2015 TRINITY RIVER
SEDIMENT TRANSPORT MONITORING
FINAL REPORT

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EXECUTIVE SUMMARY

Measurements of sediment transport (bedload and suspended sediment concentration) were collected at four locations (stations) during a high flow dam release on the Trinity River in May 2015. Water Year 2015 was a "Dry" water year type as classified by the California Department of Water Resources (DWR). Typical for a Dry Year, 453,000 acre feet of Trinity River water were allocated for restoration releases. The resulting hydrograph included a two-day peak 8,500 cfs flow bench, representing a new strategy for a "Dry" water year. Water Year 2015 was the 11th year monitored under the auspices of the Trinity River Restoration program since 2004. 2007, 2009 and 2013 were also Dry water years. By comparison, the 2011 Spring Flow Release provided the highest flow release yet made by the program: 11,600 cfs peak flow (a Wet Year with an allocation of 701,000 acre feet).

As per the agreement between the Trinity River Restoration program (TRRP) and GMA Hydrology (GMA), the level of effort for a typical Dry Water Year flow release was modified to cover the larger magnitude flow release. A total of 52 bedload and 27 suspended sediment samples were collected at the four mainstem sediment transport monitoring stations: Trinity River at Lewiston (TRAL), Trinity River above Grass Valley Creek (TRGV), Trinity River below Limekiln Gulch (TRLG), and Trinity River at Douglas City (TRDC) over the course of the flow release. The seven day monitoring effort spanned from May 3, 2015 to May 9, 2015. Crews collected one to three two-pass bedload samples, one two-pass suspended sediment sample and two water surface slope measurements at each station each day.

Continuous turbidity records were collected at three of the four stations (none at TRAL due to the very low turbidity which occurs in the short distance downstream of the dam) for use as a surrogate for computing continuous suspended sediment concentration. The TRGV station was also operated to collect continuous stage for the development of continuous streamflow during the release. This is the one station where a USGS gage is not co-located with the sediment monitoring station. Ten discharge measurements were collected at the TRGV station between April 23 and August 8 (using ADCP and conventional current meter techniques) and were used to develop and shift rating curves for continuous discharge record computation.

Suspended sediment loads were computed for the following (partial load) size ranges: <0.063mm, 0.063-0.5mm and ≥0.5mm. Total suspended sediment load is computed as the sum of the partial loads. Total suspended sediment loads for the spring flow release period (April 1 to July 31) increased in the downstream direction: 946 tons at TRAL, 3,160 tons at TRGV, 4,570 tons at TRLG, and 11,900 tons at TRDC.

Bedload discharge was computed for two (partial-load) size classes: 0.5-8mm and ≥8mm. The <0.5mm fraction is omitted as the samplers employ as 0.5mm mesh and an unknown quantity of <0.5mm bedload escapes measurement. Total bedload is derived as the sum of the two partial loads. Total computed bedload increased in the downstream direction with the exception of TRGV to TRLG: 861 tons at TRAL, 1,770 tons at TRGV, 670tons at TRLG, and 3,520 tons at TRDC.

The percentage of fine and coarse fractions within total bedload varies considerably by station, as 17 percent of the total bedload at TRAL was in the fine (0.5-8mm) size fraction, while TRGV had 23 percent; TRLG had 51 percent, and TRDC 46 percent. The coarse bedload transport was quite low at TRLG (326 tons), as was the case in 2012 and 2013. The computed >8mm bedload for all stations were considerably larger (>100 percent) than all three preceding Dry Year type release. At some stations, bedload discharge held fairly steady across the flow bench, suggesting that even in very low flow type releases, some falling limb data must be collected in order to more accurately compute sediment loads.

1.0 INTRODUCTION

The mainstem Trinity River drains a 2,036 square mile (mi^2) watershed (excluding the South Fork Trinity) joining the Klamath River at Weitchpec, some 43 miles above the Klamath's entry into the Pacific Ocean. The Trinity River is the largest tributary to the Klamath River and historically produced large runs of Chinook (*Oncorhynchus tshawytscha)*, Coho (*Oncorhynchus kisutch*) salmon and steelhead trout (*Oncorhynchus mykiss*). Impacts from industrial gold mining and logging in the early to mid 1900s substantially changed the mainstem and tributary channels. Placer mining overturned the streambeds and washed hillslopes into stream channels; while logging of highly erosive watersheds, such as Grass Valley Creek, introduced considerable quantities of sand into the mainstem. Following the start of flow regulation in November 1960, the Trinity River Diversion Project (TRD) was fully completed in 1964 to increase water supplies to the Central Valley Irrigation Project. The TRD blocked the upper 700 square miles of the watershed to fish passage, eliminated upstream large wood and sediment contributions, and severely reduced streamflow; in all, TRD diverted nearly 90 percent of the streamflow. The constant low flow releases below Lewiston Dam failed to transport the tributary sediment contributions, leaving large tributary deltas and significant quantities of sand-size decomposed granite. The low flows and large quantities of fine sediment provided the optimum conditions for riparian encroachment and berm development along the low-flow channel margin. This essentially eliminated channel migration, rendered the larger alluvial features immobile, and greatly simplified stream channel geometry (e.g., continuous rectangular channel). The subsequent habitat loss and aquatic species decline were documented in numerous studies by the U.S. Fish and Wildlife Service, the Hoopa Valley Tribe, and other agencies (e.g. Trinity River Maintenance Flow Study (McBain and Trush, 1997)).

In an effort to restore the Trinity River fish and wildlife, the Secretary of the Interior directed the U.S. Fish and Wildlife Service to prepare the Trinity River Flow Evaluation Study in 1981 (TRFE, U.S. Fish and Wildlife Service and Hoopa Valley Tribe, 1999). The TRFE produced recommendations "to fulfill fish and wildlife mandates" of the Congressional Act authorizing the Trinity River Diversion. The study also provided the basis for the Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Environmental Impact Report (US Fish and Wildlife Service, US Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County, 2000) and the Record of Decision signed in 2000 (ROD, U.S. Dept. of Interior, 2000). The ROD established the Trinity River Restoration Program (TRRP) with minimum water volume allocations based annually on water year type. The TRRP's purpose is to restore and maintain the natural production of fish and wildlife populations in the Trinity River, downstream of Lewiston Dam. To achieve this goal the TRFE and ROD provide the scientific framework and management strategy to reestablish natural physical processes that promote a dynamic alluvial system which, in turn, enhance aquatic habitat conditions capable of restoring salmonid populations. Restoration efforts focus on the Trinity River mainstem from Lewiston Dam downstream to the confluence with the North Fork Trinity River (Figure 1). The restoration strategy requires Spring Flow Releases, fine and coarse sediment management, and mechanical channel rehabilitation.

Managing dam releases to route fine and coarse sediment through a river system requires an accounting of the sediment inputs, outputs, and a change in stream channel storage (i.e., a sediment budget). The simplest form of a sediment budget is expressed by the mass balance relation:

Input – Output = Change in Storage

Sediment inputs downstream from the dam are delivered by tributaries and coarse sediment injections which are necessary to supplement lost upstream supplies or disconnected tributary supplies (i.e. Grass Valley Creek). Sediment outputs are simply the sediment transported by the mainstem at the downstream end of each sediment budget cell (Figure 2).

Several sediment budgets have been computed for the Trinity River between Lewiston Dam and Douglas City, including: the Trinity River Maintenance Flow Study (TRMFS, McBain & Trush, 1997); the Sediment Source Analysis for the Mainstem Trinity River (GMA, 2001); the Draft Sediment Budget and Monitoring Plan (SBMP, Wilcock, 2004); and the 2010 Bed-Material Sediment Budget Update (Gaeuman and Krause, 2011). Each sediment budget used the most current streamflow data, sediment transport measurements, tributary delta volumetric estimates, particle-size distribution measurements, and streamflow and sediment transport models to estimate the inputs and outputs to each mainstem sediment budget cell (Figure 2).

The TRFE, ROD, and subsequent scientific contributions (Wilcock, 2004; Gaeuman and Krause, 2011), specify monitoring actions to address sediment budgeting related hypotheses and questions, and evaluate specific sediment management objectives. “A sediment budget provides a consistent and comprehensive framework within which the sediment objectives of the TRRP may be evaluated” (Wilcock, 2004). The central TRRP *sediment budgeting* objectives outlined in the TRFE are to:

- Reduce fine sediment storage in the mainstem;
- Increase and maintain coarse sediment storage in the mainstem Trinity River;
- Route coarse sediment supply through all reaches of the mainstem; and
- Reduce fine sediment inputs to the Trinity River.

Sediment transport monitoring is intended to estimate the inputs and outputs to mainstem sediment budget cells, which support flow scheduling (e.g., determining flow magnitude and duration) and sediment management efforts (e.g., sediment budgeting and gravel management planning).

1.1 Sediment Management Objectives

The magnitude, duration, frequency, timing, and rate of change of the ROD flow hydrographs were selected based on thresholds required to initiate specific geomorphic processes (e.g., the flow magnitude necessary to scour a certain depth), the flow required to do work (e.g., flow duration required to transport various quantities of sediment), or historical aspects of the flow regime (e.g. historically, snowmelt flows occurred annually from April to June). This explanation focuses on the flow-induced geomorphic process and only partially explains the flow evaluation process described in the TRMFS and TRFE.

Previous monitoring indicates sediment transport rates vary considerably over time and space, and can span up to several orders of magnitude; therefore direct measurement provides the best method for estimating continuous sediment transport and annual loads (GMA, 2006b; Wilcock, 2004). Sediment discharge and load estimates provide feedback and predictive tools for sediment management efforts such as peak-flow duration and gravel injection locations and rates. The magnitude and duration of the Spring Flow Release helps determine the quantity of sediment transported through the mainstem sediment budget cells. Therefore the sediment management objectives were designed with the understanding that sediment inputs and mainstem transport vary with adjustments in the system (e.g., decreased tributary sediment input). Sediment Management objectives for all Water-Year Type Flow-Releases include transporting coarse and fine sediment delivered to the mainstem from tributaries (TRFE, p O-11)

1.2 Report Organization

This report presents the results of WY2015 mainstem sediment transport monitoring efforts. The scope, scale and historical context of sediment sampling on the Trinity River are detailed under *Sediment Transport Monitoring.* WY2015 *Methods* and *Results* are described in their respective sections. Results are compared to those from previous years to examine general trends (which may be of use by Trinity River managers for predictive purposes and to assess management actions such as gravel augmentation and channel/floodplain restoration). Explanatory figures and tables are included in the text, whereas larger datasets are relegated to the Appendix to improve readability. All data and seminal report files are included in a digital format. Less relevant documents (staff certification and SLQA compliance) are included with the digital files.

Definitions useful for this report:
"Site" and "Station" are used interchangeably to refer to the sediment monitoring locations. "Station" may also refer to a sampling location along a cross section – though in this case, we attempt to clarify in the associated text.

"Sediment discharge" is often used to describe both the instantaneous rate of sediment transport and/or the cumulated load over time. While others' definitions may vary, in this report we attempt to distinguish between sediment discharge and sediment load as follows.

(1) Sediment discharge: an instantaneous sediment transport rate, expressed in mass or volume per unit time (tons/day). For example, "a bedload discharge of 105 tons/day was measured on the Trinity River below Limekiln Gulch sample measurement #7 on 5/6/12 at 13:15;" and
(2) Sediment load: a mass or volume of sediment transported over a pre-defined unit of time (tons). This is the rate (sediment discharge) integrated over a period of time. For example, "674 tons of bedload were transported past the Trinity River below Limekiln Gulch monitoring station during the WY 2013 Spring Flow Release".

In this report, *sediment discharge* describes sediment in transport, and *sediment load* describes the quantity that was accumulated over a longer time period. A useful comparison is with streamflow: discharge is the instantaneous rate (cfs, analogous to sediment discharge) and yield is the volume of water cumulated over time (acre feet, analogous to sediment load).

2.0 SEDIMENT TRANSPORT MONITORING

WY2015 marks the 11th year (2004-2013, 2015) of mainstem Trinity River sediment transport monitoring by GMA Hydrology (GMA, formerly Graham Matthews and Associates) for TRRP. Sediment transport monitoring, in various forms, has periodically occurred at a range of sites in the TRRP study area during the last thirty years. For example, the US Geological Survey (USGS) collected sediment data from 1976-1999 at the Grass Valley Creek at Fawn Lodge gaging station, and from 1981-1991 at the Trinity River below Limekiln Gulch gaging station. Most of these sediment monitoring efforts supported the TRFE process, or watershed restoration and fine sediment reduction efforts occurring in tributary basins such as Grass Valley Creek. Previous results and data collection methods were described in detail in other reports, including the TRMFS; the Sediment Source Analysis for the Mainstem Trinity River Report (GMA, 2001); and the Annual Sediment Transport Monitoring Reports from WY 2002, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2013, 2014 (GMA, 2003, 2006a, 2006b, 2007, 2008, 2009, 2010, 2013, 2014, 2015).

In WY 2002, following recommendations from the ROD and TRFE, the Trinity River Restoration Program began operating several tributary and mainstem streamflow and sediment monitoring stations. Subsequent recommendations laid out in the SBMP (2004) focused the sediment transport monitoring efforts on three major tributaries and four mainstem sites (Figure 1). Sediment monitoring on the tributaries was discontinued after the 2006 Water Year.

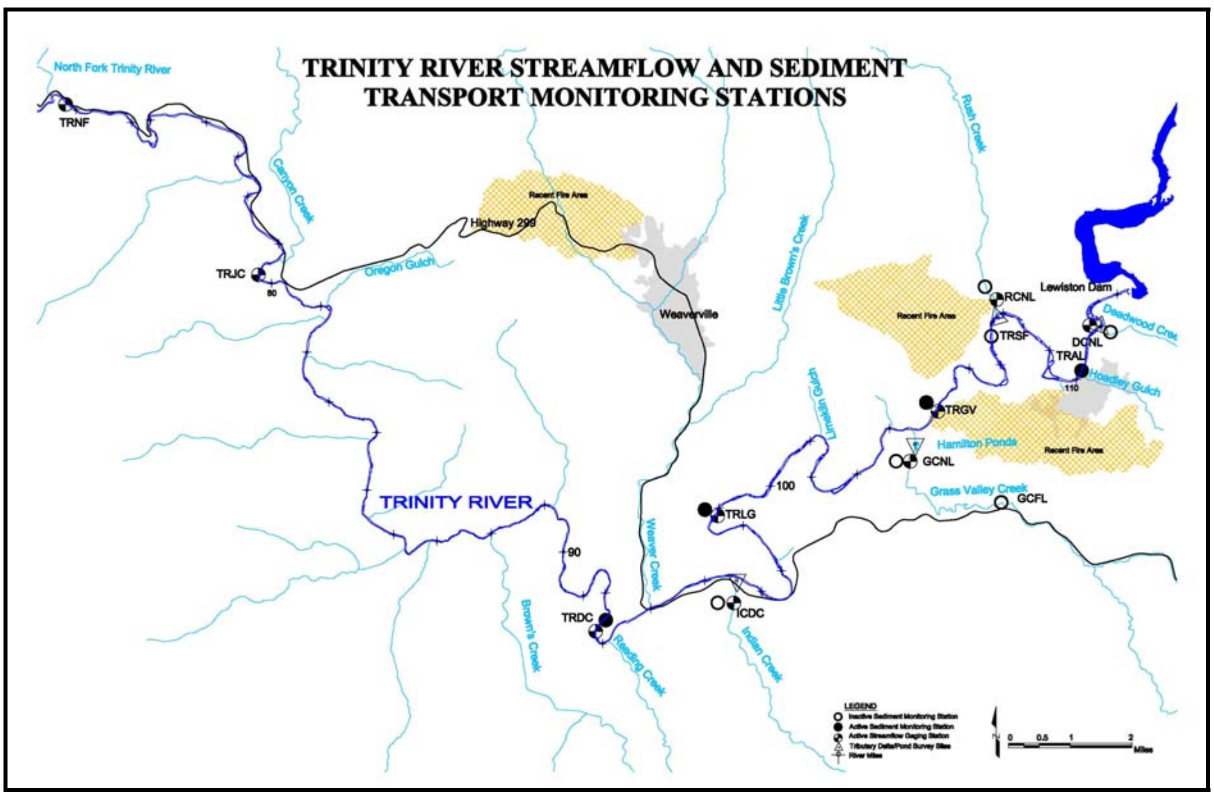


Figure 1. Location Map for the Trinity River Spring Flow Release Sediment Transport Monitoring.

2.1 Sediment Transport Monitoring Locations

In WY 2015, sediment transport data were collected at four mainstem Trinity River monitoring stations during the Spring Flow Release: Trinity River at Lewiston (TRAL, USGS gage #11525500, approximate River Mile [distance upstream from confluence with Klamath River, RM] 109.95), Trinity River above Grass Valley Creek near Lewiston (TRGV, GMA gage #11525540, RM 104.5), Trinity River below Limekiln Gulch near Douglas City (TRLG, USGS gage #11525655, RM 98.7), and Trinity River at Douglas City (TRDC, USGS gage #11525670, RM 92.6) (Figure 1). The USGS operated the streamflow gages at the TRAL, TRLG, and TRDC stations. GMA operated the seasonal streamflow gaging station at TRGV.

The monitoring stations were designed to provide sediment flux data for the four mainstem sediment budget cells between Lewiston Dam and Douglas City (Figure 2). The larger tributaries (site name initials provided for reference in Figure 1), Deadwood (DCNL), Rush (RCNL), Grass Valley (GCFL, GCNL), Indian (ICDC), Weaver, and Reading Creeks, provide the majority of the natural sediment contributions for the mainstem within the study area. The downstream-most sediment budget boundary is located near Douglas City, where additional streamflow and sediment contributions (from Indian, Weaver, and Reading Creeks) significantly reduce the coarse sediment and streamflow deficits. Below Douglas City, dam releases and natural runoff events are generally capable of transporting sediment influxes (TRFE, 1999; GMA, 2007).

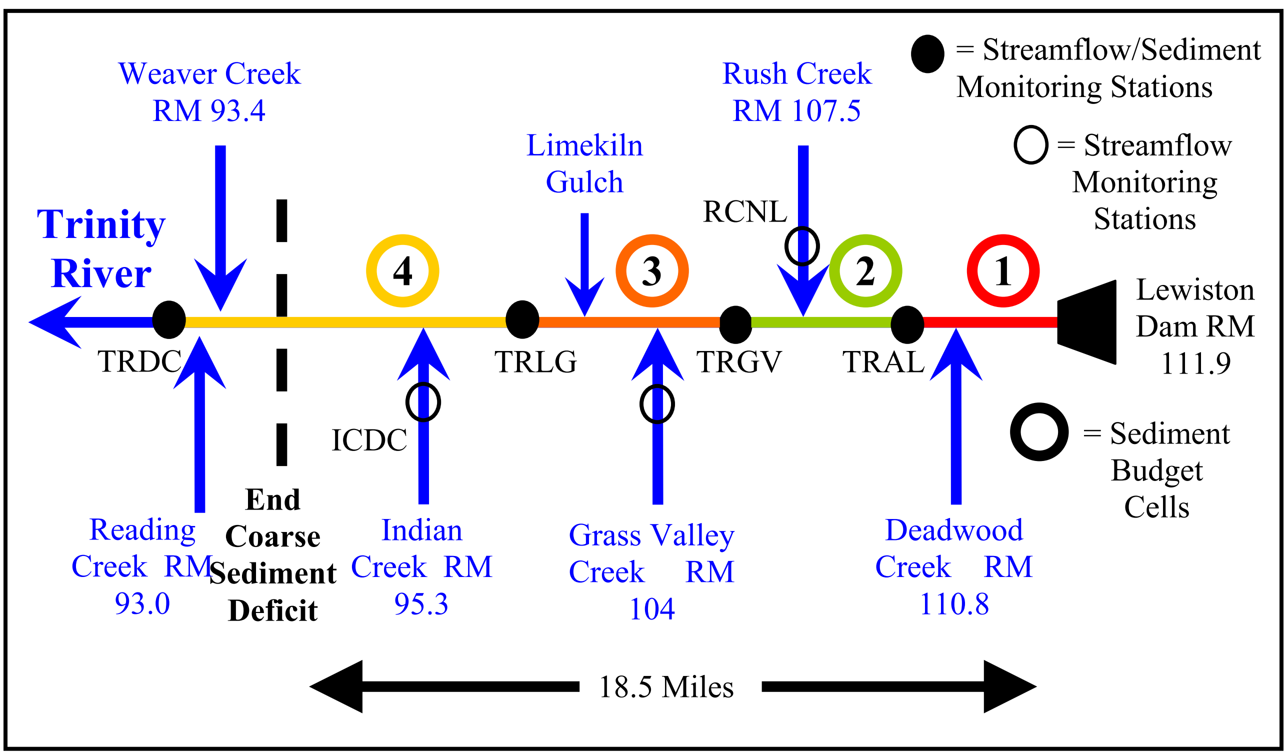


Figure 2. Trinity River Sediment Budget Cells

2.2 Sediment Transport Monitoring: Objectives and Tasks

WY 2015 sediment transport monitoring was limited to the Spring Flow Release period. The overall objectives were to determine the rate, volume (load) and texture of total sediment load at the four monitoring locations.

Primary sediment monitoring tasks designed to accomplish these objectives included:

- Operating mainstem sediment transport monitoring stations at: the Old Lewiston Bridge (TRAL); above the Grass Valley Creek confluence (TRGV); at the USGS gaging station below Limekiln Gulch (TRLG); and just downstream of the USGS streamflow gaging station at the Bureau of Land Management (BLM) Douglas City Campground (TRDC);
- Collecting continuous turbidity at three of the four mainstem sampling stations TRGV, TRLG, TRDC;
- Collecting streamflow measurements and continuous stage data at TRGV during the Spring Flow Release period;
- Developing stage/discharge relationships and computing streamflow records for TRGV;
- Developing turbidity/suspended sediment concentration (SSC) relationships, SSC/discharge, and bedload/discharge relationships where appropriate;
- Computing continuous bedload and suspended sediment discharge using sediment samples collected by GMA and methods developed by the USGS. Sediment sample analyses provide transport rates by size fraction: <0.063mm (suspended), 0.063-<0.5mm (suspended), ≥0.5mm (suspended), 0.5-<8.0mm (bedload), and ≥8.0mm (bedload); and
- Computing annual bedload and suspended sediment load estimates for these size classes.

Additional data were collected to support sediment transport computations, and subsequent sediment budgeting efforts, including: water surface slopes (during the flow release), bed-surface particle size distributions and cross section surveys at the sediment transport monitoring stations (pre and post the flow release) (Appendices A, B, C, D). New for 2015 was an experimental “bedload variability test” (repeat sampling at one location) to assess the potential range in magnitude of bedload transport.

2.3 Sediment Transport Monitoring Methods

Sampling protocols and methods, lab analysis, data entry, quality assurance, and sediment computation methods are described in detail in previous reports (GMA, 2006b); thus the following section provides only the absolutely essential descriptions.

2.3.1 Streamflow Monitoring and Computational Methods

Streamflow monitoring and continuous-discharge computation for the Trinity River above Grass Valley Creek was carried out using standard or modified USGS methods. Continuous stage was recorded using a Design Analysis H-310 pressure transducer. The H-310 has an accuracy of less than or equal to 0.025 percent of the full-scale output (FSO). Continuous stage readings were recorded in the data collection platform (DCP) at 15-minute intervals. Stage observations from staff plates were recorded on all site visits. All surface water data including electronic gage data, staff-height readings, the gage datum, and discharge measurements were entered and processed in the WISKI Suite (Water Information

Management System Kisters), developed by KISTERS AG. WISKI is a Windows-based time-series hydrological data management package, based on a relational database client-server platform such as Microsoft Sequel Server. The WISKI Suite is comprised of three components: WISKI, BIBER, and SKED. The main WISKI shell is the hydrologic workbench where all data are organized and where computations on time-series data are carried out. BIBER is used to evaluate and manage discharge measurements as well as track current meters and personnel using those meters. SKED is a rating curve editor that uses a graphical user interface to assist the hydrologist in developing, maintaining, and applying rating curves. The U.S. version of WISKI uses standard hydrologic computations and techniques as set forth by the USGS. Full details of computations can be found in the station analyses contained in Appendix B.

2.3.2 Mainstem Sediment Sampling

All sediment sampling was conducted from cataraft-based sampling platforms as in previous years. The catarafts were attached to tensioned cableways (temporary cableways of 3/8" galvanized wire rope) securely attached to trees or other anchors on either side of the channel. Various types of equipment were deployed from the cataraft platform, including TR-2 bedload samplers (with 0.5mm mesh, Figure 3) and US D-74 suspended sediment samplers. This was the 9th year that TR-2 bedload samplers were utilized at all four stations.

Crews consisted of two on-river personnel supported by a safety kayaker. All GMA staff have attended First Aid and CPR training and Swift Water Rescue Training. Crews collected up to three two pass bedload samples, one two pass suspended sediment sample and two water surface slope measurements per day. On the first and last days of sampling, crews covered two sites per day, with the modified goal of collecting one two-pass bedload sample, one two-pass suspended sediment sample and one water surface slope measurements.

TRGV, TRLG, and TRDC were each fitted with a Forest Technology Systems DTS-12 in-situ turbidity probe and a Campbell CR200 data collection platform, set to record on 15-minute intervals. Articulating booms were again used in 2015 to house the turbidity probes, whereas prior to 2011 the probes had been mounted in fixed locations. The articulated booms (Figure 4) allow turbidity probes to shed debris and produce much cleaner turbidity records.

Suspended sediment measurements were taken over a range of flows and at various positions on the hydrograph on six consecutive days, May 3-8, 2015. Cross-sections were typically sampled at 11-15 verticals. Protocols followed standard USGS procedures (Edwards and Glysson, 1999) for Equal Width Increment (EWI) sampling. Information recorded for each sample included: time, date, site, stage, bottle #, pass#, method, equipment used, etc. The GMA suspended sediment laboratory in Placerville, CA processed the suspended sediment samples, reporting suspended sediment concentration for all samples and particle-size ranges (<0.063mm, 0.063-<0.5mm or ≥0.5mm.

Bedload measurements were collected on six days within the release period. The sampling down-times ranged from 60 to 180 seconds. Because bedload transport at a cross-section is often highly variable over short periods, two cross-section passes were completed for nearly all samples. Bedload samples were analyzed in the GMA Coarse Sediment Lab in Placerville, CA (Figure 5).

Figure 3. A 200 lb twin-tube TR2 bedload sampler deployed from a cataraft.

Figure 4. An articulated turbidity boom deployed on Clear Creek, CA.

Figure 5. GMA Coarse Sediment Laboratory, Placerville, CA.

Station Analyses, detailing sediment data collection and computational methods, were developed for each sampling station (Appendices A, B, C, D). Quality Assurance plans for both laboratories are available to interested parties.

2.3.3 Continuous Suspended Sediment Discharge and Load Computations

The computational period for the mainstem stations was April 1, 2015 00:00 to July 31, 2015 23:45. (i.e. the Spring Flow Release). Suspended sediment transport curves were generated in order to develop estimates of continuous suspended sediment concentration (SSC). Sediment-transport curve analysis investigated whether streamflow and/or turbidity provided reasonable surrogate measures for predicting continuous suspended sediment concentration. SSC points for the transport curve plots were obtained from depth-integrated suspended sediment samples and the corresponding streamflow or turbidity values. Once sedigraphs of continuous concentration were generated using the transport curves, the plotted traces were adjusted to pass through the depth-integrated sample data points. Continuous concentration was transformed into continuous suspended sediment discharge (SSD) using the standard equation:

$$Q \text{ (cfs)} * SSC \text{ (mg/l)} * 0.002697 = SSD \text{ (tons/day)}$$

Continuous suspended sediment discharge was then summed over the release period to compute the load for the following size classes (partial loads): < 0.063mm, 0.063mm - <0.5mm, and ≥ 0.5mm. Mainstem total suspended sediment load was computed by summing the partial loads. For detailed information on suspended sediment discharge computations see the individual Station Analyses in Appendices A, B, C, and D

2.3.4 Continuous Bedload Discharge and Bedload Computations

The computational period for the mainstem stations was April 1, 2015 00:00 to July 31, 2015 23:45 (i.e. the Spring Flow Release). Continuous partial-bedload discharge was computed for 0.5-<8mm and ≥ 8mm size classes. Single (or multiple) sediment transport curves were fitted through distinct groupings of measured bedload vs stream discharge points. Continuous bedload sediment discharge was estimated as a function of stream discharge for the two size classes. Bedload sedigraphs (graphical depictions of continuous sediment discharge) were constructed and were manually fitted through the measured sediment discharge points. We believe this combined approach (utilizing multiple temporal transport curves and sedigraph fitting through measured data points) is more accurate for assessing the transport variability on the Trinity River (observed during previous flow releases) than the application of a single, general transport curve for the entire release period. While comparisons between the combined and single-curve approaches have shown minor differences in computed bedload discharge totals (GMA 2006b; 2007), the combined method highlights short term trends which the single regression method does not . In WY2015 the single general equation and multiple equation approaches were applied as appropriate

The TR-2 samplers were equipped with 0.5mm mesh sampler bags, which allowed an unknown portion of the <0.5mm size sediment particles to pass through the samplers. Therefore, continuous bedload discharge was not computed for the <0.5mm size fraction. For simplicity, the 0.5-<8mm and ≥ 8mm size classes are hereafter referred to as “fine” and “coarse” bedload. Continuous total bedload discharge was computed by summing these partial bedload discharges. Bedload was estimated for the release period by summing the area under the respective sedigraph. For detailed information on bedload discharge and bedload computations see the individual Station Analyses in Appendices A, B, C, and D.

2.4 Sediment Transport Monitoring Results

2.4.1 Hydrology and Streamflow

The following description of the Water Year 2015 hydrologic setting and the resulting flow release hydrograph. WY2015 was determined to be a “Dry” water year (TRRP 2015). The approved release hydrograph included a two-week rise to 7,500 cfs (for one day), followed by a two-day peak flow bench at 8,500 cfs.

The discharge hydrograph is described here as the *daily flow* reported for the USGS gage near Lewiston (11525500). Flow releases from Lewiston Dam to the Trinity River remained around 300 cfs through April 21 then flow was increased to 404 cfs on April 22. The remainder of the flow release commenced as follows:

- April 23-- April 27 – gradual increase to 586 cfs
- April 28 – May 4 – steep, continuous rise to 6,250 cfs,
- May 4 – brief flow bench at approximately 7,500 cfs

- May 5 – May 6 – two day peak flow bench at approximately 8,270 cfs

The falling limb was less steep and much longer and occurred as follows:

- May 7 – fall to 6,750 cfs
- May 8 – fall to 4,430 cfs
- May 9 – fall to 3,140 cfs
- May 10 – May 12 – flow bench of approximately 3,000 cfs
- May 13 – fall to 2,160 cfs
- May 13 – May 29 – flow bench of approximately 2,000 cfs
- May 30 – July 1 – gradual fall to summer base flow of approximately 450 cfs

Examination of the *15 minute* discharge data (Figure 6) reveals the following:

The peak flow measured at the Lewiston gage was 8,830 cfs (May 4 at 23:00). Rising limb flow benches were relatively brief. The rising-limb 7,500 cfs flow bench lasted 8 hours on May 4 at 14:00 hours to 22:00 hrs. At this point the flow increased 1,000 cfs in one 15 minute recording interval and remained above 8,000 cfs through May 7 at 01:15 (2.4 days). During the 8,500 cfs flow bench, flows fluctuated from 8,020 cfs to 8,830, with a mean of 8,270 cfs. The falling limb 7,500 cfs flow bench lasted 7.5 hours from 01:45 to 09:15 on May 7. Another 8 hour falling-limb flow bench (approximately 6,500 cfs) occurred between 10:00 and 18:00 on May 7, then flows dropped steadily through May 9 at 12:00 to the 3,000 cfs flow bench which lasted until May 12 at 13:30. No sampling (other than turbidity) occurred after May 9.

2.4.2 Mainstem Sediment Transport Monitoring

GMA sampling crews collected suspended sediment and bedload measurements during seven days from May 3 to May 9, 2015. Crews were able to collect one to three bedload samples and one suspended sediment sample each day (the sampling period at TRAL ended May 8). Table 1 summarizes the number of bedload and suspended sediment samples collect by station. For 2015, experimental bedload-variability testing (repeated sampling at a high-transport location) was conducted at three of the four stations. Crews collected ten discharge measurements during the release period (for computing continuous discharge at TRGV). The Appendices provide hydrographs displaying the timing of bedload and suspended sediment samples at each station (Appendices A, B, C, and D).

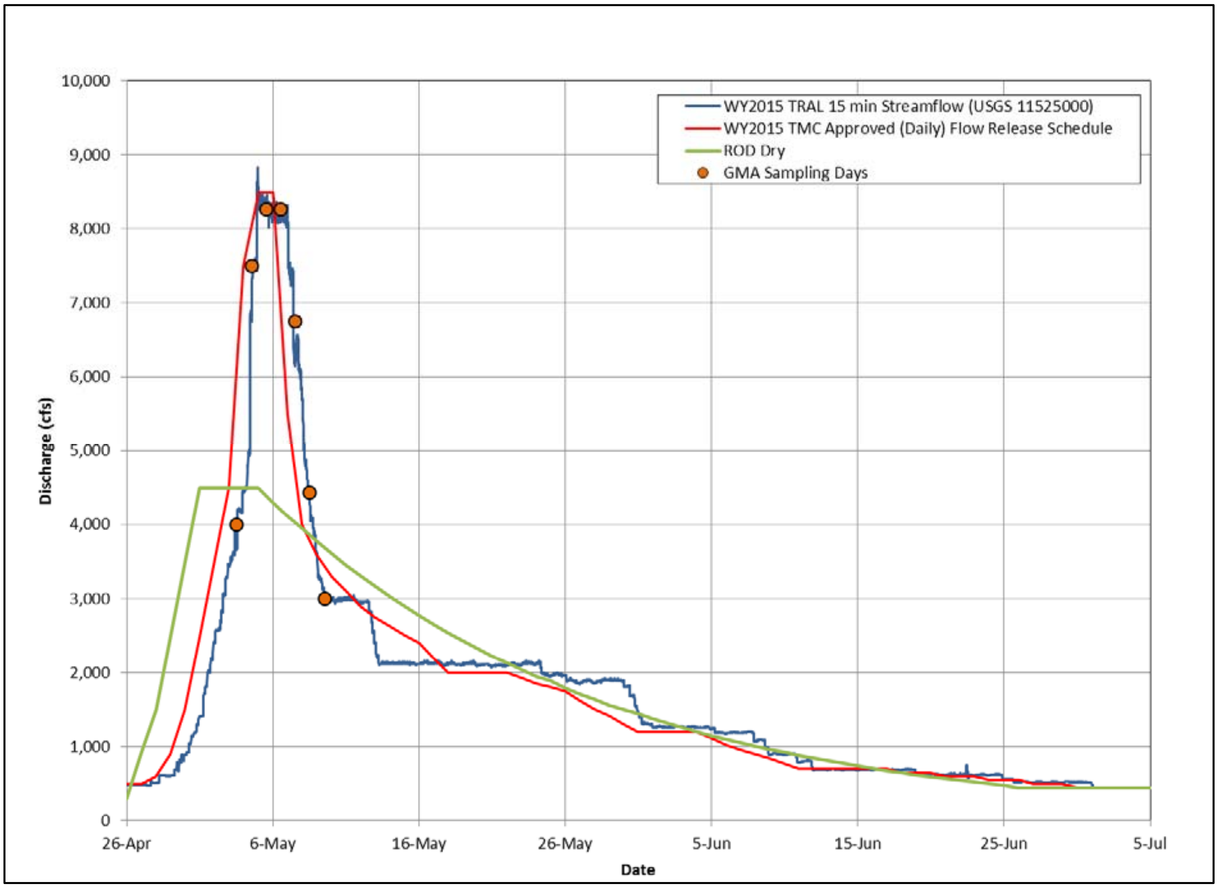


Figure 6. ROD Dry, TMC Approved, and WY2015 Streamflow for USGS Gage #11525500, Trinity River at Lewiston, CA for the 2015 Spring Flow Release

Table 1. WY 2015 Mainstem Sediment Sample Summary

SEDIMENT MONITORING STATION	SUSPENDED SEDIMENT SAMPLES (# collected)	BEDLOAD SAMPLES (# collected)
Trinity River at Lewiston (TRAL)	6	10
Trinity River above Grass Valley Creek (TRGV)	7	14
Trinity River below Limekiln Gulch (TRLG)	7	15
Trinity River near Douglas City (TRDC)	7	13

2.4.2.1 Trinity River at Lewiston

Station Description

The TRAL station defines the end of the first sediment budgeting cell which starts at Lewiston Dam (Figure 1, Figure 7). Since WY 2005, sediment transport monitoring has occurred directly beneath the old Lewiston Bridge. Previous sediment transport monitoring occurred 1,150 ft upstream, near the USGS Trinity River at Lewiston Gaging Station cableway. The USGS streamflow gaging station (#11525500) is located farther upstream, just below the old fish weir. The WY2015 water surface slope through the reach at 8,500 cfs is 0.0017.

Suspended Sediment Transport Data

Six suspended sediment discharge samples were collected at TRAL during the Spring Flow Release. All of the suspended sediment samples were two-pass samples. Sample concentrations ranged from 4 to 14 mg/l (Table 2), and the corresponding suspended sediment discharges ranged from 39 to 288 tons/day (Table 2, Figure 8).

The low concentrations and low turbidity at TRAL preclude the use of turbidity as a surrogate for SSC. Consequently, continuous suspended-sediment concentration is derived using measured concentrations and continuous discharge as a surrogate for SSC. The WY 2015 total suspended sediment discharge measurements were plotted in Figure 8 along with data from WY 2004-13. Appendix A-3 contains the transport curves used for the WY 2015 load computations.

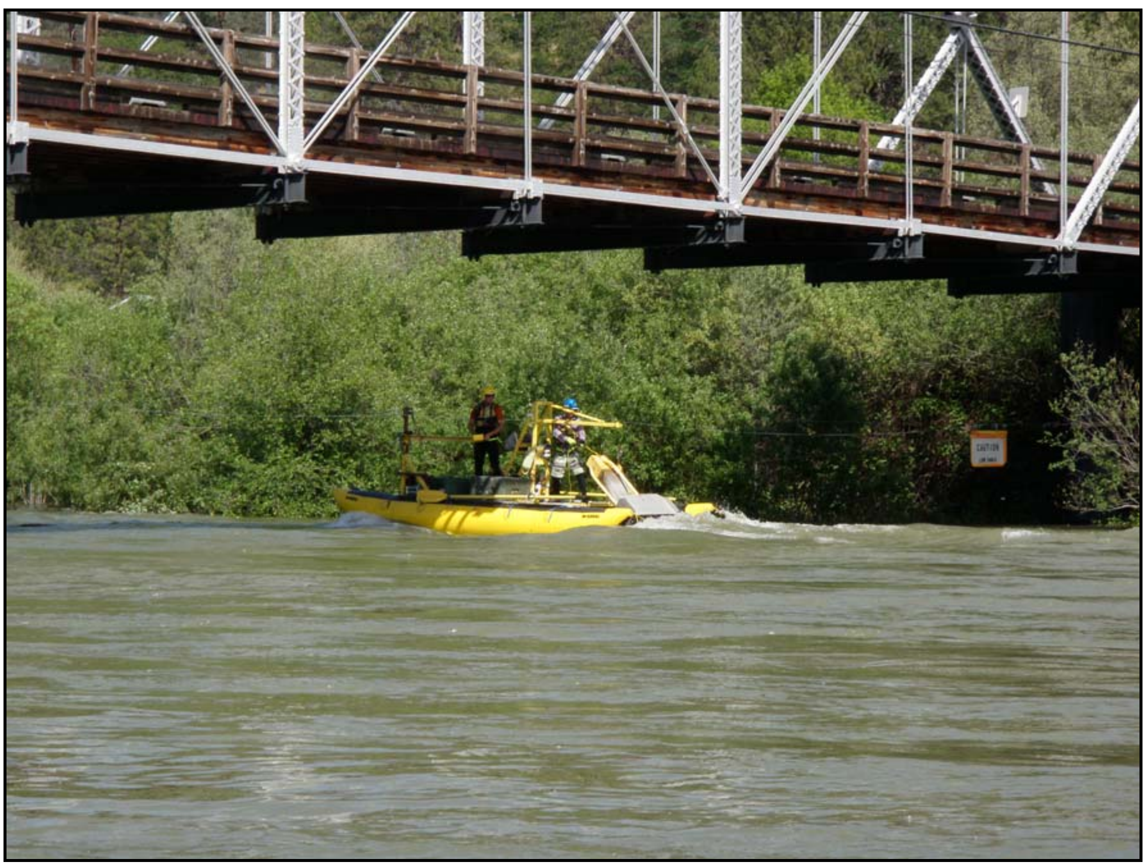


Figure 7. Upstream view of TRAL Sampling Site, WY2015. Flow is ~8,500 cfs.

Table 2. Trinity River at Lewiston, CA -- USGS Gage #11525500, Suspended Sediment Sampling Summary -- WY2015.

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC (mg/l)	Average SSD (tons/day)
TRAL-SSCT2015-01	5/3/2015 13:05	3,670	4	39
TRAL-SSCT2015-02	5/4/2015 17:41	7,510	14	288
TRAL-SSCT2015-03	5/5/2015 16:25	8,280	10	217
TRAL-SSCT2015-04	5/6/2015 18:53	8,160	7	157
TRAL-SSCT2015-05	5/7/2015 10:38	6,330	7	114
TRAL-SSCT2015-06	5/8/2015 11:45	4,320	5	56

Values Rounded According to Porterfield (1972)

The <0.063mm SSC data does not exhibit hysteresis (Appendix D-1), therefore a single generalized transport curve was developed (Appendix A-3). The 0.063-<0.5mm and the ≥0.5mm size classes do show a pattern of hysteresis, however they were too complex to describe with multiple equations, so single generalized equations were also used. Hysteresis was addressed by adjusting the continuous concentration to the individual sample data points using proportional and hydrograph-fitting techniques (Appendix A-1). Continuous suspended sediment discharge (SSD) was computed from continuous SSC, then SSD was integrated over the release period to generate load. Computational methods and assumptions are detailed in the Station Analysis (Appendix A-1). The sedigraphs are presented in Appendix A-5.

The partial and total loads for the computational period were 662, 83, 201, and 946 tons (Table 3). Appendix A-8 contains the suspended sediment sample data (particle size distributions, summary tables, etc.) and the computations (daily and 15-min suspended sediment discharge and cumulative load values).

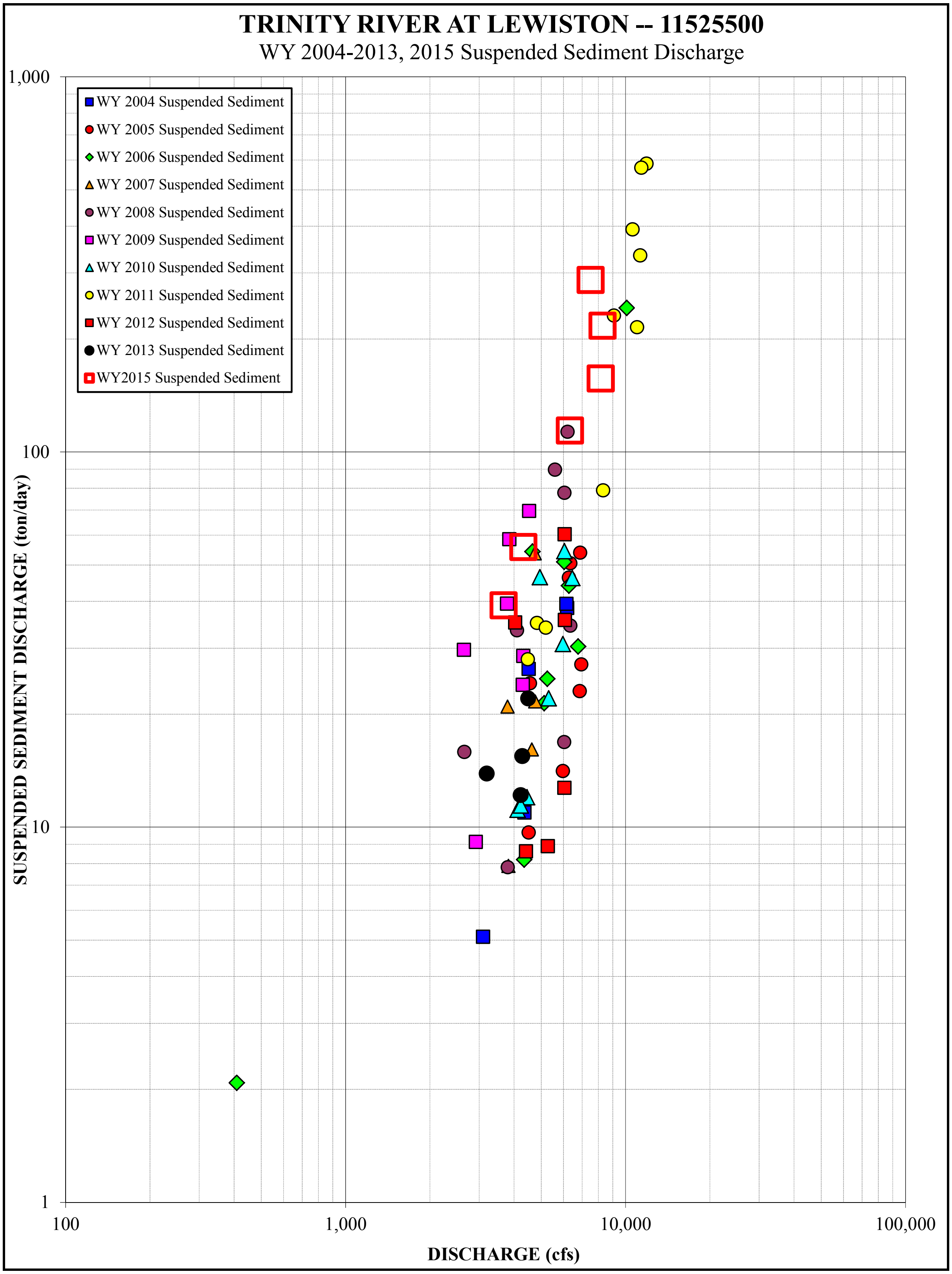


Figure 8. Suspended Sediment Discharge at TRAL 2004-2013, 2015.

Table 3. Trinity River at Lewiston, CA -- USGS Gage #11525500, Suspended Sediment Loads -- WY2015.

< 0.063 mm (tons)	0.063 mm-<0.50 mm (tons)	≥0.50 mm (tons)	Total Load (tons)
662	**83**	**201**	**946**

Bedload Data

Ten bedload samples were collected at TRAL during the Spring Flow Release. Eight samples were two-pass samples. Bedload sample data are displayed in Table 4. Bedload sample times were plotted on the hydrographs in Appendix A-4 and displayed in the Bedload Summary in Appendix A-7. WY 2015 fine, coarse, and total bedload discharge points were plotted with historic data in Figures 9-11. Measured total bedload discharge (sum of fine and coarse bedload) varied from 0.66 tons/day on May 3 to a peak of 365 tons/day on May 6 and back down to 1.3 tons/day on May 8. The bedload transport curves used to compute continuous bedload discharge are located in Appendix A-2.

Table 4. Trinity River at Lewiston -- USGS #11525500, Bedload Sampling Summary -- WY2015.

Sample Number	Date & Mean Time	Discharge (cfs)	Total Bedload Discharge (tons/day)	≥ 8mm Bedload Discharge (tons/day)	0.5-<8 mm Bedload Discharge (tons/day)
TRAL-BLM2015-01	05/03/2015 11:53	3,650	0.66	0.00	0.66
TRAL-BLM2015-02	05/04/2015 13:35	6,830	143	126	17
TRAL-BLM2015-03	05/04/2015 15:59	7,470	288	246	43
TRAL-BLM2015-04	05/05/2015 11:14	8,340	261	201	60
TRAL-BLM2015-05	05/05/2015 12:55	8,380	311	247	64
TRAL-BLM2015-06	05/06/2015 12:45	8,180	343	333	10
TRAL-BLM2015-07	05/06/2015 14:53	8,170	365	318	47
TRAL-BLM2015-08	05/06/2015 17:22	8,250	272	222	50
TRAL-BLM2015-09	05/07/2015 12:50	6,220	89	70	19
TRAL-BLM2015-10	05/08/2015 12:50	4,280	1.3	0.66	0.67

Values Rounded According to Porterfield (1972)

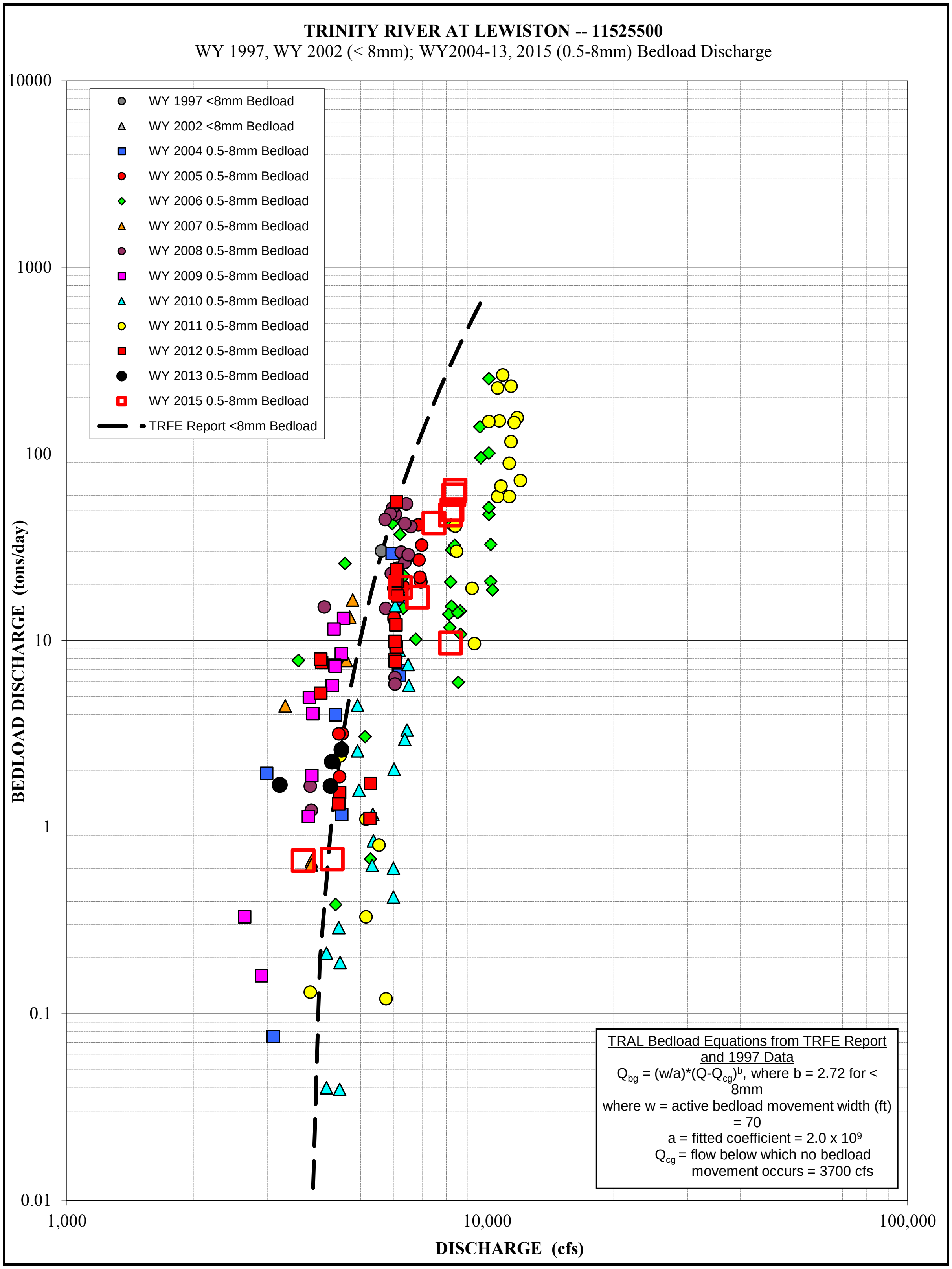


Figure 9. Fine Bedload Discharge (0.5-<8mm) at TRAL, WY1997-2015.

The 1999 TRFE bedload equations were used to develop flow recommendations based in part on bedload discharge predictions at TRAL and TRLG. They are included here for comparison with subsequent measure bedload transport rates.

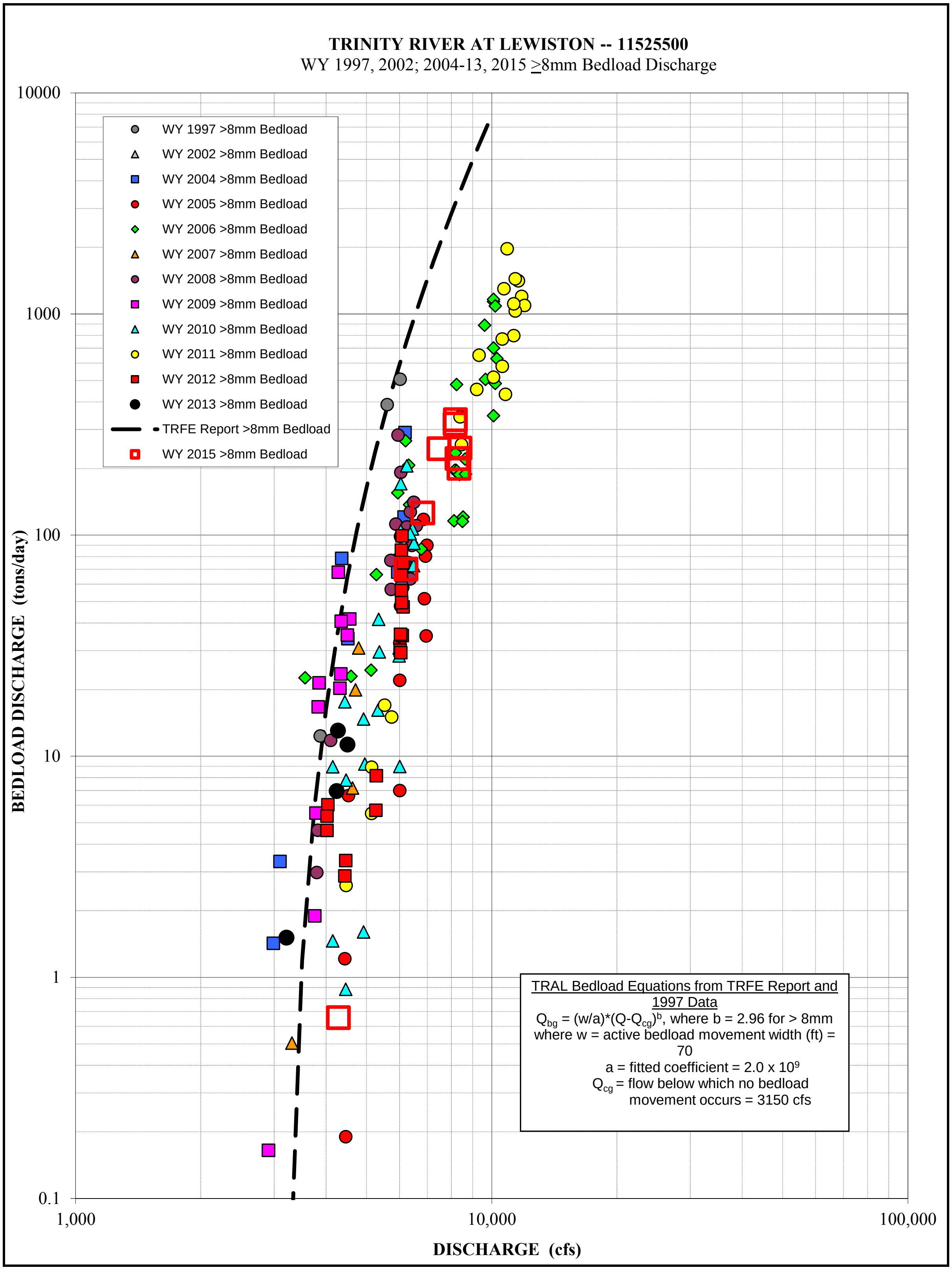


Figure 10. Coarse Bedload Discharge (≥8mm) at TRAL, WY1997-2015.
The 1999 TRFE bedload equations were used to develop flow recommendations based in part on bedload discharge predictions at TRAL and TRLG. They are included here for comparison with subsequent measure bedload transport rates.

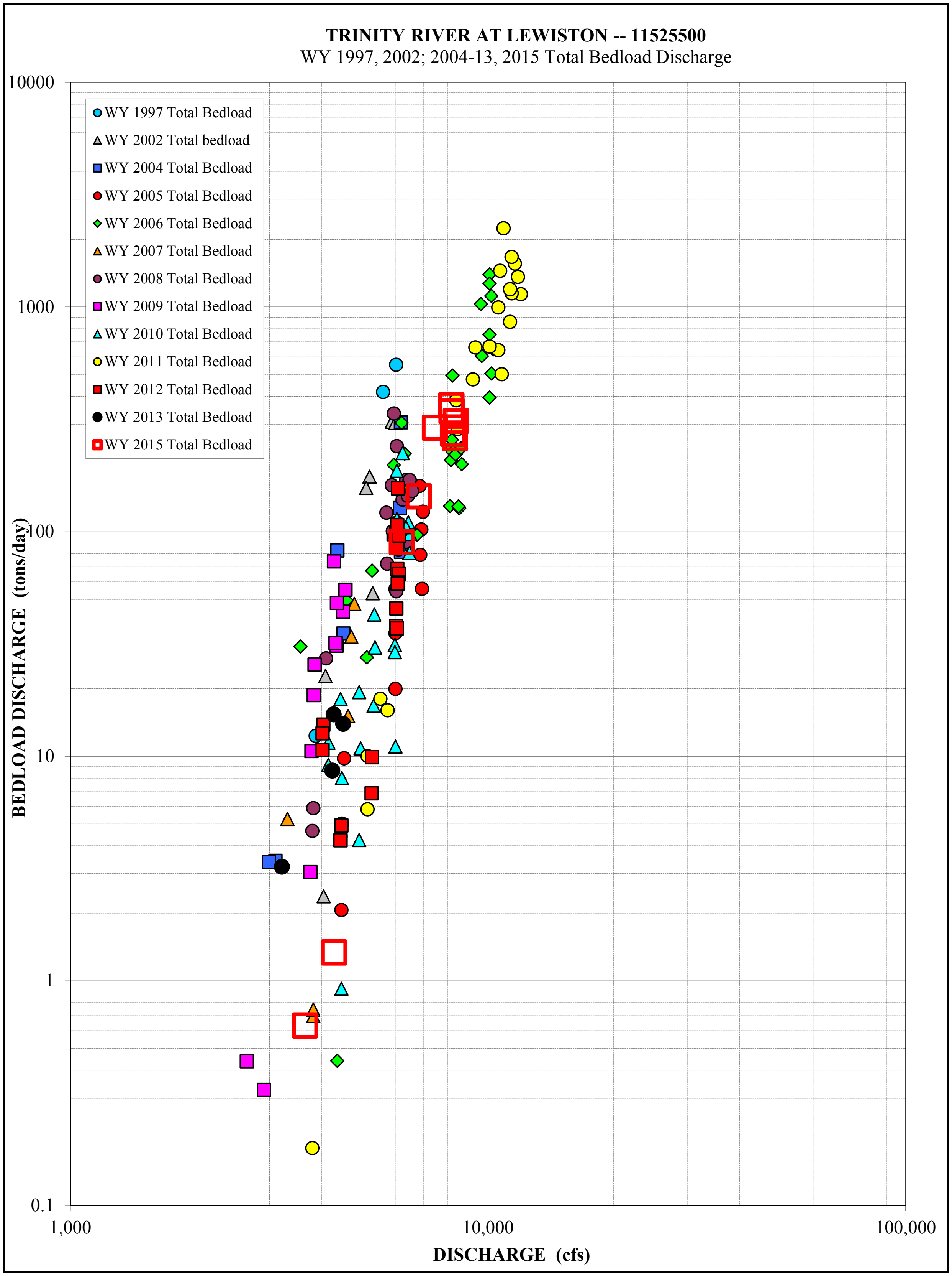


Figure 11. Total Bedload Discharge at TRAL, WY1997-2015.

Continuous bedload-discharge sedigraphs are displayed in Appendix A-4. Flow release fine, coarse, and total bedload estimates for WY 2015 were 146, 715, and 861 tons (Table 5). Detailed explanations of the bedload discharge and load computations are provided in the Station Analysis (Appendix A-1). Appendix A-9 contains the particle size distributions, sample data, (e.g. sample times, weights, computed transport rates) and bedload computation values. As discussed in section 2.3.4, the <0.5mm fraction is omitted from bedload data and computations. The fraction is included for graphical comparisons with historic values (e.g. Figure 11). The <0.5mm fraction comprised an average of 0.6 percent of bedload sample masses in 2015.

Table 5. Trinity River at Lewiston, CA -- USGS Gage #11525500, Bedload -- WY2015.

0.5-<8 mm (tons)	≥8 mm (tons)	Total Bedload (tons)
146	**715**	**861**

Cross Section and Pebble Count Changes

One cross section at the TRAL sediment monitoring site is typically surveyed pre- and post-Spring Flow Release to assess topographic changes at the sampling section. In addition, pebble counts (n=150+ particles) were collected along the cross section at the same time to examine textural changes related to the flow release. Surveyed changes in the cross section and changes in the particle size distribution from the pebble count data are presented in Figures 12 and 13. The channel cross section showed only very minor reorganization, and is essentially unchanged. The deeper, coarser left side of the channel is not included in the annual pebble count which essentially describes the right half of the low flow channel. The finer half of the distribution grew somewhat coarser, with the portion <45mm decreasing from 41 percent to 26 percent. The coarse end of the distribution shows a very slight fining, with its shift toward the left. The D50 (grain size for which 50 percent of the sample is smaller) remained essentially unchanged at approximately 55mm pre and post.

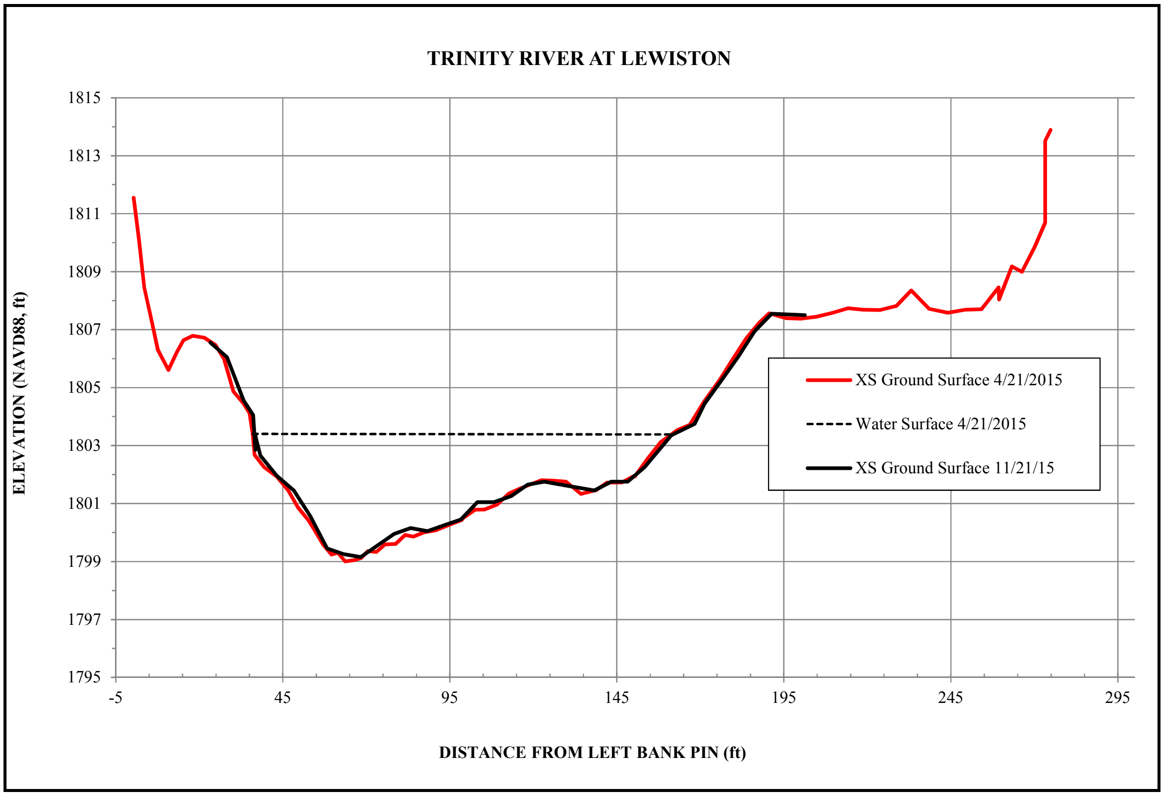


Figure 12. Cross Section changes at TRAL, pre/post Spring Flow Release 2015. Downstream view.

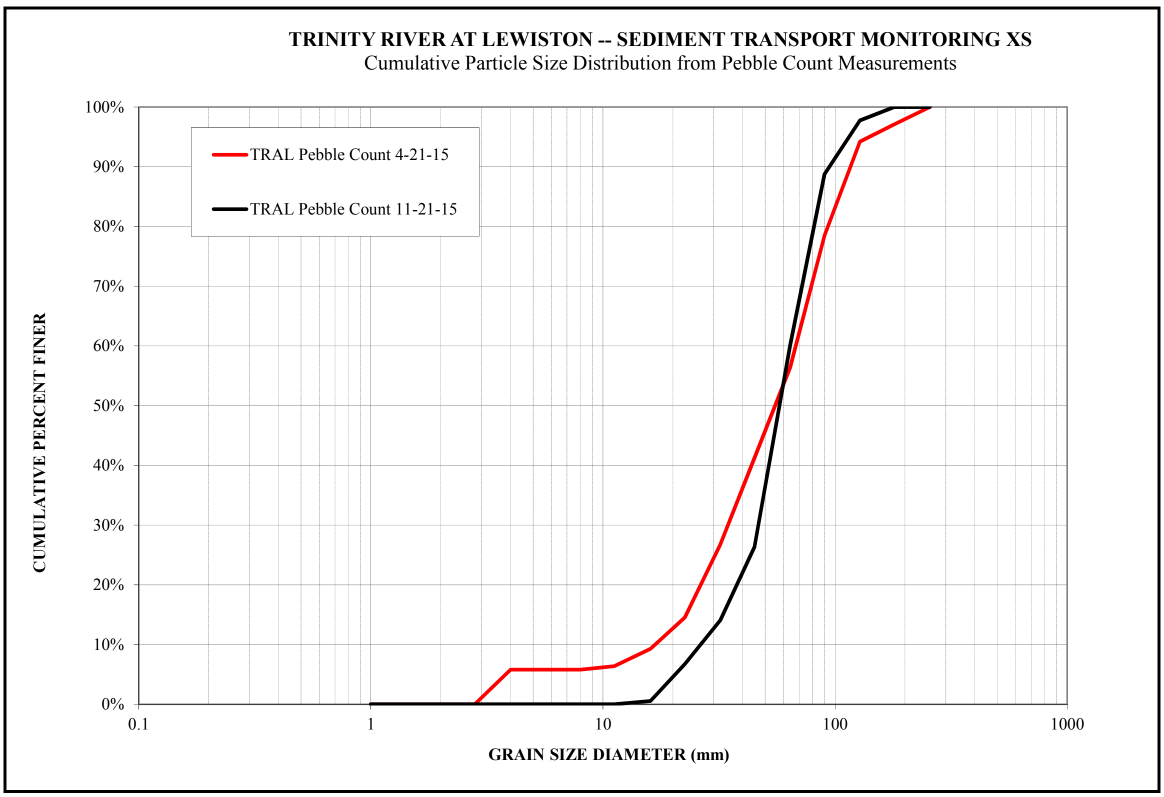


Figure 13. Changes in bed texture at TRAL, pre/post Spring Flow Release 2015.

2.4.2.2 Trinity River above Grass Valley Creek

Station Description

The TRGV sediment transport monitoring station is located approximately 1,800 feet upstream of the Grass Valley Creek confluence on the BLM Lowden Ranch property (Figure 1, Figure 14). A seasonal streamflow and turbidity gaging station was established at TRGV (Appendix B-1) just prior to the WY 2006 Spring Flow Release. The station was originally located in a relatively straight and uniformly-shaped low-gradient section of the Trinity River. The station was relocated about 200 feet downstream in WY 2011, as a result of restoration construction activities in 2010 which created a forced meander only a short distance upstream from the original gage site.

In WY 2015, the gage was operated from April 23 to July 31. The TRGV gage defines the downstream end of the second sediment budget cell (Figures 1 and 2). A cable was strung between two large conifers outside the active channel to allow cataraft sampling. High streamflow measurements were collected using an ADCP or current meter with sounding weight, deployed from either a jet boat or cataraft. Low, wadeable flows, were measured using a 4-ft top-set rod, a Price AA meter, and an AquaCalc streamflow computer. TRGV presented few safety concerns and provided an excellent sediment sampling location and a good streamflow gaging site, although restoration activities and gravel injection upstream cause deposition at the gaging site resulting in shifts in the stage-discharge. The average 8,500 cfs water surface slope at the sampling location (0.0005) is the lowest of the four stations.

Figure 14. Photograph of TRGV sampling crew, WY2012. View is downstream.

Streamflow Gaging

The relatively straight, uniform channel created by the riparian berms and old mining activities provided an ideal streamflow gaging reach for the 2006-2010 period. The reach was modified substantially during construction of the restoration project in 2010. Removal of the left bank riparian berm and tailing piles and construction of a floodplain resulted in a channel with a substantial floodplain flow component at the higher discharges. Continuous stage height readings were recorded from April 23 through August 3, but streamflow records were computed (or estimated) for the Spring Flow Release period (April 1 through July 31). Ten discharge measurements (Figure 15) were collected during the computation period (Appendix B-1; B-5). Measured discharge for the period ranged from 435 cfs to 9,280 cfs (the latter was excluded). Computed instantaneous discharged ranged from 310 cfs to 8,640 cfs.

The stage-discharge relationship, Rating 5.1 was established in WY 2011 as a result of gage relocation (Appendix B-2). Rating 5.1 was used during Water Year 2015 with a stage variable shift applied. A detailed explanation of the methods and assumptions used to compute the discharge record are provided in the Streamflow Station Analysis (Appendix B-1).

Figure 15. Photograph of discharge measurement using Price AA current meter and 100 lb sounding weight.

Suspended Sediment Transport Data

Seven two-pass suspended sediment samples were collected between May 3 and May 9, 2015 at TRGV (Table 6). Measured SSC fluctuated from a peak of 54 mg/l on May 4 at 7,620 cfs, to a low of 6 mg/l on May 9 at 3,230 cfs. The associated transport rates were 1,120 and 52 tons/day respectively. WY 2015 suspended sediment discharge values are plotted in Figure 16 along with sample data from WY 2006-2013.

Table 6. Trinity River above Grass Valley Creek -- GMA Gage #11525540, Suspended Sediment Sampling Summary -- WY2015

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC (mg/l)	Average SSD (tons/day)
TRGV-SSCT2015-01	5/3/2015 16:44	4,390	32	378
TRGV-SSCT2015-02	5/4/2015 18:00	7,620	54	1,120
TRGV-SSCT2015-03	5/5/2015 12:34	8,540	45	1,030
TRGV-SSCT2015-04	5/6/2015 10:49	8,420	19	429
TRGV-SSCT2015-05	5/7/2015 14:14	6,610	12	214
TRGV-SSCT2015-06	5/8/2015 15:25	4,420	8	97
TRGV-SSCT2015-07	5/9/2015 11:40	3,230	6	52

Values Rounded According to Porterfield (1972)

Turbidity was used as a surrogate for SSC (Appendix B-1). Turbidity closely followed the rising portions of the hydrograph but dropped off rapidly (Appendix B-5). One additional spike in turbidity occurs during the flow bench on May 5 and is associated with active gravel augmentation upstream of the gage location. Sampling crews observed a distinct turbidity plume whenever the gravel was placed into the river. Continuous suspended sediment discharge for the three size classes was computed using turbidity versus SSC relationships (Appendix B-1; B-4). Partial and total suspended sediment load for the Spring Flow Release were 1,650, 1,100, 408 and 3,160 tons for the <0.063mm, 0.063-<0.50mm, ≥0.50mm size classes and total load respectively (Table 7). The Sediment Station Analysis (Appendix B-1) details the relationships and periods of record for which the transport curves were applied. Appendix B-10 contains the sample data and SSC computations.

Table 7. Trinity River above Grass Valley Creek -- GMA Gage #11525540, Suspended Sediment Loads -- WY2013

< 0.063 mm (tons)	0.063 mm-<0.50 mm (tons)	≥0.50 mm (tons)	Total Load (tons)
1,650	1,100	408	3,160

Values Rounded According to Porterfield (1972)

Figure 16. Suspended Sediment Discharge at TRGV, WY2006-2013, 2015.

Bedload Data

Fourteen bedload samples were collected at TRGV between May 3 and May 8, 2015. Bedload sampling times were plotted on hydrographs in Appendix B-5. Bedload sample data and bedload discharge computations are summarized in Table 8. Fine, coarse, and total bedload discharge rates for WY 2006-15 are plotted in Figures 17-19. As discussed in section 2.3.4, the <0.5mm fraction is omitted from bedload data and computations. The fraction is included for graphical comparisons with historic values (e.g. Figure 19). The <0.5mm fraction comprised an average of 1 percent of bedload sample masses in 2015.

The measured (Total) transport rates started at 11 tons/day at 4,050 cfs on May 3, peaked at 998 tons/day at 6,830 cfs on May 4 during gravel augmentation, and finished at 8.2 tons/day at 4,310 cfs on May 8, 2015. The Sediment Station Analysis (Appendix B-1) describes the development of the bedload transport curves and the periods of record over which each was applied. The transport curves and bedload measurements were used to compute continuous bedload discharge and load estimates (Appendix B-10). Appendix B-3 contains the bedload transport curves used to estimate continuous bedload discharge. Appendix B-6 contains the bedload sedigraphs for the Spring Flow Release Period. Fine, coarse, and total bedload estimates for the period April 1 to July 31, 2015 were 400, 1,370 and 1,770 tons (Table 9). Appendix B-9 contains the sample data (weights and computed transport rates) and bedload computation values.

Table 8. Trinity River above Grass Valley Creek -- GMA Gage #11525540, Bedload Sediment Sampling Summary -- WY2015.

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	≥ 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRGV-BLM2015-01	5/3/2015 15:07	4,050	11	3.9	7.4
TRGV-BLM2015-02	5/4/2015 11:22	5,150	44	18	26
TRGV-BLM2015-03	5/4/2015 14:06	6,830	985	784	200
TRGV-BLM2015-04	5/4/2015 16:25	7,420	802	683	119
TRGV-BLM2015-05	5/5/2015 11:16	8,560	494	384	110
TRGV-BLM2015-06	5/5/2015 14:35	8,500	649	473	176
TRGV-BLM2015-07	5/5/2015 16:12	8,490	276	200	76
TRGV-BLM2015-08	5/6/2015 12:12	8,460	324	239	85
TRGV-BLM2015-09	5/6/2015 13:34	8,510	404	312	93
TRGV-BLM2015-10	5/6/2015 15:33	8,460	409	314	95
TRGV-BLM2015-11	5/7/2015 11:13	7,590	176	145	31
TRGV-BLM2015-12	5/7/2015 12:27	6,880	100	77	23
TRGV-BLM2015-13	5/7/2015 16:06	6,790	102	69	33
TRGV-BLM2015-14	5/8/2015 16:34	4,310	8.2	5.5	2.7

Values Rounded According to Porterfield (1972)

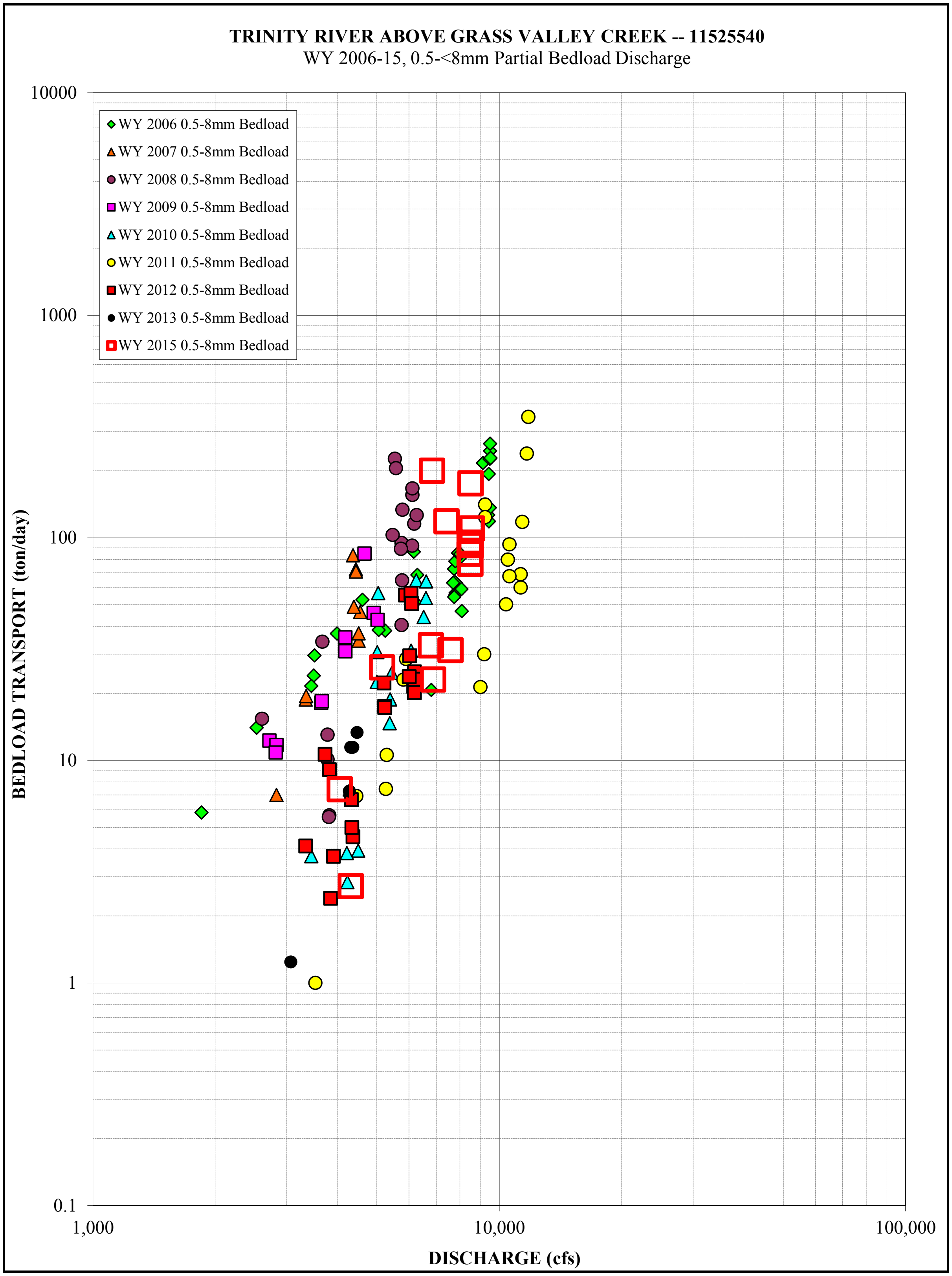


Figure 17. Fine Bedload Discharge (0.5-8mm) at TRGV, WY2006-2013, 2015.
The 1999 TRFE bedload equations that were used to develop flow recommendations did not include this site. Thus, no transport curve is presented as was for Figure 9.

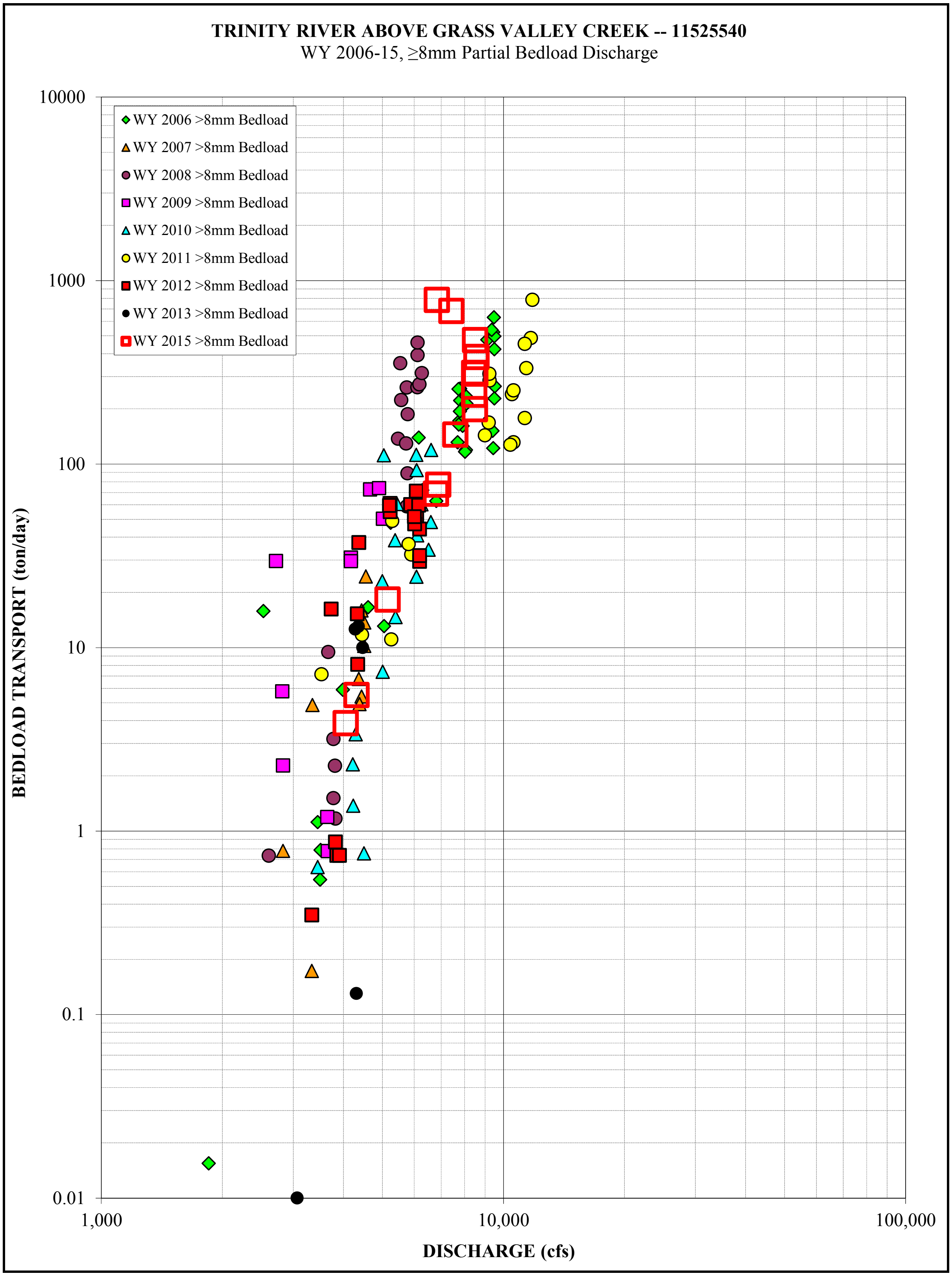


Figure 18. Coarse Bedload Discharge (≥8mm) at TRGV, WY2006-2013, 2015.
The 1999 TRFE bedload equations that were used to develop flow recommendations did not include this site. Thus, no transport curve is presented as was for Figure10.

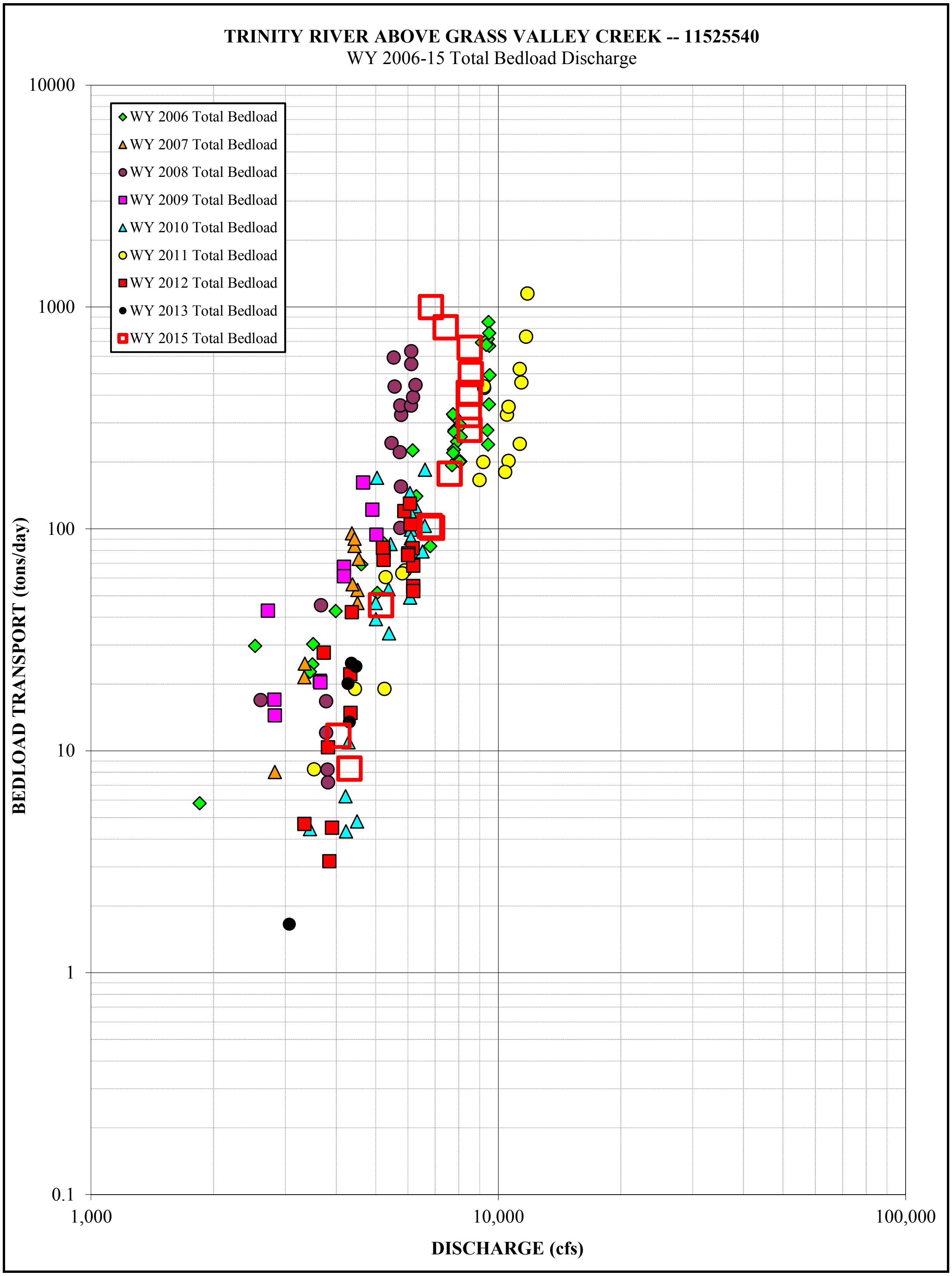


Figure 19. Total Bedload Discharge at TRGV, WY2006-2013, 2015.

Table 9. Trinity River above Grass Valley Creek -- GMA Gage #11525540, Bedload -- WY2013

0.5-<8 mm (tons)	≥8 mm (tons)	Total Bedload (tons)
400	**1,370**	**1,770**

Values Rounded According to Porterfield (1972)

Cross Section and Pebble Count Data

Cross section (Figure 20) and pebble count (Figure 21) data were collected at the TRGV sediment monitoring site pre- and post-Spring Flow Release to assess changes at the sampling section. The thalweg scoured on the order of a foot (near station 280) as a result of the Spring Flow Release. Deposition occurred from station 192 to 225, which appears to offset the scour at the thalweg, resulting in no apparent net change in cross sectional area. The entire cross section is comprised of a fairly uniform grain size distribution and pebble counts typically cover the entire cross section except for a short sandy section along the right bank. The pebble count (n=150+ particles) grain-size distribution curve (Figure 21) shows a shift to the left for the upper 70th percentile of the distribution, suggesting fining of the bed for the coarse end but showing coarsening for the lower end (Figure 21). The D_{50} was reduced from 55 to 43 mm.

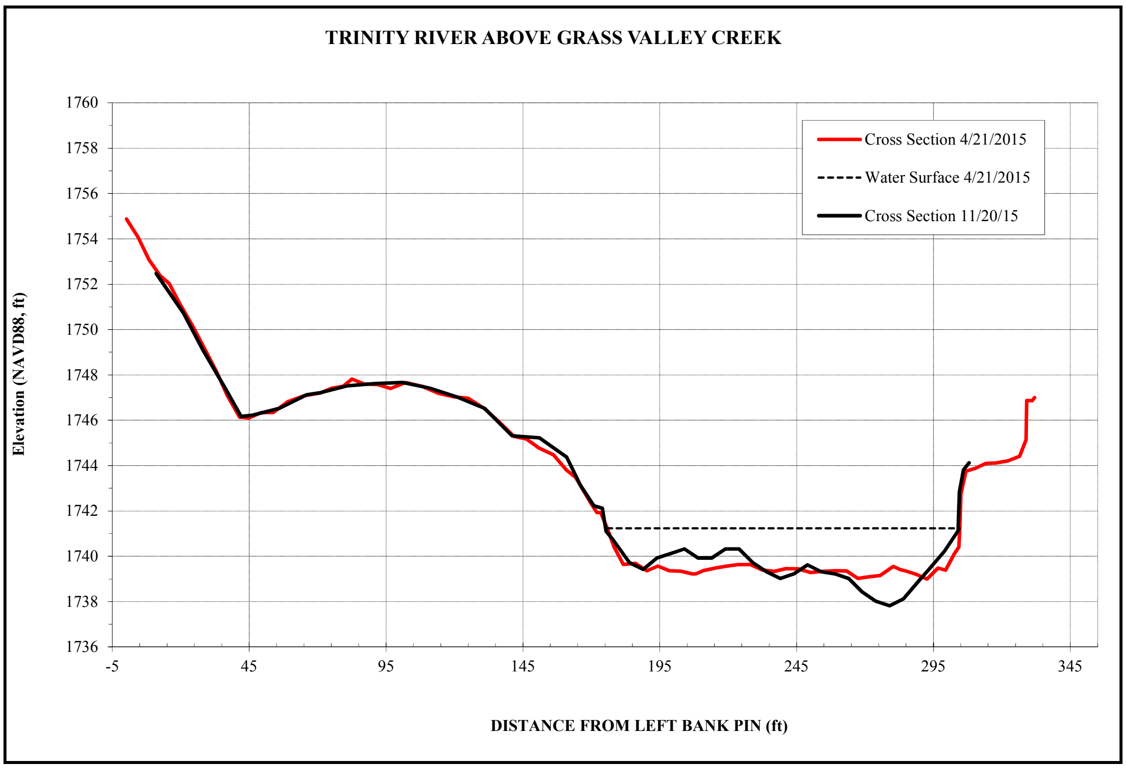


Figure 20. Cross Section Changes at TRGV, pre and post-Spring Flow Release 2015. Downstream view.

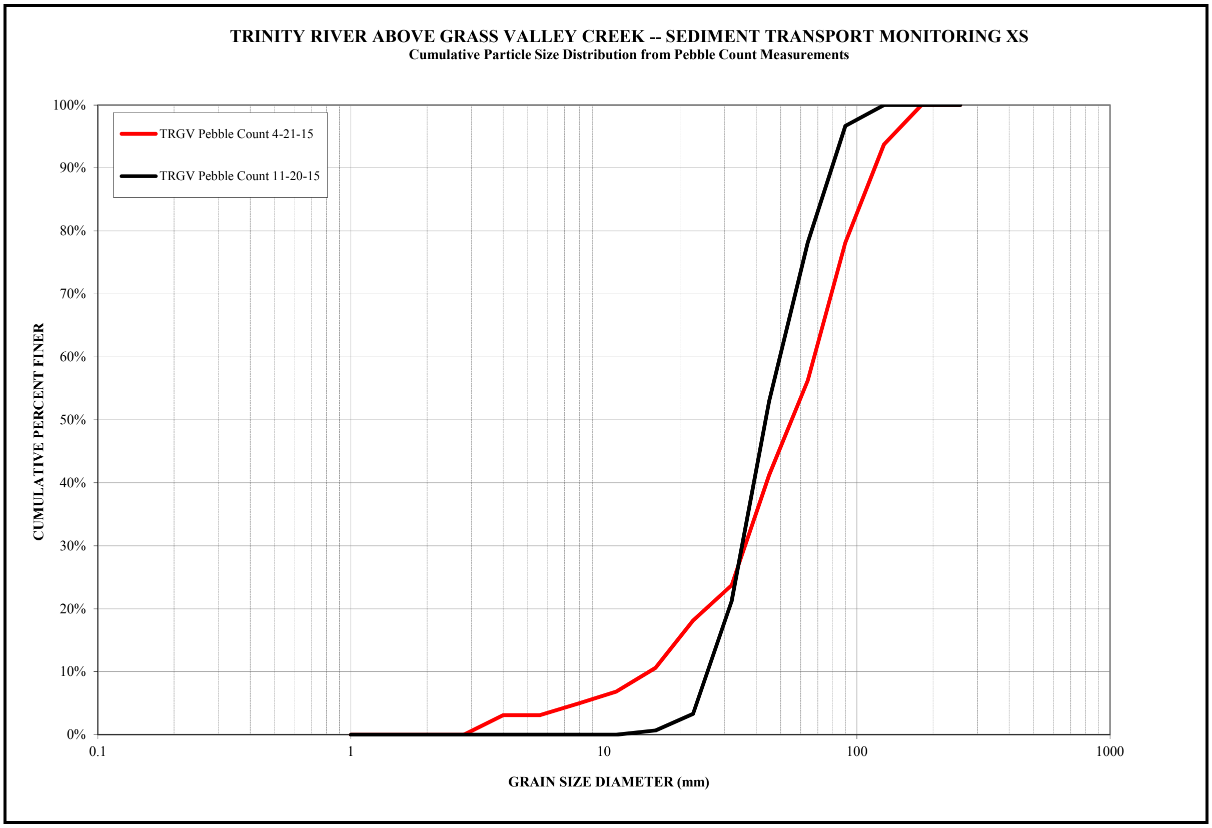


Figure 21. Changes in bed texture at TRGV, Spring Flow Release 2015.

2.4.2.3 Trinity River below Limekiln Gulch

Station Description

Sampling occurred 60 feet downstream of the USGS streamflow gaging station (#11525655) and the GMA turbidimeter (Figure 22). Sampling has occurred at the current sampling location or approximately 30 ft upstream since WY 1998. The 8,500 cfs water surface slope at this site is 0.0022. A two-person cataraft crew collected 15 bedload and seven suspended sediment samples at TRLG during the 2015 Spring Flow Release.

Suspended Sediment Transport Data

Seven two-pass suspended sediment samples were collected during the Spring Flow Release (Table 10). Measured SSC ranged from a high of 49 mg/l on May 3 to a low of 8 mg/l on May 9. The streamflows for both the high and the low concentration occurred on the rising and falling limbs (4,150 and 3,300 cfs). The computed suspended sediment discharges for these measurements were 548 and 70 tons/day (Table 10). The highest suspended sediment discharge (948 tons/day) occurred on May 5 with a lower concentration (42 mg/l) but a much higher discharge (8,470 cfs) than the May 3 sample (Table 11). Computed suspended sediment loads for the Spring Flow Release are provided in Table 11.

Figure 22. Photograph: left bank view of TRLG sampling crew at 8,500 cfs.

Table 10. Trinity River below Limekiln Gulch -- USGS Gage #11525655, Suspended Sediment Sampling Summary -- WY2015.

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC (mg/l)	Average SSD (tons/day)
TRLG-SSCT2015-01	5/3/2015 18:43	4,150	49	548
TRLG-SSCT2015-02	5/4/2015 10:10	4,700	32	406
TRLG-SSCT2015-03	5/5/2015 12:29	8,470	42	948
TRLG-SSCT2015-04	5/6/2015 16:48	8,350	24	530
TRLG-SSCT2015-05	5/7/2015 10:15	7,440	17	336
TRLG-SSCT2015-06	5/8/2015 13:07	4,550	10	124
TRLG-SSCT2015-07	5/9/2015 10:15	3,300	8	70

Values Rounded According to Porterfield (1972)

Table 11. Trinity River below Limekiln Gulch-- USGS Gage #11525655, Suspended Sediment Loads -- WY2015.

< 0.063 mm (tons)	0.063 mm-<0.50 mm (tons)	≥0.50 mm (tons)	Total Load (tons)
2,580	**1,600**	**392**	**4,570**

Values Rounded According to Porterfield (1972)

Total suspended sediment discharge values were plotted in Figure 23 along with all historic transport data collected at TRLG, including the historic USGS data from multiple natural winter storm events. A strong hysteresis has been evident during the WY 2004-15 Spring Flow Releases (Figure 24); suspended sediment concentrations rise rapidly with the rising flow and drop off quickly during the various flow benches.

Continuous turbidity was collected through most of the Spring Flow Release (Appendix C-4). The turbidity versus SSC relationship for <0.063mm, 0.063mm-<0.5mm and ≥0.5mm proved adequate; therefore turbidity was used as a surrogate for SSC (Appendix C-3). Partial discharges were computed for all three size classes and then summed to compute total SS discharge (Appendix C-1).

The continuous concentration traces show the initial increase in SSC with rising flow and the rapid drop-off in during the peak flow bench (Appendix C-6). As in previous years, turbidity, and consequently suspended sediment discharge, was highest during the largest increases in streamflow. Partial and total suspended sediment load for the Spring Flow Release were 2,580, 1,600, 392 and 4,570 tons for the <0.063mm, 0.063-<0.50mm, ≥0.50mm size classes and total load respectively (Table 11). The computational methods, assumptions, surrogate relationships, and period of records for which they were applied are described in detail in the Station Analysis (Appendix C-1). Appendix C-10 contains the sample data and SSC computations.

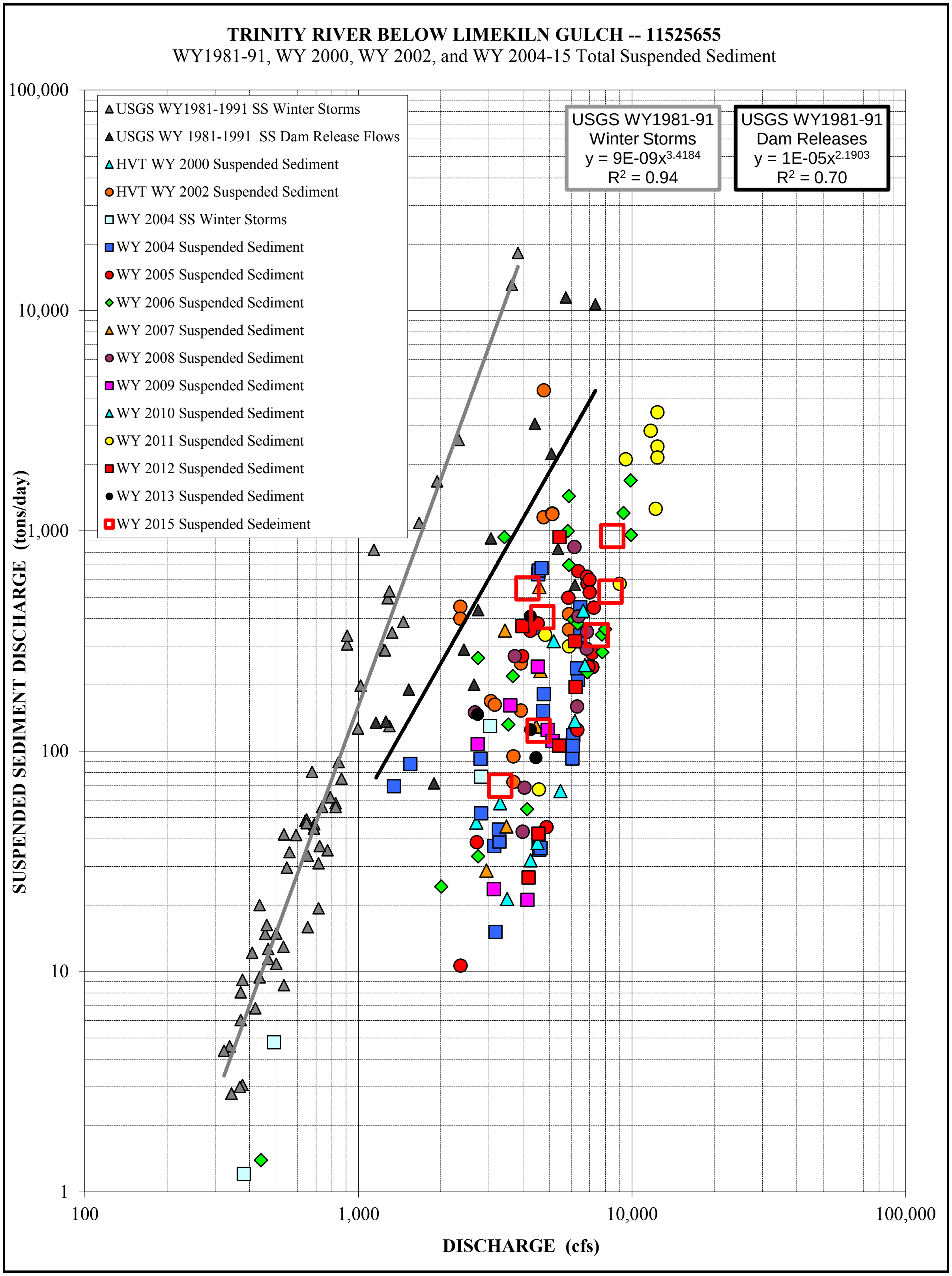


Figure 23. Suspended Sediment Discharge at TRLG, WY1981-1991, 2000, 2002, 2004-2013, 2015.

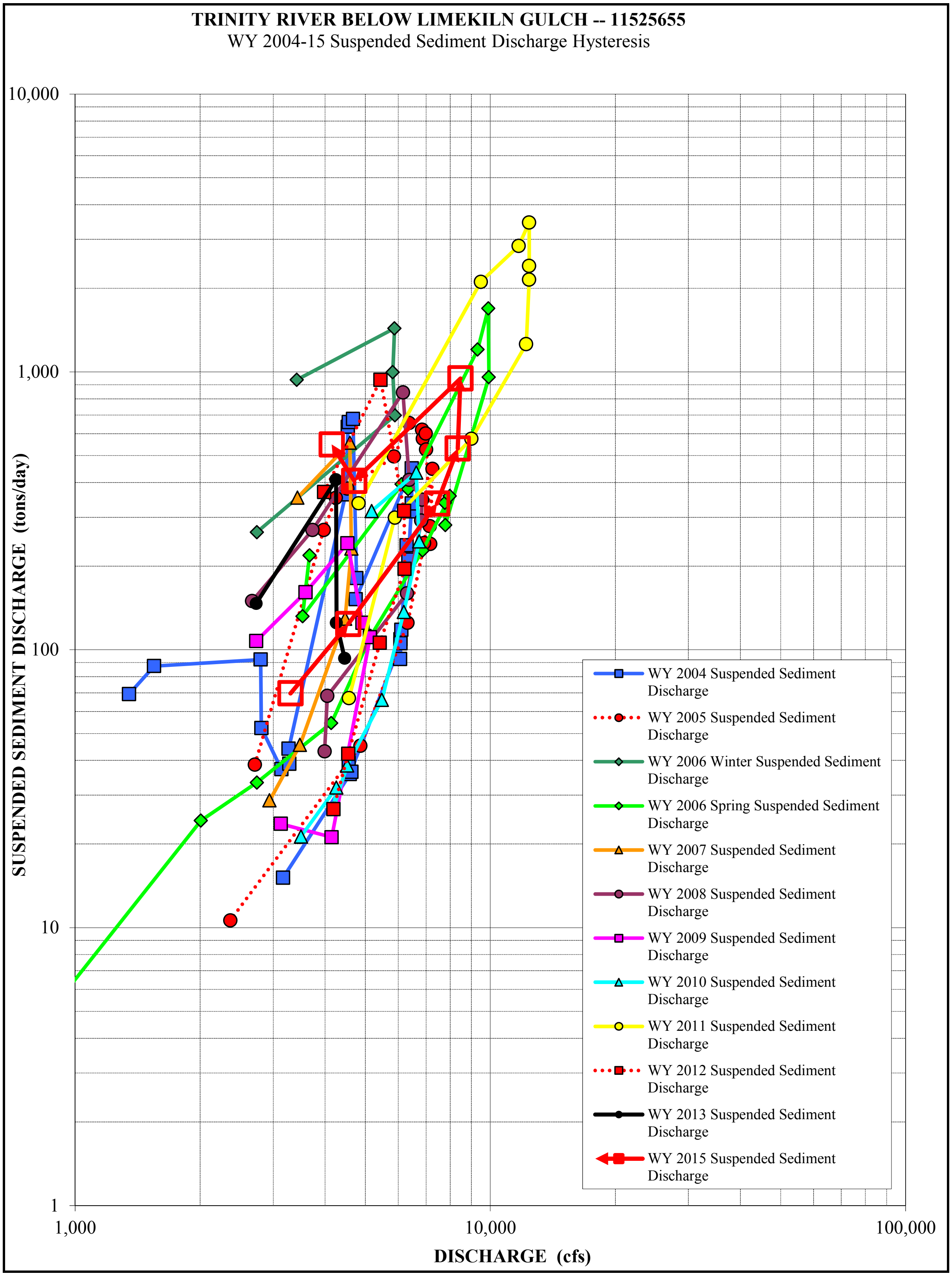


Figure 24. Suspended Sediment Discharge Hysteresis at TRLG, WY 2004-2013, 2015.

Bedload Transport Data

Four one-pass samples (due to rapidly changing stage or near-zero transport) and 11 two-pass bedload samples, for a total of fifteen bedload samples were collected during the Spring Flow Release (Table 12). Appendix C-5 displays the bedload sample collection times on the Spring Flow Release hydrograph. The highest bedload transport rate of 326 tons/day was measured at 8,450 cfs on May 5, while the lowest, 2.9 tons/day was measured at 3,300 cfs on May 9. All measured fine, coarse, and total bedload discharge rates were plotted in Figures 25-27 along with historic data from WY 1981-2013. Details regarding the samples and the sediment discharge computations are provided in the Station Analysis (Appendix C-1). Bedload transport curves were fit to the WY 2015 bedload discharge data in SKED. A single generalized equation was developed for both fine and coarse bedload (Appendix C-2). The Sediment Station Analysis (Appendix C-1) describes the time periods over which the transport curves were used for estimating continuous bedload discharge.

Appendix C-5 displays the continuous fine, coarse, and total bedload discharge rates for the Spring Flow Release period. Continuous bedload discharge followed a similar pattern than the hydrograph (Appendix C-5). Coarse and fine bedload both peak on the first day of the peak flow bench (May 4) and slowly decline over the bench and through the falling limb. Detailed explanations of assumptions and relationships developed for computing continuous bedload discharge are provided in the Station Analysis (Appendix C-1). All bedload transport curves used to compute continuous sediment discharge are included in Appendix C-2. Appendix C-9 contains the sample data (e.g. weights and computed transport rates) and continuous bedload computation values.

The fine, coarse, and total bedload computed estimates for WY 2015 were 344, 326 and 670 tons (Table 13). As discussed in section 2.3.4, the <0.5mm fraction is omitted from bedload data and computations. The fraction is included for graphical comparisons with historic values (e.g. Figure 27). The <0.5mm fraction comprised an average of 3 percent of bedload sample masses in 2015.

Table 12. Trinity River below Limekiln Gulch -- USGS Gage #11525655, Bedload Sediment Sampling Summary -- WY2015.

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	≥ 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRLG-BLM2015-01	05/03/2015 17:40	4,100	6.6	0.02	6.6
TRLG-BLM2015-02	05/04/2015 11:35	4,820	31	1.8	29
TRLG-BLM2015-03	05/04/2015 14:18	5,920	93	57	37
TRLG-BLM2015-04	05/04/2015 16:15	6,690	45	13	32
TRLG-BLM2015-05	05/05/2015 10:52	8,470	289	148	141
TRLG-BLM2015-06	05/05/2015 15:02	8,450	326	199	128
TRLG-BLM2015-07	05/05/2015 16:49	8,480	297	196	101
TRLG-BLM2015-08	05/06/2015 10:26	8,360	167	46	121
TRLG-BLM2015-09	05/06/2015 12:13	8,330	45	13	32
TRLG-BLM2015-10	05/06/2015 15:40	8,320	209	91	118
TRLG-BLM2015-11	05/07/2015 13:37	6,690	91	43	48
TRLG-BLM2015-12	05/07/2015 15:29	6,280	47	21	27
TRLG-BLM2015-13	05/07/2015 16:57	6,380	56	13	44
TRLG-BLM2015-14	05/08/2015 11:38	4,730	43	23	20
TRLG-BLM2015-15	05/09/2015 10:55	3,330	2.9	0.07	2.8

Values Rounded According to Porterfield (1972)

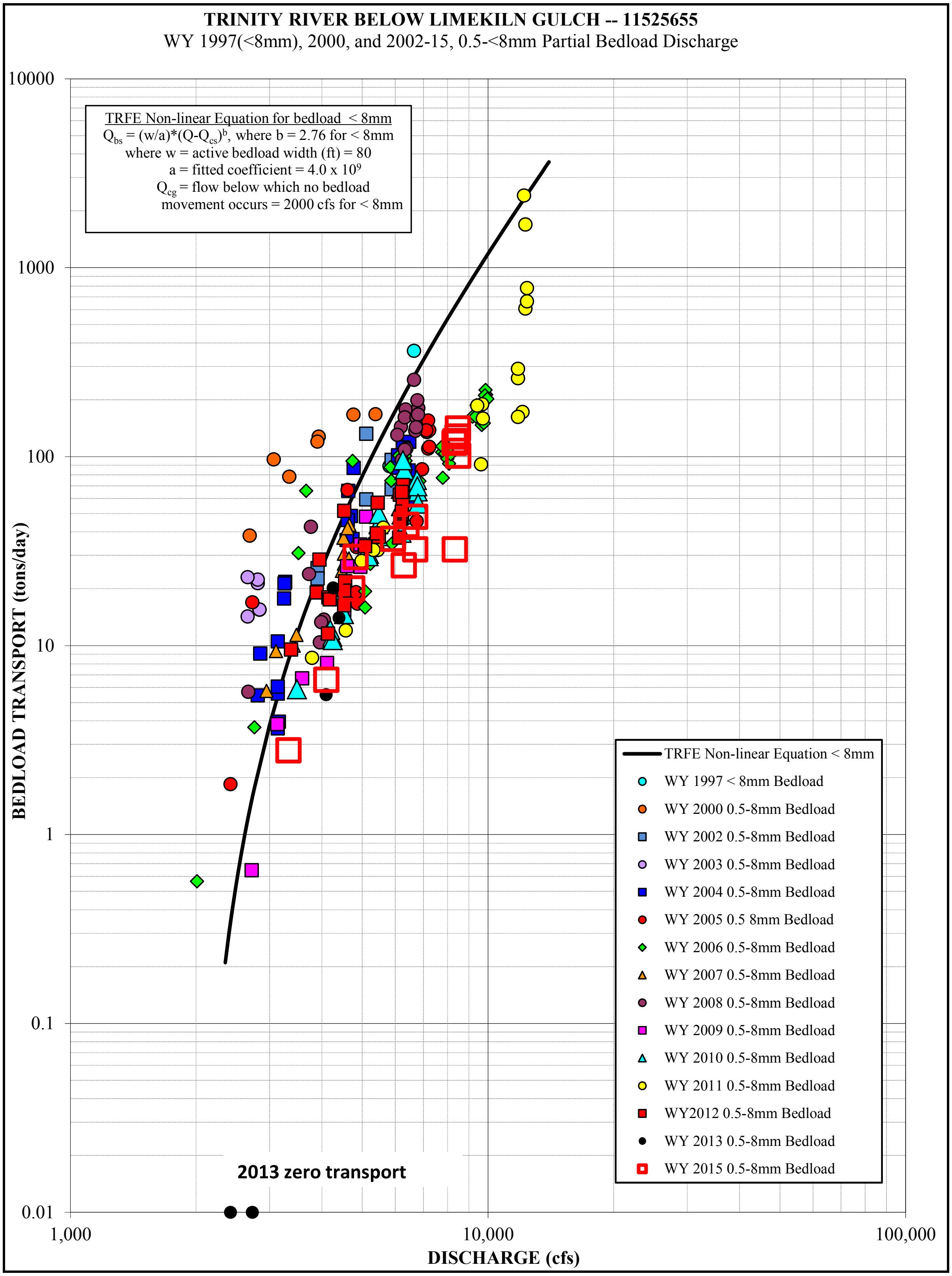


Figure 25. Fine Bedload Discharge (0.5-<8mm) at TRLG, WY1997-2013., 2015.
The 1999 TRFE bedload equations were used to develop flow recommendations based in part on bedload discharge predictions at TRAL and TRLG and are included here for comparison with subsequent measured bedload transport rates.

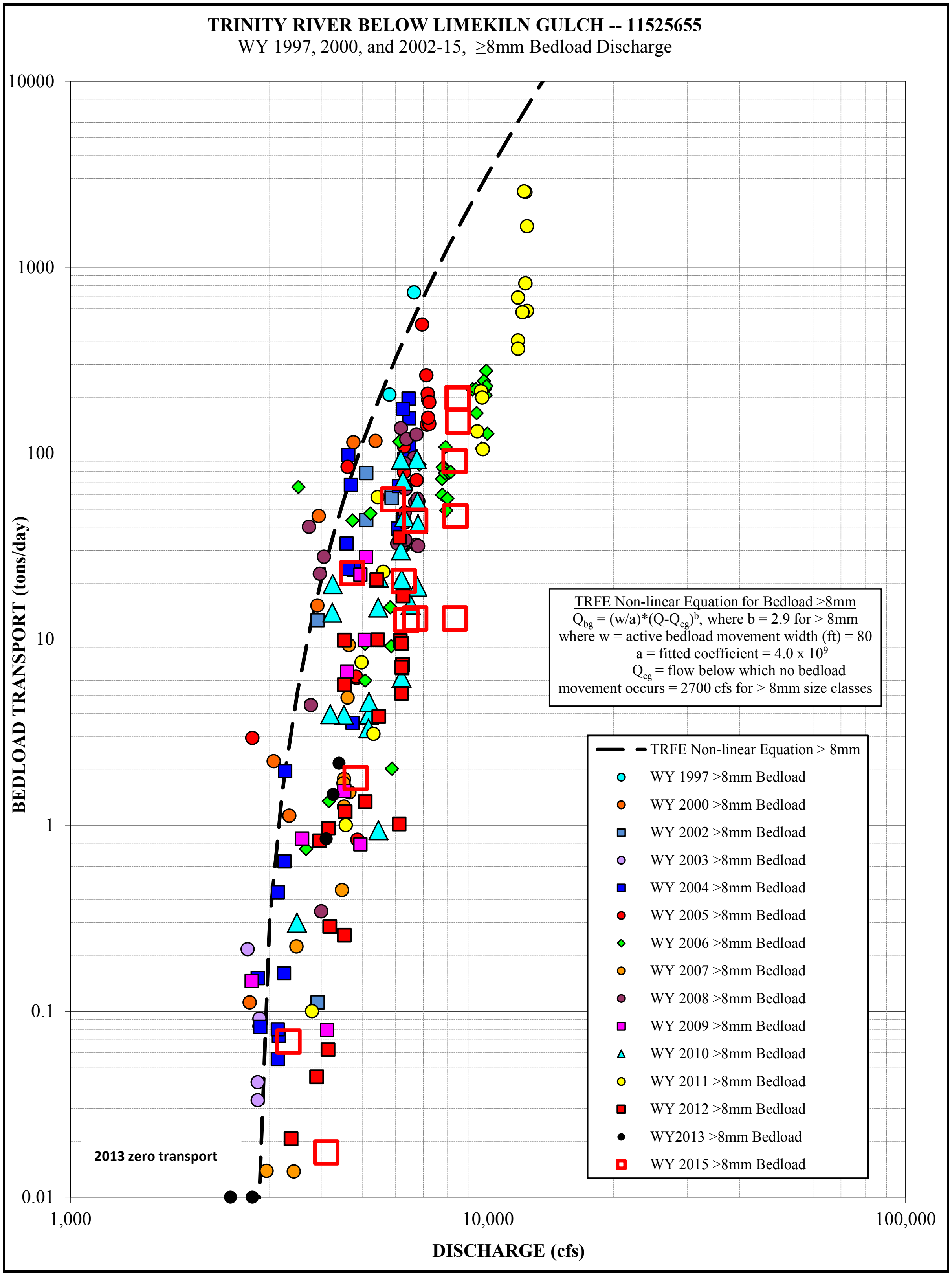


Figure 26. Coarse Bedload Discharge (≥8mm) at TRLG, WY1997-2013., 2015.

The 1999 TRFE bedload equations were used to develop flow recommendations based in part on bedload discharge predictions at TRAL and TRLG. They are included here for comparison with subsequent measure bedload transport rates.

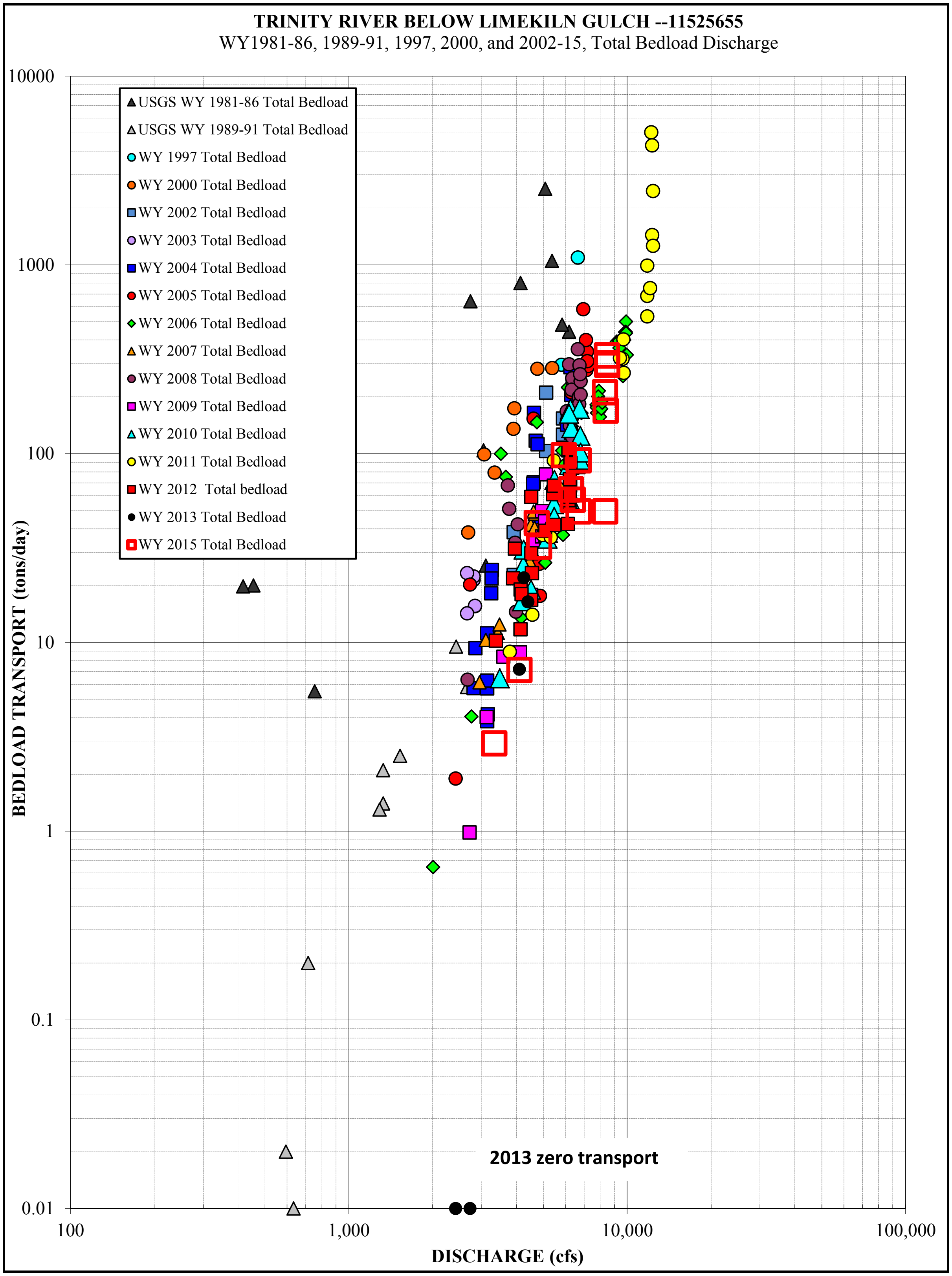


Figure 27. Total Bedload Discharge at TRLG, WY1997-2013, 2015.

Table 13. Trinity River below Limekiln Gulch -- USGS Gage #11525655, Bedload -- WY2015.

0.5-8 mm (tons)	≥8 mm (tons)	Total Bedload (tons)
344	**326**	**670**

Values Rounded According to Porterfield (1972)

Cross Section and Pebble Count Data

Cross section and pebble count data were collected at the TRLG sediment monitoring site pre- and post-Spring Flow Release to assess changes at the sampling section. Changes in the cross section and particle size distribution from the pebble count data are shown in Figures 28 and 29. Little change of the cross section was observed as a result of the Spring Flow Release, with only minor rearrangement of gravels among the bedrock fins near station 100 (Figure 28). The pebble count at this site describes the transverse riffle intersecting the right quarter (near station 200) of the sampling section. The left half of the section is deeper with bedrock fins and coarser boulder elements. The pebble count pre and post curves clearly suggest coarsening, more pronounced at the finer end of the distribution where separation of the curves is greater (Figure 29). The D50 increases from 31 to 58mm.

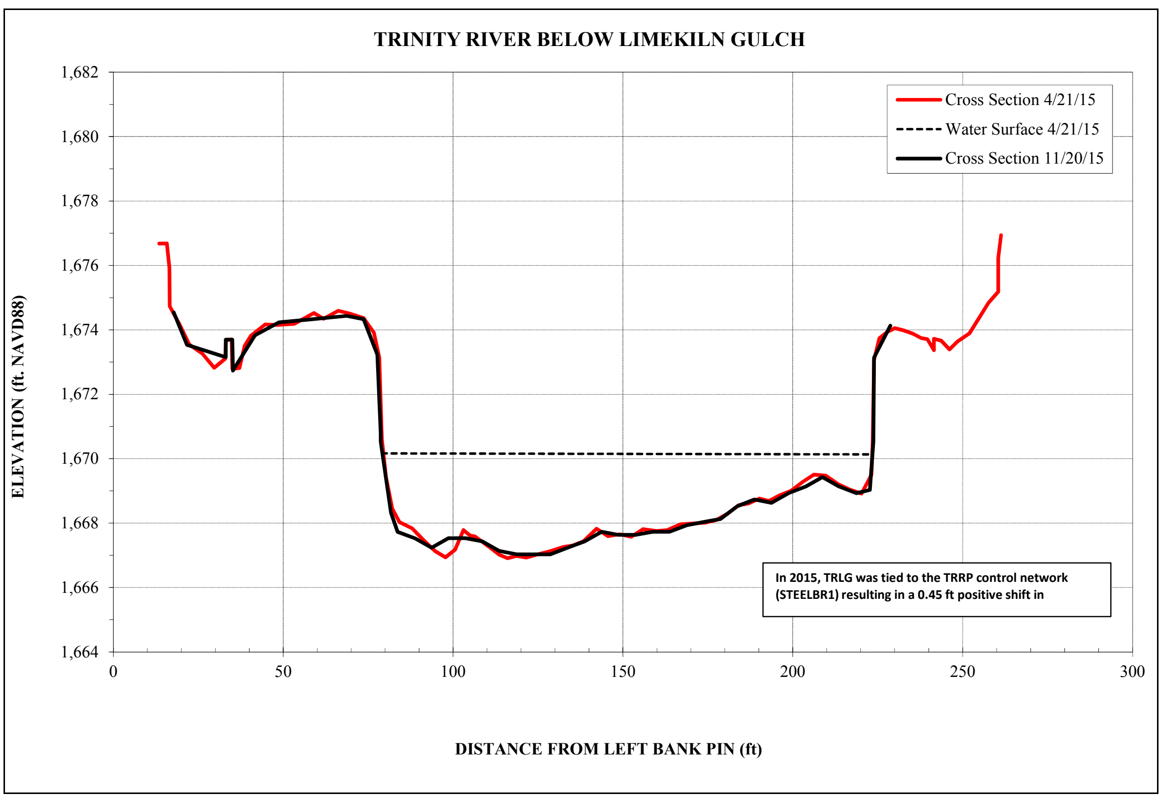


Figure 28. Cross Section Changes, pre and post-Spring Flow Release 2015.

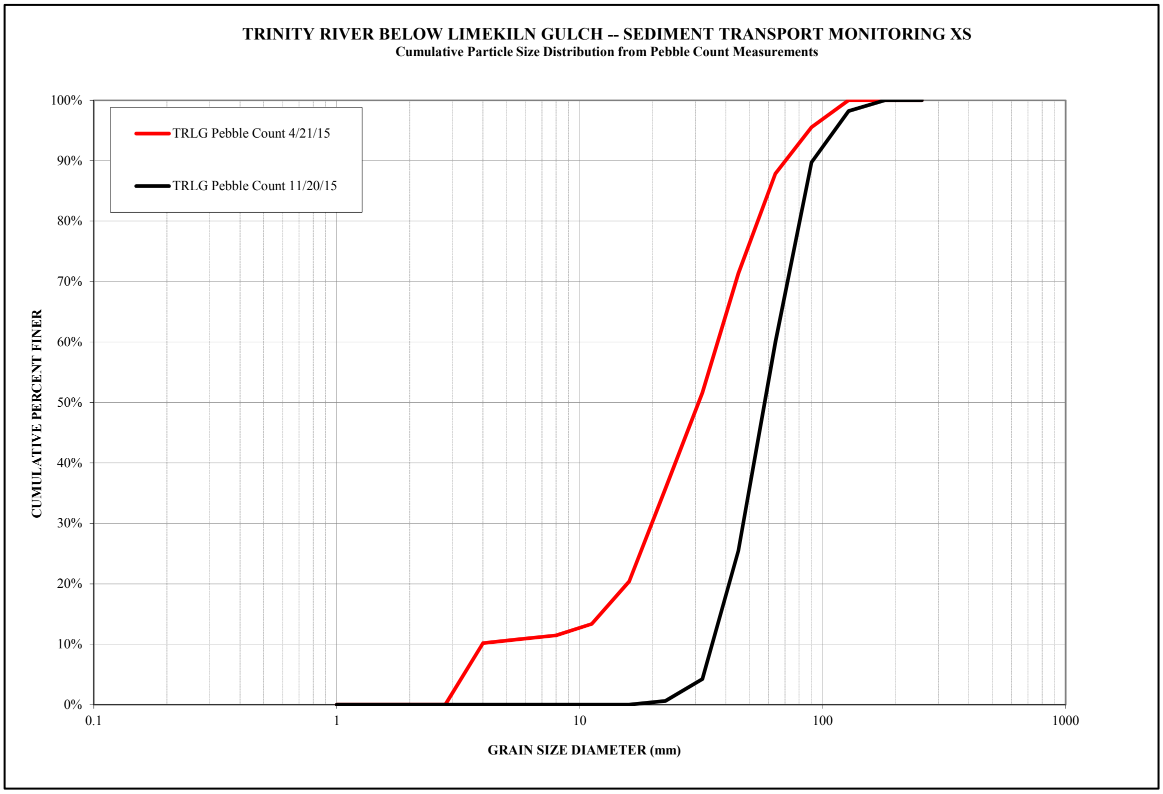


Figure 29. Changes in bed texture at TRLG, pre and post Spring Flow Release 2015.

2.4.2.4 Trinity River near Douglas City

Station Description

The TRDC sediment monitoring cross-section (Figure 30) was relocated approximately 200 feet downstream in 2012 from its 2011 location due to hydraulic complexity and bedrock elements at and upstream of the sampling section. The more favorable hydraulic conditions at the new sampling location facilitate more comprehensive sampling coverage and presumably, results in higher quality sediment transport data. The 8,500 cfs water surface slope is the highest of all the mainstem stations at 0.0039. Sediment transport monitoring has occurred at TRDC since WY 2004. The USGS gaging station is now located at the very upstream end of the BLM Douglas City Campground, and the sediment transport monitoring station is located approximately two hundred and forty feet downstream of the gaging station.

Figure 30. Right bank downstream view of TRDC sampling site, WY2015. Discharge is 4,800 cfs.

Suspended Sediment Transport Data

All seven suspended sediment samples consisted of two pass samples. Measured SSC ranged from a high of 249 mg/l on May 8, to 13 mg/l on May 9, the last day of suspended sediment sampling. The associated computed suspended sediment discharges were 2,960 and 113 tons/day which were measured at 4,420 and 3,160 cfs (Table 14). The highest suspended sediment discharge was observed on May 4 during the rise to the peak flow bench: 217 mg/l at 5,910 cfs for 3,460 tons/day. Total suspended sediment discharge values are plotted in Figure 31, with transport data from WY 2004-2013. The data show a strong hysteresis during the Spring Flow Release.

Continuous turbidity was measured beginning April 29, 2015 at 12:00 (Appendix D-4). The turbidity versus SSC relationship proved adequate for the <0.063 and 0.063-<0.5mm classes and turbidity was used as a surrogate for SSC (Appendix D-3). The ≥0.5mm fraction was computed with a discharge relation (Appendix D-1). A discharge versus SSC relationship was also necessary for the <0.063mm size class during the start of the rising limb before the turbidimeter became submerged. The three classes were then summed to compute the total suspended sediment discharge (Appendix D-6). The <0.063mm, 0.063-<0.5mm, and ≥0.5mm partial loads and total load were 3,730, 4,880, 3,320 and 11,900 tons (Table 15). Appendix D-10 contains the sample data and SSC computations.

Table 14. Trinity River at Douglas City-- USGS Gage #11525854, Suspended Sediment Sampling Summary -- WY2015.

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC (mg/l)	Average SSD (tons/day)
TRDC-SSCT2015-01	5/3/2015 17:58	3,900	61	637
TRDC-SSCT2015-02	5/4/2015 15:47	5,910	217	3,460
TRDC-SSCT2015-03	5/5/2015 18:52	8,520	135	3,090
TRDC-SSCT2015-04	5/6/2015 9:50	8,370	126	2,850
TRDC-SSCT2015-05	5/7/2015 14:45	6,970	44	818
TRDC-SSCT2015-06	5/8/2015 16:01	4,420	249	2,960
TRDC-SSCT2015-07	5/9/2015 16:28	3,160	13	113

Values Rounded According to Porterfield (1972)

Table 15. Trinity River at Douglas City-- USGS Gage #11525854, Suspended Sediment Loads -- WY2015.

< 0.063 mm (tons)	0.063 mm-<0.50 mm (tons)	≥0.50 mm (tons)	Total Load (tons)
3,730	4,880	3,320	11,900

Values Rounded According to Porterfield (1972)

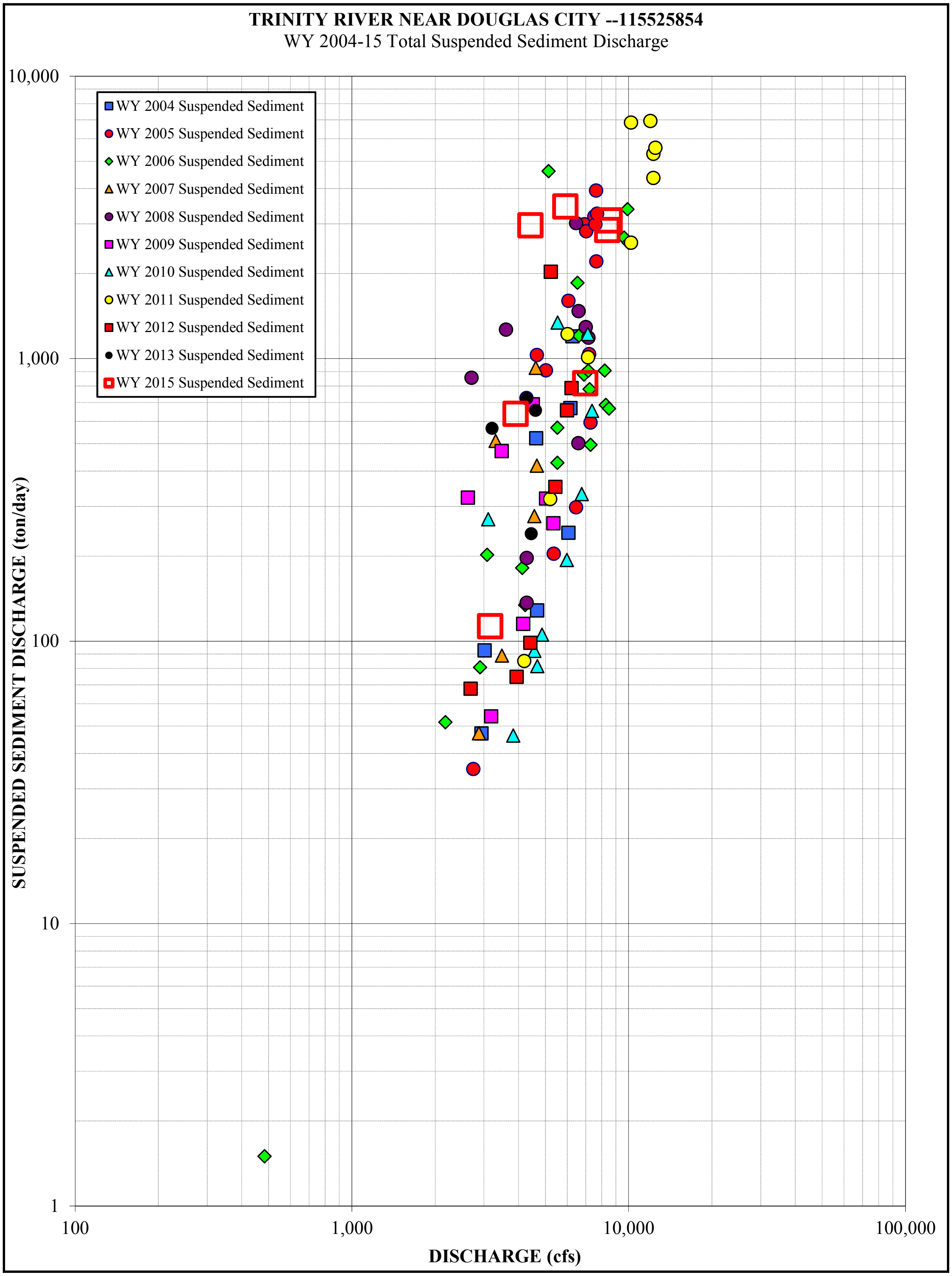


Figure 31.Total Suspended Sediment Discharge at TRDC, WY2004-2013, 2015.

Bedload Transport Data
Thirteen bedload samples were collected during the Spring Flow Release. Table 16 summarizes the sample bedload discharge data. Measured bedload discharge for all computed size classes peaked on May 7 with the 7,500 cfs falling limb flow bench, with the total at 1,460 tons/day (Table 16). Appendix D-9 contains the sample data (e.g. weights and computed transport rates) and bedload computation values. Bedload transport rates for fine and coarse sediment were computed using a single generalized equation developed from WY 2015 bedload samples (Appendix D-2). Fine, coarse, and total bedload estimates were 1,600, 1,920 and 3,520 tons respectively (Table 17). As discussed in section 2.3.4, the <0.5mm fraction is omitted from bedload data and computations. The fraction is included for graphical comparisons with historic values (e.g. Figure 34). The <0.5mm fraction comprised an average of 4 percent of bedload sample masses in 2015.

Bedload discharge rates were plotted in Figures 32-34 with the previous nine years of data. The partial transport curves used to compute continuous bedload discharge are included in Appendix D-4. A complete explanation of assumptions and techniques employed in the continuous bedload discharge and load computation process is provided in the Station Analysis (Appendix D-1). The bedload sedigraphs are shown in Appendix D-2.

Table 16. Trinity River at Douglas City -- USGS Gage #11525854, Bedload Sediment Sampling Summary -- WY2015.

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	≥ 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRDC-BLM2015-01	05/03/2015 17:04	3,690	112	21	92
TRDC-BLM2015-02	05/04/2015 11:29	4,680	152	99	53
TRDC-BLM2015-03	05/04/2015 14:07	4,920	210	90	120
TRDC-BLM2015-04	05/04/2015 17:21	6,580	121	91	30
TRDC-BLM2015-05	05/05/2015 11:18	8,460	775	462	314
TRDC-BLM2015-06	05/05/2015 13:55	8,480	428	261	167
TRDC-BLM2015-07	05/05/2015 16:48	8,450	892	437	455
TRDC-BLM2015-08	05/06/2015 17:43	8,350	830	584	246
TRDC-BLM2015-09	05/07/2015 08:56	7,580	1,430	857	573
TRDC-BLM2015-10	05/07/2015 10:47	7,480	970	623	346
TRDC-BLM2015-11	05/07/2015 12:01	7,470	657	320	337
TRDC-BLM2015-12	05/08/2015 17:12	4,350	353	140	213
TRDC-BLM2015-13	05/09/2015 15:01	3,220	75	22	53

Values Rounded According to Porterfield (1972)

Table 17. Trinity River at Douglas City -- USGS Gage #11525854, Bedload -- WY2015.

0.5-8 mm (tons)	≥8 mm (tons)	Total Bedload (tons)
1,600	1,920	3,520

Values Rounded According to Porterfield (1972)

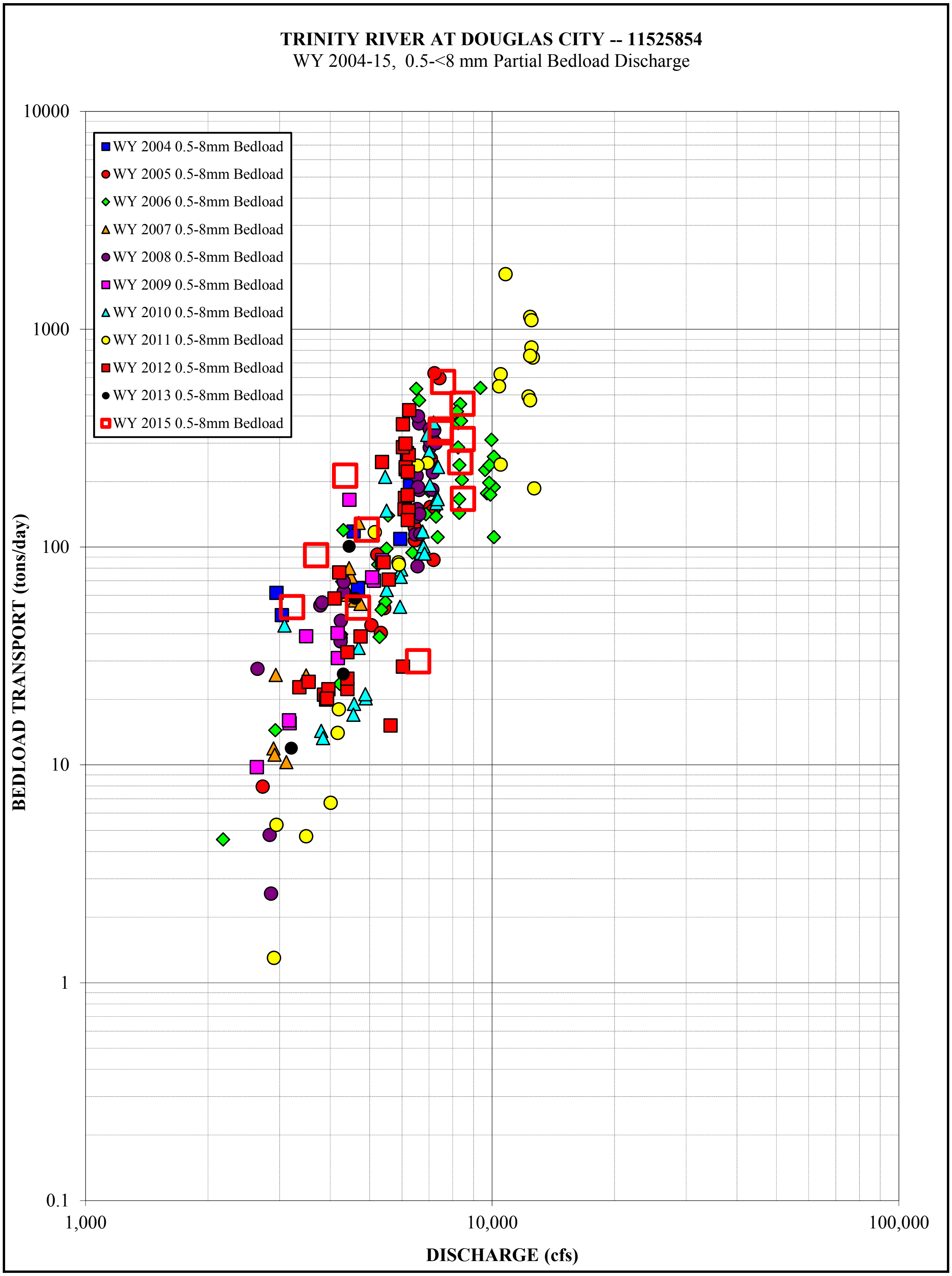


Figure 32. Fine Bedload Discharge at TRDC, WY2004-2013, 2015.

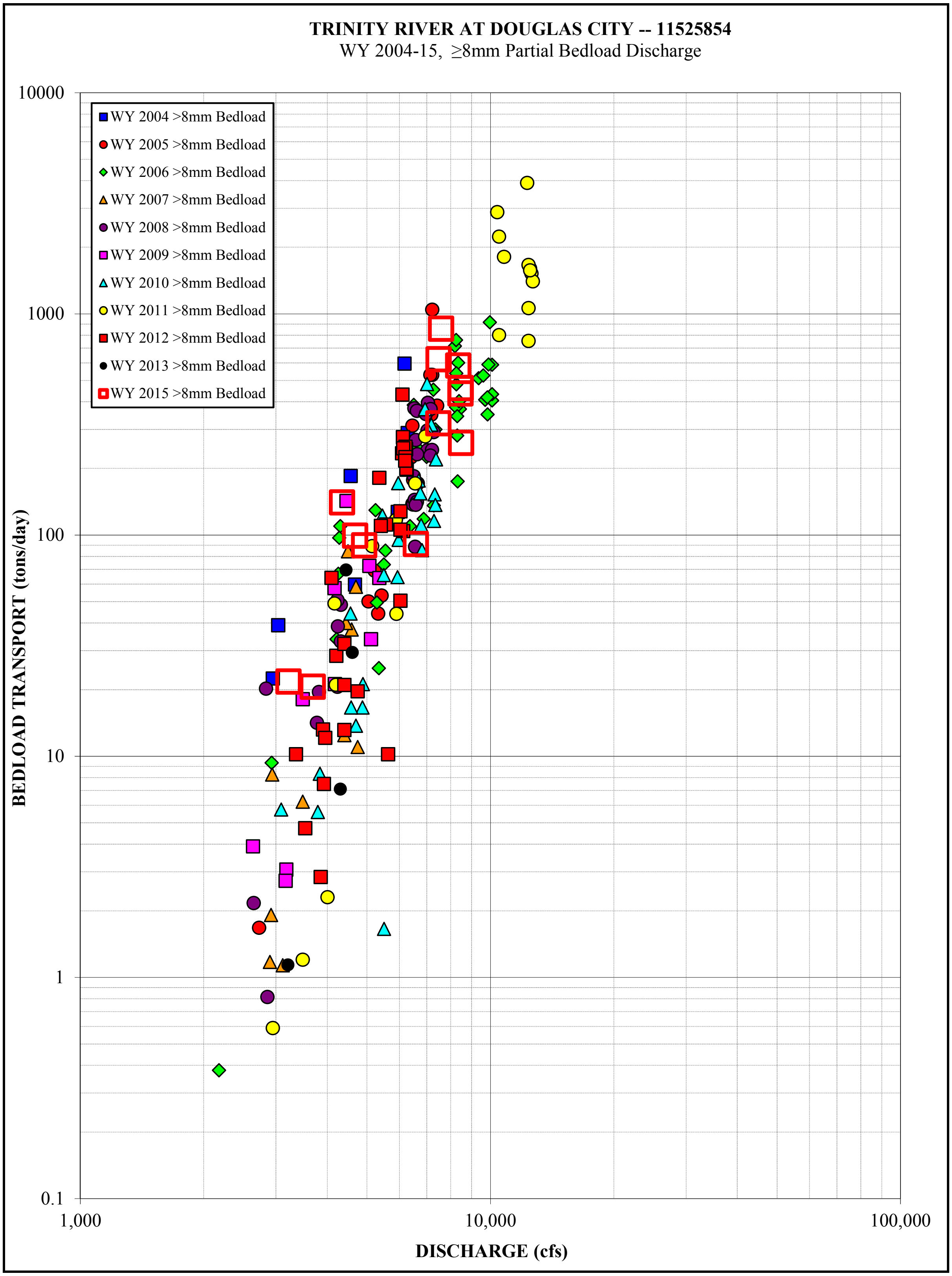


Figure 33. Coarse Bedload Discharge at TRDC, WY2004-2013, 2015.

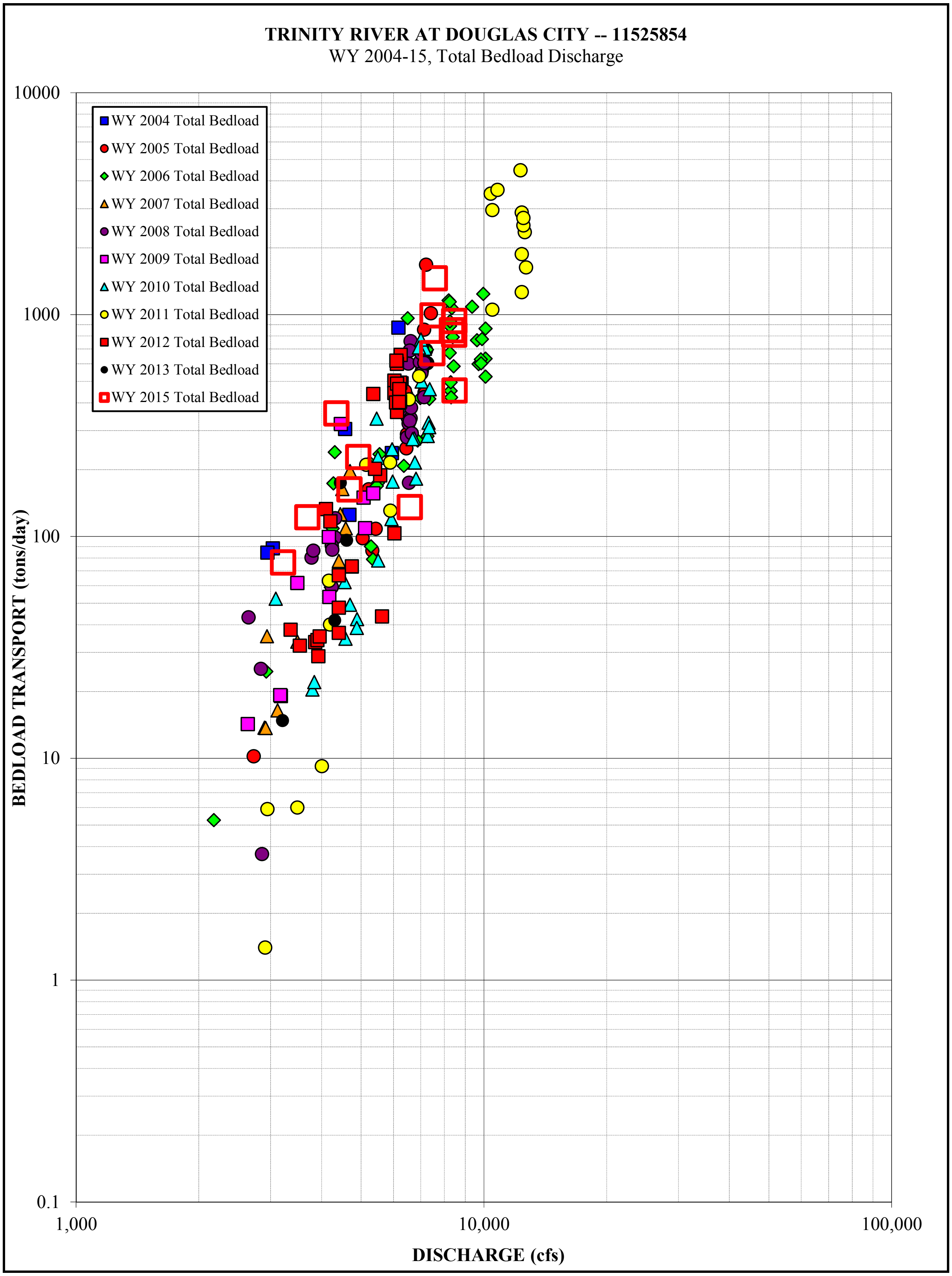


Figure 34. Total Bedload Discharge at TRDC, WY2004-2013, 2015.

Cross Section and Pebble Count Data

Cross section and pebble count data were collected at the TRDC sediment monitoring station pre- and post-Spring Flow Release to assess changes at the sampling section. Changes in the cross section and particle size distribution are shown in Figures 35 and 36. The cross section showed over 0.5 feet of scour along the right bank of the transverse bar crossing the section, while the left side of the bar shows nearly a foot of aggradation near the bedrock protrusions Figure 35). The pebble count describes the right side of the same transverse riffle. The pebble count showed relatively uniform coarsening across the distribution, with the D50 increasing from 30 to 45mm (Figure 36). The <16mm component did not appear in the post, so this fine tail shows even more coarsening.

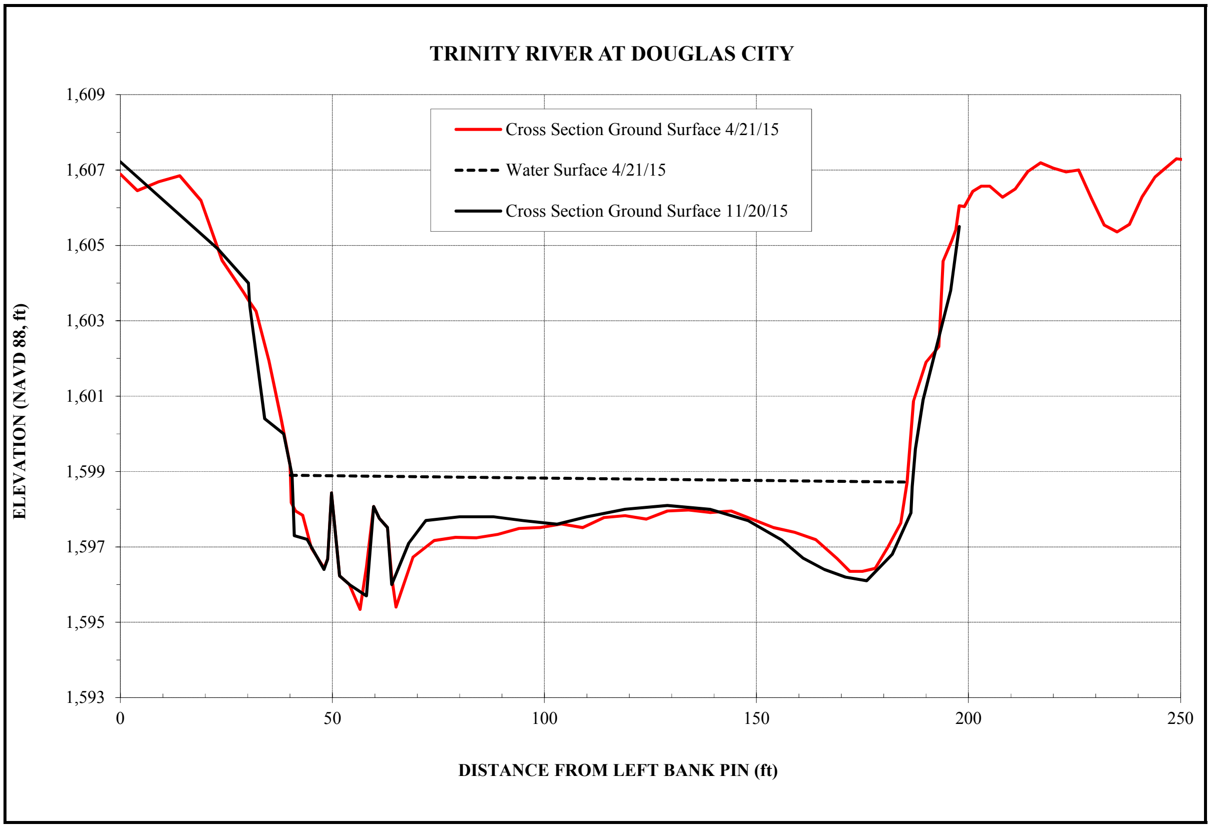


Figure 35. Cross section changes at TRDC, pre and post Spring Flow Release 2015.

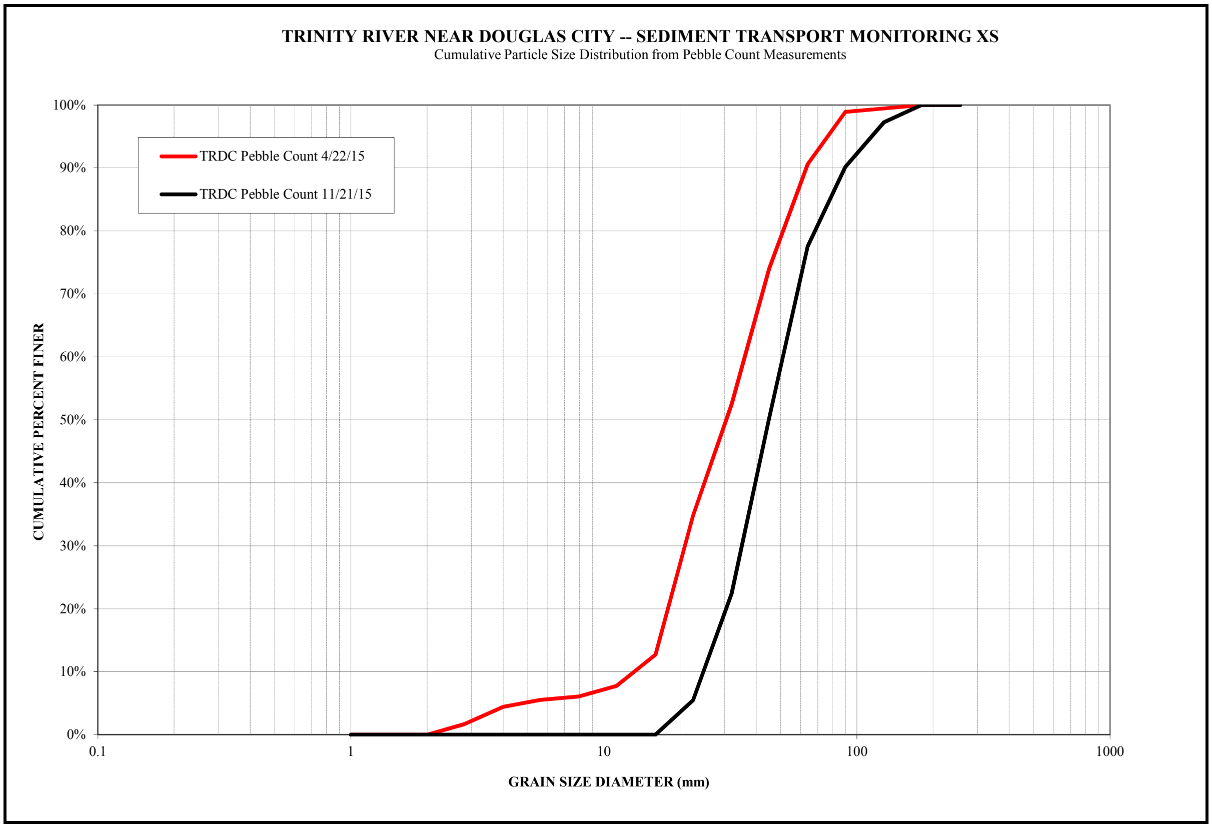


Figure 36. Changes in bed texture at TRDC, Spring Flow Release 2015.

2.5 Discussion

Sediment transport rates derived from field samples display considerable variability within and between years. For example, the bedload transport rates at long-term sediment transport monitoring stations, TRAL, and TRLG, show up to several orders of magnitude variation for a given discharge (Figures 9-11; 25-27). The suspended sediment data display less variation (Figures 8 and 23). The need to accurately estimate sediment transport rates for sediment load computations and to differentiate sediment transport/supply periods (via transport curves) provides the impetus for repeat annual sampling efforts.

The sediment budgeting objectives outlined in the TRFE and SBMP require an accounting of sediment inputs and outputs to sediment budget cells. These values are used to determine the dam release flow duration required to transport sediment and the sediment quantities and particle sizes needed to augment various reaches. Monitoring results which inform sediment budgets and help explain the linkages between management actions and desired restoration outcomes (e.g. as described in TRFE, 1999) include:

- Differences in sediment discharge between stations;
- Differences in sediment loads between stations;
- Differences in bedload sediment particle sizes;
- Changes in sediment transport rates at a station over time;
- Changes in sediment loads at a station over time.

These topics are presented in the following sections. In 2015, we also explored uncertainty in some of the sediment load calculations as implied by temporal bedload discharge variation. The results of this pilot study are provided in section 2.5.5.

2.5.1 Differences in Sediment Discharge between Stations

2.5.1.1 Mainstem Suspended Sediment

WY 2015 suspended sediment discharge data for the four mainstem stations were plotted together (Figure 37) to highlight downstream transport variation. Mainstem suspended sediment transport rates increase (shift to the left) with distance downstream from the dam. Assuming all stations are transporting below their potential SSD transport capacity, the progressive downstream increase in transport rate indicates that fine sediment supply increases with distance downstream. This is likely due both to tributary contributions and greater length of channel banks (e.g. sandy lateral berms) available to recruit fine material. Much of the scatter within each of the mainstem stations' data can be attributed to hysteresis during the Spring Flow. While gravel was being introduced, increases in turbidty and suspended sediment were observed that were not associated with increases in discharge. This further contributed to the scatter observed at TRGV and to a lesser degree TRLG and TRDC (the injection-related turbidity pulse was observed at all three stations).

The WY 2015 sedigraphs for total suspended sediment discharge were plotted with their respective hydrographs to highlight sediment discharge variation across the hydrograph (at a station) and in the downstream direction (between stations) (Figures 38, 39). All stations (with minor exceptions) show a rapid rise in SSD with the hydrograph, then a gradual decline across the 8,500 cfs flow bench as the supply is depleted. TRGV shows a second pulse of SSD during the 8,500 cfs bench which is likely related to gravel injection occurring during the flow release. TRAL peaked at less than 200 tons/day. Both TRGV and TRLG show SSD instantaneous maxima around 2,500 tons/day and TRDC peaks well above 4,500 tons/day.

The hysteresis described above is also illustrated in the shape of each sedigraph relative to the hydrograph shape; SSD drops off quickly after the steep rise to the 8,500 cfs flow bench.

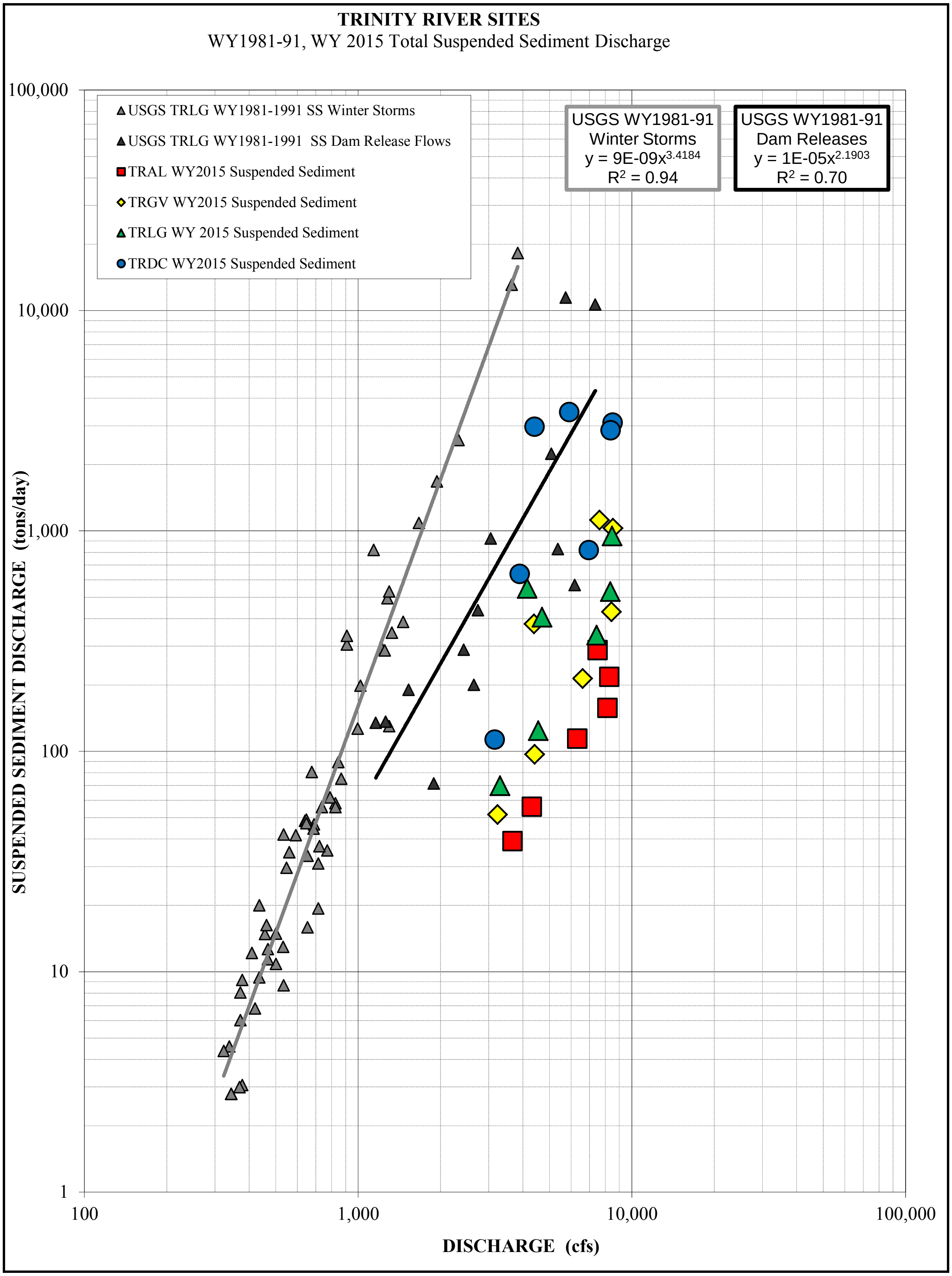
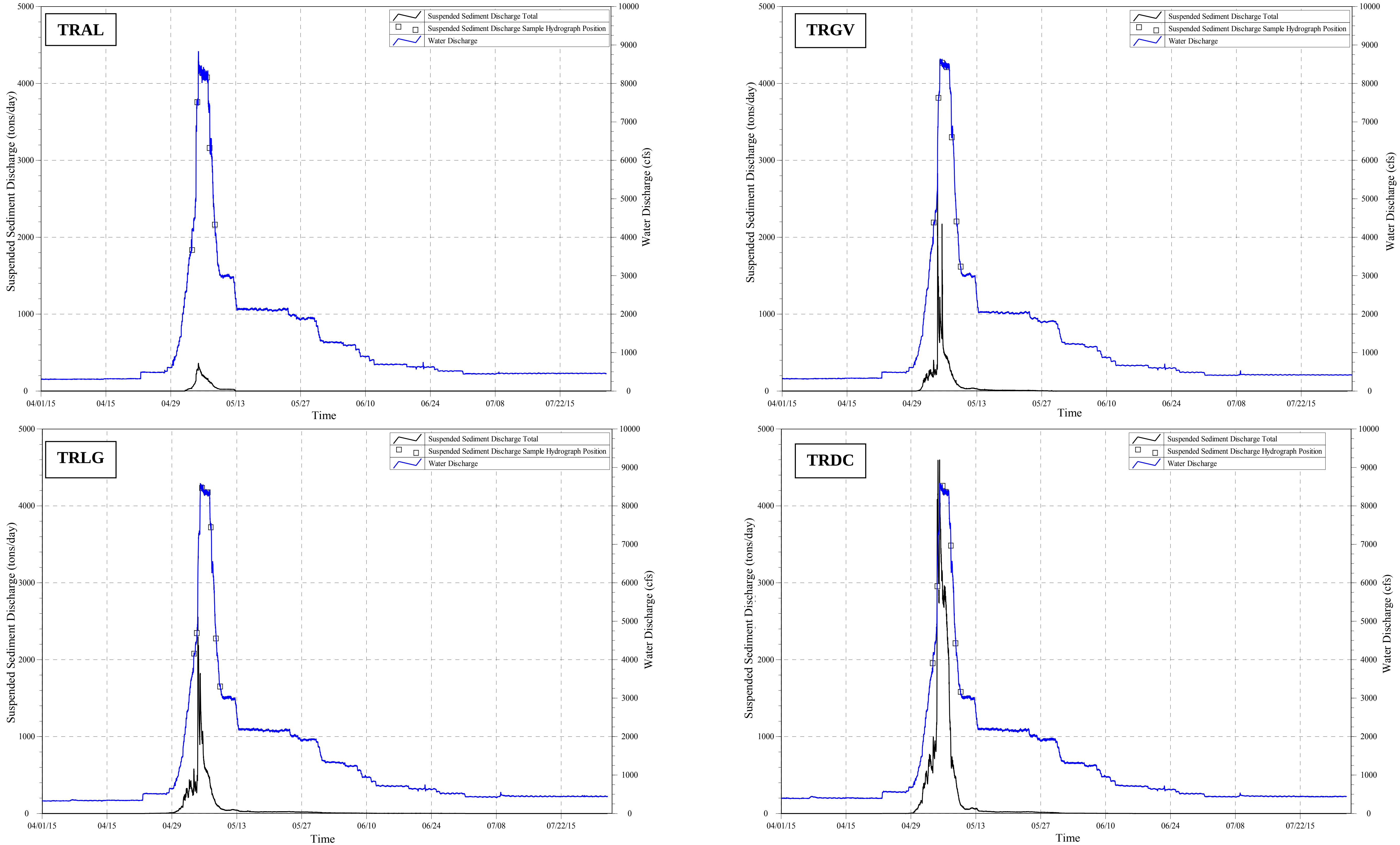


Figure 37. Suspended Sediment Discharge, Mainstem Trinity River Monitoring Stations, WY 2015 with TRLG Data from 1981-1991 for comparison.
See Figures 1 and 2 for sampling site locations.

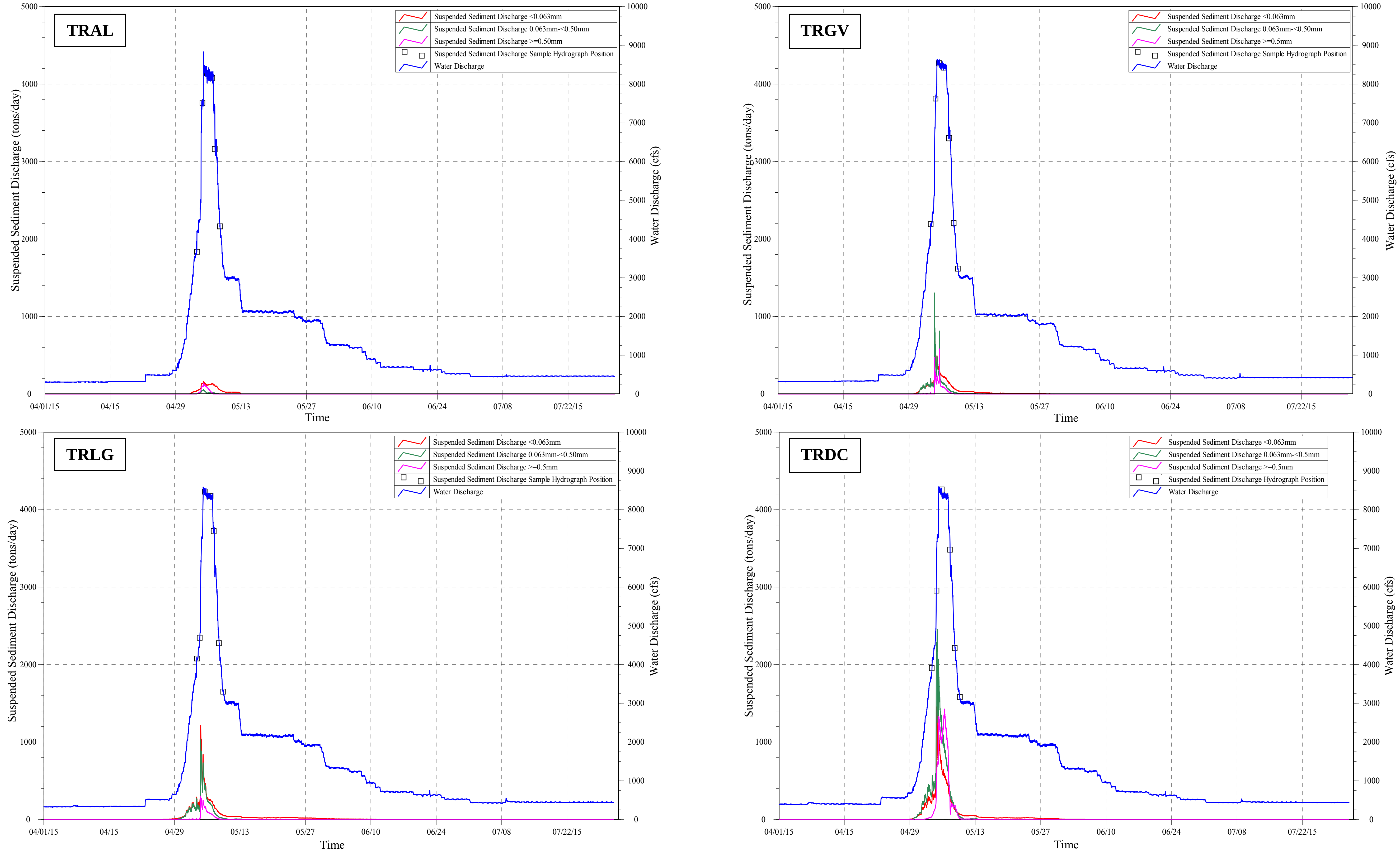
TRINITY RIVER MAINSTEM STATIONS

Suspended Sediment Discharge -- Spring Flow Release WY 2015



TRINITY RIVER MAINSTEM STATIONS

Suspended Sediment Discharge -- Spring Flow Release WY 2015



WY2015 SEDIMENT TRANSPORT MONITORING REPORT	TRINITY RIVER RESTORATION PROGRAM	GMA Hydrology | Geomorphology | Stream Restoration	FIGURE 39

2.5.1.2 Mainstem Bedload

The WY 2015 total bedload discharge measurements for all stations were plotted together in Figure 40. Trend lines were added strictly to aid in distinguishing relative trends. Data-point scatter was attributed to: the hysteresis that occurs across the flow benches, the inherent variability in sample particle-size distributions (e.g. periodic large particles affecting the sample weight), and the inherent temporal variability in bedload transport.

TRAL bedload shows the highest rate of increase (exponent = 7.8 in the power function). TRLG and TRGV generally plot together, though TRGV contains several samples which plot much higher than TRLG (around 900-1,000 tons/day), which groups with the upper end of TRDC. TRDC has the lowest rate of increase (exponent = 2.3), but since it sits above and to the left, clearly transports more total bedload at lower flows than do the other three stations. This reflects the greater availability of sediment for transport towards the downstream end of the study area due to tributary inflows. A higher sediment transport capacity may also contribute to higher bedload discharge rates at TRDC which has the steepest water surface slope of all the stations.

The four mainstem total bedload sedigraphs and sedigraphs for fine (0.5-<8mm) and coarse (≥ 8mm) bedload size fraction were plotted (Figures 41, 42) to highlight bedload discharge variation across the Spring Flow Release hydrograph and in the downstream direction. Mainstem bedload transport rates followed very different hysteresis patterns than was observed with SSD. The sedigraph at TRAL appears to reflect the shape of the highest portions of the hydrograph. TRDC shows increasing total bedload across the peak flow bench while TRGV and TRLG show a gradual decrease following the initial steep rise to maximum bedload discharge (Figure 41). Similar trends are illustrated in the partial bedload discharge sedigraphs (Figure 42).

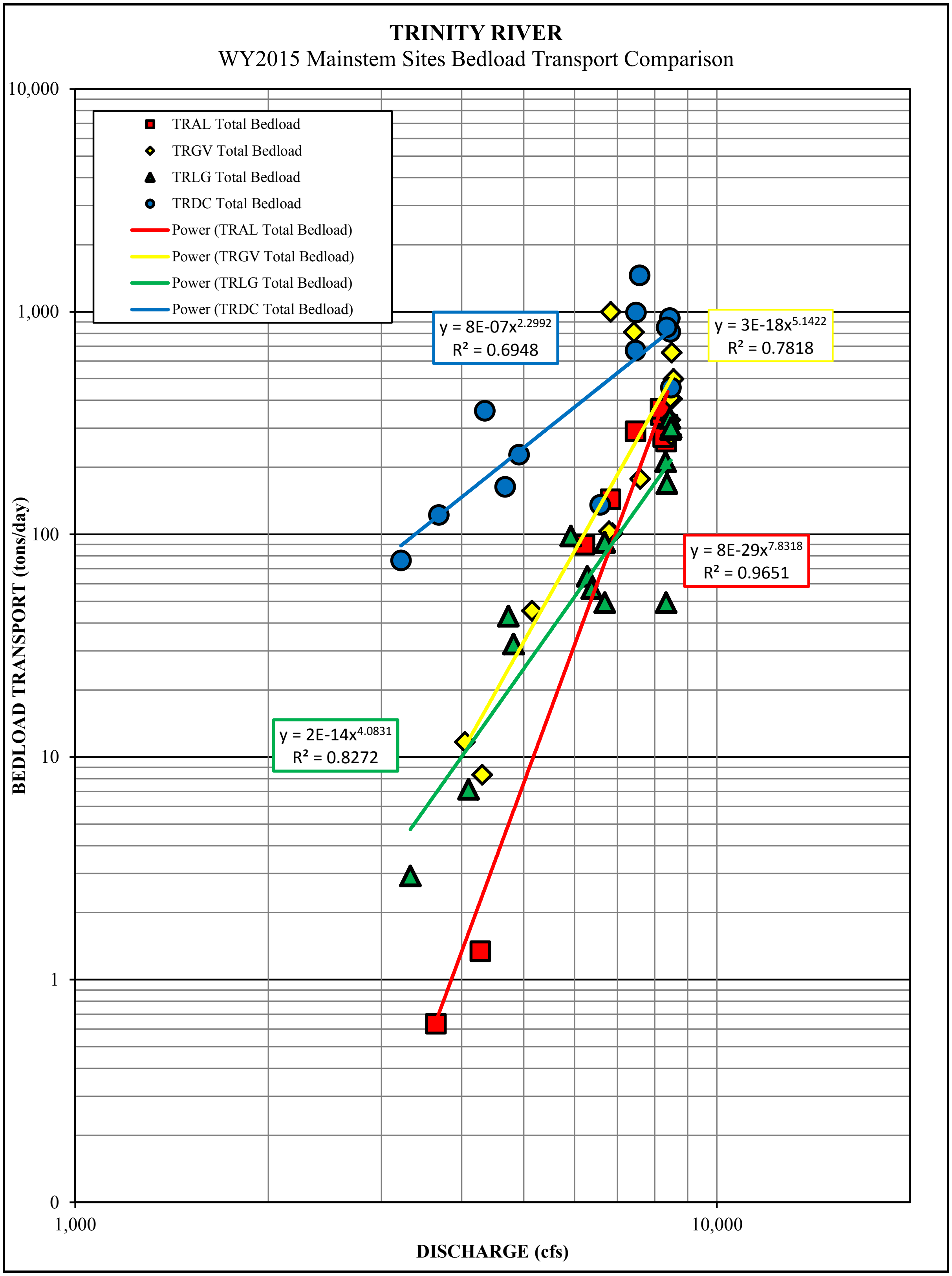
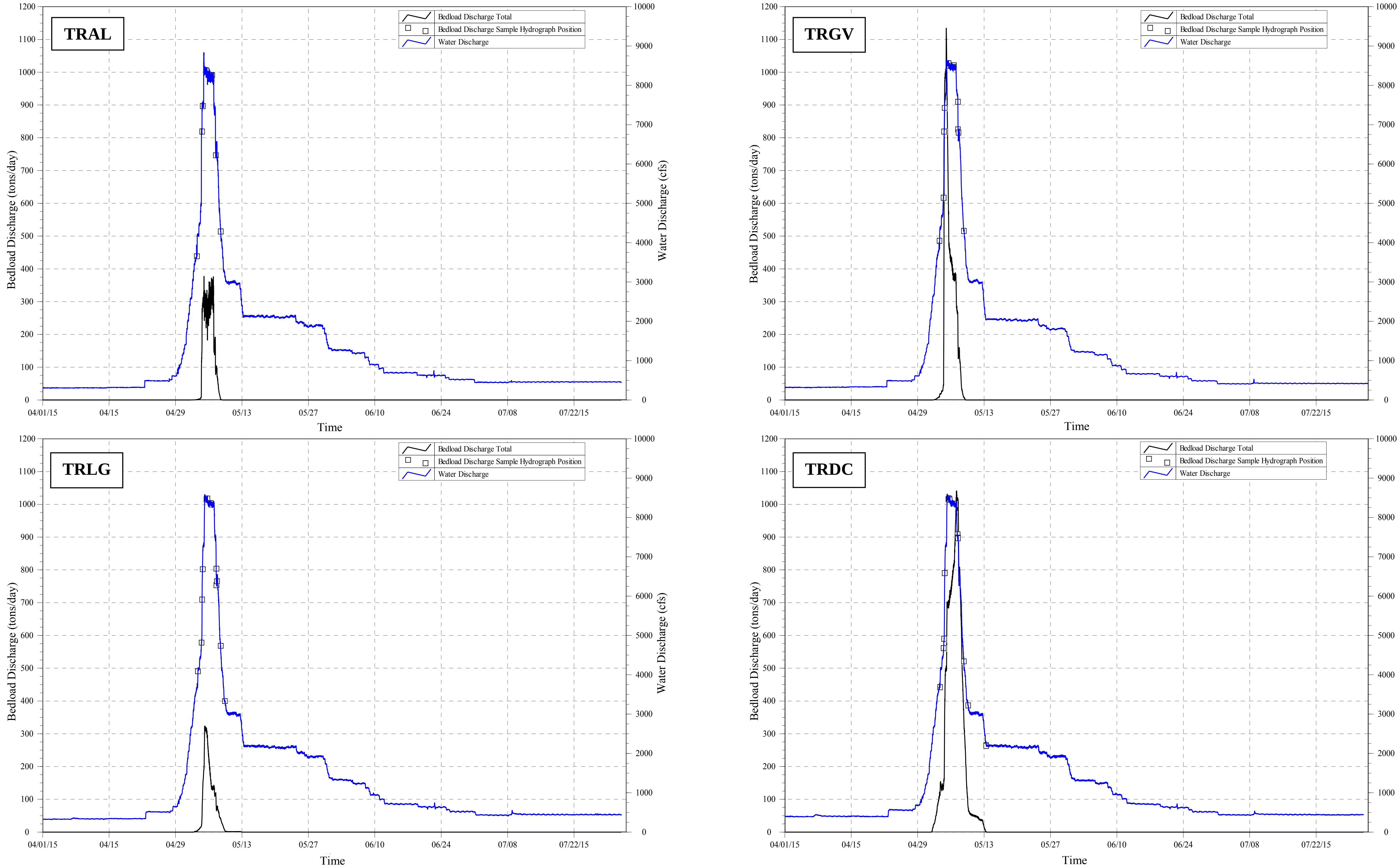


Figure 40. Total Bedload Discharge, Mainstem Trinity River Monitoring Stations, WY2015.
See Figures 1 and 2 for sampling station locations.

TRINITY RIVER MAINSTEM STATIONS

Bedload Discharge -- Spring Flow Release WY 2015



WY2015 SEDIMENT TRANSPORT MONITORING REPORT

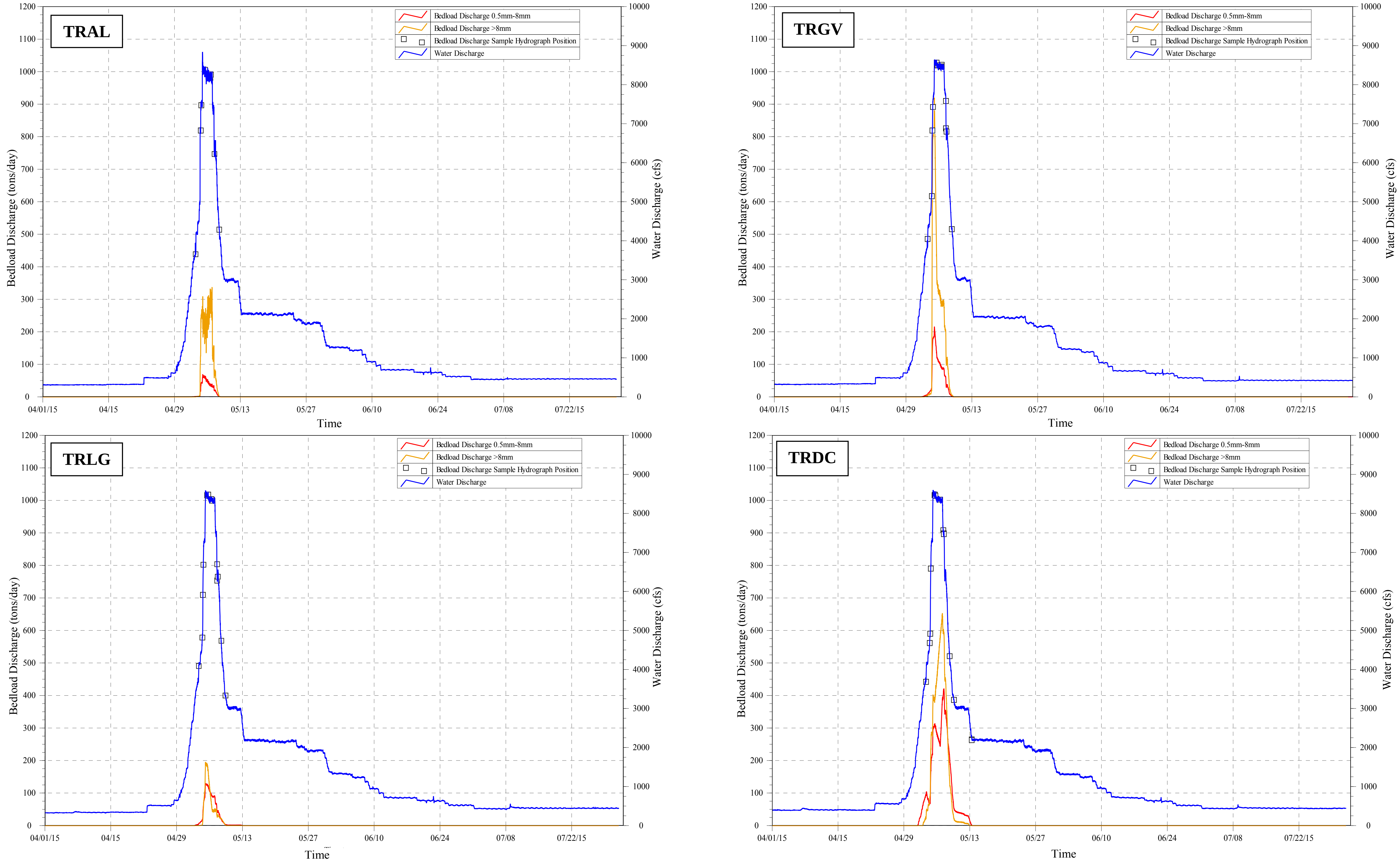
TRINITY RIVER RESTORATION PROGRAM

GMA
Hydrology | Geomorphology | Stream Restoration

FIGURE

41

TRINITY RIVER MAINSTEM STATIONS
Bedload Discharge -- Spring Flow Release WY 2015



WY2015 SEDIMENT TRANSPORT MONITORING REPORT	TRINITY RIVER RESTORATION PROGRAM	GMA Hydrology | Geomorphology | Stream Restoration	FIGURE 42

2.5.1.3 Differences in Bedload Sample Particle Size Distributions

The bedload sample particle-size distributions for the mainstem stations were compared to examine general downstream transport variations in grain size. Particle-size distributions were averaged for all samples collected during the 2015 Spring Flow Release by station (Figure 43). Maximum grain sizes are in the range of 90-120 mm. TRAL and TRGV show very similar curves which are noticeably coarser than the others – perhaps due to their proximity to gravel injection sites, and in the case of TRAL, likely due to lack of tributary deliveries.

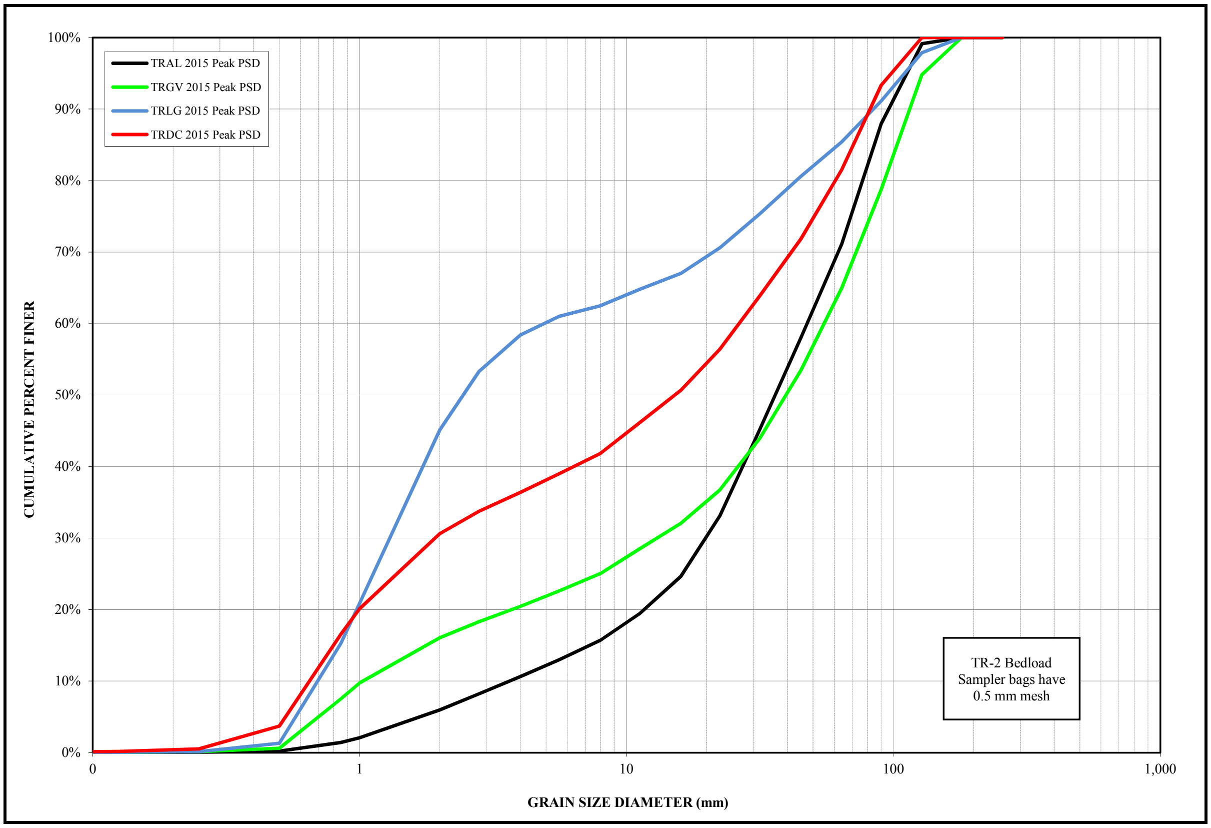


Figure 43. 8,500 cfs Flow-Bench (May 5 & 6) Averaged Bedload Particle Size Distributions from the WY2015 Spring Flow Release.
See Figures 1 and 2 for sampling station locations.

Figure 44 shows the variation of bedload particle size distribution for bedload samples at TRAL over the course of the release. After the initial flush of finer material on May 3, the samples revealed a fairly uniform composition for the remainder of the sampling period with the D_{50} in the range of 28-51mm (Figure 44). On the last day of sampling, the curve shifts back to the left (during a flow of 4,280 cfs) on the falling limb. At TRGV, an initial coarsening occurs and the sample distributions for subsequent days with a D_{50} in the 28-50mm range (very similar to TRAL, Figure 45). On the final day, a single large particle skews the sample distribution by skipping several size classes (seemingly an anomaly at 4,310 cfs).

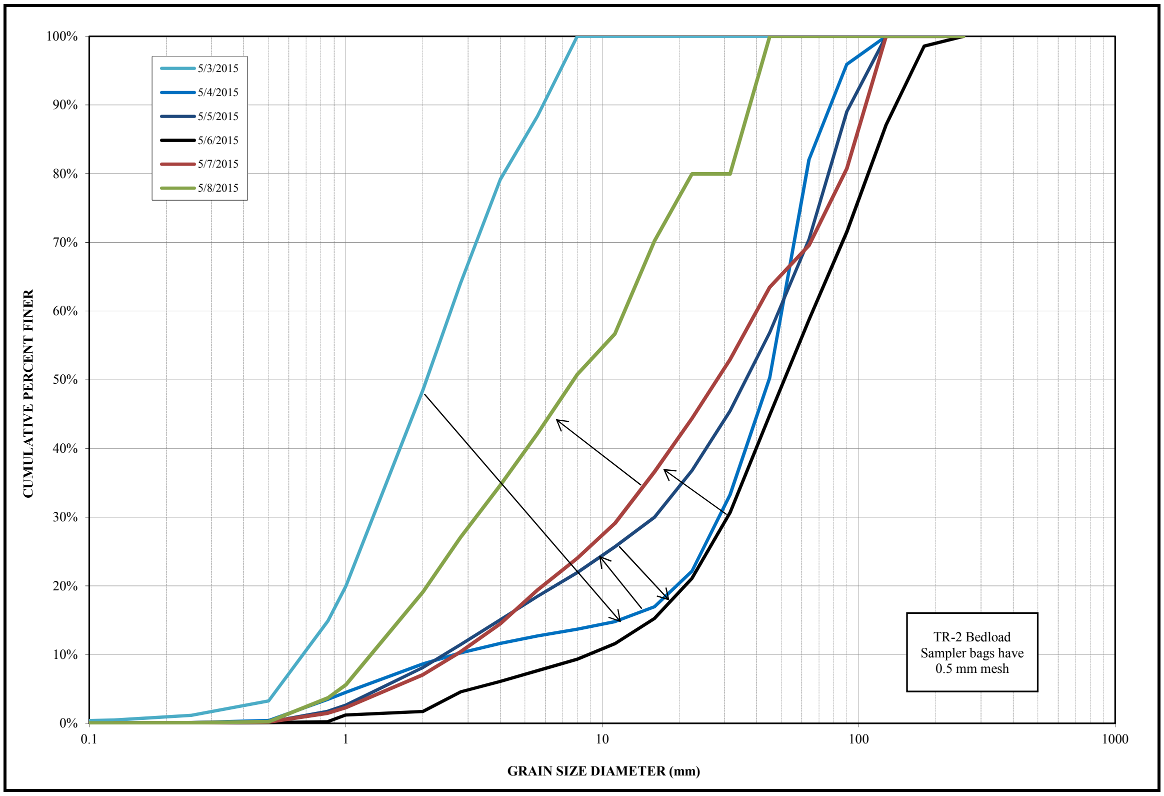


Figure 44. TRAL, Daily Bedload Particle Size Distributions, Spring Flow Release, WY2015.

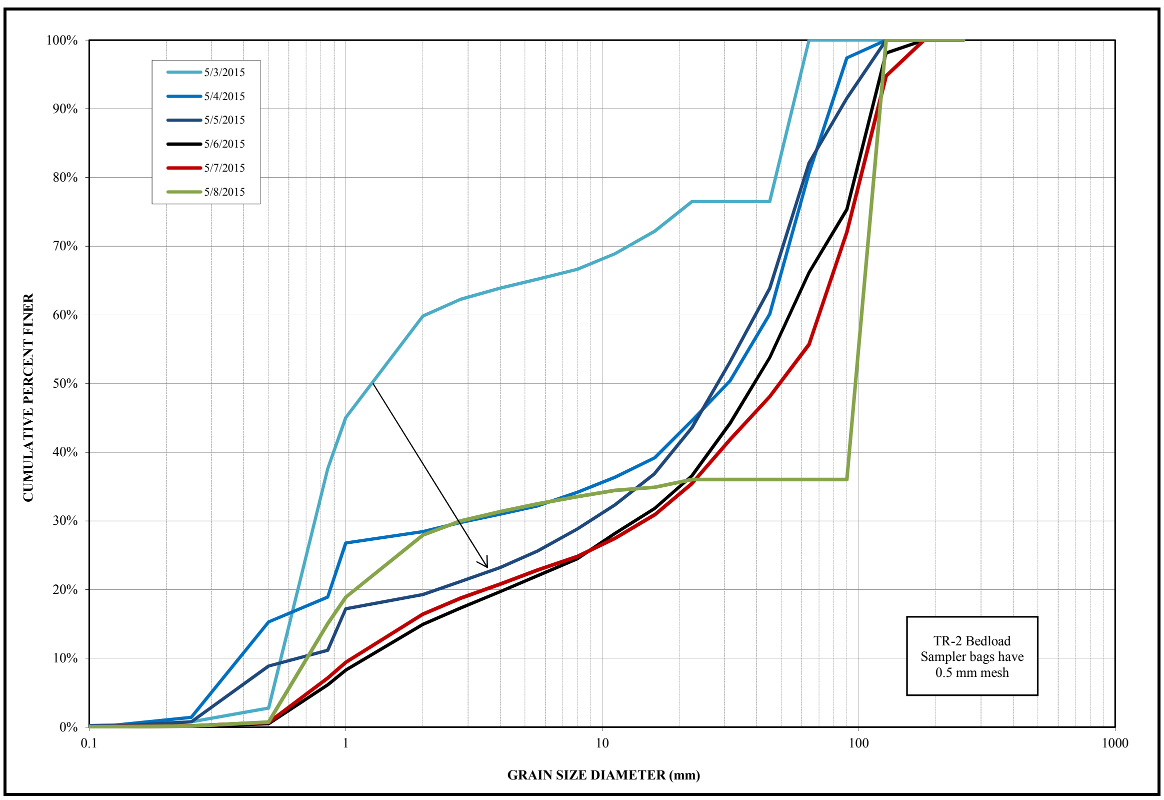


Figure 45. TRGV, Daily Bedload Particle Size Distributions, Spring Flow Release, WY2015.

At TRLG, the only clear pattern is one of gradual coarsening over the first three days, then some oscillation over the tail of the peak flow bench and into the falling limb (Figure 46). On the very last day, the particle size distribution falls back in the direction of the first day's sample.

At TRDC, the daily-averaged samples show less oscillation and describe instead a coarsening load through the end of the 8,500 cfs bench, then gradually fining throughout the falling limb portion of the sampling period (Figure 47).

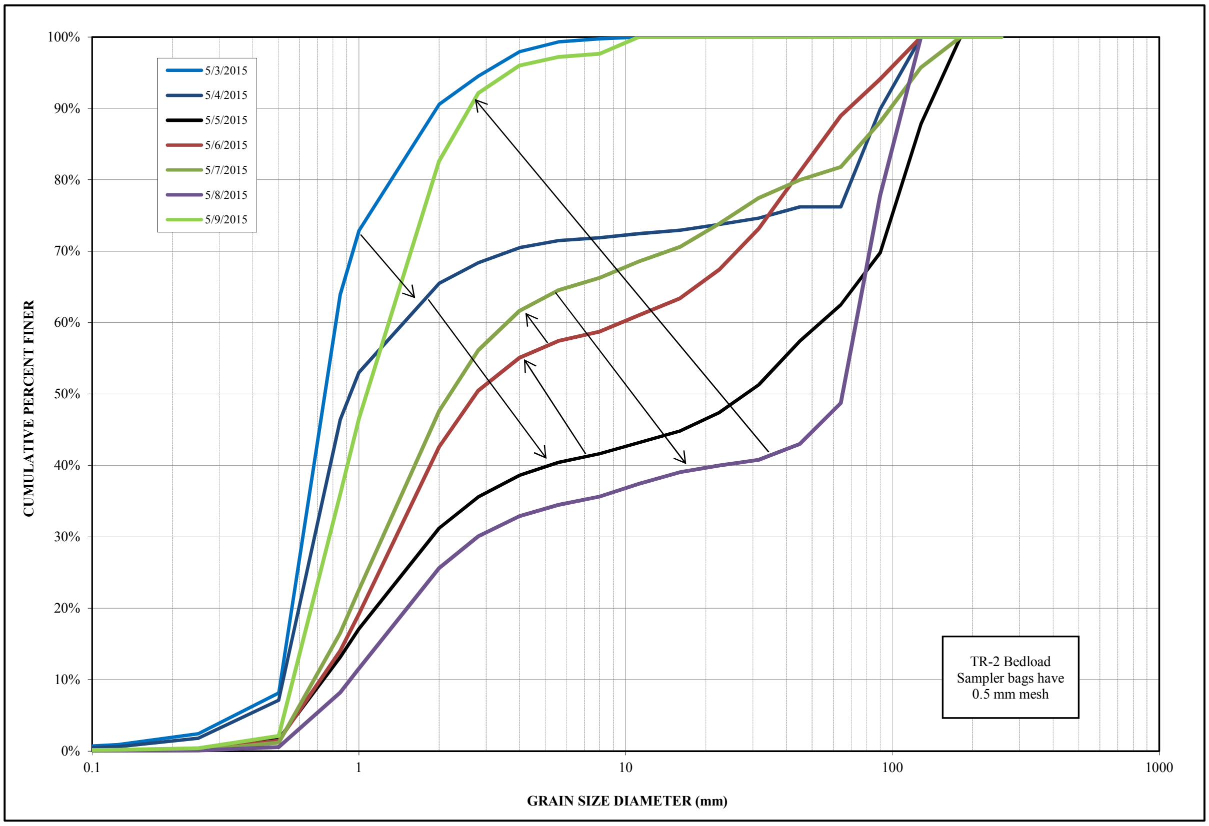


Figure 46. TRLG, Daily Bedload Particle Size Distributions, Spring Flow Release, WY2015.

2.5.2 Differences in Sediment Load between Stations

2.5.2.1 Mainstem Suspended Sediment Loads

The computed partial and total suspended sediment loads for the WY2015 Spring Flow Release are presented in Table 18. Suspended sediment loads increased in the downstream direction. Total suspended sediment load during the computation period varied in a downstream direction from 946 tons at TRAL, to 3,160 tons at TRGV, to 4,570 tons at TRLG, and 11,900 tons at TRDC.

2.5.2.2 Mainstem Bedload

Total bedload estimates for TRAL, TRGV, TRLG, and TRDC in WY2015 were 861, 1,770, 670 and 3,520 tons, respectively (Table 18). The total bedload varies, with TRGV transporting approximately double the loads of TRLG and TRAL and TRDC transporting approximately double the load of TRGV.

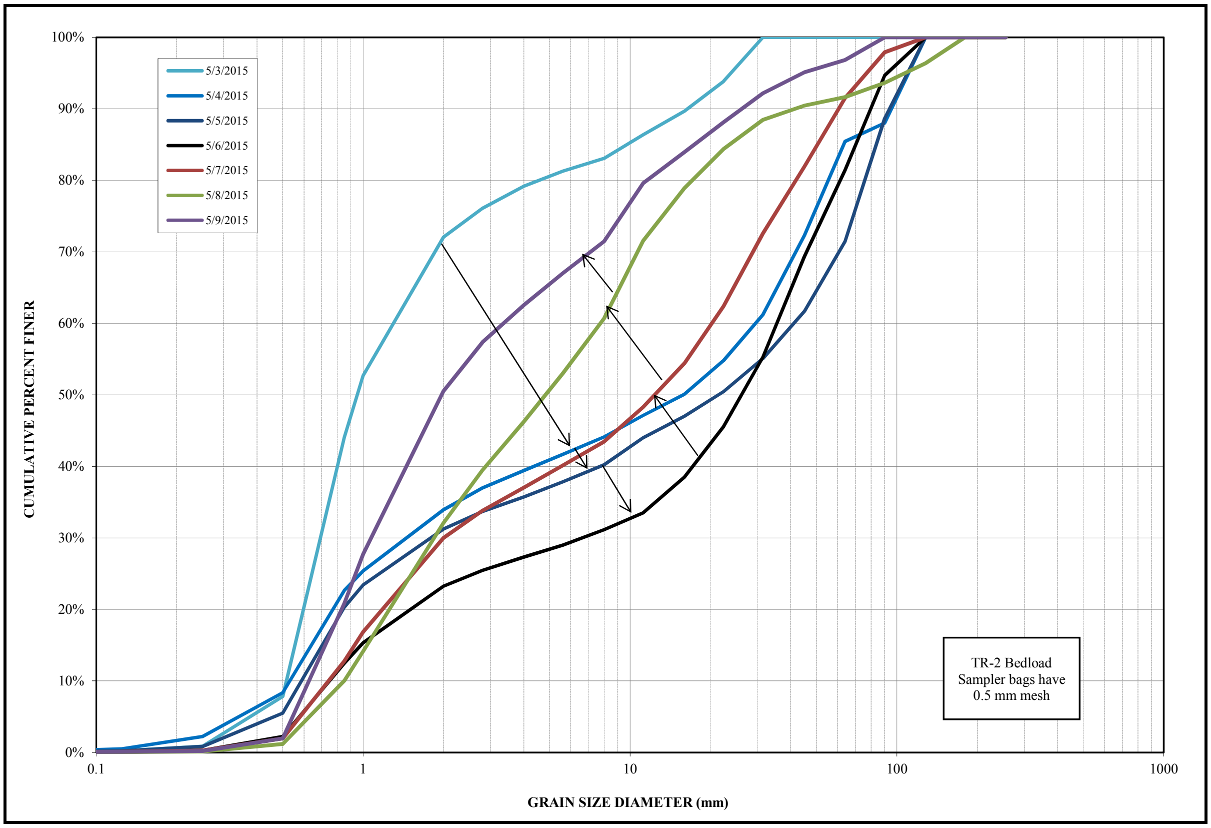


Figure 47. TRDC, Daily Bedload Particle Size Distributions, Spring Flow Release, WY2015.

Table 18. WY 2015 Mainstem Sediment Loads

	Suspended Sediment				Bedload		
SEDIMENT MONITORING STATION	SS <0.063 mm (tons)	SS 0.063 mm - <0.50 mm (tons)	SS ≥0.50 mm (tons)	SS Total (tons)	Bedload 0.5-8 mm (tons)	Bedload ≥8 mm (tons)	Total Bedload (tons)
Trinity River at Lewiston (TRAL)	662	83	201	946	146	715	861
Trinity River above Grass Valley Creek (TRGV)	1,650	1,100	408	3,160	400	1,370	1,770
Trinity River below Limekiln Gulch (TRLG)	2,580	1,600	392	4,570	344	326	670
Trinity River near Douglas City (TRDC)	3,730	4,880	3,320	11,900	1,600	1,920	3,520

All loads rounded using methods by Porterfield (1972)

Bedload composition also varied between stations, with the station transporting nearly the lowest total bedload (TRLG) also showing the highest percentage of 0.5-<8mm (51 percent). Expectedly, TRAL with its proximity to the dam and relative lack of fine sediment contribution potential, showed 83 percent of its bedload to be ≥8mm.

2.5.2.3 Mainstem Suspended and Bedload Ratio to Total Load

Comparison of the ratio of suspended load or bedload to total load at the various mainstem sites can provide additional insight into transport dynamics. TRAL generally has a much higher percentage of bedload versus total load compared to the other sites, 31 percent in WY2013 and 48 percent in WY2015. In the downstream direction, the percentage of total load comprised of bedload at the other sites ranges from 36 percent at TRGV, to 13 percent at TRLG and 23 percent at TRDC.

2.5.3 Coarse Bedload -- 2004-2013

The magnitude of Spring Flow Release sediment loads is dependent upon numerous factors, including: peak flow magnitude, hydrograph shape, sediment augmentation efforts, changes in transport capacity (e.g. channel and floodplain restoration) and tributary sediment contributions. Here, we examine potential trends in the coarse bedload (≥8mm) Spring Flow Release load totals from 2004 to 2015. Table 19 provides water year types, release volumes and peak flow magnitudes for WY2004-2015. In addition, Table 19 provides the Spring Flow Release type (as described in the TRFE recommendations). In the previous 10 years of sediment sampling, there have been three ”Dry” type releases (2007, 2009, 2013), five ”Normal” releases (2004, 2005, 2008, 2010, and 2012), and two “Extremely Wet” releases (2006 and 2011). The distinction between water year type and Spring Flow release type is important because there were some variations (e.g. 2011 was a Wet water year type, but had an Extremely Wet release, 2004 was a wet year, but had a Normal Year release type). Lastly, WY2015 was classified a dry water year with a dry-type allocation and a modified flow release hydrograph (Figure 6).

Table 19. Water Year Types, Restoration Release Volumes, Flow Release Type and Peak Flow Release Magnitudes: 2004-2015 (source: TRRP 2013, 2015).

Water Year	Forecast Water Year Type	Actual Restoration Release (acre feet)	Spring Flow Release Type	Peak Release Magnitude (cfs)*
2004	Wet	651,000	Normal	6,200
2005	Normal	647,600	Normal	6,970
2006	Ex. Wet	809,900	Ex Wet	10,100
2007	Dry	453,700	Dry	4,750
2008	Normal	648,700	Normal	6,470
2009	Dry	445,500	Dry	4,410
2010	Normal	656,700	Normal	6,840
2011	Wet	721,800	Ex wet	11,600
2012	Normal	647,100	Normal	6,080
2013	Dry	451,900	Dry	4,420
2014	Crit. Dry	370,500	Crit. Dry	3,410
2015	Dry	453,000**	Dry (modified)	8,310

**Mean daily discharge at Trinity River at Lewiston (USGS 11525500)*

***Allocation value approved by TMC March 26, 2015*

Figures 48-51 compare the computed ≥8mm bedload at all stations for the 10 years of monitoring (eight years at TRGV). The ≥8mm component of bedload is of primary interest for creating beneficial channel and habitat characteristics (alternate bars, spawning riffles etc). Comparing the ≥8mm component also removes much of the tributary influence as the <8mm component is not included in gravel injections and must therefore be delivered by tributaries or derived from in-channel sources, adjacent banks or hillslopes.

2006 and 2011 clearly dominate the relative bedload transport at all stations. The data at TRAL may be skewed by the fact that 2004 sampling took place at a location strongly influenced by gravel injection. All stations exhibit an apparent downward trend in ≥8mm transport during Normal release types (Figures 48-51). This trend warrants additional inquiry (such as examining peak discharge versus loads normalized by flow bench duration). The trend among Dry Flow Release types is less clear (2007, 2009 and 2013). 2009 clearly transported more bedload ≥8mm than 2007 and 2013, which appear of similar magnitude within stations. Most notably, however 2015 with its “Dry (modified)” release type (that is a dry year restoration total release (453,000 af) with an 8,500 cfs flow bench) showed an evident increase over preceding “Dry-type” flow releases at all stations. At TRGV, WY2015 exceeds some wet years (Figure 49) and at TRAL and TRDC, WY2015 approximates the magnitude of “Normal” flow release types (Figures 48 and 51).

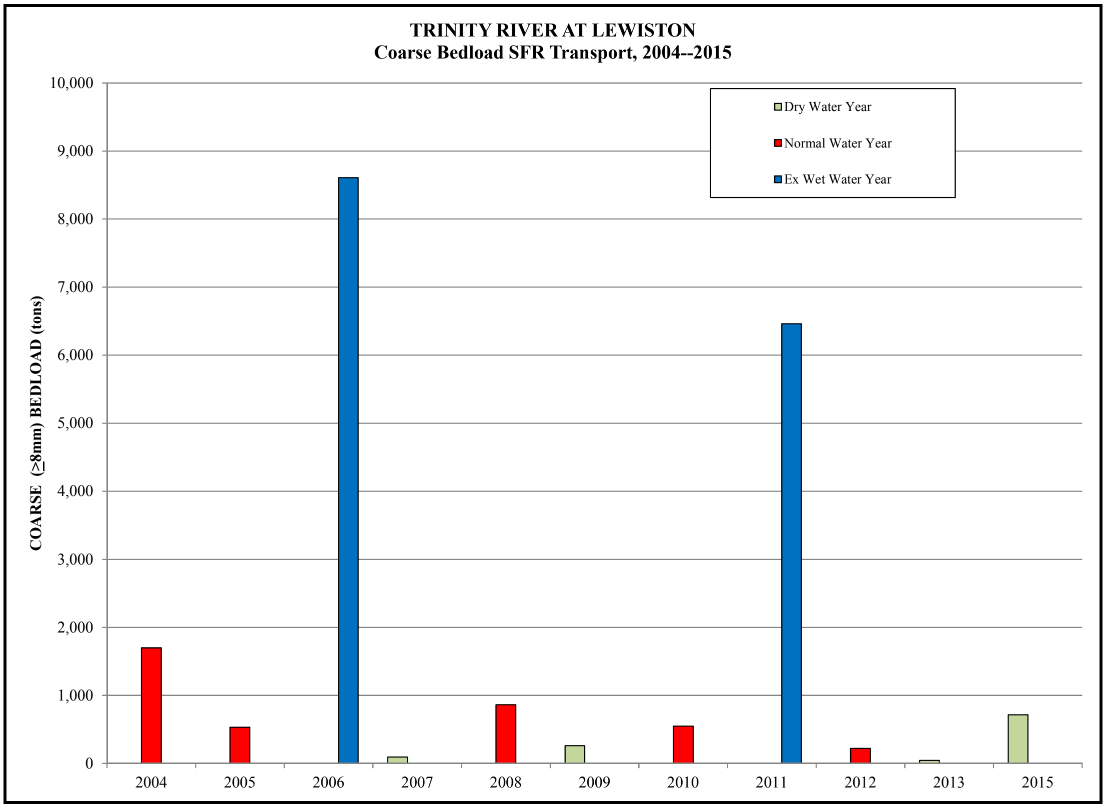


Figure 48. Trinity River at Lewiston, ≥8mm Bedload 2004-2013, 2015.

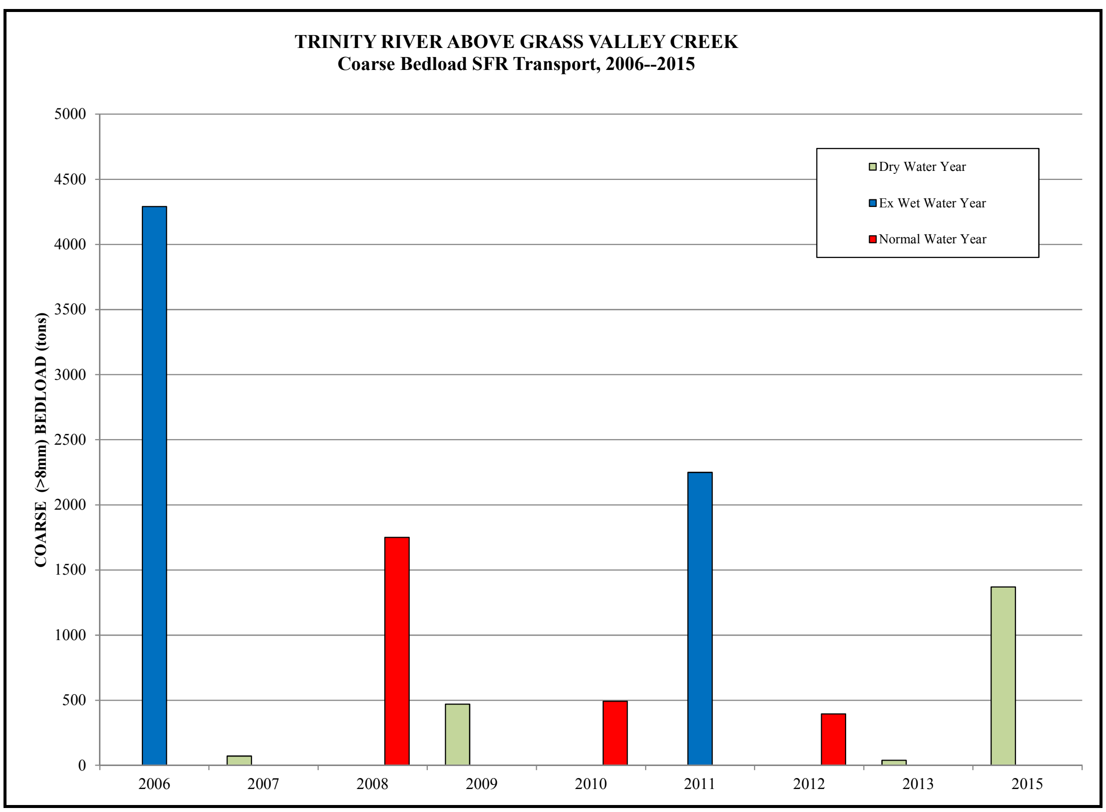


Figure 49. Trinity River above Grass Valley Creek, ≥8mm Bedload 2004-2013, 2015.

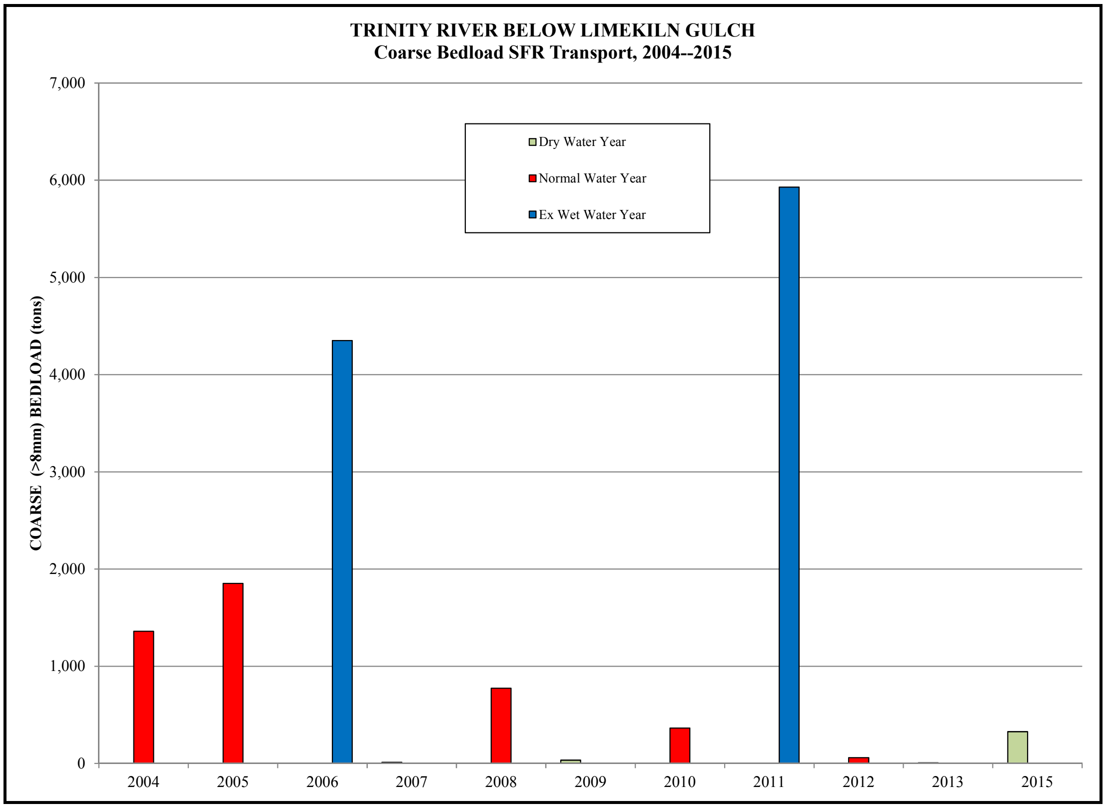


Figure 50. Trinity River below Limekiln Gulch, ≥8mm Bedload 2004-2013, 2015.

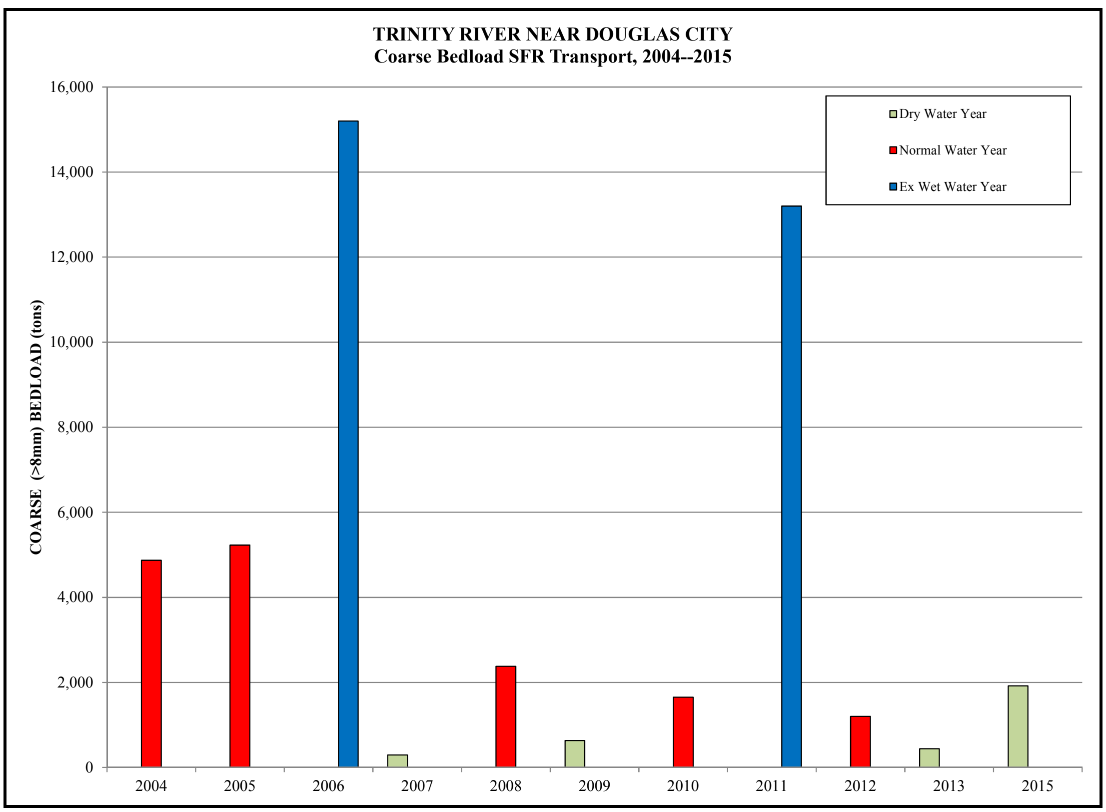


Figure 51. Trinity River below Limekiln Gulch, ≥8mm Bedload 2004-2013, 2015.

2.5.4 WY 2015 Sediment Discharge -- Comparison to TRFE/Historic Data

This discussion is limited to the long-term mainstem monitoring stations used in the TRFE to predict the fine and coarse fractions of bedload transport (TRAL and TRLG).

<u>2.5.4.1 Trinity River at Lewiston, CA</u>
The total bedload transport rates for WY 1997, WY 2002, and WY 2004-15 appear in Figure 11. The WY2015 data plotted well within the overall cloud of points, but the maximum transport values for the three other Dry water year flow releases (2007, 2009, 2013) were much lower than the maximum rates observed in 2015 (366 tons/day). For the 0.5-<8mm and ≥8mm bedload classes (Figures 9 and 10), most of the TRAL 2015 data fell to the right of the TRFE curve.

<u>2.5.4.2 Trinity River below Limekiln Gulch</u>
Partial and total bedload discharge data are available for TRLG during WY 1981-86, WY 1989-91, WY 1997, WY 2000, and WY 2002-2015 (Figures 25-26). The WY 2015 ≥8mm data fall generally within the cloud of historic data points but sit to the right of the TRFE curve (Figure 26). As with TRAL, the highest rates observed in similar release-type years (Dry, 2007, 2009, 2013) were much lower than those observed in 2015: 9.87, 27.6 and 2.15tons/day versus 199 tons/day in 2015. The 0.5-<8mm class generally follows the same pattern (Figure 25).

2.5.3 Spatial and Temporal Variation in Bedload Discharge

<u>Spatial Variation</u>
In 2006, between May 25 and June 12, at flows in the 5,000-10,000 cfs range, GMA conducted a number of experiments at the TRDC station (GMA 2007). Bedload samples were separated by 11 sampling locations (stations) along the cross section and were processed separately to examine the variability in bedload transport across the section (Figure 52). Samples are typically composited. These data clearly indicate where most of the transport is occurring (station 75 and from 105-125). Note that while, peak transport shifts among stations within the 105-125 range on different days, the peak always remains within this range.

<u>Temporal Variation</u>
In 2015, GMA implemented a pilot study to assess the potential temporal variation in bedload measurements by sampling repeatedly at a single vertical over a pre-determined time period (at least 30 minutes). Crews were instructed to sample a high transport station on a high transport day. Bedload discharge was computed over a 10 foot width, equivalent to a single computational cell in the SEWI computational method. Total bedload is the sum of the fine and coarse loads. The study was successfully implemented at three of the four stations (the study was implemented differently at TRDC and the results were not comparable to the other three, thus these data were not analyzed). Sample sizes are relatively small (n=8) and only very basic summary statistics were computed from the data (Table 20).

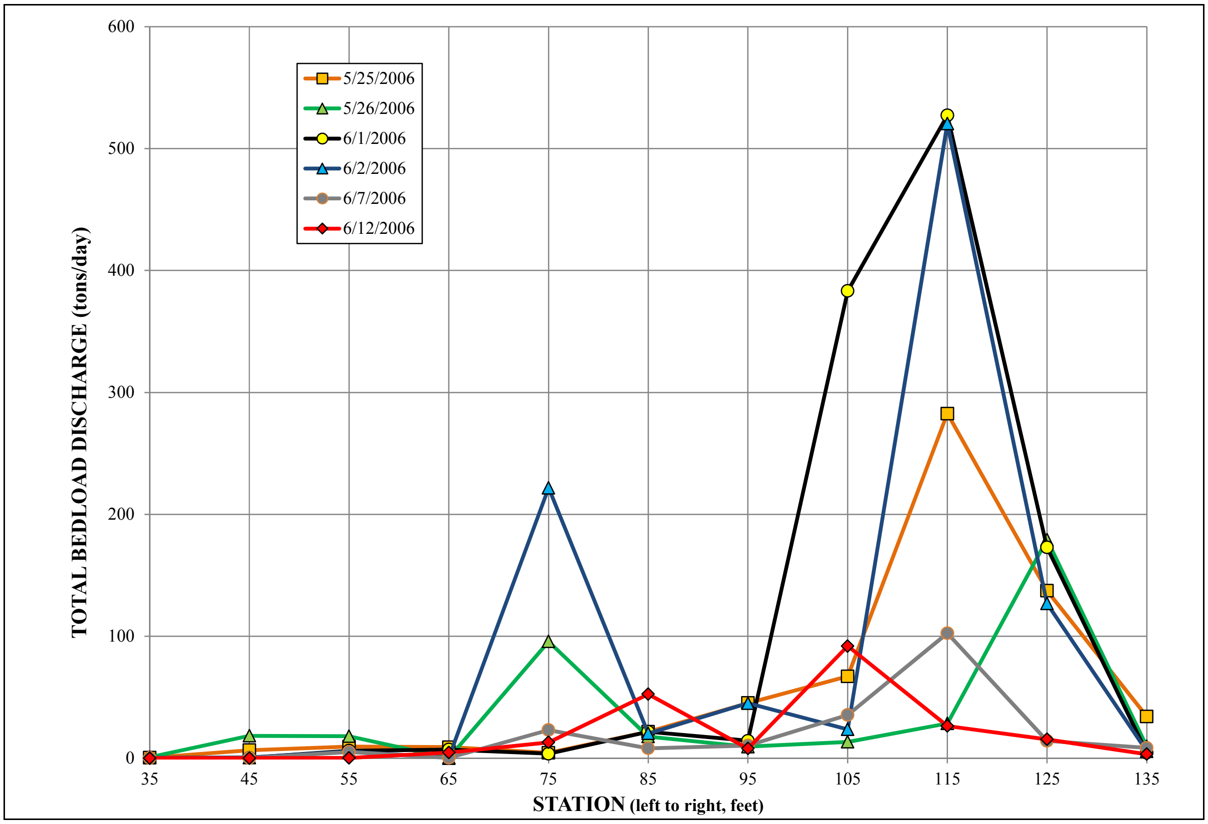


Figure 52. Spatial variation in total bedload discharge at TRDC in WY2006. Downstream view.

Table 20. Summary data for pilot study of bedload variability at TRAL, TRGV and TRLG.

	TRAL			TRGV			TRLG		
	Total Transport Rate	Transport ≥ 8mm	Transport 0.5-8 mm	Total Transport Rate	Transport ≥ 8mm	Transport 0.5-8 mm	Total Transport Rate	Transport ≥ 8mm	Transport 0.5-8 mm
#1	57.26	36.56	20.71	8.55	4.87	3.67	25.33	13.00	12.33
#2	21.40	19.07	2.33	6.02	3.50	2.52	111.33	88.85	22.47
#3	89.05	86.01	3.04	15.19	10.53	4.67	25.66	15.38	10.28
#4	37.47	33.42	4.04	65.46	55.07	10.39	110.06	85.19	24.88
#5	70.17	56.05	14.12	39.55	34.30	5.25	93.24	64.87	28.37
#6	74.52	52.02	22.51	3.12	1.03	2.09	73.04	46.20	26.84
#7	103.80	79.10	24.70	8.85	5.21	3.64	65.90	40.29	25.62
#8	85.62	57.30	28.32	11.90	8.29	3.61	57.59	38.78	18.81
mean	67.4	52.4	15.0	19.8	15.3	4.5	70.3	49.1	21.2
SD	27.5	22.7	10.6	21.6	19.2	2.6	33.8	28.7	6.8
min	21.40	19.07	2.33	3.12	1.03	2.09	25.33	13.00	10.28
max	103.80	86.01	28.32	65.46	55.07	10.39	111.33	88.85	28.37
range	82.40	66.94	25.99	62.34	54.04	8.30	86.00	75.85	18.08

values are not rounded as per Porterfield 1972

At TRAL and TRLG, sampling was conducted at equal time intervals and for equal down times (60 and 120 seconds respectively), thus providing a systematic sample over the 30 minute the time period. At TRGV, downtimes ranged from three to 15 minutes and while the longer downtimes capture greater variability in bedload discharge, they homogenize some data into a longer-term mean value and do not represent a systematic sampling of the time period. Figures 53-55 are provided as a visual representation of bedload variability for the pilot study (the y-axes are standardized for comparison). Figure 56 portrays all three stations together.

At TRAL, the fine bedload varied over a range of only 26 tons per day while the coarse load varied by 67 tons per day. The relative contributions of the two size ranges varies considerably; note Sample 3 with the highest coarse load (86 tons/day) and the second-lowest fine bedload (3 tons/day) (Figure 53). This station shows the highest coarse percentage (79 percent), which is likely due to the fact that only one small tributary enters between TRAL and the dam (Deadwood Creek), thus limiting the potential for fine bedload recruitment).

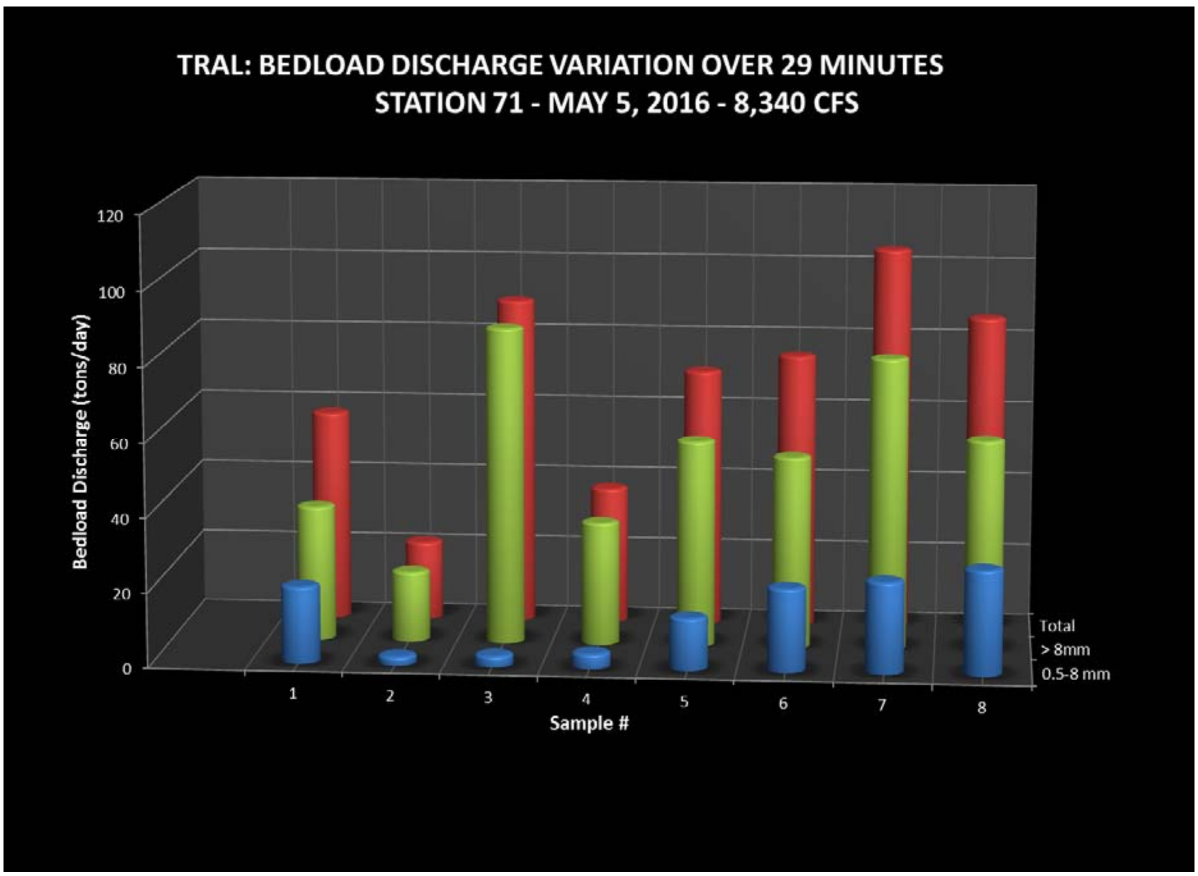


Figure 53. Bedload discharge at TRAL over 29 minutes at 60 second downtimes.

At TRGV, Samples 4 and 5 clearly suggest a short term higher transport phenomenon (Figure 54). Sample 3 was the 15 minute sample. Samples 4 and 5 were 3 minute samples. The grain size data showed no anomalies with multiple grains in the larger classes (suggesting the data was not biased by “scooping” a single large particle). The range in the fine fraction data is 8.3 tons/day while the range in the coarse data is 54 tons/day (Table 20).

With sample 6, the relative contributions of coarse and fine bedload are reversed, with the fine component contributing exactly twice as much as the coarse fraction. On average, for this 87 minute period, the coarse fraction represents 64 percent of the total load.

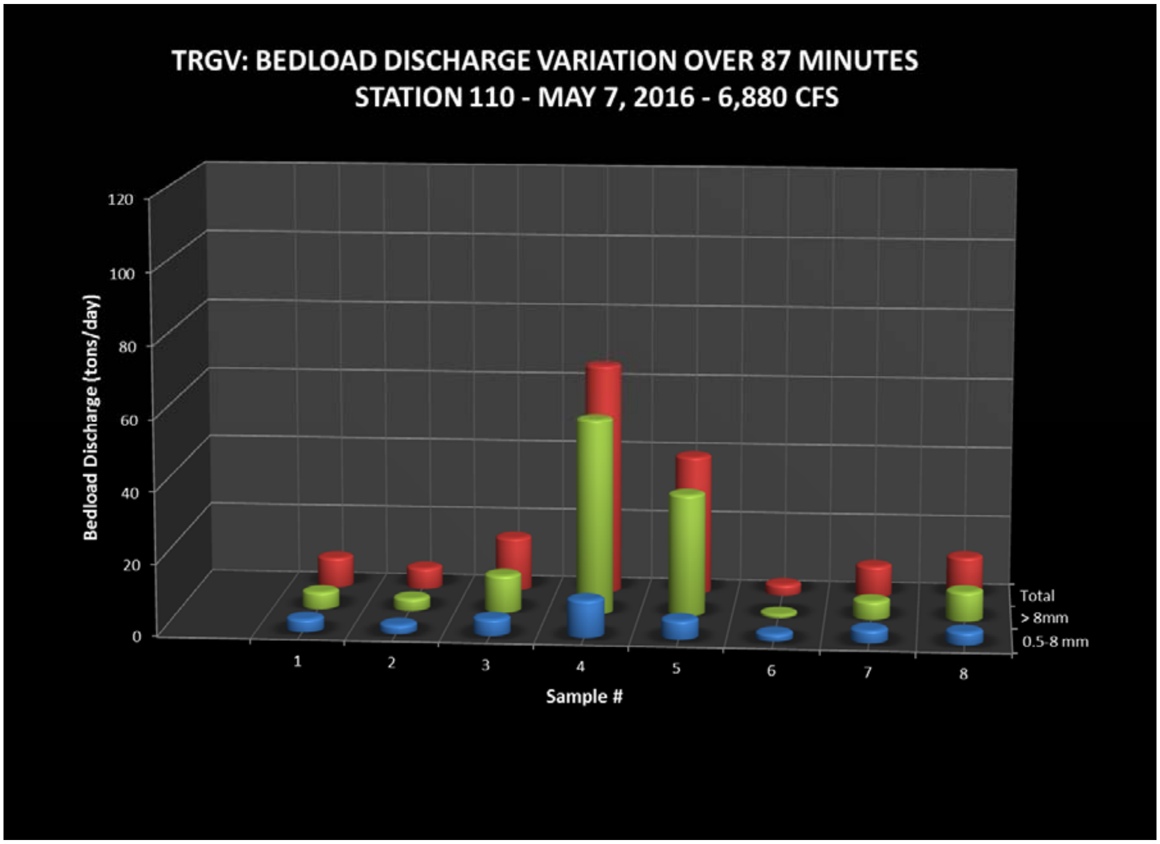


Figure 54. Bedload discharge at TRGV over 87 minutes at three to 15 minute downtimes.

At TRLG, the data present a contrast to the TRGV data (where two of the eight samples showed much higher transport): two of the TRLG samples are much lower than the other six (Figure 55). The relative contributions of fine and coarse bedload appear to be more consistent, averaging 66 percent coarse and 34 percent fine, though Sample 1 is closer to 50/50 fine and coarse.

WY2015 crews reported most of the load is typically generated at one to three stations). If we apply the 2006 spatial inference (most of the load is transported at 3 to 4 stations) to the 2015 temporal study, then we can assume that at TRLG, a full cross section total load computed from data collected at time #1 will differ greatly (>400 percent) from a load computed from time #2 (Figure 55). While these pilot study data are far from conclusive, they do suggest a need for more sampling at fewer stations in order to derive a more accurate estimate of average bedload discharge.

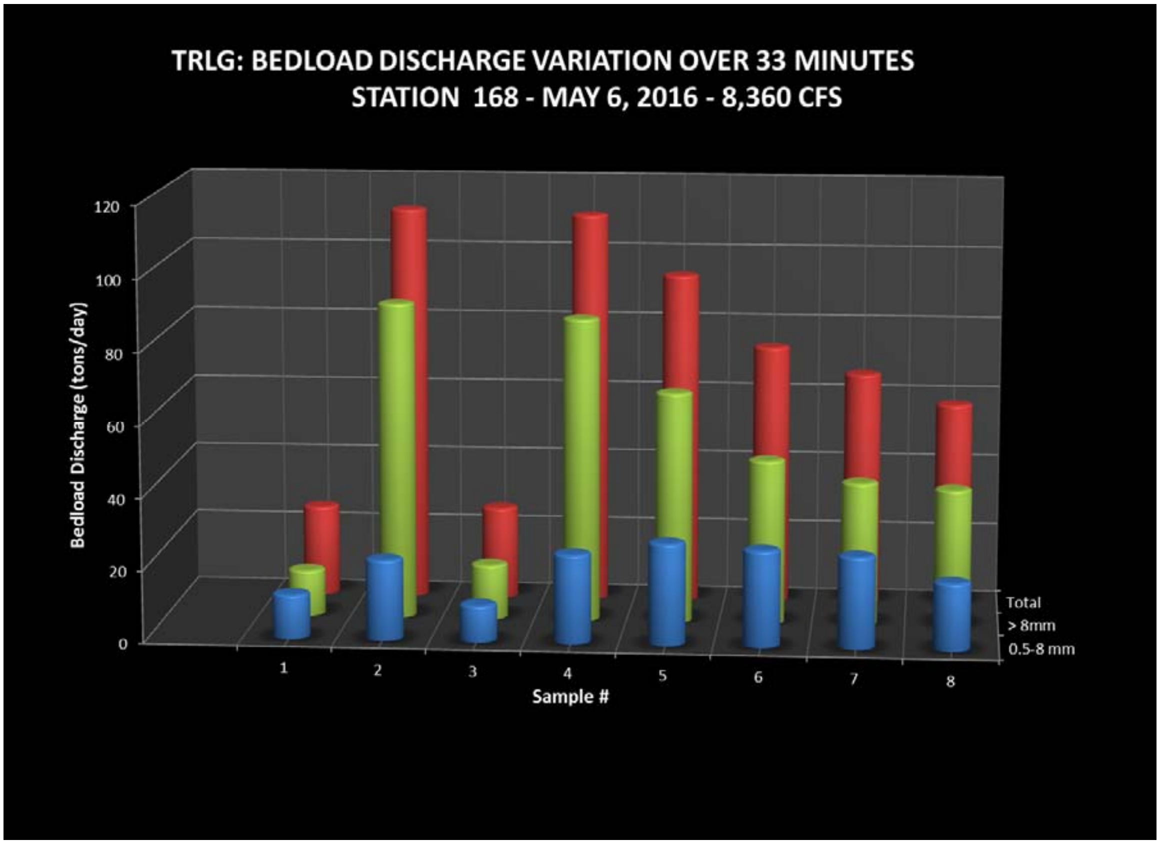


Figure 55. Bedload discharge at TRLG over a 33 minute period at 2 minute downtimes.

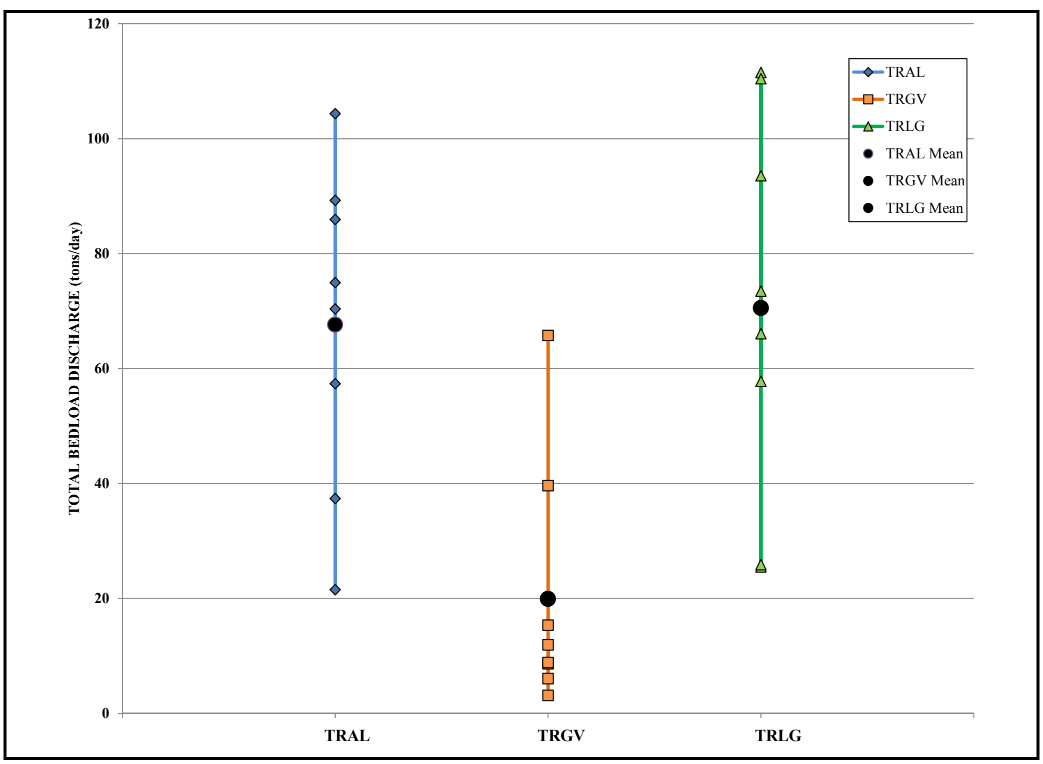


Figure 56. Total bedload discharge (range and mean values) during the variability pilot study at three Trinity River sampling locations.

3.0 MONITORING RECOMMENDATIONS

In an effort to improve future sediment transport monitoring, the following recommendations were developed:

- The potential trend of reduced bedload transport in Normal and Dry Year type Spring Flow Releases may warrant further investigation. Clearly, the modified Dry release-type applied in WY2015 was successful in moving more sediment than was observed in other Dry water years. Future analyses should compare flow bench magnitude and duration versus loads transported by flow release type. This may have implications toward changing the scope of the sampling effort in such year types.
- Improved integration of transport data with volumetric analysis of bathymetric surveys pre- and post-flow release will increase confidence in the results, and lead to improvements in the sediment budget. Before and after wet or extremely wet years only, we suggest surveying complete bathymetry for at least ½ mile upstream of each station. Such surveys will provide additional feedback to the sediment budget.
- Consider altering the bedload sampling protocols to use multiple occupations of single verticals, with the number of replicates based on the variability and magnitude of transport rates. At low transport rate verticals, a single long duration sample will provide a reasonable estimate of mean transport, while in high rate verticals; multiple samples would provide a more robust estimate of the mean. Such an approach will increase the accuracy of estimating a mean daily value to guide sedigraph development.
- GMA typically monitors bed texture of the same sub-section of the cross section each year (e.g. a transverse riffle that is shallow enough to sample and represents a significant portion of where transport occurs during high flow sampling). The boundaries of these areas shift with changes in bed evolution. If TRRP's desire is to represent the entire cross section with a single pebble count (as in to provide a roughness estimate for a hydraulic model), this should be discussed prior to future years' monitoring.
- The TRGV gaging location has been severely impacted by the collapse of the large cottonwood tree supporting the gage house. We suggest rebuilding the station for WY2016, as the existing stump appears unreliable.
- Water surface slope measurement at some stations (e.g. TRGV, TRLG) is strongly influenced by overbank flow slope reduction. The reported highest-flow slopes are really floodplain water surface slope. Presumably, analysts are more interested in the slope responsible for grain mobilization which is typically steeper than that measured on the floodplain. We suggest installing taller stage references at fewer locations to improve the accuracy of water surface slope measures.
- As was observed in WY2013, some stations (e.g. TRDC) continue transporting considerable sediment after the sampling period ends. At a minimum, plan an additional partial sampling day for TRDC to improve the accuracy of the falling limb sediment load computation.
- The TRLG turbidity boom is mounted to a tree that has nearly collapsed into the river. Suggest upgrading this station by re-installing the boom in a more robust location.

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2015 TRINITY RIVER
SEDIMENT TRANSPORT MONITORING
TECHNICAL APPENDICES

US Bureau of Reclamation Contract R14C00122
Task 2, Action Order 8

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Ammended August 2019 to Add Missing Pages

Hydrology – Geomorphology – Stream Restoration
Land and Hydrographic Surveys

WY 2015 SEDIMENT TRANSPORT MONITORING REPORT SUMMARY OF DATA PRESENTED IN TECHNICIAL APPENDIXES A - F			
	Appendix		**Description**
Trinity River at Lewiston	**A**	1	Sediment Station Analysis
USGS Gage #11525500		2	Bedload Transport Curves
		3	Suspended Sediment Transport Curves
		4	Bedload Sedigraphs
		5	Suspended Sediment Sedigraphs
		6	15-min and Daily-Mean Streamflow Data (electronic files)
		7	Bedload Data and Computations (electronic files)
		8	Suspended Sediment Data and Computations (electronic files)
		9	Channel Geometry and Pebble Count Data (electronic files) and Water Surface Slopes
Trinity River above Grass Valley Creek	**B**	1	Streamflow and Sediment Station Analysis
USGS Gage #11525540		2	Discharge Rating Curves
		3	Bedload Transport Curves
		4	Suspended Sediment Transport Curves
		5	Turbidity and Streamflow Hydrograph Plot
		6	Bedload Sedigraphs
		7	Suspended Sediment Sedigraphs
		8	15-min and Daily-Mean Streamflow Data (electronic files)
		9	Turbidity (electronic files)
		10	Bedload Data and Computations (electronic files)
		11	Suspended Sediment Data and Computations (electronic files)
		12	Channel Geometry and Pebble Count Data (electronic files) and Water Surface Slopes
Trinity River below Limekiln Gulch	**C**	1	Sediment Station Analysis
USGS Gage #11525655		2	Bedload Transport Curves
		3	Suspended Sediment Transport Curves
		4	Turbidity and Streamflow Hydrograph Plot
		5	Bedload Sedigraphs
		6	Suspended Sediment Sedigraphs
		7	15-min and Daily-Mean Streamflow Data (electronic files)
		8	Turbidity (electronic files)
		9	Bedload Data and Computations (electronic files)
		10	Suspended Sediment Data and Computations (electronic files)
		11	Channel Geometry and Pebble Count Data (electronic files) and Water Surface Slopes
Trinity River at Douglas City	**D**	1	Sediment Station Analysis
USGS Gage #11525854		2	Bedload Transport Curves
		3	Suspended Sediment Transport Curves
		4	Turbidity and Streamflow Hydrograph Plot
		5	Bedload Sedigraphs
		6	Suspended Sediment Sedigraphs
		7	15-min and Daily-Mean Streamflow Data (electronic files)
		8	Turbidity (electronic files)
		9	Bedload Data and Computations (electronic files)
		10	Suspended Sediment Data and Computations (electronic files)
		11	Channel Geometry and Pebble Count Data (electronic files) and Water Surface Slopes
Sediment Lab Quality Assurance	**E**		Sediment Lab Quality Assurance Plans and Results
USGS Training Certificates	**F**		USGS Sediment Data Collection and Computation Training Certifications

Appendix A

Trinity River at Lewiston
USGS Gage # 11525500

11525500 Trinity River at Lewiston, CA

TOTAL LOAD SEDIMENT DISCHARGE RECORD

Spring Flow Release WY 2015: (April 1 to July 31)

Records collected at station.-- Daily streamflow has been collected continuously since 1911 and peak streamflow has been recorded since 1860. Various bedload and suspended-load data have been collected by the USGS and other entities since 1997. Instantaneous air and water temperature data have been collected since 1990. The purpose for collecting sediment data at this site is to quantify sediment discharge delivered from this portion of the mainstem, versus the discharge measured at sediment collection stations downstream. This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed from the WY 2015 spring flow release by GMA Hydrology (GMA), under contract to the Trinity River Restoration Program.

Equipment.--Sampling equipment consists of a D-74 and DH-48 for suspended-sediment sampling, and a cable-deployed 12-inch x 6-inch Toutle River 2 bedload sampler (TR-2) with a 0.5mm mesh collection bag. The D-74 suspended-sediment sampler and the TR-2 sampler were deployed from a crane-mounted E-reel or B-reel. The E-reel was driven by a battery operated power-drive during periods of the release and the B-reel was operated by hand. Sampling was performed from a cataraft-based sampling platform attached to a temporary cableway. Stage references were installed near cableways. Photographs were taken with a digital camera.

Sampling program.--Total (flow release) load season for this site is from April 1 to July 31. The program consisted of 6 sampling days. A minimum of one bedload-discharge and one suspended-sediment discharge sample were collected on each of the sampling days. The sampling days and samples collected are as follows:

May 03	1 bedload discharge	1 suspended-sediment discharge
May 04	2 bedload discharge	1 suspended-sediment discharge
May 05	2 bedload discharge	1 suspended-sediment discharge
May 06	3 bedload discharge	1 suspended-sediment discharge
May 07	1 bedload discharge	1 suspended-sediment discharge
May 08	1 bedload discharge	1 suspended-sediment discharge

Sampling crews consisted of a safety kayaker, and two on-river personnel specifically trained in cataraft-based sediment data collection techniques. All samples were reviewed by the site technicians and individual analyses were standardized for suspended-sediment (concentration, particle size analysis) and bedload samples (total dry mass, particle size analysis). Sediment data were generally collected according to USGS protocols with the following exceptions: test-velocity ratings for sampler nozzles were occasionally exceeded. Suspended-sediment samples were analyzed at the GMA Suspended-Sediment Lab and bedload samples were sent to the GMA Coarse Sediment Lab, both located in Placerville, CA.

USGS Field Review. -- No USGS field review was conducted during the 2015 Spring Flow Release.

Data summary for WY 2015 spring flow release.--

Total number of samples:

Suspended sets …………………………………………………………	6
Single pass suspended samples ………………………………………	0
Box sample sets …………………………………………………………	0
Single box samples …………………………………………………………	0
Bedload sets ………………………………………………………………	8
Single pass bedload samples ………………………………………	2
Three pass bedload samples ………………………………………	0
Number of field turbidities measured ………………………………………	0
Number of suspended sediment size analysis samples:	
Particle size analysis …………………………………………………………	0
0.063mm break ………………………………………………………	6
0.50mm break …………………………………………………………	6
Number of bedload sediment size analysis samples:	
Particle size analysis …………………………………………………………	10
Number of suspended sediment discharge measurements ………………………	6
Number of bedload discharge measurements ………………………………	10
Number of visits by Field Office ………………………………………………	0
Maximum flow sampled by:	
GMA technicians, ft^3/s ………………………………………………	8,380
Range of concentrations sampled by:	
GMA technicians, mg/l ………………………………………………	4-14
GMA technicians, ton/d ………………………………………………	0.63-366
Peak flow during flow release, ft^3/s ………………………………………………	8,830
Periods of faulty record …………………………………………………………	NA

<u>Coefficients</u> -- None Used

<u>Total suspended sediment-discharge computations.</u> -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharge records.

<u>Size analysis</u>.-- 6 cross-sectional, depth-integrated samples were analyzed using a split at <0.063mm and ≥0.50mm.

<u>Partial suspended sediment-discharge computations.</u> – Discharge versus SSC transport curves were developed for use during the period. No sample results were returned in past recent years' for 0.063mm-<0.50mm and ≥0.50mm size classes, so Water Year 2015 data was analyzed alone. <0.063mm data was analyzed from Water Year 2011 through 2015 and it was determined that the current Water Year samples showed slightly higher transport rates than previous years and so only 2015 samples were used for transport curve development. Generalized transport curves were developed using all samples collected during Water Year 2015. Hysteresis was taken into account during sedigraph development, which is described below. No outliers were identified.

For the <0.063mm size class, the discharge versus SSC transport curve is defined by Eqn. (1)

$$SSC = 0.416792(Discharge - 2500)^{0.309}, \qquad r^2 = 0.87 \qquad (1)$$

The transport curve is used between April 1 at 00:00 hours and July 31 at 23:45 hours. The transport curve has a validated range between 3,670 cfs and 8,280 cfs. Zero transport was estimated during transport curve development at 2,500 cfs. Samples did not indicate hysteresis for this size class and the same zero transport threshold was used for both the rising and falling limb.

For the 0.063 - <0.5mm size class, the discharge versus SSC transport curve is defined by Eqn. (2)

$$SSC = 5.0681e-006 * Discharge^{1.34}, \qquad r^2 = 0.62 \qquad (2)$$

The transport curve is used between April 1 at 00:00 hours and July 31 at 23:45 hours. The transport curve has a validated range between 3,670 cfs and 8,280 cfs. Zero transport was estimated during sedigraph development. Samples 1 and 6 were both below the laboratory detection limit and reported as 0 mg/l. The sedigraph was brought to zero at the time of the samples and occurs at 3,660 cfs on the rising limb and 4,320 cfs of the falling limb.

For the ≥0.5mm size class, the discharge versus SSC transport curve is defined by Eqn. (3)

$$SSC = 2.03978e-16 * Discharge^{4.09}, \qquad r^2 = 0.72 \qquad (3)$$

The transport curve is used between April 1 at 00:00 hours and July 31 at 23:45 hours. The transport curve has a validated range between 3,670 cfs and 8,280 cfs. Zero transport was estimated during sedigraph development. Samples 1, 5 and 6 were both below the laboratory detection limit and reported as 0 mg/l. The sedigraph was brought to zero at the time of sample 1, which occurs at 3,660 cfs on the rising limb. On the falling limb the sedigraph was to sample 4, which resulted in zero transport prior to sample 5 and occurs at 7,530 cfs.

The tranport curve was used to develop a continuous concentration trace for each size class during the computational period. Once the continuous concentration data had been developed, the sample data were used to adjust the continuous concentration trace by fitting or proportional fitting, so that it passed through all sample points. Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous SSC) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points. Fitting and proportional fitting techniques recognize short-term correlations and address hysteresis effects by using subsets of data. When only a single sample exists on a flow bench, the proportional fitting technique assumes that the determined ratio applies for the duration of that flow bench. When SSC is not highly correlated with discharge or turbidity, it is not possible to evaluate this assumption and therefore it is a potential source of error.

Suspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

Bed material.-- None.

Bedload measurement. -- Ten bedload discharge samples were collected during the computational period, eight were two pass samples

Bedload-discharge computations. -- The sample analysis contains the portion of sample <0.5mm but the total bedload discharge was determined by summing the partial discharges for the 0.5mm-<8mm and the ≥8mm size fractions.

Partial Bedload-discharge computations – Sediment transport curves were developed and partial bedload discharges were computed for the 0.5mm-8mm and ≥8mm size classes. Both size classes were plotted with 2013 data sets, but did not follow the same trends. New transport curves were developed for 2015 using 2015 data only. In previous years, sediment transport curves were developed for the rising and falling limbs in order to define the hysteresis observed at the site. However, during 2015, no obvious trends of hysteresis were identified, so a single generalized curve was developed for each size class. No outliers were identified during analysis of either size class.

For the 0.5mm-<8mm size class, the transport curve is shown in Equation (4).

$$BLD = 1.81553e-020 * Disch\arg e^{5.46}, \qquad r^2 = 0.93 \qquad (4)$$

The transport curve was developed using samples 1-10. The transport curve is used from April 1 at 00:00 hrs until July 31 at 23:45 hours. Eqn. (4) has a valididated range between 3,650 cfs and 8,380 cfs. Zero transport for the rising limb was estimated by fitting the transport curve developed sedigraph to sample 1, and occurs at 1,000 cfs. For the falling limb, zero transport was determined by fitting the sedigraph to sample 10 and occurs at approximately 3,700 cfs.

For the ≥0.8mm size class, the transport curve is defined by Eqn. (5).

$$BLD = 1.4812e-031 * Disch\arg e^{8.52}, \qquad r^2 = 0.96 \qquad (5)$$

The transport curve was developed using samples 1-10. The transport curve is used from April 1 at 00:00 hrs until July 31 at 23:45 hours. Eqn. (5) has a valididated range between 3,650 cfs and 8,380 cfs. Zero transport for the rising limb was determined using sample 1, which contained no ≥8mm particles. Sample 1 occurs at 3,650 cfs. For the falling limb, zero transport was determined by fitting the sedigraph to sample 10 and occurs at approximately 3,900 cfs.

Once the continuous bedload-discharge traces were developed using the above transport curves, they were adjusted to the sample values using the same techniques as was described for the partial suspended-sediment discharge computations. Due to the inherent high variability in bedload sampling, during flow benches, sample values were averaged on days where multiple samples were collected to produce average transport values. These average transport values were used to adjust the continuous bedload transport trace.

Remarks. – The suspended sediment discharge record is rated as follows:

April 1 (00:00) to May 2 (23:45)	Estimated
May 3 (00:00) to May 8 (23:45)	Good
May 9 (00:00) to July 31 (23:45)	Estimated

The bedload discharge record is rated as follows:

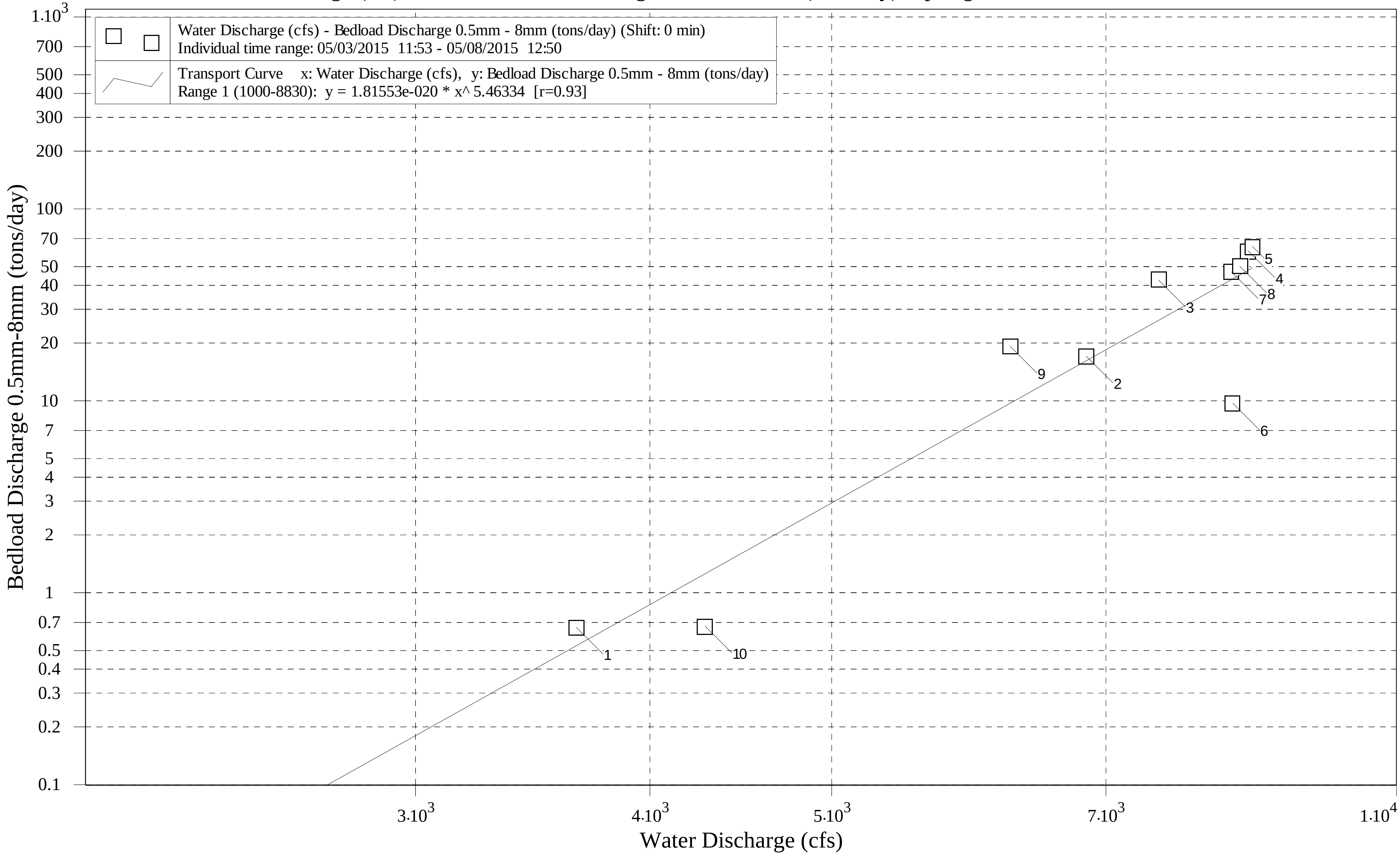
April 1 (00:00) to May 2 (23:45)	Estimated
May 3 (00:00) to May 8 (23:45)	Good
May 9 (00:00) to July 31 (23:45)	Estimated

Computed by: Brooke Pittman, December 2015

Reviewed by: S. Pittman, January 2016

TRINITY RIVER AT LEWISTON --11525500

Water Discharge (cfs) Versus Bedload Discharge 0.5mm-<8mm (tons/day): Spring Flow Release WY 2015



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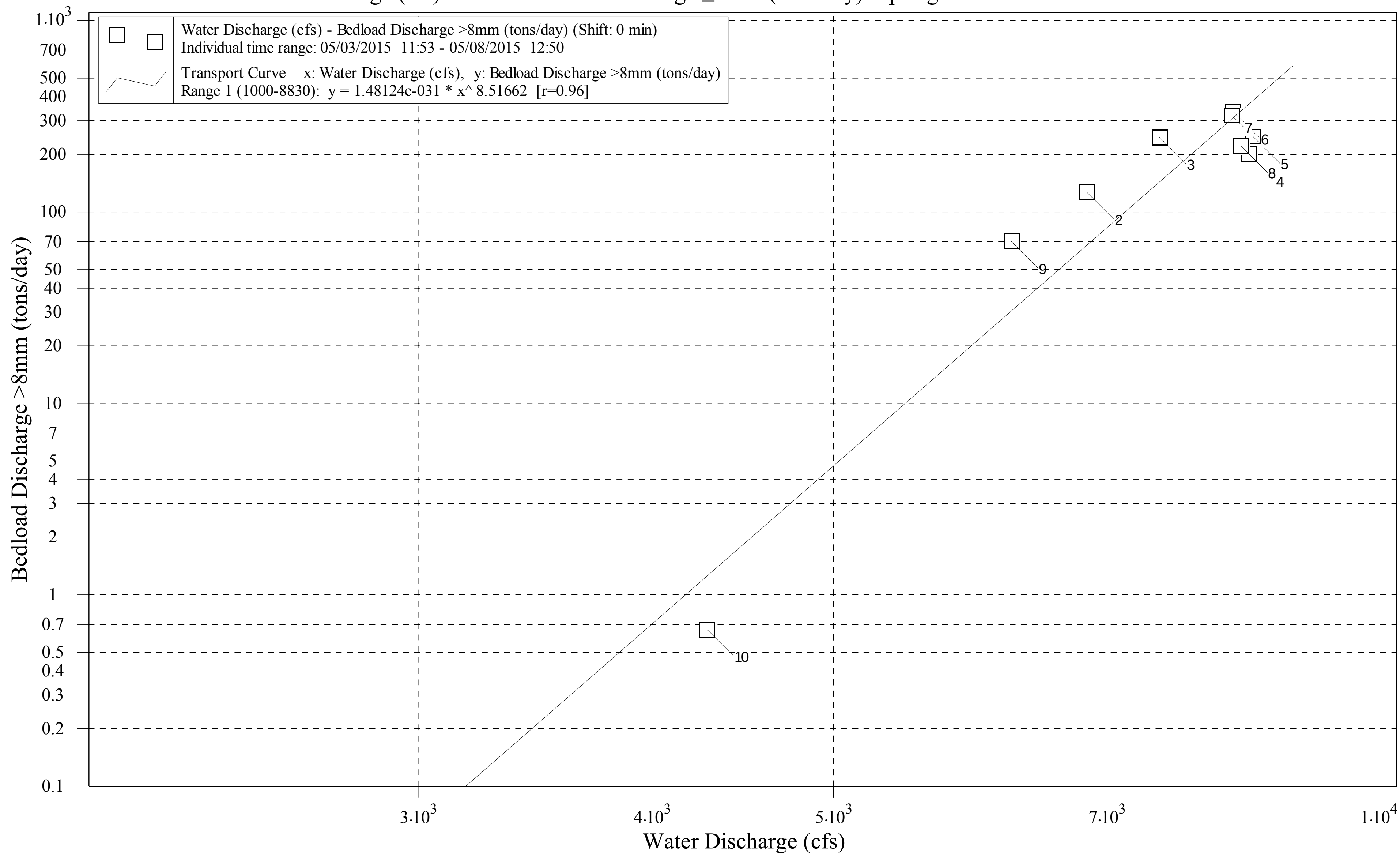
TRINITY RIVER AT LEWISTON --11525500

Water Discharge (cfs) Versus Bedload Discharge ≥8mm (tons/day): Spring Flow Release WY 2015



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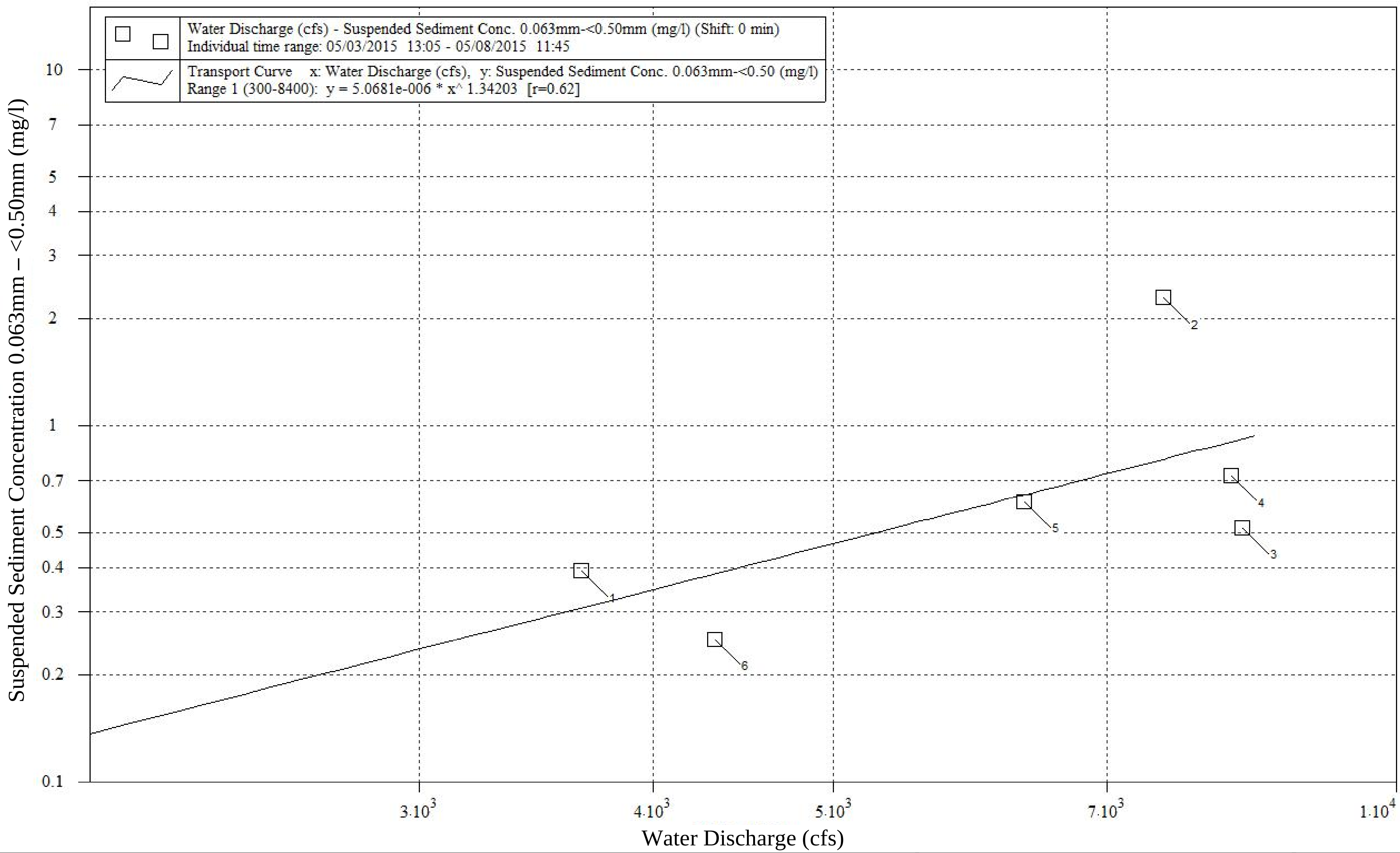
TRINITY RIVER AT LEWISTON--11525500

Water Discharge (cfs) Versus Suspended Sediment Concentration 0.063mm - <0.5mm (mg/l): Spring Flow Release WY 2015



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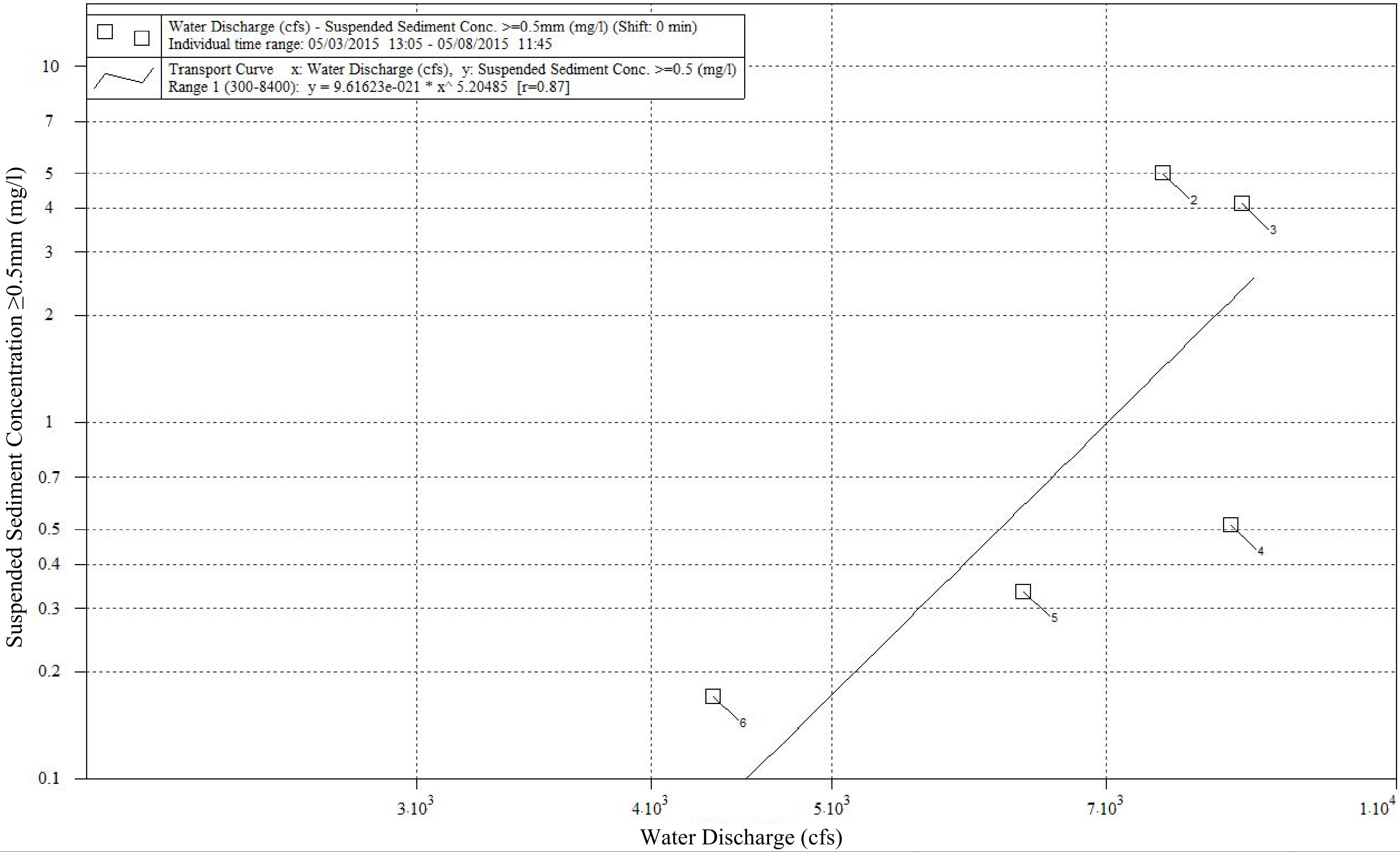
TRINITY RIVER AT LEWISTON--11525500

Water Discharge (cfs) Versus Suspended Sediment Concentration ≥0.5mm (mg/l): Spring Flow Release WY 2015



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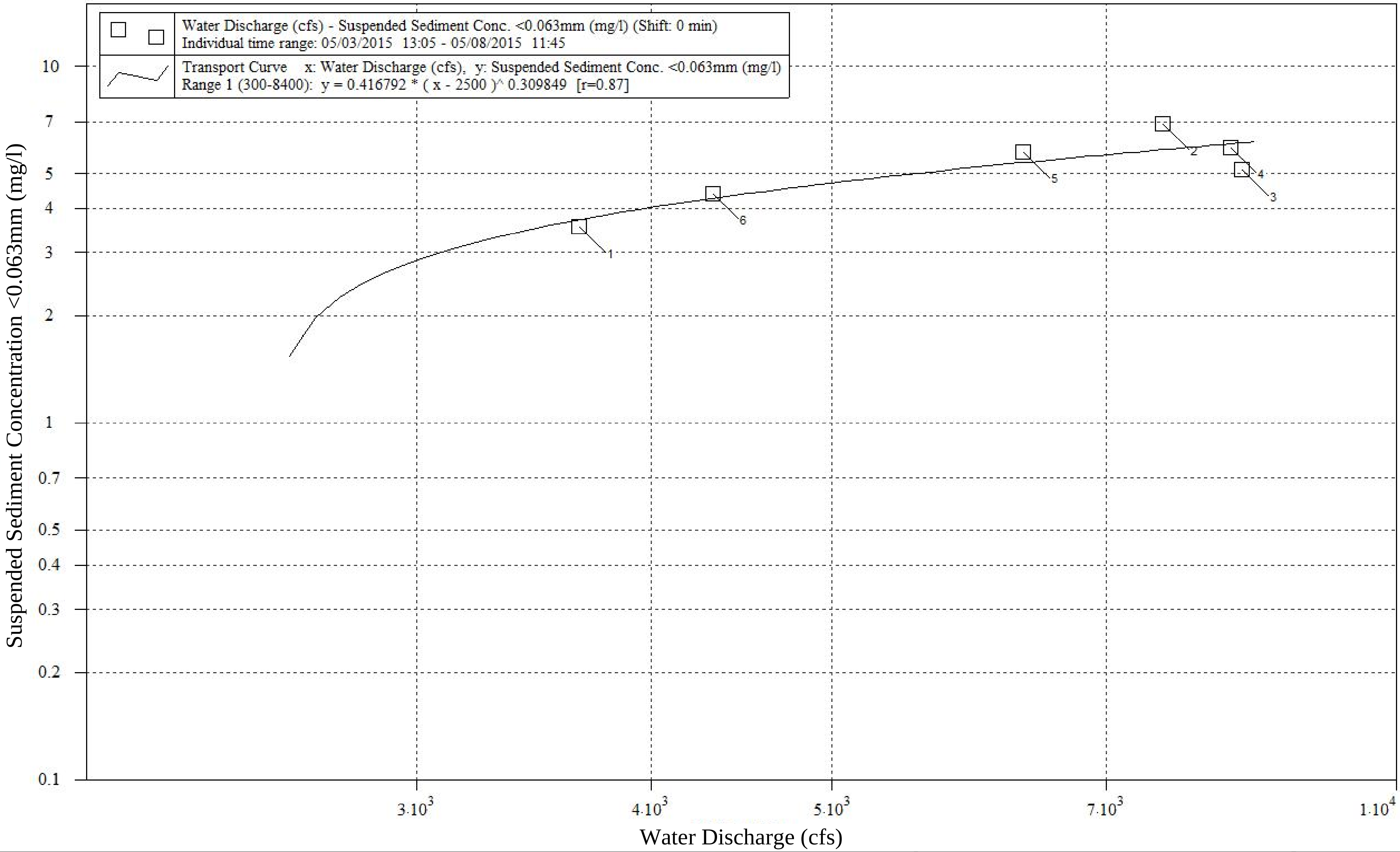
TRINITY RIVER AT LEWISTON--11525500

Water Discharge (cfs) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release WY 2015



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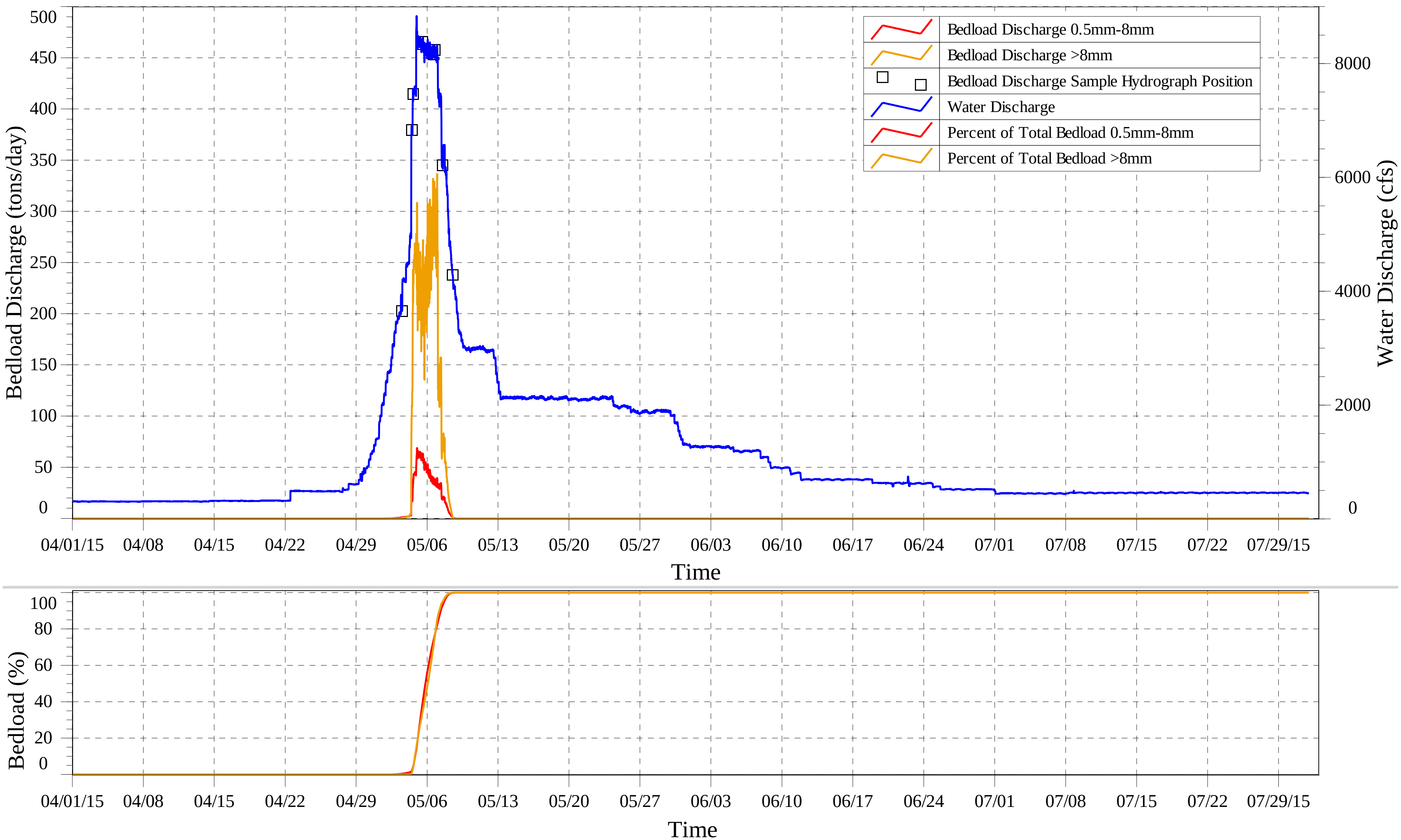
TRINITY RIVER AT LEWISTON –11525500

Bedload Discharge – Spring Flow Release WY 2015



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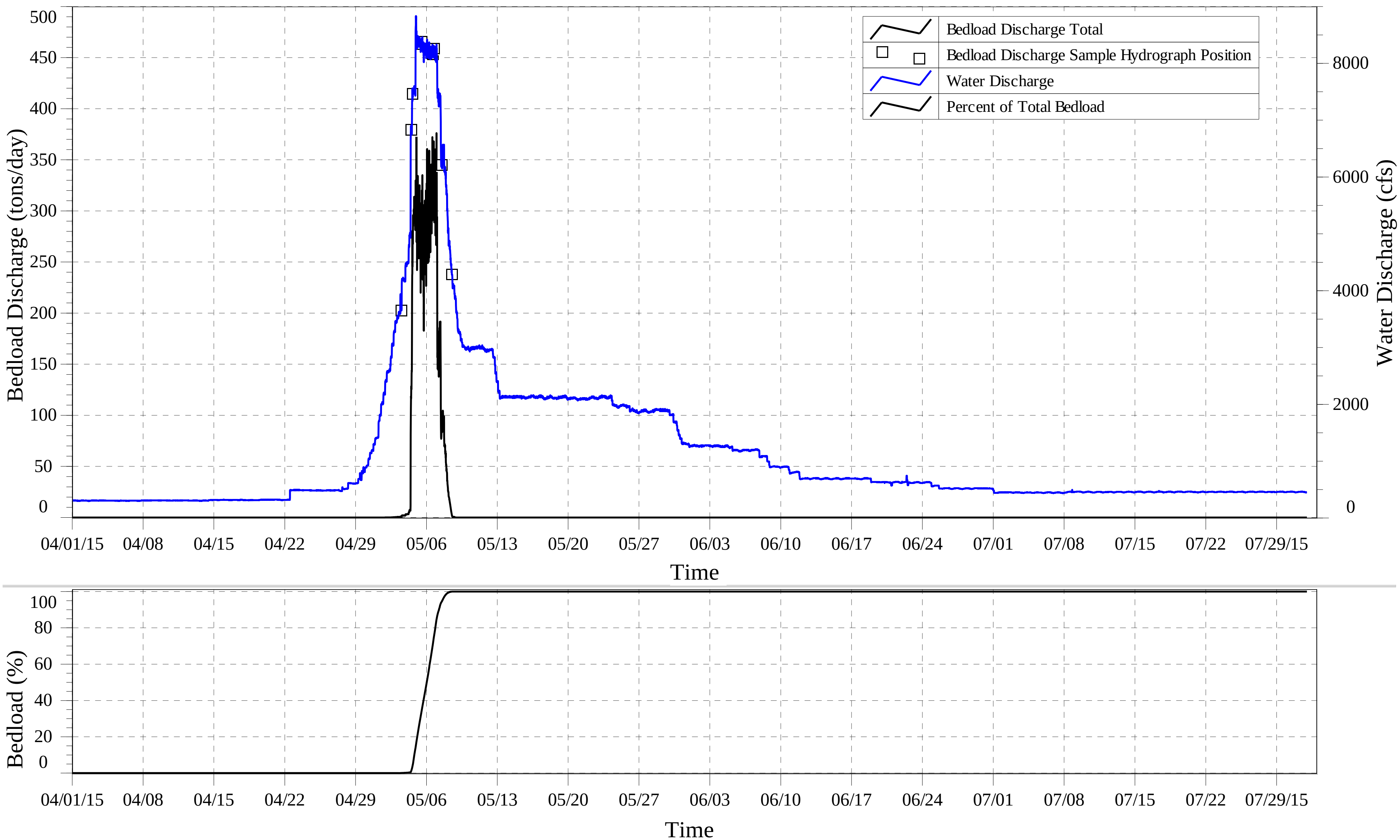
TRINITY RIVER AT LEWISTON –11525500

Bedload Discharge – Spring Flow Release WY 2015



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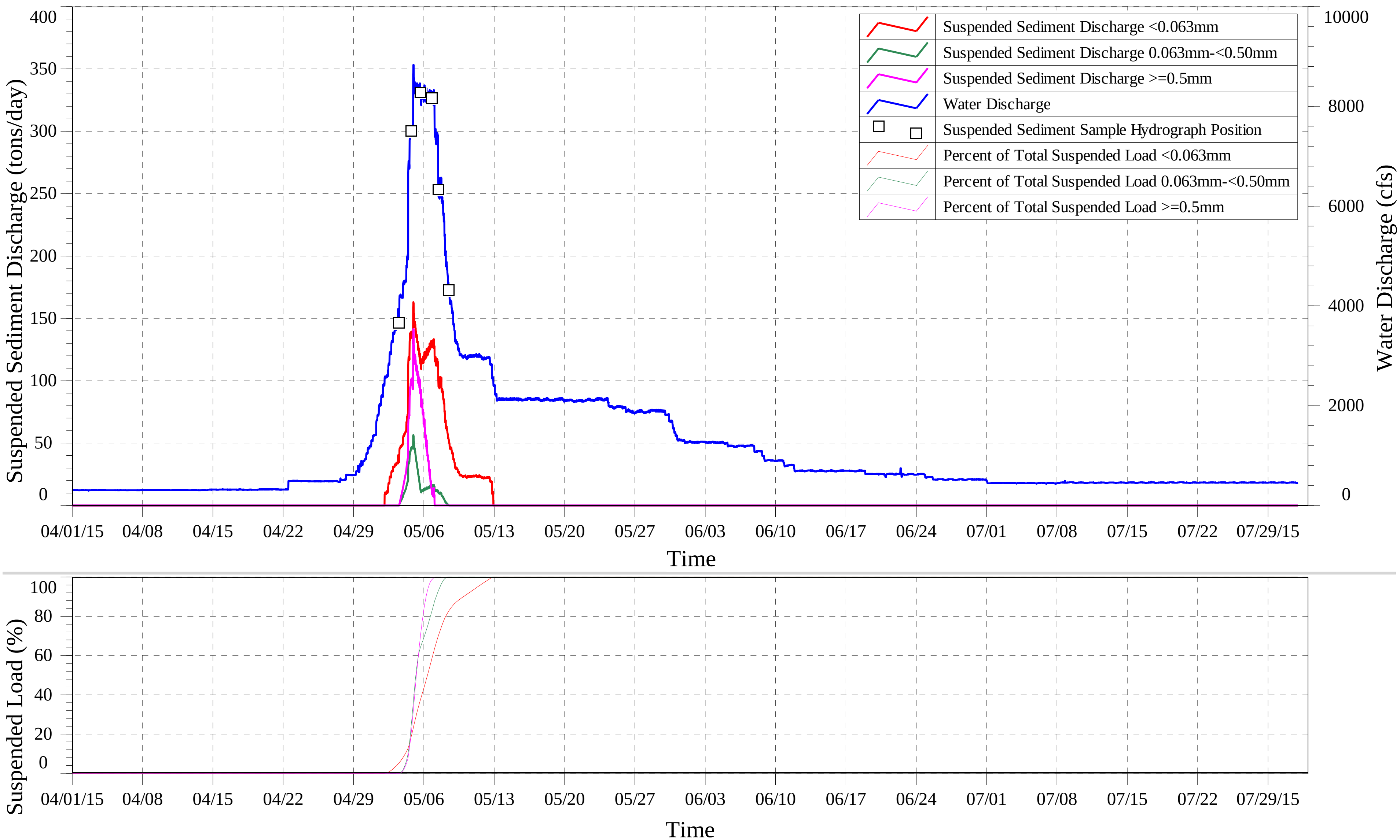
TRINITY RIVER AT LEWISTON – 11525500

Suspended Sediment Discharge – Spring Flow Release WY 2015



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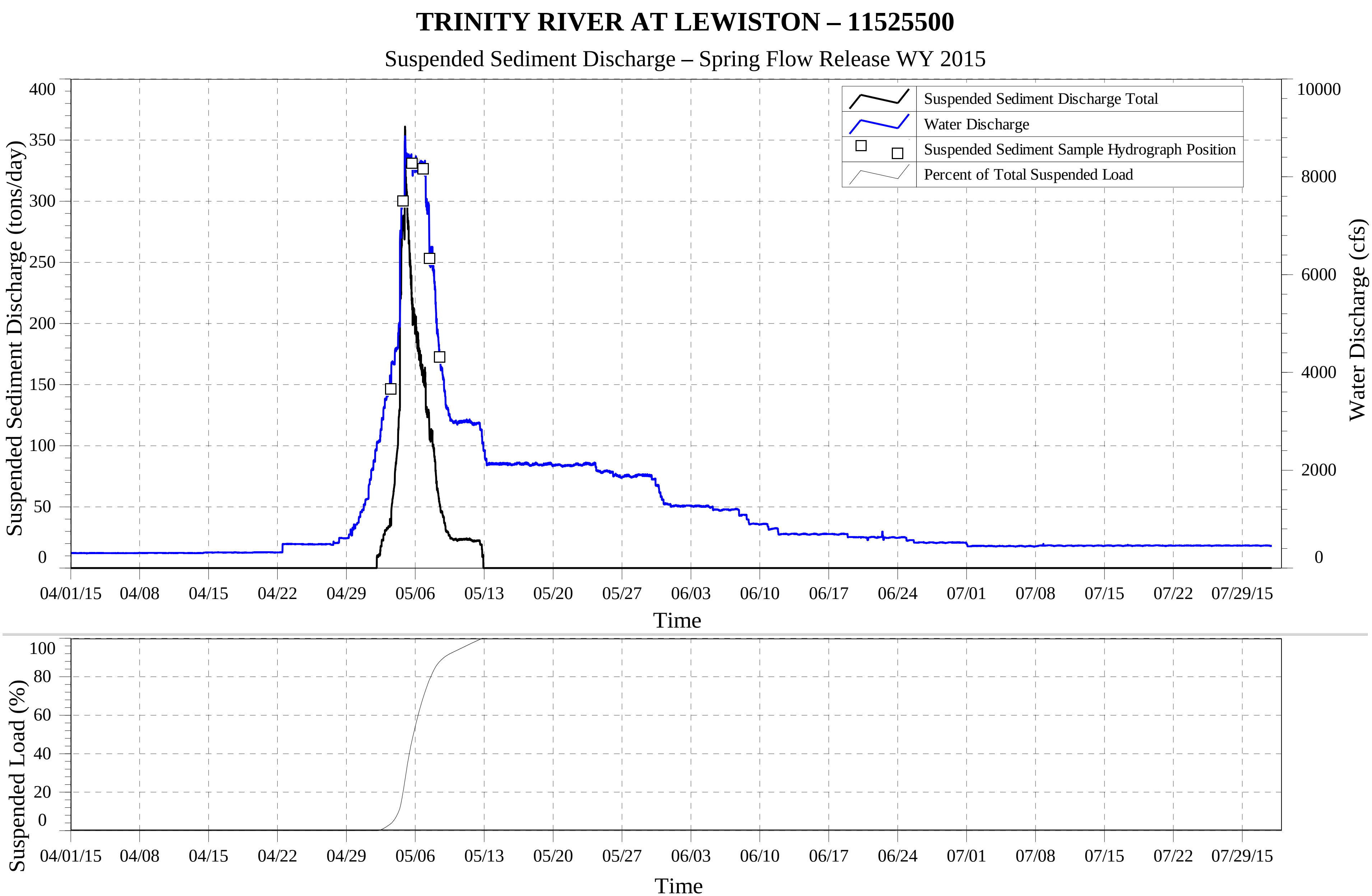

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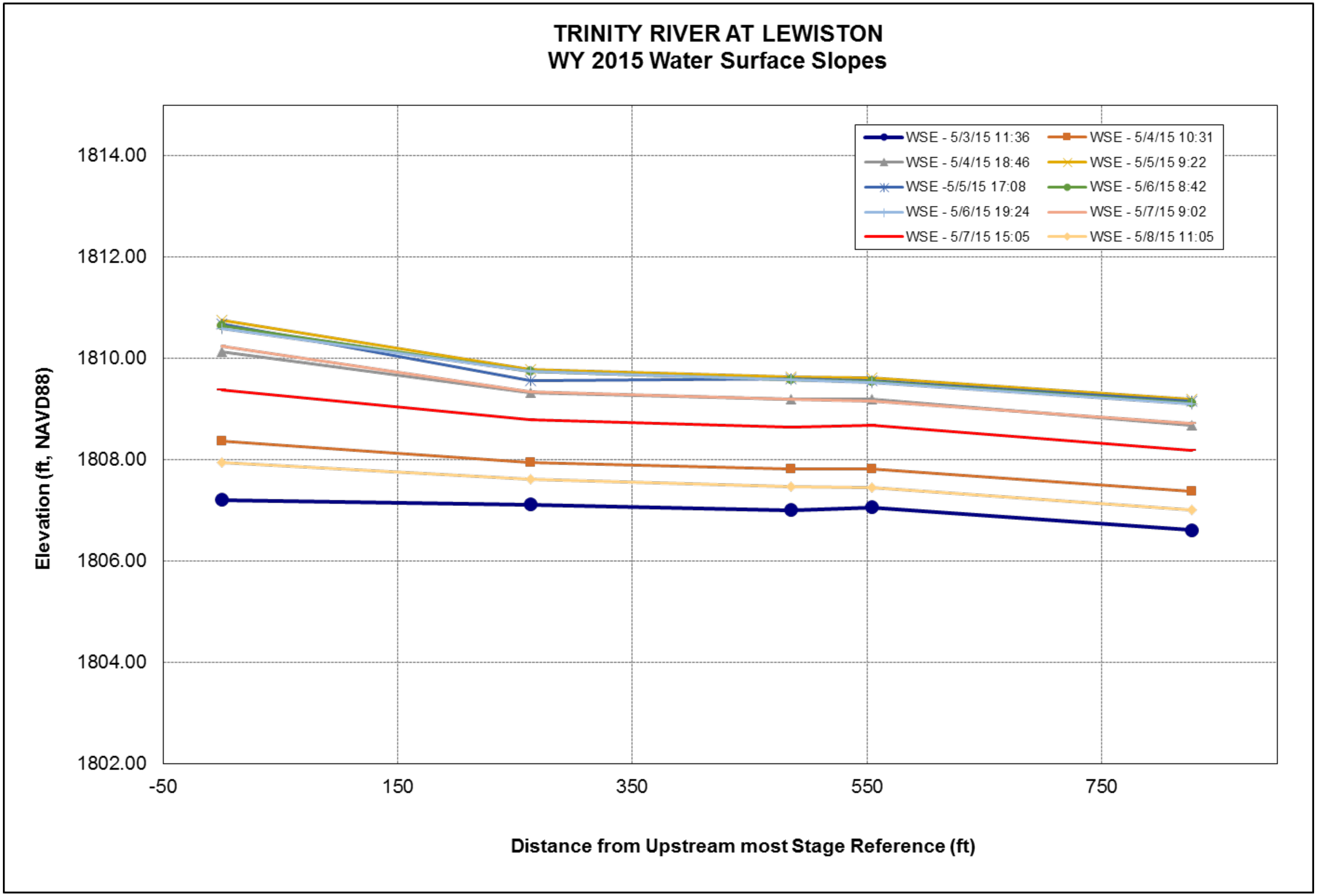

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Appendix B

Trinity River above Grass Valley Creek
USGS Gage # 11525540

11525540 Trinity River Above Grass Valley Cr. near Lewiston

STATION ANALYSIS

SURFACE WATER RECORD

Spring Flow Release WY 2015: (April 1 to July 31)

LOCATION – Lat 40°41'51", long 122°,15'11" referenced to North American Datum of 1983

RECORDS – Surface Water. The purpose for collecting streamflow at this site is to provide accurate streamflow records for bedload and supended sediment discharge computations. Potential changes in flow from tributaries between the Trinity River at Lewiston streamflow gage (11525500) and the Trinity River above Grass Valley Creek Sediment Monitoring Station require the establishment of a seasonal streamflow gaging station. This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed for the WY 2015 Spring Flow Release by GMA, under contract to the TRRP. This gage is operated during the Spring Flow Release period.

Prior to the WY 2011 Spring Flow Release this station was located 166 ft upstream. During the summer of 2010 TRRP completed a channel and floodplain restoration project in the reach which required moving the surface water monitoring station.

EQUIPMENT – Graham Matthews & Associates re-established this site in April of Water Year 2011. A Campbell Scientific Inc. CR200 DCP, Design Analysis Associates Water Log H-310 pressure transducer, and a Forest Technology Systems DTS-12 are installed at the site.
Inside recording gage: Design Analysis H-310 (Accuracy to ± 0.007 ft)
Forest Technology Systems DTS-12 (Accuracy (0-499.99 NTU ± 2% +0.2 NTU), (500.00 to 1600 NTU ± 4%))
Outside staff gage: Three enameled sections (0.00 ft – 9.99 ft).

GAGE HEIGHT RECORDS – Record is incomplete for the computational period. At the end of the previous computational period the DCP and H-310 pressure transducer were removed from the site. The DCP and H-310 pressure transducer were re-installed on April 23, 2015 at 13:30. The equipment was removed after the end of the computational period. During the computational period the maximum gage height of 8.52 ft. occurred on May 5 at 01:30 hours. The minimum gage height for the computational period of 1.77 ft. occurred on July 7 at 23:00 hours.

Staff height readings were compared to recorded gage height values. Staff height readings made during the period indicated that corrections to the electronic gage data were necessary. When flow goes over bank and reaches the second staff plate, a back watering effect occurs. This causes the staff plate water surface elevation to be different than the water surface elevation measured by the pressure transducer, which was moved farther out into the channel prior to Water Year 2012. Additionally, staff plate #3 is installed at the far edge of a large floodplain, which further accentuates the difference in electronic gage height and staff height. For this reason, very few reading were recorded from staff plate #3 during WY 2015. Even at the highest flows, water surface was measured from staff plate #2. The gage height correction was adjusted to staff height readings for staff plate #1 and #2 only and changes to the correction were prorated over rapid gage height increases or between staff height observations.

A staff height observation on April 23, 2015 confirms a 0.0’ correction at the lowest staff plate. On May 3, 2015 the gage height correction increased to an average of 0.10’. The change was prorated from April 29, 2015, when the gage height begins to increase, to the May 3, 2015 staff height observation. The 0.10’ correction is held until the start of the falling limb on May 7, 2015. As the stage decreases, the gage height correction falls back to -0.02’ by May 13, 2015 at 09:30 and remains -0.02’ for the remainder of the low flow computation period. Changes in corrections were prorated linearly. Between May 1 and May 4 GMA staff was onsite and collected approximately 5 staff height observations.

DATUM CORRECTIONS – No correction necessary. A level survey was performed on April 23, 2015 and November 20, 2015. The control, BM1 (3/8-inch capped rebar), for the station was set on April 14, 2011 and is located 20 ft upstream of the gage and roughly 140 ft to the east. Elevation of the BM1 is 1757.179 ft (NAVD88). BM2 is a cap set in the turbidity boom concrete footer. BM3 is the existing monument: HAM1. Staff plate #2 was destroyed by a fallen tree between August 2014 and April 2015. The staff plate was re-installed on April 23, 2015, however it was installed at the wrong elevation. A difference of 0.48’ was observed between zero staff heights’ surveyed on staff plate #1 and #2. All staff height observations collected from staff plate #2 were adjusted by 0.48’. Staff plate #2 will be surveyed and re-mounted prior to the 2016 SFR.

CONTROL – The low water control at the site is a downstream riffle. The low water control is prone to shifts. At high water channel control dominates. The high water channel was significantly altered during restoration activities. The floodplain was lowered and a significant amount of vegetation was removed from the left bank.

RATING – Ten discharge measurements (75-84) were made during the computational period. Measurements were made with an ADCP launched from a jet boat or with a Price AA meter and Aquacalc Pro suspended from a cataraft platform. Measured discharge for the period ranged from 435 cfs to 9,260 cfs. Computed instantaneous discharged ranged from 310 cfs to 8,640 cfs.

Rating 5.1 was developed for use during the Water Year 2011 SFR and remains in use during Water Year 2015. Measurements were plotted and inspected for use during the period. Measurements 75 through 84 indicated a shift to Rating 5.1. Hydrographic comparison with Trinity River below Limekiln Gulch (11525655) and Trinity River near Lewiston (11525500) were used to help predict the timing and shape of stage variable shift SV15-01. SV15-01 was brought directly into effect at the start of the computational period on April 1, 2013 at 00:00. Measurement 79 was excluded from computations. The measured discharge of 9,260 cfs on May 6, 2015 is not supported by hydrographic comparison with the three other USGS gaging locations where the highest reported discharge was 8,590 cfs at Trinity River at Douglas City on May 5, 2015.

Rating 5.1 has a validated range between 1.92 ft (453 cfs) and 10.1 ft (11,400 cfs).

RATING 5.1 WAS USED FROM 4/23/2013 TO 07/31/2013

DISCHARGE –Rating 5.1 is used as follows:

April 23 to Jul. 31 (23:45) SV15-01 (1.92, 0.03; 5.50, 0.27; 8.00, 0.00)

SPECIAL COMPUTATIONS – Hydrographic comparison with discharge records from Trinity River near Lewiston (11525500) and Trinity River below Limekiln Gulch near Douglas City (11525655) were used to verify the accuracy of the computed record.

Prior to the gage being installed on the April 23, 2015, discharge records were estimated using the Trinity River at Lewiston, CA (11525500) and the Rush Cr near Lewiston, CA (11525530) gaging records.

REMARKS – The record should be considered **Fair** for the computational period. The record should be considered estimated from April 1, 2015 through April 23, 2015 when the record was estimated using TRAL and RCNL data.

Record Worked by: B. Pittman, December 2015
Proofed: S. Pittman, January 2016

11525540 Trinity River Above Grass Valley Cr. near Lewiston

TOTAL LOAD SEDIMENT DISCHARGE RECORD

Spring Flow Release WY 2015: (April 1 to July 31)

Records collected at station.— GMA Hydrology established this site in May of Water Year 2006. In April 2011 the electronic monitoring equipment was moved 166 feet downstream and the sampling cableway was moved roughly 300 feet downstream. Relocation of the station was necessary due to restoration activities that occurred during the summer of 2010. A Campbell Scientific Inc. CR200 data collection platform (DCP), Design Analysis Assoc. WaterLog H-310 pressure transducer, and a Forest Technology Systems DTS-12 are installed at the site. The purpose for collecting sediment data at this site is to quantify sediment discharge delivered from this portion of the mainstem. This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed from the WY 2015 high flow release by GMA, under contract to the Trinity River Restoration Program (TRRP).

Equipment.-- Sampling equipment consists of a D-74 and DH-48 for suspended-sediment sampling, and a cable-deployed 12-inch x 6-inch Toutle River 2 bedload sampler (TR-2) with a 0.5mm mesh collection bag. The D-74 suspended-sediment sampler and the TR-2 bedload sampler were deployed from a crane-mounted E-reel or B-Reel. The E-reel was driven by a battery operated power-drive during periods of the release and the B-reel was operated by hand. Sediment sampling was performed from a cataraft-based platform attached to a temporary cableway. Stage references were installed near cableway at the streamflow gaging station. A Forest Technology Systems DTS-12 turbiditimeter was installed on April 23, 2015 at 12:15 and operated until August 3, 2015 at 12:15. Photographs were taken with a digital camera.

Sampling program.-- Total (flow release) load season for this site is from April 1 to July 31. The program consisted of 6 sampling days. A minimum of 1 bedload-discharge and one suspended-sediment discharge sample was collected on each sampling day. The sampling days and samples collected are as follows:

May 03	1 bedload discharge	1 suspended-sediment discharge
May 04	3 bedload discharge	1 suspended-sediment discharge
May 05	3 bedload discharge	1 suspended-sediment discharge
May 06	3 bedload discharge	1 suspended-sediment discharge
May 07	3 bedload discharge	1 suspended-sediment discharge
May 08	1 bedload discharge	1 suspended-sediment discharge

Sampling crews consisted of a safety kayaker, and two on-river personnel specifically trained in cataraft-based sediment data collection techniques. All samples were reviewed by the site technicians and individual analyses were standardized for suspended sediment (concentration, particle size analysis) and bedload samples (total dry mass, particle size analysis). Sediment data were generally collected according to USGS protocols with the following exceptions: test-velocity ratings for sampler nozzles were occasionally exceeded. Suspended-sediment samples were sent to the GMA Suspended-Sediment Lab and bedload samples were analyzed at the GMA Coarse Sediment Lab both located in Placerville, CA for analysis.

USGS Field Review. **--** No USGS field review was conducted in during the 2015 spring flow release.

Data summary for WY 2015 spring flow release.--

Total number of samples:

Suspended sediment sets	6
Single pass suspended sediment samples	0
Box sample sets	0
Single box samples	0
Bedload sets	13
Single pass bedload samples	1
Three pass bedload samples	0
Number of field turbidities measured	0
Number of suspended sediment size analysis samples:	
Particle size analysis	0
0.063mm break	6
0.500mm break	6
Number of bedload sediment size analysis samples:	
Particle size analysis	14
Number of suspended sediment discharge measurements	6
Number of bedload discharge measurements	14
Number of visits by Field Office	0
Maximum flow sampled by:	
GMA technicians, ft^3/s	8,510
Range of concentrations sampled by:	
GMA technicians, mg/l	6-54
GMA technicians, ton/d	8 -1,000
Peak flow during flow release, ft^3/s	8,640
Periods of faulty record	

Turbidity

April 23, 2015 at 12:15 – May 01, 2015 at 08:45
May 31, 2015 at 06:15 – July 31, 2015 at 23:45

Coefficients.**--** None used.

Continuous Turbidity.**--** The turbidity record is incomplete for the computational period. At the end of the previous computational period the DTS-12 turbidity probe, H-310 pressure transducer, and DCP were removed from the site. The equipment was re-installed on April 23 at 12:15 and operated until August 3 at 12:15.

The turbidity record is faulty from the time of installation until May 1, 2015 at 8:45 and from May 31, 2015 at 6:15 until the end of the period due to probe being out of the water.

Several turbidity spikes were removed. Turbidity spikes are defined as short periods of time, 15-minutes to several hours, during which the optics of the probe were presumably fouled. After removing the turbidity spikes the gaps were filled using linear interpolation or the gaps were filled with a constant value if turbidity was not changing.

Once the turbidity record was cleaned, the record was inspected to see if application of a turbidity offset was necessary. Analysis indicated that an offset of -5.0 FNU was necessary during the period. Additionally, the turbidity record was shifted by +1 hour to adjust the station into Pacific Daylight Savings Time.

During the computational period the maximum turbidity was 52.7 FNU on May 4 at 13:15, and the minimum turbidity was 0.20 FNU, which occurred on May 29 at 15:15.

Total suspended sediment-discharge computations. -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharges.

Size analysis. – Seven cross-sectional, depth-integrated samples were analyzed using a split at <0.063mm and ≥0.50mm. Prior to the 2011 splits were made at 0.50mm.

Partial suspended sediment-discharge computations. – Turbidity versus SSC transport curves were developed for use during the period. For the <0.063mm and the 0.063mm-<0.50mm size classes, Water Year 2011 through 2015 data were available for use in transport curve analysis. For the ≥0.50mm size class, data collected between Water Year 2006 and Water Year 2015 was available for transport curve development. For all size classes, Water Year 2015 samples showed a higher transport rates and no previously collected data was used for transport curve development. Sample 3 was collected during a rapid increase in turbidity seen during gravel injection upstream of the sampling location. Sample 3 was not used during transport curve development, however it was used in sedigraph development.

For the <0.063mm size class, the turbidity versus SSC transport curve is defined by Eqn.(1).

$$SSC = 1.13 * Turbidity + 0.73, \qquad r^2 = 0.99 \qquad (1)$$

Eqn. (1) was developed using samples 1, 2 and 4-7 collected during Water Year 2015. Eqn.(1) is used from May 1, 2015 at 09:45 hours through May 31 at 07:15 hours, when the turbidity record is available. Eqn. (1) has a validated range between 3.55 FNU and 18.9 FNU.

Because no samples were collected near zero transport on the rising and falling limbs it was necessary to estimate zero transport based on previous years' data. Zero transport was estimated at 800 cfs and 1,700 cfs for the rising and falling limb respectively.

For the 0.063mm-<0.50mm size class, the turbidity versus SSC transport curve is defined by Eqn. (2).

$$SSC = 1.48 * Turbidity - 4.90, \qquad r^2 = 0.98 \qquad (2)$$

Eqn. (2) was developed using samples 1, 2 and 4-7 collected during Water Year 2015. Eqn.(2) is used from May 1, 2015 at 09:45 hours through May 31 at 07:15 hours, when the turbidity record is available. Eqn. (2) has a validated range between 3.55 FNU and 18.9 FNU. Rising limb zero transport was estimated at 1,300 cfs. Falling limb zero transport was estimated by fitting the sedigraph to sample 7 collected on May 9, 2015, and occurred at approximately 2,050 cfs.

For the ≥0.50mm size class, the turbidity versus SSC transport curve is defined by Eqn. (3).

$$SSC = 0.61 * Turbidity - 2.60, \qquad r^2 = 0.88 \qquad (3)$$

Eqn. (3) was developed using samples 1, 2 and 4-7 collected during Water Year 2015. Eqn.(3) is used from May 1, 2015 at 09:45 hours through May 31 at 07:15 hours, when the turbidity record is available. Eqn. (3) has a validated range between 3.55 FNU and 18.9 FNU. Rising limb zero transport was estimated at 1,800 cfs. Falling limb zero transport was estimated by fitting the sedigraph to sample 6 collected on May 8, 2015, and occurred at approximately 3,800 cfs.

The tranport curves were used to develop continuous concentration curves for the <0.063mm, 0.063mm-<0.50mm, and the ≥0.5mm size classes during the computational period. Once the continuous concentration data had been developed the sample data were used to adjust the continuous concentration curves so that they passed through all sample points. The continuous concentration curves were adjusted using fitting and proportional fitting techniques.

Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous SSC) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points. Fitting and proportional fitting techniques recognize short-term correlations and address hysteresis effects by using subsets of data. When only a single sample exists on a flow bench, the proportional fitting technique assumes that the determined ratio applies for the duration of that flow bench. When SSC is not highly correlated with discharge or turbidity, it is not possible to evaluate this assumption and therefore it is a potential source of error.Suspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

Bed material.-- None.

Bedload measurement. -- Fourteen bedload discharge samples were collected during the Spring Flow Release. Sample 2015-01 was a single pass sample. The remainder of the samples were two pass samples.

Bedload-discharge computations. -- The sample analysis contains the portion of sample <0.5mm but the total bedload discharge was determined by summing the partial discharges for the >0.5mm-8mm and the ≥8mm size fractions.

Partial bedload-discharge computations -- Sediment transport curves were developed and partial bedload discharges were computed for the 0.5mm-<8mm and ≥8mm size classes. Hysteresis was observed in the sample data, however a singe generalized transport curve was developed for each size class and hysteresis was address during sedigraph development. No outliers were identified during analysis of either size class.

For the 0.5mm-<8mm size class, the transport curve is defined by Eqn. (4).

$$BLD = 2.626e-007\left(Discharge - 2500\right)^{2.27}, \qquad r^2 = 0.85 \qquad (4)$$

The rising limb transport curve was developed using samples 1-14. Zero transport on the rising limb was estimated at 2,500 cfs. Falling limb zero transport was determined by fitting the sedigraph to sample 14 and occurs at 4,000 cfs. The transport curve has a validated range between 4,050 cfs and 8,560 cfs and is used from April 1 at 00:00 hours to July 31 at 23:45 hours.

For the ≥8mm size class, the transport curve is defined by Eqn. (5).

$$BLD = 2.33e-007\left(Discharge - 3264\right)^{2.45}, \qquad r^2 = 0.95 \qquad (5)$$

The rising limb transport curve was developed using samples 1-14. Zero transport on the rising limb was estimated at 3,264 cfs. Falling limb zero transport was determined by fitting the sedigraph to sample 14 and occurs at 3,640 cfs. The transport curve has a validated range between 4,050 cfs and 8,560 cfs and is used from April 1 at 00:00 hours to July 31 at 23:45 hours.

Once the continuous bedload-discharge traces were developed using the above transport curves, they were adjusted using the sample values using the same techniques as was described for the partial suspended-sediment discharge computations. Due to the inherent high variability in bedload sampling, during flow benches, sample values were averaged on days where multiple samples were collected to produce average transport values. These average transport values were used to adjust the continuous bedload transport trace.

Remarks. – The suspended sediment discharge record is rated as follows:

April 1 (00:00) to May 2 (23:45)	Estimated
May 3 (00:00) to May 8 (23:45)	Good
May 9 (00:00) to July 31 (23:45)	Estimated

The bedload discharge record is rated as follows:

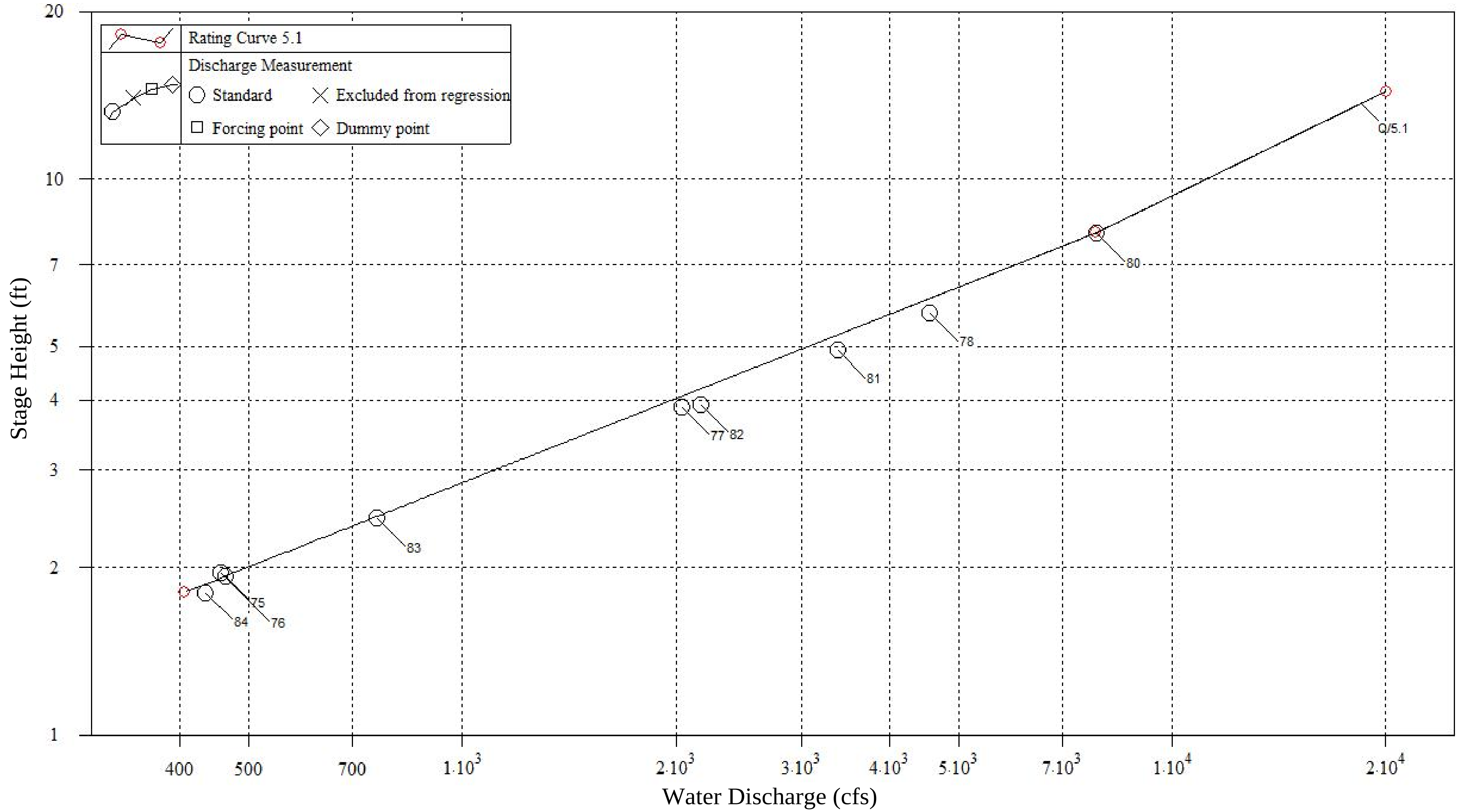
April 1 (00:00) to May 2 (23:45)	Estimated
May 3 (00:00) to May 8 (23:45)	Good
May 9 (00:00) to July 31 (23:45)	Estimated

Computed by: Brooke Pittman, December 2015

Reviewed by: S. Pittman, January 2016

TRINITY RIVER ABOVE GRASS VALLY NEAR LEWISTON --11525540

Discharge Rating Curve 5.1 – Valid From May 8, 2011 – Present



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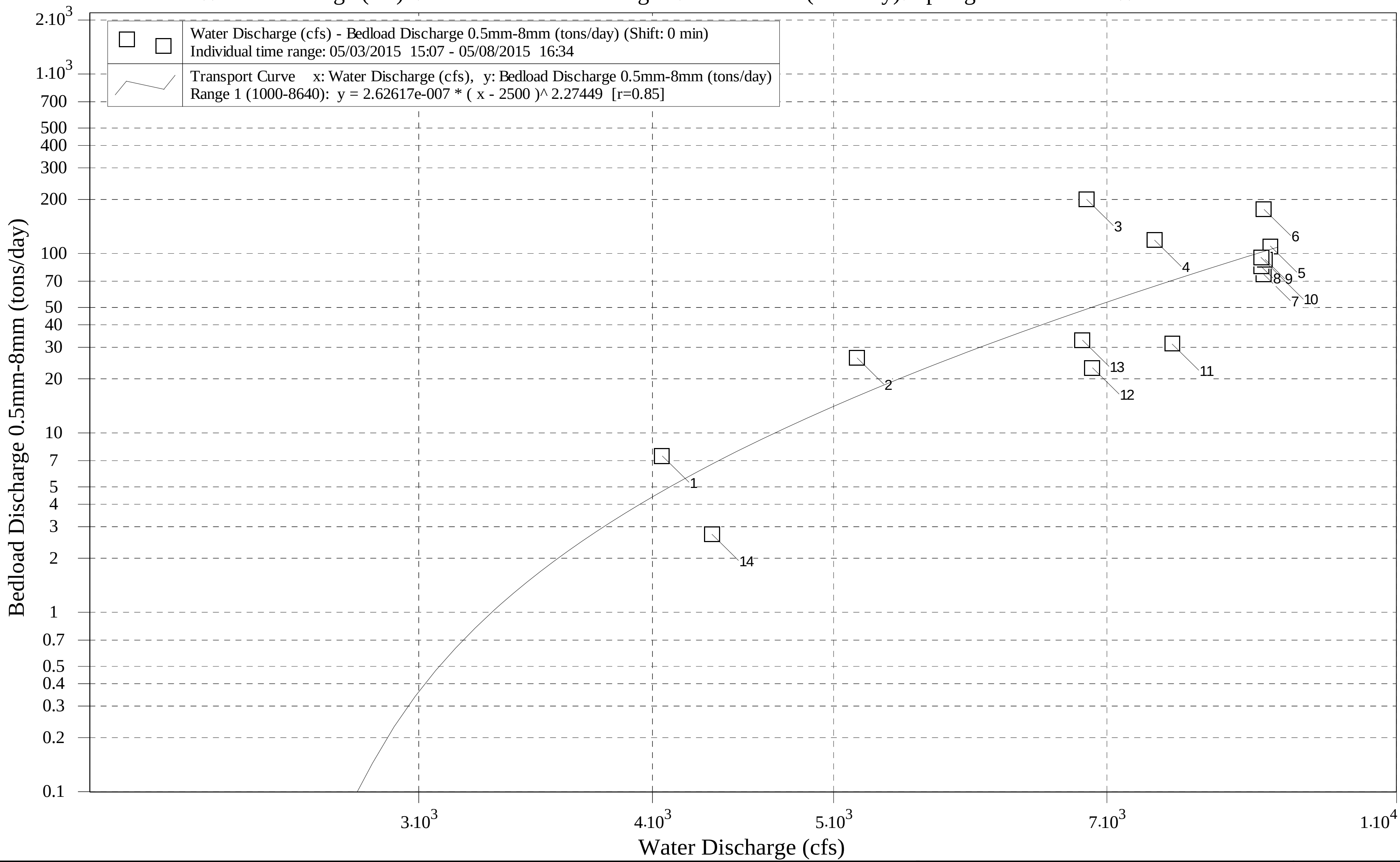
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON --11525540

Water Discharge (cfs) Versus Bedload Discharge 0.5mm-<8mm (tons/day): Spring Flow Release WY 2015



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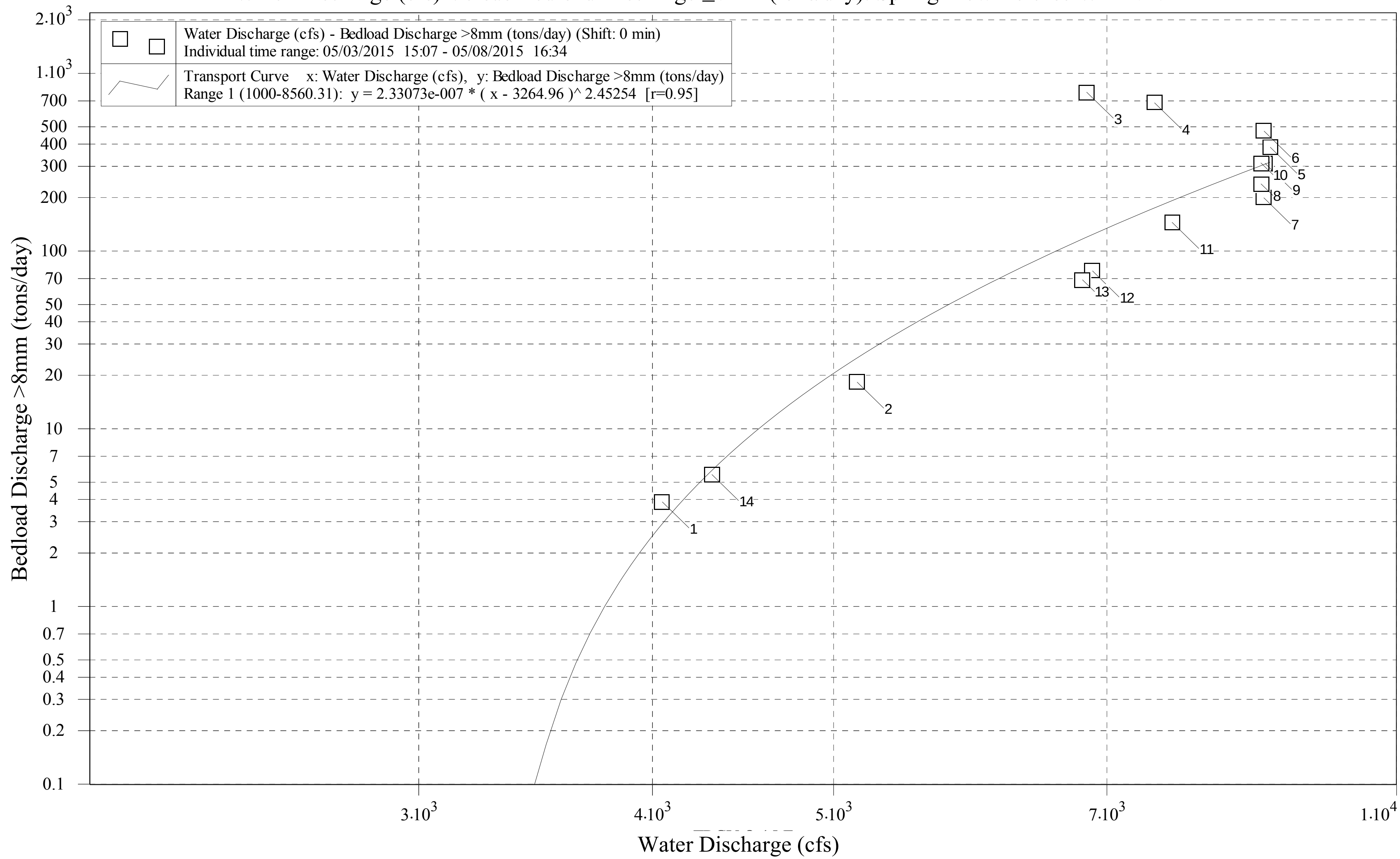
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON --11525540

Water Discharge (cfs) Versus Bedload Discharge ≥8mm (tons/day): Spring Flow Release WY 2015



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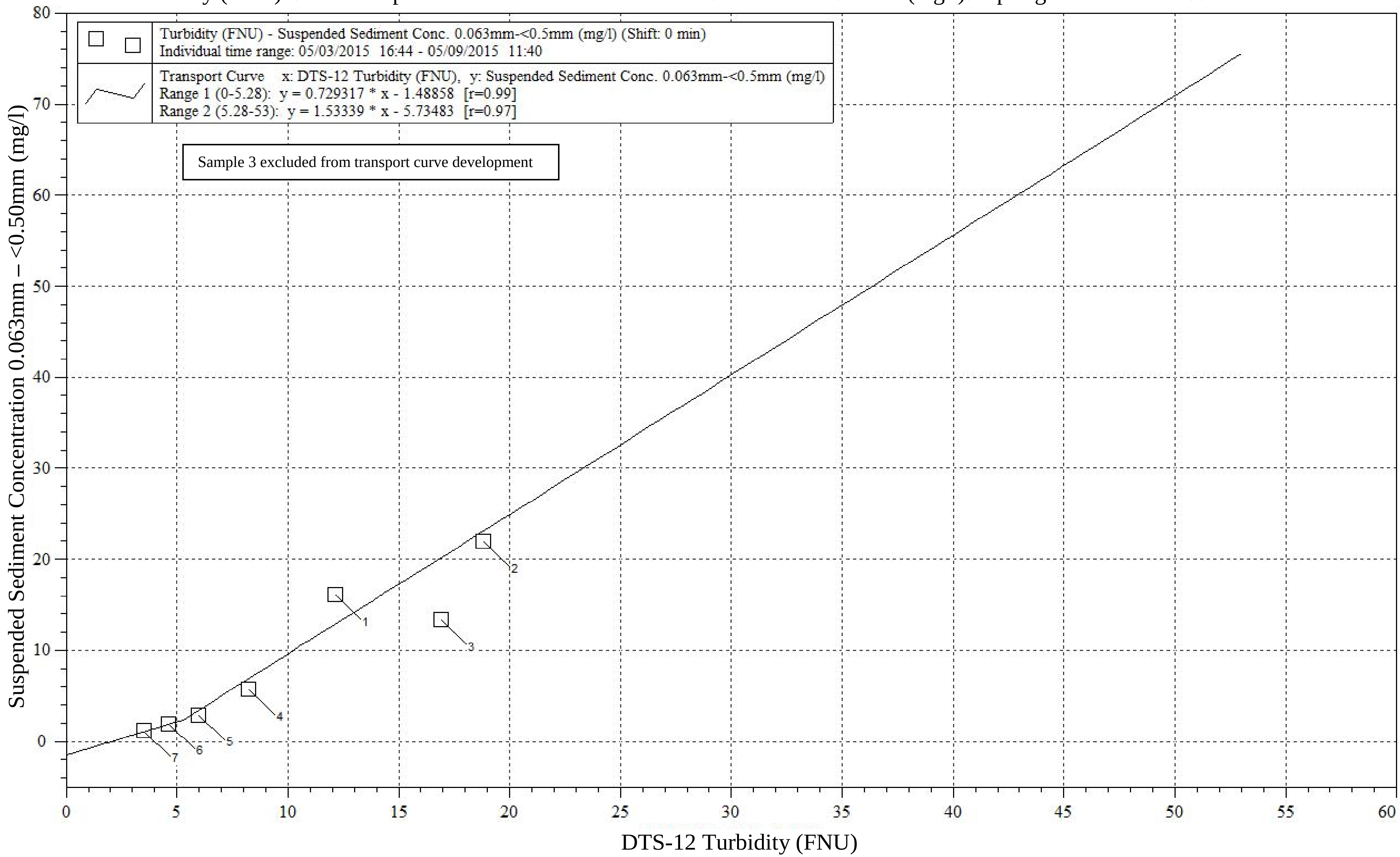
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON -- 11525540

Turbidity (FNU) Versus Suspended Sediment Concentration 0.063mm – <0.50mm (mg/l): Spring Flow Release WY 2015



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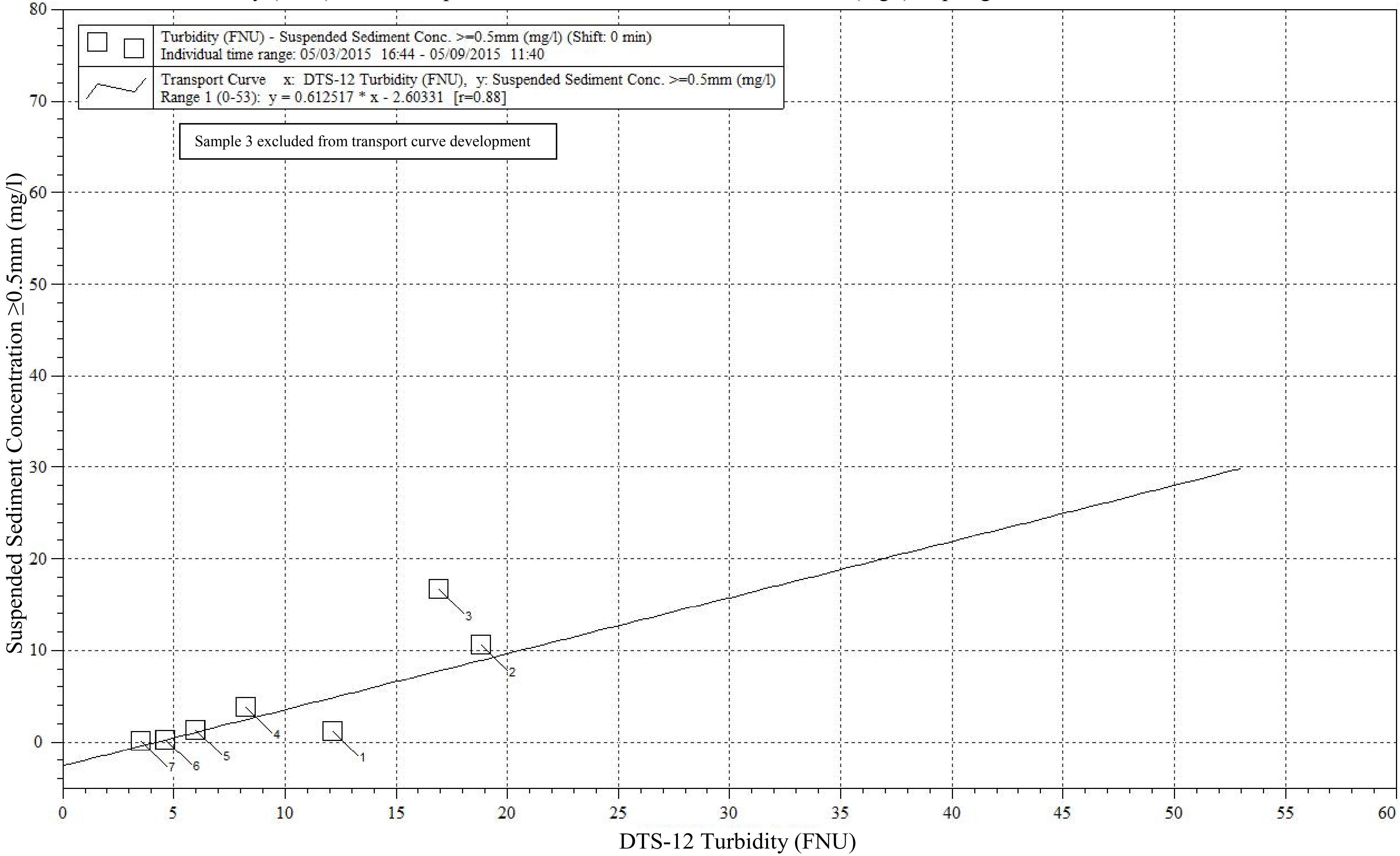
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON -- 11525540

Turbidity (FNU) Versus Suspended Sediment Concentration ≥ 0.50mm (mg/l): Spring Flow Release WY 2015



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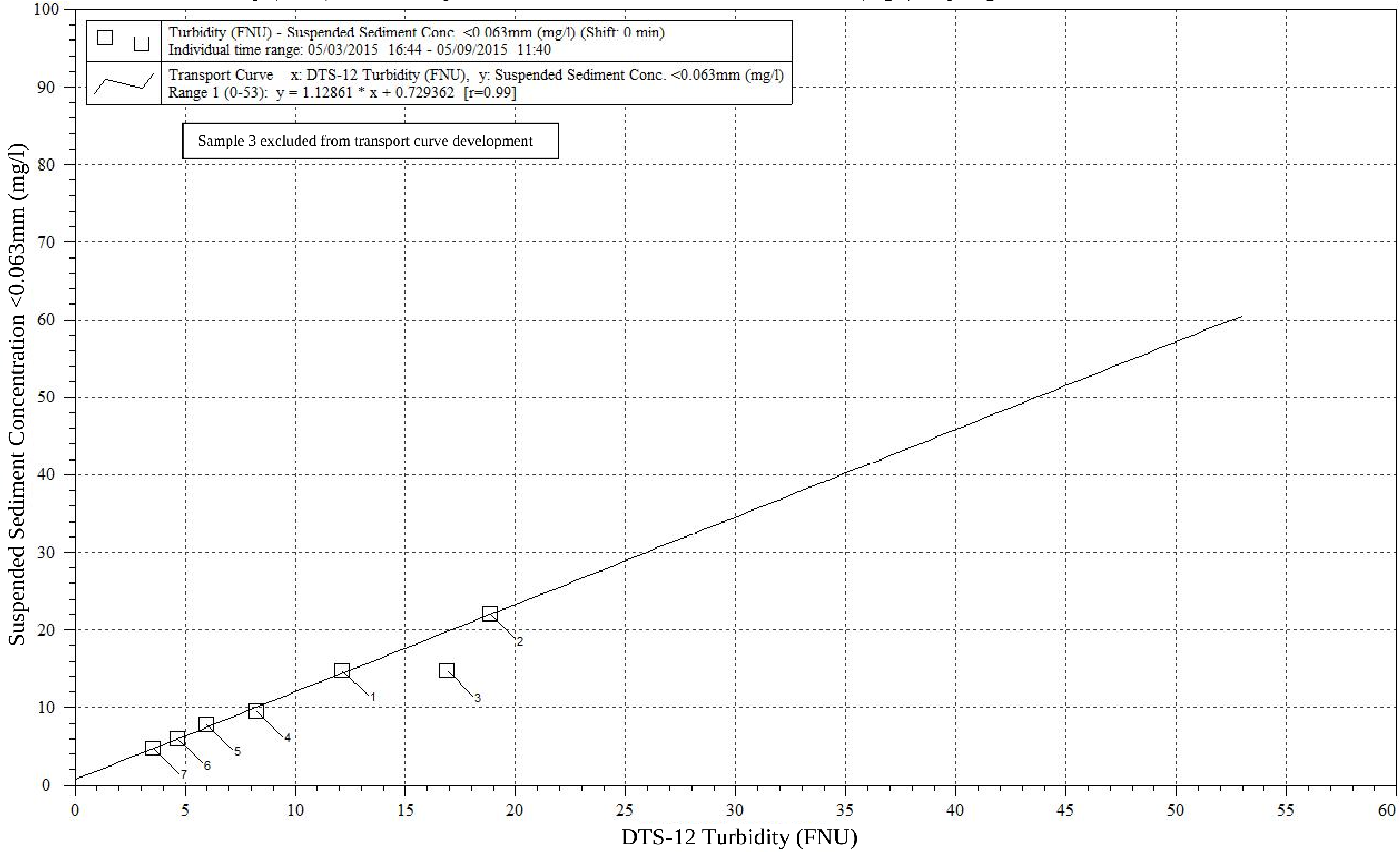
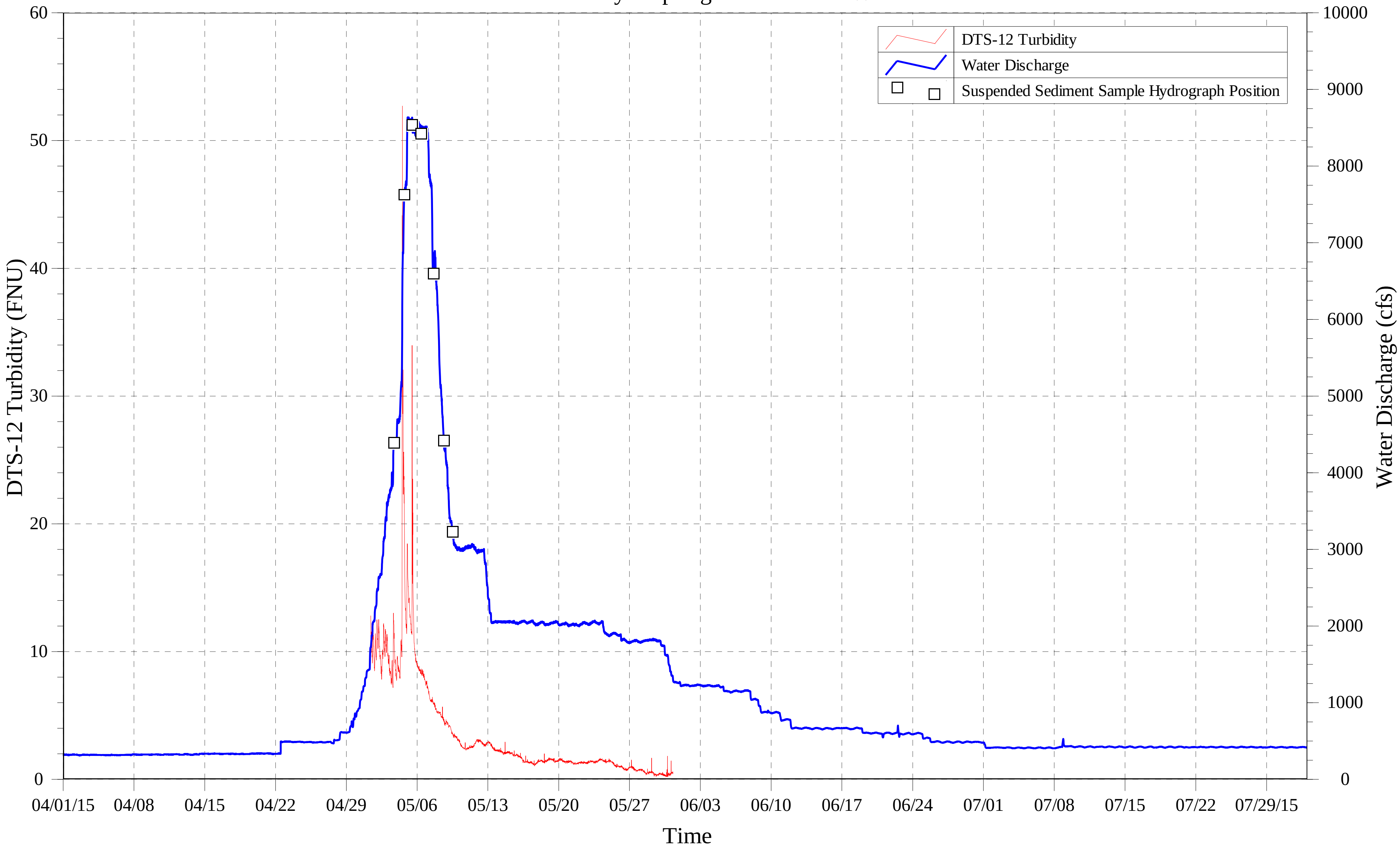
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON -- 11525540

Turbidity (FNU) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release WY 2015



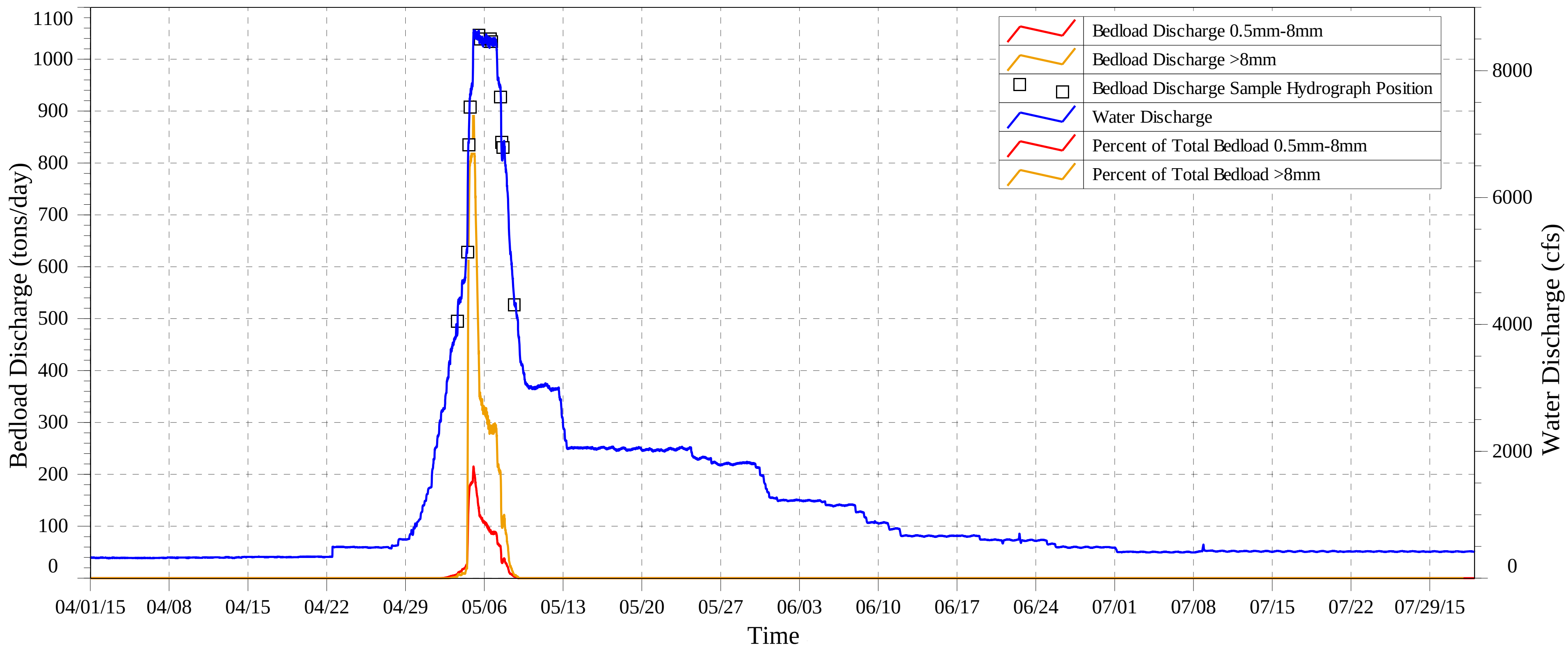
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

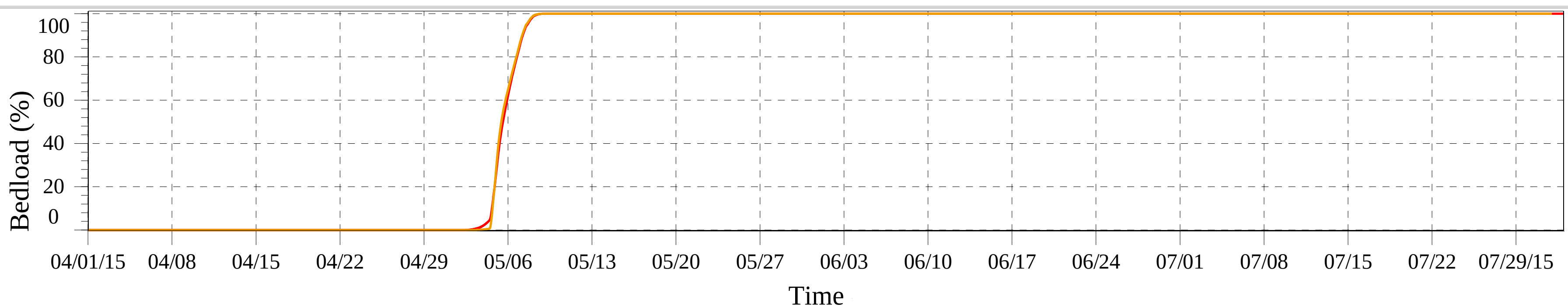
DTS-12 Turbidity – Spring Flow Release WY 2015



TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

Bedload Discharge – Spring Flow Release WY 2015





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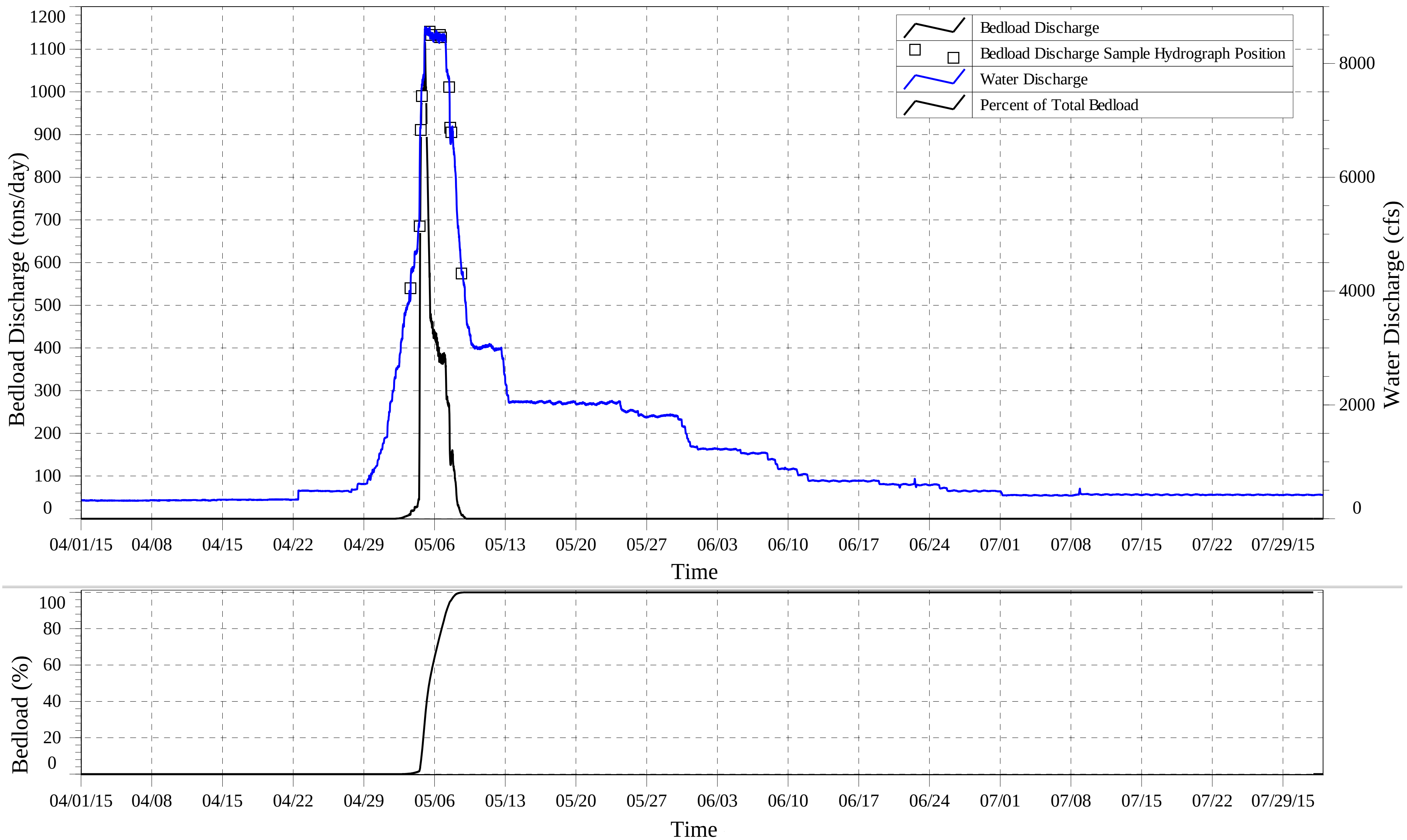
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

Bedload Discharge – Spring Flow Release WY 2015



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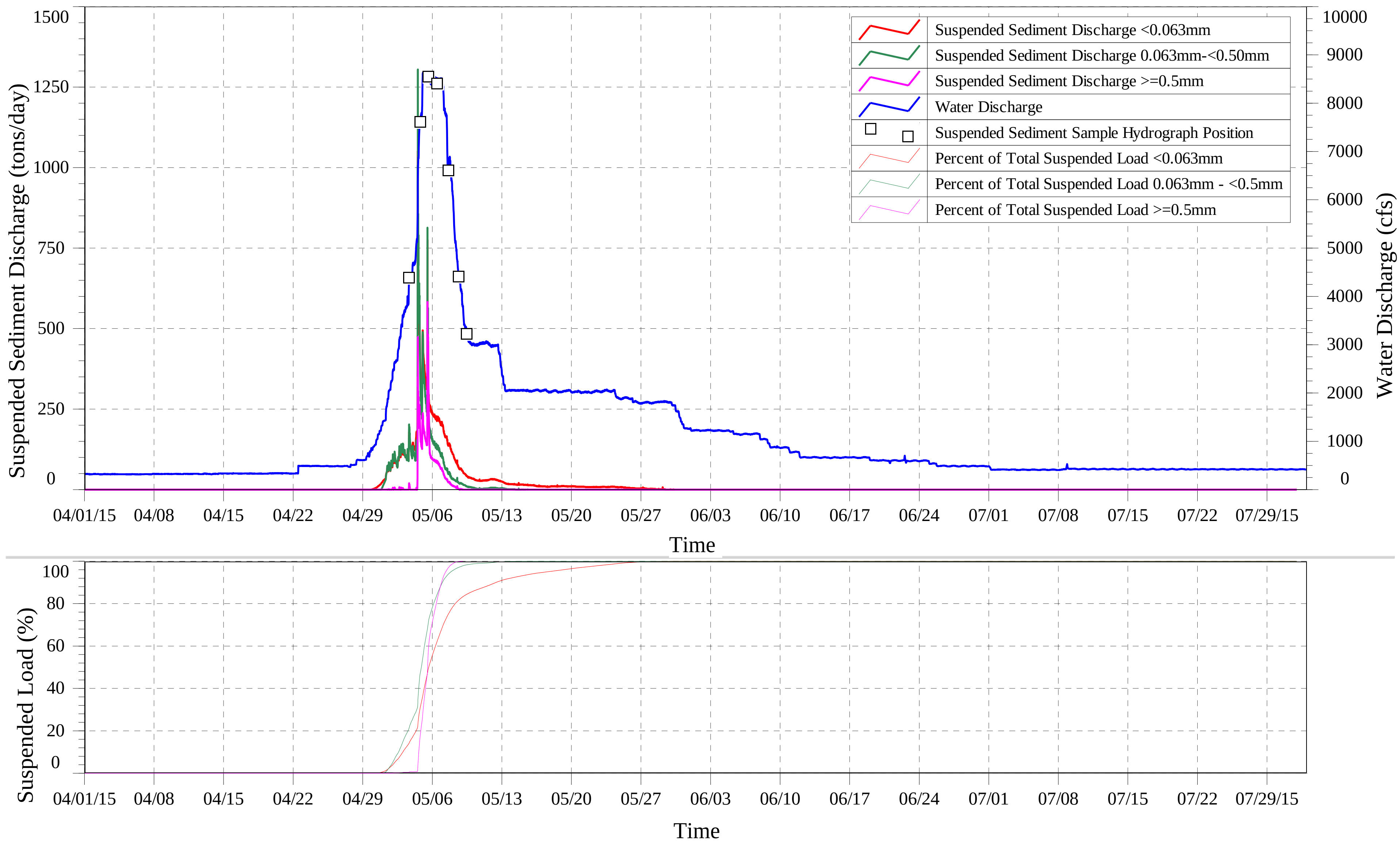
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

Suspended Sediment Discharge – Spring Flow Release WY 2015



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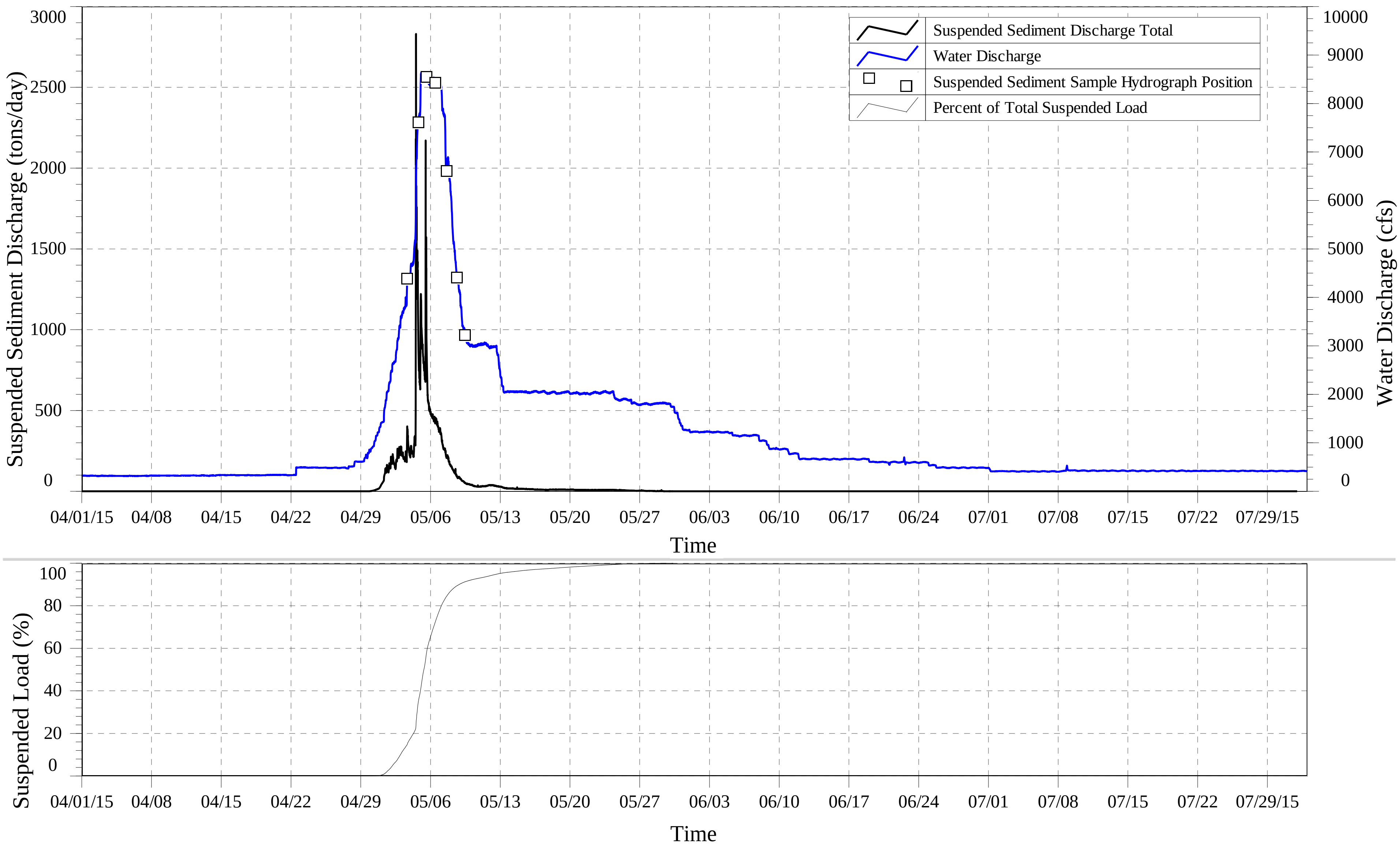
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

Suspended Sediment Discharge – Spring Flow Release WY 2015



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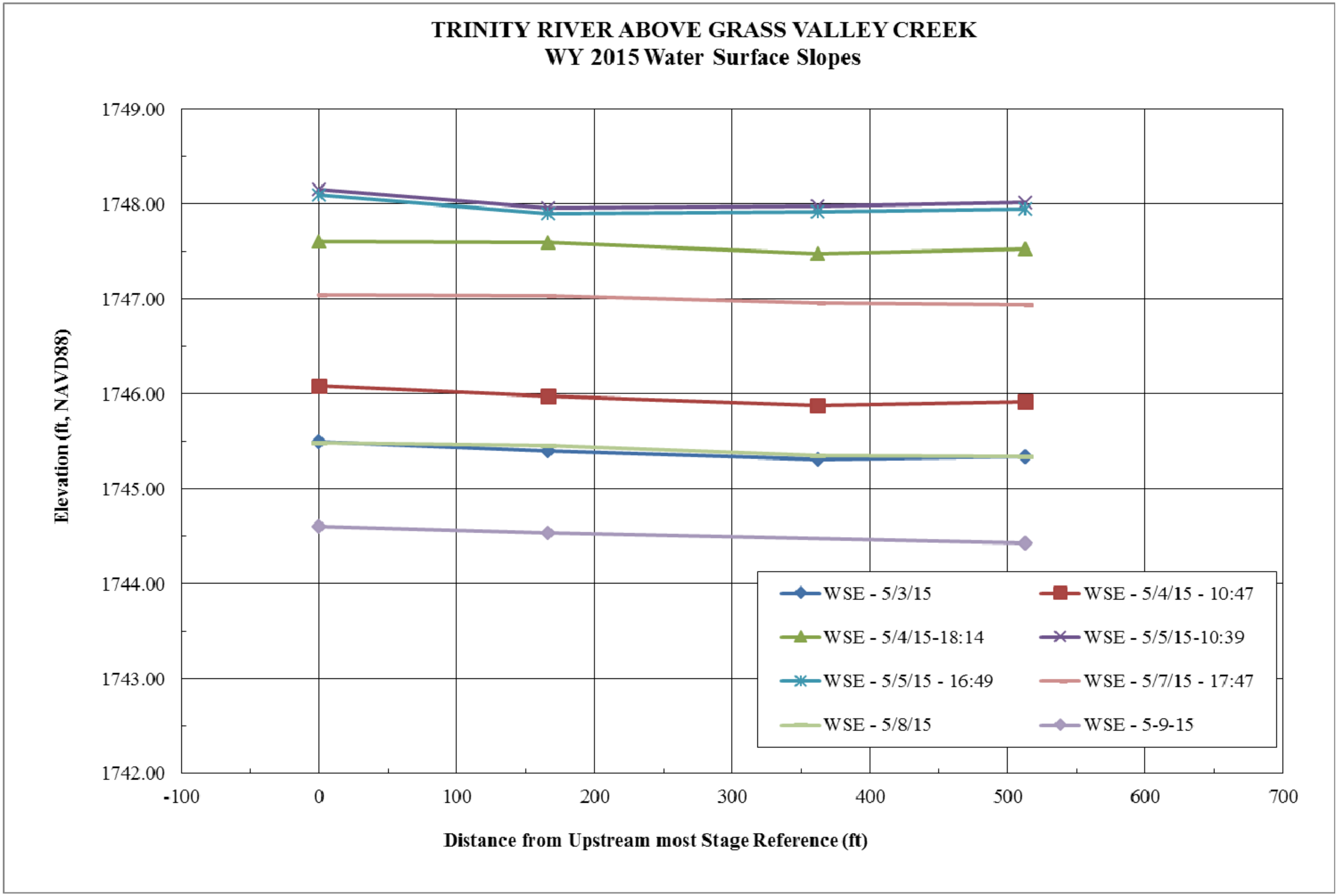

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Appendix C

Trinity River below Limekiln Gulch
USGS Gage # 11525655

11525655 Trinity River Below Limekiln Gulch near Douglas City, CA

TOTAL LOAD SEDIMENT DISCHARGE RECORD

Spring Flow Release WY 2015: (April 1 to July 31)

Records collected at station.-- Daily streamflow has been collected for the following periods: WY1981-1991, WY1999-2004 by the Hoopa Valley Tribe and 2005-present by the USGS. This site was operated as a daily sediment station from 1981-1991. Sediment sampling (storm season and flow release) has occurred intermittently since 1998 by the Hoopa Valley Tribe. Sediment sampling (flow release) has occurred on a regular basis from 2004-15. Instantaneous water temperature data have been collected in conjunction with sampling and water discharge measurements since 1981. A turbidimeter recorded data during the WY 2015 spring flow release period: a Forest Technology Systems DTS-12 linked to a Campbell CR200 data collection platform (DCP), installed and operated by GMA Hydrology (GMA). The purpose of collecting sediment data at this site is to quantify sediment discharge transported through this portion of the mainstem, versus the sediment discharge measured at sediment collection stations either upstream or downstream: Trinity River at Lewiston (11525500), Trinity River above Grass Valley Creek near Lewiston (11525540), and Trinity River at Douglas City (11525854). This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed from the WY 2015 spring flow release by GMA, under contract to the TRRP.

Equipment.-- Sampling equipment consists of a D-74 and DH-48 for suspended-sediment sampling, and a cable-deployed 12-inch x 6-inch Toutle River 2 bedload sampler (TR-2) with a 0.5 mm mesh collection bag. The D-74 suspended-sediment sampler and the TR-2 bedload sampler were deployed from a crane-mounted E-reel. The E-reel was driven by a battery operated power-drive during periods of the release and the B-reel was operated by hand. Sediment sampling was performed from a cataraft-based platform attached to a temporary cableway. Stage references were installed near the cableway at the streamflow gaging station. A Forest Technology Systems DTS-12 turbidimeter was installed and operated during the sediment sampling period. Photographs were taken with a digital camera.

Sampling program.-- Total (flow release) load season for this site is from April 1 to July 31. The program consisted of 7 sampling days. A minimum of one bedload discharge sample and one suspended-sediment discharge sample was collected on each of the sampling days. The sampling days and samples collected are as follows:

May 03	1 bedload discharge	1 suspended-sediment discharge
May 04	3 bedload discharge	1 suspended-sediment discharge
May 05	3 bedload discharge	1 suspended-sediment discharge
May 06	3 bedload discharge	1 suspended-sediment discharge
May 07	3 bedload discharge	1 suspended-sediment discharge
May 08	1 bedload discharge	1 suspended-sediment discharge
May 09	1 bedload discharge	1 suspended-sediment discharge

Sampling crews consisted of two on-river personnel specifically trained in cataraft-based sediment data collection techniques, and a safety kayaker. All samples were reviewed by the site technicians and individual analyses were standardized for suspended sediment (concentration, particle size analysis) and bedload samples (total dry mass, particle size analysis). Sediment data were generally collected according to USGS protocols with the following exceptions: test-velocity ratings for sampler nozzles were occasionally exceeded. Suspended-sediment samples were sent to the GMA Suspended-Sediment Lab and bedload samples were sent to the GMA Coarse-Sediment Lab, both located in Placerville, CA for analysis.

USGS Field Review. -- No USGS field review was conducted during the 2015 spring flow release.

Data summary for WY 2015 spring flow release. --

Total number of samples:	
Suspended sets …………………………………………………………	7
Single pass suspended samples ………………………………………	0
Box sample sets …………………………………………………………	0
Single box samples ………………………………………………………	0
Bedload sets ……………………………………………………………	11
Single pass bedload samples ………………………………………	4
Three pass bedload samples ………………………………………	0
Number of field turbidities measured ………………………………	0
Number of suspended-sediment size analysis samples:	
Particle size analysis …………………………………………………	0
0.063mm break …………………………………………………………	7
0.50mm break ……………………………………………………………	7
Number of bedload sediment size analysis samples:	
Particle size analysis …………………………………………………	15
Number of suspended-sediment discharge measurements ………………	7
Number of bedload discharge measurements …………………………	15
Number of visits by Field Office ……………………………………	0
Maximum flow sampled by:	
GMA technicians, ft^3/s ………………………………………………	8,480
Range of concentrations sampled by:	
GMA technicians, mg/l …………………………………………………	8-49
GMA technicians, ton/d …………………………………………………	3-332
Peak flow during flow release, ft^3/s ……………………………	8,580

Periods of faulty record ……………………………………………………………

Turbidity

April 23, 2015 at 10:15 to April 27, 2015 at 17:00
July 1, 2015 at 05:45 to July 31, 2015 at 23:45

Coefficients.-- None used.

Continuous Turbidity.-- The turbidity record is incomplete for the computational period. The turbidity probe had been removed at the end of the previous computational period and was not re-installed until April 23, 2015 at 10:15 hours. Additionally, the following periods of faulty turbidity data, caused by the probe being out of the water, were removed;

April 23, 2015 at 10:15 to April 27, 2015 at 17:00
July 1, 2015 at 05:45 to July 31, 2015 at 23:45

Several turbidity spikes were removed. Turbidity spikes are defined as short periods of time, 15-minutes to several hours, during which the optics of the probe were presumably fouled. After removing the turbidity spikes the gaps were filled using linear interpolation or the gaps were filled with a constant value if turbidity was not changing.

Once the turbidity record was cleaned, the record was inspected to determine if a turbidity offset was necessary. Inspection of the record indicated that a shift of -3.3 FNU was necessary. Offsets are determined by averaging turbidity values at base flows when turbidity should be at or close to 0.0 FNU.

During the computational period the maximum turbidity was 36.9 FNU on May 4 at 14:45, and the minimum turbidity was 0 FNU, which occurred several times during the period.

Total suspended sediment-discharge computations. -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharges.

Size analysis. -- Seven cross-sectional, depth-integrated samples were analyzed using a split at 0.063mm and 0.50mm.

Partial suspended sediment-discharge computations. -- Turbidity versus SSC transport curves were inspected for use during the period. For the <0.063mm, 0.063mm-<0.50mm, and the ≥0.50mm size classes, data collected during from 2011 through 2015 was analyzed, however it was determined that 2015 data showed different transport relationships. For all size classes new transport curves were developed using Water Year 2015 data only.

For the <0.63mm size class, the turbidity versus SSC transport curve is defined by Eqn. (1) and Eqn. (2).

Turbidity<10.5 FNU $$SSC = 1.03 * Turbidity + 0, \quad (1)$$

Turbidity≥10.5 FNU $$SSC = 2.28 * Turbidity - 13.0, \quad r^2 = 0.75 \quad (2)$$

For the rising limb, zero transport was estimated during sedigraph development and occurs at 500 cfs. For the falling limb, the turbidity record returns to very near 0.00 FNU. Zero transport was determined by applying the transport curve to the turbidity record and occurs at 440 cfs. Eqn. (1) and (2) are used from April 23, 2015 at 10:15 through July 1, 2015 at 05:45. Eqn. (1) and (2) have a validated range between 5.55 FNU and 15.7 FNU.

For the 0.063mm-<0.50mm size class, the turbidity versus SSC transport curve is defined by Eqn. (3) and Eqn. (4).

Turbidity<7.5 FNU $$SSC = 0.93 * Turbidity - 3.64, \quad r^2 = 1.0 \quad (3)$$

Turbidity≥7.5 FNU $$SSC = 2.04 * Turbidity - 11.9, \quad r^2 = 0.97 \quad (4)$$

Zero transport for the rising limb was determined during transport curve development, and occurs at 3.64 FNU. Falling limb zero transport was detemined by fitting the transport curve derived sedigraph to sample 2015-07 and occurs at approximately 3.90 FNU. Eqn. (3) and (4) are used from April 23, 2015 at 10:15 through July 1, 2015 at 05:45. Eqn. (3) and (4) have a validated range between 5.55 FNU and 15.7 FNU.

For the ≥0.5mm size class, both turbidity versus SSC and discharge versus SSC were analyzed. Turbidity versus SSC was produced a better relationship for ≥0.5mm SSC at TRLG. The ≥0.5mm transport curve is defined by Eqn. (5).

$$SSC = 0.70 * Turbidity - 3.81, \qquad r^2 = 0.99 \qquad (5)$$

Zero transport was estimated during sedigraph development by fitting to samples 2015-01 and 2015-07 and occurs at 13.8 FNU and 5.52 FNU on the rising and falling limb, respectively. Eqn. (5) is used from April 23, 2015 at 10:15 through July 1, 2015 at 05:45, and has a validated range between 5.55 FNU and 15.7 FNU.

The tranport curves were used to develop continuous concentration curves for the <0.063mm, ≥0.063mm-<0.50mm, and the ≥0.5mm size classes during the computational period. Once the continuous concentration data had been developed, the sample data were used to adjust the continuous concentrationtrace so that they passed through all sample points. The continuous concentration trace was adjusted using fitting and proportional fitting techniques.

Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous SSC) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points. Fitting and proportional fitting techniques recognize short-term correlations and address hysteresis effects by using subsets of data. When only a single sample exists on a flow bench, the proportional fitting technique assumes that the determined ratio applies for the duration of that flow bench. When SSC is not highly correlated with discharge or turbidity, it is not possible to evaluate this assumption and therefore it is a potential source of errorSuspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

Bed material-- None.

Bedload measurement -- Fifteen bedload samples were collected during the computational period. Sample 1, 2, 3 and 15 were a single pass samples and the remainder were two pass samples.

Bedload-discharge computations -- The sample analysis contains the portion of sample <0.5mm but the total bedload discharge was determined by summing the partial discharges for the ≥0.5mm-8mm and the ≥8mm size fractions.

Partial bedload-discharge computations -- Sediment transport curves were developed and partial bedload discharges were computed for the 0.5mm-<8mm and ≥8mm size classes. In previous years, sediment transport curves were developed for the rising and falling limbs in order to define the hysteresis observed at the site. However, during 2015, no obvious pattern of hysteresis was observed, so a single generalized curve was developed for each size class. No outliers were identified during analysis of either size class.

For the 0.5mm-<8mm size class, the transport curve is shown in Eqn. (6).

$$BLD = 2.25 * 10^{-006} \left(Disch \arg e - 2200 \right)^{2.01}, \quad r^2 = 0.93 \qquad (6)$$

The transport curve was developed using samples 1-15. The transport curve is used from April 1 at 00:00 hrs until July 31 at 23:45 hours. Eqn. (6) has a valididated range between 3,330 cfs and 8,480 cfs. Zero transport for the rising limb was estimated by fitting the sedigraph to sample 1 and occurs at approximately 3,100 cfs. For the falling limb, zero transport was determined by fitting the sedigraph to sample 15 and occurs at approximately 2,420 cfs.

For the ≥8mm size class, the transport curve developed for use during the period is defined by Eqn. (7).

$$BLD = 5.25 * 10^{-.14} \left(Discharge - 2486 \right)^{4.05}, \quad r^2 = 0.86 \qquad (7)$$

Eqn. (3) was developed using samples 1-15 and is used from April 1, 2013 at 00:00 hours through July 31, 2013 at 23:45 hours. Eqn. (7) has a valididated range between 3,330 cfs and 8,480 cfs. Zero transport for the rising limb was estimated by fitting the sedigraph to sample 1 and occurs at approximately 4,030 cfs. For the falling limb, zero transport was determined by fitting the sedigraph to sample 15 and occurs at approximately 3,000 cfs.

Once the continuous bedload-discharge traces were developed using the above transport curves, they were adjusted using the sample values using the same techniques as was described for the partial suspended-sediment discharge computations. Due to the inherent high variability in bedload sampling, during flow benches, sample values were averaged on days where multiple samples were collected to produce average transport values. These average transport values were used to adjust the continuous bedload transport trace.

Remarks. – The suspended sediment discharge record is rated as follows:

April 1 (00:00) to May 2 (23:45)	Estimated
May 3 (00:00) to May 9 (23:45)	Good
May 10 (00:00) to July 31 (23:45)	Estimated

The bedload discharge record is rated as follows:

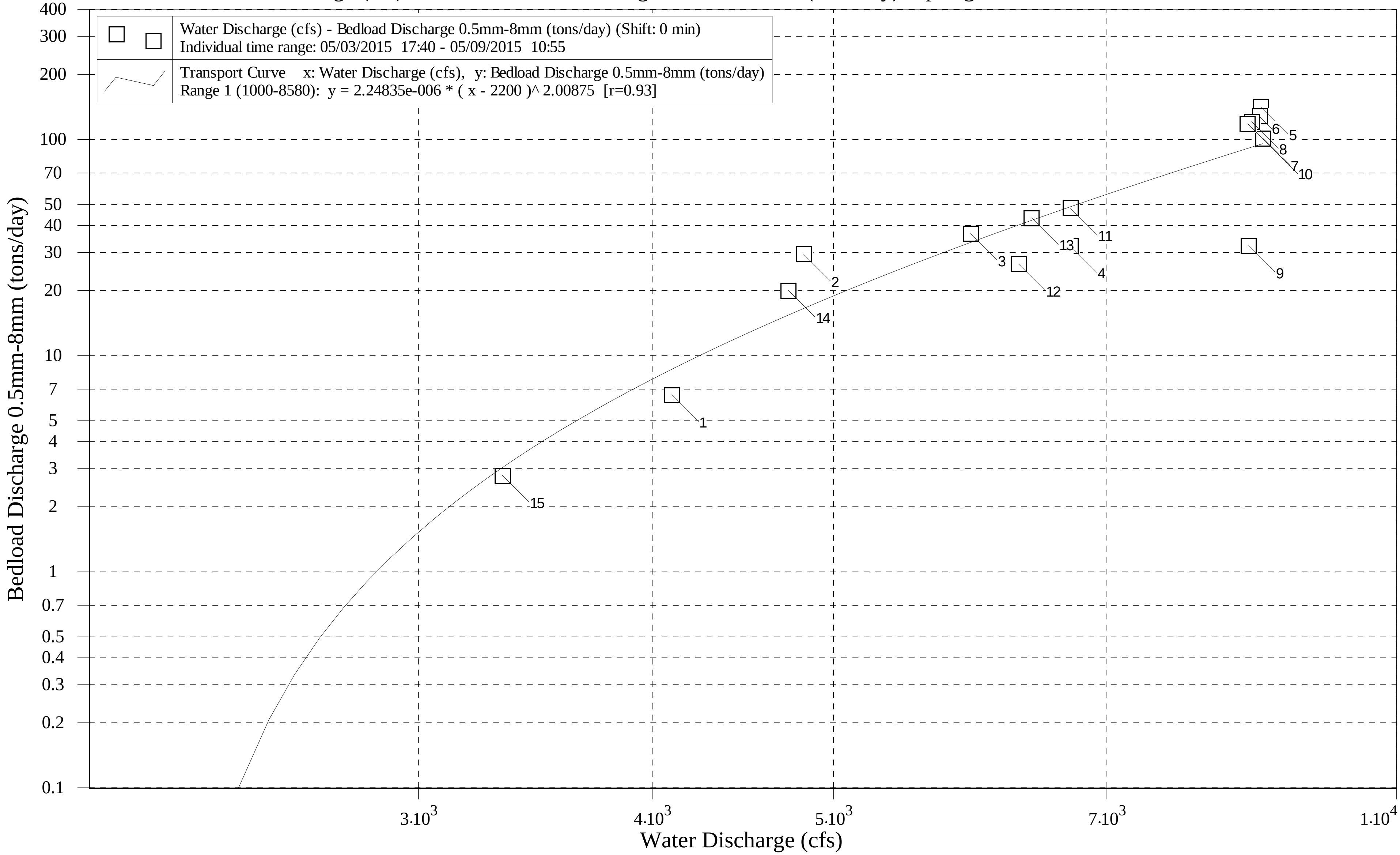
April 1 (00:00) to May 2 (23:45)	Estimated
May 3 (00:00) to May 9 (23:45)	Good
May 10 (00:00) to July 31 (23:45)	Estimated

Computed by: Brooke Pittman, December 2015

Reviewed by: S. Pittman January 2016

TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Water Discharge (cfs) Versus Bedload Discharge 0.5mm-<8mm (tons/day): Spring Flow Release WY 2015



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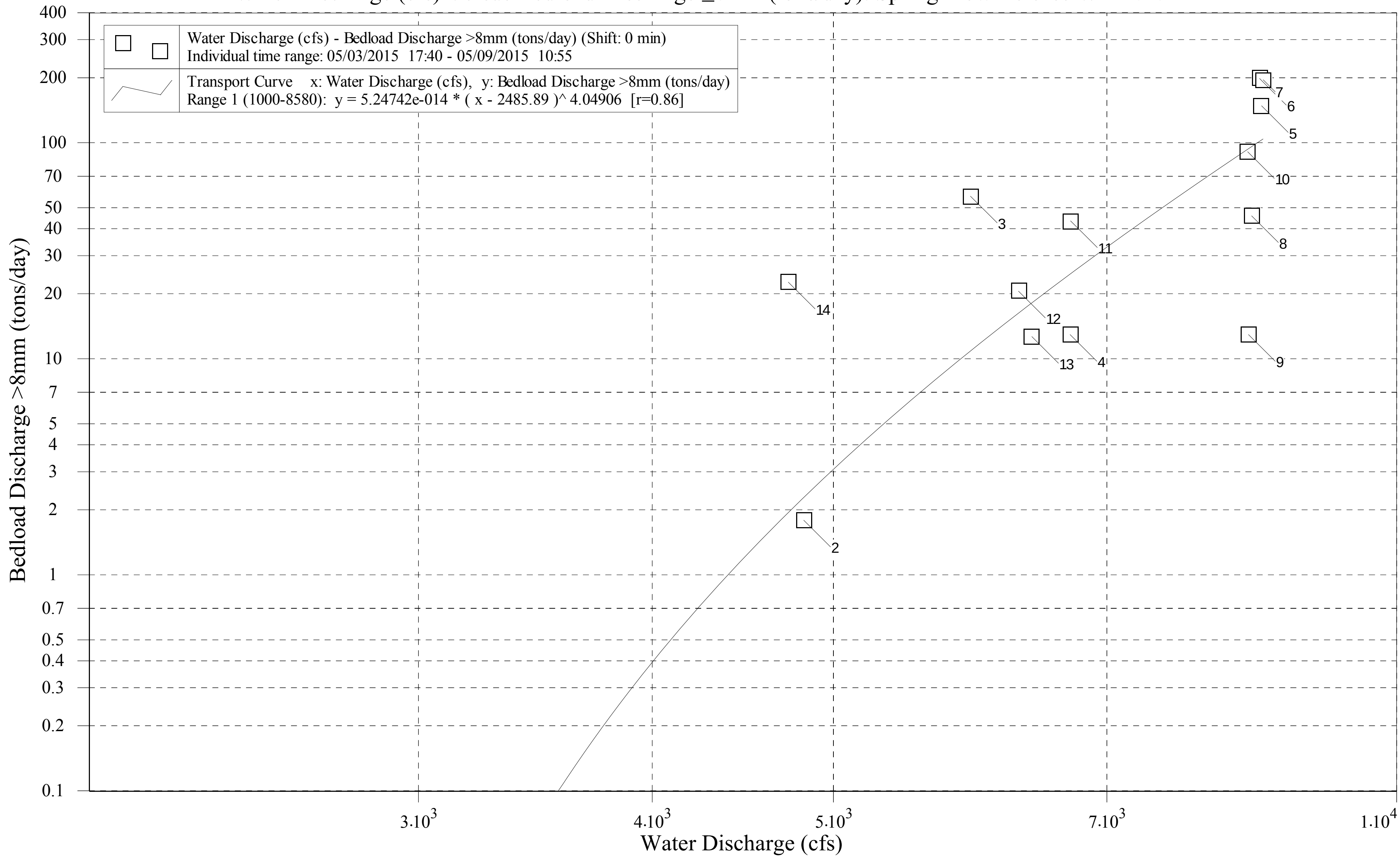
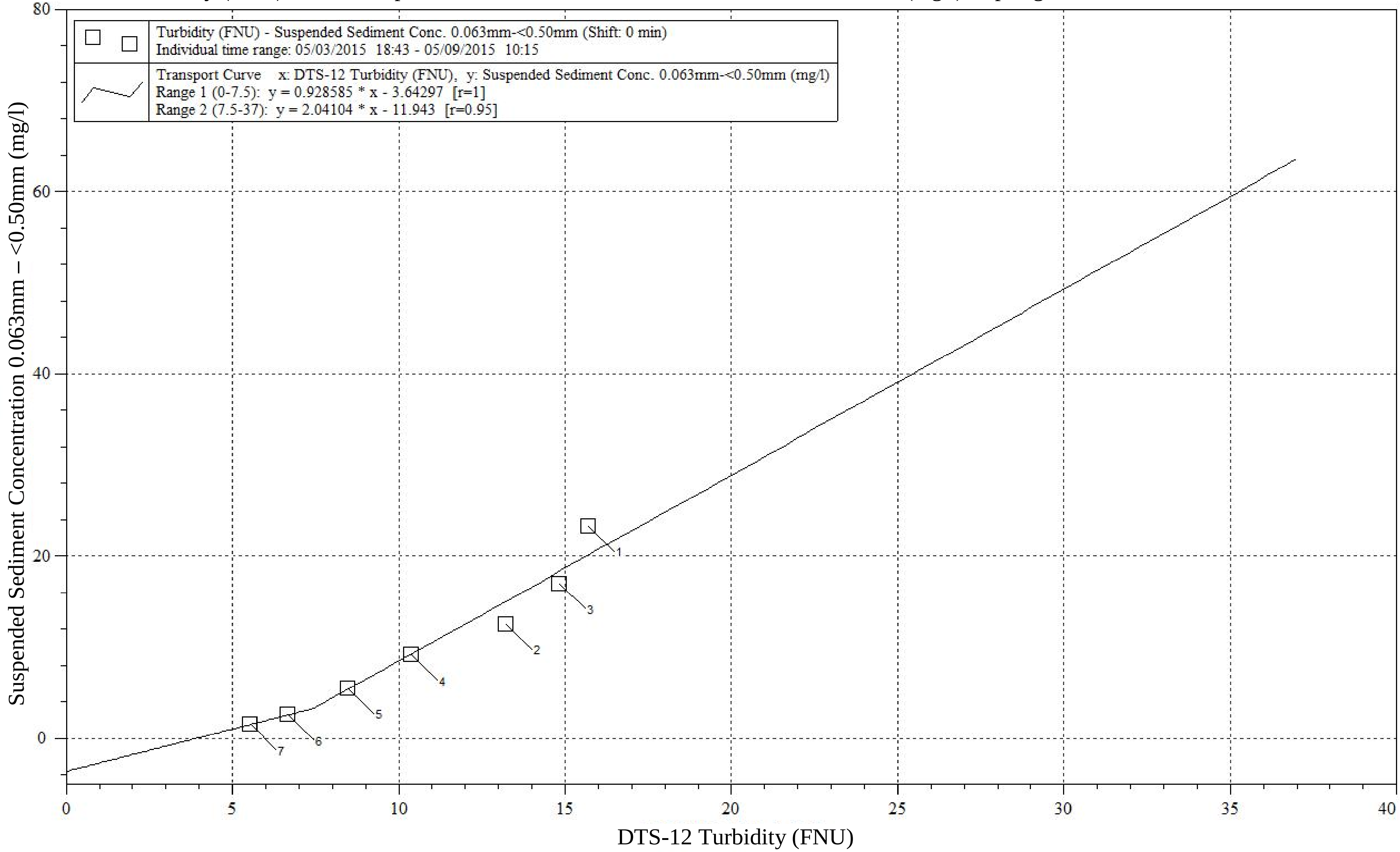
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Water Discharge (cfs) Versus Bedload Discharge ≥8mm (tons/day): Spring Flow Release WY 2015



TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Turbidity (FNU) Versus Suspended Sediment Concentration 0.063mm - <0.50mm (mg/l): Spring Flow Release WY 2015



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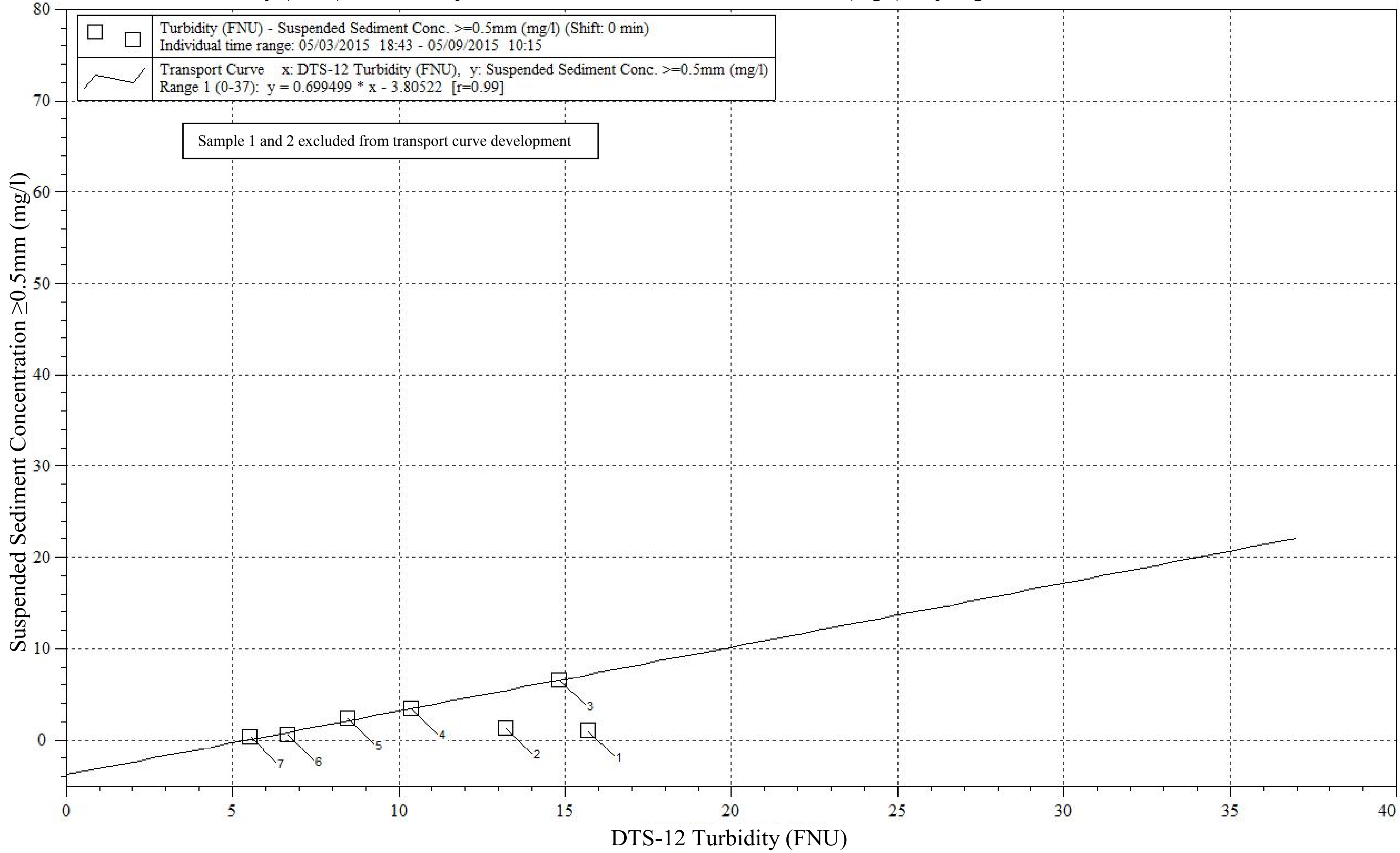
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Turbidity (FNU) Versus Suspended Sediment Concentration ≥0.5mm (mg/l): Spring Flow Release WY 2015



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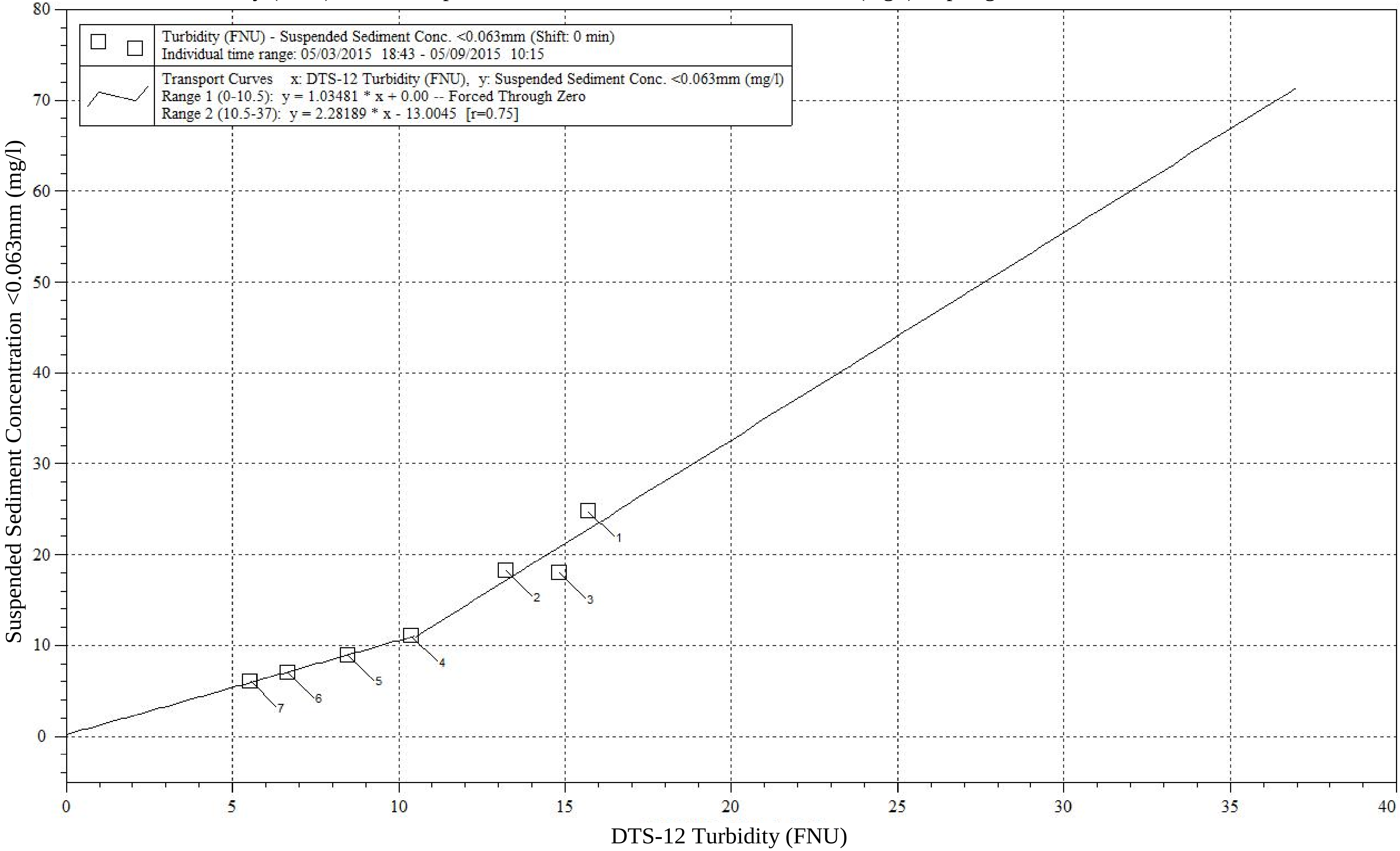
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Turbidity (FNU) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release WY 2015



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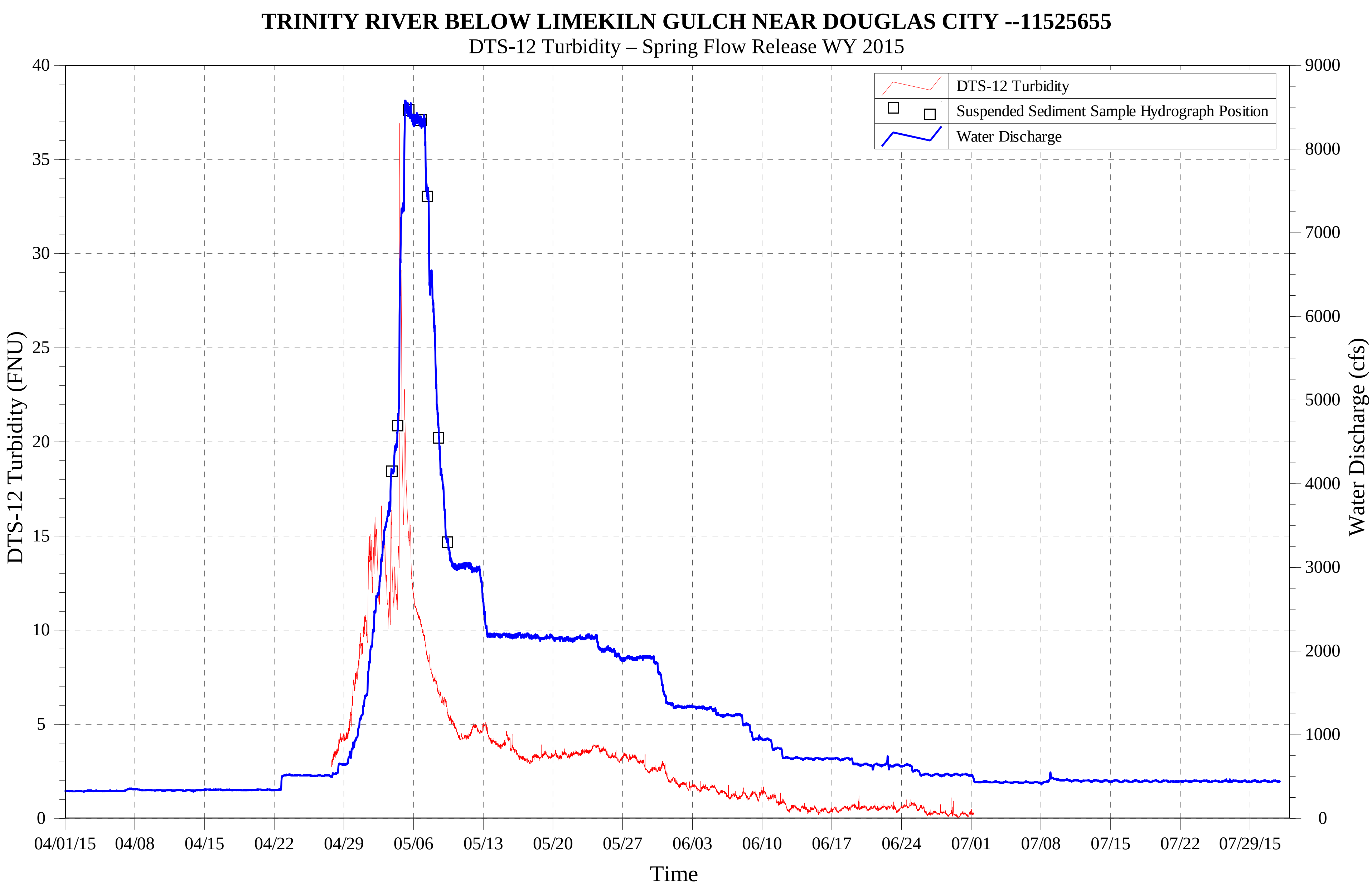

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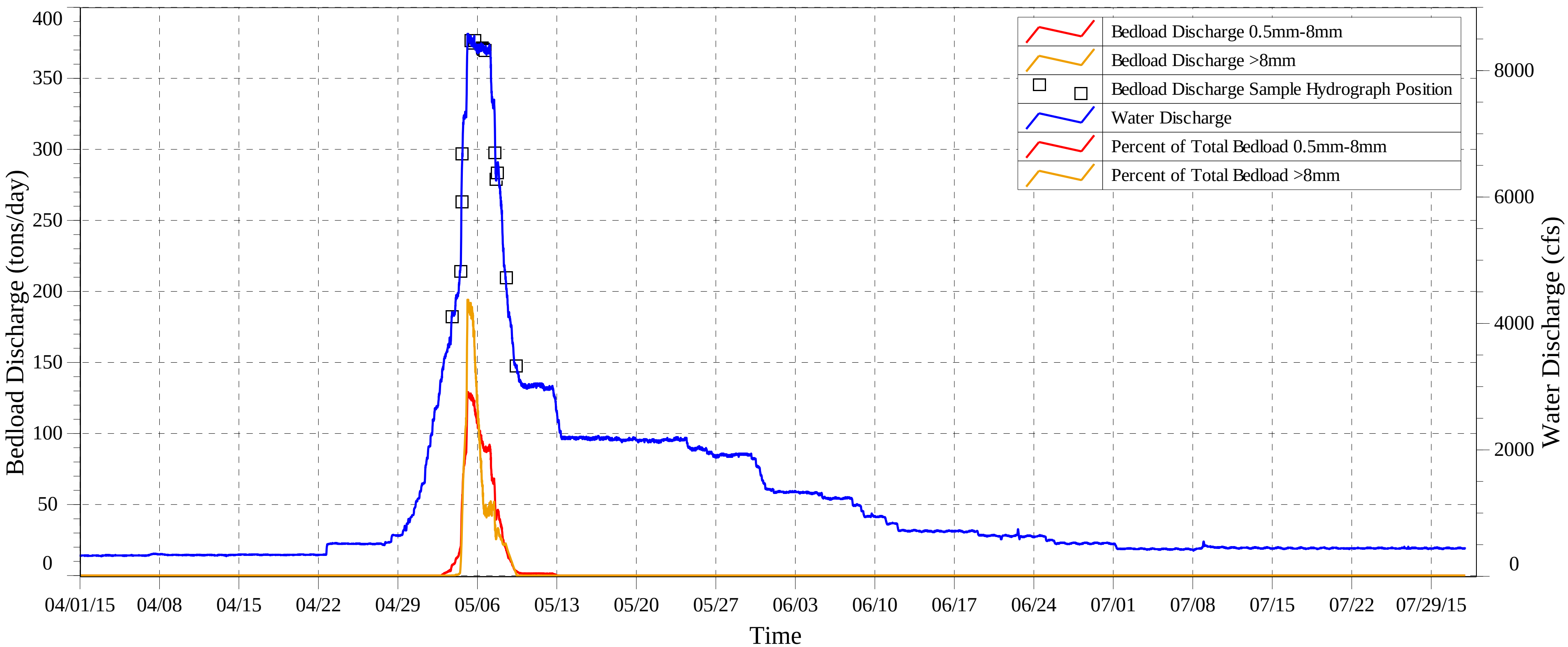
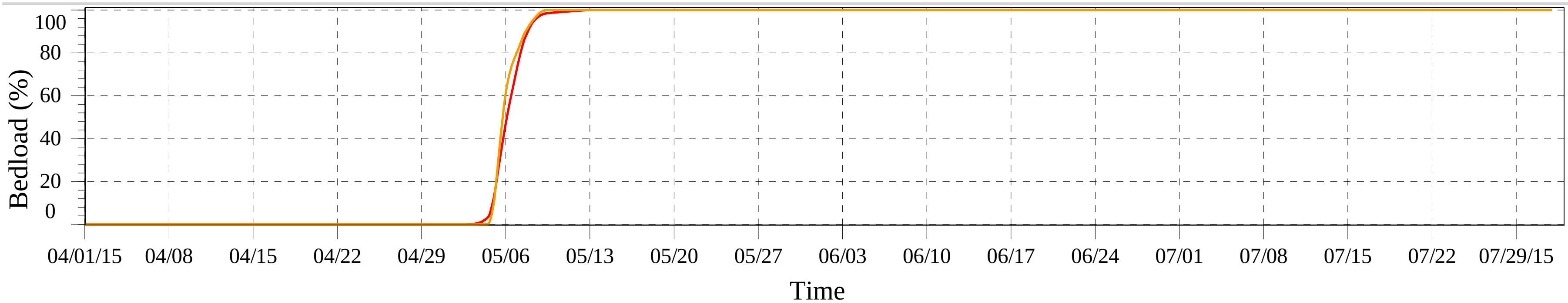
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY –11525655

Bedload Discharge – Spring Flow Release WY 2015





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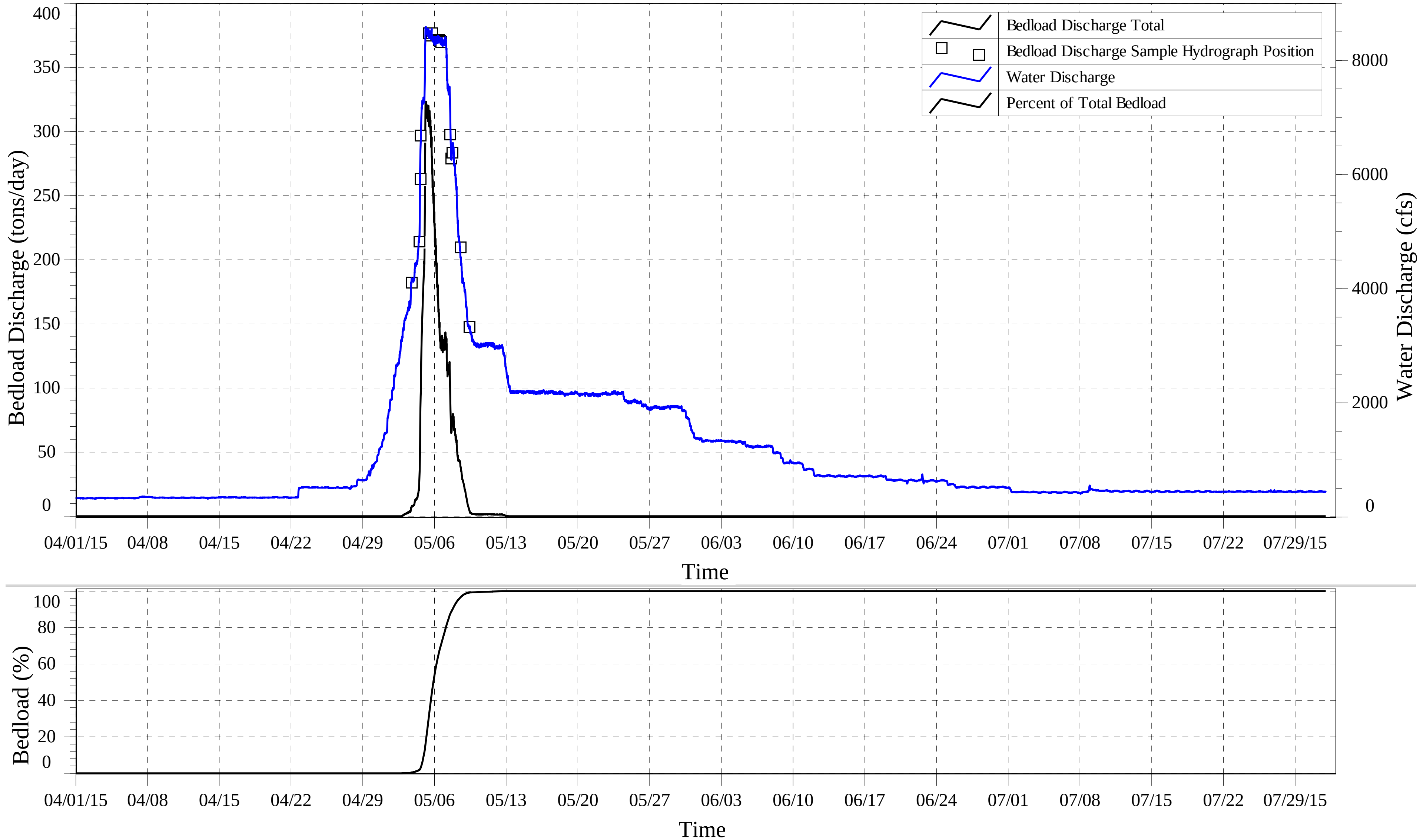
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY –11525655

Bedload Discharge – Spring Flow Release WY 2015



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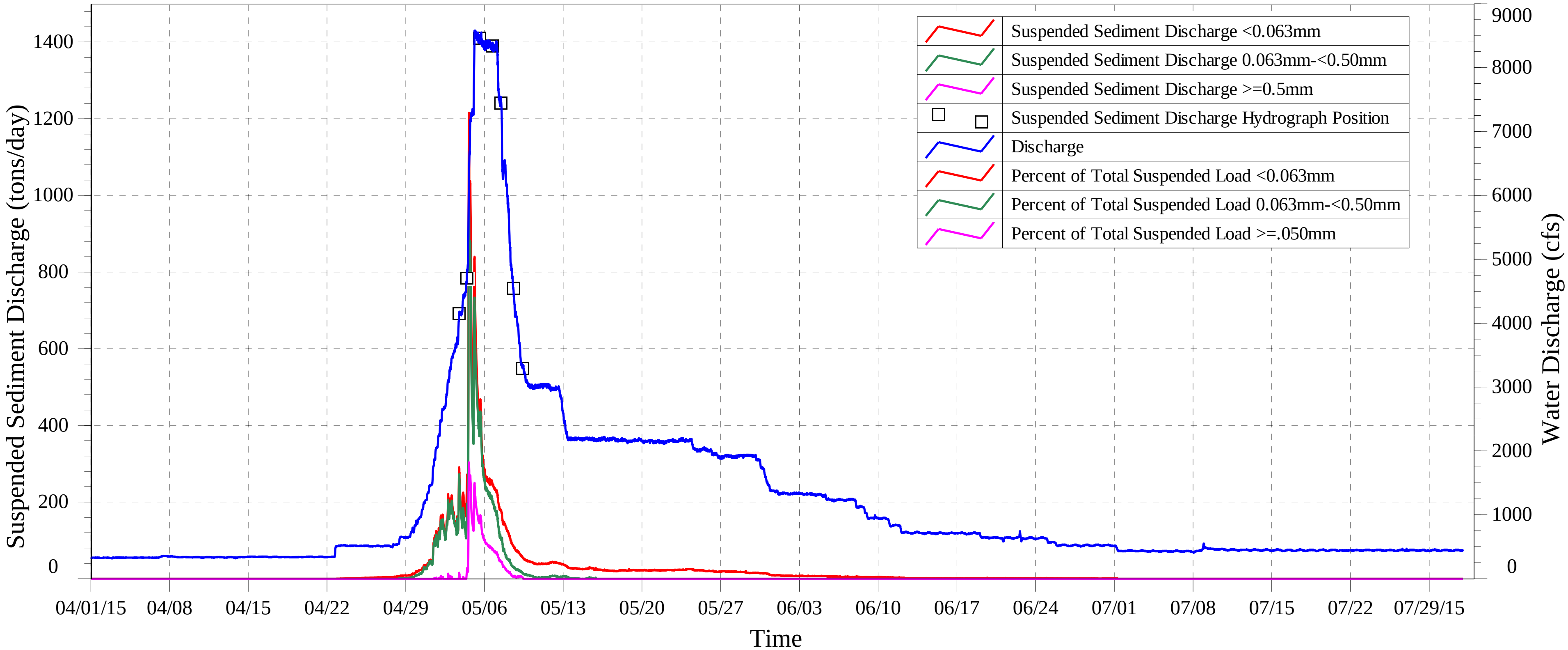
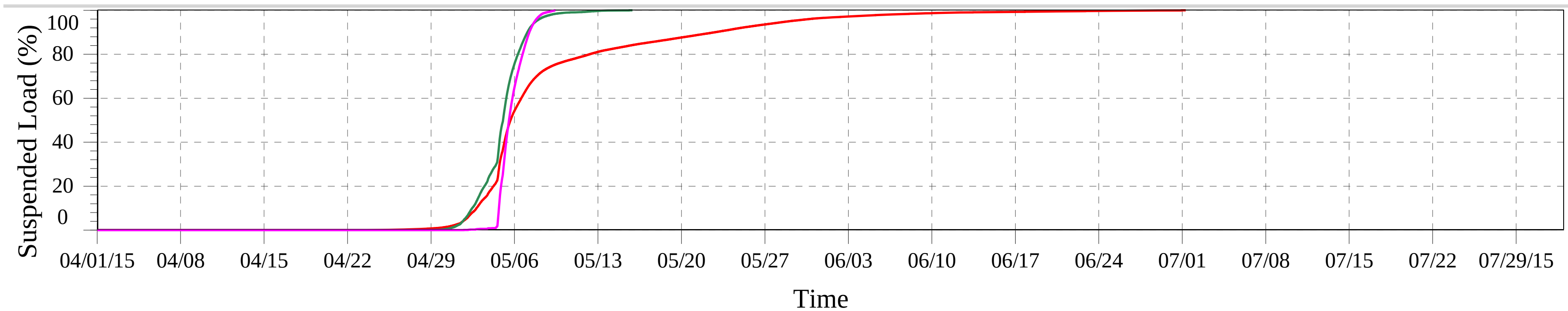
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY –11525655

Suspended Sediment Discharge – Spring Flow Release WY 2015





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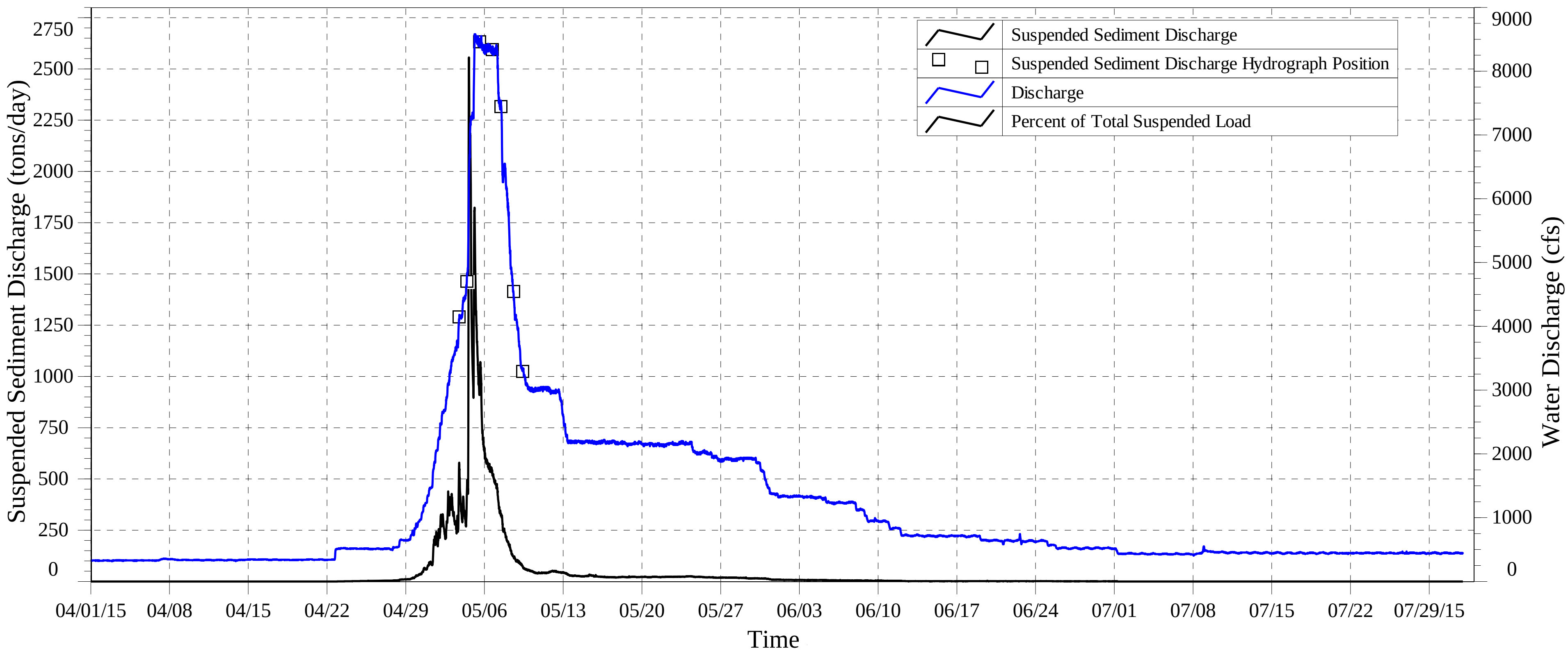
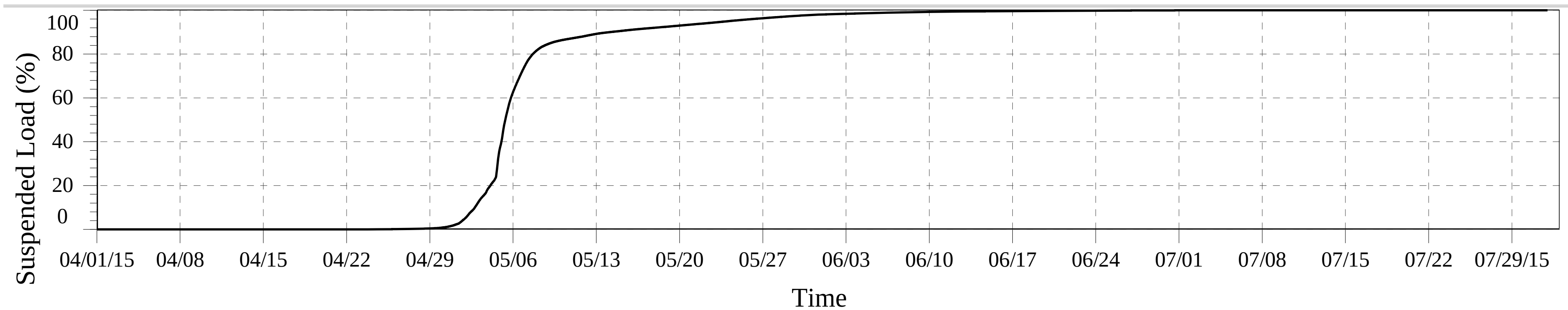
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY –11525655

Suspended Sediment Discharge – Spring Flow Release WY 2015





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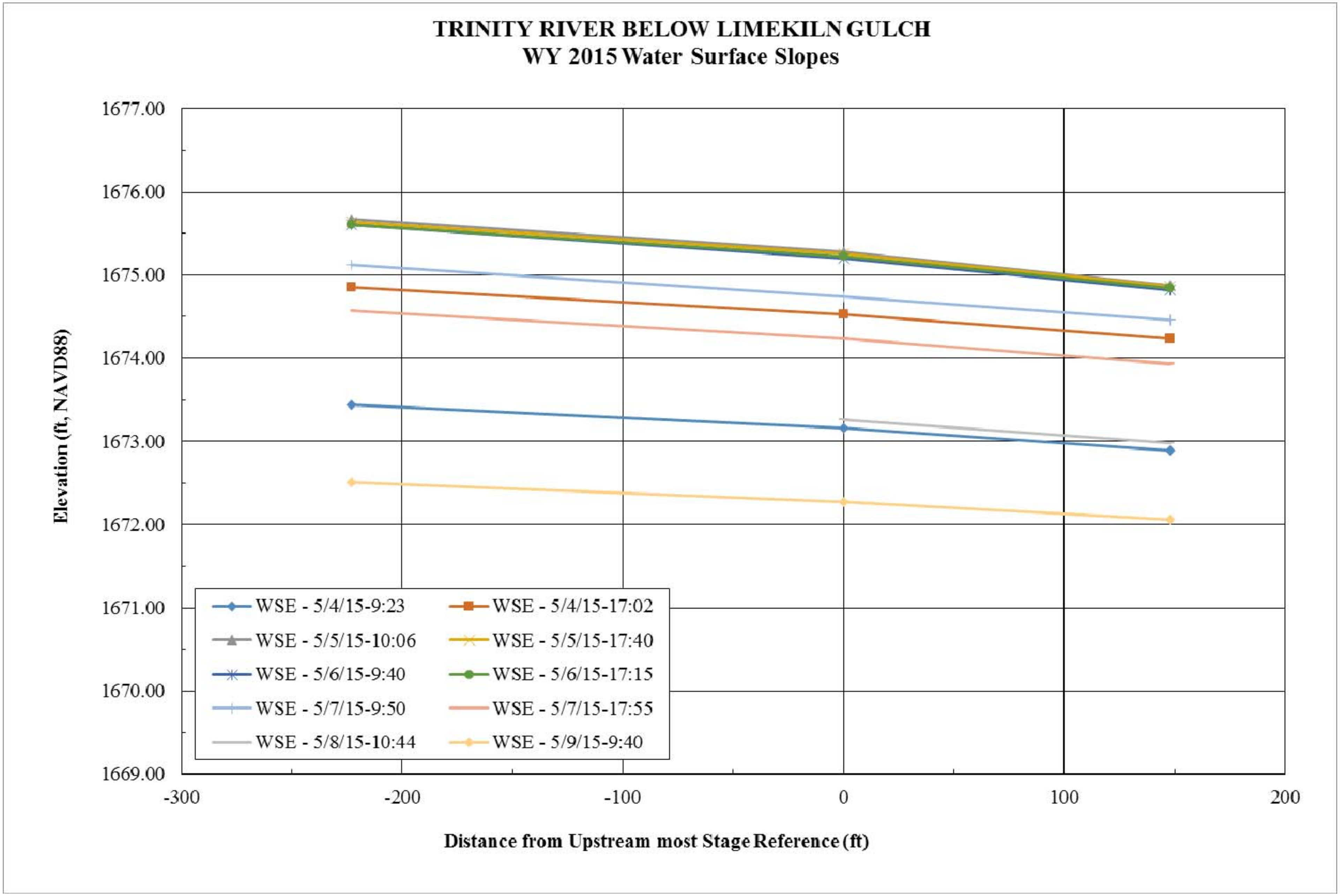


TRINITY RIVER BELOW LIMEKILN GULCH
WY 2015 Water Surface Slopes
Elevation (ft, NAVD88)
1677.00
1676.00
1675.00
1674.00
1673.00
1672.00
1671.00
1670.00
1669.00
-300
-200
-100
0
100
200
Distance from Upstream most Stage Reference (ft)
WSE - 5/4/15-9:23
WSE - 5/4/15-17:02
WSE - 5/5/15-10:06
WSE - 5/5/15-17:40
WSE - 5/6/15-9:40
WSE - 5/6/15-17:15
WSE - 5/7/15-9:50
WSE - 5/7/15-17:55
WSE - 5/8/15-10:44
WSE - 5/9/15-9:40

Appendix D

Trinity River near Douglas City
USGS Gage # 11525854

11525854 Trinity River at Douglas City, CA

TOTAL LOAD SEDIMENT DISCHARGE RECORD

Spring Flow Release WY 2015: (April 1 to July 31)

Records collected at station. -- Daily streamflow has been collected continuously since 1995 by the Hoopa Valley Tribe and since 2005 by USGS. Sediment sampling (flow release) has occurred in 2002 and 2004-13. Instantaneous water temperature data have been collected since 1992. A Forest Technology Systems DTS-12 turbidity probe collects continuous turbidity data during the spring flow release. The purpose for collecting sediment data at this site is to quantify sediment discharge delivered from this portion of the main stem, versus the sediment discharge measured at sediment collection stations upstream, notably Trinity River at Limekiln Gulch (11525655). This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed from the WY 2015 spring flow release by GMA Hydrology (GMA), under contract to the TRRP.

Prior to the 2012 release, the section was moved 225 ft downstream of the USGS gaging station. The Forest Technology Systems DTS-12 turbidity probe is now located at the USGS stream gage.

Equipment .-- Sampling equipment consists of a D-74 and DH-48 for suspended-sediment sampling, and a cable-deployed 12-inch x 6-inch Toutle River 2 bedload sampler (TR-2) with a 0.5mm mesh collection bag. The D-74 suspended-sediment sampler and the TR-2 sampler were deployed from a crane-mounted E-reel or B-Reel. Sampling was performed from a cataraft-based sampling platform attached to a temporary cableway. Stage references were installed near cableways. Photographs were taken with a digital camera.

Sampling program. -- Total (flow release) load season for this site is from April 1, 2013 to July 31, 2013. The program consisted of 7 sampling days. The sampling days and samples collected are as follows:

May 03	1 bedload discharge	1 suspended-sediment discharge
May 04	3 bedload discharge	1 suspended-sediment discharge
May 05	3 bedload discharge	1 suspended-sediment discharge
May 06	1 bedload discharge	1 suspended-sediment discharge
May 07	3 bedload discharge	1 suspended-sediment discharge
May 08	1 bedload discharge	1 suspended-sediment discharge
May 09	1 bedload discharge	1 suspended-sediment discharge

Sampling crews consisted of two on-river personnel specifically trained in cataraft-based sediment data collection techniques and a safety kayaker. All samples were reviewed by the site technicians and individual analyses were standardized for suspended-sediment (concentration, particle size analysis) and bedload samples (total dry mass, particle size analysis). Sediment data were generally collected according to USGS protocols with the following exception: test-velocity ratings for sampler nozzles were occasionally exceeded. Suspended-sediment samples were sent to the GMA Suspended-Sediment Lab and bedload samples were sent to the GMA Coarse-Sediment Lab, both located in Placerville, CA for analysis.

USGS Field Review. -- No USGS field review was conducted during the 2015 spring flow release.

Data summary for WY 2015 Spring Flow Release --

Total number of samples:

Suspended sets …………	7
Single pass suspended samples …………	0
Box sample sets…………	0
Single box samples …………	0
Bedload sets …………	11
Single pass bedload samples …………	2
Three pass bedload samples …………	0
Number of field turbidities measured …………	0
Number of suspended sediment size analysis samples:	
Particle size analysis …………	0
0.063mm break …………	7
0.50mm break …………	7
Number of bedload sediment size analysis samples:	
Particle size analysis …………	13
Number of suspended sediment discharge measurements …………	7
Number of bedload discharge measurements …………	13
Number of visits by Field Office …………	0
Maximum flow sampled by:	
GMA technicians, ft^3/s …………	8,480
Range of concentrations sampled by:	
GMA technicians, mg/l …………	13-249
GMA technicians, ton/d…………	76-1,460
Peak flow during flow release, ft^3/s …………	8,590
Periods of faulty record …………	
Turbidity	
April 24, 2015 at 08:00 to April 29, 2015 at 11:45	

Coefficients -- None used.

Continuous Turbidity.-- The turbidity record is incomplete for the computational period. At the end of the 2013 spring flow release the turbidity probe at the site was removed for calibration. The probe was reinstalled April 24, 2015 at 08:00. Additionally, erroneous turbidity data was removed from the record from April 24, 2015 at 08:00 until April 29, 2015 at 11:45, when the probe was out of the water.

For unknown reasons, the turbidity probe returned erroneous NAN values intermittently throughout the computational period. From the time of installation until May 29, 2015 at 01:45, short gaps in the record were filled by linear interpolation. On May 29, 2015 at 01:45, the probe returned NAN values for the remainder of the period.

Once the turbidity record was cleaned, the record was inspected to determine if a turbidity offset was necessary. It was determnined that the probe was not functioning properly at times during which the turbidity record should be at or close to 0.00 FNU and an offset was not able to be determined. No offset was applied.FNU.

During the computational period the maximum turbidity was 52.1 FNU on May 4 at 15:00, and the minimum turbidity was 5.56 FNU, which occurred on May 29, 2015 at 01:45.

Total suspended sediment-discharge computations -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharges.

Size analysis -- Seven cross-sectional, depth-integrated samples were analyzed using a split at 0.063mm and ≥0.50mm.

Partial suspended sediment-discharge computations -- Turbidity versus SSC and discharge versus SSC transport curves were inspected for use during the period. For the <0.063mm, 0.063mm-<0.50mm, and the ≥0.50mm size classes, data collected during from 2011 through 2015 were analyzed, however it was determined that 2015 data showed different transport relationships. For all size classes new transport curves were developed using Water Year 2015 data only.

For the <0.063mm and 0.063-<0.5mm size classes, all 2015 samples were used in turbidity versus SSC transport curve developement.

As was seen in Water Year 2013, analysis of the ≥0.5mm size class showed showed no relationship with turbidity. Samples were plotted against discharge, which showed a good relationship ($r^2 = 0.89$). All 2015 samples, with the exception of pass 2 from 2015-06, which was determined to be an outlier for this size class, were used to develop the discharge versus SSC transport curve.

For the <0.63mm size class, the turbidity versus SSC transport curve is defined by Eqn. (1).

$$SSC = 1.69 * Turbidity + 0, \qquad (1)$$

Eqn. (1) is used from April 29 at 12:00 hours to May 29 at 01:45 hours. Eqn. (1) has a validated range between 3.39 FNU and 41.5 FNU, and was forced through 0. The turbidity record doesn't reach 0.0 on the rising limb, so zero transport, for the <0.063mm size class was estimated during sedigraph analysis at 575 cfs. For the falling limb, zero transport occurs at 0.0 FNU and was determined during transport curve development.

For the 0.063mm-<0.50mm size class, the turbidity versus SSC transport curve is defined by Eqn. (2).

$$SSC = 3.04 * Turbidity - 4.1094, \qquad r^2 = 0.99 \qquad (2)$$

Eqn. (2) is used from April 29 at 12:00 hours to May 29 at 01:45 hours. Eqn. (2) have a validated range between 3.39 FNU and 41.5 FNU. Zero transport for the rising limb was estimated by fitting the sedigraph to sample 2015-01 and occurs at 1.29 FNU. Zero transport for the falling limb was estimated by fitting the sedigraph to sample 2015-07 and occurs at 2.04 FNU.

For the ≥0.5mm size class the discharge versus SSC transport curve developed for the computational period is defined by Eqn. (3).

$$SSC = 7.88332 * 10^{-012} * Discharge^{3.25}, \qquad r^2 = 0.89 \qquad (3)$$

Eqn. (3) is used from April 29 at 12:00 hours to May 29 at 01:45 hours. Eqn. (2) have a validated range between 3,160 cfs and 8,520 cfs. Zero transport for the rising limb was estimated during sedigraph development and occurs at 1,300 cfs. Zero transport for the falling limb was estimated by fitting the sedigraph to sample 2015-07 and occurs at 2,440 cfs.

The tranport curves were used to develop continuous concentration curves for the <0.063mm, 0.063mm-<0.50mm, and the ≥0.5mm size classes during the computational period. Once the continuous concentration data had been developed the sample data were used to adjust the continuous concentration curves so that they passed through all sample points. The continuous concentration curves were adjusted using fitting and proportional fitting techniques.

Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous SSC) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points. Fitting and proportional fitting techniques recognize short-term correlations and address hysteresis effects by using subsets of data. When only a single sample exists on a flow bench, the proportional fitting technique assumes that the determined ratio applies for the duration of that flow bench. When SSC is not highly correlated with discharge or turbidity, it is not possible to evaluate this assumption and therefore it is a potential source of error

Suspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

Bed material -- None.

Bedload measurement – Thirteen bedload samples were collected during the Spring Flow Release. Samples 2015-01 and 2015-11 were single pass samples, the rest were two pass samples.

Bedload-discharge computations -- The sample analysis contains the portion of sample <0.5mm but the total bedload discharge was determined by summing the partial discharges for the ≥0.5mm-8mm and the ≥8mm size fractions.

Partial Bedload-discharge computations -- Sediment transport curves were developed and partial bedload discharges were computed for the 0.5mm-<8mm and ≥8mm size classes. In previous years, sediment transport curves were developed for the rising and falling limbs in order to define the hysteresis observed at the site. However, during 2015, no obvious pattern of hysteresis was observed, so a single generalized curve was developed for each size class. No outliers were identified during analysis of either size class.

For the 0.5mm-<8mm size class, the transport curve developed for use during the computational period is defined by Eqn. (4).

$$BLD = 0.00837074 * \left(Discharge - 2200\right)^{1.20}, r^2 = 0.94 \qquad (4)$$

The transport curve is used from April 1 at 00:00 hours through July 31 at 23:45 hours. The transport curve has a validated range between 3,220 cfs and 8,480 cfs. Zero transport was determined during transport curve development and occurs at 2,200 cfs for both the rising and falling limb.

For the ≥8mm size class, the transport curve developed for use during the computational period is defined by Eqn. (5).

$$BLD = 0.00526039 * \left(Discharge - 2800\right)^{1.31}, \qquad r^2 = 0.89 \qquad (5)$$

The transport curve is used from April 1 at 00:00 hours through July 31 at 23:45 hours. The transport curve has a validated range between 3,220 cfs and 8,480 cfs. Zero transport for the rising limb was estimated by fitting the transport curve to sample 2015-01 and occurs at 3,300 cfs. Zero transport on the falling limb was estimated during transport curve development and occurs at 2,800 cfs.

Once the continuous bedload-discharge traces were developed using the above transport curves, they were adjusted using the sample values using the same techniques as was described for the partial suspended-sediment discharge computations. Due to the inherent high variability in bedload sampling, during flow benches, sample values were averaged on days where multiple samples were collected to produce average transport values. These average transport values were used to adjust the continuous bedload transport trace.

Remarks. – The suspended sediment discharge record is rated as follows:

April 1 (00:00) to May 2 (23:45)	Estimated
May 3 (00:00) to May 9 (23:45)	Good
May 10 (00:00) to July 31 (23:45)	Estimated

The bedload discharge record is rated as follows:

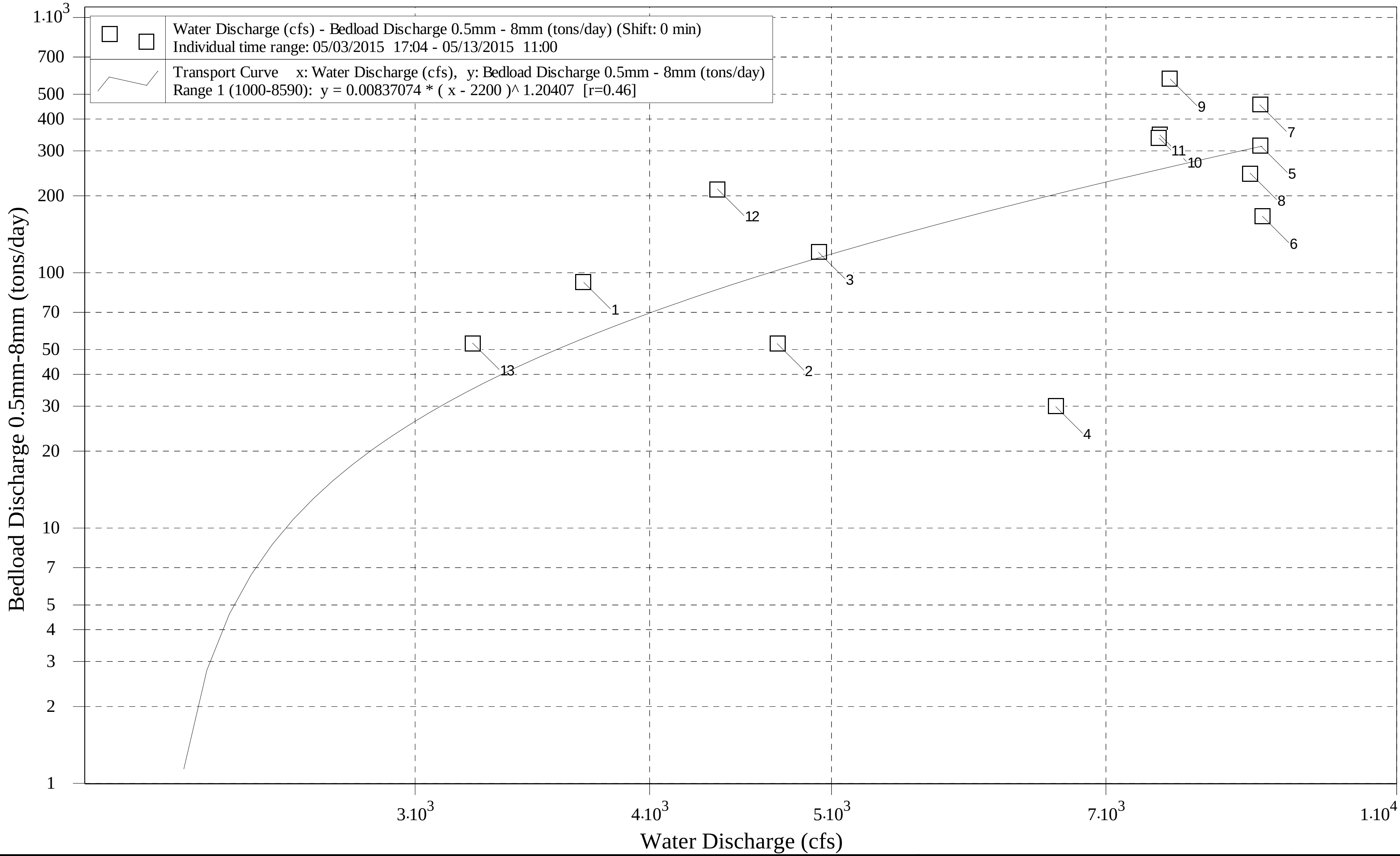
April 1 (00:00) to May 2 (23:45)	Estimated
May 3 (00:00) to May 9 (23:45)	Good
May 10 (00:00) to July 31 (23:45)	Estimated

Computed by: Brooke Pittman, December

2015 Reviewed by: S. Pittman, January 2016

TRINITY RIVER AT DOUGLAS CITY --11525854

Water Discharge (cfs) Versus Bedload Discharge 0.5mm-<8mm (tons/day): Spring Flow Release WY 2015



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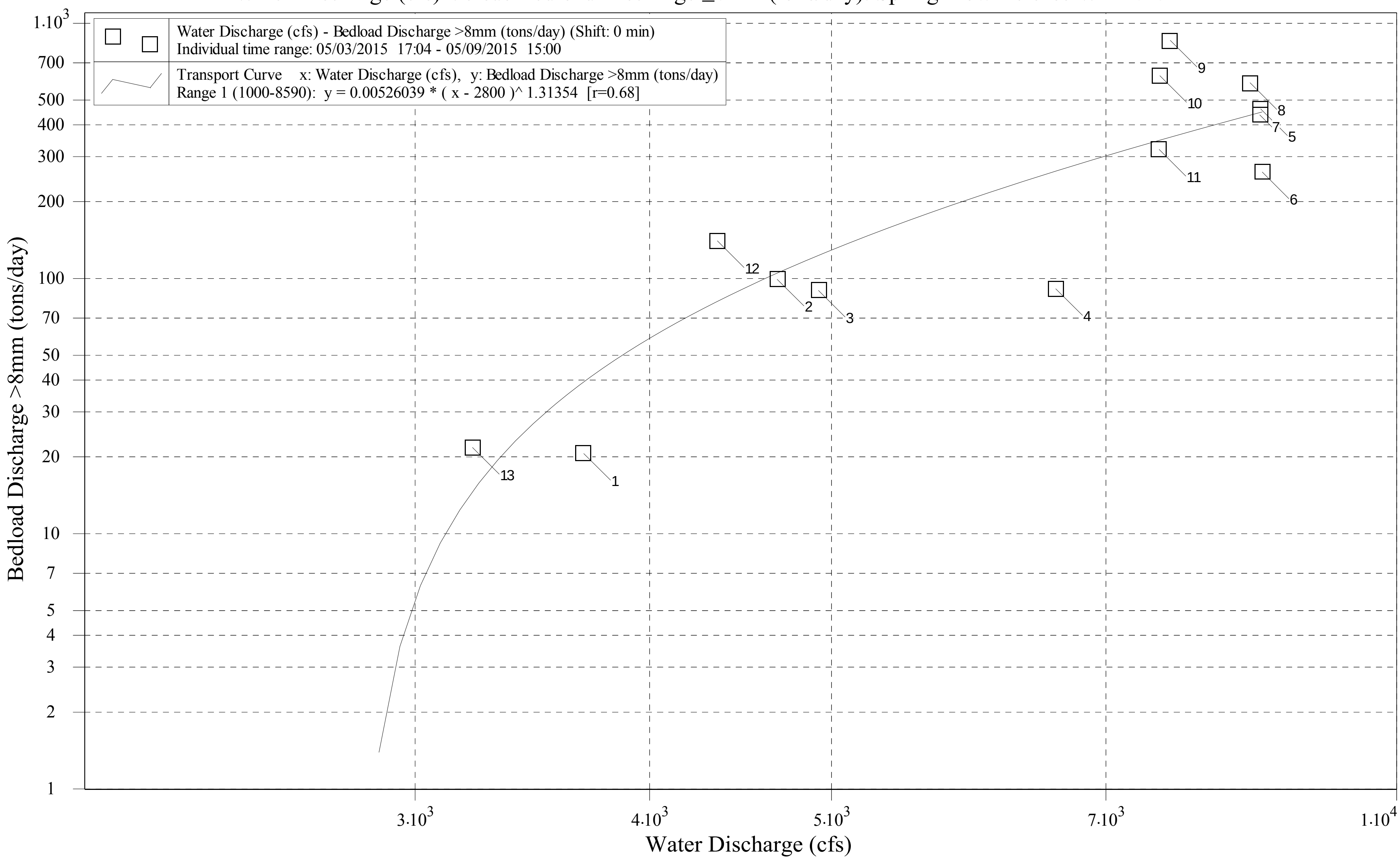
TRINITY RIVER AT DOUGLAS CITY --11525854

Water Discharge (cfs) Versus Bedload Discharge ≥8mm (tons/day): Spring Flow Release WY 2015



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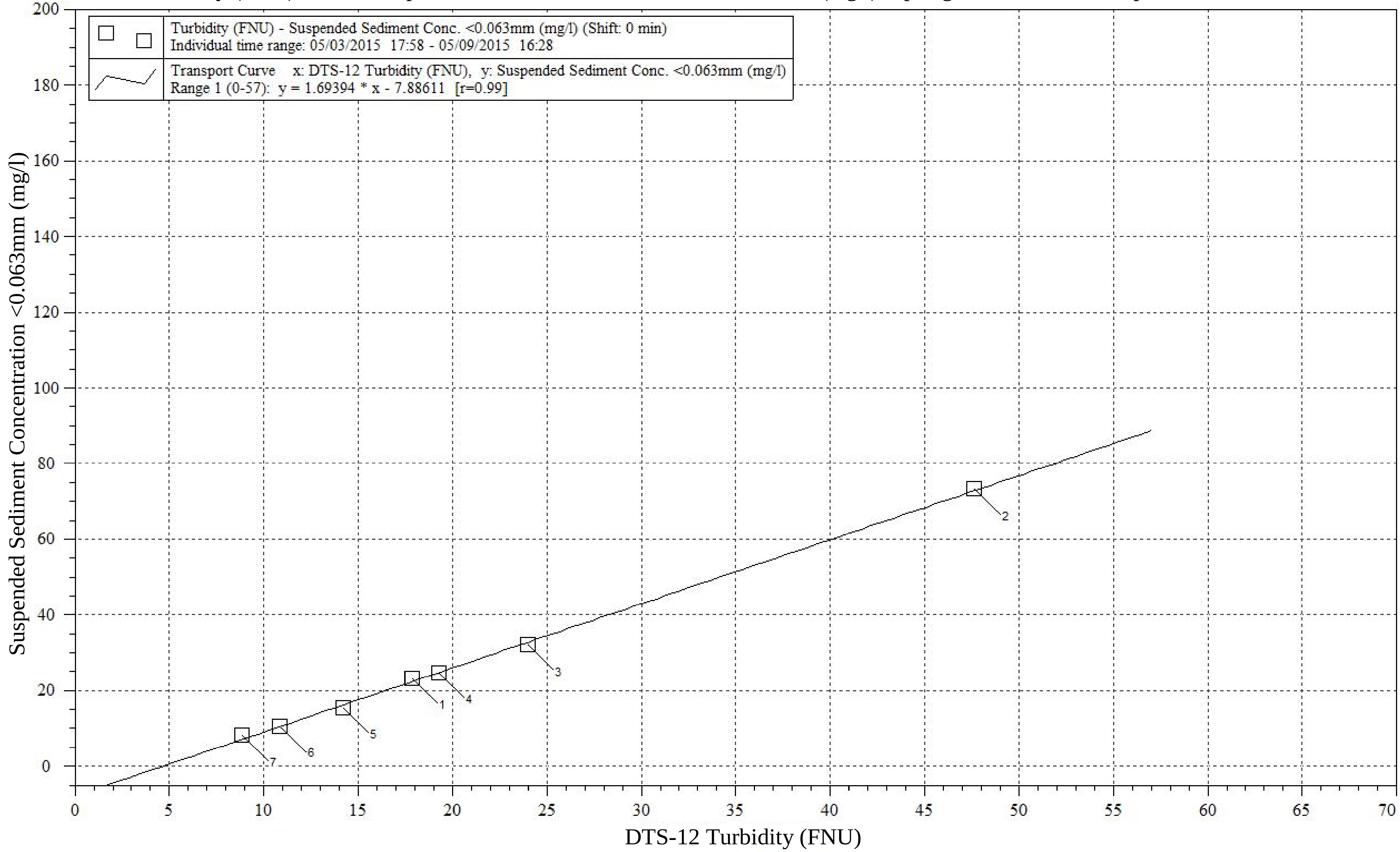
TRINITY RIVER AT DOUGLAS CITY –115525854

Turbidity (FNU) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release Samples WY2015



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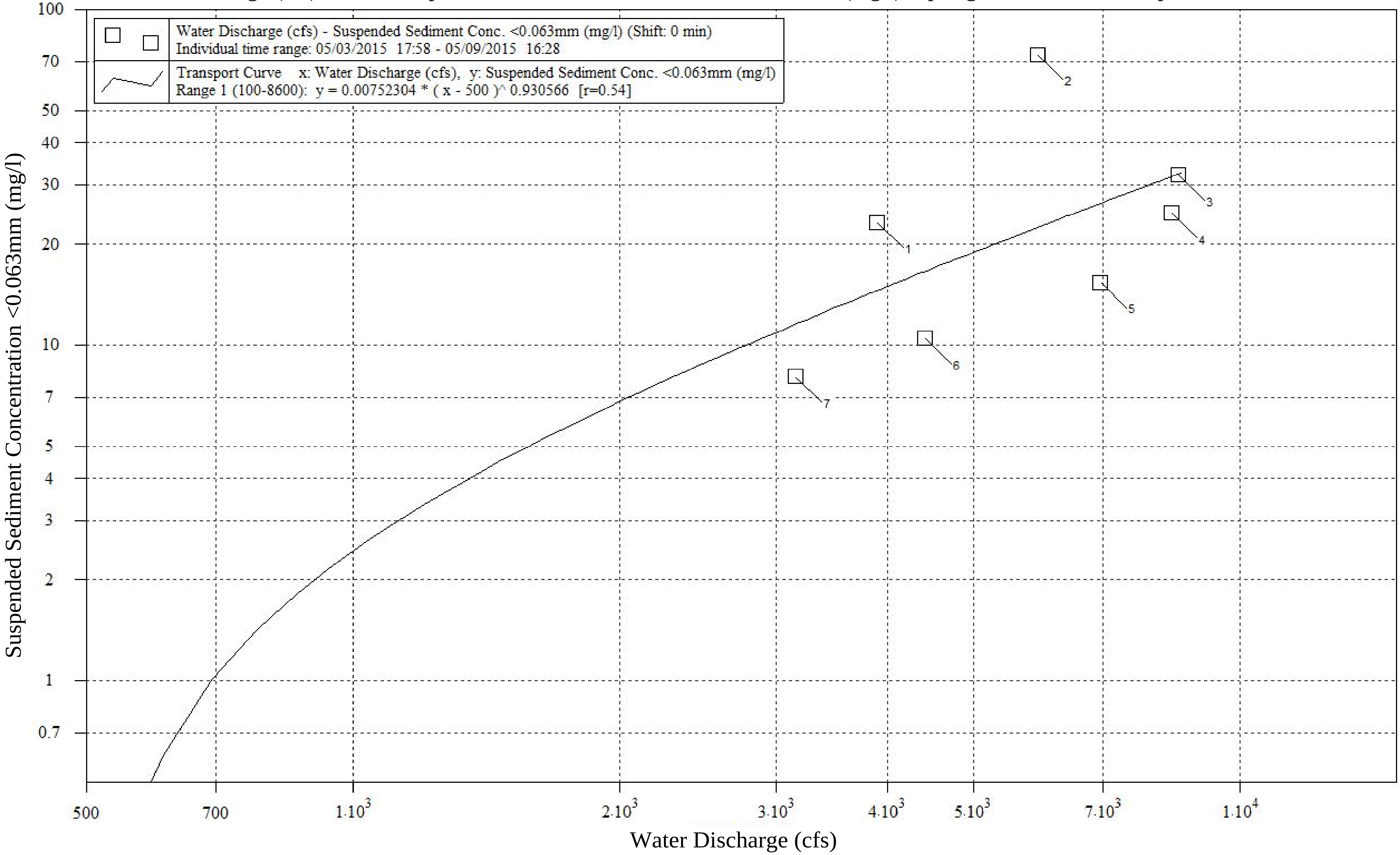
TRINITY RIVER AT DOUGLAS CITY –115525854

Water Discharge (cfs) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release Samples WY2015



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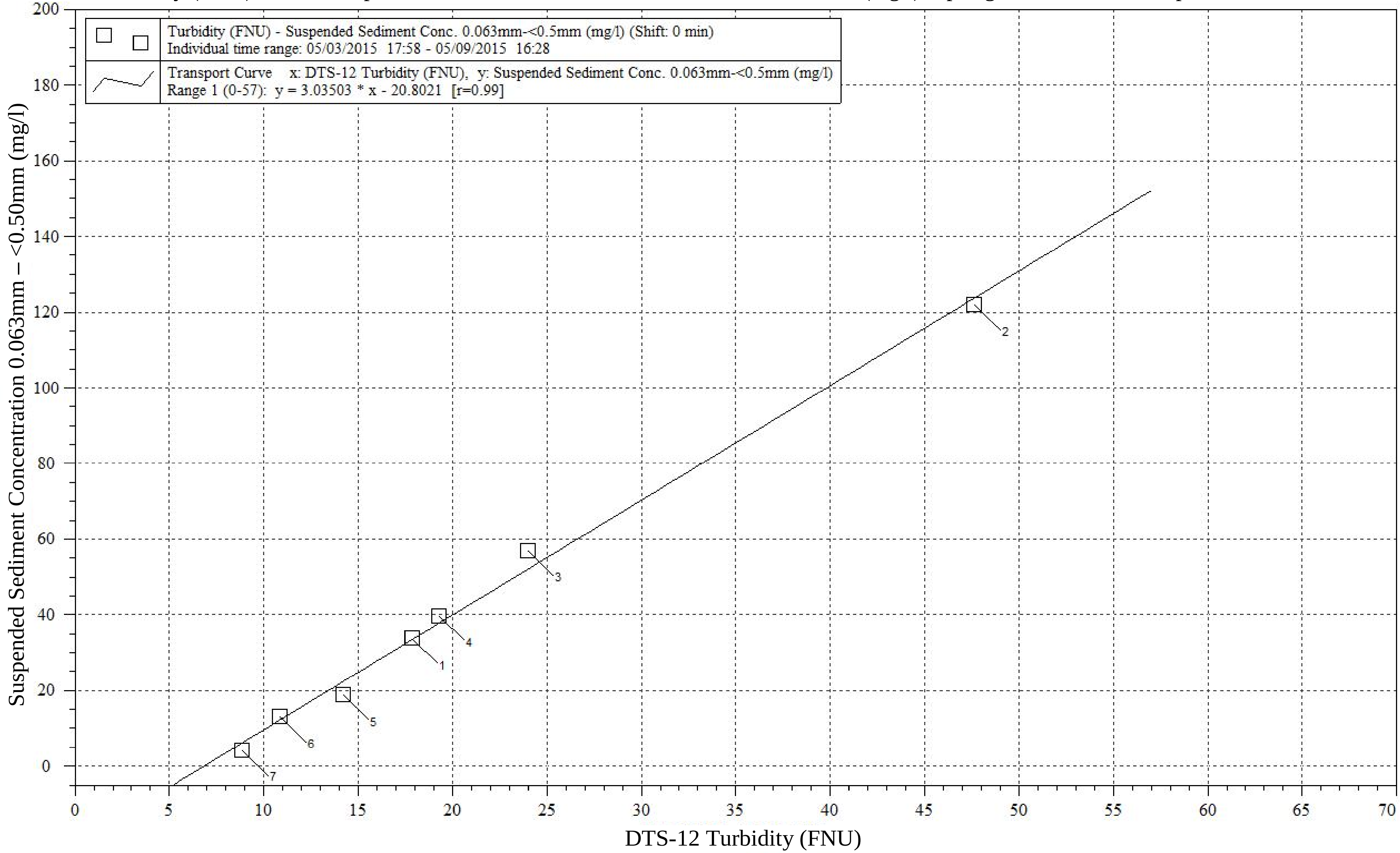
Turbidity (FNU) Versus Suspended Sediment Concentration 0.063mm-<0.50mm (mg/l): Spring Flow Release Samples WY2015



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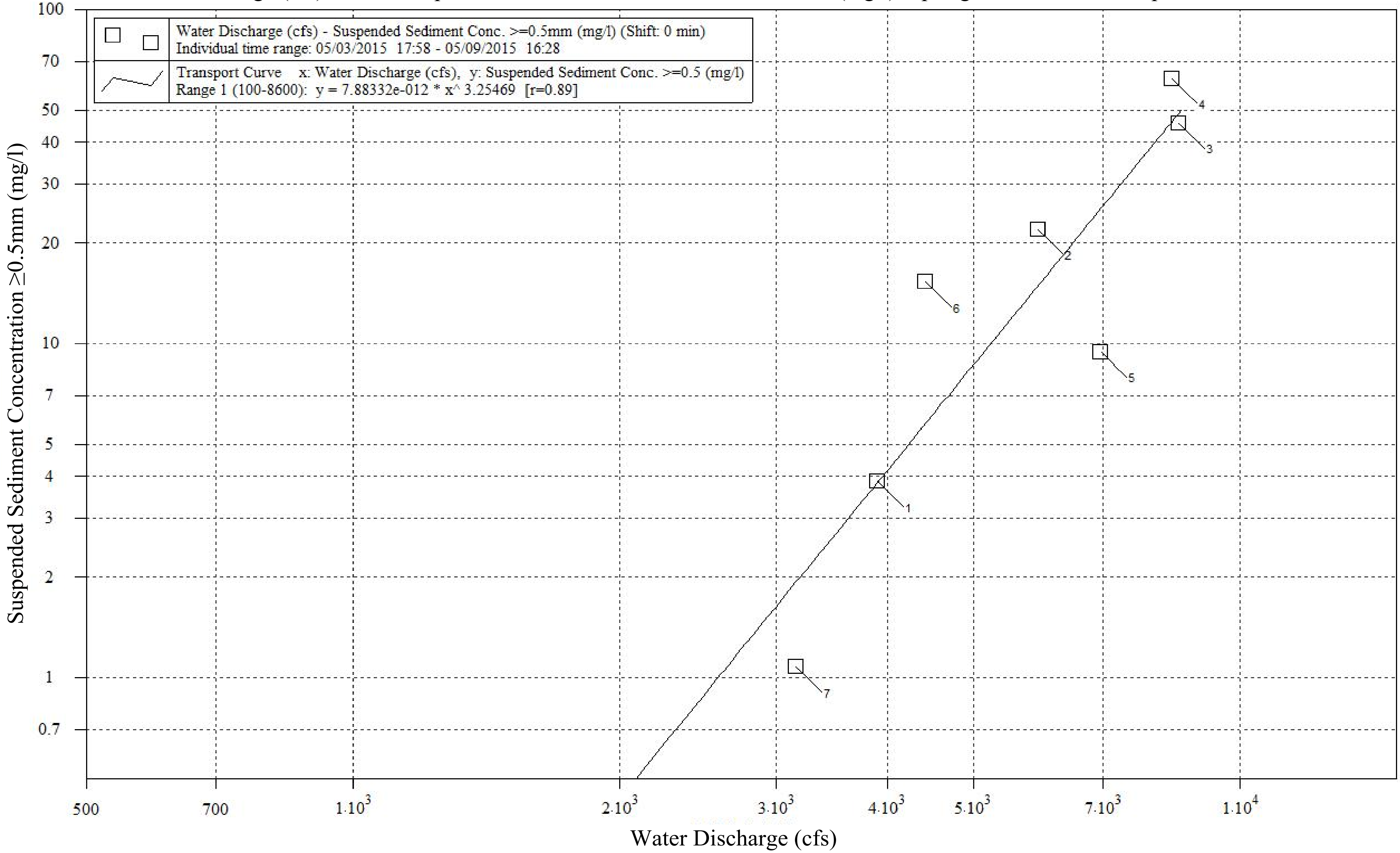
TRINITY RIVER AT DOUGLAS CITY –115525854

Water Discharge (cfs) Versus Suspended Sediment Concentration ≥0.50mm (mg/l): Spring Flow Release Samples WY2015



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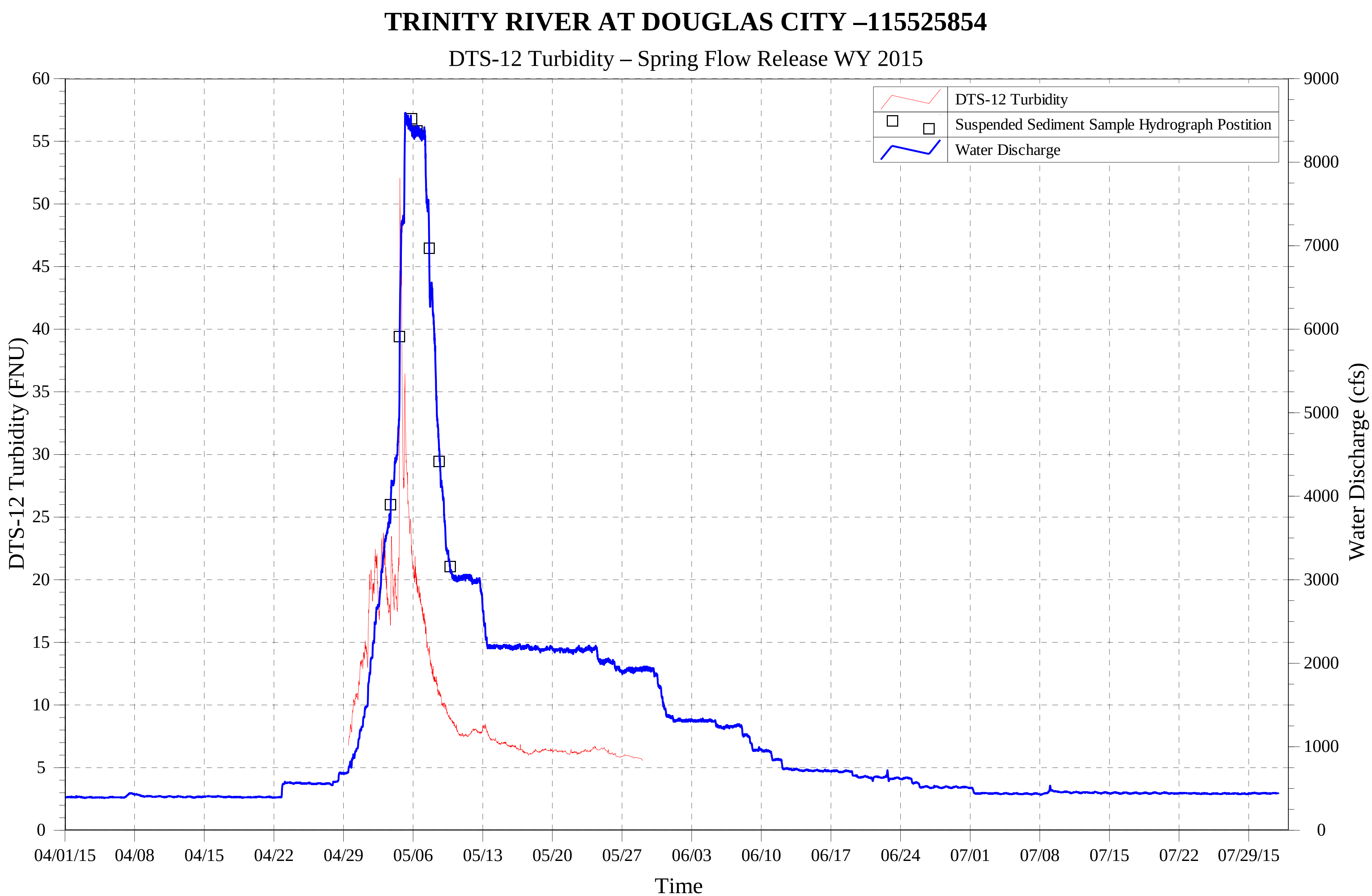

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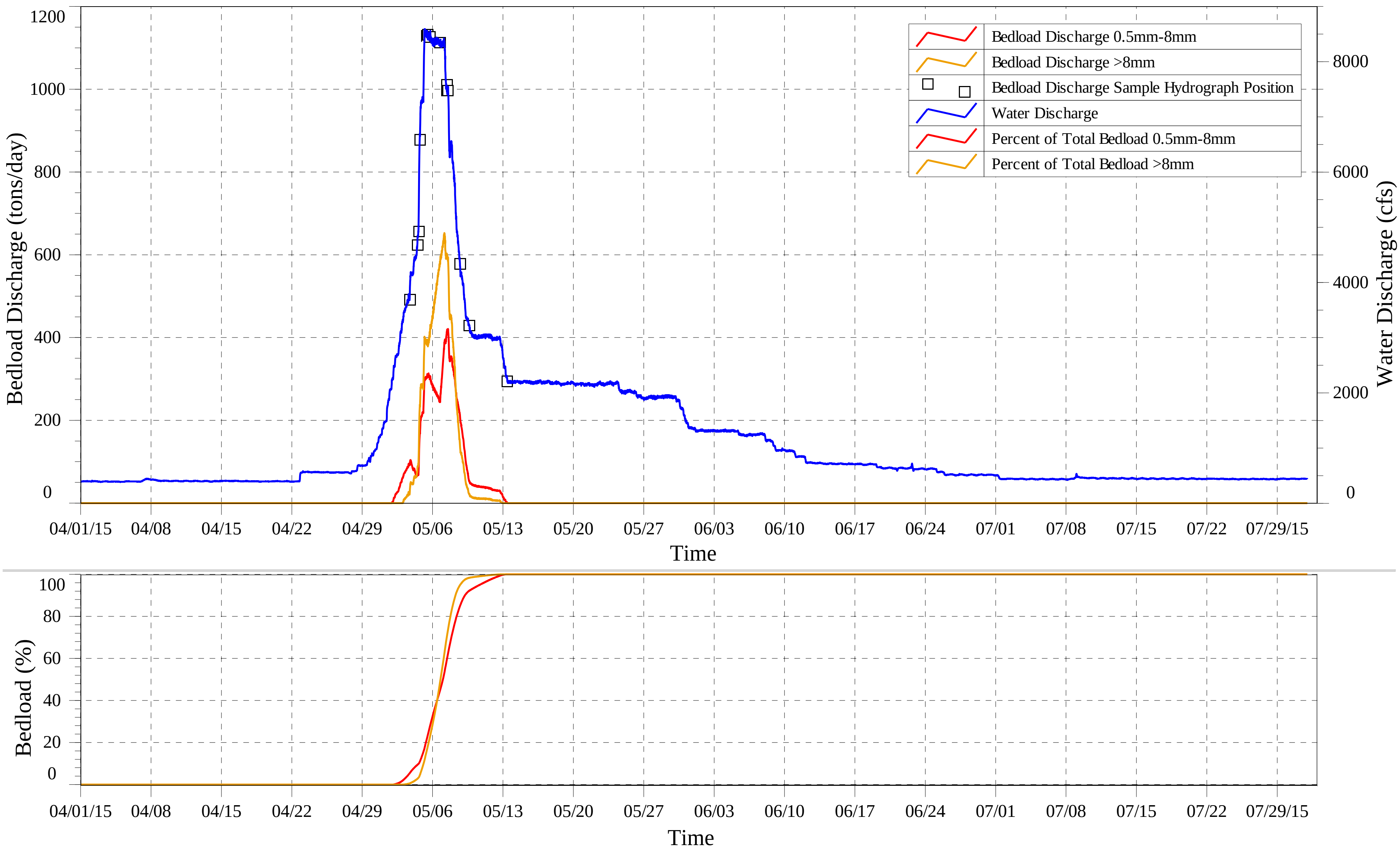
Bedload Discharge – Spring Flow Release WY 2015



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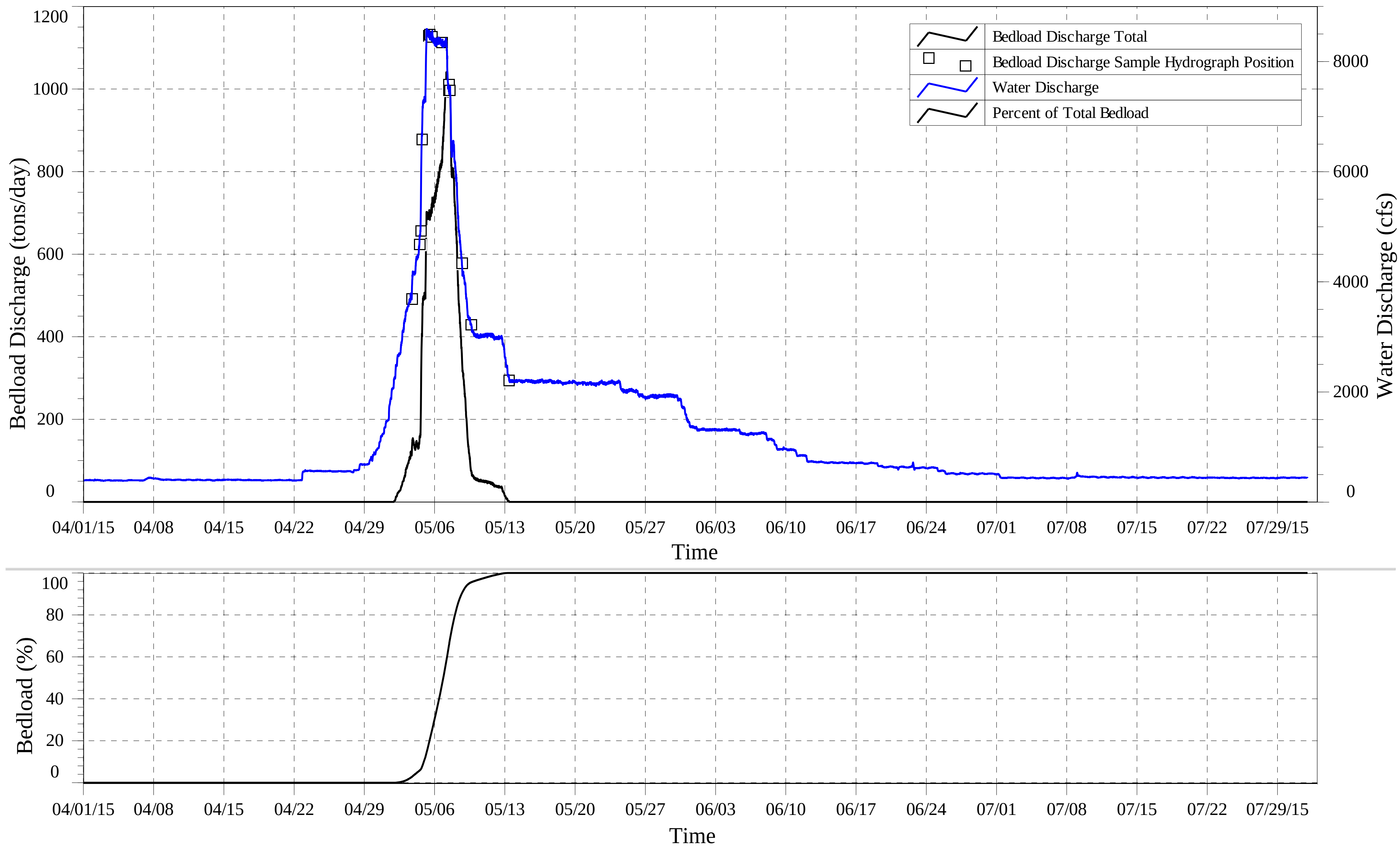
TRINITY RIVER AT DOUGLAS CITY –115525854

Bedload Discharge – Spring Flow Release WY 2015



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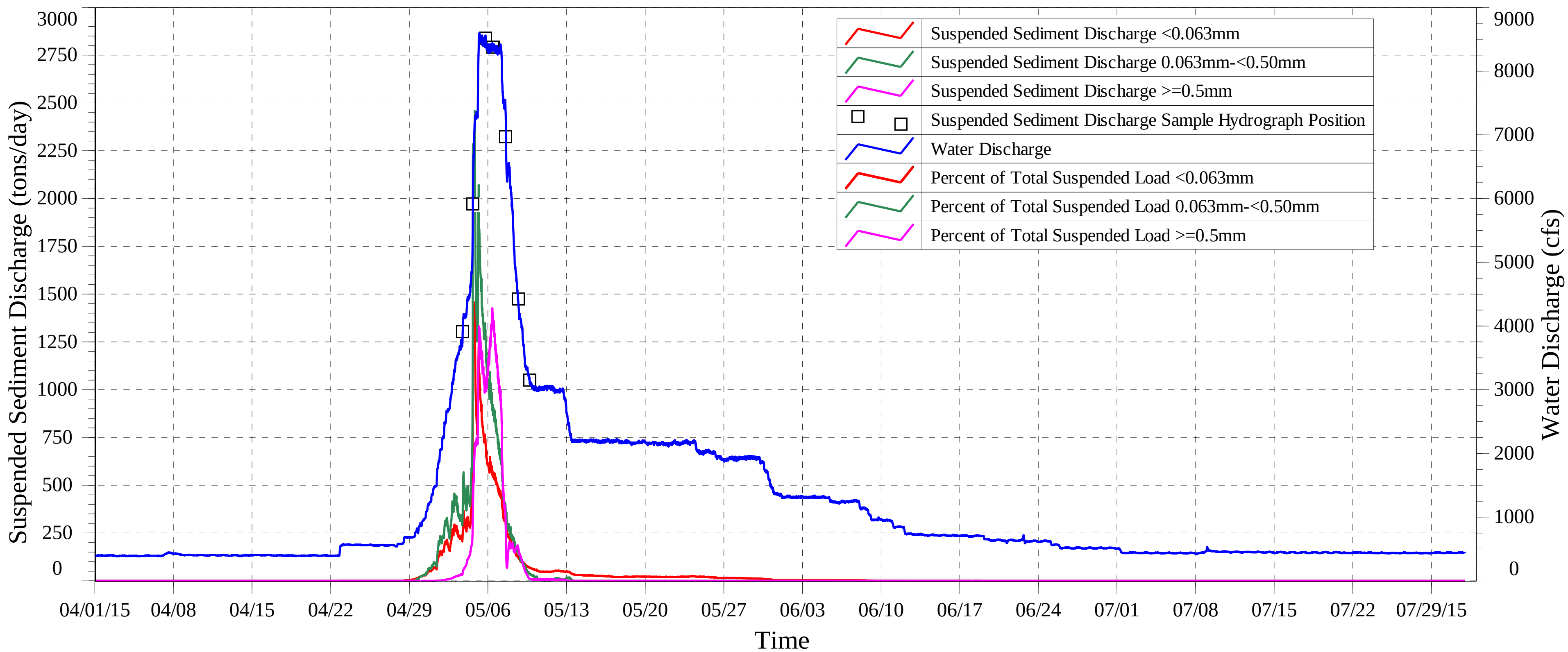
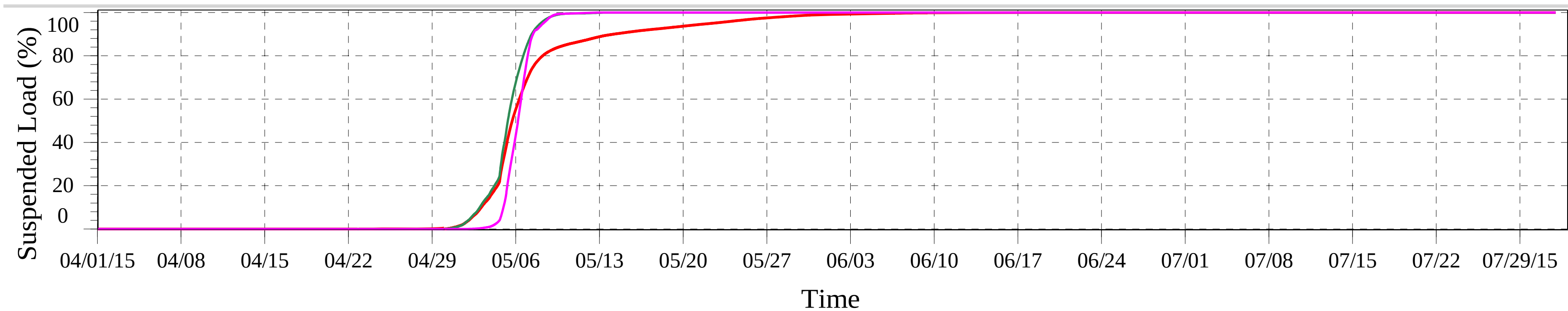
TRINITY RIVER AT DOUGLAS CITY –115525854

Suspended Sediment Discharge – Spring Flow Release WY 2015





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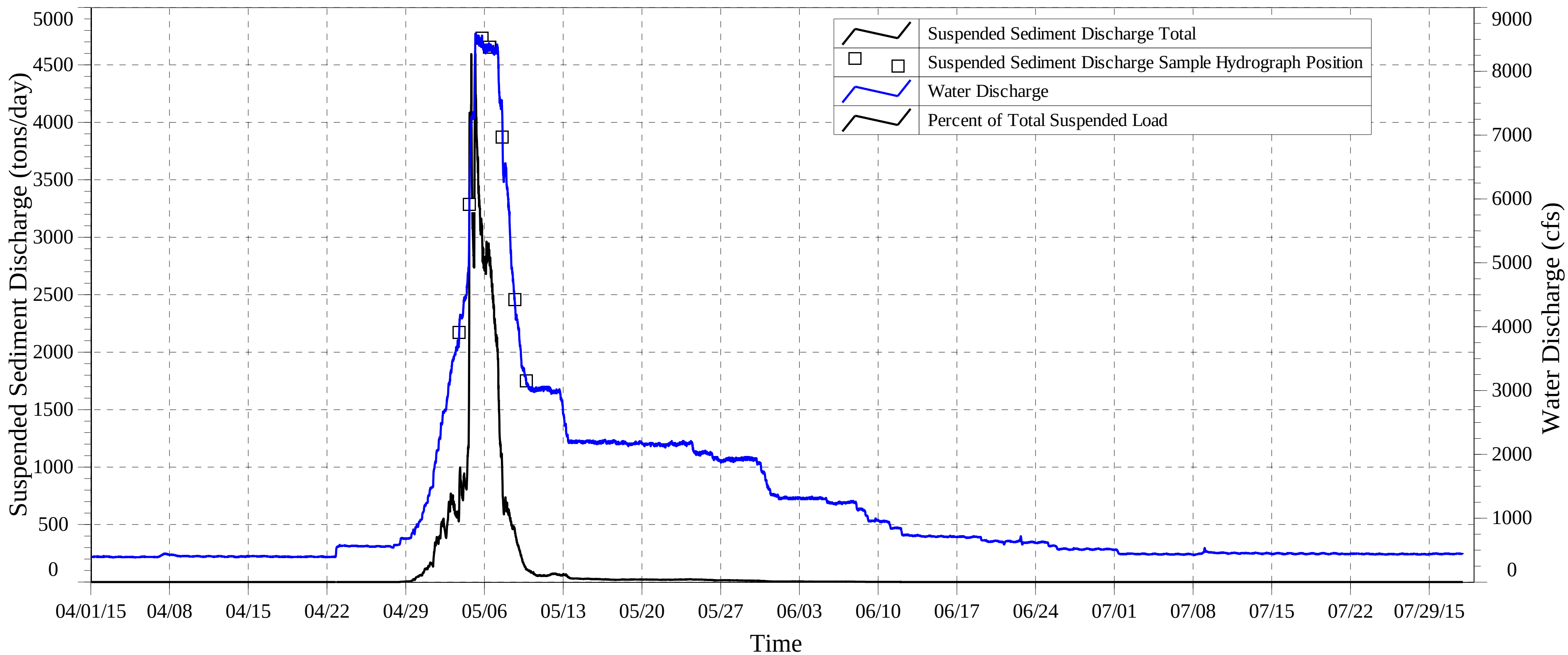
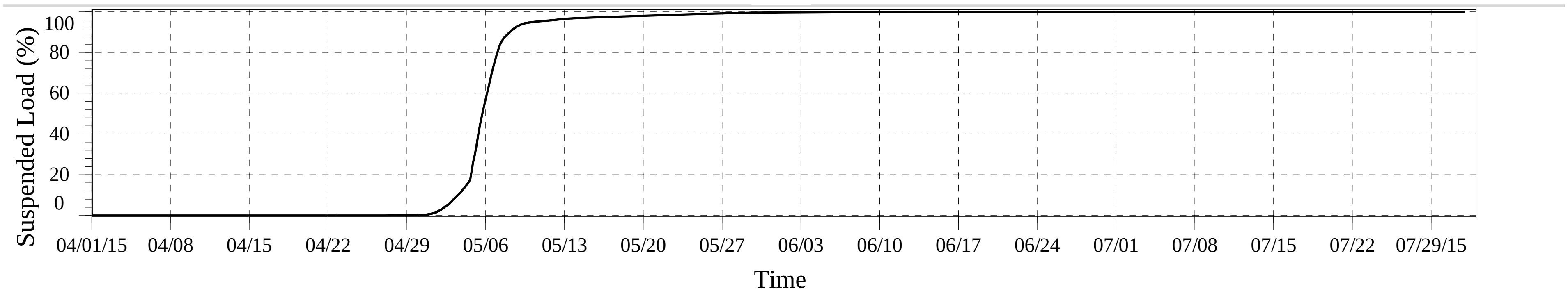
TRINITY RIVER AT DOUGLAS CITY –115525854

Suspended Sediment Discharge – Spring Flow Release WY 2015





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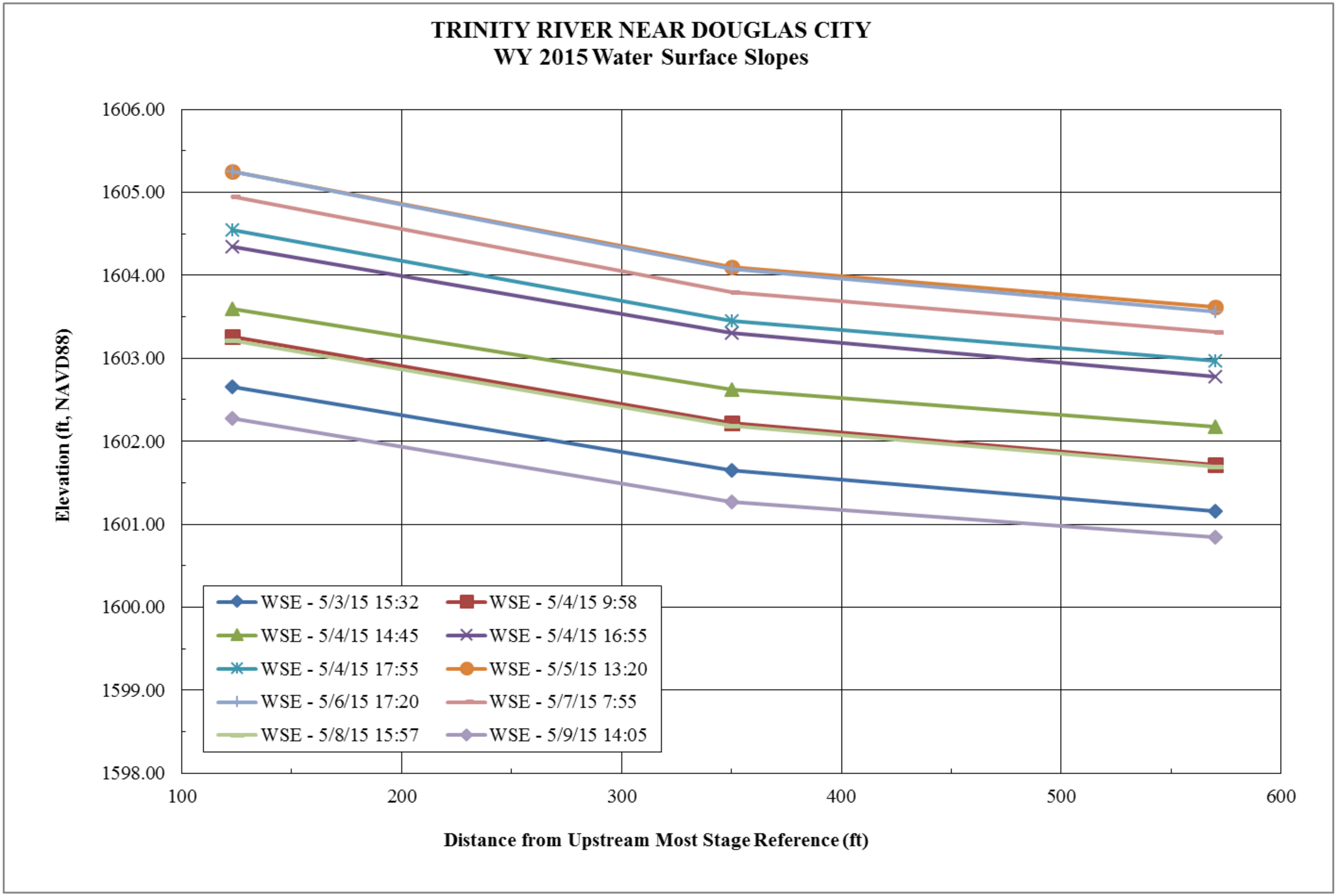

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