

SEDIMENT AUGMENTATION FINAL PILOT STUDY REPORT

Prepared for

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM



April 2014

Prepared by

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In association with
HDR Engineering, Inc. and Tetra Tech, Inc.**





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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 yd³) 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



1 trigger moved into Class II at the U.S. Geological Survey (USGS) gage near Overton, Nebraska,
 2 on April 13, 2013, during Phase II. Prior to increasing monitoring frequency from monthly to bi-
 3 weekly, the trigger was back below the Class II threshold criteria on April 16, 2013, at Overton.

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

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

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

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

Location (method)	Pros	Cons
Dyer (pumping)	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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.

24
 25 As discussed with Program staff, several other options for full-scale augmentation are provided
 26 for consideration by the Program. Options that include pumping as part of the operation will



1 maximize source material per disturbed acre and may provide an increase in nesting or habitat
 2 area over time. However, pumping options will have higher unit costs, and are more labor and
 3 equipment intensive. Options that include pushing as part of the operation will have a low unit
 4 cost, can increase habitat or flow area, and allow for more efficient distribution of material.
 5 However, the low-cost source area may be limited by depth as well as distance, which may
 6 affect unit costs if source material below depths that can be easily accessed by bulldozers is
 7 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	

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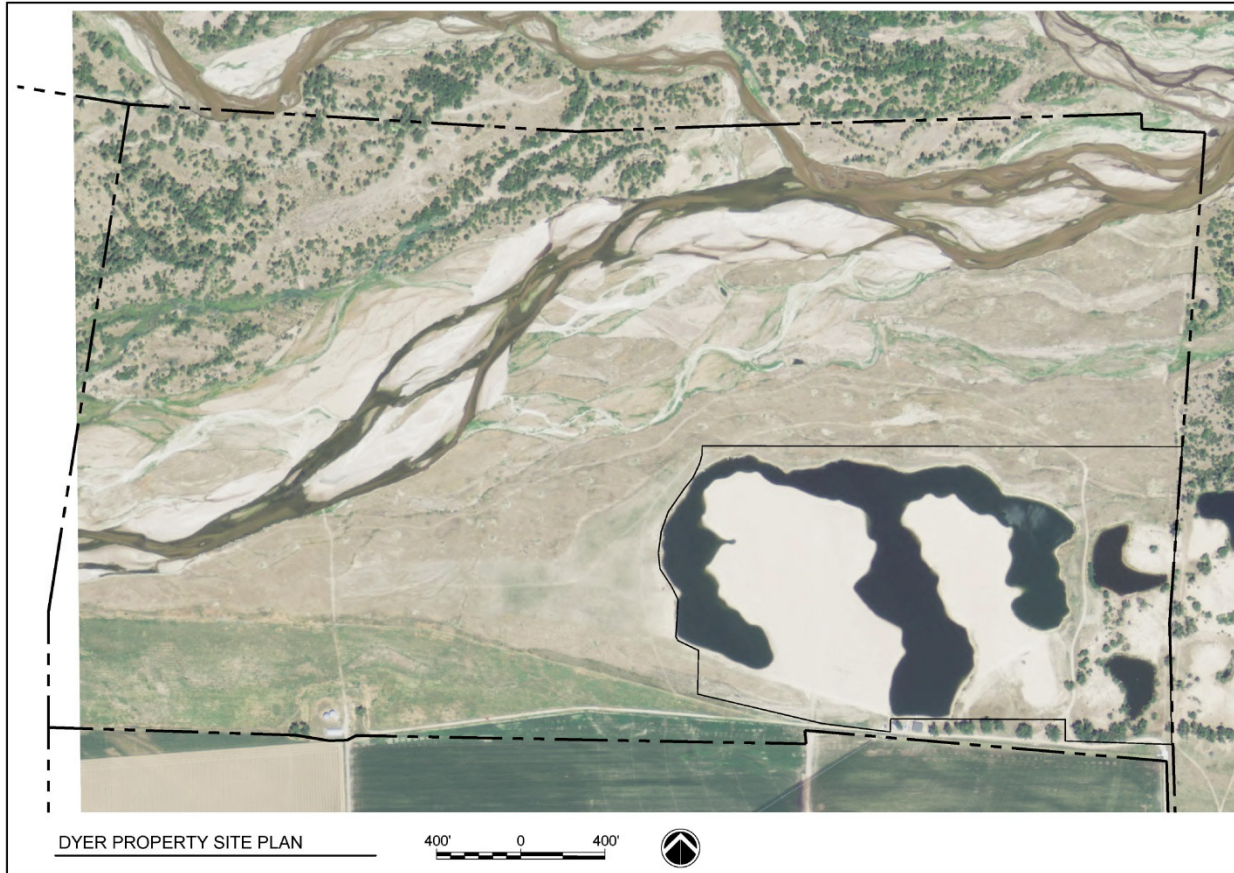
9 **2. BACKGROUND**

10 A Screening Study (The Flatwater Group, Inc. [TFG] et al. February 2011), developed for the
 11 Program estimated that the average annual sediment deficit in the project reach (that is, from
 12 Lexington to Odessa) is approximately 150,000 tons/year based on a 12.5-year sediment
 13 transport model simulation (hydrology from October 1, 1989, through April 1, 2002). The
 14 Screening Study recommended a Pilot Study, the objective of which was to collect and evaluate
 15 data associated with the means and methods of introducing sediment in order to provide the
 16 foundation for full-scale sediment augmentation. The Pilot Study management action was
 17 designed to introduce 100,000 tons (80,000 yd³) of sediment into the project reach each year for
 18 two (2) years. Two locations within the reach and two different methods of sediment
 19 augmentation were identified for the management action, as follows:

- 20 ➤ Sand pumping was tested at the Program’s Dyer property, where approximately
 21 50,000 tons of sediment was proposed to be mined on site and pumped into the river
 22 each year (Figure 1).
- 23 ➤ Mechanical placement was tested at CWR as a continuation of the grading activities that
 24 have been performed by Nebraska Public Power District (NPPD) and the Program over
 25 the past several years. The management action proposed directly pushing
 26 approximately 50,000 tons of sediment into the river each year from existing sand bars
 27 within the river or overbank areas adjacent to the river (Figure 2).

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

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Dyer Property

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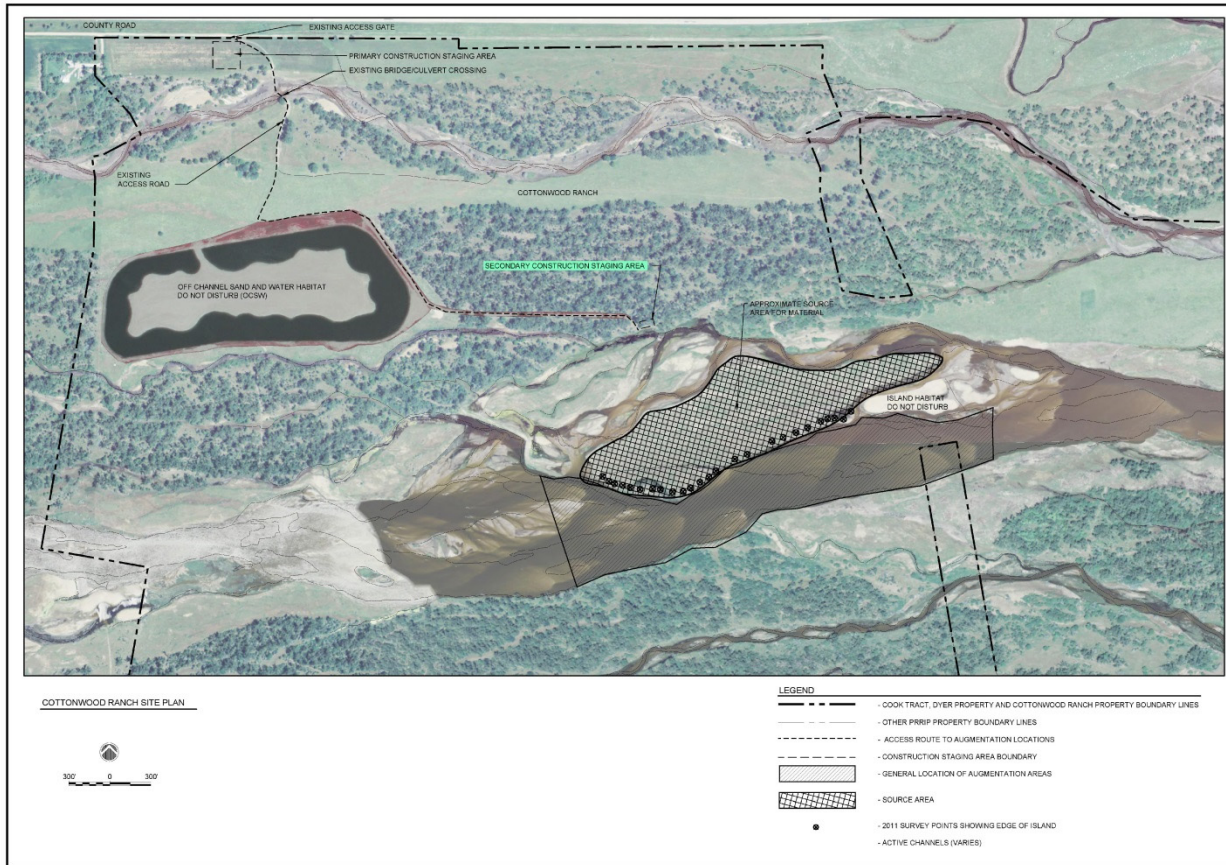
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FIGURE

1



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Cottonwood Ranch Property

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FIGURE	2



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

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

19 **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

20
21 The TM (TFG et al. July 2012a) defines three classes of stage and bed elevation changes for
22 purposes of identifying management action triggers:

- 23 ➤ Class I – The observed data point falls within the scatter of the measured gage data,
24 indicating that augmentation has not significantly affected stage or bed elevation, and no
25 action is required.
- 26 ➤ Class II – The observed data point falls outside the scatter of the measured data but is
27 less than the predicted maximum envelope, indicating that it has affected the stage or
28 bed elevations, but effects are within the levels predicted by the hydraulic and sediment
29 transport model. No immediate action is required, but the intensity of monitoring
30 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.



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

- 4 ➤ PRRIP Channel Geomorphology and In-channel Vegetation Monitoring of the Central
5 Platte River Program (PRRIP 2010)
- 6 ➤ Water Quality Monitoring (EA Engineering, Science, and Technology, Inc. [EA] February
7 2013)
- 8 ➤ NPPD habitat enhancement activities at CWR
- 9 ➤ USGS monitoring data at CWR
- 10 ➤ Monitoring data from Elm Creek Complex FSM Experiment (Tetra Tech 2011 and data
11 from ongoing and future monitoring activities)
- 12 ➤ Data from the Kearney Canal Monitoring Program (EA 2011)
- 13 ➤ PRRIP aerial photos and Light Detection and Ranging (LiDAR) data
- 14 ➤ Stream gage data at Overton (USGS gage 06768000, Platte River near Overton, NE),
15 CWR North and South Channels, Kearney Canal, and Odessa, and discharge
16 information from the J-2 return

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

21 **2.3 Topographic and Bathymetric Data**

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

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

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



1

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

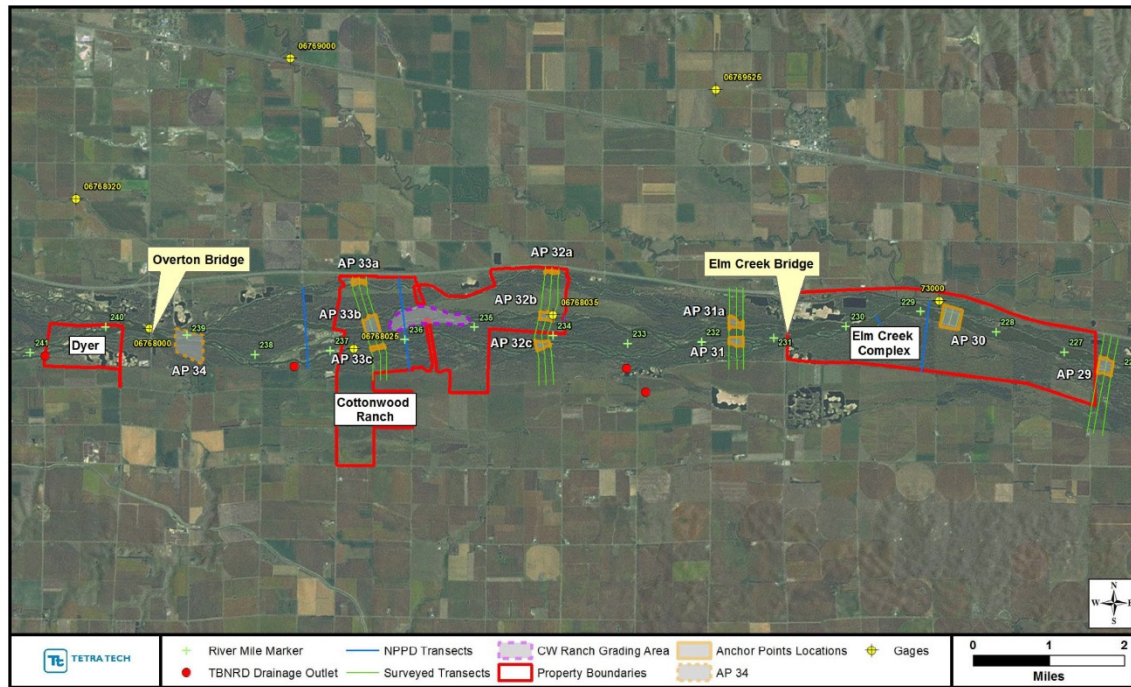
2 Notes:

3 ^a Collected as part of the Program’s System-wide Geomorphology and Vegetation Monitoring Protocol

4 ^b Provided by Tri-Basin Natural Resources District (NRD)

5 ^c Collected as part of the Program’s System-wide Water Quality Monitoring Protocol

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Reach Monitoring Locations

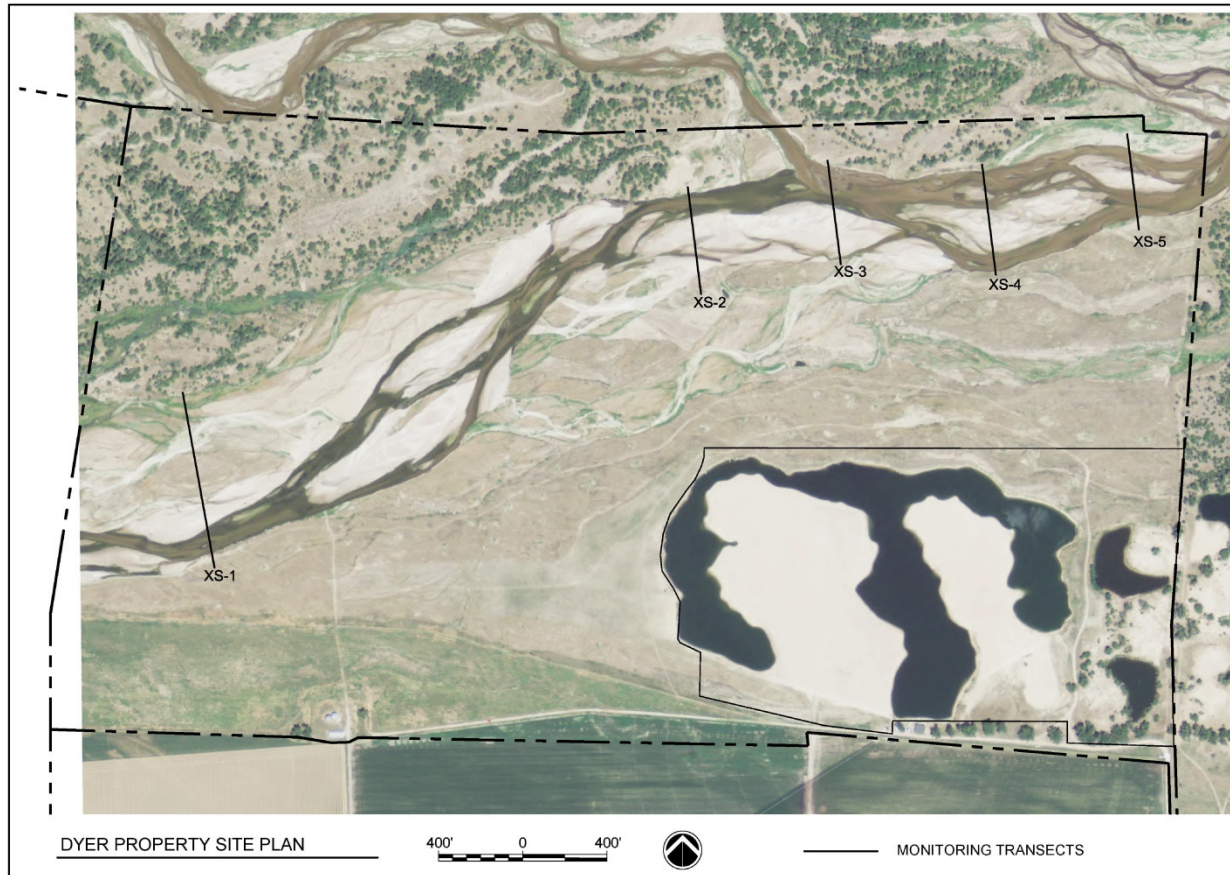
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FIGURE
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Dyer Monitoring Plan Cross Section Locations

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FIGURE
4



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).

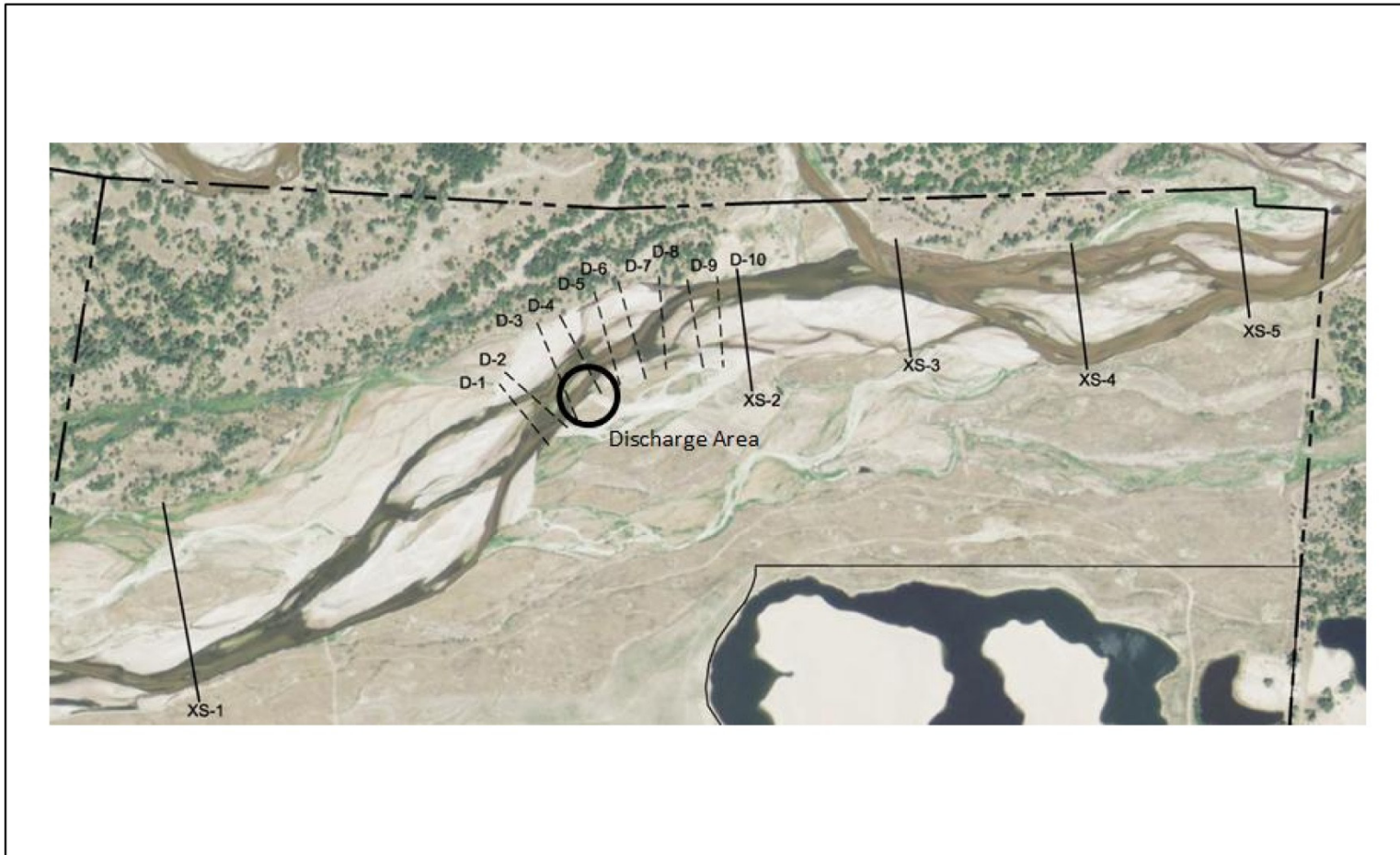
The distance that the material could be projected into the river was limited by the size of the pump. The combination of low flow, pump size, and a single discharge point resulted in material buildup adjacent to the channel during Phase I. The monitoring plan for the Dyer Property was established to 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.

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Dyer Site Cross Sections

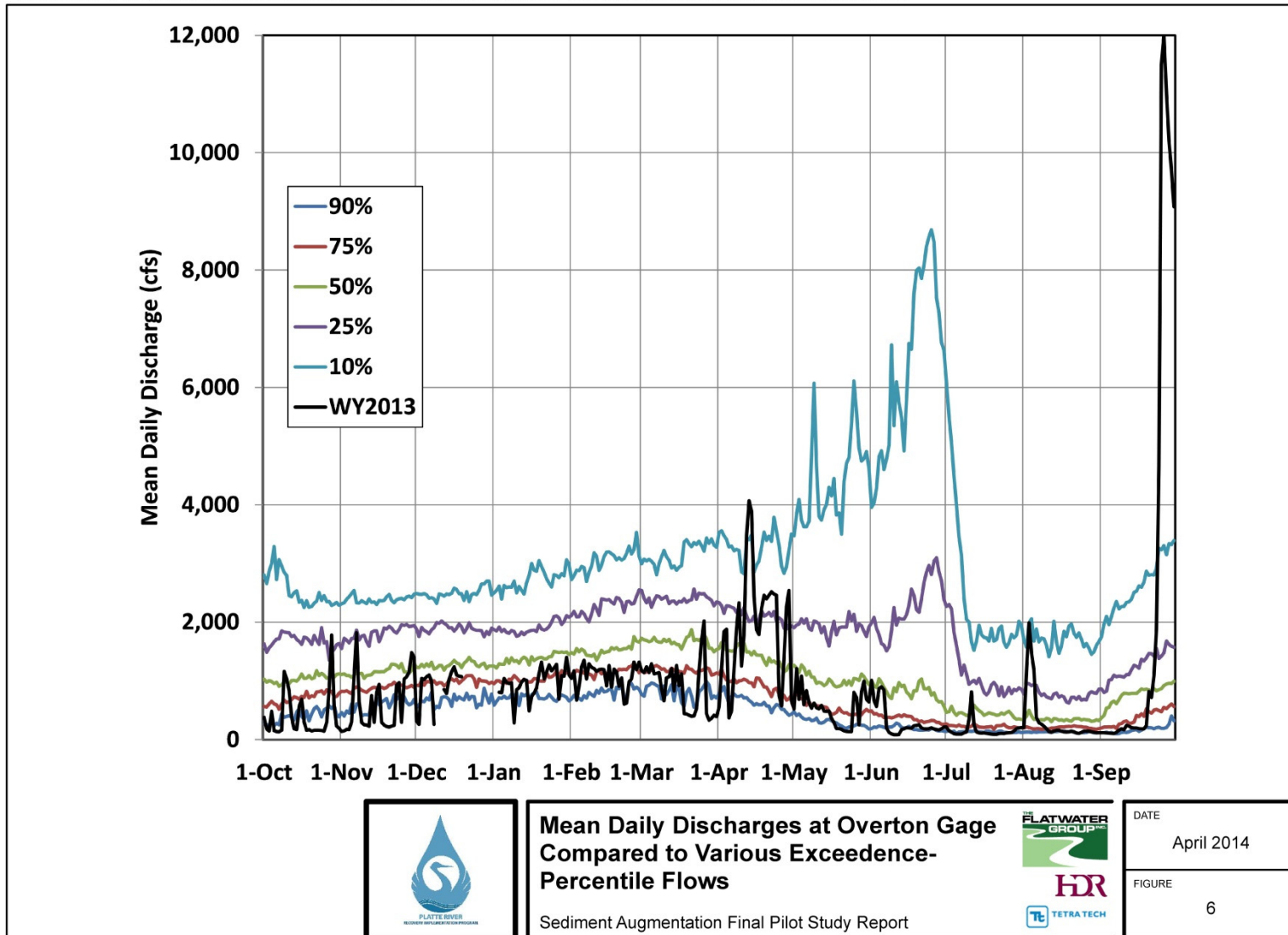
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FIGURE	5



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1 Pre-sediment augmentation and pre-runoff surveys were also conducted as part of this Pilot
2 Project at the upstream, middle, and downstream transects at AP 32 and AP 34. The first
3 system-wide Program survey was conducted at AP 34 in July 2012 and serves as the pre-
4 augmentation survey at this location. AP 32 was initially surveyed in 2009, and the next survey
5 was not scheduled until summer 2013. A pre-augmentation survey and post-augmentation
6 survey were conducted in the active channel at AP 32 and AP 34 in August and December
7 2012, respectively. AP 32 consists of three sets of cross sections, corresponding to the main
8 middle channel (AP 32a), the minor south channel (AP 32b), and the minor north channel
9 (AP 32c). Surveys of the three primary transects at AP 32b and 32c were conducted pre- and
10 post-augmentation as part of this Pilot Project. The pre-sediment augmentation survey at
11 transect AP 32a (middle channel) was inadvertently omitted as part of the Pilot Project
12 monitoring. The post-runoff survey was conducted as part of the Program's ongoing System-
13 wide Geomorphology and Vegetation Monitoring in July 2013.

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

19 **2.4 River Stage Data**

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

34 **2.5 Bed and Bar Material Sampling**

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



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

5 **2.6 Tri-Basin Drains**

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

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

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

27 **2.7 Sediment Transport and Water Quality Measurements**

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

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

40



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 yd³ (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.

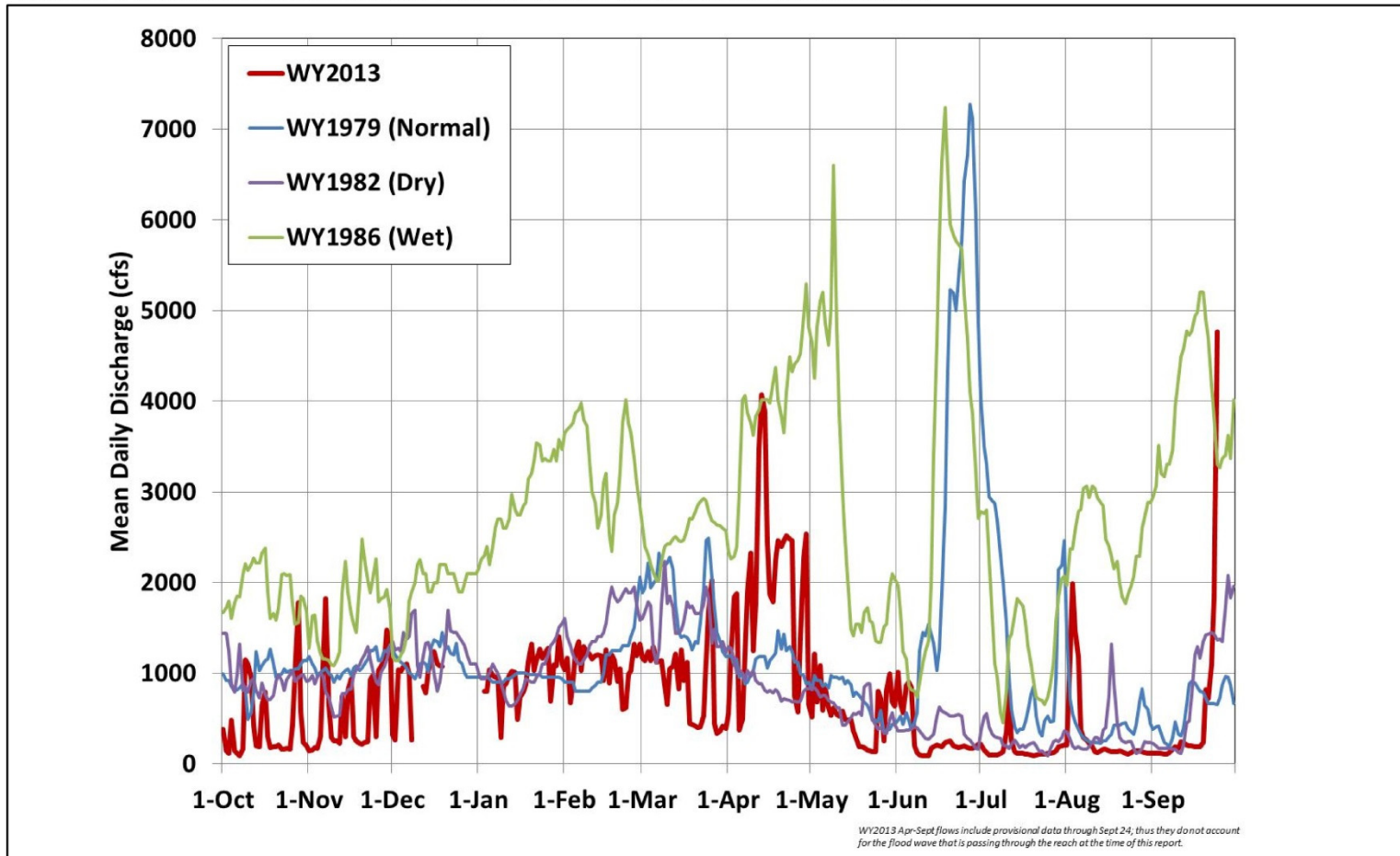
3.1 Hydrologic Conditions

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.



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Mean Daily Flows at the Overton Gage for an Average Wet, Dry, and Normal Year

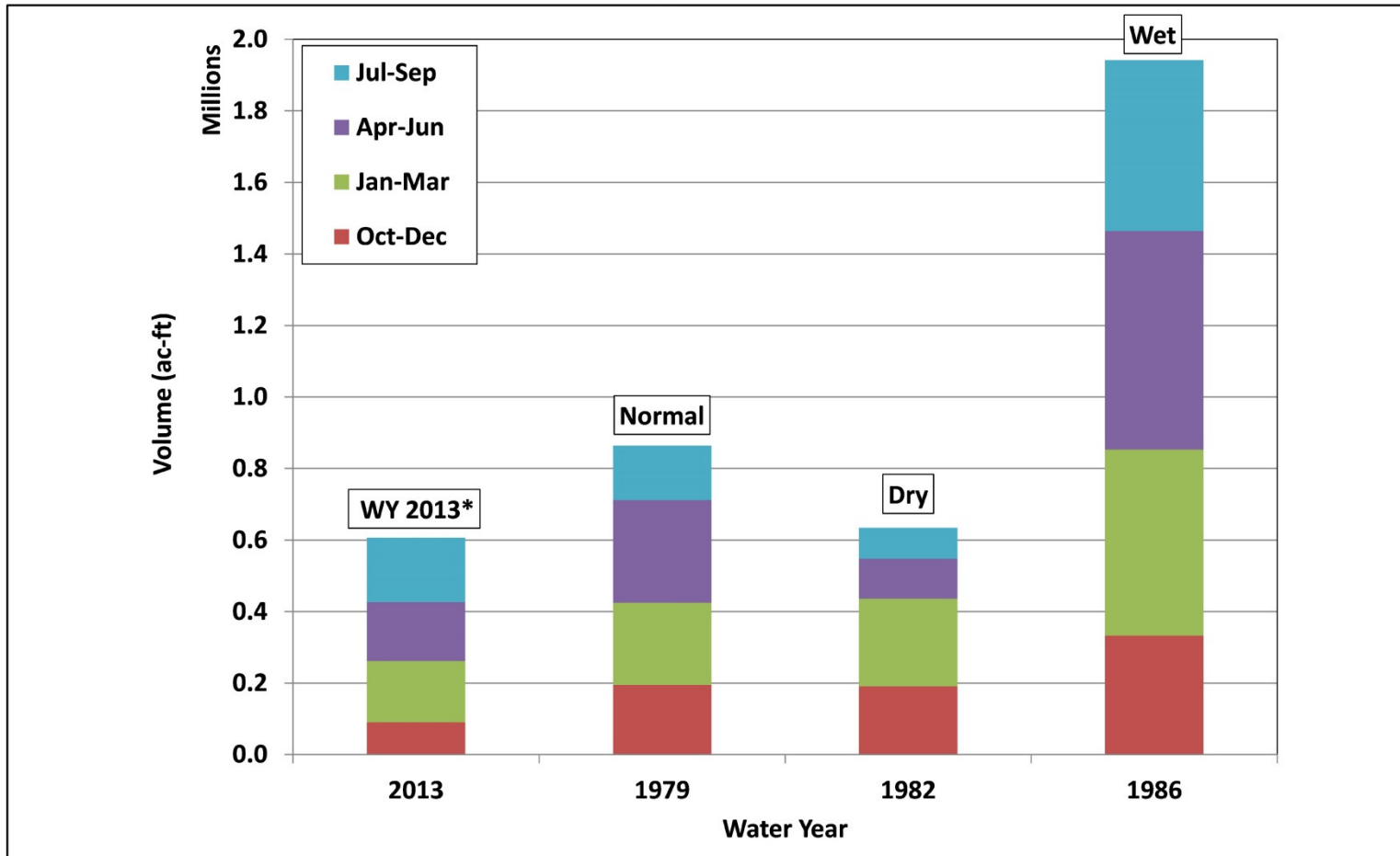
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FIGURE	7



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Flow Volumes at the Overton Gage

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FIGURE
8



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:

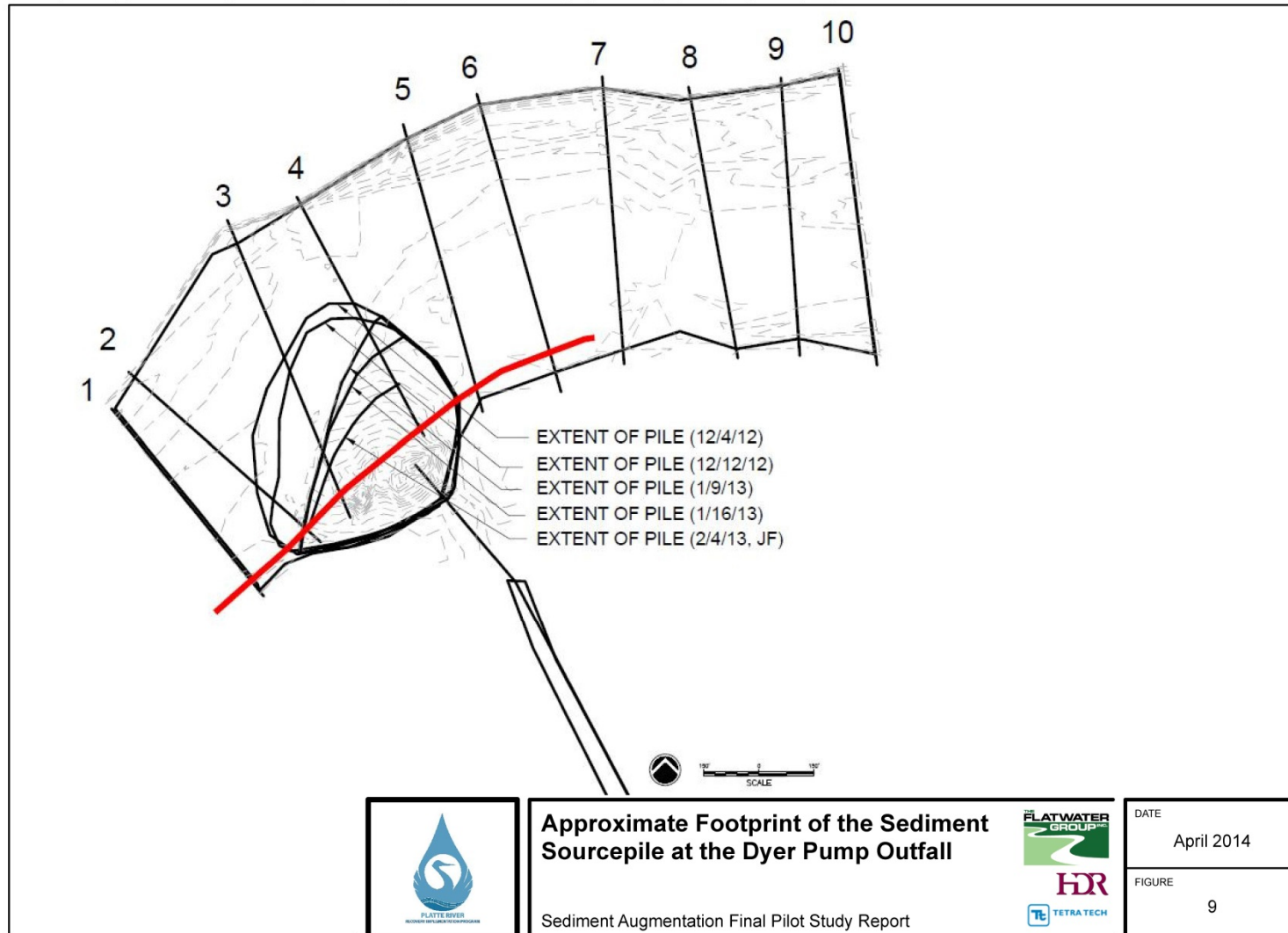
^a Calculated from site survey of discharge area

^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



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

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FIGURE	10



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

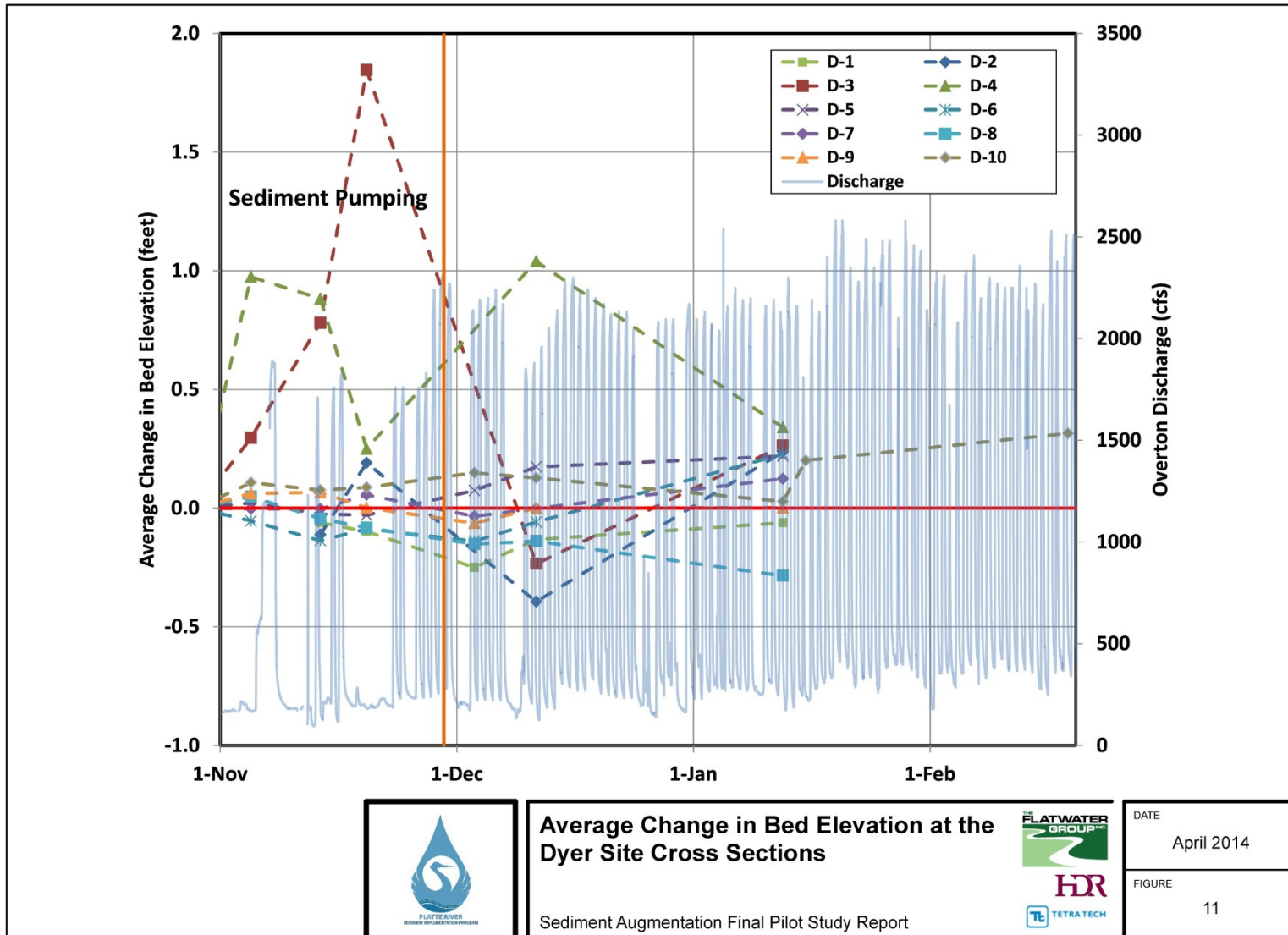
16 The survey data for the Dyer Site cross sections indicate significant aggradation at D-1 and D-3,
17 while the remainder of the cross sections showed very modest net change over the entire period
18 (Figure 11). D-2, D-3, and D-4 intersect the source pile; D-1 is located just upstream of the
19 source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

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

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



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

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

15 As previously stated, approximately 75,000 tons (60,000 yd³) of material were mechanically
16 redistributed at CWR. This resulted in some channel narrowing and deepening along the south
17 bank. No impact triggers were initiated during or immediately after Phase I.

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

21 **3.2.2 Phase II**

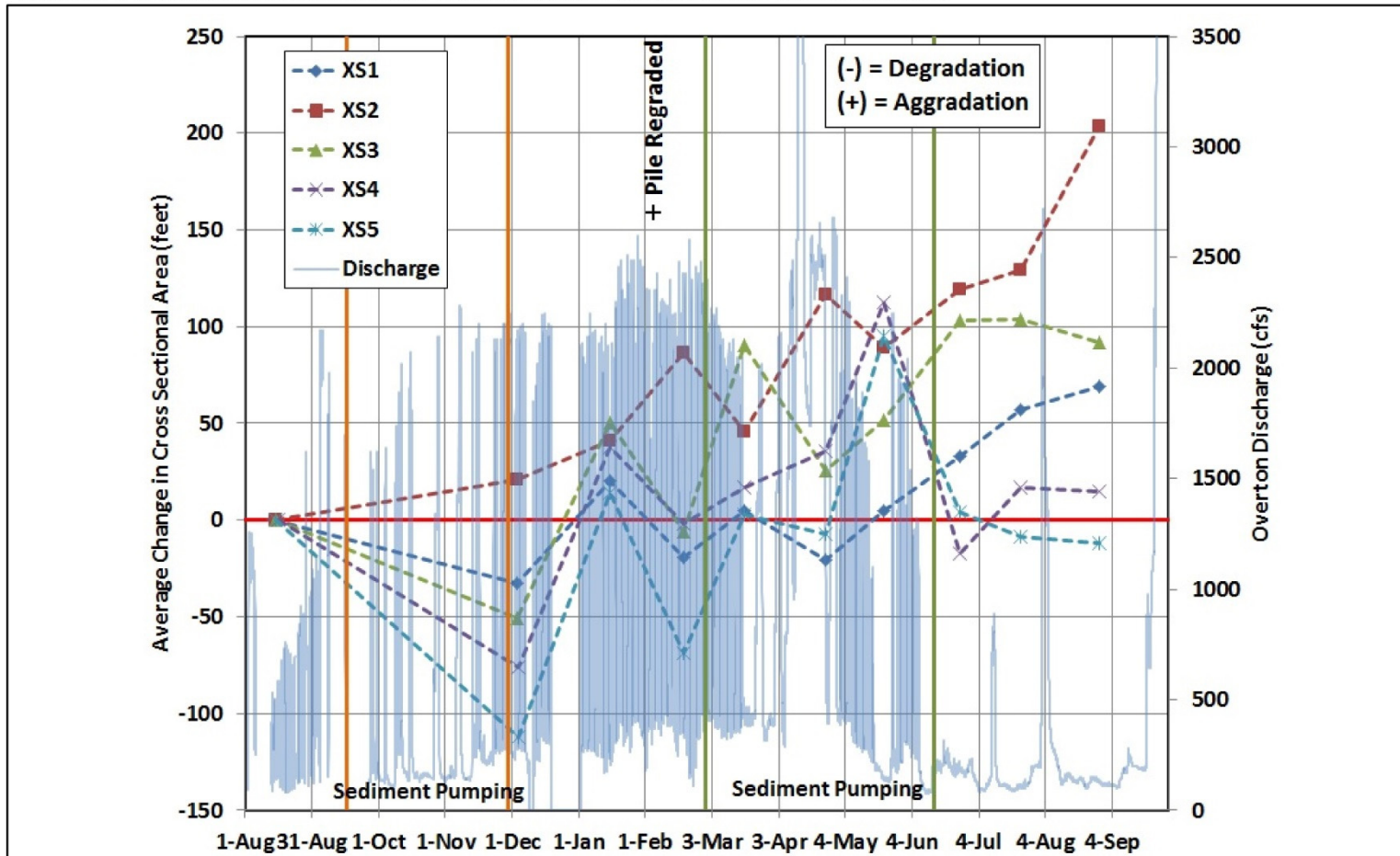
22 Monthly cross-section surveys continued in Phase II from April through August 2013 at the five
23 primary monitoring cross sections (cross sections XS-1 through XS-5, shown in Figure 5).
24 Because of the changes in the location of the pump outfall, the ten more closely spaced cross
25 sections (cross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

29 Phase II data at XS-1 through XS-5 generally showed an aggradational trend throughout the
30 monitoring period. In particular, XS-2 and XS-3, the first and second cross-sections
31 downstream of the pump outfall, showed the greatest overall aggradation, approximately
32 0.5 foot and 0.25 foot, respectively, since the beginning of the Pilot Study (Figures 12a and
33 12b). Only a limited amount of aggradation (~0.1 foot and <0.1 foot, respectively, since the start
34 of the Pilot Study) occurred at XS-4 and XS5, the two cross sections farthest downstream of the
35 pump outfall. XS-1, the single monitoring cross section upstream of the pump outfall, also
36 aggraded by a small amount. This may have been caused by backwater and the associated
37 reduction in transport capacity created by the sediment accumulation in the vicinity of the pump
38 outlet as well as upstream bank sloughing. The cross sections surveyed in July 2013 at AP 32
39 showed little to no change from previous surveys (Appendix A).

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



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

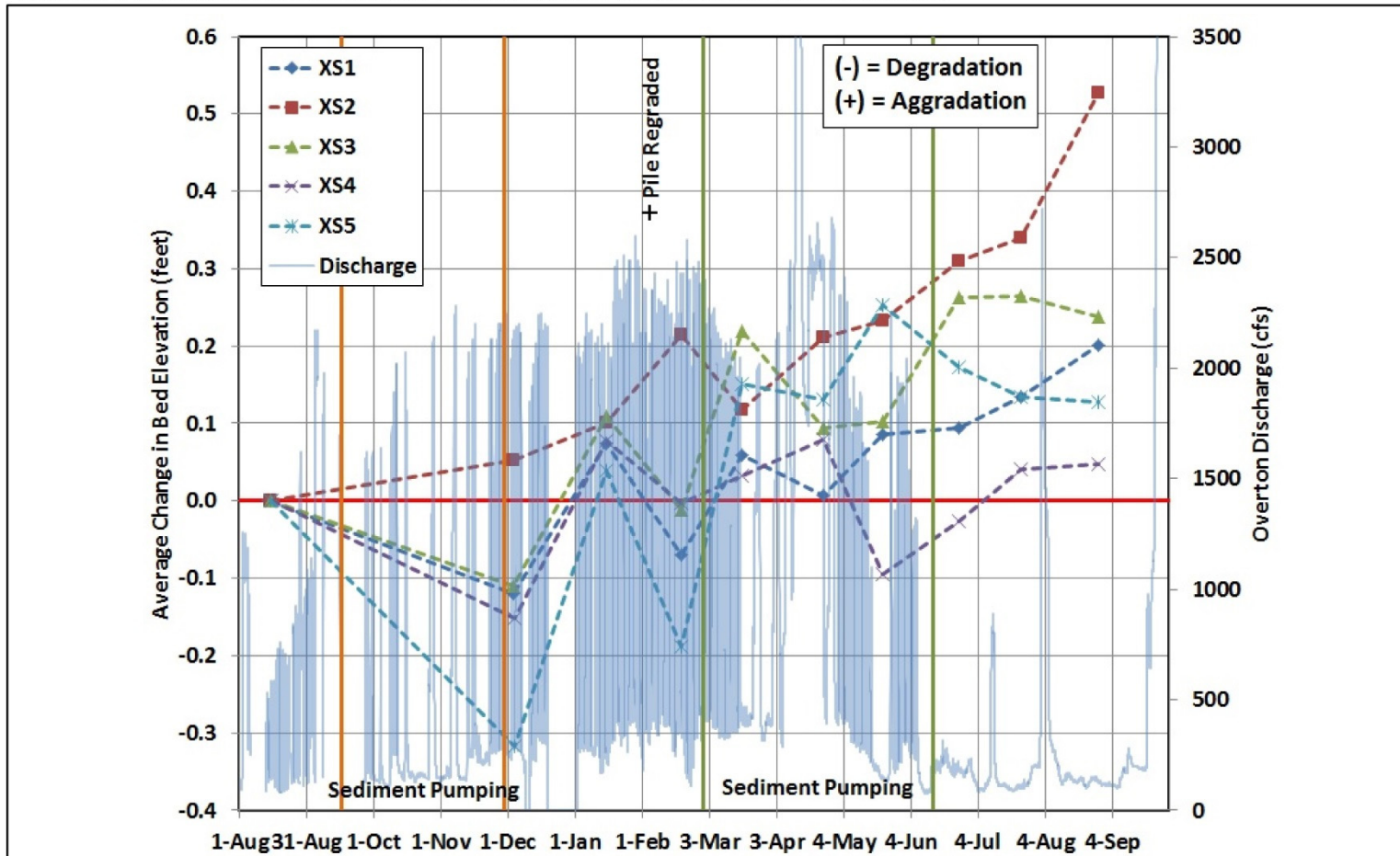
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FIGURE	12a



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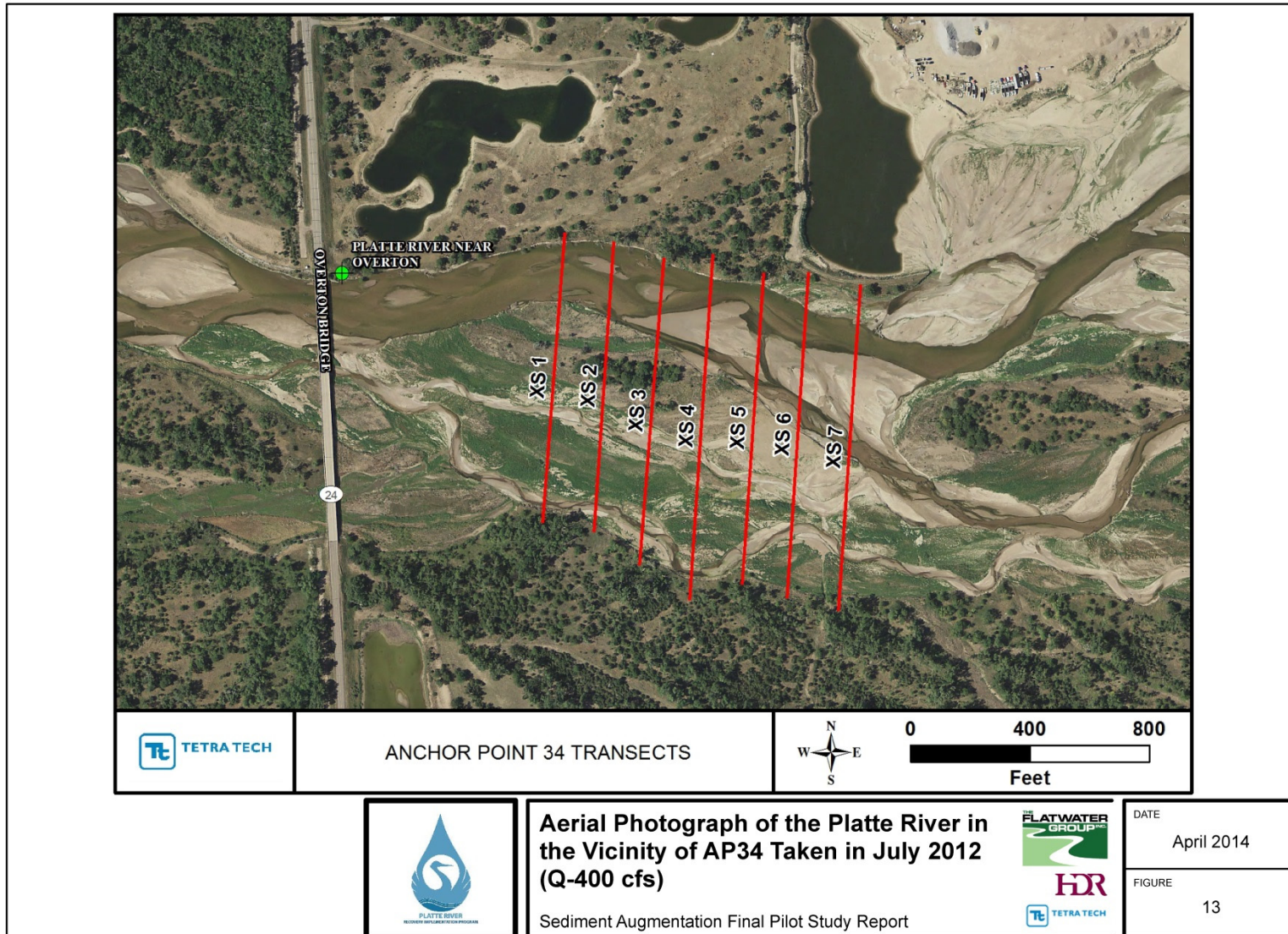
Average Change in Bed Elevation at the Monitoring Plan Cross-Sections

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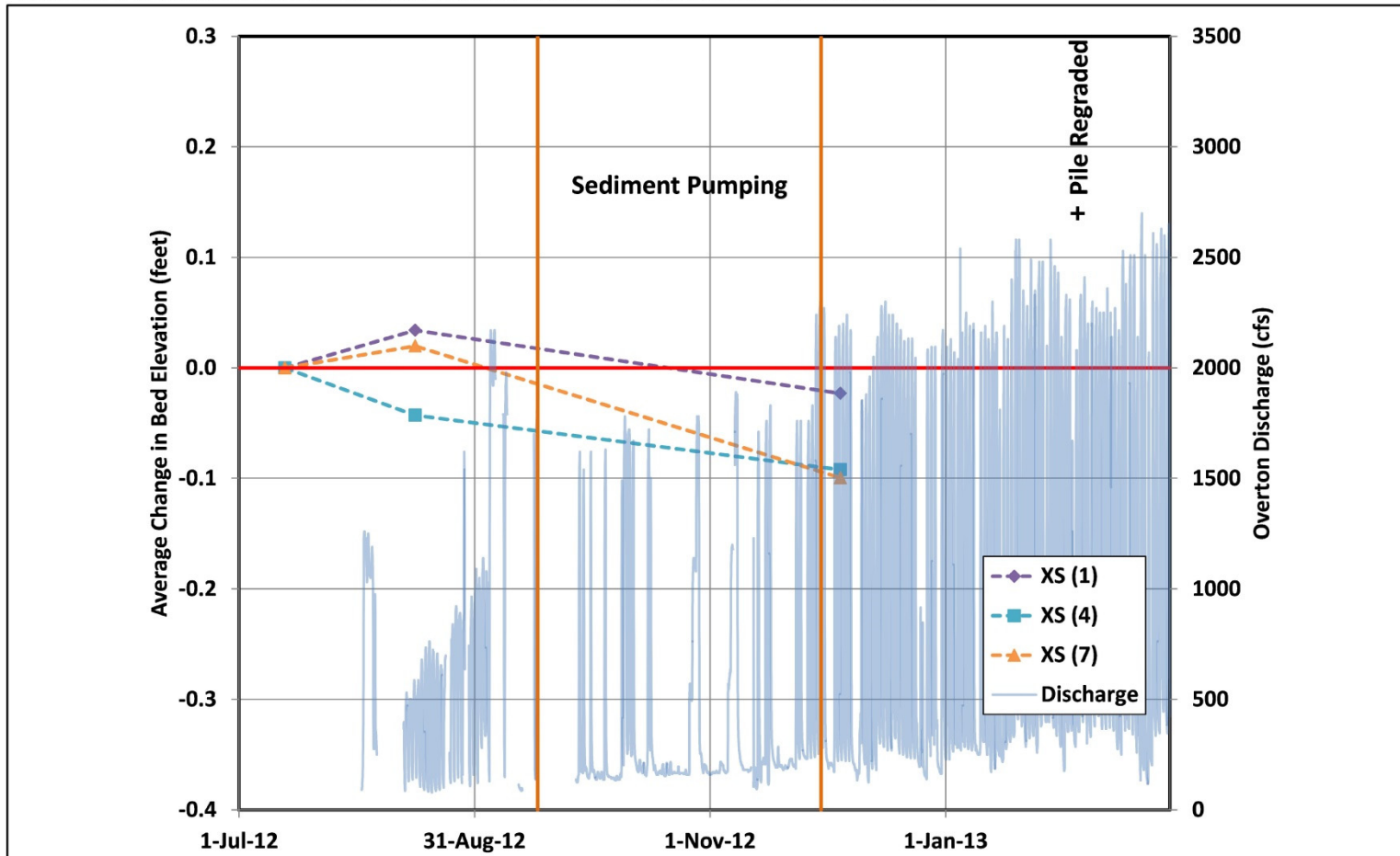
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FIGURE	12b

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Average Change in Bed Elevation at AP34

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FIGURE	14



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

5 **3.3 River Stage Data**

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

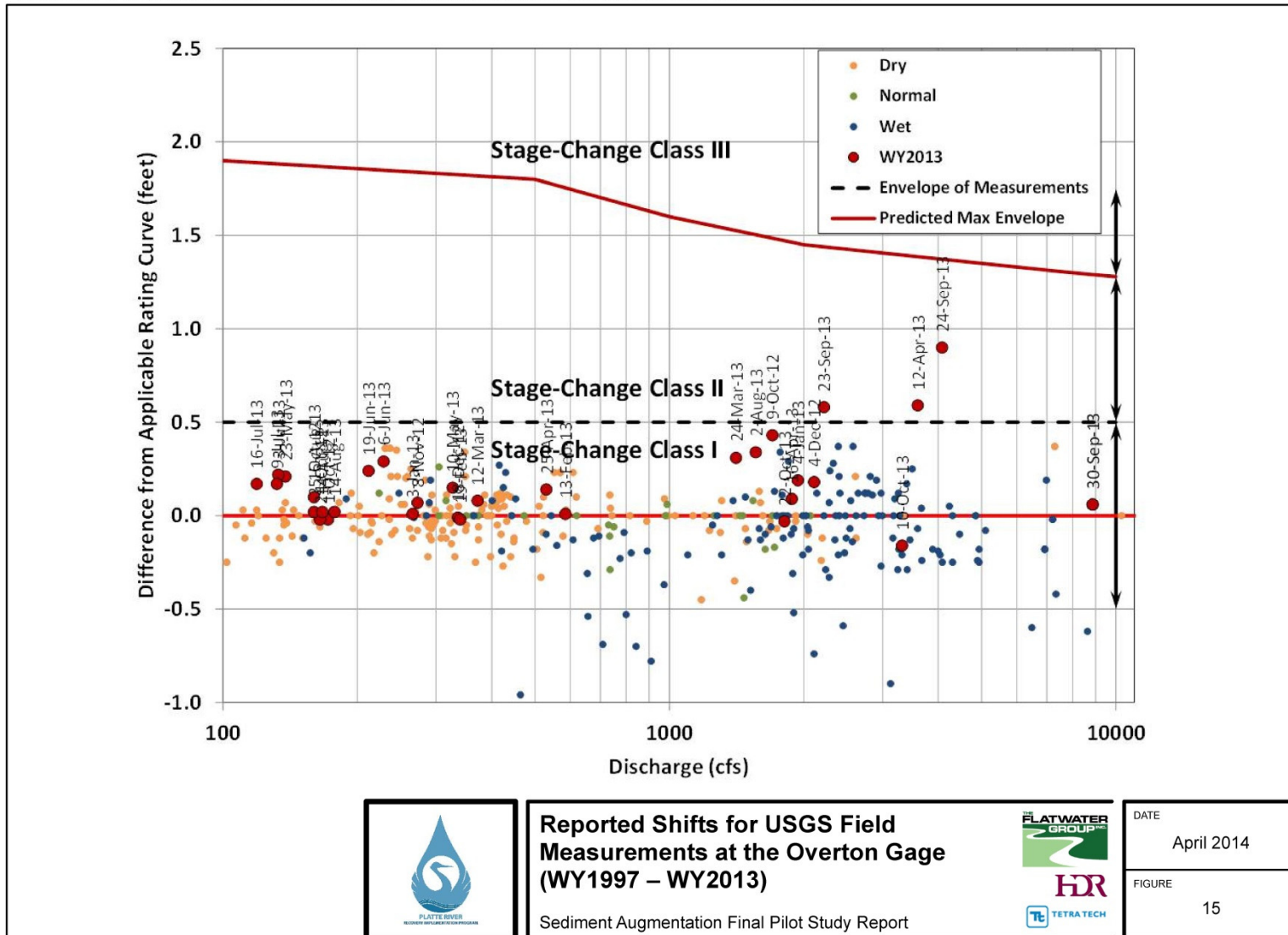
12 The Overton gage data were also used to provide a near-real-time assessment of changes that
13 could trigger modifications to the augmentation activities to avoid damage to adjacent
14 properties. The shifts that are applied by USGS to the gage rating curve for purposes of
15 computing the discharge represent the variability in individual measurements from the current
16 rating curve. The vast majority of the reported shifts² for gage measurements taken since
17 WY 1997 vary from about -1 to +0.5 foot (Figure 15); thus, the boundary between Class I and
18 Class II stage changes was set at 0.5 foot. The variability appears to be somewhat greater
19 during wet and dry years than it is during normal runoff years (as defined by Anderson and
20 Rodney, 2006). The sediment transport model results described above indicate maximum
21 variability in the water surface elevation for a given discharge ranging from 1.6 to 1.9 feet at
22 discharges less than 1,000 cfs, and declining to about 1.3 feet at 9,000 cfs (shown as a red line
23 in Figure 15). The USGS field measurements taken between the start of pumping and the end
24 of March 2013 all fall within the historic scatter, which is below the limit for a Class II stage
25 change. The April 12 and September 23, 2013, measurements both exceeded the 0.5 foot
26 threshold at 0.59 foot and 0.58 foot, respectively. Both of these data points are at the low end
27 of the Class II zone. The shift on September 24, 2013, during the passage of the flood wave
28 from the 2013 Northern Colorado floods, was more significant, at 0.9 foot. Prior to increasing
29 monitoring frequency from monthly to bi-weekly per the TM for these excursions, the trigger was
30 back below the Class II threshold criteria on April 16, 2013, and September 30, 2013,
31 respectively, at Overton.

32 A similar analysis was performed for the CWR Mid-Channel gage, which is located
33 approximately 2 miles downstream of the CWR grading area (Figure 16). The variability about
34 the current rating curve is smaller at this location, with all of the values except for the
35 measurement taken on September 25, 2013, during the passage of the flood wave, well below
36 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.



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

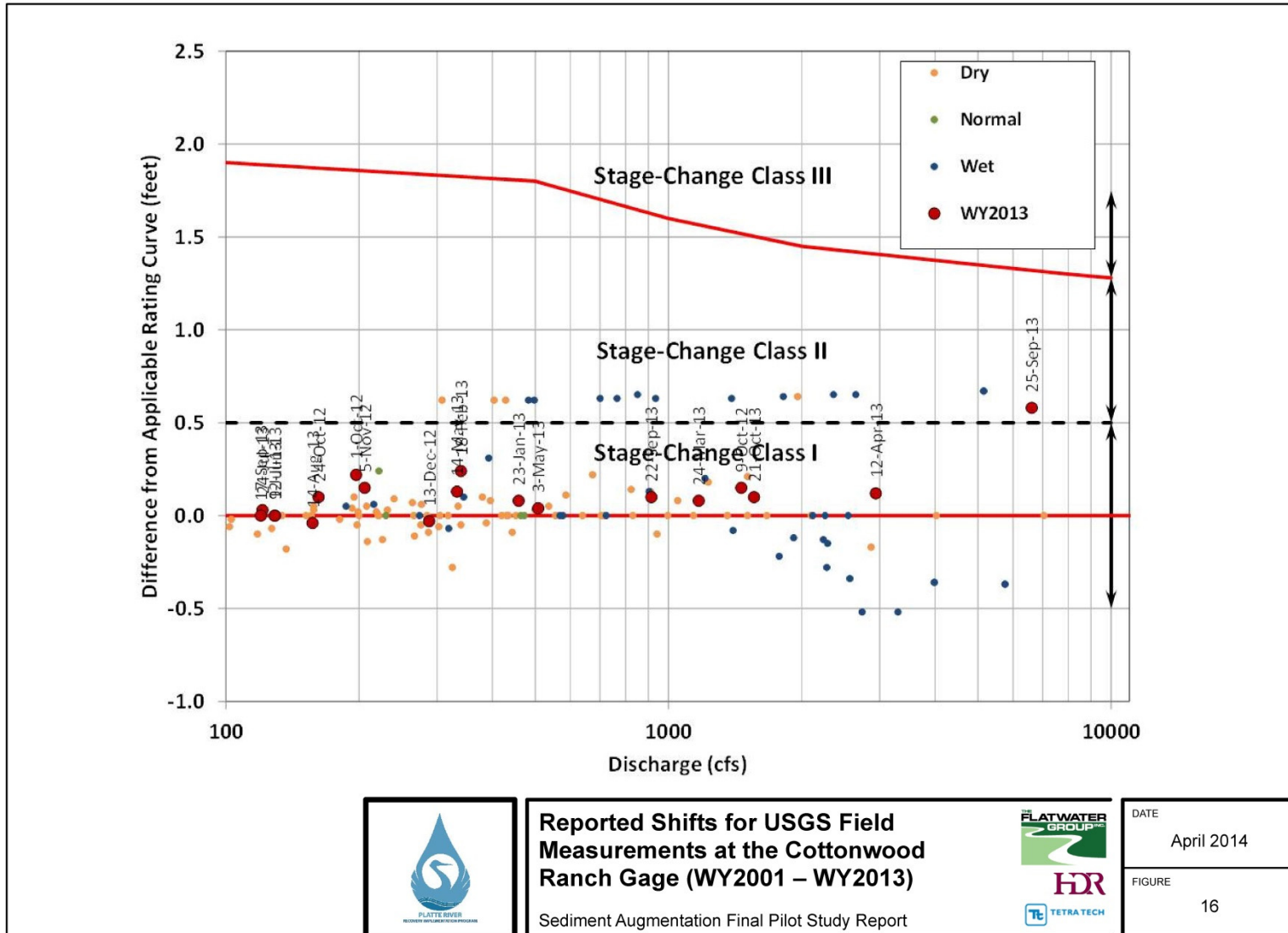
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FIGURE	15



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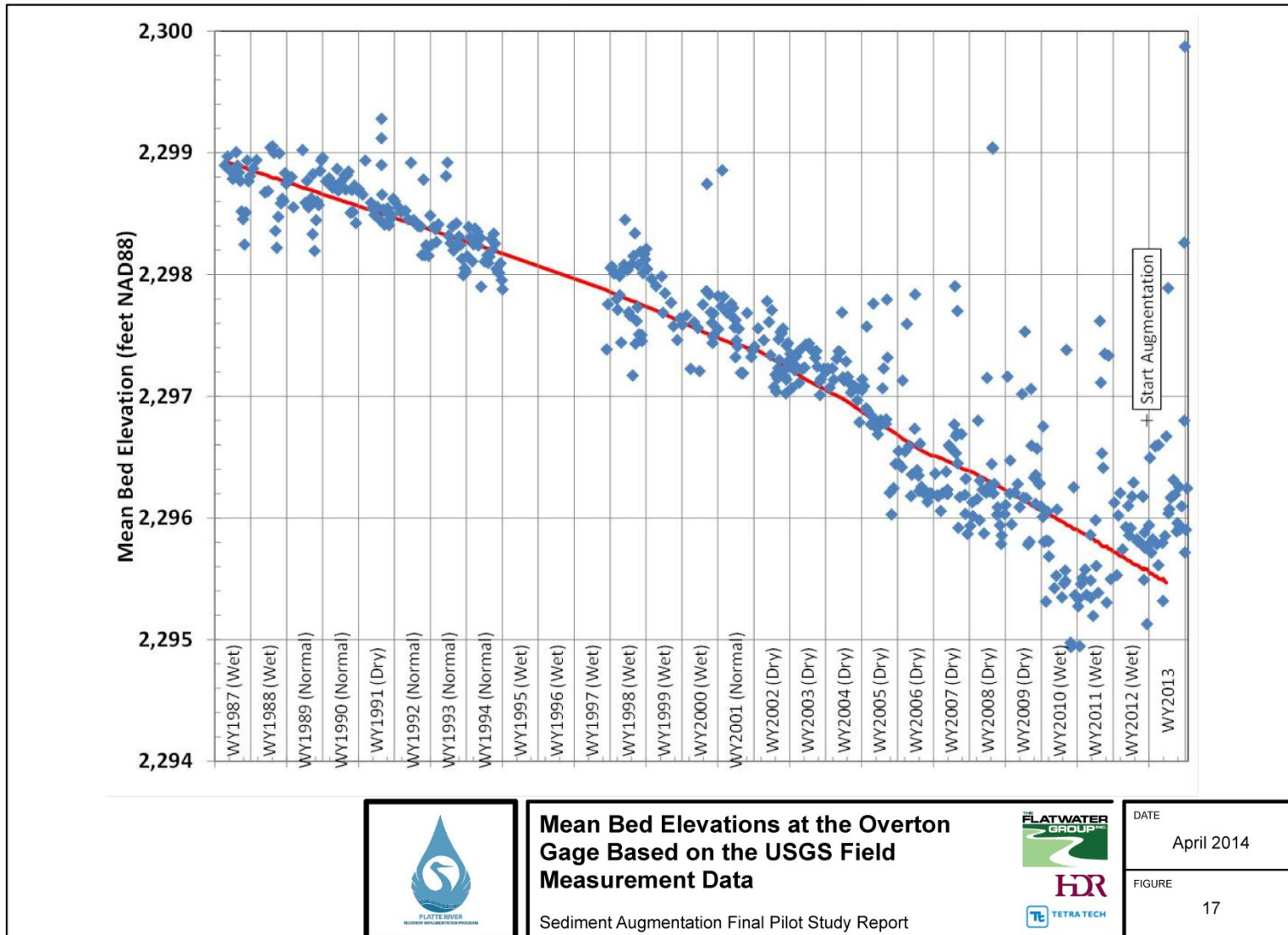
1 The long-term trends in mean bed elevation at the Overton gage were assessed by computing
2 the mean channel depth for each of the measurements that have been taken since the gage
3 was moved to its current location at the beginning of WY 1987 and then subtracting each depth
4 from the reported water surface elevation (computed by adding the reported stage to the
5 applicable gage datum) (Figure 17). Similar to the stage data, the variability in the data about a
6 best-fit trend line (developed using the Lowess technique) is greatest during wet and dry years
7 and smallest during normal years (Figure 18). These data show a clear degradational trend
8 over essentially the entire period, with the mean bed elevations decreasing from about
9 2,299 feet NAVD88 in 1987 to about 2,295 feet NAVD88 over the past 3 years (Figure 17).
10 Although there is significant scatter, the recent data indicate that the bed was lowest during the
11 high-flow period in WY 2010 and WY 2011, and may have rebounded by up to 0.5 foot during
12 the subsequent drier period that began well before the start of the Pilot Project. WY 2013
13 appears to continue this trend as a dry year, with data scattered around 2,296 feet NAVD88
14 (Figure 17). This trend is consistent with an aggradational tendency in the system-wide
15 geomorphology monitoring data for the 100-mile Central Platte River study reach. As a result,
16 at least a portion of the aggradation at the monitoring sites may reflect changes that are not
17 directly related to sediment augmentation.

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

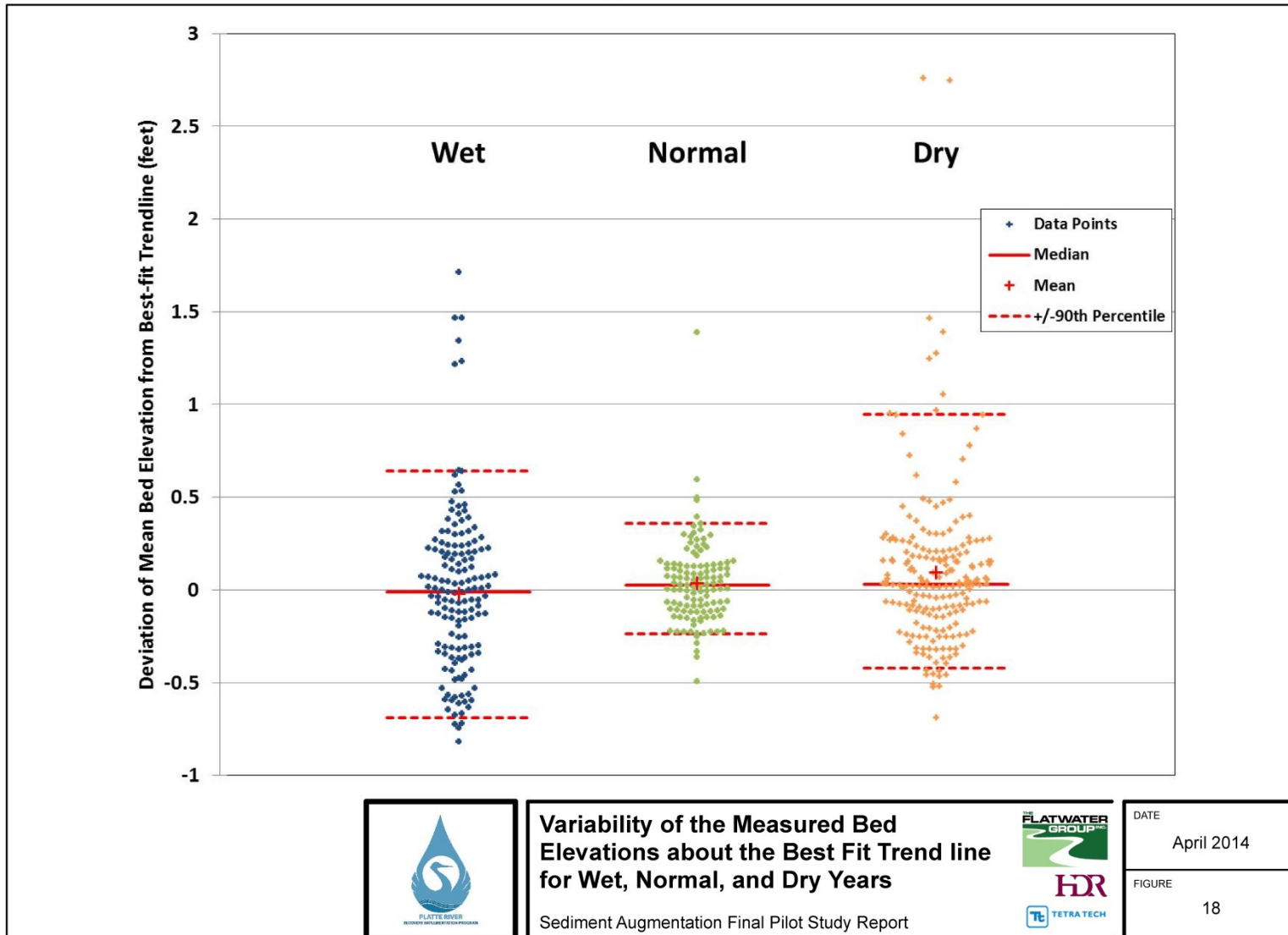
30 As required by the monitoring plan, pressure transducer stage recorders were installed before
31 the start of augmentation. One transducer was placed at XS-1 in the south channel and another
32 was placed on the left bank in the vicinity of the Todd Brown property in the north channel.
33 These recorders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



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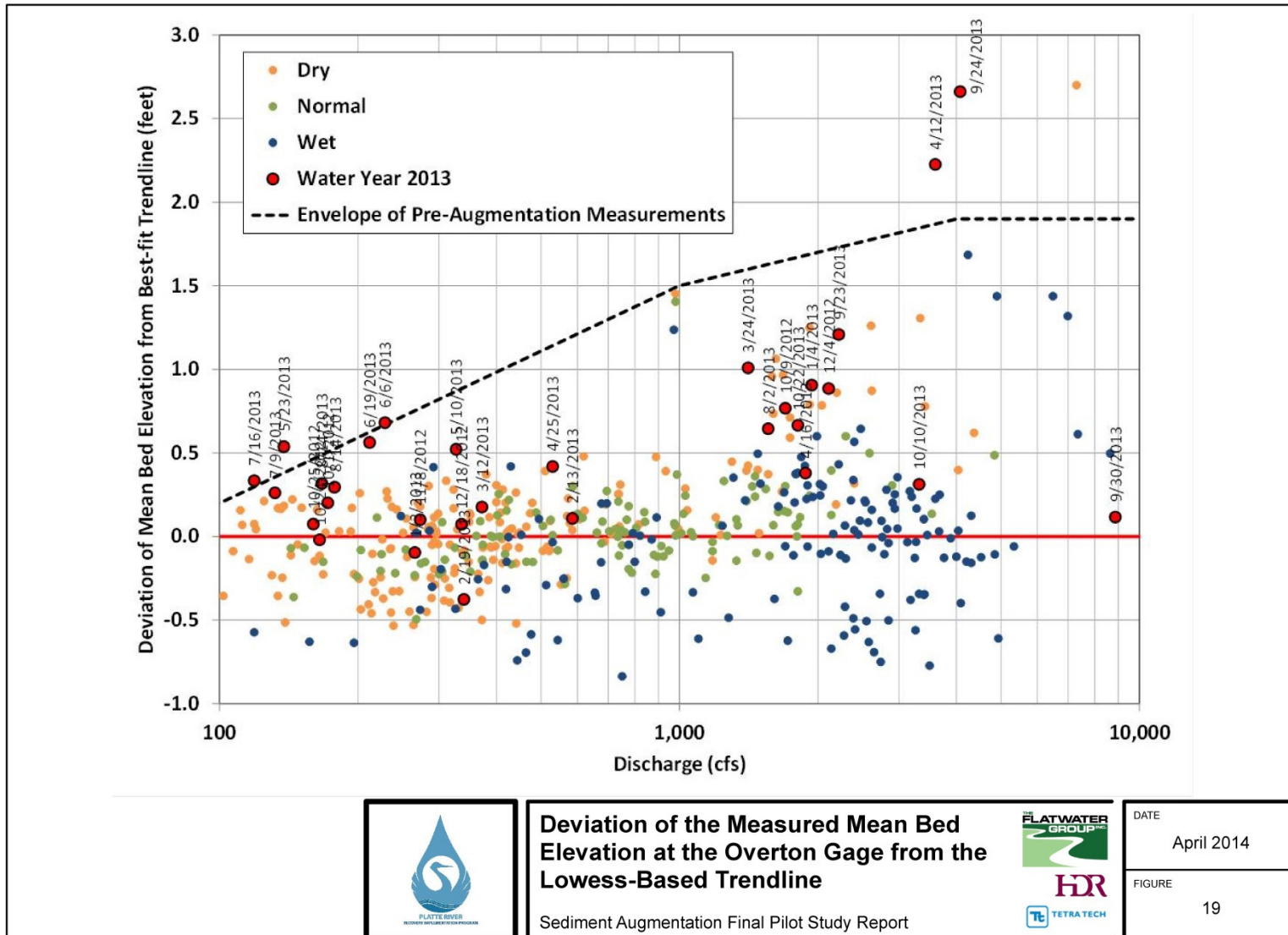


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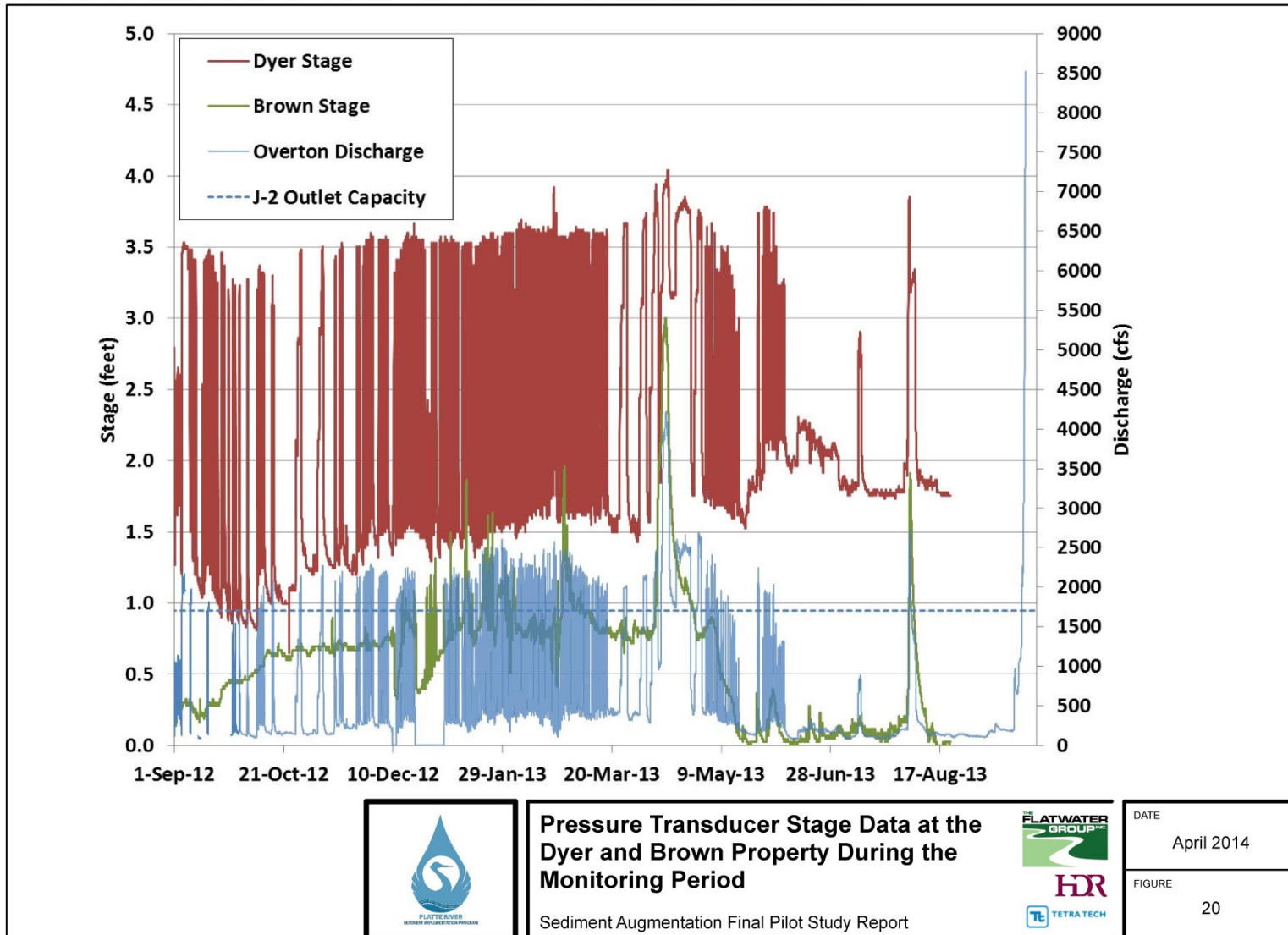




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1 A major precipitation event occurred in Colorado on the upper tributaries to the South Platte
2 River in September 2013. This rainfall resulted in downstream runoff resulting in record or near
3 record stages in Colorado and Nebraska for the South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

8 **3.4 Bed and Bar Material Sediment Sizes**

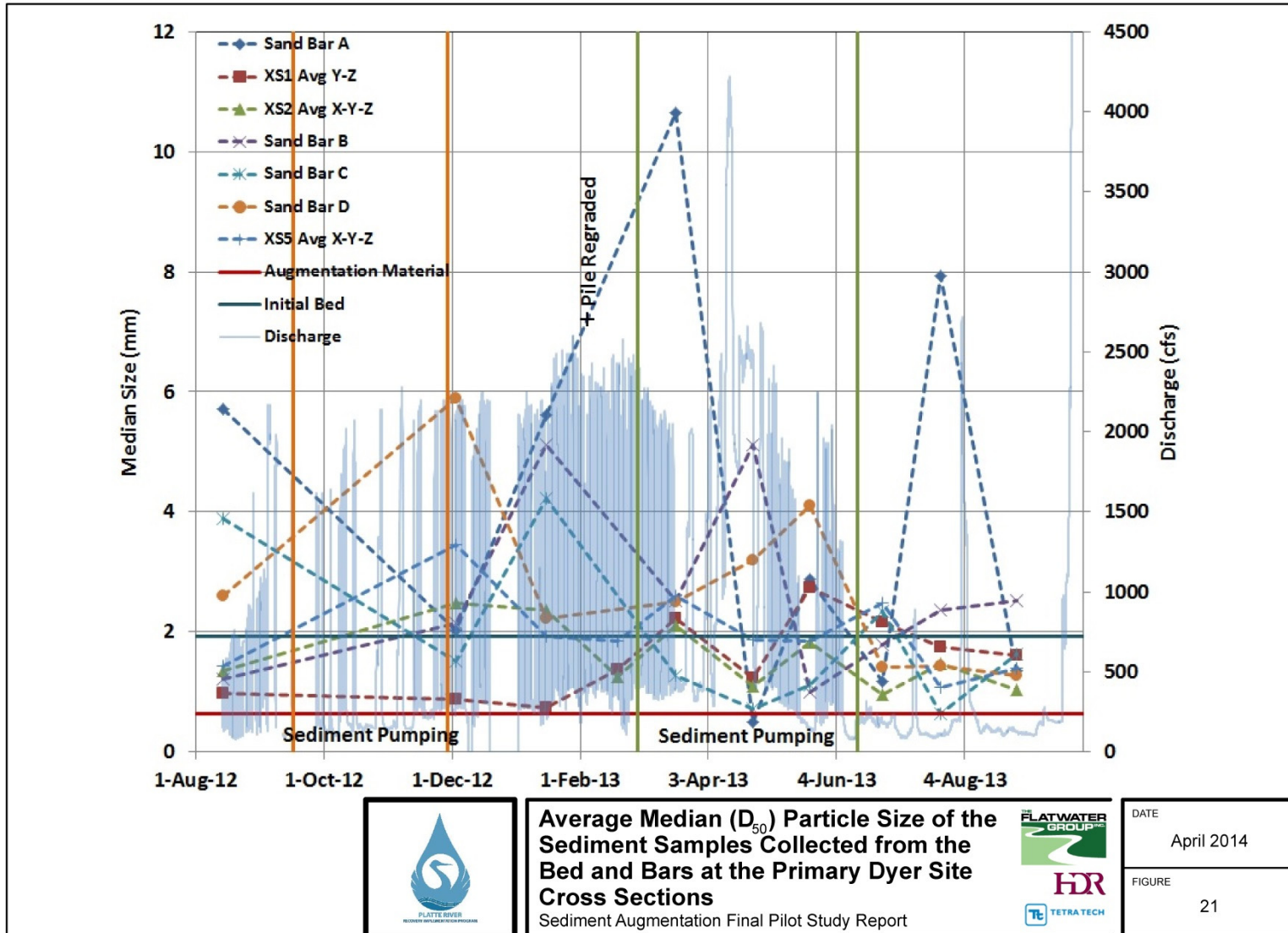
9 Bed and bar material samples were collected in accordance with the Monitoring Protocol
10 (PRRIP 2011). During each survey, three samples were collected from each of the primary
11 monitoring cross sections XS-1, XS-2, and XS-5. In addition, samples were collected from the
12 head of four sand bars within the surveyed reach. A similar sampling procedure was followed
13 during the surveys at AP 32 and AP 34. The combined sample set for Phase I includes
14 94 samples collected during the four surveys that were conducted in August 2012 (baseline),
15 December 2012, January 2013, and February 2013. The Phase II sample set includes
16 69 individual samples collected during the five surveys that were conducted monthly from March
17 through July 2013. The gradation of the individual samples, along with the D_{16} , median (D_{50}),
18 and D_{84} sizes and the gradation coefficient, are tabulated in Appendix B.

19 Based on the average D_{50} at each cross section, the bed material at XS-1, upstream of the
20 pump outfall, was considerably finer than at the other monitoring cross sections and remained
21 relatively constant (0.74 to 0.97 mm) from August 2012 through January 2013, but then
22 coarsened significantly to about 1.4 mm in February 2013 (Figure 21). This overall coarsening
23 trend continued through Phase II. At XS-1, the average D_{50} peaked during the May 2013 survey
24 at 2.74 mm and then tapered down to 1.61 mm by the August 2013 survey. The bed at XS-2
25 and XS-5, downstream of the outfall, coarsened significantly between August and December
26 2012, and then showed a general fining trend through January and February 2013. This overall
27 fining trend continued through Phase II, with the average D_{50} from the August 2013 samples
28 decreasing to 1.04 mm and 1.39 mm for XS-2 and XS-5, respectively. XS-2 had a slightly finer
29 average D_{50} from the August 2013 data than the August 2012 baseline sample, while XS-5
30 remained about the same.

31 Sand Bar A, located just upstream of XS-1 and the pump outfall, fined significantly between
32 August and early December 2012, and then coarsened back to near its original size by mid-
33 January 2013. The gradation then coarsened significantly by the March 2013 survey to 10.64
34 mm and fluctuated from less than 0.5 mm to nearly 8 mm during the remaining surveys. Sand
35 Bar C, located just upstream of XS-4, also fined significantly between August and early
36 December 2012 and then coarsened back to near its original size by mid-January 2013. Sand
37 Bar C and Sand Bar A both became finer overall by the August 2013 survey in comparison to
38 the August 2012 baseline survey. Sand Bar B, located between XS-2 and XS-3, just
39 downstream of the pump outfall, coarsened from about 1.2 mm in August 2012 to 2 mm in
40 December 2012, and then coarsened even more significantly to about 5 mm by mid-January
41 2013. The gradation of this sand bar became finer, to 0.99 mm, by the May 2013 survey and
42 then coarsened again, to 2.52 mm, by the August 2013 survey. Sand Bar D, located between
43 XS-4 and XS-5, coarsened significantly to nearly 6 mm by early December 2012 and then fined
44 back to about 2.2 mm by mid-January 2013. It coarsened again to just over 4 mm during the
45 May 2013 survey and then became finer, at 1.28 mm, by the August 2013 survey. Similar
46 samples collected at AP 32 and AP 34 showed a general coarsening trend over the Phase I
47 period (Figure 22). Except for the samples taken at the most downstream cross section at
48 AP 34, these samples indicate a general coarsening trend throughout the monitoring period.

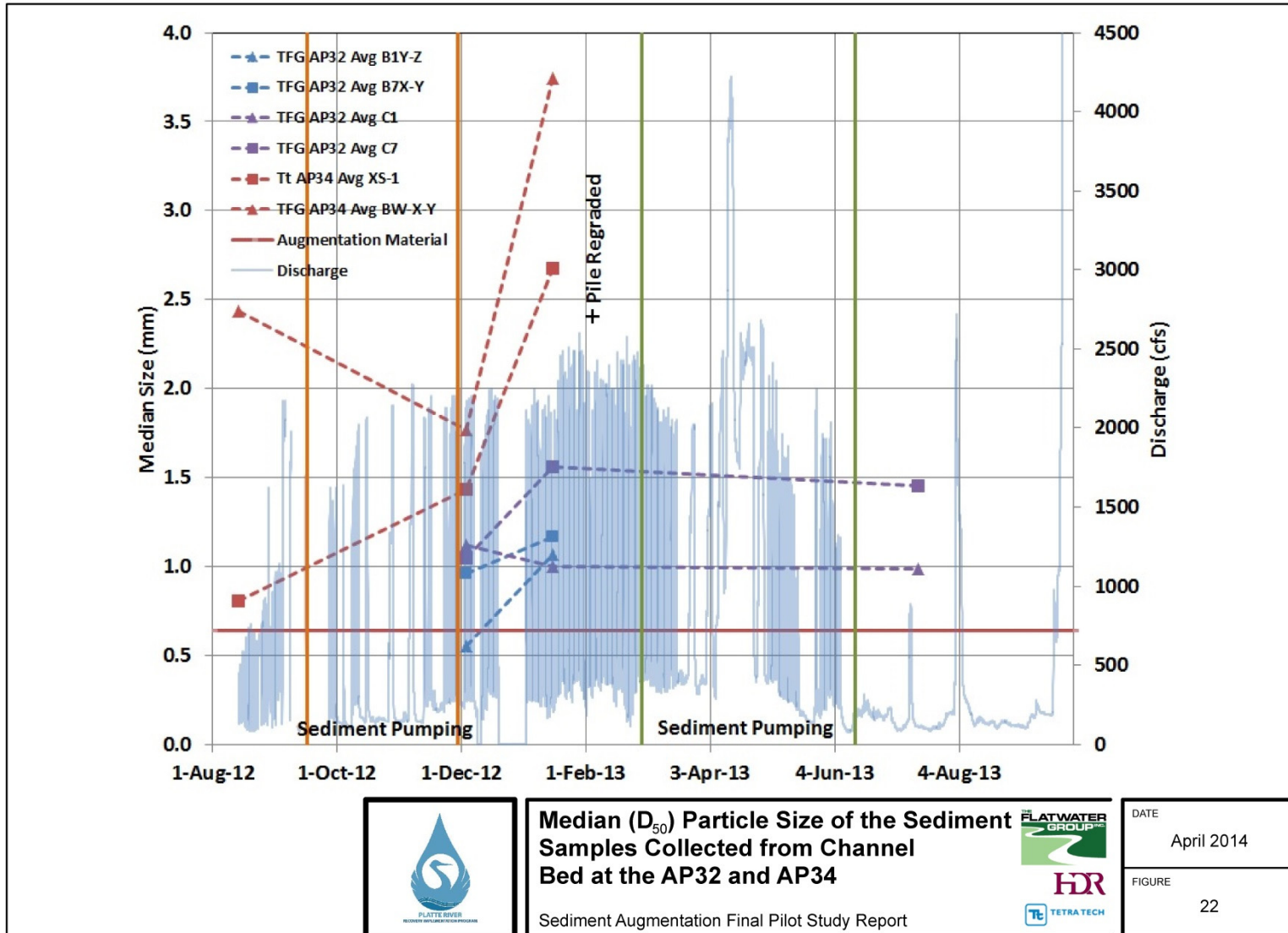


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1 At the AP 34 downstream cross section, the bed fined from about 2.5 to 1.8 mm between
2 August and December 2012, and then coarsened back to about 2.6 mm by mid-January 2013.
3 Sediment samples were not collected at AP 34 during Phase II. At AP 32,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

6 **3.5 Tri-Basin Drains**

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

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

19 **3.6 Sediment Transport Modeling**

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

33 **3.6.1 Anticipated Augmentation Rates**

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

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

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



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

4 **3.6.2 Actual Augmentation Rates**

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

7 Sand pumps were used to deliver about 25,000 tons of material to the South Channel at the
8 Dyer Property between September 26, 2012, to November 30, 2012, during Phase I, and about
9 57,000 tons of material was pumped to the river between March 1 and June 14, 2013, during
10 Phase II (Figure 23). Daily pumping times and rates varied considerably depending on flow
11 conditions and accumulation of sediment in the discharge area. Continuous steady pumping
12 was not possible because of the variability of flow during the two augmentation periods. An
13 attempt was made to pump material primarily during or prior to projected flow releases from the
14 J-2 return release schedule provided by CNPPID to ensure that sufficient quantities of
15 augmented sediment would be available for transport during these relatively higher flows.
16 Overall, the average daily rates were significantly lower than the rates that were modeled in the
17 pre-augmentation model runs, even though the hourly pumping rates during actual pumping
18 were significantly higher than the modeled rates.

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

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

32 At CWR, Phase I augmentation commenced on September 17, 2012, and was completed by
33 November 8, 2012 (Figure 24). The actual volume of material augmented (that is, pushed into
34 the river) at CWR was 75,000 tons. As the work proceeded, the contractor underestimated the
35 quantity of material moved in Phase I, and by the time Phase I augmentation ceased, the
36 augmented quantity exceeded the Pilot Project goal for this site (50,000 tons) by approximately
37 50 percent. However, a significant portion of the material remained in the river channel and did
38 not mobilize during Phase I due to low river flows. The remaining material in the channel was
39 available for more rapid augmentation when flow conditions increased in the spring.



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	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



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FIGURE	23



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

10 The Phase I total augmentation goal was met by introducing 25,000 tons of material at the Dyer
11 Property and 75,000 tons of material at CWR. Phase II total augmentation quantities included
12 57,000 tons at the Dyer Property and 25,000 tons at CWR, for a Phase II total of 82,000 tons.
13 As of this report, based on aerial photos and the monitoring data at Monitoring XS2 where the
14 average bed elevation is about 0.5 foot higher than during the pre-augmentation survey, it
15 appears that a portion of the augmented material at both locations remains on site awaiting
16 entrainment.

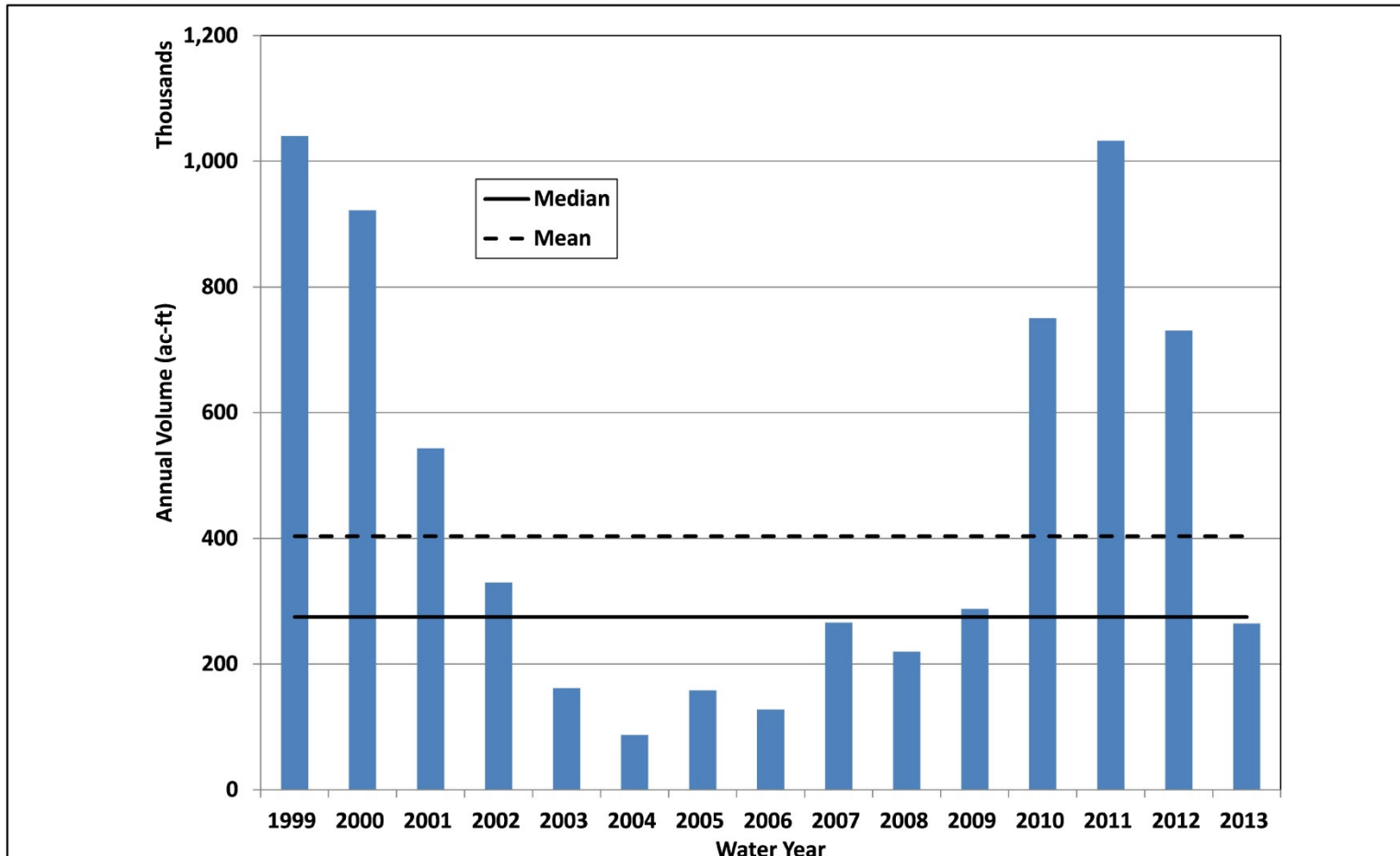
17 **3.6.3 Discharge Record**

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

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



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Annual Release Volumes from the J-2 Return

Sediment Augmentation Final Pilot Study Report

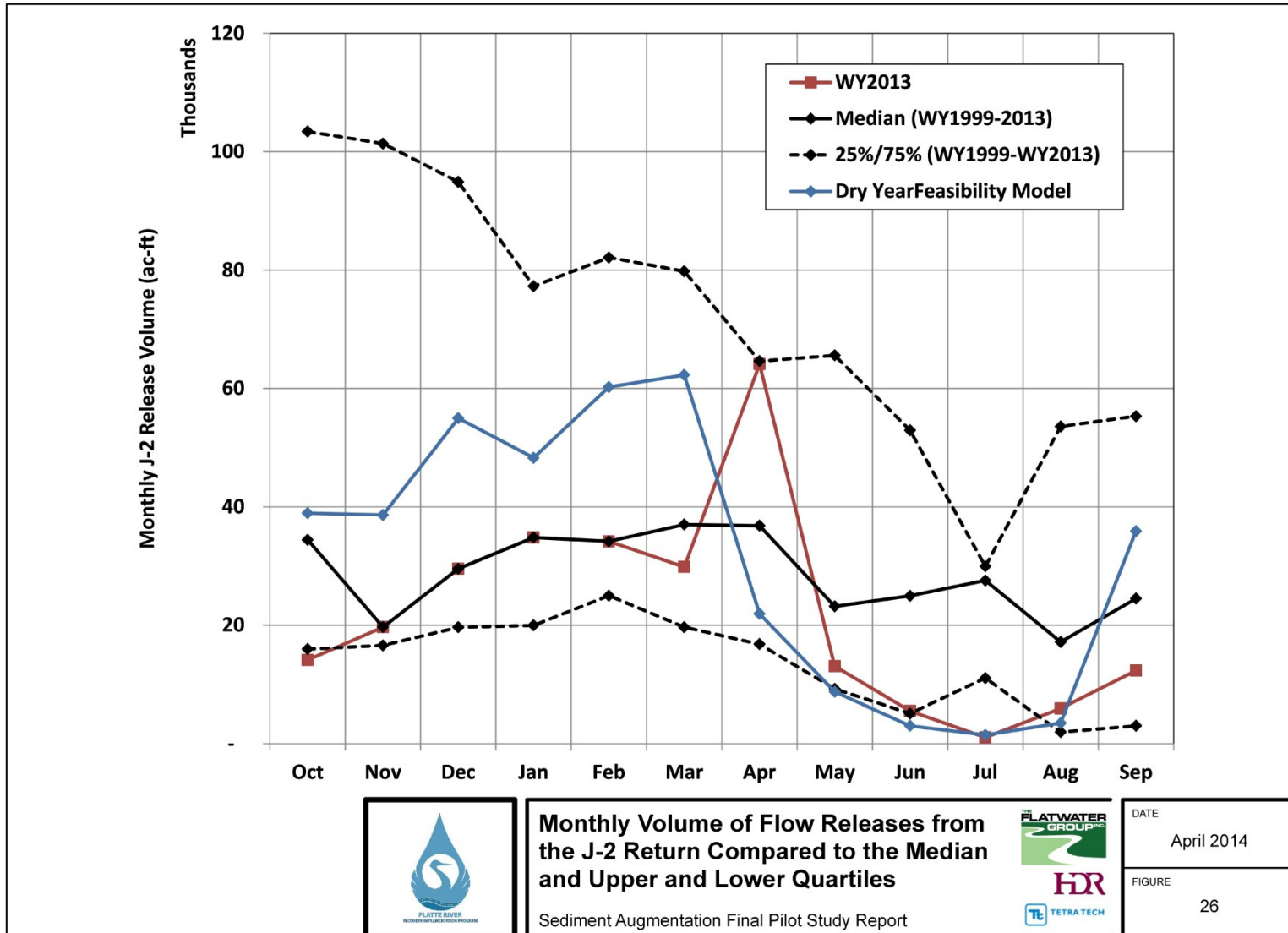


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FIGURE
25



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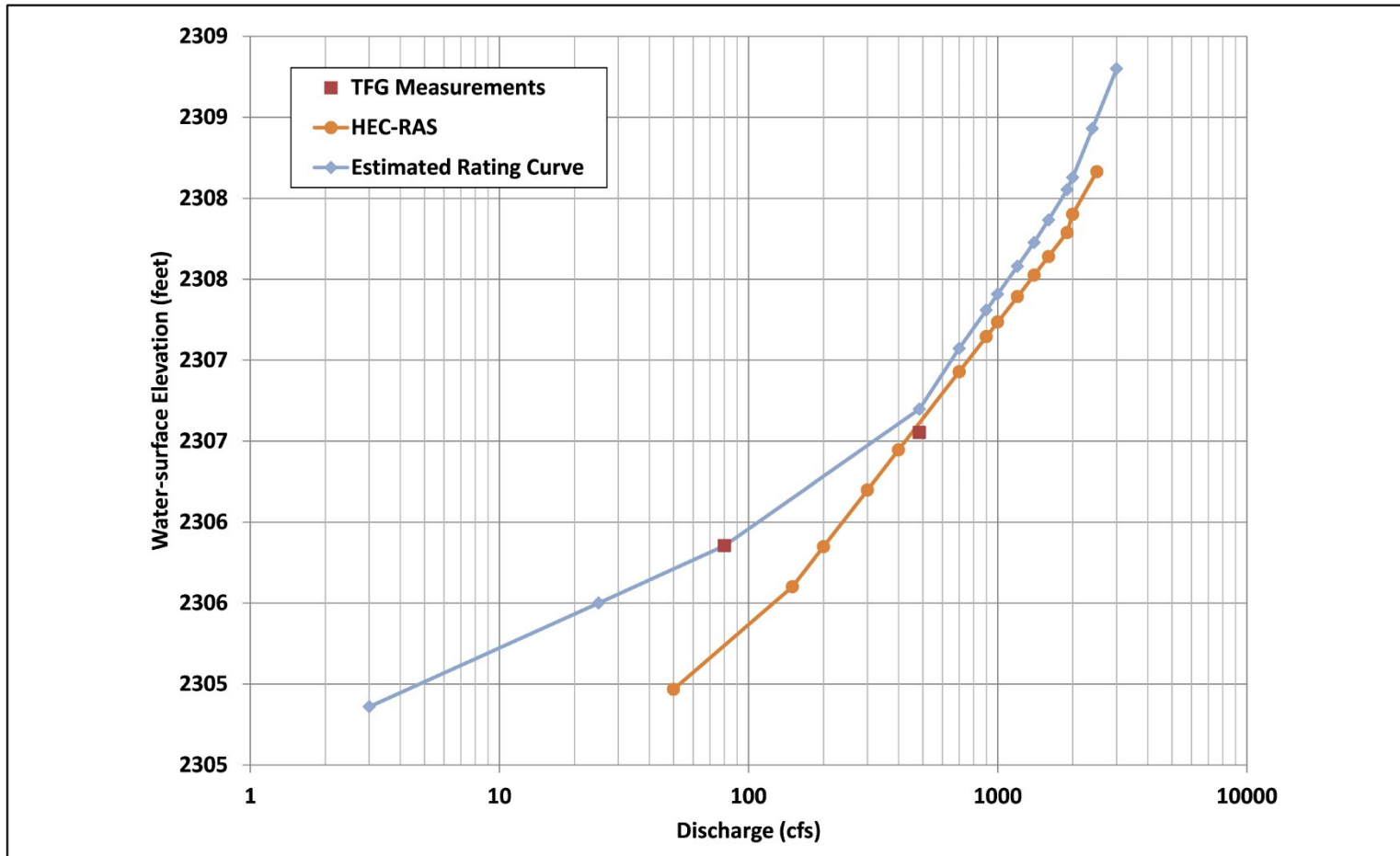
1 To facilitate sediment transport modeling of the study reach during the Pilot Project, an hourly
2 flow record was developed for the North and South Channels for the 1-year period from
3 September 1, 2012, through August 31, 2013, based on a combination of the USGS provisional
4 flows at the Overton gage, the record of mean daily J-2 return flow releases provided by
5 CNPPID, and the detailed record of stages at the Dyer Property pressure transducer that is
6 located a short distance upstream from the pump outfall. Only two discharge measurements
7 were made at the pressure transducer during the augmentation project (485 cfs on August 15,
8 2012, prior to the start of pumping, and 80 cfs on November 14, 2012, near the end of the
9 Phase I pumping); thus, there is insufficient field data to directly estimate a stage-discharge
10 rating curve. In addition, it appears from the data that the sediment stockpile created by the
11 augmentation caused backwater during at least some periods that could influence the stage-
12 discharge relationship, particularly at low flows (Figure 27). To facilitate development of the flow
13 record for the South Channel, an initial rating curve was developed from the existing conditions
14 HEC-RAS model, and this curve was shifted during the augmentation period to match the
15 November flow measurement and to provide high flows that are consistent with the typical J-2
16 peaking releases of about 1,700 cfs. The curve was also periodically adjusted to ensure that
17 the low flows in the South Channel and the corresponding flows in the North Channel were
18 reasonable based on the available information. The resulting estimated flow record follows the
19 recorded pattern of J-2 releases indicated by the Dyer Property transducer, with typical
20 maximum flows in the South Channel at the Dyer Property in the range of 2,000 cfs or less
21 during the releases and dropping to 50 cfs to 150 cfs during the non-release periods
22 (Figure 28). Based on the provisional USGS data, the total flow volume passing the Overton
23 gage during the period was 528,000 ac-ft. From the estimated records, about 141,000 ac-ft
24 came down the North Channel, and about 387,000 ac-ft passed the Dyer Property in the South
25 Channel (Figure 29). For comparison, the total volume in the South Channel for the dry-year
26 feasibility model run was very similar (378,000 ac-ft), but the volume in the North Channel was
27 significantly greater (255,000 ac-ft).

28 **3.6.4 Sediment Gradations**

29 The pre-augmentation modeling considered two different gradations for the Dyer Property pump
30 input. The finer of the two had a median size (D_{50}) of approximately 0.5 mm, similar to the
31 excess material generated at the Overton Sand and Gravel plant (Figure 30). The coarser
32 gradation was developed by averaging the fine gradation with the gradation of the existing
33 channel bed material to provide a gradation that was believed to be more representative of
34 material at the mining location on the Dyer Property. This gradation had a D_{50} of approximately
35 0.7 mm.



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

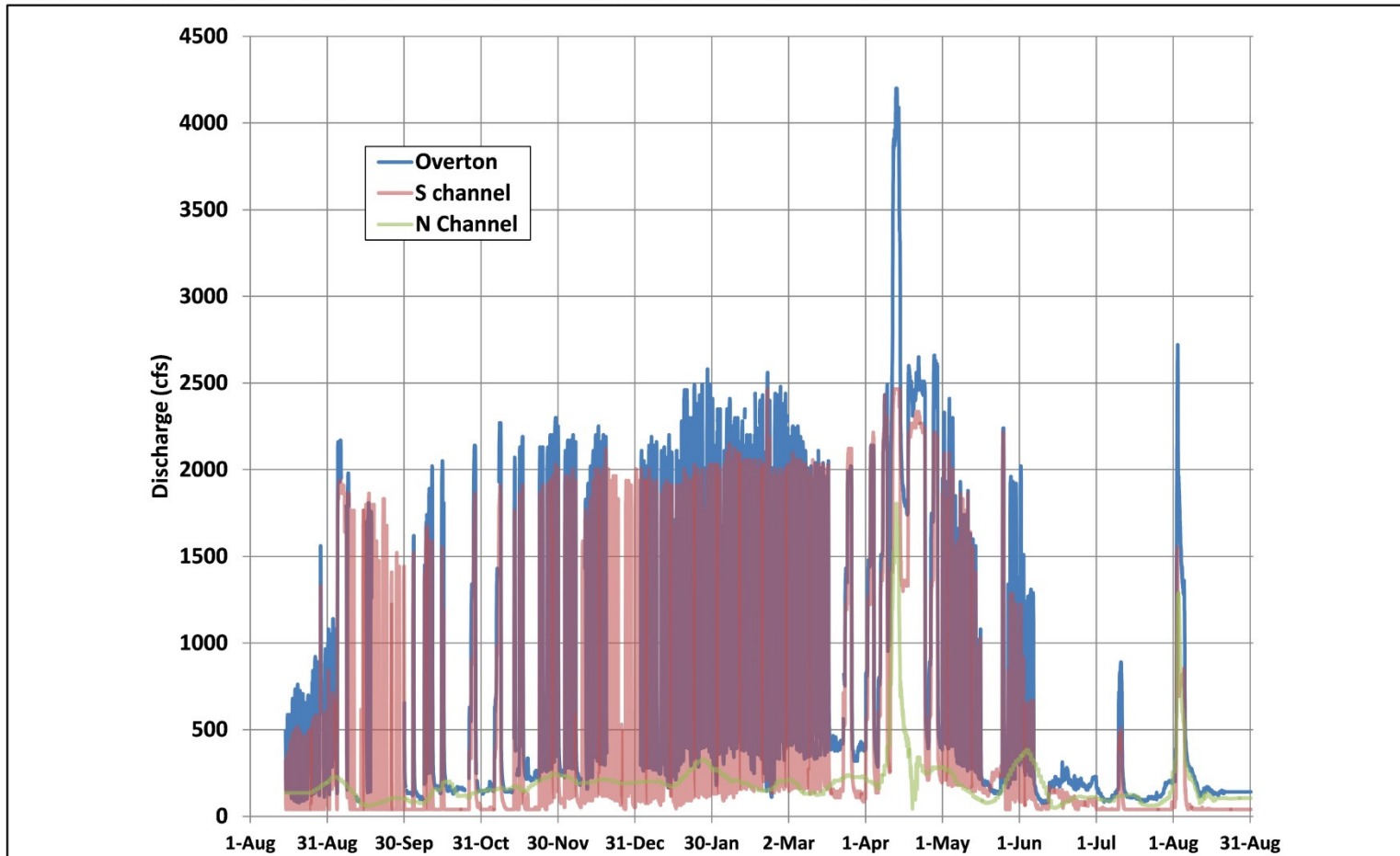
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FIGURE	27



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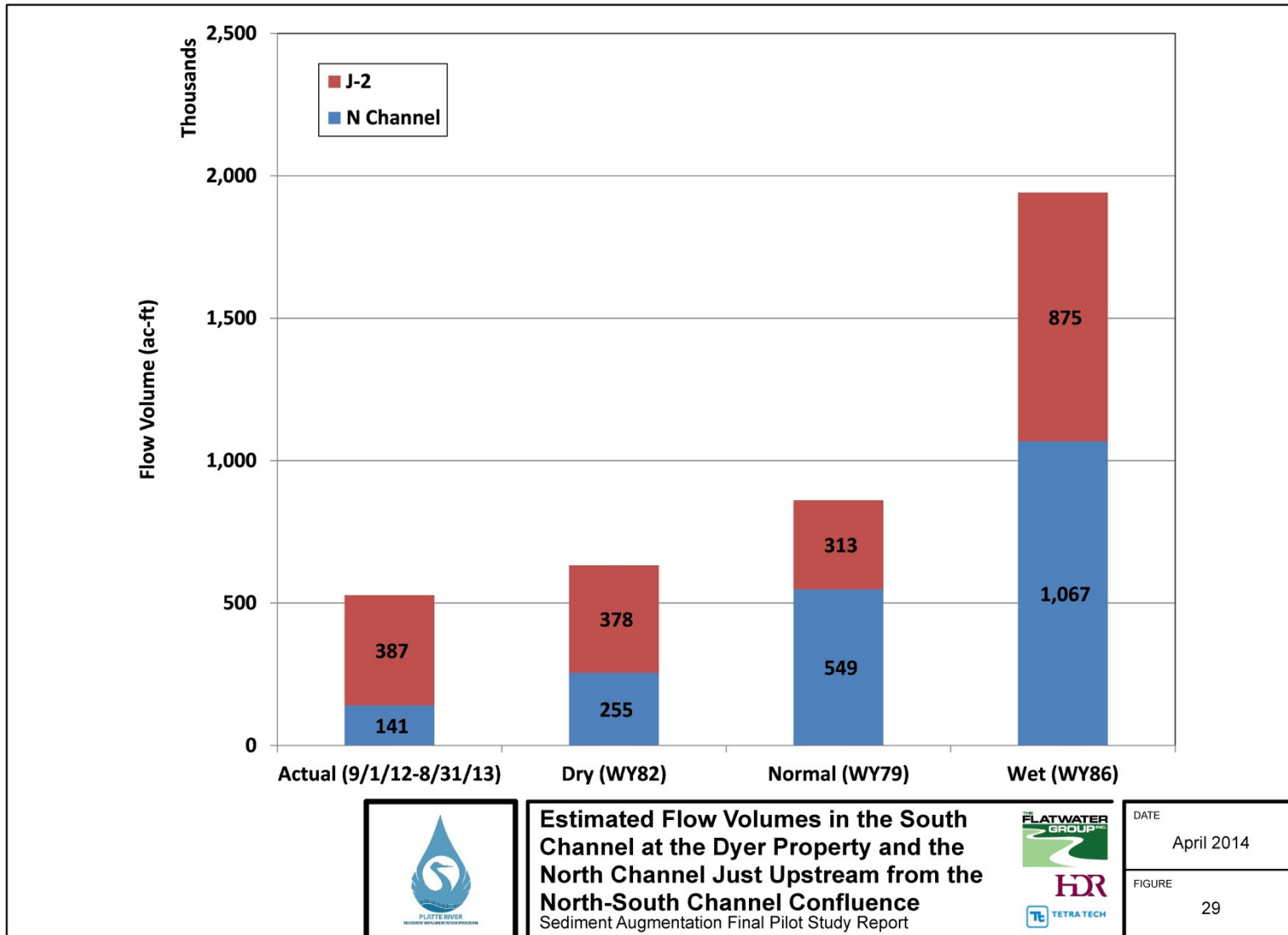
Provisional Hourly Discharges at the USGS Overton Gage and the Estimated Hourly Discharges in the South Channel at the Dyer Property and in the North Channel
Sediment Augmentation Final Pilot Study Report



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FIGURE	28

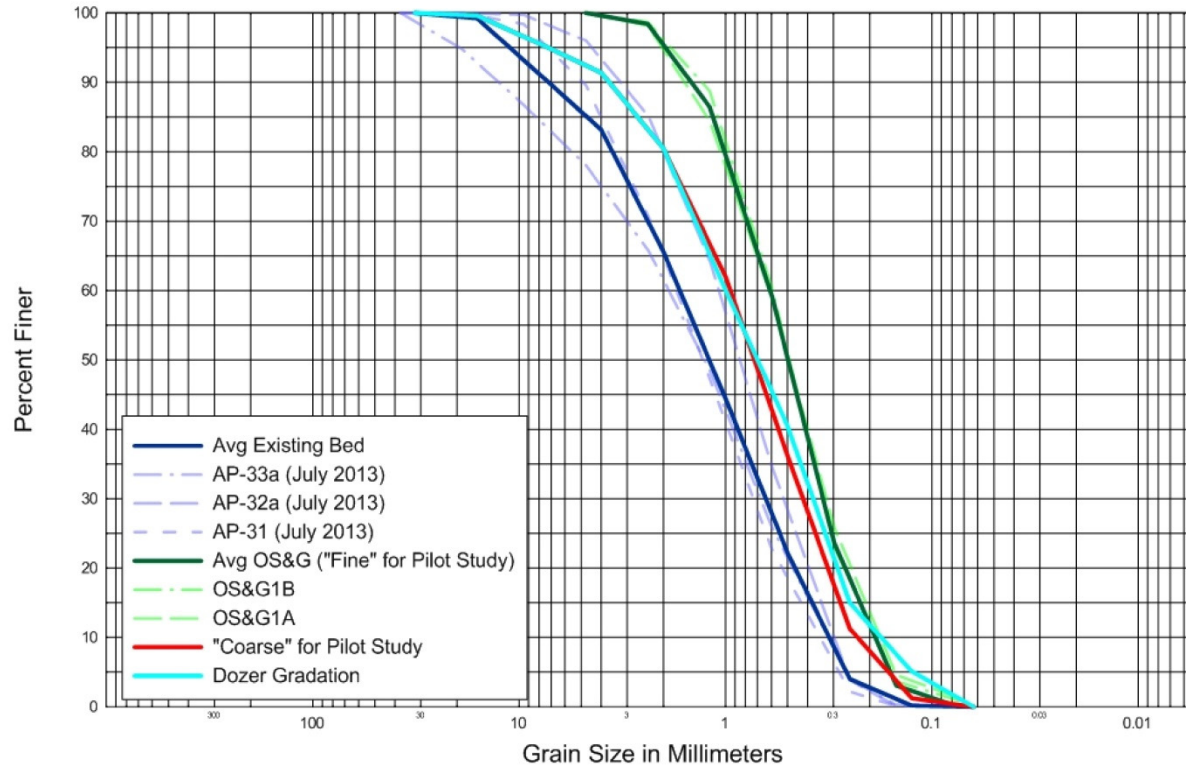


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BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	



Gradation Curves of the Augmented Sediment

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FIGURE	30



1 The specifications for the Pilot Project were modified slightly prior to implementation because
2 the originally specified band of permissible gradations would have required a rotary screen,
3 significantly increasing the cost. The modified gradation involved relaxing the tolerances for the
4 size classes greater than 0.6 mm, allowing the contractor to use traditional flat screens and still
5 achieve a gradation that was within the desired range of target augmentation (Table 4). The
6 average gradation of the pumped material had median (D_{50}), D_{16} , and D_{84} sizes of 0.64 mm,
7 0.32 mm, and 1.6 mm, respectively (Figure 31). This range of sizes was within the range
8 allowed in the modified specifications, and somewhat coarser than the gradation used in the fine
9 sediment model runs for the feasibility study ($D_{50}=0.5$ mm).

10 **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

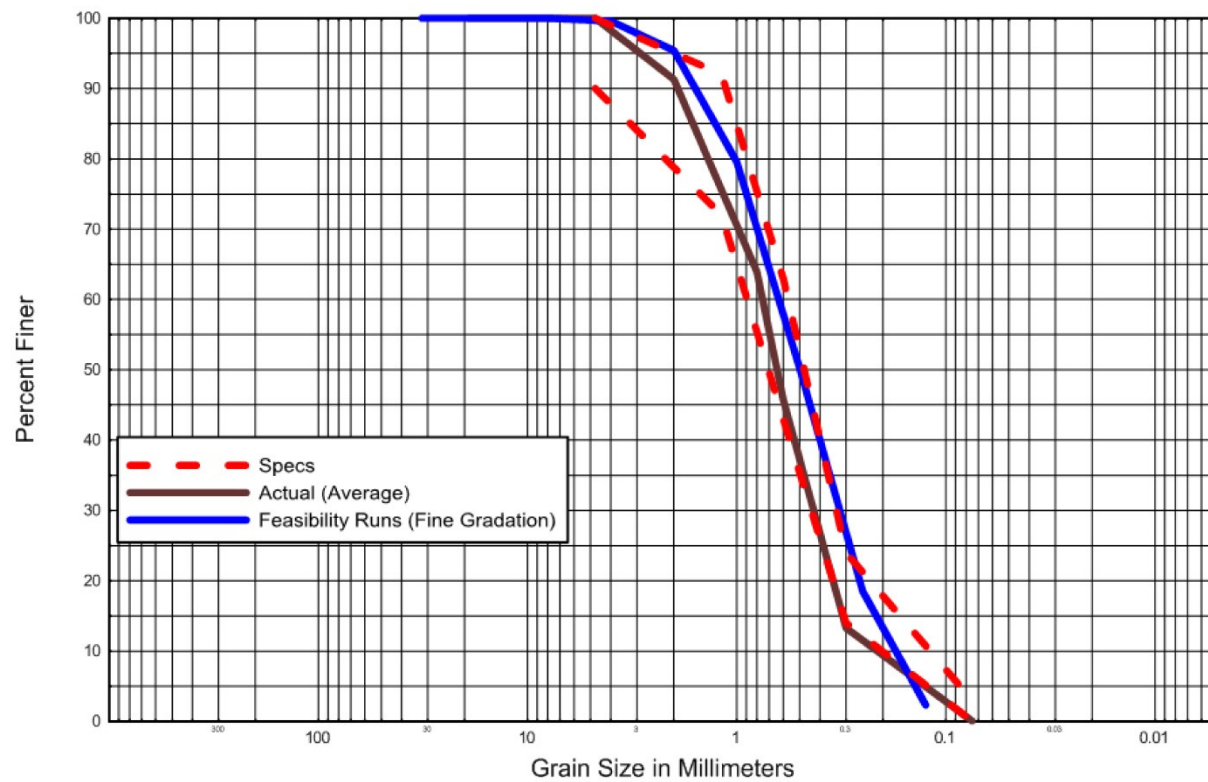
11
12 **3.6.5 Model Results**

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

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



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



Average Particle Size Gradation of the Material Pumped into the River at the Dyer Property During the Phase I and Phase II Sediment Augmentation
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FIGURE	31



1 The model results indicate that about 40,000 tons of sediment was delivered to the vicinity of
2 the Overton Bridge through the North Channel during the 1-year period for both the no-
3 augmentation and with-augmentation runs (Figure 32). In contrast, about 96,000 tons came
4 down the North Channel during the first full water-year of the dry-year feasibility study run. The
5 model also predicts that about 87,000 tons of sediment would have been delivered to the vicinity
6 of the Overton Bridge through the South Channel with no augmentation, and this increases to
7 about 119,000 tons with augmentation. This suggests that only about 32,000 tons of the total
8 82,000 tons of sediment delivered to the river at the Dyer Property was transported to Overton
9 during the model year. For comparison, about 112,000 tons of sediment was delivered to
10 Overton from the South Channel in the dry-year feasibility study run, in which 50,000 tons
11 sediment was added at the Dyer Property.

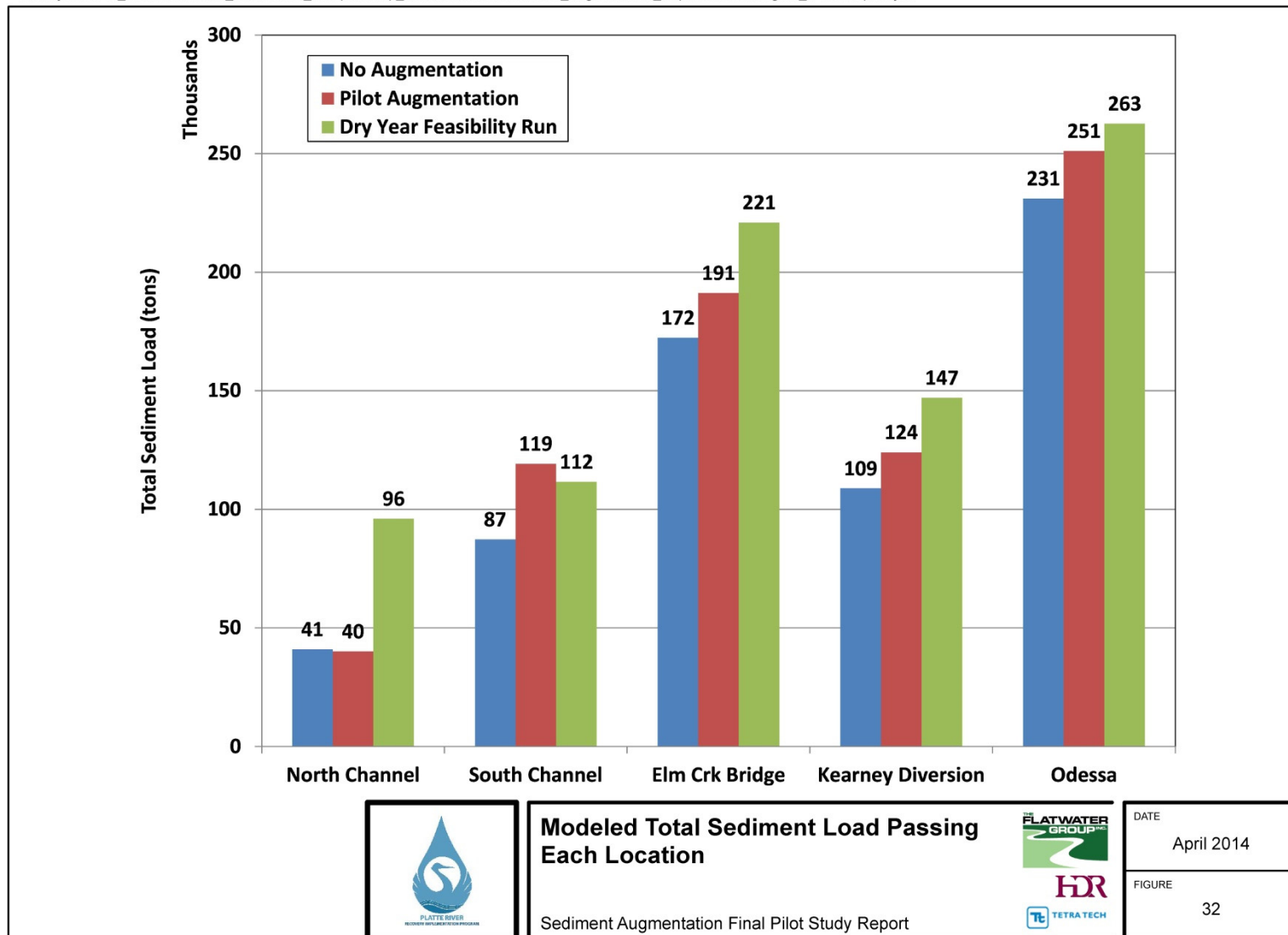
12 Farther downstream at the Elm Creek Bridge, the cumulative effects of the augmentation at the
13 Dyer Property and CWR increased the total sediment load from about 172,000 tons to about
14 191,000 tons; thus, only about 19,000 tons of the combined 182,000 tons of augmented
15 sediment was delivered to the head of the Elm Creek Reach. About 109,000 tons of sediment
16 would have been delivered to the Kearney Diversion Structure (KDS) under no-augmentation
17 conditions, and this increased to about 124,000 tons under augmentation conditions.

18 Comparison of the volumes passing the boundaries of the previously defined subreaches
19 indicates that about 87,000 tons of degradation would have occurred during the year in the
20 South Channel downstream from the J-2 return under no-augmentation conditions, and this
21 decreased to about 37,000 tons under augmentation conditions (Figure 33, Subreach 2). The
22 reach between Overton and the Elm Creek Bridge (Subreach 3) would have degraded by about
23 44,000 tons with no augmentation, and this reach shows net overall aggradation of about
24 68,000 tons with augmentation, primarily as a result of the grading activities at CWR. The
25 additional sediment load associated with the augmentation increases the amount of deposition
26 between the Elm Creek Bridge and the KDS by about 3,000 tons. The indicated differences
27 downstream of the KDS are quite small and likely within the range of uncertainty in the model
28 results. For comparison, the South Channel degraded by about 62,000 tons during the first year
29 of the dry-year feasibility study run and the Subreach 3 aggraded by about 51,000 tons. The
30 increased downstream movement of sediment in the dry-year feasibility study runs result from
31 two primary factors: the increased combined flow volume from the North and South Channels
32 passing through the reach; and the somewhat finer augmentation material that was considered
33 in this run ($D_{50}=0.5$ mm for the feasibility study versus 0.64 mm for the actual pilot
34 augmentation).

35 The total amount of sediment passing other key locations in the vicinity of the augmentation
36 activities was also assessed to provide higher resolution view (both temporally and spatially) of
37 the sediment distribution along the reach with and without the pilot augmentation (Figures 34
38 and 35). The sediment balance in the South Channel in the vicinity of the Dyer Property pump
39 outfall (labeled Dyer Aug Site in Figure 34 and 35) was evaluated based on an approximately
40 0.7 mile segment that has upstream limit at the Dyer Property pressure transducer. The
41 segment labeled Dyer-Overton in the figures consists of the approximately 1.1-mile reach of the
42 North and South Channels upstream from the Overton Bridge. The next downstream segment
43 (Overton & AP 34) includes the Overton Bridge and the Geomorphic and Vegetation Monitoring
44 Rotating Panel AP 34 (~0.4 mile). AP 34-CWR extends from the downstream side of AP 34 to
45 just upstream from the grading area at CWR (~2.4 miles), and Segment CWR includes about
46 0.9 mile of the main river channel through and downstream of the CWR grading area. The other
47 labels in the figures are self-explanatory.

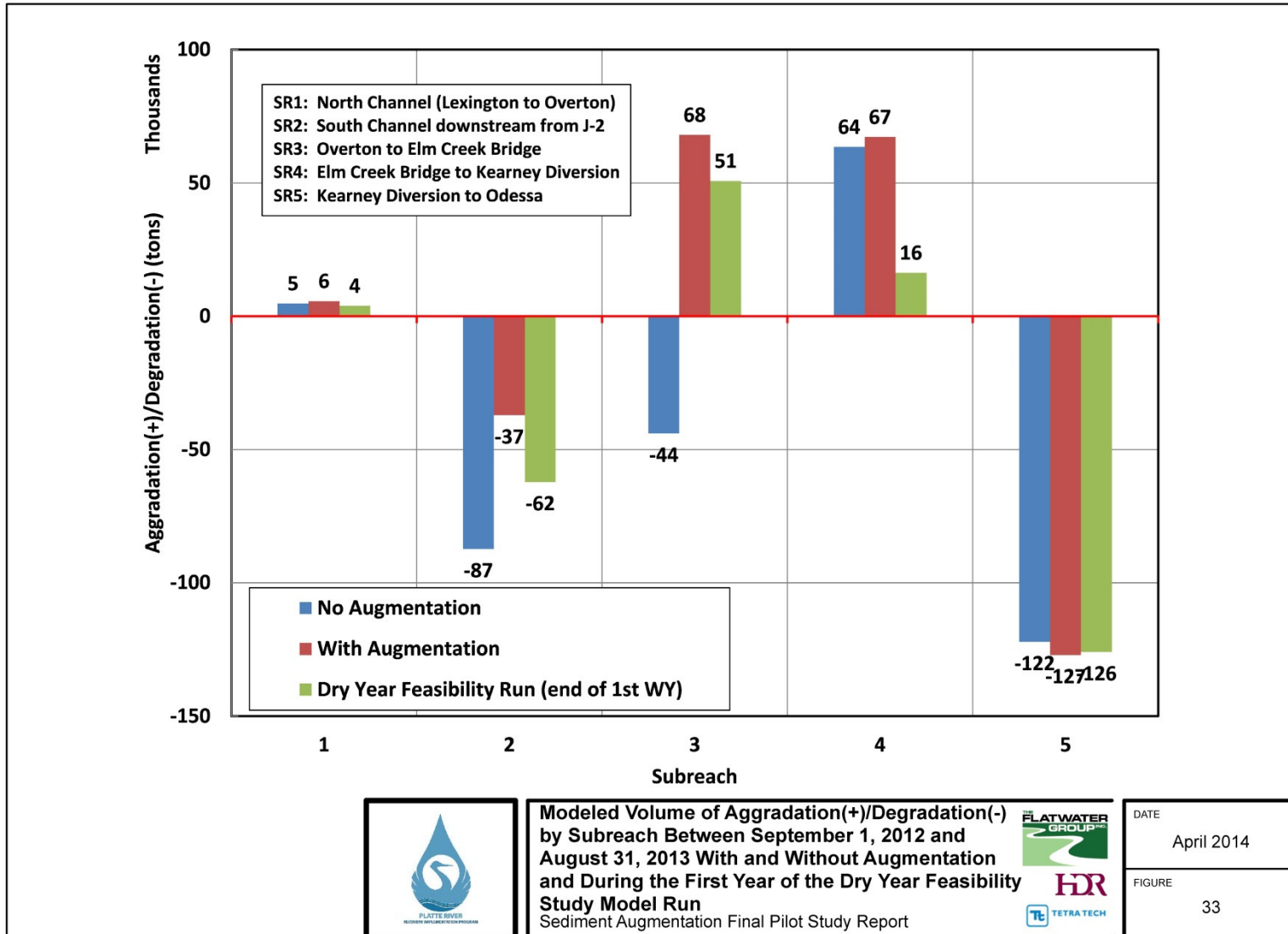


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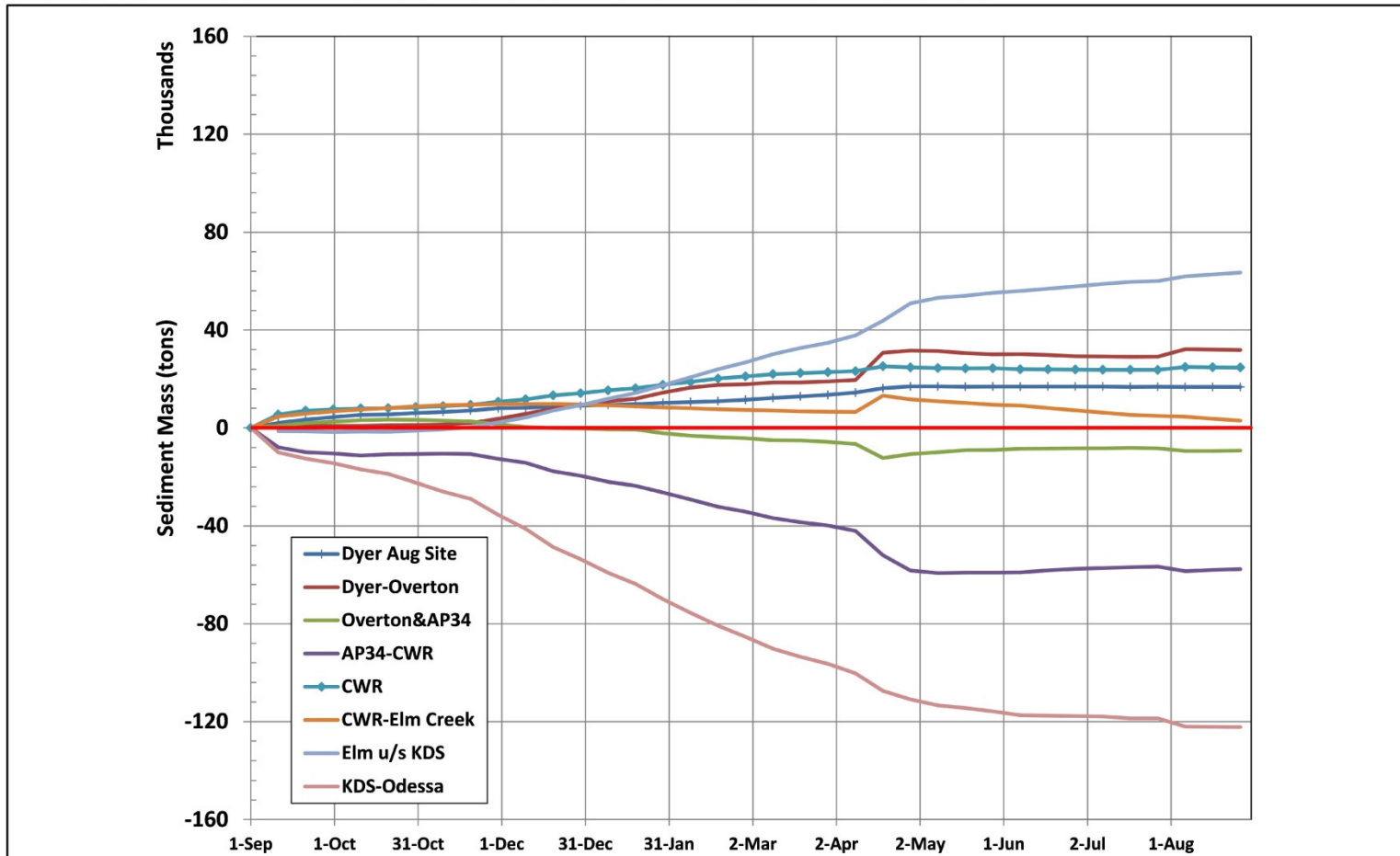
Modeled Volume of Aggradation(+)/Degradation(-) by Subreach Between September 1, 2012 and August 31, 2013 With and Without Augmentation and During the First Year of the Dry Year Feasibility Study Model Run
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FIGURE	33



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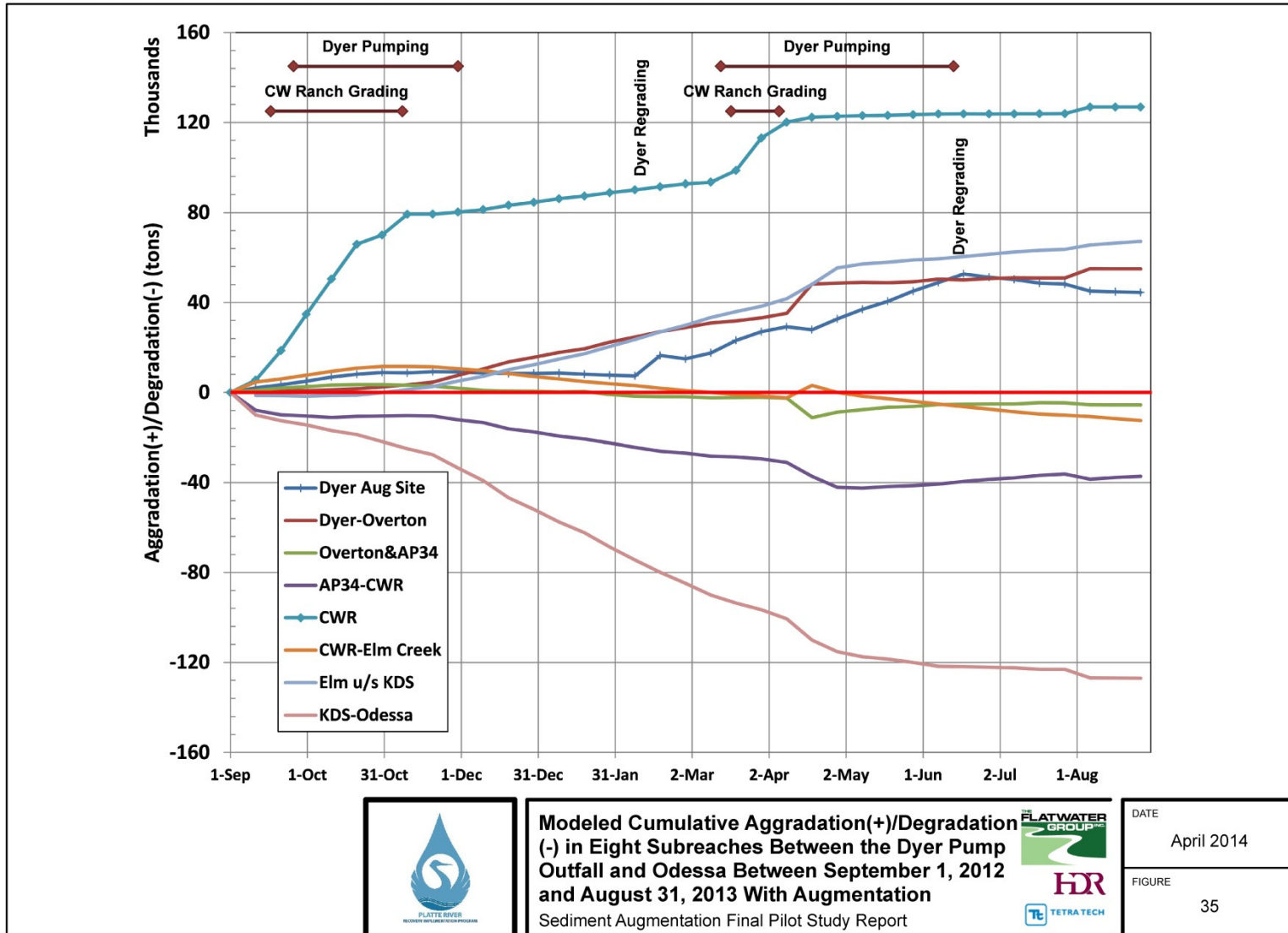
Modeled Cumulative Aggradation(+)/Degradation (-) Mass in Eight Subreaches Between the Dyer Pump Outfall and Odessa Between September 1, 2012 and August 31, 2013 Without Augmentation
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FIGURE	34



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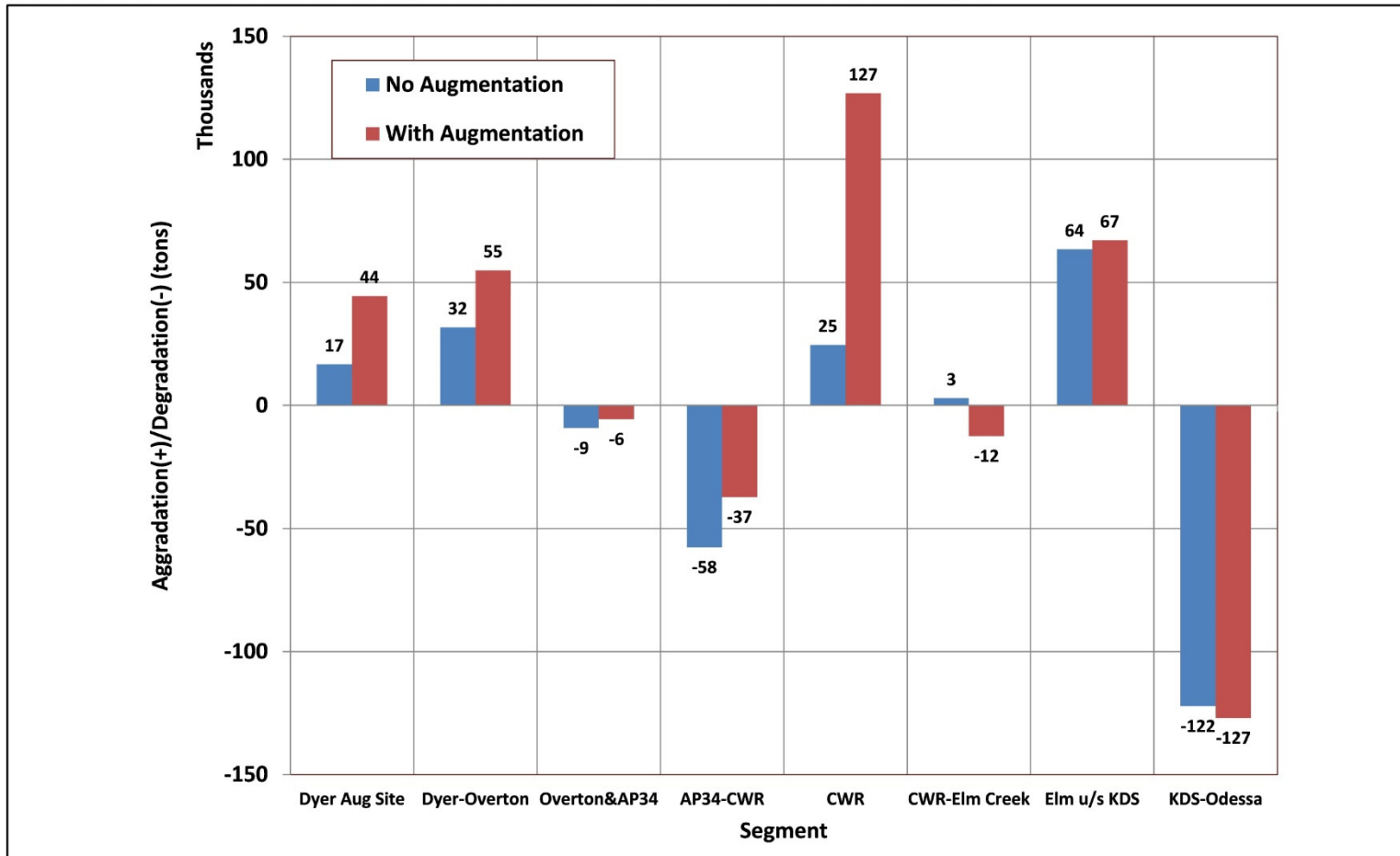
1 The model results indicate that the segment in the vicinity of the Dyer Property pump outfall
2 would have been mildly aggradational, even without augmentation, and the amount of
3 aggradation increases by about 70 percent from about 17,000 tons to 29,000 tons with
4 augmentation (Figure 36). Similarly, the approximately 1.1-mile reach of the combined North
5 and South Channels just upstream from the Overton Bridge would have been aggradational in
6 the absence of augmentation, and the amount of aggradation increases by about 75 percent
7 from 32,000 tons to 55,000 tons with the augmentation. The 0.4-mile reach through the Overton
8 Bridge and AP 34 would have been degradational without augmentation, and this tendency was
9 reduced by about half (from 9,200 tons to 5,100 tons) with augmentation. The 2.4-mile reach
10 from AP 34 to just upstream from the CWR grading area would have degraded by about
11 58,000 tons without the augmentation, and this decreased to about 35,000 tons with the
12 augmentation. The biggest change in the aggradation/degradation pattern occurred in the
13 ~0.9-mile reach through the CWR grading area. The model indicates that this area would have
14 aggraded by about 25,000 tons without the augmentation, primarily due to the wide,
15 depositional character of this part of the reach. The grading activities pushed an additional
16 100,000 tons of sediment into the river, and the area accumulated about 130,000 tons during
17 the model year. This indicates that a small portion (~5,000 tons) of the material from the Dyer
18 Property pumping operations also accumulated in this portion of the reach. Interestingly, the
19 model suggests that the reach from below the CWR grading area to the Elm Creek Bridge
20 changed from about in-balance with no augmentation to slightly degradational with
21 augmentation. The reason for this change is not apparent, but it may result from additional
22 trapping of sediment in the CWR grading area due to the additional widening of the channel and
23 an associated reduction in the transport capacity. The small increase in deposition in the reach
24 from the Elm Creek Bridge to the KDS probably results from an increase in the amount of finer-
25 grained sand from the augmentation activities reaching this area. As noted above, the relatively
26 small increase in the degradational character of the reach between the KDS and Odessa is
27 probably within the uncertainty of the model results, and is, therefore, not believed to be a
28 meaningful impact of the augmentation activities.

29 **3.6.6 Comparison of Model Results and Monitoring Data**

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



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

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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.



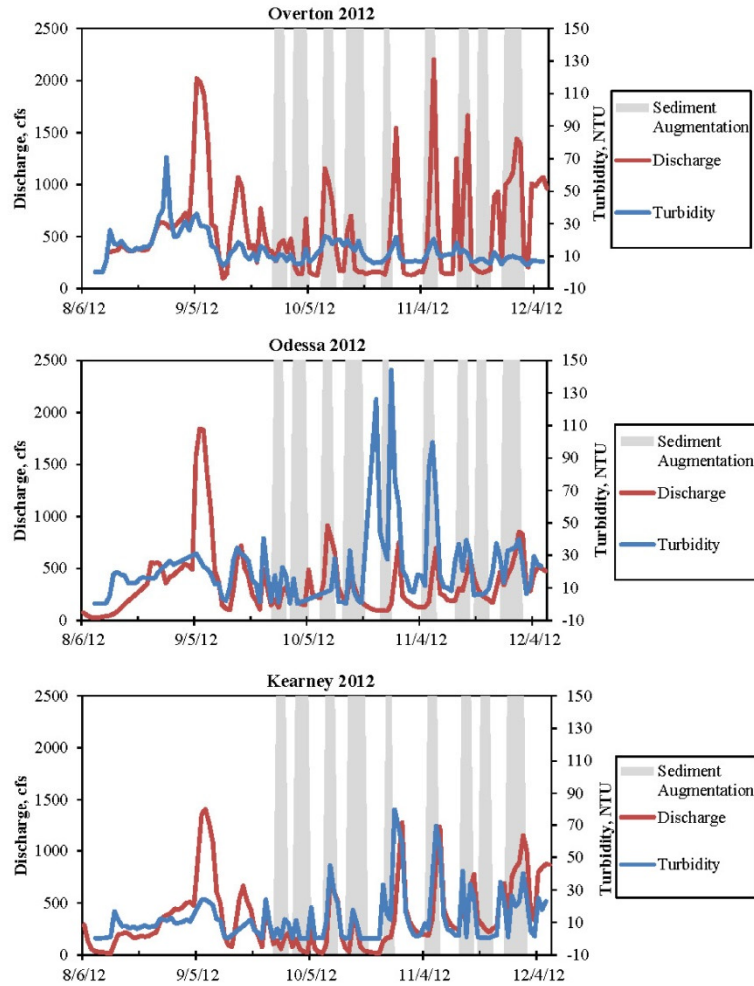
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Figure B-35. Sediment Augmentation Timeline (Dyer Property), Discharge and Turbidity



Appendix B – Figures – Annual Data Summary Report – 2012

Page B-43



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

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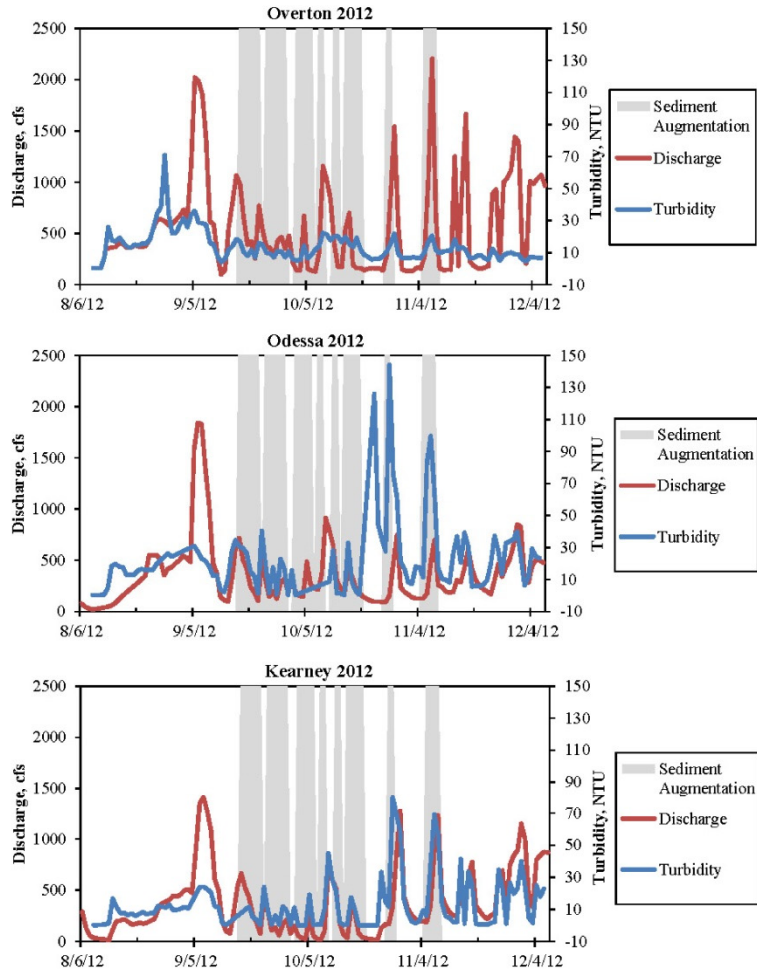


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FIGURE	37

2



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



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

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FIGURE	38



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

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

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

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

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

27 **4.1 Dyer Property**

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

32 **4.1.1 Observations**

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

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



- 1 operation, necessitated by the persistent low flows, is not the most efficient way to
2 operate this system.
- 3 2. There is not a good method for determining the instantaneous rate or even the daily
4 quantity of material actually delivered to the river because of the variation in pumping
5 rates, variation in subsurface formation, and variation and efficiencies in the pumping
6 operation itself (that is, equipment and operators).
- 7 3. The pipe location is limited to discharging from the bank. The ability to move the
8 discharge pipe into the flowing water in a cost effective manner is limited because of the
9 requirements that the pipe be supported structurally (for example, by a sand bridge,
10 wooden supports, or floats) and to provide enough back pressure head on the pump. At
11 the Dyer Property, a land bridge would be required to get the pipe out to the active
12 channel of the river.
- 13 4. Even at lower daily pumping volumes, excess material continued to build up in the
14 discharge area. This resulted in a channel shift toward the north river bank, which
15 reduced the ability of the river to mobilize sediment even further (that is, less of an attack
16 angle) and resulted in some minor erosion of the north bank.
- 17 5. Sediment that was mobilized was initially being re-deposited in bars just downstream of
18 the discharge area, resulting in large bar areas.
- 19 6. As the sediment pile, referred to as the source pile, continued to expand and the
20 downstream bar area continued to expand, the Program expressed concern that the
21 deposited material would become vegetated, thus preventing effective mobilization over
22 time.
- 23 7. As flow remained low, it became evident that it would not be possible to augment the full
24 50,000 tons of material.

25 **4.1.2 Modifications**

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

- 28 1. During Phase I, augmentation material accumulated near the discharge location
29 because of the contractor's limited ability to adjust the discharge location. The initial
30 monitoring survey at the closest primary monitoring cross section (XS-2) after the start of
31 pumping indicated very little change due to limited mobilization of the augmented
32 material; therefore, the monitoring plan was revised to include a localized reach (referred
33 to as the control section) from just upstream of the source pile to XS-2 approximately
34 750 feet downstream of the source pile. This was achieved using a series of ten cross
35 sections (D-1 through D-10) spaced 75 to 100 feet apart. These cross sections were
36 surveyed on a 1- to 2-week interval rather than monthly. These sections were used to
37 estimate how much material was pumped from the source pit and evaluate how the
38 augmented material was being distributed within the control section. XS-1 through XS-5
39 continued to be monitored approximately monthly in accordance with the monitoring
40 plan.
- 41 2. To decrease accumulation of introduced material near the pipe outfall, an attempt was
42 made to better match the sediment pumping to coincide the CNPPID releases from the
43 J-2 return. Unfortunately, these "higher" flow rates did not always occur during the work
44 day of the pumping crew; thus, the effects of this change on entrainment of the material
45 were very limited.



- 1 3. The source pile was surveyed on a regular basis as were the waste piles (that is,
2 material that was screened out as too large for augmentation under this Pilot Project).
- 3 4. The additional monitoring data that were collected, including cross-section surveys near
4 the source pile and a bathymetric survey of the existing sand pit prior to the
5 management action, were used with results from the sediment transport model to
6 estimate the following during Phase I:
 - 7 a. Quantity of material pumped
 - 8 b. Quantity of material delivered to the river
 - 9 c. Quantity of material in the source pile in the river (that is, material augmented but
10 not mobilized)
 - 11 d. Quantity of material mobilized from the source pile but still within the control
12 section (monitored with cross sections D-1 through D-10)
 - 13 e. Quantity of material mobilized and moved beyond the control section
14 (downstream of D-10/XS-2)
- 15 5. This information was also used to verify estimated quantities completed by the
16 contractor for purposes of approving payment requests. Because of the variation in
17 flows and the resulting need for the contractor to start and stop operations to minimize
18 excessive buildup of material, it was difficult to estimate the quantity of pumped material.
- 19 6. At the end of Phase I implementation, the Program hired a separate contractor to
20 mechanically manipulate the source pile by knocking down the height to generally match
21 the corresponding low bank and spreading the material fairly evenly across the entire
22 width of the channel. A dike was constructed at the upstream end of the source pile and
23 then breached in the middle to allow flows to entrain augmented material more
24 efficiently. The manipulation of the source pile redirected the river upstream of the
25 source area into the north bank, causing approximately 25 to 30 feet of bank scour
26 within a week after the mechanical manipulation. The erosion on the north bank has
27 since stabilized. The mechanical manipulation was effective in helping mobilize
28 sediment, and this was aided by an increase of flows from the J-2 return.
- 29 7. For Phase II, the Project Team recommended that the augmentation pipe be moved
30 approximately 100 feet upstream of the original source pile location once the material
31 began to accumulate to an elevation above the water surface during the maximum
32 hydrocycle releases from the J-2 return. The contractor was instructed to continue to
33 move the pipe incrementally upstream (in approximately 100-foot increments) creating a
34 series of windrows adjacent to the bank. This process was to continue until the
35 contractor was approximately due west of the dredge location. Augmentation areas
36 were limited to the more active portions of the channel beyond the low bank. In addition,
37 the height of any accumulated sediment was limited to the low bank elevation that
38 roughly corresponds to the 2,000 cfs flow rate. In that manner, most, if not all, of the
39 augmented material would be inundated at flows of 2,000 cfs and greater.

40 **4.2 Cottonwood Ranch**

41 Approximately 75,000 tons of sediment was augmented by pushing material into the river from
42 an adjacent island at CWR in Phase I from September 17, 2012, through November 8, 2012.
43 The augmentation quantity at CWR was exceeded by 50 percent compared to the anticipated
44 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).



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Dyer Property at the Conclusion of Phase II

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

- 2 1. Flows in the South Channel that are mostly derived from J-2 return releases were near
3 normal during the first half of the Phase II pumping, except during the Program's SDMF
4 release that occurred in April 2013, and then dropped well below the typical rates during
5 the second half of the pumping period. The gradation of the augmented material
6 continued to be consistent with that of the Phase I material.
- 7 2. The average rate of entrainment of the augmented material during Phase II pumping
8 was more than 3 times higher than during Phase I pumping, primarily because the
9 contractor moved the outfall periodically to distribute the material so that it was more
10 accessible by the river. The SDMF release also played a role in the greater amount of
11 entrainment. By the end of April 2013, about 29,000 tons of the Phase II material had
12 been pumped to the river. During the period from the beginning of March 2013 to the
13 end of April 2013, the cumulative sediment load past Primary Monitoring XS-2, located a
14 short distance downstream from the pump outfall, was about 16,000 tons greater than it
15 would have been without augmentation. Despite the efforts to better distribute the
16 sediment, the pumping rate still exceeded the ability of the river to entrain and carry
17 downstream all of the augmented material.
- 18 3. There appears to be a systematic aggradational trend at all but one of the five
19 monitoring cross sections, with XS-2, the cross section closest to the pump outfall on the
20 downstream side, showing the strongest trend. This cross section has aggraded by over
21 0.5 foot since the start of augmentation. Only XS-4 does not show a clear aggradational
22 trend. XS-1, located just upstream of the outfall, also appears to have systematically
23 aggraded by about 0.2 foot since the start of augmentation.
- 24 4. The bed and bar sediment gradations collected during monitoring show considerable
25 variability, but no systematic trends.
- 26 5. Based on the USGS stage-discharge field measurements at the Overton gage, the
27 deviation of the stage from the current rating curve has remained well within the Class I
28 and II stage changes, beyond which immediate action is required under the monitoring
29 plan. Three of the measurements taken in the 2,000 to 4,100 cfs range are above the
30 Class I stage change threshold. Of these, only the April 12, 2013, measurement
31 exceeds the threshold by more than 0.1 foot, moving it into Class II at the Overton gage.
32 Prior to increasing monitoring frequency from monthly to bi-weekly, the trigger was back
33 below the Class II threshold criteria on April 16, 2013, and no action was taken.
- 34 6. The deviations in stage from the current rating curve at the CWR Mid-Channel gage are
35 considerably less than at Overton. With the exception of the September 25, 2013,
36 measurement during the passage of the Northern Colorado flood wave that is about
37 0.55 foot above the rating curve, all of the Phase I and Phase II measurements are well
38 within the Class I stage change threshold.
- 39 7. There appears to have been a 0.5- to 0.8-foot increase in the stage during baseflow
40 conditions at the stage-recorder in the North Channel near the Todd Brown property
41 over the course of Pilot Study. This station records only stage and does not have a
42 stage-discharge curve developed for it. Qualitative observations of the river near this
43 gage suggest that the increases are likely the result of baseflow increases along the
44 reach as a result of irrigation and upstream diversions ending. Trends at higher flows
45 are much less certain. The 2012 system-wide monitoring data indicate a general
46 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.

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

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

23 **6.1.2 Cottonwood Ranch**

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

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

35 Phase II augmentation commenced in March 2013 and ended the first week of April 2013, prior
36 to the SDMF event planned by the Program. The Phase II augmentation design for CWR was
37 modified based on the results of Phase I augmentation. The remaining 25,000 tons of material
38 were removed from the source island and pushed into the river generally in the same area as
39 the Phase I material. The combined material was reshaped into a series of three piles with
40 interconnected channels to try to expose more of the material to the higher cycling flows.
41 Material remaining in the newly constructed source piles continues to provide source material to
42 the river. It is anticipated that higher spring flows in the river along with hydrocycling releases
43 from the J2 return will move a significant amount of the remaining material downstream in spring
44 2014.

45 The total augmentation cost for Phase I and Phase II at CWR was \$176,200. This cost included
46 mobilization, pushing the material into the river, shaping and restoring the augmentation site,
47 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:

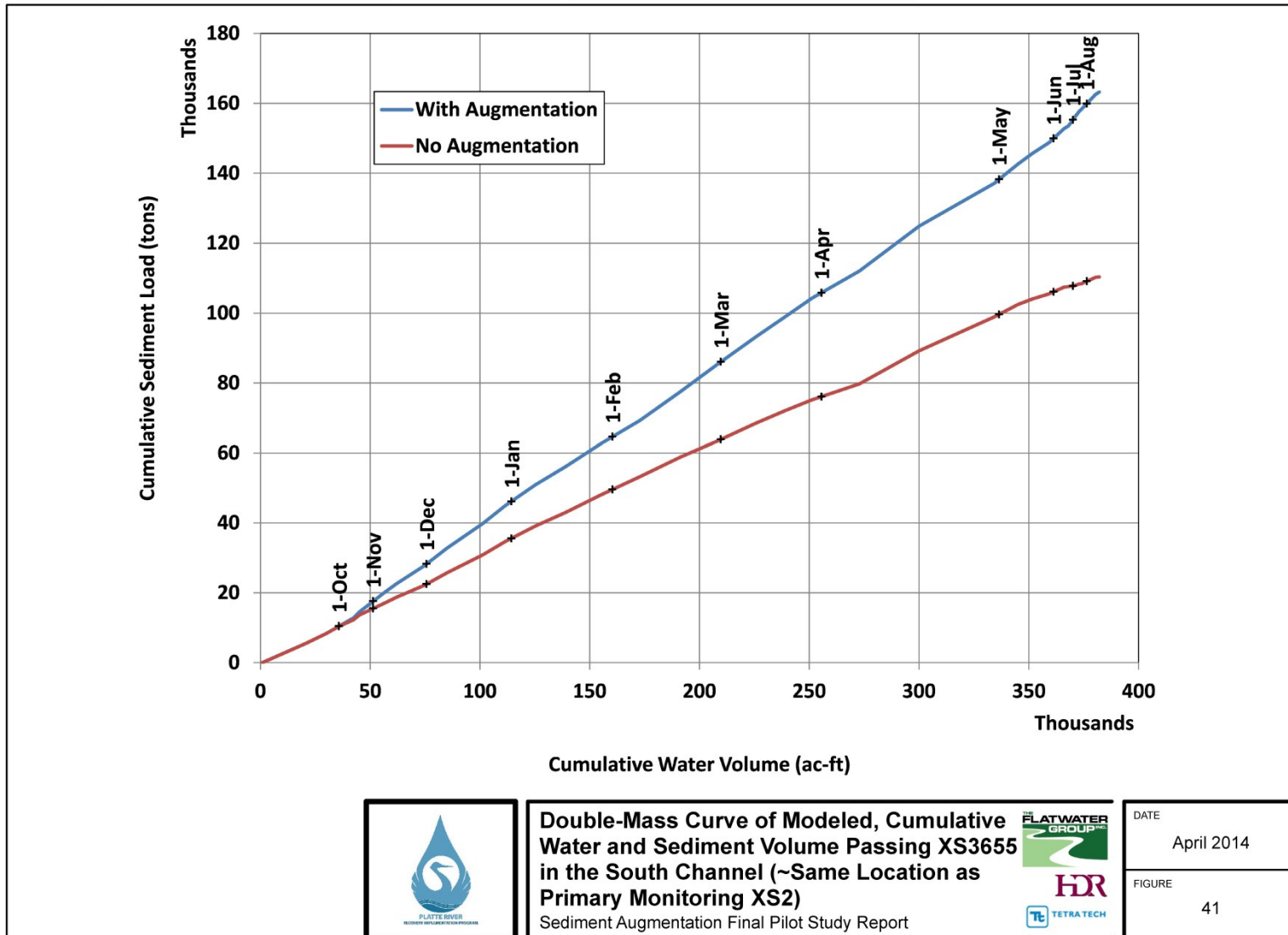
1. How much material can be augmented into the river under Normal Flow Hydrologic Classifications?

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.

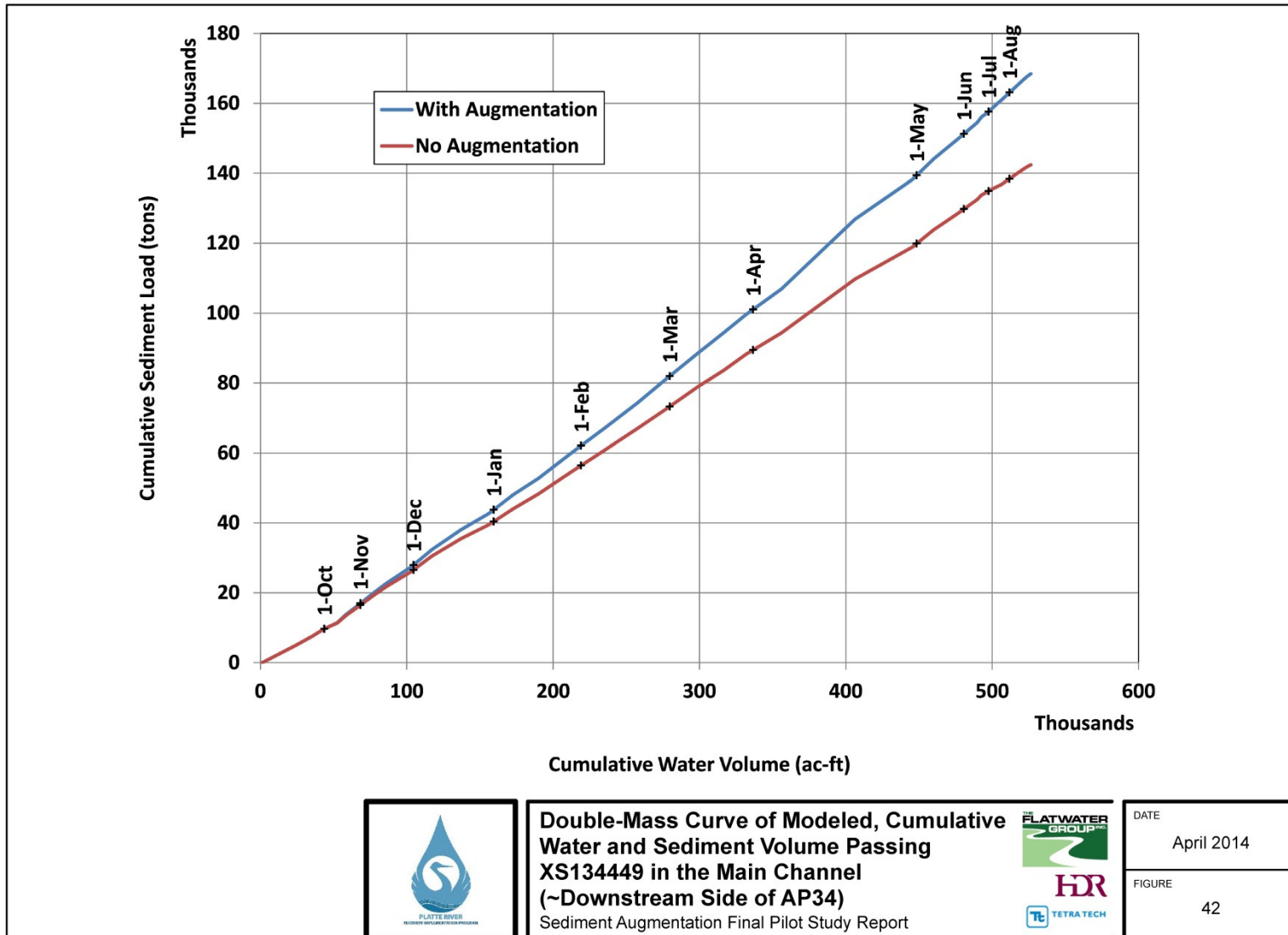


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Double-Mass Curve of Modeled, Cumulative Water and Sediment Volume Passing XS13449 in the Main Channel (~Downstream Side of AP34)
Sediment Augmentation Final Pilot Study Report



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FIGURE	42



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

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

18 Based on the modeling performed for the feasibility study using the flows that occurred
19 during the 12.5-year period from WY 1990 through WY 2001 (Tetra Tech, 2010), the
20 annual deficit between the Overton and Elm Creek Bridges averages about 109,000 tons
21 and ranges from 25,000 tons to about 220,000 tons (Figure 44). The annual bed
22 material sediment loads passing Overton during this period averaged about 1.2M tons
23 and ranged from about 500,000 tons to about 1.9M tons; thus, the annual deficit is in the
24 range of 10 percent of the total load (Figure 45). (For the longer period from WY 1980
25 through WY 2013, the loads averaged 680,000 tons, and ranged from 35,000 tons to
26 4.6M tons, exceeding 2.5M tons in WY 1983, WY 1984, and WY 2011.) The feasibility
27 study modeling indicates that pumping 150,000 tons of sediment per year to the river at
28 the Cook and Dyer Property would reduce the existing approximately 109,000 ton
29 average in-channel deficit in the Overton to Elm Creek reach to about 43,000 tons if finer
30 material ($D_{50} \sim 0.5$ mm) were used for the augmentation and to about 73,000 tons if
31 coarser material ($D_{50}=1.2$ mm) were used (Figure 46).

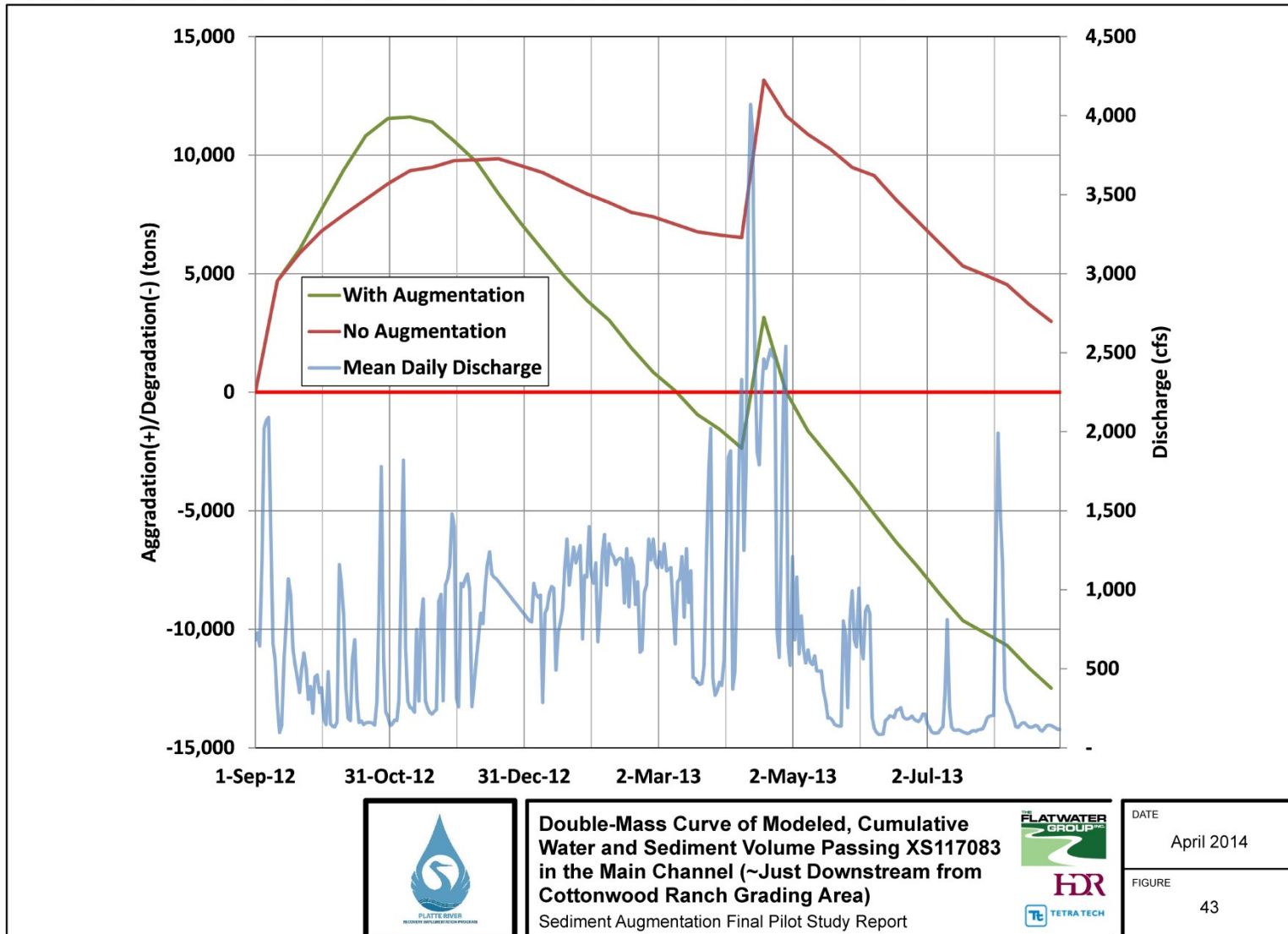
32 It is important to understand that the sediment deficit (or excess) in the reach varies
33 significantly from year to year; thus, decisions based on the average may not produce
34 the desired results (Figure 47). Under no augmentation conditions (that is, baseline), the
35 deficit in the reach between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

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

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



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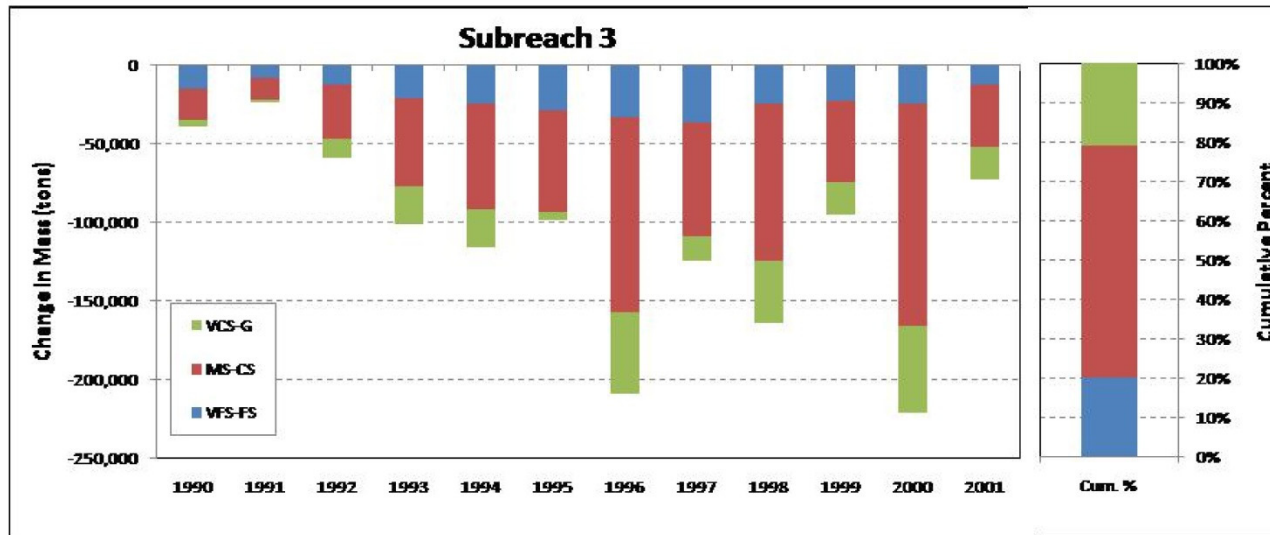


Double-Mass Curve of Modeled, Cumulative Water and Sediment Volume Passing XS117083 in the Main Channel (~Just Downstream from Cottonwood Ranch Grading Area)
Sediment Augmentation Final Pilot Study Report



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FIGURE	43

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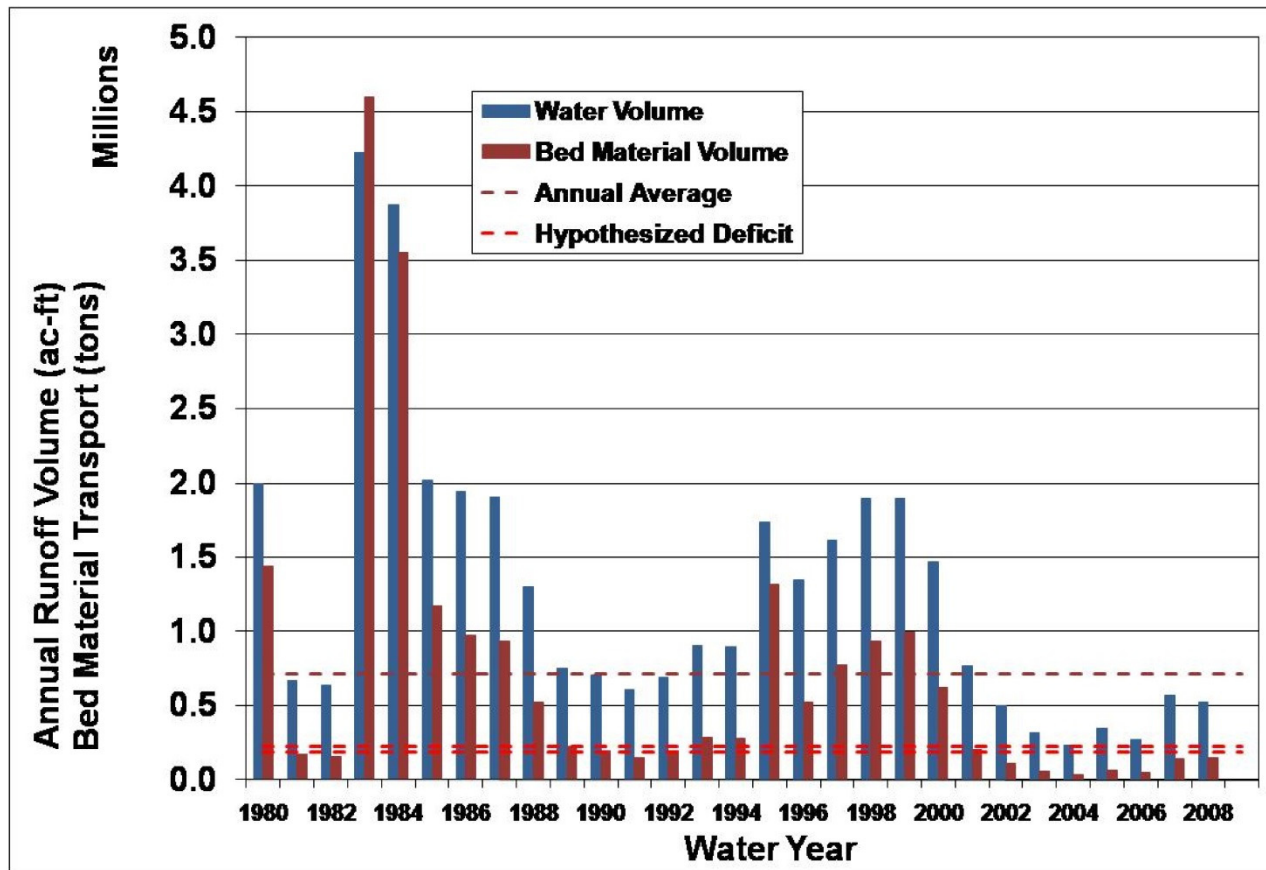
Annual Mass Eroded or Deposited Between the Overton and Elm Creek Bridges by Size Fraction, and the Cumulative Percentage Deposited Under No-Augmentation Condition
Sediment Augmentation Final Pilot Study Report



DATE	April 2014
FIGURE	44



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

Sediment Augmentation Final Pilot Study Report



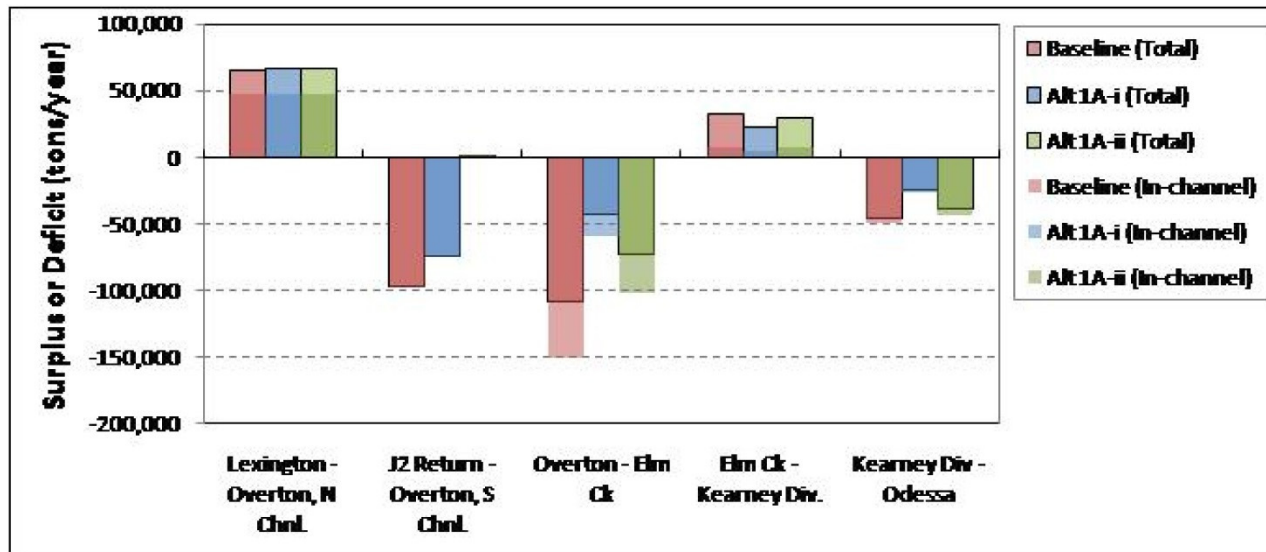
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FIGURE
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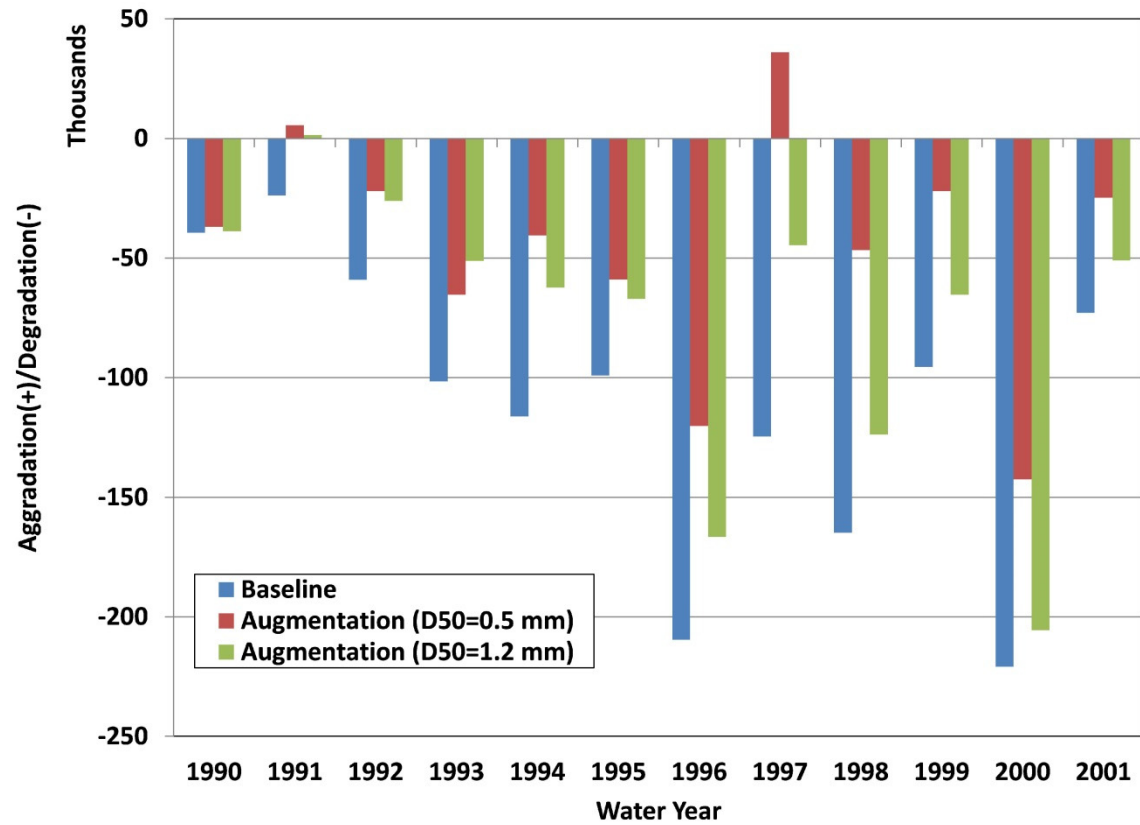
Comparison of Total and In-Channel Surplus or Deficit by Subreach Under Baseline, Alternative 1A-i and Alternative 1A-ii
Sediment Augmentation Final Pilot Study Report



DATE	April 2014
FIGURE	46



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

Sediment Augmentation Final Pilot Study Report



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FIGURE
47



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 be 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.



1 **Proximity of Augmentation Material to Augmentation Sites**

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

8 **Availability of Contractors**

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

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

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

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

23 **Level of Flexibility in Design**

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

29 **Market Conditions for Material Not Used**

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

39 **7.1.2 Land Availability**

40 Land availability is a key concern in determining the viability of a long-term augmentation
41 project. Without agreement from private landowners or additional acquisition of property, the
42 Program is limited in its ability to augment material to lands that are under its control. In
43 addition, a finite amount of material is available on current program lands. It is not anticipated



1 that land availability would be a significant deterrent to full-scale augmentation in the near future
2 (that is, 10 to 25 years). Evaluation during the Screening Study indicated that both pushing
3 material in the river at CWR and onsite mining and sorting material onsite at the Dyer Property
4 have a 10+ year long-term viability.

5 **7.1.3 Permitting**

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

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

18 **7.2 Onsite Production of Material at the Dyer Property using Pumping**

19 **7.2.1 Dyer Property Pumping as Conducted During Pilot Study**

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

38 **7.2.2 Variations in Dyer Property Pumping**

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

41 One option would be to mine and sort the material onsite rather than pump it to the river, create
42 a stockpile of augmentation material on the bank, and use bulldozers to spread the material in
43 the river channel. This would allow greater control of the placement of material and allow it to
44 be manipulated to maximize entrainment. This option would make it easier to match



1 augmentation with flow. While placement efficiency would be improved, costs would likely
2 increase because of additional handling of the material and haul distance from the source pit.
3 Stockpiling the material on the bank also would require management of the discharge water,
4 which could be as simple as creating a drainage channel to the river to drain the water off the
5 stockpile.

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

14 **7.3 Variations in Cottonwood Ranch Bulldozer Pushing**

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

27 **7.4 Other Sand Pit Operators**

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

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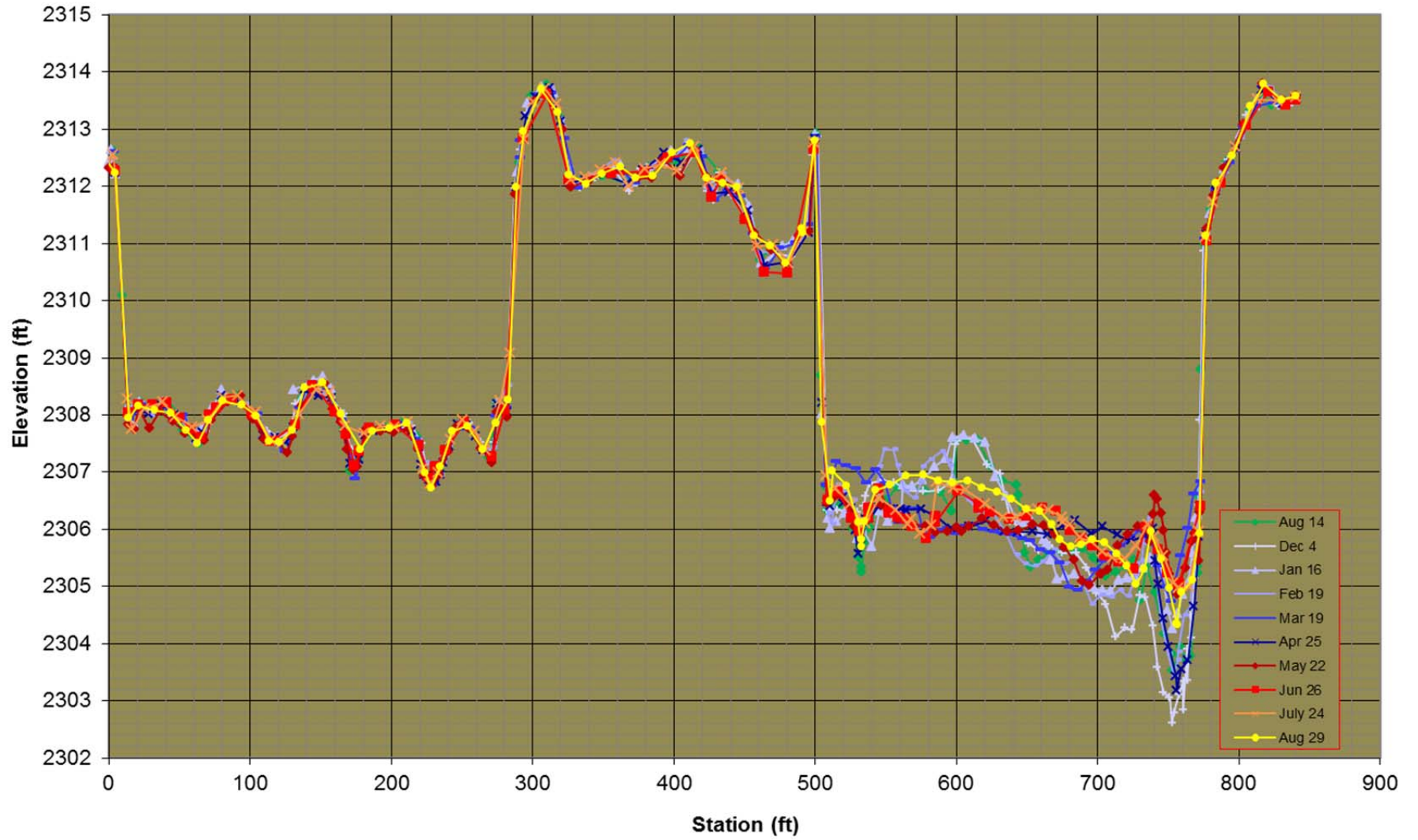
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APPENDIX A

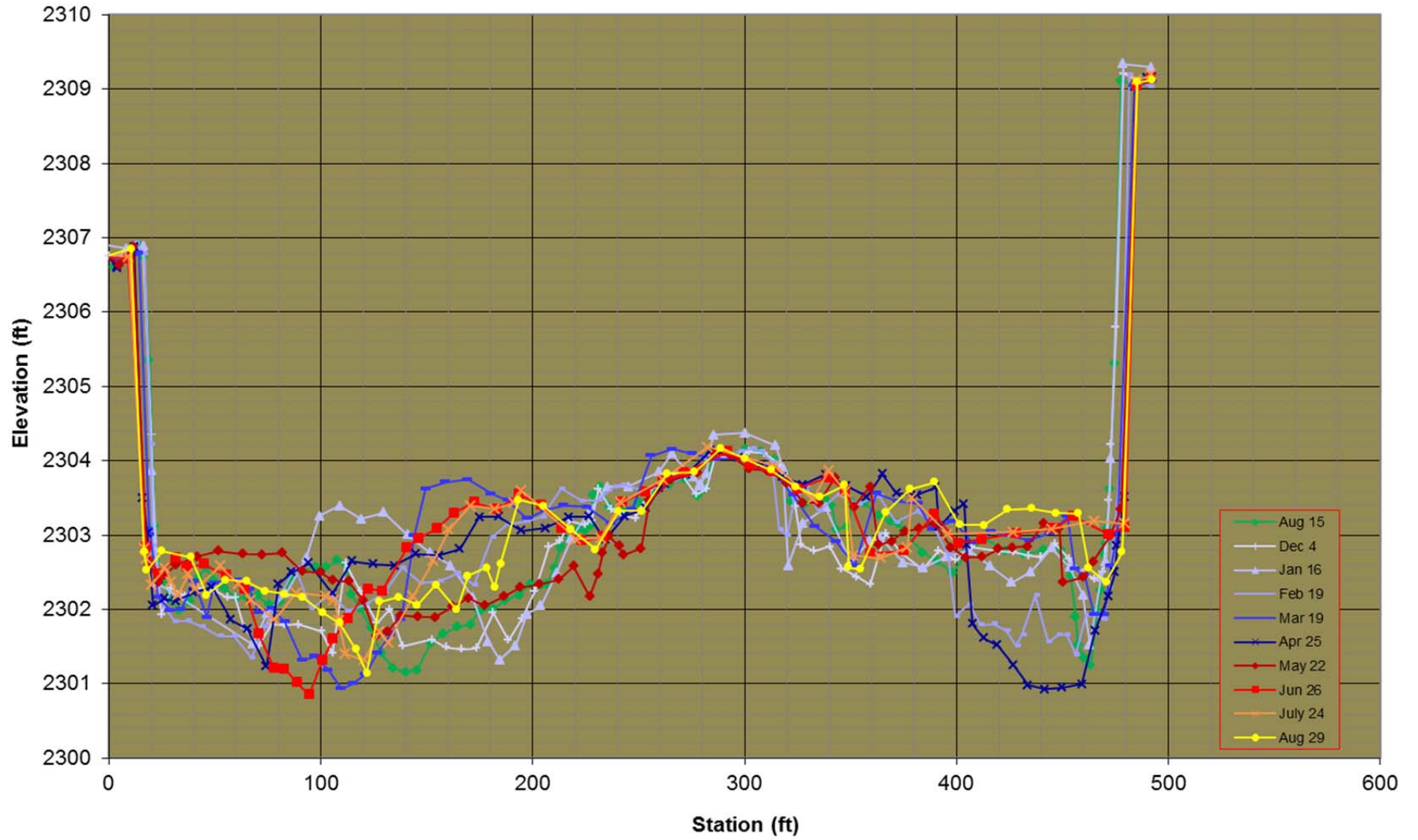
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MONITORING CROSS SECTIONS

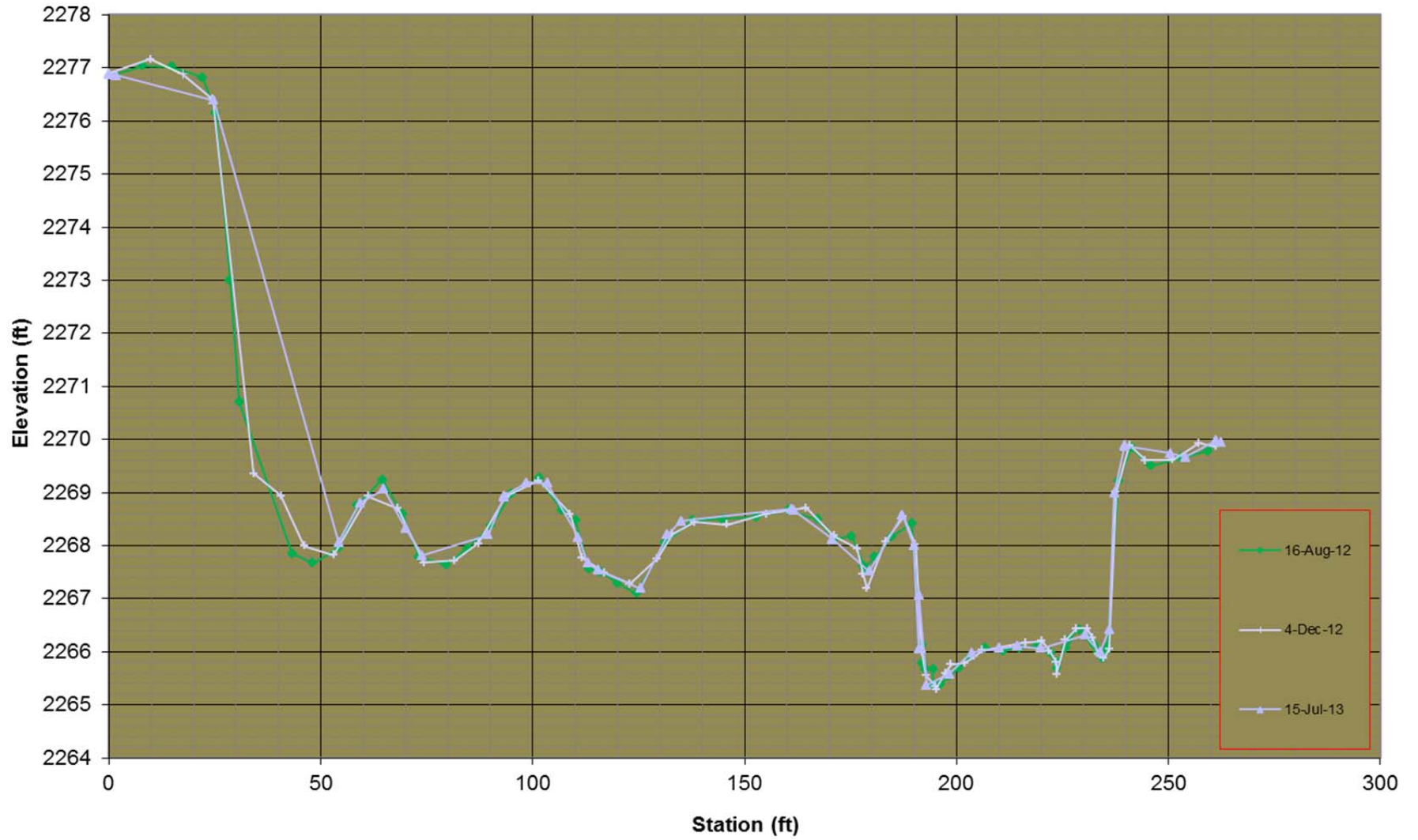
Dyer XS-1 Monitoring Cross-Section Comparison



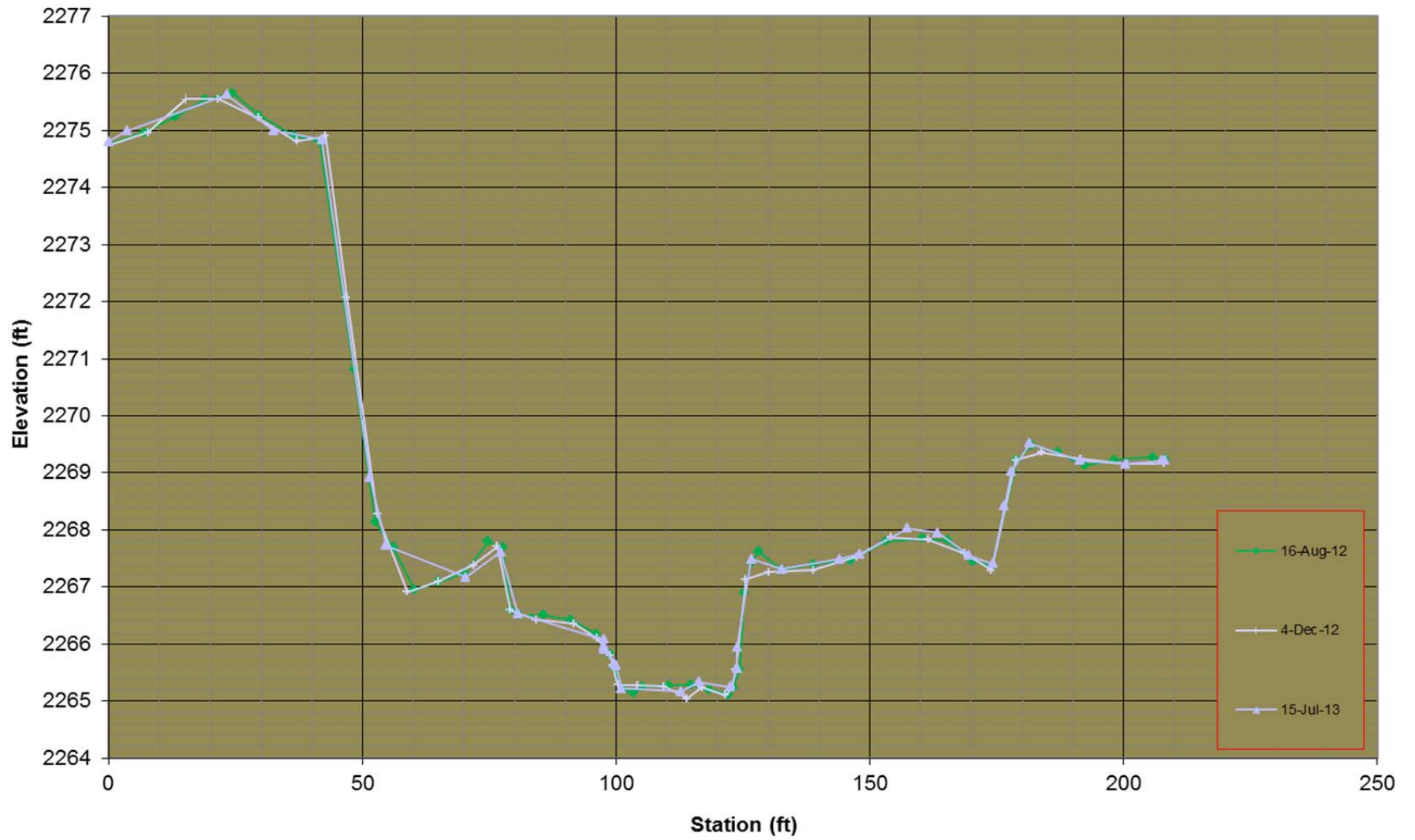
Dyer XS-3 Monitoring Cross-Section Comparison



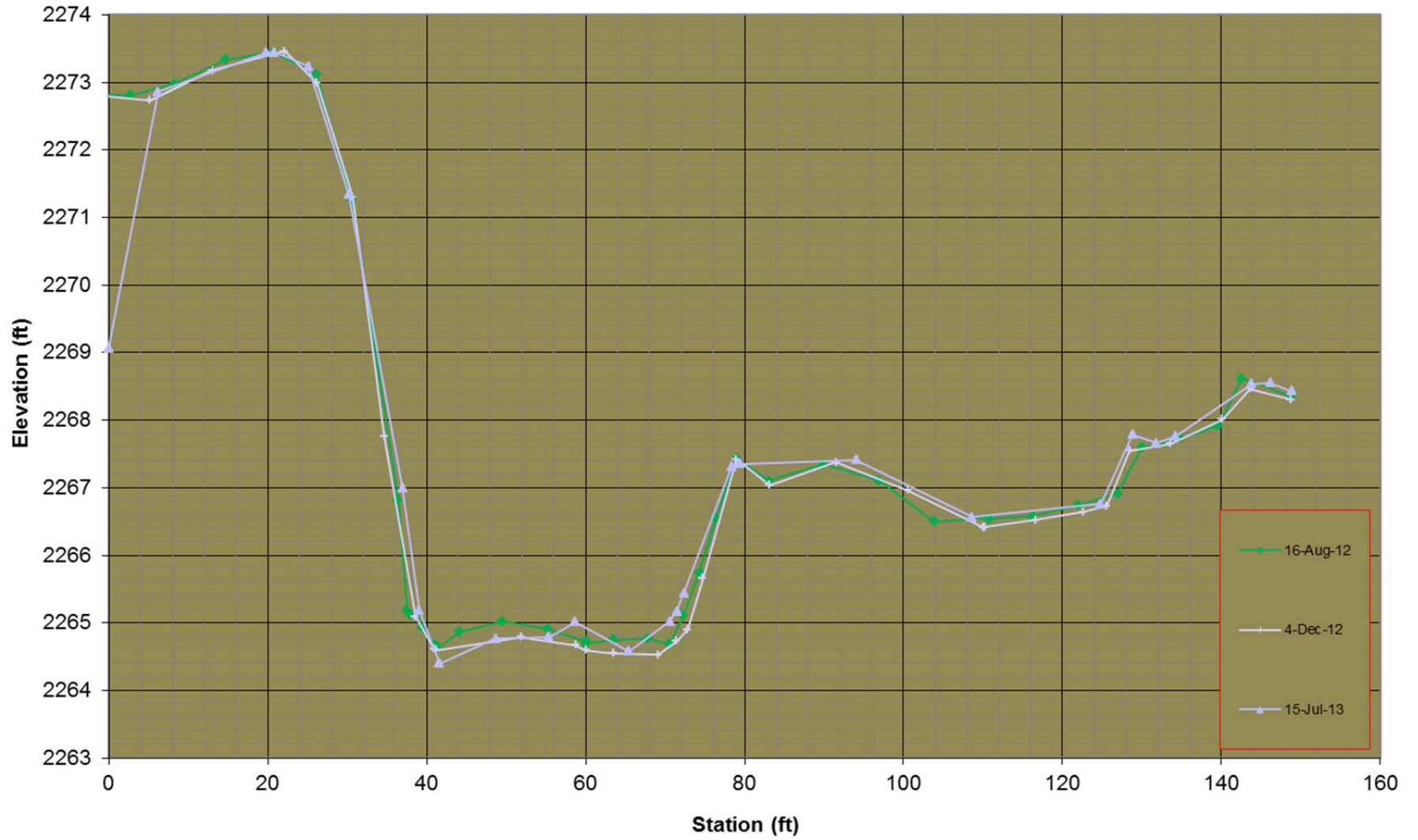
AP32B1 Monitoring Cross-Section Comparison



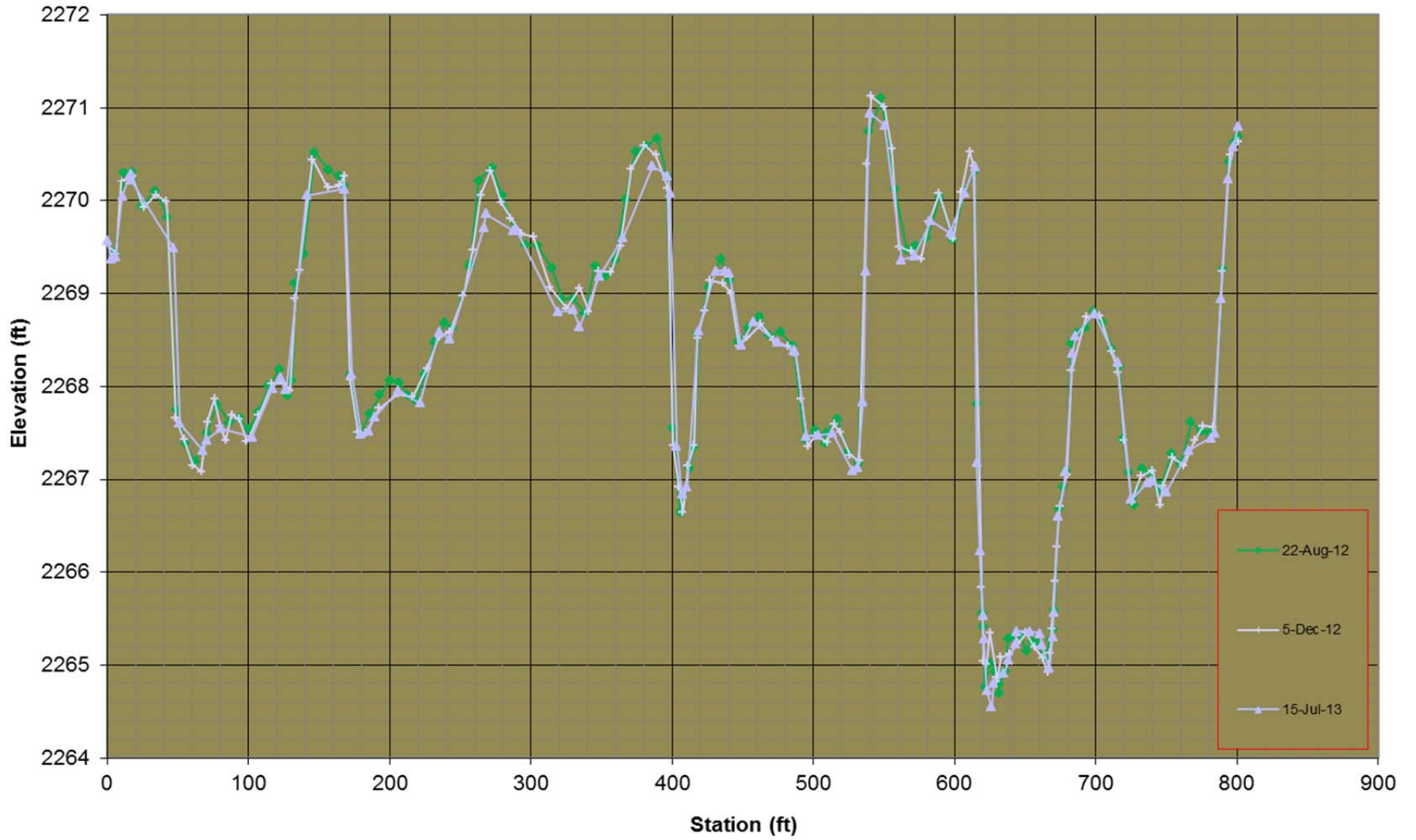
AP32B4 Monitoring Cross-Section Comparison



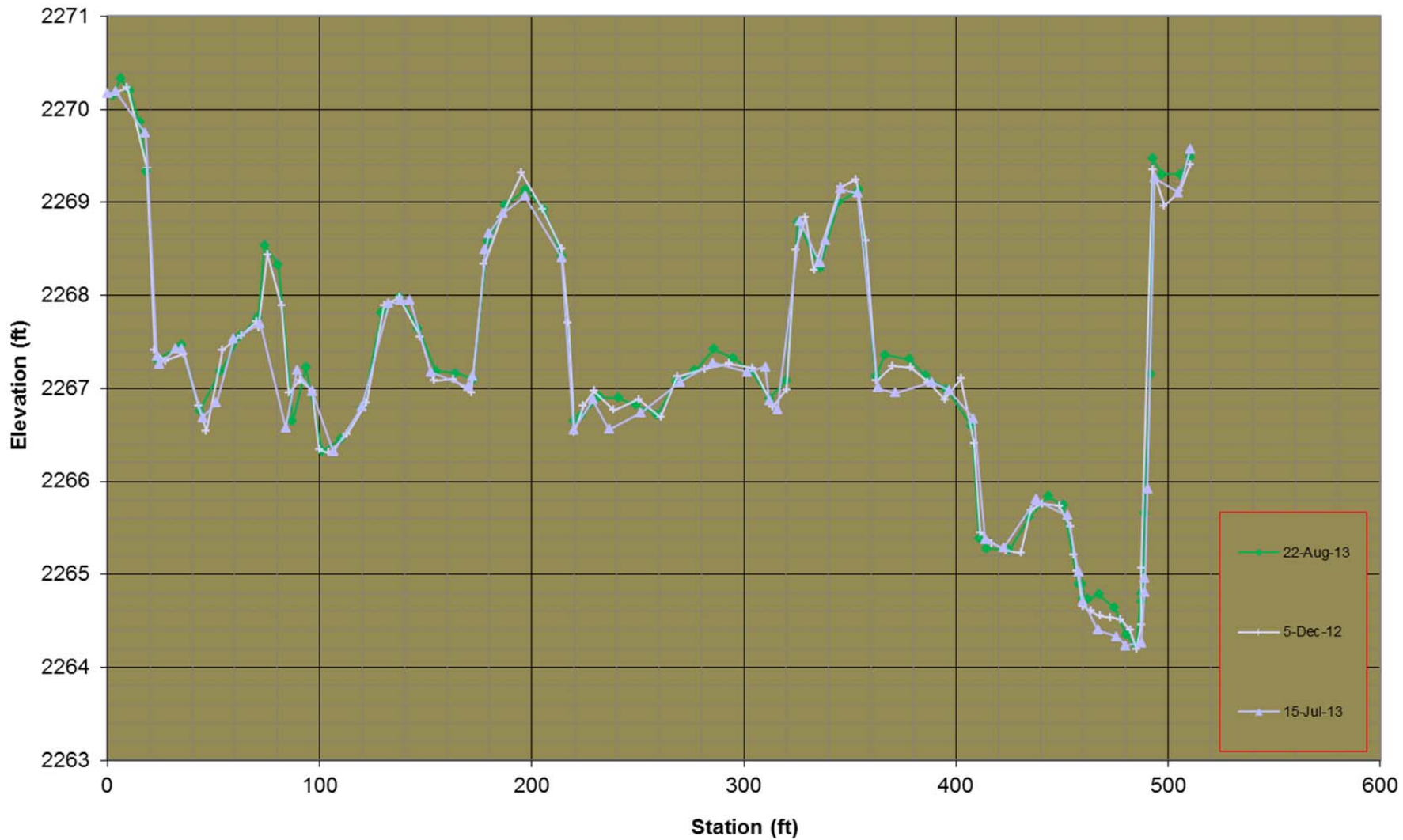
AP32B7 Monitoring Cross-Section Comparison



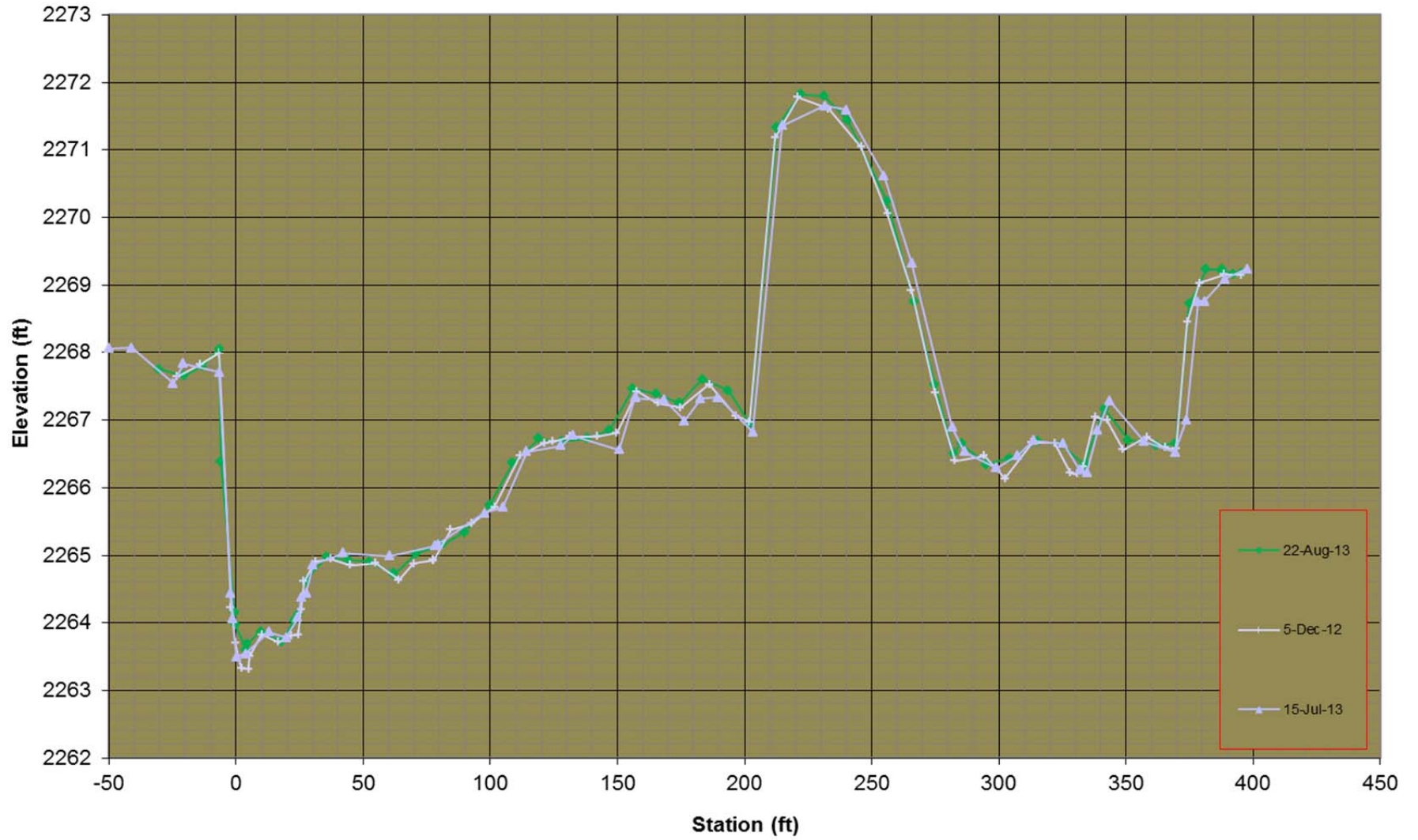
AP32C1 Monitoring Cross-Section Comparison



AP32C4 Monitoring Cross-Section Comparison



AP32C7 Monitoring Cross-Section Comparison



APPENDIX B

1

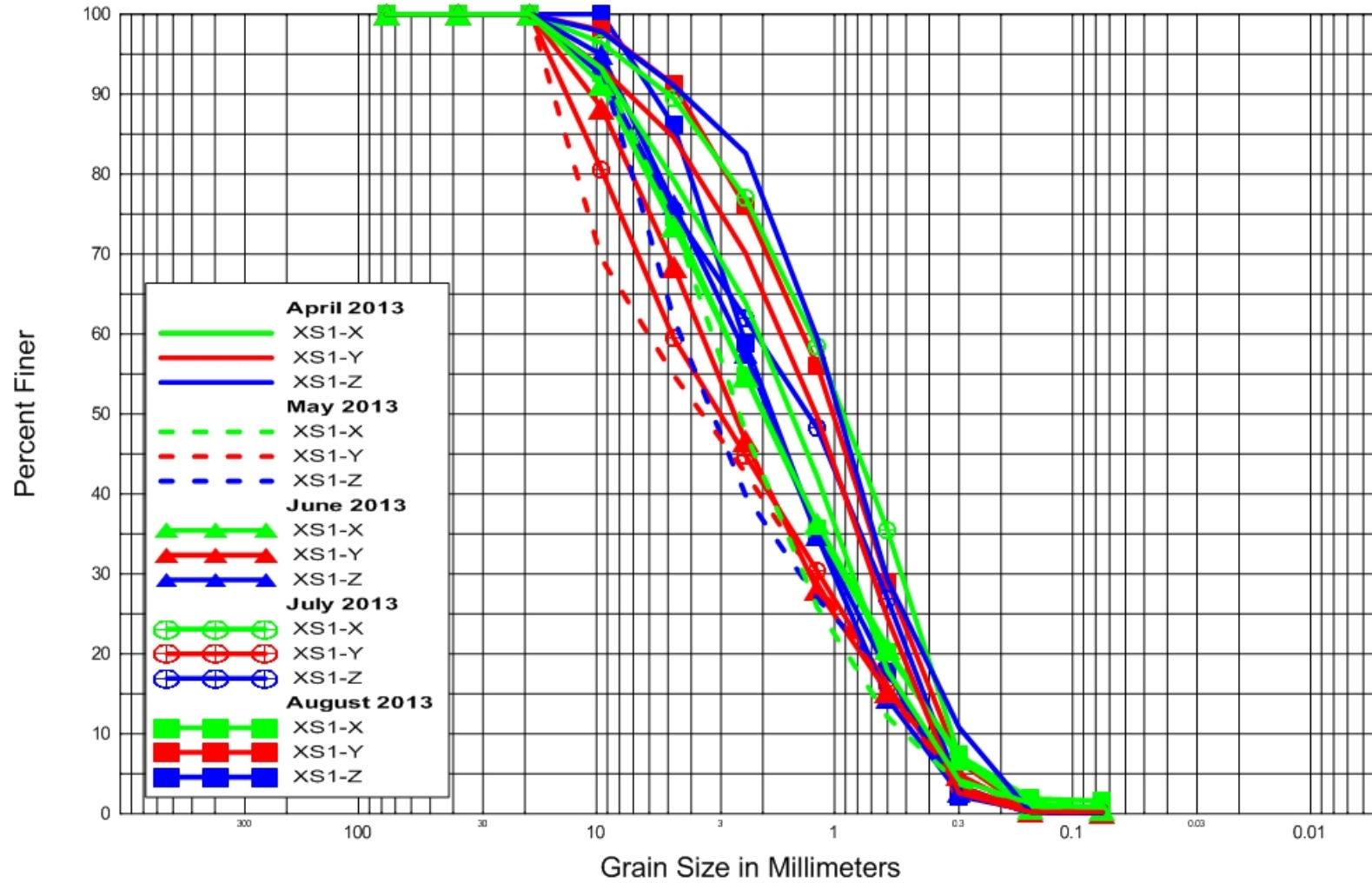
2

3

SAMPLE GRADATIONS

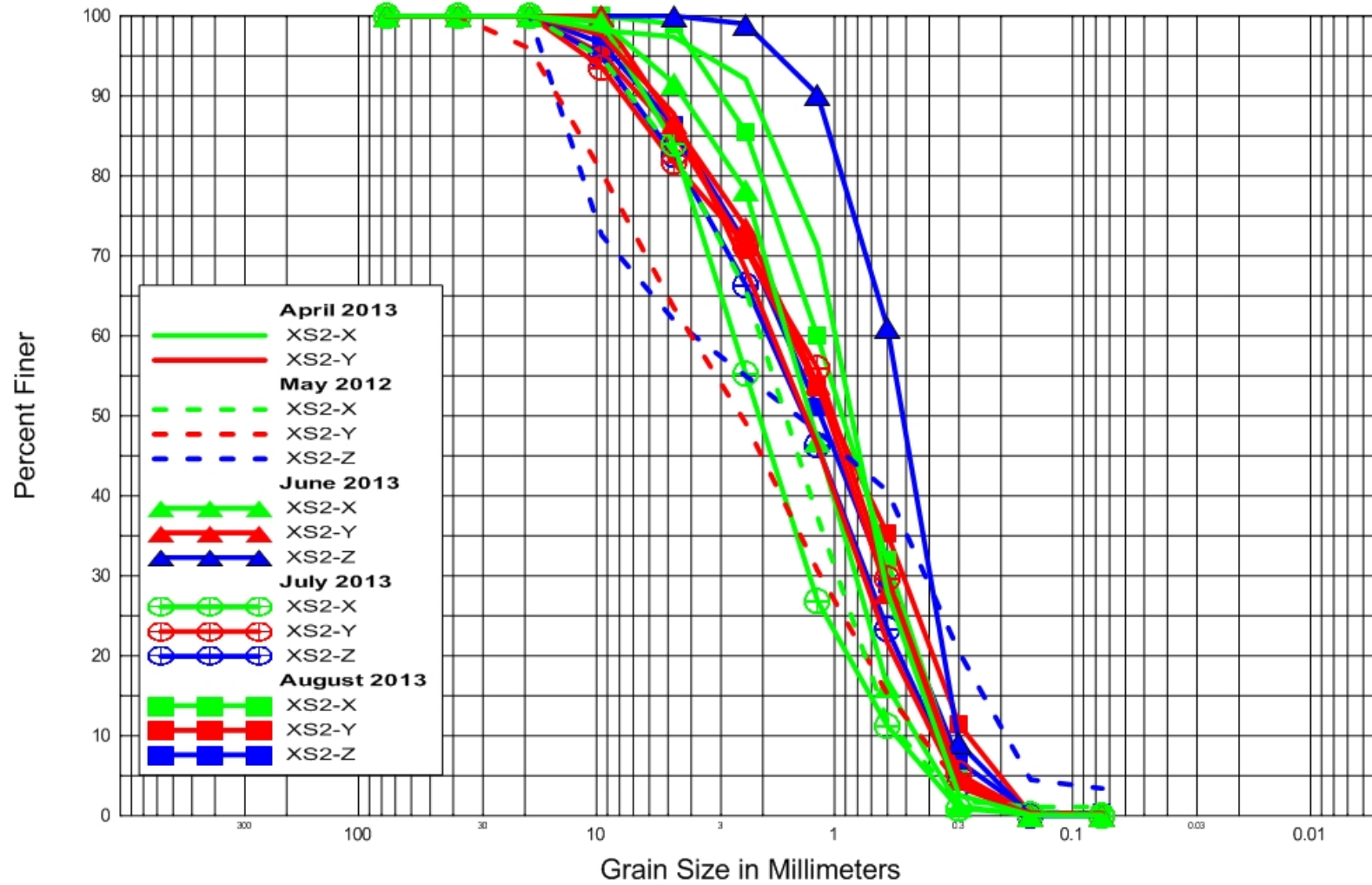
4

Dyer XS1



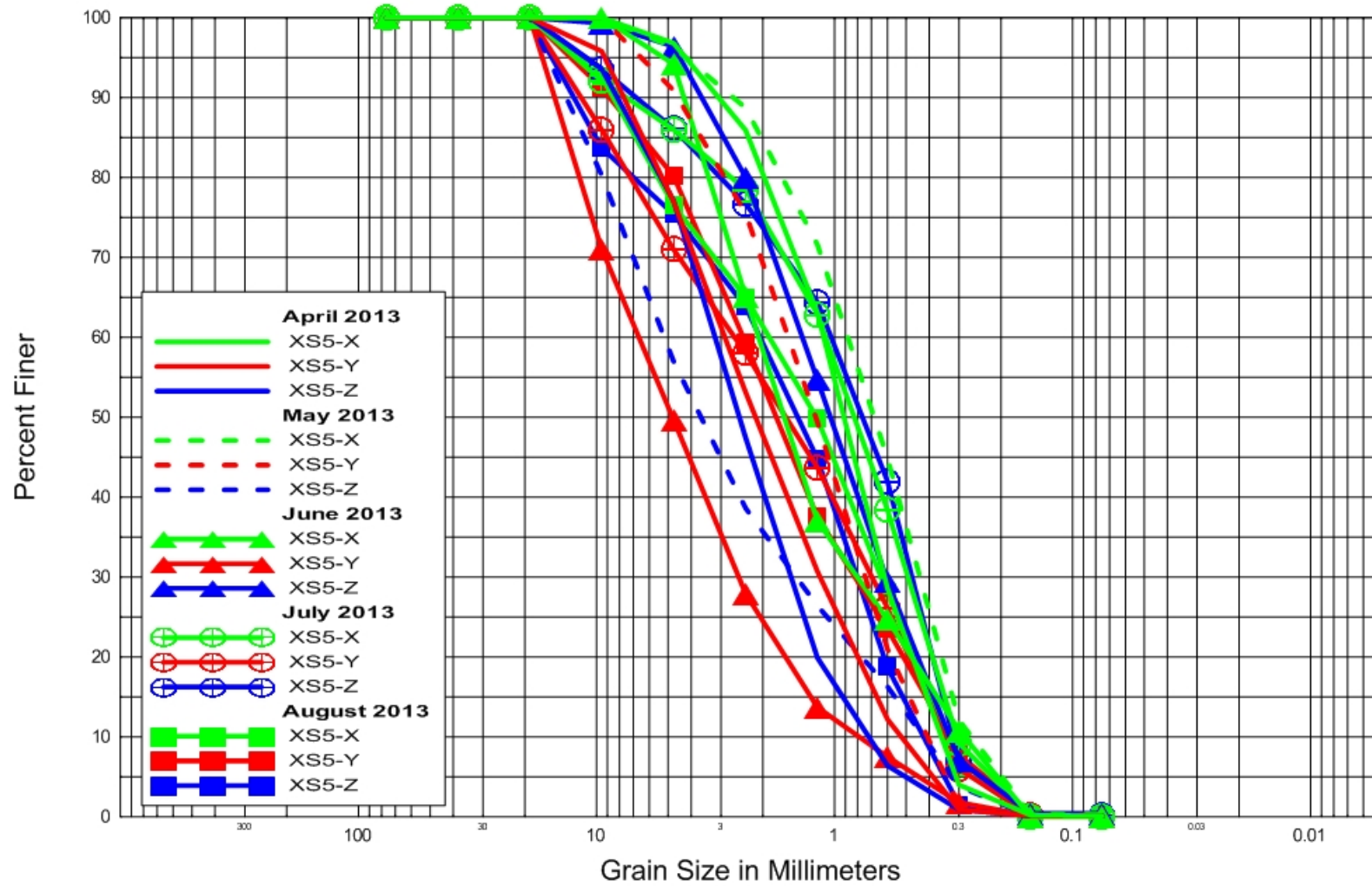
BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

Dyer XS2



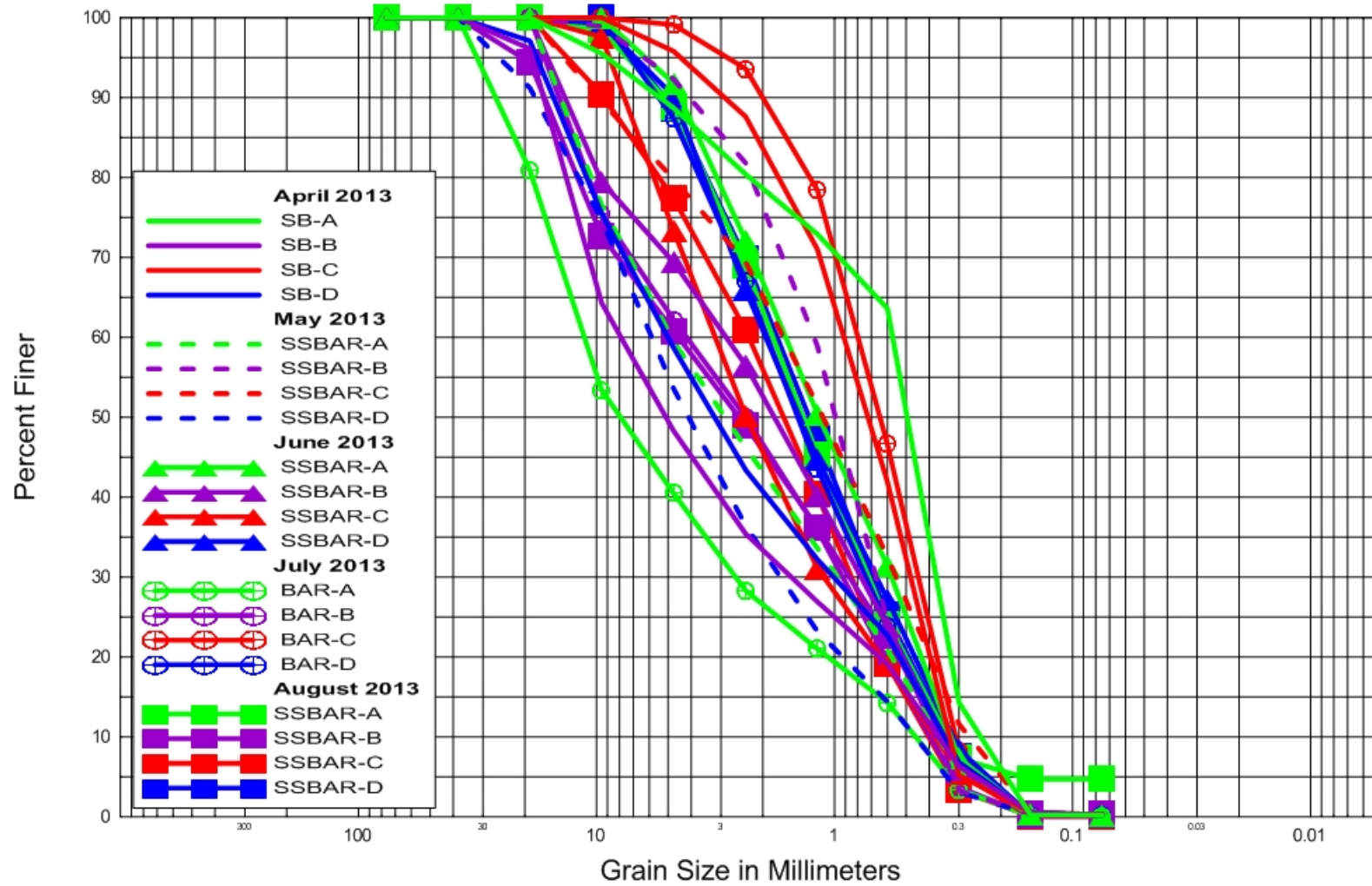
BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

Dyer XS5



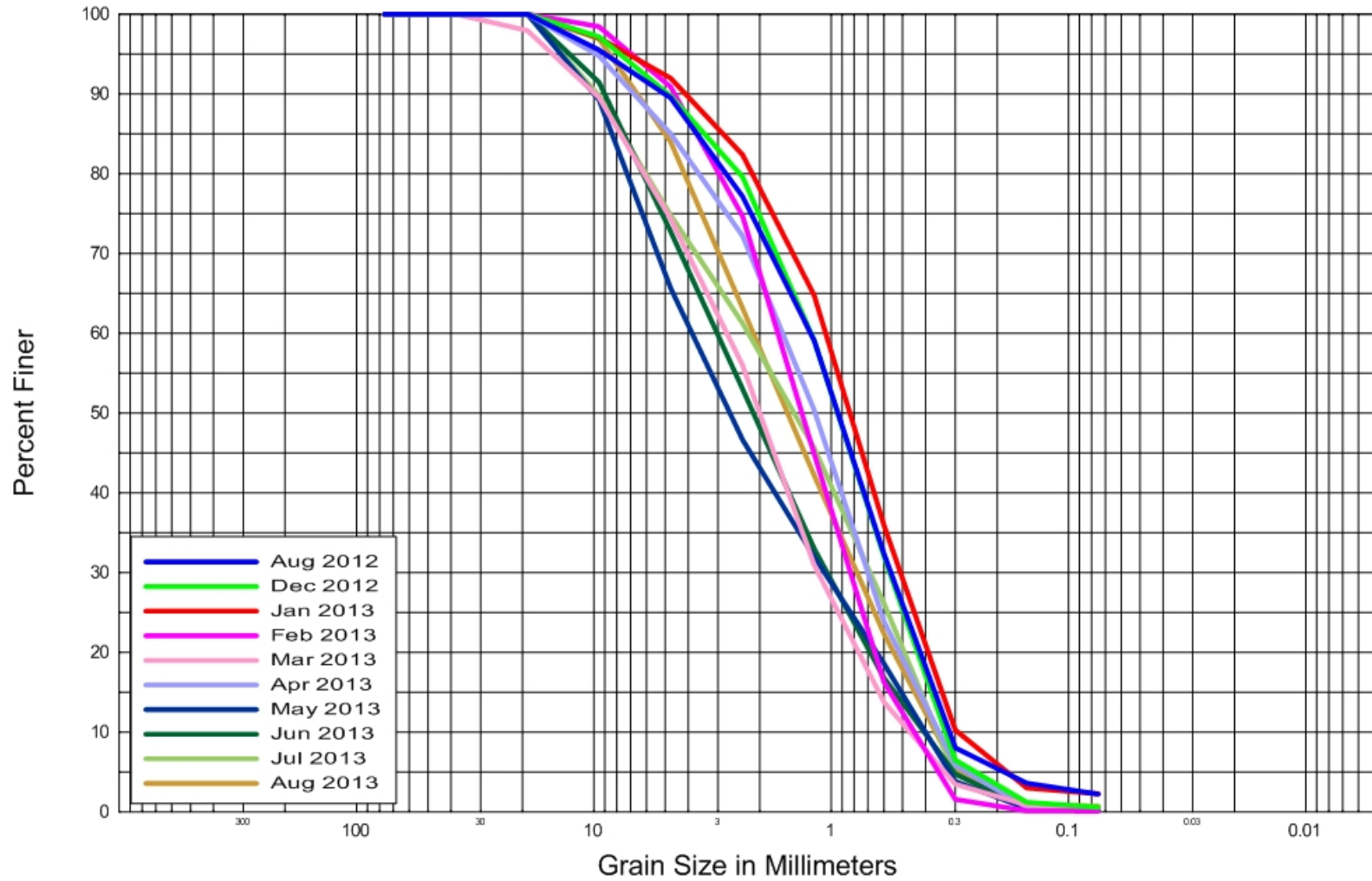
BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

Dyer Bars A through D



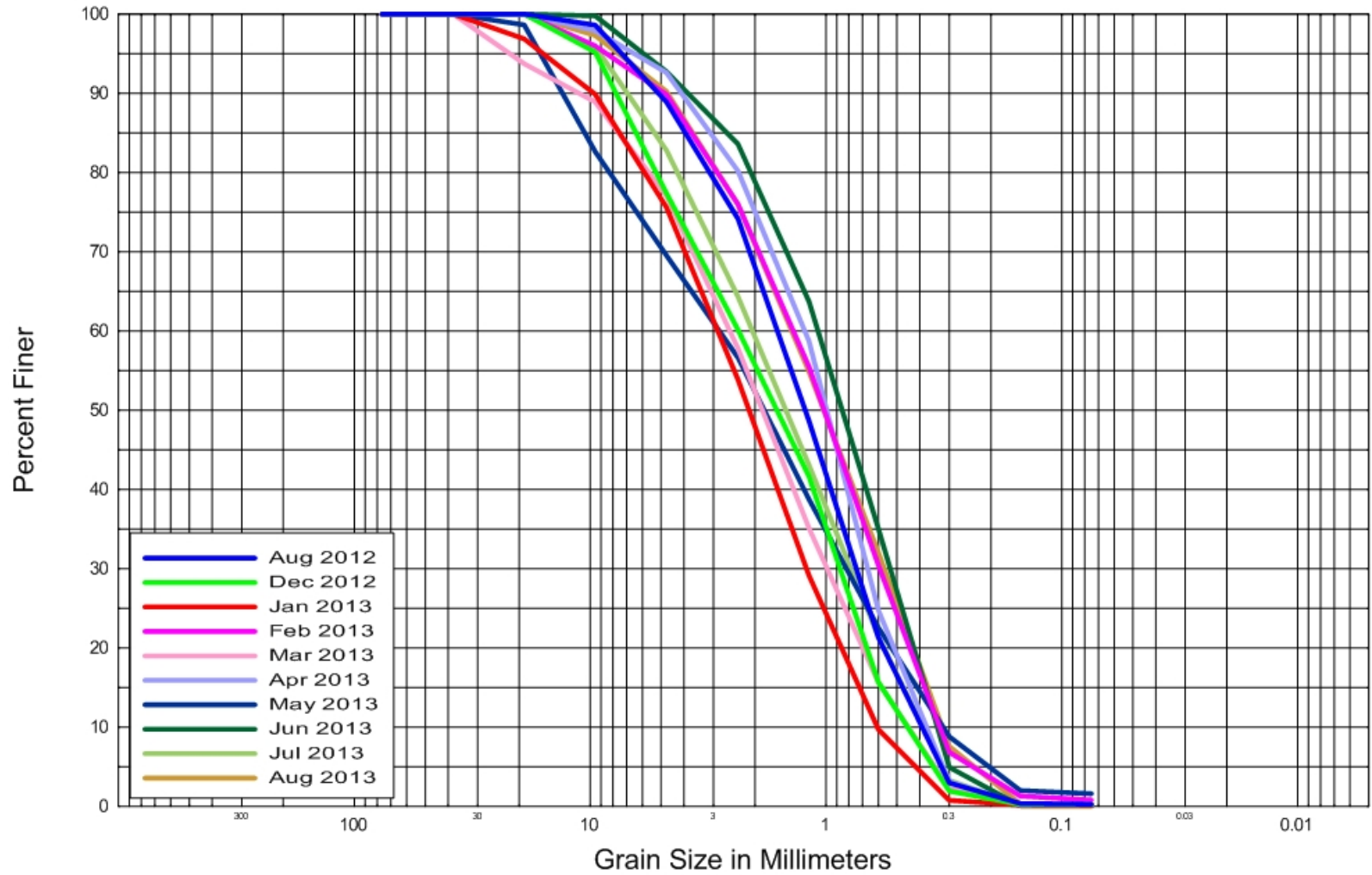
BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

Dyer XS1



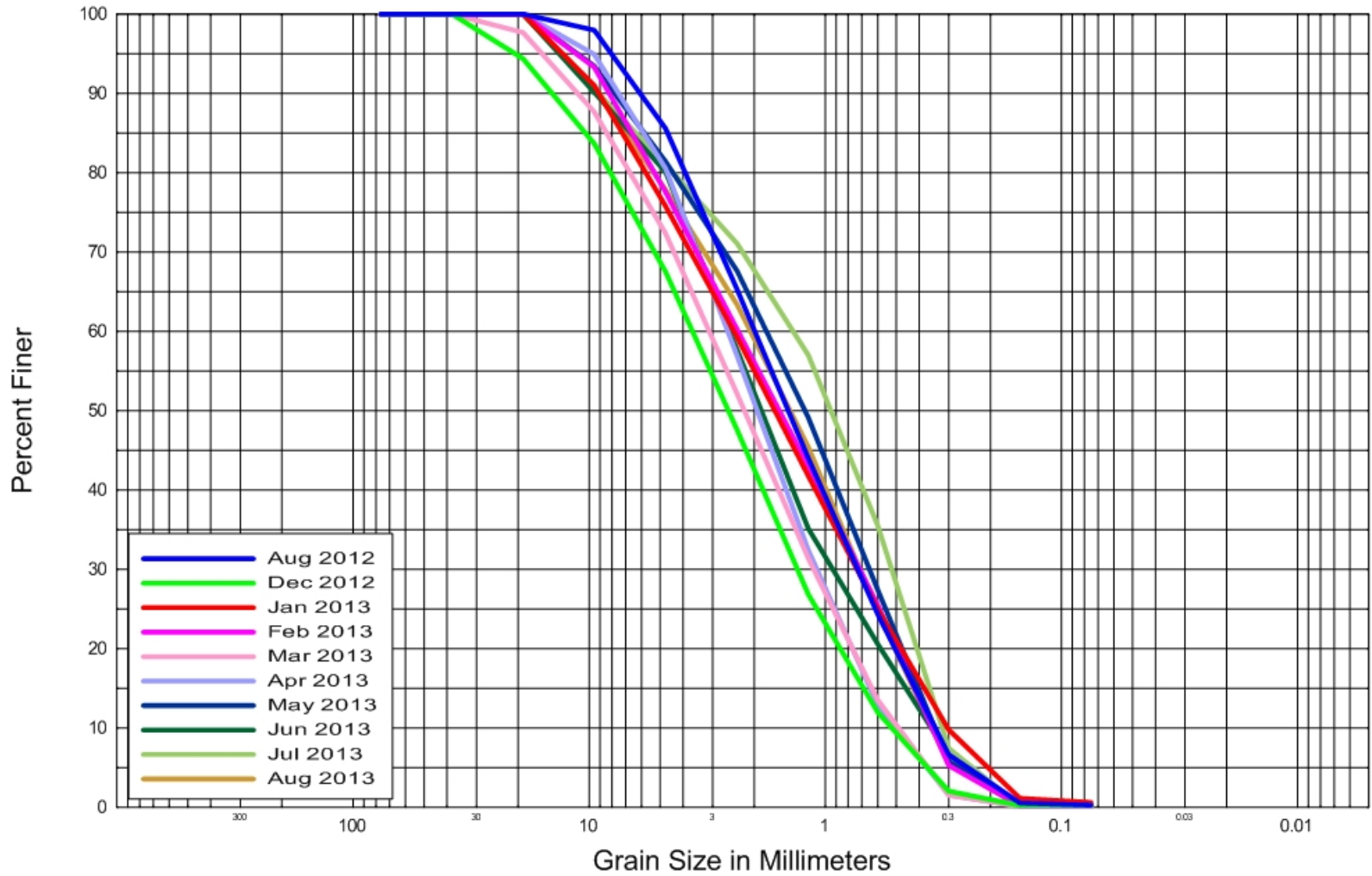
BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

Dyer XS2



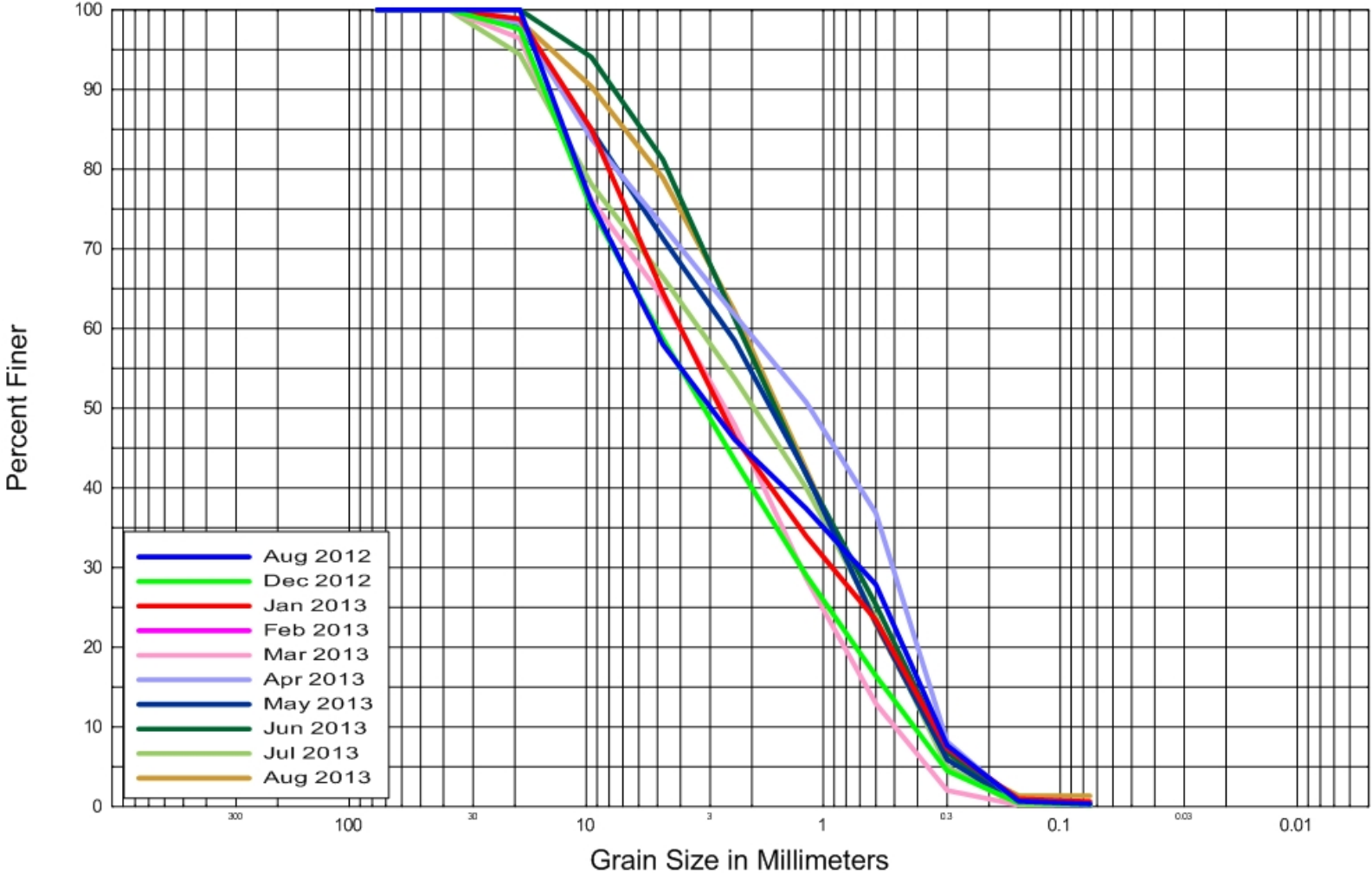
BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

Dyer XS5



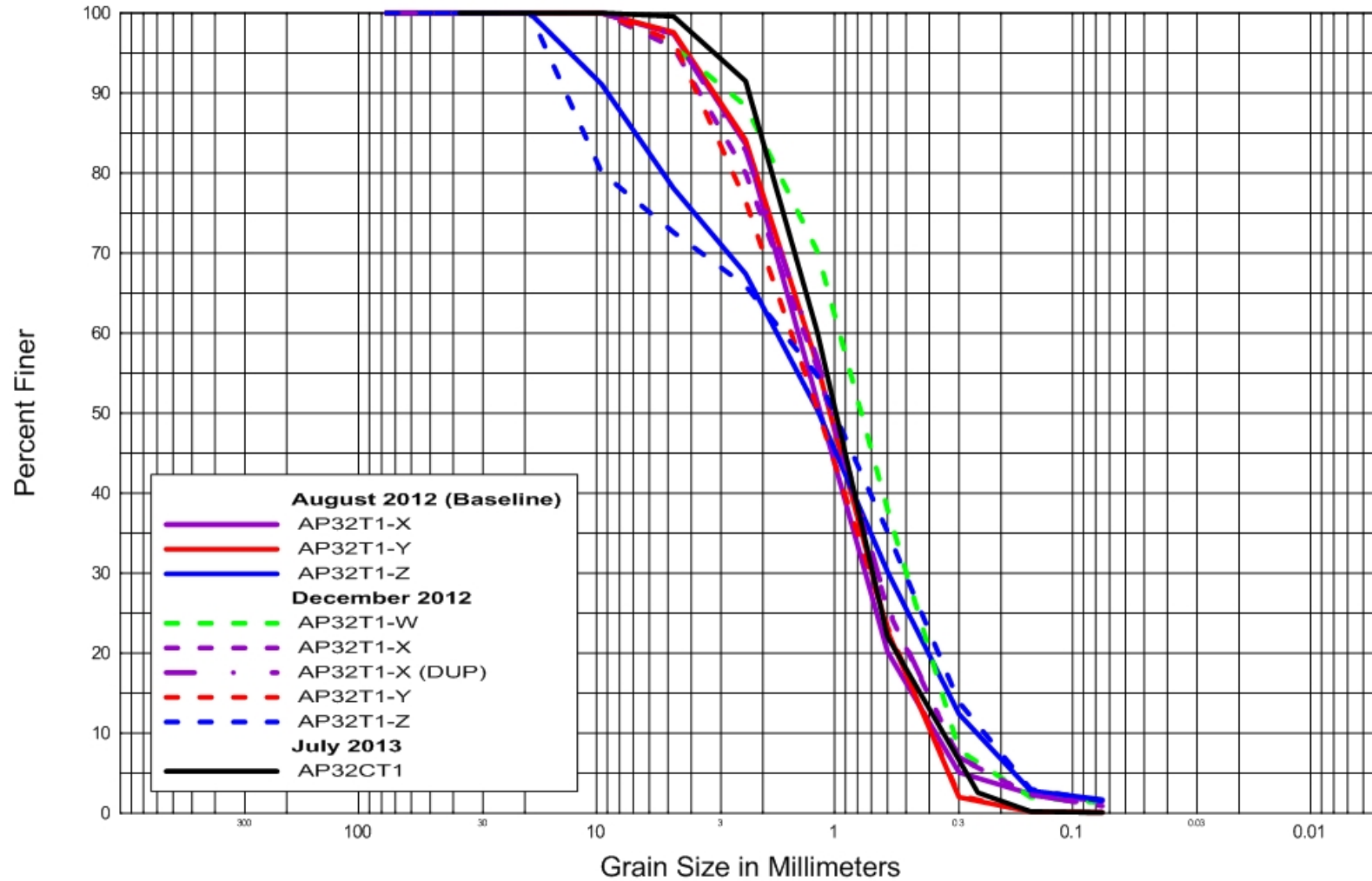
BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

Dyer Bars



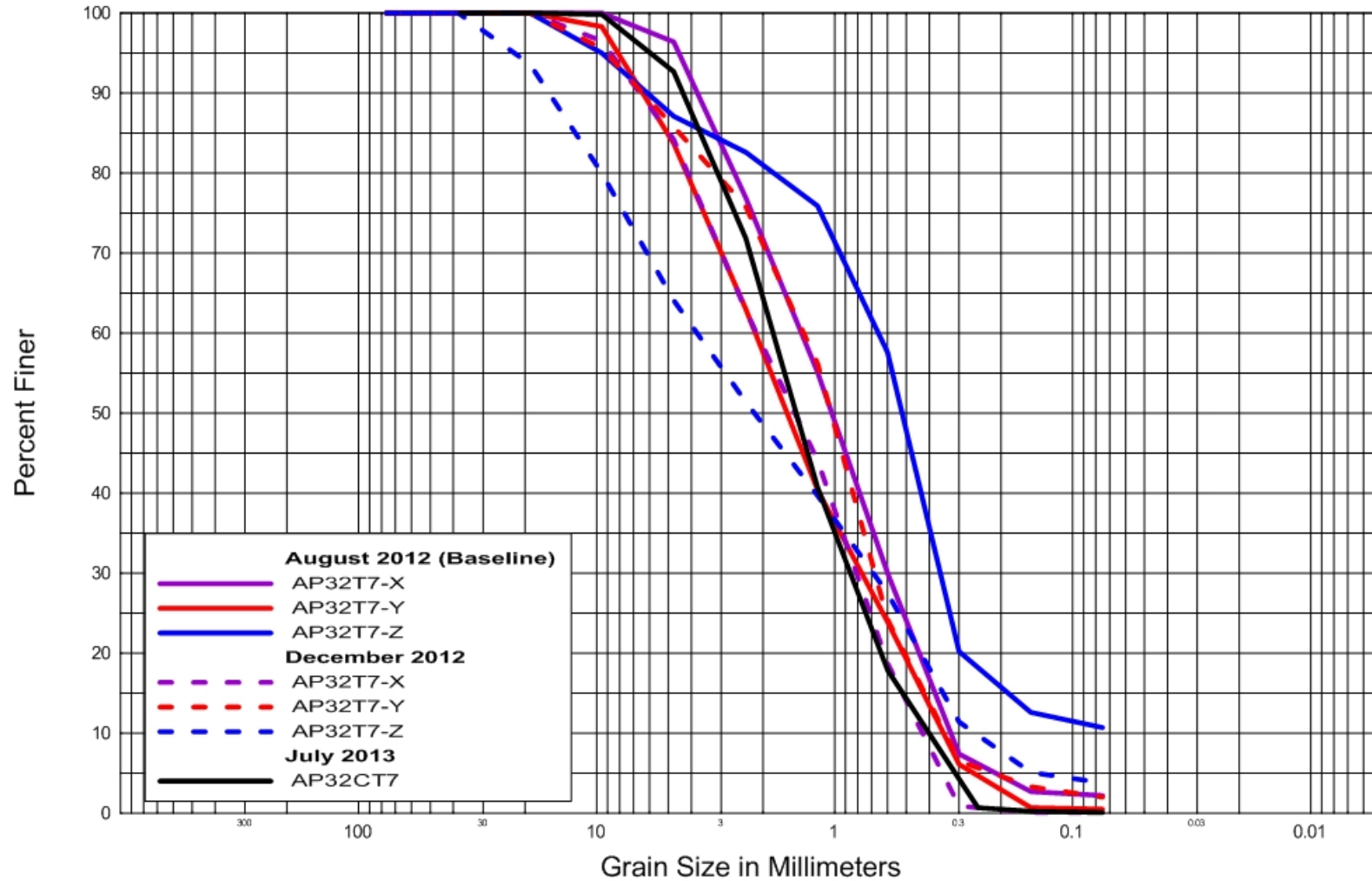
BOULDERS	COBBLES	GRAVEL					SAND					SILT or CLAY
		VC	C	M	F	VF	VC	C	M	F	VF	

AP 32CT1 (South)



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

AP 32CT7 (South)



APPENDIX C

1
2
3
4

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.