Middle Snake Watershed Instream Habitat Assessment

Preliminary Draft Report

Submitted to the
Watershed Resource Inventory Area 35 Planning Unit

Prepared by
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Pullman, Washington

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Waterbodies:

Alpowa Creek
Almota Creek
Couse Creek
Deadman Creek
George Creek
Joseph Creek
Pataha Creek
Tenmile Creek

Approvals

Approved by: ______________________________ ____________

Bradley Johnson, Watershed Planning Director, Asotin County Public Utility District, Lead Agency WRIA 35 — Date

Approved by: ______________________________ ____________

Mimi Wainwright, Watershed Lead, Department of Ecology — Date

Approved by: ______________________________ ____________

Jim Pacheco, Water Resources Program, Department of Ecology — Date

Approved by: ______________________________ ____________

Terra Hegy, Habitat Program, Department of Fish and Wildlife — Date

Approved by: ______________________________ ____________

David Karl, Fish Management, Department of Fish and Wildlife — Date

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Abstract

Instream habitat assessment for the Middle Snake Watershed (WRIA 35), located in southeast Washington, is being conducted to provide data to support setting instream flows. Eight streams within WRIA 35 are considered, each possessing distinct flow regime characteristics. Instream habitat assessment uses the Toe-Width, Wetted Perimeter, and Tennant Methods. Hydrologic and field data will be compared to current and historic gauge data from targeted streams in the final report. These data will then be related to existing fish data for select streams. Data evaluation will not be presented here, all data should be collected before providing comments.

This study is conducted by researchers from Washington State University in conjunction with the WRIA 35 Planning Unit, Washington Department of Ecology (Ecology) and Washington Department of Fish & Wildlife (WDFW).

Background

Washington State established a pathway for developing locally-based watershed enhancement plans based on Water Resource Inventory Areas (WRIAs) by passing the Watershed Management Act of 1998. This optional program is outlined in Chapter 90.82 RCW and provides a framework within which citizens, tribes, local governments and others can collaborate to develop watershed management plans. Sponsored by the Washington Department of Ecology, watershed management plans address water supply reliability issues, while water quality, instream flows, and habitat are optional.

In the Middle Snake Watershed (WRIA 35), Asotin, Columbia, Garfield, and Whitman Counties, the City of Clarkston, and the Asotin County Public Utility District joined to initiate organization of the WRIA 35 Planning Unit in 2002. The 37-member Middle Snake Watershed Planning Unit is comprised of the initiating governments and the following stakeholder groups:

- landowners and citizens
- tribes
- conservation districts
- agricultural groups
- local governments
- environmental groups
- state and federal agencies

Located in the southeast corner of Washington, the Middle Snake River Watershed (WRIA 35, Figure 1) occupies approximately 2,250 square miles in southeastern Washington along the Idaho border to the east and Oregon border to the south. Land use is approximately 50 percent rangeland, 33 percent agriculture, 15 percent forestland and 1 percent urban. The population is approximately 25,000.[1]

The watershed planning process in WRIA 35 aims to address water supply, instream flows, water quality, and habitat issues.[2] An assessment of the instream flows in streams within the Middle Snake Watershed will assist the Planning Unit with certain aspects of these aims. This draft report follows the Quality Assurance Project Plan (QAPP) that was developed to assure that results of the instream habitat assessment are of appropriate quality for the Planning Unit, Washington Department of Ecology (Ecology) and Washington Department of Fish & Wildlife (WDFW) to address instream flow issues.

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[1] Middle Snake River Watershed, Watershed Plan, Executive Summary, http://www.asotinpud.org/msww/documents/Draft%20Plan/Sections/Executive%20Summary.pdf

[2] Middle Snake, WRIA 35 Watershed Planning, http://www.asotinpud.org/msww/ms_watershed_planning.htm

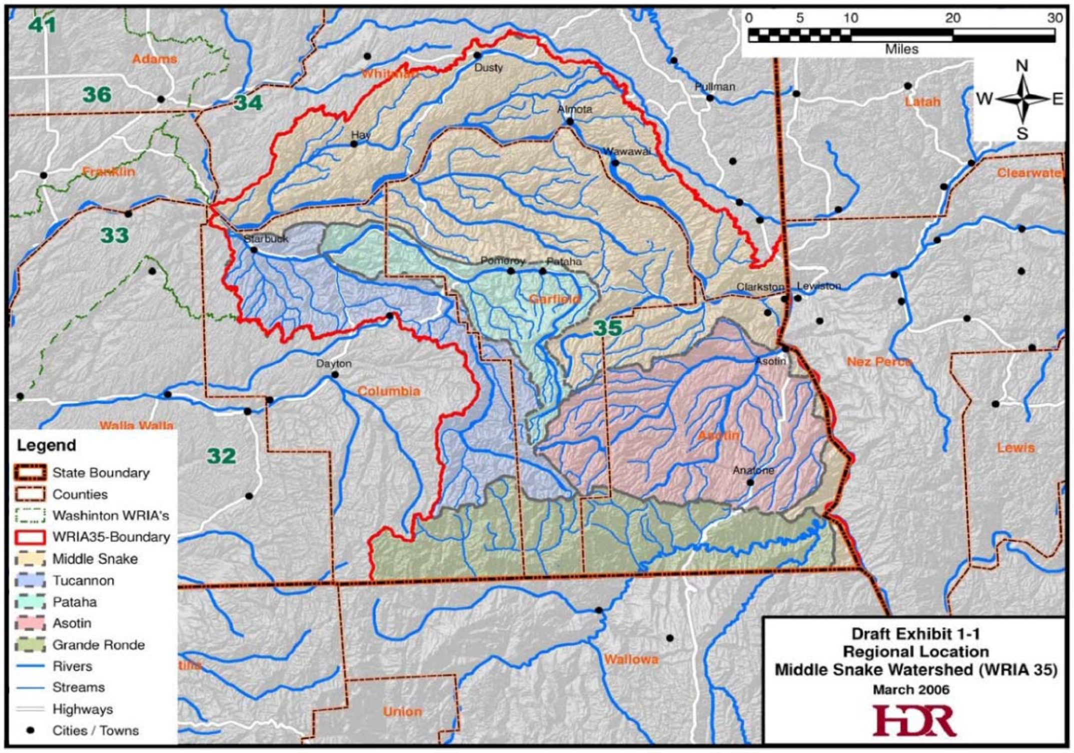

Figure 1. WRIA 35 base map.

Project Description

The goal of this project is to evaluate instream habitat needs for Alpowa, Almota, Couse, Deadman, George, Joseph, Pataha and Tenmile Creeks within WRIA 35.

Data is being collected on stream flow, alluvium substrate and habitat characteristics and accompanying analysis will be completed. Flow levels at critical locations within the eight drainage basins are being assessed. The study will also incorporate additional analyses that will provide insight into: 1) differences between methods used to determine minimum flow requirements, and 2) preliminary understanding of links between fish species presence and flow regimes.

Hydrologic and accompanying field data is being collected and analyzed, and will be compared to current and historic gauge data from the targeted streams (as well as other streams in the area). Flow assessment methods will be compared to determine the applicability for use in small southeast Washington streams. Available fish species presence data collected by WDFW from two or three streams in the study area will be discussed in regards to instream flow; however, direct relationships between fish and instream flow are beyond the scope of this study.

This project is designed to provide support for future discussions on setting instream flows in the administrative framework set by the State of Washington. Specifically, the final assessment will provide the technical framework needed to support the Planning Unit and State agencies in basing their instream flow discussions and final recommendations. Instream flows in this context are developed by considering existing data, the hydrology of a stream and its natural variation in stream flow and base flow over the course of the year, studying the need for fish habitat and other factors[3]. This process is often considered in regard to minimum streamflows to provide habitat for fish and wildlife; thus, more emphasis will be placed on low flow periods but it is important to consider high flow periods as well to provide an assessment through the yearly seasons.

The distinct nature of each stream in this study provides different flow regimes, including both intermittent and perennial systems. In the final report, differences in flow regimes for the streams will be discussed based on the collected and existing data. The seasonality or timing when a stream reach is dry will be considered in regards to timing of fish lifecycles (e.g., migration, spawning, rearing). Stage-discharge curves will reflect the stage at zero flow for each transect. Associated with these curves will be surveying at specified locations to record accurate locations of water elevations with respect to an approximate local elevation determined by GPS. Each transect will be assigned weighting factors to represent the percent of typical stream reach (i.e., pool, riffle).

Quality Objectives

The primary objective of this study is to provide data to support the process of setting instream flows for streams in WRIA 35. Instream habitat assessment techniques primarily consist of the Toe-Width, Wetted Perimeter, and Tennant Methods. Hydrologic and field data will be compared to current and historic gauge data from targeted streams in the final report.

Although these methods do not produce results that can be evaluated for bias and precision, they are performed according to the guidelines described below.

Study Design, Procedures and Measurement Methods

Site Reconnaissance:
For site reconnaissance, extensive travel was conducted in each watershed and potential access points were explored based on topographic and road maps, as well as communication with landowners. Selection criteria consisted of suitability for surveying and representativeness of the stream. Sites are paired to represent two distinct channel

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[3] Ecology. 2001. Setting Instream Flows in Washington State. Publication #98-1813-WR.

unit types to help verify flow rates. Access was a limiting factor in the region due to steep and rugged terrain, impenetrable brush, lack of nearby roadways, and reluctant landowners. Many of the study streams were characterized by intermittent flow, which further limited available survey points. Natural differences in streams has to be accounted for in a multi-stream study, which prohibits direct comparisons but allows for stream habitat assessment based on inherent characteristics of each watershed.

The coordinates for selected sites are reported using a GPS unit and site locations have been photographed. Surveying transect locations occur for at least two locations for each stream. Transect location information will also identify the location of the established staff and telemetered stream gauges managed by Ecology. In addition, potential management points will be identified.

Stream Habitat Assessment Methodology:

Tennant Method

The average annual flow of the study streams is determined according to Tennant[4] using published data collected by Ecology. Records for the streams will be studied for daily, monthly, and annual flow patterns. In the field, gauges will be checked so as to view and study natural flows.

Cross-sectional data on width, depth, and velocity measurements for flow regimens under study is being obtained. This information will be used to plot and compare water widths, depths, and velocities to known requirements for aquatic resources. Average daily, monthly, and annual streamflow regimen tables and previous historic low-flow data will be analyzed to establish base flow patterns typical for a climatic year.

Based on the average annual flows for the study streams, instream flow regimes will be determined from Table 1.

Table 1. Instream Flow Regimens from Tennant.

Narrative Description of Flow[a]	April to September	October to March
Flushing or maximum flow	200% from 48 to 72 hours	
Optimum range of flow	60-100%	60-100%
Outstanding habitat	60%	40%
Excellent habitat	50%	30%
Good habitat	40%	20%
Fair or degrading habitat	30%	10%
Poor or minimum habitat	10%	10%
Severe degradation	<10%	<10%

[a] For fish, wildlife, recreation, and related environmental resources

[4] Tennant, D., 1976, Instream Flow Regimens for Fish, Wildlife, Recreation and Related Environmental Resources, Fisheries 1(4): 6-10

Cross-Section Measurement

Cross-section measurements are being performed in accordance with Bain[5]. A tape measure is stretched across the stream perpendicular to streamflow and anchored between two stakes; the tape measure is held level and taut. Interfering brush is cleared when necessary.

The width of the stream is measured and divided into intervals. No interval contains more than 10% of the total discharge. Generally, 12 to 15 intervals are sought at each transect. At each interval the following measurements are taken:

- distance from the left bank,
- water depth, and
- water velocity.

Figure 2 provides a diagram illustrating the cross-section of a stream showing sampling locations. The average velocity found along the midpoint location of each sub-area is assumed to be valid for the entire sub-area.

When depth is less than 2 feet, water velocity is measured at 0.6 the water depth at each interval (mean velocity for a position). For depths greater than 2 feet, velocity is measured at 0.2d and 0.8d.

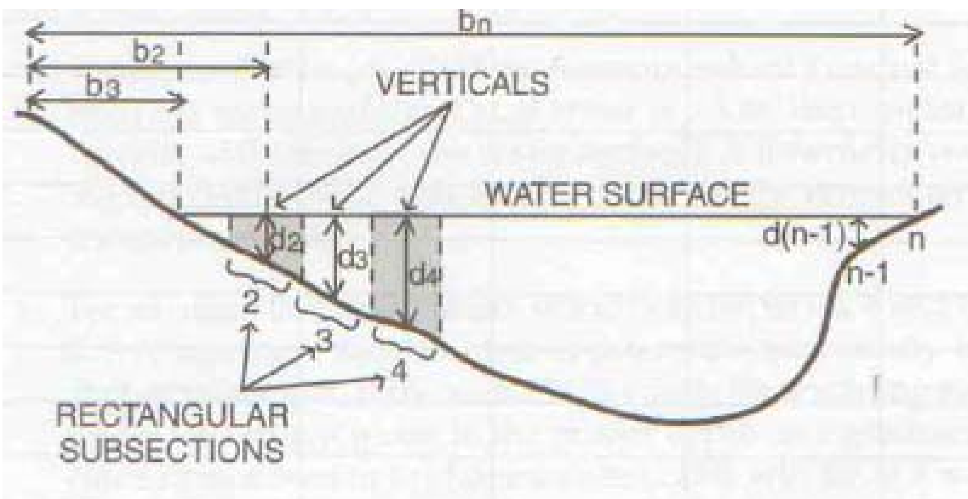


Figure 2. Cross section of a stream showing sampling locations for water depth (d) and velocity.

[5] Bain, M.B., and Stevensen, N.J. (ed.), 1999, Aquatic Habitat Assessment: Common Methods 14: Streamflow, American Fisheries Society, Bethesda, MD

Toe-Width Method

Toe-width is determined according to Swift[6] and according to State methods discussed with Ecology and WDFW (i.e., considering changes in slope, substrate and vegetation). The bank toe is field determined as the point where the streambed and bank join. After each bank toe is established, toe-width is measured between the two points perpendicular across the stream. Figure 3 displays a photograph of a typical scenario for demonstrating the location of the toe of the respective banks.

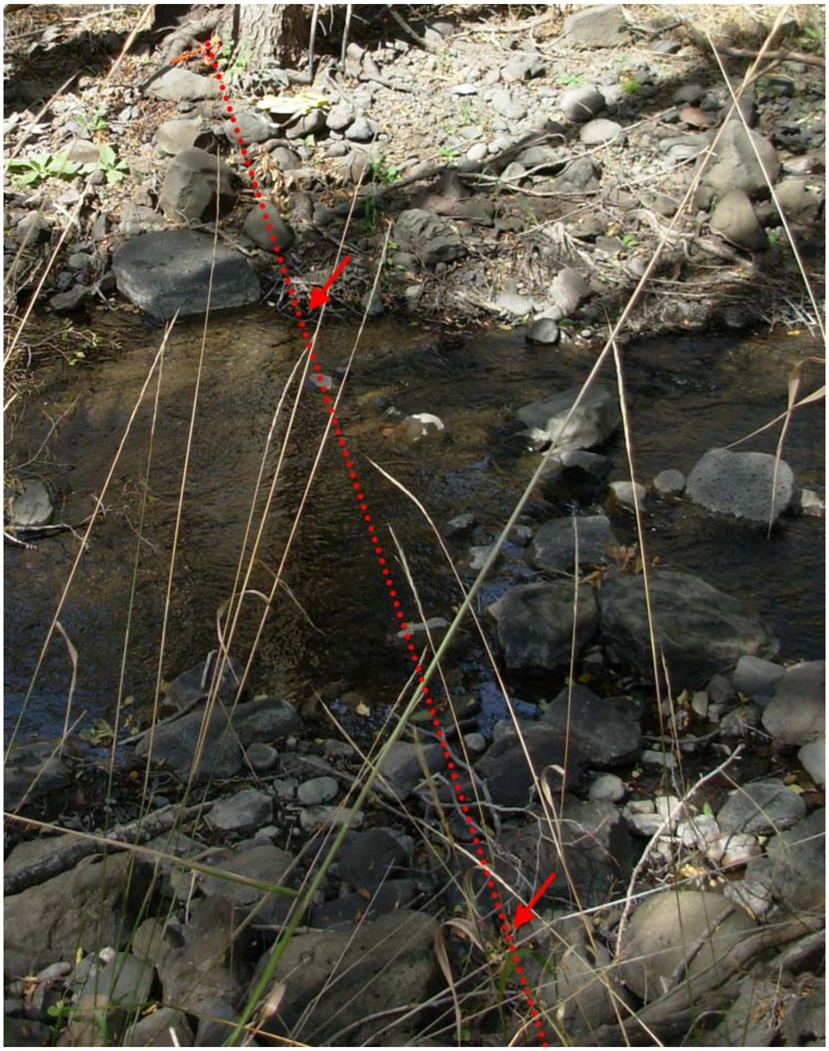


Figure 3. Photograph demonstrating the selection of the toe locations for each bank. The left bank toe (upper arrow) is easily identified by presence of a defined cut bank; the water's edge and bank toe correspond in this instance. The right bank toe (bottom arrow) is defined by a definite change in slope; the water's edge is below the bank toe in this instance.

[6] Swift, C.H. III, 1976, Estimation of Stream Discharges Preferred by Steelhead Trout for Spawning and Rearing in Western Washington, USGS Open-File Report 75-155, Tacoma, WA

Wetted Perimeter Method

The wetted perimeter is established by calculating the width of the streambed and the stream bank in contact with water at each transect. Ultimately, inflection points are determined by comparing discharge and wetted perimeter as shown in Figure 4. These inflection points are used to determine instream habitat needs.

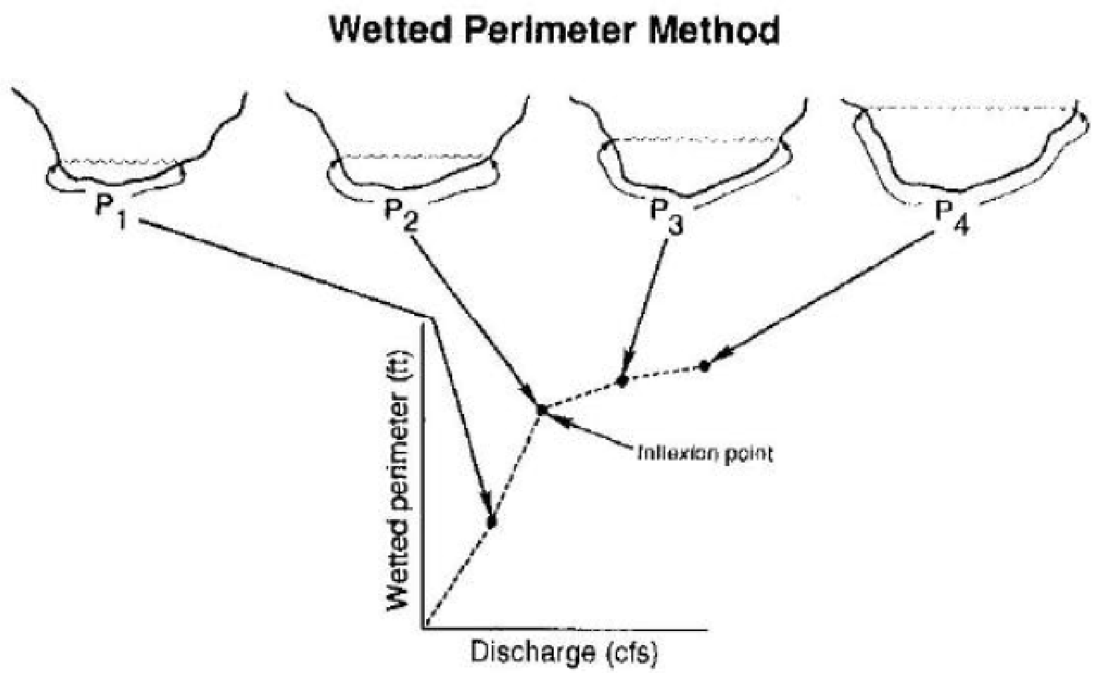


Figure 4. Diagram portraying the Wetted Perimeter Method.

A goal of collecting data in the field 7 to10 times (minimum of 7 times) using the Wetted Perimeter Method was set, but sample occurrences vary between streams based on discussions with the Planning Unit and other factors such as weather conditions. Coordinates for the selected sites are provided in Table 2 for locations considering the Wetted Perimeter and Toe-Width Method. Satellite images showing the locations of each paired site can be found in Appendix A.

Table 2. Coordinates for site locations selected for each stream.

Stream	Long. (N)	Lat. (W)
Almota	46° 42.188'	117° 28.075'
Almota	46° 42.200'	117° 28.033'
Little Almota	46° 42.200'	117° 28.071'
Alpowa	46° 24.733'	117° 12.800'
Alpowa	46° 25.545'	117° 17.609'
Alpowa	46° 25.540'	117° 17.645'
Alpowa	46° 24.976'	117° 20.466'
Alpowa	46° 24.955'	117° 20.504'
Alpowa	46° 23.939'	117° 24.571'
Alpowa	46° 23.897'	117° 24.580'
Couse	46º 12.287'	116º 58.062'
Couse	46º 12.283'	116º 58.000'
Couse	46º 12.286'	116º 58.086'
Couse	46º 11.722'	116º 59.521'
Couse	46º 11.734'	116º 59.541'
Couse	46º 10.371'	117º 00.579'
Couse	46º 10.362'	117º 00.618'
Deadman	46º 37.117'	117º 45.583'
Deadman	46° 37.087'	117° 45.692'
Deadman	46° 37.115'	117° 45.650'
Deadman	46° 37.575'	117° 40.803'
Deadman	46° 37.547'	117° 40.776'
Deadman	46° 36.300'	117° 36.483'
George	46º 19.517'	117º 06.417'
George	46º 19.487'	117º 06.424'
George	46º 19.467'	117º 06.431'
George	46º 18.174'	117º 07.041'
George	46º 18.150'	117º 07.046'
George	46º 16.622'	117º 09.794'
George	46º 16.618'	117º 09.791'
Joseph	46º 01.767'	117º 00.950'
Joseph	46º 00.591'	117º 01.928'
Joseph	46º 00.403'	117º 02.521'
Cottonwood	46º 00.378'	117º 02.525'
Pataha	46º 30.717'	117º 58.383'
Pataha	46º 28.500'	117º 33.300'
Pataha	46º 26.604'	117º 28.028'
Pataha	46º 16.519'	117º 31.189'
Pataha	46º 16.511'	117º 31.192'

Tenmile	46º 17.800'	116º 59.450'
Tenmile	46º 17.794'	116º 59.524'
Tenmile	46º 16.833'	117º 00.273'
Tenmile	46º 16.825'	117º 00.277'
Tenmile	46º 16.076'	116º 59.93'
Tenmile	46º 16.080'	116º 59.930'

Historic Data:
Historic data on migratory fish corridors within the target streams will be compared with findings on available spawning and rearing habitat. This historic information is comprised of fish data collected from WDFW previous to this study available on-line and through WDFW. The data collected by this study will be evaluated in regards to this historic fish data by describing flow regimes in respect to potential habitat usage (e.g., migration, spawning, rearing).

Quality Control

Streamflow data for the Toe-Width and Wetted Perimeter Methods is collected in accordance with Bain (1999) as stated above. Cross-section sites remain similar throughout the project for consistency. Hydrologic and field data will be compared to historic gauge data from targeted streams in the final report. The previous data will be used to assess whether study conditions reflected wet, dry, or average periods. Flow data from Ecology's staff and telemetered gauges during the study period will also be incorporated into the overall data set and included in the final report.

In situ flow measures follow standard quality control protocol. Flow is measured using current meters consisting of a balanced bucket wheel representative of the primary type of unit used in USGS gauging operations. The mini current meter is designed to be used in low flow conditions and represents the primary model for this study. The meter is attached to a portable flow meter. The meter has been sent to a certified lab for calibration.

Technical training and evaluation of field technicians is overseen by Michael Barber to ensure quality data collection. Quality control methods include duplicate measures at two cross sections per stream during two different sampling events.

Data Management Procedures

Field measurements and observations are being recorded on-site in a field notebook. A sample data collection sheet can be found in Appendix B. These data are entered into and stored in computer data files, and the originals are stored in a project file at Washington State University, Pullman. Field notes will be copied and made available to project partners along with the final report. Data will be compatible with Ecology data management (Environmental Information Management) requirements.

Deliverables

The final report will include:

- GPS coordinates for each site.
- Listings of the output files for discharge calculation.
- Listings of the output files from running the wetted perimeter program for each transect.
- A table showing discharges and wetted perimeter for each transect by the collection dates.
- Results and interpretation of data collected in relation to comparing flow methods.
- Discussion on fish species presence in relation to flow conditions in the respective streams.
- The following plots:
    - Transect profiles - distance (x-axis), bottom elevation (y-axis).
    - Arithmetic stage versus discharge - discharge (x-axis), water elevation (y-axis).
    - Wetted perimeter –discharge (x-axis) and wetted perimeter (y-axis).

Data Verification and Validation

Data will be made available to WRIA 35 Planning Unit and Ecology and may be assessed by experts within those agencies and compared with the Quality Objectives of this study. Modifications to measuring procedures, quality control, and analysis procedures will be considered for future efforts.

Data Quality Assessment

Once the validity of the data has been established, the WSU Project Team will work with project partners at WRIA 35 Planning Unit, Ecology and WDFW to determine if the data has met the objective of the project in determining instream habitat needs for WRIA 35.

Project Organization

The roles and responsibilities of the project team are as follows:

<u>Assessment Program Team</u>

- *Brad Johnson, Watershed Director, Asotin County Public Utility District*: Responsible for project oversight. Serves as primary point of contact and communication between Assessment Program Team, State of Washington Technical Team and Middle Snake WRIA 35 Watershed Planning Unit.

- *Jeffrey Ullman, Instream Habitat Assessment Project Manager, Washington State University*: Responsible for overall project management. Coordinates field surveys and field data collection. Manages data collection program and analysis. Primary author of written deliverables. Disseminates field data and communicates project status to Watershed Director, State of Washington Technical Team and Middle Snake WRIA 35 Watershed Planning Unit, and correspondingly incorporates suggestions into project design.

- *Michael Barber, Hydrologist and Technical Advisor, Washington State University*: Provides technical assistance in running overall project with specific contributions to hydrology and instream flow. Contributes to final written report.

- *John Foltz and Brandon Kruger, Field Technicians, Washington State University*: Conduct field surveys and responsible for data collection. Enter project data into electronic format.

<u>State of Washington Technical Team</u>

- *Mimi Wainwright, Watershed Lead, Washington State Department of Ecology*: Responsible for reviewing and approving the QAPP, reviewing and approving the project report, and interacting with stakeholders and interested members of the public.

- *Jim Pacheco, Water Resources Program, Washington State Department of Ecology*: Responsible for reviewing and approving the QAPP, as well as reviewing and approving the project report. Provide technical comments on hydrologic methods.

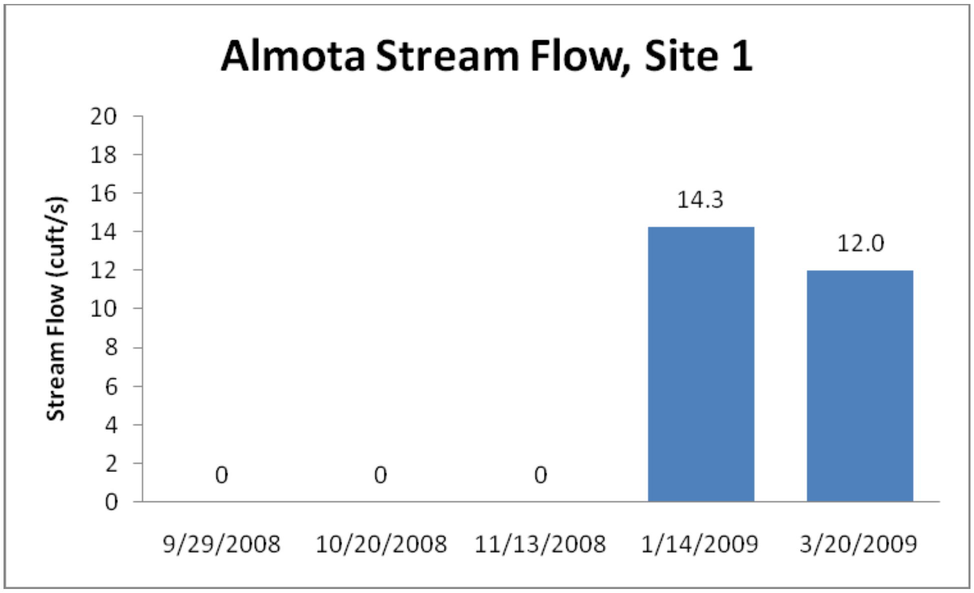
- *Terra Hegy, Habitat Program, Washington Department of Fish and Wildlife*: Responsible for reviewing and approving the QAPP, as well as reviewing and approving the project report. Provide technical comments on habitat assessment.

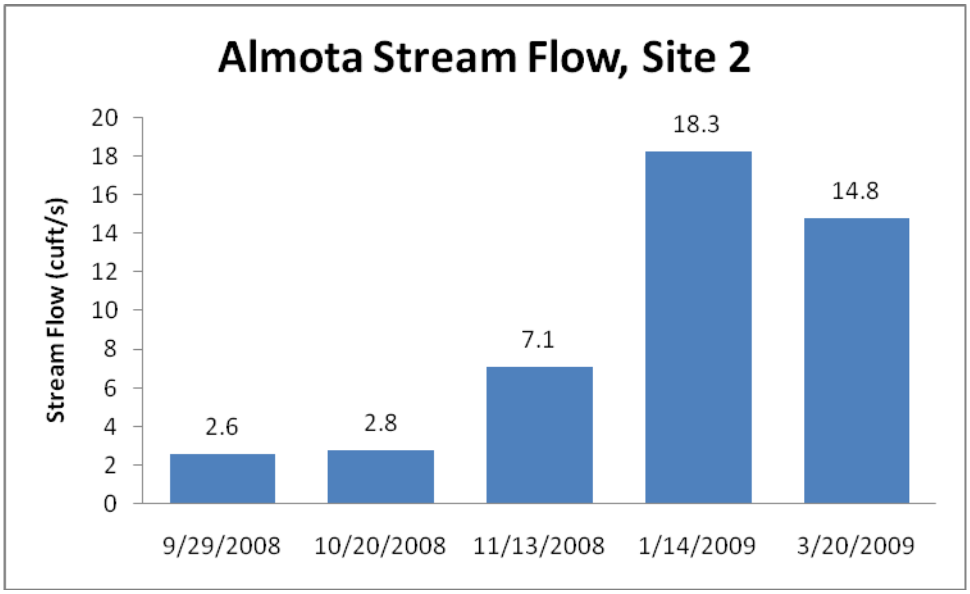
- *David Karl, Fish Management, Washington Department of Fish and Wildlife*: Responsible for reviewing and approving the QAPP, as well as reviewing and approving the project report. Provide technical comments in relation to fish populations.

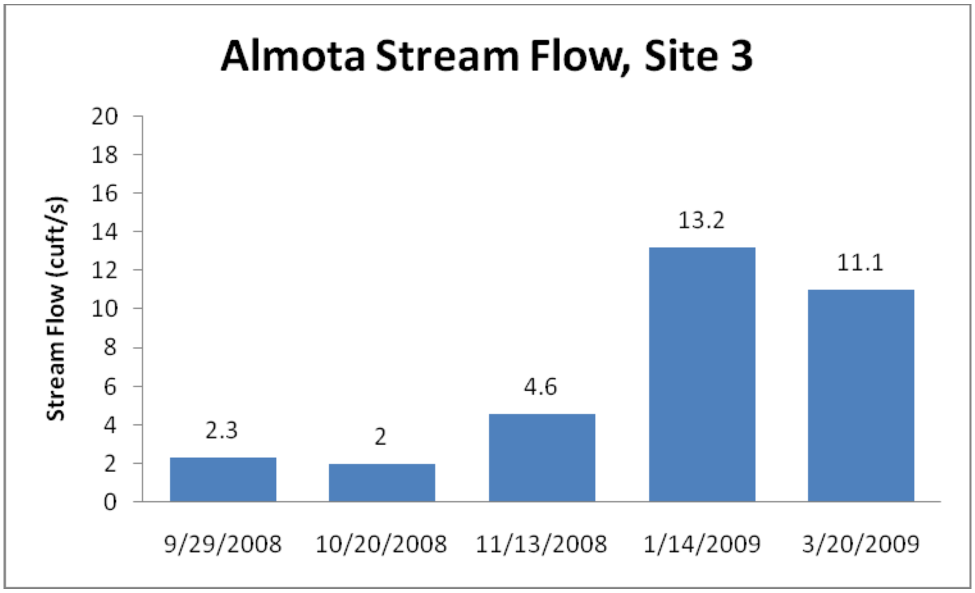
Results

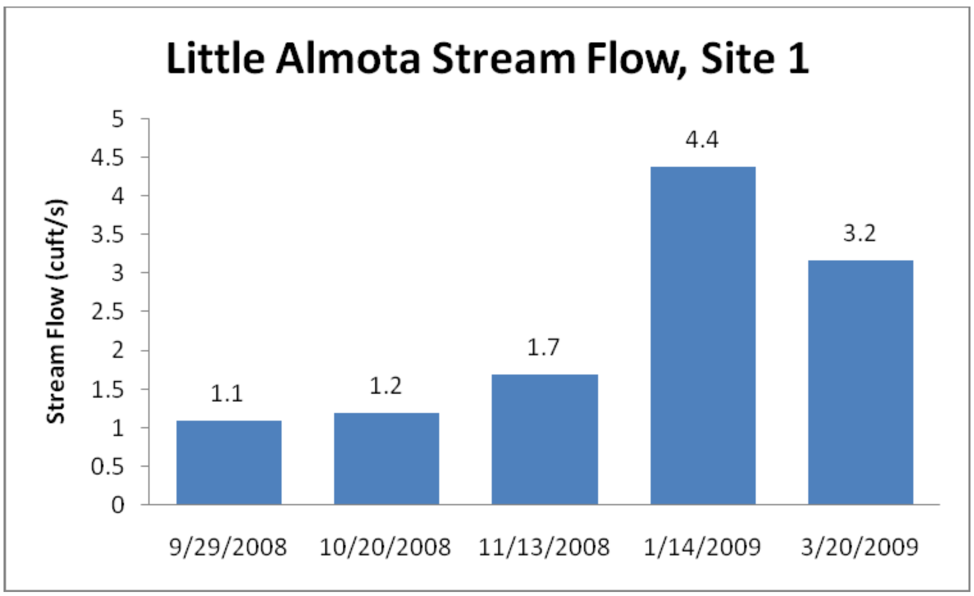
The following results are displayed for each location site, grouped by the respective streams. Dates of data collection are indicated on each graph.

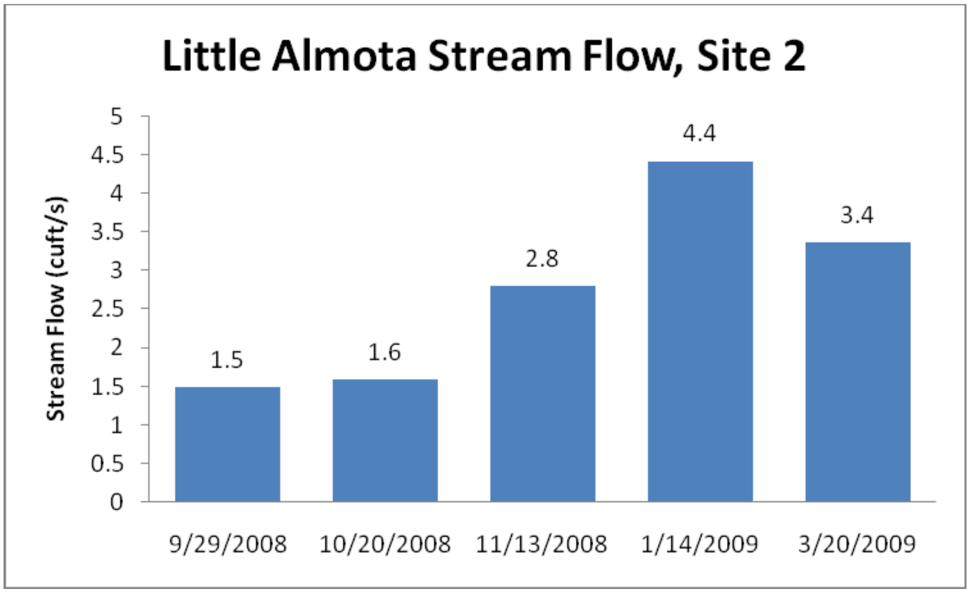
Almota Creek:

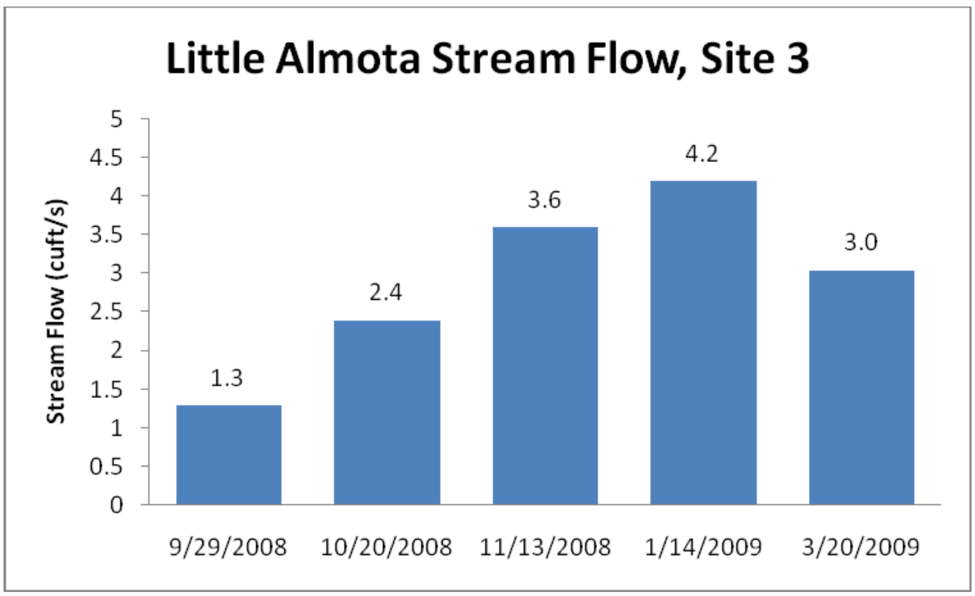




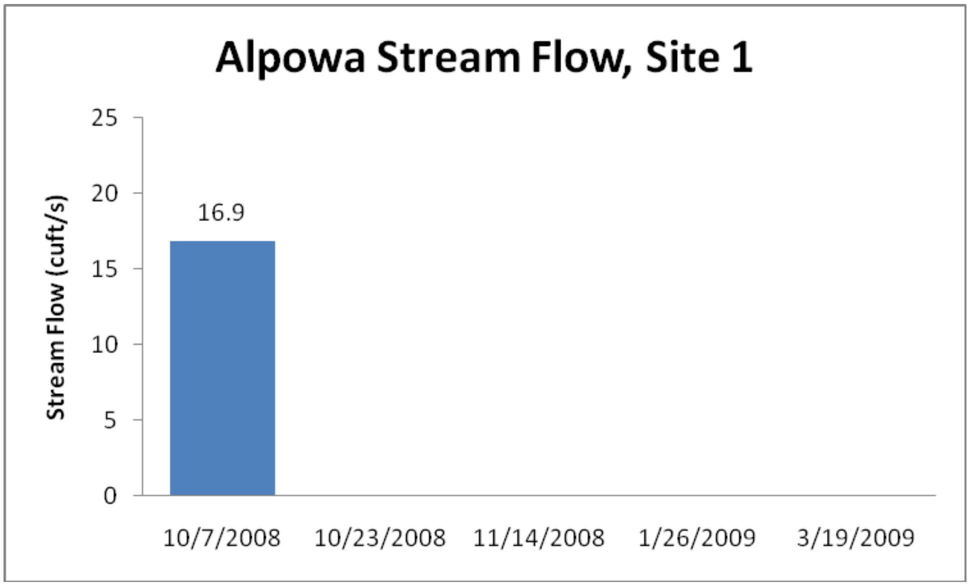

Almota Stream Flow, Site 3
Stream Flow (cuft/s)
20
18
16
14
12
10
8
6
4
2
0
2.3
2
4.6
13.2
11.1
9/29/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

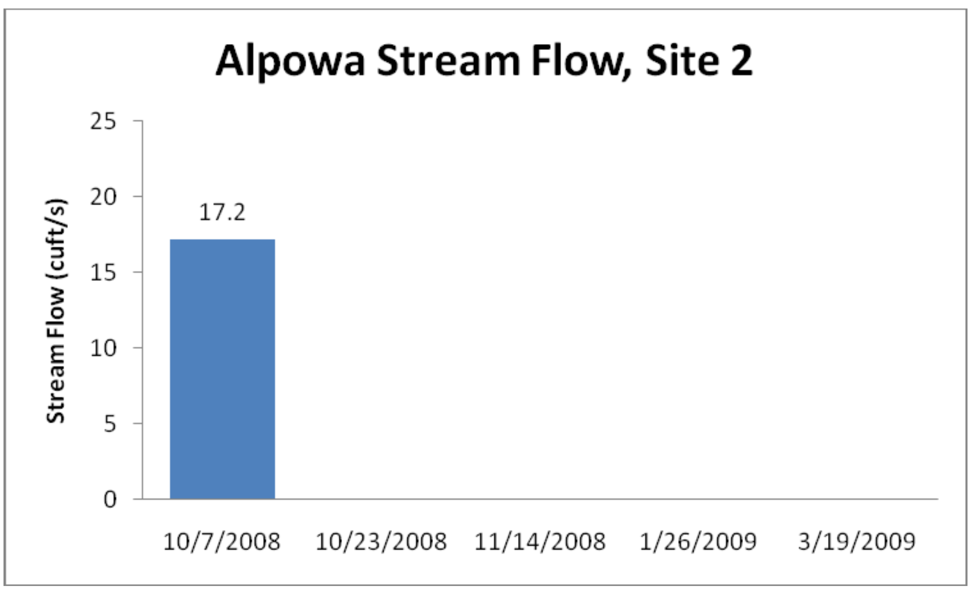

Little Almota Stream Flow, Site 1
Stream Flow (cuft/s)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1.1
1.2
1.7
4.4
3.2
9/29/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

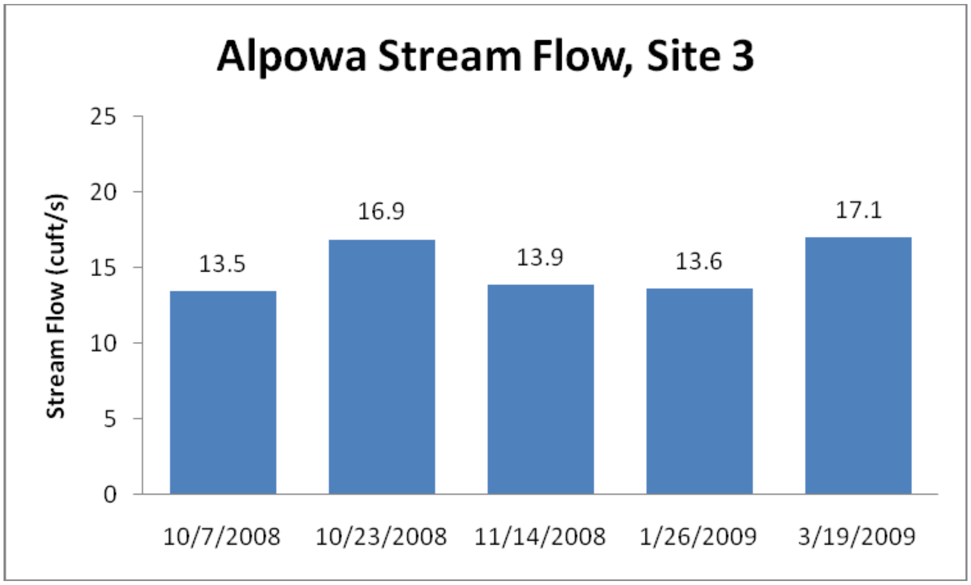

Little Almota Stream Flow, Site 2
Stream Flow (cuft/s)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1.5
1.6
2.8
4.4
3.4
9/29/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

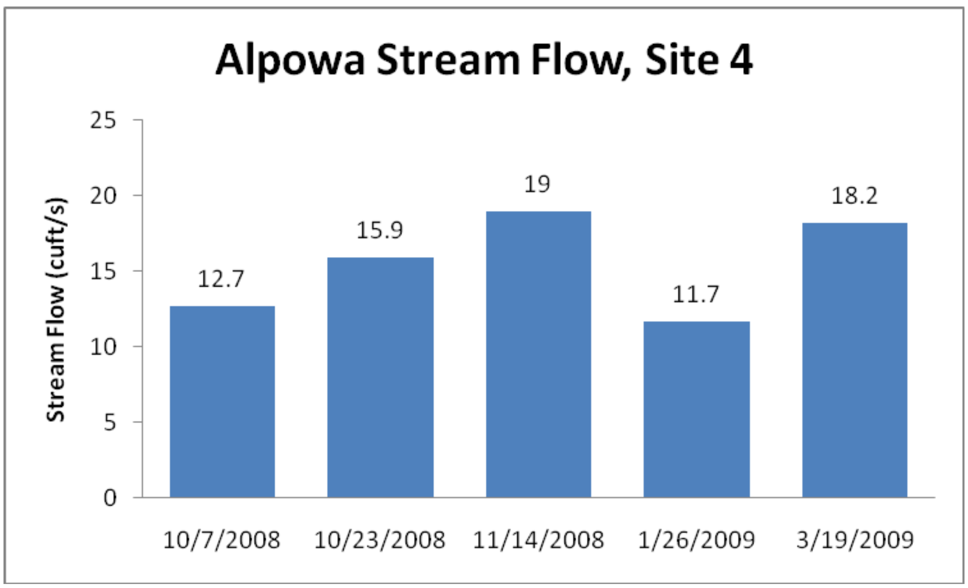

Little Almota Stream Flow, Site 3
Stream Flow (cuft/s)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1.3
2.4
3.6
4.2
3.0
9/29/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

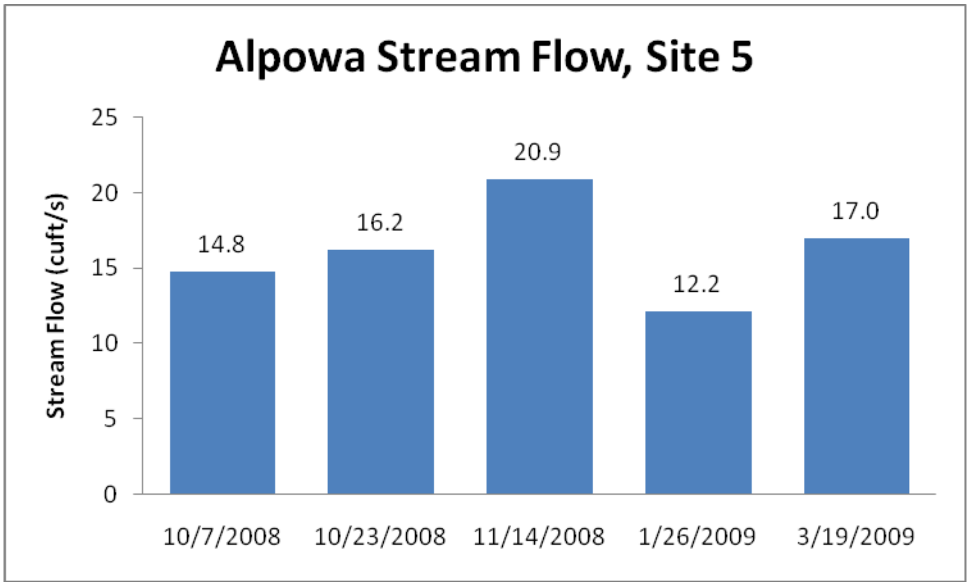
Alpowa Creek:

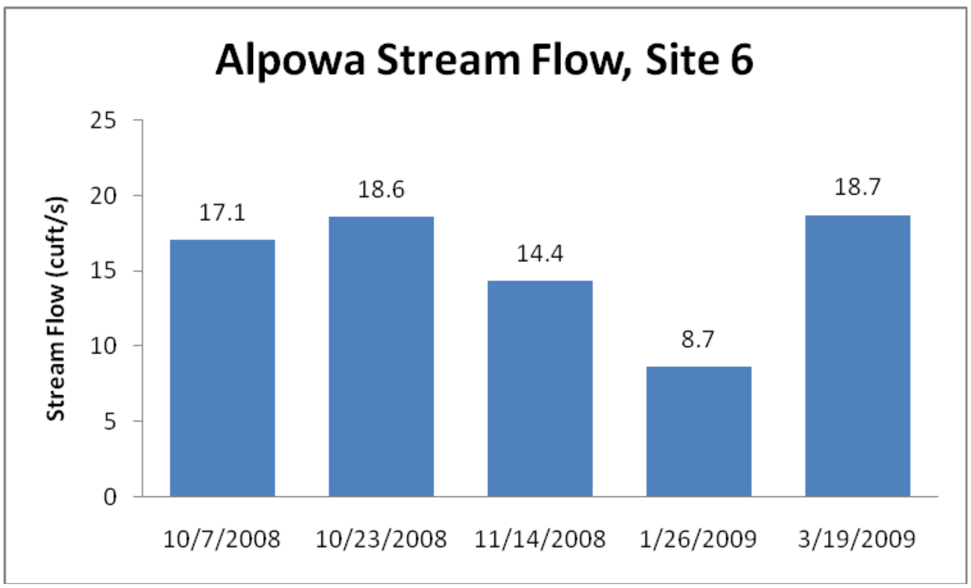


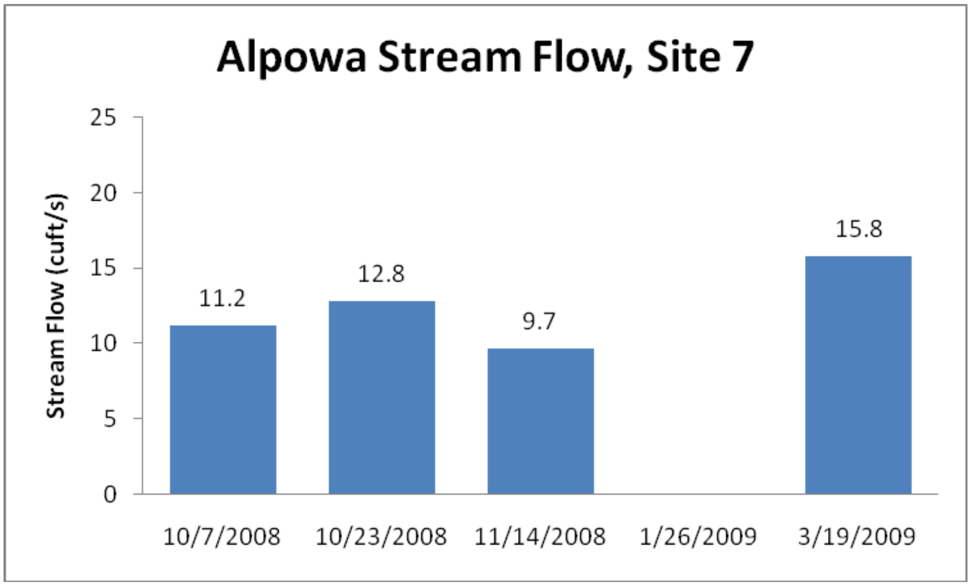


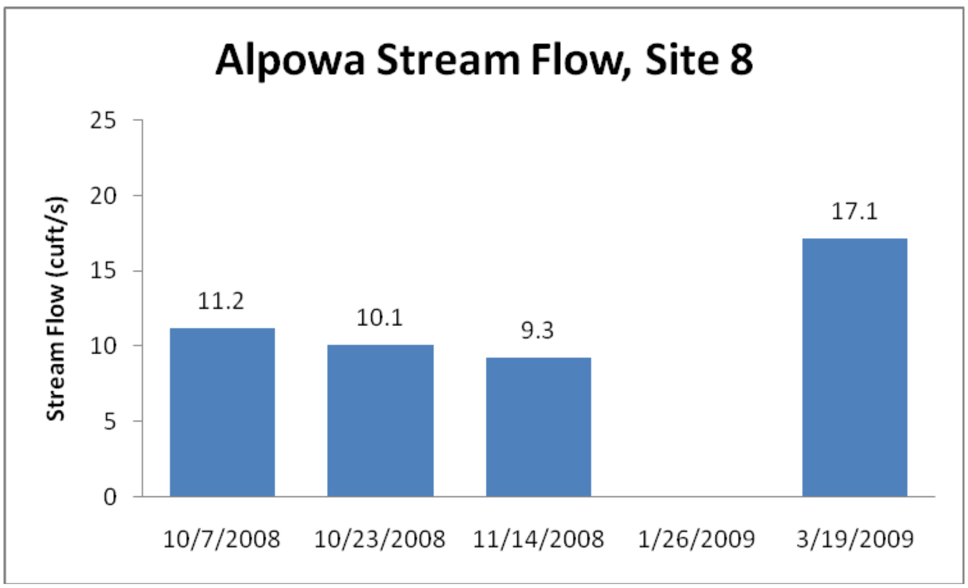

Alpowa Stream Flow, Site 3
Stream Flow (cuft/s)
25
20
15
10
5
0
13.5
16.9
13.9
13.6
17.1
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009


Alpowa Stream Flow, Site 4
Stream Flow (cuft/s)
25
20
15
10
5
0
12.7
15.9
19
11.7
18.2
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009

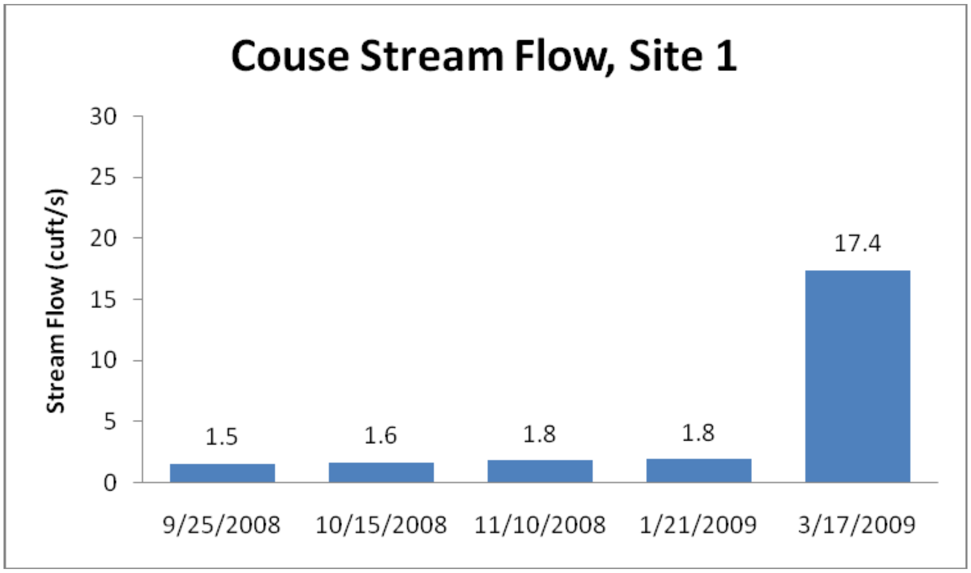

Alpowa Stream Flow, Site 5
Stream Flow (cuft/s)
25
20
15
10
5
0
14.8
16.2
20.9
12.2
17.0
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009


Alpowa Stream Flow, Site 6
Stream Flow (cuft/s)
25
20
15
10
5
0
17.1
18.6
14.4
8.7
18.7
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009

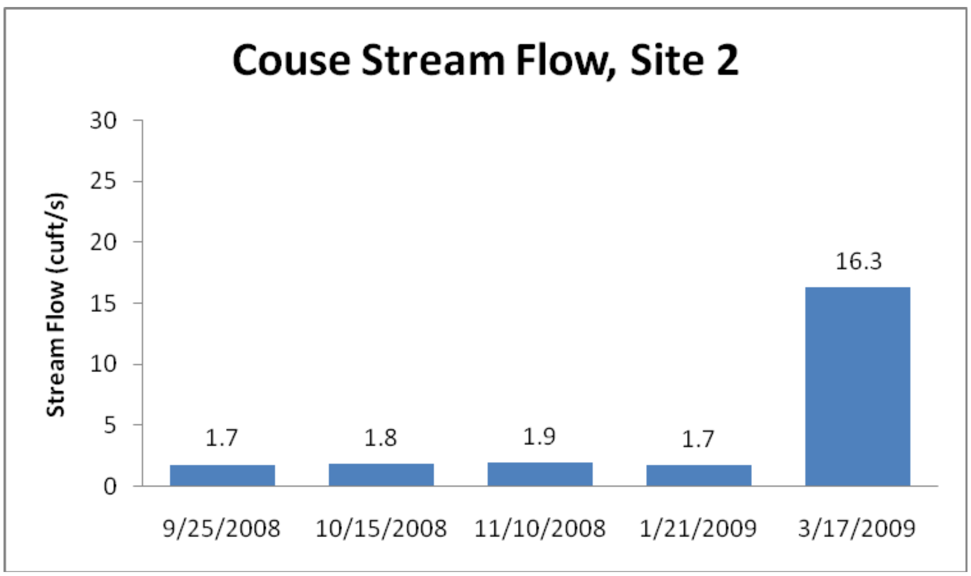

Alpowa Stream Flow, Site 7
Stream Flow (cuft/s)
25
20
15
10
5
0
11.2
12.8
9.7
15.8
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009


Alpowa Stream Flow, Site 8
Stream Flow (cuft/s)
25
20
15
10
5
0
11.2
10.1
9.3
17.1
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009

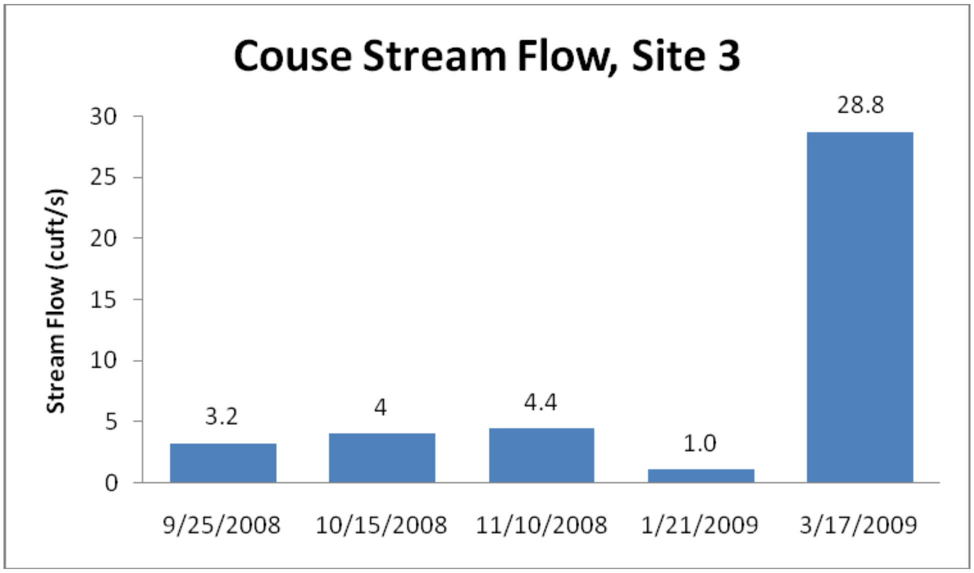
Couse Creek:

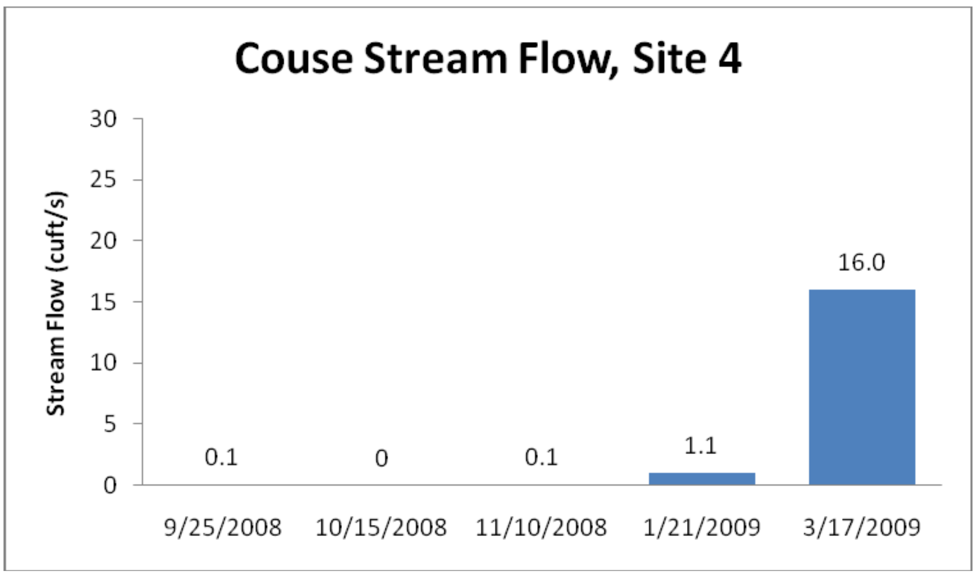


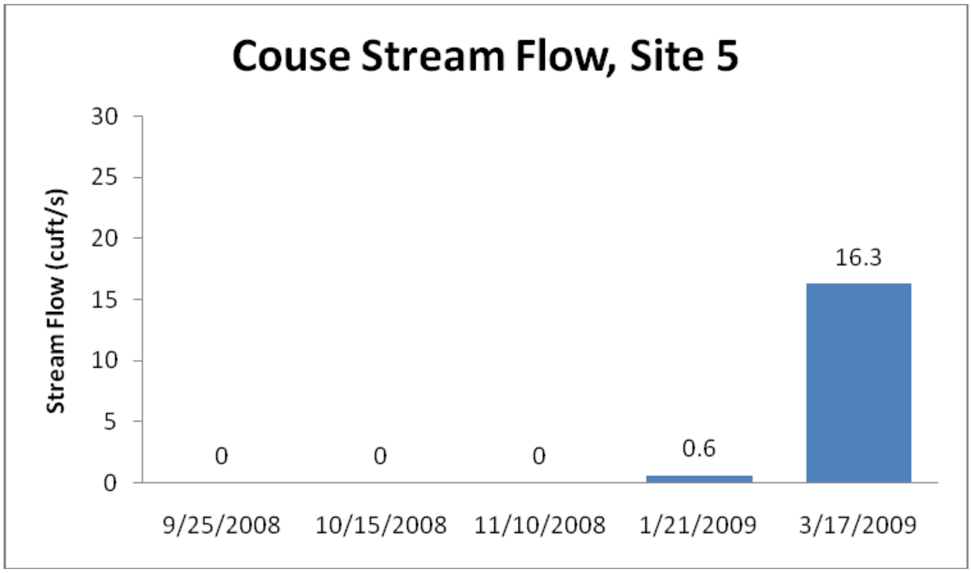
Couse Stream Flow, Site 1
Stream Flow (cuft/s)
30
25
20
15
10
5
0
1.5
1.6
1.8
1.8
17.4
9/25/2008
10/15/2008
11/10/2008
1/21/2009
3/17/2009

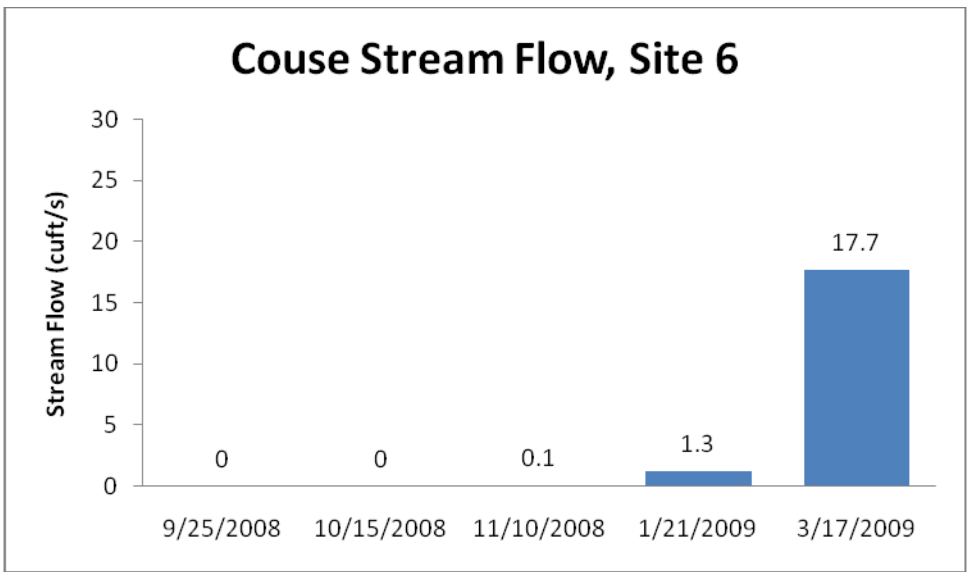


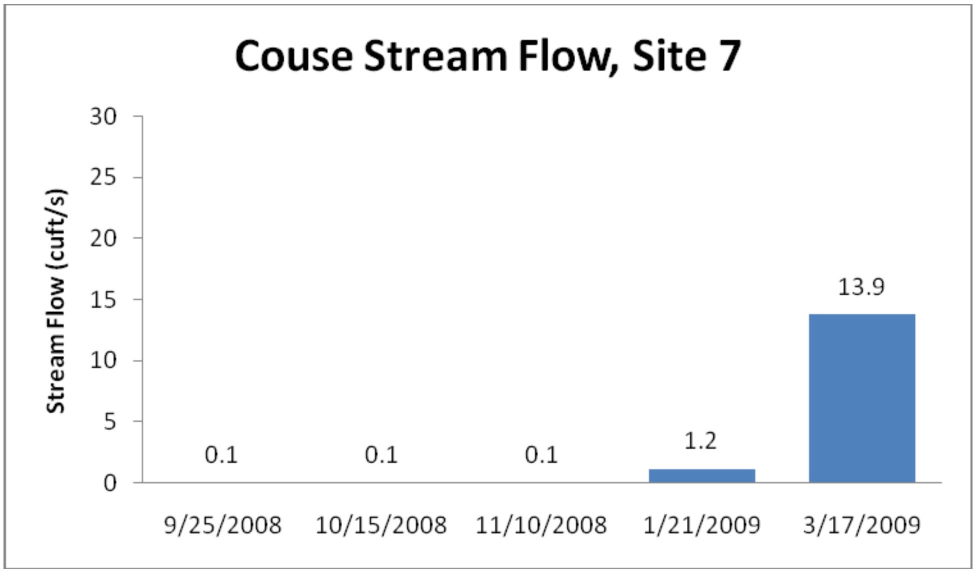
Couse Stream Flow, Site 2
Stream Flow (cuft/s)
30
25
20
15
10
5
0
1.7
1.8
1.9
1.7
16.3
9/25/2008
10/15/2008
11/10/2008
1/21/2009
3/17/2009


Couse Stream Flow, Site 3
Stream Flow (cuft/s)
30
25
20
15
10
5
0
3.2
4
4.4
1.0
28.8
9/25/2008
10/15/2008
11/10/2008
1/21/2009
3/17/2009

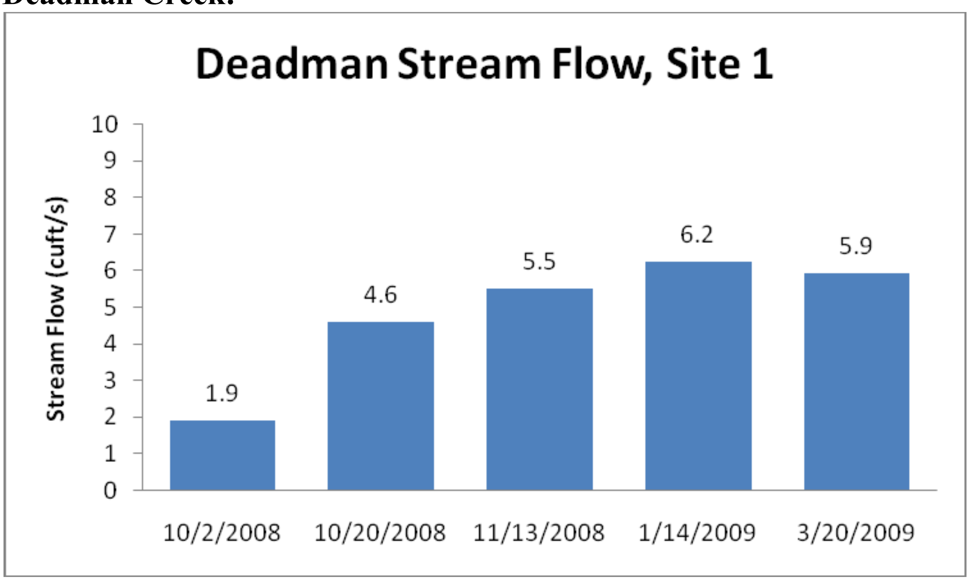

Couse Stream Flow, Site 4
Stream Flow (cuft/s)
30
25
20
15
10
5
0
0.1
0
0.1
1.1
16.0
9/25/2008
10/15/2008
11/10/2008
1/21/2009
3/17/2009

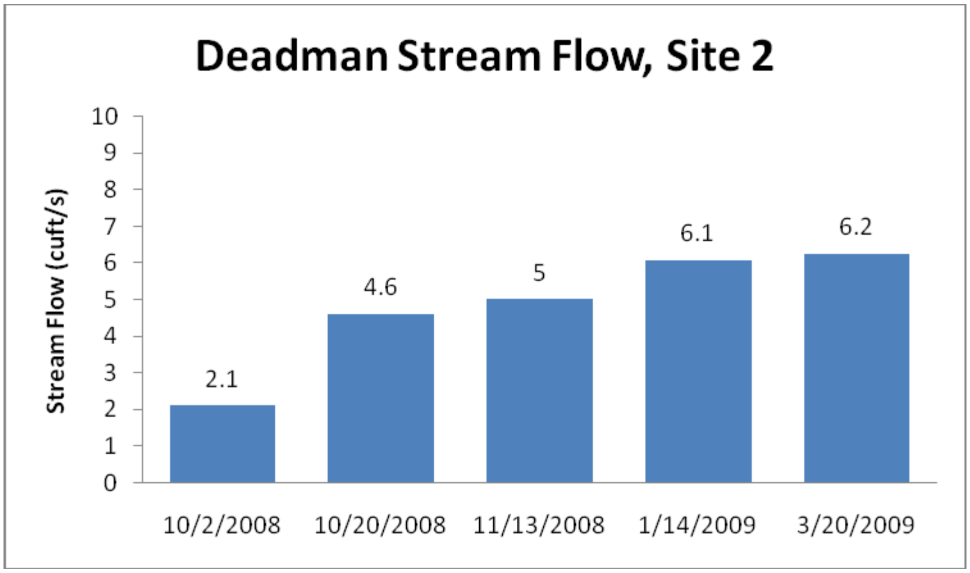

Couse Stream Flow, Site 5
Stream Flow (cuft/s)
30
25
20
15
10
5
0
0
0
0
0.6
16.3
9/25/2008
10/15/2008
11/10/2008
1/21/2009
3/17/2009

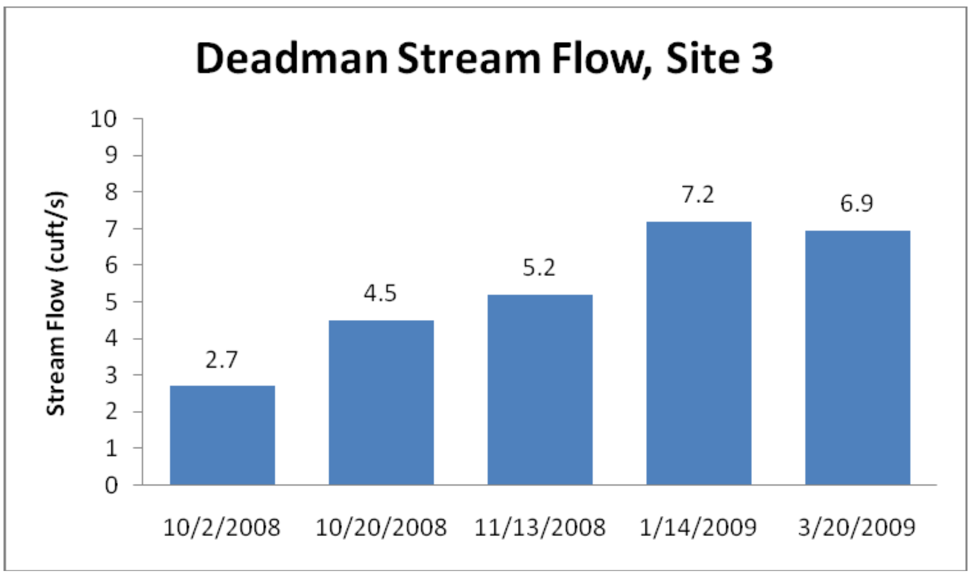

Couse Stream Flow, Site 6
Stream Flow (cuft/s)
30
25
20
15
10
5
0
0
0
0.1
1.3
17.7
9/25/2008
10/15/2008
11/10/2008
1/21/2009
3/17/2009

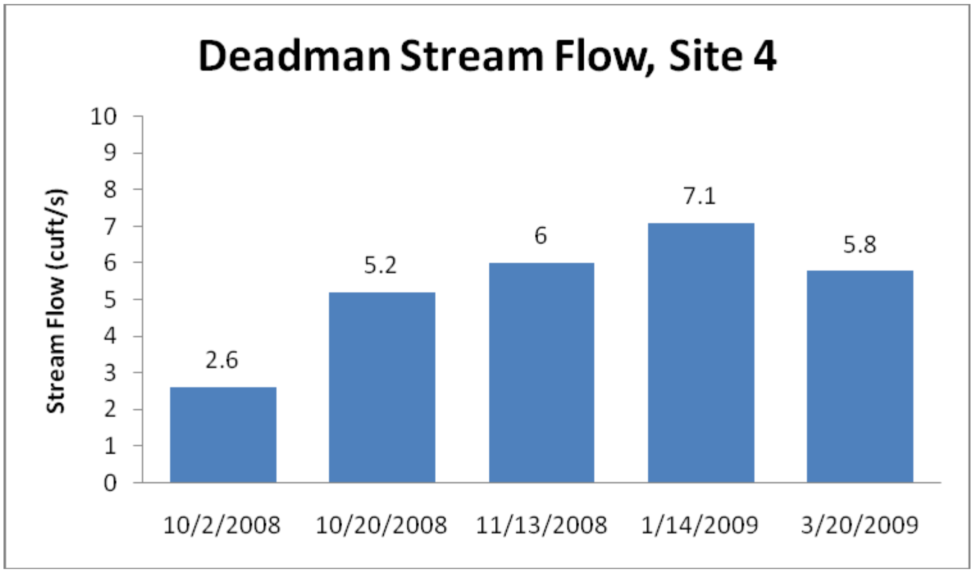


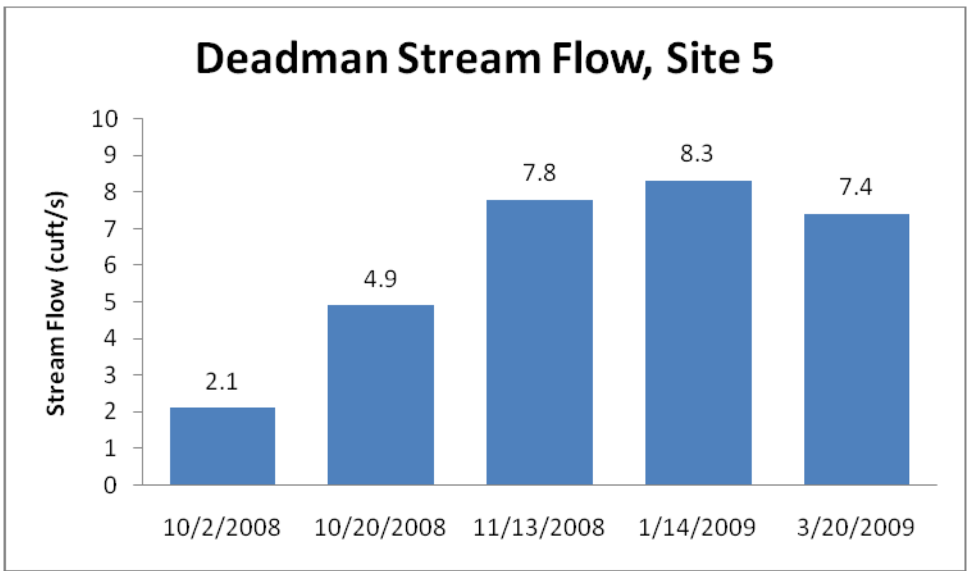
Deadman Creek:

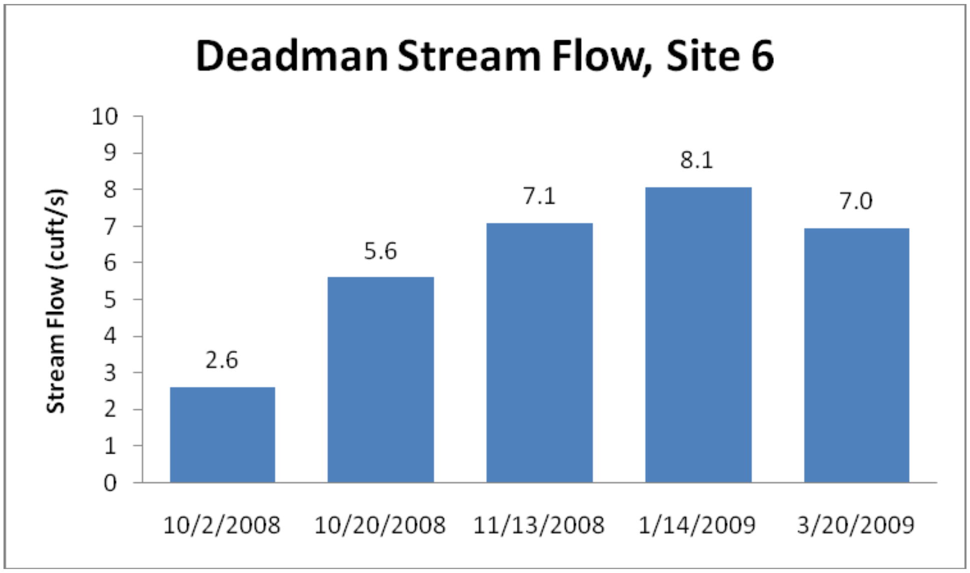


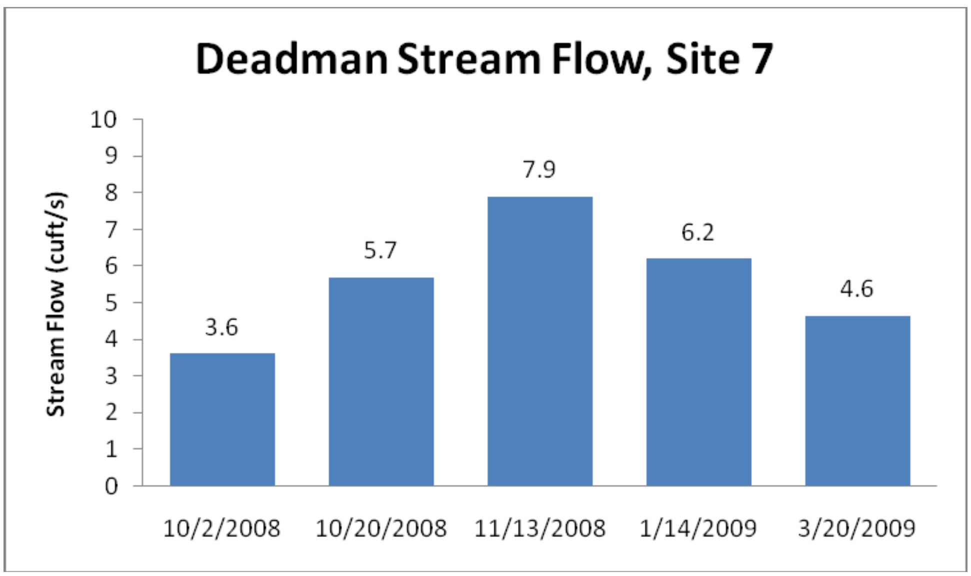

Deadman Stream Flow, Site 2
Stream Flow (cuft/s)
10
9
8
7
6
5
4
3
2
1
0
2.1
4.6
5
6.1
6.2
10/2/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

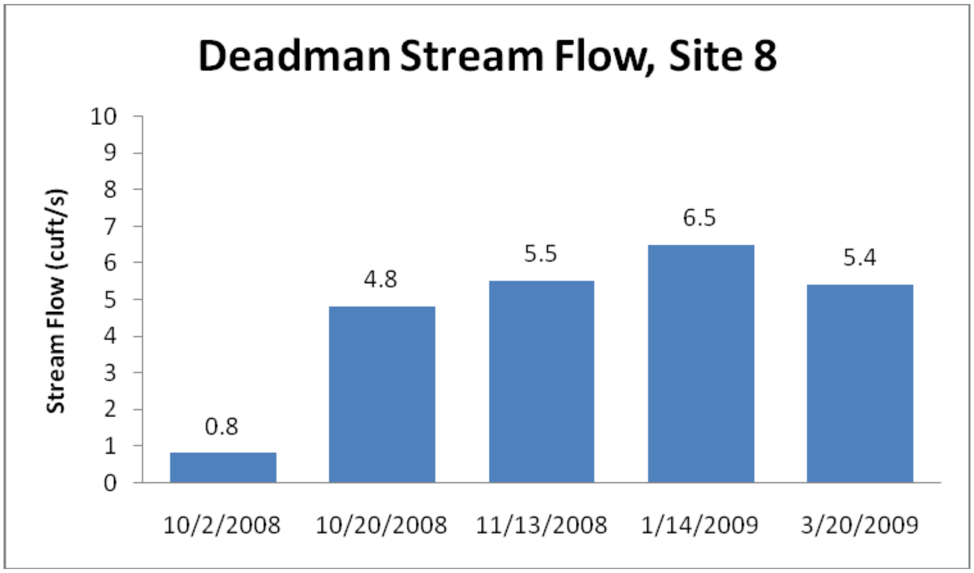

Deadman Stream Flow, Site 3
Stream Flow (cuft/s)
10
9
8
7
6
5
4
3
2
1
0
2.7
4.5
5.2
7.2
6.9
10/2/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009


Deadman Stream Flow, Site 4
Stream Flow (cuft/s)
10
9
8
7
6
5
4
3
2
1
0
2.6
5.2
6
7.1
5.8
10/2/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

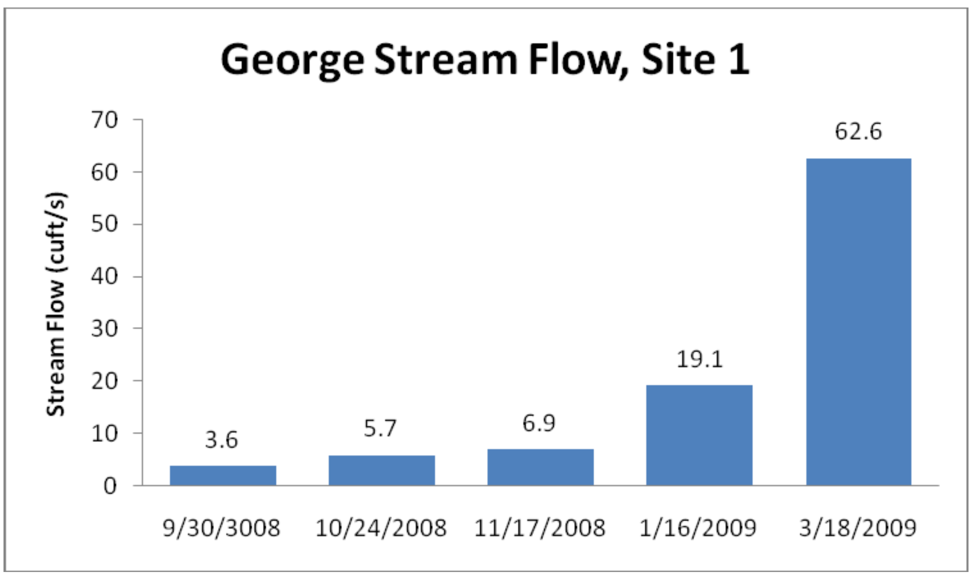

Deadman Stream Flow, Site 5
Stream Flow (cuft/s)
10
9
8
7
6
5
4
3
2
1
0
2.1
4.9
7.8
8.3
7.4
10/2/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

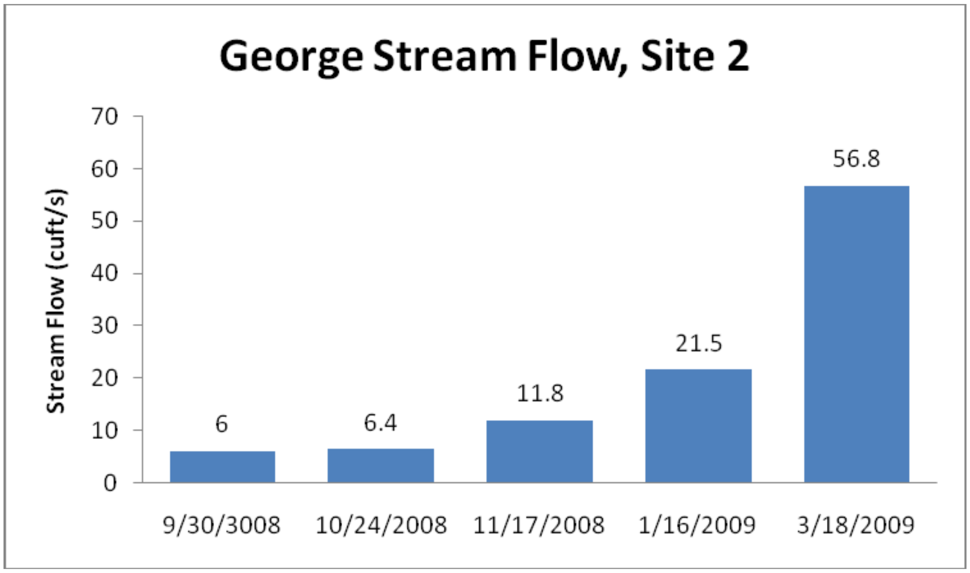

Deadman Stream Flow, Site 6
Stream Flow (cuft/s)
10
9
8
7
6
5
4
3
2
1
0
2.6
5.6
7.1
8.1
7.0
10/2/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

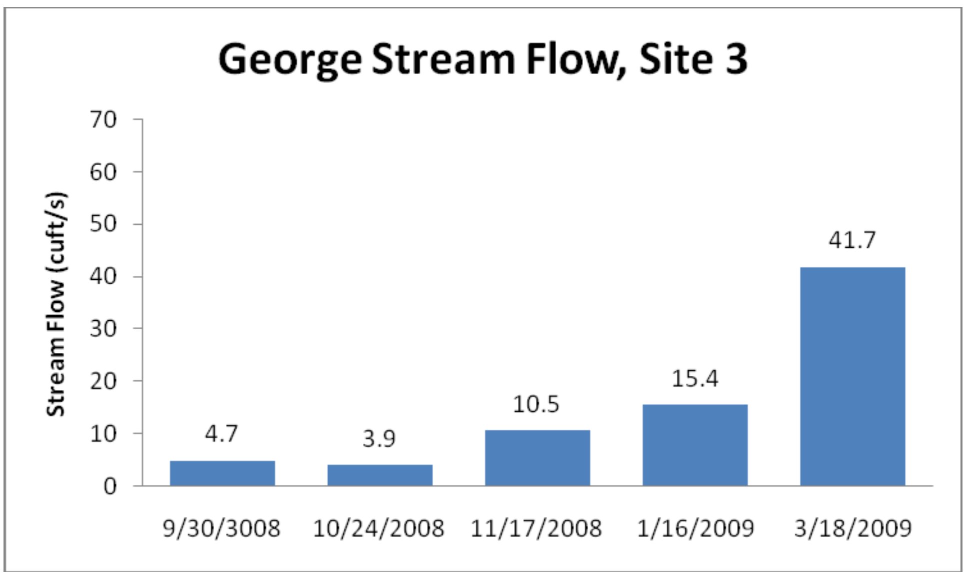

Deadman Stream Flow, Site 7
Stream Flow (cuft/s)
10
9
8
7
6
5
4
3
2
1
0
3.6
5.7
7.9
6.2
4.6
10/2/2008
10/20/2008
11/13/2008
1/14/2009
3/20/2009

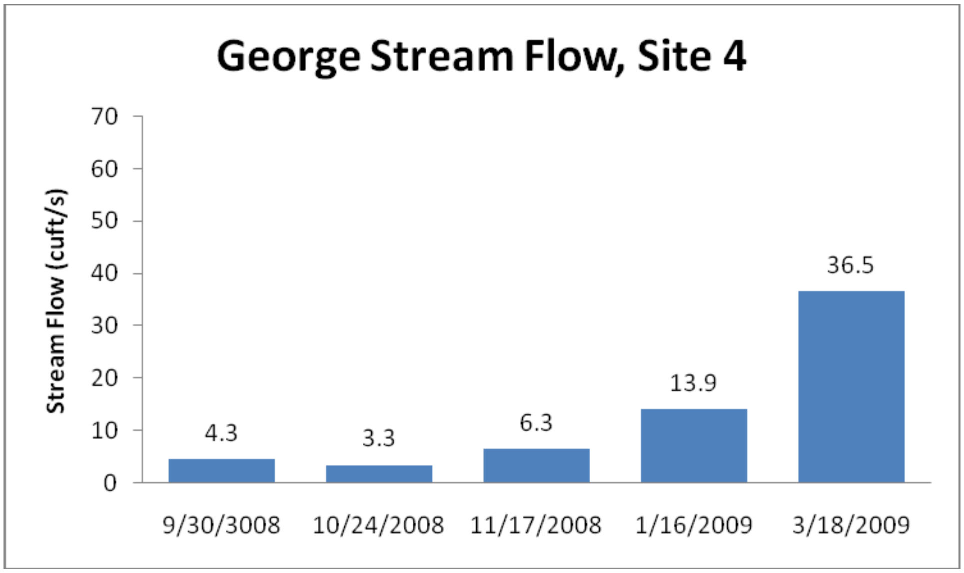


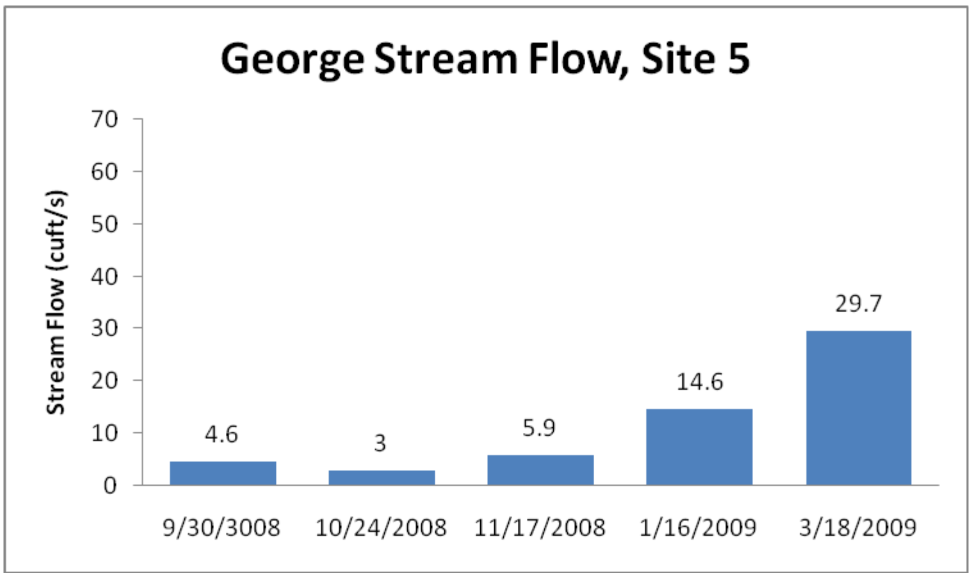
George Creek:

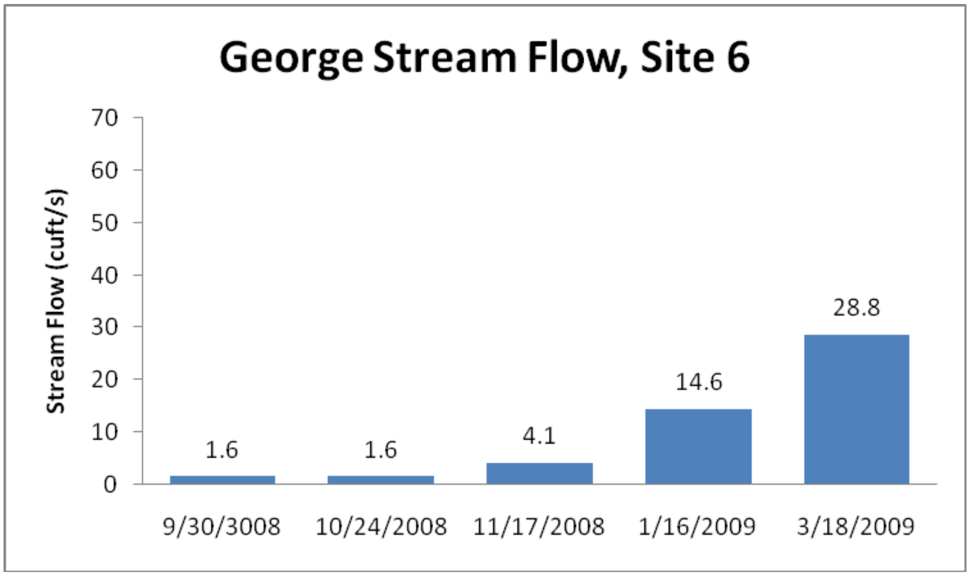


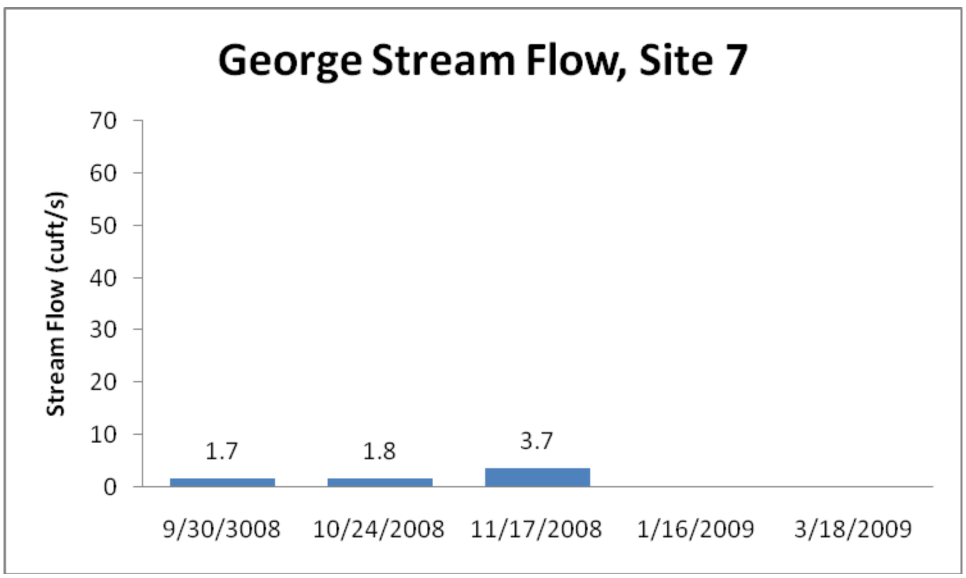

George Stream Flow, Site 2
Stream Flow (cuft/s)
70
60
50
40
30
20
10
0
6
6.4
11.8
21.5
56.8
9/30/3008
10/24/2008
11/17/2008
1/16/2009
3/18/2009

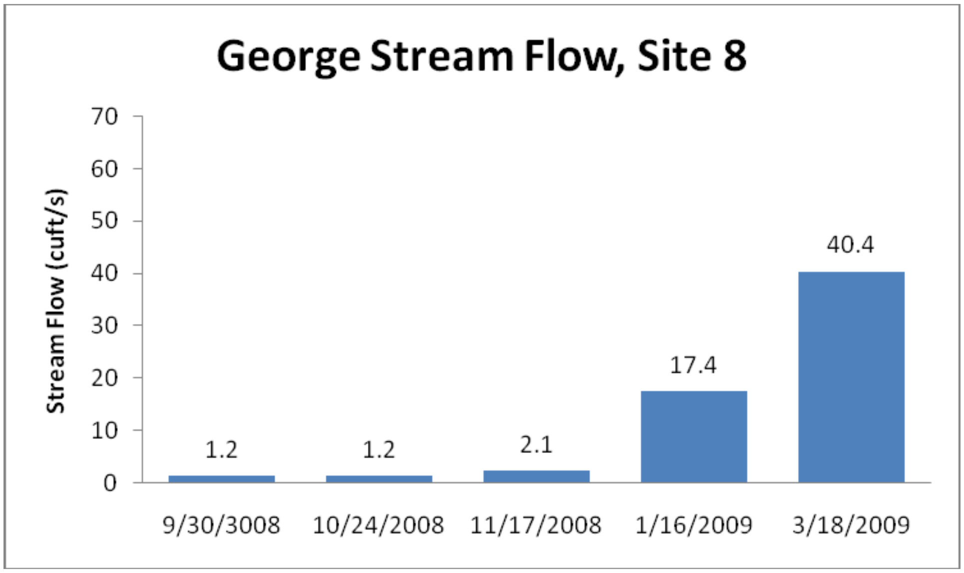

George Stream Flow, Site 3
Stream Flow (cuft/s)
70
60
50
40
30
20
10
0
4.7
3.9
10.5
15.4
41.7
9/30/3008
10/24/2008
11/17/2008
1/16/2009
3/18/2009


George Stream Flow, Site 4
Stream Flow (cuft/s)
70
60
50
40
30
20
10
0
4.3
3.3
6.3
13.9
36.5
9/30/3008
10/24/2008
11/17/2008
1/16/2009
3/18/2009

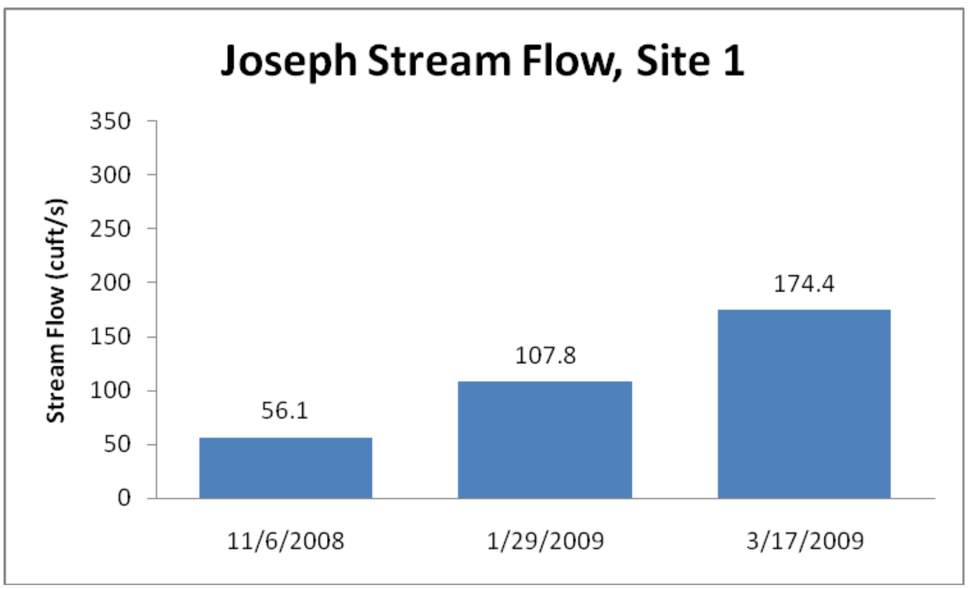

George Stream Flow, Site 5
Stream Flow (cuft/s)
70
60
50
40
30
20
10
0
4.6
3
5.9
14.6
29.7
9/30/3008
10/24/2008
11/17/2008
1/16/2009
3/18/2009

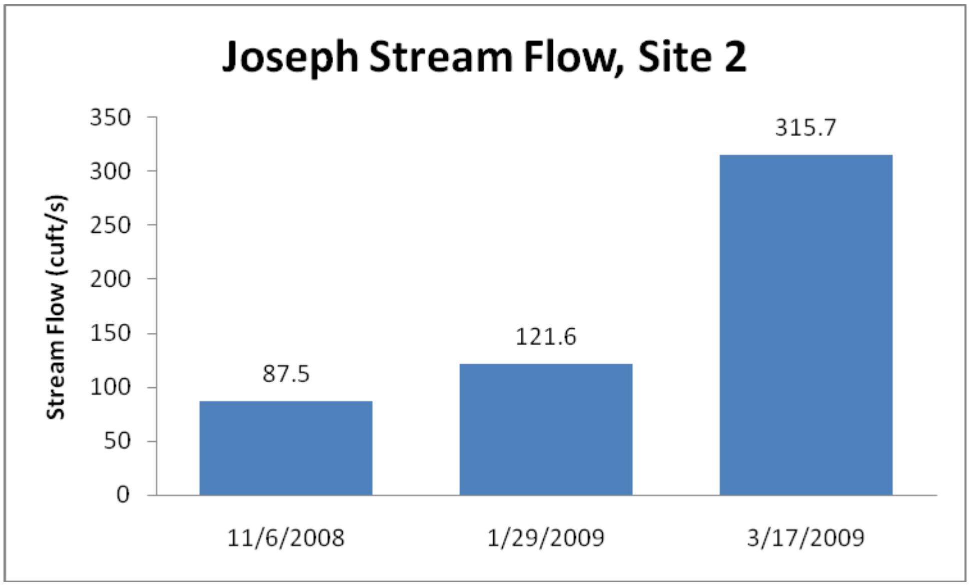

George Stream Flow, Site 6
Stream Flow (cuft/s)
70
60
50
40
30
20
10
0
1.6
1.6
4.1
14.6
28.8
9/30/3008
10/24/2008
11/17/2008
1/16/2009
3/18/2009

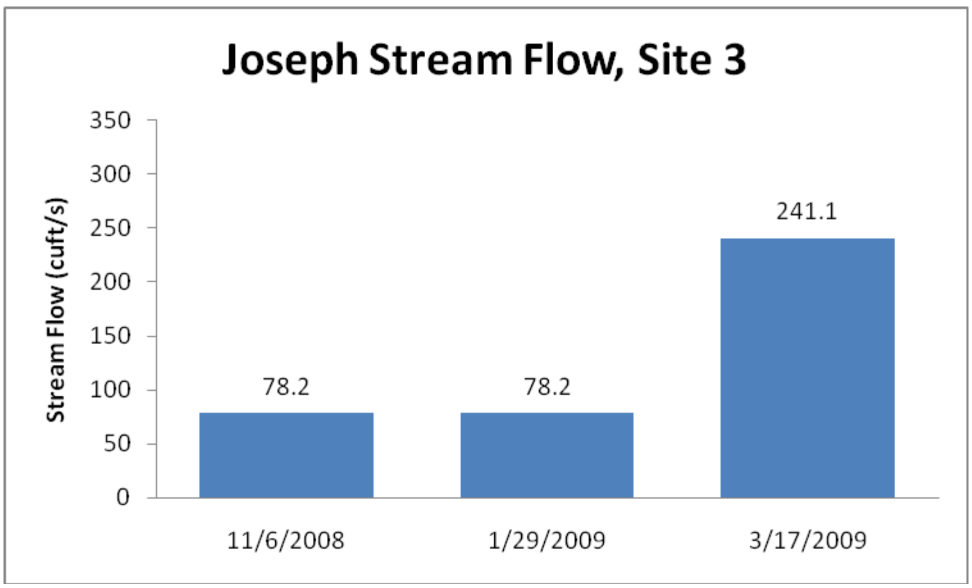

George Stream Flow, Site 7
Stream Flow (cuft/s)
70
60
50
40
30
20
10
0
1.7
1.8
3.7
9/30/3008
10/24/2008
11/17/2008
1/16/2009
3/18/2009

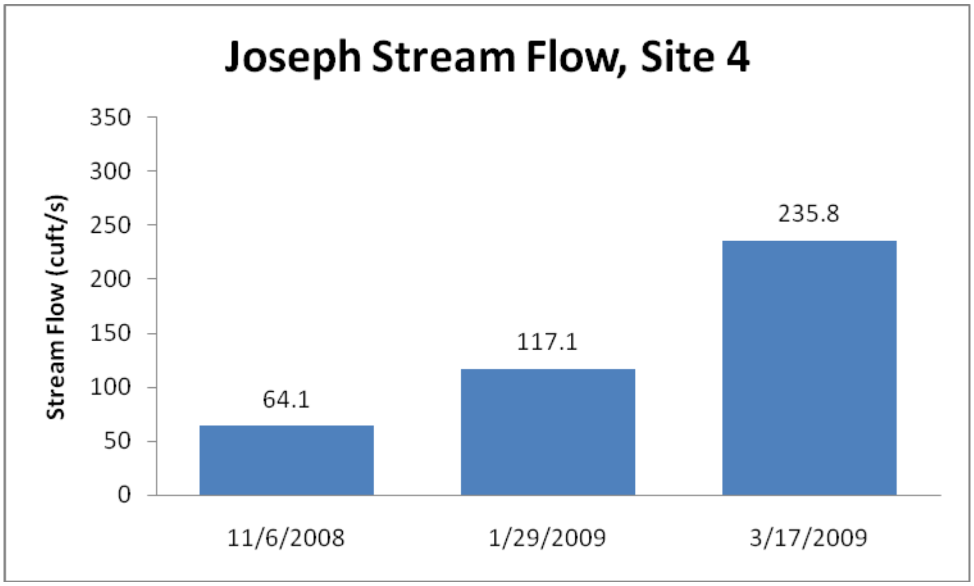


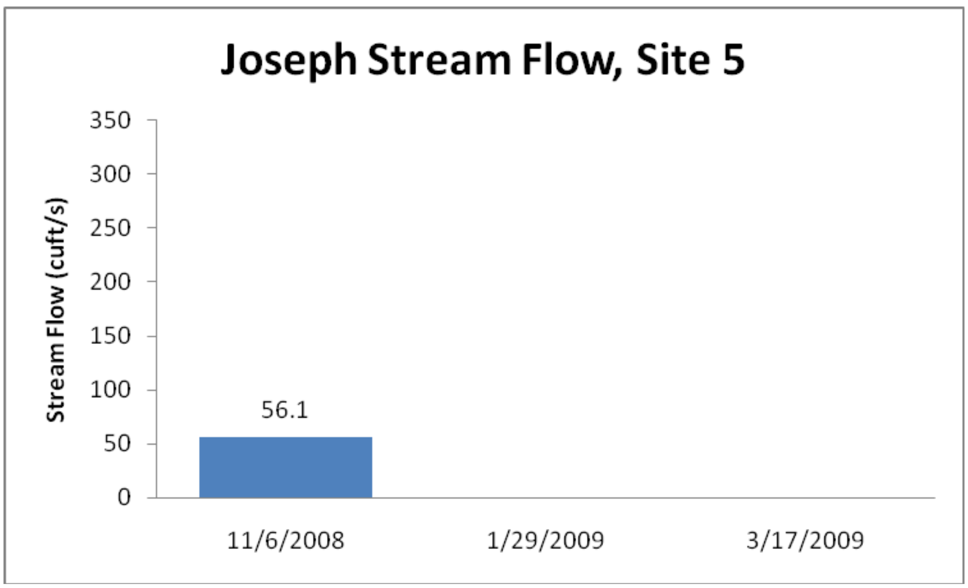
Joseph Creek:

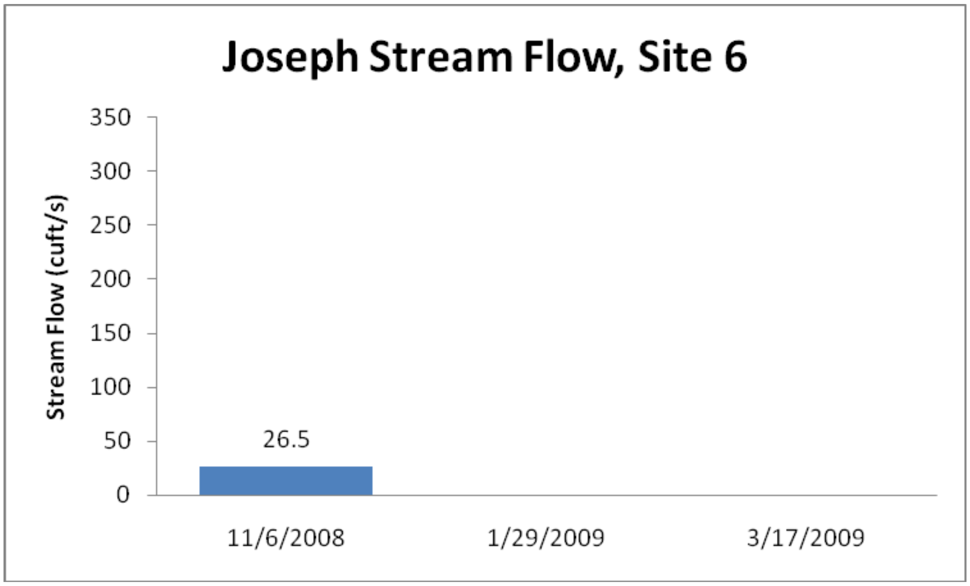


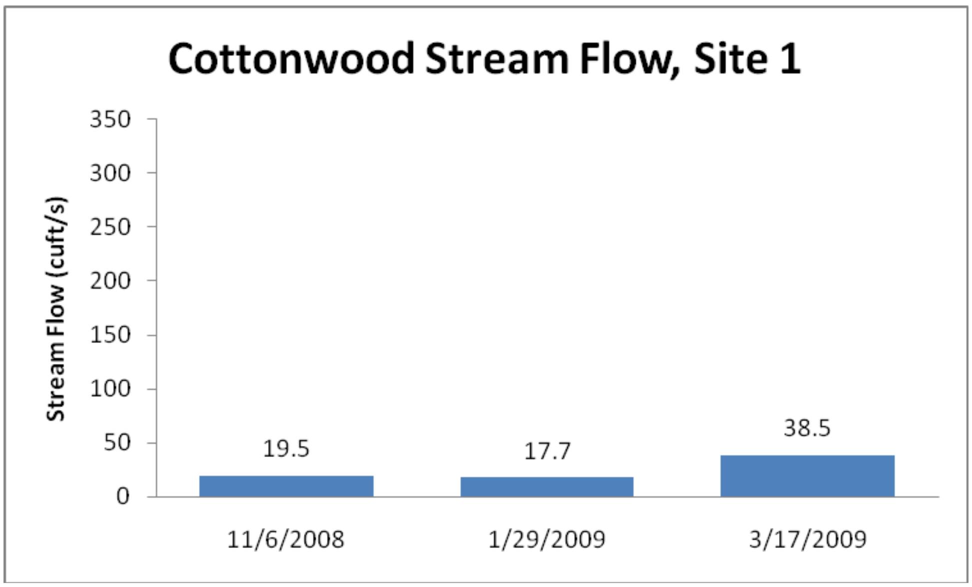

Joseph Stream Flow, Site 2
Stream Flow (cuft/s)
350
300
250
200
150
100
50
0
87.5
121.6
315.7
11/6/2008
1/29/2009
3/17/2009

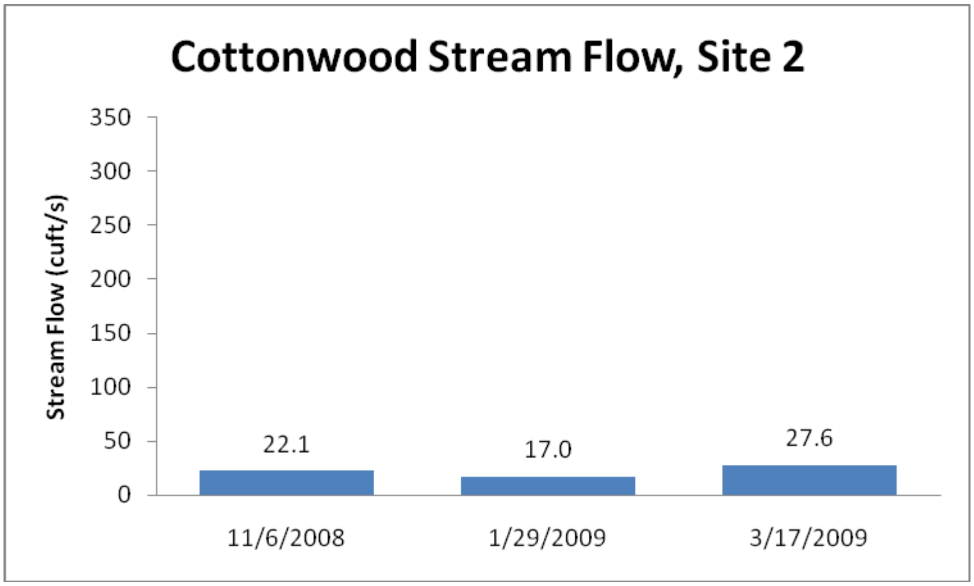

Joseph Stream Flow, Site 3
Stream Flow (cuft/s)
350
300
250
200
150
100
50
0
78.2
78.2
241.1
11/6/2008
1/29/2009
3/17/2009


Joseph Stream Flow, Site 4
Stream Flow (cuft/s)
350
300
250
200
150
100
50
0
64.1
117.1
235.8
11/6/2008
1/29/2009
3/17/2009

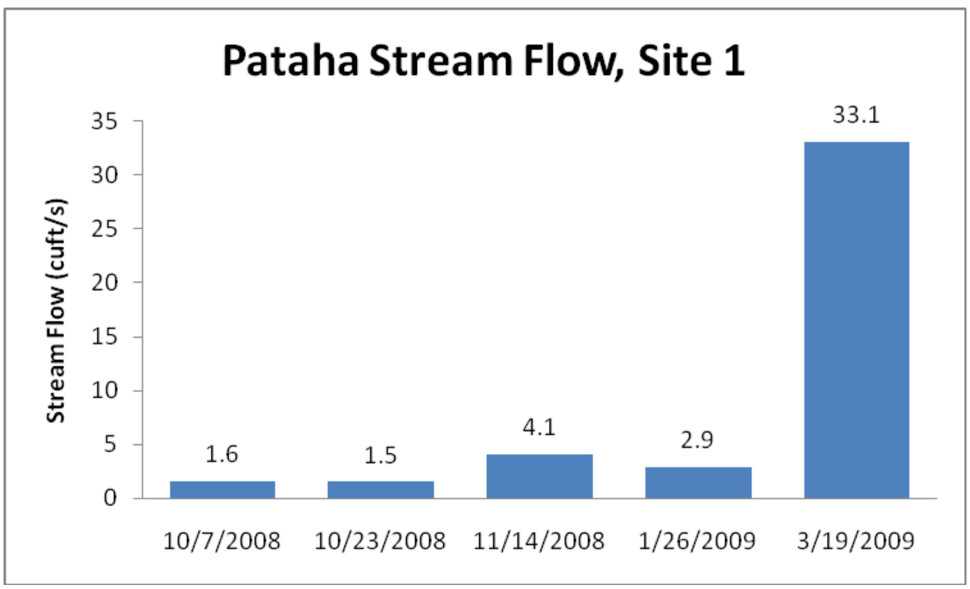

Joseph Stream Flow, Site 5
Stream Flow (cuft/s)
350
300
250
200
150
100
50
0
56.1
11/6/2008
1/29/2009
3/17/2009

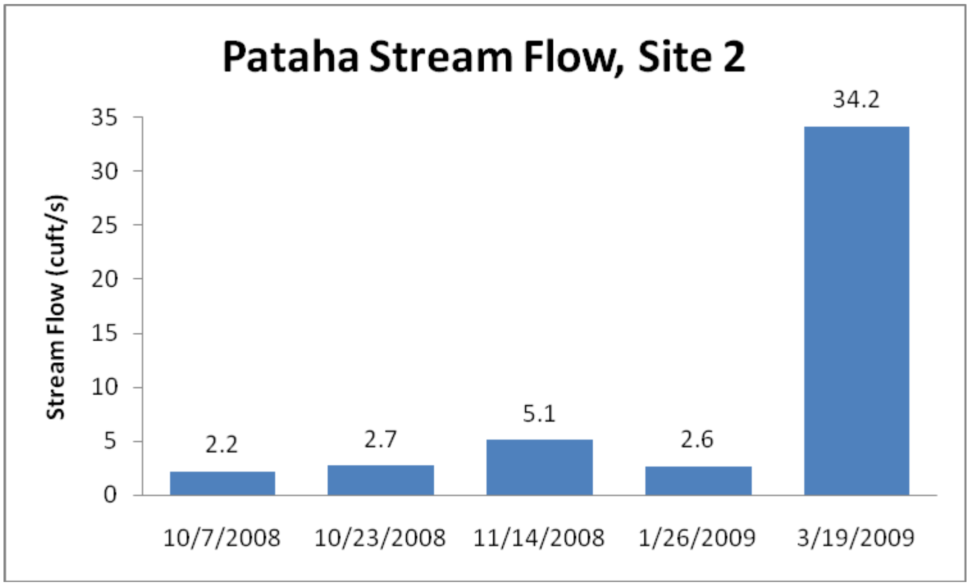

Joseph Stream Flow, Site 6
Stream Flow (cuft/s)
350
300
250
200
150
100
50
0
26.5
11/6/2008
1/29/2009
3/17/2009

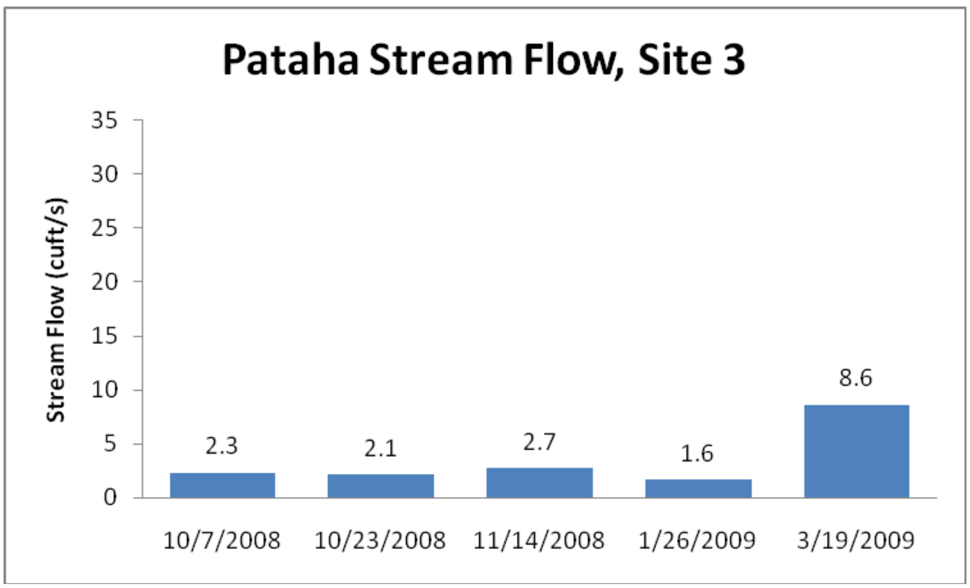

Cottonwood Stream Flow, Site 1
Stream Flow (cuft/s)
350
300
250
200
150
100
50
0
19.5
17.7
38.5
11/6/2008
1/29/2009
3/17/2009

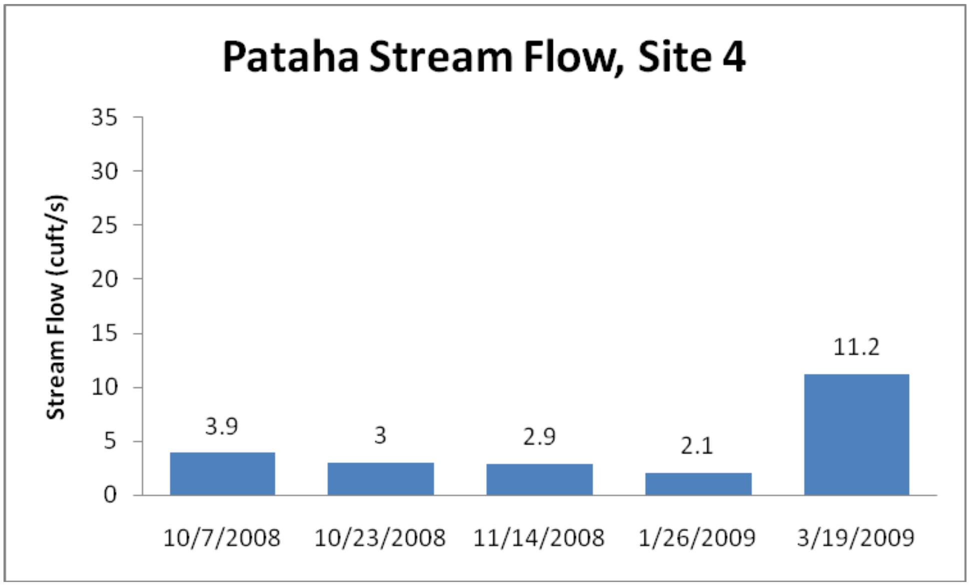


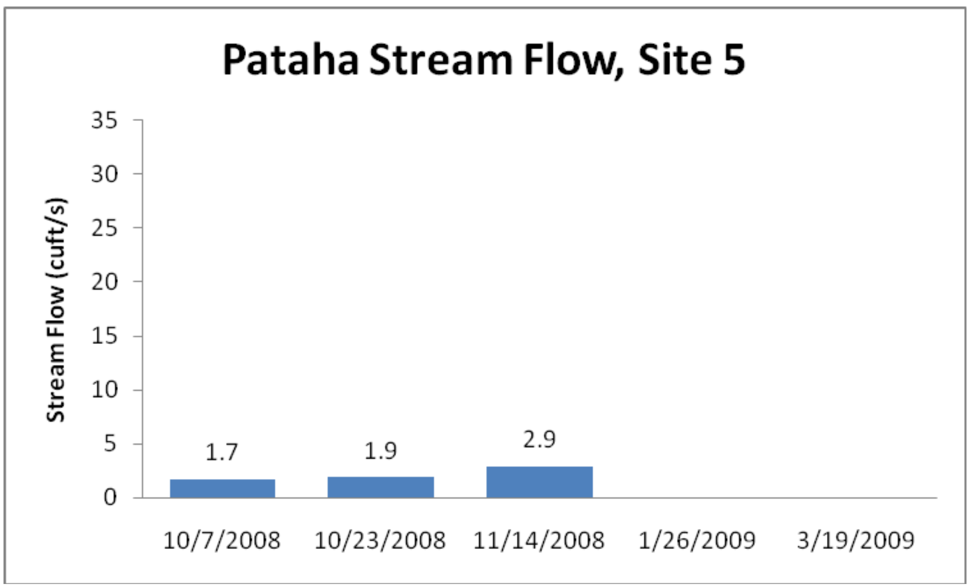
Pataha Creek:

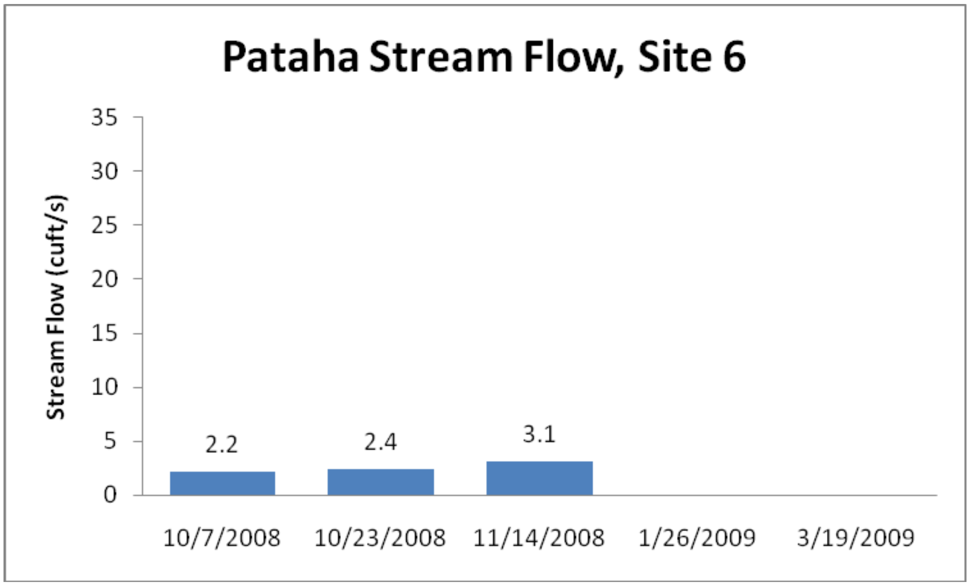



Pataha Stream Flow, Site 2
Stream Flow (cuft/s)
35
30
25
20
15
10
5
0
2.2
2.7
5.1
2.6
34.2
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009

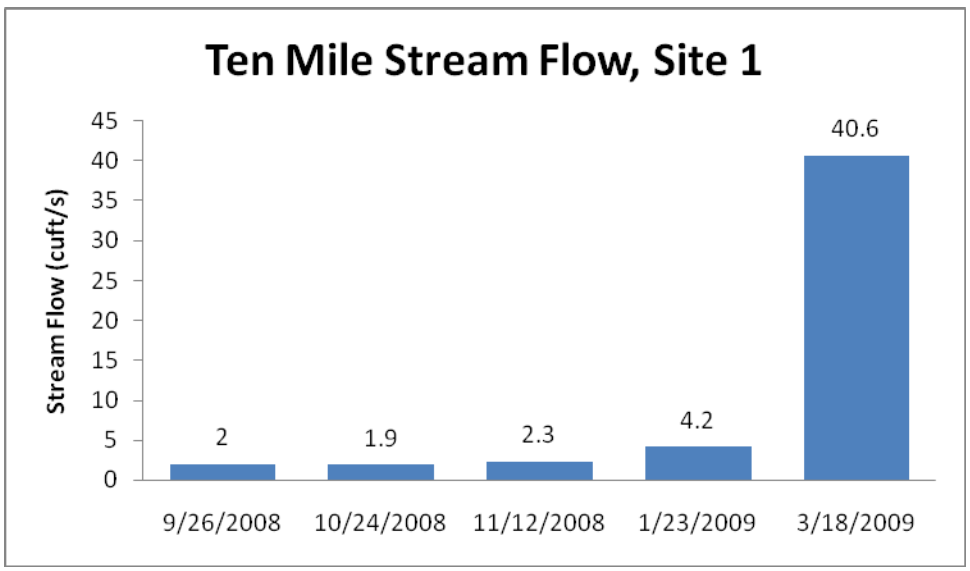

Pataha Stream Flow, Site 3
Stream Flow (cuft/s)
35
30
25
20
15
10
5
0
2.3
2.1
2.7
1.6
8.6
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009

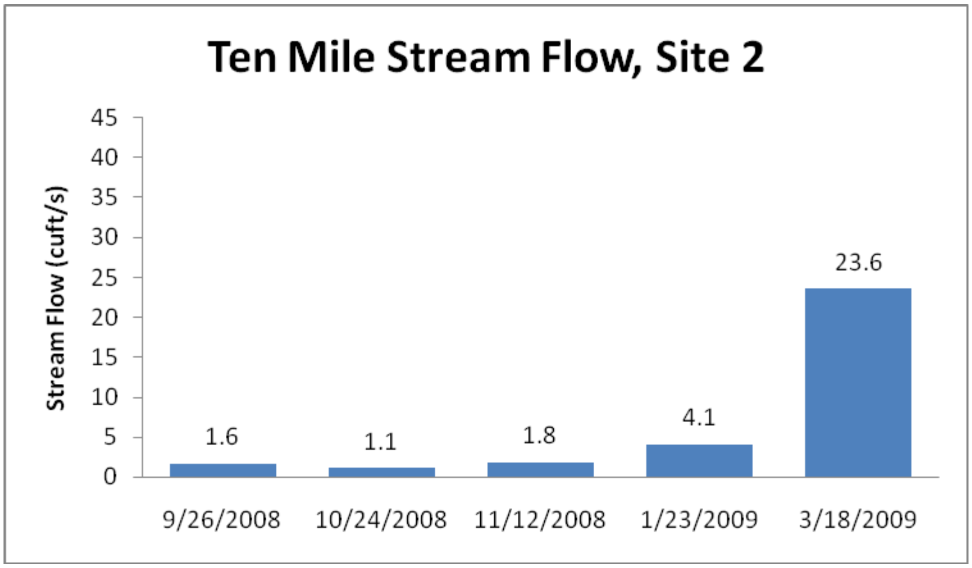

Pataha Stream Flow, Site 4
Stream Flow (cuft/s)
35
30
25
20
15
10
5
0
3.9
3
2.9
2.1
11.2
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009

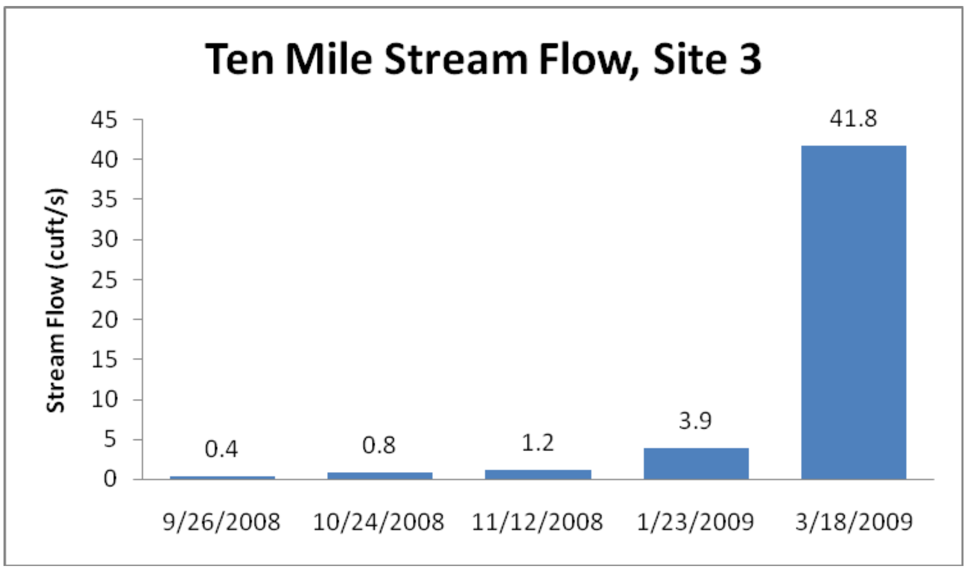

Pataha Stream Flow, Site 5
Stream Flow (cuft/s)
35
30
25
20
15
10
5
0
1.7
1.9
2.9
10/7/2008
10/23/2008
11/14/2008
1/26/2009
3/19/2009

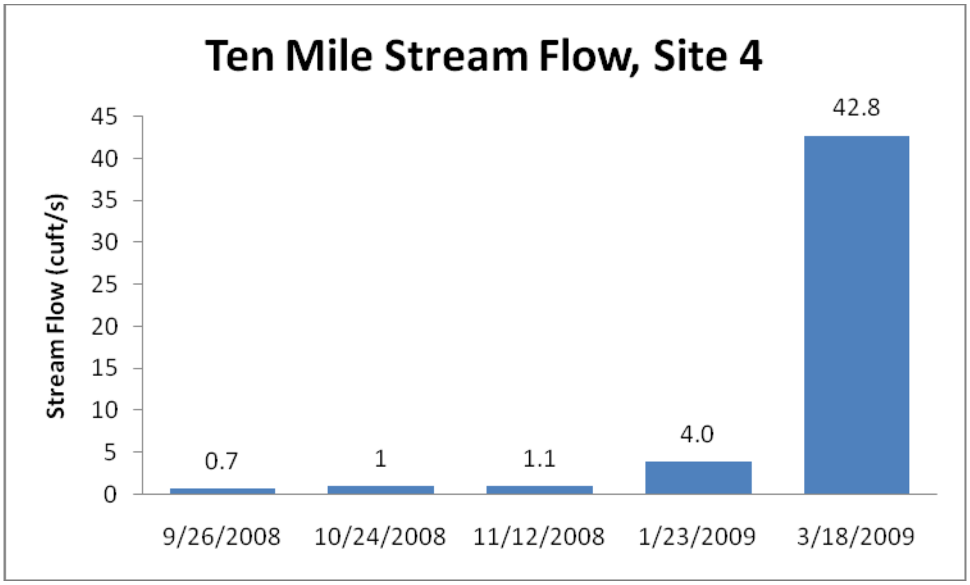


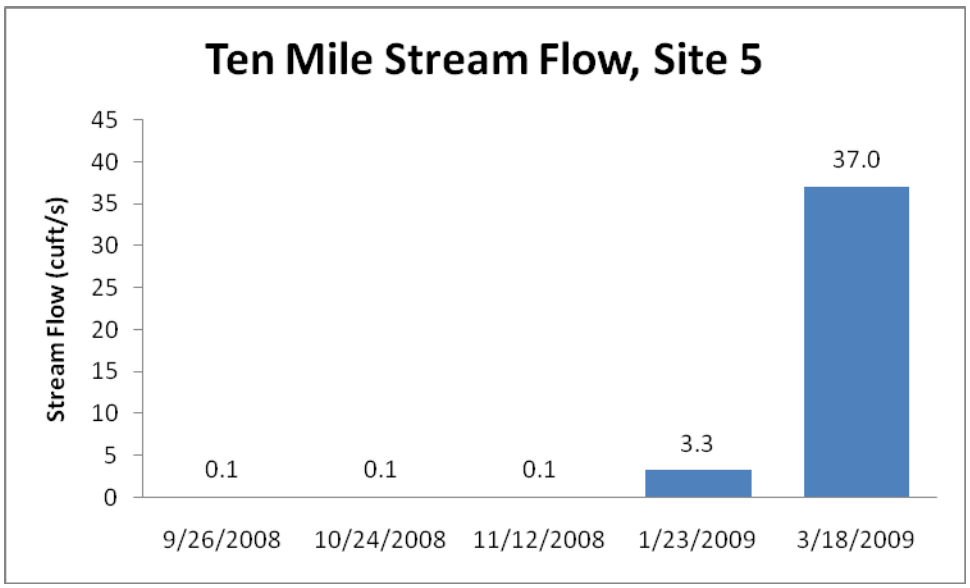
Tenmile Creek:

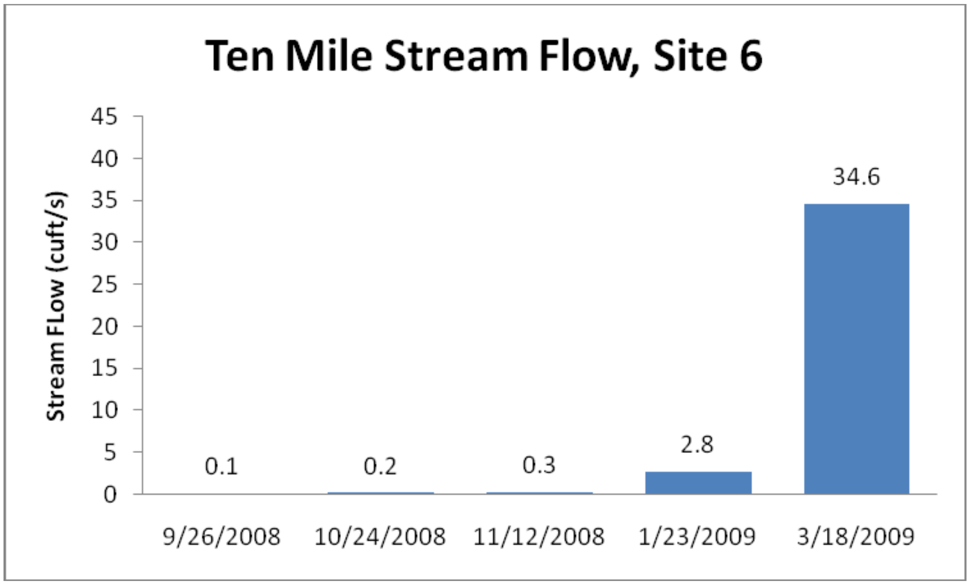


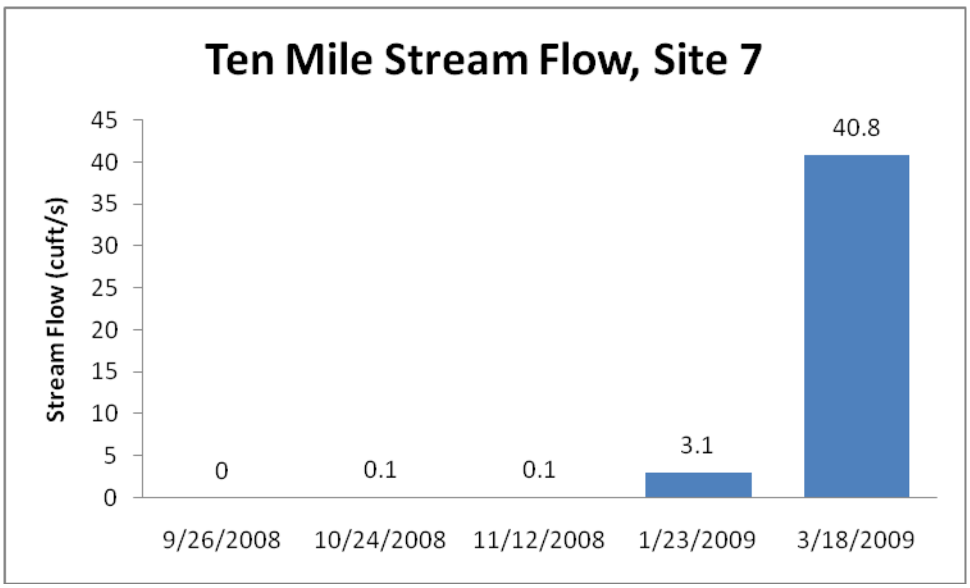

Ten Mile Stream Flow, Site 2
Stream Flow (cuft/s)
45
40
35
30
25
20
15
10
5
0
1.6
1.1
1.8
4.1
23.6
9/26/2008
10/24/2008
11/12/2008
1/23/2009
3/18/2009

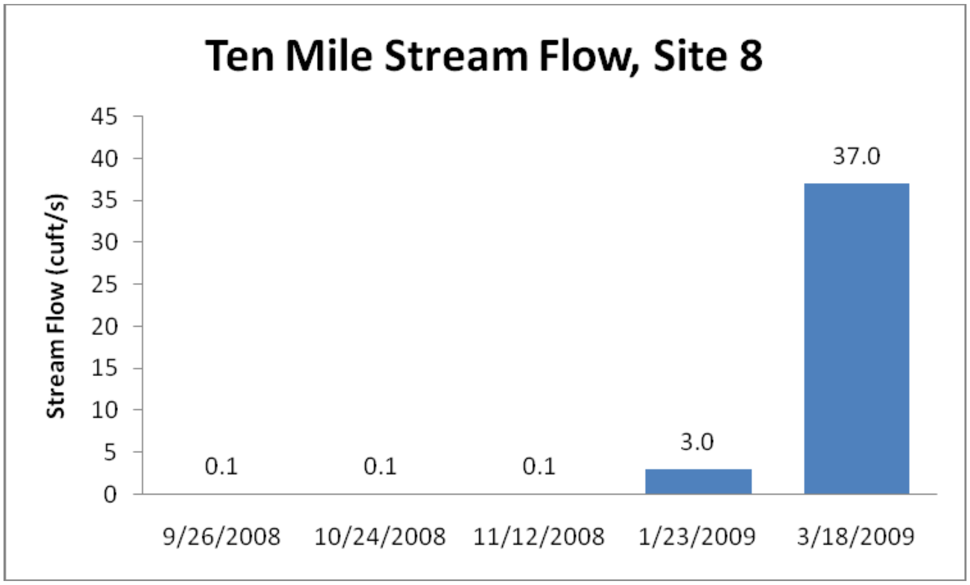

Ten Mile Stream Flow, Site 3
Stream Flow (cuft/s)
45
40
35
30
25
20
15
10
5
0
0.4
0.8
1.2
3.9
41.8
9/26/2008
10/24/2008
11/12/2008
1/23/2009
3/18/2009


Ten Mile Stream Flow, Site 4
Stream Flow (cuft/s)
45
40
35
30
25
20
15
10
5
0
0.7
1
1.1
4.0
42.8
9/26/2008
10/24/2008
11/12/2008
1/23/2009
3/18/2009


Ten Mile Stream Flow, Site 5
Stream Flow (cuft/s)
45
40
35
30
25
20
15
10
5
0
0.1
0.1
0.1
3.3
37.0
9/26/2008
10/24/2008
11/12/2008
1/23/2009
3/18/2009


Ten Mile Stream Flow, Site 6
Stream FLow (cuft/s)
45
40
35
30
25
20
15
10
5
0
0.1
0.2
0.3
2.8
34.6
9/26/2008
10/24/2008
11/12/2008
1/23/2009
3/18/2009

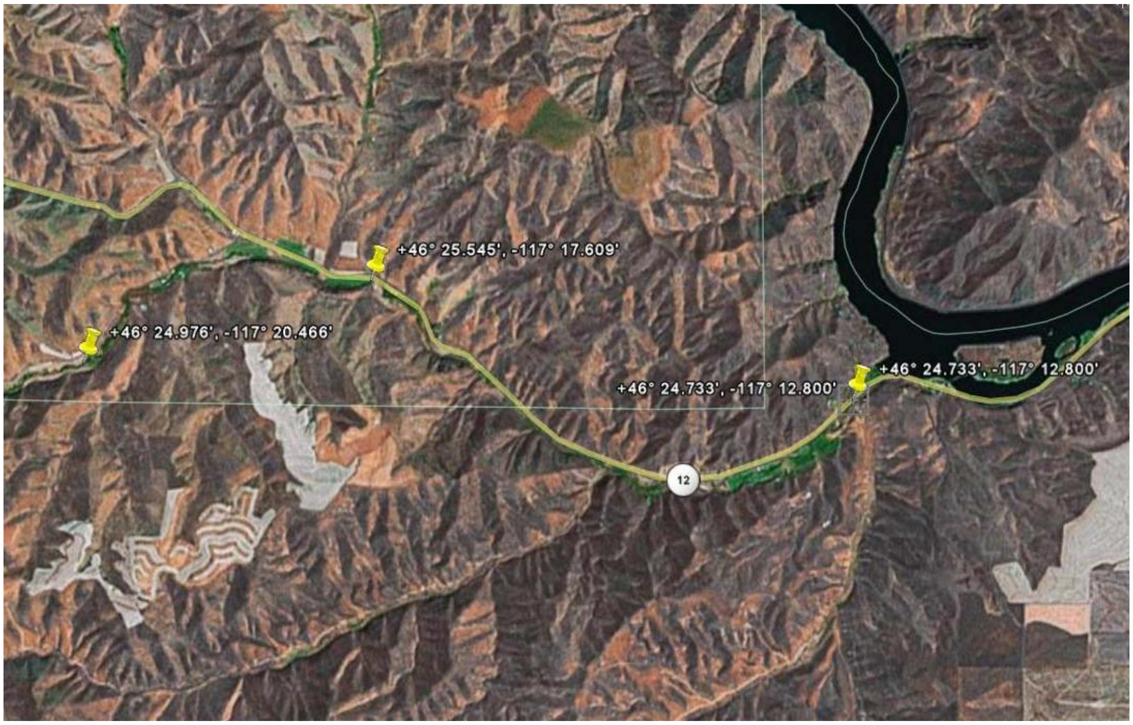

Ten Mile Stream Flow, Site 7
Stream Flow (cuft/s)
45
40
35
30
25
20
15
10
5
0
0
0.1
0.1
3.1
40.8
9/26/2008
10/24/2008
11/12/2008
1/23/2009
3/18/2009


Ten Mile Stream Flow, Site 8
Stream Flow (cuft/s)
45
40
35
30
25
20
15
10
5
0
0.1
0.1
0.1
3.0
37.0
9/26/2008
10/24/2008
11/12/2008
1/23/2009
3/18/2009

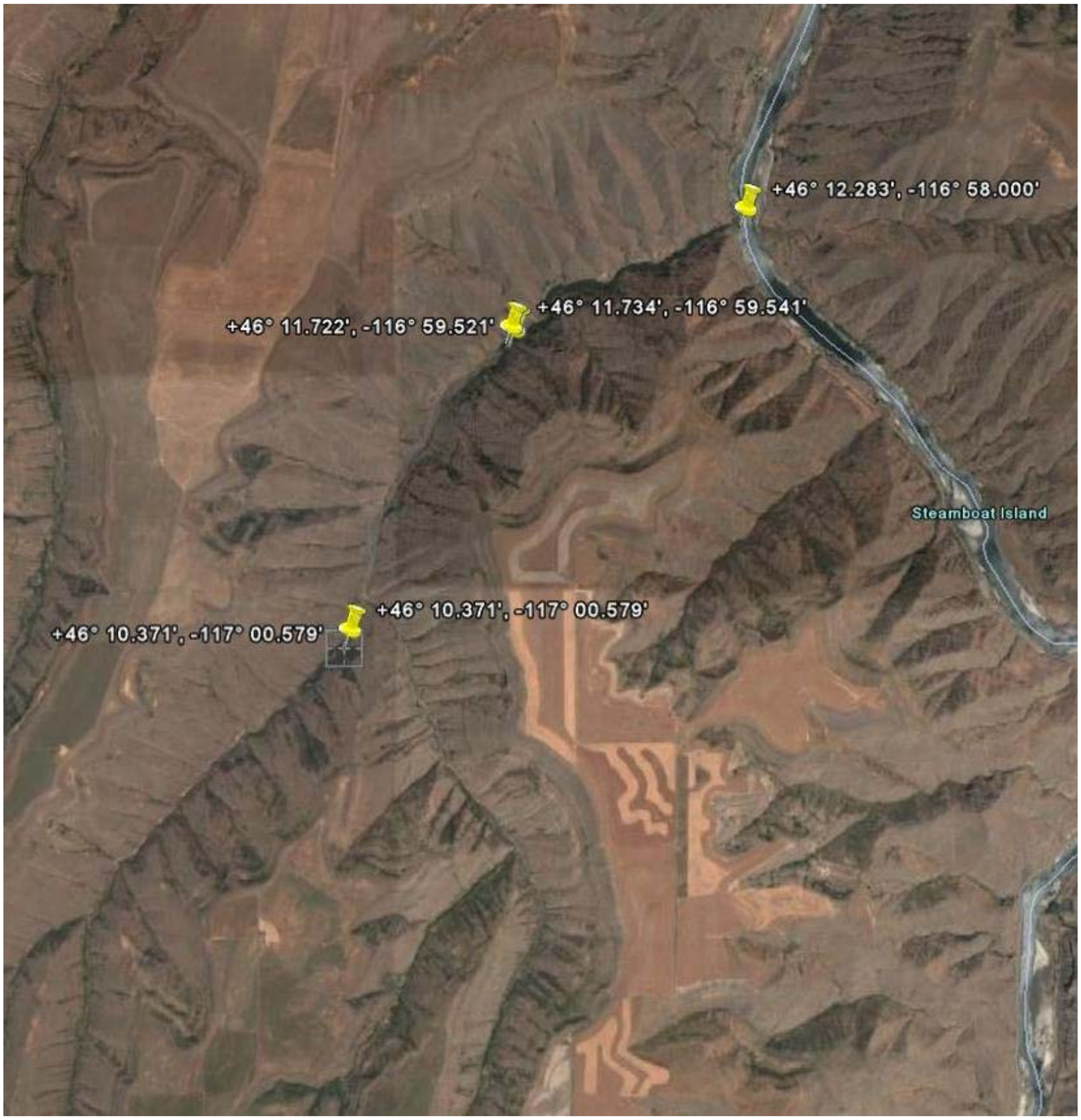
Appendix A

Satellite images showing locations for paired sites selected for the study

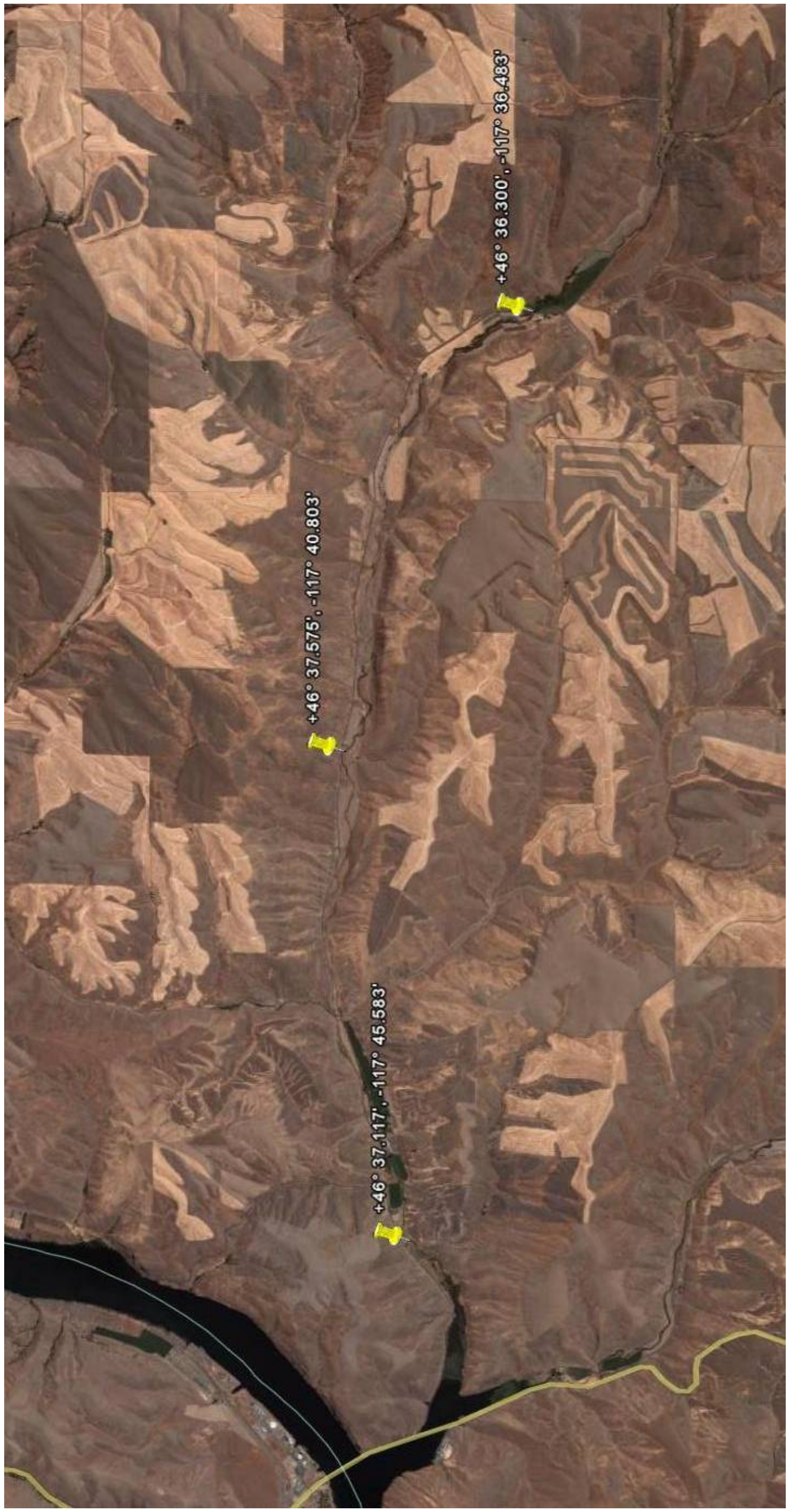
Almota Creek Basin



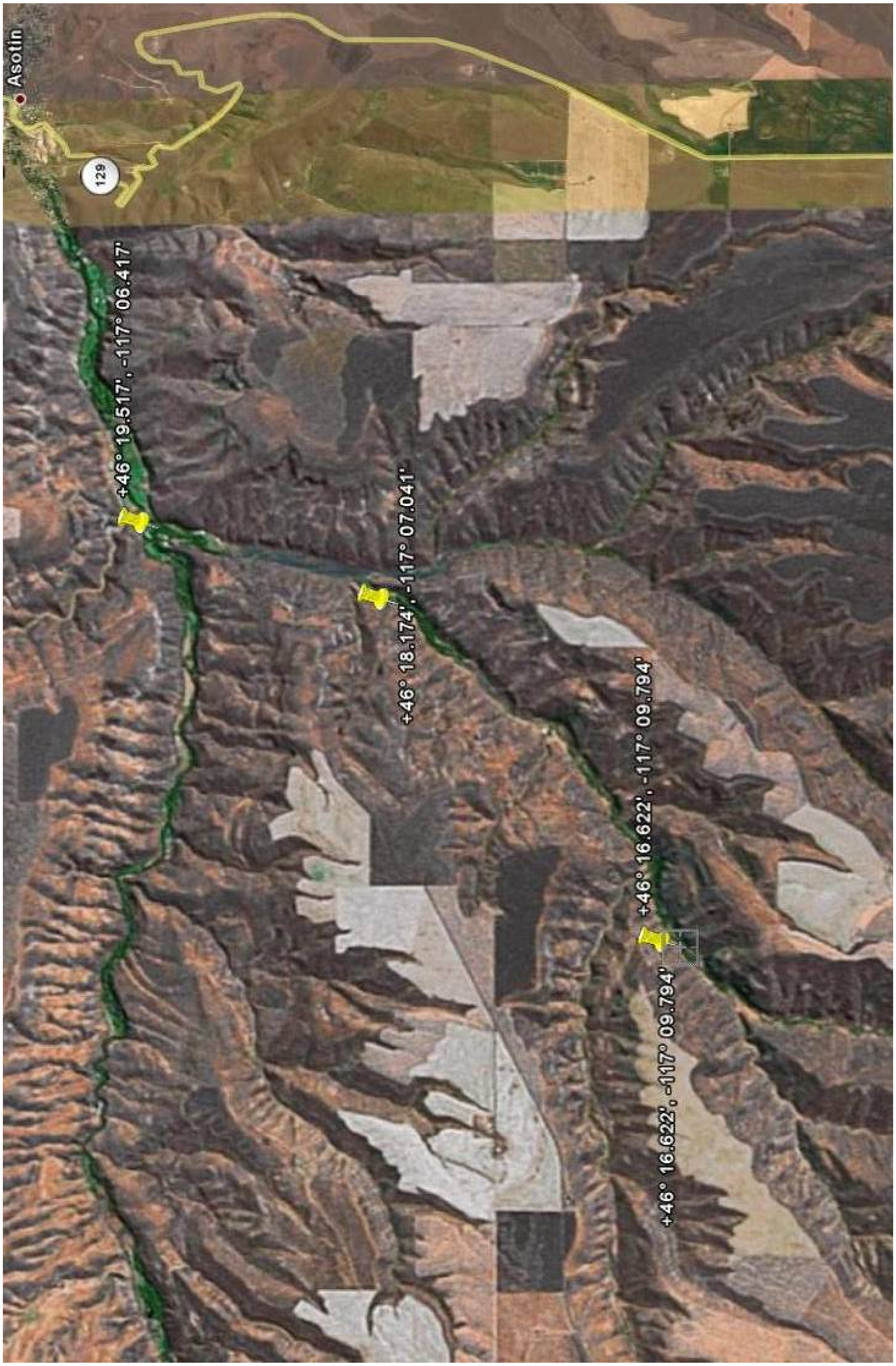
Alpowa Creek Basin



Couse Creek Basin


+46° 36.300', -117° 36.483'
+46° 37.575', -117° 40.803'
+46° 37.117', -117° 45.583'

Deadman Creek Basin

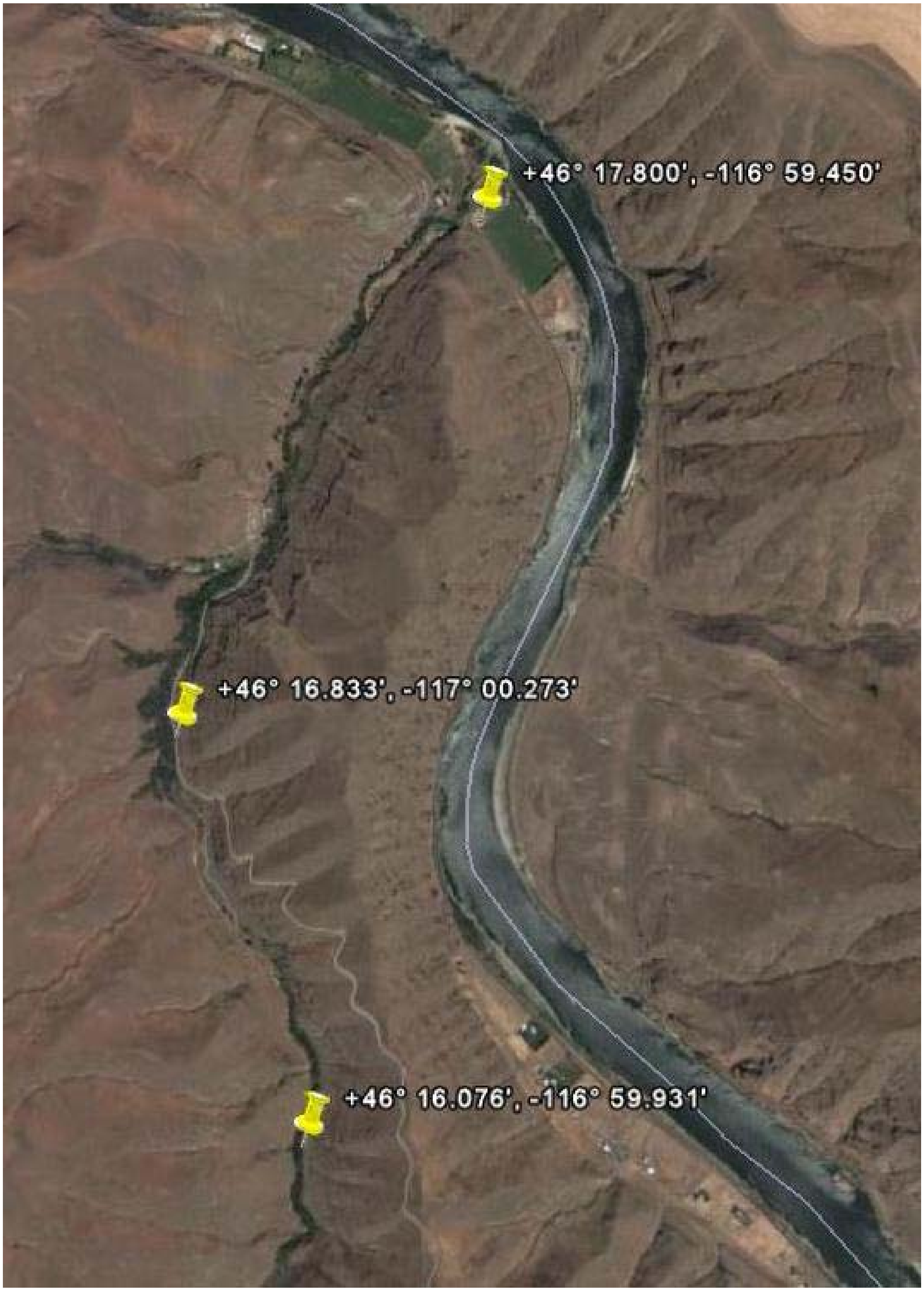


George Creek Basin

Joseph Creek Basin


+46° 30.717', -117° 58.383'
+46° 28.500', -117° 33.300'
+46° 26.604', -117° 28.028'
+46° 16.519', -117° 31.189'
+46° 16.519', -117° 31.189'
Garfield
Columbia
12

Pataha Creek Basin



Tenmile Creek Basin

Appendix B

Sample data collection sheet.

Stream Name:		Water Temp/Air Temp (°C):	
Site Number & Habitat Type:		Dissolved Oxygen (mg/L):	
Sampling Crew:		pH:	
Date:		Sp. Conductivity (µs/cm):	
Time:		Wetted Perimeter (ft.):	

'Flow must be measured at the same spot every time, i.e. tape must be placed at the same place every time

Station No.	Station Postion (ft)	Total Depth (ft)	Depth	Rev	Time (s)	Velocity (ft/s)	Area (sqft)	Discharge (cfs)	Cumulative Discharge
L. Bank									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
R. Bank									
Pin									
	GPS Coordinates:								