Klamath Hydroelectric Project
FERC Project No. 2082

# Klamath Hydroelectric Settlement Agreement
# Interim Measure 7
# J.C. Boyle Gravel Monitoring Report
# 2012

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# KLAMATH HYDROELECTERIC PROJECT SETTLEMENT AGREEMENT
# INTERIM MEASURE 7
# J.C. BOYLE 2012 GRAVEL MONITORING REPORT

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# 1 INTRODUCTION

## 1.1 PROJECT DESCRIPTION

PacifiCorp Energy (PacifiCorp) owns and operates the Klamath Hydroelectric Project (Project), located on the upper Klamath River in Klamath County (south-central Oregon) and Siskiyou County (north-central California). The Project has five dams on the Klamath River-Keno, J.C. Boyle, Copco 1, Copco 2, and Iron Gate; and one dam on the Fish Creek tributary. The Link River dam is owned by the U.S. Bureau of Reclamation. A map of the Project area is shown below (Figure 1.1-1).


**Figure 1.1-1. Location map.**

## 1.2 BACKGROUND

On February 18, 2010, the United States, the States of California and Oregon, PacifiCorp, Tribes, and a number of other stakeholder groups signed the Klamath Hydroelectric Settlement Agreement (KHSA). The KHSA includes provisions and detailed actions for the

interim operation of PacifiCorp's dams and mitigation activities prior to removal of the dams or the termination of the KHSA. One of the measures, titled Interim Measure 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement, requires habitat restoration in the J.C. Boyle bypass and peaking reaches.

As described in Interim Measure 7 of the KHSA, PacifiCorp is to provide funding annually for the planning, permitting, and implementation of gravel placement and habitat enhancement projects, including related monitoring, in the Klamath River above Copco Reservoir and below J.C. Boyle dam. The key objective of this measure is to place suitable gravels in the J.C. Boyle bypass and peaking reaches for resident trout and potential future salmon spawning and ecological restoration purposes. The full text of Interim Measure 7 is included below.

**Interim Measure 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement**

> Beginning on the Effective Date and continuing through decommissioning of the J.C. Boyle Facility, PacifiCorp shall provide funding of $150,000 per year, subject to adjustment for inflation as set forth in Section 6.1.5 of the Settlement, for the planning, permitting, and implementation of gravel placement or habitat enhancement projects, including related monitoring, in the Klamath River above Copco Reservoir.
>
> Within 90 days of the Effective Date, PacifiCorp, in consultation with the IMIC, shall establish and initiate a process for identifying such projects to the Committee, and, upon approval of a project by the Committee, issuing a contract or providing funding to a third party approved by the Committee for implementation of the project.
>
> The objective of this Interim Measure is to place suitable gravels in the J.C. Boyle bypass and peaking reach using a passive approach before high flow periods, or to provide for other habitat enhancement providing equivalent fishery benefits in the Klamath River above Copco Reservoir. Projects undertaken before the Secretarial Determination shall be located outside the FERC project boundary.

Interim Measure 7 falls under the auspices of the Interim Measures Implementation Committee (IMIC). The IMIC is comprised of state, federal, tribal and private signatories to the KHSA whose purpose is to collaborate with PacifiCorp on ecological and other issues related to the implementation of several Interim Measures as set forth in Appendix D of the KHSA. The IMIC formed a technical subcommittee comprised of representatives from the Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Water Resources (ODWR), the Klamath Tribes, PacifiCorp, and the Bureau of Land Management (BLM) to discuss the goals, objectives, regulatory requirements, and planning for Interim Measure 7. This subcommittee recommended the development of a long term gravel enhancement plan that would cover the expected time period (2010-2020) for implementation of Interim Measure 7.

Per the KHSA, PacifiCorp developed the J.C. Boyle Gravel Placement and Monitoring Plan (Plan) in the spring of 2011 (Mason, Bruce and Girard, et al. 2011). The Plan details monitoring objectives, methods for both gravel placement and monitoring, and annual reporting requirements. In November 2011, approximately 500 cubic yards of gravel was placed at 2 locations in the Klamath River below the J.C. Boyle powerhouse (J.C. Boyle peaking reach). In October 2012, approximately 675 cubic yards of gravel were placed at three sites: two in the bypass reach and one in the peaking reach. This document describes the second year of monitoring (2012-2013) under Interim Measure 7.

### 1.3 MONITORING OBJECTIVES

The monitoring objectives outlined in the Plan include assessments of both the implementation and effectiveness of gravel enhancements under Interim Measure 7. Field observations related to implementation were intended to answer three primary questions:

1. Were placement methods cost-effective and implemented within the proposed budget constraints?

2. Were placement procedures safe and effective for getting gravel placed in the intended locations and quantities?

3. Were there any unanticipated problems in either the implementation or the effectiveness of the placements?

Effectiveness monitoring is intended to evaluate whether the placed gravel distributed and sorted as predicted given the flow regime experienced during the performance period (October through June). Effectiveness monitoring is designed to provide data to answer the following specific gravel distribution/sorting questions for each gravel placement site:

- Did the flows that occurred since the previous gravel placement result in movement (scour) of the placed gravel?

- Did the flows that occurred since the previous gravel placement result in a change in channel cross section (net scour or aggradation) across the gravel placement site or some distance downstream?

- Did the gravel placement result in a change in substrate composition across the gravel placement site or some distance downstream?

Methods used for both implementation and effectiveness monitoring are described below.

## 2 METHODS

### 2.1.1 Implementation Monitoring

Implementation of the gravel placement was addressed primarily through a questionnaire given to PacifiCorp's project manager and the gravel placement contractor foreman. Responses addressed gravel quantities, the methods and safety of gravel placement activities, and any recommended actions to improve placement methods or related operations.

### 2.1.2 Effectiveness Monitoring

Effectiveness monitoring methods (described below) were designed to determine whether placed gravel distributed and sorted as intended given the flow regime experienced during the monitoring period.

At each gravel placement site, transects are established for cross section and substrate composition measurements based on site and safety considerations. One transect is located within the gravel placement area and, if feasible, a second approximately 50-100 feet downstream. Two to three headpins are established to allow the same transect to be re-monitored each year. A permanent benchmark is also established at each gravel augmentation site using a bolt in a small concrete pad or rock bolt drilled into bedrock or a large stable boulder. The headpin and benchmark locations are recorded in GPS, triangulated from obvious landmarks, and photographed to assist with future relocation.

Using a laser level and survey rod, each of the transects is surveyed along a tape strung between the end pins. The elevation relative to the benchmark is recorded at one-foot intervals. At each survey station within the normal wetted water channel, the particle at the base of the survey rod is picked up and passed through a gravelometer to measure grain size and replaced on the bed. Surveying continues across the entire transect if possible. If deep/fast water precluded measurement across the entire length of some transects; measurements were made as far as safely possible along these transects.

Transects across two of the three intended gravel placement areas were surveyed in July 2012 (RM 224.5 and RM 223.8) prior to gravel placement. No pre-gravel placement transects were measured at RM 219.9 due to safety concerns – fast, deep water with little river bank exposed. Gravel was placed on October 24-25, 2012. However, gravel could not be placed at the original RM 224.5 site using the existing gravel placement methods, so it was placed at an alternate site (approximately 350 feet upstream) where no pre- gravel placement transects had been established. Following gravel placement, two transects were established and surveyed at the alternate RM 224.5 location and one partial transect (the measured transect did not cover the entire river width) was established at RM 219.9. The transects at RM 223.8 were also surveyed immediately following gravel placement. All transects were surveyed again on June 18-19, 2013. Results were recorded and entered into a spreadsheet program for analysis.

Four sliding bead scour monitors (Shuett-Hames et al. 1999) were inserted within the gravel along/close to the transect intersecting each gravel placement area on October 24-25, 2012 (Figure 2.1-1). Depth of scour and fill were recorded for each monitor on June 18-19, 2013.

**Figure 2.1-1. Scour monitor placement.**

# 3 RESULTS

Gravel was placed at three sites in October 2012: approximately 225 cubic yards at RM 224.5 (alternate site); 105 cubic yards at RM 223.8; and 250 cubic yards at RM 219.9 (Figure 3.1-1). These sites were monitored in June 2013 to determine: 1) if flows during the intervening time had transported any gravel; and 2) if additional gravel should be added to the sites where gravel had been placed in 2012.

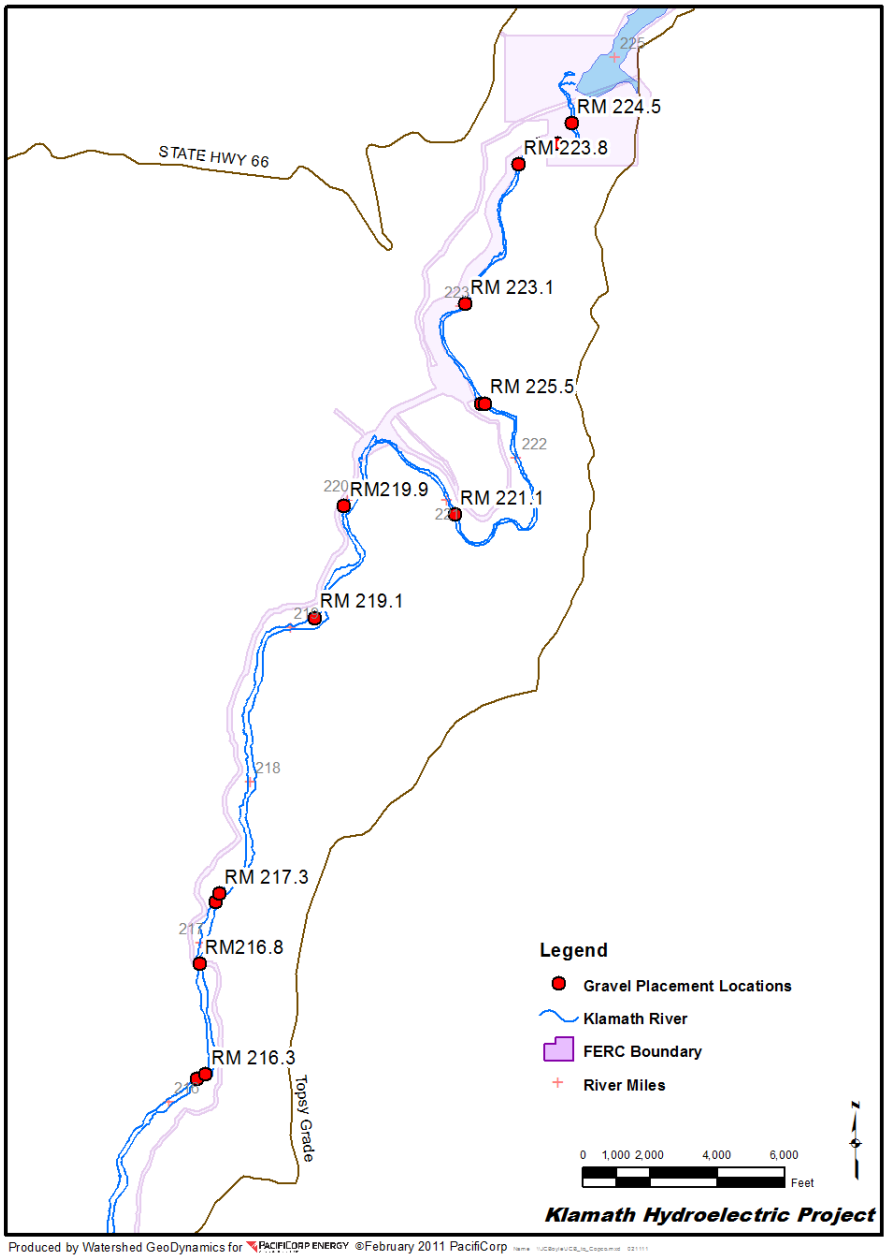


**Figure 3.1-1. Potential gravel placement locations identified in monitoring plan.**

## 3.1 POST-GRAVEL PLACEMENT FLOWS

One gravel placement site (RM 219.9) is located in the peaking reach downstream of the J.C. Boyle powerhouse and the other sites are located in the bypass reach (RM 224.5 and 223.8). Fifteen-minute flows at the USGS gage downstream of the J.C. Boyle powerhouse (USGS 1151070) were collected from the USGS website. These flows are provisional and have not been finalized by the USGS but are unlikely to change substantially since there were no high flows to alter the hydraulic control. Post gravel placement flows (October through June) ranged from 358 to 1,970 cfs (Figure 3.1-2). There was no spill at J.C. Boyle dam and into the bypass reach between gravel placement (October 2012) and the June 2013 monitoring trip.

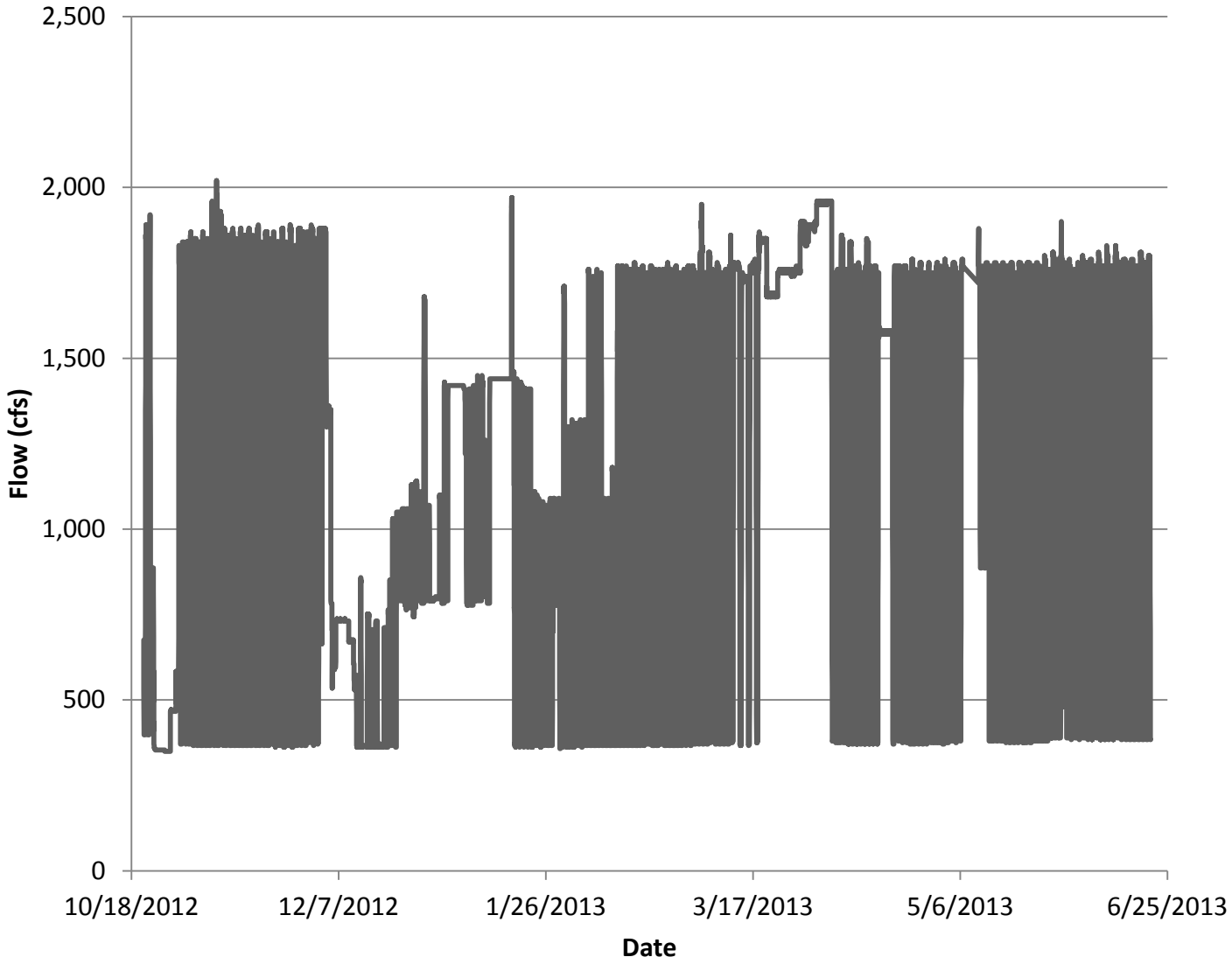


**Figure 3.1-2. Post- gravel placement flows at USGS gage 1151070, October 2012-June 2013**

## 3.2 IMPLEMENTATION MONITORING

Implementation monitoring questionnaires were filled out by the PacifiCorp project manager and the construction foreman to determine the amount of gravel placed, placement costs, and any efficiency/safety issues. Responses are compiled below (Table 3.2-1). Approximately 250 cubic yards of gravel was placed using gravel shooter trucks at the RM 219.9 site. Due to the distance from the road to the river, the gravel shooter truck could not reach the designated RM 223.8 or 224.5 sites. At the RM 223.8 site, , the rock was transferred and placed using a hopper and temporary 12-inch diameter pipe that went from the road, down the hillside, and out into the river to the placement area (Figure3.2-1). At the original RM 224.5 site, there was a bench at the base of the slope that precluded placement using the pipe/sluice method (gravel would get stuck in the bend in the pipe at the base of the slope). An alternate RM 224.5 site was chosen on the left bank of the river approximately 350 feet upstream from the original RM 224.5 site. No safety issues were encountered during placement.

**Table 3.2-1. Implementation monitoring questions.**

| Monitoring Question | 2012 Results |
|---|---|
| How may cubic yards of gravel were placed at each site? | RM 224.5 – 225 cubic yards<br>RM 223.8 – 105 cubic yards<br>RM 219.9 – 250 cubic yards |
| What was the average cost/yard of gravel placement? | Approximately $245/cu yard |
| Were the placement methods (truck/helicopter) able to place gravel where planned? | No. Gravel shooter/slinger could not reach the originally designated RM 224.5 site or RM 223.8 site. A modified pipe/sluicing method was used to place gravel at the RM 223.8 site, and an alternate site was chosen close to the original RM 224.5 site. |
| Were any safety issues encountered? | No; did encounter bad weather (snow/rain). |
| Were any problems encountered during placement? | Gravel shooter could not reach two of the originally chosen sites. Gravel pipe/sluicing method was an issue at locations where there was a flat bench at the base of the slope (gravel would get stuck in pipe). |
| Are there any recommendations to improve placement methods in the future? | Select placement sites that trucks can access easily (within 50 feet) or sites with a straight slope down to the placement site. |

**Figure 3.2-1. Gravel placement at RM 223.8 using a pipe.**

## 3.3 EFFECTIVENESS MONITORING

Bedload transport calculations performed during relicensing studies at RM 219.9 suggested that flows of 1,800 cfs could initiate transport of 0.5 inch (12.7 mm) rocks, and flows above 2,200 to 3,900 cfs could move 1 to 3 inch (25.4 to 76.2 mm) rocks, respectively, at this site (PacifiCorp 2004, 2005). Gravel added in 2012 was within this size range. Flows in the peaking reach where the RM 219.9 site is located (downstream of the powerhouse) ranged from 300-1,800 cfs during the monitoring period, so it was expected that some of the gravel would be transported away from the site.

There were no bedload calculations performed at the RM 223.8 or 224.5 sites during the relicensing studies, but calculations at nearby areas suggested that flows of 1,500-1,840 cfs could initiate transport of 0.5 inch (12.7 mm) rocks, and flows above 1,600 to 2,500 cfs could move 1 to 3 inch (25.4 to 76.2 mm) rocks, respectively, in these areas (PacifiCorp 2004, 2005). Gravel added in 2012 at these two sites was within this size range. There was no spill into the bypass reach during the monitoring period, so flow was limited to the minimum flow release of 100 cfs (plus the estimated 250 cfs spring flow accretion)). It was not expected that any of the gravel would be transported away from the sites in the bypass reach. Results of effectiveness monitoring at each of the three sites are described below.

### 3.3.1 Turnoff Downstream of Spring Island Boat Launch RM 219.9

The RM 219.9 site is located along the road just downstream of the Spring Island Boat Launch (Figures 3.1-1 and 3.3-1). Gravel was shot from a truck on the road into the river.

Location: Peaking reach, RM 219.9, right bank looking downstream

Type of placement: Truck – gravel shooter

Habitat Description: Boulder run, outside of river bend. Average wetted width 85 feet; average local gradient 0.013.

Placement volume: 250 cu yd.

**Figure 3.3-1. Photo of placed gravel at RM 219.9.**

One partial transect (the transect did not cover the full width of the river) was monitored at the RM 219.9 site across the gravel placement area. The transect was not surveyed prior to gravel placement because of safety concerns – fast, deep water and very little river bank exposed. The transect was surveyed immediately post- gravel placement (October 25, 2012) and again following eight months of normal powerhouse flows on June 19, 2013. The post-monitoring survey results showed the majority of the placed gravel was moved away from the site (Figure 3.3-2). Elevations on the placed gravel were up to five feet lower in June 2013 than in October 2012. Scour monitors were placed at stations 30, 40, 45.4 and another approximately 10 feet upstream of the transect. All scour monitors were gone during the June survey; three were found lodged in boulders downstream of the site.

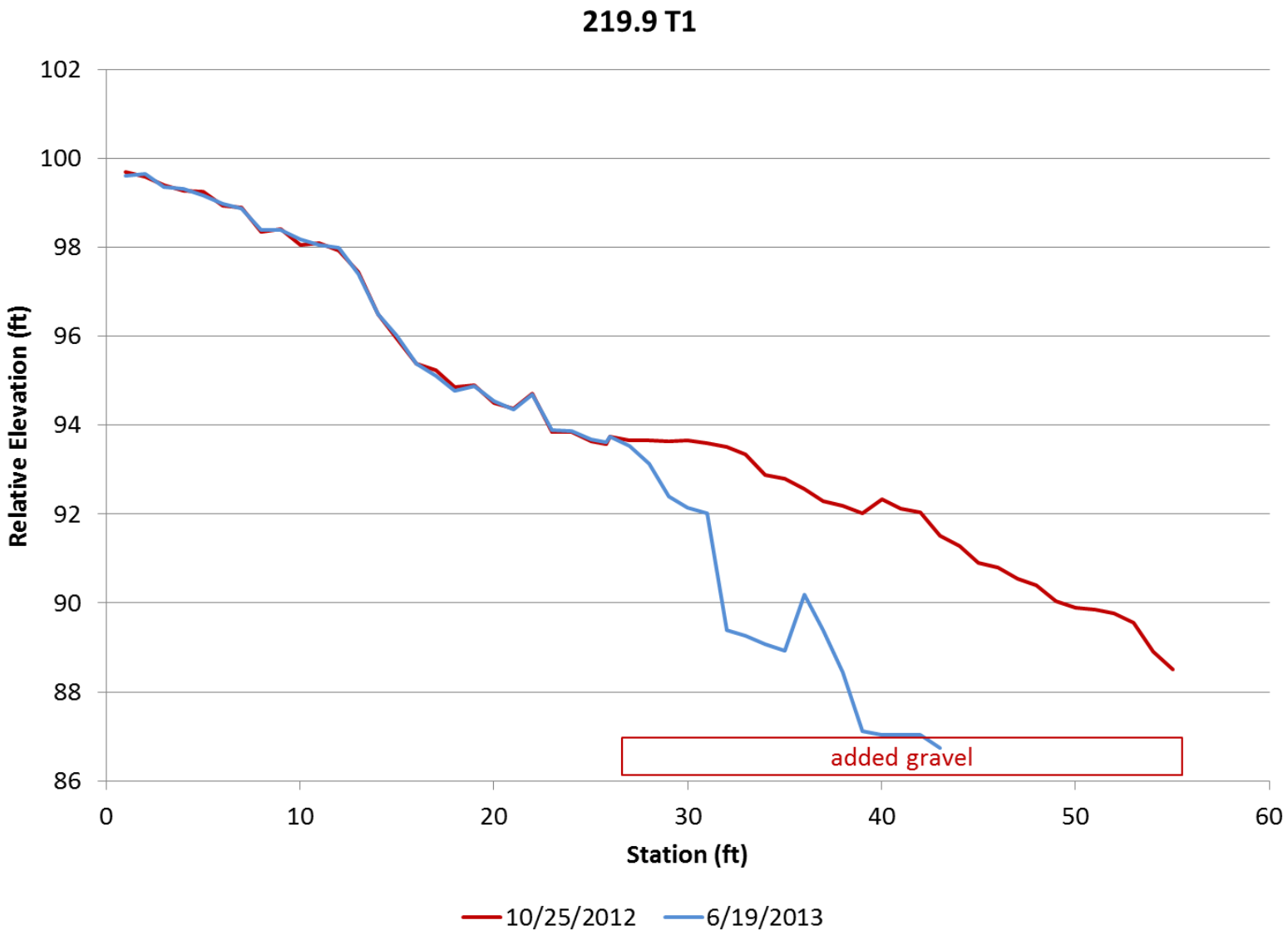


**Figure 3.3-2. Cross section at RM 219.9.**

Visual observations at the RM 219.9 site were consistent with the measurements; the majority of placed gravel had been transported away from the site during the monitoring period (Figure 3.3-3).

**Figure 3.3-3. Photos of placed gravel at RM 219.9 in October 2012 (L) and June 2013 (R).**

Substrate size was assessed at each wetted cell immediately after the gravel was placed and again during the following summer (Figure 3.3-4). The average grain size of added gravel (post-placement) was finer than the average grain size the following June (Table 3.3-1).

**Table 3.3-1. Change in grain size parameters at RM 219.9 transects.**

| | Pre-placement | | Post-placement (October 2012) | | Following Summer (June 2013) | |
|---|---|---|---|---|---|---|
| Transect | Average (mm) | Median ($D_{50}$ mm) | Average (mm) | Median ($D_{50}$ mm) | Average (mm) | Median ($D_{50}$ mm) |
| T1 (gravel placement) | Not measured | Not measured | 41 | 32 | 53 | 32 |

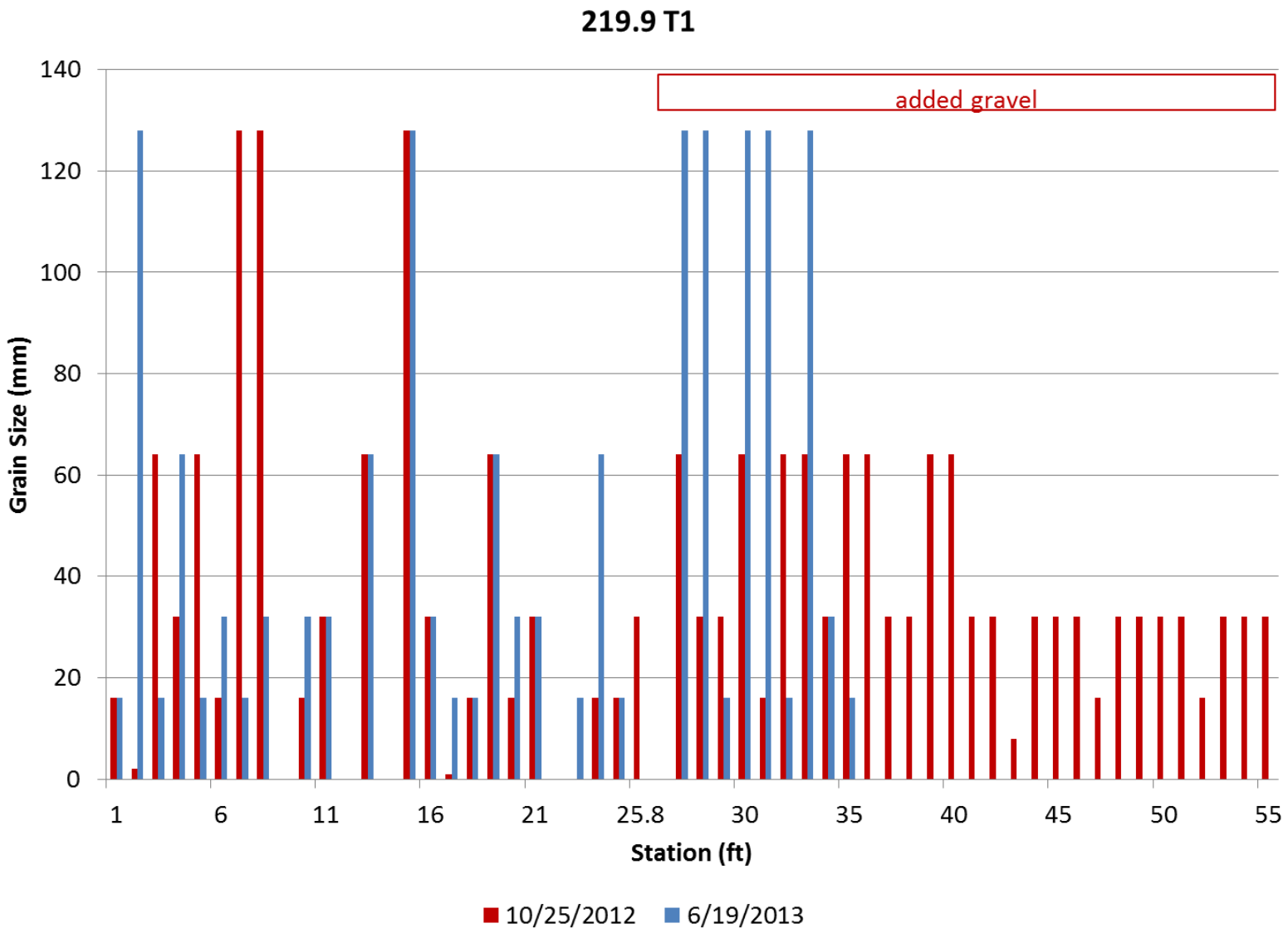


**Figure 3.3-4. Grain size at T1 (across gravel placement area) at RM 219.9.**

### 3.3.2 Upper Bypass Reach Site RM 223.8

The RM 223.8 site is located in the upper bypass reach (Figures 3.1-1 and 3.3-5). Gravel was placed at this site through a pipe because the distance from the road to the river was too far to effectively use the gravel shooter.

Location: Bypass reach, RM 223.8, right bank looking downstream

Type of placement: Truck – sluice pipe

Habitat Description: Boulder riffle/run and pool tailout. Average wetted width 30 feet; average local gradient 0.013.

Placement volume: 105 cu yd.

**Figure 3.3-5. Gravel placed at RM 223.8.**

Two transects were monitored at RM 223.8; one across the gravel placement area (T1) and one approximately 50 feet downstream (T2).

At the transect T1, cross sections and grain size were surveyed prior to gravel placement (July 11, 2012), immediately following gravel placement (October 25, 2012), and the following June (June 18, 2013). The surveyed cross section showed gravel was placed 0.5 to 4.3 feet deep at T1; minimal transport of gravel took place during the monitoring period (Figure 3.3-6). Elevations on the placed gravel were up to eight inches lower in June 2013 than in October 2012 between stations 33-37, indicating some movement of gravel at the side of the bar, but little movement of gravel elsewhere on the transect. Scour monitors were placed near stations 25, 30, and 33 and ten feet upstream of the transect. The scour monitors

showed 0 to 1 inch of scour. Elevation changes between station 40 and 55 were the result of the exact placement of the survey rod on the large boulders rather than changes in bed elevation due to scour or fill.

Substrate size was assessed at each wetted cell on Transect 1 (Figure 3.3-7). The added gravel was much finer than the pre-placement substrate size (Table 3.3-2). A slight fining of the overall grain size was measured during June 2013. This was likely the result of some movement of gravel from upstream parts of the placed gravel out across the monitoring transect.

**Table 3.3-2. Change in grain size parameters at RM 223.8 transects.**

| | Pre-placement | | Post-placement | | Following Summer (June 2013) | |
|---|---|---|---|---|---|---|
| Transect | Average (mm) | Median ($D_{50}$ mm) | Average (mm) | Median ($D_{50}$ mm) | Average (mm) | Median ($D_{50}$ mm) |
| T1 (gravel placement | Boulder | Boulder | 32 | 24 | 23 | 16 |
| T2 (50 feet downstream) | Boulder | Boulder | not measured | not measured | Boulder | Boulder |

Transect 2 at the RM 223.8 site is located approximately 50 feet downstream of T1. Pre-placement measurements were made at T2 in July 2012; the transect was surveyed again in June 2013 (Figure 3.3-8). No major changes were noted other than elevation differences related to exact survey rod placement on the boulders. Substrate was entirely boulders during both inventories (Table 3.3-2).

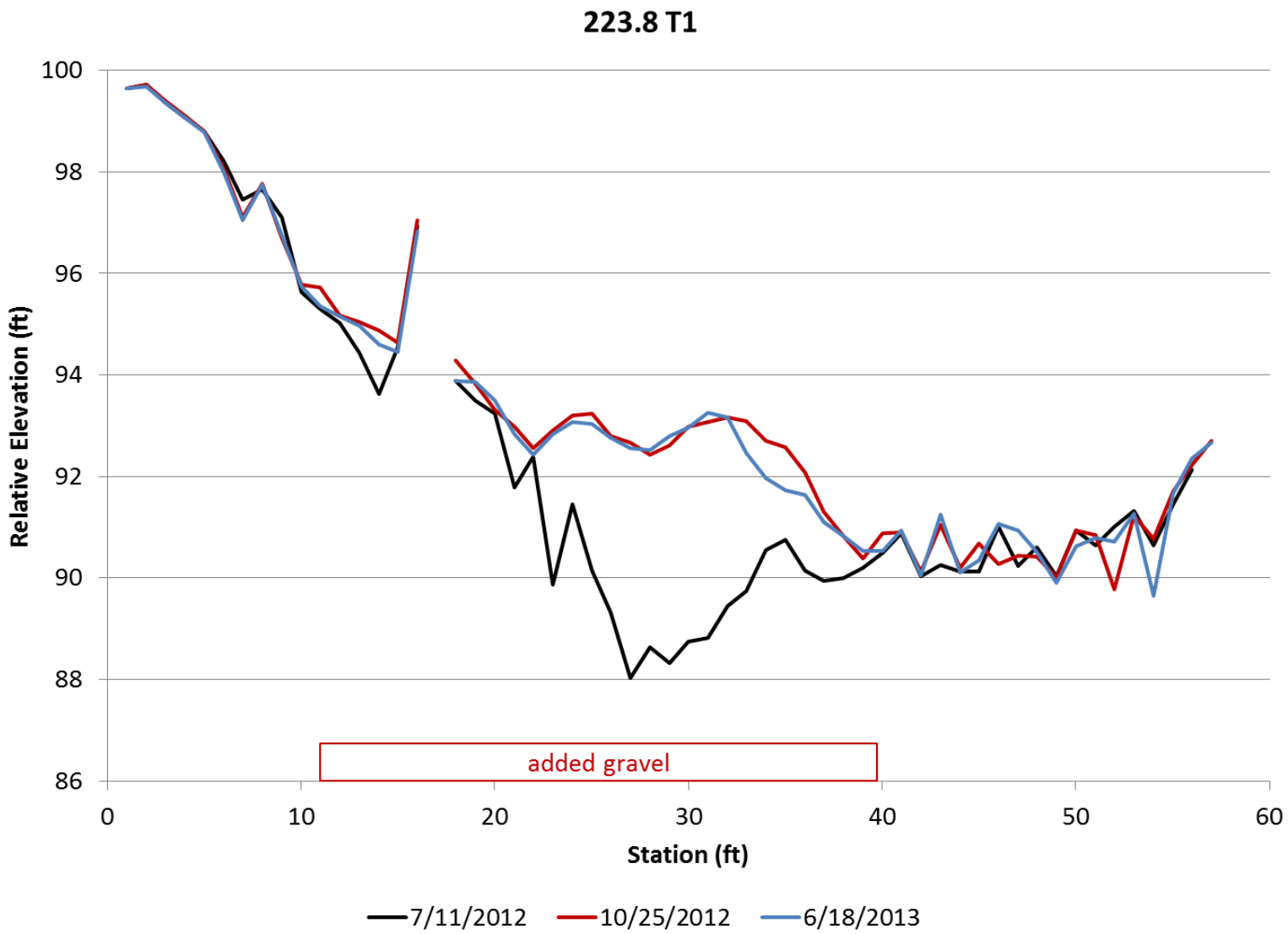


**Figure 3.3-6. Cross section at T1 (across gravel placement) at RM 223.8.**

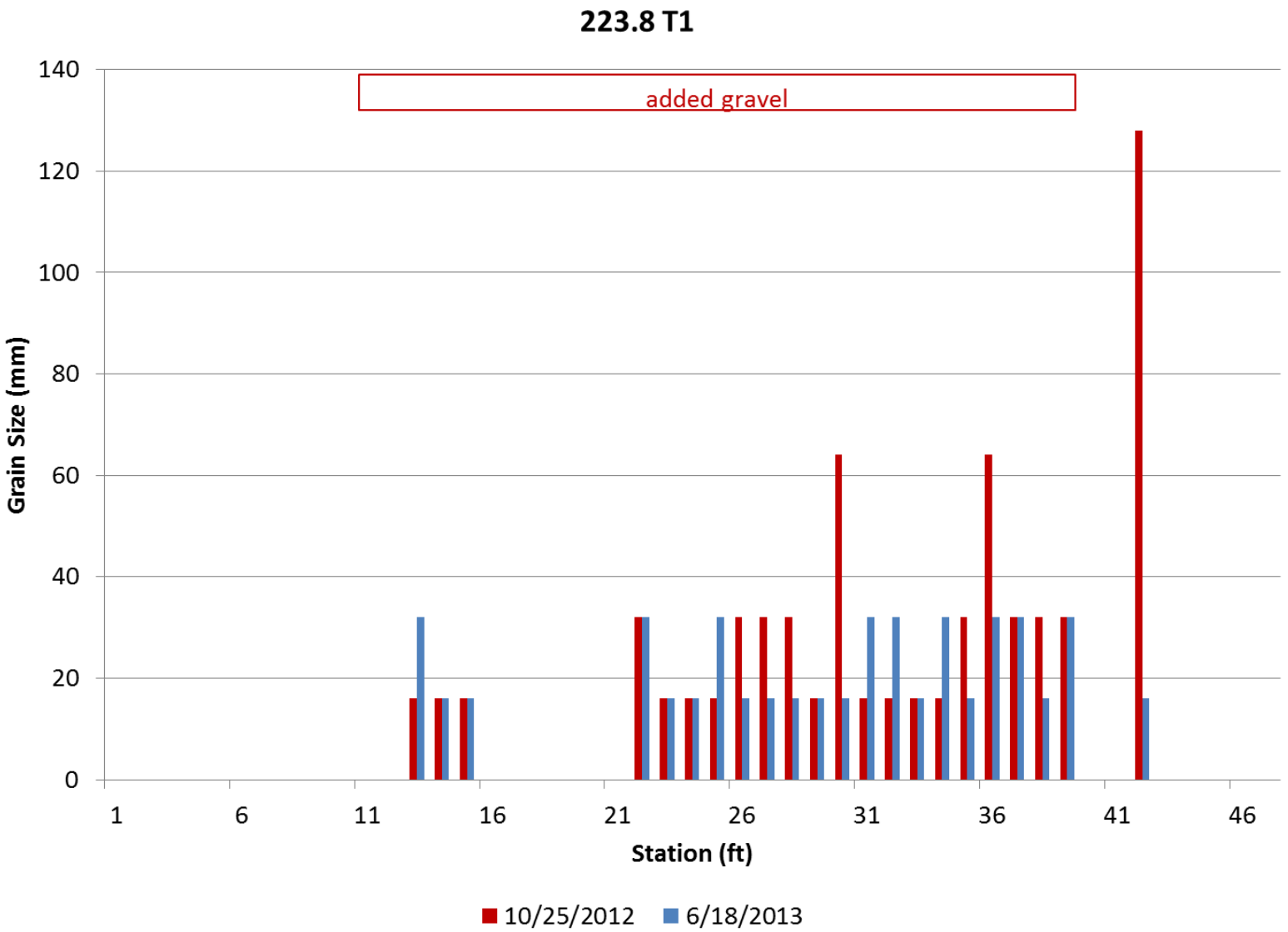


**Figure 3.3-7. Grain size at T1 (across gravel placement) at RM 223.8.**

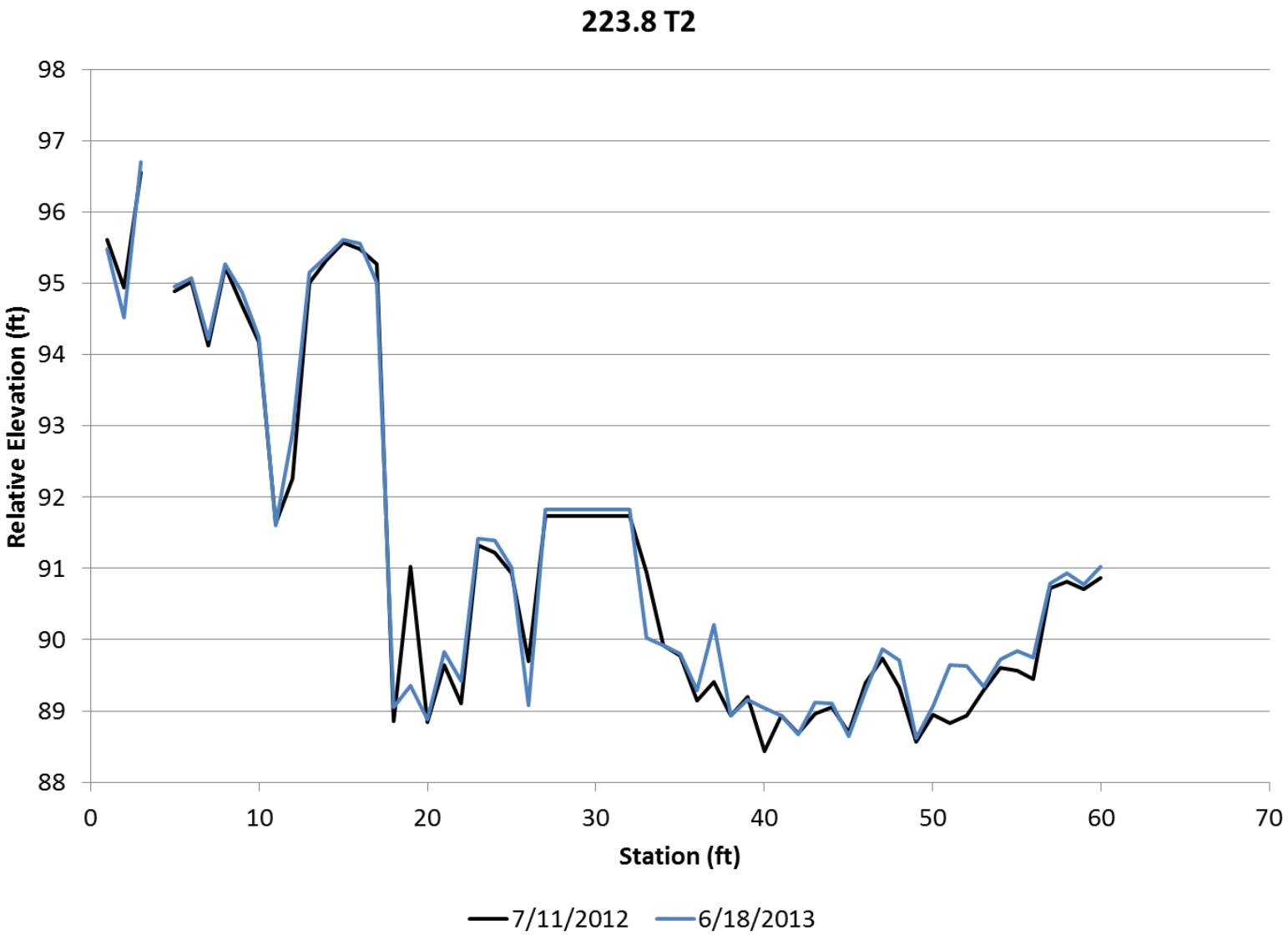


**Figure 3.3-8. Cross section at T2 at RM 223.8.**

### 3.3.3 Upper Bypass Reach Site RM 224.5

The RM 224.5 site is located in the upper bypass reach in a riffle below the USGS gage site (Figures 3.1-1 and 3.3-9). Gravel was placed at this site using the gravel shooter. The RM 224.5 site was originally envisioned to be approximately 350 feet downstream of the site where gravel was placed, but the original site was too far away from the road to be reached by the gravel shooter, and a bench at the base of the slope precluded use of the pipe method, so the alternate site was used.

Location: Bypass reach, RM 224.5, left bank looking downstream

Type of placement: Truck-gravel shooter

Habitat Description: Boulder riffle/run. Average wetted width 70 feet; average local gradient 0.013.

Placement volume: 225 cu yd.

**Figure 3.3-9. Gravel placed at RM 224.5.**

Two transects were monitored at RM 224.5; one across the gravel placement area (T1) and one approximately 40 feet downstream (T2).

At T1, cross sections and grain size were surveyed immediately following gravel placement (October 24, 2012), and the following June (June 18-19, 2013). Minimal mass transport of gravel took place during the monitoring period, but there appeared to be some re-distribution of gravel between station 5 and 20 (Figure 3.3-10). Scour monitors were placed near stations 12, 15, and 17 and near the benchmark pin. The scour monitors showed no change except for

the monitor at station 17 which showed 5.25 inches of scour. Elevation changes beyond station 35 were the result of where the survey rod was place on the large boulders rather than changes in bed elevation due to scour or fill.

Substrate size was assessed at each wetted cell on Transect 1 (Figure 3.3-11, Table 3.3-3). There was little change in grain size between the two survey periods.

**Table 3.3-3. Change in grain size parameters at RM 224.5 transects.**

| | Pre-placement | | Post-placement | | Following Summer (June 2013) | |
|---|---|---|---|---|---|---|
| Transect | Average (mm) | Median ($D_{50}$ mm) | Average (mm) | Median ($D_{50}$ mm) | Average (mm) | Median ($D_{50}$ mm) |
| T1 (gravel placement | not measured | not measured | 55 | 32 | 56 | 32 |
| T2 (40 feet downstream) | not measured | not measured | 86 | 128 | 91 | 128 |

Transect 2 at the RM 224.5 site is located approximately 40 feet downstream of T1. Post-placement measurements were made at T2 in October 2012; the transect was surveyed again in June 2013 (Figure 3.3-2). There was a small amount of added gravel between station 12 and 32 at Transect 2, but substrate was dominantly boulder during both survey periods (Figure 3.3-13, Table 3.3-3). Minor movement and slight coarsening of placed gravel was measured at T2.

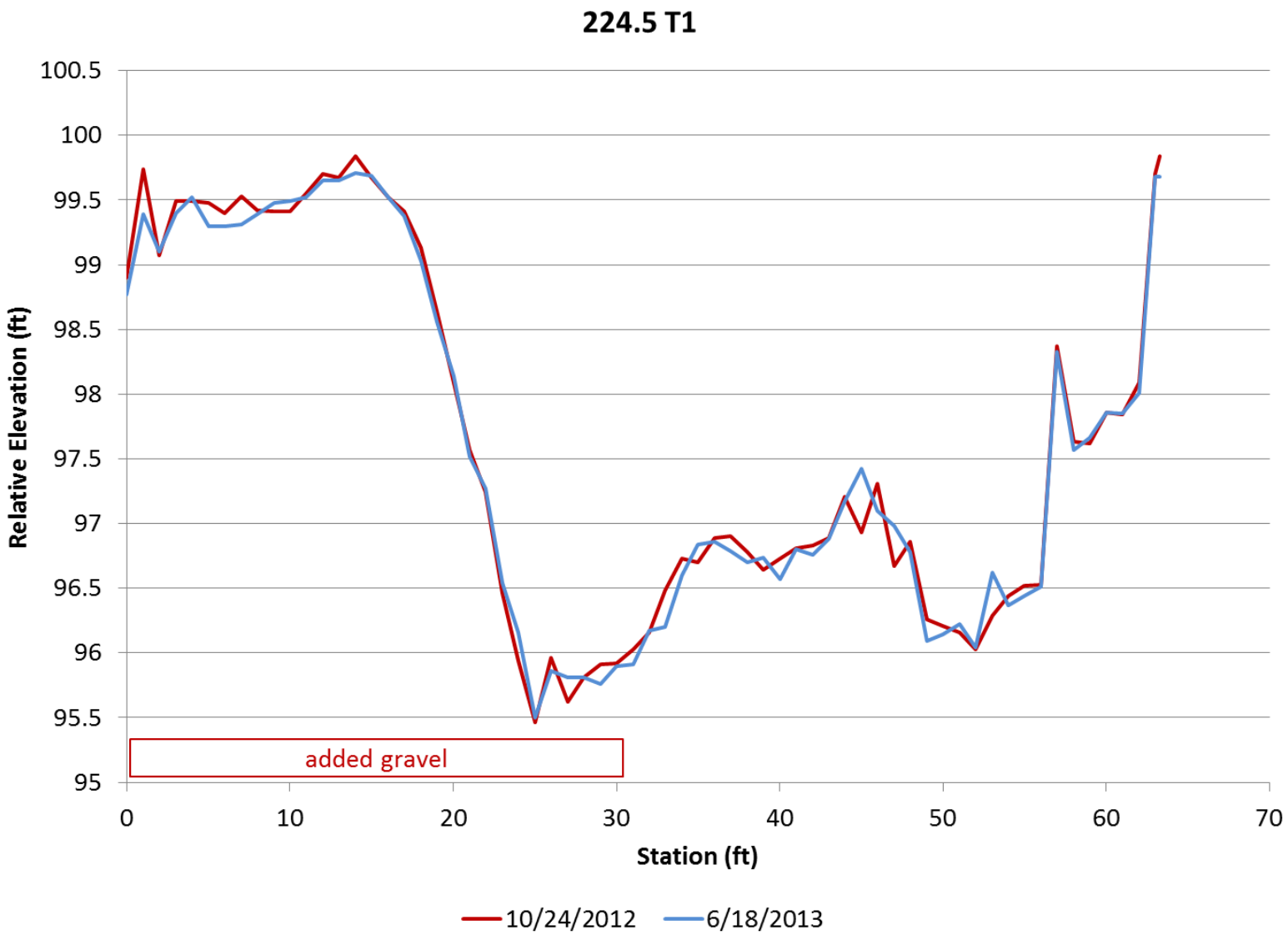


**Figure 3.3-10. Cross section at T1 (across gravel placement) at RM 224.5.**

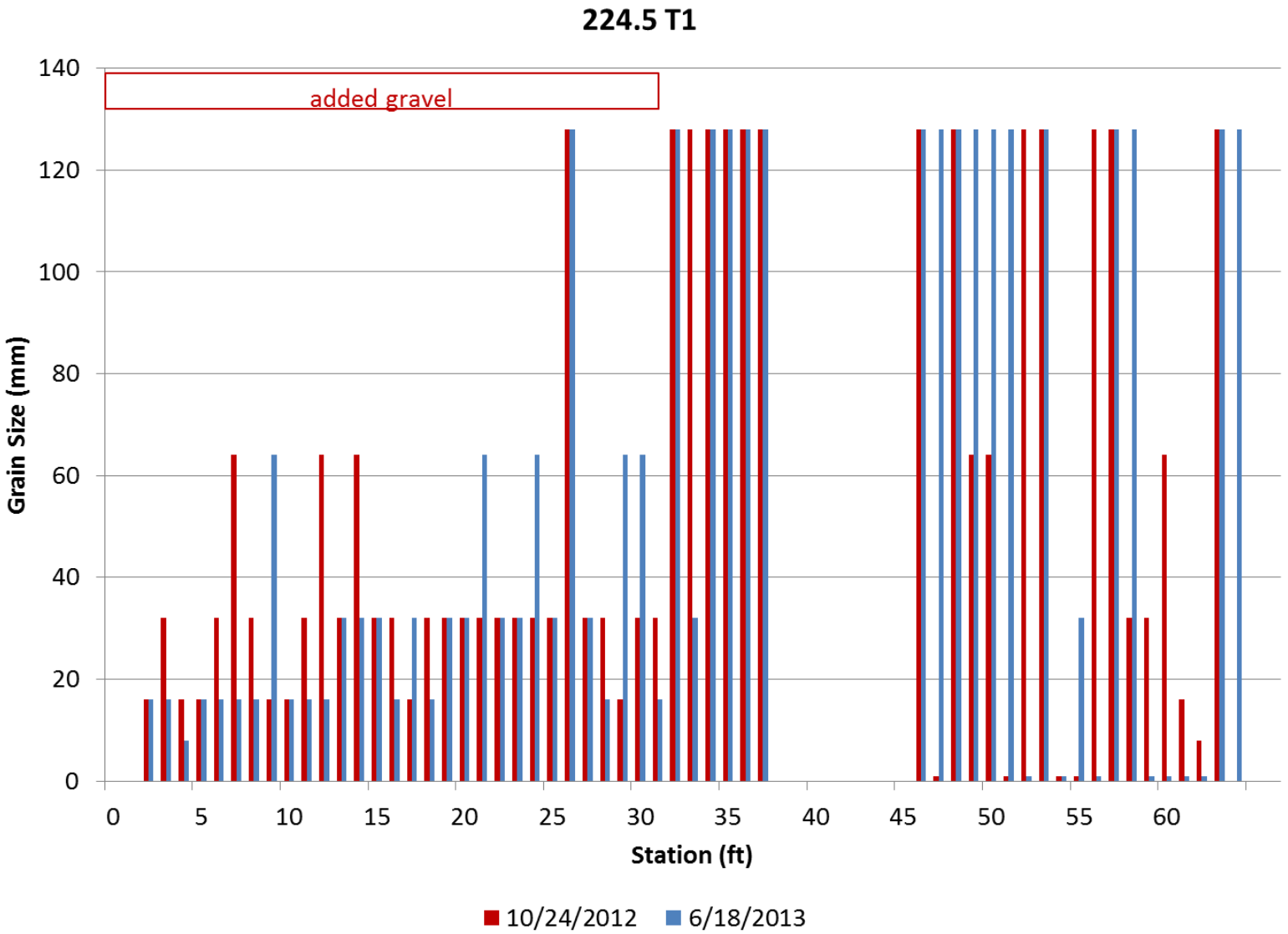


**Figure 3.3-11. Grain size at T1 (across gravel placement) at RM 224.5.**

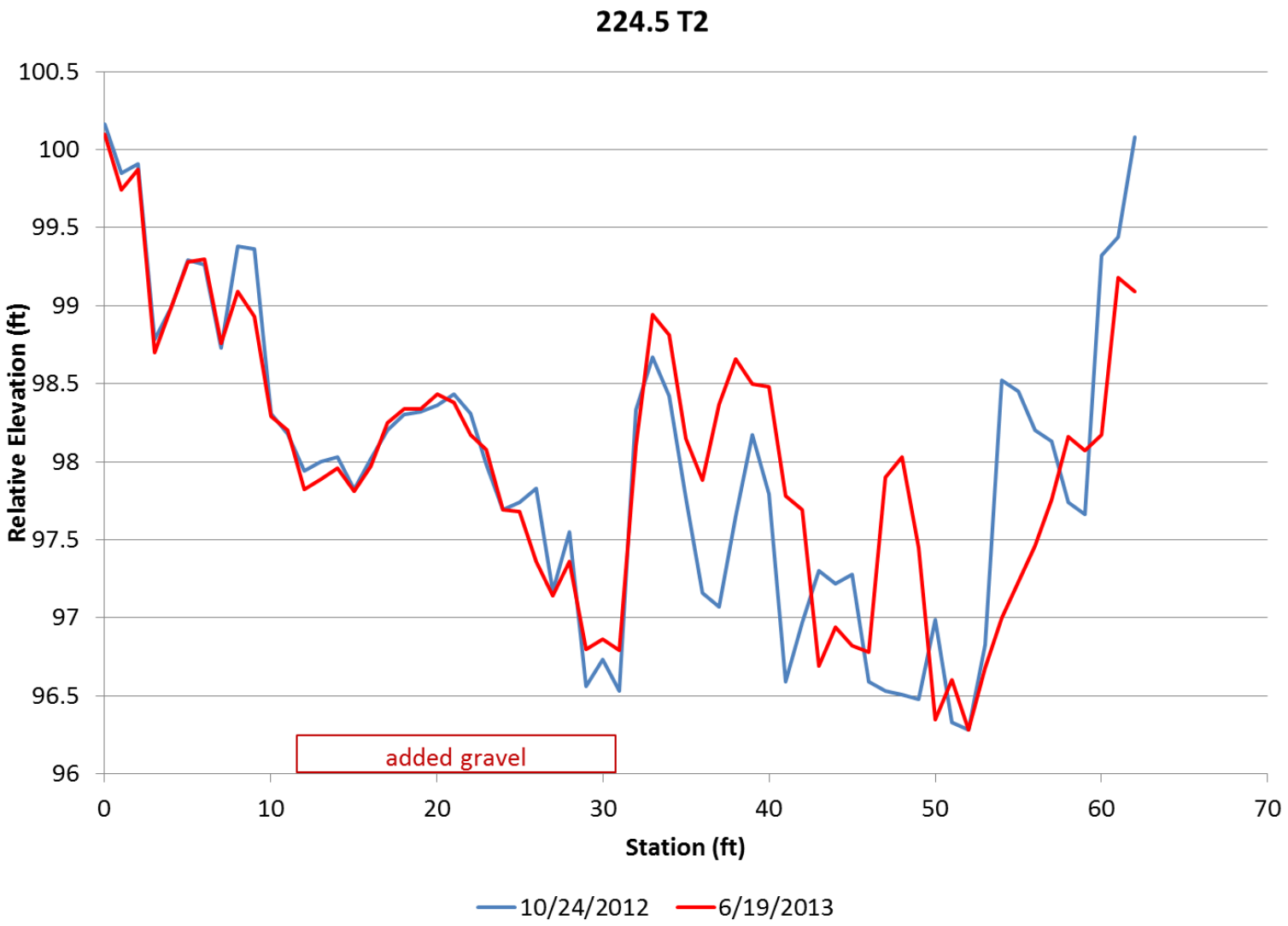


**Figure 3.3-12. Cross section at T2 at RM 224.5.**

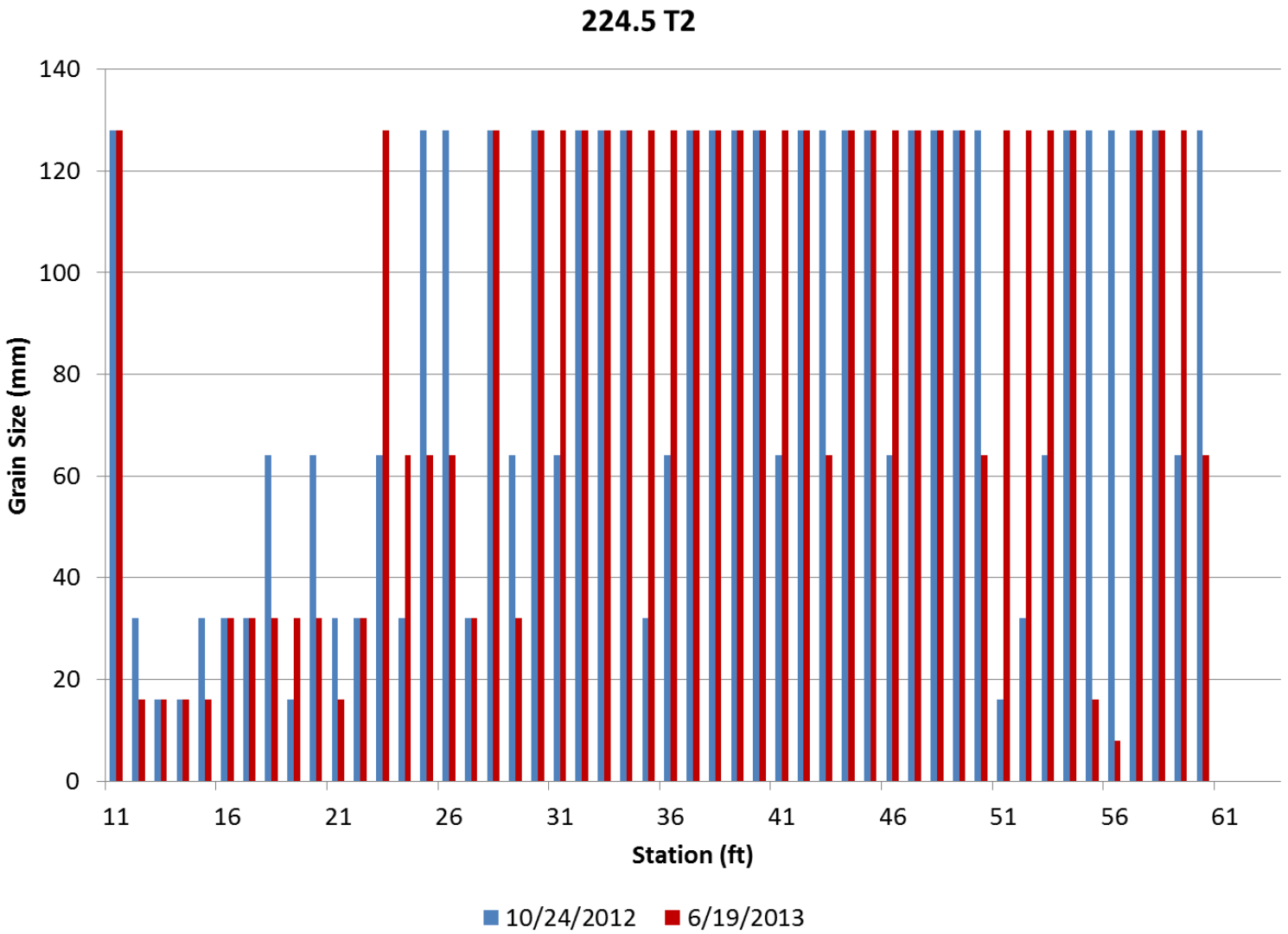


**Figure 3.3-13. Grain size at T2 (across gravel placement) at RM 224.5.**

### 3.3.4 BLM Klamath Campground Site RM 217.3 and Turtle Campground RM 216.3

The 2011 gravel placement sites at the BLM Campground (RM 217.3) and the dispersed campsite informally called Turtle Campground (RM 216.3) were visually checked to determine if gravel had moved. There appears to have been little movement of placed gravel at these sites since the July 2012 monitoring trip. This is consistent with the lack of high flows during this period.

## 3.4 SUMMARY OF 2012 GRAVEL PLACEMENT

The truck-based gravel placement at the RM 219.9 (peaking reach), 223.8 and 224.5 (bypass reach) sites occurred in October 2012. The RM 223.8 and original 224.5 sites were too far away from the road to allow for gravel placement using a truck. The contractor was able to place gravel at the planned RM 223.8 site using a pipe, but the original 224.5 site had a bench at the base of the slope that precluded gravel placement using the pipe method. An alternate RM 224.5 site, 350 feet upstream of the original site, was used instead. No safety issues were encountered during the 2012 gravel placement.

Approximately 105-250 cubic yards of gravel was placed at each site. Monitoring of the placed gravel showed that the lack of spill/high flows in the bypass reach resulted in little gravel movement at either of the two gravel placement sites in this reach. Flows in the peaking reach (350-1,800 cfs) removed the majority of gravel from the RM 219.9 site. The two 2011 gravel placement sites at RM 217.3 and 216.3 were visually inspected; it did not appear that any gravel had been transported at these locations.

Based on the placement and monitoring of gravel at the sites, it appears that gravel can again be added to the RM 219.9 site in the peaking reach; operating flows are capable of transporting added gravel from this site. No additional gravel should be placed at the RM 223.8, 224.5 (bypass reach) or RM 217.3 or 216.3 (peaking reach) sites until higher flows occur that have the opportunity to move the placed gravel. In addition to the RM 219.9 site, gravel placement for 2013 is also proposed at a site immediately below the powerhouse at approximately RM 220.3

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