SEDIMENT AUGMENTATION
FINAL PILOT STUDY REPORT

Prepared for

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

April 2014

Prepared by

The Flatwater Group, Inc.
In association with
HDR Engineering, Inc. and Tetra Tech, Inc.

TABLE OF CONTENTS

1. Pilot Study Critical Summary

A Sediment Augmentation Experiment Alternatives Screening Study (Screening Study) was conducted to evaluate alternatives to reduce the approximately 150,000-ton/year average annual sediment deficit in the Platte River reach between Lexington and Odessa, Nebraska. The Screening Study recommended that a Pilot Study be conducted to evaluate the means and methods of sediment augmentation as a way to reduce uncertainties associated with full-scale implementation. The Pilot Study management action was intended to introduce 100,000 tons (80,000 yd^3) of sediment into the project reach each year for 2 years (2012 and 2013). The results of the Pilot Study will be used to inform the Platte River Recovery Implementation Program (Program or PRRIP) on considerations for full-scale sediment augmentation.

Two locations within the reach and two different methods of sediment augmentation were selected for the management action. The first location was at the Program's Dyer Property, located just west of the Overton Bridge. A sand pumping operation was used to introduce material produced by expanding an existing sand pit on the property. The material was screened to the desired gradation and was directly introduced into the river via a discharge pipe. The second augmentation location was at Cottonwood Ranch (CWR), where mechanical placement (that is, a bulldozer) was used to move material presently located within the river banks and augment, or push, this material into active flow areas.

Performance indicators and impact triggers were developed to assist the Program with decision making during and after the management action. In addition, decision criteria and actions were established in the event that the triggers were initiated. These triggers were primarily rooted in data collection to include channel survey data, materials testing, river flow information, and photographic/video evidence. The data collection provided insight into the placement and fate of the augmented material as well as real-time information to assess potential negative impacts on adjacent property owners resulting from the sediment augmentation. The decision criteria were set up to help guide the Program during implementation of the management action and to inform decision makers whether to proceed with the action, stop the action, modify the action, or adjust the monitoring associated with the action (see Section 2).

The Pilot Study management action commenced in September 2012 and concluded in June 2013. Phase I was conducted from September to December 2012, and Phase II was conducted from April to June 2013. Monitoring of the operation spanned 13 months, including pre- and post-sediment introduction data collection.

At Dyer, approximately 25,000 tons of sediment was augmented during Phase I (see Sections 4.1 and 5.1). During Phase I, the pipe outfall remained in a relatively static location near the right channel bank, and pumping was generally timed to coincide with higher return flows from J-2. The bulk of the sediment accumulated in the vicinity of the discharge location. A combination of lower flows and the limited ability to distribute the material during pumping resulted in the decision to mechanically redistribute the accumulated material prior to Phase II. During Phase II the decision was made to allow the contractor to stockpile material in the river in anticipation that mechanical manipulation would be required to better distribute the material. The contractor also pumped approximately twice as many days during Phase II. A total of approximately 57,000 tons were placed during Phase II. The stockpiled material placed during Phase II was mechanically redistributed after pumping ceased. The cost to pump the material into the river during both Phases I and II was $498,400, which is $6.08 per ton. Approximately half of the cost is associated with sorting the material. The mechanical manipulation of the pumped material added $34,200 to the cost of the project for a project total of $532,600. No impact triggers were initiated during or immediately after Phase I. However, the stage change trigger moved into Class II at the U.S. Geological Survey (USGS) gage near Overton, Nebraska, on April 13, 2013, during Phase II. Prior to increasing monitoring frequency from monthly to bi-weekly, the trigger was back below the Class II threshold criteria on April 16, 2013, at Overton.

At CWR, approximately 75,000 tons of material was placed in the river during Phase I (see Sections 4.2 and 5.2). As at Dyer, low flow proved challenging for augmentation entrainment, and the augmented material accumulated along the edge of the source material. A channel was excavated along the edge of the source material to promote entrainment during Phase II. Approximately 25,000 tons of material was excavated and placed in the river. The cost per ton of augmented material for CWR was $1.76, for a project total of $176,200. No impact triggers were initiated during or after Phase I or Phase II.

The key issue encountered during the Pilot Study was low flows, which necessitated greater spatial distribution of the augmented material to promote entrainment. Flows during Phase I were at or near the median flow, while flows during Phase II were below the 75% exceedance probability. Approximately 182,000 tons of material were placed in the river during Phase I and Phase II (over approximately 9 months), while the average annual sediment deficit is approximately 150,000 tons/year based on a 12.5 year sediment transport model simulation (that is, hydrology from October 1, 1989, through April 1, 2002). However, the benefit is that this provided a snapshot of how augmentation would perform during dry hydrologic conditions.

Several uncertainties remain. Two of those uncertainties include how the augmented material will be transported downstream during less extreme flow conditions and whether the augmented quantity and gradation is sufficient to arrest the average annual deficit of 150,000 tons/year.

The following table summarizes the pros and cons of the means and methods of sediment augmentation evaluated during the Pilot Study:

Location (method)	Pros	Cons
Dyer (pumping)	• Maximizes volume of source material per surface acre disturbed. • Minimizes disturbed area. • Ability to manage material gradation. • Potential to provide multiple benefits, such as Off Channel Sand and Water nesting habitat.	• High unit cost. • More labor/equipment intensive. • Difficult to match augmentation rates to flows during low flows. • Low spatial flexibility (point source operation)
CWR (pushing)	• Has a low unit cost. • Distributes material more efficiently. • Potential to provide multiple benefits, such as channel widening or in-channel nesting habitat. • Flexibility/adaptability in location and approaches.	• Low material per surface-acre disturbed. • Limited work during high flows when source area inundated. • Requires an increased haul distance from source area during extremely low flows. • No ability to control gradation.

As discussed with Program staff, several other options for full-scale augmentation are provided for consideration by the Program. Options that include pumping as part of the operation will maximize source material per disturbed acre and may provide an increase in nesting or habitat area over time. However, pumping options will have higher unit costs, and are more labor and equipment intensive. Options that include pushing as part of the operation will have a low unit cost, can increase habitat or flow area, and allow for more efficient distribution of material. However, the low-cost source area may be limited by depth as well as distance, which may affect unit costs if source material below depths that can be easily accessed by bulldozers is needed. The following is a list of other pump and push options:

Pumping Options	Pushing Options
Dyer Property – Mine and pump to river (no sorting)	Cook Property – Push material directly into river
Dyer Property – Mine and haul to river	Overton Bridge to CWR – Channel widening
Adjacent sandpit operators	

2. BACKGROUND

A Screening Study (The Flatwater Group, Inc. [TFG] et al. February 2011), developed for the Program estimated that the average annual sediment deficit in the project reach (that is, from Lexington to Odessa) is approximately 150,000 tons/year based on a 12.5-year sediment transport model simulation (hydrology from October 1, 1989, through April 1, 2002). The Screening Study recommended a Pilot Study, the objective of which was to collect and evaluate data associated with the means and methods of introducing sediment in order to provide the foundation for full-scale sediment augmentation. The Pilot Study management action was designed to introduce 100,000 tons (80,000 yd^3) of sediment into the project reach each year for two (2) years. Two locations within the reach and two different methods of sediment augmentation were identified for the management action, as follows:

- Sand pumping was tested at the Program's Dyer property, where approximately 50,000 tons of sediment was proposed to be mined on site and pumped into the river each year (Figure 1).
- Mechanical placement was tested at CWR as a continuation of the grading activities that have been performed by Nebraska Public Power District (NPPD) and the Program over the past several years. The management action proposed directly pushing approximately 50,000 tons of sediment into the river each year from existing sand bars within the river or overbank areas adjacent to the river (Figure 2).

During Pilot Study planning, it was anticipated that Year 1 augmentation would occur in fall 2012 and Year 2 augmentation would occur in fall 2013. However, later in the planning phase, this schedule was modified because of projected dry conditions and low river flows (both natural flows and J-2 return flows). Under the revised schedule, the two augmentation time frames were referred to as Phase I and Phase II. Phase I augmentation would occur in fall 2012 after irrigation season and run until winter conditions necessitated shutting down pumping operations. Then Phase II augmentation would begin in late winter or early spring 2013, when weather conditions warmed enough to re-establish pumping operations. This would allow Phase II implementation to occur during higher springtime flows and prior to the start of irrigation season. Short-duration medium flow (SDMF) releases were also anticipated in the spring, and the Project Team wanted to ensure that there would be sufficient augmented sediment in place to evaluate transport mechanisms related to the augmented sediment.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_1.mxd\apr14\jcm

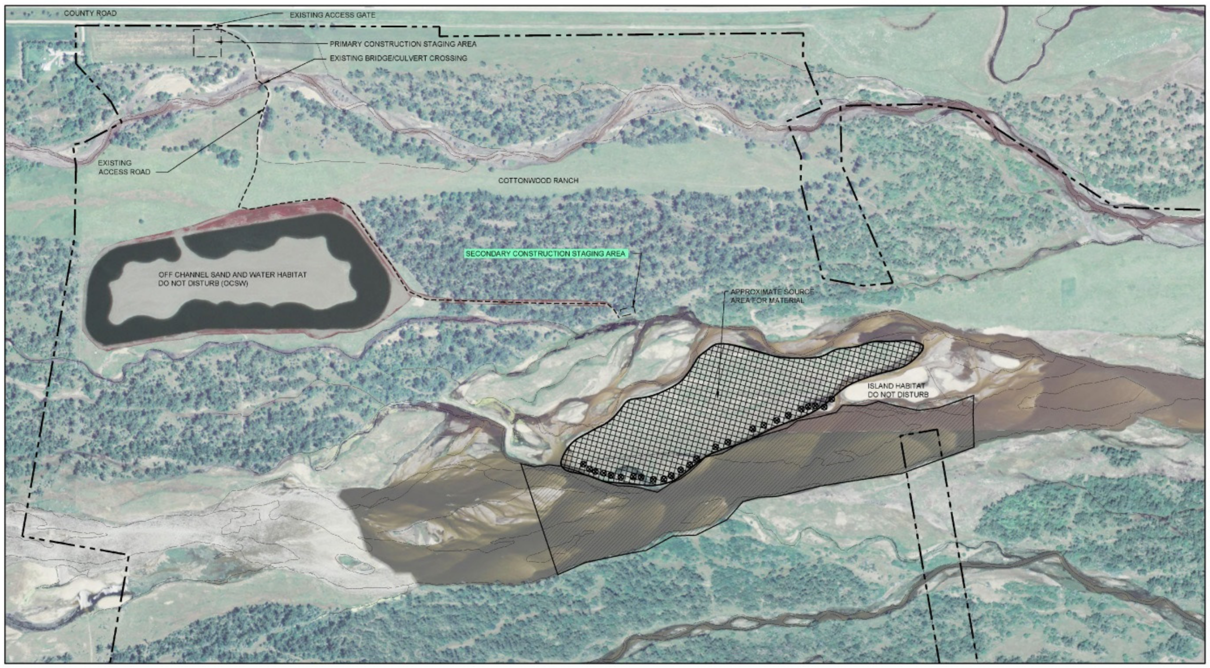
Dyer Property

Sediment Augmentation Final Pilot Study Report

DATE
April 2014

FIGURE
1

1



COTTONWOOD RANCH SITE PLAN

300' 0 300'

LEGEND

- COOK TRACT, DYER PROPERTY AND COTTONWOOD RANCH PROPERTY BOUNDARY LINES
- OTHER PRRIP PROPERTY BOUNDARY LINES
- ACCESS ROUTE TO AUGMENTATION LOCATIONS
- CONSTRUCTION STAGING AREA BOUNDARY
- GENERAL LOCATION OF AUGMENTATION AREAS
- SOURCE AREA
- 2011 SURVEY POINTS SHOWING EDGE OF ISLAND
- ACTIVE CHANNELS (VARIES)

Cottonwood Ranch Property

Sediment Augmentation Final Pilot Study Report

THE FLATWATER GROUP INC.

HDR

TETRA TECH

DATE

April 2014

FIGURE

2

1

The condensed Phase I and Phase II augmentation schedule required decision-making primarily during Phase I implementation with the available data that were being collected rather than relying on a longer monitoring time frame. As this was a means and methods Pilot Study, this on-the-go decision making was conducive to informing the Program of the challenges and approaches that need to be incorporated to sediment augmentation strategies during the lowest flow conditions. The results from the monitoring program (TFG et al. July 2012b) that continued through August 2013 will help guide the Program in future decision making regarding the feasibility of conducting long-term full-scale sediment augmentation.

Performance indicators and impact triggers were developed to assist the Program with decision making during and after the management action. In addition, decision criteria and actions were established in the event that the triggers were initiated. These are detailed in the Revised Final Pilot Scale Management Action Technical Memorandum (TM) (TFG et al. July 2012a). The decision criteria were set up on a “reach scale” basis (on the order of miles) to help guide the Program during implementation of the management action and to inform decision makers whether to proceed with the action, stop the action, modify the action, or adjust the monitoring associated with the action. The performance indicators established for the Pilot Study and the methods for measurement are listed in Table 1. A full description of the monitoring plan can be found in TM Appendix A, Pilot Study Monitoring Plan (TFG et al. July 2012b).

Table 1 – Performance Indicator Measurement Method(s), Location(s), and Frequency

Performance Indicator	Measurement Method(s)	Location(s)	Frequency
Stage-Discharge Relationship	Pressure transducers and gages	Upstream of discharge on south channel; Near Todd Brown property on north channel; Overton gage; CWR	Pre-, during, and post-augmentation for approximately 4 to 6 weeks
Bed Elevation	Topographic and bathymetric surveys; Photographic documentation	Five sections at Dyer Property at ~1,000-foot spacing; Program Anchor Points (APs) 29-34	Dyer sections: Pre- and post-augmentation, and monthly for 9 months AP section: Pre- and post-runoff
Bed and Bar Gradation	Bed and bar material sampling	Five sections at Dyer Property at ~1,000-foot spacing; Program APs 29-34	Dyer sections: Pre- and post-augmentation, and monthly for 9 months AP section: Pre- and post-runoff

The TM (TFG et al. July 2012a) defines three classes of stage and bed elevation changes for purposes of identifying management action triggers:

- Class I – The observed data point falls within the scatter of the measured gage data, indicating that augmentation has not significantly affected stage or bed elevation, and no action is required.
- Class II – The observed data point falls outside the scatter of the measured data but is less than the predicted maximum envelope, indicating that it has affected the stage or bed elevations, but effects are within the levels predicted by the hydraulic and sediment transport model. No immediate action is required, but the intensity of monitoring increases to more closely monitor for unanticipated impacts.

- Class III – The observed data point is greater than the predicted maximum envelope, indicating that augmentation has significantly affected the stage beyond the levels predicted by the model, and immediate action is required to avoid damages.

2.1 Data Collection Background

A monitoring and data analysis plan (TFG et al. July 2012b) was developed for the Pilot Study (or Pilot Project) to understand the response of the project reach to the augmented sediment and to assess the potential for adverse impacts upstream and downstream of the primary project area. The amount of sediment added to the river at the Dyer Property via pumping during the Pilot Project was projected to be small relative to the typical annual sediment loads. Therefore, the monitoring plan for the Dyer Property was designed to focus on the reach within 1 to 2 miles of the sand pumping operation outfall. At CWR, the Program and others have conducted extensive monitoring at and downstream of the CWR reach, and these activities continued during the Pilot Project. As a result, no specific additional monitoring was included in the monitoring and data analysis plan for CWR. As such, the data collection procedures and, particularly, the data assessment focused on the sand pumping management action activities at the Dyer Property.

The management action was implemented in two phases. Phase I occurred in the fall 2012, and Phase II occurred in the spring/early summer 2013. Phase I monitoring was initiated following Phase I augmentation. Shortly after Phase I augmentation (that is, in approximately 3 months), Phase II augmentation started. Therefore, monitoring was continuous from its initiation after Phase I, through Phase II augmentation, and following Phase II, for a total of 9 months (that is, through August 2013).

2.2 Data Collection and Procedures

The monitoring program for the Pilot Project followed the guidelines in the PRRIP Project-scale Geomorphology and Vegetation Monitoring Protocol (PRRIP 2011) for collecting and analyzing specific types of data. For the Pilot Project, the following data types were collected:

- Topographic/bathymetric data, including both the aggradation/degradation response of the river bed and lateral migration. The topographic/bathymetric data were collected using global positioning system (GPS) and total station equipment.
- River stage at key locations and discharges. Pressure transducers were installed at the Dyer Property (south channel) and adjacent to the Todd Brown Property (north channel) approximately 1 mile upstream of the Overton Bridge.
- Changes in bed material sediment sizes. Sediment samples were obtained using a petite Ponar Grab Sampler and standard excavation tools.
- Photographic documentation. Site photos at Dyer and CWR were taken and cataloged during each topographic/bathymetric survey trip.

In addition to the data collected specifically for the Pilot Project, relevant data from other ongoing Program monitoring activities were used to meet the objectives of the project. These activities include:

- PRRIP Channel Geomorphology and In-channel Vegetation Monitoring of the Central Platte River Program (PRRIP 2010)
- Water Quality Monitoring (EA Engineering, Science, and Technology, Inc. [EA] February 2013)
- NPPD habitat enhancement activities at CWR
- USGS monitoring data at CWR
- Monitoring data from Elm Creek Complex FSM Experiment (Tetra Tech 2011 and data from ongoing and future monitoring activities)
- Data from the Kearney Canal Monitoring Program (EA 2011)
- PRRIP aerial photos and Light Detection and Ranging (LiDAR) data
- Stream gage data at Overton (USGS gage 06768000, Platte River near Overton, NE), CWR North and South Channels, Kearney Canal, and Odessa, and discharge information from the J-2 return

The data collection procedures, including clarifications and/or deviations from the Project-scale Monitoring Protocol, are discussed in the following sections. A summary of the data collection (that is, monitoring activities) at each location is provided in Table 2, and the associated locations are shown in Figures 3 and 4.

2.3 Topographic and Bathymetric Data

Topographic and bathymetric data for the Pilot Project were collected based on location to the outfall:

1. Near-outfall surveys were conducted to understand the rate of entrainment and downstream movement of augmented material, particularly near the pump site.
2. Downstream river surveys were conducted to monitor the overall response of the river to the augmented sediment.

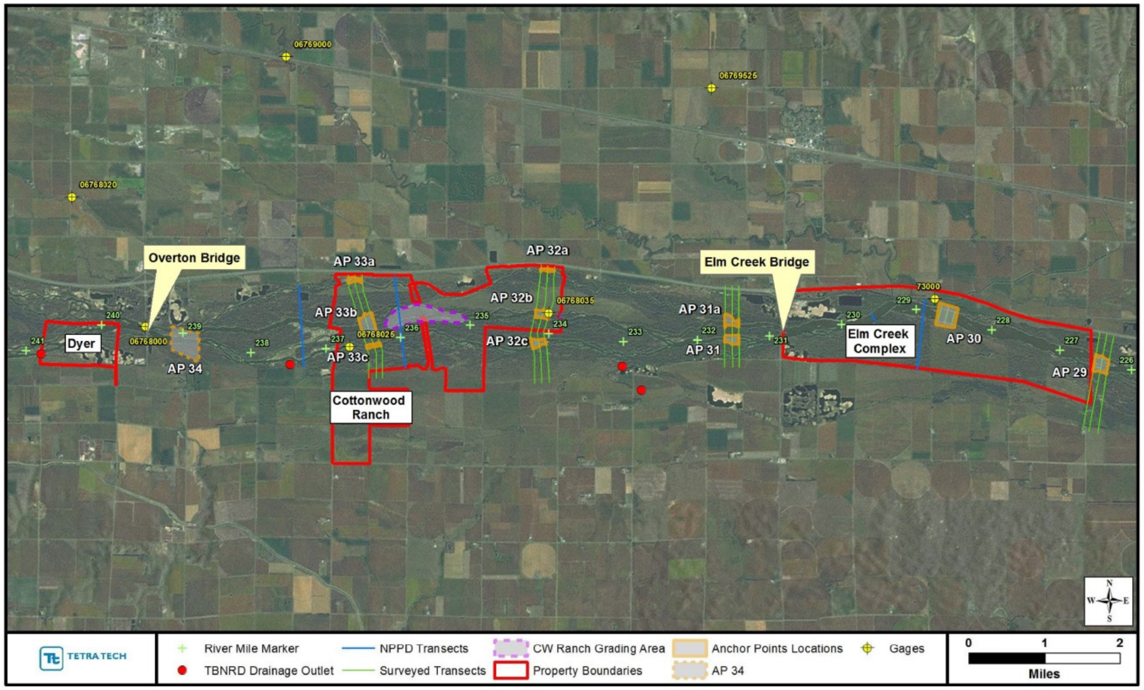
Cross-section surveys performed specifically for the Pilot Project included sufficient points to define the bed and bank topography with sufficient accuracy to detect changes in aggradation/degradation. During the survey, significant changes, if any, in the bed and bar elevations were identified and noted, and each cross section surveyed included the top-of-bank on either side of the channel.

Table 2. Summary of Pilot Study Monitoring Locations, Types, and Timing

Monitoring Location	Type of Monitoring	Timing of Monitoring
Dyer Property near outfall (South Channel at Jeffrey Island) – 5 cross sections	1. Topographic survey 2. Bed and bar material sampling	1. Prior to the start of pumping (baseline survey) 2. Within 1 week after completion of pumping 3. At monthly intervals over 9 months (conditions permitting)
Anchor Point (AP) 29[a]	1. Topographic survey 2. Bed and bar material sampling	Post-runoff
AP 31[a]	1. Topographic survey 2. Bed and bar material sampling	Post-runoff
AP 32	1. Topographic survey 2. Bed and bar material sampling	Pre-sediment augmentation Post-runoff
AP 33[a]	1. Topographic survey 2. Bed and bar material sampling	Post-runoff
AP 34[a]	1. Topographic survey 2. Bed and bar material sampling	Pre-sediment augmentation Post-runoff
Elm Creek Complex	1. Topographic survey 2. Bed and bar material sampling	Pre-runoff Post-runoff
North Phelps County Drainage Ditch; Batie Drain; Peterson Drainage Ditch; Benson Drain; South Channel of the Platte River[b]	1. Visual inspection and photographic documentation of drain at time of data collection 2. Topographic or cross-section surveys at the mouth or upstream of the mouth, if warranted	Pre-sediment augmentation Post-sediment augmentation
Lexington and Elm Creek Platte River Bridges; in the Kearney Canal[c]	1. In-stream sondes water quality measurements 2. Discrete samples collected during periodic maintenance of sondes	Mid-March through November, weather permitting
Overton Bridge	Water quality sampling – continuous turbidity, conductivity, temperature data; daily point suspended sediment samples	During the pumping period and for 2 weeks after cessation of pumping
Up to three locations near the Dyer property (two upstream, one downstream)	Stage data	1. Pre-sediment augmentation 2. Post-sediment augmentation for approximately 4 to 6 weeks

Notes:
[a] Collected as part of the Program's System-wide Geomorphology and Vegetation Monitoring Protocol
[b] Provided by Tri-Basin Natural Resources District (NRD)
[c] Collected as part of the Program's System-wide Water Quality Monitoring Protocol

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_3.mxd\apr14\jcm

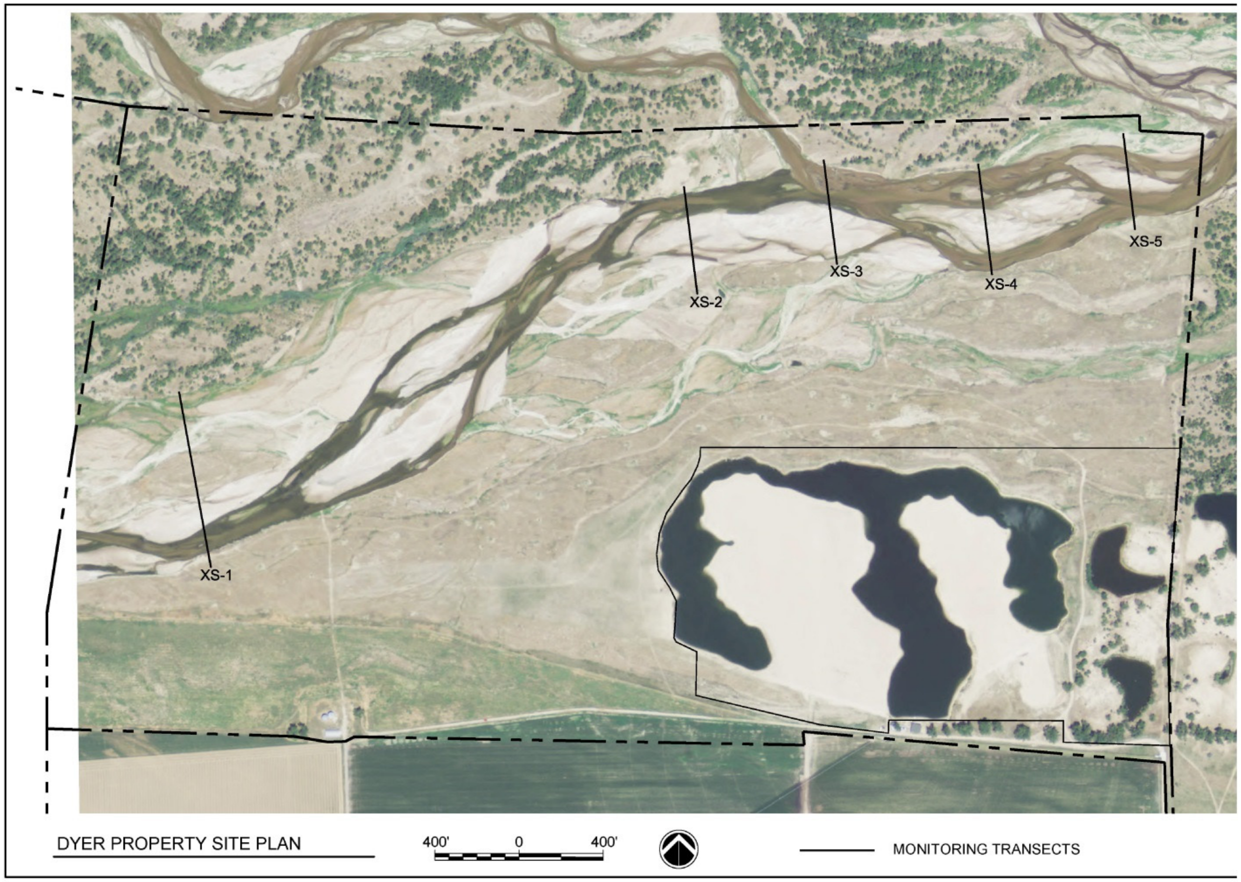


Reach Monitoring Locations

Sediment Augmentation Final Pilot Study Report

DATE	April 2014
FIGURE	3

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_4.mxd\apr14\jcm



Dyer Monitoring Plan Cross Section Locations

Sediment Augmentation Final Pilot Study Report

DATE
April 2014

FIGURE
4

1

2.3.1 Near-Outfall Surveys at Dyer

A baseline bathymetric survey was performed prior to the start of Phase I pumping. The survey was conducted between August 12 and August 23, 2012. The baseline survey was performed in the approximate 1-mile reach of the South Channel at Jeffrey Island, starting approximately 1,000 feet upstream of the pump outfall location and extending approximately 4,000 feet downstream of the pump outfall location. The near-outfall survey was designed to include five monumented cross sections of the active channel between the confining banks. These cross sections are identified as XS-1 through XS-5 (Figure 5).

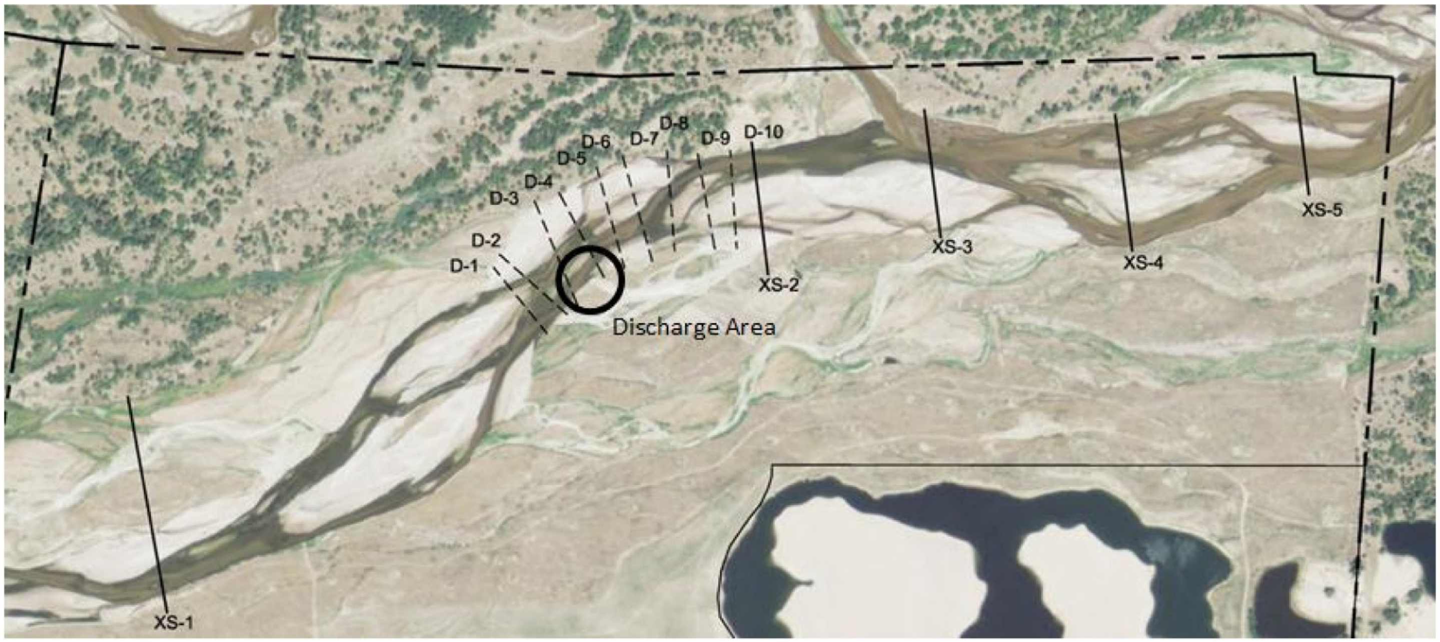
The distance that the material could be projected into the river was limited by the size of the pump. The combination of low flow, pump size, and a single discharge point resulted in material buildup adjacent to the channel during Phase I. The monitoring plan for the Dyer Property was established to collect, process, and evaluate data at the reach level by the Project Team. However, sediment did not entrain within the reach at a rate that could be measured. In consultation with Program staff, the Project Team modified the monitoring scope and added a series of 10 closely spaced (~100 feet) cross sections in the immediate vicinity of the discharge area where source material accumulated at the Dyer Property. These Dyer Site cross sections created a “control section,” with two sections upstream of the source pile, two sections crossing the source pile, and six sections downstream of the source pile within approximately 750 feet downstream of the discharge location. The furthest downstream Dyer Site cross section corresponded to the first original monitoring plan cross section downstream of the discharge location. The monitoring plan cross section locations as well as the Dyer Site cross section locations are shown in Figure 5. The Dyer Site cross sections are denoted as D-1 through D-10. The Project Team conducted surveys at the Dyer Site cross sections on a weekly or bi-weekly basis during Phase I of the management action to evaluate how much material was pumped from the source pit and how the augmented material was being distributed within the control section. The material in the vicinity of these cross sections was graded into the river in early February, prior to the start of Phase II pumping. During Phase II, the pipe outfall was shifted over an approximately 1,200-foot zone upstream of the Phase I outfall in an effort to better distribute the augmented material. As a result, data collection at cross sections D-1 through D-10 that were intended to monitor changes to the sediment pile was discontinued during Phase II.

Cross-section surveys were repeated at approximate monthly intervals through the end of the summer months (approximately 9 months) including those months when Phase II augmentation was occurring (March through June).

2.3.2 Downstream River Surveys

Prior to implementation of the Pilot Project, it was anticipated that downstream monitoring of bed elevations could be accomplished using the Program’s system-wide Geomorphology and Vegetation Monitoring cross sections. Post-runoff surveys were conducted at Anchor Points (APs) 29, 31, and 33 during both phases of the Pilot Project (2012 and 2013), and a post-runoff survey was conducted in July 2012 at AP 34 as part of the system-wide Geomorphology and Vegetation Monitoring Program. Surveys were also conducted in April, May, and August 2013 at the Elm Creek Complex as part of the ongoing FSM Experiment. Because flows in the mainstem were very low during this period (Figure 6), bed responses at the Elm Creek Complex that can be directly tied to the sediment augmentation project are probably undetectable. This issue will be addressed in more detail in relation to the sediment transport modeling below. Data from these surveys were to be used to assess the downstream response of the river to the Pilot Project.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_5.mxd\apr14\jcm



Dyer Site Cross Sections

Sediment Augmentation Final Pilot Study Report

THE FLATWATER GROUP INC

HDR

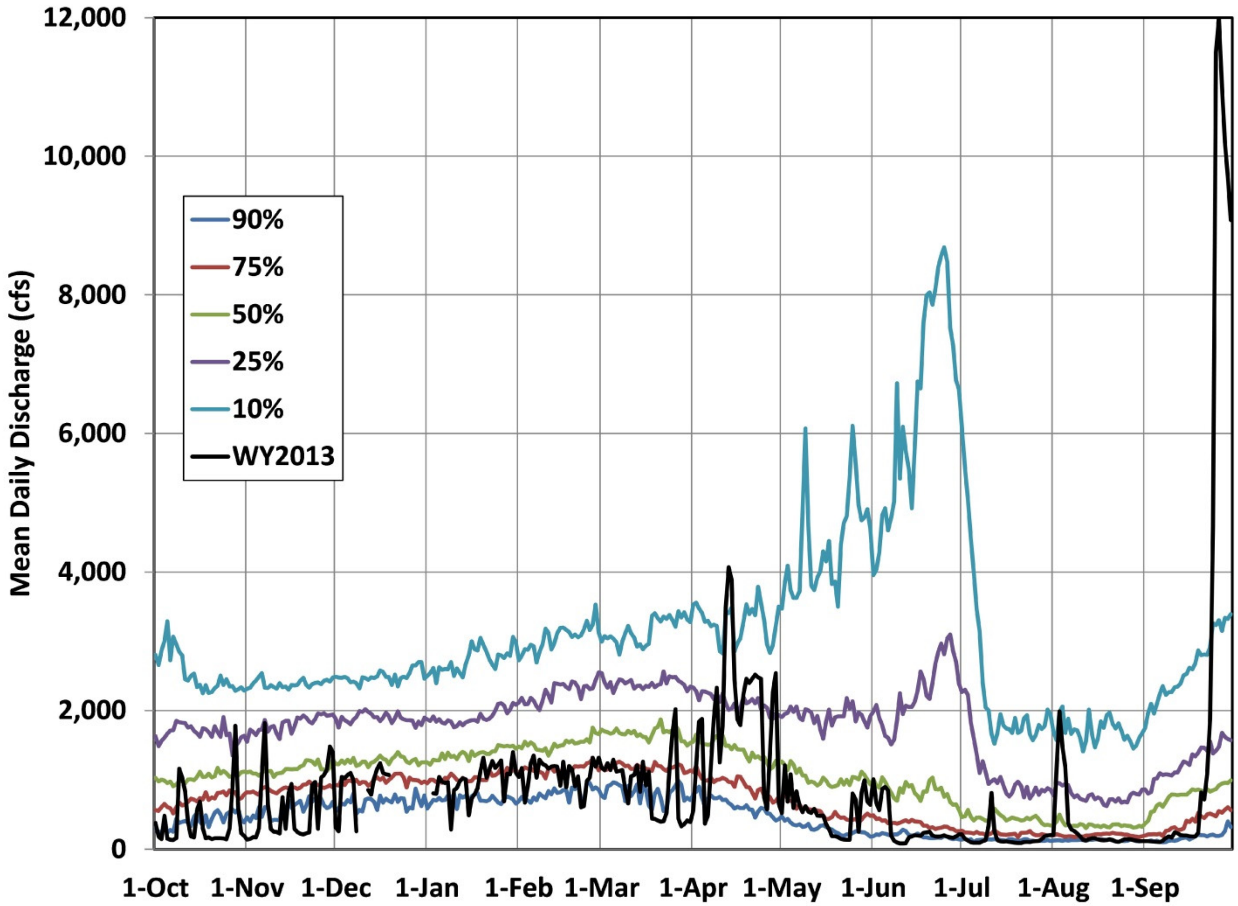
TETRA TECH

DATE April 2014

FIGURE 5

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_6.mxd\apr14\jcm



Mean Daily Discharges at Overton Gage Compared to Various Exceedence-Percentile Flows

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 6

Pre-sediment augmentation and pre-runoff surveys were also conducted as part of this Pilot Project at the upstream, middle, and downstream transects at AP 32 and AP 34. The first system-wide Program survey was conducted at AP 34 in July 2012 and serves as the pre-augmentation survey at this location. AP 32 was initially surveyed in 2009, and the next survey was not scheduled until summer 2013. A pre-augmentation survey and post-augmentation survey were conducted in the active channel at AP 32 and AP 34 in August and December 2012, respectively. AP 32 consists of three sets of cross sections, corresponding to the main middle channel (AP 32a), the minor south channel (AP 32b), and the minor north channel (AP 32c). Surveys of the three primary transects at AP 32b and 32c were conducted pre- and post-augmentation as part of this Pilot Project. The pre-sediment augmentation survey at transect AP 32a (middle channel) was inadvertently omitted as part of the Pilot Project monitoring. The post-runoff survey was conducted as part of the Program's ongoing System-wide Geomorphology and Vegetation Monitoring in July 2013.

The monitoring plan protocol also indicated that additional surveys may be conducted at specific locations where increased sediment deposition associated with the augmentation could cause adverse impacts. These locations were to be identified and visually evaluated, including taking photographic documentation, on a case-by-case basis as data were collected. No such locations were identified during the management action or subsequent monitoring.

2.4 River Stage Data

Pressure transducer stage recorders were installed prior to the Phase I management action upstream of the pump outfall at the Dyer Property. One transducer was installed at the monitoring cross section (XS-1, shown in Figure 5) on the south channel. The second was installed on the north channel near the Todd Brown property. Additionally, staff gages were co-located at the pressure transducers. A discharge measurement of 80 cubic feet per second (cfs) was taken at the transducer upstream of the pump outfall on August 15, 2012, to relate a stage for monitoring the 100 cfs permit requirement. The contractor at the Dyer Property observed the staff gage on a daily basis so that the 100 cfs flow threshold required by the permit was not being violated. The stage recorders included a telemetry system that permitted remote monitoring and interrogation of 15-minute stage data for the life of the project. Transducer stage data were used in conjunction with the Overton gage managed by USGS and the Nebraska Department of Natural Resources (NDNR) to make decisions about triggers and evaluate discharge data through the reach. Both transducers were still in place at the end of the post-augmentation monitoring period that ended in August 2013.

2.5 Bed and Bar Material Sampling

Bed and bar material samples were collected at both Dyer and CWR during each survey following a modified version of the System-Wide Monitoring Protocol (PRRIP 2011). In accordance with the protocol, a minimum of three samples were collected from the channel bed at each monitoring plan cross section. Three samples from the head of a typical sand bar in the vicinity of the transects were also collected, with the samples composited to create one typical sand bar gradation. For this Pilot Project, bed samples were collected at three of the five Dyer Property monitoring cross sections. Bed samples were collected at the cross sections upstream of the pump outfall at the Dyer Property (XS-1) and at the most upstream and downstream of the four transects downstream of the outfall (XS-2 and XS-5). A bar sample was collected from the head of a typical bar in the vicinity of the upstream transect (XS-1), and three bar samples were collected from the head of at least three typical bars between cross sections XS-2 through XS-5.

Three bed samples were also collected at each of the most upstream and downstream transects during the surveys of AP 32 and AP 34 pre- and post-augmentation. The gradation of bed and bar samples was analyzed by a qualified soils laboratory (that is, Midwest Laboratories, Inc.) following procedures specified in ASTM Standard D422.

2.6 Tri-Basin Drains

Prior to implementation, Tri-Basin Natural Resources District (NRD) raised concerns regarding the effects that sediment augmentation might have on a series of local drainage ditches and a secondary stream channel that discharge into the river in the vicinity of, and downstream of, the augmentation activities. Tri-Basin NRD's concern was that augmentation activities may have an adverse impact on these drains by closing off the mouths and causing water to back up into the drainages. These drainages were initially identified as locations where additional specific surveys may be warranted. The drainages, all discharging into the river from the south bank, included:

- North Phelps County Drainage Ditch – Outlet located in Sec. 11, T8N, R20W
- Batie Drain – Outlet located in Sec. 8, T8N, R19W
- Peterson Drainage Ditch – Outlet located in Sec. 18, T8N, R18W
- Benson Drain – Outlet located in Sec. 18, T8N, R18W
- South Channel of the Platte River – where it diverges from the main channel in Sec. 12, T8N, R19W

Prior to augmentation, attempts were made to locate, visually observe, and take photographic documentation of the drainage ditches where they entered the river. However, not all of the drainage ditches were located. Those drainage ditches that were located included the North Phelps County Drainage Ditch, the Batie Drain, and the Peterson Drainage Ditch and/or Benson Drain near Odessa Bridge. The Peterson Drainage Ditch and/or Benson Drain appear to re-enter the river at the same location. The other location may no longer be discharging to the river, is no longer functioning, or may have been diverted to another drainage ditch.

2.7 Sediment Transport and Water Quality Measurements

Data from the Program's System-wide and Kearney Diversion Water Quality Monitoring Programs (EA September 2013) were used to analyze whether there were discernible effects on water quality due to sediment augmentation. Primary data sets were collected using continuous data from sondes located at Overton, Lexington, and Elm Creek on the Platte River and in the Kearney Canal just downstream of the diversion structure.

Water quality data collected downstream of the Dyer Property and CWR included temperature, dissolved oxygen, turbidity, pH, and specific conductance. As part of the projects' permit that addressed water quality, the Nebraska Department of Environmental Quality (NDEQ) issued Order of Variance #3130, which specified data collection requirements. The variance required that pH and dissolved oxygen data be collected during sediment augmentation on a weekly basis. Additionally, daily observations for fish mortality, water color, and condition changes were to be made.

3. MONITORING AND DATA COLLECTION

The Phase I management action began at the Dyer Property on September 26, 2012. Continued low flows in the South Channel and increasingly colder temperatures resulted in a decision to cease Phase I pumping at the Dyer Property on November 30, 2012, after augmentation of approximately half (25,000 tons) of the projected Phase I total of 50,000 tons. The first post-augmentation cross-section survey was conducted on December 5, 2012. At the end of Phase I, the Project Team anticipated that a portion of the quantity of material that was not augmented in Phase I could be made up during typically higher springtime flow releases from the J-2 return and a planned SDMF event in the project reach.

Phase II augmentation at the Dyer Property commenced on March 1, 2013, as temperatures moderated. This coincided with the end of NPPD's outage, spring releases from the J-2 return, and the Program's SDMF event that passed through the reach between approximately April 10 and April 15. Based on lessons learned during the Phase I augmentation, adjustments were made to the pumping outfall locations so that a larger discharge area could be used in hopes of exposing the maximum amount of augmented material to active flows as possible.

The contractor began Phase I augmentation at CWR on September 17, 2012. By November 5, 2012, approximately 60,000 yd^3 (75,000 tons) of material were placed into the river. This quantity was 50 percent more than the projected Phase I total of 50,000 tons. The material was pushed into the channel from an existing island at CWR. Due to the lower than expected flows and greater than planned augmentation volume, the material did not mobilize as effectively as anticipated during design, and some of the material remained in the channel adjacent to the island. This material provided a sediment source during higher flow periods. However, the higher flow periods were not sufficient to mobilize all of the material.

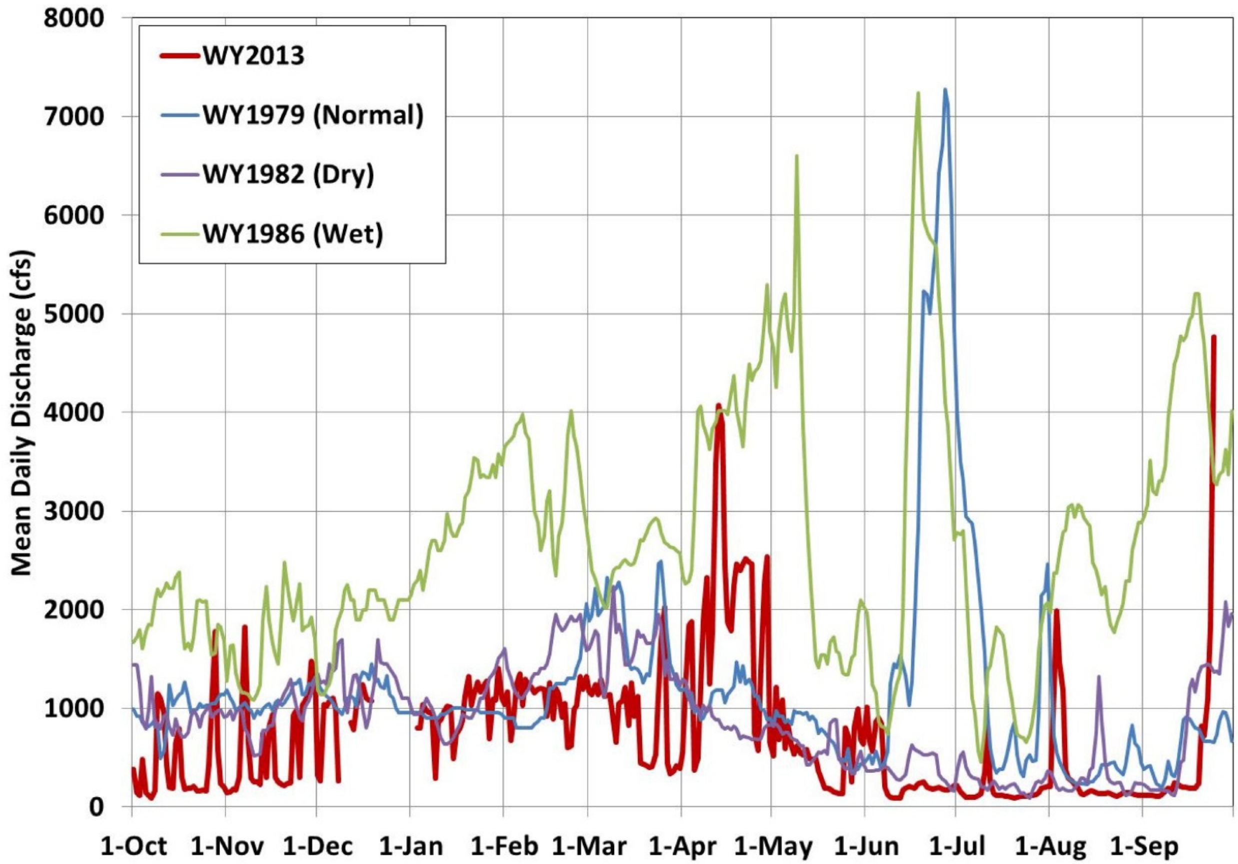
Phase II augmentation commenced on March 18, 2013, and was completed by April 6, 2013, ahead of the scheduled SDMF event. The residual source pile was reshaped and the additional 25,000 tons of material were excavated to create a series of channels behind and through the augmented material.

3.1 Hydrologic Conditions

3.1.1 Phase I

The flow conditions during and after input of additional sediment are a key driver of the channel response. As discussed in Section 3.6, the modeling was conducted for three flow sequences that were intended to encompass the range of flows that could reasonably be anticipated in the study reach. The river flows that contribute to the Overton gage (both from the North Channel at Jeffrey Island and the J-2 return) were in the median to low range during Phase I of the management action from September through November 2012 (Figure 7). The total flow volume passing the Overton gage during these 3 months was only about 71,000 acre-feet, compared to 191,000 acre-feet for the same period used in the dry year model simulations (Water Year [WY] 1982) (Figure 8). The flows during this period of 2012 were the third lowest in the 72 years of recorded data at the Overton gage. The subsequent 3 months, from January through March 2013, were slightly higher, but still well below the volume for the dry year simulation (~176,000 acre-feet in 2012 versus ~245,000 acre-feet in WY 1982). A combination of lower flows and the limited ability to distribute the material during pumping limited the ability of the river to entrain and transport the augmented sediment downstream away from the pump outfall.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_7.mxd\apr14\jcm

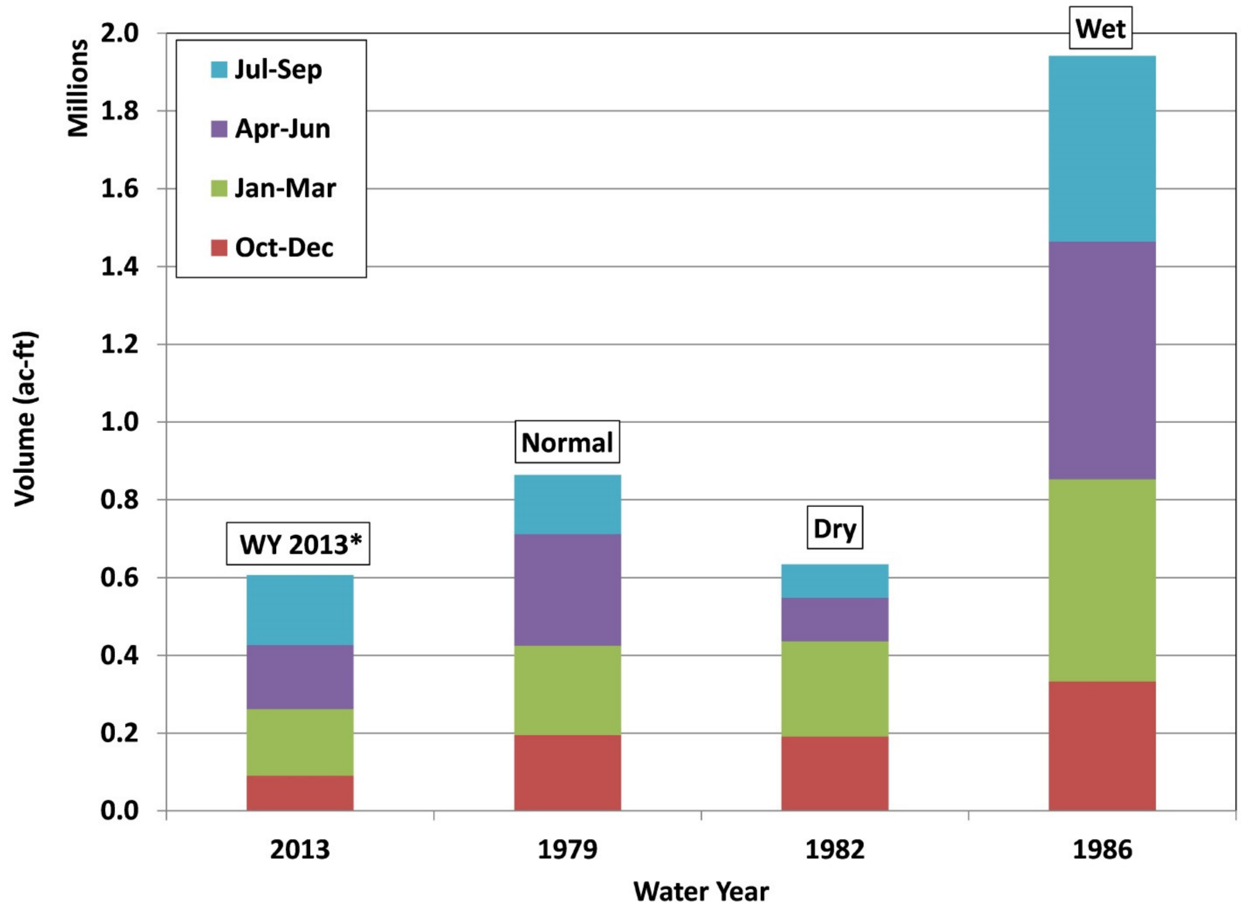


WY2013 Apr-Sept flows include provisional data through Sept 24; thus they do not account for the flood wave that is passing through the reach at the time of this report.

Mean Daily Flows at the Overton Gage for an Average Wet, Dry, and Normal Year	DATE	April 2014
Sediment Augmentation Final Pilot Study Report	FIGURE	7

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_8.mxd\apr14\jcm



Flow Volumes at the Overton Gage

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 8

1

3.1.2 Phase II

Similar to Phase I, the Phase II flow volumes were also low. The total flow volume passing the Overton gage from April through June 2013 was about 165,000 acre-feet. This was about 53,000 acre-feet more than the modeled dry year simulations (WY 1982, ~112,000 acre-feet) and about 122,000 acre-feet less than the modeled normal year simulation (WY 1979, ~287,000 acre-feet). The following 3 months, spanning July through September, again displayed low water volumes, ranking the nineteenth lowest in the 72 year period of record. (The available data through September 24, 2013, were used for this analysis.) The modeled dry year (WY 1982) flow volume totaled about 86,000 acre-feet in the months of July through September while the actual flows during this period in Phase II yielded a total of only about 55,000 acre-feet. These low flows again inhibited the ability of the river to entrain and transport the augmented sediment downstream.

3.2 Topographic and Bathymetric Data

3.2.1 Phase I

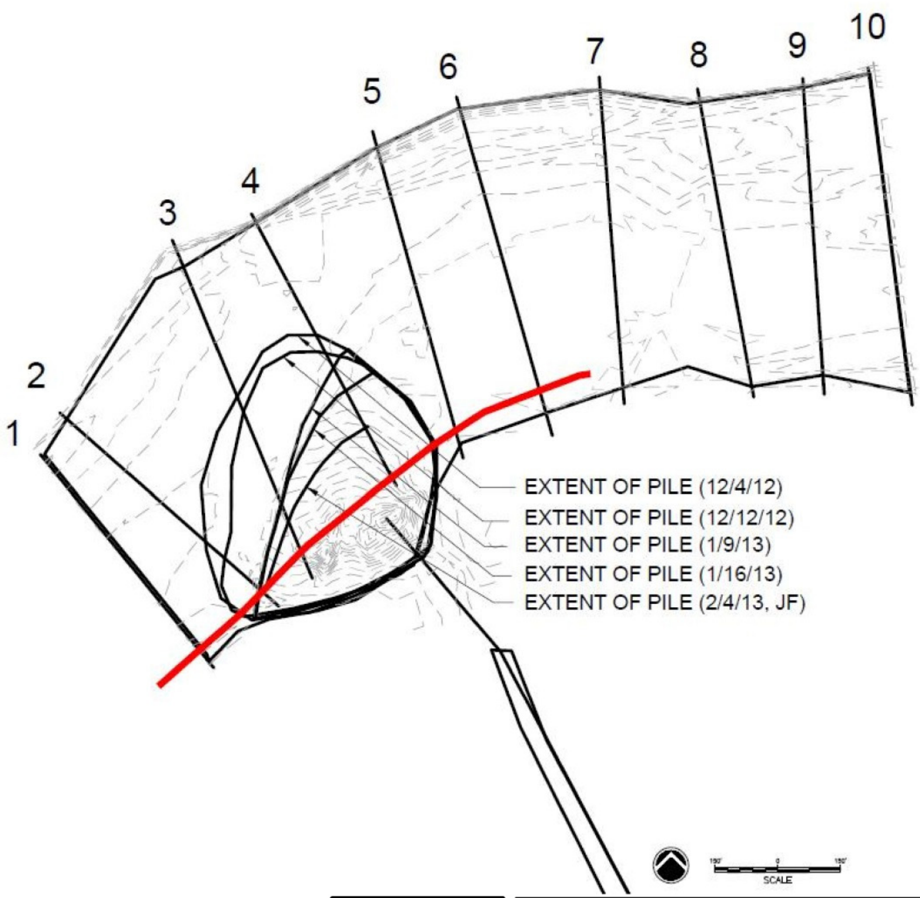
Based on a combination of the periods of actual pumping and the estimated pumping rates, along with measurements of the waste pile, approximately 25,000 tons of material was pumped during Phase I. Of this quantity, about 17,989 tons remained in the source pile at the edge of the river as of December 4, 2012 (Table 3). The source pile continued to diminish through December 2012 and January 2013 to about 12,370 tons by February 9, 2013, as the J-2 return flows cut into the toe of the source pile (Table 3, Figures 9 and 10). Based on these estimates, approximately 7,000 tons (a change from 25,000 to ~18,000 tons) of the augmented material were carried away from the source pile into the downstream river by early December 2012, and this increased to about 12,630 tons (a change from 25,000 to 12,370 tons) by early February 2013. Table 3 shows the incremental changes to the source pile and control section based on the 10 detailed cross section surveys conducted from the end of October 2012 through the first part of February 2013.

Table 3. Dyer Property Sediment Augmentation Comparison Quantities at River (tons)

Date	Quantity at Source Pile[a]	Change to Source Pile	Change to Control Section Excluding Source Pile[b]	Change to Control Section[b,c]	Notes
9/26/2012	-				Start of pumping to river
10/29/2012	9,125				
11/5/2012	9,275	150	651	801	
11/14/2012	11,941	2,666	(1,726)	940	
11/20/2012	14,460	2,519	40	2,559	
11/30/2012	-				End of pumping
12/4/2012	17,989	3,529	(2,581)	948	
12/12/2012	17,345	(644)	394	(250)	
1/9/2013	13,955	(3,390)	1,976	(1,414)	
1/16/2013	13,626	(329)	216	(113)	
2/9/2013	12,370	(1,256)	(4,619)	(5,875)	Last Dyer Property 10-x survey

Notes:
[a] Calculated from site survey of discharge area
[b] Control section is defined as just upstream of the sediment discharge location to approximately 750 feet downstream
[c] Based on volumes calculated using survey cross sections

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_9.mxd\apr14\jcm



Approximate Footprint of the Sediment Sourcepile at the Dyer Pump Outfall

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 9

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_10.mxd\apr14\jcm

Oblique Aerial Photo of the Dyer Sand Pumping Site (Taken 4_13_2013)

Sediment Augmentation Final Pilot Study Report

DATE
April 2014

FIGURE
10

1

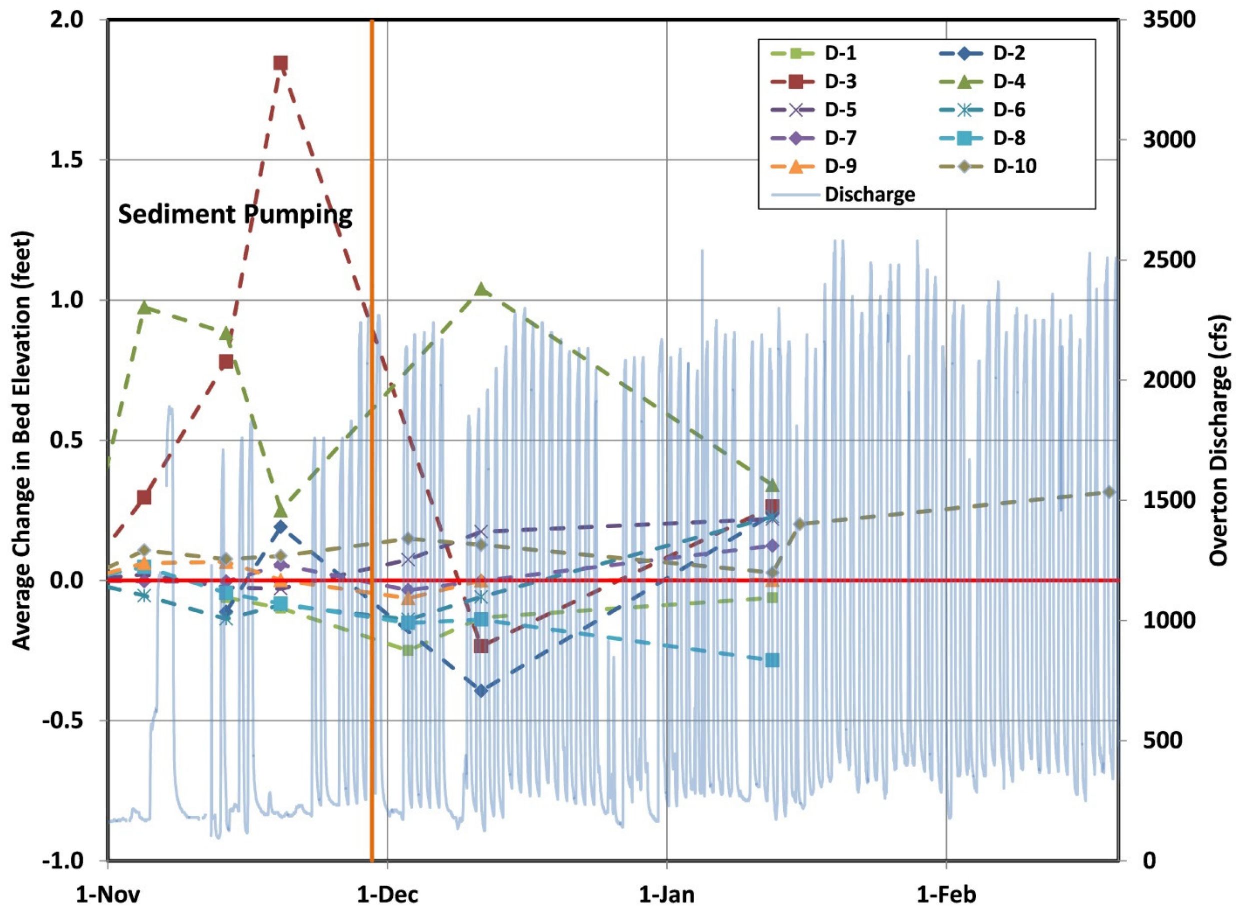
Changes in bed topography associated with the sand pumping were assessed by comparing repeat cross-section surveys at the five cross sections in the vicinity of the pump outfall that were originally identified in the monitoring plan (TFG et al. July 2012b) (cross sections XS-1 through XS-5, shown in Figure 5). In addition, ten more closely spaced cross sections were added to the monitoring plan in late October to provide more detail on the changes in the immediate vicinity of the outfall (cross sections D-1 through D-10,[1] shown in Figure 5). The initial five cross sections were surveyed in mid-August prior to the start of pumping, resurveyed in early December after the fall 2012 pumping was complete, and then resurveyed again in mid-January and mid-February. Eight of the additional ten cross sections (D-3 through D-10) were surveyed in late October, and these cross sections, along with XS-1 that was added in early November and XS-2 that is co-located with D-10, were surveyed at 1- to 2-week intervals until the last survey that was conducted on February 19, 2013. The three primary geomorphic cross sections at system-wide AP 32 and AP 34 were also re-surveyed in August and December 2012 in conjunction with the other primary monitoring cross sections. Overlay plots of these cross sections from each survey are provided in Appendix A.

The survey data for the Dyer Site cross sections indicate significant aggradation at D-1 and D-3, while the remainder of the cross sections showed very modest net change over the entire period (Figure 11). D-2, D-3, and D-4 intersect the source pile; D-1 is located just upstream of the source pile; and D-5 through D-10, the remaining cross sections, are located downstream of the source pile (Figure 5). The area changes that were used to compute the average bed elevation changes at D-2, D-3, and D-4 shown in Figure 5 do not include the actual stockpile.)

The indicated aggradation at D-1 likely results from reduced velocities due to backwater caused by the constriction at the source pile and upstream bank sloughing. D-2 aggraded by up to 1 foot across most of the river bed during and subsequent to the pumping, but the channel eroded laterally into the adjacent bar along the left bank; thus, the average bed elevation changes at the cross section that alternated between aggradation and degradation are relatively small. The indicated aggradation at D-4 occurred primarily through deposition along the right bank in the separation zone downstream of the stockpile; a modest amount of lateral erosion occurred along the left bank. D-5 through D-8 all experienced varying amounts of aggradation along the right bank, similar to D-4, due to the effects of the source pile on hydraulic conditions in this part of the channel. These cross sections also experienced significant deepening along the left bank adjacent to the steep channel bank due, at least in part, to steering of the flow by the source pile and the constricting effects of the deposition along the right bank. D-9 showed little net change throughout the monitoring period. D-10 (XS-2) aggraded by a modest amount between the baseline survey and early November 2012 due to processes likely unrelated to the augmentation, and then degraded slightly through early January 2013. Although the topography shifted noticeably during this period, this cross section showed little net change. The January 13 and February 19, 2013, surveys at D-10 (XS-2) that were conducted for cross sections XS-1 through XS-5 indicate an aggradational trend. Although sufficient data are not available to be certain, this trend may indicate downstream progression of the augmented sediment deposits. On February 4, the source pile was mechanically graded into the active channel, which likely had an effect on the trend.

[1] Cross section D-10 is co-located with XS-2.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_11.mxd\apr14\jcm



Average Change in Bed Elevation at the Dyer Site Cross Sections

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 11

1

The changes at XS-1 through XS-5 were relatively modest (Figures 12a and b). All of the cross sections except XS-2 (D-10) showed net degradation of a few tenths of a foot between August and early December 2012, aggradation back to an average elevation slightly above the baseline surveys by mid-January 2013, and then degradation by the mid-February 2013 survey. XS-2 shows an aggradational trend after mid-January 2013.

In addition to the surveys in the vicinity of the pump outfall, the three primary monitoring cross sections at AP 34 were also surveyed in August and December 2012 as part of this study. The survey data indicate that AP 34, which is located about 1,000 feet downstream of the Overton Bridge (Figure 13), aggraded slightly between the July and August 2012 surveys at XS-1 and XS4, but degraded slightly at XS4 (Figure 14). All three cross sections showed a slight degradational trend between August and December 2012. All of the indicated changes in average bed elevation were less than 0.1 foot, and probably within the error bands of the data; thus, no definitive conclusion can be drawn about the long-term trends or possible impacts of the pilot-scale augmentation.

As previously stated, approximately 75,000 tons (60,000 yd^3) of material were mechanically redistributed at CWR. This resulted in some channel narrowing and deepening along the south bank. No impact triggers were initiated during or immediately after Phase I.

No adverse downstream impacts were identified during Phase I at the Dyer Property other than the additional cross sections at the Dyer outfall location noted above; no additional surveys were conducted.

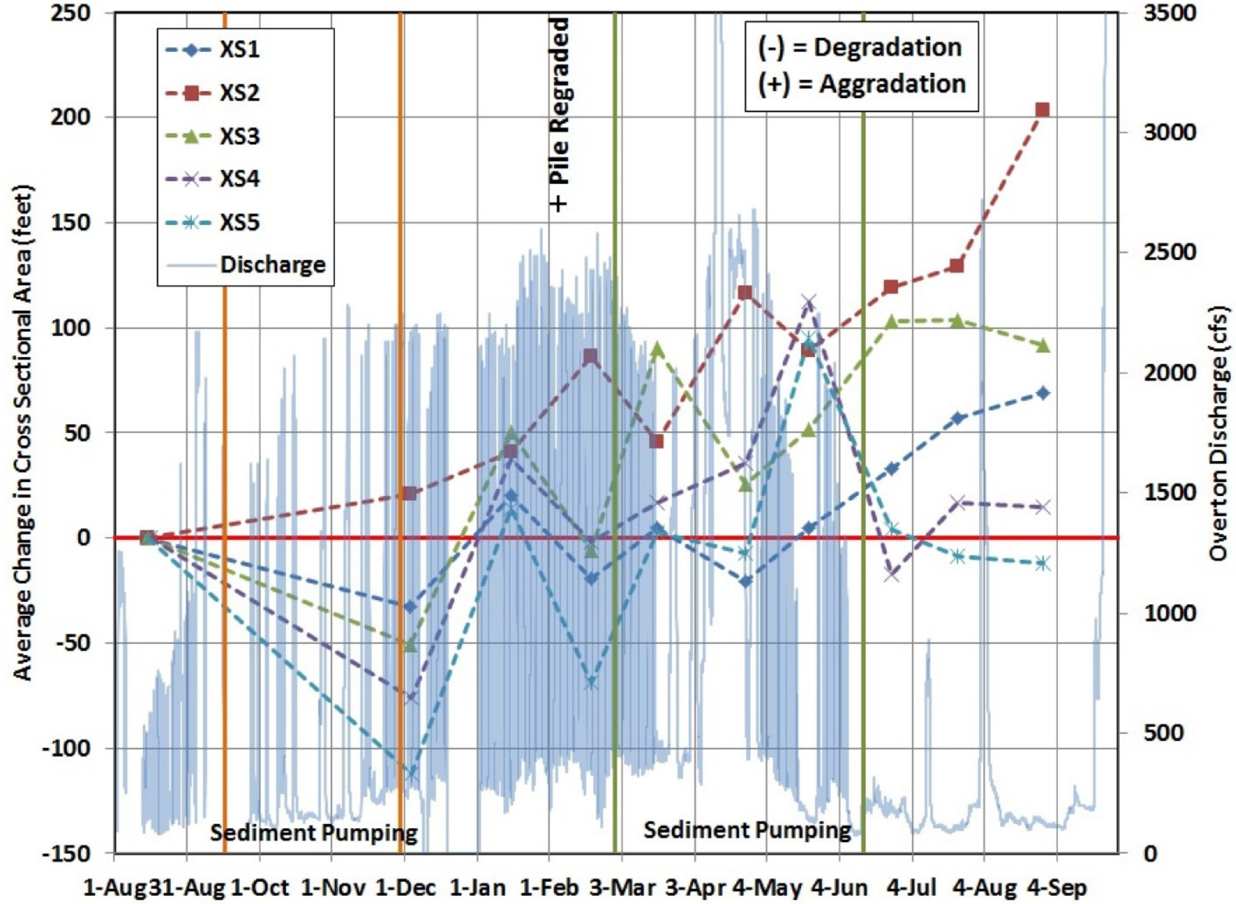
3.2.2 Phase II

Monthly cross-section surveys continued in Phase II from April through August 2013 at the five primary monitoring cross sections (cross sections XS-1 through XS-5, shown in Figure 5). Because of the changes in the location of the pump outfall, the ten more closely spaced cross sections (cross sections D-1 through D-10, shown in Figure 5) in the immediate vicinity of the Phase I outfall were not surveyed in Phase II. AP 32 and AP 34 were also surveyed in Phase II in July 2013 as part of the system-wide Geomorphology and Vegetation Monitoring Program. Overlay plots of the cross sections from each survey are provided in Appendix A.

Phase II data at XS-1 through XS-5 generally showed an aggradational trend throughout the monitoring period. In particular, XS-2 and XS-3, the first and second cross-sections downstream of the pump outfall, showed the greatest overall aggradation, approximately 0.5 foot and 0.25 foot, respectively, since the beginning of the Pilot Study (Figures 12a and 12b). Only a limited amount of aggradation (~0.1 foot and <0.1 foot, respectively, since the start of the Pilot Study) occurred at XS-4 and XS5, the two cross sections farthest downstream of the pump outfall. XS-1, the single monitoring cross section upstream of the pump outfall, also aggraded by a small amount. This may have been caused by backwater and the associated reduction in transport capacity created by the sediment accumulation in the vicinity of the pump outlet as well as upstream bank sloughing. The cross sections surveyed in July 2013 at AP 32 showed little to no change from previous surveys (Appendix A).

The cross sections also show significant erosion (that is, 25 to 30 feet) of the north bank upstream of XS-2 after mechanical manipulation of the sediment after Phase I. Another area of significant bank erosion occurred on the south bank in the vicinity of the western-most transducer installed as part of the Pilot Study. This area was upstream of XS-1 and outside the limits of the monitoring for this study. Both areas of bank erosion resulted in additional sediment being added to the reach that was not quantified and not included in the volumes presented in the data in this report.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_12a.mxd\apr14\jcm



Average Change in Cross Sectional Area at the Monitoring Plan Cross-Sections

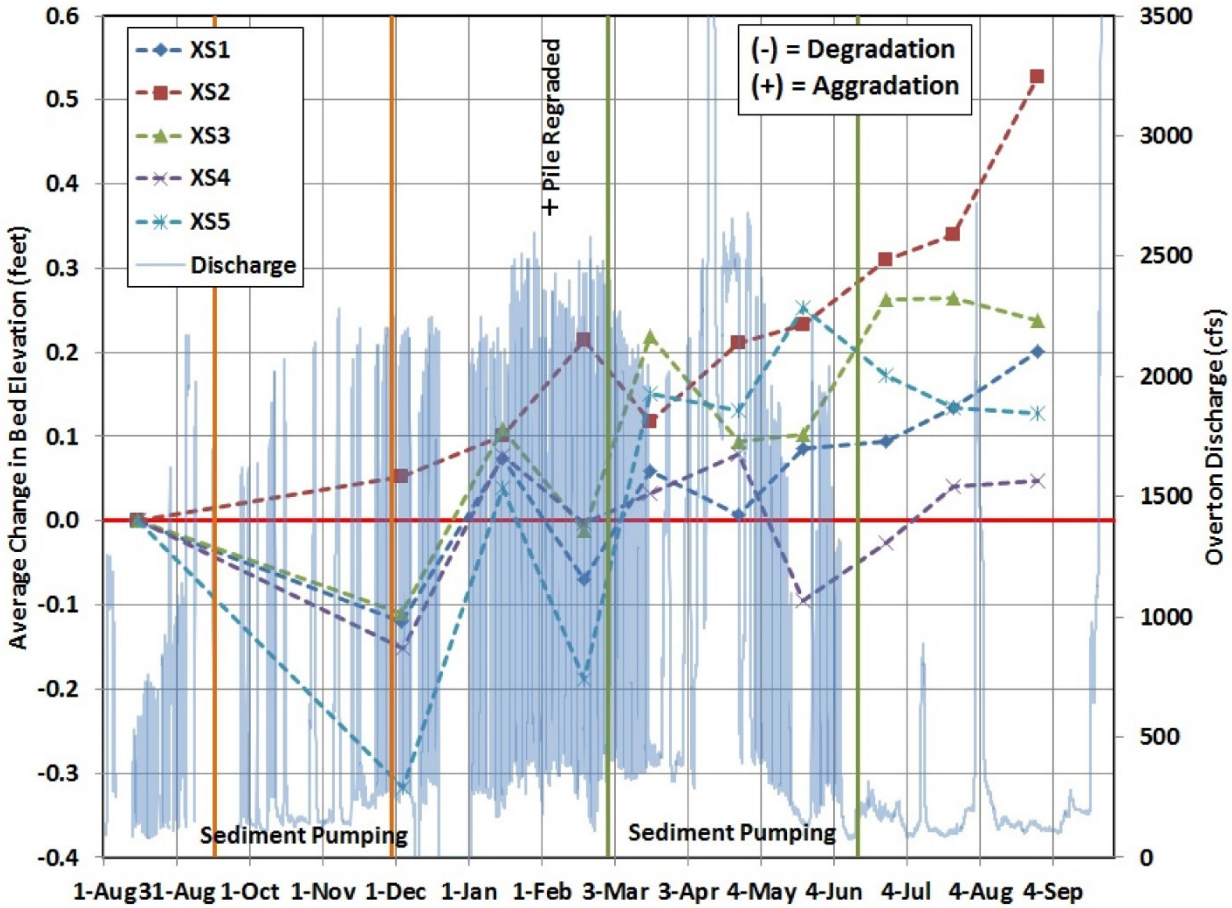
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 12a

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_12b.mxd\apr14\jcm



Average Change in Bed Elevation at the Monitoring Plan Cross-Sections

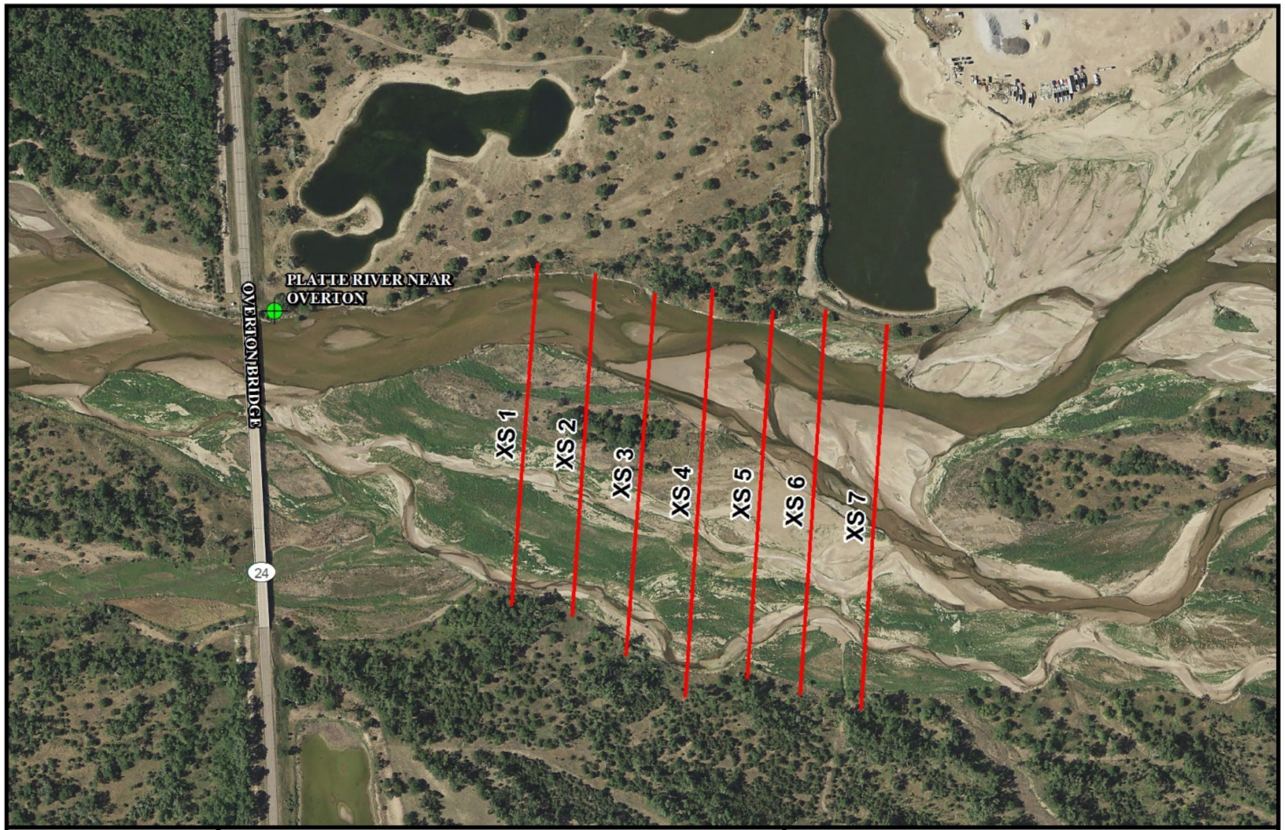
Sediment Augmentation Final Pilot Study Report

DATE
April 2014

FIGURE
12b

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_13.mxd\apr14\jcm



TETRA TECH

ANCHOR POINT 34 TRANSECTS

N W E S

0 400 800

Feet

Aerial Photograph of the Platte River in the Vicinity of AP34 Taken in July 2012 (Q-400 cfs)

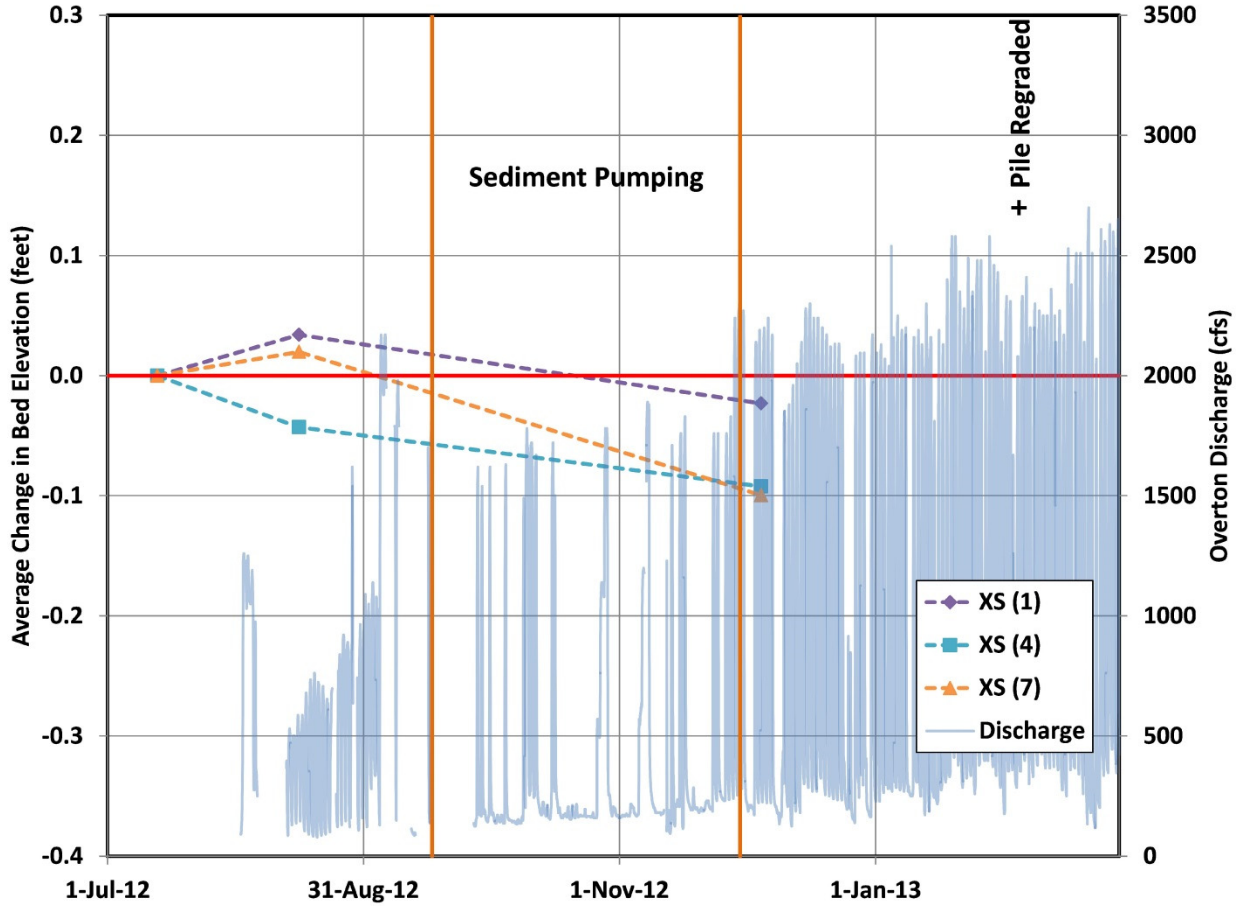
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 13

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_14.mxd\apr14\jcm



Average Change in Bed Elevation at AP34

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 14

Although no impact triggers were initiated during or immediately after Phase I, the stage change trigger moved into Class II at the Overton gage on April 13, 2013, during Phase II. Prior to increasing monitoring frequency, per the TM, from monthly to bi-weekly, the trigger was back below the Class II threshold criteria on April 16, 2013, at Overton.

3.3 River Stage Data

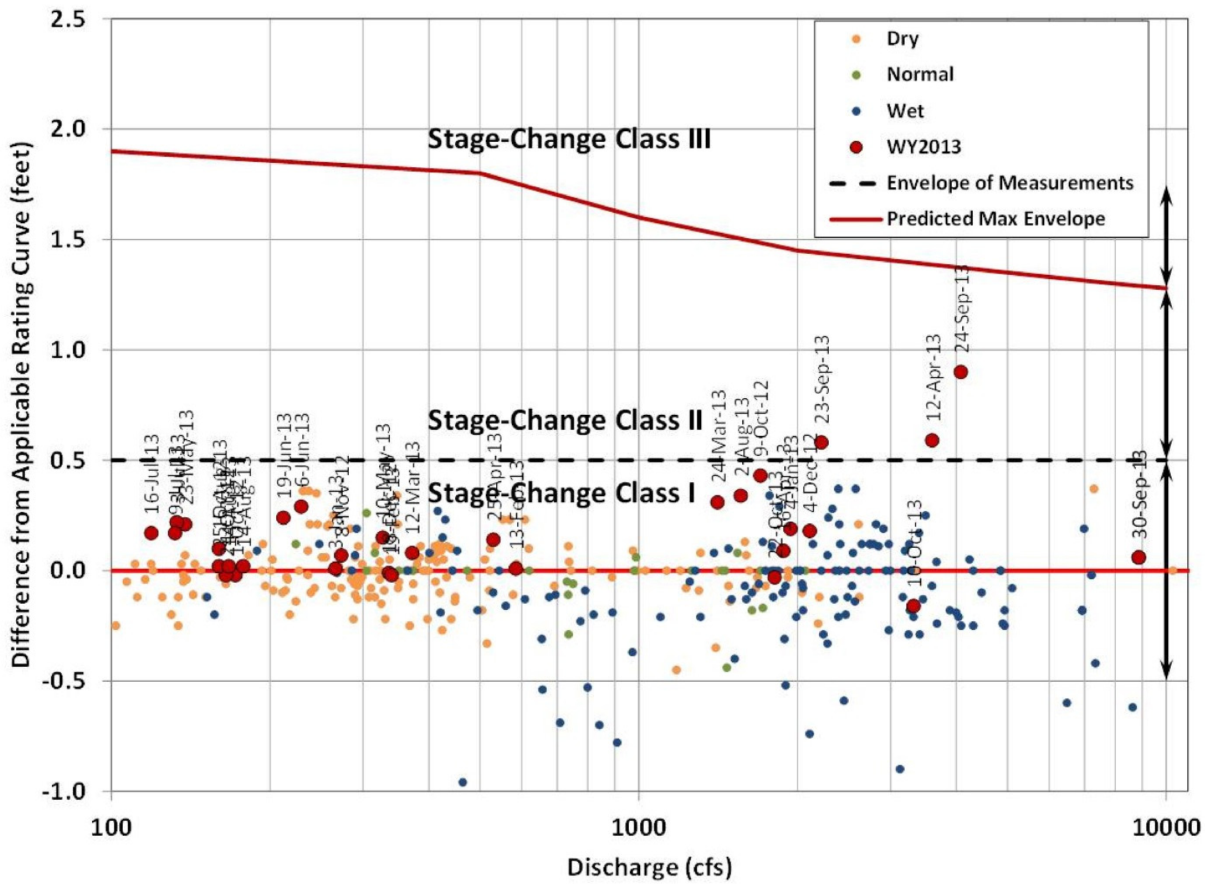
The field measurement data at the Overton gage and the CWR Mid-Channel stream gage were evaluated to supplement the channel change data collected specifically for this monitoring plan and to provide a longer-term context for the changes that were observed during the monitoring period. The data analysis considered the trends and variability in the measured water surface stages and long-term trends and variability in the mean bed elevation that was estimated from the gaging measurement data.

The Overton gage data were also used to provide a near-real-time assessment of changes that could trigger modifications to the augmentation activities to avoid damage to adjacent properties. The shifts that are applied by USGS to the gage rating curve for purposes of computing the discharge represent the variability in individual measurements from the current rating curve. The vast majority of the reported shifts[2] for gage measurements taken since WY 1997 vary from about -1 to +0.5 foot (Figure 15); thus, the boundary between Class I and Class II stage changes was set at 0.5 foot. The variability appears to be somewhat greater during wet and dry years than it is during normal runoff years (as defined by Anderson and Rodney, 2006). The sediment transport model results described above indicate maximum variability in the water surface elevation for a given discharge ranging from 1.6 to 1.9 feet at discharges less than 1,000 cfs, and declining to about 1.3 feet at 9,000 cfs (shown as a red line in Figure 15). The USGS field measurements taken between the start of pumping and the end of March 2013 all fall within the historic scatter, which is below the limit for a Class II stage change. The April 12 and September 23, 2013, measurements both exceeded the 0.5 foot threshold at 0.59 foot and 0.58 foot, respectively. Both of these data points are at the low end of the Class II zone. The shift on September 24, 2013, during the passage of the flood wave from the 2013 Northern Colorado floods, was more significant, at 0.9 foot. Prior to increasing monitoring frequency from monthly to bi-weekly per the TM for these excursions, the trigger was back below the Class II threshold criteria on April 16, 2013, and September 30, 2013, respectively, at Overton.

A similar analysis was performed for the CWR Mid-Channel gage, which is located approximately 2 miles downstream of the CWR grading area (Figure 16). The variability about the current rating curve is smaller at this location, with all of the values except for the measurement taken on September 25, 2013, during the passage of the flood wave, well below the threshold for a Class II stage change.

[2] A negative shift in the original USGS data set indicates that the measured stage is higher than the current rating curve, and a positive shift indicates that a measured stage is lower than the rating curve. For purposes of this analysis, the sign of the reported values was reversed so that positive values indicate stages that are higher than the rating curve.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_15.mxd\apr14\jcm



Reported Shifts for USGS Field Measurements at the Overton Gage (WY1997 – WY2013)

Sediment Augmentation Final Pilot Study Report

DATE

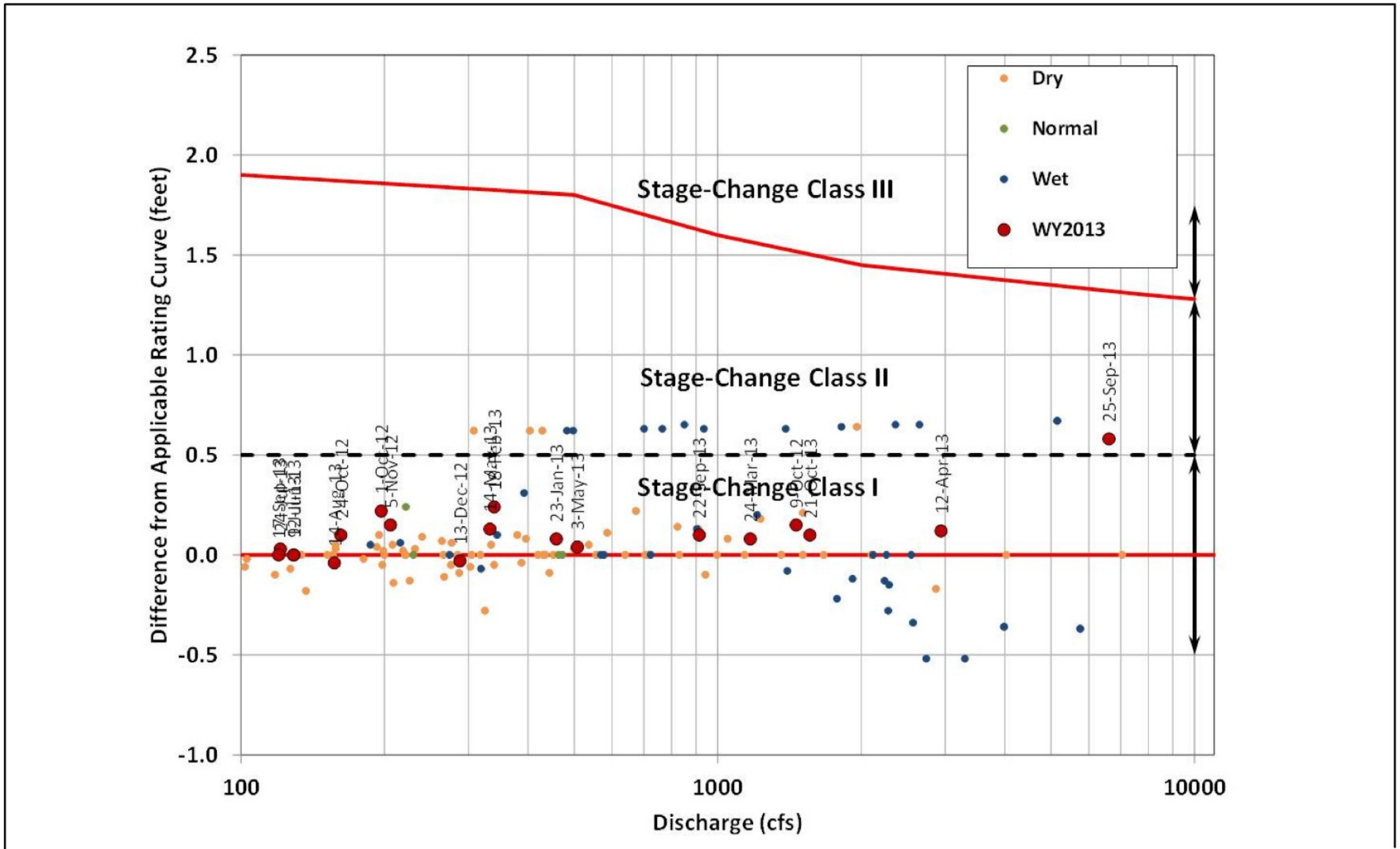
April 2014

FIGURE

15

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_16.mxd\apr14\jcm



Reported Shifts for USGS Field Measurements at the Cottonwood Ranch Gage (WY2001 – WY2013)

Sediment Augmentation Final Pilot Study Report

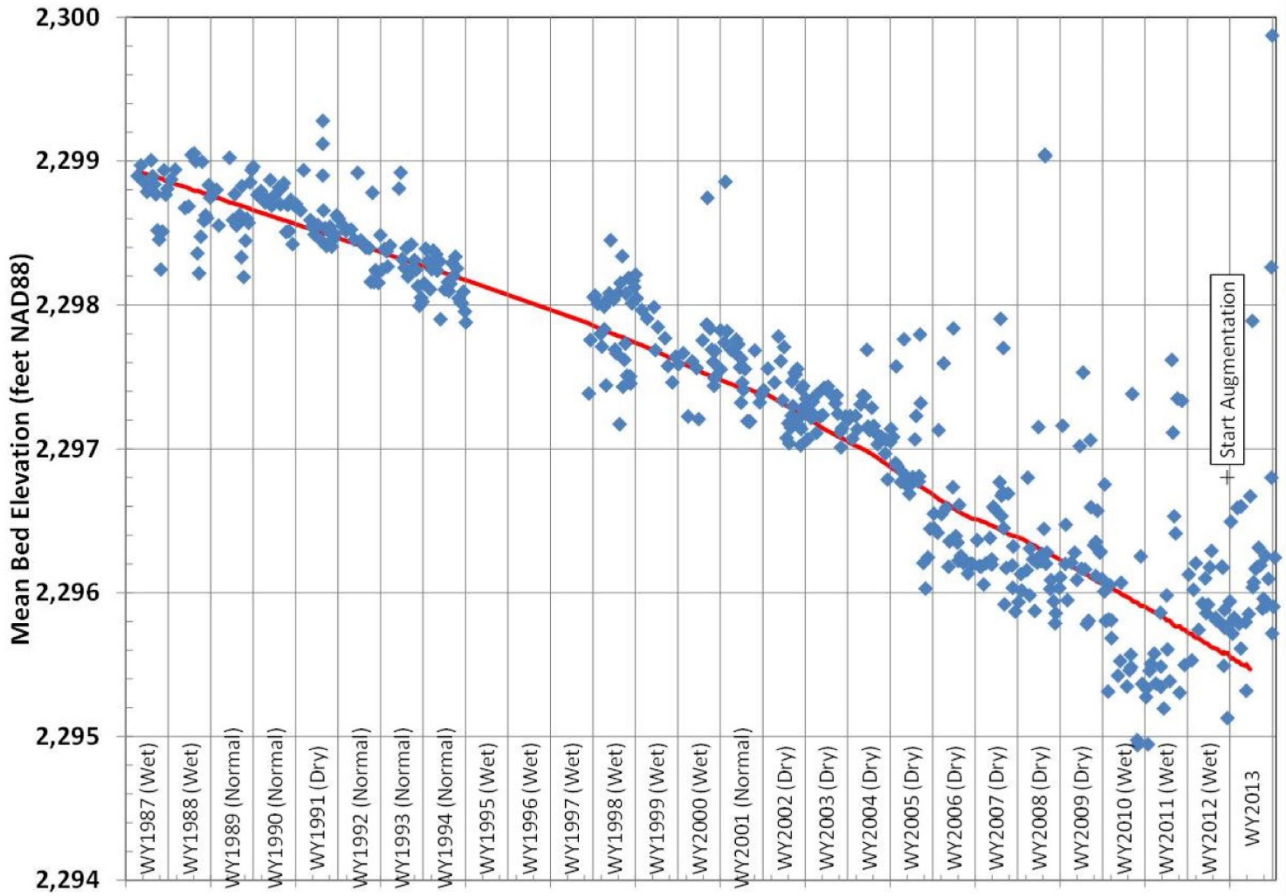
DATE	April 2014
FIGURE	16

The long-term trends in mean bed elevation at the Overton gage were assessed by computing the mean channel depth for each of the measurements that have been taken since the gage was moved to its current location at the beginning of WY 1987 and then subtracting each depth from the reported water surface elevation (computed by adding the reported stage to the applicable gage datum) (Figure 17). Similar to the stage data, the variability in the data about a best-fit trend line (developed using the Lowess technique) is greatest during wet and dry years and smallest during normal years (Figure 18). These data show a clear degradational trend over essentially the entire period, with the mean bed elevations decreasing from about 2,299 feet NAVD88 in 1987 to about 2,295 feet NAVD88 over the past 3 years (Figure 17). Although there is significant scatter, the recent data indicate that the bed was lowest during the high-flow period in WY 2010 and WY 2011, and may have rebounded by up to 0.5 foot during the subsequent drier period that began well before the start of the Pilot Project. WY 2013 appears to continue this trend as a dry year, with data scattered around 2,296 feet NAVD88 (Figure 17). This trend is consistent with an aggradational tendency in the system-wide geomorphology monitoring data for the 100-mile Central Platte River study reach. As a result, at least a portion of the aggradation at the monitoring sites may reflect changes that are not directly related to sediment augmentation.

Similar to the stage change data, the deviation of the measured mean bed elevations at the Overton gage taken between the start of the management action and April 2013 generally fell within the variability of the historic measurements (Figure 19). Therefore, no impact triggers were initiated during Phase I of the management action. The fact that all of these points are higher than the trend line since the beginning of WY 2012 (October 1, 2011) is a reflection of the apparent general aggradational trend that began a year before the start of augmentation, and does not appear to be directly related to sediment augmentation. Four of the measurements taken during and after April 2013 (that is, on April 12, May 23, June 6, July 16) fall above the pre-augmentation envelope line. Other measurements taken between these dates, however, were well within the pre-augmentation envelope; thus, it does not appear that a systematic aggradational trend that can be directly tied to the management action that is occurring in the vicinity of the Overton Bridge.

As required by the monitoring plan, pressure transducer stage recorders were installed before the start of augmentation. One transducer was placed at XS-1 in the south channel and another was placed on the left bank in the vicinity of the Todd Brown property in the north channel. These recorders were operated throughout the sediment augmentation period. Stage and discharge data for the same time period were also obtained from USGS records at the Overton gage. These stage records were monitored daily to evaluate the need to modify the management action. As shown in Figure 20, the stage trends during Phase I and Phase II indicate a modest trend of increased stage at baseflows of 0.5 foot to 0.8 foot over the monitoring period. Because there appears to have been a general aggradational trend throughout the reach that started before the augmentation activities, this relatively modest change does not appear to be related to the Pilot Project. The aggradational trend may be attributed to observed bank erosion on the south bank of the channel upstream of XS-1 and lower velocity of the river flows due to the backwater effect caused by the partial obstruction of the channel from augmentation activities.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_17.mxd\apr14\jcm



Mean Bed Elevations at the Overton Gage Based on the USGS Field Measurement Data

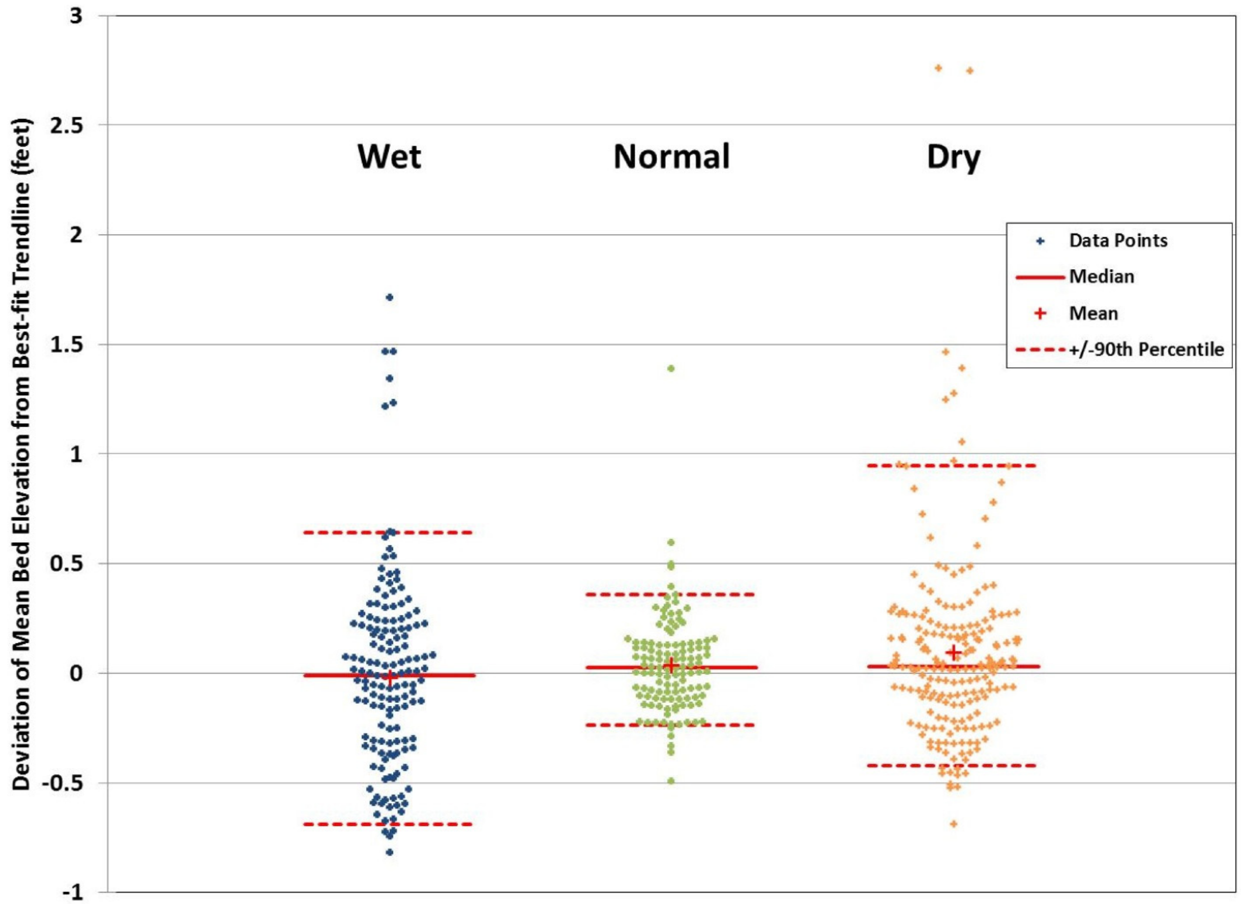
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 17

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_18.mxd\apr14\jcm



Variability of the Measured Bed Elevations about the Best Fit Trend line for Wet, Normal, and Dry Years

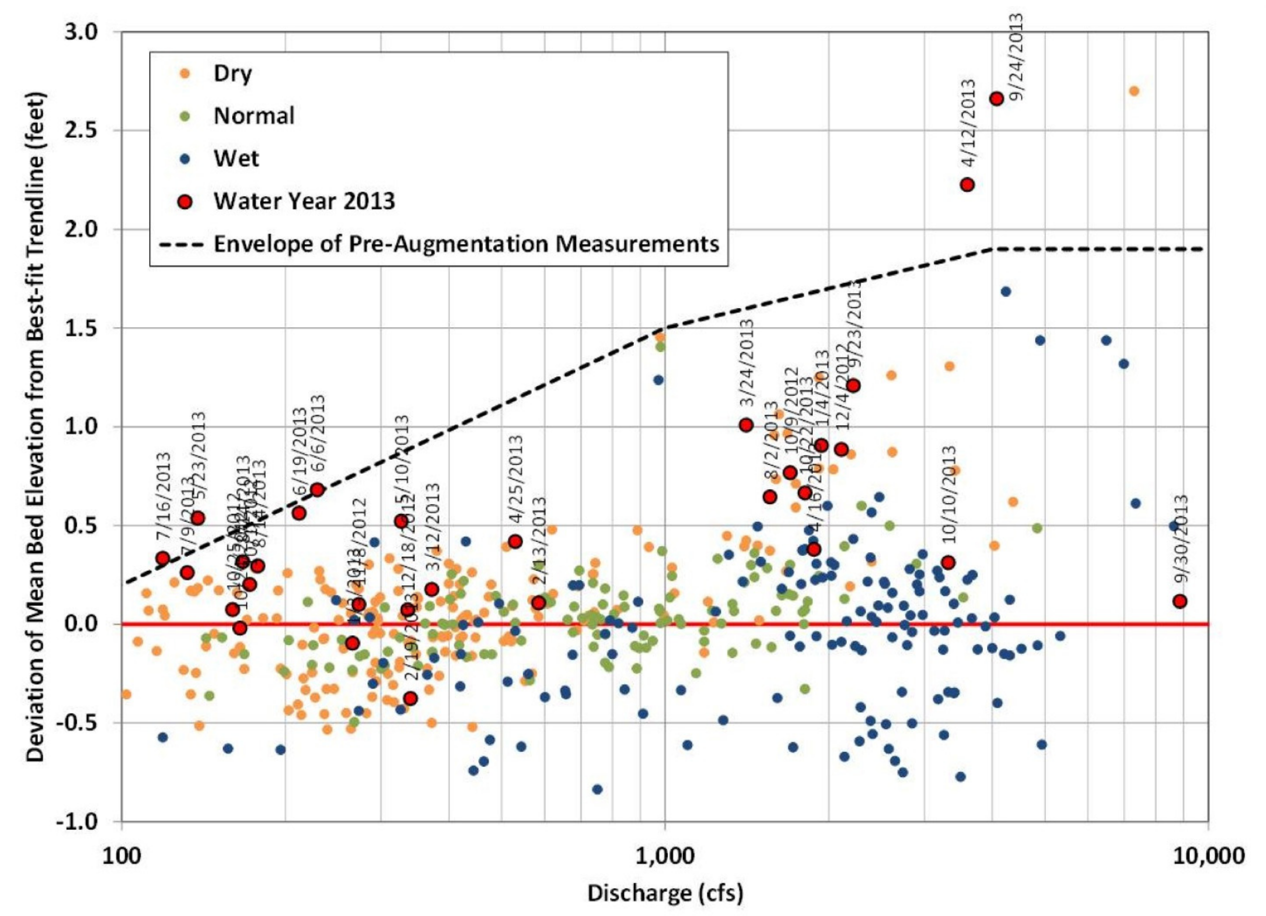
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 18

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_19.mxd\apr14\jcm



Deviation of the Measured Mean Bed Elevation at the Overton Gage from the Lowess-Based Trendline

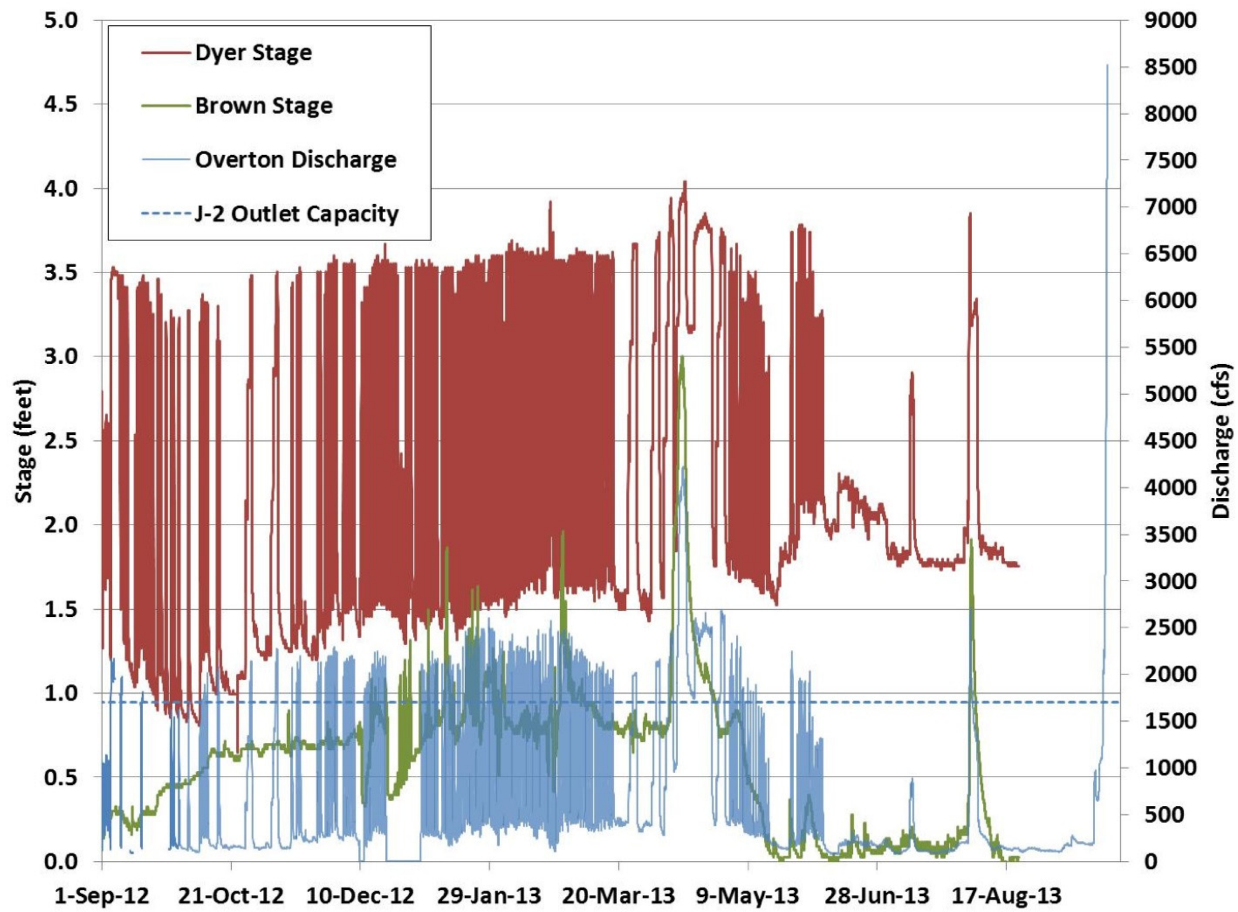
Sediment Augmentation Final Pilot Study Report

DATE
April 2014

FIGURE
19

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_20.mxd\apr14\jcm



Pressure Transducer Stage Data at the Dyer and Brown Property During the Monitoring Period

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 20

A major precipitation event occurred in Colorado on the upper tributaries to the South Platte River in September 2013. This rainfall resulted in downstream runoff resulting in record or near record stages in Colorado and Nebraska for the South Platte River. The flood wave resulting from this event required USGS and NDNR to use temporary shift adjustments to gage station rating curves along the South Platte and Platte rivers, including the gage at Overton. Although the September 24, 2013, reading indicated an upward shift, the September 30, 2013, reading was back near the zero line. No trend can be inferred.

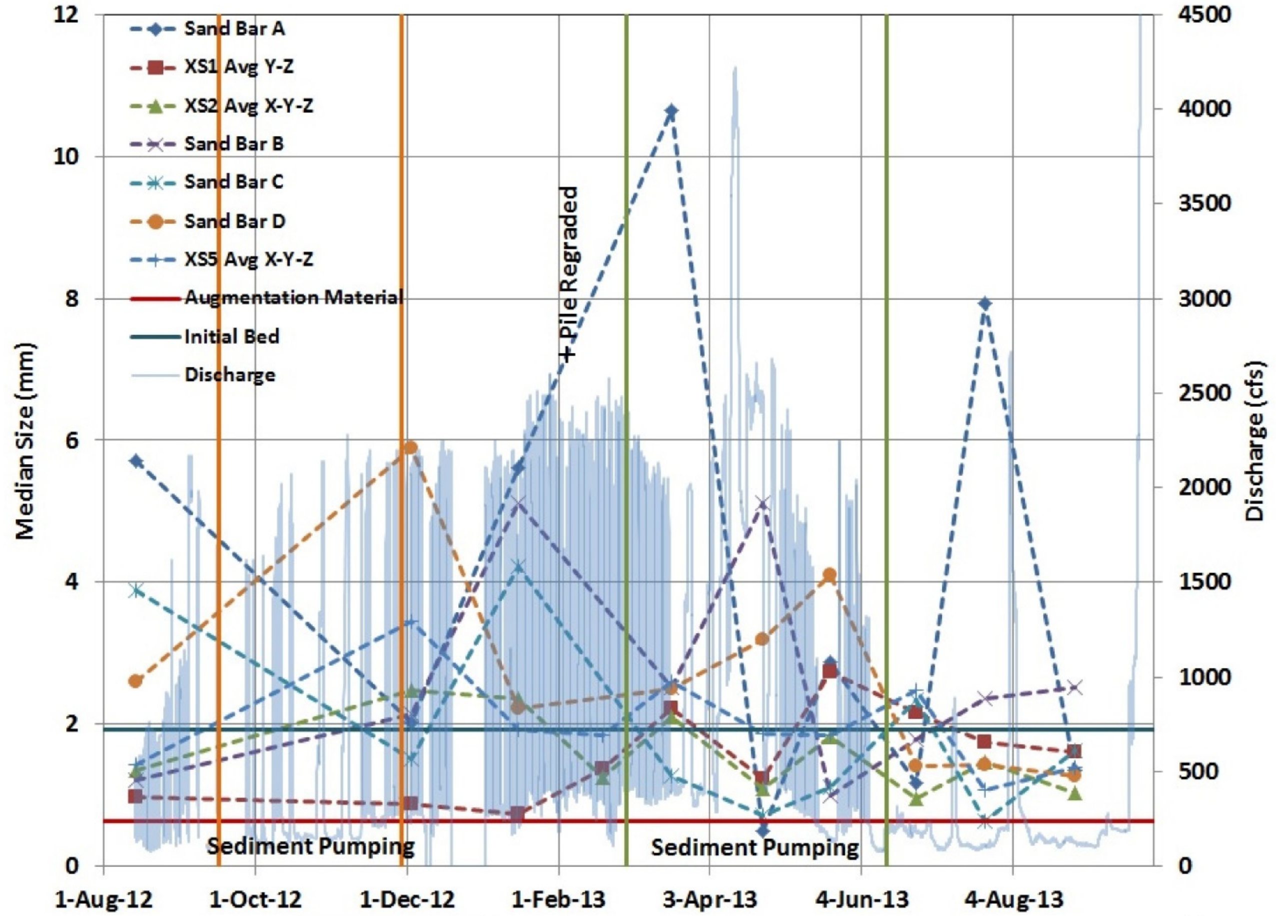
3.4 Bed and Bar Material Sediment Sizes

Bed and bar material samples were collected in accordance with the Monitoring Protocol (PRRIP 2011). During each survey, three samples were collected from each of the primary monitoring cross sections XS-1, XS-2, and XS-5. In addition, samples were collected from the head of four sand bars within the surveyed reach. A similar sampling procedure was followed during the surveys at AP 32 and AP 34. The combined sample set for Phase I includes 94 samples collected during the four surveys that were conducted in August 2012 (baseline), December 2012, January 2013, and February 2013. The Phase II sample set includes 69 individual samples collected during the five surveys that were conducted monthly from March through July 2013. The gradation of the individual samples, along with the D_{16}, median (D_{50}), and D_{84} sizes and the gradation coefficient, are tabulated in Appendix B.

Based on the average D_{50} at each cross section, the bed material at XS-1, upstream of the pump outfall, was considerably finer than at the other monitoring cross sections and remained relatively constant (0.74 to 0.97 mm) from August 2012 through January 2013, but then coarsened significantly to about 1.4 mm in February 2013 (Figure 21). This overall coarsening trend continued through Phase II. At XS-1, the average D_{50} peaked during the May 2013 survey at 2.74 mm and then tapered down to 1.61 mm by the August 2013 survey. The bed at XS-2 and XS-5, downstream of the outfall, coarsened significantly between August and December 2012, and then showed a general fining trend through January and February 2013. This overall fining trend continued through Phase II, with the average D_{50} from the August 2013 samples decreasing to 1.04 mm and 1.39 mm for XS-2 and XS-5, respectively. XS-2 had a slightly finer average D_{50} from the August 2013 data than the August 2012 baseline sample, while XS-5 remained about the same.

Sand Bar A, located just upstream of XS-1 and the pump outfall, fined significantly between August and early December 2012, and then coarsened back to near its original size by mid-January 2013. The gradation then coarsened significantly by the March 2013 survey to 10.64 mm and fluctuated from less than 0.5 mm to nearly 8 mm during the remaining surveys. Sand Bar C, located just upstream of XS-4, also fined significantly between August and early December 2012 and then coarsened back to near its original size by mid-January 2013. Sand Bar C and Sand Bar A both became finer overall by the August 2013 survey in comparison to the August 2012 baseline survey. Sand Bar B, located between XS-2 and XS-3, just downstream of the pump outfall, coarsened from about 1.2 mm in August 2012 to 2 mm in December 2012, and then coarsened even more significantly to about 5 mm by mid-January 2013. The gradation of this sand bar became finer, to 0.99 mm, by the May 2013 survey and then coarsened again, to 2.52 mm, by the August 2013 survey. Sand Bar D, located between XS-4 and XS-5, coarsened significantly to nearly 6 mm by early December 2012 and then fined back to about 2.2 mm by mid-January 2013. It coarsened again to just over 4 mm during the May 2013 survey and then became finer, at 1.28 mm, by the August 2013 survey. Similar samples collected at AP 32 and AP 34 showed a general coarsening trend over the Phase I period (Figure 22). Except for the samples taken at the most downstream cross section at AP 34, these samples indicate a general coarsening trend throughout the monitoring period.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_21.mxd\apr14\jcm



Average Median (D_{50}) Particle Size of the Sediment Samples Collected from the Bed and Bars at the Primary Dyer Site Cross Sections

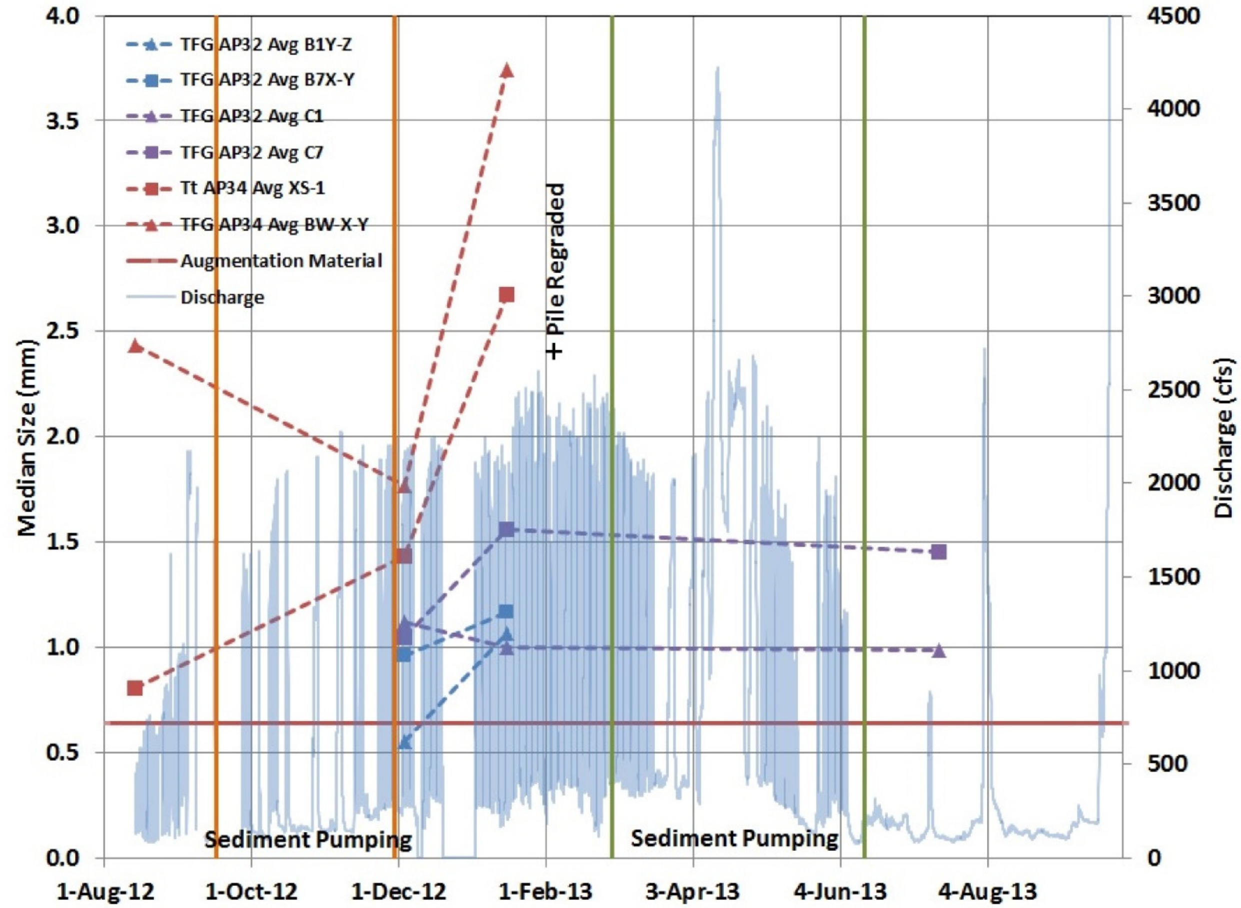
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 21

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_22.mxd\apr14\jcm



Median (D_{50}) Particle Size of the Sediment Samples Collected from Channel Bed at the AP32 and AP34

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 22

1

At the AP 34 downstream cross section, the bed fined from about 2.5 to 1.8 mm between August and December 2012, and then coarsened back to about 2.6 mm by mid-January 2013. Sediment samples were not collected at AP 34 during Phase II. At AP 32, sediment samples were collected only in the North ("C") channel at XS-1 and XS-7 during the Phase II survey. The data show little change in the average D_{50}.

3.5 Tri-Basin Drains

Photographs were taken at each site for those drains that were located. Impacts from the Pilot Project were not quantifiable downstream of the augmentation areas at the location of the drains.

Due to the overall low flow and low sediment transport conditions prevalent during a good portion of the Pilot Project, none of the identified drainages appeared impacted by the Project. A final visual observation was conducted and photographic documentation was taken of the drains in August 2013. Observations from these site visits confirmed that there were no impacts on the drains. Based on the location of the drains and the condition of the river channel at the outlet of the drains, it is highly unlikely that sediment augmentation conducted at the two locations used during the Pilot Project would impact the drains regardless of the level of augmentation unless drastic changes to the river channel were to occur. Photos of the drain locations before and after augmentation activities are included in Appendix C.

3.6 Sediment Transport Modeling

The 1-dimensional (1-D) HEC-RAS-based sediment transport model that was developed for the Sediment Augmentation Feasibility Study was revised to represent the sediment inputs for this Pilot Project. Prior to the start of the Pilot Project, the model was run for three 2-year flow sequences that represent dry, normal, and wet conditions to assess the potential response of the river (Tetra Tech 2011; Tetra Tech 2010). At the end of the monitoring season, the models were re-run using the actual flows that occurred in the reach between September 1, 2012, and August 31, 2013, to assess how well the model predicts the actual bed response and to provide information on the likely fate of the augmented sediment. Two versions of the model were run for this analysis, one with and one without the augmented sediment, to provide information on the relative impact of the augmented sediment on the downstream channel. The modeled reach extends from approximately 0.8 mile downstream of the Odessa Bridge to approximately 3.5 miles upstream of the Lexington Bridge, and includes the South Channel at Jeffery Island downstream from the J-2 return.

3.6.1 Anticipated Augmentation Rates

The initial model runs that were reported in Tetra Tech (2011) were made for two scenarios at the Dyer Property to capture the potential range of pumping rates:

- Scenario 1: 75 tons per hour with 24-hour work days and 6 work days per week starting on October 15 until a total of 50,000 tons is added
- Scenario 2: 75 tons per hour with 16-hour work days and 6 work days per week starting on October 15 until a total of 50,000 tons is added

Under Scenario 1, the pumping occurred at a rate of approximately 1,800 tons per day (tpd) over an approximately 30-day period from mid-October to mid-November. For Scenario 2, the pumping occurred at a rate of approximately 1,200 tpd over an approximately 45-day period from mid-October through the end of November in each year.

At CWR, the dozing operations were assumed to occur 5 work days per week over a 3-week period beginning on October 15, with a daily load of about 3,300 tons (total of 50,000 tons) delivered to the river.

3.6.2 Actual Augmentation Rates

During both Phase I and Phase II of the management action, actual augmentation rates varied from the modeled scenarios developed for the Screening Study (TFG et al. February 2011).

Sand pumps were used to deliver about 25,000 tons of material to the South Channel at the Dyer Property between September 26, 2012, to November 30, 2012, during Phase I, and about 57,000 tons of material was pumped to the river between March 1 and June 14, 2013, during Phase II (Figure 23). Daily pumping times and rates varied considerably depending on flow conditions and accumulation of sediment in the discharge area. Continuous steady pumping was not possible because of the variability of flow during the two augmentation periods. An attempt was made to pump material primarily during or prior to projected flow releases from the J-2 return release schedule provided by CNPPID to ensure that sufficient quantities of augmented sediment would be available for transport during these relatively higher flows. Overall, the average daily rates were significantly lower than the rates that were modeled in the pre-augmentation model runs, even though the hourly pumping rates during actual pumping were significantly higher than the modeled rates.

The quantity of sediment augmented during Phase I at the Dyer Property was only about half of the quantity anticipated prior to implementation. This occurred because the discharge outfall remained in essentially one location throughout the pumping period, resulting in significant accumulation of sediment in a source pile that projected into the channel. Some erosion did occur; however, it was not sufficient enough to eliminate the source pile. This source pile was eventually mechanically redistributed into the active river channel in early February 2013. It was necessary to cease augmentation activities in late November due to freezing temperatures.

During Phase II, the discharge outfall was moved periodically to reduce the tendency for the augmented material to accumulate in one location above the adjacent bank elevation. Subsequent to completion of the Phase II pumping, the Program hired a contractor to spread the source piles out into the channel and cut a channel behind the main pile to allow better access of river flows and more effective entrainment of the augmentation material. This manipulation of material created a source island and also provided some temporary bird habitat.

At CWR, Phase I augmentation commenced on September 17, 2012, and was completed by November 8, 2012 (Figure 24). The actual volume of material augmented (that is, pushed into the river) at CWR was 75,000 tons. As the work proceeded, the contractor underestimated the quantity of material moved in Phase I, and by the time Phase I augmentation ceased, the augmented quantity exceeded the Pilot Project goal for this site (50,000 tons) by approximately 50 percent. However, a significant portion of the material remained in the river channel and did not mobilize during Phase I due to low river flows. The remaining material in the channel was available for more rapid augmentation when flow conditions increased in the spring.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_23.mxd\apr14\jcm

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
September																										X	X	X			
October	X	X	X	X					X	X	X				X	X	X	X	X						X	X					
November					X	X	X							X	X	X			X	X	X					X	X	X	X	X	
December																															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
March	X			X	X		X	X			X	X	X	X	X			X	X	X	X	X				X	X	X	X		
April	X	X	X	X	X															X		X	X	X	X	X			X	X	
May		X	X			X	X	X	X	X			X	X	X	X	X			X	X	X	X	X				X	X	X	X
June			X	X	X	X	X			X	X	X	X	X																	

Dyer Management Action Summary - Phase I and II (Days)

Sediment Augmentation Final Pilot Study Report

DATE: April 2014

FIGURE: 23

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
September																	X	X	X	X	X	X		X	X	X	X	X	X		
October		X	X	X	X	X		X	X			X	X		X	X	X	X	X							X	X				
November					X	X	X	X																							
December																															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
March																		X	X	X	X	X	X		X	X	X	X	X	X	
April	X	X			X	X																									
May																															
June																															

Cottonwood Ranch Management Action Summary - Phase I and II (Days)

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 24

1

Phase II augmentation commenced on March 18, 2013, and was completed by April 6, 2013, ahead of the scheduled SDMF event (Figure 24). The Phase II augmentation strategy was modified at CWR to allow more effective entrainment of the residual augmentation material from Phase I as well as an additional 25,000 tons of material to achieve the site goal of 100,000 tons augmented to the river. The residual source pile was reshaped and the additional 25,000 tons of material were excavated to create a series of channels behind and through the augmented material. Elevation of the augmentation piles was kept to a level that would be inundated during higher flows. It is anticipated that this material will gradually be entrained as flows pass over and around the augmentation islands.

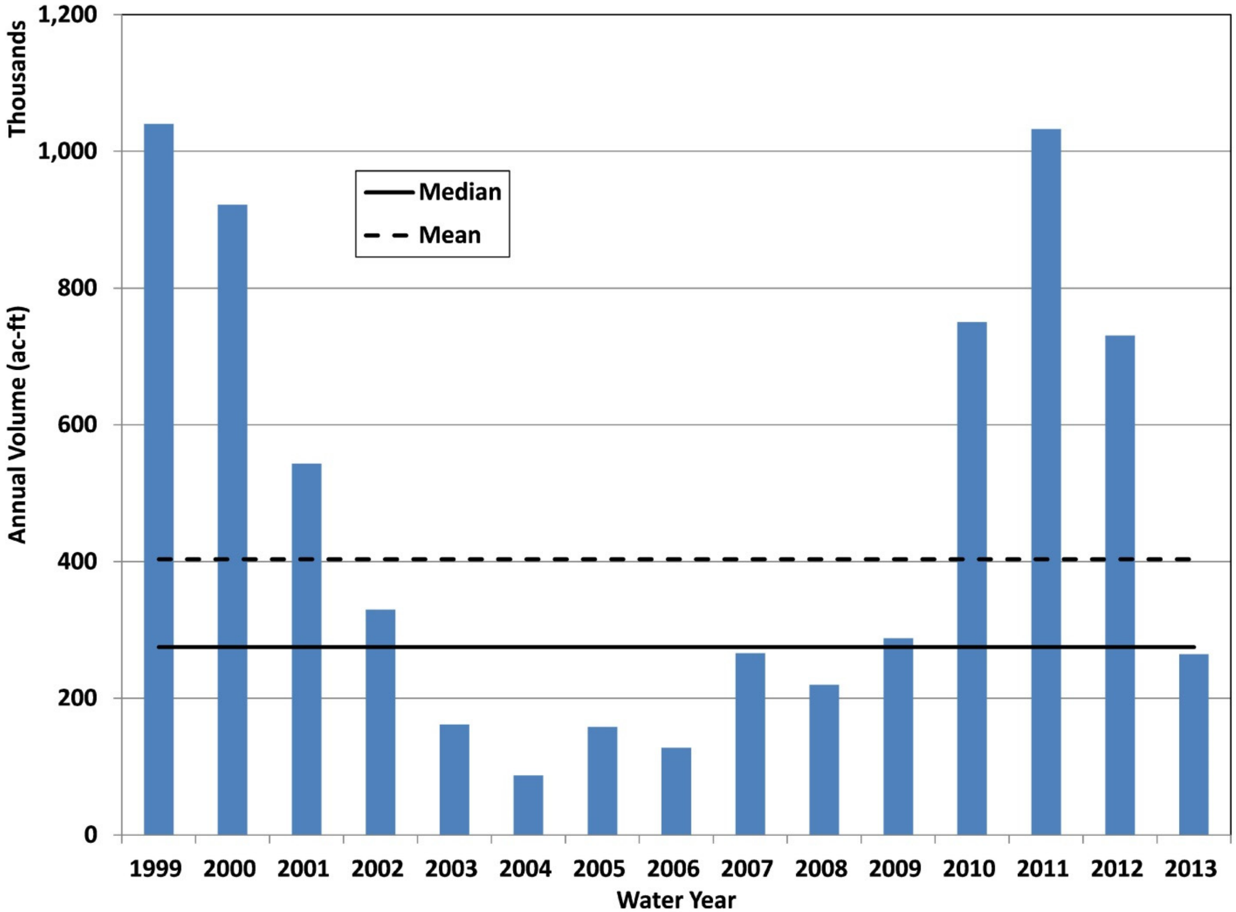
The Phase I total augmentation goal was met by introducing 25,000 tons of material at the Dyer Property and 75,000 tons of material at CWR. Phase II total augmentation quantities included 57,000 tons at the Dyer Property and 25,000 tons at CWR, for a Phase II total of 82,000 tons. As of this report, based on aerial photos and the monitoring data at Monitoring XS2 where the average bed elevation is about 0.5 foot higher than during the pre-augmentation survey, it appears that a portion of the augmented material at both locations remains on site awaiting entrainment.

3.6.3 Discharge Record

For the feasibility study, model runs were made for three water year types (dry, normal, and wet). As defined by Anderson et al. (2006), wet conditions correspond to the wettest one-third of flows, dry conditions to the driest one-quarter of flows, and normal to all remaining conditions. The dry flow sequences were represented by WY 1982 and WY 1983, the normal flow sequences were represented by WY 1979 and WY 1980, and the wet flow sequences were represented by WY 1986 and WY 1987. The total flow volume passing the Overton gage during the first year of each of these sequences was 634,000, 864,000 and 1.94M acre-feet, respectively (Figure 8). For comparison, the total flow volume passing the Overton gage during WY 2013 that included the Pilot Study implementation period was approximately 607,000 ac-ft. It is important to note, however, that about 150,000 ac-ft of this volume occurred in September after the last monitoring survey, and the vast majority of this occurred during the last few days of September when the 2013 flood passed through the area. As a result, the total flow volume passing the Overton gage during the monitoring period was significantly less than even the dry year feasibility study model run (~457,000 ac-ft versus 634,000 ac-ft), and a significant portion of the Overton flow was delivered to the river through the J-2 return and the South Channel at Jeffrey Island. Based on mean daily flow records provided by CNPPID, releases from the J-2 return totaled 264,300 ac-ft in WY 2013, compared to the median value for the 15-year period from WY 1999 through WY 2013 of about 275,000 ac-ft (Figure 25). Based on the monthly releases, WY 2013 was consistent with the median values during Phase I and the early part of the Phase II pumping at the Dyer Property (October through February), slightly lower in March, and then quite high in April due to the Program's SDMF release (Figure 26). The releases during the period from May through September were very low compared to the earlier years.

The CNPPID Reregulating Reservoir Elwood and J-2 Alternatives Analysis Project Report concluded that flow gains of about 50 cfs occur in the J-2 Canal downstream from the release point during the spring, and the amount varies during other parts of the year. Because the irrigation canals add additional surcharge to the groundwater levels, the gains are likely much higher during the summer irrigation season. Although no flow records are available for the North Channel, the above information indicates that the flow volume from the upstream mainstem during WY 2013 was very low compared to normal conditions.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_25.mxd\apr14\jcm



Annual Release Volumes from the J-2 Return

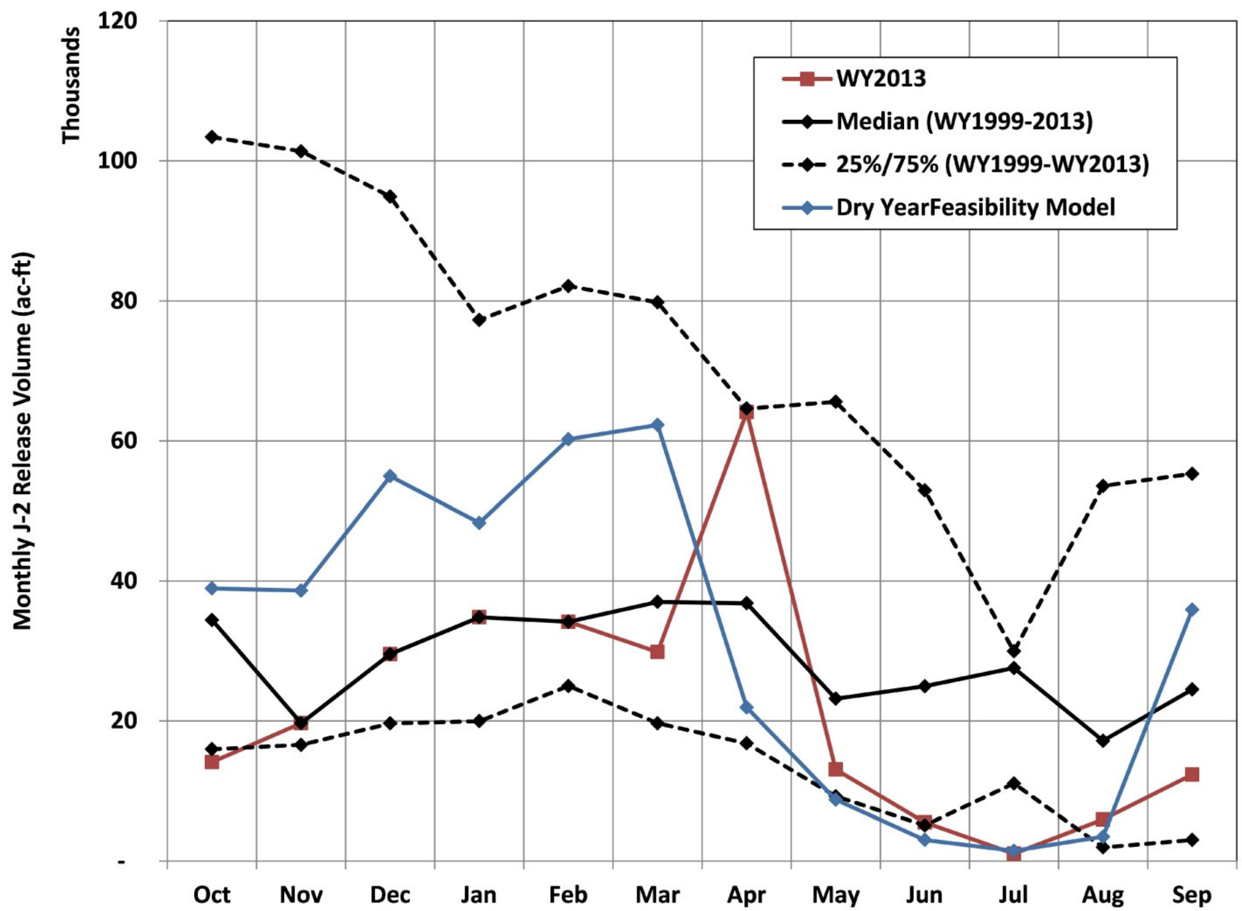
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 25

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_26.mxd\apr14\jcm



Monthly Volume of Flow Releases from the J-2 Return Compared to the Median and Upper and Lower Quartiles

Sediment Augmentation Final Pilot Study Report

DATE April 2014

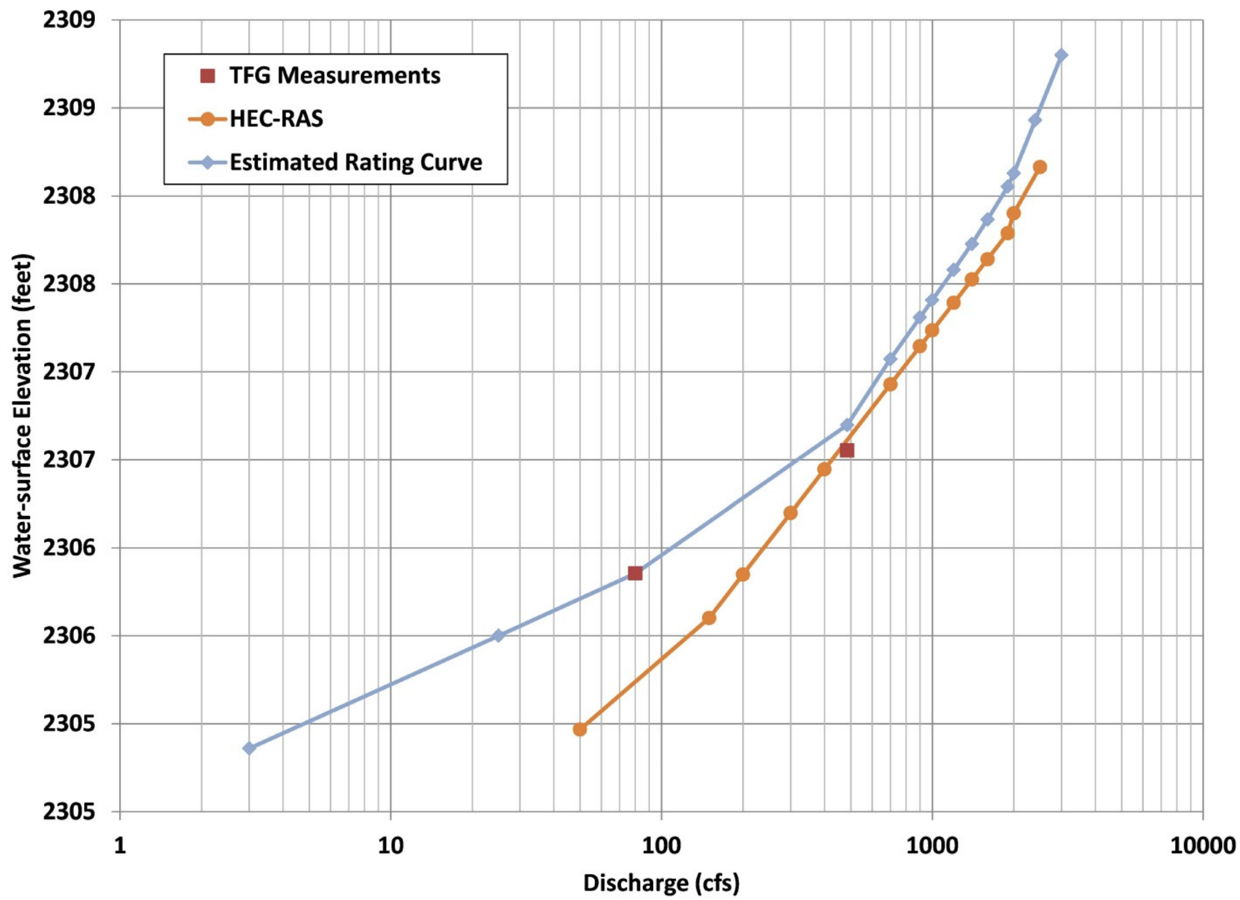
FIGURE 26

To facilitate sediment transport modeling of the study reach during the Pilot Project, an hourly flow record was developed for the North and South Channels for the 1-year period from September 1, 2012, through August 31, 2013, based on a combination of the USGS provisional flows at the Overton gage, the record of mean daily J-2 return flow releases provided by CNPPID, and the detailed record of stages at the Dyer Property pressure transducer that is located a short distance upstream from the pump outfall. Only two discharge measurements were made at the pressure transducer during the augmentation project (485 cfs on August 15, 2012, prior to the start of pumping, and 80 cfs on November 14, 2012, near the end of the Phase I pumping); thus, there is insufficient field data to directly estimate a stage-discharge rating curve. In addition, it appears from the data that the sediment stockpile created by the augmentation caused backwater during at least some periods that could influence the stage-discharge relationship, particularly at low flows (Figure 27). To facilitate development of the flow record for the South Channel, an initial rating curve was developed from the existing conditions HEC-RAS model, and this curve was shifted during the augmentation period to match the November flow measurement and to provide high flows that are consistent with the typical J-2 peaking releases of about 1,700 cfs. The curve was also periodically adjusted to ensure that the low flows in the South Channel and the corresponding flows in the North Channel were reasonable based on the available information. The resulting estimated flow record follows the recorded pattern of J-2 releases indicated by the Dyer Property transducer, with typical maximum flows in the South Channel at the Dyer Property in the range of 2,000 cfs or less during the releases and dropping to 50 cfs to 150 cfs during the non-release periods (Figure 28). Based on the provisional USGS data, the total flow volume passing the Overton gage during the period was 528,000 ac-ft. From the estimated records, about 141,000 ac-ft came down the North Channel, and about 387,000 ac-ft passed the Dyer Property in the South Channel (Figure 29). For comparison, the total volume in the South Channel for the dry-year feasibility model run was very similar (378,000 ac-ft), but the volume in the North Channel was significantly greater (255,000 ac-ft).

3.6.4 Sediment Gradations

The pre-augmentation modeling considered two different gradations for the Dyer Property pump input. The finer of the two had a median size (D_{50}) of approximately 0.5 mm, similar to the excess material generated at the Overton Sand and Gravel plant (Figure 30). The coarser gradation was developed by averaging the fine gradation with the gradation of the existing channel bed material to provide a gradation that was believed to be more representative of material at the mining location on the Dyer Property. This gradation had a D_{50} of approximately 0.7 mm.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_27.mxd\apr14\jcm



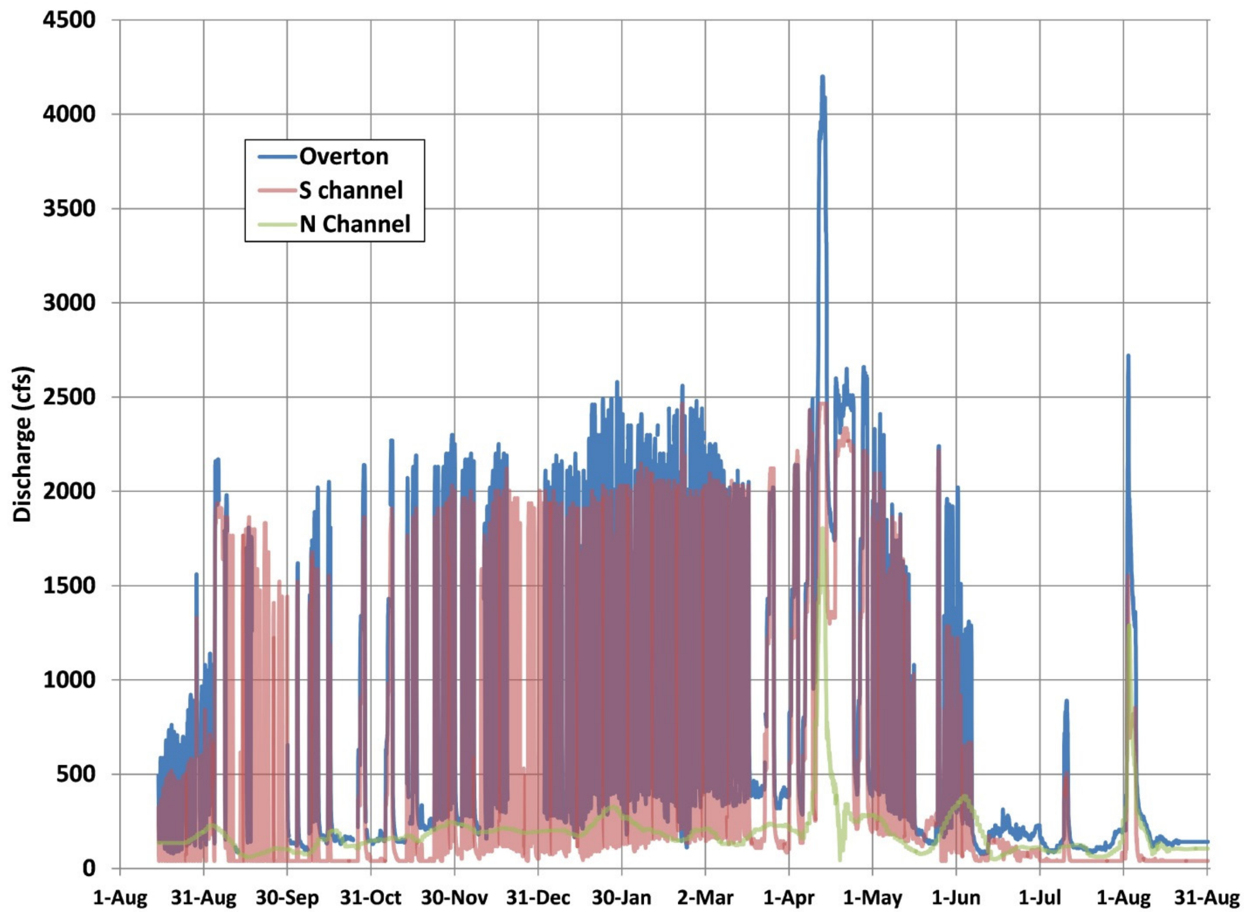
Stage-Discharge Rating Curves at the Pressure Transducer Upstream from the Dyer Outfall

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 27

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_28.mxd\apr14\jcm



Provisional Hourly Discharges at the USGS Overton Gage and the Estimated Hourly Discharges in the South Channel at the Dyer Property and in the North Channel

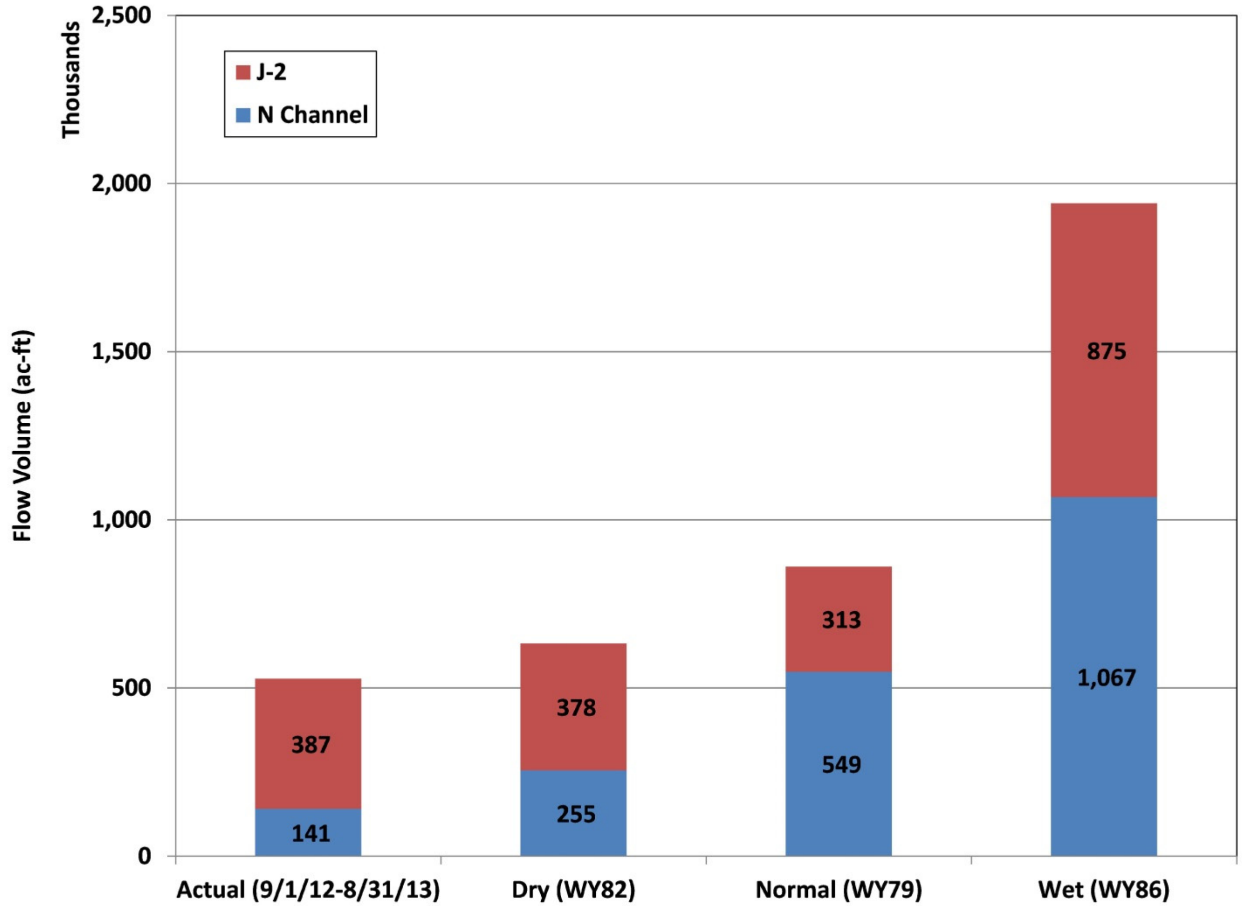
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 28

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_29.mxd\apr14\jcm



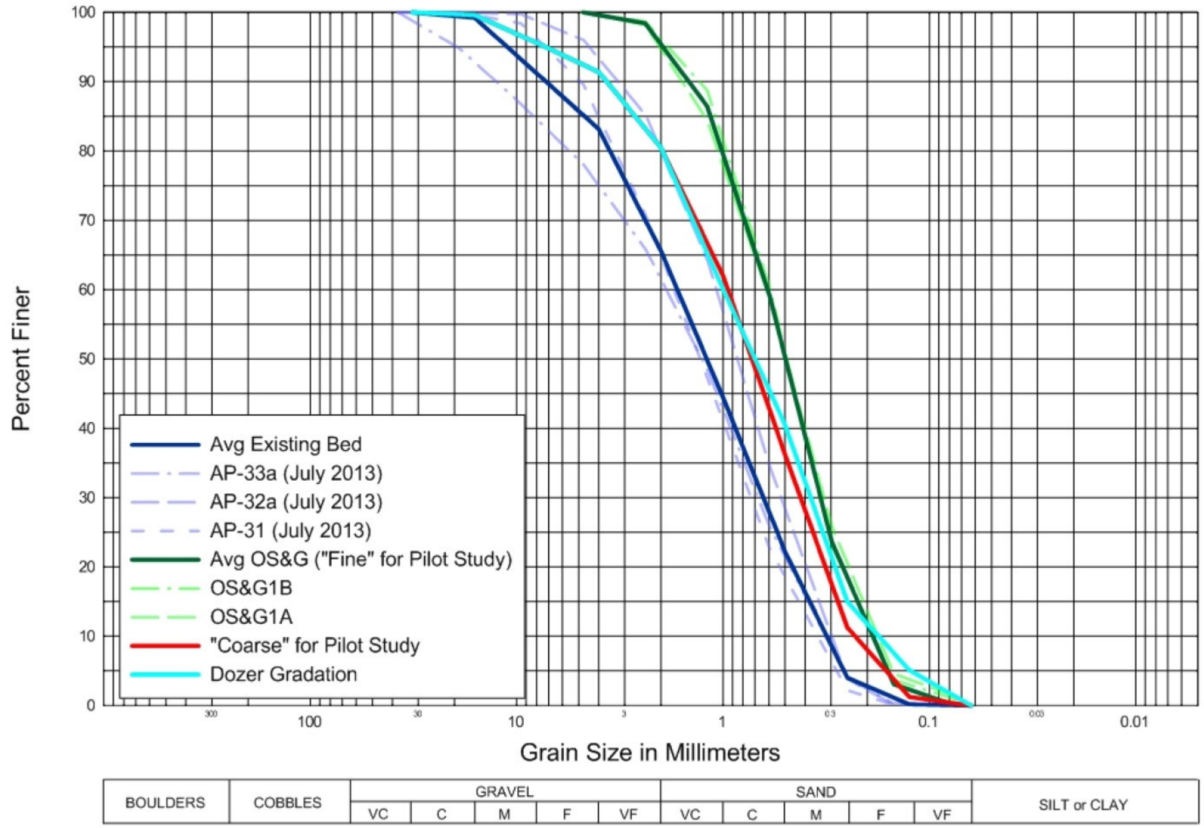
Estimated Flow Volumes in the South Channel at the Dyer Property and the North Channel Just Upstream from the North-South Channel Confluence
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 29

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_30.mxd\apr14\jcm



Gradation Curves of the Augmented Sediment

Sediment Augmentation Final Pilot Study Report

DATE
April 2014

FIGURE
30

The specifications for the Pilot Project were modified slightly prior to implementation because the originally specified band of permissible gradations would have required a rotary screen, significantly increasing the cost. The modified gradation involved relaxing the tolerances for the size classes greater than 0.6 mm, allowing the contractor to use traditional flat screens and still achieve a gradation that was within the desired range of target augmentation (Table 4). The average gradation of the pumped material had median (D_{50}), D_{16}, and D_{84} sizes of 0.64 mm, 0.32 mm, and 1.6 mm, respectively (Figure 31). This range of sizes was within the range allowed in the modified specifications, and somewhat coarser than the gradation used in the fine sediment model runs for the feasibility study (D_{50}=0.5 mm).

Table 4. Augmentation Gradation 1 – Screening Summary Report

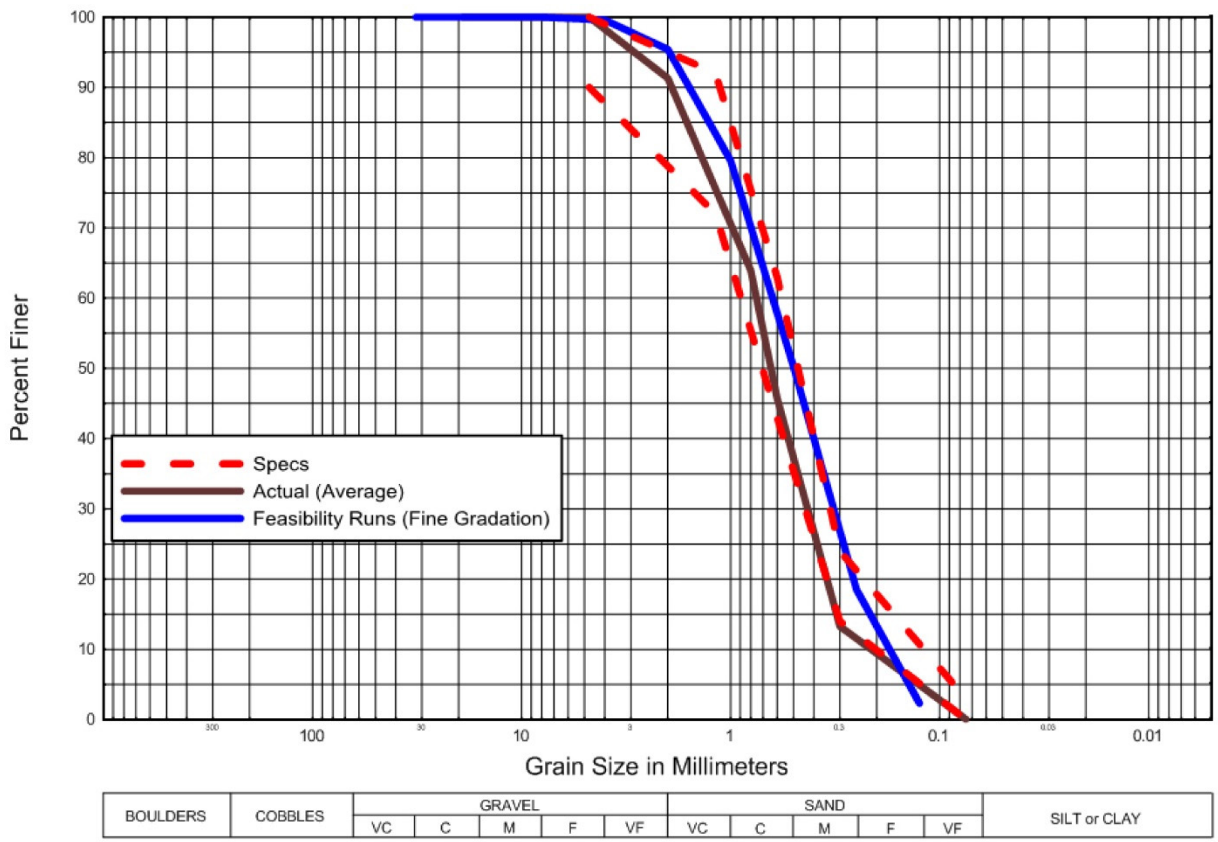
Sieve #	Equivalent size (mm)	% Passing	% Retained	Tolerance	
				Original	Modified
4	4.75	100	0	±0	±10
16	1.18	85	15	±5	±10
30	0.6	60	40	±10	±10
50	0.3	25	75	±5	±5
200	0.075	1	99	±2	±2

3.6.5 Model Results

The mobile-boundary HEC-RAS model used for the feasibility study was modified to incorporate the estimated hourly flow record and run for two conditions to provide an understanding of the effects of the pilot augmentation on aggradation/degradation patterns within the reach: (1) no augmentation, and (2) with augmentation. The no-augmentation model used the same inflowing sediment rating curves that were used in the feasibility study, including the assumption that no sediment is delivered to the river from the J-2 return. These same sediment inflows were used for the with-augmentation model, along with a record of estimated sediment augmentation inputs that was developed from the pumping schedule and detailed monitoring data at the Dyer Property and the grading schedule at CWR.

As noted above, all of the sediment pumped to the river during Phase I and Phase II operations at the Dyer Property was not available for entrainment by the river. For purposes of the modeling, the inflowing sediment load to the river during Phase I was developed by uniformly apportioning the quantity that was eroded from the sediment stockpile between the monthly, detailed surveys in the vicinity of the pump outfall, totaling approximately 12,630 tons as listed in Table 3. The remaining approximately 12,370 tons that was graded into the river in early February was assumed to be available for entrainment uniformly over a 10-day period. Field estimates indicate that about 25,000 tons of material remained in the immediate vicinity of the pump outfall at the end of Phase II pumping; thus, it was assumed that 32,000 tons of material was delivered to the river uniformly over the 106-day Phase II pumping period, and the remaining 25,000 tons was distributed over a 10-day period in mid-June when the pumping was completed and the material was graded into the river. The resulting inflow rates at the Dyer Property averaged about 93 tpd and ranged from a low of about 6 tpd in mid-November to a high of about 140 tpd in late October during the Phase I pumping period. During the Phase II pumping period, the sediment inflow rate to the river averaged about 300 tpd. The sediment inflow rates for the grading activities at CWR were estimated by apportioning the total volume of graded material during each period uniformly over the grading period. This resulted in an average inflow rate of about 3,240 tpd during Phase I and about 1,560 tpd during Phase II.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_31.mxd\apr14\jcm



Average Particle Size Gradation of the Material Pumped into the River at the Dyer Property During the Phase I and Phase II Sediment Augmentation

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 31

1

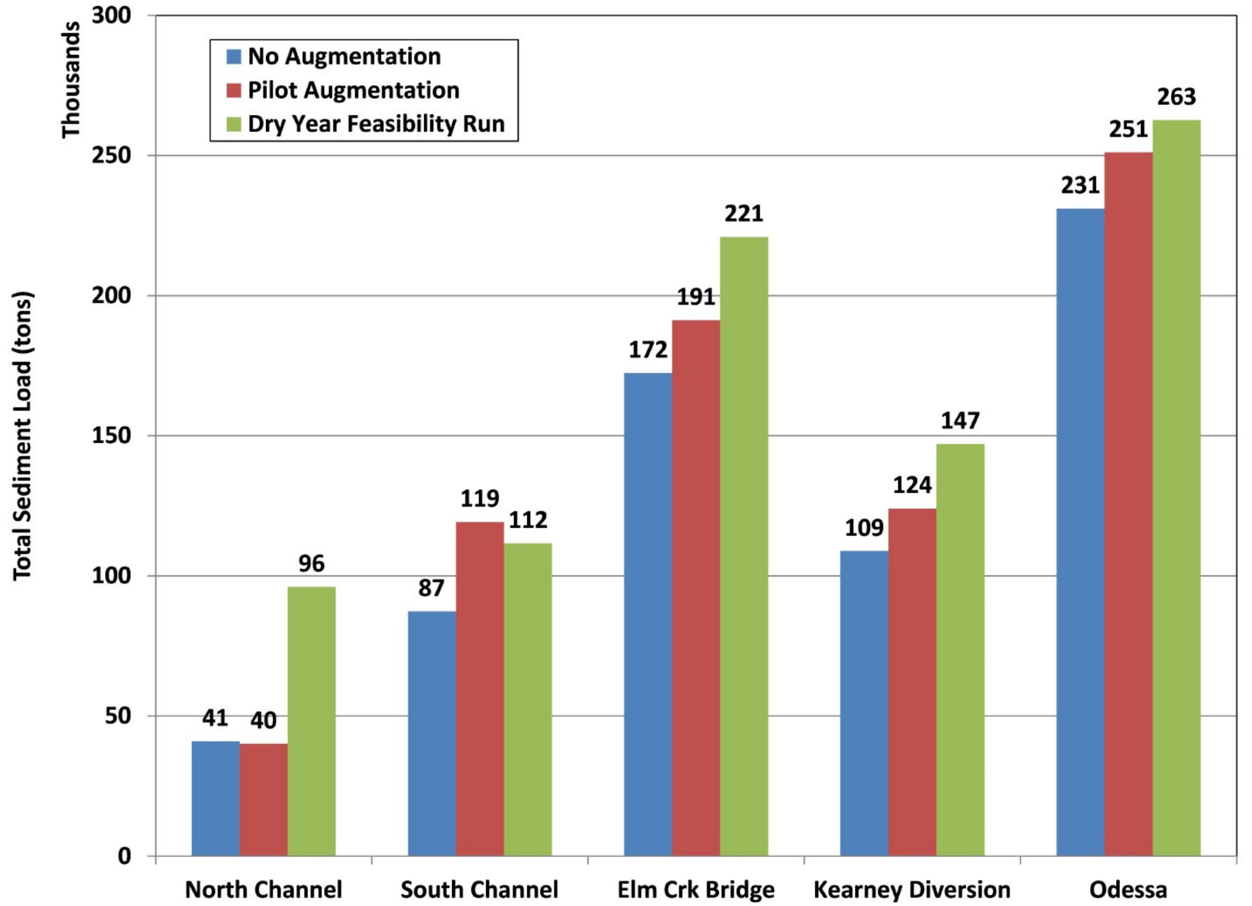
The model results indicate that about 40,000 tons of sediment was delivered to the vicinity of the Overton Bridge through the North Channel during the 1-year period for both the no-augmentation and with-augmentation runs (Figure 32). In contrast, about 96,000 tons came down the North Channel during the first full water-year of the dry-year feasibility study run. The model also predicts that about 87,000 tons of sediment would have been delivered to the vicinity of the Overton Bridge through the South Channel with no augmentation, and this increases to about 119,000 tons with augmentation. This suggests that only about 32,000 tons of the total 82,000 tons of sediment delivered to the river at the Dyer Property was transported to Overton during the model year. For comparison, about 112,000 tons of sediment was delivered to Overton from the South Channel in the dry-year feasibility study run, in which 50,000 tons sediment was added at the Dyer Property.

Farther downstream at the Elm Creek Bridge, the cumulative effects of the augmentation at the Dyer Property and CWR increased the total sediment load from about 172,000 tons to about 191,000 tons; thus, only about 19,000 tons of the combined 182,000 tons of augmented sediment was delivered to the head of the Elm Creek Reach. About 109,000 tons of sediment would have been delivered to the Kearney Diversion Structure (KDS) under no-augmentation conditions, and this increased to about 124,000 tons under augmentation conditions.

Comparison of the volumes passing the boundaries of the previously defined subreaches indicates that about 87,000 tons of degradation would have occurred during the year in the South Channel downstream from the J-2 return under no-augmentation conditions, and this decreased to about 37,000 tons under augmentation conditions (Figure 33, Subreach 2). The reach between Overton and the Elm Creek Bridge (Subreach 3) would have degraded by about 44,000 tons with no augmentation, and this reach shows net overall aggradation of about 68,000 tons with augmentation, primarily as a result of the grading activities at CWR. The additional sediment load associated with the augmentation increases the amount of deposition between the Elm Creek Bridge and the KDS by about 3,000 tons. The indicated differences downstream of the KDS are quite small and likely within the range of uncertainty in the model results. For comparison, the South Channel degraded by about 62,000 tons during the first year of the dry-year feasibility study run and the Subreach 3 aggraded by about 51,000 tons. The increased downstream movement of sediment in the dry-year feasibility study runs result from two primary factors: the increased combined flow volume from the North and South Channels passing through the reach; and the somewhat finer augmentation material that was considered in this run (D_{50}=0.5 mm for the feasibility study versus 0.64 mm for the actual pilot augmentation).

The total amount of sediment passing other key locations in the vicinity of the augmentation activities was also assessed to provide higher resolution view (both temporally and spatially) of the sediment distribution along the reach with and without the pilot augmentation (Figures 34 and 35). The sediment balance in the South Channel in the vicinity of the Dyer Property pump outfall (labeled Dyer Aug Site in Figure 34 and 35) was evaluated based on an approximately 0.7 mile segment that has upstream limit at the Dyer Property pressure transducer. The segment labeled Dyer-Overton in the figures consists of the approximately 1.1-mile reach of the North and South Channels upstream from the Overton Bridge. The next downstream segment (Overton & AP 34) includes the Overton Bridge and the Geomorphic and Vegetation Monitoring Rotating Panel AP 34 (~0.4 mile). AP 34-CWR extends from the downstream side of AP 34 to just upstream from the grading area at CWR (~2.4 miles), and Segment CWR includes about 0.9 mile of the main river channel through and downstream of the CWR grading area. The other labels in the figures are self-explanatory.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_32.mxd\apr14\jcm



Modeled Total Sediment Load Passing Each Location

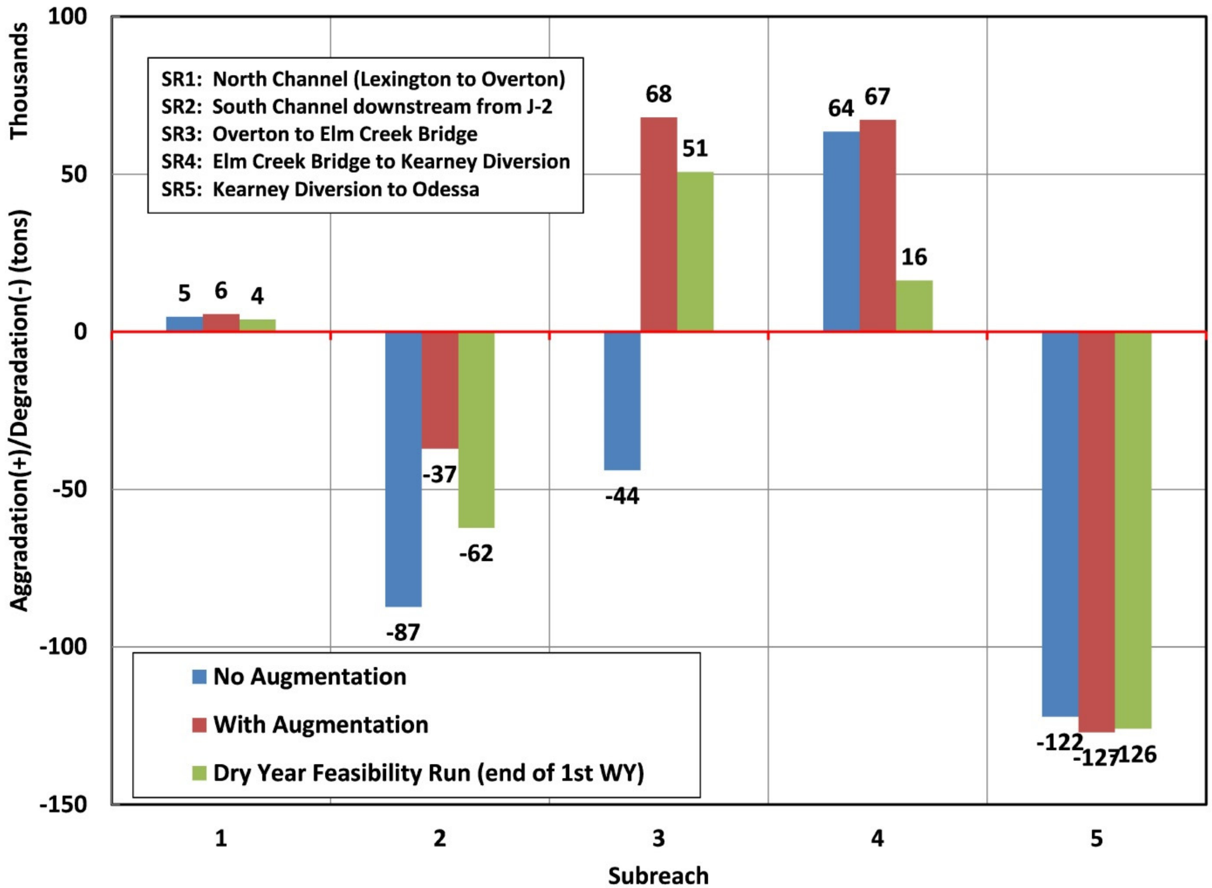
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 32

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_33.mxd\apr14\jcm



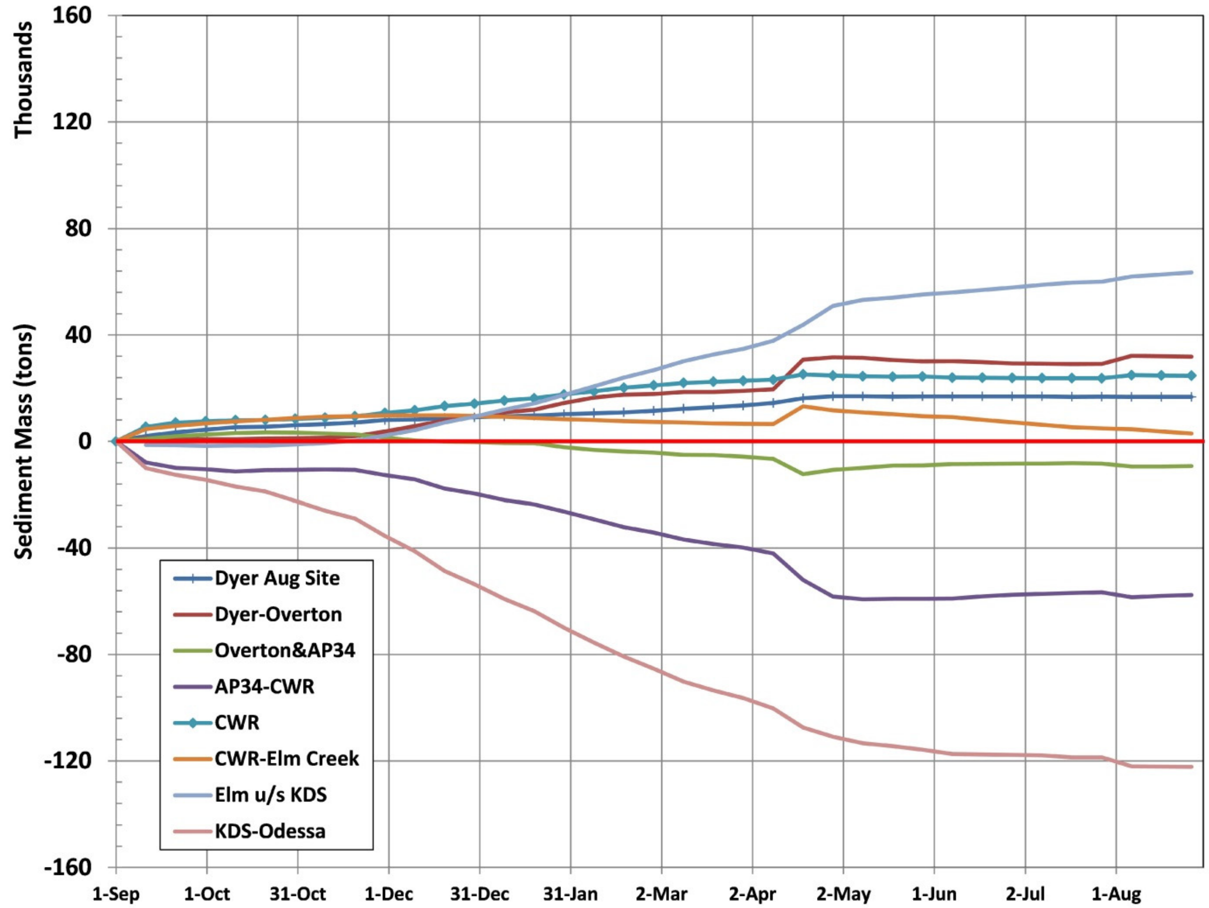
Modeled Volume of Aggradation(+)/Degradation(-) by Subreach Between September 1, 2012 and August 31, 2013 With and Without Augmentation and During the First Year of the Dry Year Feasibility Study Model Run
Sediment Augmentation Final Pilot Study Report

DATE
April 2014

FIGURE
33

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_34.mxd\apr14\jcm



Modeled Cumulative Aggradation(+)/Degradation (-) Mass in Eight Subreaches Between the Dyer Pump Outfall and Odessa Between September 1, 2012 and August 31, 2013 Without Augmentation

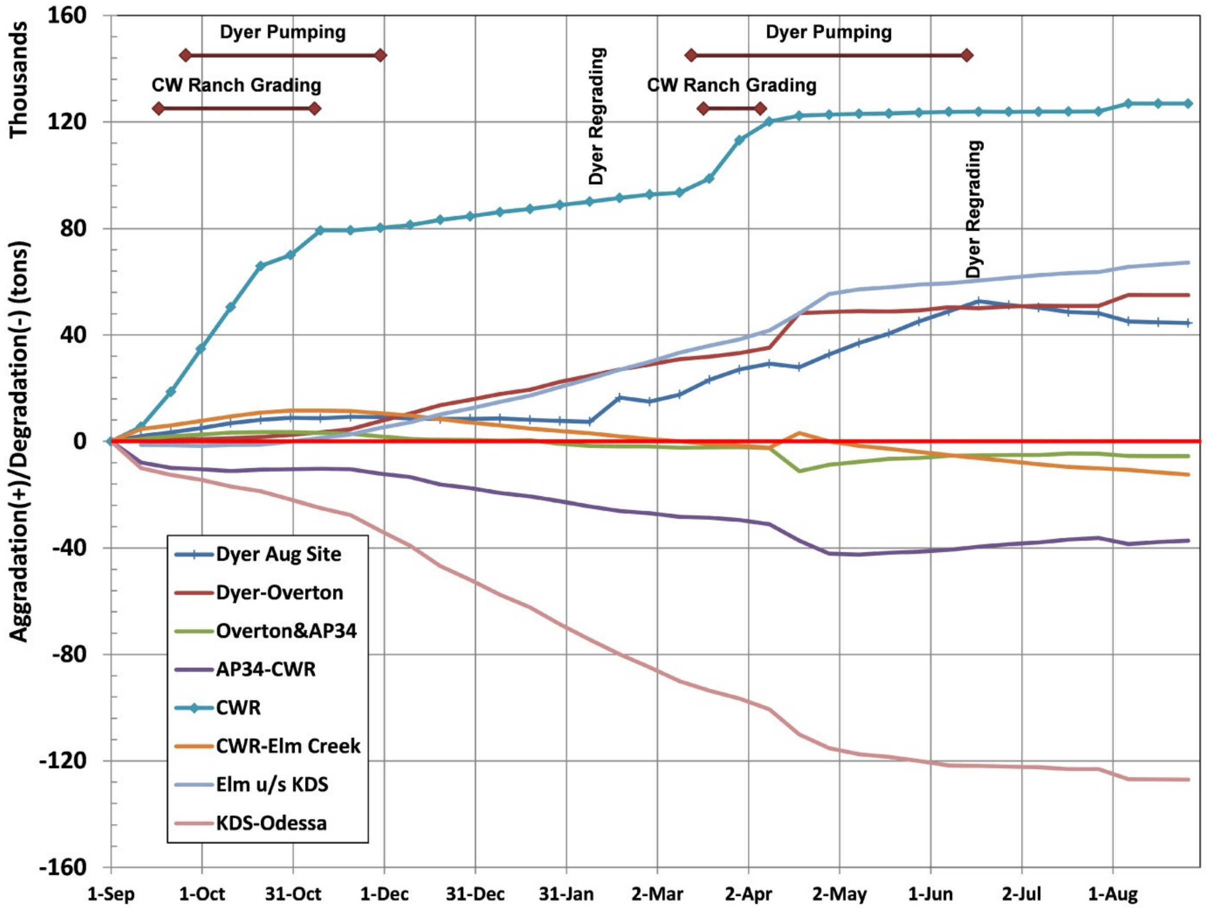
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 34

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_35.mxd\apr14\jcm



Modeled Cumulative Aggradation(+)/Degradation (-) in Eight Subreaches Between the Dyer Pump Outfall and Odessa Between September 1, 2012 and August 31, 2013 With Augmentation

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 35

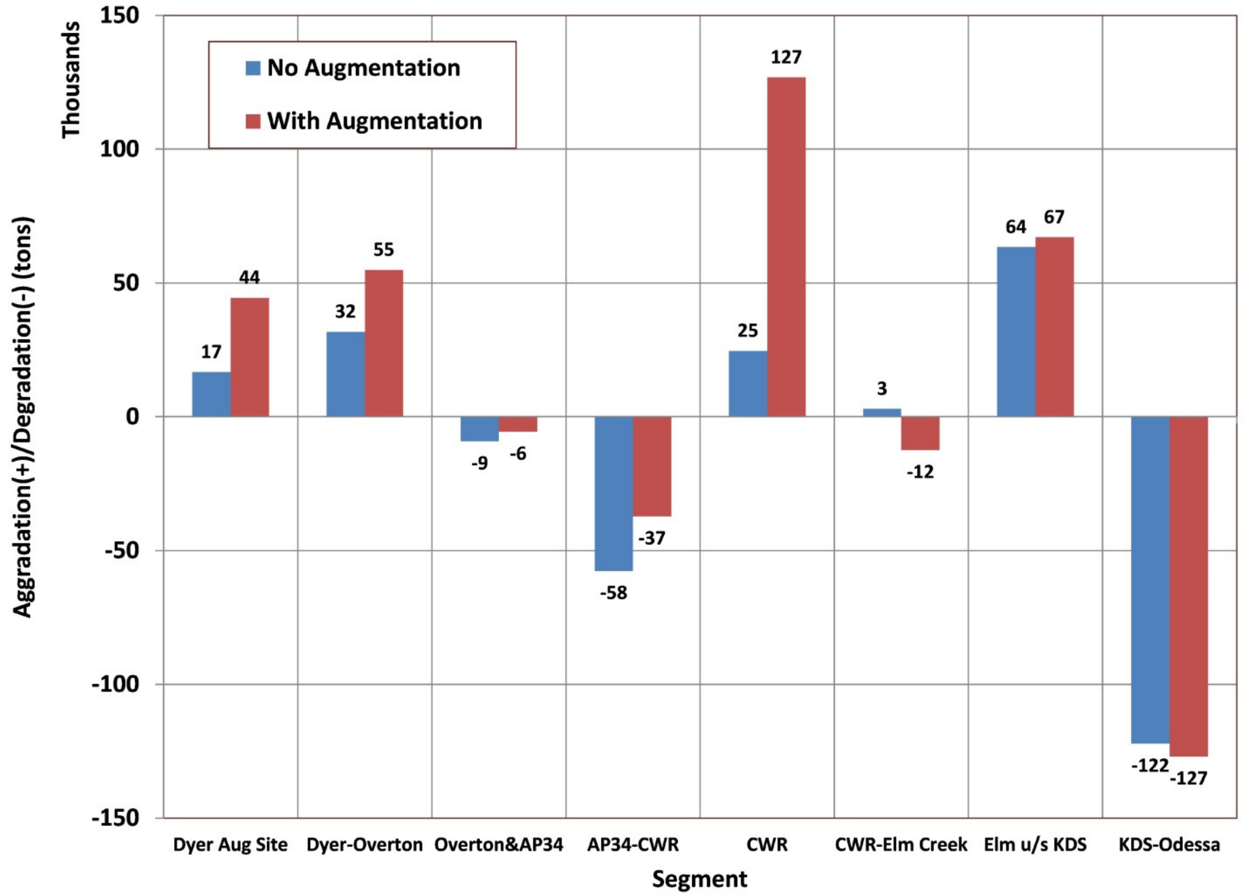
1

The model results indicate that the segment in the vicinity of the Dyer Property pump outfall would have been mildly aggradational, even without augmentation, and the amount of aggradation increases by about 70 percent from about 17,000 tons to 29,000 tons with augmentation (Figure 36). Similarly, the approximately 1.1-mile reach of the combined North and South Channels just upstream from the Overton Bridge would have been aggradational in the absence of augmentation, and the amount of aggradation increases by about 75 percent from 32,000 tons to 55,000 tons with the augmentation. The 0.4-mile reach through the Overton Bridge and AP 34 would have been degradational without augmentation, and this tendency was reduced by about half (from 9,200 tons to 5,100 tons) with augmentation. The 2.4-mile reach from AP 34 to just upstream from the CWR grading area would have degraded by about 58,000 tons without the augmentation, and this decreased to about 35,000 tons with the augmentation. The biggest change in the aggradation/degradation pattern occurred in the ~0.9-mile reach through the CWR grading area. The model indicates that this area would have aggraded by about 25,000 tons without the augmentation, primarily due to the wide, depositional character of this part of the reach. The grading activities pushed an additional 100,000 tons of sediment into the river, and the area accumulated about 130,000 tons during the model year. This indicates that a small portion (~5,000 tons) of the material from the Dyer Property pumping operations also accumulated in this portion of the reach. Interestingly, the model suggests that the reach from below the CWR grading area to the Elm Creek Bridge changed from about in-balance with no augmentation to slightly degradational with augmentation. The reason for this change is not apparent, but it may result from additional trapping of sediment in the CWR grading area due to the additional widening of the channel and an associated reduction in the transport capacity. The small increase in deposition in the reach from the Elm Creek Bridge to the KDS probably results from an increase in the amount of finer-grained sand from the augmentation activities reaching this area. As noted above, the relatively small increase in the degradational character of the reach between the KDS and Odessa is probably within the uncertainty of the model results, and is, therefore, not believed to be a meaningful impact of the augmentation activities.

3.6.6 Comparison of Model Results and Monitoring Data

The model results are generally consistent with the monitoring data. The five primary monitoring cross sections show a general aggradational trend through the period from the start of the pumping through August 2013 (Figures 12a and 12b), and the model indicates that this part of the reach (represented by Segment Dyer Aug Site in Figures 34, 35, and 36) also shows modest aggradation. The monitoring data at AP 34 indicate a modest degradation trend from August 2012, prior to the start of pumping, to the survey that was completed in early December 2012 just after completion of the Phase I pumping (Figure 14), and the model also indicates degradation in this area. It should be noted, however, that the USGS field measurements at the Overton Bridge indicate a slight aggradation tendency (Figure 17). The monitoring data show a slight degradational trend from the pre-augmentation survey in mid-August and the early December survey after the end of Phase I pumping. In general, the model results are reasonably consistent with the monitoring data.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_36.mxd\apr14\jcm



Modeled Aggradation(+)/Degradation(-) in Specific Segments of the Study Reach

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 36

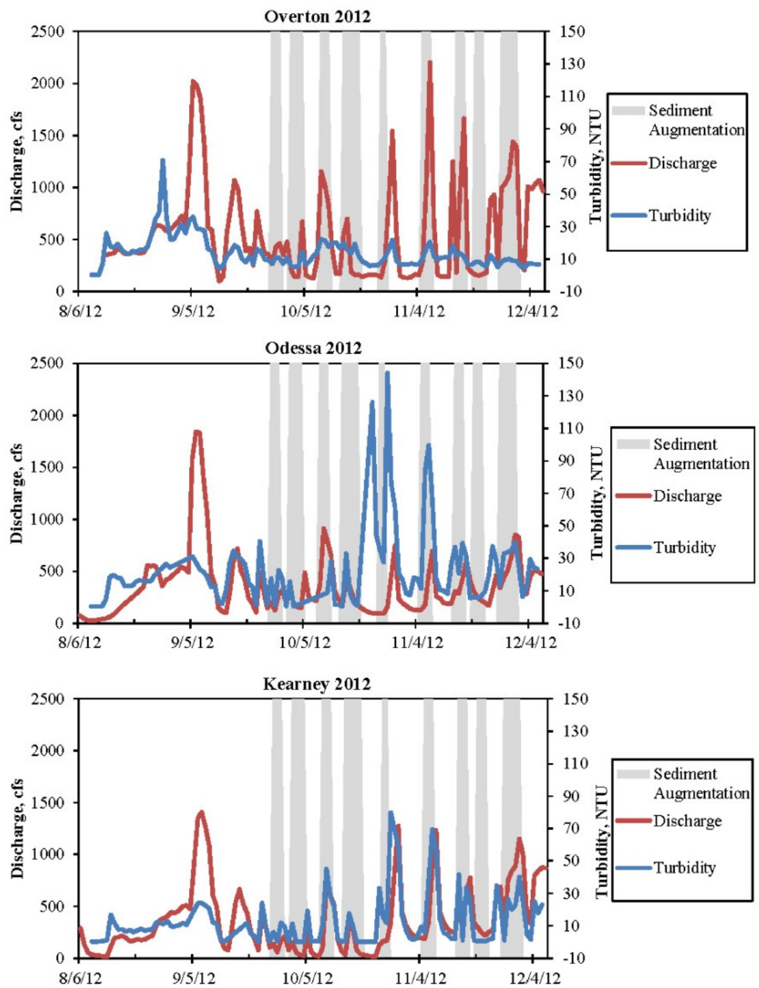
1

3.7 Sediment Transport and Water Quality Measurements

The water quality data obtained by the Program are summarized in the Annual Data Summary Report for 2012 (EA, 2013). Water quality data results suggest that neither project had an effect outside of the expectations of data without the projects in place. The only exception is the statistical suggestion that turbidity increased as a result of mechanical manipulation at CWR. The discussion from the Annual Data Summary Report for 2012 that relates to sediment augmentation is below, including Figures B-35 and B-36, which are denoted as Figures 37 and 38 in this report:

> Evidence of the Program's sediment augmentation (major events) effect on Platte River water quality was evident in the inter- and intra-year turbidity data. The Program completed two major sediment augmentation events in the central Platte River in 2012 (Table A-43 and Table A-44).
>
> - Sediment Augmentation – Dyer Property. Action performed from 26 September 2012 through 30 November 2012 upstream of the Overton monitoring location. Augmentation material was produced by establishing a sand pit operation at an existing sand pit at the Dyer property. The sand pumping operation produced augmentation material that was pumped to an active river channel for disbursement.
> - Sediment Augmentation – Cottonwood Ranch. Action performed from 17 September 2012 through 30 November 2012 upstream of the Odessa monitoring location. Augmentation material was produced by mechanical placement of existing material located in high areas within the river channel into active flowing areas within the Platte River channel.
>
> The discharge point for the sand pumping operation was located approximately 1 mile upstream of the Overton monitoring location. Figure B-35 presents turbidity, Platte River discharge at the Overton, Odessa, and Kearney monitoring locations, and sediment augmentation discharge periods into the Platte River. Turbidity at the Overton location did not increase as a result of the sand pumping operation for sediment augmentation. Statistically, turbidity at Overton in 2012 was not significantly different ($p=0.05$) between the pre- and active augmentation time periods and between turbidity in 2012 and turbidity in the baseline years. Linear regression models for flow and turbidity were significantly positive at the 95% confidence interval accounting for all of the observed turbidity at Overton during the study period. Statistically there is no evidence that the sand pumping operation for sediment augmentation of the Platte River affected the water quality observed at the Overton monitoring location.
>
> The area for sediment augmentation by mechanical placement of sediments into a Platte River channel was located approximately 5 miles upstream of the Odessa monitoring location (approximately 3.5 miles downstream of Overton – Figure 2). Figure B-36 presents turbidity, Platte River discharge at Overton, Odessa, and Kearney monitoring locations and sediment augmentation periods into the Platte River.

Figure B-35. Sediment Augmentation Timeline (Dyer Property), Discharge and Turbidity



Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_37P.mxd\apr14\jcm

Program Annual Data Summary Report for 2012 Figure B-35 (EA, September 2013)

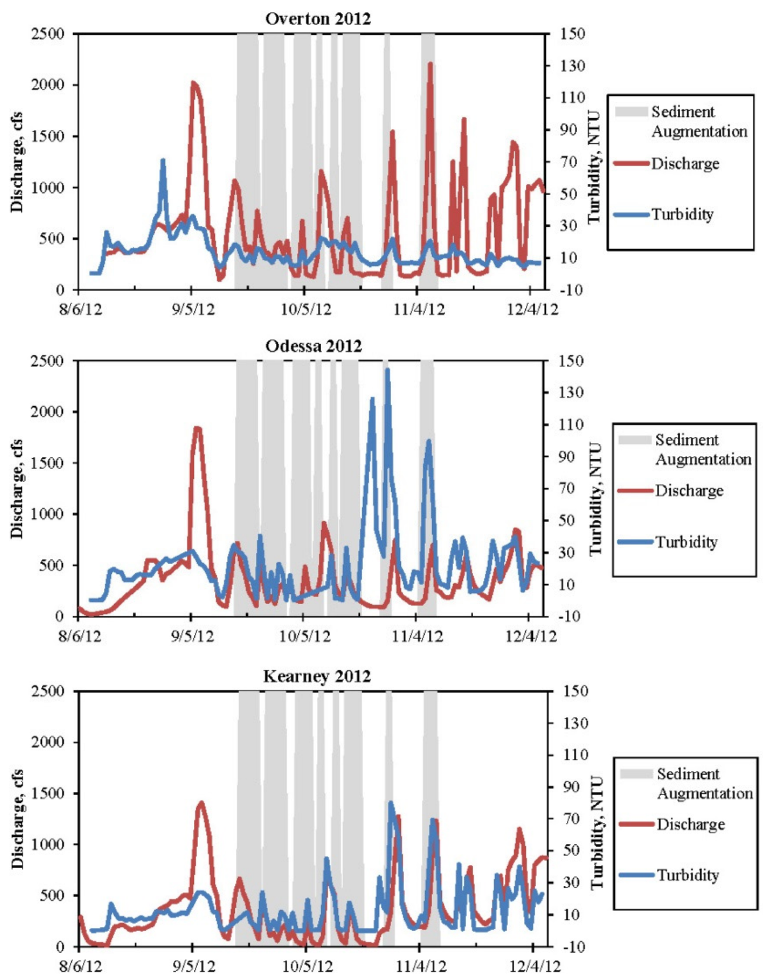
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 37

PRRIP – FINAL 9/16/2013

Figure B-36. Sediment Augmentation Timeline (Cottonwood Ranch). Discharge and Turbidity



Appendix B – Figures – Annual Data Summary Report – 2012 Page B-44

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_37P.mxd\apr14\jcm

Program Annual Data Summary Report for 2012 Figure B-36 (EA, September 2013)

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 38

Peaks in turbidity are evident at Odessa and Kearney that are significantly different (P>0.05) between the turbidity prior to sediment augmentation, within the active augmentation time period, and between 2012 turbidities and the baseline year turbidities. Linear regression models for flow and turbidity at Odessa and Kearney were not significant indicating that flow could not account for all of the observed turbidity. Additionally, residuals from the flow and turbidity linear regressions models that account for turbidity induced by flow do not explain all of the observed turbidity at Odessa and Kearney. Statistically there is evidence that Program-actions, specifically sediment augmentation via mechanical placement of sediments increased ambient turbidity levels in the Platte River.

At the time of this report, data for 2013 are still being analyzed and conclusions drawn for development of the 2013 Annual Data Summary for the Program. However, draft data collected as part of the Program's system-wide monitoring for 2013 were obtained for review. While these 2013 provisional data are subject to change, a cursory review of the water quality data suggests similar conclusions to those from the 2012 report about the effect on water quality resulting from sediment augmentation.

As discussed in Section 2.7, NDEQ Order of Variance #3130 contained several requirements that pH and dissolved oxygen data be collected at both sites. The draft data, the 2012 annual monitoring report, and site observations were transmitted to NDEQ following both phases of sediment augmentation.

For each workday, the on-site contractor made observations of the river for any unusual fish kills, water turbidity, color changes, or other conditions of the river including the presence of endangered species. There was no report made of any unusual conditions on the river either by the on-site contractor or during site inspections by the engineer.

4. Assessment of Phase I Activities, Monitoring Data, and Model Results

4.1 Dyer Property

Approximately 25,000 tons of sediment was augmented at the Dyer Property in Phase I from September 26, 2012, through November 30, 2012. The augmentation quantity at the Dyer Property was half of the anticipated Pilot Project quantity of 50,000 tons, primarily because of the low flows in the South Channel.

4.1.1 Observations

Several key observations and concerns noted during Phase I and listed below were considered as the Project Team continued to adapt augmentation strategies at the Dyer Property:

1. There are practical technological limitations to the methods used to augment material at the Dyer Property. Traditional sand pit mining and pumping operations are most effective when they can continuously operate over longer periods of time. The ability to regulate output is limited due to the volume of water required to mobilize sand and the propensity of the piping system to plug at low velocities, among other things. Early in the Phase I implementation period, pumping was limited to a few hours per day because of excessive augmentation material buildup at the outfall location, and some days pumping could not occur at all until some of the accumulated augmentation material was transported from the immediate outfall area. The start-stop nature of the augmentation

operation, necessitated by the persistent low flows, is not the most efficient way to operate this system.

2. There is not a good method for determining the instantaneous rate or even the daily quantity of material actually delivered to the river because of the variation in pumping rates, variation in subsurface formation, and variation and efficiencies in the pumping operation itself (that is, equipment and operators).
3. The pipe location is limited to discharging from the bank. The ability to move the discharge pipe into the flowing water in a cost effective manner is limited because of the requirements that the pipe be supported structurally (for example, by a sand bridge, wooden supports, or floats) and to provide enough back pressure head on the pump. At the Dyer Property, a land bridge would be required to get the pipe out to the active channel of the river.
4. Even at lower daily pumping volumes, excess material continued to build up in the discharge area. This resulted in a channel shift toward the north river bank, which reduced the ability of the river to mobilize sediment even further (that is, less of an attack angle) and resulted in some minor erosion of the north bank.
5. Sediment that was mobilized was initially being re-deposited in bars just downstream of the discharge area, resulting in large bar areas.
6. As the sediment pile, referred to as the source pile, continued to expand and the downstream bar area continued to expand, the Program expressed concern that the deposited material would become vegetated, thus preventing effective mobilization over time.
7. As flow remained low, it became evident that it would not be possible to augment the full 50,000 tons of material.

4.1.2 Modifications

Several adjustments were made to the augmentation and monitoring strategies during Phase I to optimize learning opportunities:

1. During Phase I, augmentation material accumulated near the discharge location because of the contractor’s limited ability to adjust the discharge location. The initial monitoring survey at the closest primary monitoring cross section (XS-2) after the start of pumping indicated very little change due to limited mobilization of the augmented material; therefore, the monitoring plan was revised to include a localized reach (referred to as the control section) from just upstream of the source pile to XS-2 approximately 750 feet downstream of the source pile This was achieved using a series of ten cross sections (D-1 through D-10) spaced 75 to 100 feet apart. These cross sections were surveyed on a 1- to 2-week interval rather than monthly. These sections were used to estimate how much material was pumped from the source pit and evaluate how the augmented material was being distributed within the control section. XS-1 through XS-5 continued to be monitored approximately monthly in accordance with the monitoring plan.
2. To decrease accumulation of introduced material near the pipe outfall, an attempt was made to better match the sediment pumping to coincide the CNPPID releases from the J-2 return. Unfortunately, these “higher” flow rates did not always occur during the work day of the pumping crew; thus, the effects of this change on entrainment of the material were very limited.

3. The source pile was surveyed on a regular basis as were the waste piles (that is, material that was screened out as too large for augmentation under this Pilot Project).

4. The additional monitoring data that were collected, including cross-section surveys near the source pile and a bathymetric survey of the existing sand pit prior to the management action, were used with results from the sediment transport model to estimate the following during Phase I:

    a. Quantity of material pumped

    b. Quantity of material delivered to the river

    c. Quantity of material in the source pile in the river (that is, material augmented but not mobilized)

    d. Quantity of material mobilized from the source pile but still within the control section (monitored with cross sections D-1 through D-10)

    e. Quantity of material mobilized and moved beyond the control section (downstream of D-10/XS-2)

5. This information was also used to verify estimated quantities completed by the contractor for purposes of approving payment requests. Because of the variation in flows and the resulting need for the contractor to start and stop operations to minimize excessive buildup of material, it was difficult to estimate the quantity of pumped material.

6. At the end of Phase I implementation, the Program hired a separate contractor to mechanically manipulate the source pile by knocking down the height to generally match the corresponding low bank and spreading the material fairly evenly across the entire width of the channel. A dike was constructed at the upstream end of the source pile and then breached in the middle to allow flows to entrain augmented material more efficiently. The manipulation of the source pile redirected the river upstream of the source area into the north bank, causing approximately 25 to 30 feet of bank scour within a week after the mechanical manipulation. The erosion on the north bank has since stabilized. The mechanical manipulation was effective in helping mobilize sediment, and this was aided by an increase of flows from the J-2 return.

7. For Phase II, the Project Team recommended that the augmentation pipe be moved approximately 100 feet upstream of the original source pile location once the material began to accumulate to an elevation above the water surface during the maximum hydrocycle releases from the J-2 return. The contractor was instructed to continue to move the pipe incrementally upstream (in approximately 100-foot increments) creating a series of windrows adjacent to the bank. This process was to continue until the contractor was approximately due west of the dredge location. Augmentation areas were limited to the more active portions of the channel beyond the low bank. In addition, the height of any accumulated sediment was limited to the low bank elevation that roughly corresponds to the 2,000 cfs flow rate. In that manner, most, if not all, of the augmented material would be inundated at flows of 2,000 cfs and greater.

4.2 Cottonwood Ranch

Approximately 75,000 tons of sediment was augmented by pushing material into the river from an adjacent island at CWR in Phase I from September 17, 2012, through November 8, 2012. The augmentation quantity at CWR was exceeded by 50 percent compared to the anticipated Pilot Project quantity of 50,000 tons (75,000 tons total augmentation).

4.2.1 Observations

Several key observations and concerns noted during Phase I and listed below were considered as the Project Team continued to adapt augmentation strategies at CWR:

1. During Phase I of the Pilot Project, the material pushed into the river was not mobilized and carried downstream at a rate fast enough to prevent buildup. The contractor continued to push material farther into the channel, which effectively only narrowed the channel. Attempts were made to cut pilot channels and build small diversion dikes, but these attempts were not effective. The result was that a significant amount of material accumulated in what was once the channel with very slow mobilization of material. As a result, the Program raised concerns about the reduction of the channel width as well as the potential for vegetation of the augmented material that was not mobilized.
2. Due to a misunderstanding by the contractor regarding the finished design elevations on the source island, the contractor removed and augmented more material than was proposed in the design. The contractor was contractually responsible for surveys to verify design compliance and contract quantities; however, the contractor did not provide the requested survey data during periodic pay requests, and the amount of those requests was not unreasonable based on contractor work time, site visits, and field observations conducted during implementation. By the time the Project Team was made aware of the contractor's concerns that they were over contract quantities, the overage amounted to approximately 25,000 tons. Contractor billings to that point were only at 70 percent.
3. Streamflows did not consistently reach an elevation to inundate the augmented material, and when they did, flows were not of a duration to effectively entrain the material.

4.2.2 Modifications

After discussions with the Project Team regarding plans for Phase II augmentation, it was determined that the augmentation design at CWR could be modified by incorporating a series of augmentation source islands and a series of pilot channels excavated to an elevation that would allow higher flows (that is, greater than 1,700 to 2,000 cfs) to flow through augmented material and gradually mobilize it. The design was modified so that the material from excavated channels would be approximately equal to the remaining 25,000 tons of material for the Phase II augmentation. The goal of augmentation of 100,000 tons of material in Phase I and Phase II was achieved at Cottonwood Ranch.

5. Assessment of Phase II Activities, Monitoring Data, and Model Results

5.1 Dyer Property

It became evident that the material was building up quickly in this east location and at a pace unacceptable for the project. At the Project Team's direction, the contractor changed strategies and moved the outfall west of the original source pile. This allowed the contractor to place a majority of the remaining 25,000 tons of material from Phase I to the northwest of the original source pile into a portion of the channel where flows could directly attack the augmented material. The contractor was able to pump approximately 57,000 tons during Phase II. At the end of Phase II pumping, the accumulated material was mechanically redistributed (Figure 39).

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_39.mxd\apr14\jcm

Dyer Property at the Conclusion of Phase II

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 39

1

The following key observations and concerns were noted during Phase II:

1. Flows in the South Channel that are mostly derived from J-2 return releases were near normal during the first half of the Phase II pumping, except during the Program's SDMF release that occurred in April 2013, and then dropped well below the typical rates during the second half of the pumping period. The gradation of the augmented material continued to be consistent with that of the Phase I material.
2. The average rate of entrainment of the augmented material during Phase II pumping was more than 3 times higher than during Phase I pumping, primarily because the contractor moved the outfall periodically to distribute the material so that it was more accessible by the river. The SDMF release also played a role in the greater amount of entrainment. By the end of April 2013, about 29,000 tons of the Phase II material had been pumped to the river. During the period from the beginning of March 2013 to the end of April 2013, the cumulative sediment load past Primary Monitoring XS-2, located a short distance downstream from the pump outfall, was about 16,000 tons greater than it would have been without augmentation. Despite the efforts to better distribute the sediment, the pumping rate still exceeded the ability of the river to entrain and carry downstream all of the augmented material.
3. There appears to be a systematic aggradational trend at all but one of the five monitoring cross sections, with XS-2, the cross section closest to the pump outfall on the downstream side, showing the strongest trend. This cross section has aggraded by over 0.5 foot since the start of augmentation. Only XS-4 does not show a clear aggradational trend. XS-1, located just upstream of the outfall, also appears to have systematically aggraded by about 0.2 foot since the start of augmentation.
4. The bed and bar sediment gradations collected during monitoring show considerable variability, but no systematic trends.
5. Based on the USGS stage-discharge field measurements at the Overton gage, the deviation of the stage from the current rating curve has remained well within the Class I and II stage changes, beyond which immediate action is required under the monitoring plan. Three of the measurements taken in the 2,000 to 4,100 cfs range are above the Class I stage change threshold. Of these, only the April 12, 2013, measurement exceeds the threshold by more than 0.1 foot, moving it into Class II at the Overton gage. Prior to increasing monitoring frequency from monthly to bi-weekly, the trigger was back below the Class II threshold criteria on April 16, 2013, and no action was taken.
6. The deviations in stage from the current rating curve at the CWR Mid-Channel gage are considerably less than at Overton. With the exception of the September 25, 2013, measurement during the passage of the Northern Colorado flood wave that is about 0.55 foot above the rating curve, all of the Phase I and Phase II measurements are well within the Class I stage change threshold.
7. There appears to have been a 0.5- to 0.8-foot increase in the stage during baseflow conditions at the stage-recorder in the North Channel near the Todd Brown property over the course of Pilot Study. This station records only stage and does not have a stage-discharge curve developed for it. Qualitative observations of the river near this gage suggest that the increases are likely the result of baseflow increases along the reach as a result of irrigation and upstream diversions ending. Trends at higher flows are much less certain. The 2012 system-wide monitoring data indicate a general aggradational trend throughout the overall study reach that is consistent with this trend.

5.2 Cottonwood Ranch

Phase II augmentation was completed in the first part of April 2013 at CWR. In Phase II, the decision was made to revise the augmentation design. Rather than limiting the contractor to augmenting during times of higher flows, a change was made to allow the contractor to place the remaining augmentation material not placed during Phase I (25,000 tons) by excavating a series of channels and using that 25,000 tons of material to construct three nesting islands. The elevation of the islands was limited to a height that would be inundated during 1,700 to 2,000 cfs events, providing augmentation material during those flows. The contractor was provided with specific design parameters and was able to construct the islands within a short period of time (that is, 16 working days) ahead of anticipated higher early spring flows. These early spring flows, including the SDMF, were conveyed in the newly constructed channels around the nesting islands. It is anticipated that higher flows will continue to flow around and over the islands, gradually mobilizing the material until the islands are gone (Figure 40).

6. Pilot Study Recap

The design was completed and let for bid on June 15, 2012. T&F Sand and Gravel, Inc. was the contractor at the Dyer Property, and Jim Ostgren Construction, Inc. of Holdrege was the contractor at CWR. Work was to be conducted in two phases, identified as Phase I augmentation that occurred in fall 2012 and Phase II augmentation that occurred in spring and early summer 2013.

6.1 Operation and Costs

6.1.1 Dyer Property

The final design for the Dyer Property included expanding an existing onsite sand pit to provide sediment augmentation material (medium-coarse and coarse sand) meeting specific gradation requirements identified during the Pilot Study. The final design proposed pumping 50,000 tons of augmentation material into the river on the Dyer Property in Phase I and another 50,000 tons in Phase II.

A total of approximately 25,000 tons of material were pumped into the river between September 26 and November 30, 2012, when Phase I augmentation ceased. Low flows resulted in pumped material accumulating faster than the river could move it downstream. The Project Team and the Program determined that augmenting the entire 50,000 tons planned in Phase I at the Dyer Property would not be possible and decided to limit the augmentation quantity to 25,000 tons. The resulting augmentation material continued to act as a source area for augmentation over the winter months as the pile was slowly eroded and transported by the river. Augmentation material that remained (approximately 12,370 tons; see Table 3) was mechanically redistributed into the river using a bulldozer.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Figure_40.mxd\apr14\jcm

Cottonwood Ranch at the Conclusion of Phase II

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 40

1

Phase II augmentation at the Dyer Property commenced in spring 2013 as weather allowed to take advantage of higher hydrocycling release flows from CNPPID's operations as well as an SDMF event planned for April 2013 by the Program. Phase II augmentation commenced on March 1, 2013, with the goal of placing as much material into the river as possible ahead of the high flows. Changes were made to vary the discharge location to spread the material out over a larger area and allow greater access to the flowing water to try to maximize the amount of material entrained in the river flows. Parameters were established to limit the height of the augmented material to the approximate height of the low bank inundation potential and entrainment opportunity. The discharge location also varied upstream and downstream to accommodate the material placement within the set parameters. This strategy also allowed the material to be placed over a larger footprint, resulting in a total of approximately 57,000 tons of material placed by June 15, 2013, when augmentation ceased. The decision to stop augmentation was based on the return of low flows in the project reach as irrigation began. The Program hired a contractor to manipulate the accumulated augmentation material that had not been entrained by the flows and to cut a channel on both sides of the source pile to allow greater access by river flows. The total augmentation volume at the Dyer Property during Phase I and Phase II was approximately 82,000 tons.

The total augmentation cost for Phase I and Phase II at the Dyer Property was $498,400. This cost included mobilization, site preparation, dredging, sorting, and pumping material into the river, hauling waste material offsite, and demobilization and site restoration. The cost per ton of material augmented was $6.08. An additional $34,200 was used to mechanically distribute material at the conclusion of Phase I and Phase II.

6.1.2 Cottonwood Ranch

The final design for CWR included excavating/pushing 100,000 tons of sediment augmentation material (generally sand or sandy gravel) from deposits located on islands within the high banks of the river into the active channels on the Program's CWR property located near Overton, Nebraska.

Approximately 75,000 tons of material was augmented during Phase I between September 17 and November 30, 2012. Material was stripped from high areas on islands within the banks of the river using scrapers and bulldozers and pushed into the river using bulldozers. The Phase I augmentation quantity was approximately 50 percent more than anticipated in the final design. Due to low flows, some of the augmented material that was pushed into the river remained in piles in the river, serving as source material that is being slowly transported by the river primarily during higher hydrocycling flows from CNPPID's J-2 return.

Phase II augmentation commenced in March 2013 and ended the first week of April 2013, prior to the SDMF event planned by the Program. The Phase II augmentation design for CWR was modified based on the results of Phase I augmentation. The remaining 25,000 tons of material were removed from the source island and pushed into the river generally in the same area as the Phase I material. The combined material was reshaped into a series of three piles with interconnected channels to try to expose more of the material to the higher cycling flows. Material remaining in the newly constructed source piles continues to provide source material to the river. It is anticipated that higher spring flows in the river along with hydrocycling releases from the J2 return will move a significant amount of the remaining material downstream in spring 2014.

The total augmentation cost for Phase I and Phase II at CWR was $176,200. This cost included mobilization, pushing the material into the river, shaping and restoring the augmentation site, and demobilization and site restoration. The cost per ton of material augmented was $1.76.

6.2 Identification of Key Remaining Uncertainties

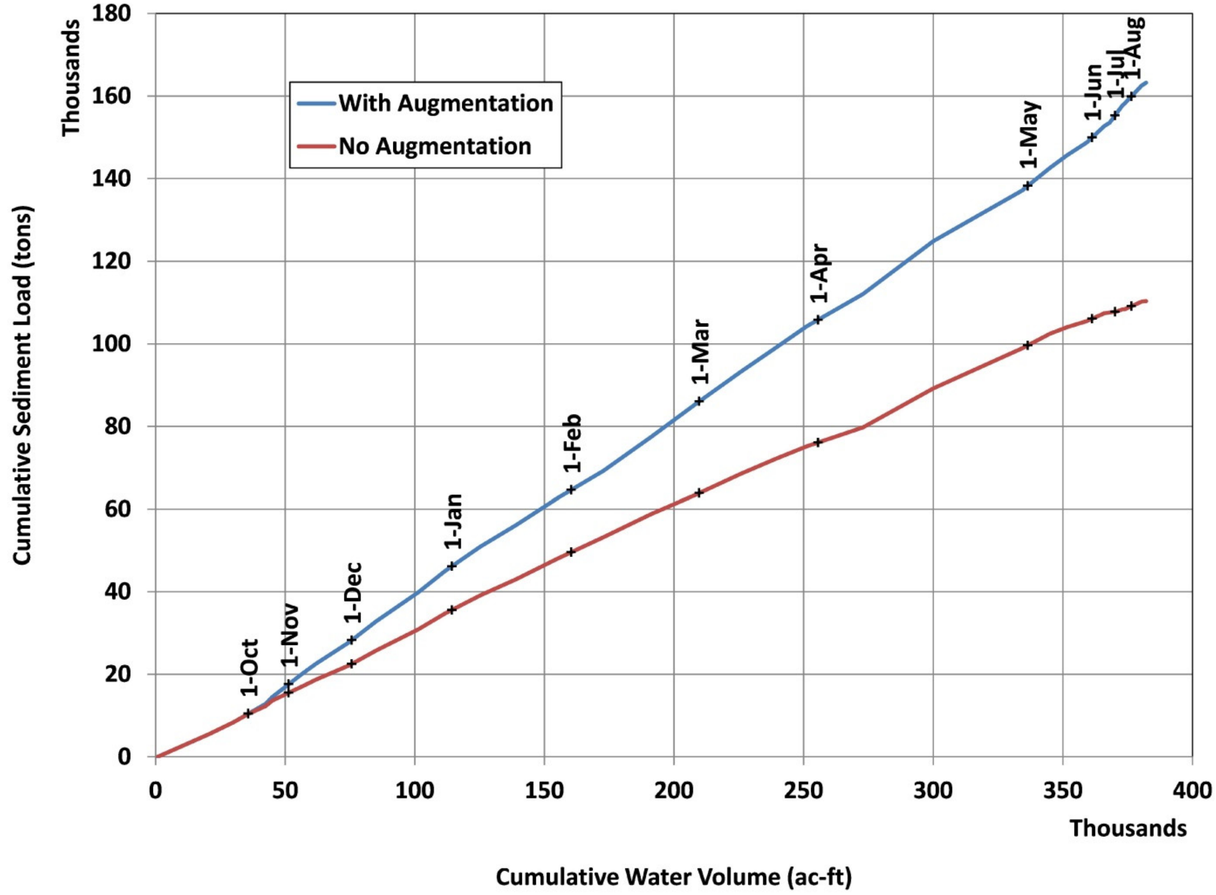
In considering the following information, it is important to understand that the primary purpose of the Pilot Project was to test the means and methods for conducting sediment augmentation. The project was not specifically designed to answer questions regarding how much sediment must be delivered to the river to eliminate the deficit in the CWR reach. Nevertheless, results from the Pilot Project, when considered in conjunction with the sediment transport modeling for the pilot augmentation period discussed above and results the modeling that was previously performed for the feasibility study (Tetra Tech, 2010), do provide information to help answer this question and to identify the uncertainties that still remain for full-scale implementation. After two phases of augmentation under the Pilot Project, several uncertainties remain:

1. How much material can be augmented into the river under Normal Flow Hydrologic Classifications?

   Flow releases from the J-2 return during Phase I pumping and the early part of Phase II pumping were in the typical range that can be expected in future years, and then dropped to near the low end of the range during the summer months after pumping was completed (Figure 26). Based on the difference between double-mass curves of the cumulative water and sediment volume under augmentation and no-augmentation conditions, about 45,000 tons of the total 82,000 tons of augmented sediment at the Dyer Property had been entrained and transported past the Primary Monitoring XS-2 by early June when the pumping was completed, and an additional 7,500 tons (for a total of 52,500 tons) had moved past XS-2 by the end of August 2103 (Figure 41). The difference in slope of the no-augmentation and with-augmentation curves suggests that the South Channel is capable of transporting about 130 tons of additional sediment (above the baseline loads) in the size ranges that were pumped into the river (D_{50}=0.64 mm) per 1,000 ac-ft of flow releases into the South Channel. Although sediment transport rates tend to be highly non-linear, these rates should be reliable for future conditions because the J-2 releases tend to occur on a regular basis and are limited by the outlet capacity and operational requirements from 1,700 cfs to 2,000 cfs. Based on the annual variability in flow release volumes shown in Figure 25, this indicates that the annual volume of augmentation that can be sustained at the Dyer Property without causing excess sediment accumulation in the South Channel between the outfall and the Overton Bridge would average about 60,000 tons and range from about 11,000 tons (based on the WY 2004 releases of about 87,000 ac-ft) to about 135,000 tons (based on the releases of approximately 1M ac-ft in WY 1999 and WY 2011). This result is based on the gradation of the sediment that was input during the Pilot Study. The rates would increase if a finer sediment gradation were pumped to the river and decrease if coarser sediment were used by amounts that depend on the actual input sediment gradation.

   The double-mass curves also indicate that the augmentation at the Dyer Property increased the total sediment load past the downstream side of AP 34 by about 26,000 tons over the Pilot Project (Figure 42). The reach between the Overton Bridge and CWR remained degradational, even under augmentation conditions (Figure 36). Because a significant portion of the augmented sediment remained in storage in the South Channel, it appears that the overall transport capacity of the South Channel downstream of the Dyer Property will limit the ability of sediment augmented into the South Channel to overcome the sediment deficit between Overton and CWR. More frequent mechanical grading of the pumped material so that it is more accessible by the South Channel flows may help overcome at least part of this limitation.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_41.mxd\apr14\jcm



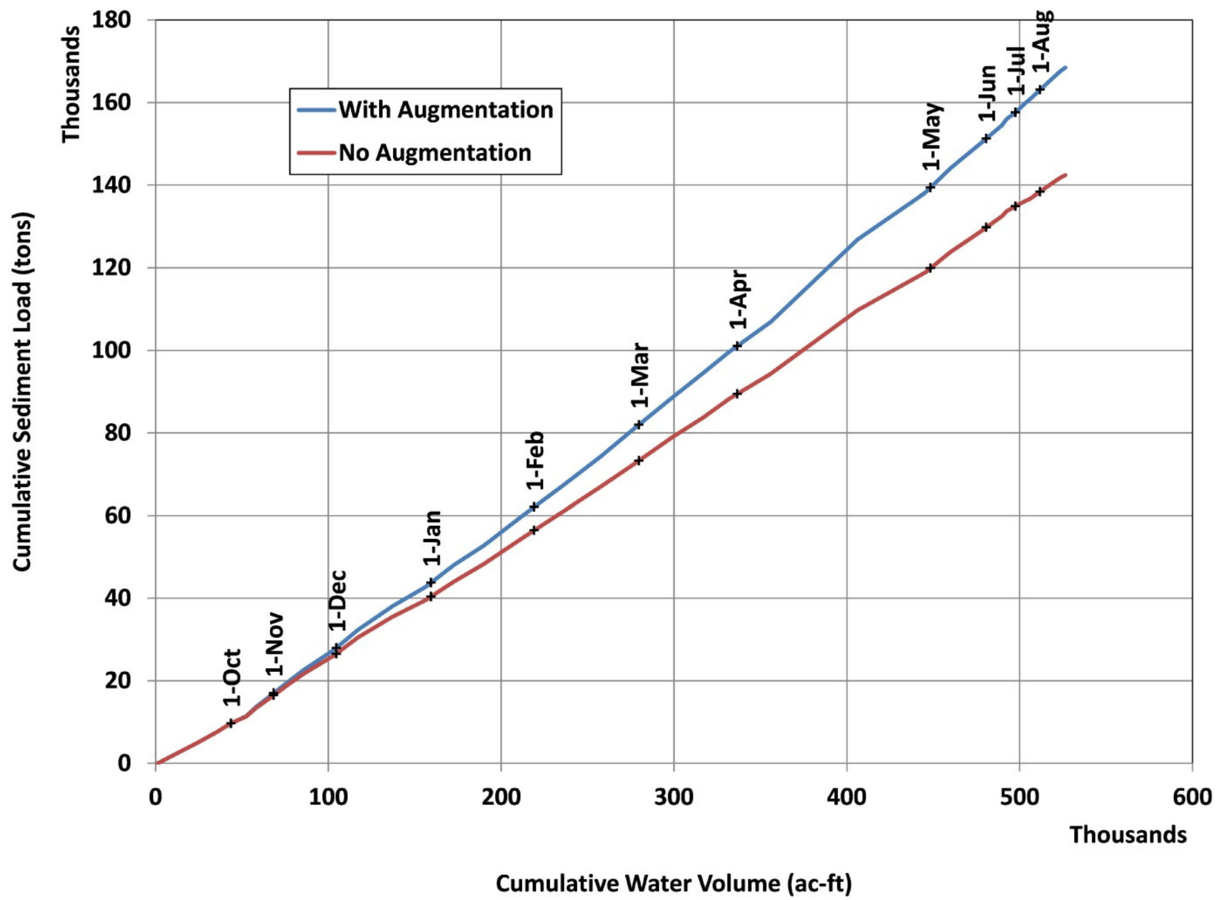
Double-Mass Curve of Modeled, Cumulative Water and Sediment Volume Passing XS3655 in the South Channel (~Same Location as Primary Monitoring XS2)

Sediment Augmentation Final Pilot Study Report

DATE
April 2014

FIGURE
41

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_42.mxd\apr14\jcm



Double-Mass Curve of Modeled, Cumulative Water and Sediment Volume Passing XS134449 in the Main Channel (~Downstream Side of AP34)

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 42

1

Under current conditions, the grading activities at CWR result in a strongly aggradational tendency within, and for a short-distance downstream of, the grading area. Unfortunately, the grading also reduces the transport capacity through this part of the reach. As a result, the CWR grading area has become a sediment trap that reduces the amount of sediment delivered downstream, causing the reach between CWR and Elm Creek to become generally degradational. The model indicates that, under no-augmentation conditions, the reach aggrades through late December, degrades during the winter and early spring until the early April SDMF, during which time the reach aggrades, and them becomes strongly aggradational throughout the remainder of the period (Figure 43). Under augmentation conditions, the reach aggrades even more strongly early in the period, but switches to degradation in early November and then becomes strongly degradation thereafter (except during the SDMF), most likely because the CWR grading area traps sediment during low to moderate flows. It is also interesting to note that the amount of aggradation during the SDMF was less under augmentation conditions than without augmentation.

2. How much material would need to be added to achieve sediment balance in the reach, and is it feasible to add those quantities on a sustained basis?

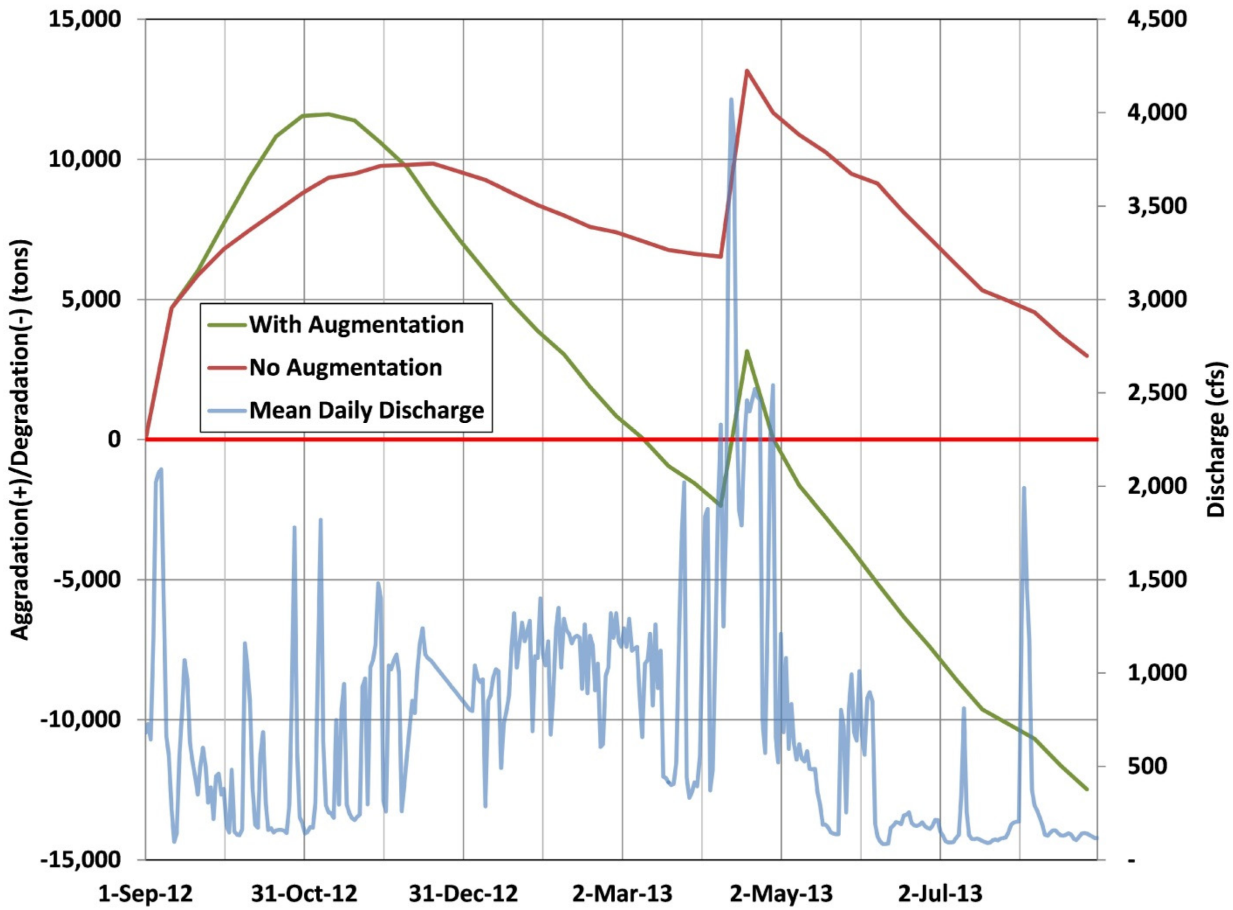
Based on the modeling performed for the feasibility study using the flows that occurred during the 12.5-year period from WY 1990 through WY 2001 (Tetra Tech, 2010), the annual deficit between the Overton and Elm Creek Bridges averages about 109,000 tons and ranges from 25,000 tons to about 220,000 tons (Figure 44). The annual bed material sediment loads passing Overton during this period averaged about 1.2M tons and ranged from about 500,000 tons to about 1.9M tons; thus, the annual deficit is in the range of 10 percent of the total load (Figure 45). (For the longer period from WY 1980 through WY 2013, the loads averaged 680,000 tons, and ranged from 35,000 tons to 4.6M tons, exceeding 2.5M tons in WY 1983, WY 1984, and WY 2011.) The feasibility study modeling indicates that pumping 150,000 tons of sediment per year to the river at the Cook and Dyer Property would reduce the existing approximately 109,000 ton average in-channel deficit in the Overton to Elm Creek reach to about 43,000 tons if finer material (D_{50} ~ 0.5 mm) were used for the augmentation and to about 73,000 tons if coarser material (D_{50}=1.2 mm) were used (Figure 46).

It is important to understand that the sediment deficit (or excess) in the reach varies significantly from year to year; thus, decisions based on the average may not produce the desired results (Figure 47). Under no augmentation conditions (that is, baseline), the deficit in the reach between the Overton and Elm Creek Bridges ranged from about 24,000 tons to 221,000 tons over the 12.5-year feasibility-study modeling period. With augmentation of 150,000 tons per year of fine sediment (D_{50}=0.5 mm), the overall balance in this reach ranged from 36,000 ton excess to 142,000 ton deficit, and with the same quantity augmentation with coarser material (D_{50}=1.2 mm), the balance ranged from a slight (1,400 ton) excess to 210,000 ton deficit.

3. What is the downstream response of the river as the material moves from the discharge locations?

Although some minor changes in cross sectional area were detected in the monitoring surveys, these changes were not sufficient to cause a perceptible change in channel capacity or stability. The quantity of material and duration of the Pilot Project was not sufficient to judge whether continued long-term augmentation at similar rates will cause the channel form to change in a manner that is consistent with Program goals.

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_43.mxd\apr14\jcm



Double-Mass Curve of Modeled, Cumulative Water and Sediment Volume Passing XS117083 in the Main Channel (~Just Downstream from Cottonwood Ranch Grading Area)

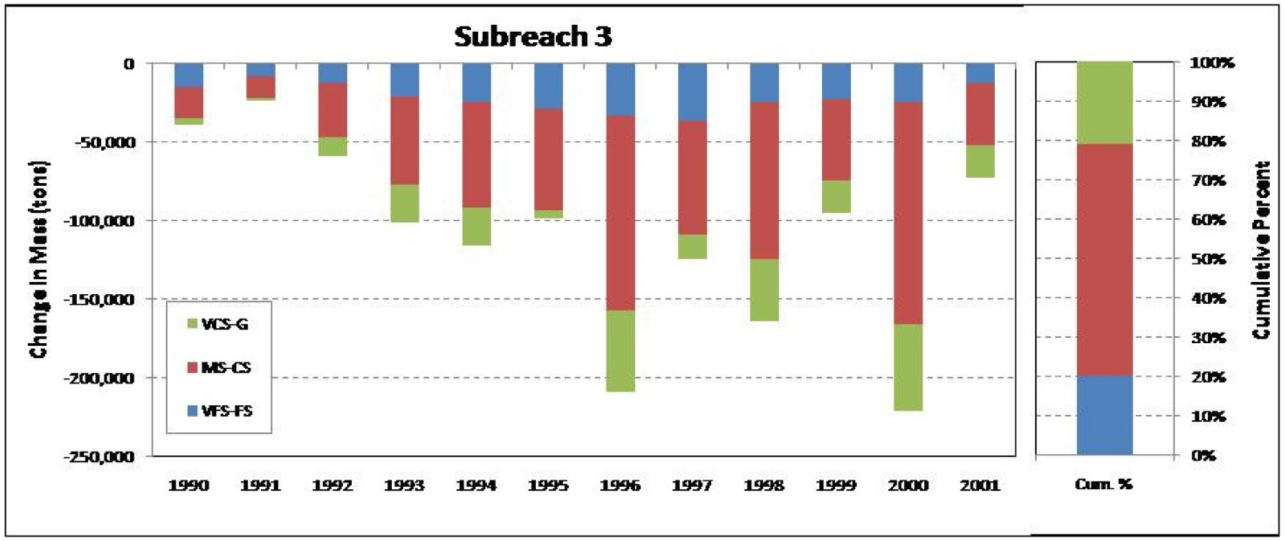
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 43

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_44.mxd\apr14\jcm



Annual Mass Eroded or Deposited Between the Overton and Elm Creek Bridges by Size Fraction, and the Cumulative Percentage Deposited Under No-Augmentation Condition

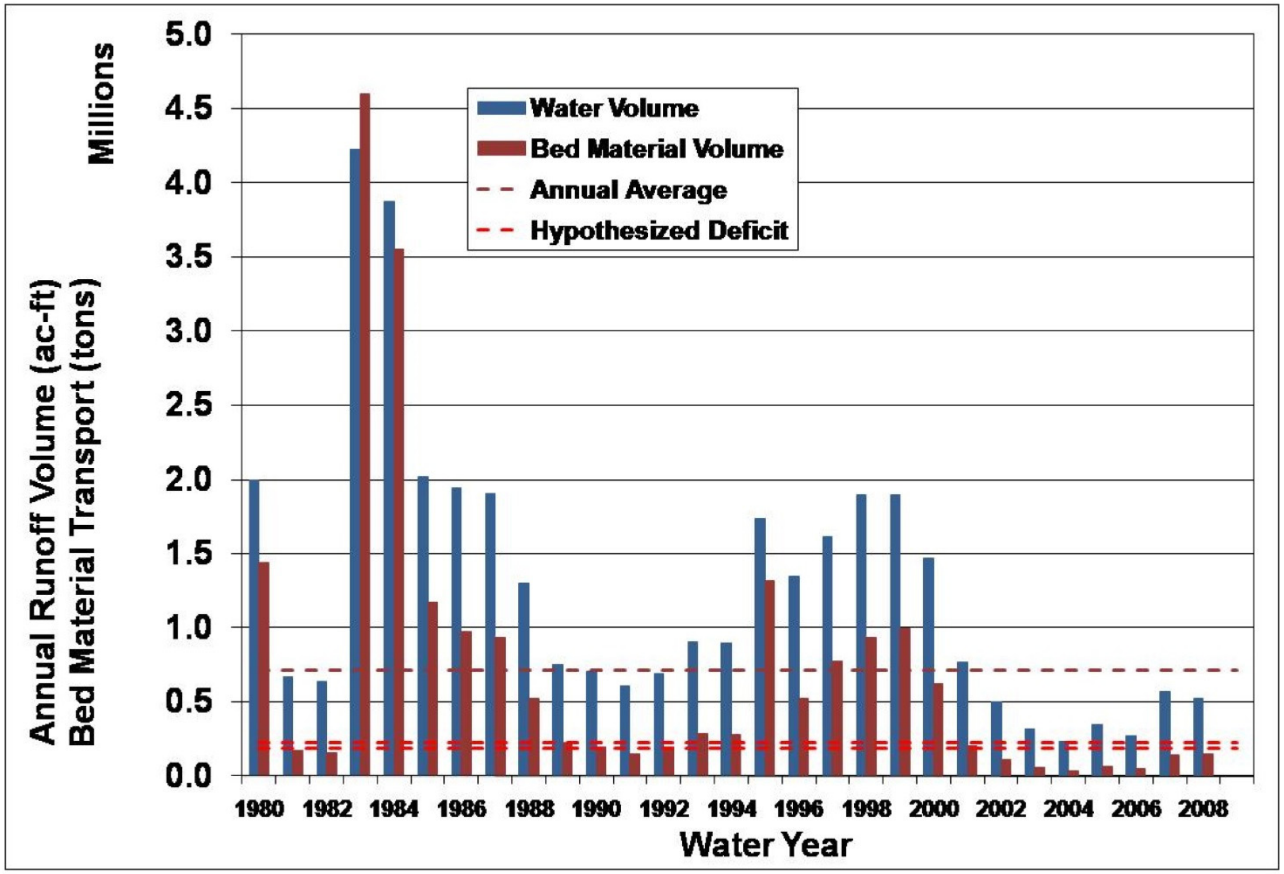
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 44

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_45.mxd\apr14\jcm



Estimated Annual Bed Material Sediment Load Passing the Overton Gage for WY1980 through 2008

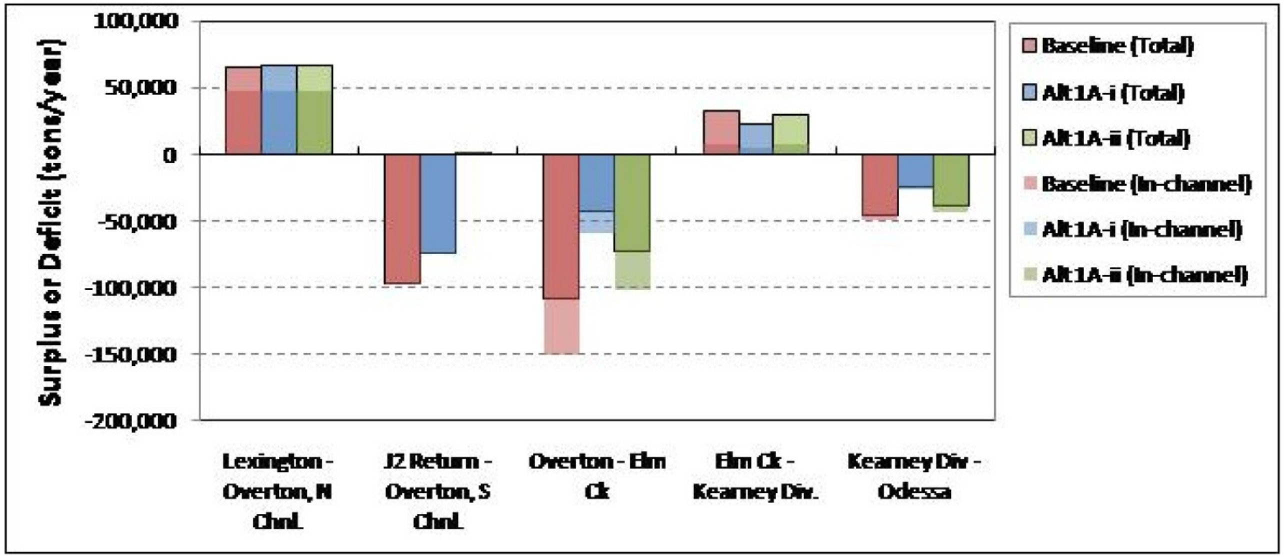
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 45

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_46.mxd\apr14\jcm



Comparison of Total and In-Channel Surplus or Deficit by Subreach Under Baseline, Alternative 1A-i and Alternative1A-ii

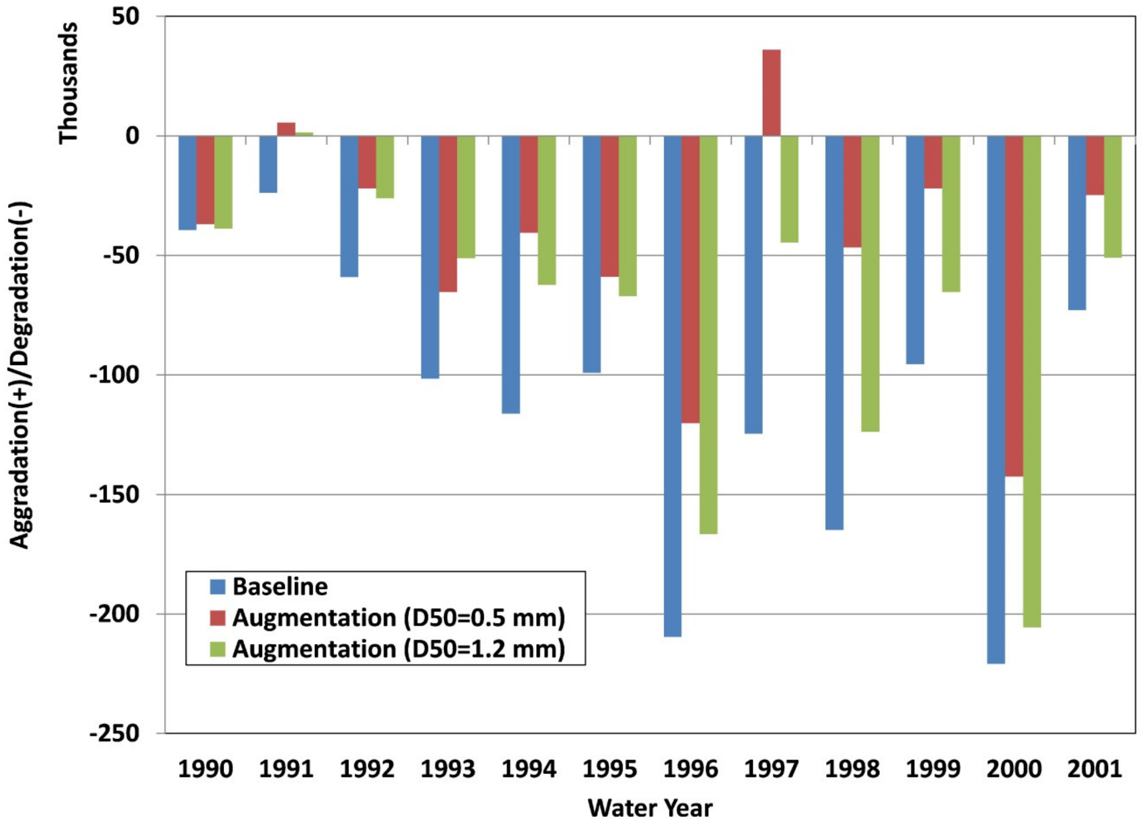
Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 46

1

Z:\Projects\TFG_HDWTR\119677_Shoemaker_Complex\Map_Docs\Draft\Sedimentation_Augmentation_Report\Revised\Figure_47.mxd\apr14\jcm



Year-to-Year Sediment Balance in Reach 3 (Overton to Elm Creek Bridge)

Sediment Augmentation Final Pilot Study Report

DATE April 2014

FIGURE 47

1

7. Considerations for Full-Scale Implementation

7.1 General Considerations

General considerations include cost, land availability, and permitting, as discussed in the following sections.

7.1.1 Cost

Several factors that affect augmentation cost should be considered when evaluating whether to move forward with full-scale implementation:

- Flows in the river
- Availability of suitable augmentation material
- Proximity of augmentation material to the augmentation sites
- Availability of contractors to conduct the work
- Level of flexibility of how and when the contractors conduct work
- Market conditions for material produced and not used for augmentation

Flows in the River

The volume of water in the river during times when augmentation is occurring is a significant factor in determining how much material can be placed in the river in a given time frame. For mechanical manipulation options, the unit cost per ton of material augmented is relatively the same during low or high flows. Material can placed during both low and high flows unless source areas or augmentation areas where material is placed are inundated. Pumping options are more sensitive to river flows during periods of low flow because it is generally more difficult to move the discharge locations and to distribute the material over a greater area. More frequent starts and stops also impact productivity and cost during low flows. Pumping operations are more suited for sustained longer-term pumping than short durations. High flows within the river banks have little effect on pumping operations as capacity and duration can increase during these times. Long-term augmentation contracts may be a way to average costs over time for pumping operations.

Availability of Suitable Augmentation Material

The availability of suitable augmentation material is the key factor in determining cost to augment material to the river. Ample suitable material is available in close proximity to the locations where augmentation will occur. Some of this material is available on Program-controlled property, and some of the material is available from offsite sources, which are generally commercial sand and gravel producers. Material on Program property in sandbars within the banks of the river channel (for example, CWR) is generally a suitable gradation for augmentation in those areas where the sand bars are located. Material in the overbank areas on Program property (for example, the Dyer Property) generally requires mining and processing to screen out material that is not readily mobilized during most flow conditions. The more processing required to obtain suitable material, the higher the cost to augment. Material handling is a significant cost component for sediment augmentation.

Proximity of Augmentation Material to Augmentation Sites

The closer the material to the augmentation location, the more cost effective the material will be. Material in the sand bars within the banks of the river will be the most cost effective augmentation solution while supplies are available. However, there is a finite amount of this material within the areas that the Program controls (for example, CWR). Material is also available in the overbank adjacent to the river on some of the Program's property (e.g., Dyer Property).

Availability of Contractors

Using a competitive bid process is usually the most effective method of ensuring competitive prices from contractors. The timing of the projects (that is, contractor peak or off season), other work being conducted in the area (for example, large paving or dirt projects), and the methods specified all affect the number of potential bidders on a project.

The mobilization time and effort for mechanical push contractors is relatively low, and the likelihood of contractor availability for bulldozer contractors is greater than for pumping contractors.

There are only a handful of pumping contractors in the vicinity of the augmentation sites, and the high level of mobilization and commitment make it likely that the contractor pool is smaller when projects do come up.

There may also be a perception among some contractors, especially sand and gravel operators, that these environmental projects result in additional challenges and work restrictions compared to their typical projects, which may influence their desire to compete for these projects and likely increases cost.

Level of Flexibility in Design

The more rigid the project requirements, the higher the unit cost will be. Flexibility in terms of timing (for example, matching augmentation rates to flow rates versus augmenting a specified quantity), project duration (for example, a longer versus shorter construction window), and to some extent, means and methods specified to the contractor all can impact the cost of the project.

Market Conditions for Material Not Used

If material must be produced onsite to achieve the specified gradation, there will be a component that is not usable for augmentation. If there is a market for this material and the contractor has the option to offset its costs by using the excess material in the secondary market, there can be cost savings. Because of the number of producers in the project area and an ample material source, there likely would be minimal cost savings from using the material. It likely would be more cost effective to allow the contractor to leave any excess material onsite (for example, pushing it back into the pits at sites where a sandpit is developed). One option to increase the marketability of the excess material would be to allow the contractor to produce what they needed and accept the gradation of the fine material as is.

7.1.2 Land Availability

Land availability is a key concern in determining the viability of a long-term augmentation project. Without agreement from private landowners or additional acquisition of property, the Program is limited in its ability to augment material to lands that are under its control. In addition, a finite amount of material is available on current program lands. It is not anticipated that land availability would be a significant deterrent to full-scale augmentation in the near future (that is, 10 to 25 years). Evaluation during the Screening Study indicated that both pushing material in the river at CWR and onsite mining and sorting material onsite at the Dyer Property have a 10+ year long-term viability.

7.1.3 Permitting

The basic assumption is that some form of permit would be required for any augmentation project, whether using sand pumps or bulldozers. Regulatory agencies are generally less familiar with sand pump alternatives since they are generally more complex and harder to permit than alternatives that involve activities that are similar to those currently authorized by USACE (that is, dozers). There has also been a reluctance to allow pumping of excess sand from commercial operation back into the river. The Program was successful in obtaining a permit for the Pilot Project, and it is expected that there would not be any significant impediments in securing those permits.

Dozer alternatives are generally similar to activities currently authorized by USACE and are generally less complex and easier to permit than other alternatives. The Program received permits to conduct dozing for this Pilot Project, and it is not expected that additional permits to continue bulldozing would be a significant issue.

7.2 Onsite Production of Material at the Dyer Property using Pumping

7.2.1 Dyer Property Pumping as Conducted During Pilot Study

The results of the Pilot Project at the Dyer Property indicate that the means and methods employed to mine, process, and place material in the river were successful in terms of the contractor being able to get a majority of the required material in the river in a given time. However, the ability to adjust to inconsistent flows and conditions that necessitate more frequent movement of discharge locations proved challenging and required that additional mechanical manipulation of the material be conducted after cessation of pumping. This technology provides excellent gradation control, and the rate of augmentation can be varied at higher pump volumes. The placement method can be scaled up to provide higher augmentation rates during higher flows. There is a practical limit on the lower augmentation rates because a minimum amount of water and pressure must be employed to deliver the material to the river. During low flow periods like those that occurred during the Pilot Study, it is difficult to maintain an effective operation without placing more material than the river can effectively mobilize. The pumping operation is fairly labor and equipment intensive, and the material must be handled multiple times, which increases the cost relative to a bulldozer alternative. This technology is also limited to use during non-freezing weather. The most significant problem encountered during the Pilot Study was not related to the limited ability to adjust output volume and location in response to the flow conditions, which required additional mechanical manipulation of the material after placement.

7.2.2 Variations in Dyer Property Pumping

There are some variations to the mining and pumping operation at the Dyer Property that could be implemented to improve efficiency and/or reduce the unit cost of the pumped material.

One option would be to mine and sort the material onsite rather than pump it to the river, create a stockpile of augmentation material on the bank, and use bulldozers to spread the material in the river channel. This would allow greater control of the placement of material and allow it to be manipulated to maximize entrainment. This option would make it easier to match augmentation with flow. While placement efficiency would be improved, costs would likely increase because of additional handling of the material and haul distance from the source pit. Stockpiling the material on the bank also would require management of the discharge water, which could be as simple as creating a drainage channel to the river to drain the water off the stockpile.

Another option would be to either pump the material directly to the river or a stockpile on the bank without sorting the material to a specified gradation. All of the material pumped, from the cobbles to the fine sand, would be augmented to the river. The logistics are similar to the above options; however, there would be a significant cost savings in not having to screen the material. The Pilot Study contractor indicated that one-half to one-third of the production cost of mining the material was screening the material, stockpiling the waste, and removing the waste material from the site. The larger material would likely build up over time and potentially cause channel armoring.

7.3 Variations in Cottonwood Ranch Bulldozer Pushing

The Program has been conducting bulldozer push operations at CWR for several years, and the technology is proven and generally effective as long as there is enough source material in the sand bars in the river on Program property. This material also has to be close to the active channel to make it cost effective because costs escalate quickly as push distance increases. At some point, source material will become limited and additional sources would be required. One option would be to work with local landowners between CWR and Overton and to conduct channel widening projects on their properties. Sand bars could be pushed into the active channels in this reach to provide augmentation material; improve conveyance, which would aid in augmentation; and potentially provide additional habitat. The actual bulldozing cost should be comparable assuming adequate access to the sites. There could be some additional cost if landowners require compensation in order to participate. There may also be general reluctance by some landowners to participate.

7.4 Other Sand Pit Operators

A final option to consider would be to work with local sand pit operators and have them discharge their sand material directly to the river as part of their operation. The majority of the sand material produced as a byproduct of their aggregate production is within or very close to the optimal gradation and would essentially be similar to the pumping operations at the Dyer Property. The cost of this option is not known, and it would be dependent on the operators' willingness to participate. There may be some reluctance from individual operators if it is perceived to interfere with their ongoing operations. Permitting under this scenario may also be more difficult.

8. BIBLIOGRAPHY

Anderson, D.M. and Rodney, M.W., 2006. Characterization of hydrologic conditions to support Platte River species recovery efforts, Jour. American Water Resources Associations, AWRA Paper 04110, October, pp. 1391-1403.

EA Engineering, Science, and Technology, Inc. September 2013. Platte River Recovery Implementation Program. Final Annual Data Summary Report, Platte River Water Quality Monitoring 2012 Monitoring Season.

The Flatwater Group, Inc., HDR Engineering, Inc. and Tetra Tech, Inc., February 2011. Sediment Augmentation Experiment Alternatives Screening Summary Report.

The Flatwater Group, Inc., HDR Engineering, Inc. and Tetra Tech, Inc., July 2012a. Revised Final Pilot Scale Management Action Technical Memorandum, prepared for Platte River Recovery Implementation Program, July, 33 pp.

The Flatwater Group, Inc., HDR Engineering, Inc. and Tetra Tech, Inc., July 2012b. Revised Final Pilot Scale Management Action Technical Memorandum, Appendix A, Platte River Recovery Implementation Program Sediment Augmentation Pilot-Scale Management Action Monitoring and Data Analysis Plan, prepared for Platte River Recovery Implementation Program, July, 13 pp.

Platte River Recovery Implementation Program, 2010. Channel Geomorphology and In-channel Vegetation Monitoring of the Central Platte River Program.

Platte River Recovery Implementation Program, 2011. Project-scale Geomorphology and Vegetation Monitoring Protocol.

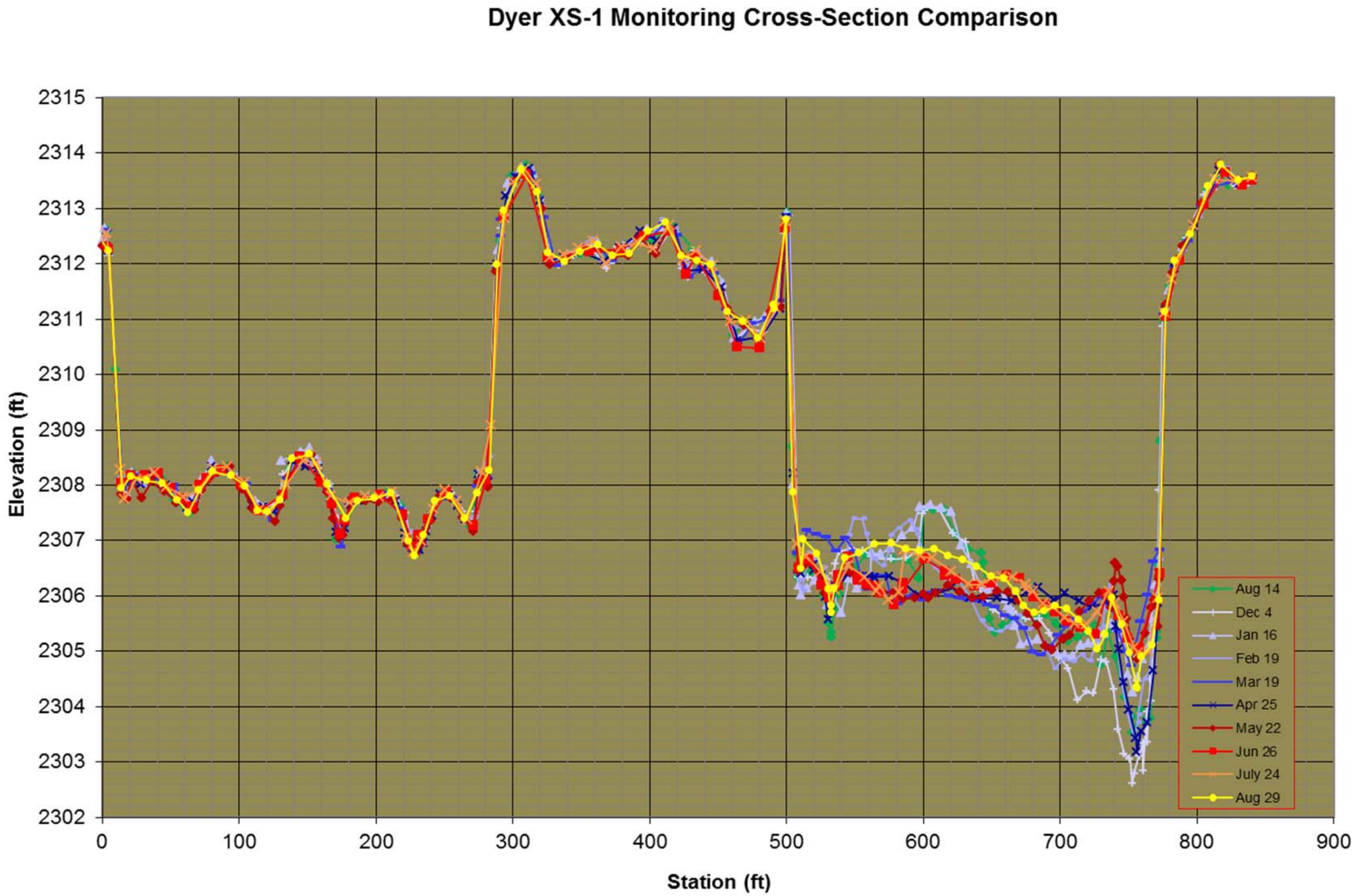
Tetra Tech, 2010. Hydraulic and Sediment-transport Modeling for the Platte River Sediment Augmentation Feasibility Study, Nebraska. Appendix B, Modeling Evaluation, Final Platte River from Lexington to Odessa Bridges, Sediment Augmentation Experiment Alternatives Screening Study Summary Report, prepared for Platte River Recovery Implementation Program, September 7, 92 pp.

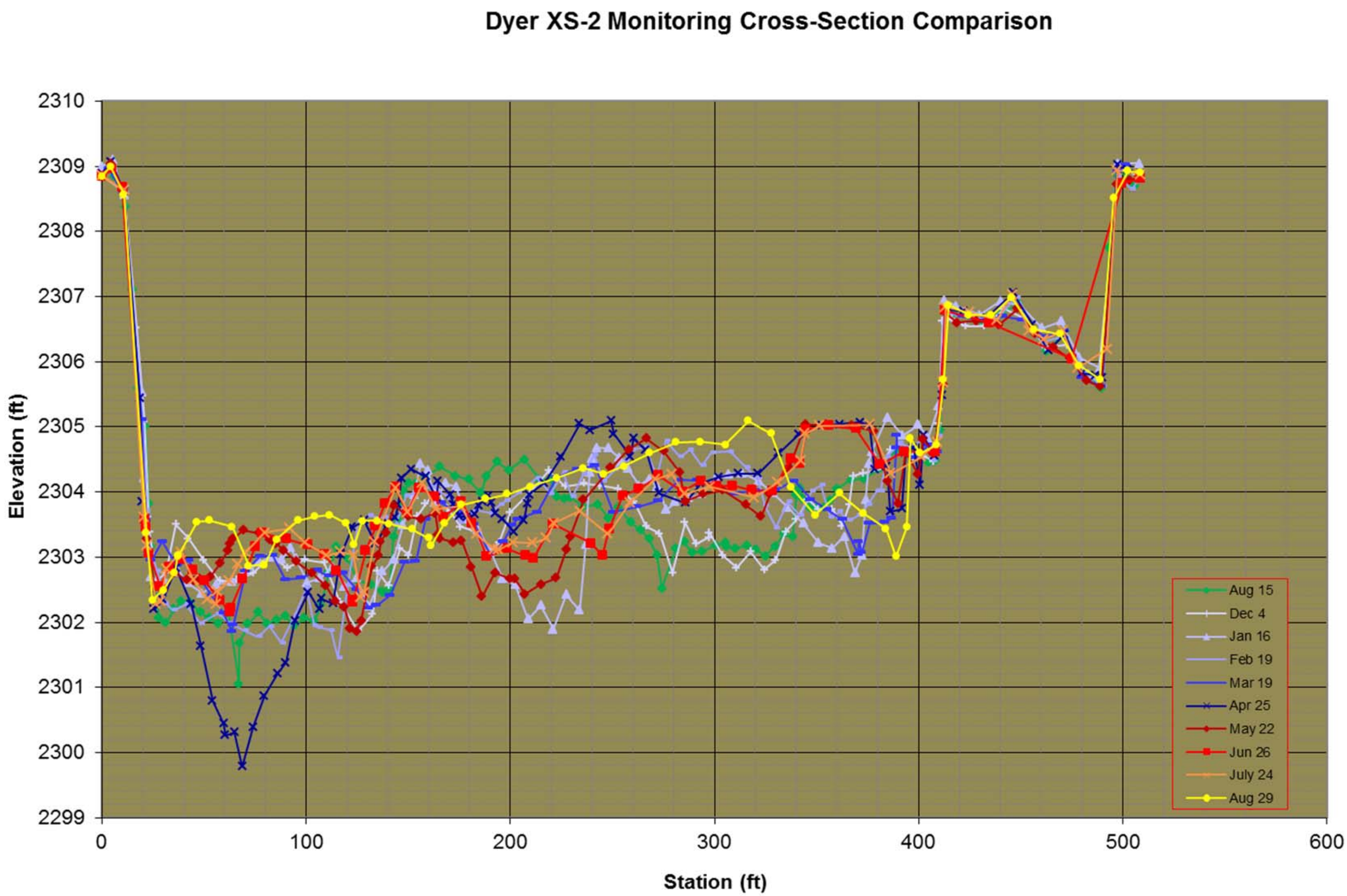
Tetra Tech, 2011. Platte River Sediment Augmentation Pilot Study, Memorandum from Stuart Trabant to Rick Krushenisky and Tom Riley, The Flatwater Group and Pat Engelbert, HDR Engineering, Inc. September 13, 14 pp.

Tetra Tech, 2013. 2012 Elm Creek FSM Annual Monitoring Report. Draft, Submitted to Platte River Recovery Implementation Program, April 3, 146 pp.

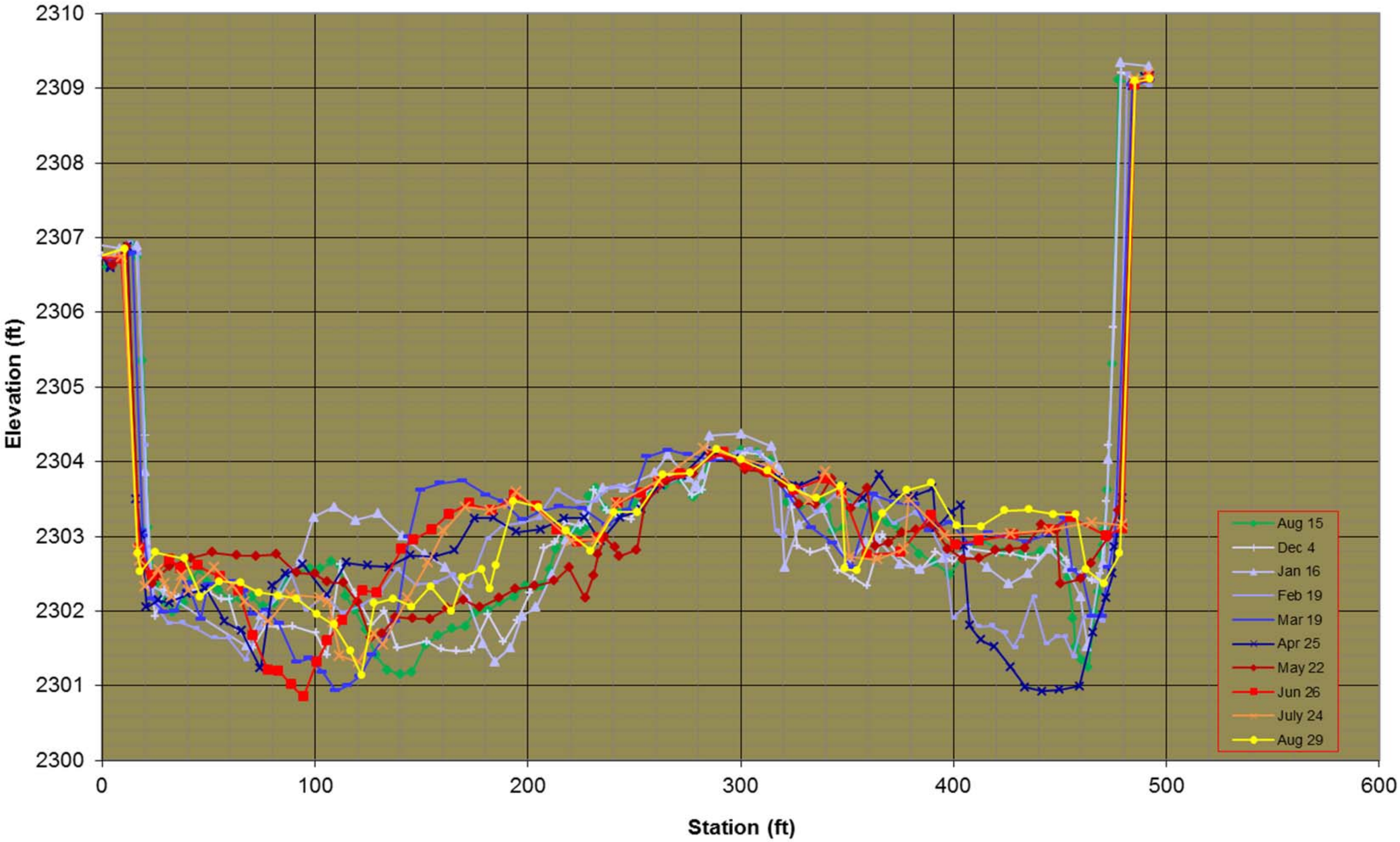
APPENDIX A

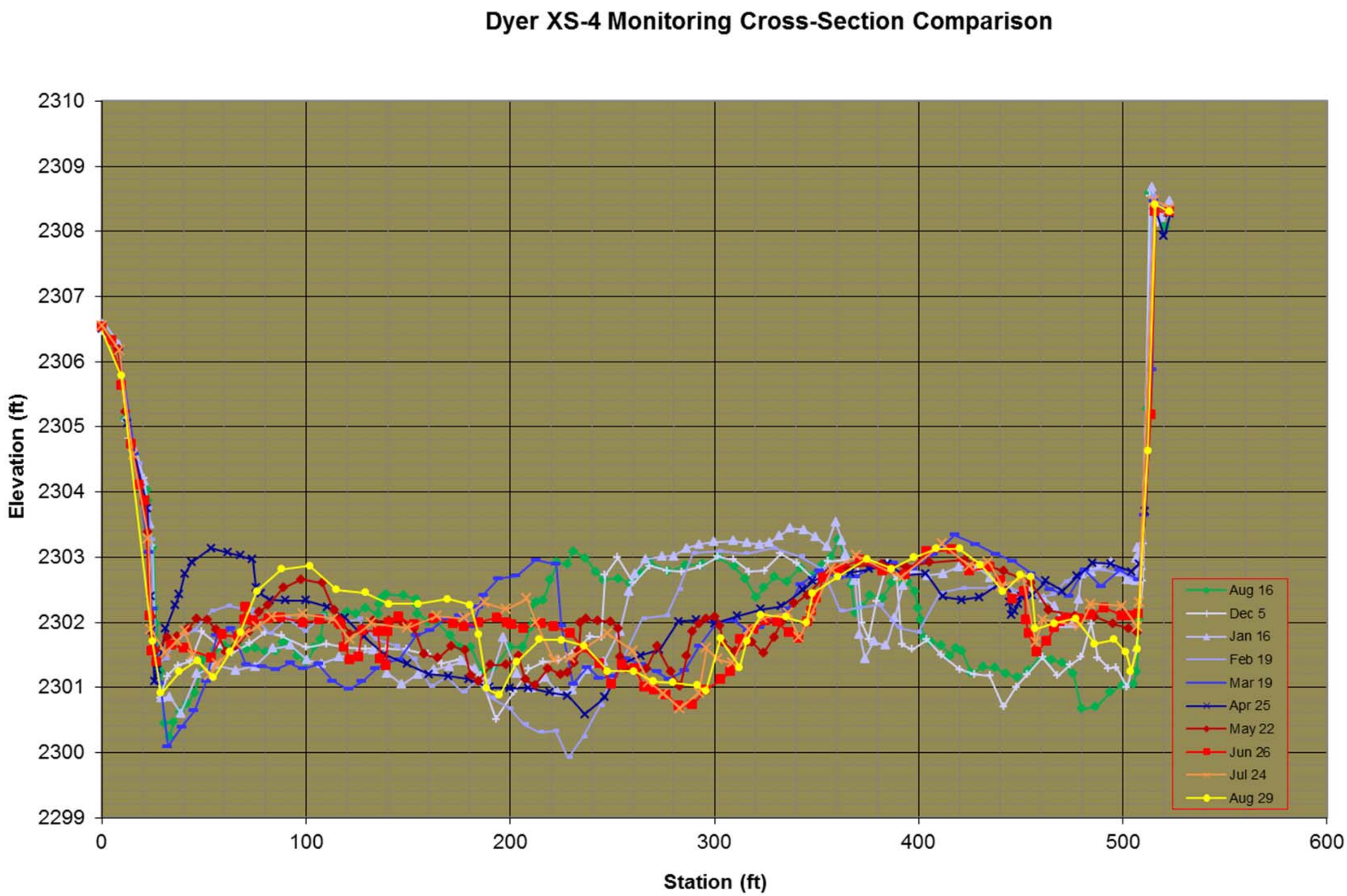
MONITORING CROSS SECTIONS


Dyer XS-1 Monitoring Cross-Section Comparison
Elevation (ft)
Station (ft)
2315
2314
2313
2312
2311
2310
2309
2308
2307
2306
2305
2304
2303
2302
0
100
200
300
400
500
600
700
800
900
Aug 14
Dec 4
Jan 16
Feb 19
Mar 19
Apr 25
May 22
Jun 26
July 24
Aug 29

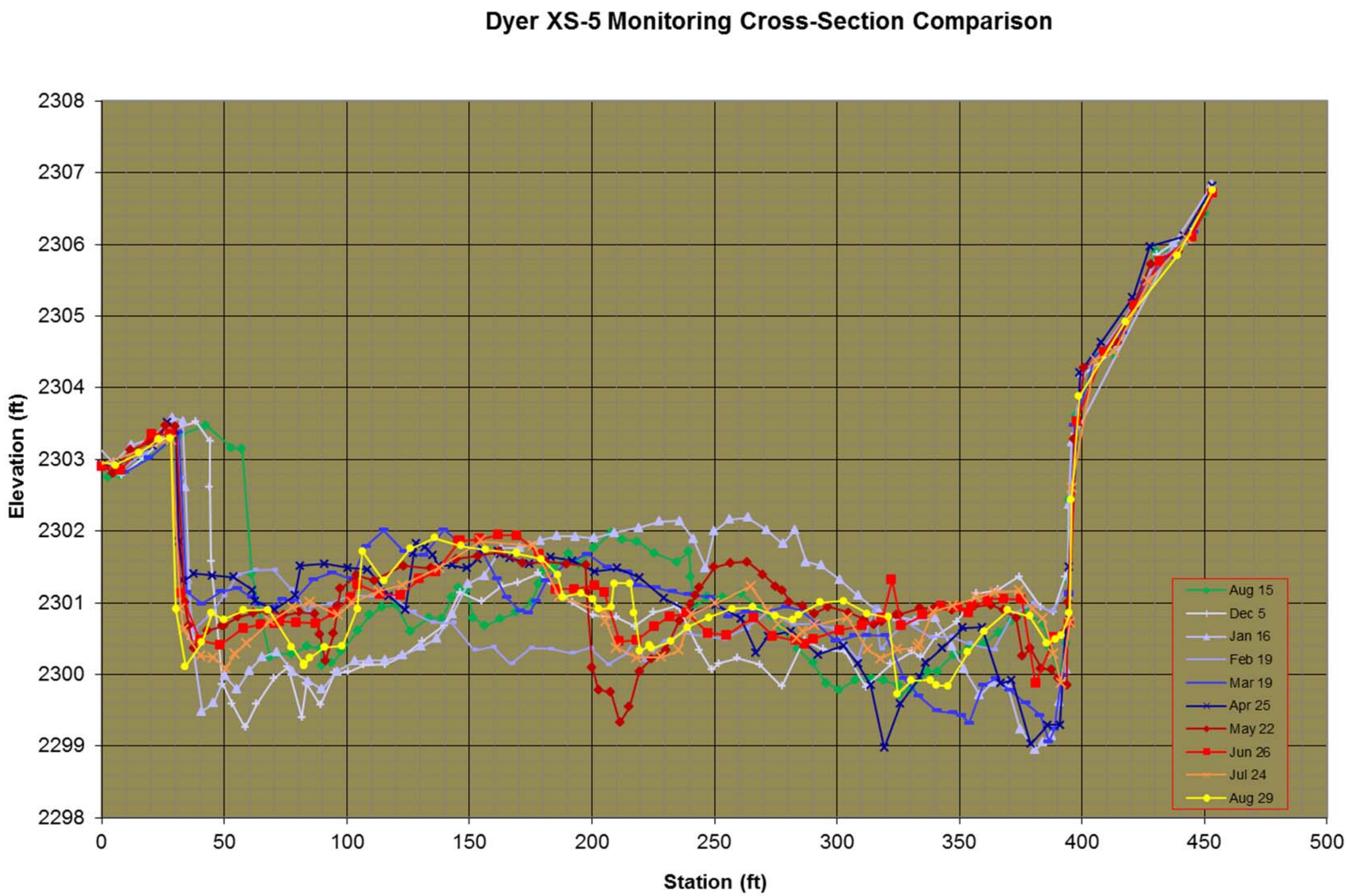

Dyer XS-2 Monitoring Cross-Section Comparison
Elevation (ft)
Station (ft)
2310
2309
2308
2307
2306
2305
2304
2303
2302
2301
2300
2299
0
100
200
300
400
500
600
Aug 15
Dec 4
Jan 16
Feb 19
Mar 19
Apr 25
May 22
Jun 26
July 24
Aug 29

Dyer XS-3 Monitoring Cross-Section Comparison

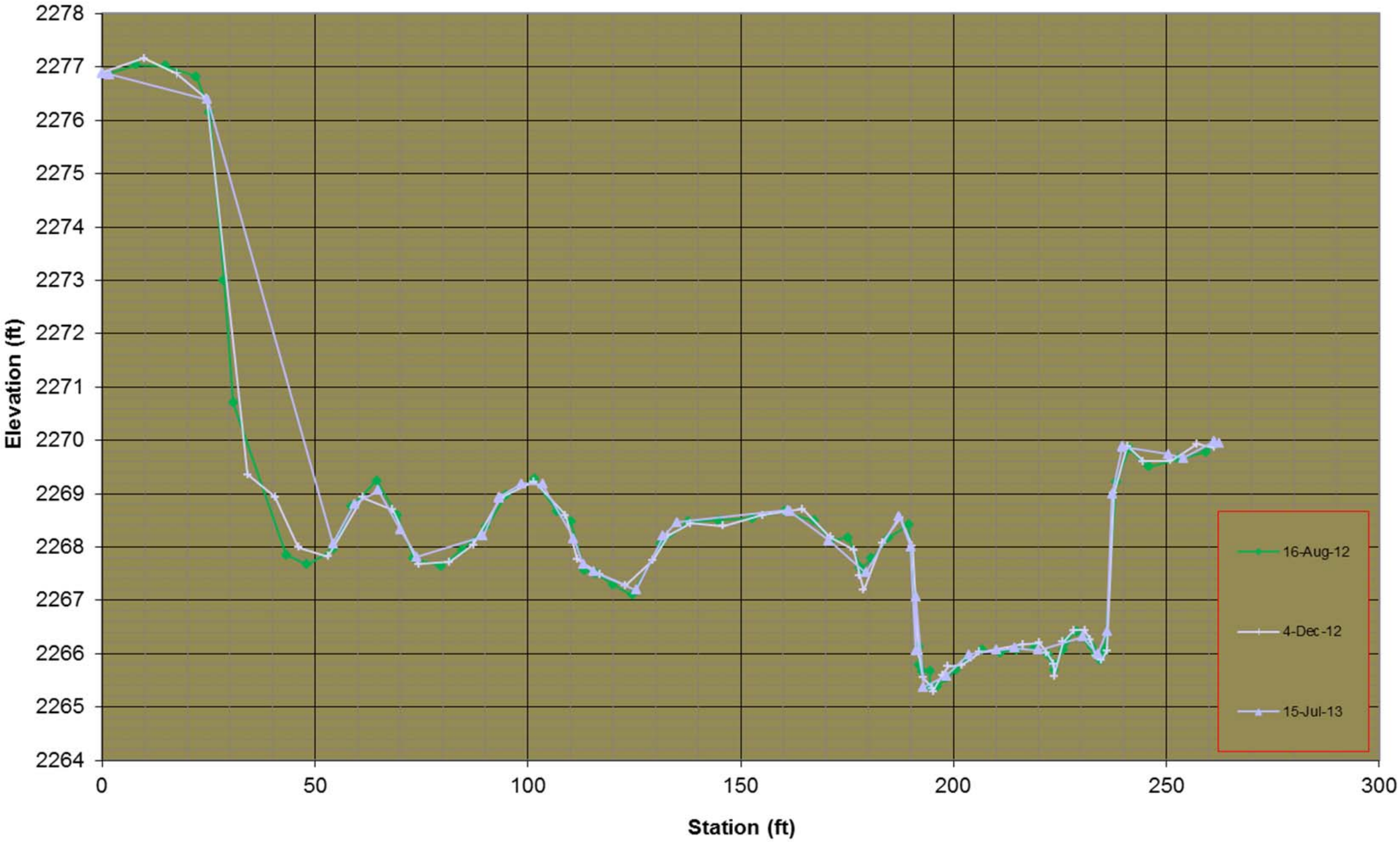


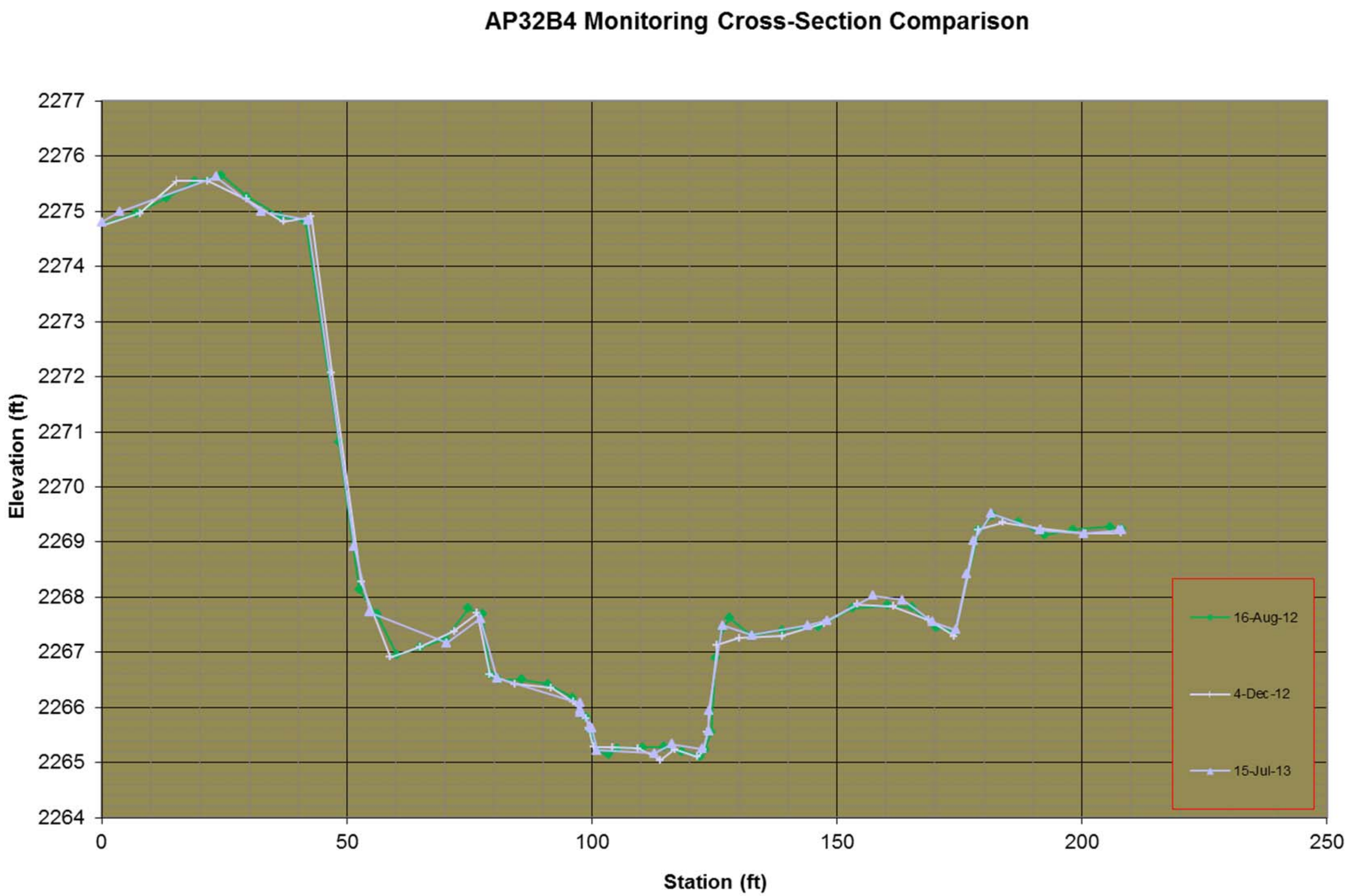


Dyer XS-4 Monitoring Cross-Section Comparison
2310
2309
2308
2307
2306
2305
2304
2303
2302
2301
2300
2299
Elevation (ft)
0
100
200
300
400
500
600
Station (ft)
Aug 16
Dec 5
Jan 16
Feb 19
Mar 19
Apr 25
May 22
Jun 26
Jul 24
Aug 29


Dyer XS-5 Monitoring Cross-Section Comparison
Elevation (ft)
2308
2307
2306
2305
2304
2303
2302
2301
2300
2299
2298
Station (ft)
0
50
100
150
200
250
300
350
400
450
500
Aug 15
Dec 5
Jan 16
Feb 19
Mar 19
Apr 25
May 22
Jun 26
Jul 24
Aug 29

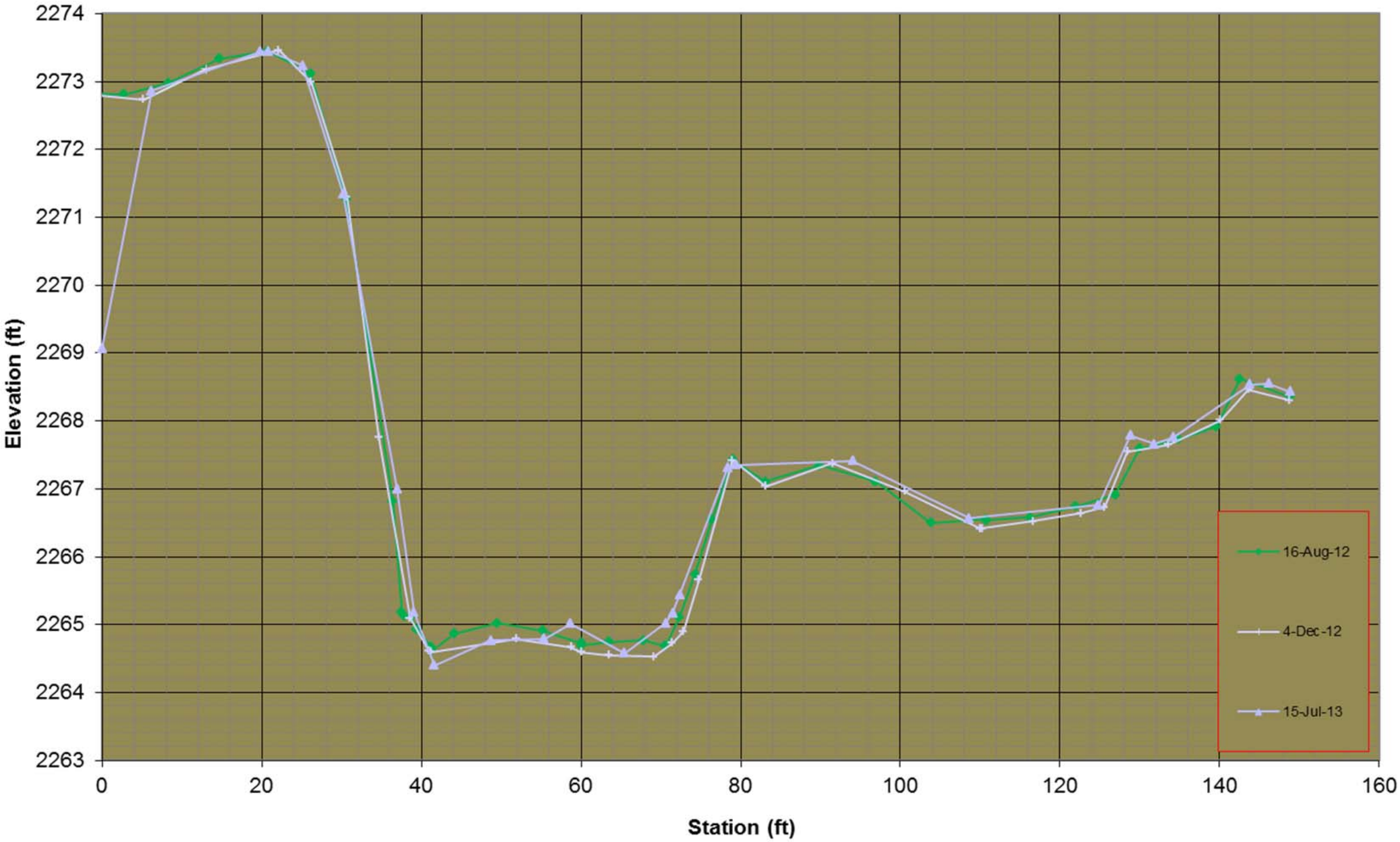
AP32B1 Monitoring Cross-Section Comparison

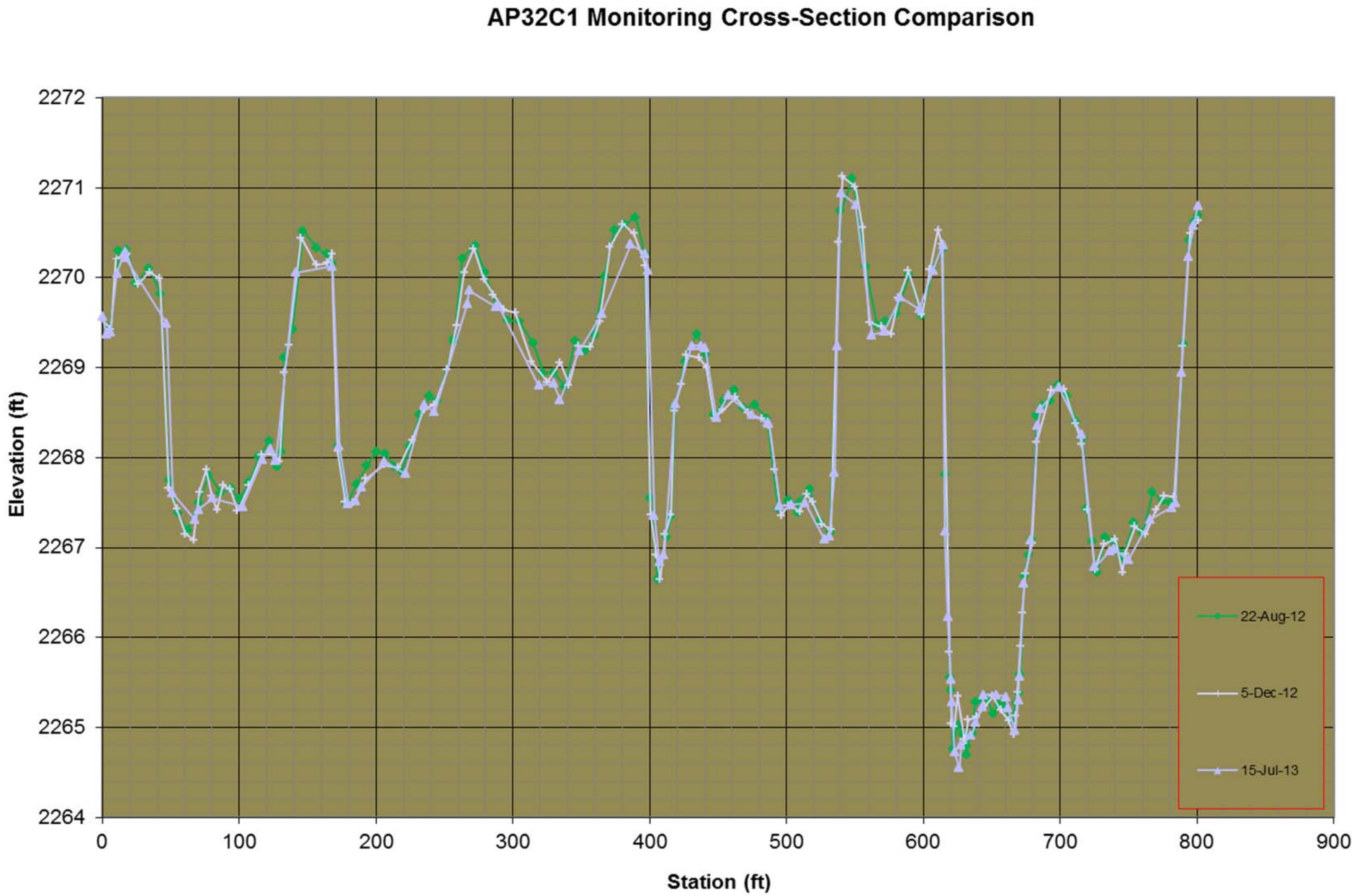




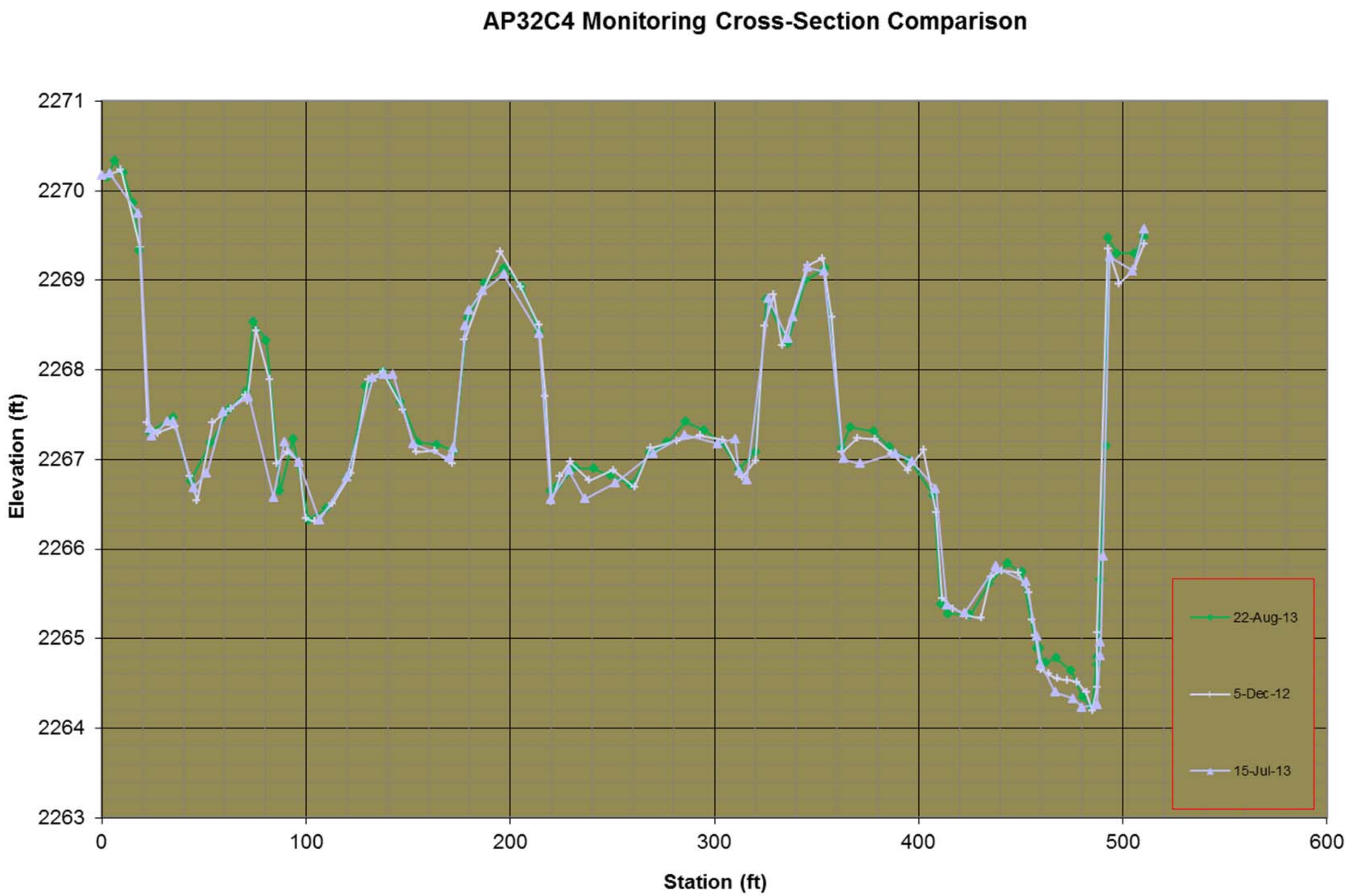
AP32B4 Monitoring Cross-Section Comparison
Elevation (ft)
2277
2276
2275
2274
2273
2272
2271
2270
2269
2268
2267
2266
2265
2264
Station (ft)
0
50
100
150
200
250
16-Aug-12
4-Dec-12
15-Jul-13

AP32B7 Monitoring Cross-Section Comparison

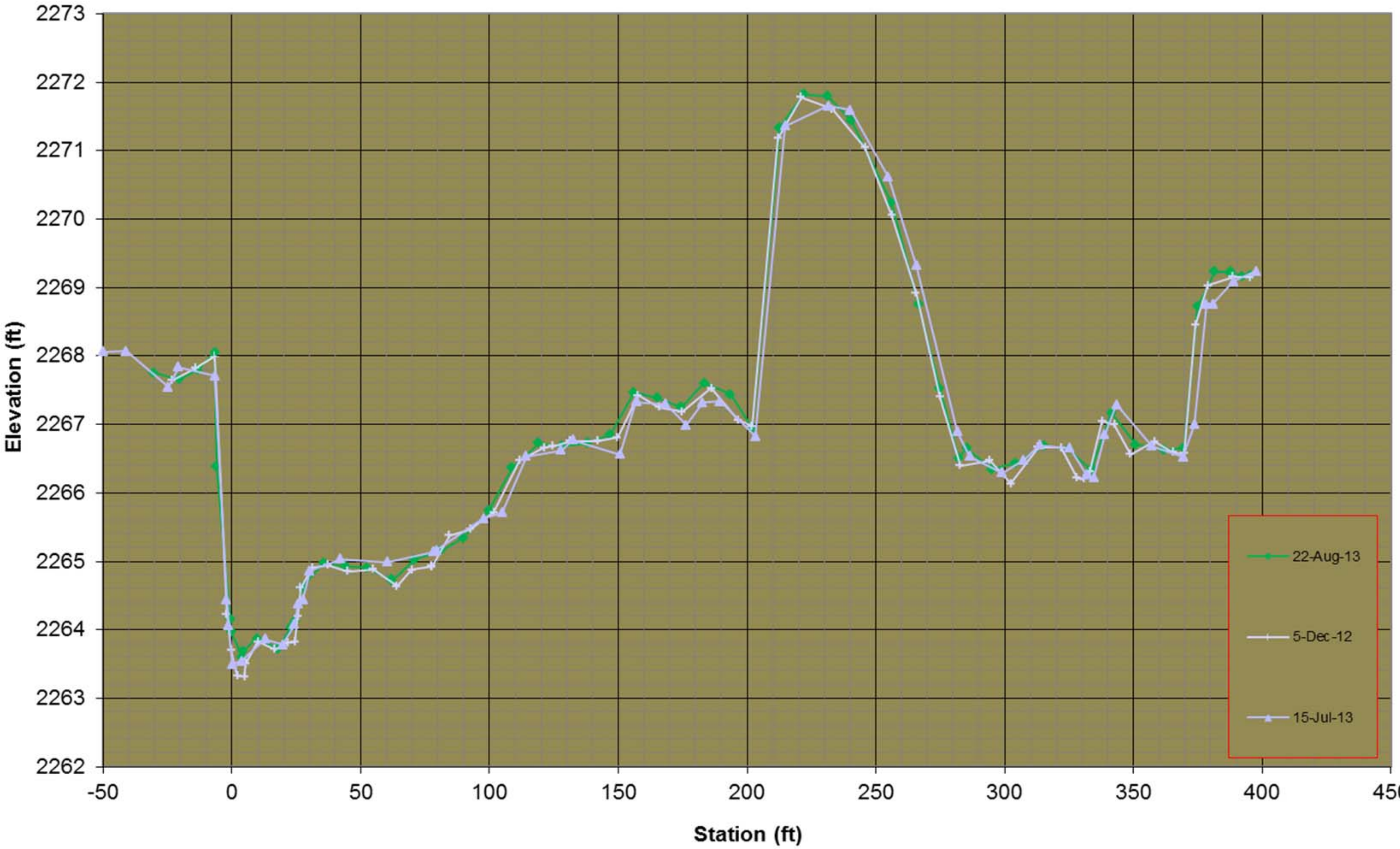




AP32C1 Monitoring Cross-Section Comparison
2272
2271
2270
2269
2268
2267
2266
2265
2264
Elevation (ft)
0
100
200
300
400
500
600
700
800
900
Station (ft)
22-Aug-12
5-Dec-12
15-Jul-13

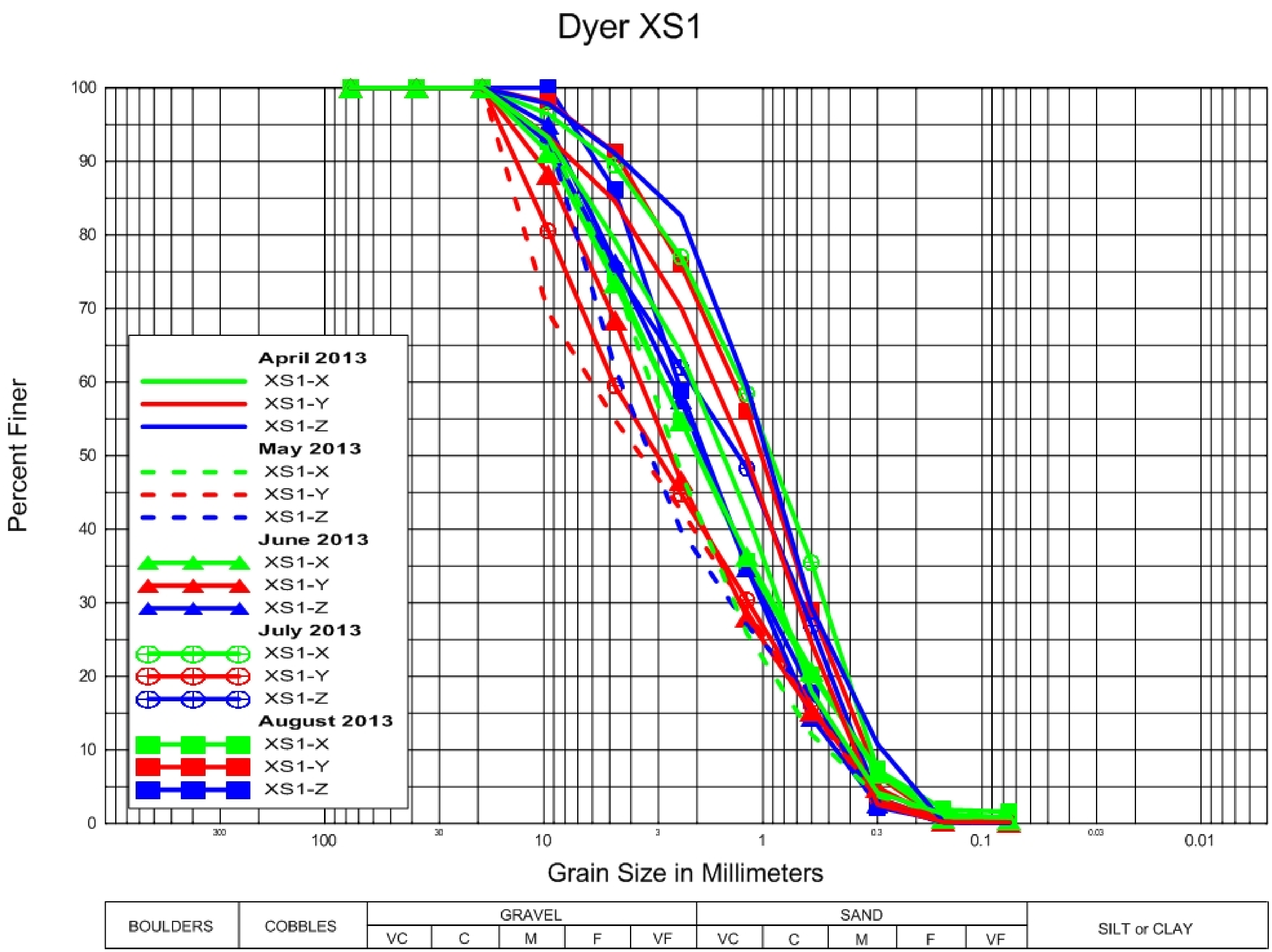

AP32C4 Monitoring Cross-Section Comparison
Elevation (ft)
2271
2270
2269
2268
2267
2266
2265
2264
2263
0
100
200
300
400
500
600
Station (ft)
22-Aug-13
5-Dec-12
15-Jul-13

AP32C7 Monitoring Cross-Section Comparison

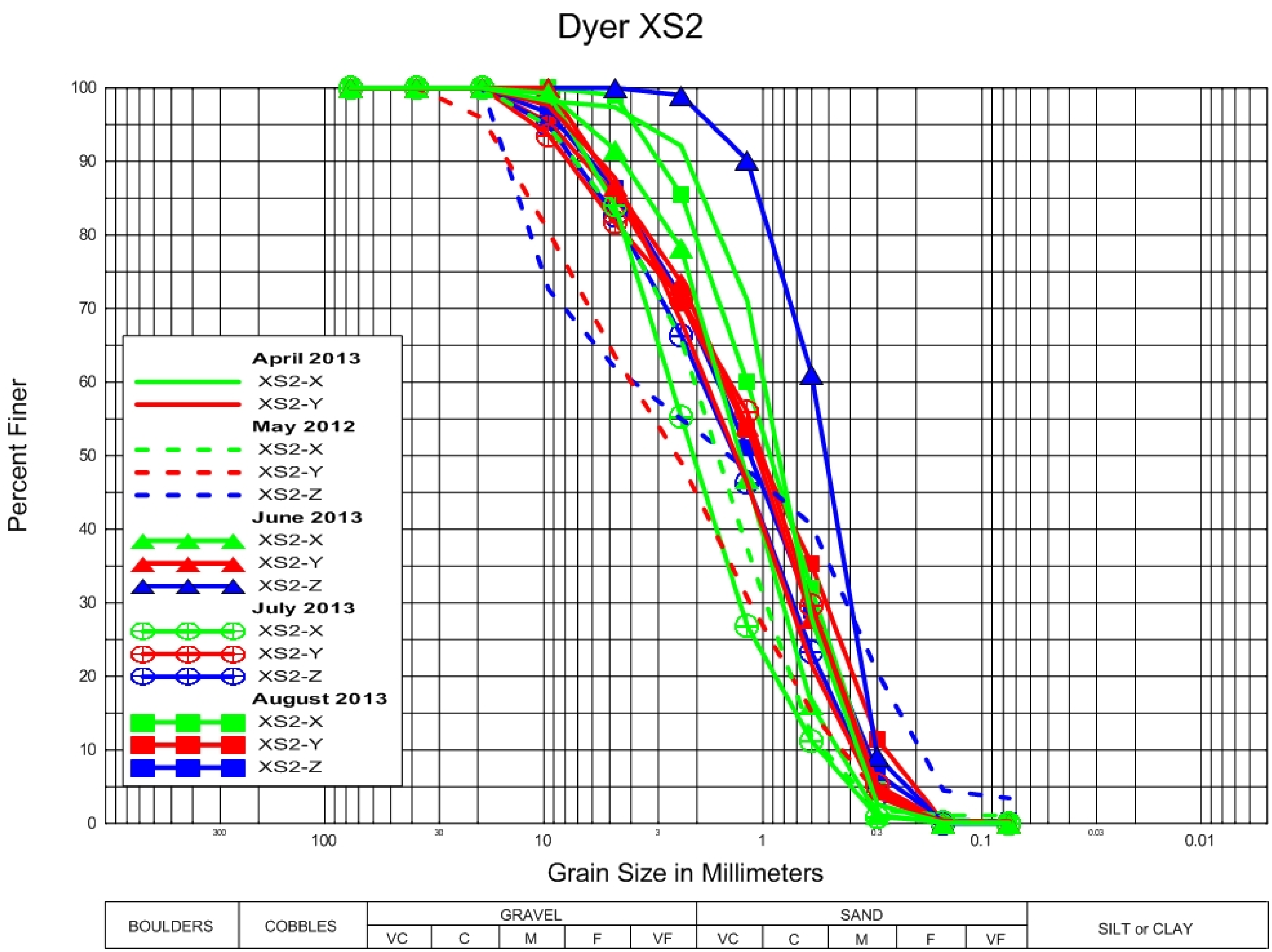


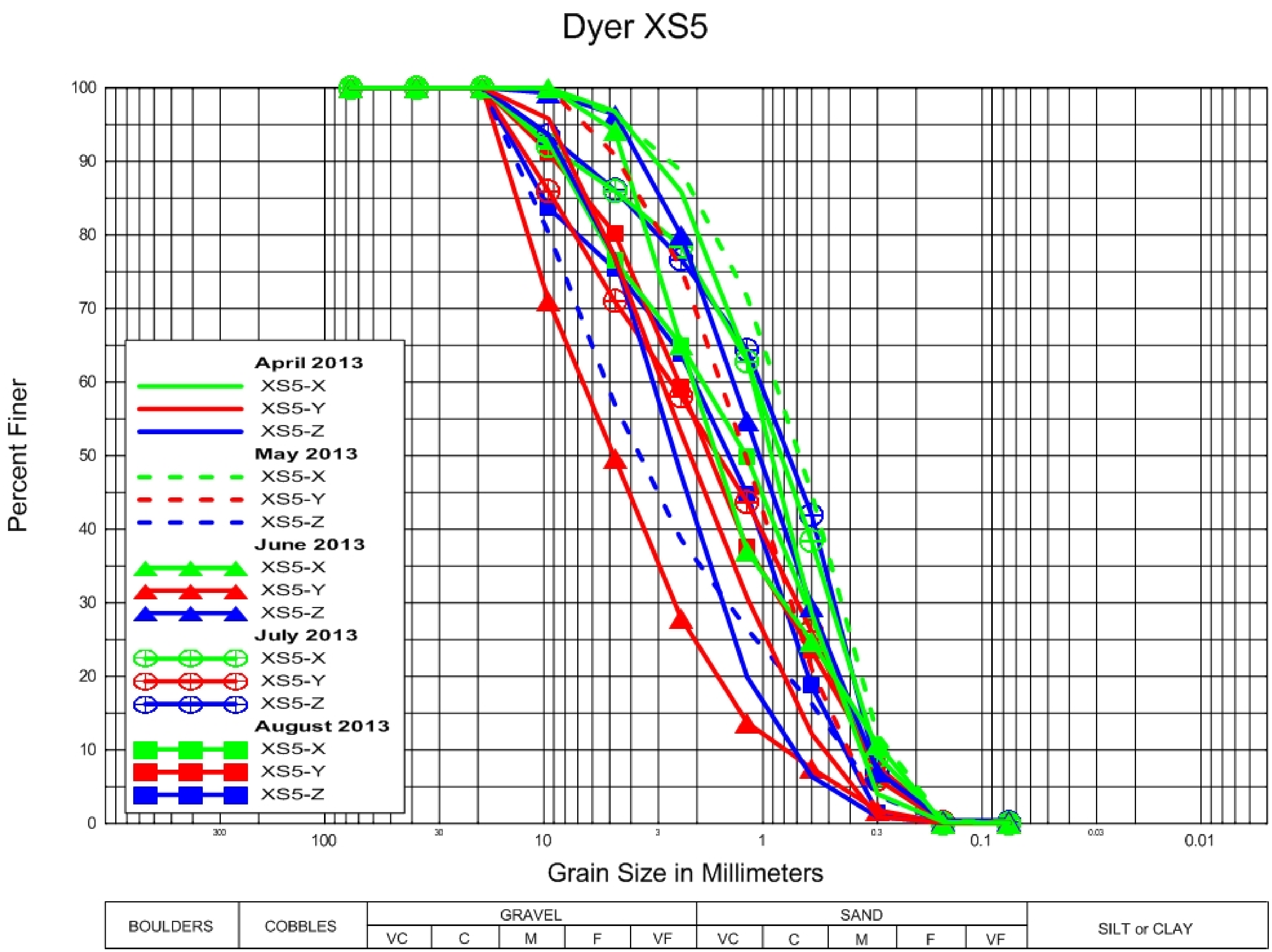
APPENDIX B

SAMPLE GRADATIONS

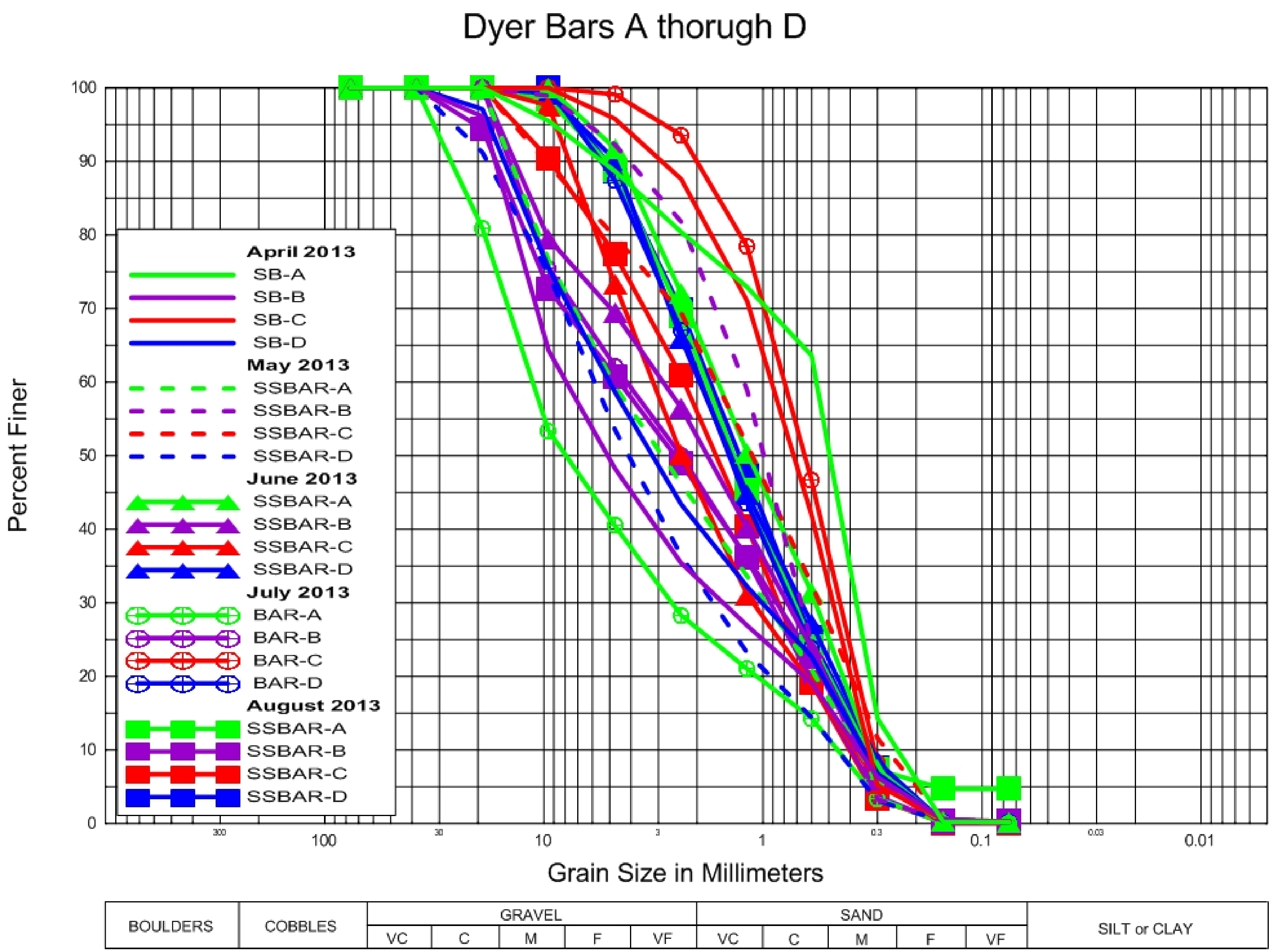


Dyer XS1
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
300
100
30
10
3
1
0.3
0.1
0.03
0.01
Grain Size in Millimeters
April 2013
XS1-X
XS1-Y
XS1-Z
May 2013
XS1-X
XS1-Y
XS1-Z
June 2013
XS1-X
XS1-Y
XS1-Z
July 2013
XS1-X
XS1-Y
XS1-Z
August 2013
XS1-X
XS1-Y
XS1-Z
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY


Dyer XS2
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
300
100
30
10
3
1
0.3
0.1
0.03
0.01
Grain Size in Millimeters
April 2013
XS2-X
XS2-Y
May 2012
XS2-X
XS2-Y
XS2-Z
June 2013
XS2-X
XS2-Y
XS2-Z
July 2013
XS2-X
XS2-Y
XS2-Z
August 2013
XS2-X
XS2-Y
XS2-Z
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY

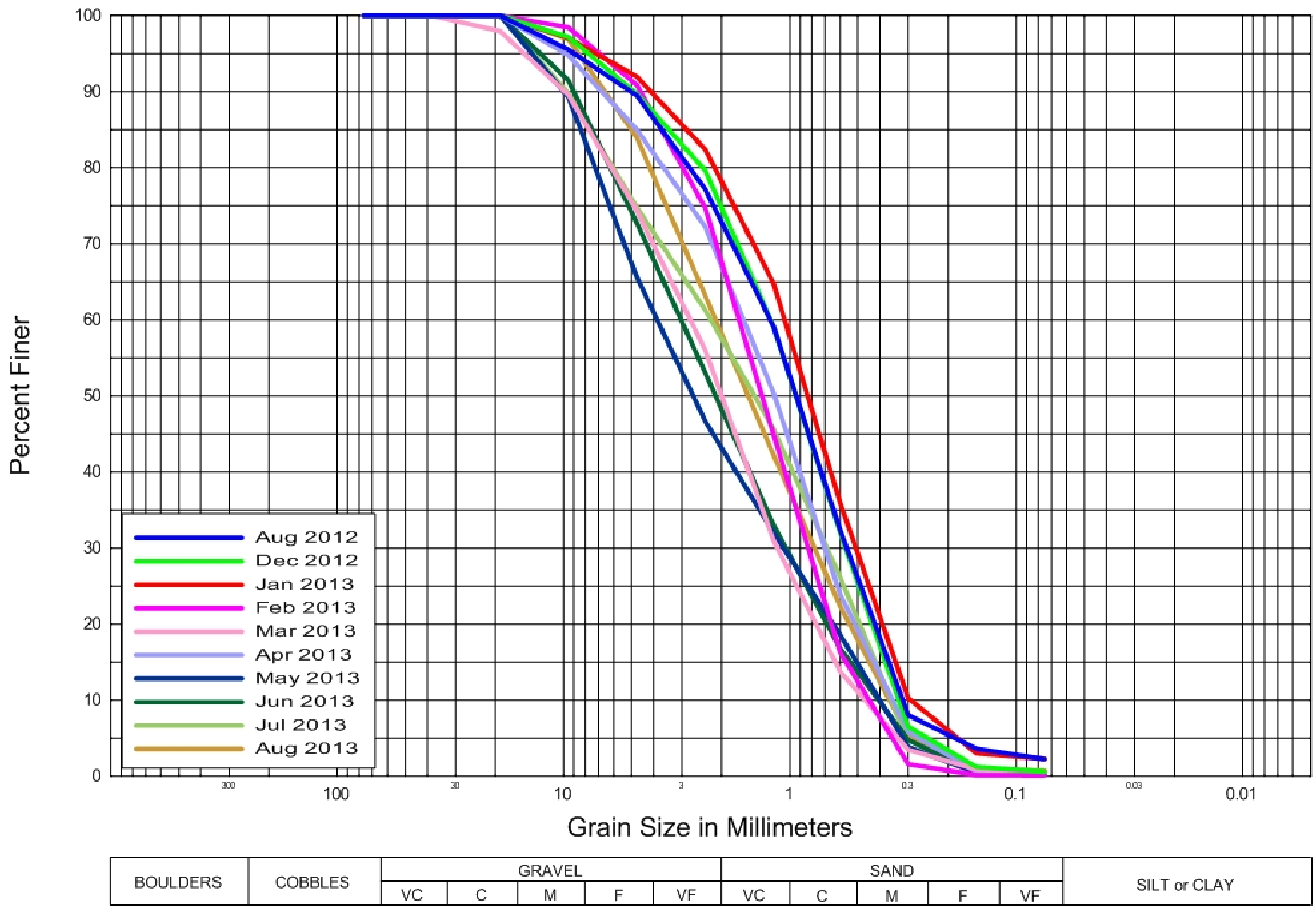


Dyer XS5
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
300
100
30
10
3
1
0.3
0.1
0.03
0.01
Grain Size in Millimeters
April 2013
XS5-X
XS5-Y
XS5-Z
May 2013
XS5-X
XS5-Y
XS5-Z
June 2013
XS5-X
XS5-Y
XS5-Z
July 2013
XS5-X
XS5-Y
XS5-Z
August 2013
XS5-X
XS5-Y
XS5-Z
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY



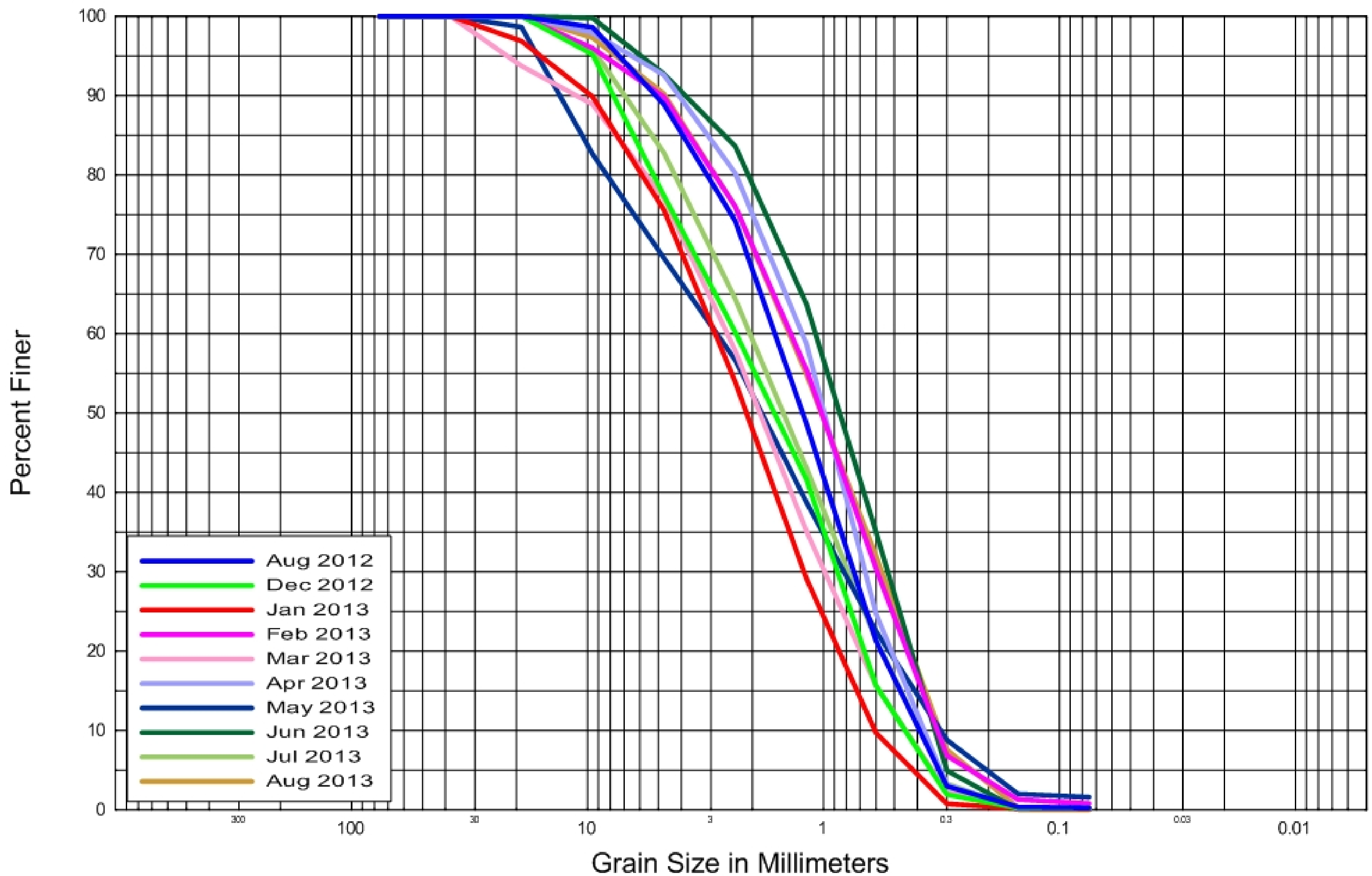
Dyer Bars A thorugh D
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
300
100
30
10
3
1
0.3
0.1
0.03
0.01
Grain Size in Millimeters
April 2013
SB-A
SB-B
SB-C
SB-D
May 2013
SSBAR-A
SSBAR-B
SSBAR-C
SSBAR-D
June 2013
SSBAR-A
SSBAR-B
SSBAR-C
SSBAR-D
July 2013
BAR-A
BAR-B
BAR-C
BAR-D
August 2013
SSBAR-A
SSBAR-B
SSBAR-C
SSBAR-D
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY

Dyer XS1

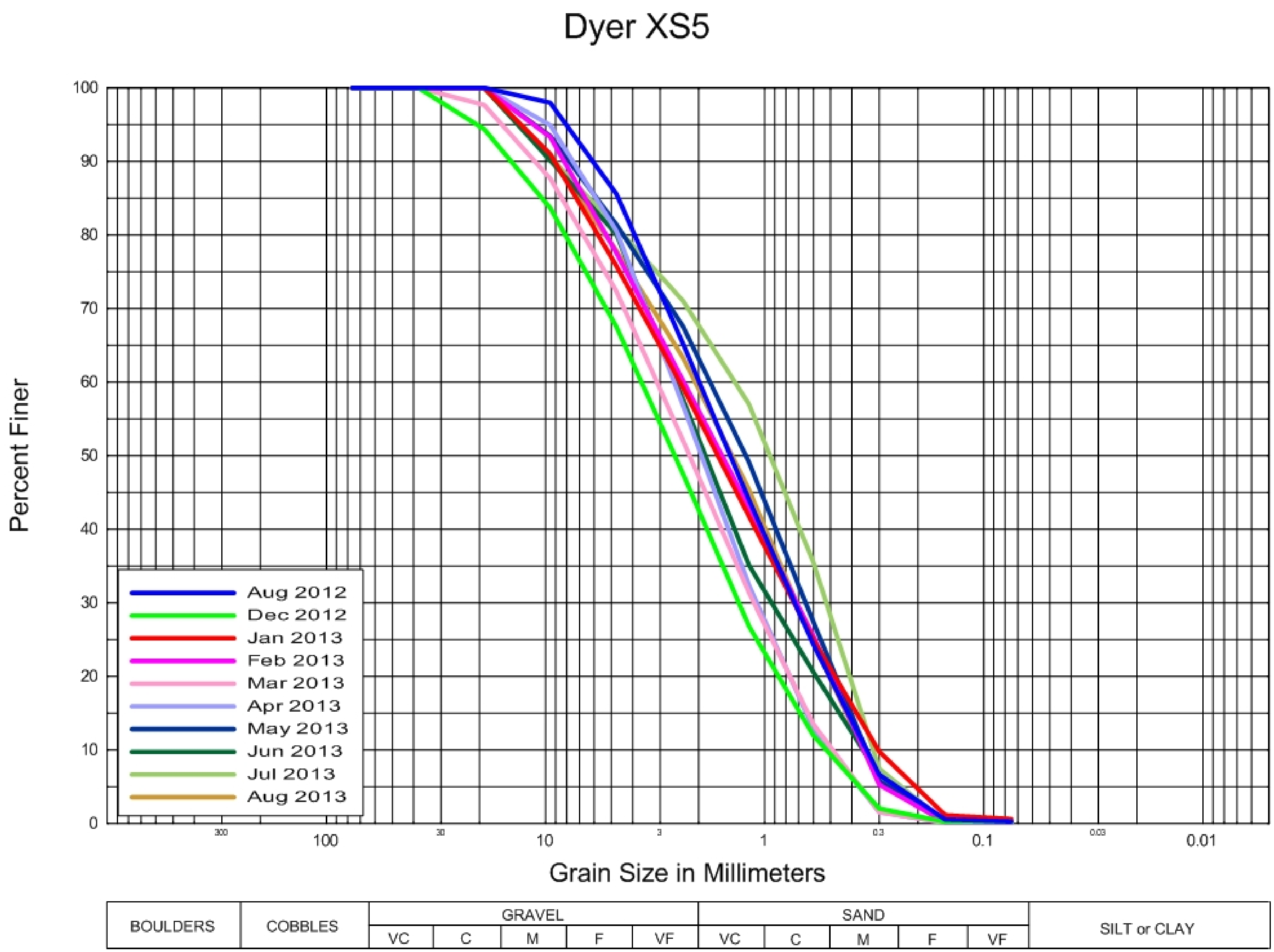


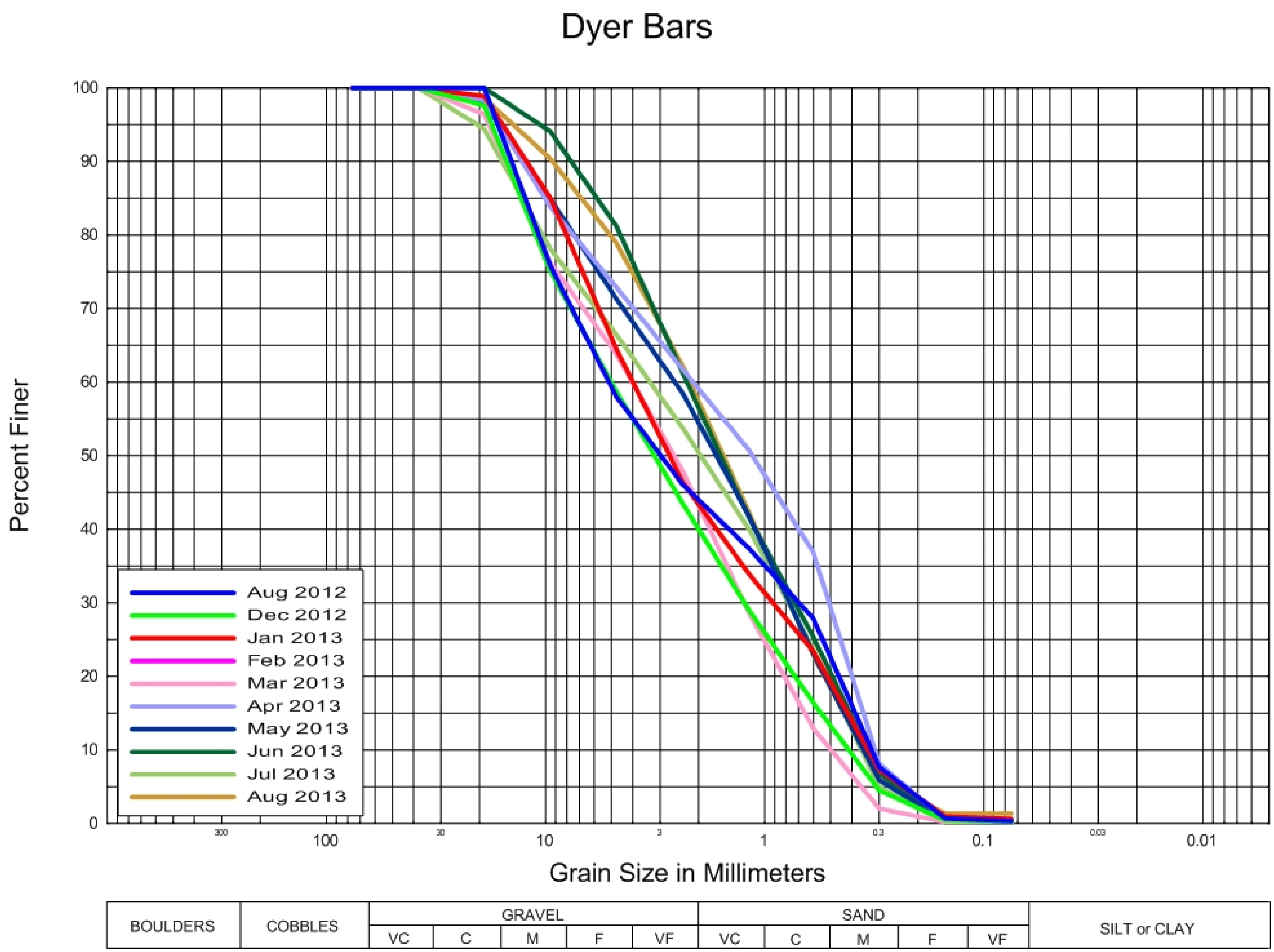
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
Aug 2012
Dec 2012
Jan 2013
Feb 2013
Mar 2013
Apr 2013
May 2013
Jun 2013
Jul 2013
Aug 2013
100
10
1
0.1
0.01
Grain Size in Millimeters
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY

Dyer XS2

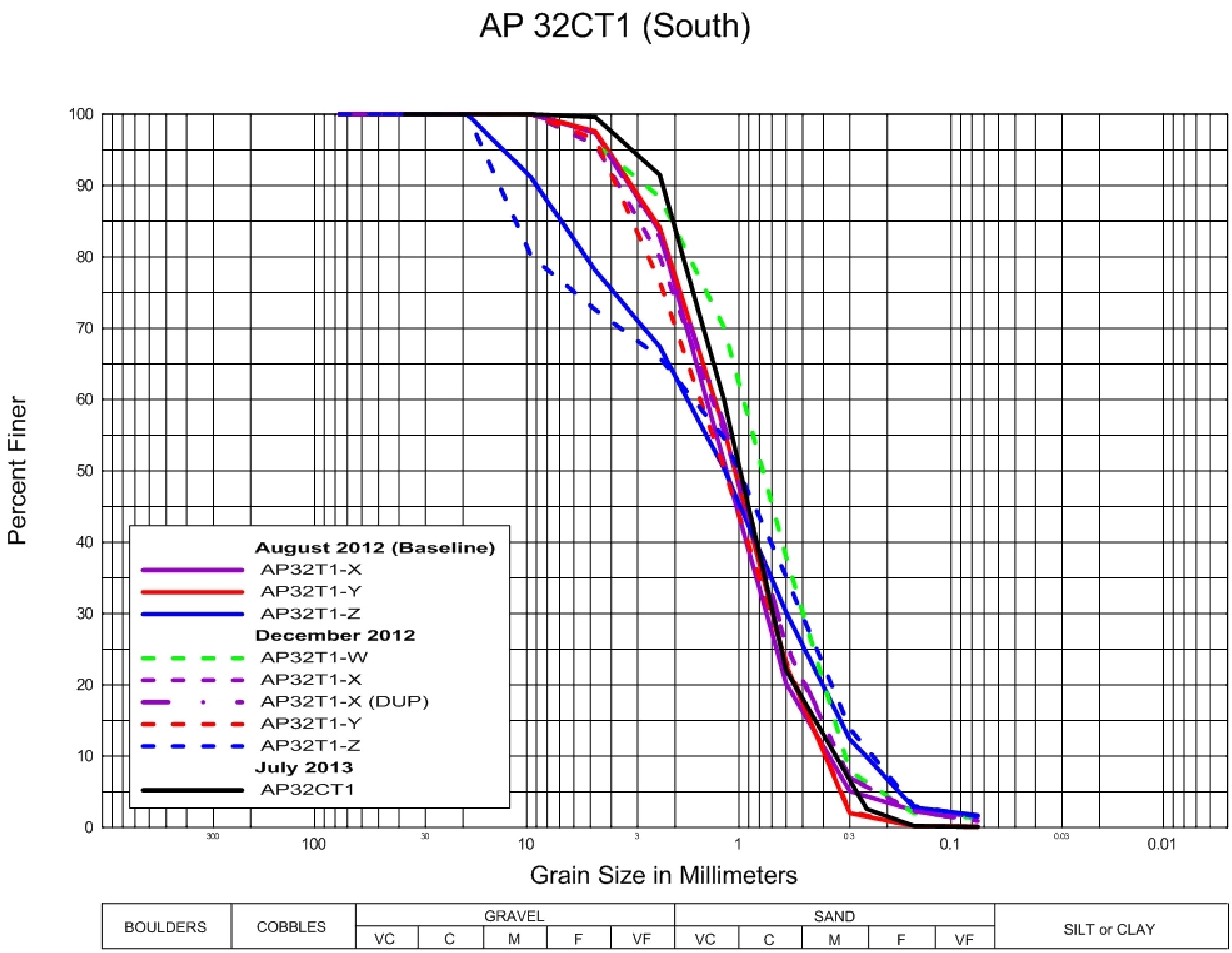


BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

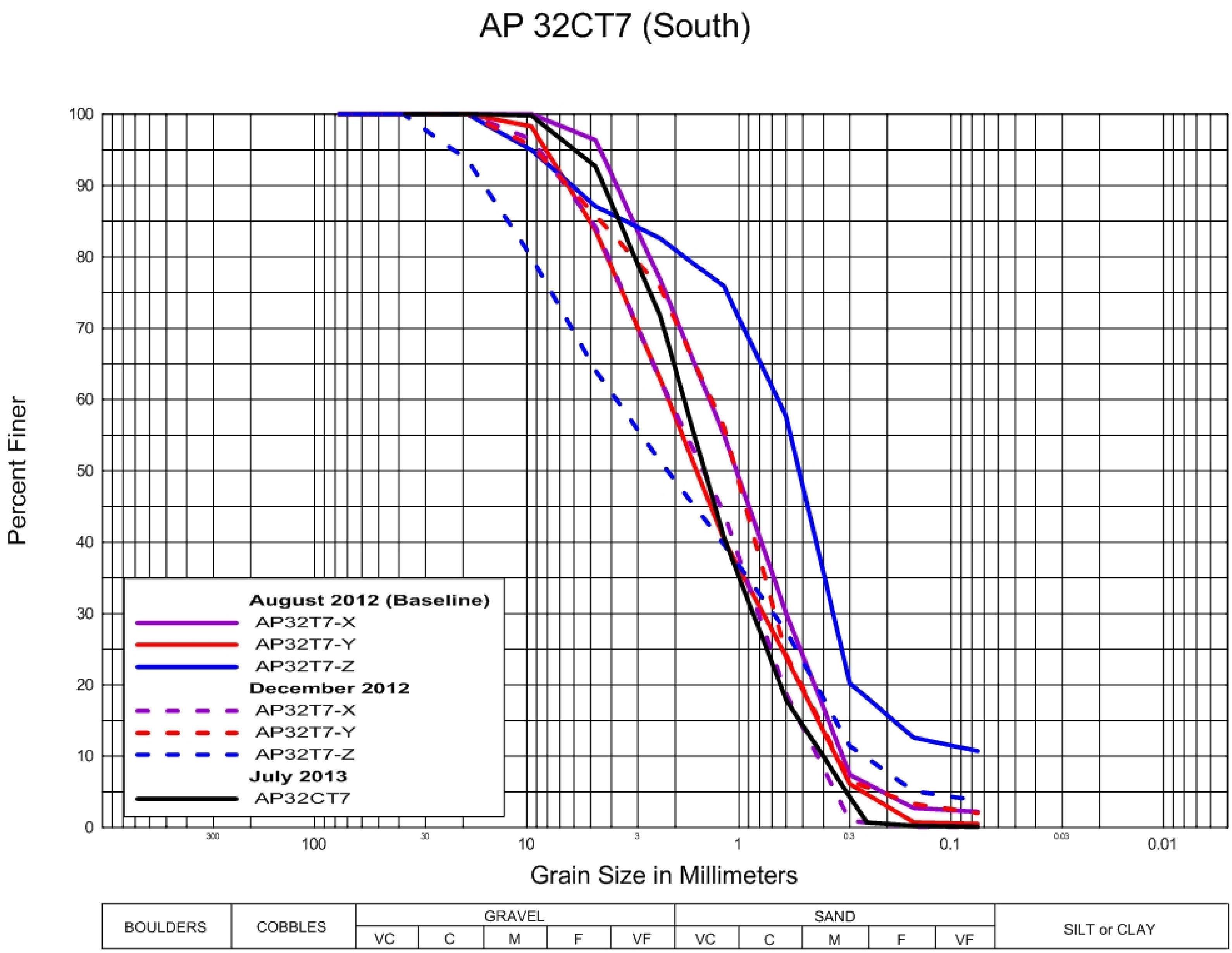

Dyer XS5
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
300
100
30
10
3
1
0.3
0.1
0.03
0.01
Grain Size in Millimeters
Aug 2012
Dec 2012
Jan 2013
Feb 2013
Mar 2013
Apr 2013
May 2013
Jun 2013
Jul 2013
Aug 2013
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY



Dyer Bars
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
300
100
30
10
3
1
0.3
0.1
0.03
0.01
Grain Size in Millimeters
Aug 2012
Dec 2012
Jan 2013
Feb 2013
Mar 2013
Apr 2013
May 2013
Jun 2013
Jul 2013
Aug 2013
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY



AP 32CT1 (South)
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
300
100
30
10
3
1
0.3
0.1
0.03
0.01
Grain Size in Millimeters
August 2012 (Baseline)
AP32T1-X
AP32T1-Y
AP32T1-Z
December 2012
AP32T1-W
AP32T1-X
AP32T1-X (DUP)
AP32T1-Y
AP32T1-Z
July 2013
AP32CT1
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY


AP 32CT7 (South)
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
300
100
30
10
3
1
0.3
0.1
0.03
0.01
Grain Size in Millimeters
August 2012 (Baseline)
AP32T7-X
AP32T7-Y
AP32T7-Z
December 2012
AP32T7-X
AP32T7-Y
AP32T7-Z
July 2013
AP32CT7
BOULDERS
COBBLES
GRAVEL
VC
C
M
F
VF
SAND
VC
C
M
F
VF
SILT or CLAY

APPENDIX C

Tri Basin NRD Drain Photos

Tri-Basin NRD Drains
Photo Log
Pre-augmentation (August 2012)
And Post Augmentation (July 2013)

Batie Drain. Pre-augmentation (2012) looking west.

Batie Drain. Post augmentation looking west.

Batie Drain. Post augmentation (2013) looking southwest.

North Phelps Drain. Pre-augmentation looking southwest.

North Phelps Drain. Post augmentation looking southwest.

North Phelps Drain. Pre-augmentation looking west.

North Phelps Drain. Post augmentation looking west.

Benson and Patterson Drains. Pre-augmentation looking south.

Benson and Patterson Drains. Post augmentation looking south.

Benson and Patterson Drains. Pre-augmentation looking west.

Benson and Patterson Drains. Post augmentation looking west.