# APPENDIX A:

## Individual Monitoring Site Detail Maps

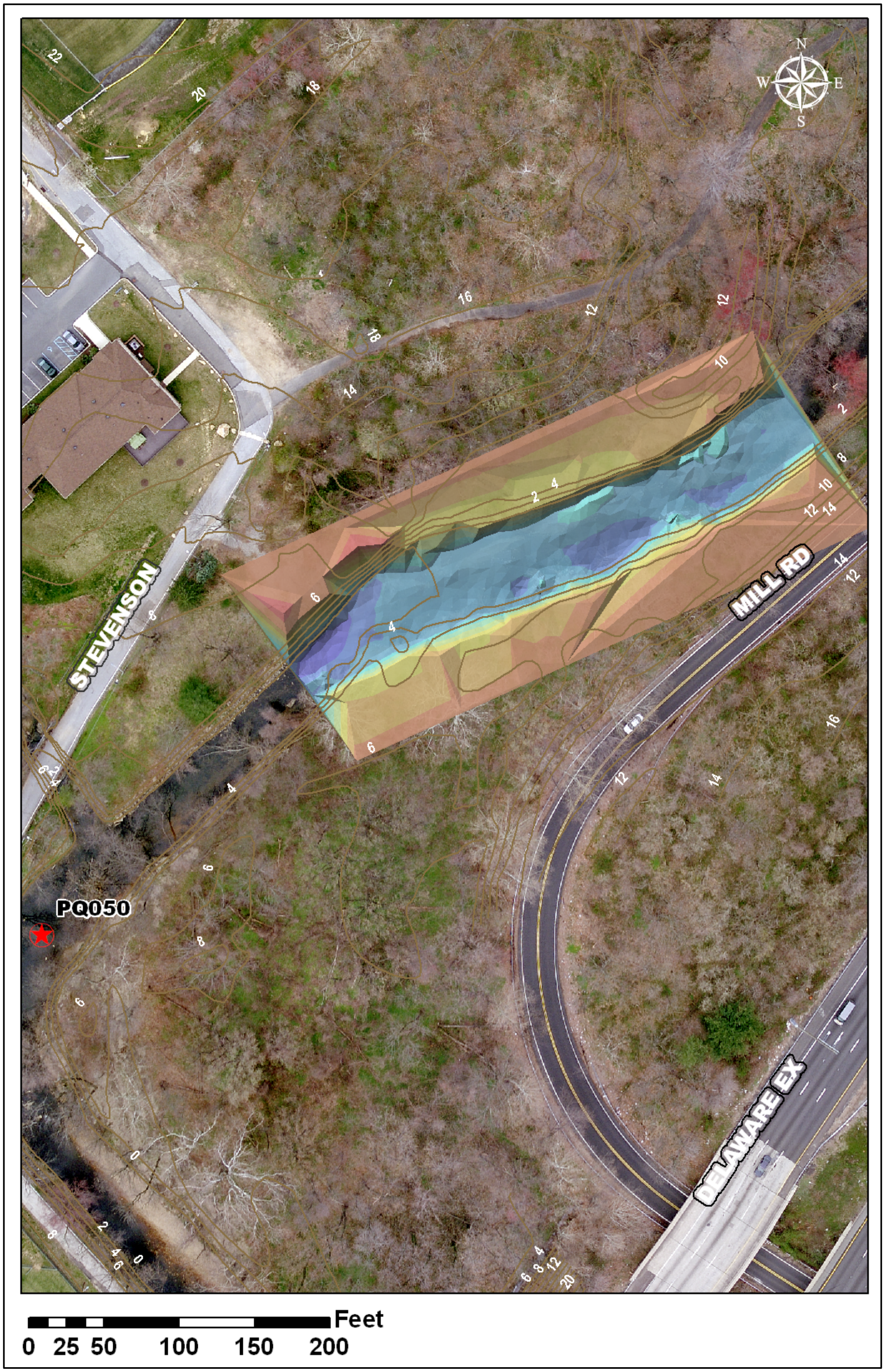
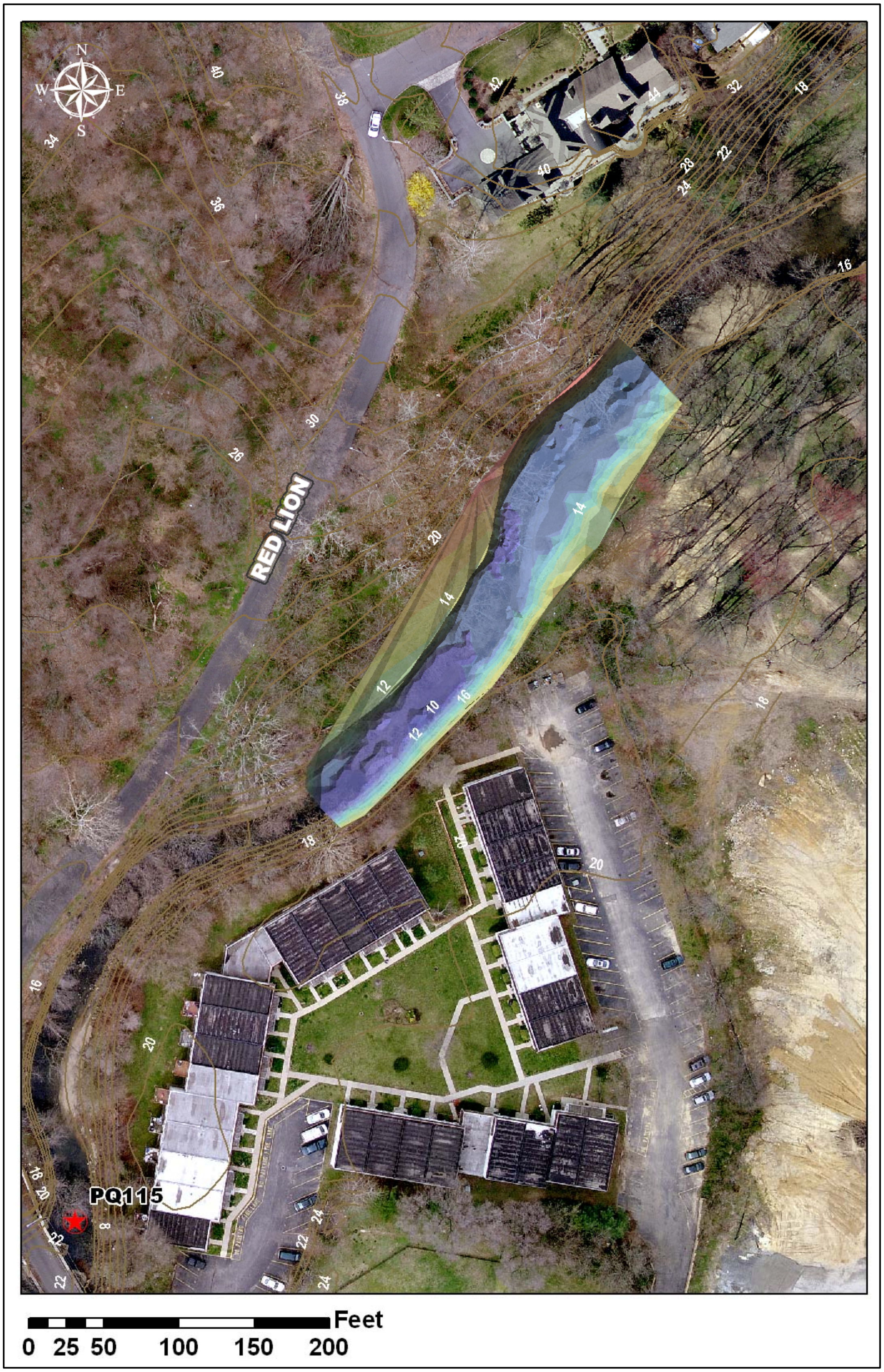
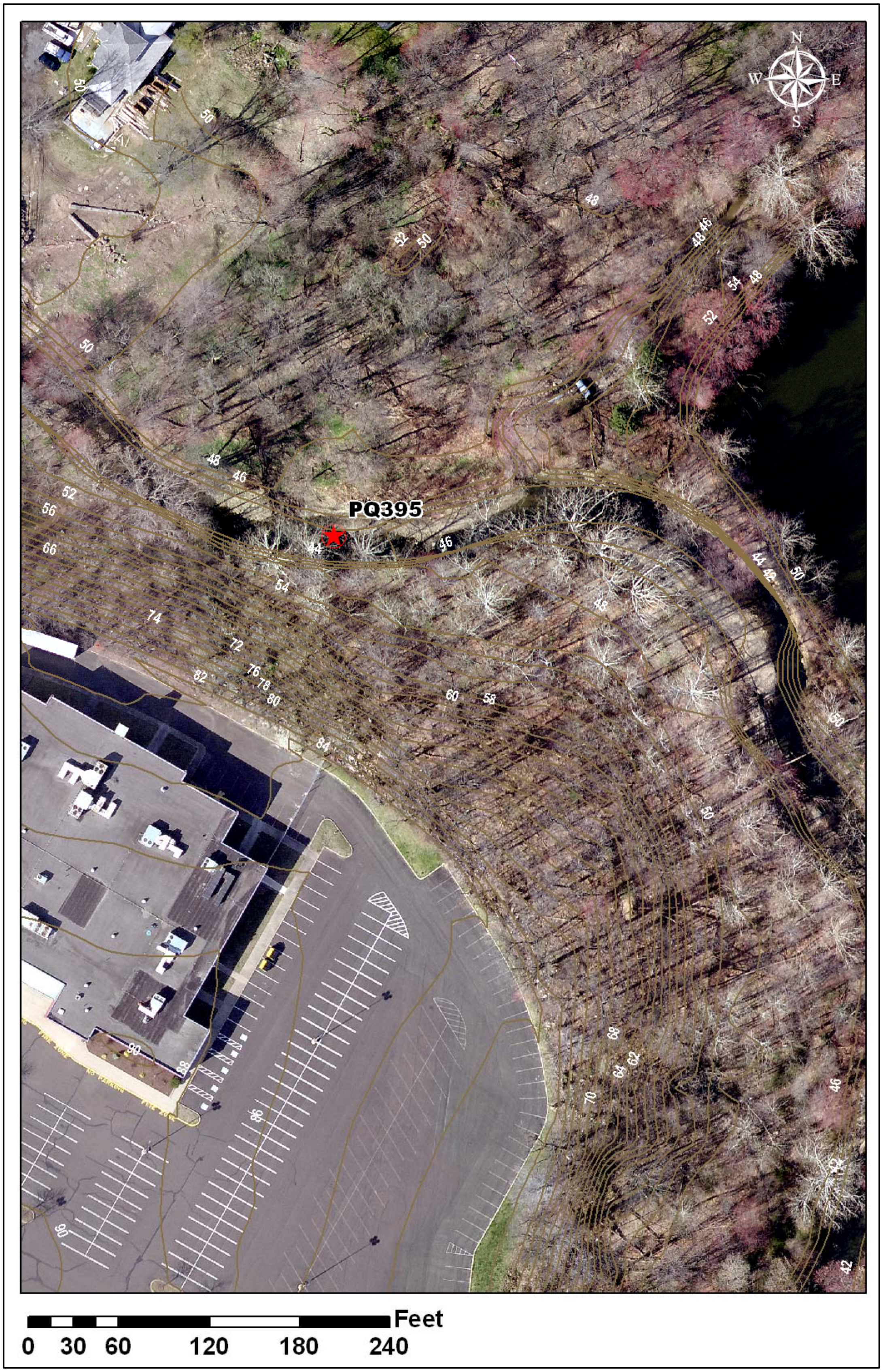


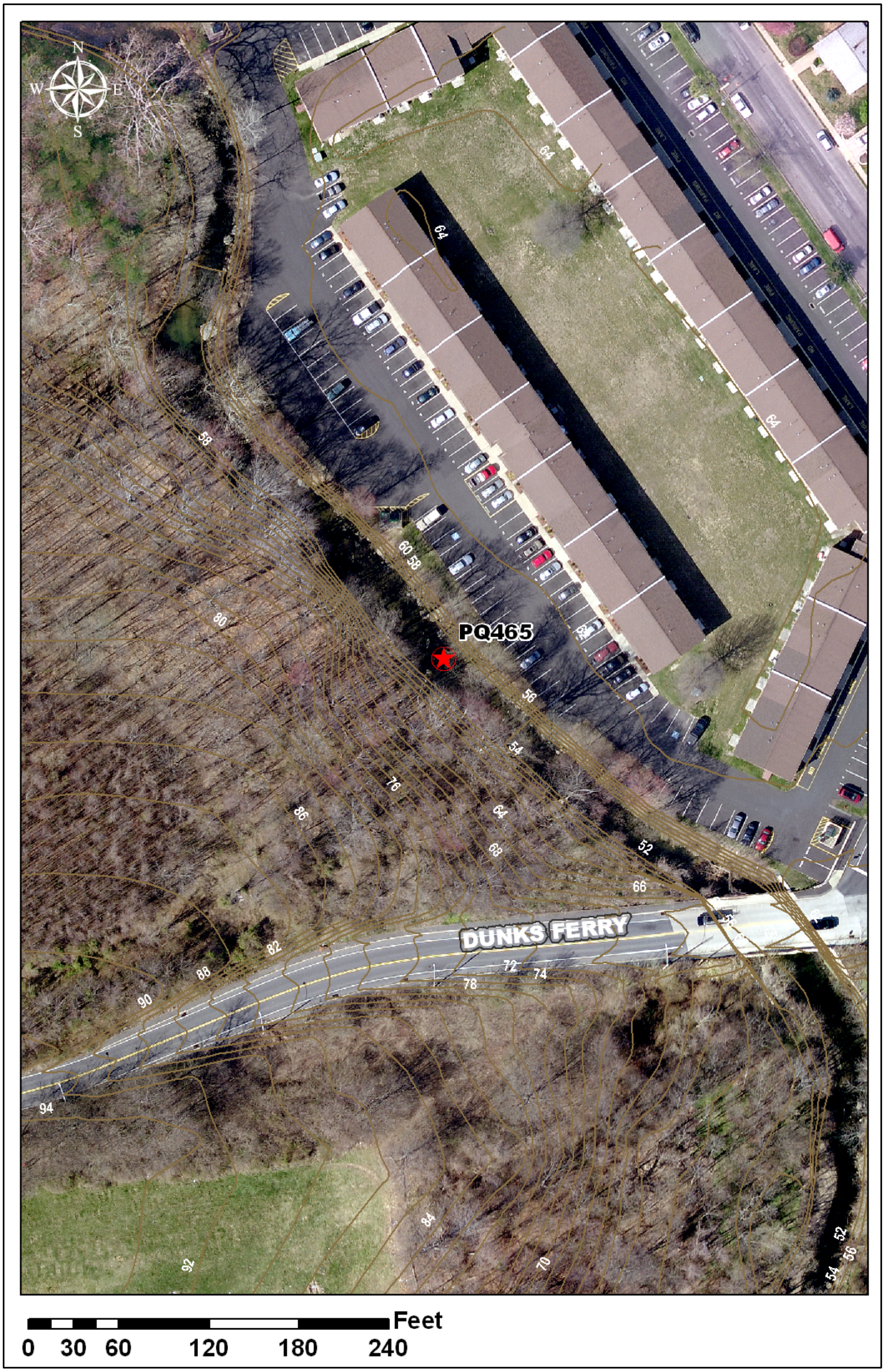

**Figure A.1 Poquessing Creek Site PQ050 with 2008 Digital Orthoimagery and Fish Assessment Site Detail**



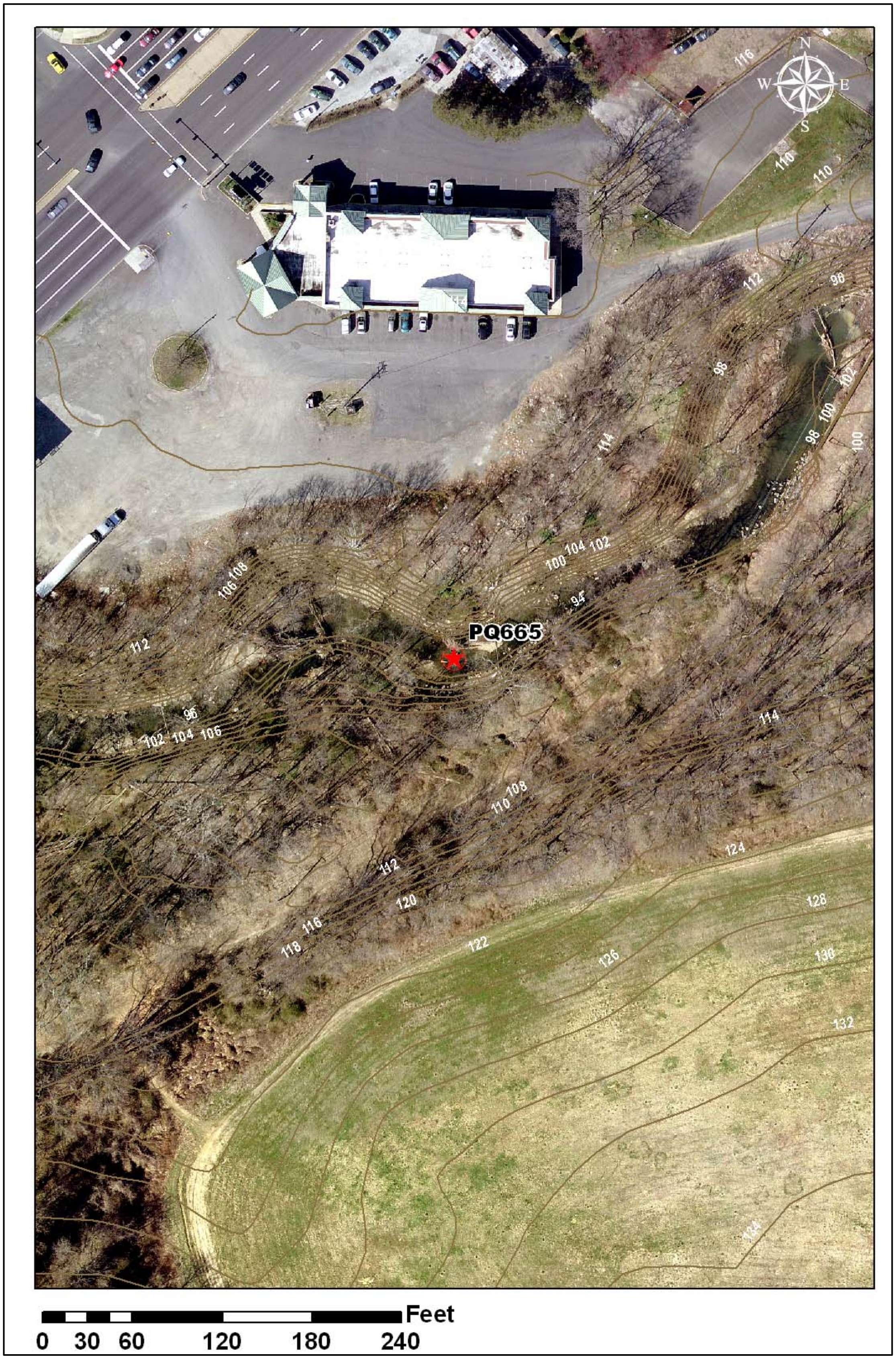

**A.2 Poquessing Creek Site PQ115 with 2008 Digital Orthoimagery and Fish Assessment Site Detail**



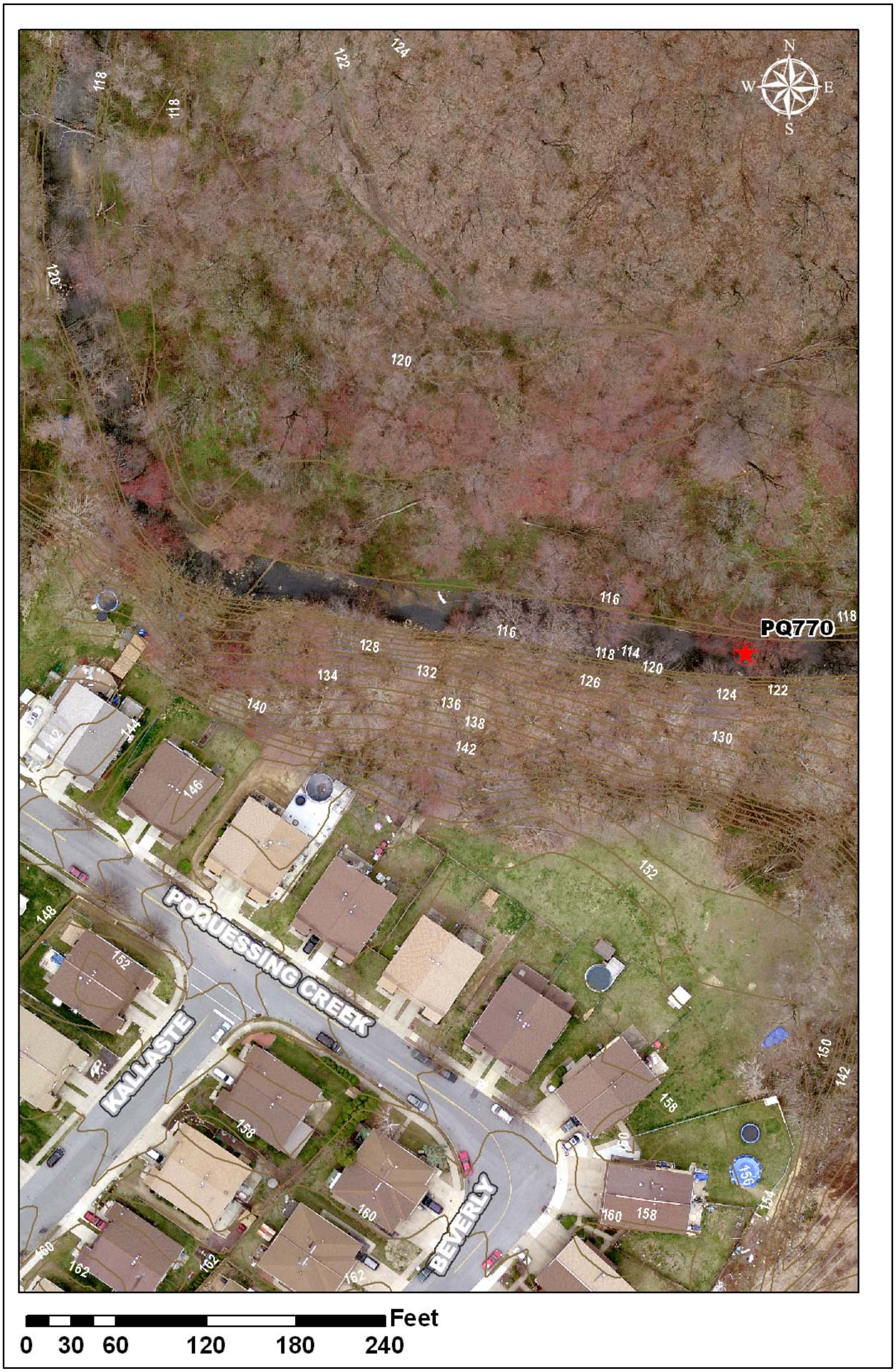

**A.3 Poquessing Creek Site PQ395 with 2008 Digital Orthoimagery**




**A.4 Poquessing Creek Site PQ465 with 2008 Digital Orthoimagery**

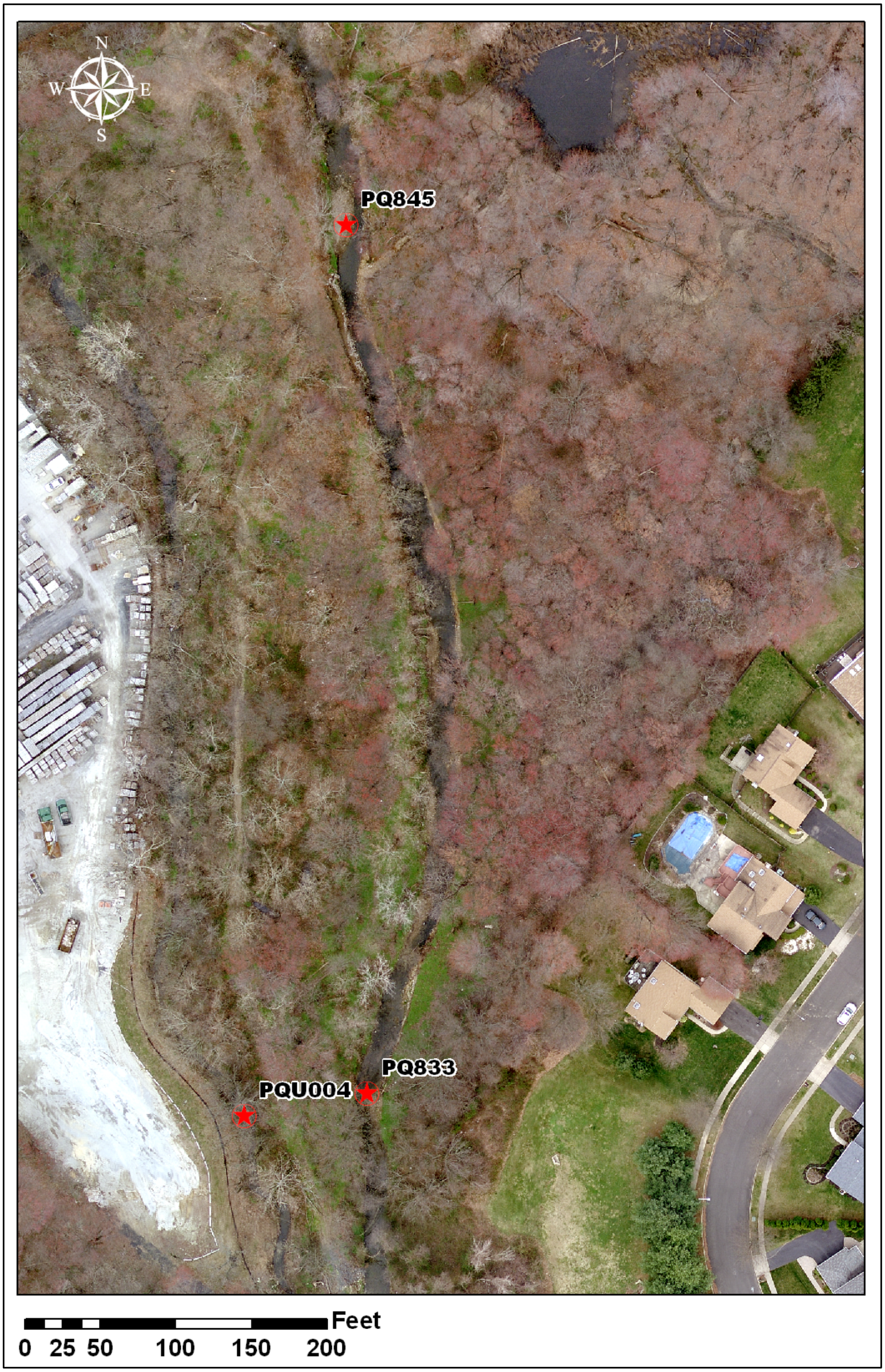



## A.5 Poquessing Creek Site PQ665 with 2008 Digital Orthoimagery

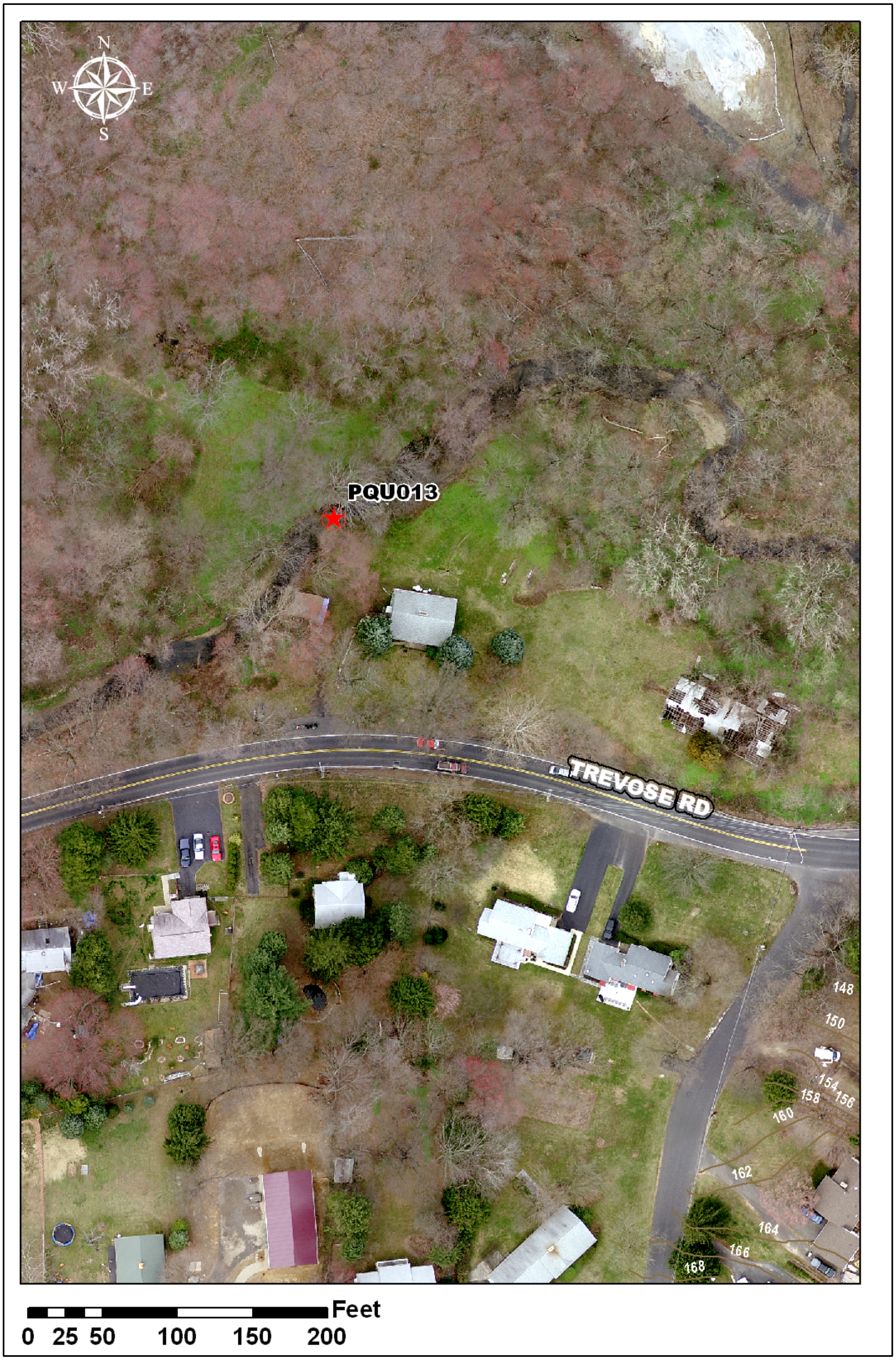



**A.6 Poquessing Creek Site PQ770 with 2008 Digital Orthoimagery**


**A.7 Poquessing Creek Site PQ820 and PQ825 with 2008 Digital Orthoimagery and Fish Assessment Site Detail**

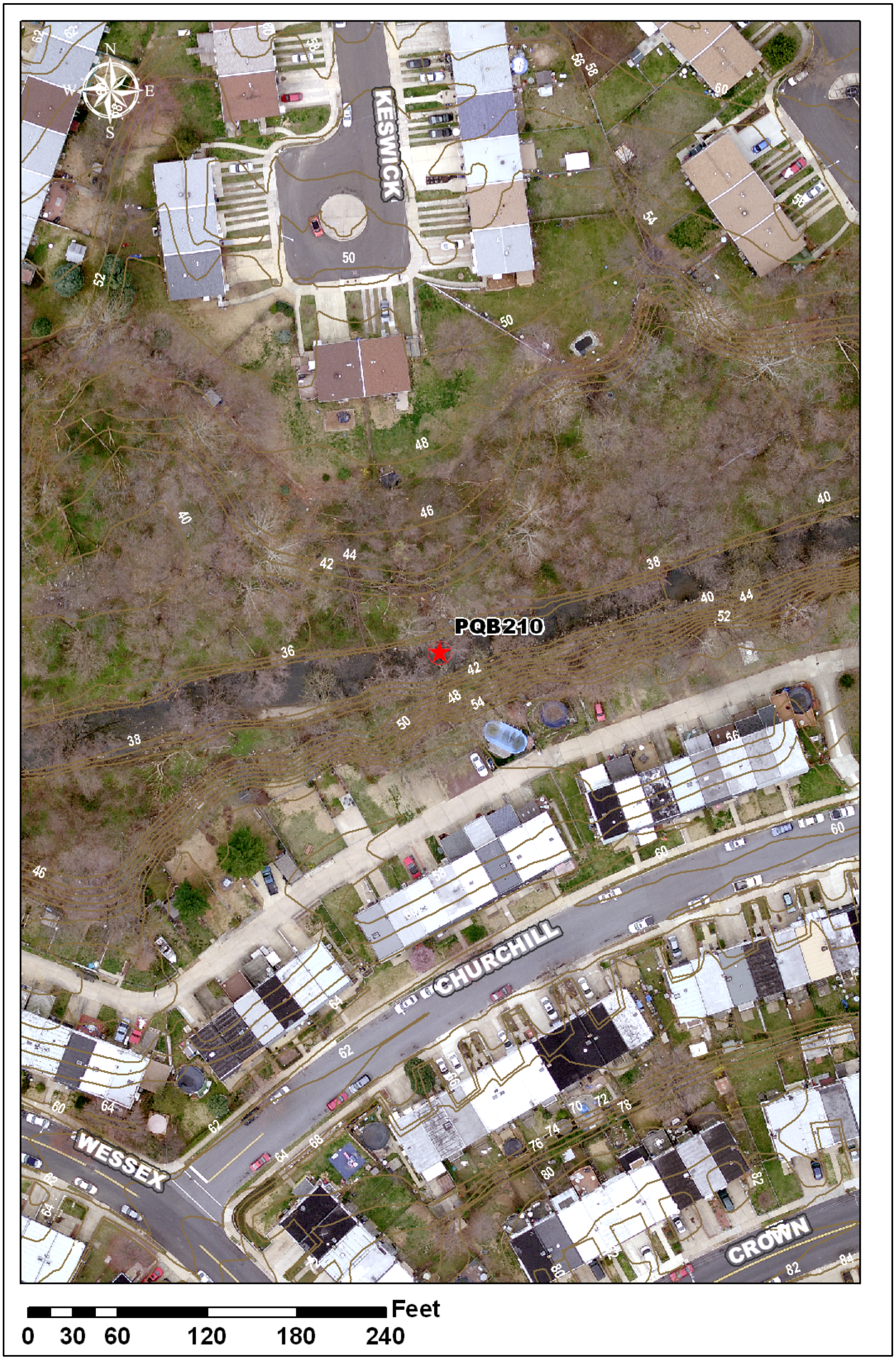



**A.8 Poquessing Creek Site PQ845 with 2008 Digital Orthoimagery**

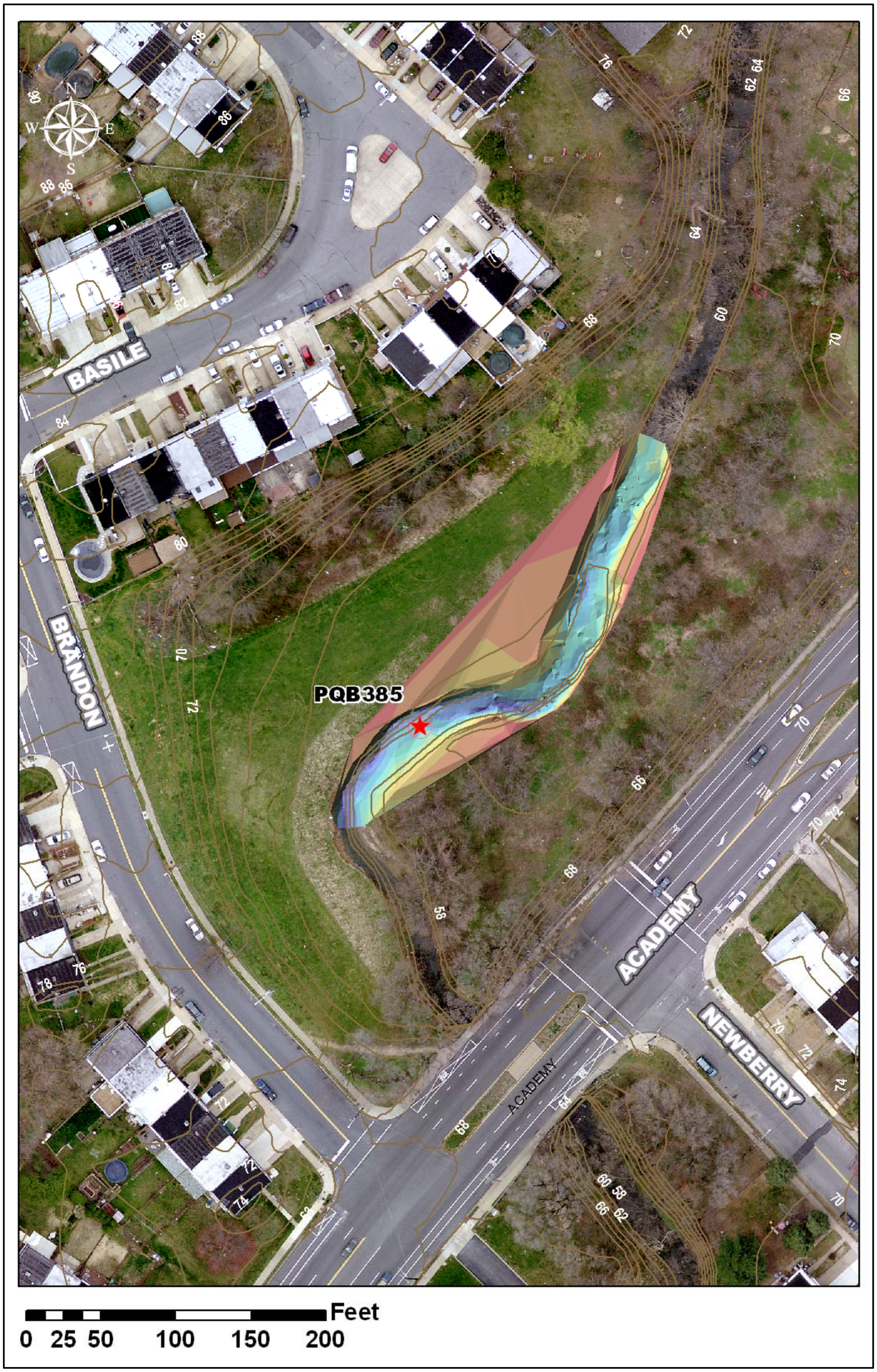



**A.9 Poquessing Creek Tributary Site PQU013 with 2008 Digital Orthoimagery**

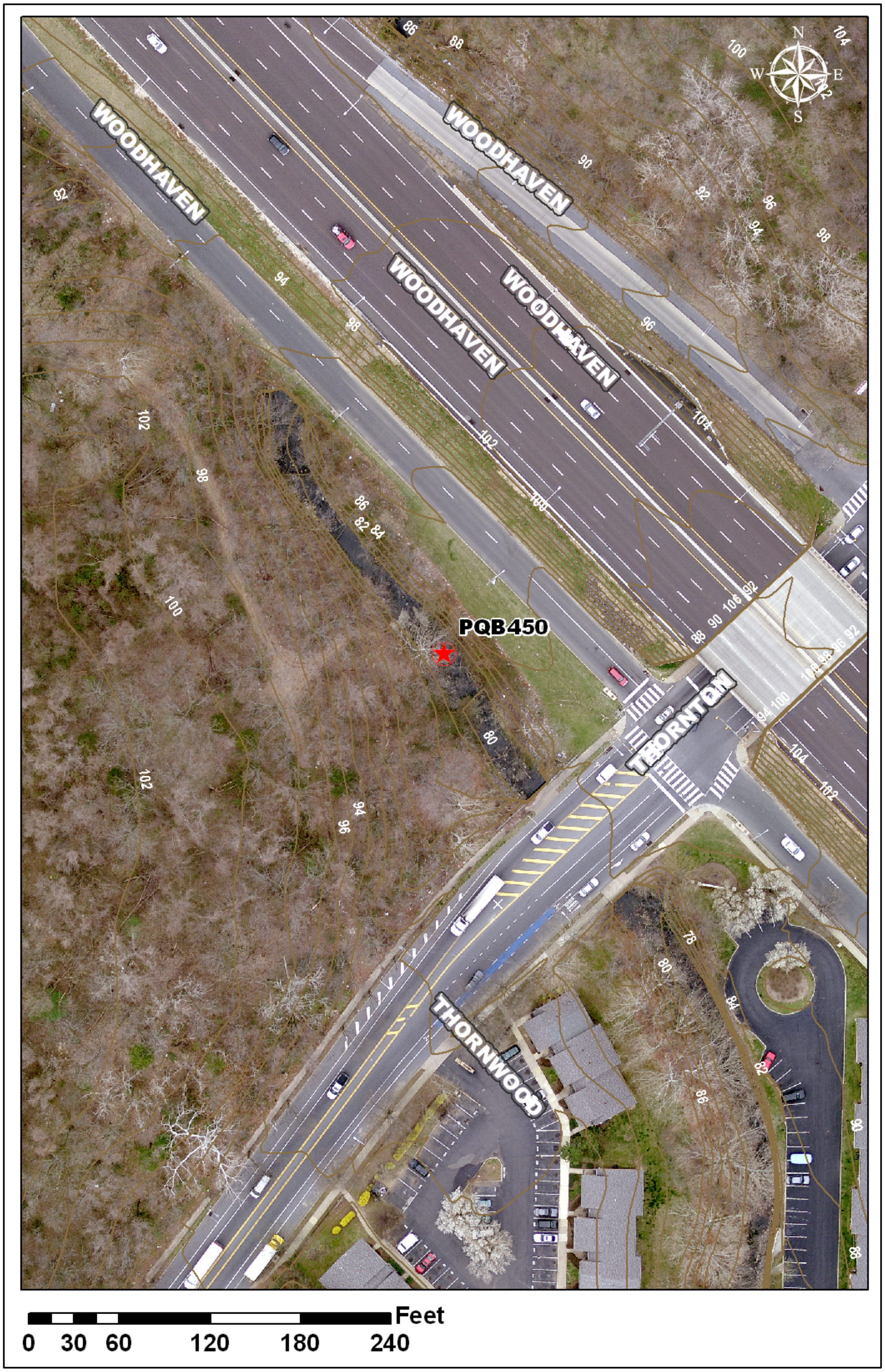

**A.10 Byberry Creek Site PQB025 with 2008 Digital Orthoimagery and Fish Site Assessment Detail**




**A.11 Byberry Creek Site PQB210 with 2008 Digital Orthoimagery**




**A.12 Byberry Creek Site PQB385 with 2008 Digital Orthoimagery and Fish Assessment Site Detail**




## A.13 Byberry Creek Site PQB450 with 2008 Digital Orthoimagery

# APPENDIX B:

## Standard Operating Procedures

# A STANDARD OPERATING PROCEDURES

## A.1 STANDARD OPERATING PROCEDURE FOR THE FIELD COLLECTION OF GRAB SAMPLES

STANDARD OPERATING PROCEDURE

FOR THE

FIELD COLLECTION OF GRAB SAMPLES

Bureau of Laboratory Services

Philadelphia Water Department

Signatures and Dates

Lab Analysts ______________________

______________________

______________________

Supervisor ______________________

QA Supervisor ______________________

Revised January 2009
Timothy McMahon, Biologist Trainee

**1.0 Identification of test method**

1.1. The purpose of this SOP is to establish a uniform procedure for collecting grab samples from Philadelphia's surface waters. The procedure is based on standard method 1060.

**2.0 Applicable matrix or matrices**

2.1. This SOP applies to surface waters.

**3.0 Method detection limit**

3.1. N/A

**4.0 Scope and application, including components to be analyzed**

4.1. This SOP describes procedures and requirements for collecting water grab samples, recording the necessary field data and transmitting the collected samples to laboratory facilities for analysis. This includes requirements regarding sample handling, field notes, and chain-of-custody records, along with requirements for quality assurance and quality control (QA/QC). Record keeping is briefly discussed.

**5.0 Summary of the test method**

5.1. Samples of surface waters are collected in appropriate bottles for the required analytes. The necessary field data is recorded from a multi-parameter sonde placed in-situ. Once collected, the sample is poured off into the correct bottles, as prepared by BLS, for specific analytes, and preserved, if necessary. The samples are then packed into a cooler with ice and transported to BLS for analysis and turned over to the central receiving unit (CRU) with the correct chain-of-custody record. Field-staff file field sheets and input field data into the LIMS system.

**6.0 Definitions**

6.1. Discrete Grab Sample - A sample that is taken at a selected location, depth and time.

6.2. Multi-Parameter Sonde – A multi-meter that reads instantaneous pH, specific conductivity, temperature, turbidity, and dissolved oxygen when placed in a body of water.

**7.0 Interferences**

7.1. Contaminants introduced into the sample containers through careless handling, or by using "dirty" preservatives can bias the true values of the sample.

**8.0 Safety**

8.1. Gathering of water samples may result in exposure to sewage and bacteriologically contaminated water. Field personnel must wear suitable hand protection during the collection and handling of samples and take care to minimize exposure to surface waters. Anti-bacterial wipes should be used after contact with waters.

8.2. Adequate medical protection against risk of infectious disease (tetanus, polio, pertussis, diphtheria and hepatitis A/B) is recommended.

8.3. While working in the field, the field crew must carry a complete first-aid kit that provides materials for disinfection and protection of any skin cuts or abrasions. Personnel will promptly attend to any such cuts or abrasions, and seek medical attention if appropriate, and any such instances will be recorded in the field log, including time and location of incident and description of first-aid treatment applied.

8.4. Field personnel must wear sturdy boots with adequate ankle support. If personnel need to enter a stream, correctly fitting hip- or chest-waders with felt bottoms that have been inspected for water-tightness must be worn, and care taken to avoid slipping.

8.5. When working in cold weather, the field crew must take extra precautions for warmth and keep chemical hand-warmers in the vehicle. Having extra dry clothes is recommended as well.

8.6. If using concentrated acid to acidify samples, sampler must wear safety glasses and latex gloves.

**9.0 Equipment and supplies**

9.1. Sample bottles or containers prepared and preserved in accordance with BLS protocols (see Table 1, section 23.0) and concentrated $H_2SO_4$ as preservative if collecting $TKN^-$ samples.
9.2. 0.45 µm pore-size screw-tip filters and 60 mL syringes (if sampling dissolved metals)
9.3. Insulated coolers for sample transport
9.4. Ice
9.5. Chain-of-custody forms
9.6. BLS field sheets (attached in section 23.0)
9.7. Multi-parameter field sonde (usually YSI 6920 sonde, but can also use YSI 6600 or 600XLM sondes, or YSI 85D/YSI 60 portable meters) with check standards (see section 10.0)
9.8. Hip- or chest-waders with felt bottoms, to allow personnel to wade into stream.
9.9. First aid kit
9.10. Latex gloves

**10.0 Reagents and standards**

10.1. **Where catalog numbers are given, equivalent products may be used. Any chemical or reagent without a manufacturer's expiration date is valid for up to ten years of receipt.**
10.1.1. Conductivity check standards, 100 and 500 µmhos/cm (100 µmhos/cm – Ricca Chemical, cat. No 2237-1; 500 µmhos/cm – Ricca Chemical, cat. No 2241-1)
10.1.2. pH check standards at 6.86 and 7.40 (pH 7.40 – Ricca Chemical, cat. No 1565-5; pH 6.86 – Ricca Chemical, cat. No 1540-1)
10.1.3. Turbidity check standard (either Milli-Q DI water (0.0-NTU) or prepared 9.0-NTU check std, diluted from 1000-NTU stock solution) (1000-NTU solution- Ricca Chemical, cat. No 8825-16)
10.1.4. Concentrated sulfuric acid, to acidify necessary samples.

**11.0 Sample collection, preservation, shipment and storage**

11.1. For sample collection, shipment and storage, see section 14.0
11.2. For sample preservation, see Table 1 in section 23.0

**12.0 Quality control**

12.1. Field sonde must be calibrated prior to sampling in the field.
12.2. Field sonde must be checked with check standards before sampling and recorded in the appropriate section on the field sheet.
12.3. After ten samples are taken, field sonde must be checked with check standards and recorded in the appropriate section on the field sheet.
12.4. After sampling, field sonde must be checked with check standards and recorded in the appropriate section on the field sheet.

**13.0 Calibration and standardization**

13.1. For calibration information, see appropriate SOP for the field meter being used.

**14.0 Procedure**

14.1. Drop the field sonde into the stream near to where sample will be drawn from. Sample must be taken from a representative and well-mixed area of the stream, generally mid-channel and mid-depth, where the flow is swift enough that solids do not settle out.

14.2. To gather a water sample, dip the sample bottle into the flow stream being careful not to draw in bottom sediments or detritus. Do not include large non-homogeneous particles in the sample.

14.3. Face the sampling bottle upstream to avoid contamination.

14.4. Once the sample bottle has been filled, cap it. Pour off samples into appropriate containers with labels that contain date, time, location, and analyte. Labels are provided by CRU. Sampler must fill out information legibly and accurately with waterproof ink. Add preservative if necessary (label adequately any bottle containing concentrated acid as corrosive) and place sample in a cooler with ice. Preservative must be added within 15 minutes of sample collection. Take care to minimize risk of contamination by handling samples as little as possible and by as few people as possible.

14.4.1. Do not touch the inner portion of sample bottles and caps with bare or gloved hands.

14.4.2. Sample bottles must be kept in a clean environment away from dust, dirt, fumes, and grime. Vehicle cleanliness is important to eliminating contamination problems.

14.4.3. Samples must never be allowed to stand in the sun and must remain cool.

14.5. For dissolved metals, sample filtration must occur on site.

14.5.1. Season syringe with 60 mL of well mixed sample and discard.

14.5.2. Fill syringe with 60 mL of sample.

14.5.3. Attach filter head to syringe and filter.

14.5.4. Use first 5 mL of filtrate to rinse dissolved metals container and discard.

14.5.5. Collect appropriate aliquot of sample into the dissolved metals container.

14.6. Record field notes on BLS field sheet with appropriate date, time, and location. Each location sampled must have a field sheet. Field notes will also include:

14.6.1. Sampling team initials

14.6.2. Weather conditions

14.6.3. General observations regarding flow, water clarity, odors at sampling sites

14.6.4. Modifications to established procedures

14.6.5. Readings from field sonde (pH, temperature, specific conductivity, dissolved oxygen, and turbidity). Record readings once sonde values have stabilized. Be careful that sonde is reading a representative sample of the stream (if detritus and sediment is disturbed by wading into the stream, place sonde upstream of the murky area).

14.7. The field sampling crew will initiate a chain-of-custody form for all samples. Chain-of-custody forms will include information on project name, date and time of sample collection, sample description, sample location, which analysis is required on each sample, method of sample preservation used at the time of sample collection, and date and time of sample custody transfer. Chain-of-custody forms are provided by BLS.

14.8. Return samples to the Central Receiving Unit at BLS immediately upon return and relinquish them with the chain-of-custody form.

14.9. Add field data to LIMS system.

## 15.0 Calculations – N/A

## 16.0 Method performance

16.1. Quality control data can be found on the sample field sheet.

## 17.0 Pollution Prevention

17.1. Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation.

17.2. For information about pollution prevention that may be applicable to laboratories and research institutions, consult "Less is Better: Laboratory Chemical Management for Waste Reduction", available from the QA Department or from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street N.W., Washington D.C. 20036, (202)872-4477.

**18.0 Data assessment and acceptance criteria for quality control measures**

18.1. Calibration – Calibration criteria are listed in the SOP for the multi-meters used (Standard Operating Procedure For YSI 60 Portable Meter, Standard Operating Procedure For YSI 85 Portable Meter, & Standard Operating Procedure For YSI Sondes Models 600XLM, 6600, 6820, And 6920 To Monitor Water Quality In Streams)

**19.0 Corrective actions for out of control data**

19.1. Calibration check – If calibration check fails, recalibrate field sonde for whichever parameter failed the check.

**20.0 Contingencies for handling out of control or unacceptable data**

20.1. If a parameter on the field sonde fails a calibration check, the data points recorded since the last valid calibration check must be flagged. A "failed check standard" flag must be noted both on field sheets and in the LIMS system.

**21.0 Waste management**

21.1. All check standards for this procedure used in the field must be collected in a waste container and brought back to BLS, where they can be poured down the drain with sufficient water for dilution.

**22.0 References**

22.1. Standard Methods for the Examination of Water and Wastewater, 1995. American Public Health Association, American Water Works Association, American Environmental Federation, 20th Edition. Eaton, A.D., Clesceri, L.S., and A.E. Greenberg, Eds.

**23.0 Tables, diagrams, flowcharts, and validation data**

## Table 1
## Recommended sample containers and sample preservation

| Parameter | Container | Sample Container Size | Preservation |
|---|---|---|---|
| Total Suspended Solids | Polyethylene or Glass | 500 ml | |
| Carbonaceous and Biochemical Oxygen Demand | Polyethylene or Glass | 500 ml | |
| Fecal Coliform, | Sterilized Polyethylene or Glass | 250 ml | (Add $Na_2S_2O_7$)(1) |
| Ammonia | Polyethylene or Glass | 500 ml | Add $H_2SO_4$ until pH <2 |
| Nitrate + Nitrite | Polyethylene or Glass | 100 ml | Add $H_2SO_4$ until pH <2 |
| Ortho-Phosphate | Polyethylene or Glass | 50 ml | Filter on site or within 6 hours |
| Phosphorus | Polyethylene or Glass | 50 ml | Add $H_2SO_4$ until pH <2 |
| Metals (Total Recoverable and/or Dissolved) | Polyethylene | 250 ml | |
| E. coli | Polyethylene or Glass | 500 ml | Add $Na_2S_2O_3$ (0.008%) |
| Alkalinity | Polyethylene or Glass | 500 ml | |
| Fluoride | Polyethylene | 500 ml | |
| Osmotic pressure | Polyethylene | 120 ml | |
| Total Dissolved Solids | Polyethylene | 500 ml | |
| Turbidity | Polyethylene | 100 ml | |
| TKN | Polyethylene or Glass | 500 ml | Add $H_2SO_4$ until pH <2 |
| Chlorophyll | Amber Glass Only | 1000ml | |
| Phenols | Glass only | 500 ml | Add $H_2SO_4$ until pH <2 |

## A.2 STANDARD OPERATING PROCEDURE FOR CONTINUOUS WATER QUALITY MONITORING WITH YSI MODEL 6600 AND 600XLM SONDES

(For more information, please contact PWD Bureau of Laboratory Services 1500 E. Hunting Park Ave, Philadelphia 19124)

## A.3 STANDARD OPERATING PROCEDURE FOR WET WEATHER SAMPLING USING THE ISCO 6712 AND ISCO 720 LEVEL MODULE

STANDARD OPERATING PROCEDURE

FOR

WET WEATHER SAMPLING USING THE ISCO 6712 AND ISCO 720 LEVEL MODULE

Bureau of Laboratory Services

Philadelphia Water Department

Signatures and Dates

Lab Analysts ________________________

________________________

________________________

Supervisor ________________________

QA Supervisor ________________________

Revised January 2009
Timothy McMahon, Biologist Trainee

## 1.0 Identification of test method

1.1. The purpose of this SOP is to establish a uniform procedure for sampling wet weather events from Philadelphia surface waters using the ISCO 6712 unit with the ISCO 720 level module. The procedure is based on the Standard Method 1060 for the collection and preservation of samples and the manufacturer recommendations.

## 2.0 Applicable matrix or matrices

2.1. This SOP applies to surface waters.

## 3.0 Method detection limit

3.1. N/A

## 4.0 Scope and application, including components to be analyzed

4.1. This SOP describes procedures and requirements for auto-sampling during wet weather events using the ISCO 6712 unit with the ISCO 720 level module, recording the necessary field data, transmitting the collected samples to laboratory facilities for analysis, and transferring data collected by the ISCO unit to a lab computer for analysis. This includes requirements regarding sample handling, field notes, and chain-of-custody records, along with requirements for quality assurance and quality control (QA/QC). The results of these analyses, along with the water level data logged by the ISCO unit, allow the Philadelphia Water Department to monitor effects of storm water runoff.

## 5.0 Summary of the test method

5.1. The ISCO autosampler unit is set up at the desired site before a rain event and programmed to begin sampling when the stream level increases by 0.1 ft (unless the stream normally has a daily variation larger than 0.1 ft, in which case the trigger level is set accordingly). The goal is to capture a view of the entire rain event so the unit is programmed to sample at desired intervals, determined by the sampler, based on the event's forecasted length and intensity. A grab sample is collected and field readings recorded before the rain event, as a baseline. During the rain event, the ISCO sampler is maintained by retrieving level data, removing full samplers and replacing with empty bottles, if necessary. Samples are returned to BLS and composited in CRU. Analyses requested are based on Philadelphia Water Department's Office of Watersheds requirements. A chain-of-custody form is completed when the samples are relinquished. The ISCO unit is allowed to run for several days after the rain event without sampling in order to collect level data as the stream returns to base flow. Level data from the ISCO unit is transferred to a lab computer and analyzed.

## 6.0 Definitions

6.1. Autosampler Enclosure – Fiberglass or metal enclosure with a locking lid which protects ISCO units from water and vandalism.

6.2. Baseline – The values of a given set of parameters before precipitation begins and against which the wet weather event values are measured.

6.3. Composite Sample – A representative water or wastewater sample made up of individual smaller samples taken at periodic intervals.

6.4. Discrete Grab Sample – A sample that is taken at a selected location, depth and time.

6.5. ISCO 6712 – Portable, programmable auto-sampler used to collect samples remotely during wet weather events.

6.6. ISCO 720 Level Module – Attachment to ISCO 6712 that measures stream depth with a level probe.

6.7. Multi-Parameter Sonde – A multi-meter that reads instantaneous pH, specific conductivity, temperature, turbidity, and dissolved oxygen when placed in a body of water.
6.8. RTD 581 Data Logger – The data logger which plugs into the ISCO 6712 unit in the field and quickly downloads the data collected since the program was started.
6.9. Wet Weather Event – A period of precipitation during which stream flows increase due to runoff and then return to base flow

## 7.0 Interferences

7.1. Contaminants introduced into the sample containers through careless handling, or by using “dirty” preservatives can bias the true values of the sample.
7.2. An improperly set-up ISCO sampler can fail to collect samples or to collect the necessary amount of sample.

## 8.0 Safety

8.1. Gathering of water samples may result in exposure to sewage and bacteriologically contaminated water. Field personnel must wear suitable hand protection during the collection and handling of samples and take care to minimize exposure to surface waters. Anti-bacterial wipes should be used after contact with waters.
8.2. Adequate medical protection against risk of infectious disease (tetanus, polio, pertussis, diphtheria and hepatitis A/B) is recommended.
8.3. While working in the field, the field crew must carry a complete first-aid kit that provides materials for disinfection and protection of any skin cuts or abrasions. Personnel will promptly attend to any such cuts or abrasions, and seek medical attention if appropriate, and any such instances will be recorded in the field log, including time and location of incident and description of first-aid treatment applied.
8.4. Field personnel must wear sturdy boots with adequate ankle support. If personnel need to enter a stream, correctly fitting hip- or chest-waders with felt bottoms that have been inspected for water-tightness must be worn, and care taken to avoid slipping.
8.5. When working in cold weather, the field crew must take extra precautions for warmth and keep chemical hand-warmers in the vehicle. Having extra dry clothes is recommended as well.
8.6. If using concentrated acid to acidify samples, sampler must wear safety glasses and latex gloves.
8.7. Field personnel must be aware of depth of streams and strength of current, especially during rain events, and use appropriate precautions. Entering a stream during a rain event is discouraged.
8.8. ISCO units are powered by deep cycle batteries, which are similar to car batteries. When attaching leads from the ISCO unit, work gloves must be worn.
8.9. The pump in the ISCO 6712 has a safety mechanism which does not allow the pump to run when the pump band is open. Do not tamper with this safety mechanism. The pump rollers can cause severe injury. Disconnect power from the sampler before replacing pump tubing.

## 9.0 Equipment and supplies

9.1. ISCO 6712 sampler, including base containing 24 1-liter polypropylene wedge shaped cage-bottles (ISCO part #68-6700-087) with new plastic sampling bags (ISCO part #68-6700-096) (including caps)
9.2. Fully charged deep cycle marine battery or 12 volt car battery with clip attachment
9.3. ISCO 720 Module (ISCO part #60-9004-030)
9.4. Fiberglass autosampler enclosure with necessary padlocks to secure the lid
9.5. 25 ft cable and level probe (ISCO part #60-3224-002)

9.6. 25 ft extension cable (if needed)
9.7. Pump head tubing for ISCO unit (ISCO part #68-6700-045)
9.8. Discharge tubing for sampler arm (ISCO part #60-9003-260)
9.9. precut length (site-specific, determined in advance) of vinyl suction tubing (ISCO part #68-1680-059)
9.10. Rapid Transfer Device (RTD) 581 data logger (ISCO part #60-9004-027)
9.11. Strainer (stainless steel), 7 mm pore size, for autosampler intake (ISCO part #69-2903-138)
9.12. Multi-parameter field sonde (usually YSI 6920 sonde, but can also use YSI 6600 or 600XLM sondes, or YSI 85D/YSI 60 portable meters) with check standards (see section 10.0)
9.13. Tool box (pliers, wrench, tape measure, screw drivers, tubing cutter, ratchet)
9.14. Wooden base for ISCO unit
9.15. PVC pipe for running sampler tubing and level probe down to the stream
9.16. Steel spikes/rebar/metal U-clamps (2-3 per site) to secure pipe in stream-bed, bank or to stone structure
9.17. Sample bottles or containers prepared and preserved in accordance with BLS protocols and concentrated $H_2SO_4$ as preservative if collecting $TKN^-$ samples.
9.18. 0.45 µm pore-size screw-tip filters and 60 mL syringes (if sampling dissolved metals)
9.19. Insulated coolers for sample transport
9.20. Ice for ISCO unit and sample transport
9.21. 1000 ml graduated cylinder for check of ISCO sample volumes
9.22. BLS field sheets
9.23. Chain-of-custody forms
9.24. Keys to the ISCO housing units
9.25. Sledge hammer
9.26. Sawz-all
9.27. Hammer drill
9.28. Electric drill with drill bits
9.29. Various nuts, bolts, and washers needed to secure ISCO enclosure to base and stream bank
9.30. Angle irons
9.31. Hip- or chest-waders with felt bottoms, to allow personnel to wade into stream.
9.32. Latex Gloves
9.33. First aid kit

## 10.0 Reagents and standards

10.1. **Where catalog numbers are given, equivalent products may be used. Any chemical or reagent without a manufacturer's expiration date is valid for up to ten years of receipt.**
10.1.1. Conductivity check standards, 100 and 500 µmhos/cm (100 µmhos/cm – Ricca Chemical, cat. No 2237-1; 500 µmhos/cm – Ricca Chemical, cat. No 2241-1)
10.1.2. pH check standards at 6.86 and 7.40 (pH 7.40 – Ricca Chemical, cat. No 1565-5; pH 6.86 – Ricca Chemical, cat. No 1540-1)
10.1.3. Turbidity check standard (either Milli-Q DI water (0.0-NTU) or prepared 9.0-NTU check std, diluted from 1000-NTU stock solution) (1000-NTU solution- Ricca Chemical, cat. No 8825-16)
10.1.4. Concentrated sulfuric acid, to acidify necessary samples.

## 11.0 Sample collection, preservation, shipment and storage

11.1. For sample collection, shipment and storage, see section 14.0

11.2. For sample preservation, see Table 1 in section 23.0

## 12.0 Quality control

12.1. Field sonde must be calibrated prior to baseline grab sampling (conducted before and after wet weather event)

12.2. Field sonde must be checked with check standards before baseline grab sampling and recorded in the appropriate section on the field sheet.

12.3. After baseline grab sampling, field sonde must be checked with check standards and recorded in the appropriate section on the field sheet.

## 13.0 Calibration and standardization

13.1. For calibration information, see appropriate SOP for the field meter being used.

## 14.0 Procedure

14.1. Preparation for wet weather event (at lab)

14.1.1. Install new internal ISCO sampler pump head tubing and sampler arm tubing according to manufacturer's instructions.

14.1.2. Turn on ISCO unit in the lab and attach level probe. Insure level probe is reading a steady depth for several hours. The level does not need to be 0.000 ft, as the probe will be zeroed in the field. If level probe reading is erratic, replace with a different probe and check for stable reading.

14.1.3. Install new plastic bags in the sample cages and arrange sample cages according to numbering on ISCO base. Numbering on the cages should match the numbering on the outside of the base. Each base is given a number (1,2,3…) and cages are numbered from 1-24. The cages in base 1 will be denoted as (1.1, 1.2, 1.3…1.24).

14.2. Setting up ISCO unit at sampling site

14.2.1. Set up the ISCO unit at the site the day before the storm, if possible. A baseline grab sample will be taken at this time, also. If installing an ISCO at a new site, secure wooden base to stream bank by driving angle irons into a flat area of the stream bank with sledgehammer and bolting the base in place. Bolt the fiberglass enclosure to the wooden base and check that locks are functional and open with the correct key. Using metal spikes or metal U-clamps, secure two lengths of PVC pipe to stream bank between ISCO enclosure and stream bed. The level probe and sampler tubing will run through these pipes in order to hold them in place during heavy flow and to protect them against vandalism.

14.2.2. Place ISCO unit in the enclosure on top of the correct base for that site, making sure that all sample bottles are in correct numbered locations and caps are removed.

14.2.3. Attach tubing (pre-cut to the correct length for that site) and level module probe cable to ISCO unit.

14.2.4. Attach battery to ISCO unit using battery clips and turn on the unit.

14.2.5. Feed sampler tubing, with stainless steel strainer attached to the end, through one of the PVC pipes until it hits the streambed. Pull tubing back until strainer is positioned in main stream flow, off the streambed. Cut tubing to correct length if necessary.

14.2.6. Remove cap from dessicant assembly attached to ISCO 720 module.

14.2.7. Fill the center of the ISCO base with ice.

14.3. Programming ISCO unit

14.3.1. When programming the ISCO unit to sample, the sampling schedule and volumes will be based on both the weather forecast and the analyses requested by the Office of Watersheds. 4-5 samples should fall on the rising limb of the rain event and 3-4 samples should fall on the descending limb, unless instructed otherwise. The weather forecast should be monitored in the days leading up to the event and the sample timing should be based on when most precipitation is forecasted to occur.

14.3.2. The ISCO menus are navigated by using the arrow keys and the enter button. For a full graphic depiction of menus and options, see the ISCO 6712 manual.

14.3.3. Before programming the ISCO to sample, first check the date and time and correct if necessary.

14.3.3.1. From the main menu, choose "other functions"→ "maintenance" → "set clock"

14.3.3.2. Set date and time with keypad, using 24-hr time and DD-MON-YY format for the date.

14.3.4. While the ISCO has several "standard programs" available, an "extended program" is used to sample wet weather events to allow more control over the sampling schedule. The program used is a "20-minute 2-part program" and the parameters will be adjusted based on the storm.

14.3.5. From the main menu screen, select "Program." The ISCO will now scroll through all of the set parameters for the current program, which can be altered by using the arrow and enter keys, and the numerical keypad. The parameters which must be tailored for each event are: Site description (the assigned names used for each site and for the LIMS system), units selected (for tubing length), submerged probe (level-only or flow-sensitive probe), current level, data interval (how often the ISCO logs a level reading), number and volume of bottles, length of suction line (the tubing which the ISCO uses to draw a sample from the stream), number of rinses and retries in case of failure, type of program, bottle assignments (if a two part program: the number of bottles which are assigned to parts A & B), the pacing, distribution, volume, depth at which to trigger the program, and any scheduled pauses for each program. For example, a standard program for a wet weather event is:

14.3.5.1. 20-minute 2-part program
14.3.5.2. Site description: BYBE150
14.3.5.3. Units selected: ft
14.3.5.4. Submerged Probe: level only
14.3.5.5. 15 minute data interval
14.3.5.6. 24, 1000mL bottles
14.3.5.7. 15 ft suction line
14.3.5.8. 0 rinses, 0 retries
14.3.5.9. Bottle Assignments: 1-15 to "A", 16-24 to "B"
14.3.5.10. "A" pacing: Time, every 0 hours, 30 minutes
14.3.5.11. "A" distribution: 3 bottles/sample
14.3.5.12. "A" volume: 1000 mL samples
14.3.5.13. "A" enable: level > 2.65 ft
14.3.5.14. "B" pacing: Time, every 2 hours, 0 minutes
14.3.5.15. "B" distribution: 3 bottles/sample
14.3.5.16. "B" volume: 1000 mL samples
14.3.5.17. "B" enable: When "A" is done
14.3.5.18. "B" enable: 30 minute delay to start of sampling

This program will trigger the ISCO to fill three 1000 mL bottles when the level probe reads a depth of 2.65 ft. The ISCO will then sample at 30 minute intervals, filling three 1000 mL bottles at each sample. After the first 5 samples (15 bottles) are finished (after 2 hours), the ISCO will switch to part "B". It will wait 30 minutes and then fill three 1000 mL bottles.

The ISCO will then sample at 2 hour intervals, filling three 1000 mL bottles at each sample. After the 30 minute delay, the final 9 bottles will be full after 4 hours. The ISCO will not sample after that point, but will continue logging level readings every fifteen minutes.

14.3.6. While scrolling through the program parameters, the level probe reading must be set to zero (before putting the probe in the stream).

14.3.6.1. Set the level probe reading to 0.000 ft by highlighting the current level and pressing the enter key. The screen will prompt the user to enter the current level. Enter 0.000 ft by using the keypad once the current reading is stable. Put the probe in the stream and let the level reading stabilize. The level at which the ISCO is set to start sampling is based on this initial level. In most streams, the trigger level is set to 0.1 ft (1.2 inches) more than the baseline level. In a stream with a regular daily fluctuation (tidal or due to wastewater discharge upstream), the trigger level must be set slightly higher so the ISCO does not trigger before the wet weather event.

14.3.7. Once the program parameters are set, the ISCO will ask if it should start the program. Choose "yes" and the ISCO will start sampling once the trigger level is reached.

14.3.8. Once the program is running, the pump must be checked to insure it pumps the correct amount per sample.

14.3.8.1. Disconnect the pump tube from the bulkhead fitting and place the end of the tube over the 1000 mL graduated cylinder.

14.3.8.2. Press the red button on the keypad to access the menu.

14.3.8.3. Scroll to "calibrate volume" and follow prompts. Type in the desired sample volume (the volume the ISCO is going to sample while running the program) and press enter. The ISCO will run through the sample collection process.

14.3.8.4. When the full volume is delivered, type in the amount in the graduated cylinder. The ISCO will adjust the pump settings. Repeat this process until the pump delivers the desired amount.

14.3.8.5. Reconnect the pump tube to the bulkhead fitting.

14.3.9. The ISCO is now ready to sample.

14.4. Collect a grab sample at the site for the analyses requested by the Office of Watersheds using the procedure outlined in "Standard Operating Procedure for the Field Collection of Grab Samples". This sample functions as a baseline sample against which the wet weather samples are compared.

14.5. Maintenance of the ISCO unit during a wet weather event

14.5.1. Depending on when the wet weather event starts, the ISCO will need periodic visits to ensure proper collection of samples. The following procedures should be followed when visiting an ISCO unit.

14.5.1.1. Take new sampler base with 24 1-liter bottles (with caps) to the sampler. Fill the center hole with ice.

14.5.1.2. Unlock the enclosure and observe the sampler display to determine if sampling is completed or if the program is still running.

14.5.1.3. If the sampler has finished the original program, follow these steps:

14.5.1.3.1. Place the RTD into the back of the sampler and download stored data. The yellow light on the RTD will be lit to indicate the device is receiving power, and the green light will blink as the data reports are collected. The green light stops blinking when the transfer is successfully completed. A constant red light indicates that the RTD memory is full and a blinking red light indicates a transfer error. In the case of full memory, use another RTD. In the case of transfer error, unplug the RTD and wait briefly before trying again. Use another RTD if there is another transfer error.

14.5.1.3.2. Check and record the reports summary for sample start times and for the last sample collected time.

14.5.1.3.3. Remove base and cap all filled bottles. Replace with a new base of empty bottles. Drain any excess water from the first base and fill center hole with ice for transport to BLS.

14.5.1.3.4. Depending on the weather forecast, reprogram the ISCO to continue sampling as desired. If no more samples are desired, set trigger level to 28.00 ft. The ISCO will continue logging level values without sampling.

14.5.1.3.5. Take field readings for DO, pH, conductivity, and temperature with a multi-parameter sonde and fill out field sheets.

14.5.1.3.6. Fill out chain of custody forms.

14.5.1.3.7. Close and lock the enclosure and proceed to next destination.

14.5.1.4. If the sampler has not finished the original program, follow these steps:

14.5.1.4.1. Check display for the number of samples already collected and when the next sample will be collected. Depending on the number of samples taken and time of day, it might be better to let the sampler continue with the original program before replacing bottles.

14.5.1.4.2. If the next sample will be sampled soon, wait for the ISCO to take the next sample.

14.5.1.4.3. Take field readings for DO, pH, conductivity and temperature with the multi-parameter sonde when the next sample is taken.

14.5.1.4.4. Manually stop the sampler and follow above procedure for collecting stored sample and level data with the RTD.

14.5.1.4.5. Replace the filled sample base with a new base and cap all filled sample bottles. Drain first base of any excess water and fill center hole with ice for transport to BLS.

14.5.1.4.6. Depending on the weather forecast, reprogram the ISCO to continue sampling as desired. If no more samples are desired, set trigger level to 28.00 ft. The ISCO will continue logging level values without sampling.

14.5.1.4.7. Fill out chain of custody forms.

14.5.1.4.8. Close and lock the enclosure and proceed to next destination.

14.6. Compositing of the ISCO sample bottles at CRU

14.6.1. Each sample collected by the ISCO unit is contained in three bottles, for a total volume of 3 liters, as per the programming schedule. Upon arrival at BLS, the samples must be composited and poured off to specific analyte bottles. CRU has the composite sample bottles (4 liter collection bottles) labeled for each site. A full 24-bottle base will need 8 composite bottles and each one will indicate which ISCO bottles need to be poured into it. For example, a composite bottle will be labeled "1.1-1.3" and bottles 1.1, 1.2, and 1.3 must be poured into that bottle. The samples from the ISCO must be inverted to suspend particulate matter that may have settled out and then the full volume poured into the composite bottle. Do this for all of the samples in the collected ISCO bases.

14.6.2. Each composite bottle must be inverted to suspend any particulate matter that may have settled out and then poured off into appropriate analysis bottles provided by CRU.

The analysis bottles must be labeled with the date and time the sample was taken. This information is retrieved in the field from the ISCO program summary.

14.6.3. A completed chain of custody form must be signed and dated by both the sampler and CRU. Each ISCO site will have its own chain of custody, and any grab samples must be on a separate chain of custody. An example of the format used on a chain of custody for a wet weather event:

| (2) SAMPLE LOCATION (CODE) | COLLECTION DATE | COLLECTION TIME | SAMPLE DESCRIPTION | SAMPLE PROGRAM CODE | GRAB COMP # Hrs C |
|---|---|---|---|---|---|
| TACO250 | 1/13/04 | 13:50 | Bottles 1.1 - 1.3 | Wet Weather | C |
| TACO 250 | 1/13/04 | 14:50 | Bottles 1.4 - 1.6 | Wet Weather | C |
| | | | | | |

14.7. Maintenance of ISCO unit after wet weather event until eventual shut down

14.7.1. When no more samples are desired, the ISCO should be left running with the trigger level changed to 28.00 ft. The ISCO will continue logging level data without sampling.

14.7.2. 3-4 days after the end of a wet weather event, when the stream has returned to base flow levels, collect level data (using the RTD) and another baseline grab sample. Collect field data using a multi-parameter sonde and fill out a field sheet. At this time, the ISCO can be turned off. Replace dessicant assembly cap. Bring the battery, sample tubing, and level probe back to BLS. Discard sample tubing. Recharge the battery.

14.8. Retrieval and formatting of data from ISCO unit

14.8.1. Connect the RTD power cord into one of the serial ports on the computer, and plug the power cord into an electrical outlet. Connect the RTD data logger to the power cord and click on the FLOWLINK 4.1 software icon. Click on the Isco.exe file to launch the application.

14.8.2. Click the RTD icon on the screen to transfer the ISCO data from the datalogger into the FLOWLINK folder.

14.8.3. Once the data has been successfully transferred, click on the site folder to show all site locations and data.

14.8.4. Click once on the (+) sign next to the site name to show the most recent level data file. Click on the level file to display the graph of the level readings. Switch between the graph and the raw data by clicking on the “Graph/Table” icon in the menu bar.

14.8.5. Right click on either the graph or table values and choose “Properties”. Click the “Time Scale” tab and adjust the “Date”, “Time”, and “Timespan” boxes to adjust displayed data as desired.

14.8.6. Click on the “File” menu and select “Export”. Select the desired folder to export data to and click “Export”.

14.8.6.1. Exported data is saved as a “.csv” file; open the .csv in excel and save as an “.xls” file.

14.8.7. Click on the “Site Setup” box to show the “Reports” box. Click on the “Reports” box to view the ISCO program settings used and the details of the sampling times. Save this report data in the appropriate file folder.

## 15.0 Calculations

15.1. N/A

## 16.0 Method Performance

16.1. Quality control data can be found on the sample field sheets.

## 17.0 Pollution Prevention

17.1. Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation.

17.2. For information about pollution prevention that may be applicable to laboratories and research institutions, consult "Less is Better: Laboratory Chemical Management for Waste Reduction", available from the QA Department or from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street N.W., Washington D.C. 20036, (202)872-4477.

## 18.0 Data assessment and acceptance criteria for quality control measures

18.1. Calibration – Calibration criteria are listed in the SOP for the multi-meters used (Standard Operating Procedure for YSI 60 Portable Meter, Standard Operating Procedure for YSI 85 Portable Meter, & Standard Operating Procedure for YSI Sondes Models 600XLM, 6600, 6820, And 6920 To Monitor Water Quality In Streams)

## 19.0 Corrective actions for out of control data

19.1. Calibration check – If calibration check fails, recalibrate field sonde for whichever parameter failed the check.

## 20.0 Contingencies for handling out of control or unacceptable data

20.1. If a parameter on the field sonde fails a calibration check, the data points recorded since the last valid calibration check must be flagged. A "failed check standard" flag must be noted both on field sheets and in the LIMS system.

## 21.0 Waste management

21.1. All check standards for this procedure used in the field must be collected in a waste container and brought back to BLS, where they can be poured down the drain with sufficient water for dilution.

## 22.0 References

22.1. Teledyne Isco. 6712 Portable Samplers Installation and Operation Guide. 2008.

22.2. Teledyne Isco. 720 Submerged Probe Module Installation and Operation Guide. 2007.

# APPENDIX C:

## Sonde Data Flagging Protocol

# Sonde Data Processing & Analysis Protocols

With 10 USGS gages collecting data for multiple water quality parameters continuously at half hour intervals, a large amount of data are generated. PWD Office of Watersheds (OOW) staff has developed procedures for the processing and analysis of these data using Microsoft Excel and Access software, as well as R, a free software environment for statistical computing and graphics. Most aspects of the data processing and analysis have been automated with custom Visual Basic and R code.

OOW independently maintains databases of water quality and streamflow via automated regular retrievals of these data from USGS NWIS. On a monthly basis, the databases are queried and results for each gage are imported into MS Excel workbooks. If available, any field data collected during that period (*e.g.*, hand meter readings from field maintenance checks, water quality grab samples, etc.) are also imported. Once all required data have been entered, separate plots are produced for each parameter (dissolved oxygen, turbidity, pH, specific conductance, and temperature) to enable a subjective review of data quality.

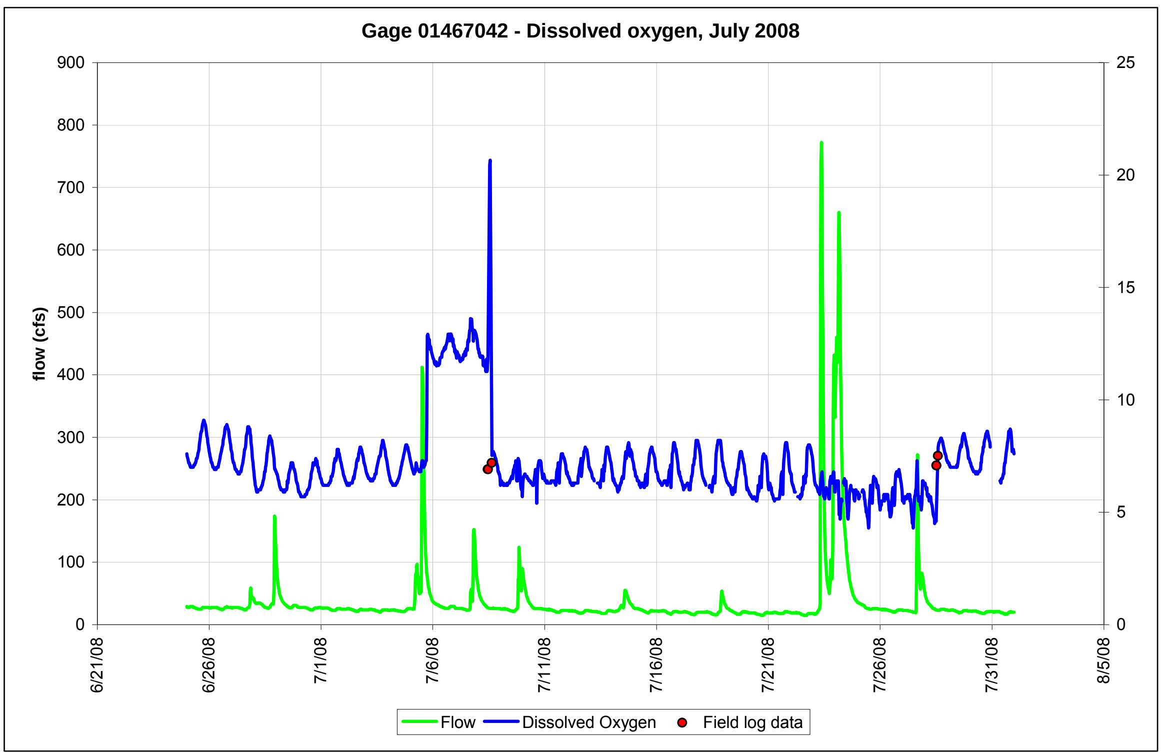



**Figure B.1 Example of an Excel-generated data processing/analysis plot; Gage 01467042, Dissolved Oxygen, July 2008.**

These plots are examined and are the primary basis for the selection of good vs. questionable data for a given month. Intervals of questionable data are located, and added to a table of "flagged" data for that particular parameter, which is then used to update the water quality database.

The final step of the procedure utilizes R, a statistical programming language and software environment. The R software code developed by OOW staff analyzes all of the water quality data in a database, as well as the good and questionable flags, and generates statistical and graphic results in a variety of forms. These include monthly plots for all data parameters for each site, showing accepted and questionable data, water quality criteria, grab sample data, and stream flow (Figure 3); assorted statistics including accepted and questionable data comparisons, monthly exceedance percentages, and comparisons of wet and dry weather periods; additional plots, including average dissolved oxygen (DO), percent DO saturation, and pH/percent DO saturation.

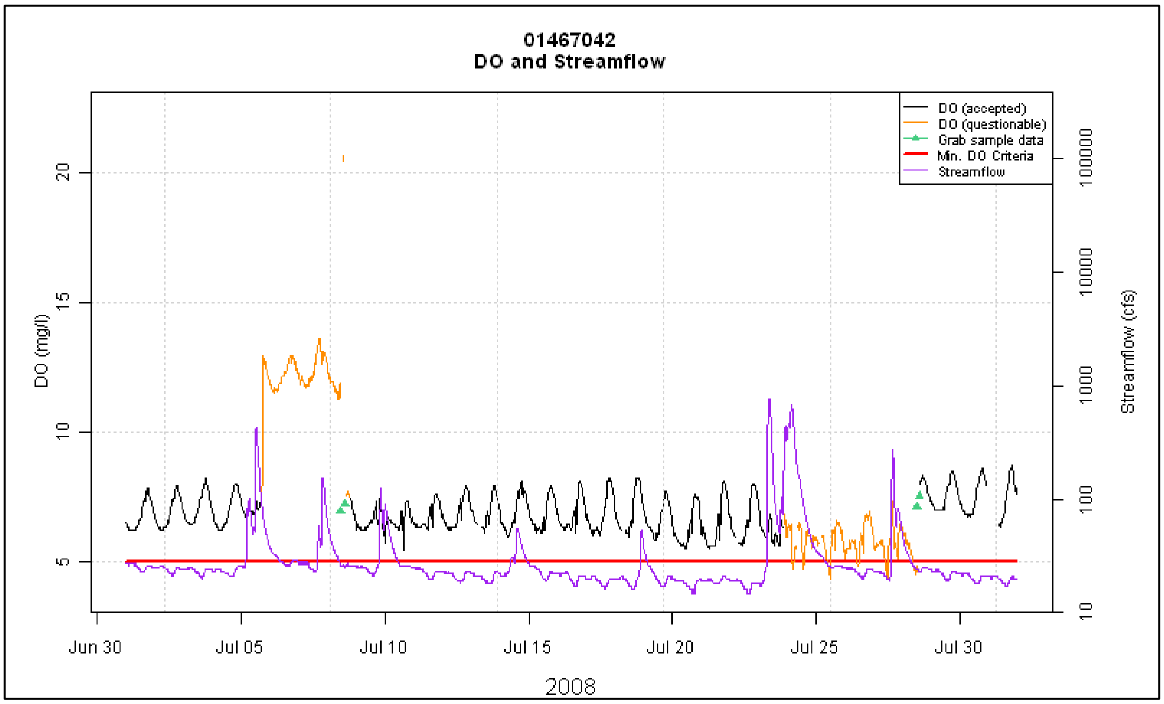



**Figure B.2 Example of an R-generated plot showing accepted and questionable data, and minimum water quality criteria; Gage 01467042, Dissolved Oxygen, July 2008.**

# APPENDIX D:

## Rejected Sample Data

# Rejected Sample Data

This section pertains to the QA/QC process applied to 2008-2009 water quality data that was collected via grab samples and ISCO automated sampling equipment. Of the 35 rejected samples, 34 were rejected on the basis of being nonvalid (e.g., dissolved Fe >> total Fe), and 1 sample was rejected as a clear outlier.

| Site | Parameter | Value | Units | DateTime | Weather | Flag |
|---|---|---|---|---|---|---|
| PQ050 | Zinc | 0.007 | mg/L | 7/31/2008 10:00 | dry | Nonvalid |
| PQ050 | Dissolved Zinc | 0.01 | mg/L | 7/31/2008 10:00 | dry | Nonvalid |
| PQ395 | Zinc | 0.012 | mg/L | 1/9/2008 10:00 | dry | Nonvalid |
| PQ395 | Dissolved Zinc | 0.02 | mg/L | 1/9/2008 10:00 | dry | Nonvalid |
| PQ395 | Lead Dissolved | 0.007 | mg/L | 7/31/2008 10:05 | dry | outlier |
| PQ395 | Zinc | 0.003 | mg/L | 7/31/2008 10:05 | dry | Nonvalid |
| PQ395 | Dissolved Zinc | 0.01 | mg/L | 7/31/2008 10:05 | dry | Nonvalid |
| PQ820 | Iron | 0.057 | mg/L | 7/31/2008 11:15 | dry | Nonvalid |
| PQ820 | Dissolved Iron | 0.179 | mg/L | 7/31/2008 11:15 | dry | Nonvalid |
| PQB025 | Zinc | 0.013 | mg/L | 7/31/2008 11:20 | dry | Nonvalid |
| PQB025 | Dissolved Zinc | 0.017 | mg/L | 7/31/2008 11:20 | dry | Nonvalid |
| PQB025 | Zinc | 0.012 | mg/L | 8/27/2008 12:40 | dry | Nonvalid |
| PQB025 | Dissolved Zinc | 0.02 | mg/L | 8/27/2008 12:40 | dry | Nonvalid |
| PQB305 | Zinc | 0.019 | mg/L | 7/31/2008 10:55 | dry | Nonvalid |
| PQB305 | Dissolved Zinc | 0.023 | mg/L | 7/31/2008 10:55 | dry | Nonvalid |
| PQ050 | Zinc | 0.014 | mg/L | 8/6/2008 10:10 | wet | Nonvalid |
| PQ050 | Dissolved Zinc | 0.026 | mg/L | 8/6/2008 10:10 | wet | Nonvalid |
| PQ050 | TSS | 395 | mg/L | 9/6/2008 18:51 | wet | Nonvalid |
| PQ050 | Total Solids | 348 | mg/L | 9/6/2008 18:51 | wet | Nonvalid |
| PQ050 | Zinc | 0.022 | mg/L | 9/7/2008 9:10 | wet | Nonvalid |
| PQ050 | Dissolved Zinc | 0.039 | mg/L | 9/7/2008 9:10 | wet | Nonvalid |
| PQ665 | TSS | 926 | mg/L | 9/6/2008 20:56 | wet | Nonvalid |
| PQ665 | Total Solids | 370 | mg/L | 9/6/2008 20:56 | wet | Nonvalid |
| PQ665 | Copper | 0.008 | mg/L | 10/26/2008 10:15 | wet | Nonvalid |
| PQ665 | Dissolved Copper | 0.016 | mg/L | 10/26/2008 10:15 | wet | Nonvalid |
| PQB025 | TSS | 256 | mg/L | 9/6/2008 15:10 | wet | Nonvalid |
| PQB025 | Total Solids | 217 | mg/L | 9/6/2008 15:10 | wet | Nonvalid |
| PQB025 | TSS | 277 | mg/L | 9/6/2008 15:40 | wet | Nonvalid |
| PQB025 | Total Solids | 227 | mg/L | 9/6/2008 15:40 | wet | Nonvalid |
| PQB025 | TSS | 190 | mg/L | 9/6/2008 18:41 | wet | Nonvalid |
| PQB025 | Total Solids | 111 | mg/L | 9/6/2008 18:41 | wet | Nonvalid |
| PQB025 | TSS | 246 | mg/L | 10/26/2008 0:51 | wet | Nonvalid |
| PQB025 | Total Solids | 200 | mg/L | 10/26/2008 0:51 | wet | Nonvalid |
| PQB025 | Zinc | 0.03 | mg/L | 10/26/2008 9:50 | wet | Nonvalid |
| PQB025 | Dissolved Zinc | 0.035 | mg/L | 10/26/2008 9:50 | wet | Nonvalid |

# APPENDIX E:

## Continuous Dissolved Oxygen Plots

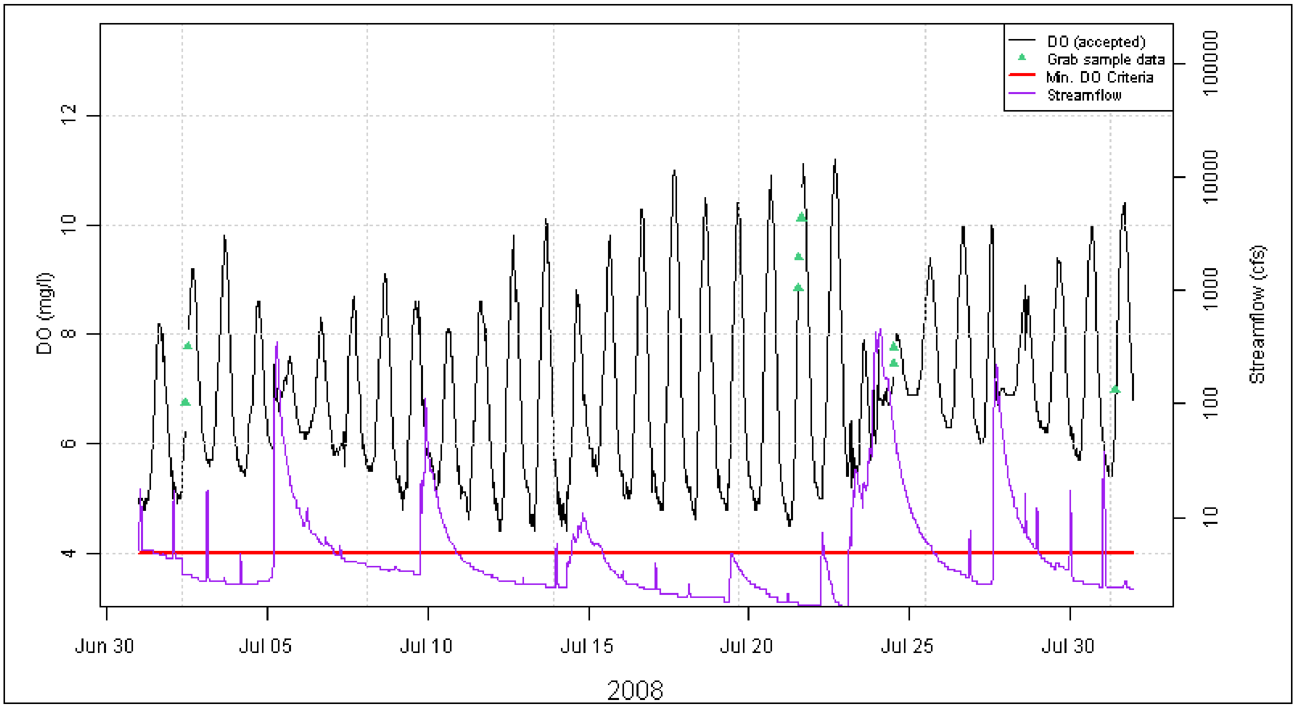



**Figure E.1 Dissolved Oxygen and Streamflow at Site PQ050, July 2008**

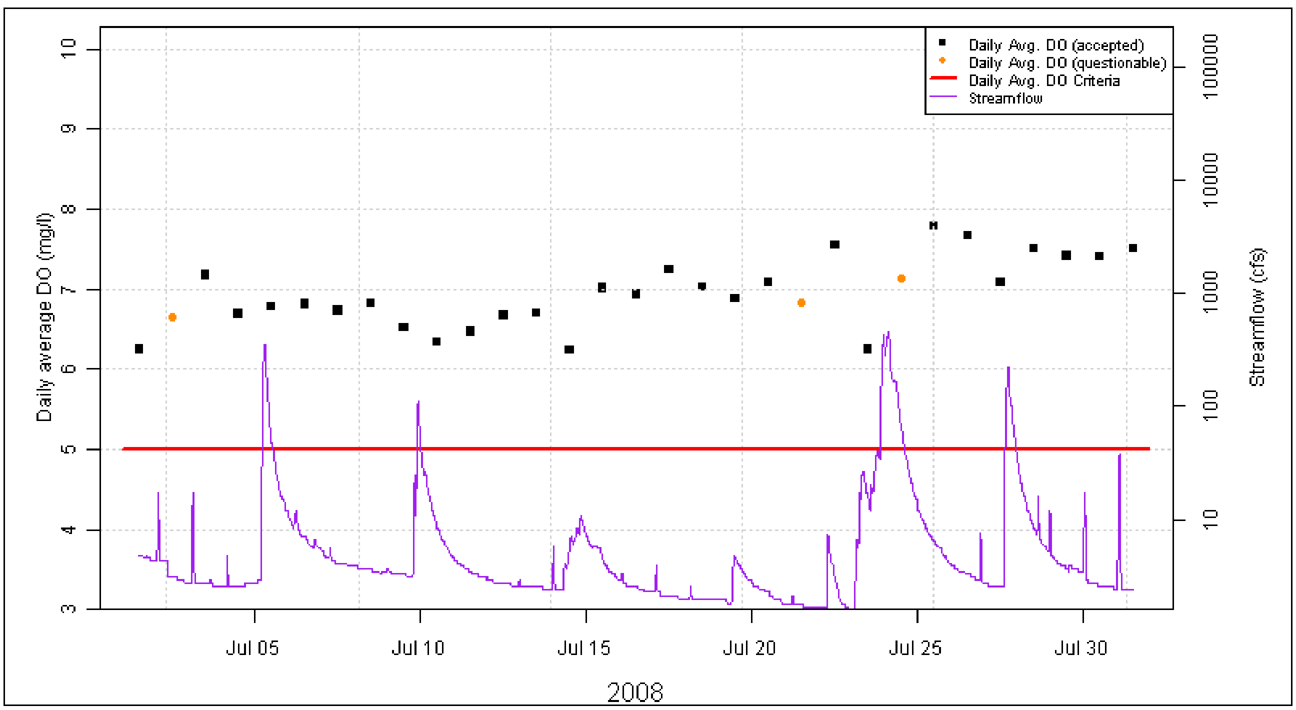



**Figure E.2 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, July 2008**

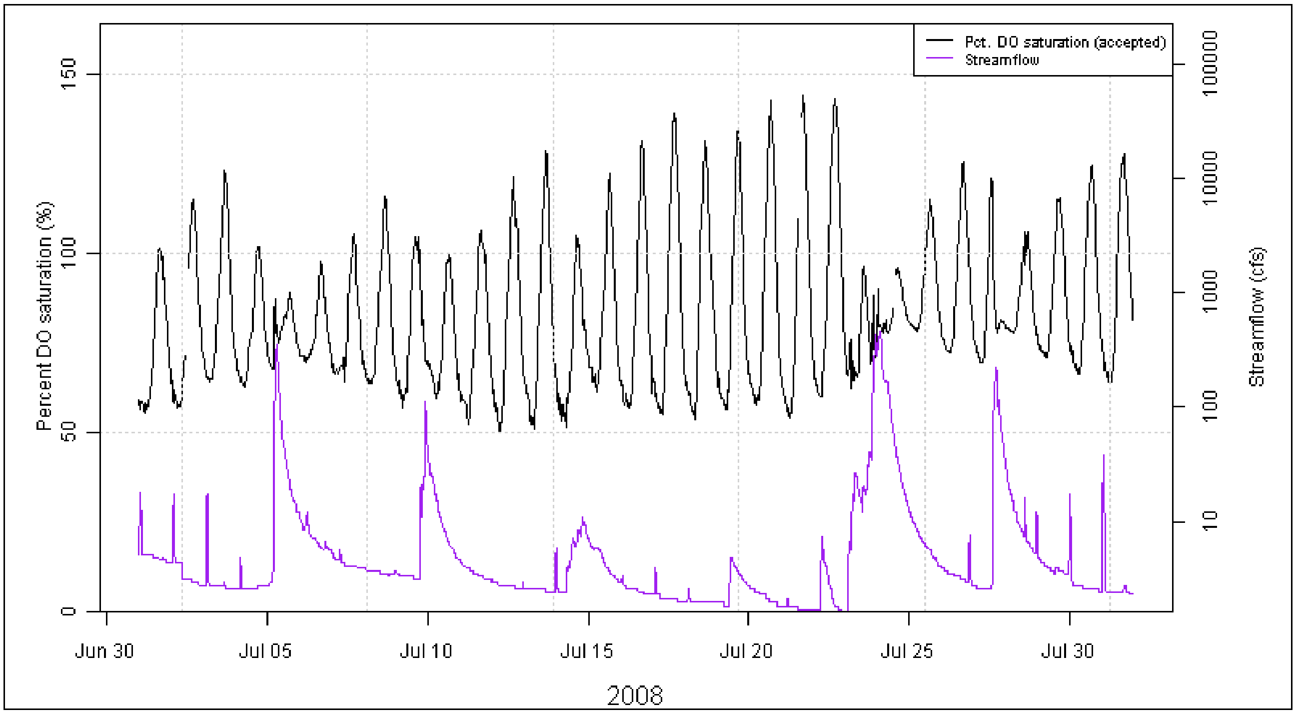



**Figure E.3 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, July 2008**

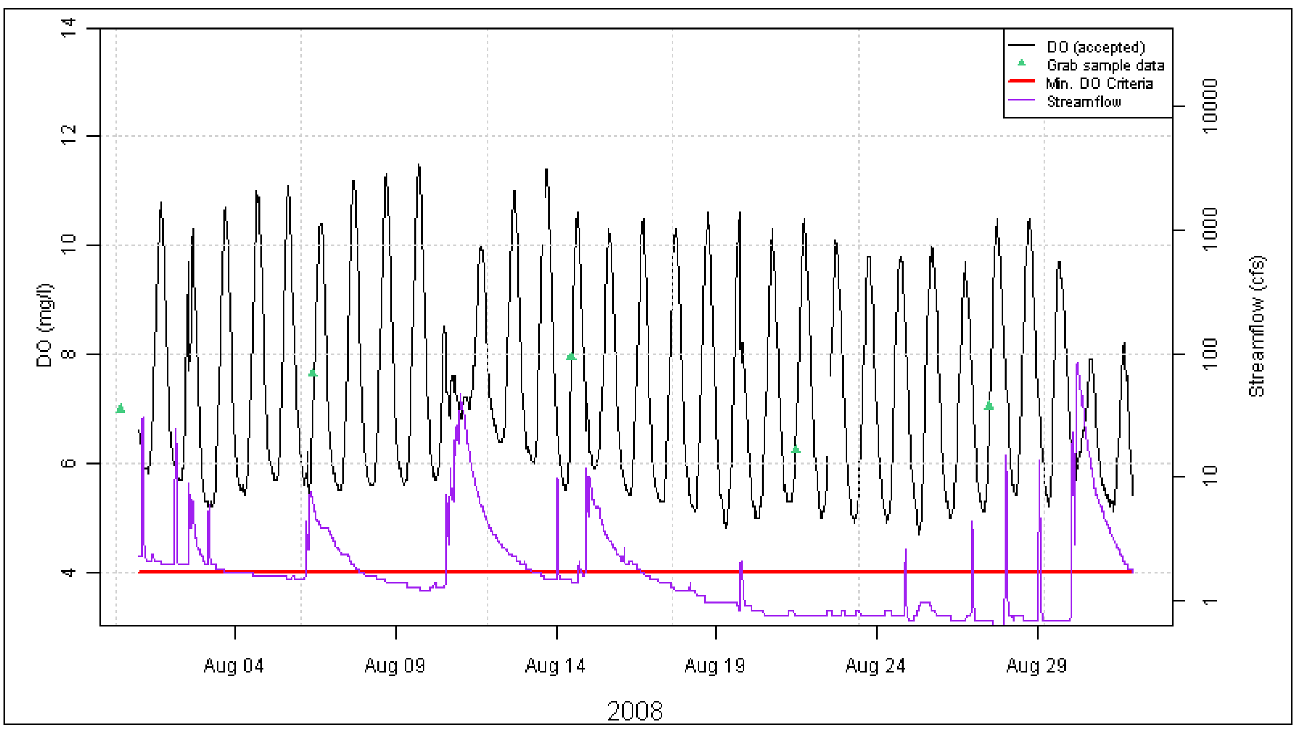



**Figure E.4 Dissolved Oxygen and Streamflow at Site PQ050, August 2008**

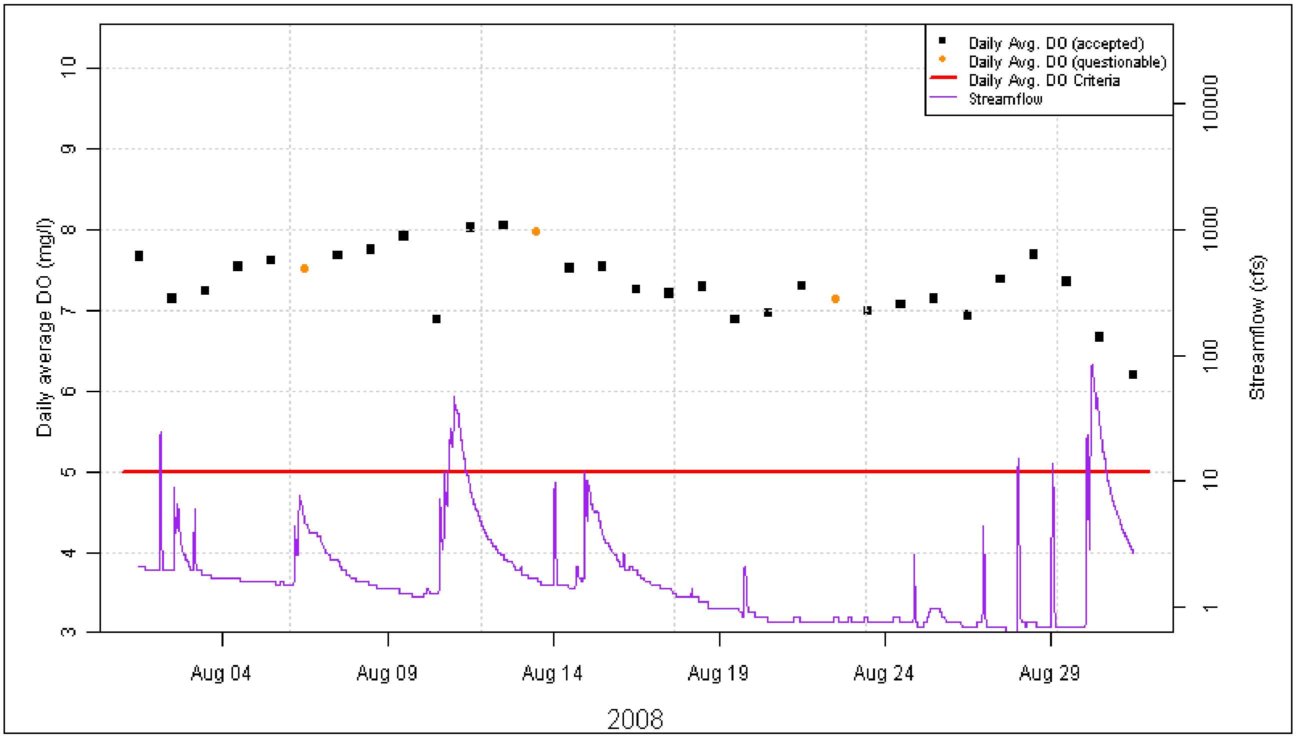



**Figure E.5 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, August 2008**

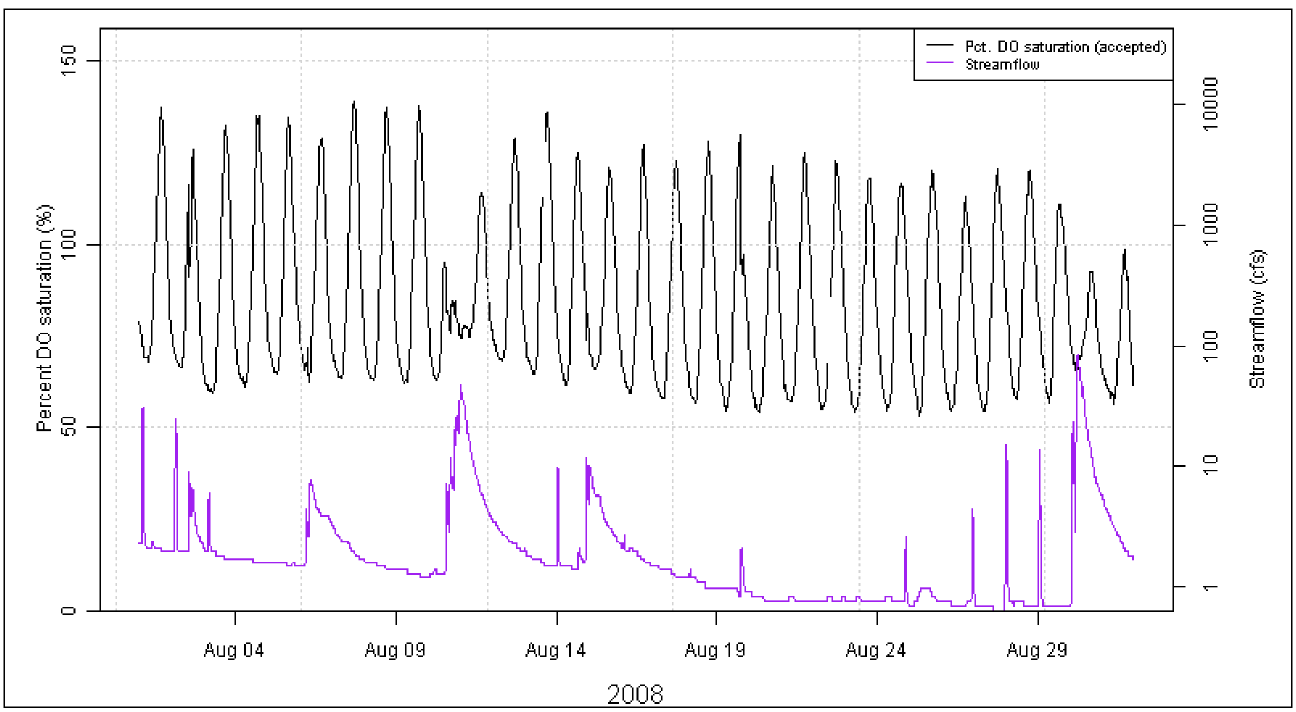



**Figure E.6 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, August 2008**

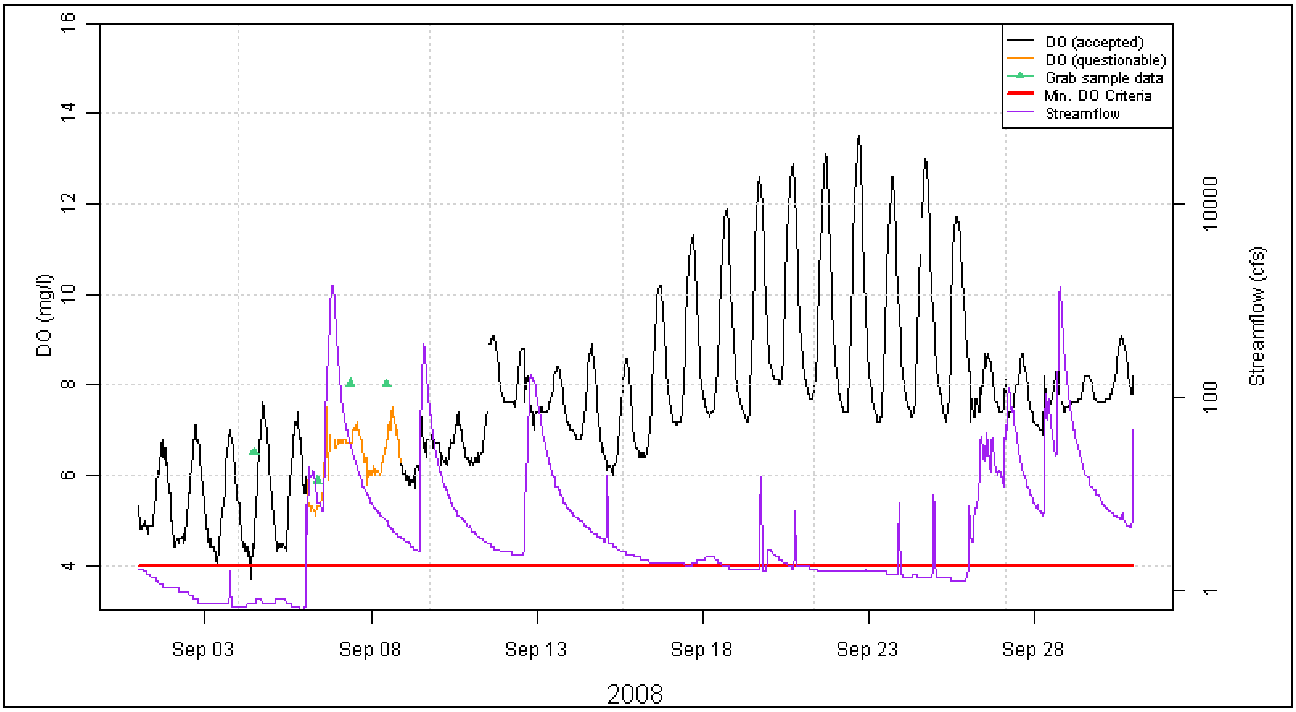



**Figure E.7 Dissolved Oxygen and Streamflow at Site PQ050, September 2008**

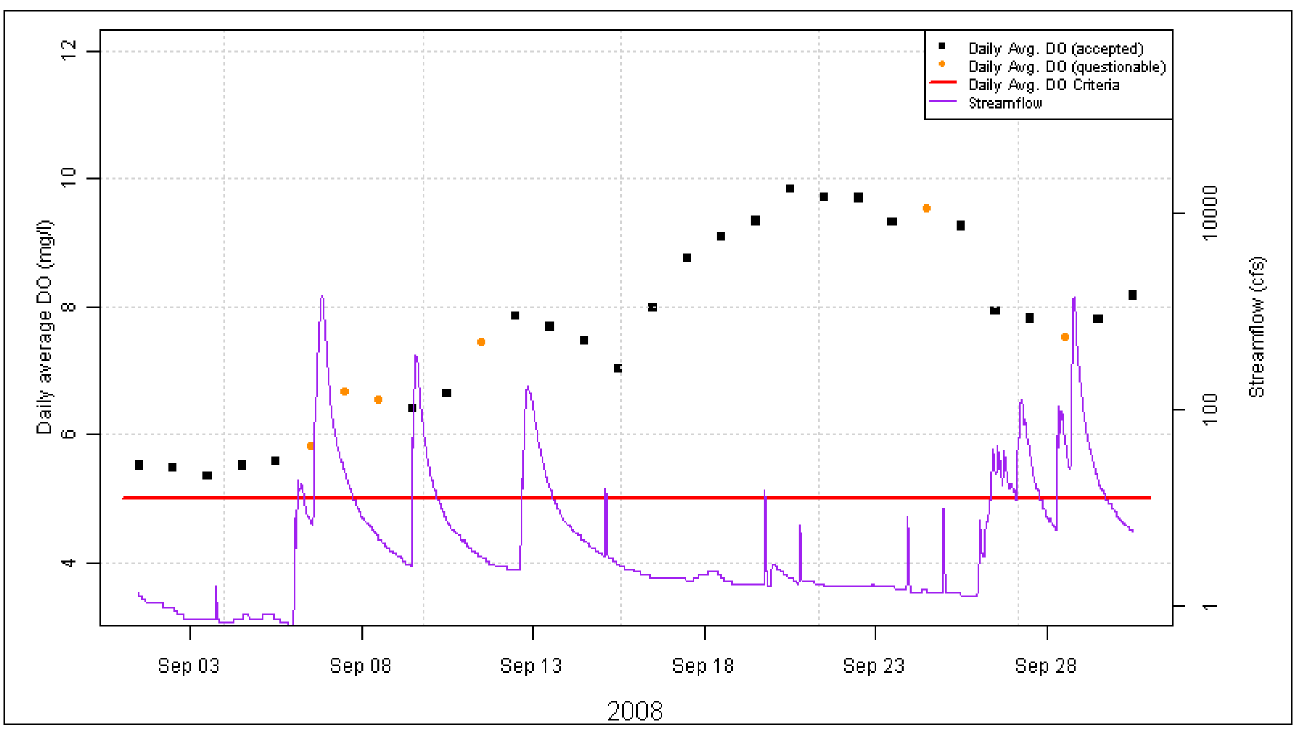



**Figure E.8 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, September 2008**

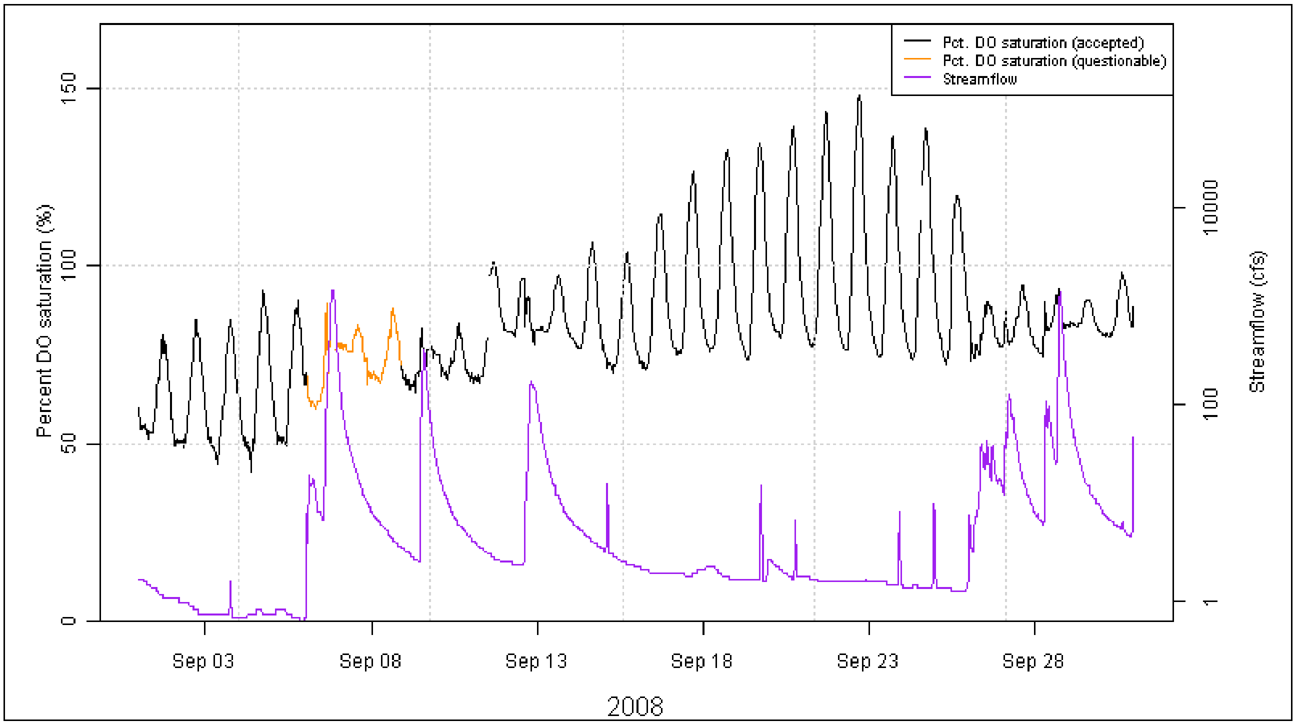



**Figure E.9 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, September 2008**

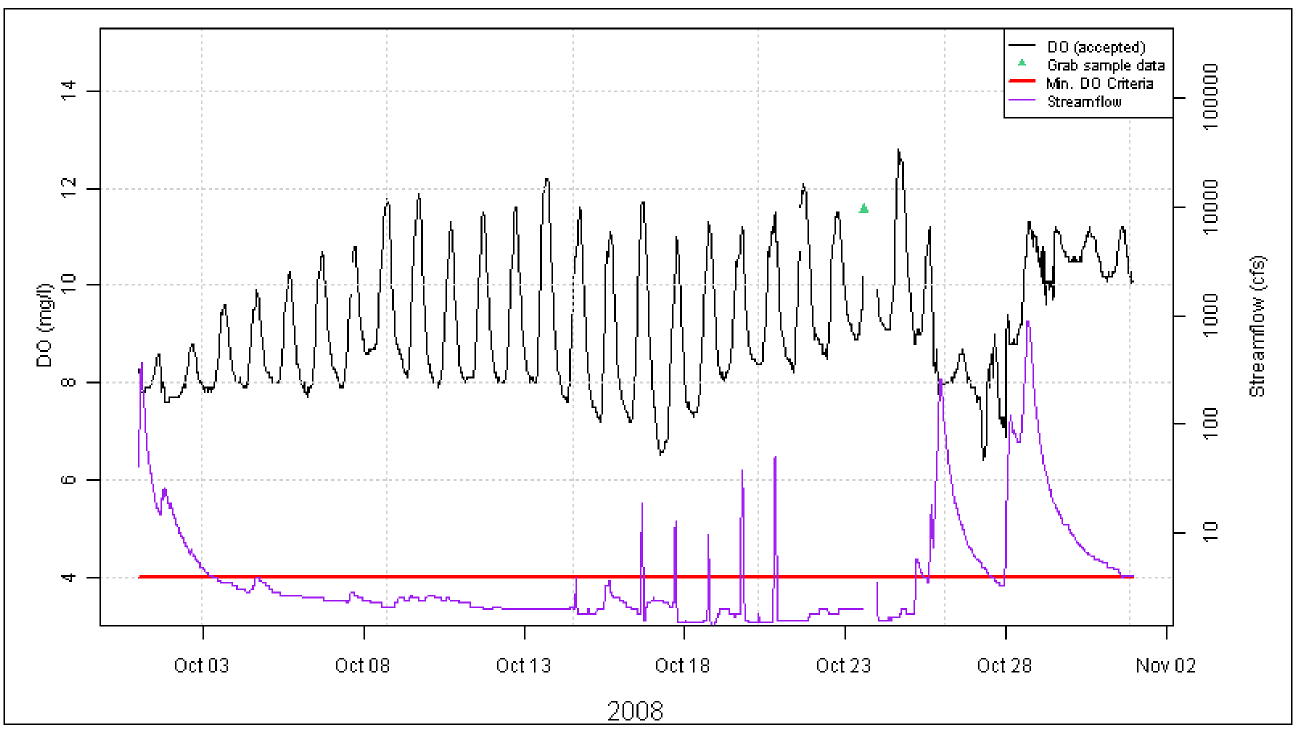



**Figure E.10 Dissolved Oxygen and Streamflow at Site PQ050, October 2008**

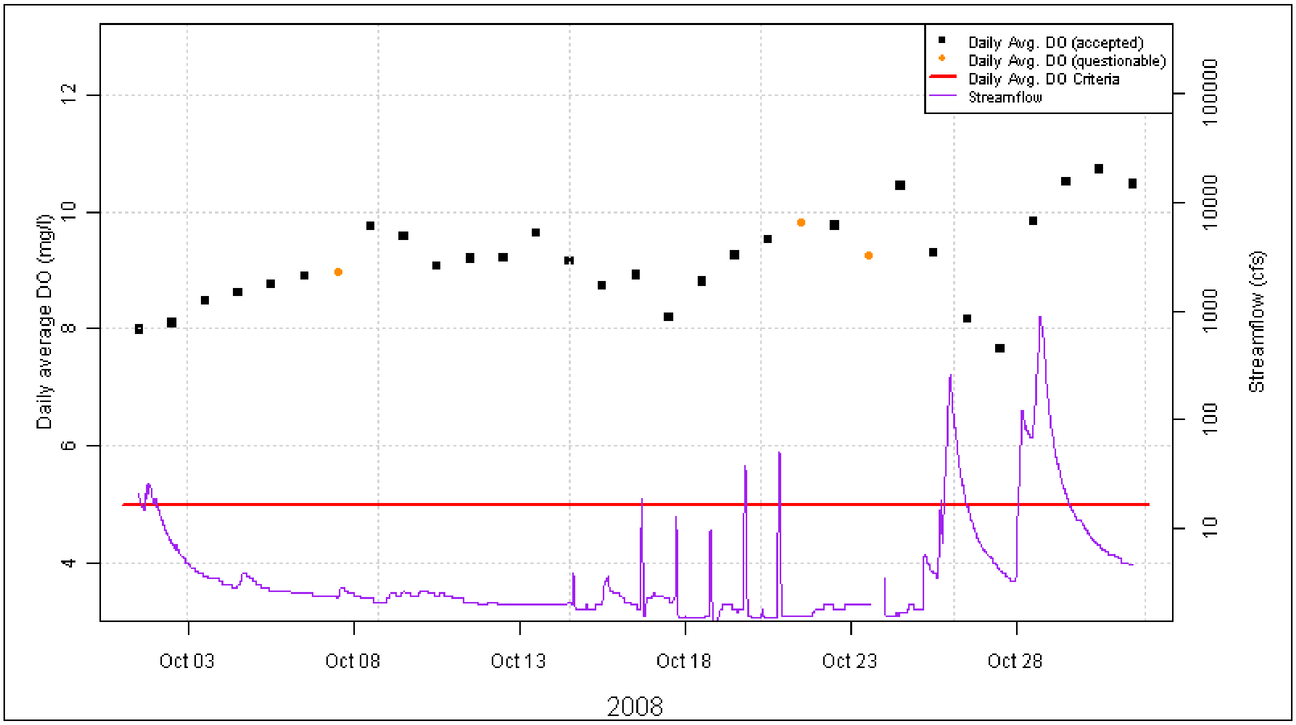



**Figure E.11 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, October 2008**

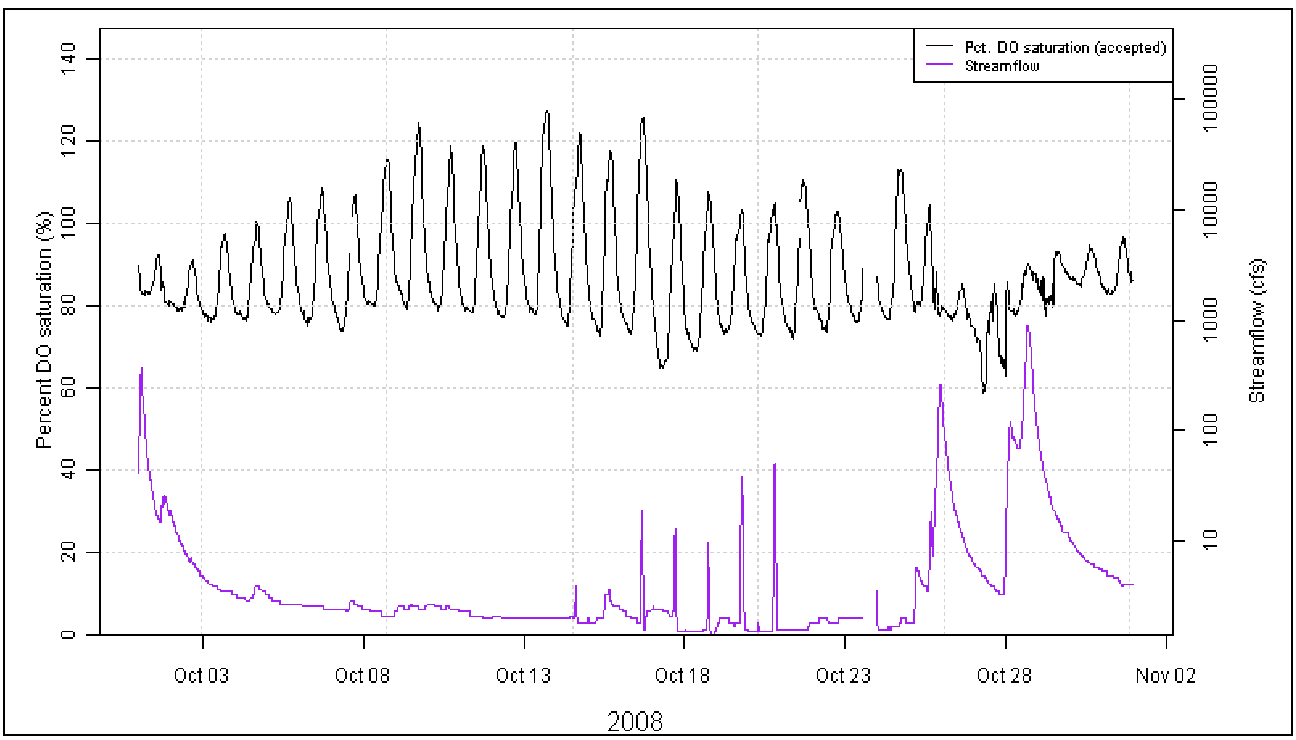



**Figure E.12 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, October 2008**

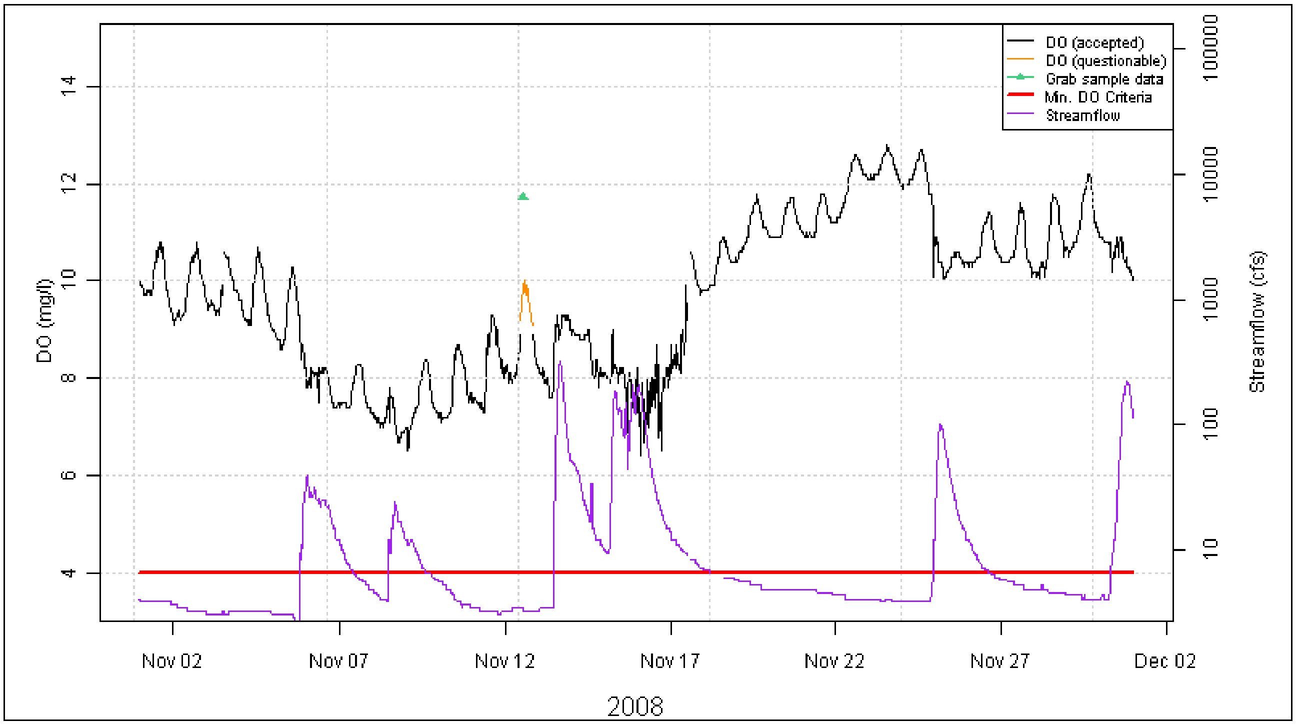



**Figure E.13 Dissolved Oxygen and Streamflow at Site PQ050, November 2008**

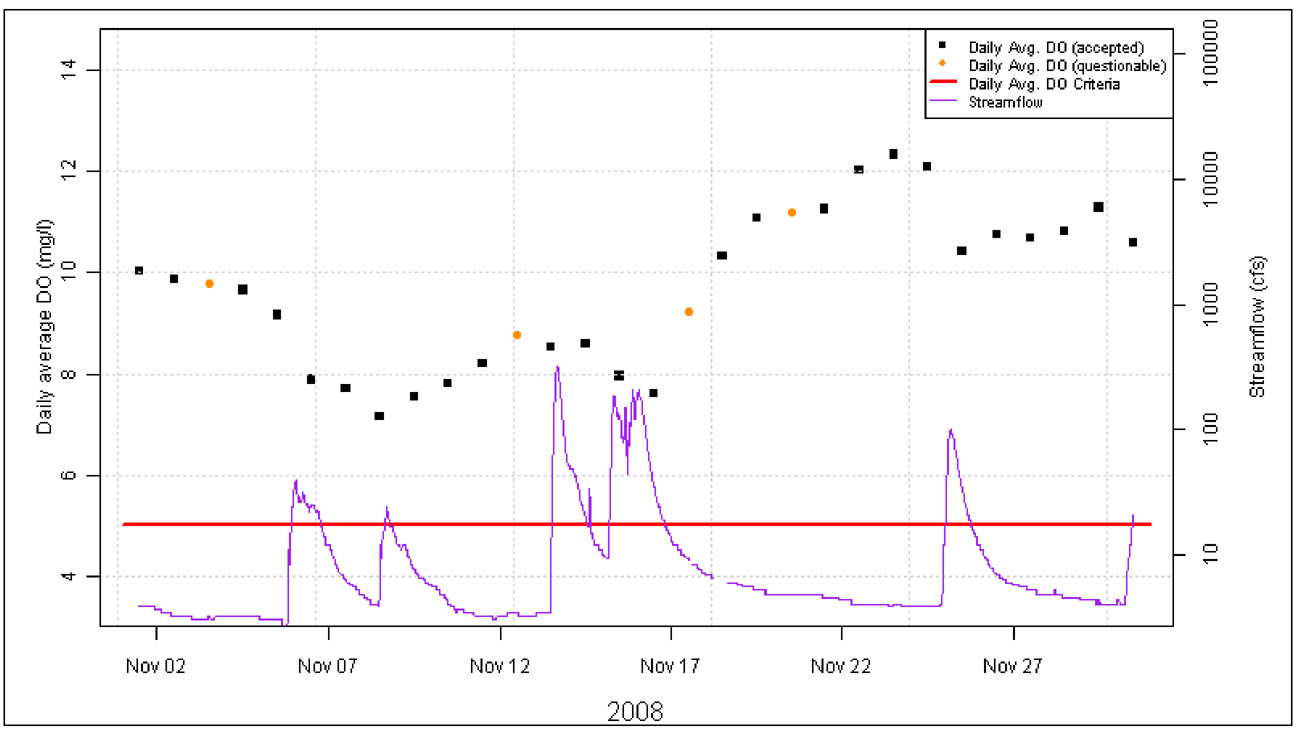



**Figure E.14 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, November 2008**

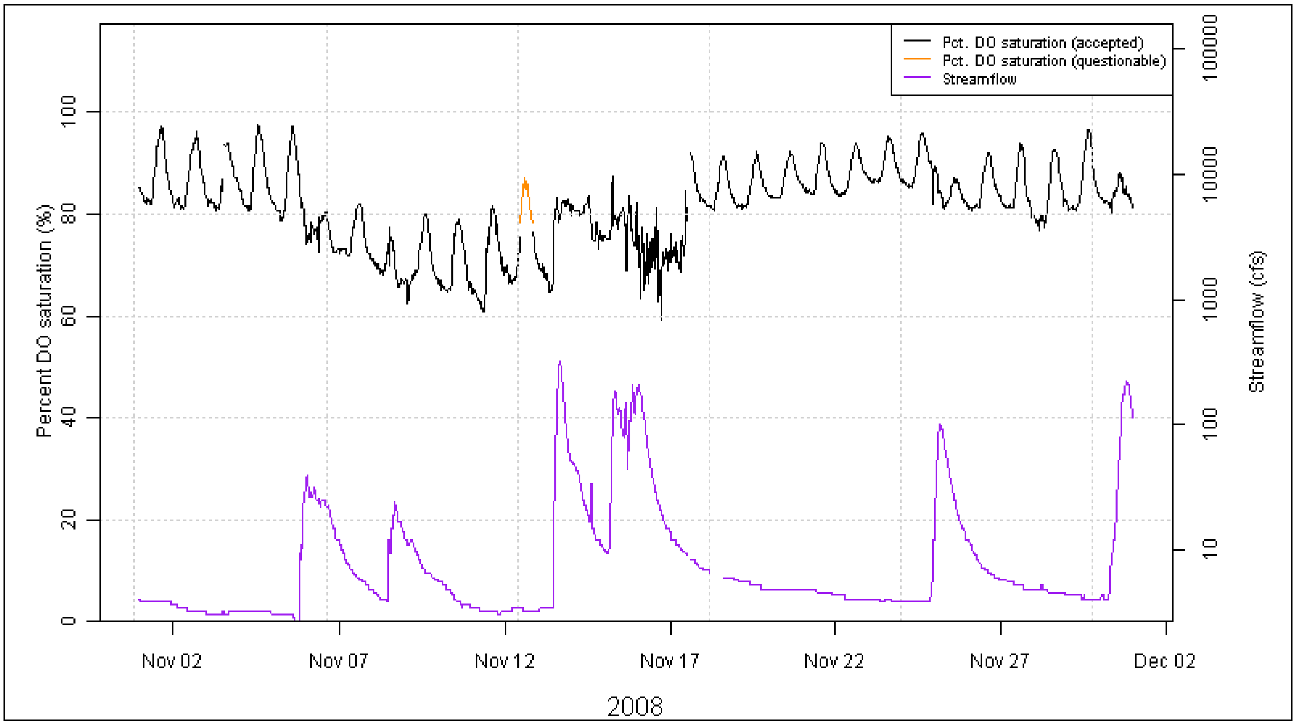



**Figure E.15 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, November 2008**

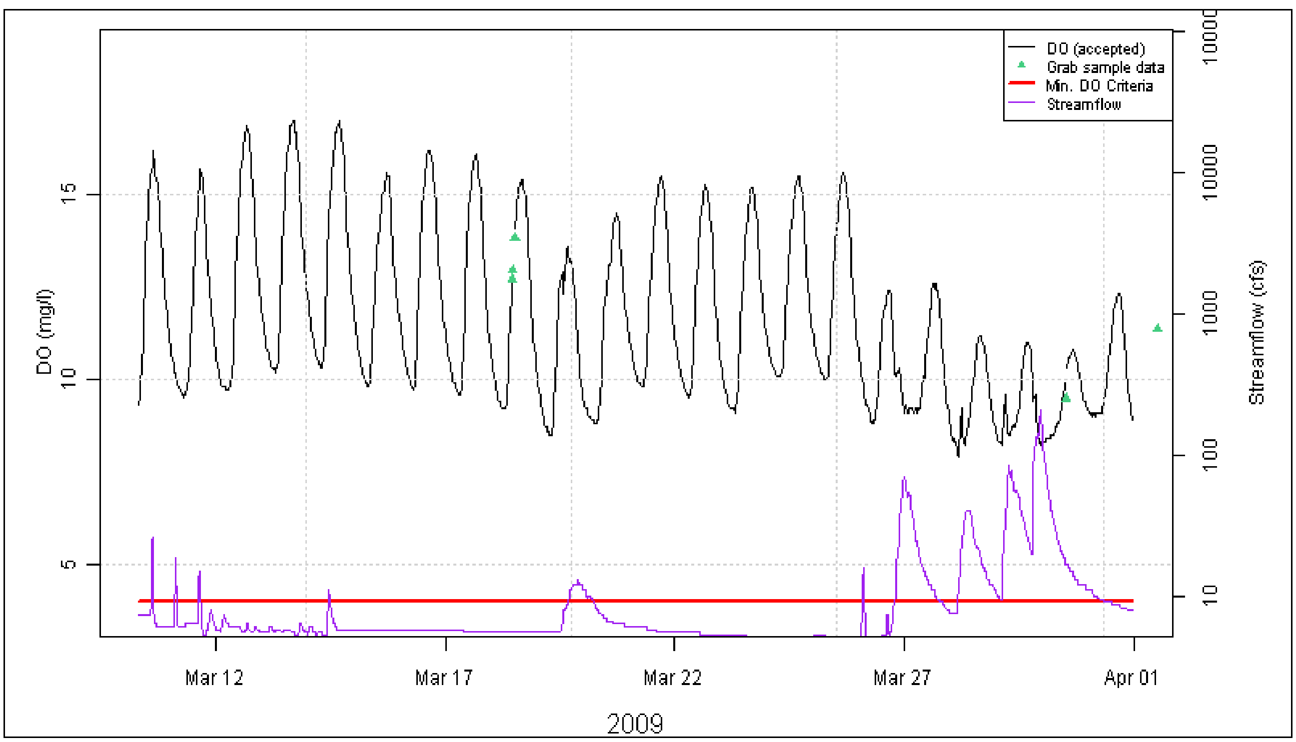



**Figure E.16 Dissolved Oxygen and Streamflow at Site PQ050, March 2009**

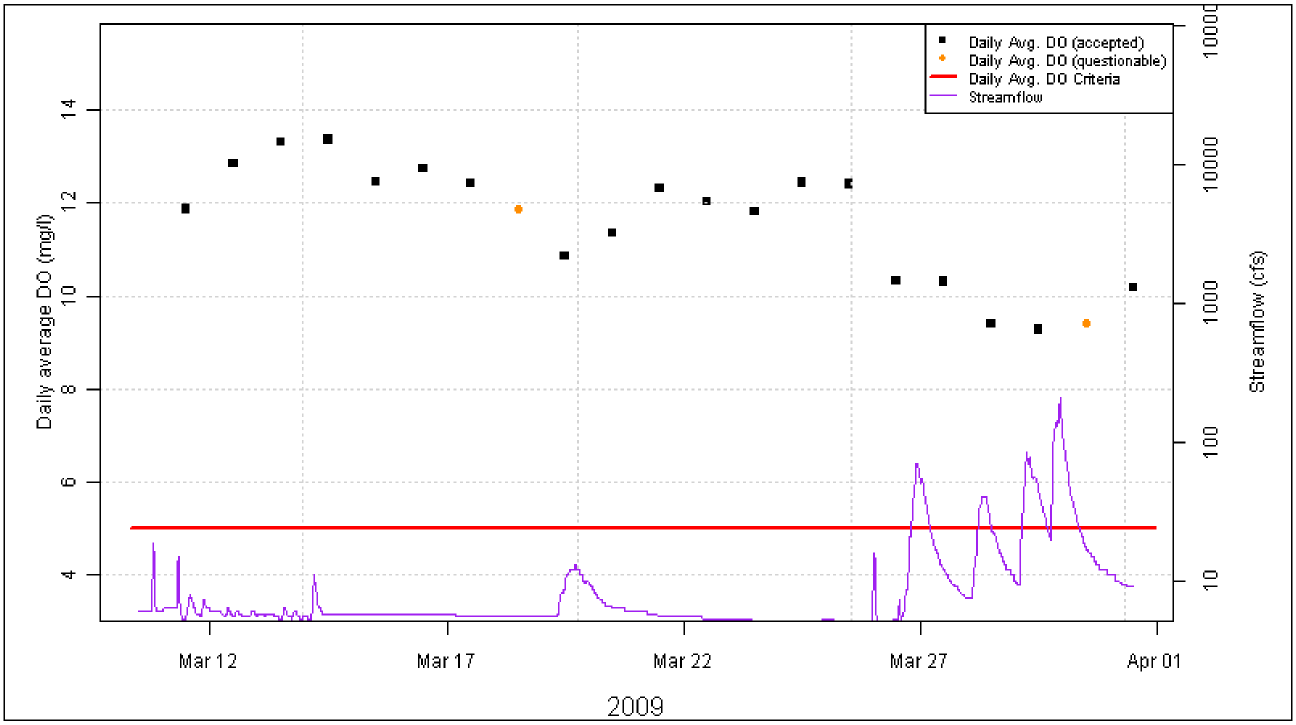



**Figure E.17 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, March 2009**

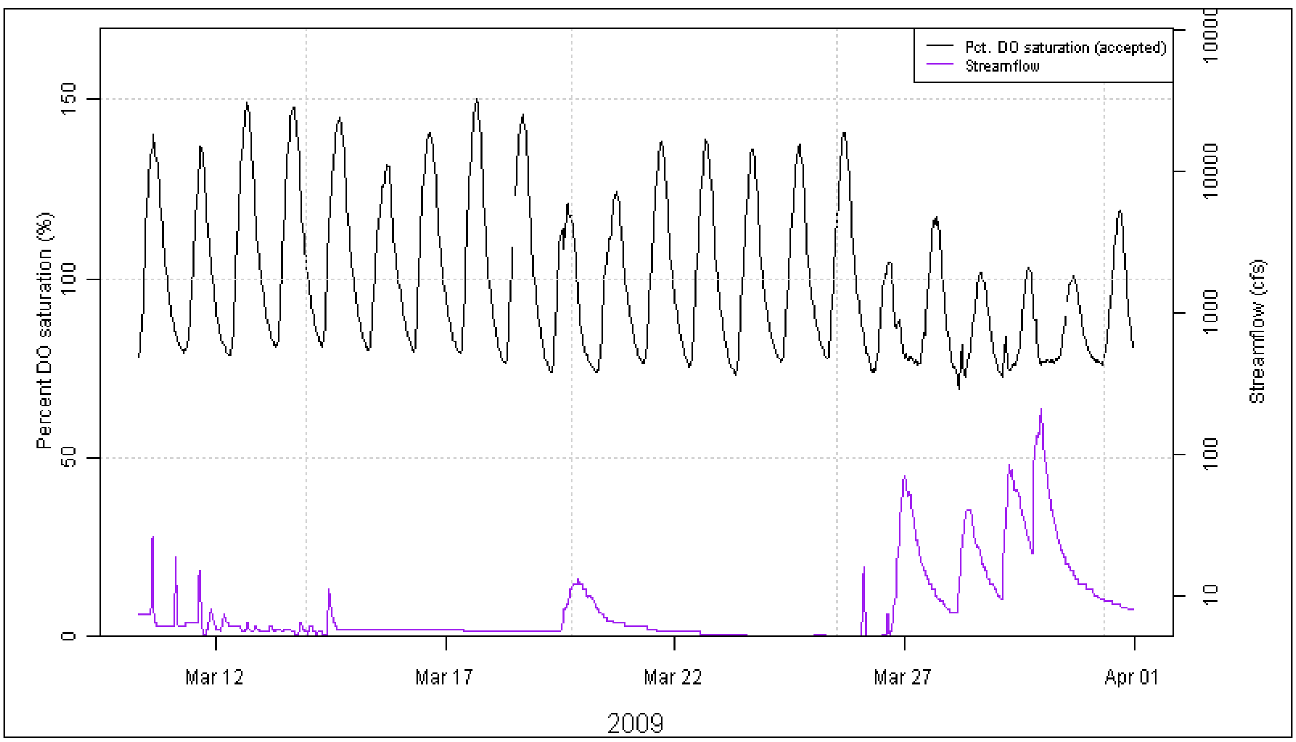



**Figure E.18 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, March 2009**

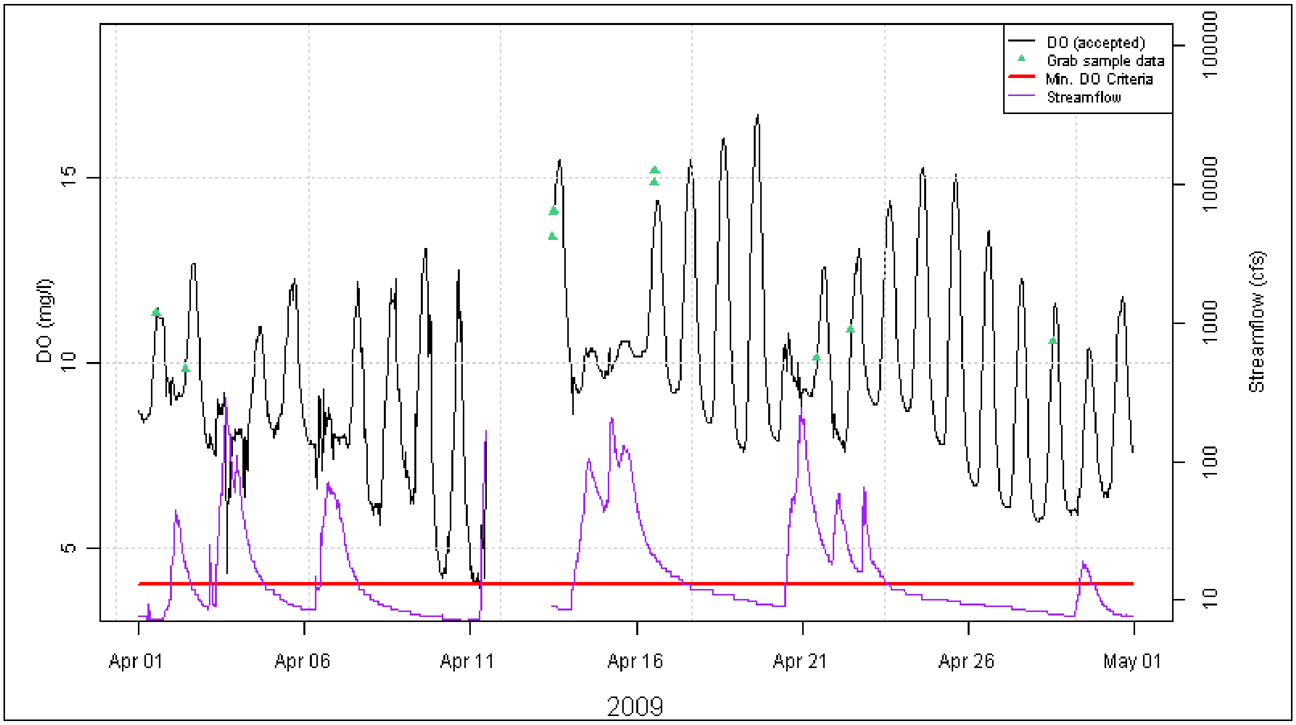



**Figure E.19 Dissolved Oxygen and Streamflow at Site PQ050, April 2009**

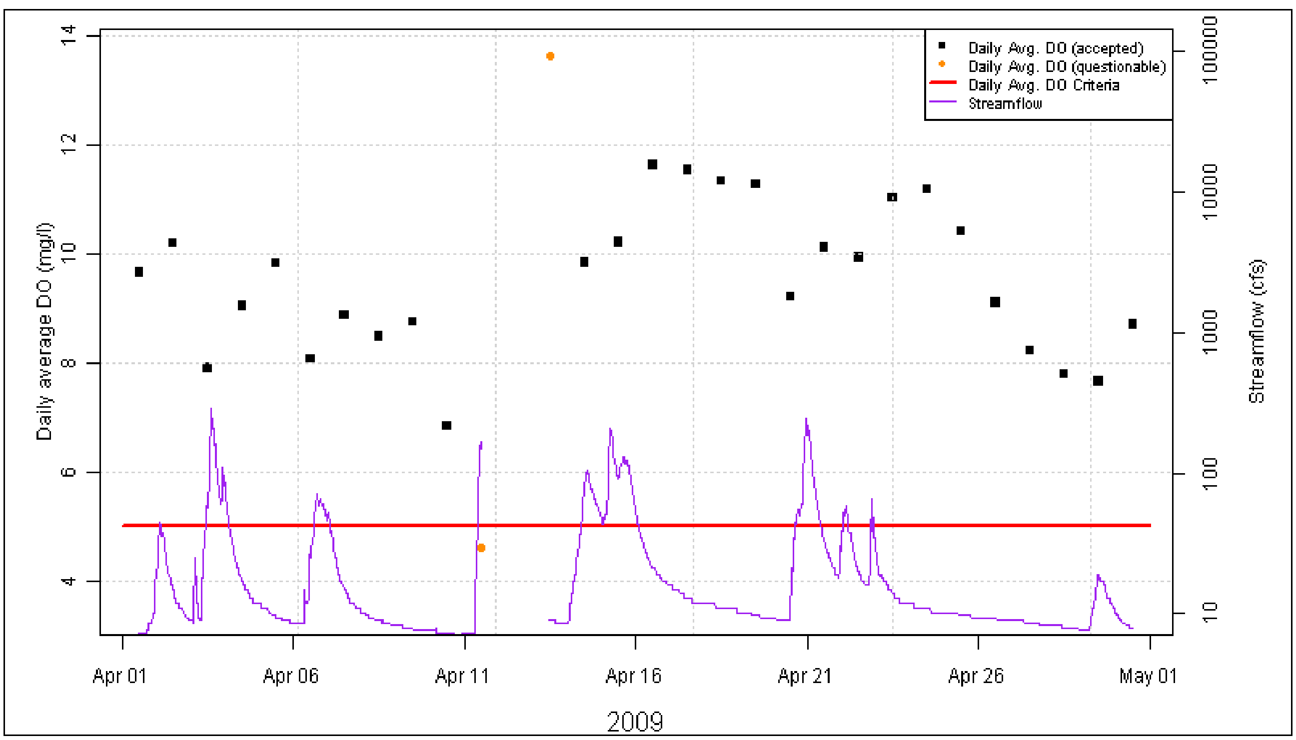



**Figure E.20 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, April 2009**

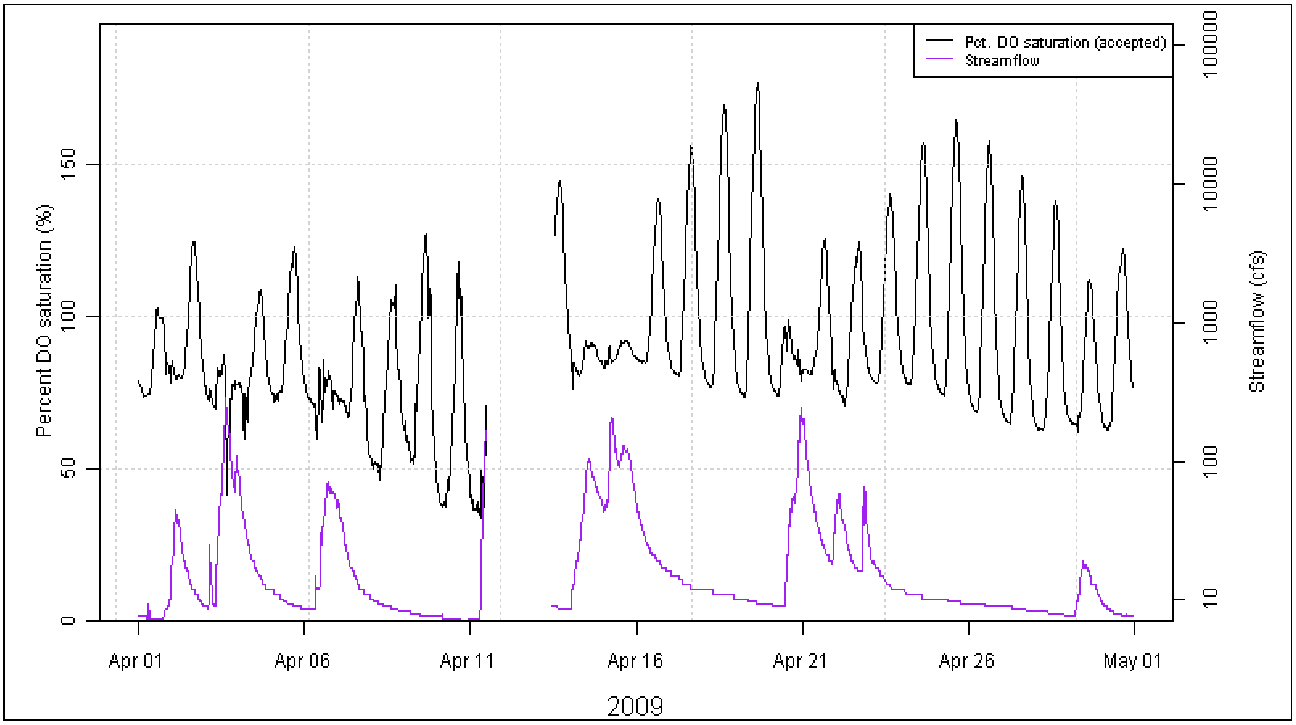



**Figure E.21 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, April 2009**

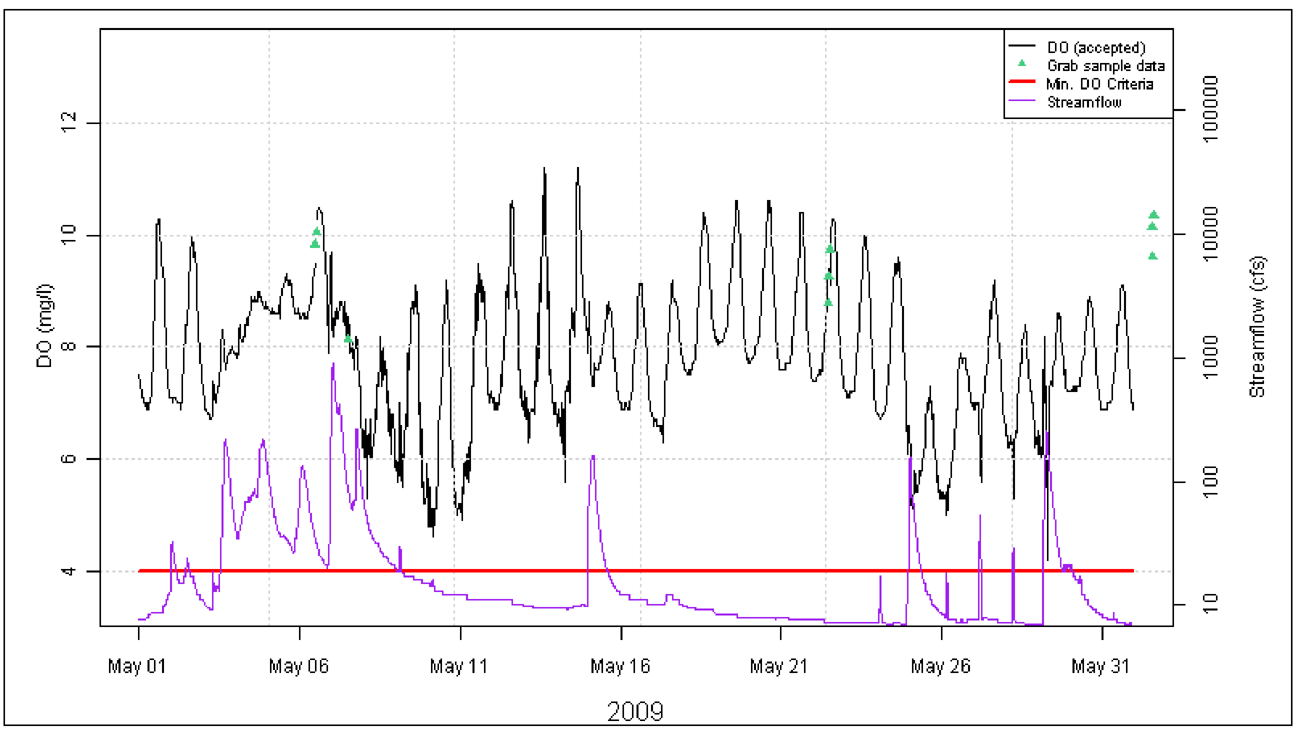



**Figure E.22 Dissolved Oxygen and Streamflow at Site PQ050, May 2009**

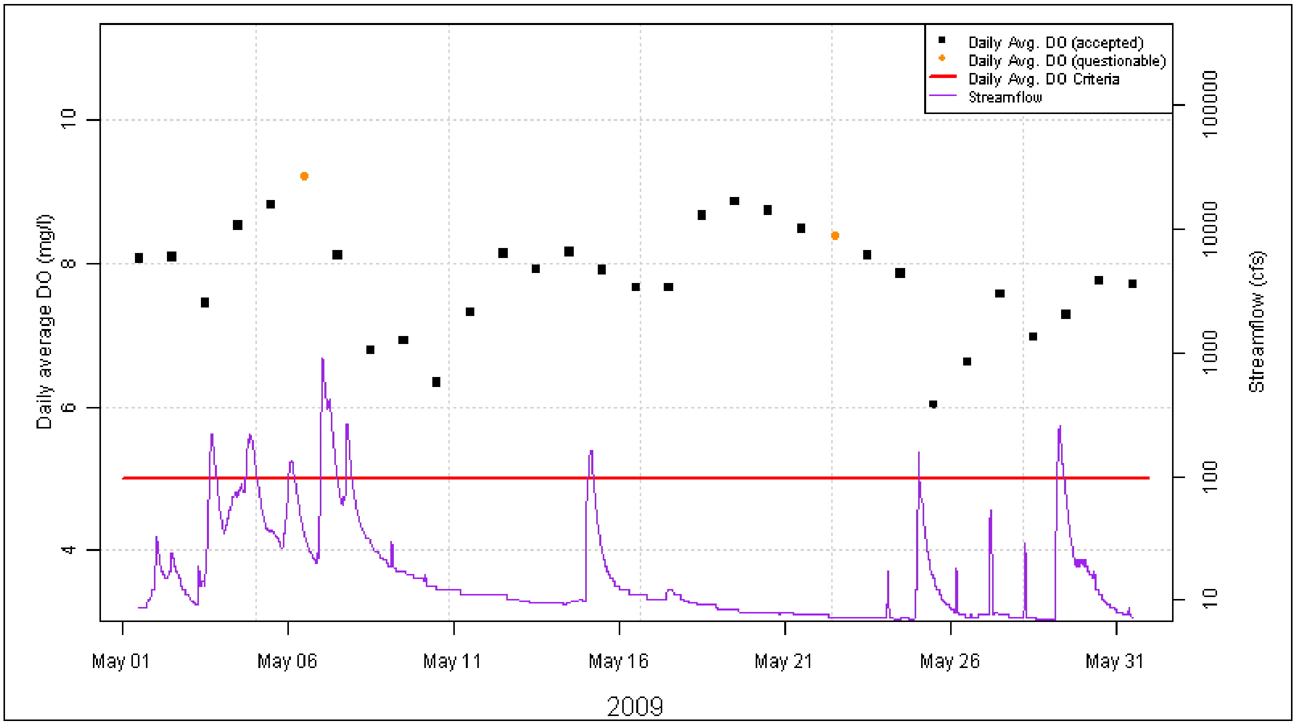



**Figure E.23 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, May 2009**

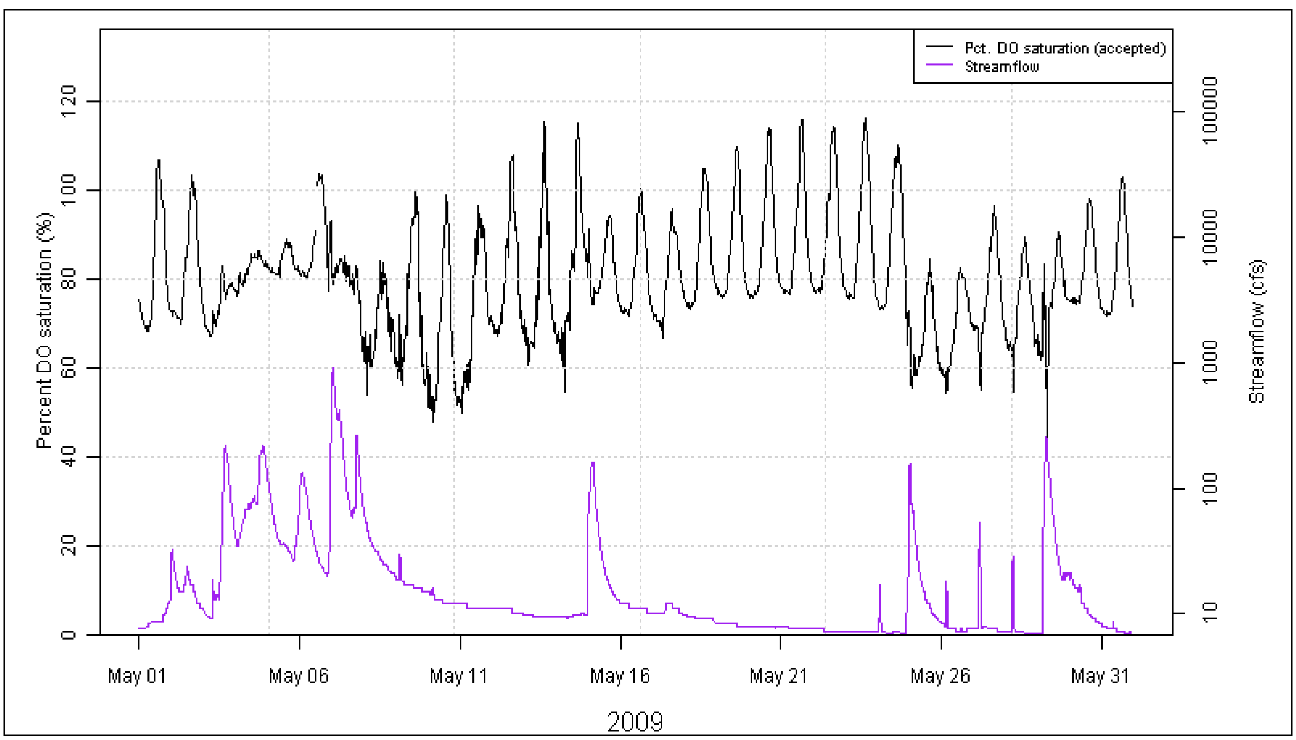



**Figure E.24 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, May 2009**

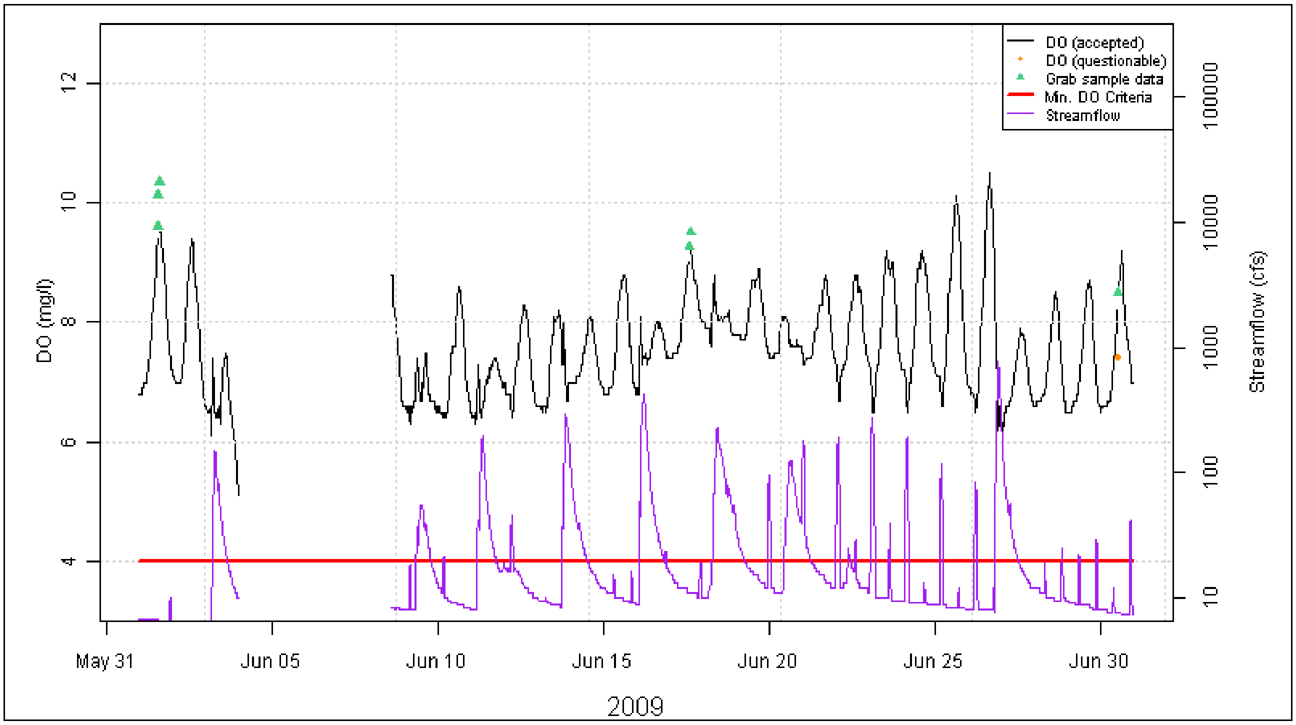



**Figure E.25 Dissolved Oxygen and Streamflow at Site PQ050, June 2009**

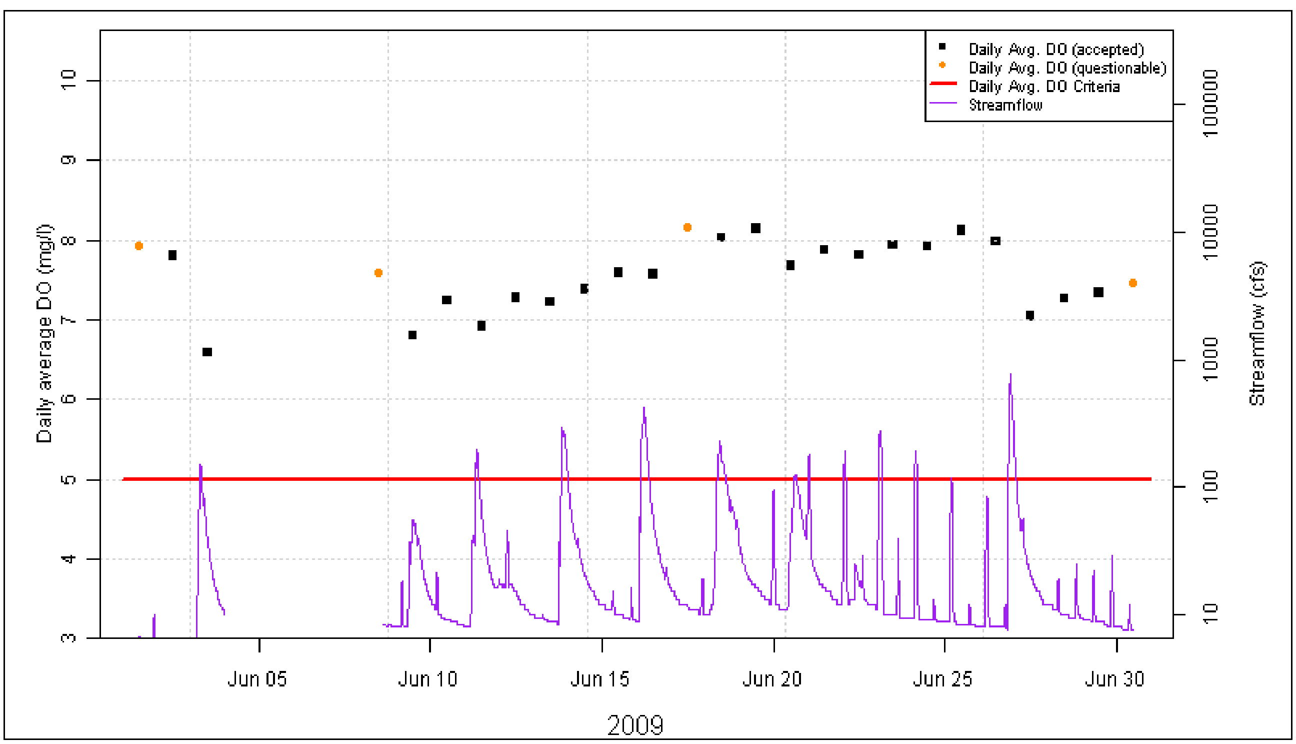



**Figure E.26 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, June 2009**

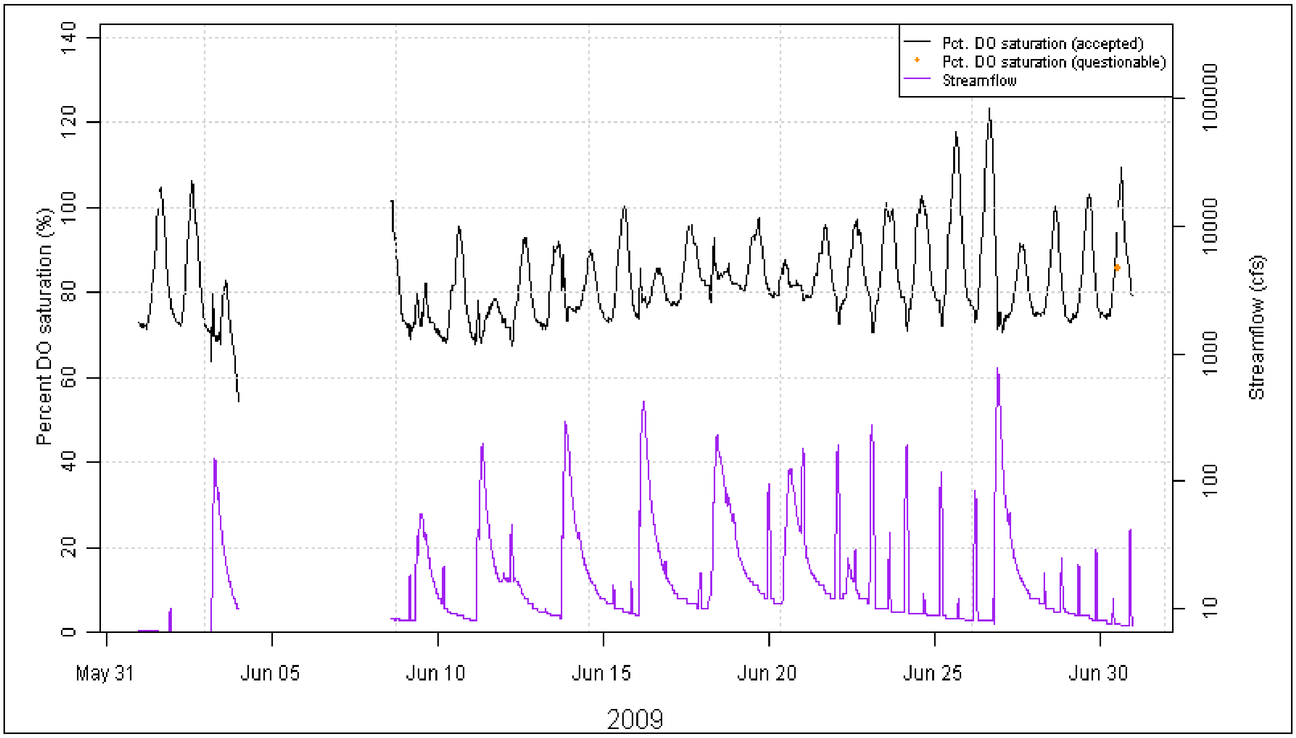



**Figure E.27 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, June 2009**

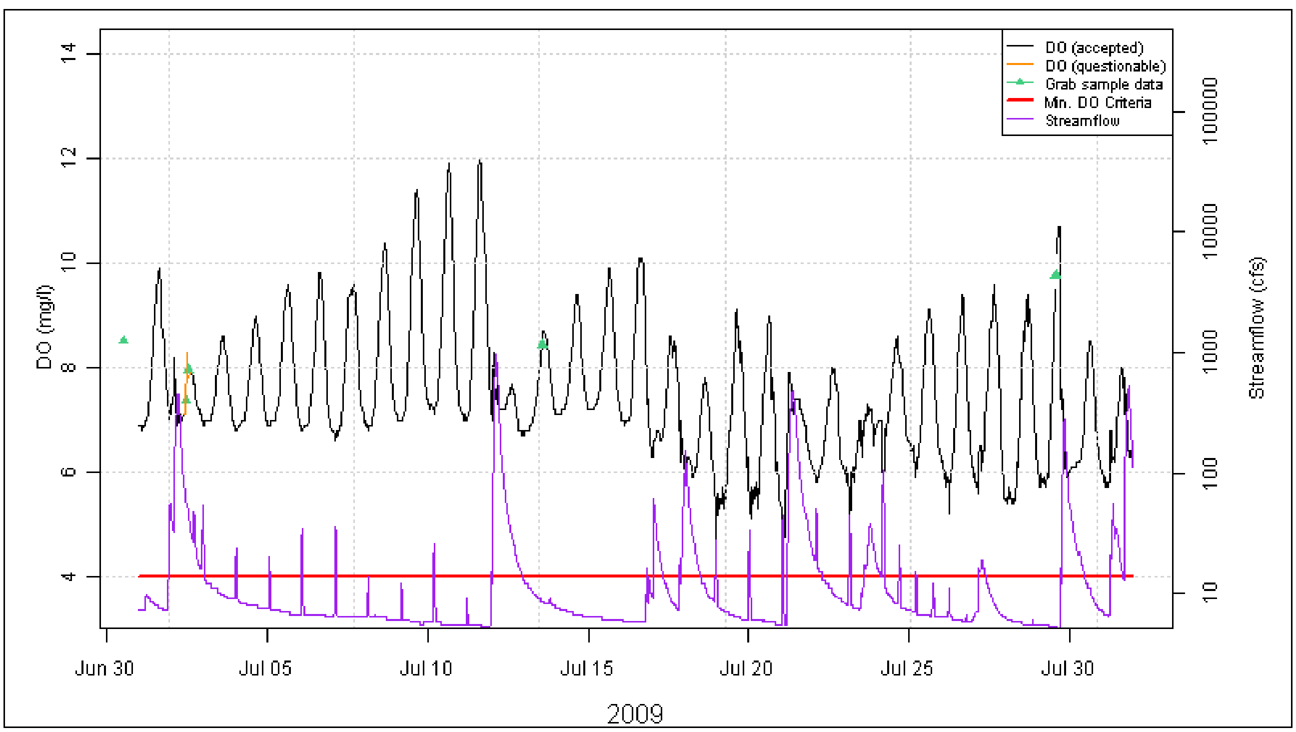



**Figure E.28 Dissolved Oxygen and Streamflow at Site PQ050, July 2009**

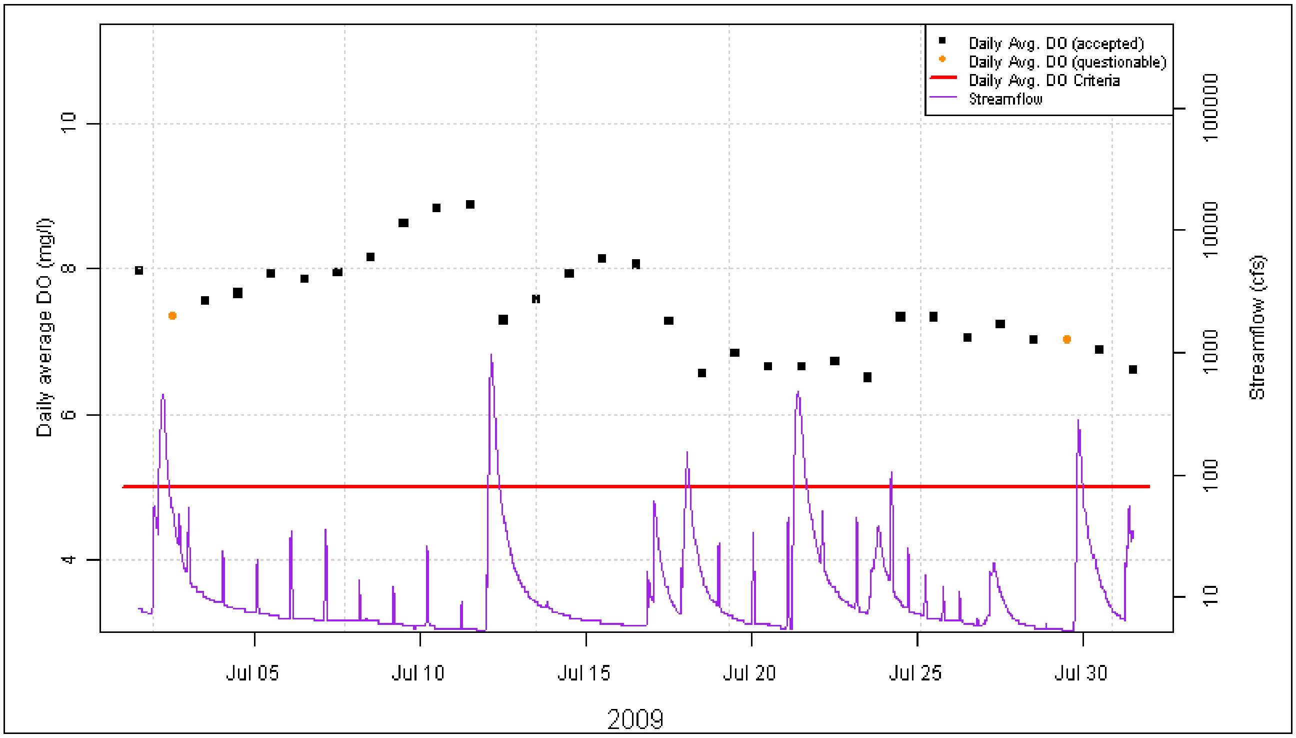



**Figure E.29 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, July 2009**

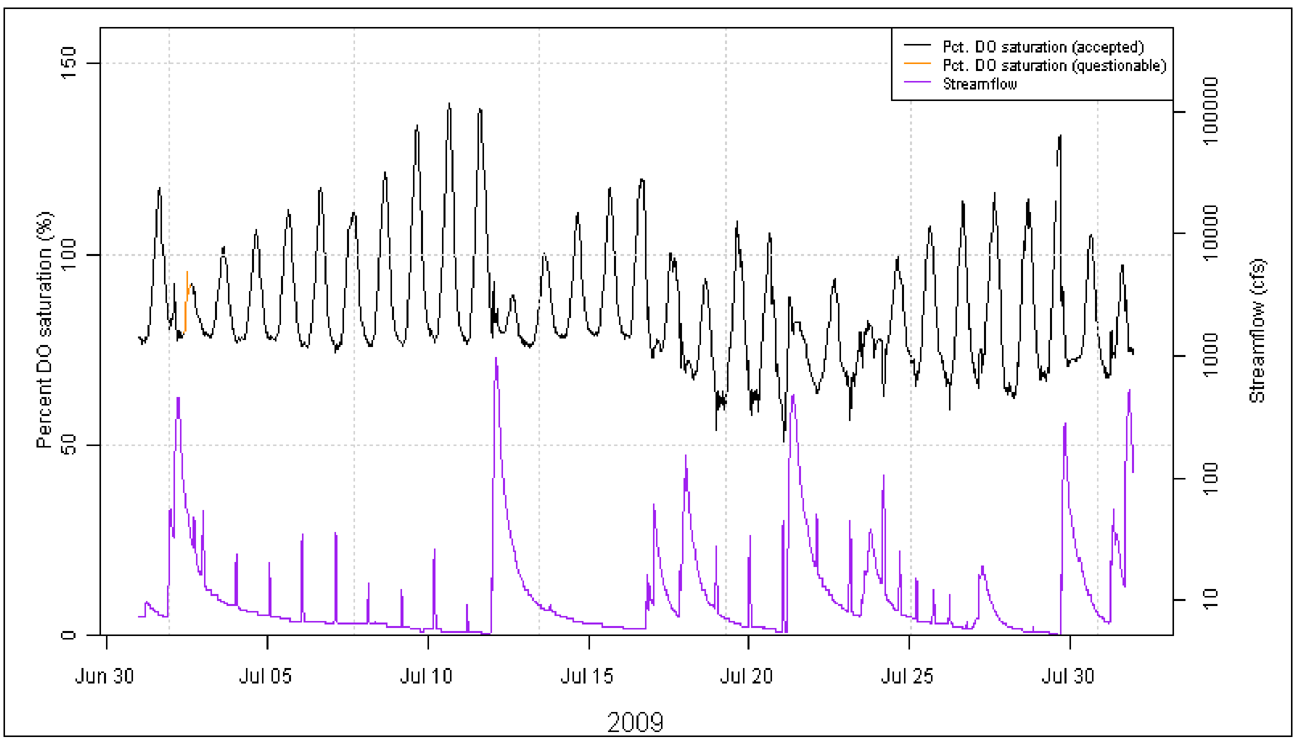



**Figure E.30 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, July 2009**

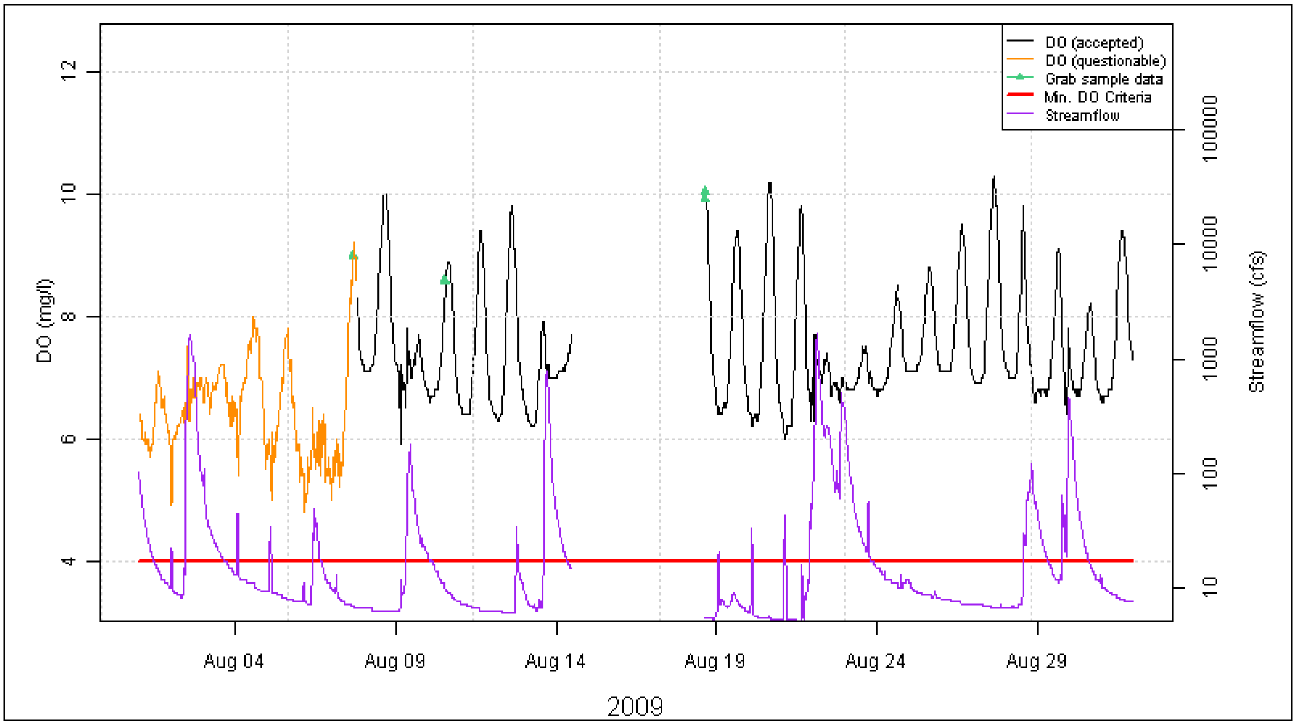



**Figure E.31 Dissolved Oxygen and Streamflow at Site PQ050, August 2009**

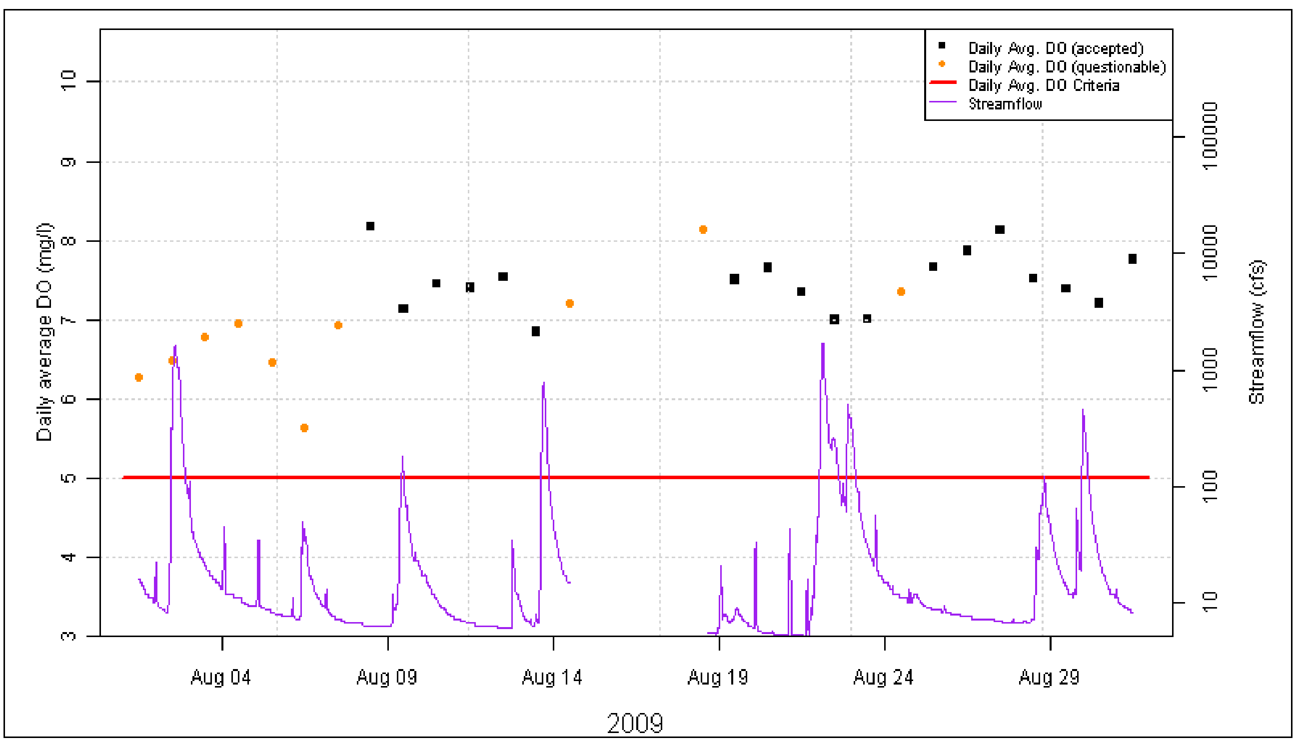



**Figure E.32 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, August 2009**

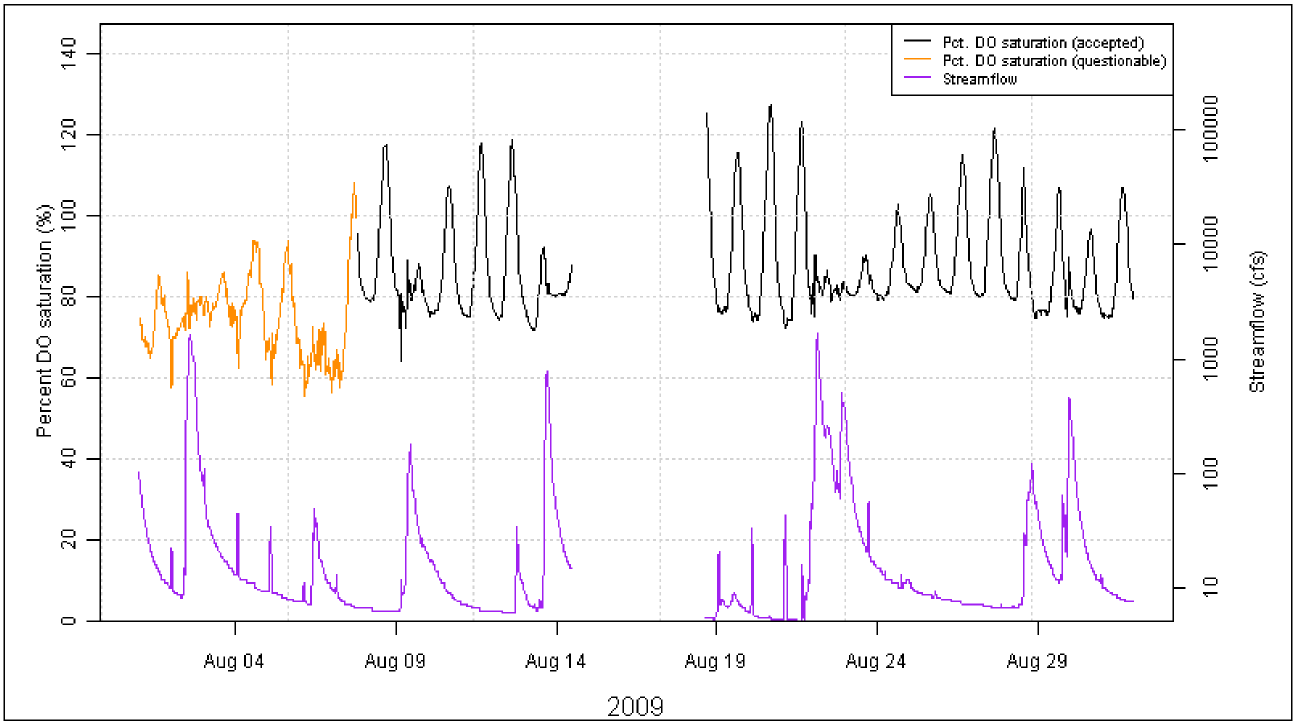



**Figure E.33 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, August 2009**

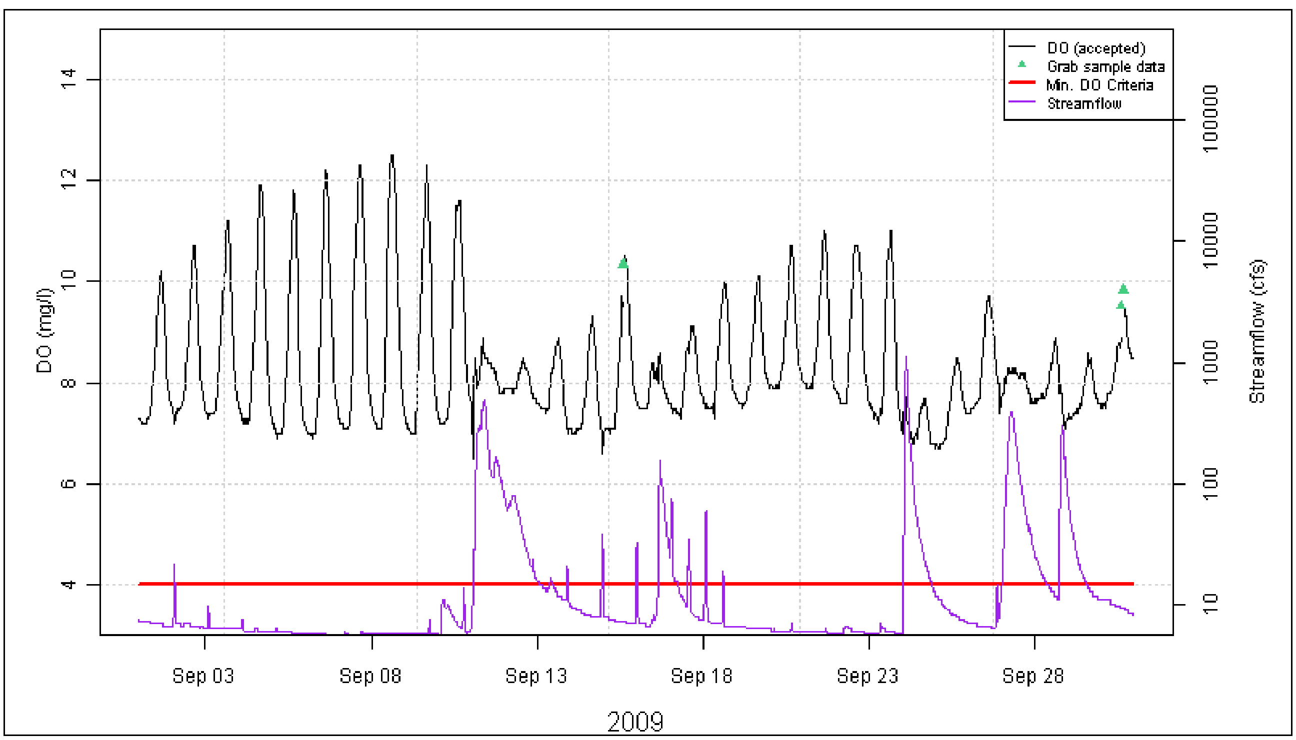



**Figure E.34 Dissolved Oxygen and Streamflow at Site PQ050, September 2009**

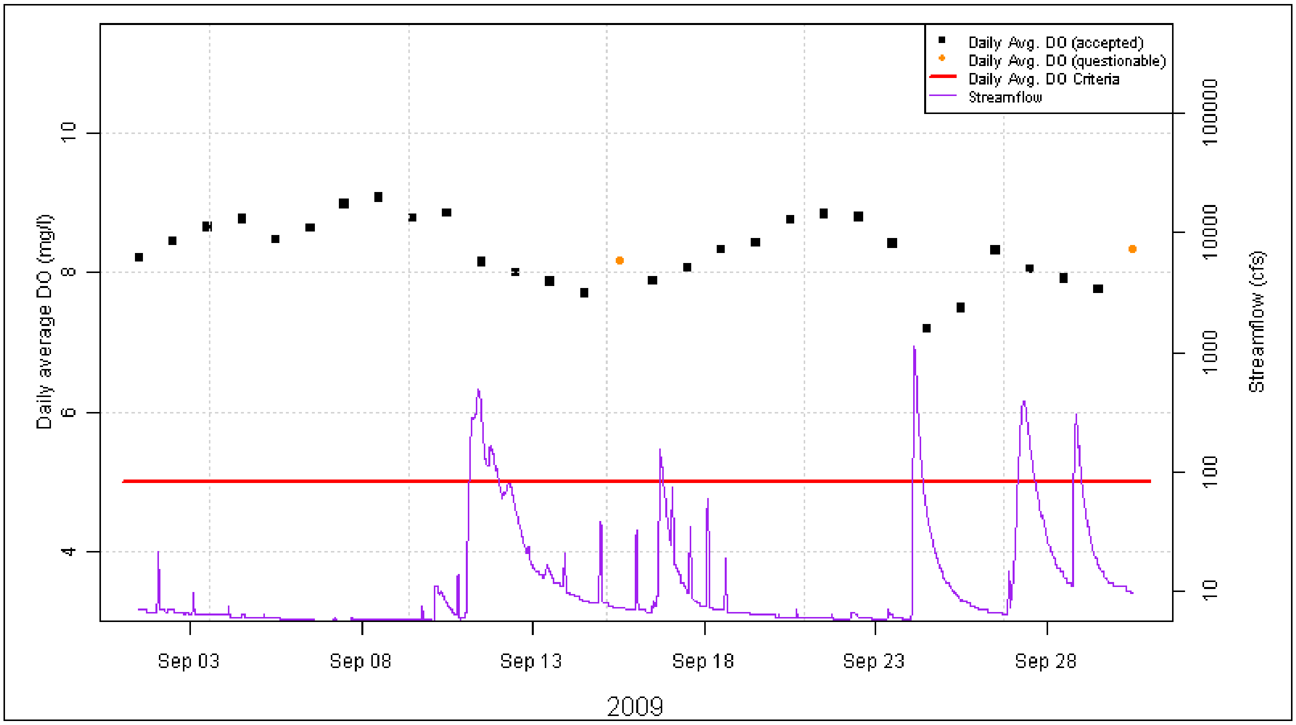



**Figure E.35 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, September 2009**

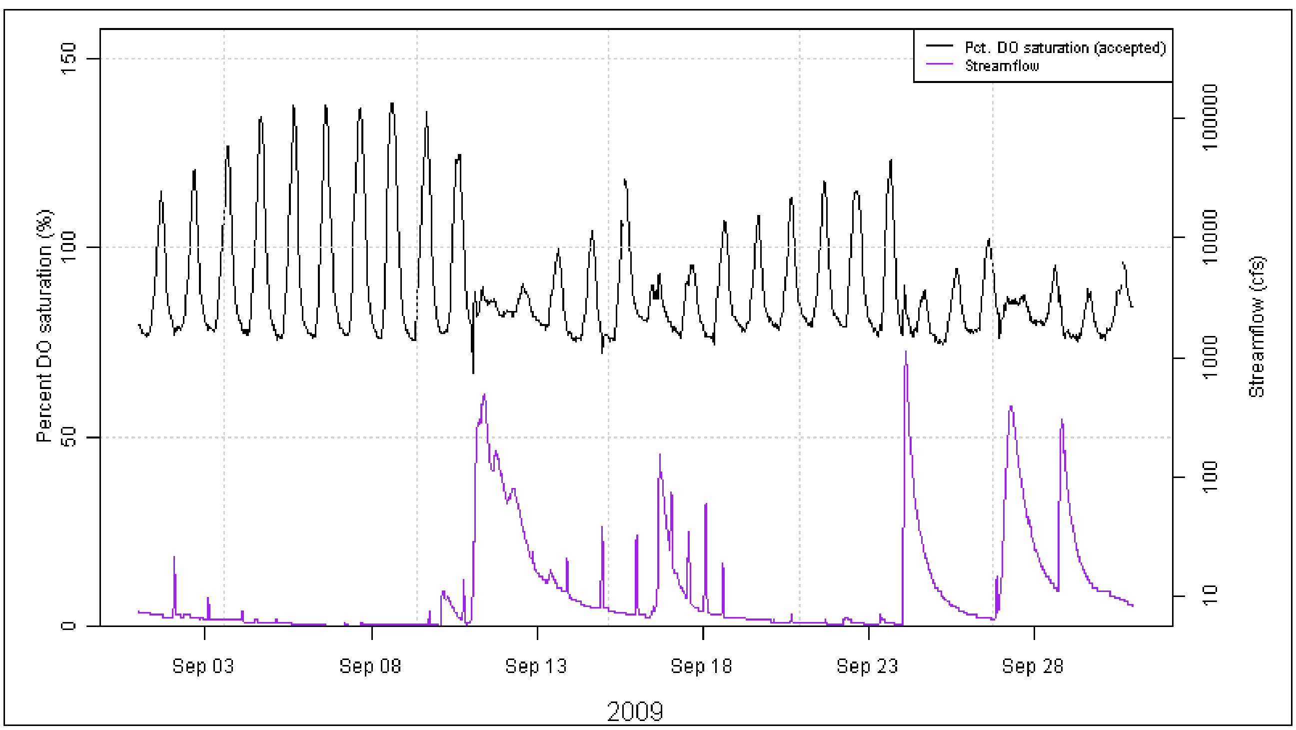



**Figure E.36 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, September 2009**

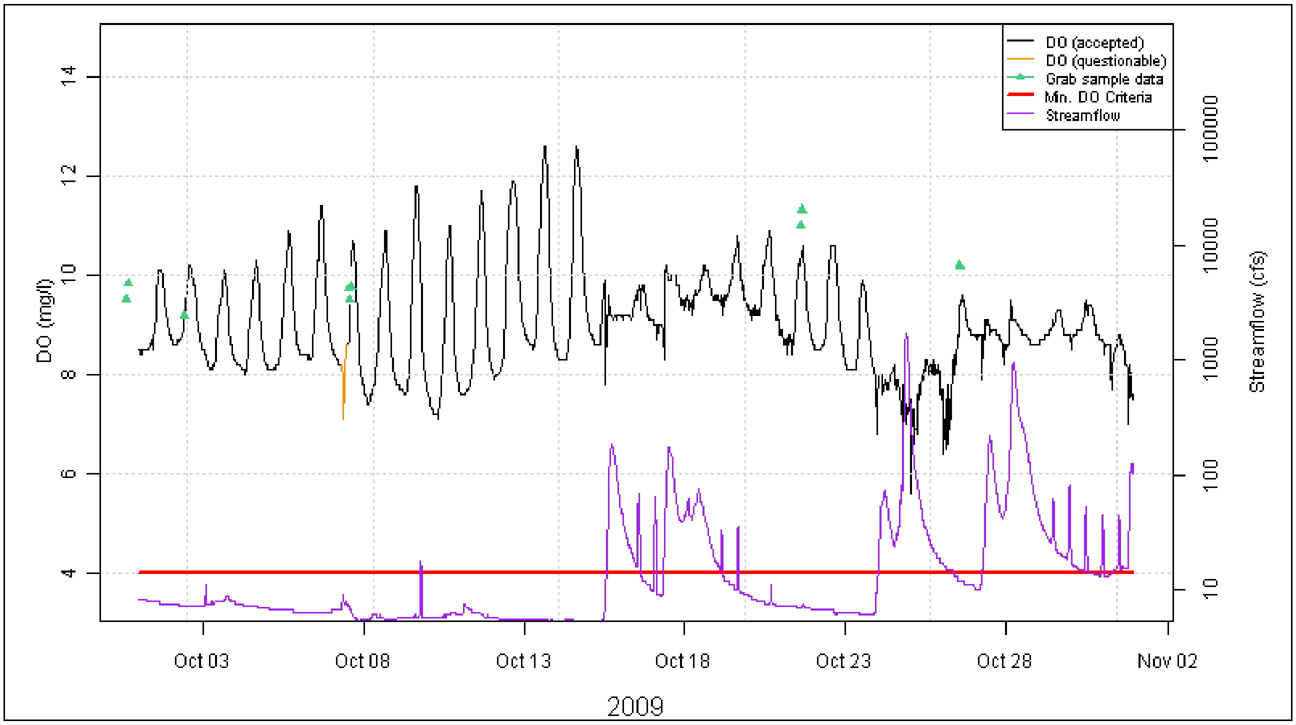



**Figure E.37 Dissolved Oxygen and Streamflow at Site PQ050, October 2009**

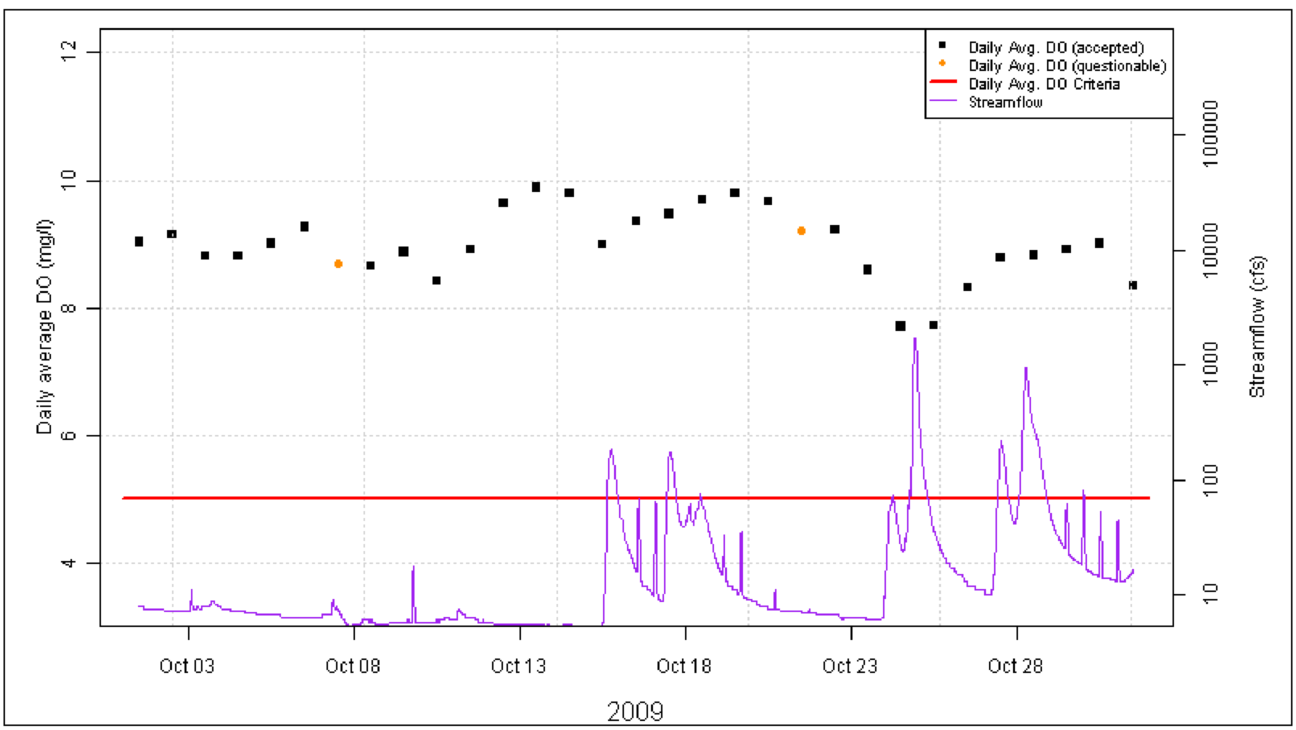



**Figure E.38 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, October 2009**

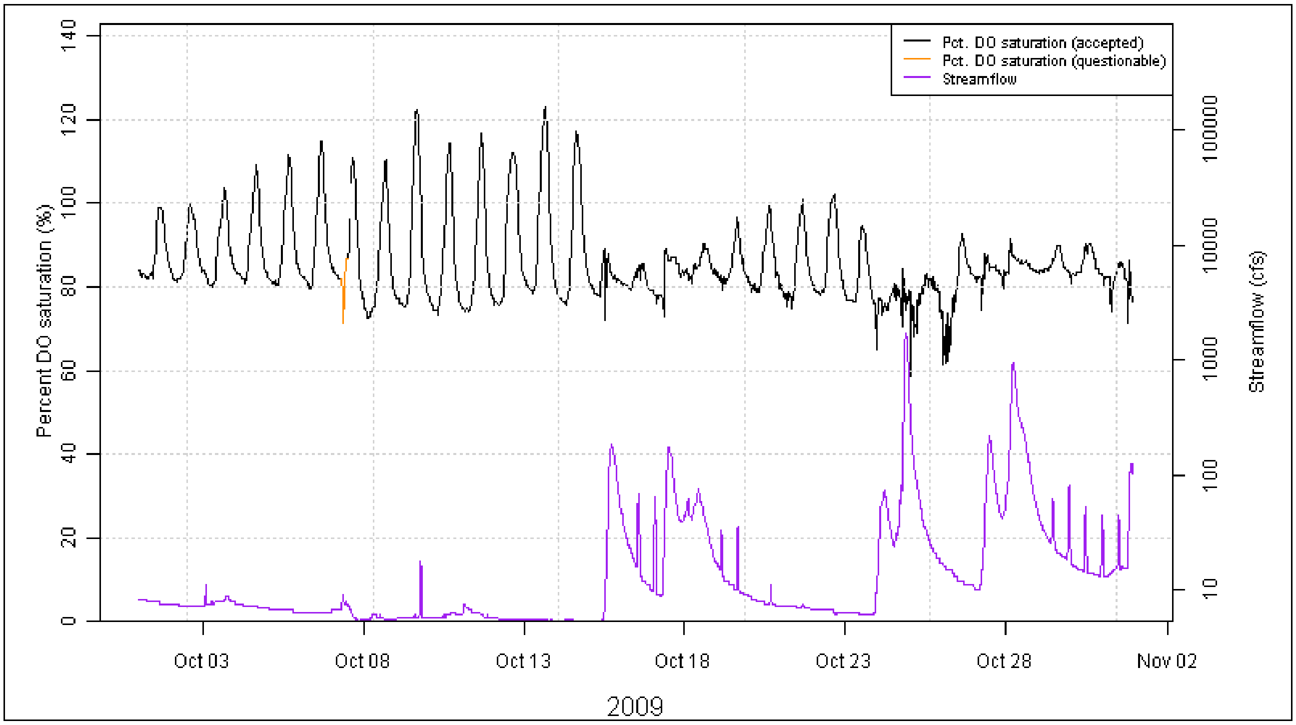



**Figure E.39 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, October 2009**

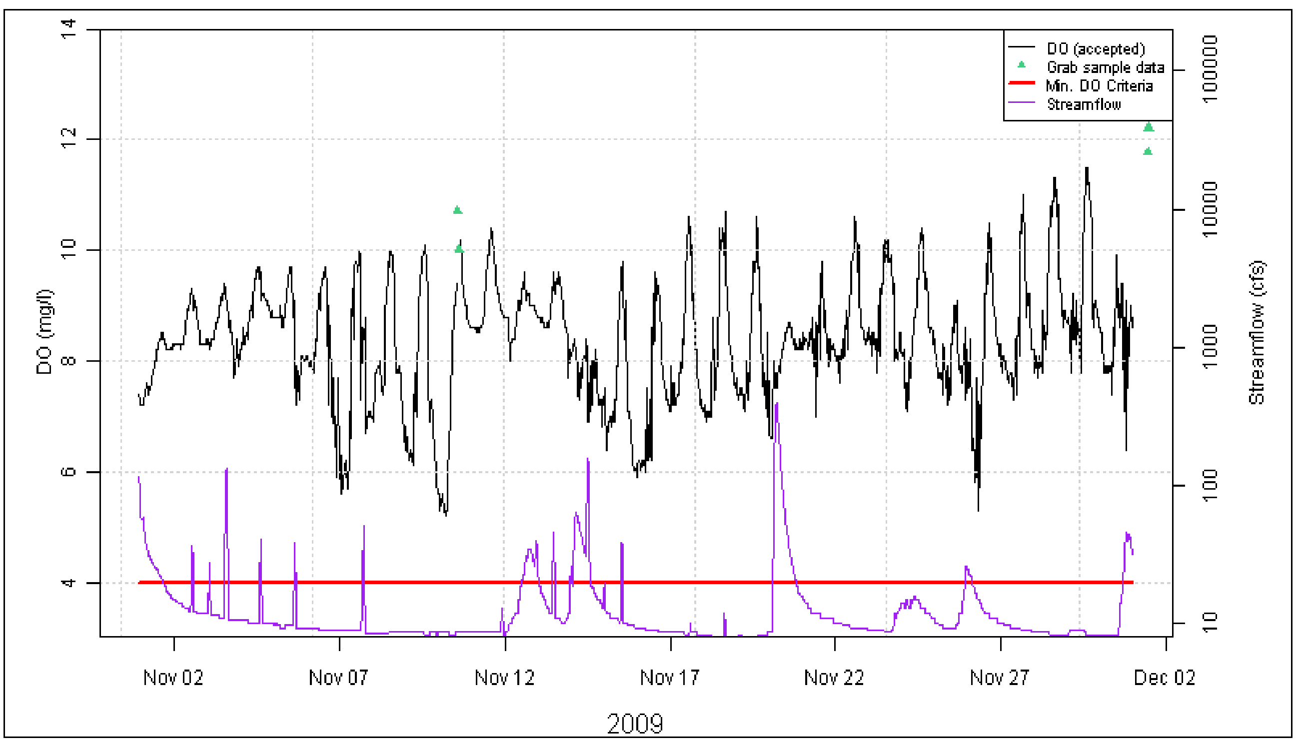



**Figure E.40 Dissolved Oxygen and Streamflow at Site PQ050, November 2009**

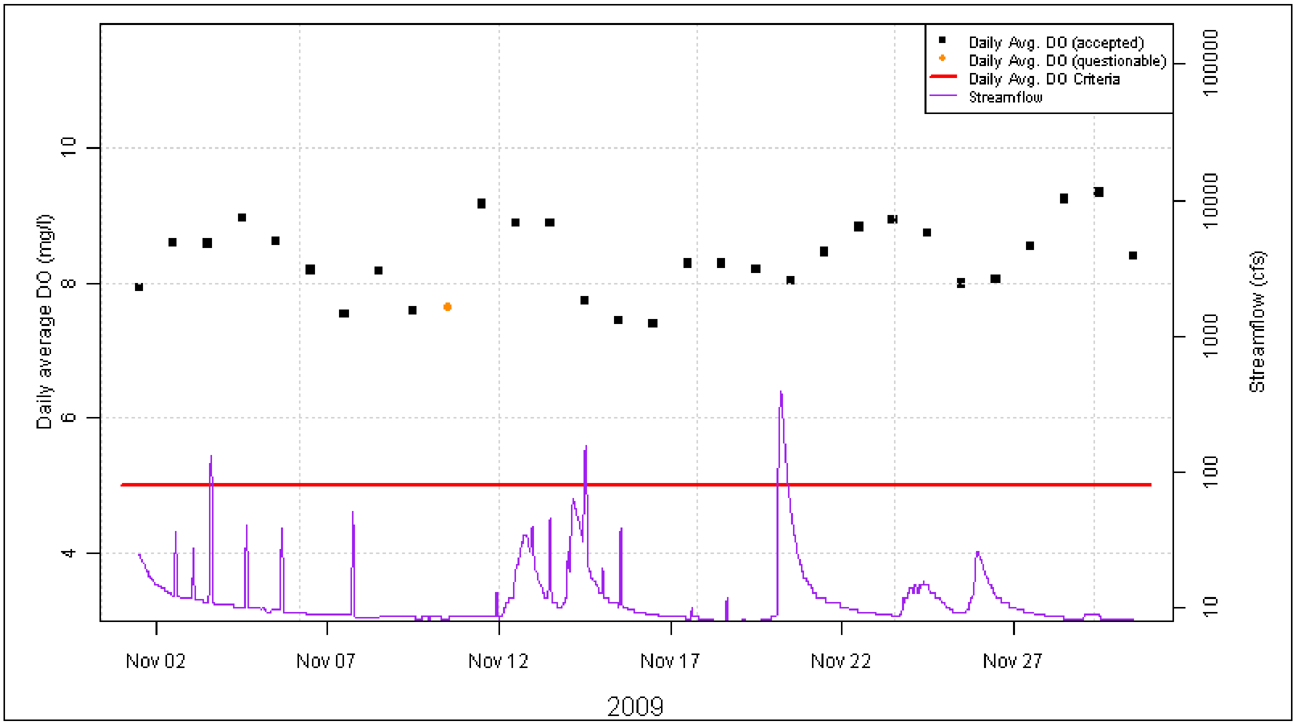



**Figure E.41 Daily Average Dissolved Oxygen and Streamflow at Site PQ050, November 2009**

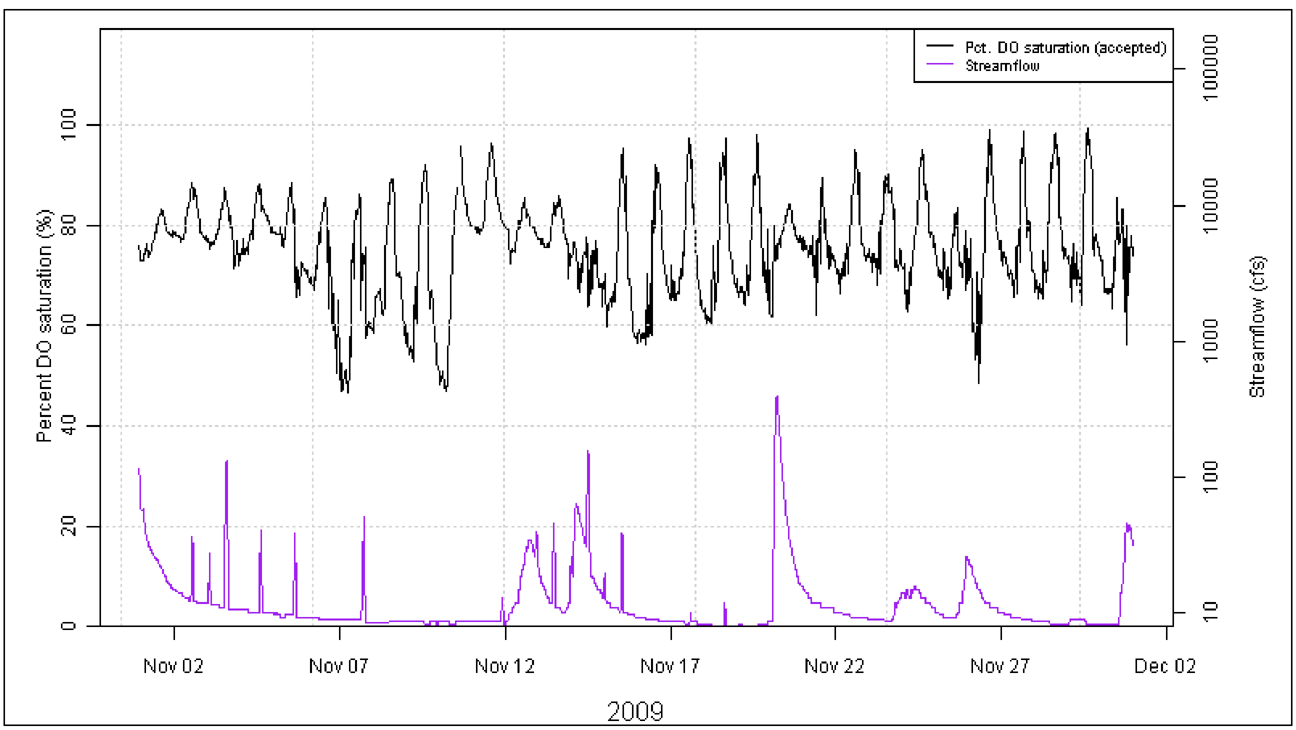



**Figure E.42 Percent Saturated Dissolved Oxygen and Streamflow at Site PQ050, November 2009**

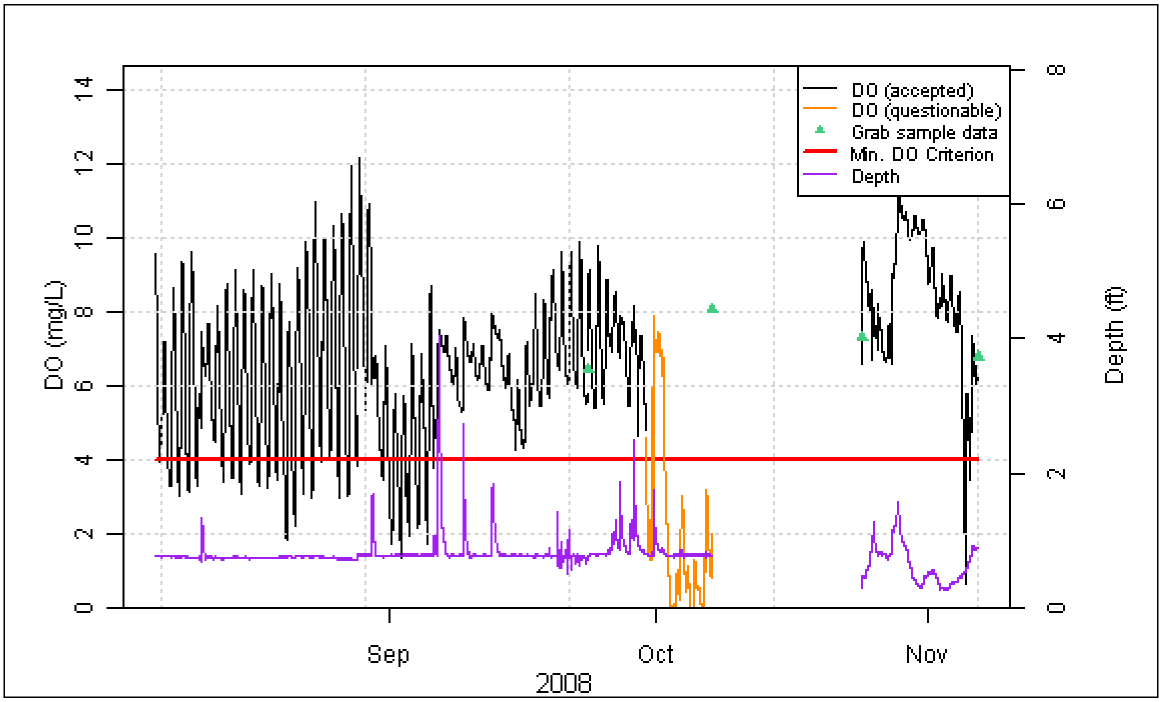



**Figure E.43 Dissolved Oxygen and Stream Depth at Site PQ665, 8/5/08 – 11/6/08**

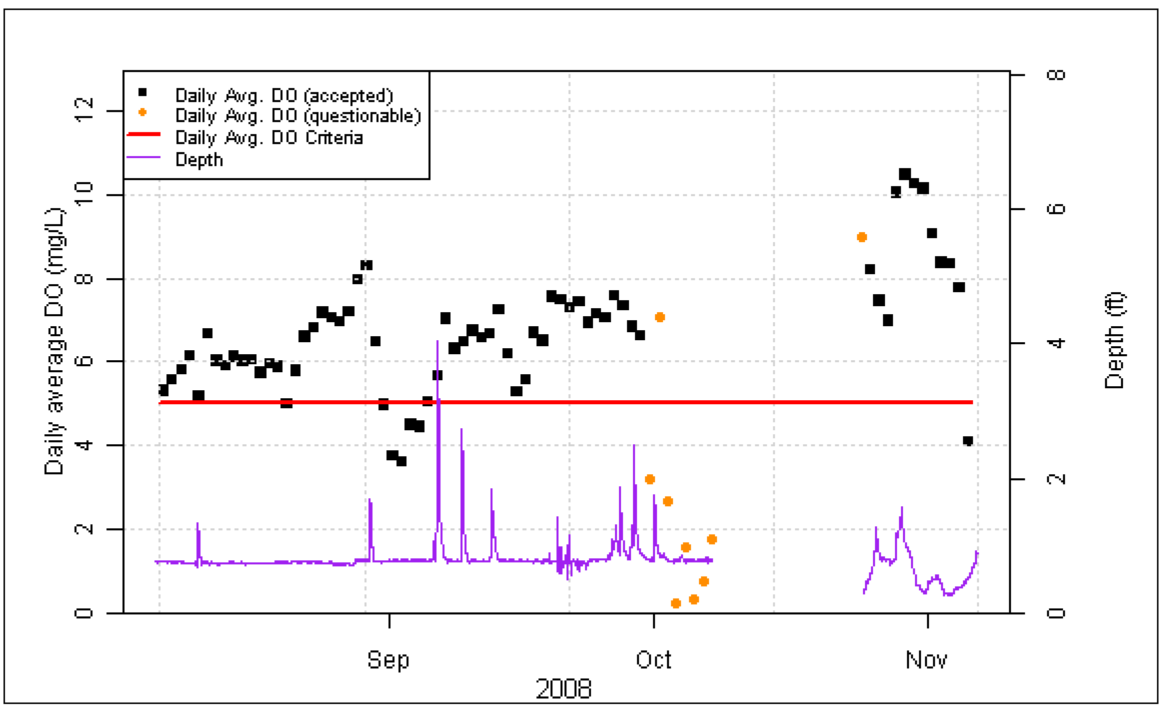



**Figure E.44 Daily Average Dissolved Oxygen and Stream Depth at Site PQ665, 8/5/08 – 11/6/08**

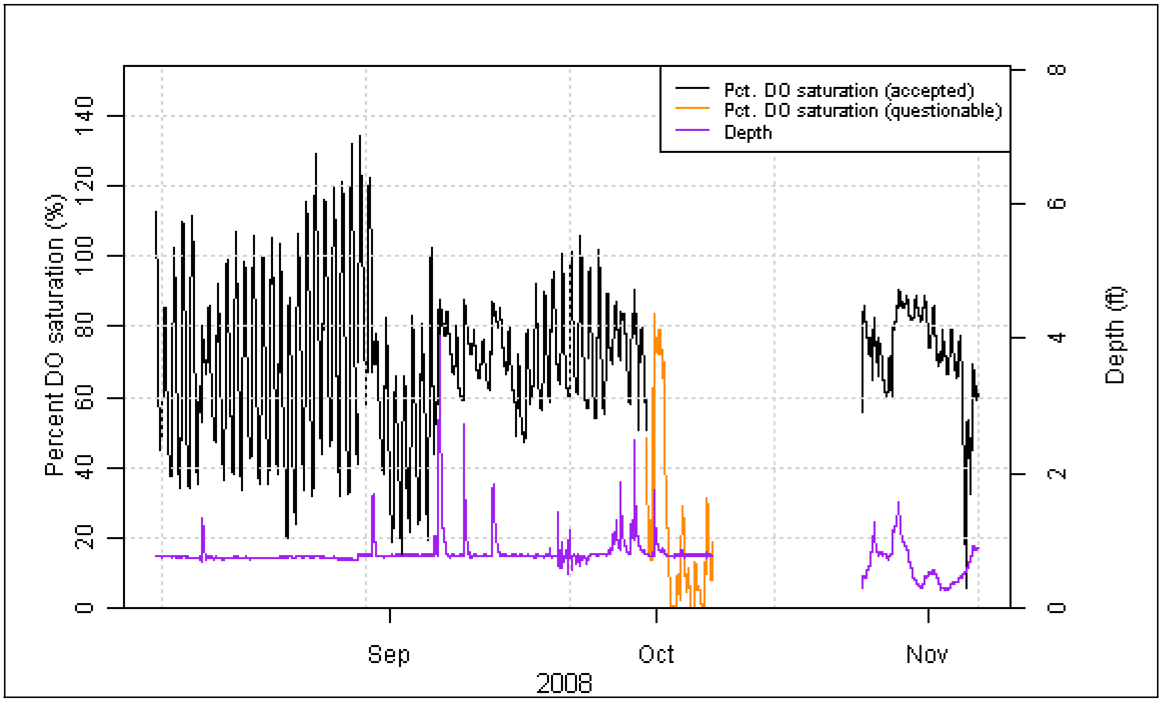



**Figure E.45 Percent Saturated Dissolved Oxygen and Stream Depth at Site PQ665, 8/5/08 – 11/6/08**

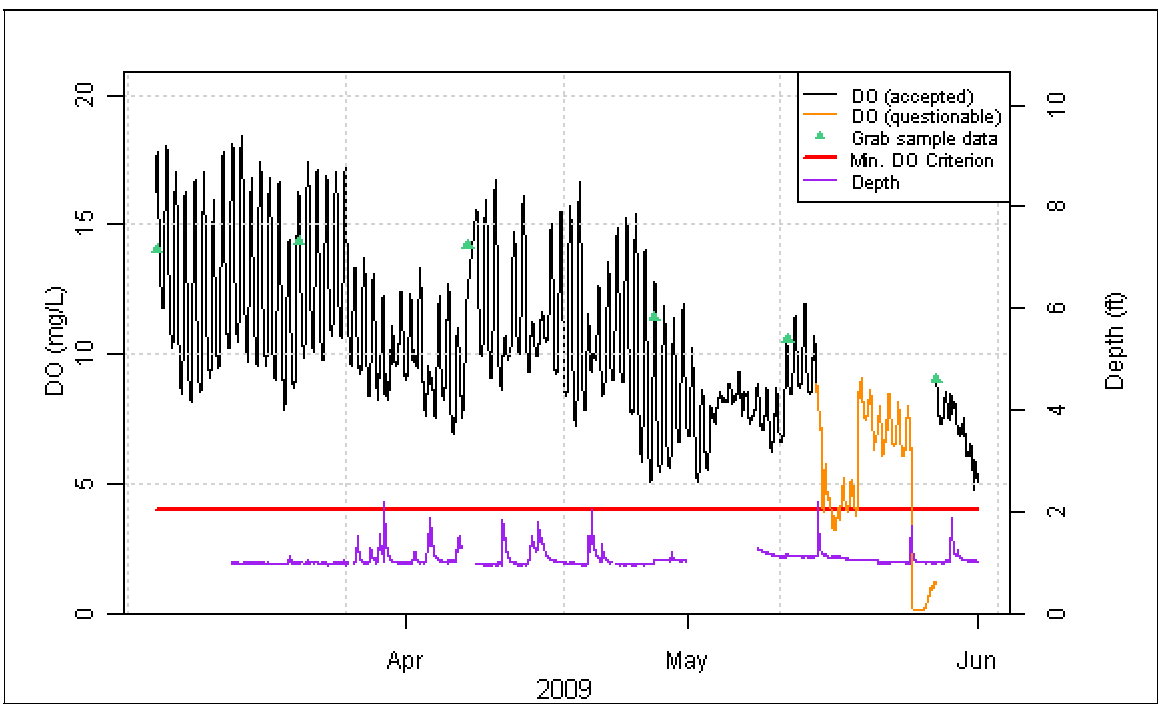



**Figure E.46 Dissolved Oxygen and Stream Depth at Site PQ665, 3/5/09– 5/31/09**

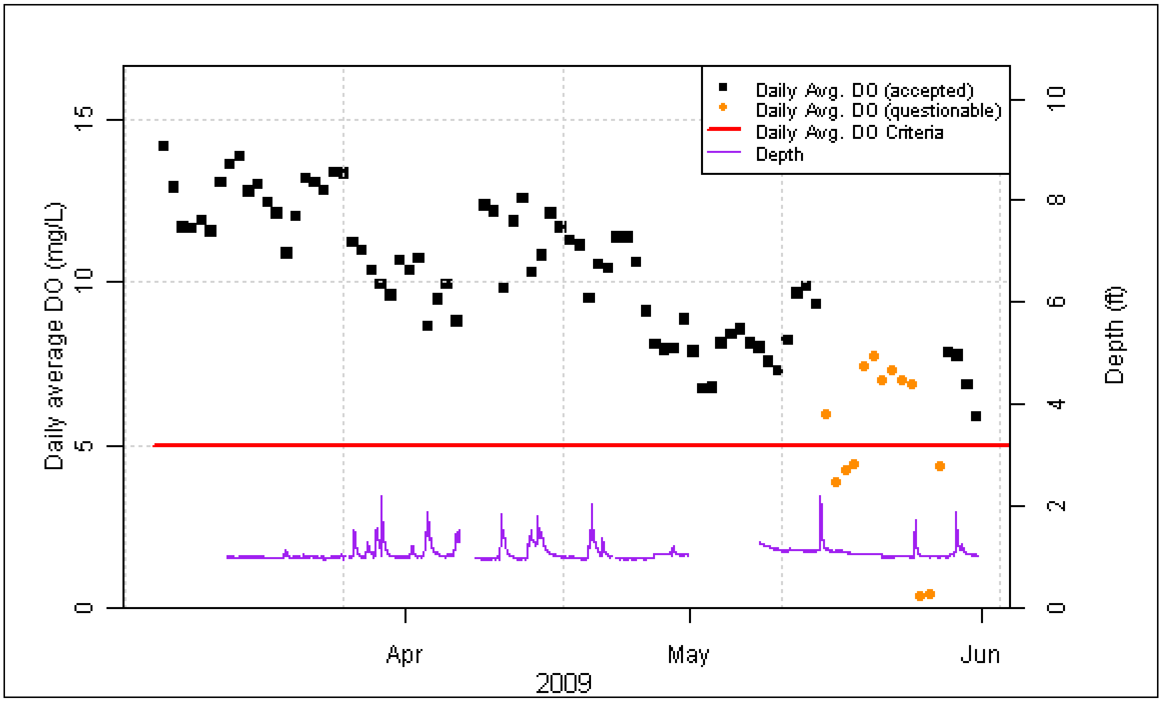



**Figure E.47 Daily Average Dissolved Oxygen and Stream Depth at Site PQ665, 3/5/09 – 5/31/09**

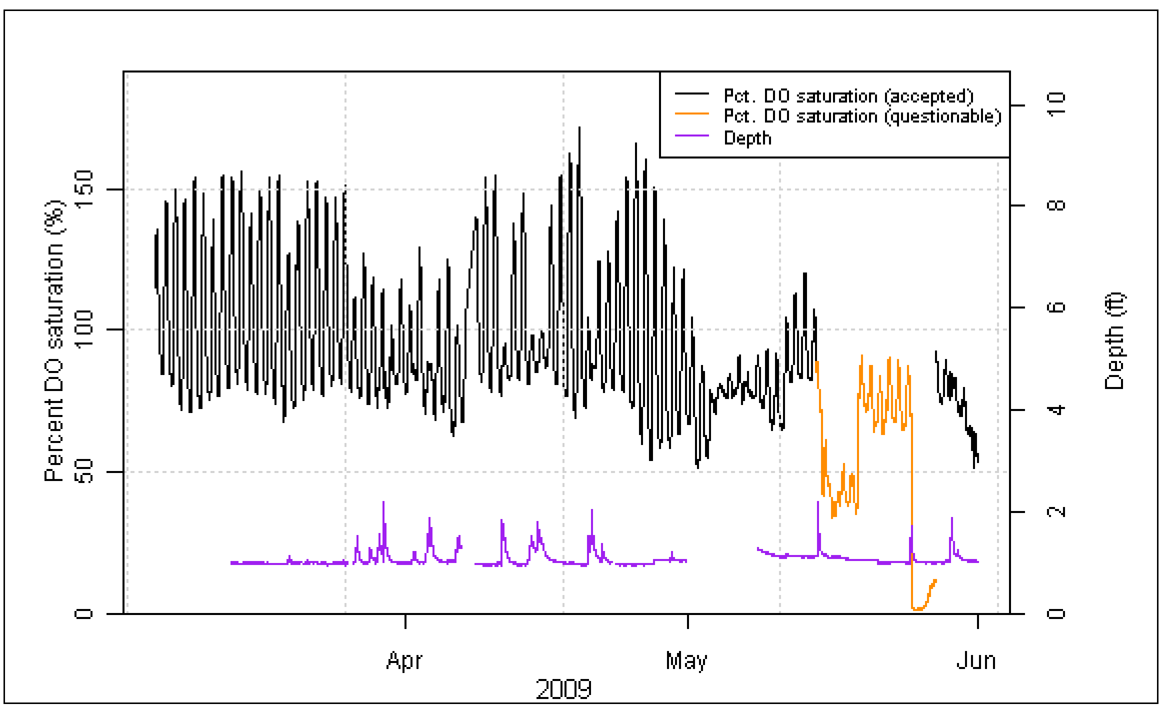



**Figure E.48 Percent Saturated Dissolved Oxygen and Stream Depth at Site PQ665, 3/5/09 – 5/31/09**

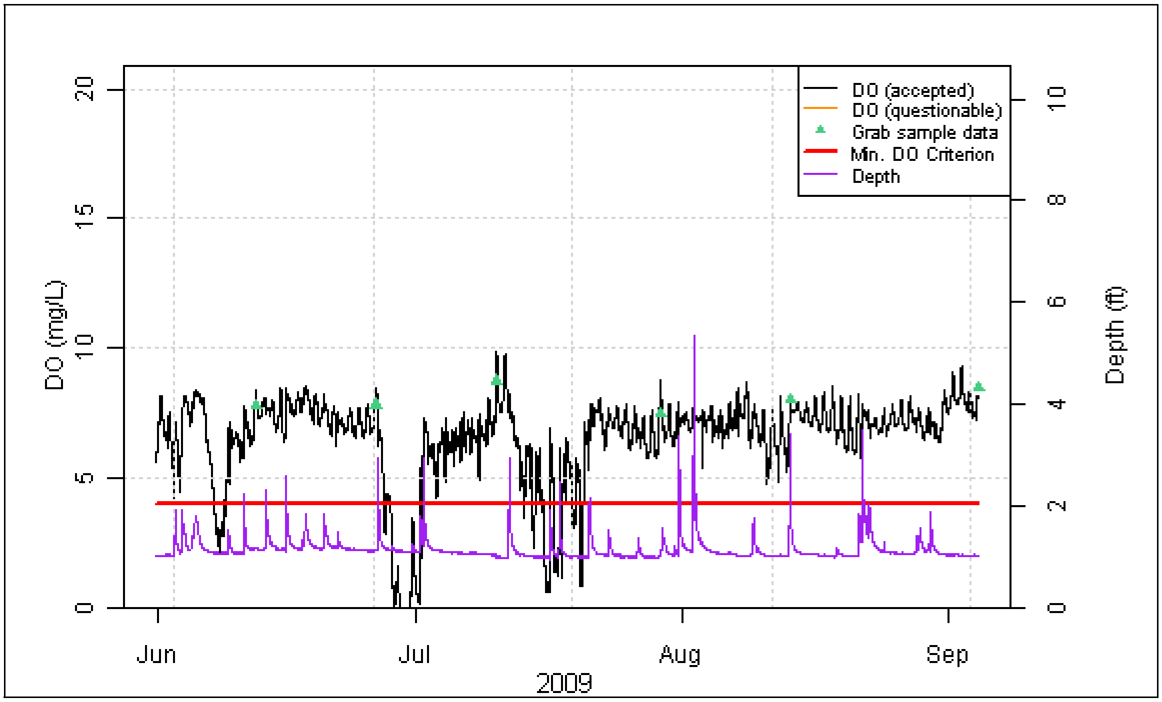



**Figure E.49 Dissolved Oxygen and Stream Depth at Site PQ665, 6/1/09 – 9/4/09**

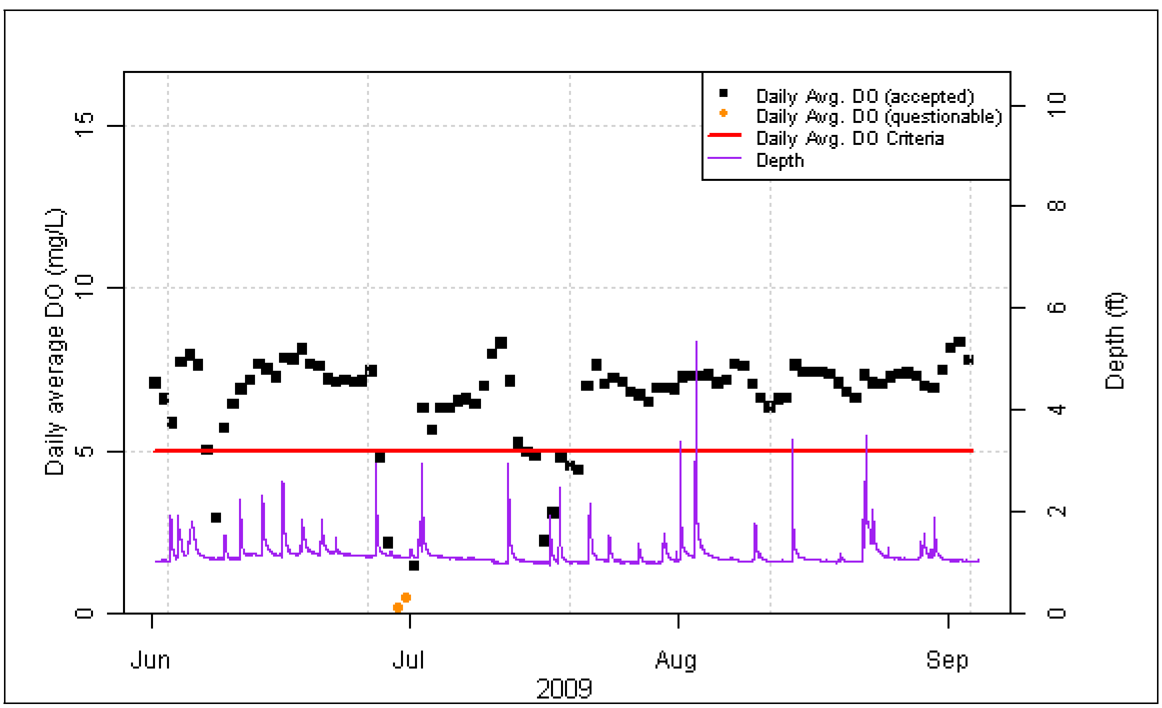



**Figure E.50 Daily Average Dissolved Oxygen and Stream Depth at Site PQ665, 6/1/09 – 9/4/09**

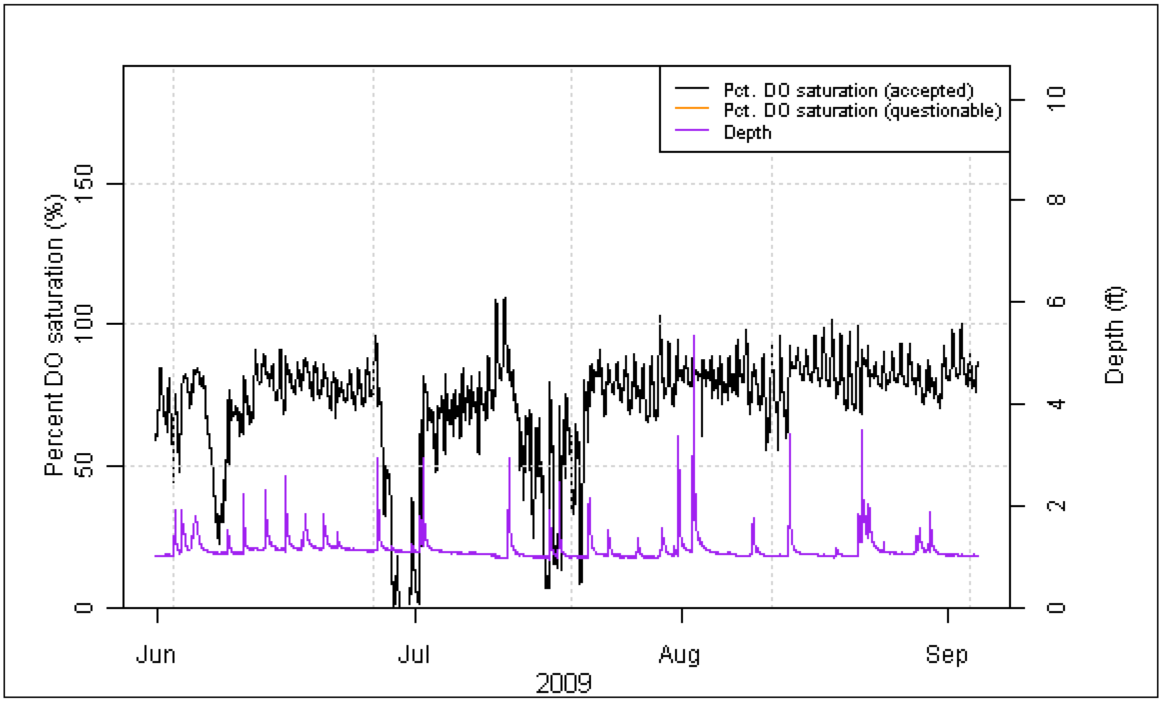



**Figure E.51 Percent Saturated Dissolved Oxygen and Stream Depth at Site PQ665, 6/1/09 – 9/4/09**

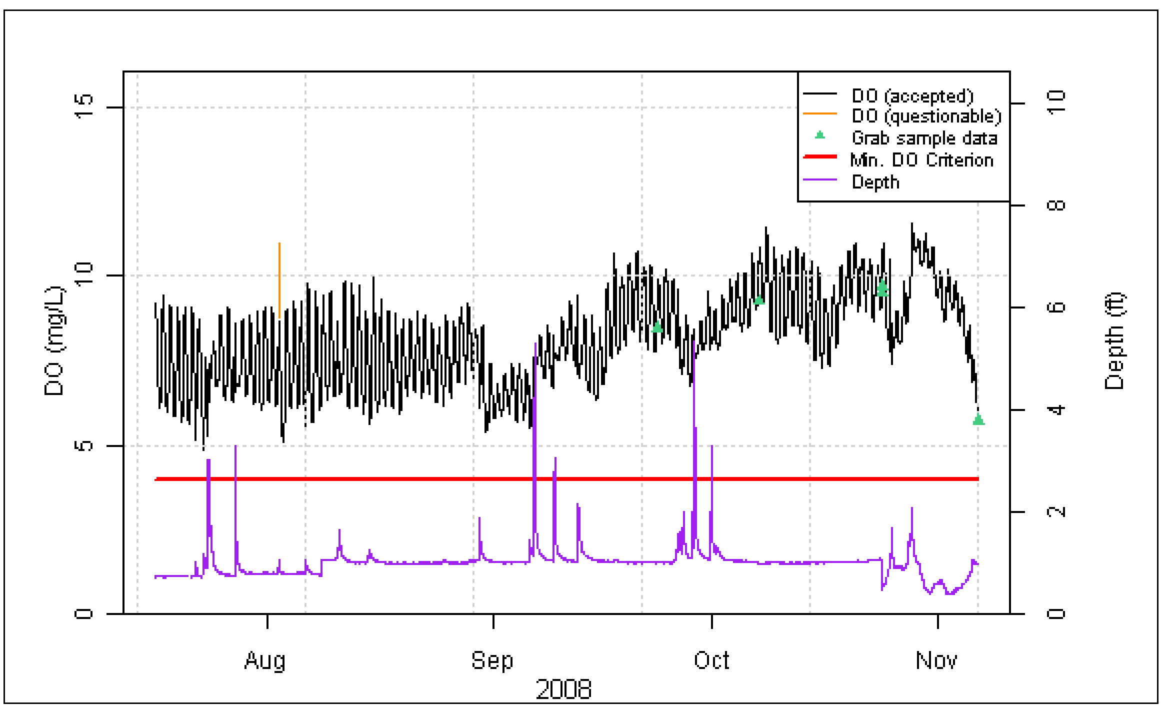



**Figure E.52 Dissolved Oxygen and Stream Depth at Site PQB025, 7/16/08 – 11/6/08**

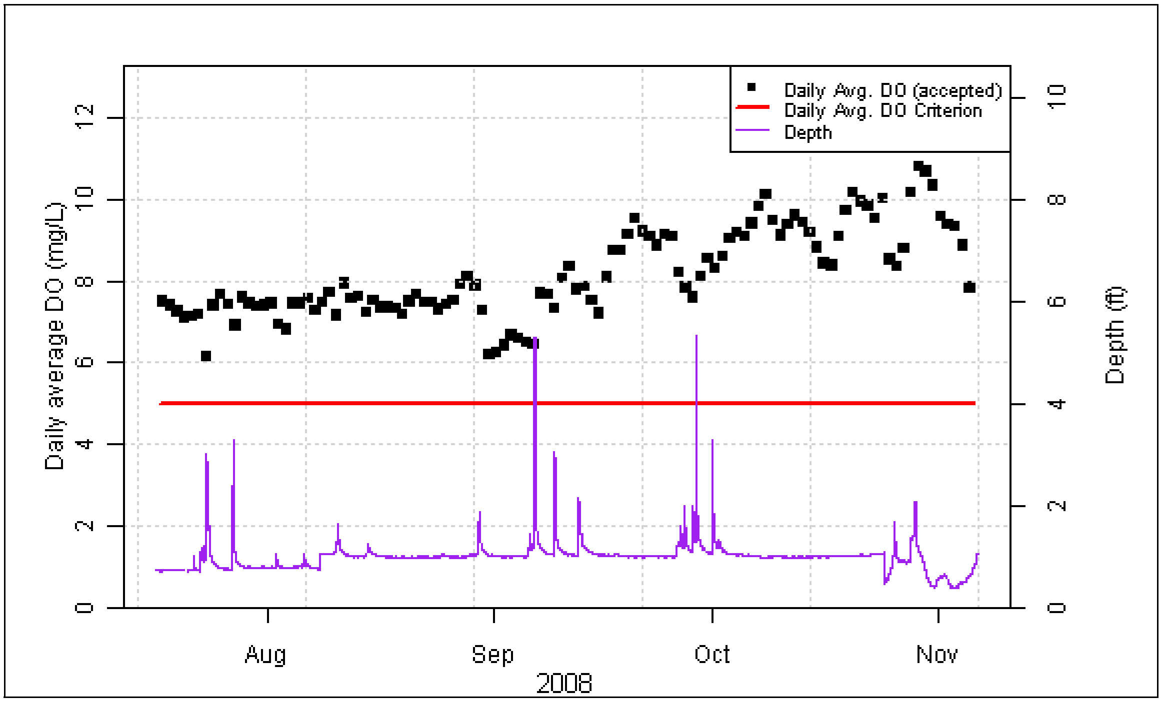



**Figure E.53 Daily Average Dissolved Oxygen and Stream Depth at Site PQB025, 7/16/08 – 11/6/08**

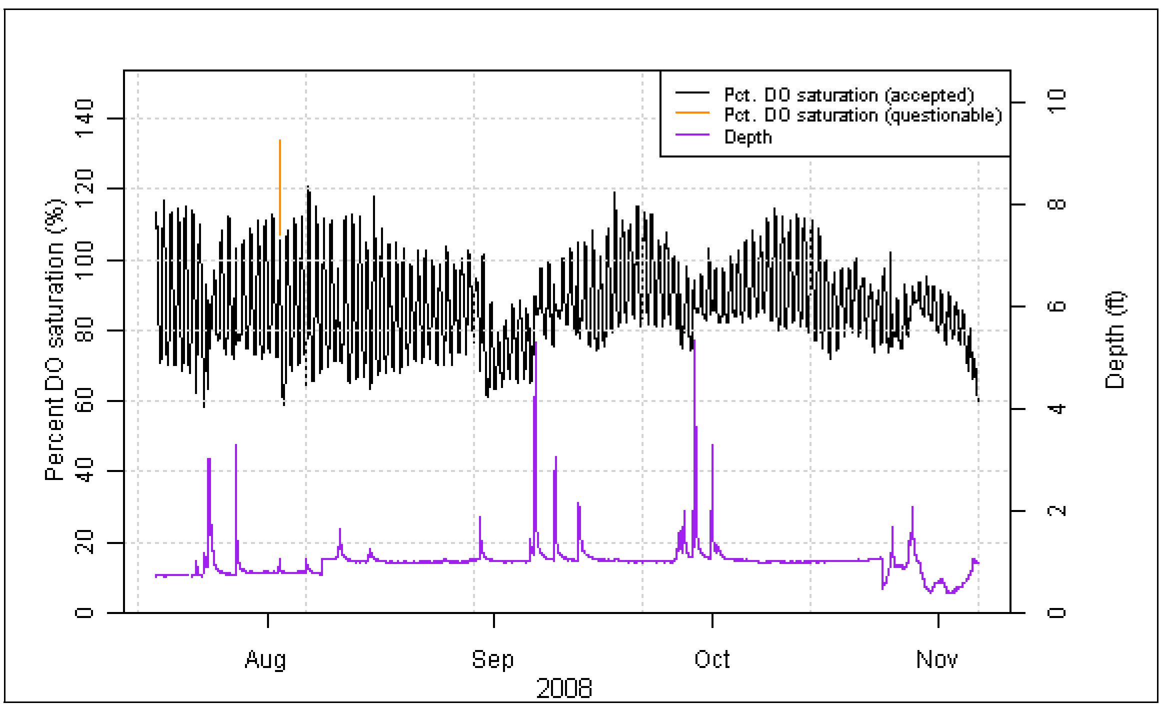



**Figure E.54 Percent Saturated Dissolved Oxygen and Stream Depth at Site PQB025, 7/16/08 – 11/6/08**

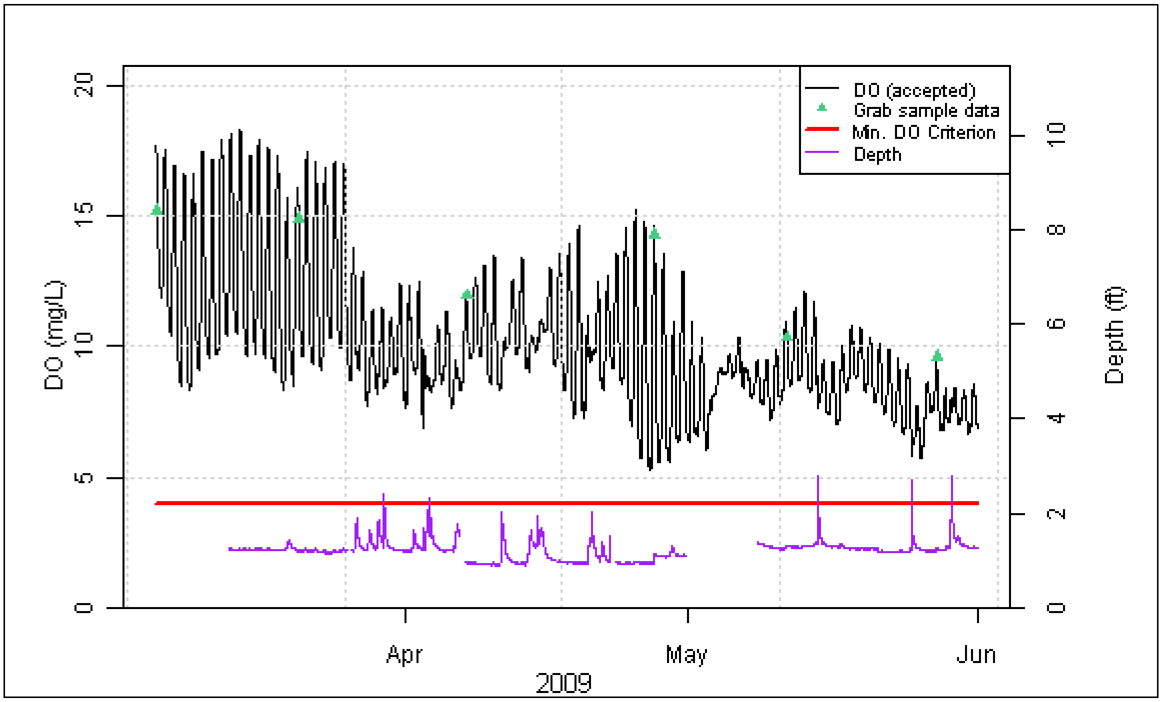



**Figure E.55 Dissolved Oxygen and Stream Depth at Site PQB025, 3/5/09 – 5/31/09**

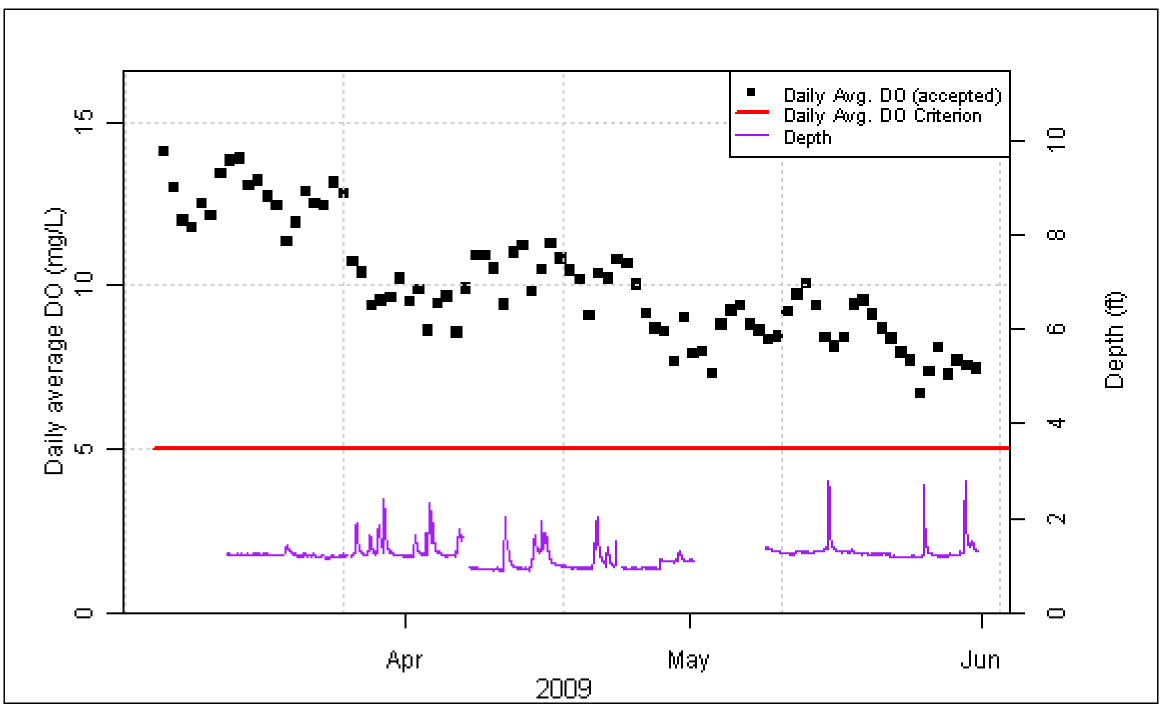



**Figure E.56 Daily Average Dissolved Oxygen and Stream Depth at Site PQB025, 3/5/09 – 5/31/09**

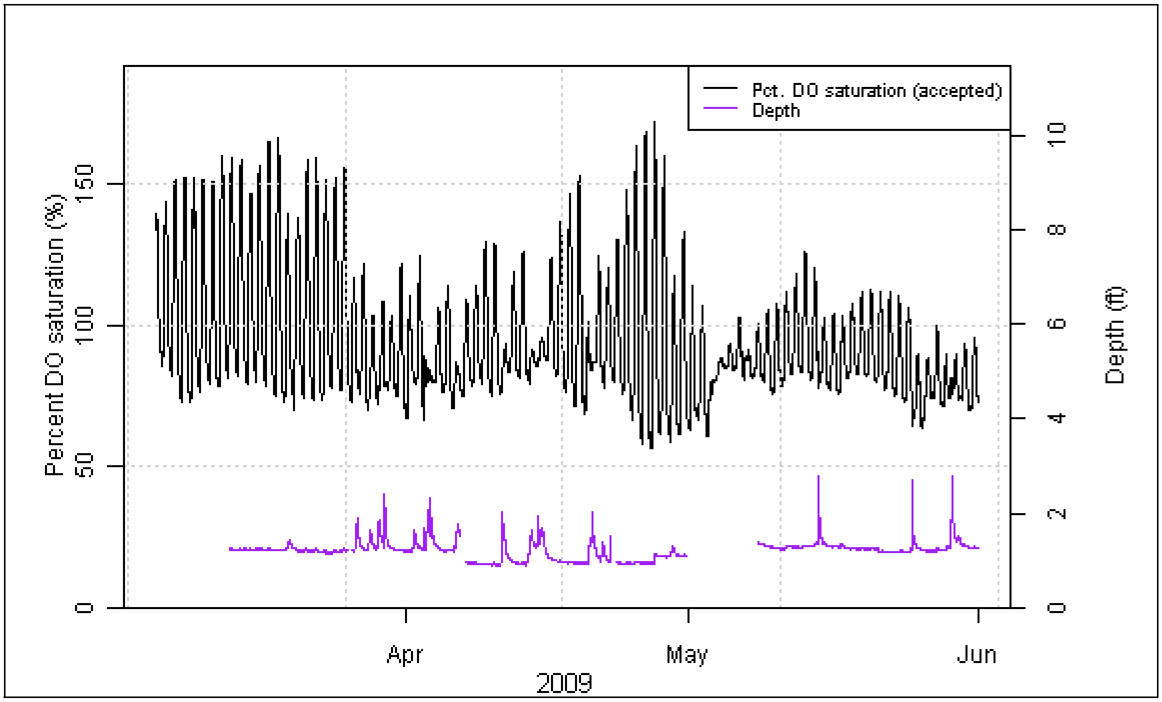



**Figure E.57 Percent Saturated Dissolved Oxygen and Stream Depth at Site PQB025, 3/5/09 – 5/31/09**

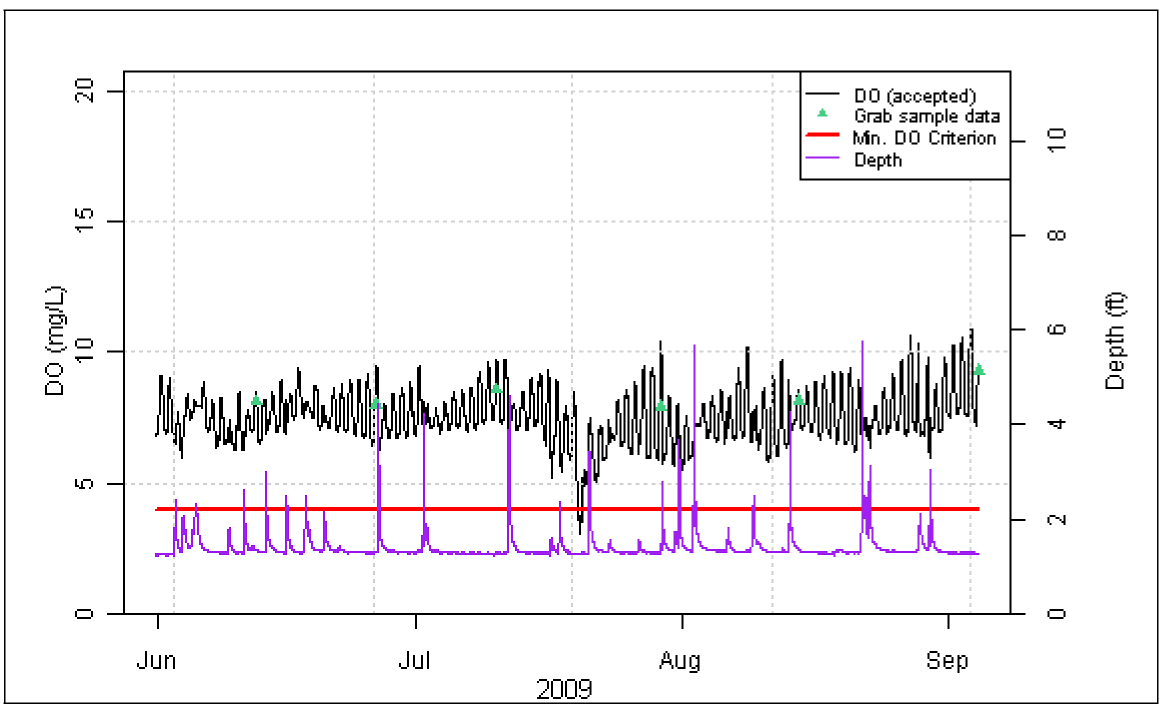



**Figure E.58 Dissolved Oxygen and Stream Depth at Site PQB025, 6/1/09 – 9/4/09**

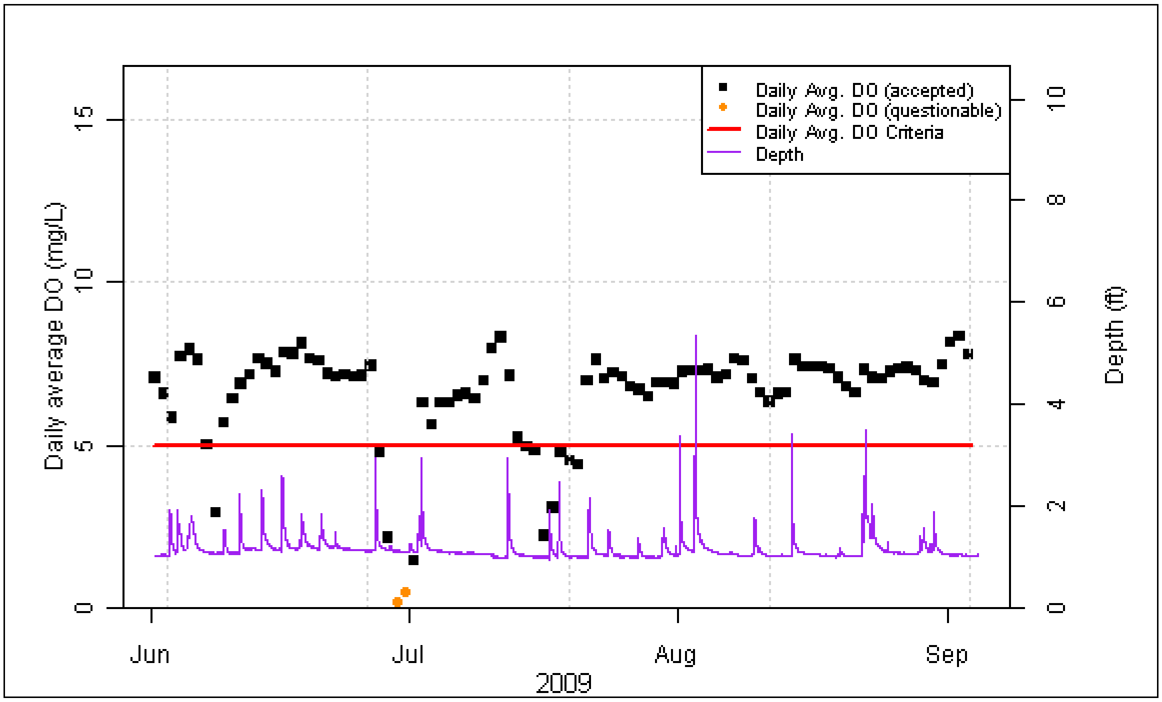



**Figure E.59 Daily Average Dissolved Oxygen and Stream Depth at Site PQB025, 6/1/09 – 9/4/09**

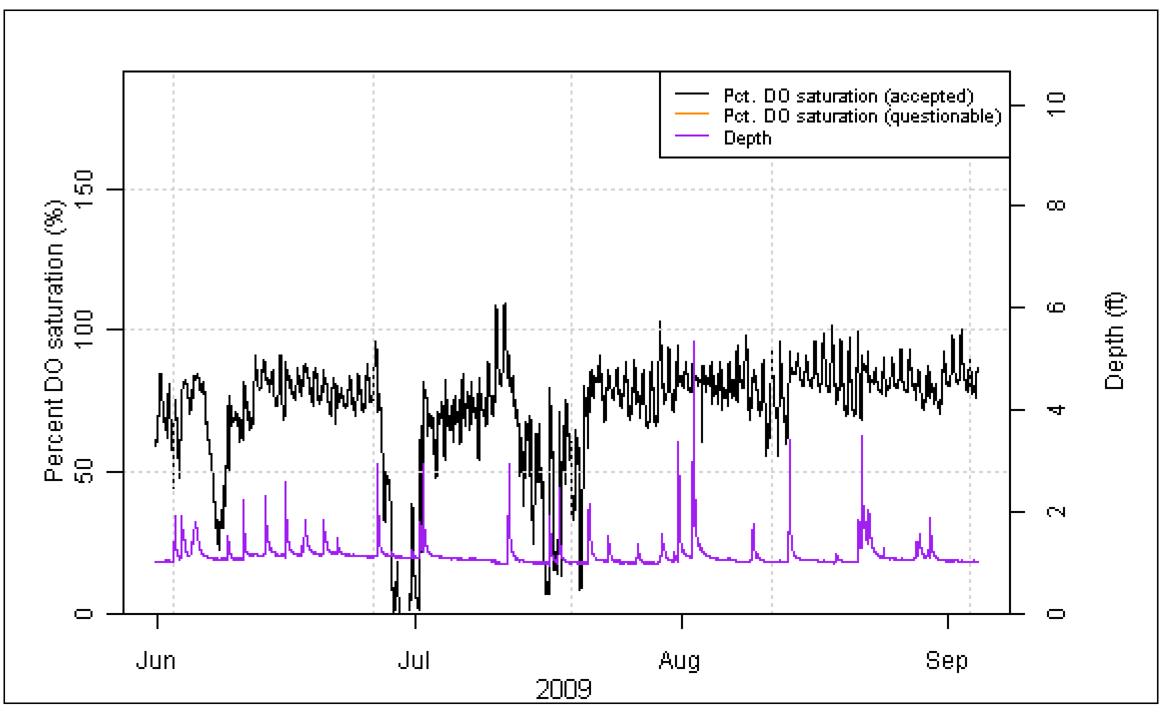



**Figure E.60 Percent Saturated Dissolved Oxygen and Stream Depth at Site PQB025, 6/1/09 – 9/4/09**

# APPENDIX F:

## Temperature Plots

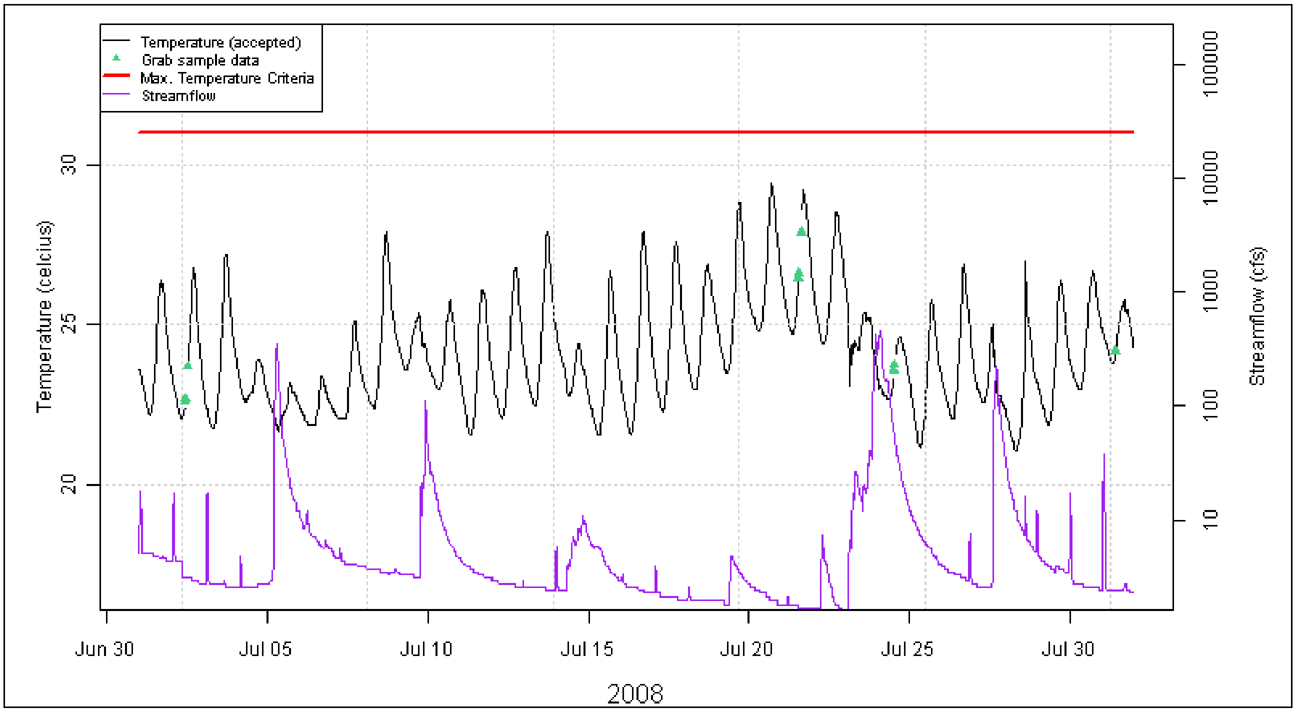



**Figure F.1 Temperature and Streamflow at Site PQ050, July 2008**

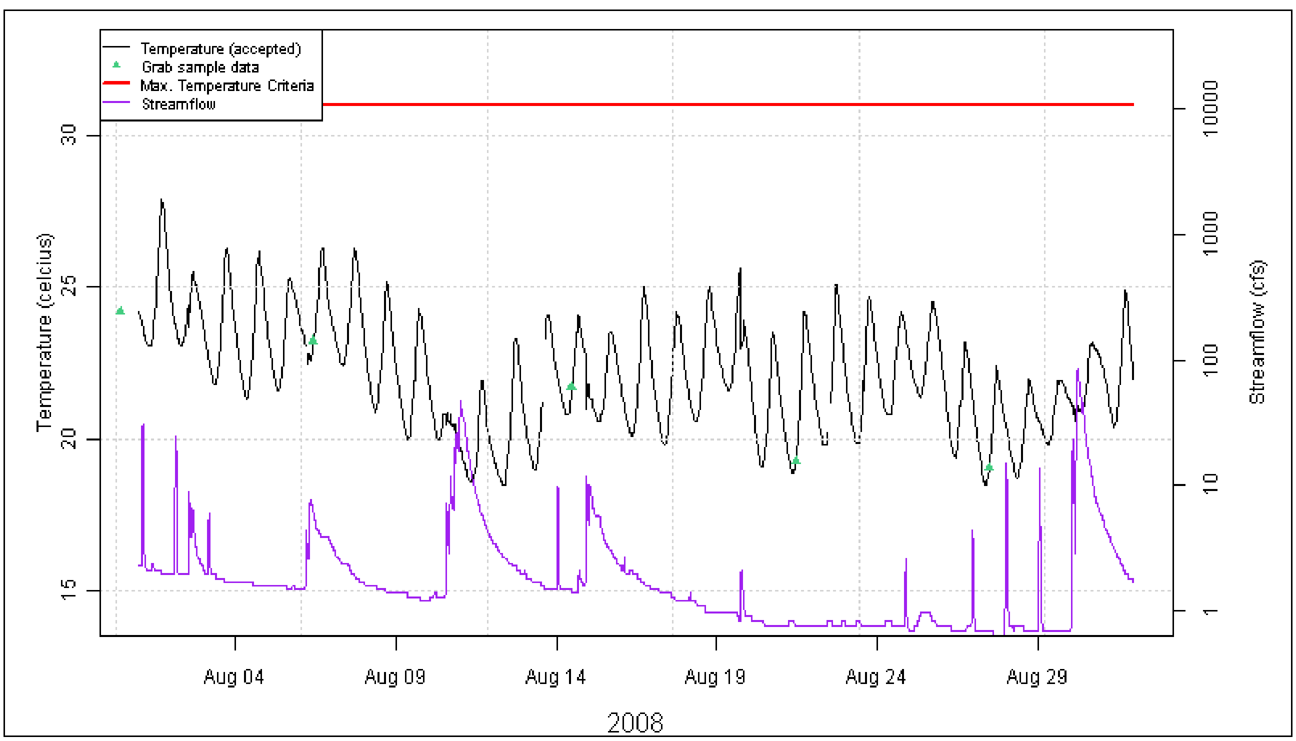



**Figure F.2 Temperature and Streamflow at Site PQ050, August 2008**

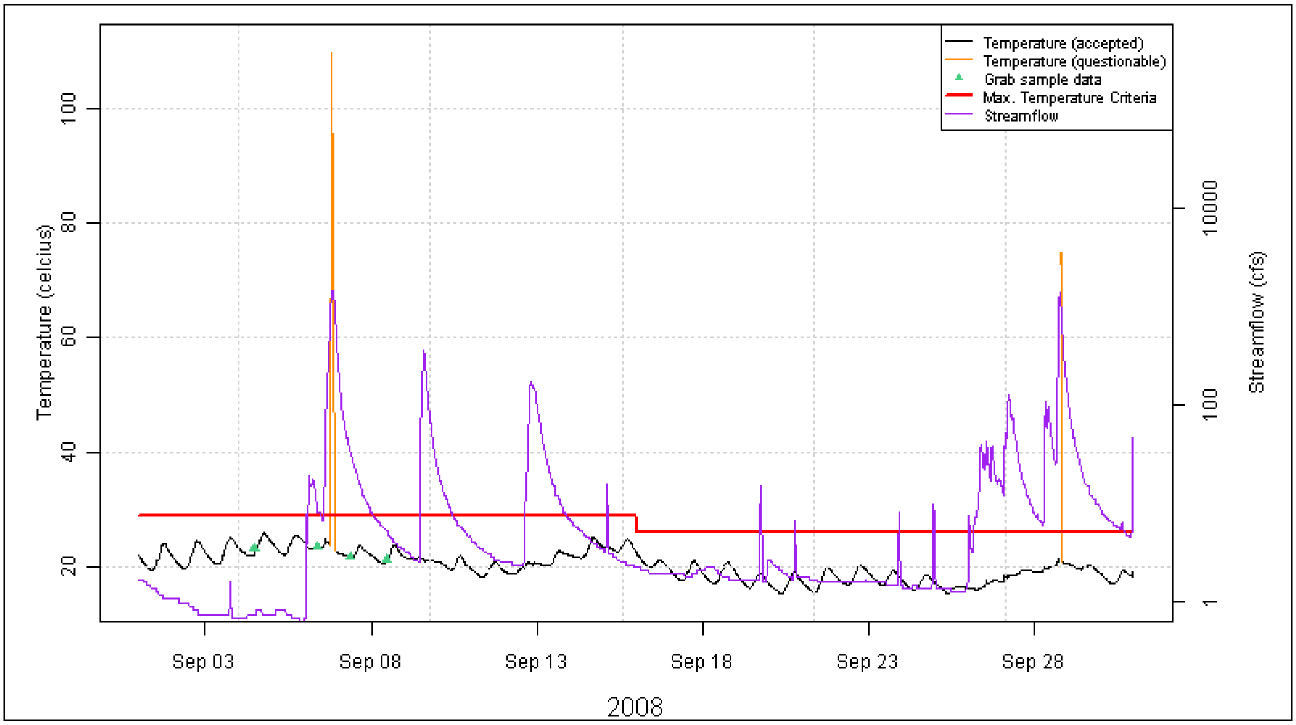


**Figure F.3 Temperature and Streamflow at Site PQ050, September 2008**

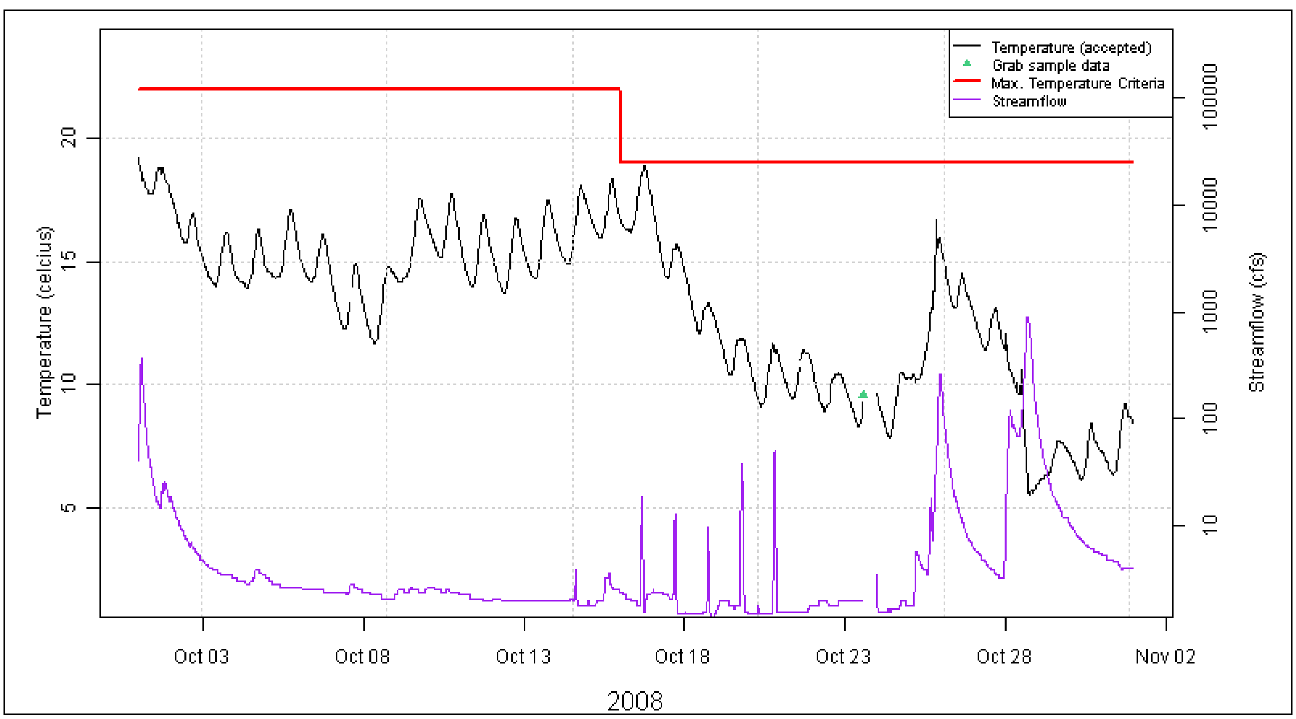


**Figure F.4 Temperature and Streamflow at Site PQ050, October 2008**

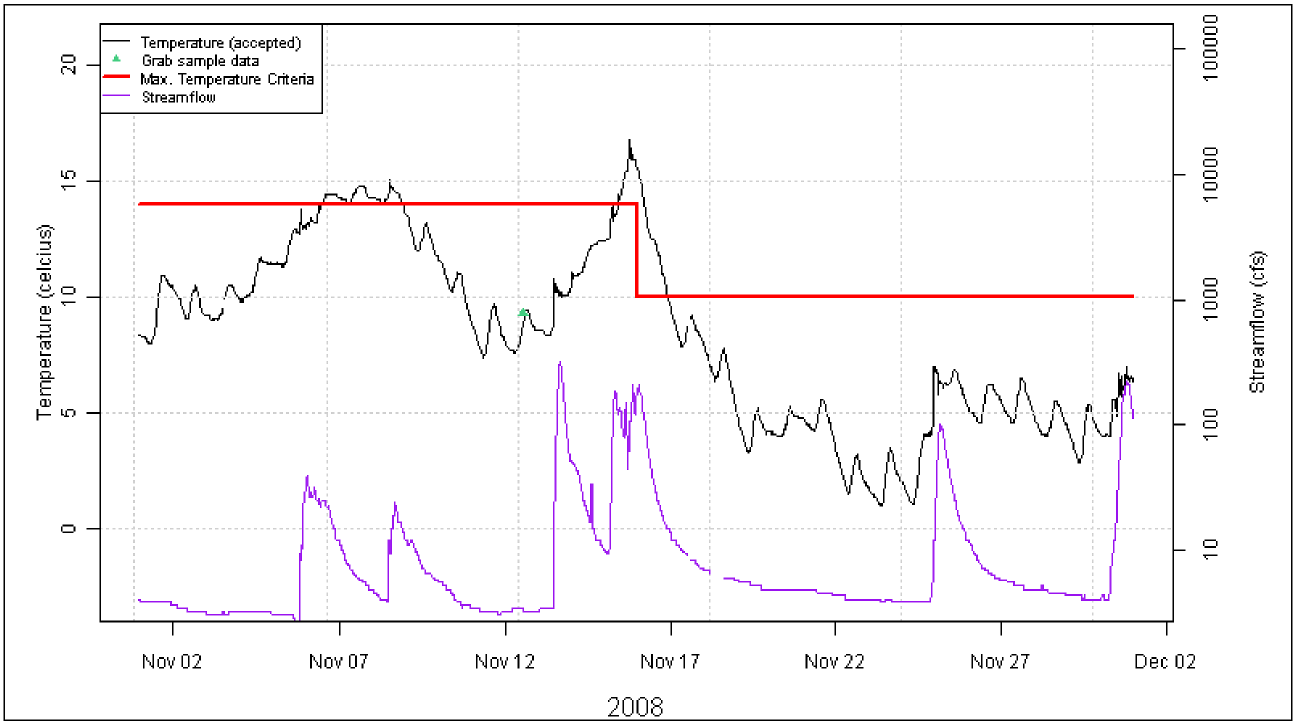



**Figure F.5 Temperature and Streamflow at Site PQ050, November 2008**

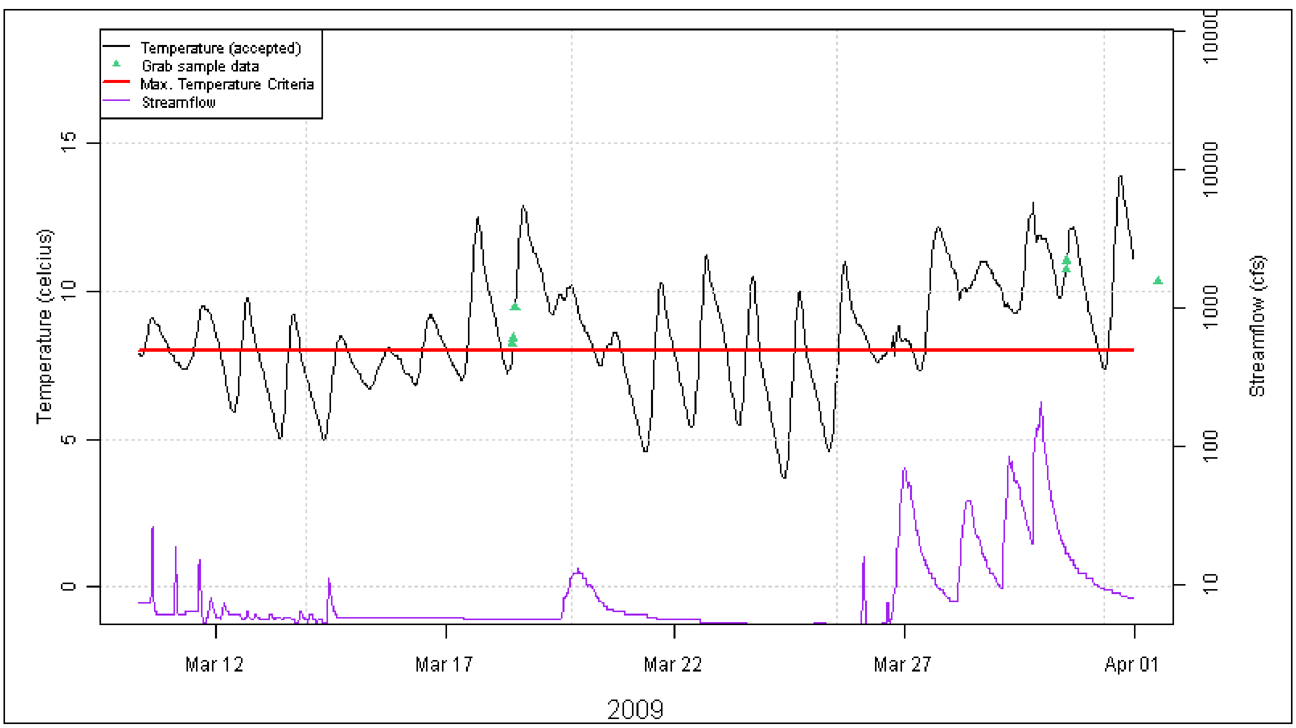



**Figure F.6 Temperature and Streamflow at Site PQ050, March 2009**

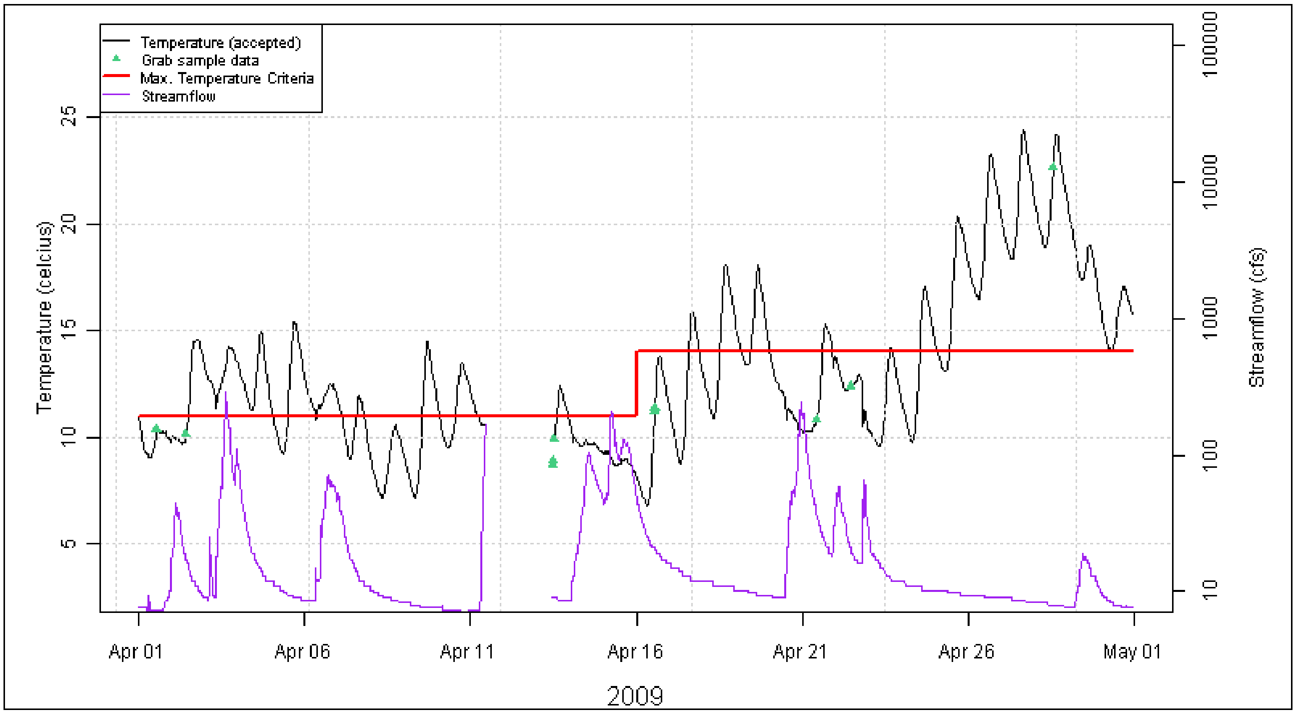



**Figure F.7 Temperature and Streamflow at Site PQ050, April 2009**

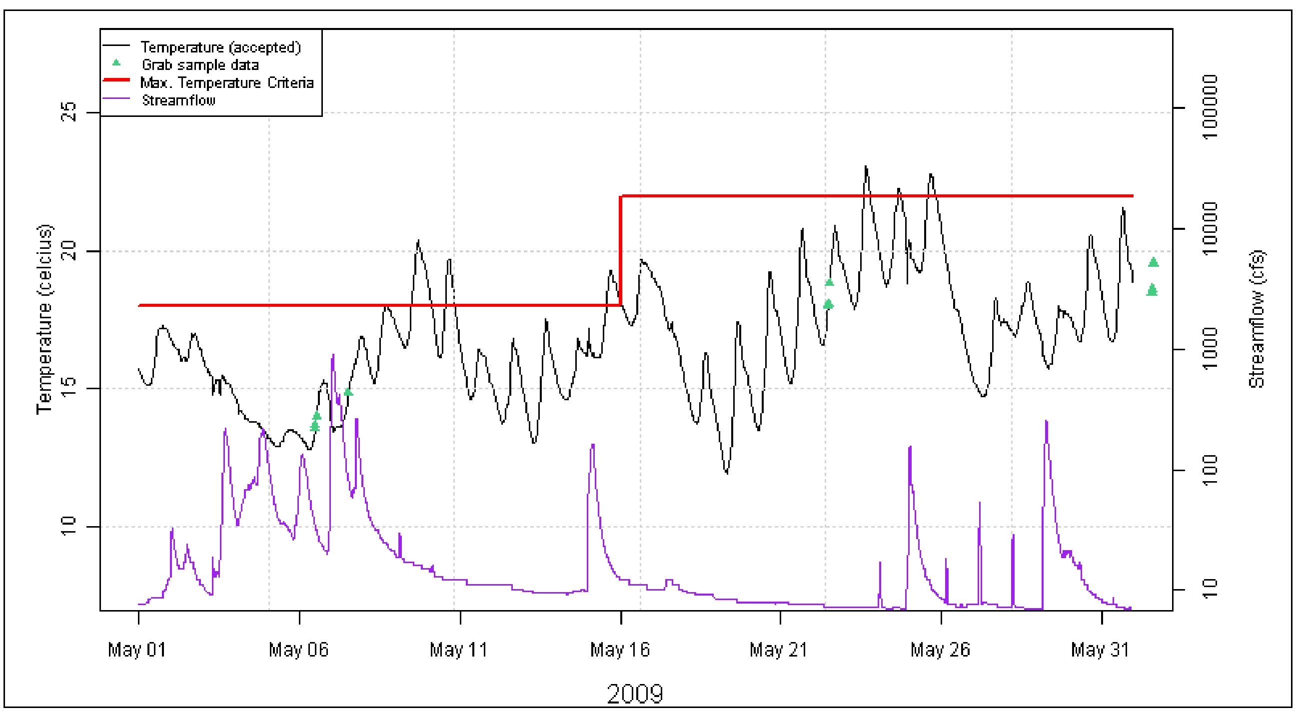



**Figure F.8 Temperature and Streamflow at Site PQ050, May 2009**

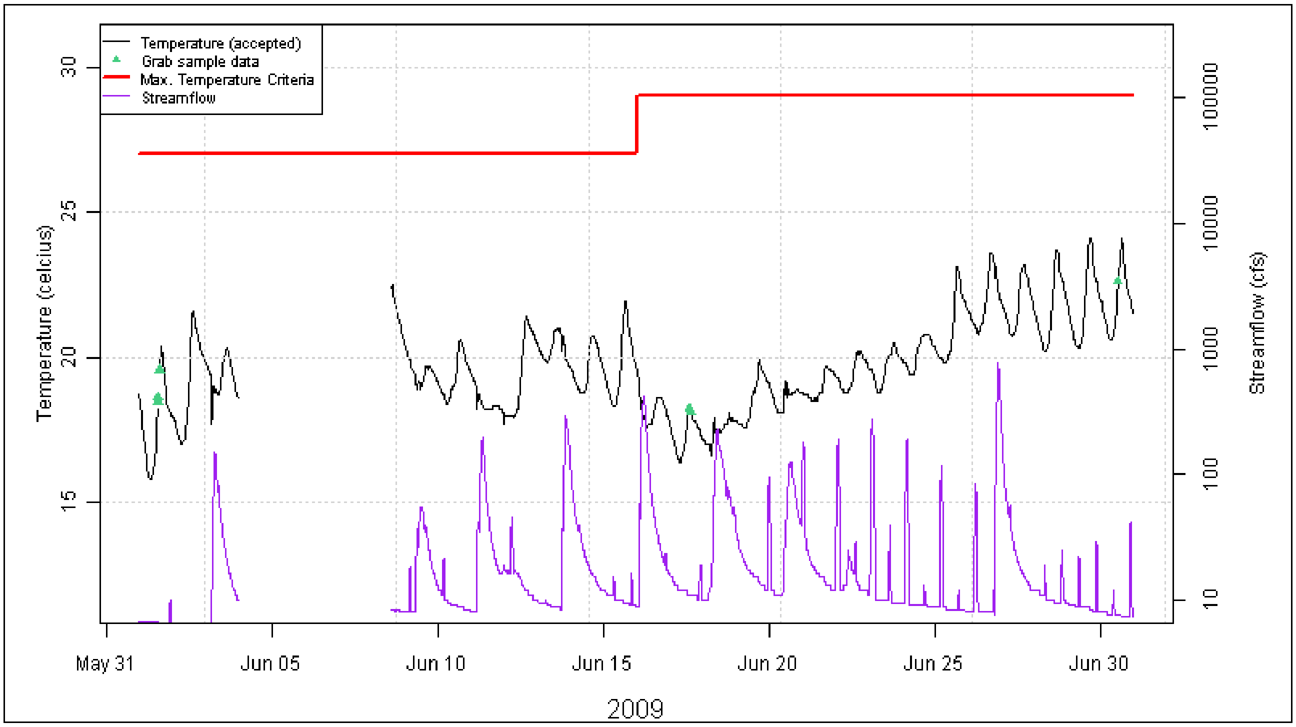



**Figure F.9 Temperature and Streamflow at Site PQ050, June 2009**

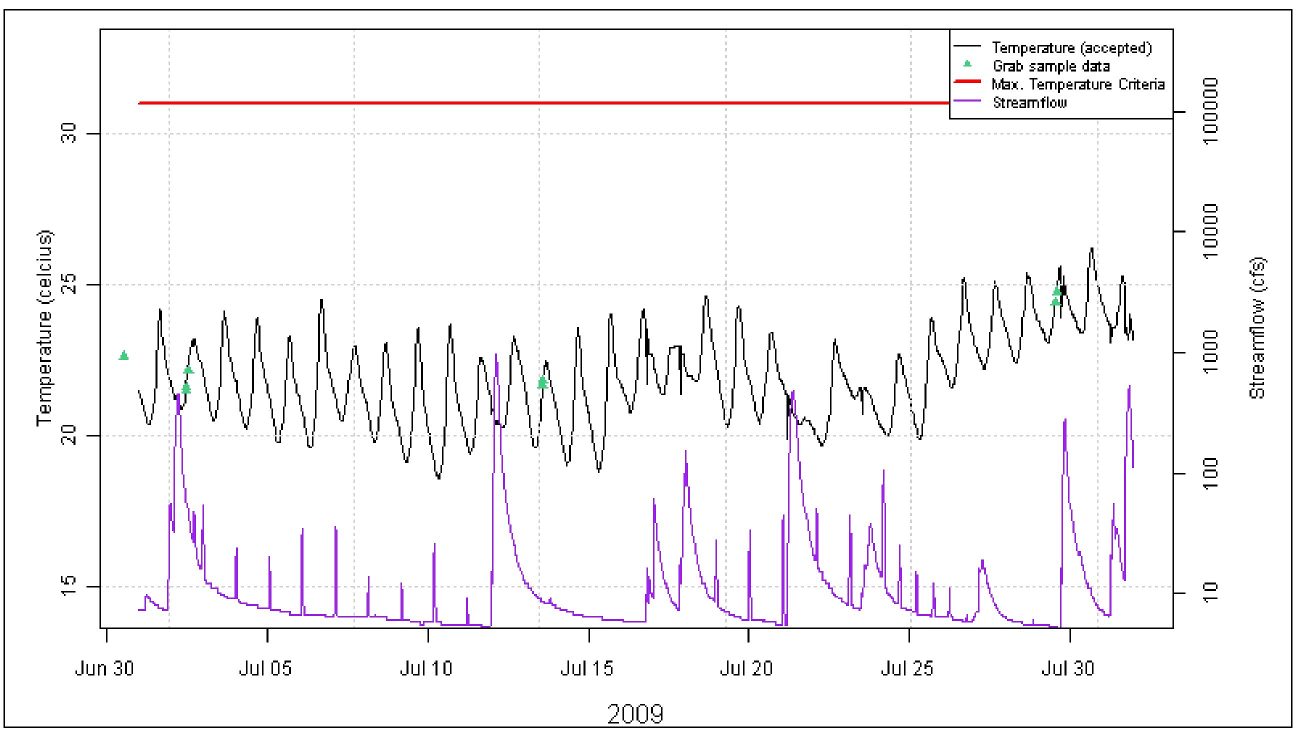



**Figure F.10 Temperature and Streamflow at Site PQ050, July 2009**

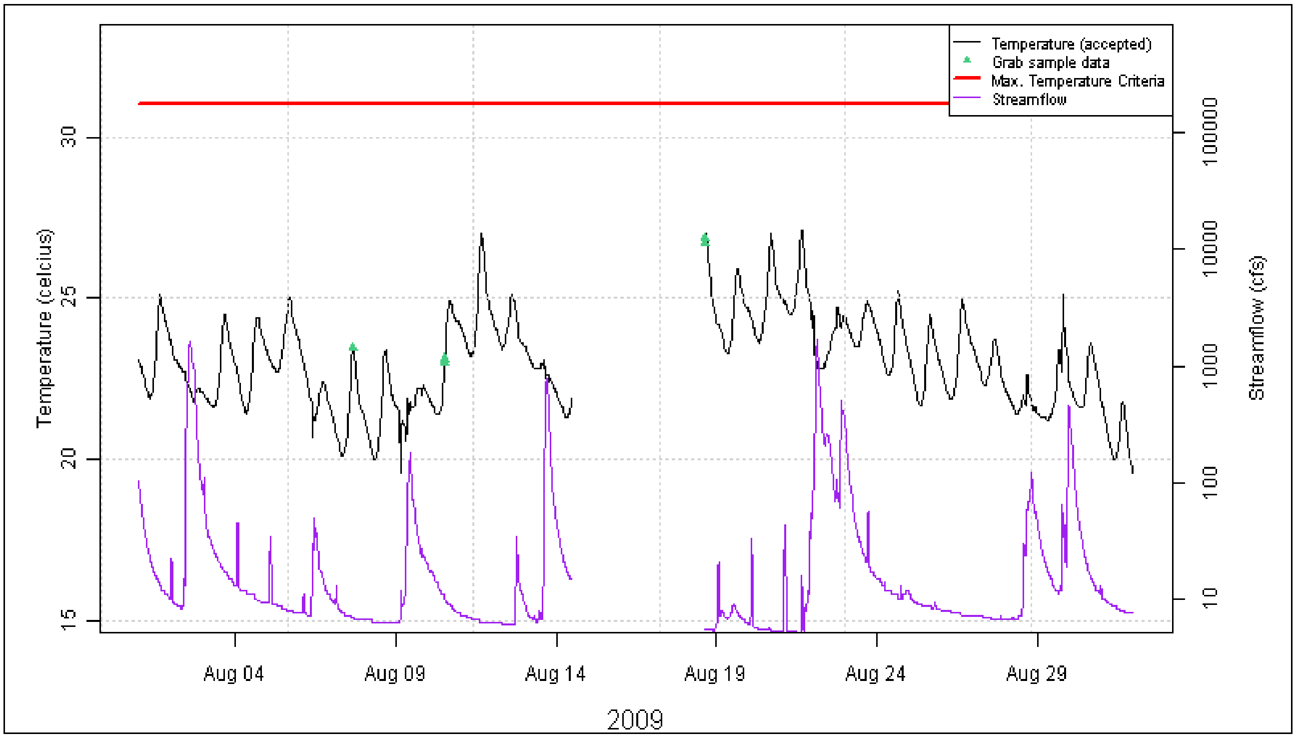



**Figure F.11 Temperature and Streamflow at Site PQ050, August 2009**

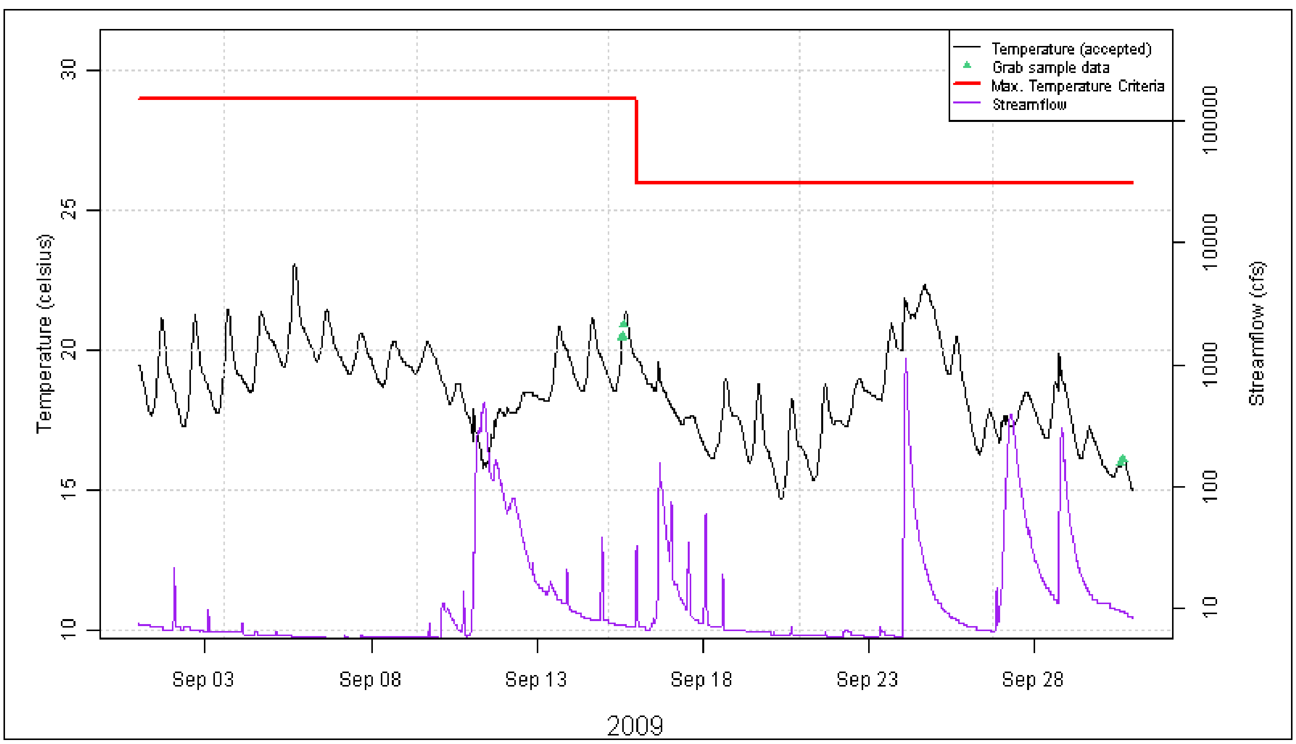



**Figure F.12 Temperature and Streamflow at Site PQ050, September 2009**

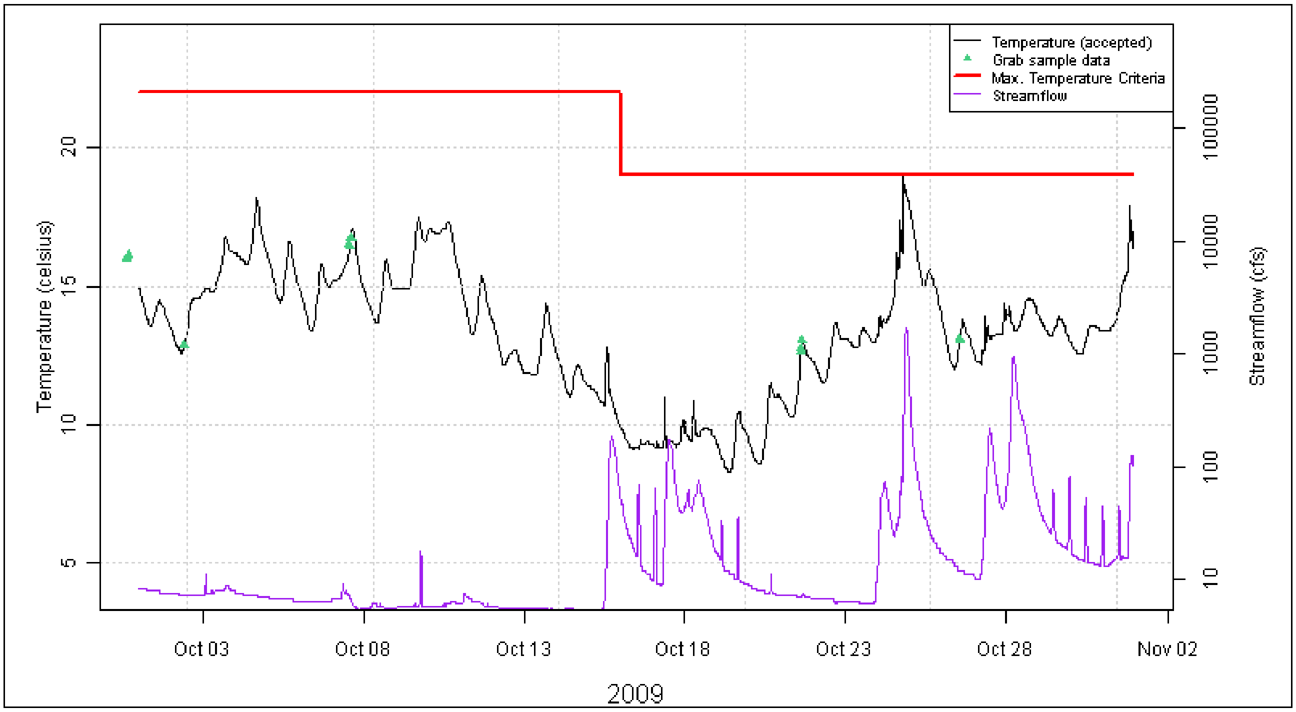



**Figure F.13 Temperature and Streamflow at Site PQ050, October 2009**

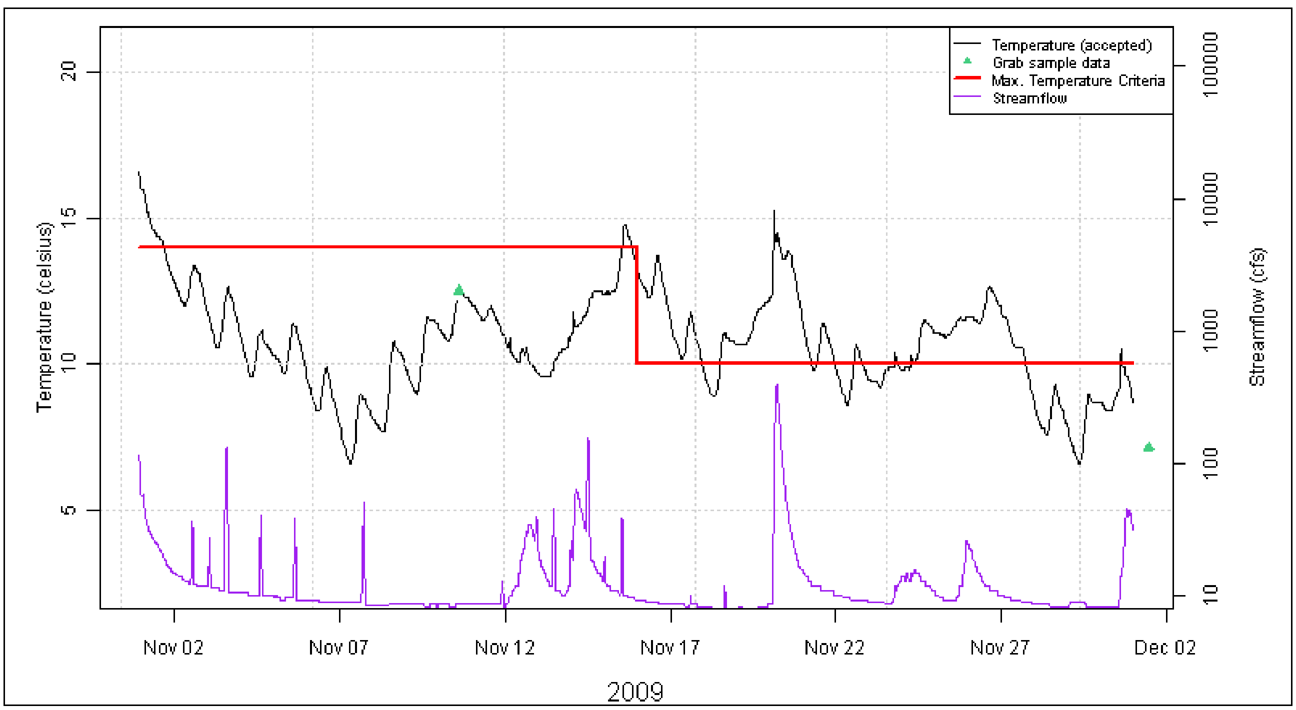



**Figure F.14 Temperature and Streamflow at Site PQ050, November 2009**

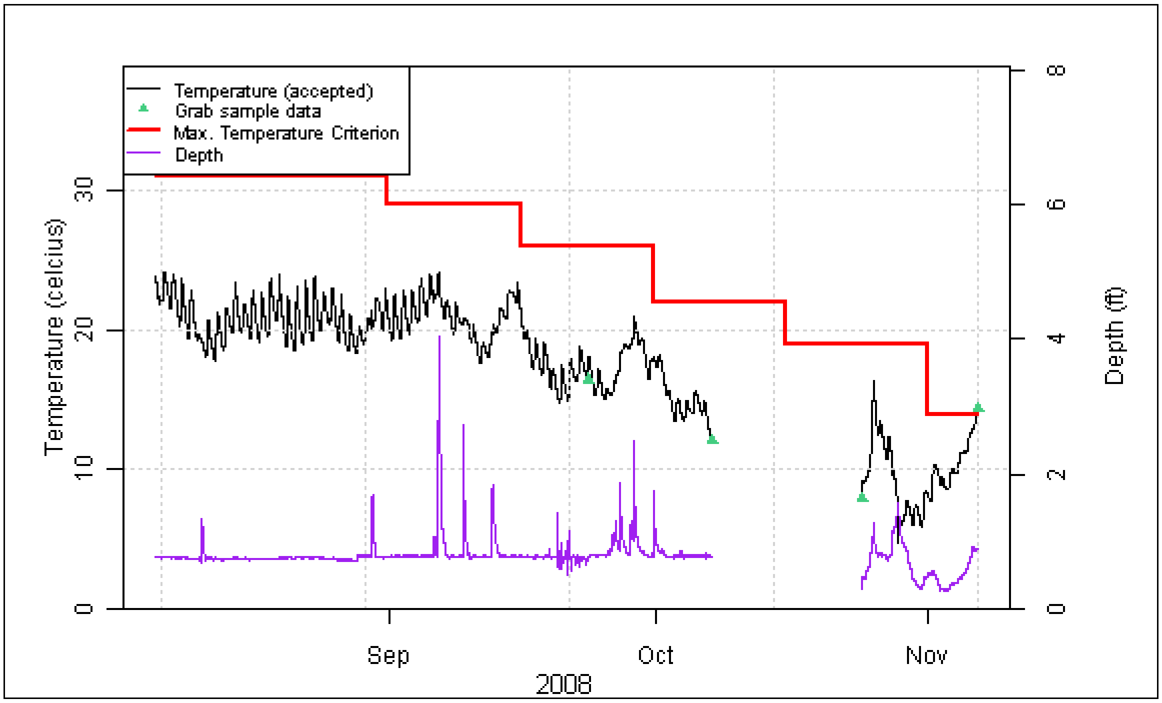



**Figure F.15 Temperature and Stream Depth at Site PQ665, 8/5/08 – 11/6/08**

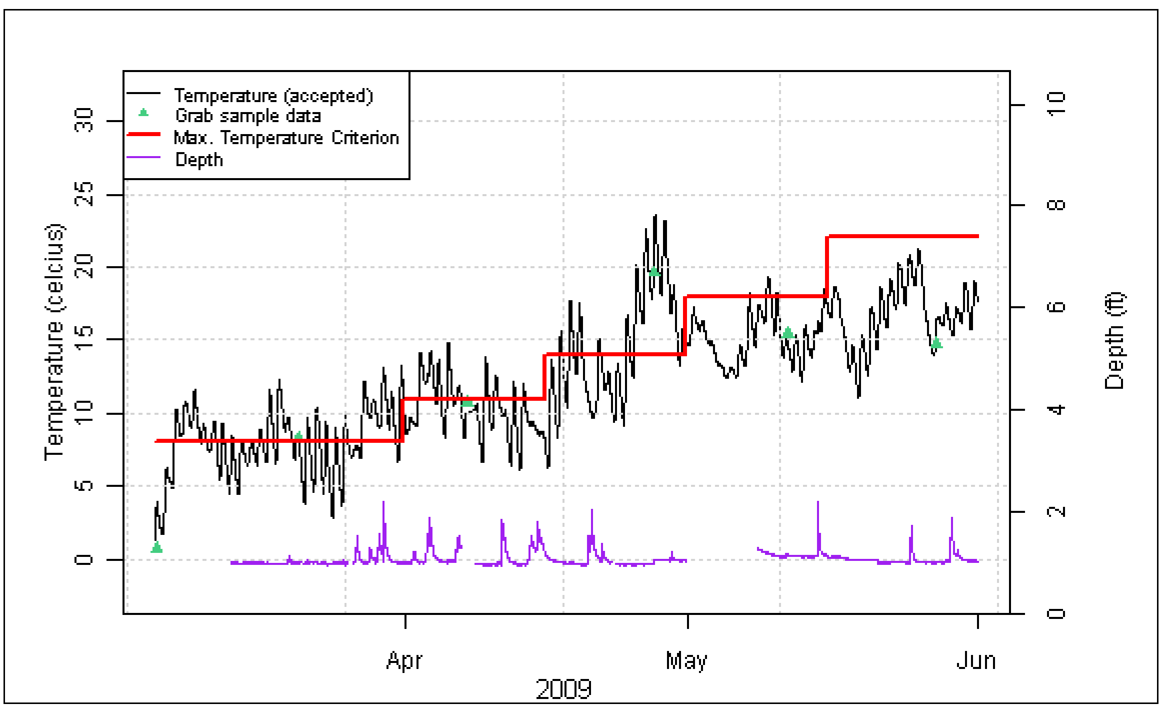



**Figure F.16 Temperature and Stream Depth at Site PQ665, 3/5/09 – 5/31/09**

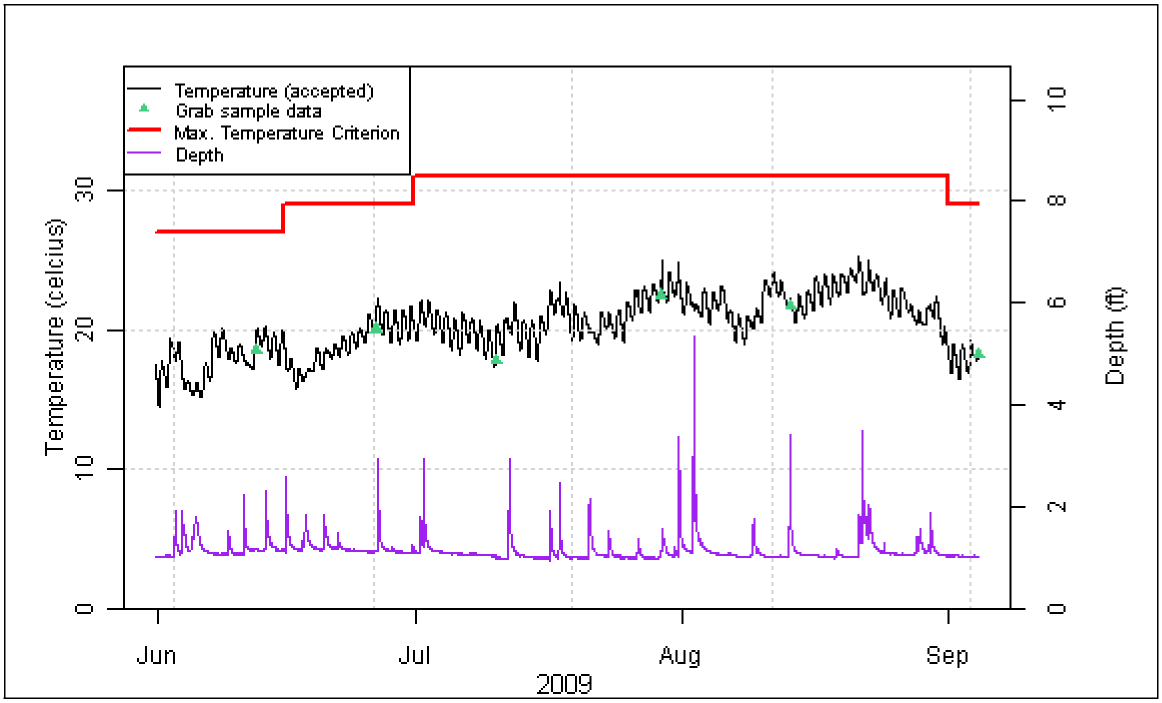



**Figure F.17 Temperature and Stream Depth at Site PQ665, 6/1/09 – 9/4/09**

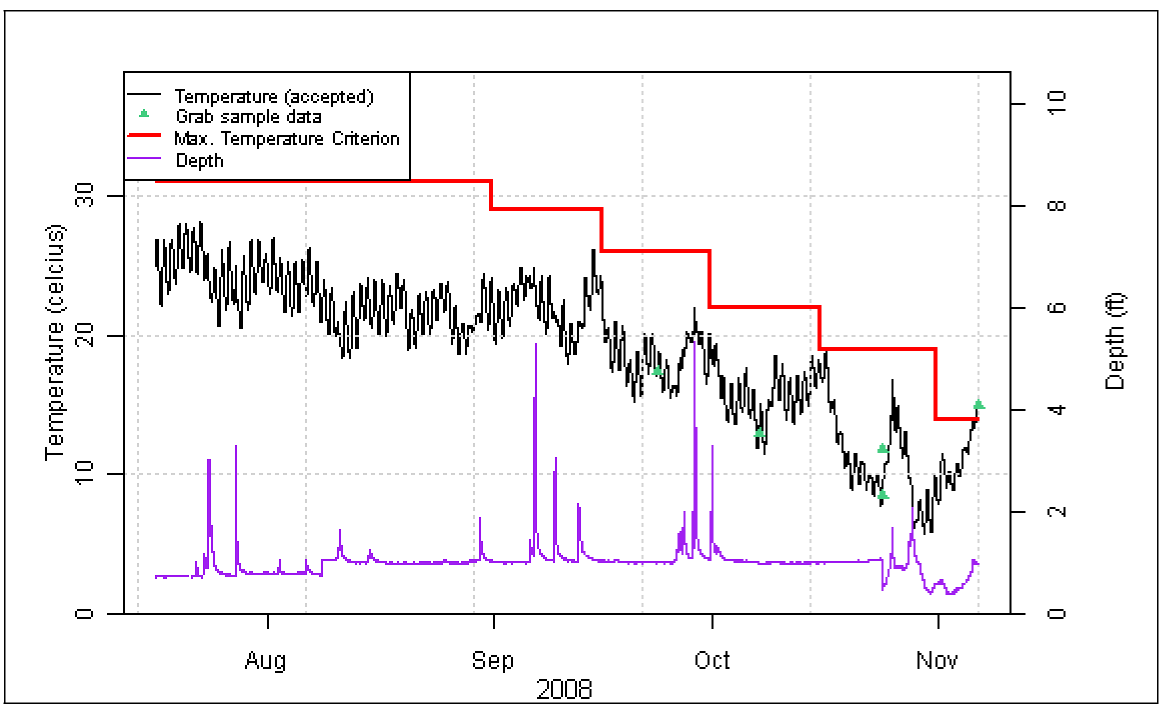



**Figure F.18 Temperature and Stream Depth at Site PQB025, 7/16/08 – 11/6/08**

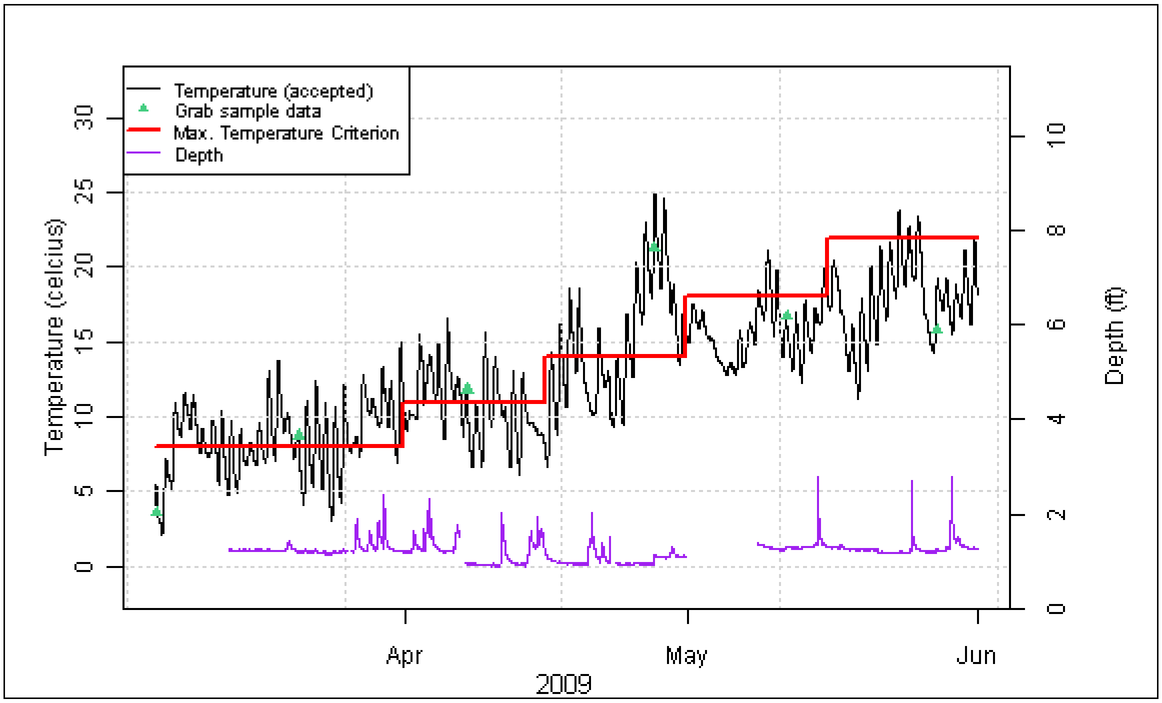



**Figure F.19 Temperature and Stream Depth at Site PQB025, 3/5/09 – 5/31/09**

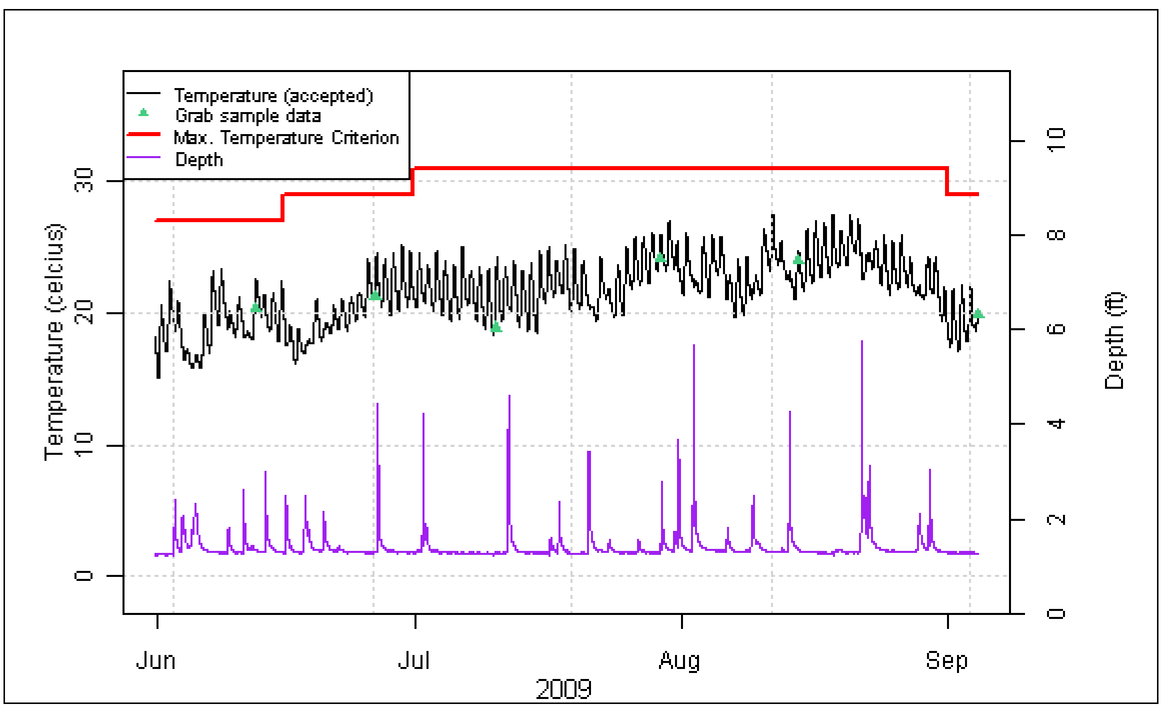



**Figure F.20 Temperature and Stream Depth at Site PQB025, 6/1/09 – 9/4/09**

# APPENDIX G:

## pH Plots

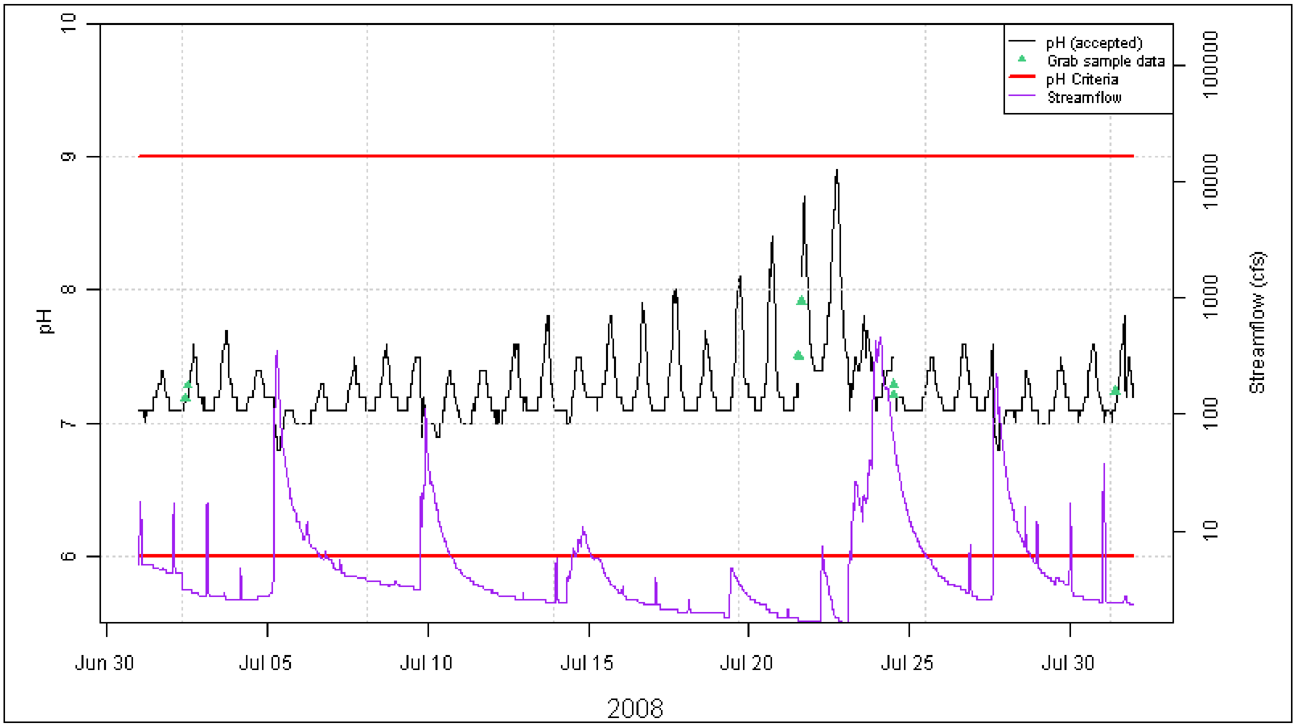



**Figure G.1 pH and Streamflow at Site PQ050, July 2008**

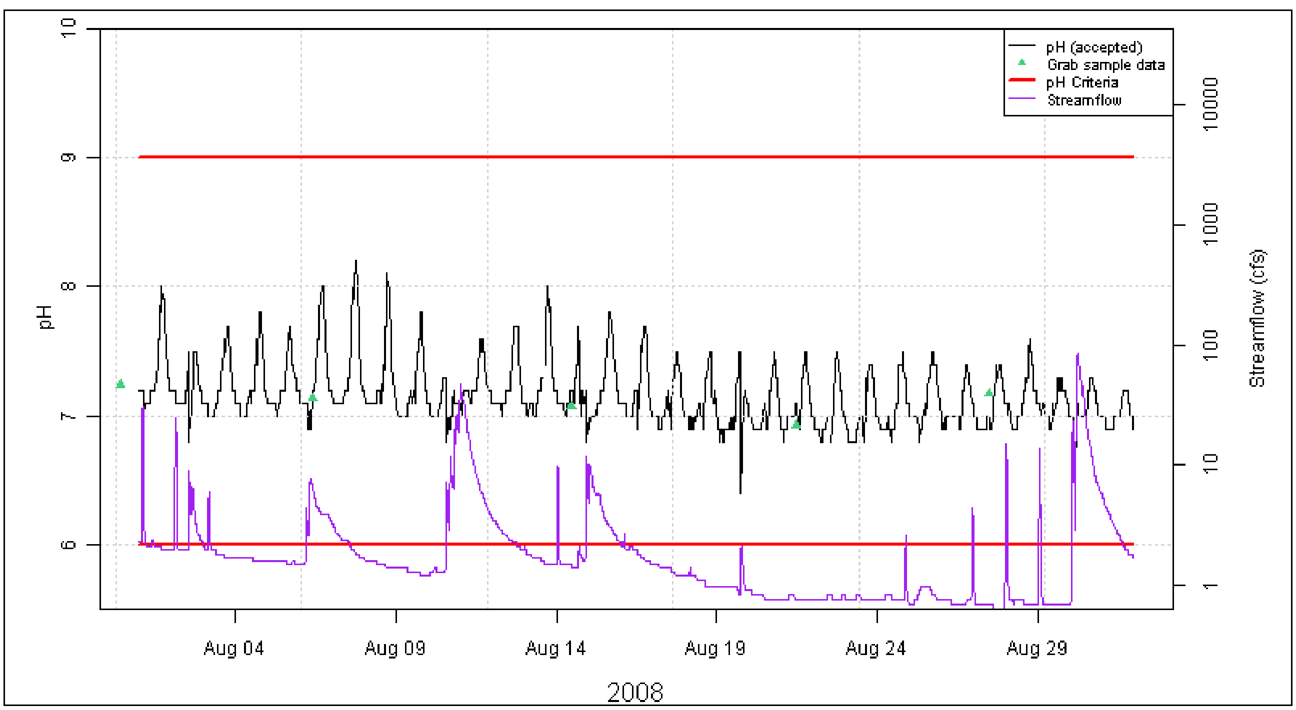



**Figure G.2 pH and Streamflow at Site PQ050, August 2008**

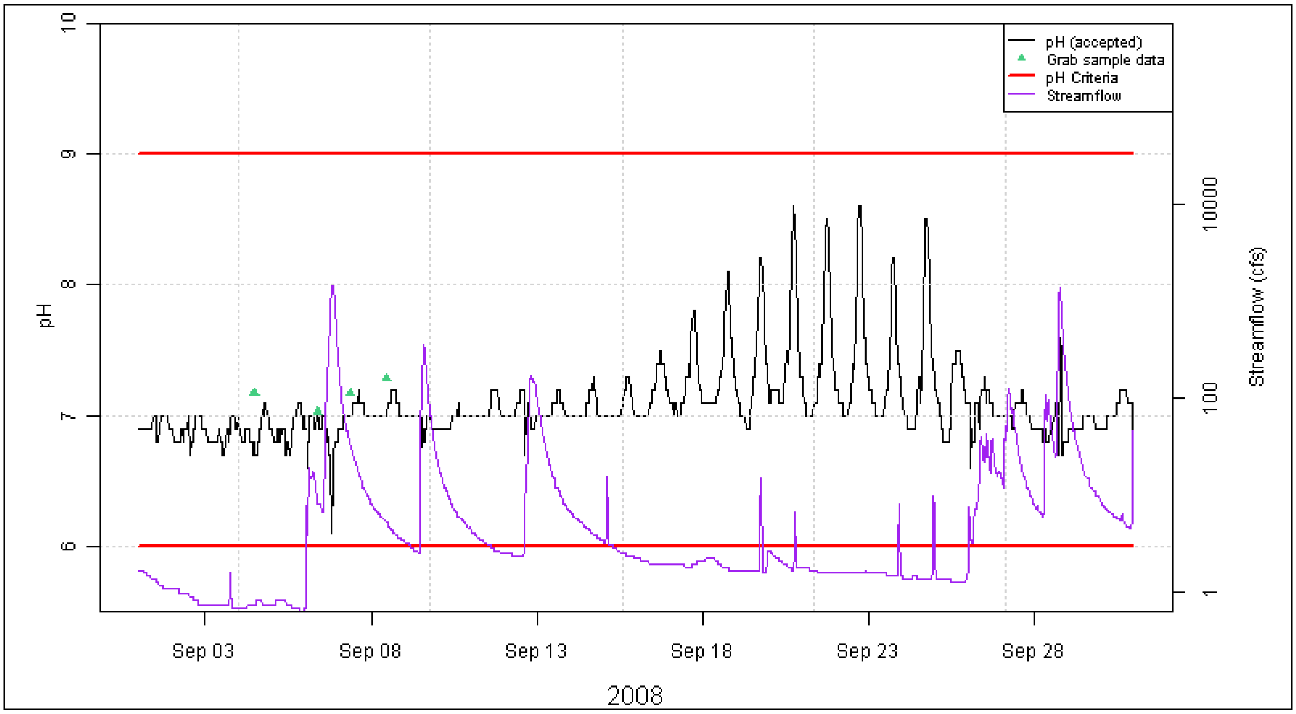



**Figure G.3 pH and Streamflow at Site PQ050, September 2008**

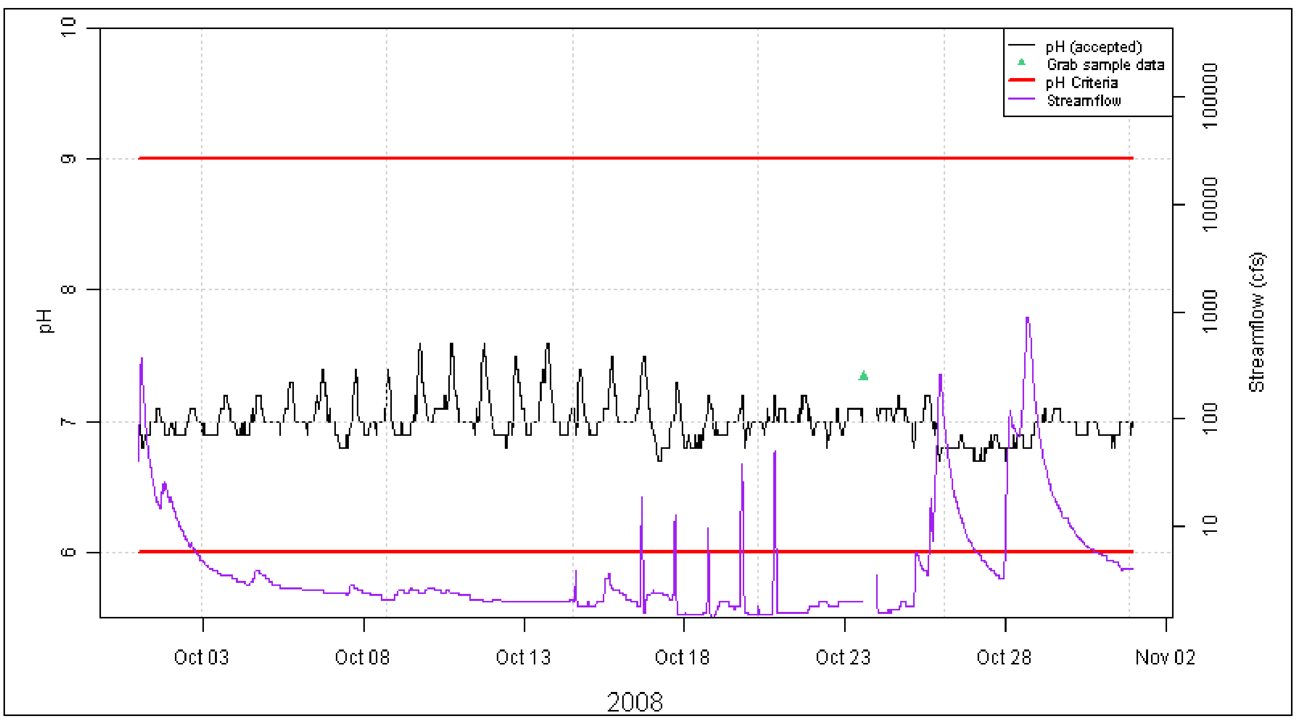



**Figure G.4 pH and Streamflow at Site PQ050, October 2008**


**Figure G.5 pH and Streamflow at Site PQ050, November 2008**

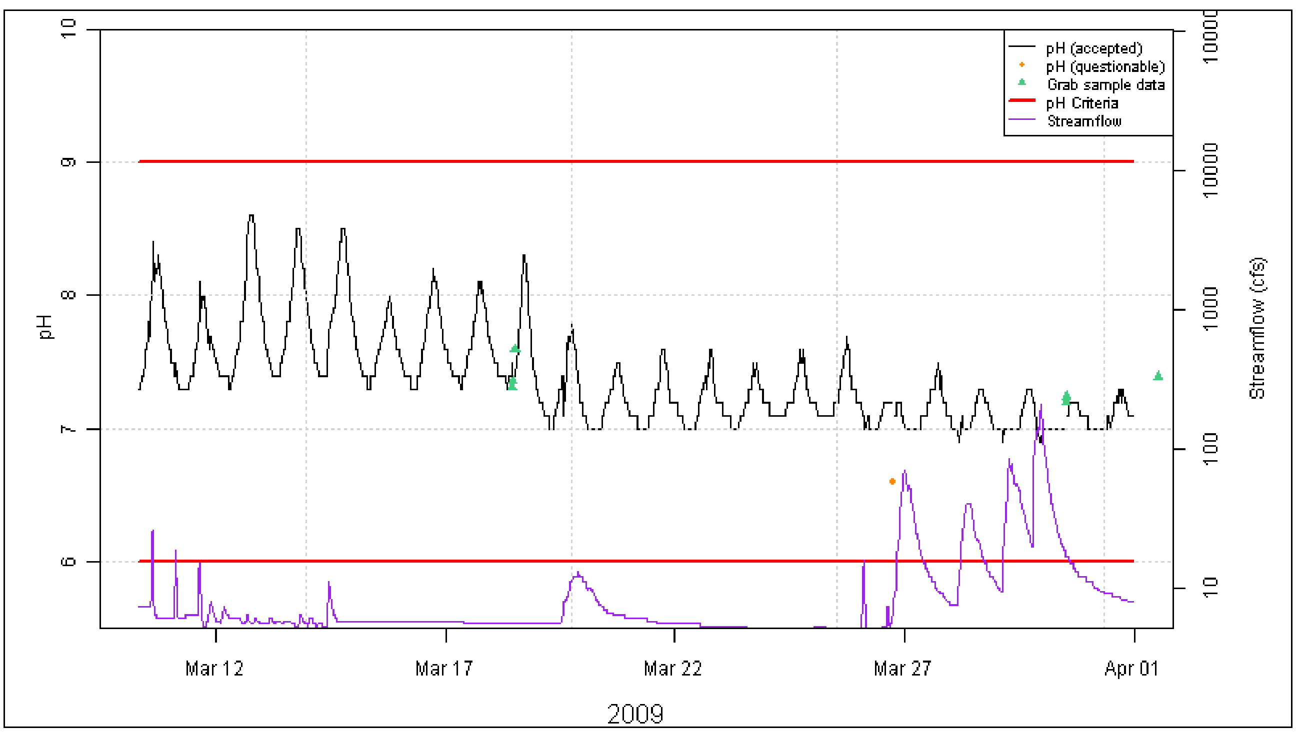



**Figure G.6 pH and Streamflow at Site PQ050, March 2009**

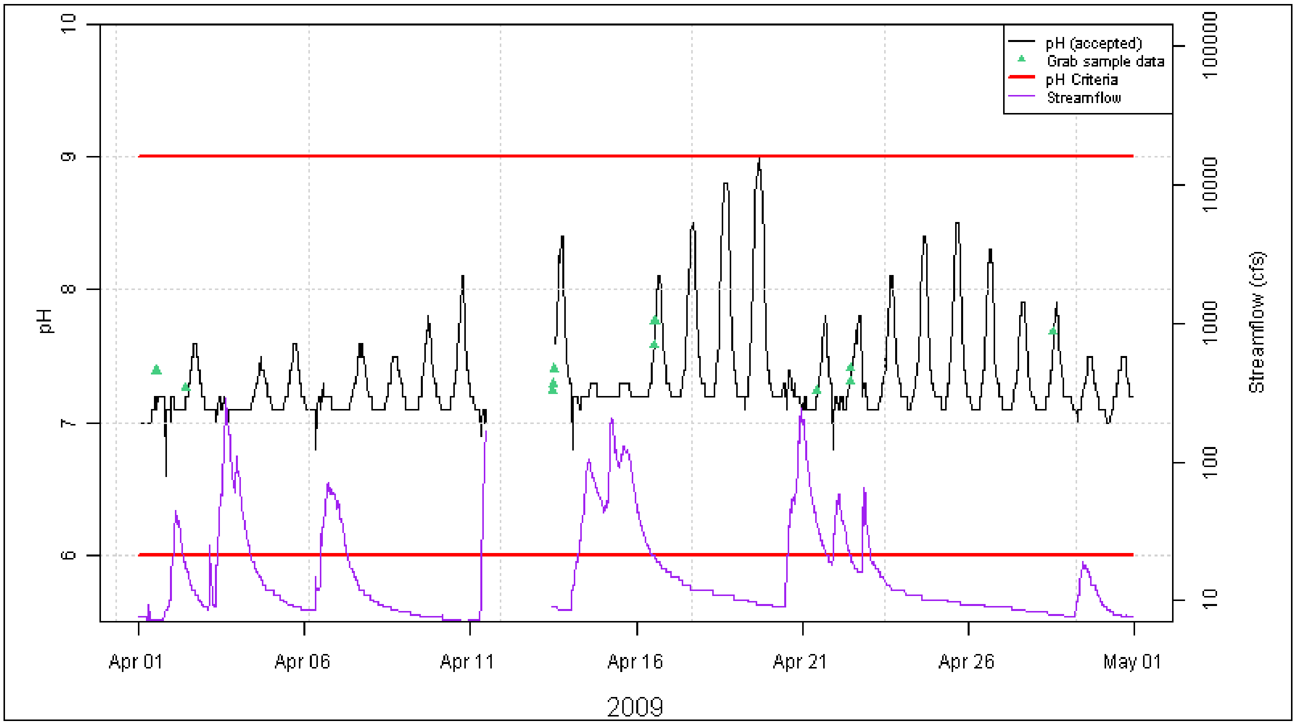



**Figure G.7 pH and Streamflow at Site PQ050, April 2009**

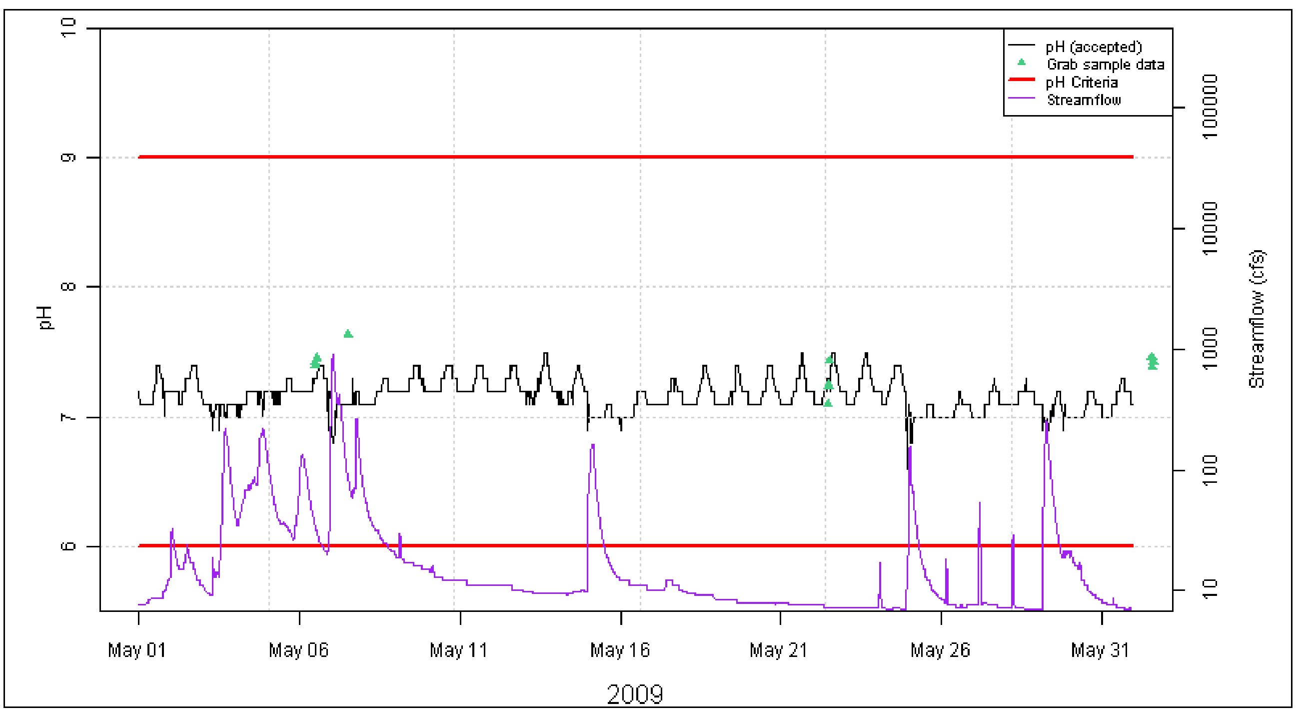



**Figure G.8 pH and Streamflow at Site PQ050, May 2009**

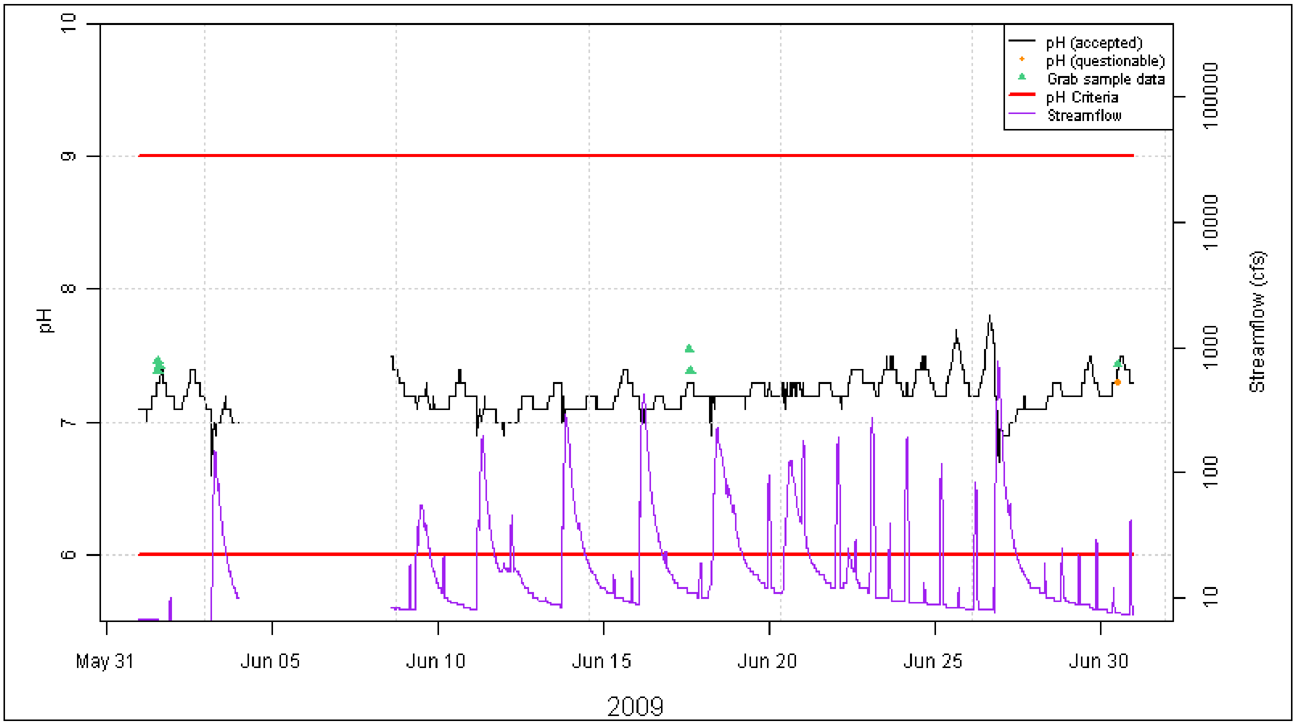



**Figure G.9 pH and Streamflow at Site PQ050, June 2009**

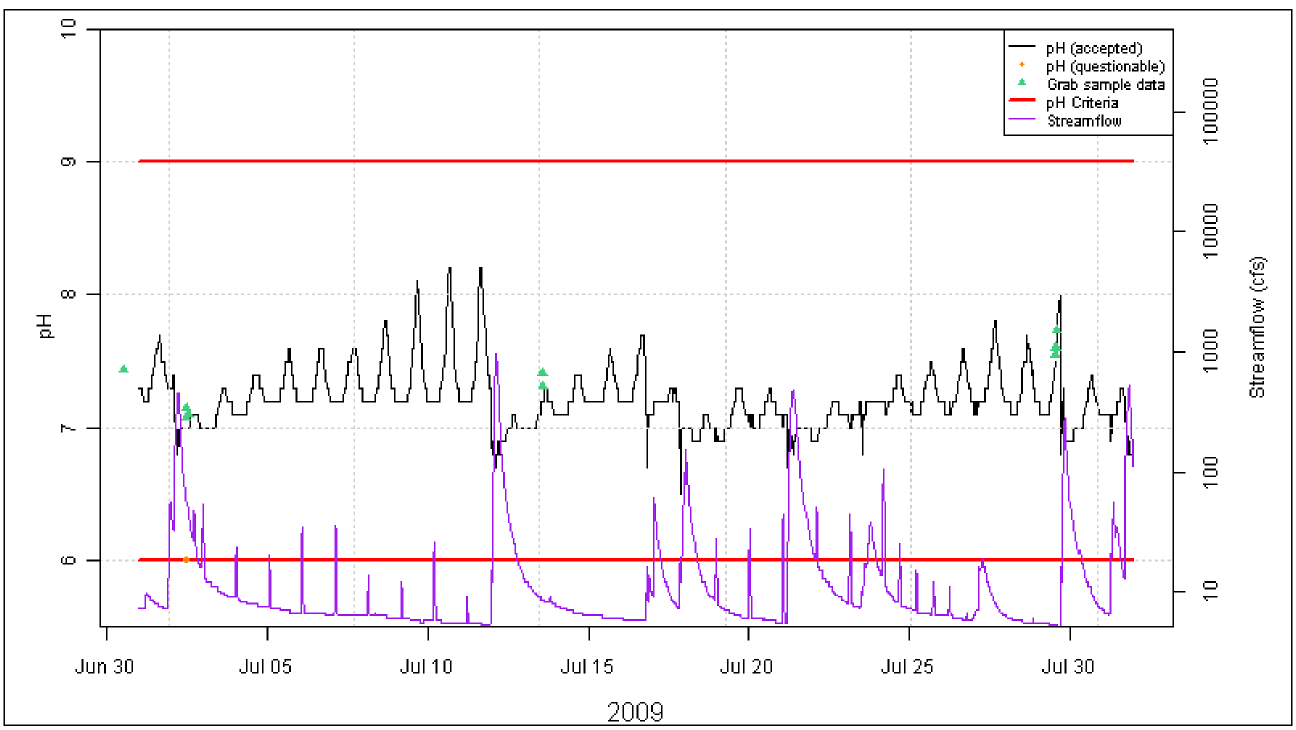



**Figure G.10 pH and Streamflow at Site PQ050, July 2009**

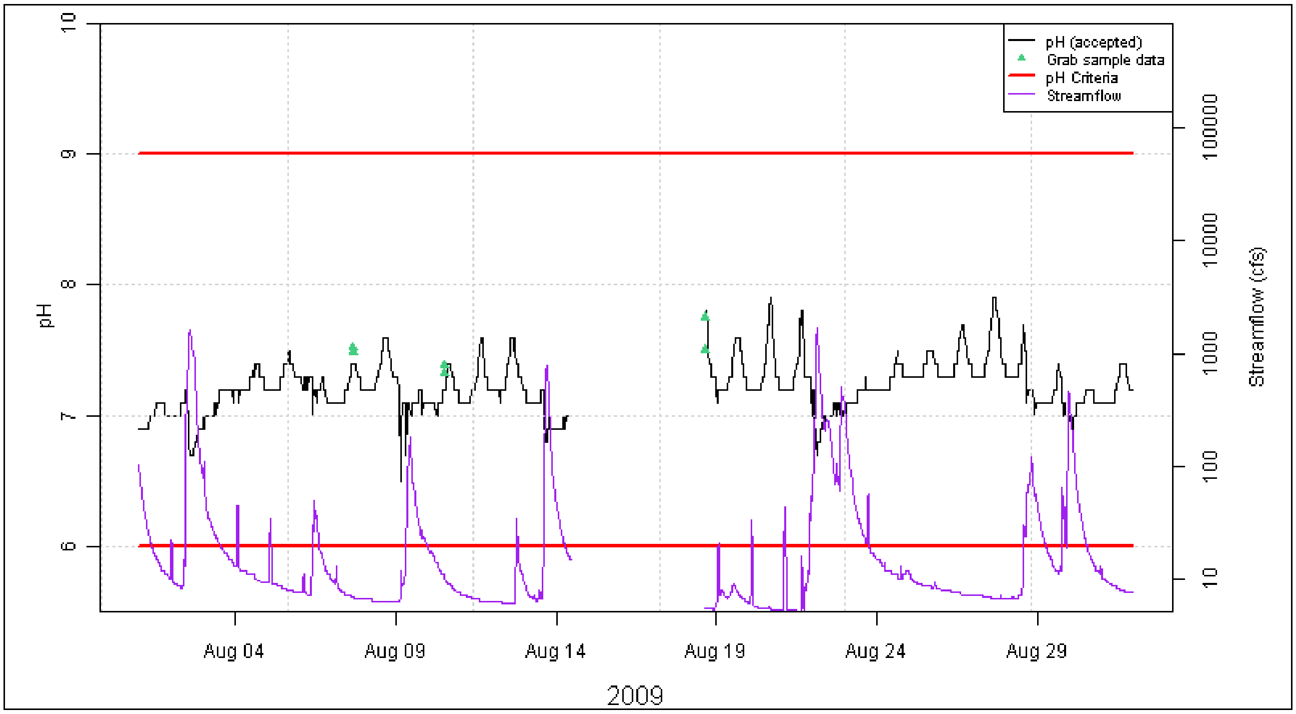



**Figure G.11 pH and Streamflow at Site PQ050, August 2009**

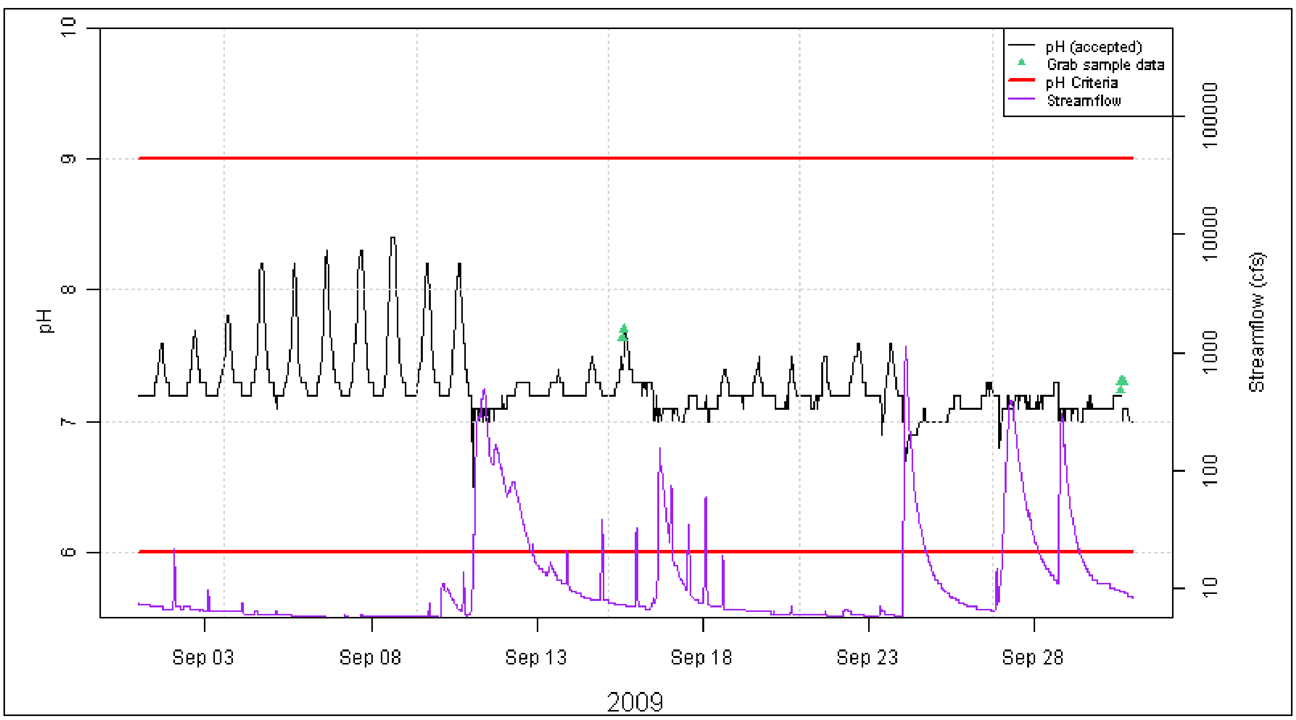



**Figure G.12 pH and Streamflow at Site PQ050, September 2009**

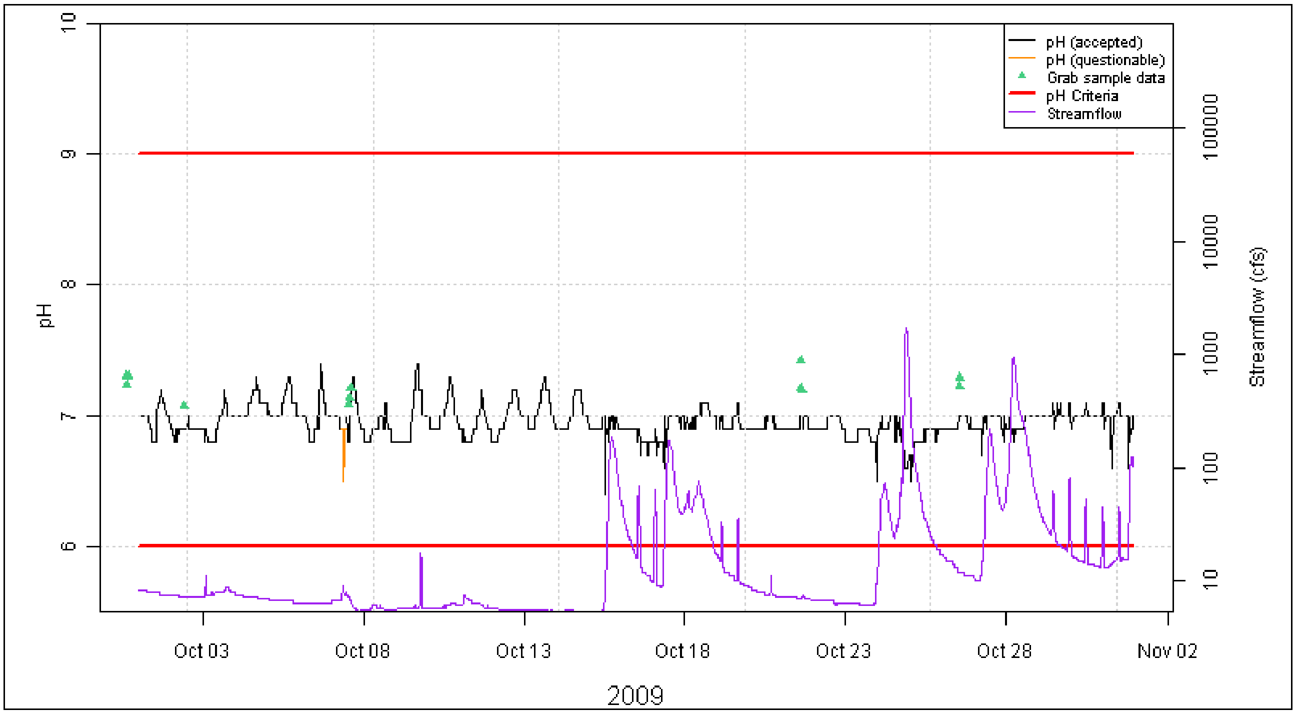



**Figure G.13 pH and Streamflow at Site PQ050, October 2009**

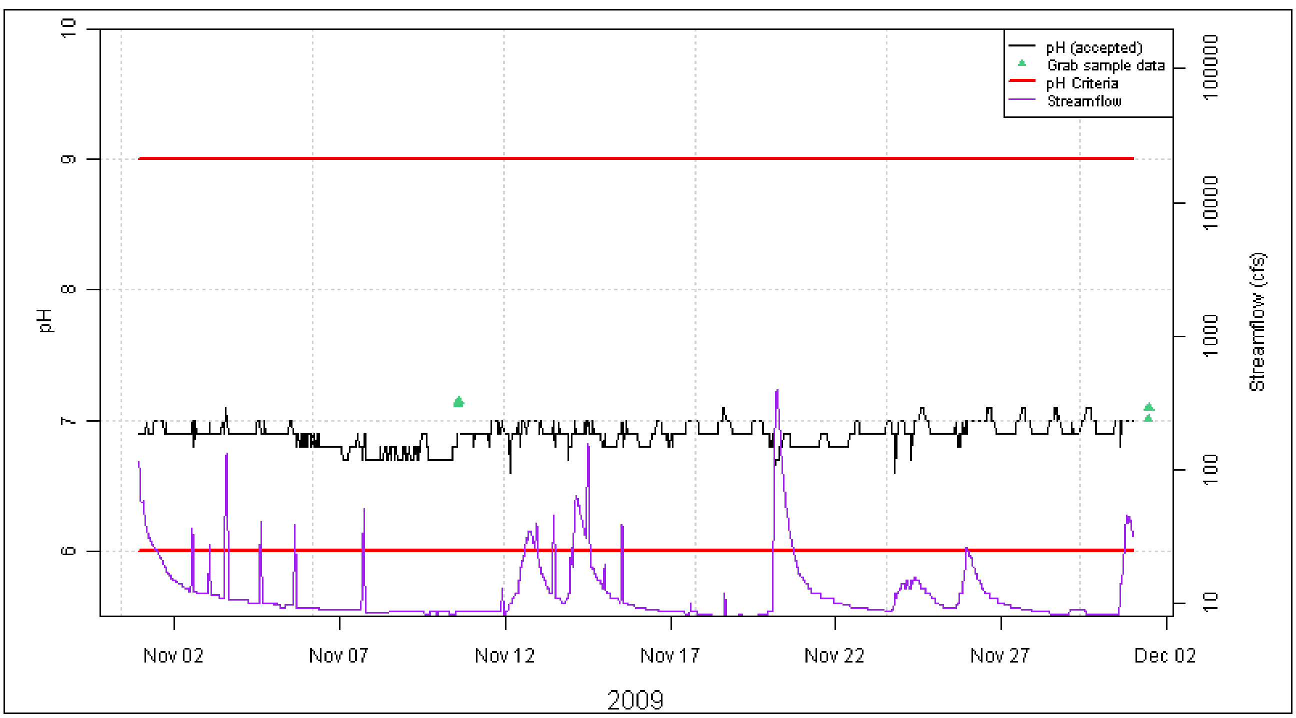



**Figure G.14 pH and Streamflow at Site PQ050, November 2009**

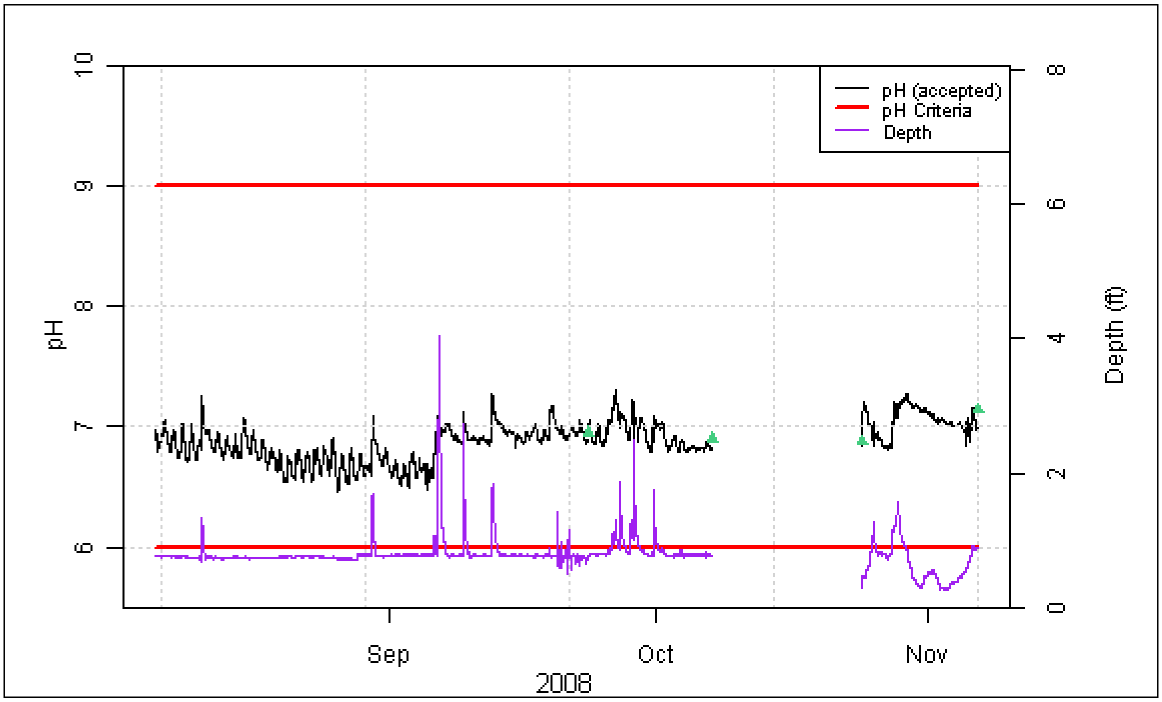



**Figure G.15 pH and Stream Depth at Site PQ665, 8/5/08 – 11/6/08**

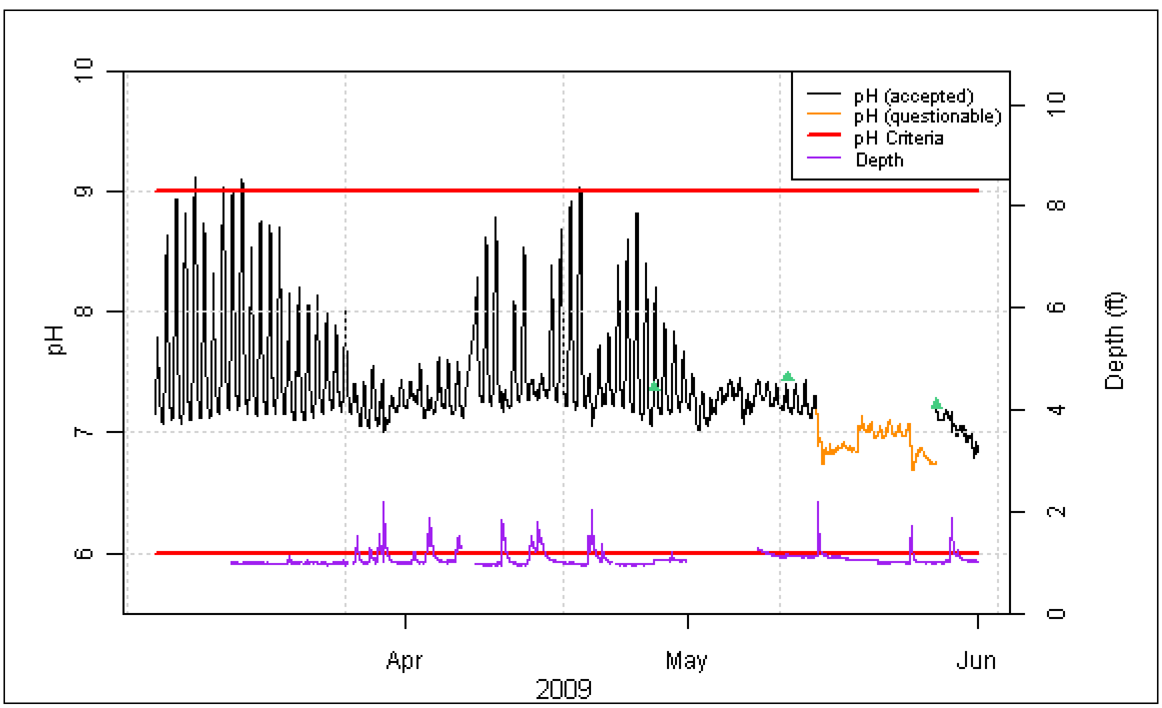



**Figure G.16 pH and Stream Depth at Site PQ665, 3/5/09 – 5/31/09**

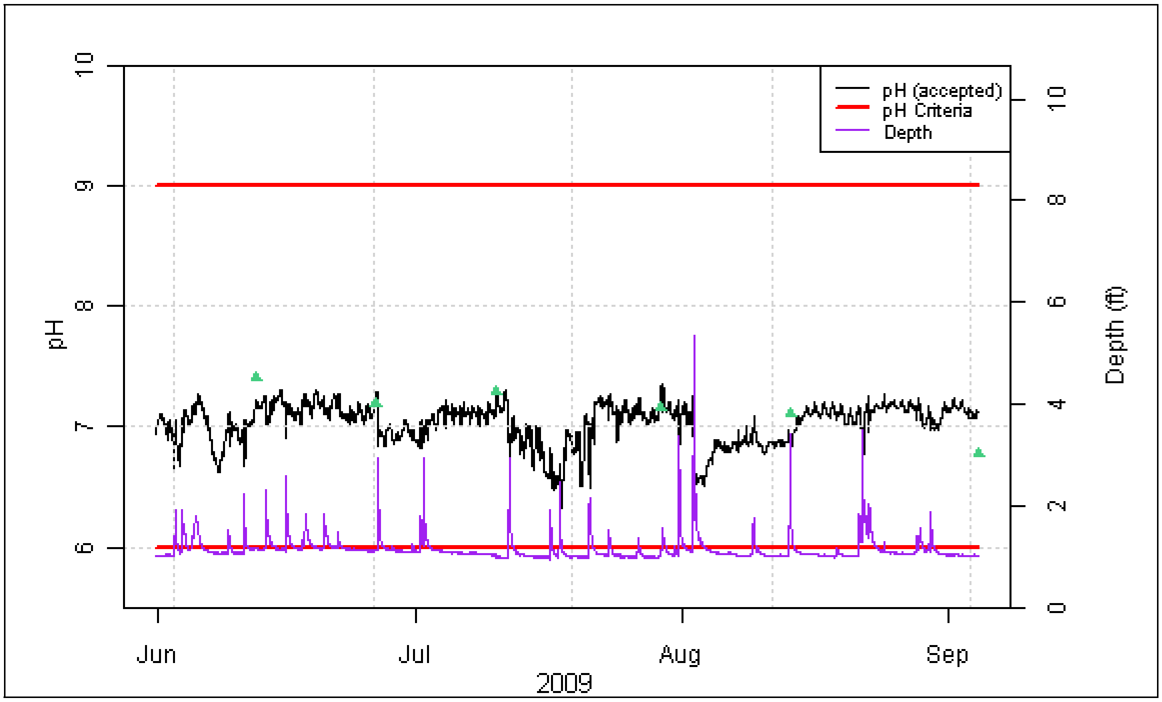



**Figure G.17 pH and Stream Depth at Site PQ665, 6/1/09 – 9/4/09**

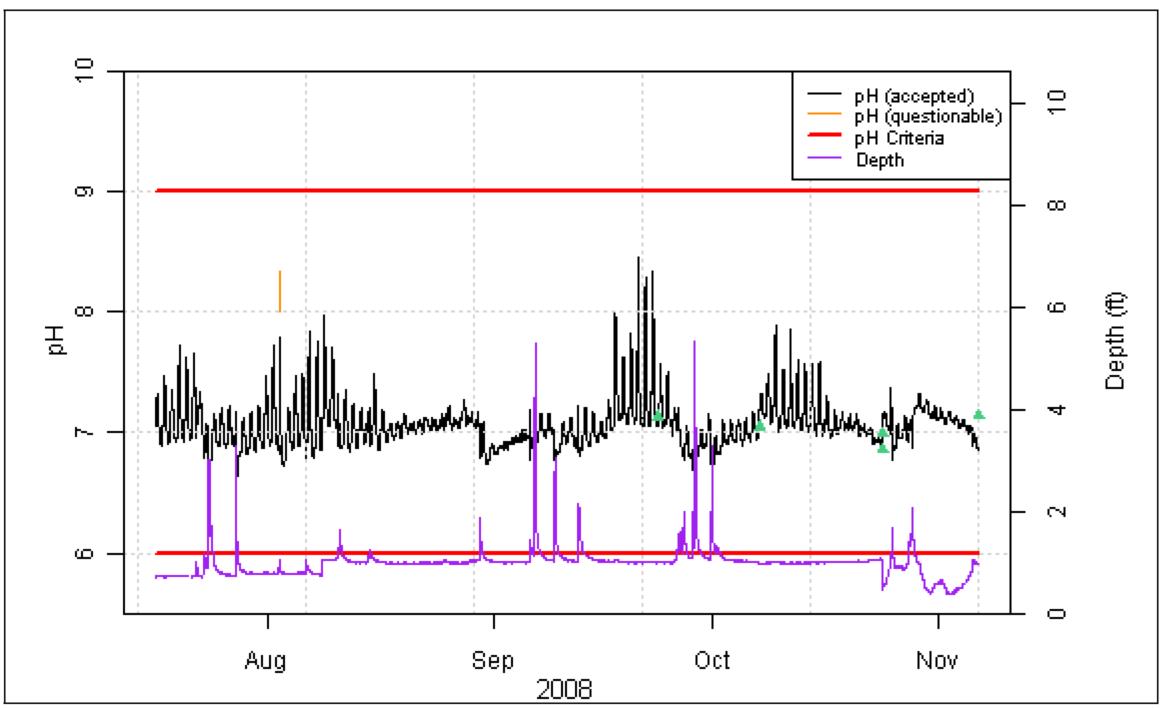



**Figure G.18 pH and Stream Depth at Site PQB025, 7/16/08 – 11/6/08**

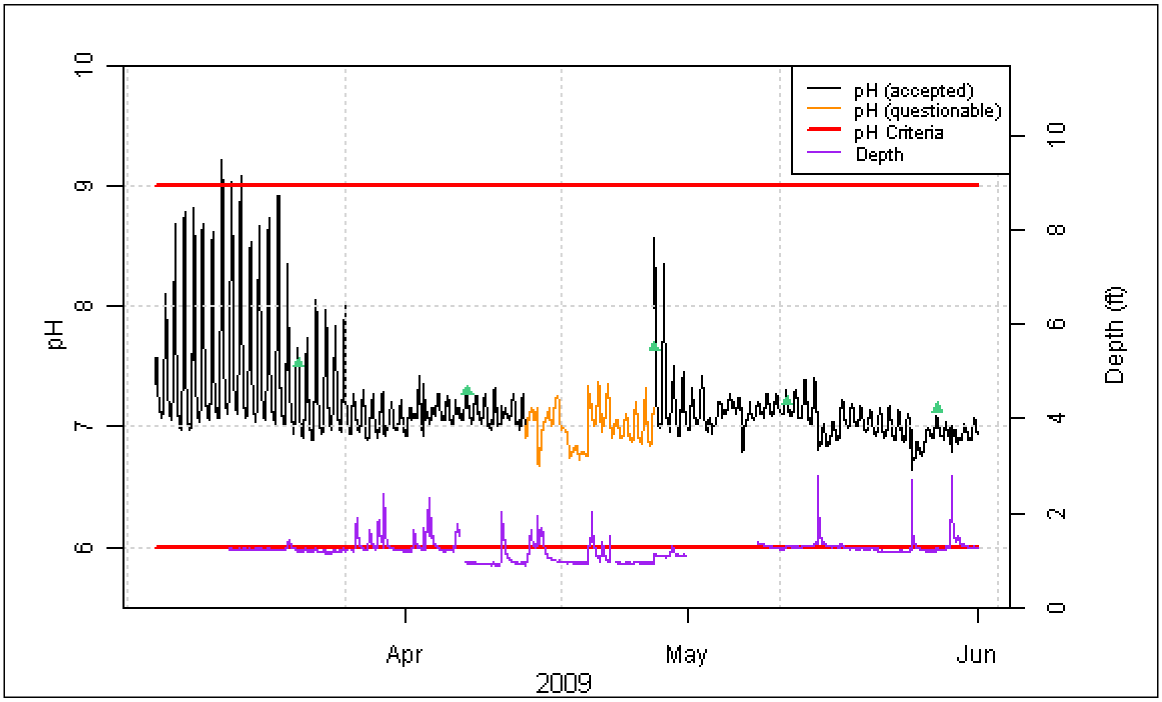



**Figure G.19 pH and Stream Depth at Site PQB025, 3/5/09 – 5/31/09**

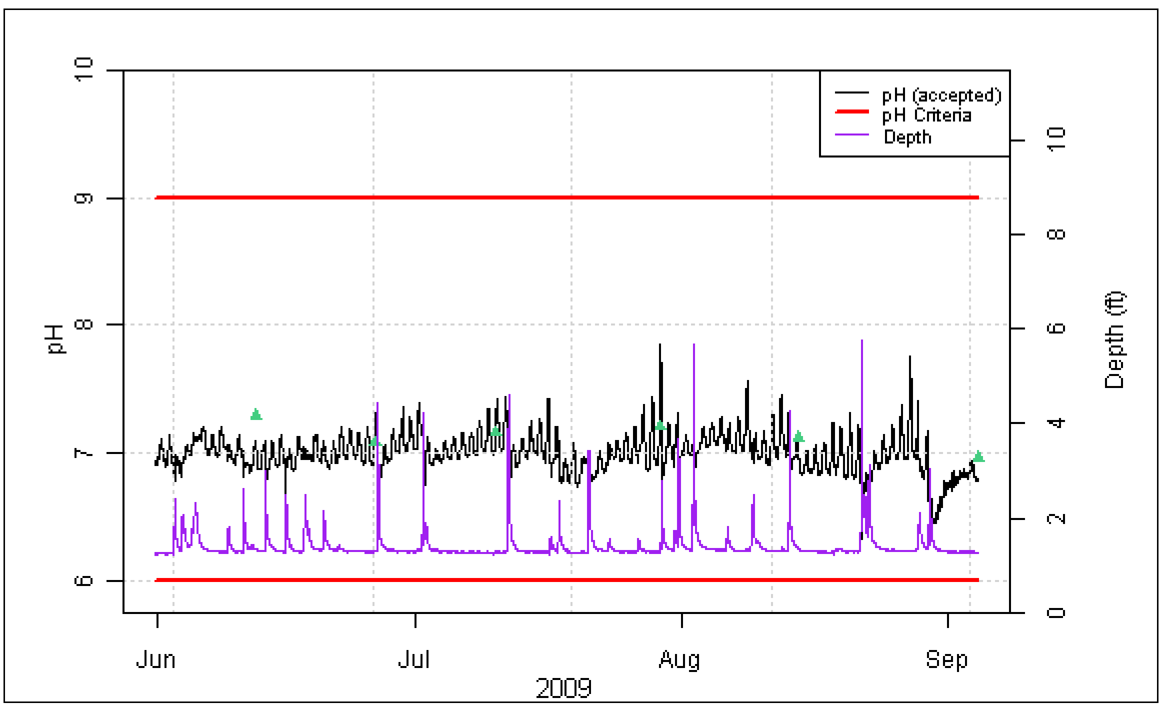



**Figure G.20 pH and Stream Depth at Site PQB025, 6/1/09 – 9/4/09**

# APPENDIX H:

## Conductivity Plots

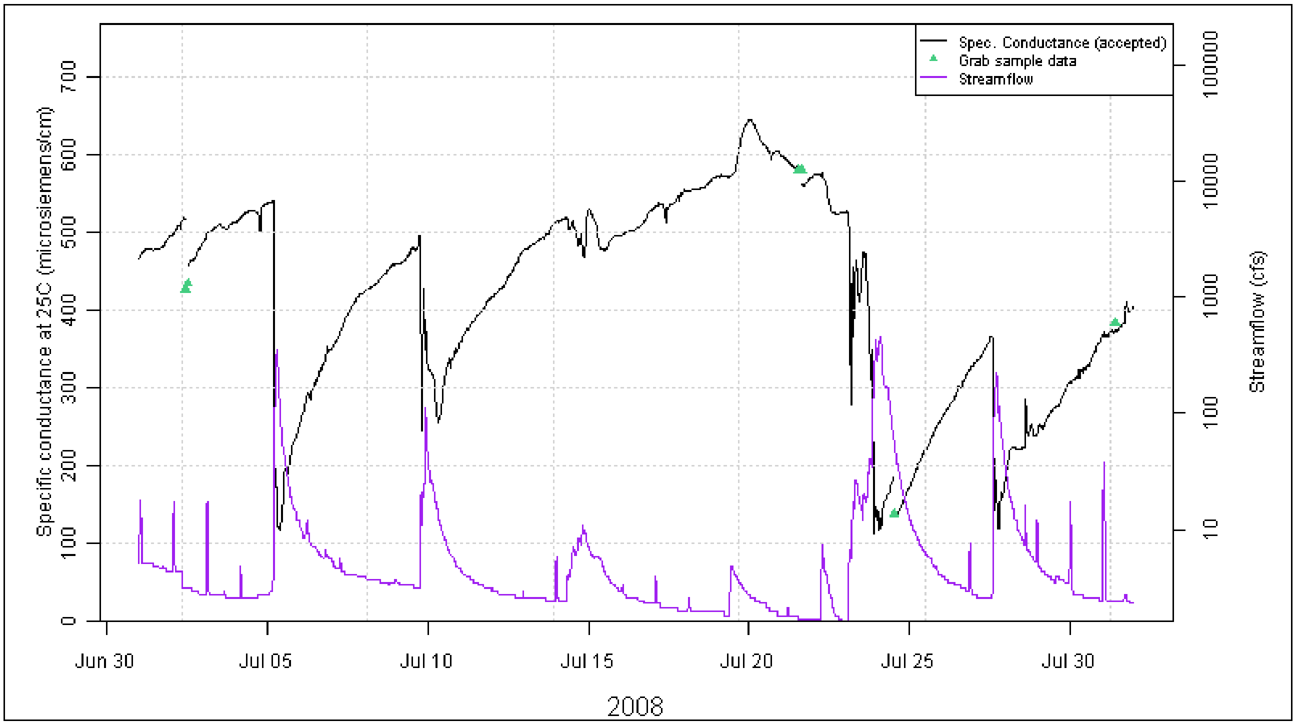



**Figure H.1 Conductivity and Streamflow at Site PQ050, July 2008**

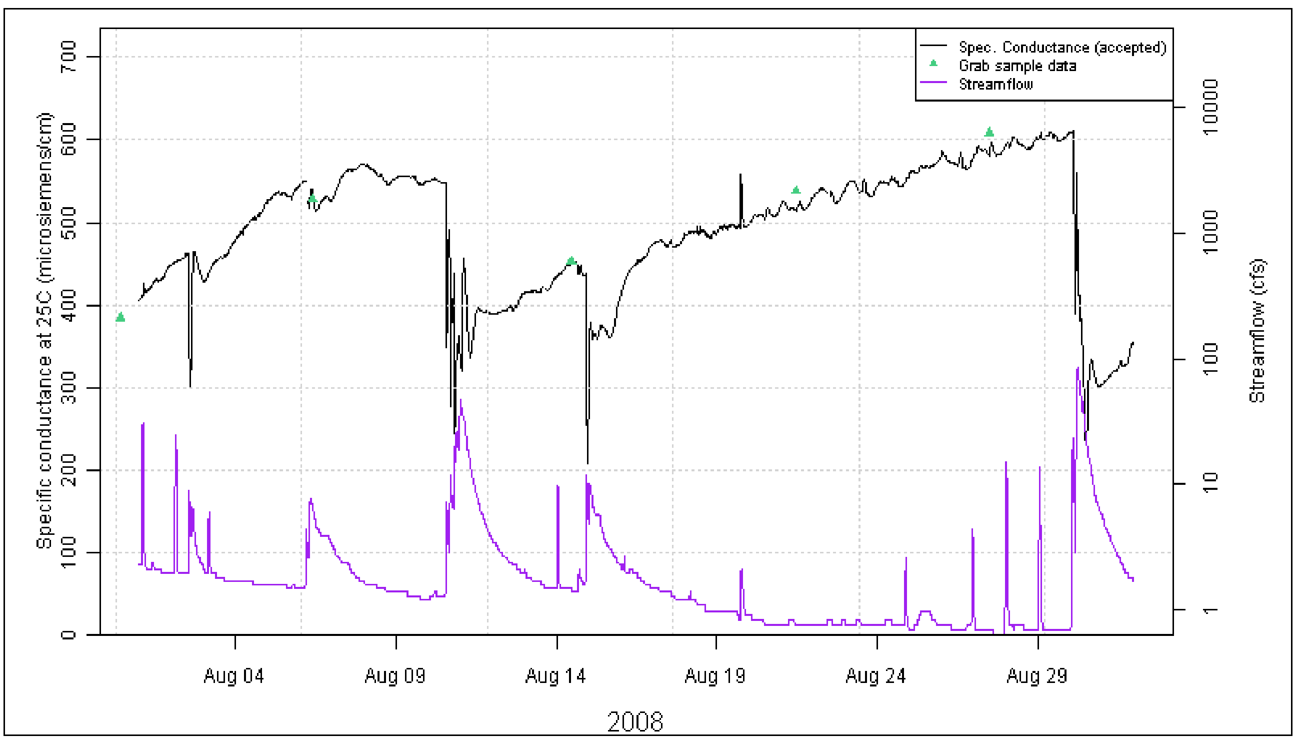



**Figure H.2 Conductivity and Streamflow at Site PQ050, August 2008**

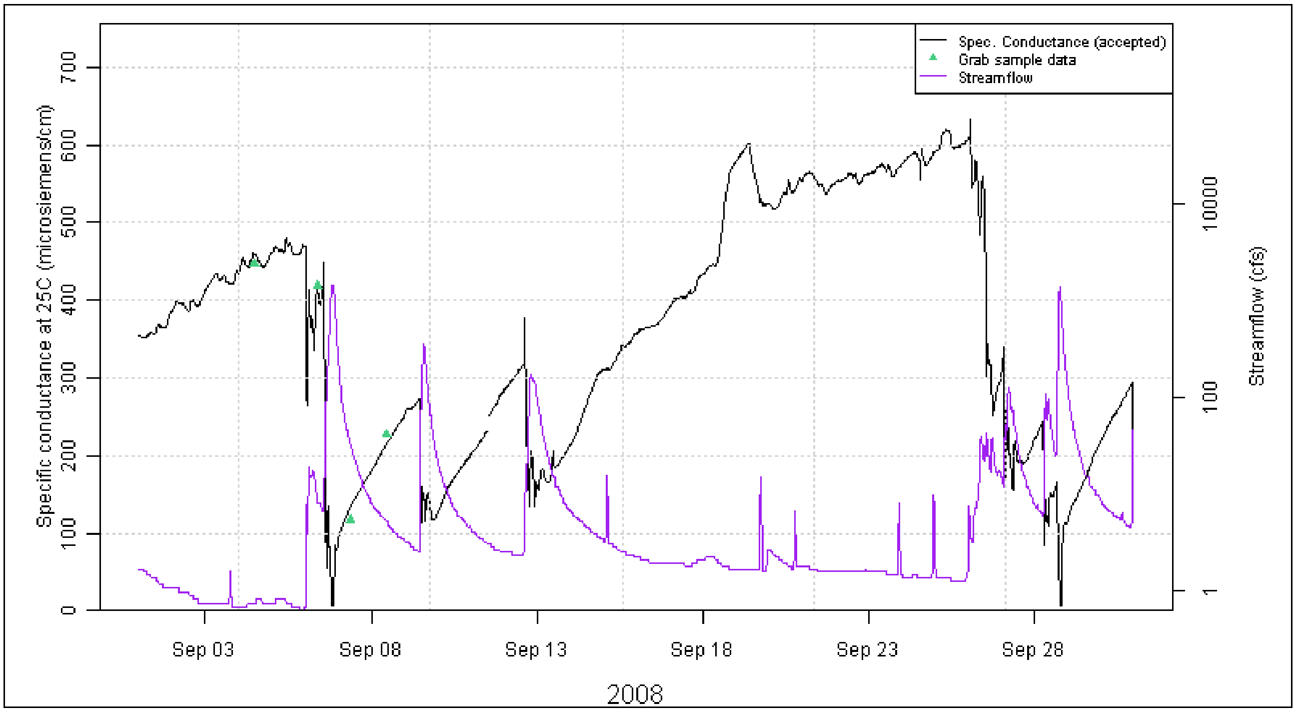



**Figure H.3 Conductivity and Streamflow at Site PQ050, September 2008**

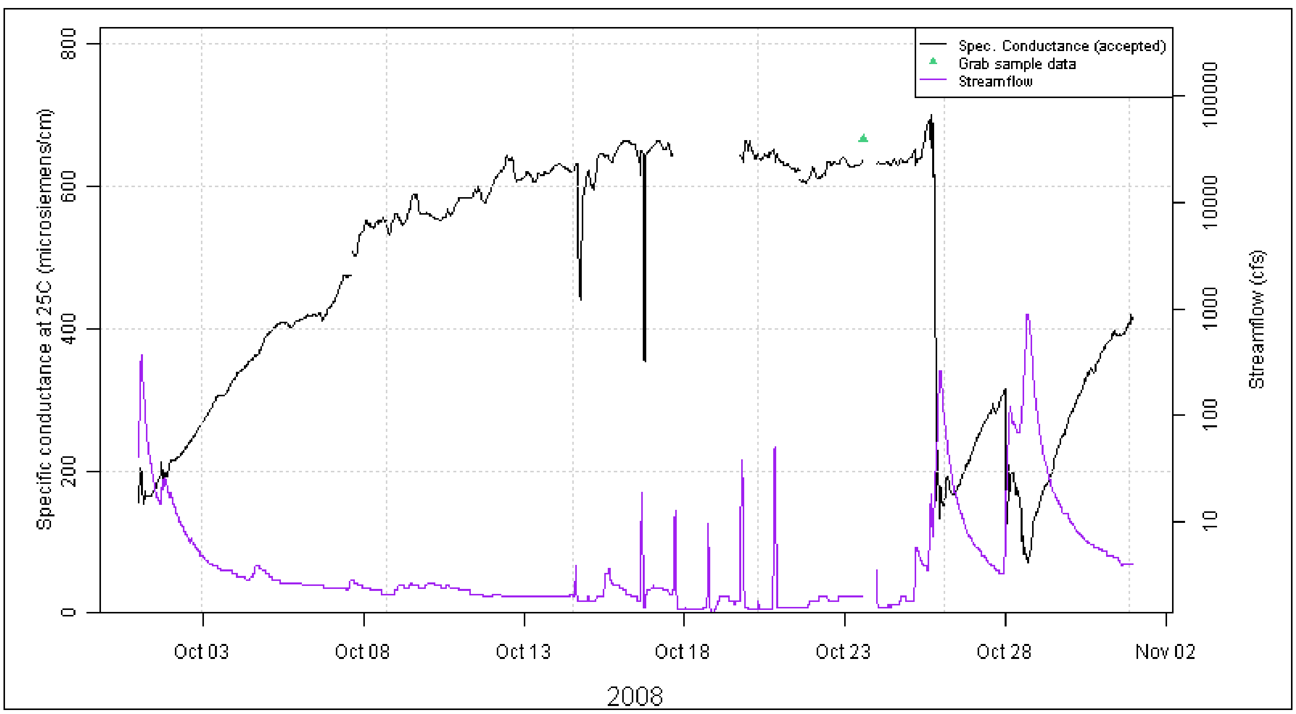



**Figure H.4 Conductivity and Streamflow at Site PQ050, October 2008**

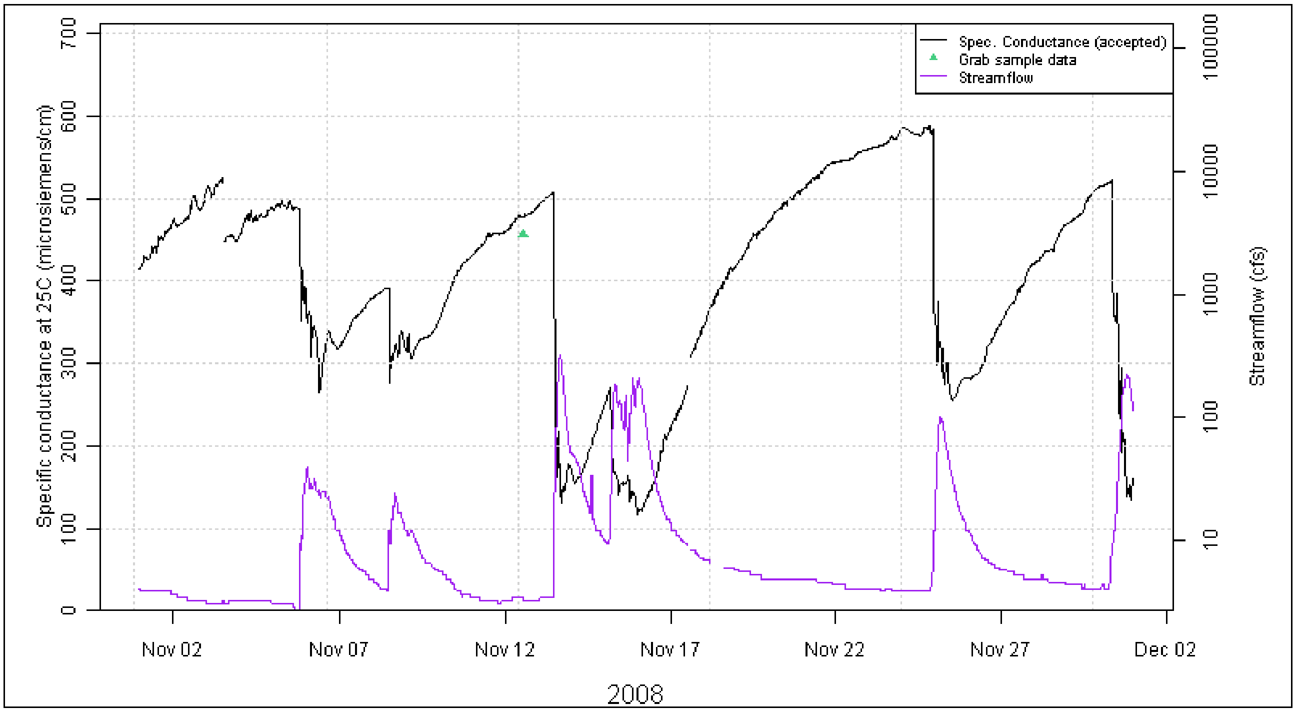



**Figure H.5 Conductivity and Streamflow at Site PQ050, November 2008**

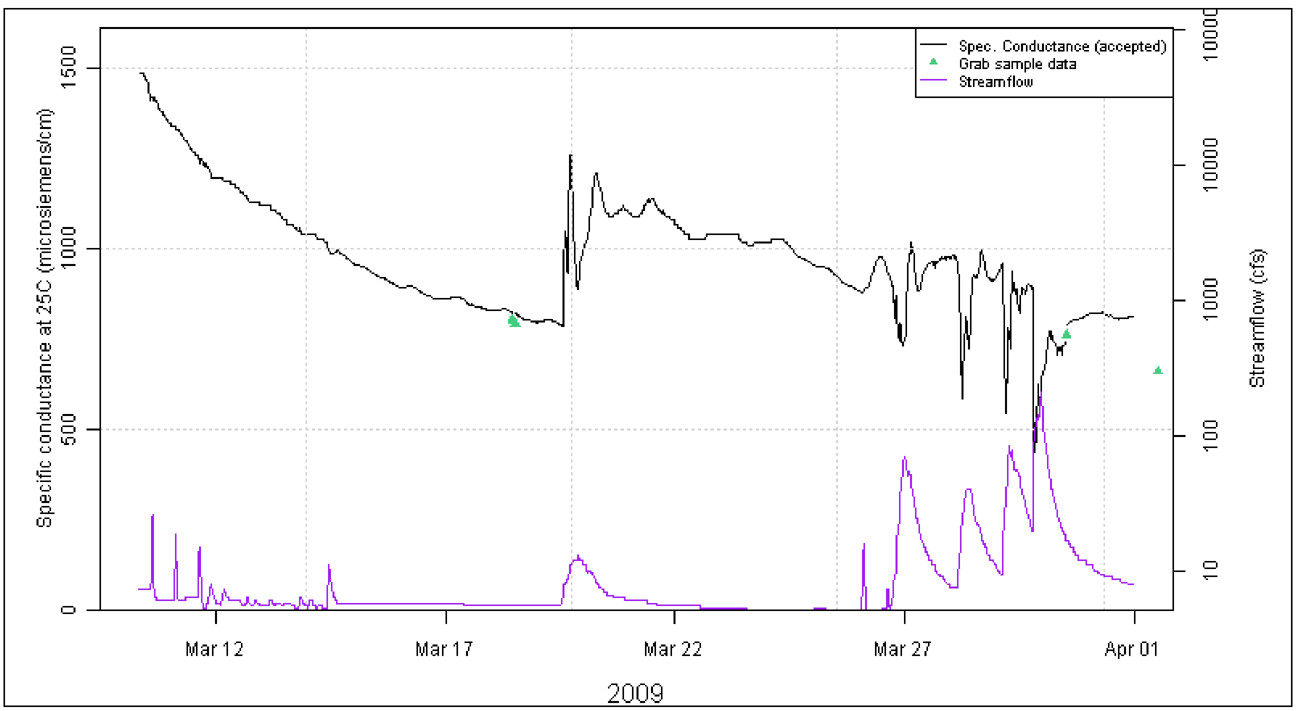



**Figure H.6 Conductivity and Streamflow at Site PQ050, March 2009**

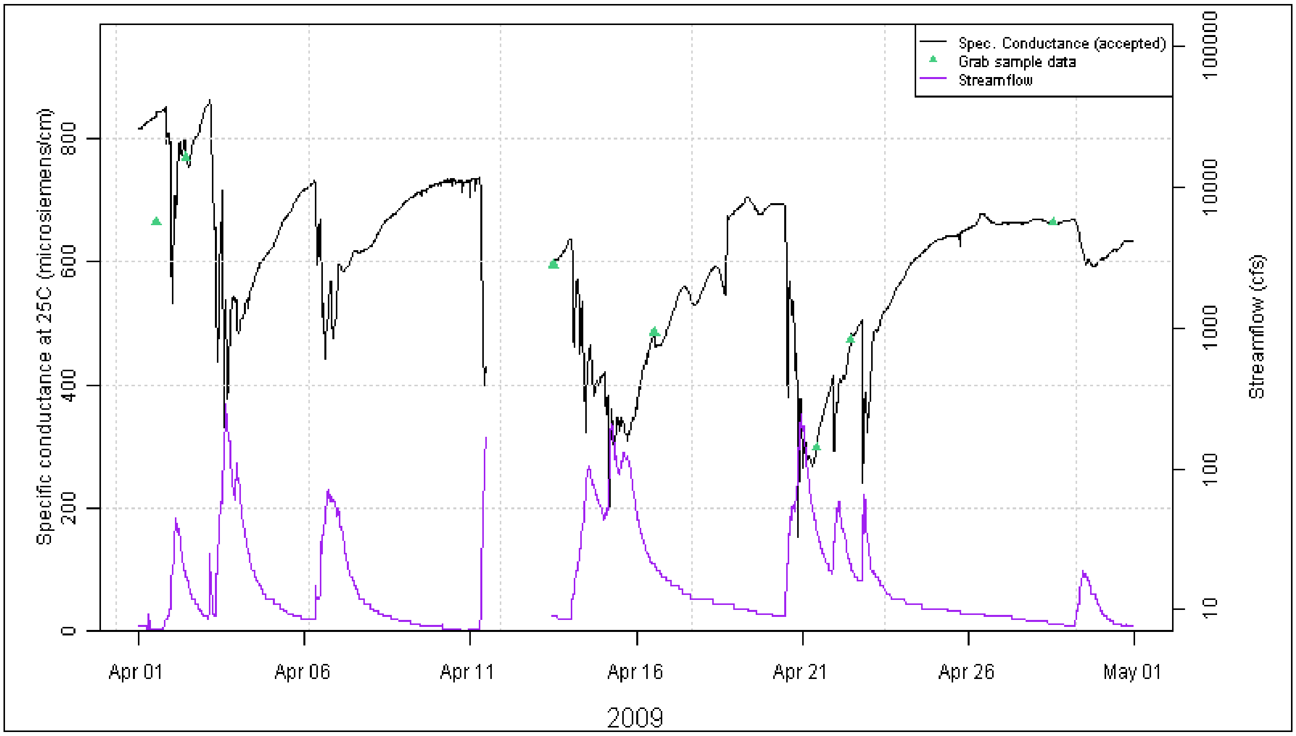



**Figure H.7 Conductivity and Streamflow at Site PQ050, April 2009**

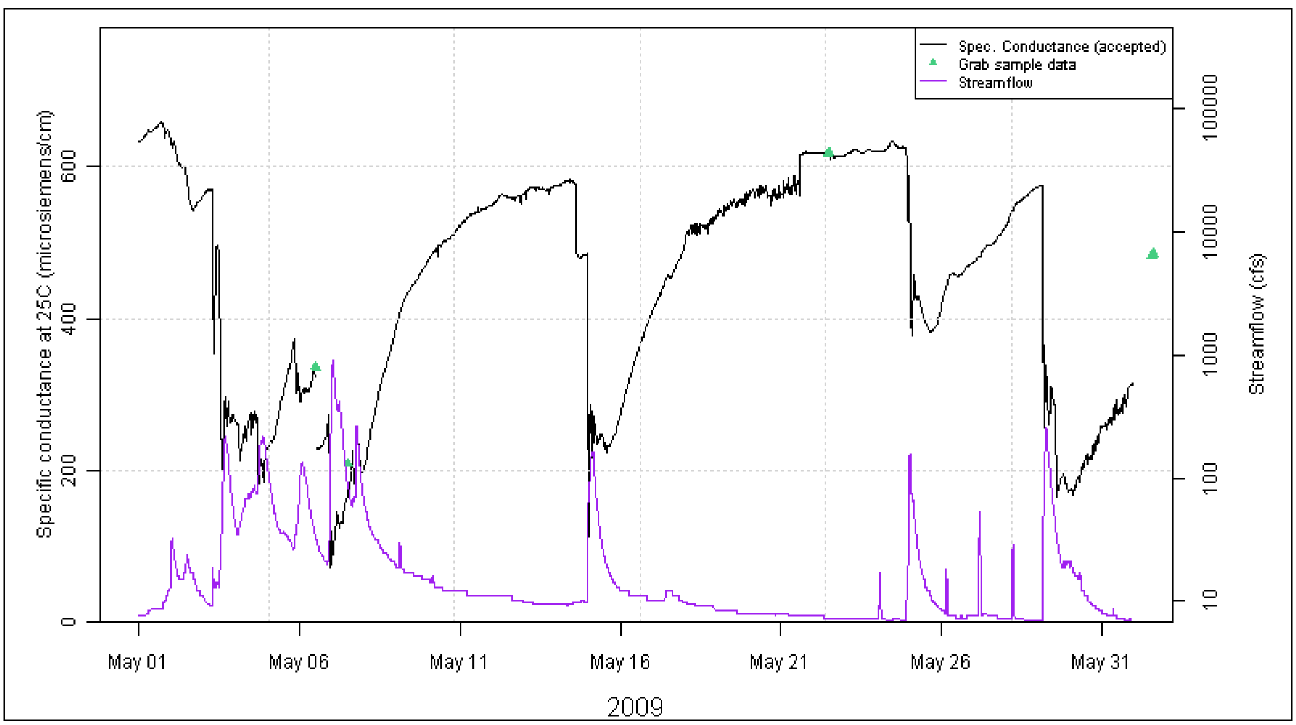



**Figure H.8 Conductivity and Streamflow at Site PQ050, May 2009**

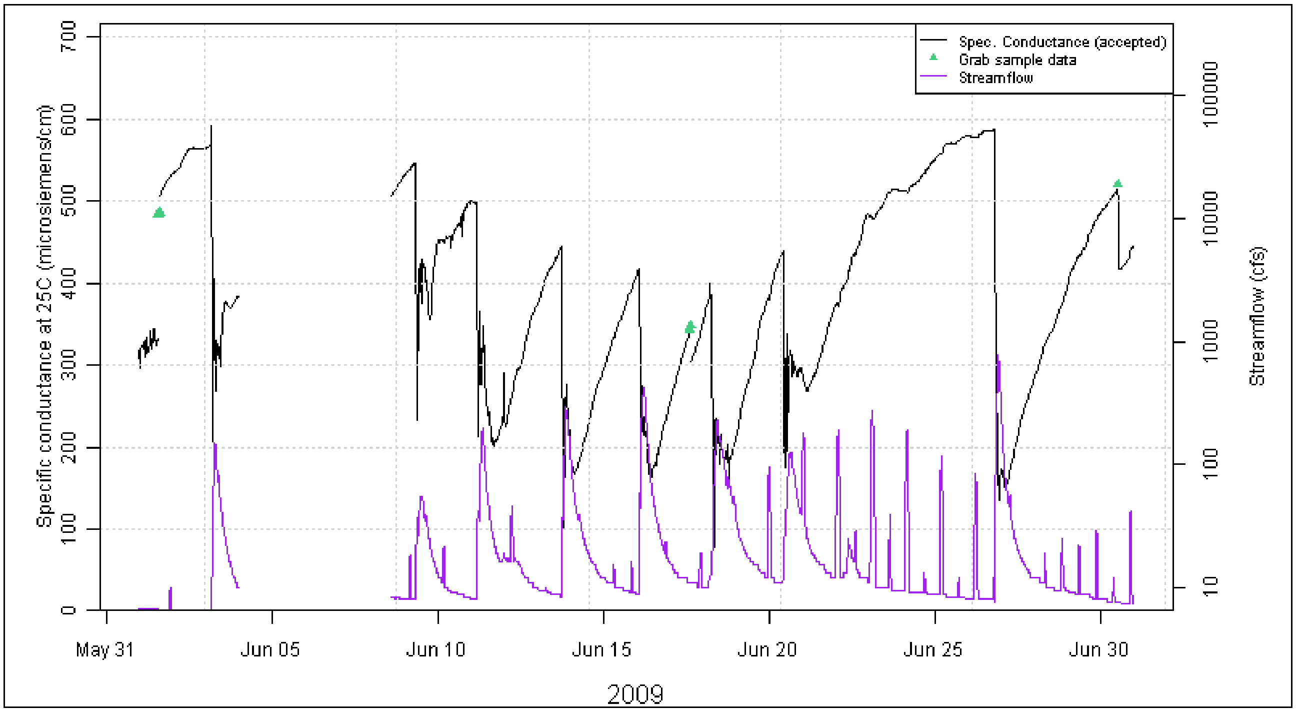



**Figure H.9 Conductivity and Streamflow at Site PQ050, June 2009**

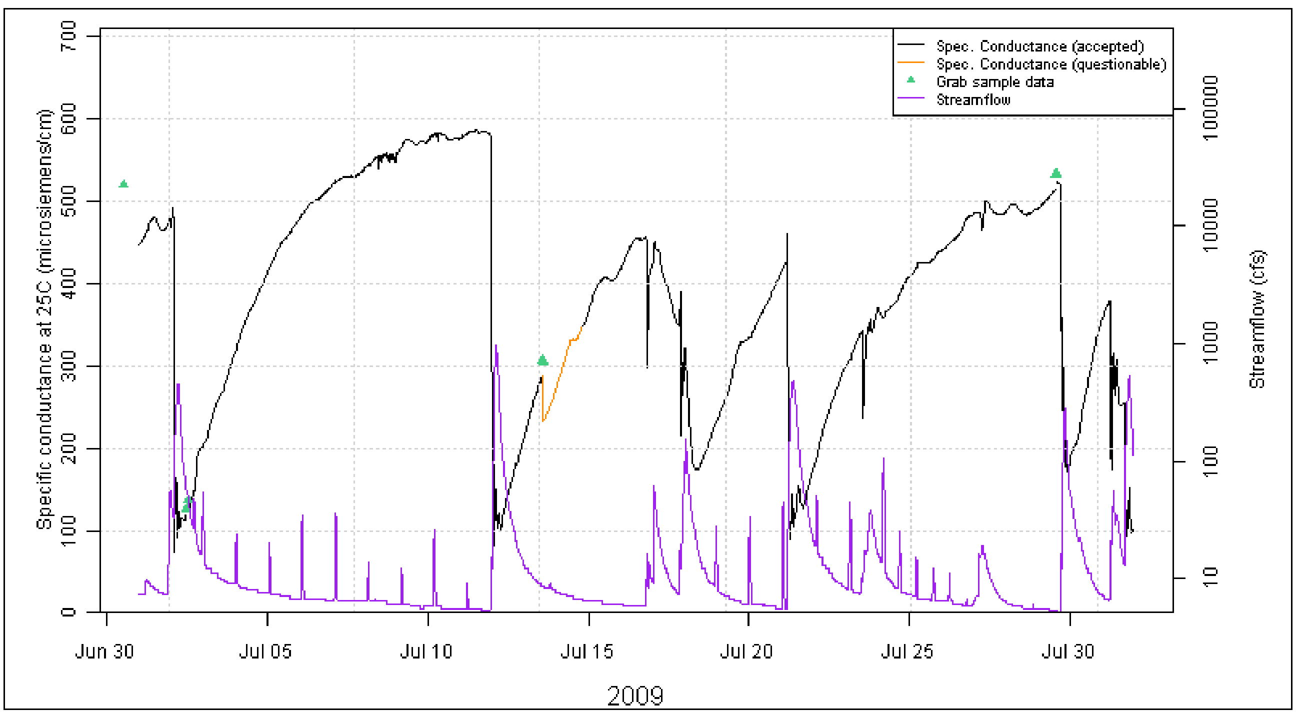



**Figure H.10 Conductivity and Streamflow at Site PQ050, July 2009**

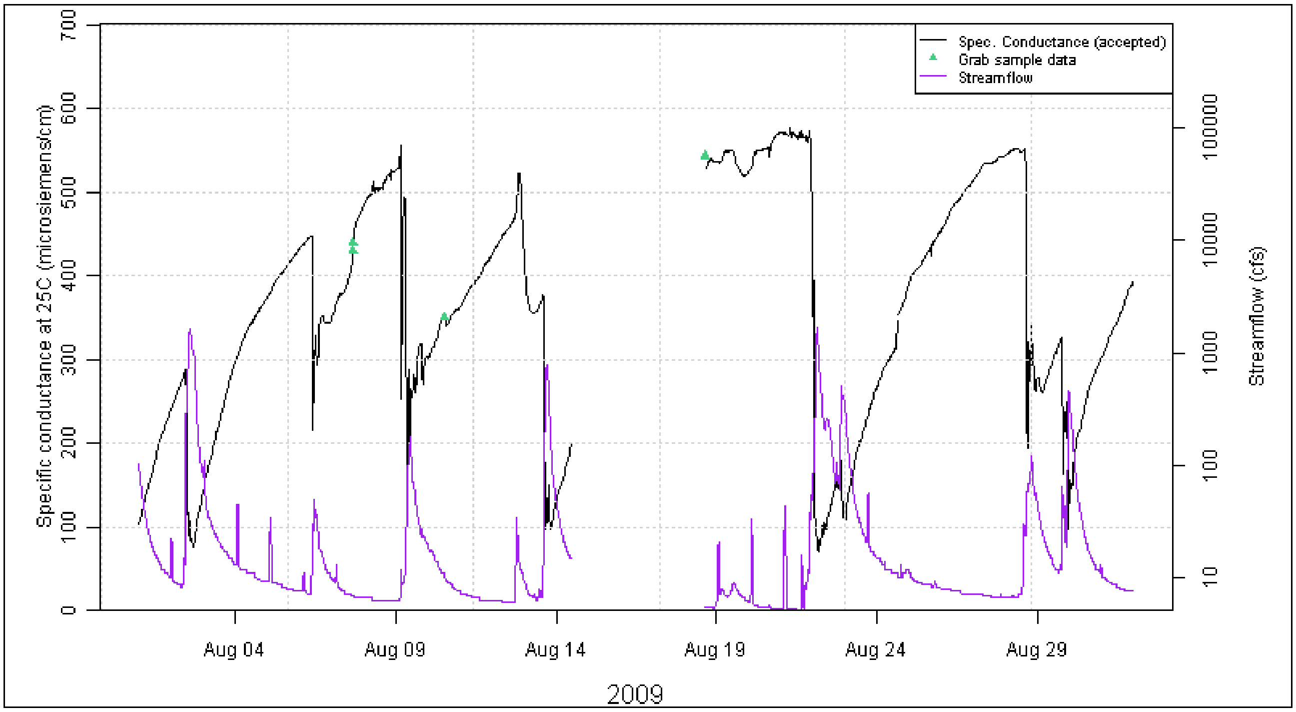



**Figure H.11 Conductivity and Streamflow at Site PQ050, August 2009**

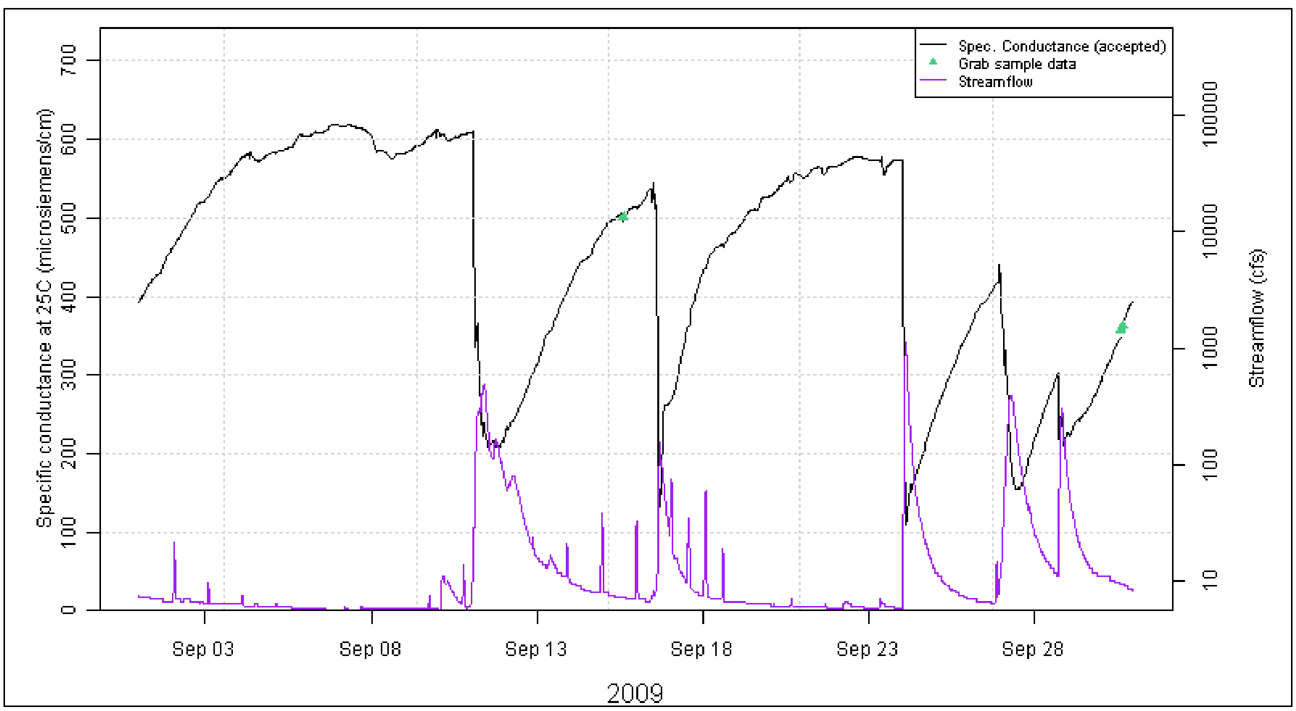



**Figure H.12 Conductivity and Streamflow at Site PQ050, September 2009**

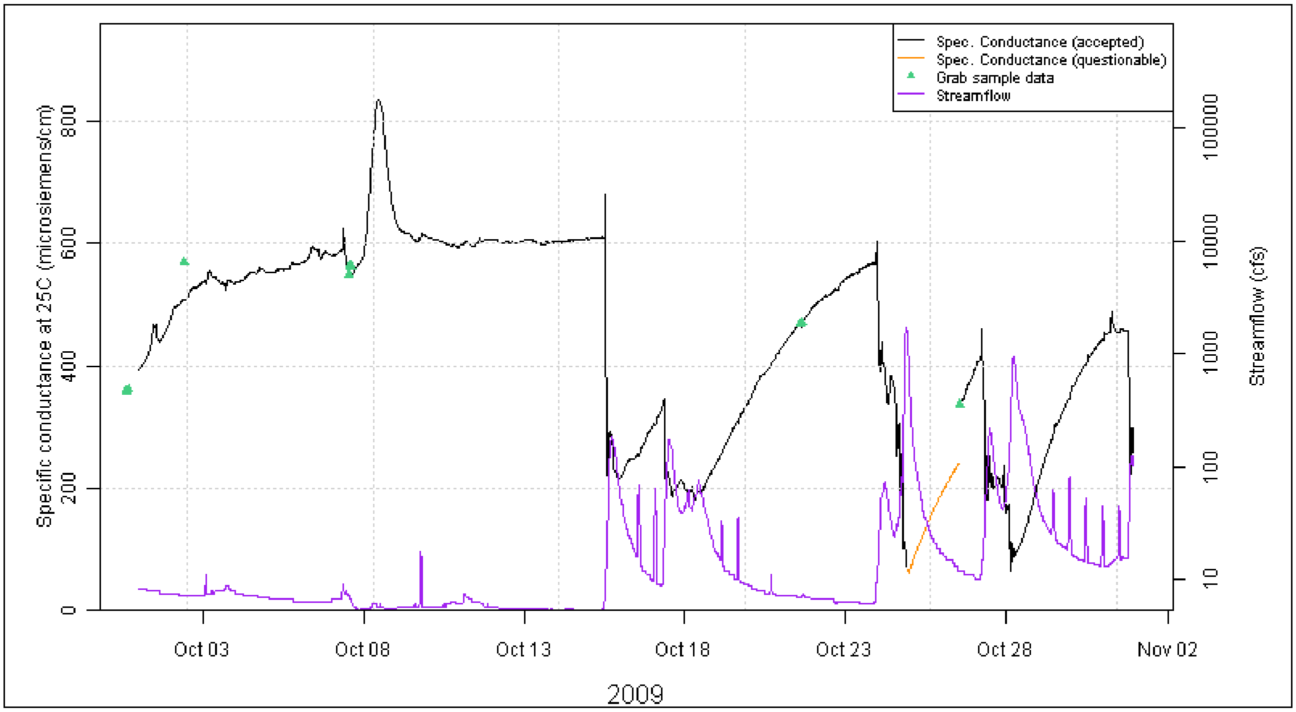



**Figure H.13 Conductivity and Streamflow at Site PQ050, October 2009**

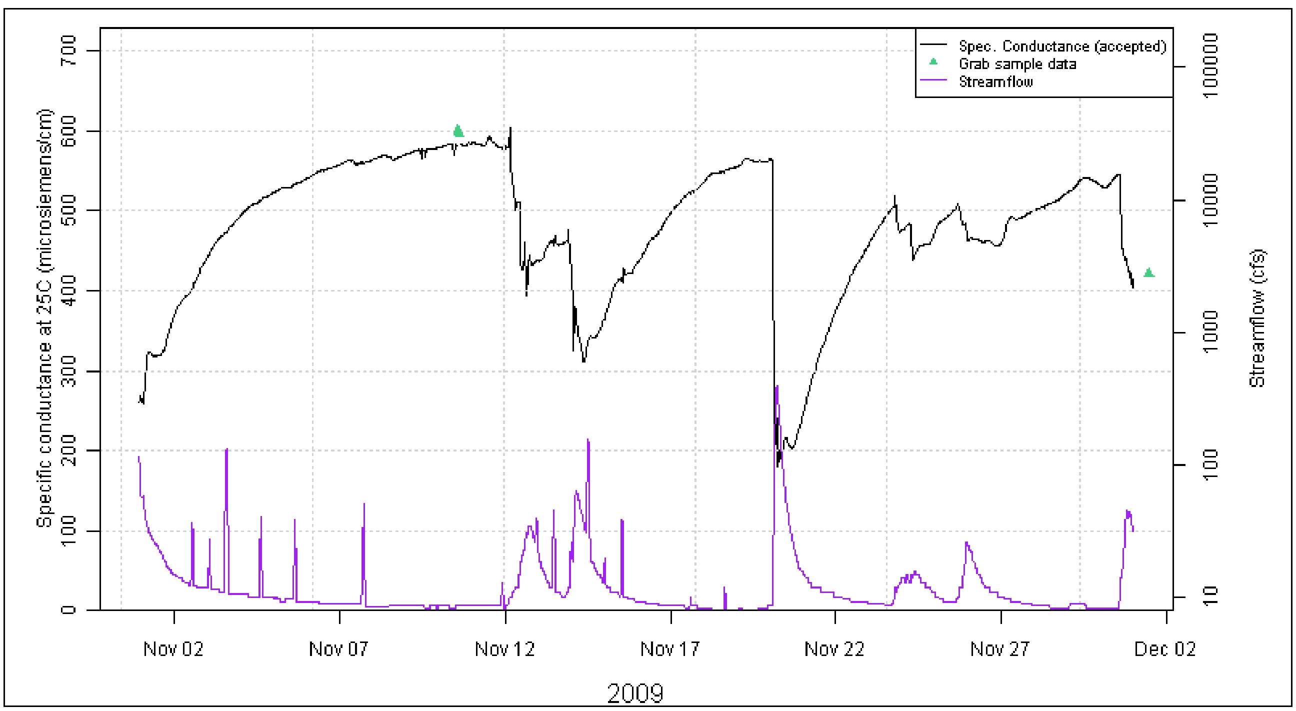



**Figure H.14 Conductivity and Streamflow at Site PQ050, November 2009**

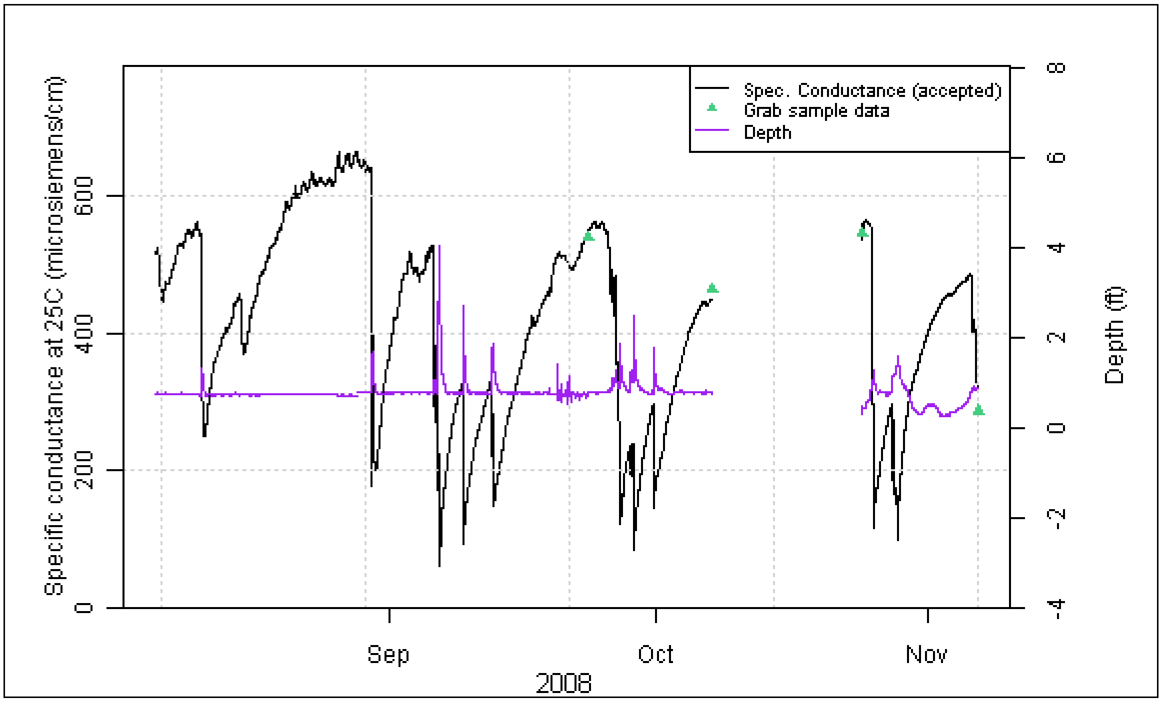



**Figure H.15 Conductivity and Stream Depth at Site PQ665, 8/5/08 – 11/6/08**

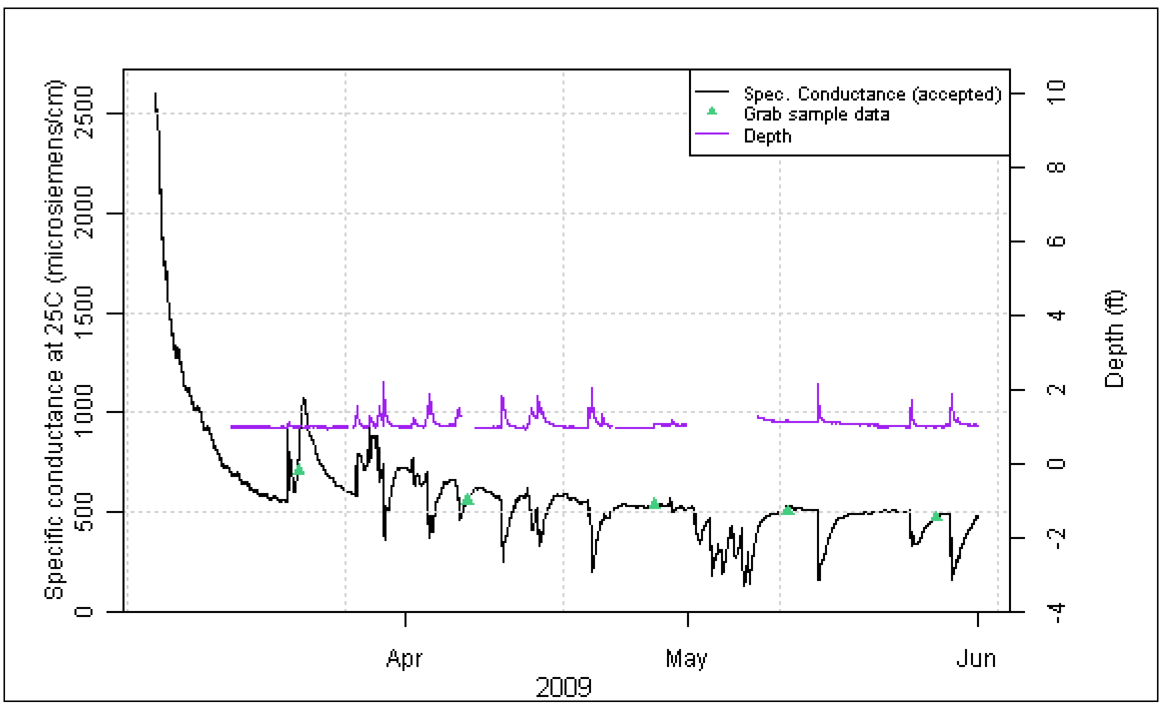



**Figure H.16 Conductivity and Stream Depth at Site PQ665, 3/5/09 – 5/31/09**

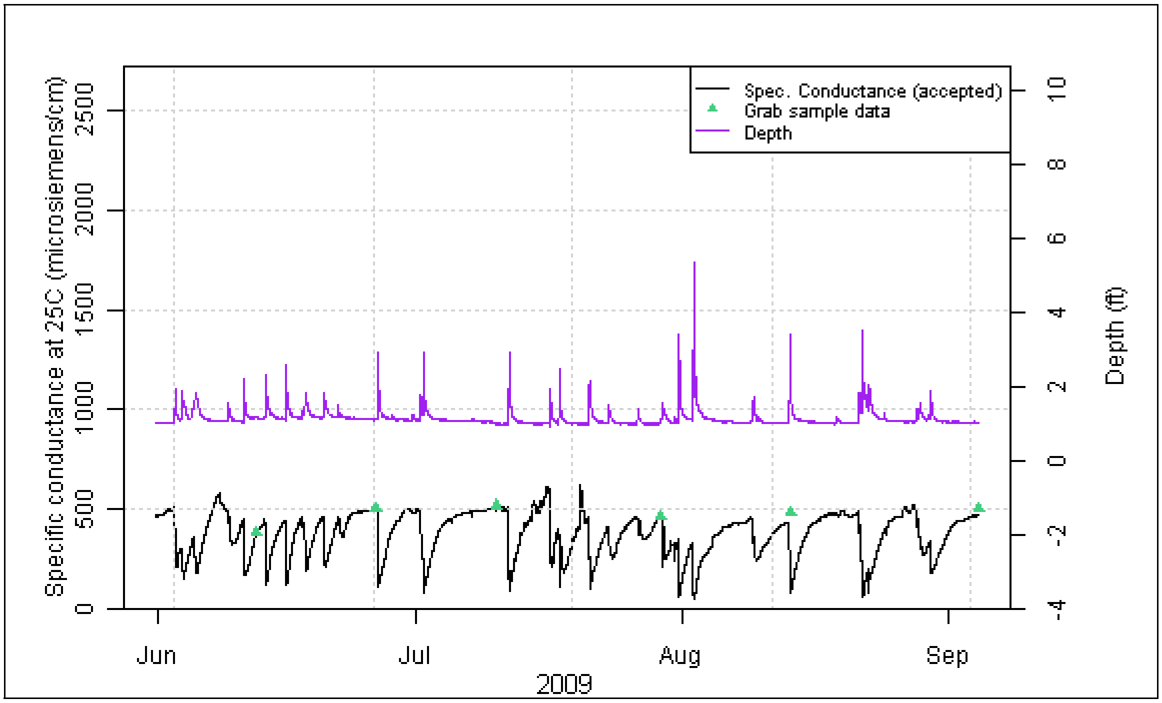



**Figure H.17 Conductivity and Stream Depth at Site PQ665, 6/1/09 – 9/4/09**

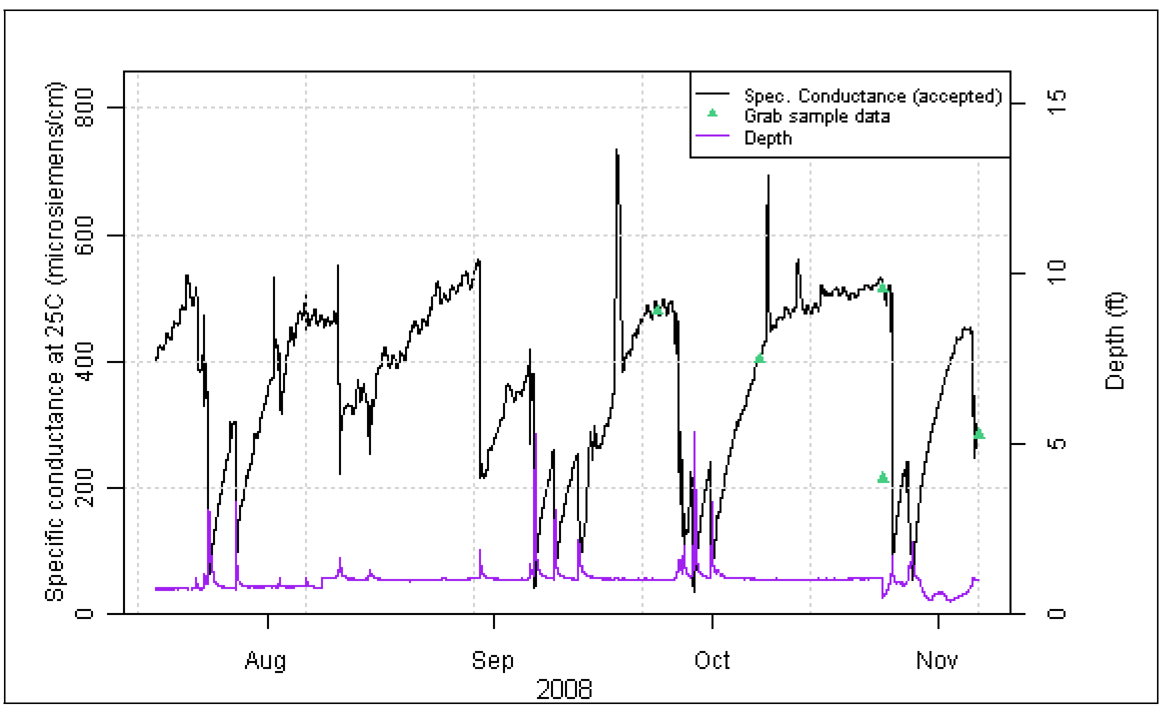



**Figure H.18 Conductivity and Stream Depth at Site PQB025, 7/16/08 – 11/6/08**

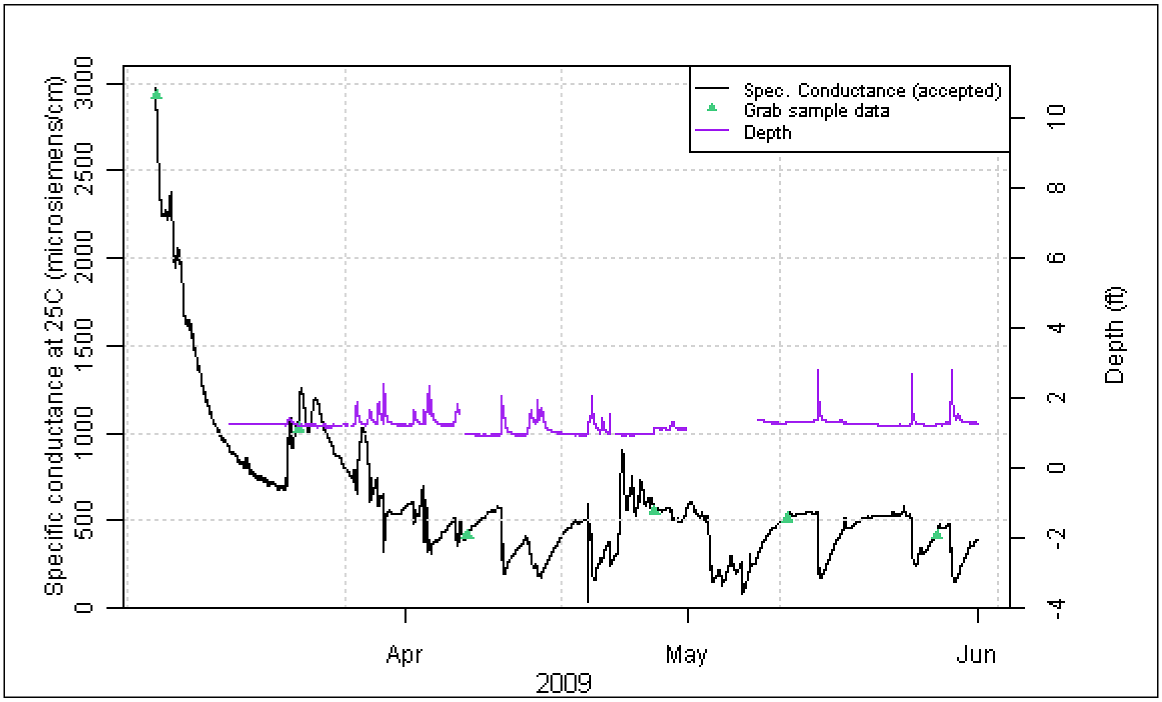



**Figure H.19 Conductivity and Stream Depth at Site PQB025, 3/5/09 – 5/31/09**

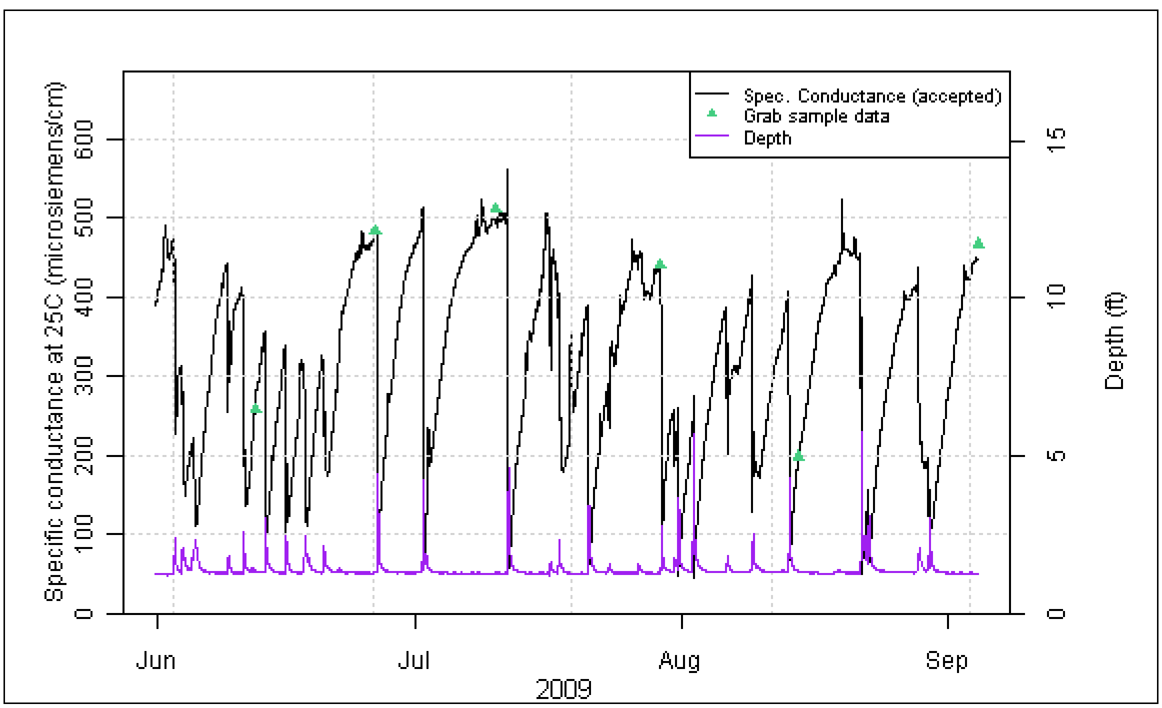



**Figure H.20 Conductivity and Stream Depth at Site PQB025, 6/1/09 – 9/4/09**

# APPENDIX I:

## Turbidity Plots

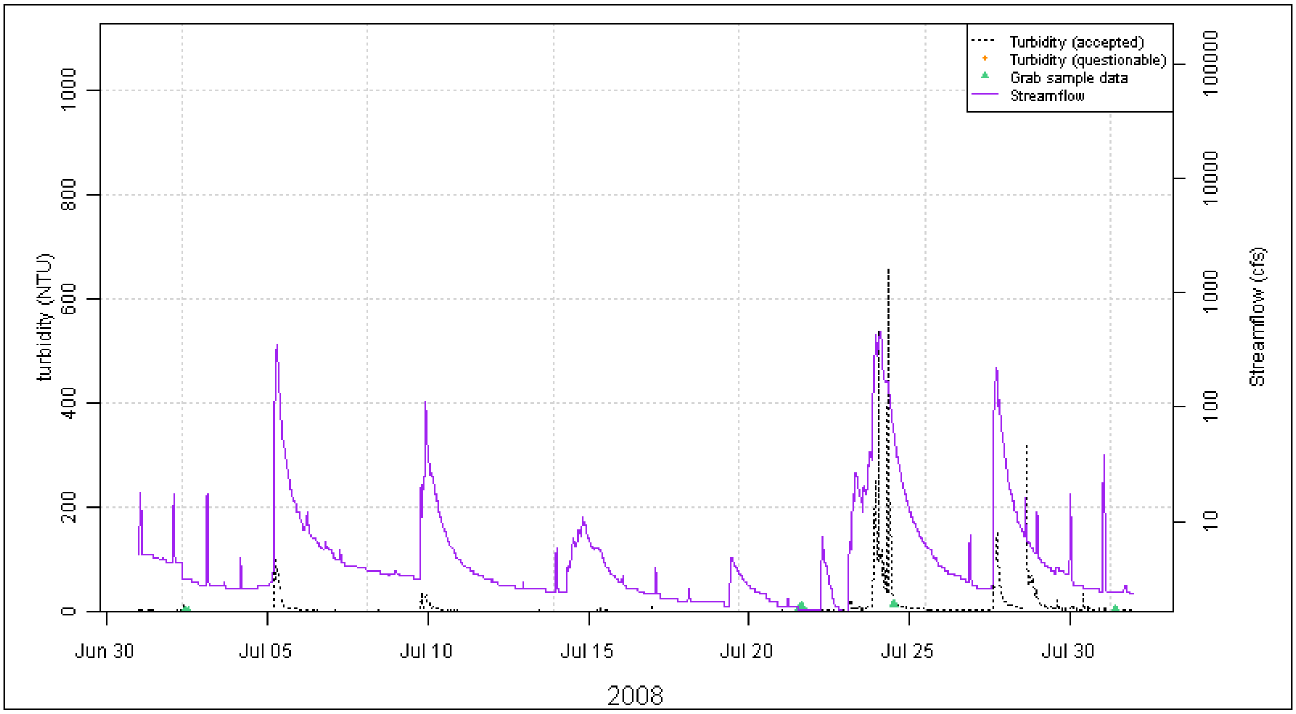



**Figure I.1 Turbidity and Streamflow at Site PQ050, July 2008**

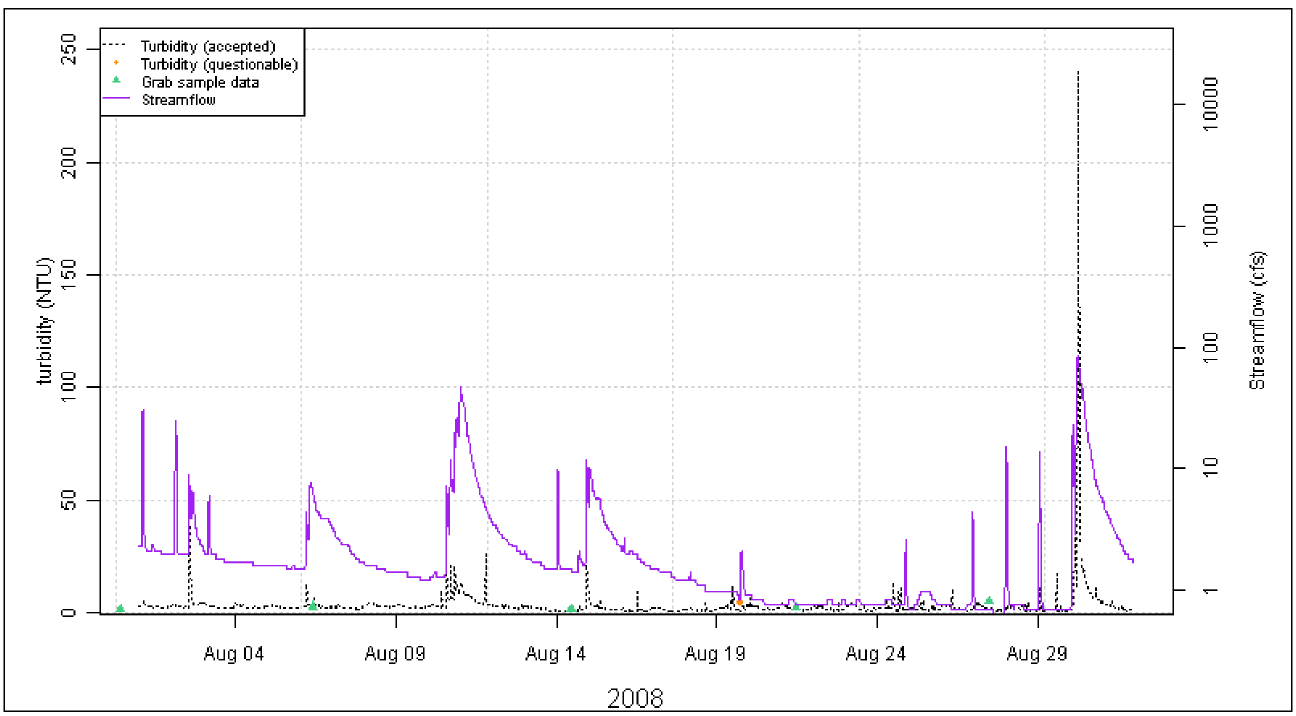



**Figure I.2 Turbidity and Streamflow at Site PQ050, August 2008**

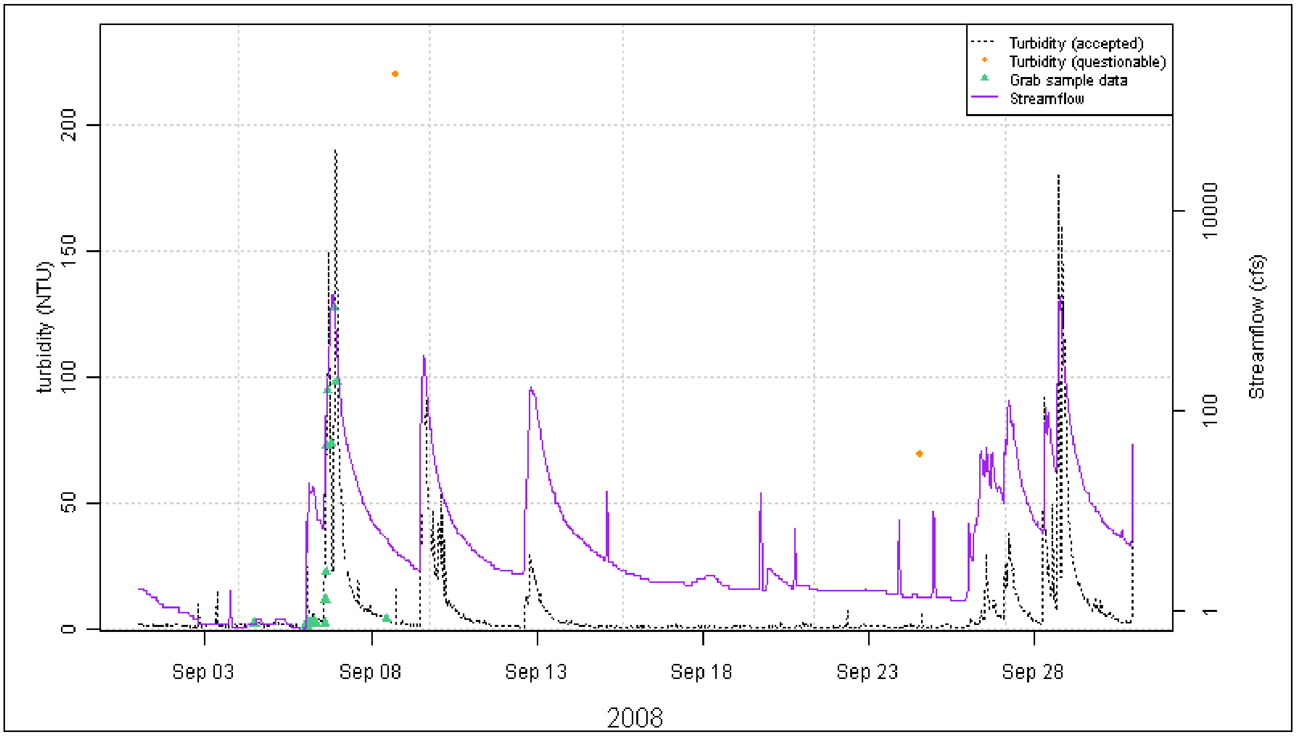



**Figure I.3 Turbidity and Streamflow at Site PQ050, September 2008**

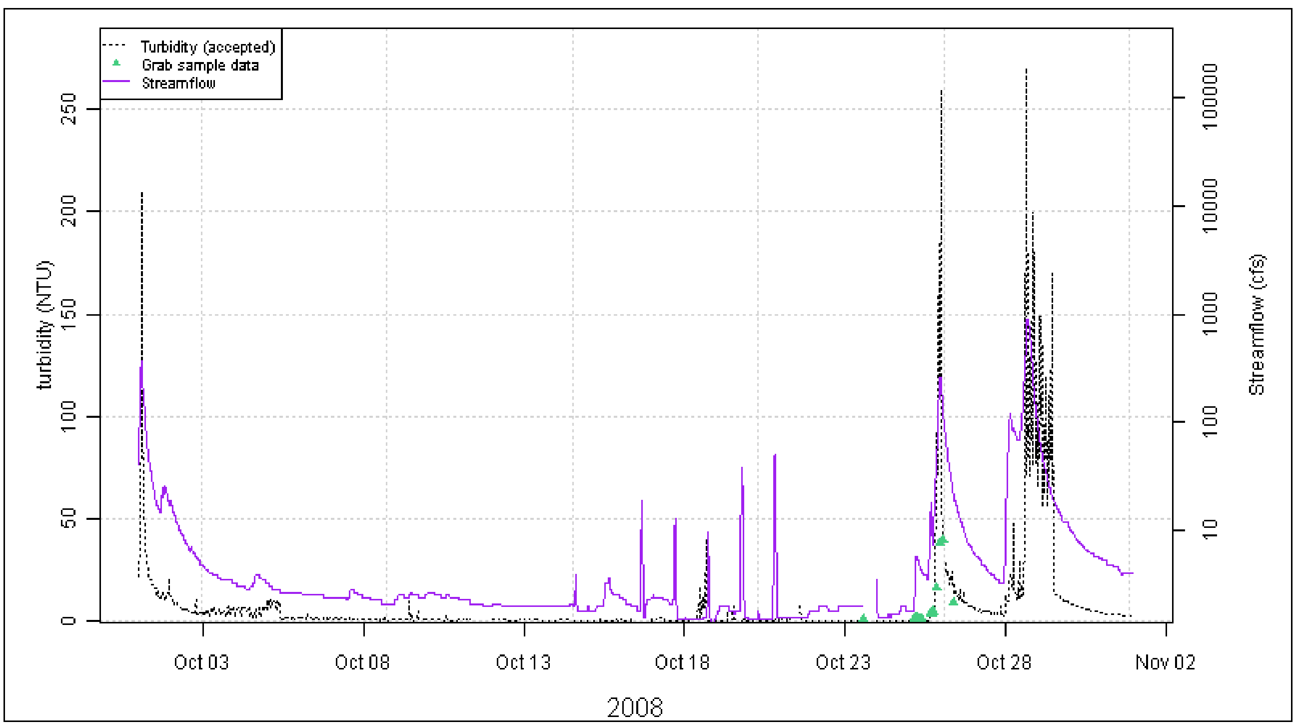



**Figure I.4 Turbidity and Streamflow at Site PQ050, October 2008**

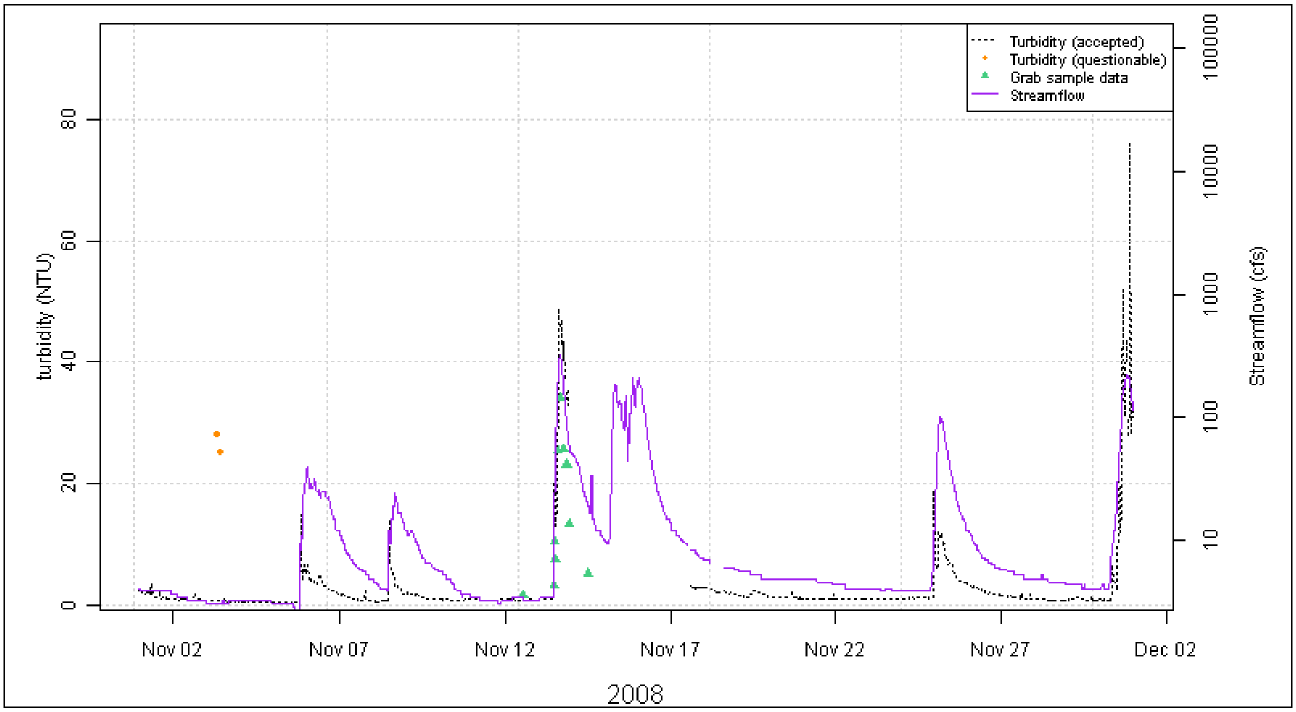



**Figure I.5 Turbidity and Streamflow at Site PQ050, November 2008**

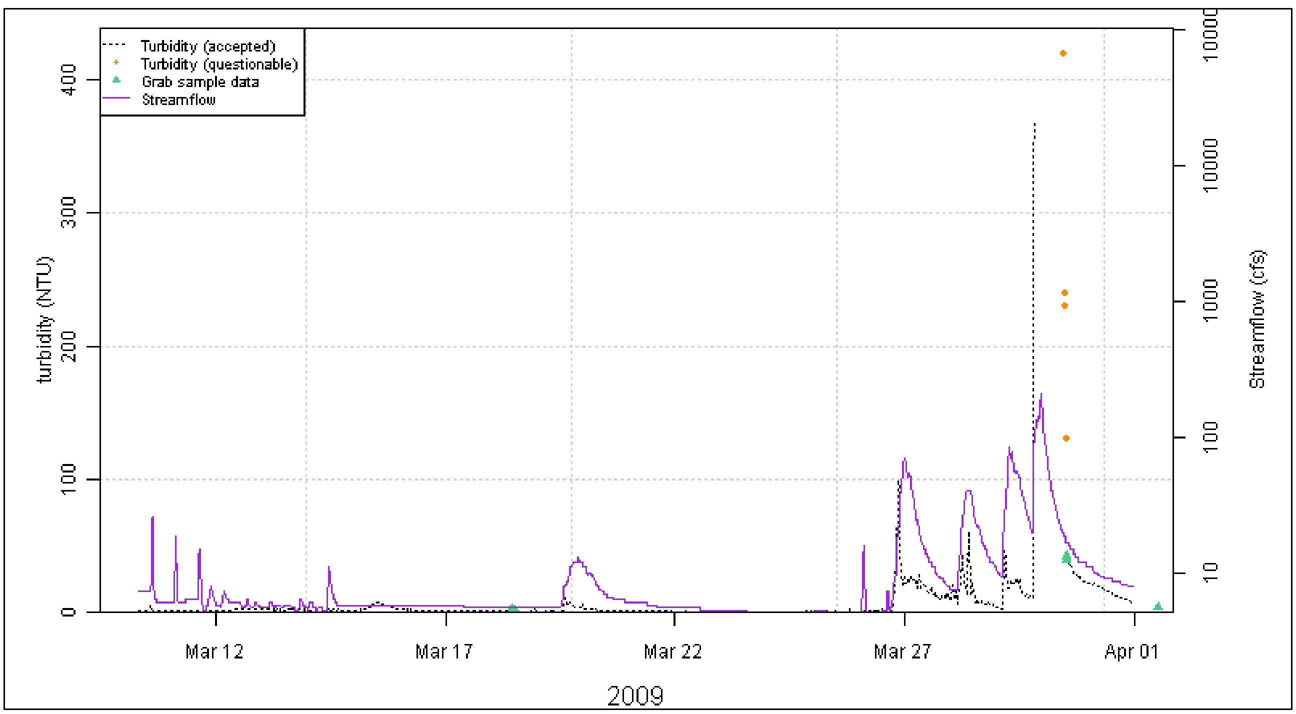



**Figure I.6 Turbidity and Streamflow at Site PQ050, March 2009**

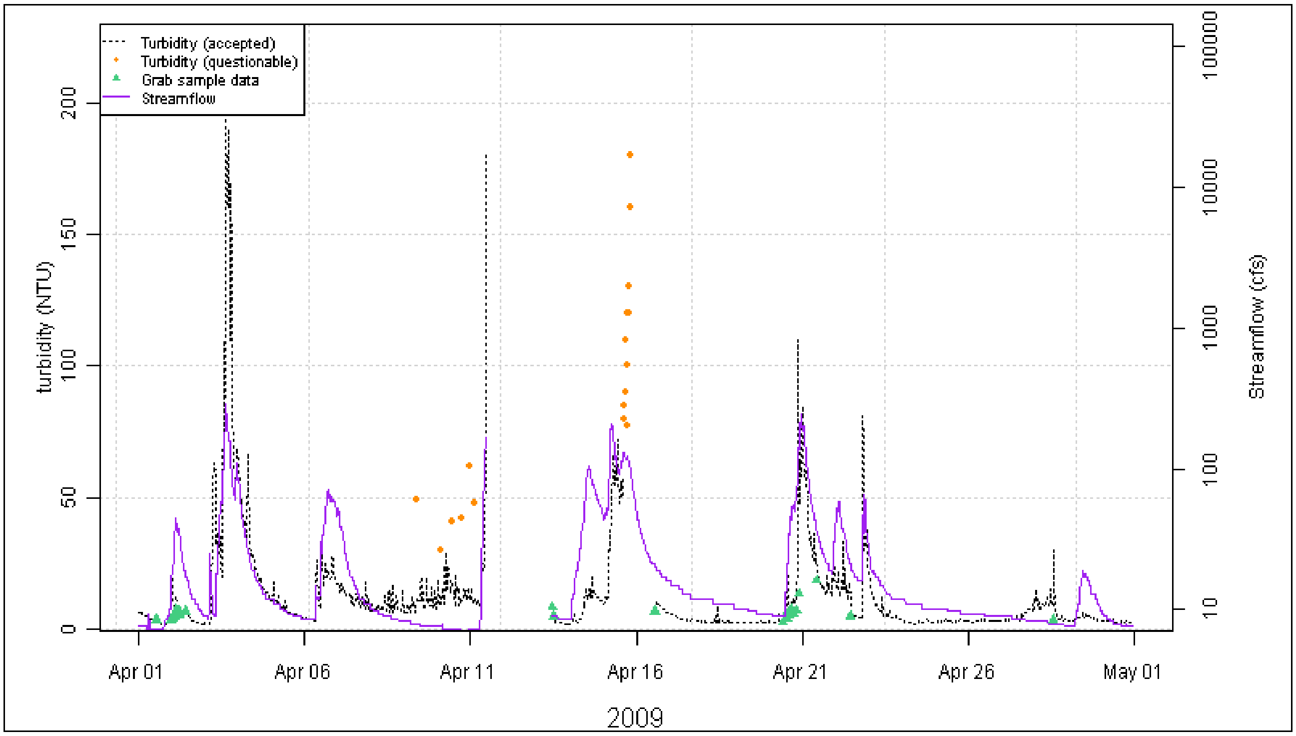



**Figure I.7 Turbidity and Streamflow at Site PQ050, April 2009**

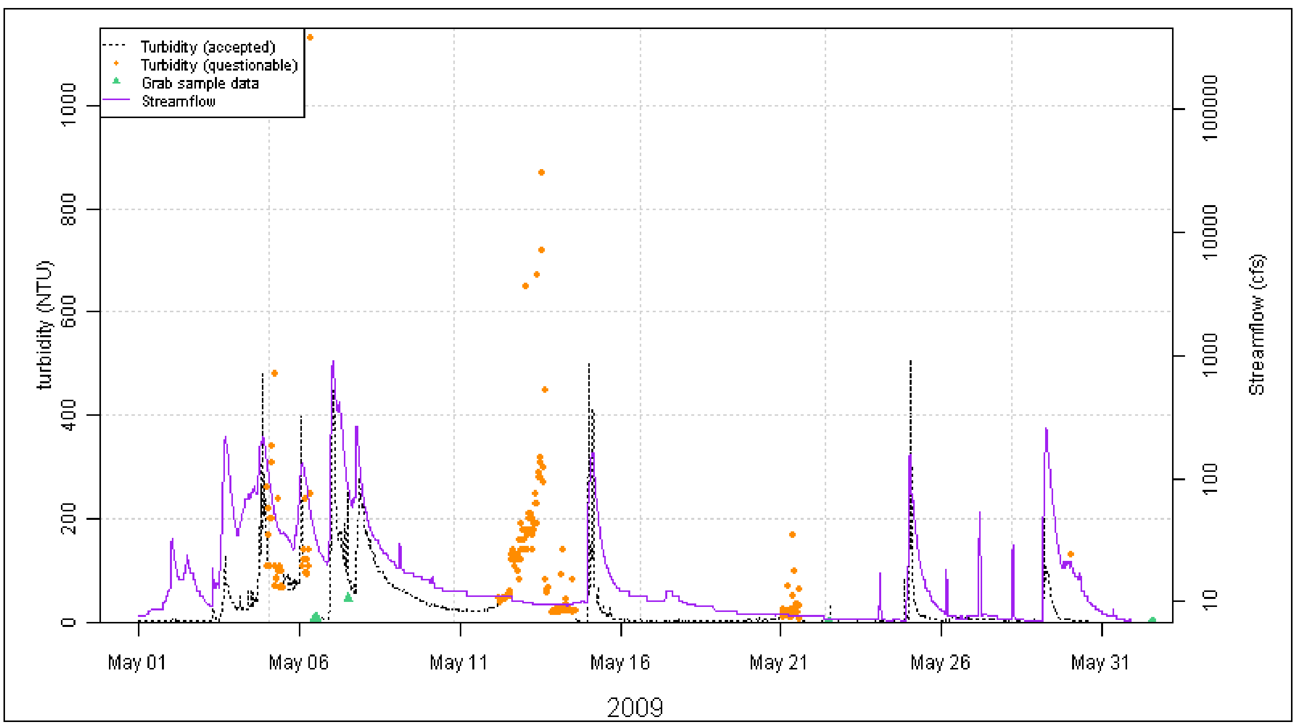



**Figure I.8 Turbidity and Streamflow at Site PQ050, May 2009**

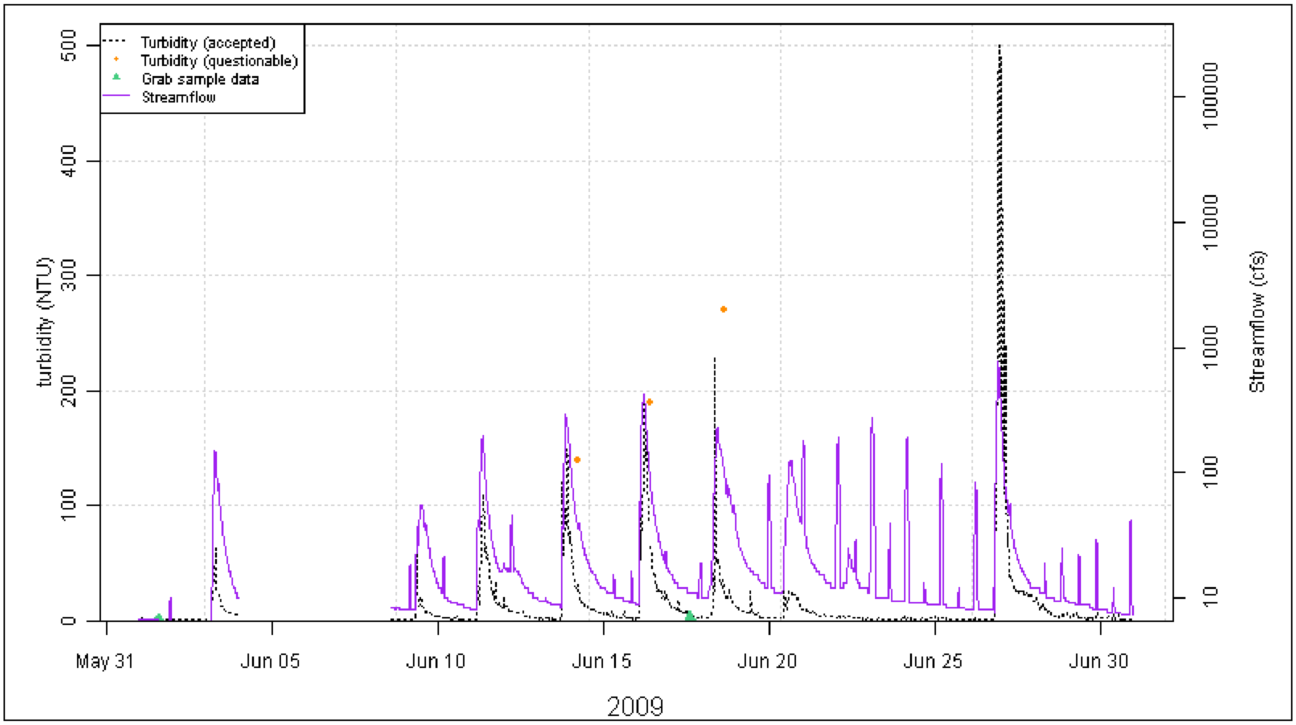



**Figure I.9 Turbidity and Streamflow at Site PQ050, June 2009**

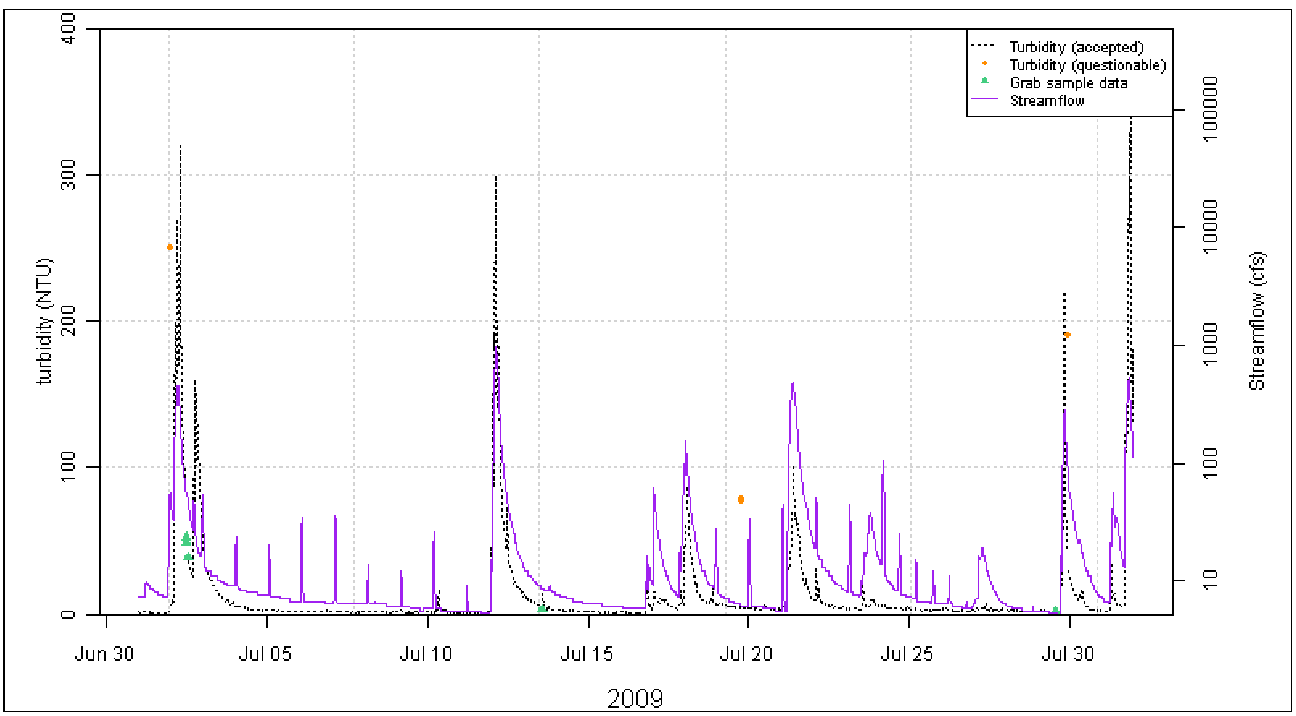



**Figure I.10 Turbidity and Streamflow at Site PQ050, July 2009**

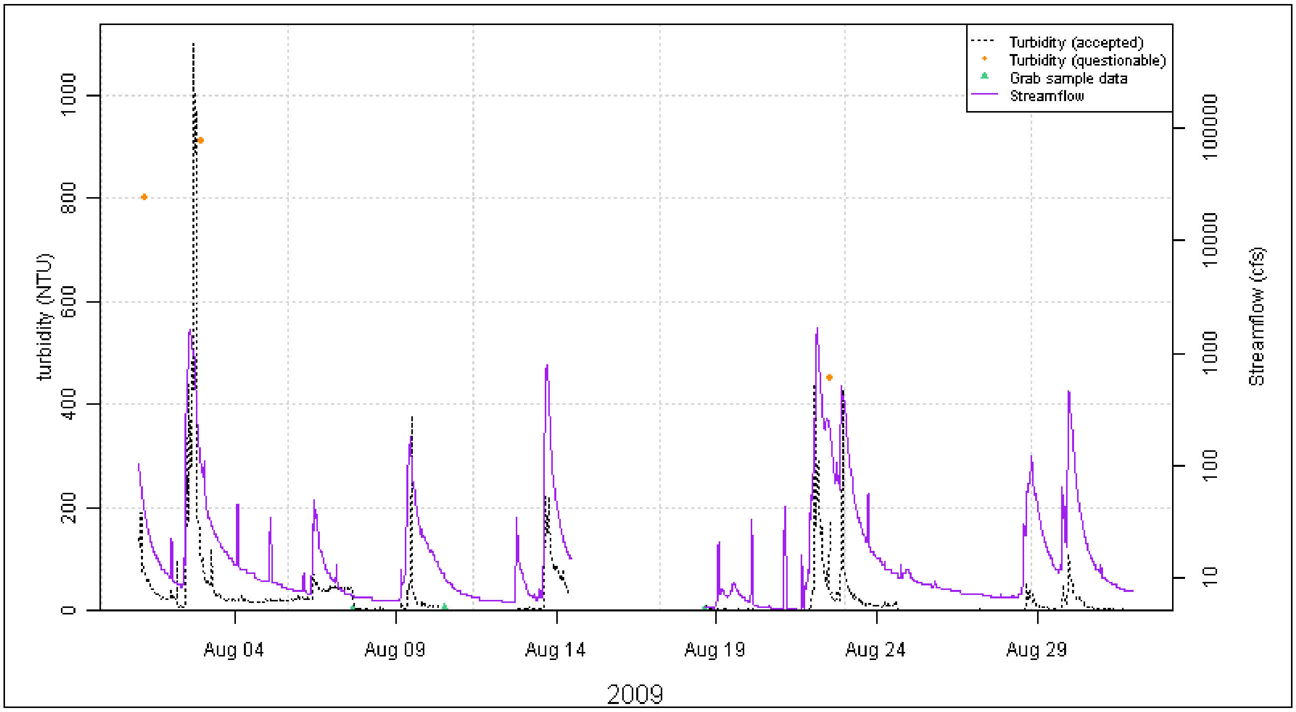



**Figure I.11 Turbidity and Streamflow at Site PQ050, August 2009**

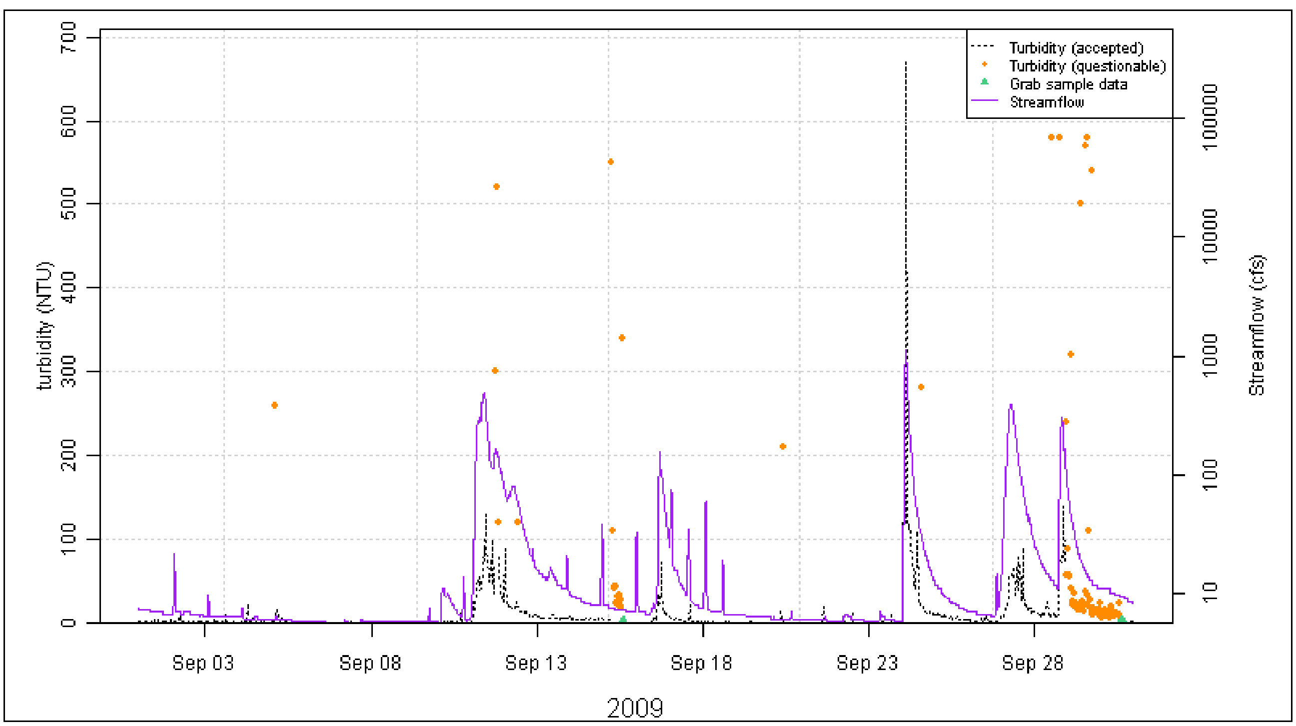



**Figure I.12 Turbidity and Streamflow at Site PQ050, September 2009**

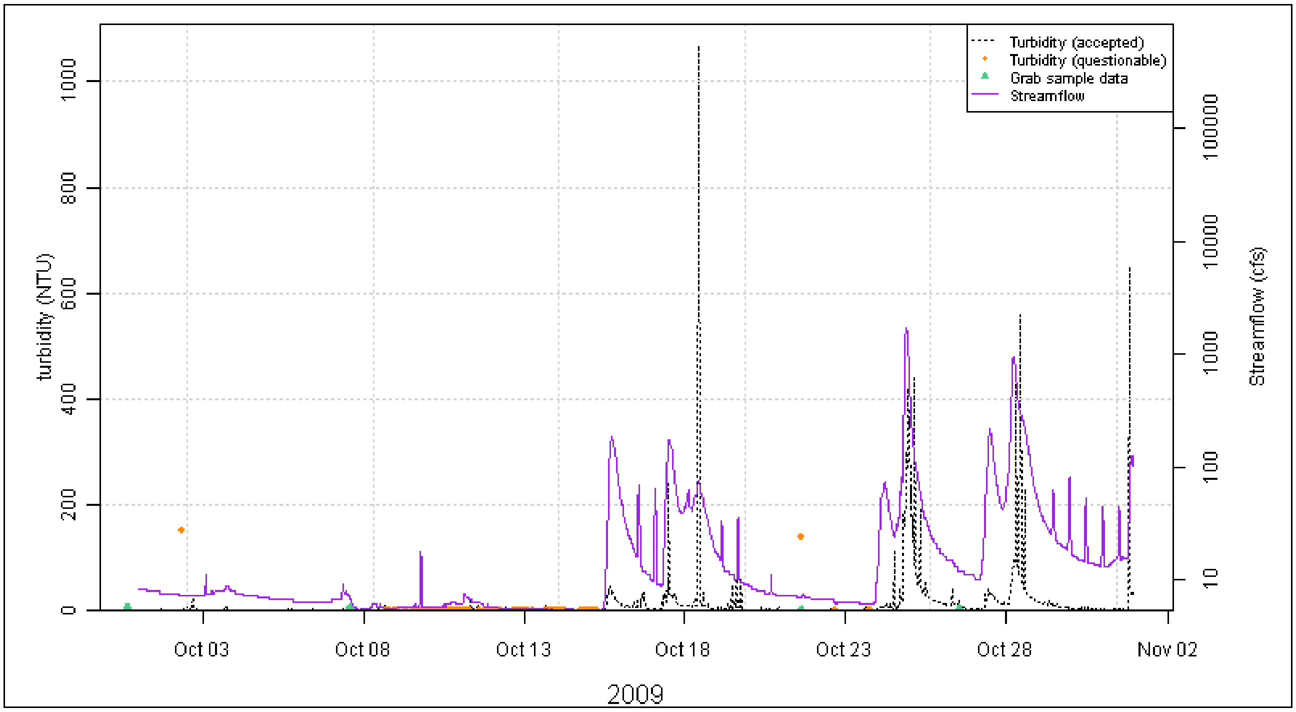



**Figure I.13 Turbidity and Streamflow at Site PQ050, October 2009**

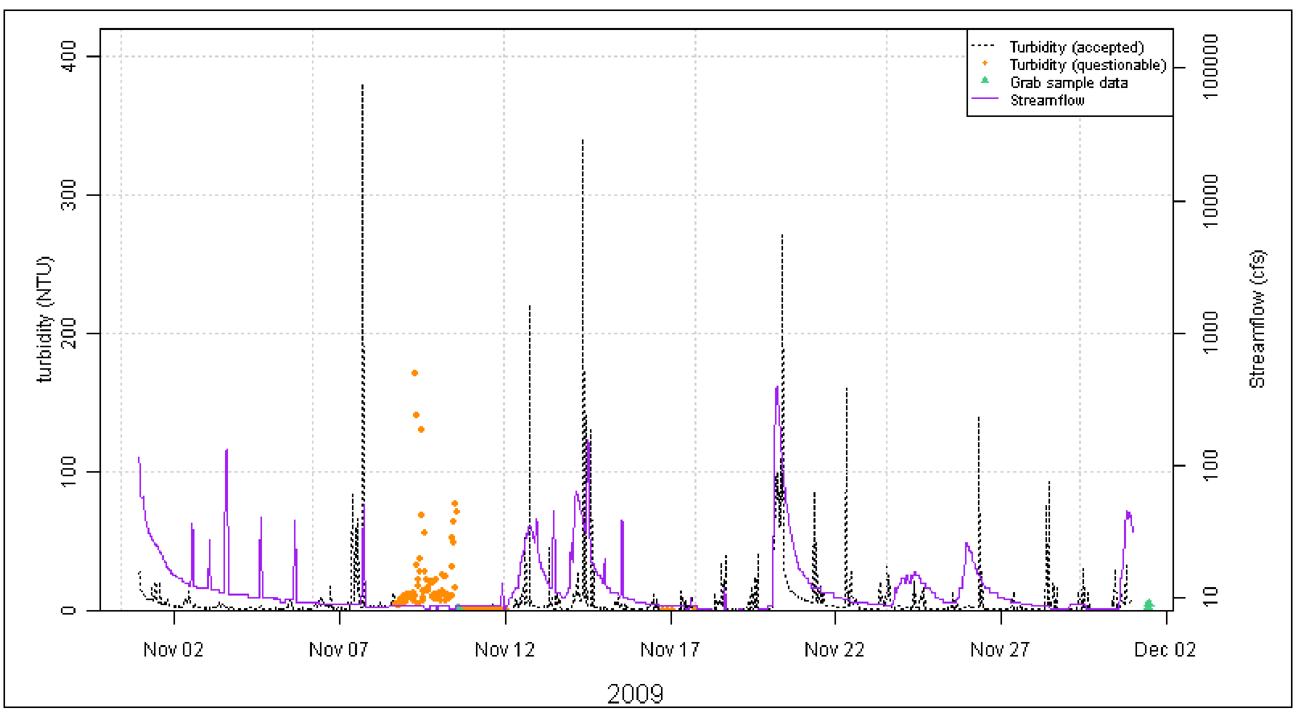



**Figure I.14 Turbidity and Streamflow at Site PQ050, November 2009**

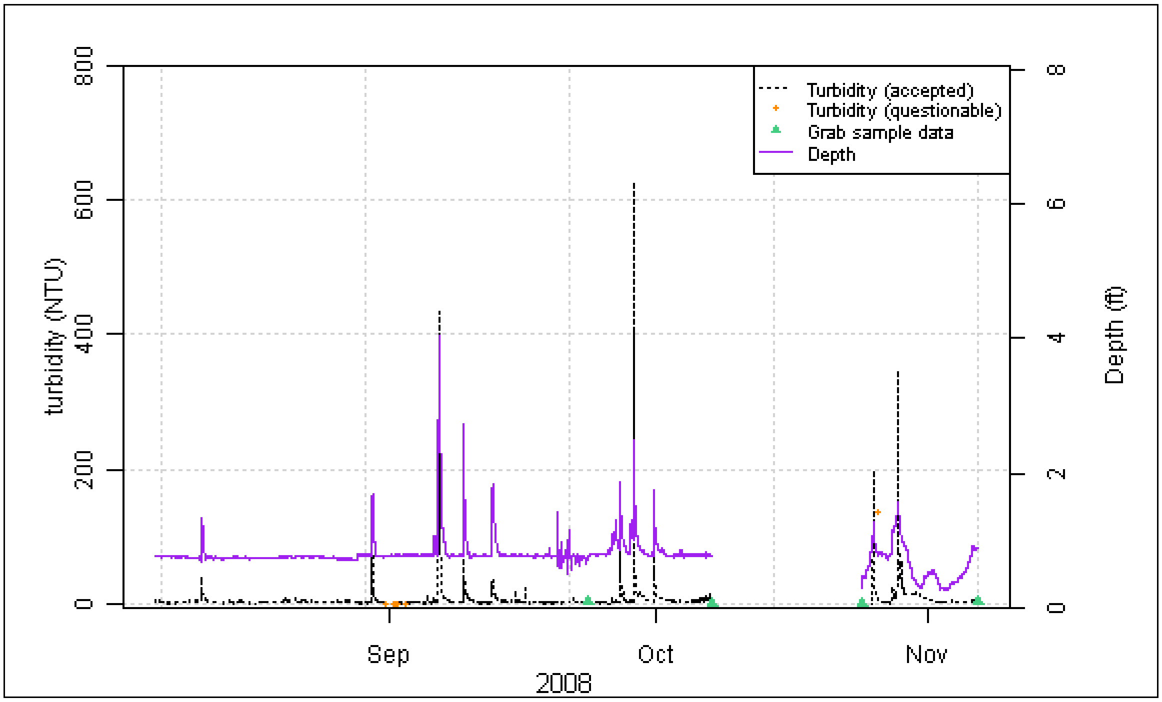



**Figure I.15 Turbidity and Stream Depth at Site PQ665, 8/5/08 – 11/6/08**

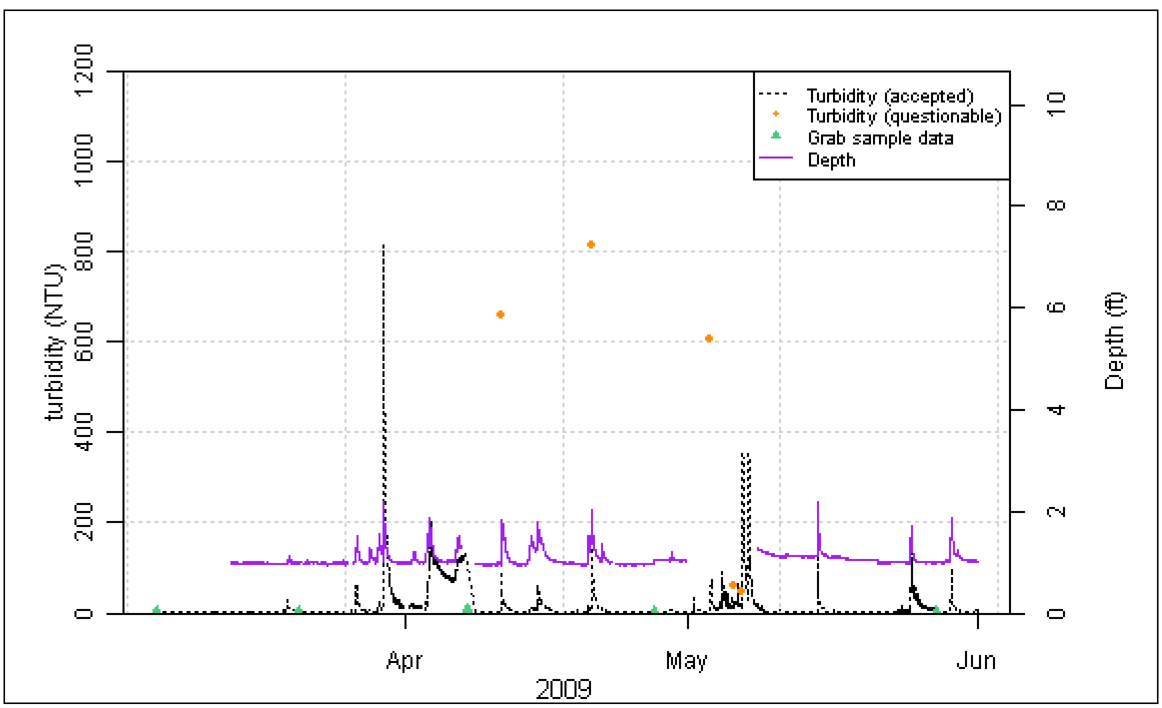



**Figure I.16 Turbidity and Stream Depth at Site PQ665, 3/5/09 – 5/31/09**

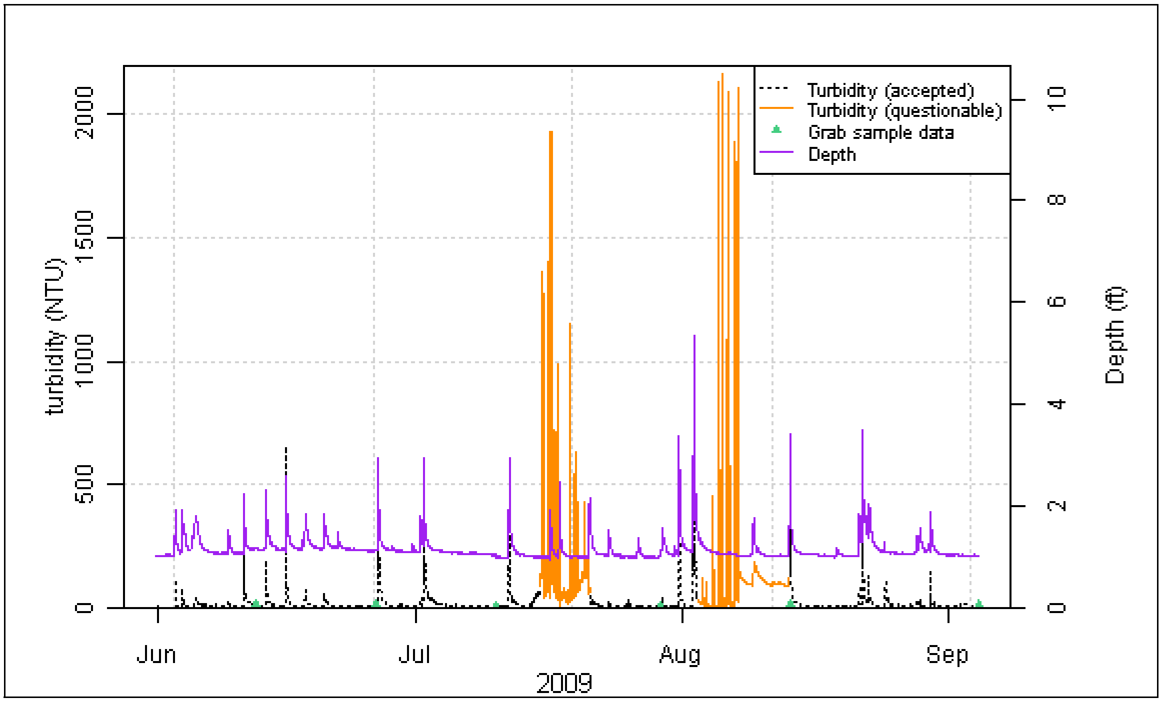



**Figure I.17 Turbidity and Stream Depth at Site PQ665, 6/1/09 – 9/4/09**

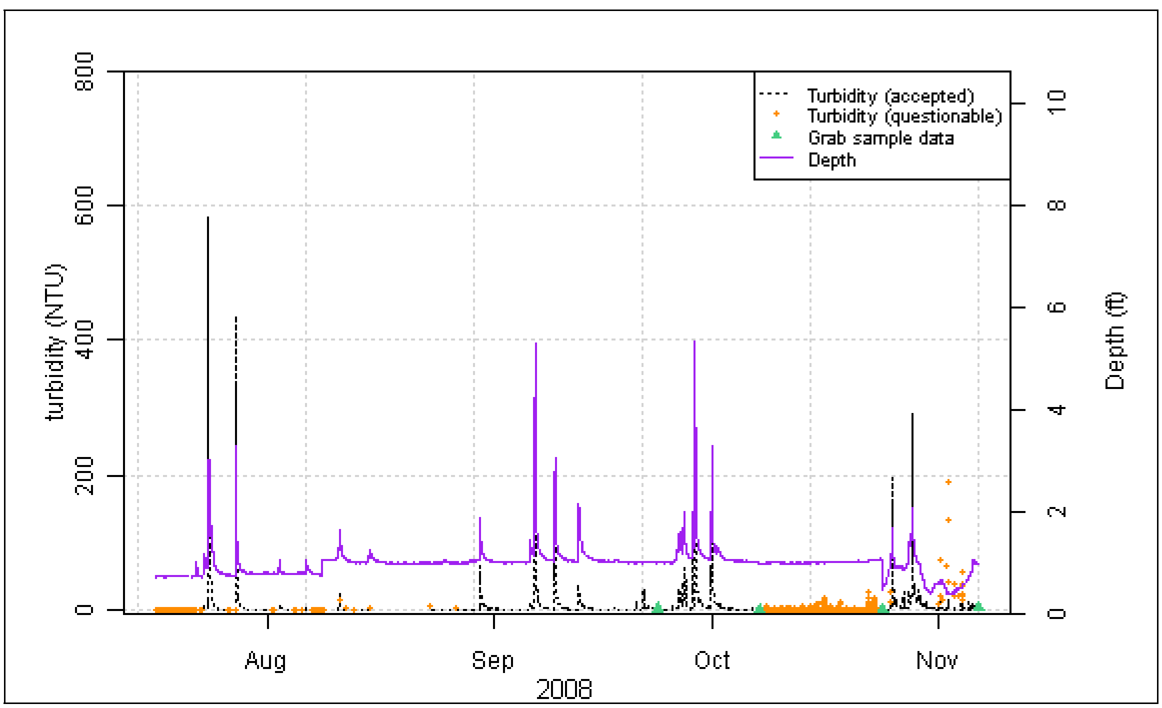



**Figure I.18 Turbidity and Stream Depth at Site PQB025, 7/16/08 – 11/6/08**

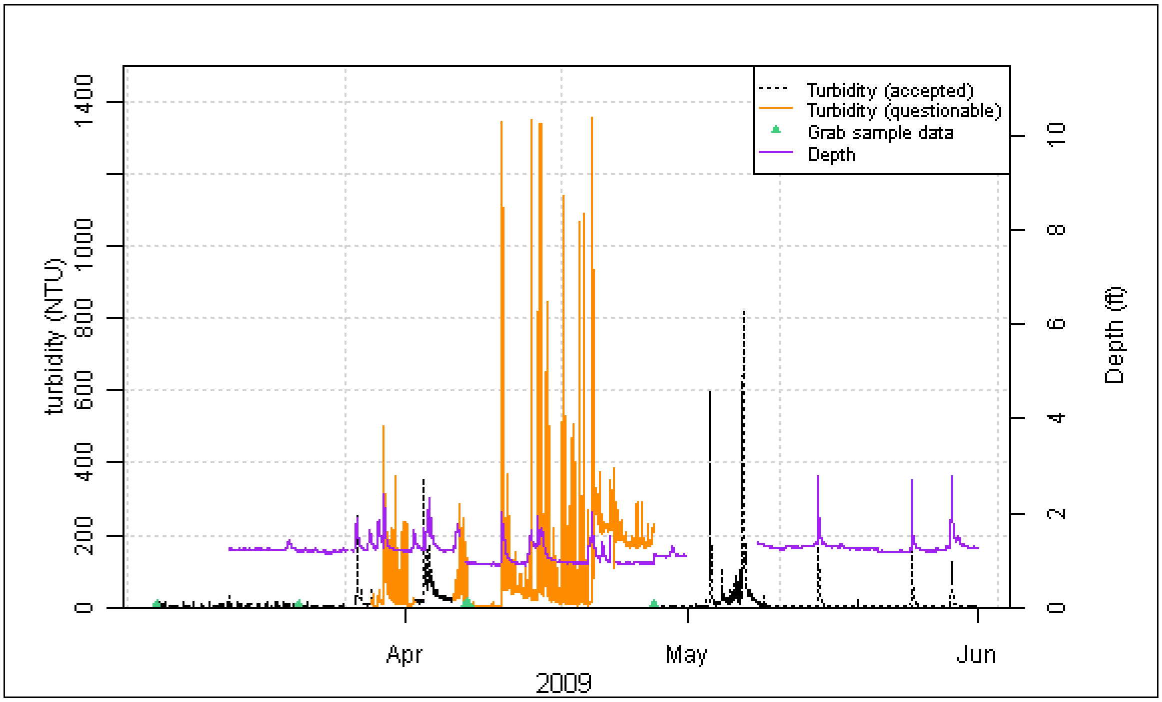



**Figure I.19 Turbidity and Stream Depth at Site PQB025, 3/5/09 – 5/31/09**

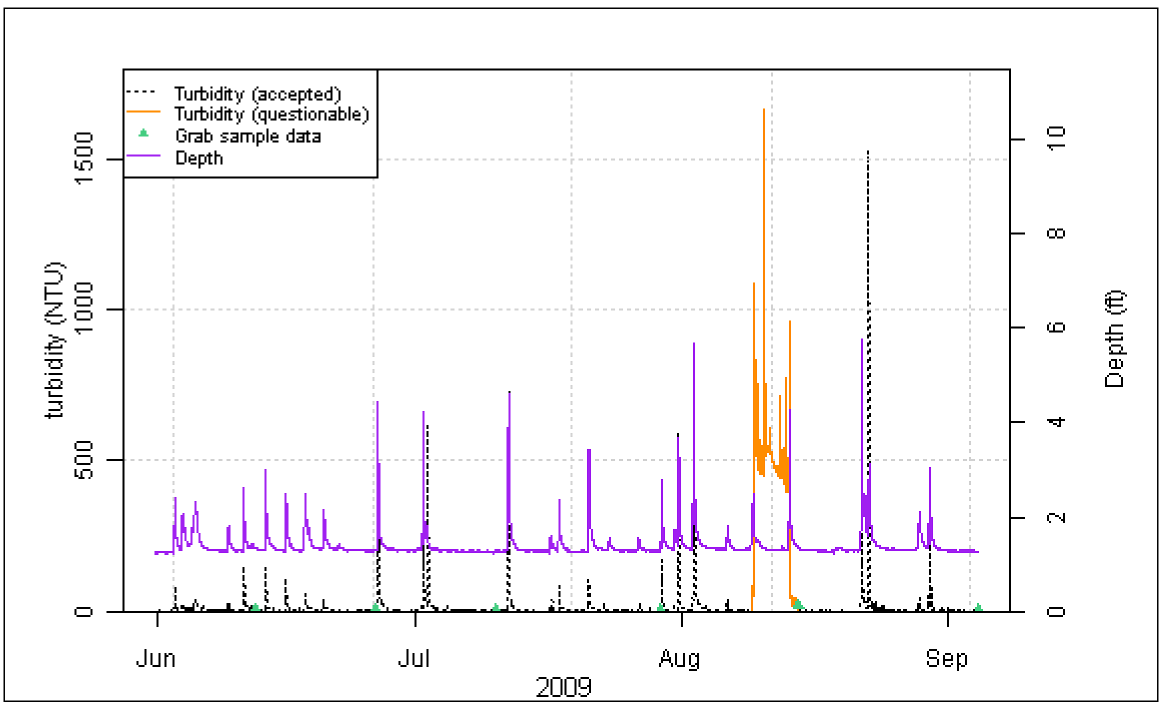



**Figure I.20 Turbidity and Stream Depth at Site PQB025, 6/1/09 – 9/4/09**

# APPENDIX J:

## Water Quality Parameter Boxplots

# Water Quality Parameter Boxplots

The plots in Appendix J supplement those contained in Section 4. All boxplots use the following conventions: only subsets with sample size > 4 are plotted; sample size and number of samples below reporting limits are listed above each subset; boxplot whiskers extend to 1st and 99th percentiles. All plots are based on data collected in 2008-2009.

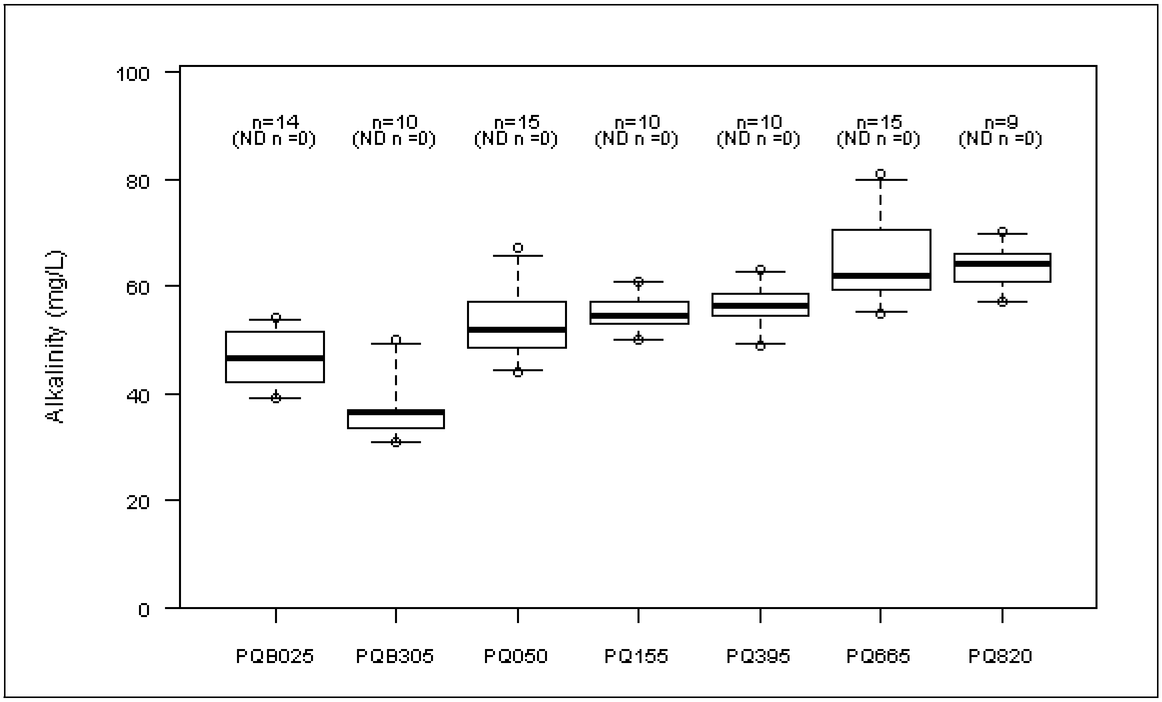



**Figure J.1 Alkalinity Concentrations by Site in Dry Weather Conditions, 2008-2009**

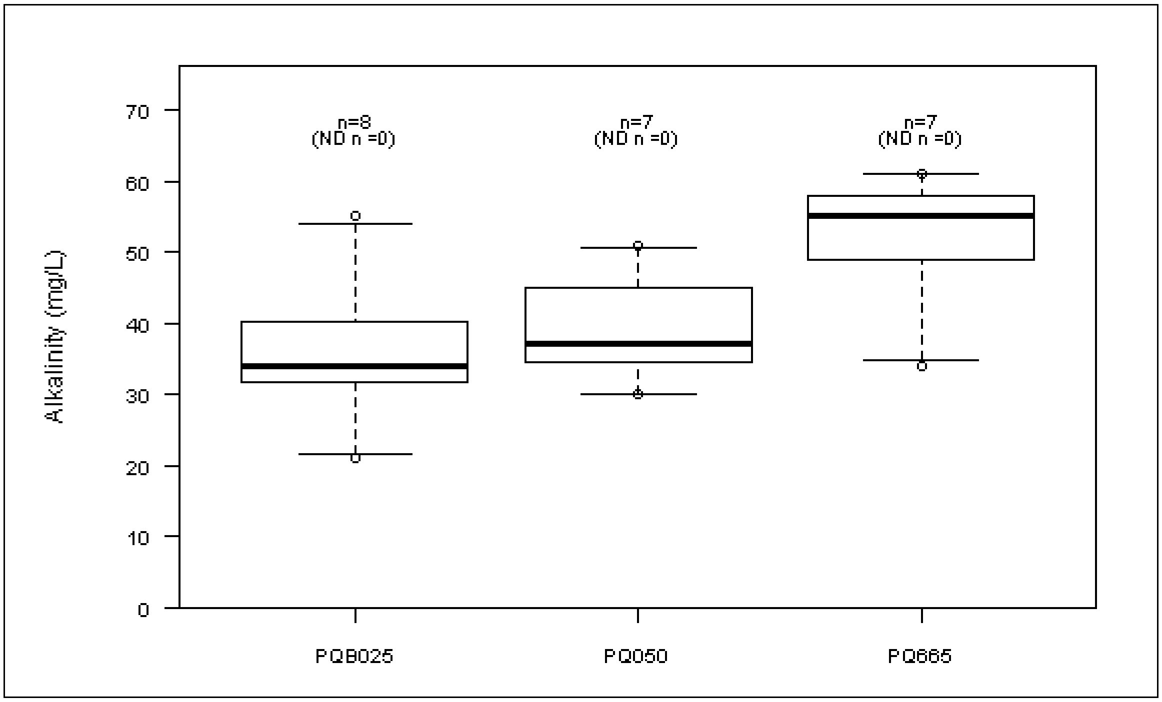



**Figure J.2 Alkalinity Concentrations by Site in Wet Weather Conditions, 2008-2009**

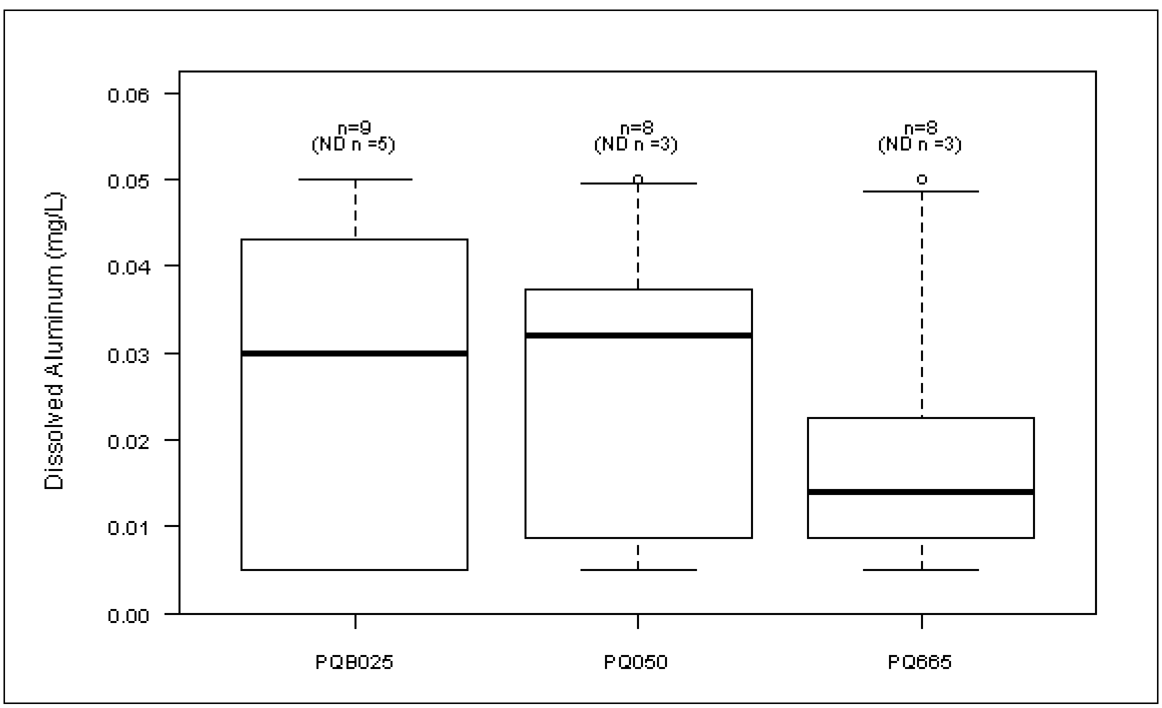



**Figure J.3 Dissolved Aluminum Concentrations by Site in Wet Weather Conditions, 2008-2009**

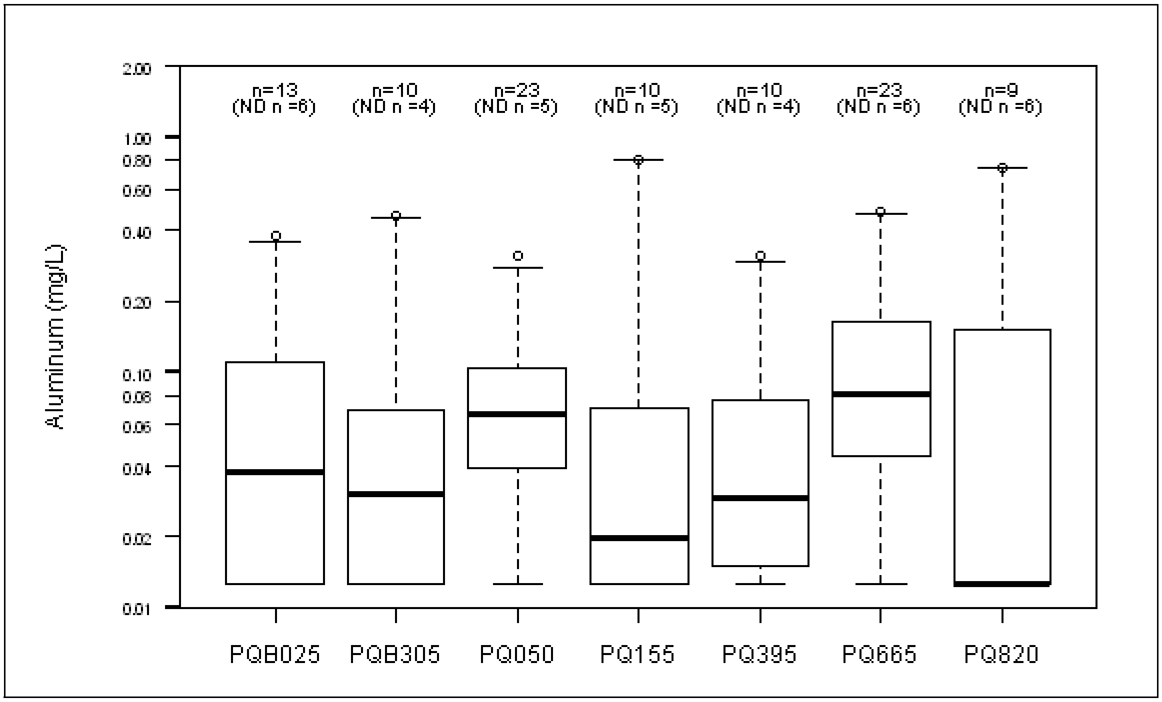



**Figure J.4 Total Recoverable Aluminum Concentrations by Site in Dry Weather Conditions, 2008-2009**

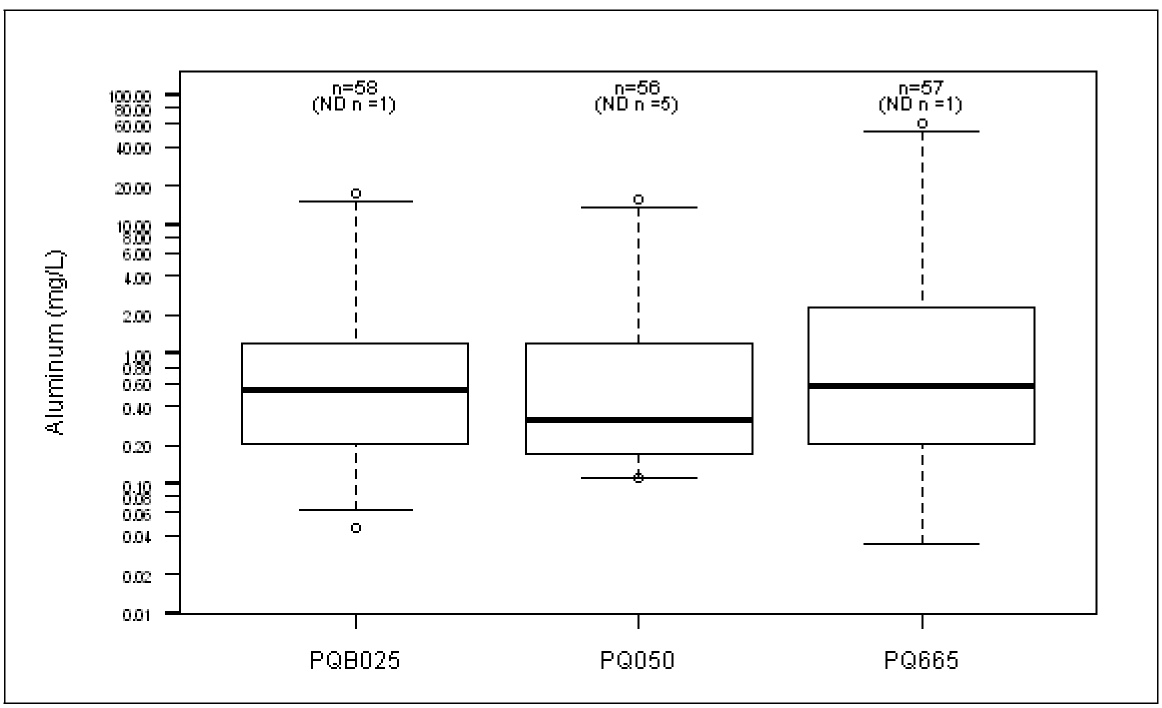



**Figure J.5 Total Recoverable Aluminum Concentrations by Site in Wet Weather Conditions, 2008-2009**

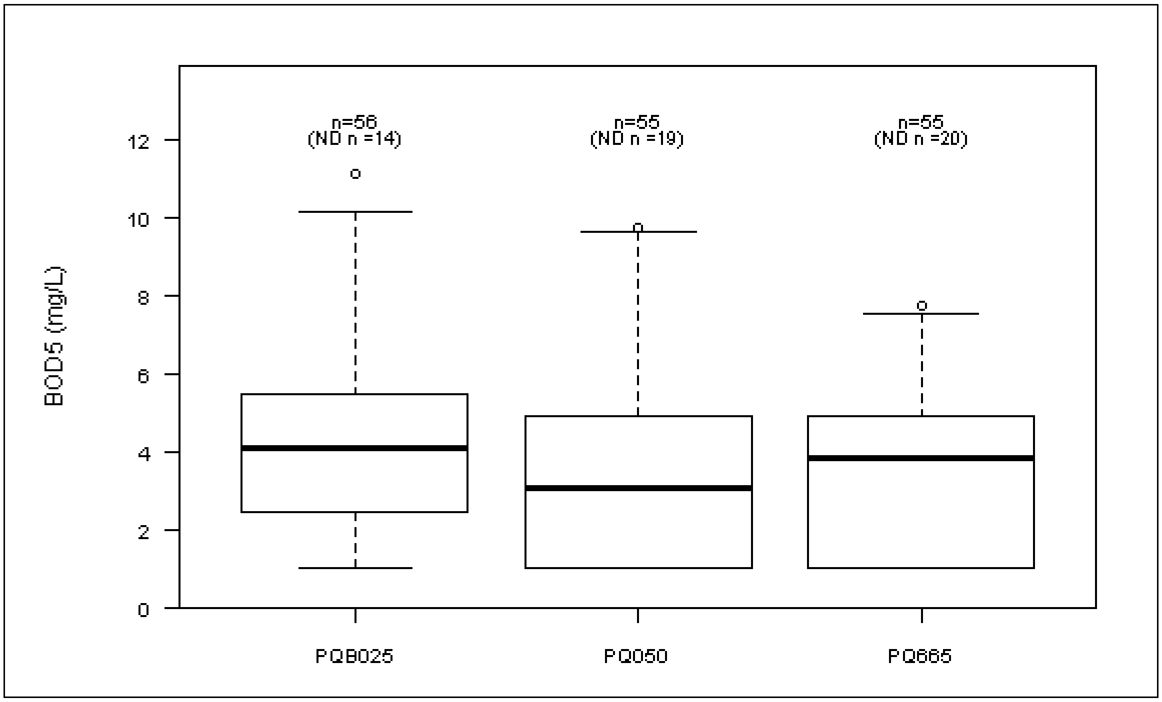



**Figure J.6 BOD5 Concentrations by Site in Wet Weather Conditions, 2008-2009**

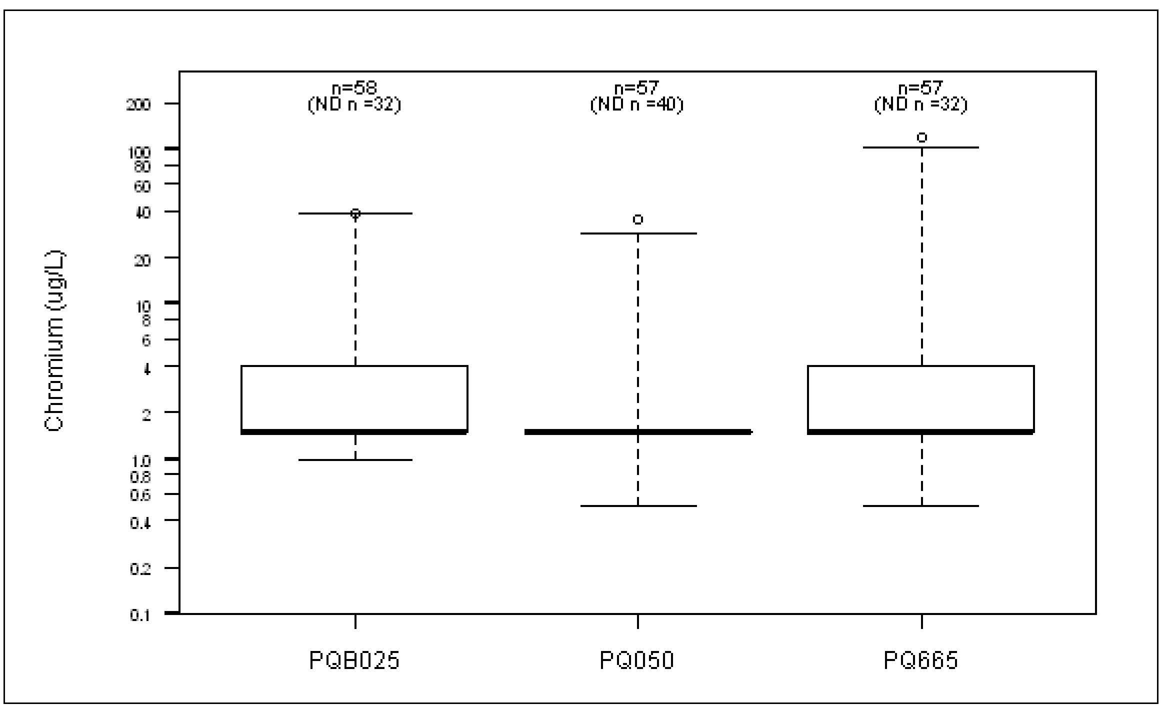



**Figure J.7 Total Recoverable Chromium Concentrations by Site in Wet Weather Conditions, 2008-2009**

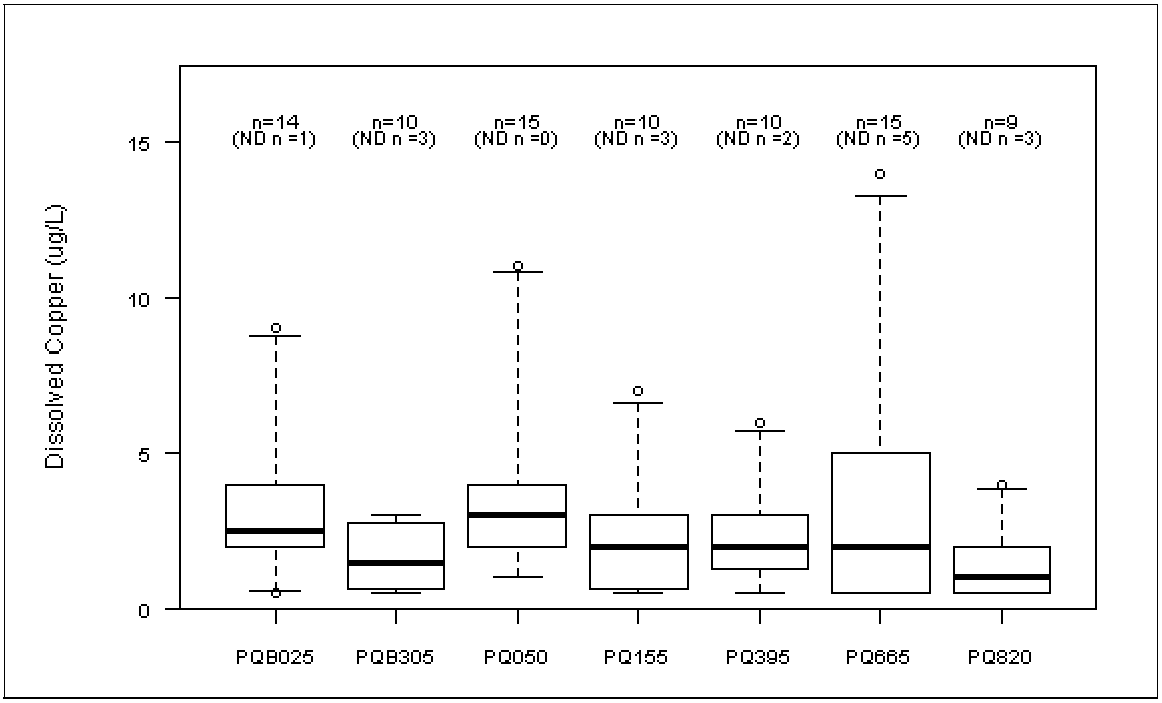



**Figure J.8 Dissolved Copper Concentrations by Site in Dry Weather Conditions, 2008-2009**

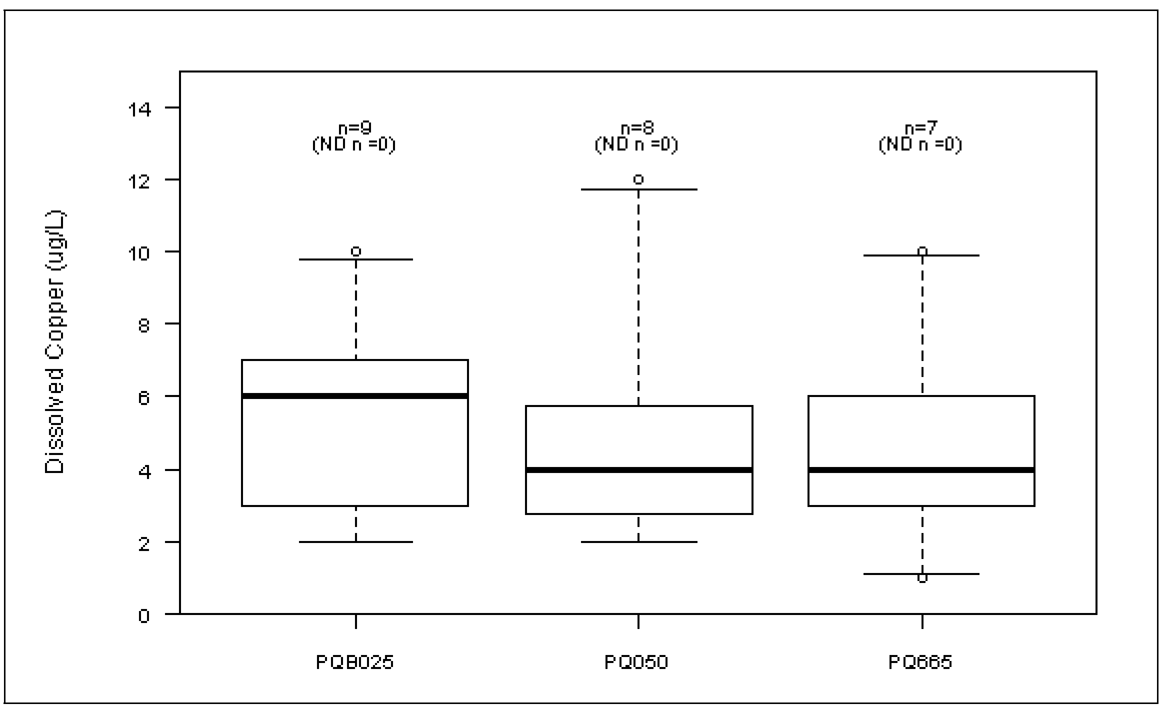



**Figure J.9 Dissolved Copper Concentrations by Site in Wet Weather Conditions, 2008-2009**

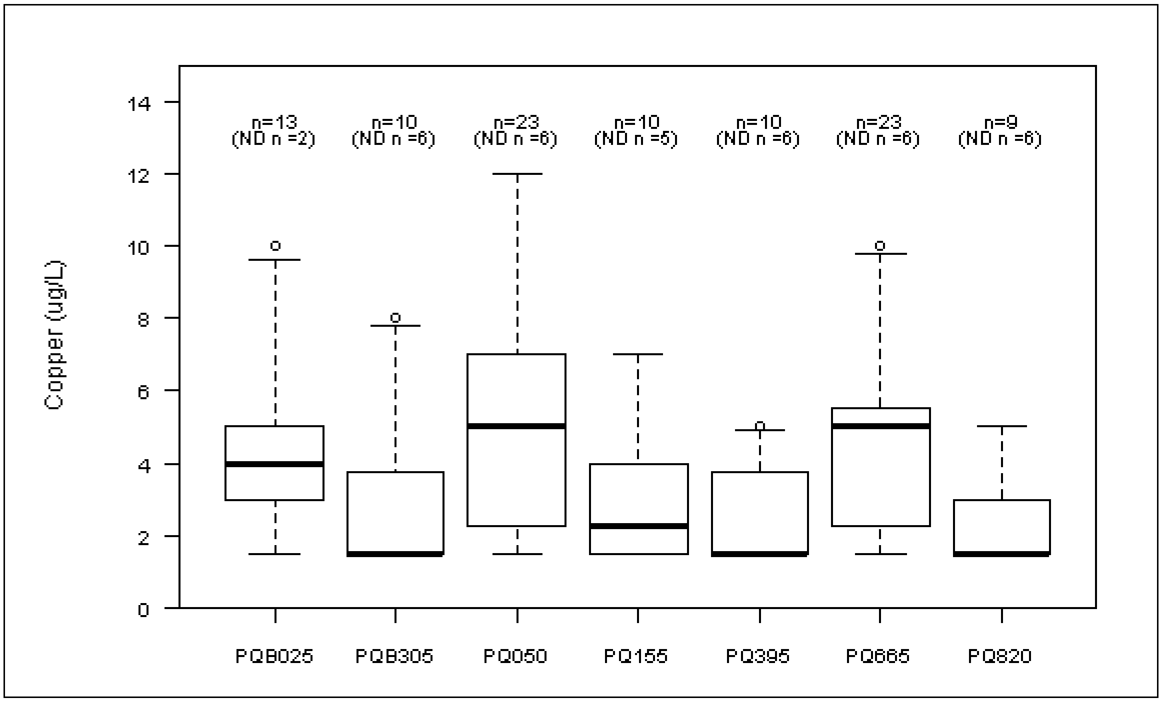



**Figure J.10 Total Recoverable Copper Concentrations by Site in Dry Weather Conditions, 2008-2009**

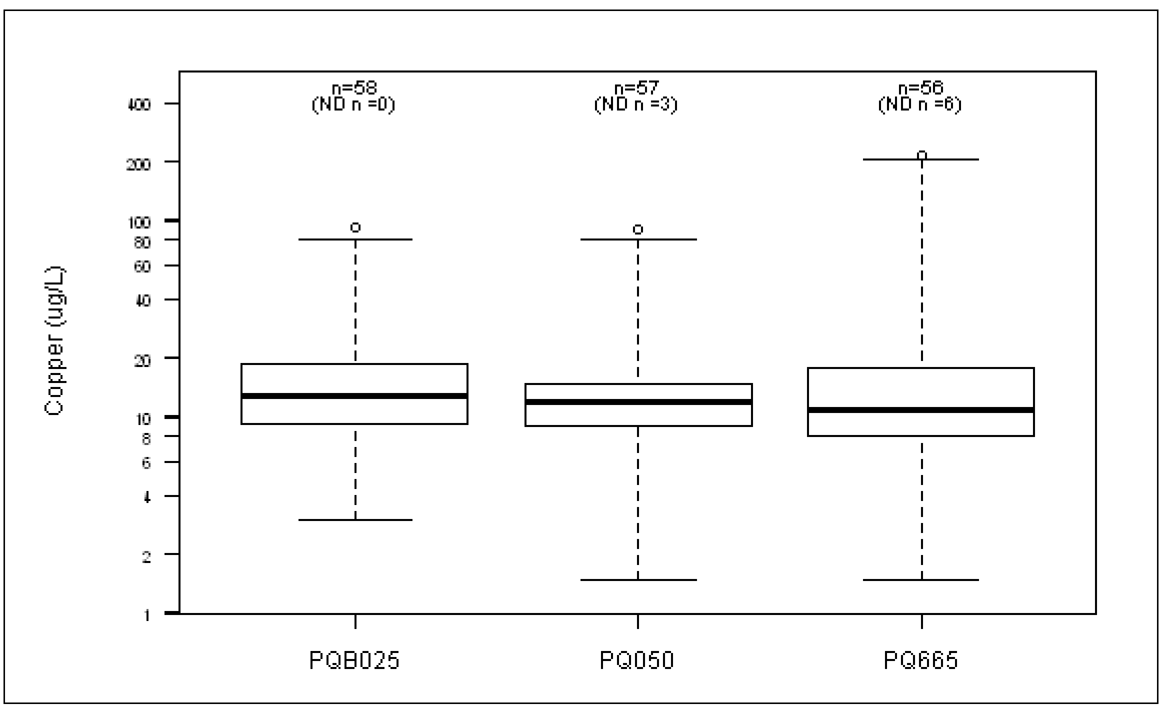



**Figure J.11 Total Recoverable Copper Concentrations by Site in Wet Weather Conditions, 2008-2009**

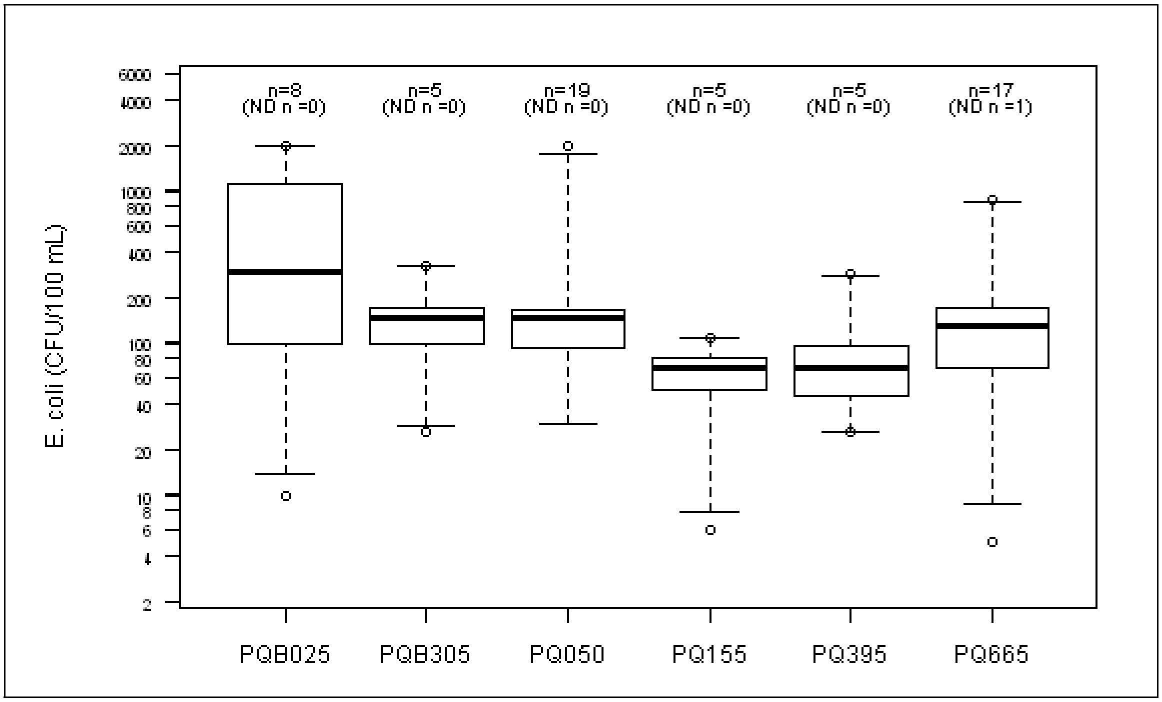



**Figure J.12 *E. coli* Concentrations by Site during Non-swimming Season in Dry Weather Conditions, 2008-2009**

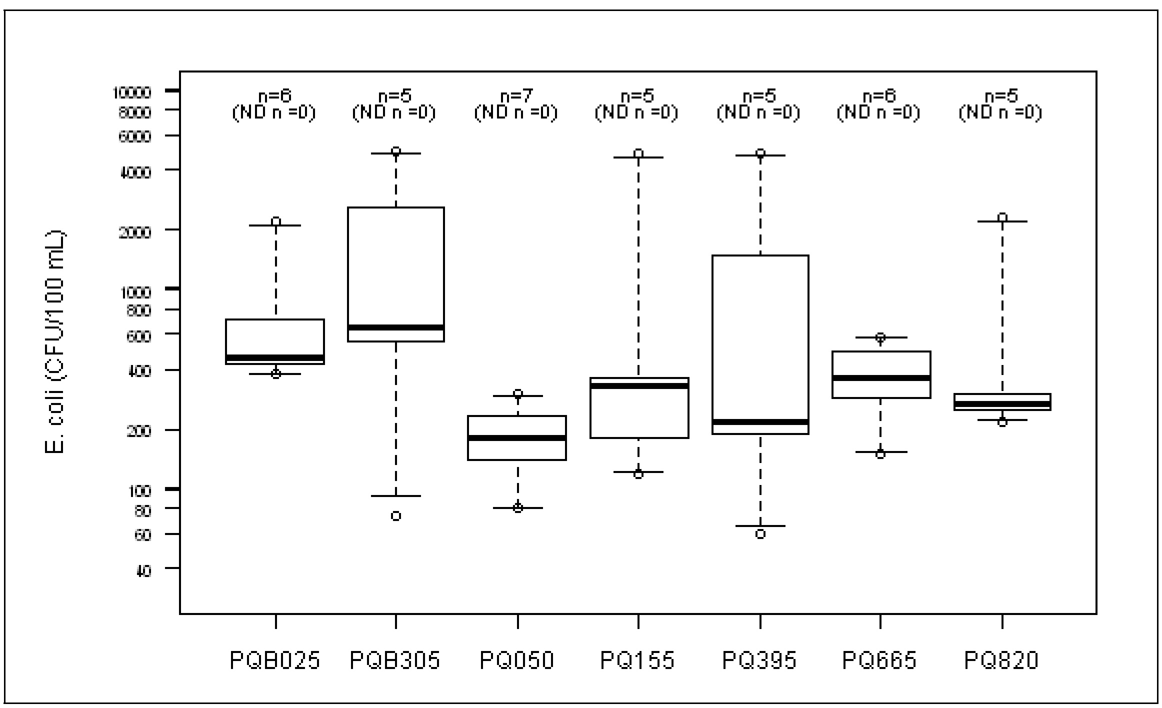



**Figure J.13 *E. coli* Concentrations by Site during Swimming Season in Wet Weather Conditions, 2008-2009**

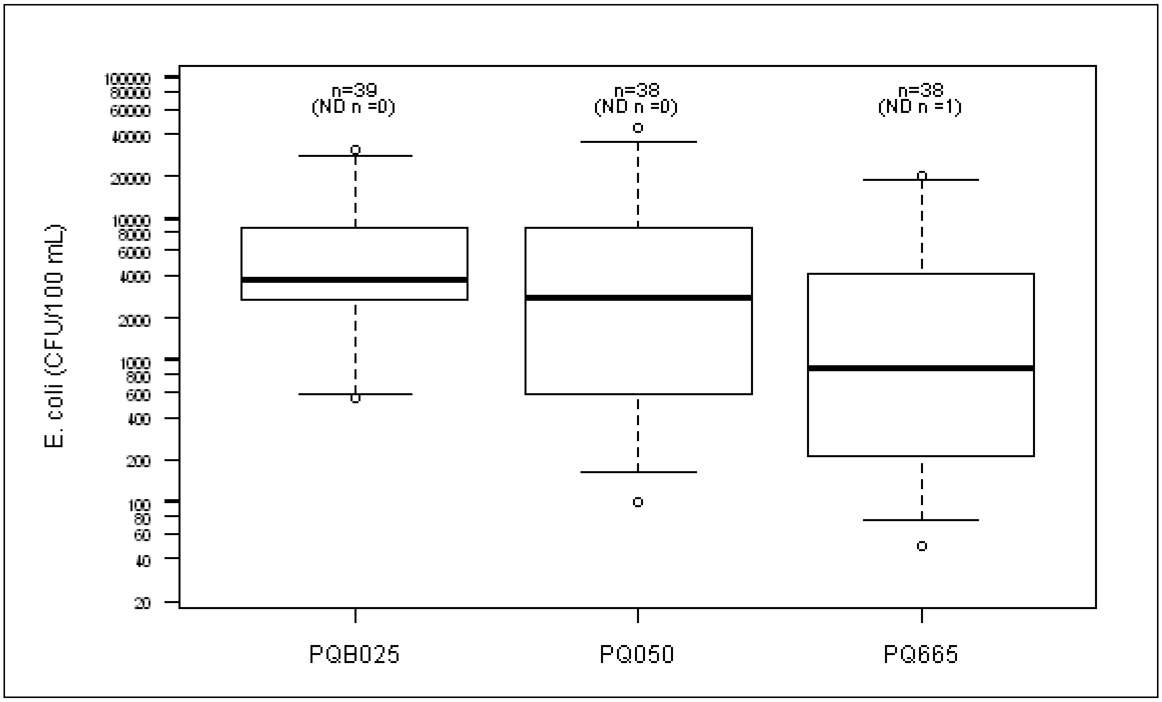



**Figure J.14 *E. coli* Concentrations by Site during Non-swimming Season in Wet Weather Conditions, 2008-2009**

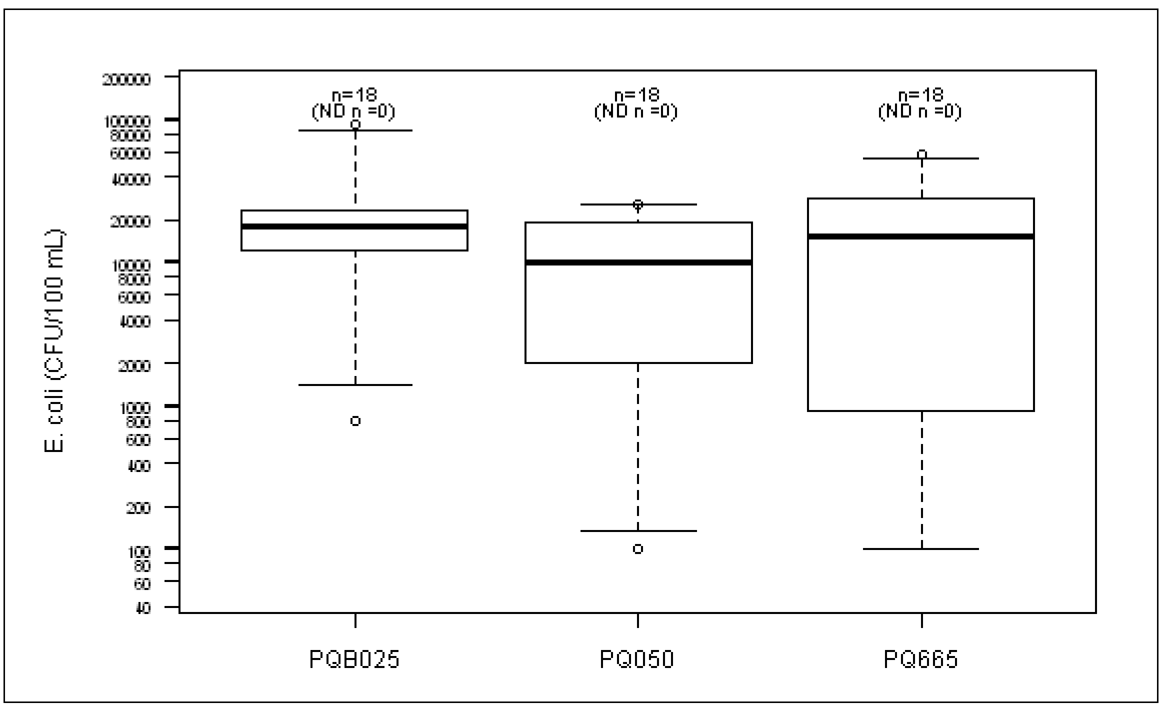



**Figure J.15 *E. coli* Concentrations by Site during Swimming Season in Wet Weather Conditions, 2008-2009**

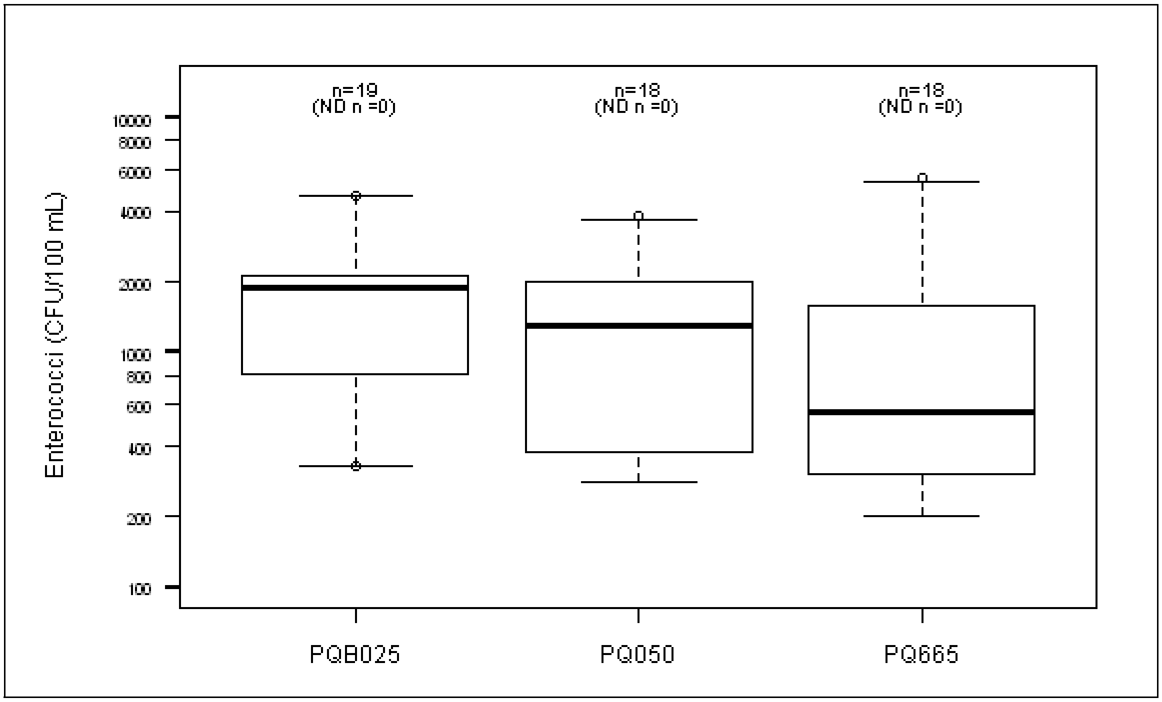



**Figure J.16 Enterococci Concentrations by Site during Non-swimming Season in Wet Weather Conditions, 2008-2009**

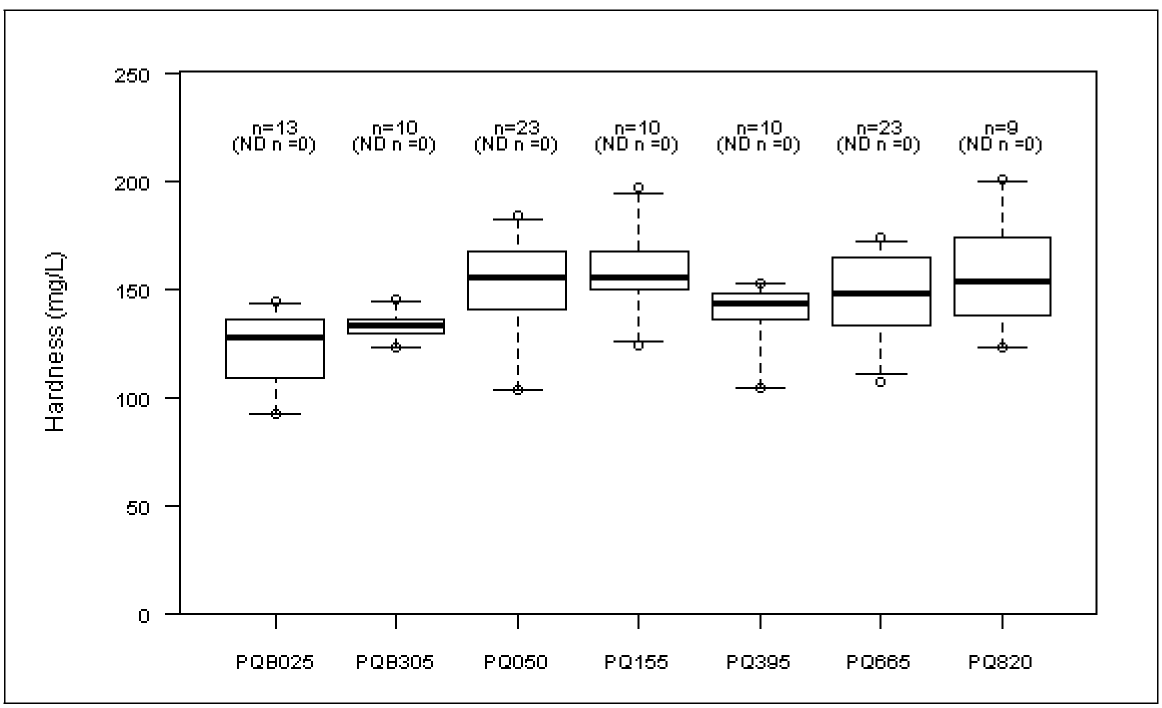



**Figure J.17 Hardness Concentrations by Site in Dry Weather Conditions, 2008-2009**

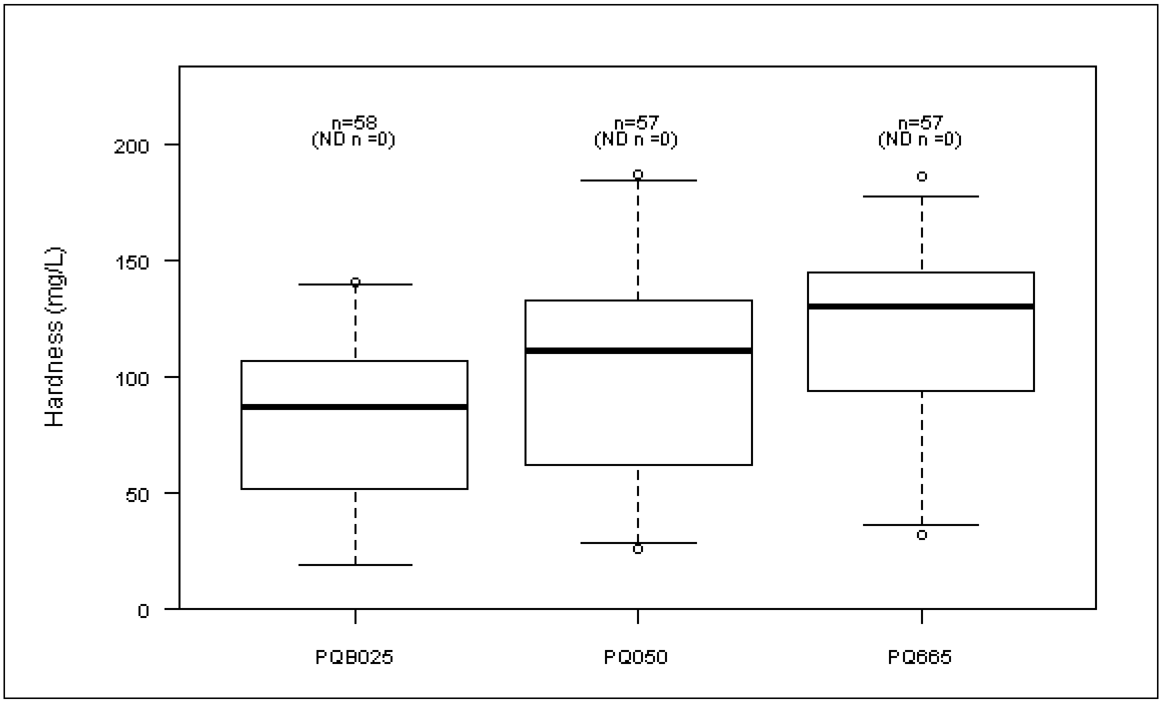



**Figure J.18 Hardness Concentrations by Site in Wet Weather Conditions, 2008-2009**

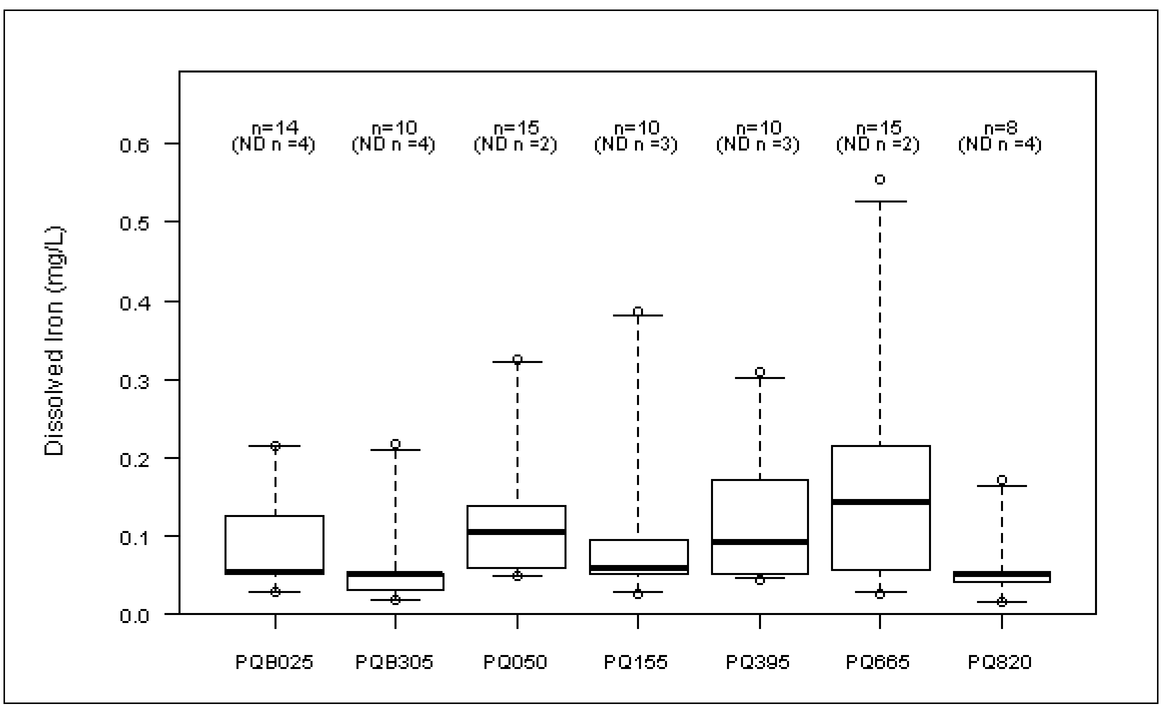



**Figure J.19 Dissolved Iron Concentrations by Site in Dry Weather Conditions, 2008-2009**

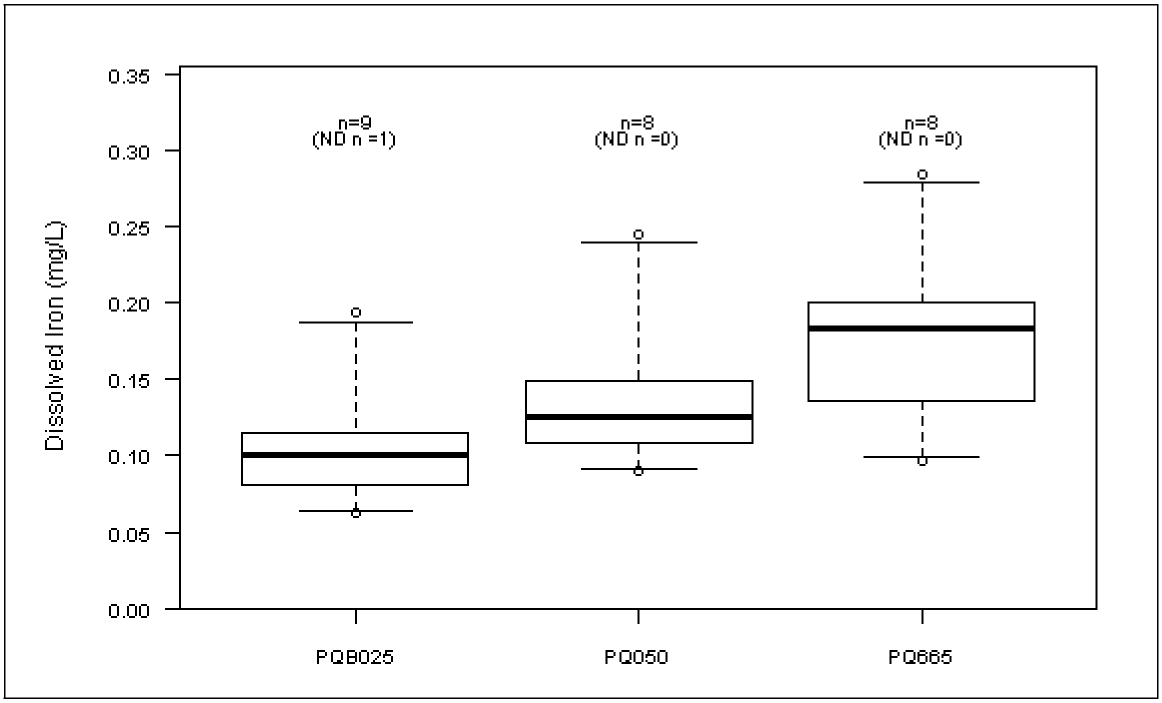



**Figure J.20 Dissolved Iron Concentrations by Site in Wet Weather Conditions, 2008-2009**

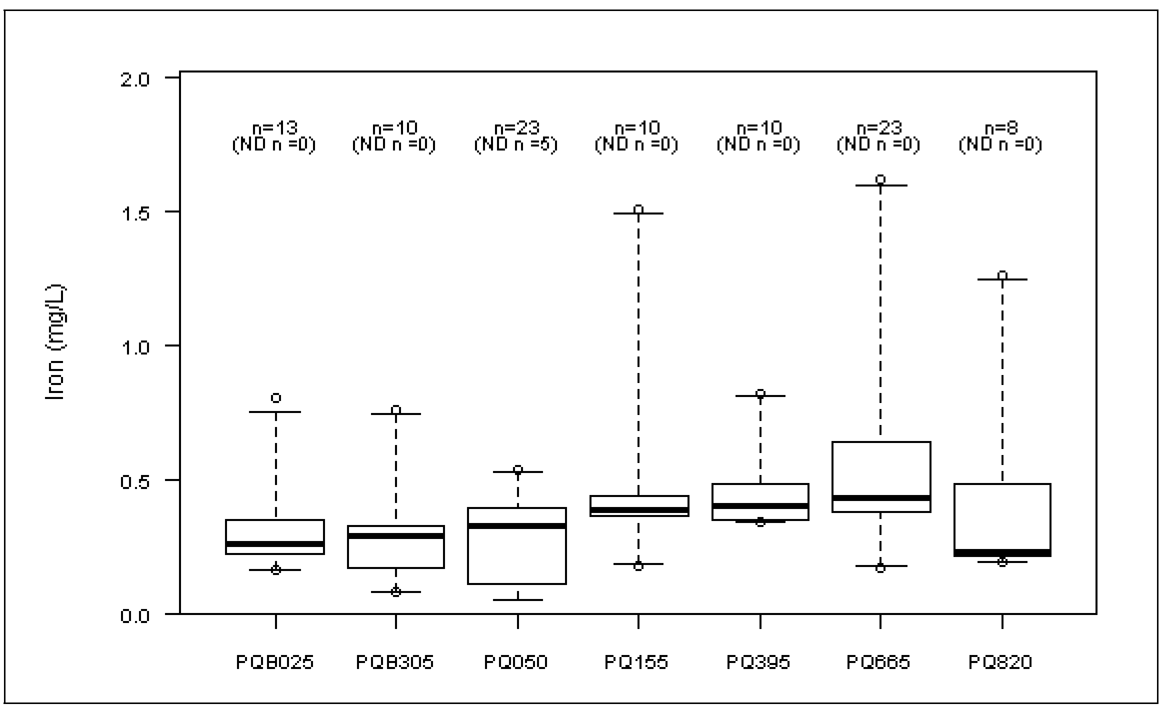



**Figure J.21 Total Recoverable Iron Concentrations by Site in Dry Weather Conditions, 2008-2009**

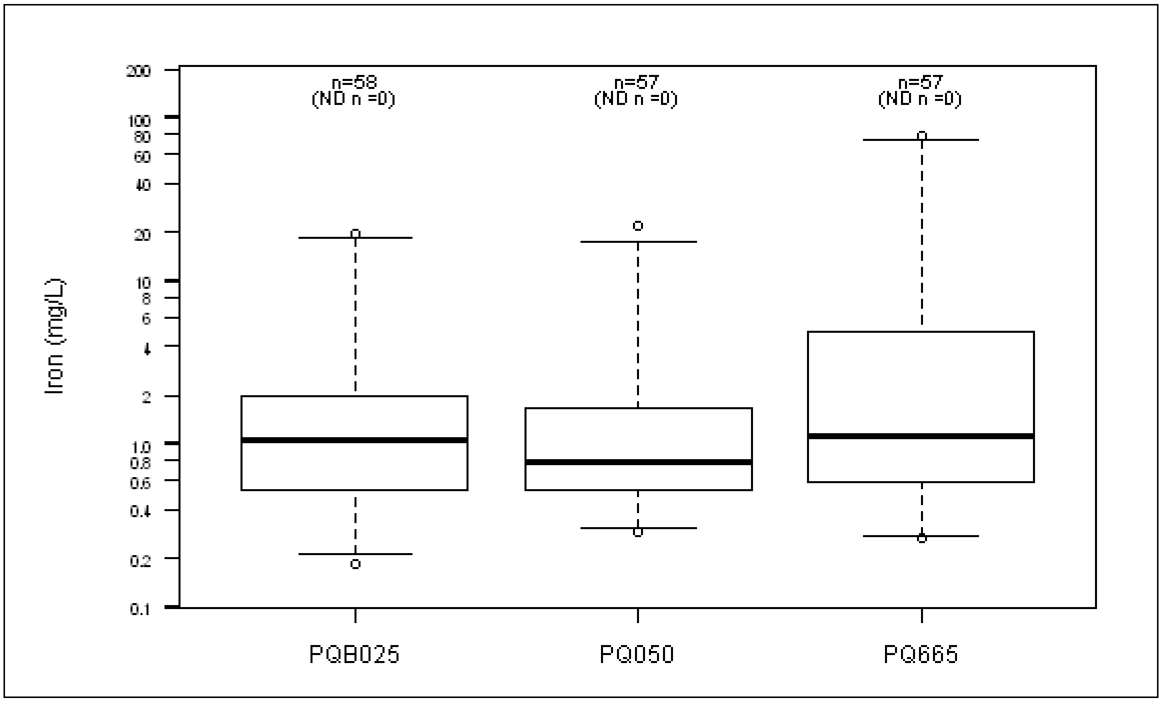



**Figure J.22 Total Recoverable Iron Concentrations by Site in Wet Weather Conditions, 2008-2009**

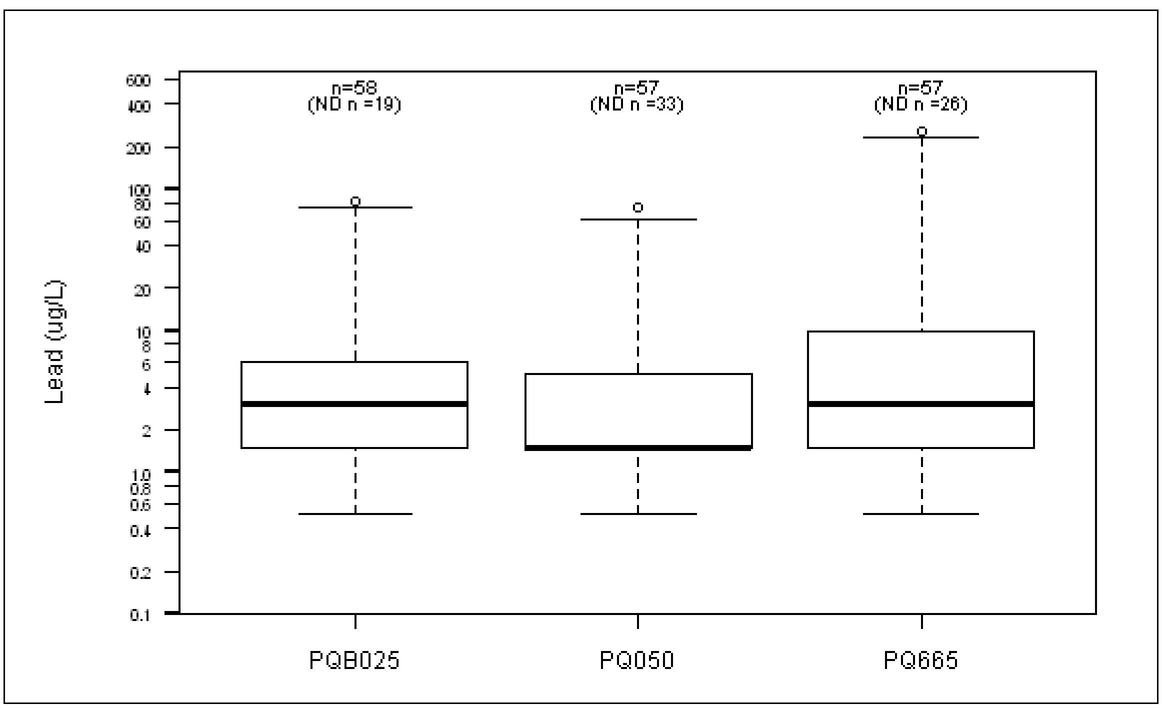



**Figure J.23 Total Recoverable Lead Concentrations by Site in Wet Weather Conditions, 2008-2009**

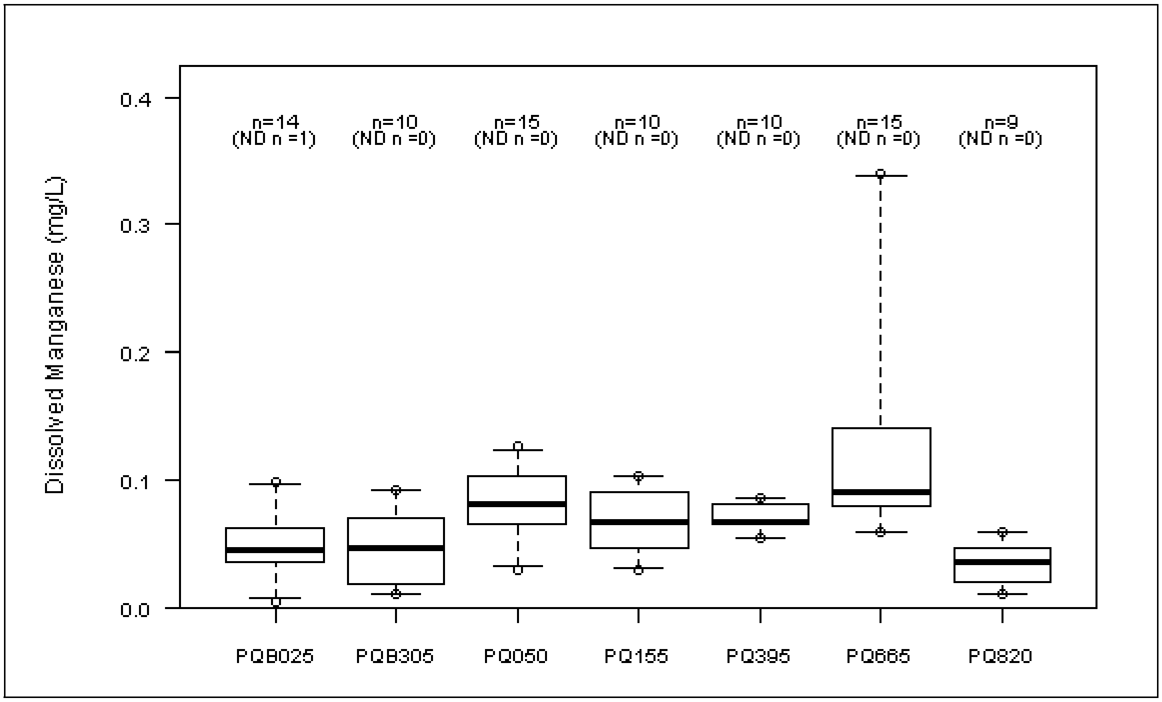



**Figure J.24 Dissolved Manganese Concentrations by Site in Dry Weather Conditions, 2008-2009**

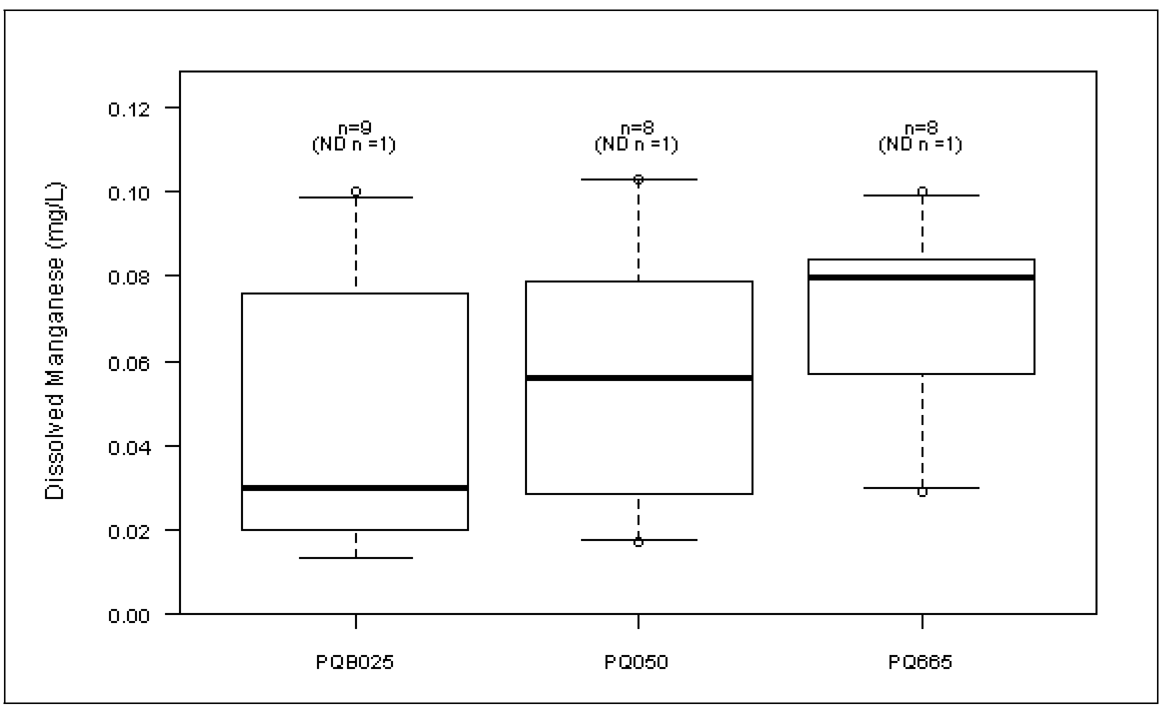



**Figure J.25 Dissolved Manganese Concentrations by Site in Wet Weather Conditions, 2008-2009**

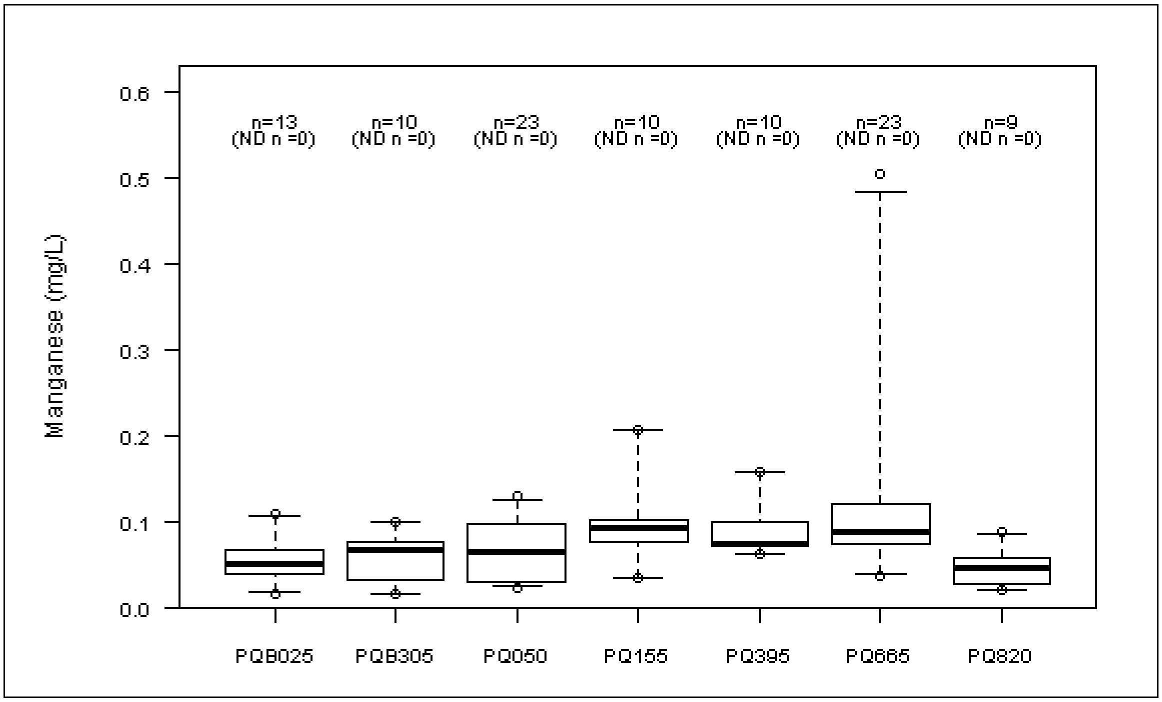



**Figure J.26 Total Recoverable Manganese Concentrations by Site in Dry Weather Conditions, 2008-2009**

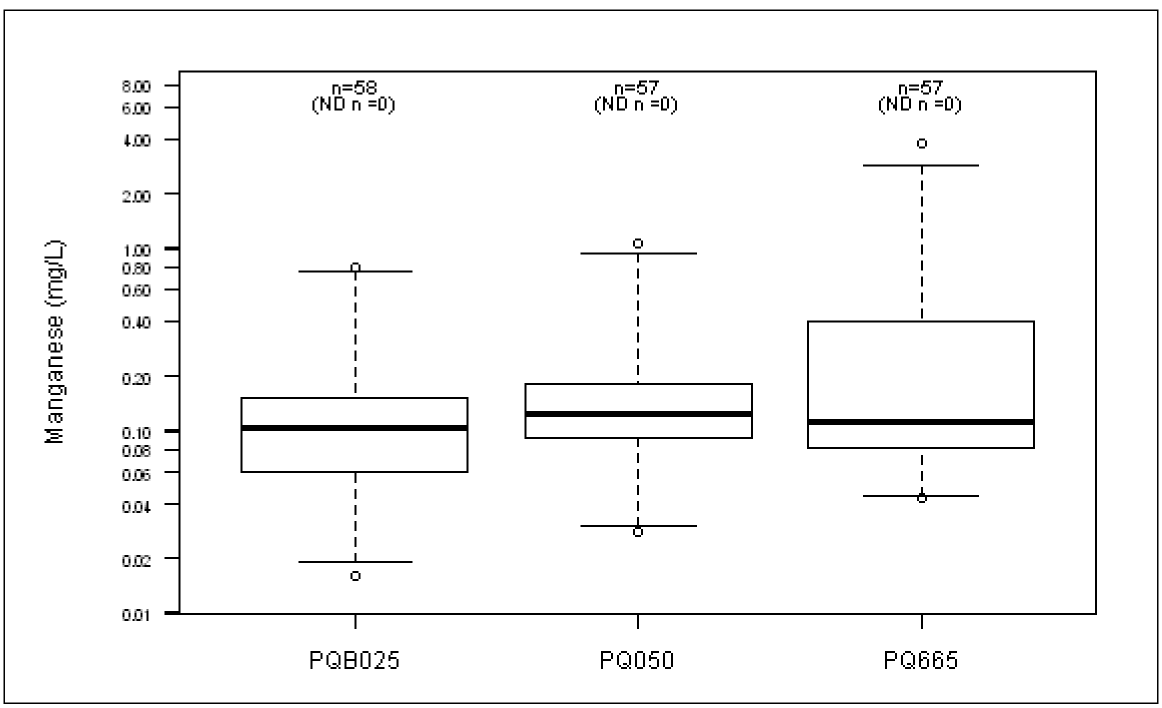



**Figure J.27 Total Recoverable Manganese Concentrations by Site in Wet Weather Conditions, 2008-2009**

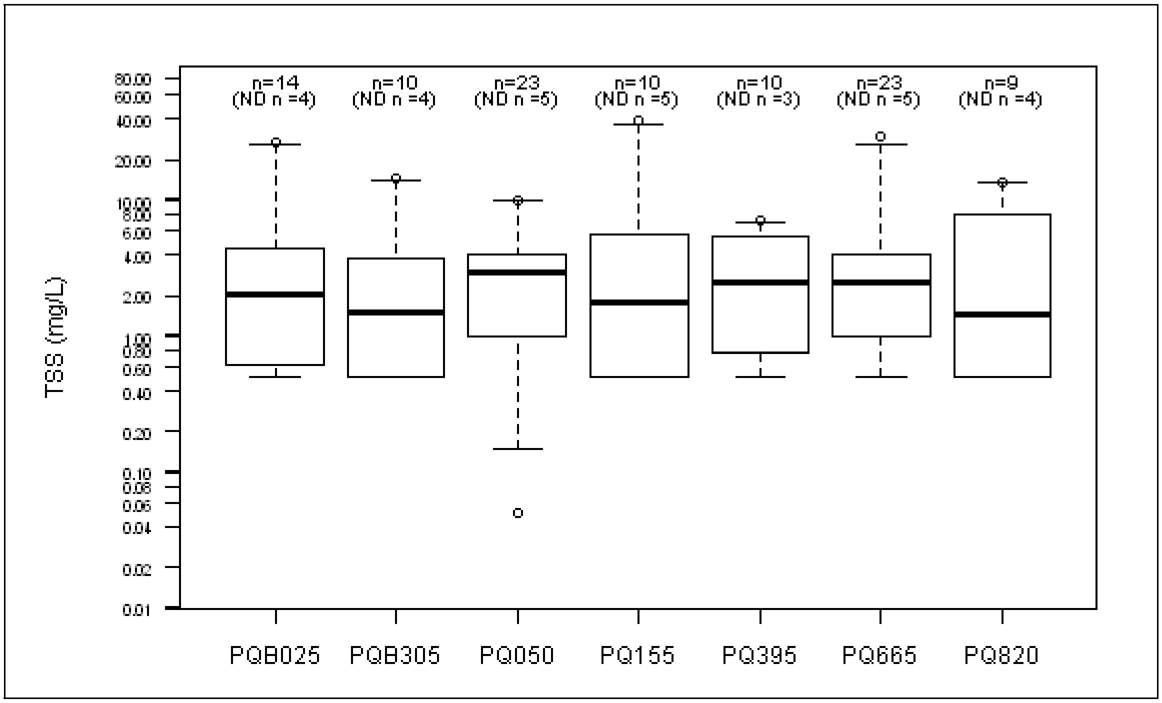



**Figure J.28 TSS Concentrations by Site in Dry Weather Conditions, 2008-2009**

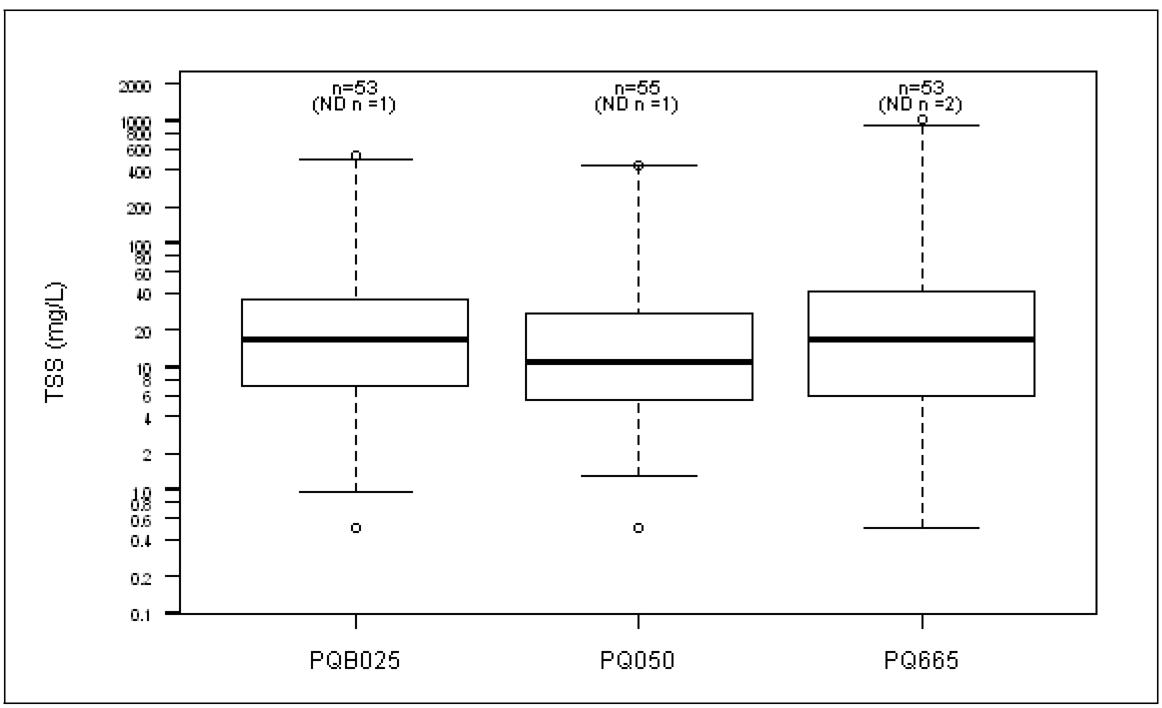



**Figure J.29 TSS Concentrations by Site in Wet Weather Conditions, 2008-2009**

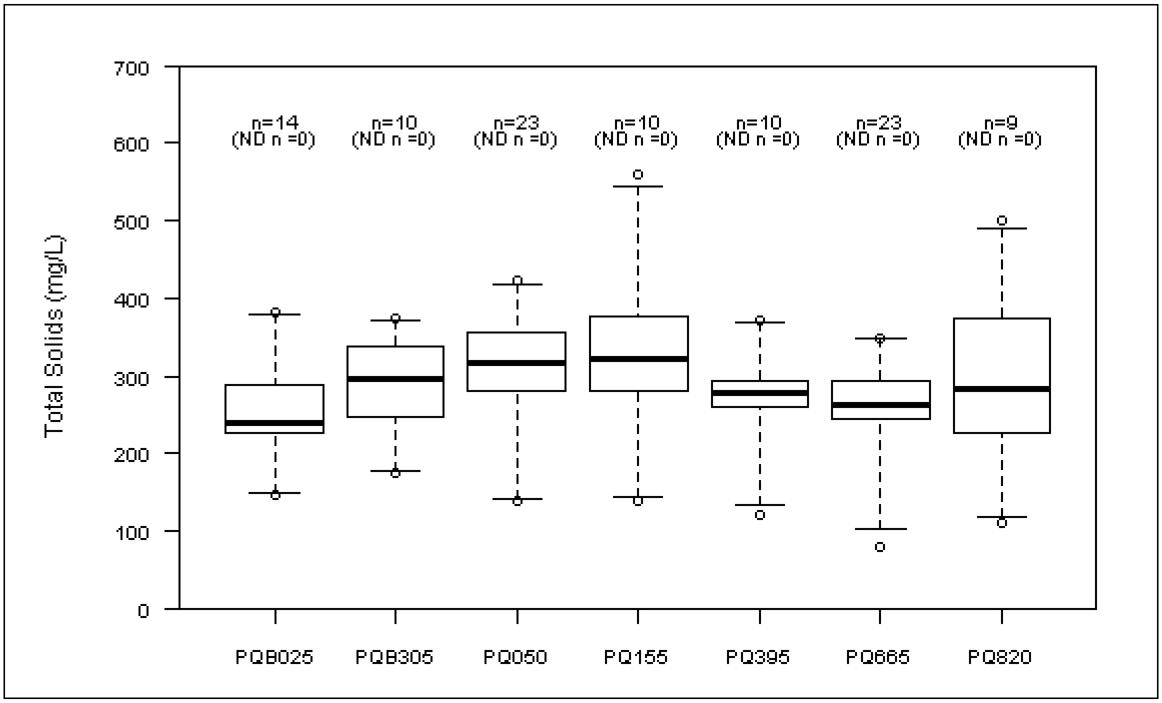



**Figure J.30 Total Solids Concentrations by Site in Dry Weather Conditions, 2008-2009**

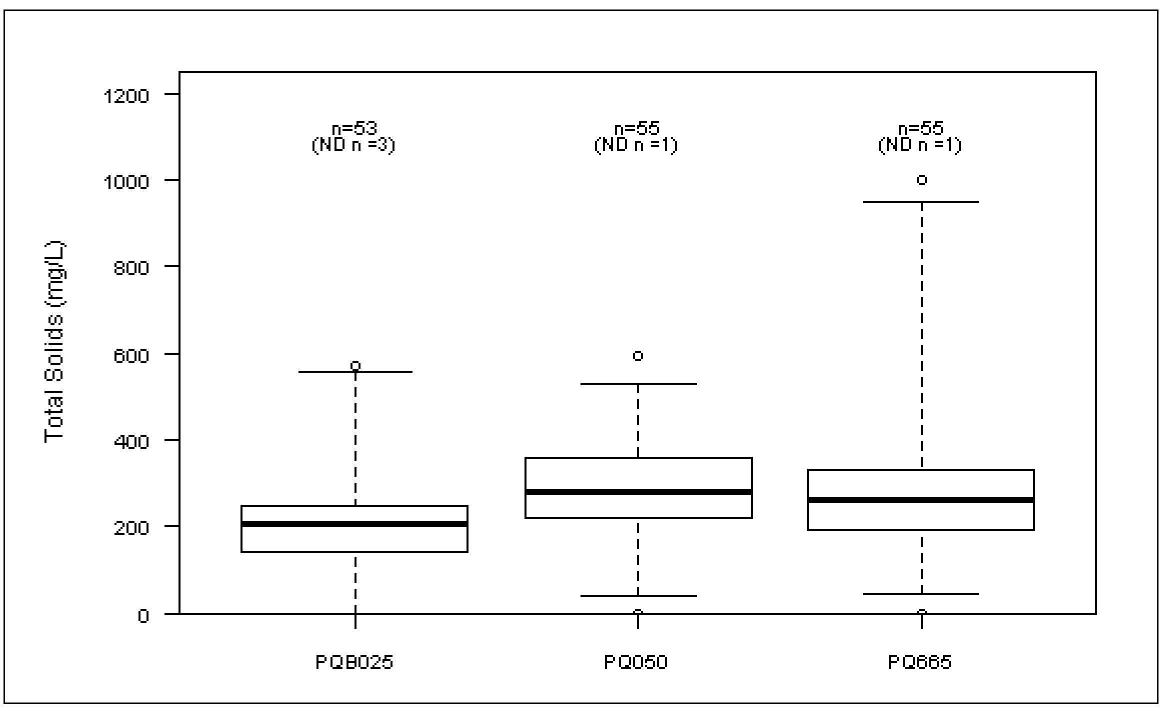



**Figure J.31 Total Solids Concentrations by Site in Wet Weather Conditions, 2008-2009**

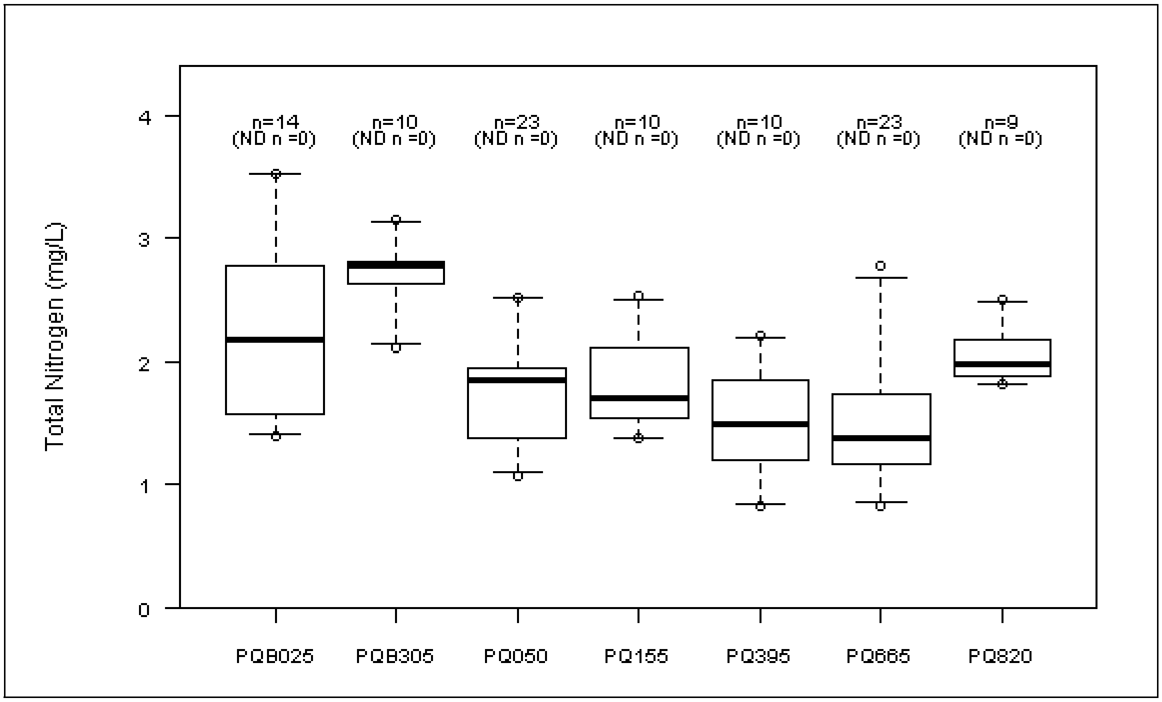



**Figure J.32 Total Nitrogen Concentrations by Site in Dry Weather Conditions, 2008-2009**

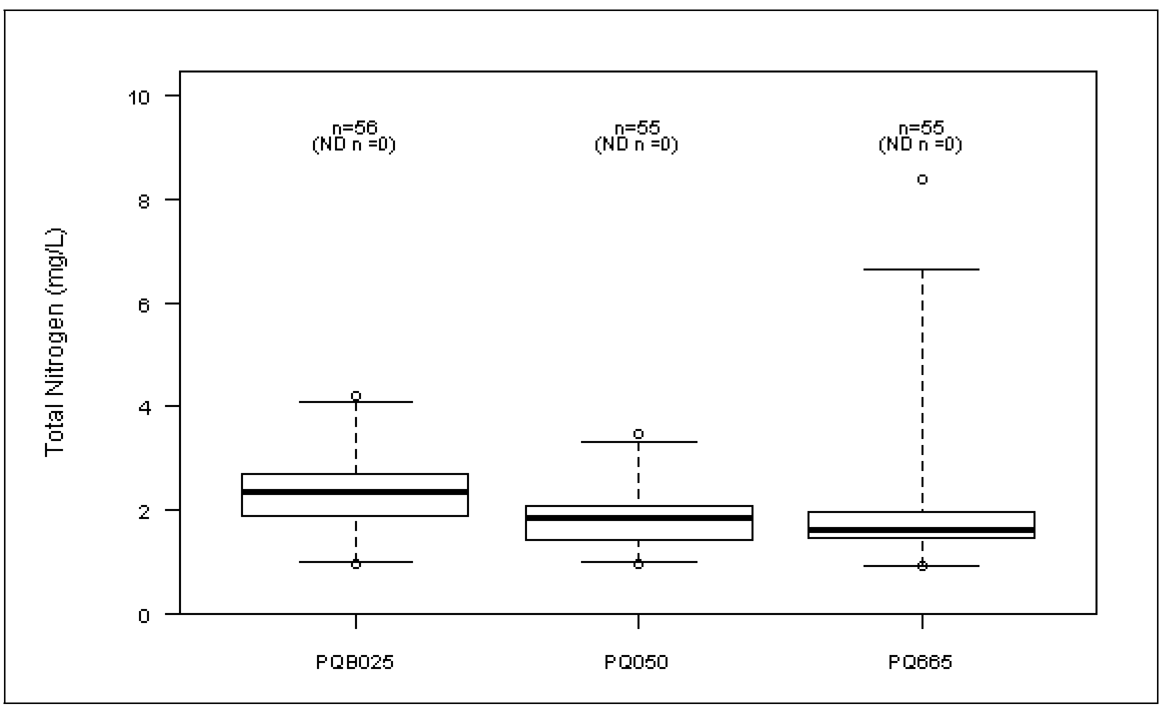



**Figure J.33 Total Nitrogen Concentrations by Site in Wet Weather Conditions, 2008-2009**

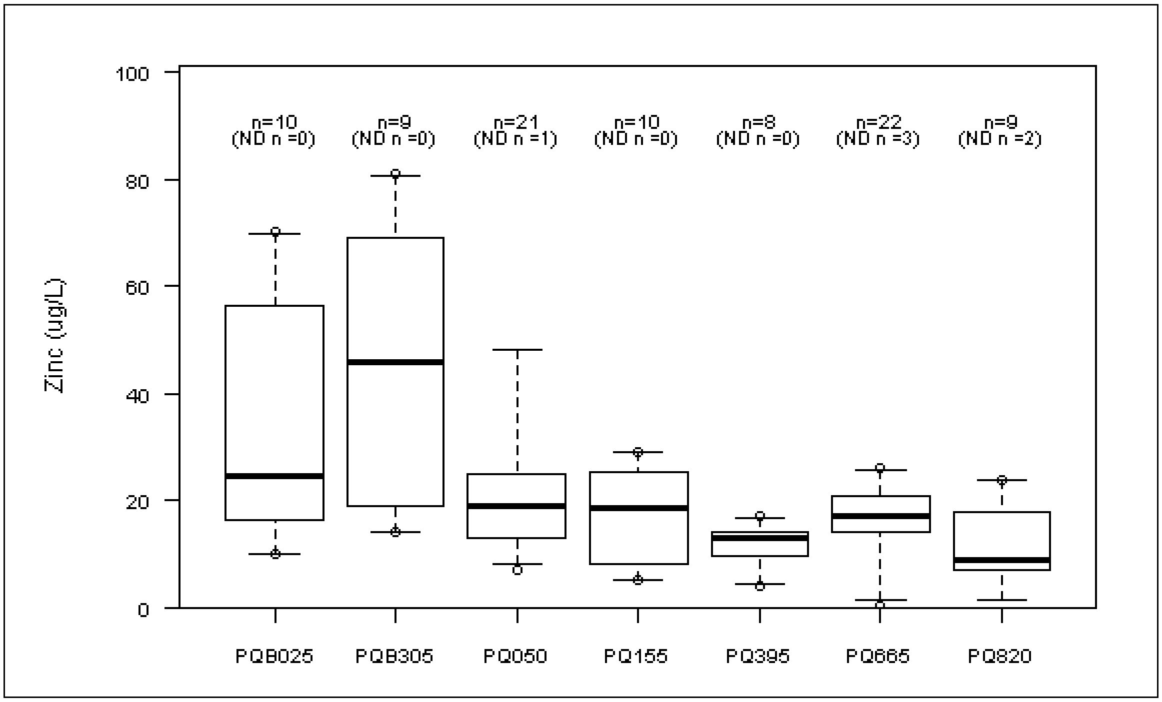



**Figure J.34 Total Recoverable Zinc Concentrations by Site in Dry Weather Conditions, 2008-2009**

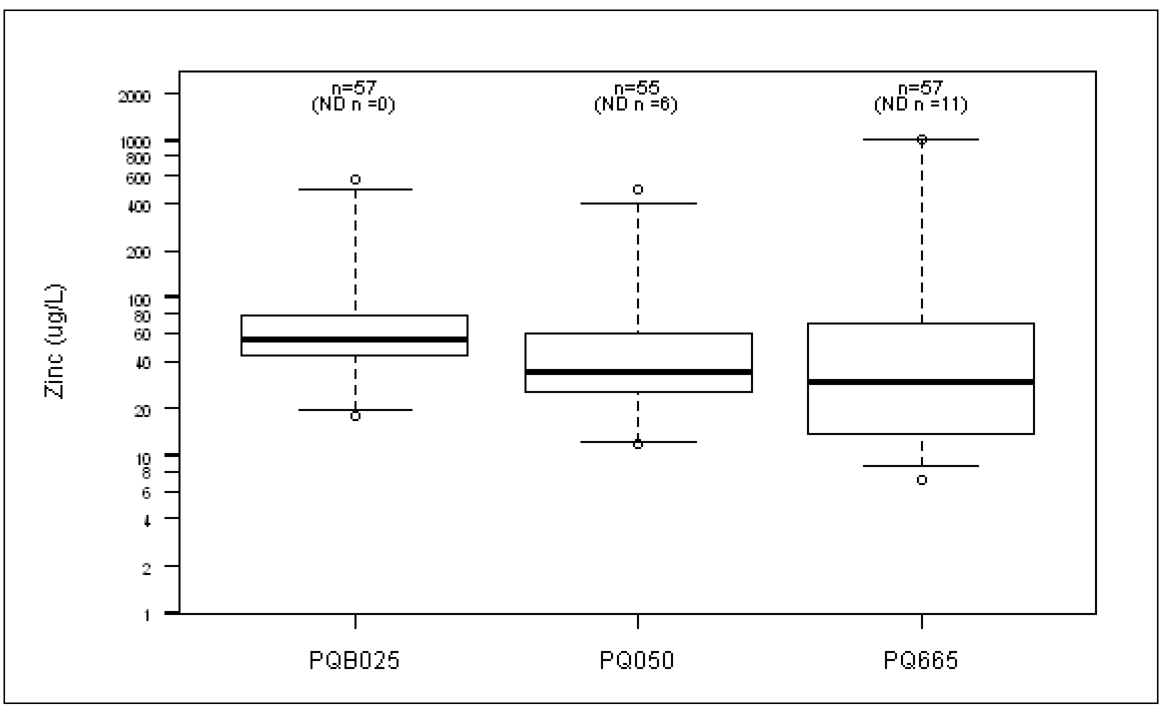



**Figure J.35 Total Recoverable Zinc Concentrations by Site in Wet Weather Conditions, 2008-2009**

# APPENDIX K:

## Macroinvertebrate Data Historical Comparison Using Random Subsamples

As described in Section 5.3.1.4, macroinvertebrate samples were collected from Poquessing Creek Watershed using different methods in the baseline (2001) and comprehensive (2008) assessments. Dissimilar sample sizes (Table K.1) make comparisons and evaluation of trends in macroinvertebrate community composition difficult. Sample size was significantly greater in 2008 samples collected with the PADEP ICE protocol (Mann-Whitney U=143, p=0.0008876) than samples collected in 2001. As sample size increases, the likelihood of encountering rare or sparsely distributed taxa increases, which has implications particularly for richness and other "count" based metrics (*i.e.*, taxa richness, Beck's Index, modified EPT index). Weighted (*e.g.*, HBI, Shannon diversity index, and proportionality metrics) are also affected, but are not subject to as much variation due to sample size as richness metrics.

| | Sample Size Comparison | |
|---|---|---|
| | **2001** | **2008** |
| **PQ050** | 440 | 206 |
| **PQ115** | 161 | 212 |
| **PQ190** | 129 | N/A |
| **PQ395** | 133 | 206 |
| **PQ465** | 102 | 207 |
| **PQ665** | 109 | 204 |
| **PQ770** | 136 | 217 |
| **PQ845** | 139 | 214 |
| **PQB025** | 101 | 207 |
| **PQB210** | 103 | 204 |
| **PQB385** | 116 | 218 |
| **PQB450** | 101 | 212 |
| **PQU013** | 148 | 240 |

**Table K.1 Sample size comparison of macroinvertebrate samples collected from Poquessing Creek Watershed in 2001 and 2008.**

When unequal sample sizes were compared, it appeared that more taxa were observed in samples from Poquessing Creek watershed sites in 2008 than in 2001, suggesting that sites had become more diverse. In order to facilitate a more appropriate comparison of invertebrate community structure between samples collected in 2001 and 2008, 100-individual subsamples were randomly selected for each sample. The R statistical programming language was used to produce a series of non-repeating random numbers selected from a uniform distribution equal to the total number of individuals in the sample. A non-repeating series of numbers was used to ensure that each taxon would be represented in the subsample at a level not greater than its proportional abundance in the original sample. This procedure was chosen in lieu of a more complicated rarefaction algorithm in order to facilitate comparisons of all scoring metrics rather than simply a taxa richness-based comparison.

Randomly selected 100 individual subsamples from 2001 and 2008 were compared using PADEP IBI metrics as described in Section 5.3.1.4 (Tables K.2 and K.3, respectively). As expected, there were differences in scores for most metrics when data from entire samples was compared to 100 individual subsamples. Again, as expected, consistently large differences were observed for taxa richness of 2008 samples (Table K.4). Many sites sampled in 2001 had sample sizes close to 100 individuals (mean sample size = 124 individuals) and thus did not show major changes in metric scoring when unmodified samples were compared to 100 individual random subsamples (Table K3). While there were observed major differences in some weighted metrics, upon further investigation it is clear that these cases are primarily due to the presence or absence of one or two individual specimens, sensitive invertebrates being very relatively rare overall.

Based on this comparison, it appears that differences in taxa richness observed between 2001 and 2008 are more likely the product of differences in sample collection and processing methods and the resulting sizes, rather than a real change in invertebrate community composition. The fact that there were only minor differences observed in modified EPT and Beck's indices is likely due to the severely impaired nature of Poquessing Creek Watershed. Had more sensitive taxa been present, it is likely that we would have also observed more pronounced differences between the unmodified and randomly subsampled data collected in 2008.

| | Taxa Richness | | EPT Richness | | Beck's Index | | Hilsenhoff Biotic Index | | Shannon Diversity Index | | Percent Intolerant Taxa | | Percent Comparability (IBI) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample |
| **PQ050** | 8 | 7 | 0 | 0 | 0 | 0 | 5.53 | 5.65 | 1.24 | 1.25 | 3.86 | 1 | 21.22 | 19.93 |
| **PQ115** | 9 | 7 | 0 | 0 | 0 | 0 | 5.68 | 5.72 | 1.53 | 1.4 | 6.21 | 5 | 23.58 | 21.47 |
| **PQ190** | 8 | 8 | 0 | 0 | 0 | 0 | 5.82 | 5.82 | 1.08 | 1.12 | 1.55 | 2 | 19.26 | 19.55 |
| **PQ395** | 8 | 8 | 0 | 0 | 0 | 0 | 5.85 | 5.88 | 1.35 | 1.31 | 0 | 0 | 20.46 | 20.13 |
| **PQ465** | 8 | 8 | 0 | 0 | 0 | 0 | 5.76 | 5.77 | 1.76 | 1.77 | 0 | 0 | 23 | 23.02 |
| **PQ665** | 8 | 8 | 0 | 0 | 0 | 0 | 6.71 | 6.71 | 1.52 | 1.53 | 0 | 0 | 19.64 | 19.72 |
| **PQ770** | 8 | 7 | 0 | 0 | 0 | 0 | 6.32 | 6.36 | 0.97 | 1.01 | 0 | 0 | 17.27 | 16.89 |
| **PQ845** | 6 | 6 | 1 | 1 | 0 | 0 | 5.82 | 5.78 | 1.04 | 1.08 | 0 | 0 | 18.55 | 18.86 |
| **PQB025** | 9 | 9 | 0 | 0 | 0 | 0 | 6.44 | 6.42 | 1.79 | 1.78 | 0.99 | 1 | 22.51 | 22.49 |
| **PQB210** | 8 | 8 | 0 | 0 | 0 | 0 | 5.89 | 5.89 | 1.52 | 1.54 | 0.97 | 1 | 21.53 | 21.64 |
| **PQB385** | 13 | 13 | 0 | 0 | 0 | 0 | 5.88 | 5.85 | 1.36 | 1.4 | 0.86 | 1 | 23.11 | 23.43 |
| **PQB450** | 10 | 10 | 0 | 0 | 0 | 0 | 5.94 | 5.94 | 1.28 | 1.29 | 0.99 | 1 | 21.03 | 21.08 |
| **PQU013** | 13 | 10 | 0 | 0 | 0 | 0 | 5.86 | 5.86 | 1.41 | 1.44 | 0 | 0 | 23.27 | 21.97 |

**Table K.2 Comparison of six PADEP IBI Scoring metrics for unmodified and 100 individual ramdom subsamples, 2001 Baseline Aassessment of Poquessing Creek Watershed**

| | Taxa Richness | | EPT Richness | | Beck's Index | | Hilsenhoff Biotic Index | | Shannon Diversity Index | | Percent Intolerant Taxa | | Percent Comparability (IBI) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample | Original Sample | Sub-sample |
| **PQ050** | 14 | 13 | 0 | 0 | 1 | 1 | 6.7 | 6.5 | 1.7 | 1.7 | 5.83 | 6 | 25.3 | 25.2 |
| **PQ115** | 9 | 7 | 0 | 0 | 1 | 0 | 6.7 | 6.8 | 1.6 | 1.5 | 4.25 | 4 | 21.7 | 19.8 |
| **PQ190** | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **PQ395** | 15 | 10 | 1 | 1 | 1 | 0 | 7 | 7.1 | 1.5 | 1.4 | 0.97 | 0 | 23.9 | 20 |
| **PQ465** | 10 | 8 | 1 | 1 | 1 | 0 | 5.9 | 5.9 | 1.1 | 1.1 | 4.35 | 3 | 22 | 20.4 |
| **PQ665** | 13 | 9 | 0 | 0 | 0 | 0 | 6.4 | 6.3 | 1.4 | 1.3 | 4.41 | 4 | 23.2 | 20.7 |
| **PQ770** | 14 | 11 | 1 | 1 | 1 | 0 | 6.1 | 6 | 1.5 | 1.5 | 1.38 | 1 | 25.4 | 23.3 |
| **PQ845** | 13 | 8 | 1 | 1 | 1 | 0 | 5.8 | 5.9 | 1.4 | 1.4 | 0.93 | 0 | 25 | 21.3 |
| **PQB025** | 10 | 7 | 0 | 0 | 0 | 0 | 7 | 7.1 | 1.4 | 1.4 | 1.93 | 1 | 20 | 17.9 |
| **PQB210** | 8 | 8 | 0 | 0 | 0 | 0 | 8.1 | 8.3 | 1.2 | 1.2 | 0 | 0 | 14.9 | 14.5 |
| **PQB385** | 13 | 11 | 0 | 0 | 0 | 0 | 5.8 | 5.8 | 1.6 | 1.6 | 10.6 | 10 | 26.7 | 25.5 |
| **PQB450** | 8 | 5 | 0 | 0 | 1 | 0 | 6 | 6.1 | 1.2 | 1 | 3.77 | 4 | 20.1 | 17.5 |
| **PQU013** | 11 | 7 | 1 | 1 | 0 | 0 | 5.9 | 5.9 | 0.9 | 0.8 | 0.83 | 0 | 20 | 17.3 |

**Table K.3 Comparison of six PADEP IBI Scoring metrics for unmodified and 100 individual ramdom subsamples, 2008 Comprehensive Aassessment of Poquessing Creek Watershed**

| | Taxa Richness | | EPT Richness | | Beck's Index | | Hilsenhoff Biotic Index | | Shannon Diversity Index | | Percent Intolerant Taxa | | Percent Comparability (IBI) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | 2008 | 2001 | 2008 | 2001 | 2008 | 2001 | 2008 | 2001 | 2008 | 2001 | 2008 | 2001 | 2008 |
| PQ050 | -12.50% | -7.10% | 0 | 0 | 0 | 0 | 2.10% | -2.40% | 0.40% | 0.60% | -74.1 | 3.00% | -6.10% | -0.30% |
| PQ115 | -22.20% | -22.20% | 0 | 0 | 0 | -100% | 0.60% | 1.50% | -8.80% | -1.70% | -19.5 | -5.80% | -8.90% | -8.60% |
| PQ190 | 0 | N/A | 0 | N/A | 0 | N/A | 0 | N/A | 3.20% | N/A | 29 | N/A | 1.50% | N/A |
| PQ395 | 0 | -33.30% | 0 | 0 | 0 | -100% | 0.50% | 1.90% | -3.50% | -4.80% | 0 | -100% | -1.60% | -16.10% |
| PQ465 | 0 | -20.00% | 0 | 0 | 0 | -100% | 0.10% | -0.10% | 0.30% | 0.60% | 0 | -31 | 0.10% | -7.50% |
| PQ665 | 0 | -30.80% | 0 | 0 | 0 | 0 | 0.10% | -0.70% | 0.90% | -6.20% | 0 | -9.30% | 0.40% | -10.90% |
| PQ770 | -12.50% | -21.40% | 0 | 0 | 0 | -100% | 0.60% | -1.30% | 3.60% | -2.90% | 0 | -27.70% | -2.20% | -8.30% |
| PQ845 | 0 | -38.50% | 0 | 0 | 0 | -100% | -0.70% | 1.80% | 3.90% | -4.10% | 0 | -100% | 1.70% | -14.80% |
| PQB025 | 0 | -30.00% | 0 | 0 | 0 | 0 | -0.20% | 1.10% | -0.50% | -3.10% | 1 | -48.30% | -0.10% | -10.60% |
| PQB210 | 0 | 0 | 0 | 0 | 0 | 0 | -0.10% | 2.60% | 1.10% | 1.20% | 3 | 0 | 0.50% | -2.30% |
| PQB385 | 0 | -15.40% | 0 | 0 | 0 | 0 | -0.50% | 0.30% | 2.90% | 0.40% | 16 | -5.20% | 1.40% | -4.20% |
| PQB450 | 0 | -37.50% | 0 | 0 | 0 | -100% | 0 | 1.00% | 0.60% | -9.50% | 1 | 6.00% | 0.20% | -13.30% |
| PQU013 | -23.10% | -36.40% | 0 | 0 | 0 | 0 | -0.10% | 0.50% | 2.40% | -10.50% | 0 | -100% | -5.60% | -13.90% |

**Table K.4 Percent Difference in PADEP IBI scoring metrics between unmodified and 100 individual random subsamples, 2001 and 2008 Assessments of Poquessing Creek Watershed**

# APPENDIX L:

## French Creek Reference Sites

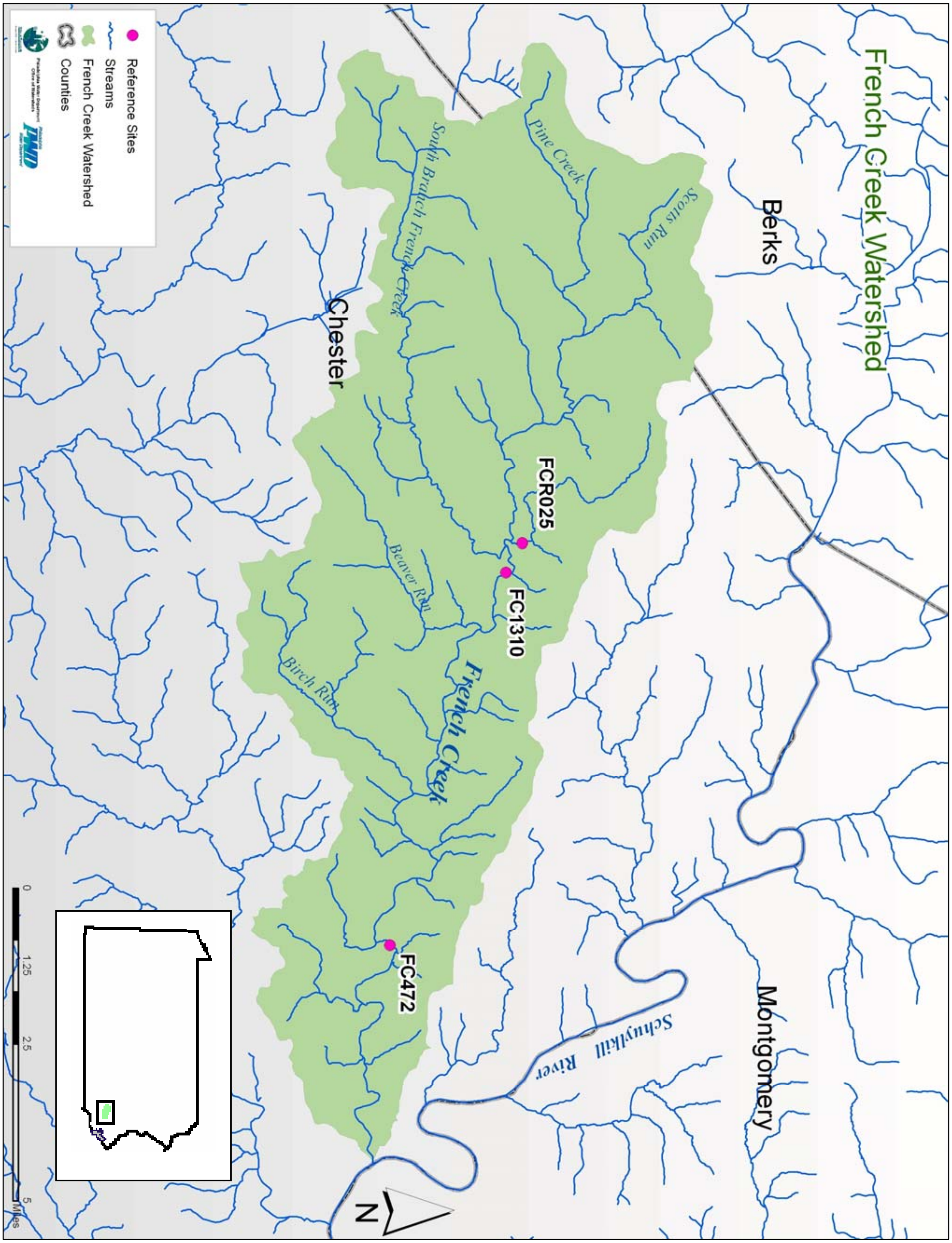



**Figure L.1 French Creek Reference Sites**

# APPENDIX M:

## River 2D Model Output

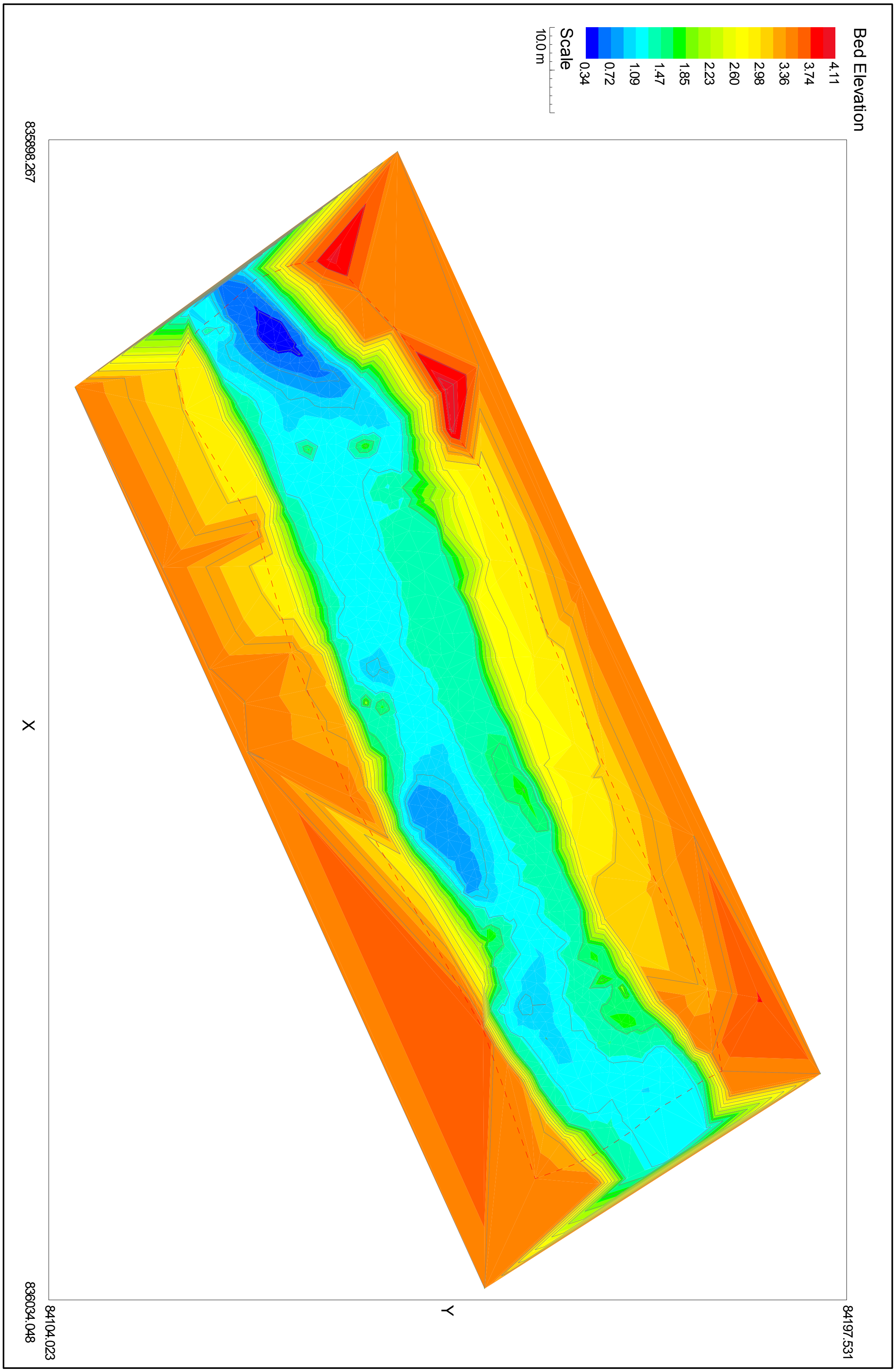



**Figure M.1 River 2D Adjusted Final Model Input Bed Elevation File, Poquessing Creek Site PQ050**

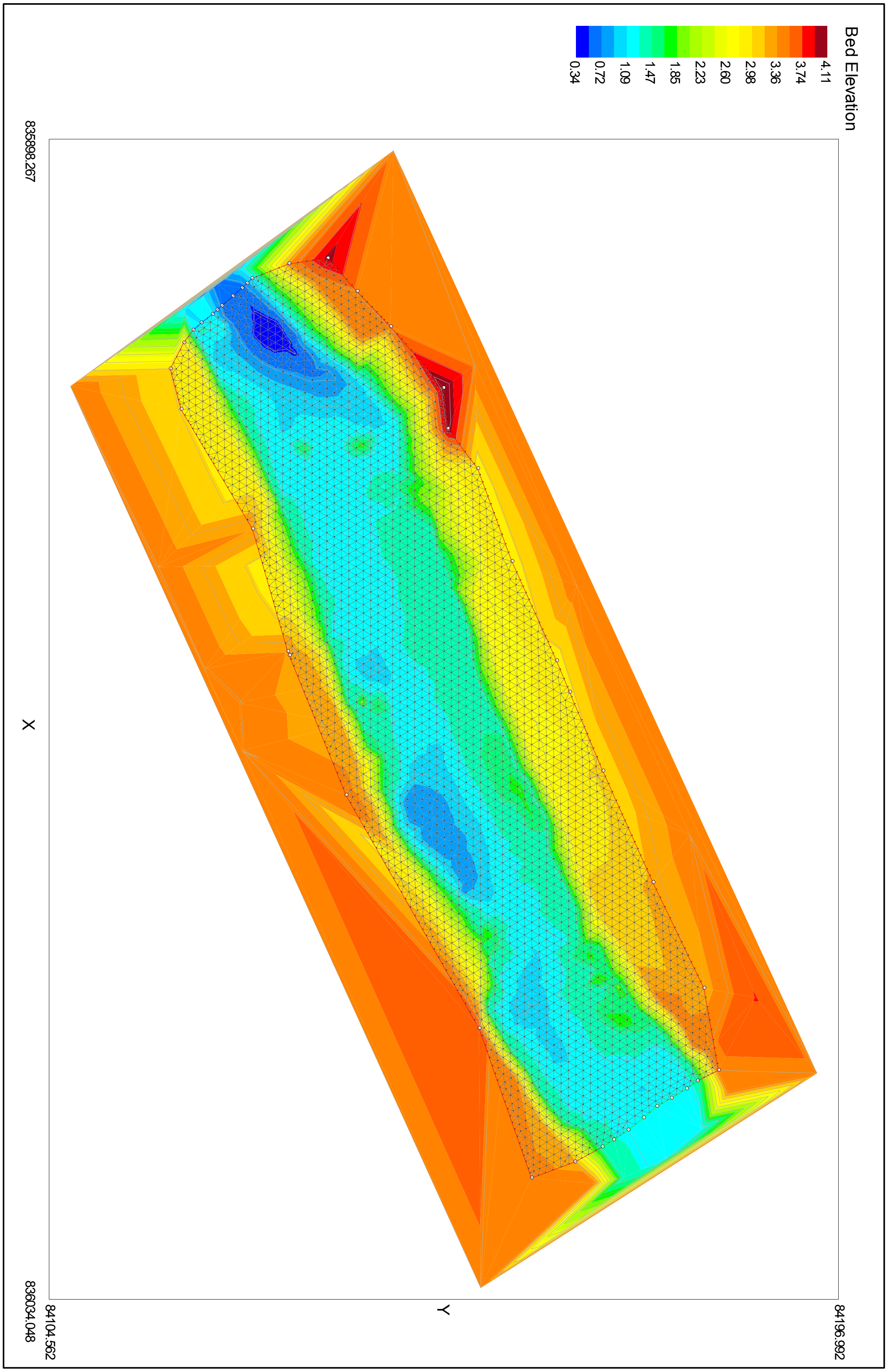



**Figure M.2 River 2D Adjusted Final Model Input Mesh File, Poquessing Creek Site PQ050**

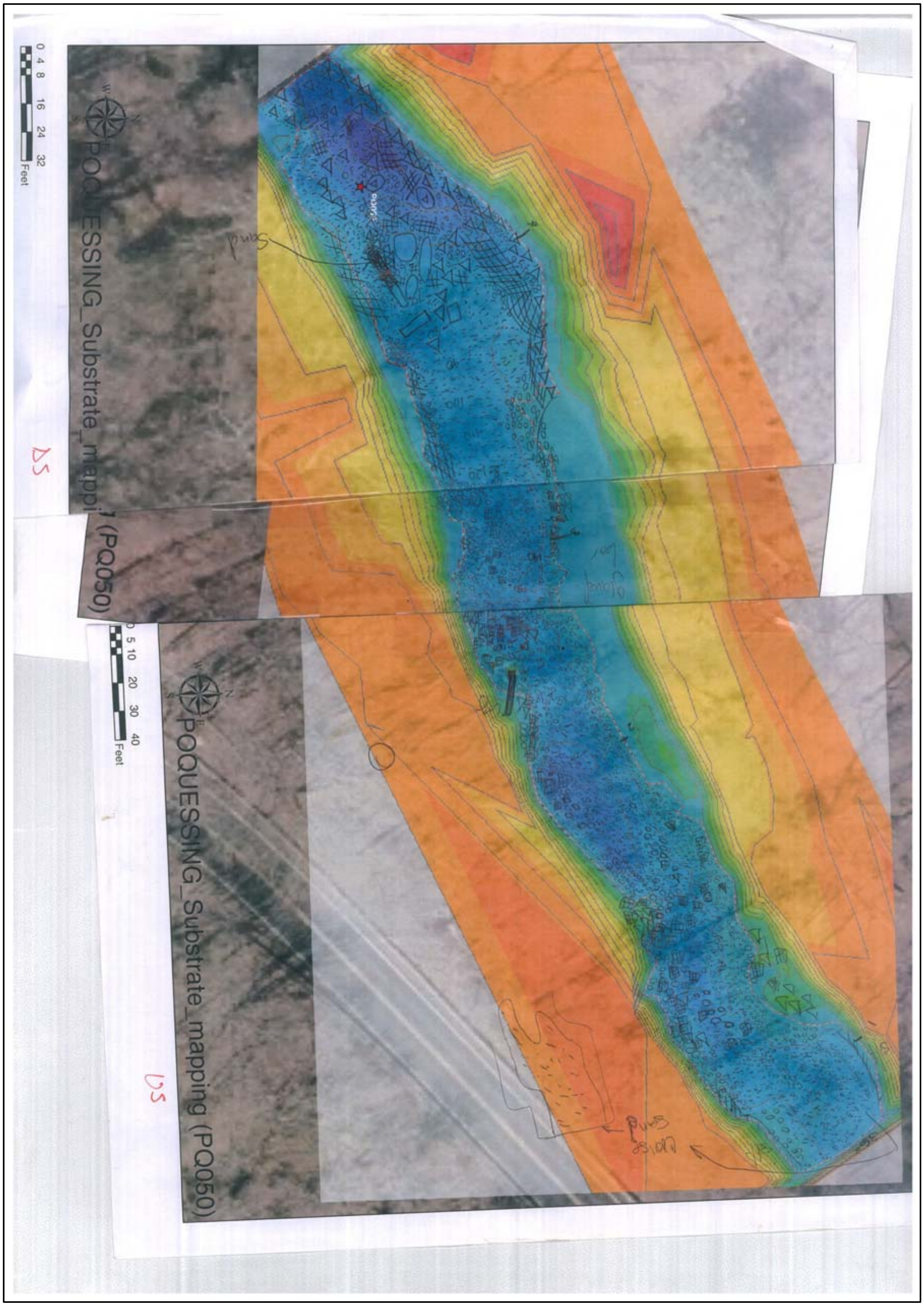



**Figure M.3 River 2D Substrate Classification Field Survey Map for Poquessing Creek Site PQ050**

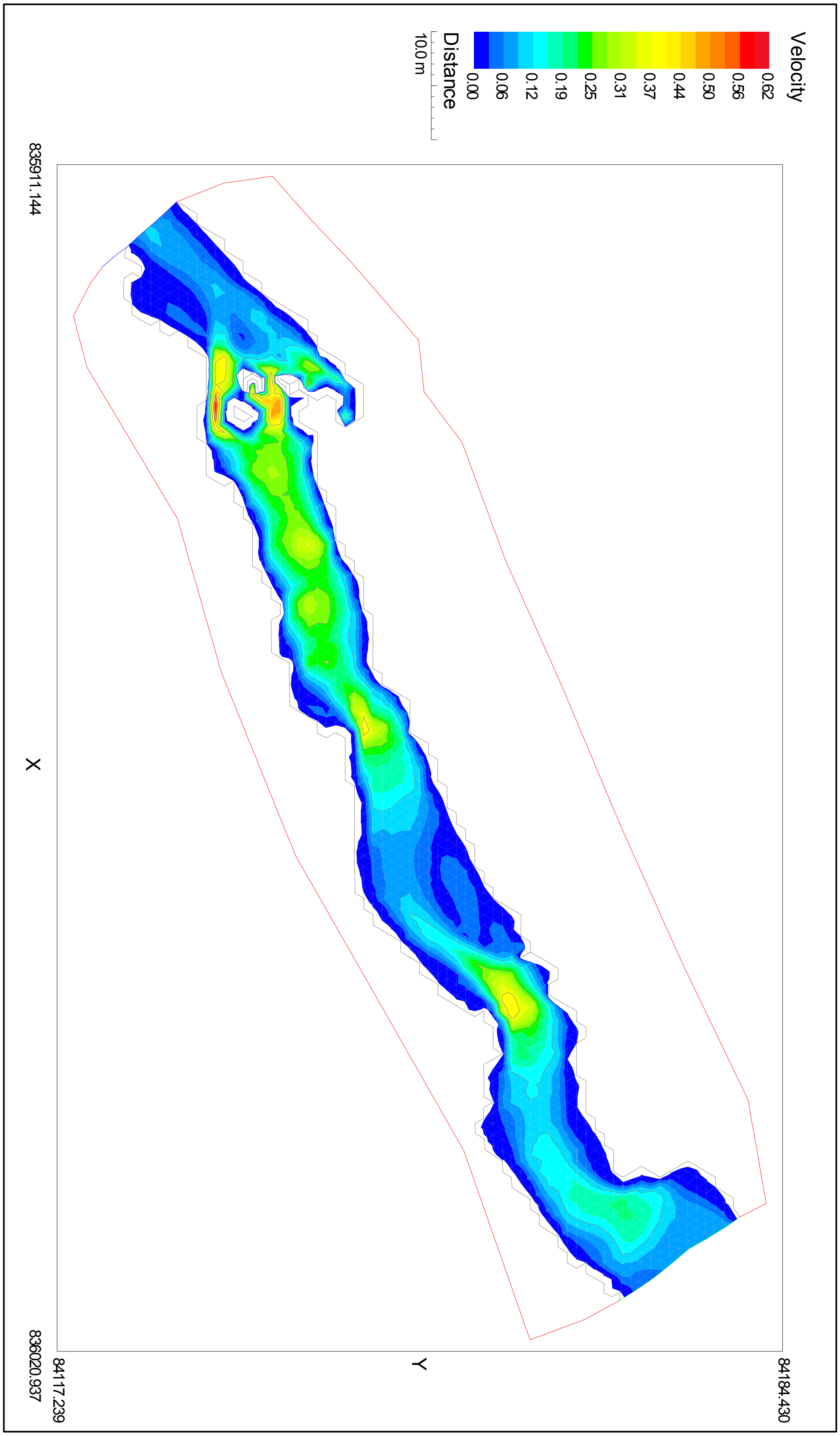



**Figure M.4 River 2D Generated Velocity Profile of Poquessing Creek Site PQ050**

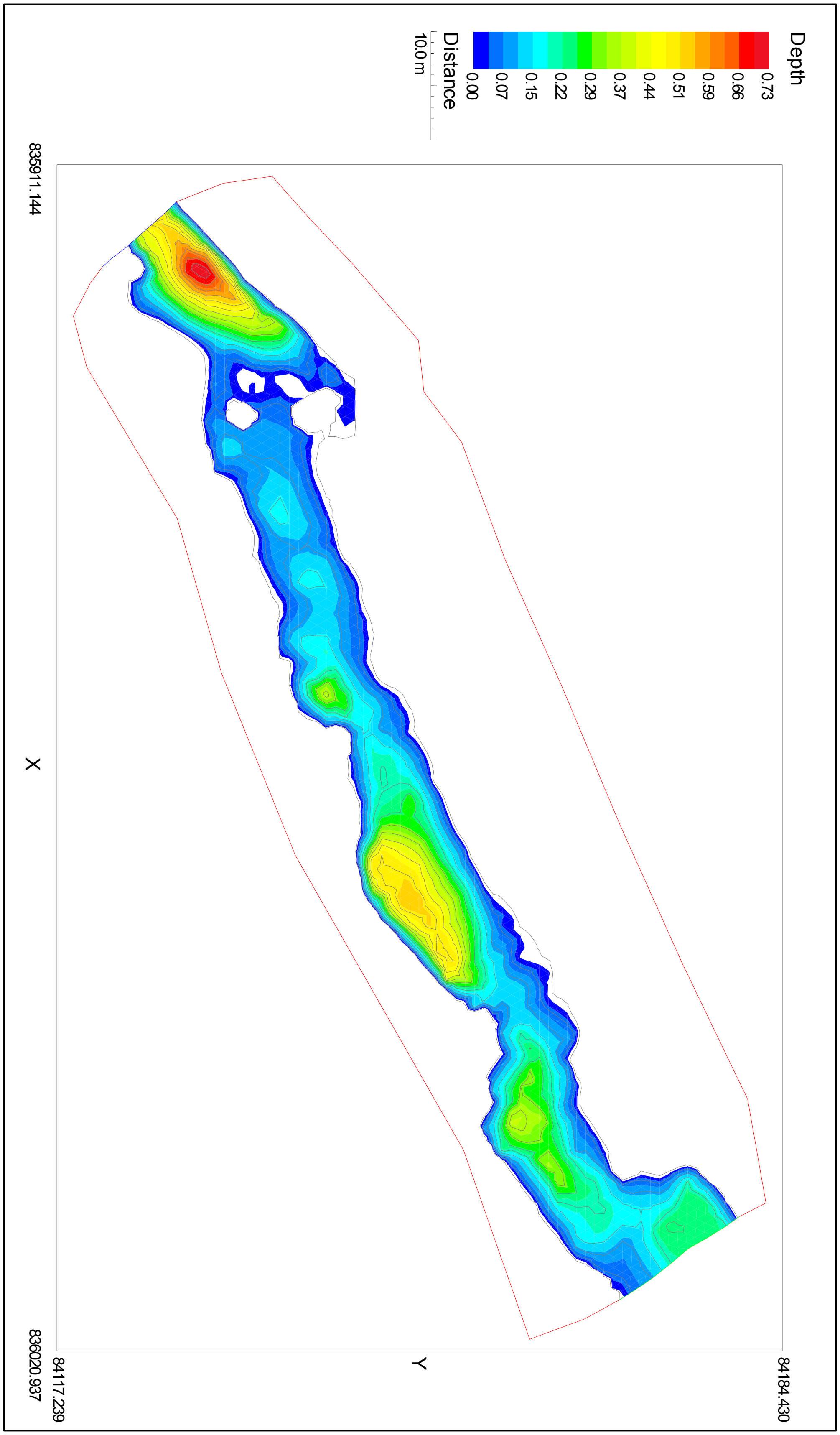



**Figure M.5 River 2D Generated Depth Profile of Poquessing Site PQ050**

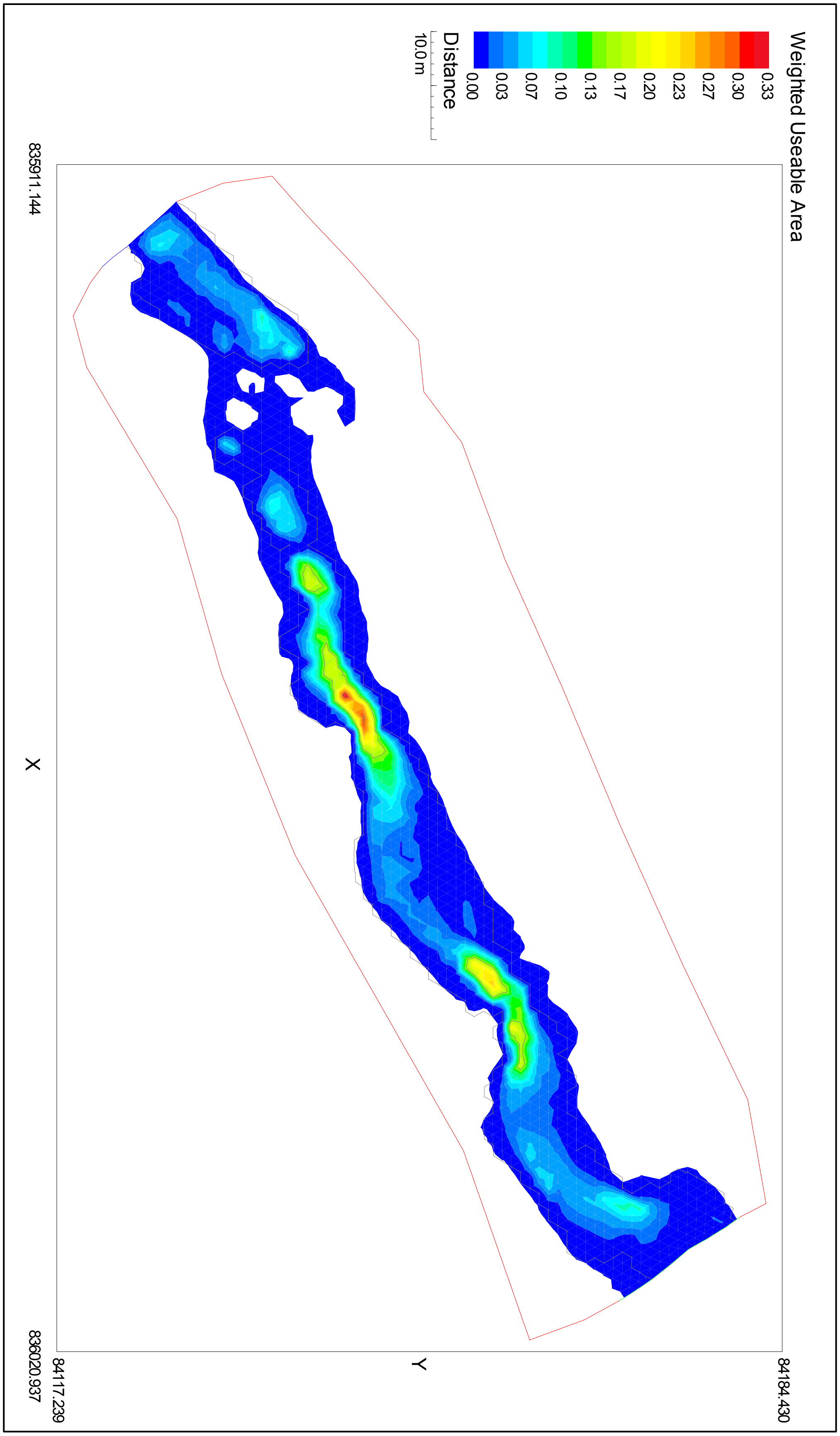



**Figure M.6 River 2D Generated Weighted Usable Habitat Area for Riffle Fish Guild, Poquessing Creek Site PQ050**

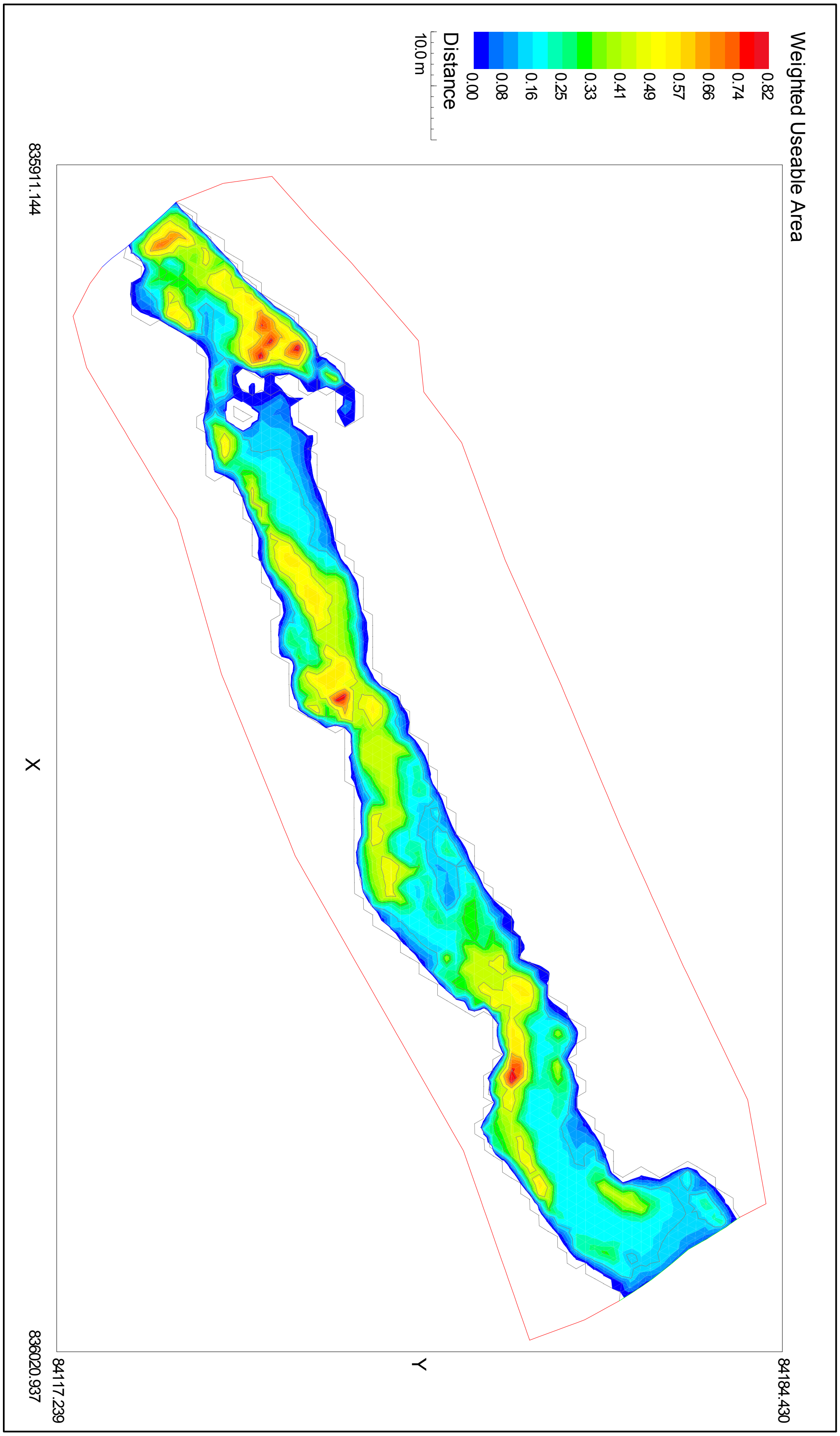



**Figure M.7 River 2D Generated Weighted Usable Habitat Area for Generalist Fish Guild, Poquessing Creek Site PQ050**

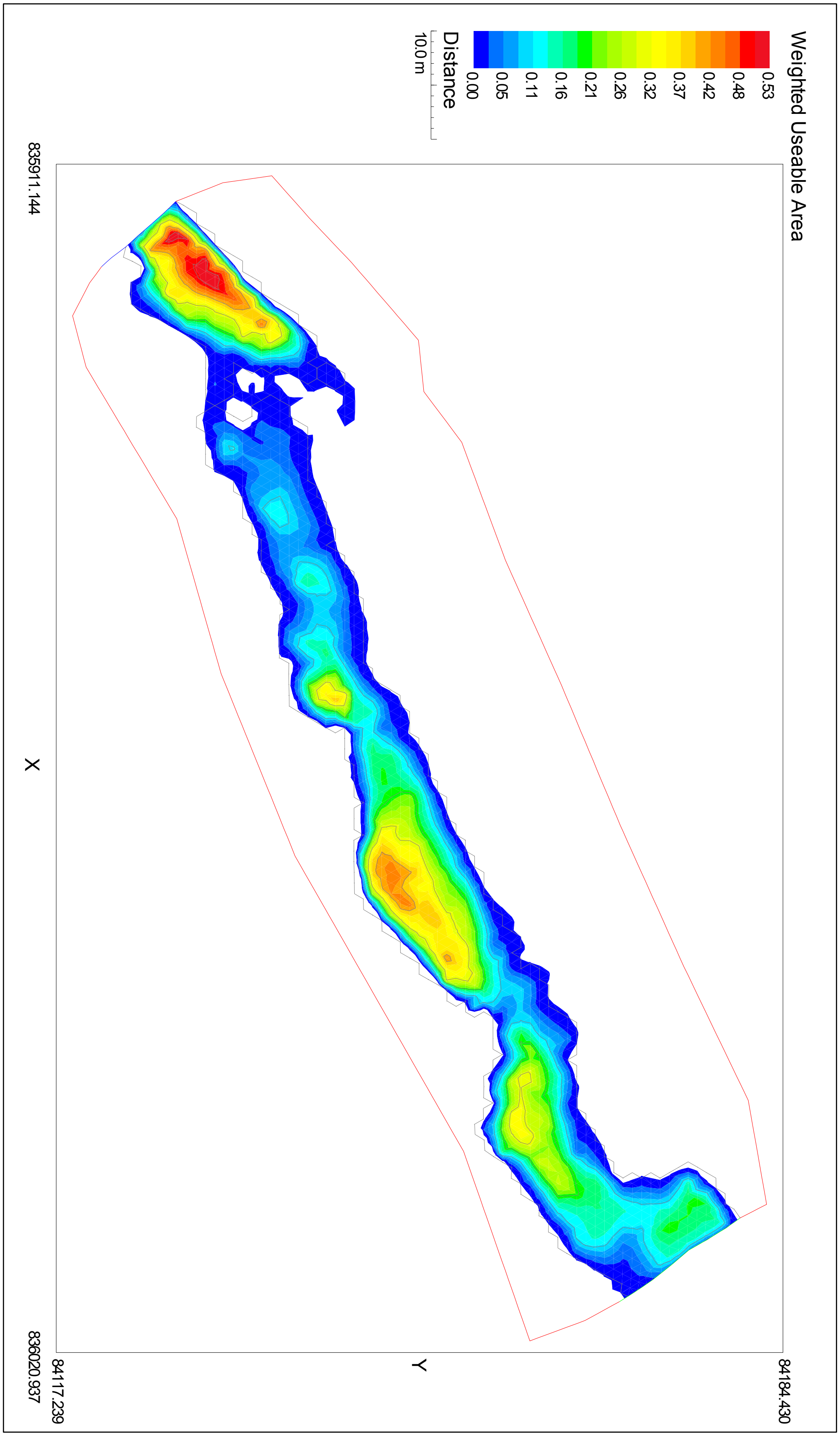



**Figure M.8 River 2D Generated Weighted Usable Habitat Area for Pool Fish Guild, Poquessing Creek Site PQ050**

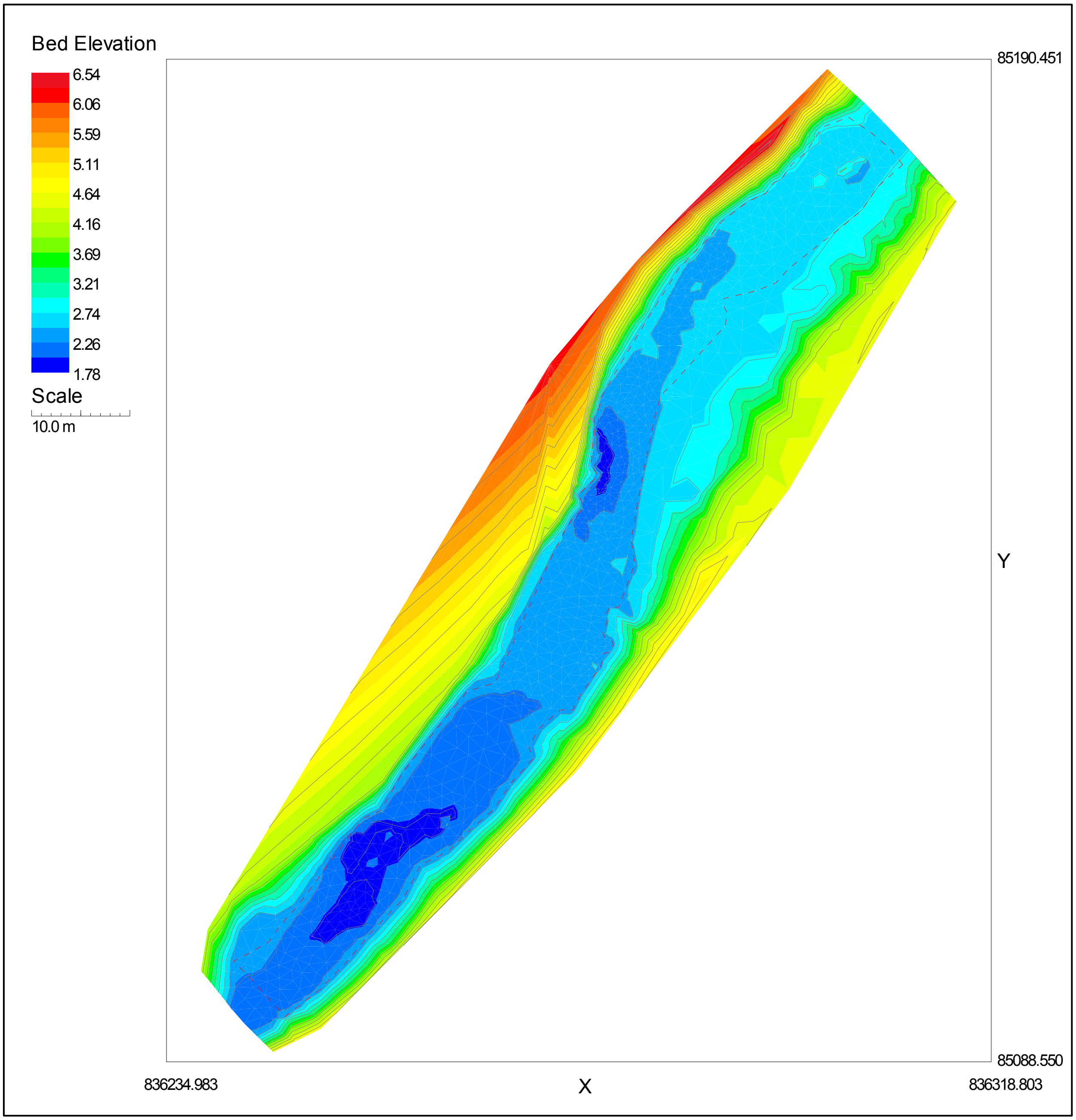



**Figure M.9 River 2D Adjusted Final Model Input Bed Elevation File, Poquessing Creek Site PQ115**

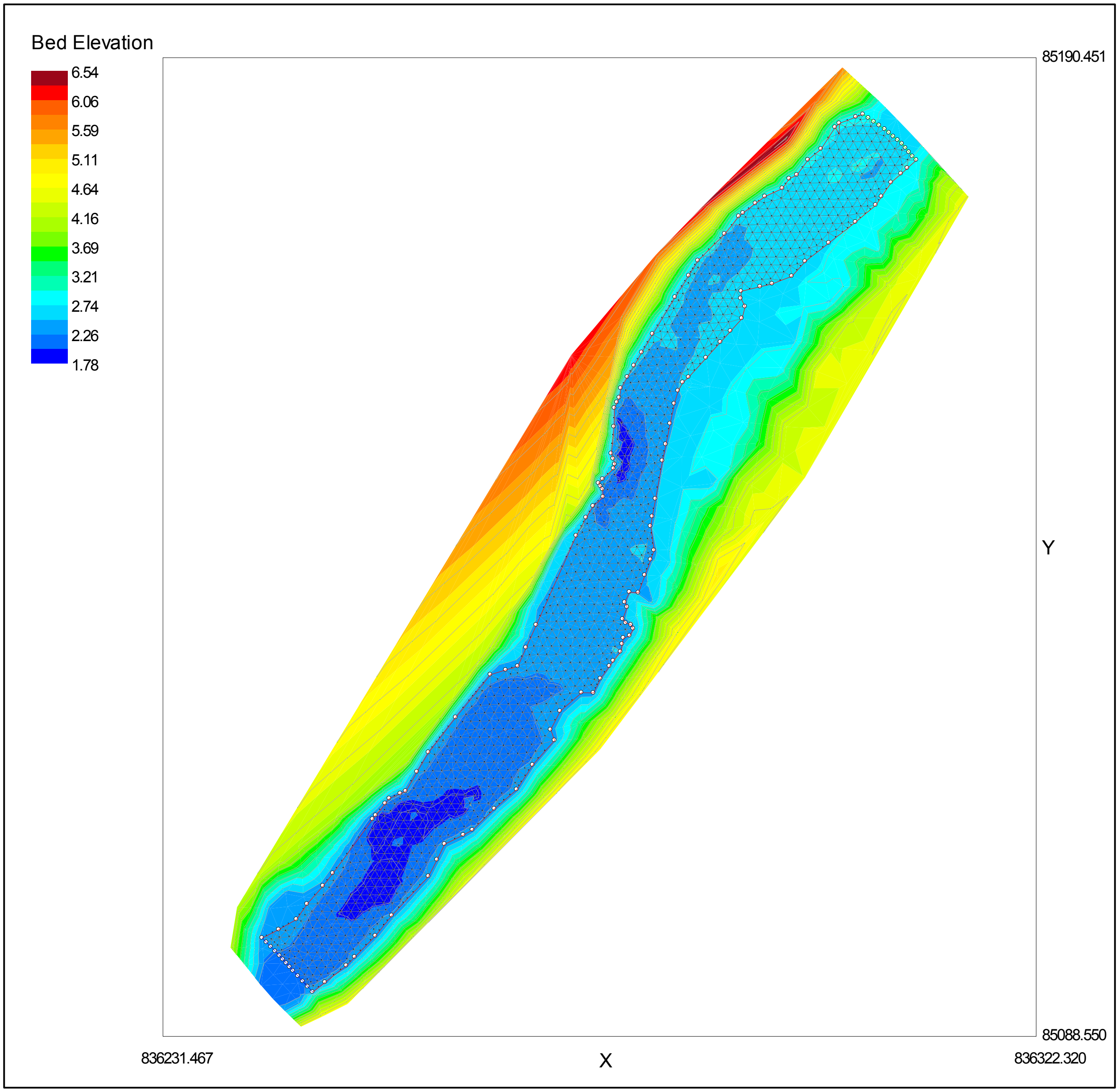



**Figure M.10 River 2D Adjusted Final Model Input Mesh File, Poquessing Creek Site PQ115**

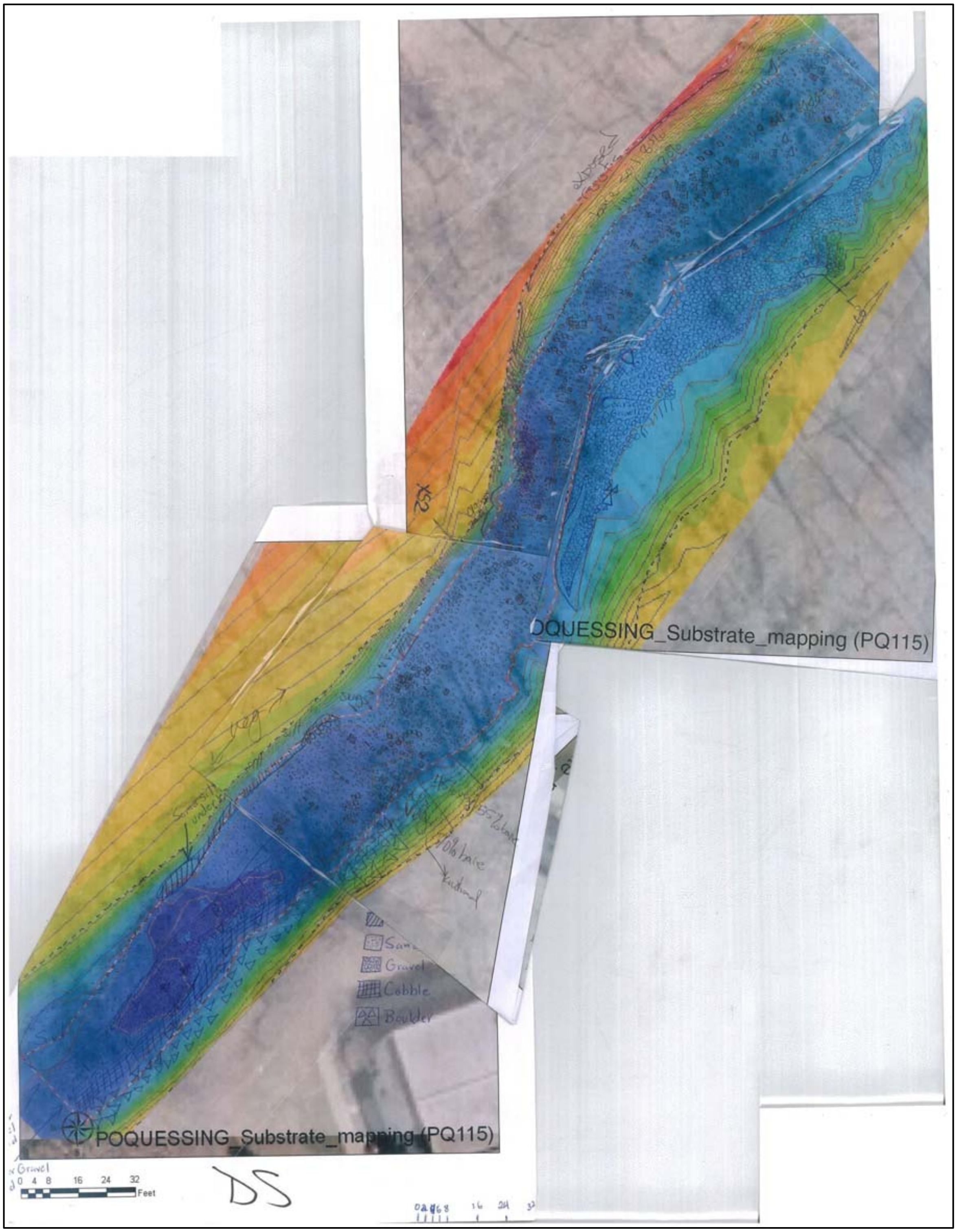



**Figure M.11 River 2D Substrate Classification Field Survey Map for Poquessing Creek Site PQ115**

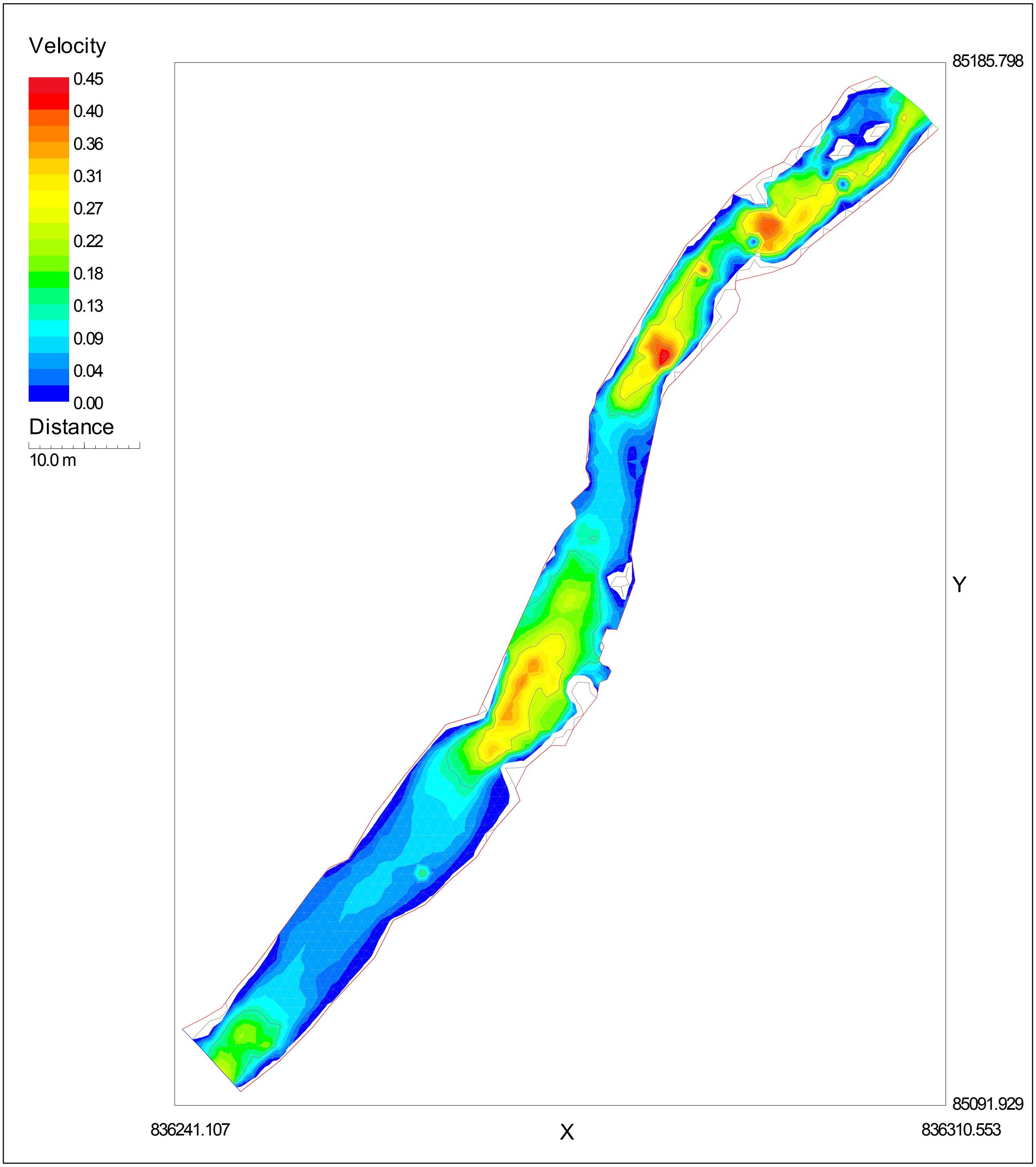



**Figure M.12 River 2D Generated Velocity Profile of Poquessing Creek Site PQ115**

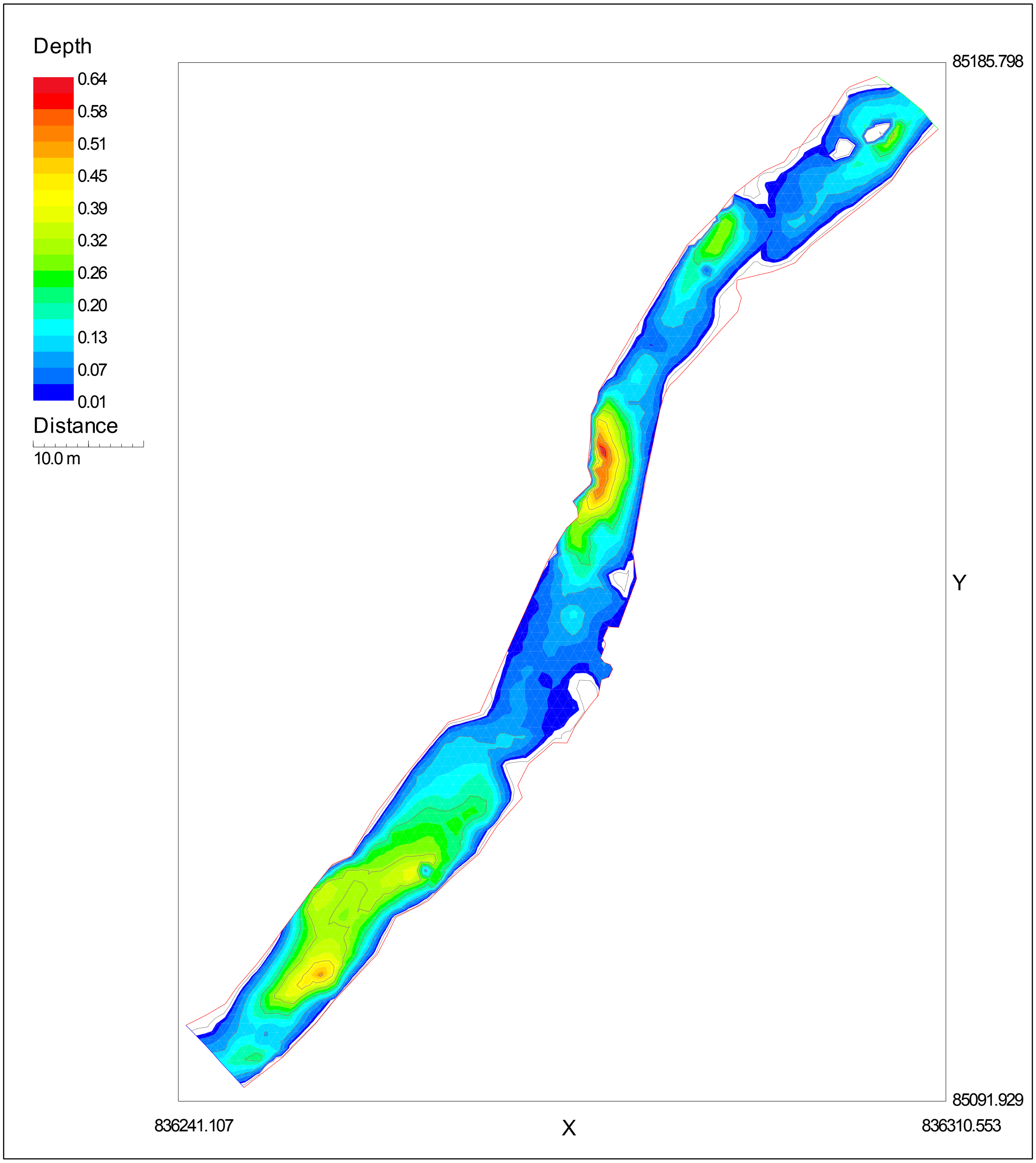



**Figure M.13 River 2D Generated Depth Profile of Poquessing Creek Site PQ115**

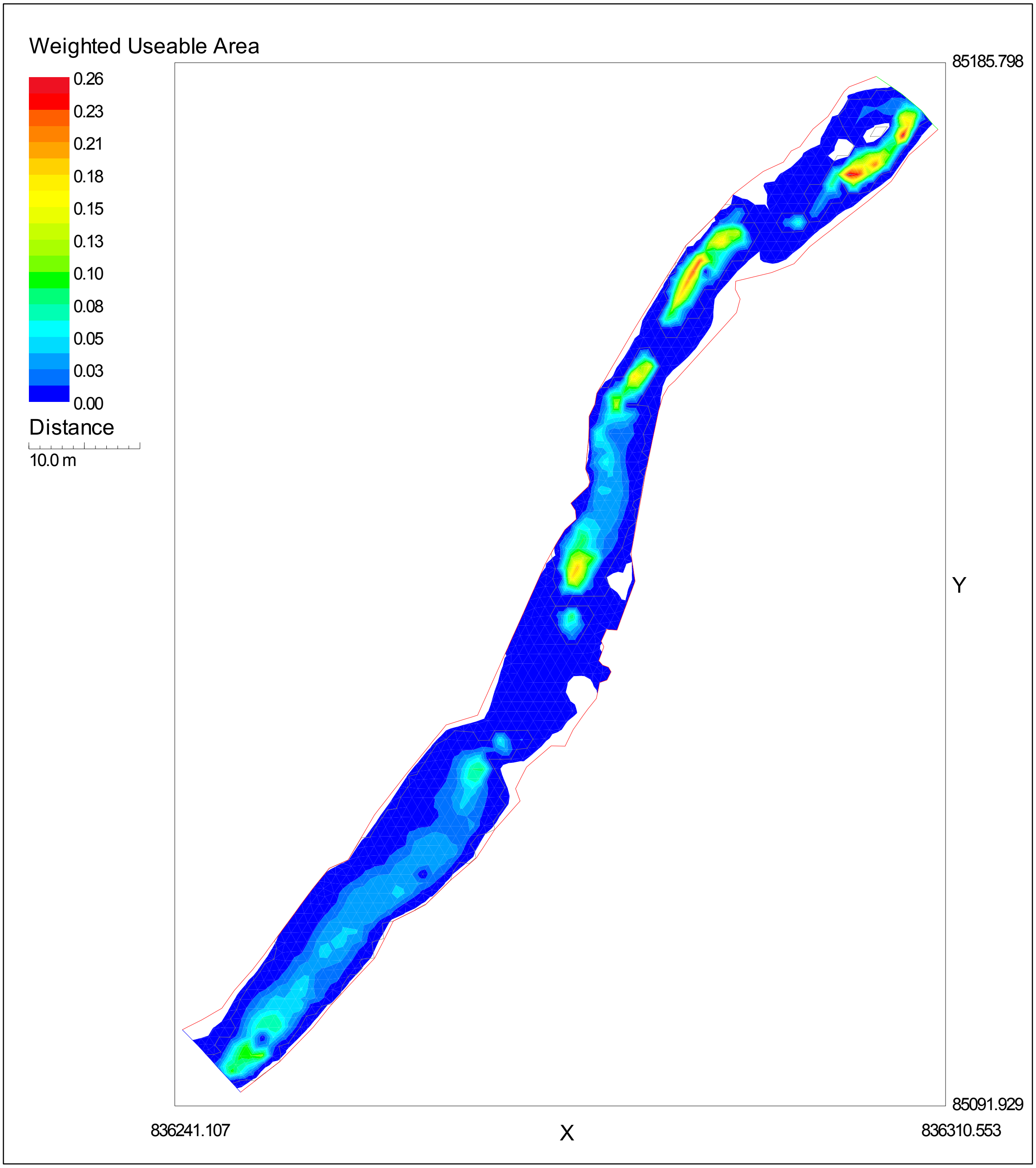



**Figure M.14 River 2D Generated Weighted Usable Habitat Area for Riffle Fish Guild, Poquessing Creek Site PQ115**

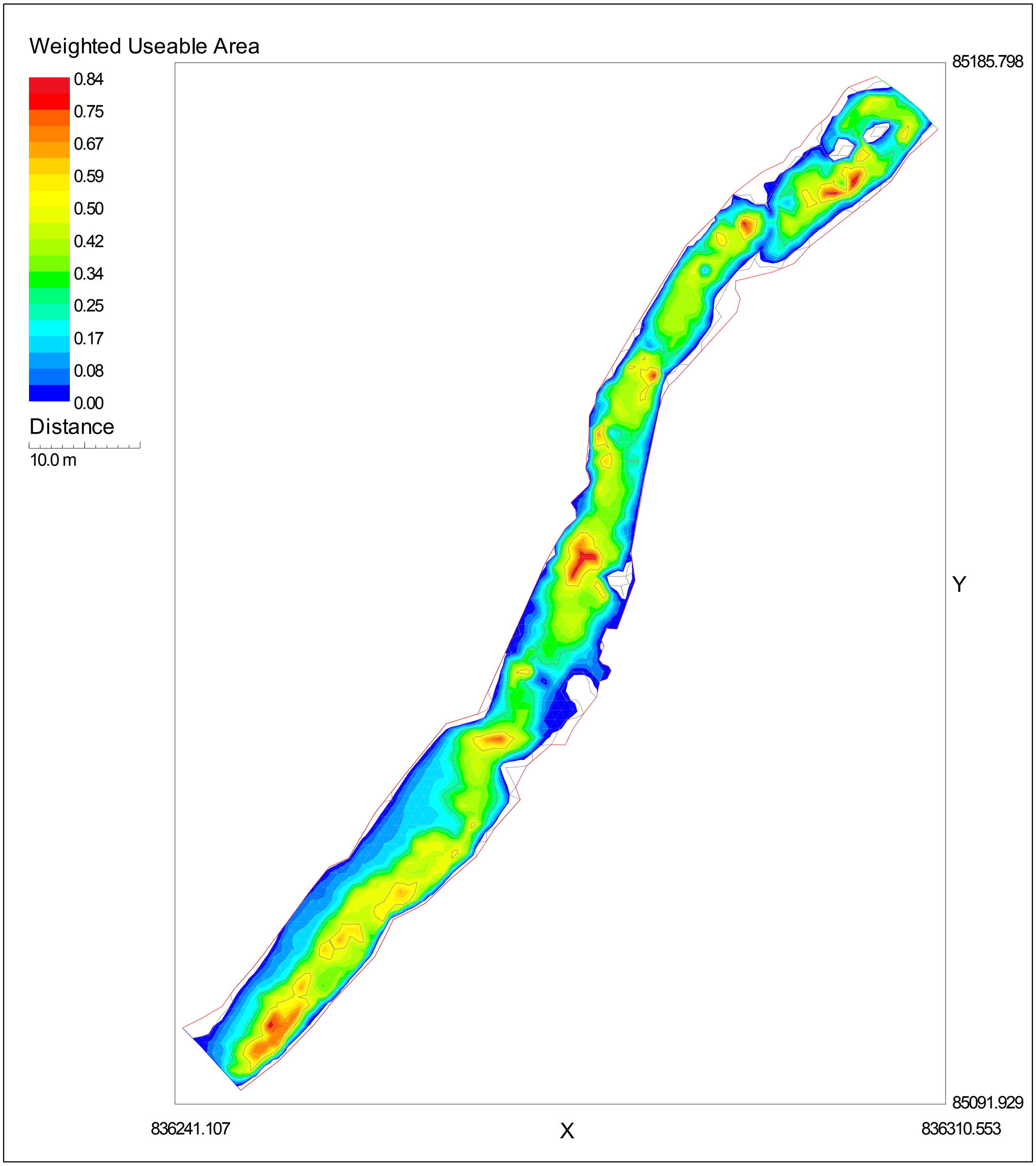



**Figure M.15 River 2D Generated Weighted Usable Habitat Area for Generalist Fish Guild, Poquessing Creek Site PQ115**

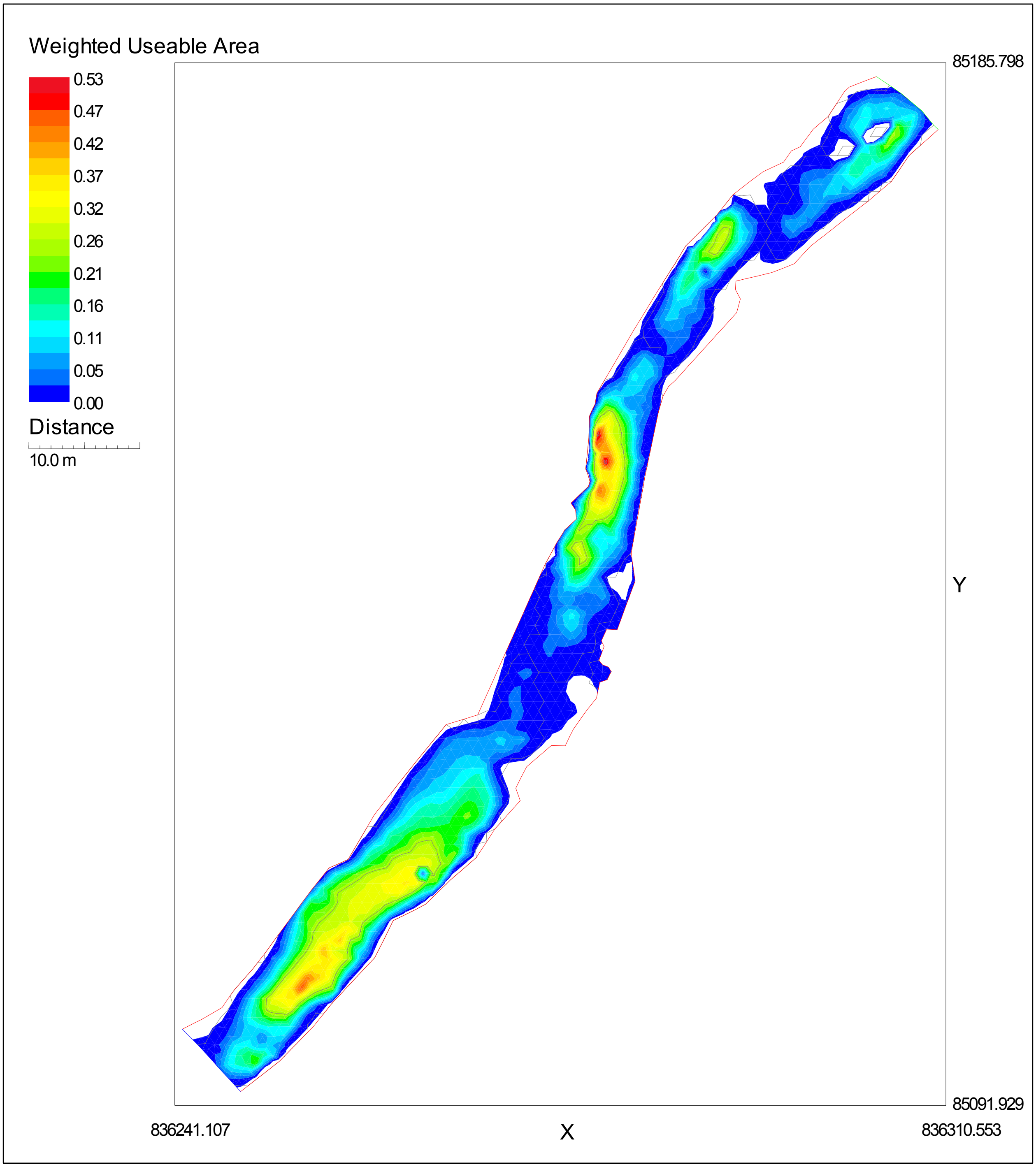



**Figure M.16 River 2D Generated Weighted Usable Habitat Area for Pool Fish Guild, Poquessing Creek Site PQ115**

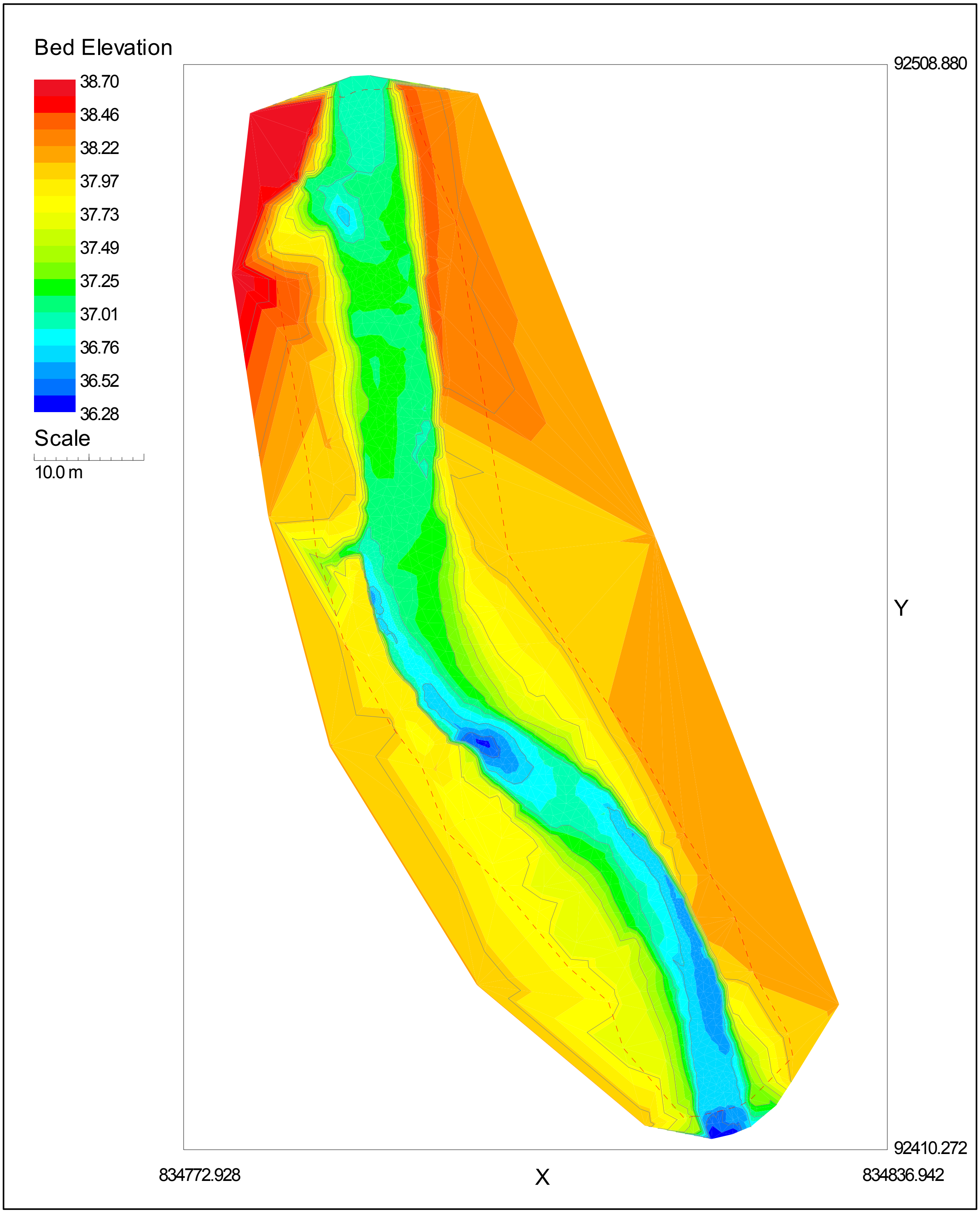



**Figure M.17 River 2D Adjusted Final Model Input Bed Elevation File, Poquessing Creek Site PQ825**

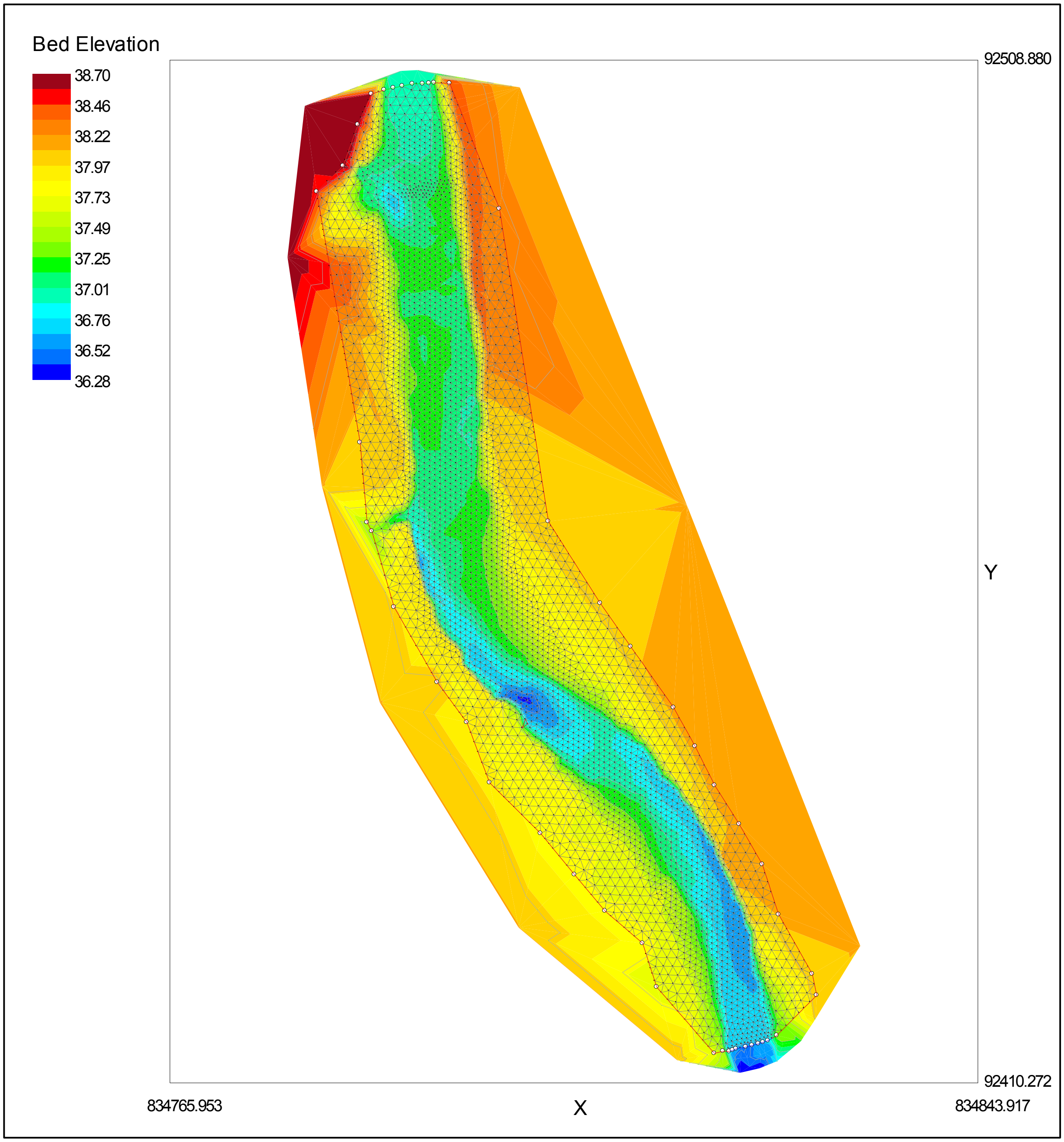



**Figure M.18 River 2D Adjusted Final Model Input Mesh File, Poquessing Creek Site PQ825**

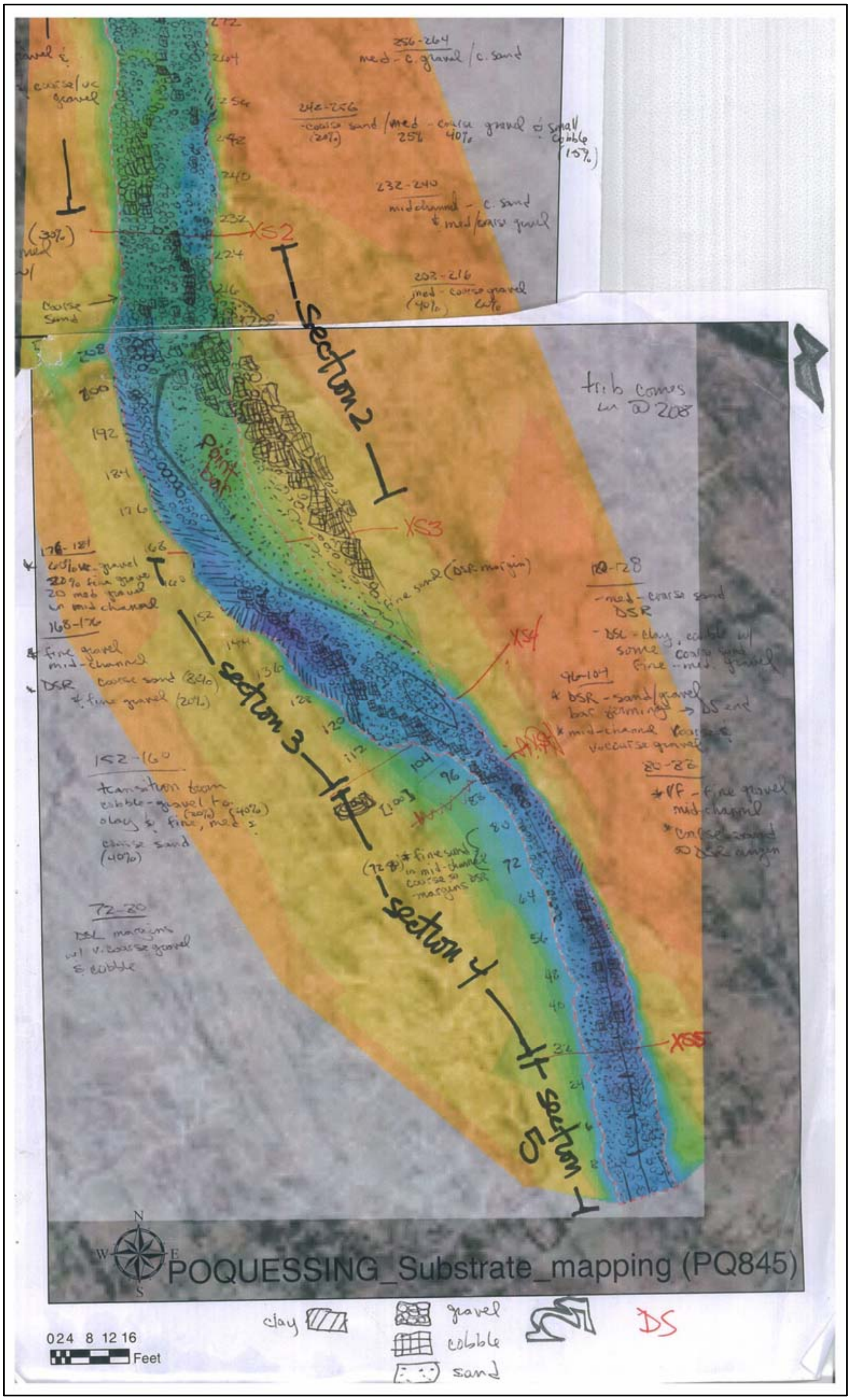



**Figure M.19 River 2D Substrate Classification Field Survey Map for Poquessing Creek Site PQ825**

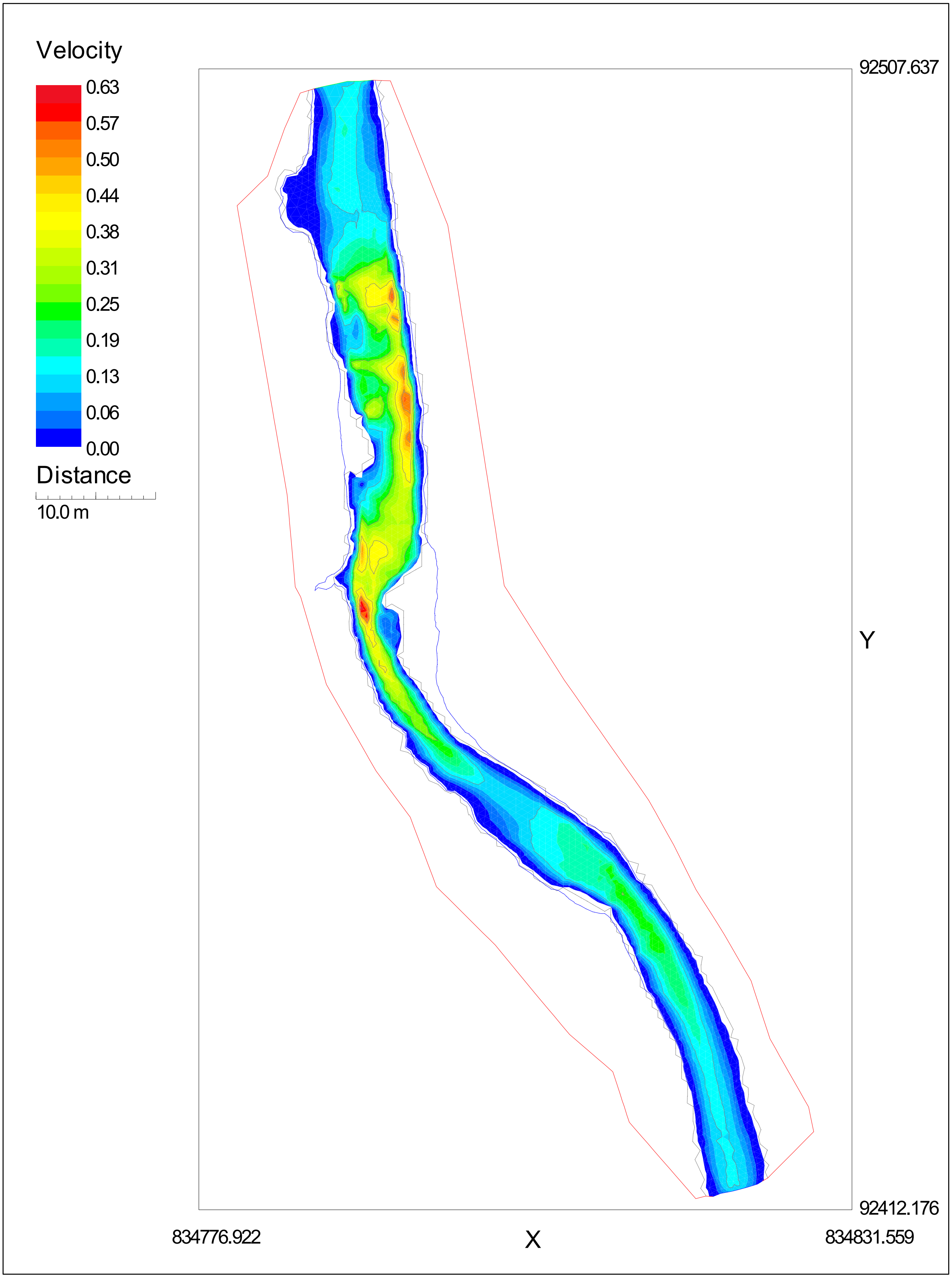



**Figure M.20 River 2D Generated Velocity Profile of Poquessing Creek Site PQ825**

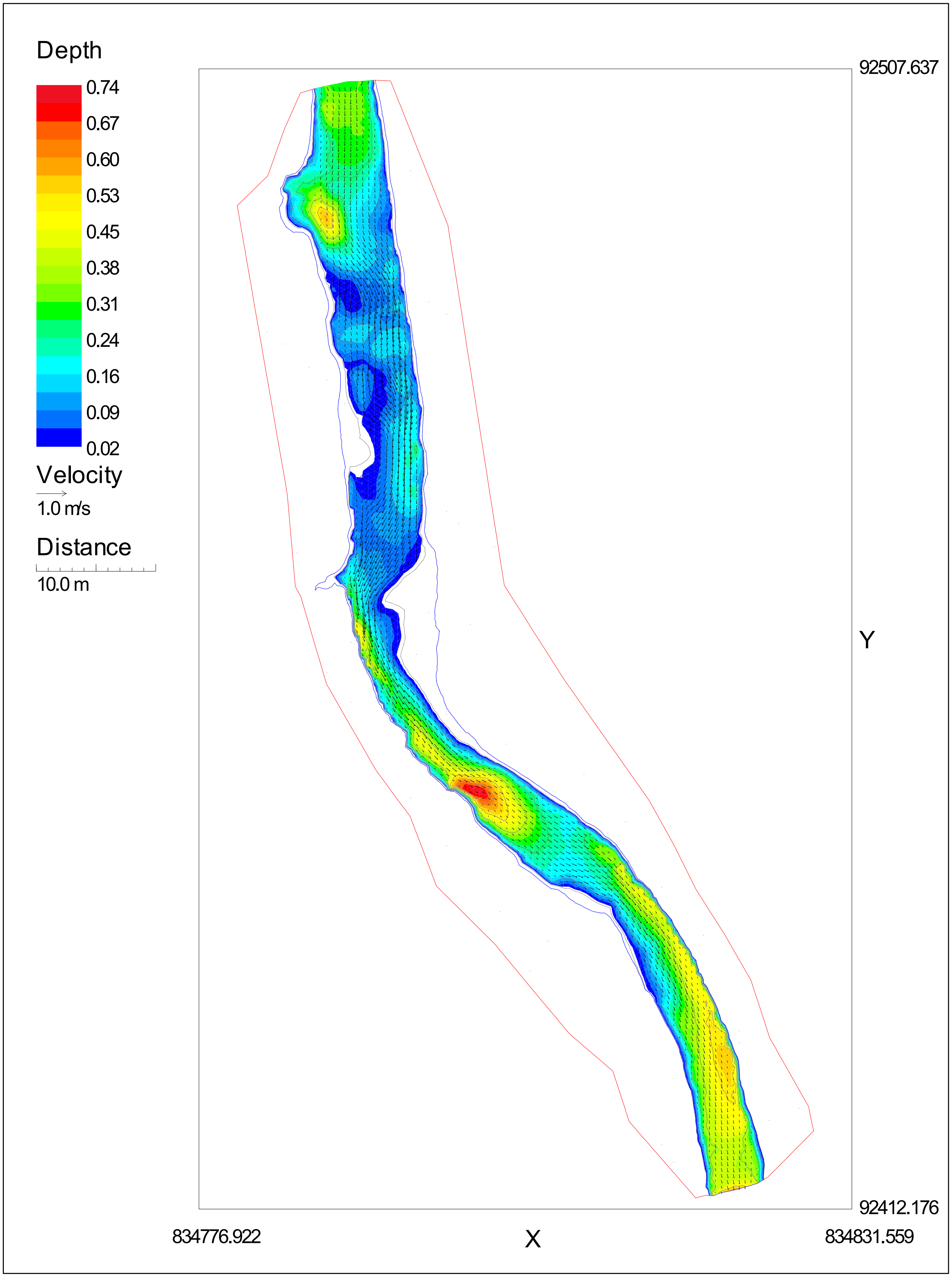



**Figure M.21 River 2D Generated Depth Profile of Poquessing Creek Site PQ825**

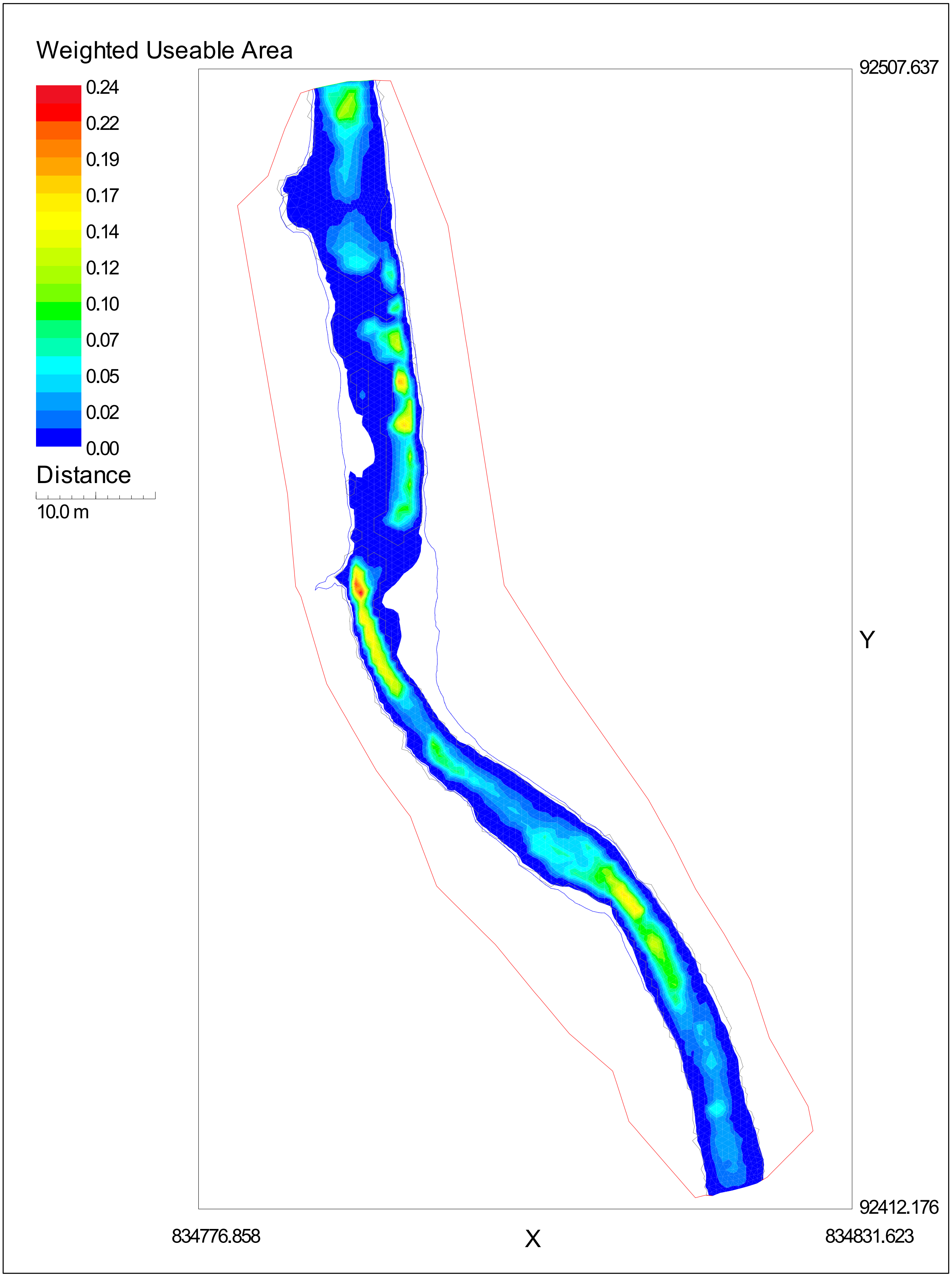



**Figure M.22 River 2D Generated Weighted Usable Habitat Area for Riffle Fish Guild, Poquessing Creek Site PQ825**

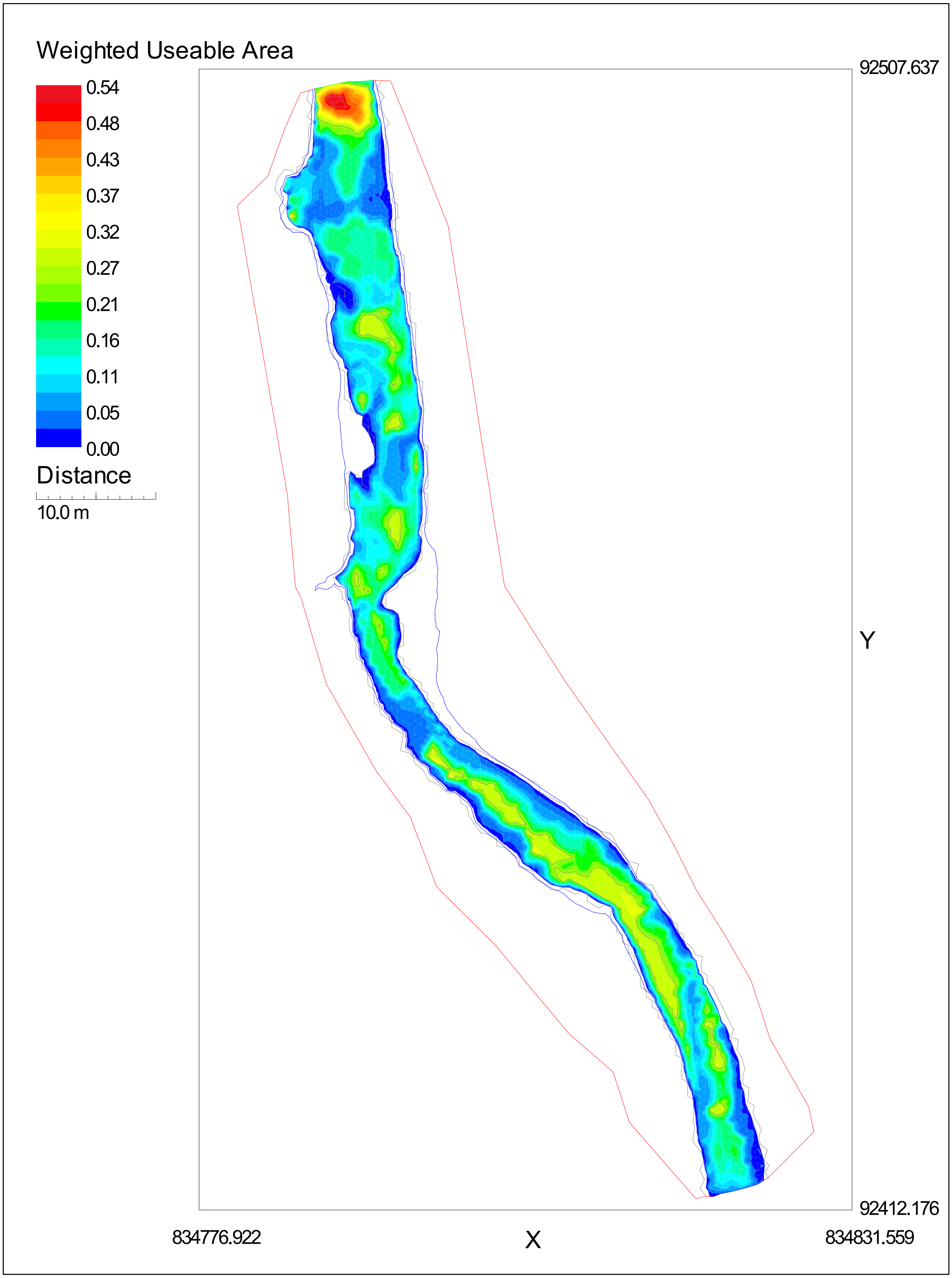



**Figure M.23 River 2D Generated Weighted Usable Habitat Area for Generalist Fish Guild, Poquessing Creek Site PQ825**

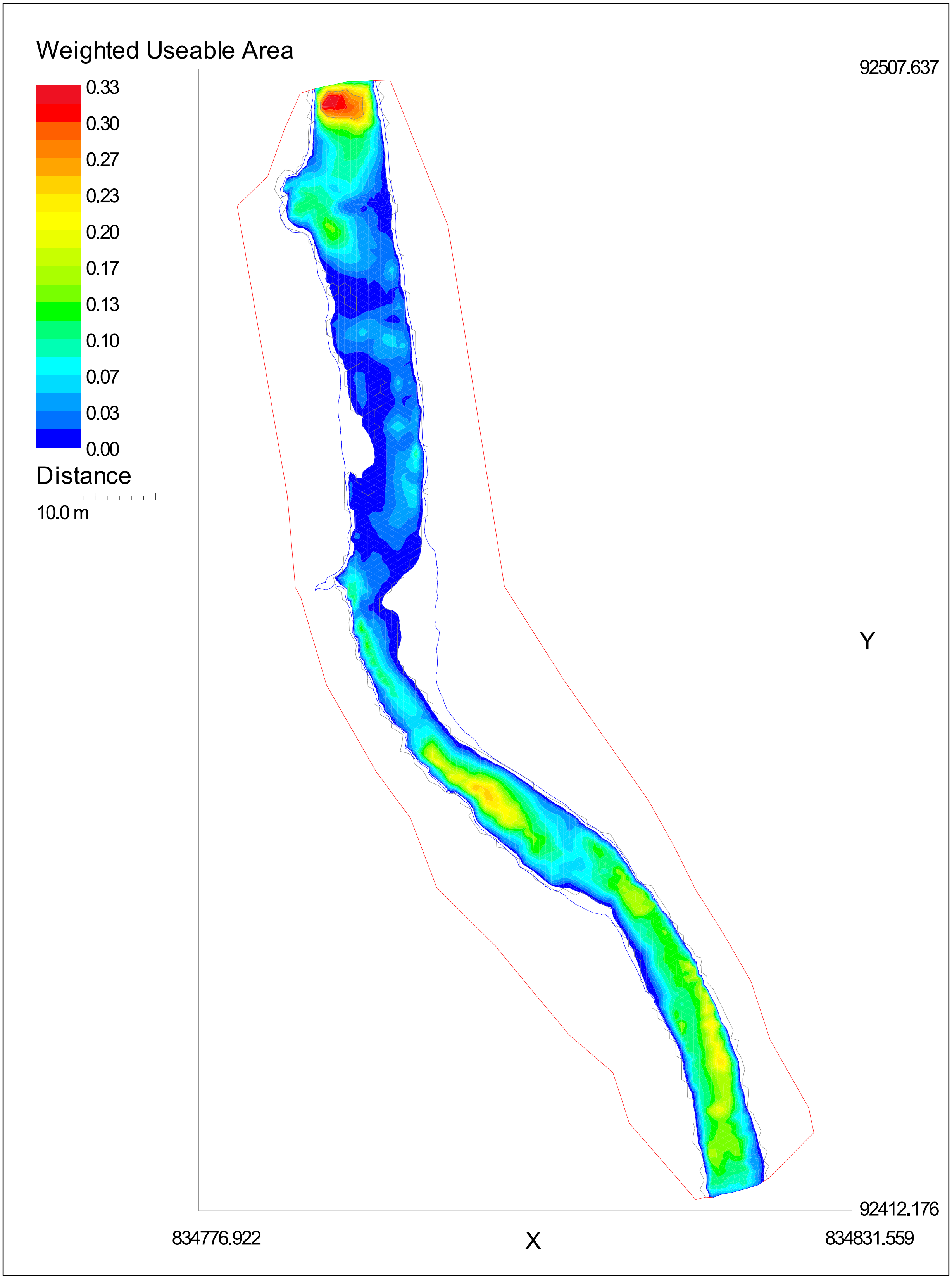



**Figure M.24 River 2D Generated Weighted Usable Habitat Area for Pool Fish Guild, Poquessing Creek Site PQ825**

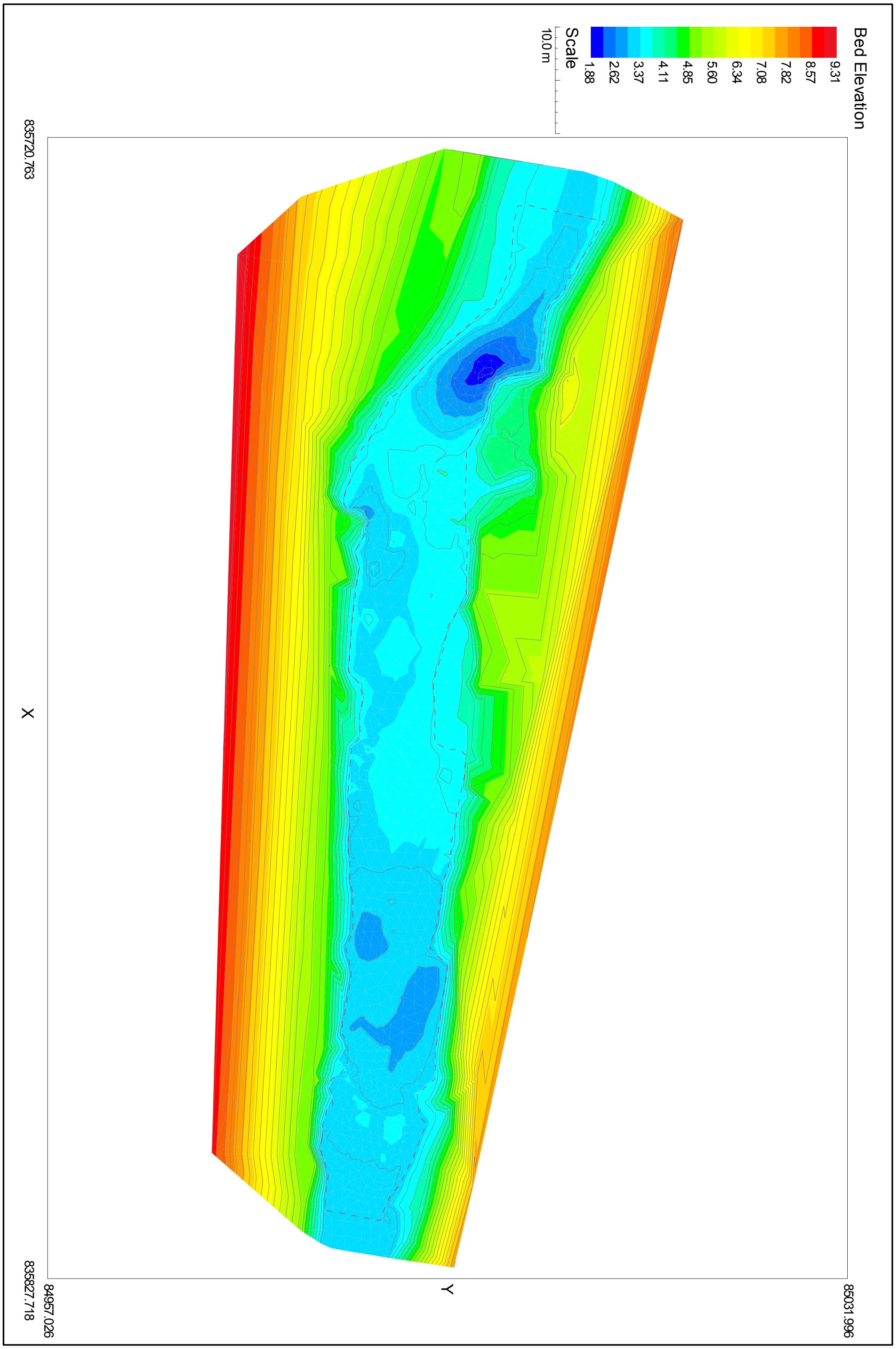



**Figure M.25 River 2D Adjusted Final Model Input Bed Elevation File, byberry Creek Site PQB025**

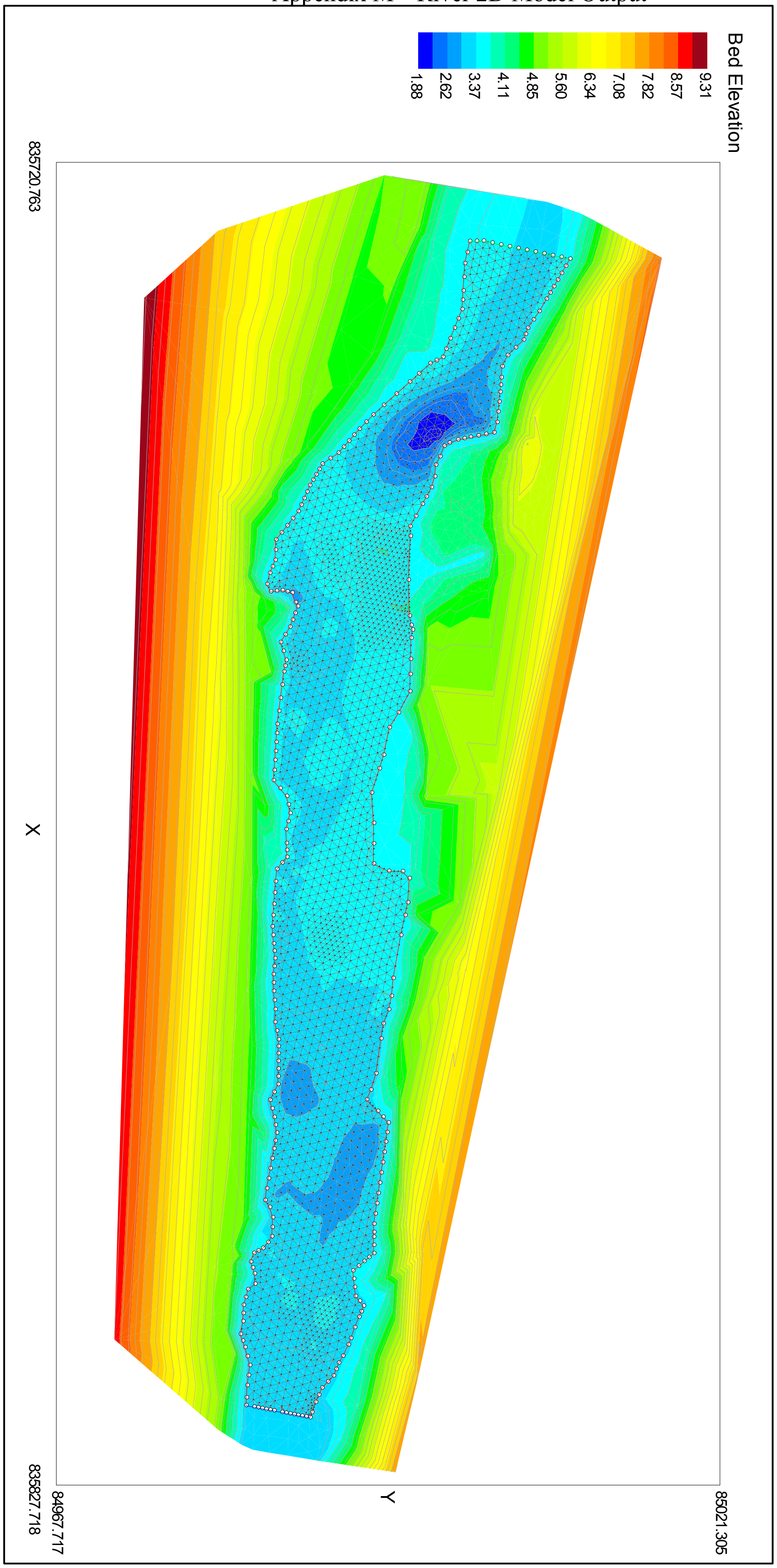



**Figure M.26 River 2D Adjusted Final Model Input Mesh File, Byberry Creek Site PQB025**

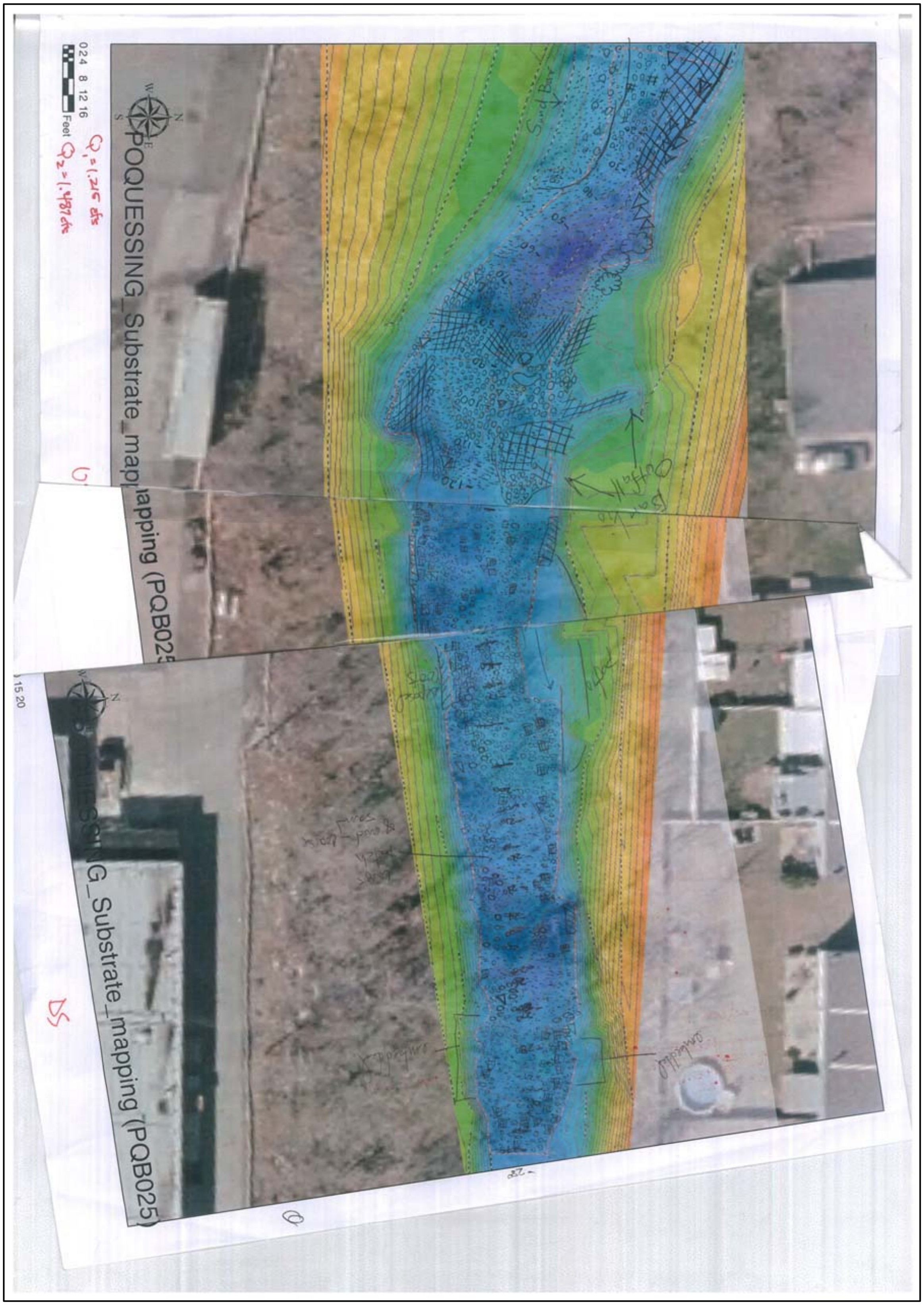



**Figure M.27 River 2D Substrate Classification Field Survey Map for Byberry Creek Site PQB025**

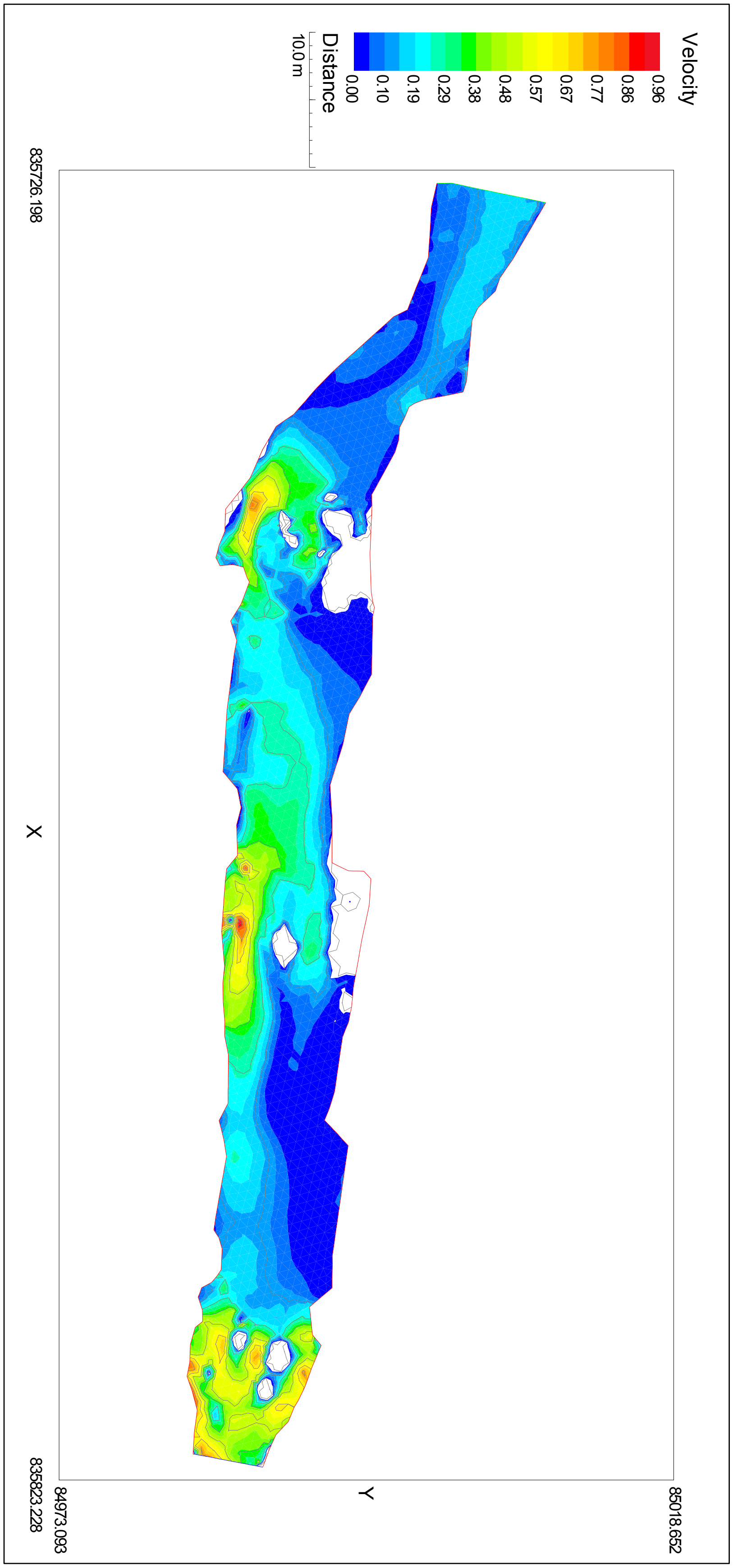



**Figure M.28 River 2D Generated Velocity Profile of Byberry Creek Site PQB025**

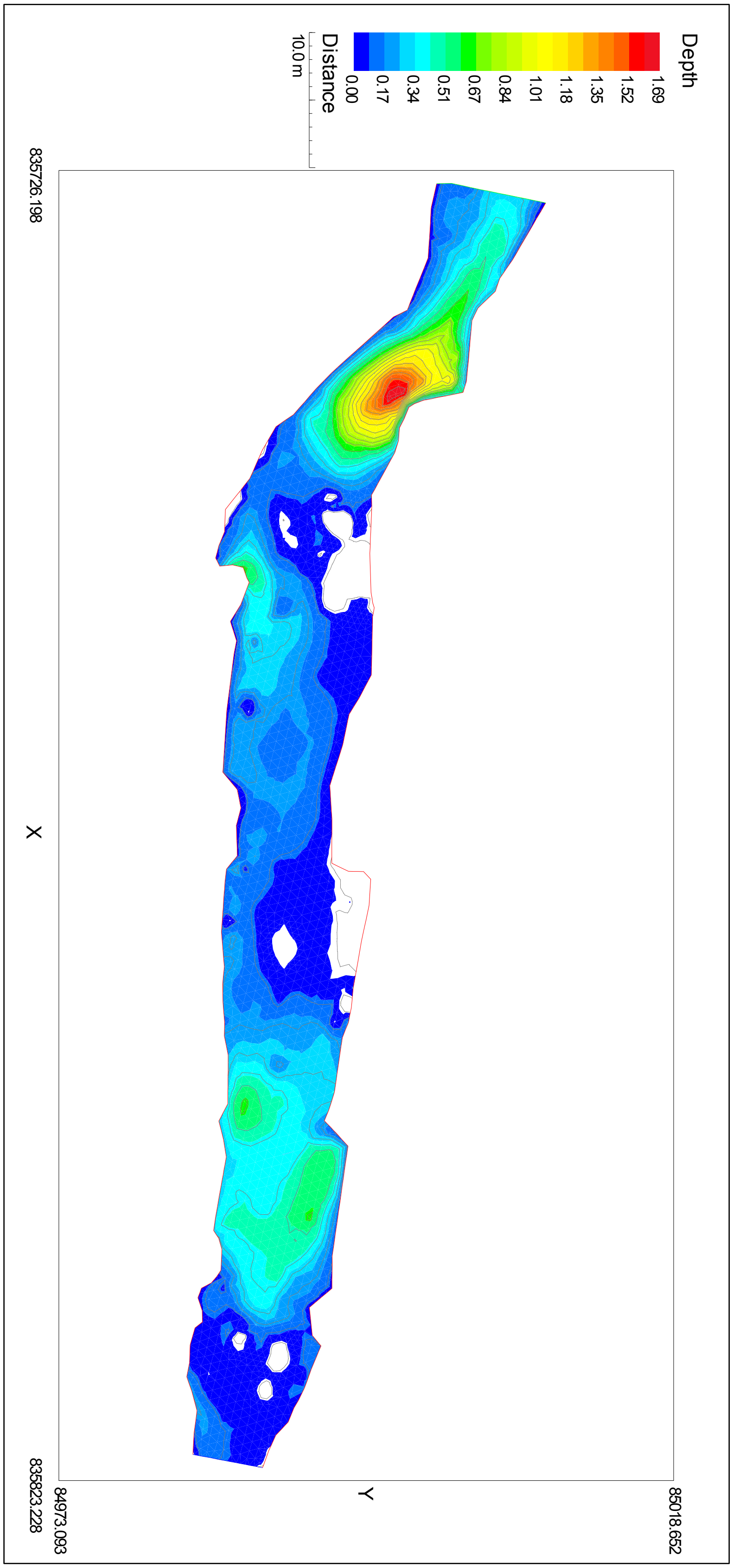



**Figure M.29 River 2D Generated Depth Profile of Byberry Creek Site PQB025**

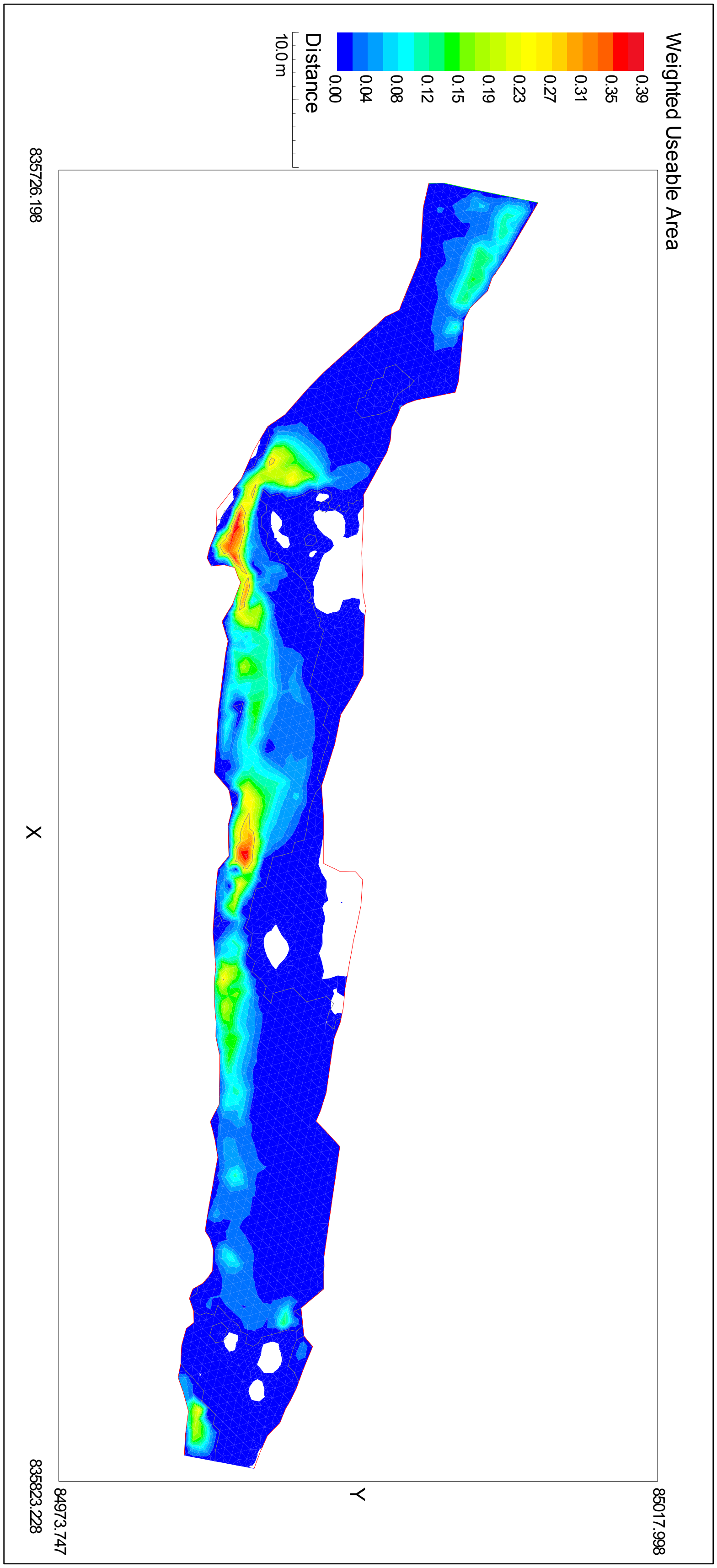



**Figure M.30 River 2D Generated Weighted Usable Habitat Area for Riffle Fish Guild, Byberry Creek Site PQB025**

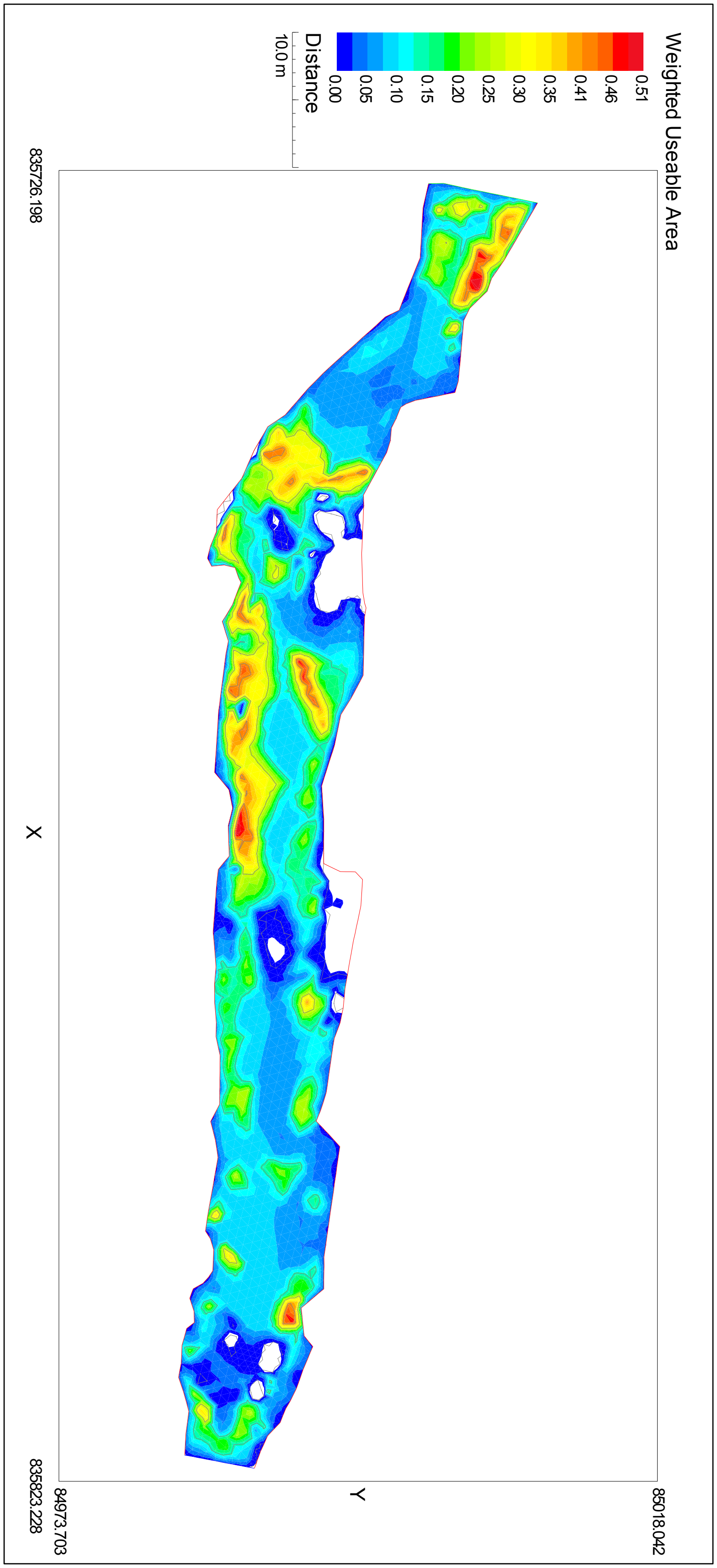



**Figure M.31 River 2D Generated Weighted Usable Habitat Area for Generalist Fish Guild, Byberry Creek Site PQB025**

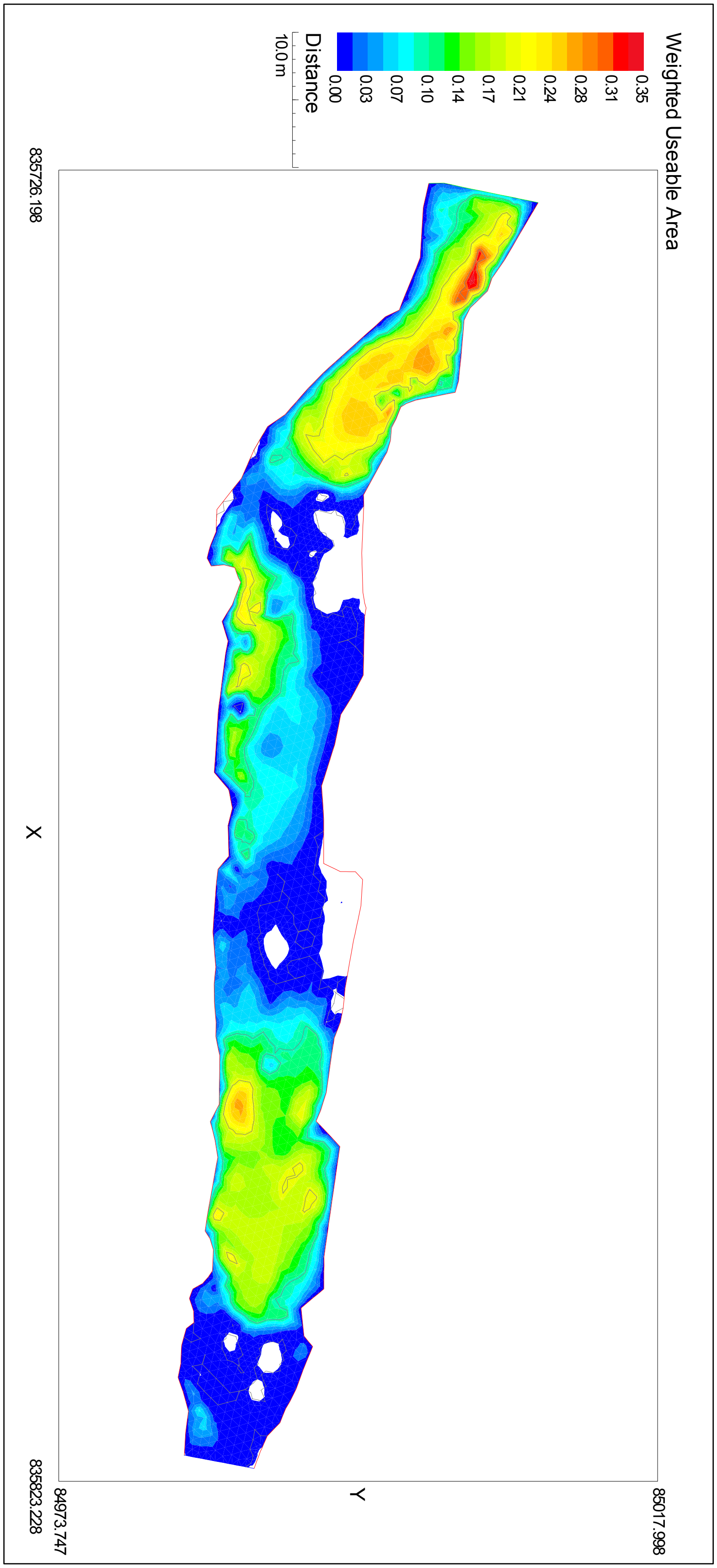



**Figure M.32 River 2D Generated Weighted Usable Habitat Area for Pool Fish Guild, Byberry Creek Site PQB025**

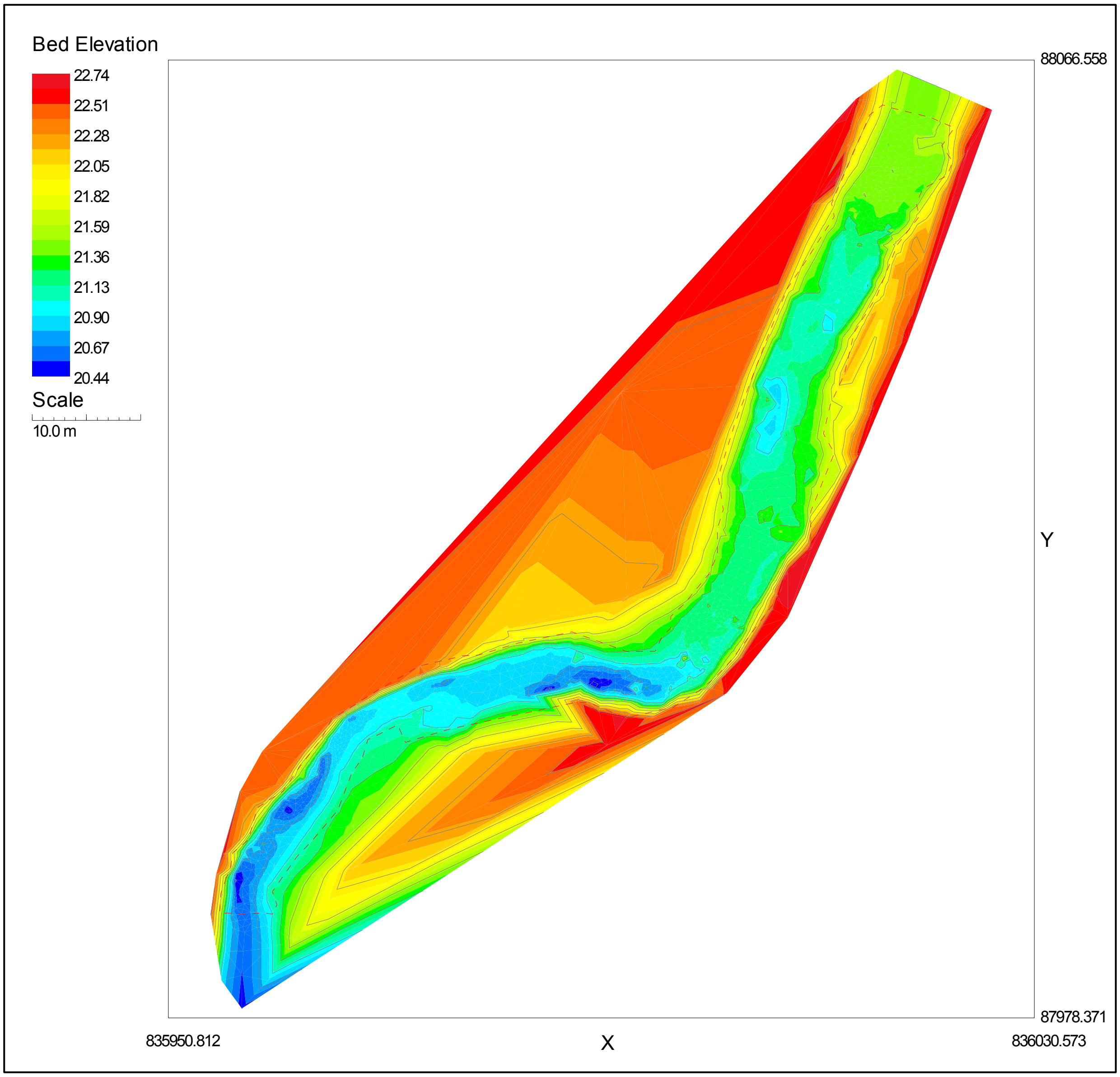



**Figure M.33 River 2D Adjusted Final Model Input Bed Elevation File, Byberry Creek Site PQB385**

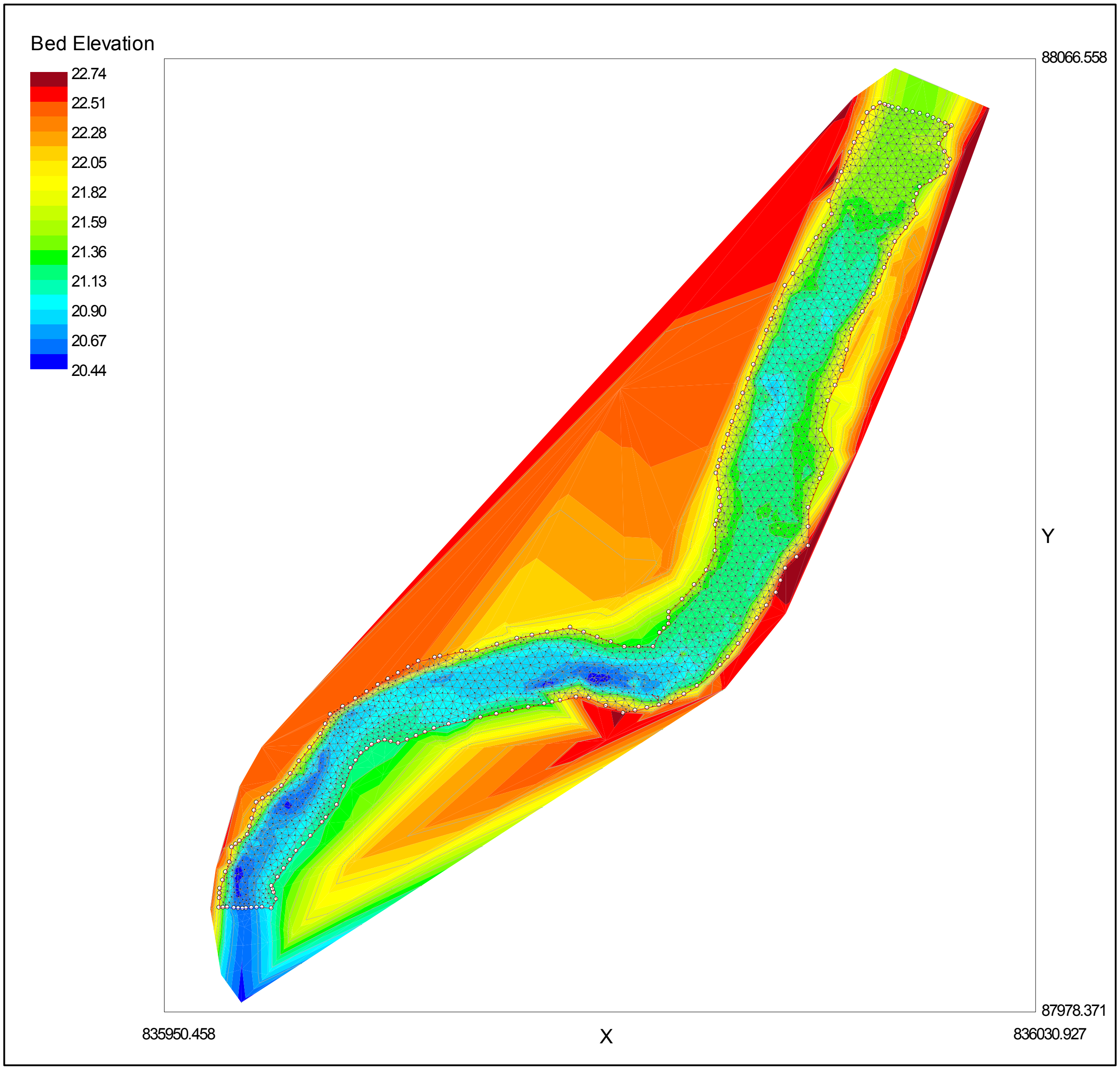



**Figure M.34 River 2D Adjusted Final Model Input Mesh File, Byberry Creek Site PQB385**

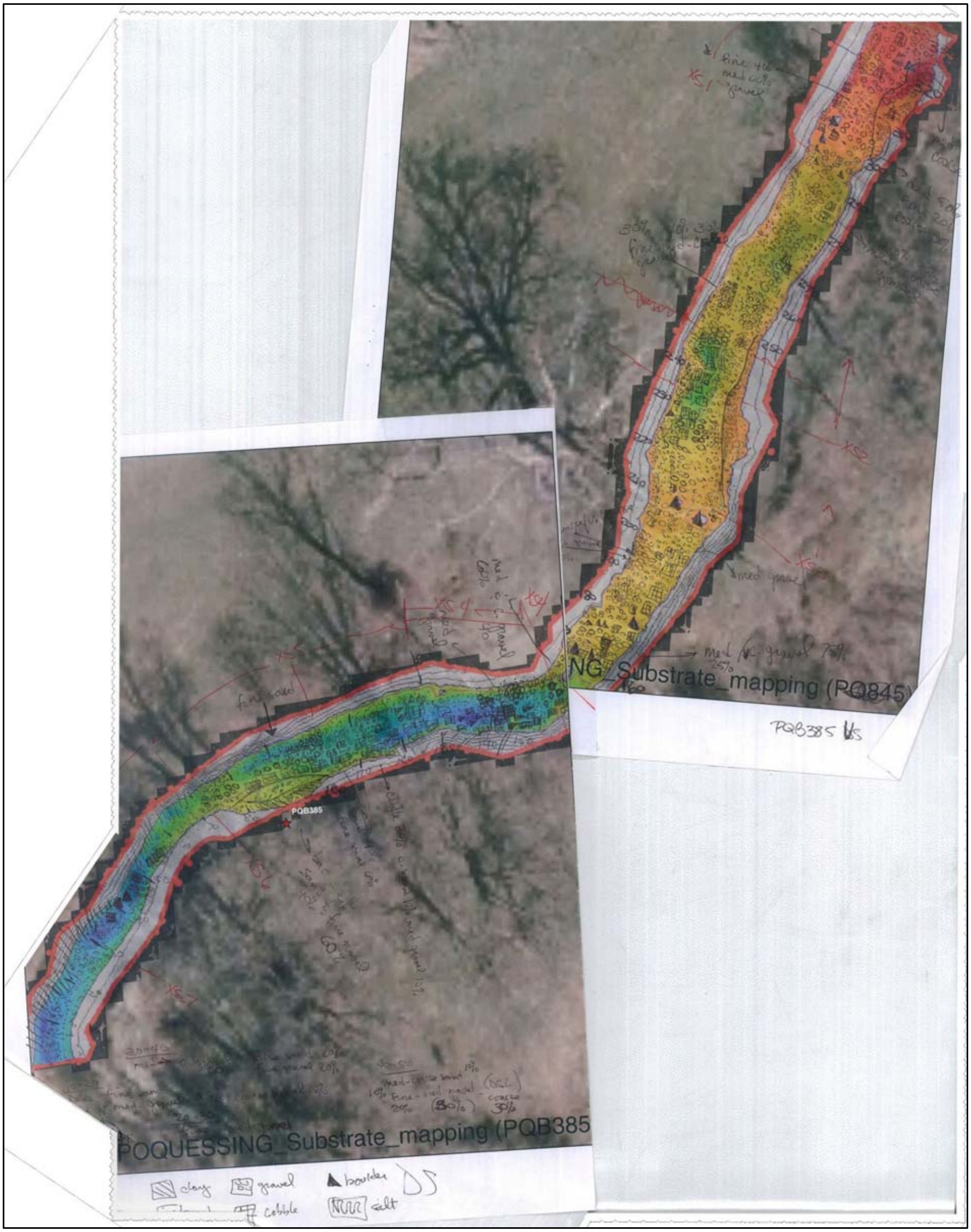



**Figure M.35 River 2D Substrate Classification Field Survey Map for Poquessing Creek Site PQB385**

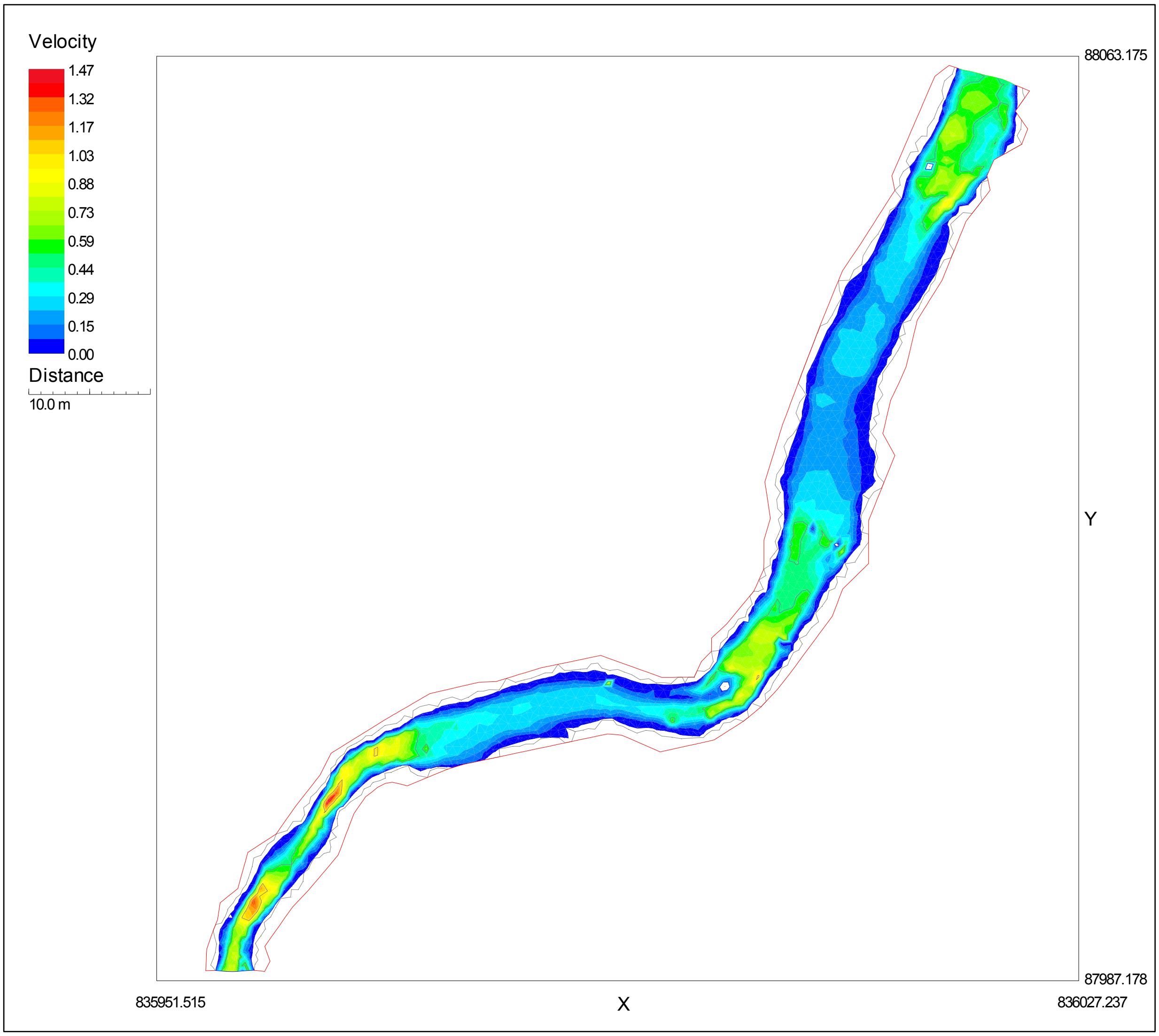



**Figure M.36 River 2D Generated Velocity Profile of Byberry Creek Site PQB385**

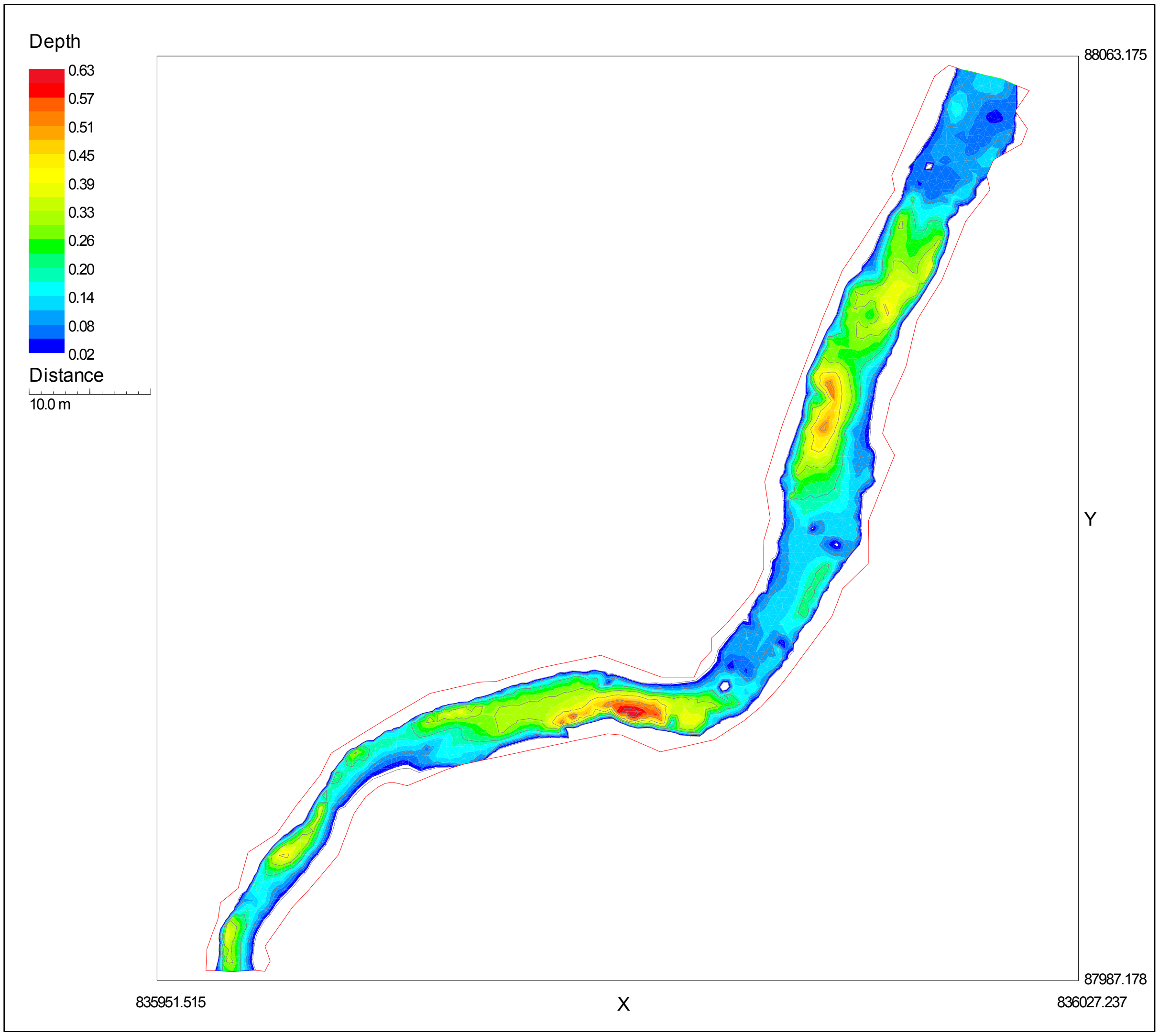



**Figure M.37 River 2D Generated Depth Profile of Byberry Creek Site PQB385**

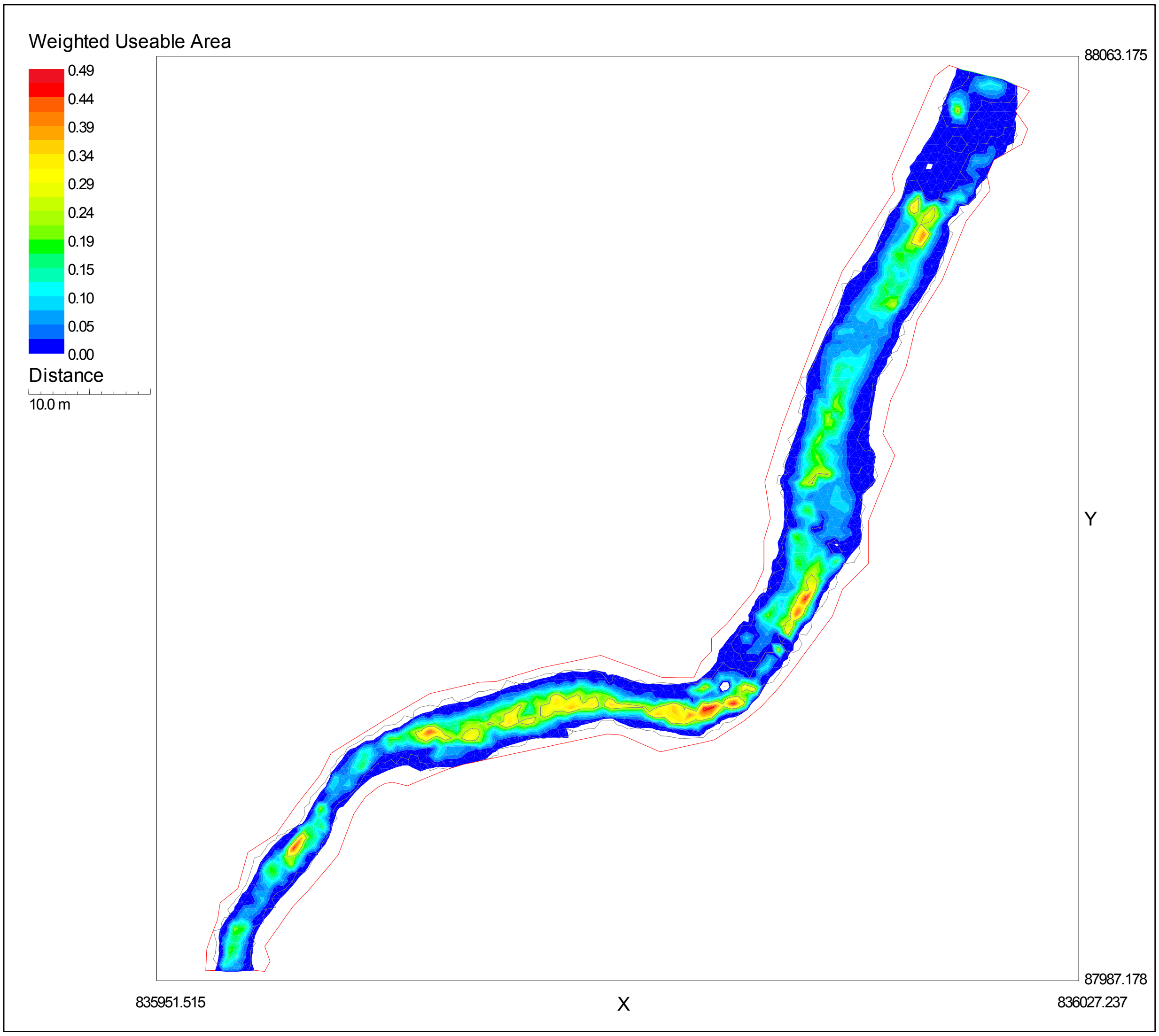



**Figure M.38 River 2D Generated Weighted Usable Habitat Area for Riffle Fish Guild, Byberry Creek Site PQB385**

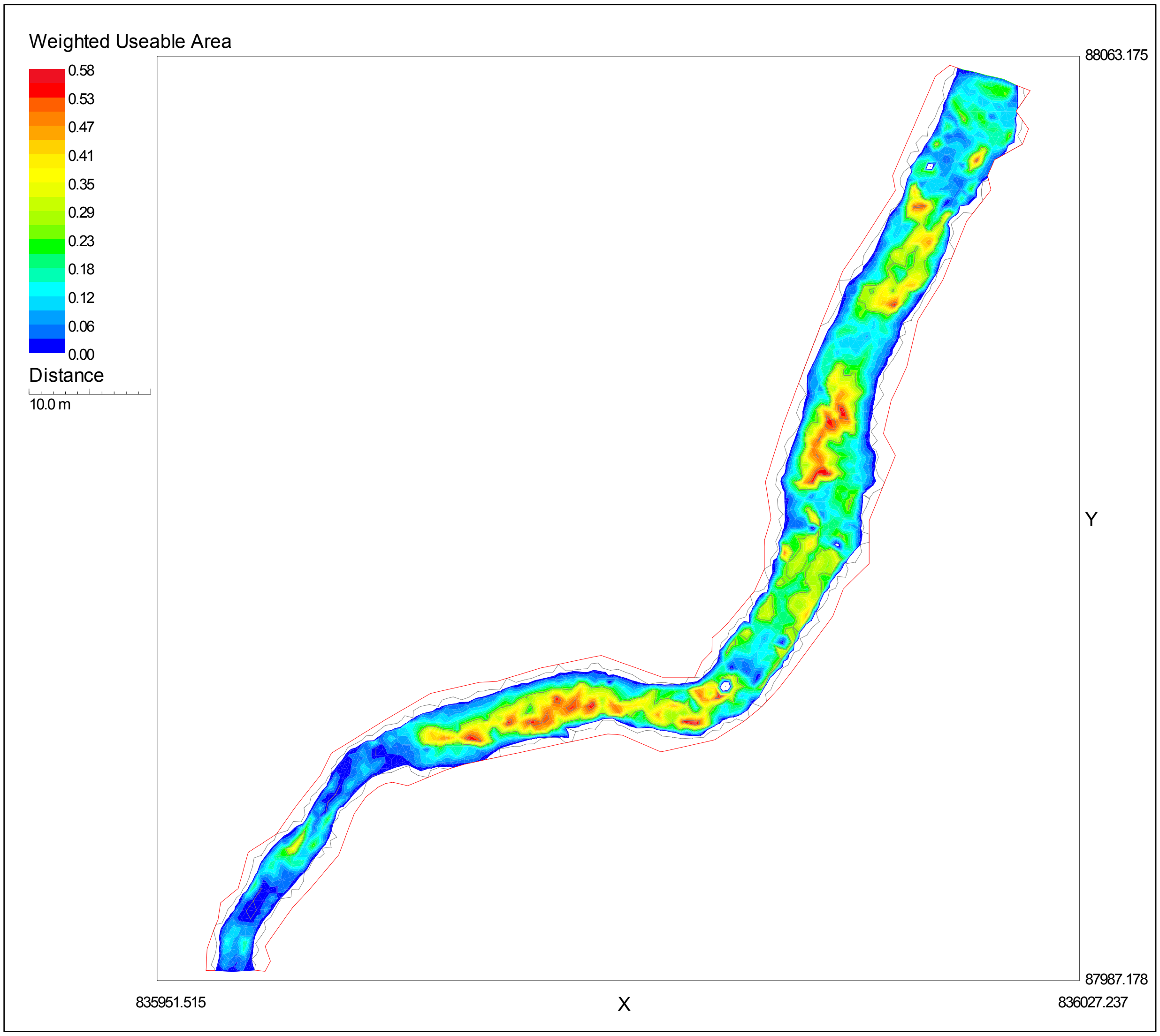



**Figure M.39 River 2D Generated Weighted Usable Habitat Area for Generalist Fish Guild, Byberry Creek Site PQB385**

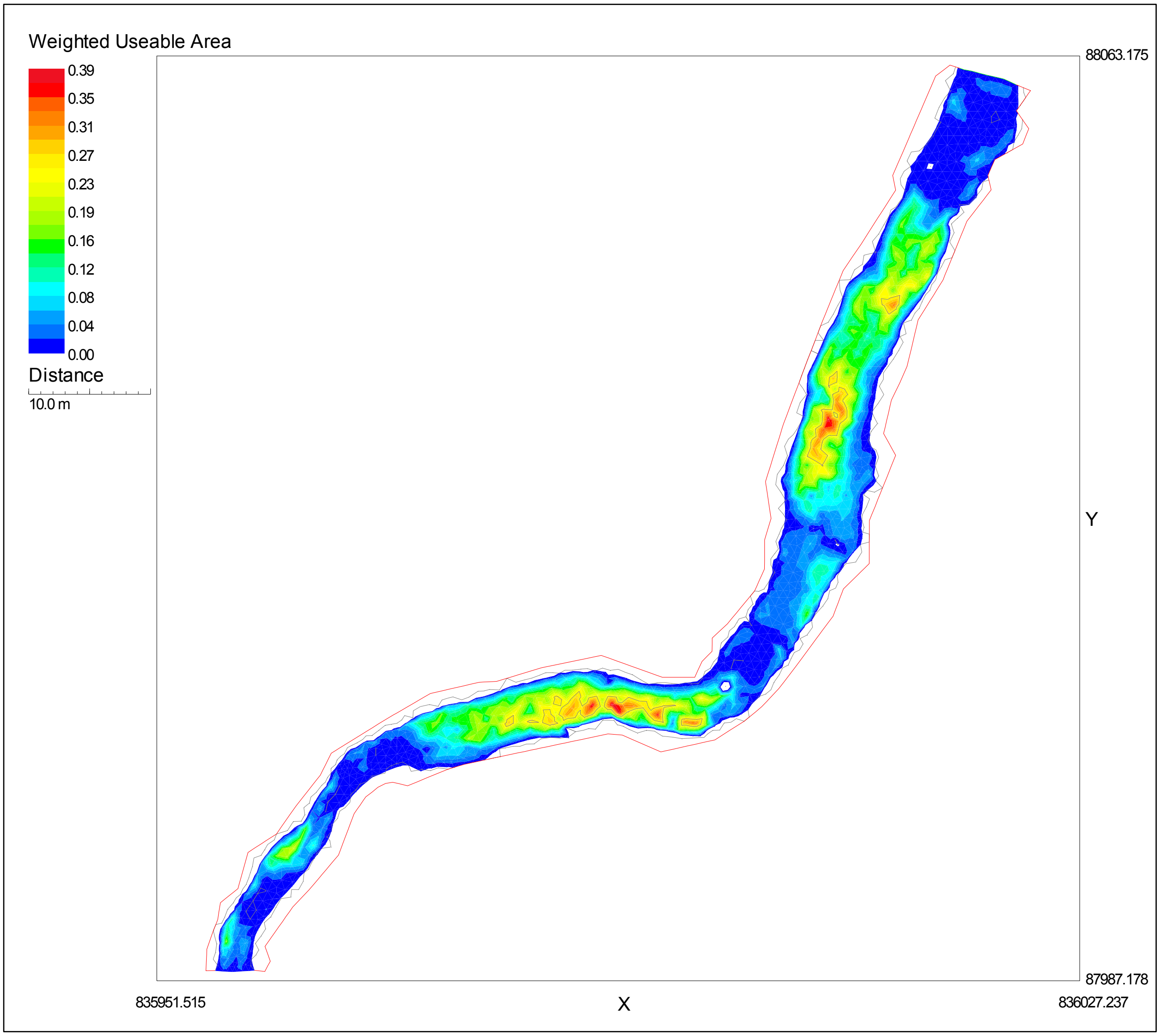



**Figure M.40 River 2D Generated Weighted Usable Habitat Area for Pool Fish Guild, Byberry Creek Site PQB385**

# APPENDIX N:

## References

# REFERENCES

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