22	15.75	0.25	0.40	0.10	0.08	0.01	on rock	1.3%
	23	16.00	0.25	0.09	0.02	0.08	0.00	on rock	0.3%
	24	16.25	0.25	0.08	0.02	0.10	0.00	on rock	0.3%
	25	16.50	0.25	0.09	0.02	0.03	0.00	on rock	0.1%
	26	16.75	0.30	0.09	0.03	0.07	0.00	on rock	0.3%
	27	17.00	0.35	0.14	0.02	0.06	0.00	on rock	0.2%
	REW	17.10				TOTAL=	0.62	Stage: 0.51' @ 16:29	Rank: Good
								Entered by DRM 9/10/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/8/2010	LEW	11.00						Stage: 0.50' @ 11:50	
	1	11.25	0.38	0.56	0.11	-0.04	0.00	Taken by DRM	-0.7%
	2	11.50	0.25	0.67	0.17	-0.02	0.00	rock upstream	-0.5%
	3	11.75	0.25	0.75	0.19	0.03	0.01	rock upstream	0.9%
	4	12.00	0.25	0.80	0.20	0.03	0.01	rock upstream	1.0%
	5	12.25	0.25	0.85	0.21	0.05	0.01		1.7%
	6	12.50	0.25	0.75	0.19	0.11	0.02		3.3%
	7	12.75	0.25	0.82	0.21	0.20	0.04		6.6%
	8	13.00	0.25	0.82	0.21	0.23	0.05		7.6%
	9	13.25	0.25	0.90	0.23	0.16	0.04		5.8%
	10	13.50	0.25	0.96	0.24	0.12	0.03		4.6%
	11	13.75	0.25	0.98	0.25	0.10	0.02		3.9%
	12	14.00	0.25	1.01	0.25	0.15	0.04		6.1%
	13	14.25	0.25	0.96	0.24	0.22	0.05		8.5%
	14	14.50	0.25	0.90	0.23	0.20	0.05		7.2%
	15	14.75	0.25	0.94	0.24	0.22	0.05		8.3%
	16	15.00	0.25	0.92	0.23	0.19	0.04		7.0%
	17	15.25	0.25	0.90	0.23	0.19	0.04		6.9%
	18	15.50	0.25	0.89	0.22	0.19	0.04		6.8%
	19	15.75	0.25	0.90	0.23	0.18	0.04		6.5%
	20	16.00	0.25	0.72	0.18	0.17	0.03	on rock	4.9%
	21	16.25	0.25	0.38	0.10	0.12	0.01	on rock	1.8%
	22	16.50	0.25	0.15	0.04	0.11	0.00	on rock	0.7%
	23	16.75	0.25	0.10	0.03	0.10	0.00	on rock	0.4%
	24	17.00	0.25	0.09	0.02	0.07	0.00	on rock	0.3%
	25	17.25	0.25	0.09	0.02	0.09	0.00	on rock	0.3%
	26	17.50	0.23	0.12	0.01	0.11	0.00	on rock	0.2%
	REW	17.60				TOTAL=	0.62	Stage: 0.50' @ 12:54	Rank: Fair
								Entered by SJB 9/9/2010	

SG-1: FENTON RIVER NEAR WELL A

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/9/2010	LEW	10.75						Stage: 0.49' @ 10:38	
	1	11.00	0.38	0.10	0.02	-0.01	0.00	rock upstream	0.0%
	2	11.25	0.25	0.66	0.17	-0.03	0.00	rock upstream	-0.7%
	3	11.50	0.25	0.73	0.18	0.02	0.00	rock upstream	0.5%
	4	11.75	0.25	0.78	0.20	0.06	0.01		1.6%
	5	12.00	0.25	0.83	0.21	0.08	0.02		2.3%
	6	12.25	0.25	0.79	0.20	0.09	0.02		2.4%
	7	12.50	0.25	0.74	0.19	0.18	0.03		4.6%
	8	12.75	0.25	0.81	0.20	0.24	0.05		6.7%
	9	13.00	0.25	0.86	0.22	0.24	0.05		7.1%
	10	13.25	0.25	0.92	0.23	0.17	0.04		5.4%
	11	13.50	0.25	0.98	0.25	0.13	0.03		4.4%
	12	13.75	0.25	0.97	0.24	0.15	0.04		5.0%
	13	14.00	0.25	0.91	0.23	0.18	0.04		5.6%
	14	14.25	0.25	0.97	0.24	0.22	0.05		7.3%
	15	14.50	0.25	0.94	0.24	0.23	0.05		7.4%
	16	14.75	0.25	0.92	0.23	0.22	0.05		6.9%
	17	15.00	0.25	0.89	0.22	0.20	0.04		6.1%
	18	15.25	0.25	0.91	0.23	0.22	0.05		6.9%
	19	15.50	0.25	0.90	0.23	0.21	0.05		6.5%
	20	15.75	0.25	0.89	0.22	0.20	0.04		6.1%
	21	16.00	0.25	0.58	0.15	0.19	0.03	on rock	3.8%
	22	16.25	0.25	0.38	0.10	0.13	0.01	on rock	1.7%
	23	16.50	0.25	0.32	0.08	0.12	0.01	on rock	1.3%
	24	16.75	0.25	0.10	0.03	0.12	0.00	on rock	0.4%
	25	17.00	0.25	0.07	0.02	0.09	0.00	on rock	0.2%
	26	17.25	0.25	0.08	0.02	0.12	0.00	on rock	0.3%
	27	17.50	0.23	0.10	0.01	0.12	0.00	on rock	0.2%
	REW	17.60				TOTAL=	0.73	Stage: 0.50' @ 11:30	Rank: Good
								Entered by SJB 9/9/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/10/2010	LEW	10.75						Stage: 0.51' @ 7:30	
	1	11.00	0.38	0.10	0.02	0.03	0.00	rock upstream	0.1%
	2	11.25	0.25	0.73	0.18	0.01	0.00	rock upstream	0.2%
	3	11.50	0.25	0.75	0.19	0.03	0.01	rock upstream	0.7%
	4	11.75	0.25	0.79	0.20	0.08	0.02		2.0%
	5	12.00	0.25	0.84	0.21	0.08	0.02		2.1%
	6	12.25	0.25	0.79	0.20	0.10	0.02		2.5%
	7	12.50	0.25	0.78	0.20	0.19	0.04		4.7%
	8	12.75	0.25	0.84	0.21	0.28	0.06		7.4%
	9	13.00	0.25	0.93	0.23	0.24	0.06		7.0%
	10	13.25	0.25	0.97	0.24	0.19	0.05		5.8%
	11	13.50	0.25	0.99	0.25	0.15	0.04		4.7%
	12	13.75	0.25	0.99	0.25	0.16	0.04		5.0%
	13	14.00	0.25	0.92	0.23	0.20	0.05		5.8%
	14	14.25	0.25	0.96	0.24	0.23	0.06		6.9%
	15	14.50	0.25	0.96	0.24	0.23	0.06		6.9%
	16	14.75	0.25	0.94	0.24	0.26	0.06		7.7%
	17	15.00	0.25	0.91	0.23	0.20	0.05		5.7%
	18	15.25	0.25	0.93	0.23	0.20	0.05		5.8%
	19	15.50	0.25	0.91	0.23	0.20	0.05		5.7%
	20	15.75	0.25	0.89	0.22	0.18	0.04		5.0%
	21	16.00	0.25	0.62	0.16	0.19	0.03	on rock	3.7%
	22	16.25	0.25	0.48	0.12	0.12	0.01	on rock	1.8%
	23	16.50	0.25	0.26	0.07	0.15	0.01	on rock	1.2%
	24	16.75	0.25	0.10	0.03	0.15	0.00	on rock	0.5%
	25	17.00	0.25	0.07	0.02	0.14	0.00	on rock	0.3%
	26	17.25	0.25	0.08	0.02	0.14	0.00	on rock	0.4%
	27	17.50	0.32	0.12	0.02	0.14	0.00	on rock	0.3%
	REW	17.70				TOTAL=	0.80	Stage: 0.51' @ 8:27	Rank: Good
								Entered by SJB 9/10/2010	

SG-1: FENTON RIVER NEAR WELL A

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/10/2010	LEW	10.75						Stage: 0.51' @ 10:58	
	1	11.00	0.38	0.09	0.02	0.01	0.00	rock upstream	0.0%
	2	11.25	0.25	0.74	0.19	0.00	0.00	rock upstream	0.0%
	3	11.50	0.25	0.78	0.20	0.02	0.00	rock upstream	0.5%
	4	11.75	0.25	0.80	0.20	0.09	0.02		2.2%
	5	12.00	0.25	0.79	0.20	0.11	0.02		2.7%
	6	12.25	0.25	0.78	0.20	0.13	0.03		3.2%
	7	12.50	0.25	0.85	0.21	0.23	0.05		6.1%
	8	12.75	0.25	0.84	0.21	0.26	0.05		6.8%
	9	13.00	0.25	0.88	0.22	0.22	0.05		6.0%
	10	13.25	0.25	0.97	0.24	0.13	0.03		3.9%
	11	13.50	0.25	0.99	0.25	0.14	0.03		4.3%
	12	13.75	0.25	0.99	0.25	0.18	0.04		5.6%
	13	14.00	0.25	0.96	0.24	0.18	0.04		5.4%
	14	14.25	0.25	0.98	0.25	0.23	0.06		7.0%
	15	14.50	0.25	0.96	0.24	0.23	0.06		6.9%
	16	14.75	0.25	0.94	0.24	0.25	0.06		7.3%
	17	15.00	0.25	0.90	0.23	0.22	0.05		6.2%
	18	15.25	0.25	0.94	0.24	0.21	0.05		6.2%
	19	15.50	0.25	0.89	0.22	0.20	0.04		5.6%
	20	15.75	0.25	0.89	0.22	0.21	0.05		5.8%
	21	16.00	0.25	0.63	0.16	0.19	0.03	on rock	3.7%
	22	16.25	0.25	0.44	0.11	0.15	0.02	on rock	2.1%
	23	16.50	0.25	0.29	0.07	0.14	0.01	on rock	1.3%
	24	16.75	0.25	0.07	0.02	0.13	0.00	on rock	0.3%
	25	17.00	0.25	0.09	0.02	0.11	0.00	on rock	0.3%
	26	17.25	0.25	0.09	0.02	0.14	0.00	on rock	0.4%
	27	17.50	0.23	0.12	0.01	0.13	0.00	on rock	0.2%
	REW	17.60				TOTAL=	0.80	Stage: 0.51' @ 11:45	Rank: Good
								Entered by DRM 9/10/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/11/2010	LEW	8.35						On boulder from bedrock	
	1	8.80	0.58	0.42	0.12	0.00	0.00	Rocks us	0.0%
	2	9.05	0.25	0.48	0.12	0.01	0.00	On sand	0.1%
	3	9.30	0.25	0.35	0.09	0.01	0.00	On rock	0.1%
	4	9.55	0.25	0.43	0.11	0.03	0.00	On rock	0.4%
	5	9.80	0.25	0.50	0.13	0.04	0.01	On rock	0.6%
	6	10.05	0.25	0.48	0.12	0.12	0.01	On rock	1.8%
	7	10.30	0.25	0.50	0.13	0.14	0.02	On rock	2.2%
	8	10.55	0.25	0.70	0.18	0.20	0.04	On sand	4.4%
	9	10.80	0.25	0.74	0.19	0.26	0.05	On sand	6.0%
	10	11.05	0.25	0.83	0.21	0.24	0.05	On sand	6.2%
	11	11.30	0.25	0.75	0.19	0.22	0.04	On rocks	5.1%
	12	11.55	0.25	0.70	0.18	0.22	0.04	On rock	4.8%
	13	11.80	0.25	0.65	0.16	0.22	0.04	On rock	4.5%
	14	12.05	0.25	0.70	0.18	0.24	0.04	On rock	5.2%
	15	12.30	0.25	0.90	0.23	0.21	0.05	On sand	5.9%
	16	12.55	0.25	0.90	0.23	0.21	0.05	On sand	5.9%
	17	12.80	0.25	0.90	0.23	0.24	0.05	On sand	6.7%
	18	13.05	0.25	0.88	0.22	0.22	0.05	On rock	6.0%
	19	13.30	0.25	0.89	0.22	0.24	0.05	On rock	6.7%
	20	13.55	0.25	0.90	0.23	0.23	0.05	Next to boulder	6.5%
	21	13.80	0.25	0.60	0.15	0.21	0.03	On boulder	3.9%
	22	14.05	0.25	0.40	0.10	0.20	0.02	On boulder	2.5%
	23	14.30	0.25	0.30	0.08	0.18	0.01	On boulder	1.7%
	24	14.55	0.25	0.20	0.05	0.16	0.01	On boulder	1.0%
	25	14.80	0.94	0.15	0.07	0.13	0.01	On boulder, too shallow to REW	1.1%
	REW	15.62				TOTAL=	0.72	Stage: 0.49' @ 10:00	Rank: Good
								Entered by SMG 9/12/2010	

SG-1: FENTON RIVER NEAR WELL A

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/12/2010	LEW	10.75						Stage: 0.48' @ 11:11	
	1	11.00	0.38	0.06	0.01	-0.05	0.00	rock upstream	-0.1%
	2	11.25	0.25	0.71	0.18	0.00	0.00	rock upstream	0.0%
	3	11.50	0.25	0.74	0.19	0.01	0.00	rock upstream	0.3%
	4	11.75	0.25	0.75	0.19	0.07	0.01		1.8%
	5	12.00	0.25	0.82	0.21	0.10	0.02		2.9%
	6	12.25	0.25	0.75	0.19	0.10	0.02		2.6%
	7	12.50	0.25	0.75	0.19	0.17	0.03		4.5%
	8	12.75	0.25	0.87	0.22	0.25	0.05		7.7%
	9	13.00	0.25	0.90	0.23	0.24	0.05		7.6%
	10	13.25	0.25	0.89	0.22	0.18	0.04		5.6%
	11	13.50	0.25	0.93	0.23	0.12	0.03		3.9%
	12	13.75	0.25	0.97	0.24	0.14	0.03		4.8%
	13	14.00	0.25	0.93	0.23	0.17	0.04		5.6%
	14	14.25	0.25	0.93	0.23	0.20	0.05		6.5%
	15	14.50	0.25	0.92	0.23	0.20	0.05		6.5%
	16	14.75	0.25	0.91	0.23	0.20	0.05		6.4%
	17	15.00	0.25	0.90	0.23	0.20	0.05		6.3%
	18	15.25	0.25	0.90	0.23	0.21	0.05		6.7%
	19	15.50	0.25	0.89	0.22	0.19	0.04		6.0%
	20	15.75	0.25	0.91	0.23	0.19	0.04		6.1%
	21	16.00	0.25	0.66	0.17	0.16	0.03	on rock	3.7%
	22	16.25	0.25	0.43	0.11	0.14	0.02	on rock	2.1%
	23	16.50	0.25	0.29	0.07	0.14	0.01	on rock	1.4%
	24	16.75	0.25	0.06	0.02	0.14	0.00	on rock	0.3%
	25	17.00	0.25	0.05	0.01	0.12	0.00	on rock	0.2%
	26	17.25	0.25	0.07	0.02	0.13	0.00	on rock	0.3%
	27	17.50	0.23	0.11	0.01	0.12	0.00	on rock	0.2%
	REW	17.60				TOTAL=	0.71	Stage: 0.48' @ 12:00	Rank: Good
								Entered by DRM 9/13/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/13/2010	LEW	10.75						Stage: 0.48' @ 9:59	
	1	11.00	0.38	0.07	0.01	-0.03	0.00	rock upstream	-0.1%
	2	11.25	0.25	0.62	0.16	-0.01	0.00	rock upstream	-0.2%
	3	11.50	0.25	0.72	0.18	0.01	0.00	rock upstream	0.3%
	4	11.75	0.25	0.75	0.19	0.04	0.01		1.1%
	5	12.00	0.25	0.80	0.20	0.08	0.02		2.3%
	6	12.25	0.25	0.80	0.20	0.09	0.02		2.5%
	7	12.50	0.25	0.78	0.20	0.17	0.03		4.7%
	8	12.75	0.25	0.84	0.21	0.25	0.05		7.4%
	9	13.00	0.25	0.83	0.21	0.22	0.05		6.4%
	10	13.25	0.25	0.89	0.22	0.21	0.05		6.6%
	11	13.50	0.25	0.90	0.23	0.17	0.04		5.4%
	12	13.75	0.25	0.93	0.23	0.14	0.03		4.6%
	13	14.00	0.25	1.00	0.25	0.18	0.05		6.3%
	14	14.25	0.25	0.96	0.24	0.20	0.05		6.8%
	15	14.50	0.25	0.92	0.23	0.21	0.05		6.8%
	16	14.75	0.25	0.90	0.23	0.18	0.04		5.7%
	17	15.00	0.25	0.90	0.23	0.19	0.04		6.0%
	18	15.25	0.25	0.89	0.22	0.19	0.04		6.0%
	19	15.50	0.25	0.90	0.23	0.20	0.05		6.3%
	20	15.75	0.25	0.92	0.23	0.19	0.04		6.2%
	21	16.00	0.25	0.68	0.17	0.16	0.03	on rock	3.8%
	22	16.25	0.25	0.49	0.12	0.16	0.02	on rock	2.8%
	23	16.50	0.25	0.30	0.08	0.13	0.01	on rock	1.4%
	24	16.75	0.25	0.08	0.02	0.11	0.00	on rock	0.3%
	25	17.00	0.25	0.05	0.01	0.15	0.00	on rock	0.3%
	26	17.25	0.25	0.05	0.01	0.14	0.00	on rock	0.2%
	27	17.50	0.23	0.09	0.01	0.11	0.00	on rock	0.2%
	REW	17.60				TOTAL=	0.71	Stage: 0.48' @ 10:45	Rank: Good
								Entered by DRM 9/13/2010	

SG-1: FENTON RIVER NEAR WELL A

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/14/2010	LEW	10.75						Stage: 0.485' @ 9:19	
	1	11.00	0.38	0.07	0.01	-0.03	0.00	rock upstream	-0.1%
	2	11.25	0.25	0.70	0.18	-0.02	0.00	rock upstream	-0.5%
	3	11.50	0.25	0.72	0.18	0.01	0.00	rock upstream	0.3%
	4	11.75	0.25	0.76	0.19	0.04	0.01		1.1%
	5	12.00	0.25	0.81	0.20	0.08	0.02		2.3%
	6	12.25	0.25	0.78	0.20	0.08	0.02		2.2%
	7	12.50	0.25	0.78	0.20	0.18	0.04		4.9%
	8	12.75	0.25	0.88	0.22	0.26	0.06		8.1%
	9	13.00	0.25	0.89	0.22	0.23	0.05		7.2%
	10	13.25	0.25	0.89	0.22	0.18	0.04		5.6%
	11	13.50	0.25	0.90	0.23	0.16	0.04		5.1%
	12	13.75	0.25	0.96	0.24	0.16	0.04		5.4%
	13	14.00	0.25	0.94	0.24	0.20	0.05		6.6%
	14	14.25	0.25	0.96	0.24	0.20	0.05		6.8%
	15	14.50	0.25	0.93	0.23	0.20	0.05		6.5%
	16	14.75	0.25	0.91	0.23	0.18	0.04		5.8%
	17	15.00	0.25	0.91	0.23	0.19	0.04		6.1%
	18	15.25	0.25	0.91	0.23	0.18	0.04		5.8%
	19	15.50	0.25	0.92	0.23	0.19	0.04		6.2%
	20	15.75	0.25	0.94	0.24	0.18	0.04		6.0%
	21	16.00	0.25	0.65	0.16	0.16	0.03	on rock	3.7%
	22	16.25	0.25	0.43	0.11	0.17	0.02	on rock	2.6%
	23	16.50	0.25	0.28	0.07	0.14	0.01	on rock	1.4%
	24	16.75	0.25	0.09	0.02	0.11	0.00	on rock	0.3%
	25	17.00	0.25	0.09	0.02	0.10	0.00	on rock	0.3%
	26	17.25	0.25	0.07	0.02	0.12	0.00	on rock	0.3%
	27	17.50	0.23	0.11	0.01	0.10	0.00	on rock	0.2%
	REW	17.60				TOTAL=	0.71	Stage: 0.485' @ 10:02	Rank: Good
								Entered by DRM 9/14/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/15/2010	LEW	10.75						Stage: 0.47 @ 14:48	
	1	11.00	0.38	0.06	0.01	-0.03	0.00	rock upstream	-0.1%
	2	11.25	0.25	0.65	0.16	-0.05	-0.01	rock upstream	-1.3%
	3	11.50	0.25	0.71	0.18	0.00	0.00	rock upstream	0.0%
	4	11.75	0.25	0.75	0.19	0.04	0.01		1.2%
	5	12.00	0.25	0.79	0.20	0.07	0.01		2.2%
	6	12.25	0.25	0.81	0.20	0.10	0.02		3.2%
	7	12.50	0.25	0.75	0.19	0.15	0.03		4.5%
	8	12.75	0.25	0.87	0.22	0.24	0.05		8.3%
	9	13.00	0.25	0.86	0.22	0.22	0.05		7.5%
	10	13.25	0.25	0.89	0.22	0.18	0.04		6.4%
	11	13.50	0.25	0.92	0.23	0.12	0.03		4.4%
	12	13.75	0.25	0.99	0.25	0.15	0.04		5.9%
	13	14.00	0.25	1.00	0.25	0.15	0.04		6.0%
	14	14.25	0.25	0.93	0.23	0.18	0.04		6.7%
	15	14.50	0.25	0.93	0.23	0.18	0.04		6.7%
	16	14.75	0.25	0.90	0.23	0.20	0.05		7.2%
	17	15.00	0.25	0.90	0.23	0.18	0.04		6.4%
	18	15.25	0.25	0.90	0.23	0.17	0.04		6.1%
	19	15.50	0.25	0.91	0.23	0.17	0.04		6.1%
	20	15.75	0.25	0.91	0.23	0.15	0.03		5.4%
	21	16.00	0.25	0.59	0.15	0.13	0.02	on rock	3.0%
	22	16.25	0.25	0.42	0.11	0.12	0.01	on rock	2.0%
	23	16.50	0.25	0.28	0.07	0.12	0.01	on rock	1.3%
	24	16.75	0.25	0.06	0.02	0.10	0.00	on rock	0.2%
	25	17.00	0.25	0.07	0.02	0.09	0.00	on rock	0.3%
	26	17.25	0.25	0.06	0.02	0.10	0.00	on rock	0.2%
	27	17.50	0.23	0.10	0.01	0.10	0.00	on rock	0.2%
	REW	17.60				TOTAL=	0.63	Stage: 0.47' @ 15:20	Rank: Fair
								Entered by DM over phone 9/15/2010	

SG-1: FENTON RIVER NEAR WELL A

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/16/2010	LEW	10.75						Stage: 0.465 @ 15:18	
	1	11.00	0.38	0.05	0.01	-0.03	0.00	rock upstream	0.0%
	2	11.25	0.25	0.67	0.17	-0.05	-0.01	rock upstream	-1.4%
	3	11.50	0.25	0.7	0.18	-0.01	0.00	rock upstream	-0.3%
	4	11.75	0.25	0.77	0.19	0.04	0.01		1.3%
	5	12.00	0.25	0.79	0.20	0.06	0.01		2.0%
	6	12.25	0.25	0.8	0.20	0.10	0.02		3.4%
	7	12.50	0.25	0.76	0.19	0.13	0.02		4.3%
	8	12.75	0.25	0.87	0.22	0.23	0.05		8.6%
	9	13.00	0.25	0.88	0.22	0.19	0.04		7.2%
	10	13.25	0.25	0.88	0.22	0.15	0.03		5.7%
	11	13.50	0.25	0.91	0.23	0.12	0.03		4.7%
	12	13.75	0.25	0.92	0.23	0.15	0.03		6.0%
	13	14.00	0.25	0.94	0.24	0.15	0.04		6.1%
	14	14.25	0.25	0.95	0.24	0.17	0.04		7.0%
	15	14.50	0.25	0.90	0.23	0.17	0.04		6.6%
	16	14.75	0.25	0.90	0.23	0.16	0.04		6.2%
	17	15.00	0.25	0.89	0.22	0.18	0.04		6.9%
	18	15.25	0.25	0.90	0.23	0.16	0.04		6.2%
	19	15.50	0.25	0.90	0.23	0.16	0.04		6.2%
	20	15.75	0.25	0.91	0.23	0.15	0.03		5.9%
	21	16.00	0.25	0.60	0.15	0.13	0.02	on rock	3.4%
	22	16.25	0.25	0.42	0.11	0.10	0.01	on rock	1.8%
	23	16.50	0.25	0.28	0.07	0.11	0.01	on rock	1.3%
	24	16.75	0.25	0.06	0.02	0.11	0.00	on rock	0.3%
	25	17.00	0.25	0.06	0.02	0.09	0.00	on rock	0.2%
	26	17.25	0.25	0.05	0.01	0.12	0.00	on rock	0.3%
	27	17.50	0.23	0.09	0.01	0.10	0.00	on rock	0.2%
	REW	17.60				TOTAL=	0.58	Stage: 0.465' @ 16:05	Rank: Fair
								Entered by DRM 9/17/2010	

SG-2: FENTON RIVER DOWNSTREAM OF GURLEYVILLE ROAD

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/8/2010	LEW	8.75						Stage: 0.26' @ 13:36	
	1	9.75	1.50	0.62	0.47	0.03	0.01	Taken by DRM	1.2%
	2	10.75	1.00	0.79	0.79	0.09	0.07		6.2%
	3	11.75	1.00	0.88	0.88	0.08	0.07		6.1%
	4	12.75	1.00	0.80	0.80	0.10	0.08		6.9%
	5	13.75	1.00	0.96	0.96	0.11	0.11	boulder upstream	9.2%
	6	14.75	1.00	0.72	0.72	0.01	0.01	boulder upstream	0.6%
	7	15.75	1.00	0.88	0.88	0.09	0.08	boulder upstream	6.9%
	8	16.75	0.75	1.13	0.85	0.09	0.08		6.6%
	9	17.25	0.50	1.19	0.60	0.08	0.05		4.1%
	10	17.75	0.50	1.21	0.61	0.10	0.06		5.2%
	11	18.25	0.50	1.19	0.60	0.10	0.06		5.2%
	12	18.75	0.50	1.23	0.62	0.10	0.06		5.3%
	13	19.25	0.50	1.03	0.52	0.09	0.05		4.0%
	14	19.75	0.50	0.98	0.49	0.06	0.03		2.5%
	15	20.25	0.50	0.82	0.41	0.08	0.03		2.8%
	16	20.75	0.75	0.78	0.59	0.06	0.04		3.0%
	17	21.75	1.00	0.83	0.83	0.09	0.07		6.5%
	18	22.75	1.00	0.49	0.49	0.10	0.05		4.2%
	19	23.75	1.00	0.49	0.49	0.09	0.04		3.8%
	20	24.75	1.00	0.53	0.53	0.04	0.02		1.8%
	21	25.75	1.00	0.58	0.58	0.04	0.02		2.0%
	22	26.75	1.00	0.72	0.72	0.05	0.04		3.1%
	23	27.75	1.00	0.60	0.60	0.02	0.01		1.0%
	24	28.75	1.00	0.48	0.48	0.03	0.01		1.2%
	25	29.75	1.25	0.15	0.09	0.02	0.00		0.2%
	REW	30.50				TOTAL=	1.15	Stage: 0.26' @ 14:18	Rank: Fair
								Entered by SJB 9/9/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/9/2010	LEW	9.00						Stage: 0.25' at 12:58	
	1	10.00	1.50	0.63	0.47	0.03	0.01	Taken by DRM	1.4%
	2	11.00	1.00	0.79	0.79	0.05	0.04		3.9%
	3	12.00	1.00	0.89	0.89	0.06	0.05		5.3%
	4	13.00	1.00	0.79	0.79	0.08	0.06		6.3%
	5	14.00	1.00	0.75	0.75	0.09	0.07	boulder upstream	6.7%
	6	15.00	1.00	0.67	0.67	0.02	0.01	boulder upstream	1.3%
	7	16.00	1.00	0.89	0.89	0.08	0.07	boulder upstream	7.0%
	8	17.00	0.75	1.04	0.78	0.09	0.07		6.9%
	9	17.50	0.50	1.04	0.52	0.11	0.06		5.7%
	10	18.00	0.50	1.19	0.60	0.07	0.04		4.1%
	11	18.50	0.50	1.19	0.60	0.10	0.06		5.9%
	12	19.00	0.50	1.22	0.61	0.09	0.05		5.4%
	13	19.50	0.50	1.00	0.50	0.07	0.04		3.5%
	14	20.00	0.50	0.97	0.49	0.05	0.02		2.4%
	15	20.50	0.50	0.95	0.48	0.10	0.05		4.7%
	16	21.00	0.50	0.89	0.45	0.05	0.02		2.2%
	17	21.50	0.50	0.69	0.35	0.05	0.02		1.7%
	18	22.00	0.75	0.82	0.62	0.06	0.04		3.7%
	19	23.00	1.00	0.54	0.54	0.10	0.05		5.3%
	20	24.00	1.00	0.47	0.47	0.08	0.04		3.7%
	21	25.00	1.00	0.56	0.56	0.06	0.03		3.3%
	22	26.00	1.00	0.53	0.53	0.05	0.03		2.6%
	23	27.00	1.00	0.69	0.69	0.05	0.03		3.4%
	24	28.00	1.00	0.60	0.60	0.02	0.01		1.2%
	25	29.00	1.00	0.45	0.45	0.04	0.02		1.8%
	26	30.00	1.20	0.24	0.14	0.04	0.01		0.6%
	REW	30.70				TOTAL=	1.01	Stage: 0.25' at 13:37	Rank: Good
								Entered by SJB 9/9/2010	

SG-2: FENTON RIVER DOWNSTREAM OF GURLEYVILLE ROAD

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/10/2010	LEW	9.00						Stage: 0.27' at 9:09	
	1	10.00	1.50	0.71	0.53	0.03	0.02	Taken by DRM	1.3%
	2	11.00	1.00	0.82	0.82	0.06	0.05		4.0%
	3	12.00	1.00	0.89	0.89	0.06	0.05		4.4%
	4	13.00	1.00	0.88	0.88	0.10	0.09		7.2%
	5	14.00	1.00	0.79	0.79	0.12	0.09	boulder upstream	7.8%
	6	15.00	1.00	0.69	0.69	0.02	0.01	boulder upstream	1.1%
	7	16.00	1.00	0.91	0.91	0.09	0.08	boulder upstream	6.7%
	8	17.00	0.75	1.15	0.86	0.10	0.09		7.1%
	9	17.50	0.50	1.20	0.60	0.07	0.04		3.4%
	10	18.00	0.50	1.27	0.64	0.12	0.08		6.2%
	11	18.50	0.50	1.22	0.61	0.12	0.07		6.0%
	12	19.00	0.50	1.28	0.64	0.10	0.06		5.2%
	13	19.50	0.50	1.29	0.65	0.07	0.05		3.7%
	14	20.00	0.50	0.96	0.48	0.07	0.03		2.7%
	15	20.50	0.50	0.97	0.49	0.09	0.04		3.6%
	16	21.00	0.50	0.90	0.45	0.07	0.03		2.6%
	17	21.50	0.50	0.73	0.37	0.05	0.02		1.5%
	18	22.00	0.75	0.84	0.63	0.07	0.04		3.6%
	19	23.00	1.00	0.55	0.55	0.11	0.06		4.9%
	20	24.00	1.00	0.50	0.50	0.12	0.06		4.9%
	21	25.00	1.00	0.52	0.52	0.06	0.03		2.6%
	22	26.00	1.00	0.59	0.59	0.06	0.04		2.9%
	23	27.00	1.00	0.70	0.70	0.07	0.05		4.0%
	24	28.00	1.00	0.61	0.61	0.03	0.02		1.5%
	25	29.00	1.00	0.48	0.48	0.02	0.01		0.8%
	26	30.00	1.20	0.20	0.12	0.03	0.00		0.3%
	REW	30.70				TOTAL=	1.22	Stage: 0.27' at 10:02	Rank: Good
								Entered by SJB 9/10/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/10/2010	LEW	9.00						Stage: 0.27' at 12:13	
	1	10.00	1.50	0.67	0.50	0.04	0.02	Taken by DRM	1.6%
	2	11.00	1.00	0.82	0.82	0.06	0.05		3.8%
	3	12.00	1.00	0.90	0.90	0.07	0.06		4.9%
	4	13.00	1.00	0.87	0.87	0.08	0.07		5.4%
	5	14.00	1.00	0.79	0.79	0.12	0.09	boulder upstream	7.4%
	6	15.00	1.00	0.74	0.74	0.02	0.01	boulder upstream	1.2%
	7	16.00	1.00	0.90	0.90	0.11	0.10	boulder upstream	7.7%
	8	17.00	0.75	1.17	0.88	0.11	0.10		7.5%
	9	17.50	0.50	1.22	0.61	0.09	0.05		4.3%
	10	18.00	0.50	1.24	0.62	0.09	0.06		4.3%
	11	18.50	0.50	1.22	0.61	0.12	0.07		5.7%
	12	19.00	0.50	1.27	0.64	0.12	0.08		5.9%
	13	19.50	0.50	1.29	0.65	0.07	0.05		3.5%
	14	20.00	0.50	0.88	0.44	0.11	0.05		3.8%
	15	20.50	0.50	0.89	0.45	0.10	0.04		3.5%
	16	21.00	0.50	0.92	0.46	0.06	0.03		2.2%
	17	21.50	0.50	0.92	0.46	0.10	0.05		3.6%
	18	22.00	0.75	0.85	0.64	0.09	0.06		4.5%
	19	23.00	1.00	0.53	0.53	0.12	0.06		5.0%
	20	24.00	1.00	0.49	0.49	0.10	0.05		3.8%
	21	25.00	1.00	0.58	0.58	0.06	0.03		2.7%
	22	26.00	1.00	0.59	0.59	0.04	0.02		1.8%
	23	27.00	1.00	0.70	0.70	0.08	0.06		4.4%
	24	28.00	1.00	0.60	0.60	0.01	0.01		0.5%
	25	29.00	1.00	0.52	0.52	0.02	0.01		0.8%
	26	30.00	1.20	0.21	0.13	0.03	0.00		0.3%
	REW	30.70				TOTAL=	1.28	Stage: 0.27' at	Rank: Good
								Entered by DRM 9/10/2010	

SG-2: FENTON RIVER DOWNSTREAM OF GURLEYVILLE ROAD

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/11/2010	REW	6.99						Stage: 0.28' at 11:30	
	1	8.30	1.66	0.35	0.29	0.08	0.02	Under 1st tree, 1st spot sflows possible	2.1%
	2	9.00	0.85	0.50	0.43	0.06	0.03	Branches ds	2.3%
	3	10.00	1.00	0.55	0.55	0.07	0.04	Branches ds	3.5%
	4	11.00	1.00	0.38	0.38	0.11	0.04	On rocks	3.8%
	5	12.00	1.00	0.48	0.48	0.08	0.04	Boulder ds	3.5%
	6	13.00	1.00	0.43	0.43	0.10	0.04	Edge of boulder ds	3.9%
	7	14.00	1.00	0.50	0.50	0.10	0.05		4.6%
	8	15.00	1.00	0.58	0.58	0.06	0.03	On rock, rock us	3.2%
	9	16.00	1.00	0.60	0.60	0.05	0.03	Rock us, boulder ds	2.7%
	10	17.00	1.00	0.78	0.78	0.10	0.08	Rock us, boulder ds	7.1%
	11	18.00	1.00	1.00	1.00	0.08	0.08	Rock ds	7.3%
	12	19.00	1.00	1.23	1.23	0.11	0.14		12.3%
	13	20.00	1.00	1.00	1.00	0.11	0.11	On rock	10.0%
	14	21.00	1.00	0.90	0.90	0.09	0.08	On rock	7.4%
	15	22.00	1.00	0.80	0.80	0.03	0.02	Boulder us	2.2%
	16	23.00	1.00	0.12	0.12	0.08	0.01	On boulder	0.9%
	17	24.00	1.00	0.52	0.52	0.13	0.07	On rock	6.2%
	18	25.00	1.00	0.72	0.72	0.09	0.06		5.9%
	19	26.00	1.00	0.83	0.83	0.08	0.07		6.1%
	20	27.00	1.00	0.62	0.62	0.07	0.04		4.0%
	21	28.00	1.08	0.54	0.29	0.04	0.01	2 rocks on boulder side	1.1%
	LEW	28.58				TOTAL=	1.10	Stage: 0.28' at	Rank: Fair
								Entered by SMG 9/12/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/12/2010	LEW	9.00						Stage: 0.24' at 12:15	
	1	10.00	1.50	0.63	0.47	0.02	0.01	Taken by DRM	0.9%
	2	11.00	1.00	0.79	0.79	0.06	0.05		4.6%
	3	12.00	1.00	0.89	0.89	0.07	0.06		6.1%
	4	13.00	1.00	0.84	0.84	0.07	0.06		5.7%
	5	14.00	1.00	0.77	0.77	0.08	0.06	boulder upstream	6.0%
	6	15.00	1.00	0.73	0.73	0.01	0.01	boulder upstream	0.7%
	7	16.00	1.00	0.89	0.89	0.08	0.07	boulder upstream	6.9%
	8	17.00	0.75	1.12	0.84	0.10	0.08		8.2%
	9	17.50	0.50	1.19	0.60	0.08	0.05		4.6%
	10	18.00	0.50	1.19	0.60	0.10	0.06		5.8%
	11	18.50	0.50	1.21	0.61	0.10	0.06		5.9%
	12	19.00	0.50	1.22	0.61	0.10	0.06		5.9%
	13	19.50	0.50	1.28	0.64	0.06	0.04		3.7%
	14	20.00	0.50	0.91	0.46	0.06	0.03		2.7%
	15	20.50	0.50	0.93	0.47	0.09	0.04		4.1%
	16	21.00	0.50	0.89	0.45	0.05	0.02		2.2%
	17	21.50	0.50	0.91	0.46	0.08	0.04		3.5%
	18	22.00	0.75	0.85	0.64	0.04	0.03		2.5%
	19	23.00	1.00	0.52	0.52	0.11	0.06		5.6%
	20	24.00	1.00	0.45	0.45	0.08	0.04		3.5%
	21	25.00	1.00	0.50	0.50	0.05	0.03		2.4%
	22	26.00	1.00	0.55	0.55	0.03	0.02		1.6%
	23	27.00	1.00	0.67	0.67	0.05	0.03		3.3%
	24	28.00	1.00	0.59	0.59	0.04	0.02		2.3%
	25	29.00	1.00	0.50	0.50	0.02	0.01		1.0%
	26	30.00	1.20	0.15	0.09	0.03	0.00		0.3%
	REW	30.70				TOTAL=	1.03	Stage: 0.24' at 13:00	Rank: Fair
								Entered by DRM 9/13/2010	

SG-2: FENTON RIVER DOWNSTREAM OF GURLEYVILLE ROAD

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/13/2010	LEW	8.80						Stage: 0.24' at 12:15	
	1	9.80	1.50	0.70	0.53	0.05	0.03	Taken by DRM	2.3%
	2	10.80	1.00	0.80	0.80	0.05	0.04		3.6%
	3	11.80	1.00	0.90	0.90	0.08	0.07		6.4%
	4	12.80	1.00	0.84	0.84	0.07	0.06		5.2%
	5	13.80	1.00	0.76	0.76	0.09	0.07	boulder upstream	6.1%
	6	14.80	1.00	0.70	0.70	0.02	0.01	boulder upstream	1.2%
	7	15.80	1.00	0.89	0.89	0.06	0.05	boulder upstream	4.8%
	8	16.80	0.75	1.13	0.85	0.10	0.08		7.5%
	9	17.30	0.50	1.20	0.60	0.09	0.05		4.8%
	10	17.80	0.50	1.22	0.61	0.10	0.06		5.4%
	11	18.30	0.50	1.22	0.61	0.10	0.06		5.4%
	12	18.80	0.50	1.26	0.63	0.10	0.06		5.6%
	13	19.30	0.50	1.28	0.64	0.09	0.06		5.1%
	14	19.80	0.50	0.92	0.46	0.07	0.03		2.9%
	15	20.30	0.50	0.95	0.48	0.09	0.04		3.8%
	16	20.80	0.50	0.81	0.41	0.06	0.02		2.2%
	17	21.30	0.50	0.74	0.37	0.04	0.01		1.3%
	18	21.80	0.75	0.82	0.62	0.08	0.05		4.4%
	19	22.80	1.00	0.53	0.53	0.11	0.06		5.2%
	20	23.80	1.00	0.48	0.48	0.10	0.05		4.3%
	21	24.80	1.00	0.50	0.50	0.06	0.03		2.7%
	22	25.80	1.00	0.56	0.56	0.05	0.03		2.5%
	23	26.80	1.00	0.70	0.70	0.06	0.04		3.7%
	24	27.80	1.00	0.60	0.60	0.03	0.02		1.6%
	25	28.80	1.00	0.49	0.49	0.04	0.02		1.7%
	26	29.80	1.20	0.15	0.09	0.02	0.00		0.2%
	REW	30.50				TOTAL=	1.12	Stage: 0.24' at 13:00	Rank: Good
								Entered by DRM 9/13/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/14/2010	LEW	9.00						Stage: 0.265' at 10:19	
	1	10.00	1.50	0.70	0.53	0.03	0.02	Taken by DRM	1.4%
	2	11.00	1.00	0.80	0.80	0.05	0.04		3.6%
	3	12.00	1.00	0.91	0.91	0.06	0.05		5.0%
	4	13.00	1.00	0.88	0.88	0.08	0.07		6.4%
	5	14.00	1.00	0.78	0.78	0.11	0.09	boulder upstream	7.8%
	6	15.00	1.00	0.74	0.74	0.02	0.01	boulder upstream	1.4%
	7	16.00	1.00	0.89	0.89	0.10	0.09	boulder upstream	8.1%
	8	17.00	0.75	1.12	0.84	0.10	0.08		7.7%
	9	17.50	0.50	1.20	0.60	0.06	0.04		3.3%
	10	18.00	0.50	1.20	0.60	0.10	0.06		5.5%
	11	18.50	0.50	1.13	0.57	0.11	0.06		5.7%
	12	19.00	0.50	1.23	0.62	0.08	0.05		4.5%
	13	19.50	0.50	1.28	0.64	0.06	0.04		3.5%
	14	20.00	0.50	0.92	0.46	0.07	0.03		2.9%
	15	20.50	0.50	0.94	0.47	0.08	0.04		3.4%
	16	21.00	0.50	0.89	0.45	0.07	0.03		2.8%
	17	21.50	0.50	0.79	0.40	0.03	0.01		1.1%
	18	22.00	0.75	0.82	0.62	0.07	0.04		3.9%
	19	23.00	1.00	0.51	0.51	0.11	0.06		5.1%
	20	24.00	1.00	0.45	0.45	0.11	0.05		4.5%
	21	25.00	1.00	0.50	0.50	0.06	0.03		2.7%
	22	26.00	1.00	0.55	0.55	0.05	0.03		2.5%
	23	27.00	1.00	0.65	0.65	0.09	0.06		5.3%
	24	28.00	1.00	0.60	0.60	0.01	0.01		0.5%
	25	29.00	1.00	0.50	0.50	0.02	0.01		0.9%
	26	30.00	1.20	0.20	0.12	0.02	0.00		0.2%
	REW	30.70				TOTAL=	1.10	Stage: 0.255' at 11:01	Rank: Good
								Entered by DRM 9/14/2010	

SG-2: FENTON RIVER DOWNSTREAM OF GURLEYVILLE ROAD

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/15/2010	LEW	9.00						Stage: 0.24' at 15:49	
	1	10.00	1.50	0.68	0.51	0.02	0.01		1.2%
	2	11.00	1.00	0.79	0.79	0.05	0.04		4.6%
	3	12.00	1.00	0.91	0.91	0.05	0.05		5.3%
	4	13.00	1.00	0.80	0.80	0.06	0.05		5.6%
	5	14.00	1.00	0.74	0.74	0.07	0.05	boulder upstream	6.0%
	6	15.00	1.00	0.66	0.66	0.01	0.01	boulder upstream	0.8%
	7	16.00	1.00	0.90	0.90	0.09	0.08	boulder upstream	9.4%
	8	17.00	0.75	1.03	0.77	0.08	0.06		7.2%
	9	17.50	0.50	1.15	0.58	0.09	0.05		6.0%
	10	18.00	0.50	1.22	0.61	0.07	0.04		4.9%
	11	18.50	0.50	1.15	0.58	0.09	0.05		6.0%
	12	19.00	0.50	1.25	0.63	0.08	0.05		5.8%
	13	19.50	0.50	0.13	0.06	0.05	0.00		0.4%
	14	20.00	0.50	0.93	0.47	0.04	0.02		2.2%
	15	20.50	0.50	0.95	0.48	0.06	0.03		3.3%
	16	21.00	0.50	0.91	0.46	0.04	0.02		2.1%
	17	21.50	0.50	0.80	0.40	0.04	0.02		1.9%
	18	22.00	0.75	0.83	0.62	0.07	0.04		5.0%
	19	23.00	1.00	0.52	0.52	0.09	0.05		5.4%
	20	24.00	1.00	0.48	0.48	0.07	0.03		3.9%
	21	25.00	1.00	0.50	0.50	0.06	0.03		3.5%
	22	26.00	1.00	0.57	0.57	0.04	0.02		2.6%
	23	27.00	1.00	0.70	0.70	0.05	0.04		4.0%
	24	28.00	1.00	0.61	0.61	0.01	0.01		0.7%
	25	29.00	1.00	0.48	0.48	0.04	0.02		2.2%
	26	30.00	1.20	0.18	0.11	0.02	0.00		0.2%
	REW	30.70				TOTAL=	0.86	Stage: 0.24' at 16:40	
								Entered by DM over phone 9/15/2010	

Date	Station ID	Tag Line (ft)	Section Width (ft)	Depth (ft)	Area (ft2)	Velocity (fps)	Discharge (cfs)	Notes	% of Discharge
9/16/2010	LEW	9.00						Stage: 0.245' at 16:11	
	1	10.00	1.50	0.67	0.50	0.01	0.01		0.6%
	2	11.00	1.00	0.78	0.78	0.04	0.03		3.6%
	3	12.00	1.00	0.90	0.90	0.04	0.04		4.2%
	4	13.00	1.00	0.75	0.75	0.06	0.05		5.2%
	5	14.00	1.00	0.75	0.75	0.06	0.05	boulder upstream	5.2%
	6	15.00	1.00	0.65	0.65	0.01	0.01	boulder upstream	0.8%
	7	16.00	1.00	0.90	0.90	0.06	0.05	boulder upstream	6.2%
	8	17.00	0.75	1.10	0.83	0.06	0.05		5.7%
	9	17.50	0.50	1.16	0.58	0.07	0.04		4.7%
	10	18.00	0.50	1.20	0.60	0.08	0.05		5.6%
	11	18.50	0.50	1.14	0.57	0.08	0.05		5.3%
	12	19.00	0.50	1.25	0.63	0.08	0.05		5.8%
	13	19.50	0.50	1.28	0.64	0.06	0.04		4.4%
	14	20.00	0.50	0.94	0.47	0.07	0.03		3.8%
	15	20.50	0.50	0.92	0.46	0.07	0.03		3.7%
	16	21.00	0.50	0.85	0.43	0.05	0.02		2.5%
	17	21.50	0.50	0.81	0.41	0.06	0.02		2.8%
	18	22.00	0.75	0.83	0.62	0.04	0.02		2.9%
	19	23.00	1.00	0.51	0.51	0.1	0.05		5.9%
	20	24.00	1.00	0.43	0.43	0.08	0.03		4.0%
	21	25.00	1.00	0.50	0.50	0.04	0.02		2.3%
	22	26.00	1.00	0.57	0.57	0.02	0.01		1.3%
	23	27.00	1.00	0.71	0.71	0.05	0.04		4.1%
	24	28.00	1.00	0.61	0.61	0.02	0.01		1.4%
	25	29.00	1.00	0.50	0.50	0.02	0.01		1.2%
	26	30.00	1.20	0.15	0.09	0.03	0.00		0.3%
	REW	30.70				TOTAL=	0.81	Stage: 0.245' at 16:50	
								Entered by DRM 9/17/2010	