Appendix F

Whipple Creek Watershed-Scale Stormwater Plan Report

Hydrology Model Calibration Report

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1. Introduction

The Washington State Department of Ecology (Ecology) issued a 2013-2018 Phase I Municipal Stormwater Permit (Permit) on August 1, 2012, that requires all Phase 1 Permittees, including Clark County (County), to select a watershed and perform watershed-scale stormwater planning as outlined in section S5.C.5.c. This section states that “the objective of watershed-scale stormwater planning is to identify a stormwater management strategy or strategies that would result in hydrologic and water quality conditions that fully support ’existing uses‘ and ‘designated uses’, as those terms are defined in WAC 173-201A-020, throughout the stream system.”

In 2014 the County proposed to conduct a watershed planning study of Whipple Creek (See Figure 1). Clark County’s proposed scope of work included eight (8) tasks including the development and calibration of hydrology and water quality models. As the base for the modeling effort, an uncalibrated HSPF model for Whipple Creek developed in 2007 was used. This model has sufficient detail to simulate scenarios required by the permit. The hydrologic model was calibrated using five years of flow data collected at stream gage WPL050 (downstream of Packard Creek) and County rain gages. The 2007 model has also been updated to reflect 2014 land use conditions. This model has been used to simulate stream flow and water quality for the calibration period (water years 2004-2008). The model parameters were adjusted to calibrate the model to match the observed streamflow and water quality values for the calibration period.

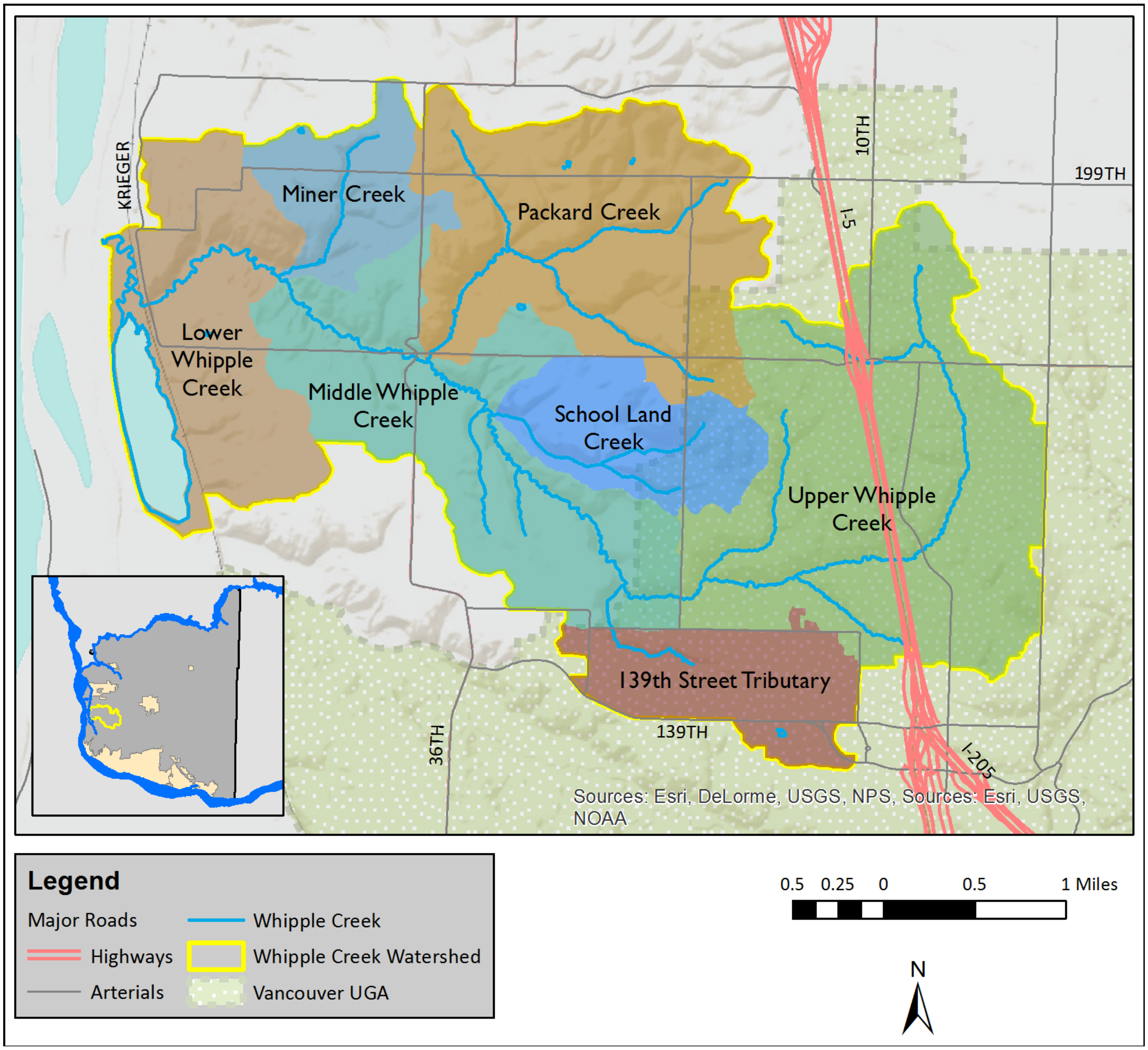


Figure 1: Whipple Creek Watershed

Model performance and calibration accuracy are described by presenting qualitative and quantitative measures, including both graphical comparisons and statistical analysis. Calibration accuracy metrics will focus on observed flow at stream gage WPL050. Statistics characterizing model accuracy may include root-mean-square error and relative percent difference. Other metrics for comparison include mean daily stream flow volumes, mean annual flow volumes, and storm peak discharge rates. Calibration results also include graphical comparisons including hydrographs for simulated flows to observed flows, duration curves, and scatter plots.

1.1 Background and Objective

During a five-year effort from 2006-2010, the Clean Water Division Stormwater Needs Assessment Program (SNAP) focused on describing stream and storm drainage conditions in Clark County watersheds. The program assessed watershed resources, identified stormwater-related problems and opportunities, and recommended specific projects or actions to help protect water quality. As part of the Stormwater Capital Improvement Plan, the CWD staff also began to study several watersheds county-wide to identify capital improvement projects. Staff selected Whipple Creek as the first watershed of which to conduct a detailed study titled "The Whipple Creek (Upper) / Whipple (Lower) Watershed Needs Assessment Report."

Clark County staff completed Part 1 of the Whipple Creek watershed study which included development of hydrologic and hydraulic models to represent the stream flow conditions. The County developed an event-based model using HEC-HMS computer program to estimate peak flow rates throughout the watershed. The county also developed a hydraulic model using HEC-RAS computer program to calculate hydraulic characteristics of Whipple Creek and help predict potential stream channel erosion problems. The second part of the Whipple Creek study involved modeling additional land use scenarios including future land use (2035) alternatives by developing a continuous flow hydrologic model.

1.2 This Report

The objective of this report is to document long-term simulation and calibration of the HSPF model for the Whipple Creek watershed to establish hydrologic parameters for selected soil, topographic, and land use conditions. The report includes a parameter definition, units, and methods for determining input value (e.g. initialize with reported values, estimate, measure, and/or calibrate). The report also includes summary tables that provide 'typical' and 'possible' ranges for the parameters, based on parameter guidance, experience with HSPF over the past four decades on watersheds across the U.S., and world-wide.

2. Hydrologic Modeling

Hydrologic simulation combines physical characteristics of a watershed and observed meteorological data to produce a simulated hydrologic response. HSPF simulates flow to the stream network from four components: surface runoff from hydraulically connected impervious areas, surface runoff from pervious areas, interflow from pervious areas, and shallow groundwater flow from pervious areas. Because historic streamflow is not divided into these four units, the relative relationship among these components must be inferred from the examination of many events over several years of continuous simulation.

In 2007, Otak developed a hydrologic model of Whipple Creek using HSPF. This model was not calibrated due to lack of adequate flow data. The calibration of Whipple Creek hydrologic model utilized the 2007 model, updated the land use within the basin to 2014 conditions, and completed calibration using flow data at Sara Gage for water years 2004 through 2008.

2.1 Modeling Background

HSPF is a mathematically-based computer code developed under U.S. Environmental Protection Agency (EPA) sponsorship to simulate water quantity and quality processes on a continuous basis in natural and man-made water systems. HSPF uses input meteorological forcing data and parameters that reflect system geometry, land use patterns, soil characteristics, and land use activities (e.g., agricultural practices) to simulate the water quantity and quality processes that occur within a catchment.

An HSPF model simulates the full flow regime, including low flows, high flows, dry periods, and back-to-back storm events. This is a useful tool in the Whipple Creek watershed where existing flow levels have already caused extensive erosion in several locations. A continuous flow model can be used to identify whether the future development will significantly increase the time a channel experiences erosive flows on an annual or seasonal basis. HSPF requires input precipitation and potential evapotranspiration (PET), which effectively 'drive' the hydrology of the watershed; actual evapotranspiration is calculated by the model from the input potential and ambient soil moisture conditions. Thus, both inputs must be accurate and representative of the watershed conditions; it is often necessary to adjust the input data derived from neighboring stations that may be some distance away in order to reflect conditions in the watershed.

2.2 HSPF Modeling Protocols

The HSPF modeling protocols are the assumptions and guidelines used in developing the model. The modeling framework has very few built-in assumptions and can be configured to simulate natural systems in a number of different ways. HSPF protocol decisions center on the following topics: precipitation, evaporation, subbasins, land use, soils, slope, calibration parameters, and flow routing.

For Whipple Creek, the modeling protocols are generally based on those developed for the Salmon Creek Watershed as documented in Barker, 2003. Otak reviewed the modeling assumptions documented in that report and found them to be fairly consistent with a number of HSPF guidance documents and modeling protocols for other HSPF projects in Western Washington.

2.3 HSPF Modeling Scenarios

The 2007 Whipple Creek Watershed study developed an HSPF model under existing (year-2002 land use) and future (projected 2016 land use) conditions, stream channel conditions based on the FEMA HEC-RAS hydraulic model (developed by West Consultants), and field observations during the County's stream assessment work. Future land use conditions were based on build-out of the urban growth boundary as defined in the County's comprehensive plan at the time of study; channel conditions remained the same as existing model.

3. Input Data and Watershed Segmentation

The calibration model used the same watershed segmentation as the original Otak hydrologic model. However, this study updated the land use to current conditions.

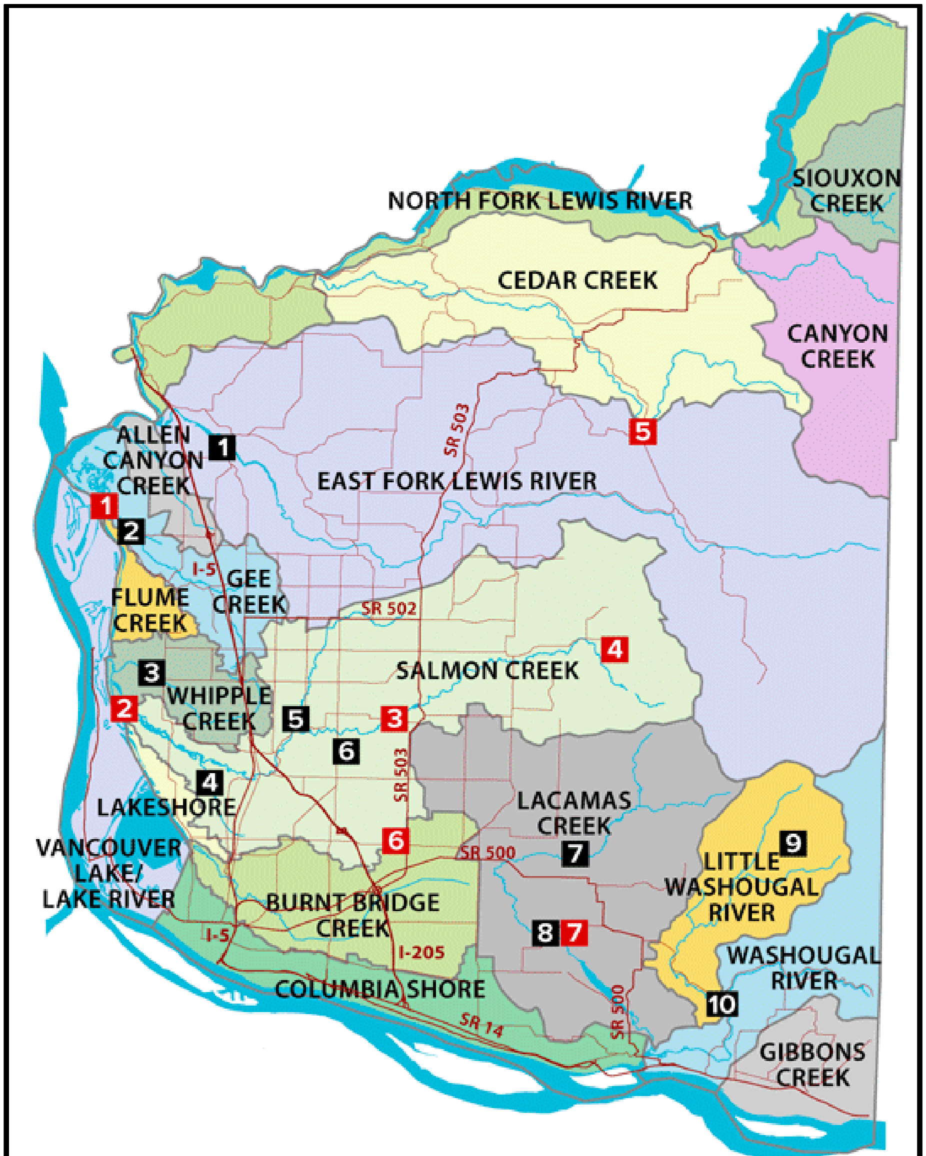
3.1 Data Sources

3.1.1 Precipitation Time Series

As part of the Salmon Creek HSPF modeling project, MGS Engineering developed five rainfall series to simulate the distribution of rainfall across the watershed. In the lower watershed, MGS used multiple scaling factors to adjust the Portland Airport rainfall record to match gage data in Clark County with a mean annual precipitation of 43 inches. The rainfall data set used for the lower Salmon Creek Watershed includes 61 years (1939-2000) of hourly rainfall data. The Salmon Creek modeling report indicated that the rainfall time series could also be used in the hydrologic analyses of other watersheds in Clark County located on the windward slopes of the Cascades with similar mean annual precipitation. As such, Otak used the rainfall dataset from the lower Salmon Creek Watershed for the development of the HSPF model for Whipple Creek Watershed.

The updated Whipple Creek hydrologic model uses extended precipitation data set from Airport Way, Portland, from 1939 to 2012 to conduct a long term simulation of the watershed. However, for the calibration model precipitation data from Salmon Creek Treatment Plant (water years 2004 through 2008) were used.

Figure 2 shows Clark County's streamflow sites and precipitation gage locations.



Stream flow sites
1. Brezee Creek
2. Gee Creek at Abrams Park
3. Whipple Creek
4. Cougar Creek
5. Mill Creek
6. Curtin Creek at NE 139th Street
7. Lacamas Creek at NE 217th Avenue
8. Lacamas Creek at Goodwin Road
9. Jones Creek
10. Little Washougal River at Blair Road

Precipitation stations
1. Ridgefield
2. Salmon Creek Wastewater Treatement Plant
3. Salmon Creek at NE 156th Street
4. Venersborg
5. Yacolt
6. Orchards
7. Lacamas

Figure 2: Clark County Streamflow Sites and Precipitation Stations

3.1.2 Evaporation Time Series

The 2007 Otak study used evaporation time series developed by MGS for the lower Salmon Creek. For the calibration model of Whipple Creek, evaporation data from Aurora Station in Oregon was used.

3.1.3 Flow Time Series

Model calibration used flow data collected at one location on the Whipple Creek main stem, stream gage WPL050. Data was collected between 2002 through 2012. An analysis of the recorded streamflow data for Whipple Creek found the data to be reliable for the five years of the ten-year period of record (water years 2004 through 2008).

The streamflow gage for Whipple Creek watershed at WPL050 was used for the calibration period, as per the scope of work. Table 1 lists information about the streamflow gage.

Table 1: Streamflow Gage Station

Watershed	Gage Location	Drainage Area (Sq. mi.)	Period of Record
Whipple Creek	Downstream of NW 179th Street	8.8	10/1/2003 - 9/30/2008

3.2 Watershed Segmentation

Segmentation procedures and data needs for the original hydrologic model are described in detail in the Whipple Creek Watershed Plan (Otak 2007). Watershed segmentation remained unchanged in the calibrated model.

The Whipple Creek watershed was divided into 102 catchments during the Stream Assessment work performed by County staff. Those catchments were the basis for both the stream assessment and the HEC-HMS modeling previously completed. The Whipple Creek HSPF model grouped these catchments into 27 subbasins. The same subbasin boundaries were used for both existing and future development scenarios.

The subbasin boundaries are shown in Figure 3.

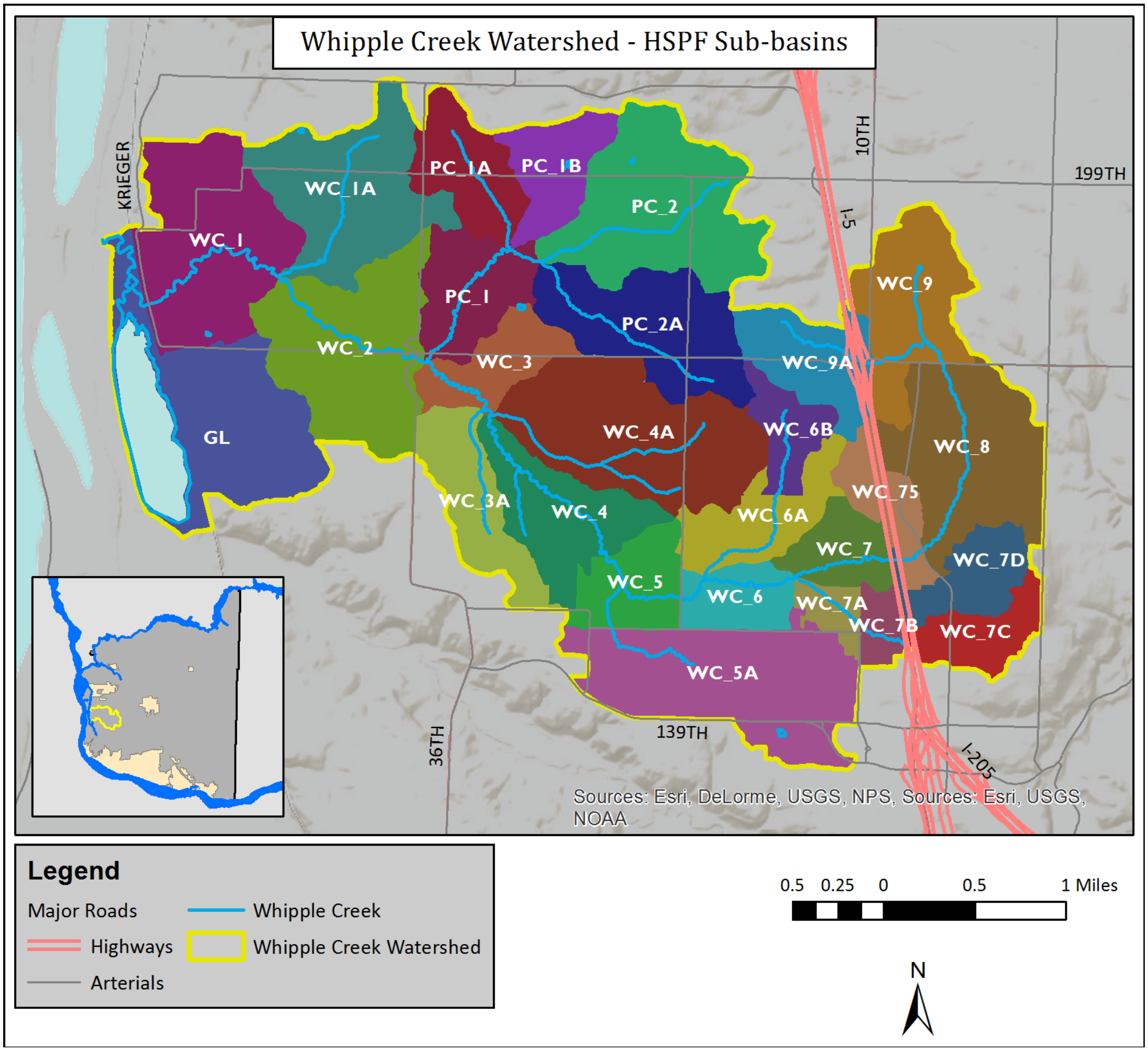


Figure 3: Whipple Creek Sub-basin Boundaries

3.2.1 Land Use

Whipple Creek watershed was once dominated by rural and agricultural land uses. It is currently moderately developed with a mix of rural, urban and urbanizing areas at the northern edge of the Vancouver Urban Growth Area.

The 2007 Otak model land use was based on raster 30-meter data assembled by the University of Washington. The model used land use from Year 2000 as the base and assigned areas to various categories. These categories included bare soil, forest, grass, paved urban, and water. For the Whipple Creek watershed planning study HSPF hydrologic model these land use has been updated using the County's 2014 aerial photos and field verifications to reflect current conditions.

3.2.2 Soils

The Washington State Department of Natural Resources surficial geology data was used to classify the soils hydrologic setting throughout the Whipple Creek Watershed. Nearly all the geology in the Whipple Creek Watershed is identified as either “outburst flood deposits, sand and silt, late Wisconsin” with the geologic unit abbreviation Qfs, or “continental sedimentary deposits or rocks” with the geologic unit abbreviation PLMc (t). Similar to land use, the geology data must be converted into generalized soil categories. The initial HSPF soil categories for Whipple Creek were Bedrock, Outwash, and Saturated. The majority of the Whipple Creek watershed was modeled as Bedrock soil, with all wetland areas modeled as saturated soil.

The NRCS soil types identified within Whipple Creek were later grouped into five categories based on drainage characteristics and knowledge of Clark County soils. From a hydrologic calibration perspective, the most important soil characteristic is infiltration capacity. Therefore, infiltration rates and soil moisture storage capability played the major role in the selection of the soils for each of the five groups. For the final HSPF calibration model PERLND soil categories were converted to SG3, SG4, and SG5 soil types to reflect county soil groups.

The five soil groups in Clark County are:

1. SG1: Excessively Drained soils (hydrologic soil groups A & B)
2. SG2: Well Drained Soils (hydrologic soil group B)
3. SG3: Moderately Drained soils (hydrologic soil groups B & C)
4. SG4: Poorly Drained soils (slowly infiltrating C soils, as well as D soils)
5. SG5: Wetlands soils (mucks)

Underlying soils in the Whipple Creek basin are a mix of SG3: Moderately Drained soils (hydrologic soil groups B & C) and SG4: Poorly Drained soils (slowly infiltrating C soils, as well as D soils).

See Figure 4 for a soils map.

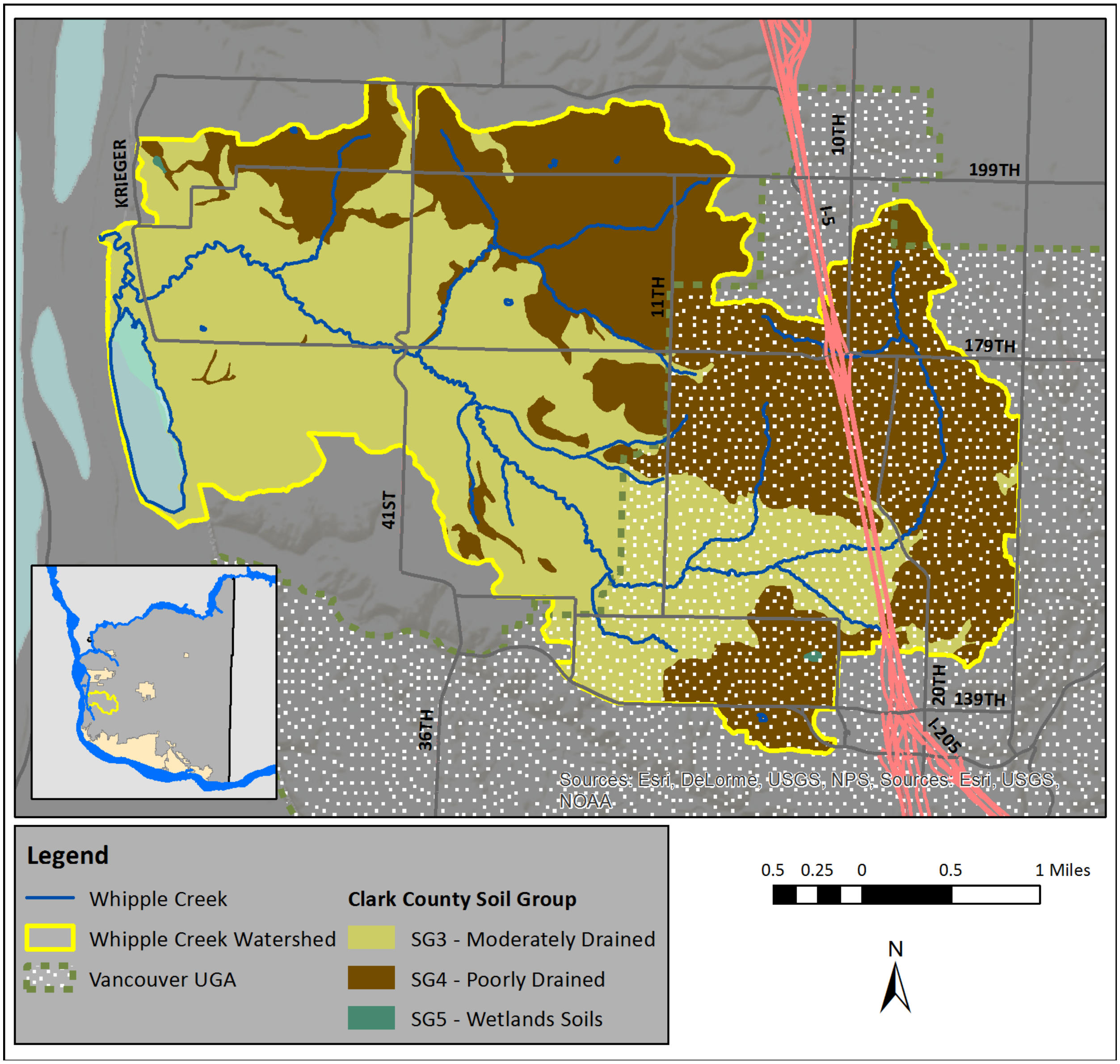


Figure 4: Whipple Creek Soils Map

3.2.3 Slope

HSPF also has the ability to model categories of ground slope. This feature is occasionally used to define different runoff rates, particularly when modeling till soils. However, the overall effect on the runoff timing and volume is usually insignificant. For the purpose of this project, ground slopes were measured from County's topographical maps and used in the updated HSPF model.

3.2.4 Flow Routing

The FTABLEs (or functional tables) in an HSPF model define the stage-storage-discharge relationship for a given stream reach. For areas of the watershed that have been defined in a HEC-RAS model, FTABLEs were developed by looking at the water surface elevation and overall channel storage for a range of flow rates. This method was used throughout the main stem of Whipple Creek and one branch of Packard Creek.

4. Calibration

Calibration of a watershed with HSPF is an iterative process of making parameter changes, running the model and producing comparisons of simulated and observed values, and interpreting the results. Calibration looks at matching the annual water balance, groundwater contributions, and hydrograph shapes to stream gages throughout a watershed. The 2007 HSPF model developed by Otak was not calibrated. However, for development of the Whipple Creek HSPF model, Otak reviewed the parameters used in the Salmon Creek model and found them to be generally consistent with published HSPF modeling guidelines. The calibration model used Otak's original model as a starting point. The model was then updated with meteorological data, modified land use, and parameters from WWHM2012 for Clark County to improve model results. For the calibration period the observed and simulated streamflow was compared at the SARA gaging station in Whipple Creek, downstream of NW 179th Street (WPL050).

4.1 Calibration Modeling

The general objective of the HSPF modeling is to determine the long-term flood frequency, flow duration, and runoff characteristics of the watershed. Model calibration is necessary and critical step in any model application. For most watershed models, calibration is an iterative procedure of parameter evaluation and refinement, as a result of comparing simulated and observed values of interest.

A review of the existing HSPF model developed by Otak in 2007 shows that the model contains sufficient detail to perform a long-term simulation. However, the model land use was based on 2002 land use. For the purpose of the Whipple Creek Watershed Study, the land use has been updated, using 2014 aerial photos and field verification of any changes within various catchments.

For the calibration precipitation data from Salmon Creek treatment plant was used. The Salmon Creek precipitation data set contained missing values for a few months during 2006 and 2007. This data gap was filled with precipitation values from a Gee Creek precipitation gage.

Evaporation data used in the calibration model was from Aurora, Oregon. Results of the calibration model are shown Section 4.3 below.

4.2 Calibration Parameters

Calibration parameters define how each land segment (pervious, impervious, bedrock grass, saturated forest, etc.) responds to rainfall events. They define how much water will run off the land segment as surface flow, move slowly as shallow subsurface flow (also called interflow), or contribute to the stream as base flow (from groundwater). In addition to the input meteorological data series, the critical HSPF parameters that affect components of the annual water balance include soil moisture storages, infiltration rates, vegetal evapotranspiration, and losses to deep groundwater recharge. Four parameters significantly influence the annual water balance: INFILT, LZSN, UZSN, and LZETP. The parameters INFILT, AGWRC, and BASETP significantly influence the low flow / high flow distribution. The parameters UZSN, INTFW, and IRC significantly influence stormflow volumes and hydrograph shape.

To develop the original HSPF model for Whipple Creek Otak staff reviewed the parameters used in the MGS Salmon Creek model and found them to be generally consistent with published HSPF Modeling guidelines. The initial Whipple Creek HSPF model was developed using the parameters used in the calibrated Salmon Creek model (October 2002, revised March 2003).

For Whipple Creek calibration model, the original Otak model was modified to reflect existing land use conditions. The model parameters were then adjusted using the parameters proposed by Clear Creek Solutions for Clark County WWHM version and EPA Basins Technical Note 6. Parameters used for the calibration model are included in Attachment B.

The revisions/modifications included the following:

- Land use based on 2014 aerial photo
- PERLND areas: used county soil types: SG3, SG4, and SG5
- Precipitation data from Salmon Creek Treatment Plant

The final calibration was conducted by Doug Beyerlein in March 2017 and consisted of making minor modifications to the original calibrated values for HSPF PERLND parameters LZSN, INFILT, AGWRC, INFEXP, and IRC.

4.3 Calibration Results

This section presents and discusses the comparison of model results with the observed Whipple Creek flow data at WPL050, performed for the calibration period.

The calibration results presented are based on the Department of Ecology's "Watershed Planning Guidance Memo" (dated March 29, 2016). Ecology recommended two types of graphical comparisons and at least one error statistic and one correlation test.

For the Whipple Creek hydrology calibration we have provided two graphical comparisons in the form of flow duration curves (Figure 5) and hydrographs (Attachment A). A hydrograph of the entire calibration period (water years 2004 through 2008) is included plus individual hydrographs for each water year and two-month period of record hydrographs for November through August for each water year. The flow duration graph and the hydrographs present a visual display of the accuracy of the calibration.

An error statistic is presented in the form of the annual runoff volume comparison for each water year and for the entire calibration period of record (water years 2004 through 2008), as shown in Table 2 below. An individual water year runoff volume error ranges from -13% to +8%; the overall calibration period runoff volume error is only 0.3%.

A correlation test is shown in Figure 5. The coefficient of determination (R squared) is calculated based on daily recorded and simulated streamflow values. The R squared value daily flows for the calibration period is 0.86. According to Donigian (2002) this R squared value is in the "Very Good" range for daily flow values.

4.3.1 Flow Duration Comparisons

The flow duration curve is a primary component of the weight-of-evidence assessing for model performance because it reflects the overall hydrologic regime of the contributing watershed. Figure 5 illustrates the percent chance of flow exceedance across the range of flows for the calibration period.

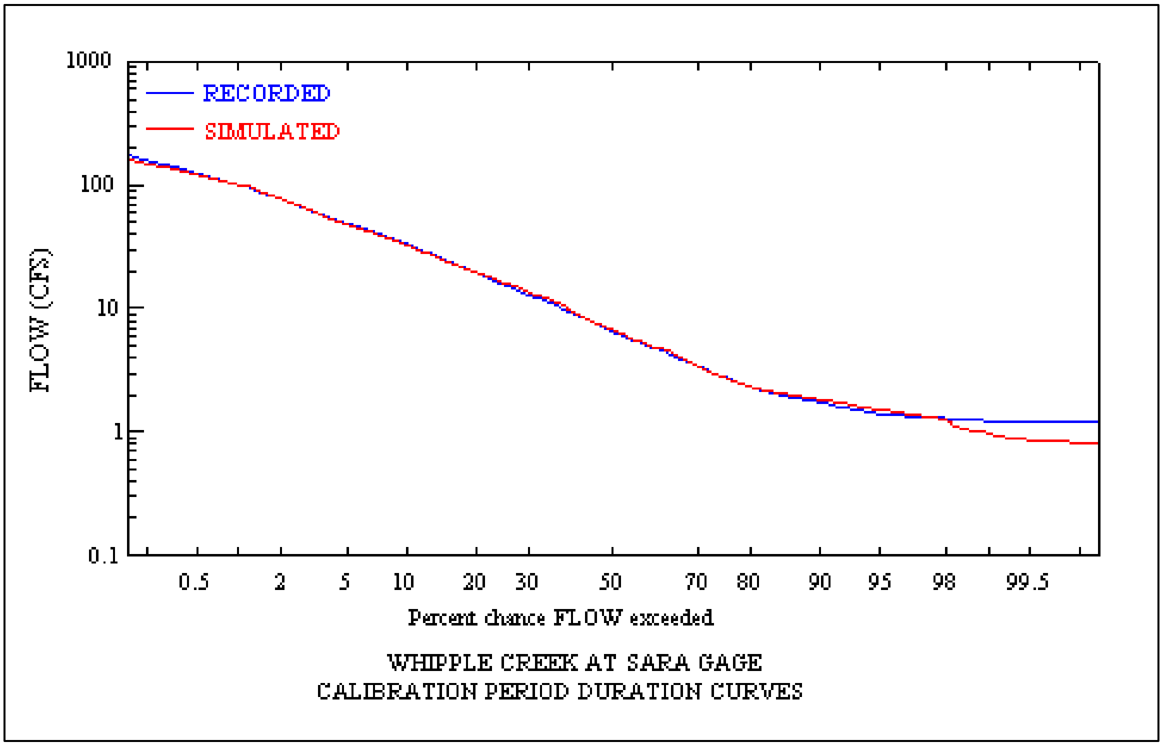


Figure 5: Whipple Creek Flow Durations – Calibration Period (WY 2004-2008)

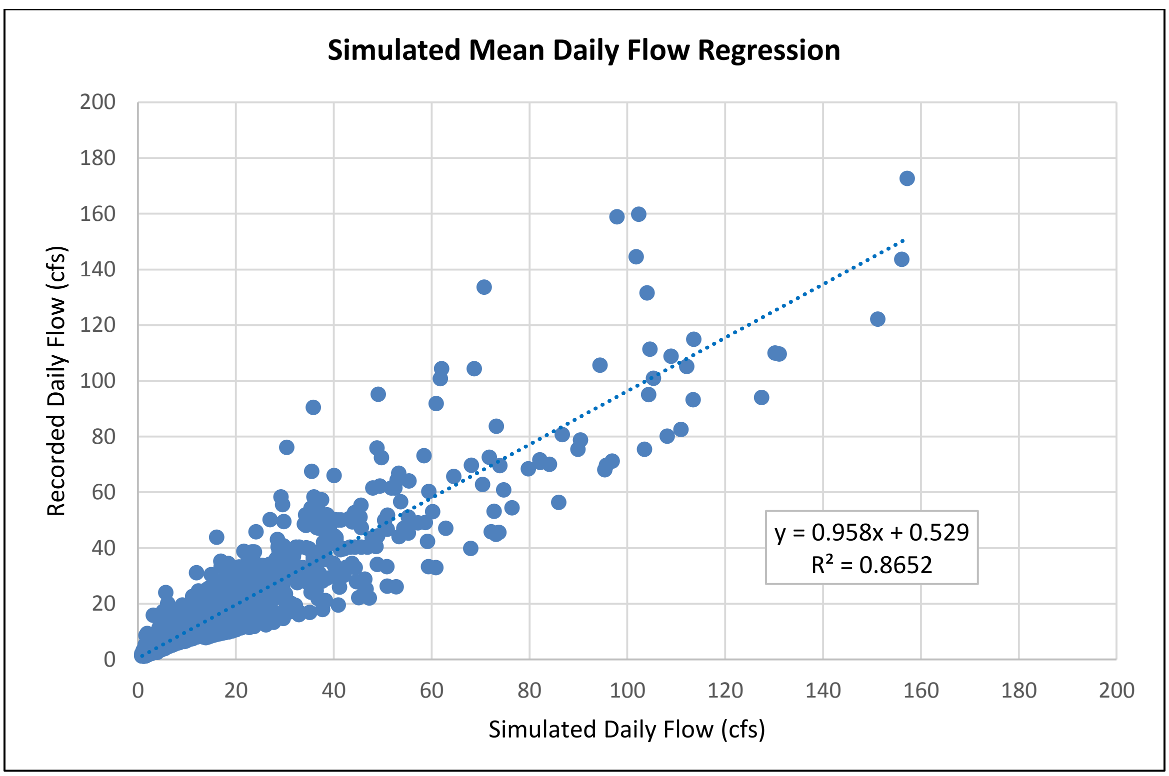


Figure 6: Regression of mean daily flows on simulated flows

Figure 6 includes the coefficient of determination (R squared) based on the daily recorded and simulated streamflow values. The R squared value daily flows for the five-year calibration period is 0.86. According to Donigian (2002), this R squared value is in the "Very Good" range for daily flow values.

4.3.2 Storm Event Comparisons

One important step is model calibration is to examine representation of individual storm hydrographs. Individual storm simulations often will show larger deviations from observed values than for daily and monthly totals, often due to dynamic variations in rainfall spatial distributions not accurately represented by the gage network. So, it is necessary to examine a number of flow events to assess the simulation accuracy; this is performed by reviewing the individual hydrographs at an hourly time interval.

A comparison of the Whipple Creek flows at the Sara Gage (WPL050) shows, in general, a very good match between the simulated and observed peak flow data. Graphical representation of storm events during the calibration period is shown in Attachment A.

Calibration periods where there is a very good match between the simulated and observed peak flow data include:

October 2004 through May 2005, February 2006 through May 2007, and January 2007 through April 2008. The model results do not demonstrate any specific bias.

4.3.3 Annual Volume Comparisons

Annual volume comparisons demonstrate the ability of the modeled flows to accurately simulate all of the components contributing to the annual water balance (stream flow, evaporation, loss to groundwater). Table 2 shows the annual precipitation, simulated flow, recorded flow and relative flow error for Whipple Creek for the calibration period.

For the Whipple Creek calibration period an error statistic is presented in the form of the annual runoff volume comparison for each water year and for the entire calibration period of record (water years 2004 through 2008), as shown in Table 2 below. An individual water year runoff volume error ranges from -13% to +8%; the overall calibration period runoff volume error is only 0.3%. According to Donigian 2002 this error statistic is in the "Very Good" range for annual flow values.

Table 2: Whipple Creek Annual Water Balance and Flow Error

Water Year	Precipitation (in)	Simulated Flow (in)	Recorded Flow (in)	Error (%)
2004	42.44	16.67	17.57	-5.1%
2005	39.74	13.41	15.49	-13.4%
2006	50.98	29.77	27.66	7.7%
2007	48.09	24.56	23.26	5.6%
2008	40.51	20.69	20.80	-0.6%
Average	44.35	21.02	20.96	0.3%

4.4 Calibration Results Summary

The observed and simulated stream flow was compared for the Whipple Creek watershed at the WPL050 stream gage.

Based on Ecology's recommendations, two types of graphical comparisons and one error statistic and one correlation test were used to evaluate the calibration effort.

The Whipple Creek calibration results show a very good match at the WPL050 gaging site with regard to mean annual flow comparisons, flow duration, and storm hydrographs. Water balance analysis resulted in 0.3% difference between the simulated and observed values. Flow duration comparison between simulated and observed flows shows an excellent result.

4.5 Conclusions

The calibration was completed by manually adjusting the HSPF parameters and making other adjustments, as appropriate.

Table 3 provides a limited weight-of-evidence summary of the various model-data comparisons performed for the simulation of the Whipple Creek watershed model for the calibration period, as discussed above. The overall model performance, shown in the last column, reflects our assessment of very good to excellent model performance for the calibration period.

Table 3: Weight-of-Evidence for Model Performance

Calibration Period (WY 2004-2008)	Whipple Creek	Overall Model Performance
Annual Volume Error	Very Good	Very Good
Daily Flow R Squared	Very Good	Very Good
Flow Duration Curves	Excellent	Very Good
Hydrographs	Good to Very Good	Very Good

The calibration results, based on the weight-of-evidence approach described herein, demonstrates a good representation of the observed data. This is the outcome of a wide range of graphical comparisons and measures of the model performance for mean annual volume, flow duration, daily flow correlation, and individual storm event simulations. These comparisons demonstrate conclusively that the model is a good representation of the water balance and hydrology of the watersheds.

Based on the model results presented and discussed in this report, the HSPF application to the Whipple Creek watershed provides a sound, calibrated hydrologic watershed model. The resulting model parameters are appropriate for impact evaluation of hydromodification management alternatives and calibrating a water quality model. The calibration results, based on the weight-of-evidence approach described herein, demonstrate a good representation of the observed data.

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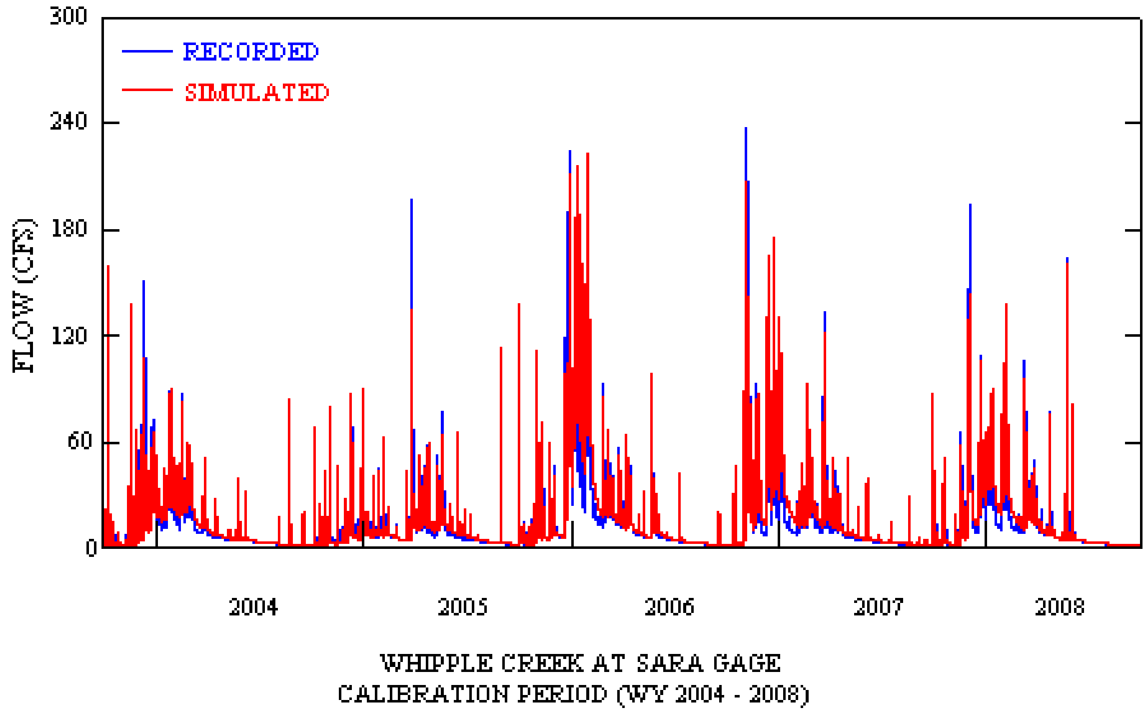
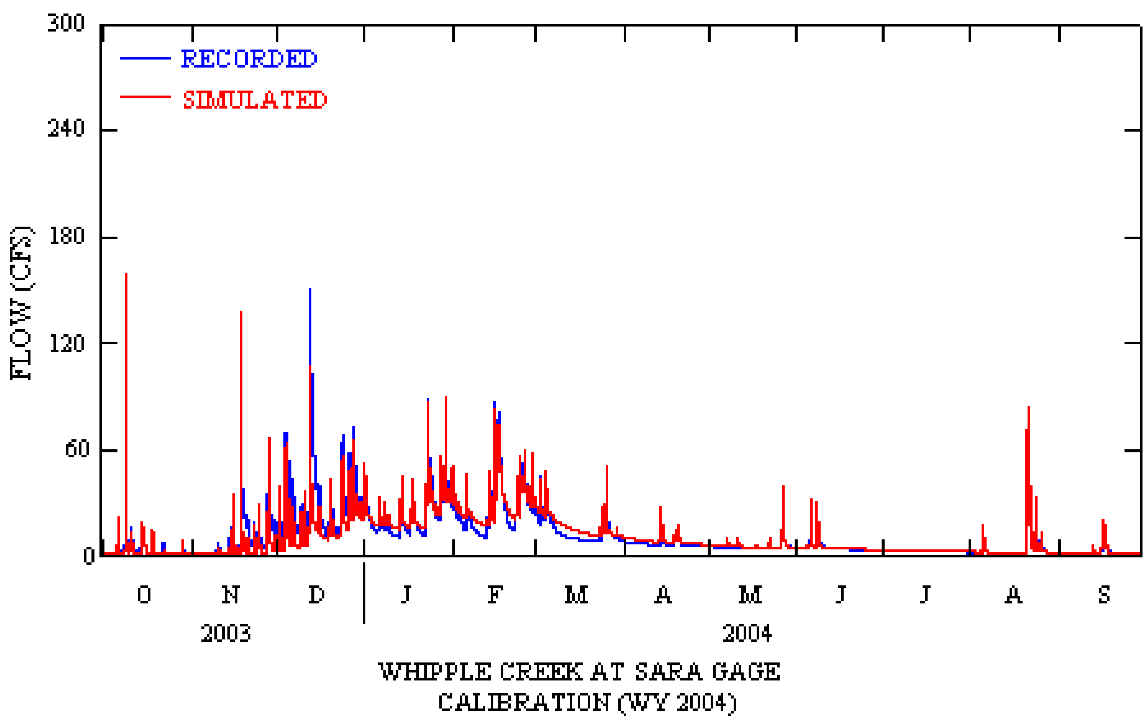
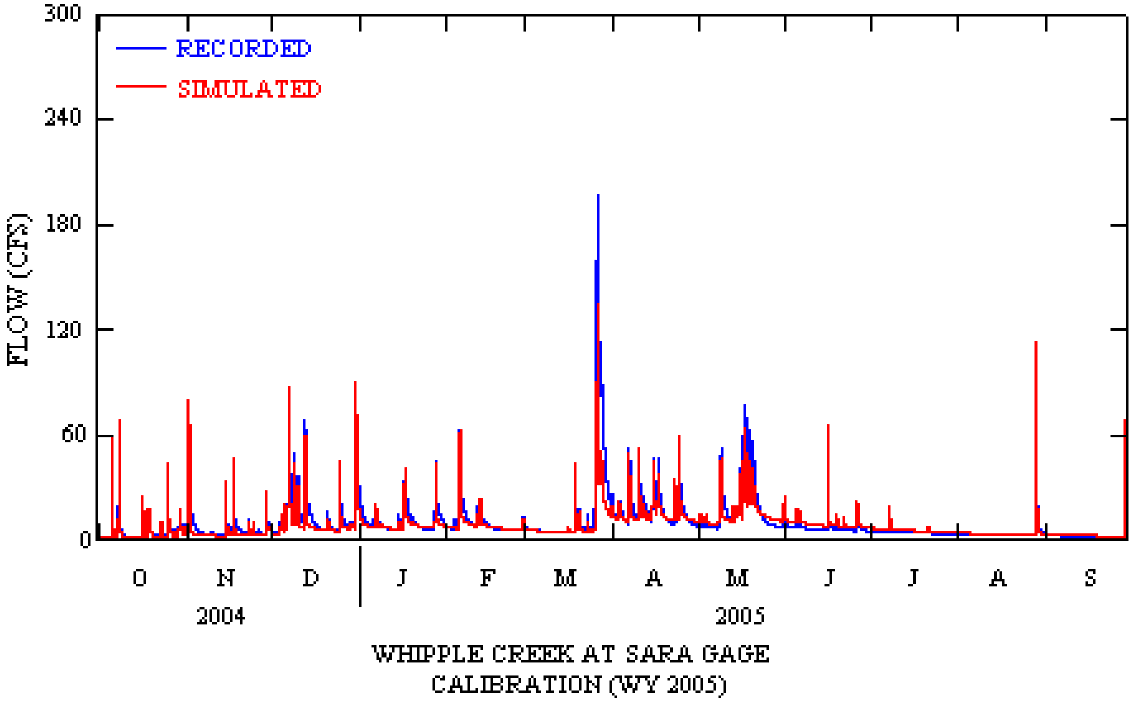
Attachment A: Hydrographs



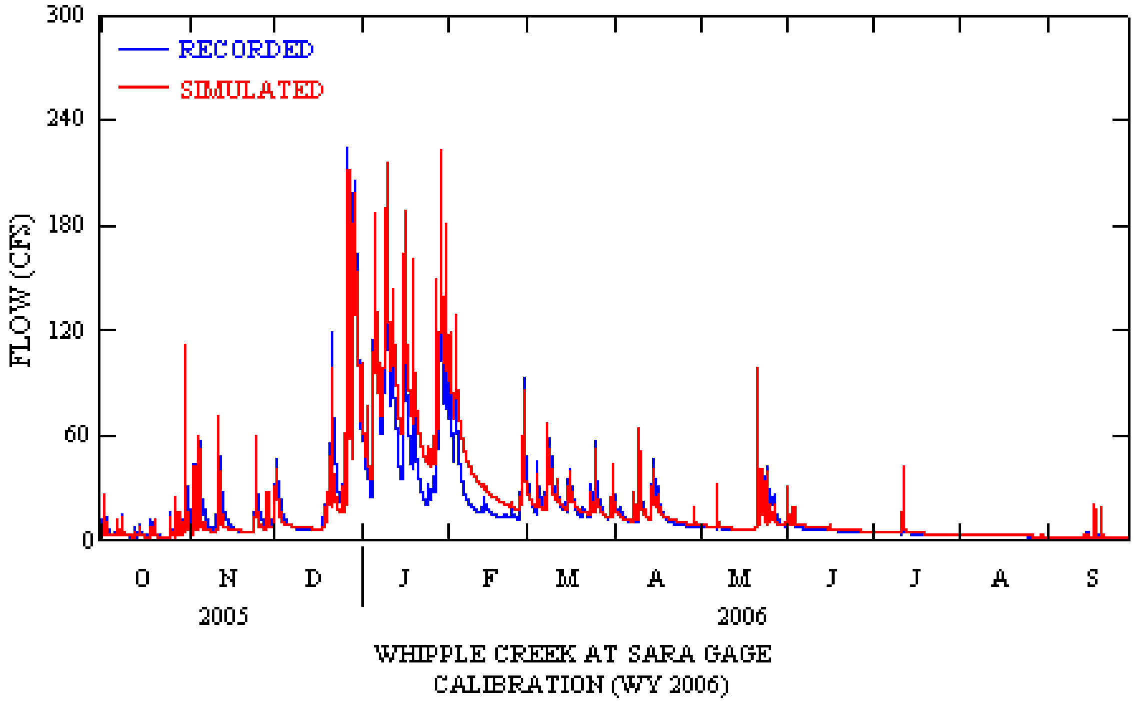
Whipple Creek Streamflow (WY 2004-2008)



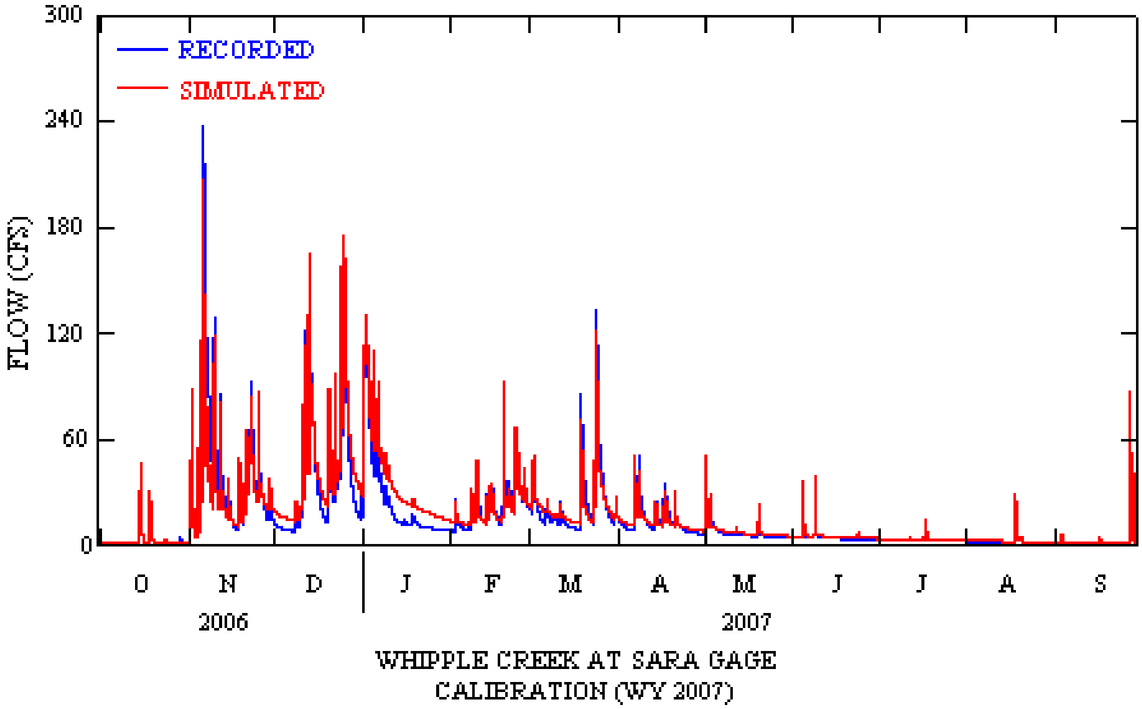
Whipple Creek Streamflow (WY 2004)



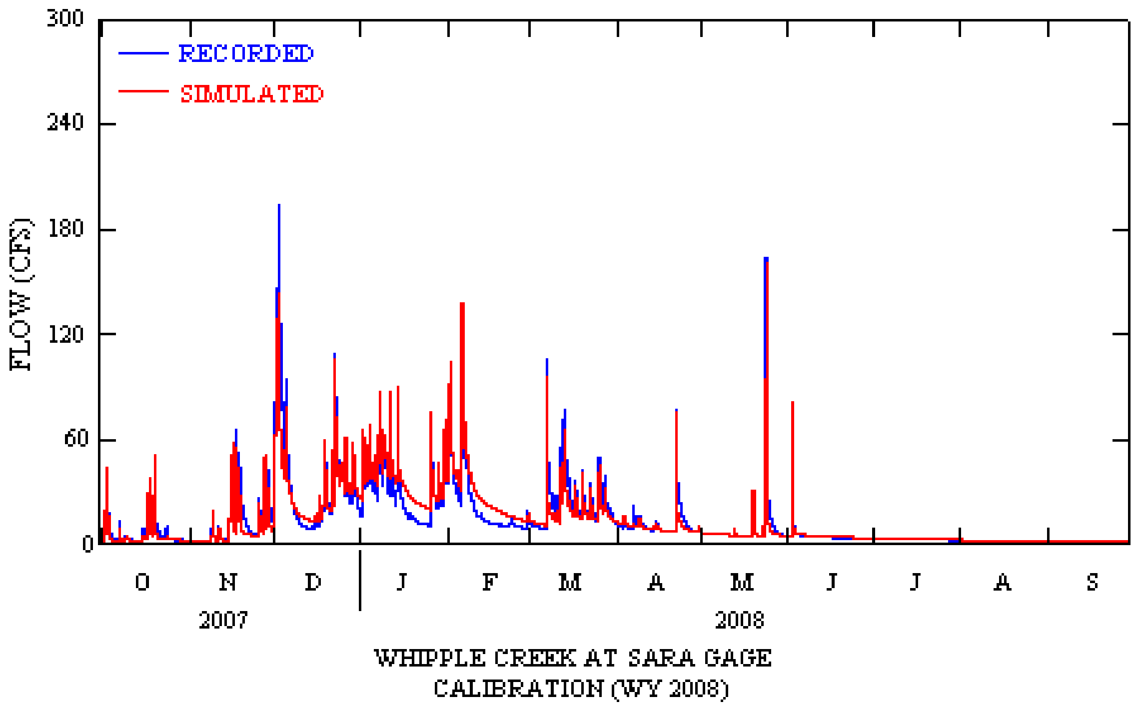
Whipple Creek Streamflow (WY 2005)



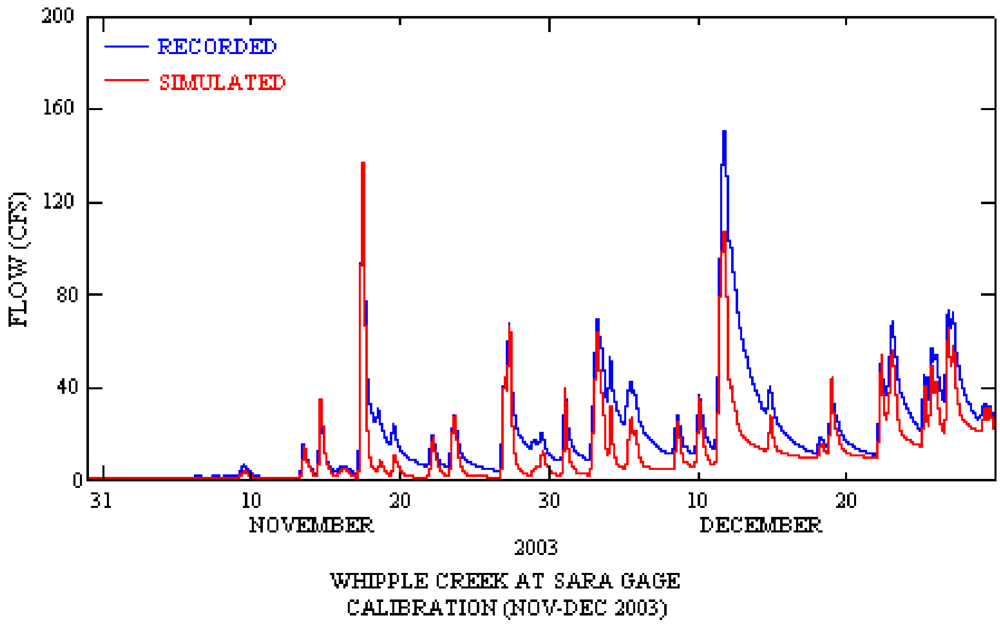
Whipple Creek Streamflow (WY 2006)



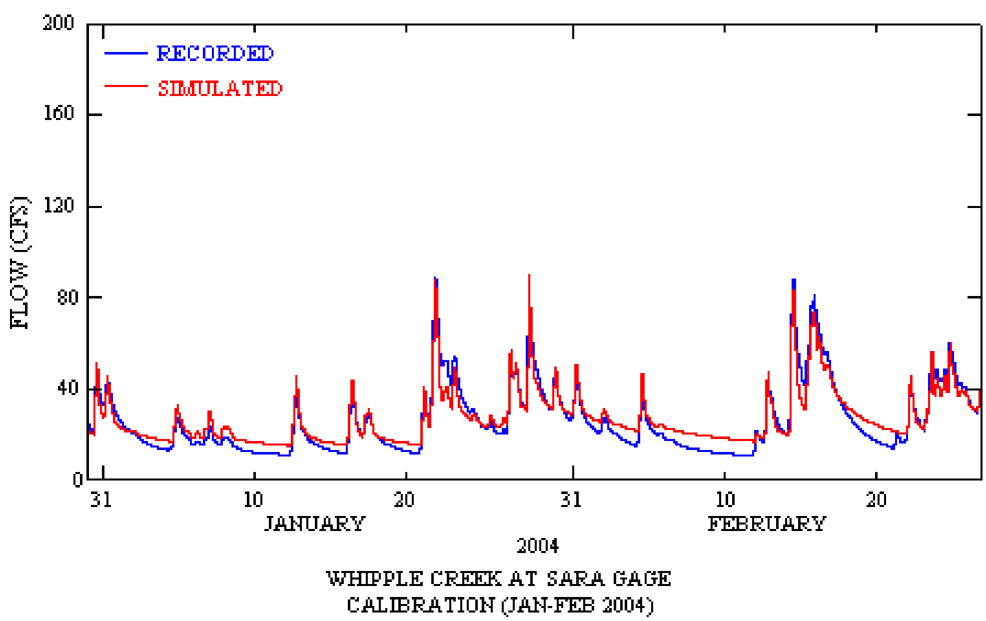
Whipple Creek Streamflow (WY 2007)



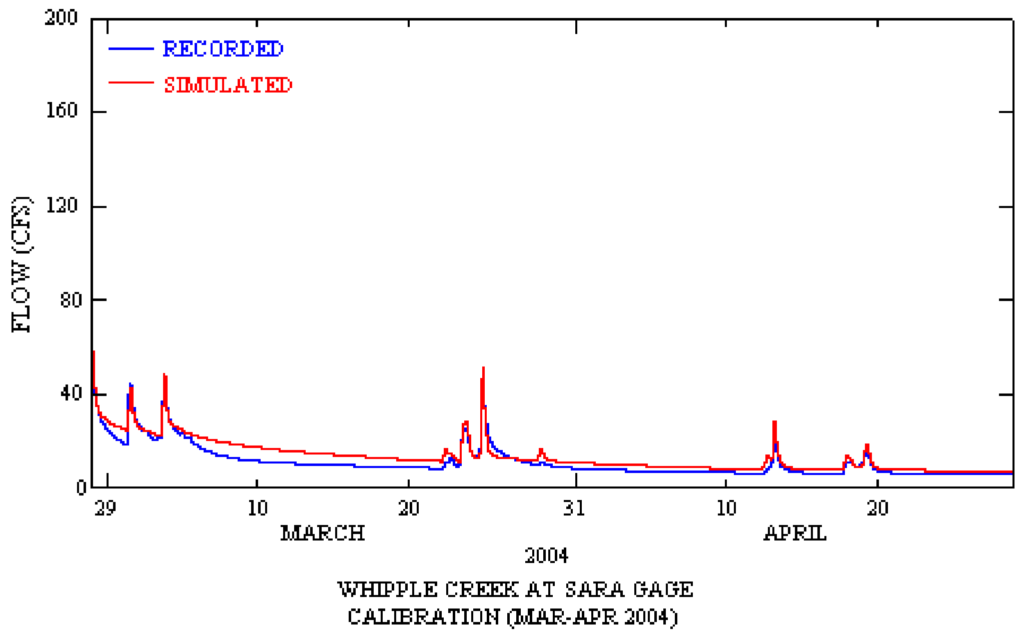
Whipple Creek Streamflow (WY 2008)



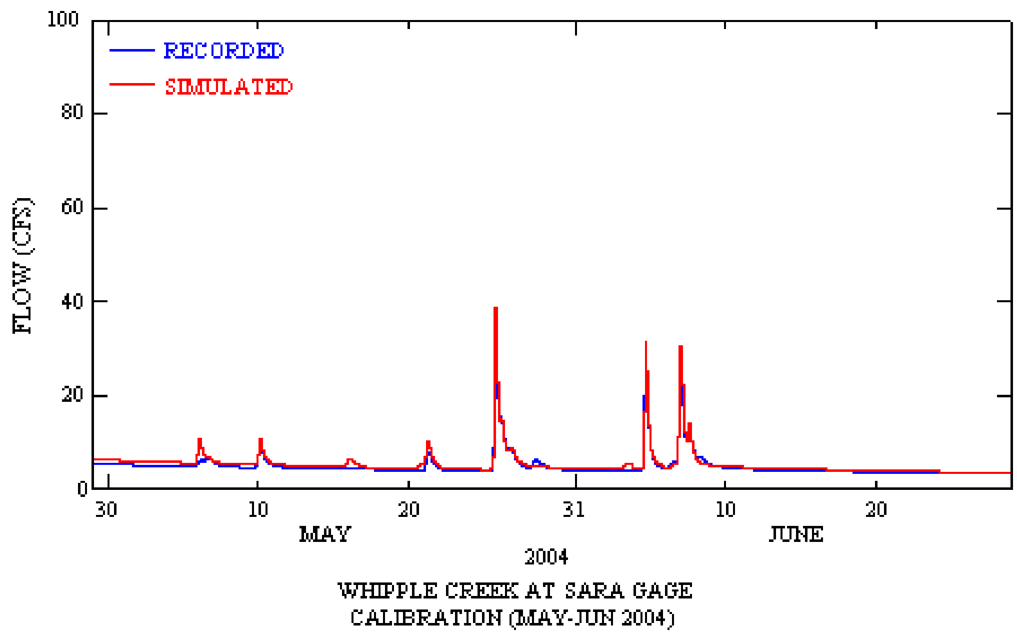
Whipple Creek Streamflow (November – December 2003)



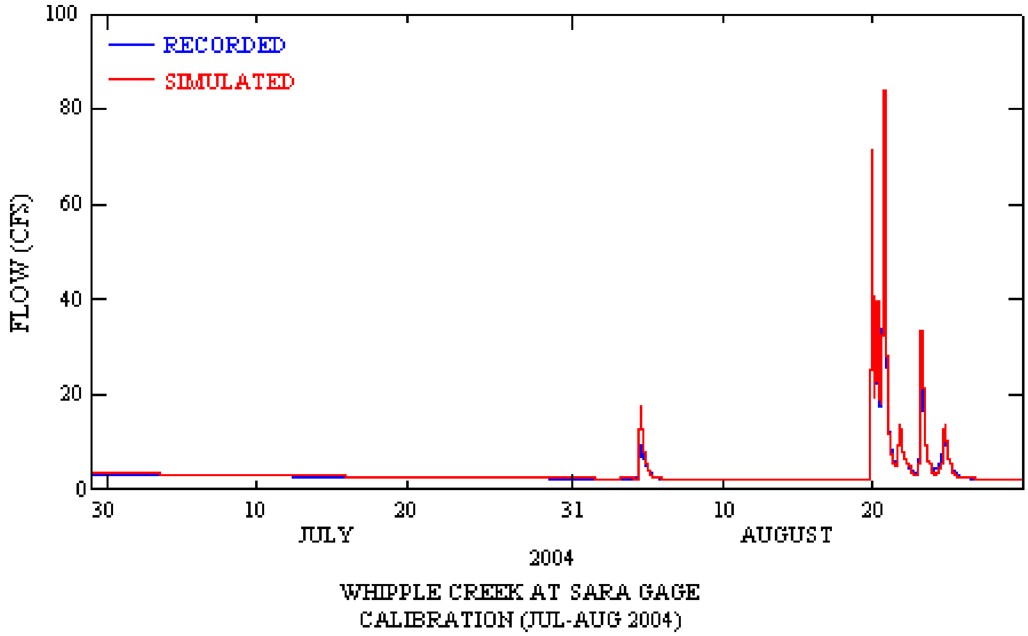
Whipple Creek Streamflow (January – February 2004)



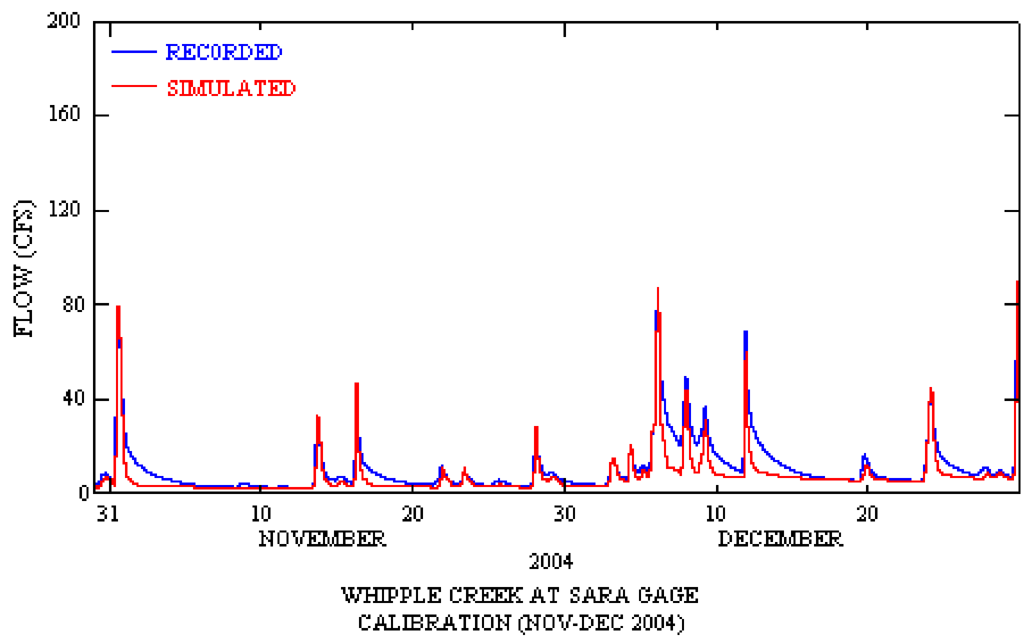
Whipple Creek Streamflow (March – April 2004)



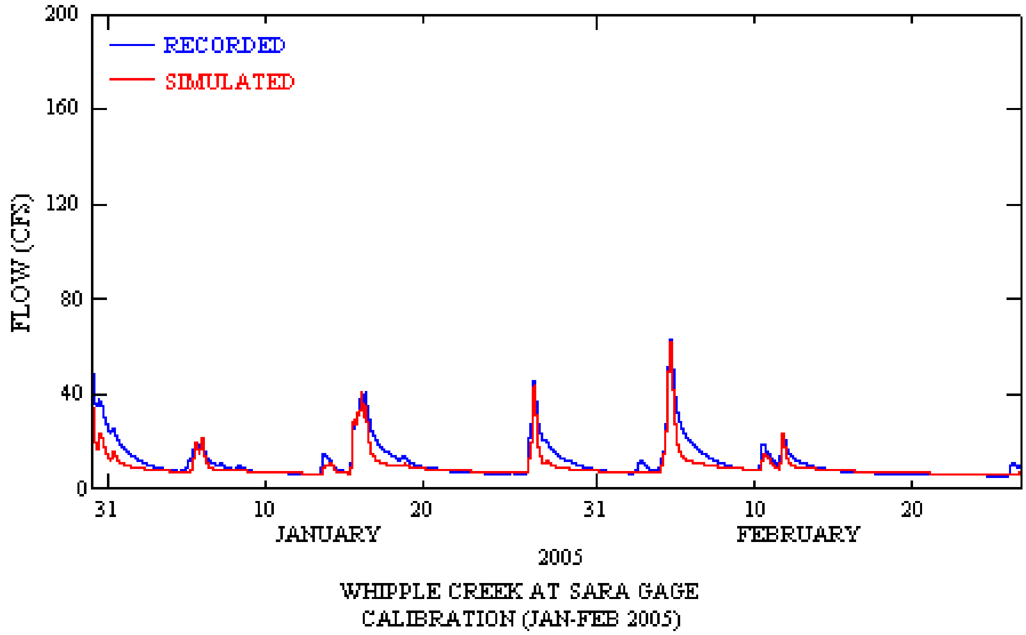
Whipple Creek Streamflow (May – June 2004)



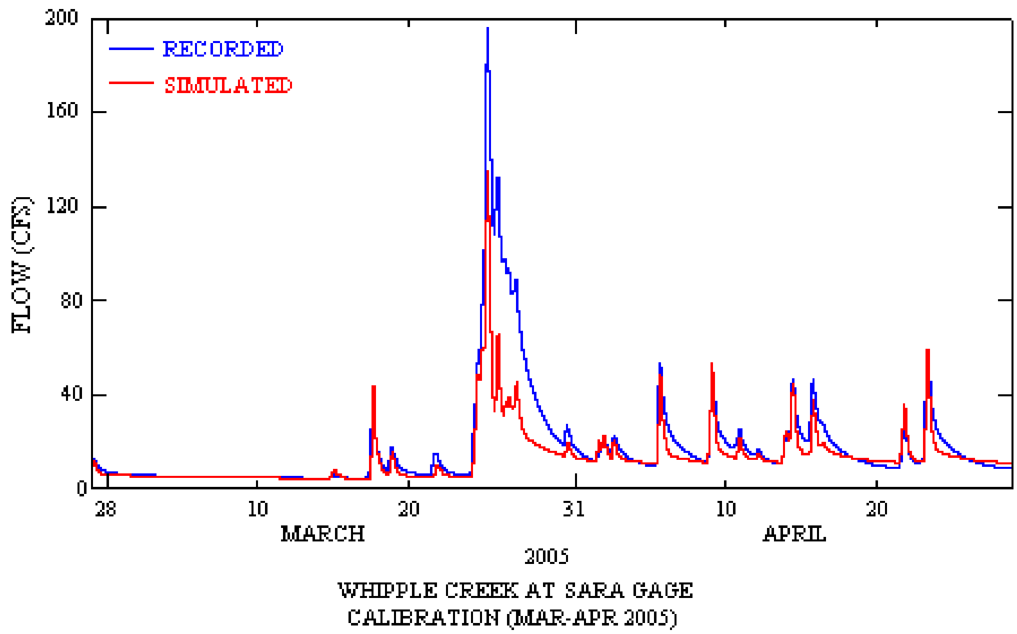
Whipple Creek Streamflow (July – August 2004)



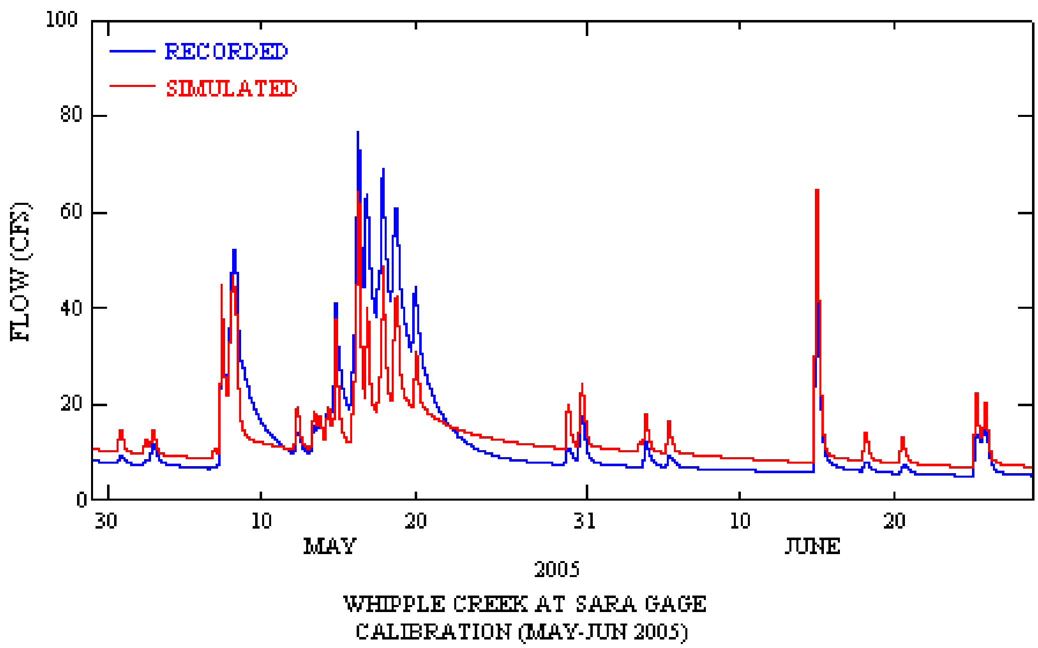
Whipple Creek Streamflow (November – December 2004)



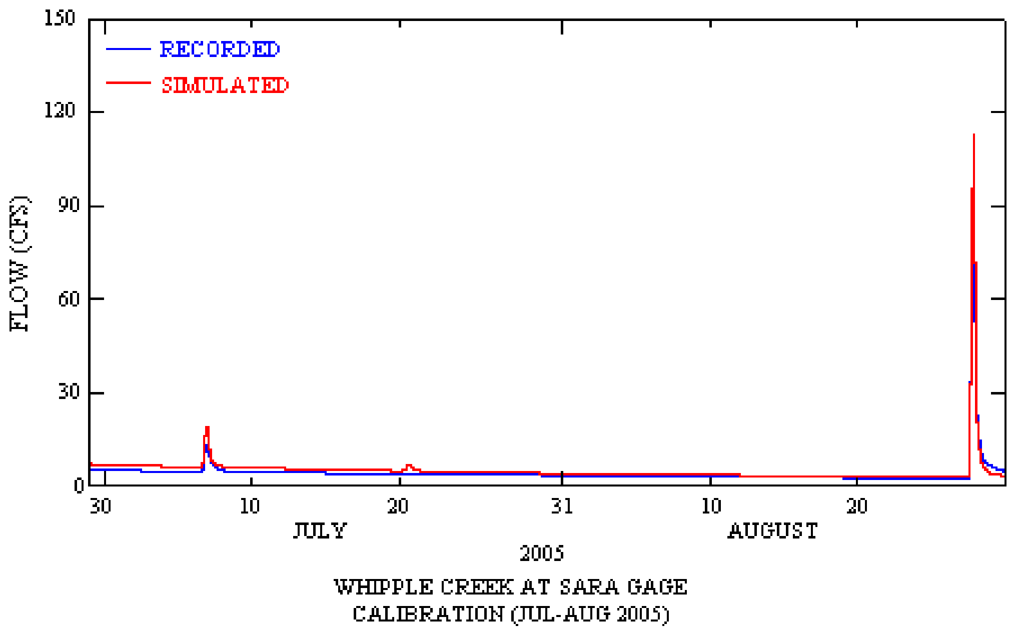
Whipple Creek Streamflow (January – February 2005)



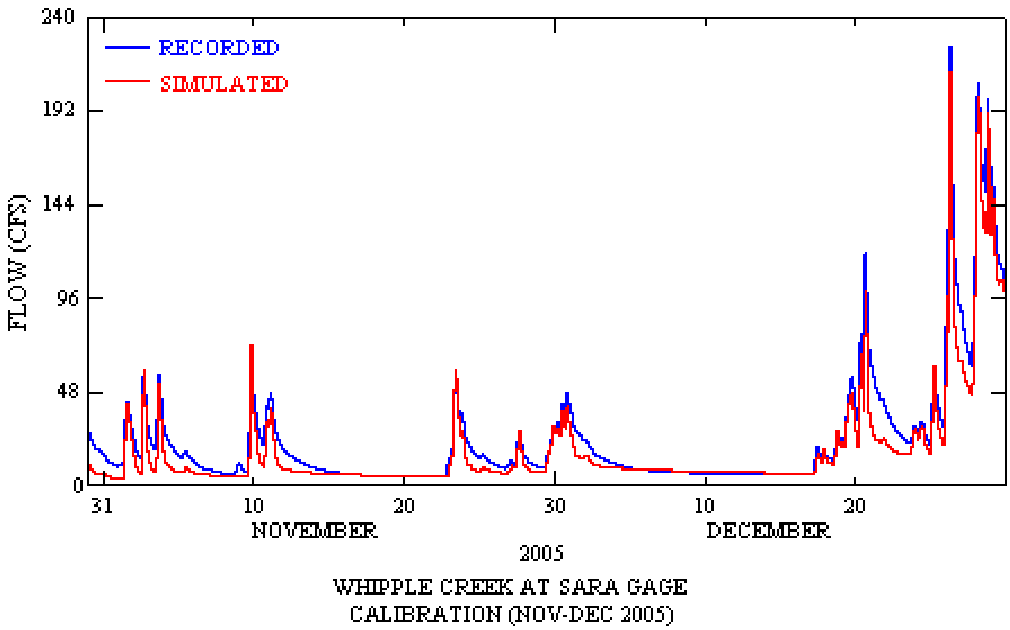
Whipple Creek Streamflow (March – April 2005)



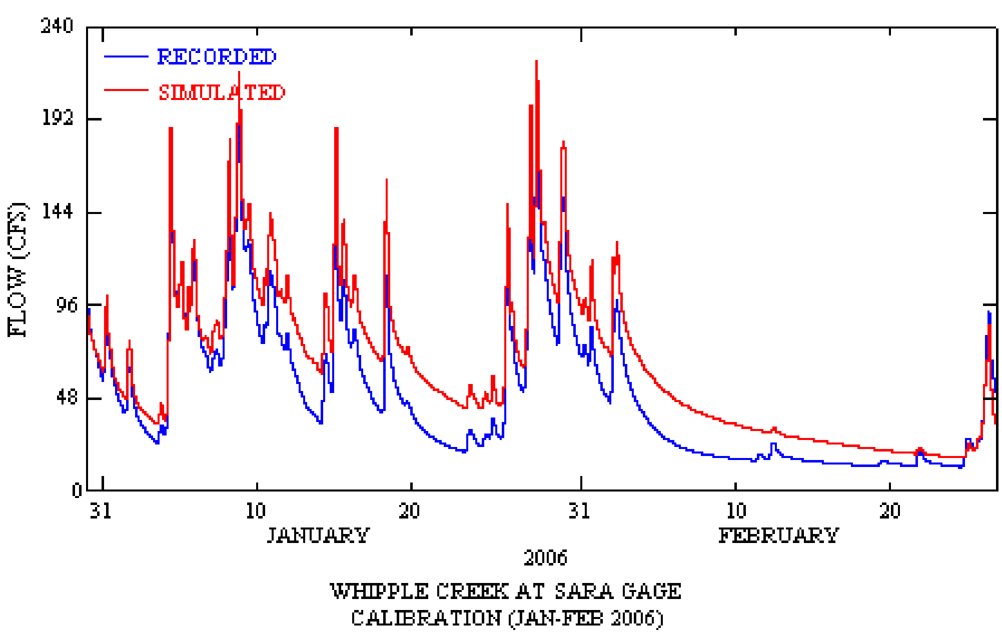
Whipple Creek Streamflow (May – June 2005)



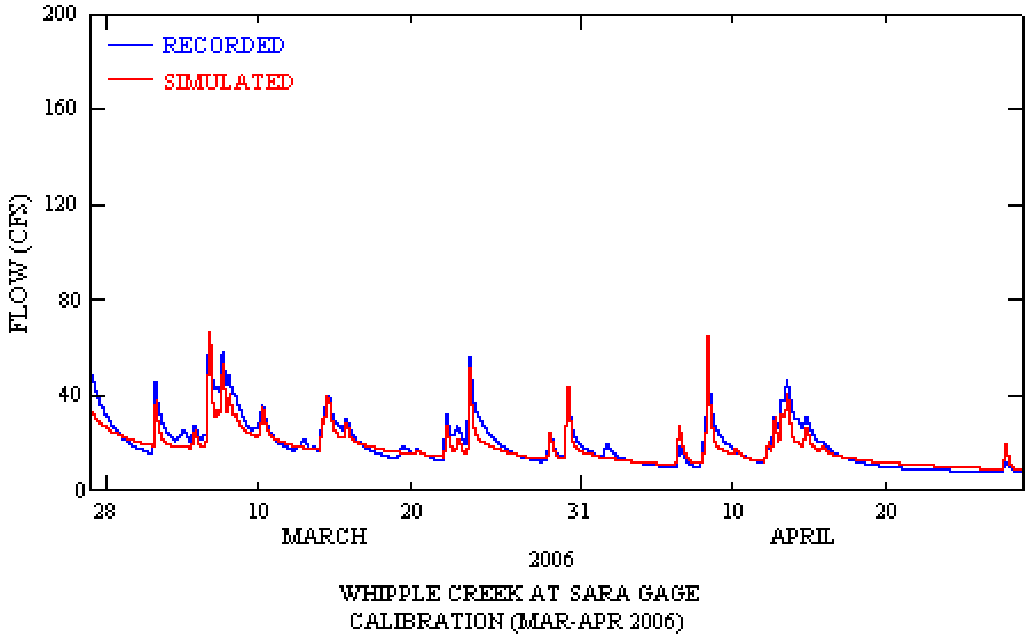
Whipple Creek Streamflow (July – August 2005)



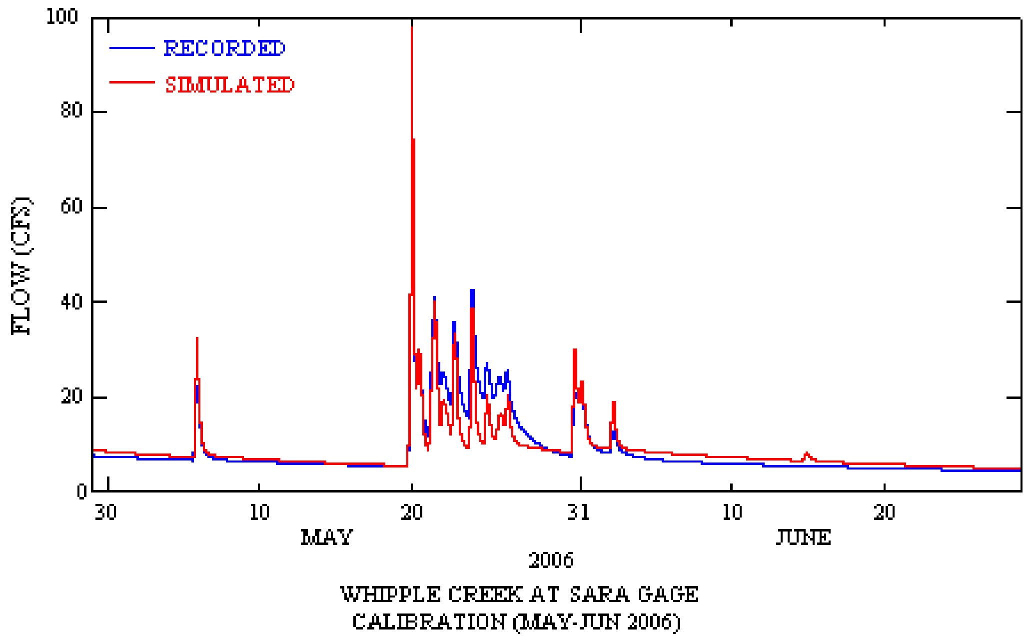
Whipple Creek Streamflow (November – December 2005)



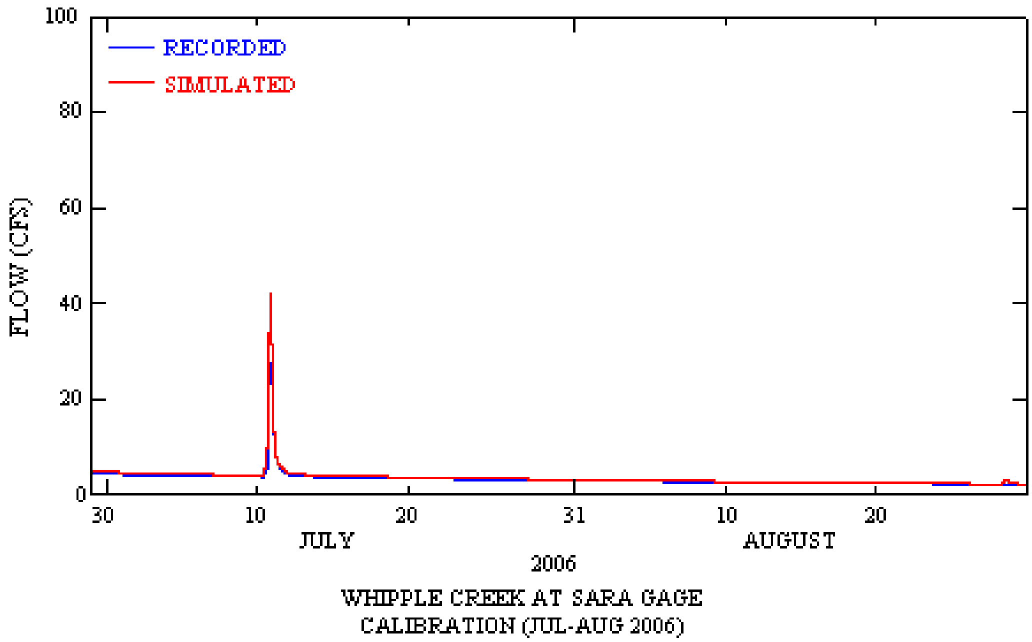
Whipple Creek Streamflow (January – February 2006)



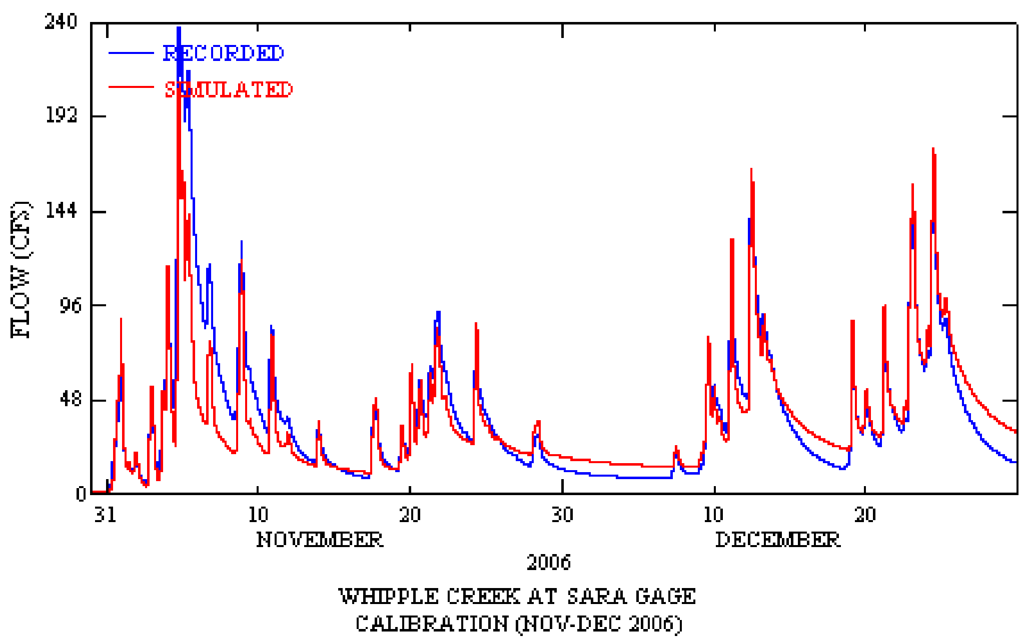
Whipple Creek Streamflow (March – April 2006)



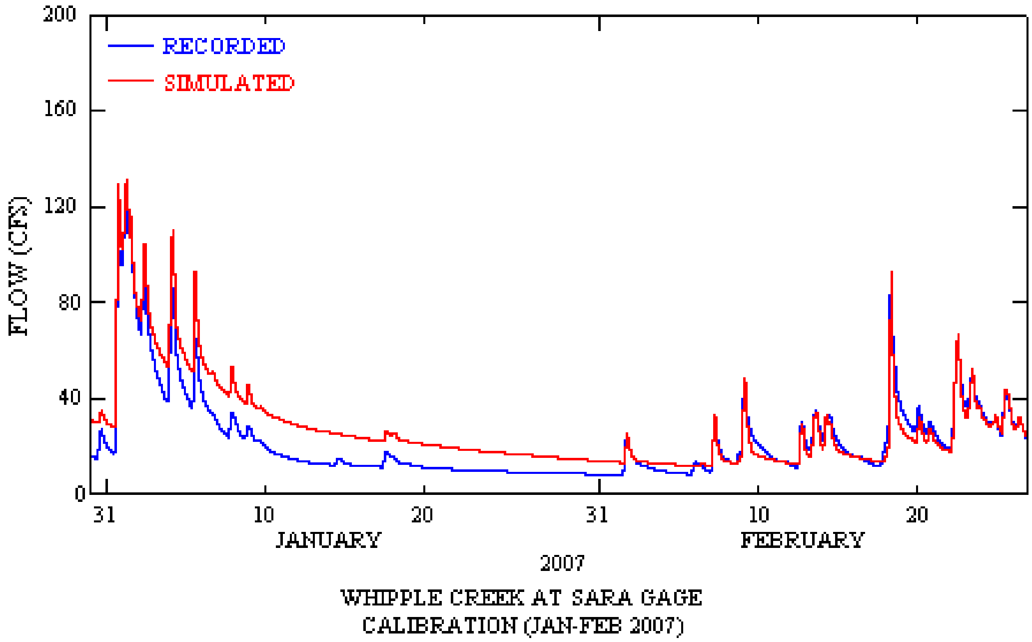
Whipple Creek Streamflow (May – June 2006)



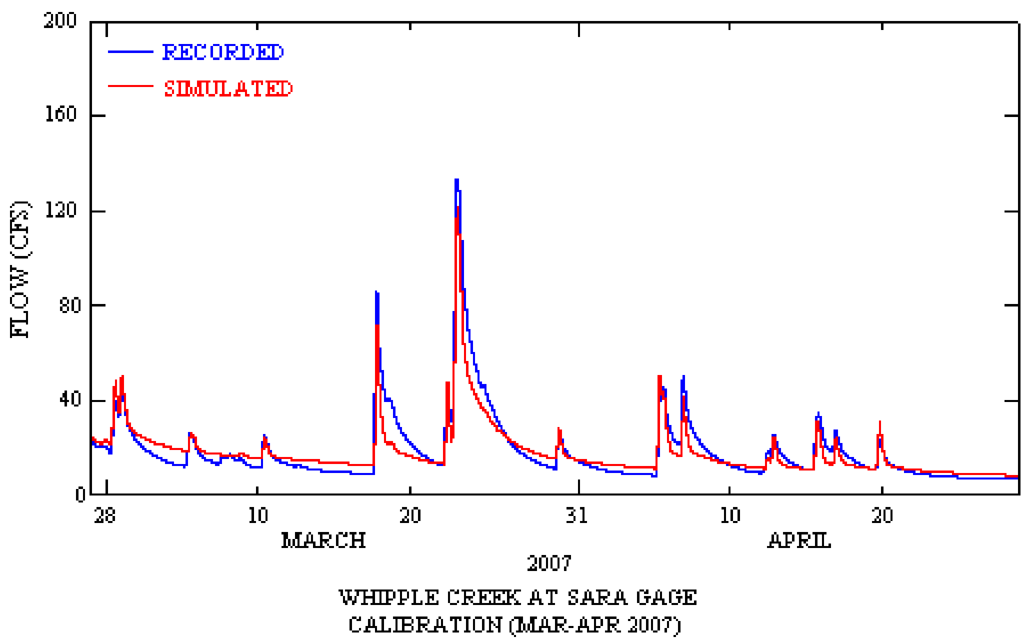
Whipple Creek Streamflow (July – August 2006)



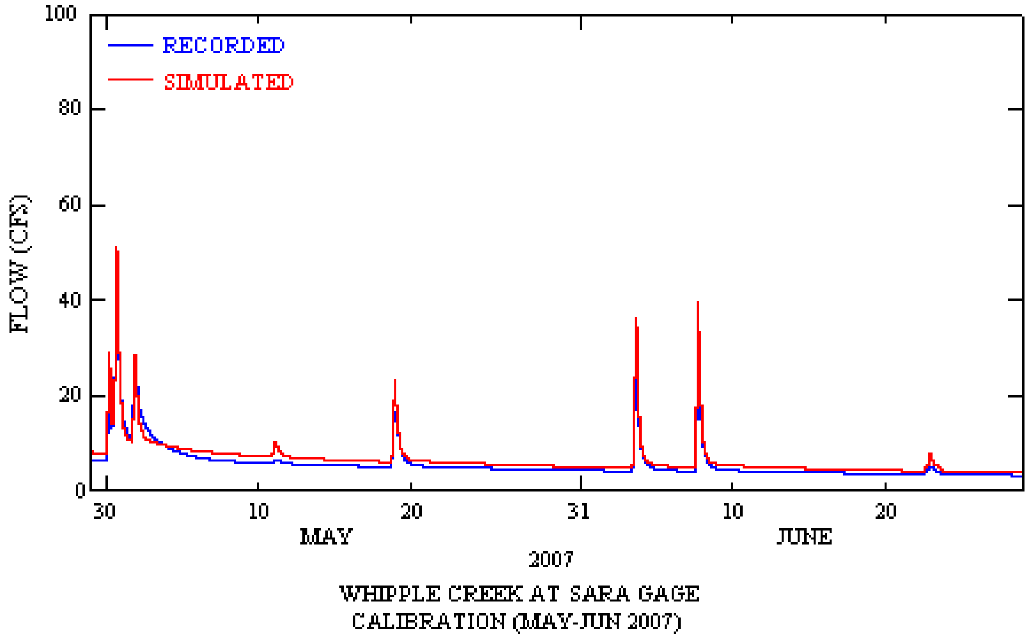
Whipple Creek Streamflow (November – December 2006)



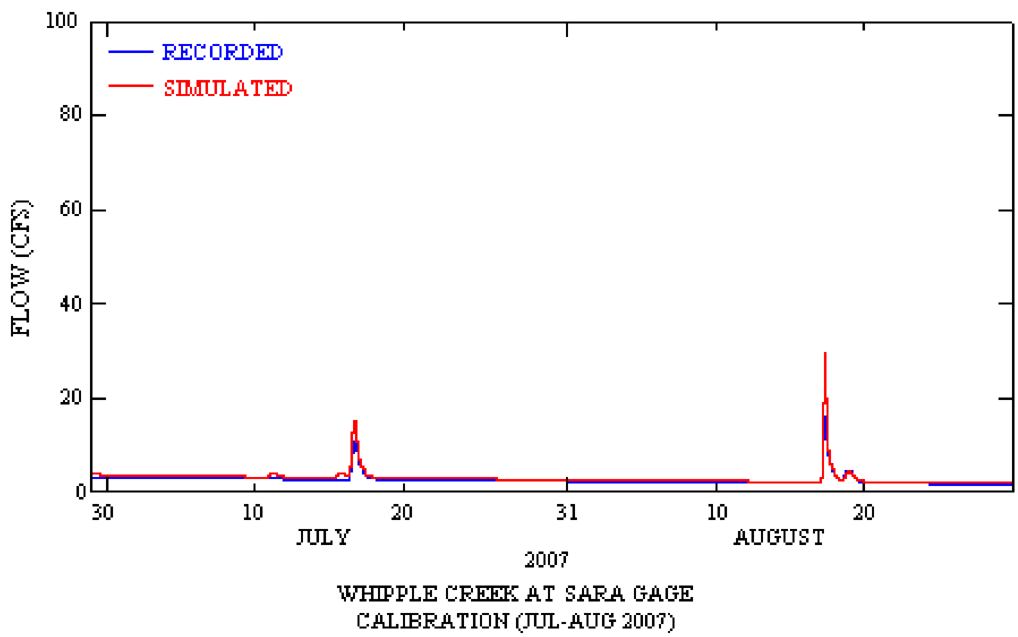
Whipple Creek Streamflow (January – February 2007)



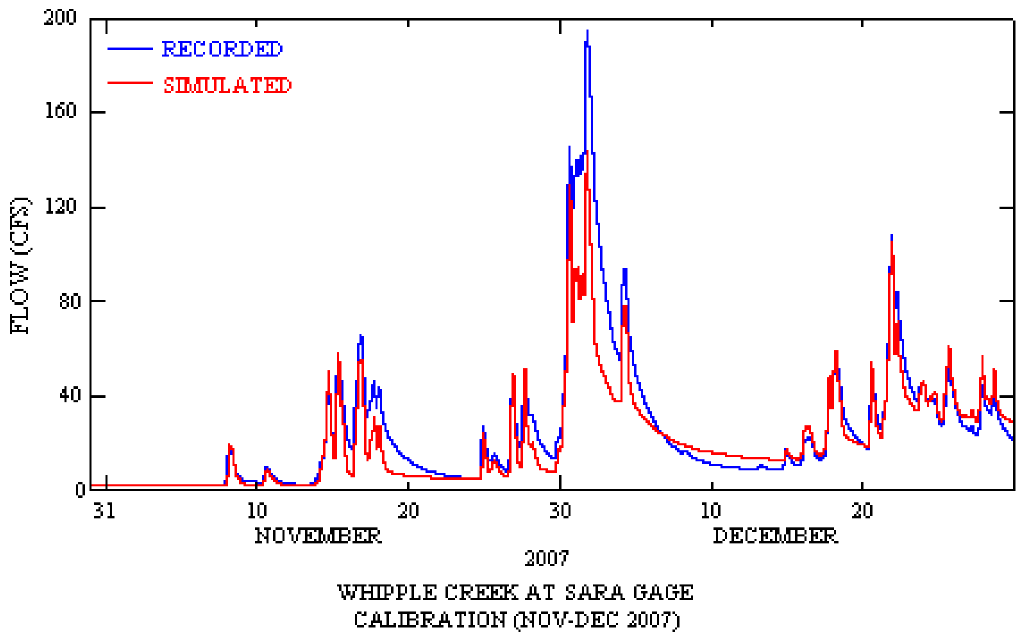
Whipple Creek Streamflow (March – April 2007)



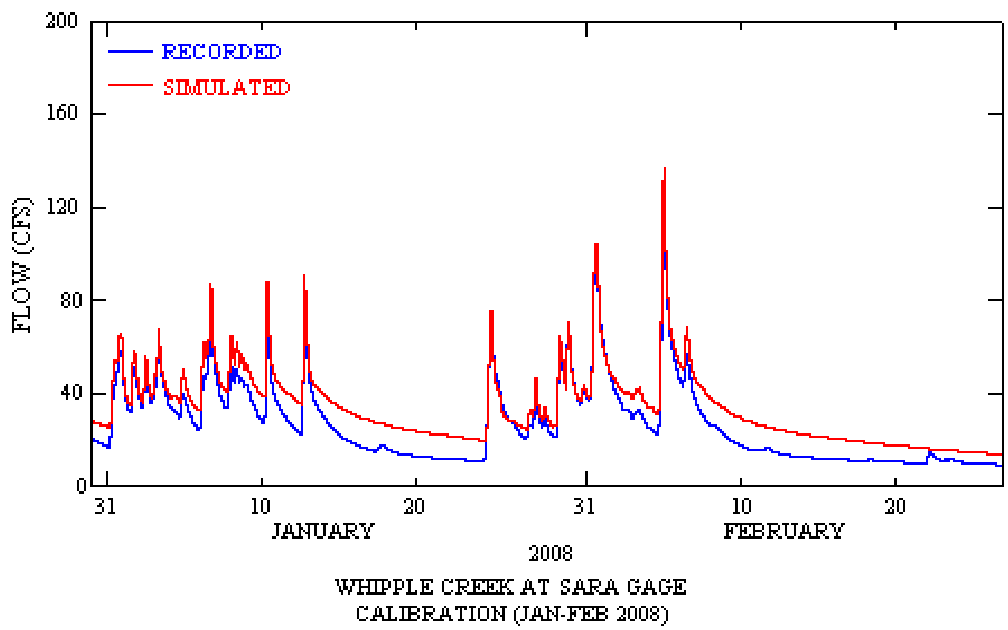
Whipple Creek Streamflow (May – June 2007)



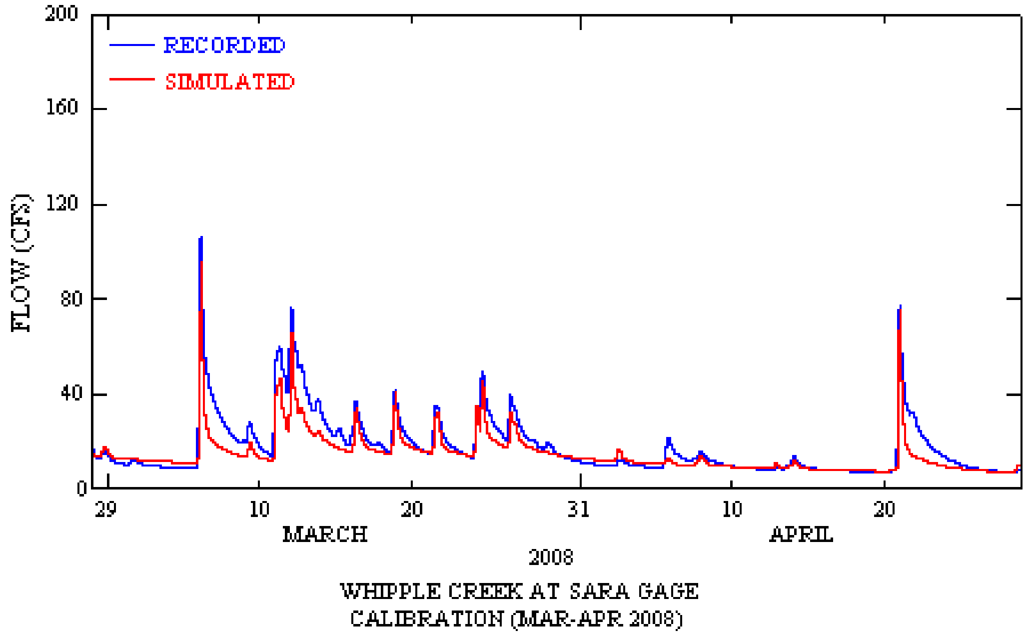
Whipple Creek Streamflow (July – August 2007)



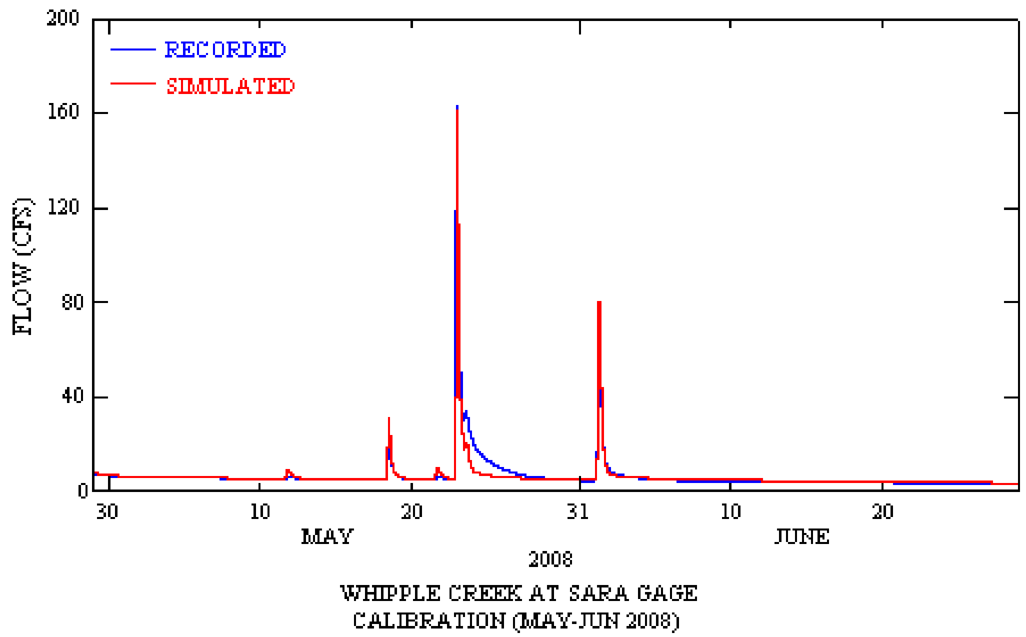
Whipple Creek Streamflow (November – December 2007)



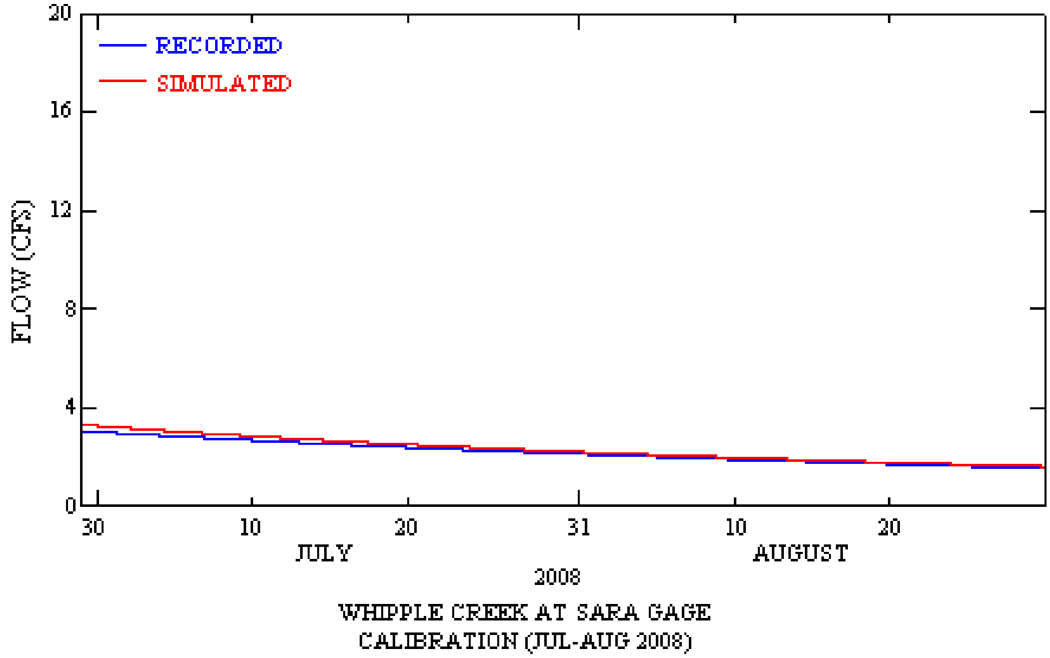
Whipple Creek Streamflow (January – February 2008)



Whipple Creek Streamflow (March – April 2008)



Whipple Creek Streamflow (May – June 2008)



Whipple Creek Streamflow (July – August 2008)

Attachment B: Model Parameters

PERLND	SOIL	VEGETATION	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
200	SG3	Forest	10.00	0.12	400	0.0570	0.50	0.991
210	SG3	Pasture	10.00	0.10	400	0.0570	0.50	0.991
220	SG3	Lawn	10.00	0.08	400	0.0570	0.50	0.991
260	SG4	Forest	8.00	0.10	400	0.0639	0.50	0.991
270	SG4	Pasture	8.00	0.08	400	0.0639	0.50	0.991
280	SG4	Lawn	8.00	0.06	400	0.0639	0.50	0.991
300	SG5	Forest	8.00	0.08	100	0.0100	0.50	0.991
310	SG5	Pasture	8.00	0.06	100	0.0100	0.50	0.991
320	SG5	Lawn	8.00	0.04	100	0.0100	0.50	0.991

PERLND	SOIL	VEGETATION	INFEXP	INFILD	DEEPFR	BASETP	AGWETP
200	SG3	Forest	2.00	2.00	0.00	0.00	0.00
210	SG3	Pasture	2.00	2.00	0.00	0.00	0.00
220	SG3	Lawn	2.00	2.00	0.00	0.00	0.00
260	SG4	Forest	2.00	2.00	0.00	0.00	0.00
270	SG4	Pasture	2.00	2.00	0.00	0.00	0.00
280	SG4	Lawn	2.00	2.00	0.00	0.00	0.00
300	SG5	Forest	10.00	2.00	0.00	0.00	0.70
310	SG5	Pasture	10.00	2.00	0.00	0.00	0.50
320	SG5	Lawn	10.00	2.00	0.00	0.00	0.35

PERLND	SOIL	VEGETATION	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
200	SG3	Forest	0.20	1.30	0.35	4.00	0.60	0.70
210	SG3	Pasture	0.15	1.30	0.30	4.00	0.60	0.40
220	SG3	Lawn	0.10	1.10	0.25	4.00	0.60	0.25
260	SG4	Forest	0.20	1.20	0.35	5.00	0.60	0.70
270	SG4	Pasture	0.15	1.20	0.30	5.00	0.60	0.40
280	SG4	Lawn	0.10	1.00	0.25	5.00	0.60	0.25
300	SG5	Forest	0.20	3.00	0.50	2.00	0.60	0.80
310	SG5	Pasture	0.15	3.00	0.50	2.00	0.60	0.60
320	SG5	Lawn	0.10	3.00	0.50	2.00	0.60	0.40

PERLND	SOIL	VEGETATION	CEPS	SURS	UZS	IFWS	LZS	AGWS	GWVS
200	SG3	Forest	0.00	0.00	0.00	0.00	1.00	0.50	0.00
210	SG3	Pasture	0.00	0.00	0.00	0.00	1.00	0.50	0.00
220	SG3	Lawn	0.00	0.00	0.00	0.00	1.00	0.50	0.00
260	SG4	Forest	0.00	0.00	0.00	0.00	1.00	0.50	0.00
270	SG4	Pasture	0.00	0.00	0.00	0.00	1.00	0.50	0.00
280	SG4	Lawn	0.00	0.00	0.00	0.00	1.00	0.50	0.00
300	SG5	Forest	0.00	0.00	0.00	0.00	1.00	0.50	0.00
310	SG5	Pasture	0.00	0.00	0.00	0.00	1.00	0.50	0.00
320	SG5	Lawn	0.00	0.00	0.00	0.00	1.00	0.50	0.00