2008 BEACH RESTORATION PROJECT
ISLE OF PALMS SOUTH CAROLINA

Monitoring Report No 5
December 2013

Prepared for:

City of Isle of Palms

2008 Isle of Palms Beach Restoration Project

YEAR 5 MONITORING REPORT

Prepared for:

City of Isle of Palms

PO Box 508 Isle of Palms SC 29451

Prepared by:

Coastal Science & Engineering (CSE)

PO Box 8056 Columbia SC 29202-8056

[2386YR2]

DECEMBER 2013

COVER PHOTO: East end of Isle of Palms (SC) at low tide on 15 November 2013
[Photo by SB Traynum]

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EXECUTIVE SUMMARY

This report presents results of Year 5 beach and inlet monitoring following the 2008 beach restoration project at the Isle of Palms, which was accomplished in May–June 2008 under permit P/N 2007-02631-2IG. Annual surveys are being conducted to track the performance of the project, measure sand volumes remaining, and provide a condition survey of the beach, inlets, and shoals from Dewees Inlet to Breach Inlet.

Year 5 monitoring involved a condition survey in July 2013. These data are compared with pre-project and post-project conditions in the project area (north of 53rd Avenue). Data for remaining areas of the Isle of Palms and Breach Inlet are compared with earlier surveys by CSE and SCDHEC–Office of Ocean & Coastal Resource Management (OCRM). The report includes:

- Shoreline history and summary of the 2008 beach restoration project.
- Important dates of events (Table A).
- Description of the data collection and analysis methods.
- Monitoring results by section of shoreline using seven (7) reaches along the island.
- Nourishment volume remaining within the project limits.
- Identification of local erosion "hot spots."
- Discussion of findings.

The 2008 beach restoration project placed 933,895 cubic yards (cy) of sand from offshore in three reaches between 53rd Avenue and Dewees Inlet. As of July 2013 (~5 years after project completion):

- Reach A (53rd Avenue to Beach Club Villas) has severely eroded along the eastern third of the reach, while the western two-thirds have shown more typical erosion. Presently, stations 258–274 contain less sand than the pre-nourishment condition, while stations 224–256 show an average of 52.1 cy/ft more sand that their pre-nourishment condition. Overall, Reach A shows a net loss of 126 percent of the nourishment volume, although ~72 percent of the fill placed from stations 224 to station 258 remains within those fill limits. Reach A lost ~123,000 cy from July 2012 to July 2013.

- Reach B (Mariners Walk Villas to the 18th fairway of Wild Dunes Links Course) retains ~64.5 percent of the nourishment volume. The reach lost ~62,800 cy over the past year. Erosion has been concentrated along the eastern third of the reach (Ocean Club – 18th Hole)

- Reach C (a 1,000-foot length of Dewees Inlet shoreline adjacent to the 17th hole and 18th tee of the Wild Dunes Links Course) retains ~196.0 percent of the nourishment volume (Fig A), gaining ~13,250 cy over the past year.

Collectively, ~40.2 percent of the nourishment fill remained within the fill limits as of July 2013. Overall, the island gained 11,200 cy (0.3 cubic yards per foot—cy/ft) of sand between July 2012 and July 2013 (Fig B) which compares to a loss of ~88,840 cy (2.4 cy/ft) over the previous year. The beach west of 53rd Avenue gained ~117,800 cy, while the beach east of 53rd Avenue lost ~106,600 cy. Erosion was prevalent near Seascape, Ocean Club, Beachwood East, Dune Crest Lane, 3rd Avenue, and Breach Inlet.

TABLE A. Important dates of events related to the 2008 beach nourishment project and subsequent monitoring.

Milestone	Date	Comment
Beach Condition Survey	Jul 2007	
Pre-Construction Survey	Mar 2008	
Project Construction	May-Jun 2008	934,000 cubic yards (cy) placed along 10,200 feet (ft) of shoreline
Monitoring Survey	Mar 2009	93 percent of nourishment volume remained within the fill placement area
Monitoring Survey	Sep 2009	81 percent of nourishment volume remained within the fill placement area
Year 1 Monitoring Report	Dec 2009	
Monitoring Survey	Mar 2010	73 percent of nourishment volume remained within the fill placement area
Monitoring Survey	Sep 2010	72 percent of nourishment volume remained within the fill placement area
Permit Application Submitted	Oct 2010	
Year 2 Monitoring Report	Mar 2011	
Monitoring Survey	Jun 2011	66 percent of nourishment volume remained within the fill placement area
Year 3 Monitoring Report	Nov 2011	
Shoal Management Project	Mar-Apr 2012	Redistribution of 87,700 cy at the northeastern end of the island
Monitoring Survey	July 2012	57 percent of nourishment volume remained within the fill placement area
Year 4 Monitoring Report	Nov 2012	
Monitoring Survey	July 2013	40 percent of nourishment volume remained within the fill placement area
Year 5 Monitoring Report	Dec 2013	

CSE anticipates that the beach condition will warrant another shoal management be completed in the 2014-2015 permitted window. The present beach condition does not allow sufficient placement of sand in the critically eroded areas to adequately protect properties through the summer. CSE believes the emergency sandbag revetment offers a better means of protection if they are allowed to remain in place for the upcoming summer season. The City should anticipate the need to complete a 250,000-cy project (maximum permitted volume) during 2014–2015. The anticipated cost, including engineering, is $900,000±$150,000.

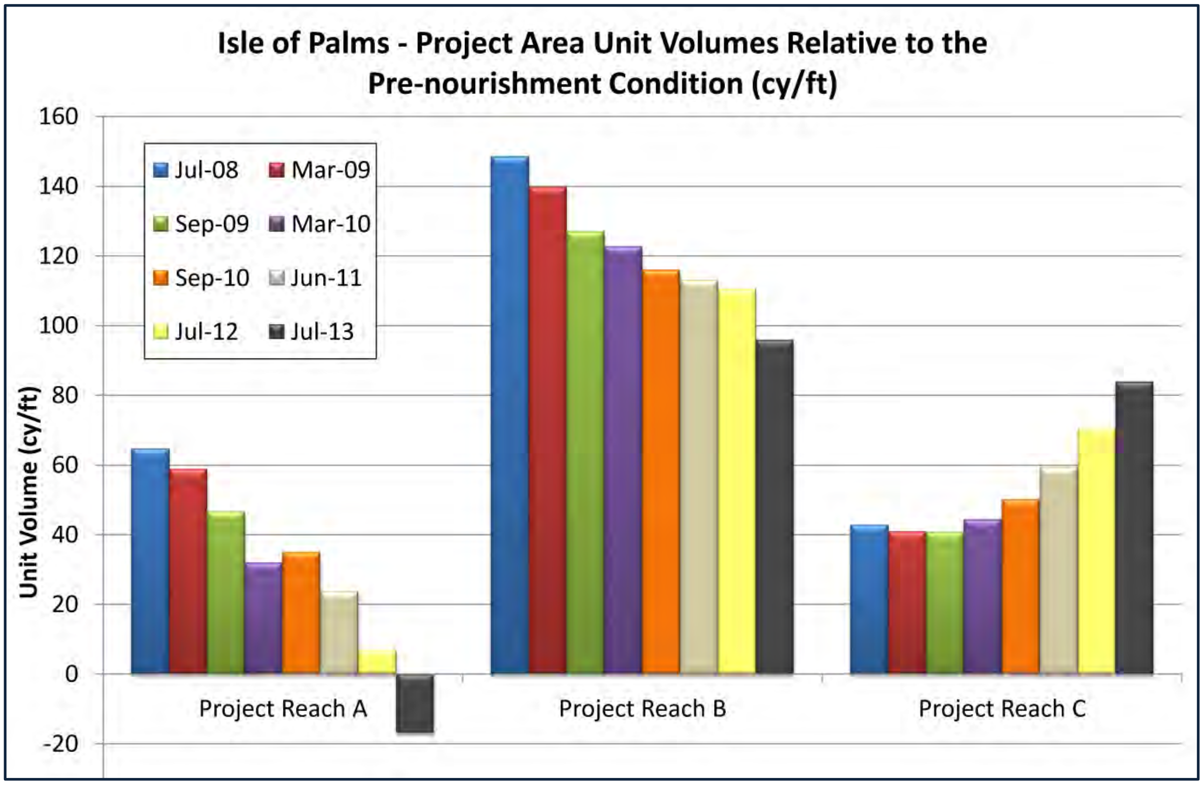

FIGURE A. Percent of nourishment volume remaining in project areas as of July 2013.

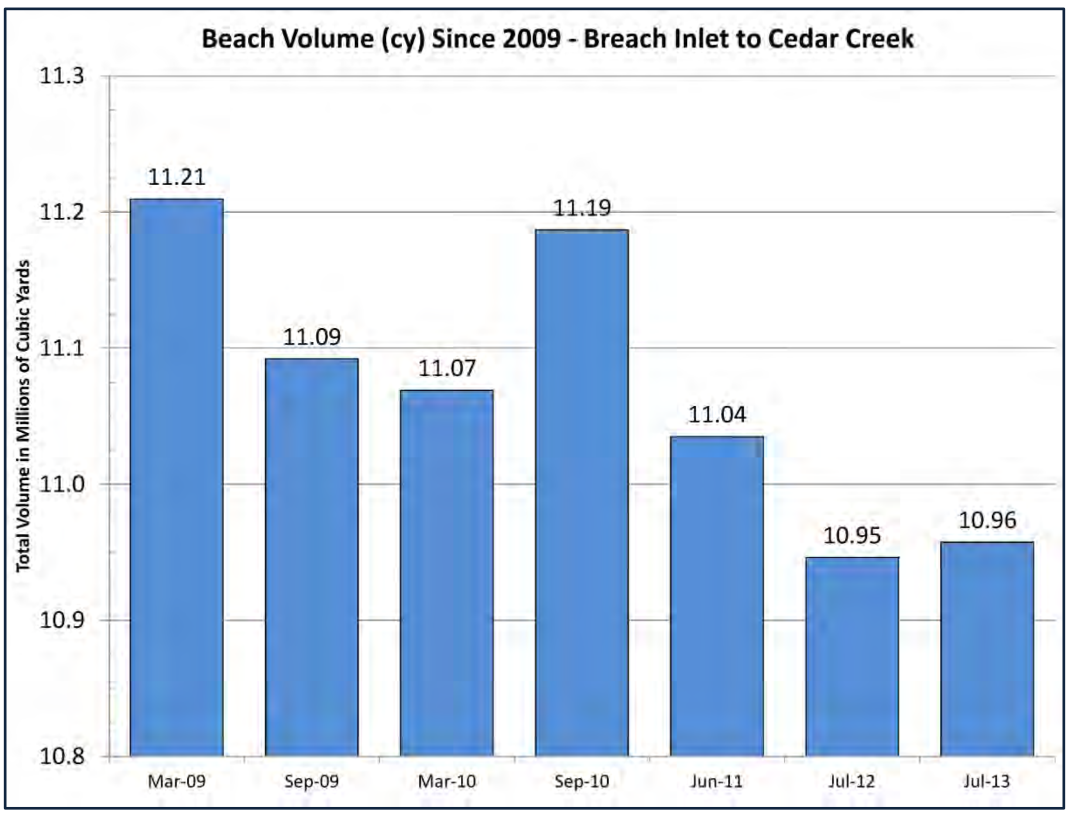

FIGURE B. Total beach volume at Isle of Palms from March 2009 to July 2013. Volume is measured to local closure depth (between −10 ft and −18 ft NAVD).

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1.0 INTRODUCTION

This monitoring report is provided to the City of Isle of Palms by Coastal Science & Engineering (CSE) as part of a three-year agreement for beach monitoring following the 2008 Isle of Palms beach restoration project (P/N 2007-02631-2IG) (CSE 2008). This report details the seventh island-wide data collection after nourishment. It follows submission of the Years 1–4 monitoring reports (CSE 2009, 2010, 2011a,b, 2012). Discussions presented herein are based on comparisons of pre-project and post-project data with surveys performed through July 2013.

The analyses presented in this report provide an updated condition of the beach ~60 months after the completion of the restoration project. This report provides beach profile volumes along the length of the Isle of Palms (IOP), including detailed volume changes in the 2008 project areas. Ground and aerial photography are included to identify features such as dunes, escarpments, sand texture and color, as well as to give a visual representation of the beach width for comparison with previous and future surveys.

1.1 Setting

Isle of Palms is an ~7-mile-long, southeast-facing, barrier island located ~8 miles east of Charleston, South Carolina. It is bounded by Dewees Inlet and Dewees Island to the northeast and Breach Inlet and Sullivan's Island to the southwest. A feature typical of the central South Carolina barrier islands is the "drumstick" shape (Hayes 1979) produced by the interaction of waves and tides, and formation of prominent ebb-tidal deltas at the inlets. Seaward shoals of each delta produce wave refraction and variable longshore transport rates, which leads to a wider upcoast (northern) end and a relatively narrow downcoast end (Breach Inlet end, Fig 1.1).

The wider end of the island is influenced by shoal bypassing, a process whereby sand is periodically released from the inlet delta and moved onshore through wave action. This process occurs at somewhat regular intervals (average interval between events from 1941 to 1997 is 6.6 years, Gaudiano 1998) and contributes to the overall health of the island. However, it also can cause focused erosion in areas adjacent to the shoal attachment zone (Kana et al 1985).

FIGURE 1.1. Isle of Palms is a typical "drumstick" barrier island (after Hayes 1979), where the upcoast end is wider due to sediment accumulation through shoal-bypass events, and the downcoast end usually forms a growing recurve spit. Other examples of drumstick barrier islands along South Carolina are Bull Island, Kiawah Island, and Fripp Island. Zones of sediment transport reversal generally occur in the lee of delta shoals which are situated offshore. Upon shoal attachment to the beach, transport directions in the vicinity of the shoal switch, spreading sand away from the attachment point (see for example — Fig 1.2).

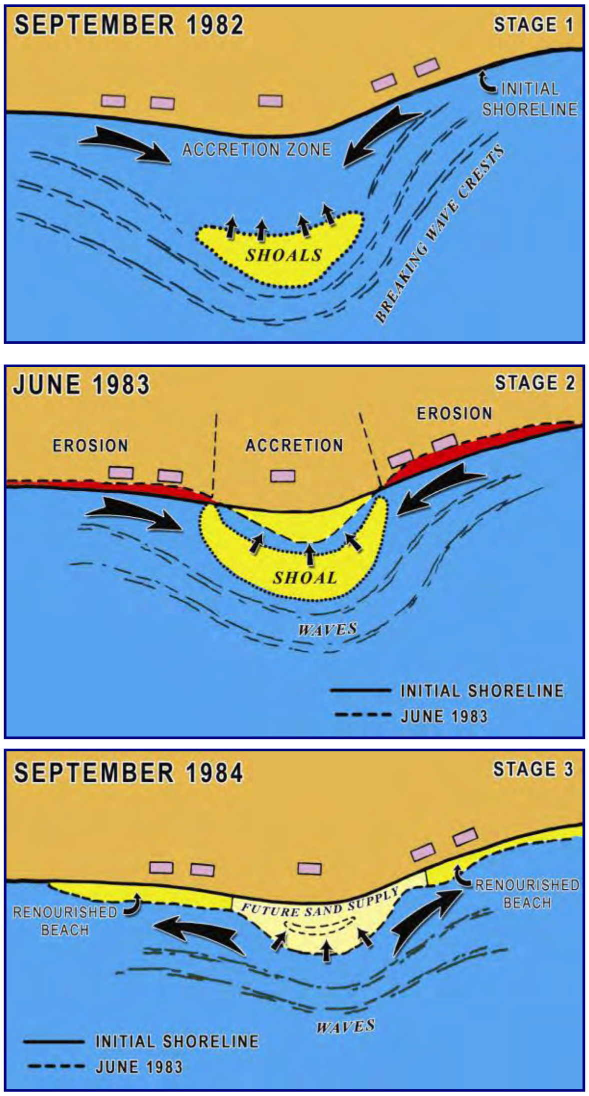

FIGURE 1.2.

[LEFT]
Schematic of the shoal-bypass cycle originally modeled from a bypass event at IOP. During Stages 1 and 2 of the cycle, accretion in the lee of the shoal is accompanied by erosion on either side of the attachment site. (After Kana et al 1985)

[RIGHT]
Shoal-bypass event at the northeastern end of IOP. The upper photo shows a shoal in Stage 1 of the bypass cycle in March 1996. The middle image, taken in 1997, shows that the shoal is beginning to attach to the beach and is in Stage 2 of the bypass cycle. The lower image (from December 1998) shows the shoal completely attached (Stage 3), and sand has spread to previously eroded areas.

The long-term accretion trend at Isle of Palms is a direct result of shoal bypassing at Dewees Inlet. Numerous episodic events have deposited sand on the northeastern end of the island (Gaudiano 1998). The annual average sand gain from shoal-bypass events is ~100,000 cubic yards per year (cy/yr); however, ~120,000–130,000 cy/yr are typically lost to downcoast areas each year, leaving a net sand deficit of ~20,000–30,000 cy/yr at the northeastern end (CSE 2007). A more detailed explanation of the coastal processes and erosion history of Isle of Palms is provided in CSE (2007, 2008, 2009).

The shoal-bypassing event which led to the 2008 project appears to have begun around 2003. By 2004, some areas (eg – Port O'Call) experienced 150 ft of beach recession in one year (ATM 2006). In February 2007, exposed bars extended nearly one-half mile offshore around Beach Club Villas and the Wild Dunes Property Owners beach house (Fig 1.3). The southern part of the attaching shoal was already in Stage 3 with some sand moving south to nourish other parts of IOP; the northern side remained in Stage 2. As Figure 1.3 shows, all properties north of Beach Club Villas had lost their dry-sand beach by then. To protect buildings, property owners placed ~5-gallon-sized sand bags along the scarped dune. These bags were quickly destroyed or washed away, and property owners replaced them with large (1 cy) sand bags in front of buildings for protection. Erosion continued into 2008, eventually claiming half of the signature 18th hole of the Wild Dunes Links Course and leaving no beach (even at low tide) in front of several properties.

FIGURE 1.3.

[UPPER]

February 2007 oblique aerial image of the northeastern end of IOP showing the approaching shoal in Stage 2 of the bypass cycle.

Note loss of dry beach and various shore-protection measures from Mariners Walk Villas to the 18th fairway (red-outlined arrows – focused erosion).

[LOWER]

Small, 5-gallon-sized sand bags (left) and large 1 cy-sized sandbags (right) installed by property owners to temporarily offer protection to buildings.

Prior to the 2008 project, little to no beach was present at low tide near the Ocean Club condominiums.

Left image courtesy of Coastal Carolina University Beach Erosion Research and Monitoring Program.

1.2 The 2008 Isle of Palms Beach Restoration Project

The 2008 beach restoration project was designed to add ~850,000 cy of sand to ~10,200 linear feet of beach (Fig 1.4). The fill was to be placed in three reaches. Reaches A and B were located along the oceanfront spanning from ~53rd Avenue to the 18th fairway of the Wild Dunes Links Course, separated by an accretion zone associated with the shoal-bypassing event. Reach C represented a portion of the Dewees Inlet shoreline. Roughly 2,600 linear feet of Reach A bordered publically accessible areas of the City. The remaining fill bordered the Wild Dunes community. Design fill volumes for full sections (excluding tapers) were 75 cy/ft in Reach A, 140 cy/ft to 180 cy/ft for Reach B, and 27 cy/ft in Reach C.

The City of Isle of Palms entered into a contract with Weeks Marine of Covington (LA) for placement of 780,000 cy of sand along 9,200 linear feet of beach. Two change orders increased the total volume to 847,400 cy over 10,200 ft of beach and added a fill section to the Dewees Inlet shoreline. The original bid was for $7,914,100, and the total cost after the change orders was $8,402,090.

The final volume added to the beach calculated from Weeks Marine's surveys was 933,895 cy, which was ~10 percent greater than the design volume of 847,400 cy. The overage of 86,495 cy was not a pay quantity as stated in the contract; therefore, the City was only required to pay for the contract volume of 847,400.

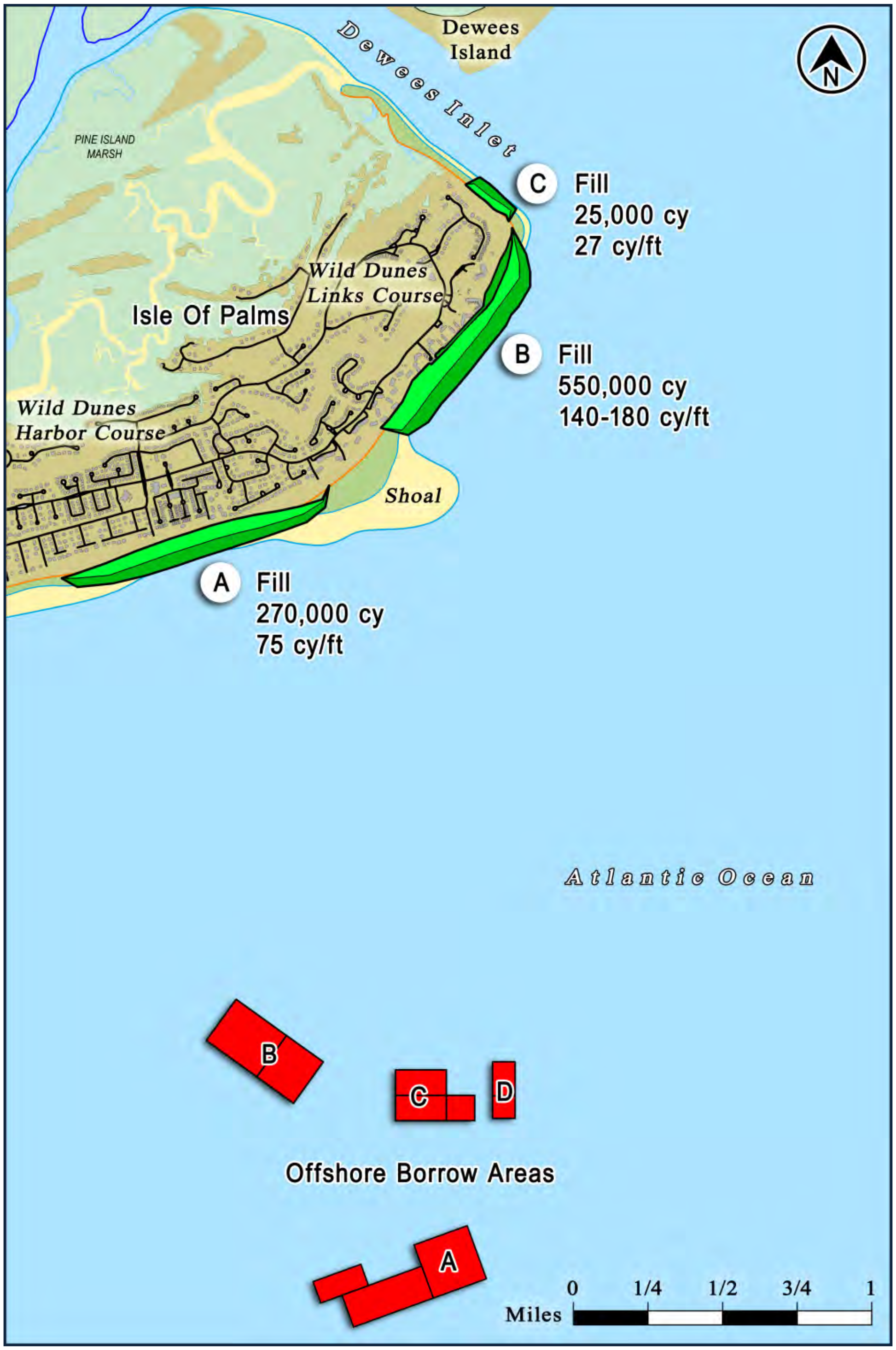

FIGURE 1.4. Project map of the 2008 IOP restoration project. The project was designed to nourish sections of the beach and provide sufficient sand to offset losses associated with long-term erosion as well as an ongoing shoal-bypass event. Borrow areas were located 2-3 miles offshore. Area D was not dredged.

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2.0 METHODS

Monitoring efforts for the present report were performed in July 2013. Changes in the volume of sand in the active beach zone were evaluated by obtaining topographic and bathymetric data along shore-perpendicular transects at established locations along the beach (herein referred to as the baseline) (Fig 2.1). The present baseline spans from the center of the Breach Inlet Bridge (station 0+00) and continues to Cedar Creek spit at the northeastern end of the island (station 376+00). The monitoring baseline overlaps the baseline used in the project beginning at 53rd Avenue which was the location of project station 0+00 (that station is now station 222+00). Stationing relates to the distance along the shore with the number before the "+" symbol representing 100 feet (ft). Therefore, station 36+00 is 3,600 ft from station 0+00. The baseline is generally set landward of the present active beach to allow for future erosion/accretion.

Topographic data were collected via RTK-GPS (Trimble™ R8 GNSS), which provides position and elevation measurements at centimeter accuracy. Beach profiles were obtained by collecting data at low tide along the dunes, berm, and active beach to low-tide wading depth. Overwater work was then performed at high tide to overlap the land-based work (Fig 2.2) and was collected with RTK-GPS coupled with an Odom CV100™ precision echo sounder mounted on CSE's survey vessel, the *RV Southern Echo*. Profiles were collected from the most landward accessible point in the dune system to a minimum of 1,500 ft from the baseline. Profiles in the project area extended up to 6,000 ft offshore to encompass the shoals associated with Dewees Inlet. Alongshore spacing of the profiles ranged from 200 ft to 1,000 ft with the more closely spaced profiles in the project area and along Breach Inlet. Comparative profiles from CSE's monitoring efforts are shown in Appendix A. The complexity of areas impacted by inlets requires more detailed analysis (closer profile spacing) to fully incorporate volume changes associated with shoal-bypassing events and inlet migration.

To better understand regional sand volume changes, seven reaches were defined along Isle of Palms. By combining several profiles into a reach, it is easier to identify overall sediment gains and losses over large portions of the beach. In the project area, the reaches differ from reaches used during construction so as to encompass areas where no work was performed. [Some sections of this report may refer to volume changes within constructed project reaches and will be clearly indicated.]

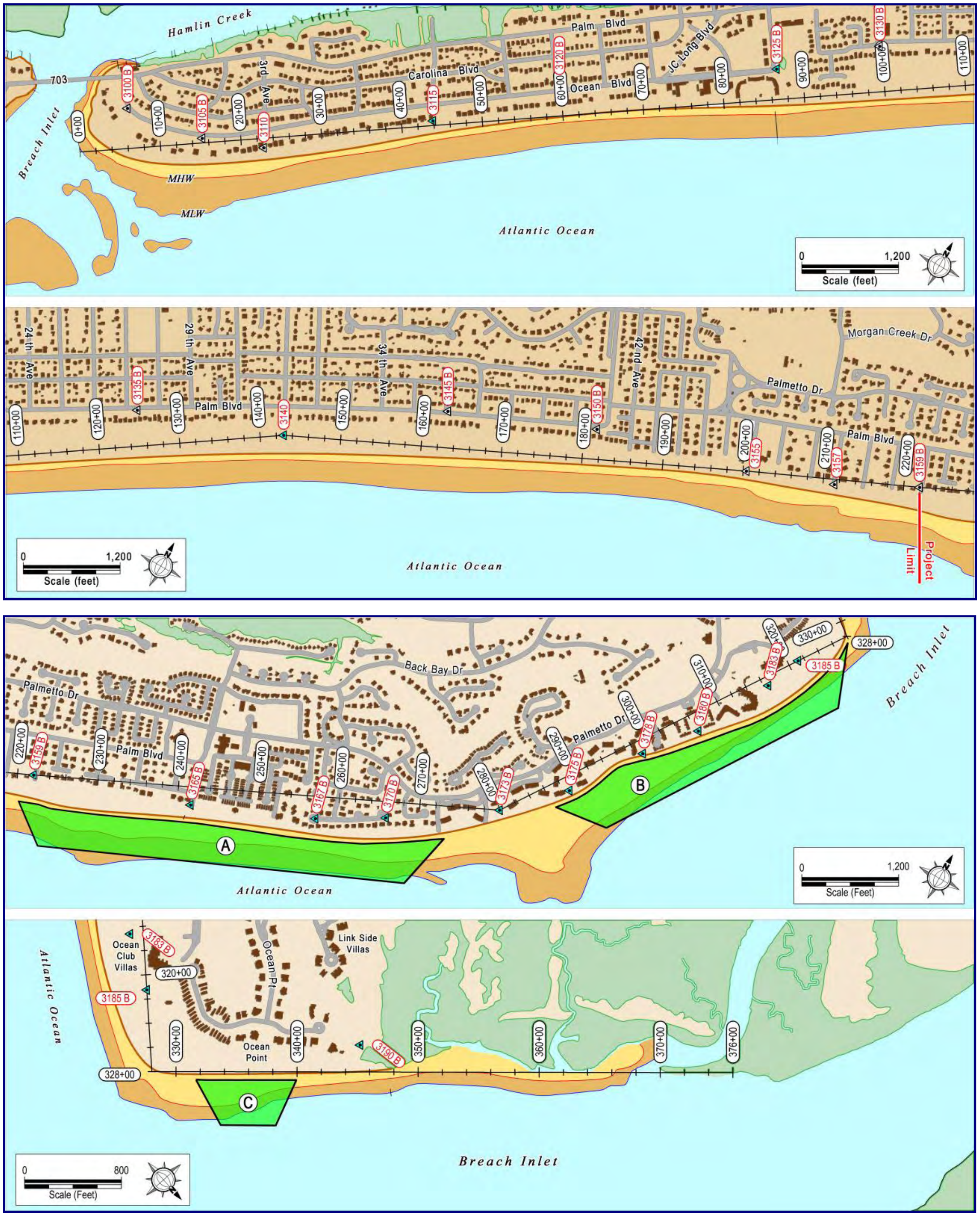

FIGURE 2.1 CSE established a monitoring baseline to encompass the length of IOP. The baseline between stations 222+00 and 376+00 corresponds to the baseline used in the 2008 project (project stations 0+00 through 174+00). Red labels indicate locations of OCRM survey monuments. CSE profile sections are oriented perpendicular to the baseline while OCRM profiles are perpendicular to the local beach azimuth. [CSE and OCRM azimuths are only significantly different at Breach Inlet.]

FIGURE 2.2. CSE beach monitoring methods include land-based data collection using Trimble™ RTK GPS from the backshore to low-tide wading depth and over-water work using RTK GPS linked to a precision echosounder aboard CSE's survey boat (RV *Southern Echo).*

The reaches used for monitoring purposes are shown in Figure 2.3 and are defined as follows:

Reach 1	0+00 to OCRM 3115	Breach Inlet to 6th Avenue
Reach 2	OCRM 3115 to OCRM 3125	6th Avenue to Sea Cabins Pier
Reach 3	OCRM 3125 to OCRM 3140	Sea Cabins Pier to 31st Avenue
Reach 4	OCRM 3140 to 222+00	31st Avenue to 53rd Avenue
Reach 5	222+00 to 280+00	53rd Avenue to Wild Dunes Property Owners Beach House
Reach 6	280+00 to 328+00	Wild Dunes Property Owners Beach House to Dewees Inlet
Reach 7	330+00 to 370+00	Dewees Inlet Shoreline

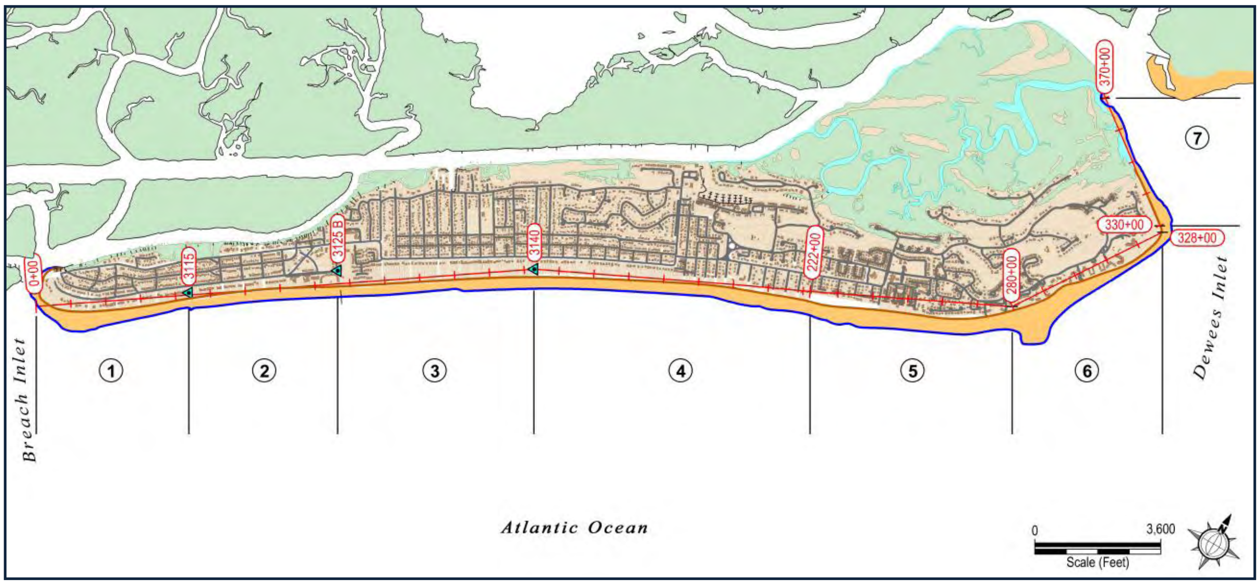

FIGURE 2.3. Location map of the reaches used in post-project monitoring at Isle of Palms. The 2008 beach restoration project occurred in subareas within Reaches 5, 6, and 7.

To determine changes in beach volume along IOP, beach profile data were entered into CSE's in-house custom software, Beach Profile Analysis System (BPAS), which converts 2D profile data in x–y (distance–elevation) format to 3D volumes. The software provides a quantitative and objective way of determining ideal minimum beach profiles and how the sand volume per unit length of shoreline compares with the desired condition. It also provides an accurate method of comparing historical profiles—as the volume method measures sand volumes in the active beach zone rather than extrapolating volumes based on single-contour shoreline position (ie – from aerial photography). Unit-volume calculations can distinguish the quantity of sediment in the dunes, on the dry beach, in the intertidal zone to wading depth, and in the remaining area offshore to the approximate limit of profile change (closure depth).

Figure 2.4 depicts the profile volume concept. The reference boundaries are site-specific, but ideally encompass the entire zone over which sand moves each year.

Sand volume was calculated between the primary dune and between −10 ft and −18 ft NAVD. The lower calculation limit was site-specific, as profiles in the center of the island and along Dewees Inlet generally have deeper closure depths than areas in the unstable inlet/shoal zones. Comparative volumes and volume changes were computed using standard procedures (average-end-area method, in which the average of the area under the profiles computed at the ends of each cell is multiplied by the length of the cell to determine the cell's sand volume). Certain adjustments were made to account for changes in the baseline direction and for volumes at the turn in the baseline at Dewees Inlet.

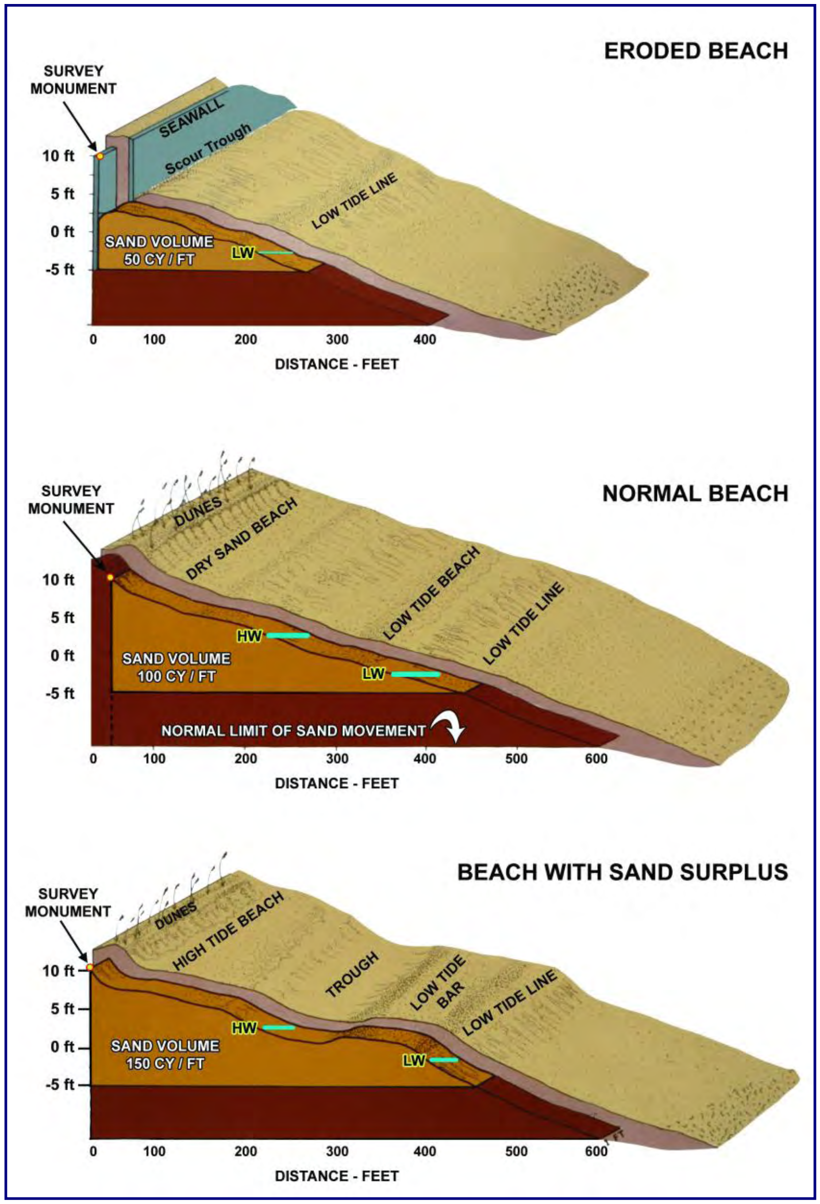

FIGURE 2.4. Calculation of unit-width profile volumes is a means of comparing the condition of one section of beach with another. Profile volumes are the amount of sand contained in a one-foot length of beach between specified elevations. [After Kana 1990]

Sand volumes for offshore areas were calculated from digital terrain models (DTMs) produced from MATLAB and AutoCAD® Civil 3D®. DTMs are digital 3D representations of the topography and bathymetry of an area and are useful for calculating changes in contour positions and calculating sediment volumes. Position data were entered into software as x–y–z coordinates and were processed to provide cross-section profiles and volumes. DTMs from the 2013 data collections were compared with earlier collections (pre-project and post-project) to determine changes in shoal positions and volumes. Color contour maps were also produced from the DTMs.

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3.0 RESULTS

3.1 Beach Condition in Monitoring Reaches

The results of the 2013 monitoring survey show that the island gained ~11,200 cy (0.3 cy/ft) of sand from July 2012 to July 2013. Reaches 1, 5, and 6 were erosional; however, each lost less sand than the previous year. The central portion of the island continues to gain sand, while portions of the eastern end (Beachwood East/Dunecrest and near Ocean Club) and the area near Breach Inlet are the most erosional. Significant accretion was observed near Beach Club Villas and Mariners Walk, in the lee of an attaching shoal. Volume change data for each monitoring station and reach are given in Figure 3.1, and Tables 3.1 and 3.2.

Previous studies have demonstrated that sand tends to move away from shoal-attachment zones in both directions (Kana et al 1985, Kana & Gaudiano 2001). This is apparent from the results illustrated in Figure 3.1. Note the diminishing volume of sand in Reach 5 and Reach 6, and the gain of sand in Reaches 2, 3, 4, and 7 since project completion. Reach 5 has fed sand to the south(west), nourishing most of the island, while losses in Reach 6 have fed sand to the Dewees Inlet shoreline (Reach 7). Sand transport along Isle of Palms is not uniformly from "north to south" but rather occurs in complex patterns which are linked to the stage of "shoal bypassing" and the proximity to inlet channels. Losses in Reach 1 (Breach Inlet area) have occurred recently despite the increasing supply of sand immediately upcoast. Erosion in Reach 1 appears to be related to movement of a secondary channel of Breach Inlet.

The following sections describe detailed volume changes within each reach and discuss changes to the inlet deltas.

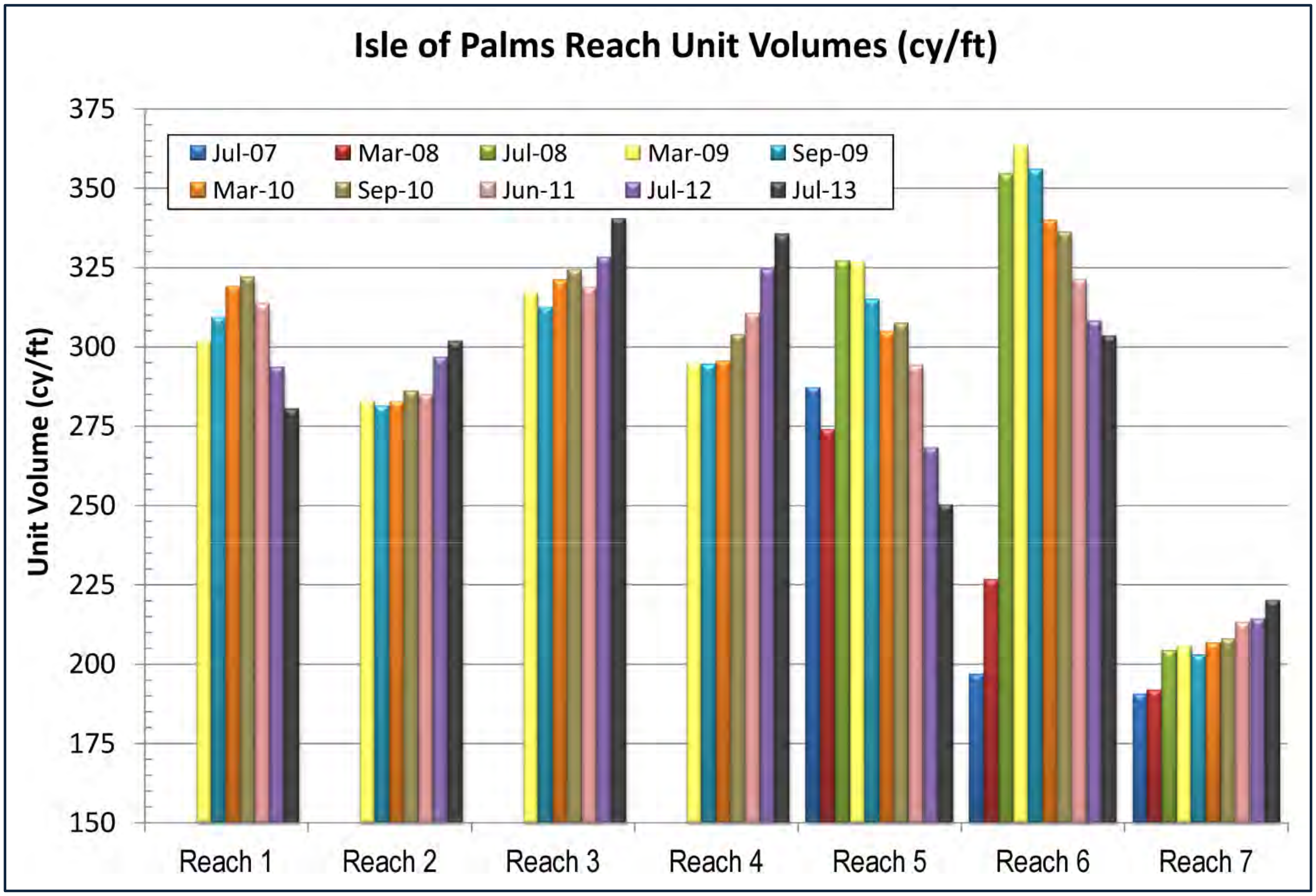


FIGURE 3.1. Average unit-width volumes for each monitoring reach at Isle of Palms. See Figure 2.3 for reach boundaries. Unit volumes were calculated from the primary dune to a profile-specific depth, generally between −9 ft and −13 ft NAVD for the beachfront. Nourishment occurred prior to the July 2008 data collection in Reaches 5, 6, and 7. Design-fill unit volumes for full sections were ~75 cy/ft in Reach 5, ~140-180 cy/ft in Reach 6, and ~27 cy/ft in Reach 7. See Figure 2.1 for beach nourishment locations.

TABLE 3.1. Profile unit-width volumes for each monitoring station at Isle of Palms. Nourishment occurred between stations 224 to 274 and stations 286 to 340 prior to the July 2008 data collection. Volumes are calculated between the approximate crest of the primary dune and the indicated “elevation lens” depth. Nourishment areas are highlighted in blue (project reach A), green, (project reach B), and yellow (project reach C). As additional surveys are completed, calculation limits may change to better encompass volume changes. This results in small differences in reported volumes between the present and earlier reports.

Reach	Line	Elevation Lens (ft NAVD)	Distance to Next (ft)	Unit Volume (cy/ft) Mar-08	Jul-08	Mar-09	Sep-09	Sep-10	Jun-11	Jul-12	Jul-13
Reach 1	3100	-13	0			371.4	371.4	390.6	-	333.4	386.2
	3105	-11	0			541.3	541.3	548.6	515.3	448.0	492.4
	0	-10	400			211.7	141.0	212.3	227.1	224.2	147.5
	4	-10	400			340.5	309.3	343.4	314.9	296.7	259.0
	8	-10	400			326.5	344.8	333.1	340.3	306.9	283.9
	12	-10	400			396.0	432.5	430.4	396.7	358.7	380.7
	16	-10	400			350.0	389.4	382.6	357.8	300.9	331.6
	20	-10	270			271.7	317.3	317.4	303.1	265.7	244.6
	3110	-11	730			295.4	311.6	323.5	318.3	292.4	270.7
	30	-12	1000			275.9	276.9	300.9	301.8	290.9	276.9
	40	-12	390			261.2	261.3	272.4	270.2	276.1	265.6
Reach 2	3115	-12	610			294.4	288.1	293.0	293.0	308.0	297.3
	50	-12	1000			293.2	296.7	305.3	298.7	307.0	302.4
	60	-12	1000			265.6	269.5	274.7	274.7	286.2	287.9
	70	-12	1000			284.1	282.7	280.1	284.9	297.0	307.9
	80	-12	670			276.3	265.7	274.9	270.5	283.2	298.5
Reach 3	3125	-12	330			312.4	308.1	314.0	312.1	326.3	333.9
	90	-13	1000			300.9	292.5	302.0	303.1	316.4	322.3
	100	-13	1000			311.1	304.4	324.0	315.0	320.8	329.9
	110	-13	1000			307.2	306.8	316.5	309.6	321.6	331.5
	120	-13	500			330.4	323.6	336.6	330.6	349.0	355.1
	3135	-12	500			315.4	314.3	318.6	313.1	322.1	341.3
	130	-13	1000			298.9	294.1	300.9	297.5	299.7	324.3
	140	-13	290			371.1	367.3	383.5	376.6	382.5	397.6
Reach 4	3140	-12	710			296.0	292.4	305.4	299.0	298.0	312.1
	150	-13	1000			311.5	299.5	309.7	311.3	313.0	330.1
	160	-13	290			297.8	284.6	283.1	291.6	305.0	316.3
	3145	-12	710			268.2	263.7	249.2	263.8	284.6	289.3
	170	-13	1000			292.5	291.8	293.4	289.8	317.0	335.4
	180	-12	150			277.7	275.7	293.6	295.4	312.0	331.2
	3150	-12	850			289.6	295.3	315.0	325.0	343.3	349.5
	190	-12	1000			280.6	275.9	293.7	310.8	327.7	331.5
	200	-12	200			316.5	307.9	328.9	337.7	349.7	356.6
	202	-12	200		280.5	317.7	325.0	337.3	341.1	351.3	360.3
	204	-12	200		286.8	315.9	333.0	343.5	344.8	352.8	360.5
	206	-12	200		288.7	314.3	336.4	344.8	346.4	353.4	363.7
	208	-11	200		255.9	281.6	294.1	308.8	311.9	327.0	343.2
	210	-11	200		287.8	306.7	328.2	341.7	346.6	354.9	367.7
	212	-11	200		258.0	274.0	298.1	310.7	316.0	335.2	335.8
	214	-11	200		251.7	281.8	305.3	306.3	321.3	334.9	340.3
	216	-11	200		253.4	286.8	302.3	303.1	317.0	332.4	344.0
	218	-11	200		274.5	309.6	312.9	318.8	332.6	342.8	352.5
	220	-11	200		269.5	305.9	309.1	315.1	327.8	343.5	357.0
Reach 5	222	-10	200	252.0	261.0	292.6	295.7	305.9	322.4	337.3	339.2
	224	-10	200	221.5	233.5	269.0	273.0	271.3	288.3	309.0	306.5
	226	-10	200	217.6	225.3	274.0	286.8	276.8	281.8	300.8	294.0
	228	-10	200	222.6	252.1	292.2	299.8	288.4	285.6	296.4	287.7
	230	-10	200	233.0	284.4	306.3	307.4	304.6	296.5	293.8	293.6
	232	-10	200	273.9	316.6	336.9	336.8	333.6	327.2	318.1	307.8
	234	-10	200	245.9	320.5	335.1	327.9	319.7	317.6	301.7	298.1
	236	-10	200	214.2	295.1	317.1	300.6	297.7	294.7	284.6	267.4
	238	-10	200	204.8	294.6	318.1	299.6	297.9	296.4	279.9	269.7
	240	-10	200	184.4	277.6	307.6	285.8	283.3	285.9	269.5	250.1
	242	-10	200	182.6	273.6	304.3	283.8	282.3	280.0	260.6	241.0
	244	-10	200	189.8	283.1	313.0	297.7	290.0	281.0	267.9	250.0
	246	-10	200	181.8	271.0	286.4	271.4	264.5	262.6	239.8	214.6
	248	-10	200	188.7	272.2	280.5	267.2	258.1	255.9	230.1	218.3
	250	-10	200	188.5	282.2	278.3	261.2	254.2	248.6	220.9	223.7
	252	-10	200	197.9	291.9	275.9	265.5	253.2	245.8	225.0	245.9

Reach	Line	Elevation Lens (ft NAVD)	Distance to Next (ft)	Unit Volume (cy/ft) Mar-08	Jul-08	Mar-09	Sep-09	Sep-10	Jun-11	Jul-12	Jul-13
Reach 5 (continued)	254	-10	200	197.5	298.1	270.3	267.1	242.3	236.0	222.0	242.8
	256	-10	200	212.3	313.2	276.2	273.8	240.7	233.6	234.1	230.9
	258	-10	200	201.7	297.6	256.8	252.6	214.6	216.7	218.2	185.2
	260	-10	200	229.1	305.9	270.5	256.9	216.8	216.5	223.7	170.5
	262	-10	200	283.5	346.2	340.9	297.5	276.0	251.1	242.2	206.3
	264	-10	200	332.0	392.1	383.9	343.7	310.1	239.8	241.9	193.3
	266	-10	200	366.5	437.5	392.2	365.7	328.0	290.3	266.8	218.5
	268	-10	200	363.3	408.5	342.5	335.4	320.3	302.1	280.9	170.8
	270	-10	200	393.0	422.7	343.0	340.3	337.1	295.1	240.5	212.9
	272	-10	200	407.3	420.9	371.0	352.7	354.2	322.9	267.1	191.5
	274	-10	200	341.5	344.6	300.7	289.8	307.6	293.4	227.6	160.5
	276	-10	200	461.8	459.1	427.9	399.1	433.3	417.3	331.7	320.3
	278	-10	400	463.2	415.2	384.9	371.7	436.7	426.2	297.4	296.8
Reach 6	280	-10	200	461.0	436.6	602.3	603.9	557.5	458.7	336.9	423.2
	282	-10	200	501.0	440.4	616.0	634.9	549.6	411.5	338.5	400.3
	284	-10	200	515.3	522.2	627.9	679.5	583.0	497.7	403.1	466.1
	286	-10	200	445.3	471.8	553.2	587.5	506.8	452.7	374.6	438.0
	288	-10	200	333.0	423.8	433.6	453.8	445.8	442.6	382.5	389.5
	290	-10	200	255.4	357.3	387.9	390.9	391.1	412.7	372.3	385.9
	292	-10	200	246.8	355.6	382.7	389.3	377.8	423.4	404.6	418.7
	294	-10	200	235.7	363.0	378.1	380.7	370.7	395.9	405.5	416.5
	296	-10	200	213.5	354.7	359.8	353.7	352.3	375.0	385.0	374.6
	298	-10	200	191.1	354.1	349.5	339.4	337.2	356.5	366.0	343.0
	300	-10	200	173.6	347.5	336.8	323.6	320.5	339.7	349.9	316.1
	302	-10	200	149.8	339.3	329.5	306.7	305.8	317.6	328.1	306.1
	304	-10	200	141.5	333.2	307.5	289.8	283.0	292.3	310.2	273.6
	306	-10	200	171.7	372.6	359.8	312.2	305.7	310.8	338.8	299.0
	308	-10	200	155.4	341.0	301.7	287.0	260.9	260.9	289.4	230.0
	310	-10	200	152.6	312.9	284.6	241.6	233.9	245.9	239.0	188.3
	312	-10	200	111.2	281.0	234.7	215.2	194.3	192.6	197.5	169.9
	314	-10	200	86.9	246.1	198.9	169.0	170.6	156.0	171.2	110.7
	316	-10	200	136.4	309.3	268.6	252.7	254.3	235.4	223.0	210.9
	318	-10	200	128.2	312.0	272.7	256.8	251.8	229.4	238.9	182.4
	320	-10	200	140.9	324.5	284.3	271.8	264.8	238.8	251.9	212.2
	322	-10	200	205.4	368.5	336.5	318.2	295.5	267.3	249.9	247.9
	324	-10	200	212.3	361.7	342.8	331.6	304.0	270.8	255.0	265.2
	326	-10	200	174.1	291.2	314.4	309.9	290.1	258.3	243.0	253.8
	328	-10	100	241.0	285.3	341.4	321.5	307.5	259.6	263.1	324.7
Reach 7	330	-18	200	228.2	262.4	281.7	297.0	348.6	374.3	374.5	372.3
	332	-18	200	286.9	333.6	340.5	344.8	383.5	389.5	396.8	409.6
	334	-18	200	252.6	295.8	324.2	328.5	349.0	357.5	372.1	391.7
	336	-18	200	232.8	284.0	281.2	291.3	300.7	319.1	330.0	343.4
	338	-18	200	214.7	261.2	247.8	240.3	245.2	252.3	266.0	280.9
	340	-18	200	204.6	244.6	223.2	216.1	212.5	218.4	224.8	233.3
	342	-18	200	227.6	246.4	239.2	232.7	226.1	232.4	246.7	253.5
	344	-18	200	201.1	209.5	208.3	205.0	196.4	198.6	209.7	215.3
	346	-18	200	198.4	198.1	201.8	197.7	189.3	193.5	194.9	199.7
	348	-15	200	150.9	147.2	150.7	149.0	136.2	147.2	144.0	146.2
	350	-15	200	170.1	169.7	170.7	167.5	165.5	165.1	168.0	173.8
	352	-15	200	159.8	160.4	155.2	153.3	157.3	158.9	160.2	169.6
	354	-15	200	170.1	171.1	168.1	165.0	171.8	174.2	176.5	184.0
	356	-15	200	186.5	185.6	183.1	177.9	185.1	189.1	188.6	195.4
	358	-15	200	175.3	171.9	173.1	163.8	174.5	180.0	178.4	175.2
	360	-15	200	177.2	172.0	174.4	164.2	175.7	181.8	177.5	170.8
	362	-15	200	173.3	167.4	173.1	164.5	174.9	174.4	167.6	154.9
	364	-15	200	146.2	141.2	137.5	139.7	145.2	136.3	129.3	117.6
	366	-13	200	137.4	131.6	146.1	138.9	131.2	136.8	135.6	132.9
	368	-13	200	168.9	174.2	183.7	178.5	177.0	174.2	180.1	188.4
	370	-13	0				176.0	178.8	193.5	-	-

TABLE 3.2. Isle of Palms reach volume analysis from March 2008 through July 2013. Nourishment occurred May-June 2008, prior to the July 2008 data collection. Volumes are calculated for each profile to a profile-specific depth, and then extrapolated to the next profile using the average-end-area method. The March 2008 data collection represents the pre-nourishment condition. As additional surveys are completed, calculation limits may change to better encompass volume changes. This results in small differences in reported volumes between the present and earlier reports.

			Total Volume (cy)								
Reach	Limits	Length (ft)	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13
Reach 1	0-3115	4,390	-	-	1,323,935	1,357,979	1,400,189	1,413,097	1,376,054	1,288,983	1,230,930
Reach 2	3115-3125	4,280	-	-	1,210,927	1,204,056	1,210,097	1,224,707	1,219,874	1,270,043	1,290,942
Reach 3	3125-3140	5,620	-	-	1,781,858	1,756,250	1,803,023	1,822,223	1,791,564	1,844,155	1,912,700
Reach 4	3140-222	7,910	-	-	2,329,739	2,329,333	2,337,148	2,403,086	2,455,964	2,566,721	2,653,128
Reach 5	222-280	6,000	1,643,654	1,961,934	1,959,318	1,889,689	1,827,412	1,844,446	1,764,364	1,609,354	1,501,967
Reach 6	280-328	4,900	1,109,721	1,737,374	1,780,813	1,743,807	1,664,778	1,647,178	1,574,542	1,509,881	1,487,043
Reach 7	330-370	4,000	766,568	816,758	822,893	810,992	826,350	832,184	852,642	857,028	880,678

	Average unit Volume (cy/ft)								
Reach	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13
Reach 1	-	-	301.6	309.3	318.9	321.9	313.5	293.6	280.4
Reach 2	-	-	282.9	281.3	282.7	286.1	285.0	296.7	301.6
Reach 3	-	-	317.1	312.5	320.8	324.2	318.8	328.1	340.3
Reach 4	-	-	294.5	294.5	295.5	303.8	310.5	324.5	335.4
Reach 5	273.9	327.0	326.6	314.9	304.6	307.4	294.1	268.2	250.3
Reach 6	226.5	354.6	363.4	355.9	339.8	336.2	321.3	308.1	303.5
Reach 7	191.6	204.2	205.7	202.7	206.6	208.0	213.2	214.3	220.2

			Net Change Since Previous								
Reach	Limits	Length (ft)	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13
Reach 1	0-3115	4,390	-	-	-	34,044	42,210	12,908	-37,043	-87,071	-58,053
Reach 2	3115-3125	4,280	-	-	-	-6,870	6,041	14,610	-4,833	50,169	20,898
Reach 3	3125-3140	5,620	-	-	-	-25,608	46,773	19,201	-30,659	52,591	68,545
Reach 4	3140-222	7,910	-	-	-	-407	7,815	65,939	52,878	110,757	86,407
Reach 5	222-280	6,000	-78,815	318,280	-2,616	-69,630	-62,276	17,033	-80,082	-155,010	-107,387
Reach 6	280-328	4,900	146,076	627,653	43,439	-37,006	-79,029	-17,599	-72,636	-64,661	-22,838
Reach 7	330-370	4,000	4,393	50,190	6,135	-11,901	15,358	5,834	20,459	4,385	23,650
Total Change Since Previous			71,655	996,123	46,958	-117,379	-23,108	117,925	-151,916	-88,840	11,222

	Unit Change Since Previous (cy/ft)								
Reach	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13
Reach 1	-	-	-	7.8	9.6	2.9	-8.4	-19.8	-13.2
Reach 2	-	-	-	-1.6	1.4	3.4	-1.1	11.7	4.9
Reach 3	-	-	-	-4.6	8.3	3.4	-5.5	9.4	12.2
Reach 4	-	-	-	-0.1	1.0	8.3	6.7	14.0	10.9
Reach 5	-13.1	53.0	-0.4	-11.6	-10.4	2.8	-13.3	-25.8	-17.9
Reach 6	29.8	128.1	8.9	-7.6	-16.1	-3.6	-14.8	-13.2	-4.7
Reach 7	1.1	12.5	1.5	-3.0	3.8	1.5	5.1	1.1	5.9
Total Change Since Previous	1.9	26.8	1.3	-3.2	-0.6	3.2	-4.1	-2.4	0.3

			Net Change Since Prenourishment (cy)								
Reach	Limits	Length (ft)	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13
Reach 5	222-280	6,000	-	318,280	315,664	246,034	183,758	200,792	120,710	-34,300	-141,687
Reach 6	280-328	4,900	-	627,653	671,092	634,086	555,057	537,458	464,822	400,161	377,322
Reach 7	330-370	4,000	-	50,190	56,325	44,424	59,782	65,615	86,074	90,459	114,109
5-7 Total Change Since Prenourishment			-	996,123	1,043,081	924,544	798,597	803,865	671,606	456,320	349,745

	Unit Change Since Prenourishment (cy/ft)								
Reach	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13
Reach 5	-	53.0	52.6	41.0	30.6	33.5	20.1	-5.7	-23.6
Reach 6	-	128.1	137.0	129.4	113.3	109.7	94.9	81.7	77.0
Reach 7	-	12.5	14.1	11.1	14.9	16.4	21.5	22.6	28.5
5-7 Total Change Since Prenourishment	-	66.9	70.0	62.0	53.6	54.0	45.1	30.6	23.5

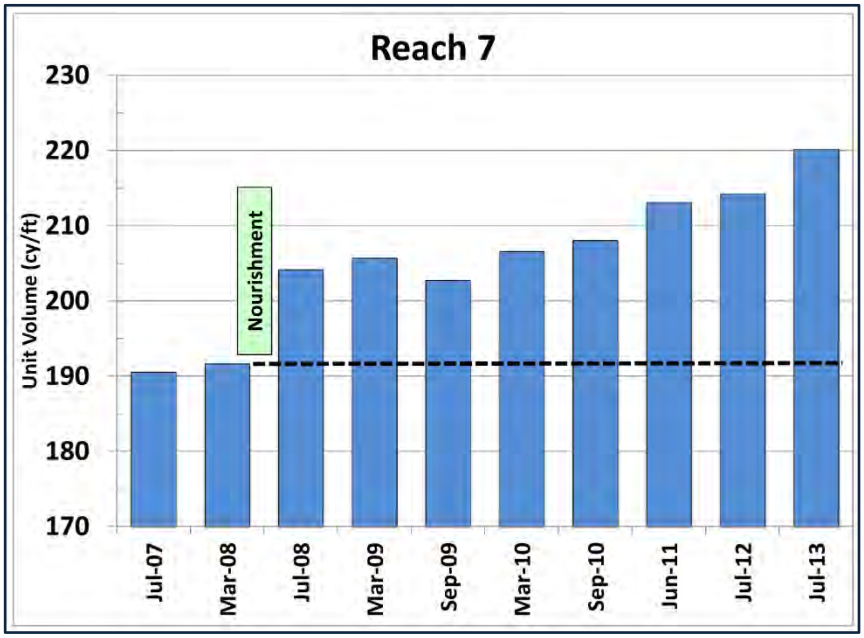
Reach 7 — Dewees Inlet (Volume Changes)

FIGURE 3.2. **[UPPER LEFT]** Reach 7 in December 2007. **[UPPER RIGHT]** June 2008 near the end of the project. **[LOWER]** November 2013. [Upper images by TW Kana] [Lower image by S Traynum]

Dewees Inlet (Fig 3.2, previous page) generally receives less wave energy than the rest of the Isle of Palms due to the sheltering effects of the ebb-tidal delta associated with the inlet. Shorelines along stable inlets usually show less dynamic volume changes than ocean-facing beaches; however, over time, they can experience severe erosion due to several factors. One factor thought to contribute to localized erosion along the Dewees Inlet shoreline is wave focusing through breaks in the inlet delta (Kana and Dinnel 1980). Breaks between the outer shoals on the Dewees Island side of the channel allow larger waves or destabilizing diffracted waves to reach the IOP shoreline and cause localized erosion. A low profile groin was built in 1981 near the 17th tee of the Wild Dunes Links Course to trap sand moving into Dewees Inlet and slow erosion (Kana et al 1985) (see Fig 3.2). The monitoring reach (Fig 3.3) extends from the turn in the shoreline near the 18th tee to the end of Cedar Creek spit.

Reach 7 has consistently gained sand since 2007 (Fig 3.4, upper), with most of the accretion being focused near the seaward end of the reach (17th green and 18th tee area). The area seaward of the groin (station 348+00 near the 17th tee) has gained ~61,750 cy of sand since nourishment in 2008 (most of which was gained between stations 330+00 and 338+00). Of note is that erosion which occurred rapidly following the project at stations 338+00 – 342+00 has recovered and the beach is healthier than the post-nourishment condition at all but station 340+00. The beach inland of the groin has been relatively stable, showing a net gain of ~2,100 cy. Within this subreach, stations 348+00 thru 356+00 accreted an average of 6.4 cy/ft while stations 358+00 thru 366+00 eroded an average of 7.4 cy/ft over the past year.

FIGURE 3.3. Station map of the Dewees Inlet area (Reach 7). Reach 7 spans from station 330+00 near the 18th tee to station 368+00 near Cedar Creek spit. The approximate limits of Reach C nourishment are identified by the orange-highlighted bar. The 1981 low profile groin is positioned near station 348+00. [July 2011 aerial image by Independent Mapping Consultants Inc]



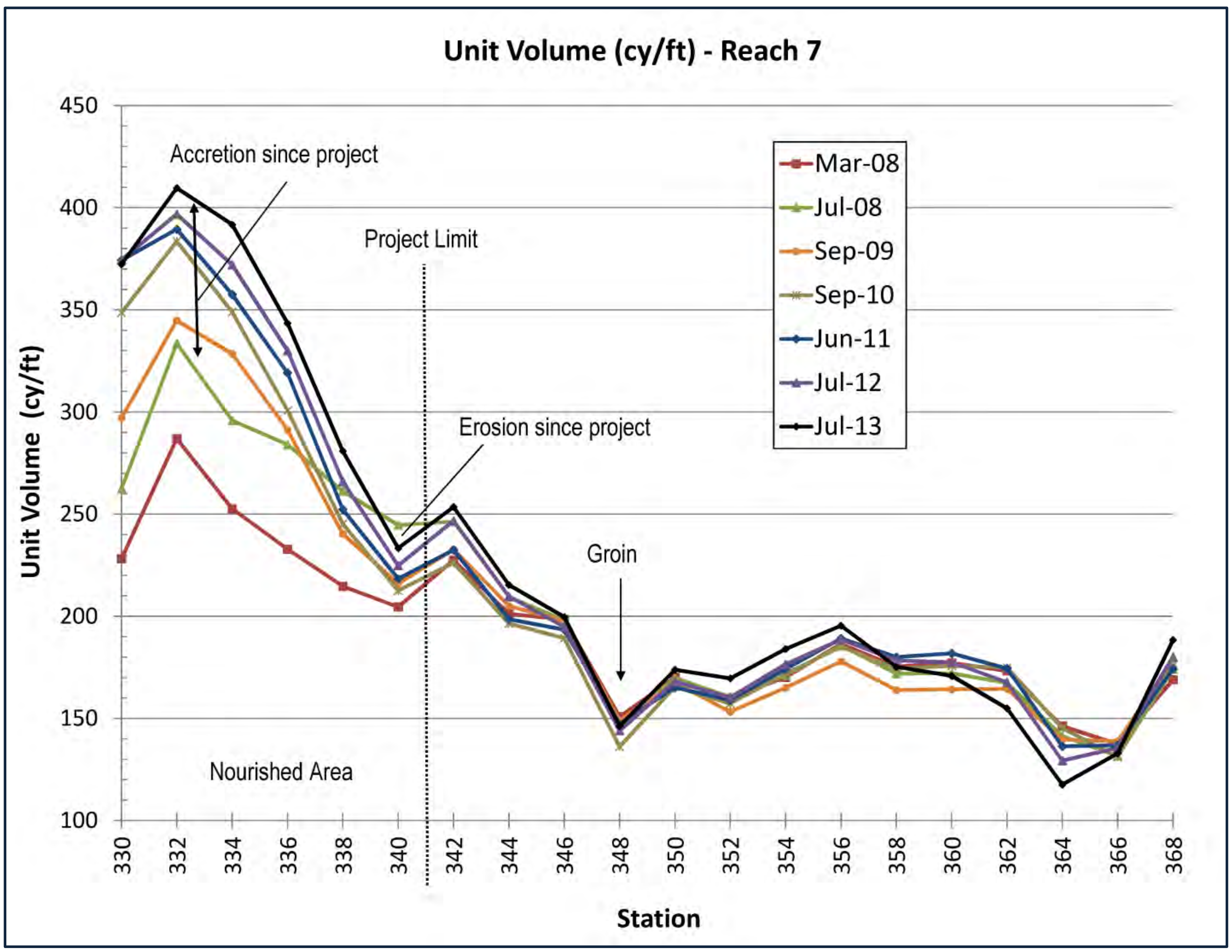


FIGURE 3.4. **[UPPER]** Cumulative unit volumes for Reach 7 from 2007 to 2013. **[LOWER]** Unit volumes for stations in Dewees Inlet. Profiles in the southwestern portion of the reach (17th green – 18th tee) have accreted following the project, while the remaining stations have been stable or have eroded. The difference between 2013 (black line) and post-nourishment (green line) shows the volume change since nourishment.

Overall, the reach gained 23,650 cy (5.9 cy/ft) of sand over the past year. As of July 2013, the reach contains 114,100 cy (28.5 cy/ft) more sand than the pre-nourishment condition. Wave action directed towards and into the inlet moves sand from the front beach to the inlet shoreline, leading to the observed accretion. Once the sand reaches Cedar Creek Spit, or is moved below the influence of wave action, tidal currents in Dewees Inlet carry it offshore, building the delta system. Over the last few years, a significant sandbar, termed a trailing ebb spit, has formed just offshore of the point (see Fig 3.17 in this section). Sand lost from the front beach, some of which may be cycled through Reach 7, is likely the source of sand for this growing feature.

Profiles from select stations in Reach 7 are shown in Figure 3.5. Station 332+00 is just seaward of the beach access at the 17th green. The 0 ft NAVD contour (approximate mean sea level) has moved over 100 ft seaward since the 2008 nourishment project. The station has accreted between every monitoring survey since 2008. Station 340+00 is located along the central portion of the 17th fairway of the Links Course. This area eroded rapidly following the project; however, since 2009, the position of the berm crest has been fairly stable. Over the past two years, the lower profile (below −7 ft NAVD) has gained a significant amount of sand, which is essentially forcing this portion of Dewees Inlet away from Isle of Palms. The wider underwater base is likely contributing to modest growth of the berm over the past year.

Station 354+00 is located near the Seagrass Lane boardwalk and has been fairly stable since 2007 with only minor fluctuations in the position of the berm crest. Significant dune growth is evident and is characteristic for an area showing long-term stability. Much like station 340+00, gains were observed in the lower profile. Profiles and aerial imagery show the spit has transitioned from bare sand flats to a vegetated dune area with a dry beach. Since May 2008, the profiles show ~4 ft of vertical dune growth, though a loss of ~70 ft of beach width at the 0 ft NAVD contour.

Ground photos of Reach 7 show that vegetation has spread and matured along the 2008 fill area (Fig 3.6). The escarpment which ran along the 17th green prior to nourishment has healed and is now well set back from the water. A substantial amount of wrack (dead marsh grass) has accumulated along the shoreline in this reach. The wrack facilitates dune growth and is a benefit to beach organisms. USFWS generally discourages removal of wrack from the beach.

[Note: These results are based on profile volumes between the foredune and −13 ft to −18 ft NAVD. They do not include changes along the Dewees Inlet channel margin between −18 ft and −38 ft, the approximate inlet depth along the reach.]

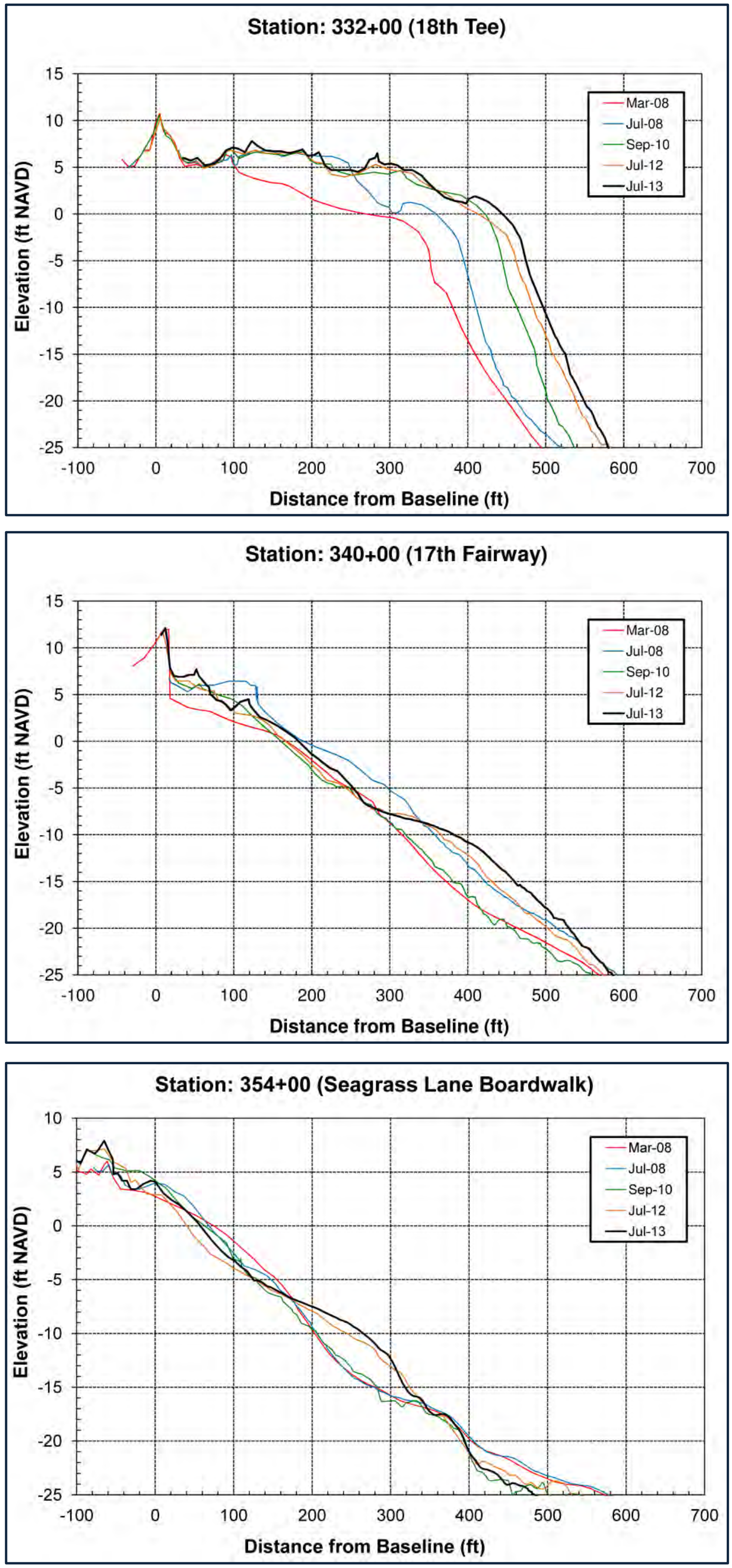


FIGURE 3.5.

Profiles for selected stations in Reach 7.

The seaward end of the reach has accreted (station 332) since nourishment, while the central and inland portions of the reach have remained fairly stable.

FIGURE 3.6. **[UPPER]** View looking south from station 332+00 in July 2013; the sand visible in this image has accreted since nourishment. **[MIDDLE]** Northwest view in July 2013 from station 344+00 ~400 ft seaward of the groin. A small scarp is visible; however, a dry berm separates the high waterline from the dune. **[LOWER]** View seaward of the nourished area of Reach 7 in July 2012. Vegetation has become well established seaward of the sand fencing. The pre-project dune line (red dotted line) is the dense vegetation ~25 ft to the right of the fencing in the image. [Photos by D Giles andS Traynum]

Reach 6 — Wild Dunes Property Owners Beach House to Dewees Inlet

FIGURE 3.7. Reach 6 in December 2007 (upper left), June 2008 near the end of the project (upper right), September 2009 (lower left) and November 2013 (center right).

[Upper images by TW Kana; lower left image by C Jones; center right image by S Traynum]

Reach 6 (Fig 3.7, previous page) extends from the Wild Dunes Property Owners Beach House ~4,900 ft northeast to the 18th fairway, where the beach turns into Dewees Inlet (station 280+00 to station 328+00, Fig 3.8). Shoal-bypassing events have highly impacted this area since the island's formation. Depending on the location and timing of the bypass events, the shoreline can change hundreds of feet over a period of several months (Kana et al 1985, Gaudiano 1998). As was the case in 2007-2008, the shoreline may encroach on development in this reach when shoal-bypass events are prolonged.

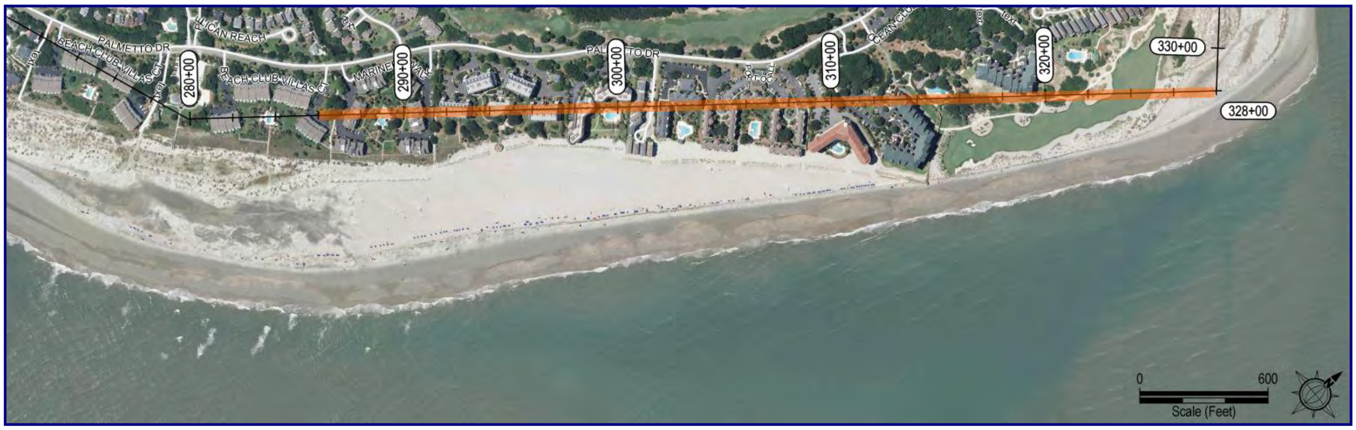


FIGURE 3.8. Reach 6 spans from the Wild Dunes Property Owners Beach House (station 280+00) to the 18th fairway of the Wild Dunes Links Course (station 328+00). The approximate limits of nourishment Reach B are identified by the orange-highlighted bar. [July 2011 aerial image by Independent Mapping Consultants Inc]

Previous studies have suggested that the background, long-term erosion for the northeastern end of IOP is between 15,000 cy/yr and 30,000 cy/yr even though the estimated average volume of sand added by each shoal-bypass event is ~500,000 cy (CSE 2007). This means that, while large fluctuations in the shoreline and severe local erosion may occur, the long-term erosion rate for the area is relatively low. Sand simply migrates from one area of the beach to another and is either transported back to Dewees Inlet or downcoast to IOP, eventually being replaced by offshore sand through another shoal-bypassing event.

Prior to nourishment in June 2008, most of Reach 6 was severely eroded with profile volumes seaward of development well below an ideal condition. Property owners had piled sand bags against buildings for protection, and little or no dry beach was present (see Fig 1.3). The condition was beginning to improve just before the nourishment as the shoal attaching at the western end of the reach was in Stage 3 of the bypass cycle. Sand was moving from the shoal toward Dewees Inlet, but not quickly enough to restore the beach along most properties north of the Wild Dunes Property Owners Beach House (WDPOBH).

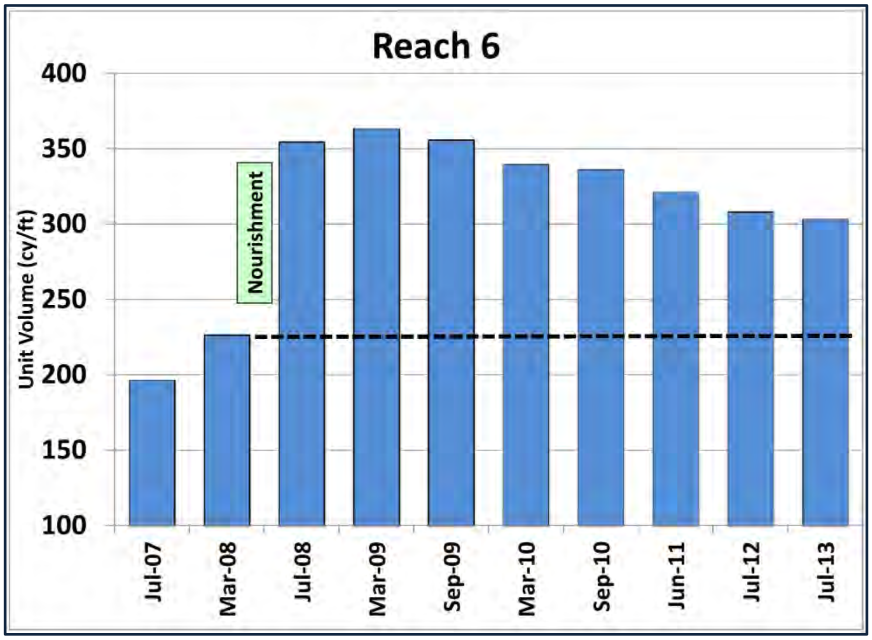
Additional sand was needed to supplement the natural sand transport condition. Between March and July 2008, ~628,000 cy of sand were added to the reach through nourishment and natural spreading of sand from the shoal (the design volume for this reach was 550,000 cy). Average profile unit volumes increased from 226 cy/ft to 355 cy/ft (calculated to −10 ft NAVD) (Fig 3.9, upper).

The western end of Reach 6 (and eastern end of Reach 5) has been the most dynamic portion of the island due to attaching shoal-bypass events. The large event occurring from 2004 to 2007, which led to the 2008 nourishment project, produced an extreme bulge in the shoreline (Fig 3.10). This bulge spread over the next two years while additional sand was moving onshore. The additional sand coalesced in another shoal-bypass event which attached in 2009, followed by a small event in 2010. These events maintained the excess sand supply near the Wild Dunes Property Owners Beach House through 2010. From 2010 until 2012, no additional sand attached to the beach, and much of the excess sand spread to downcoast areas.

Since 2007, CSE has been monitoring a large-scale channel avulsion event, which is a natural realignment of the main Dewees Inlet channel and subsequent migration of offshore sand as the new inlet and delta evolve. A large sand shoal has been migrating toward the beach over the past several years and has now shifted close enough to the beach to begin impacting the leeward shoreline. This is evident in the accretion observed near Beach Club Villas and Mariners Walk over the past year. Stations 280+00 (WDPOBH) to 294+00 (Shipwatch) gained an average of 40 cy/ft of sand from 2012 to 2013. Most of the volume gain was along the wet beach or underwater, though the dry beach accreted near Mariners Walk. CSE expects accelerated accretion in this area over the next year as the offshore shoal continues to approach the beach.

The beach between Shipwatch and Tidewater has been fairly stable since nourishment and maintains a wide, flat berm between structures and the waterline (Fig 3.11). The berm is continuing to develop dunes and vegetation along the sand fencing and over the nourished berm Fig 3.12).

The remainder of Reach 6 (east of Port O'Call) has been erosional since nourishment with the most significant erosion centered at the Ocean Club building and 18th green of the Links Course (see Fig 3.9, lower). Erosion was rapid in this area in the first year after nourishment and then slowed from 2009 through 2012. This erosion, coupled with the lower relative setback of the Ocean Club building and 18th green, resulted in the loss of most of the dry berm fronting these structures by early 2012.



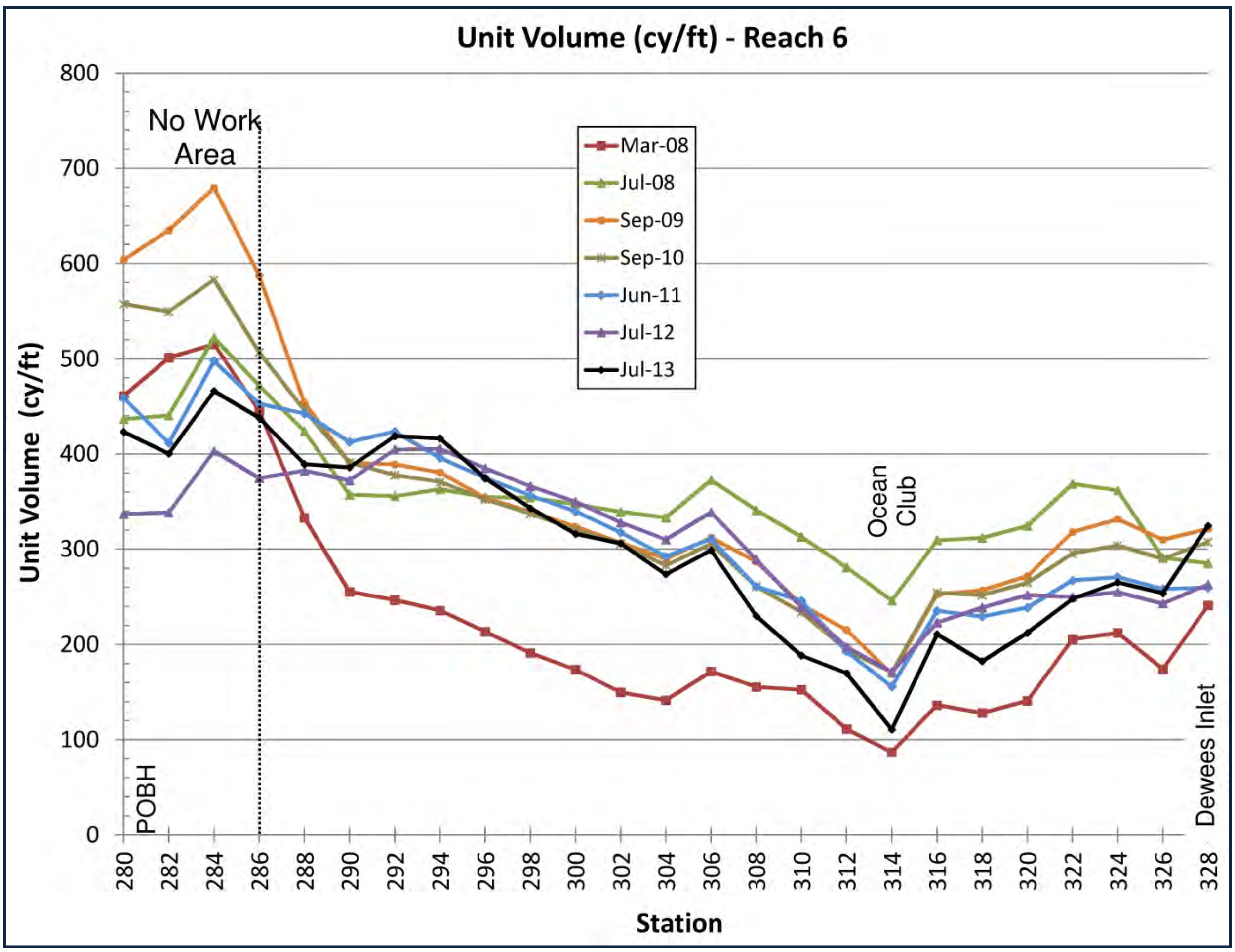


FIGURE 3.9. **[UPPER]** Bar graph showing beach unit volumes calculated to −10 ft NAVD in Reach 6. Overall, this reach has over 100 cy/ft more sand in July 2012 than in July 2007 (prior to shoal attachment and nourishment. **[LOWER]** Profile unit-width volumes for stations in Reach 6. Erosion has dominated the ends of the reach. The beach was much more stable from 2009 to 2012; however, erosion increased along the eastern portion of the reach over the past year.

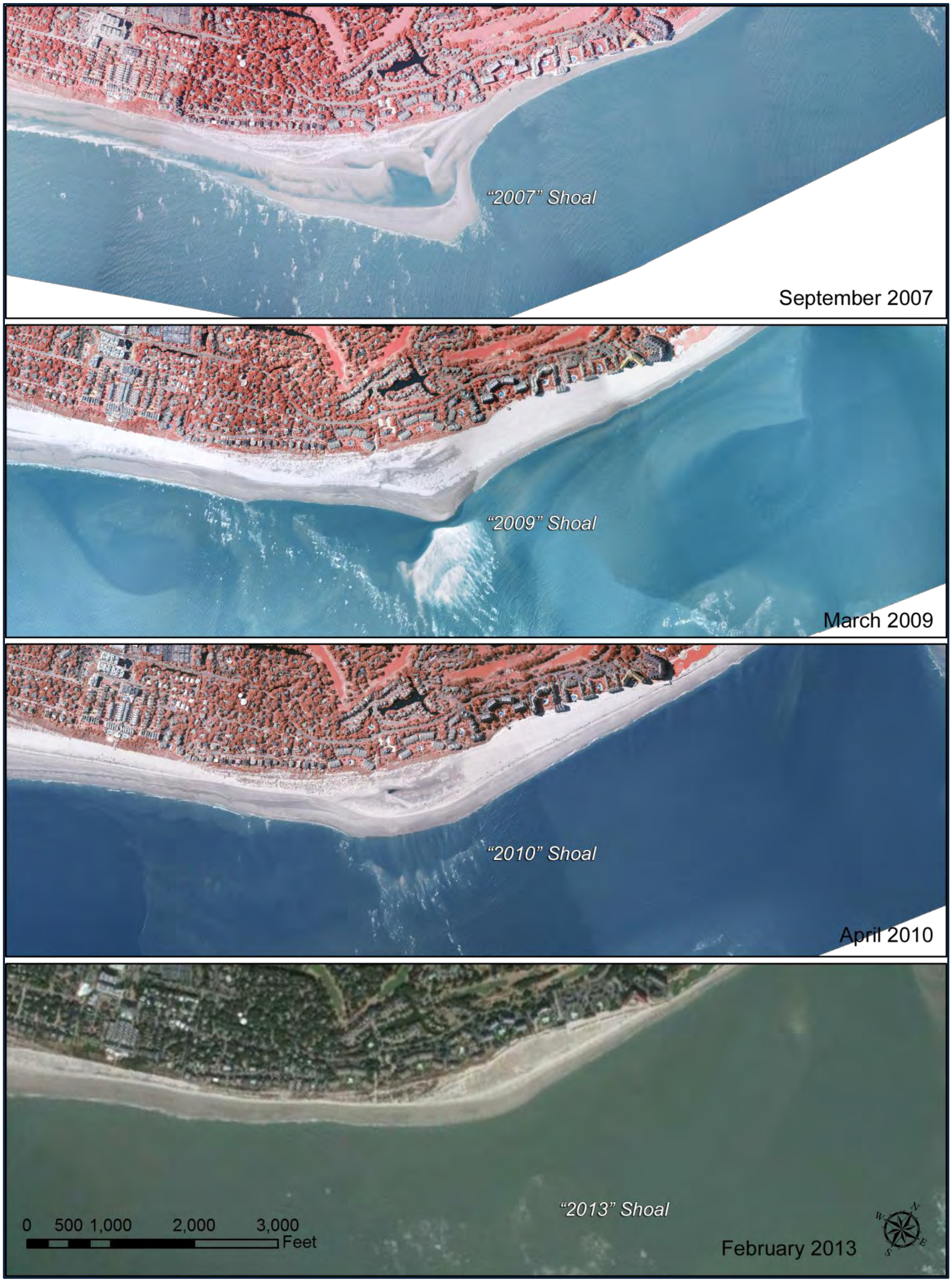


FIGURE 3.10. Sequence of aerial photographs showing four distinct shoal-bypass events occurring between 2007 and 2013. The 2009 and 2010 events were of much smaller scale than the 2007 event or the present event. The first three images were obtained by Independent Mapping Consultants (IMC, Charlotte NC); the fourth image was obtained from Google Earth (2013).

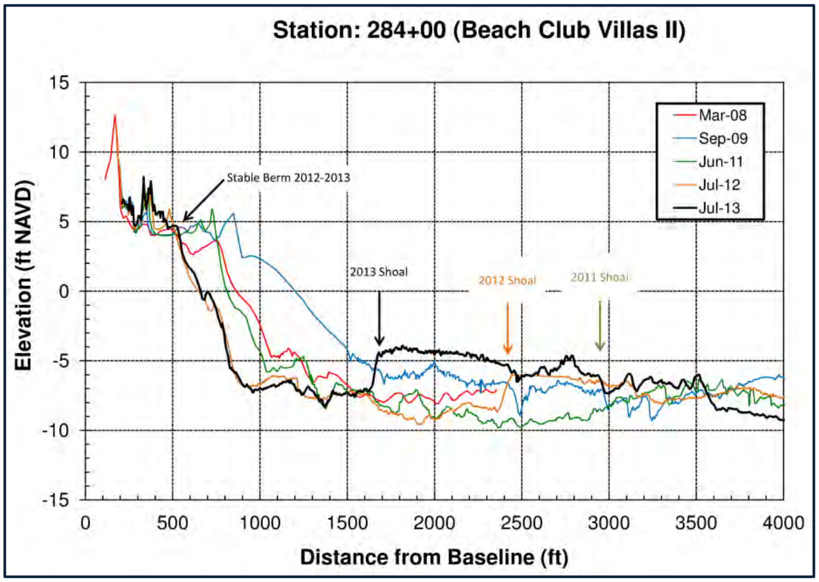


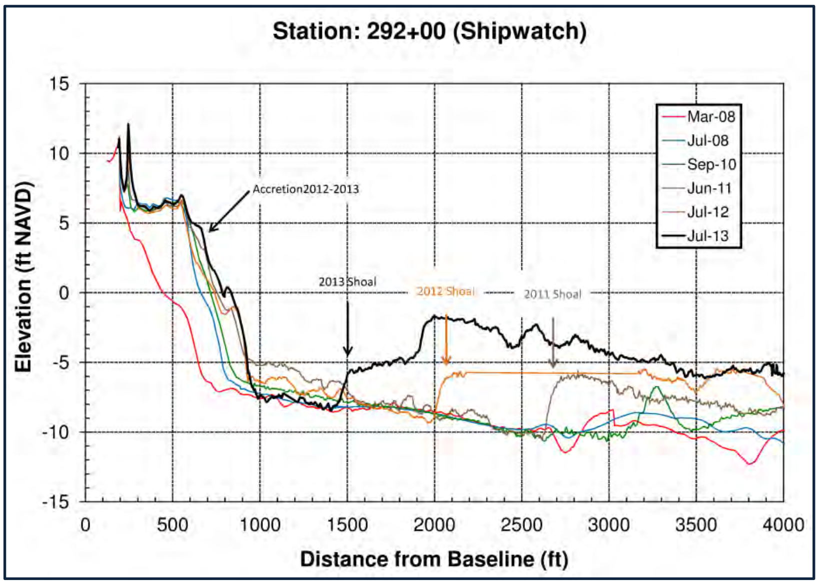
FIGURE 3.11.

Profiles for selected stations in Reach 6.

Station 284+00 rapidly eroded from 2009 to 2012; however, the berm was stable over the past year as the shoal moved closer to the beach.

Station 292+00 (Shipwatch) has accreted since nourishment. It is directly in the lee of the approaching shoal, which was ~600 ft from the beach in July 2013 and had migrated ~600 ft landward over the previous year.

Station 314+00 eroded rapidly the first year after the 2008 project and continues to be an erosion hotspot.



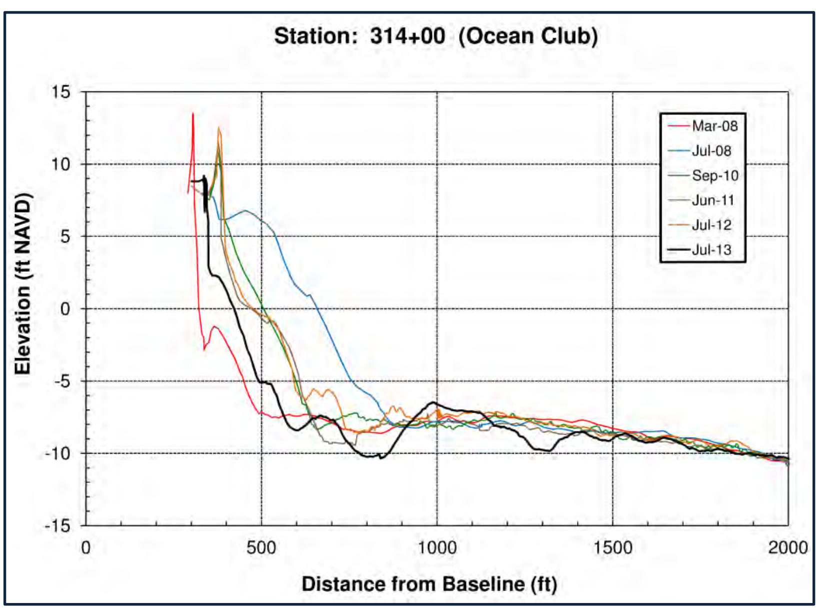


FIGURE 3.12.

[UPPER LEFT] View north in December 2007 near Summer Dunes Lane prior to the nourishment project.

[CENTER LEFT] Station 288+00 looking west (July 2013), in the lee of the attaching shoal.

[CENTER RIGHT] Station 292+00 looking east (July 2013), also in the lee of the attaching shoal. Note the dry beach, indicating accretion in this area.

[LOWER LEFT] Station 314+00 looking west (July 2013).

[LOWER RIGHT] Station 314+00 looking east (July 2013).

A shoal management project was conducted in March of 2012 which placed ~87,000 cy of sand between stations 306+00 and 320+00; however, most of the dry berm created during the project had eroded by July 2012 (more details of the 2012 shoal management project and current plans for additional work are given in Section 3.2).

Erosion has increased from Port O'Call to the 18th fairway over the past year. Stations 306+00 thru 320+00 lost an average of 43.3 cy/ft from 2012 to 2013, which is less than the rate observed following the project but higher than typical rates over the past several years, and is spread over a greater distance along the beach. Hurricane *Sandy*, passing the area in October 2012, caused significant dune recession and likely contributed to the increase in erosion observed over the past year. Profiles show an ~50-ft recession of the berm crest and a steeper beach along most of this area. The increase in erosion is believed to be in response to the approaching shoal west of the area as it is now in Stage 2 of the shoal-bypass cycle. The eroded area is the characteristic erosional arc commonly present adjacent to shoal-attachment sites. Erosion is expected to continue until the main body of the shoal attaches and sand begins to spread, or a management project is completed.

Overall, Reach 6 lost 22,838 cy (4.7 cy/ft) of sand over the past year. This is the lowest annual erosion rate observed since 2009, and only about one third of the volume lost over the previous year. Stations 280+00 thru 296+00 gained a total of 54,400 cy while stations 296+00 through 322+00 lost ~93,600 cy. The area along the front beach near the point (near the dogleg of the 18th fairway) gained sand over the past year. The reach retains ~377,000 cy (77 cy/ft) more sand than the 2008 pre-nourishment condition. It has lost ~250,000 cy since nourishment.

Reach 5 — 53rd Avenue to Wild Dunes Property Owners Beach House

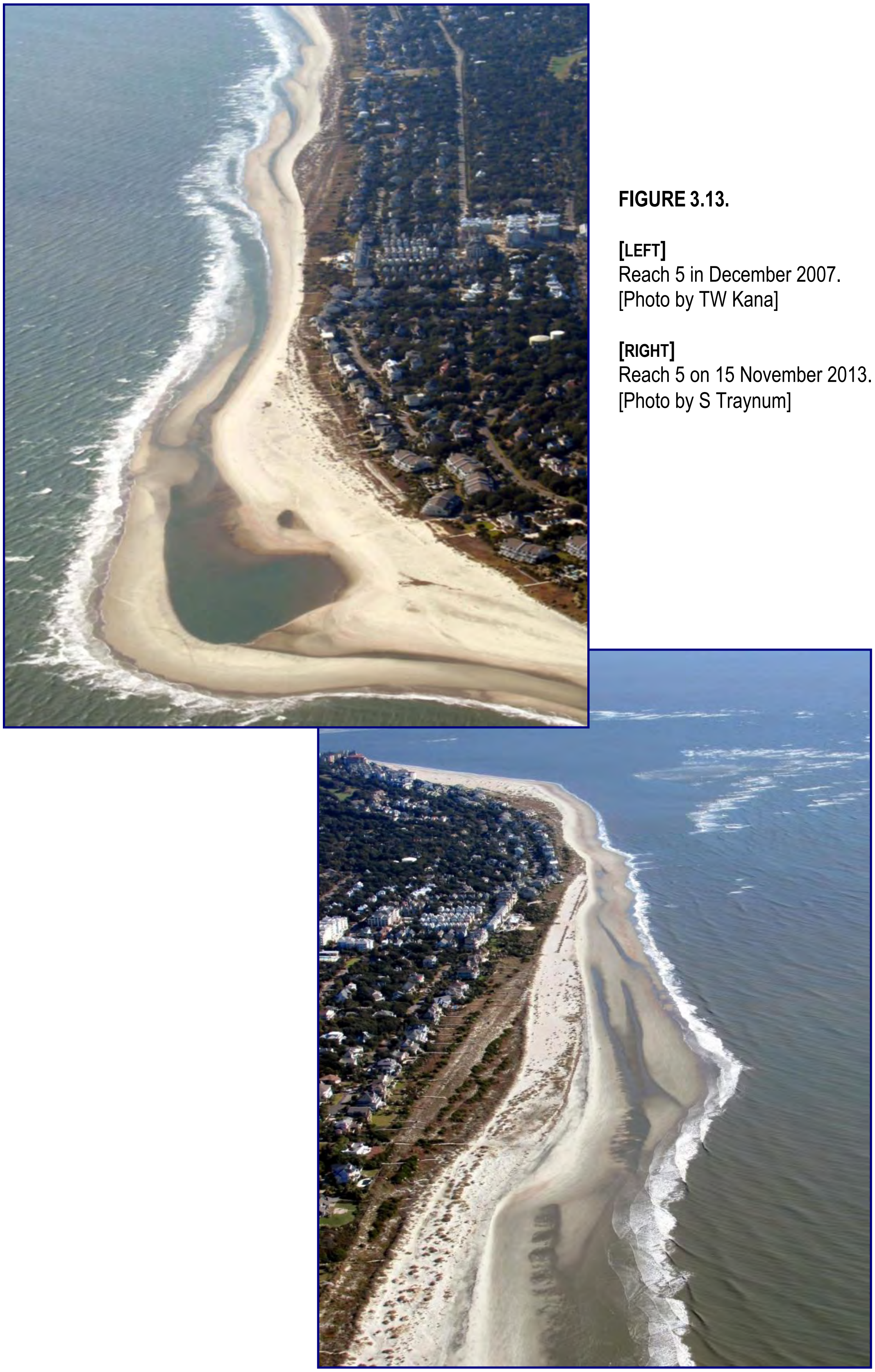


FIGURE 3.13.

[LEFT]
Reach 5 in December 2007.
[Photo by TW Kana]

[RIGHT]
Reach 5 on 15 November 2013.
[Photo by S Traynum]

Reach 5 (Fig 3.13, previous page) spans ~6,000 ft between 53rd Avenue and the Wild Dunes Property Owners Beach House and encompasses project Reach A (Fig 3.14, stations 222+00 thru 280+00). Like Reach 6, this area is greatly influenced by shoal-bypass events, especially at the northern end of the reach where the majority of shoals attach to the beach.

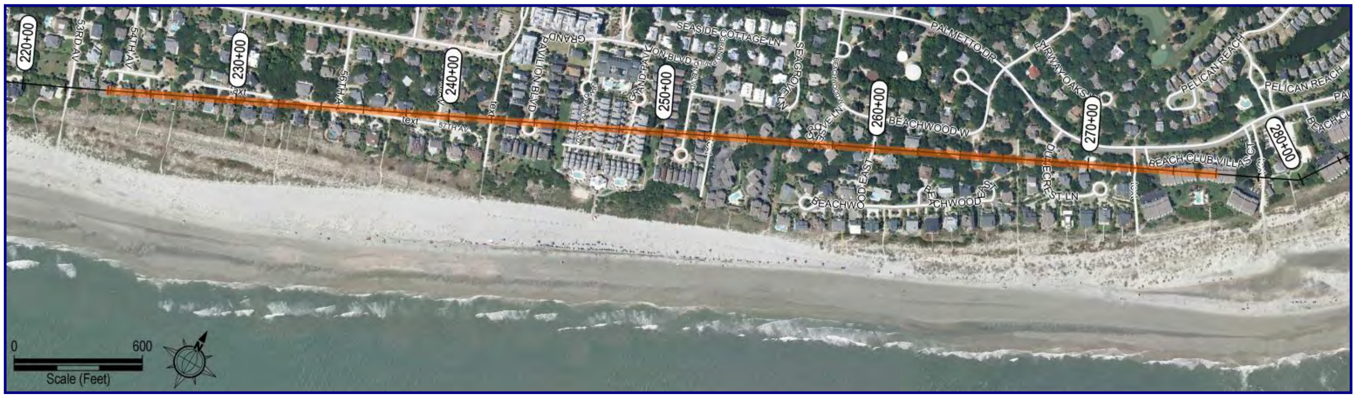
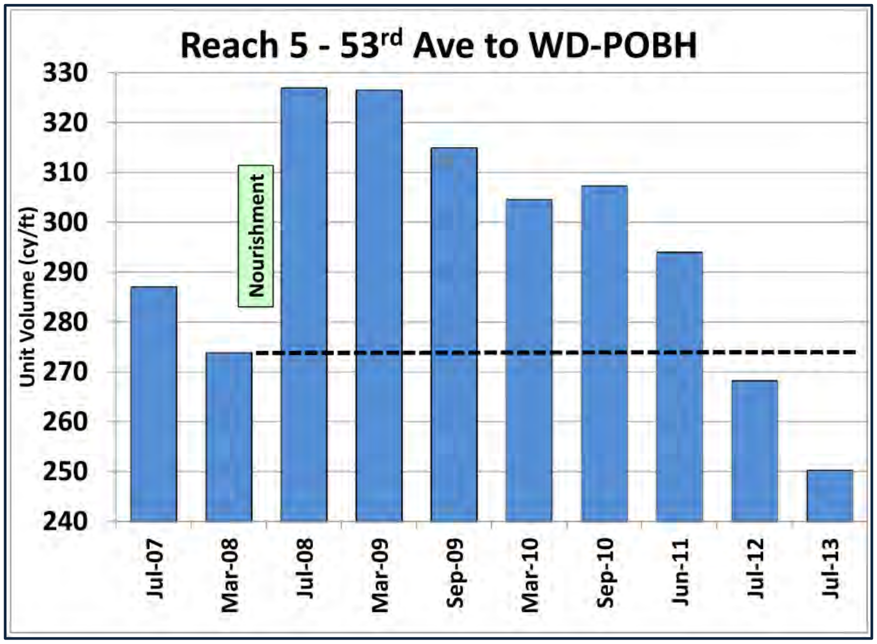


FIGURE 3.14. Reach 5 spans from 53rd Avenue (station 222+00) to the Wild Dunes POBH (station 280+00). The approximate limits of nourishment Reach A are identified by the orange-highlighted bar. [March 2009 aerial image by Independent Mapping Consultants Inc]

Prior to the 2008 nourishment, an erosional arc had formed in the area of the Wild Dunes Grand Pavilion (station ~248+00) (see Fig 3.10). Erosional arcs are typical in areas adjacent to shoal attachment sites because of wave refraction and sediment transport reversals, which drive sand from these areas into the lee of the shoal during Stages 1 and 2 of the shoal-bypass cycle. Immediately prior to nourishment, the "2007" shoal had completely attached (Stage 3) at the northern end of the reach, and sand was beginning to spread into the eroded areas.

Reach 5 gained ~318,000 cy (128.1 cy/ft) of sand between March and July 2008; this included nourishment and natural accretion from the shoal attachment (Fig 3.15, upper). The design volume was 270,000 cy, and CSE estimates ~340,000 cy of sand were added to the project area between March and July 2008. [Note the project reach limits differ from the monitoring reach, producing the difference in accretion numbers.] Design fill unit volumes were ~75 cy/ft throughout area A, decreasing in the taper sections. Dry beach width increased up to ~225 ft in this reach. The northern portion of Reach 5 was highly erosional prior to the nourishment project, losing up to 45 cy/ft between July 2007 and March 2008 (Fig 3.15, lower). The rest of the reach was more stable, gaining sand at most stations.



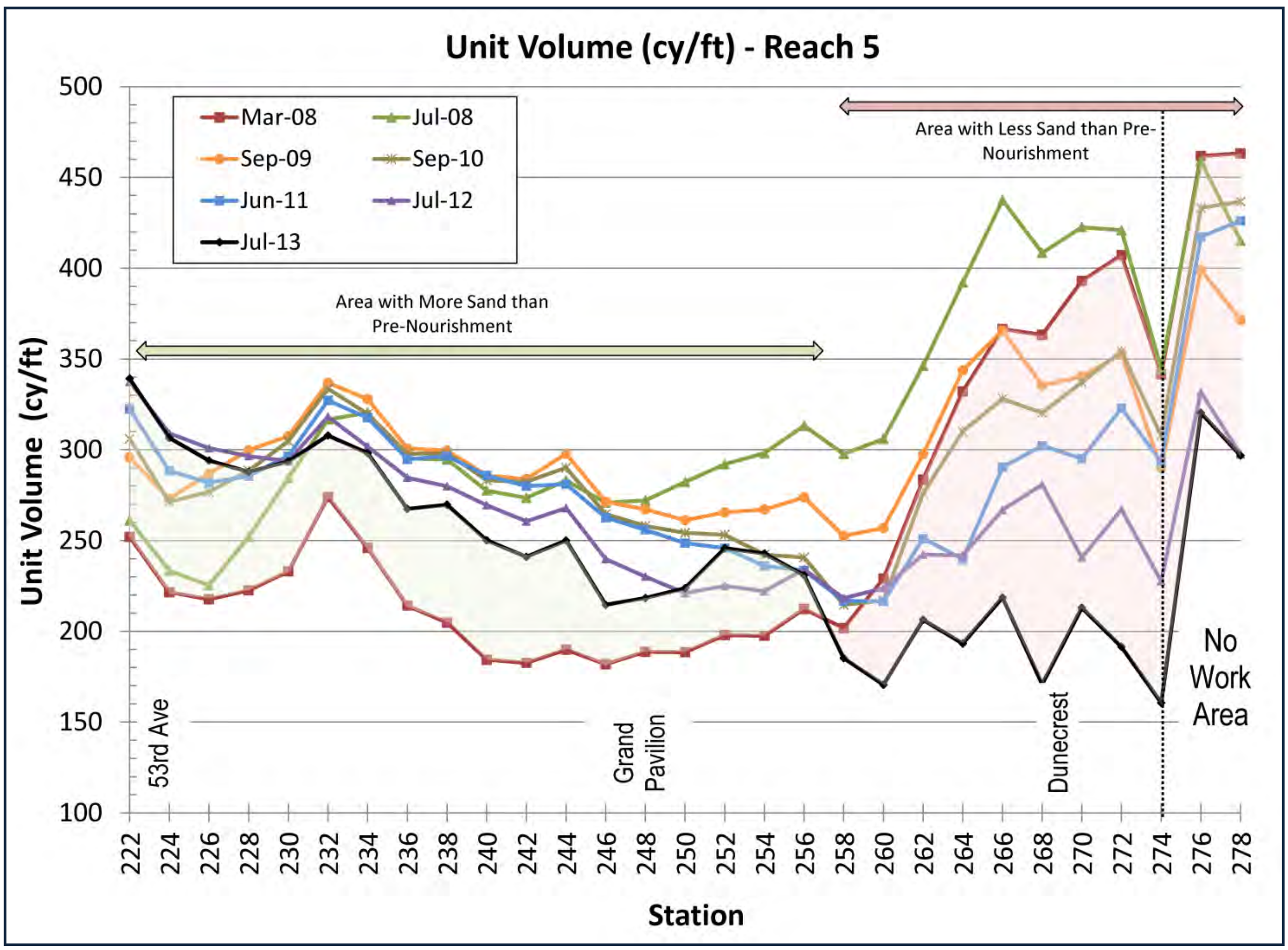


FIGURE 3.15. **[UPPER]** Bar graph showing beach unit volumes calculated to −10 ft NAVD in Reach 5. While the 2013 average sand volume is less than the pre-nourishment condition, stations 222–258 (3,600 ft of a total of 6,000 ft of Reach 5) still hold ~184,100 cy (51.1 cy/ft) more sand than the pre-nourishment condition. **[LOWER]** Profile unit-width volumes for stations in Reach 5. Erosion has dominated the northern part of the reach (stations 250–278) and is associated with excess sand spreading from shoal attachment events in 2006, 2009, and 2010 and shoal-induced erosion from the present event.

Erosion prior to the project was due to spreading of the “2007” shoal, which attached to the beach in 2007 at the northern end of the reach. The shoal created a protrusion in the shoreline focusing wave action until this area straightened between 2007 and 2008. Since project completion in June 2008, Reach 5 has shown erosion in the eastern portion (~2,000 ft) of the reach and accretion in the western part (~3,400 ft) of the reach (Fig 3.15, lower). Erosion has been most prevalent near Beachwood East and Dunecrest Lane. The beach fronting the Wild Dunes Grand Pavilion has been more stable, while the beach has accreted along the western ~1,000 ft of the reach.

Reach 5 was mostly erosional from 2012 to 2013 although some areas within the reach did gain sand in the underwater portion of the profile. Stations 222+00 through 234+00 were generally stable or showed relatively minor erosion and little change in the position of the berm. An erosional arc has developed between stations 236+00 and 254+00, causing up to 50 ft of berm recession. Greatest erosion was observed near the Grand Pavilion where stations lost 60–70 cy/ft. Near the eastern side of the Grand Pavilion and the Seagrove Condos, an underwater sand bar was present just below low-tide wading depth (−5 ft NAVD) which is likely providing sand to the beach.

A July 2013 aerial image of the bar and profiles from station 252+00 are shown in Figure 3.16. The sand attaching to the beach is a remnant of the westernmost portion of the 2007 ebb-tidal delta, which was abandoned when the inlet channel relocated to the east. The sand, which was spread over a large area offshore of the WDPOBH in 2007, has condensed into isolated shoals near stations 250+00 through 264+00 and into the linear shoal visible in Figure 3.17 west of the subaerial shoal off of Shipwatch.

Another erosional arc spans stations 260+00 through 280+00 (Beachwood East to WDPOBH), causing significant erosion over the past year. These stations lost up to 110.1 cy/ft and up to ~150 ft of beach width (station 268+00), reducing the distance between structures and the berm crest to a low of ~80 ft near Dunecrest Lane (Fig 3.18). The +5-ft NAVD contour is now landward of the 100-ft buffer line established in the shoal management permit. This area should be monitored closely over the next year (Fig 3.19). If erosion reaches a point where structures may be threatened, sand can be placed during the next shoal management project.

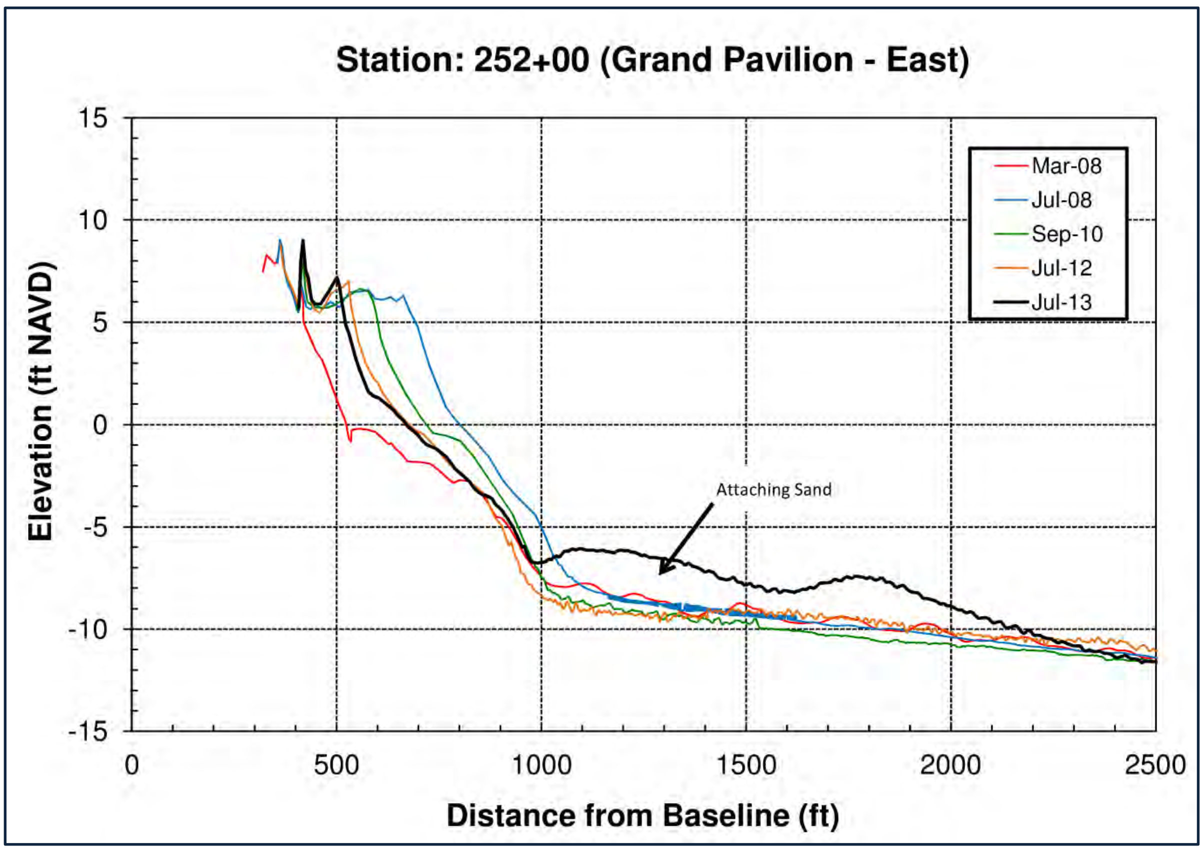
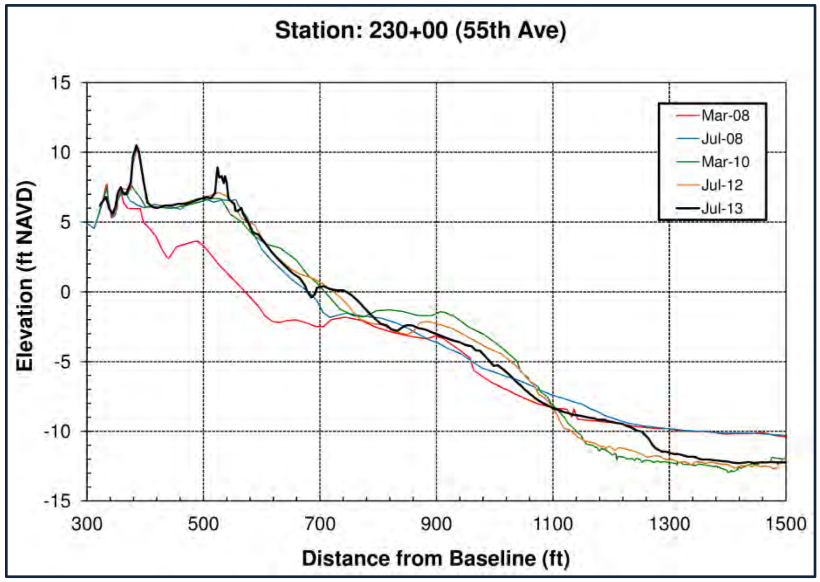


FIGURE 3.16. **[UPPER]** July 2013 aerial image of the area from the Wild Dunes Grand Pavilion to Beachwood East showing isolated sand bars (areas with breaking waves) attached or near the beach. **[LOWER]** Profiles from station 252+00 showing a sandbar attached to the beach. These bars are formed from remnants of the pre-2007 inlet channel delta fan, which collapsed following the channel avulsion event and is migrating toward the beach.

FIGURE 3.17. November 2013 oblique aerial image of the northeastern end of Isle of Palms. Several events are occurring simultaneously, all of which have an impact on the beach condition. CSE expects the beach will evolve rapidly over the next year due to the current shoal-bypass event.

Erosion diminishes toward the eastern end of the reach, though berm recession is still evident. The offshore underwater area has gained volume as the western edge of the shoal-bypass event approaches the beach and is within the volume calculation limits.

Overall, Reach 5 lost 107,400 cy (17.9 cy/ft) over the past year, which is the highest erosion rate measured on the island. The reach currently has ~141,700 cy (23.6 cy/ft) less sand than the pre-nourishment condition; however, the deficit is restricted to the area from station 258+00 to station 278+00 (eastern third of the reach). These stations have lost a total of 325,800 cy since March 2008 (pre-nourishment condition), which includes the ~62,200 cy gained during the nourishment project. The remainder of the reach from stations 222+00 to 258+00 holds 184,100 cy more sand than the pre-nourishment condition, which represents ~72 percent of the volume placed within those limits.



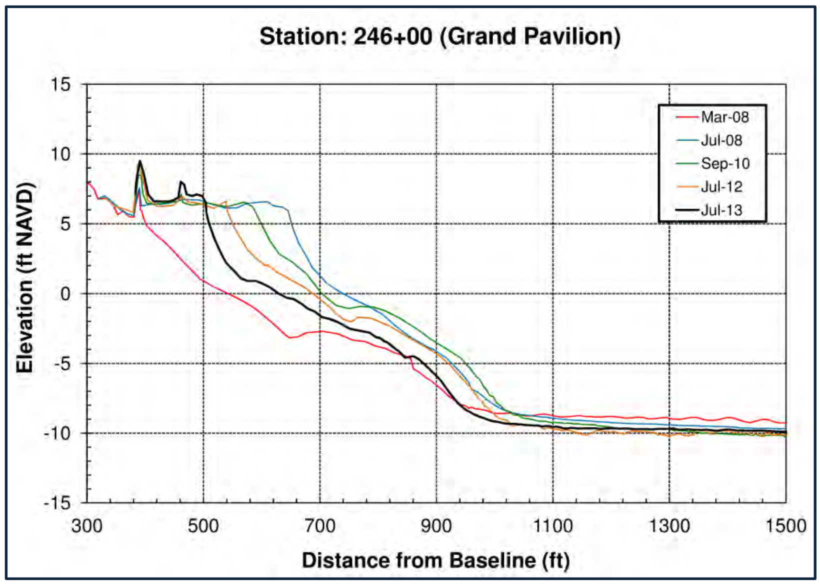


FIGURE 3.18.

Profiles for selected stations in Reach 5 (just west of Beach Club Villas).

Sand is attaching to the beach at various locations along the eastern half of the reach, causing an erosional arc (see text) and isolated sand bars.

The western edge of the bypassing shoal is visible at station 272+00 located ~700 ft offshore of the beach.

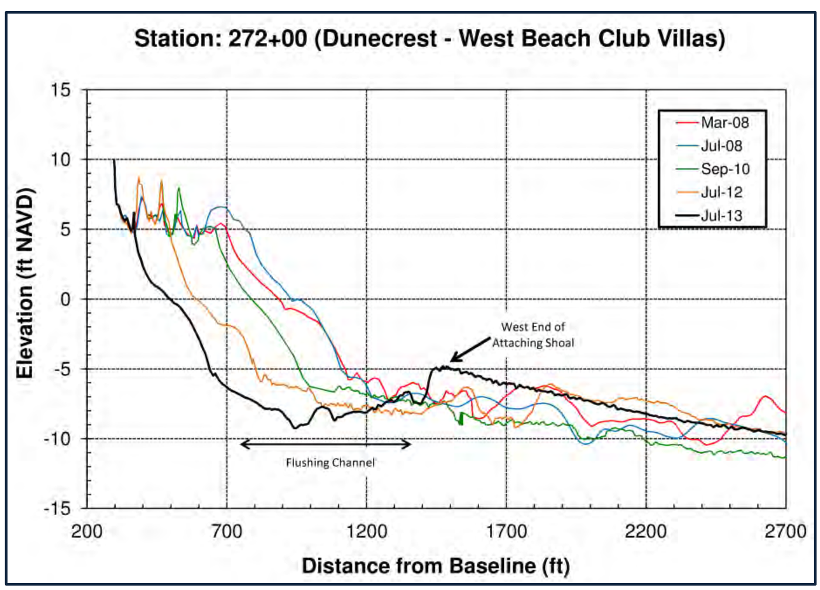


FIGURE 3.19.

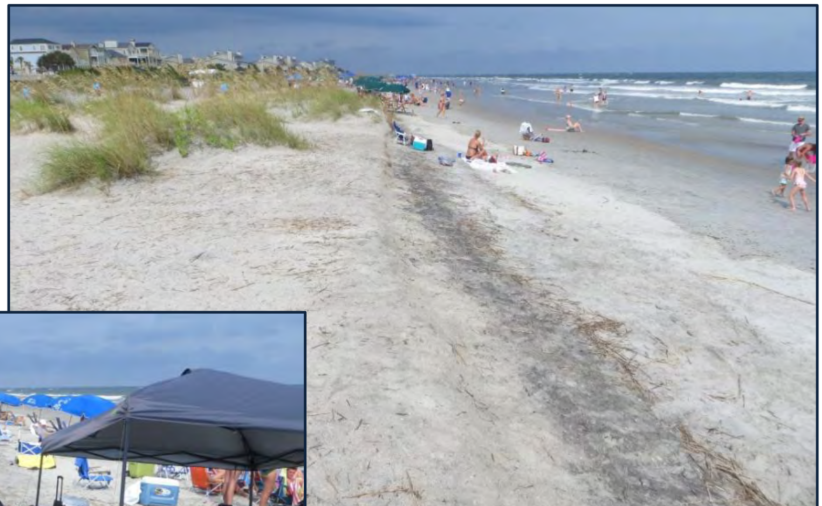
Ground photos along various areas of Reach 5 in July 2013.

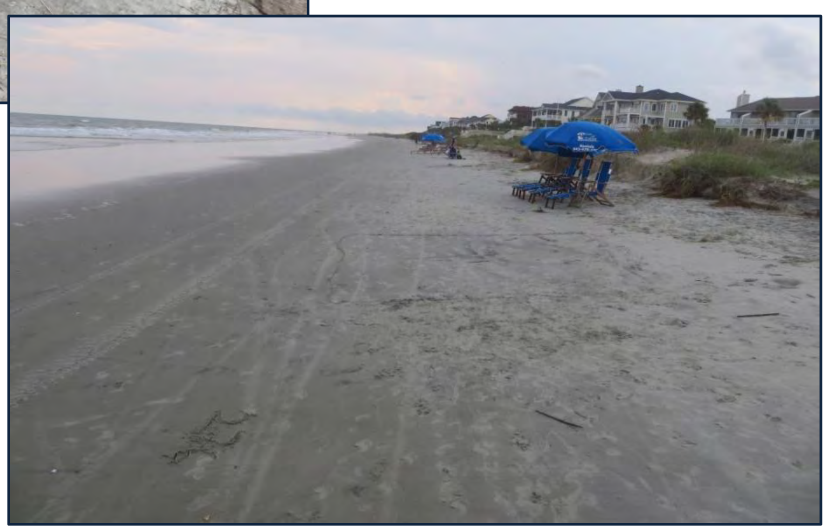
[1st RIGHT] Station 222+00 (53rd Avenue) — The 2008 dune line is located where the yellow trash cans are visible. This area has substantially accreted since 2008.

[2nd RIGHT] Station 244+00 (west side of Grand Pavilion) — The westernmost of two erosional arcs is centered along the Grand Pavilion. Note scarping of the berm.

[3rd LEFT] Looking east from station 252+00 (east end of Grand Pavilion) into the more stable area which is between the two erosional arcs.

[4th RIGHT] Looking west from station 276+00 (Beach Club Villas I) into the eastern erosional arc. Erosion has caused substantial berm recession, leaving little protection for some houses (left bottom photo).





Summary of Volume Changes in Reaches 5–7 (53rd Avenue to Cedar Creek)

The various erosion/accretion observations along the eastern end of the Isle of Palms (Reaches 5–7) were detailed in the previous sections. The influence of Dewees Inlet leads to rapid shoreline fluctuations that are difficult to predict; however, the City's monitoring efforts have generated a reliable and comprehensive dataset which allows for advance planning and better projections of future changes. Beach volume changes over the past year reflect distinct processes which are all tied to various stages of shoal-bypassing events, specifically:

- The bypassing bar is close to the beach and is impacting the shoreline. The beach near Mariners Walk and Shipwatch is accreting due to the sheltering effects of the shoal. Away from the protection of the shoal, erosion has increased, forming the characteristic erosional arcs associated with bypass events.

- Focused erosion is occurring near Ocean Club and the 18th hole, near Dunecrest Lane, and along the Wild Dunes Grand Pavilion. Erosional arcs fronting the Grand Pavilion and Dunecrest Lane are causing scarping of the berm.

- Isolated bars near the western end of the shoal attachment site (fronting Seagrove, Beachwood East, and Dunecrest Lane) are impacting the beach and creating varying topography close to shore. These small bars are causing rapid varying zones of erosion and accretion as they migrate onshore.

- The trailing ebb spit at the eastern point of the island continues to grow in extent and increase in elevation (Fig 3.20). This feature is a key to restoration of the beach along the 18th fairway and Ocean Club Villas. When fully developed, trailing ebb spits act like terminal groins, trapping and retaining sand moving toward the inlet.

FIGURE 3.20. [RIGHT] November 2013 aerial image of a trailing ebb spit (breakers at bottom left of photo) at the northeastern end of Isle of Palms. **[LEFT]** A similar, but more developed, trailing ebb spit was present in 1980 (photo by TW Kana).

Overall, Reaches 5–7 lost 106,575 cy from July 2012 to July 2013 (Fig 3.21). This compares to losses of ~215,000 cy from July 2011 to July 2012, and 152,000 cy from September 2010 to June 2011. All subreaches within Reaches 5–7 showed less erosion (or more accretion) than the previous year. Reaches 5–7 still retain ~350,000 cy (23.5 cy/ft) more sand than the pre-nourishment condition. The Wild Dunes area of Isle of Palms has lost ~646,000 cy (43.4 cy/ft) since July 2008 (post-nourishment condition), which equates to an average annual loss of 8.7 cubic yards per foot year (cy/ft/yr). Presently 54 out of 75 stations in Reaches 5–7 (72 percent) retain more sand than the pre-nourishment condition.

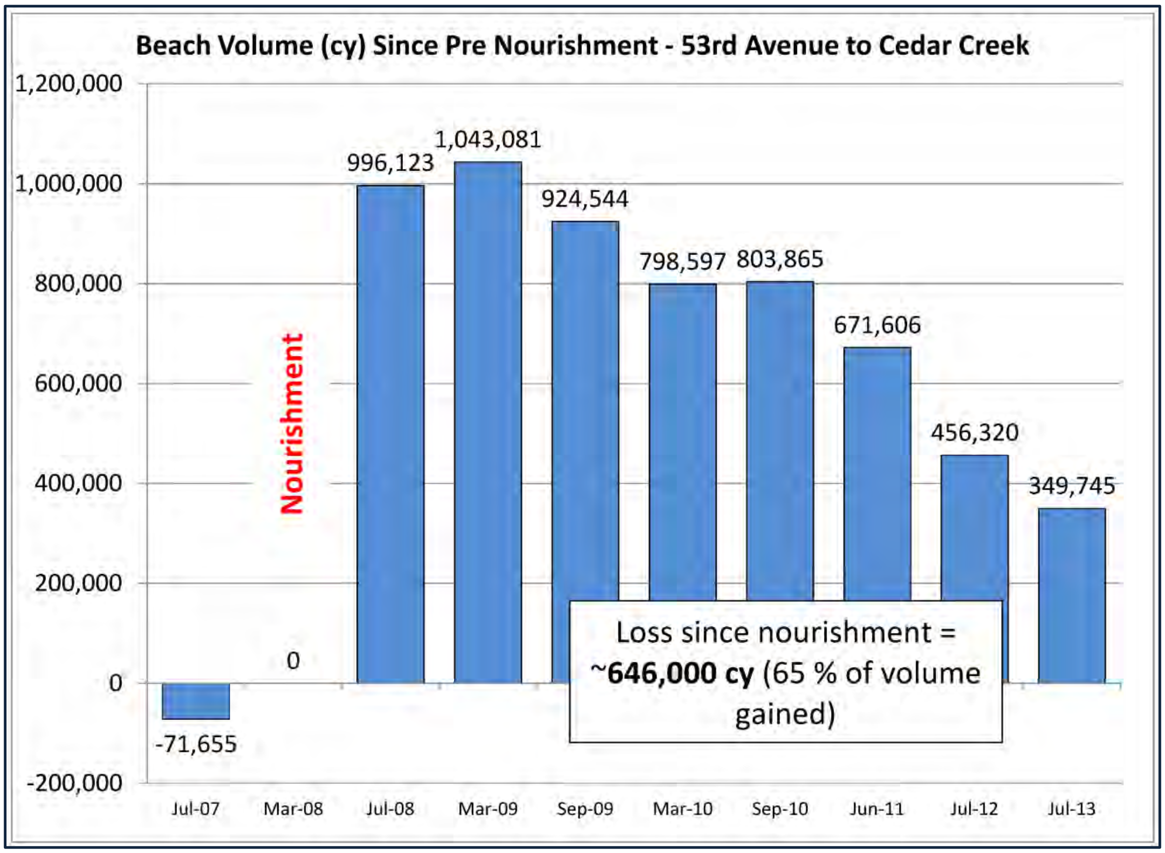


FIGURE 3.21. Beach volume relative to March 2008 (pre-nourishment). The values shown include all areas (both nourished and non-nourished) and do not account for sand accumulated at the turn in the baseline at the northeastern point, which is estimated to have gained over 50,000 cy since March 2008. These volumes do not include ~1.6 million cubic yards of sand in the bypassing shoal which is poised to weld along Wild Dunes in the next couple of years.

Central Reaches 2–4 (6th Avenue to 53rd Avenue)

Reaches 2–4 represent the central portion of the island and have historically been stable to accretional over the past century. The reaches are considered to be outside of the direct influence of Dewees and Breach Inlets and are classified as "S" for standard erosion zones by SCDHEC–OCRM. Erosion/accretion signatures along "S" zones tend to be predictable over the long term. Short-term changes in sand volume are generally smaller in magnitude than in areas close to inlets (SCSGC 2001).

Reaches 2–4 represent 17,810 ft of shoreline between 6th and 53rd Avenues (Fig 3.22). CSE established profile stations at 1,000-ft spacing and reoccupied monuments established by SCDHEC–OCRM, which have been surveyed generally every year since the early 1990s. CSE profiles were obtained in March and September of 2009 and 2010, in June 2011, and in July 2012 and 2013. Unit volume changes for Reaches 1–4 are shown in Figure 3.23.

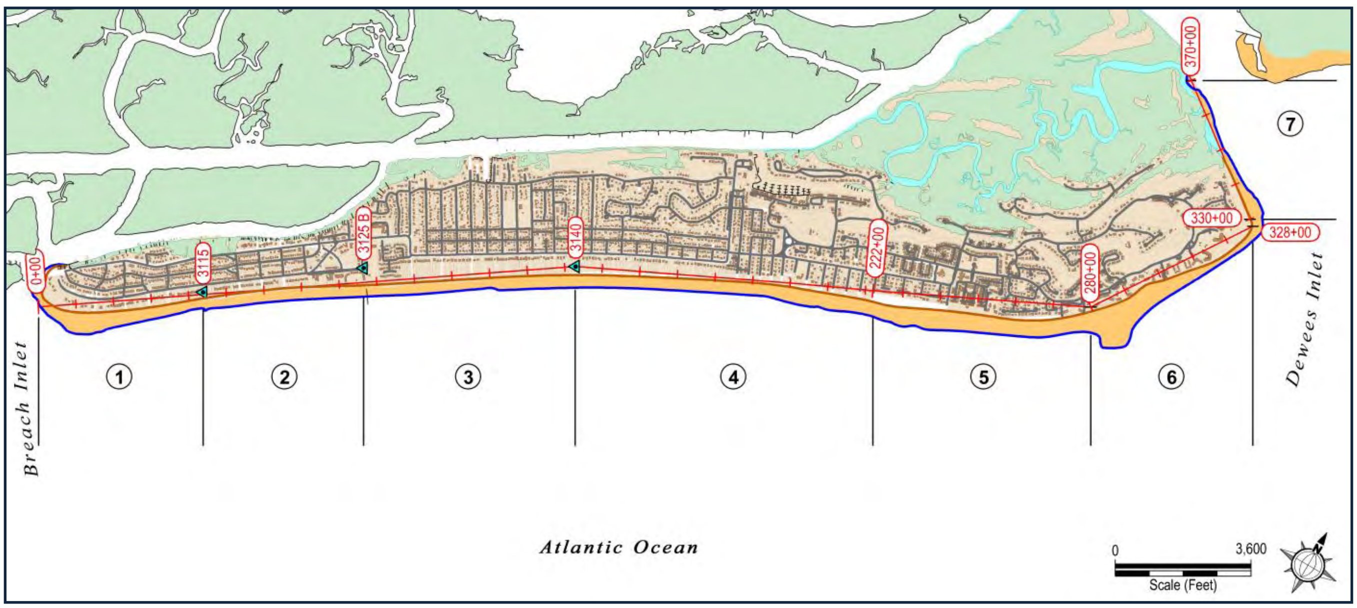


FIGURE 3.22. Monitoring reach boundaries.

From March 2009 to September 2009, Reaches 2–4 lost ~33,000 cy (1.8 cy/ft) of sand over the ~18,000 ft of shoreline represented. Since then, these reaches have shown net accretion, gaining ~176,000 cy (9.9 cy/ft) over the past year. The changes since March 2009 total 534,250 cy (30 cy/ft), which is an annual accretion rate of 6.9 cy/ft/yr. Stations 3115 and 50+00 (6th Avenue) were the only profiles that lost sand over the past year, while all other stations gained sand, averaging 10.8 cy/ft.

Details for each reach are given in the following sections.

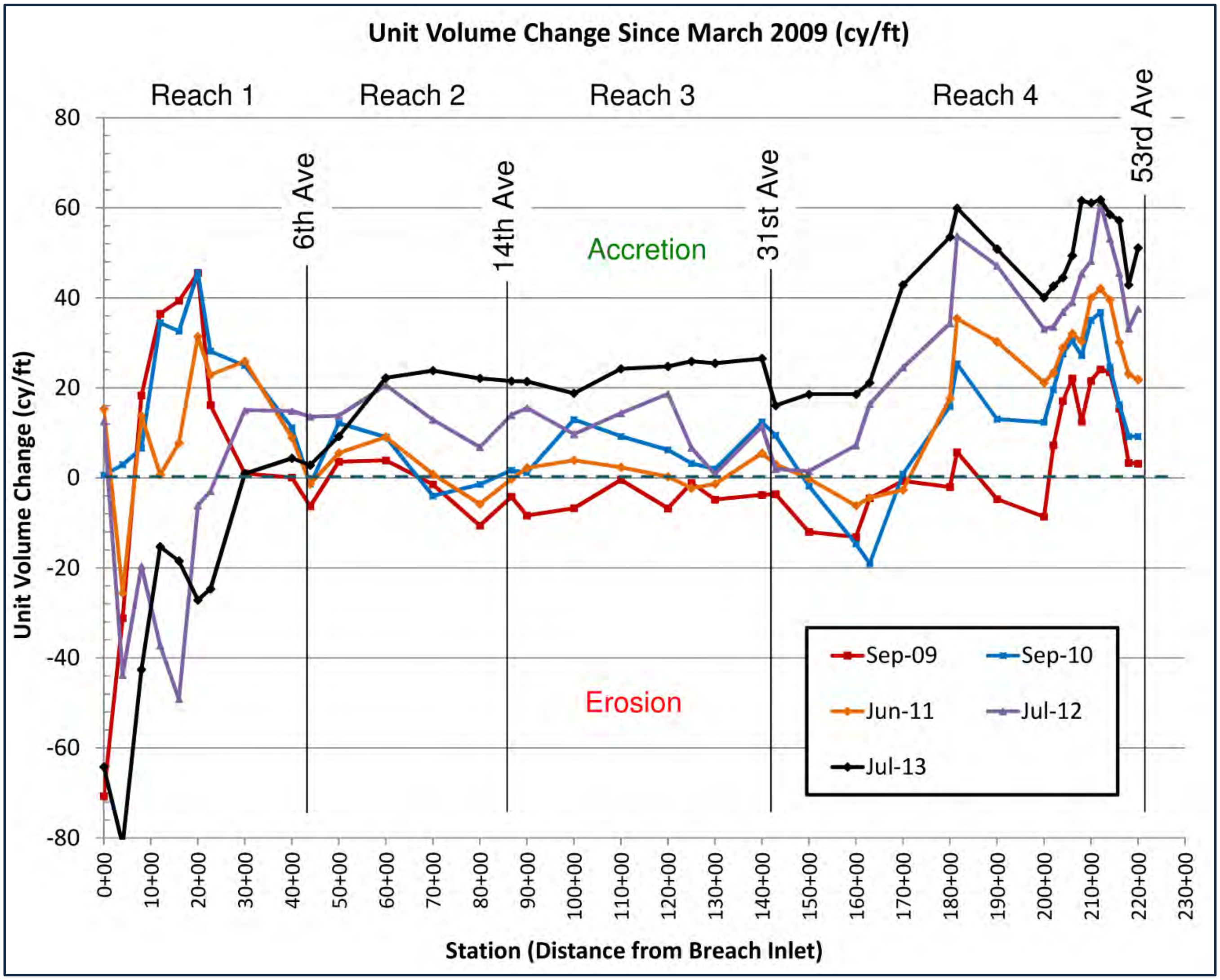


FIGURE 3.23. Profile unit-width volume change (cy/ft) between March 2009 and later dates for Reaches 1–4. CSE established and surveyed profiles spaced 1,000 ft apart within the Isle of Palms reaches and reoccupied monuments surveyed annually by SCDHEC-OCRM. Historically, these reaches have been accretional; however, between March and September 2009, most stations outside of the influence of the inlet or project were erosional. Since September 2009, most stations have shown accretion and are currently healthier than the March 2009 condition (ie – where the black line is greater than zero). The higher rates and westward sequence of accretion along Reach 4 illustrate the downcoast spread of nourishment sand from Reach 5. [Volumes are relative to the March 2009 condition.]

Reach 4 — 31st Avenue to 53rd Avenue

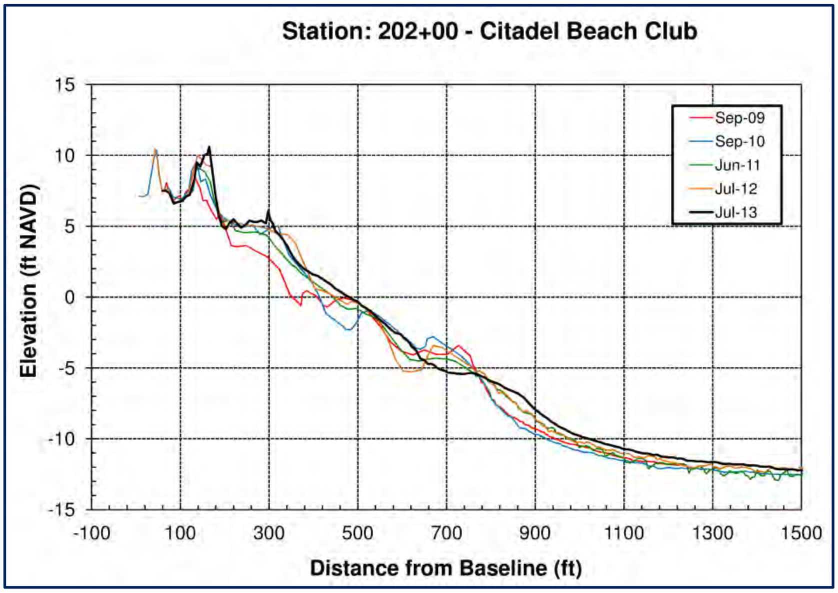
Reach 4 spans 7,910 ft between 31st Avenue and 53rd Avenue (stations OCRM 3140 to CSE 222+00) (Fig 3.24). Being immediately downdrift of the 2008 nourishment project, it should, therefore, benefit from losses of nourishment sand from the project area. Reach 4 was stable from March to September 2009 and has accreted between each monitoring event since then (see Table 3.2).

FIGURE 3.24. Reach 4 — stations OCRM 3140 (31st Avenue) to CSE 222+00 (53rd Avenue) — noted by the orange-highlighted bar.

All stations within Reach 4 gained sand from July 2012 to July 2013. Accretion was greater along the western half of the reach, averaging 14.2 cy/ft from stations 3140 to 3150 (31st to 41st Avenues). The eastern half of the reach averaged gains of 8.8 cy/ft. Reach 4 has been the most accretional area (not including local short-term accretion associated with shoal-bypass events) of the island since 2009, gaining over 40 cy/ft. Profiles from stations within Reach 4 show increasing dune height and width, and a consistent buildup of sand in the underwater profile (Fig 3.25). Ground photos from Reach 4 are shown in Figure 3.26.

Overall, Reach 4 gained ~86,400 cy (10.9 cy/ft) of sand from 2012-2013. Since March 2009, the reach has gained a total of 323,400 cy (40.9 cy/ft), which is an average annual accretion rate of 9.3 cy/ft per year. Historical accretion along this reach (combined with sufficient setbacks for development) has led to a substantial dune system between most structures and the beach. As long as there is slow steady accretion, the foredune will continue to build wider and higher, offering more storm protection to property behind the dunes (Fig 3.27).

Gains in Reach 4 are due to spreading of nourishment sand (and native material) from the eastern end. The present shoal-bypass event in Reaches 5 and 6 may interrupt the flow of sand from upcoast by drawing sand into the lee of the attaching shoal. Some sand will continue to move downcoast from Reach 5; however, most likely at a slower rate than the past two years. Once the shoal attaches (especially at the western edge), sand will again migrate downcoast. The timing of the attachment will control the volume of sand moving into Reach 4 over the next year. CSE expects the western edge of the shoal to attach by winter 2014–2015 although wave conditions may delay this.



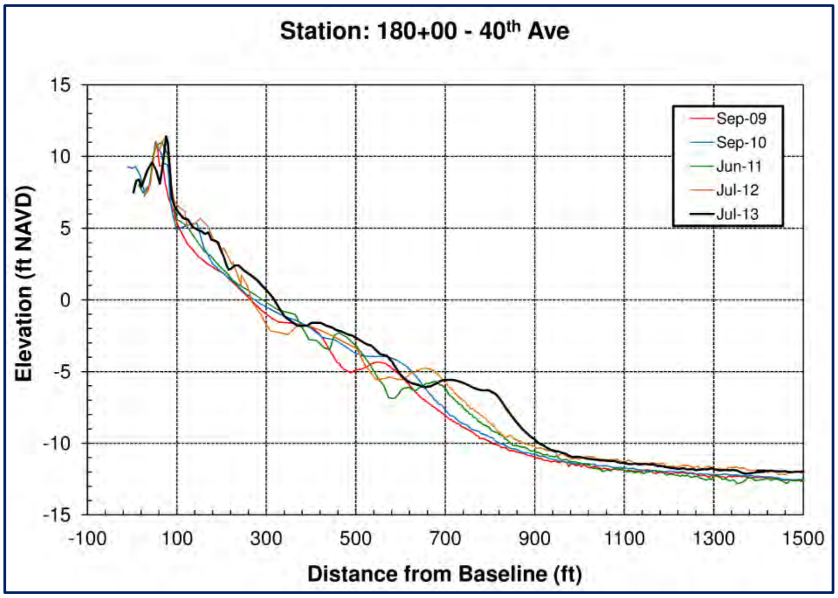


FIGURE 3.25.

Profiles from Reach 4 stations 202+00 (47th Avenue), 180+00 (40th Avenue), and 150+00 (33rd Avenue). These stations gained 9.0 cy/ft, 19.2 cy/ft, and 17.7 cy/ft (respectively) between July 2012 and July 2013.

A volume of sand is spreading downcoast from the nourishment area, evidenced as higher unit volumes (relative to March 2009) further downcoast (southwest) each year.

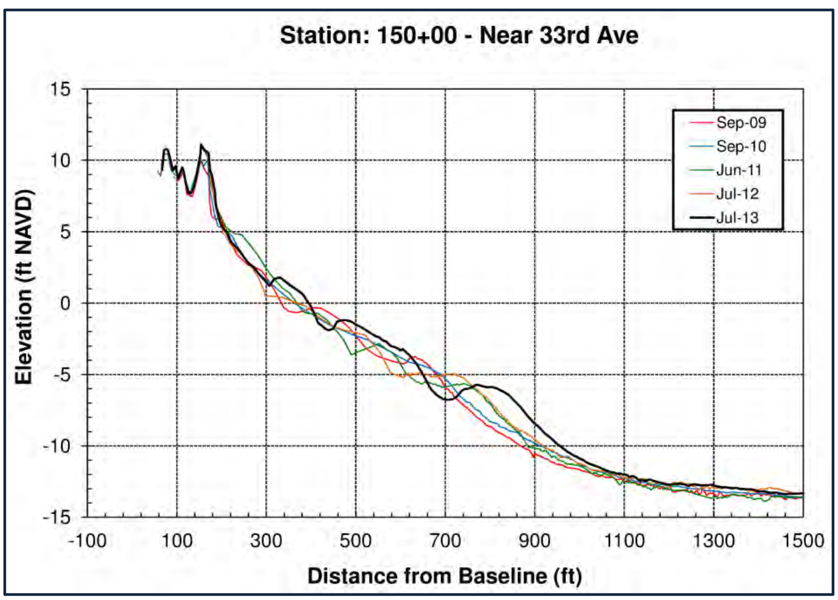


FIGURE 3.26. July 2013 photos from Reach 4. **[TOP]** View east from station 3140 (31st Avenue) showing a narrow, but growing, dry beach and stable dune. **[CENTER]** View east from station 3145 (36th Avenue) showing a wide dry beach and healthy dune system. **[BOTTOM]** Inland view of station 202+00 (Citadel Beach House) showing vegetation propagating across a stable dry berm. The 2008 dune line is the high dune landward of the surveyor. In the 1980s, the Citadel Beach House lacked a dry-sand beach, and the property was protected by an exposed seawall. [Photos by S Traynum]

FIGURE 3.27. November 2013 aerial image of the central portion of Isle of Palms. Steady long-term accretion has resulted in wide vegetative buffers and protective dunes. Note oblique low-tide bars and troughs ("runnels") along the beach, which form under the influence of waves from the northeast. [Photo by SB Traynum]

Reach 3 — The Sea Cabins Pier to 31st Avenue

Reach 3 spans the oceanfront from the Sea Cabins Pier to 31st Avenue (OCRM monuments 3125 to 3140, Fig 3.28). Like Reach 4, the long-term trend in this area is stable to accretional. Profiles from OCRM station 3135 (near 27th Avenue) show the beach has gained ~40 ft in width at the +5-ft NAVD contour (Fig 3.29) over the past ten years. A similar trend is evident at OCRM station 3125 (14th Avenue) with dune growth and beach widening over the past ten years.

FIGURE 3.28. Reach 3 spans from station OCRM 3125 (pier) to station OCRM 3140 (31st Avenue) — noted by the orange-highlighted bar.

Reach 3 has shown various periods of erosion and accretion since CSE began island-wide monitoring in 2009. This is typical for stable to moderately accretional beaches as variations in wave conditions from year to year and temporary changes in sediment supply lead to minor fluctuations in yearly volume change. Over the long term, the trend is accretion.

The reach lost 4.6 cy/ft from March to September 2009, then gained 11.7 cy/ft through September 2010. Erosion occurred from September 2010 to June 2011 (5.5 cy/ft), but the reach has accreted since then, gaining 9.4 cy/ft from June 2011 to July 2012. **Reach 3 gained 12.2 cy/ft (68,500 cy) over the past year.** Individual stations accreted from 6.1 cy/ft to 24.6 cy/ft. Since 2009, the reach has gained 130,800 cy (23.3 cy), which is an average annual rate of 5.3 cy/ft per year. Profiles show continued dune growth throughout the reach. The majority of the 2012–2013 accretion was in the underwater portion of the profile, between −5 ft and −10 ft NAVD (Fig 3.29). Photos from the reach are shown in Figure 3.30.

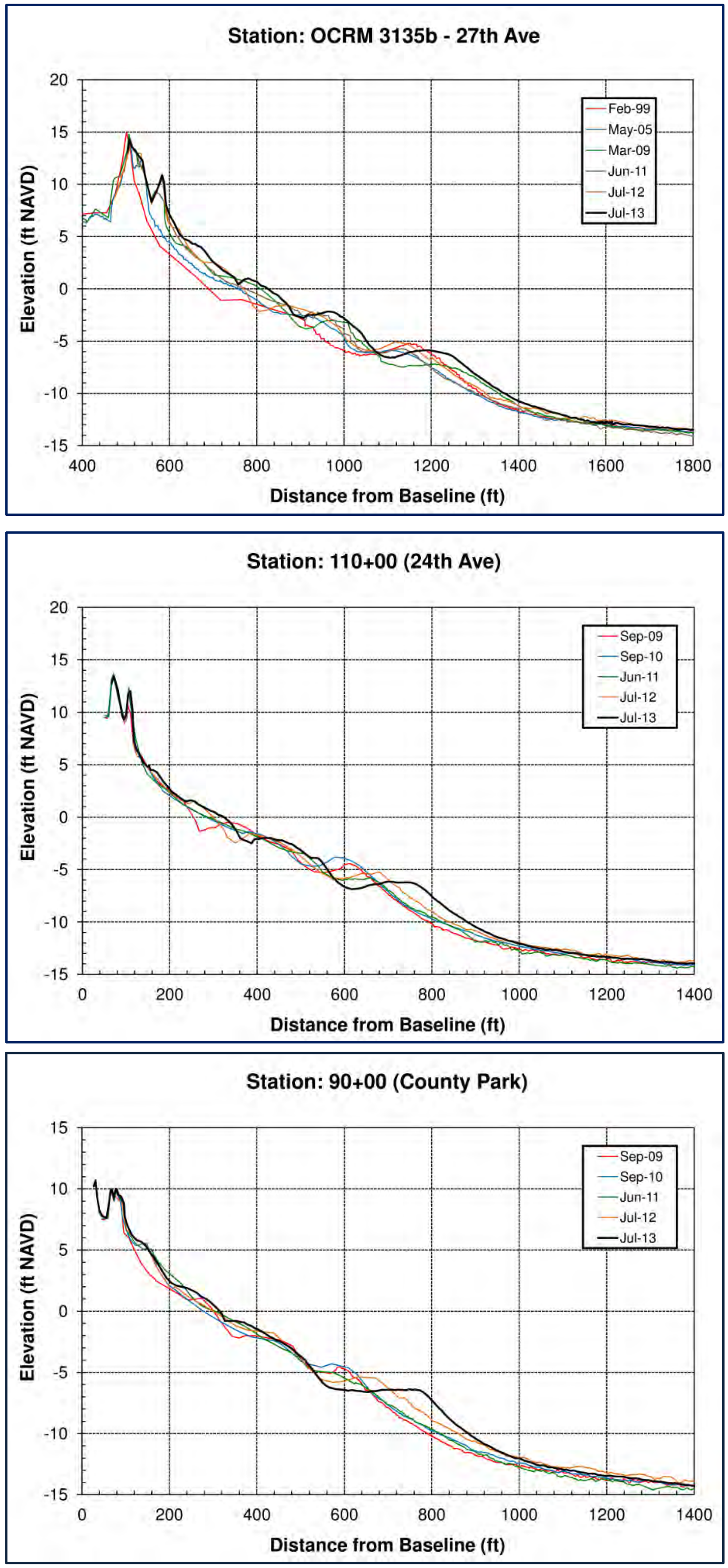


FIGURE 3.29.

Profiles from OCRM station 3135 (27th Avenue) (upper), station 110+00 (24th Avenue) (middle), and station 90+00 (County Park) (lower).

Sustained accretion has led to nearly 100 ft of beach growth over the past decade along some portions of Reach 3.

[Profiles prior to March 2009 courtesy SCDHEC-OCRM.]

FIGURE 3.30. **[UPPER LEFT]** Station 100+00 (21st Avenue) looking east in July 2013. Note the healthy dune and various wrack lines representing high-tide swash lines at various tidal stages. (Spring tide is near the dune while the neap tide is ~30 ft seaward.) **[UPPER RIGHT]** Station 120+00 (26th Avenue) shows a healthy, but relatively low, dune. Winter storms typically cause minor dune erosion along this area, which usually heals during the calmer summer months. **[CENTER LEFT]** Station 140+00 (30th to 31st Avenue) looking west. A significant dry beach is present in July 2013. **[LOWER RIGHT]** November 2013 aerial image of the area around Sea Cabins Pier (separating Reach 2 and Reach 3). [Photos by S Traynum]

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Reach 2 — 6th Avenue to the Sea Cabins Pier

Reach 2 spans 4,280 ft between 6th Avenue and the Sea Cabins Pier (OCRM monuments 3115–3125) (Fig 3.31). Reach 2 shows an erosion-accretion pattern similar to Reach 3 with net accretion since 2009 although the magnitude of volume change is generally smaller in Reach 2. The reach eroded from March to September 2009 (−1.6 cy/ft), then accreted from September 2009 to March 2010 (1.4 cy/ft) and again to September 2010 (3.4 cy/ft). Erosion was observed from September 2010 to June 2011 (−1.1 cy/ft). The reach gained ~50,000 cy (11.7 cy/ft) from June 2011 to July 2012.

FIGURE 3.31. Reach 2 spans from OCRM 3115 (6th Avenue) to OCRM 3125 (Sea Cabins Pier) — noted by the orange-highlighted bar.

Over the past year, the reach gained ~20,900 cy (4.9 cy/ft). The central and eastern portion of the reach gained sand (8th Ave thru 14th Ave), while the area between 6th and 7th Avenues eroded. An erosional arc has formed along the western end of the reach, centered near station 50+00 (Fig 3.32). This arc may have formed in connection with an expansion of the marginal flood channel of Breach Inlet, which has extended to the east, creating a mini-sand headland that modifies incipient waves. It may also be a result of an erosional wave migrating down the beach (Bodge 1995), which is a temporary interruption in sand supply moving along the island. Between 2011 and 2012, CSE observed erosion (or lower-than-normal accretion) roughly 1 mile east, which would be an indicator of an erosional wave (cf – Fig 3.23). An October 2013 assessment of the area showed that dune erosion continued at station 50+00; however, adjacent stations showed some recovery of the dune. CSE believes that the localized erosion is temporary, and likely to reverse given the healthy, upcoast sediment supply. CSE will continue to closely monitor this area as part of its quarterly monitoring effort around Breach Inlet.

Reach 2 has gained ~80,000 cy (18.7 cy/ft) of sand since March 2009, an average annual accretion rate of 4.3 cy/ft per year. Profiles show relative stability or seaward growth of the dune compared to 2009 (Fig 3.33). Similar to reaches 3 and 4, accretion was observed in the underwater portion of the profile (−5 to −10 ft NAVD) along all stations in Reach 2.

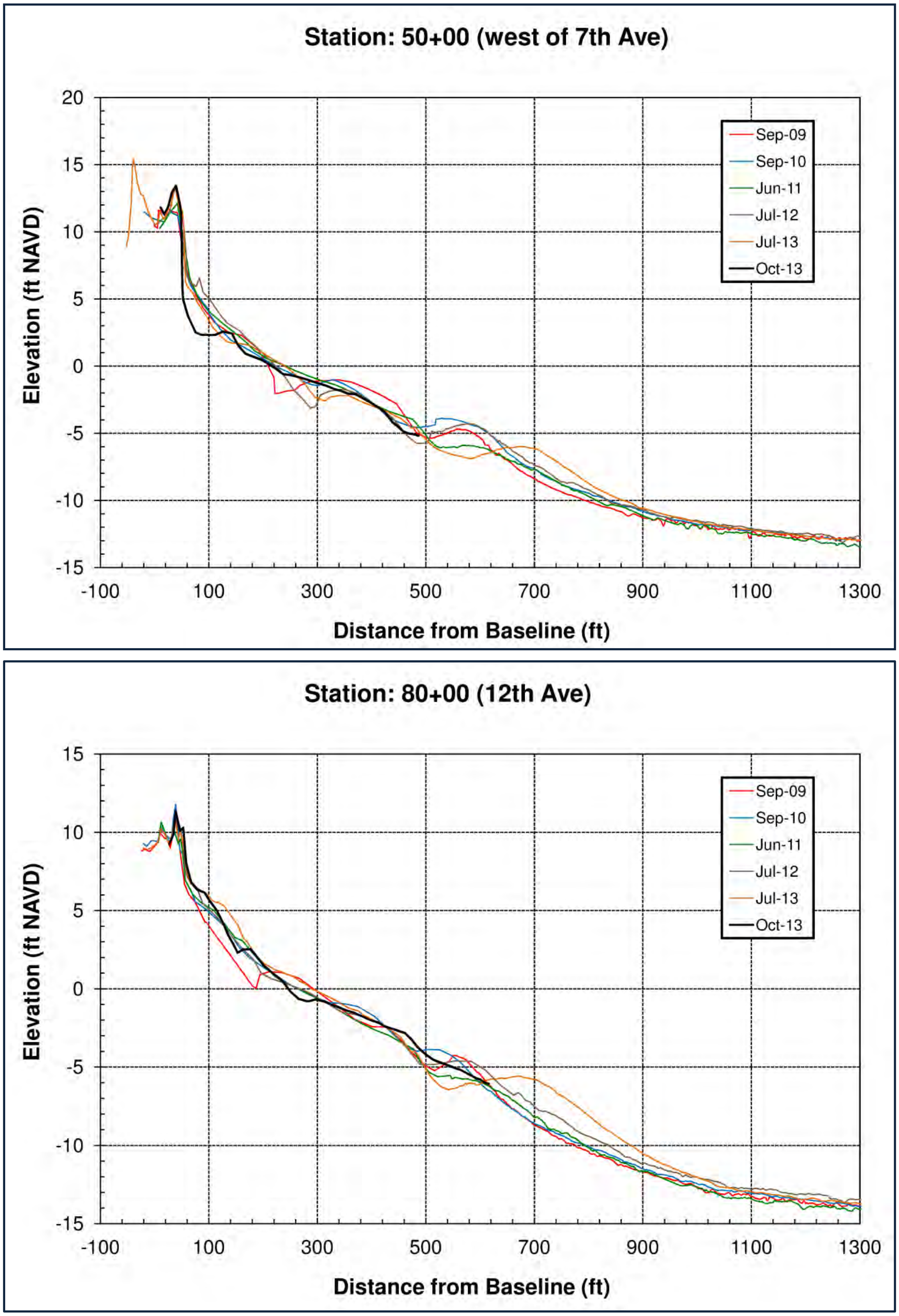

FIGURE 3.33. Profiles from station 50+00 (7th Avenue, upper) and station 80+00 (12th Avenue, lower). An erosional arc is centered at station 50+00, causing significant dune recession at this location.

FIGURE 3.34. **[UPPER]** View looking east from station 70+00 (10th Avenue) in July 2013 showing a wide dry-sand beach for volleyball nets and recreation. **[MIDDLE]** View looking west from station 50+00 (west of 7th Avenue) in July 2013 showing a scarped dune. An erosional arc was centered near this station in July and October 2013. **[LOWER]** View west from station 50+00 in October 2013. Erosion from July to October was limited to this station only. Adjacent stations showed stable dunes and gained volume (to −6 ft NAVD).

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Reach 1 — Breach Inlet

Reach 1, between Breach Inlet and 6th Avenue (Fig 3.35), is classified as an unstabilized inlet erosion zone due to the dynamic nature of the shoals associated with the inlet delta. While labeled as unstable, the long-term trend for this reach is accretion with an estimated growth of ~8.9 ft/yr (linear beach width). The historical accretion trend in this reach is due to a plentiful sand supply from upcoast and sand trapping by the Breach Inlet ebb-tidal delta.

FIGURE 3.35. Reach 1 spans between Breach Inlet and 6th Avenue — noted by the orange-highlighted bar.

Sand supply originates from shoal-bypass events at Dewees Inlet and longshore sand transport from north to south over the length of IOP. Excess sand is deposited along the southern spit of the island (Reach 1) and in the Breach Inlet ebb-tidal delta. Shoals of Breach Inlet form a protuberance in the shoreline, which backs sand up along the oceanfront much like a terminal groin traps sand. Changes in this area are related to bars from the inlet delta migrating onto the beach or marginal flood channels moving landward or seaward. Such natural processes lead to rapid changes in the beach volume compared to the central IOP reaches.

Reach 1 was accretional from March 2009 to September 2010, gaining a total of ~89,000 cy of sand. Since then, the reach has lost ~182,000 cy of sand. **Over the past year, the reach lost 58,000 cy (13.2 cy/ft)** (eg – Fig 3.1), which is down from a loss of ~87,000 cy over the previous year. Erosion was variable throughout the reach with the western end (stations 0+00–8+00) losing between 23.0 and 76.7 cy/ft, stations 12+00 and 16+00 gaining 22.0 and 30.7 cy/ft (respectively), and stations 20+00 thru 40+00 losing 10.5–21.7 cy/ft. There was substantial recession of the dunes increasing from east to west. Station 40+00 (between 5th and 6th Avenues) lost ~20 ft of dunes while station 4+00 (at the tip of the upland area near Breach Inlet) lost ~100 ft of dunes. Overall, the reach has lost ~93,000 cy (21.2 cy/ft) since March 2009, which is an average annual erosion rate of 4.8 cy/ft/yr.

Erosion has persisted along the Breach Inlet reach since 2010, though impacts of the erosion were restricted to the lower beach until this past year. When Hurricane *Sandy* passed offshore of South Carolina in late October 2012, it caused severe dune recession of the Breach Inlet area. CSE estimates that the dune receded over 50 ft in the area west of 3rd Avenue during the storm. Station 4+00, near the western tip of upland area, lost ~100 ft of dunes from July 2012 to July 2013, but was more stable from July to October 2013 (Fig 3.36). Similar trends were observed further east of the inlet, although 2012–2013 dune recession generally decreased further east.

Dune recession in Reach 1 provided evidence of ongoing erosion and generated concern among property owners in the area. In subsequent discussions with the City, CSE provided an opinion that the erosion was temporary and likely a result of cyclical changes in the delta of Breach Inlet. Based on historical trends and ebb-tidal delta morphology, CSE expects Reach 1 to rebuild naturally without intervention. Nevertheless, CSE recommended additional monitoring be conducted to document short-term volume and contour changes. Additional assessments provide quarterly updates on the beach condition and give the City information for planning mitigation efforts should they be warranted. CSE completed the first quarterly monitoring event in October 2013. Results showed that all areas other than station 50+00 gained sand and had stable dunes between July and October 2013 (Fig 3.37). A summary letter from the October assessment is included in Appendix B.

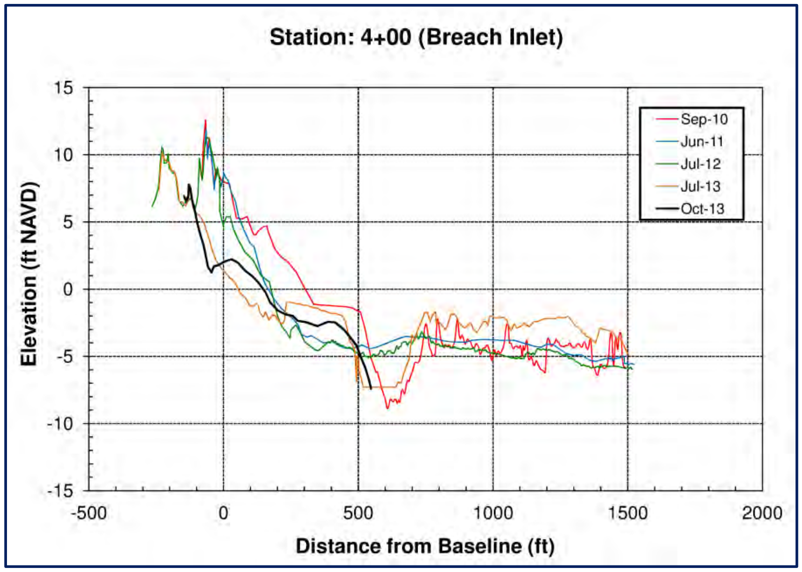
The beach condition near Breach Inlet is heavily influenced by currents and shoals. Net sediment transport to the west causes the main channel to migrate west, extending over the eastern portion of Sullivan's Island. Much like Dewees Inlet at the eastern end of Isle of Palms, periodic breaks in the delta shoals allow the main channel to relocate further east, starting the migration process over again. A realignment event occurred between 2009 and 2011, and since then, the seaward end of the inlet has migrated away from Isle of Palms. This has caused the delta shoals to shift southwest, likely drawing off sand from the beach near Breach Inlet. Digital terrain models (DTMs) show the main channel and eastern shoal shifting west from 2012 to 2013 (Fig 3.38). They also reveal that the marginal flood channel (labeled M) has shifted closer to the beach at the western tip of the island. The marginal flood channel has developed a lobe at the seaward end (labeled "L" in Figs 3.37 and 3.38) which has created a bulge in the delta. This feature modifies local waves and may be contributing to erosion along the eastern portion of Reach 1 and western portion of Reach 2.

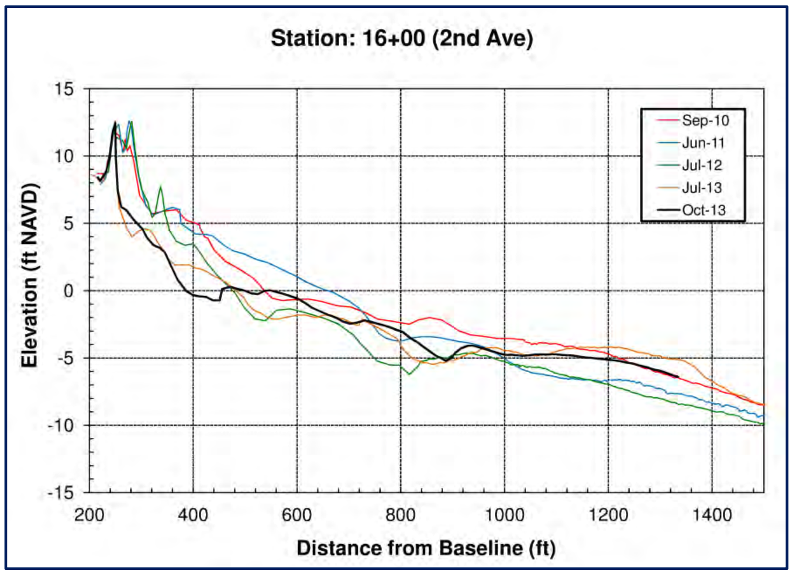
The changes observed near Breach Inlet highlight the dynamic nature of barrier island shorelines adjacent to inlets. Often, beach condition is driven by short-term events associated with inlet changes rather than long term erosional patterns. As evidenced by recent changes, decades worth of accretion can be lost rapidly due to inlet effects. Similarly, a shoal-bypass event may restore a beach which has suffered long-term erosion (eg – Fripp Island, CSE 2013). While local beach changes due to inlet effects are difficult to predict several years in advance, regular monitoring provides the best method to plan for potential issues and project near-future changes. At Breach Inlet, historical and recent data suggest that sufficient sediment will reach the inlet, keep pace with losses to the channel, and allow natural recovery within the next few years.

FIGURE 3.36.

Profiles from stations 4+00 and 16+00 near Breach Inlet and station 30+00 near 2nd Avenue.

Located about 500–700 ft from the baseline, a marginal flood channel reformed at station 4+00 between 2012 and 2013. Profiles show it migrated landward from July to October 2013.





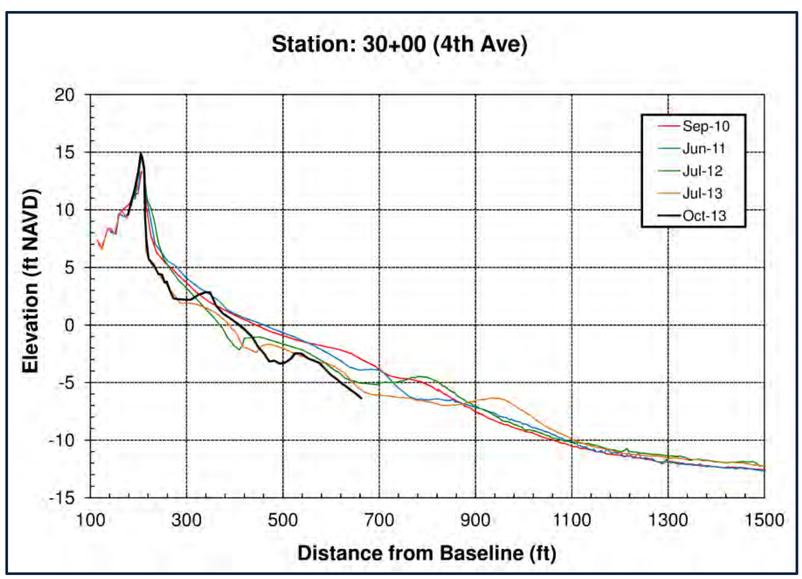


FIGURE 3.37. November 2013 aerial images of Breach Inlet area. **[UPPER]** View of the Breach Inlet delta, which extended southwest (toward Sullivan's Island) from 2012 to 2013, likely drawing sand off the IOP beach. The marginal flood channel (M) migrated toward the beach and developed a terminal lobe (L) through the delta shoal. **[LOWER]** View of the western tip of Isle of Palms showing areas which were stable or erosional between July and October 2013. While a small area showed minor dune recession, all stations in this view gained sand from July to October 2013 (measured to −6 ft NAVD). [Photos by SB Traynum]

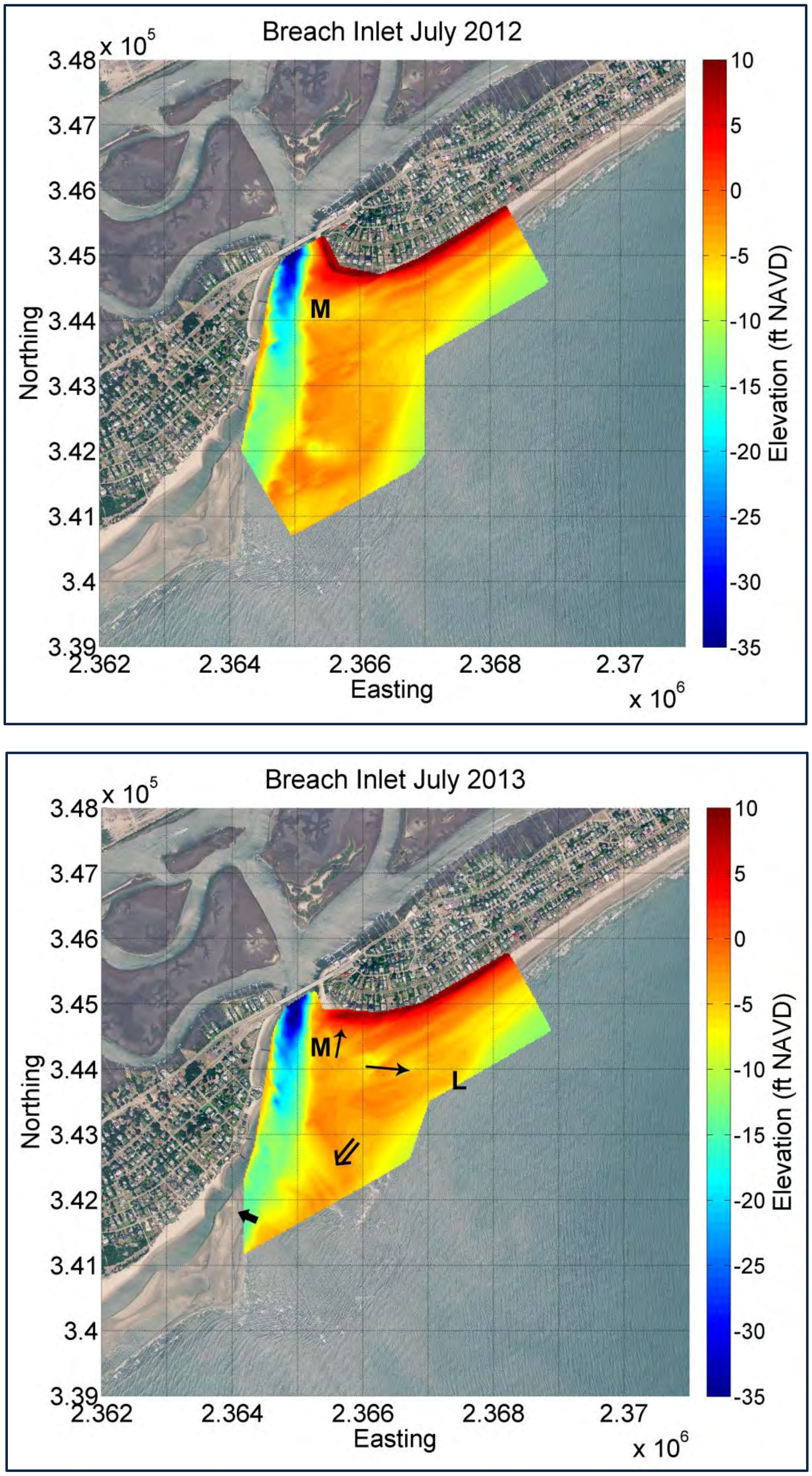


FIGURE 3.38. Color DTMs of Breach Inlet and neighboring IOP shoreline in July 2012 (upper) and July 2013 (lower). Note western migration of the channel and main shoal, landward migration of the marginal flood channel (M), and expansion of the terminal lobe (L) of the marginal flood channel.

FIGURE 3.39.

[UPPER LEFT] 4th Avenue (10 July 2012).

[UPPER RIGHT] 4th Avenue (30 October 2013) – Note the erosion extends landward of the walkover.

[2nd LEFT] View west from beach access 2 (10 July 2012).

[3rd LEFT] Beach access 2 (29 October 2012) – Hurricane *Sandy* caused over 50 ft of dune erosion and damaged walkovers in this area. [Photo by D Kynoski]

[LOWER RIGHT] Beach access 2 (October 2013) – Note recovery of the berm and healthy dunes.

3.2 Shoal Management Project Conditions

As part of the monitoring effort for the City, CSE evaluated beach volumes in the borrow and fill areas for the 2012 shoal management project. Details of the construction are given in the project final report (CSE 2012) and will not be repeated here. Volumes reported in this section only include sand that remains within the project boundaries (stations 276–298 for the borrow area and stations 306–320 for the fill area); the volumes do not consider sand that may have spread into adjacent areas. Total unit volumes for the borrow and fill areas are plotted in Figure 3.37 (to −10 ft NAVD). The trend in the borrow area is increasing volume from 2008 to September 2009 as sand from shoal-bypass events came ashore. Beach volume declined in the borrow area from September 2009 to July 2012, but gained sand over the past year, likely a result of sheltering in the lee of the offshore shoal. The borrow area is expected to gain sand at a higher rate over the next year as shoal effects increase. Also note the much higher volumes in the borrow area than the fill area.

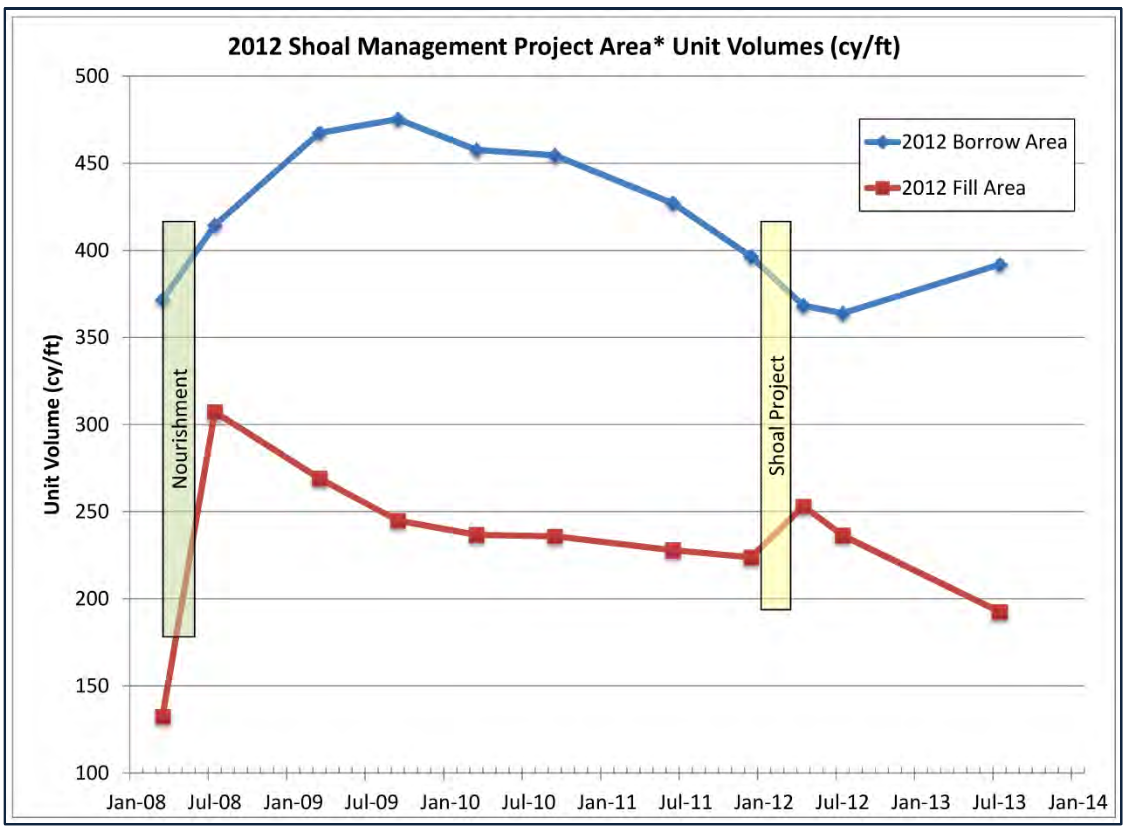


FIGURE 3.40. Unit volumes for the 2012 shoal management project borrow area (*blue, stations 276–298) and fill area (*red, stations 306–320). The fill area eroded rapidly after placement and had lost all of the project sand following passage of Hurricane *Sandy* (October 2012). The erosion rate increased over the past year compared to the 2009–2012 rate.

The fill area (red line) showed a unit volume of 132.4 cy/ft in March 2008. The 2008 nourishment increased this volume to 307.2 cy/ft in July 2008. Erosion was rapid over the first year after nourishment, and the volume decreased to 244.9 cy/ft by September 2009. Erosion continued at a slower rate through December 2011 when the unit volume reached 223.7 cy/ft. The 2012 shoal-management project increased the volume by ~30 cy/ft. Between April and July 2012, the fill area lost 16.8 cy/ft (56 percent of the in-place fill).

Erosion increased over the past year with the area within the fill limits losing ~61,308 cy (43.8 cy/ft), leaving it with an average of 60.1 cy/ft more sand than the 2008 pre-nourishment condition. Much of the erosion over the past year appears to have occurred during Hurricane *Sandy* (27 October 2012), although the area has continued to lose sand since then. Property owners have placed approximate cubic-yard-sized sand bags along the dune escarpment to protect the remaining berm until another shoal management project can be performed.

FIGURE 3.41. July 2013 photo of the temporary sandbag revetment placed by property owners along the critically eroded portion of Wild Dunes.

3.3 Dewees Inlet and Delta

CSE has monitored the morphology of Dewees Inlet since 2007. During the past six years, a major channel avulsion event shifted the main channel east. Details of the morphological changes occurring from 2007 to 2011 are given in earlier reports to the City (CSE 2010, 2011a,b). The present report focuses on current conditions of the ebb-tidal delta and the impact it is having on the beach. Morphologic changes are highlighted in digital terrain models (DTMs) (Fig 3.42). Section profiles from selected stations are shown in Figure 3.43.

The ongoing shoal-bypass event occurring at the east end of the island is now in Stage 2 of the shoal-bypass cycle (cf – Fig 1.2). The main body of the shoal migrated landward and expanded to the west over the past year (see arrows on Fig 3.42). There was also an overall increase in elevation, as evidenced by the enlargement of the area above the −5 ft contour (noted by the black line surrounding the orange-shaded area in Fig 3.42). Profiles show that the western arm of the shoal (Fig 3.43, station 278+00) has become much more defined with a characteristic "slip face" along the leading (landward) edge. The sand forming this portion of the shoal appears to have come from the terminal lobe of the 2007 inlet delta (southwest side of the old inlet channel, noted "W" on Fig 3.42), whereas the portion of the shoal off of Mariners Walk/Shipwatch (station 292+00) was sand that was previously on the eastern side of the old channel ("E" on Fig 3.42). The two shoals have merged to form one larger shoal which is situated ~550–750 ft from the shoreline between stations ~270+00 and 296+00.

The leading edge of the shoal migrated between 500 ft and 750 ft closer to the beach from July 2012 to July 2013. Oblique aerial images from July and November 2013 show even further landward migration as the leading edge appears to be ~400 ft from the beach near Mariners Walk (Fig 3.44). The elevation of the crest of the shoal has increased along all profiles, which leads to continual wave-breaking and more rapid migration. The main body of the shoal offshore of Mariners Walk has a maximum elevation of (~)−1.5 ft NAVD, and is now above the MLLW elevation at the site. The shoal is separated from the beach by an ~500-ft-wide area which allows flushing of water between the ocean on the eastern and western sides of the shoal. As the shoal moves closer to the shoreline, currents in this gap may increase as water attempts to flow from one side of the shoal to the other (especially when waves are oblique to the shoreline). This may lengthen the time it takes to attach as higher currents will sweep away some sediment. A similar, but smaller-scale, flushing channel was present in March 2009 just prior to attachment of a smaller shoal (cf – Fig 3.10).

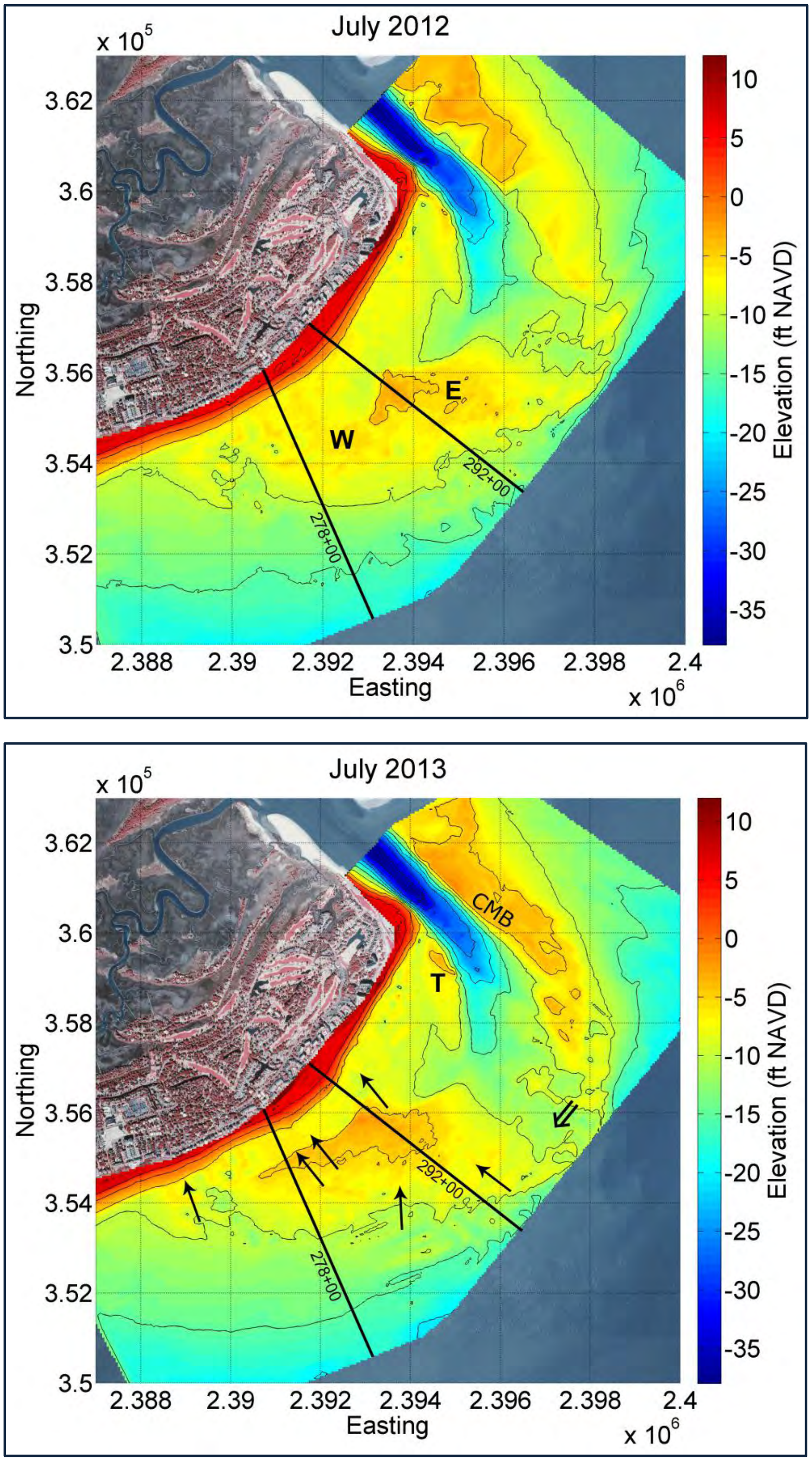


FIGURE 3.42. Color DTMs from the July 2012 (upper) and July 2013 (lower) surveys of the Dewees Inlet ebb-tidal delta. The general directions of sand/channel movement are shown by the arrows. [Labels are described in the text.]

FIGURE 3.43.

Profiles from station 278+00 (Beach Club Villas I), station 284+00 (Beach Club Villas II), and station 292+00 (Shipwatch) showing the position of the shoal migrating toward the beach. The western area (station 278+00) has migrated faster over the past year and may be the first section of the shoal to attach.

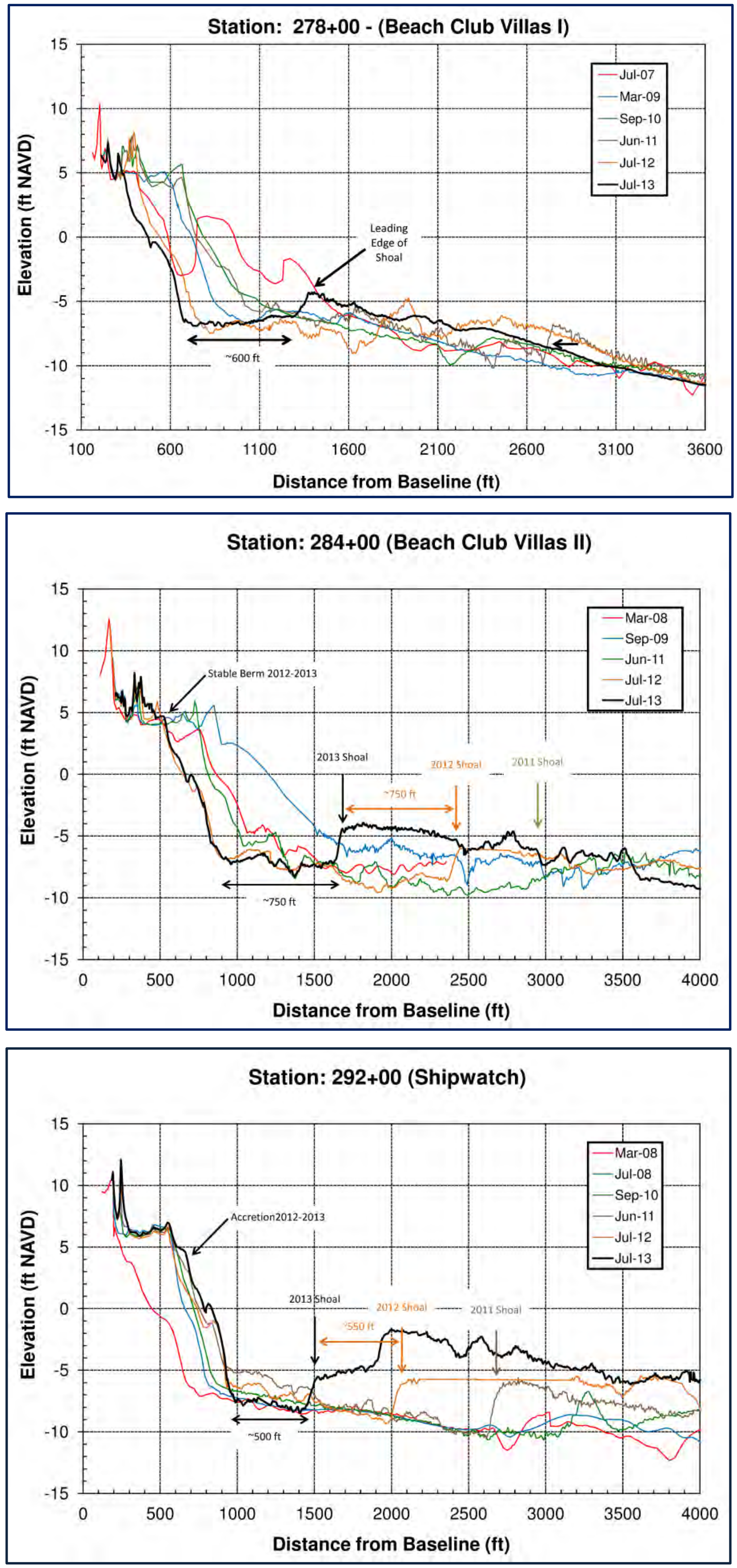


FIGURE 3.44. July 2013 (upper) and November 2013 (lower) aerial images of the ongoing shoal-bypass event at the northeastern end of Isle of Palms. It is apparent that the main body and western area of the shoal have migrated closer to the beach since July (date of survey data). [Note the November image was taken at a slightly higher tidal stage, reducing the extent of the breakers and area of exposed sand.]

Other changes visible between 2012 and 2013 include landward movement of the −10-ft contour (black line separating the yellow and green hues in Fig 3.42) along the southern side of the shoal. This indicates the old inlet channel lobe is collapsing and the sand is migrating landward. The new channel continues to extend to the southwest and expand seaward as sand accumulates on the new ebb-tidal delta. Note the buildup of the "channel margin bar" (CMB) on the northeast side of the inlet (Fig 3.42). This feature provides increasing wave attenuation and protection during northeast storms. The trailing ebb spit (labeled "T" in Fig 3.42) has also increased in elevation and area over the past year. As this feature gets larger, it can reduce wave energy impacting the beach near the golf course. It may also have the negative effect of creating a submerged headland, which, coupled with the shoal to the west, may cause wave diffracttion between Port O'Call and the golf course. This can create a sediment divergence in this area and lead to erosion.

Using the DTM generated from survey data, CSE estimates that the bypassing shoal (defined to include the area south and west of the main channel) contains ~1,600,000 cy of sand above the −10-ft NAVD contour. This is the volume of sand that will eventually merge with the beach, the majority of which is likely to attach as a distinct event beginning by fall/winter 2014-2015.

The changes listed above are continuations of changes observed over the past several years. It is worthwhile to note that the formation and growth of the trailing ebb spit over the past two years is a potential positive for future sediment supply at the eastern end of the island. The buildup of sand (area "T" in Fig 3.42) can act as a groin and trap sand moving east along the oceanfront. However, the initial buildup of this feature is associated with sand lost from the beach. The bar is likely to expand and could eventually merge with the incoming shoal, trapping a lagoon between the outer sand bar and the present shoreline. It is not yet certain if this will occur or what the direct impact of the channel margin bar will be. CSE will continue to track the feature in future monitoring events.

3.4 Project Area Volume Changes

The following section provides volume change results within the limits of the 2008 nourishment project boundaries. It provides a measure of how much sand is left within the initial alongshore fill limits. While these results are useful for measuring project performance, it should be noted that sand gained or lost from these areas may be accounted for in adjacent areas as noted in Section 3.1.

Within the fill limits of the *Dewees Inlet* project area (nourishment Reach C, Fig 3.45), the beach continued to gain sand. **Overall, the project reach gained ~13,250 cy (13.3 cy/ft) since June 2012, leaving it with 116 percent of the nourishment volume remaining** (Fig 3.46). As of July 2013, Reach C contained ~83,800 cy more sand than the pre-nourishment condition. Accretion between station 330+00 and station 338+00 (area of the 18th tee and fairway) is likely due to losses in Reach 6. The volume change trends along the 18th fairway of the Wild Dunes Links Course, which wraps around the northeastern point of the island, provide an indicator of net sand transport from the oceanfront to the inlet shoreline in this area, consistent with the findings of Kana and Dinnel (1980).

The length of beach within the project boundary Reach B (between Shipwatch and the 18th fairway) presently retains 95.8 cy/ft more sand than the pre-nourishment condition (compared to 148.4 cy/ft immediately following nourishment). **As of July 2013, 64.5 percent of the nourishment volume remains in project Reach B.** Overall project Reach B lost ~62,800 cy (14.6 cy/ft) of sand since July 2012.

Similar to the previous year, Project Reach A was the most erosional project reach, losing ~123,300 cy since July 2012. The project area presently retains an average of 16.8 cy/ft less sand than the pre-nourishment condition compared to 64.6 cy/ft more sand immediately post-nourishment. In March 2009, 90.8 percent of the nourishment volume remained in the project area. This reduced to 72.0 percent in September 2009, 53.9 percent in September 2010, 36.7 percent in June 2011, 10.7 percent in July 2012. **As a whole, the reach shows less sand than the pre-nourishment condition; however, the western two-thirds of the reach still retains more sand than the pre-nourishment condition.** Extensive erosion of the eastern end of the reach skews the overall totals. See details in Section 3.1.

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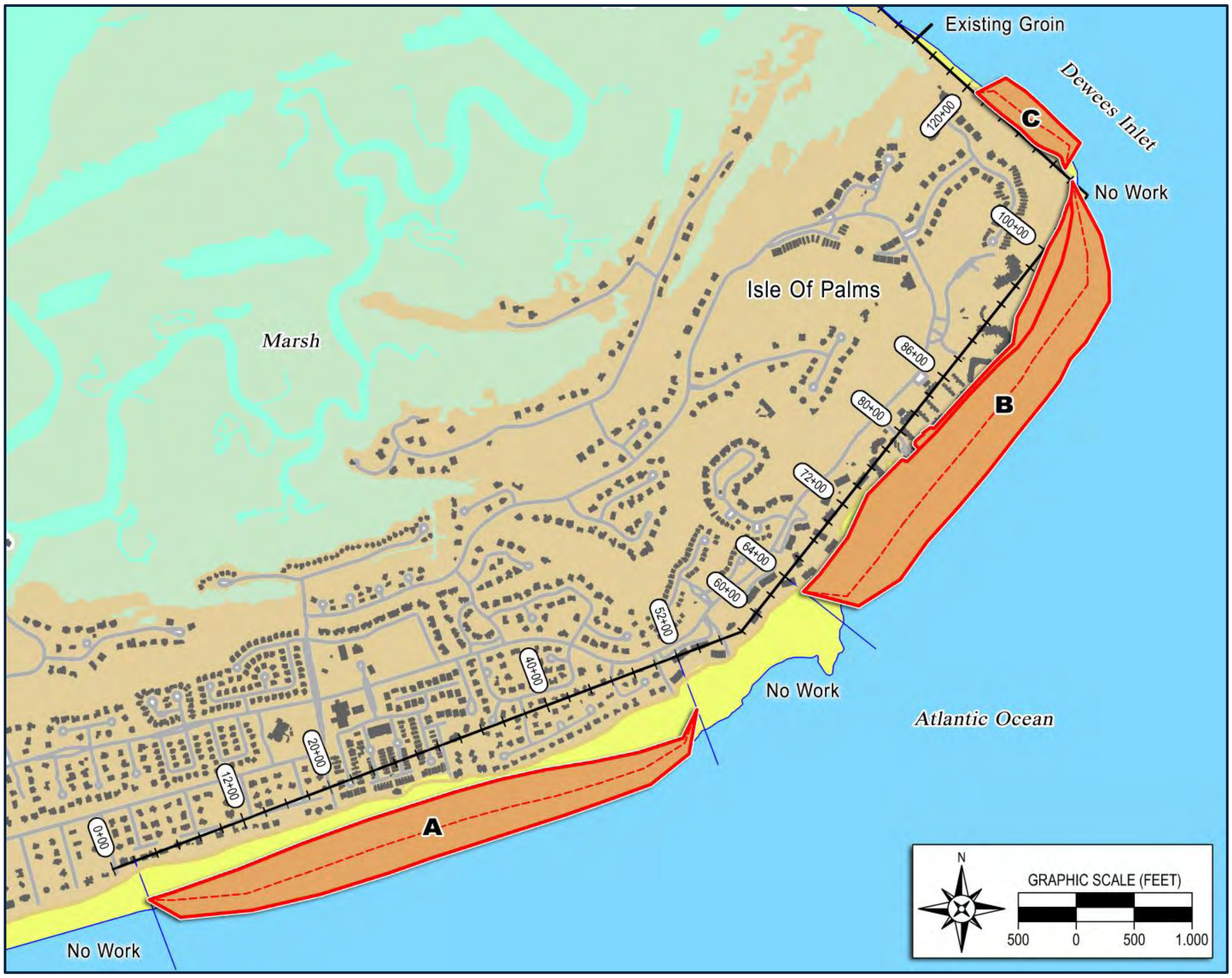
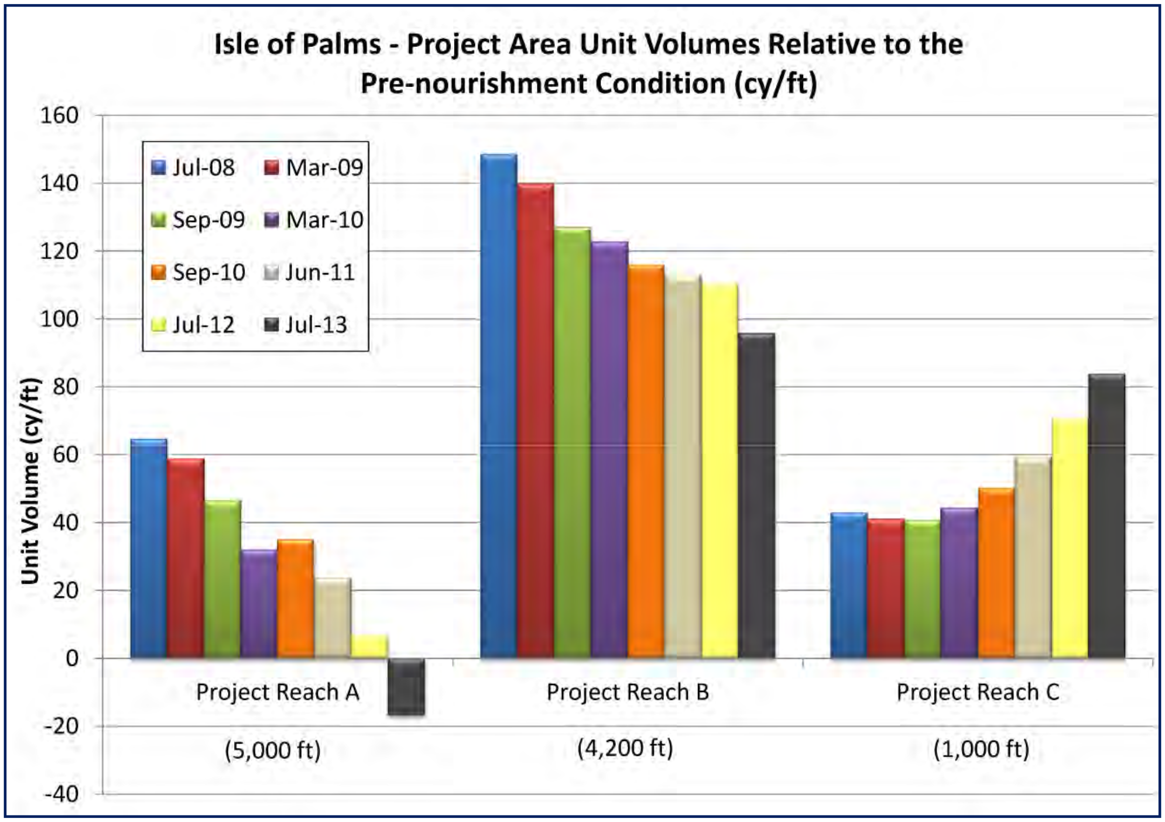


FIGURE 3.45. Reaches for the 2008 nourishment project. The graphic shows the project baseline with 0+00 located at 53rd Avenue (monitoring station 222+00).



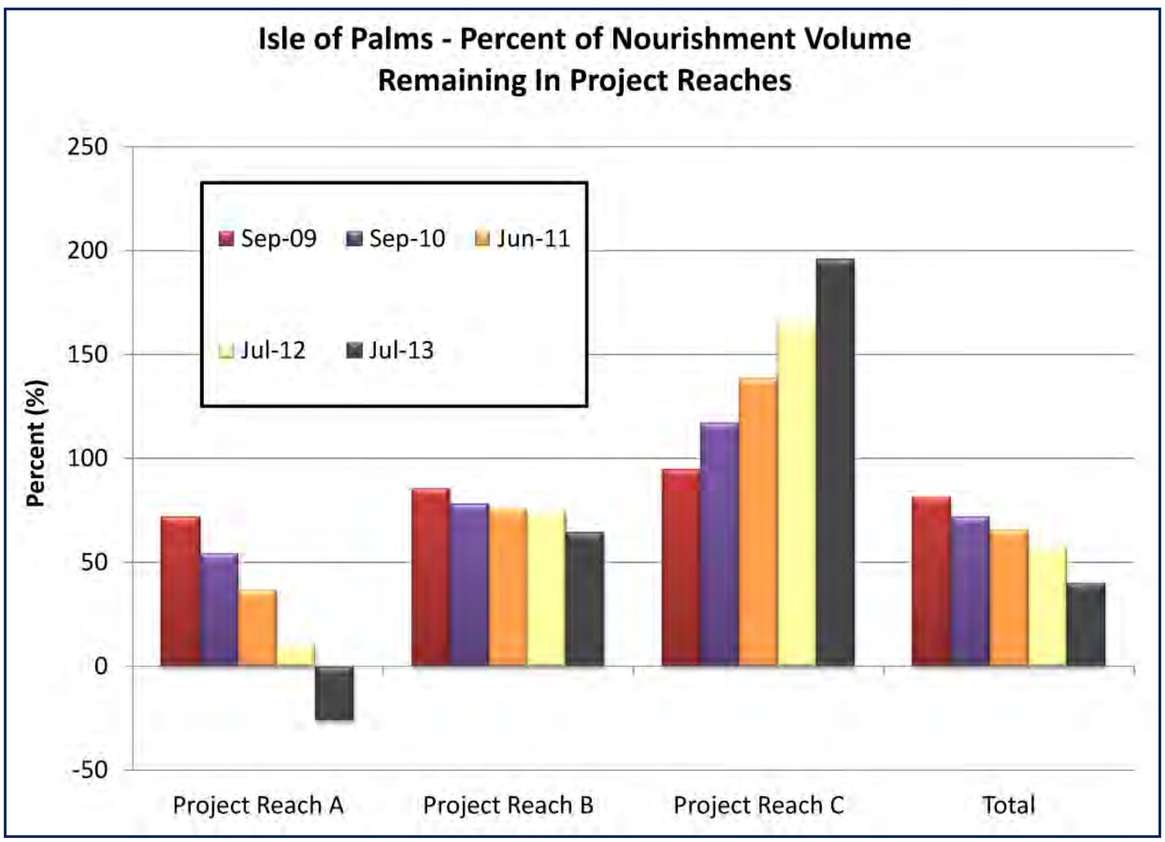


FIGURE 3.46. [UPPER] Project area unit volumes relative to the pre-nourishment (March 2008) condition, which is zero on these graphs. [Note that the project area limits differ from monitoring reach limits.] **[LOWER]** Percent of nourishment volume remaining in each project area.

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4.0 DISCUSSION AND RECOMMENDATIONS

CSE has collected detailed morphological data at Isle of Palms over the past six years (2007–2013). During that time, significant changes have occurred in Dewees Inlet which have impacted the shoreline and will continue to control beach volume changes at the northeastern end for several years. Specifically, a channel avulsion event (shift of the channel to a more northerly position) has been occurring, which has released over one million cubic yards of sand from the inlet delta. This sand is positioned just offshore and is moving slowly toward the beach. Substantial shoreline changes have also been occurring near Breach Inlet, especially over the past year.

Significant findings of the present (July 2013) monitoring effort are:

- The Dewees Inlet shoal which has been migrating to the southwest since the channel avulsion event has fully merged with sand from the terminal lobe of the 2007 inlet channel, creating a large shoal-bypass event. In July 2013, the leading edge of the shoal was 550–750 ft from the beach and spanned the shoreline from Beachwood East to Shipwatch.

- The leading edge of the incoming shoal migrated ~600 ft over the past year, suggesting that it is likely to attach by fall/winter 2014–2015. The western arm of the shoal (offshore of Beachwood East) may be the first point to attach, although it is too early to predict with certainty.

- The shoal is now in Stage 2 of the shoal-bypass cycle and impacting the beach. The beach directly behind the shoal is building seaward, while adjacent areas are suffering the characteristic erosion associated with shoal-bypass events. Erosion is likely to continue or worsen between Port O'Call and the golf course. The area between the Grand Pavilion and Beach Club Villas may experience smaller-scale erosion, but should be better protected due to the western arm of the shoal extending offshore of these areas.

- Overall, Reaches 5–7 showed lower erosion rates from 2012 to 2013 compared to the previous year. The area from 53rd Avenue to Cedar Creek spit holds ~350,000 cy (23.5 cy/ft) more sand than the 2008 pre-nourishment condition. This is about 35 percent of the volume gained during the nourishment period and 41 percent of the contract volume remaining five years after project completion.

- The central portion of the island continues to gain sand, totaling 176,000 cy over the past year.

- Erosion has persisted near Breach Inlet since 2010 and became obvious during passage of Hurricane *Sandy*, which eroded over 50 ft of dunes in some locations. The Breach Inlet reach lost ~58,000 cy from July 2012 to July 2013; however, it was accretional from July to October 2013 (to −6 ft NAVD). Evidence of recovering dunes was noted along most of the reach during an October 2013 assessment. Based on historical trends, CSE anticipates that Reach 1 will recover naturally; however, the City has initiated quarterly monitoring to ensure that appropriate planning decisions can be made should erosion continue.

Overall, the island gained 11,200 cy (0.3 cy/ft) of sand over the past year. This is the first year with net accretion since 2009–2010.

The current availability of sand in the permitted borrow area for a shoal management project is likely not sufficient to produce a project which will ensure protection of structures over the upcoming summer season. Individual property owners have secured permits for, and installed protective sandbags. Conducting a small-scale shoal management project would likely trigger a permit condition requiring these properties to remove the emergency bags. If the placed sand did not last through the summer, sandbags would likely have to be reinstalled to provide protection to the structures. A larger shoal management project should be possible in the 2014–2015 permitted window (1 November – 30 April) and allow restoration of a wider beach while the bypassing bar moves ashore.

For planning purposes, CSE recommends the City anticipate conducting a project to move the maximum amount of sand permitted (250,000 cy during one event) during the fall or winter of 2014–2015. A project of this scope, including soft costs for engineering, etc, is likely to cost ~$900,000±$150,000 and would require ~1 month to complete using similar methods to the 2012 project. This assumes that property owners will be allowed to keep sandbags in place until a project can be completed. If OCRM requires sandbags be removed before the summer turtle season, the City may need to complete a project by late winter/early spring 2014 using whatever volume of sand is available in the borrow area.

The results of this report provide the City with an updated condition of the beach and offer guidance for beach maintenance activities. The City's commitment to regular, detailed monitoring of the beach is a model for other coastal communities looking to protect their most valuable physical asset. Under the current agreement between the City and CSE, another island-wide monitoring effort is planned for summer of 2014. Quarterly assessments of Breach Inlet are also scheduled for January 2014 (including hydrographic work encompassing the delta) and April 2014 (land-based only).

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ACKNOWLEDGMENTS

This report is prepared under an agreement between the City of Isle of Palms (IOP) and CSE. It is the fourth of a series of annual reports following the 2008 beach restoration project at the north-eastern end of the island.

CSE thanks the IOP City Council (Mayor Dick Cronin), Linda Lovvorn Tucker (city administrator), and Emily Dziuban (assistant to the administrator) for their support and coordination of this project.

SCDHEC–Office of Coastal Resource Management (c/o Bill Eiser) provided historical profiles collected by Coastal Carolina University, which were incorporated into CSE's island-wide analysis.

CSE's data collection and analyses were directed by Steven Traynum with assistance by Drew Giles, Luke Fleniken, Trey Hair, and Tim Kana. Graphics were prepared by Trey Hair and Steven Traynum using AutoCAD®'s Civil 3D®, MATLAB®, and Global Mapper® for digital terrain models. The report was written by Steven Traynum and Dr. Timothy Kana (SC PG 564) with production assistance by Diana Sangster and Trey Hair.

APPENDIX A

Representative Profiles

July 2013

[Isle of Palms – Year 5]

APPENDIX B

Summary Letter

October 2013 — Breach Inlet Assessment

[Isle of Palms – Year 5]

	Landward End		Seaward End	
Station	Easting	Northing	Easting	Northing
0+00	2365547.5	344462.2	2366281.5	343154.1
4+00	2365896.3	344658.0	2366630.3	343349.8
8+00	2366245.1	344853.7	2366979.2	343545.6
10+00	2366419.5	344951.6	2367153.6	343643.4
12+00	2366594.0	345049.4	2367328.0	343741.3
16+00	2366942.8	345245.2	2367676.8	343937.1
20+00	2367291.6	345440.9	2368025.7	344132.8
30+00	2368163.7	345930.3	2368897.8	344622.2
40+00	2369035.8	346419.6	2369769.8	345111.5
50+00	2369907.9	346909.0	2370641.9	345600.9
60+00	2370780.0	347398.3	2371514.0	346090.2
70+00	2371652.1	347887.7	2372386.1	346579.6
80+00	2372524.1	348377.1	2373258.2	347068.9
90+00	2373396.2	348866.4	2374130.3	347558.3
100+00	2374268.3	349355.8	2375002.3	348047.6
110+00	2375140.4	349845.1	2375874.4	348537.0
120+00	2376012.5	350334.5	2376746.5	349026.4
130+00	2376884.6	350823.8	2377618.6	349515.7
140+00	2377756.6	351313.2	2378490.7	350005.1
150+00	2378674.1	351705.1	2379201.5	350300.9
160+00	2379610.2	352056.7	2380137.6	350652.5
170+00	2380546.4	352408.3	2381073.8	351004.1
180+00	2381482.5	352759.9	2382009.9	351355.7
190+00	2382418.6	353111.5	2382946.1	351707.3
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208+00	2384108.0	353732.7	2384612.1	352319.9
210+00	2384296.4	353799.9	2384800.5	352387.2
212+00	2384484.7	353867.1	2384988.9	352454.4
214+00	2384673.1	353934.3	2385177.2	352521.6
216+00	2384861.5	354001.6	2385365.6	352588.8
218+00	2385049.8	354068.8	2385554.0	352656.0
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226+00	2385800.8	354344.5	2386330.7	352941.3
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268+00	2389729.9	355828.5	2390789.8	353022.0
270+00	2389917.0	355899.1	2395216.8	341866.6
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274+00	2390291.2	356040.5	2391351.1	353234.0
276+00	2390478.3	356111.1	2391538.2	353304.6

	Landward End		Seaward End	
Station	Easting	Northing	Easting	Northing
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282+00	2390973.9	356413.2	2395672.9	352682.4
284+00	2391098.2	356569.8	2395797.3	352839.1
286+00	2391222.6	356726.5	2395921.7	352995.7
288+00	2391346.9	356883.1	2399178.7	350665.2
290+00	2391471.3	357039.7	2396170.4	353309.0
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300+00	2392093.1	357822.9	2396792.2	354092.2
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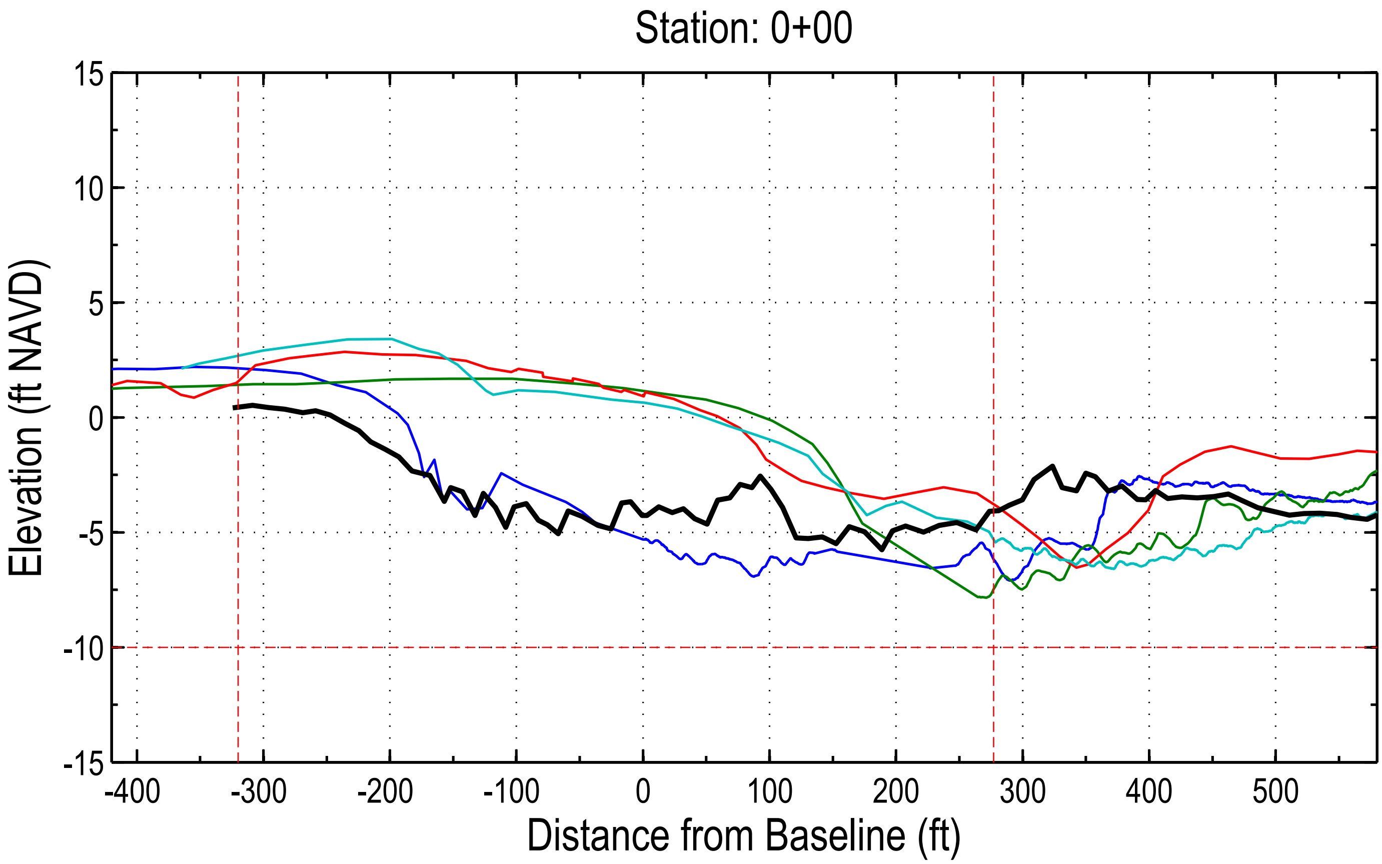

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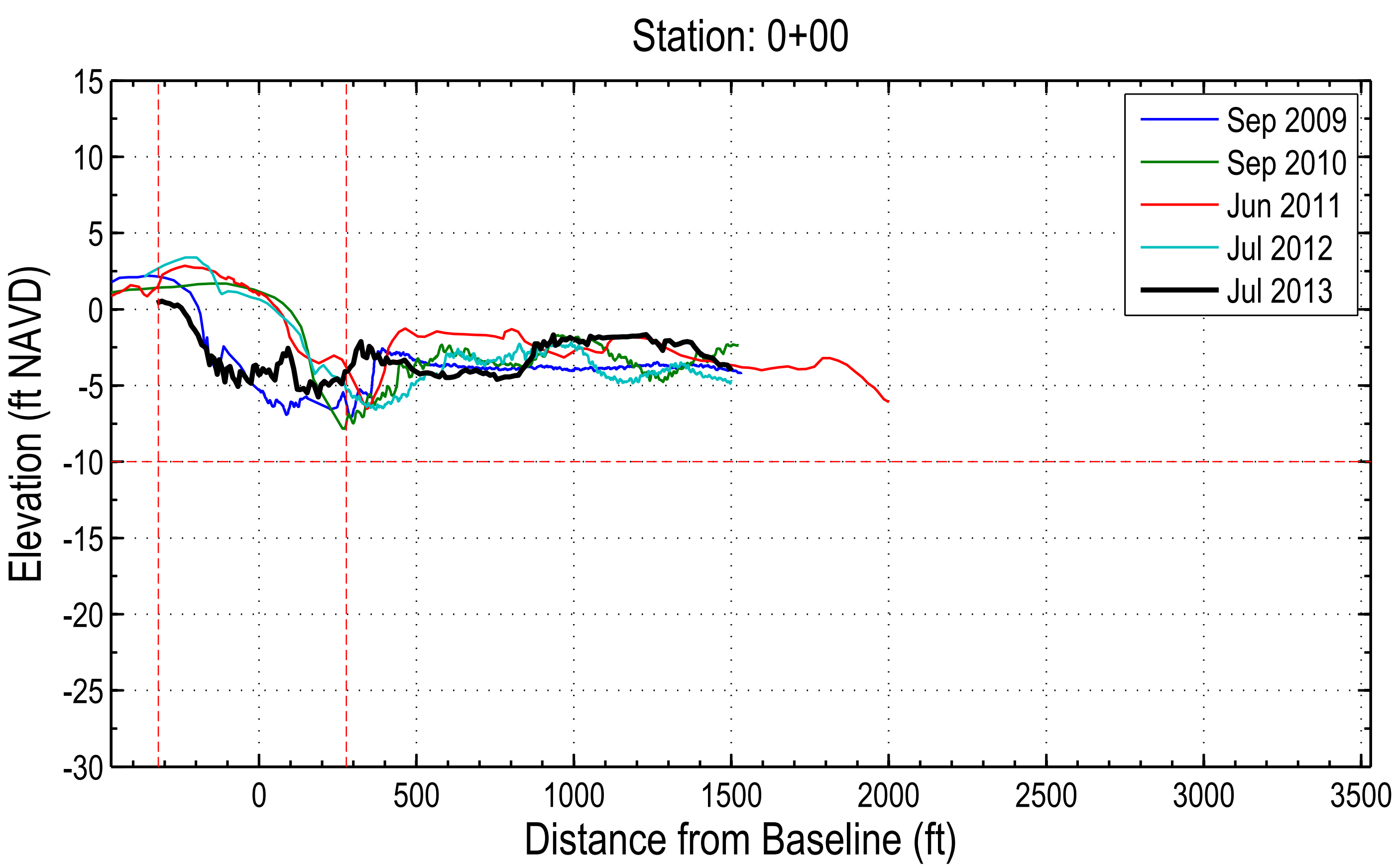

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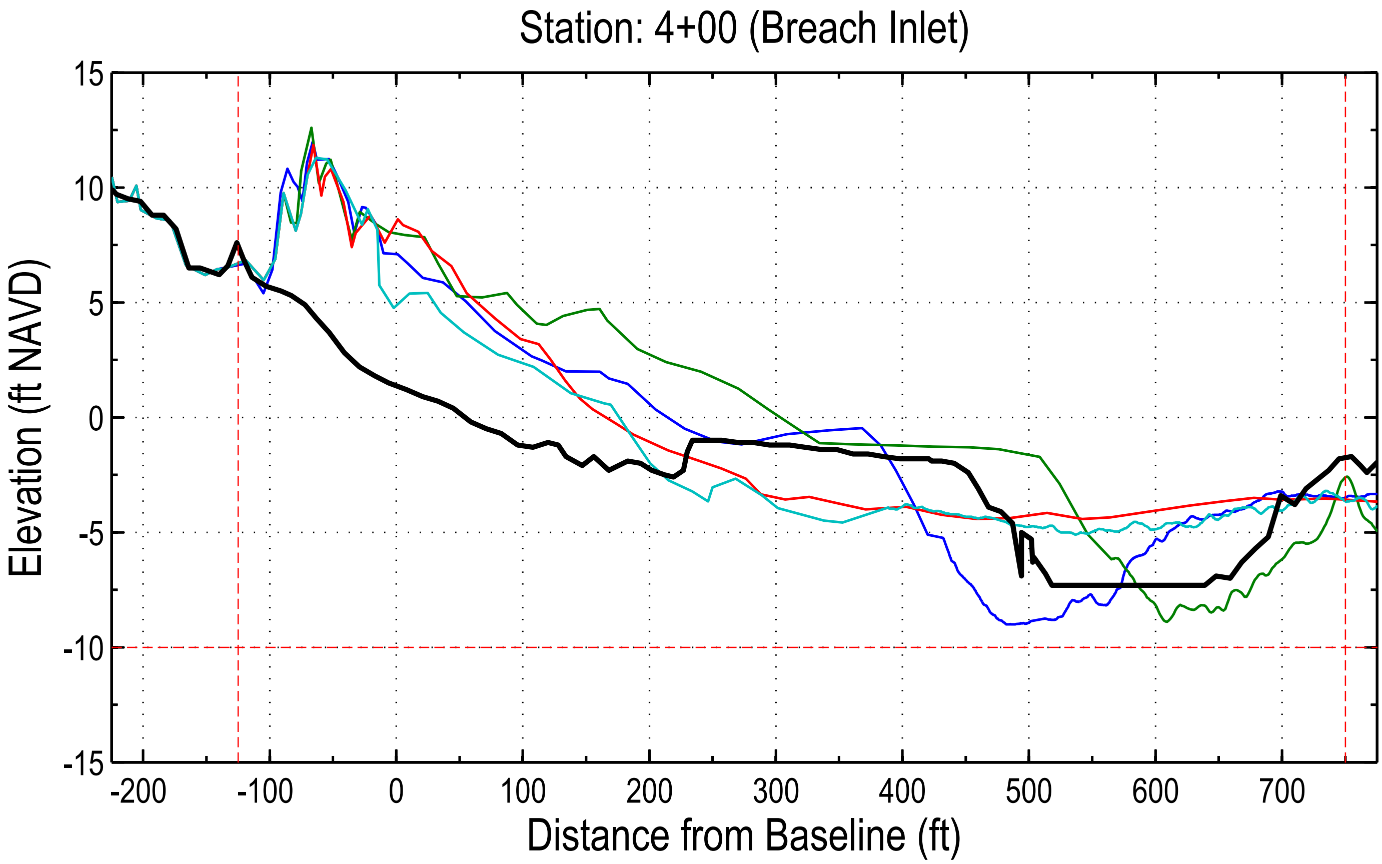

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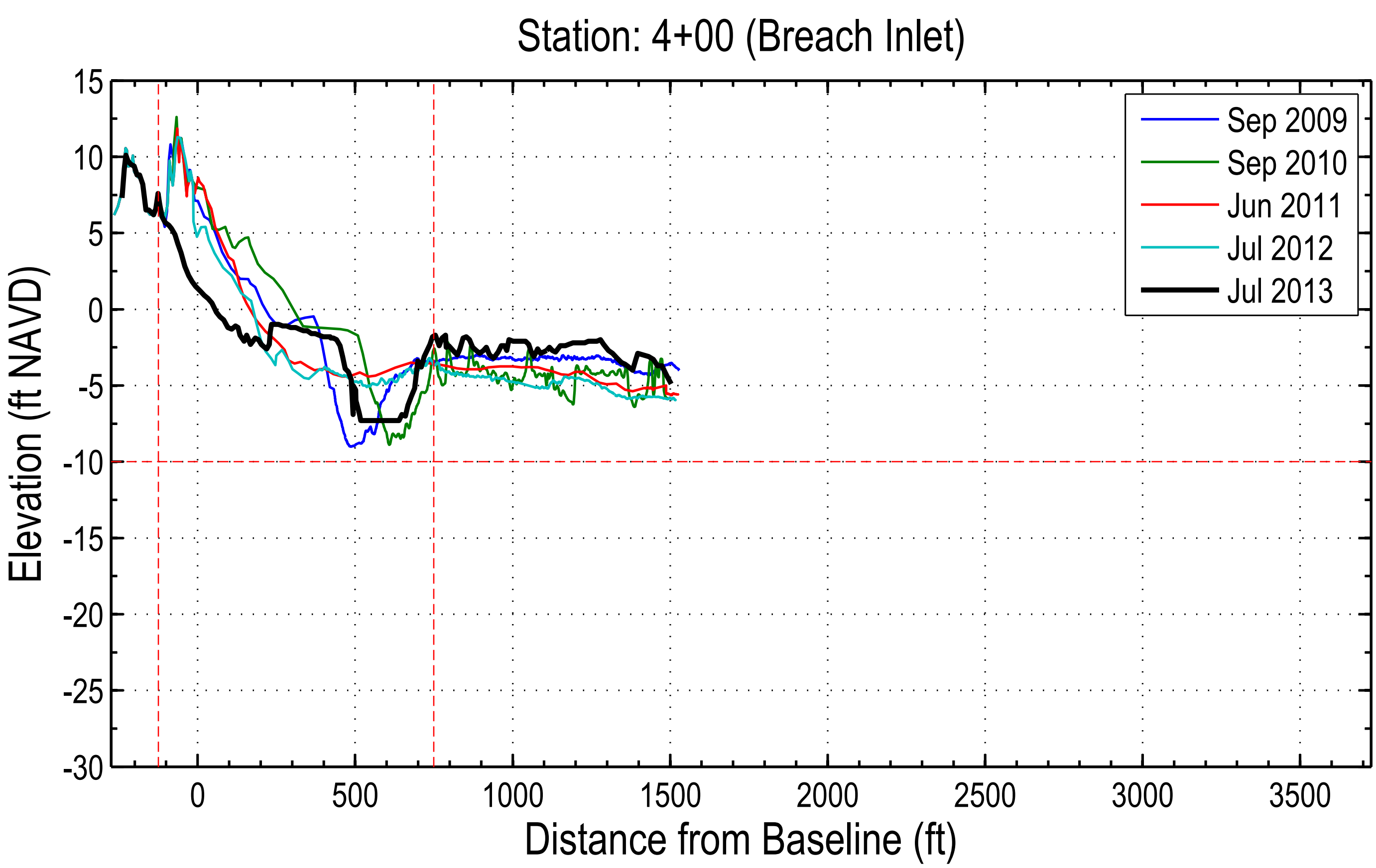

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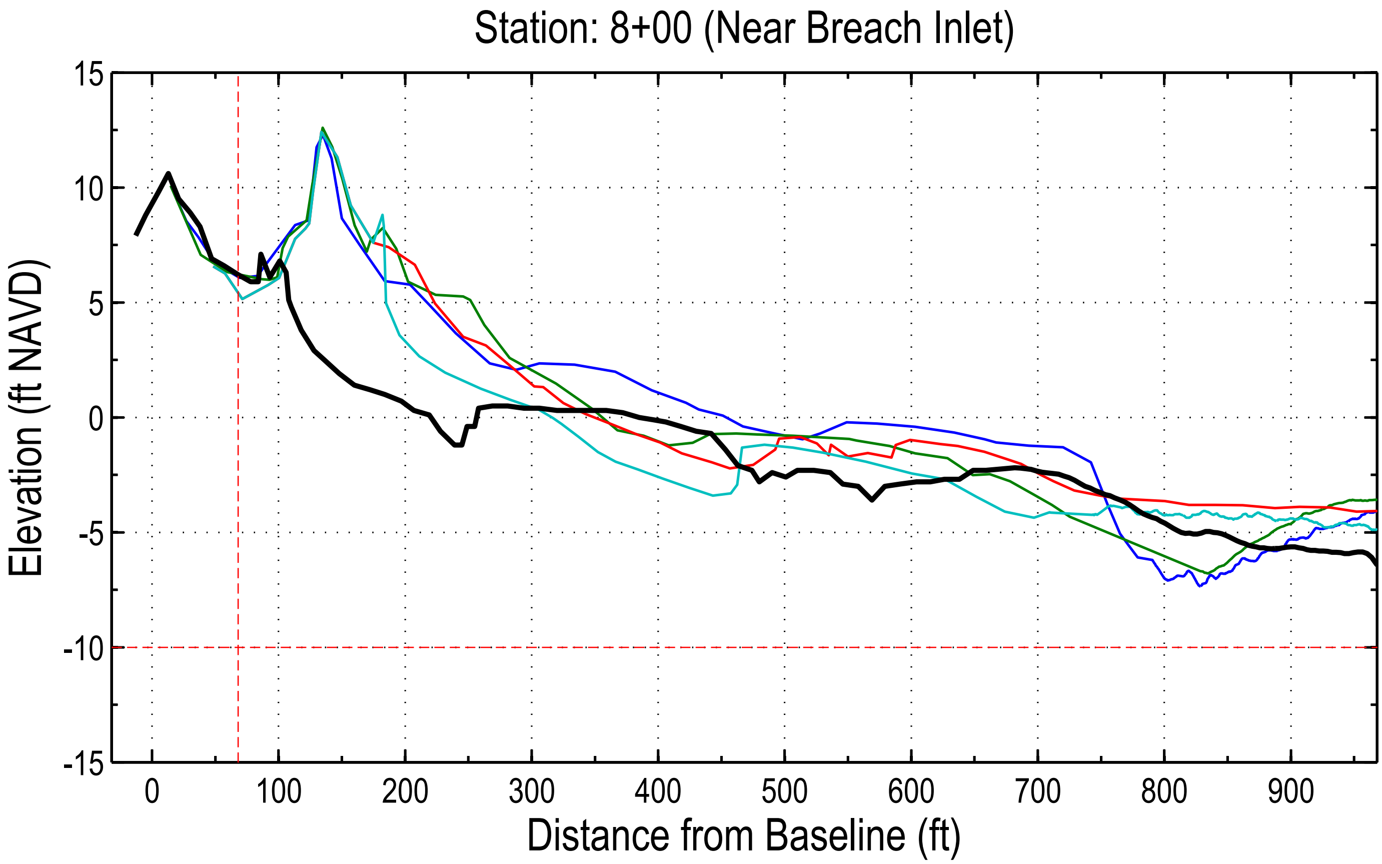
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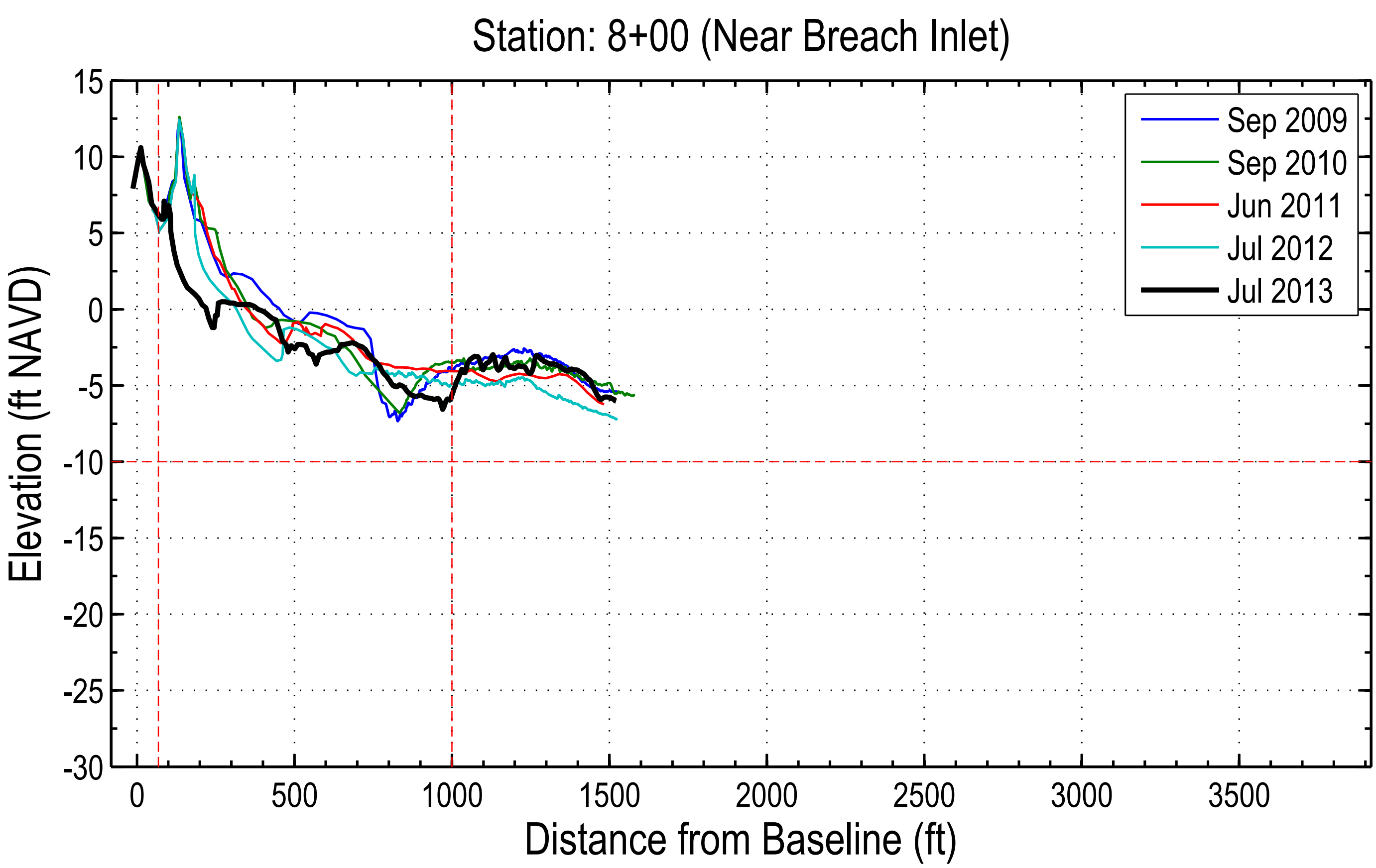
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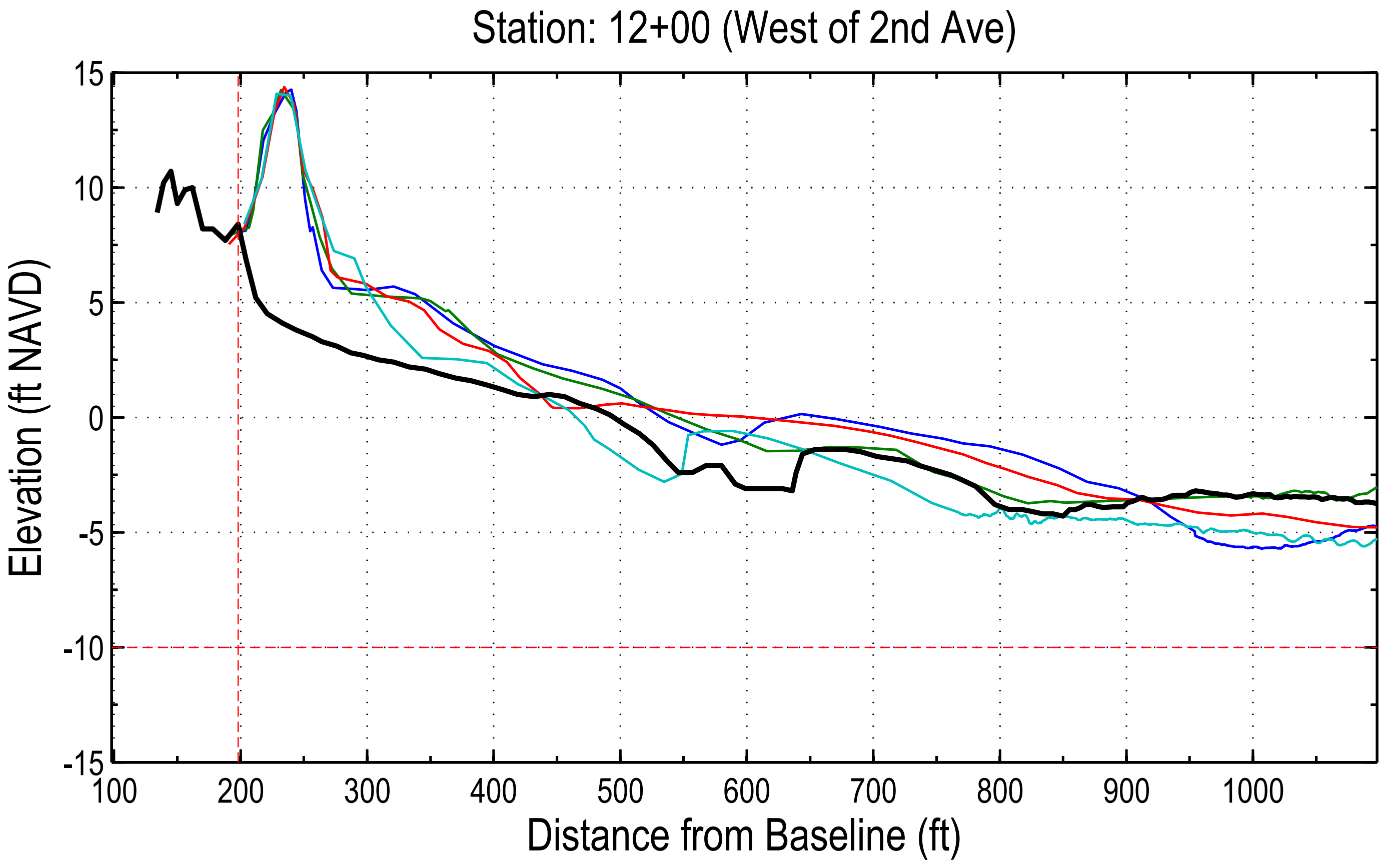
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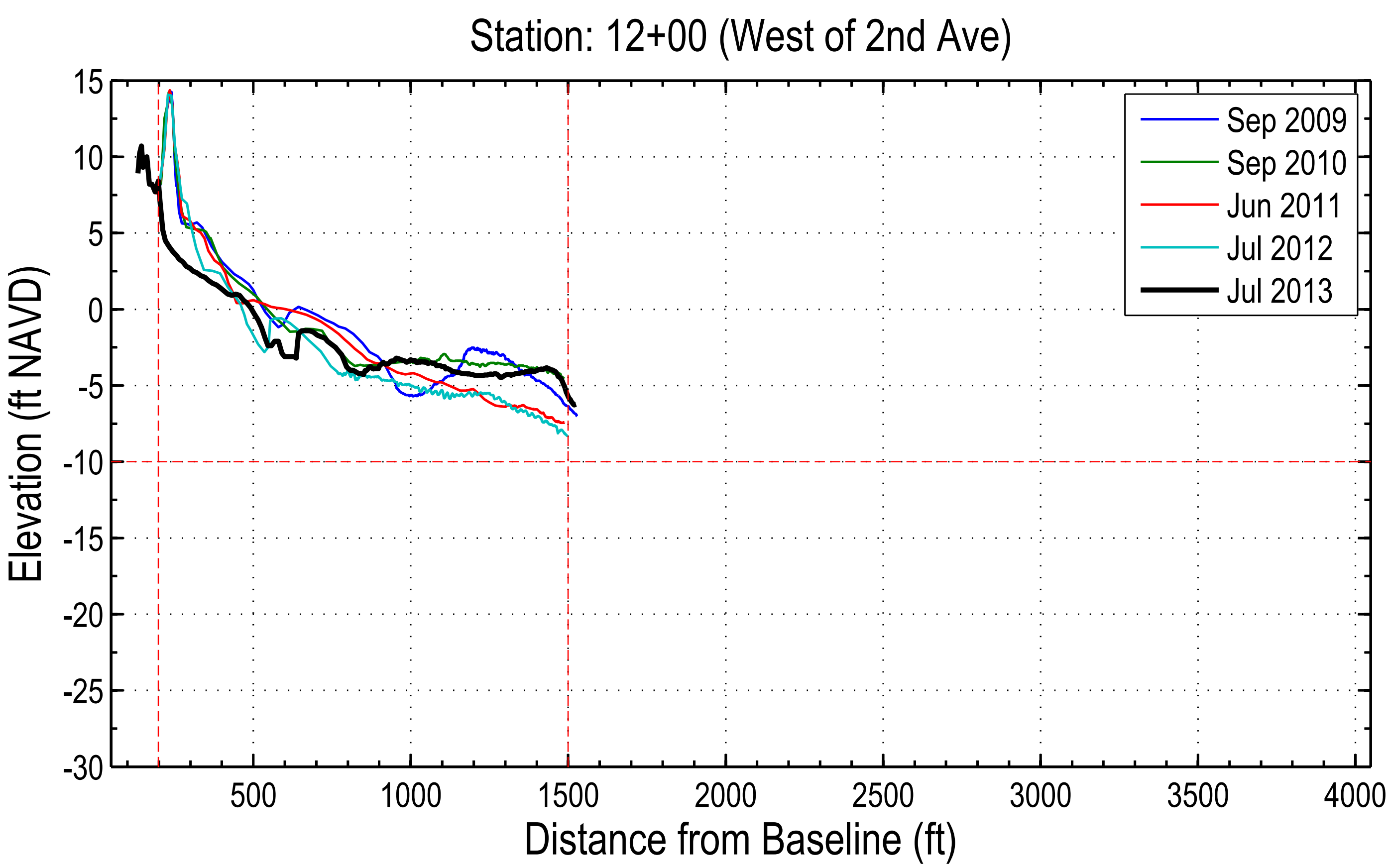
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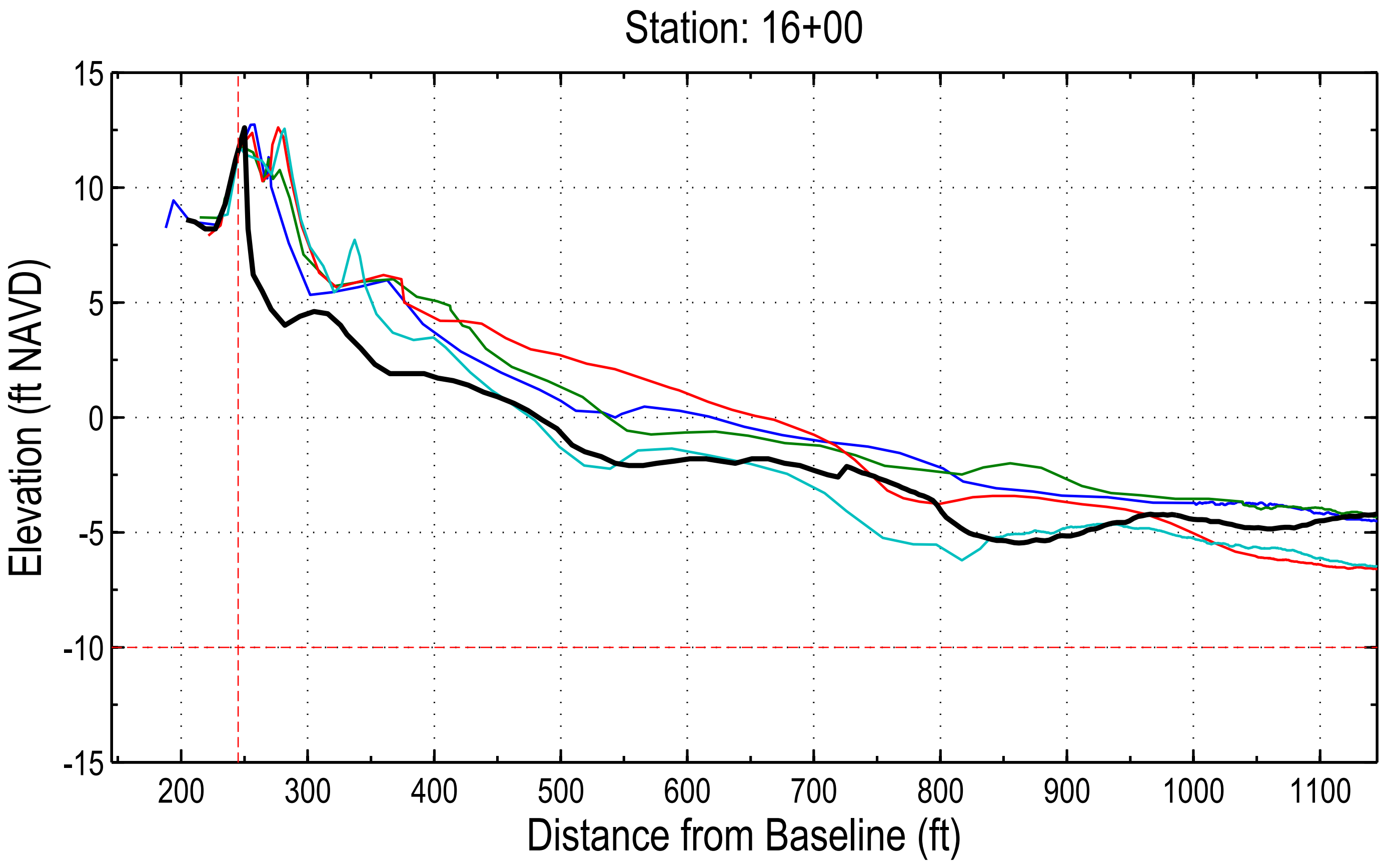
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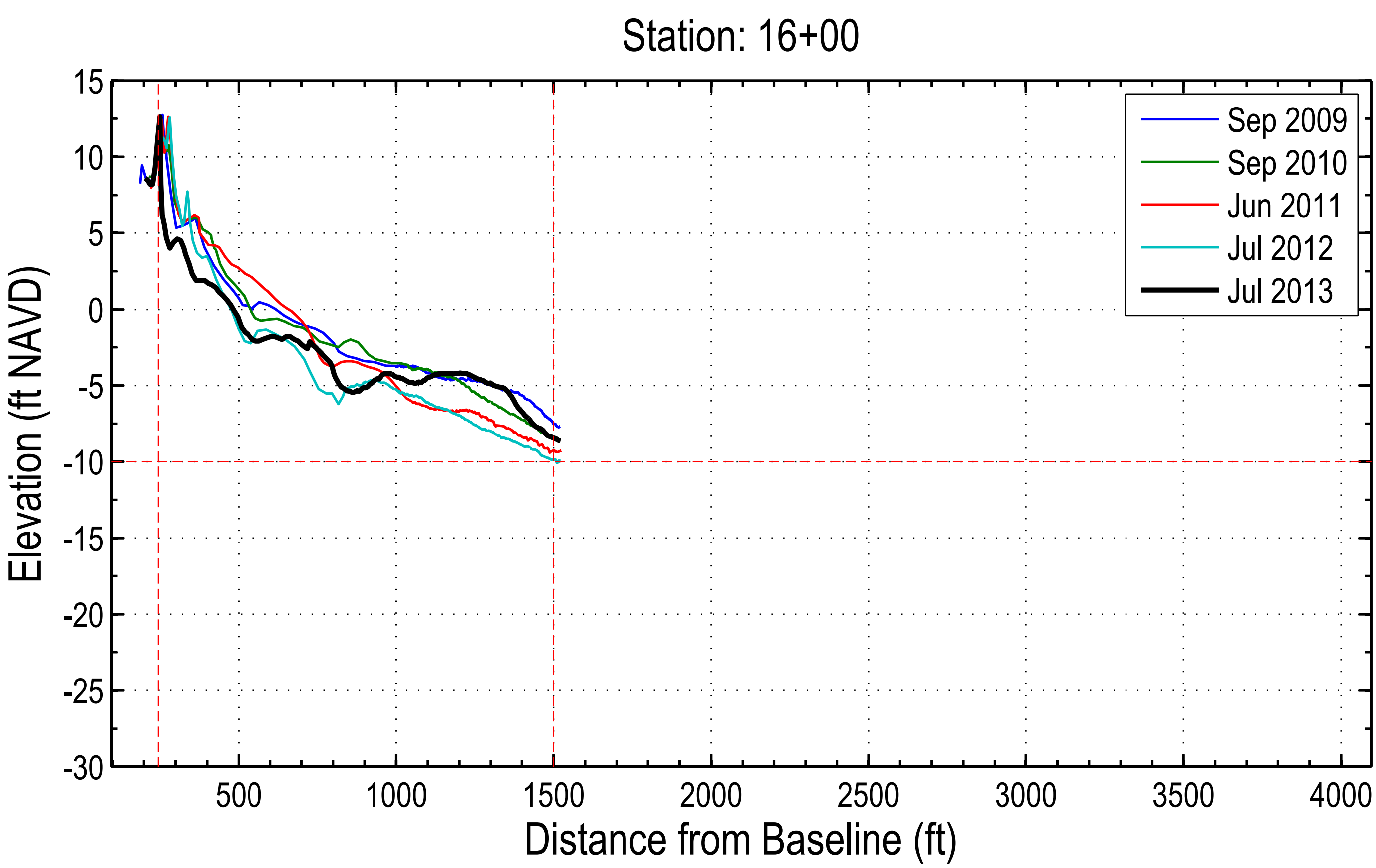
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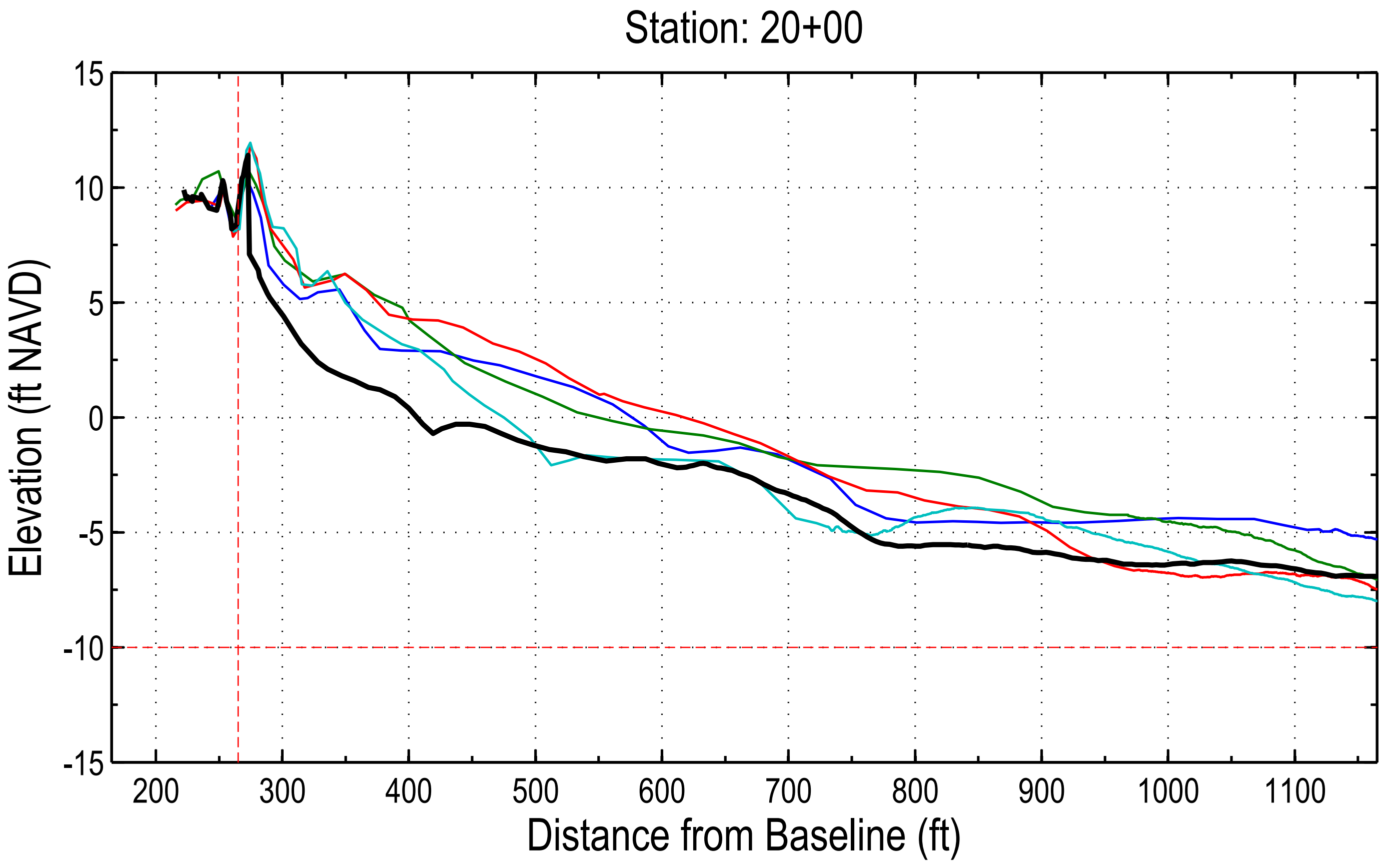
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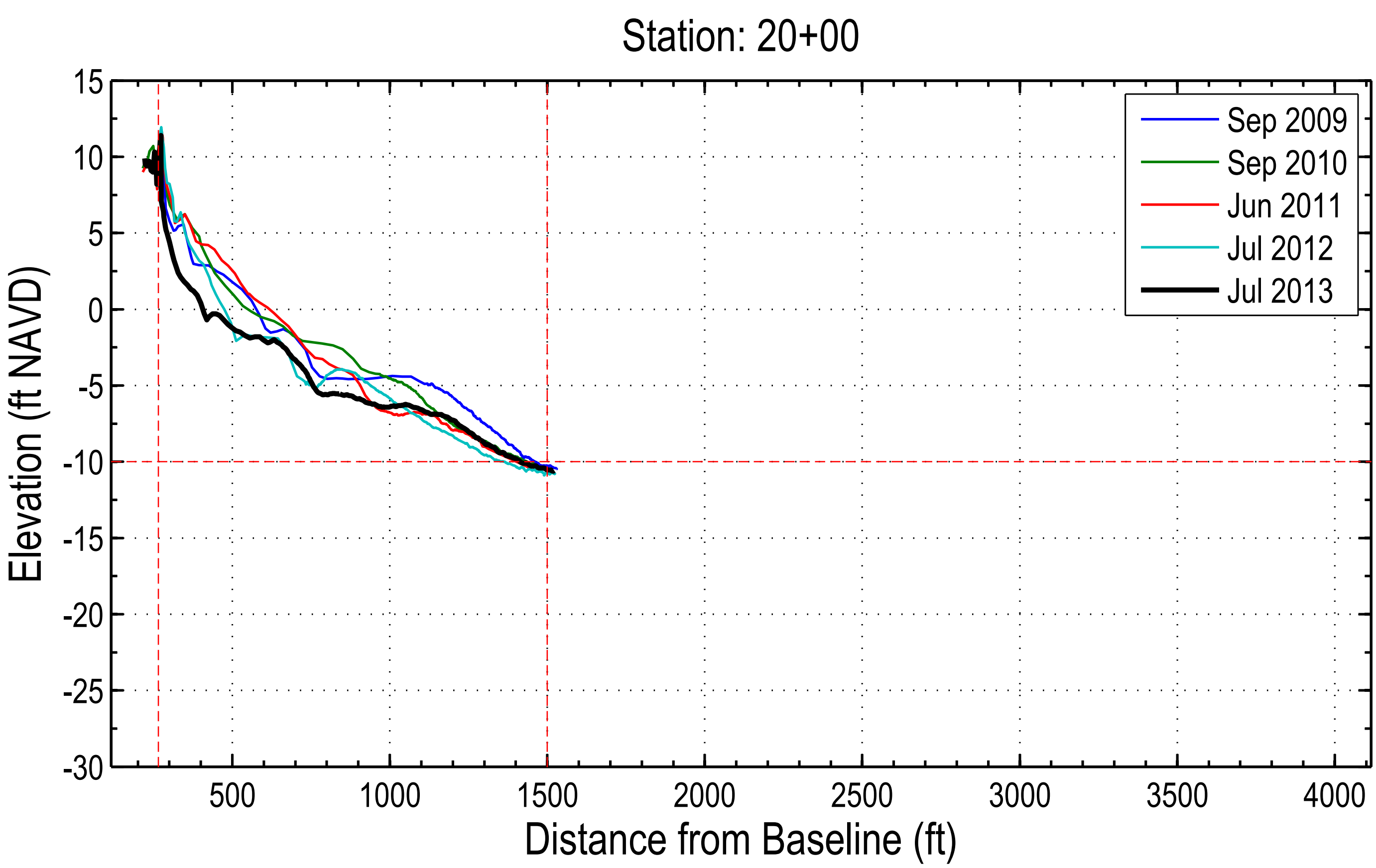
Distance from Baseline (ft)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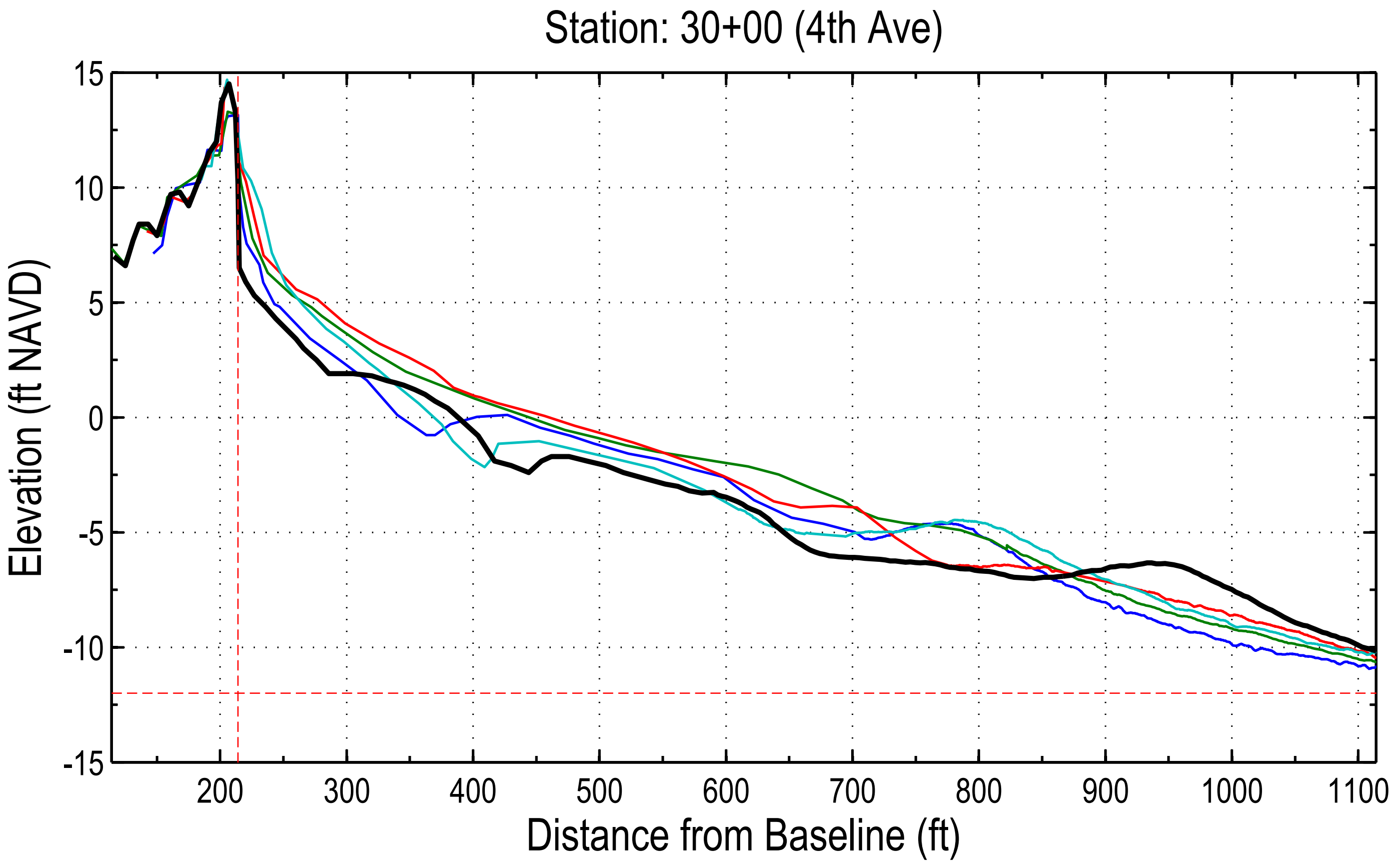

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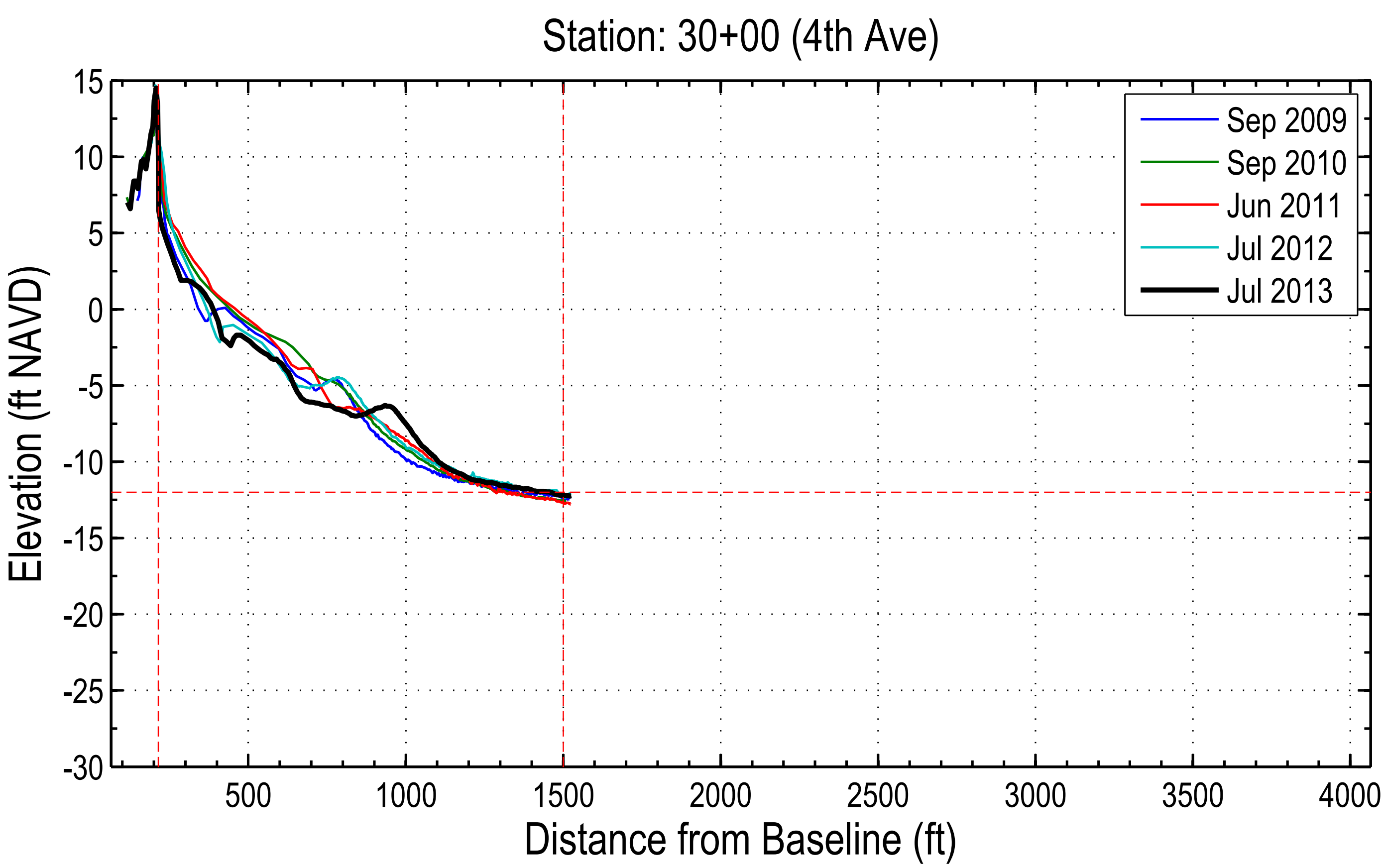

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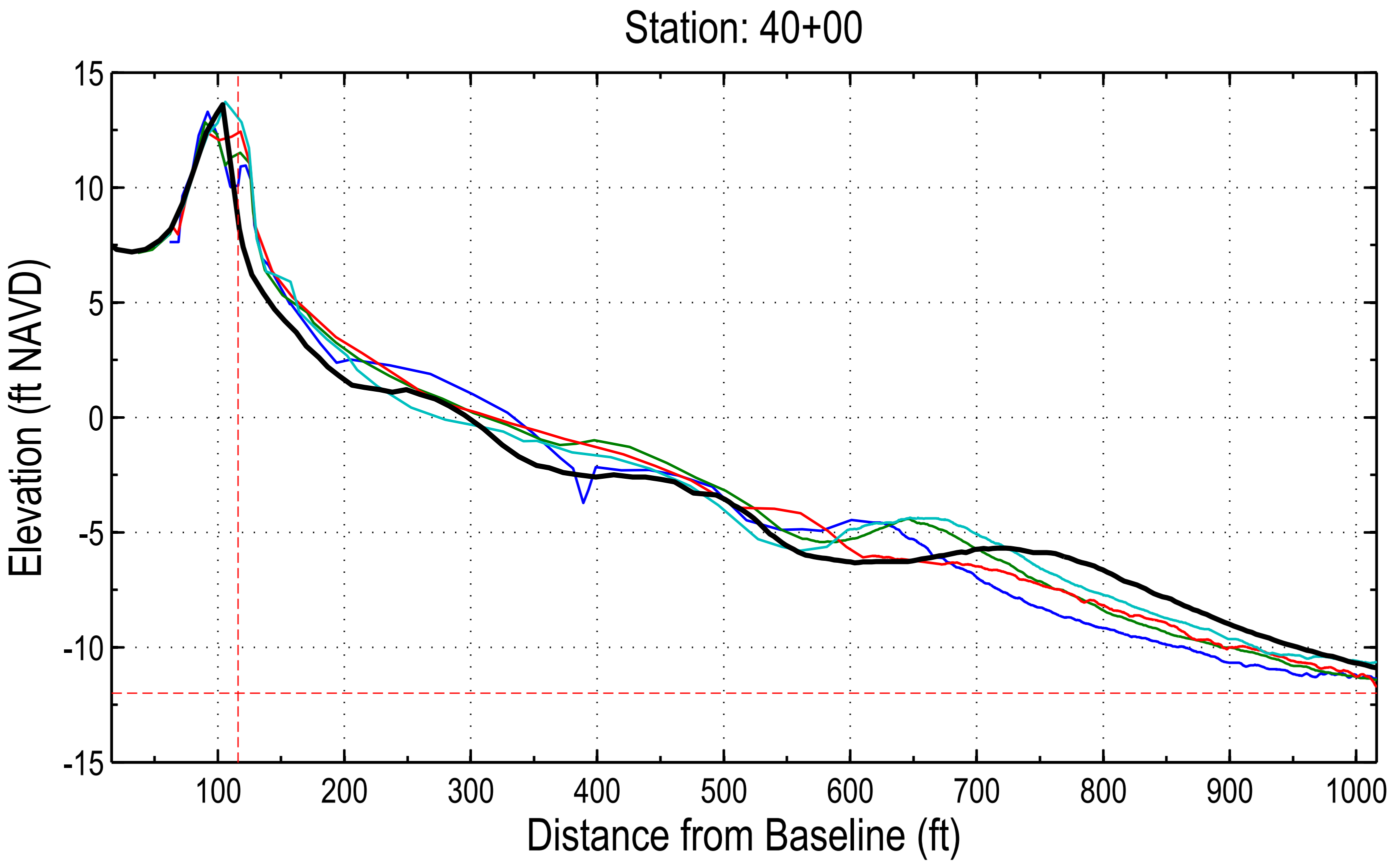
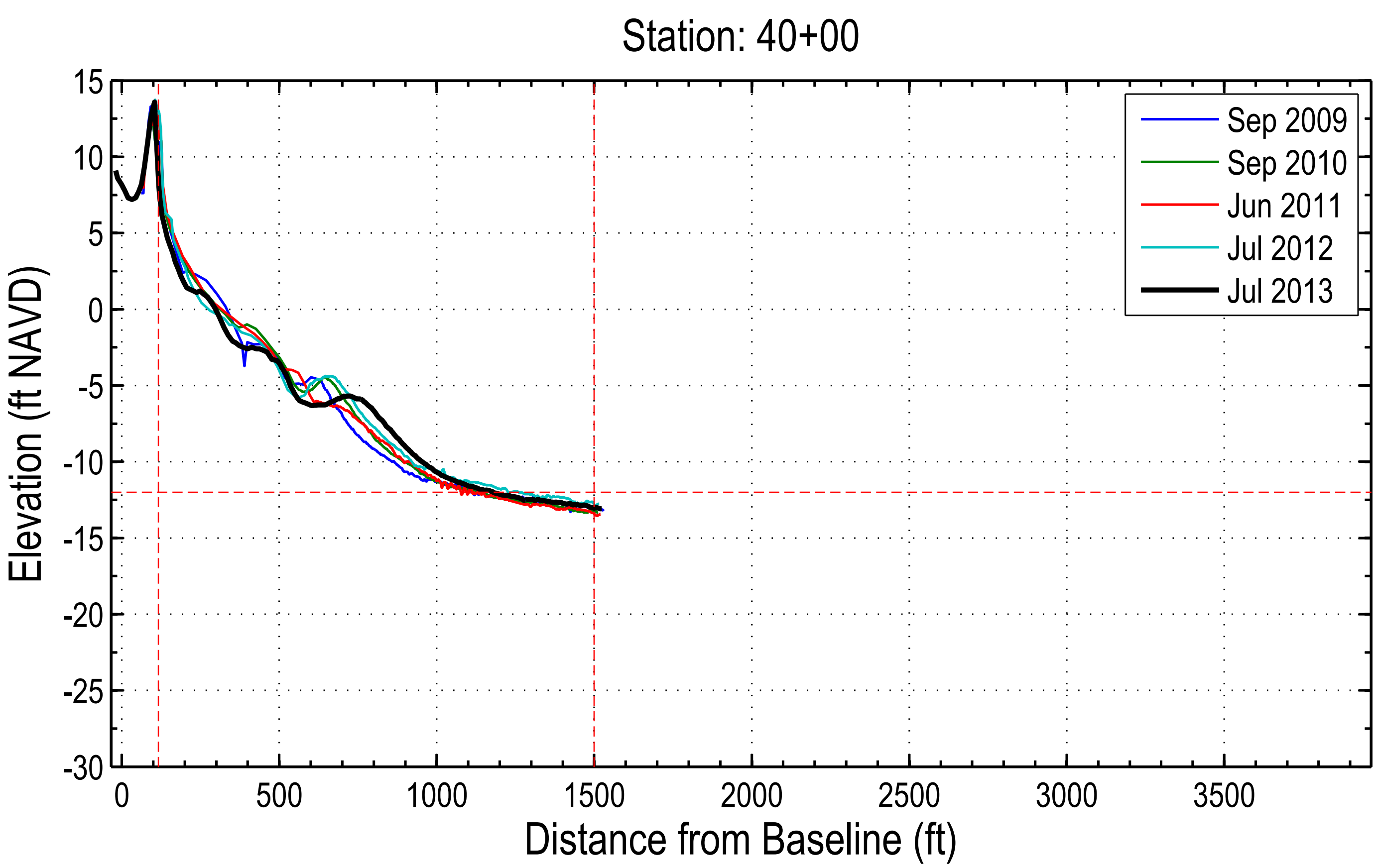
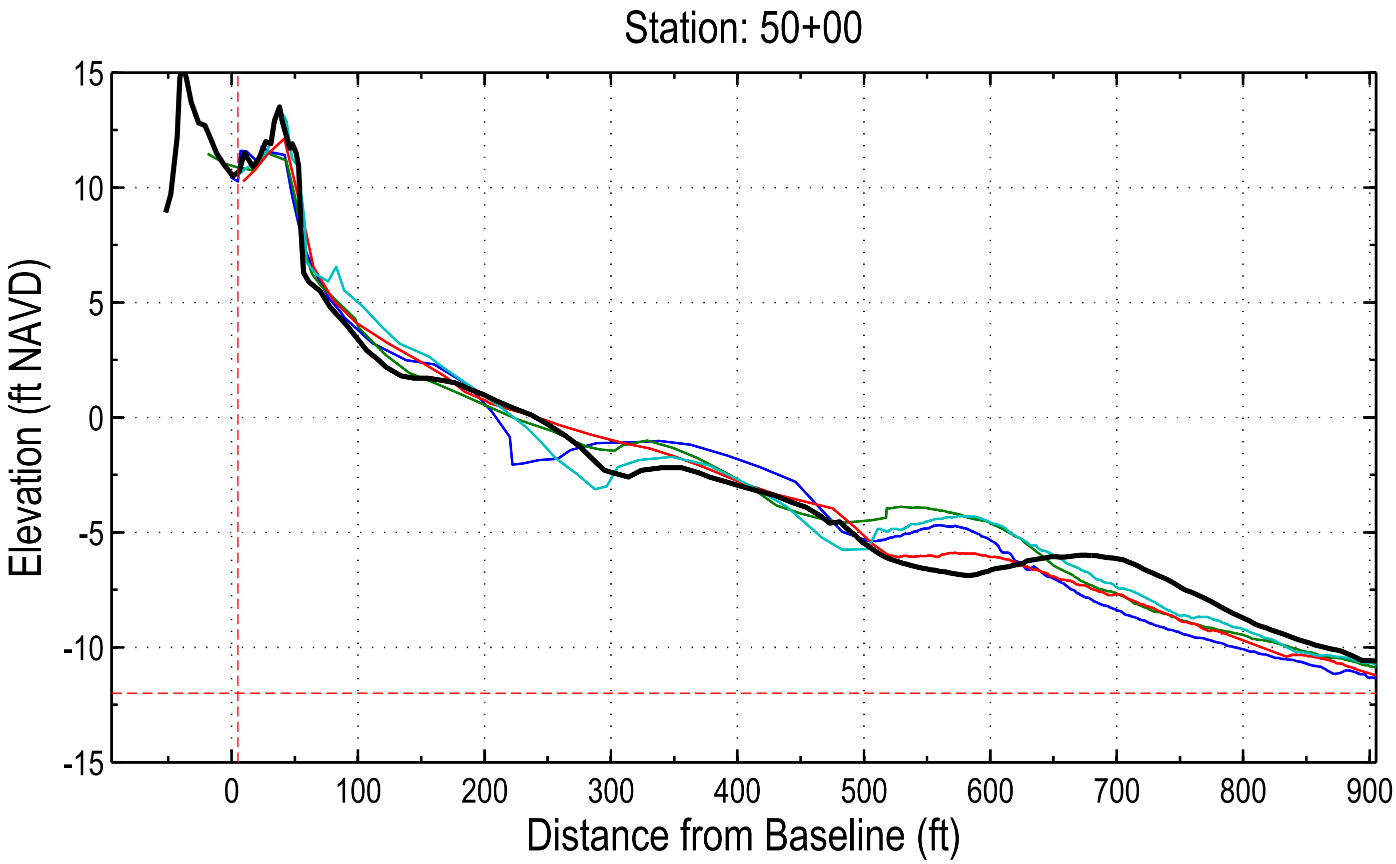
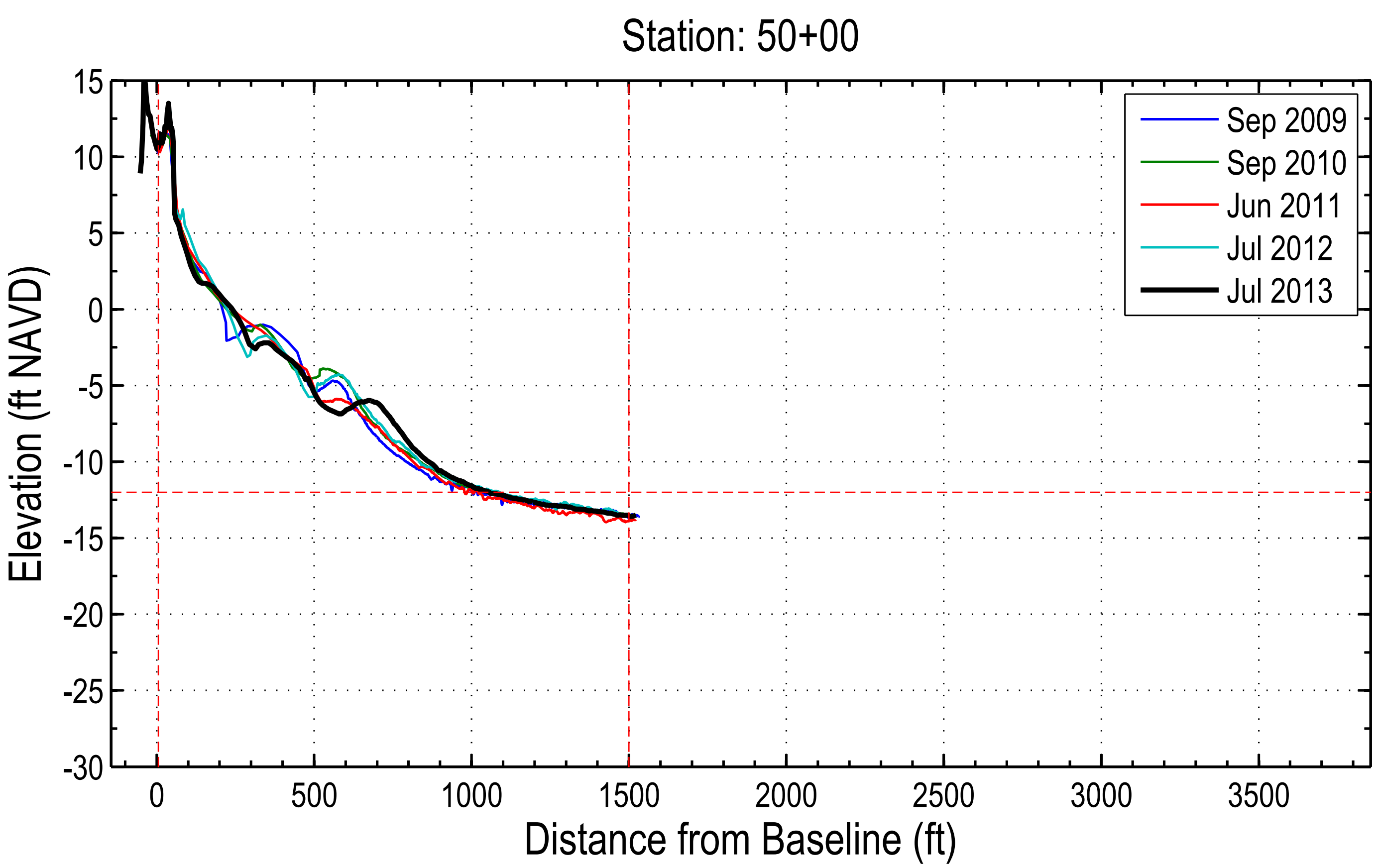
3500
4000


Station: 40+00
Elevation (ft NAVD)
Distance from Baseline (ft)

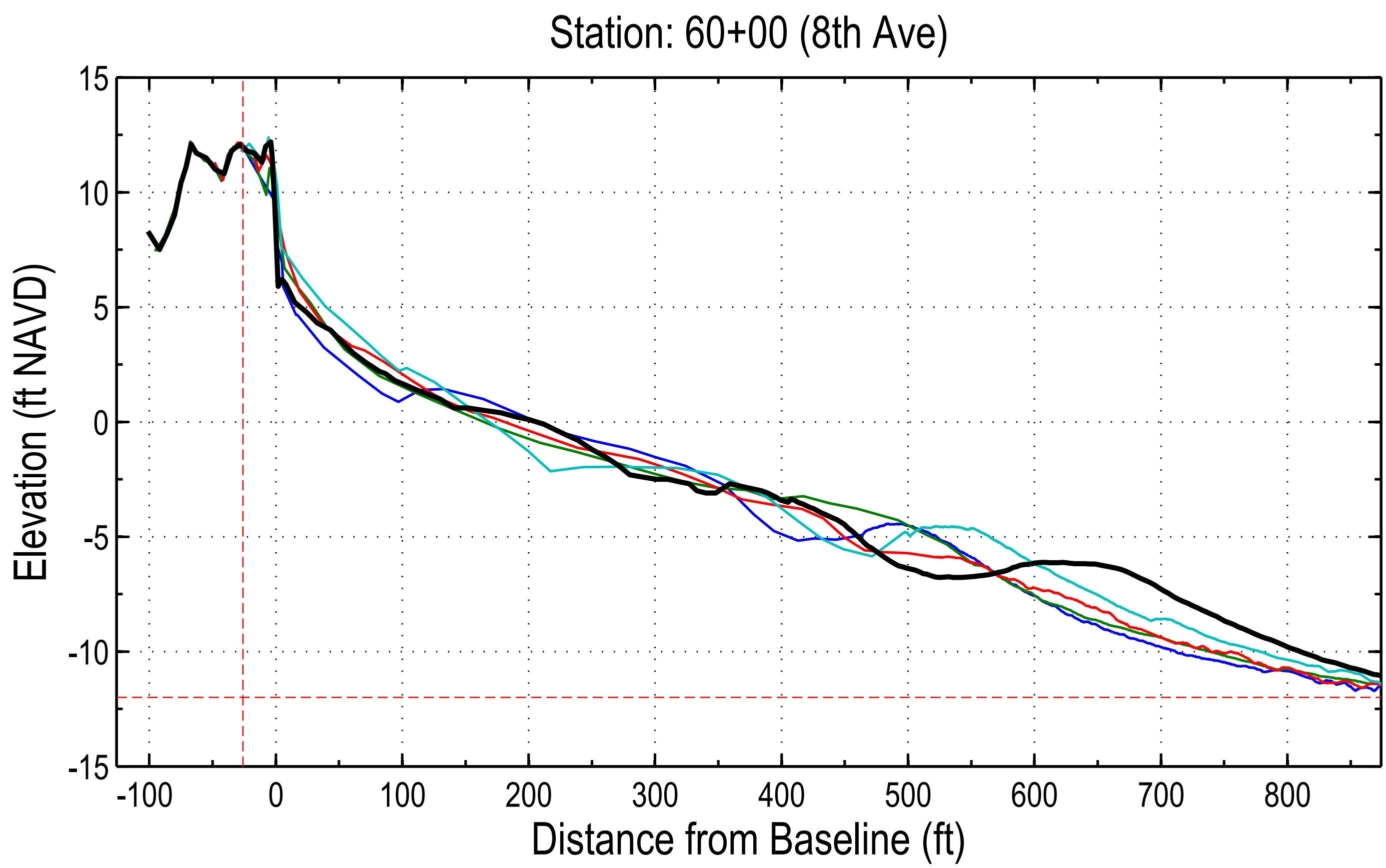

Station: 40+00
Elevation (ft NAVD)
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



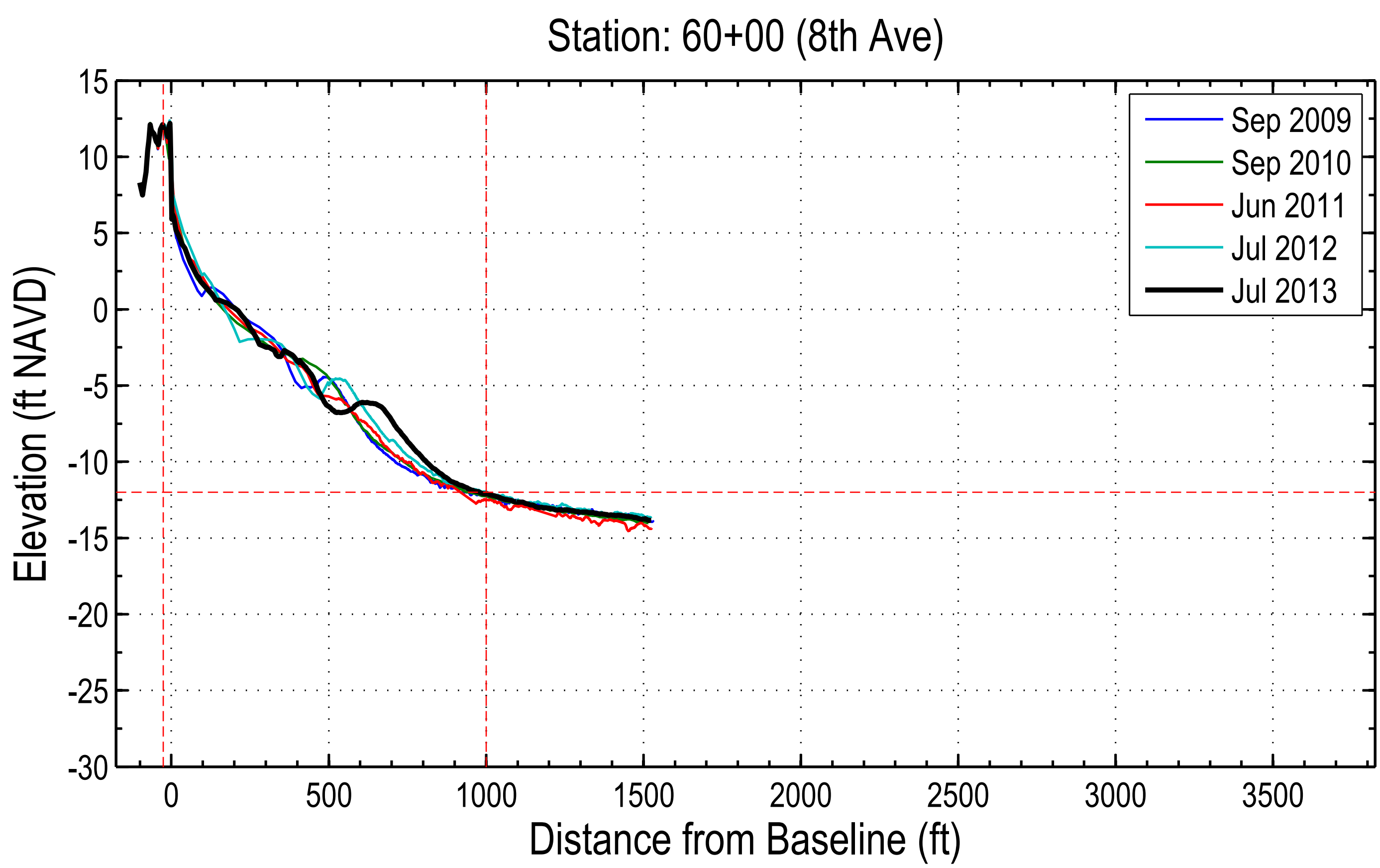
Station: 50+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900
Distance from Baseline (ft)



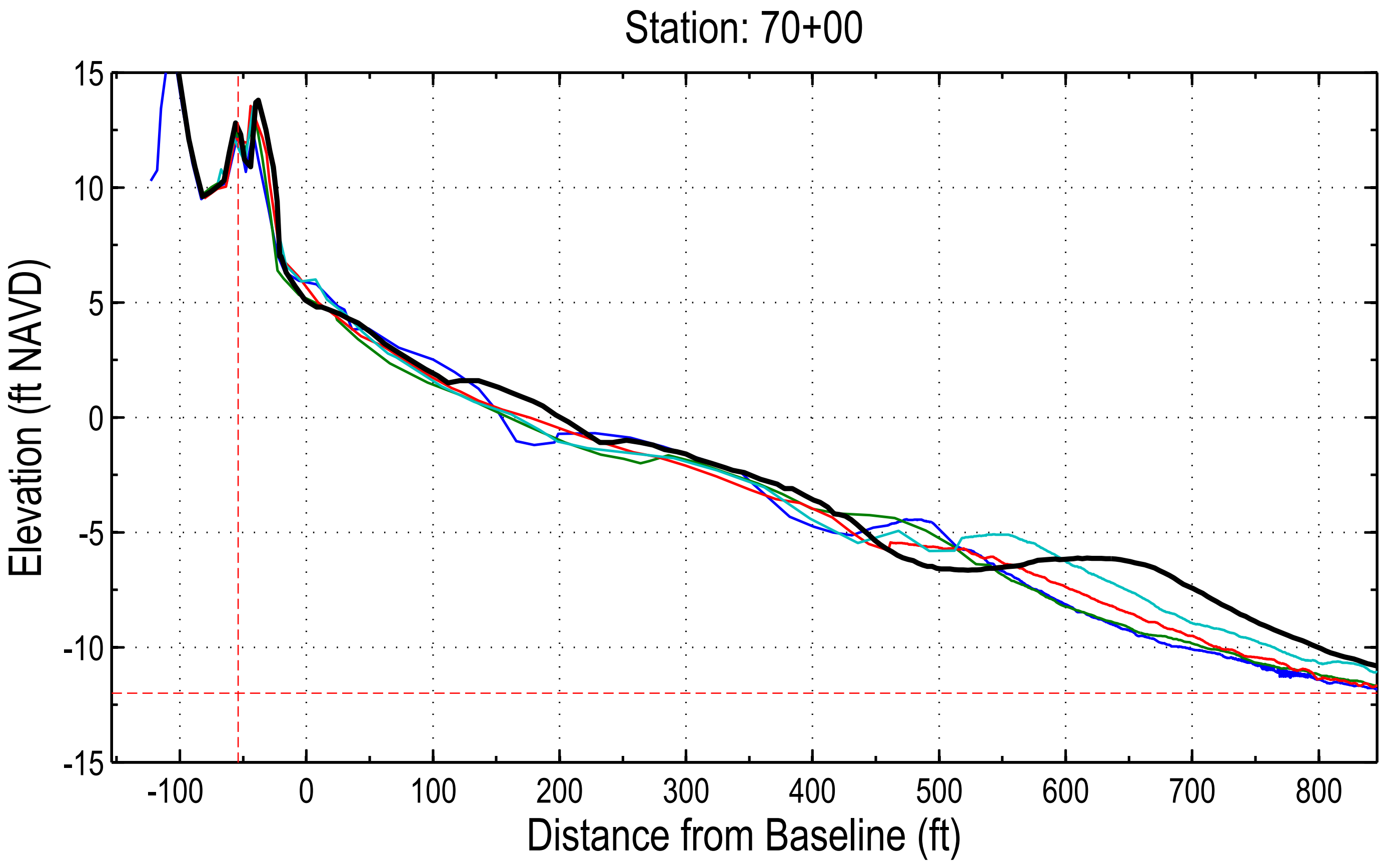
Station: 50+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



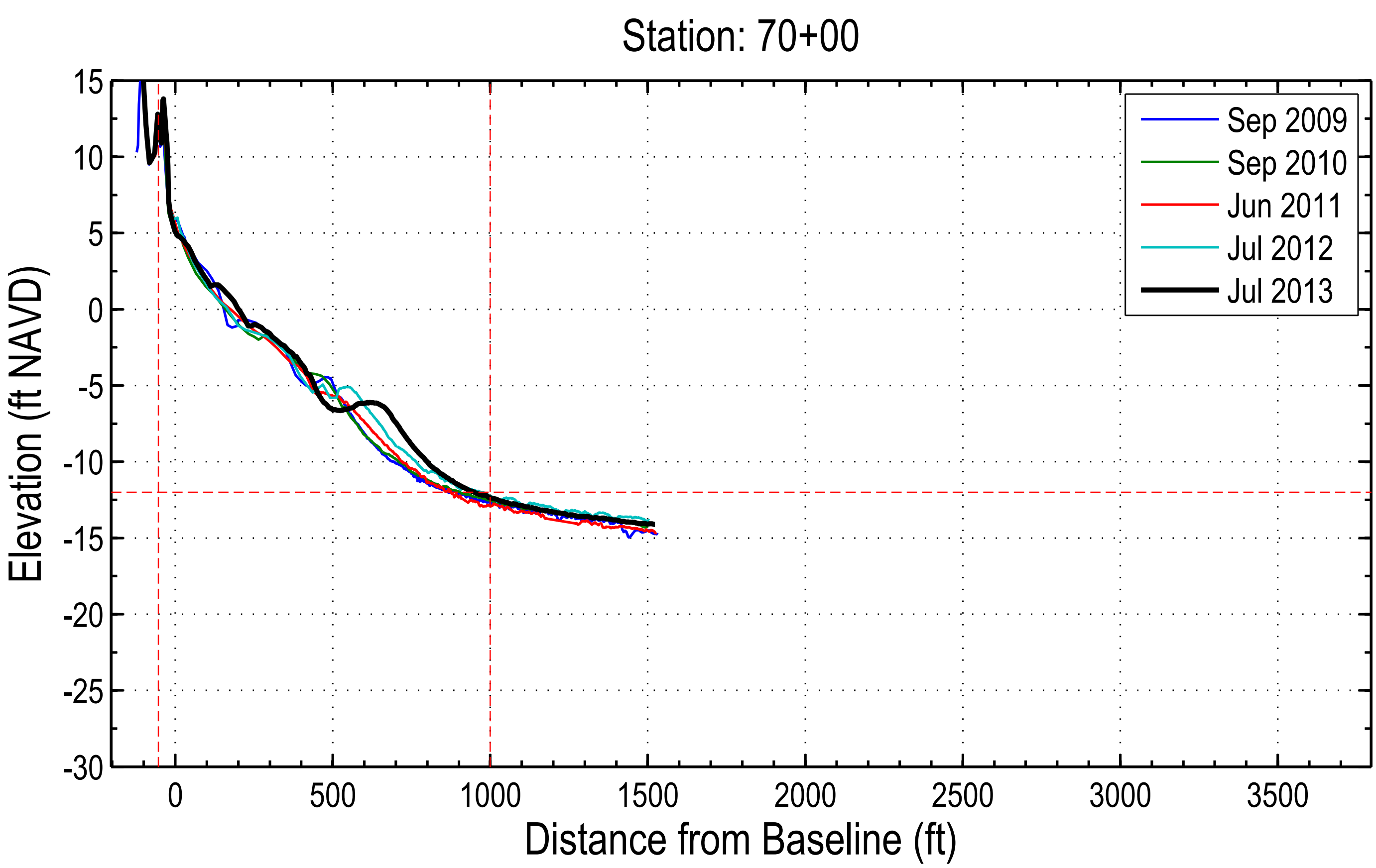
Station: 60+00 (8th Ave)
15
10
5
0
-5
-10
-15
Elevation (ft NAVD)
-100
0
100
200
300
400
500
600
700
800
Distance from Baseline (ft)



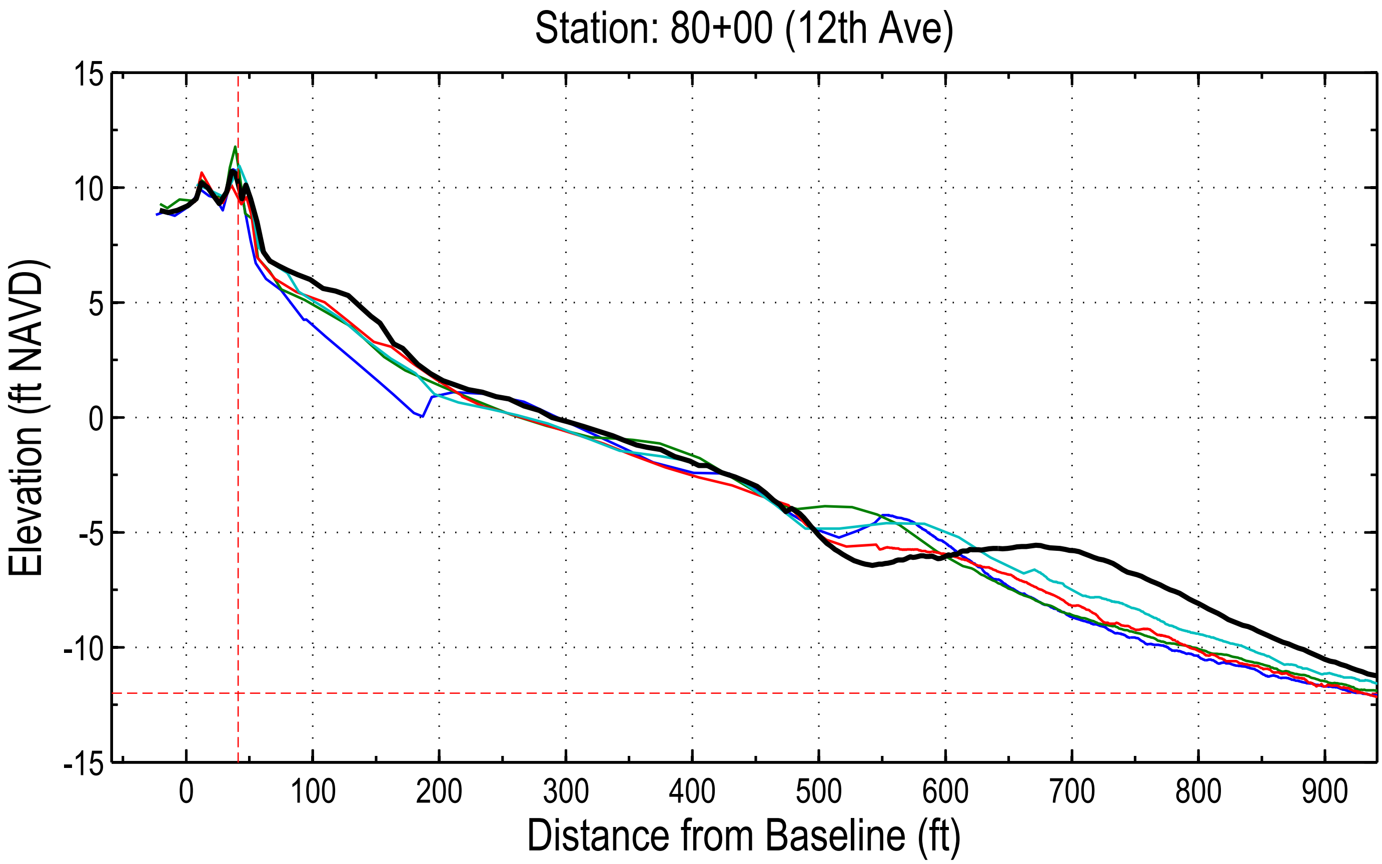
Station: 60+00 (8th Ave)
15
10
5
0
-5
-10
-15
-20
-25
-30
Elevation (ft NAVD)
0
500
1000
1500
2000
2500
3000
3500
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



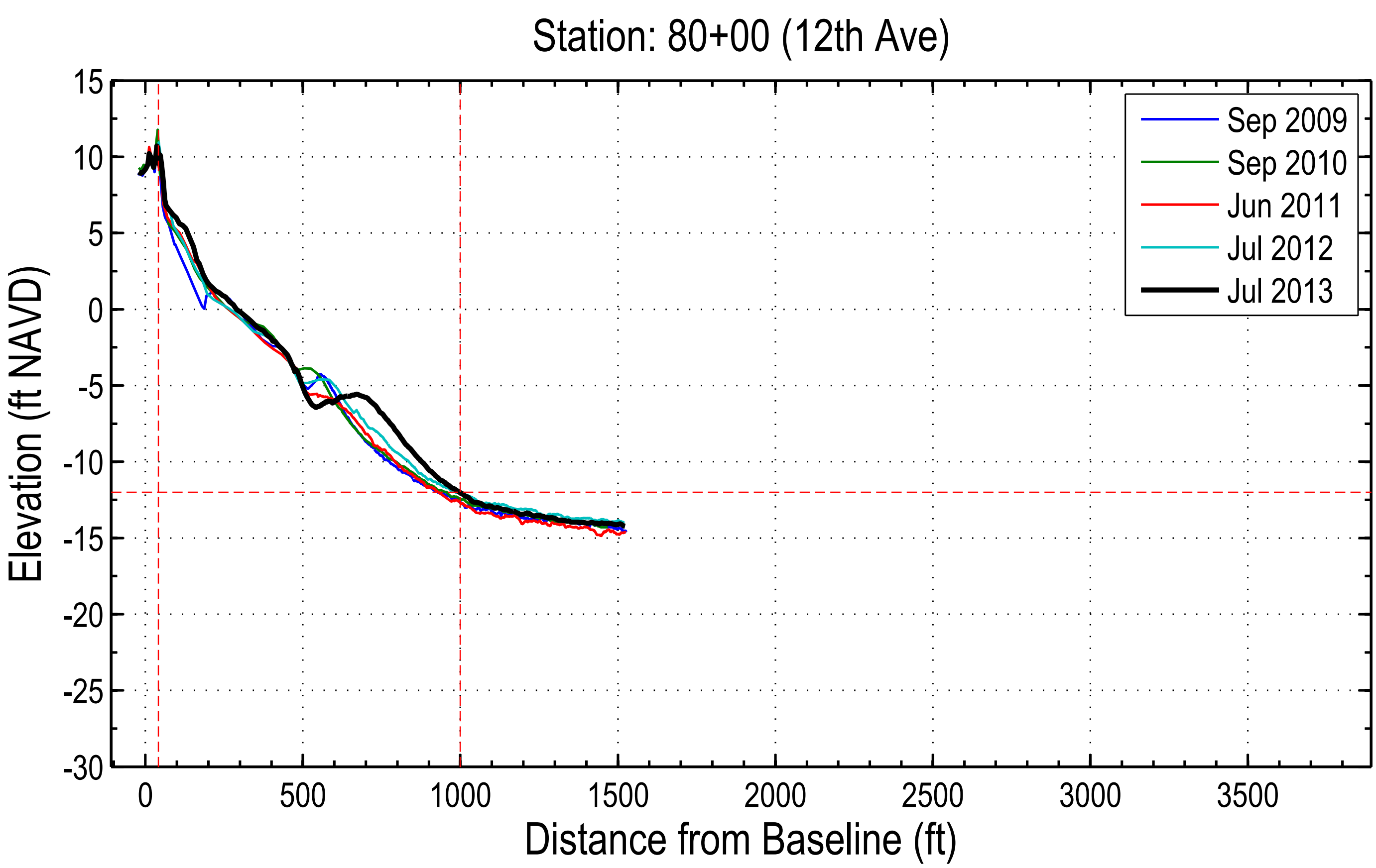
Station: 70+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-100
0
100
200
300
400
500
600
700
800



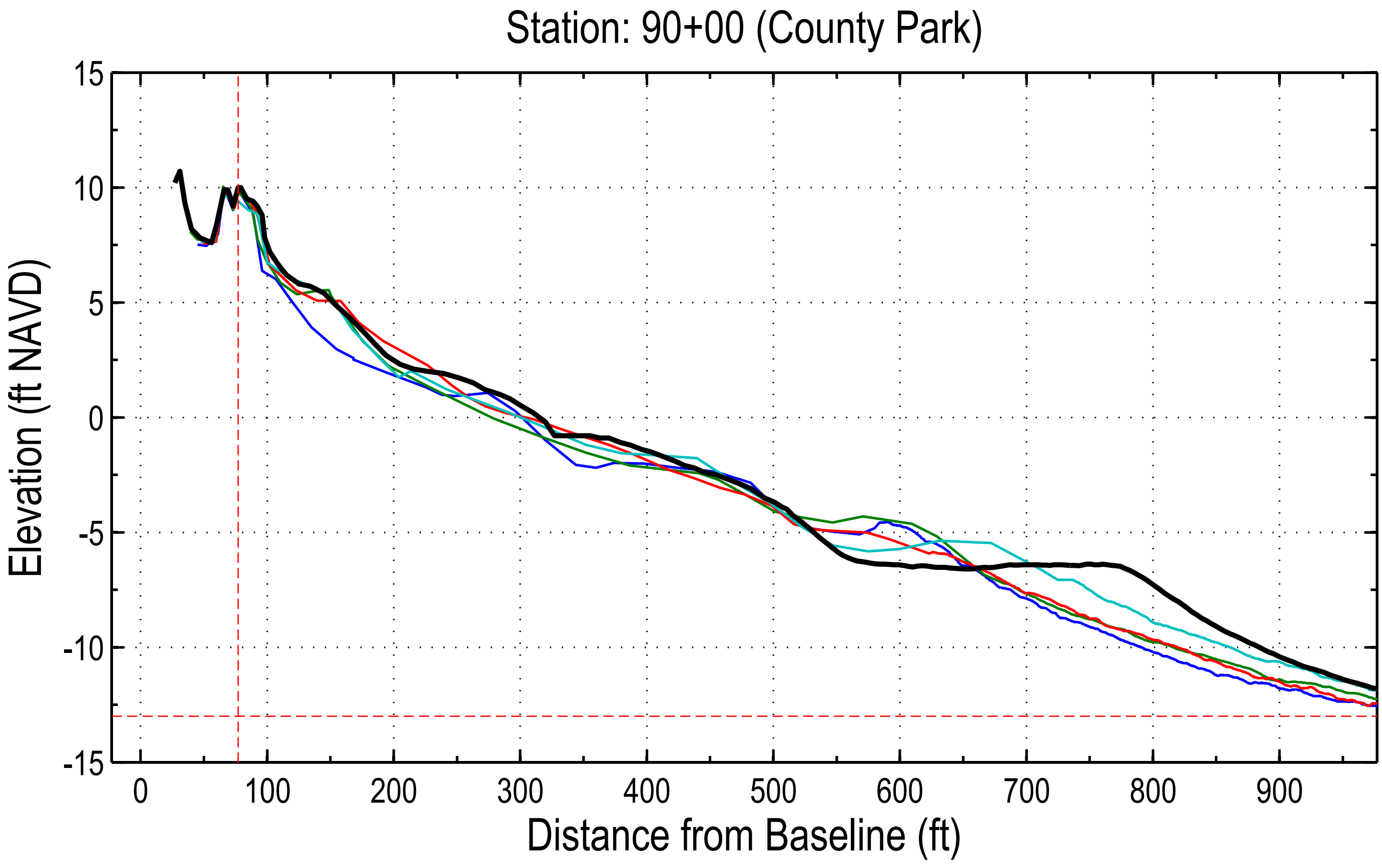
Station: 70+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



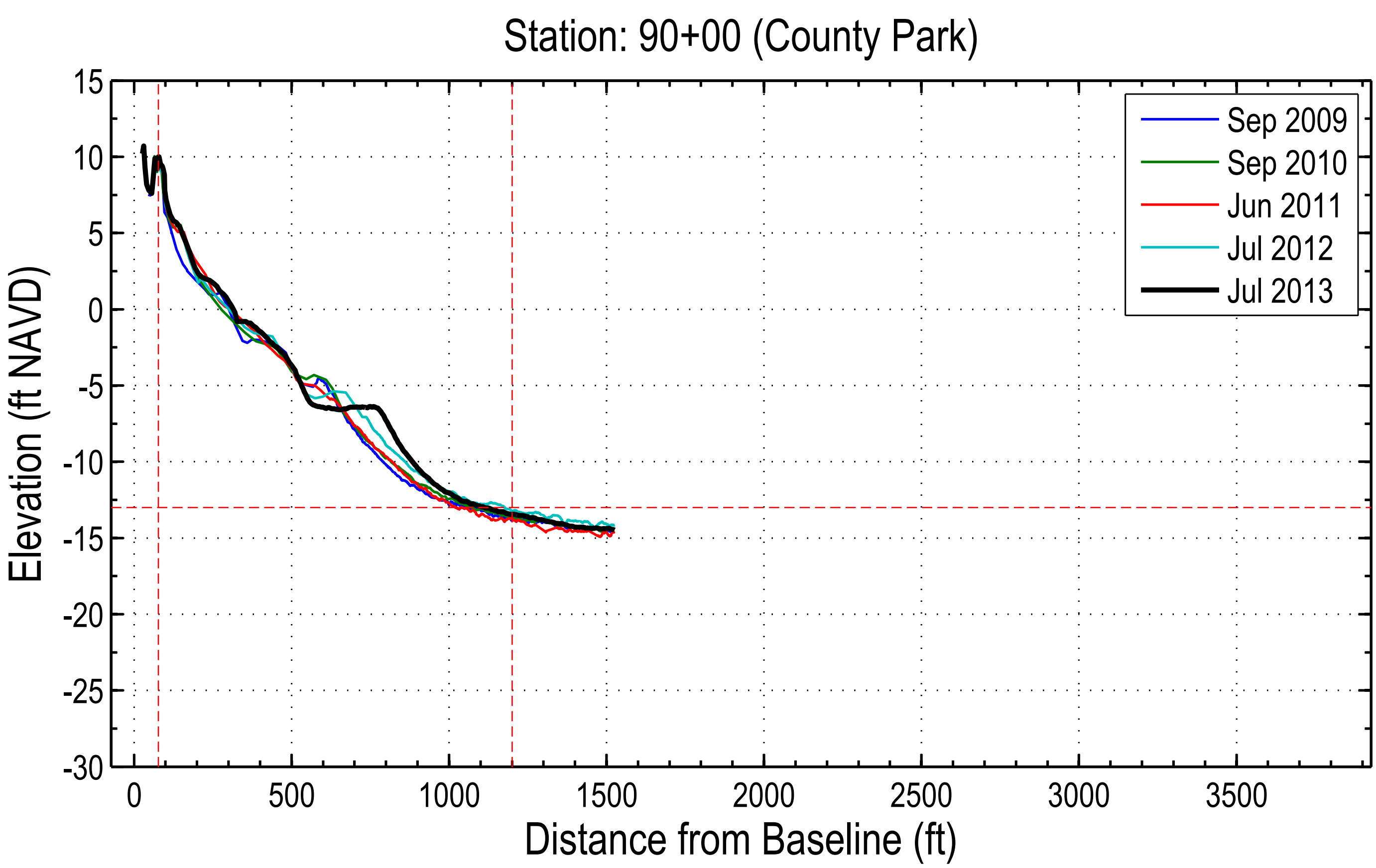
Station: 80+00 (12th Ave)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900



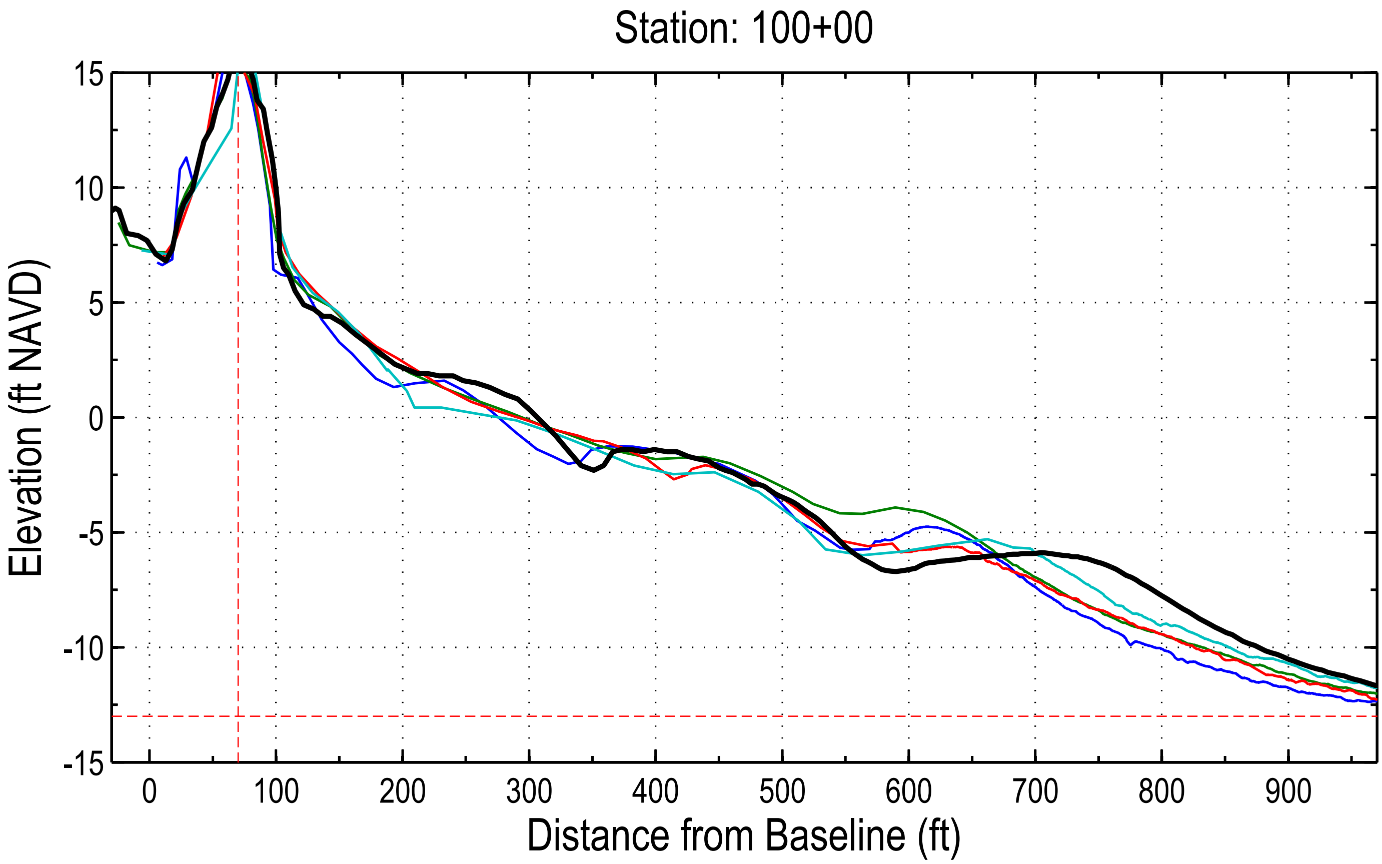
Station: 80+00 (12th Ave)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



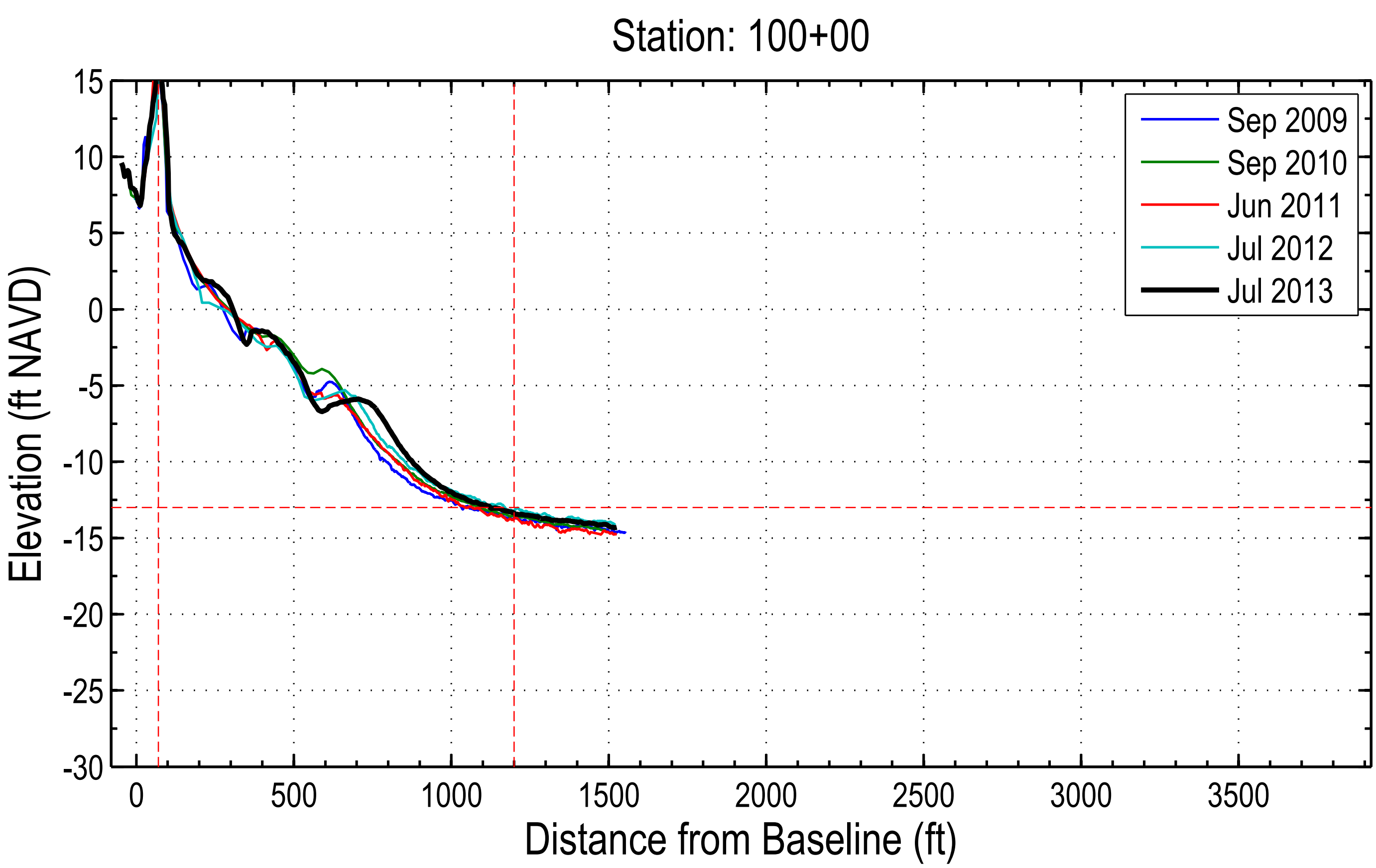
Station: 90+00 (County Park)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900



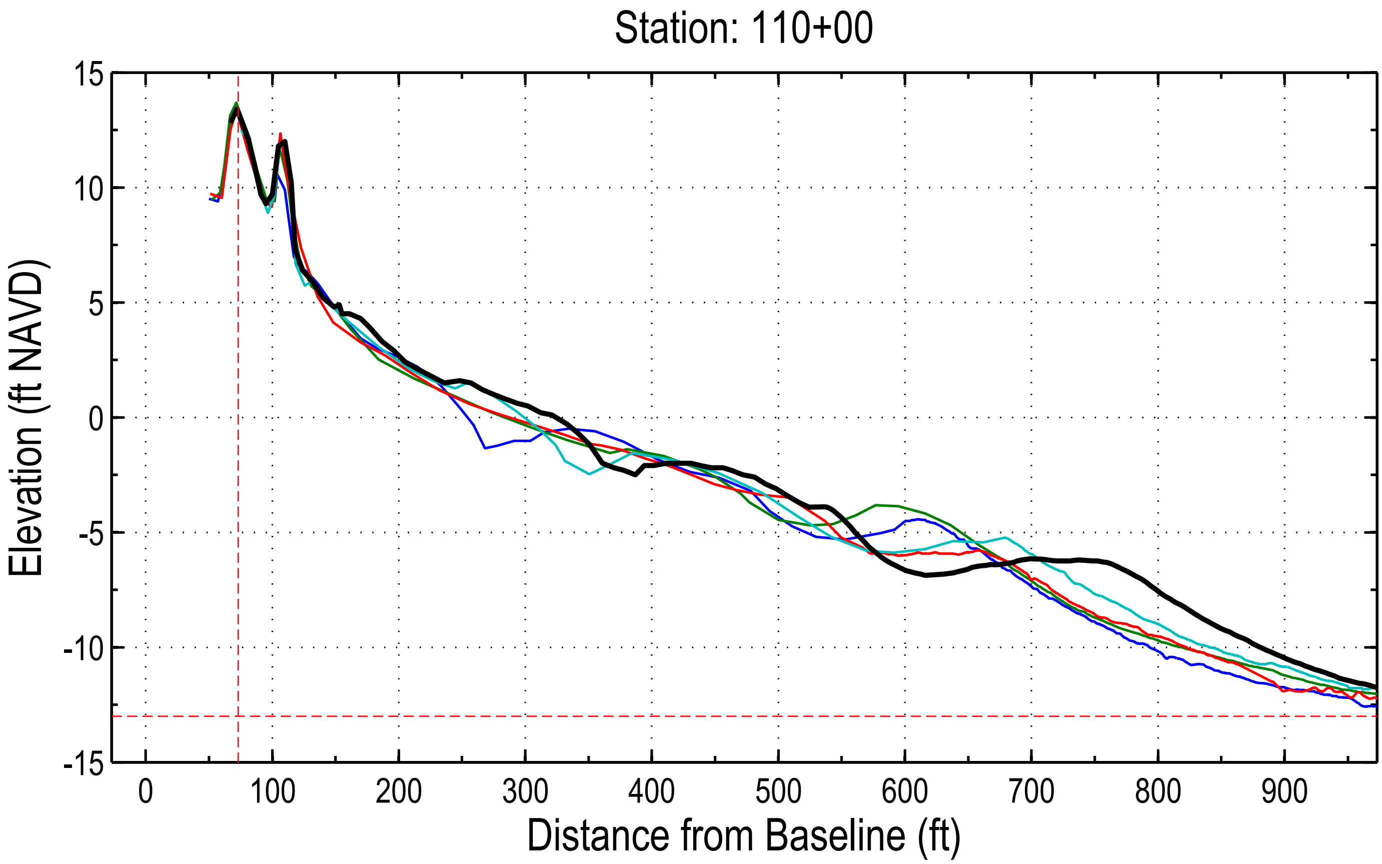
Station: 90+00 (County Park)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500

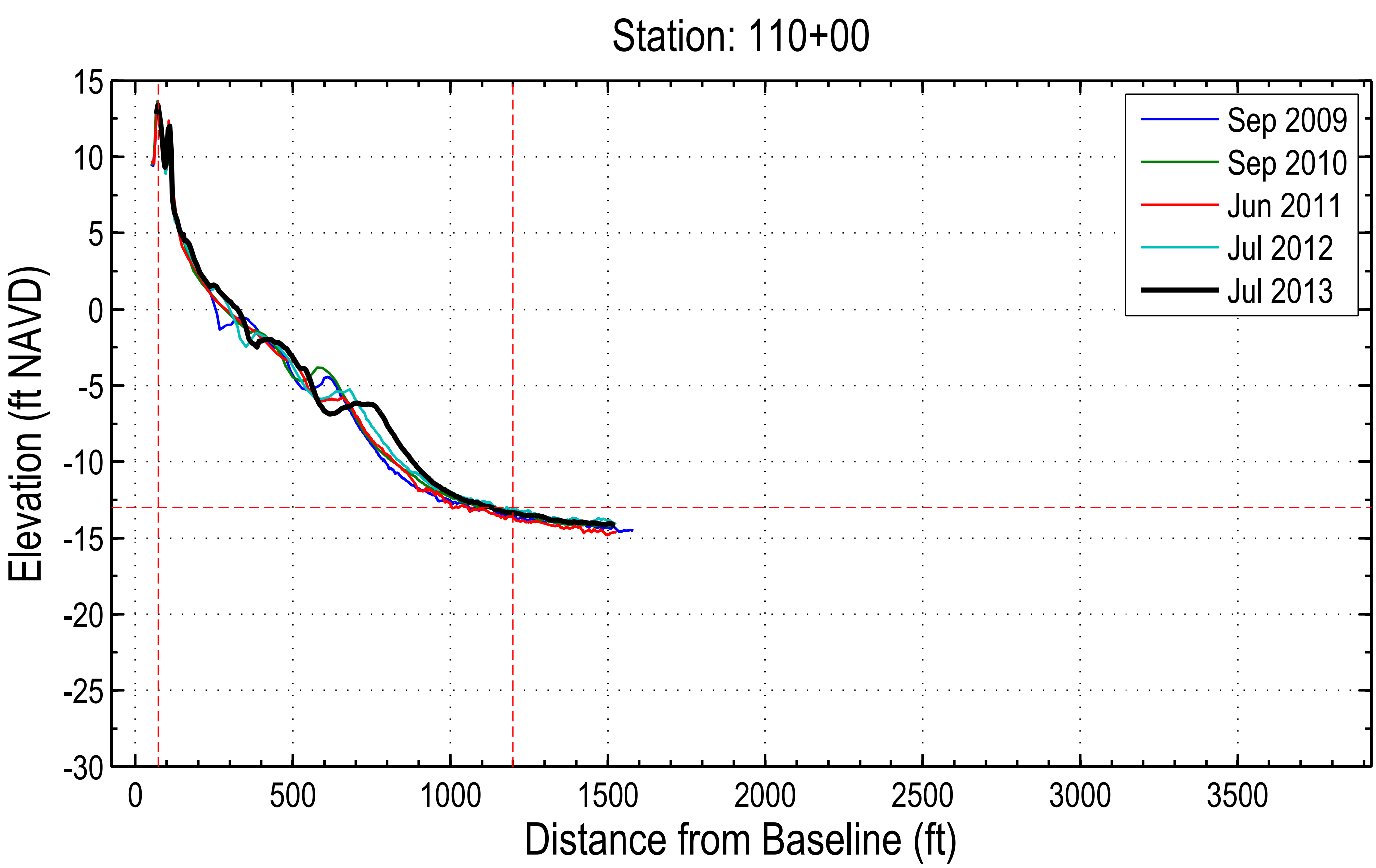


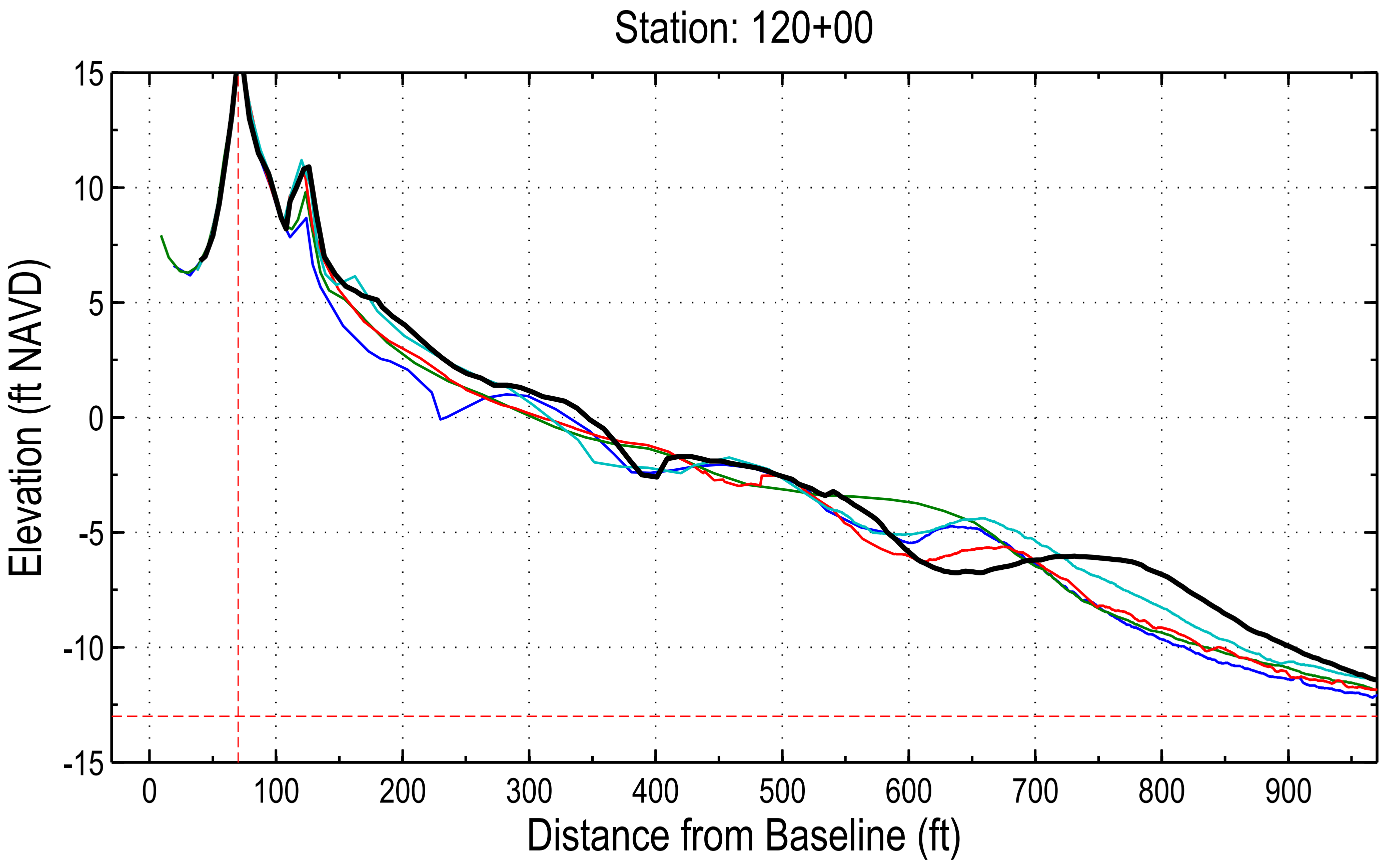
Station: 100+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900



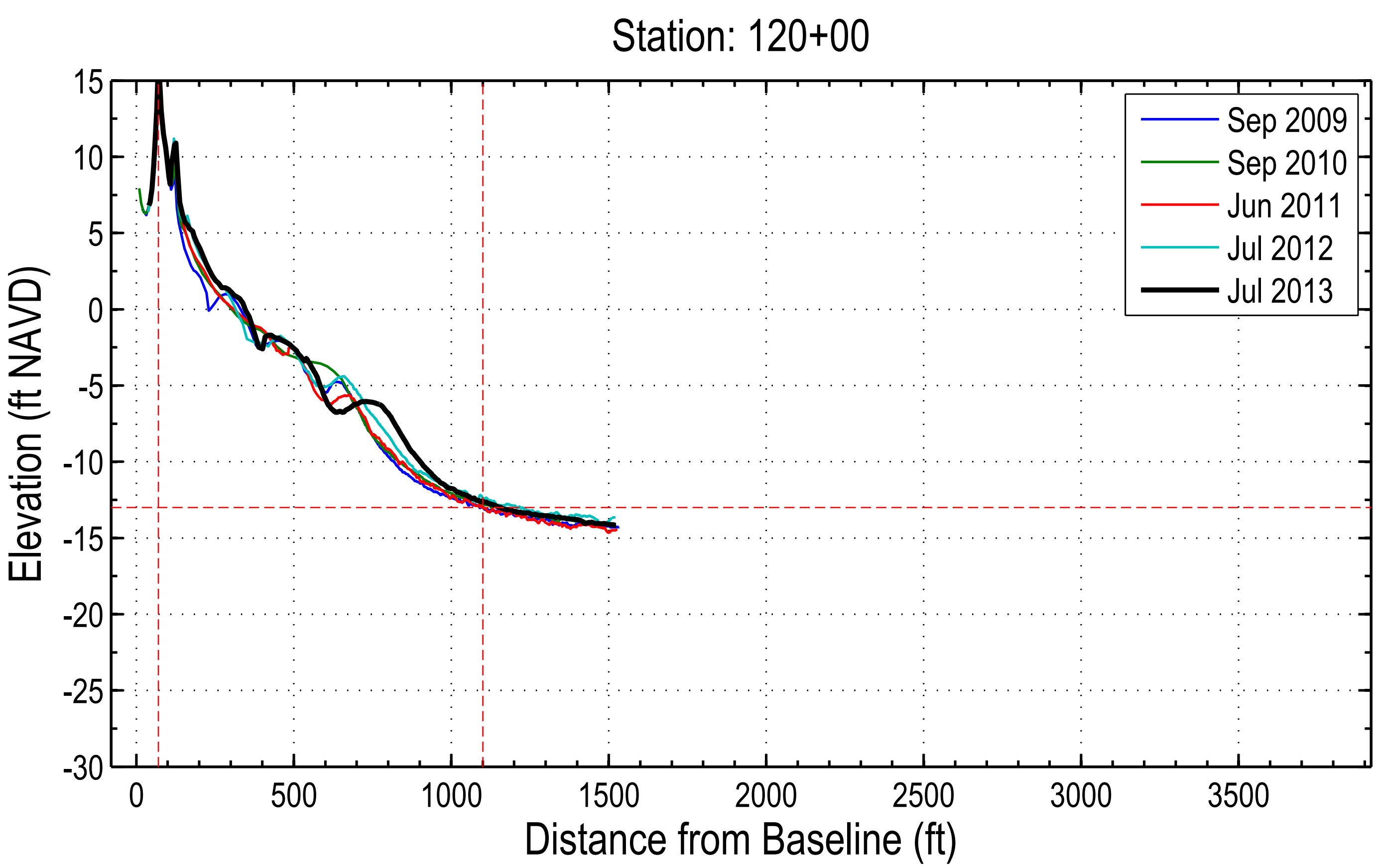
Station: 100+00
Elevation (ft NAVD)
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500


Station: 110+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900

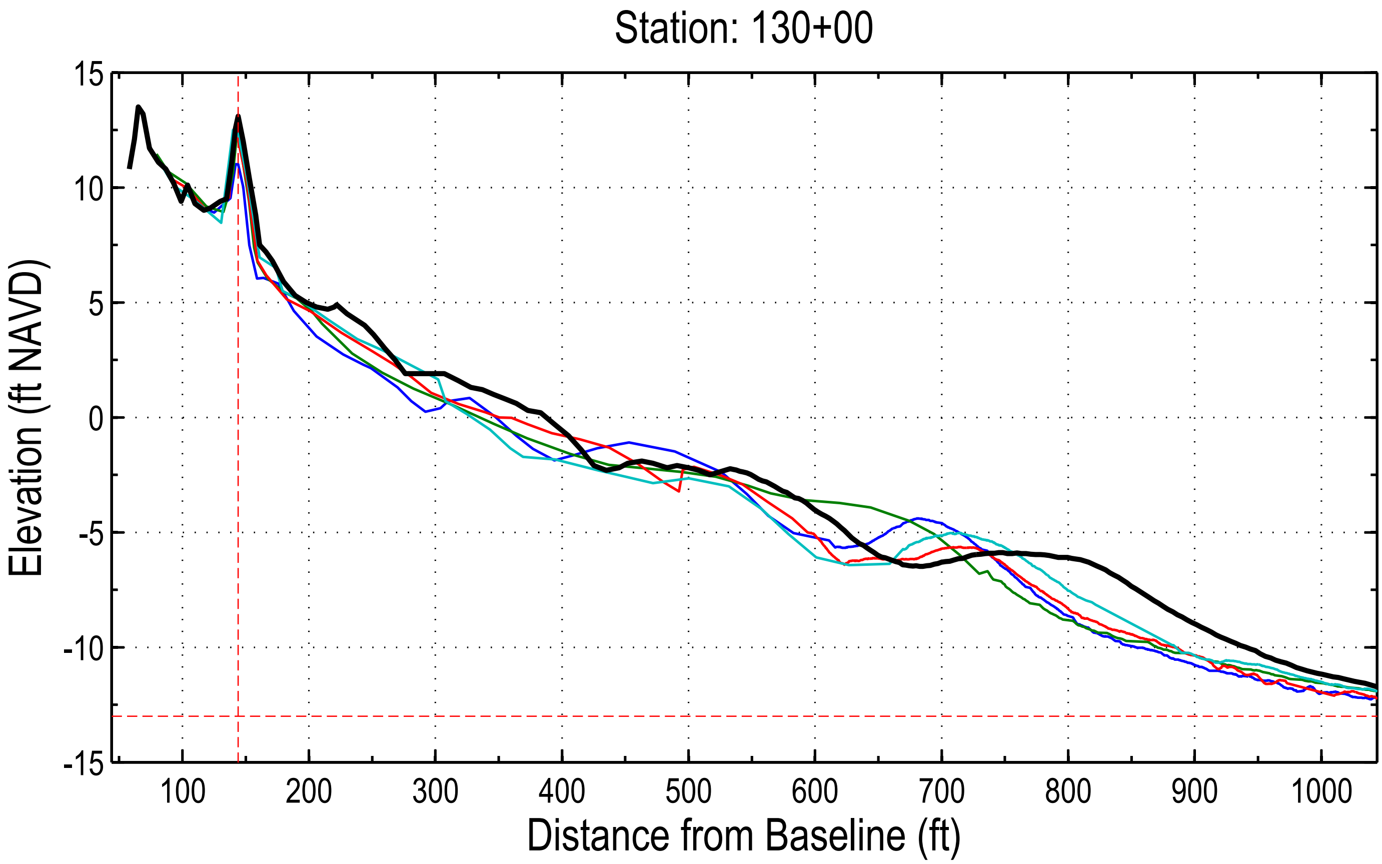

Station: 110+00
Elevation (ft NAVD)
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500



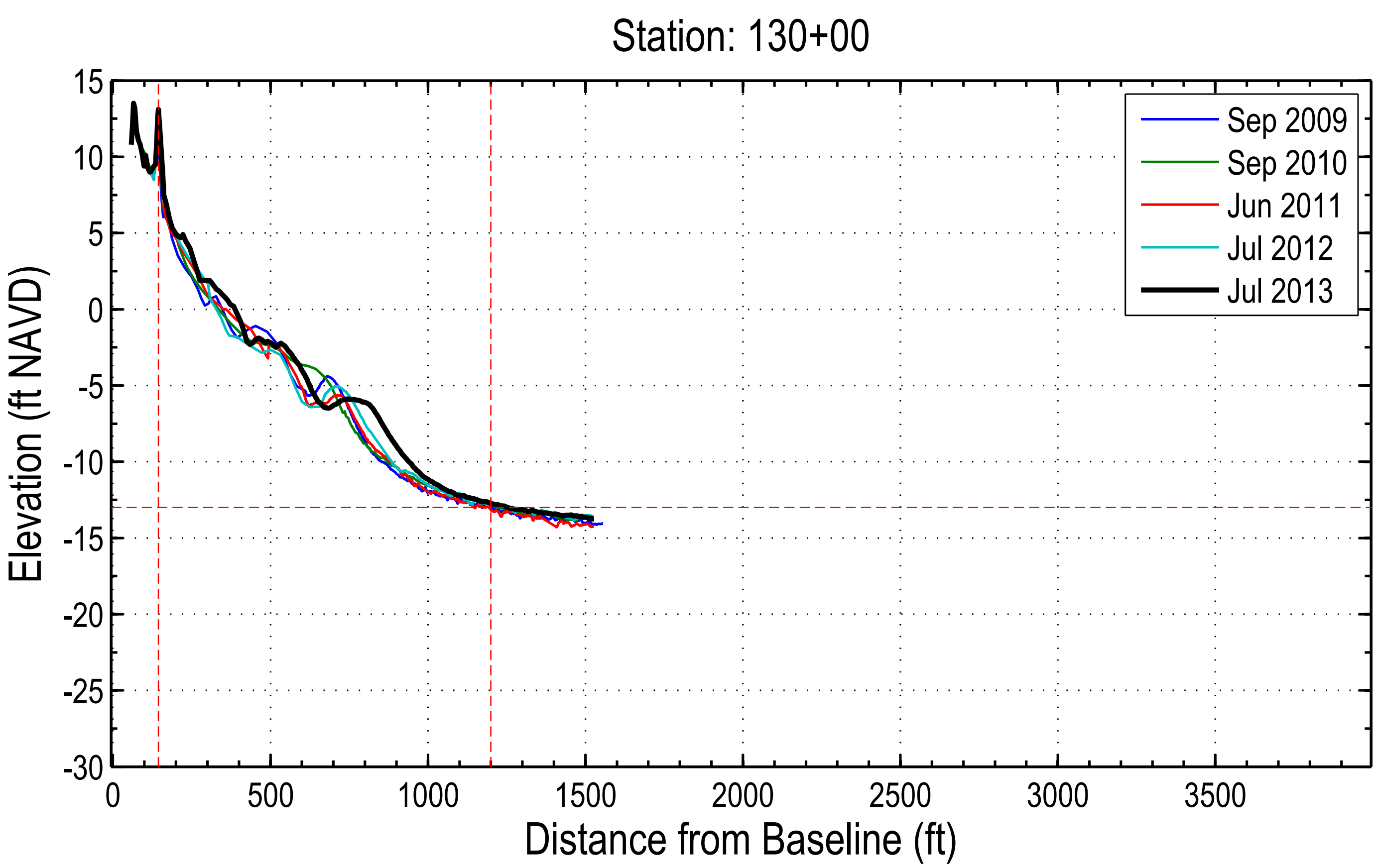
Station: 120+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900



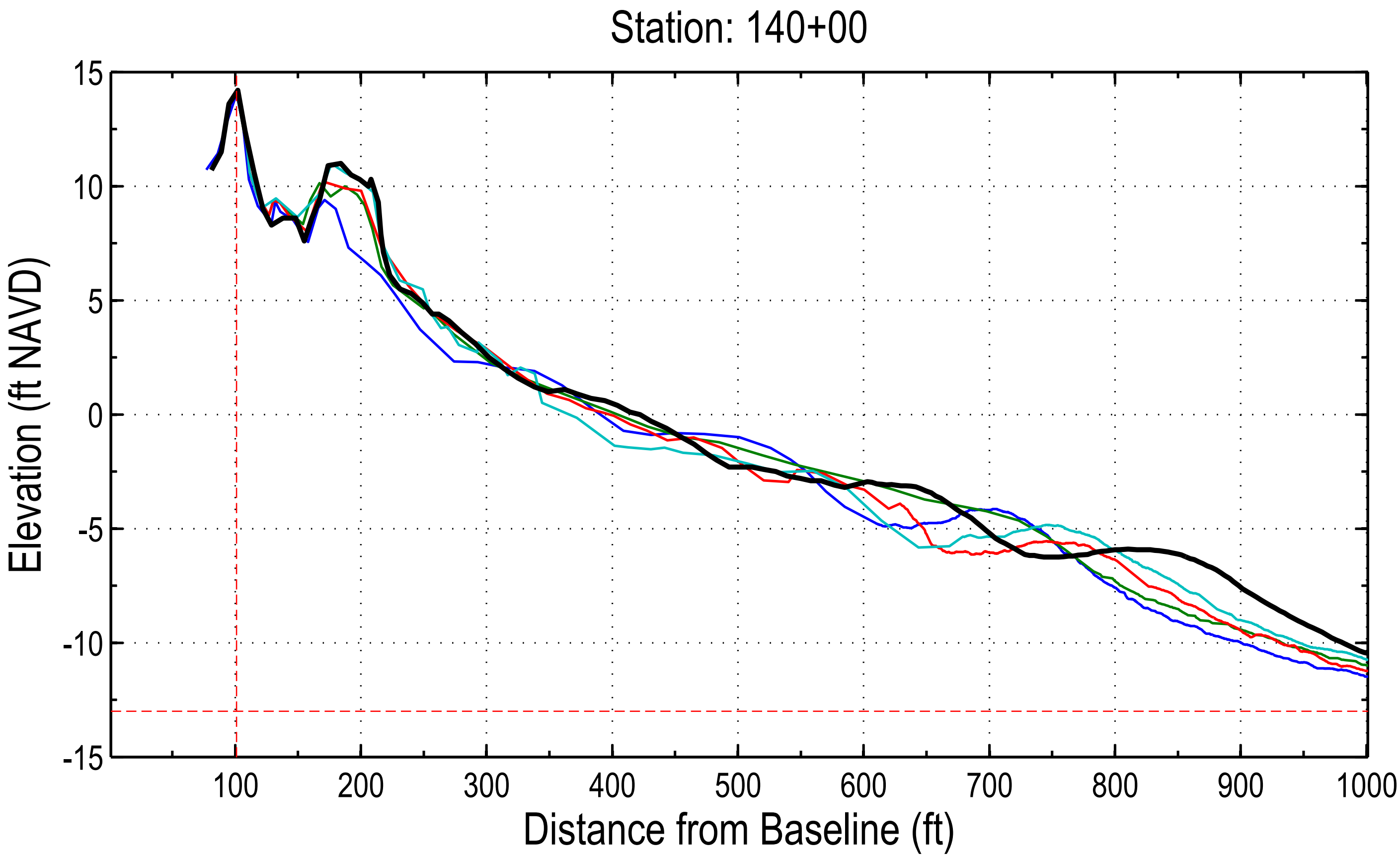
Station: 120+00
Elevation (ft NAVD)
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500

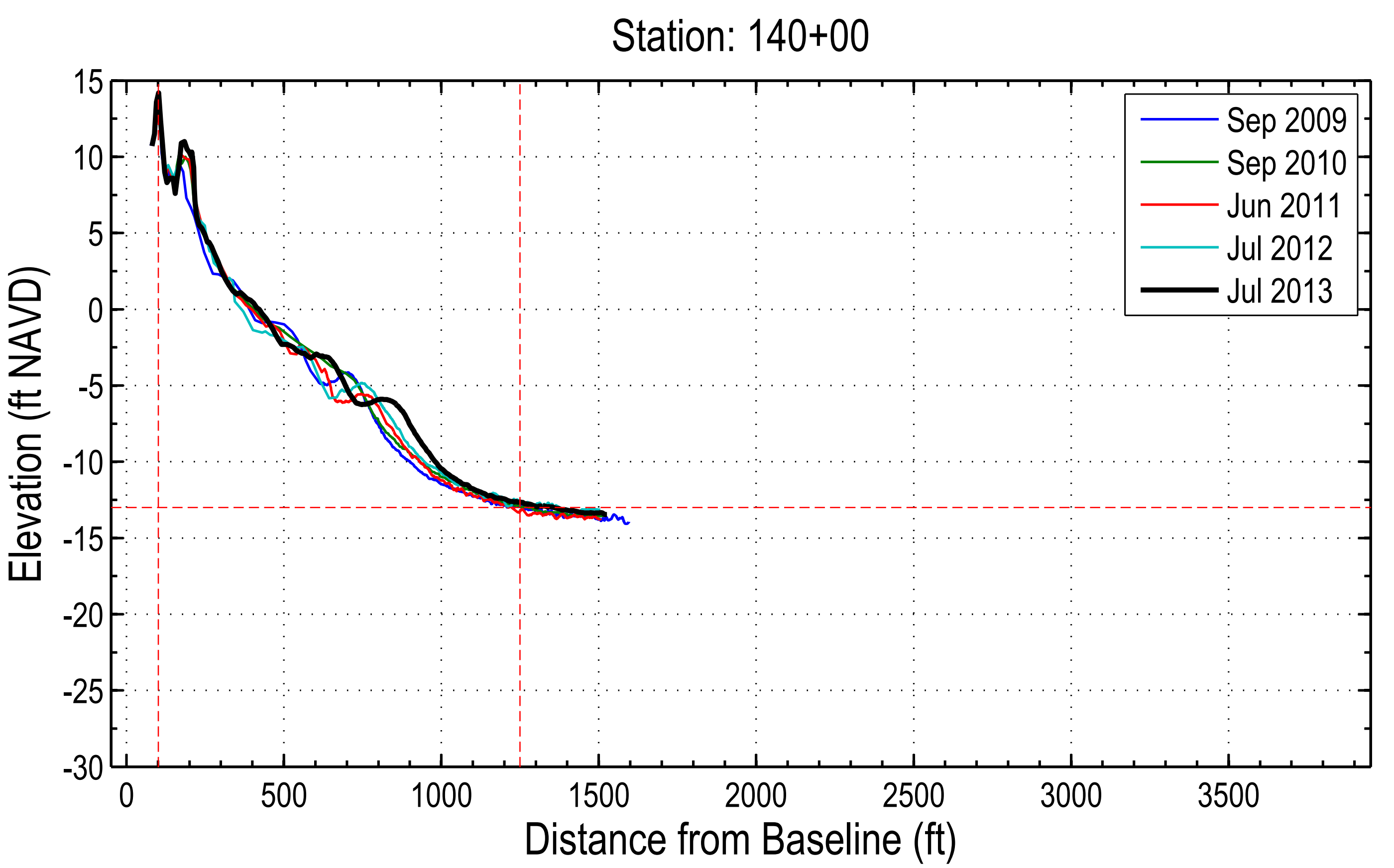


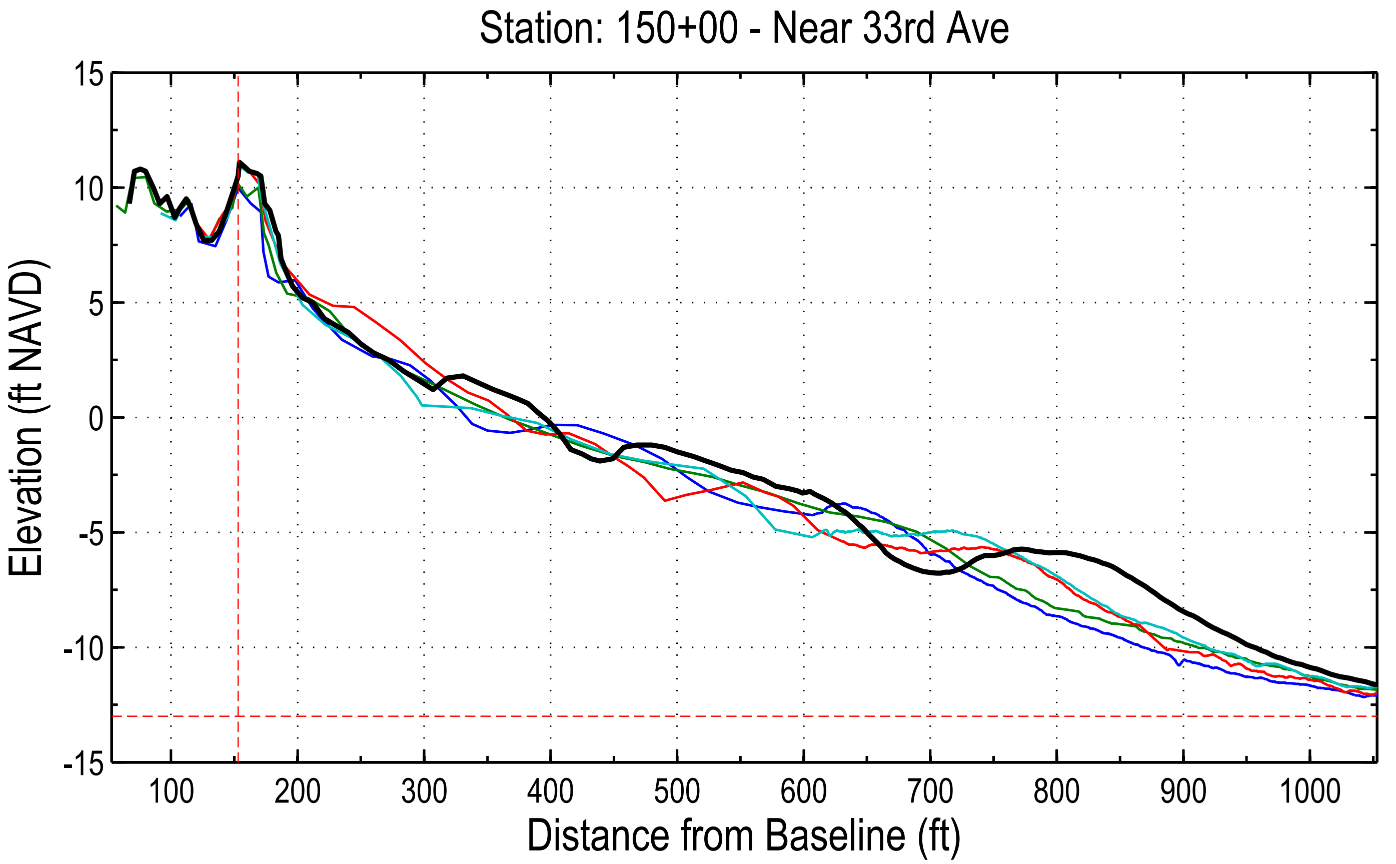
Station: 130+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000



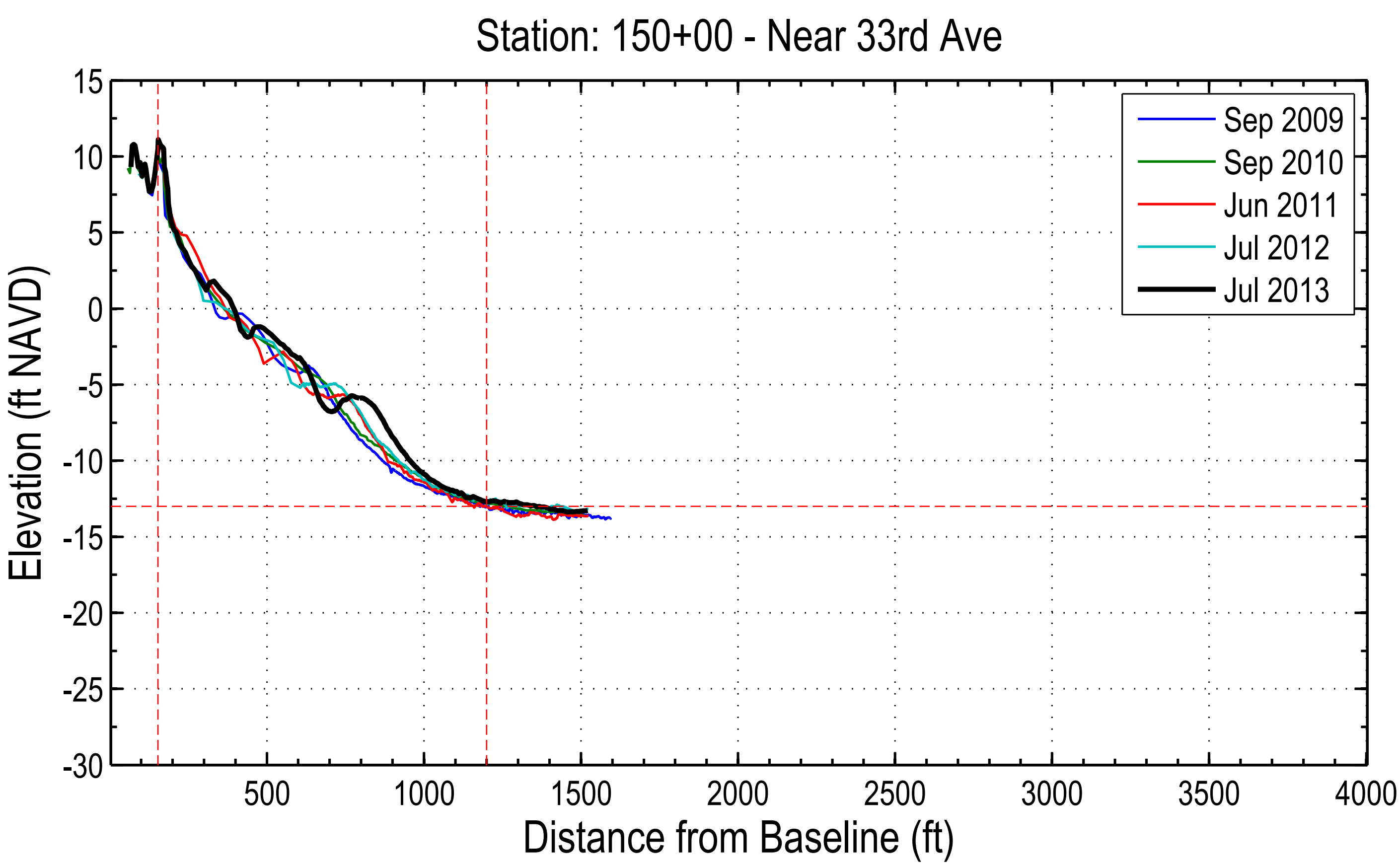
Station: 130+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 140+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000
Distance from Baseline (ft)

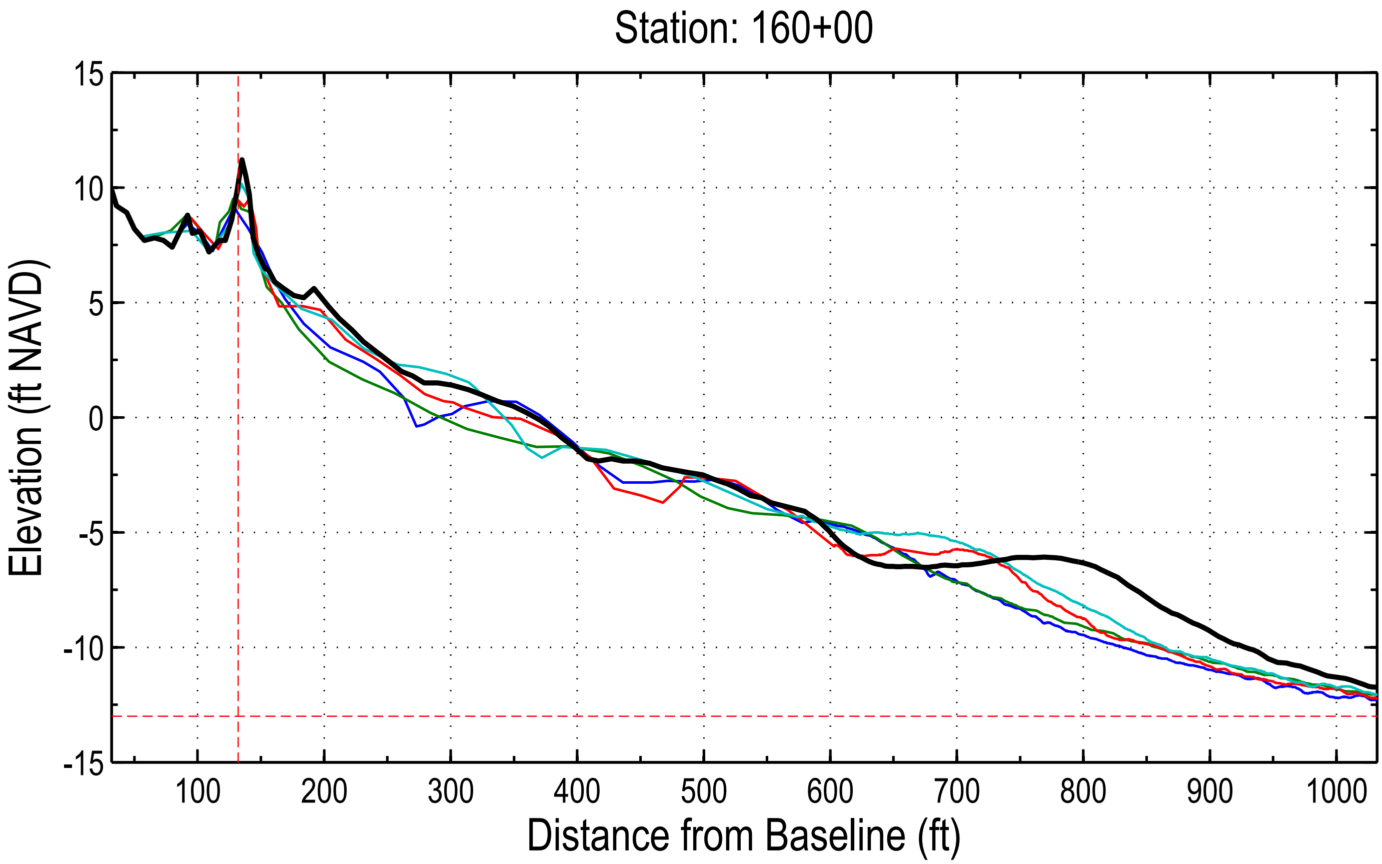

Station: 140+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



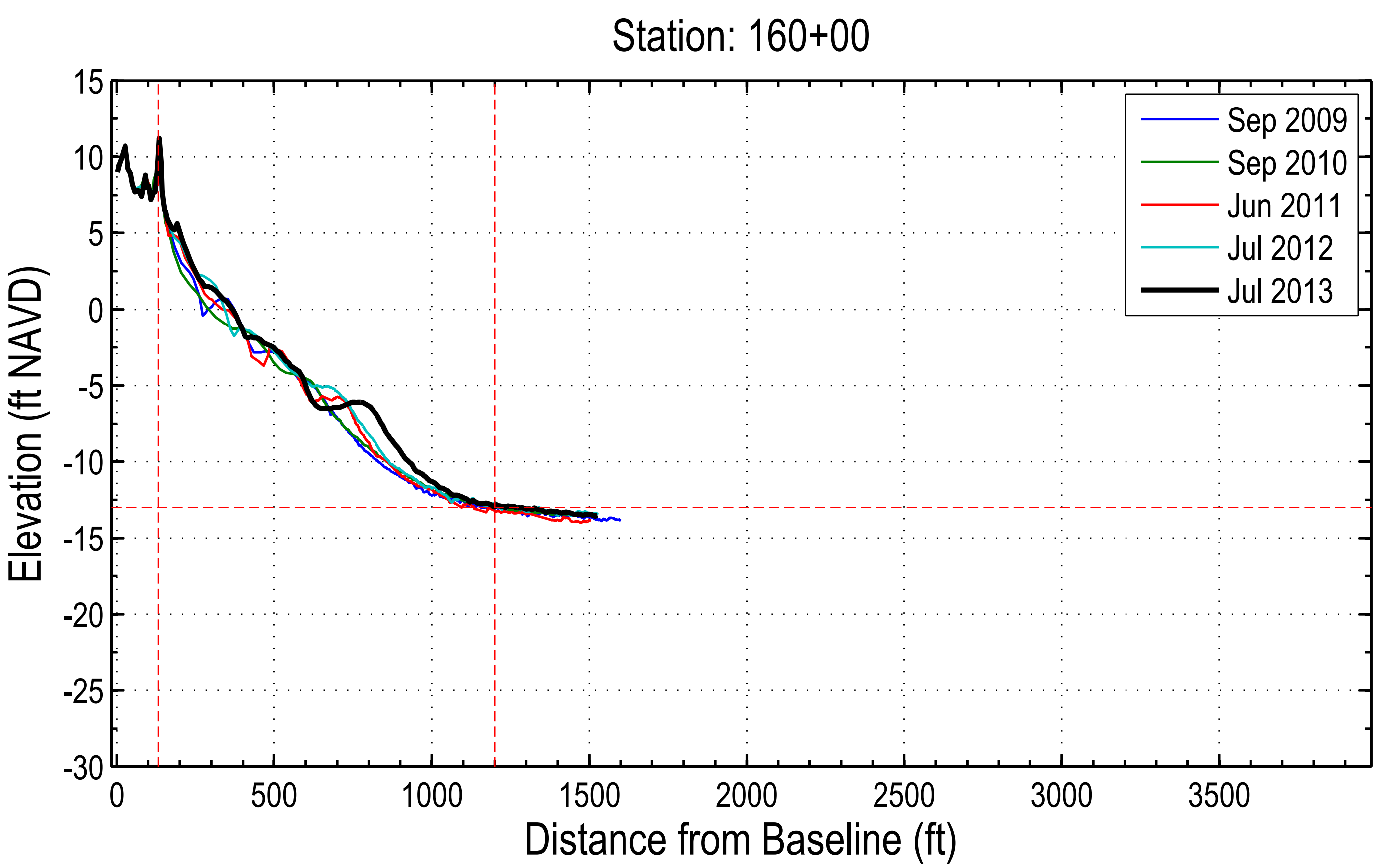
Station: 150+00 - Near 33rd Ave
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000
Distance from Baseline (ft)



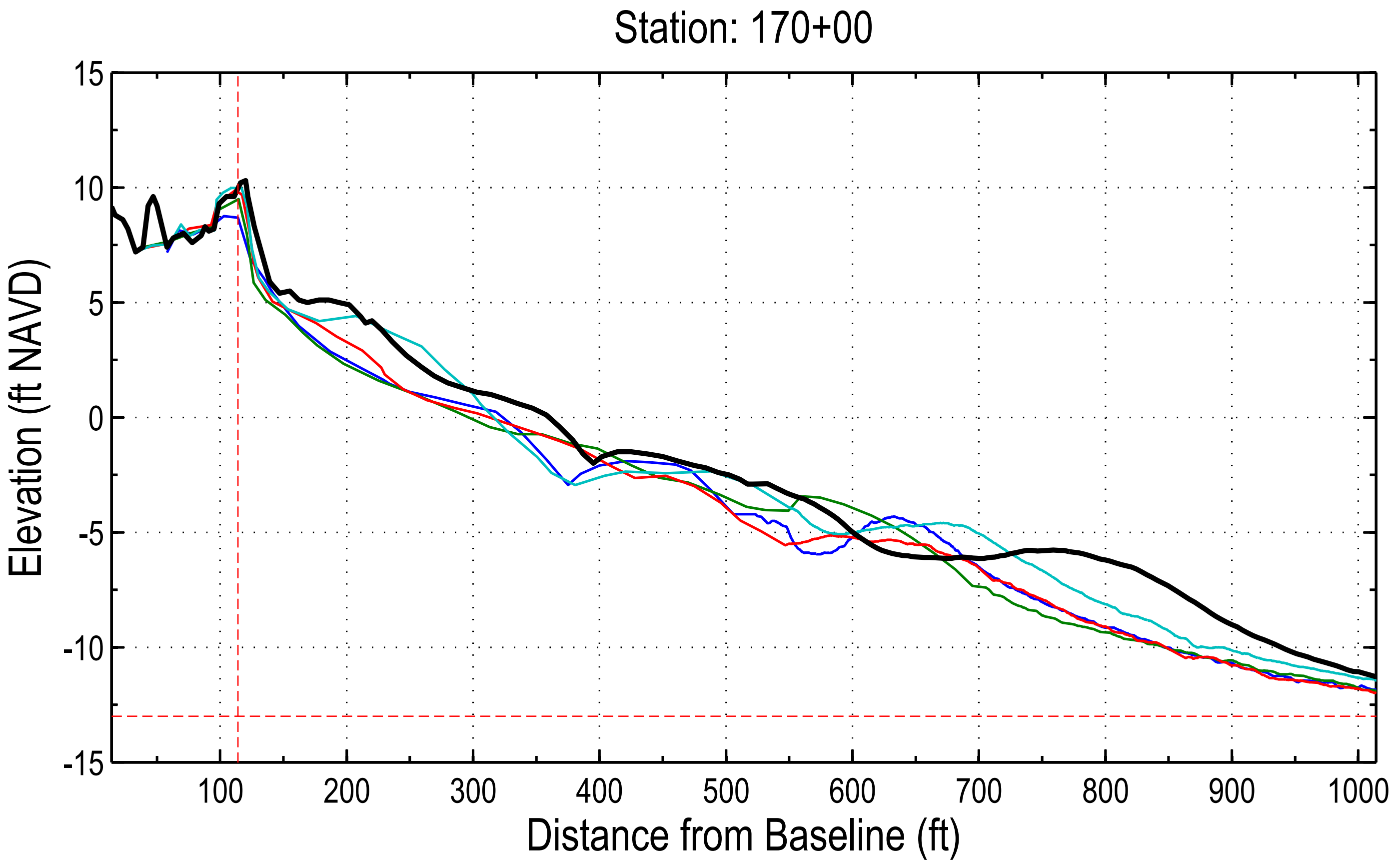
Station: 150+00 - Near 33rd Ave
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013

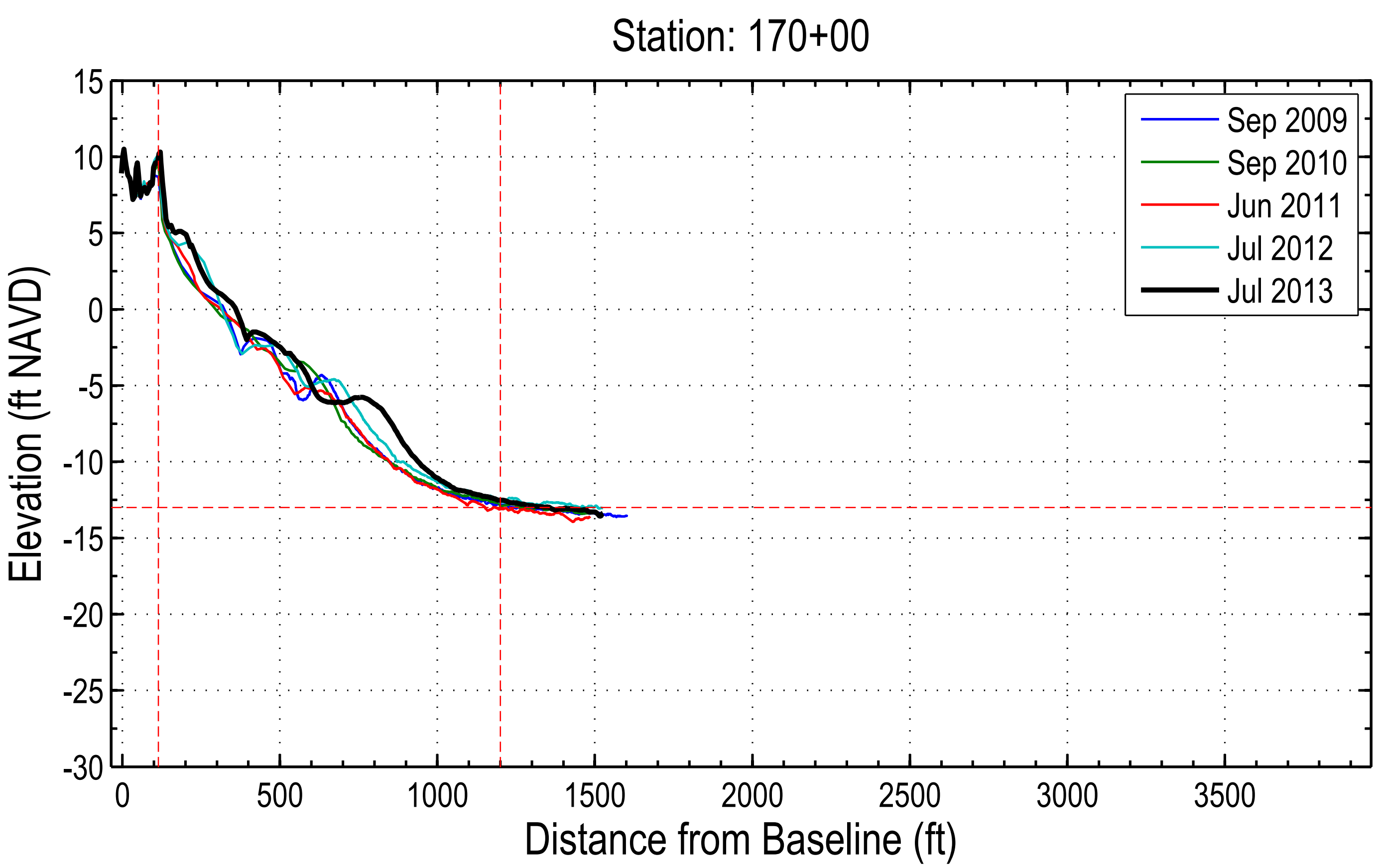


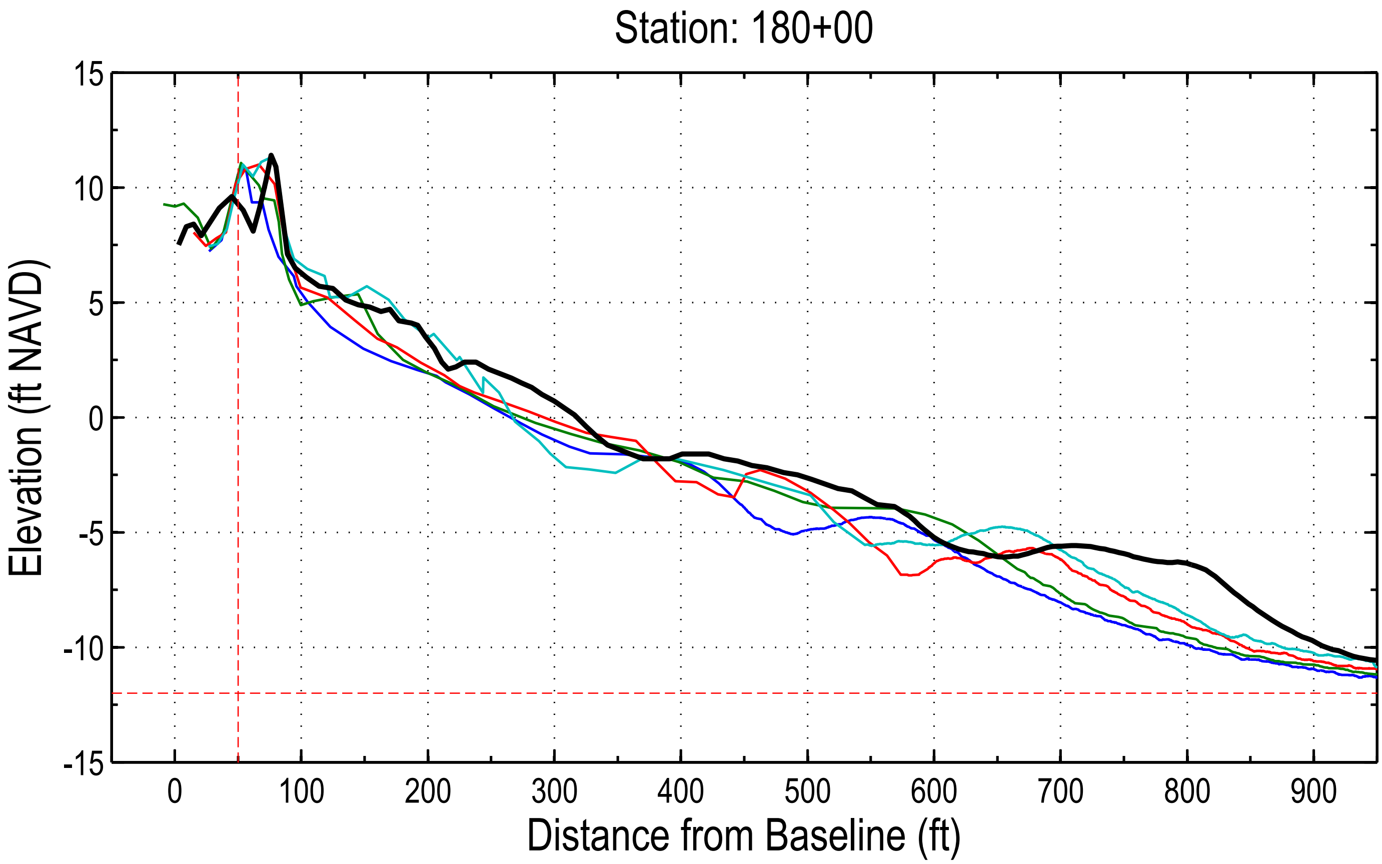
Station: 160+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000



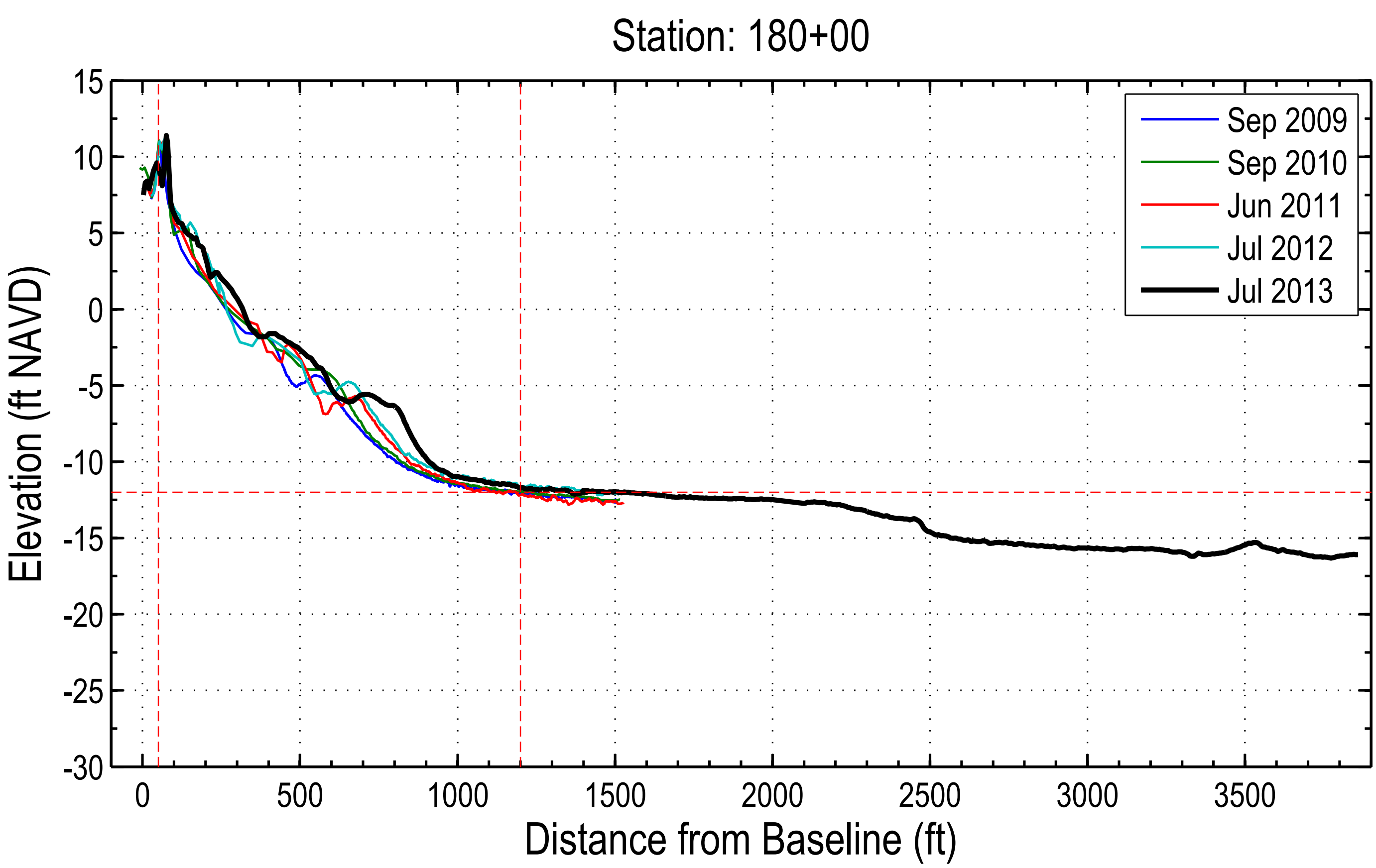
Station: 160+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 170+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000

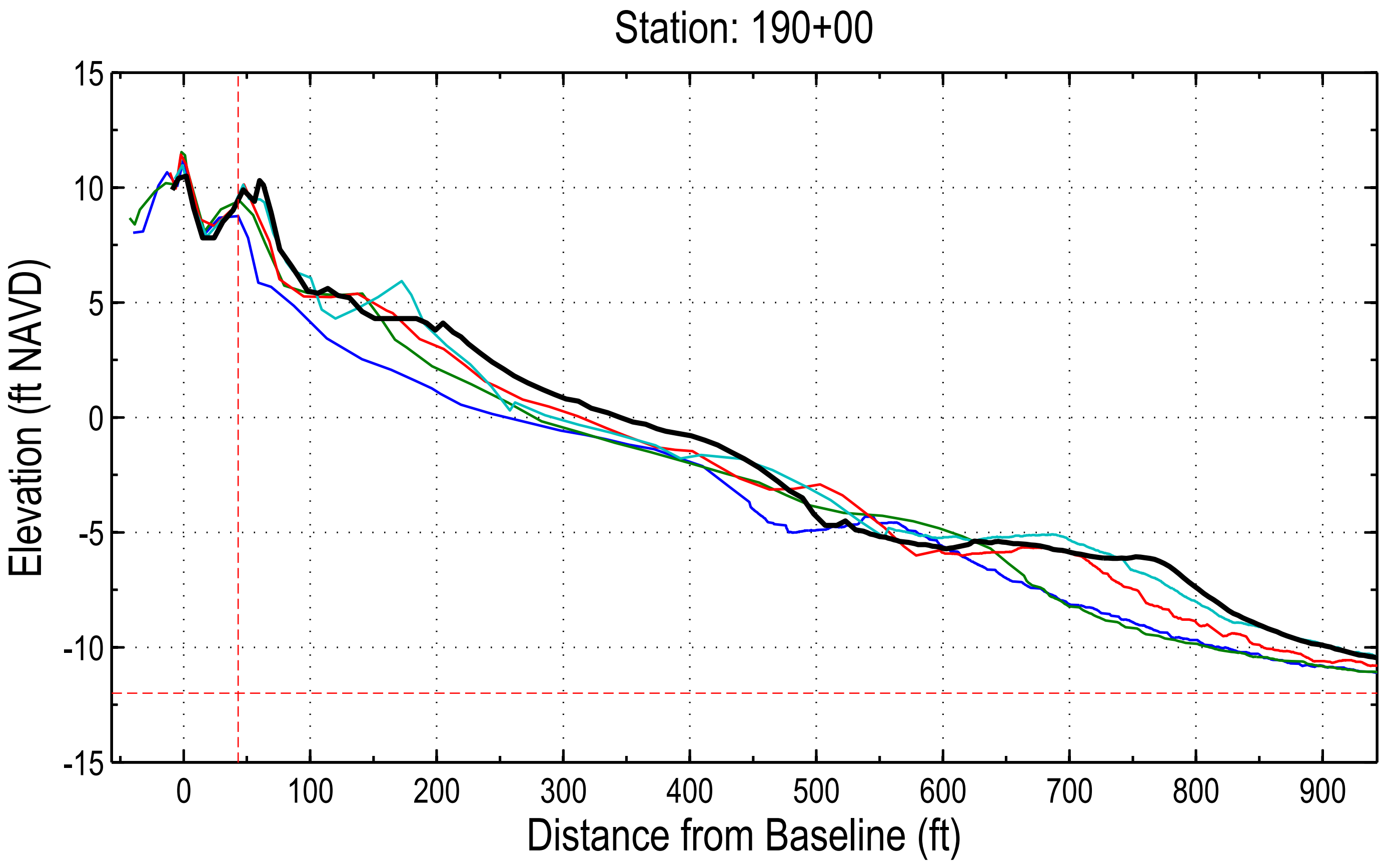

Station: 170+00
Elevation (ft NAVD)
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500



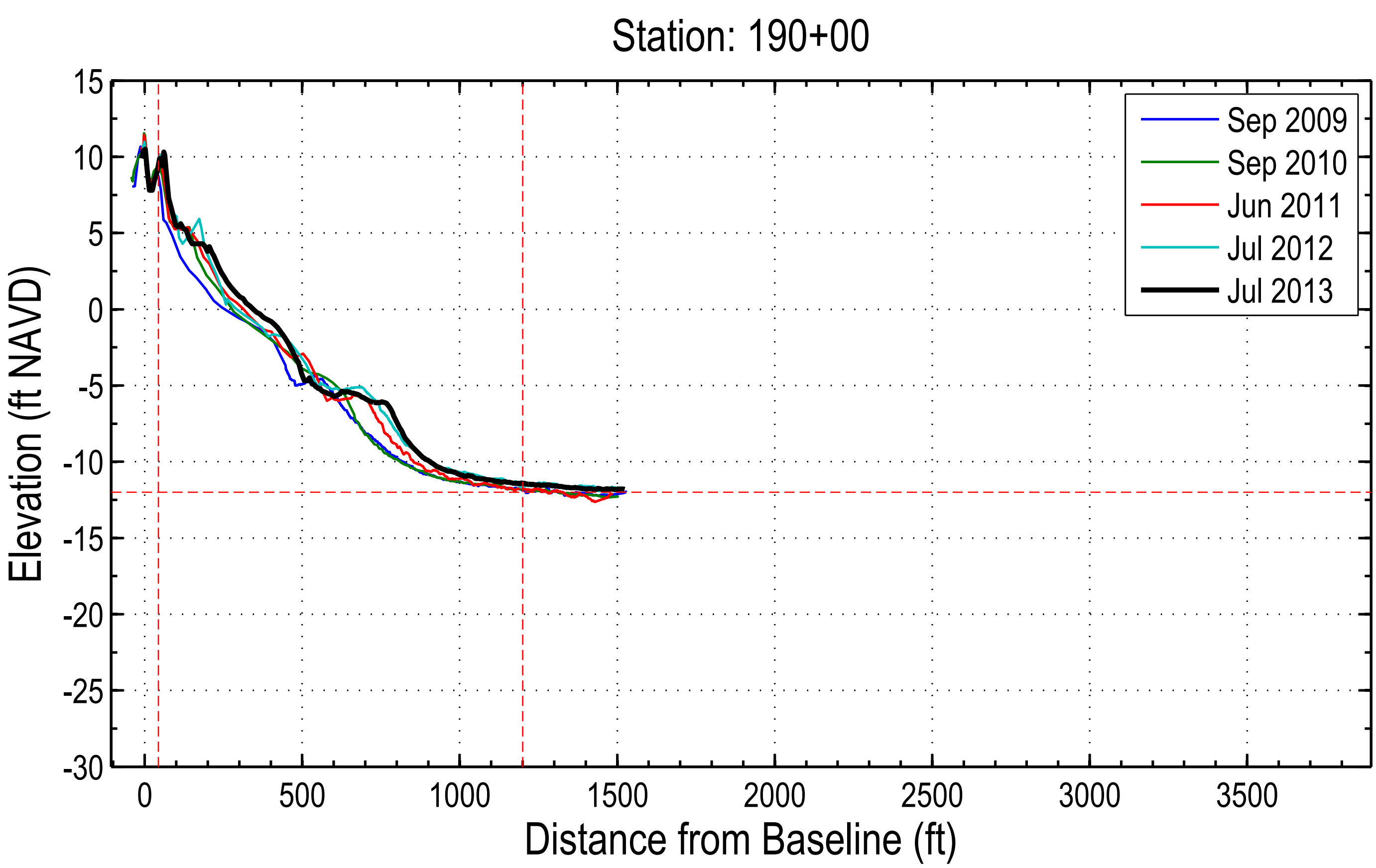
Station: 180+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900



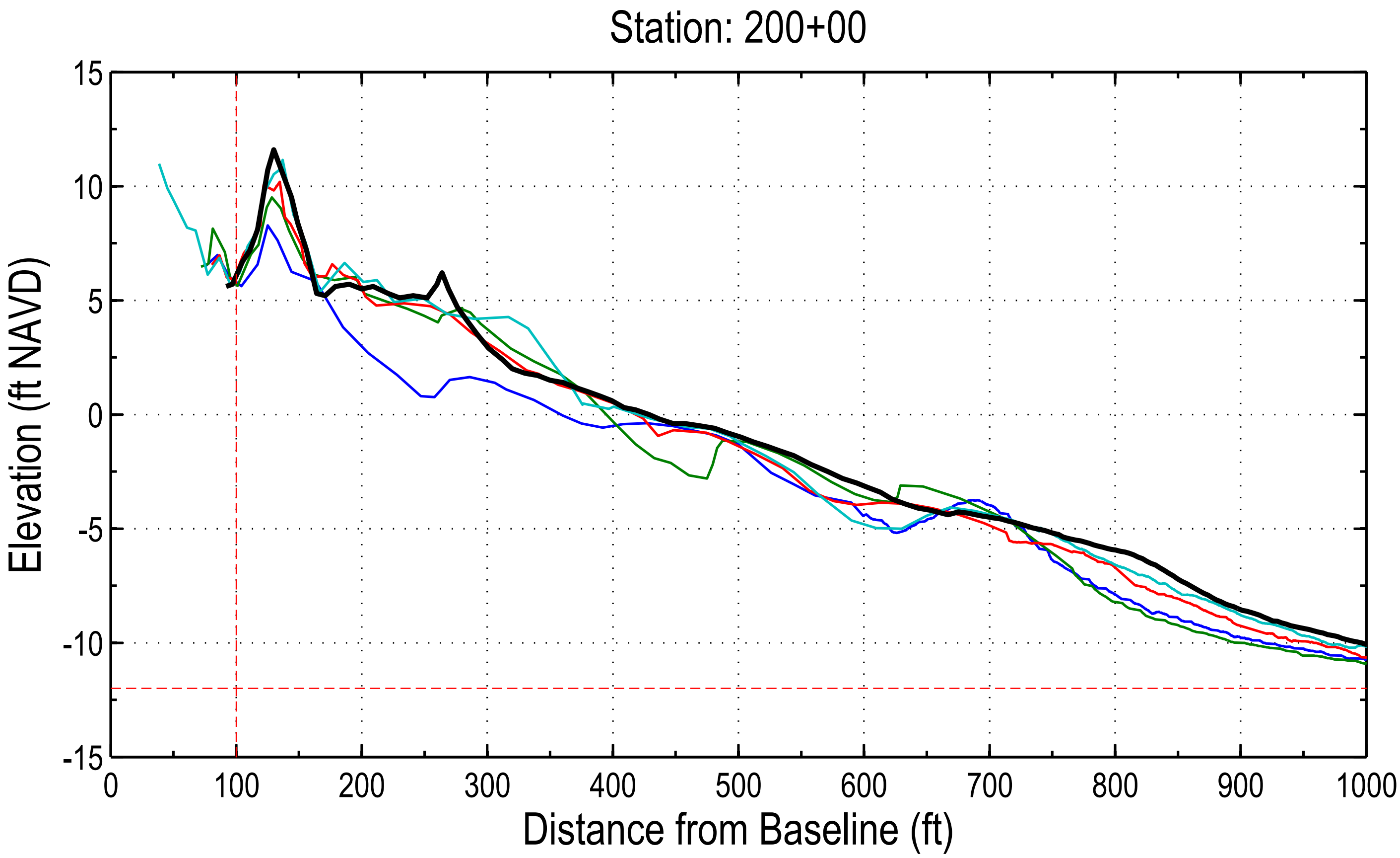
Station: 180+00
Elevation (ft NAVD)
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500



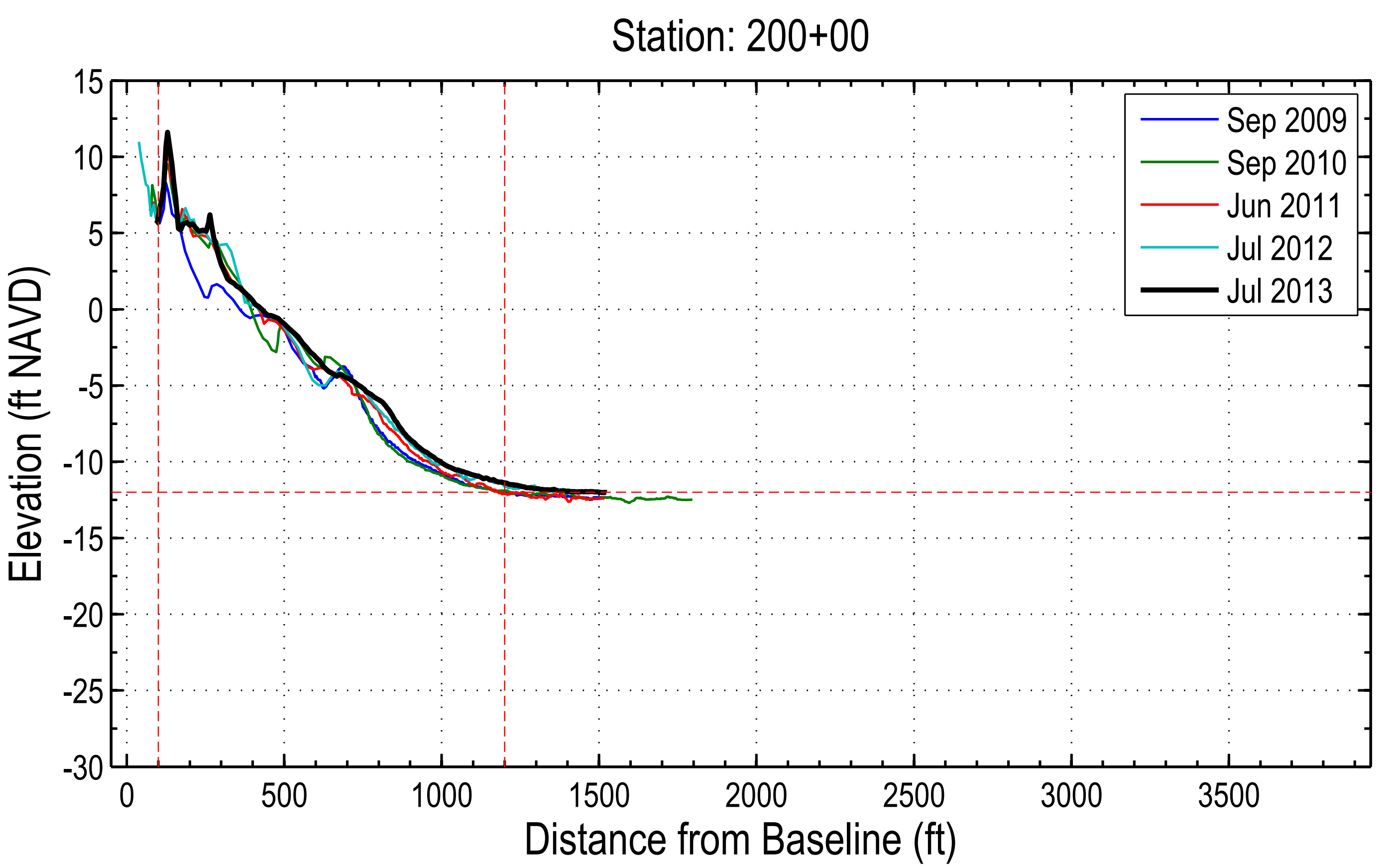
Station: 190+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900



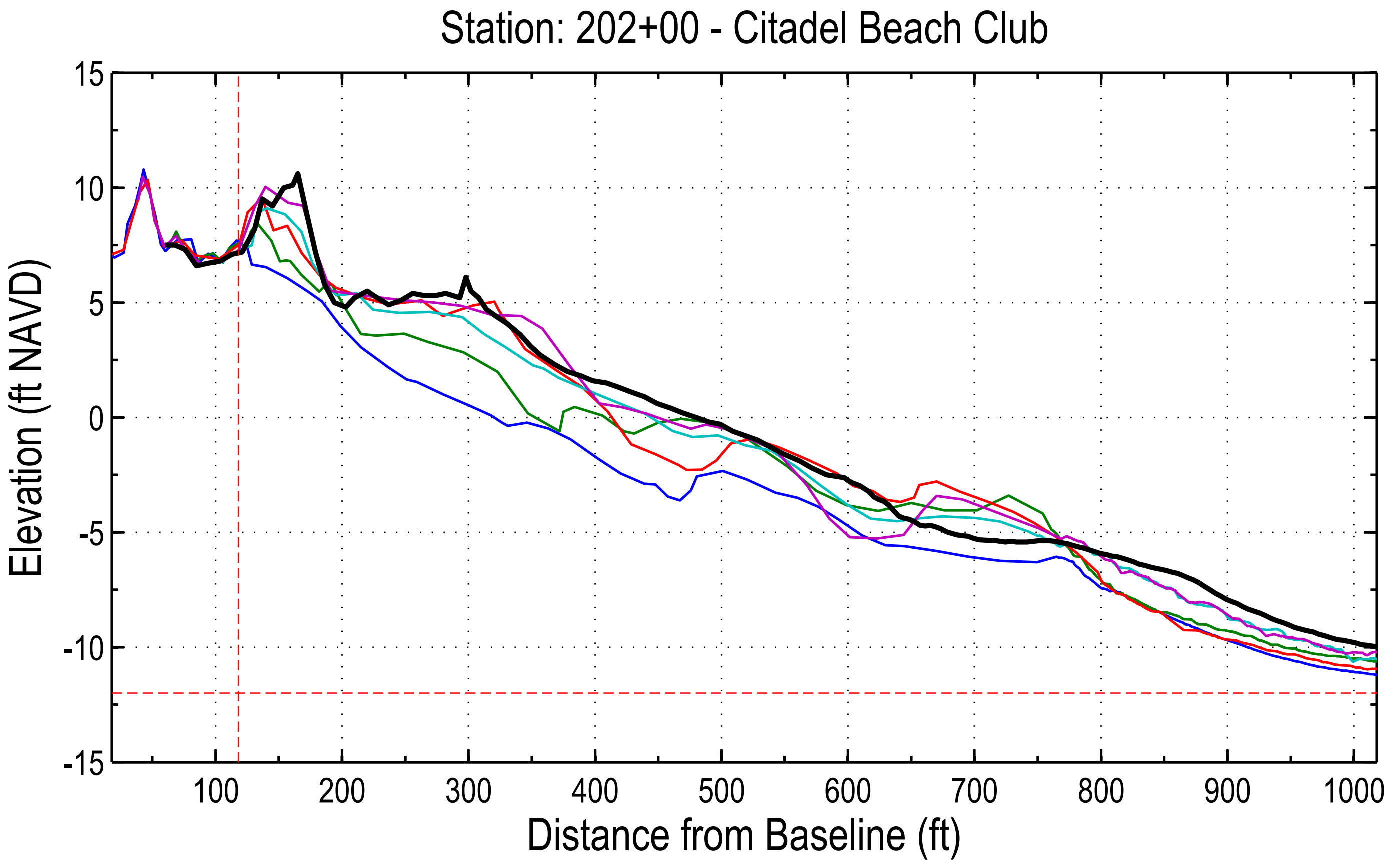
Station: 190+00
Elevation (ft NAVD)
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500

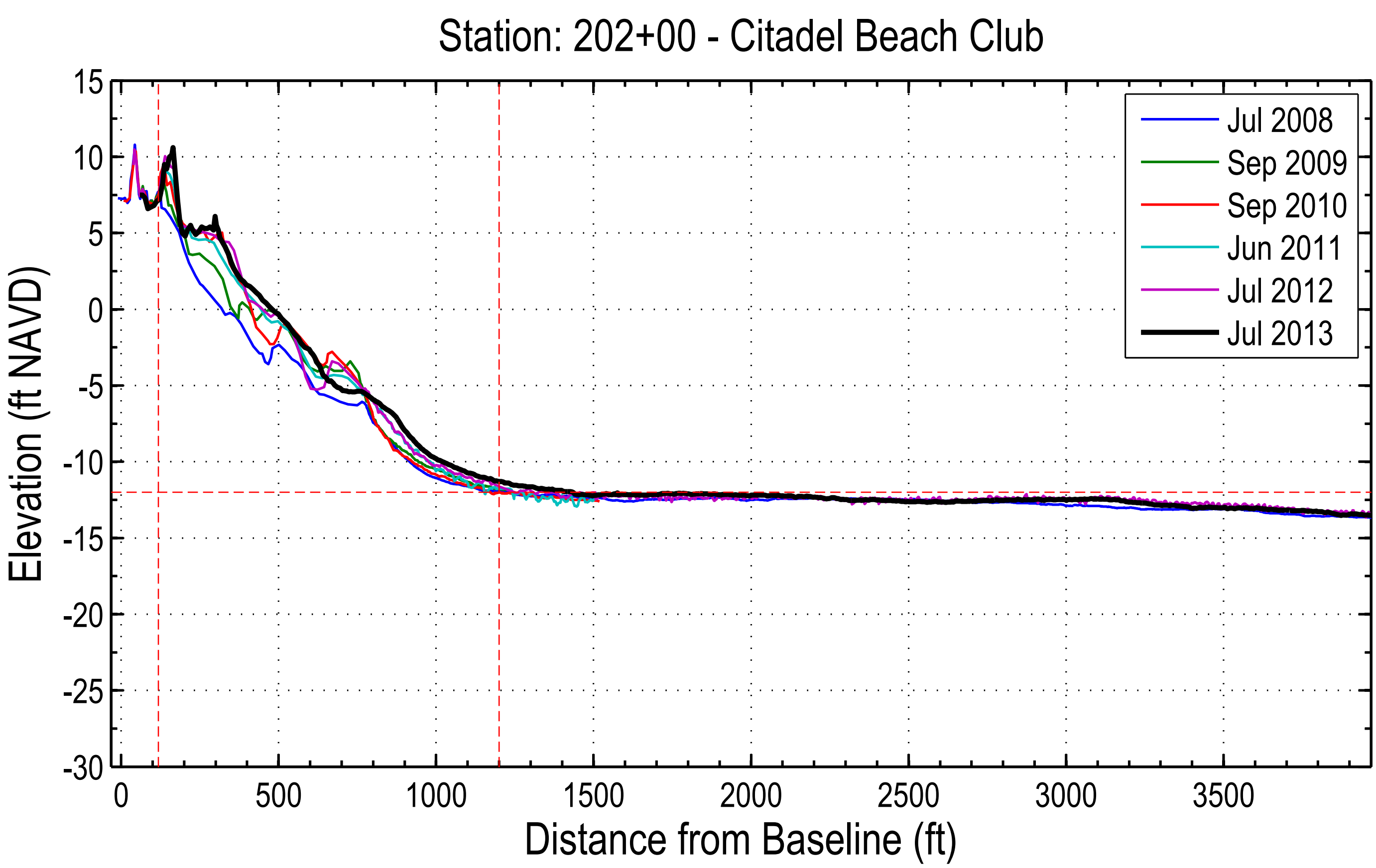


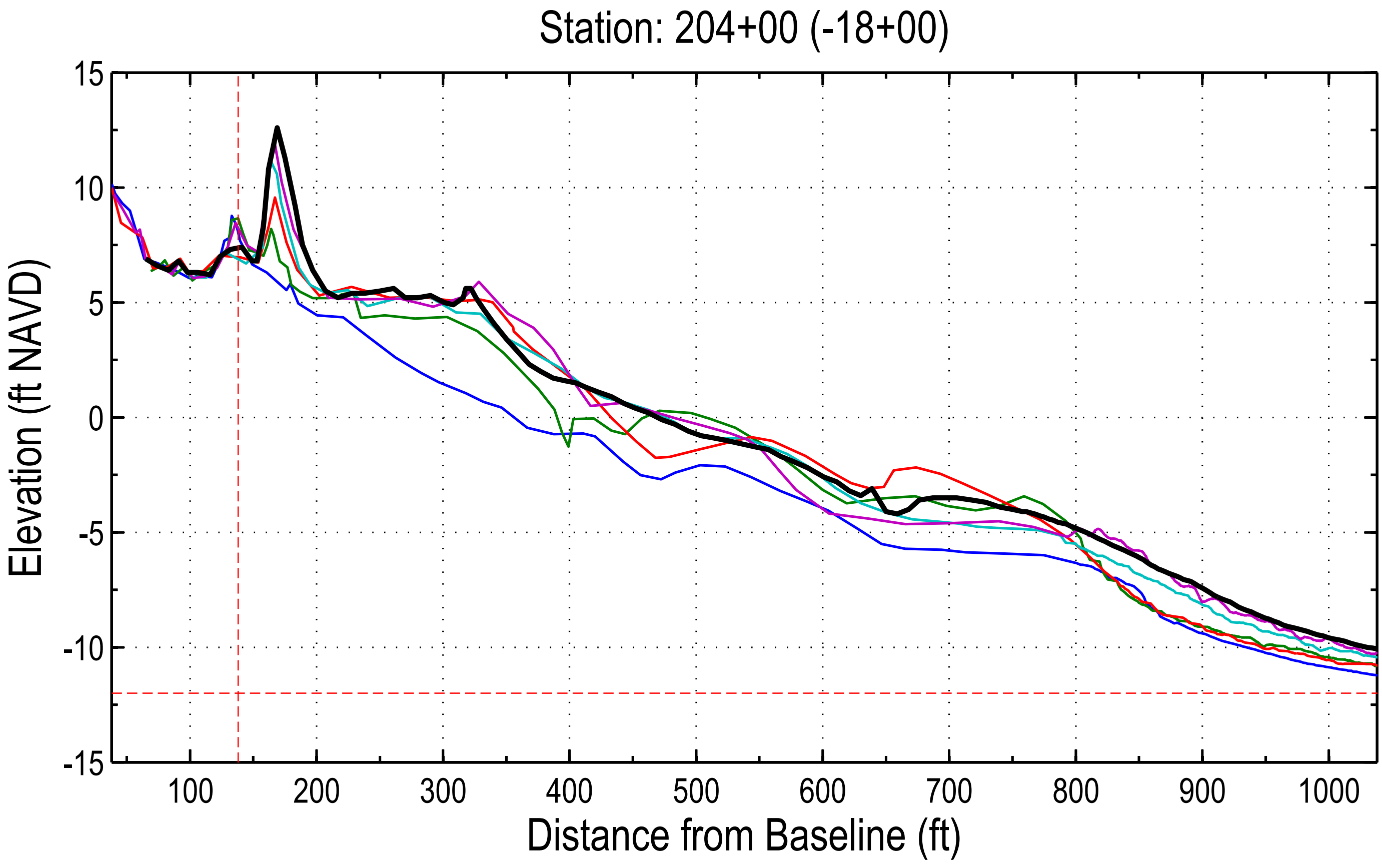
Station: 200+00
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900
1000



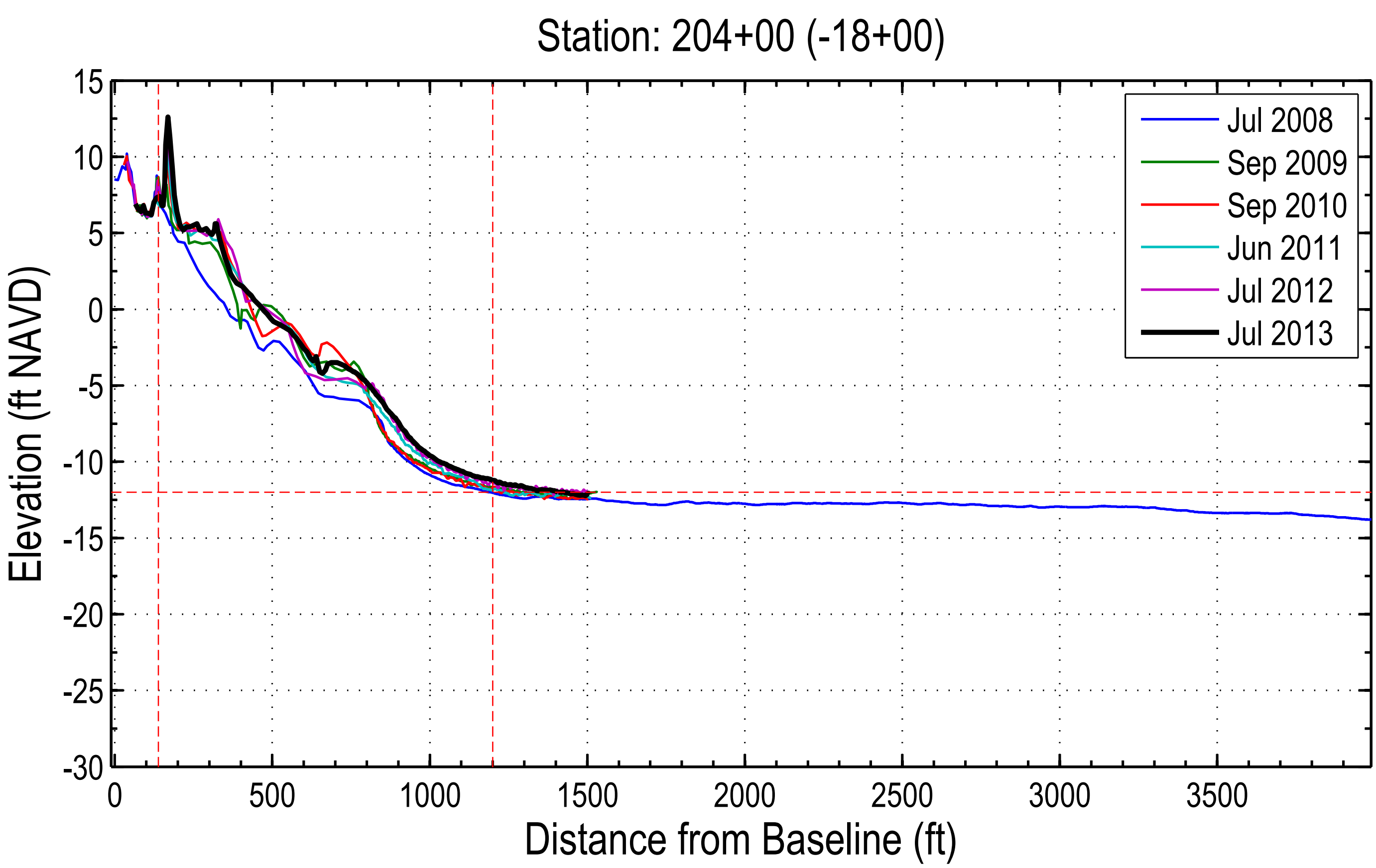
Station: 200+00
Elevation (ft NAVD)
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500


Station: 202+00 - Citadel Beach Club
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000
Distance from Baseline (ft)

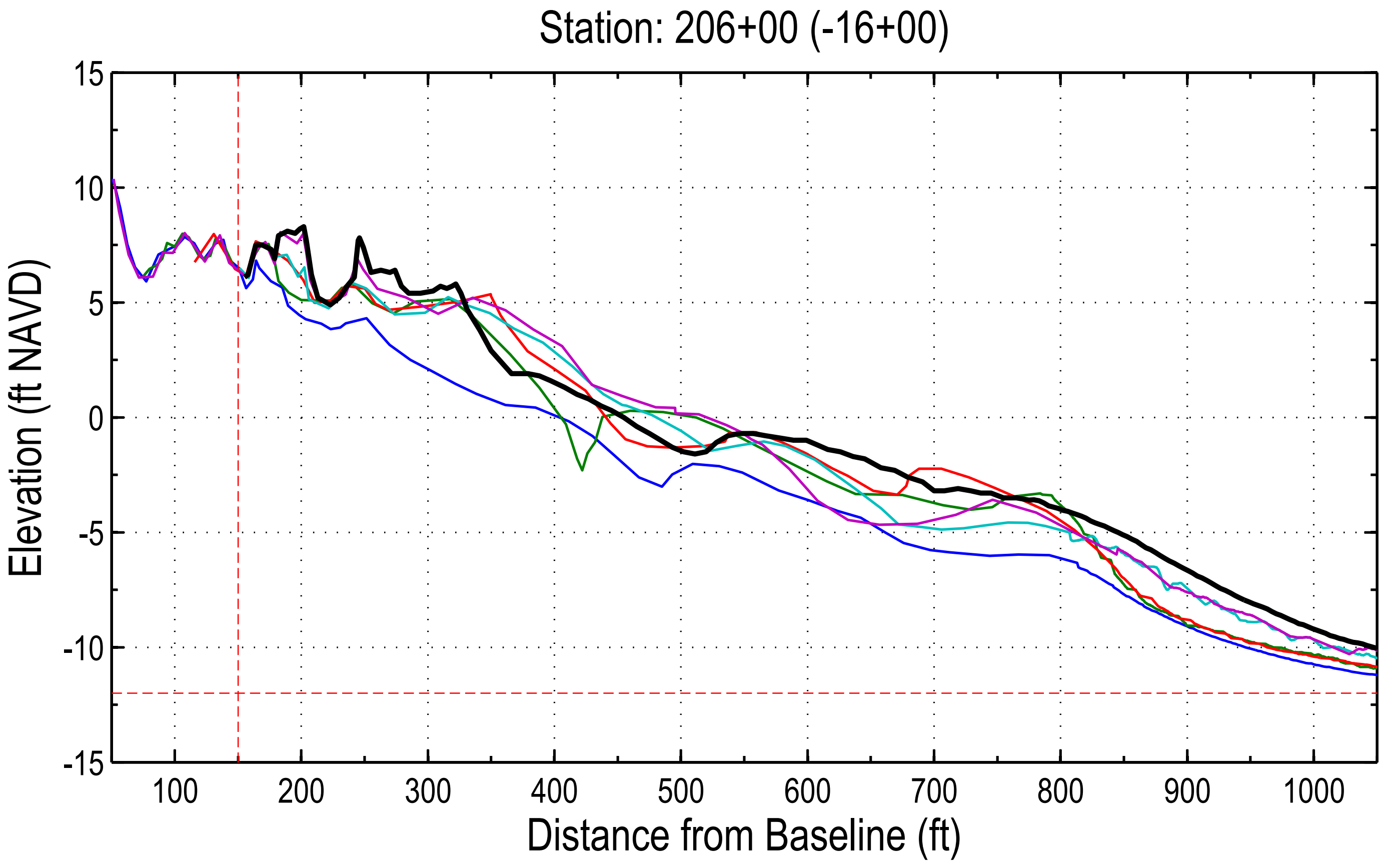

Station: 202+00 - Citadel Beach Club
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Distance from Baseline (ft)
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013

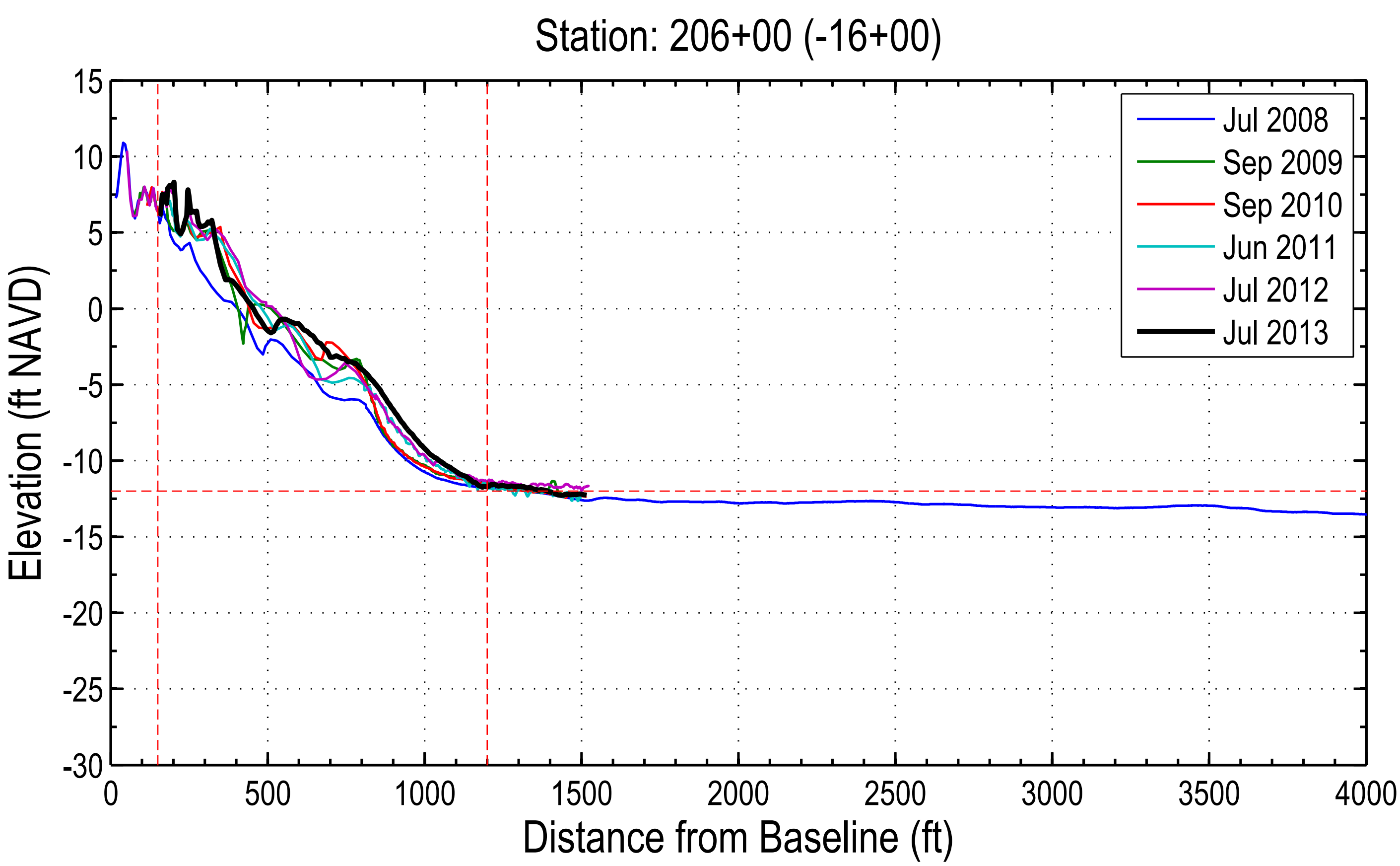


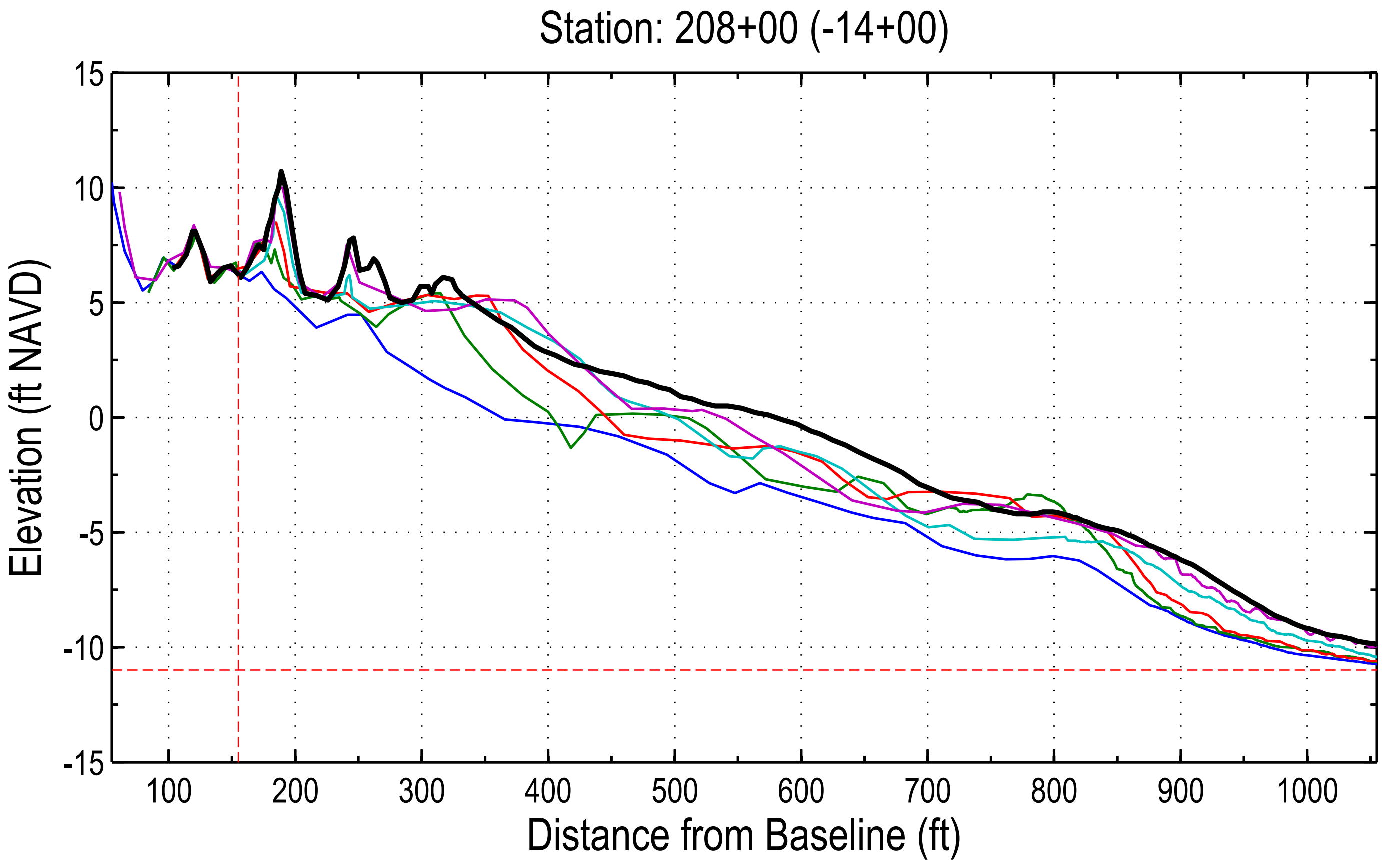
Station: 204+00 (-18+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000

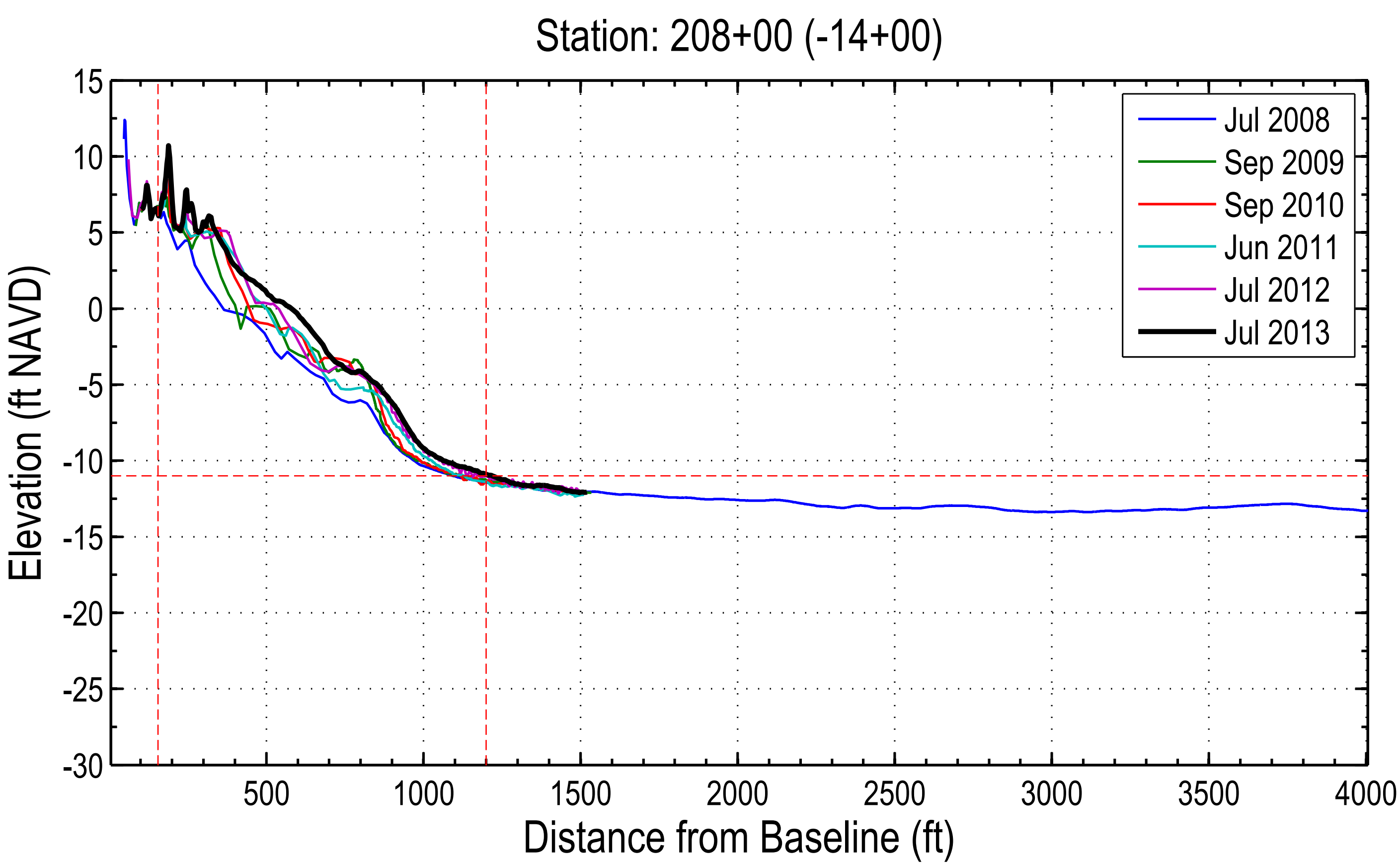


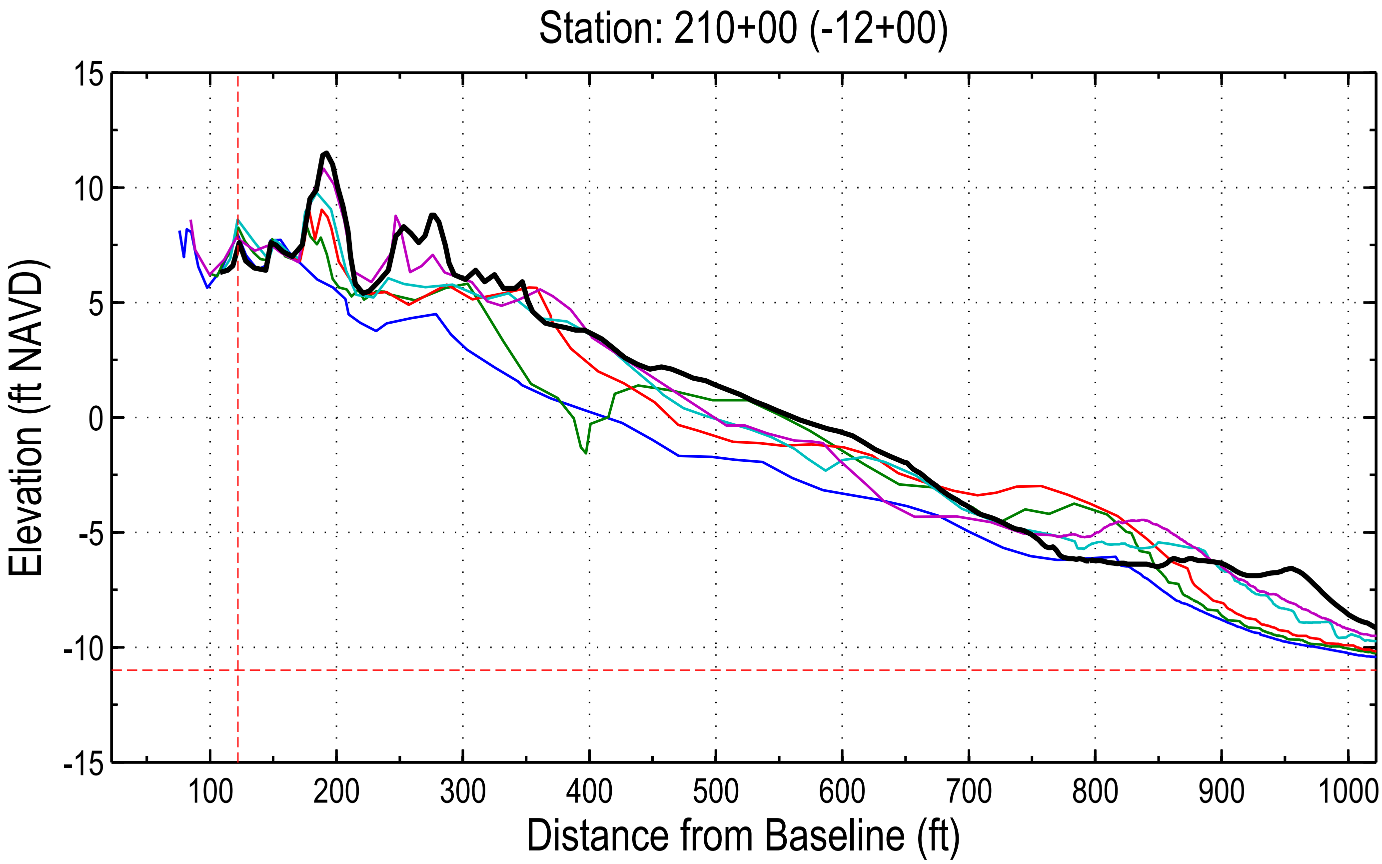
Station: 204+00 (-18+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500


Station: 206+00 (-16+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000


Station: 206+00 (-16+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
4000


Station: 208+00 (-14+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000


Station: 208+00 (-14+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 210+00 (-12+00)
15
10
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-15
100
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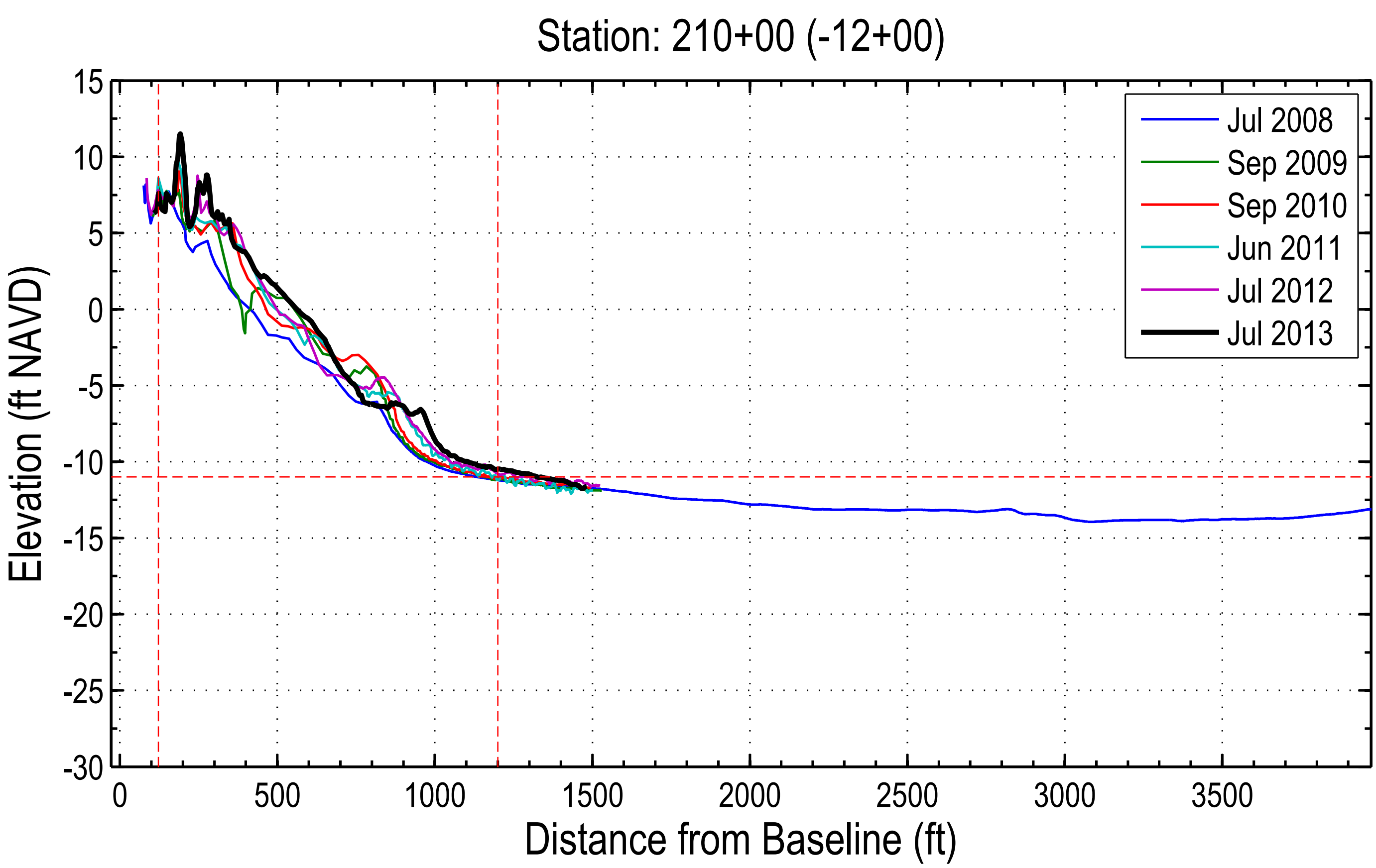
500
600
700
800
900
1000
Elevation (ft NAVD)
Distance from Baseline (ft)



Station: 210+00 (-12+00)
15
10
5
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-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
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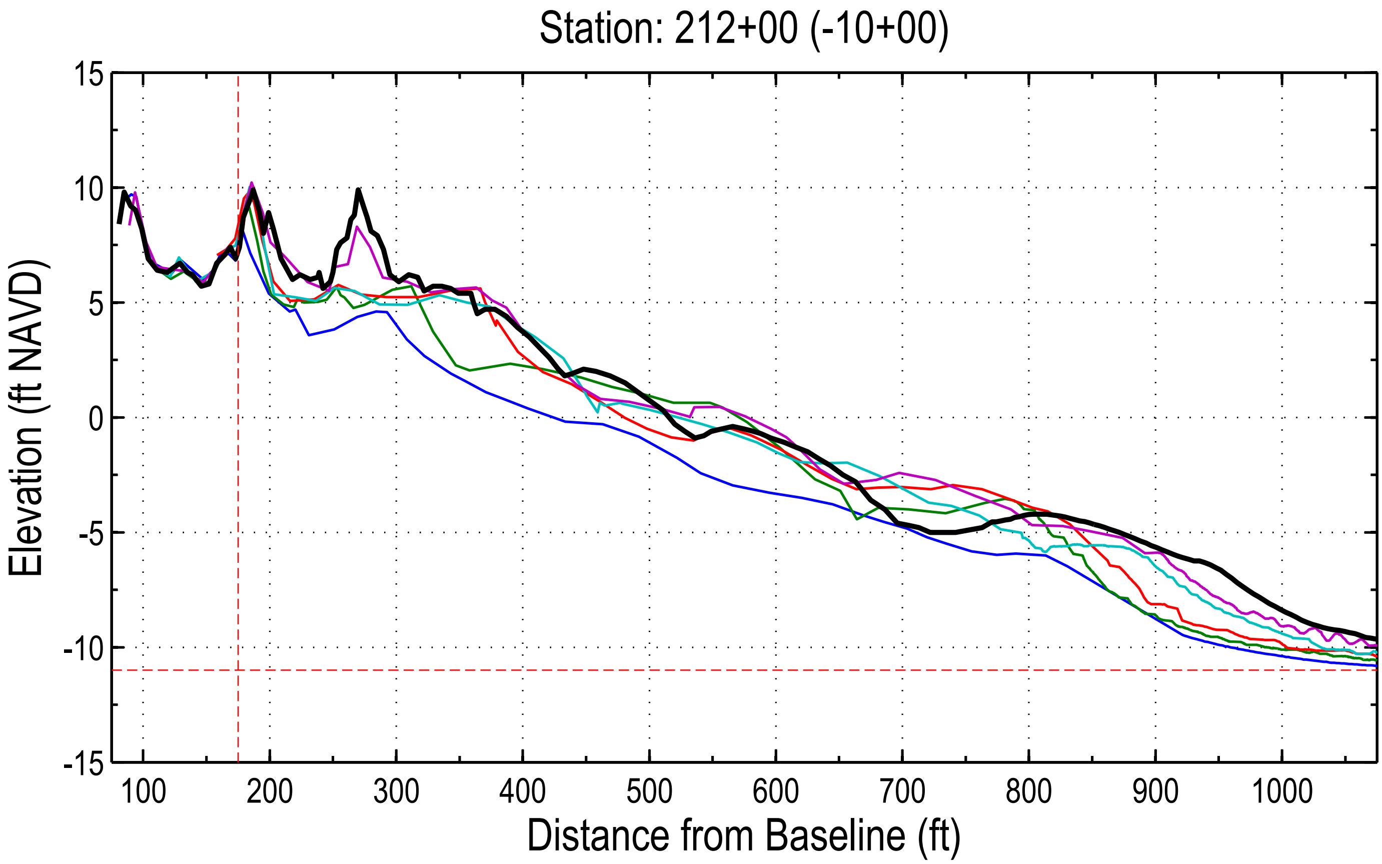
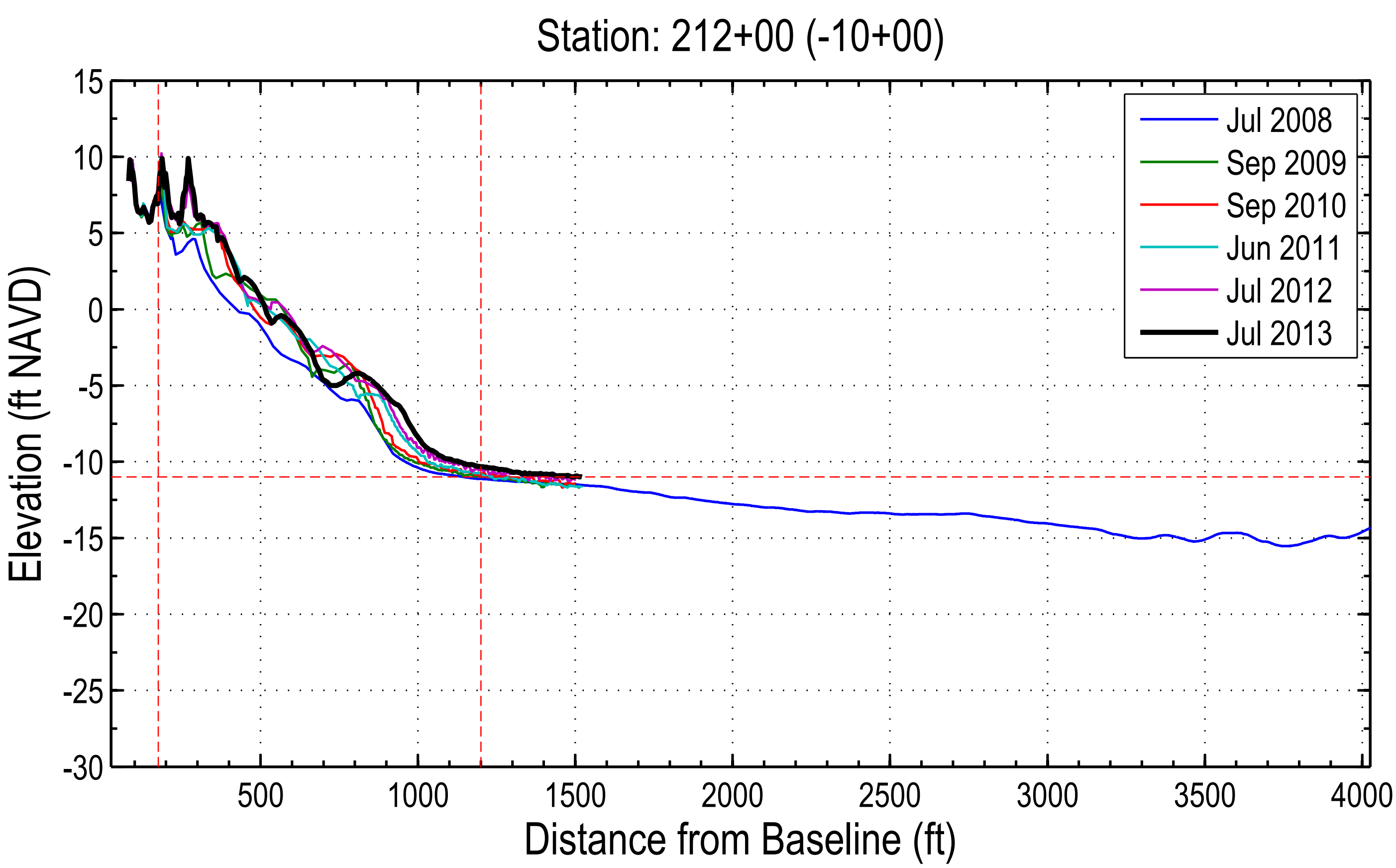
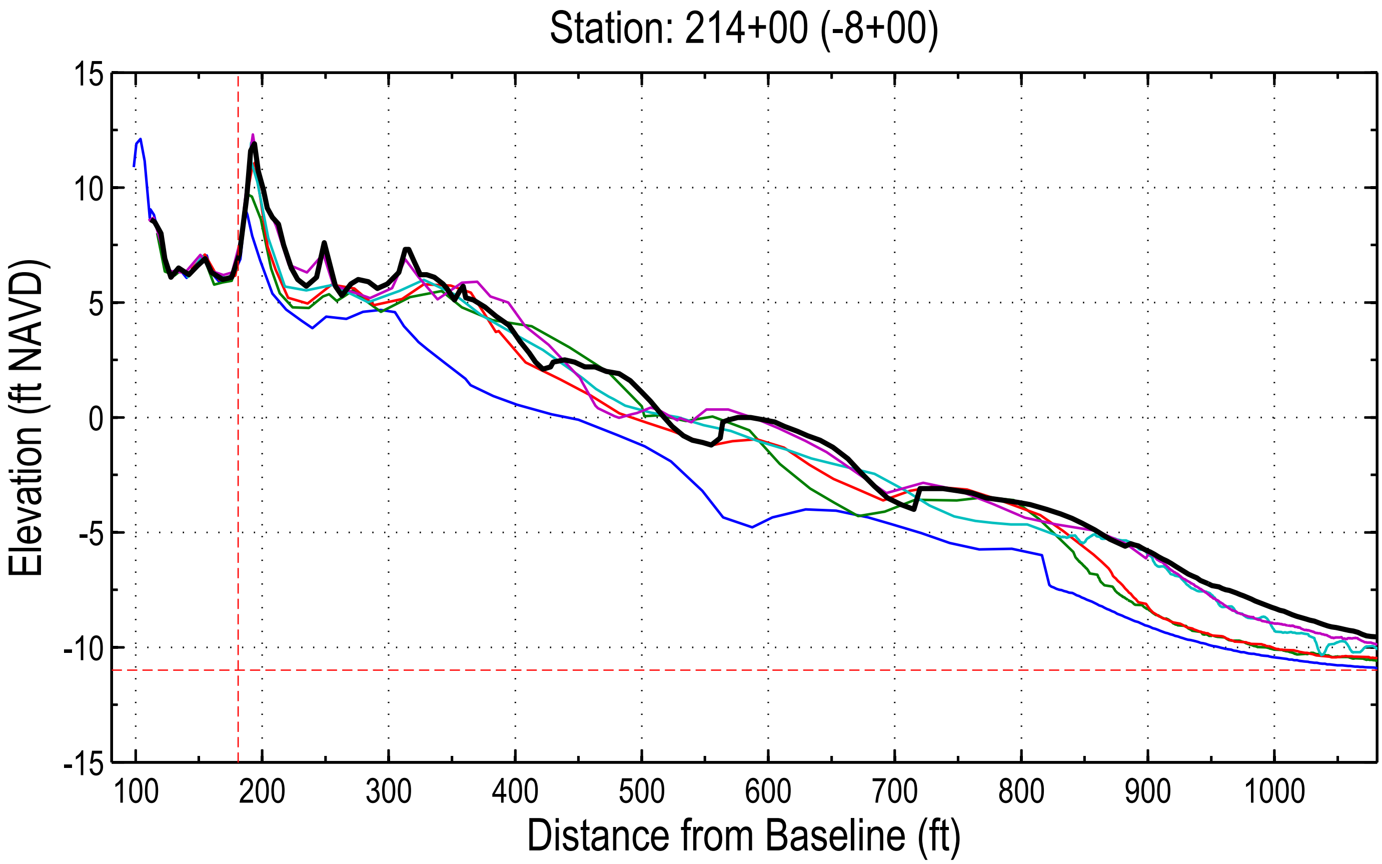
3000
3500
Elevation (ft NAVD)
Distance from Baseline (ft)
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 212+00 (-10+00)
Elevation (ft NAVD)
Distance from Baseline (ft)


Station: 212+00 (-10+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 214+00 (-8+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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10
5
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-5
-10
-15
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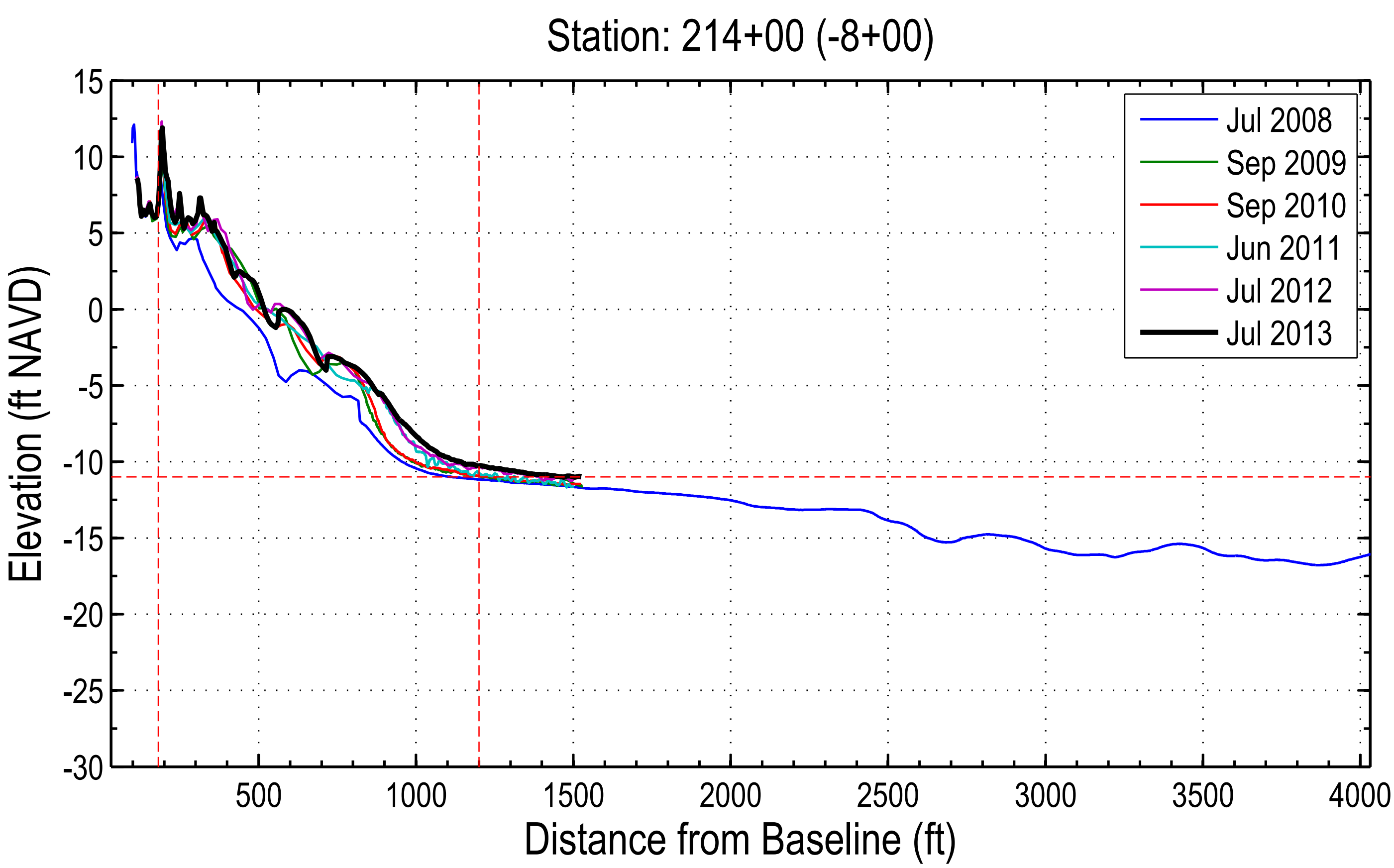
Station: 214+00 (-8+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
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-5
-10
-15
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-25
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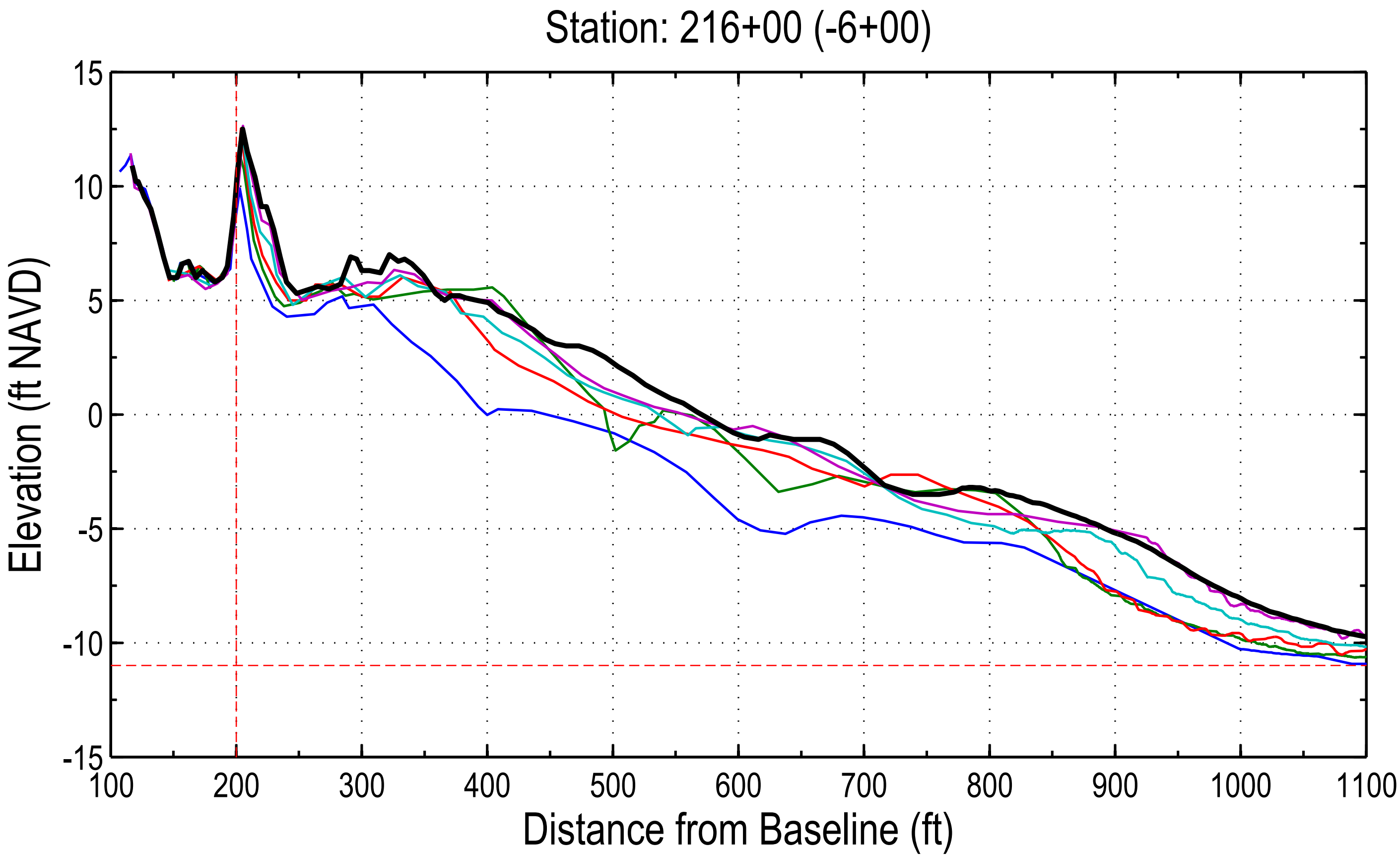
3500
4000


Station: 216+00 (-6+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
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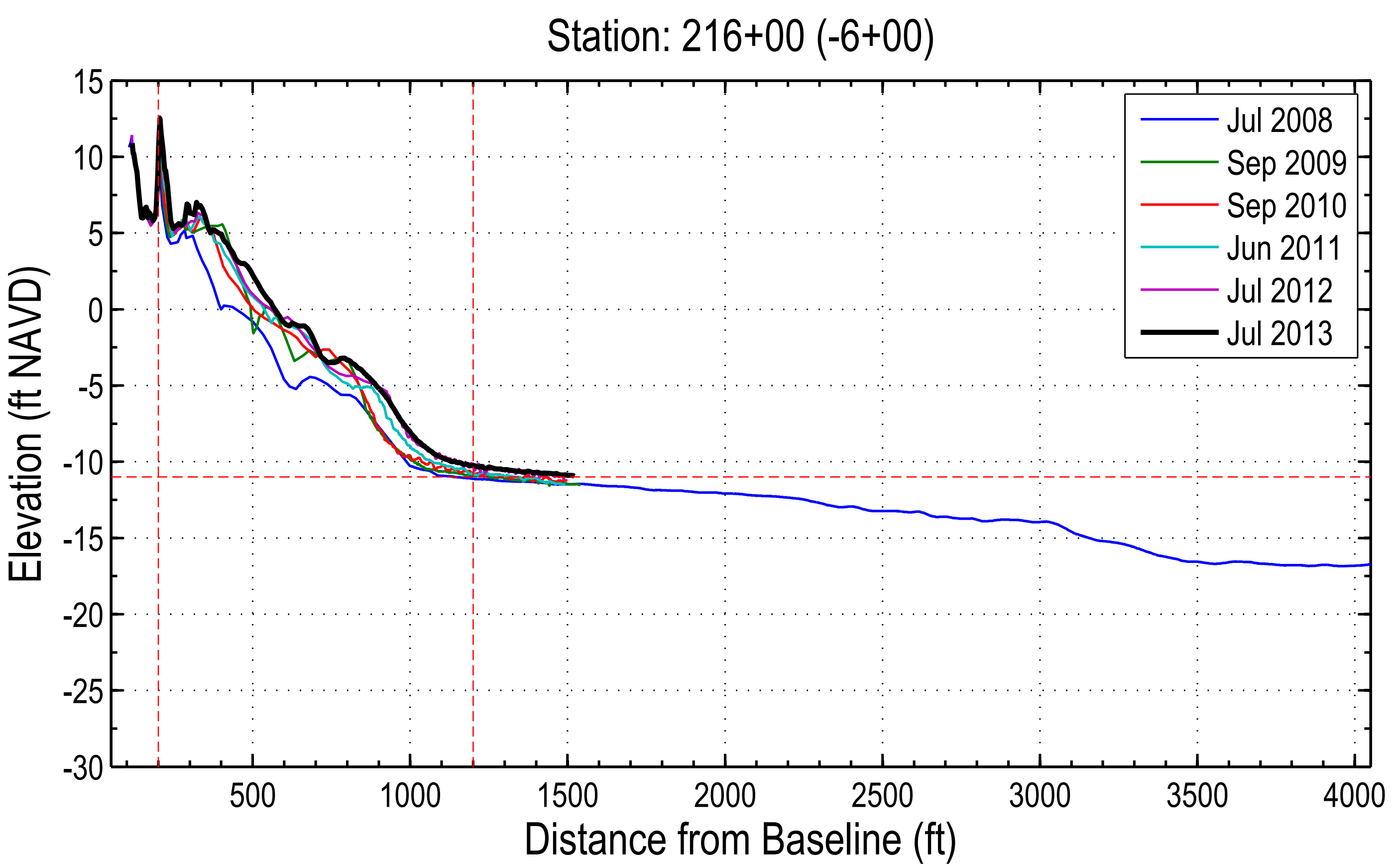
400
500
600
700
800
900
1000
1100


Station: 216+00 (-6+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
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1000
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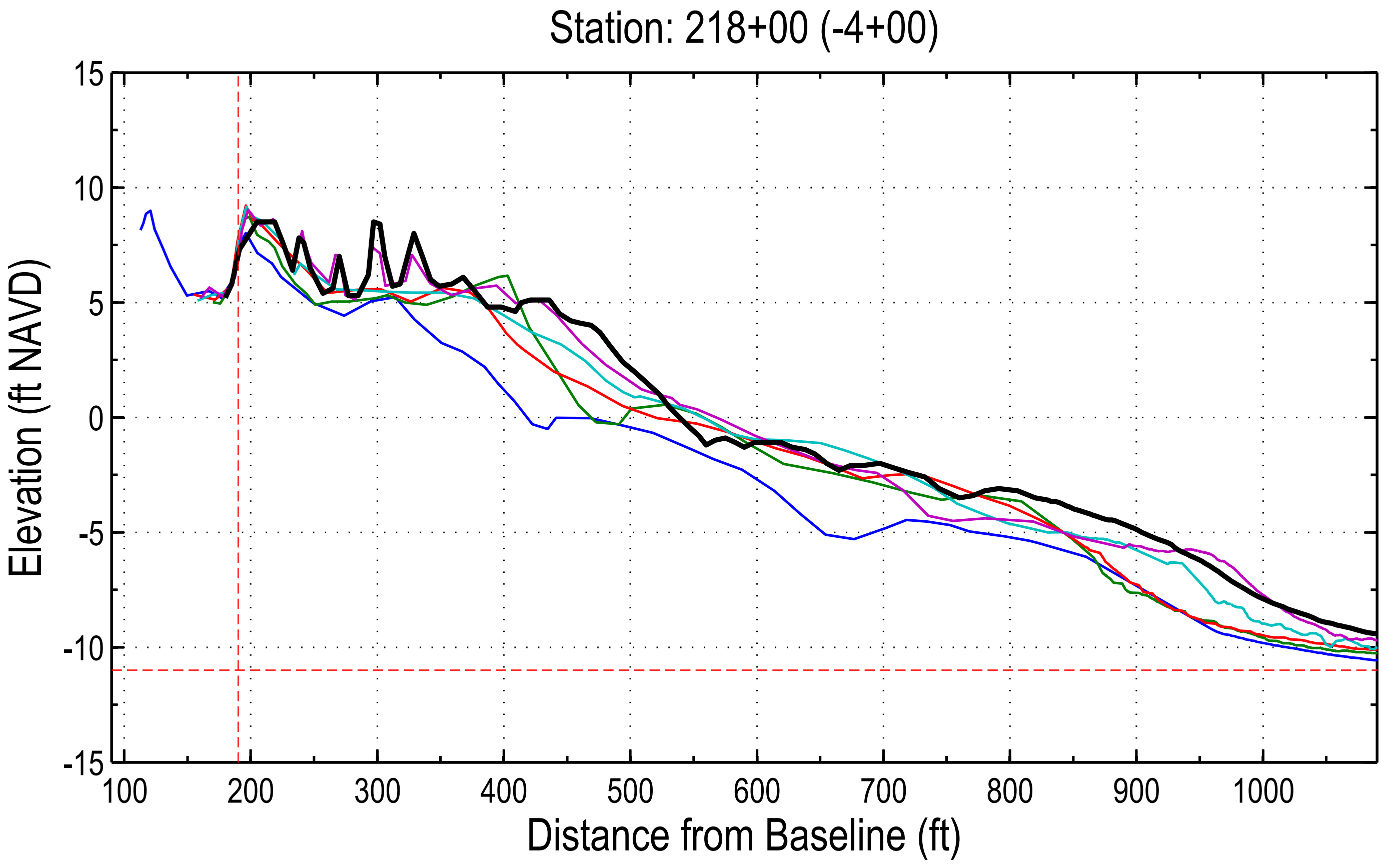
2500
3000
3500
4000
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 218+00 (-4+00)
15
10
5
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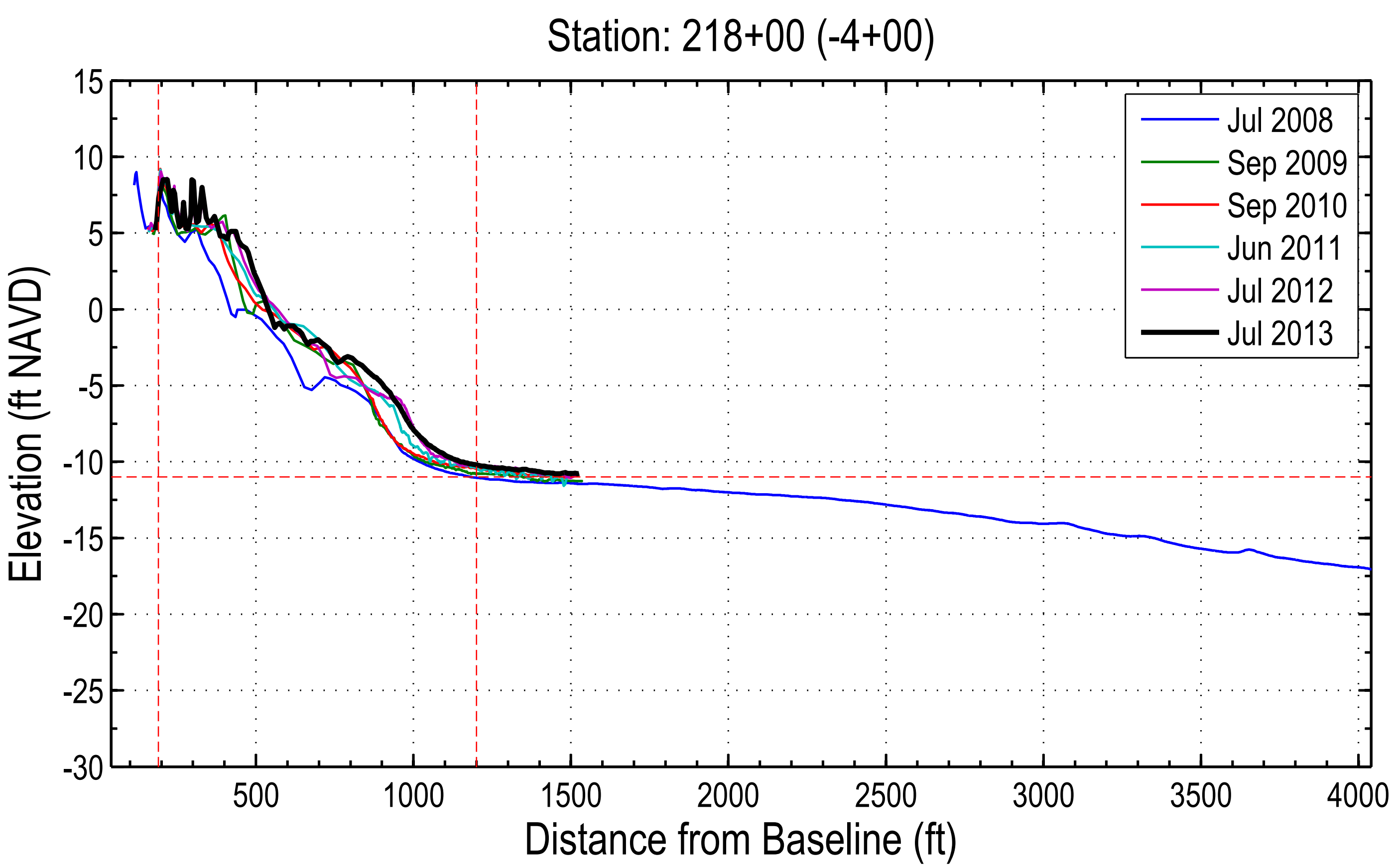
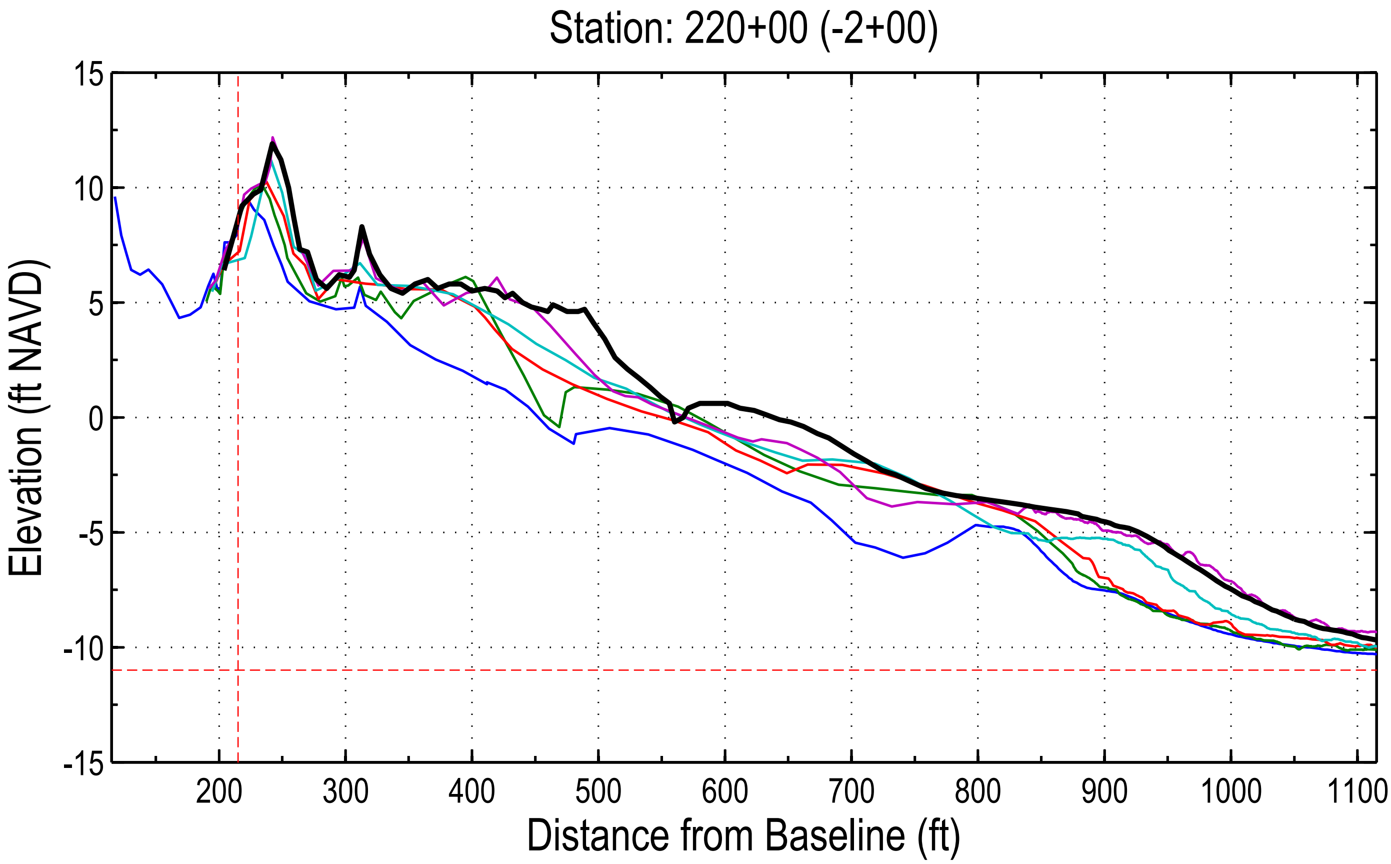
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000
Elevation (ft NAVD)
Distance from Baseline (ft)


Station: 218+00 (-4+00)
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000
Elevation (ft NAVD)
Distance from Baseline (ft)
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 220+00 (-2+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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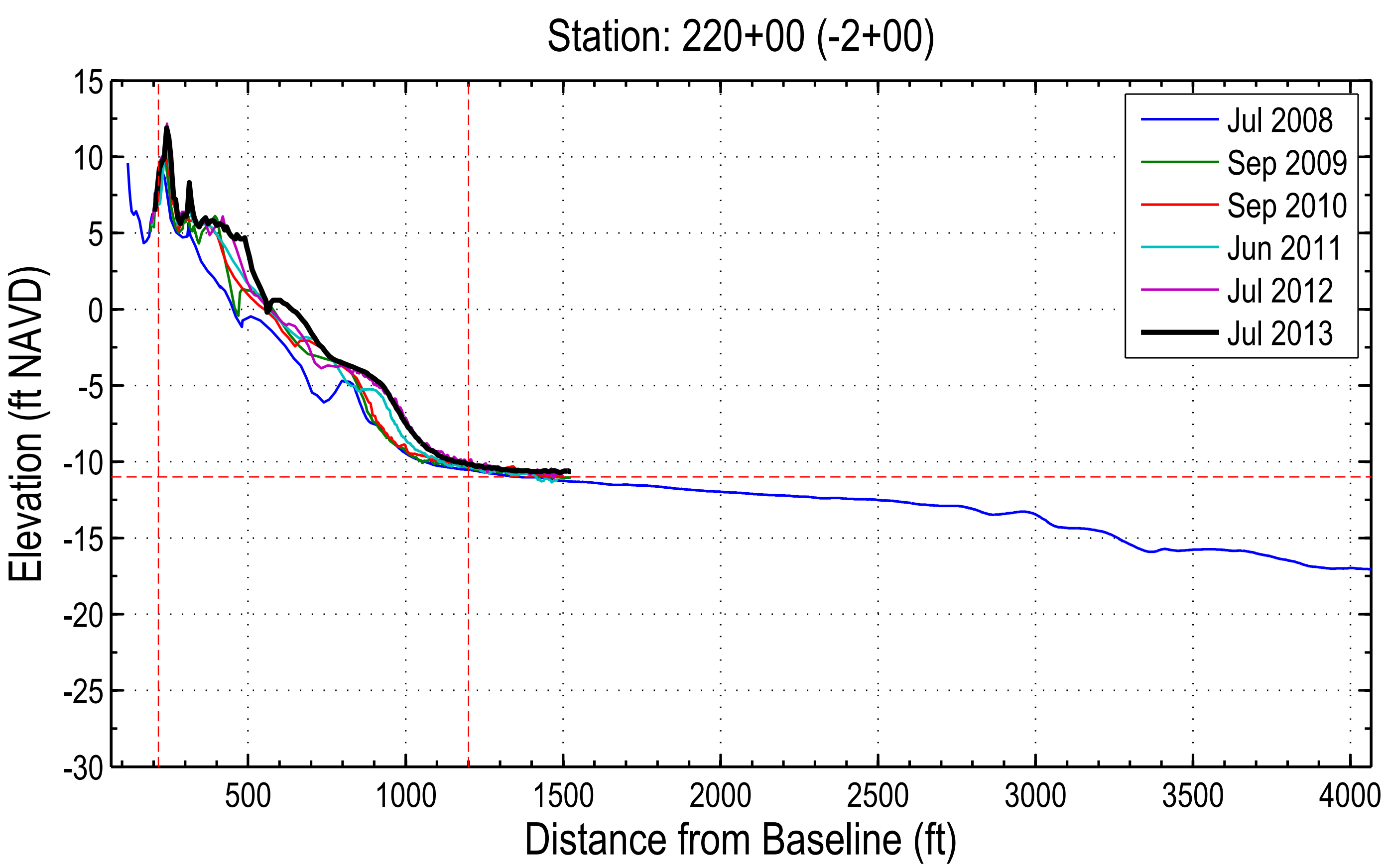
10
5
0
-5
-10
-15
200
300
400
500
600
700
800
900
1000
1100



Station: 220+00 (-2+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
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500
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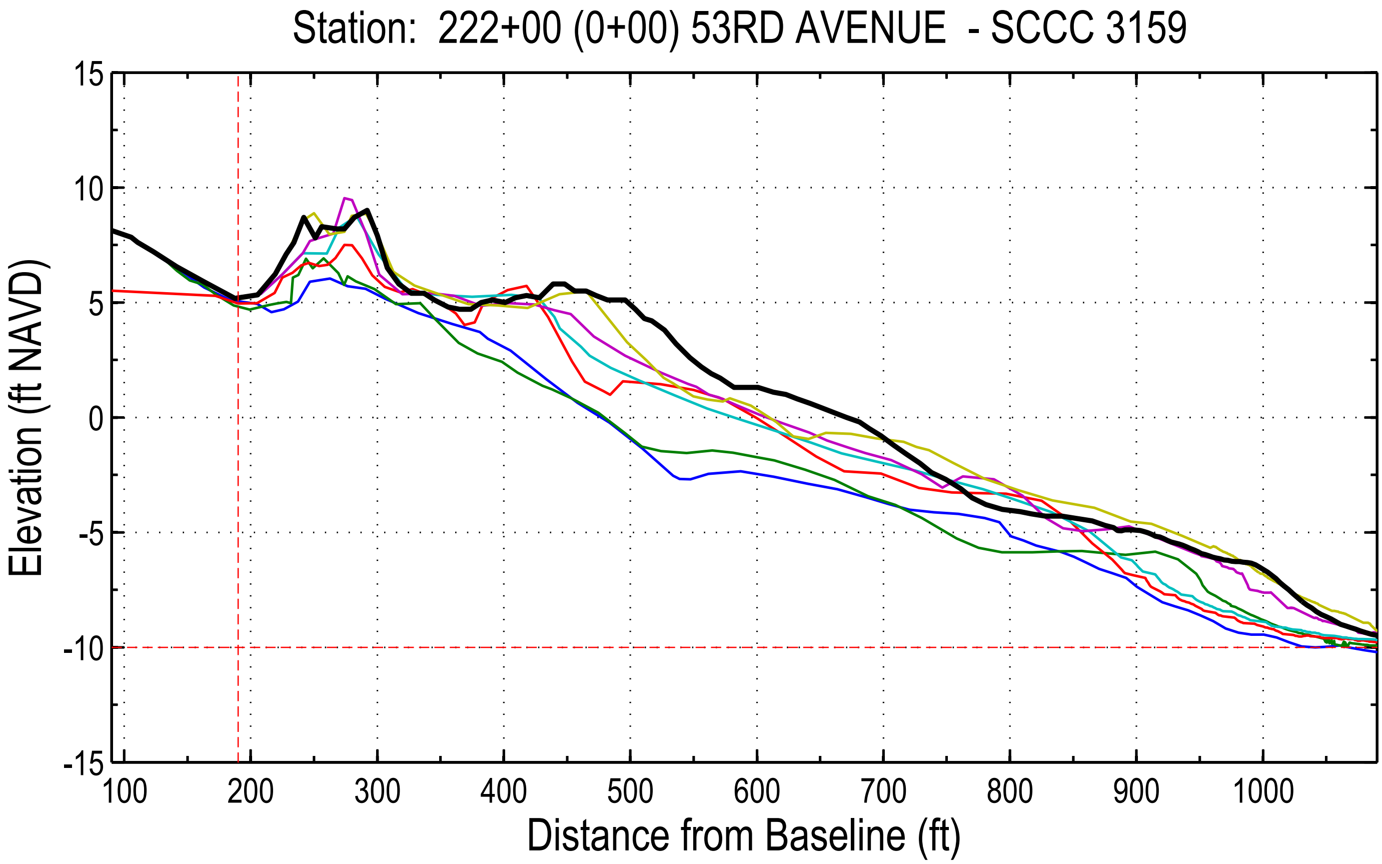
3500
4000
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 222+00 (0+00) 53RD AVENUE - SCCC 3159
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
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700
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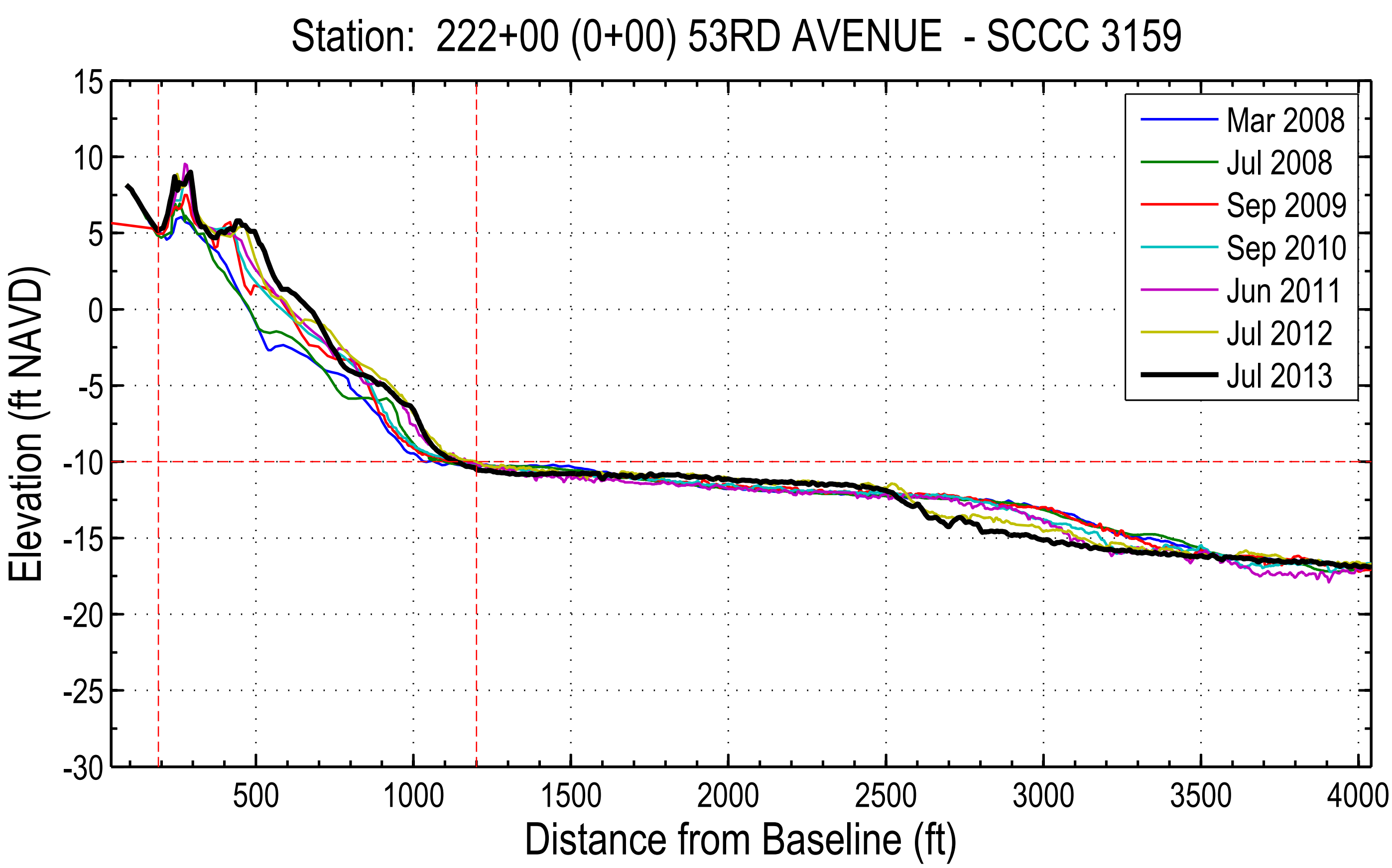

Station: 222+00 (0+00) 53RD AVENUE - SCCC 3159
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
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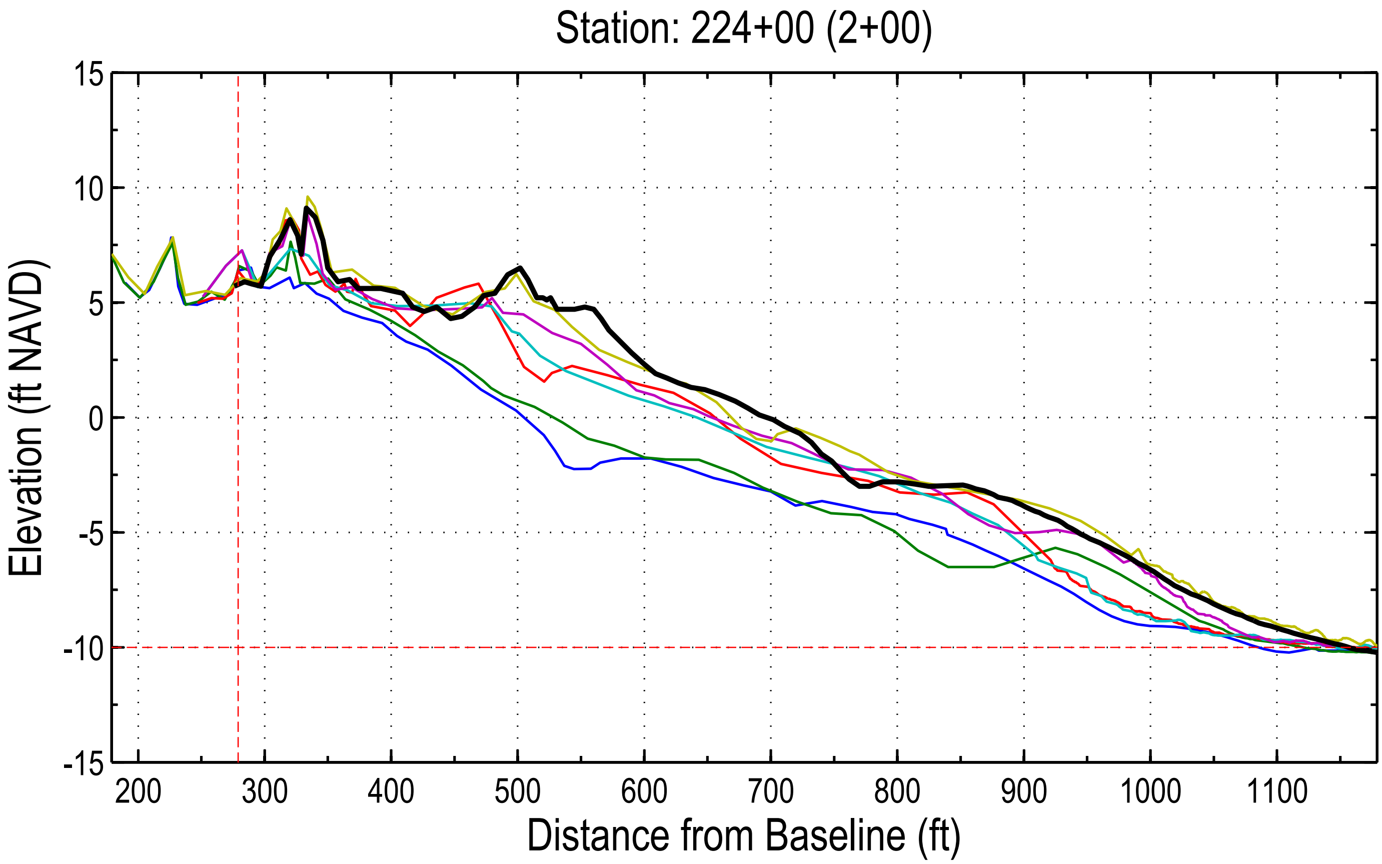
Station: 224+00 (2+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
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0
-5
-10
-15
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300
400
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600
700
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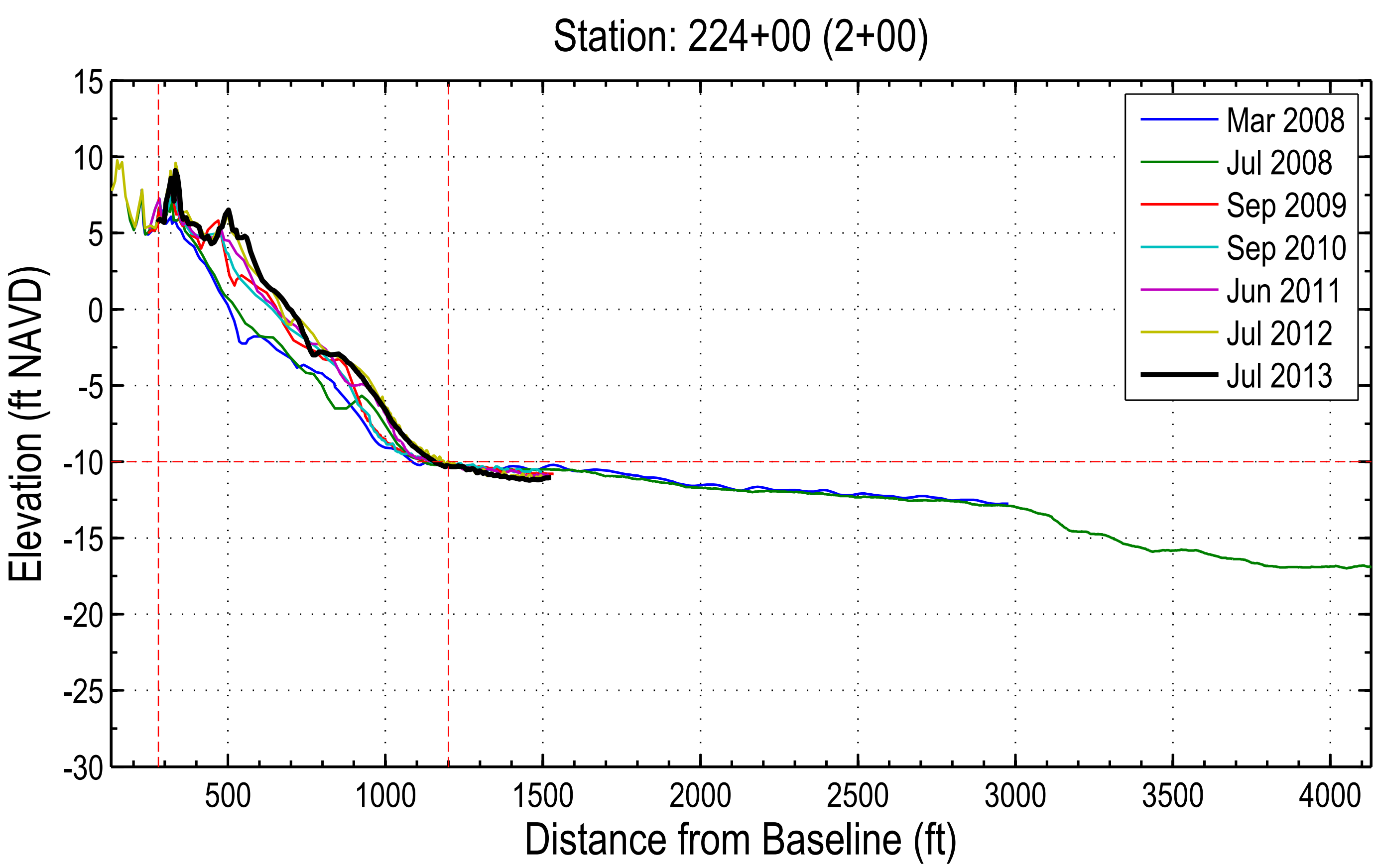
900
1000
1100


Station: 224+00 (2+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
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-25
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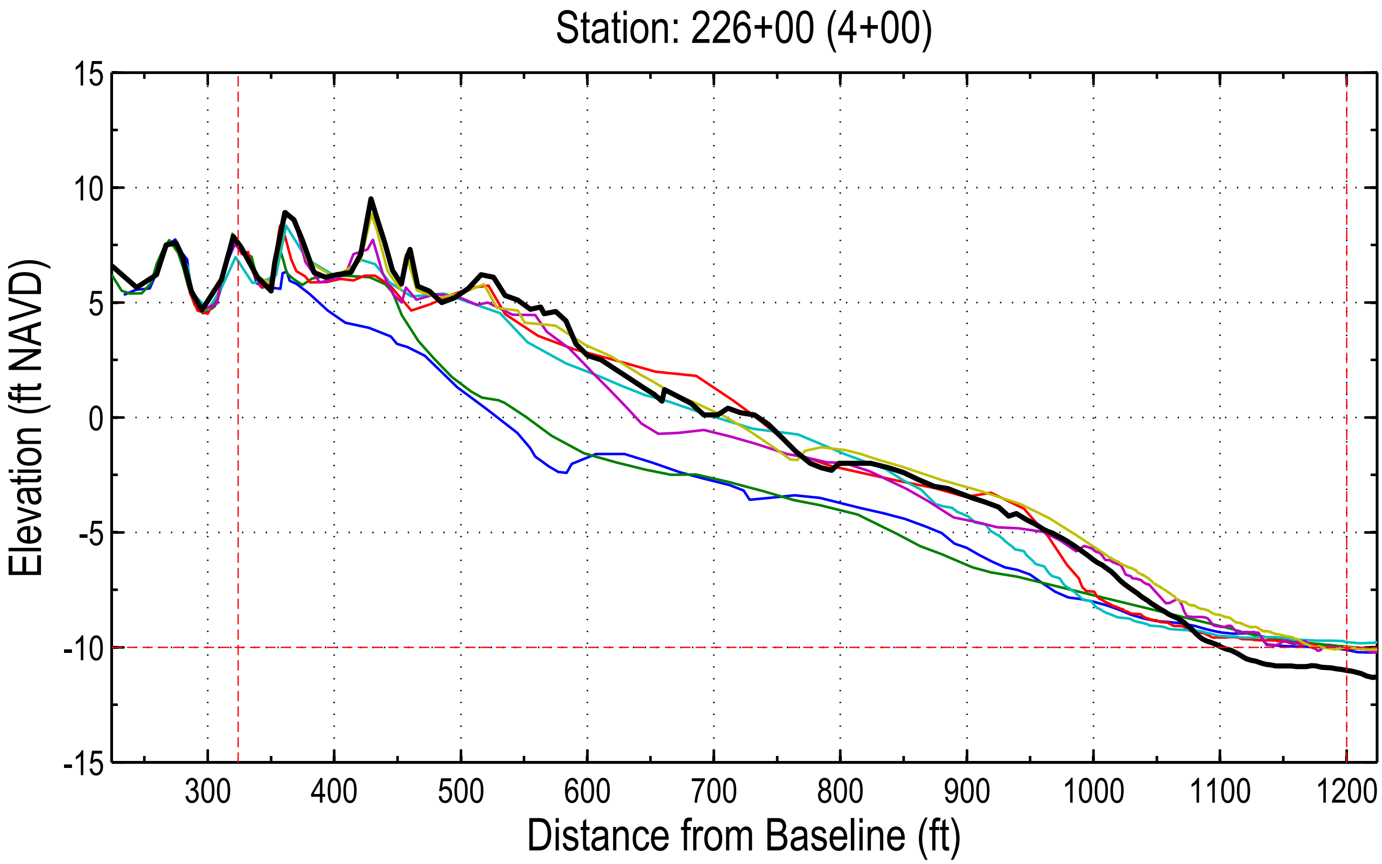

Station: 226+00 (4+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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-10
-15
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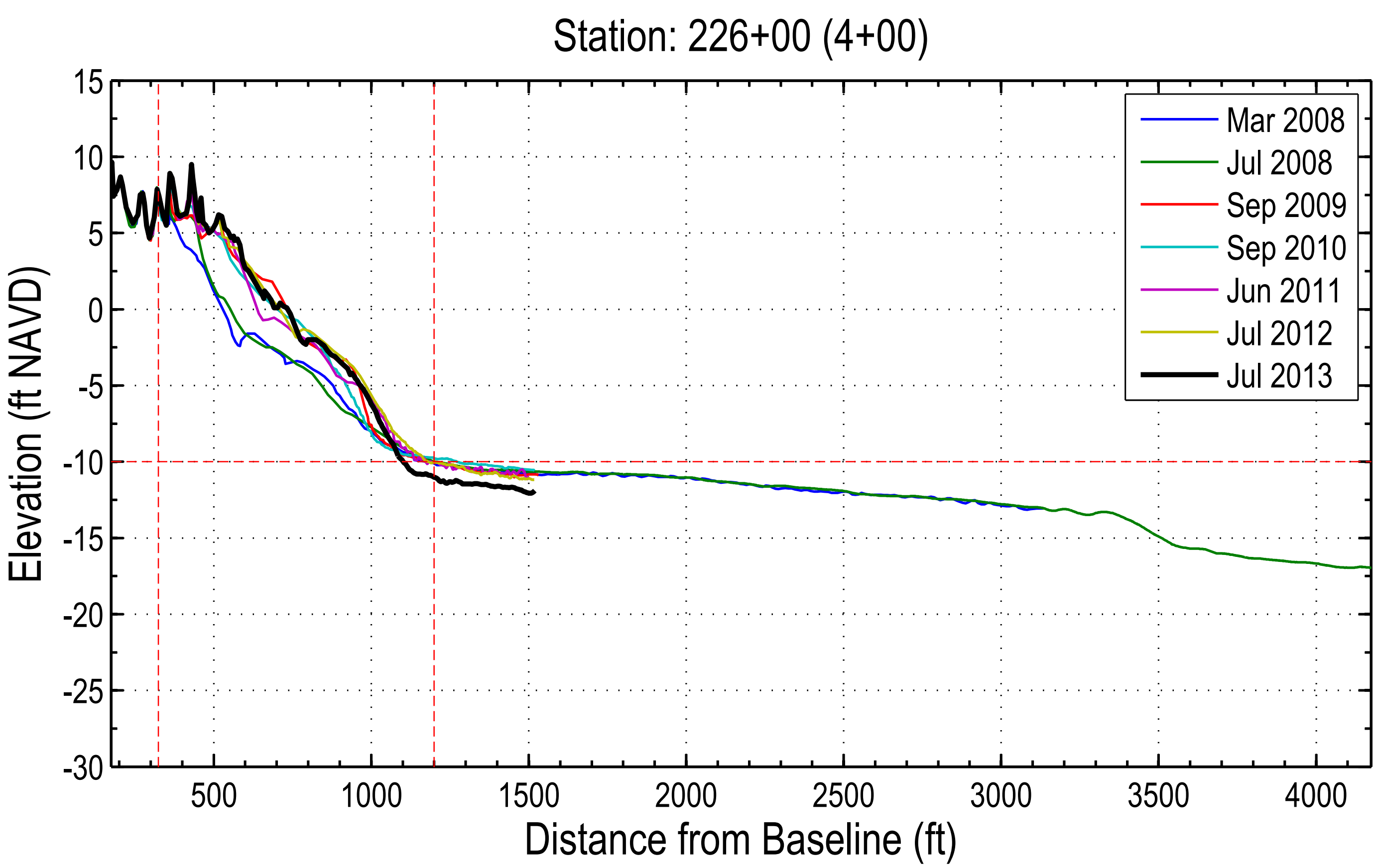
1000
1100
1200



Station: 226+00 (4+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
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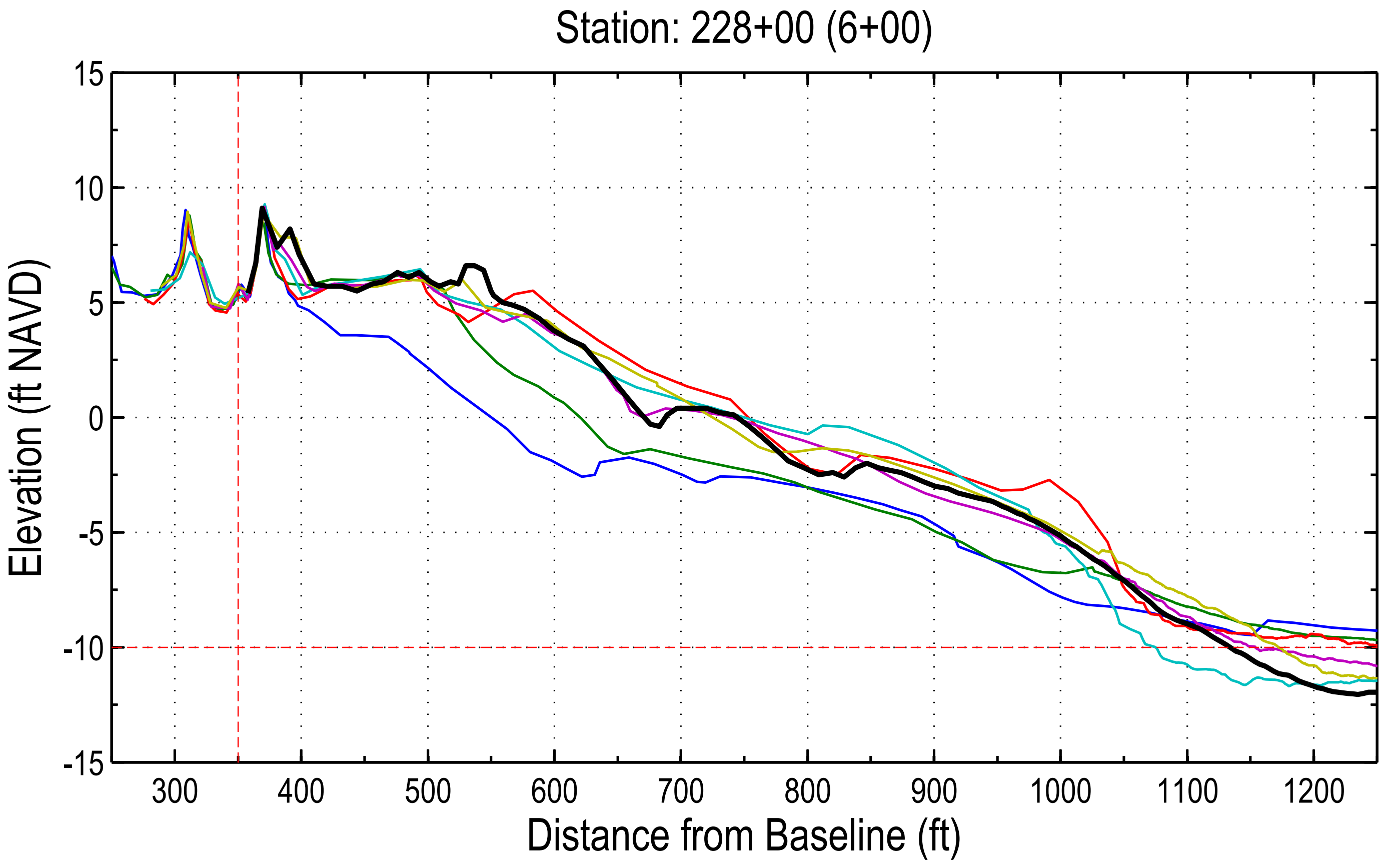
3500
4000



Station: 228+00 (6+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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10
5
0
-5
-10
-15
300
400
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600
700
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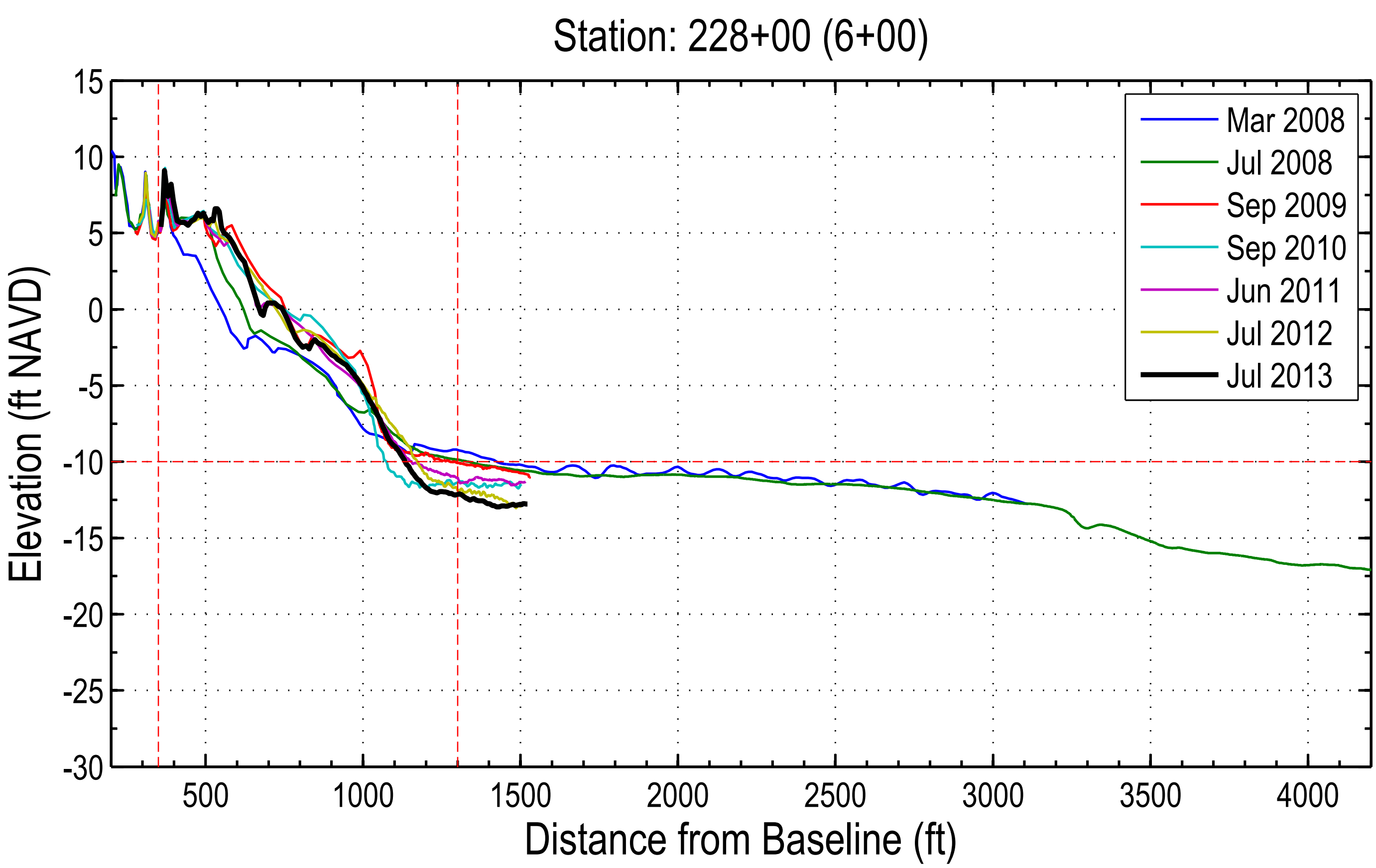
900
1000
1100
1200



Station: 228+00 (6+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
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-10
-15
-20
-25
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500
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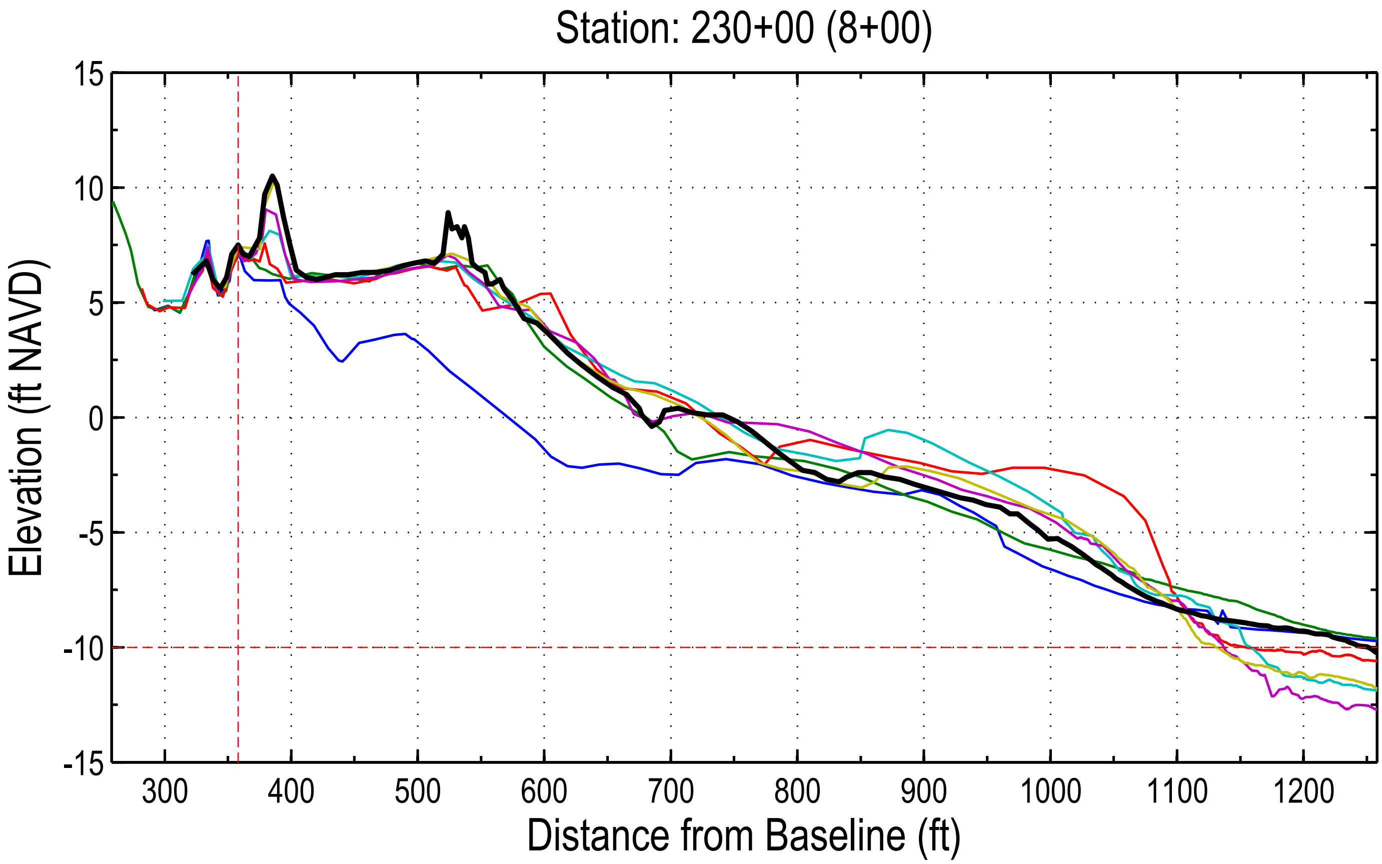
3500
4000
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 230+00 (8+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
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-5
-10
-15
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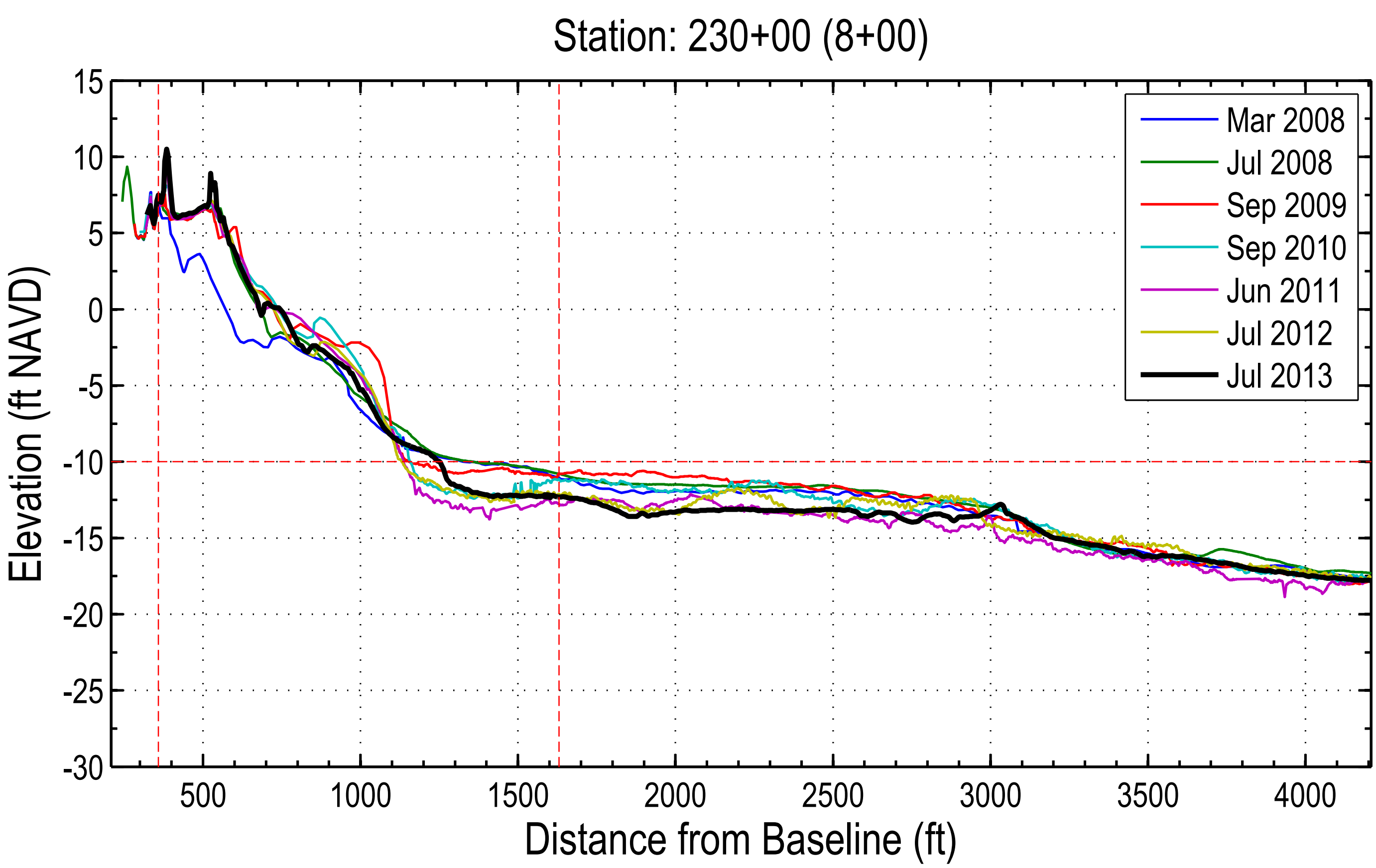
800
900
1000
1100
1200


Station: 230+00 (8+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
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-5
-10
-15
-20
-25
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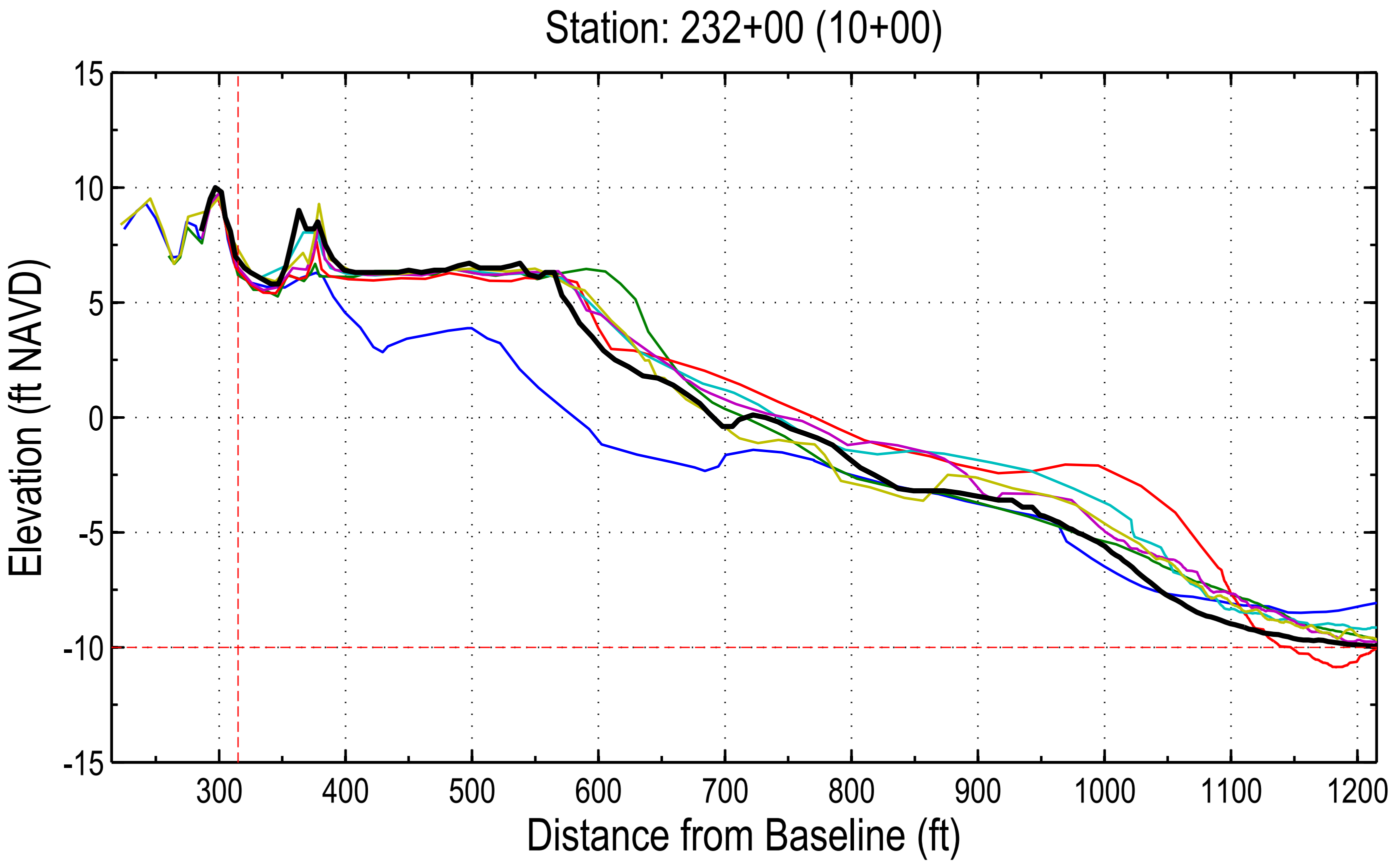
3500
4000



Station: 232+00 (10+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
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-5
-10
-15
300
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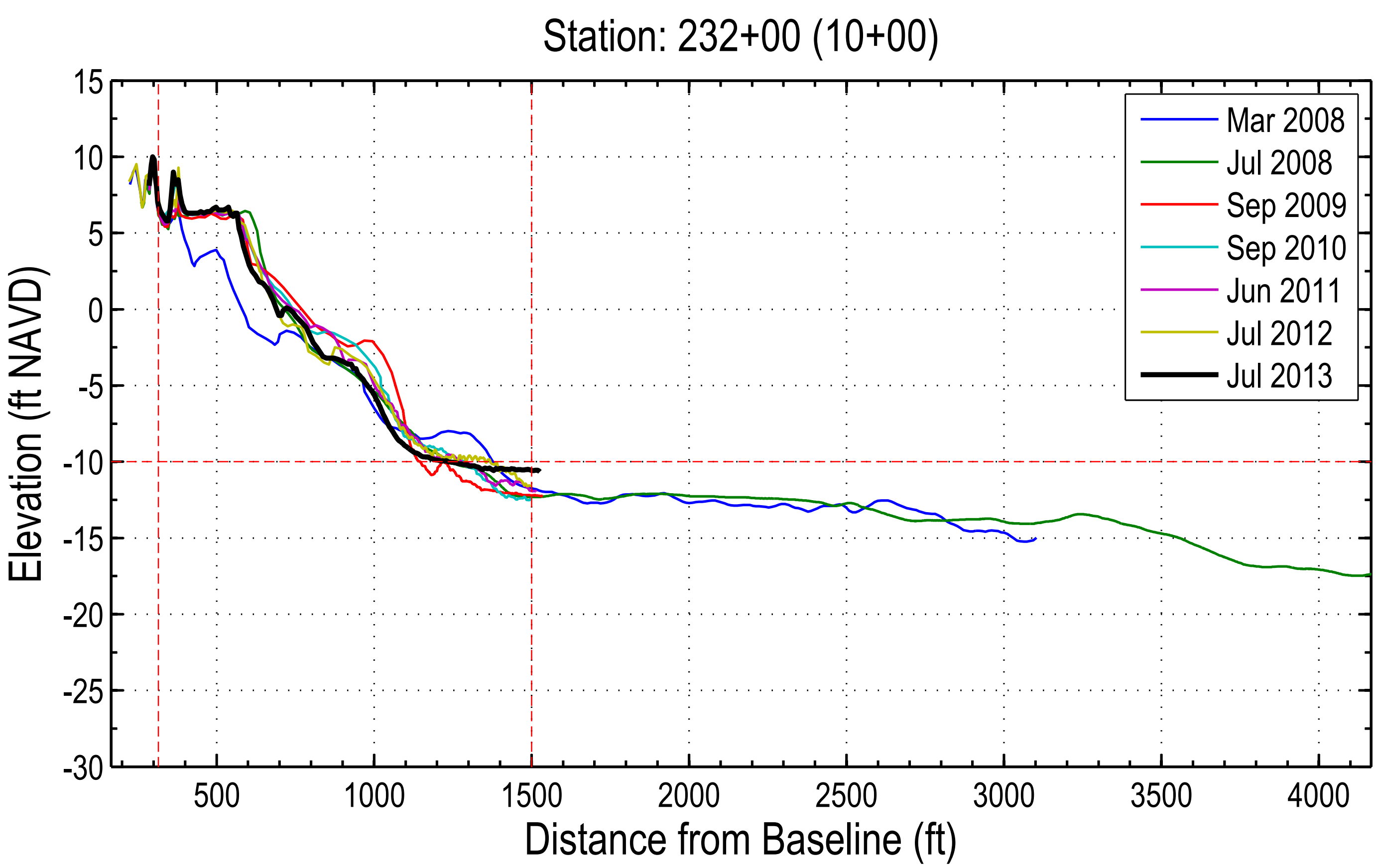
600
700
800
900
1000
1100
1200



Station: 232+00 (10+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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-5
-10
-15
-20
-25
-30
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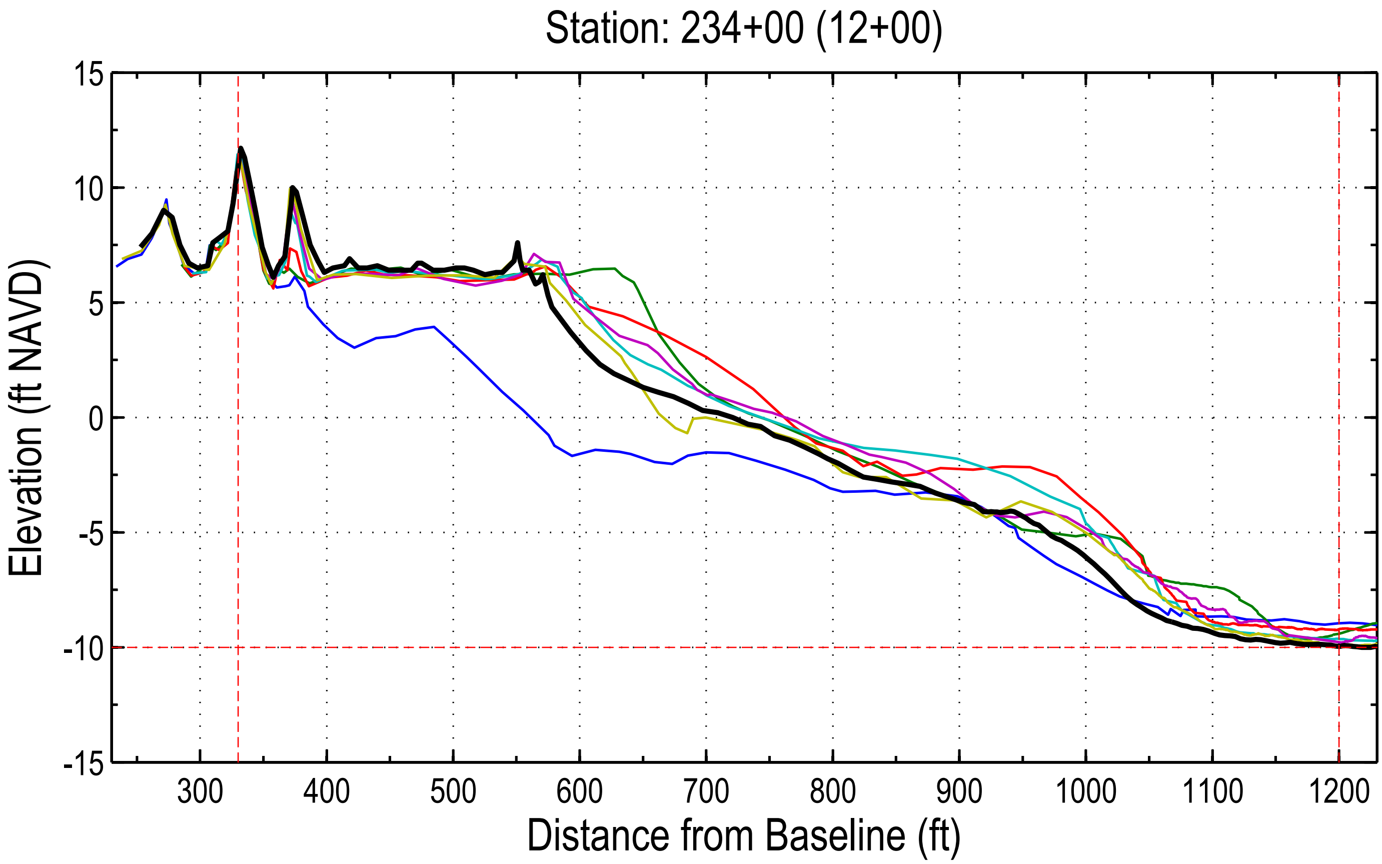
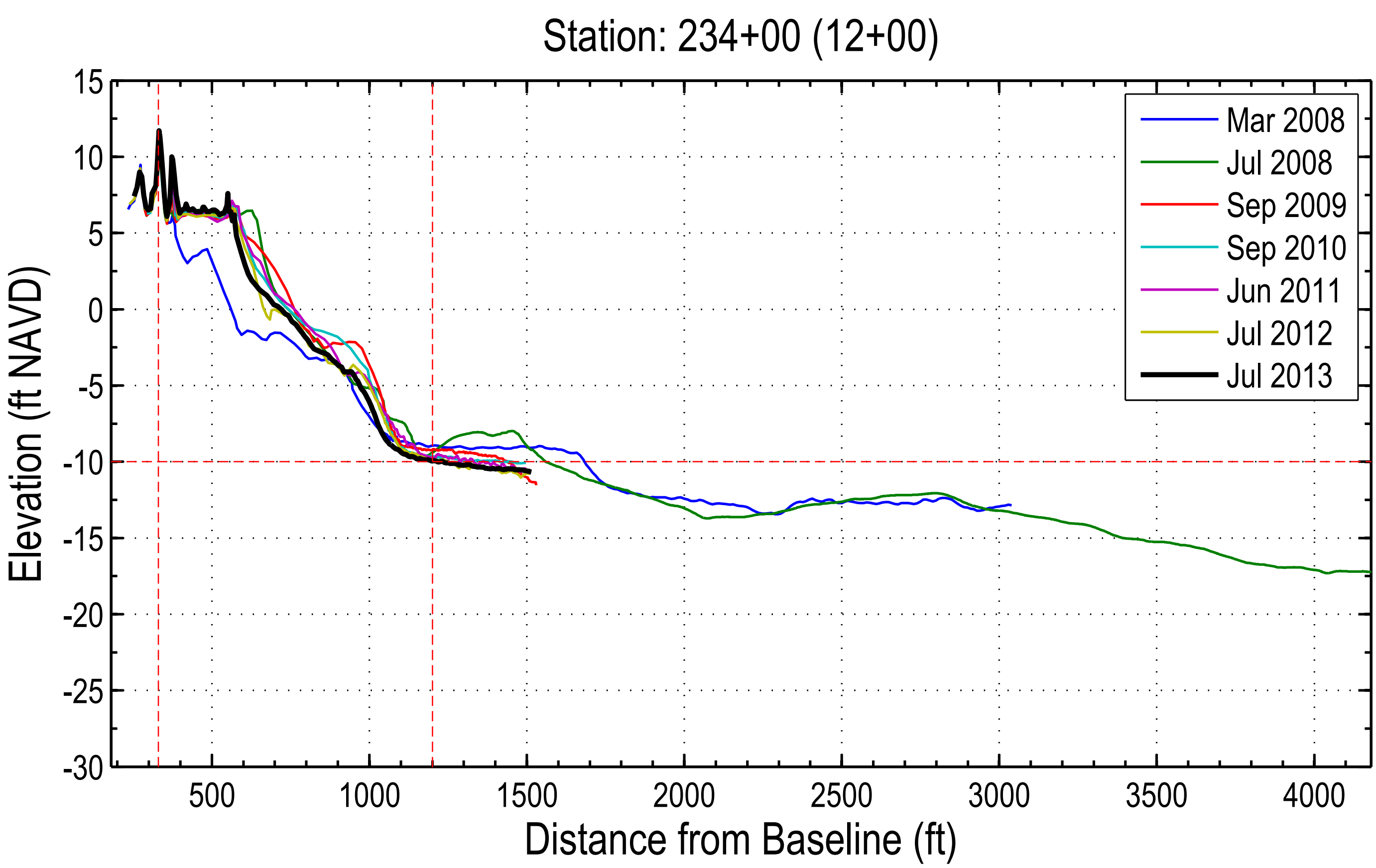
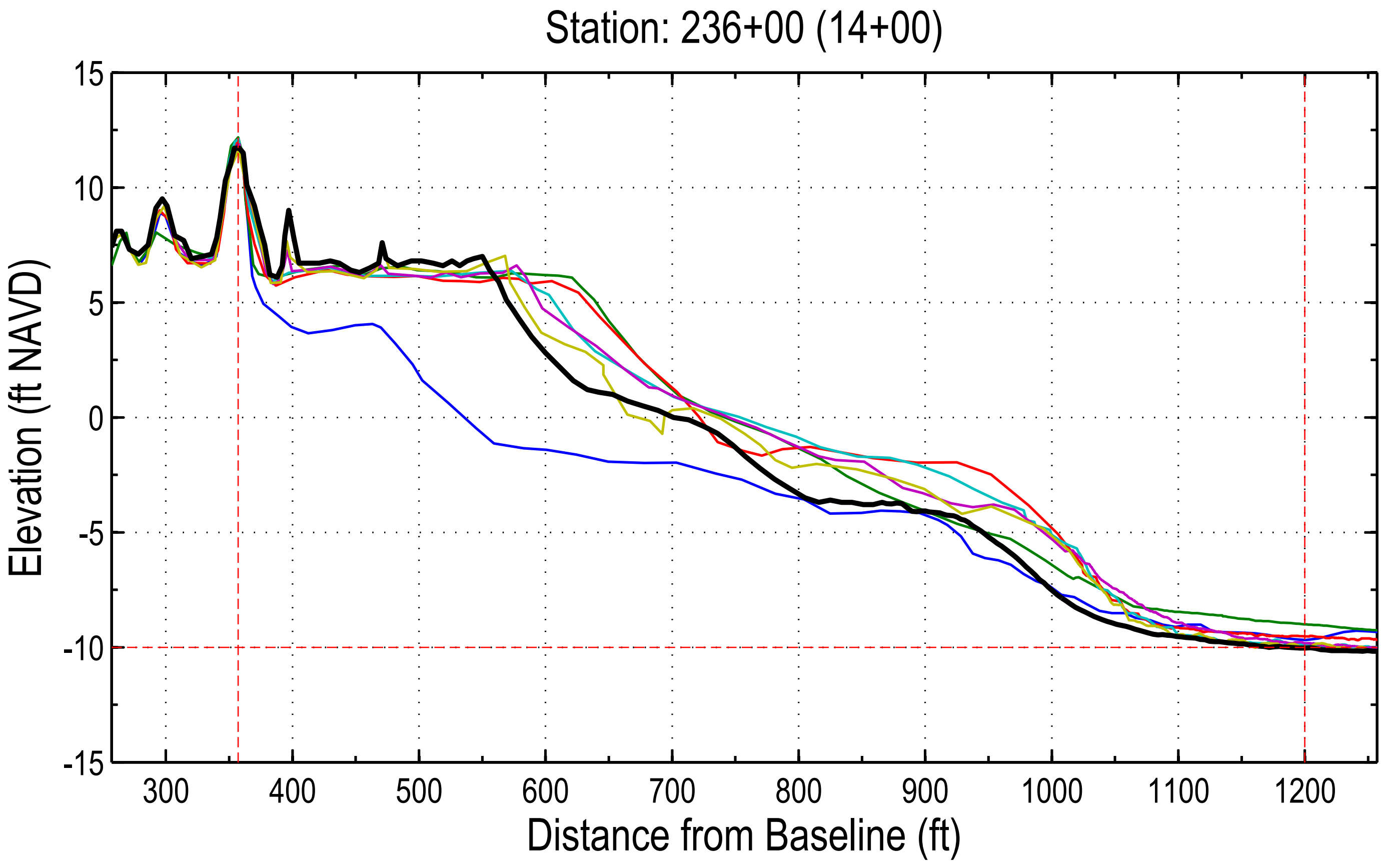
1000
1500
2000
2500
3000
3500
4000
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 234+00 (12+00)
Elevation (ft NAVD)
Distance from Baseline (ft)



Station: 234+00 (12+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 236+00 (14+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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10
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-5
-10
-15
300
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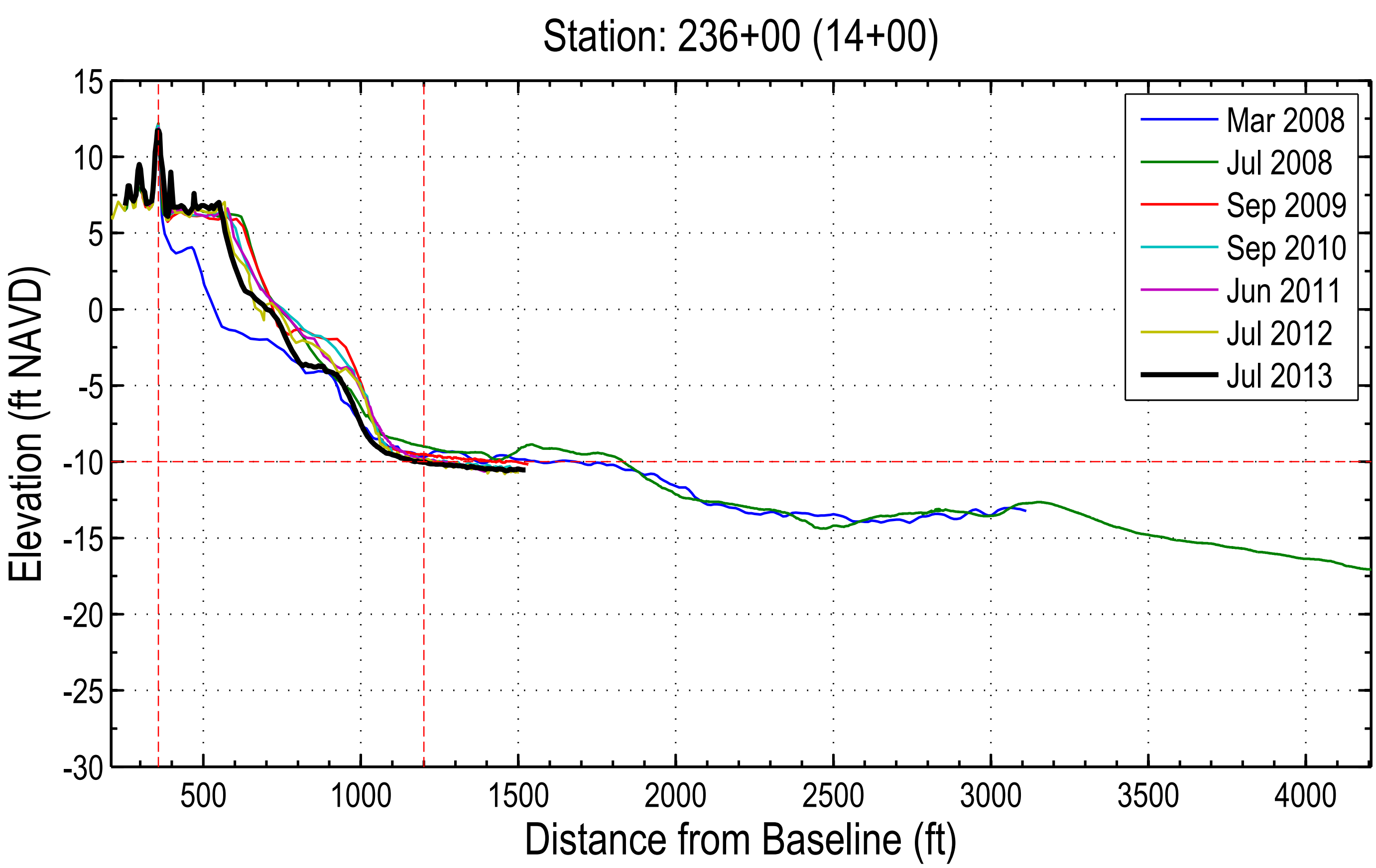
900
1000
1100
1200


Station: 236+00 (14+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
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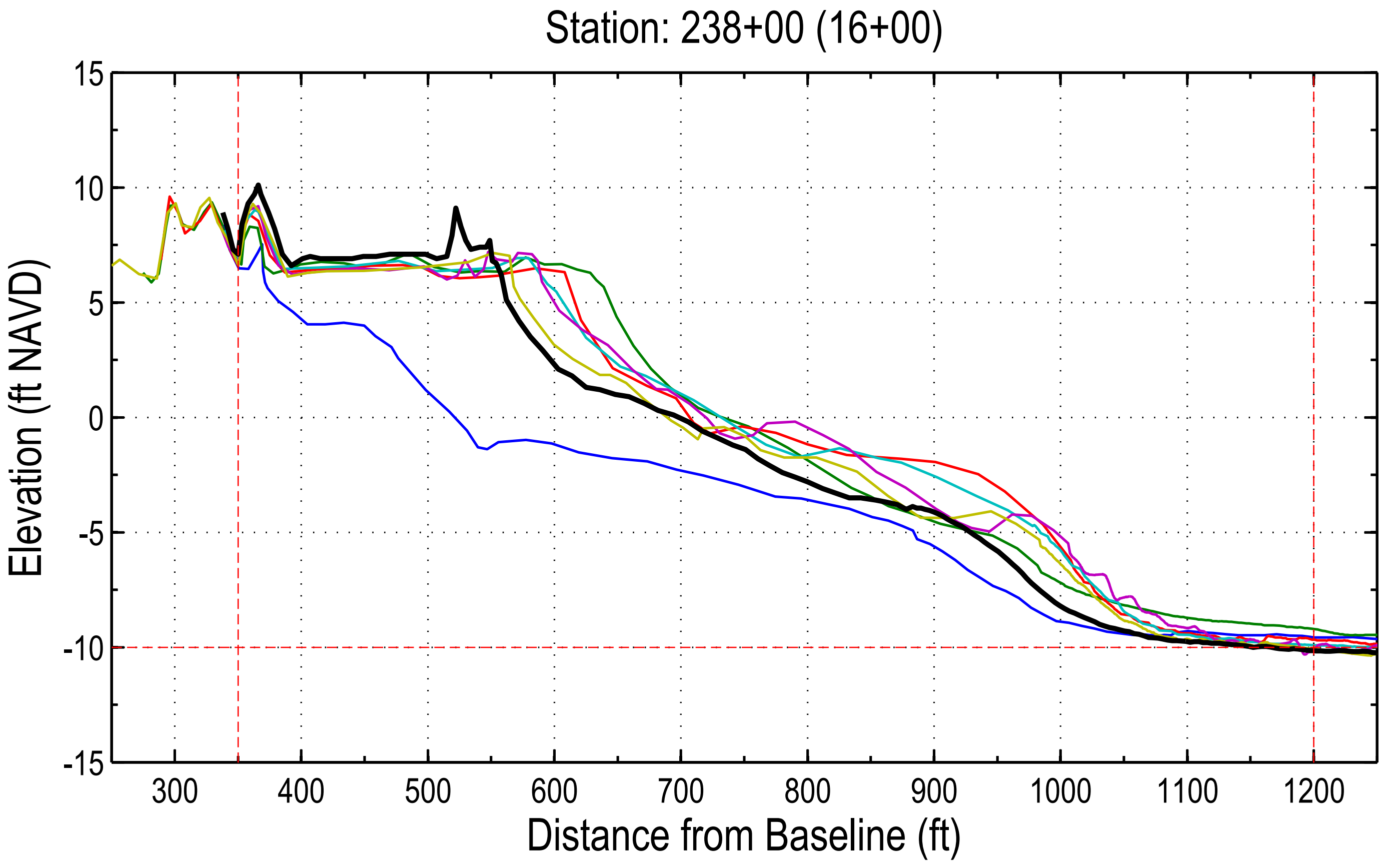
3500
4000



Station: 238+00 (16+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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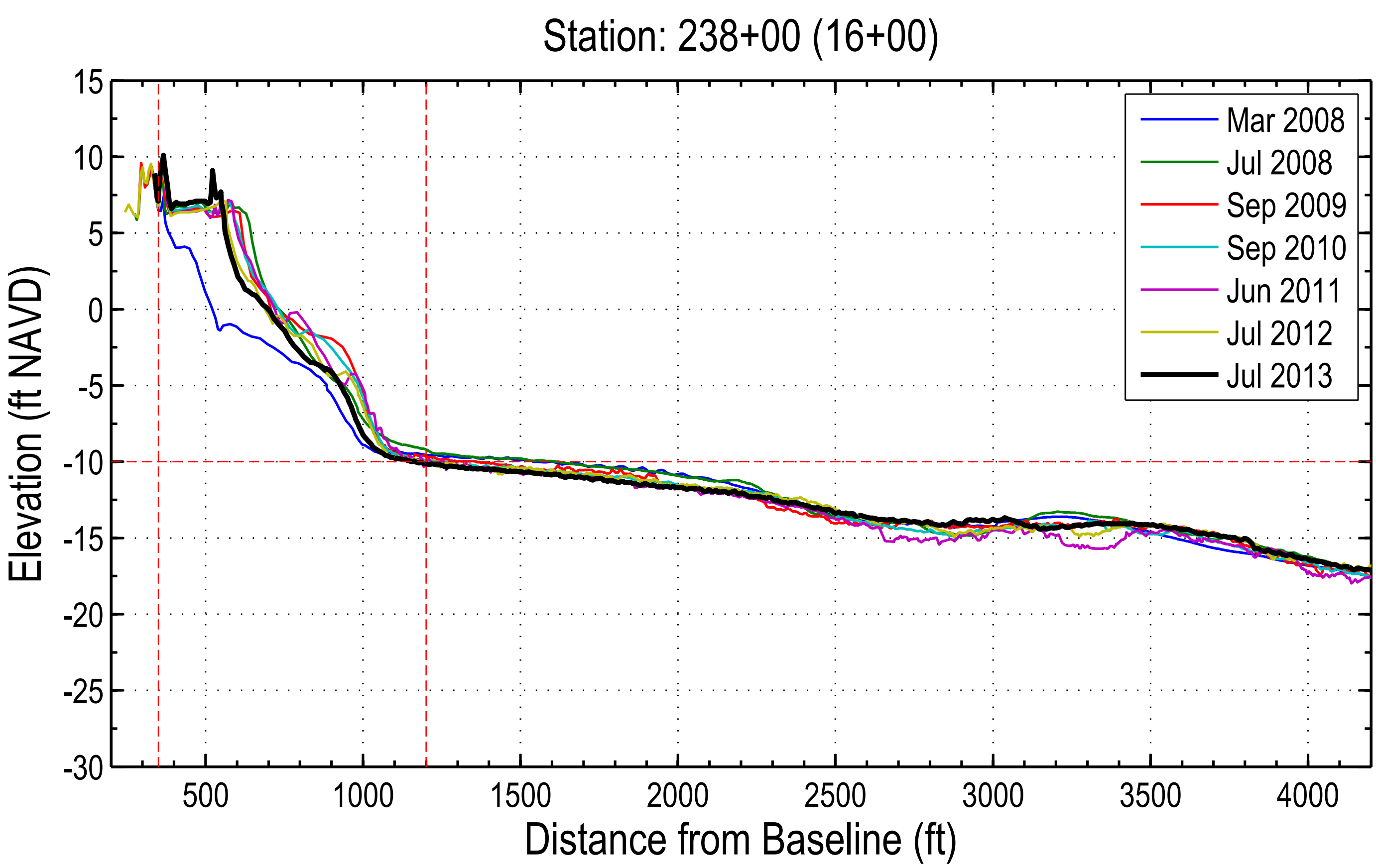
10
5
0
-5
-10
-15
300
400
500
600
700
800
900
1000
1100
1200



Station: 238+00 (16+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
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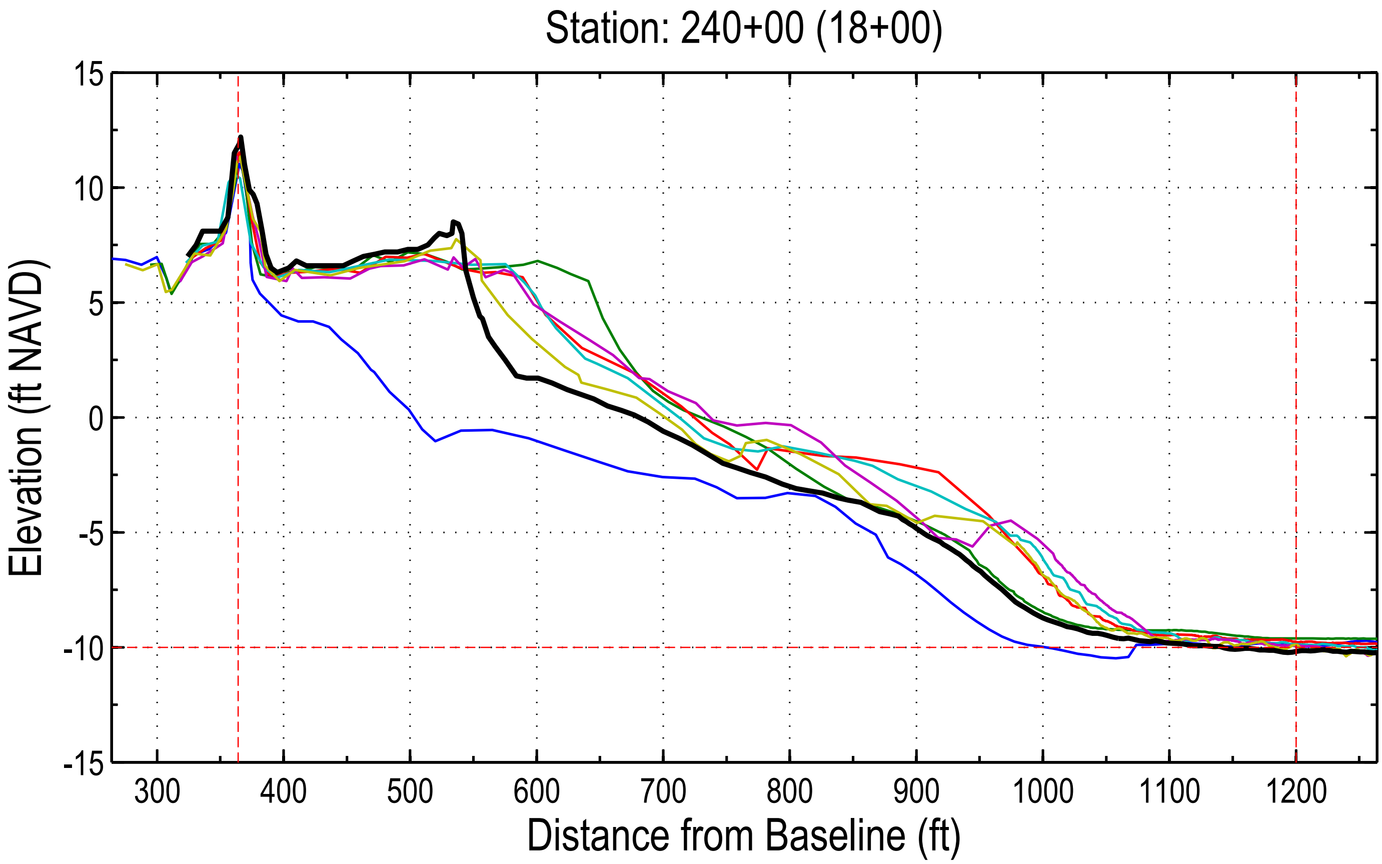

Station: 240+00 (18+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
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-5
-10
-15
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600
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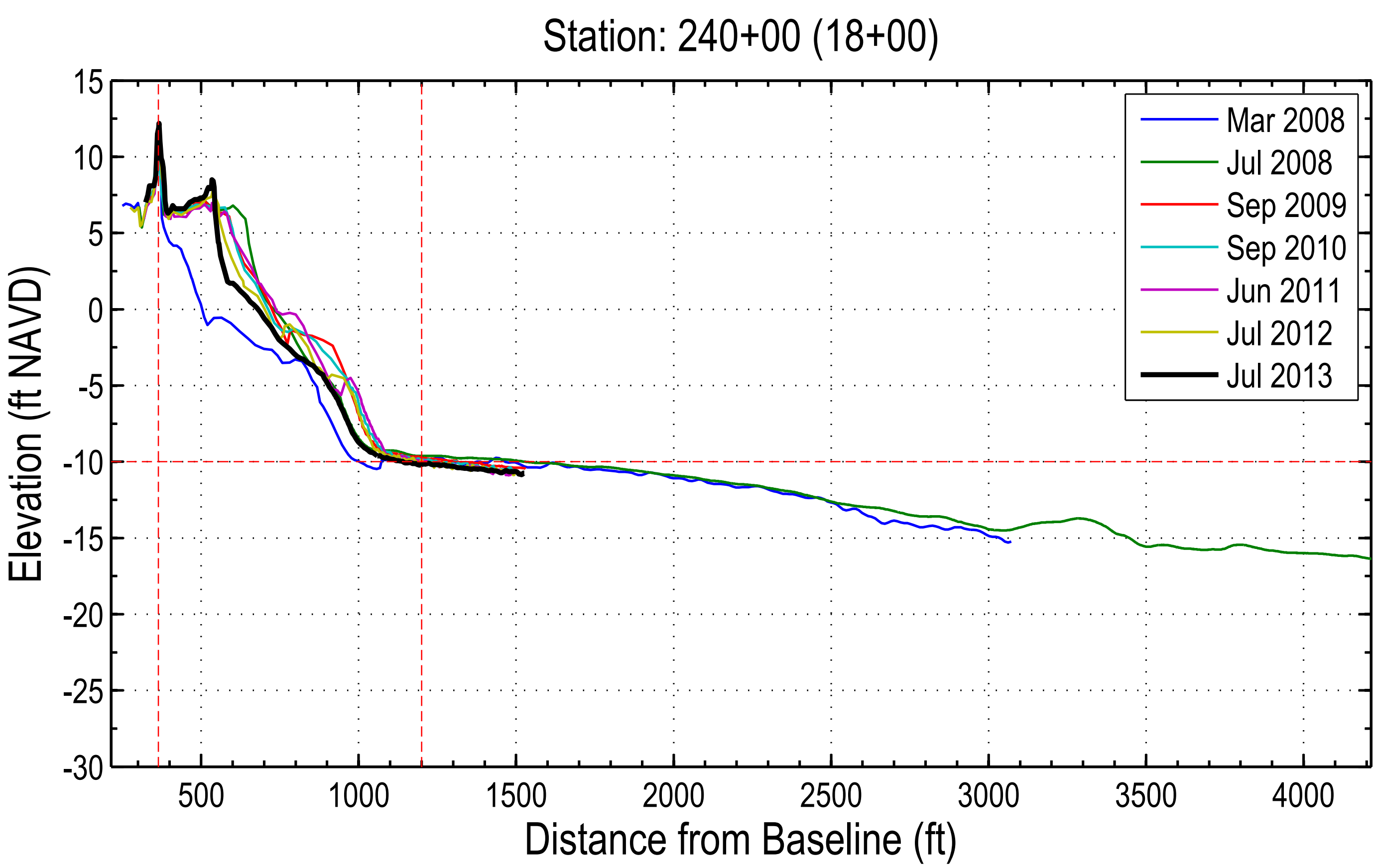
800
900
1000
1100
1200



Station: 240+00 (18+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
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2500
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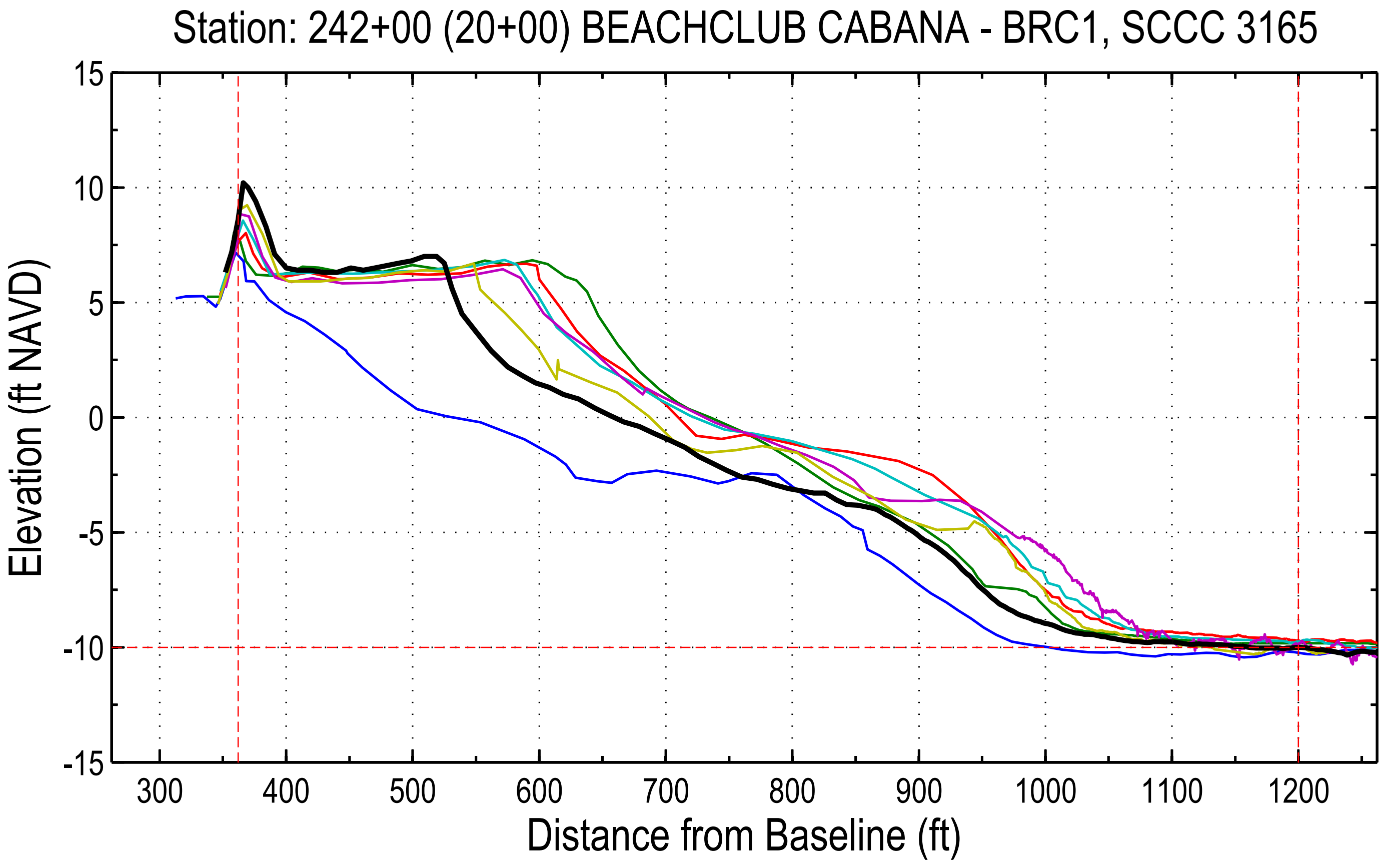
3500
4000


Station: 242+00 (20+00) BEACHCLUB CABANA - BRC1, SCCC 3165
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
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700
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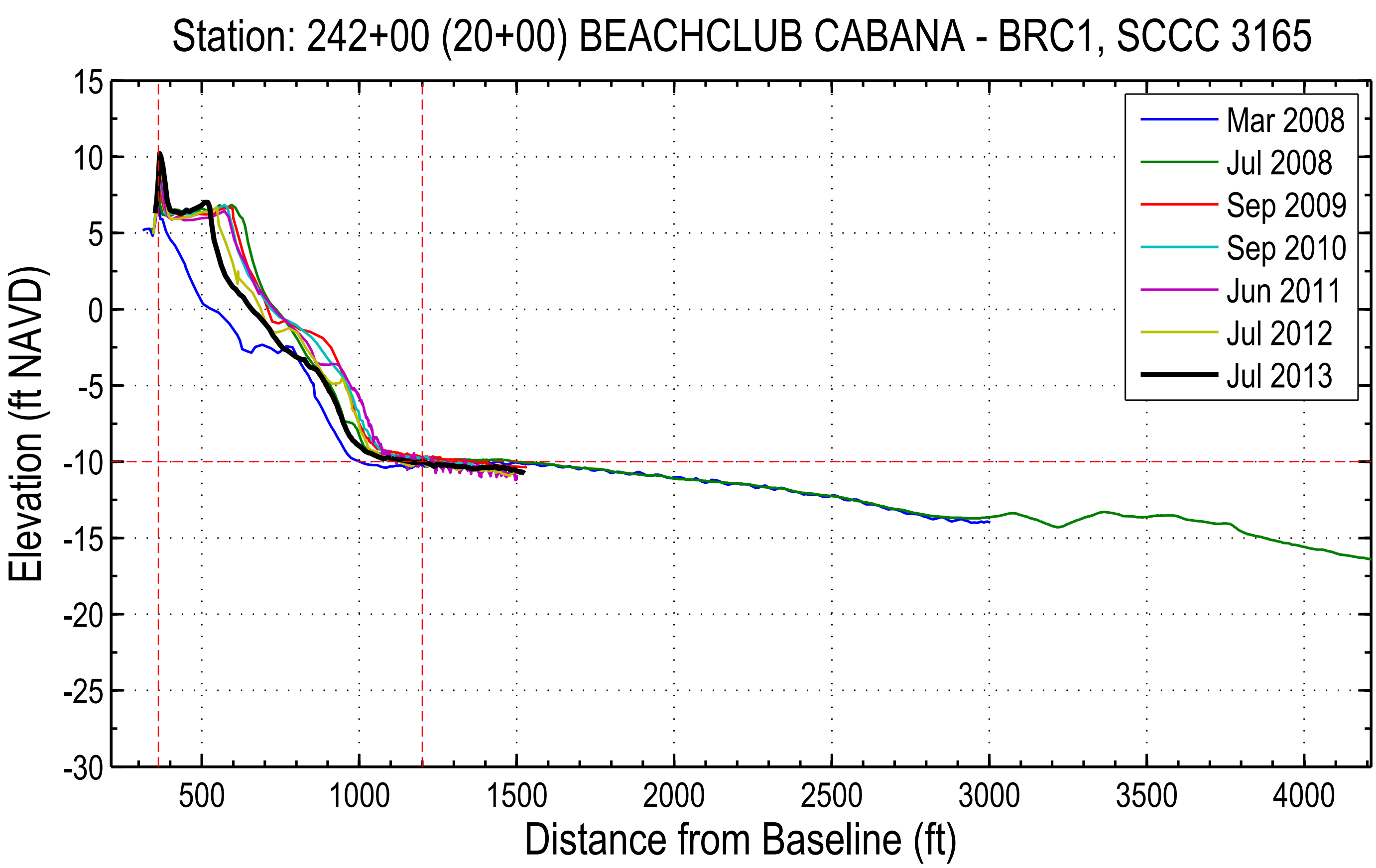
1100
1200


Station: 242+00 (20+00) BEACHCLUB CABANA - BRC1, SCCC 3165
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
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-15
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-25
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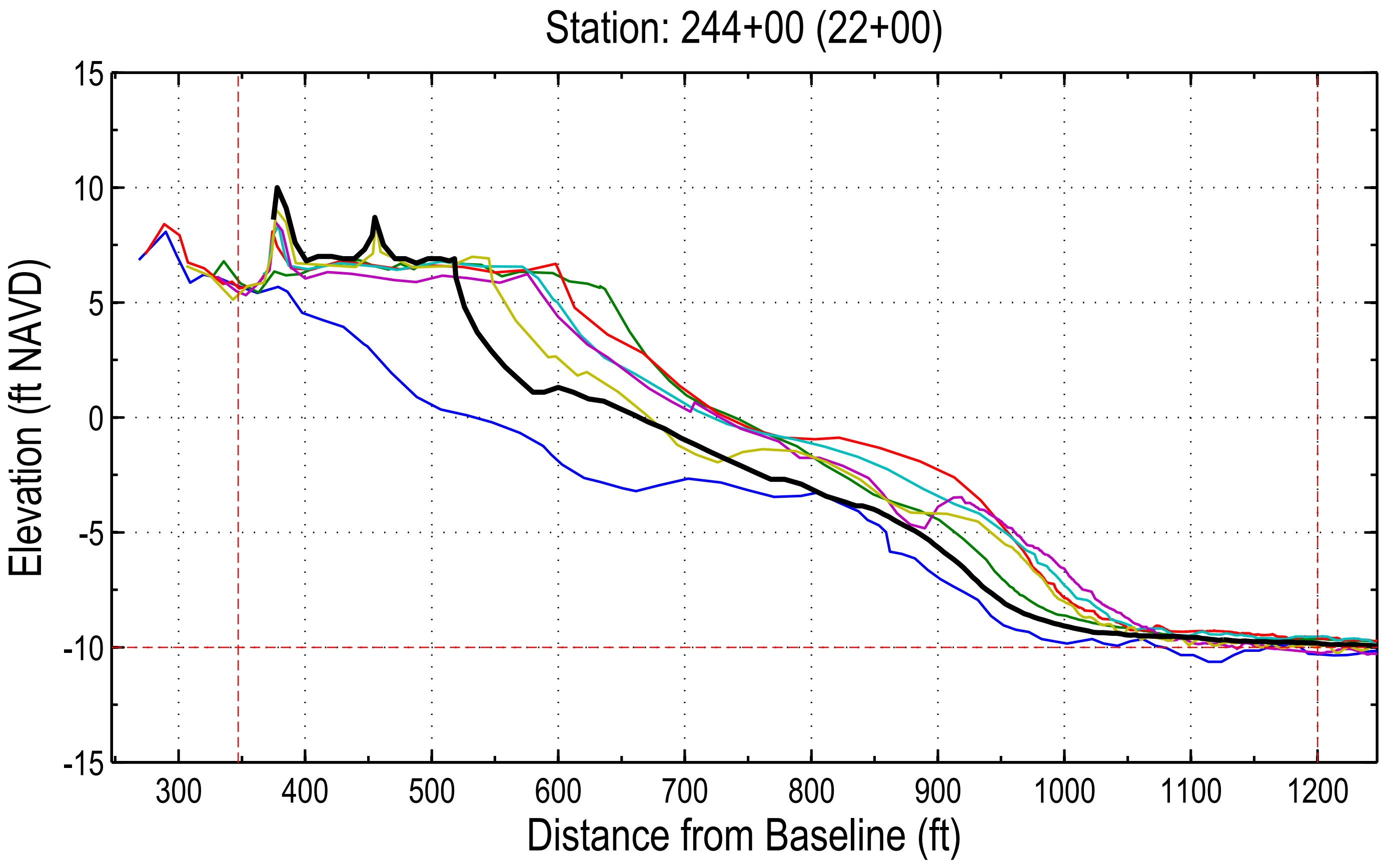
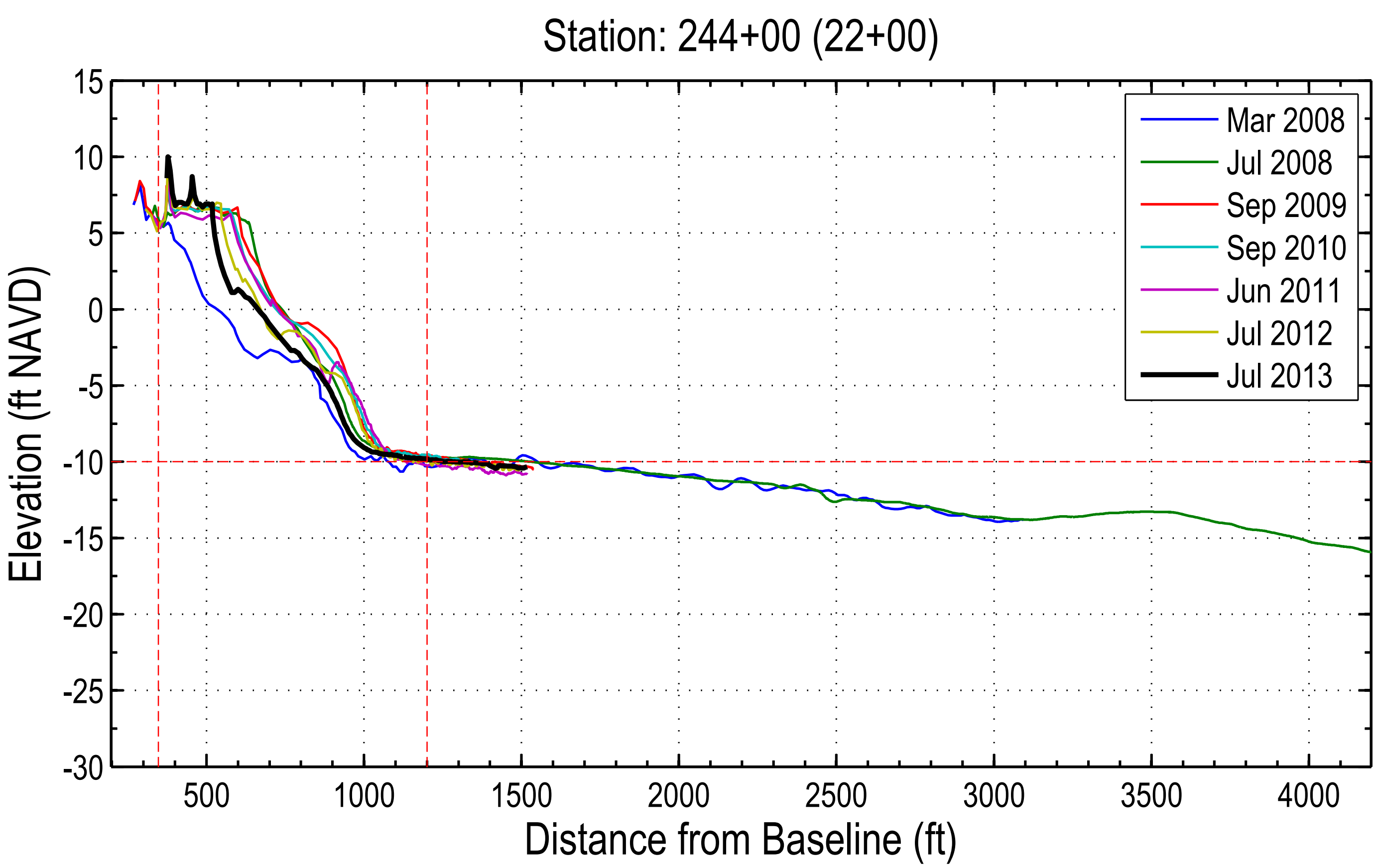
3500
4000



Station: 244+00 (22+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
300
400
500
600
700
800
900
1000
1100
1200



Station: 244+00 (22+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
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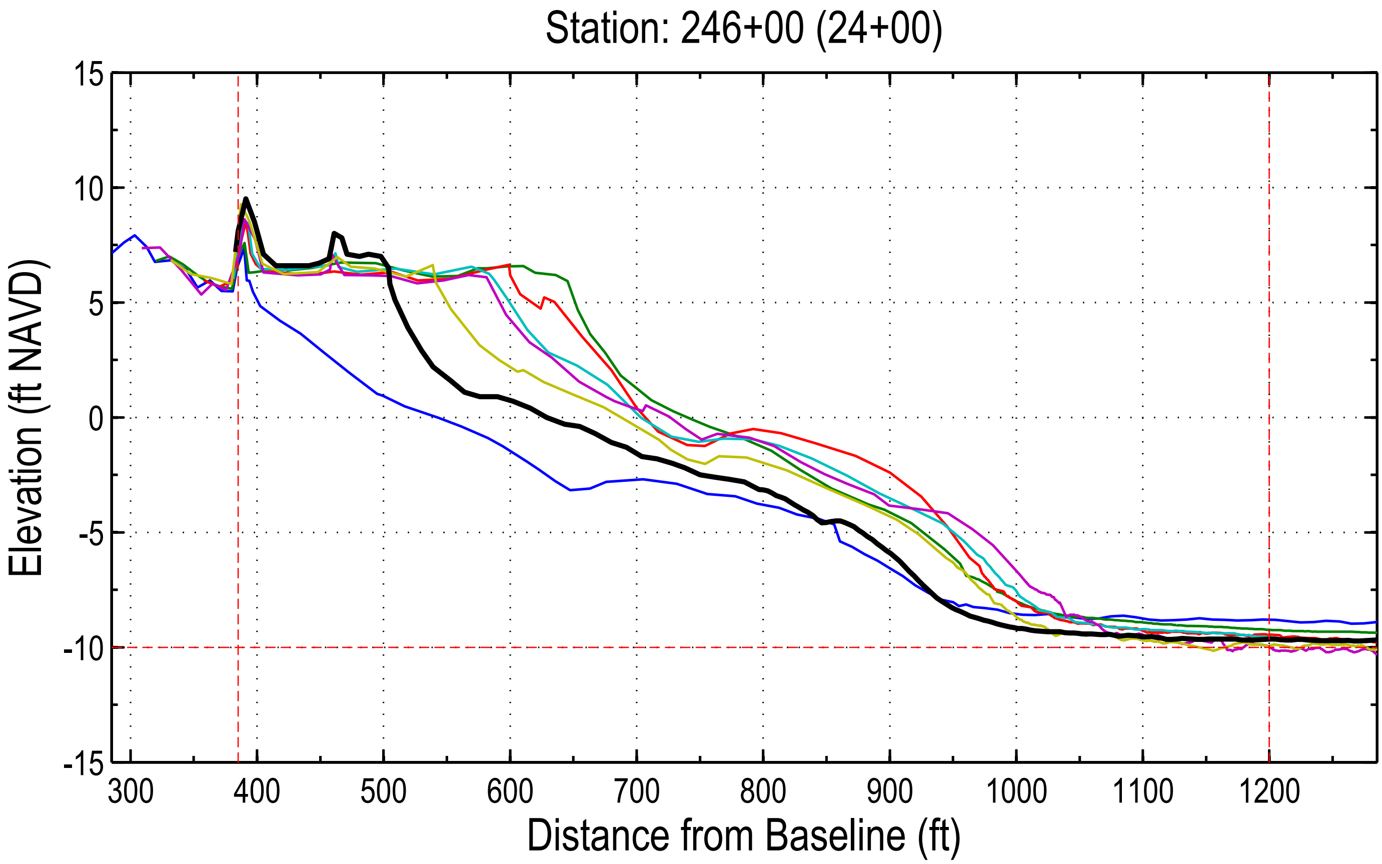
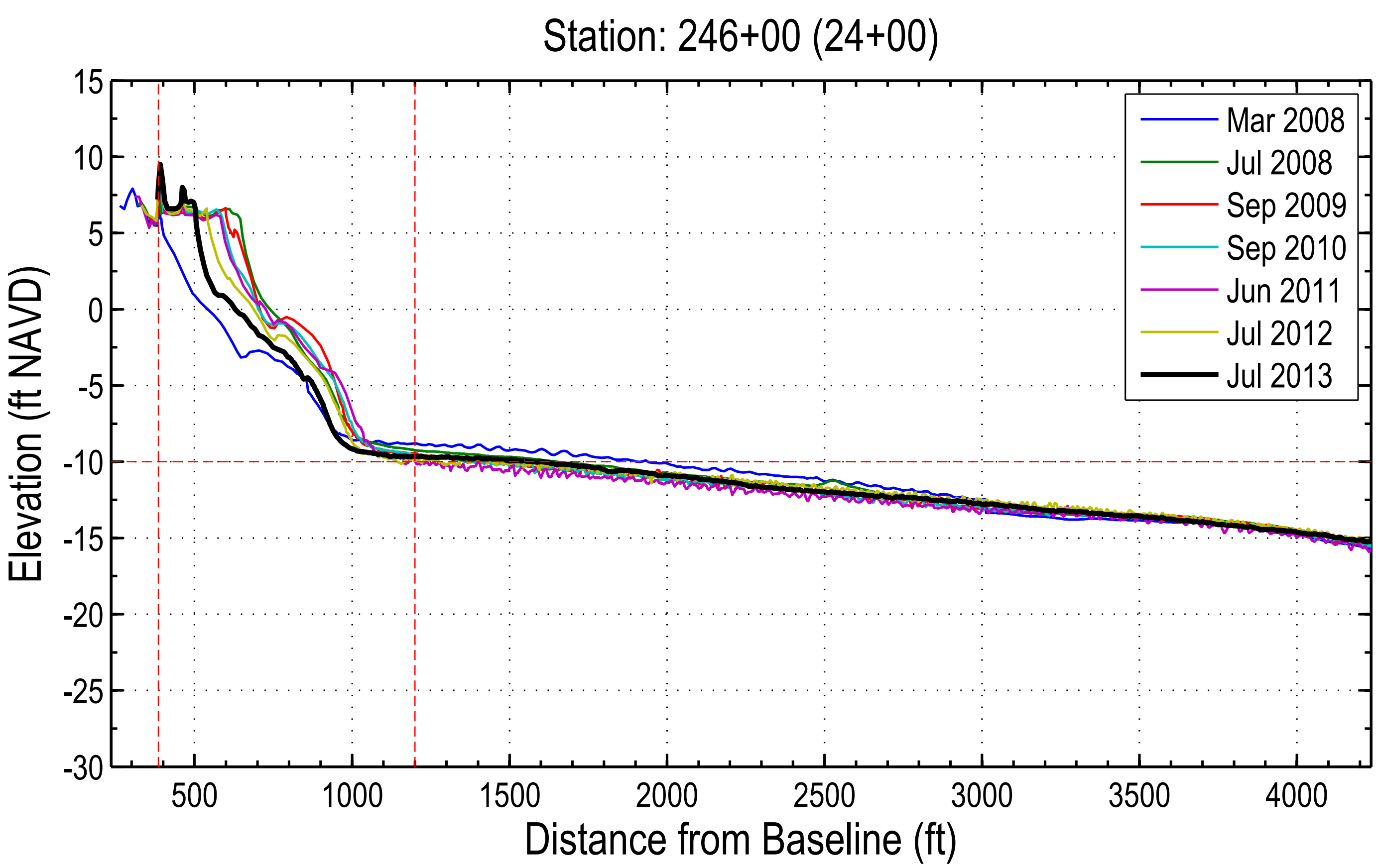
2000
2500
3000
3500
4000



Station: 246+00 (24+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
300
400
500
600
700
800
900
1000
1100
1200



Station: 246+00 (24+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
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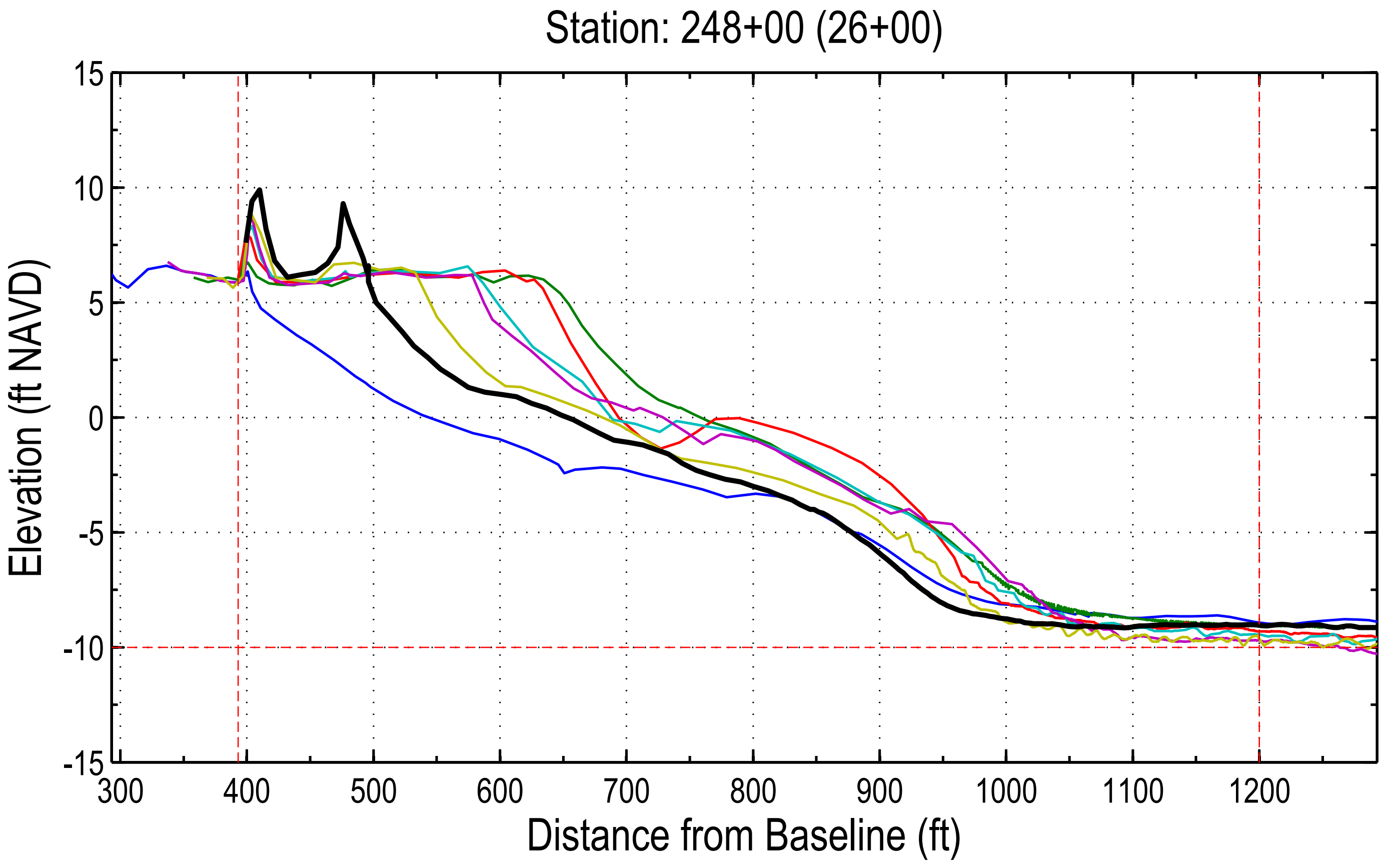
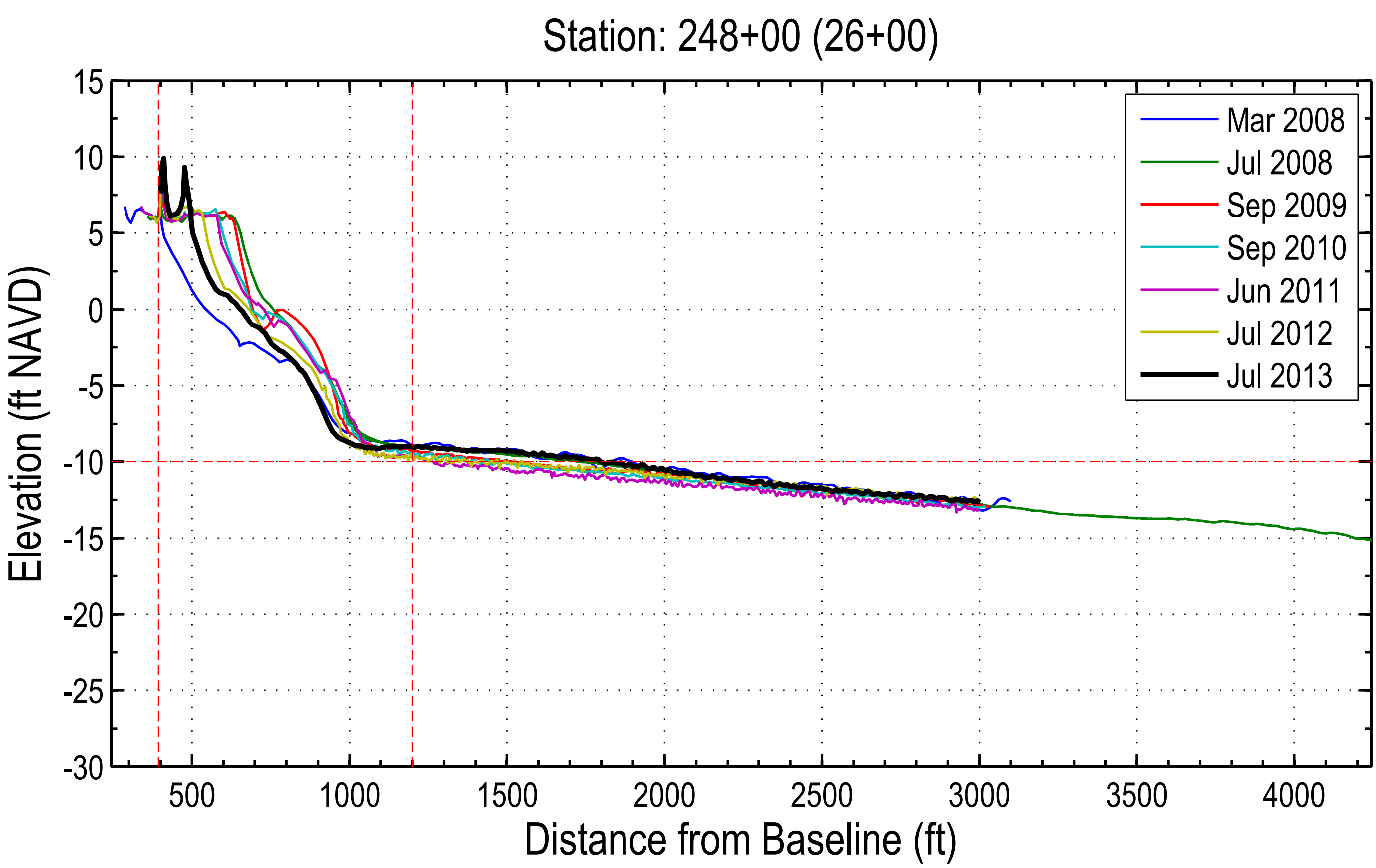
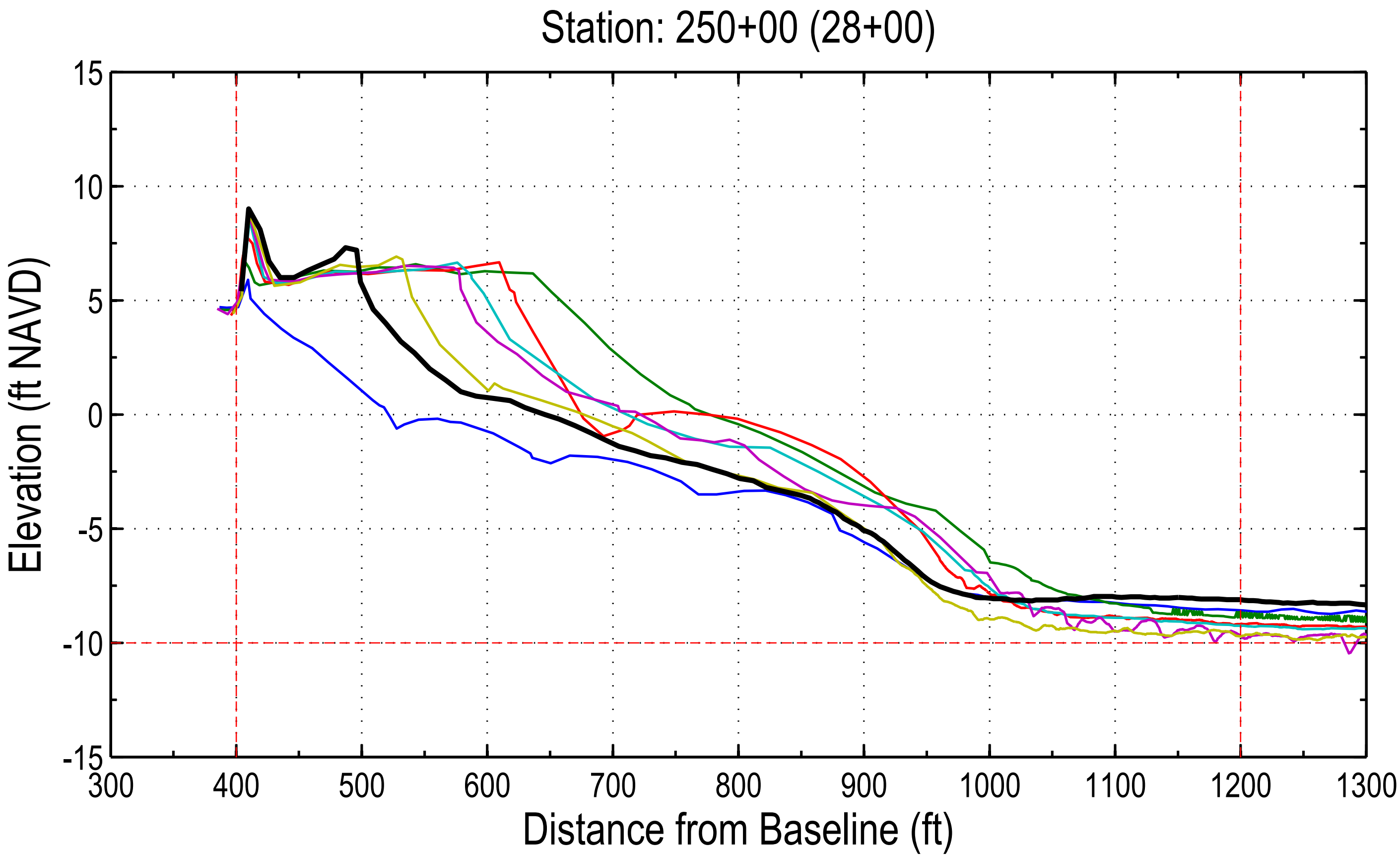
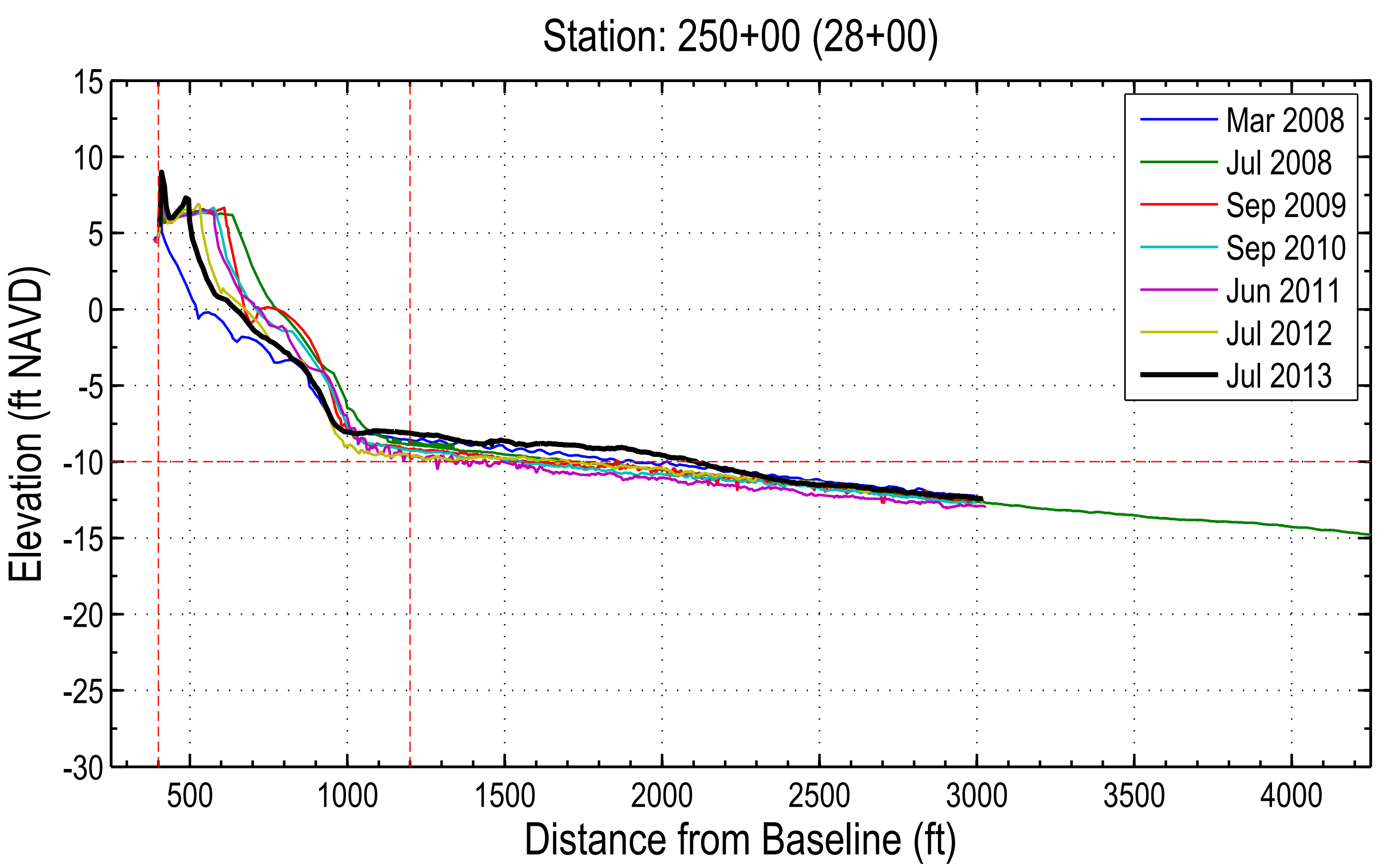
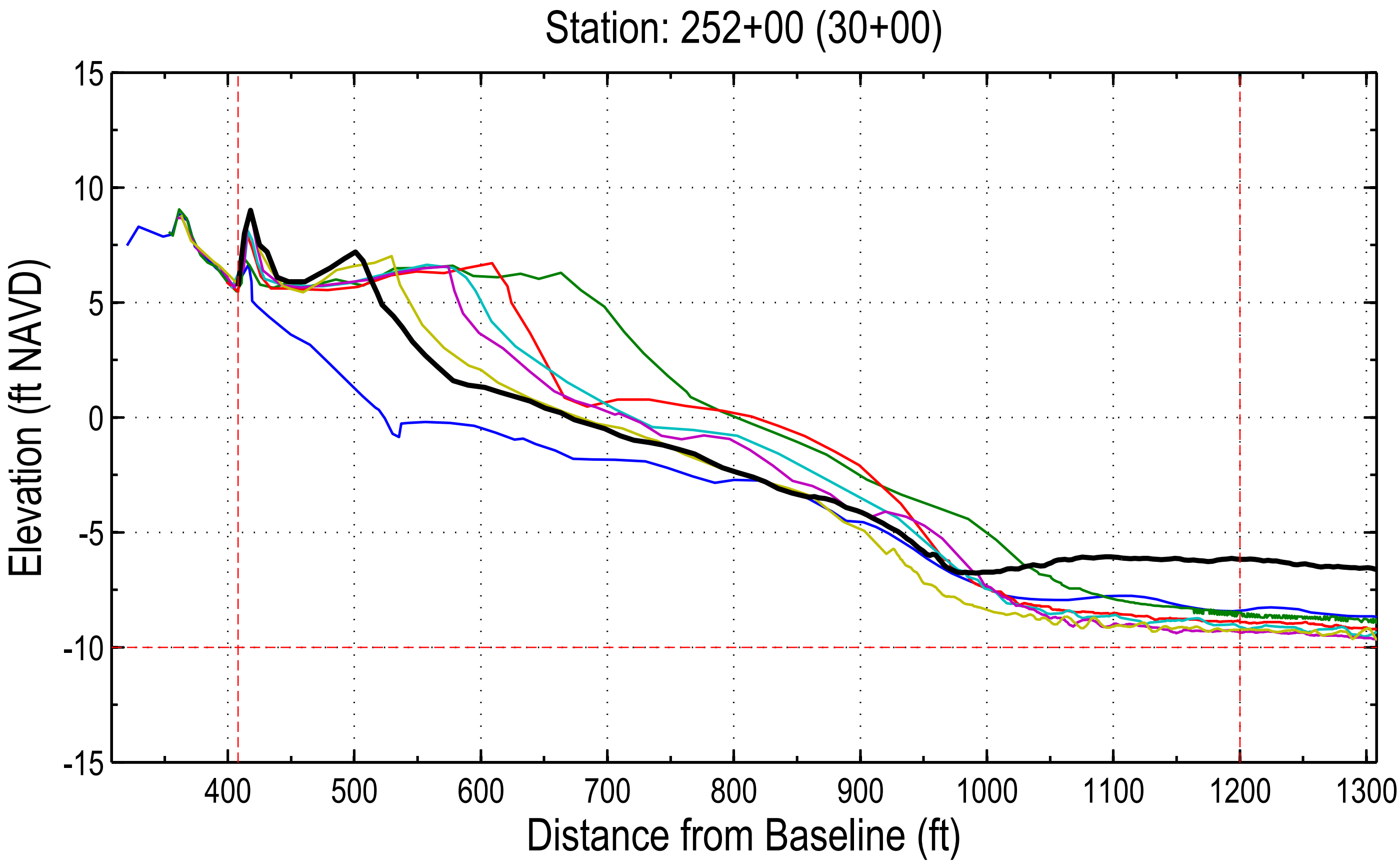
2000
2500
3000
3500
4000

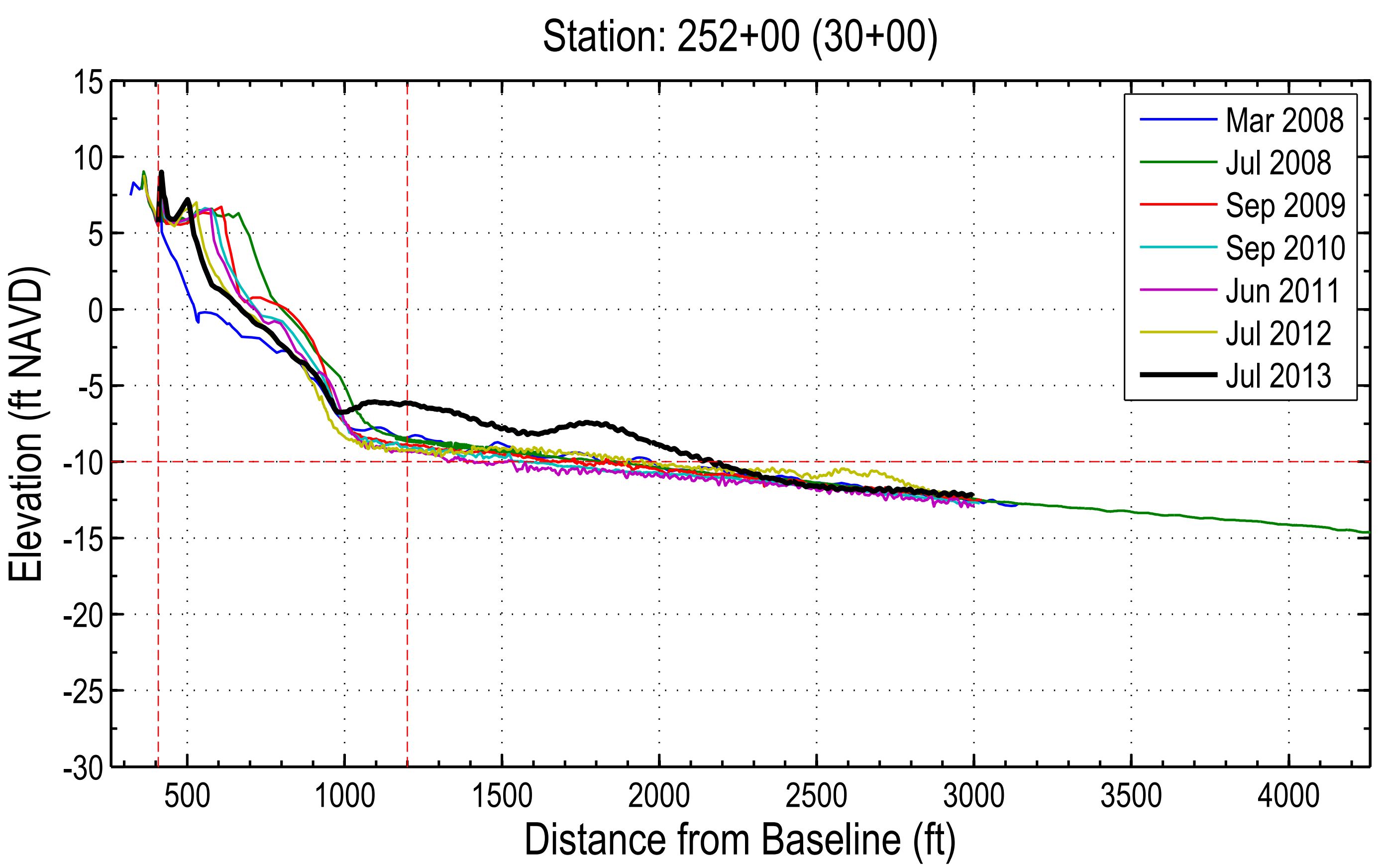

Station: 248+00 (26+00)
Elevation (ft NAVD)
Distance from Baseline (ft)

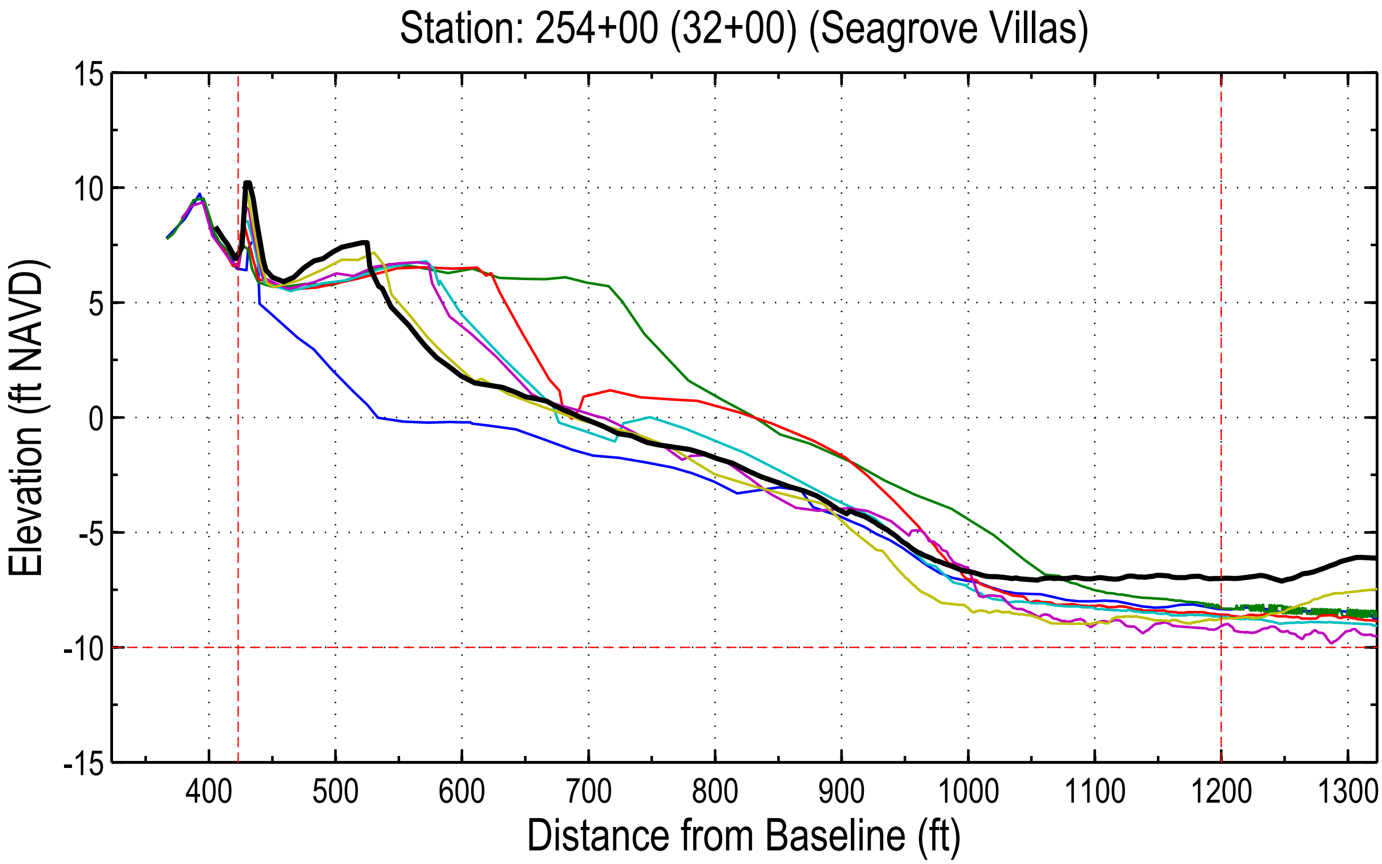

Station: 248+00 (26+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 250+00 (28+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
300
400
500
600
700
800
900
1000
1100
1200
1300


Station: 250+00 (28+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 252+00 (30+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
400
500
600
700
800
900
1000
1100
1200
1300


Station: 252+00 (30+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 254+00 (32+00) (Seagrove Villas)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
400
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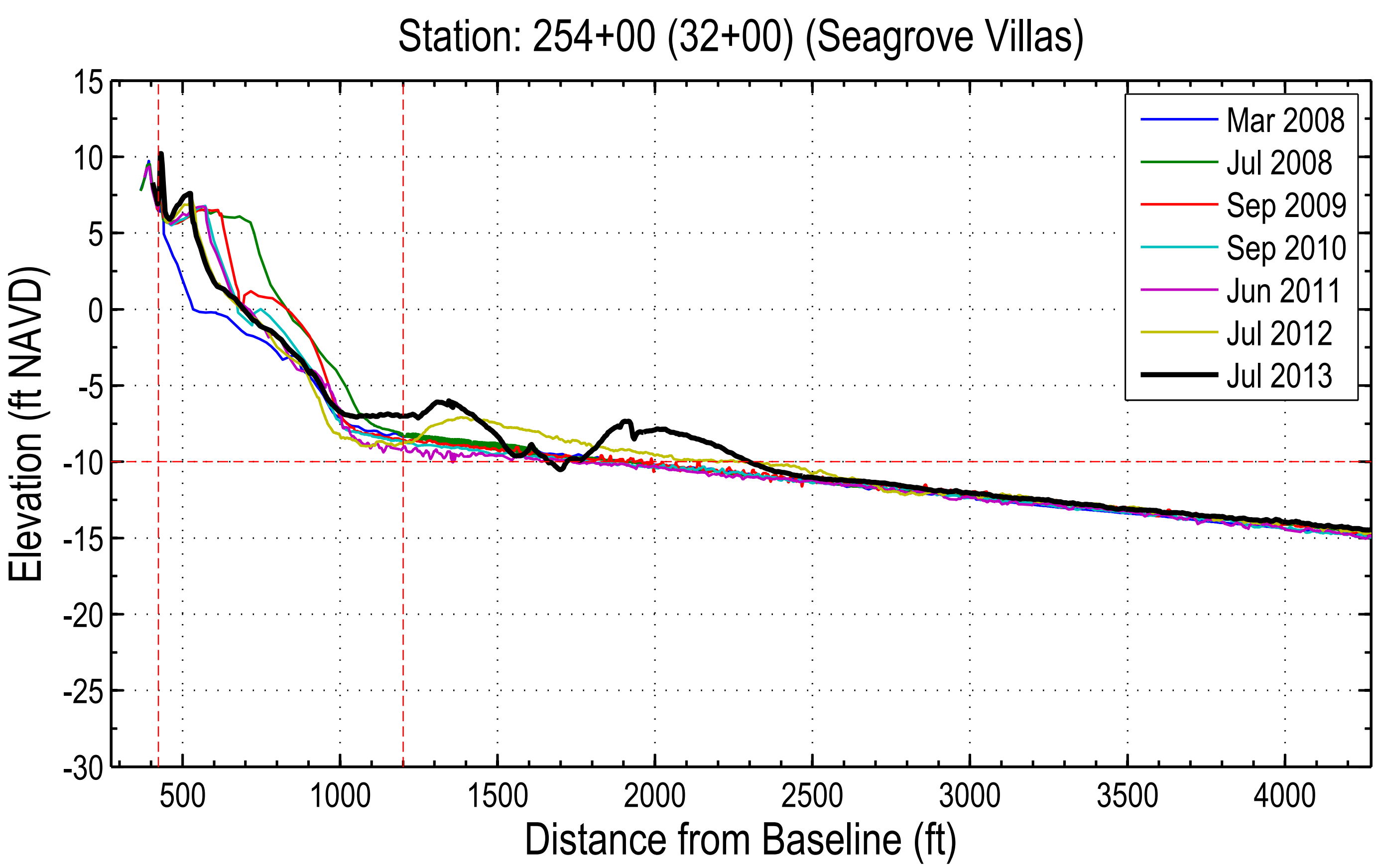
700
800
900
1000
1100
1200
1300


Station: 254+00 (32+00) (Seagrove Villas)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
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-25
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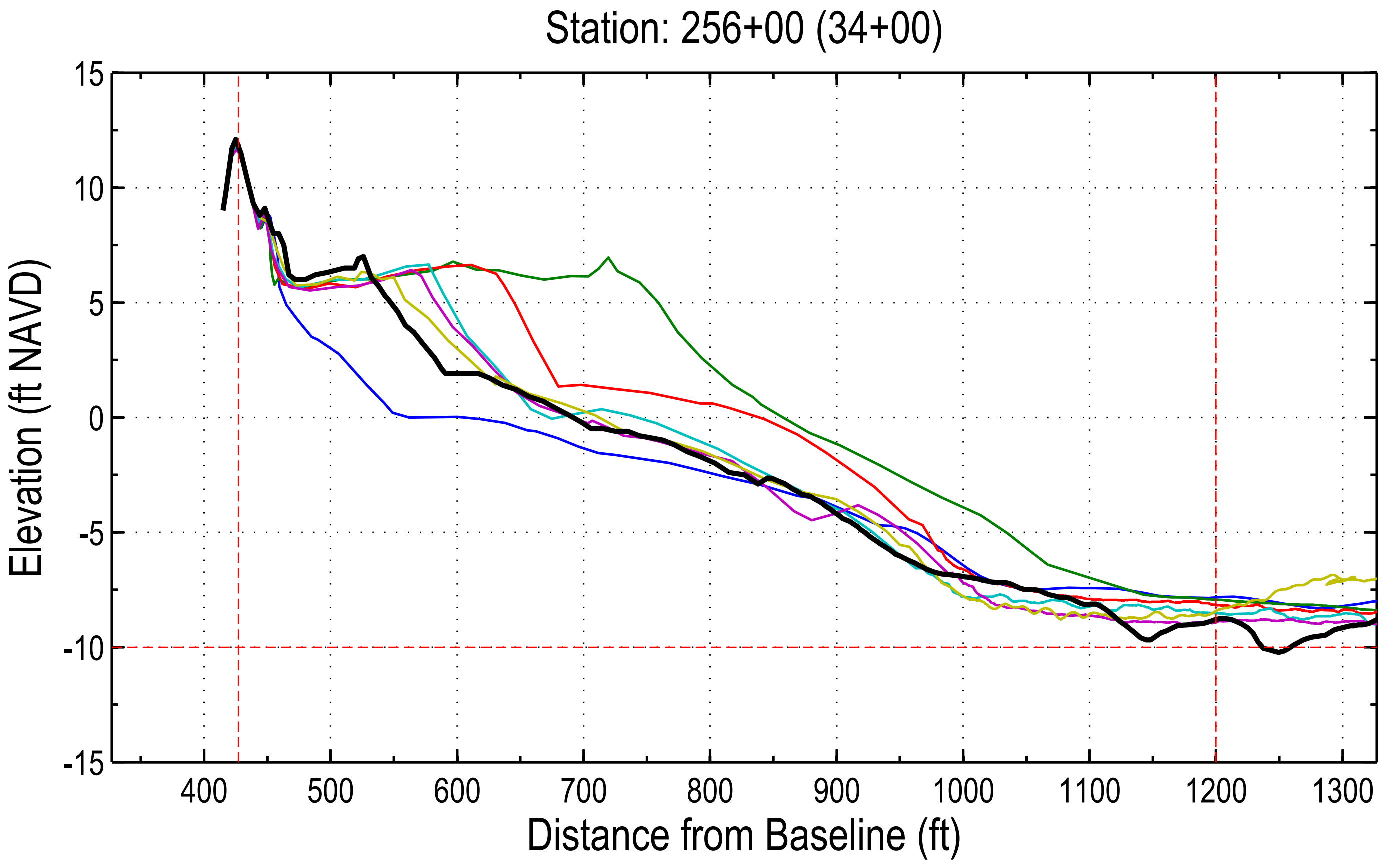
2000
2500
3000
3500
4000


Station: 256+00 (34+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
400
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700
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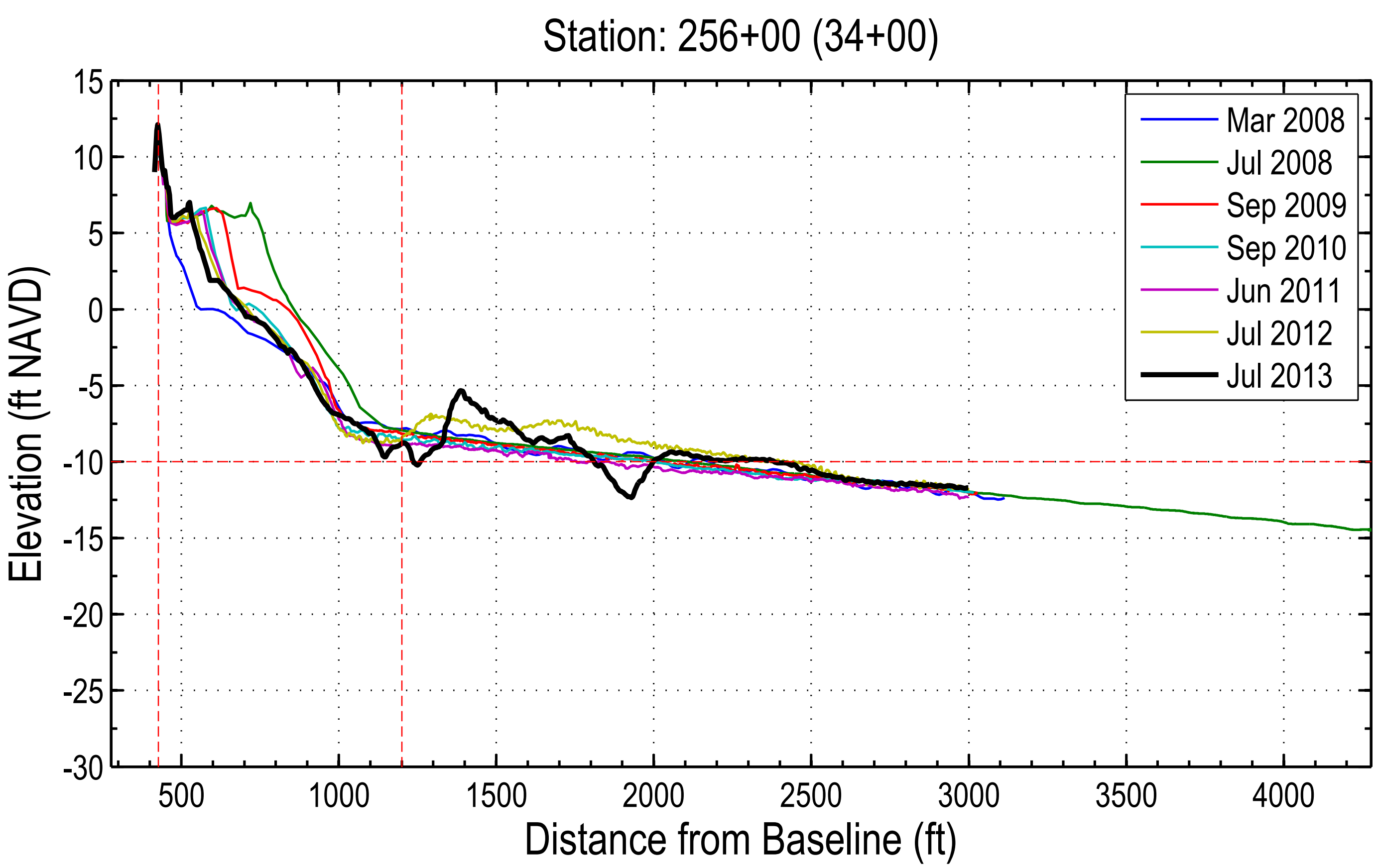
900
1000
1100
1200
1300


Station: 256+00 (34+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
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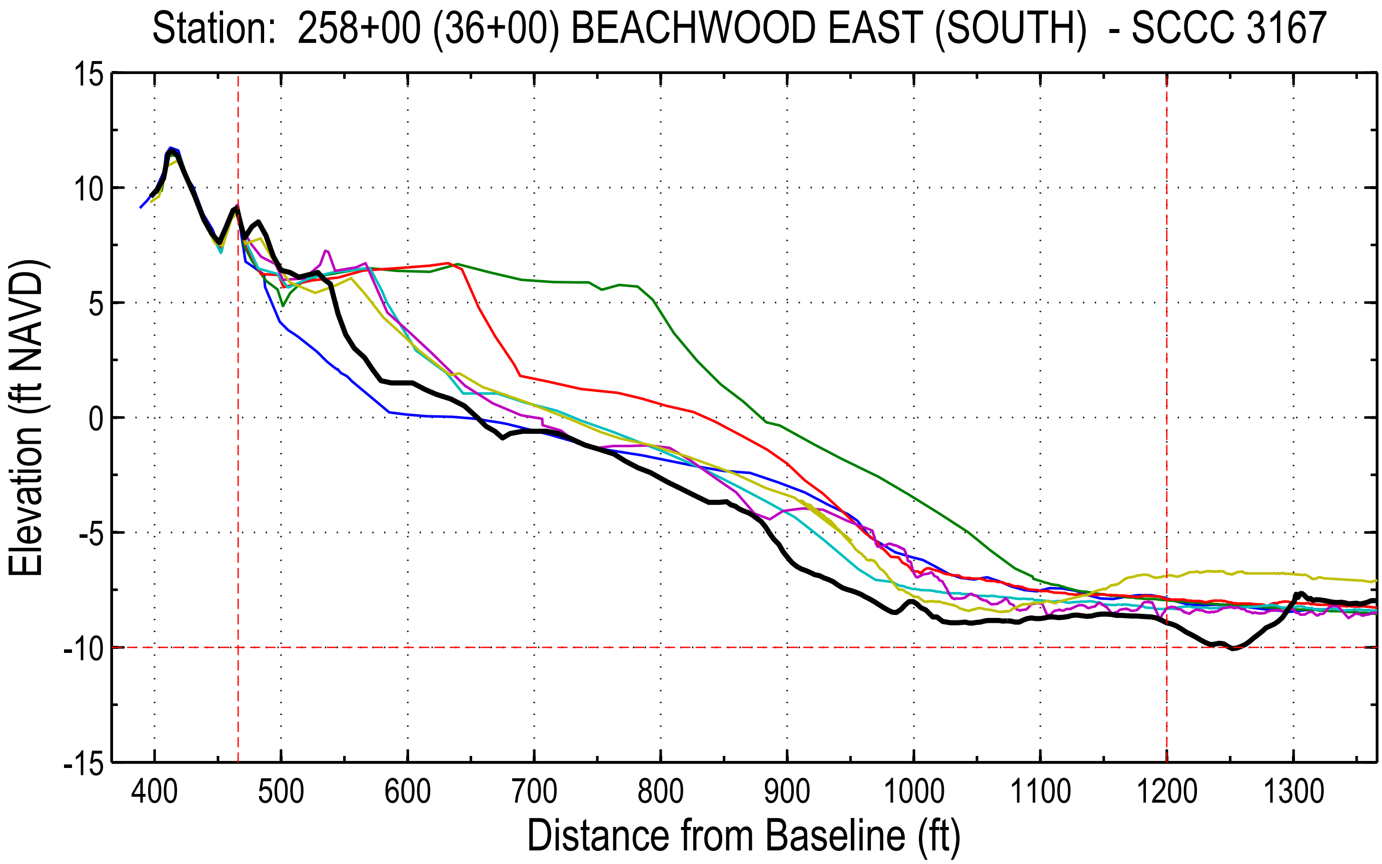
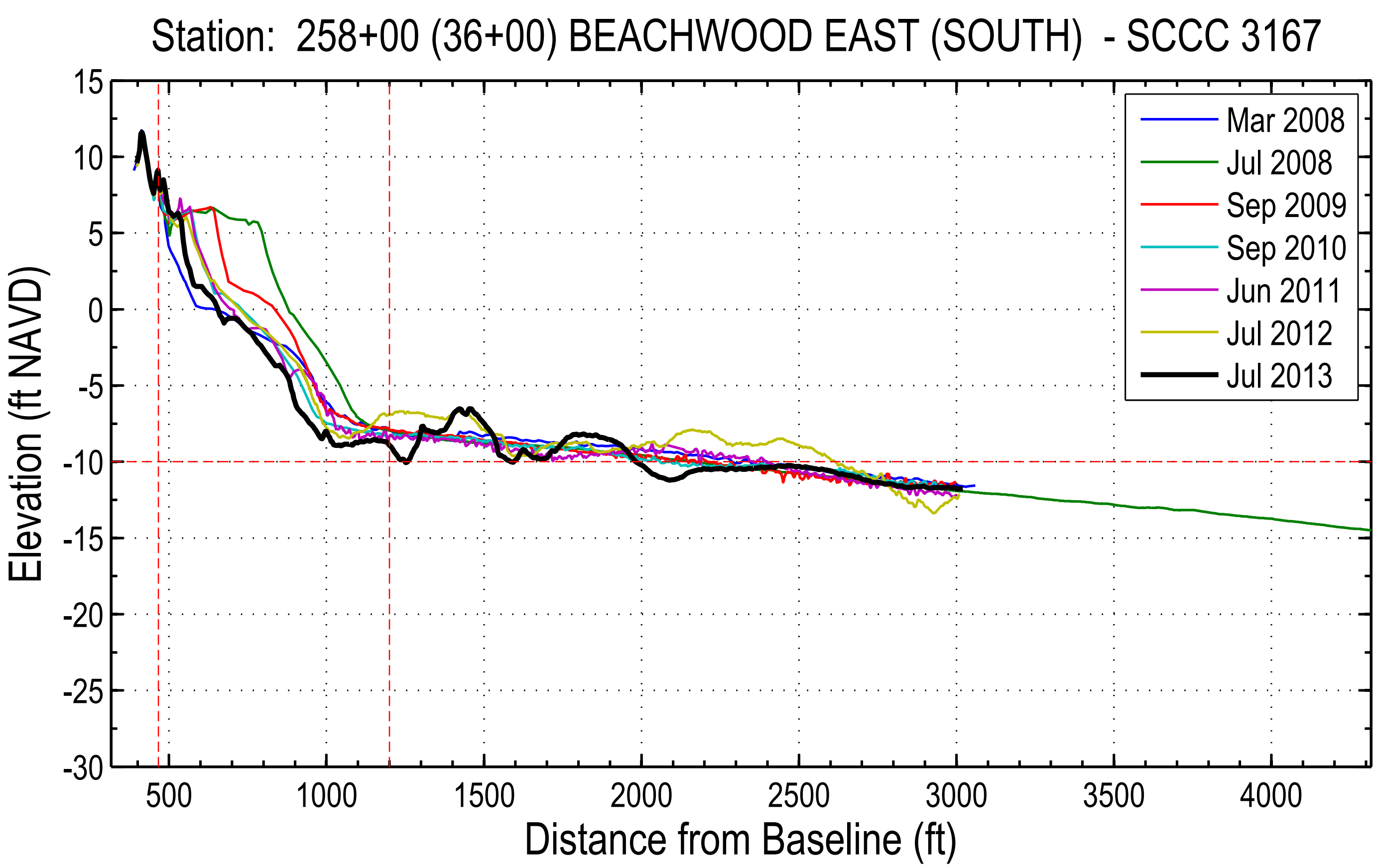
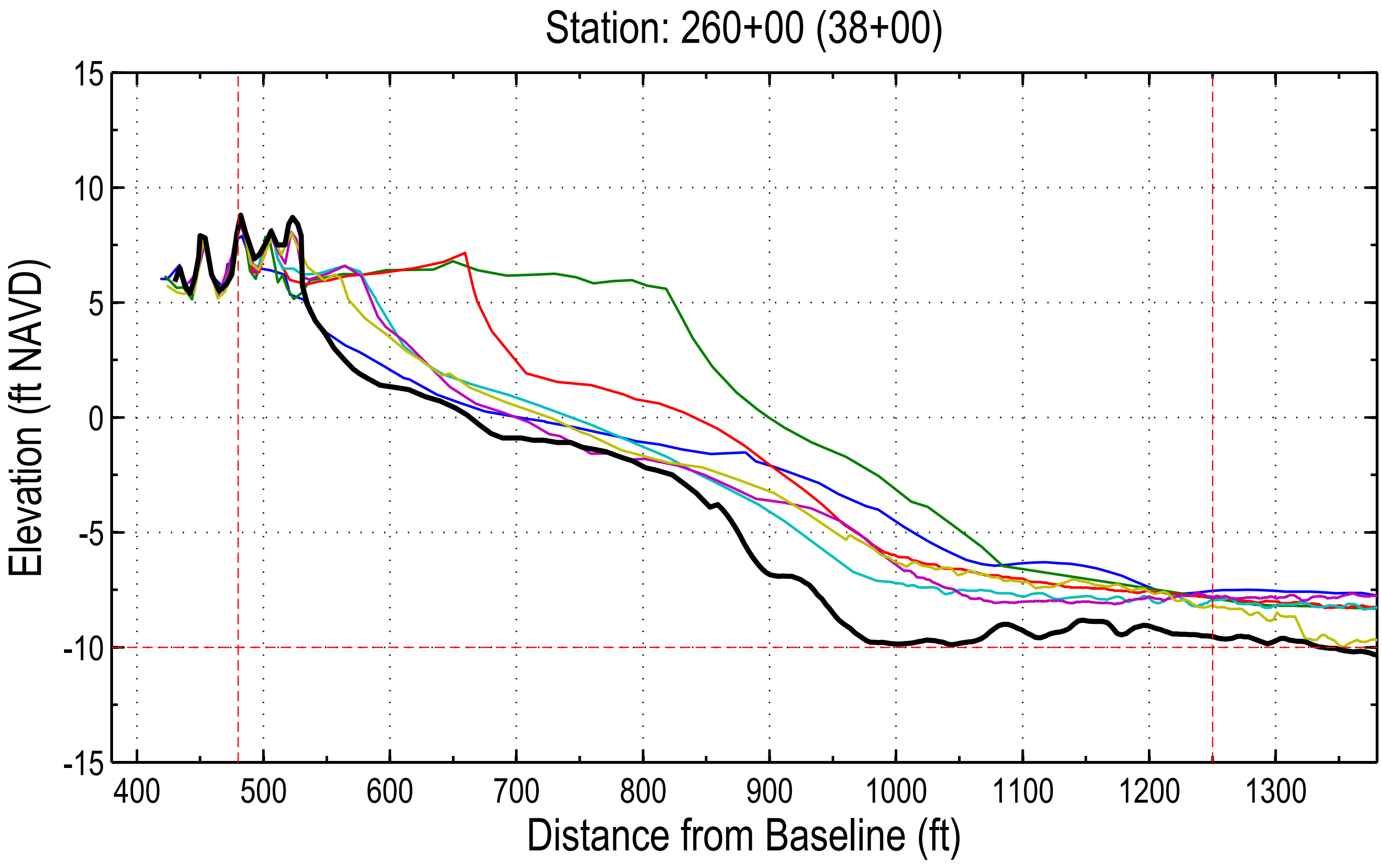
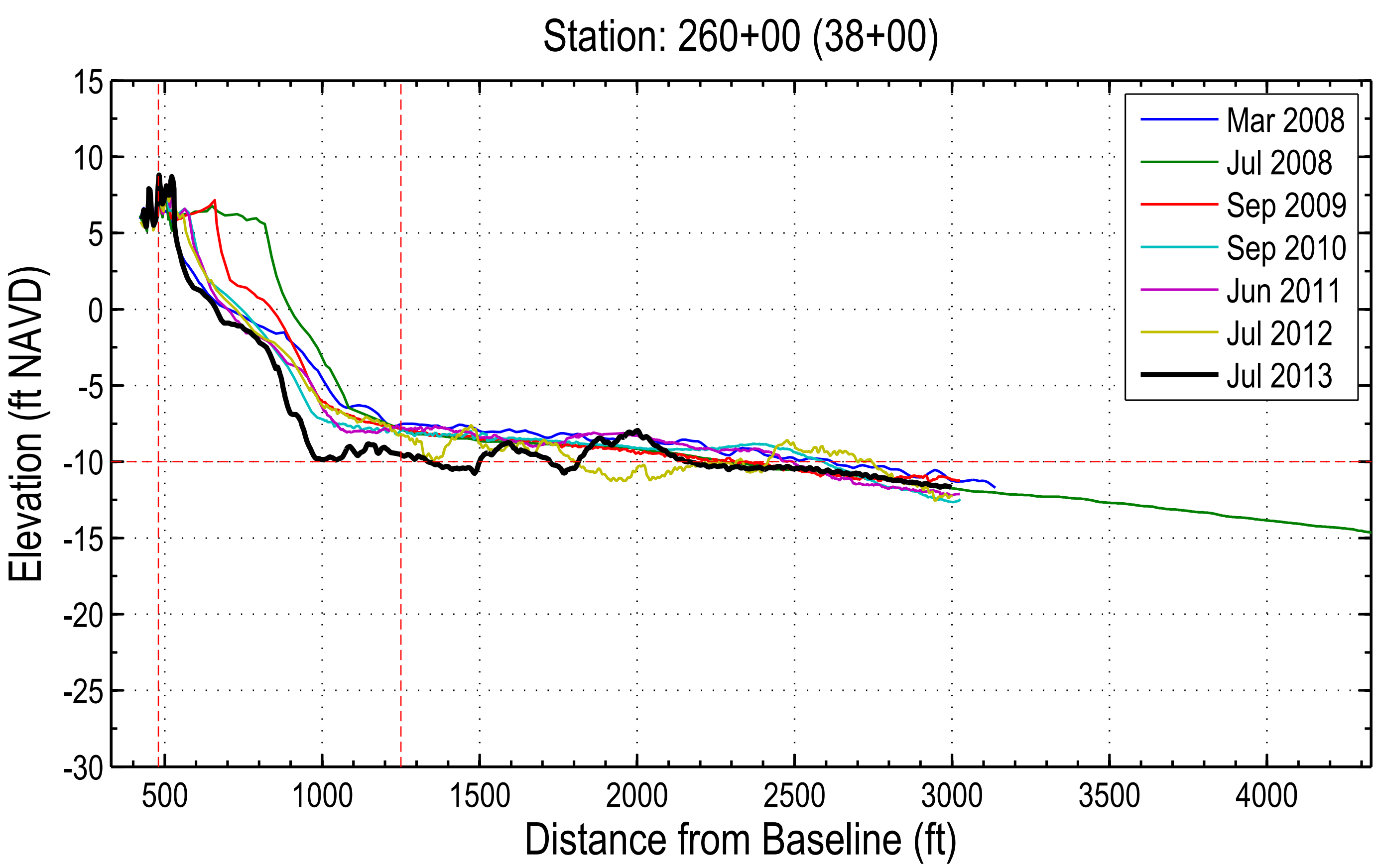

Station: 258+00 (36+00) BEACHWOOD EAST (SOUTH) - SCCC 3167
Elevation (ft NAVD)
Distance from Baseline (ft)

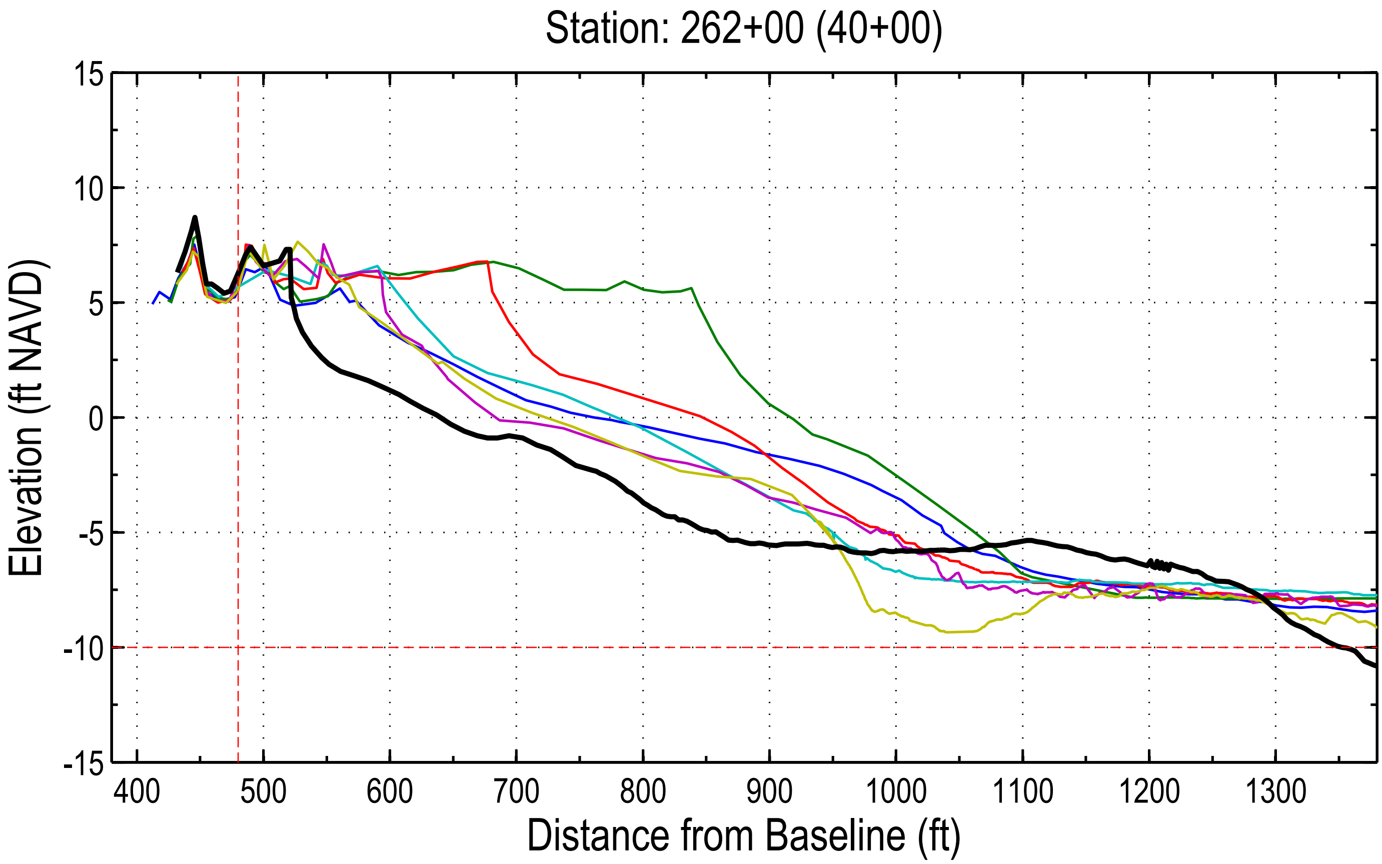

Station: 258+00 (36+00) BEACHWOOD EAST (SOUTH) - SCCC 3167
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 260+00 (38+00)
Elevation (ft NAVD)
Distance from Baseline (ft)



Station: 260+00 (38+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 262+00 (40+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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-5
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-15
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500
600
700
800
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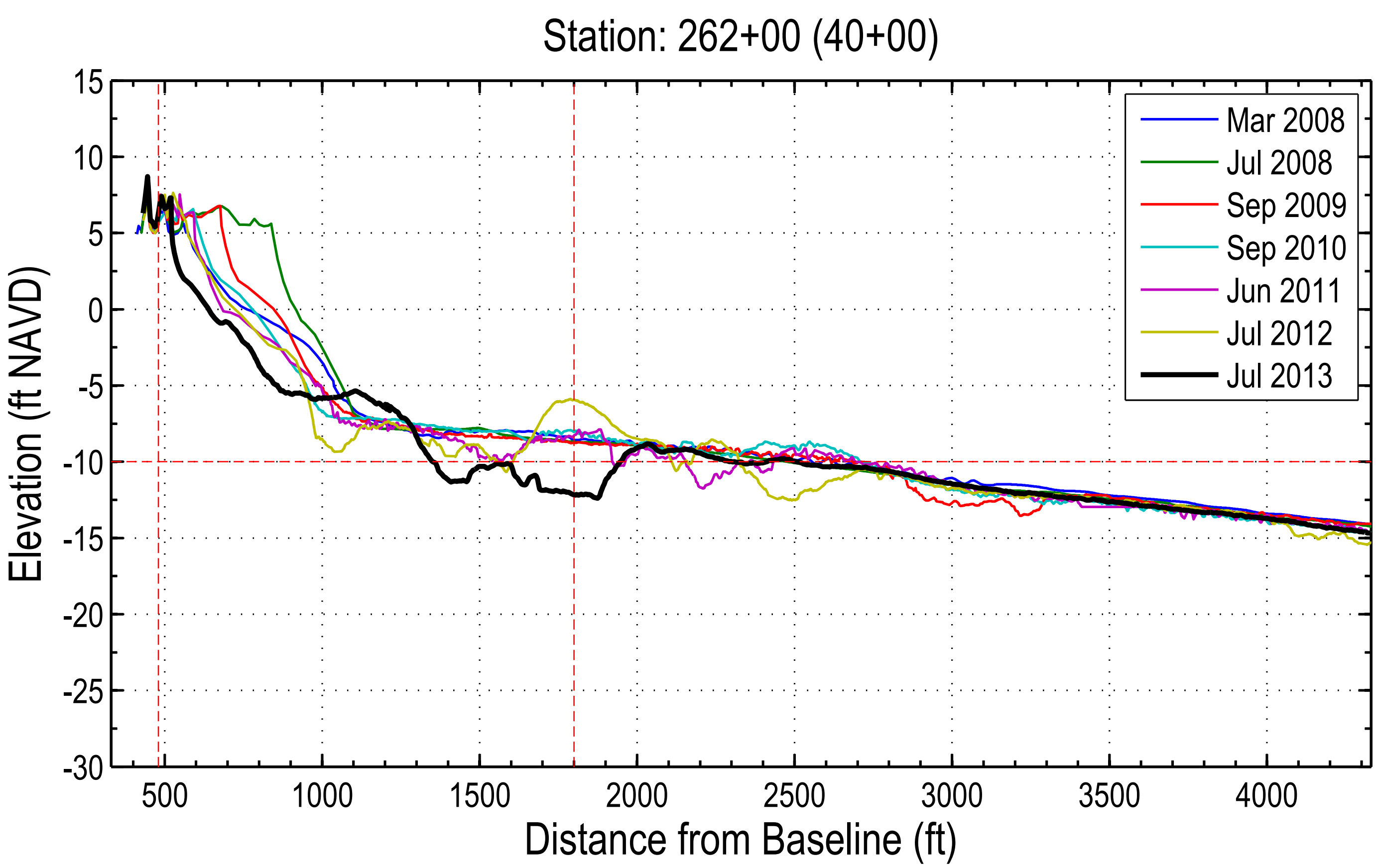
Station: 262+00 (40+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
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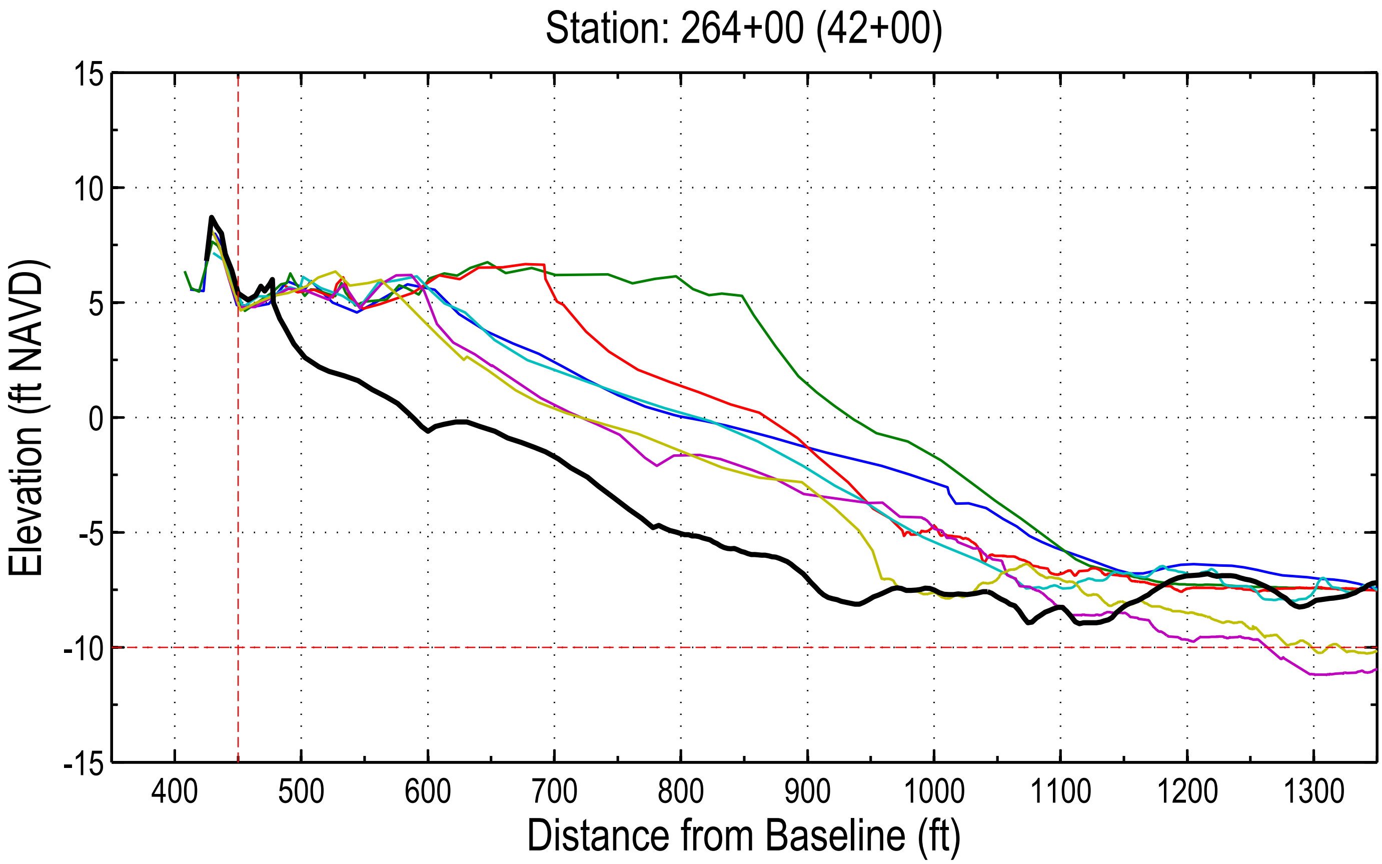
4000


Station: 264+00 (42+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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700
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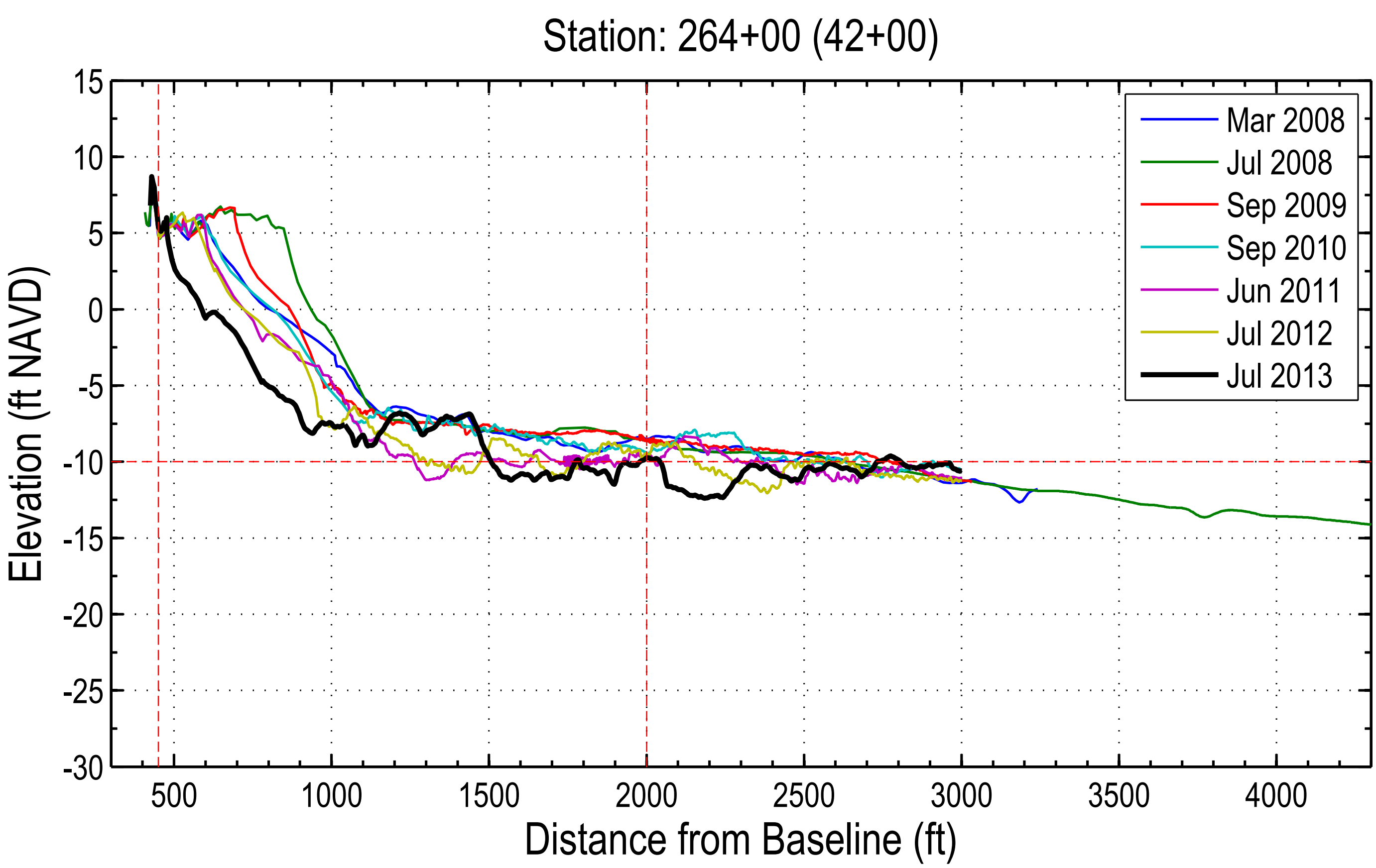
Station: 264+00 (42+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
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-5
-10
-15
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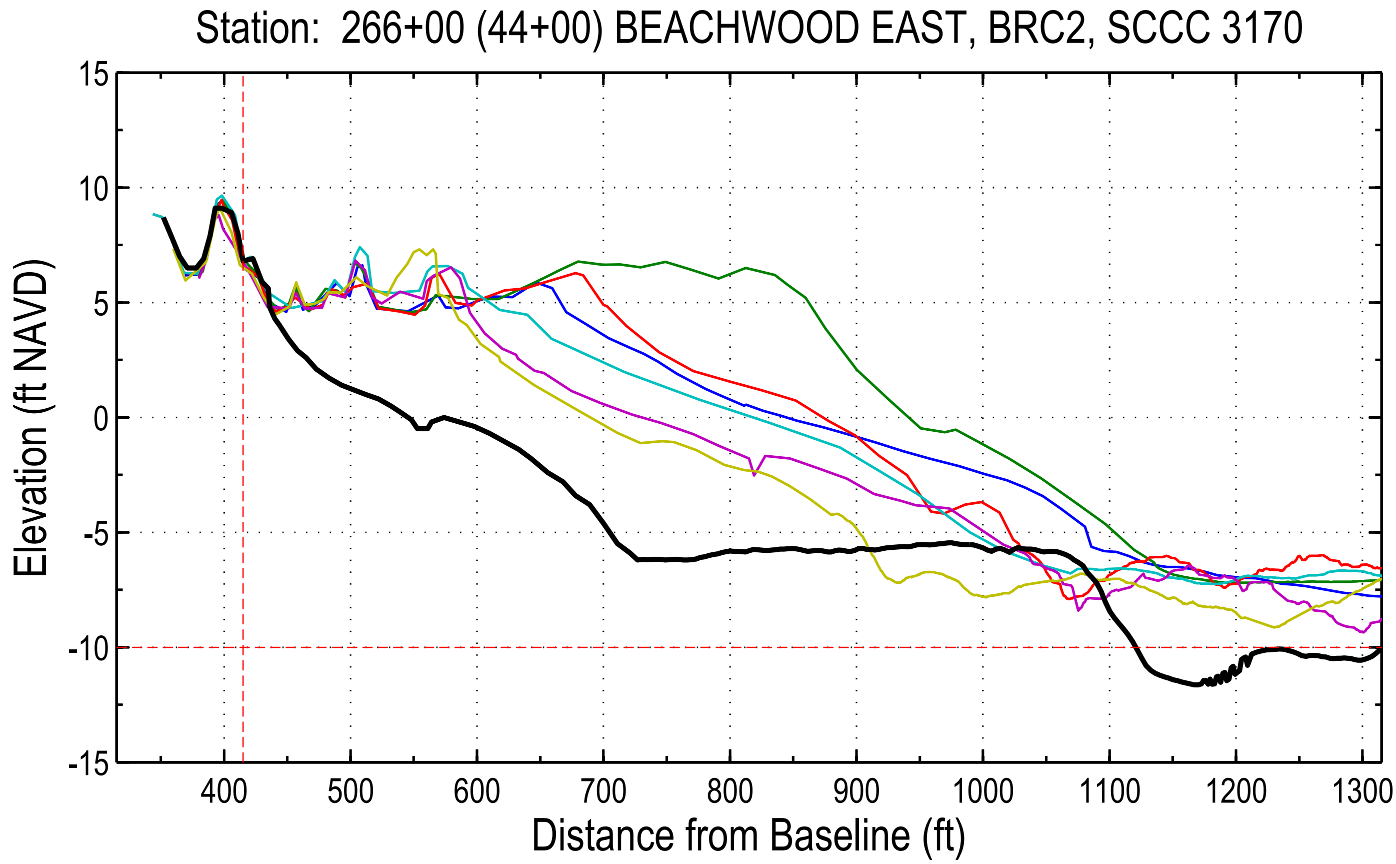
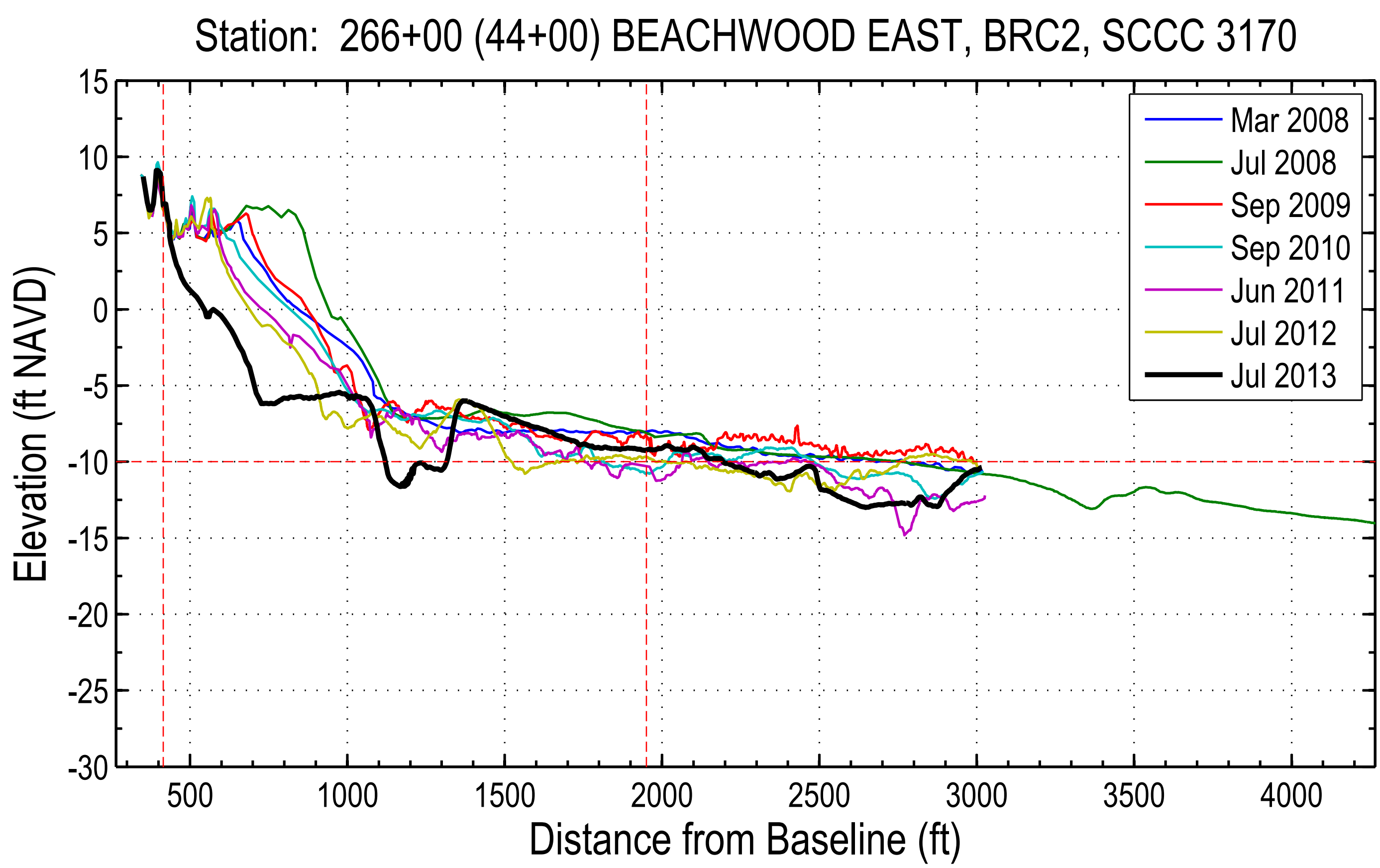
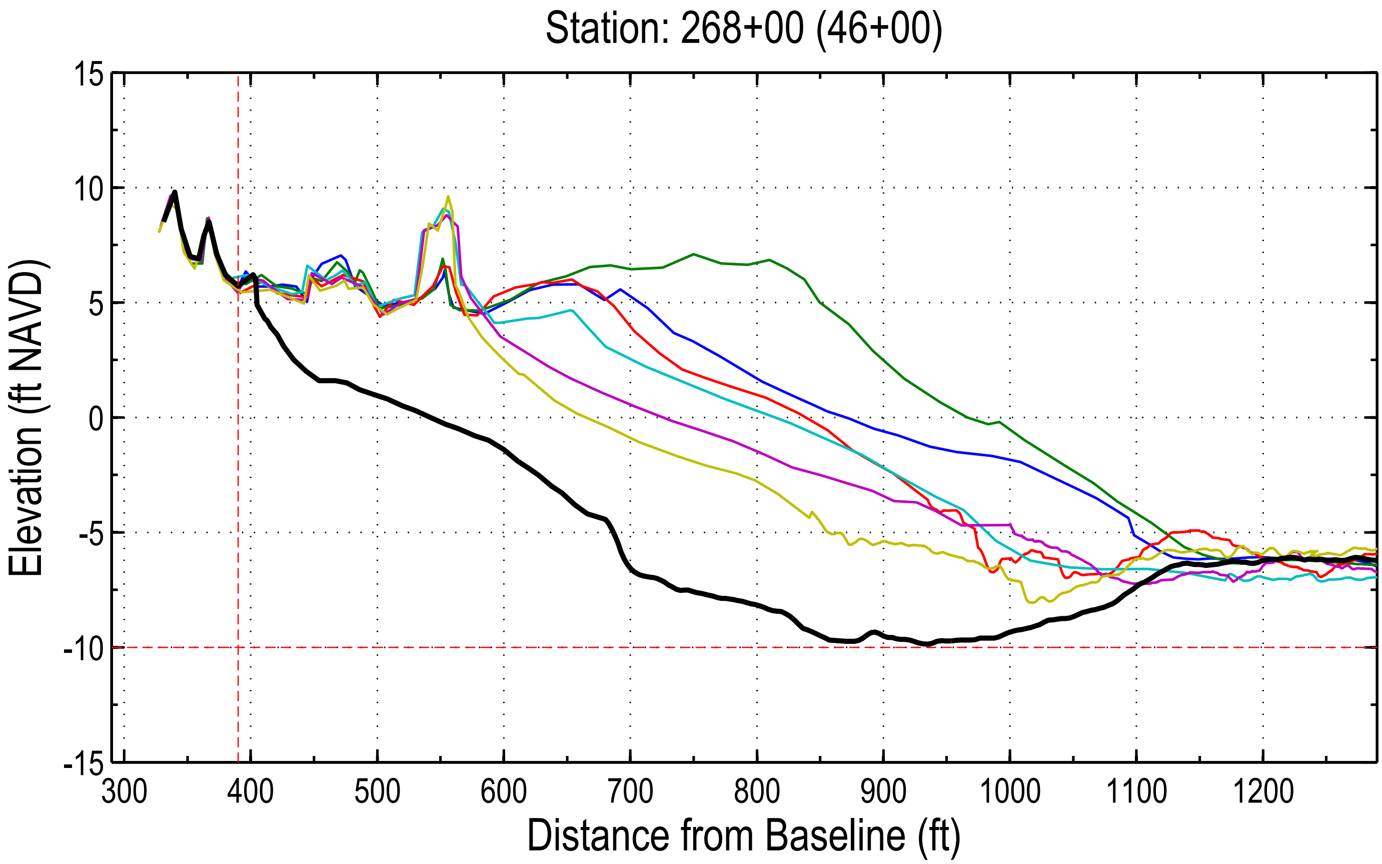

Station: 266+00 (44+00) BEACHWOOD EAST, BRC2, SCCC 3170
Elevation (ft NAVD)
Distance from Baseline (ft)


Station: 266+00 (44+00) BEACHWOOD EAST, BRC2, SCCC 3170
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 268+00 (46+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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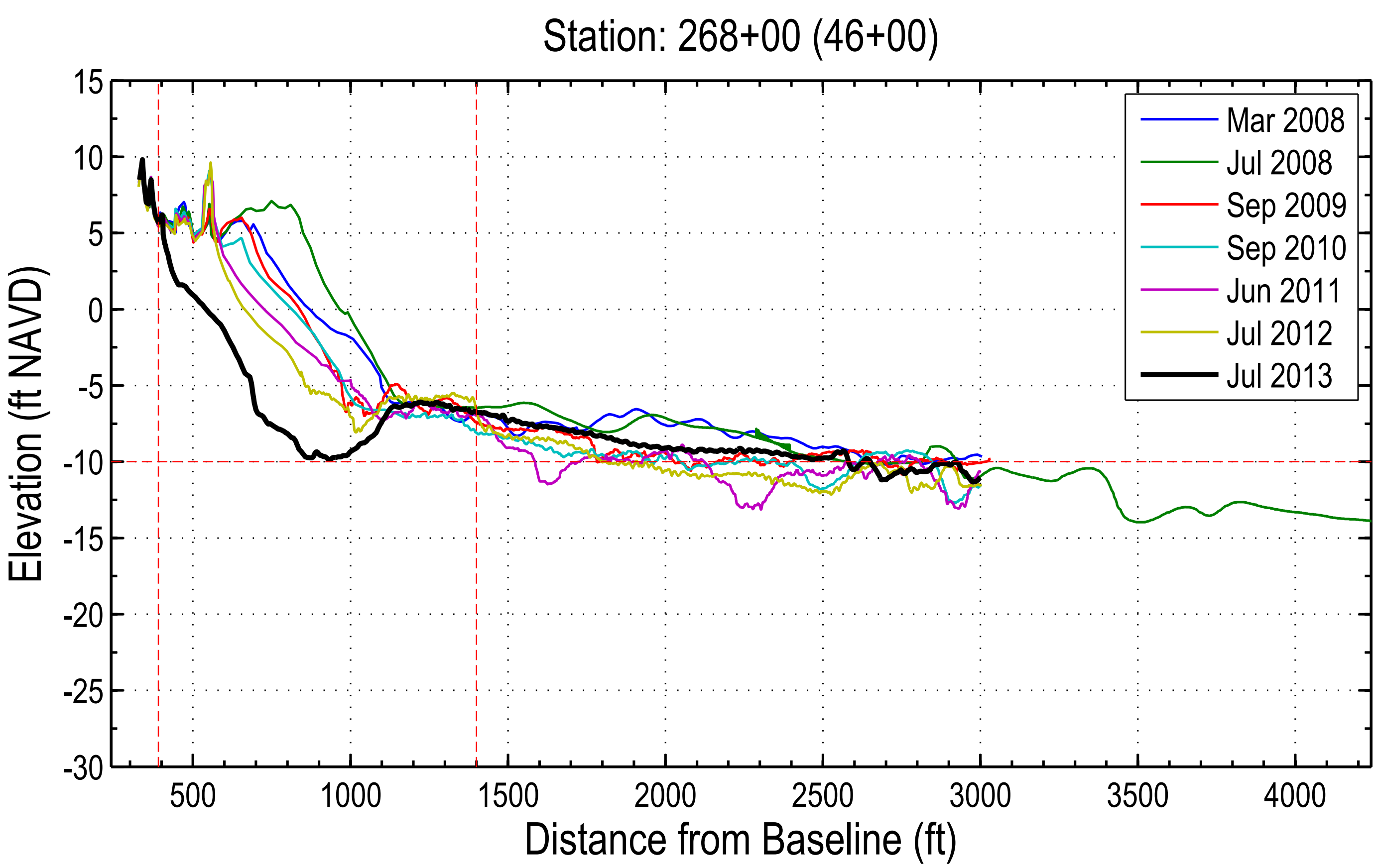

Station: 268+00 (46+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
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-5
-10
-15
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-25
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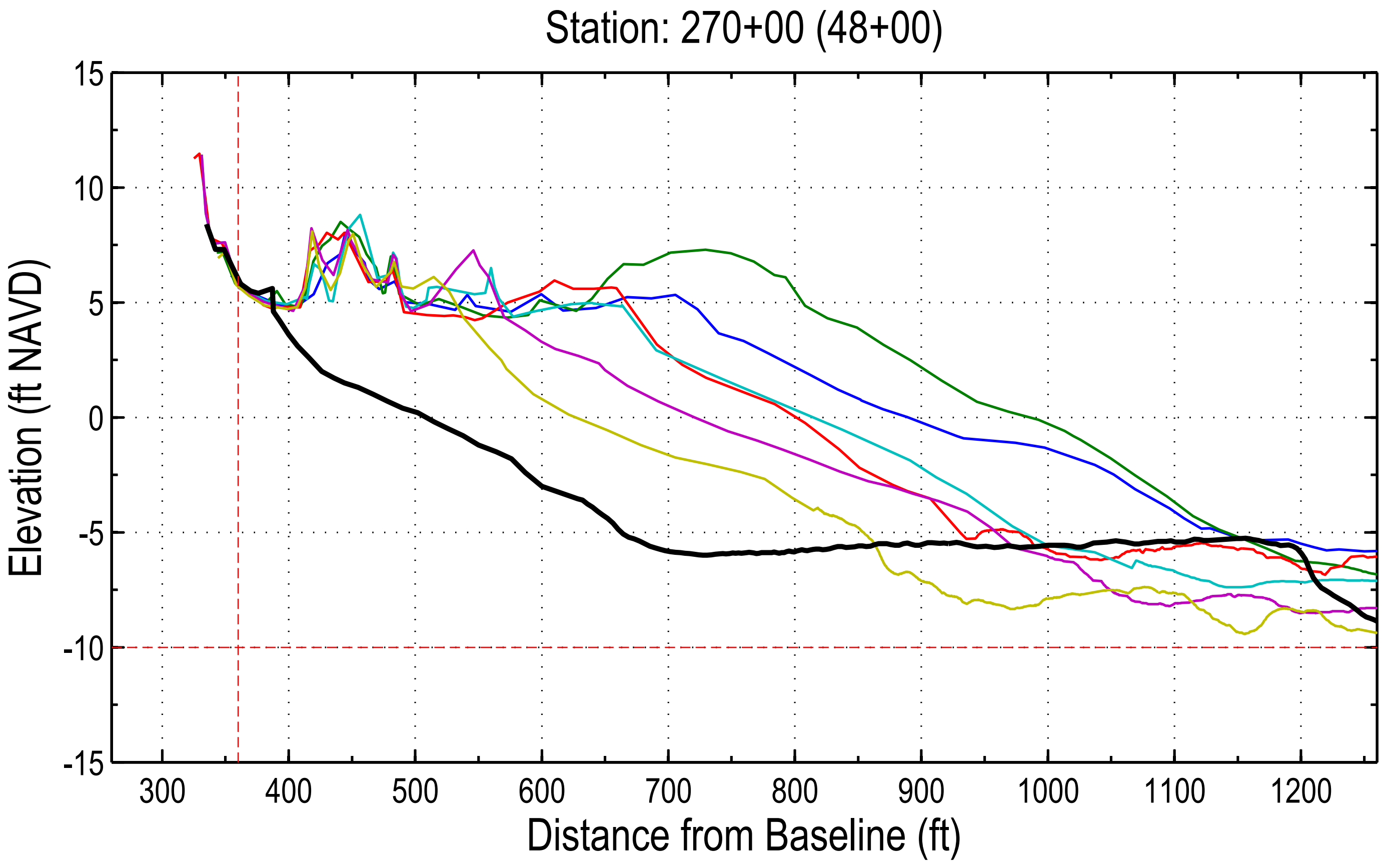
Station: 270+00 (48+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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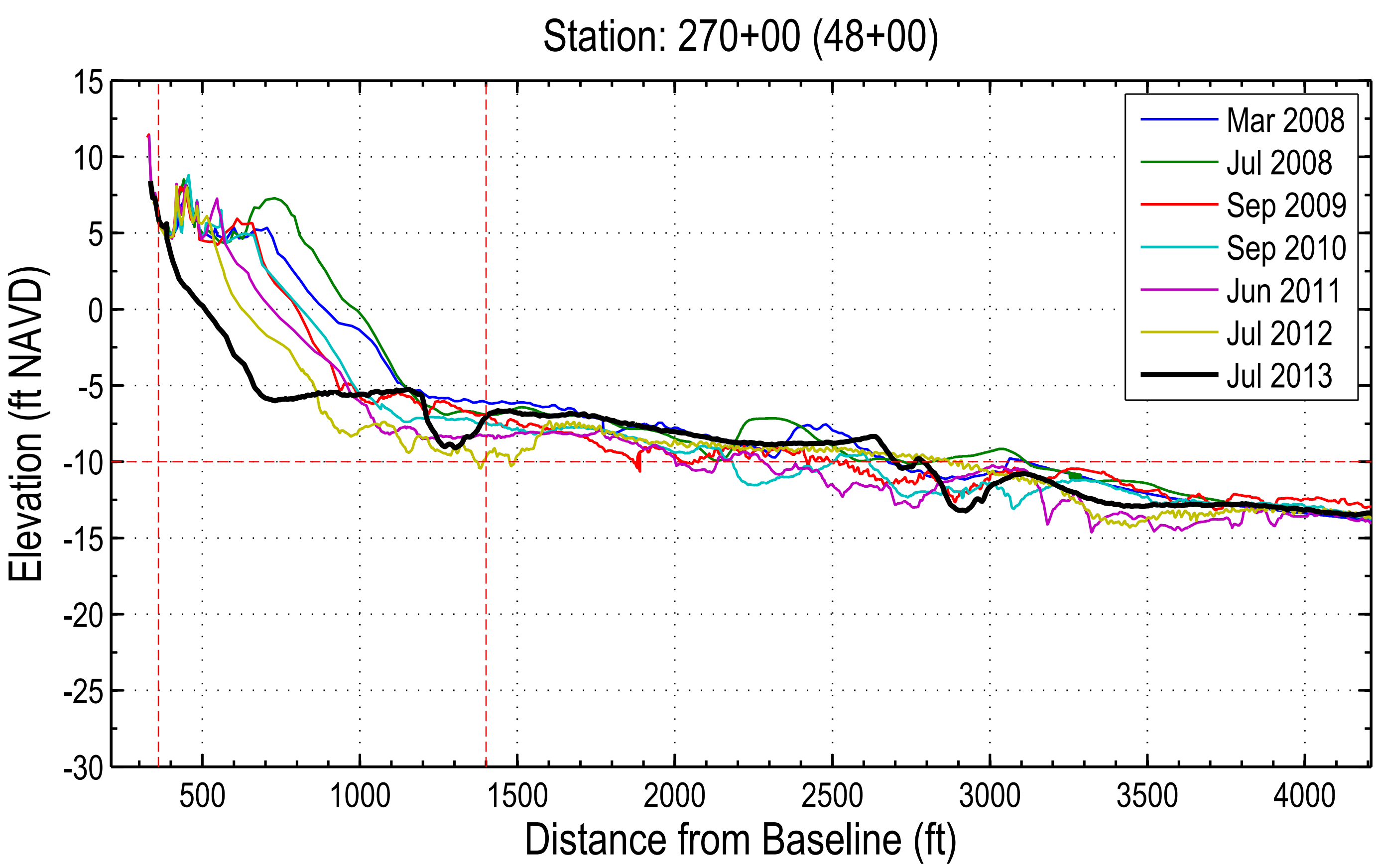
1200


Station: 270+00 (48+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
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-5
-10
-15
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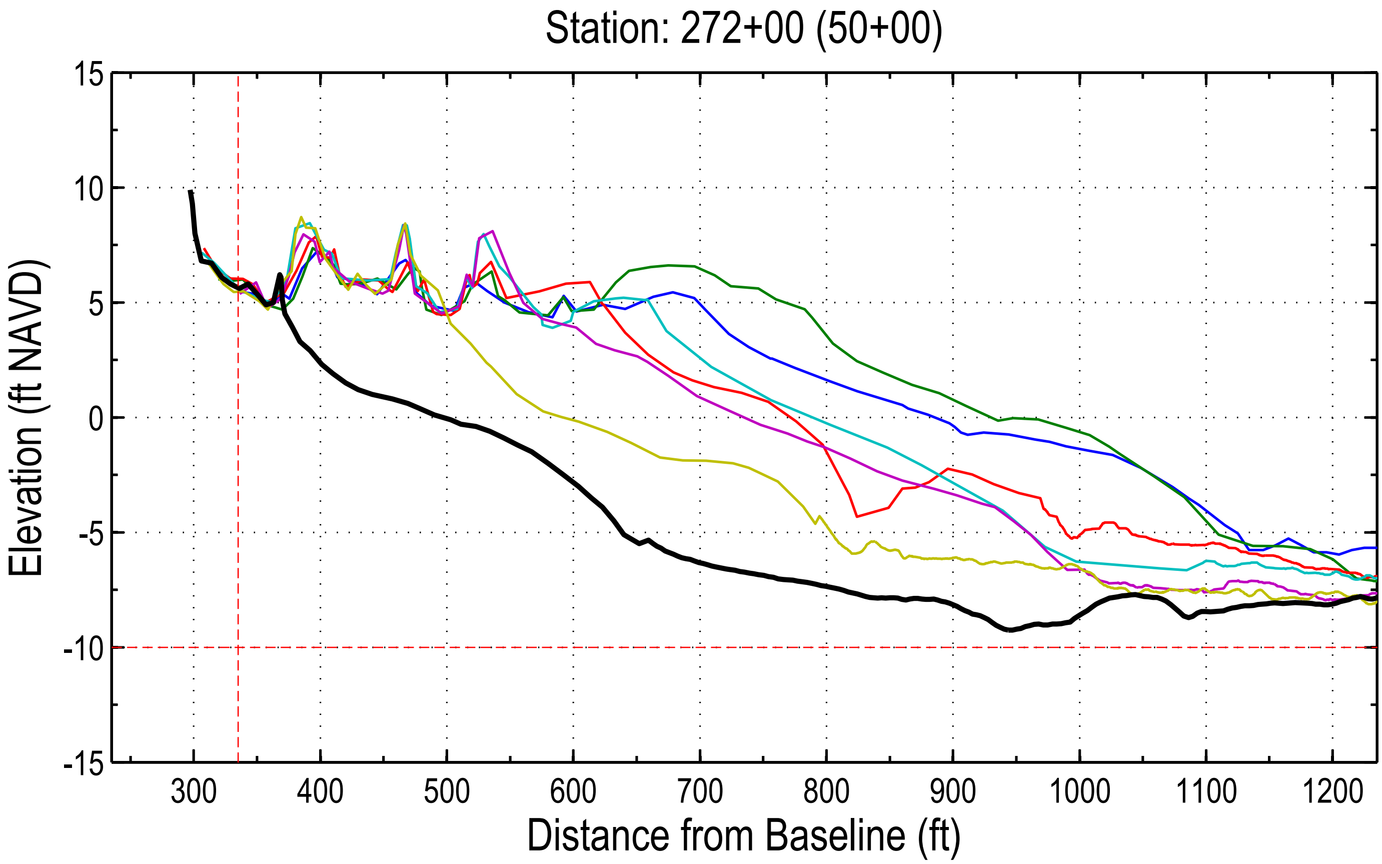

Station: 272+00 (50+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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-5
-10
-15
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900
1000
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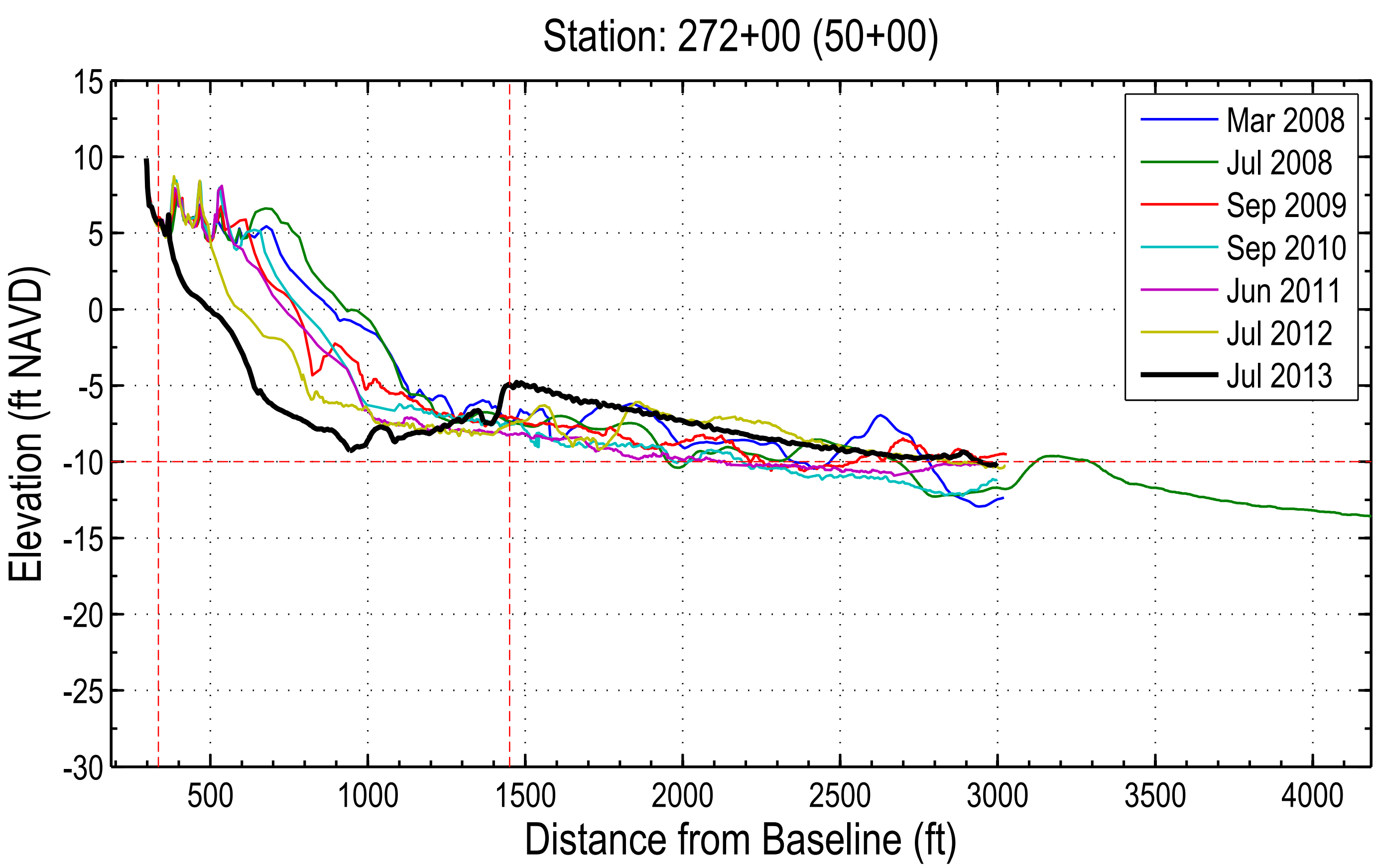
1200



Station: 272+00 (50+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
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-15
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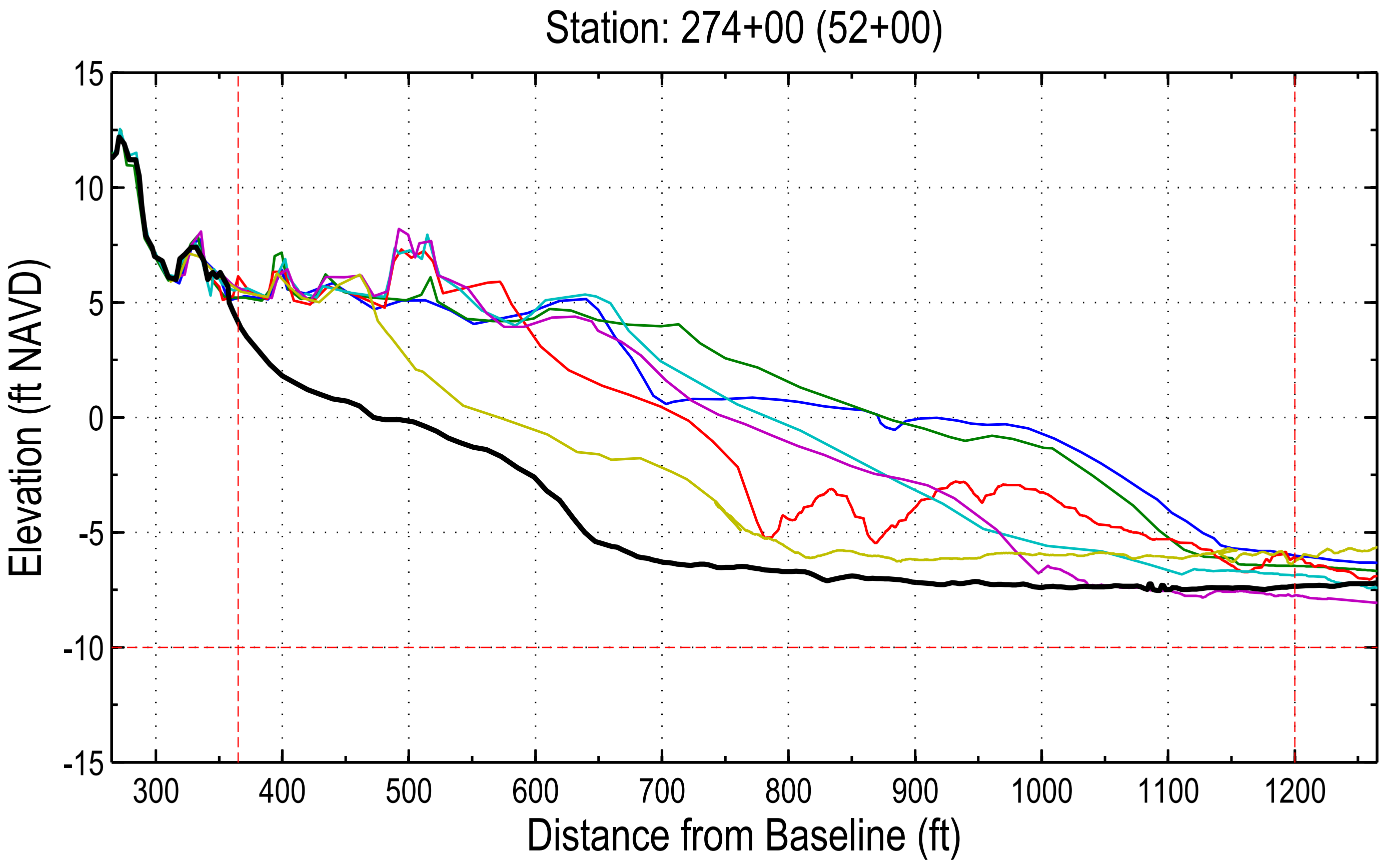
Station: 274+00 (52+00)
Elevation (ft NAVD)
15
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-5
-10
-15
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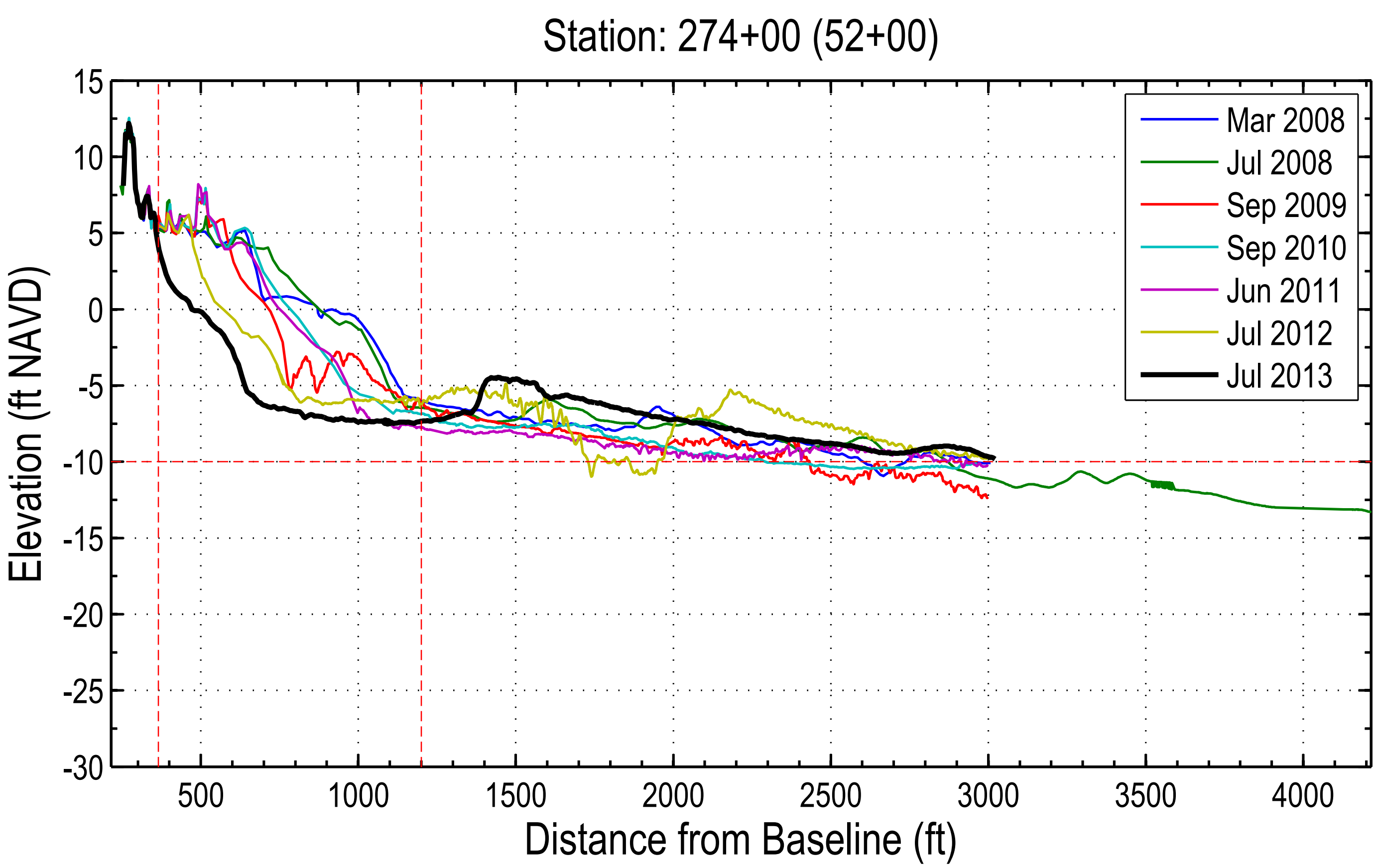
700
800
900
1000
1100
1200
Distance from Baseline (ft)


Station: 274+00 (52+00)
Elevation (ft NAVD)
15
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-10
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-30
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2500
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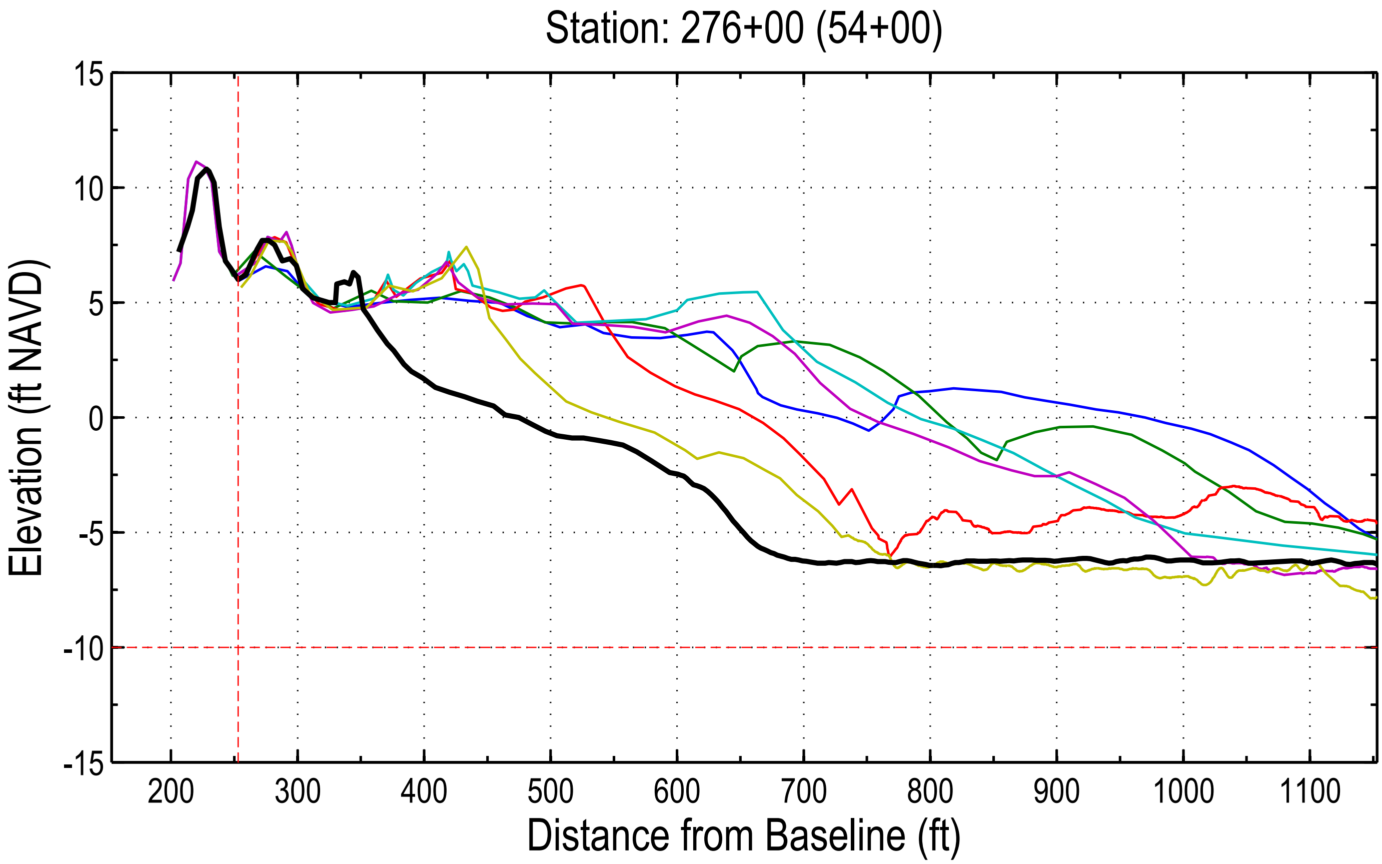
3500
4000
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 276+00 (54+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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-5
-10
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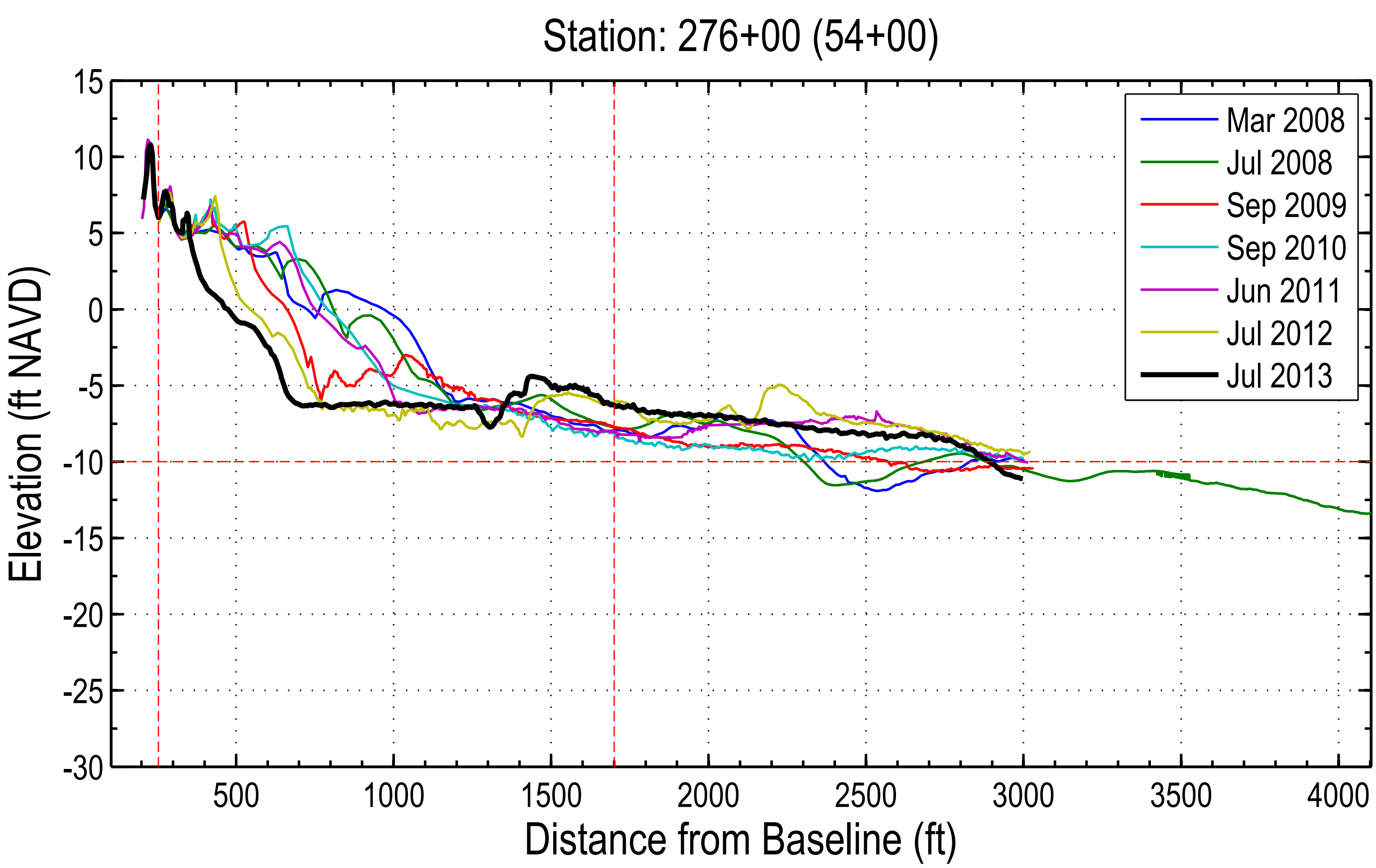
1000
1100


Station: 276+00 (54+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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0
-5
-10
-15
-20
-25
-30
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1500
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2500
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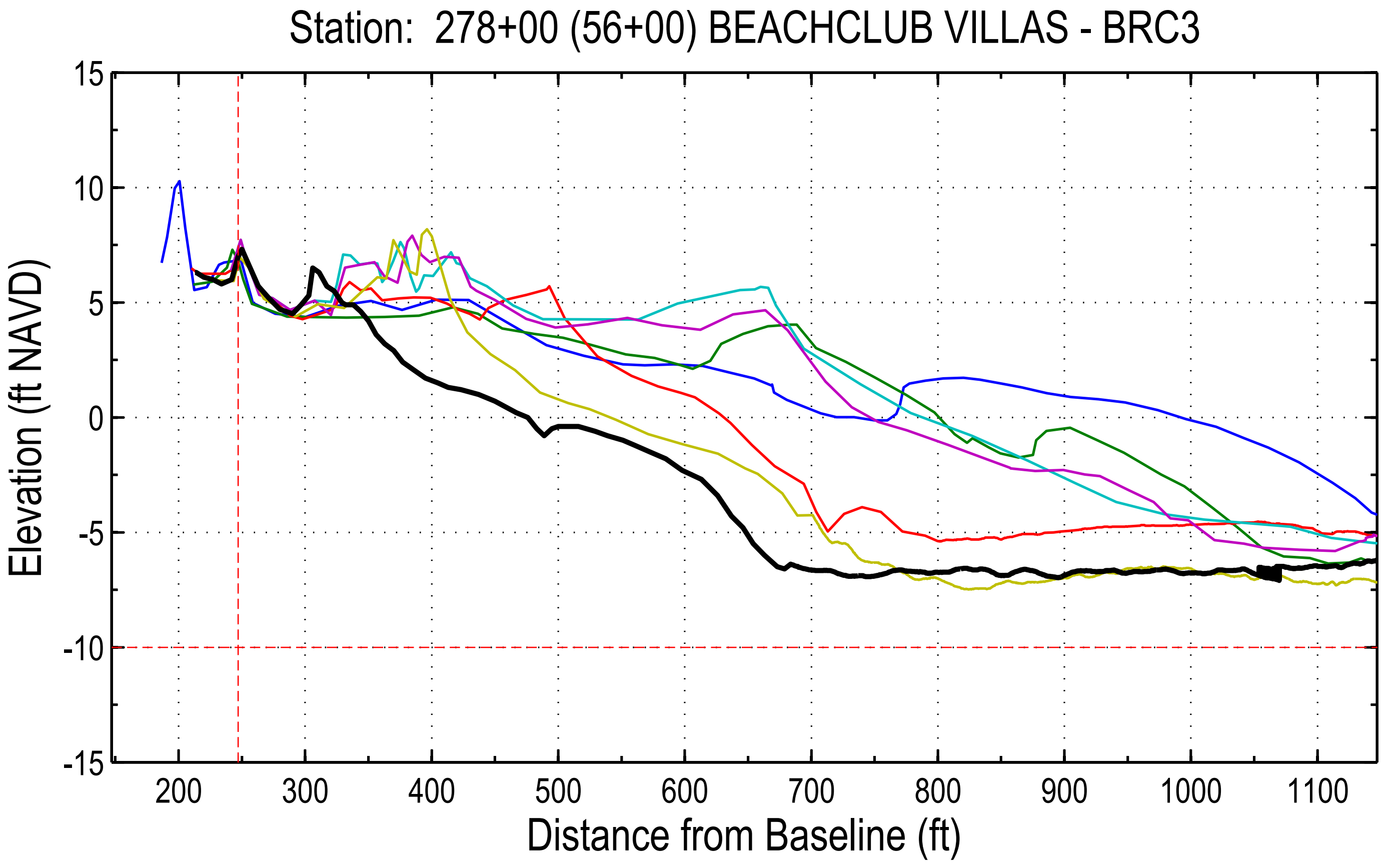
3500
4000
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 278+00 (56+00) BEACHCLUB VILLAS - BRC3
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
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0
-5
-10
-15
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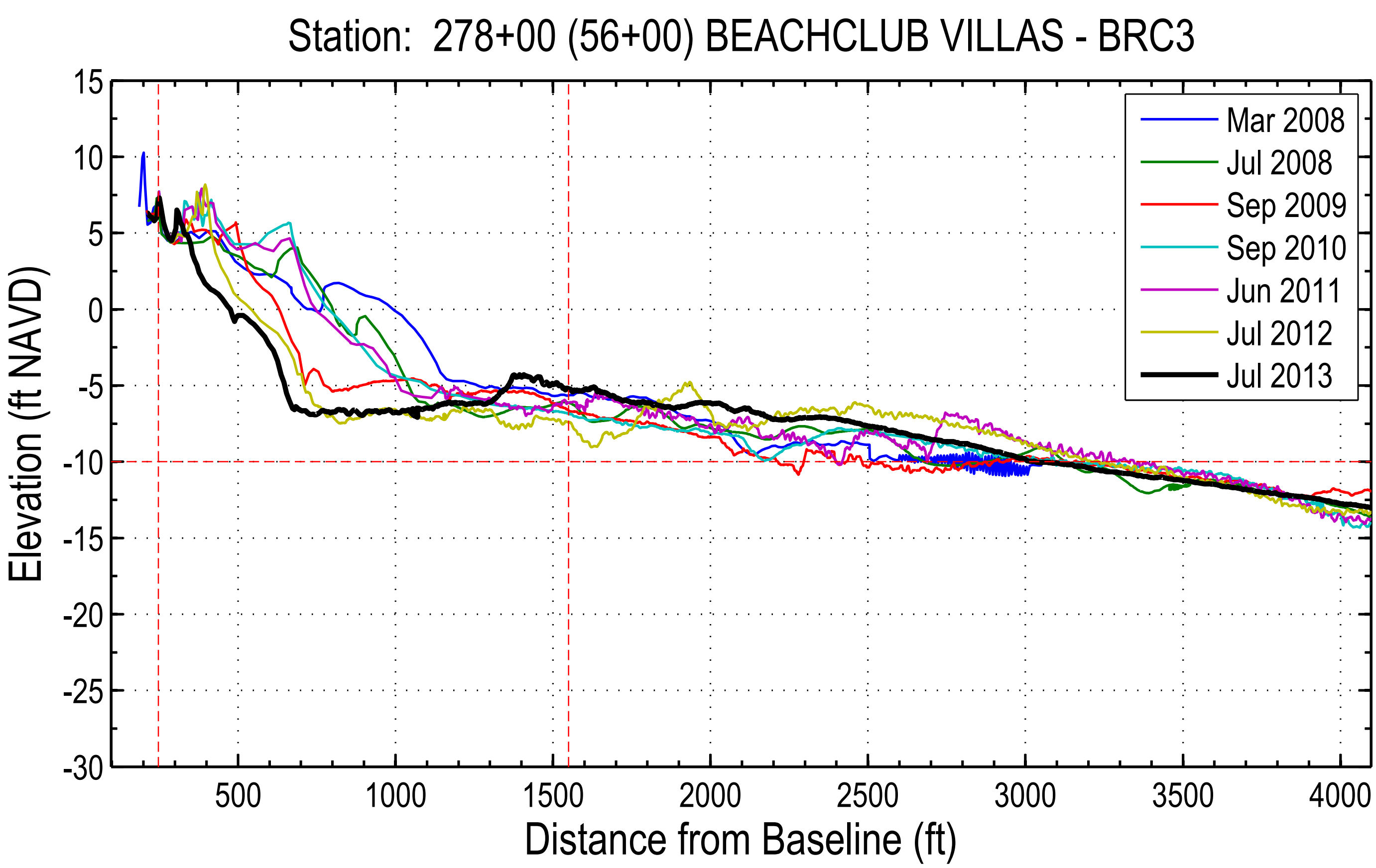
1000
1100


Station: 278+00 (56+00) BEACHCLUB VILLAS - BRC3
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
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-15
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-25
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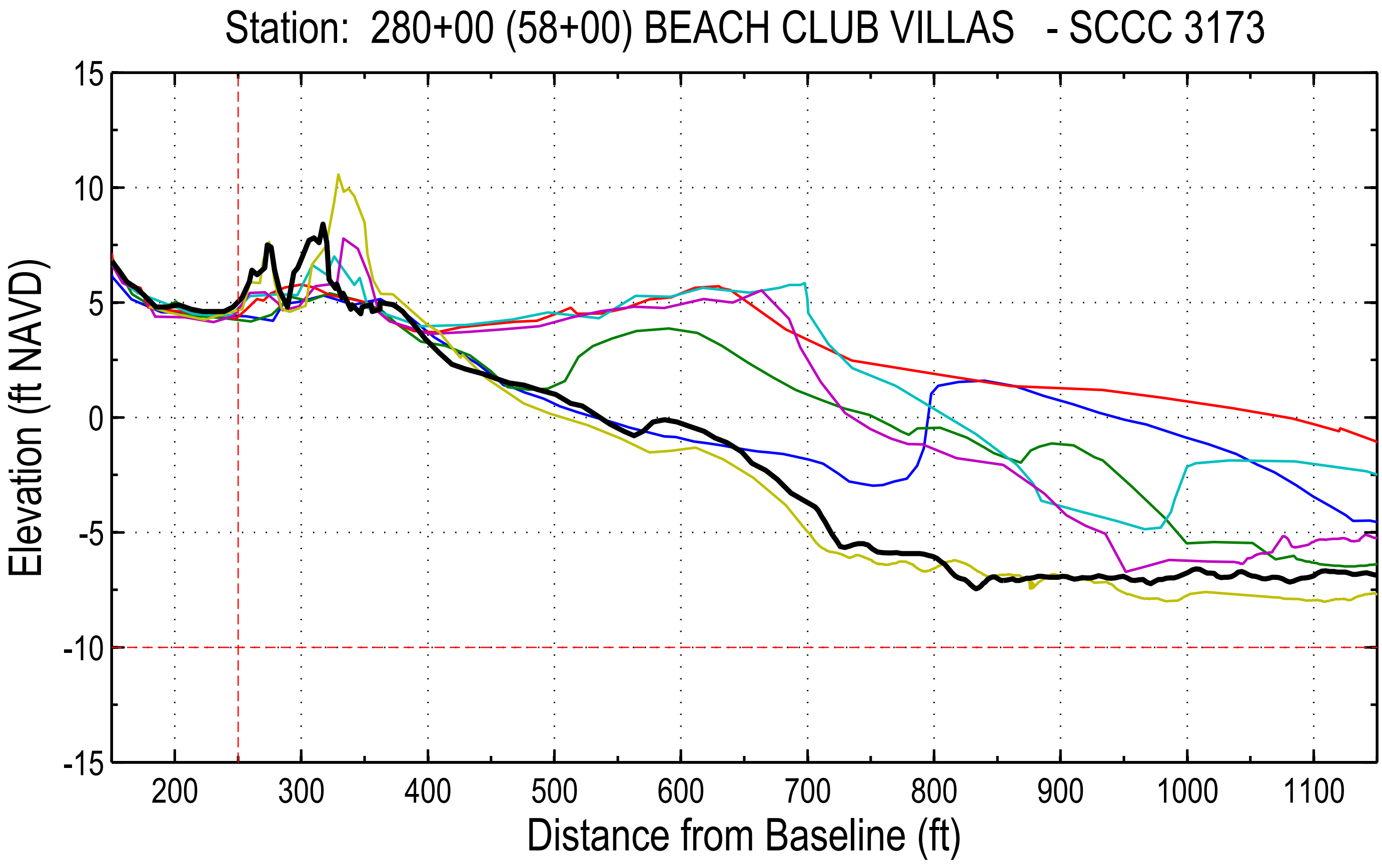
3500
4000


Station: 280+00 (58+00) BEACH CLUB VILLAS - SCCC 3173
Elevation (ft NAVD)
15
10
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-5
-10
-15
200
300
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700
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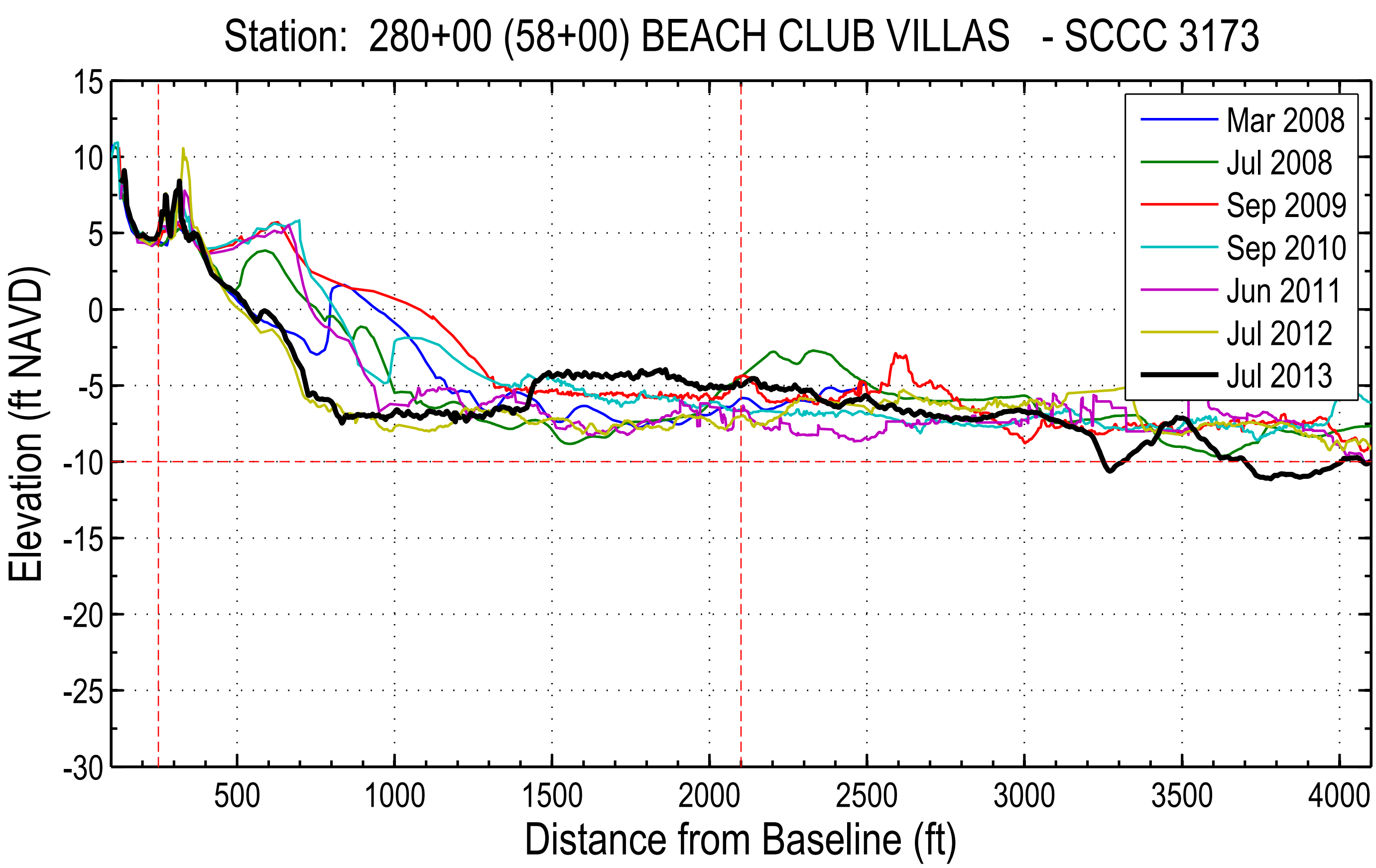
1000
1100
Distance from Baseline (ft)


Station: 280+00 (58+00) BEACH CLUB VILLAS - SCCC 3173
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
Elevation (ft NAVD)
15
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-5
-10
-15
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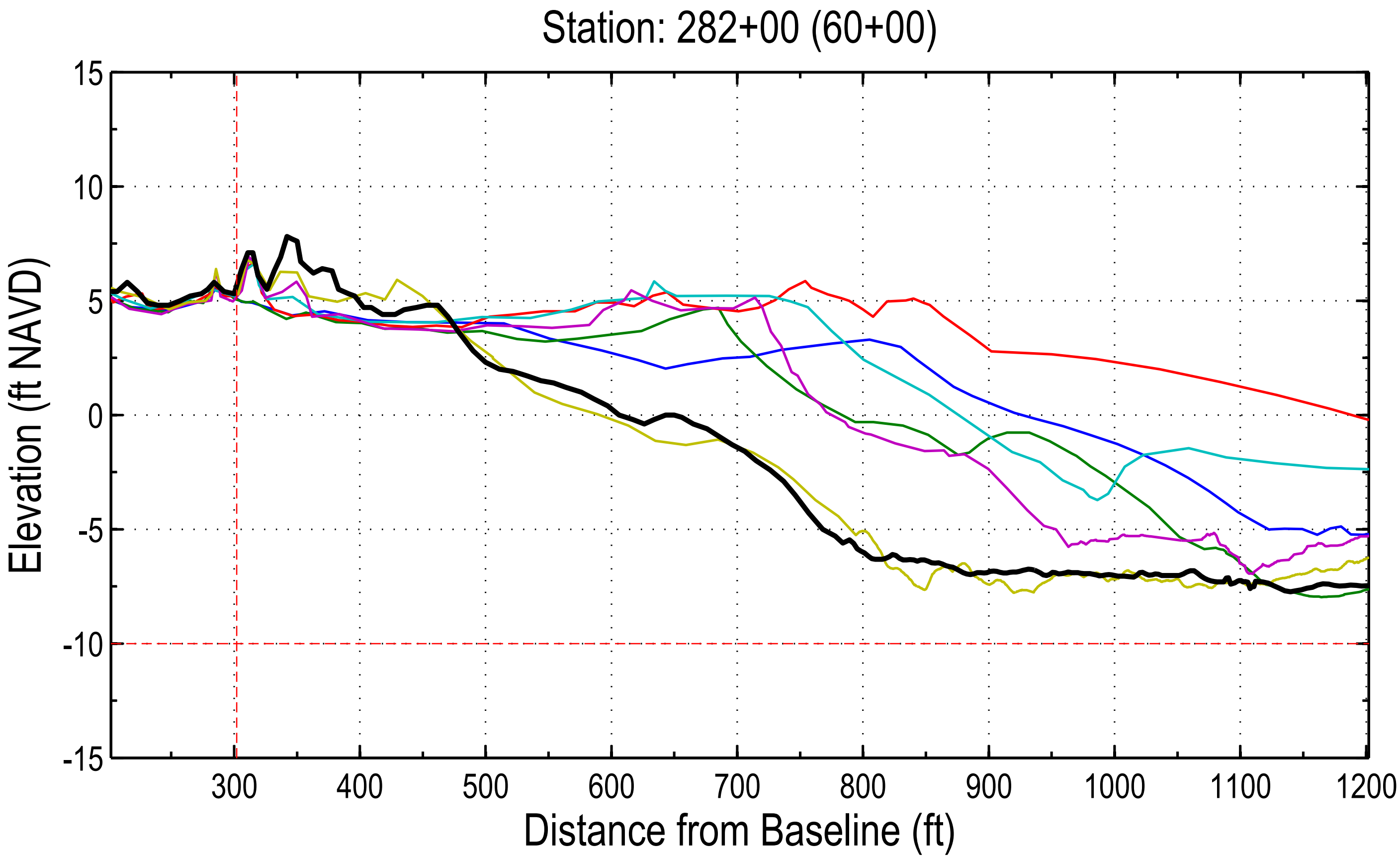
-25
-30
500
1000
1500
2000
2500
3000
3500
4000
Distance from Baseline (ft)



Station: 282+00 (60+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
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0
-5
-10
-15
300
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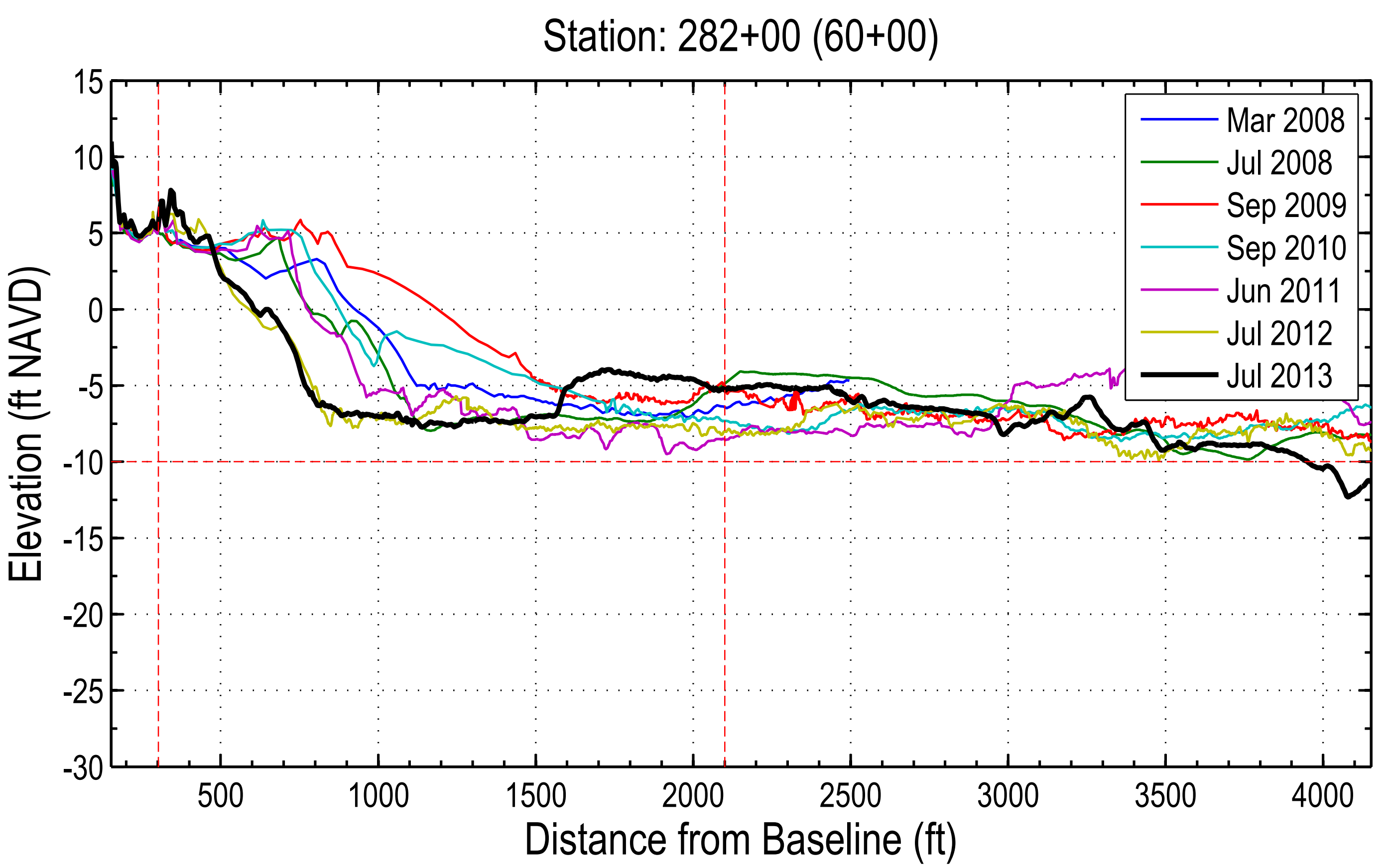

Station: 282+00 (60+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
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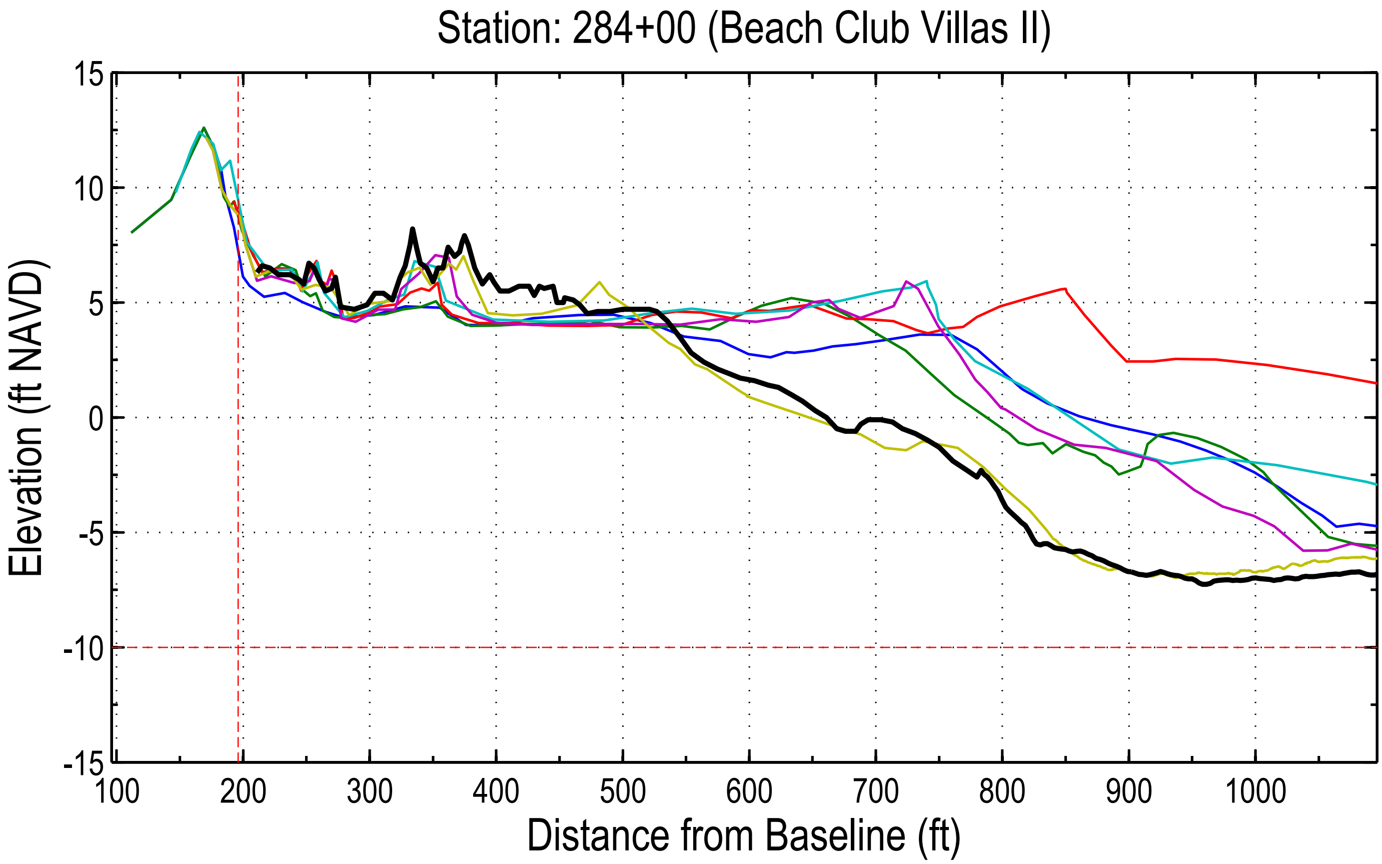

Station: 284+00 (Beach Club Villas II)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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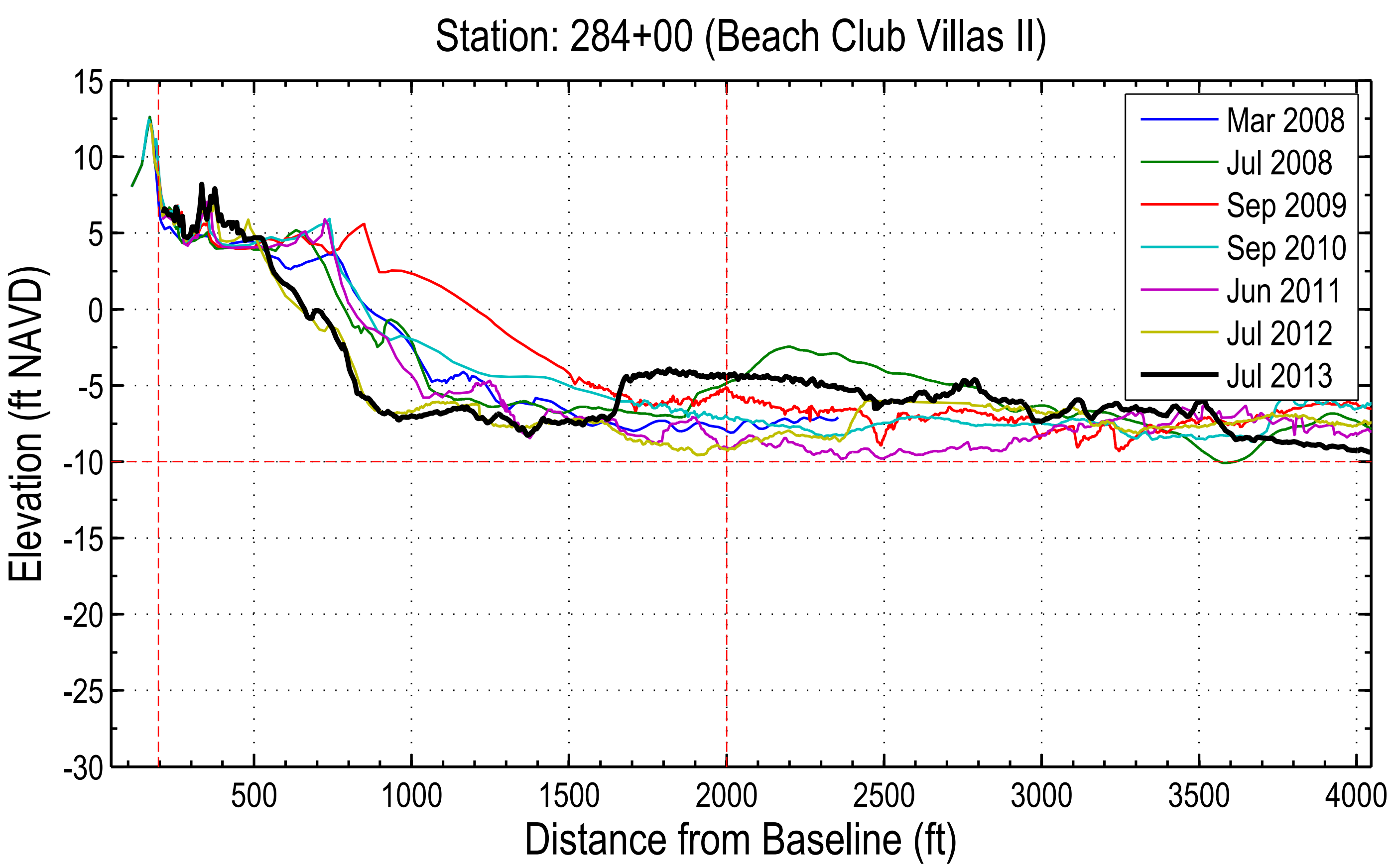

Station: 284+00 (Beach Club Villas II)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
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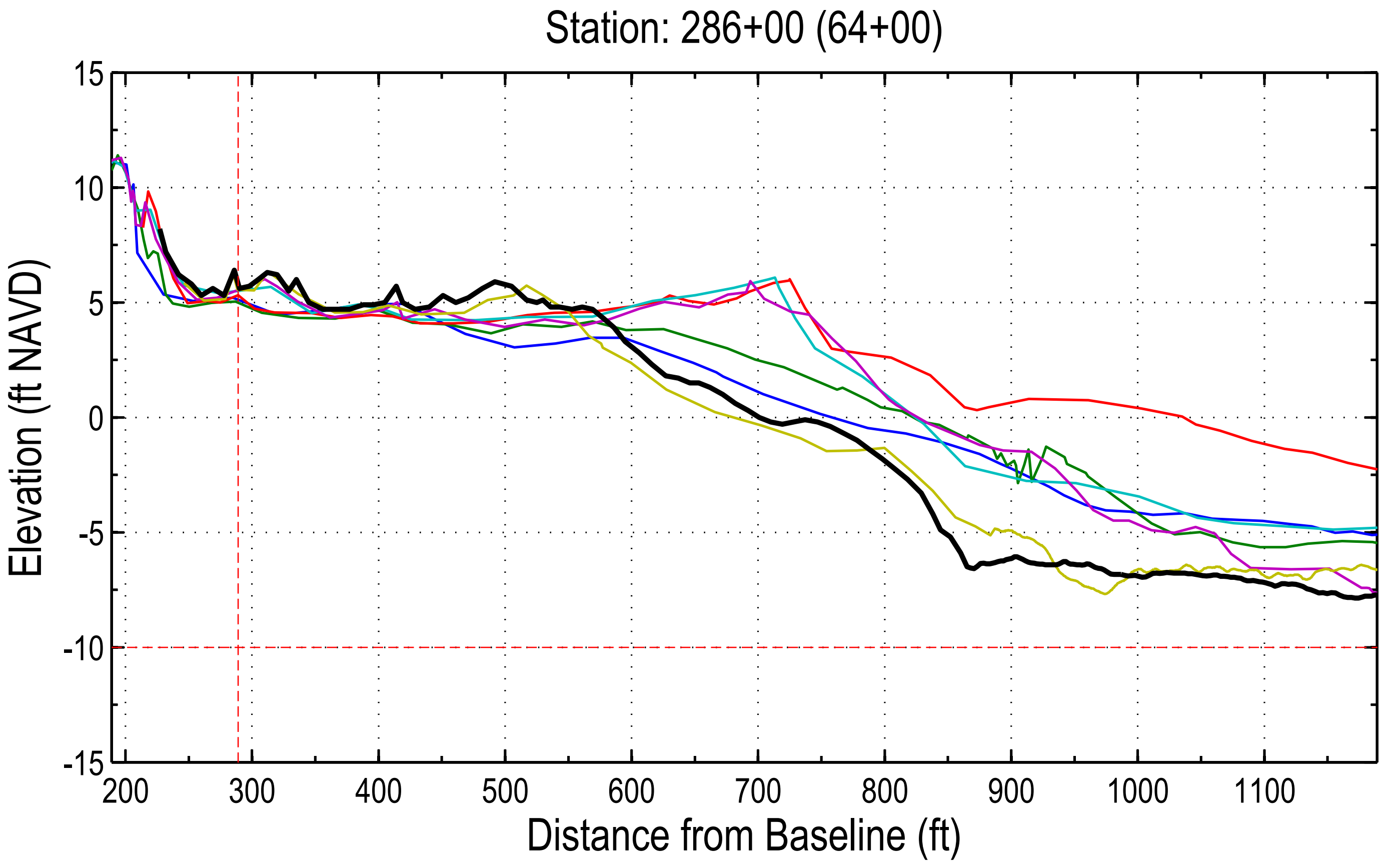

Station: 286+00 (64+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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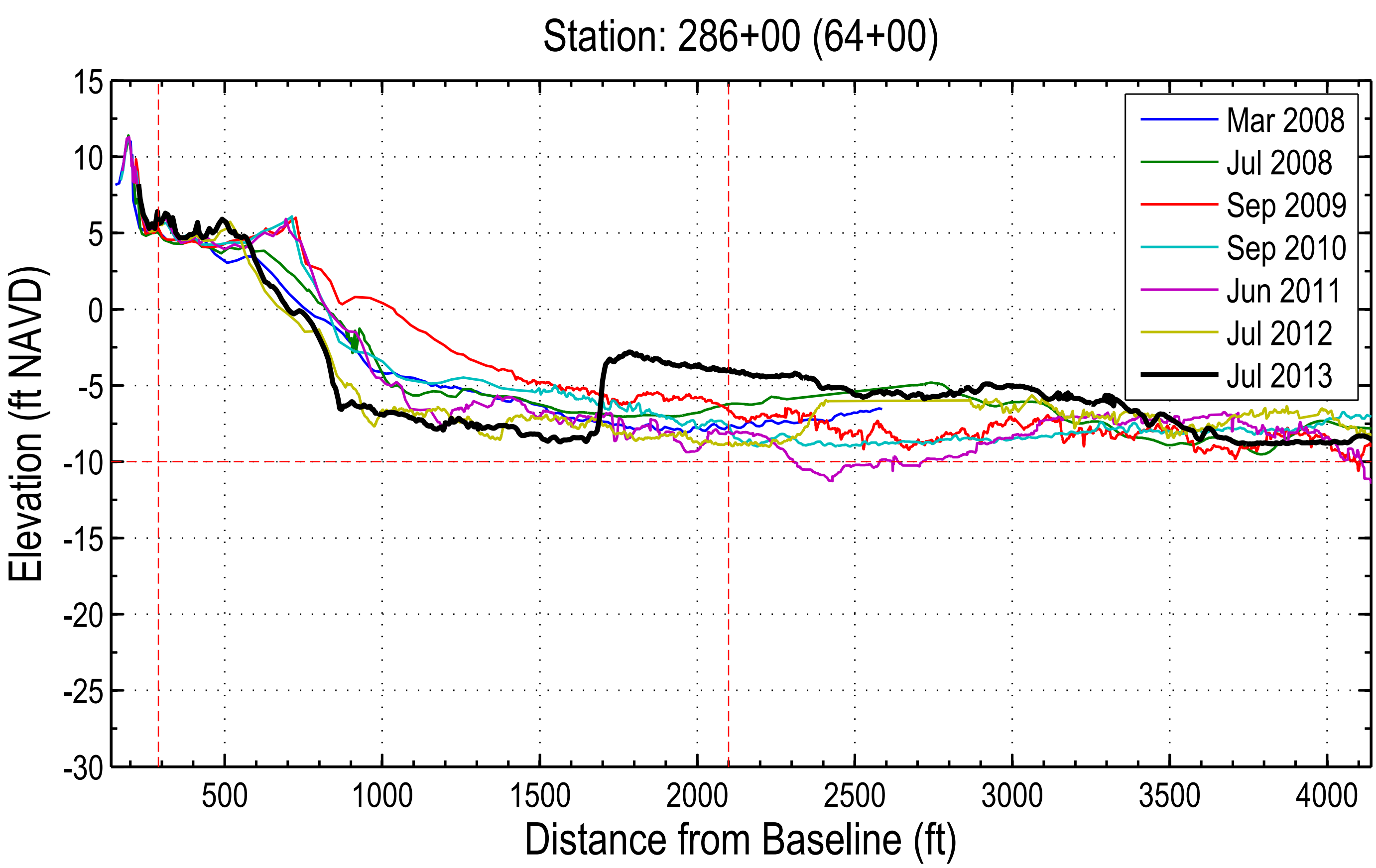

Station: 286+00 (64+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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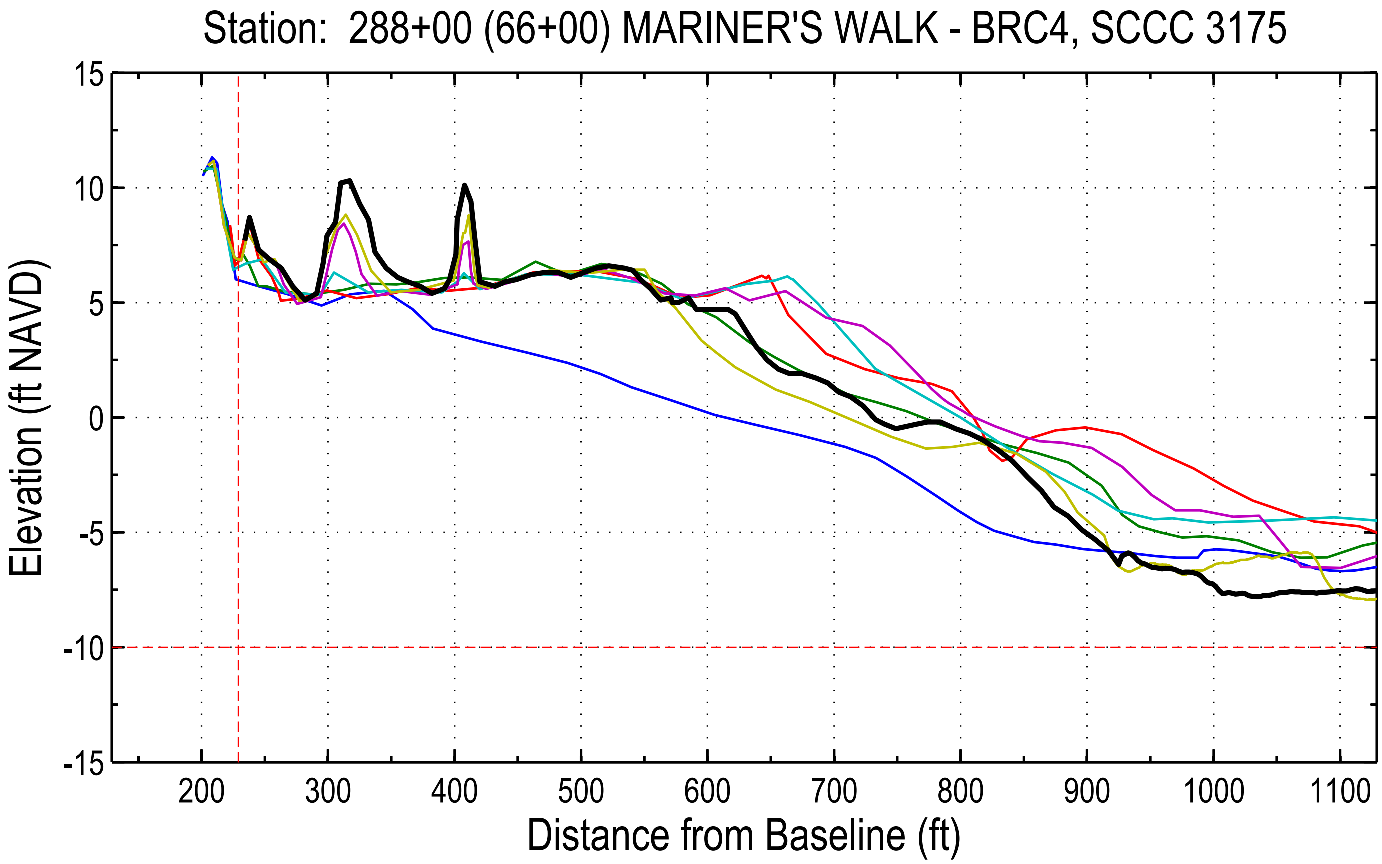
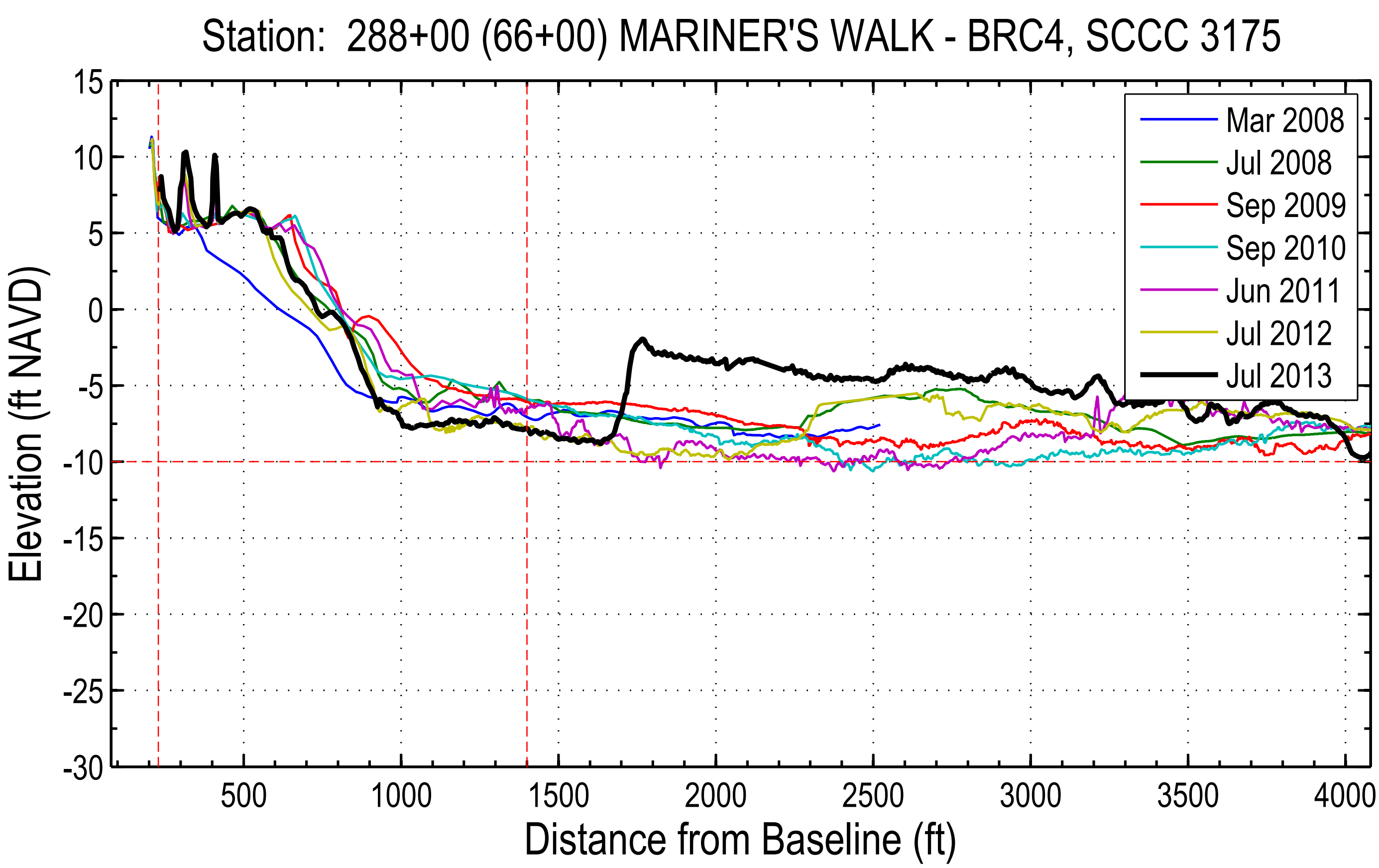
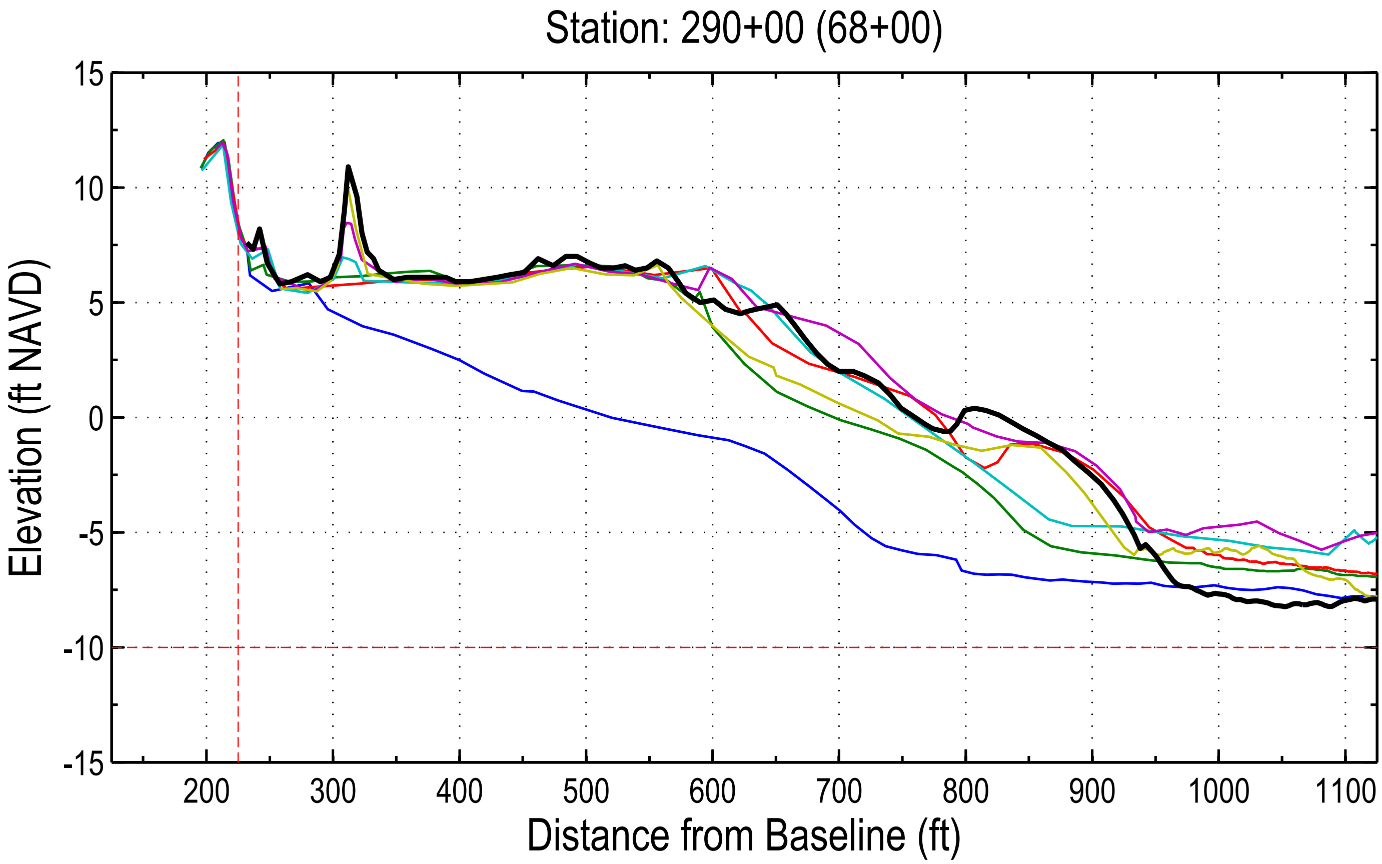
4000
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 288+00 (66+00) MARINER'S WALK - BRC4, SCCC 3175
Elevation (ft NAVD)
Distance from Baseline (ft)


Station: 288+00 (66+00) MARINER'S WALK - BRC4, SCCC 3175
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 290+00 (68+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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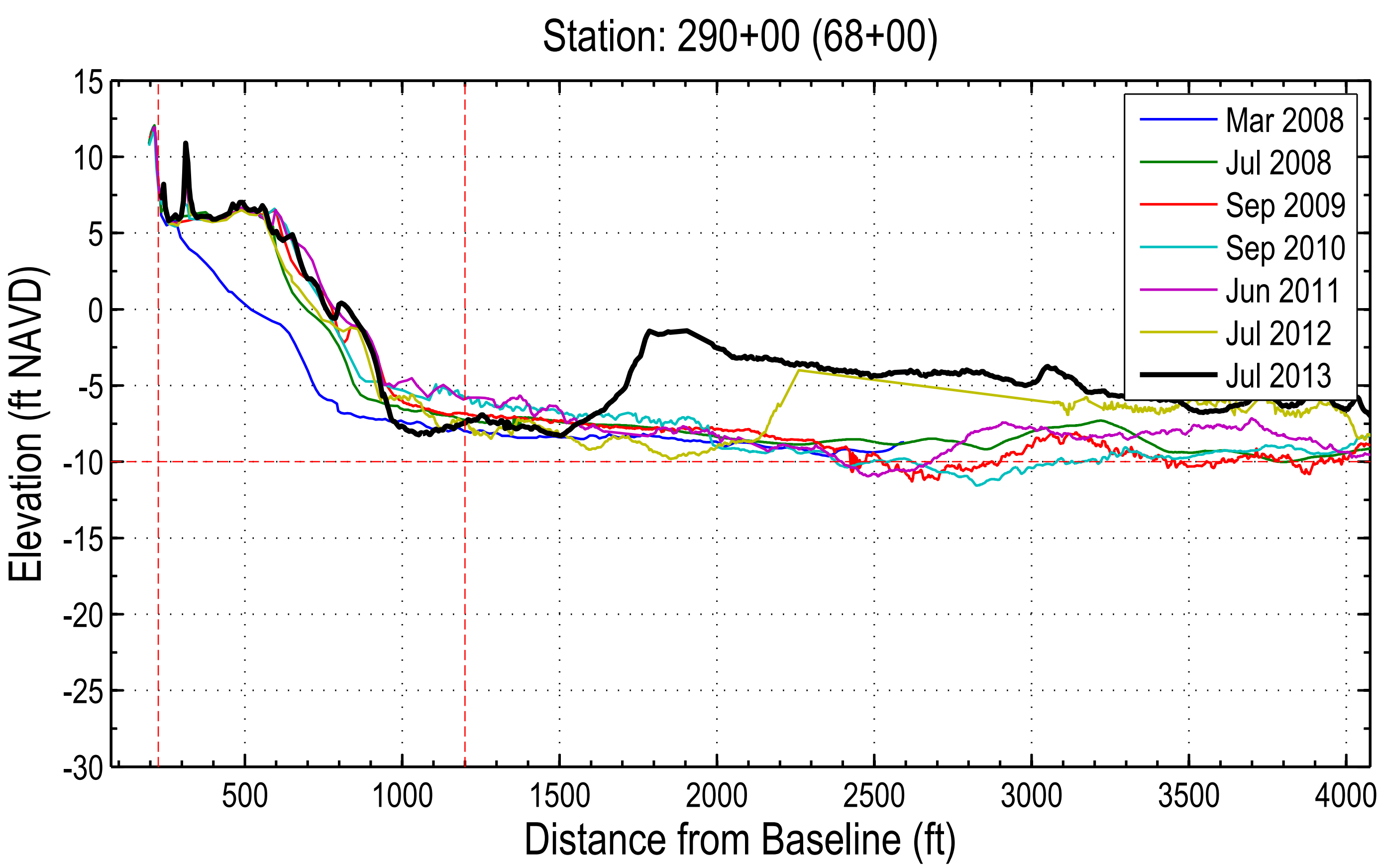
1100



Station: 290+00 (68+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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3500
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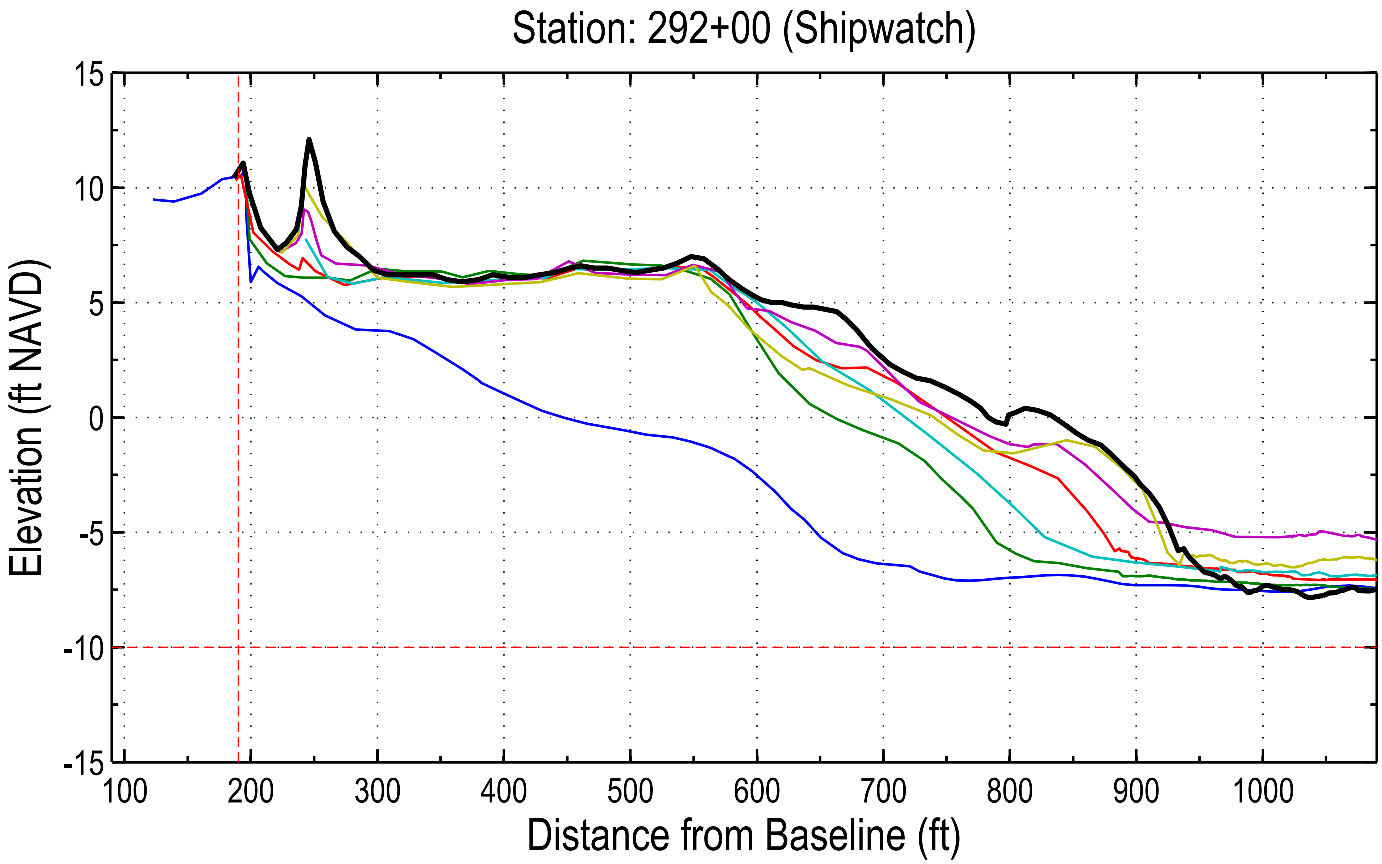
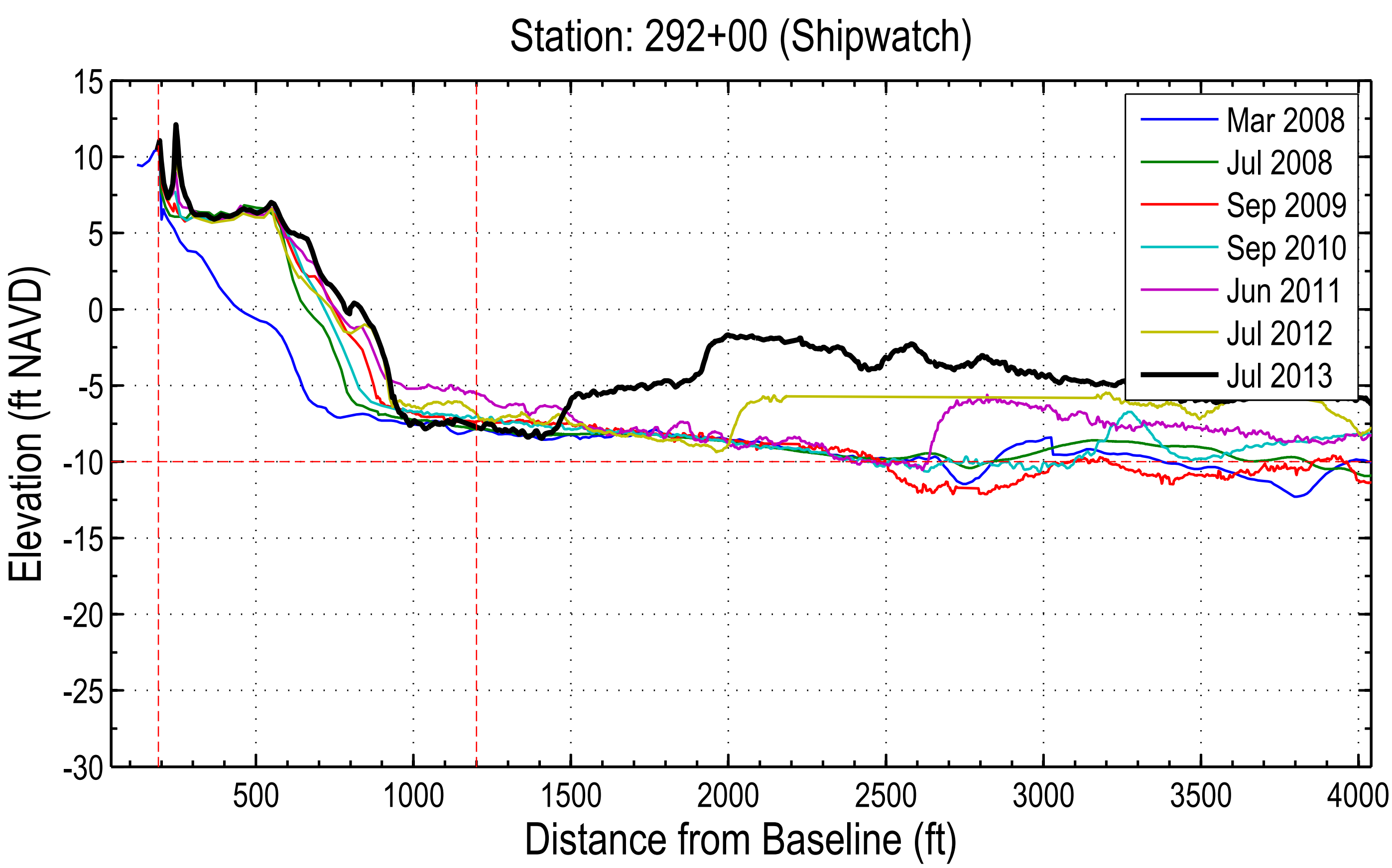
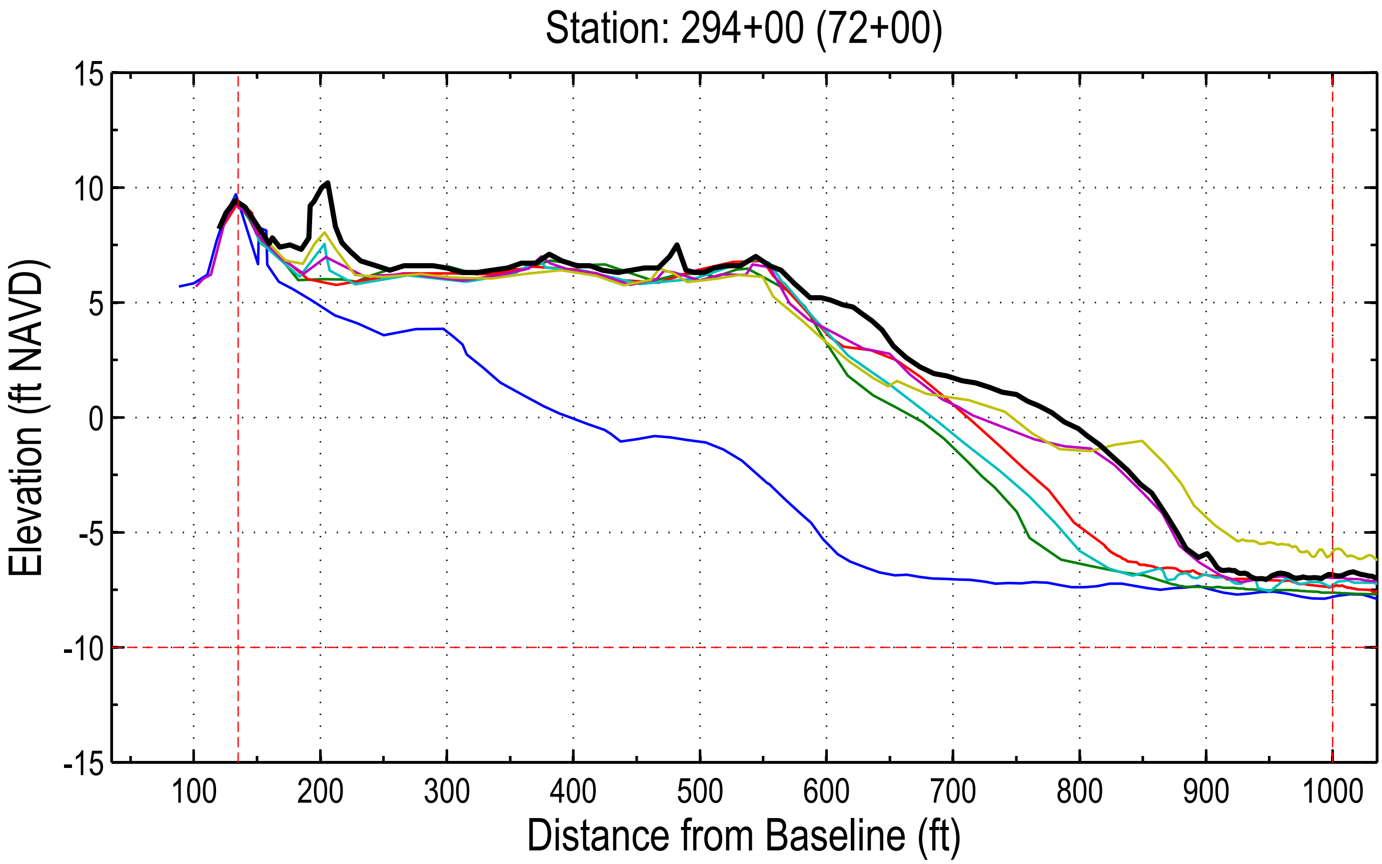
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013

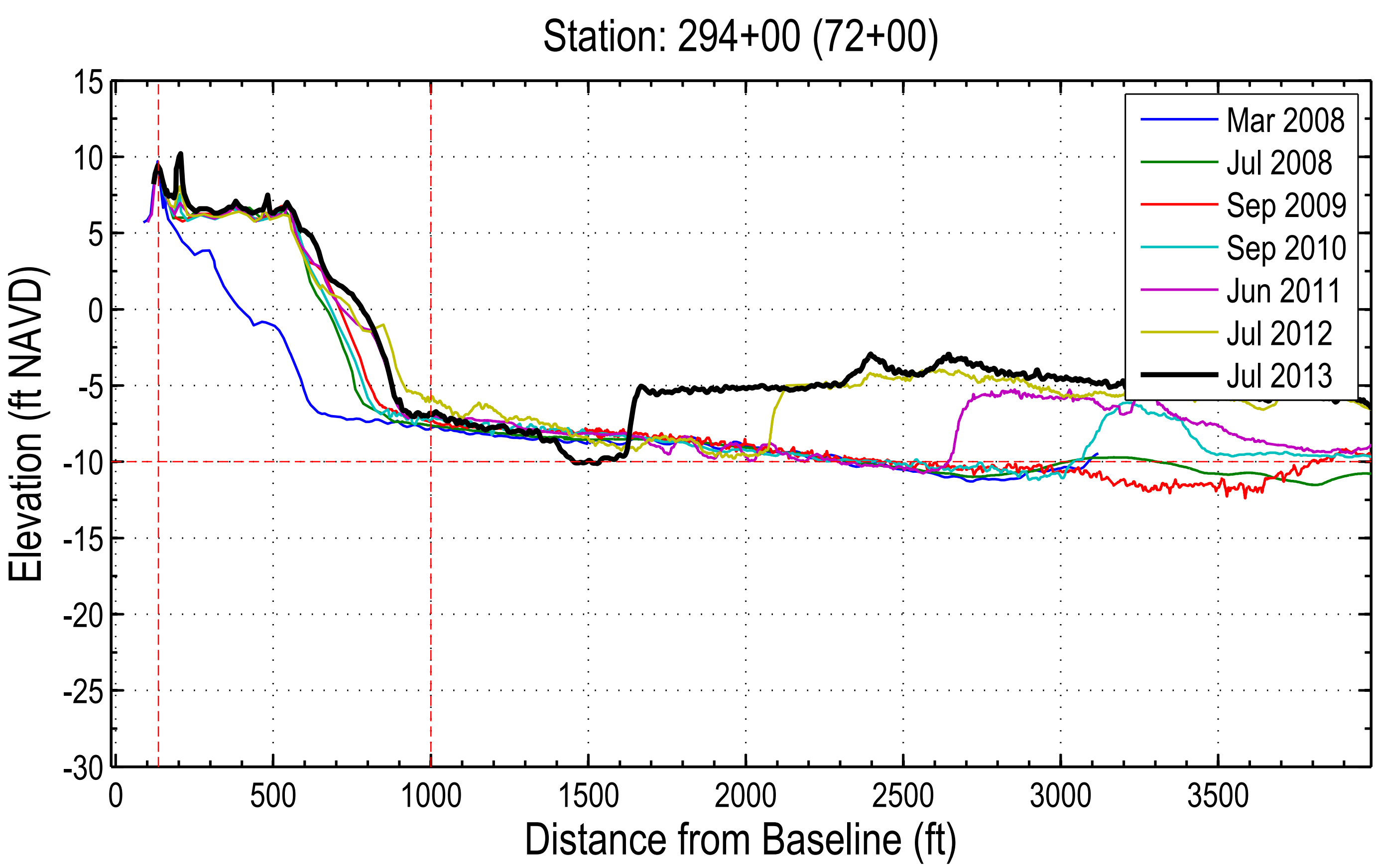


Station: 292+00 (Shipwatch)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000



Station: 292+00 (Shipwatch)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000


Station: 294+00 (72+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000


Station: 294+00 (72+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
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-25
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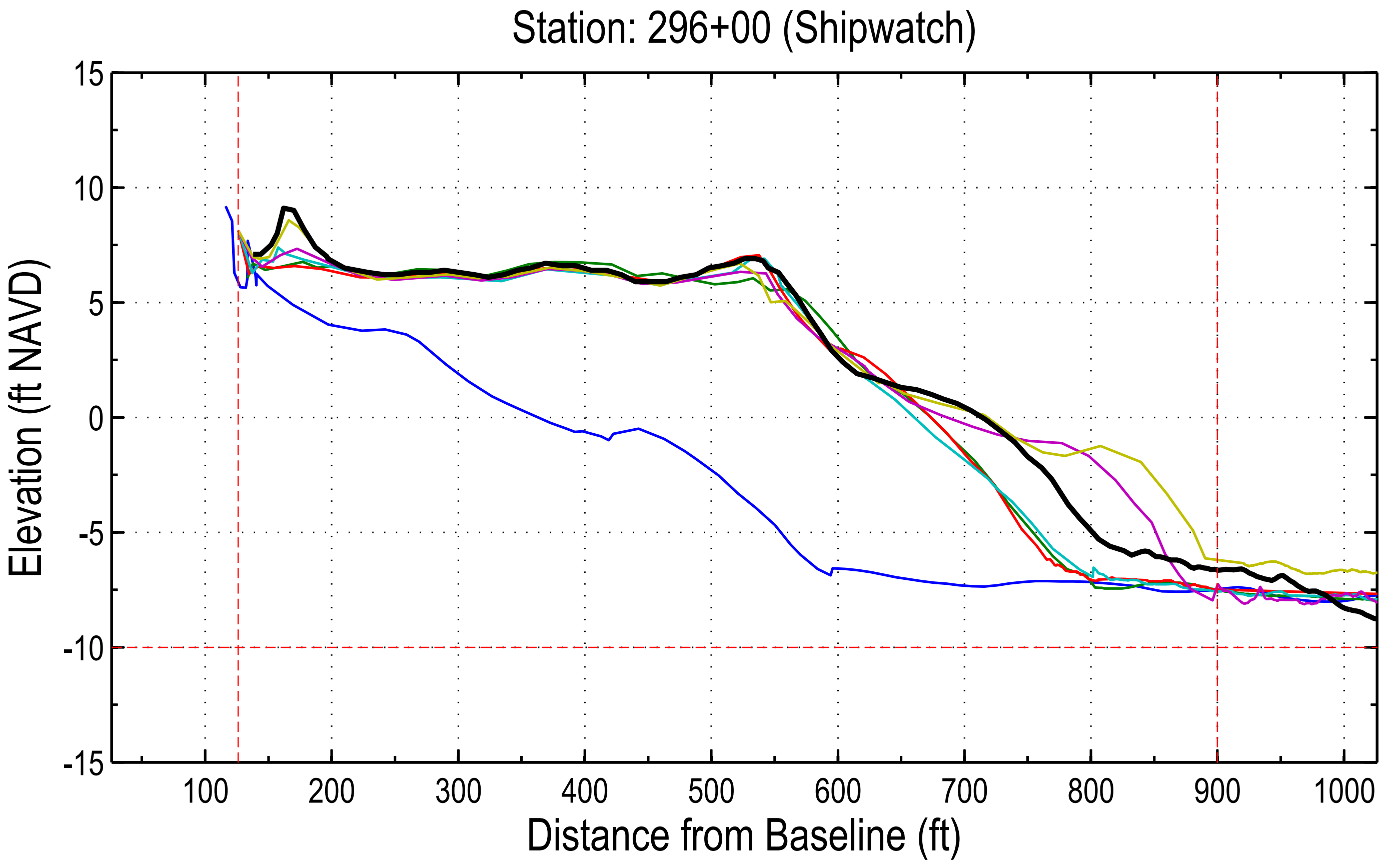
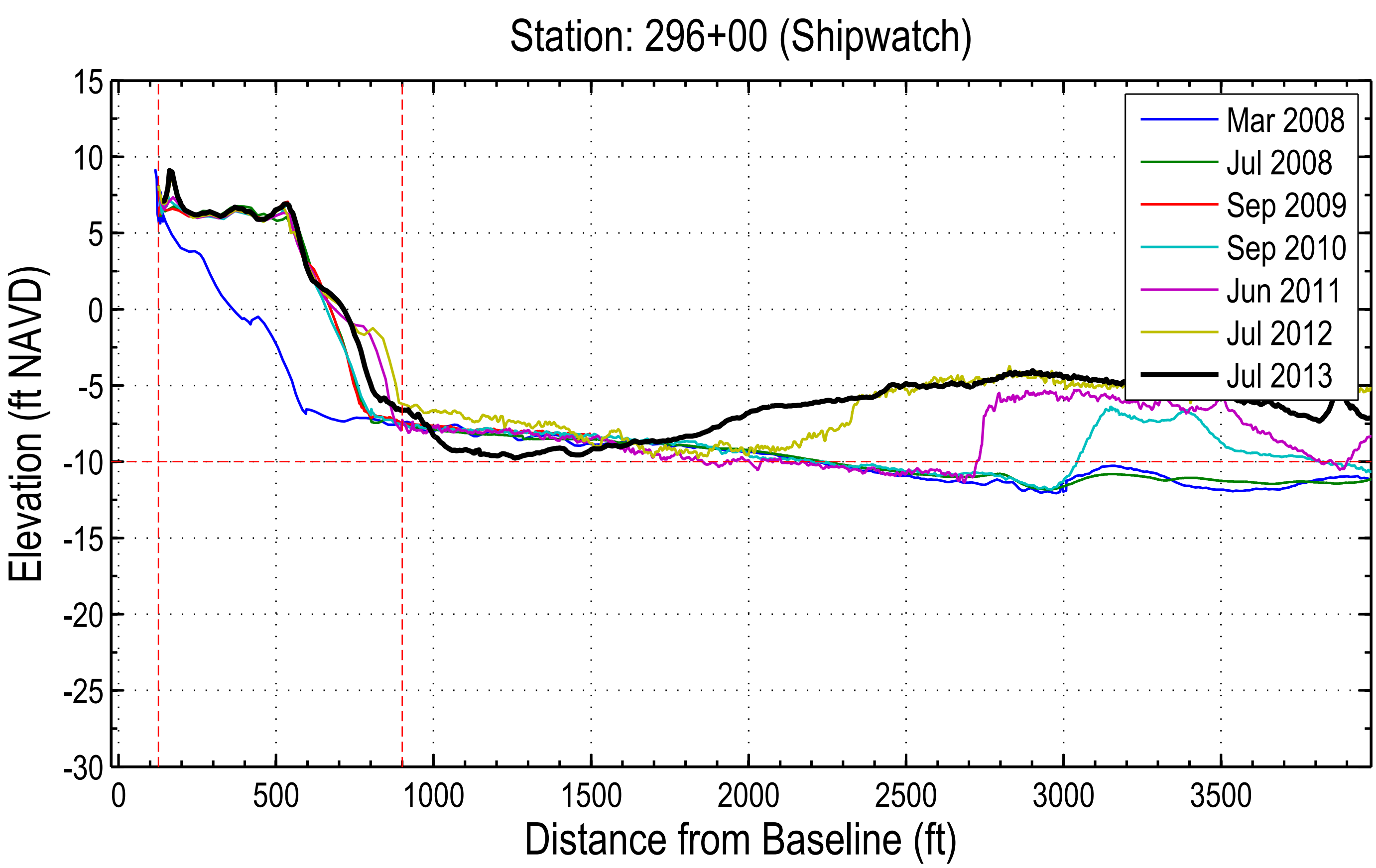
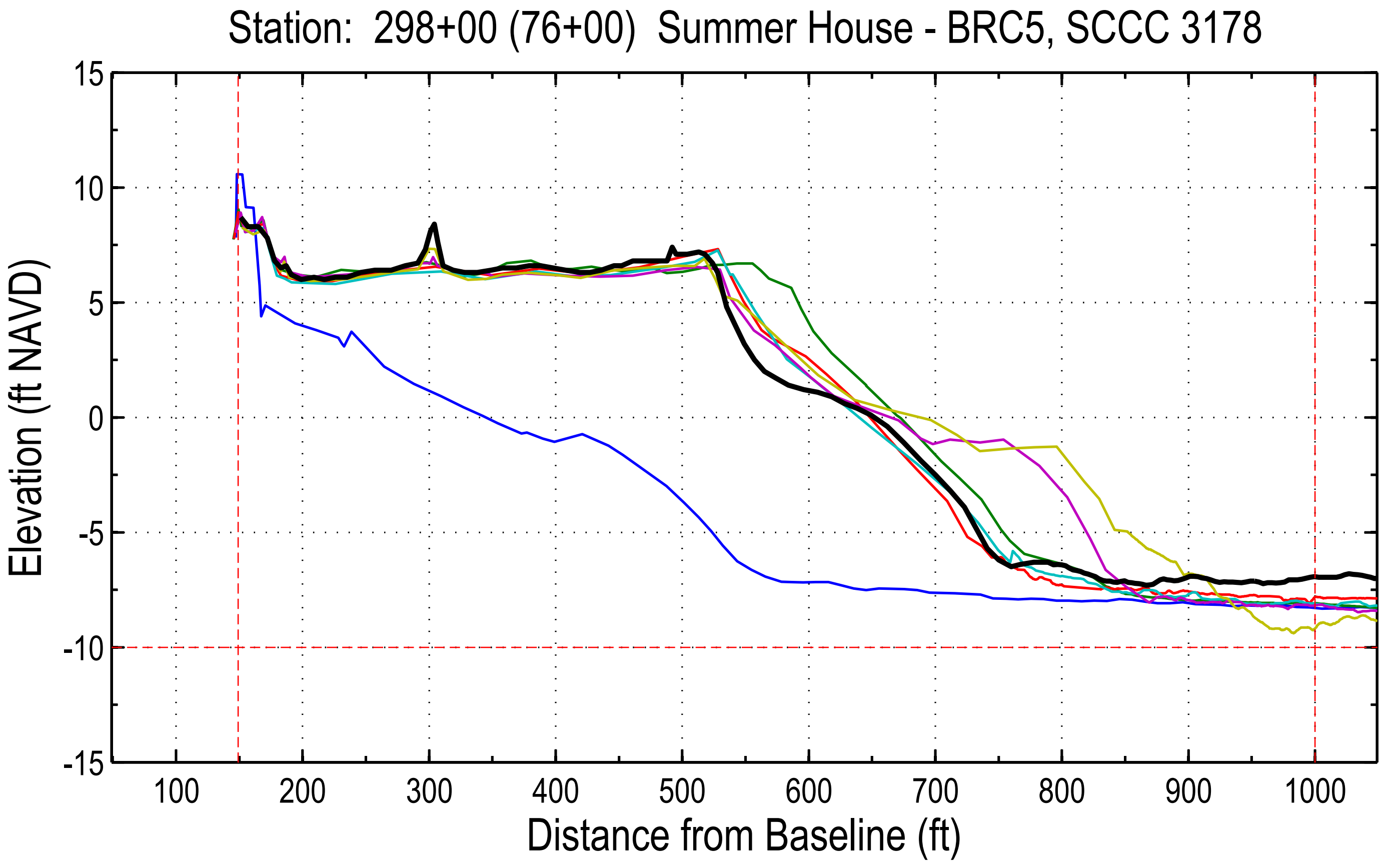
1500
2000
2500
3000
3500

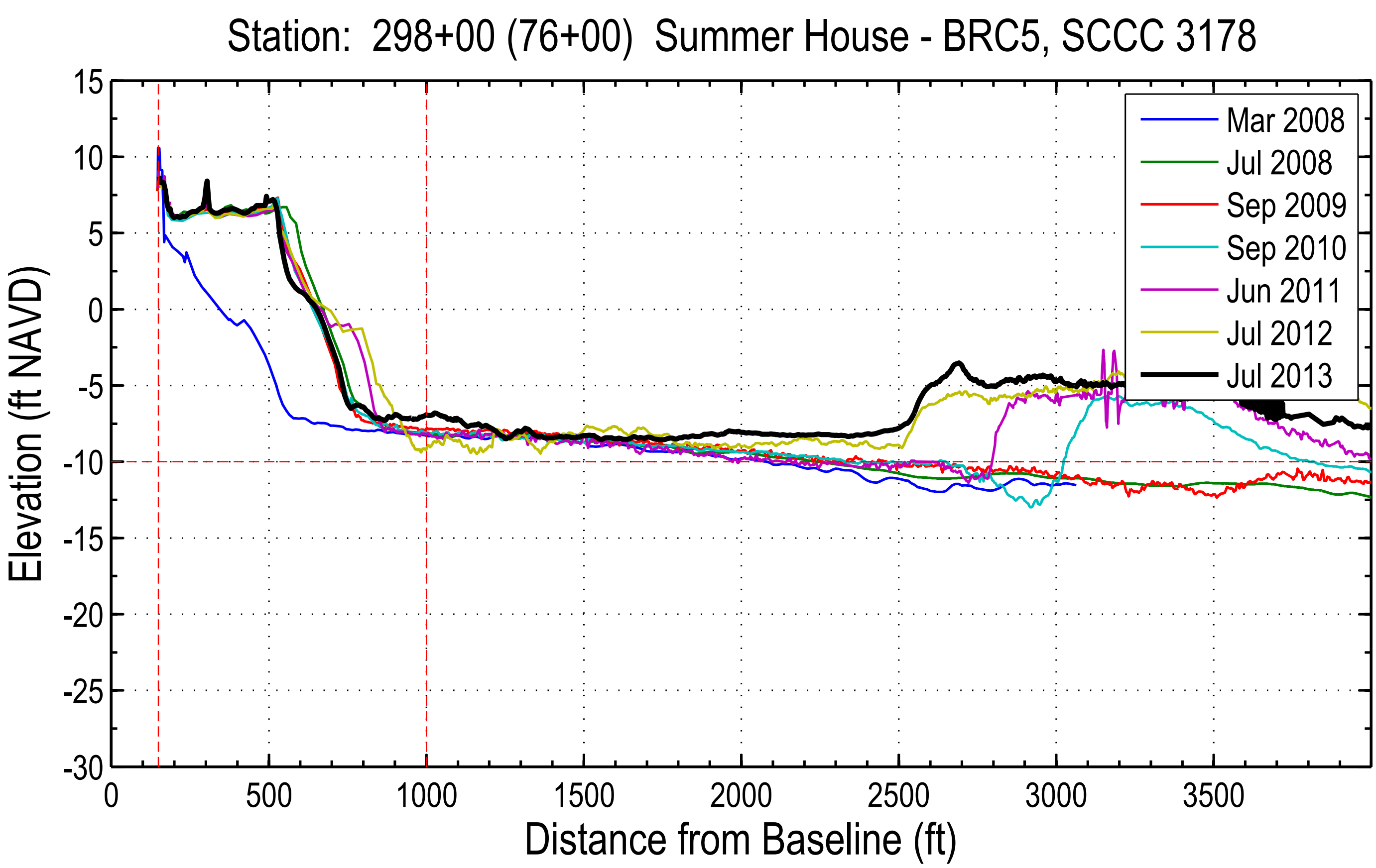


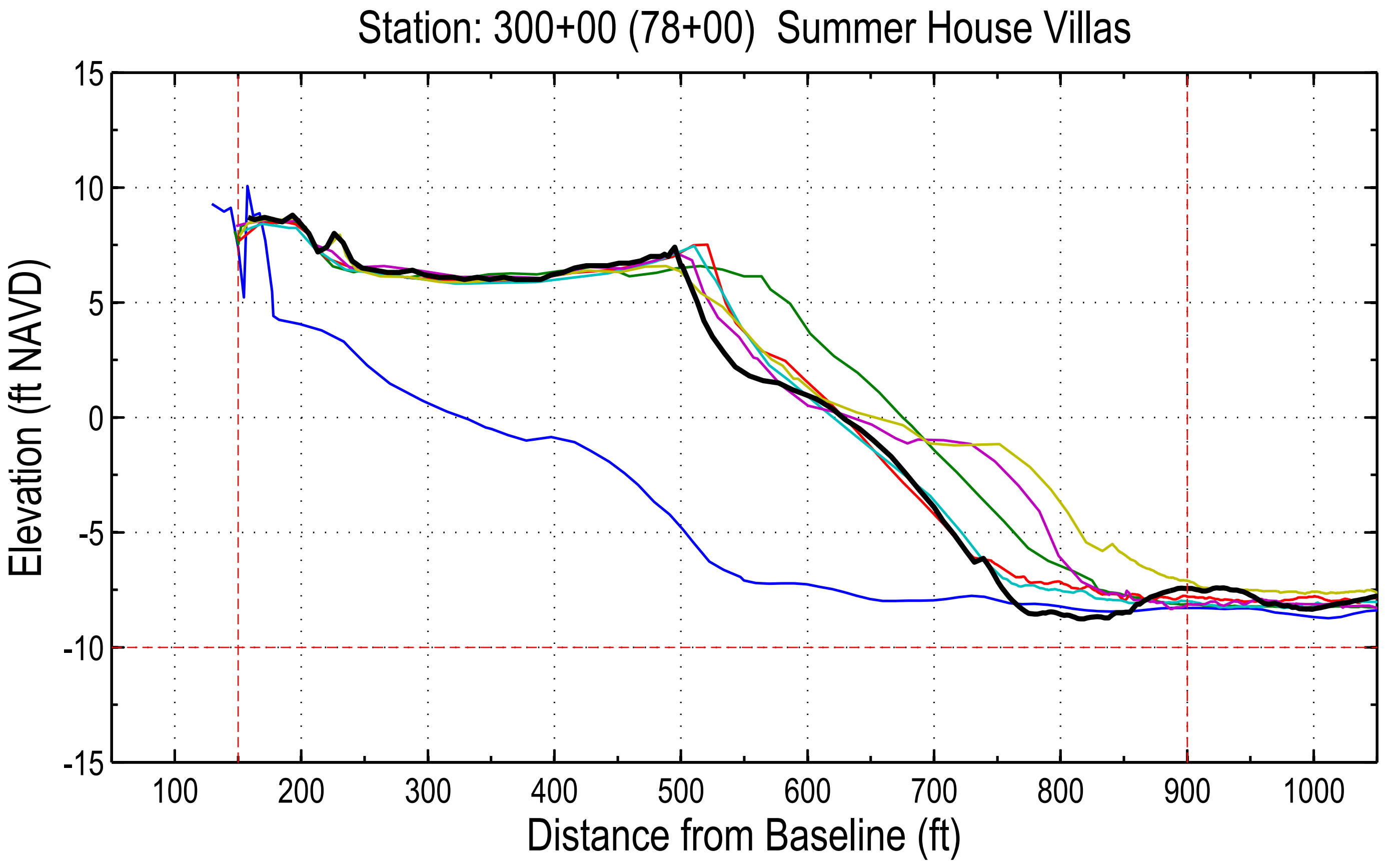
Station: 296+00 (Shipwatch)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000
Distance from Baseline (ft)

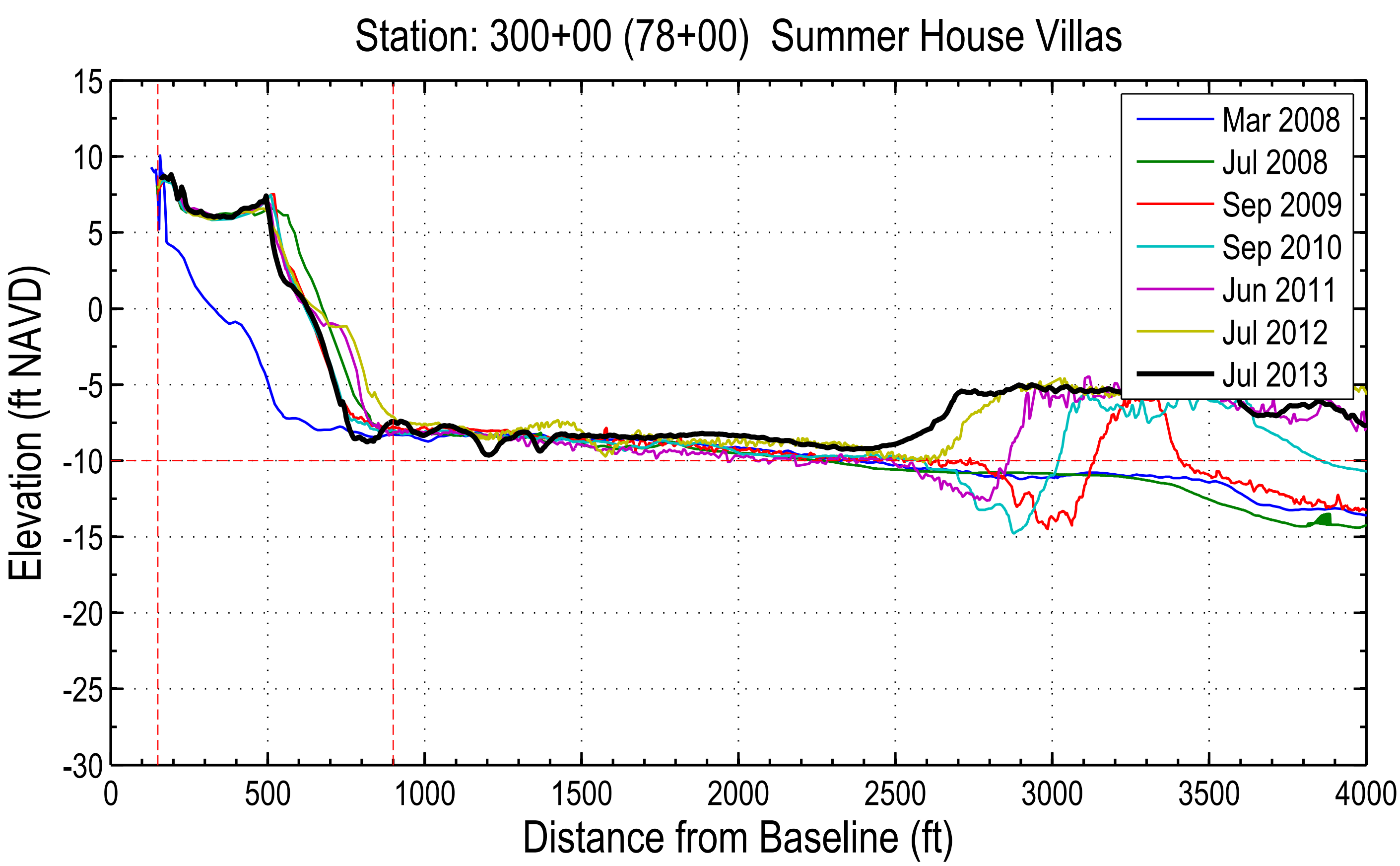


Station: 296+00 (Shipwatch)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 298+00 (76+00) Summer House - BRC5, SCCC 3178
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000
Distance from Baseline (ft)


Station: 298+00 (76+00) Summer House - BRC5, SCCC 3178
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 300+00 (78+00) Summer House Villas
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000


Station: 300+00 (78+00) Summer House Villas
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
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-25
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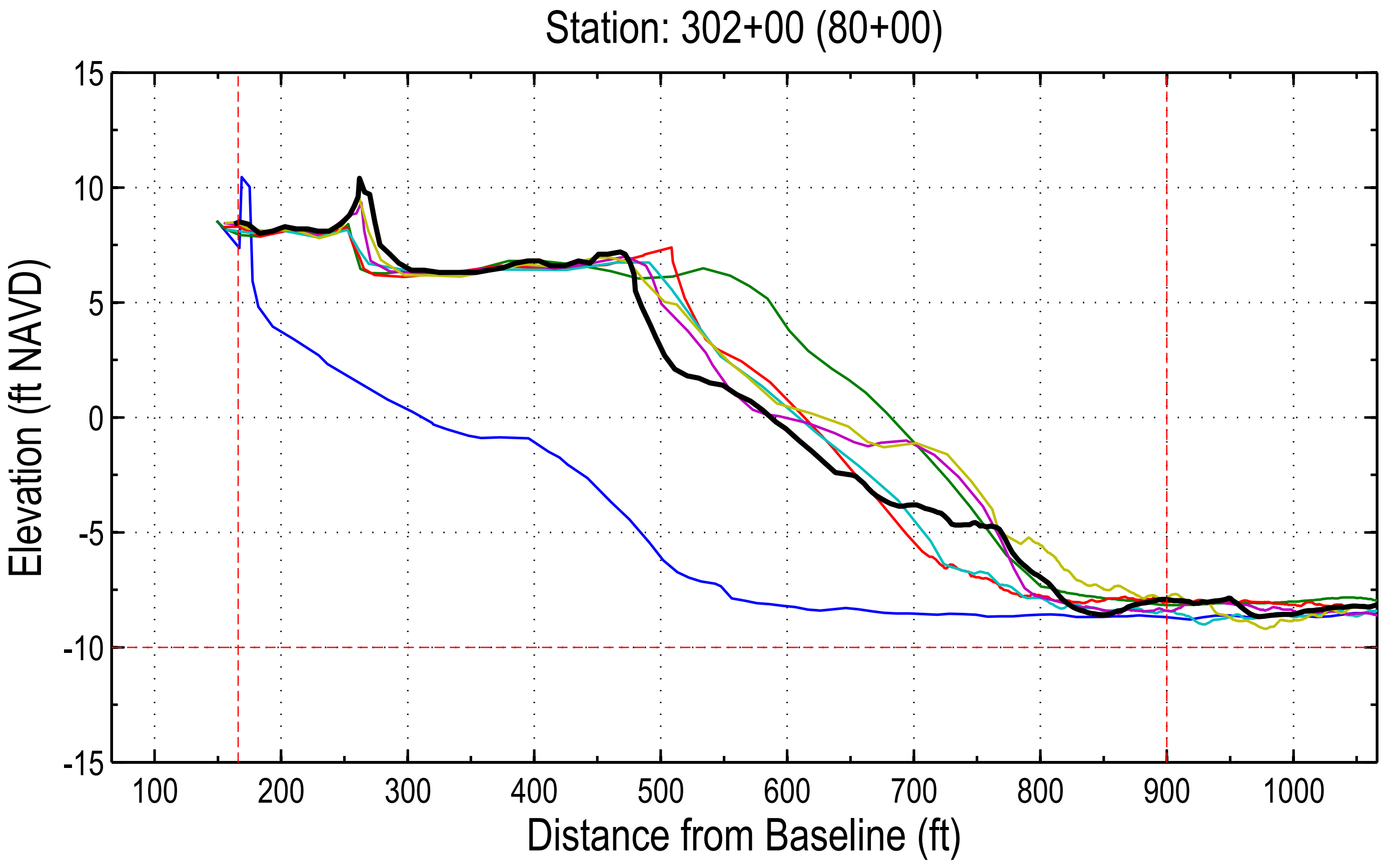
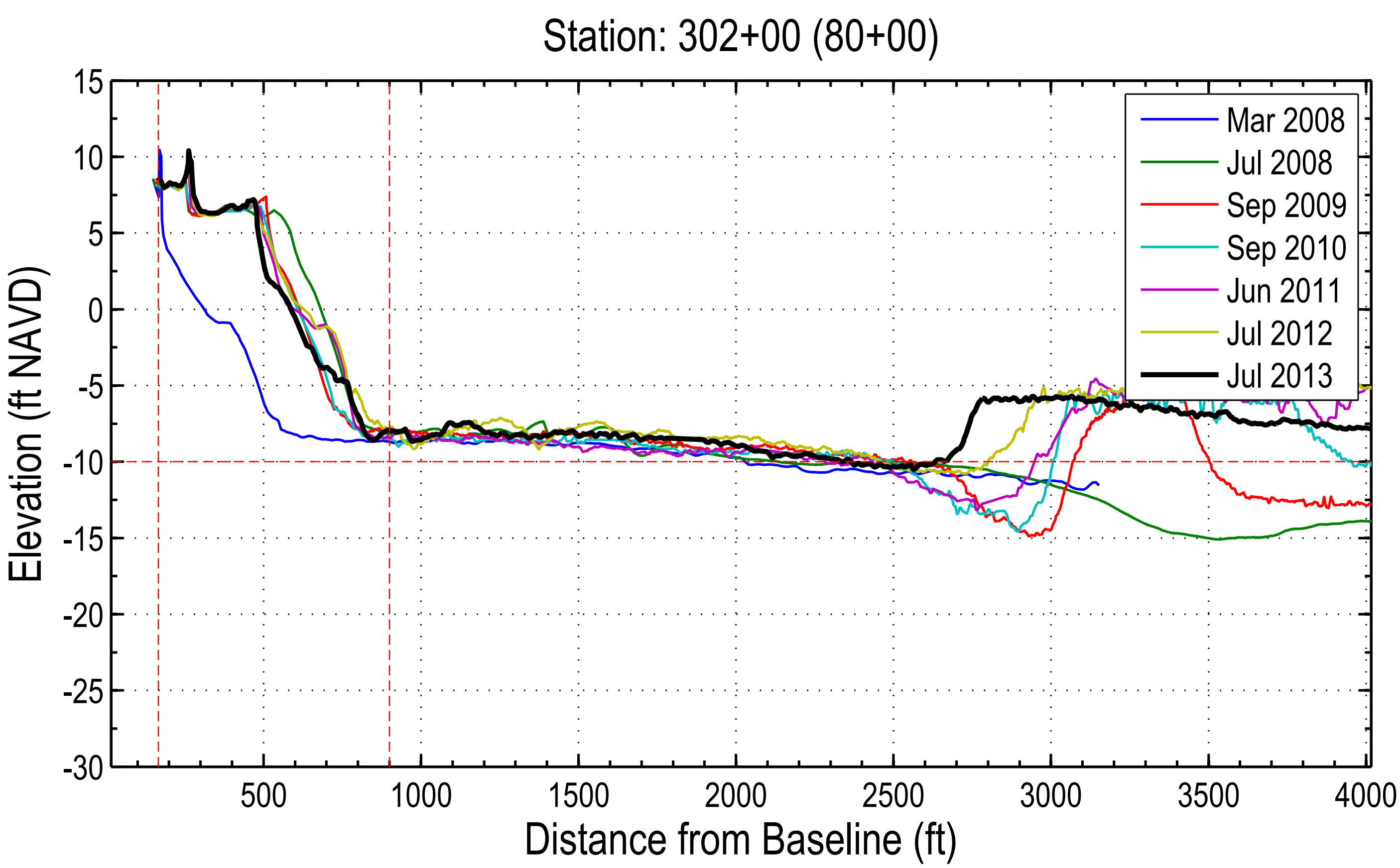
2000
2500
3000
3500
4000


Station: 302+00 (80+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000


Station: 302+00 (80+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
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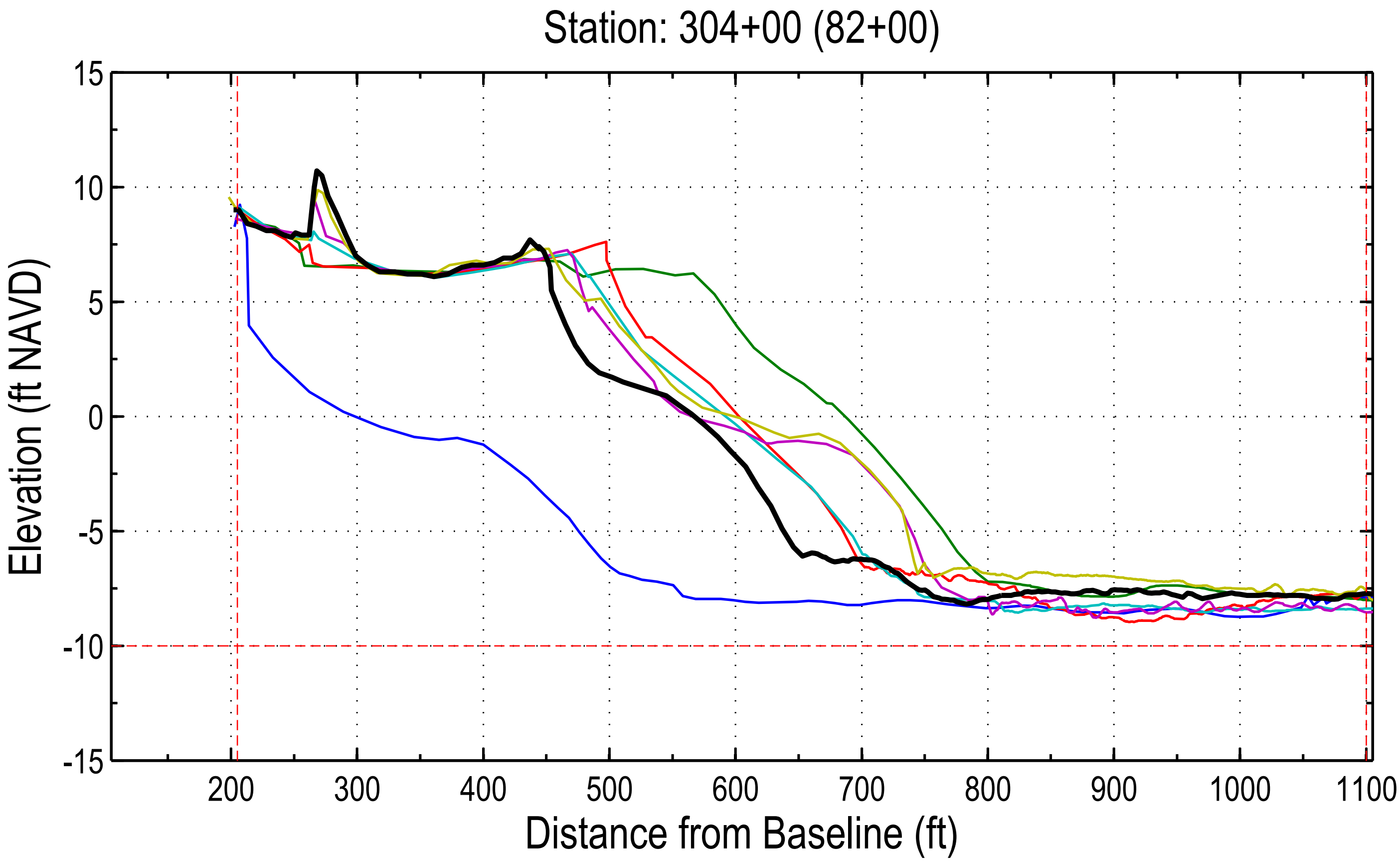
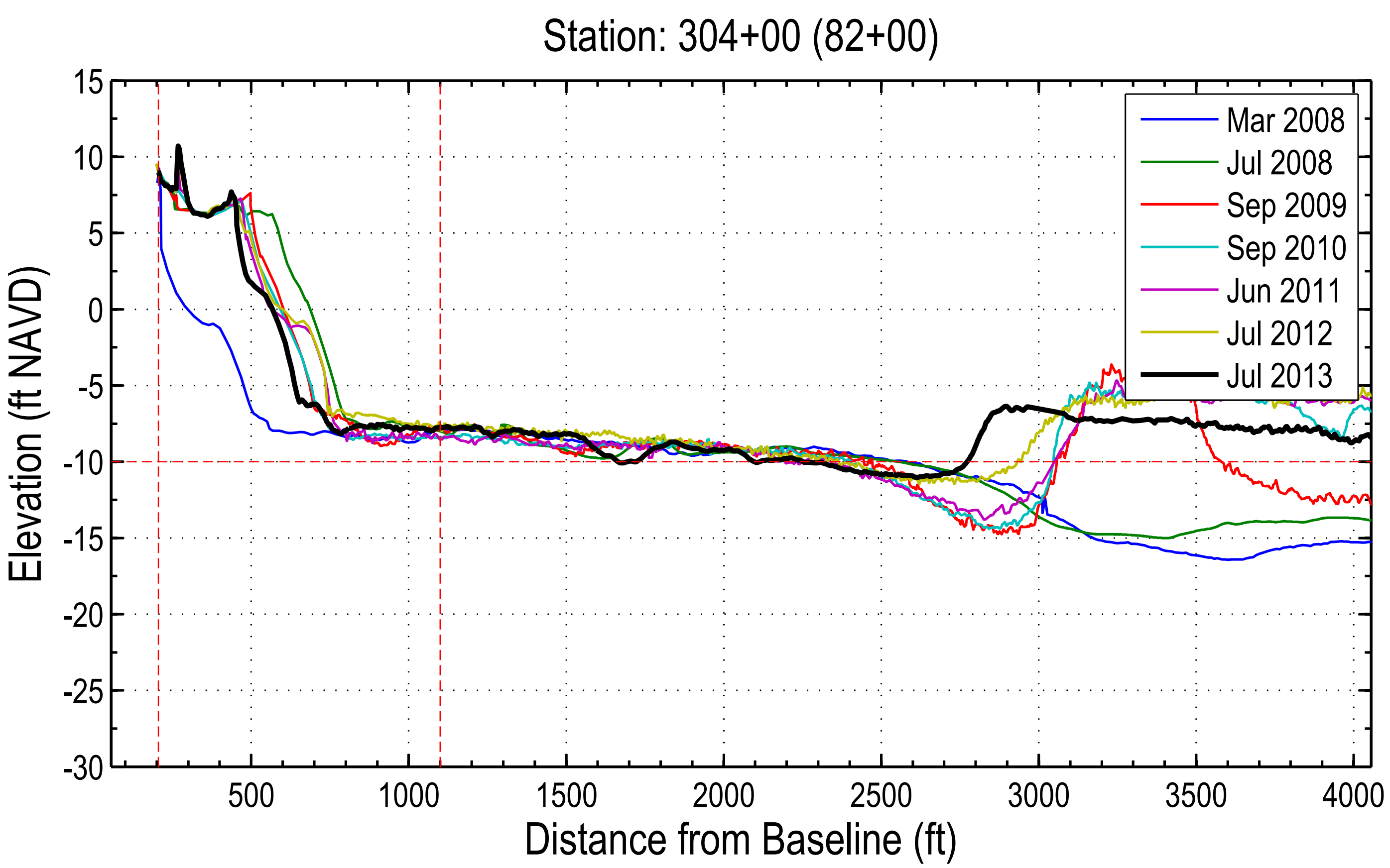
2000
2500
3000
3500
4000



Station: 304+00 (82+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
200
300
400
500
600
700
800
900
1000
1100



Station: 304+00 (82+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
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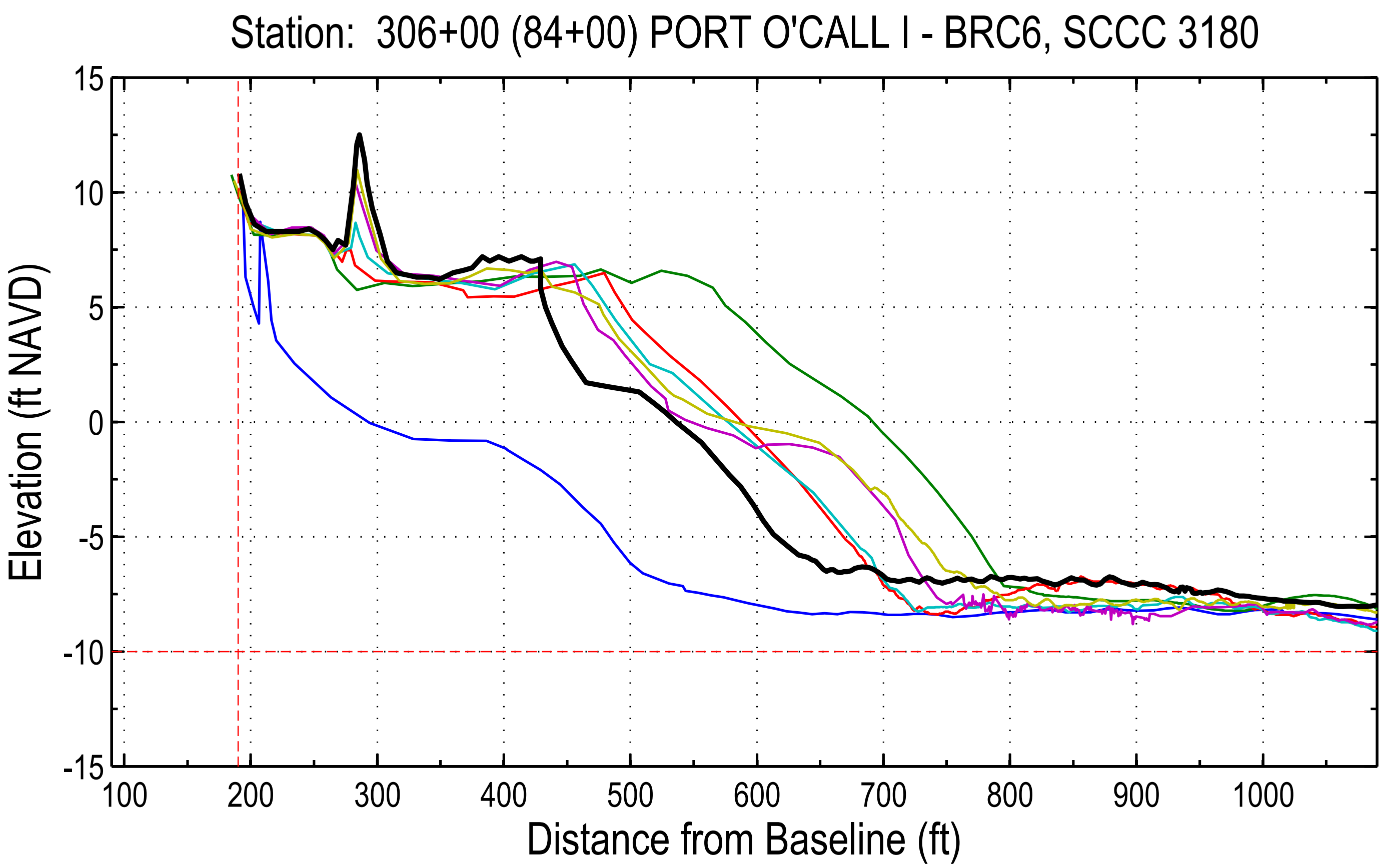
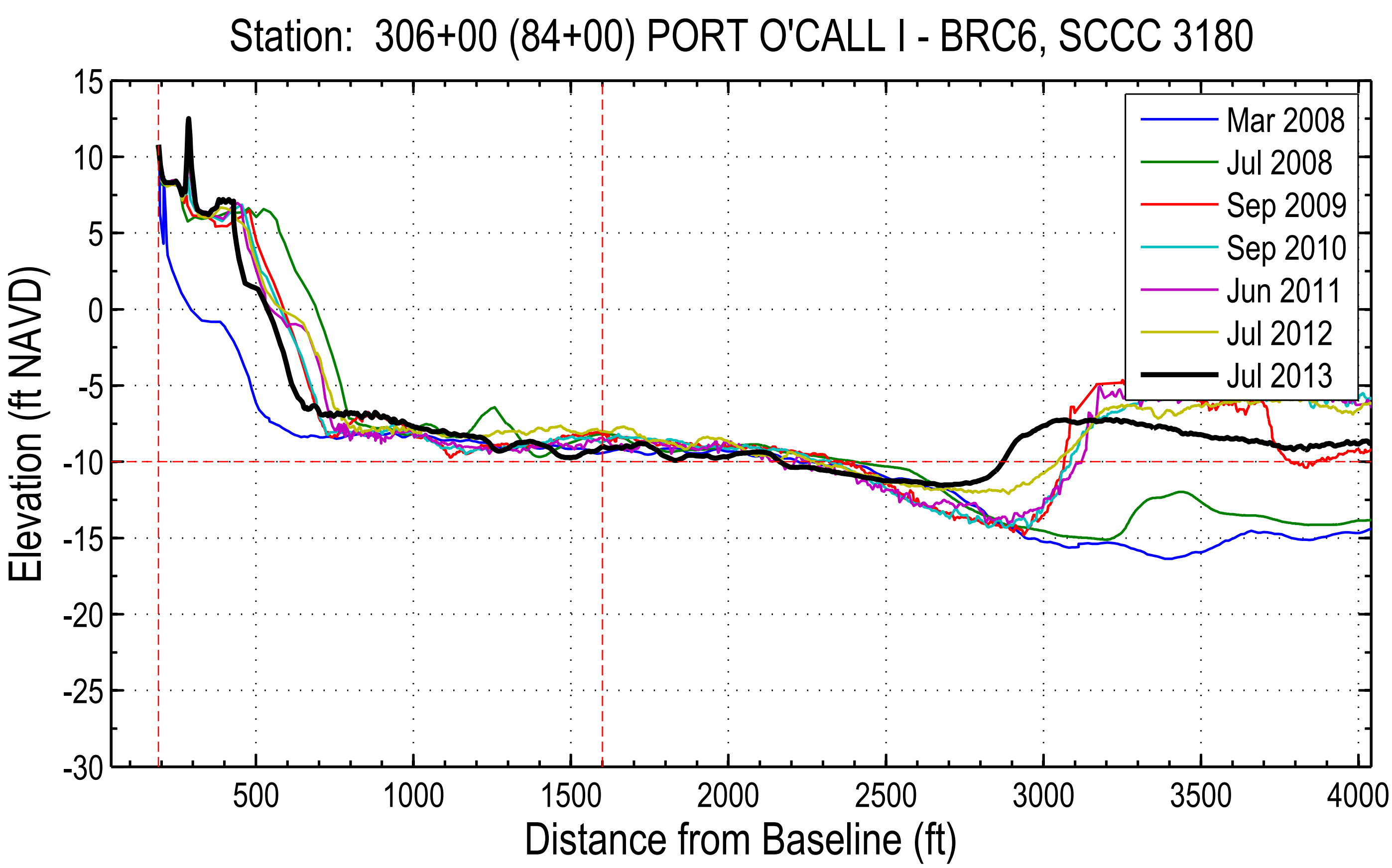
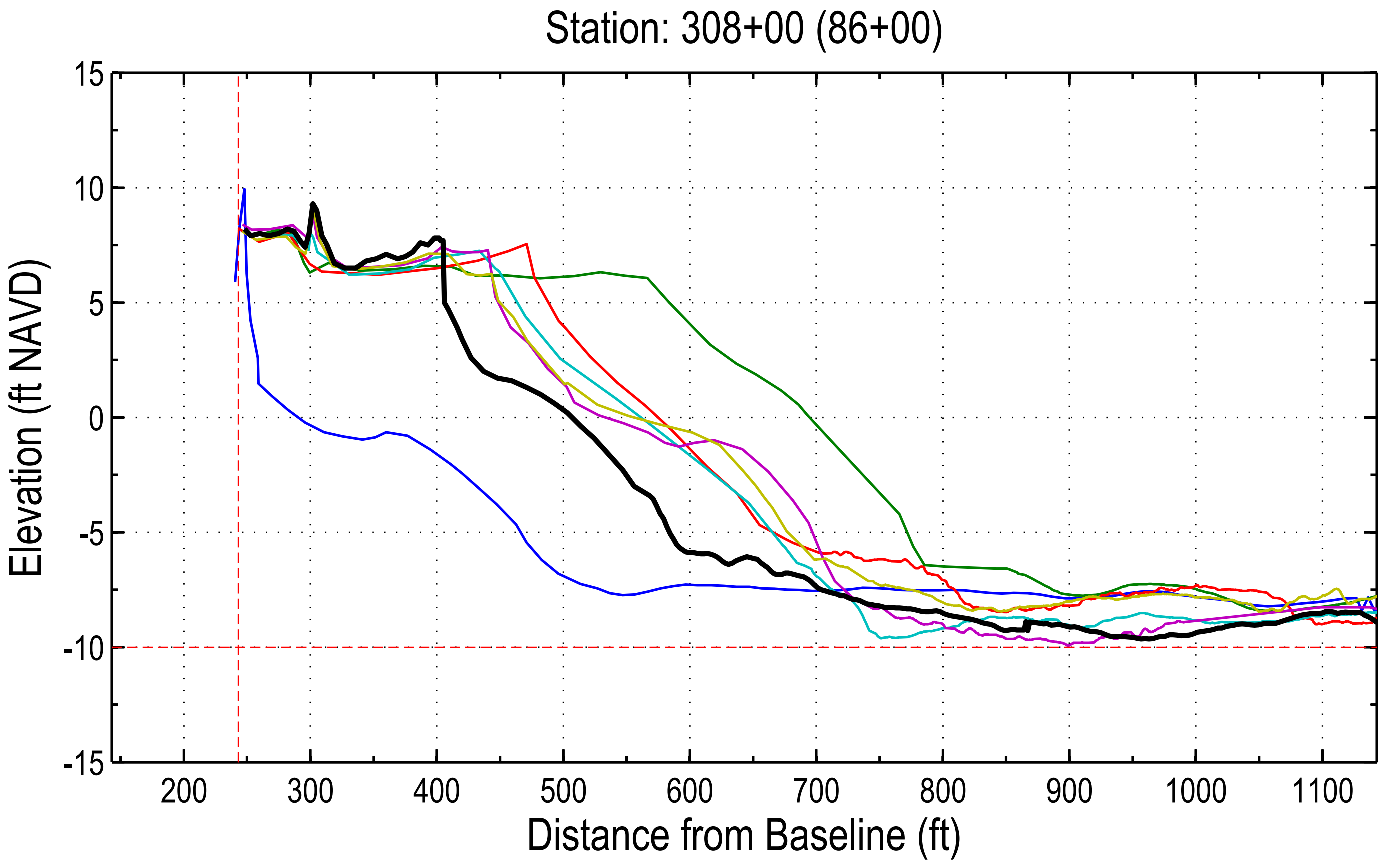
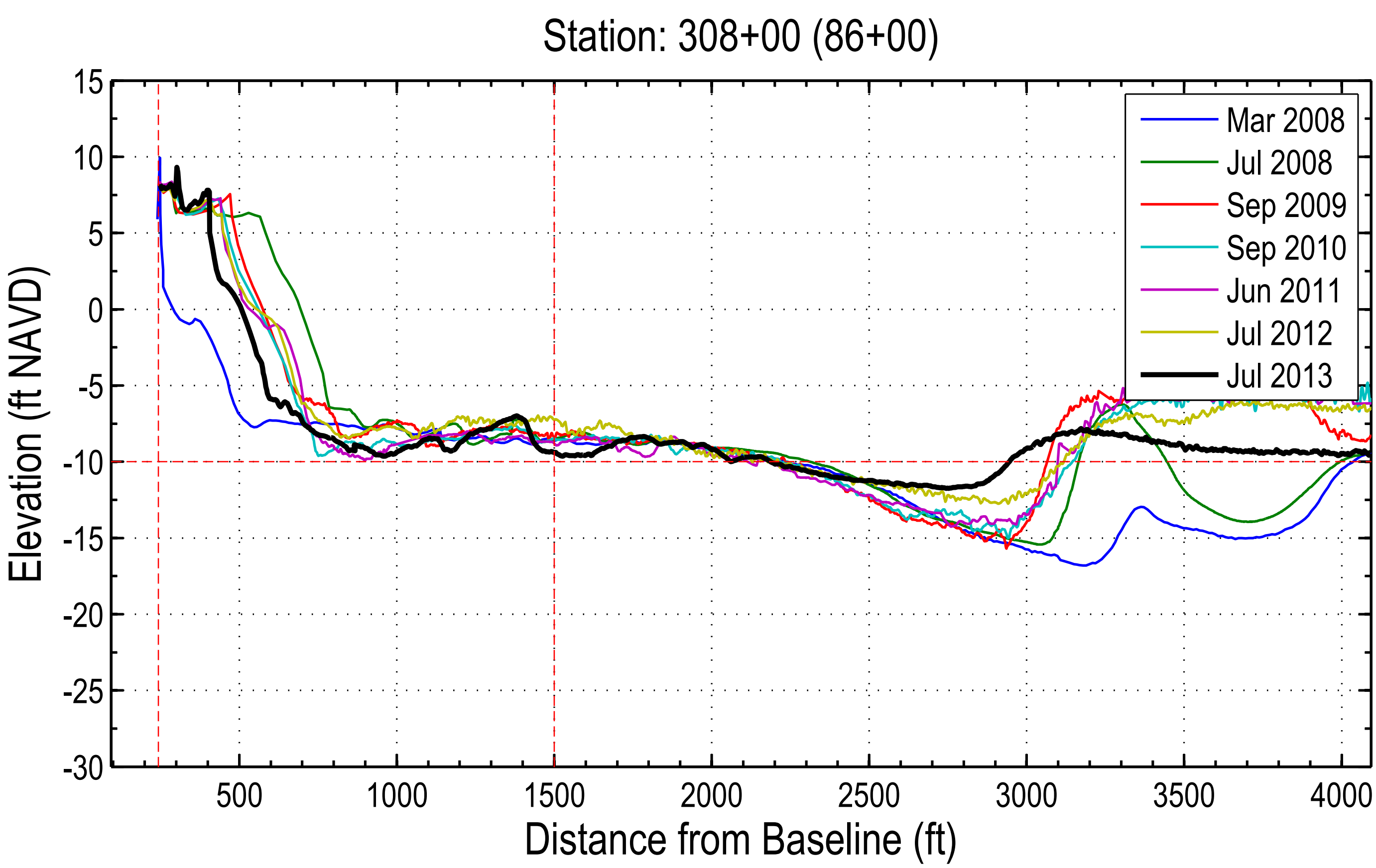
2000
2500
3000
3500
4000


Station: 306+00 (84+00) PORT O'CALL I - BRC6, SCCC 3180
Elevation (ft NAVD)
Distance from Baseline (ft)


Station: 306+00 (84+00) PORT O'CALL I - BRC6, SCCC 3180
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 308+00 (86+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
200
300
400
500
600
700
800
900
1000
1100



Station: 308+00 (86+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
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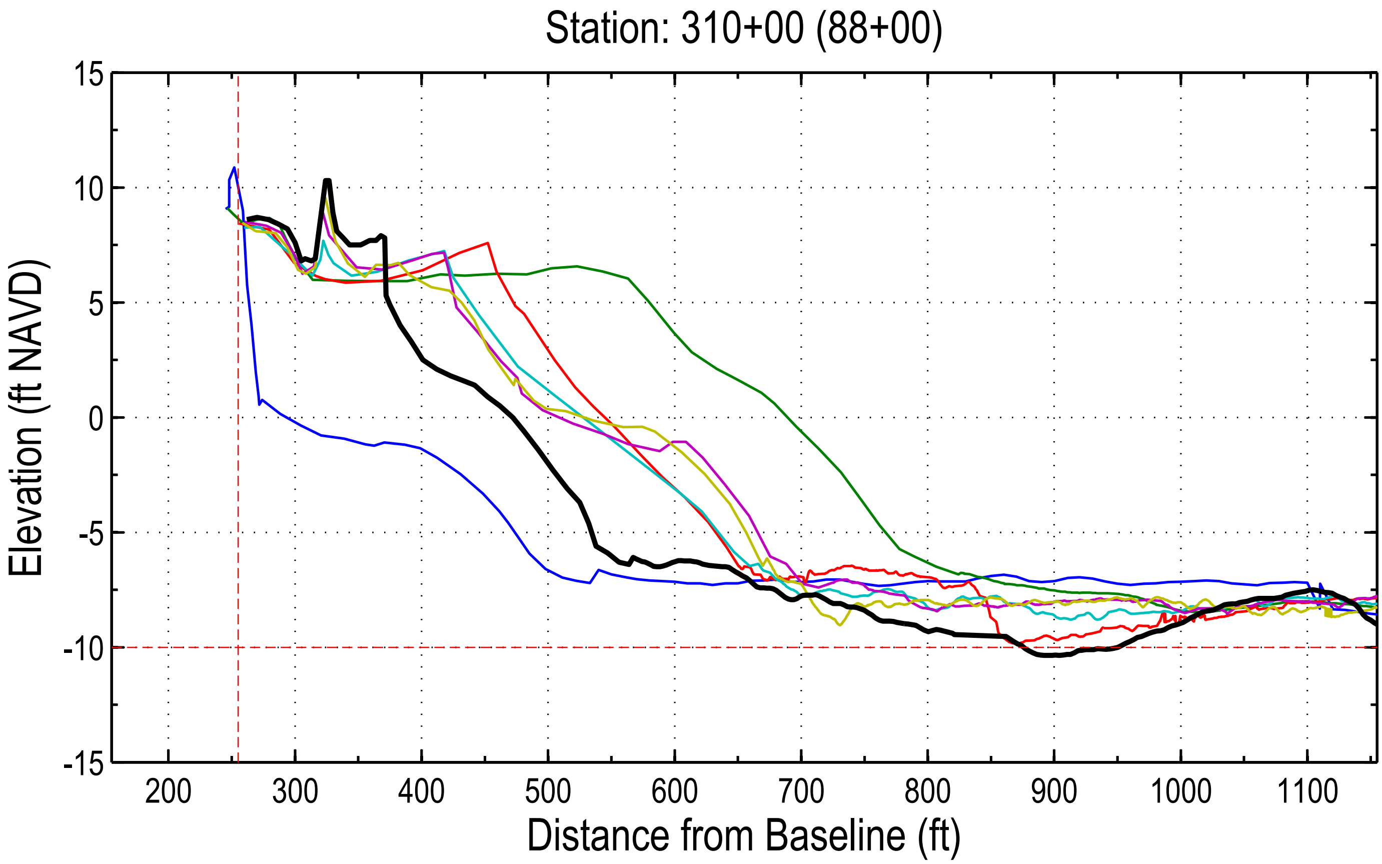
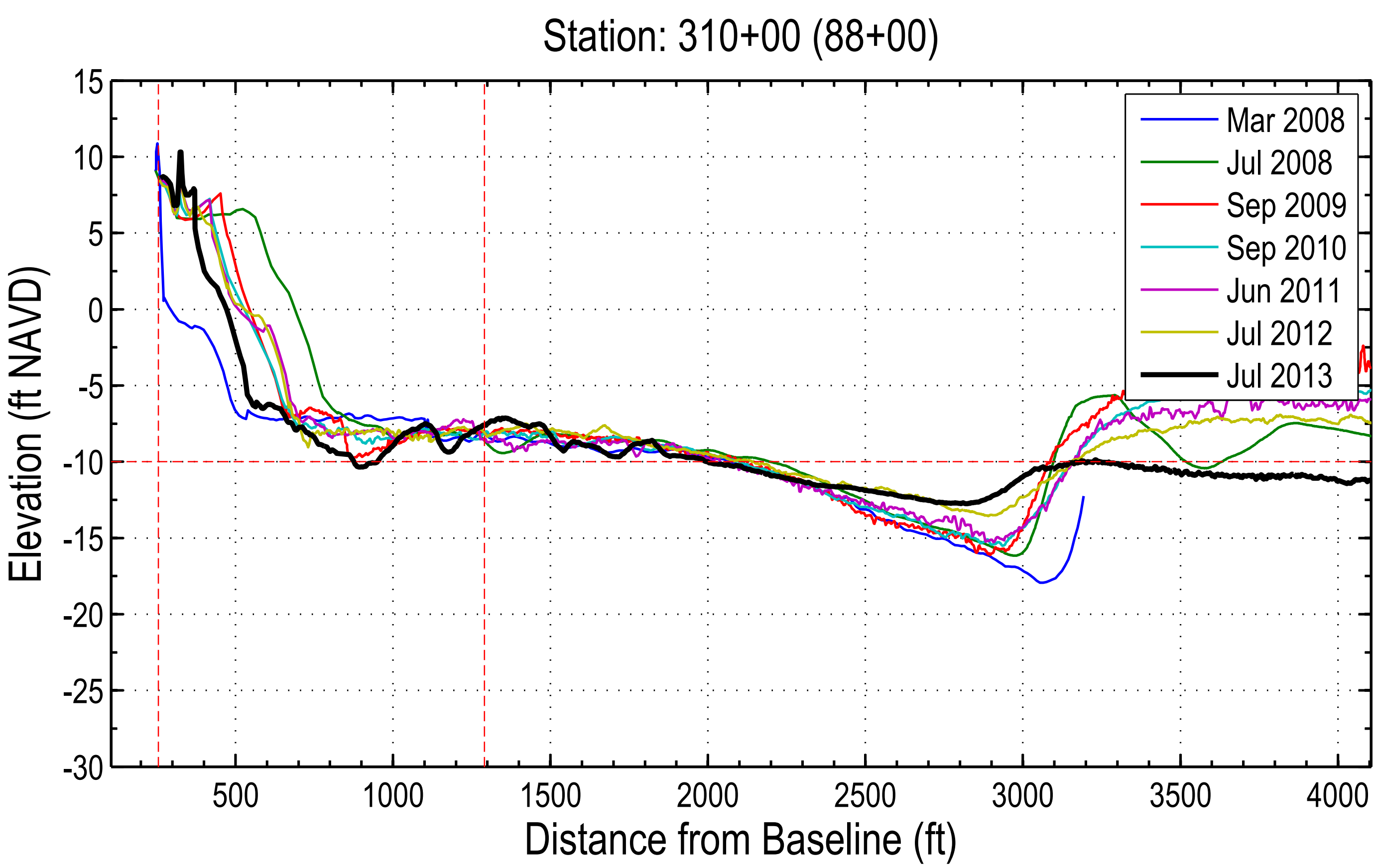
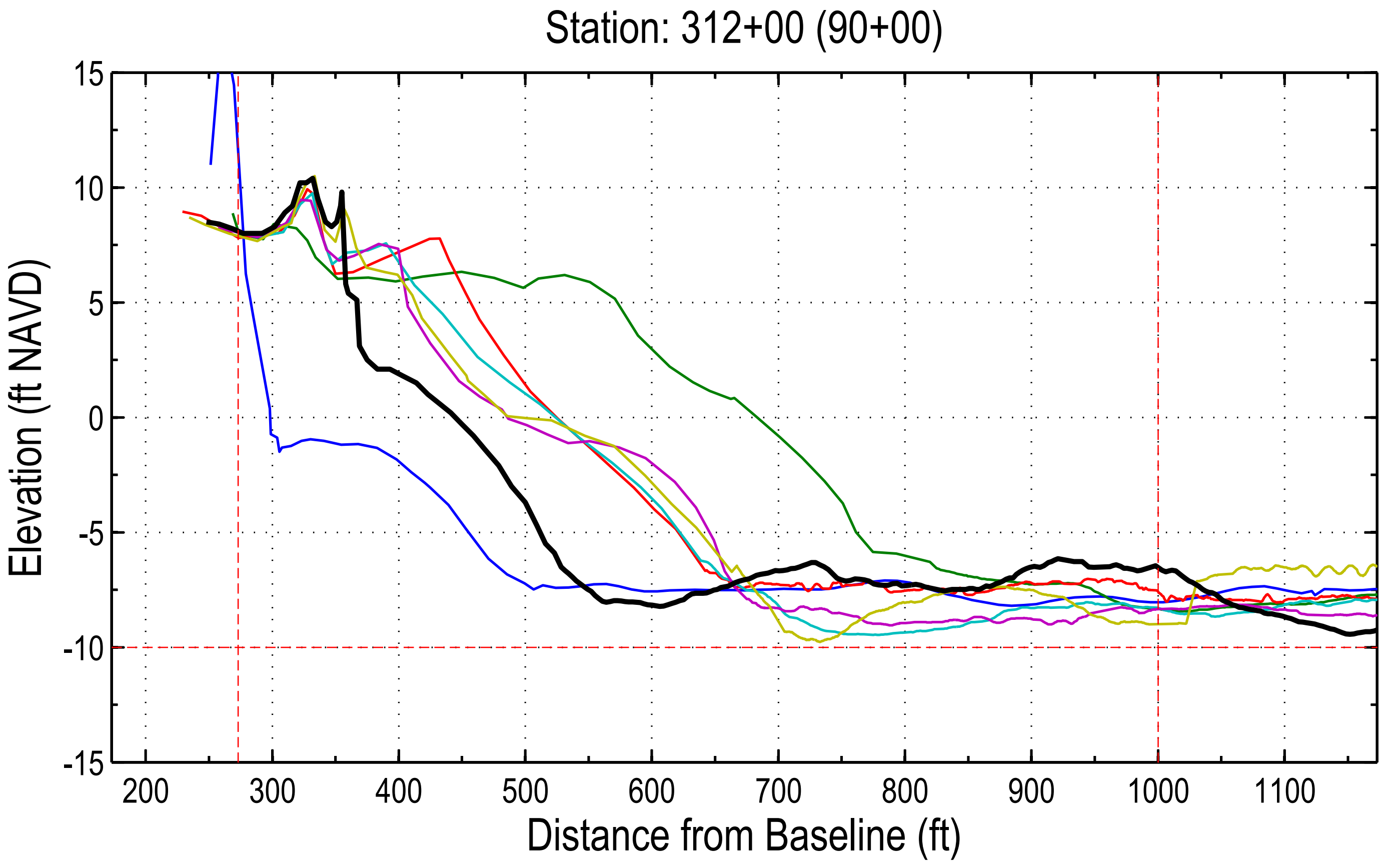
2000
2500
3000
3500
4000


Station: 310+00 (88+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
200
300
400
500
600
700
800
900
1000
1100


Station: 310+00 (88+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 312+00 (90+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
200
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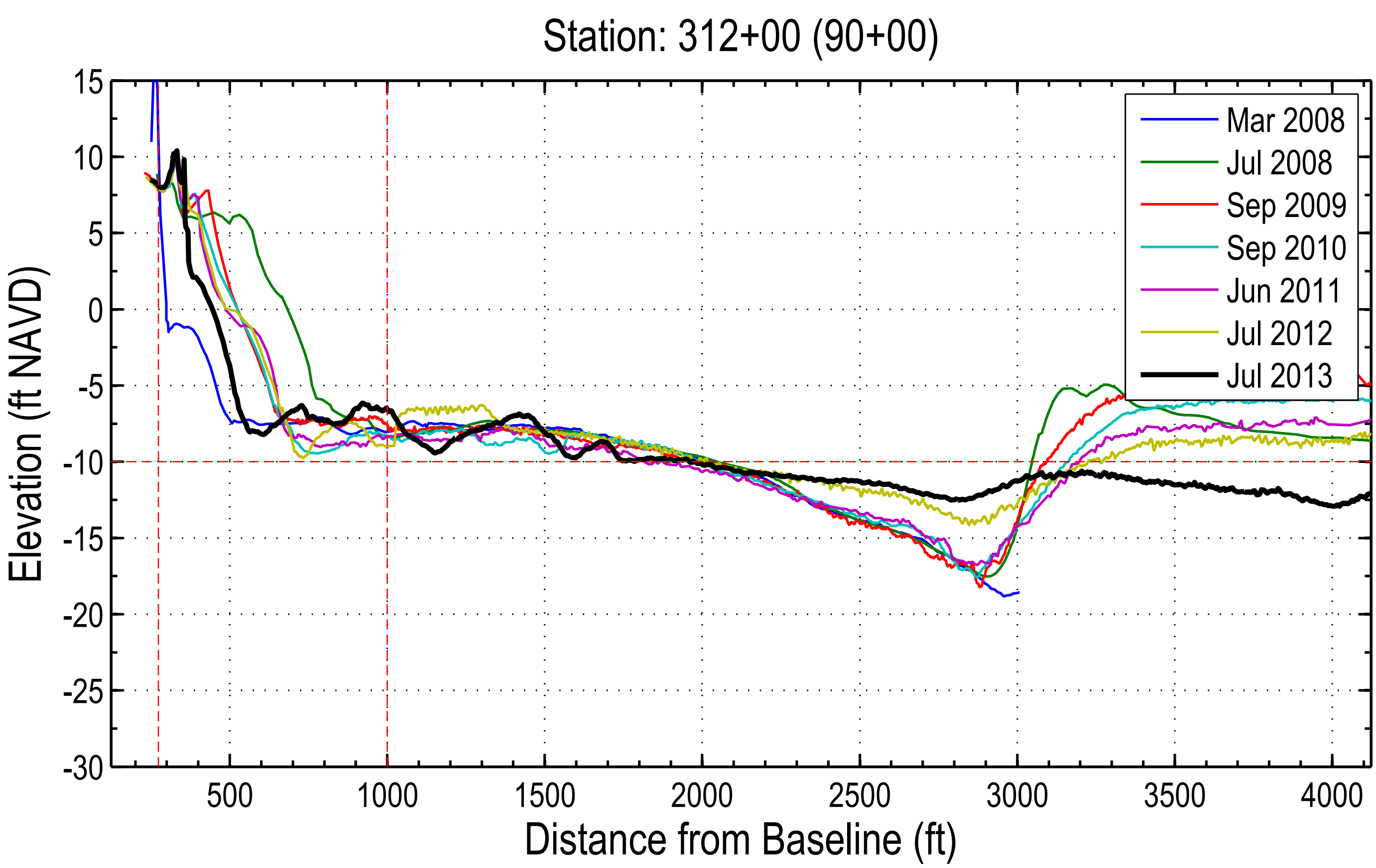
500
600
700
800
900
1000
1100


Station: 312+00 (90+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
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-25
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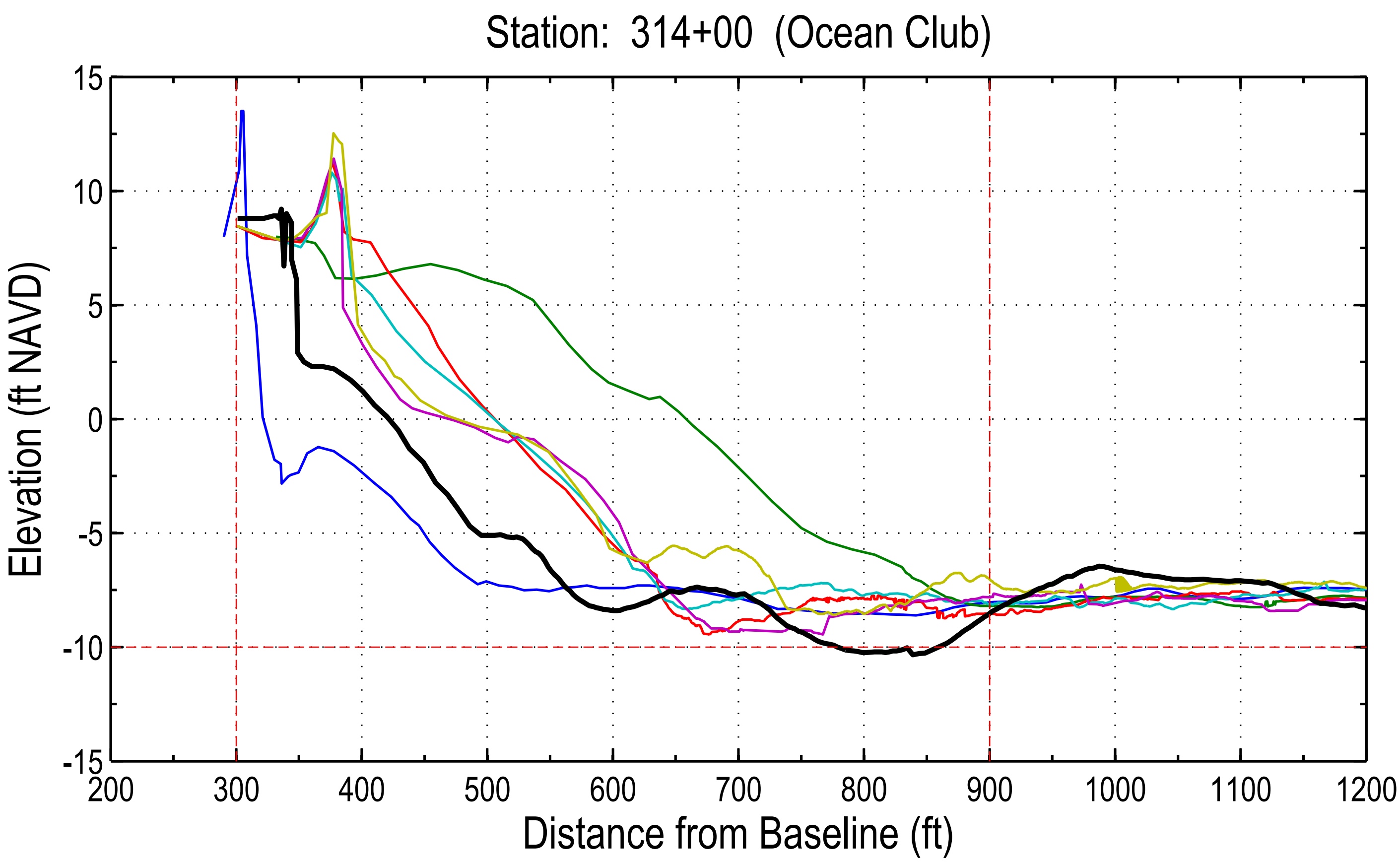
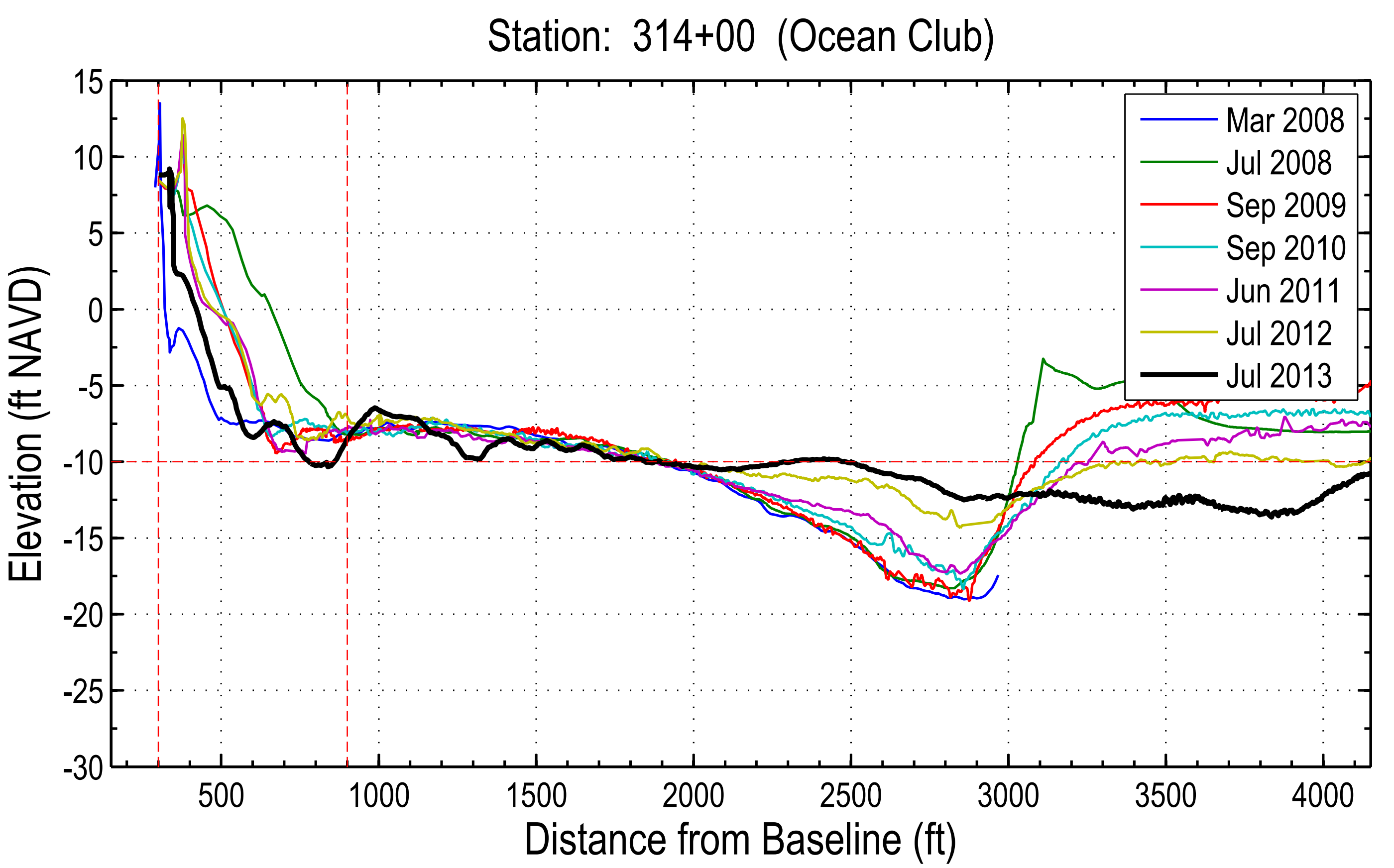
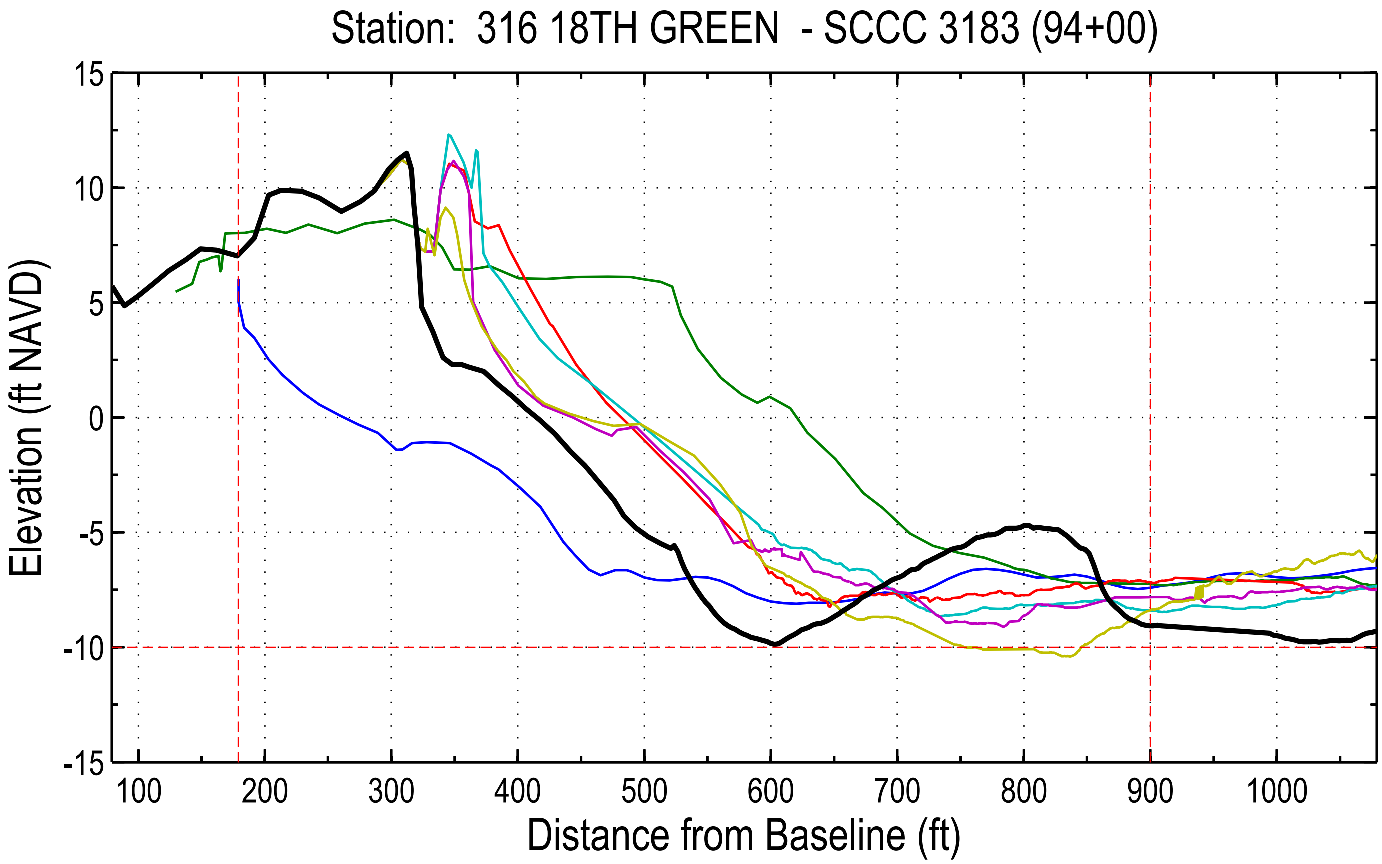
2000
2500
3000
3500
4000



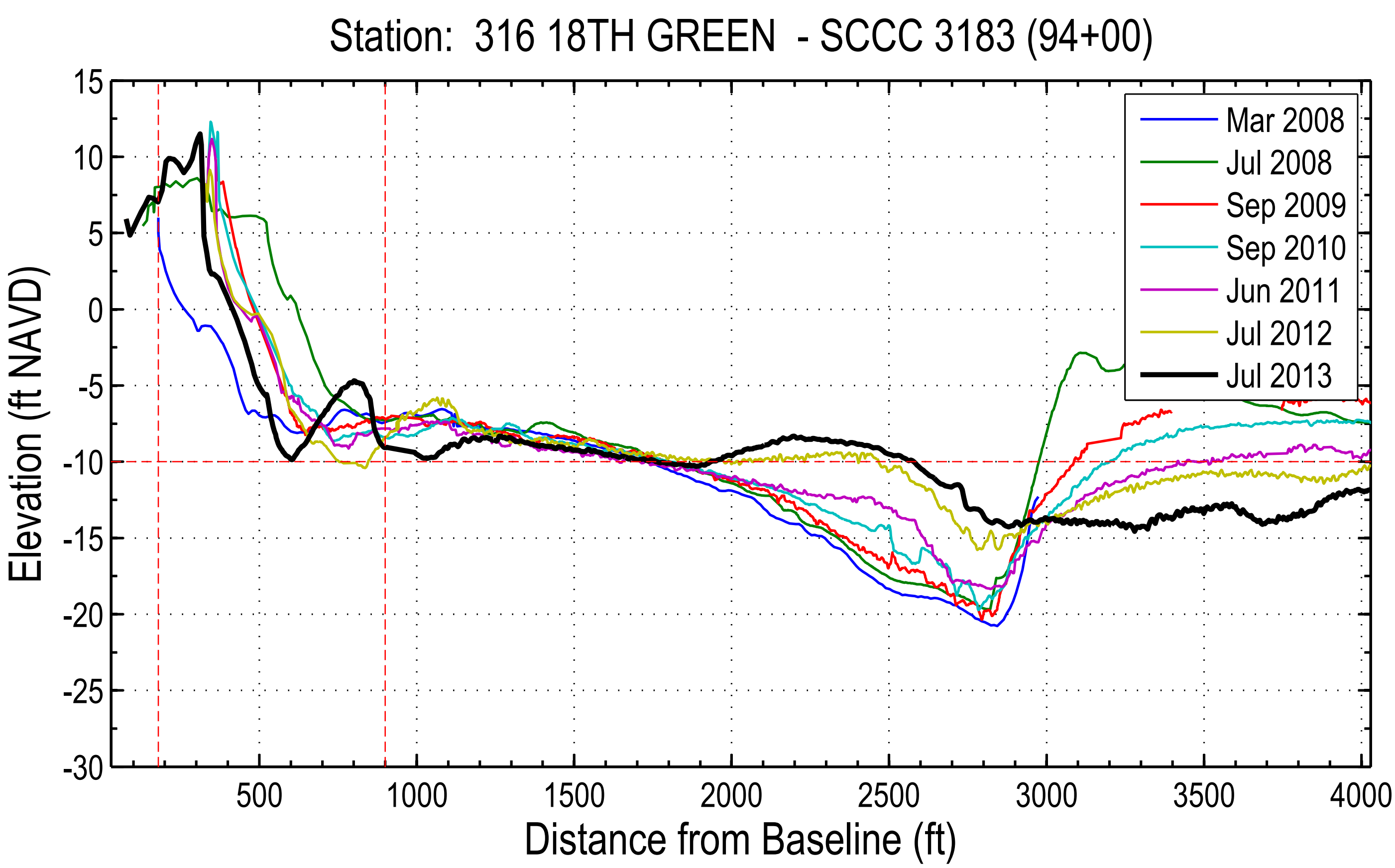
Station: 314+00 (Ocean Club)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
200
300
400
500
600
700
800
900
1000
1100
1200



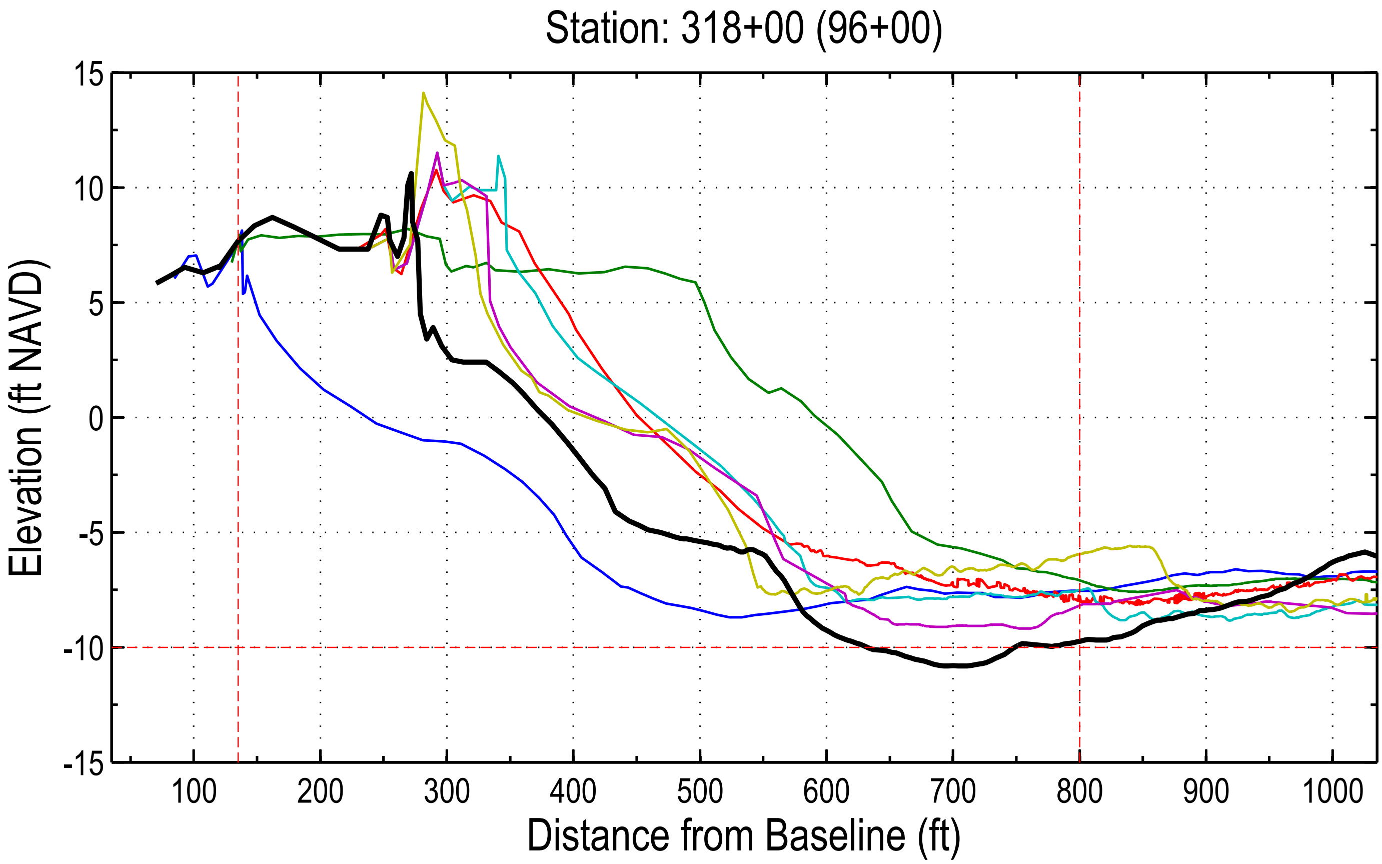
Station: 314+00 (Ocean Club)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000



Station: 316 18TH GREEN - SCCC 3183 (94+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000
Distance from Baseline (ft)



Station: 316 18TH GREEN - SCCC 3183 (94+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-20
-25
-30
500
1000
1500
2000
2500
3000
3500
4000
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 318+00 (96+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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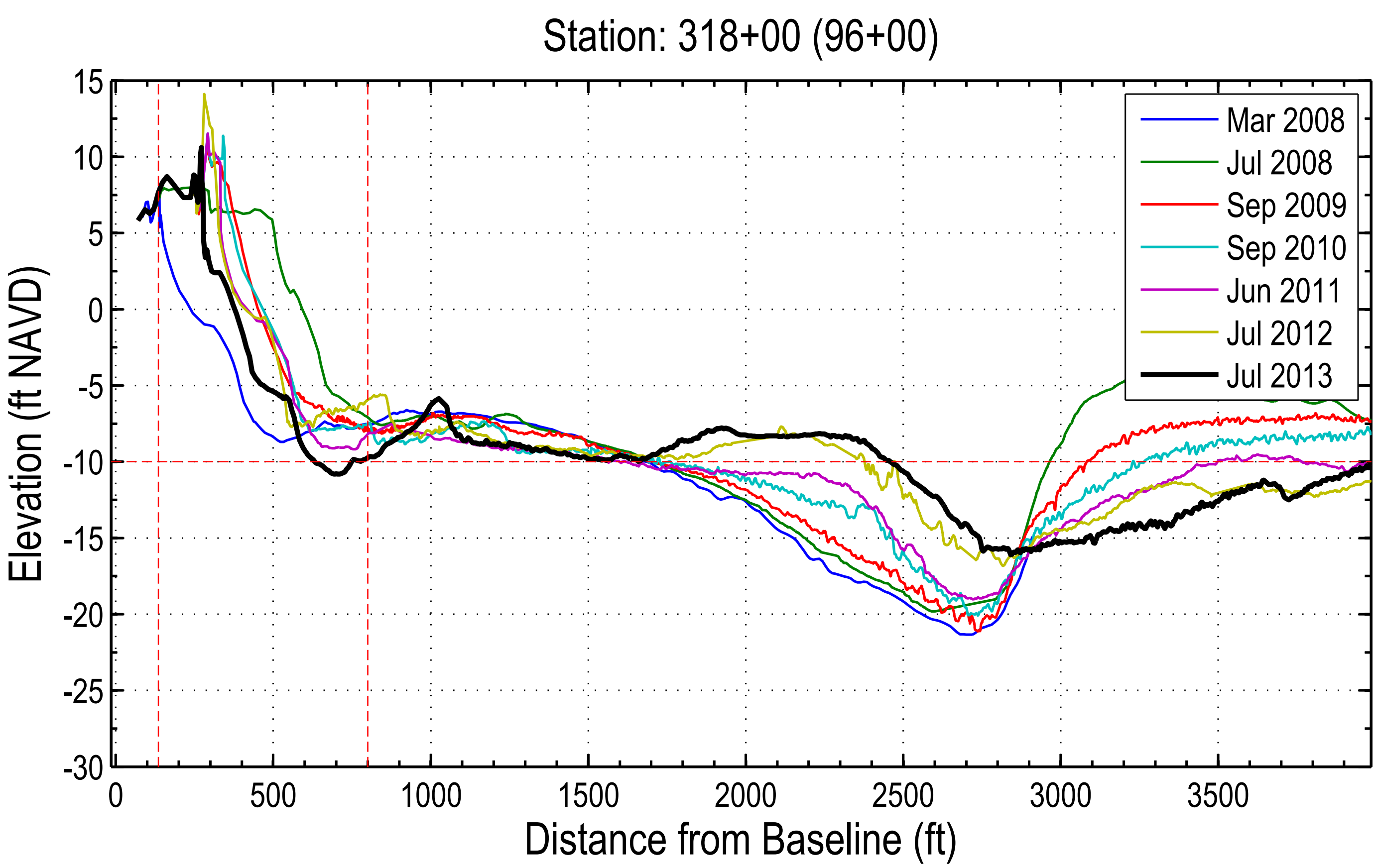
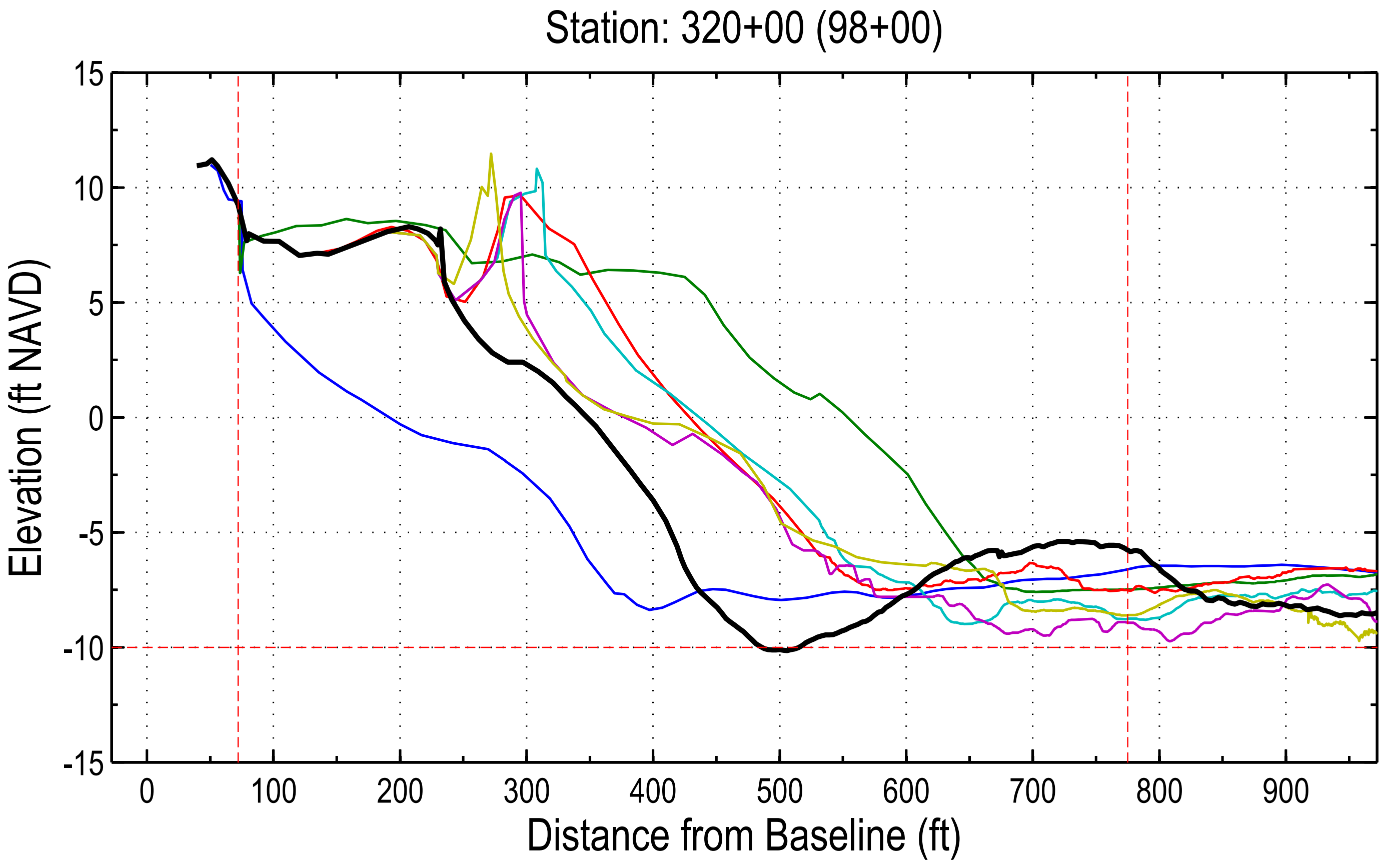
10
5
0
-5
-10
-15
100
200
300
400
500
600
700
800
900
1000



Station: 318+00 (96+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 320+00 (98+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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5
0
-5
-10
-15
0
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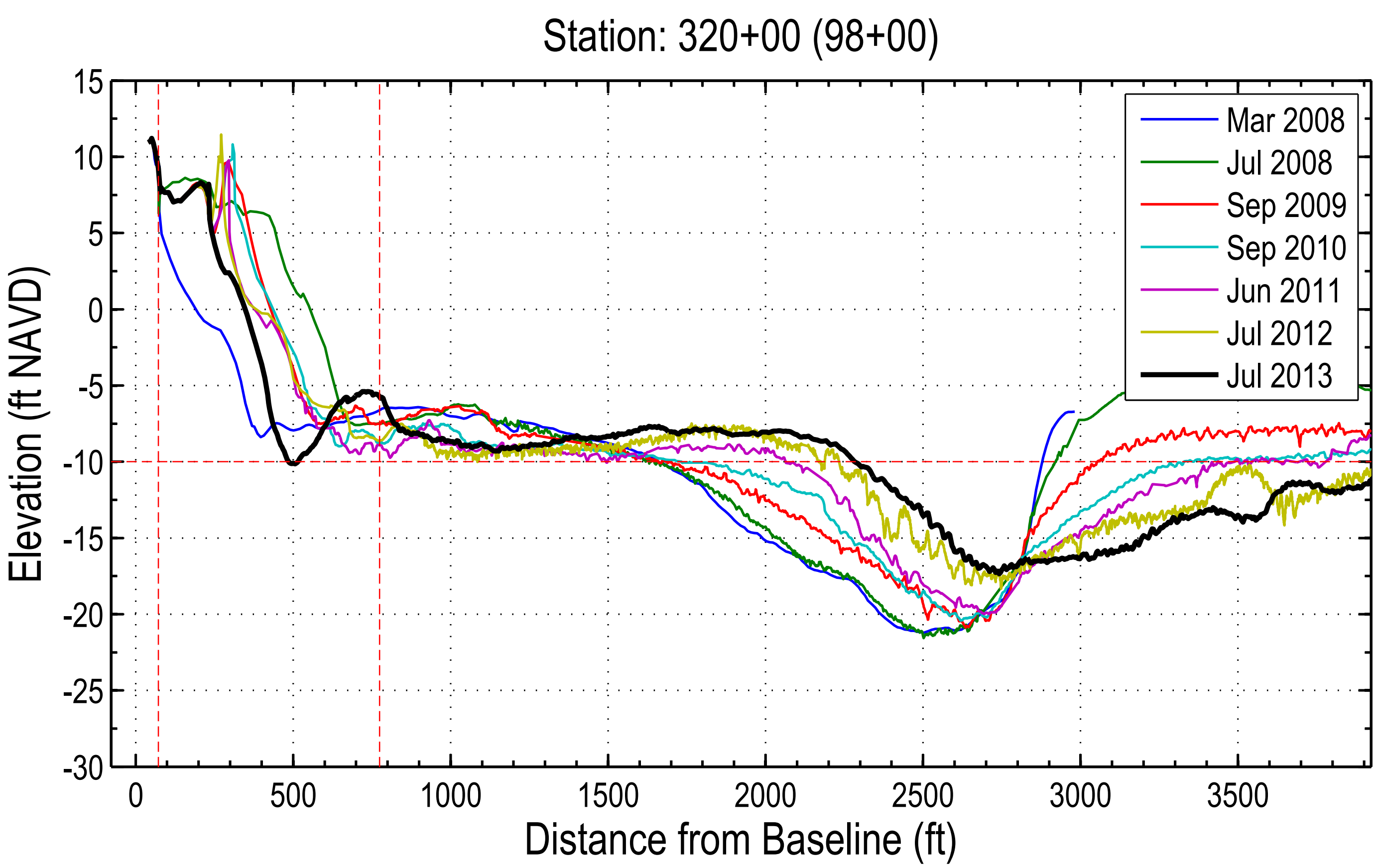
500
600
700
800
900


Station: 320+00 (98+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
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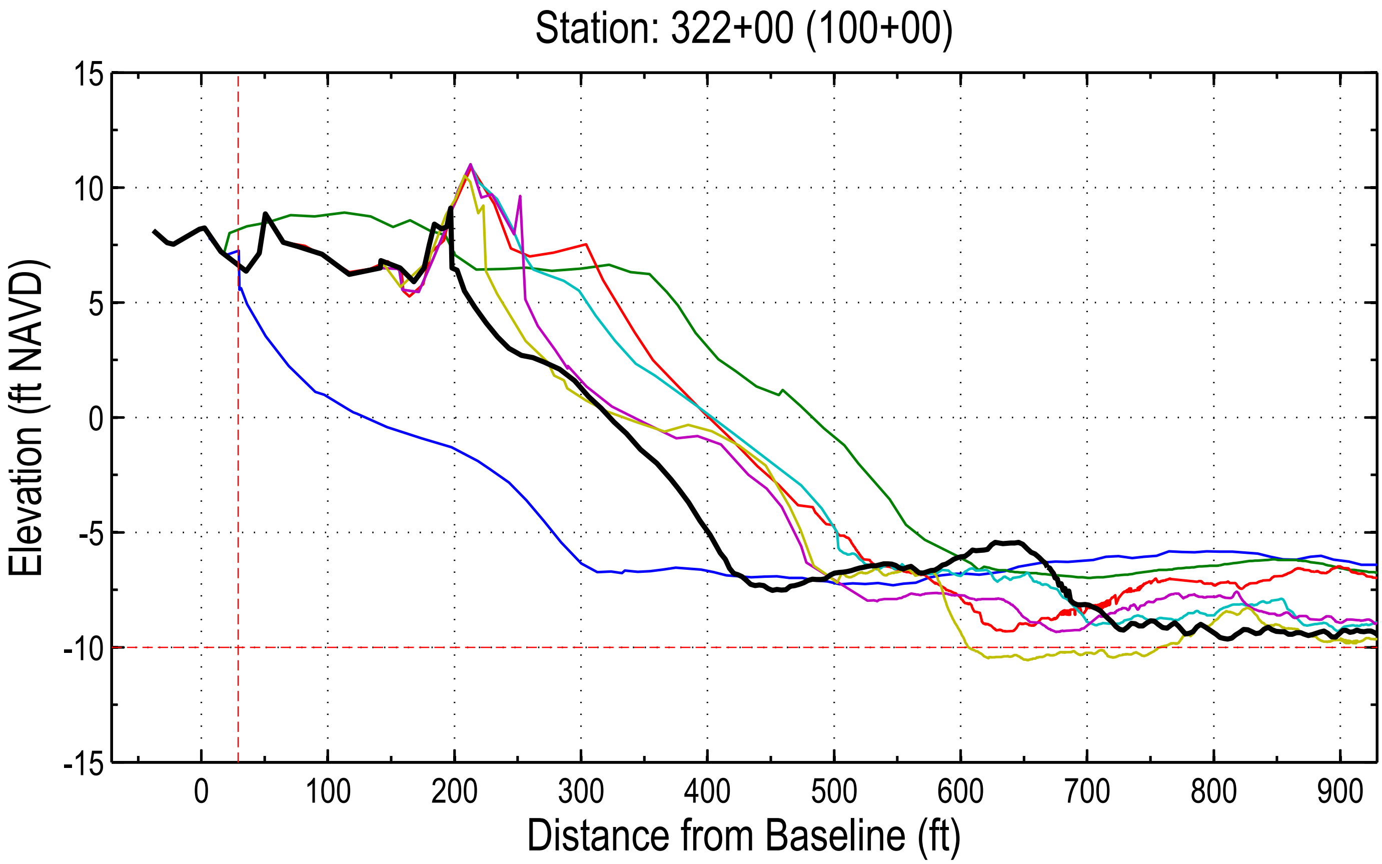
1500
2000
2500
3000
3500


Station: 322+00 (100+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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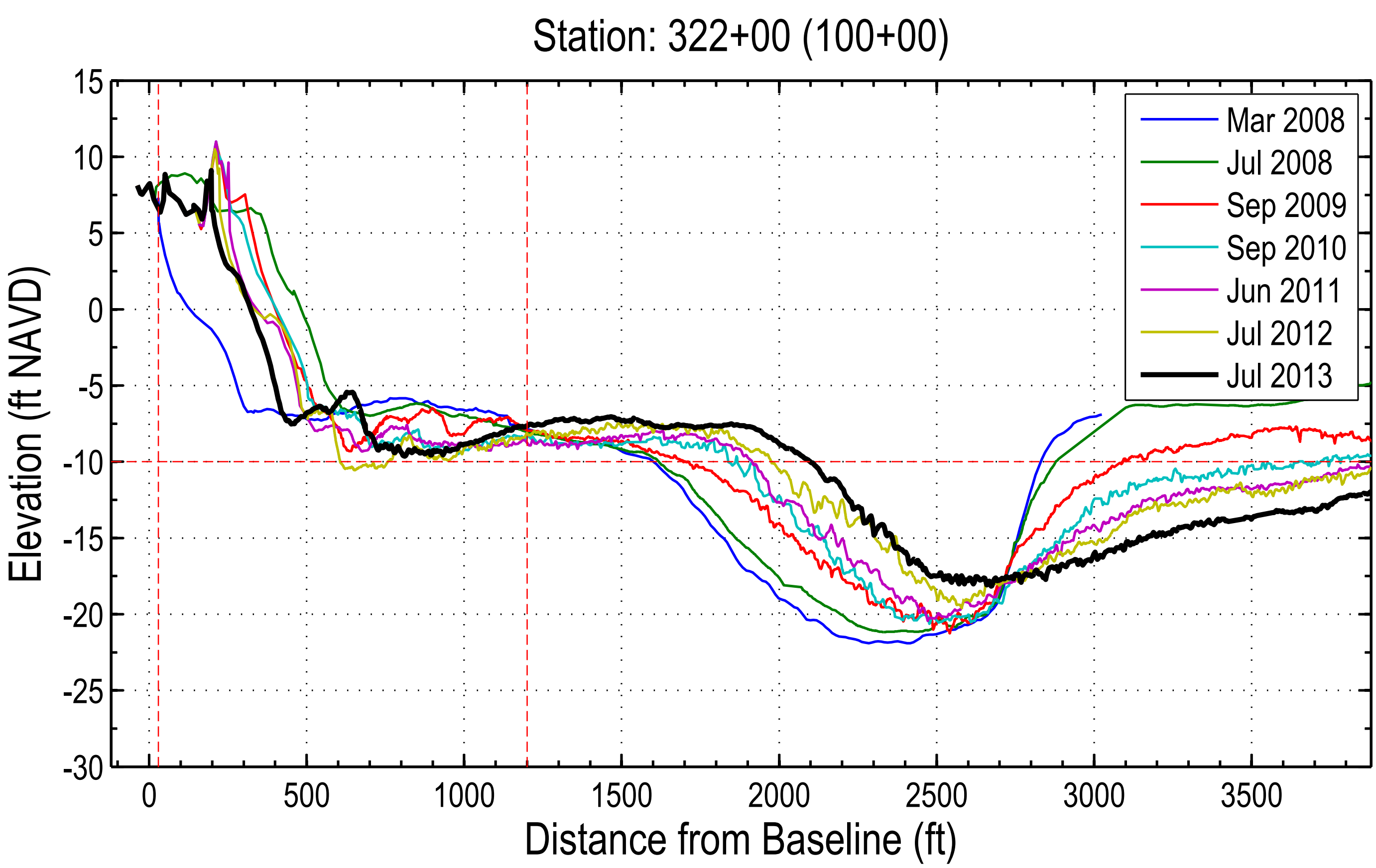
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900


Station: 322+00 (100+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
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-5
-10
-15
-20
-25
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2500
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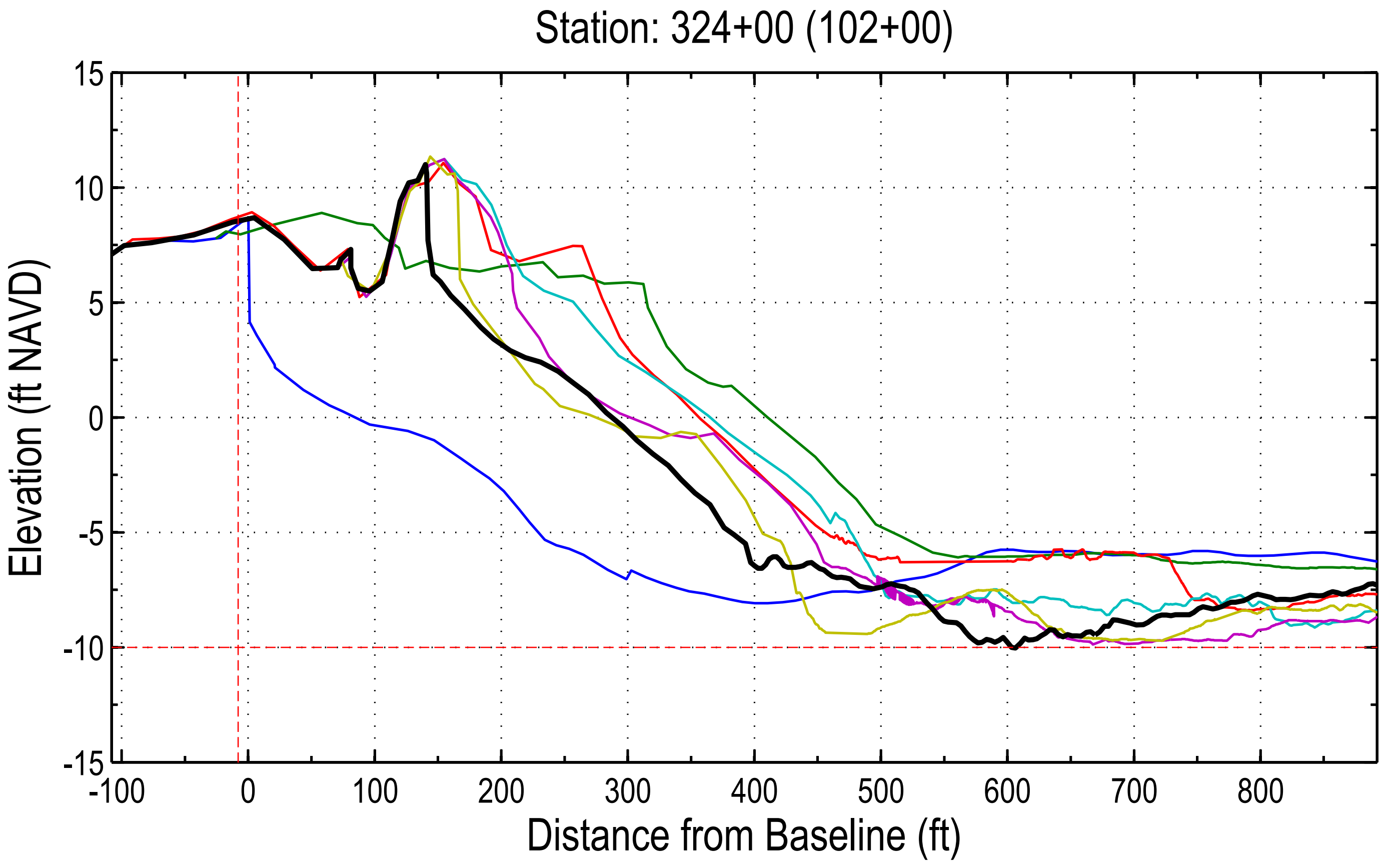
3500



Station: 324+00 (102+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
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-5
-10
-15
-100
0
100
200
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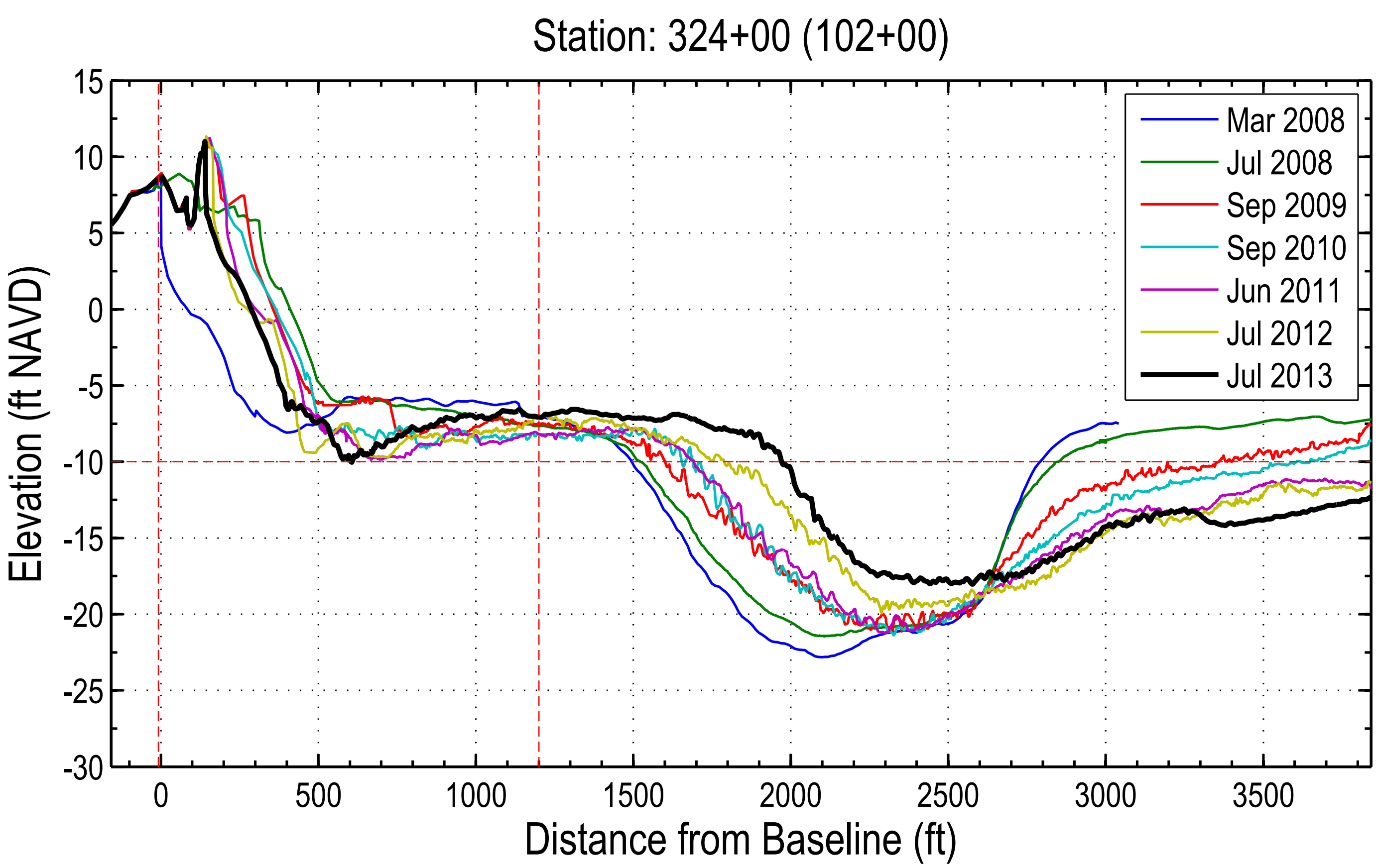
600
700
800



Station: 324+00 (102+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
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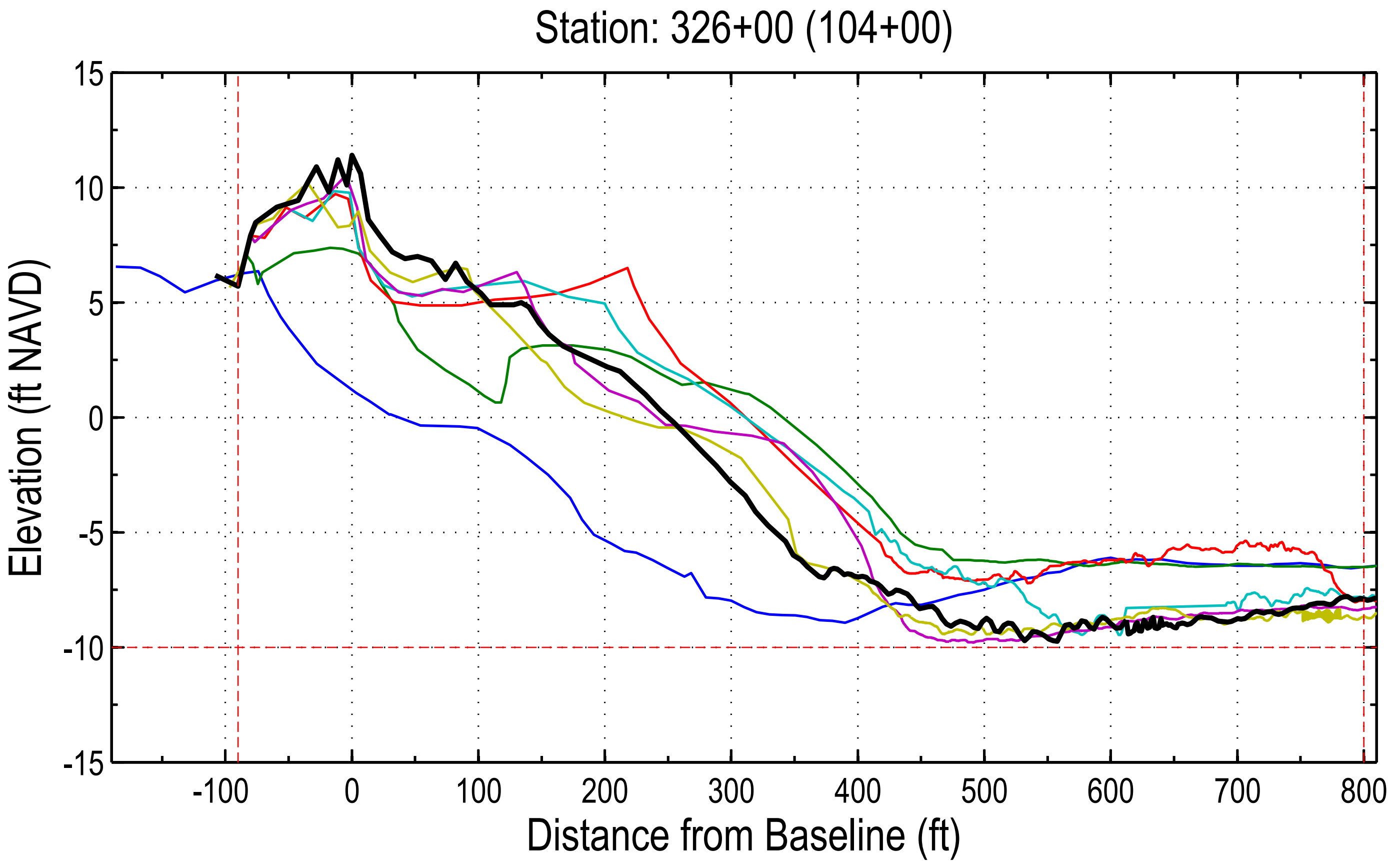
3500


Station: 326+00 (104+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-100
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100
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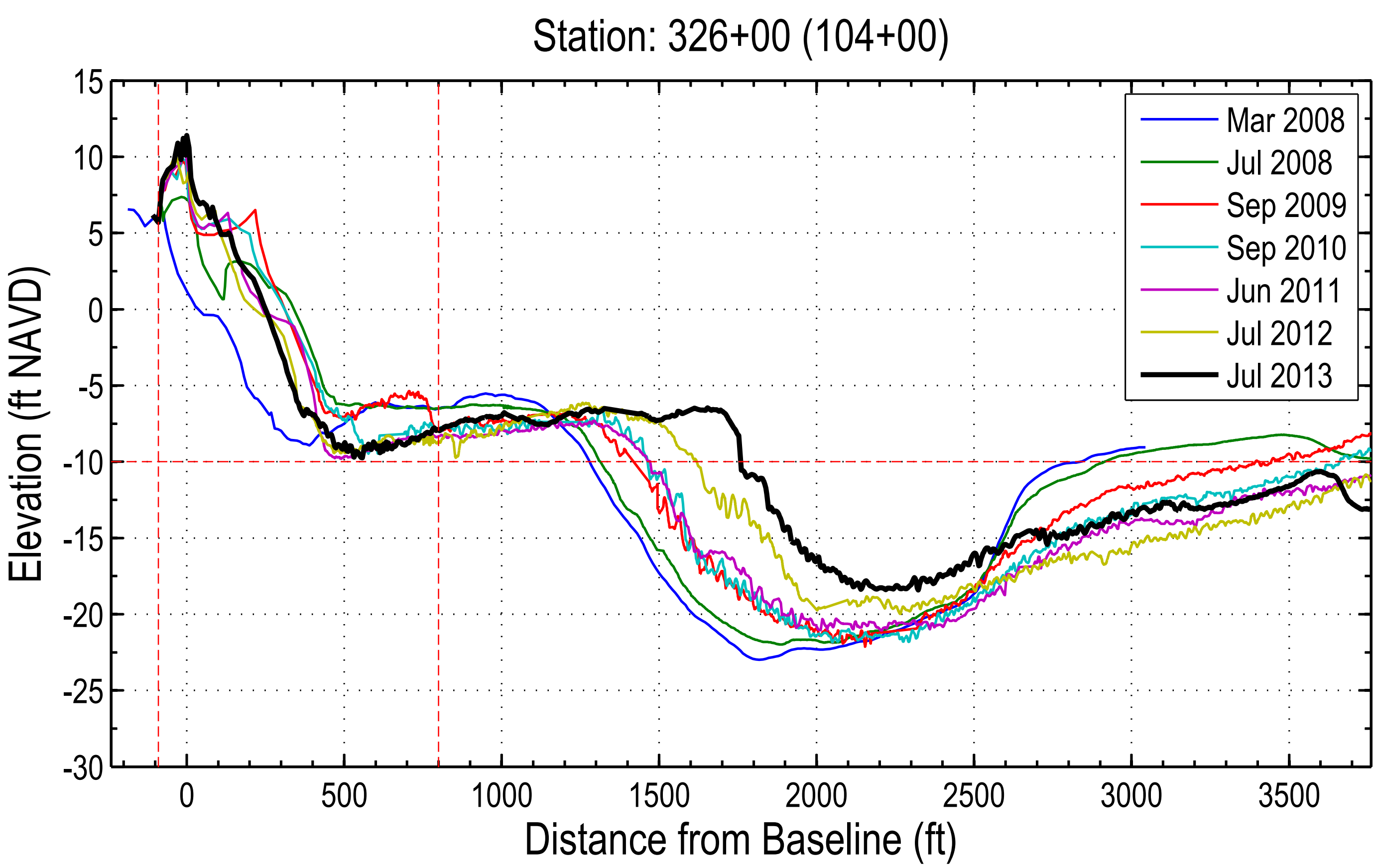
500
600
700
800


Station: 326+00 (104+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
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-5
-10
-15
-20
-25
-30
0
500
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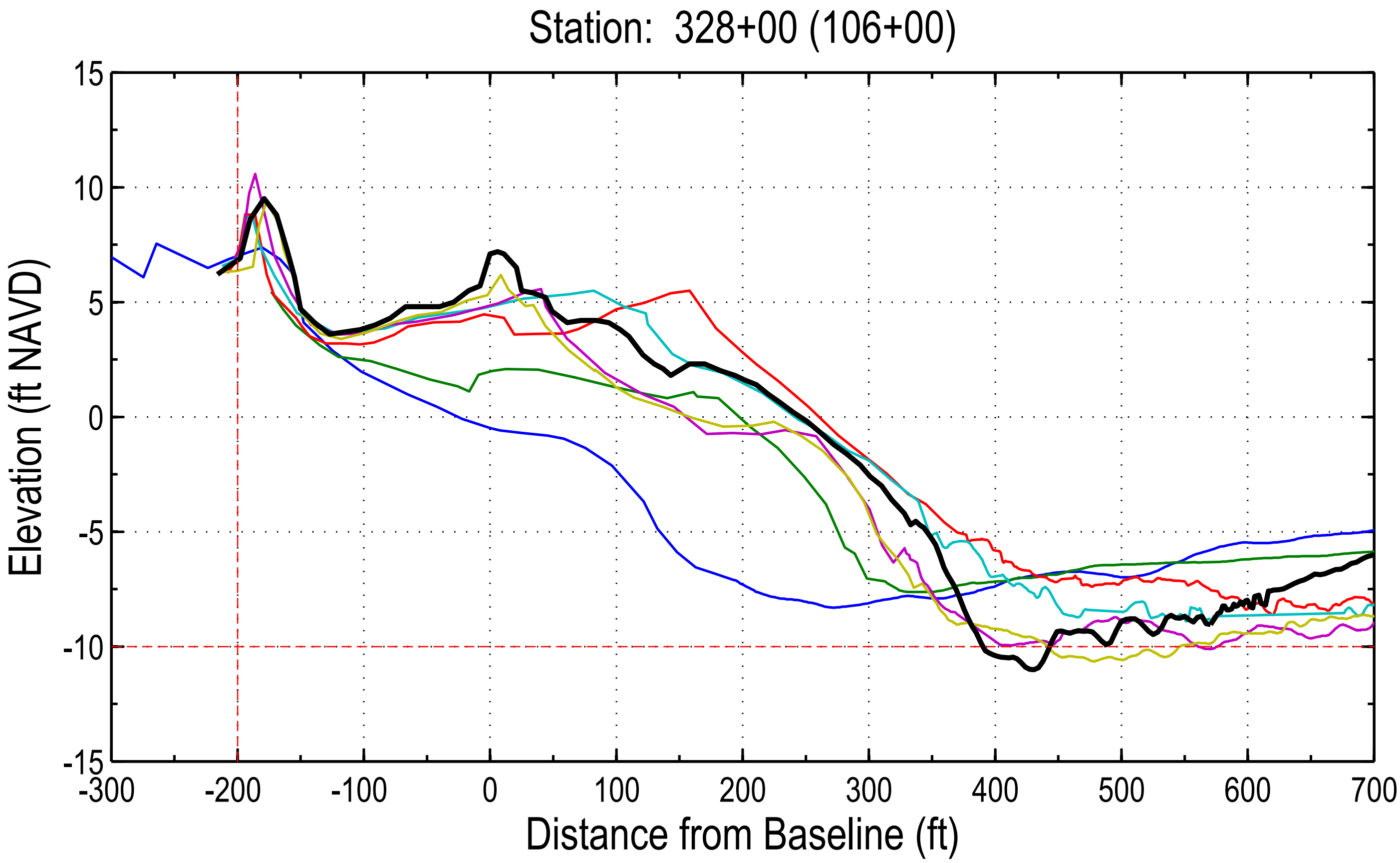
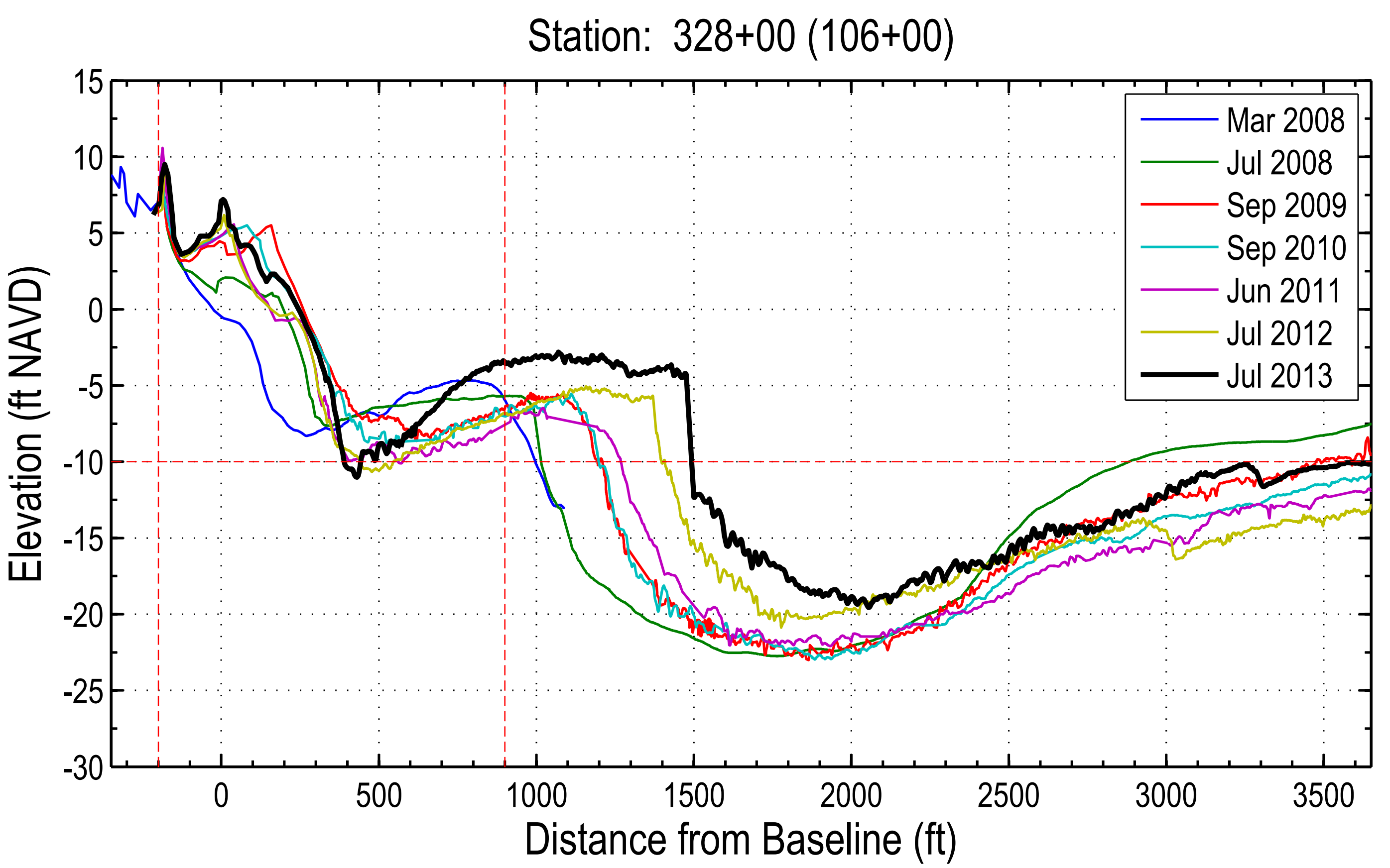
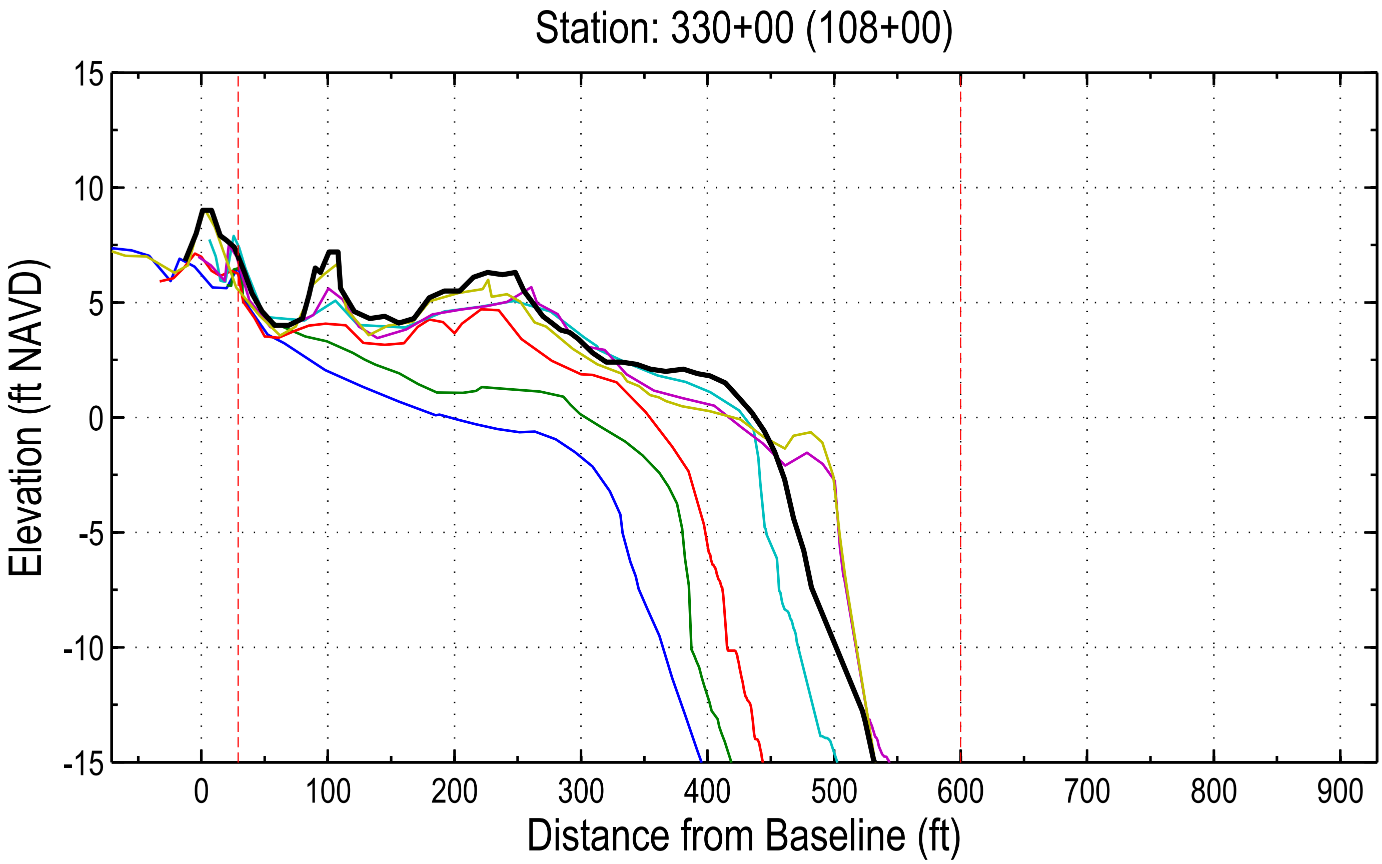
1500
2000
2500
3000
3500
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 328+00 (106+00)
Elevation (ft NAVD)
Distance from Baseline (ft)


Station: 328+00 (106+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 330+00 (108+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
0
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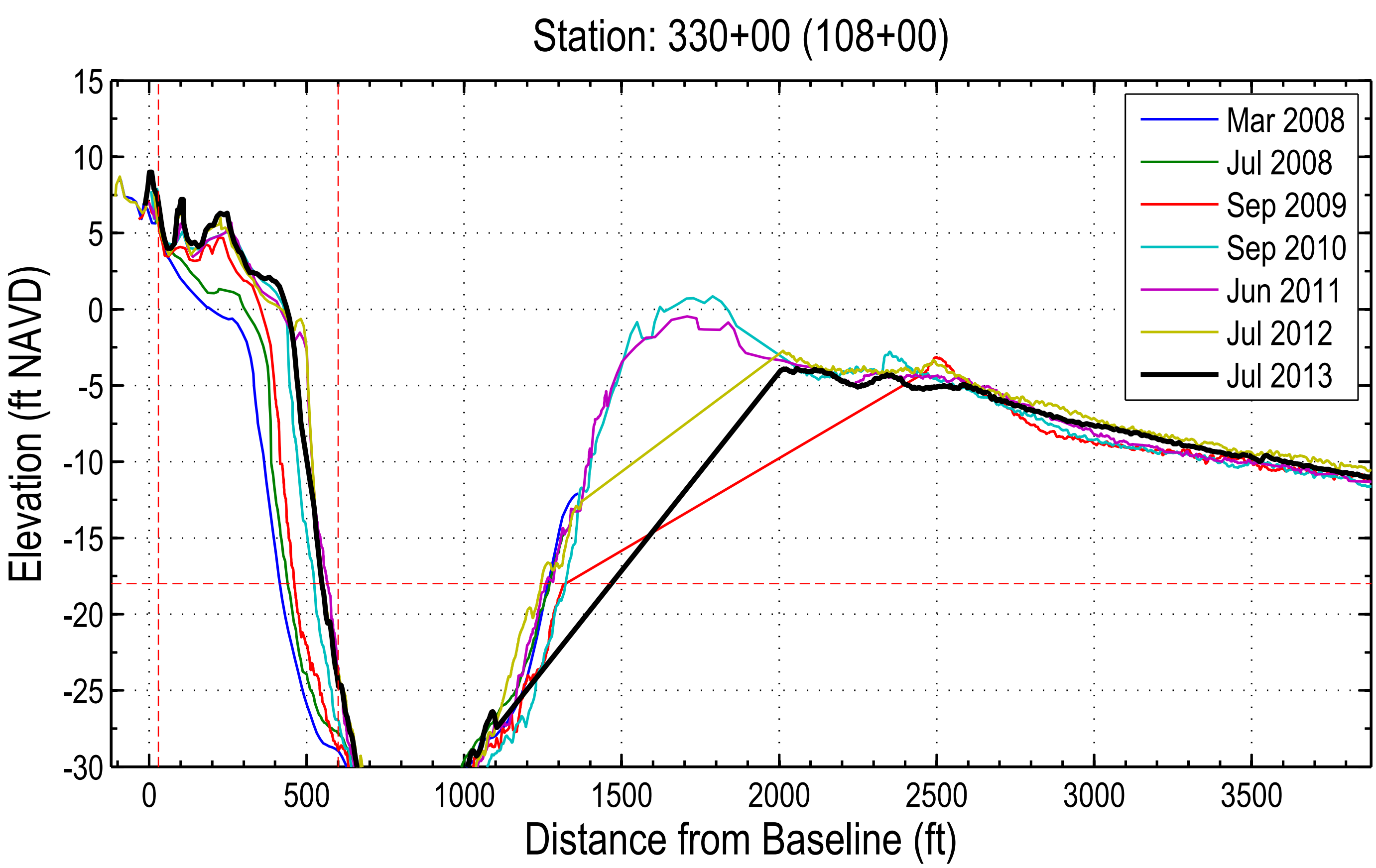
500
600
700
800
900


Station: 330+00 (108+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
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-5
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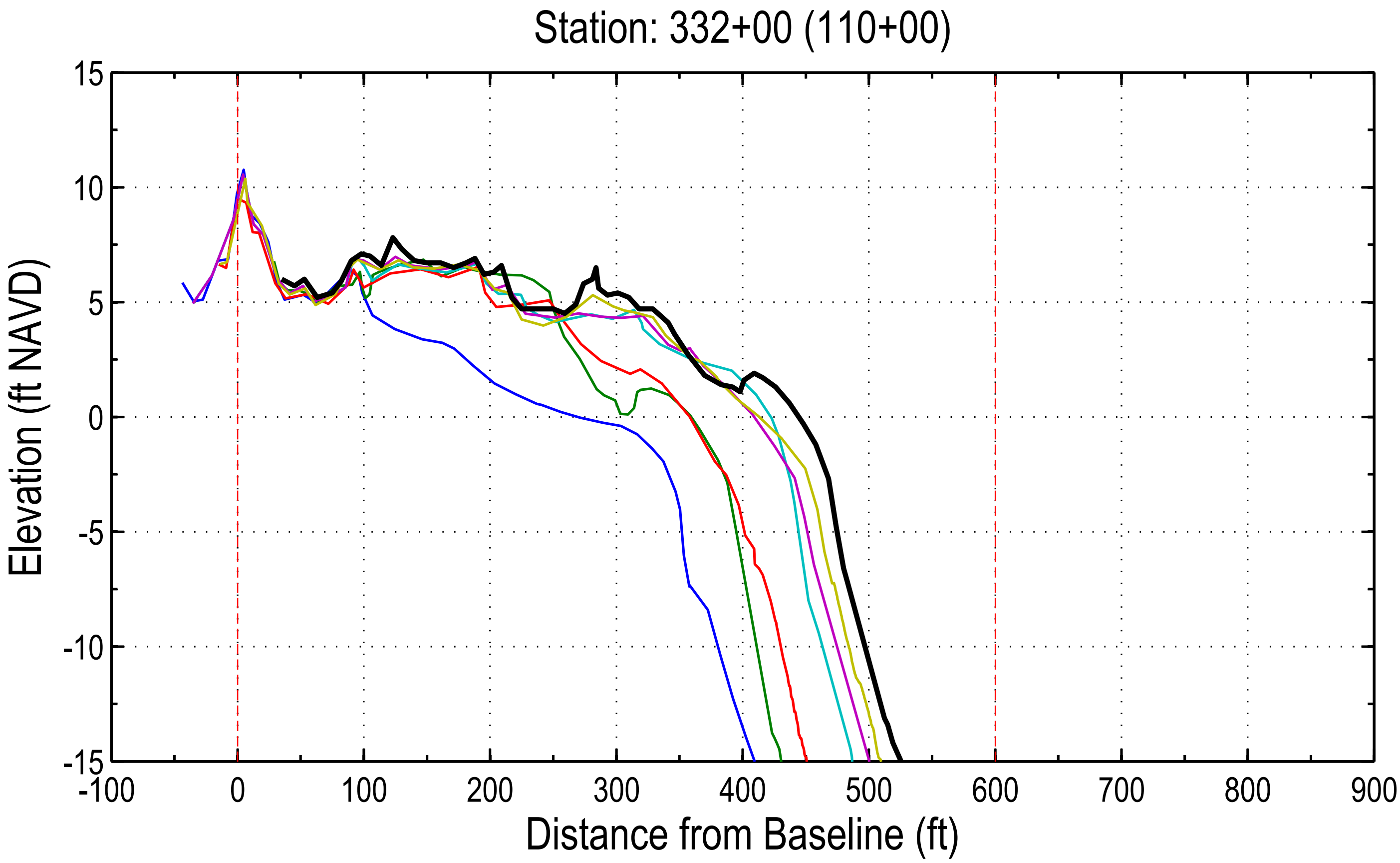

Station: 332+00 (110+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-100
0
100
200
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400
500
600
700
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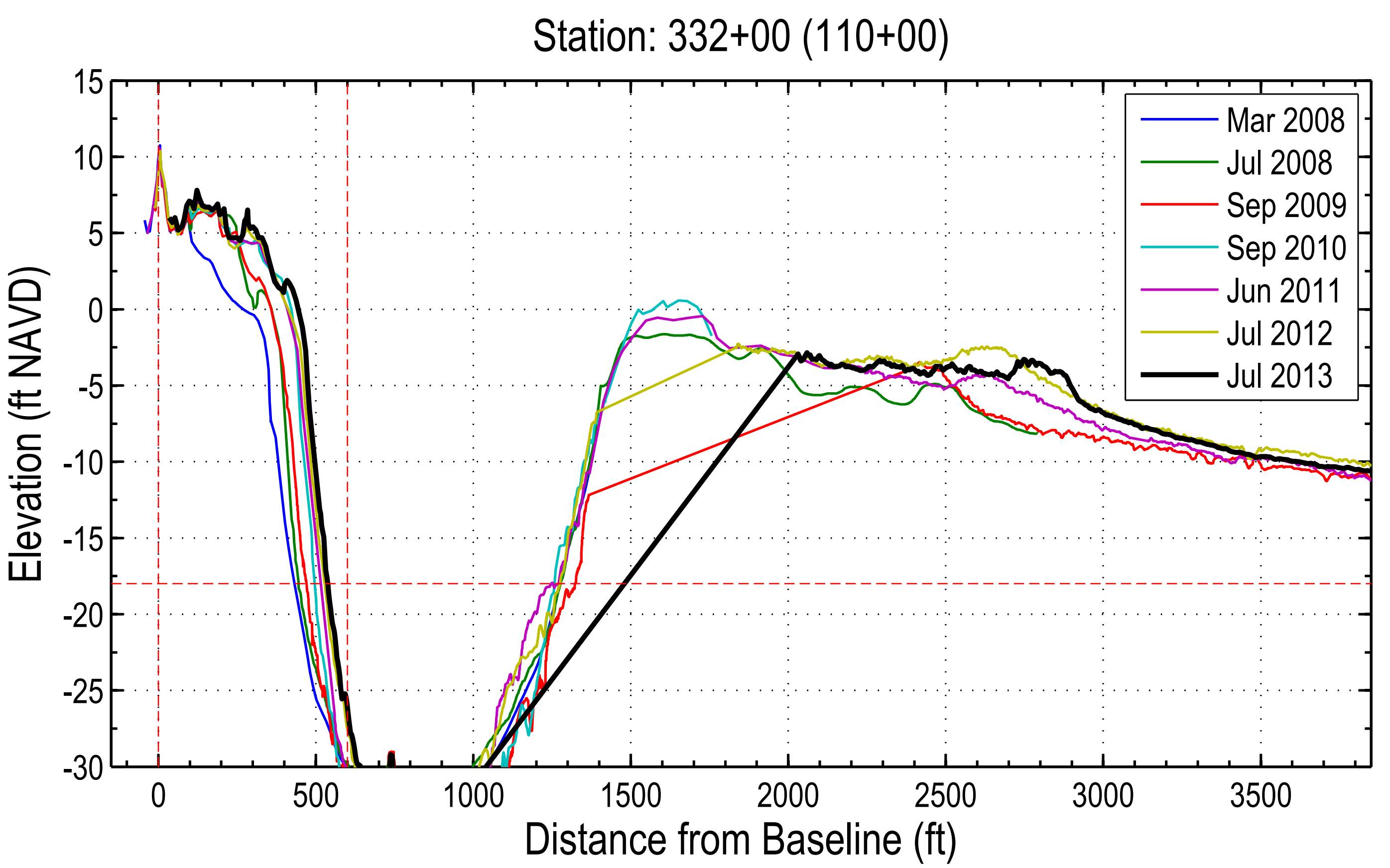
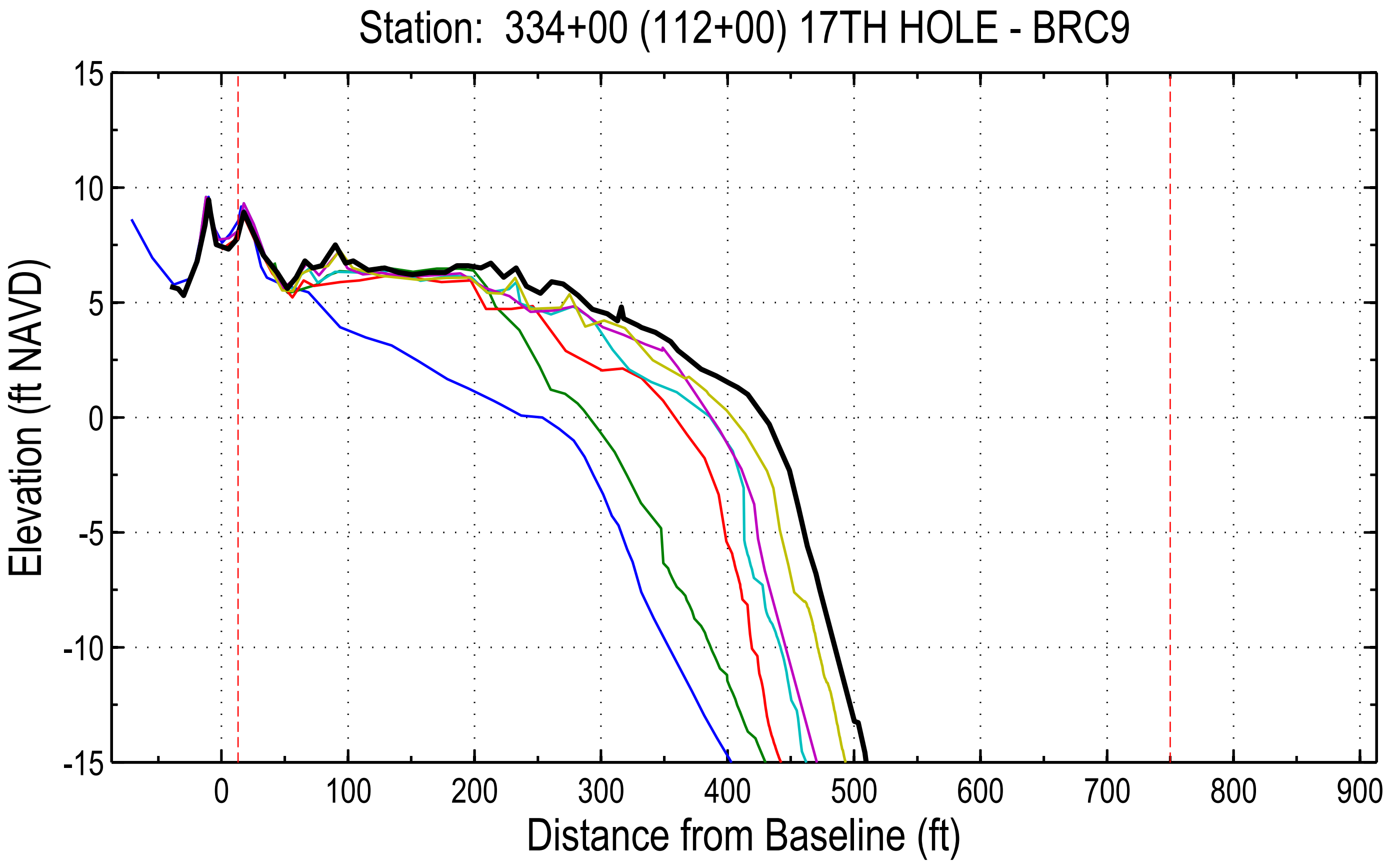
900



Station: 332+00 (110+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500



Station: 334+00 (112+00) 17TH HOLE - BRC9
Elevation (ft NAVD)
Distance from Baseline (ft)
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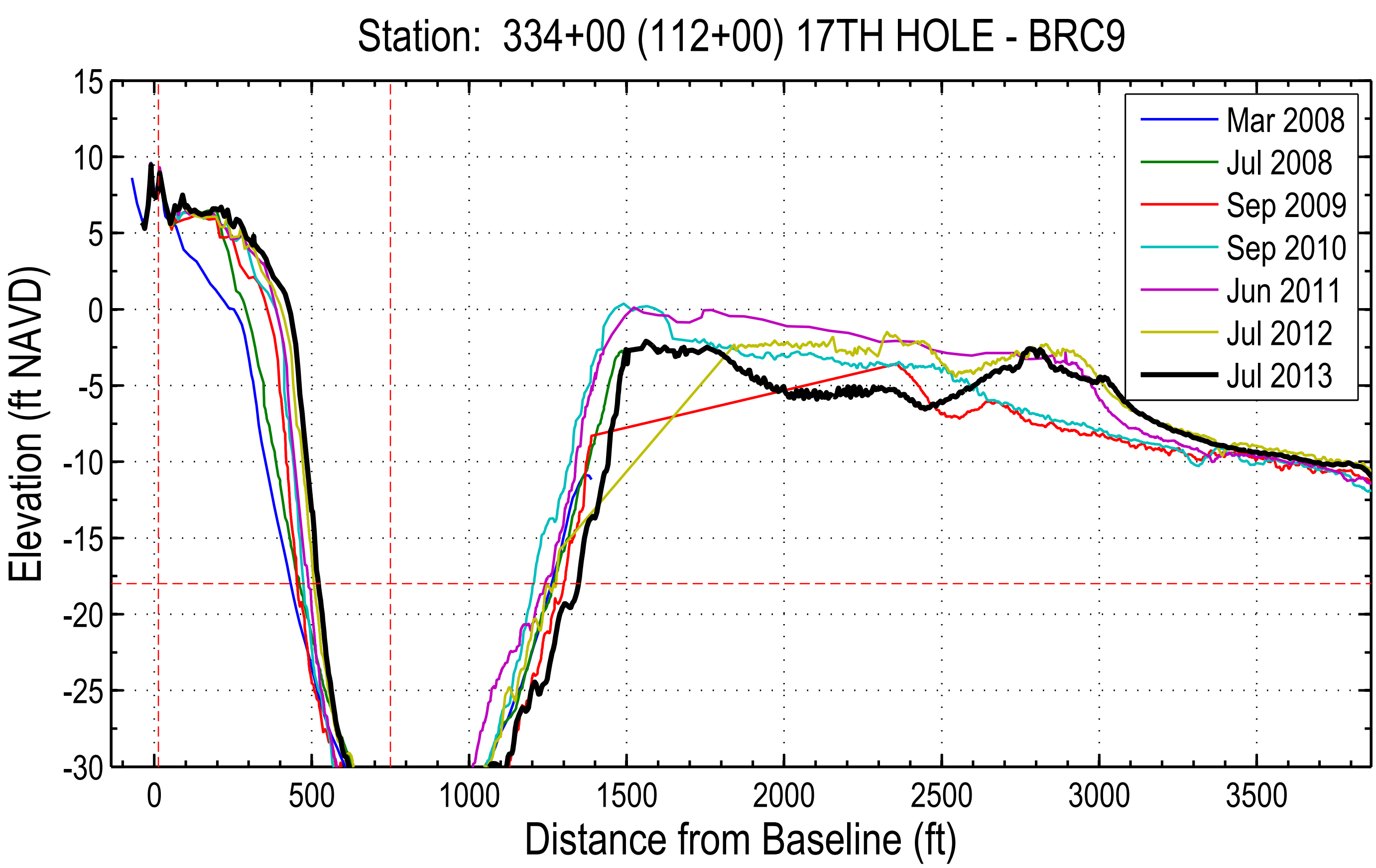
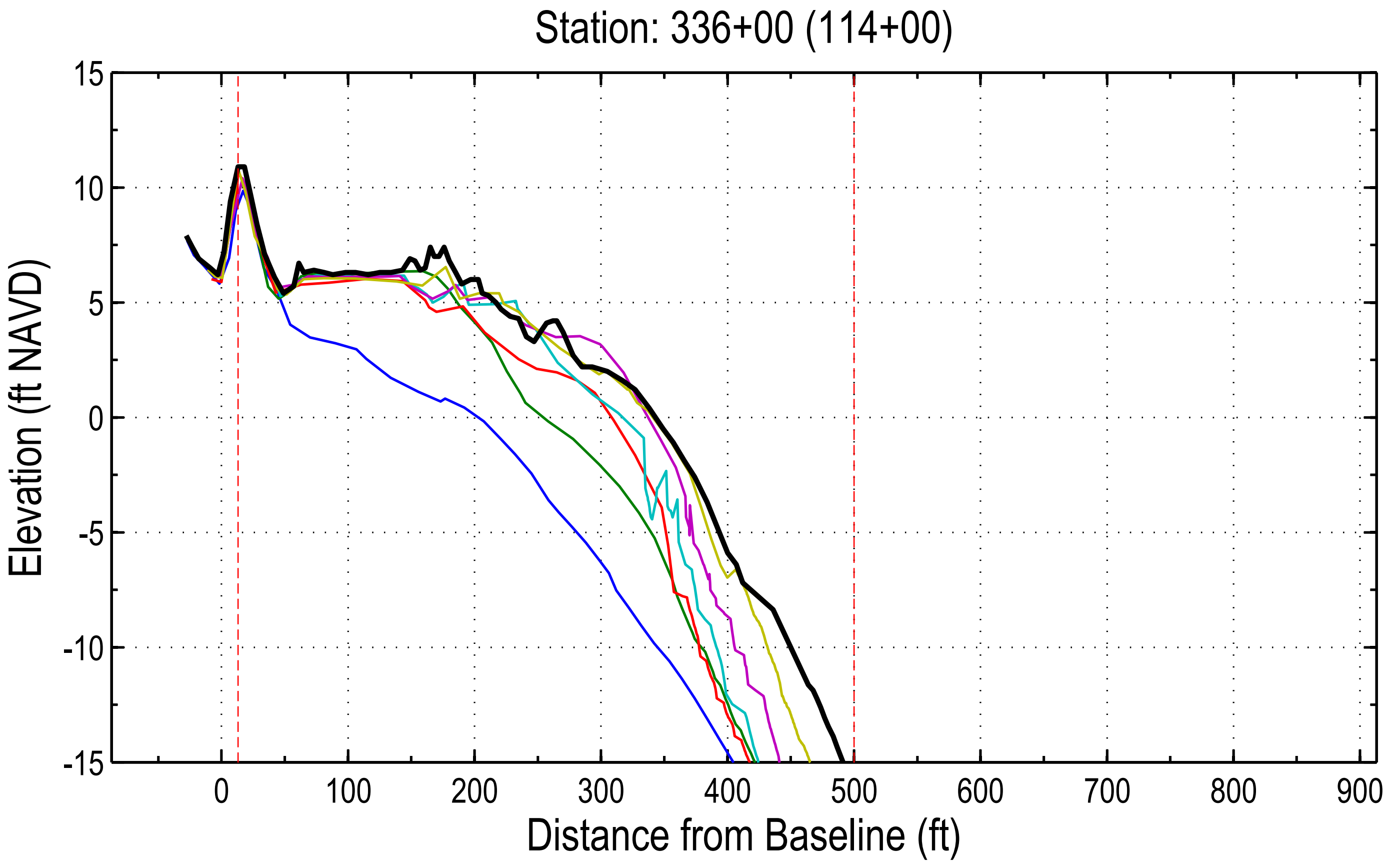
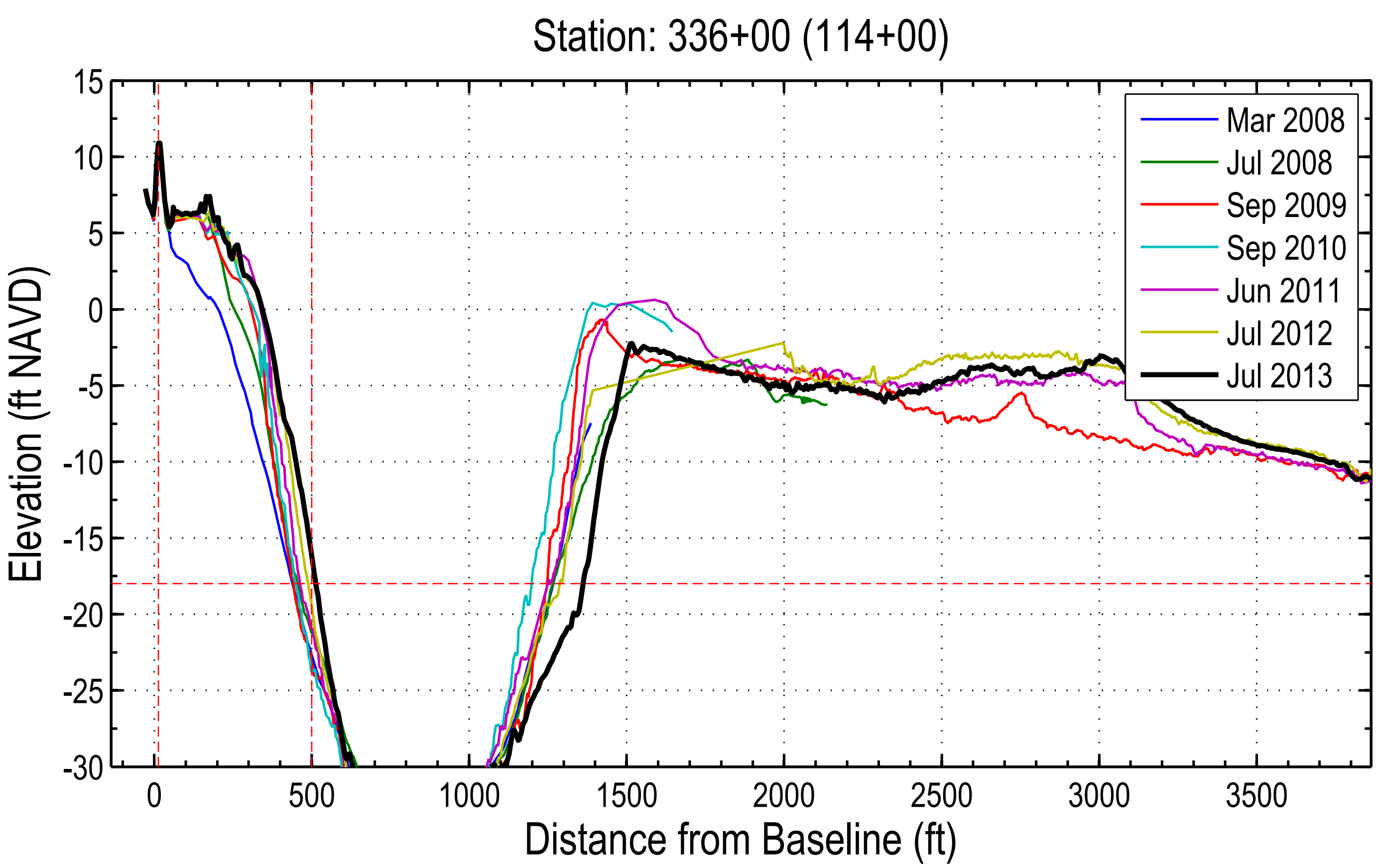
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900



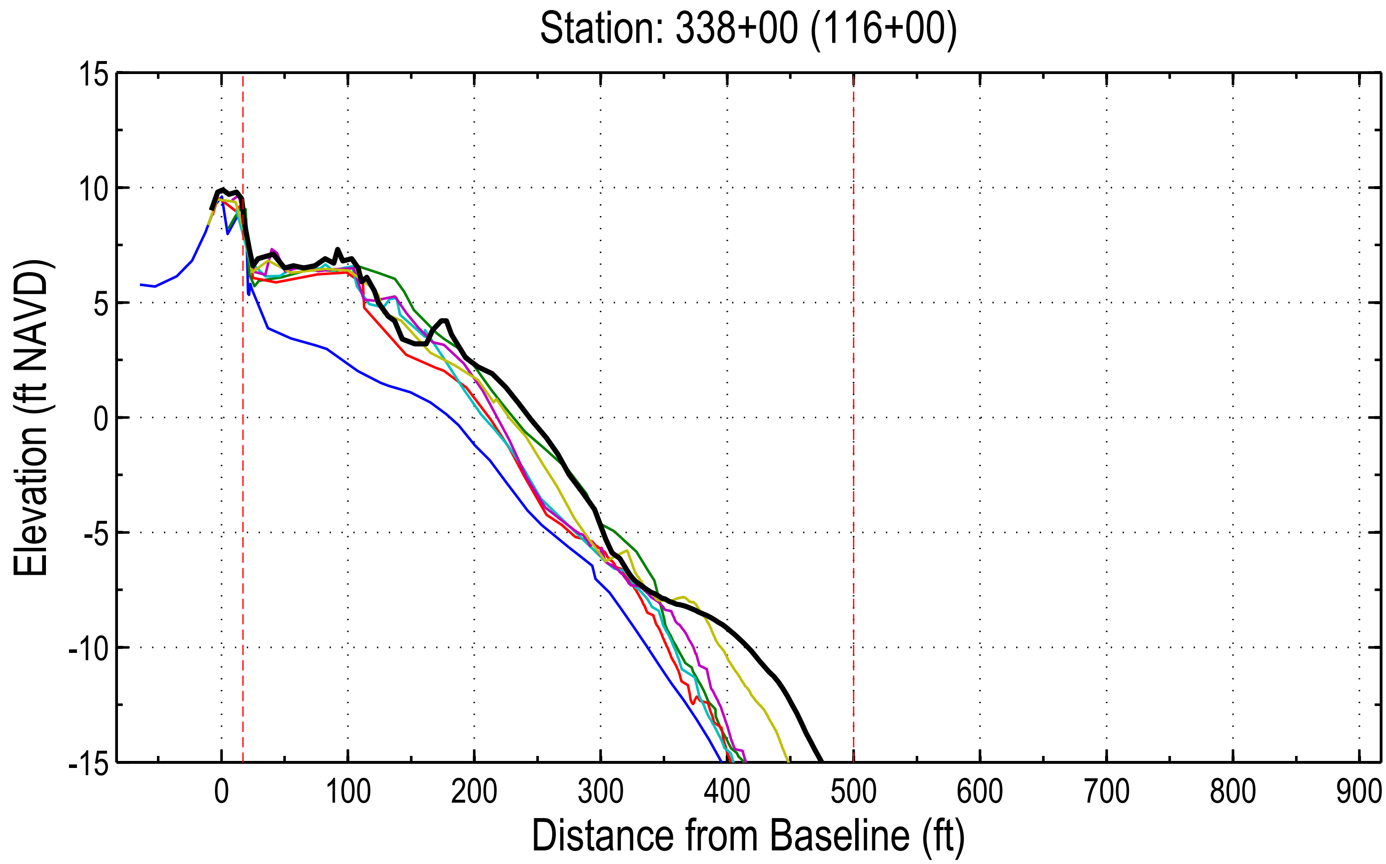
Station: 334+00 (112+00) 17TH HOLE - BRC9
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 336+00 (114+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600
700
800
900
Distance from Baseline (ft)



Station: 336+00 (114+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-20
-25
-30
0
500
1000
1500
2000
2500
3000
3500
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 338+00 (116+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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-5
-10
-15
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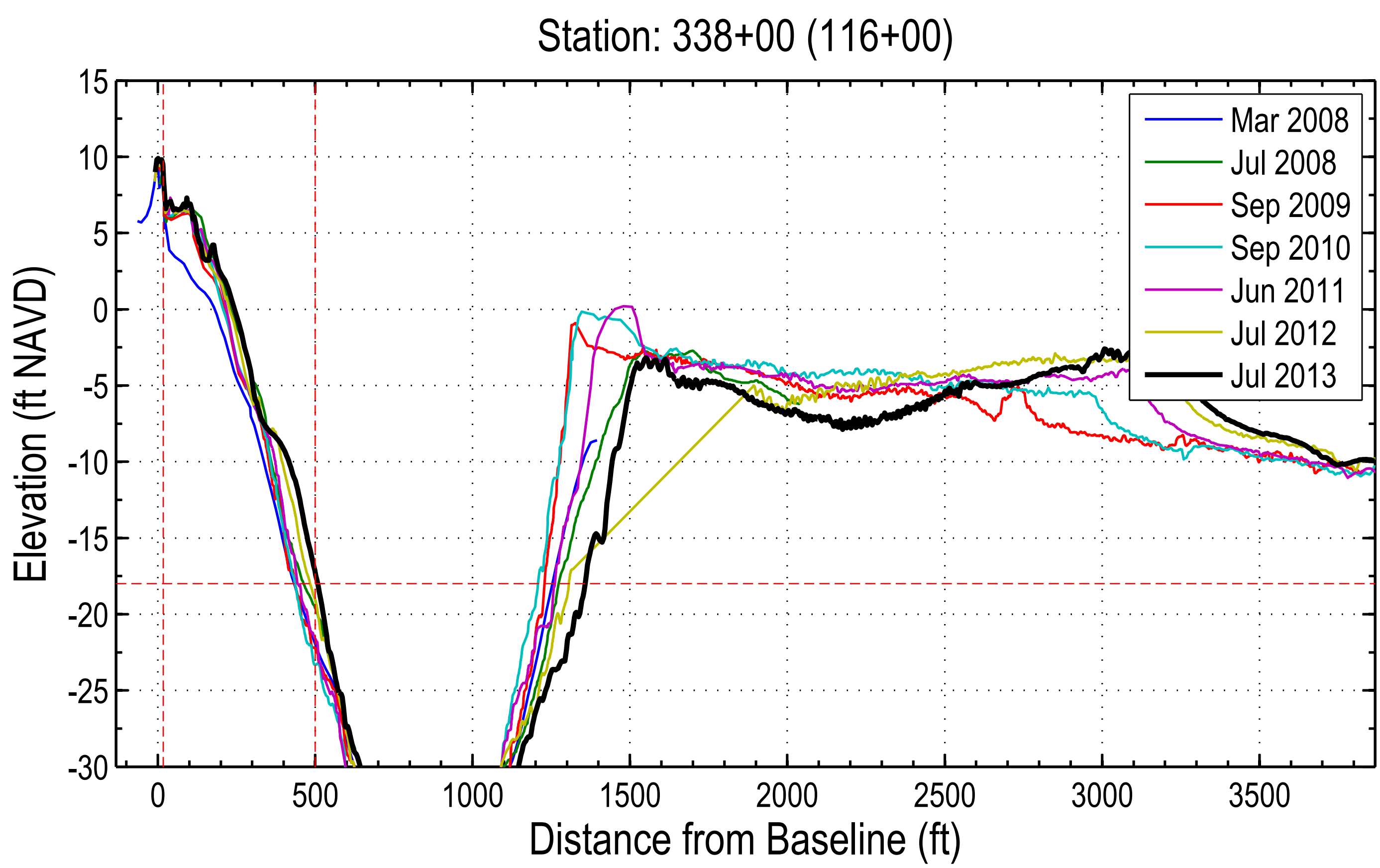
Station: 338+00 (116+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
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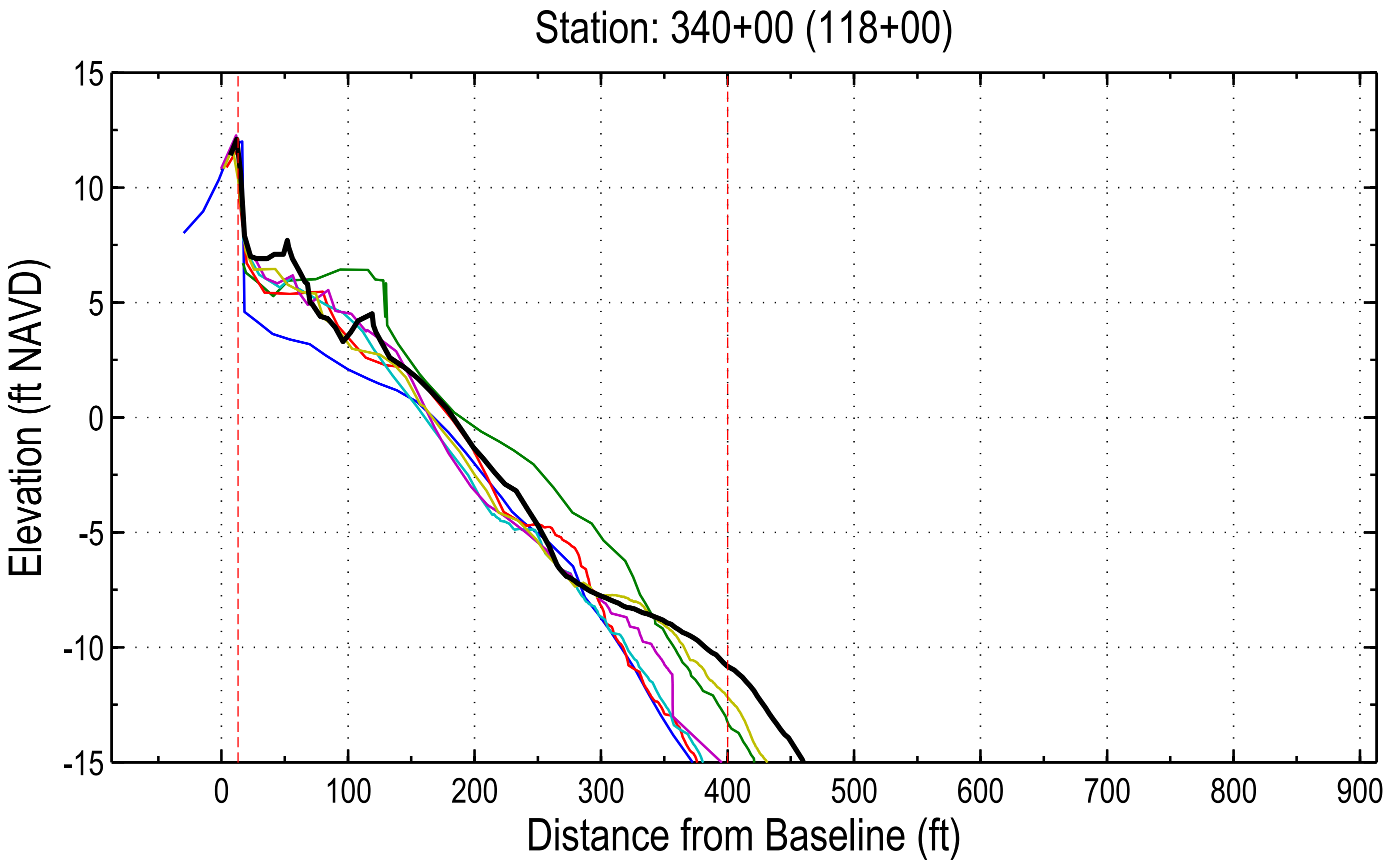
3000
3500


Station: 340+00 (118+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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10
5
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-5
-10
-15
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200
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600
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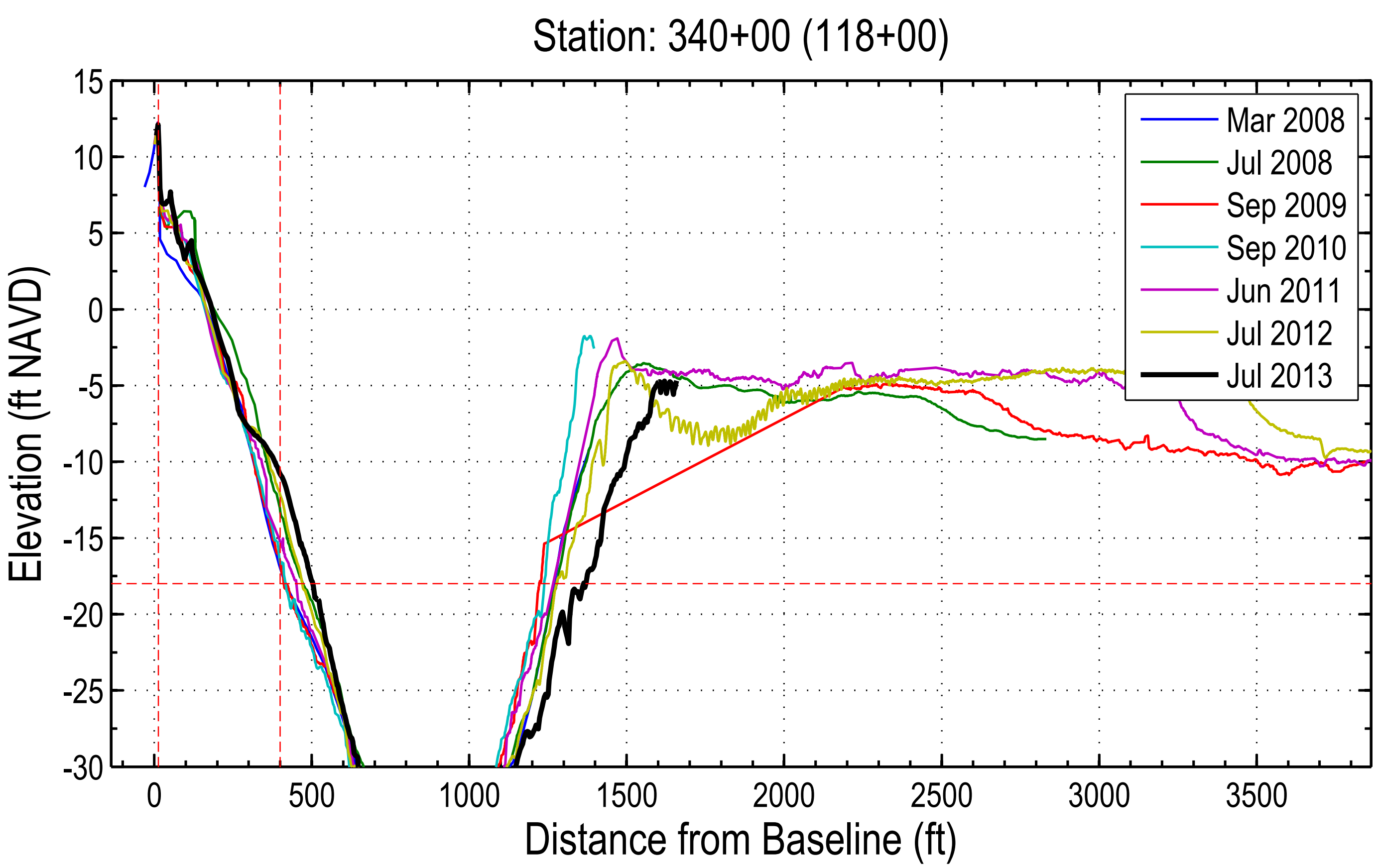
Station: 340+00 (118+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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-5
-10
-15
-20
-25
-30
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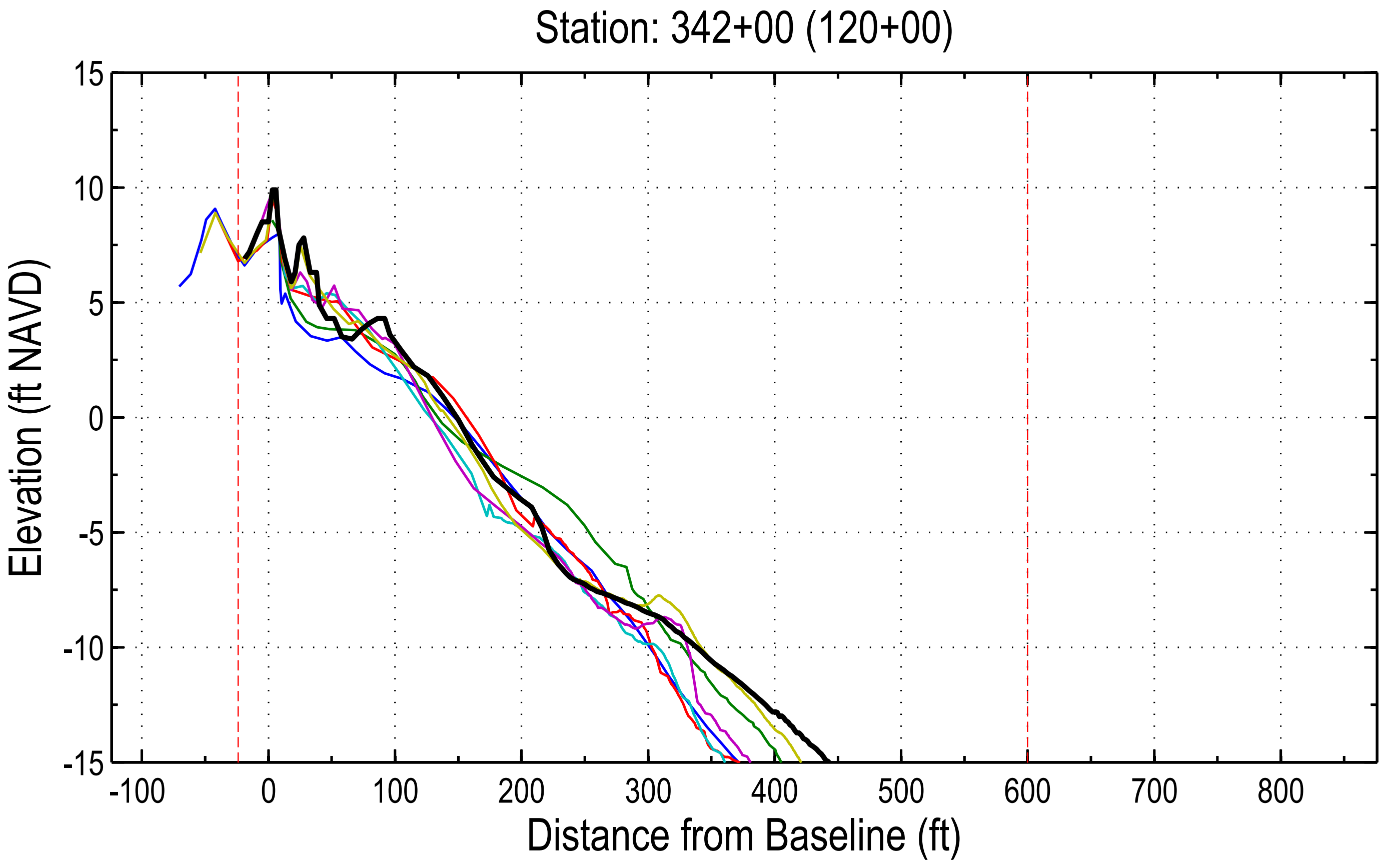
3500
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 342+00 (120+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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5
0
-5
-10
-15
-100
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100
200
300
400
500
600
700
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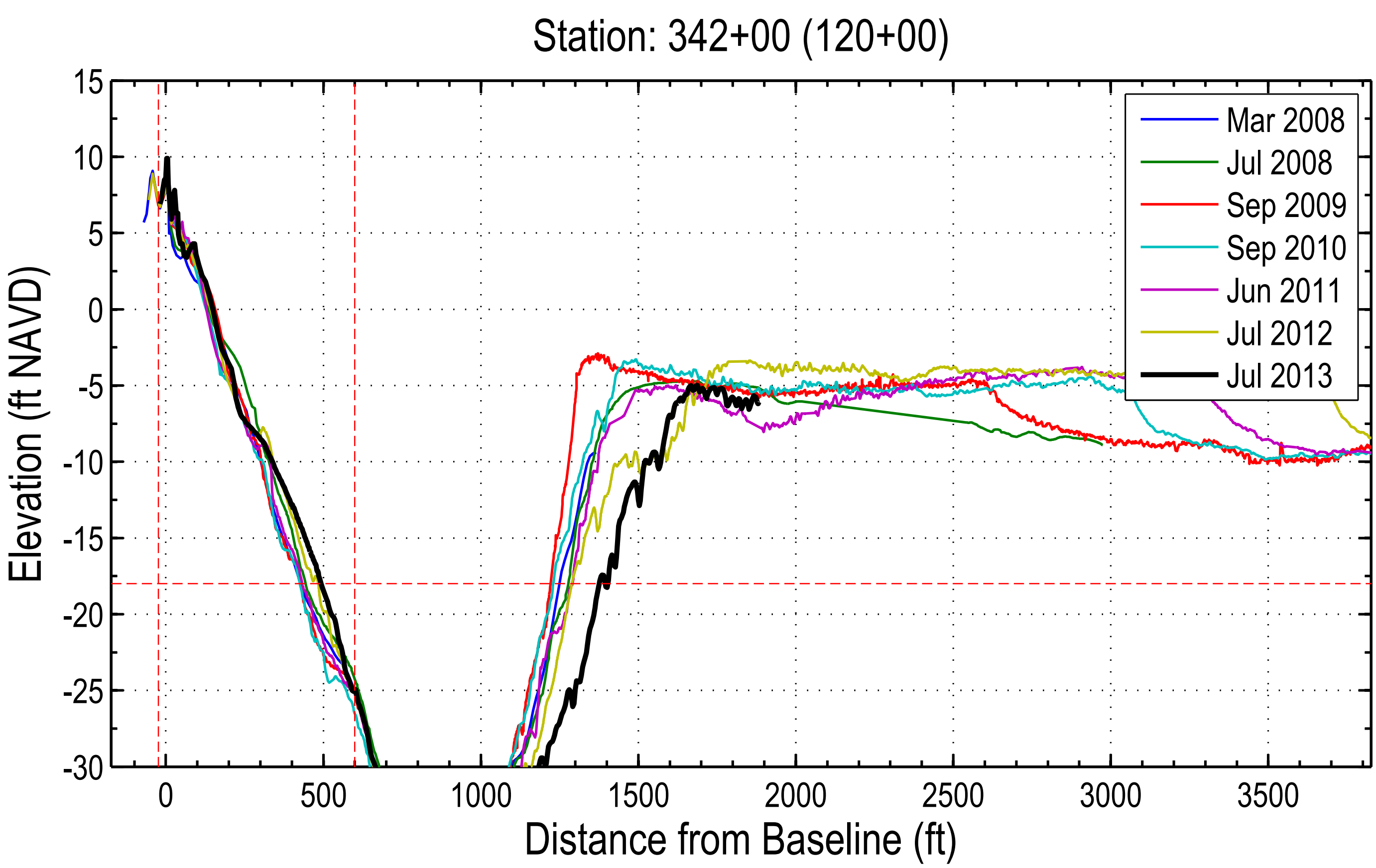
Station: 342+00 (120+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
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-5
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-15
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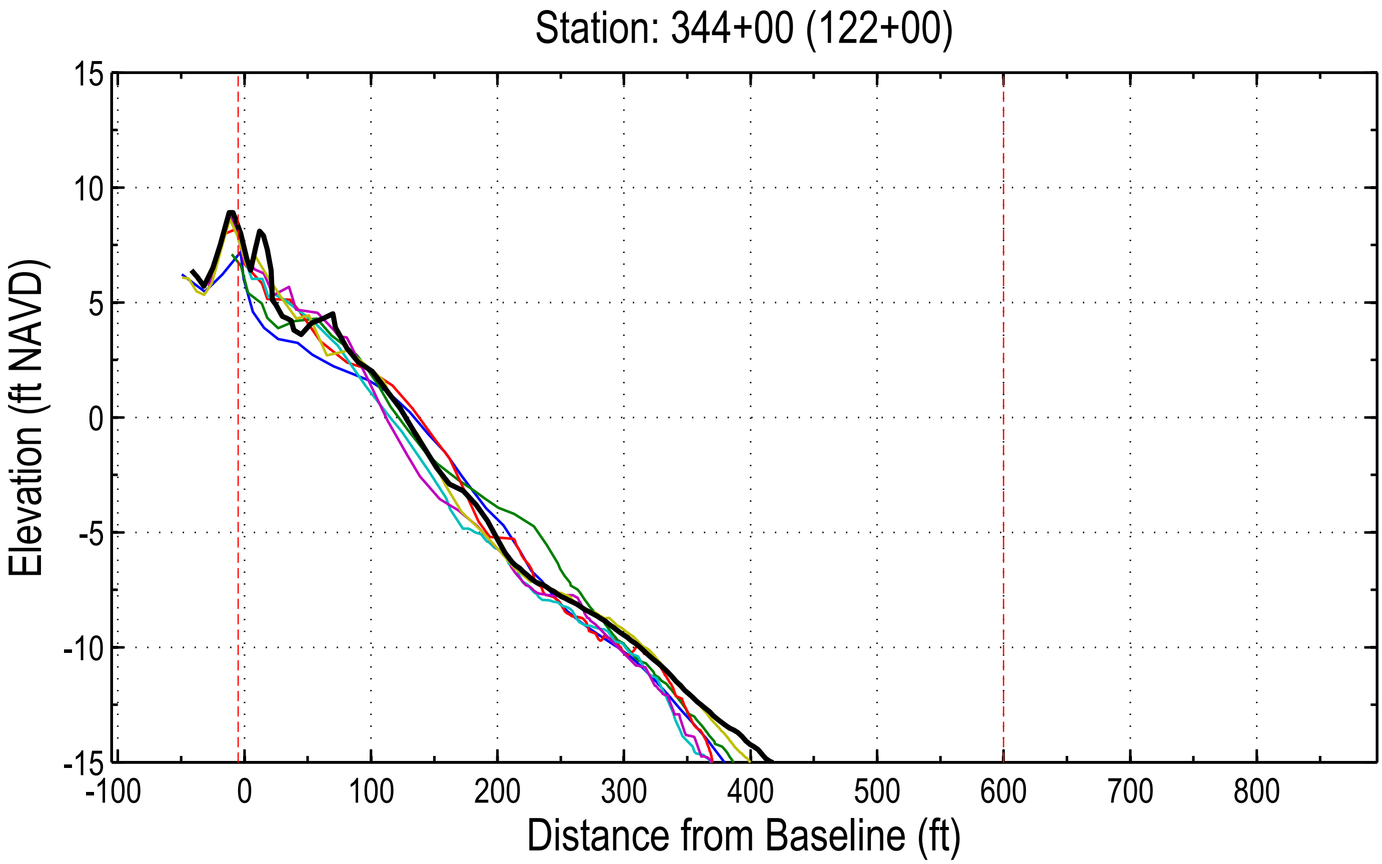
3500


Station: 344+00 (122+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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0
-5
-10
-15
-100
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100
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400
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600
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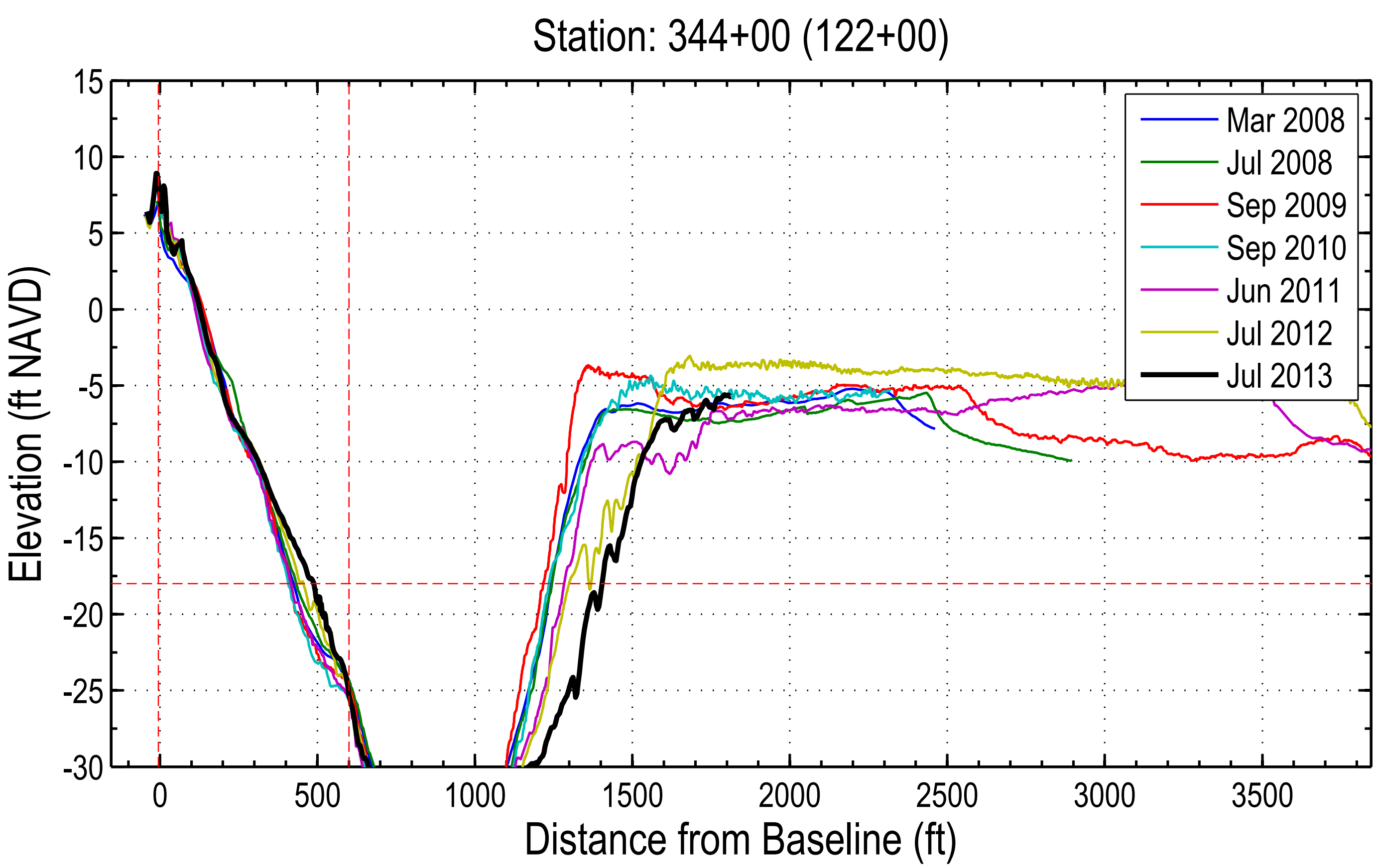
Station: 344+00 (122+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
10
5
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-5
-10
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-25
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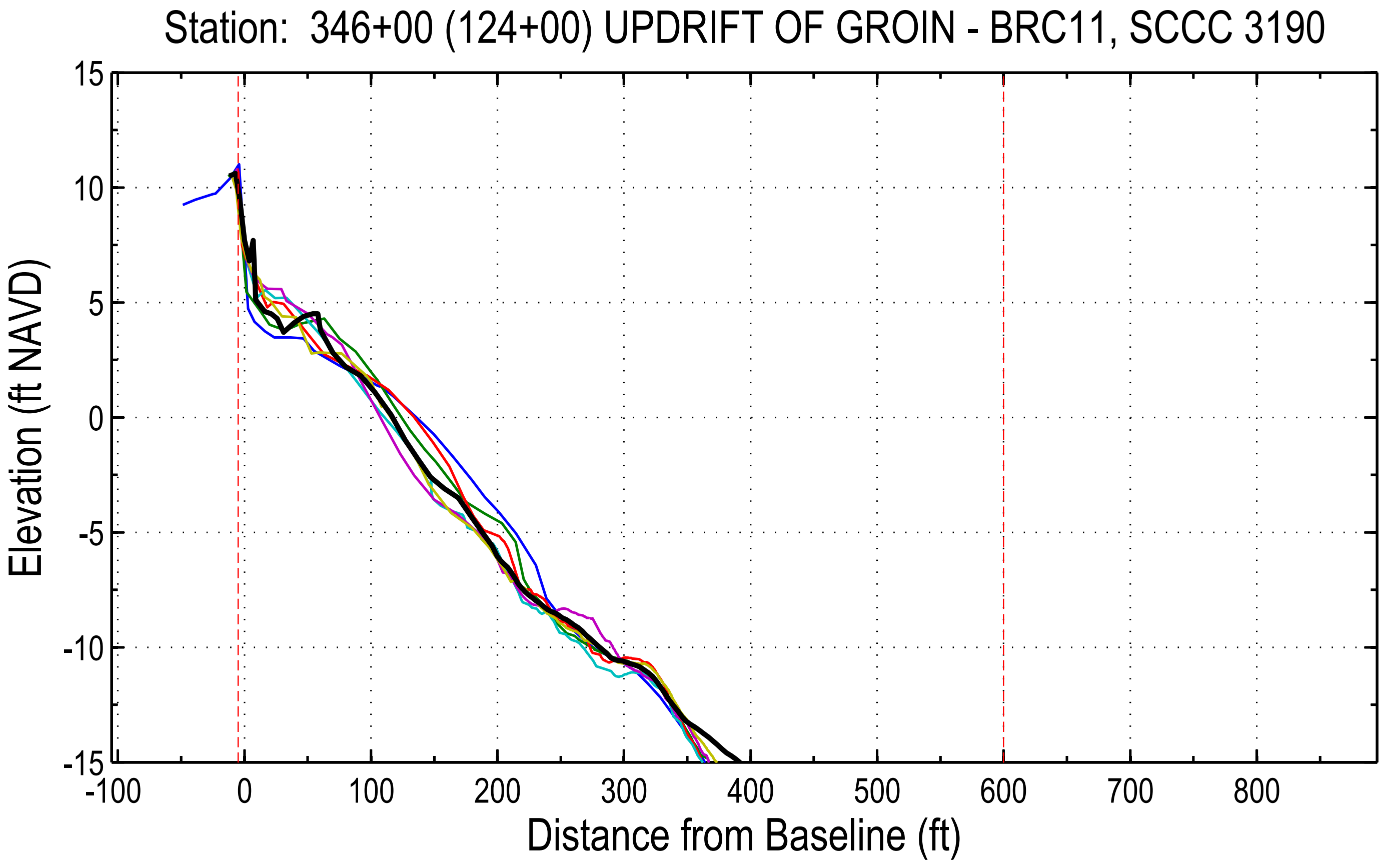

Station: 346+00 (124+00) UPDRIFT OF GROIN - BRC11, SCCC 3190
Elevation (ft NAVD)
Distance from Baseline (ft)
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-5
-10
-15
-100
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100
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700
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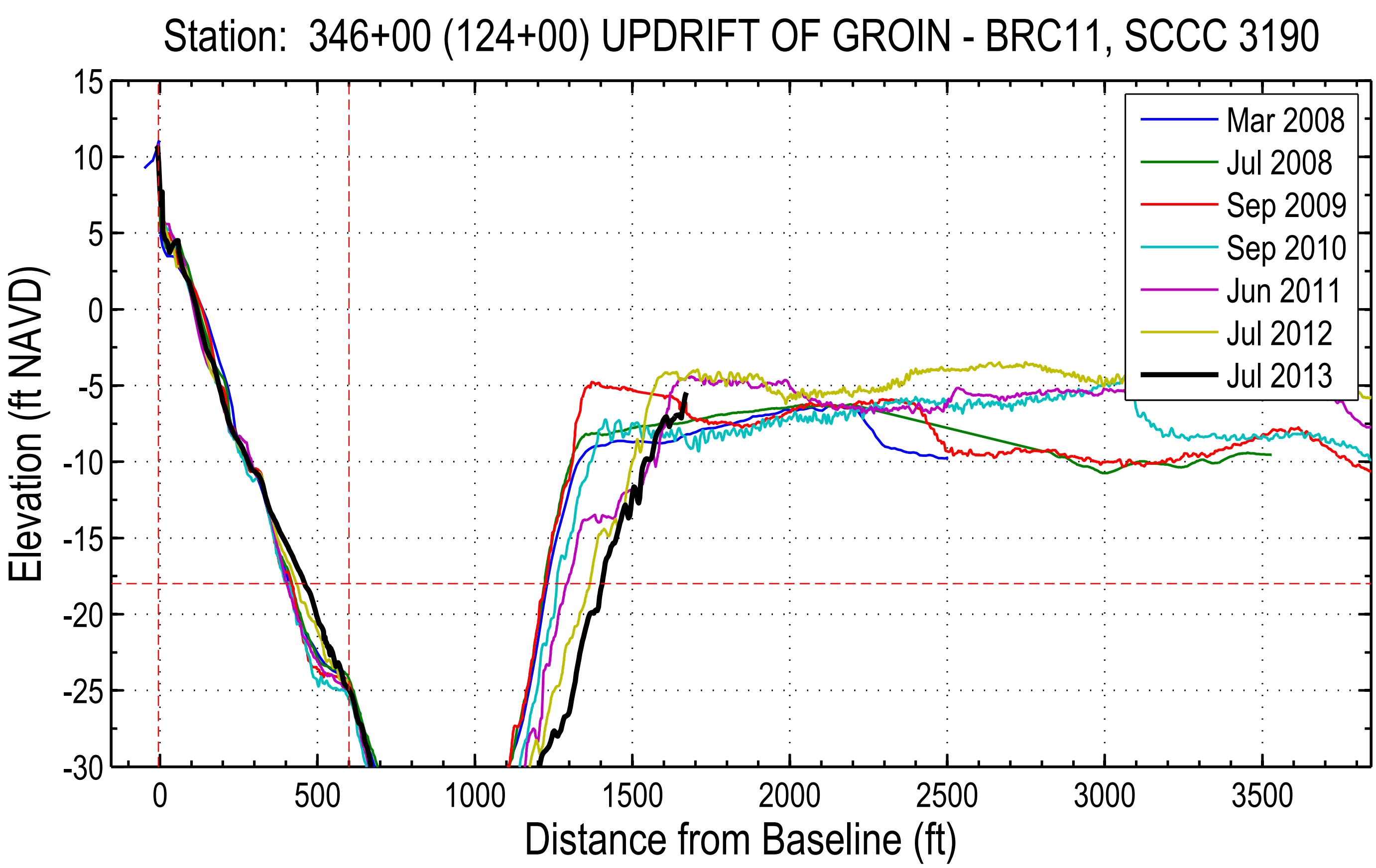

Station: 346+00 (124+00) UPDRIFT OF GROIN - BRC11, SCCC 3190
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
15
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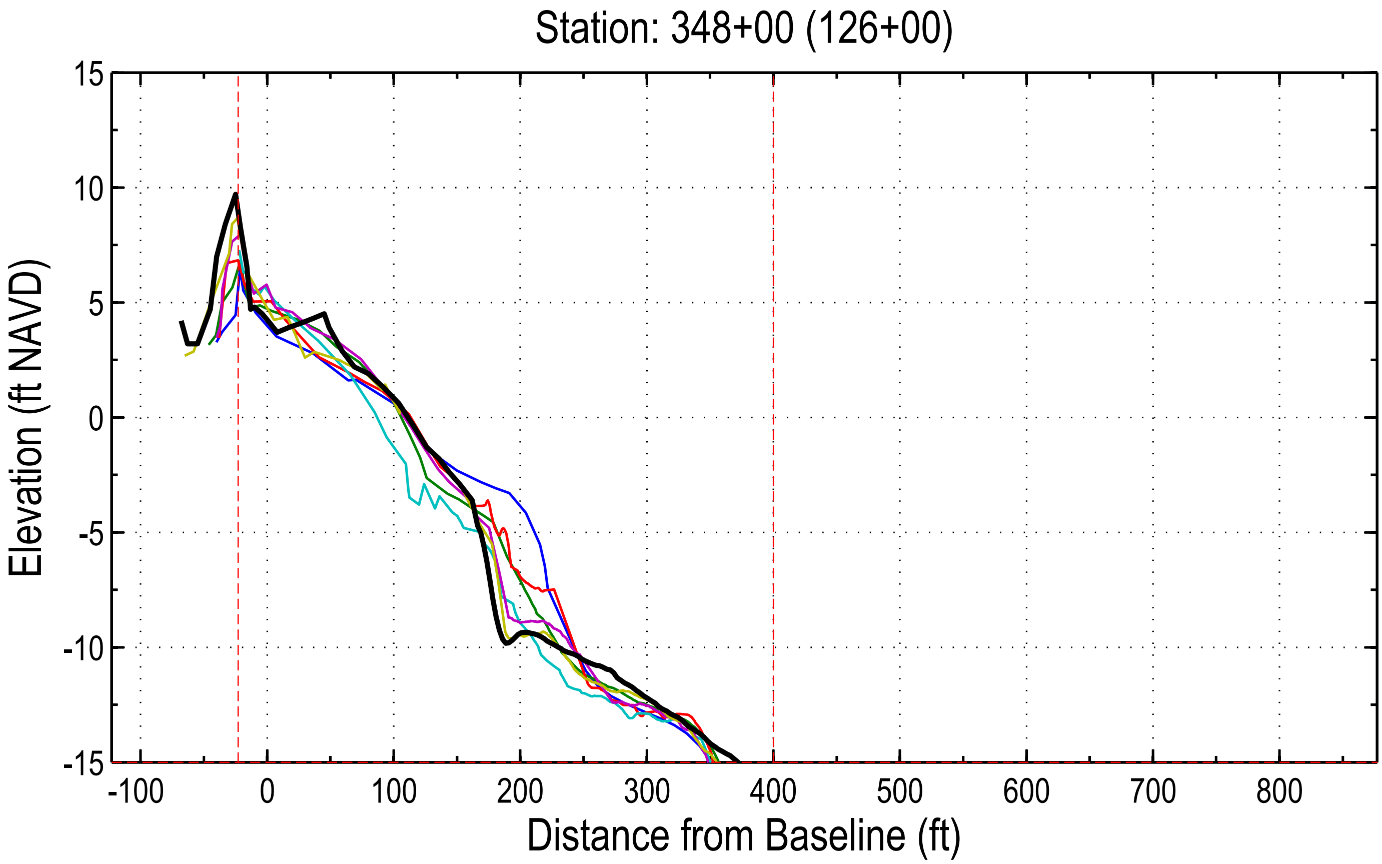
Station: 348+00 (126+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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-5
-10
-15
-100
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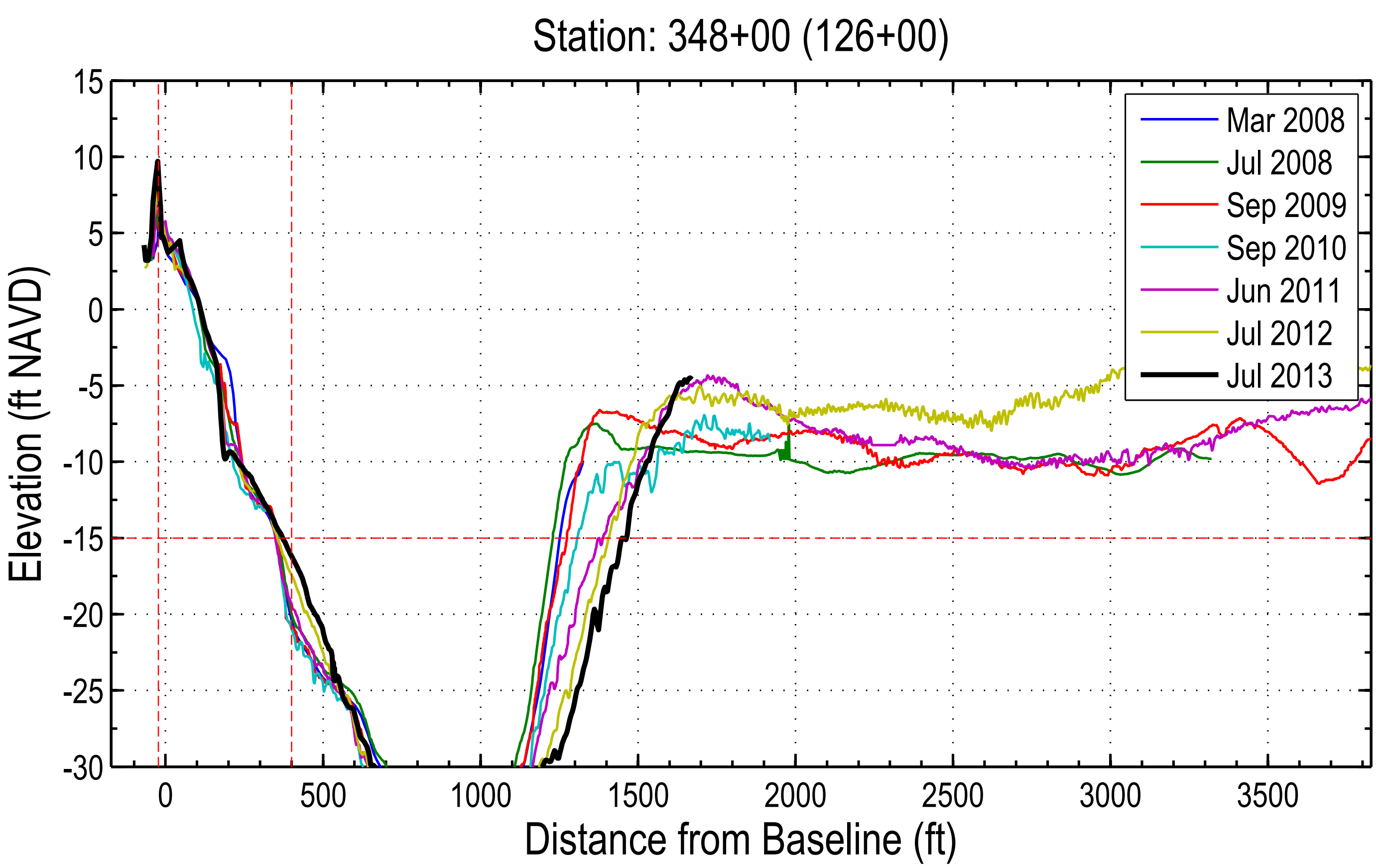
Station: 348+00 (126+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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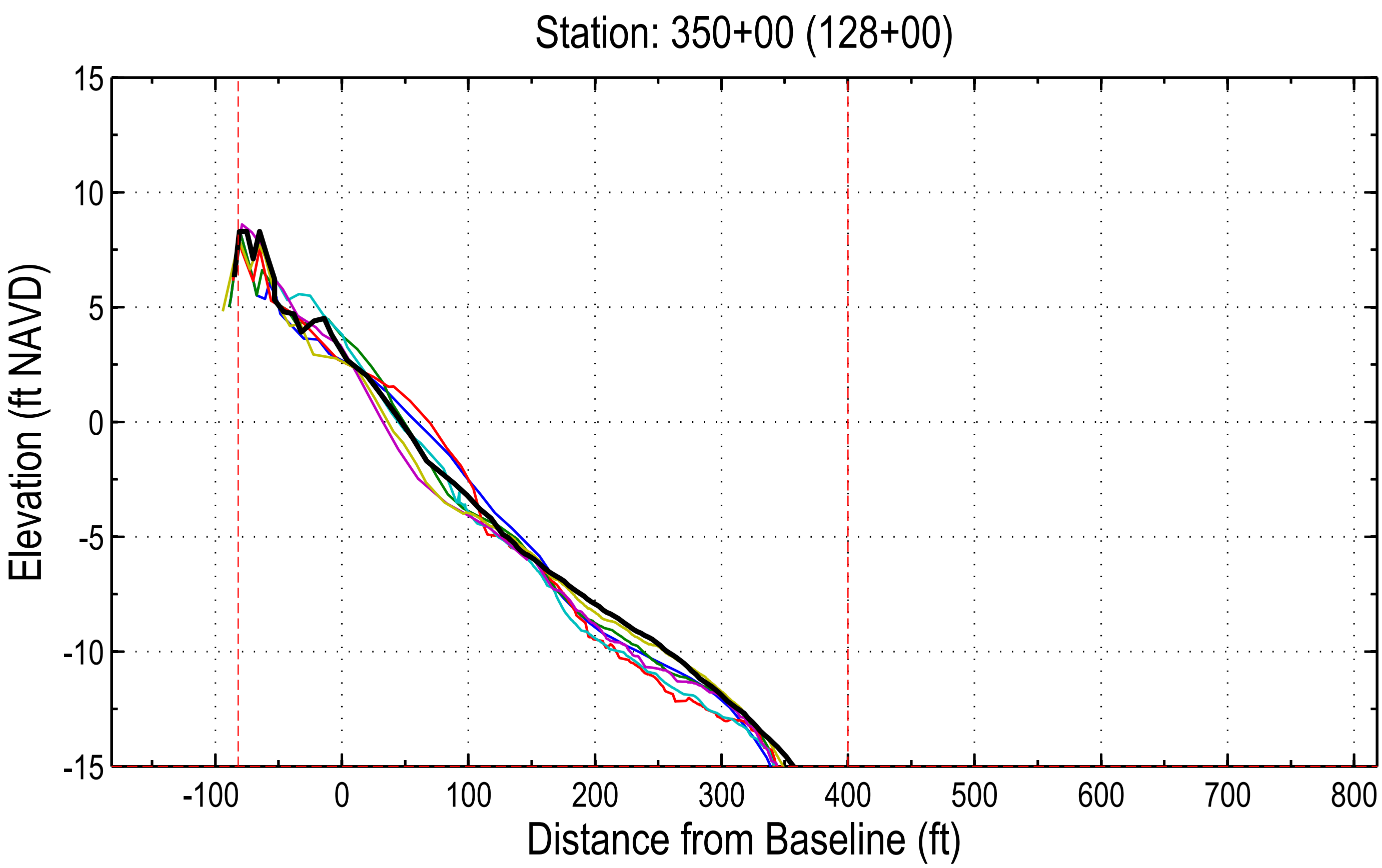
3500
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 350+00 (128+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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0
-5
-10
-15
-100
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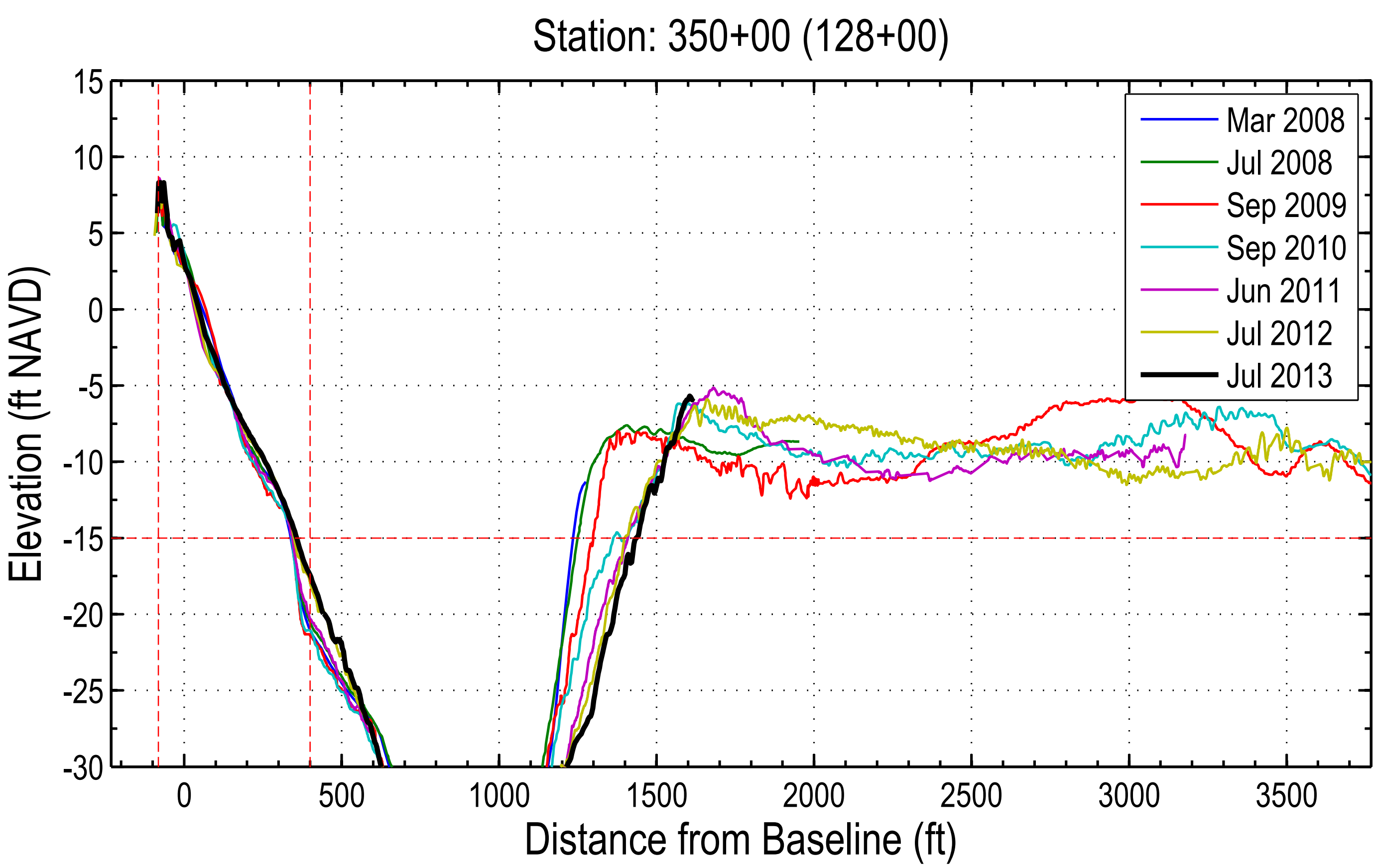

Station: 350+00 (128+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
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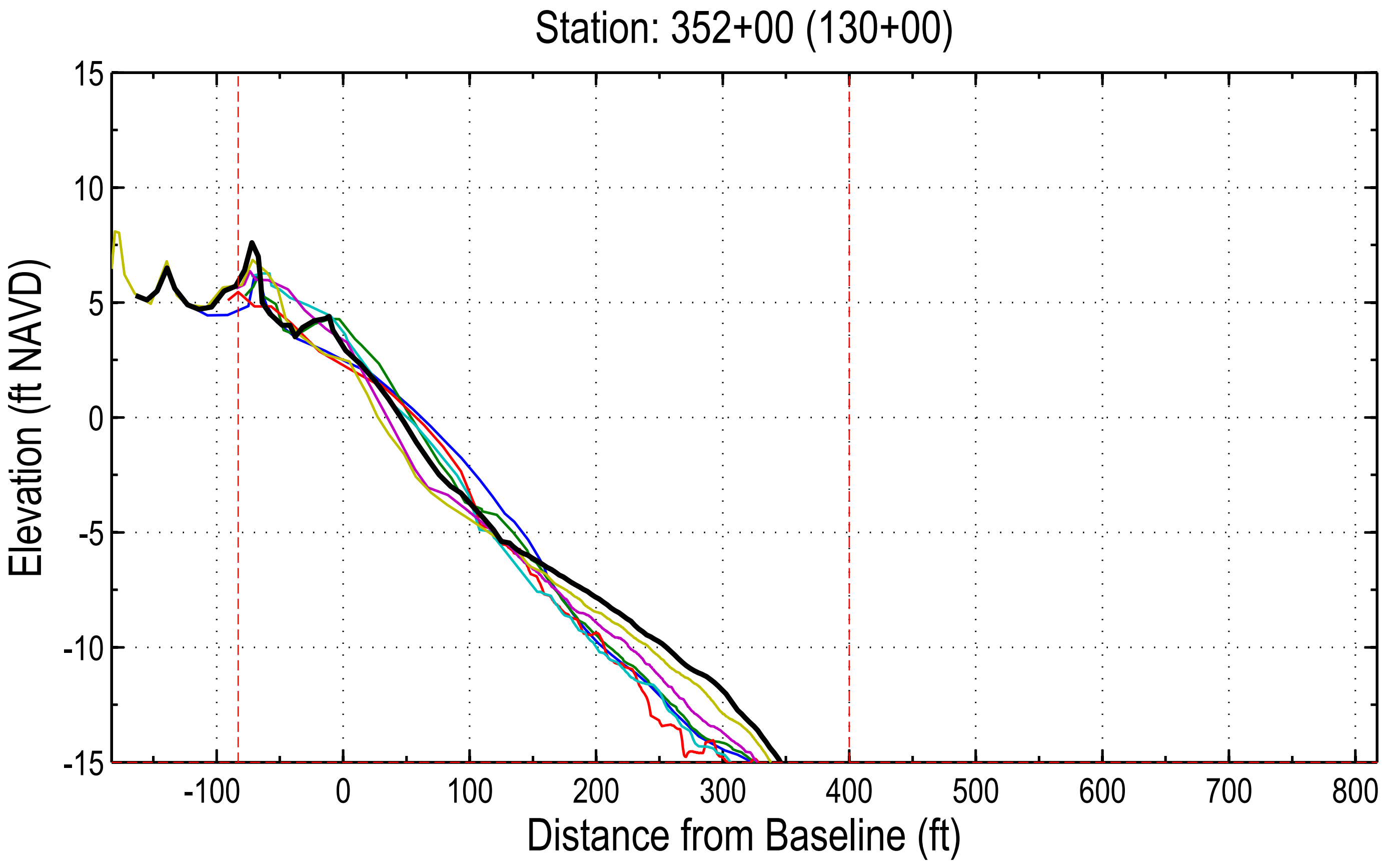

Station: 352+00 (130+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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-5
-10
-15
-100
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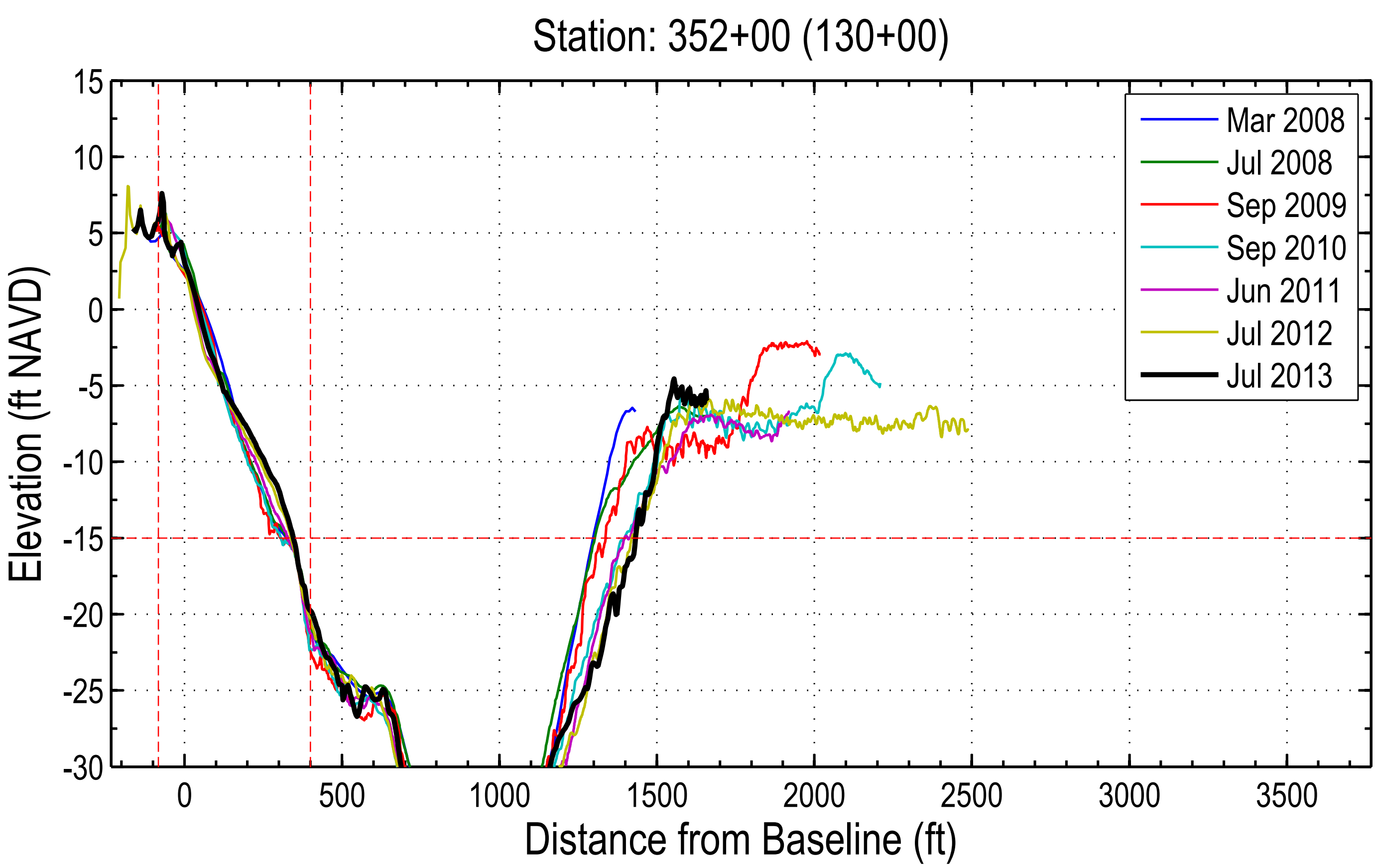

Station: 352+00 (130+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
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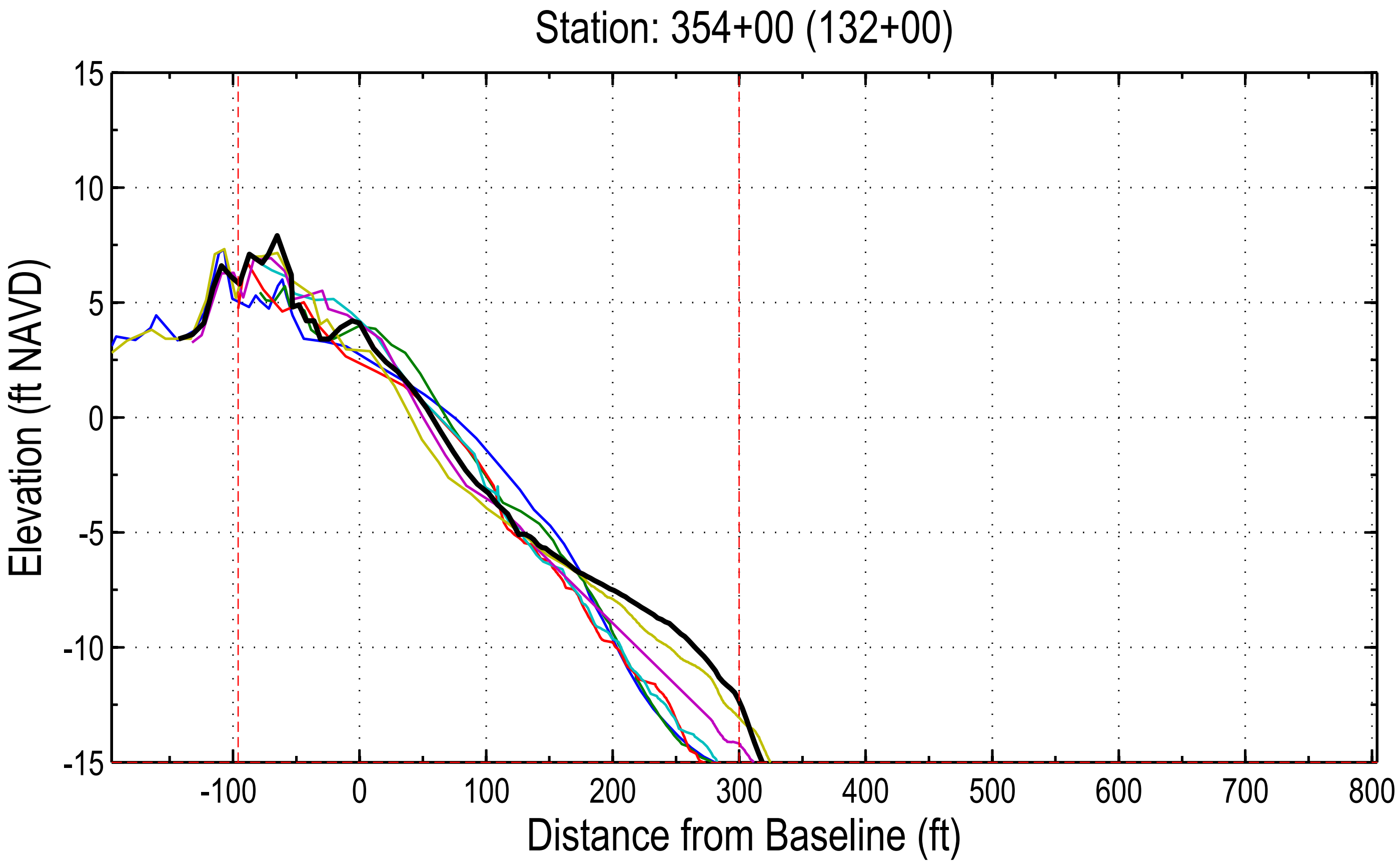
Station: 354+00 (132+00)
Elevation (ft NAVD)
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-10
-15
-100
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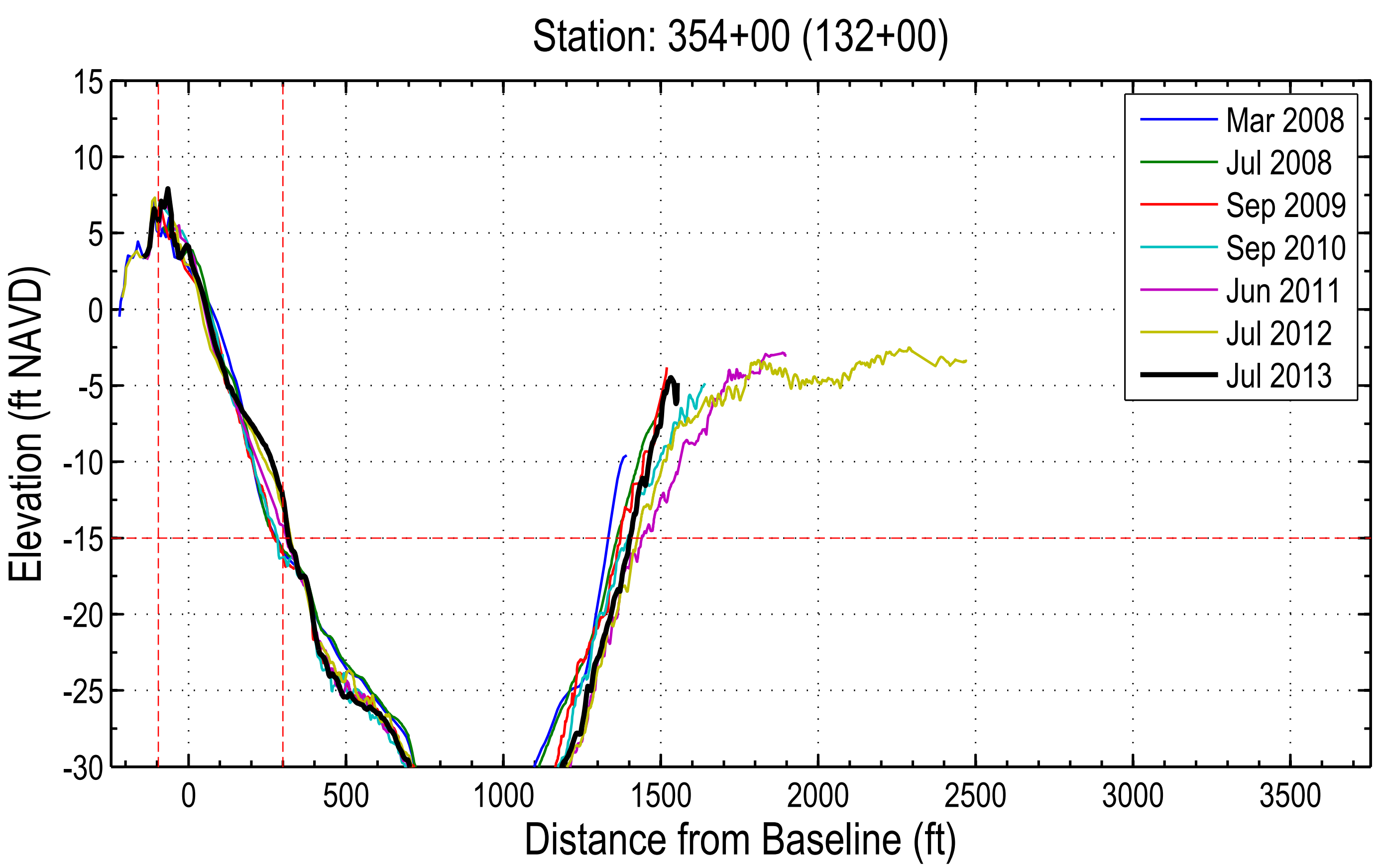
700
800
Distance from Baseline (ft)


Station: 354+00 (132+00)
Elevation (ft NAVD)
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10
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-10
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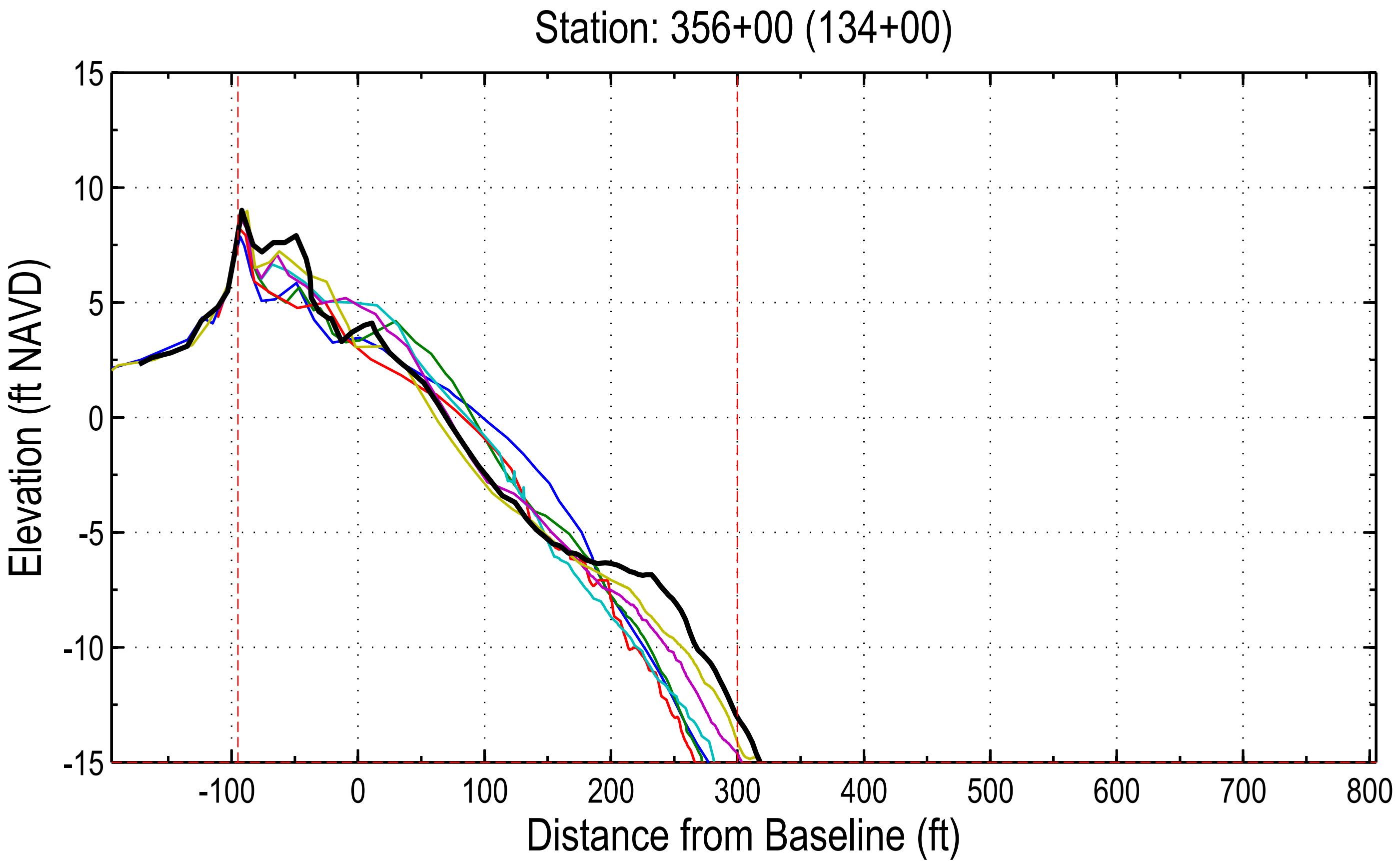
3500
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 356+00 (134+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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-10
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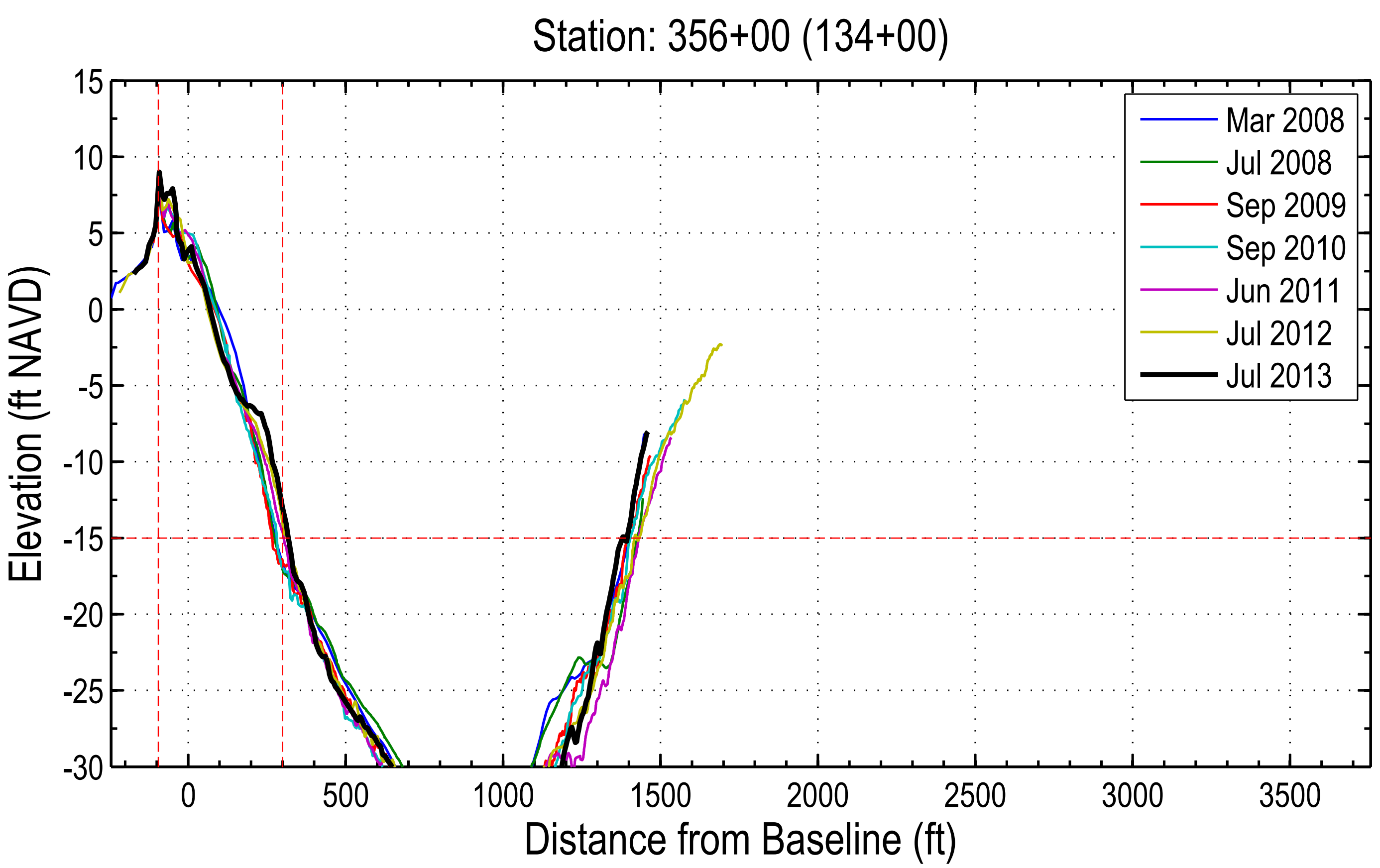
Station: 356+00 (134+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
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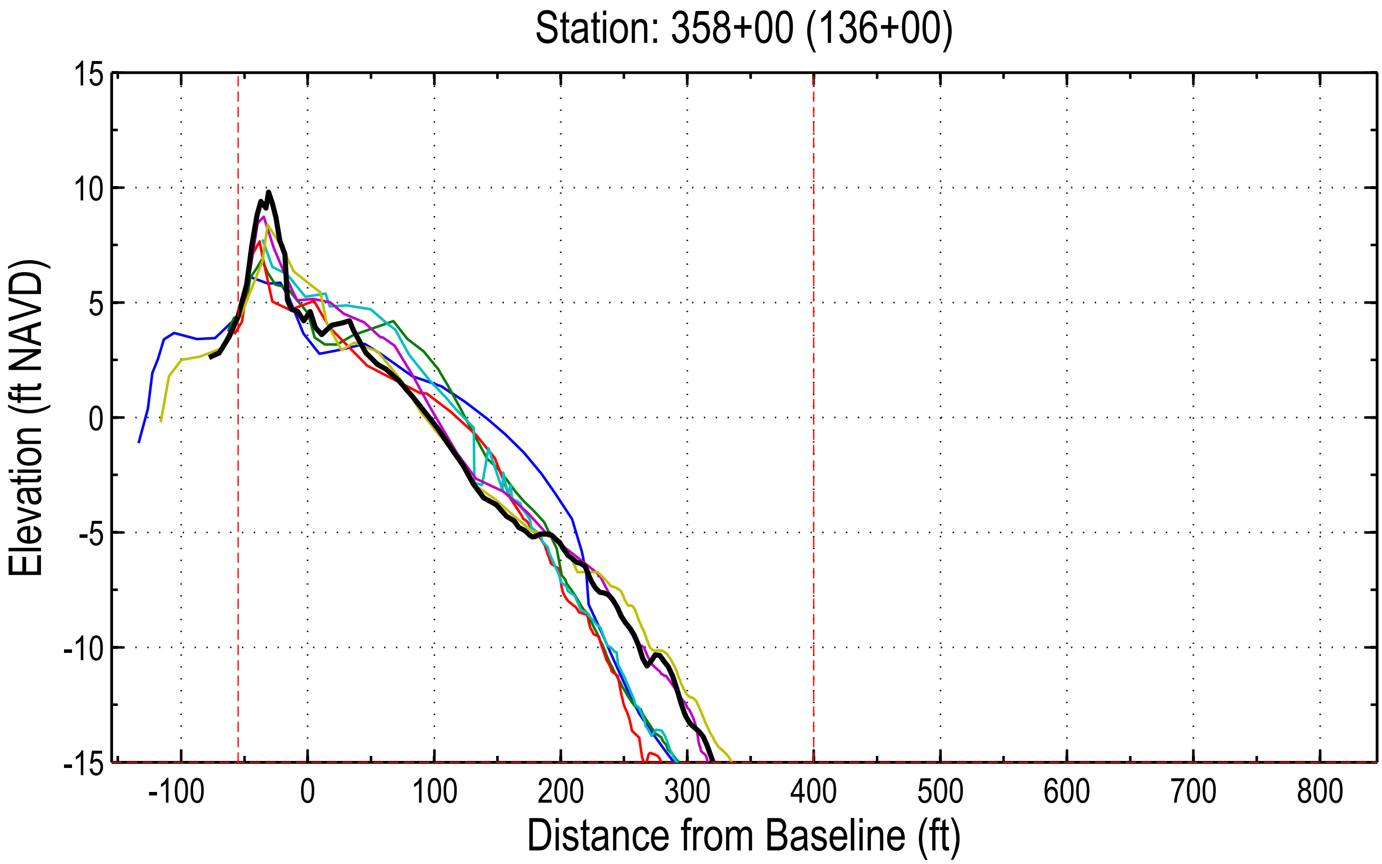
3500



Station: 358+00 (136+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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-5
-10
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-100
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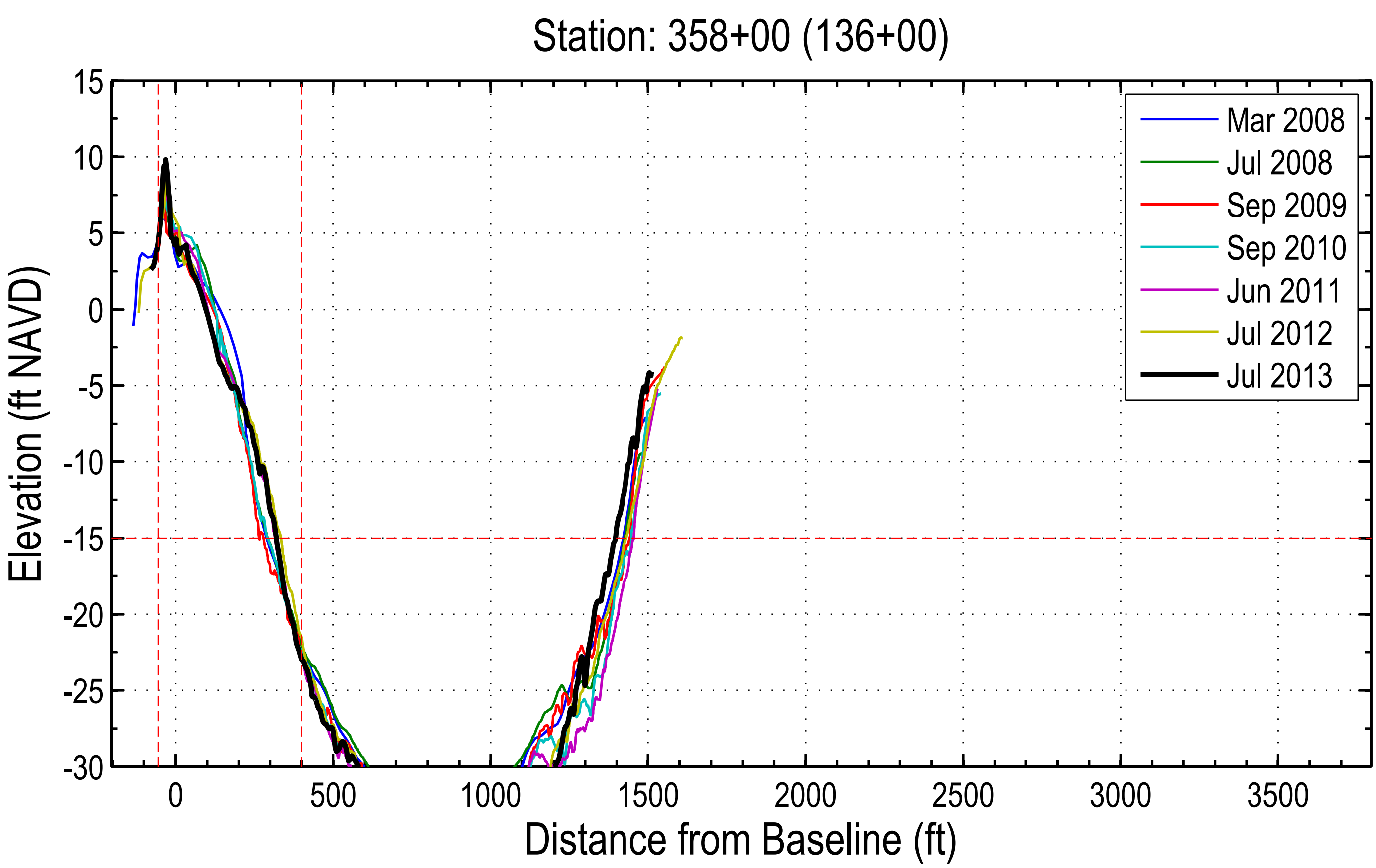
800



Station: 358+00 (136+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
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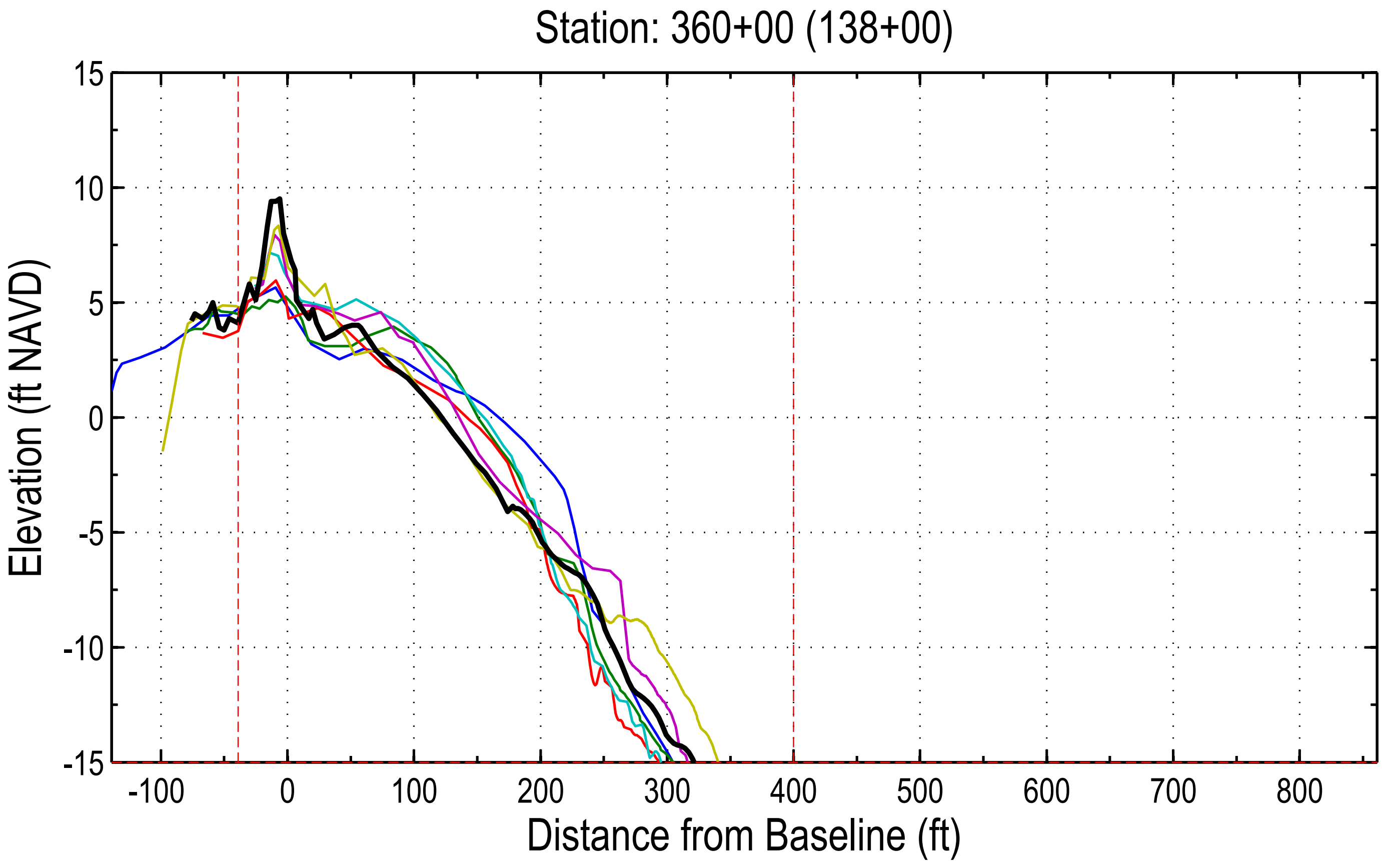
Station: 360+00 (138+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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0
-5
-10
-15
-100
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200
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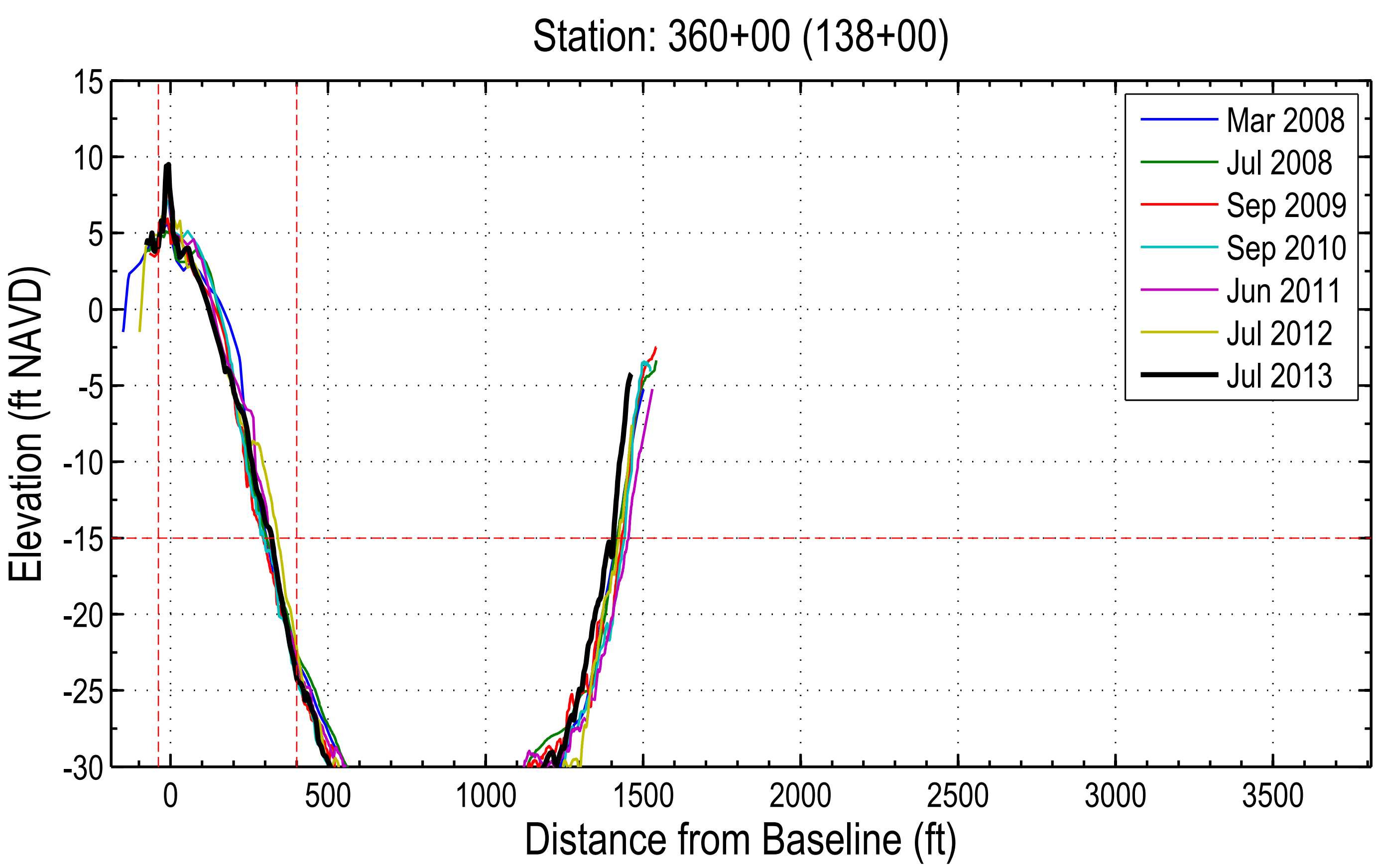
Station: 360+00 (138+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
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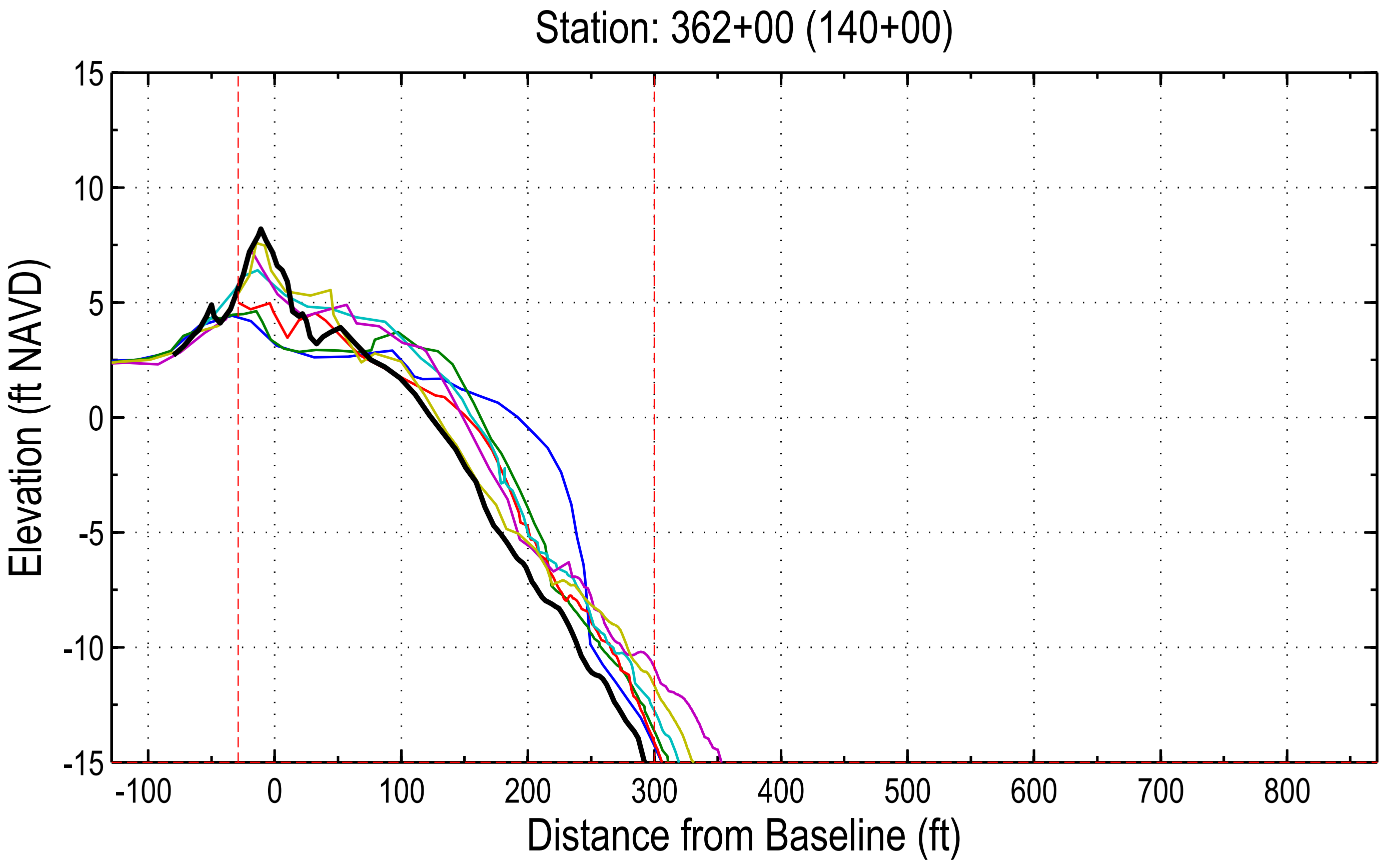
Station: 362+00 (140+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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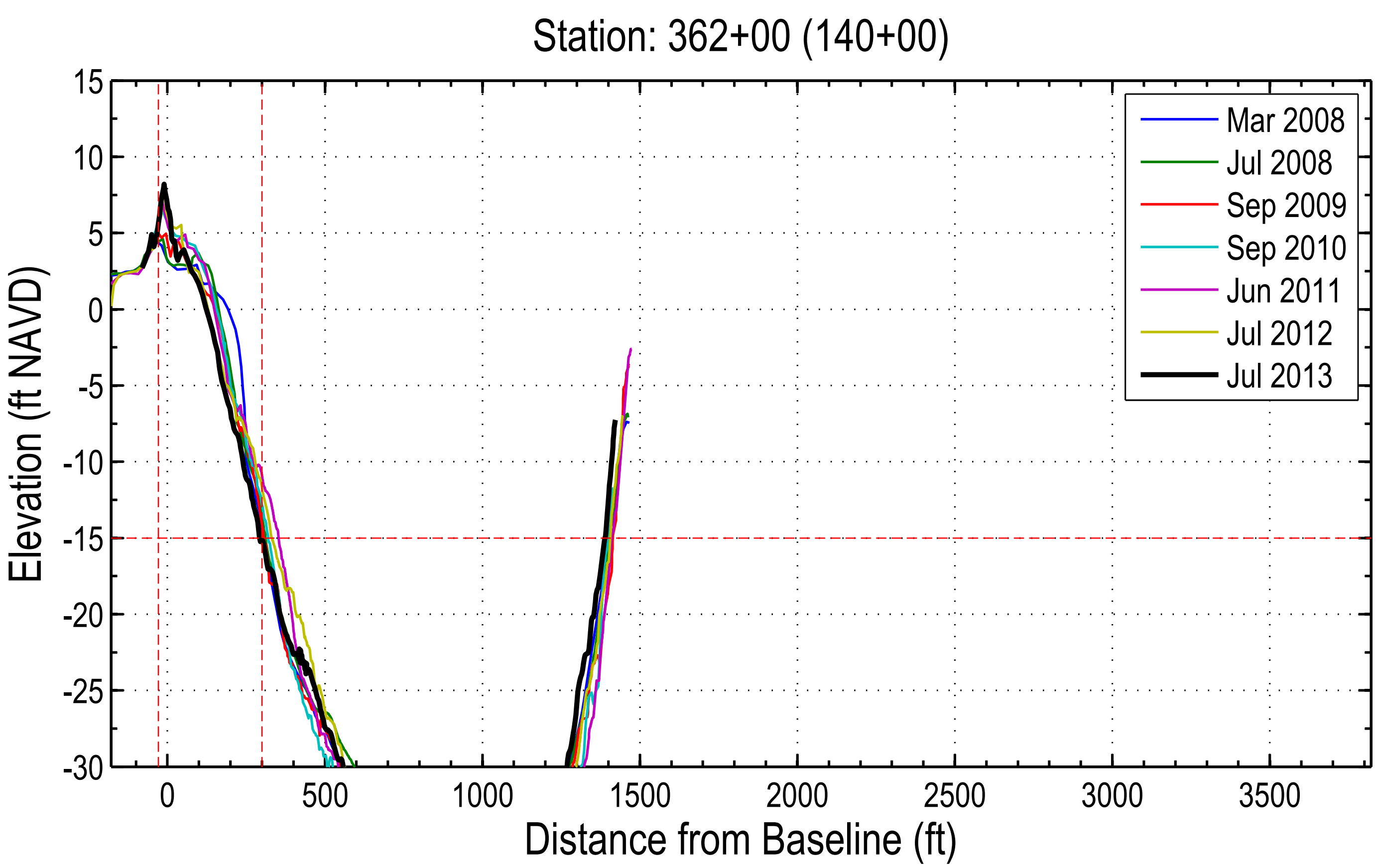
Station: 362+00 (140+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
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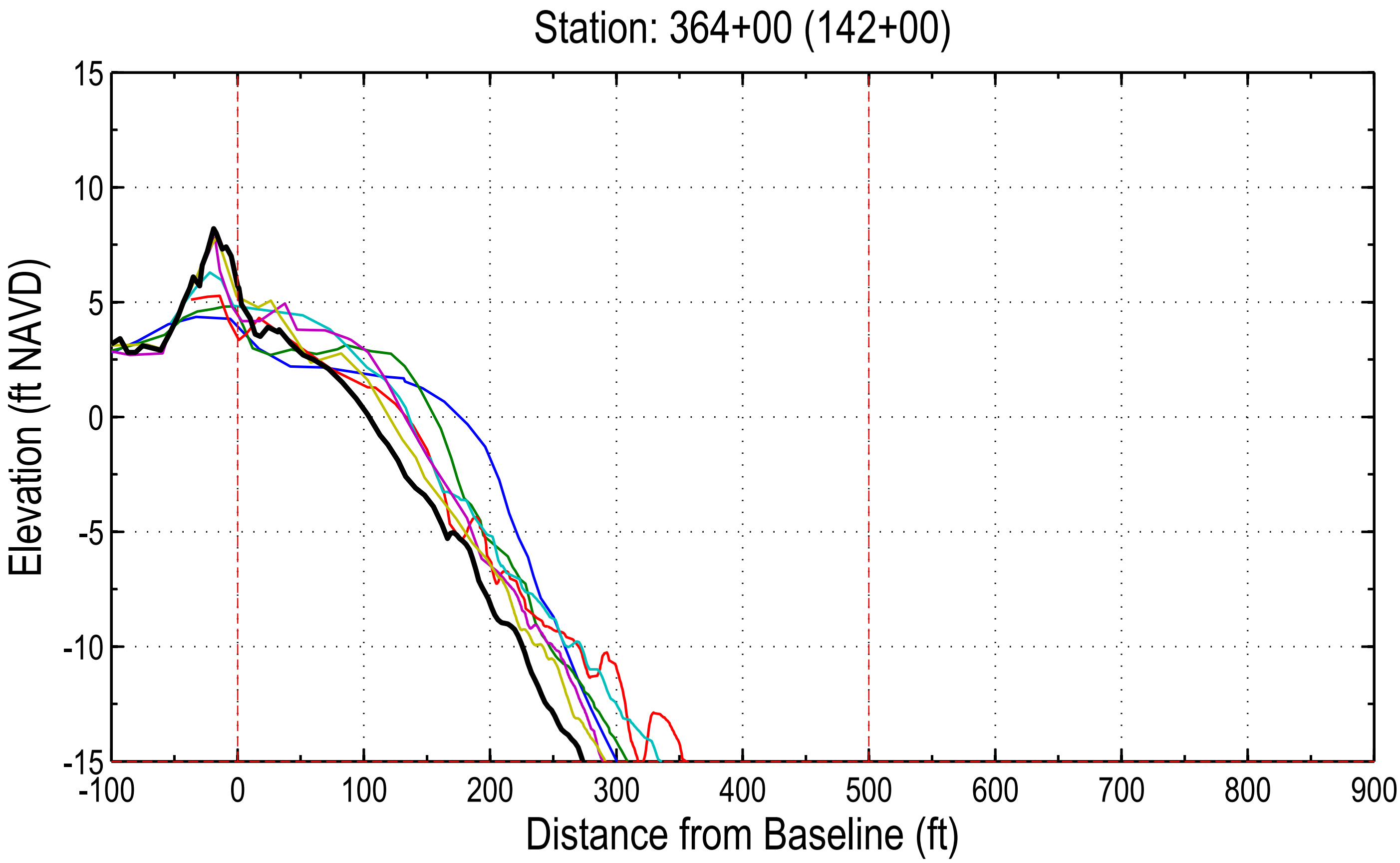
Station: 364+00 (142+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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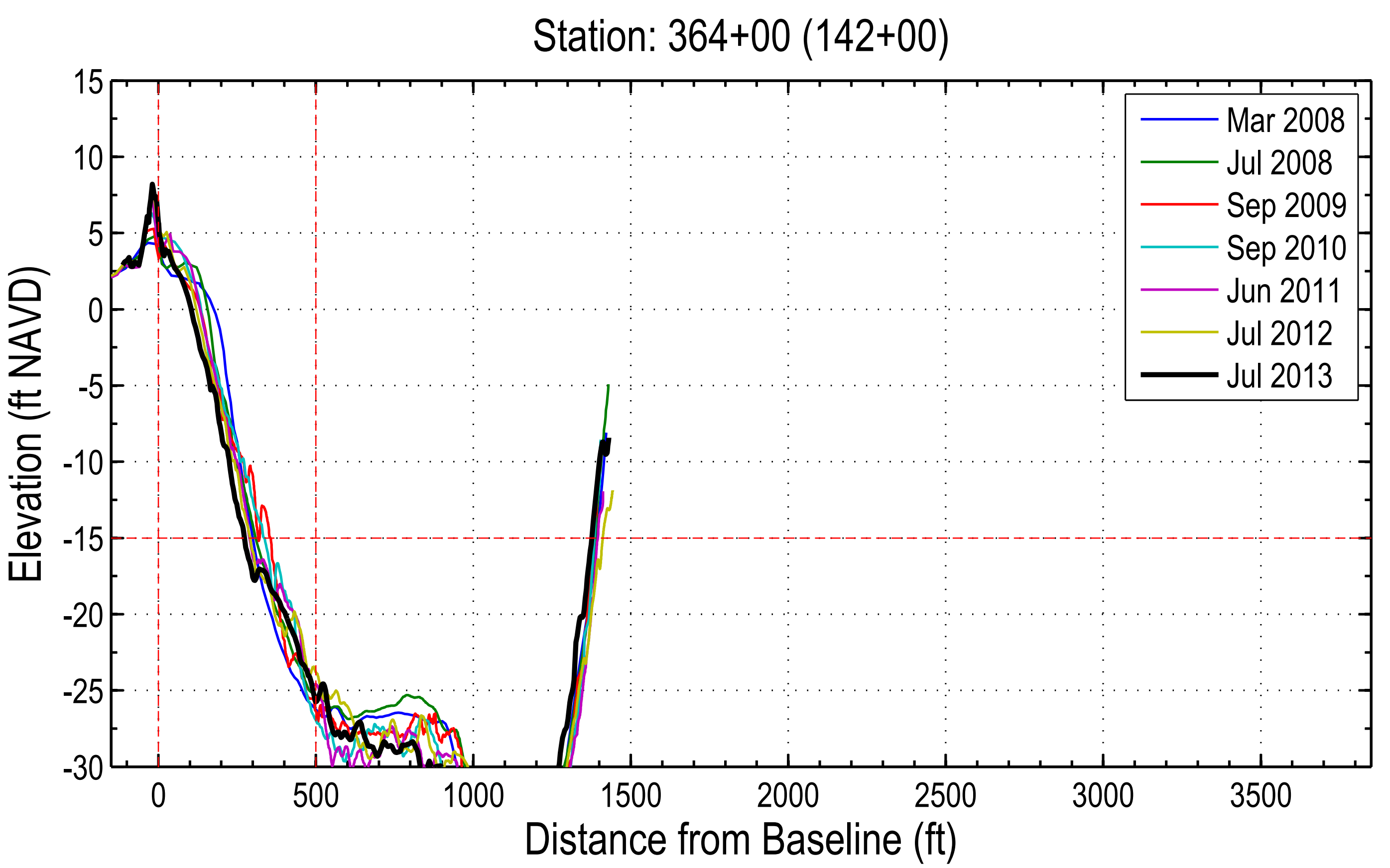
Station: 364+00 (142+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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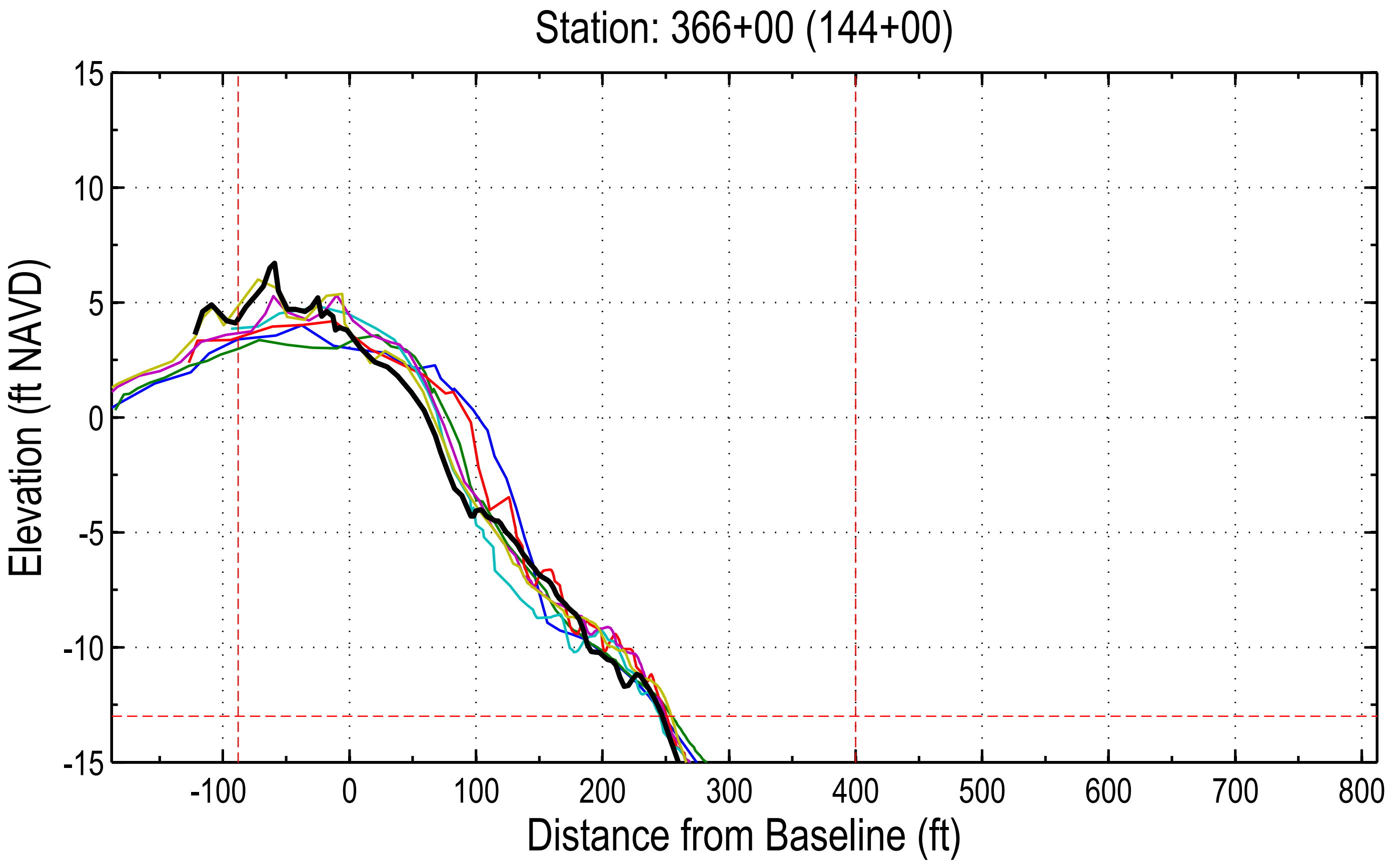
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



Station: 366+00 (144+00)
Elevation (ft NAVD)
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100
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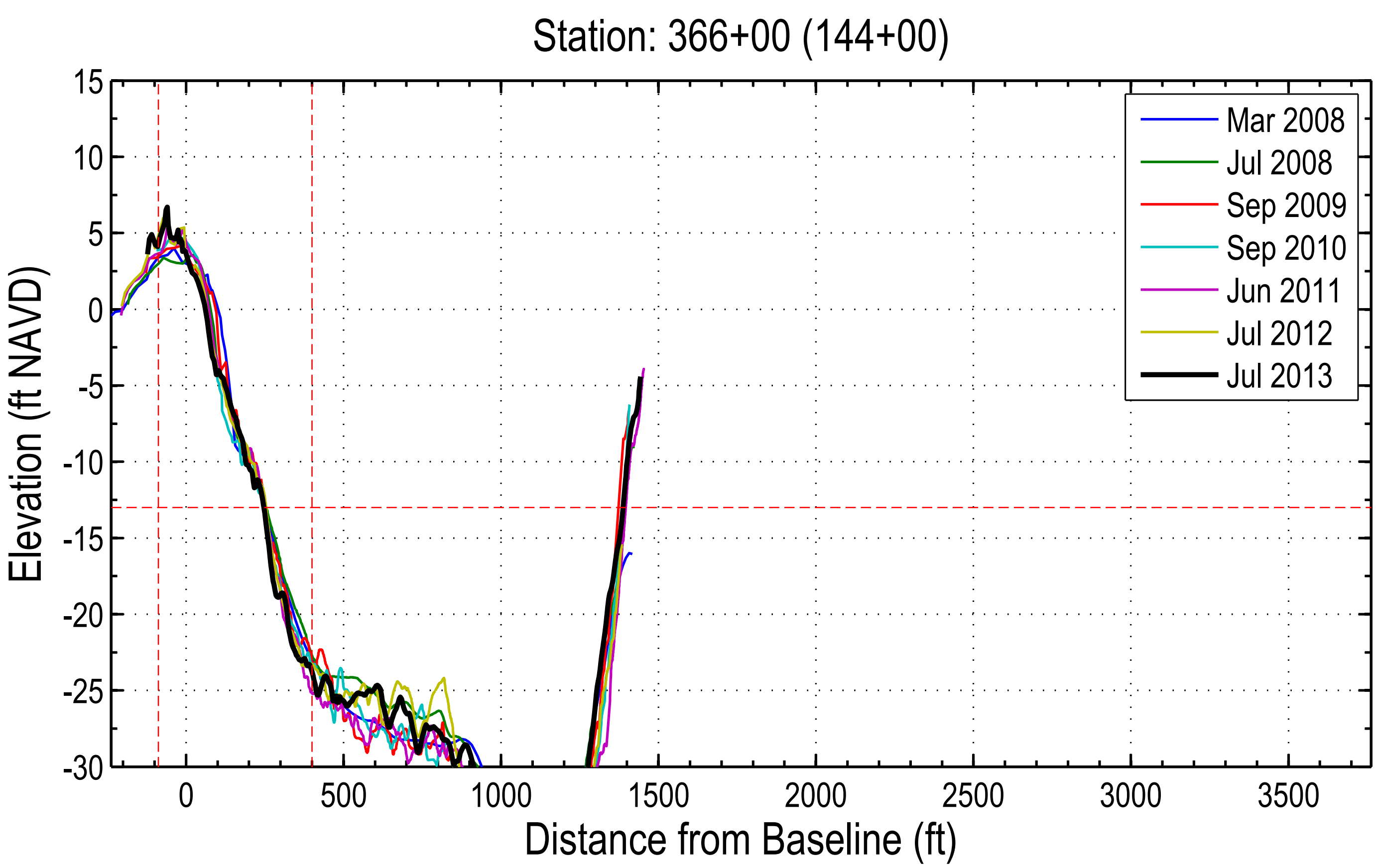
700
800
Distance from Baseline (ft)



Station: 366+00 (144+00)
Elevation (ft NAVD)
15
10
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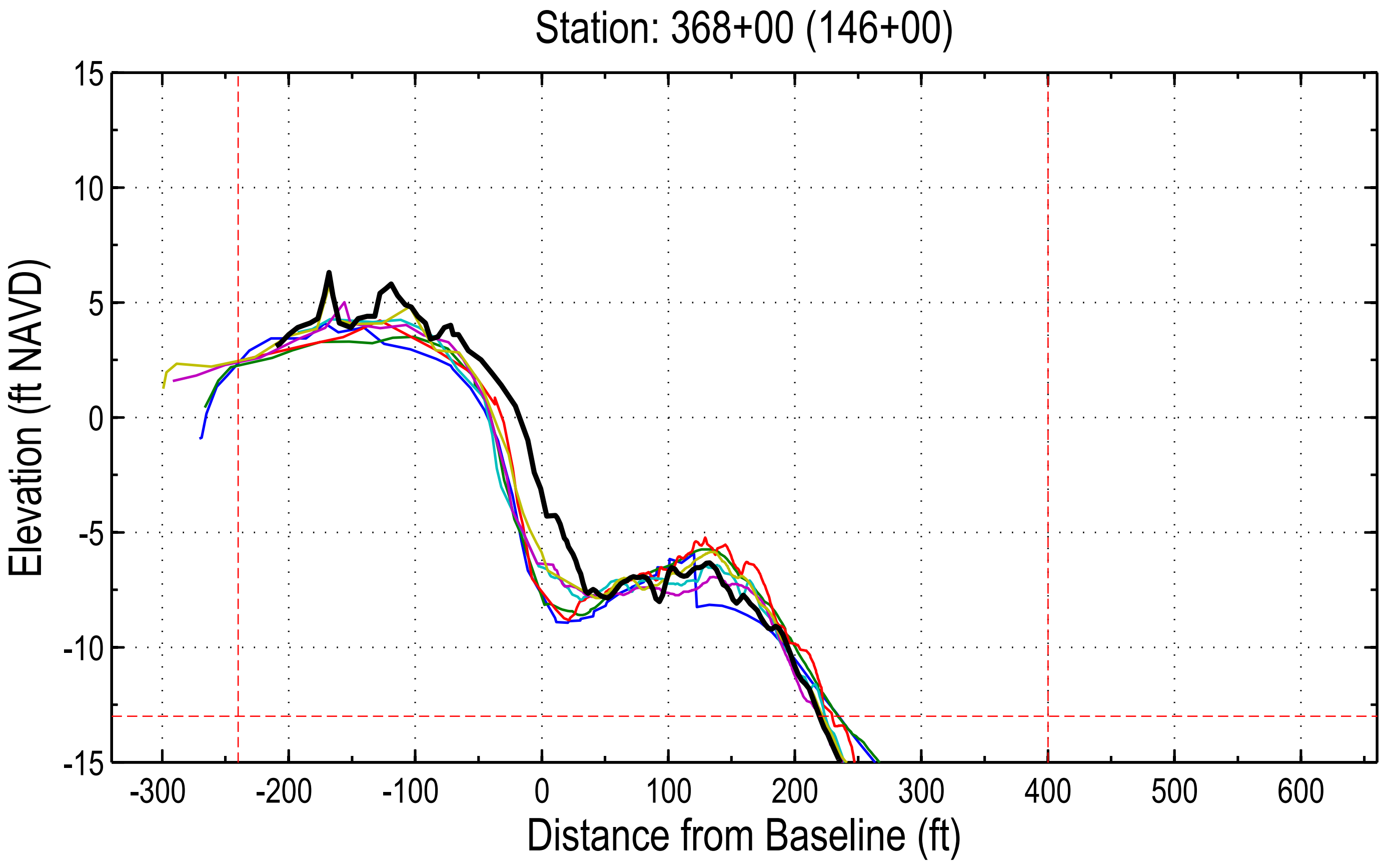
3500
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 368+00 (146+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
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100
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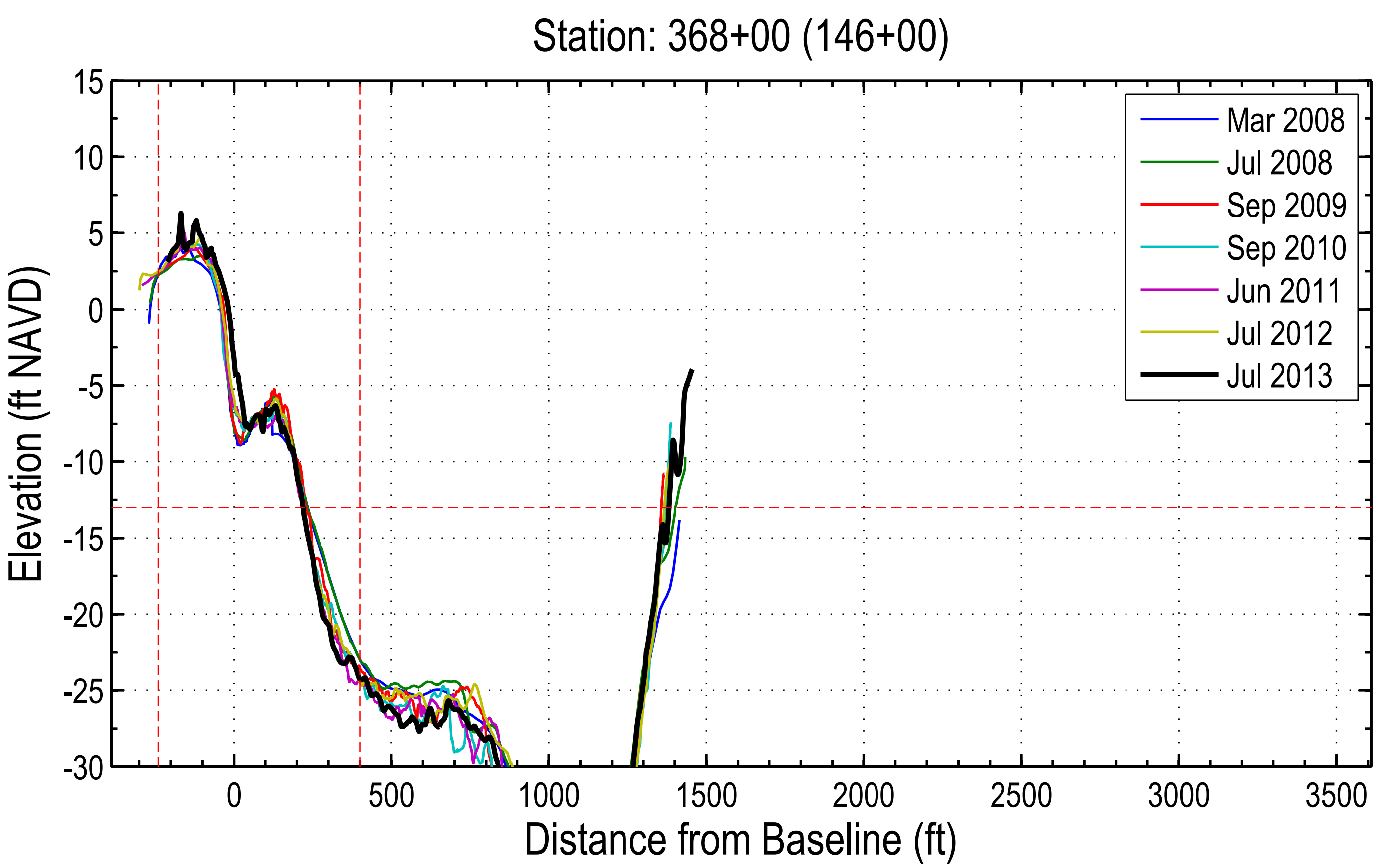
Station: 368+00 (146+00)
Elevation (ft NAVD)
Distance from Baseline (ft)
15
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-15
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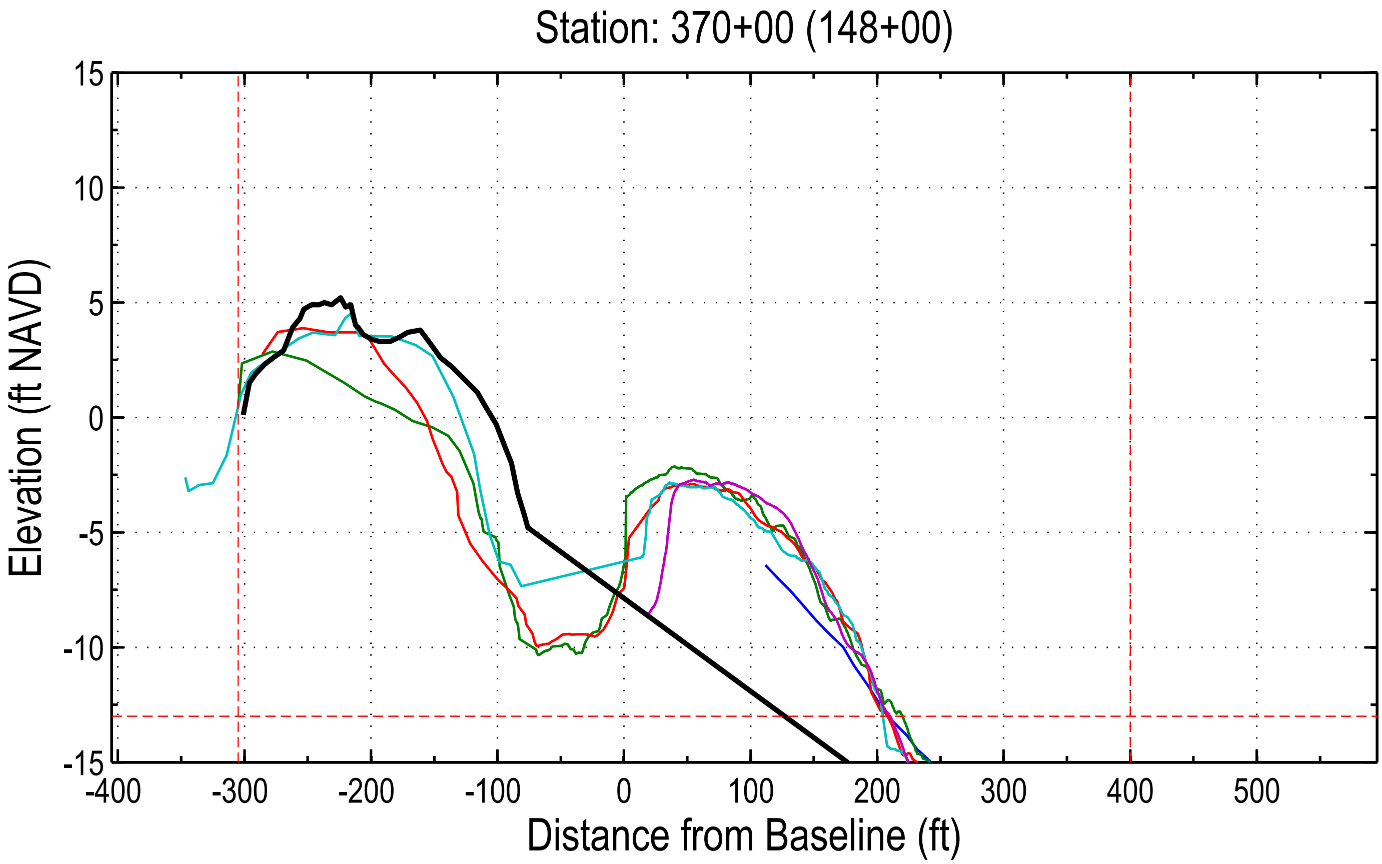
3500
Mar 2008
Jul 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013


Station: 370+00 (148+00)
15
10
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-5
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-15
-400
-300
-200
-100
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100
200
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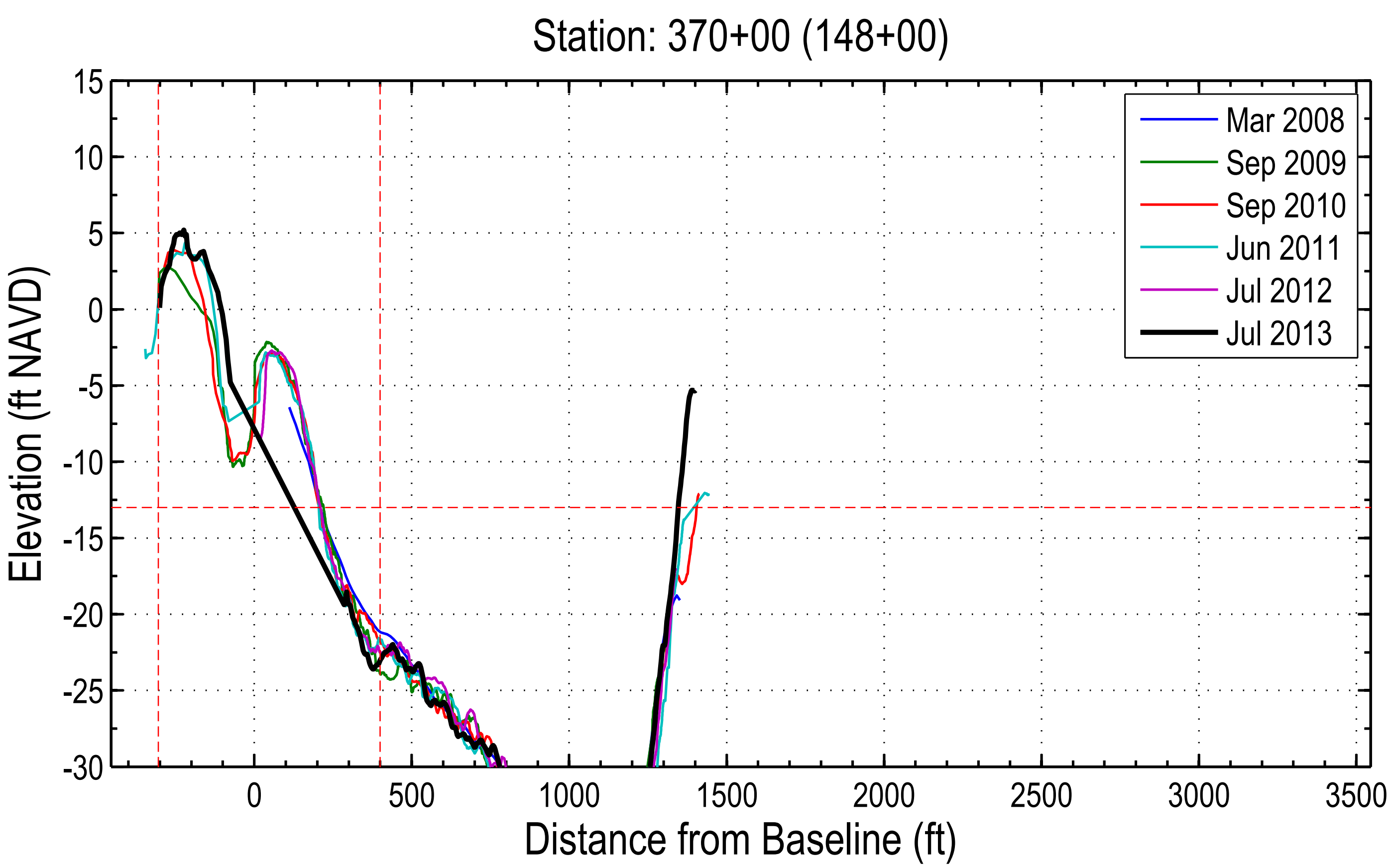
500
Elevation (ft NAVD)
Distance from Baseline (ft)


Station: 370+00 (148+00)
15
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-5
-10
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-25
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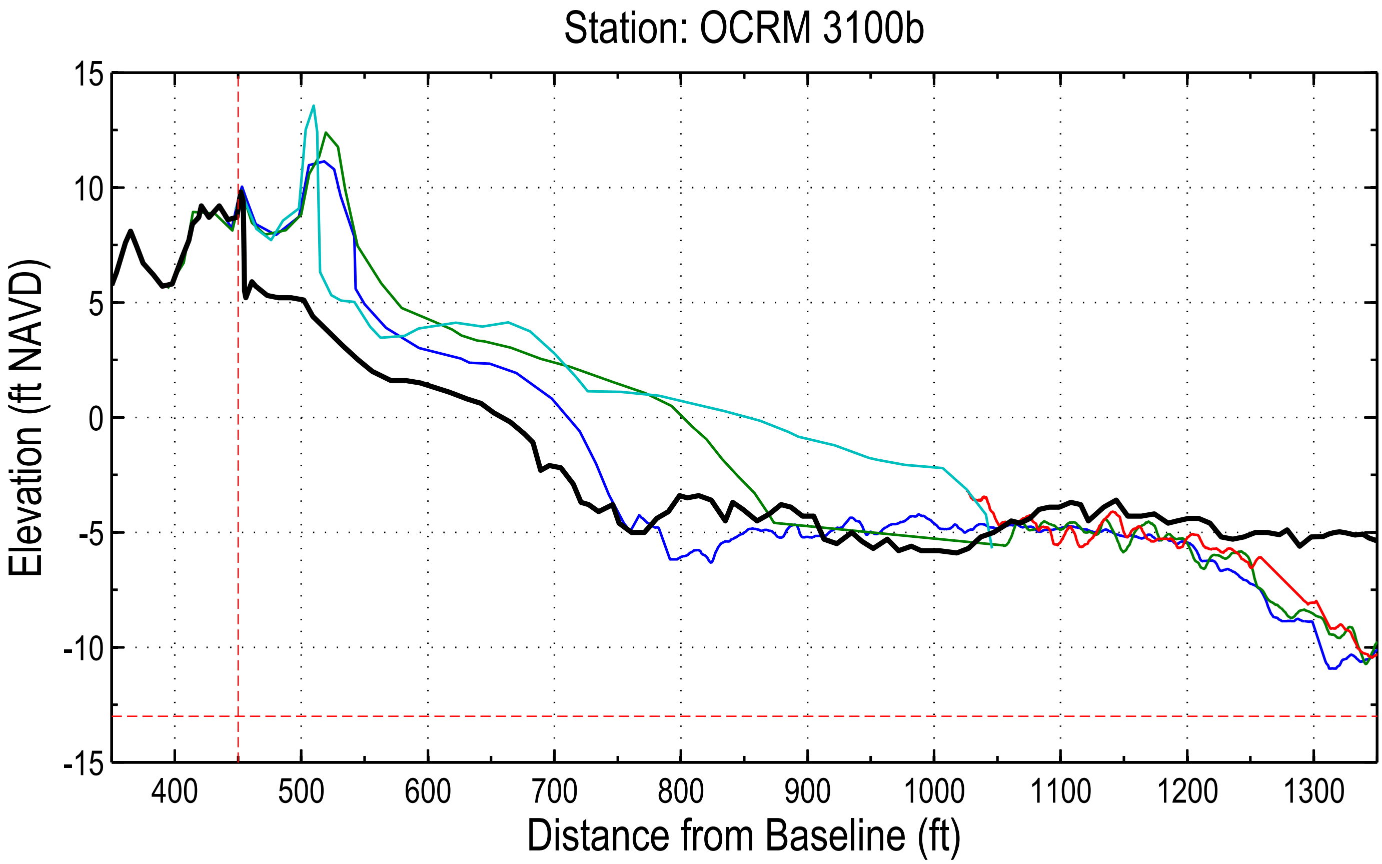
3500
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013



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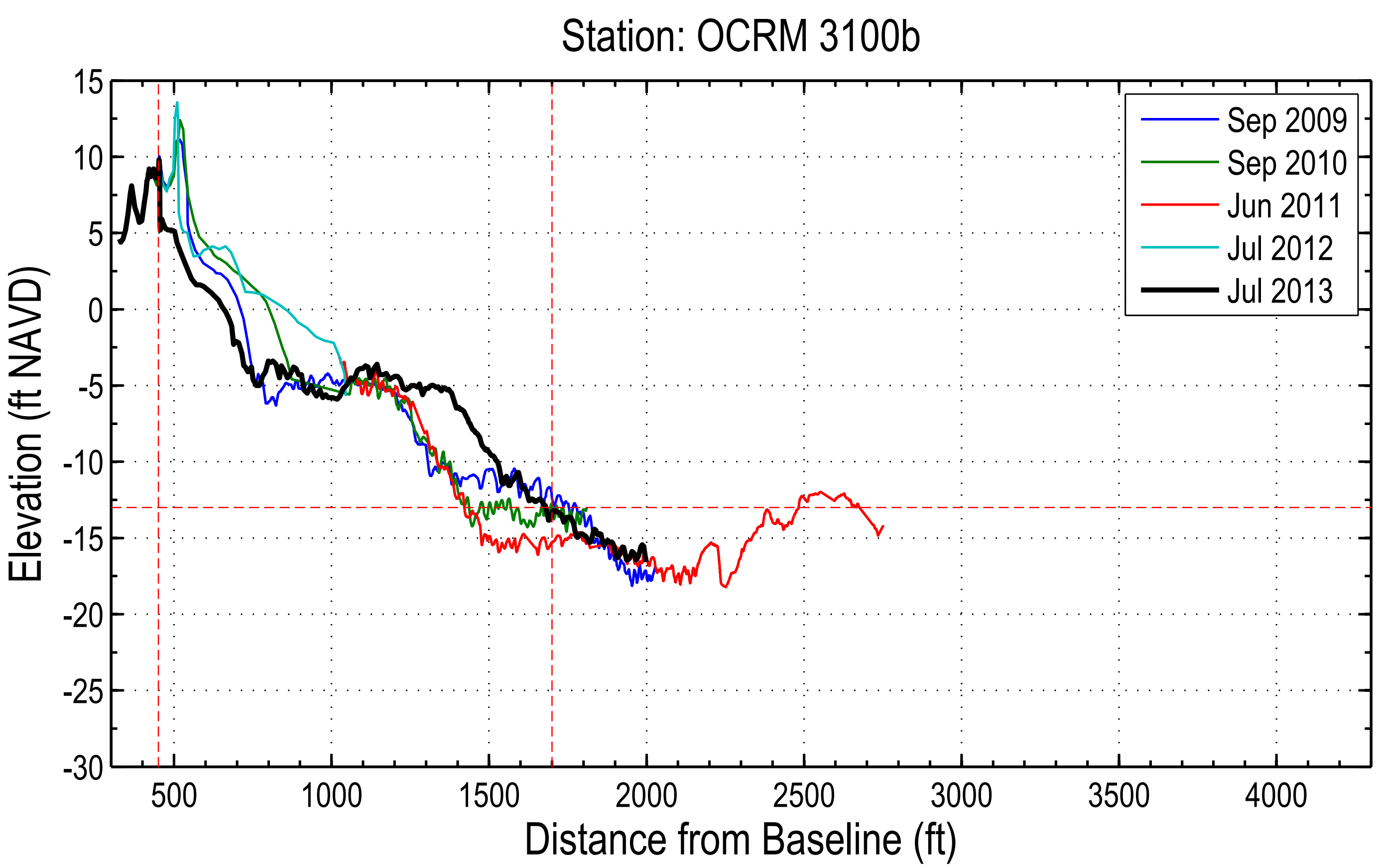

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Distance from Baseline (ft)
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Sep 2010
Jun 2011
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Jul 2013
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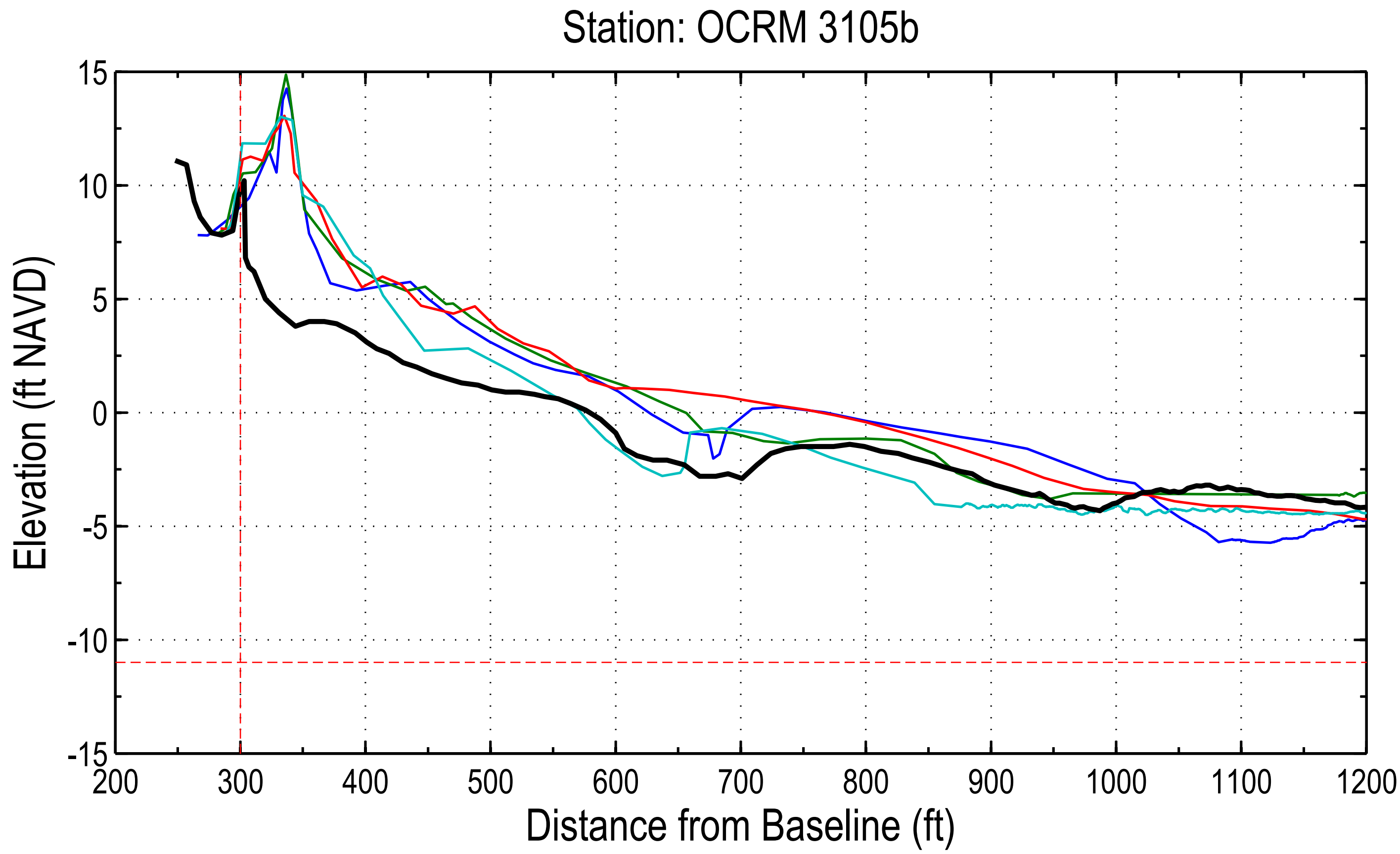
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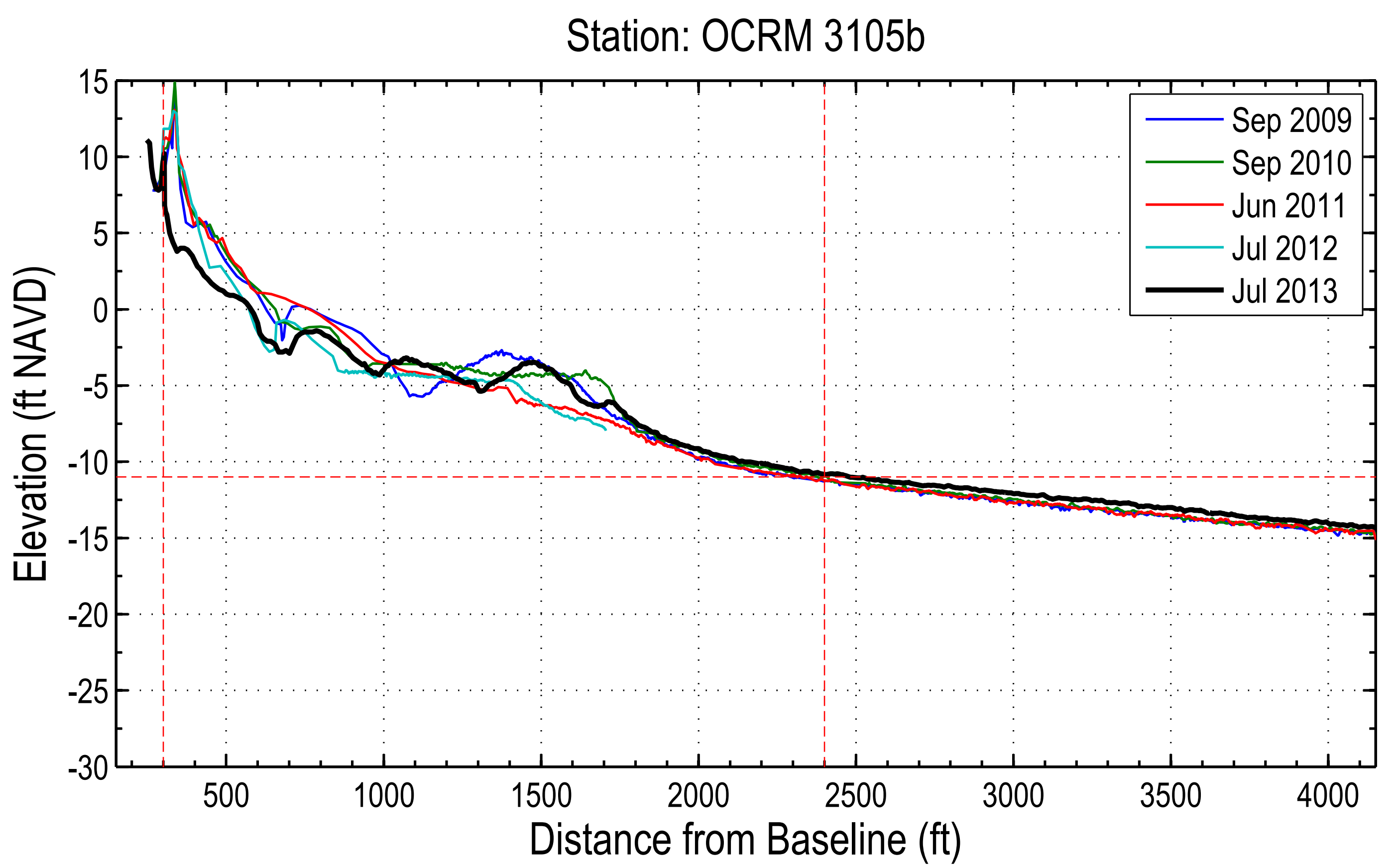
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Elevation (ft NAVD)
Distance from Baseline (ft)
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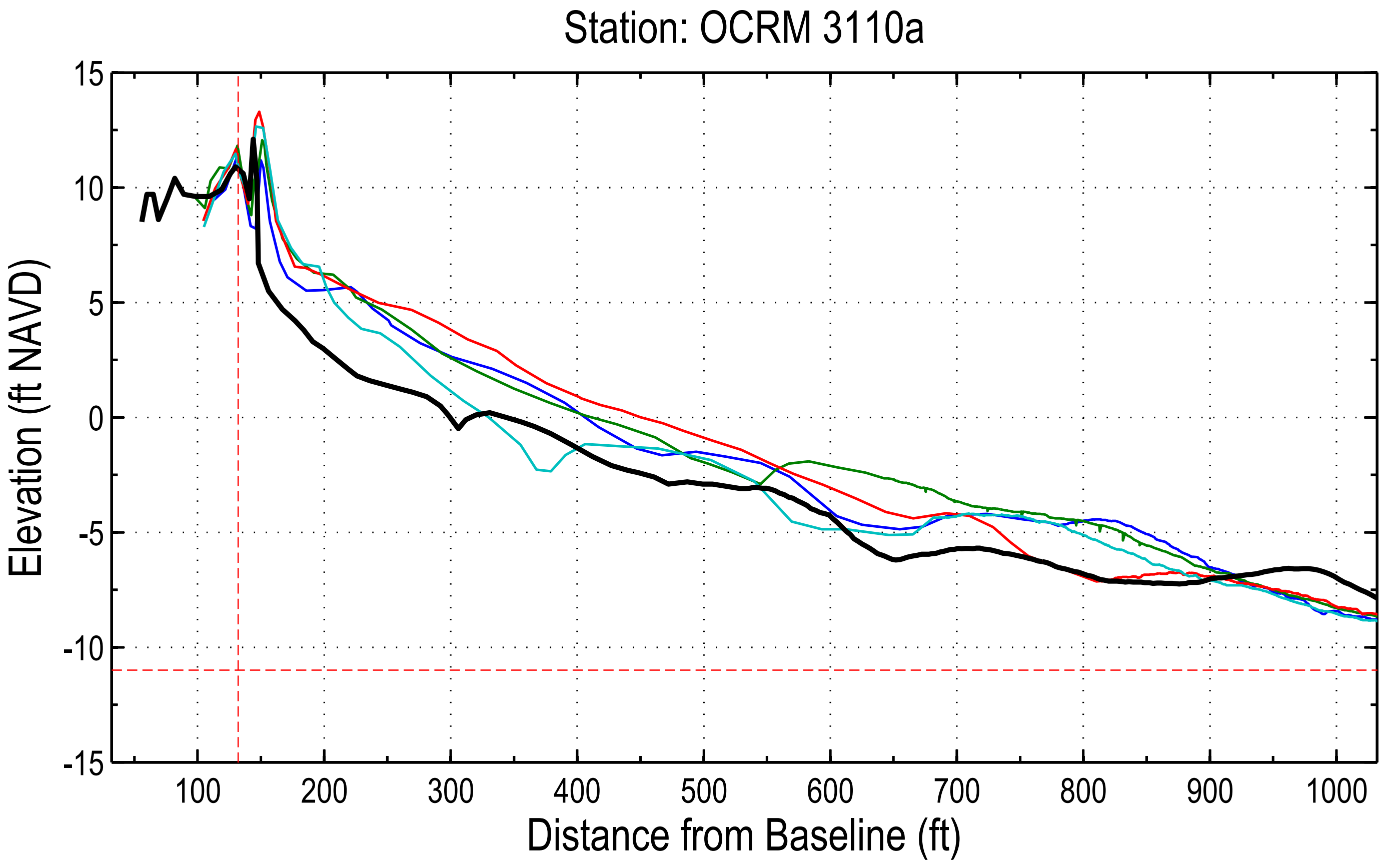

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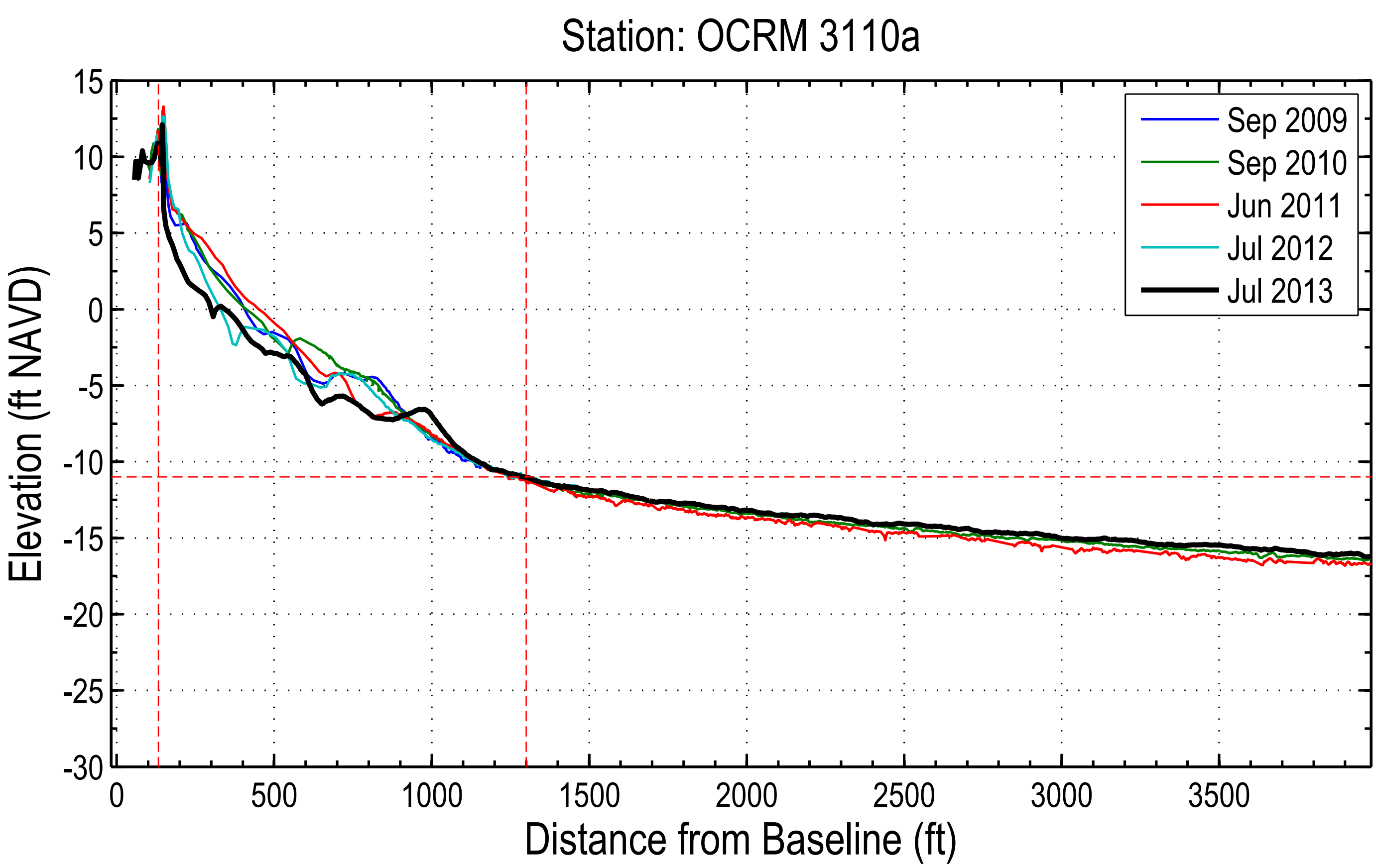
Distance from Baseline (ft)



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Elevation (ft NAVD)
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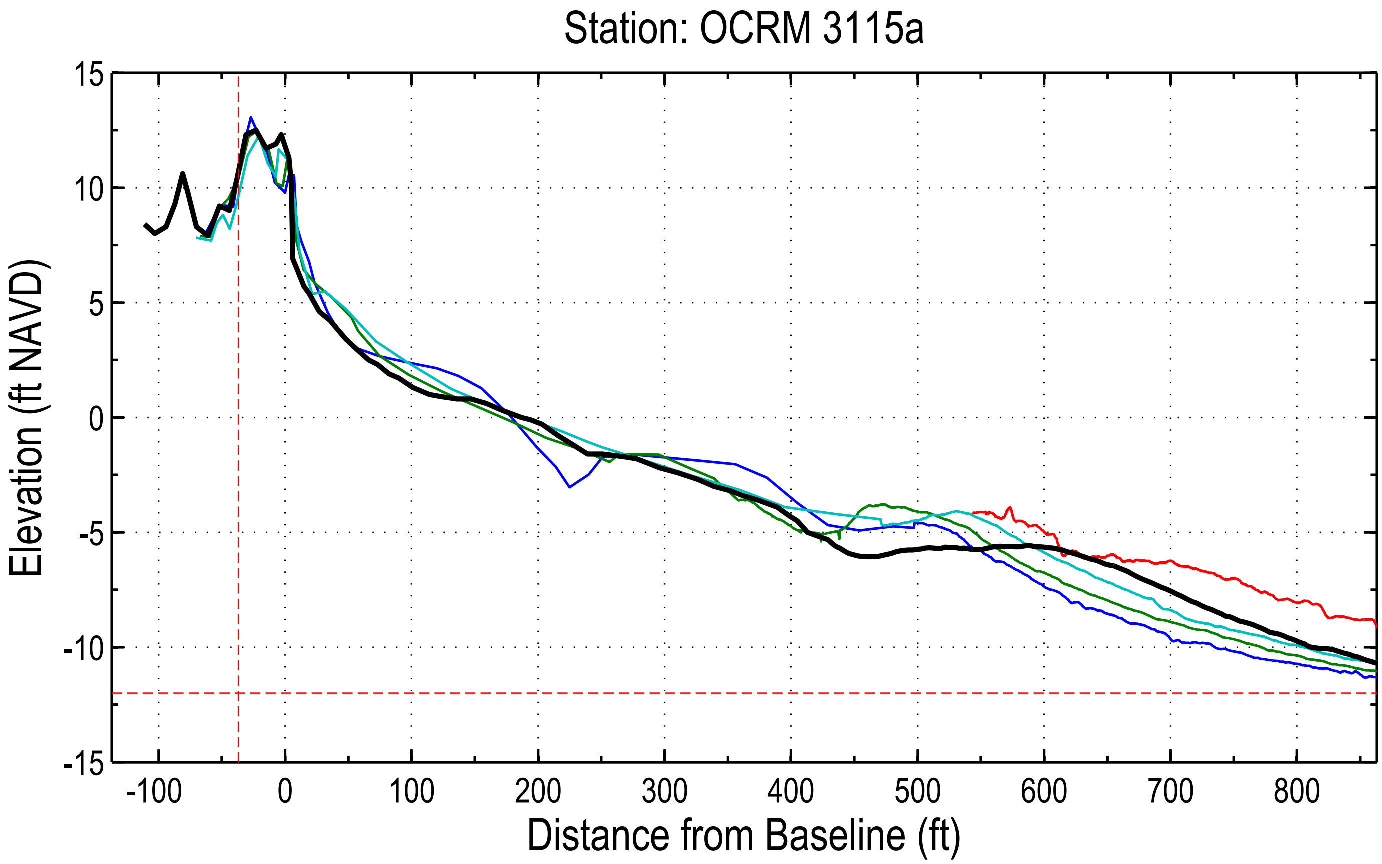
Distance from Baseline (ft)
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013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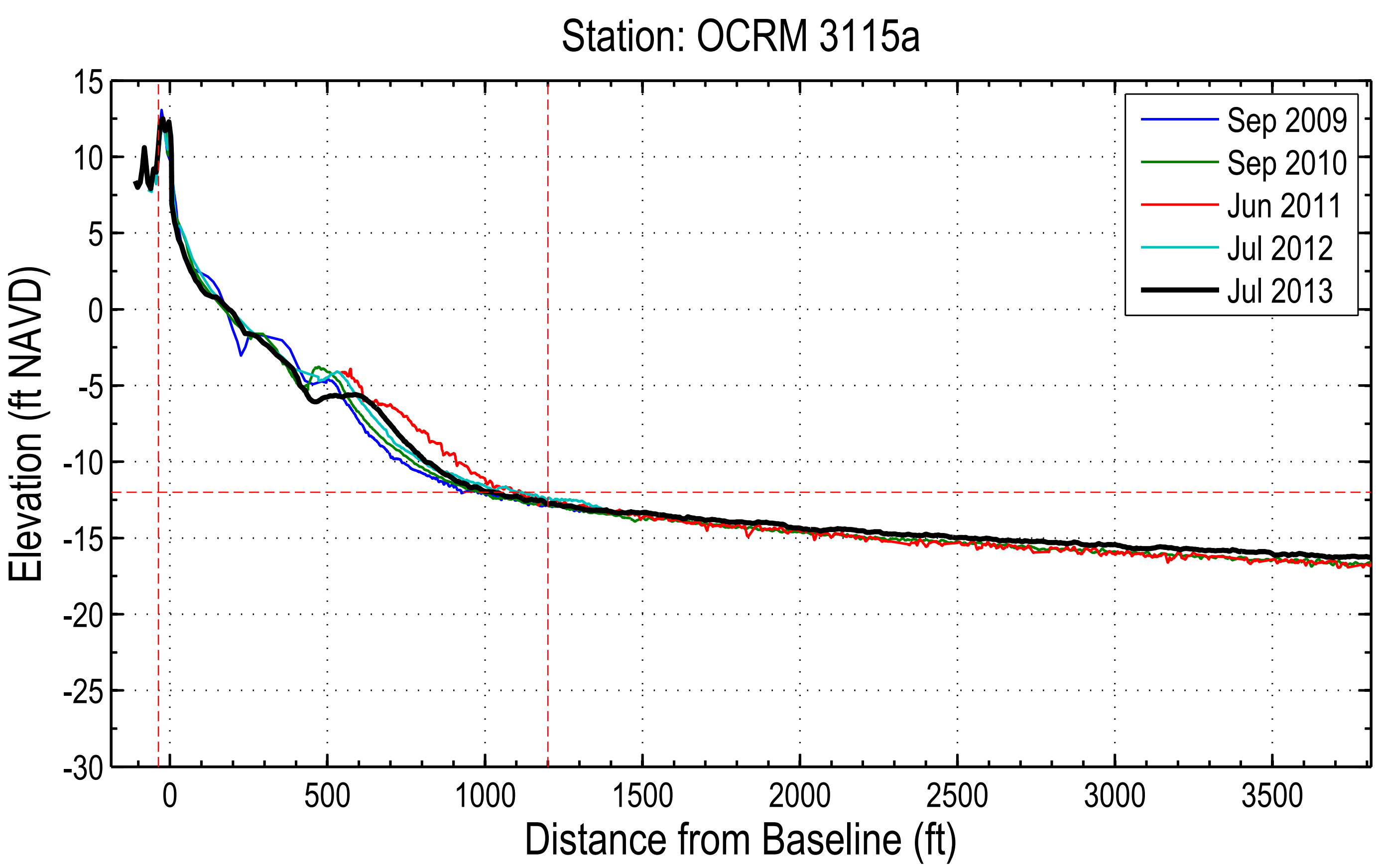
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Elevation (ft NAVD)
Distance from Baseline (ft)
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Jun 2011
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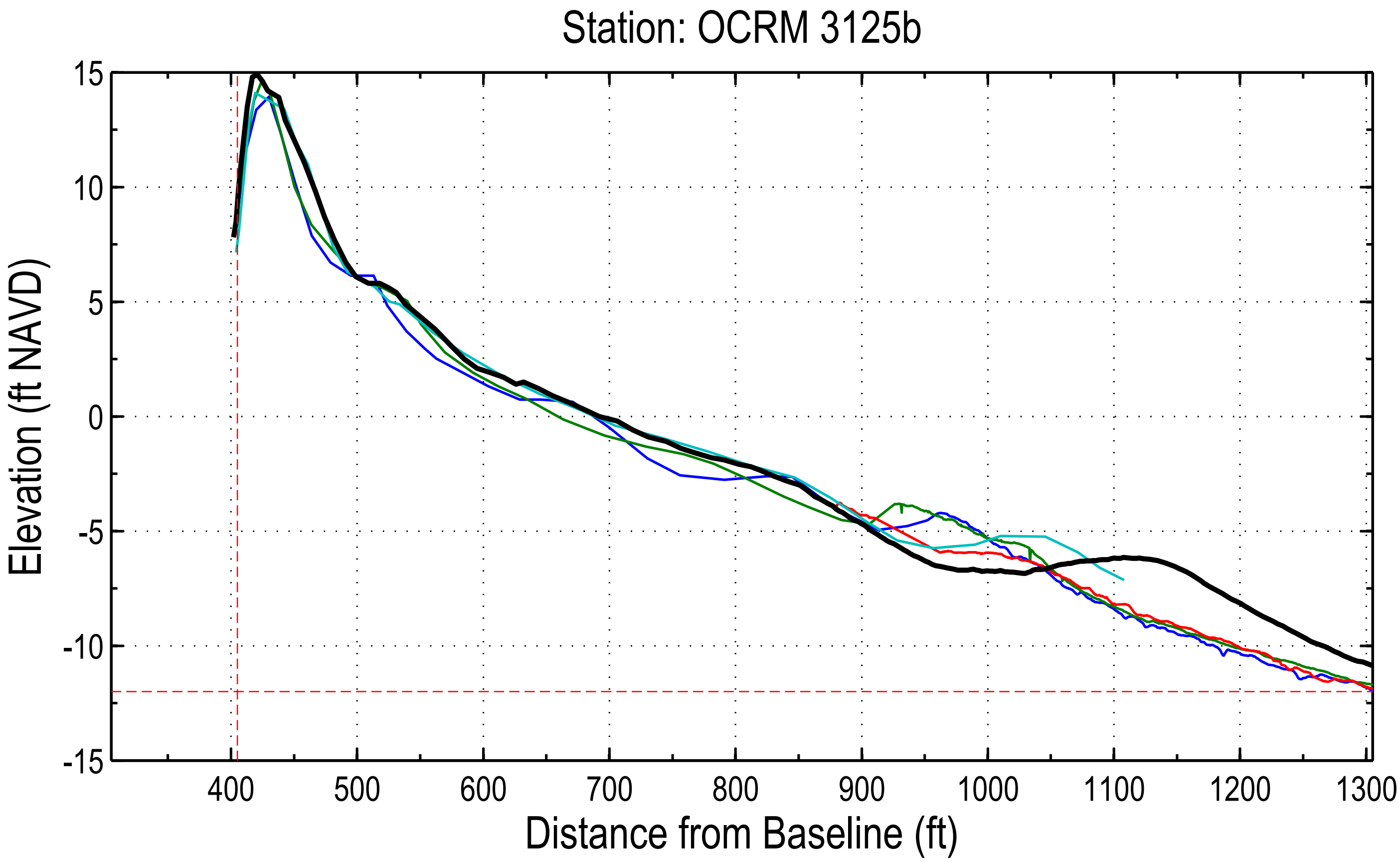
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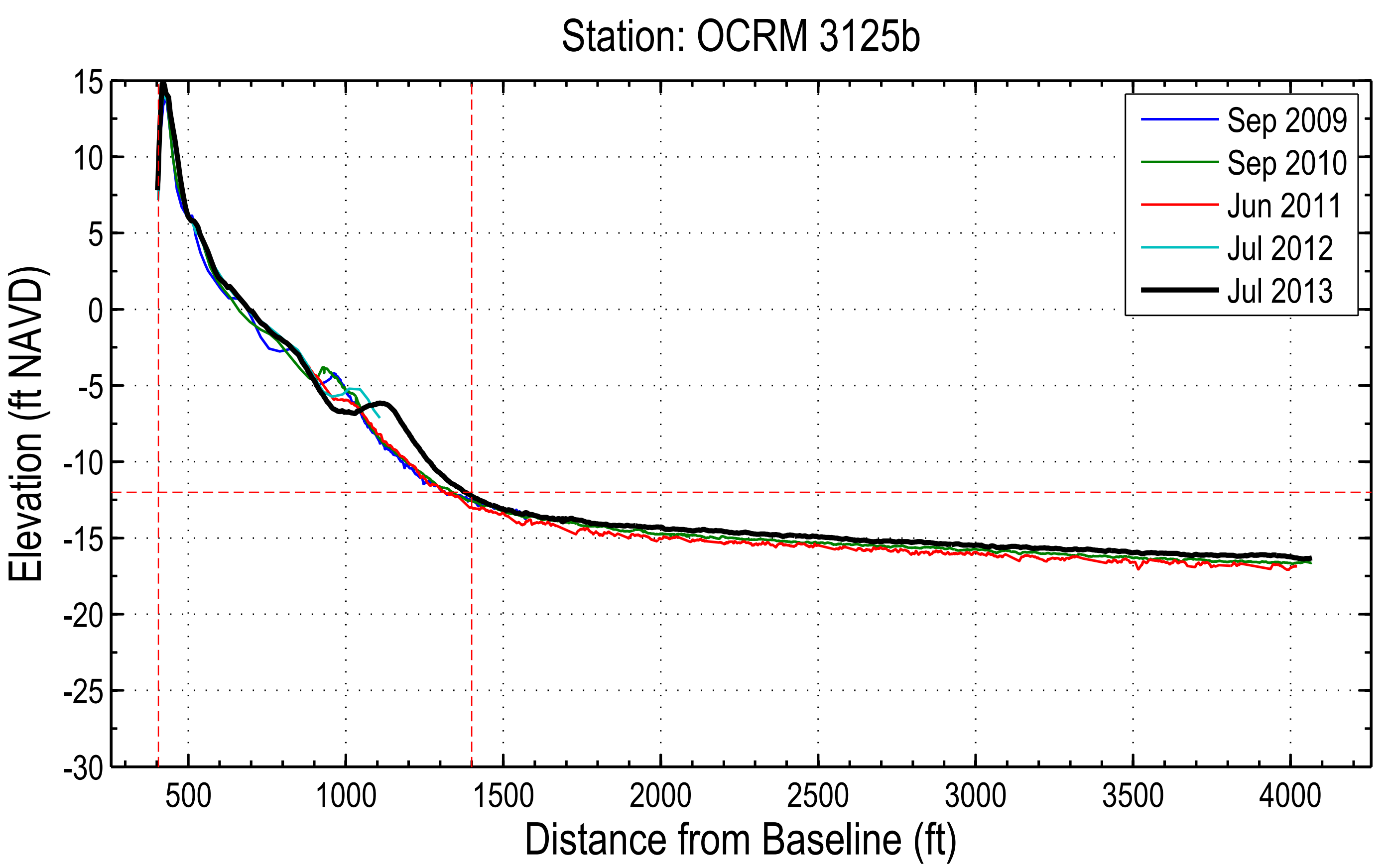
Distance from Baseline (ft)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Elevation (ft NAVD)
Distance from Baseline (ft)
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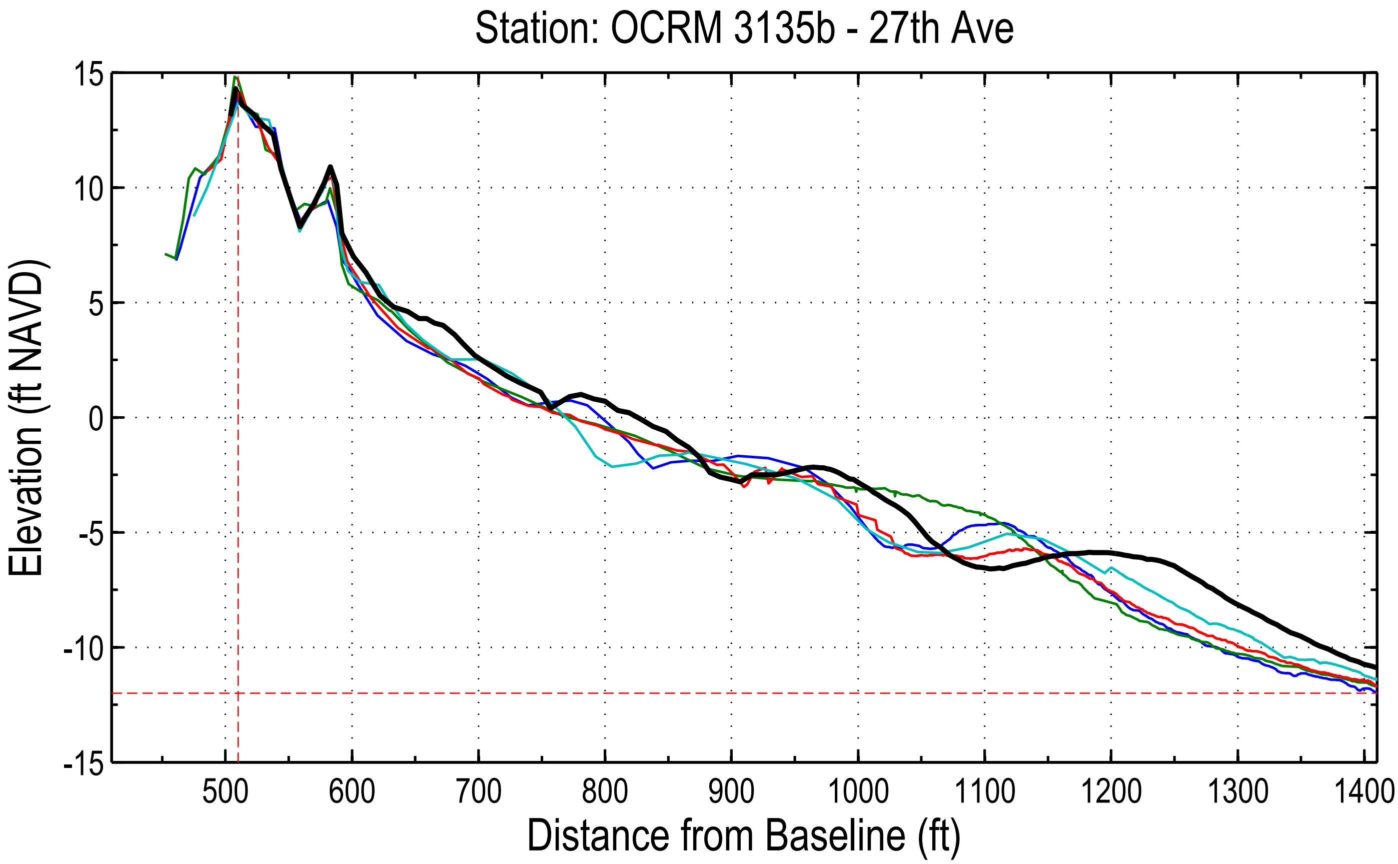
Jul 2012
Jul 2013



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Elevation (ft NAVD)
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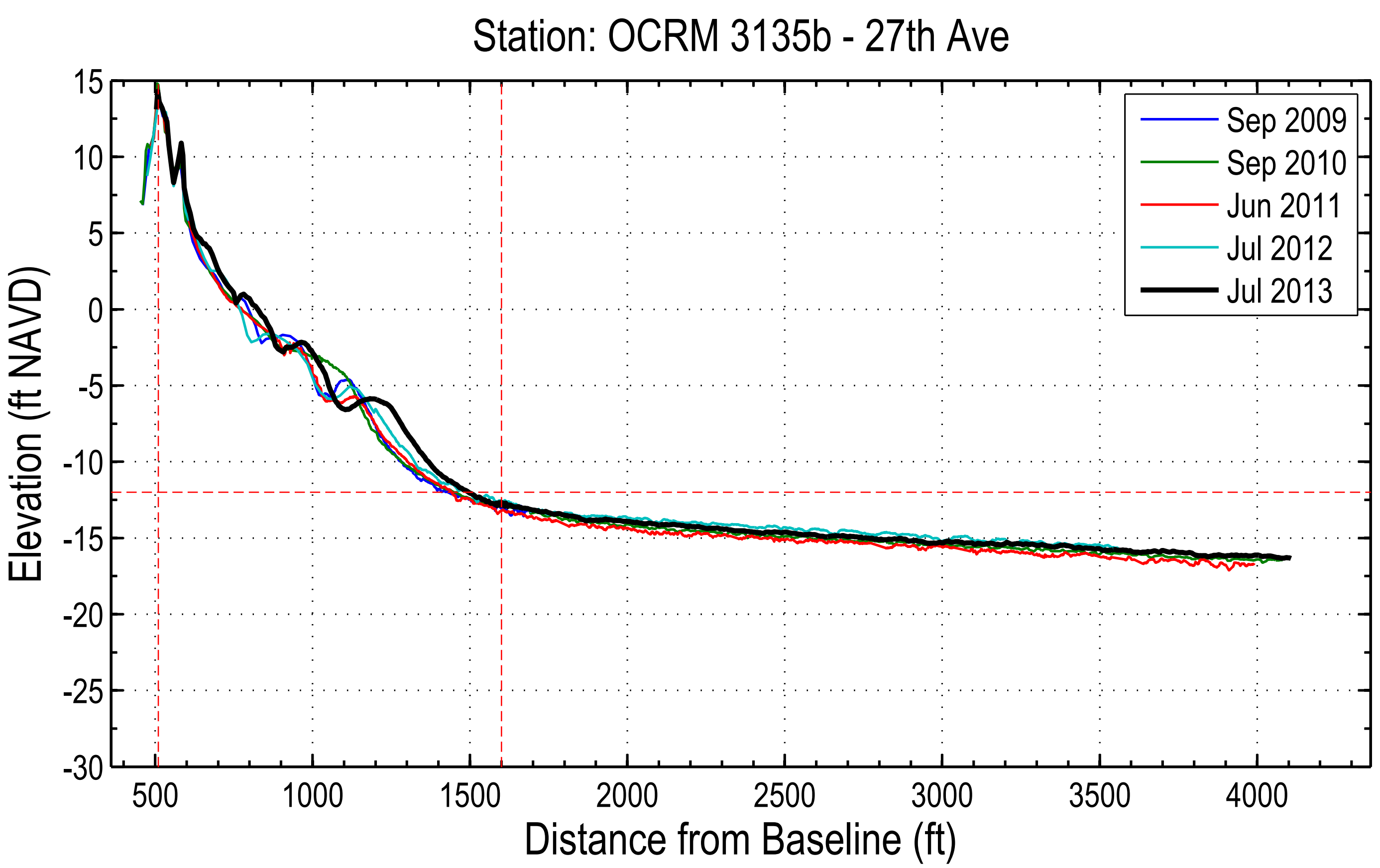
Distance from Baseline (ft)



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Elevation (ft NAVD)
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Distance from Baseline (ft)
Sep 2009
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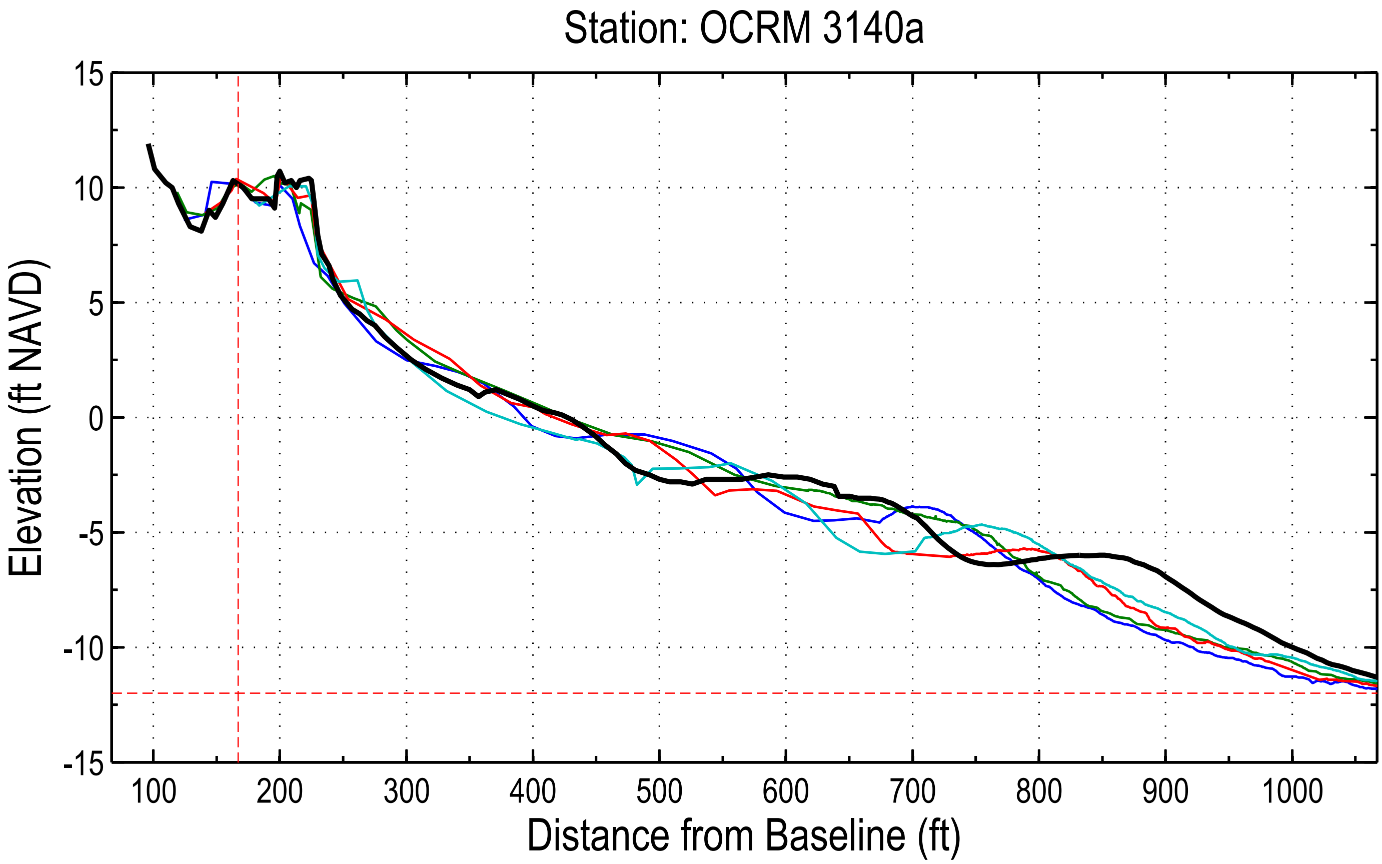
Jul 2012
Jul 2013



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Elevation (ft NAVD)
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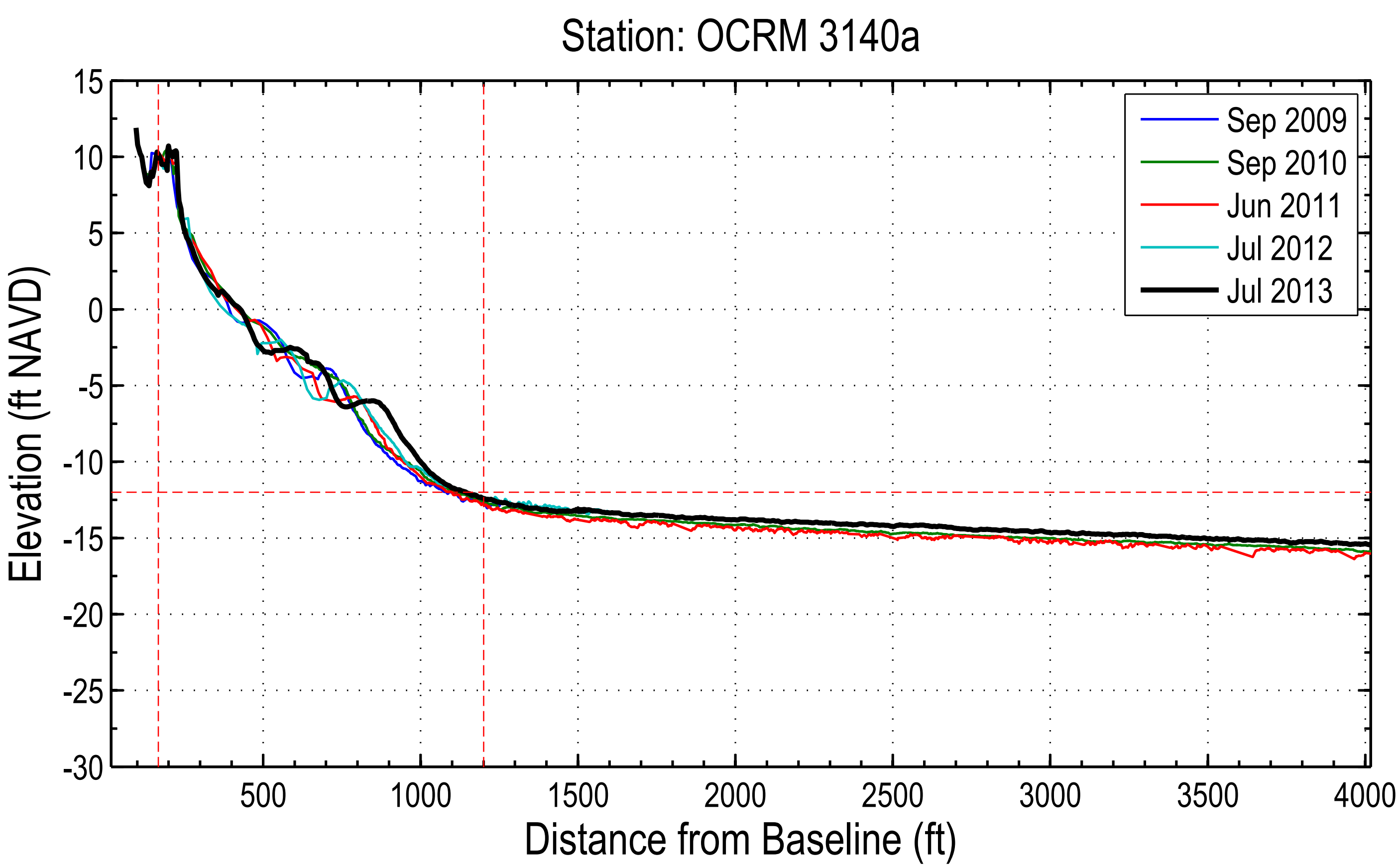

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Elevation (ft NAVD)
Distance from Baseline (ft)
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Sep 2010
Jun 2011
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Jul 2013
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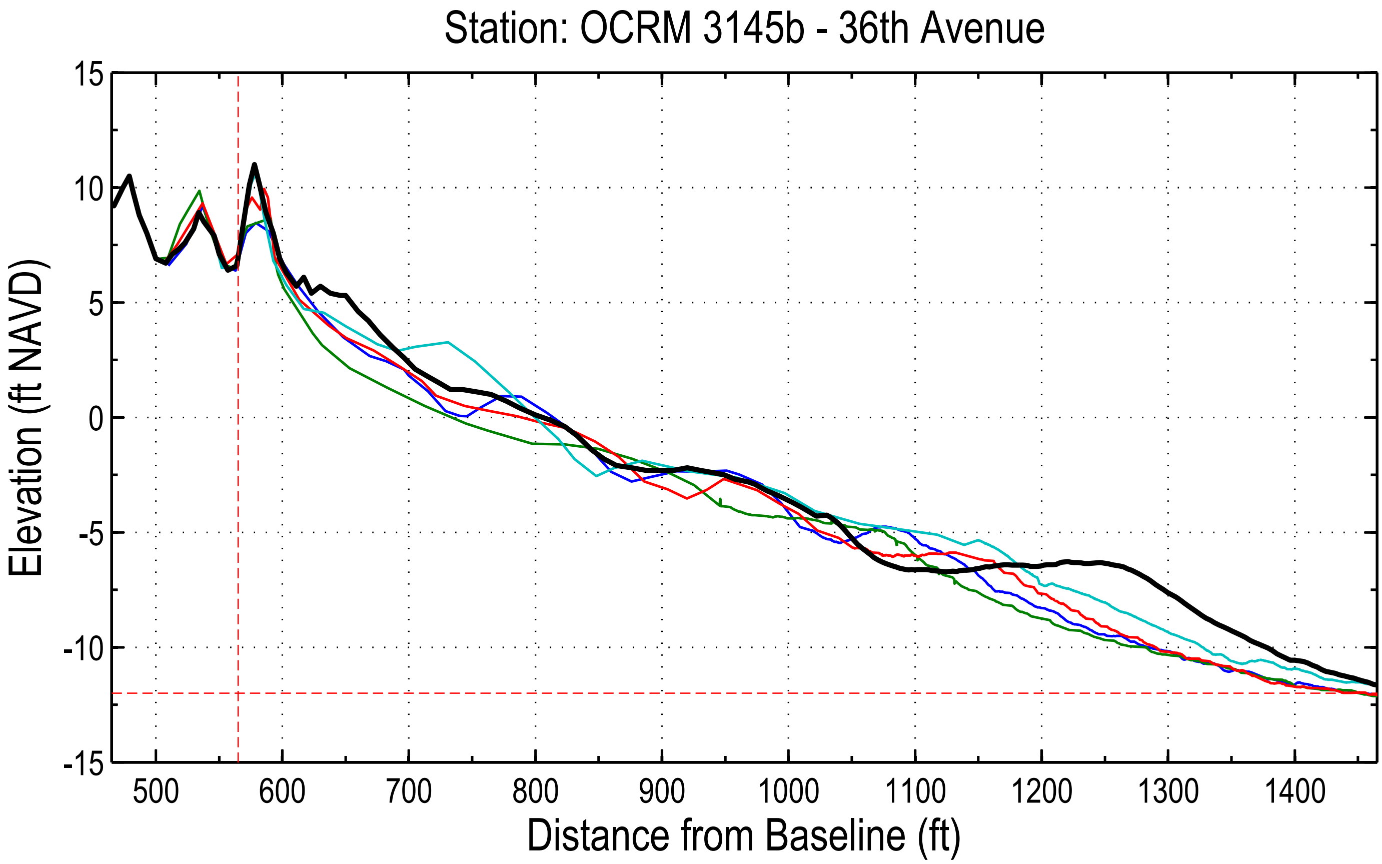
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Elevation (ft NAVD)
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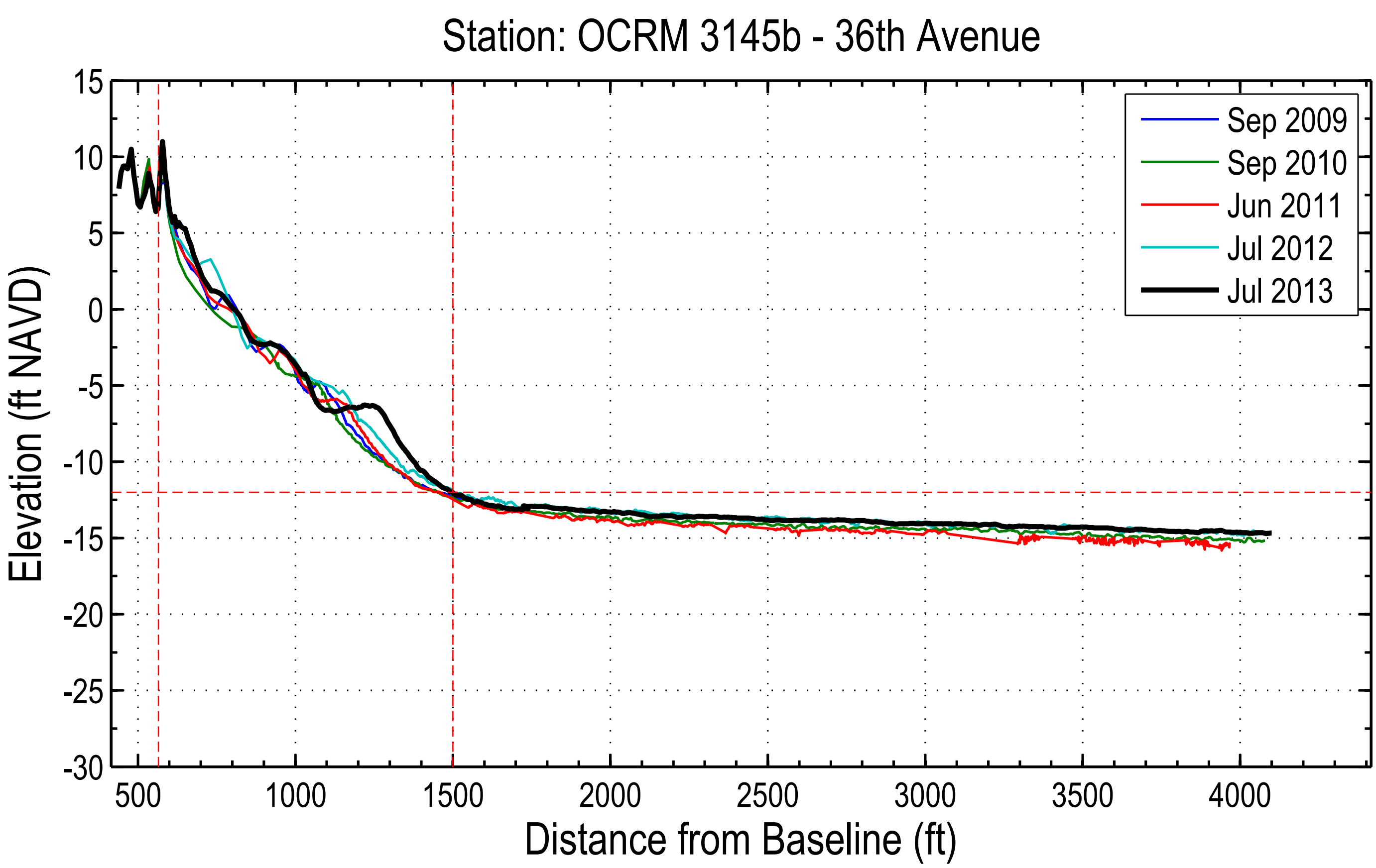
Distance from Baseline (ft)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Elevation (ft NAVD)
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Distance from Baseline (ft)
Sep 2009
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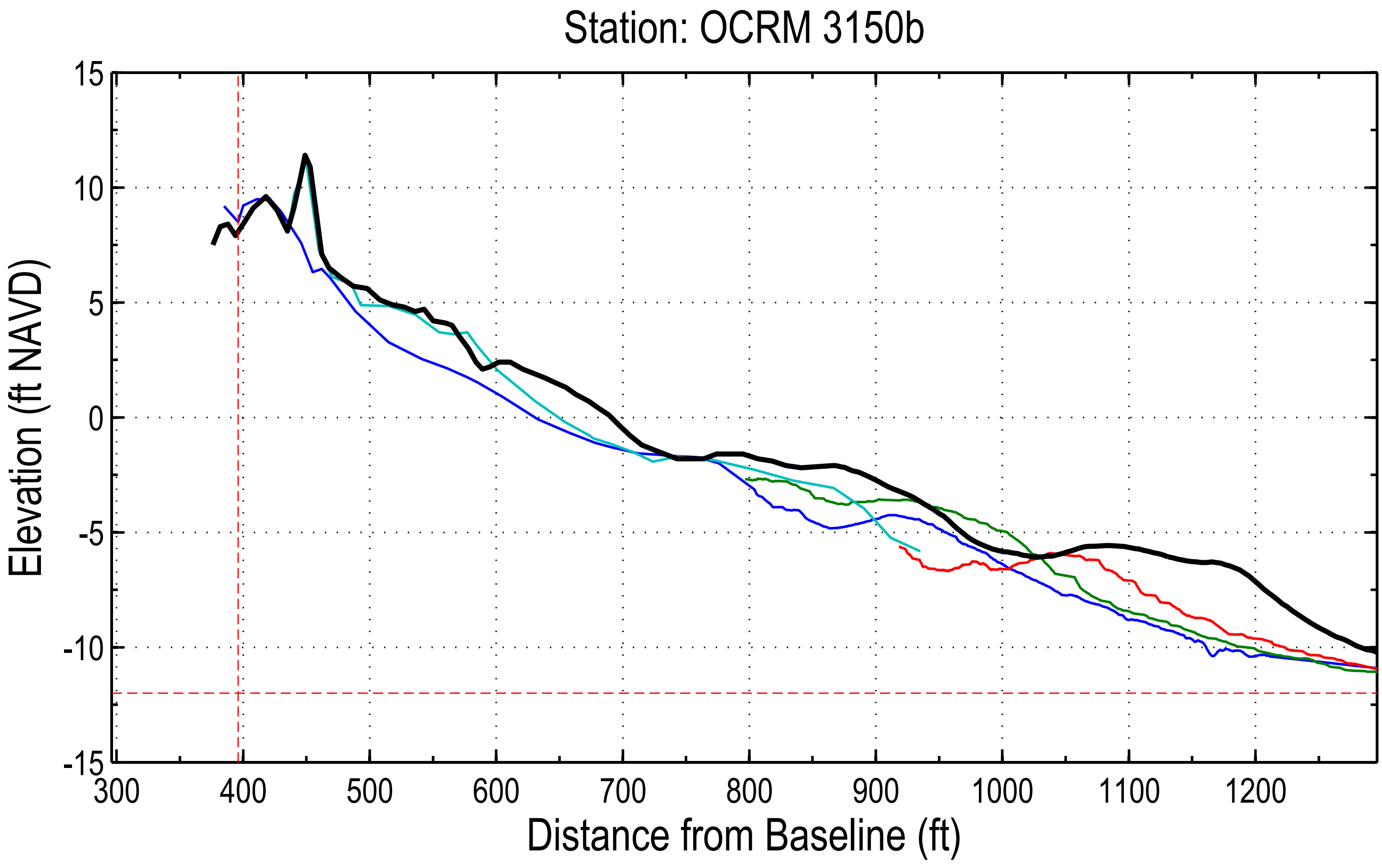
Jun 2011
Jul 2012
Jul 2013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Elevation (ft NAVD)
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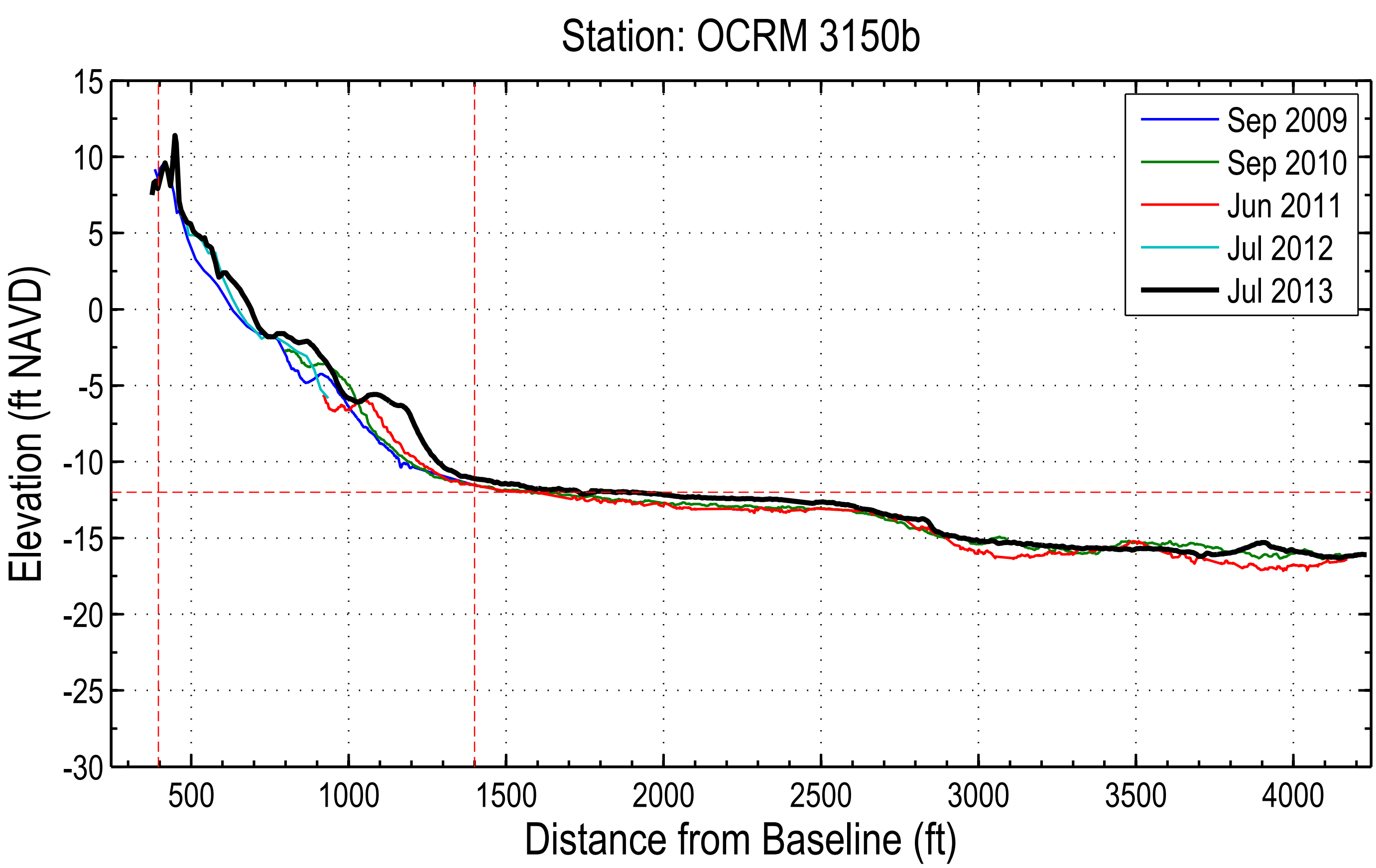
Station: OCRM 3150b
Sep 2009
Sep 2010
Jun 2011
Jul 2012
Jul 2013
Elevation (ft NAVD)
Distance from Baseline (ft)
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CSE

COASTAL SCIENCE & ENGINEERING

PO BOX 8056 COLUMBIA SC 29202 • TEL 803-799-8949 • FAX 803-799-9481 • EMAIL cse@coastalscience.com

November 20, 2013

Ms Linda Tucker
City of Isle of Palms
PO Drawer 508
Isle of Palms SC 29451

RE: Breach Inlet Quarterly Survey — October 2013 (Amendment 2 – Task 8) [CSE 2386]

Dear Ms. Tucker:

Per Amendment #2 to the agreement between the City of Isle of Palms and Coastal Science & Engineering (CSE), CSE completed an assessment of the shoreline around Breach Inlet on 30 October 2013. The assessment was conducted in response to severe erosion occurring over the past two years along the south-western end of the Isle of Palms (monitoring stations 0+00–80+00 encompassing monitoring Reach 1 and Reach 2) (Fig 1). The purpose of the assessment is to provide quarterly updates on the magnitude of erosion and potential threats to private property so that the City may inform property owners and plan remedial action if necessary.

FIGURE 1. Monitoring baseline in Reach 1 (upper) and Reach 2 (lower). The highlighted areas show the reach limits.

The scope of the October survey was limited to land-based survey work extending from landward of the frontal dune to (~)–5 feet (ft) NAVD (low-tide wading depth). The data allow for an analysis of dune recession or recovery and volume changes above low-tide wading depth. Information regarding the position and extent of channels and shoals within Breach Inlet is beyond the scope of a land-based survey. A comprehensive survey of Breach Inlet is scheduled for January/February 2014.

Beach profiles are provided in Attachment 1 and volume changes are shown in Table 1. Profile data from October show the area was generally stable to accretional between July and October. Only station 50+00 near 7th Avenue showed signs of dune recession. Stations 4+00, 50+00, and 80+00 lost sand [4.4, 17.3, and 5.9 cubic yards per foot (cy/ft), respectively]. Losses at station 4+00 occurred in the upper beach face (near the high-tide line) but were mostly offset by gains in the mid to low beach face (wet beach/runnels). Station 80+00 lost some sand near the upper beach face, but did not show any sign of dune erosion. Station 50+00 was the outlier with a steep scarp ~4–5 ft high, which appeared to be actively eroding. An erosional arc was visible centered at station 50+00. A similar arc was present in July further to the southwest. The arc appears to be migrating in response to a combination of inlet effects and southerly transport associated with fall northeasters. Ground photos are provided at the end of this letter.

Overall, the area monitored gained 29,370 cy of sand from July to October (Table 1). Reach 1 (stations 0+00 to OCRM 3115) gained 21,809 cy while Reach 2 (stations OCRM 3115 to 80+00) gained 7,561 cy. The significant gains in Reach 1 are obviously favorable and are in line with the historical accretional trend of the area. On an annual basis, the gains in Reach 1 equal an annual accretion rate of 86,526 cy/ft/yr, which would restore nearly half the sand lost from July 2011 to July 2013 (total loss of ~175,000 cy to −6 ft NAVD).

CSE produced a contour map (Fig 2) from recent surveys to aid in visualizing dune recession. The +7 ft NAVD contour was extracted from digital terrain models (DTMs) extracted from survey data. This contour represents an elevation above the normal influence of tides, but still along the lower face of the foredune. (See profiles for a typical vertical location of the +7 ft contour.) Where a dune has a significant scarp, the +7 contour will likely mark the location of the scarp. The map shows that from 2011 to 2012, there was little change in the position of the contour, though recession was evident near station 4+00. While little horizontal change occurred over this time period, there were significant volume losses in the wet beach and underwater profile, as Reach 1 lost ~100,000 cy of sand. Essentially, the foundation of the beach was being eroded while the upper beach remained stable. From 2012 to 2013, the effects of profile undermining became visible in the upper beach as the dune receded significantly between stations 4+00 and ~OCRM 3110 (3rd Avenue). Much of the recession occurred shortly after the July 2012 survey during passage of Hurricane *Sandy*. From July to October 2013, the position of the contour was stable.

The results of the October quarterly survey show partial recovery of the Breach Inlet area. Hopefully, recovery will continue, following historical accretional trends. CSE expects the area will continue to rebuild naturally over the next year, although winter storms may interrupt recovery.

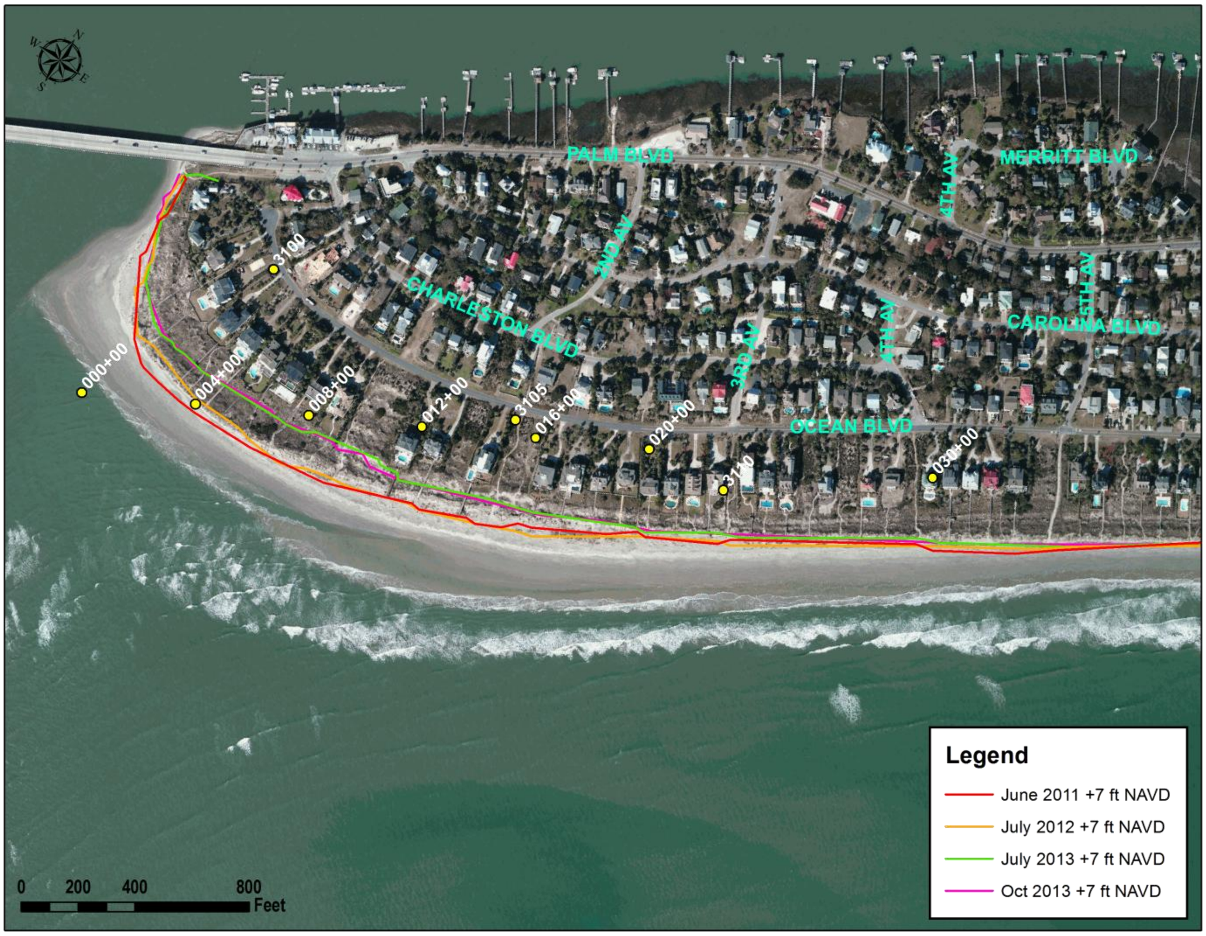


FIGURE 2. Contour map showing the location of the +7-ft NAVD contour, which is approximately the toe of the dune of the escarpment line.

Under the present agreement, CSE will complete a comprehensive assessment of the beach and inshore zone near Breach Inlet in January or February of 2014. The comprehensive assessment will allow for an updated condition of the channels and shoals of the inlet which are impacting the beach.

Sincerely,

Coastal Science & Engineering (CSE)

Steven Traynum
Coastal Scientist

Enclosure: Attachment 1 — October 2013 Profiles

TABLE 1. Volume calculations for recent surveys at Breach Inlet. Volumes were calculated to −6 ft NAVD within the boundaries shown in the profile plots (Attachment 1). Reach 1 encompasses stations 0+00 through OCRM 3115. Reach 2 encompasses the beach between stations OCRM 3115 and 80+00.

Station	Unit Volumes (cy/ft)				
	Sep-09	Jun-11	Jul-12	Jul-13	Oct-13
3100	116.7	23.7	156.1	91.5	112.3
0+00	54.3	121.7	121.2	52.7	83.1
4+00	179.2	168.9	154.0	129.7	131.7
8+00	203.3	188.1	158.8	143.5	142.4
12+00	200.0	193.1	163.6	141.2	145.2
3105	205.6	212.7	172.3	150.0	152.6
16+00	184.3	194.2	143.4	133.4	140.2
20+00	141.2	159.6	122.9	100.9	107.8
3110	134.2	150.1	119.5	102.8	111.4
30+00	98.3	116.2	98.0	87.9	88.3
40+00	101.8	106.0	95.9	87.4	92.8
3115	122.1	122.1	123.4	114.4	116.8
50+00	125.6	127.3	123.4	120.8	116.4
60+00	108.2	112.5	112.0	111.3	114.9
70+00	122.7	120.8	120.9	127.7	135.2
80+00	111.6	112.8	117.5	120.4	118.9

Unit Volume Change Since Previous (cy/ft)			
Jun-11	Jul-12	Jul-13	Oct-13
-93.0	132.4	-64.6	20.8
67.3	-0.4	-68.5	30.4
-10.3	-14.9	-24.3	2.0
-15.2	-29.3	-15.3	-1.1
-6.9	-29.5	-22.4	4.0
7.1	-40.4	-22.3	2.6
9.8	-50.8	-9.9	6.8
18.5	-36.7	-22.0	6.8
15.9	-30.6	-16.7	8.5
17.8	-18.2	-10.1	0.4
4.1	-10.1	-8.5	5.4
0.0	1.3	-9.0	2.4
1.6	-3.8	-2.6	-4.4
4.3	-0.4	-0.7	3.5
-1.9	0.1	6.8	7.5
1.3	4.7	2.8	-1.5

Station	Total Volume to Next Station (cy)				
	Sep-09	Jun-11	Jul-12	Jul-13	Oct-13
0+00	46,715	58,119	55,054	36,490	42,958
4+00	76,501	71,406	62,567	54,657	54,831
8+00	80,660	76,234	64,484	56,948	57,526
12+00	76,875	77,452	61,399	54,930	57,081
16+00	65,101	70,762	53,259	46,878	49,595
20+00	37,170	41,818	32,730	27,511	29,583
3110	84,858	97,192	79,386	69,622	72,859
30+00	100,073	111,053	96,925	87,652	90,540
40+00	43,670	44,470	42,753	39,344	40,869
3115	75,563	76,054	75,278	71,726	71,125
50+00	116,907	119,865	117,731	116,067	115,655
60+00	115,418	116,639	116,460	119,502	125,048
70+00	117,105	116,825	119,222	124,023	127,051
80+00	0	0	0	0	0
Reach 1	611,624	648,506	548,558	474,033	495,842
Reach 2	424,992	429,382	428,690	431,318	438,879

Change Since Previous				
	Jun-11	Jul-12	Jul-13	Oct-13
Reach 1 (cy)	36,881	-99,948	-74,525	21,809
Reach 2 (cy)	4,390	-692	2,628	7,561
Total (cy)	41,271	-100,639	-71,897	29,370
Reach 1 (cy/ft)	8.4	-22.8	-17.0	5.0
Reach 2 (cy/ft)	1.2	-0.2	0.7	2.1
Total (cy/ft)	5.2	-12.6	-9.0	3.7

Annual Change Rate (cy/ft per yr)				
		Jun 11 - Jul 12	Jul 12 - Jul 13	Jul 13 - Oct 13
Reach 1		-92,124	-74,525	86,526
Reach 2		-637	2,628	29,996
Total		-92,761	-71,897	116,521

Looking west from Station 50+00 (near 7th Ave). This was the only area showing an active escarpment in October 2013. There was a small erosional arc centered at this station.

Looking east from station 30+00. Wind-blown sand has accumulated at the base of a recent escarpment, suggesting stability and dune recovery at this location.

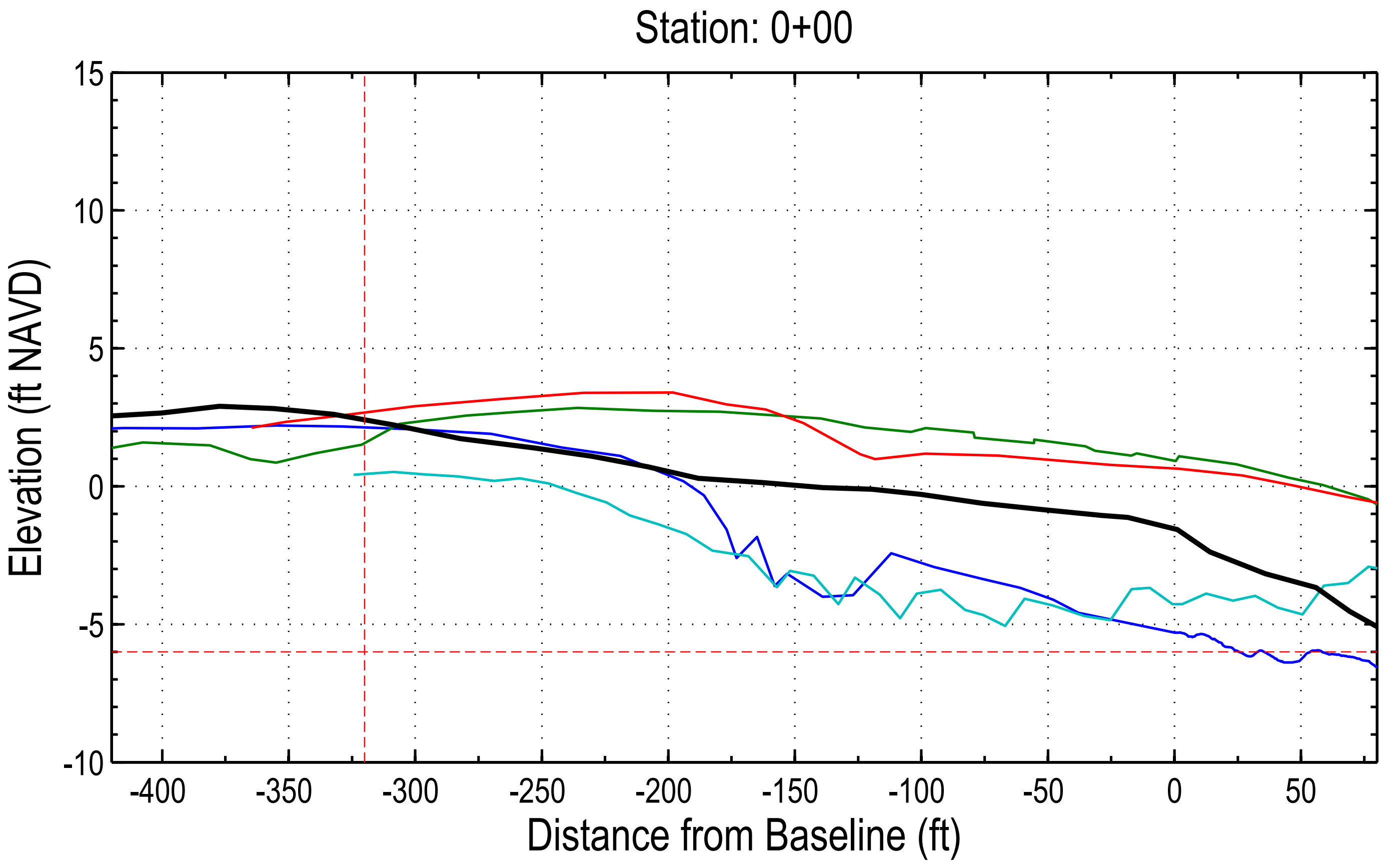
Dune at station 20+00. An old scarp has recovered, although a new, smaller scarp in the berm is evident.

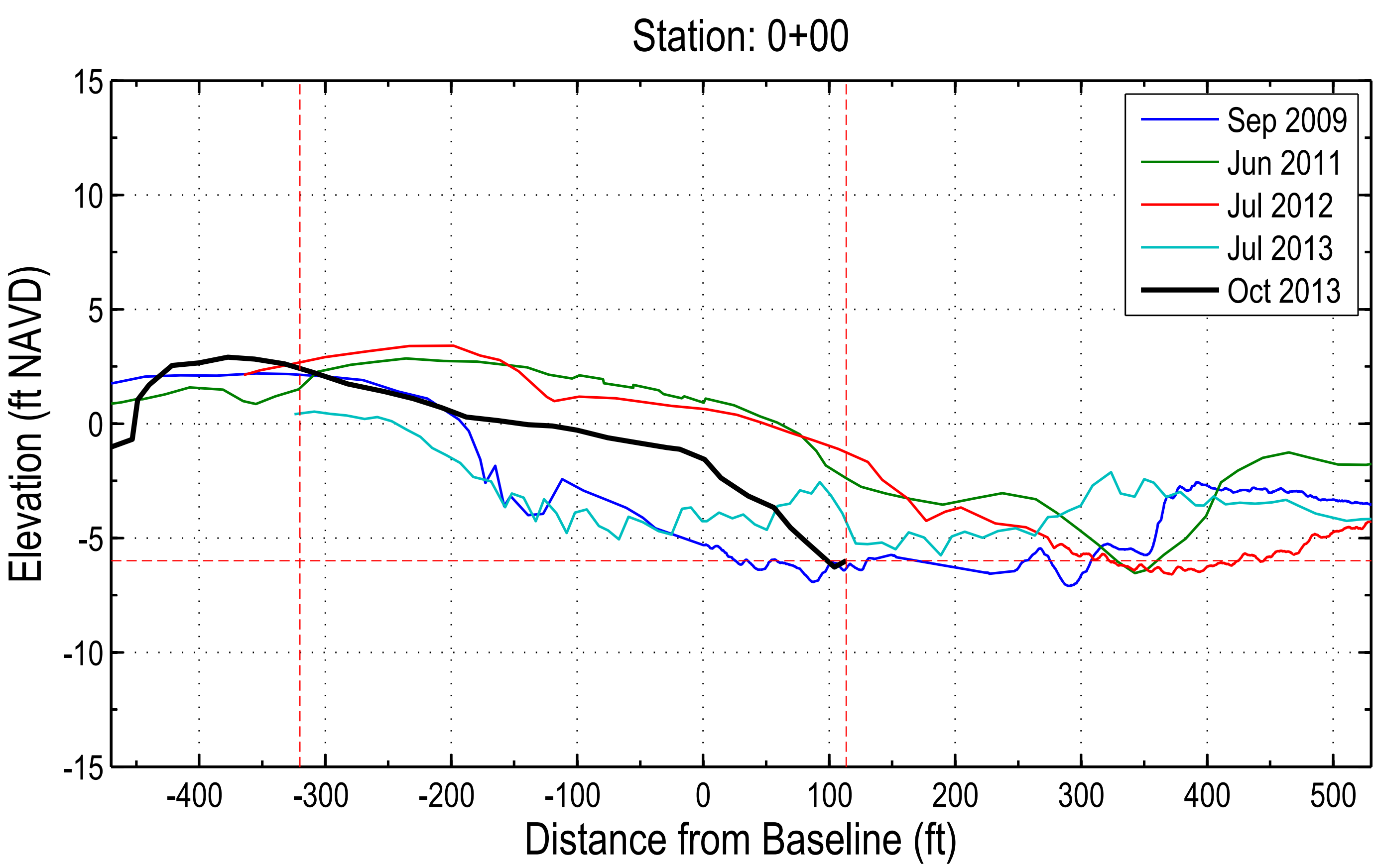
A large ridge and runnel (shown here at station 20+00) is usually evidence of an accretional pattern, which was also reflected in positive volume changes between July and October 2013.

Landward view at station 12+00 showing low dunes lacking sufficient elevation to offer significant storm protection. This area had eroded heavily from July 2012 to July 2013 but was accretional from July 2013 to October 2013.

An endangered piping plover was spotted near the inlet.

ATTACHMENT 1





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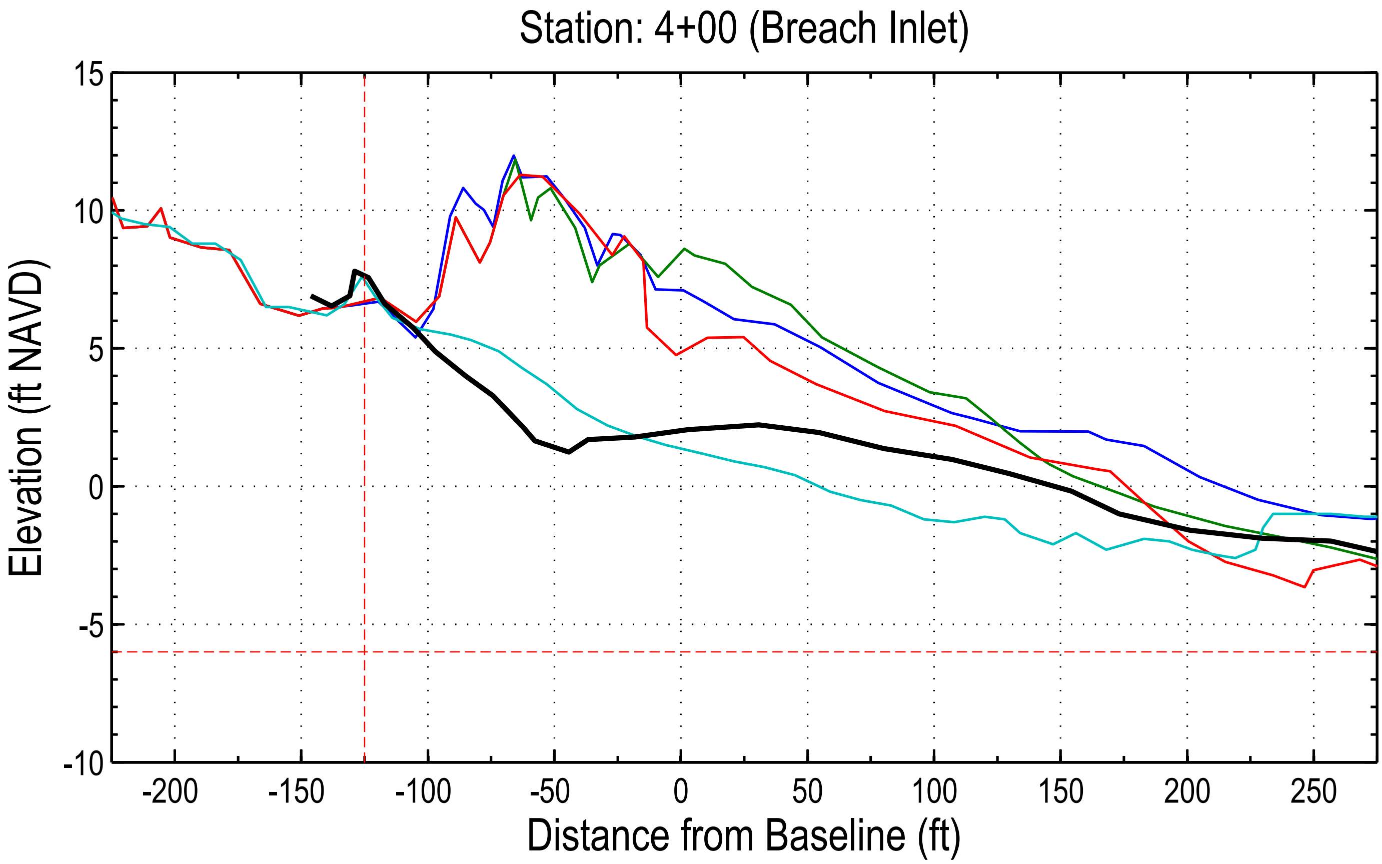

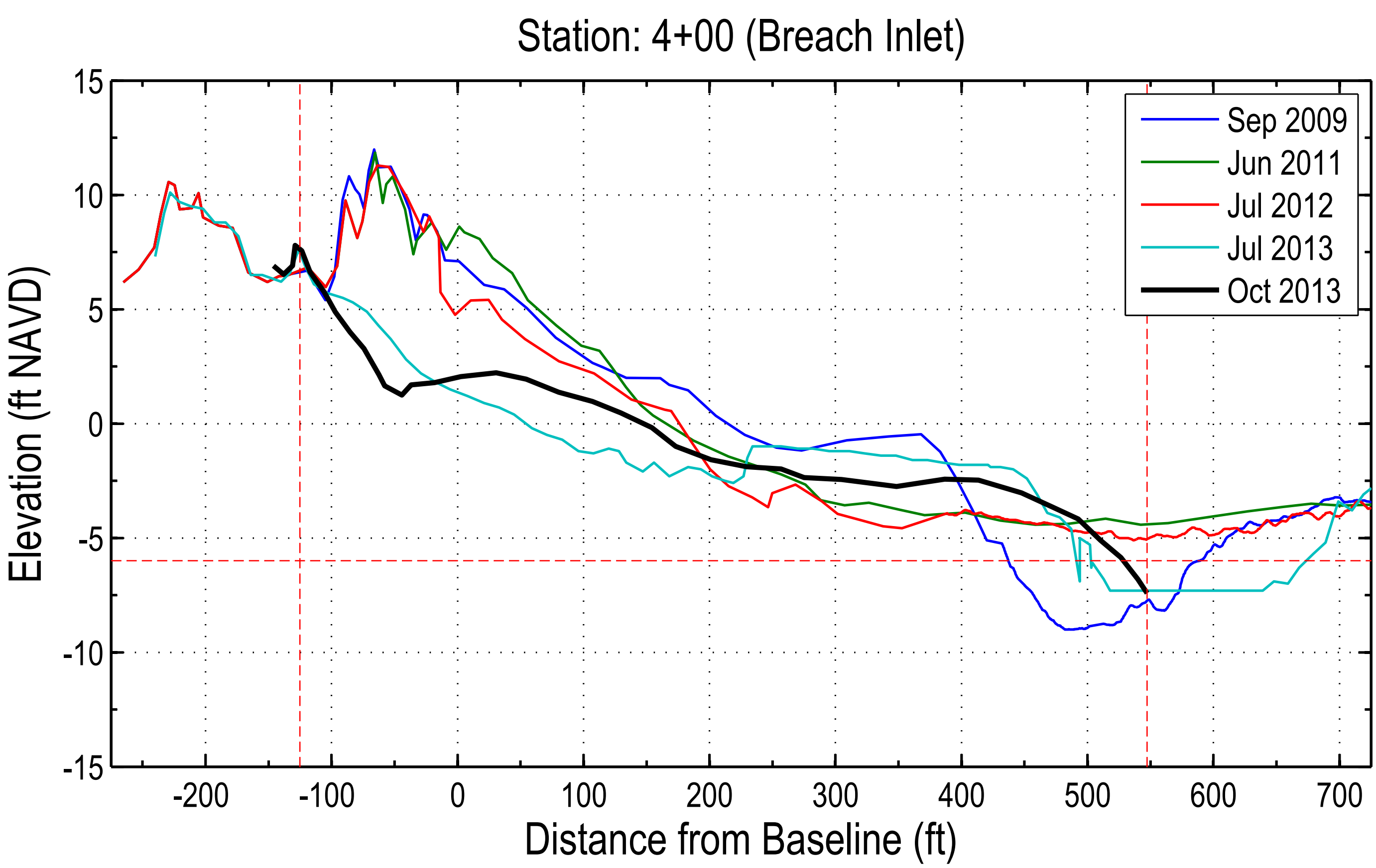

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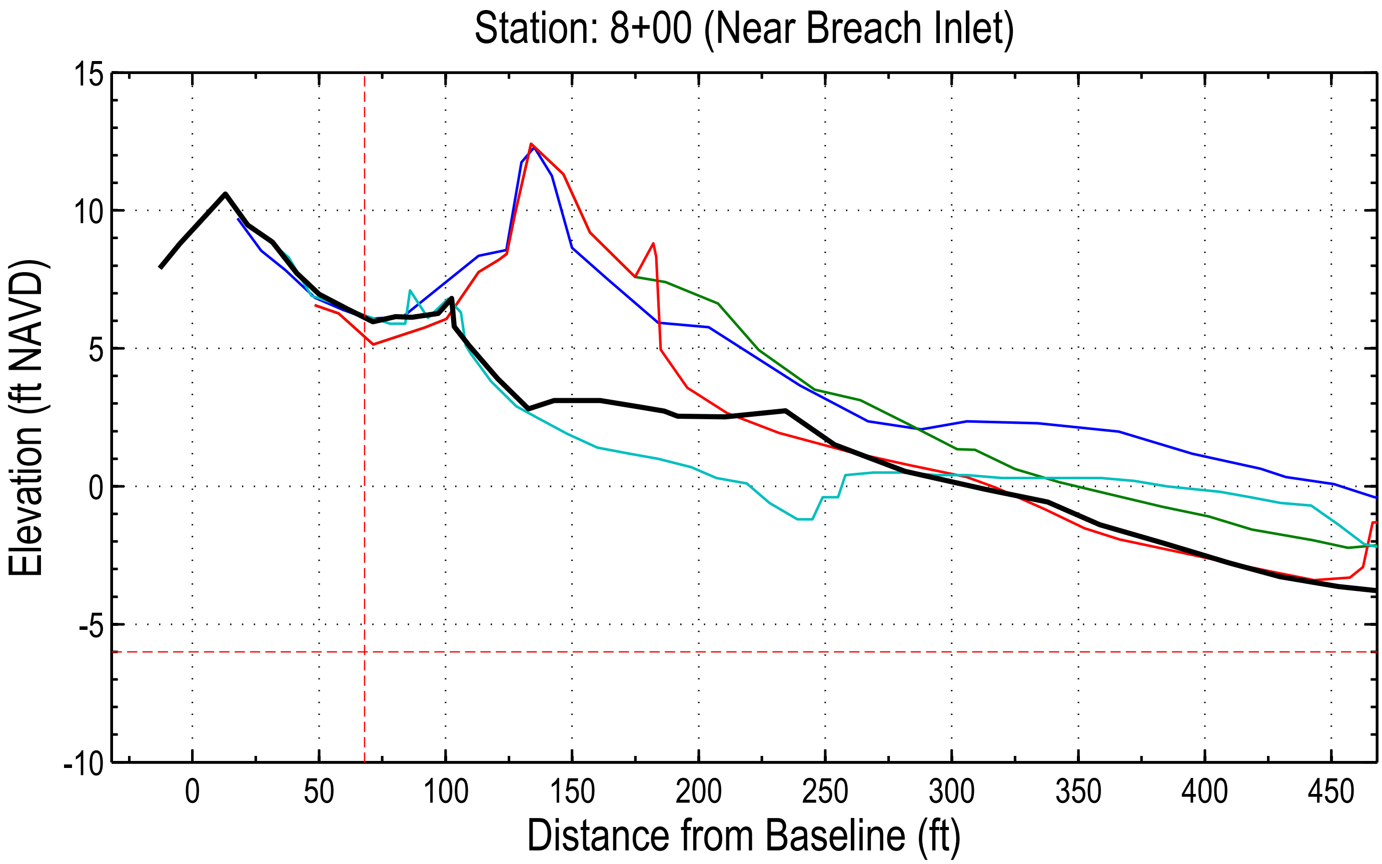

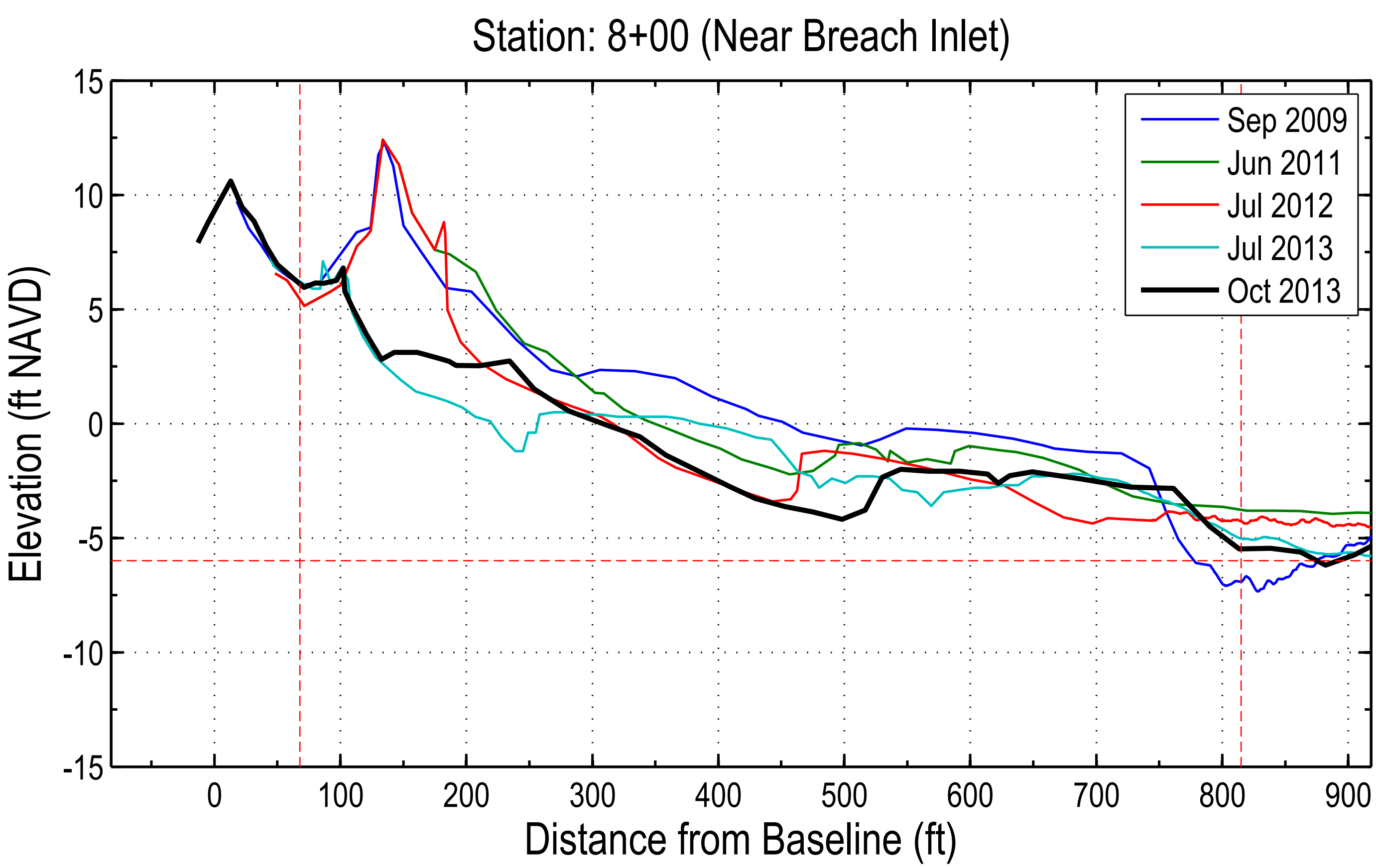

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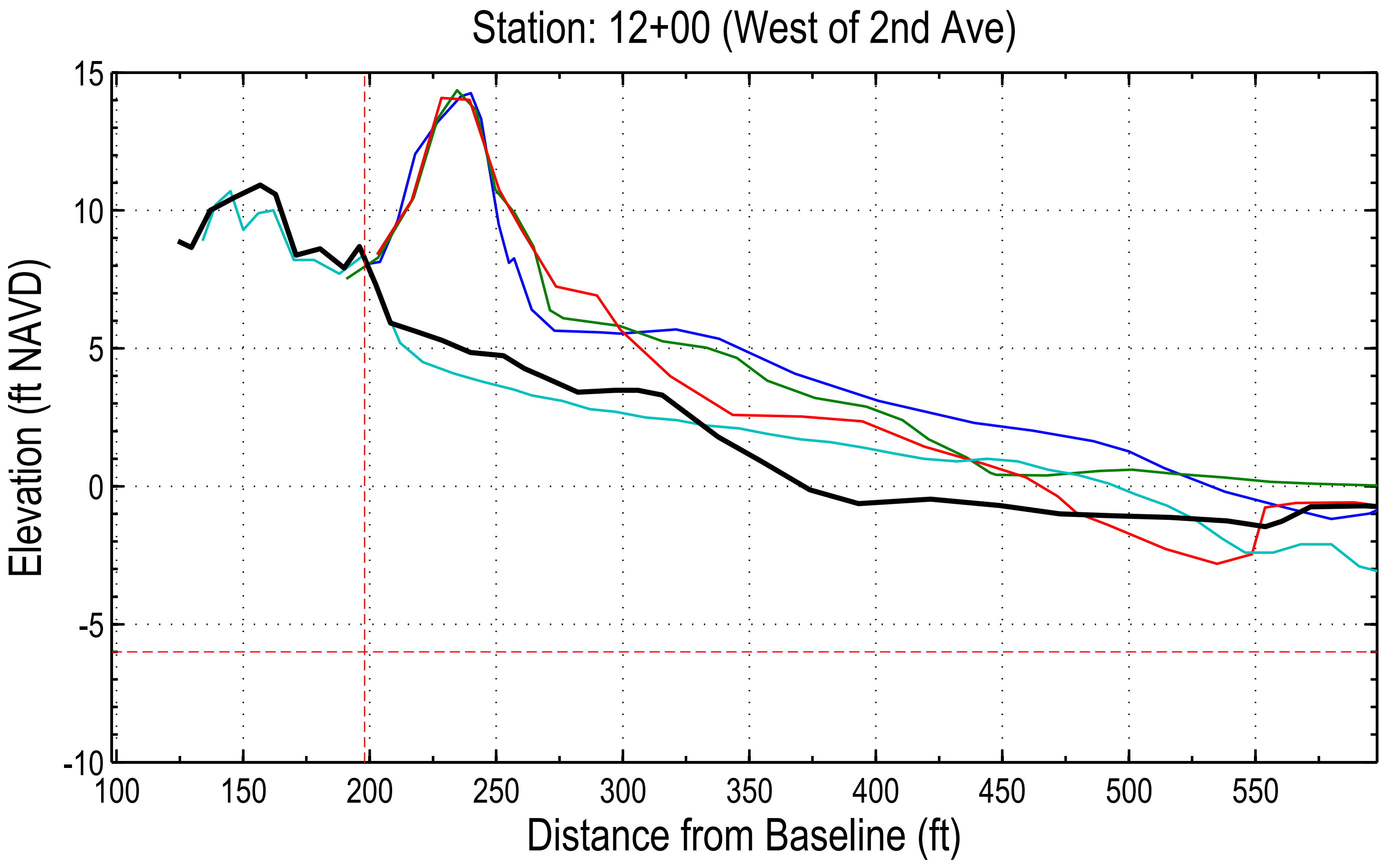

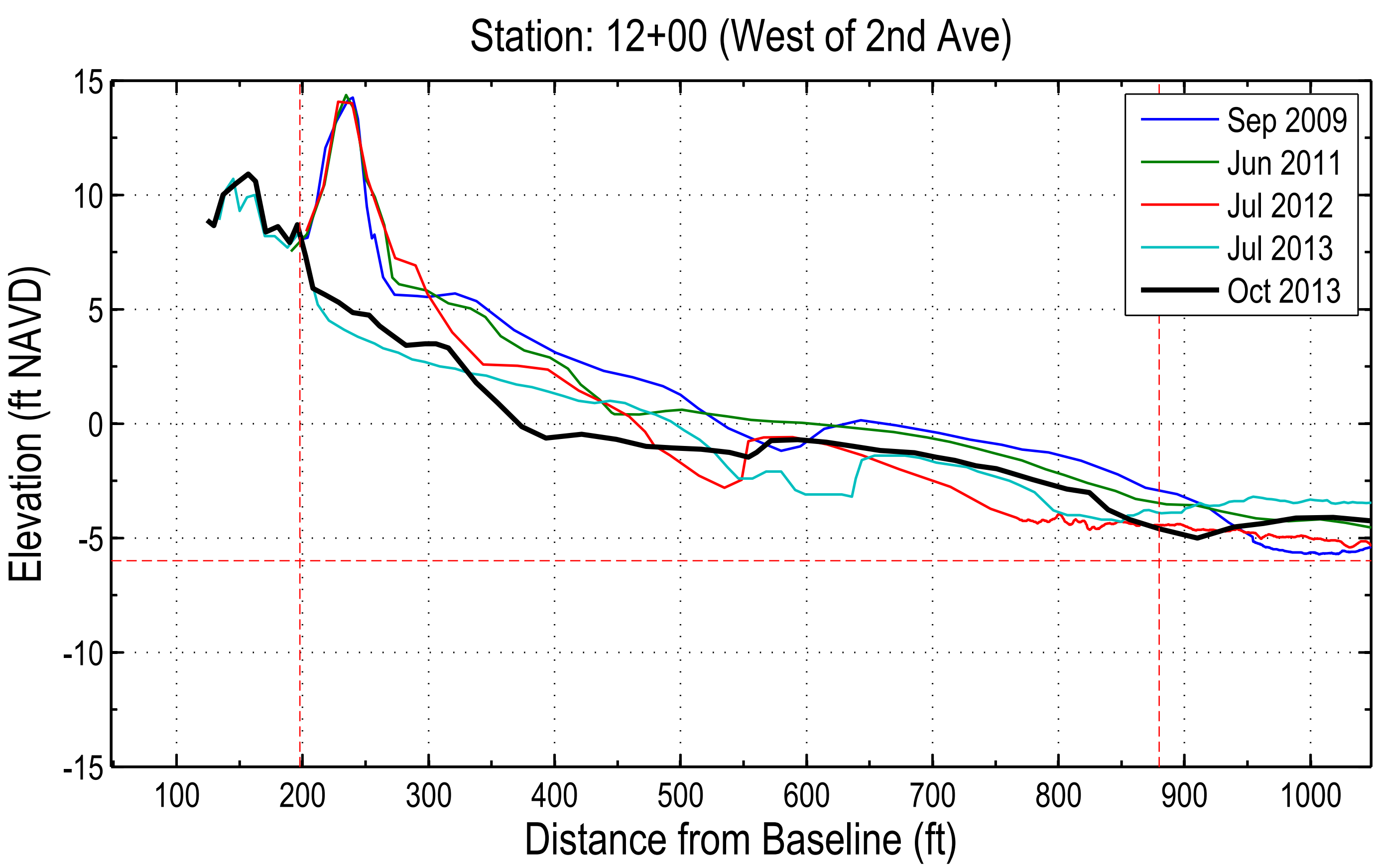

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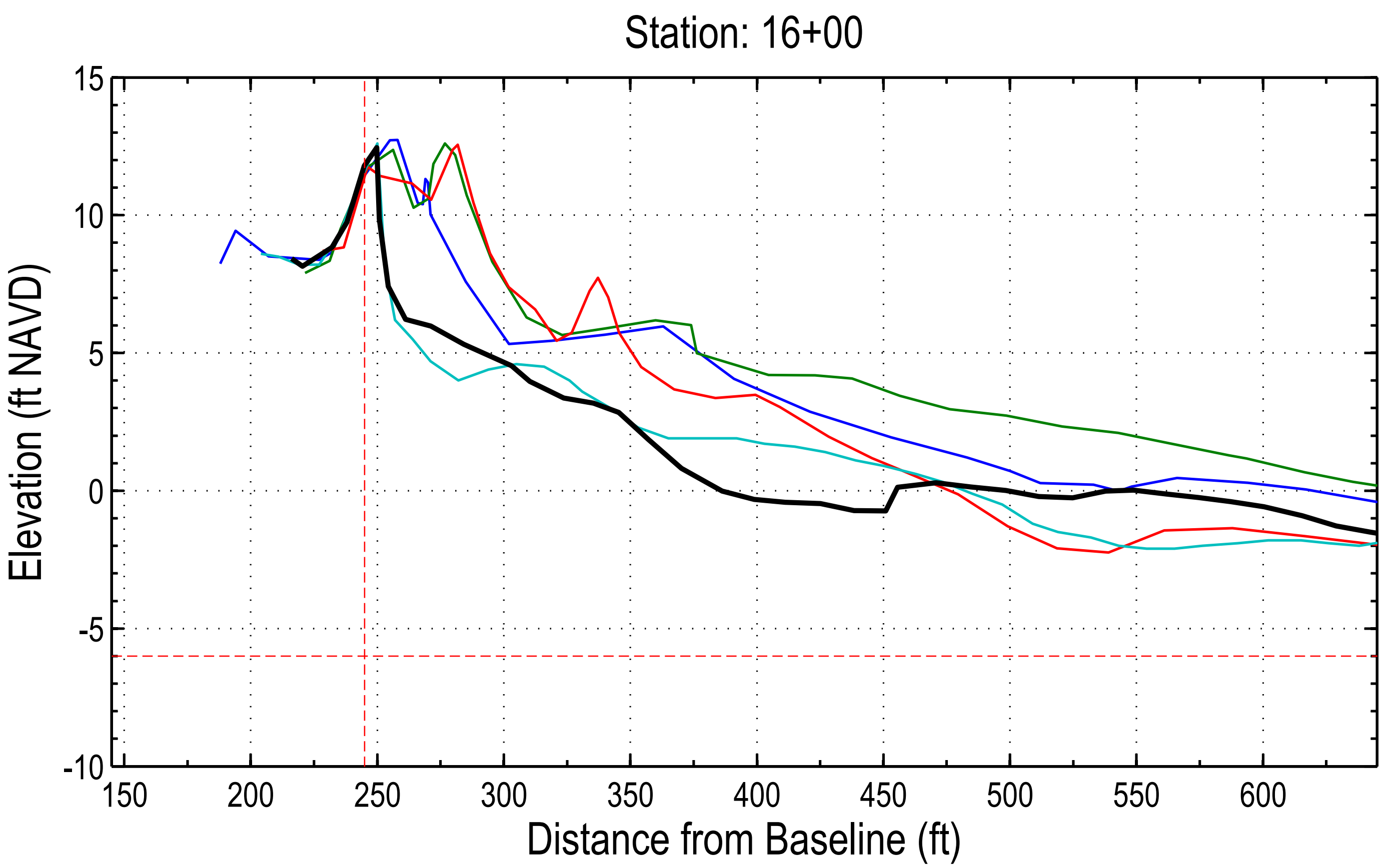

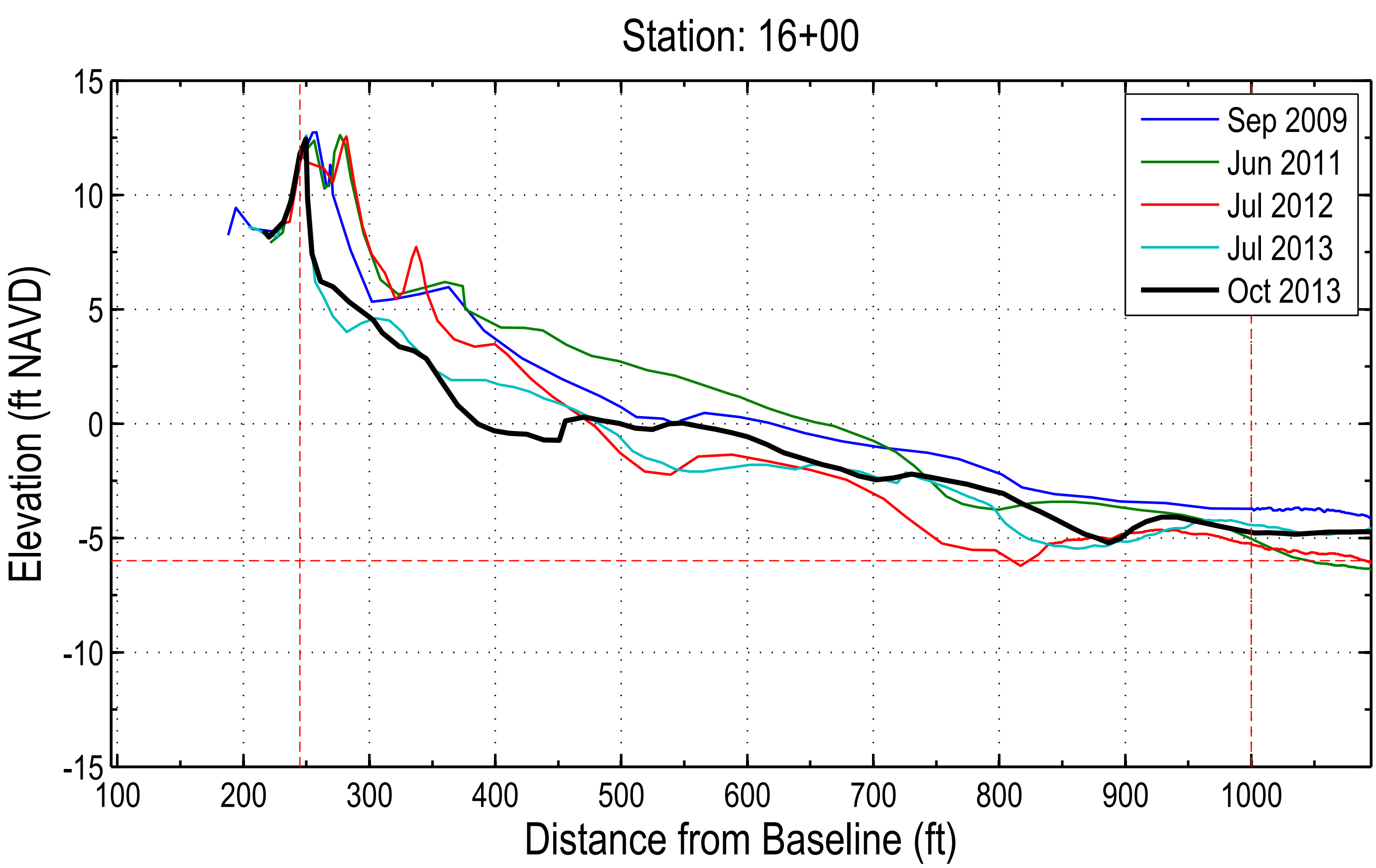

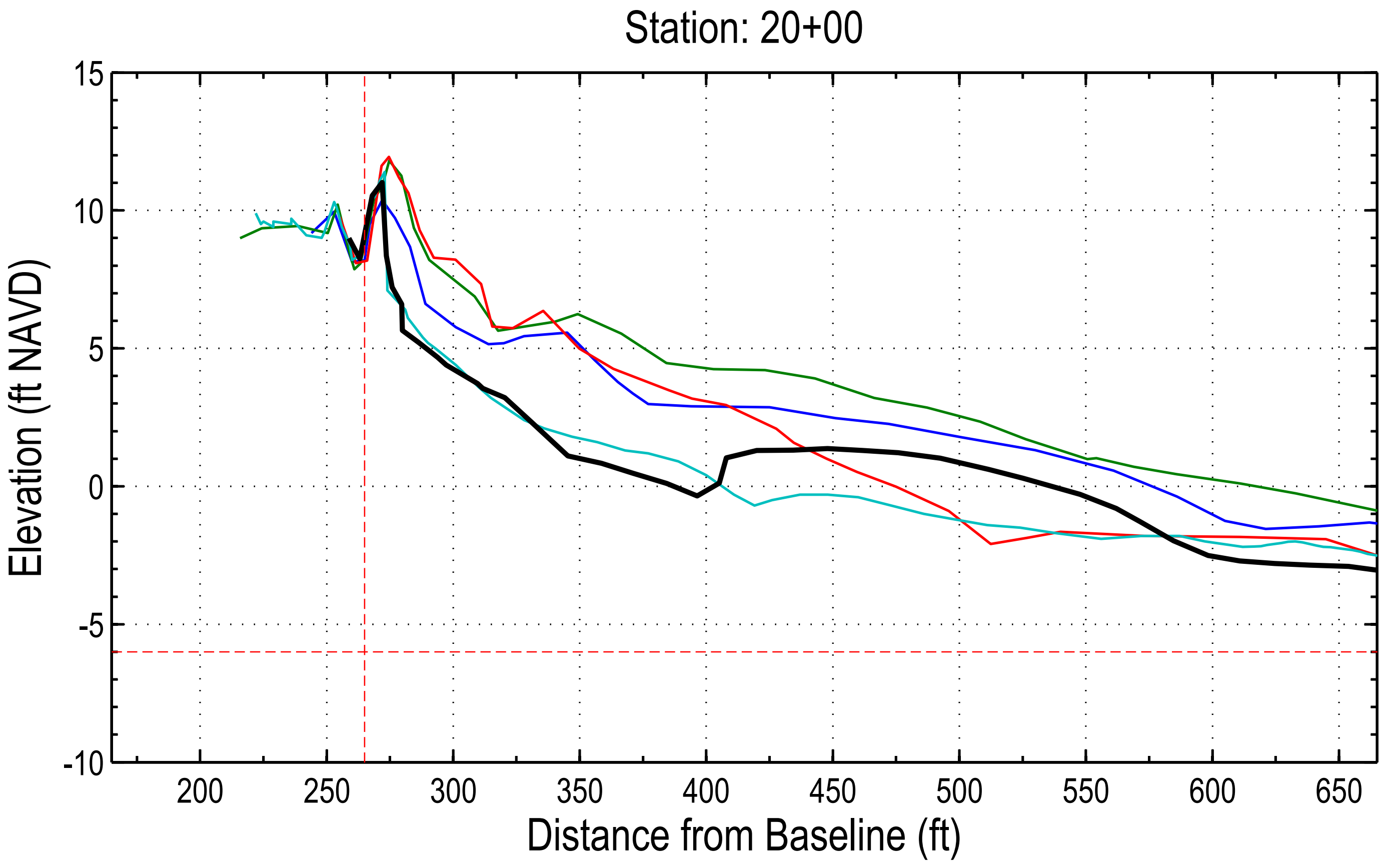
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Elevation (ft NAVD)
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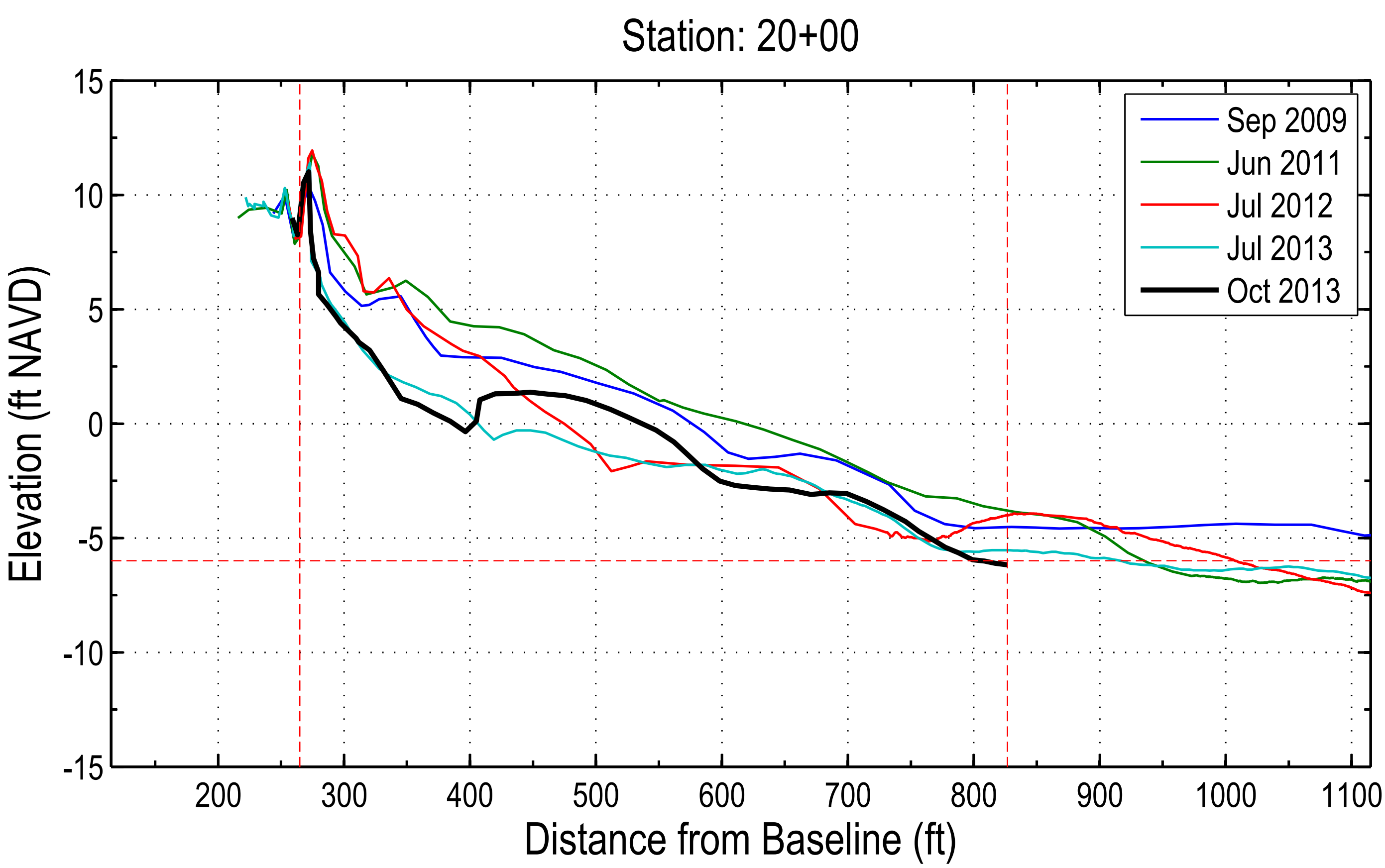
Distance from Baseline (ft)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Elevation (ft NAVD)
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Distance from Baseline (ft)
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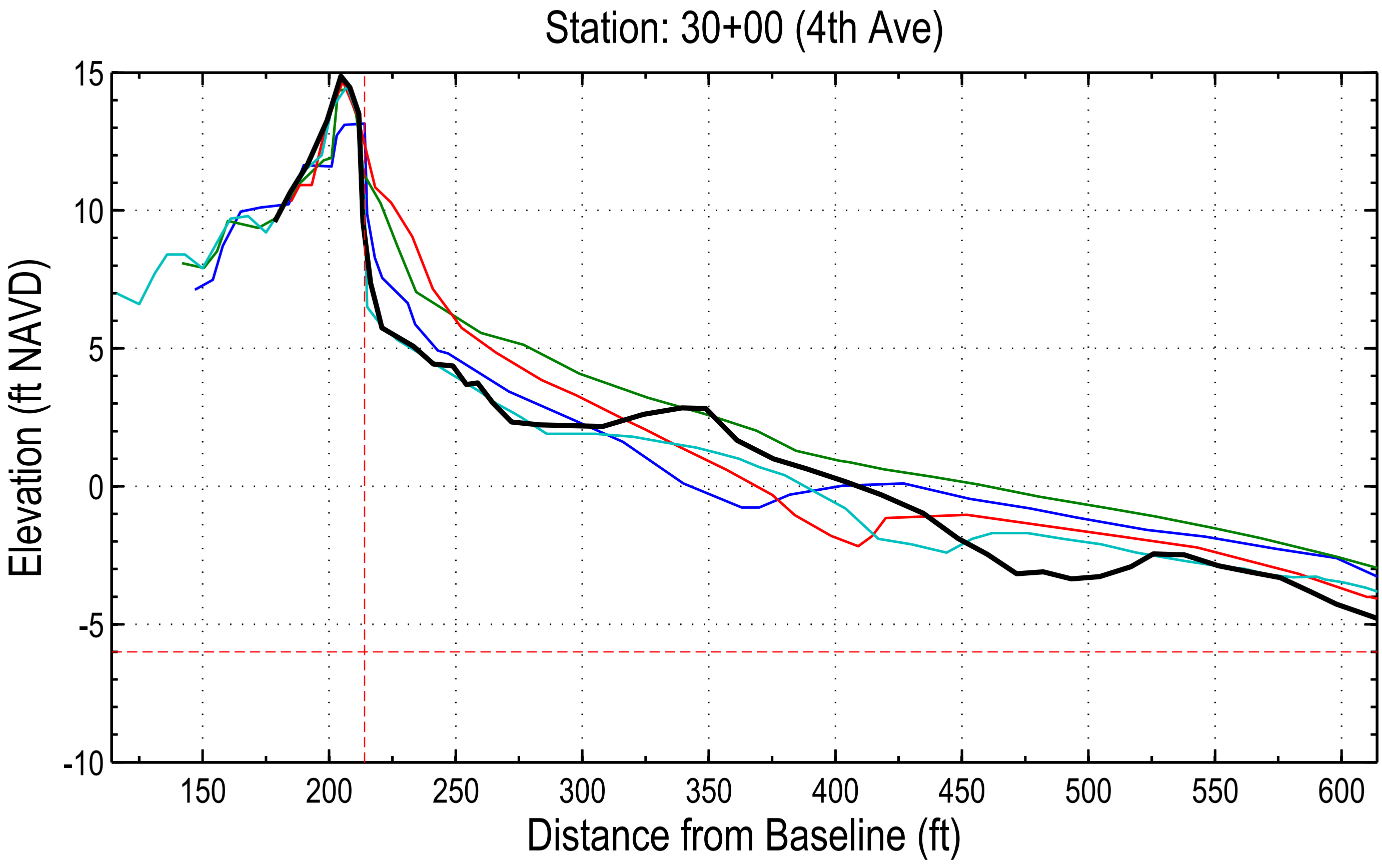
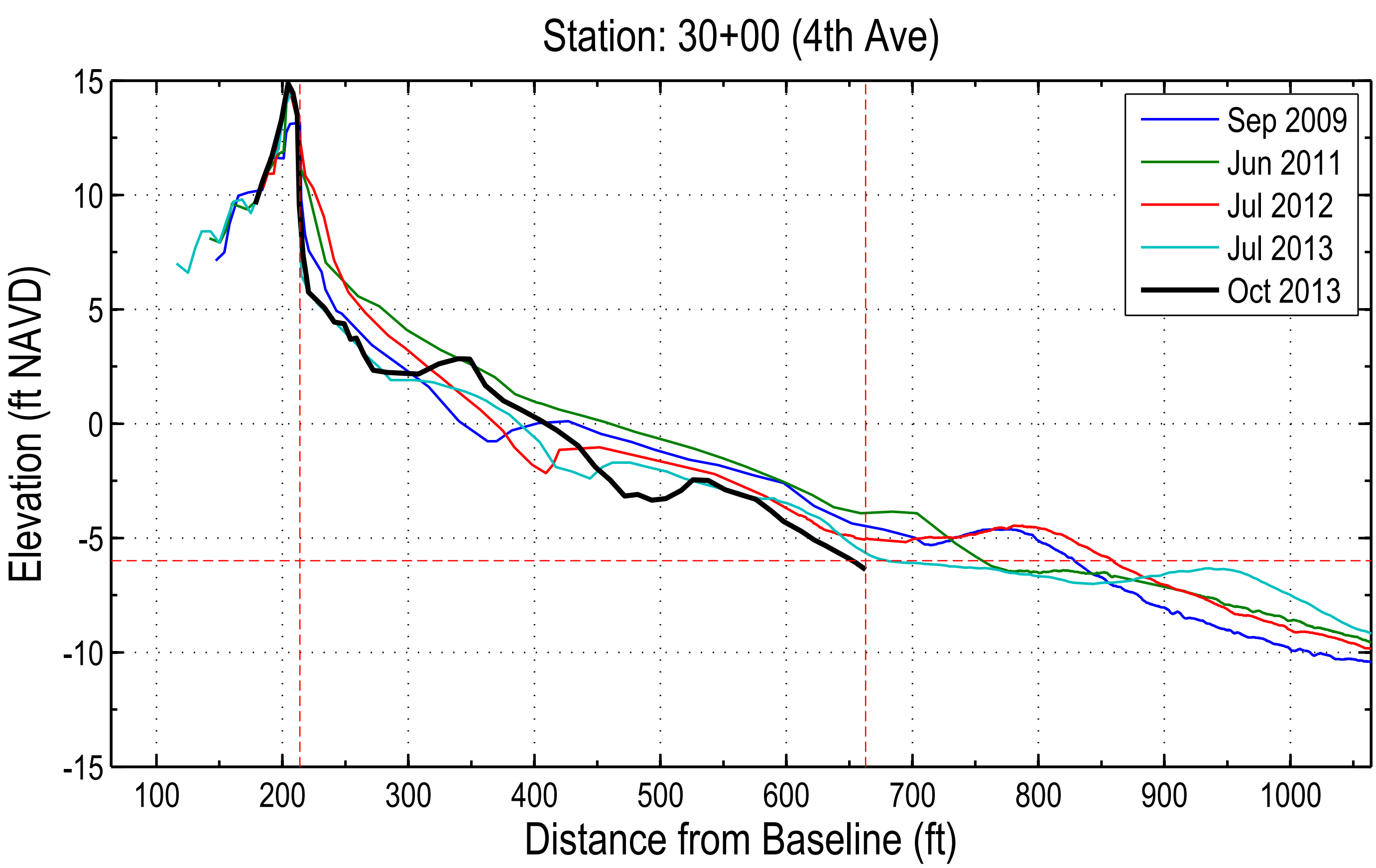
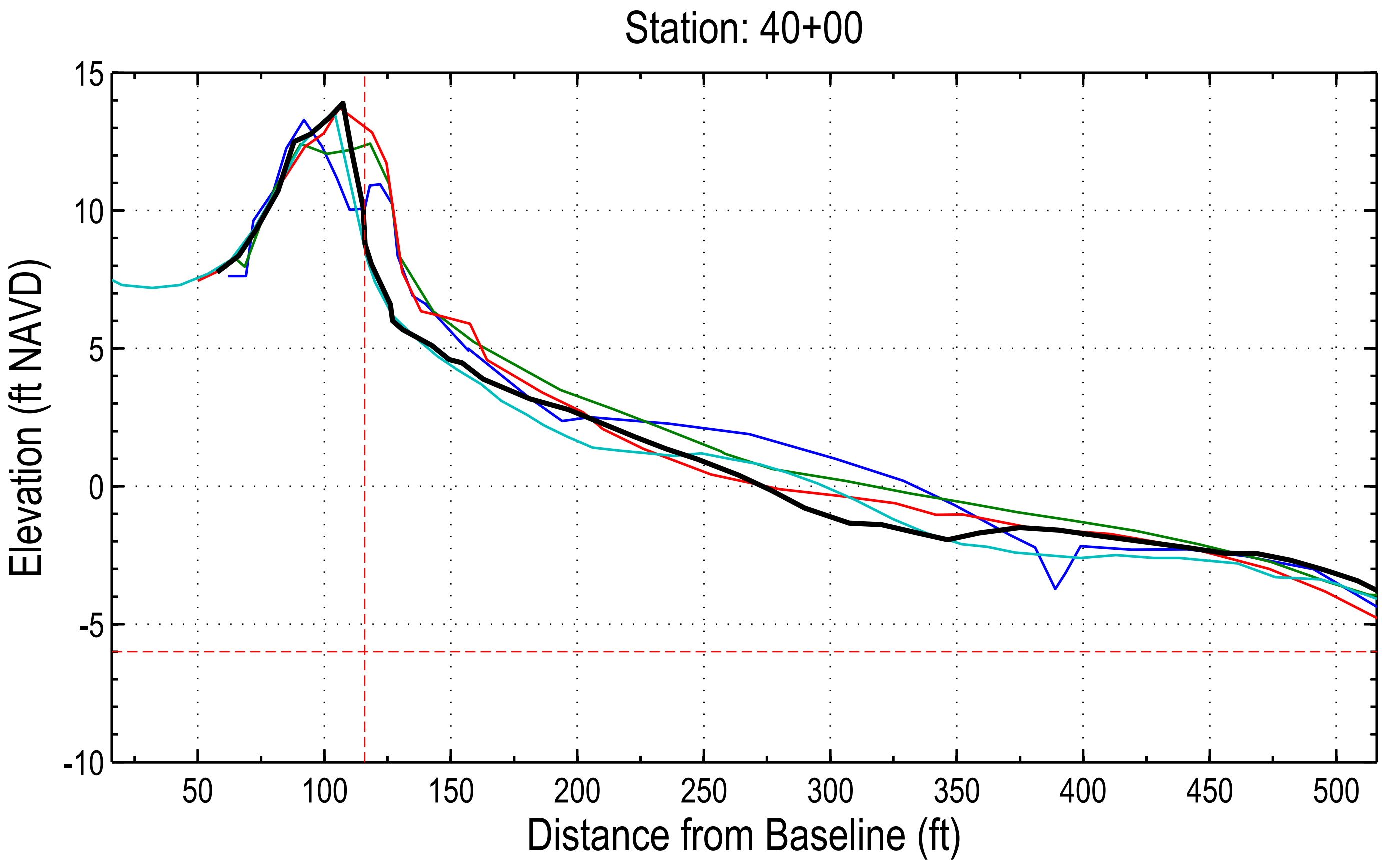
ATTACHMENT 1



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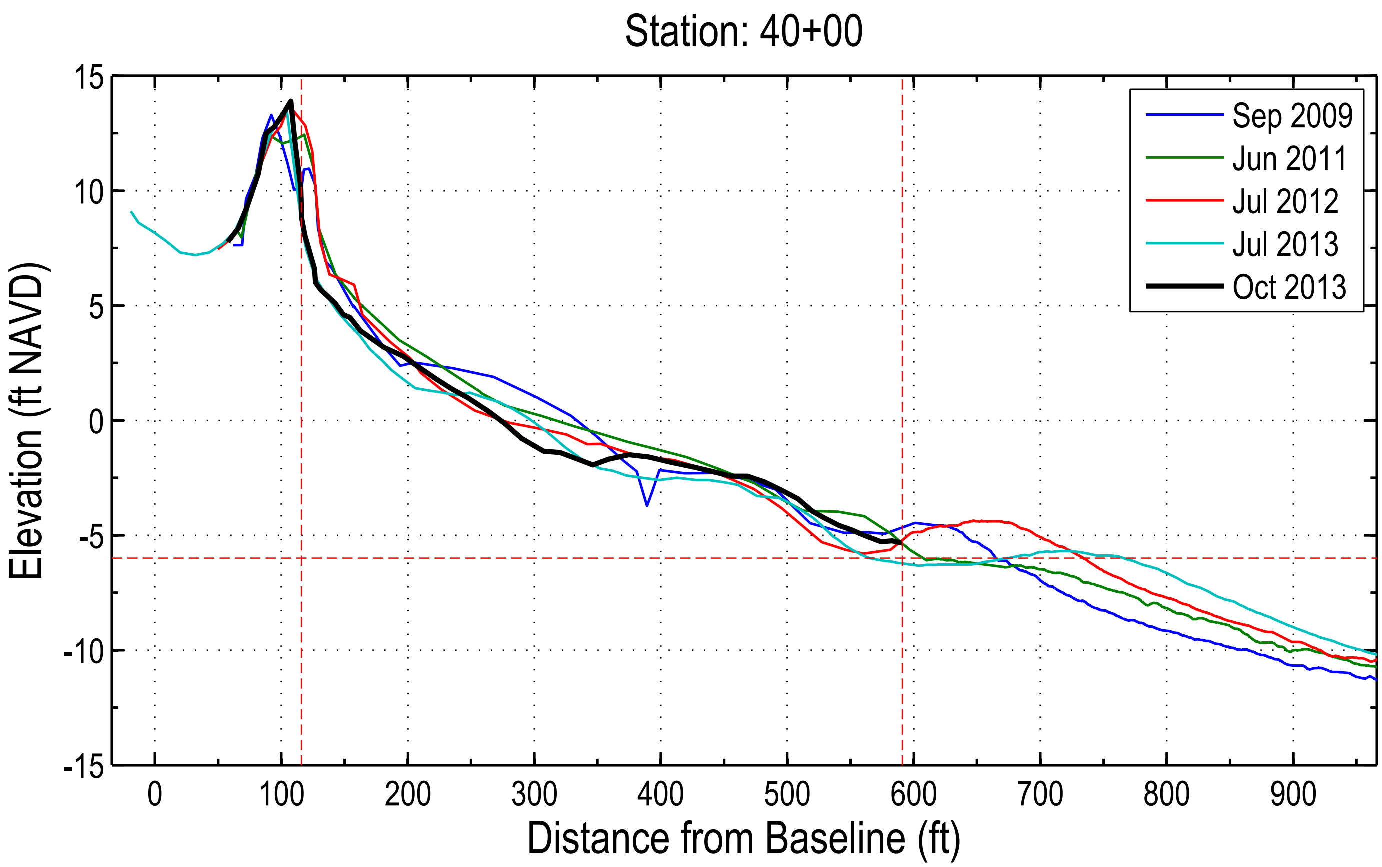
10
5
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Elevation (ft NAVD)
Distance from Baseline (ft)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15
10
5
0
-5
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-15
0
100
200
300
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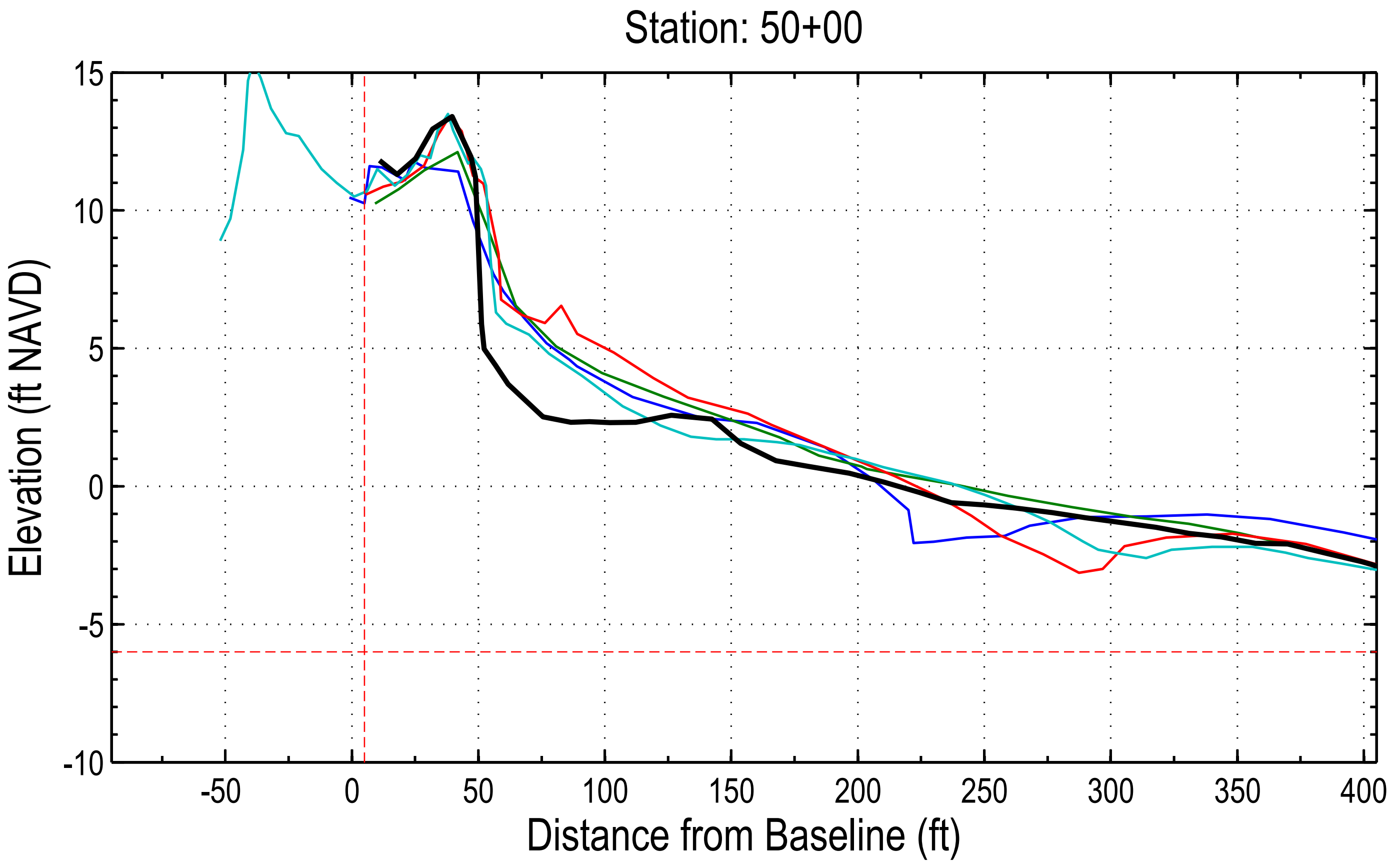
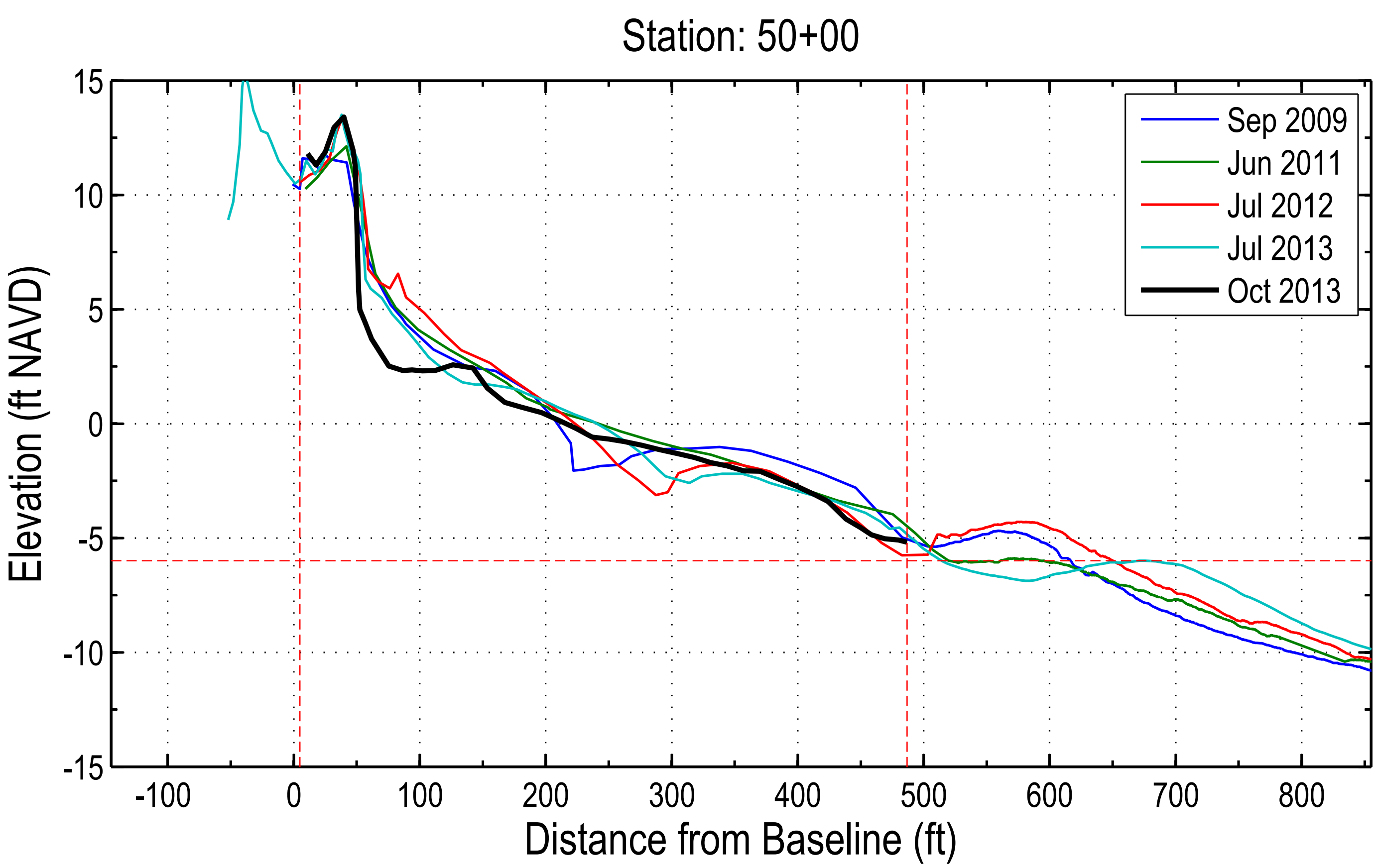
500
600
700
800
900
Sep 2009
Jun 2011
Jul 2012
Jul 2013
Oct 2013
Elevation (ft NAVD)
Distance from Baseline (ft)

ATTACHMENT 1





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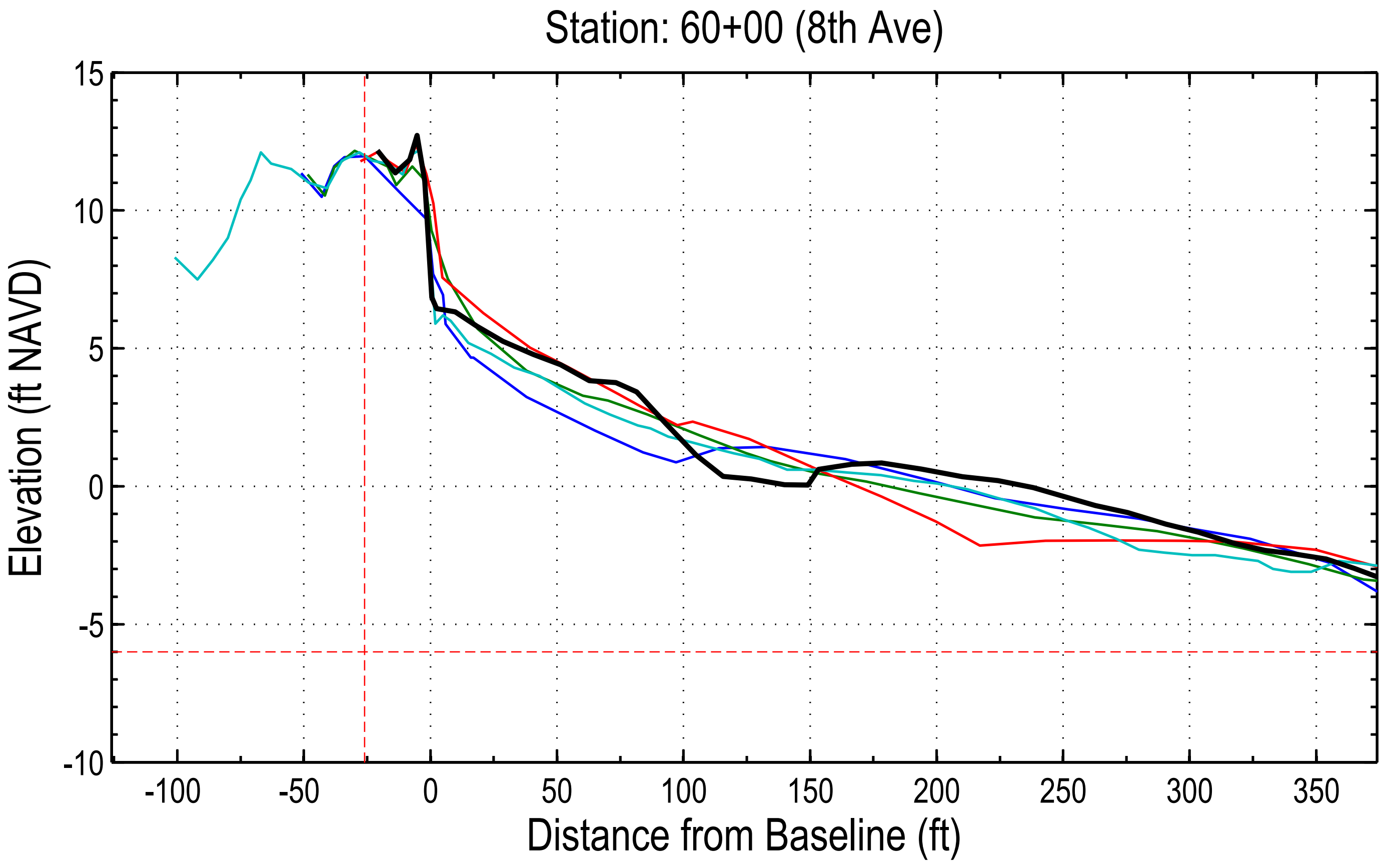

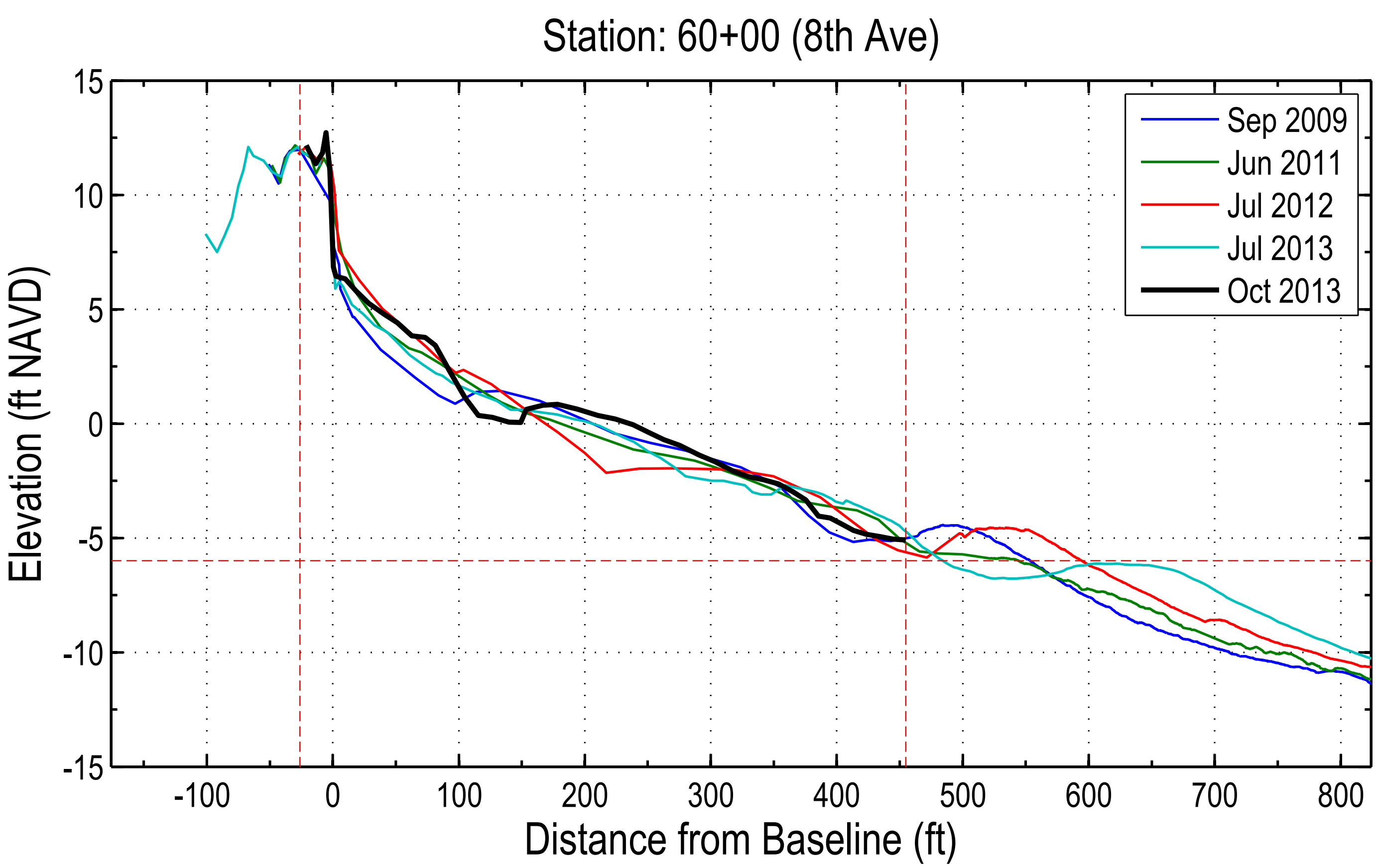

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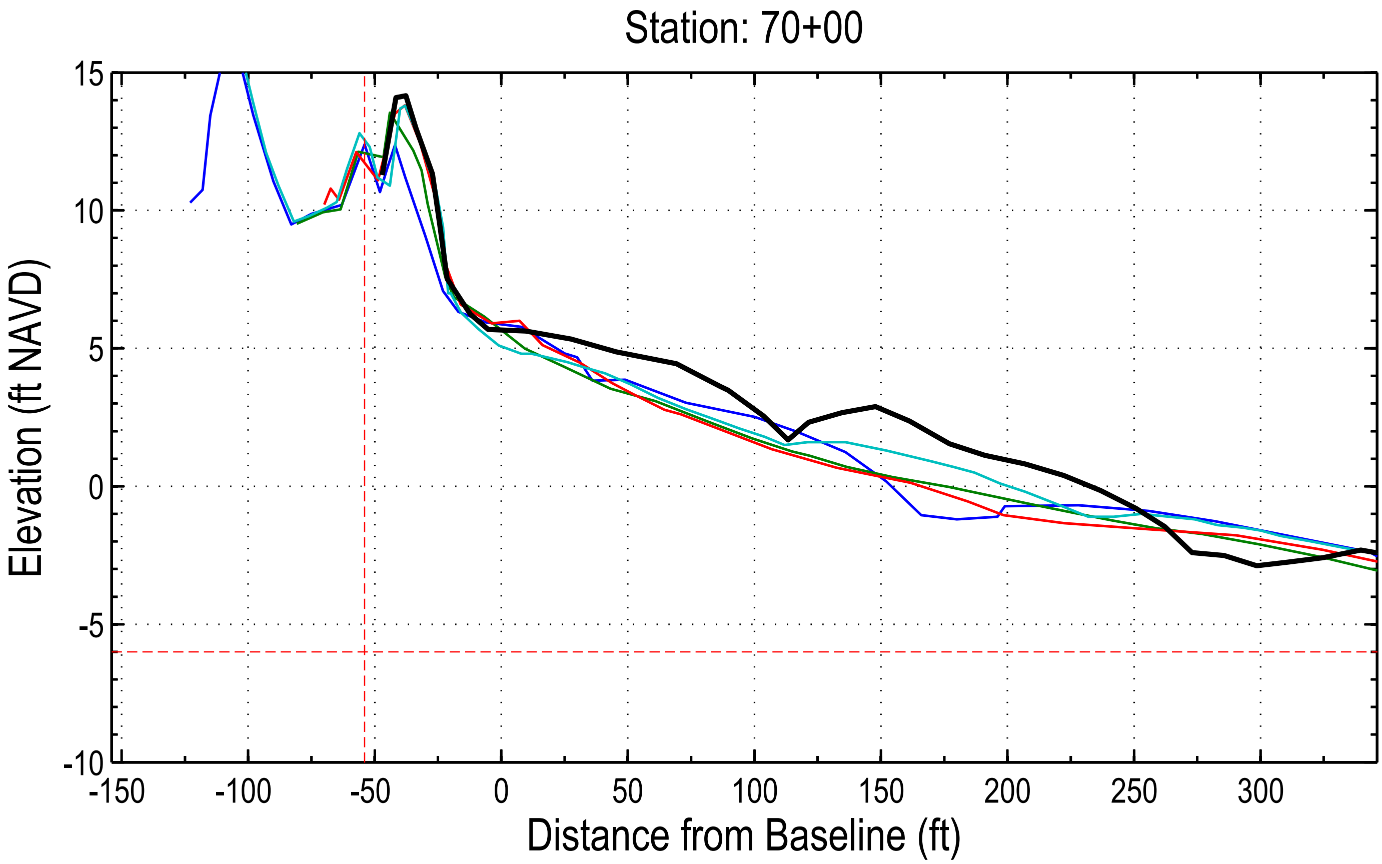

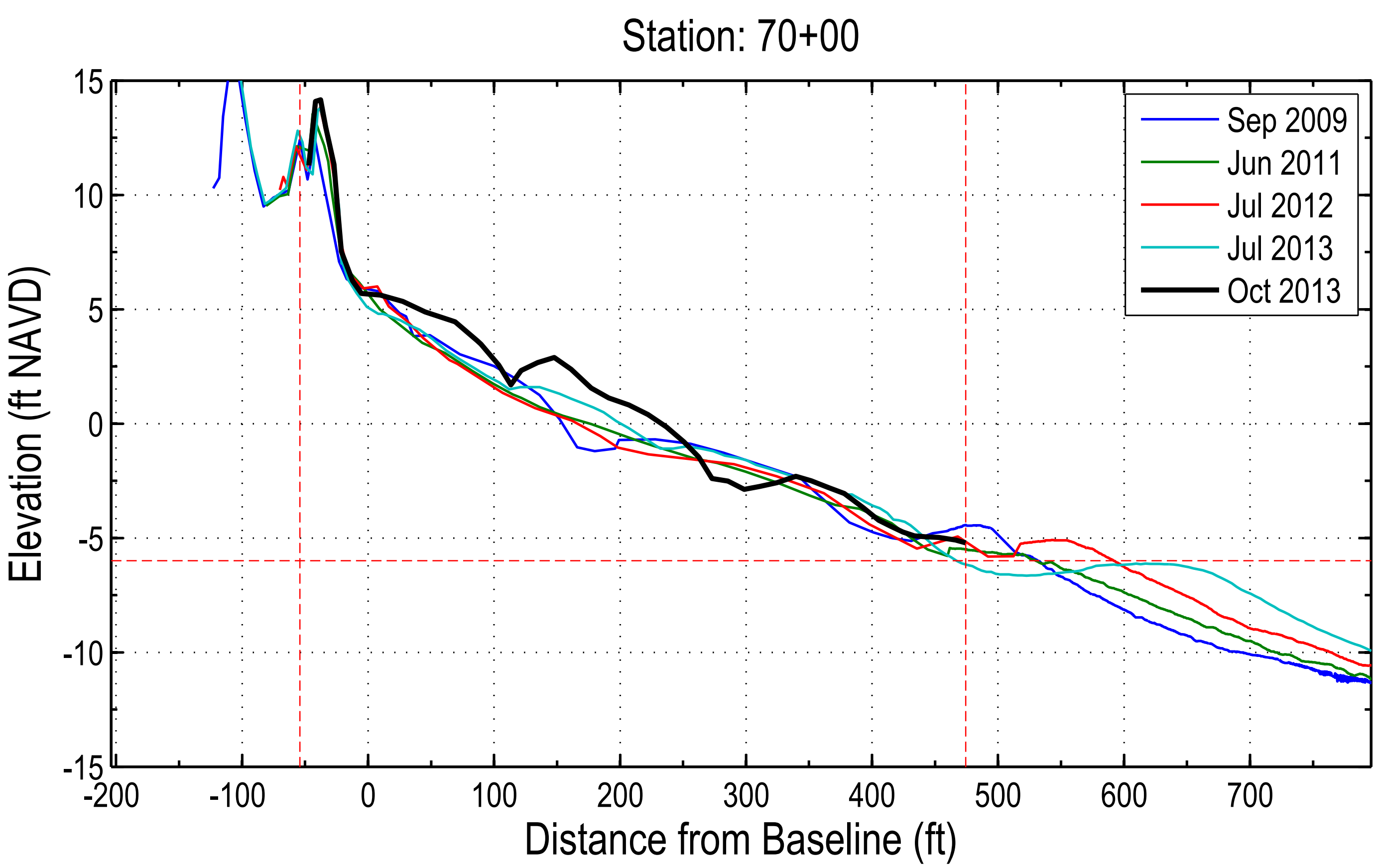

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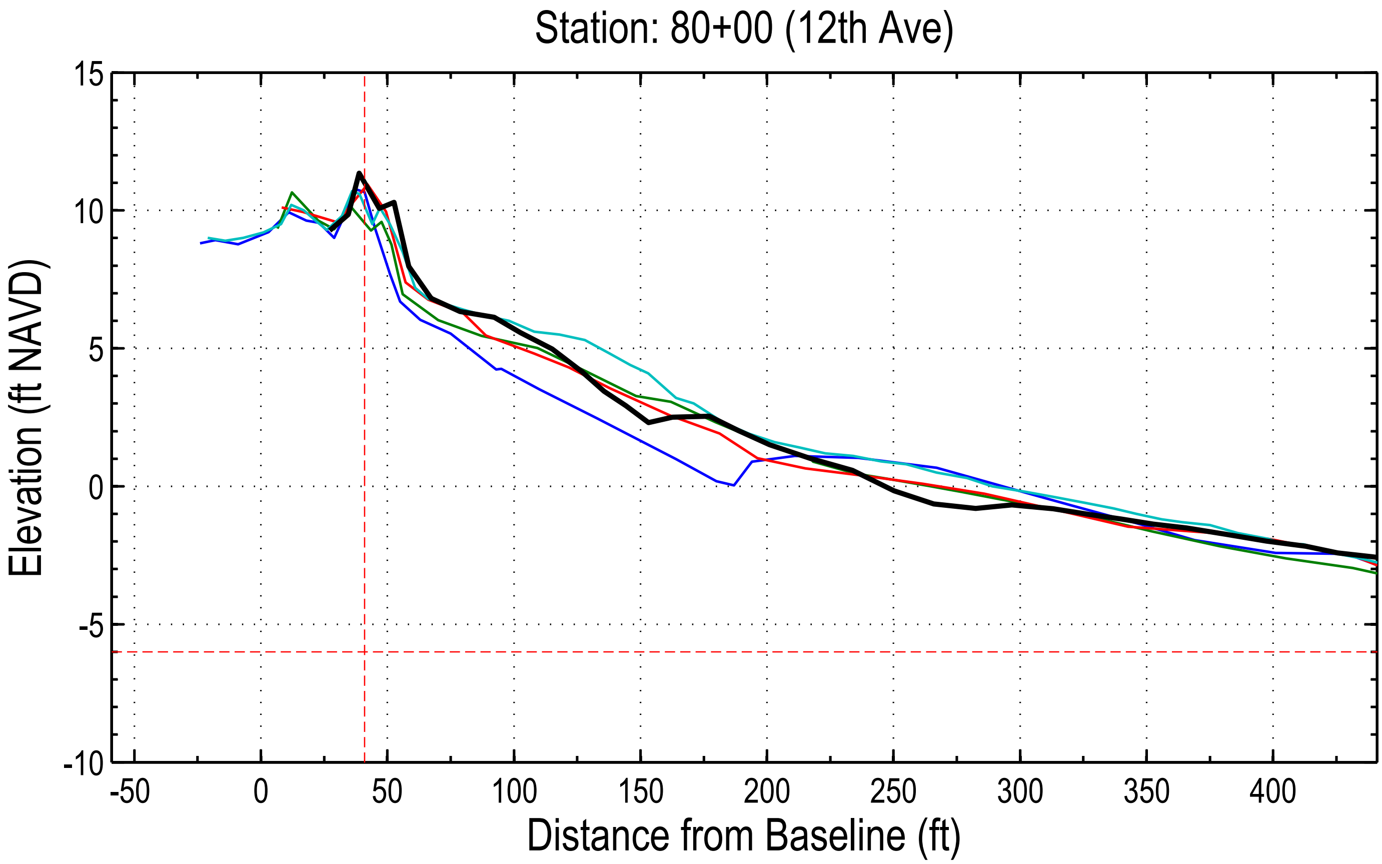

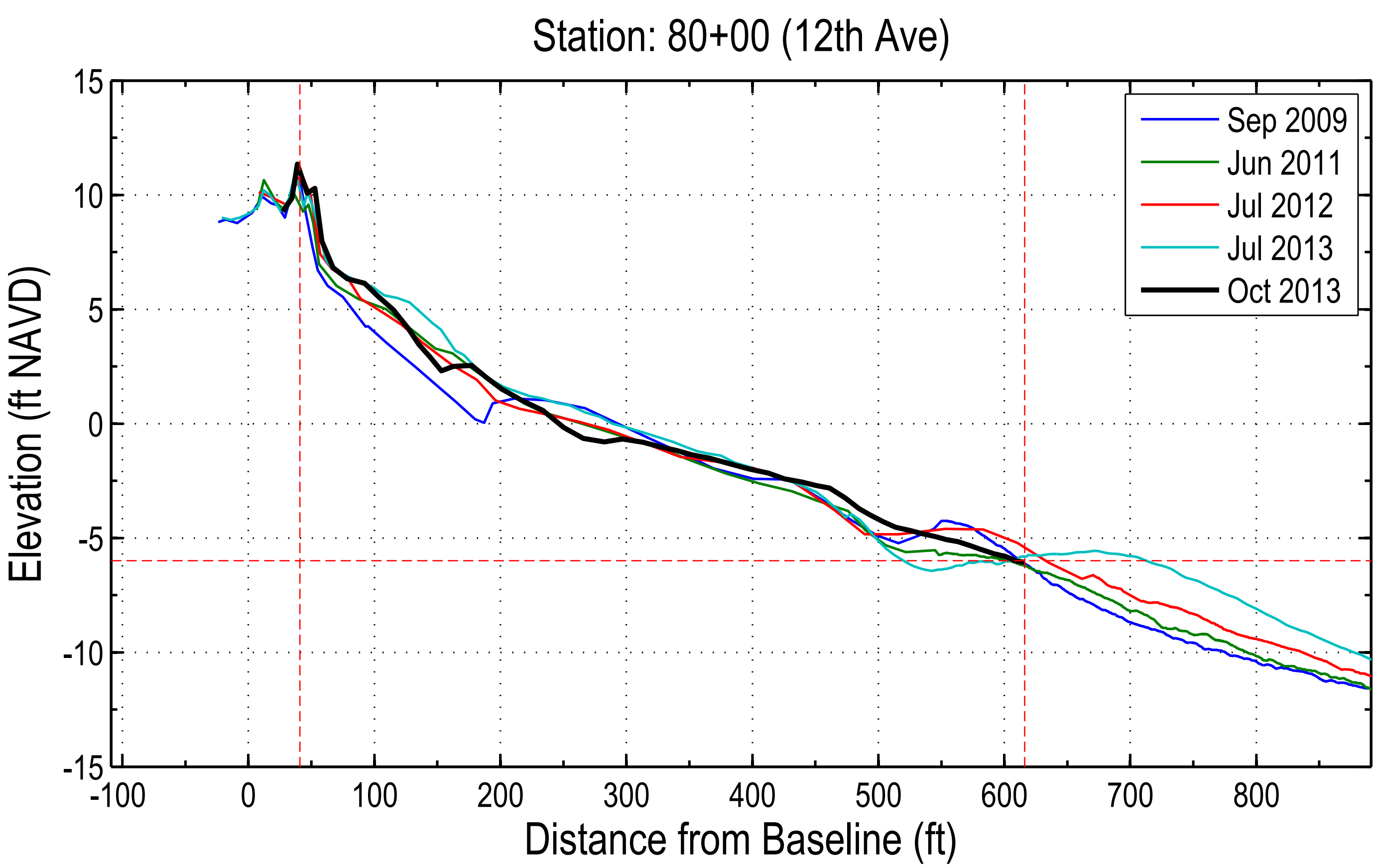

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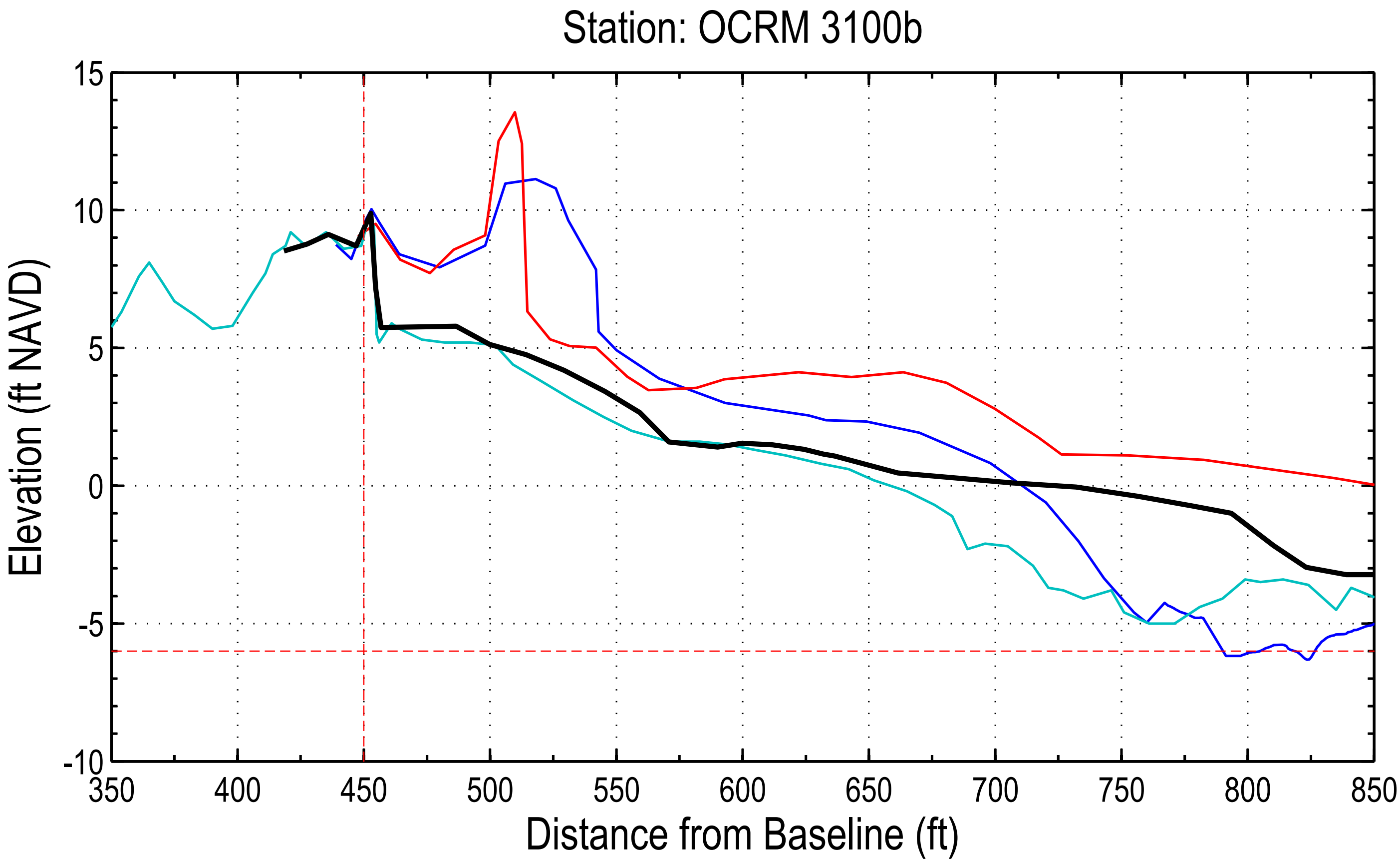

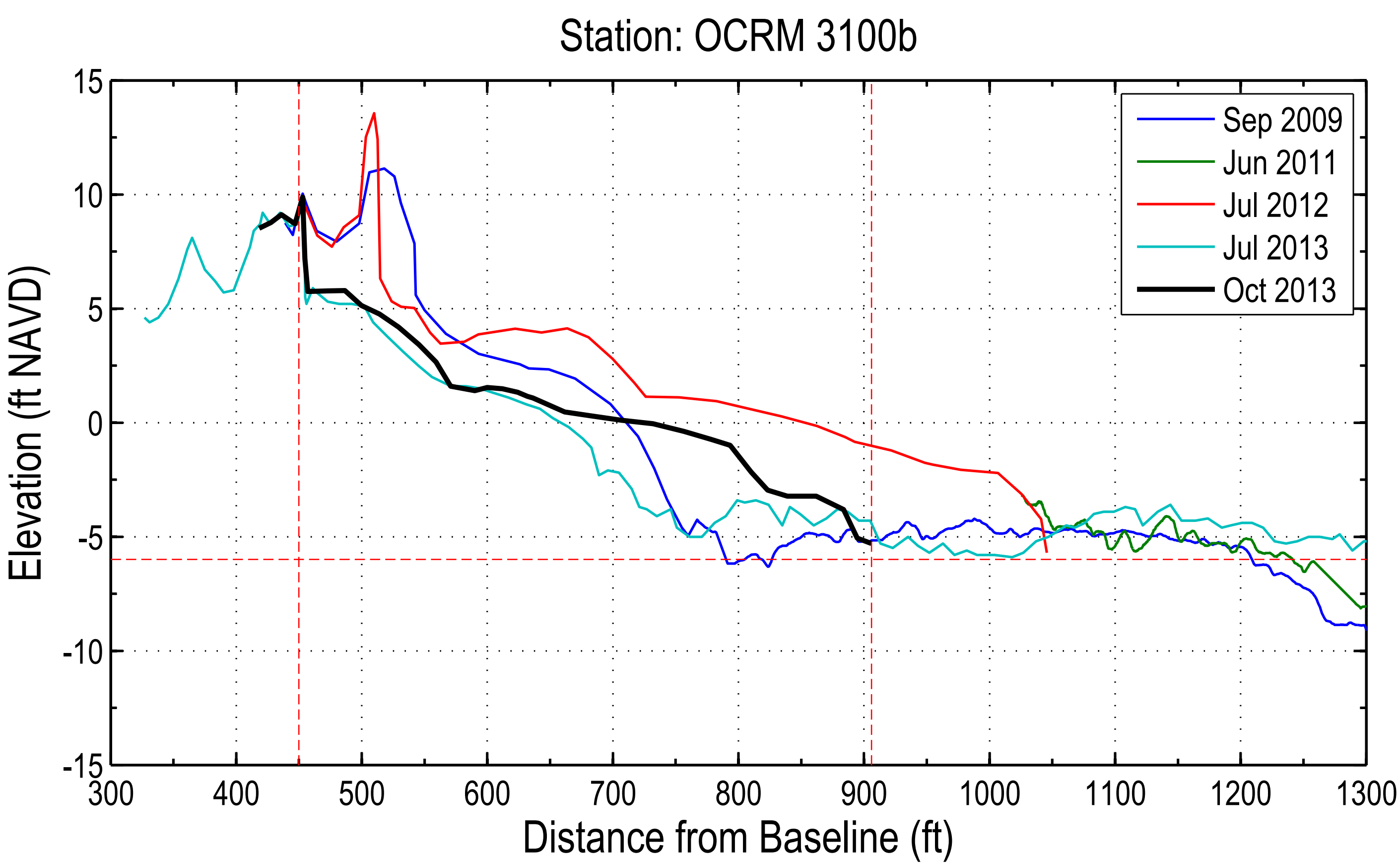

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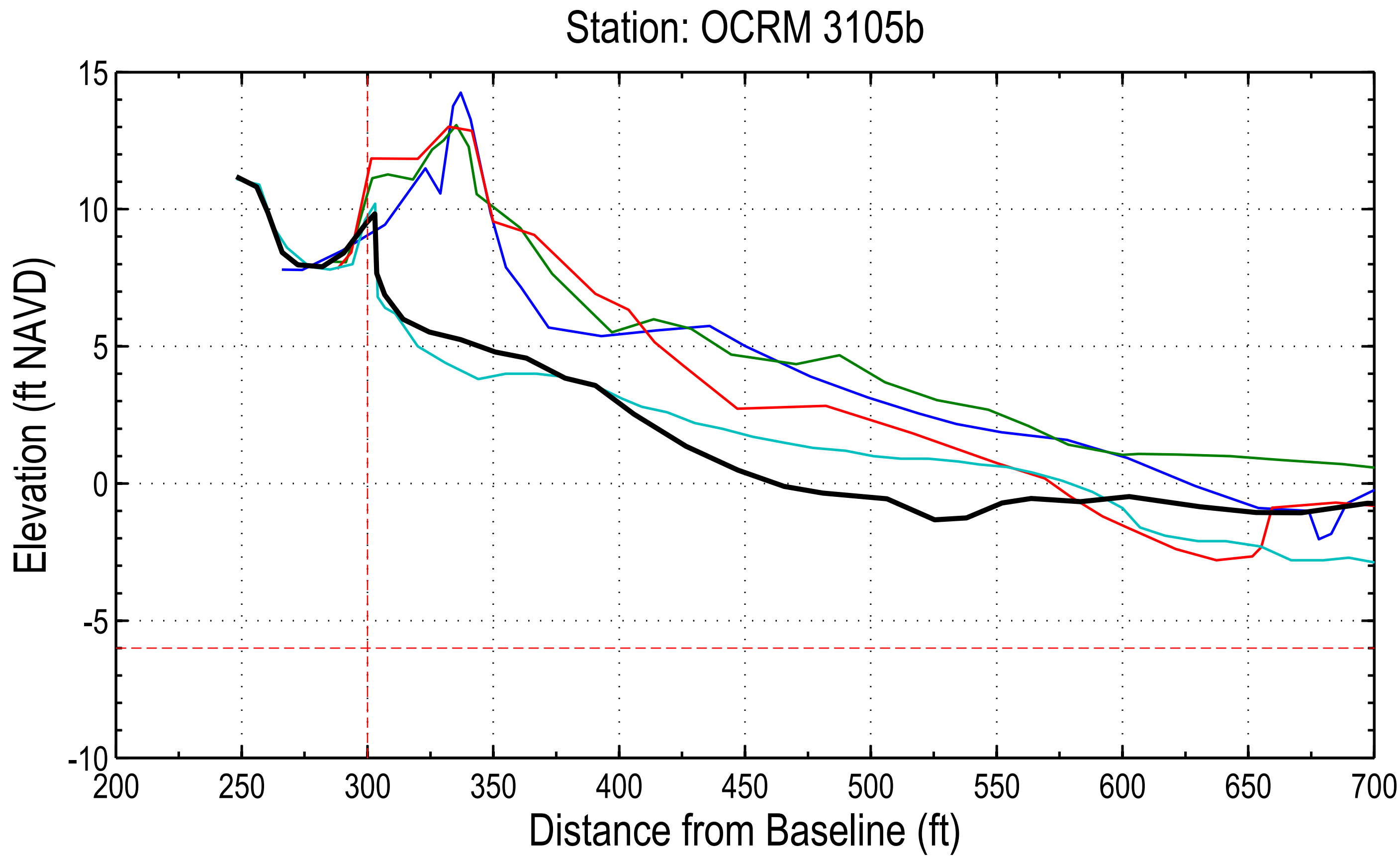

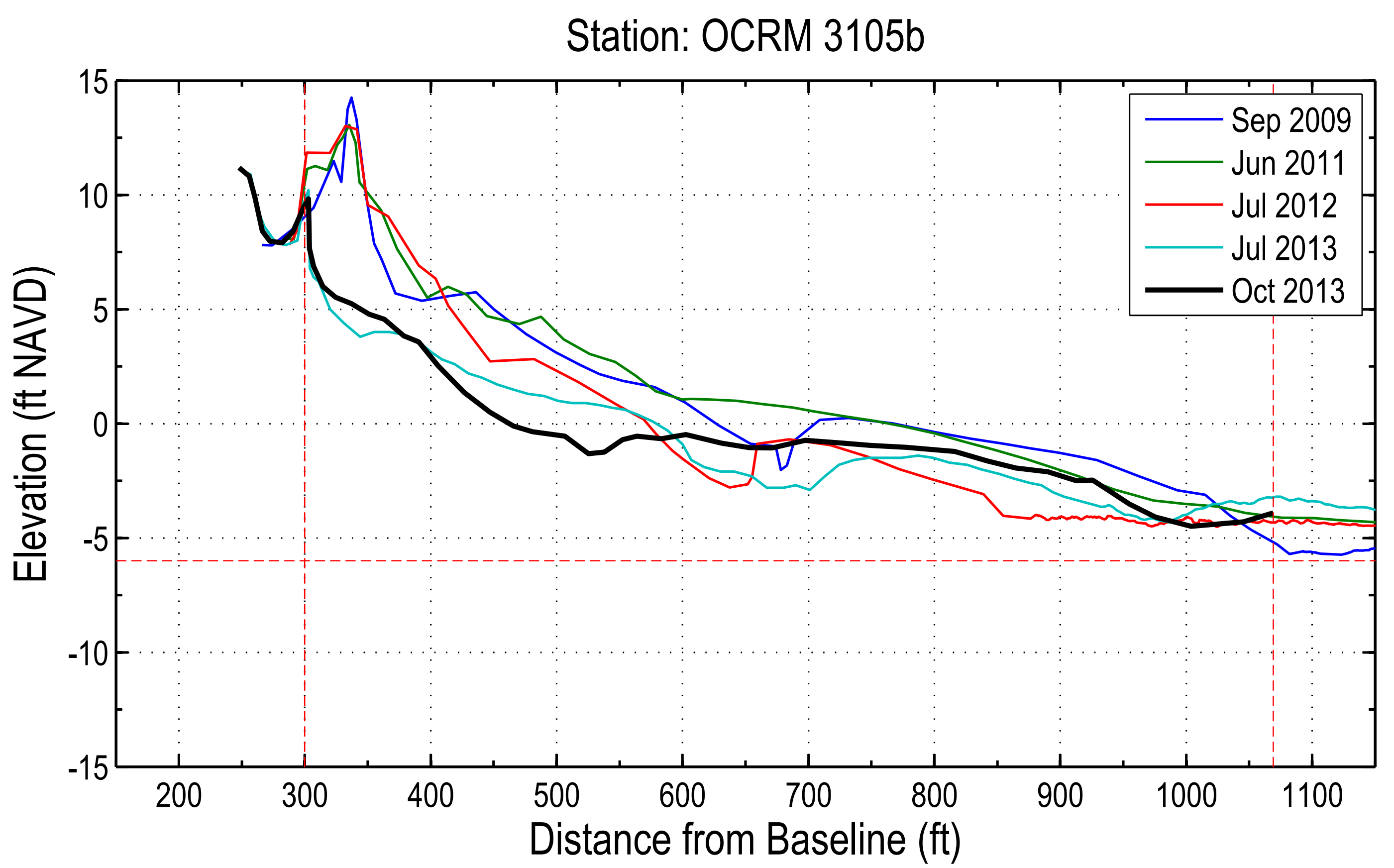

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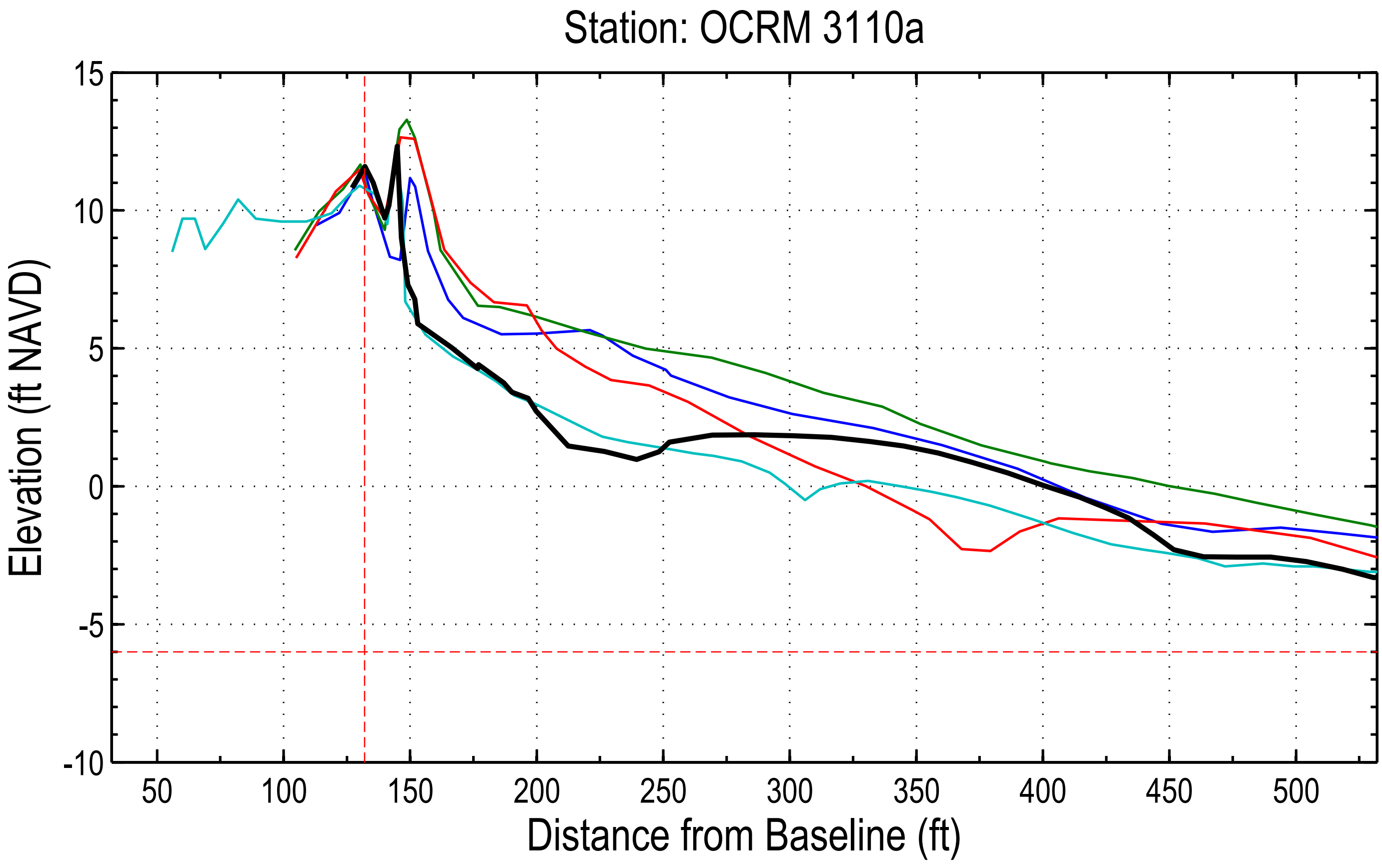

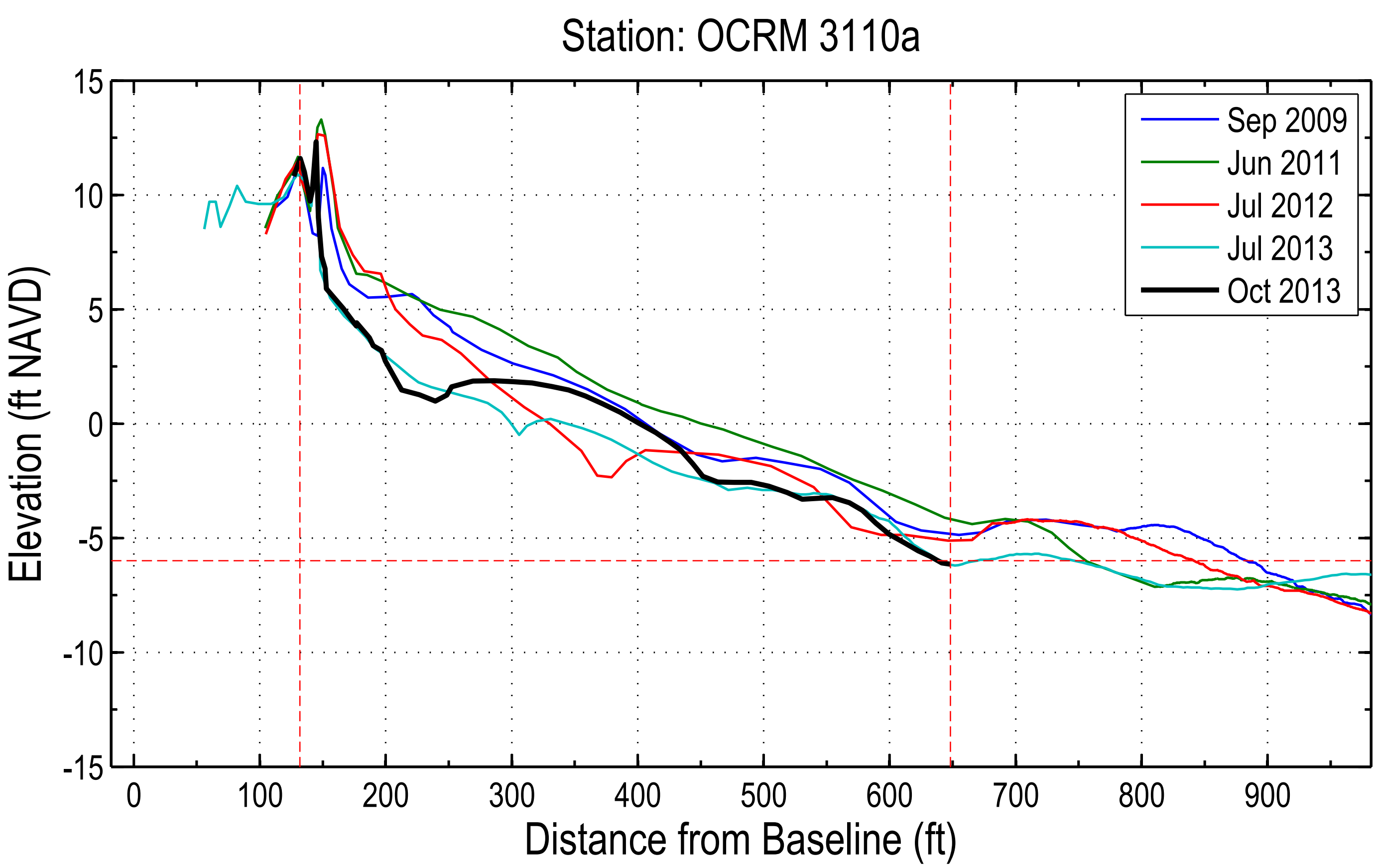

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