TECHNICAL MEMORANDUM

Date: November 28, 2016

To: Yonas Ghile, Southwest Florida Water Management District (SWFWMD)

From: Ravi Nalamothu, P.E., HSW Engineering, Inc.
Dori Sabeh, P.E., HSW Engineering, Inc.
Dean Mades, P.E., HSW Engineering, Inc.
Ken Watson, PhD., HSW Engineering, Inc.

Subject: Lower Peace River-Floodplain Analysis

Introduction

A procedure was developed to determine the functional relationship between flow and tidal stage, and Wetland Community Inundation Area (WCIA) for the river segment of the Lower Peace River (Figure 1).

Study Area Boundaries (Figure 1):

Upstream boundary: Confluence of Horse Creek with Peace River
27°06'14.95" N / 81°59'01.90" W

Downstream boundary: Peace River Manasota Regional Water Supply Authority (PRMRWSA) Intake
27°04'41.88" N / 82°00'27.27" W

The objective of the analysis was to determine the flow reduction associated with a 15% reduction in WCIA.

Analysis Approach

The water-surface elevation output of a LPR Hydrodynamic model (model) developed by SWFWMD was used for the floodplain analysis. The model provided simulated water-surface elevations, i.e., river stage, using unimpaired flows for the time period from 2007 through 2014. Because of the backwater effects from tides, the water surface elevation in the study area is controlled by both flows in the LPR and the tide signals. To capture the flow-tide variability in the LPR, 10 LPR flow scenarios and 8 stage scenarios at cross-section 46 (X46) for each flow were evaluated, resulting in 80 stage values at each cross-section (Figure 1) within the study area (Table 1).

Table 1. Summary of Selected Baseline Conditions

ID	Flow Exceedance	Flow (cfs)	Selected X46 Stage Conditions (ft NAVD88)							
F1	0%	8319	0.34	0.45	0.47	0.48	0.5	0.56	0.97	1.28
F2	0.2%	6175	0.16	0.17	0.28	0.64	0.84	0.85	1.27	1.39
F3	3%	4092	0.42	0.48	0.86	1.07	1.22	1.33	1.54	1.81
F4	6%	3012	-0.26	0.02	0.17	0.35	0.54	0.92	1.31	1.33
F5	10%	2214	0.35	0.46	0.6	0.74	0.86	1.1	1.2	1.49
F6	20%	1123	-1.05	-0.64	-0.48	-0.47	-0.47	-0.34	0.05	0.49
F7	30%	700	-1.3	-0.56	-0.35	-0.3	-0.26	-0.19	0.26	0.44
F8	40%	434	-0.07	0.07	0.61	0.74	0.92	0.97	1.18	1.4

ID	Flow Exceedance	Flow (cfs)	Selected X46 Stage Conditions (ft NAVD88)							
F9	65%	172	-1.25	-0.14	-0.03	-0.01	0.2	0.33	0.39	0.91
F10	100%	16	-0.98	-0.85	-0.23	-0.15	-0.04	0.07	0.19	0.88
Note: The maximum elevation simulated by the model at X46 is 2.563 ft										

The Hydrodynamic model results associated with 10 model input flow exceedances (F1 through F10) and 8 X46 stage conditions for each flow condition were used to generate 80 water-surface TINs in ArcGIS (Figure 2). The water-surface TINs and the District-provided LiDAR land-surface data were used to generate inundation area polygons associated with each of the 80 LPR flow-tidal stage conditions. Inundation area is defined as the area encompassed by the intersection of the water surface and land surface.

The areas of inundated wetland vegetation community types were determined using ArcGIS by overlaying the Co-operative Land Cover (CLC) shapefile with the inundation area shapefiles (Figure 2). The process was performed for each of the selected flow regimes and X46 stage conditions to characterize the association between flow, X46 stage and WCIA. Calculated WCIAs are summarized in Appendix A.

Exploratory analysis of calculated WCIAs and X46 stage showed two distinct breakpoints at about 0.4 ft and 1.2 ft X46 stage with three distinct slopes (Figure 3). Therefore, Piecewise regression analysis in SPSS was used to estimate the relationship between WCIA, Flow, and X46 stage (Table 2 and Appendix B).

Regression equation:

$$WCIA = b0+b1*(X46stage)+b3*flow, \quad \text{for } X46stage<knot1$$

$$WCIA = b0+b1*(X46stage)+b2*(X46stage-knot1)+b3*flow, \quad \text{for } knot1 =< X46stage<knot2$$

$$WCIA = b0+b1*(X46stage)+b2*(X46stage-knot1)+b3*flow+b4*(X46stage-knot2), \text{ for } X46stage>=knot2$$

in which

WCIA = Wetland Community Inundation Area, in acres;

X46stage = Stage at cross-section 46 (ft NAVD88);

b0, b1, b2, b3, and b4 are fit parameters;

knot1 and knot2 are inflection values in the piecewise regression;

Table 2. Summary of piecewise regression analysis results

b0	b1	b2	b3	b4	Knot1	Knot2	R-squared/RMSE	Number of observations
25.856	38.973	728.08	0.012	-588.9	0.426	1.173	0.987/30.21	80

The regression equations were used to calculate the hourly time series of WCIA corresponding to the flow at the upstream end of the model and the stage at XS46 for the simulation time period. Similarly, using the hydrodynamic model results corresponding to flow reductions of 5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40%, the combinations of flow and XS46 stage were used to generate time series of WCIAs. The change in average WCIAs associated with each of the flow reduction scenarios was then estimated.

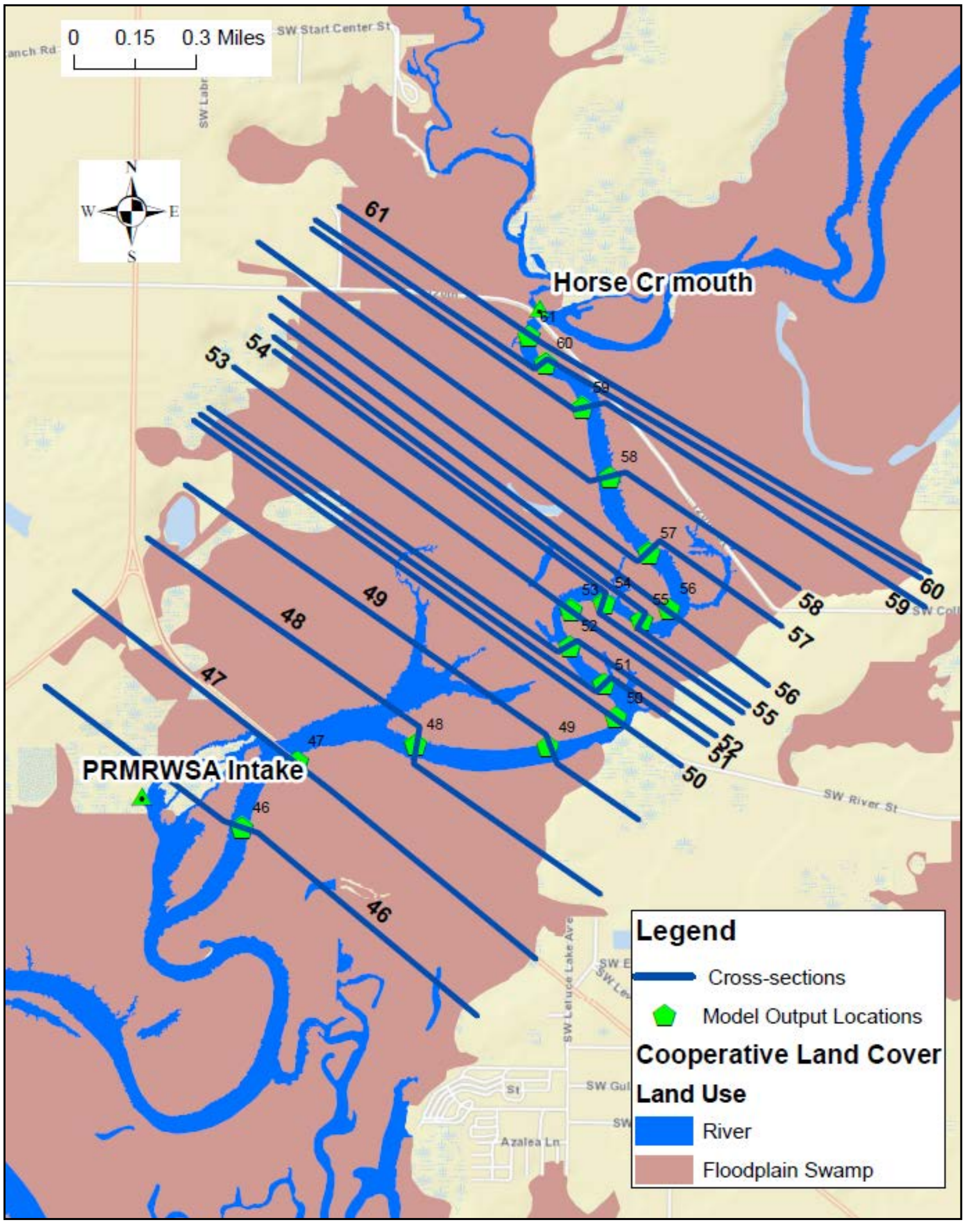


Figure 1. Wetlands near LPR study area

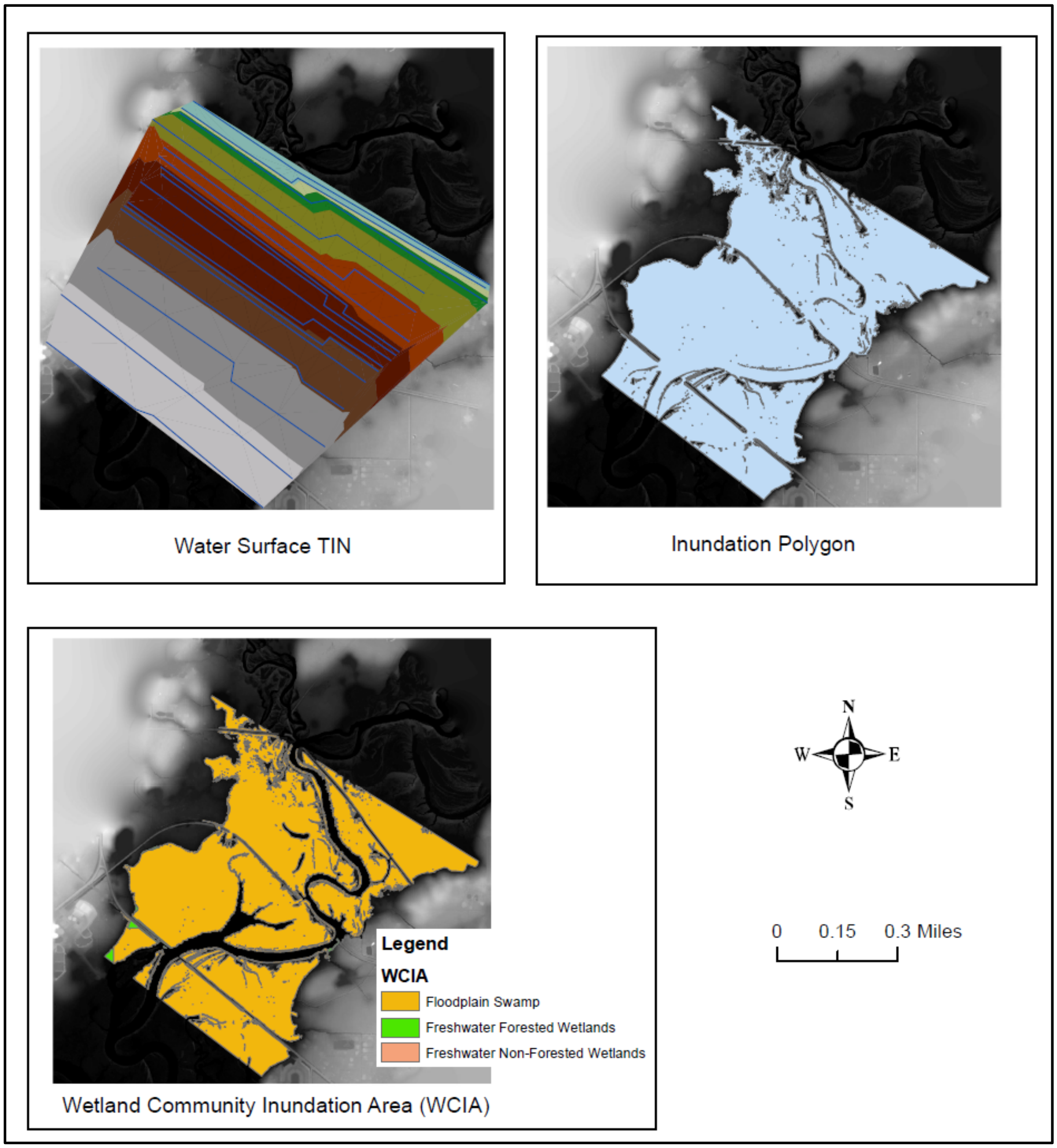


Figure 2. Wetland Community Inundation Area (WCIA) for a selected flow-stage condition near LPR study area

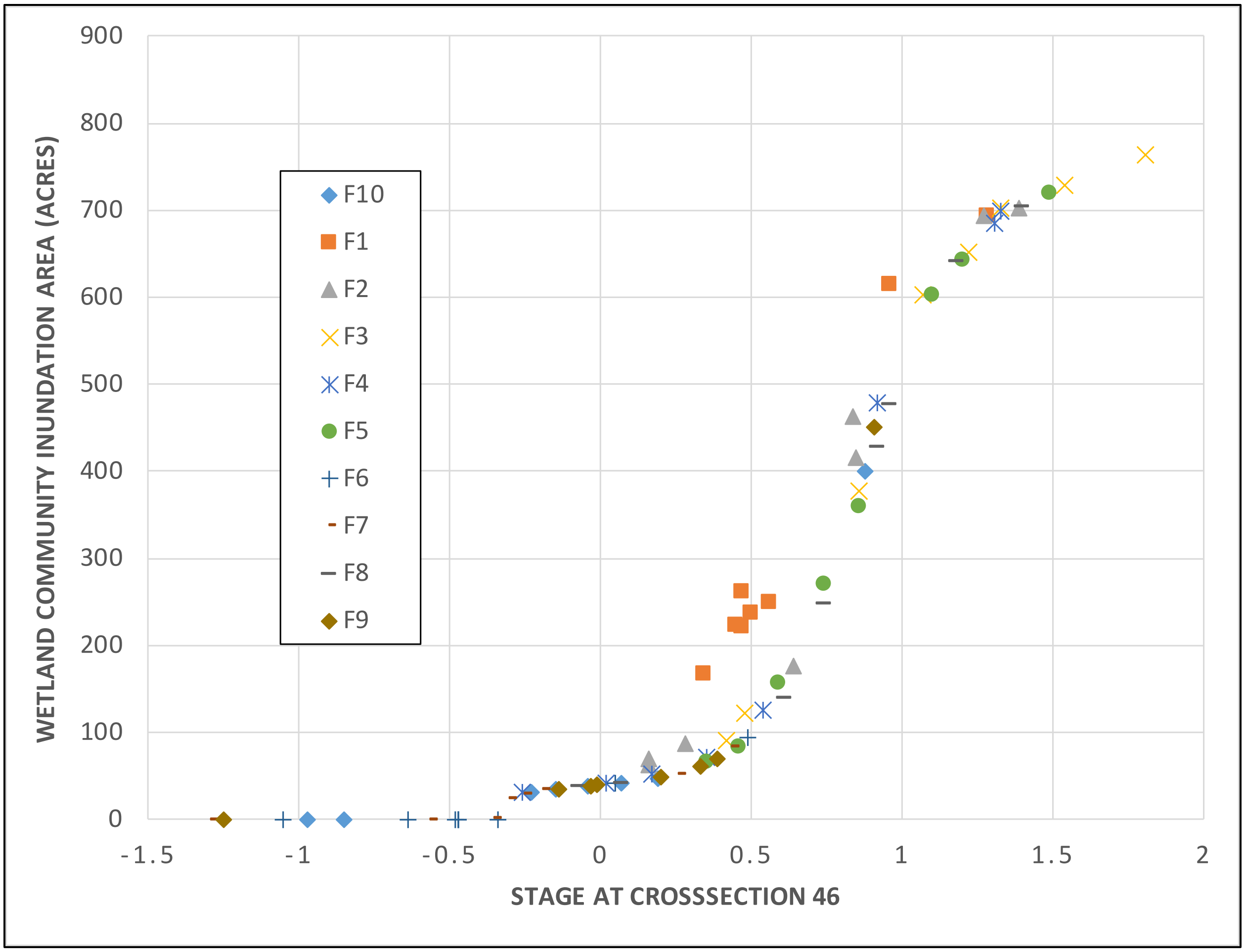


Figure 3. Wetland Community Inundation Area (WCIA) vs. Stage at Cross section 46 (X46)

Summary

The change in inundated habitat area as a function of flow represents a potential loss of the wetland community type area as it functioned under a baseline hydrologic condition and does not necessarily represent a predicted loss in wetland area. The percent change in flow corresponding to a 15% decrease in average WCIA is greater than 40% (Table 3) for the modeled time period (2007-2014). The change in WCIA is much less sensitive to flow reduction than the tidal influence.

The change in average WCIA corresponding to a 40% flow reduction is 7% (Table 3 and Figure 4). The change is average WCIA during July through October (Block 3 flows) is 10.4% (Table 3).

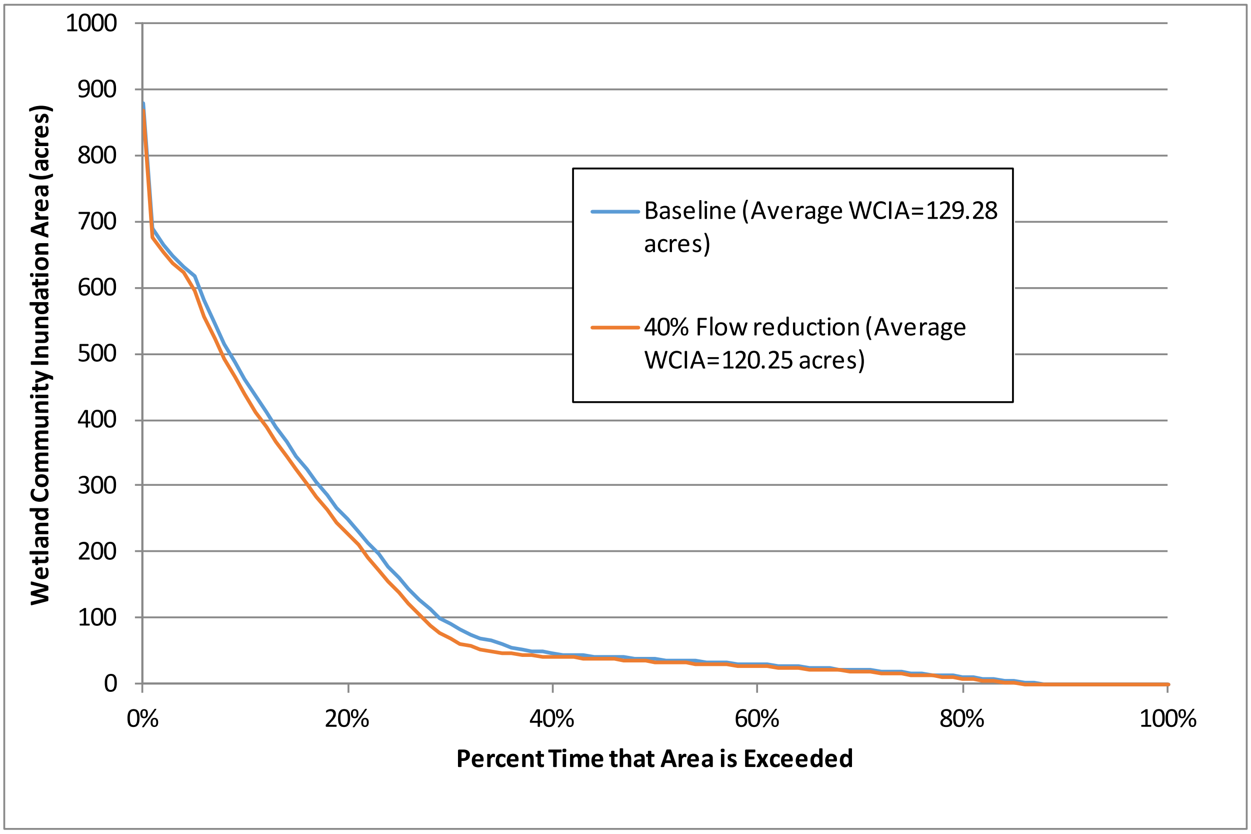


Figure 4. Wetland Community Inundation Area exceedance curve for model POR (2007-2014)

Table 3. Reduction in average WCIA corresponding to various flow reductions

	POR, January through December (2007-2014)		July through October (2007-2014)	
Flow Reduction	Area (acres)	Change in WCIA (%)	Area (acres)	Change in WCIA (%)
0% (Baseline)	129.28	---	189.37	---
5%	128.11	0.9%	186.67	1.4%
10%	126.75	2.0%	183.87	2.9%
15%	125.89	2.6%	181.74	4.0%
20%	124.86	3.4%	179.75	5.1%
25%	123.67	4.3%	177.03	6.5%
30%	122.34	5.4%	173.99	8.1%
35%	121.25	6.2%	171.75	9.3%
40%	120.25	7.0%	169.68	10.4%

APPENDIX A

ID	Flow (cfs)	X46 stage (ft NAVD88)	WCIA (acres)
F10S18	15.67	0.07	42.30
F10S23	15.67	-0.15	35.65
F10S31	15.67	-0.23	31.80
F10S49	15.67	-0.04	39.88
F10S52	15.67	-0.97	0.00
F10S58	15.67	0.88	400.60
F10S69	15.67	-0.85	0.00
F10S78	15.67	0.19	47.72
F1S16	8319.2	0.56	250.80
F1S21	8319.2	0.47	222.22
F1S29	8319.2	0.45	223.44
F1S47	8319.2	0.50	238.84
F1S54	8319.2	1.28	695.13
F1S55	8319.2	0.34	168.20
F1S66	8319.2	0.47	262.41
F1S74	8319.2	0.96	615.17
F2S12	6175.4	0.16	69.79
F2S20	6175.4	0.28	88.32
F2S28	6175.4	1.39	702.94
F2S43	6175.4	0.64	176.61
F2S53	6175.4	0.85	415.92
F2S62	6175.4	0.84	463.08
F2S70	6175.4	1.27	694.86
F2S9	6175.4	0.16	63.70
F3S1	4092.2	1.22	652.18
F3S17	4092.2	0.42	91.99
F3S2	4092.2	1.54	729.39
F3S26	4092.2	0.48	123.64
F3S36	4092.2	0.86	378.05
F3S5	4092.2	1.81	763.93
F3S51	4092.2	1.07	604.03
F3S68	4092.2	1.33	703.54
F4S11	3012.4	0.02	42.97
F4S15	3012.4	0.17	52.63
F4S19	3012.4	-0.26	32.31
F4S25	3012.4	0.35	71.89
F4S40	3012.4	0.54	126.22
F4S56	3012.4	1.31	685.90
F4S67	3012.4	1.33	699.68

F4S76	3012.4	0.92	479.41
F5S24	2214.3	0.35	67.48
F5S3	2214.3	0.86	360.79
F5S34	2214.3	0.46	84.38
F5S4	2214.3	1.20	644.49
F5S41	2214.3	0.74	270.97
F5S63	2214.3	0.59	157.60
F5S75	2214.3	1.10	603.71
F5S8	2214.3	1.49	720.44
F6S35	1123.3	-0.48	0.00
F6S38	1123.3	-0.34	0.00
F6S39	1123.3	-1.05	0.00
F6S44	1123.3	-0.64	0.00
F6S50	1123.3	-0.47	0.00
F6S60	1123.3	0.49	94.38
F6S65	1123.3	-0.47	0.00
F6S72	1123.3	0.05	42.89
F7S33	700.04	-0.25	30.48
F7S37	700.04	-0.56	0.00
F7S45	700.04	0.26	52.83
F7S48	700.04	-0.30	25.56
F7S57	700.04	-0.35	3.02
F7S61	700.04	-1.29	0.00
F7S71	700.04	0.44	84.02
F7S77	700.04	-0.19	35.52
F8S13	433.68	1.40	705.53
F8S27	433.68	-0.07	38.63
F8S30	433.68	0.74	248.44
F8S32	433.68	0.61	139.94
F8S6	433.68	0.92	428.46
F8S64	433.68	0.07	43.20
F8S7	433.68	1.18	641.31
F8S73	433.68	0.96	477.70
F9S10	172.04	0.33	61.83
F9S14	172.04	-0.01	39.96
F9S22	172.04	-0.14	35.89
F9S42	172.04	0.20	49.10
F9S46	172.04	-0.03	39.73
F9S59	172.04	-1.25	0.00
F9S79	172.04	0.91	451.48
F9S80	172.04	0.39	70.04

APPENDIX B

Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
b0	25.856	5.726	14.443	37.269
b1	38.973	10.973	17.104	60.843
b2	728.081	30.851	666.596	789.567
knot1	.426	.018	.390	.462
b3	.012	.001	.009	.015
knot2	1.173	.033	1.108	1.238
b4	-588.937	58.652	-705.831	-472.043

Correlations of Parameter Estimates

	b0	b1	b2	knot1	b3	knot2	b4
b0	1.000	.404	-.233	.326	-.459	.060	.054
b1	.404	1.000	-.401	.403	-.233	.030	.027
b2	-.233	-.401	1.000	.455	.277	-.629	-.455
knot1	.326	.403	.455	1.000	.269	-.304	-.319
b3	-.459	-.233	.277	.269	1.000	-.131	-.118
knot2	.060	.030	-.629	-.304	-.131	1.000	-.119
b4	.054	.027	-.455	-.319	-.118	-.119	1.000

ANOVA[a]

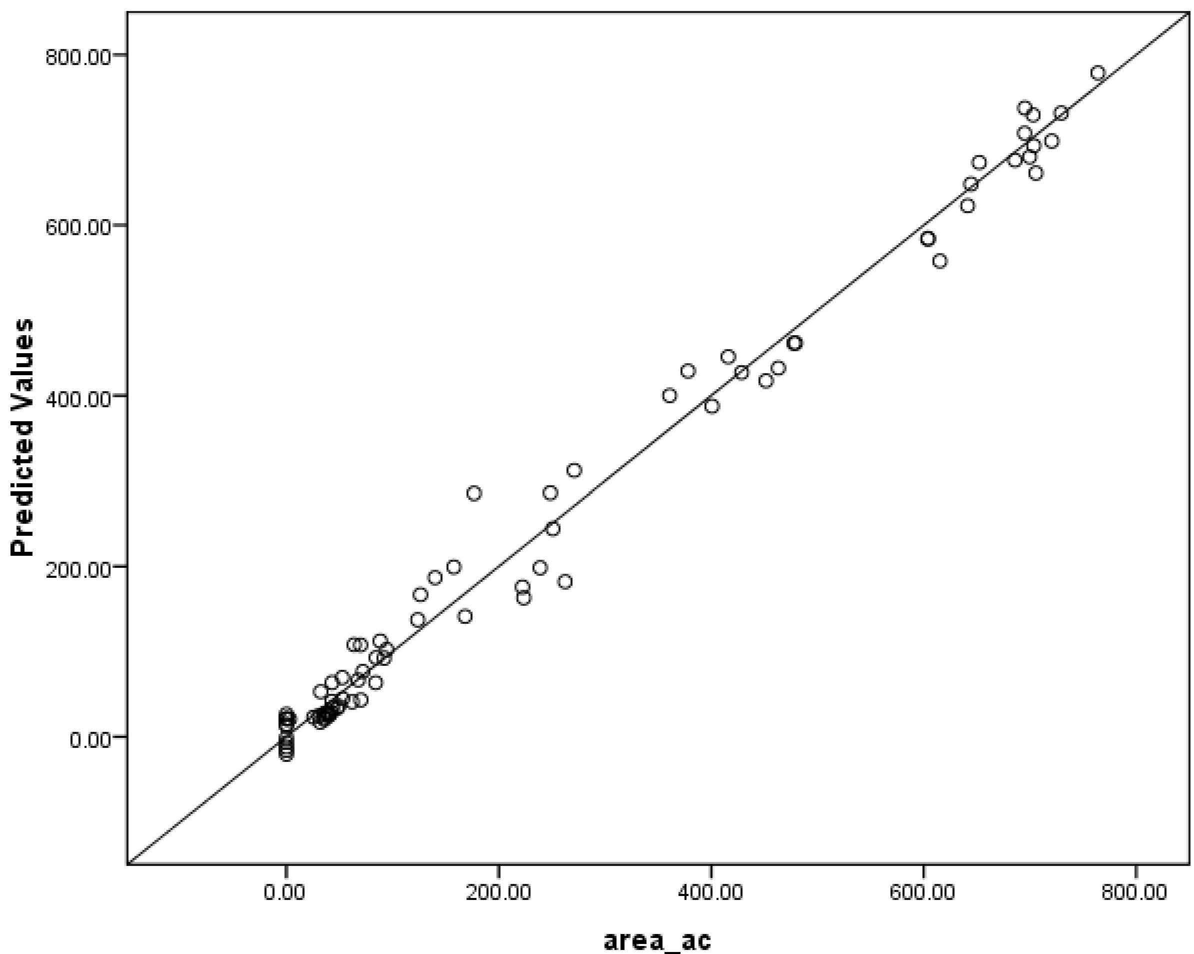
Source	Sum of Squares	df	Mean Squares
Regression	9663514.381	7	1380502.054
Residual	66637.841	73	912.847
Uncorrected Total	9730152.223	80	
Corrected Total	5247561.697	79	

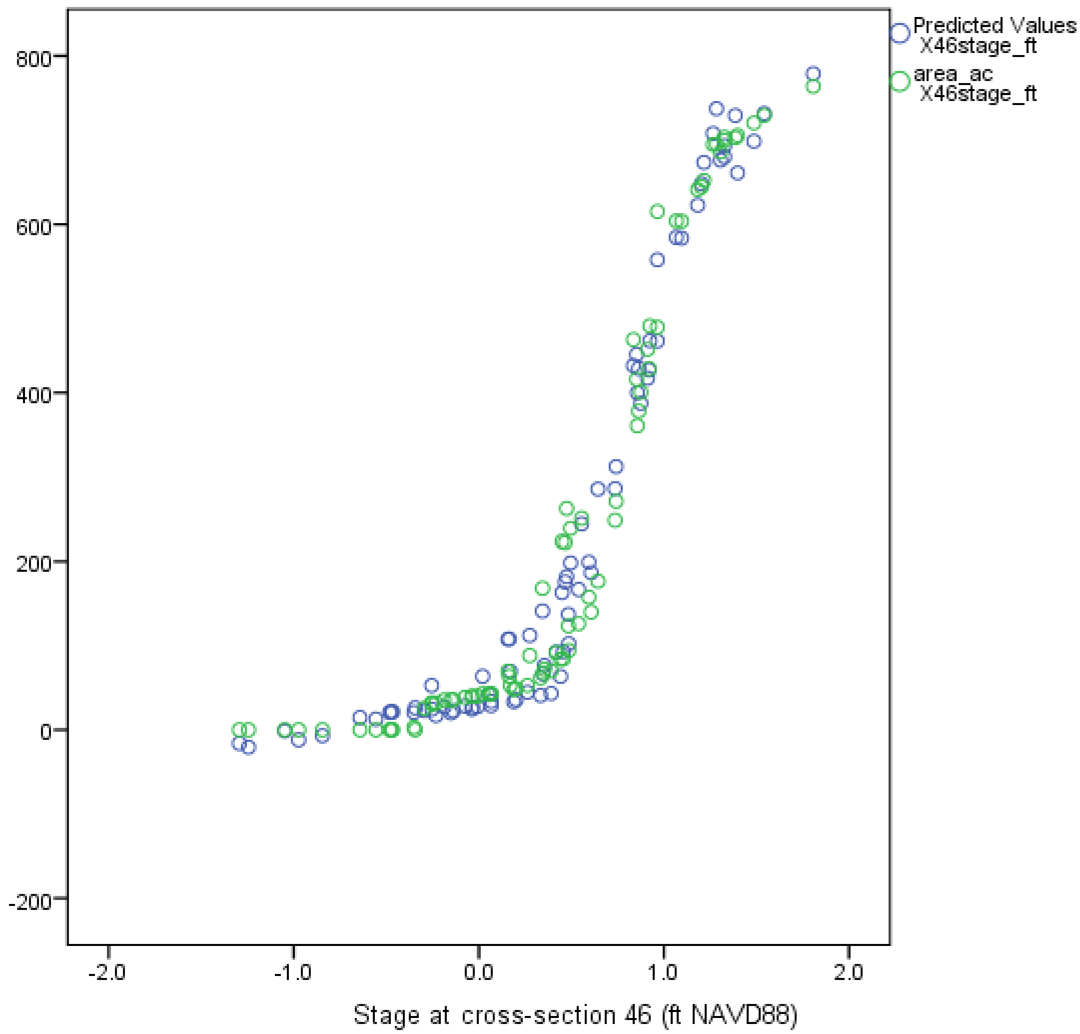
Dependent variable: area_ac

ANOVA[a]

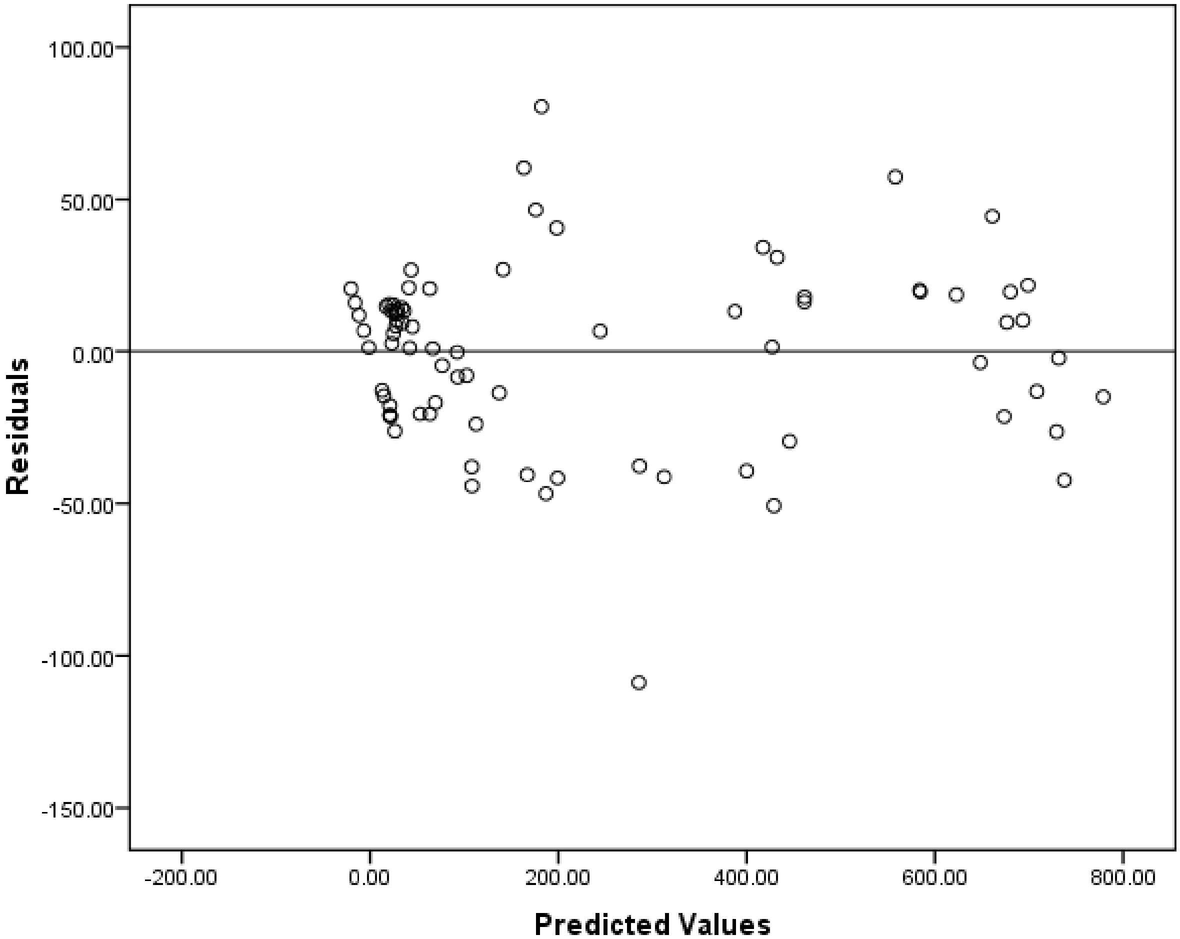
Source	Sum of Squares	df	Mean Squares
Regression	9663514.381	7	1380502.054
Residual	66637.841	73	912.847
Uncorrected Total	9730152.223	80	
Corrected Total	5247561.697	79	

a. R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .987.





800
600
400
200
0
-200
-2.0
-1.0
0.0
1.0
2.0
Stage at cross-section 46 (ft NAVD88)
Predicted Values X46stage_ft
area_ac X46stage_ft


100.00
50.00
0.00
-50.00
-100.00
-150.00
Residuals
-200.00
0.00
200.00
400.00
600.00
800.00
Predicted Values