TECHNICAL PUBLICATION
ERA # 423

RATING DEVELOPMENT FOR FLOW THROUGH CULVERTS UNDER SR9336 IN THE EVERGLADES NATIONAL PARK II: RATING CALIBRATION

BY

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April 2005

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EXECUTIVE SUMMARY

This report summarizes the results of field study, flow monitoring and rating analysis for the culverts along the State Road (SR) 9336 in the Everglades National Park.

Field study has corrected all errors in old records on the location and elevation of culverts along SR 9336. A new GIS map is created with the updated information. Inspection results of site conditions have been documented. Thirteen culvert sites are chosen for flow and water level measurement. Flow monitoring covered measurements of flow, head water and tail water. Totally, 135 flow measurements were made, along with 144 pairs of water level data. Following the procedures in Part I of this report, we estimate the discharge coefficients for 13 representative culverts. We find that discharge coefficients exhibit a linear relationship with the head water level. By using rated discharge coefficients, we calculated flows and compared them with the measurements. Calculated and measured flows compare well.

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LIST OF ACRONYMS AND ABBREVATIONS

CERP	Comprehensive Everglades Restoration Project
ENP	Everglades National Park
RECOVER	REstoration, COordination, and VERification
SR 9336	State Road 9336

Acknowledgements

The authors would like to acknowledge Matahel Ansar, Zhiming Chen, Emile Damisse, Juan Gonzalez, and Garth Redfield for their review of the draft and valuable comments. Robin Campbell and Kathy Conner are gratefully acknowledged for assistance in coordinating the review and production of this document.

INTRODUCTION

In the Everglades National Park (ENP), a 40 mile main park road SR 9336, running from the visitor center to Flamingo, divides the park into two major parts: Shark Slough on the north and west side, Taylor Slough on the south and east side. Under the road, 178 culverts connect the water flow between the two sides. To support RECOVER (REstoration, COordination, and VERification) and CERP (Comprehensive Everglades Restoration Project) efforts, accurate flow computations through the culverts under SR 9336 are needed for regional water balance and flow modeling studies, as well as for evaluating the hydrological well-being of the Everglades.

Even though there was flow and water level monitoring historically along SR 9336, this is the first project designed and implemented for rating development so that flow through all culverts can be properly estimated.

A research proposal was submitted to ENP and a one year work permit was granted to this project. To understand site conditions and select representative culverts for flow monitoring, all culverts along the 40 mile main park road have been identified, marked and labeled. A field investigation report is written on all the culverts titled "Site Conditions of 178 Culverts along SR 9336", which is a reference for flow studies along SR 9336. Information sheets on the culverts along SR 9336 are produced. Some of these sheets are listed in the Appendix.

Thirteen culvert sites were chosen for stream gauging to represent all 178 culverts along SR 9336. They are culverts 11, 24, 30, 34, 43, 59, 69, 77, 89, 108, 118, 143 and 170 (Figure 1**Error! Reference source not found.**). By coordinating with USGS Miami Facility, thirteen pairs of staff gauge tubes were installed at the selected culvert sites. A survey company was hired to determine reference elevations at the staff gauge sites and flow structures. Major survey results are listed in the Appendix.

During the wet season in 2004, extensive field measurements were made in ENP to collect flow and water level data. Data collected includes flow, up stream and down stream gauge readings at each representative culvert site. Flow is measured either by an Acoustic Doppler Flow Meter (ADFM) or a mechanical pygmy flow meter depending on depth and velocity of flow. Depending on the availability of water, some sites have more flow measurement records and some have less. The total number of flow measurements is 135 and that of water level pair measurements is 144. Rating analyses in this report are a result of this field study.

OBJECTIVE AND SCOPE

The objective of this report is to document observations from the field study and perform rating calibration for representative culvert sites along SR 9336 in ENP. The discharge coefficients of the 13 representative culverts are to be used for all the 178 culverts, with each monitoring culvert representing a group with similar characteristics under a segment of SR 9336.

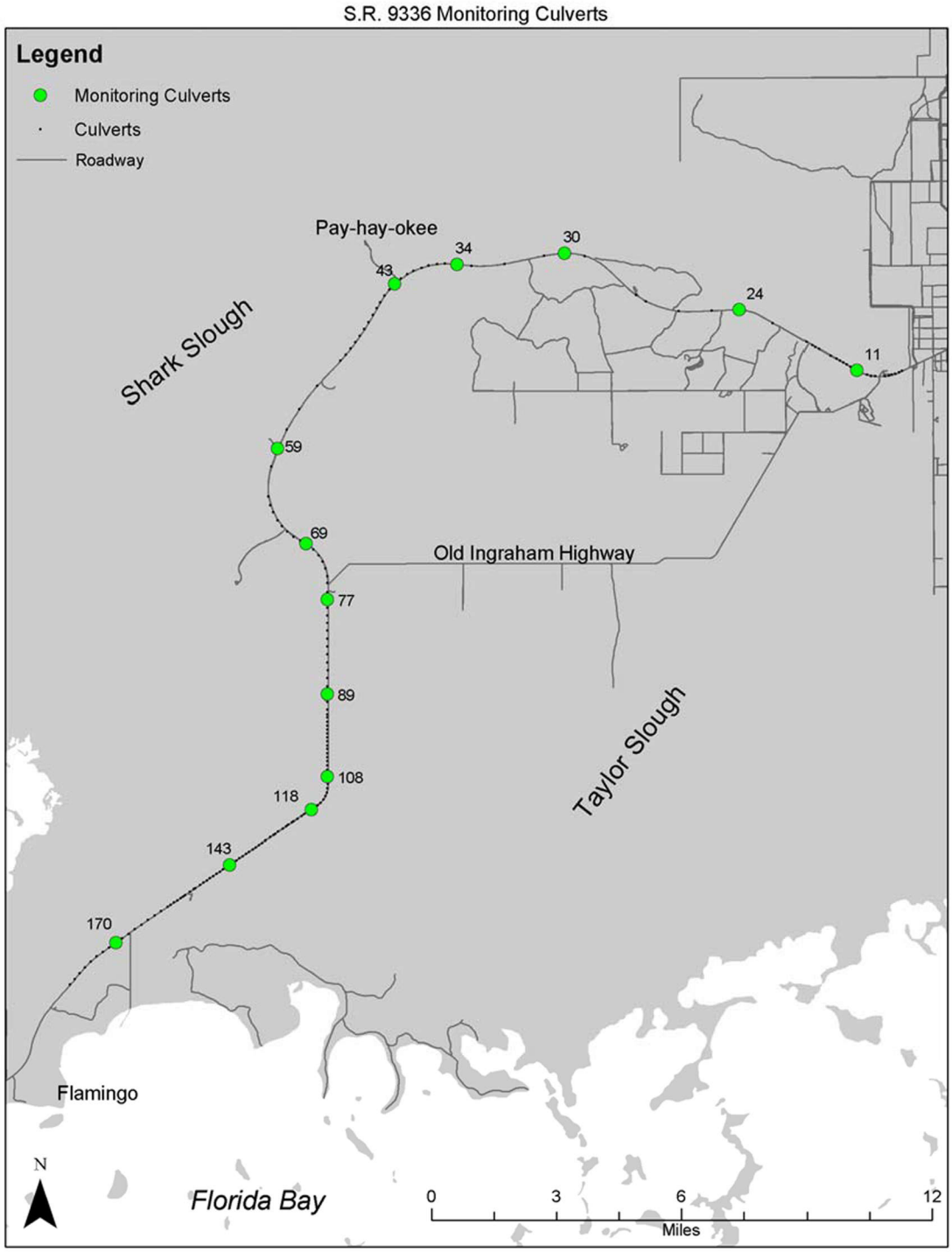

Figure 1. Monitoring culvert sites along SR 9336 in ENP

EQUATIONS DEPICTING CULVERT FLOW IN ENP

In the first volume of this report, flow through culverts along SR 9336 was classified as type 3 and type 4. The following two equations are used to calculate flow for these two types using head difference and discharge coefficient.

$$Q = C_3 A_3 \sqrt{\frac{2g(HW - TW)}{1 + \frac{2gC_3^2 A_3^2 L}{K_2 K_3}}} \quad (1)$$

$$Q = C_4 A_0 \sqrt{\frac{2g(HW - TW)}{1 + \frac{2gC_4^2 A_0^2 L}{K_0^2}}} \quad (2)$$

Where
Q = discharge through culvert,
HW = head water, that is the staff gauge reading in the upstream side,
TW = tail water, that is the staff gauge reading in the down stream side,
C_3, C_4 = coefficients of discharge for type 3 and type 4 flows respectively,
A_3 = area of section of flow at culvert exit,
K_2, K_3 = conveyance of sections at culvert entrance and exit respectively,
L = length of culvert barrel,
g = acceleration of gravity,
A_0 = area of culvert barrel,
K_0 = conveyance of full culvert barrel.

SIZE OF CULVERTS UNDER SR 9336

Except three culverts with a diameter of 3 ft, all the culverts under SR 9336 have a diameter of 2 ft. Culvert diameters are from as-built documents. They are assumed fairly accurate to be used directly to represent the culverts in the field. Direct field measurements show that culvert diameters range from 2 ft to 2.1 ft. For the 13 representative culverts, the measured diameters are used for the rating development. Based on the analysis conducted in Volume I of this report, an error of 5% in diameter will cause an error of around 5% in the calculated flow. Although flow calculation is sensitive to the culvert diameter, this factor will not create a significant discrepancy to the calculated flow when 2 ft is widely used to represent the culvert size along SR 9336.

Most of the culverts have a length ranging from 40 to 50 ft. So on average, 45 ft is used to represent the length of the culverts under SR 9336. This is justified since errors in determining the culvert length do not affect the calculated flow significantly from the analysis in Volume I of this report.

MANNING'S ROUGHNESS COEFFICIENT

The culverts under SR 9336 in ENP are made of normal concrete. A typical Manning's roughness coefficient of 0.013 (Bodhaine, 1968; Lindeburg, 2003) for ordinary concrete pipes is used to represent these culverts. Based on the sensitivity analysis presented in Volume I of this report, a deviation of 25% from n=0.013 causes a change of about 5% in the calculated flow, which is less severe than that caused by the change in discharge coefficient.

FLOW MEASUREMENT ALONG SR 9336

Stream gauging was conducted at the 13 selected sites along SR 9336 in ENP. Flow structures under SR 9336 in ENP are mostly circular culverts. To facilitate measuring flow through the culverts, ADFM (Acoustic Doppler Flow Meter) was adopted. The ADFM consists of a transducer assembly mounted in the culvert, a signal processing unit and an interface cable. Figure 2 shows a typical ADFM installation for measuring open channel flow in a pipe. A transducer assembly is mounted on the invert of a pipe or channel. Piezoelectric ceramics emit short pulses along narrow acoustic beams pointing in different directions. Echoes of these pulses are backscattered from material suspended in the flow. As this material has motion relative to the transducer, the echoes are Doppler shifted in frequency. Measurement of this frequency enables the calculation of the flow speed. A fifth ceramic mounted in the center of the transducer assembly, and aimed vertically, is used to measure the depth (MGD Technologies Inc., 2000 & 2005).

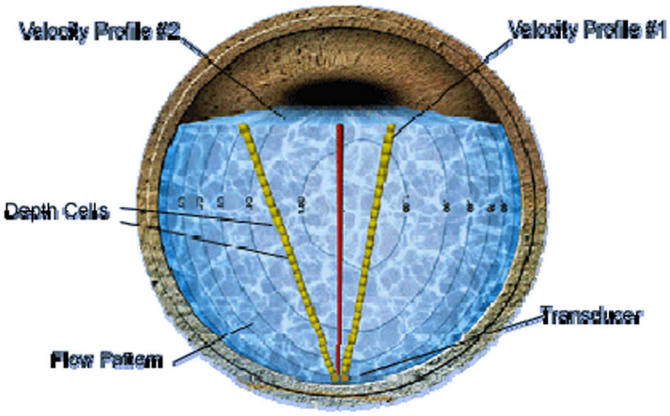

Figure 2. Typical ADFM installation

To hold the ADFM transducer in the flow, a mounting frame was fabricated for the project. The frame consists of a compression band and a flat beam. The band can be compressed or expanded to make a tight contact with the culvert wall. The flat beam is about 3 ft in length. One end is

attached to the compression band; the other end with the ADFM transducer fastened is stretched into the culvert along the bottom of the barrel.

ADFM requires a minimum flow depth of about 8 inches (or 0.67 ft). When the depth of flow is shallower than this, a pygmy meter was used in this project to measure the flow. Since size of the monitoring culverts is 2 ft and depth of flow is less than 2.5 ft, the sixth-tenths-depth (0.6-depth) method is used to measure the flow (Buchanan, et al, 1969).

Table 1 is a sample ADFM measurement record. The sample interval used is one minute, which is the minimum value that can be set for ADFM. The items Avg. Vel, Qmain, Area represent the sectional mean velocity, discharge and area of section of flow respectively. Figure 3 shows the time process of mean sectional velocity and total discharge of Table 1. There are fluctuations with the mean sectional velocity and total discharge measured by the ADFM. Treating all the measured values of every one minute from one measurement as a random sample, probability analysis reveals that the sample follows a standard normal distribution. The means of the samples, displayed as horizontal lines in Figure 3, are used to represent the mean velocity and mean discharge through a culvert during one measurement.

Table 1. A typical ADFM flow measurement record

Date/Time	Minutes	Depth	Avg. Vel	Qmain	Area	Vbm1Avg	Vbm2Avg	QPro	Qmva	HC VarN	HC FixedN
		(ft)	(ft/s)	(ft^3/s)	(ft^2)	(ft/s)	(ft/s)	(ft^3/s)	(ft^3/s)		
9/22/2004 14:13	0:00	1.473	1.52	3.944	2.595	1.348	1.89	4.338	3.944	1.658	1.403
9/22/2004 14:14	0:01	1.463	1.42	3.658	2.576	1.342	1.512	3.658	3.568	1.554	1.313
9/22/2004 14:15	0:02	1.473	1.383	3.589	2.595	1.64	1.368	4.517	3.589	1.508	1.277
9/22/2004 14:16	0:03	1.48	1.279	3.334	2.607	1.476	1.391	4.598	3.334	1.391	1.179
9/22/2004 14:17	0:04	1.48	1.519	3.96	2.607	1.48	1.798		3.96	1.652	1.401
9/22/2004 14:18	0:05	1.463	1.72	4.431	2.576	2.008	1.545		4.431	1.882	1.59
9/22/2004 14:19	0:06	1.48	1.517	3.954	2.607	1.516	1.266		3.954	1.65	1.398
9/22/2004 14:20	0:07	1.463	1.437	3.702	2.576	1.617	1.322	4.055	3.702	1.573	1.329
9/22/2004 14:21	0:08	1.473	1.733	4.498	2.595	1.969	1.473	4.669	4.498	1.89	1.6
9/22/2004 14:22	0:09	1.467	1.274	3.291	2.582	1.22	1.713		3.291	1.393	1.178
9/22/2004 14:23	0:10	1.476	1.284	3.341	2.602	1.289	1.404	3.67	3.341	1.399	1.185
9/22/2004 14:24	0:11	1.476	1.479	3.848	2.602	1.434	1.578		3.848	1.611	1.365
9/22/2004 14:25	0:12	1.473	1.772	4.596	2.594	1.841	1.591	4.596	4.711	1.932	1.635
9/22/2004 14:26	0:13	1.47	1.785	4.622	2.589	2.201	1.447	4.78	4.622	1.949	1.649
9/22/2004 14:27	0:14	1.463	1.549	3.989	2.576	1.637	1.411	3.989	4.066	1.694	1.432
9/22/2004 14:28	0:15	1.47	1.052	2.724	2.589	0.902	1.729		2.724	1.149	0.972
9/22/2004 14:29	0:16	1.47	1.414	3.661	2.589	1.745	1.339	4.32	3.661	1.544	1.306
9/22/2004 14:30	0:17	1.467	1.604	4.141	2.582	1.503	1.798		4.141	1.753	1.482
9/22/2004 14:31	0:18	1.473	1.41	3.66	2.595	1.598	1.421	4.086	3.66	1.538	1.302
9/22/2004 14:32	0:19	1.47	1.796	4.649	2.589	1.893	1.591	5.028	4.649	1.961	1.659
9/22/2004 14:33	0:20	1.483	1.279	3.343	2.613	1.014	1.585	3.913	3.343	1.39	1.179
9/22/2004 14:34	0:21	1.467	1.34	3.46	2.582	1.299	1.562	3.88	3.46	1.465	1.238
9/22/2004 14:35	0:22	1.473	1.476	3.83	2.595	1.424	1.522	4.887	3.83	1.61	1.363
9/22/2004 14:36	0:23	1.473	1.71	4.438	2.595	1.535	1.87	4.732	4.438	1.865	1.579
9/22/2004 14:37	0:24	1.467	1.47	3.797	2.582	1.654	1.355		3.797	1.607	1.359
9/22/2004 14:38	0:25	1.47	1.058	2.74	2.589	0.912	1.388	3.148	2.74	1.156	0.978
9/22/2004 14:39	0:26	1.463	1.219	3.139	2.576	1.401	1.194	3.927	3.139	1.334	1.127
9/22/2004 14:40	0:27	1.473	1.709	4.433	2.594	1.614	1.667	4.433	4.362	1.863	1.577
9/22/2004 14:41	0:28	1.463	1.445	3.722	2.576	1.791	1.257	4.284	3.722	1.581	1.336
9/22/2004 14:42	0:29	1.473	1.968	5.108	2.595	1.841	1.808	4.259	5.108	2.147	1.817
9/22/2004 14:43	0:30	1.476	1.304	3.392	2.602	1.217	1.621		3.392	1.42	1.203
9/22/2004 14:44	0:31	1.463	1.734	4.466	2.576	1.814	1.804		4.466	1.897	1.603
9/22/2004 14:45	0:32	1.47	1.726	4.467	2.589	2.133	1.601	5.224	4.467	1.884	1.594

Date/Time	Minutes	Depth (ft)	Avg. Vel (ft/s)	Qmain (ft^3/s)	Area (ft^2)	Vbm1Avg (ft/s)	Vbm2Avg (ft/s)	QPro (ft^3/s)	Qmva (ft^3/s)	HC VarN	HC FixedN
9/22/2004 14:46	0:33	1.473	1.699	4.409	2.595	1.621	1.581		4.409	1.853	1.568
9/22/2004 14:47	0:34	1.473	1.701	4.414	2.595	2.188	1.486	4.934	4.414	1.855	1.57
9/22/2004 14:48	0:35	1.47	1.734	4.489	2.589	1.814	1.791		4.489	1.893	1.601
9/22/2004 14:49	0:36	1.467	1.509	3.897	2.582	1.581	1.457		3.897	1.649	1.394
9/22/2004 14:50	0:37	1.47	1.562	4.044	2.589	1.713	1.414	4.252	4.044	1.705	1.443
9/22/2004 14:51	0:38	1.473	1.405	3.645	2.595	1.532	1.467	4.13	3.645	1.532	1.297
9/22/2004 14:52	0:39	1.47	0.897	2.321	2.589	1.155	1.047		2.321	0.979	0.828
9/22/2004 14:53	0:40	1.463	1.542	3.971	2.576	1.722	1.512	4.821	3.971	1.687	1.425
9/22/2004 14:54	0:41	1.463	1.182	3.046	2.576	1.161	1.414	3.747	3.046	1.294	1.093
9/22/2004 14:55	0:42	1.47	1.283	3.321	2.589	1.027	1.568		3.321	1.4	1.185
9/22/2004 14:56	0:43	1.47	1.751	4.531	2.588	1.736	1.654	4.531	4.455	1.911	1.617
9/22/2004 14:57	0:44	1.473	0.953	2.474	2.595	0.636	1.519		2.474	1.04	0.88
9/22/2004 14:58	0:45	1.48	1.687	4.397	2.607	1.824	1.69		4.397	1.835	1.555
9/22/2004 14:59	0:46	1.473	1.675	4.347	2.595	1.759	1.604		4.347	1.827	1.547
9/22/2004 15:00	0:47	1.47	1.372	3.552	2.589	1.677	1.391	4.308	3.552	1.498	1.267
9/22/2004 15:01	0:48	1.467	1.584	4.091	2.582	1.739	1.299		4.091	1.731	1.464

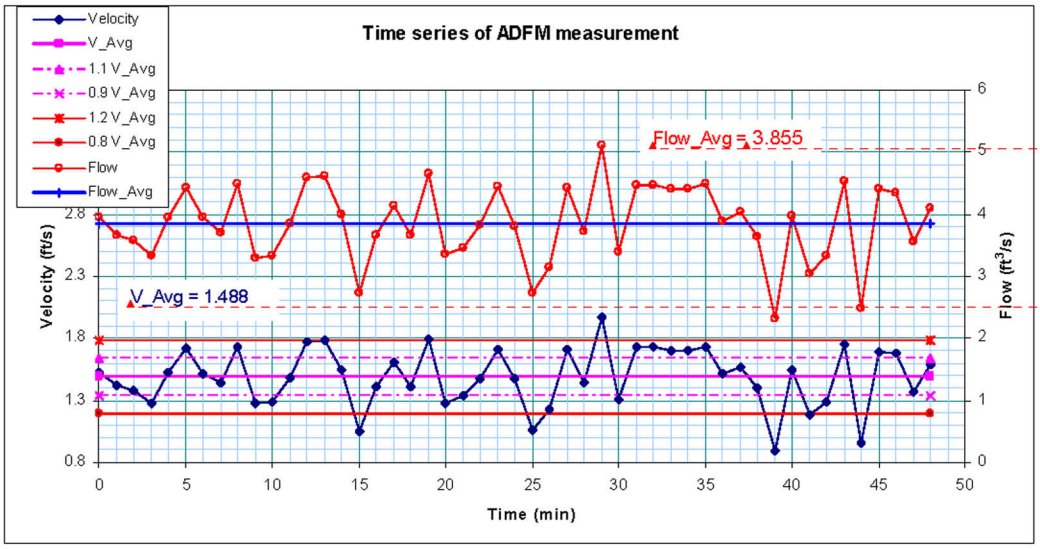

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Figure 3. Time process of mean sectional velocity and total discharge of an ADFM measurement

ESTIMATION OF DISCHARGE COEFFICIENTS

The Stream gauging records collected at the 13 selected sites along SR 9336 during the year 2004 are tabulated in Appendix VII. Using the procedures stipulated in "Part I: Concepts and Methods" of this report, we conduct rating analyses to estimate the discharge coefficients. The results are listed in Table 2 to Table 14. Some flow measurements are omitted due to unsatisfactory quality of data, which are not suitable for estimation of discharge coefficient.

Table 2. Determination of coefficient of discharge for Culvert 11

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-08-04	3.321	2.950	2.880	0.070	1.690	1.399	1.61	2.128	2.841	4.469	0.636	240.138	1.910	2.451	4.010	0.611	201.773	0.805	0.01024	0.060	0.691

Notes:

Each row in the table corresponds to one flow measurement. The notations of variables of $\Theta_2, A_2, P_2, R_2, K_2, \Theta_3, A_3, P_3, R_3, K_3$, etc are the same as those in Part I of this report.

Table 3. Determination of coefficient of discharge for Culvert 24

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-08-04	2.290	4.030	3.960	0.070	2.280	1.96	2.00	3.142	3.142	6.283	0.500	226.224	2.858	3.127	5.716	0.547	239.050	1.140	0.0044	0.066	0.356
2004-08-18	1.031	3.960	3.880	0.080	2.210	2	2.00	3.142	3.142	6.283	0.500	226.224	3.142	3.142	6.283	0.500	226.224	1.105	0.0009	0.079	0.146
2004-10-19	1.128	3.980	3.900	0.080	2.230	2	2.00	3.142	3.142	6.283	0.500	226.224	3.142	3.142	6.283	0.500	226.224	1.115	0.0011	0.079	0.159

Table 4. Determination of coefficient of discharge for Culvert 30

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-08-11	0.409	3.710	3.680	0.030	1.850	1.73	1.76	2.310	3.096	4.851	0.638	262.303	2.275	3.053	4.778	0.639	258.824	0.881	0.00011	0.030	0.097
2004-08-18	0.666	4.070	4.050	0.020	2.210	2.09	2.10	3.142	3.464	6.597	0.525	257.658	3.003	3.462	6.307	0.549	265.252	1.052	0.00029	0.020	0.171
2004-08-27	0.245	3.660	3.640	0.020	1.800	1.67	1.71	2.251	3.020	4.726	0.639	256.130	2.202	2.954	4.625	0.639	250.366	0.857	0.00004	0.020	0.073
2004-09-01	0.303	3.705	3.690	0.015	1.845	1.72	1.75	2.304	3.088	4.838	0.638	261.721	2.263	3.036	4.752	0.639	257.494	0.879	0.00006	0.015	0.102

Table 5. Determination of coefficient of discharge for Culvert 34

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-08-06	5.29	2.38	2.31	0.070	1.980	2.05	1.88	2.484	3.272	5.216	0.627	274.053	2.832	3.442	5.947	0.579	273.282	0.943	0.017	0.053	0.830
2004-08-11	3.71	2.26	2.21	0.050	1.860	1.959	1.77	2.322	3.111	4.877	0.638	263.441	2.617	3.363	5.496	0.612	277.107	0.886	0.008	0.042	0.674
2004-08-18	5.48	2.57	2.5	0.070	2.170	2.1	2.06	2.870	3.449	6.027	0.572	271.761	3.142	3.464	6.597	0.525	257.658	1.033	0.019	0.051	0.877
2004-09-01	2.87	2.24	2.18	0.060	1.840	1.93	1.75	2.298	3.081	4.826	0.638	261.132	2.565	3.332	5.386	0.619	276.474	0.876	0.005	0.055	0.459
2004-09-16	0.24	1.96	1.94	0.020	1.560	1.66	1.48	1.995	2.613	4.189	0.624	218.012	2.191	2.937	4.600	0.638	248.852	0.743	0.000	0.020	0.071
2004-09-23	1.49	2.1	2.07	0.030	1.700	1.81	1.62	2.139	2.858	4.492	0.636	241.710	2.380	3.175	4.998	0.635	268.143	0.810	0.002	0.028	0.347

2004-10-01	1.72	2.12	2.08	0.040	1.720	1.83	1.63	2.161	2.892	4.537	0.637	244.789	2.408	3.203	5.057	0.633	270.059	0.819	0.002	0.038	0.342
2004-10-05	0.66	2.03	2.01	0.020	1.630	1.74	1.55	2.065	2.738	4.338	0.631	230.287	2.288	3.068	4.804	0.639	260.120	0.776	0.000	0.020	0.190
2004-10-19	5.60	2.582	2.5	0.082	2.182	2.1	2.07	2.914	3.455	6.119	0.565	269.793	3.142	3.464	6.597	0.525	257.658	1.039	0.020	0.062	0.812
2004-11-05	1.01	2.115	2.09	0.025	1.715	1.83	1.63	2.155	2.883	4.526	0.637	244.028	2.408	3.203	5.057	0.633	270.059	0.817	0.001	0.024	0.251

Table 6. Determination of coefficient of discharge for Culvert 43

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\, h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-07-28	4.62	1.690	1.580	0.110	1.290	1.25	1.23	1.739	2.099	3.651	0.575	165.832	1.762	2.149	3.701	0.581	171.000	0.614	0.034	0.076	0.972
2004-08-06	5.61	1.86	1.70	0.160	1.460	1.29	1.39	1.898	2.427	3.985	0.609	199.358	1.802	2.233	3.785	0.590	179.604	0.695	0.040	0.120	0.903
2004-08-20	7.83	2.09	1.84	0.250	1.690	1.41	1.61	2.128	2.841	4.469	0.636	240.138	1.916	2.463	4.023	0.612	202.974	0.805	0.057	0.193	0.901
2004-08-26	5.98	1.99	1.83	0.160	1.590	1.43	1.51	2.025	2.667	4.252	0.627	223.365	1.945	2.520	4.085	0.617	208.727	0.757	0.035	0.125	0.836
2004-10-19	8.31	2.245	2.02	0.225	1.845	1.588	1.75	2.304	3.088	4.838	0.638	261.721	2.109	2.810	4.428	0.635	237.188	0.879	0.050	0.175	0.881

Table 7. Determination of coefficient of discharge for Culvert 59

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\, h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-06-16	2.75	0.40	0.27	0.13	1.24	1.20	1.18	1.693	2.000	3.555	0.563	155.782	1.718	2.054	3.608	0.569	161.286	0.590	0.014	0.116	0.489
2004-07-23	2.66	0.42	0.32	0.10	1.26	1.20	1.20	1.711	2.039	3.594	0.568	159.804	1.712	2.042	3.596	0.568	160.016	0.600	0.012	0.088	0.548
2004-08-06	7.83	0.89	0.54	0.35	1.73	1.47	1.64	2.172	2.908	4.560	0.638	246.294	1.979	2.584	4.156	0.622	215.145	0.824	0.052	0.298	0.692
2004-08-12	5.61	0.70	0.52	0.18	1.54	1.45	1.46	1.975	2.576	4.148	0.621	214.375	1.962	2.551	4.119	0.619	211.856	0.733	0.031	0.149	0.710
2004-08-20	11.15	1.21	0.76	0.45	2.05	1.68	1.95	2.596	3.351	5.451	0.615	276.936	2.211	2.965	4.643	0.639	251.409	0.976	0.080	0.370	0.771
2004-08-26	8.74	1.08	0.80	0.28	1.92	1.71	1.82	2.400	3.195	5.039	0.634	269.503	2.249	3.019	4.724	0.639	255.992	0.914	0.050	0.230	0.752
2004-09-15	4.88	0.69	0.57	0.12	1.53	1.47	1.45	1.965	2.558	4.127	0.620	212.537	1.977	2.580	4.152	0.621	214.760	0.729	0.023	0.097	0.758
2004-09-22	3.86	0.75	0.61	0.14	1.59	1.47	1.51	2.025	2.667	4.252	0.627	223.365	1.983	2.592	4.165	0.622	215.913	0.757	0.014	0.126	0.522
2004-10-01	2.30	0.74	0.70	0.04	1.58	1.53	1.50	2.015	2.649	4.231	0.626	221.595	2.042	2.698	4.289	0.629	226.403	0.752	0.005	0.035	0.565
2004-10-06	2.49	0.62	0.58	0.04	1.46	1.43	1.39	1.898	2.427	3.985	0.609	199.358	1.939	2.508	4.072	0.616	207.545	0.695	0.007	0.033	0.678
2004-10-12	2.02	0.60	0.55	0.05	1.44	1.40	1.37	1.878	2.389	3.945	0.606	195.506	1.907	2.445	4.004	0.611	201.170	0.686	0.005	0.045	0.482
2004-10-21	11.02	1.32	0.93	0.39	2.16	1.77	2.05	2.838	3.443	5.960	0.578	273.044	2.325	3.114	4.883	0.638	263.676	1.029	0.076	0.314	0.788

Table 8. Determination of coefficient of discharge for Culvert 69

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\, h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}

	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-07-23	0.61	0.15	0.14	0.01	1.05	1.03	1.00	1.544	1.594	3.165	0.504	115.329	1.576	1.661	3.230	0.514	121.812	0.512	0.001	0.009	0.485
2004-07-29	4.54	0.62	0.52	0.10	1.52	1.43	1.44	1.992	2.485	4.083	0.608	203.947	1.973	2.451	4.044	0.606	200.631	0.741	0.023	0.077	0.831
2004-08-05	4.92	0.71	0.57	0.14	1.61	1.40	1.53	2.085	2.641	4.275	0.618	218.991	1.944	2.400	3.986	0.602	195.574	0.785	0.025	0.115	0.755
2004-08-19	5.15	0.73	0.58	0.15	1.63	1.50	1.55	2.107	2.675	4.319	0.619	222.148	2.050	2.584	4.203	0.615	213.598	0.795	0.025	0.125	0.703
2004-08-26	3.66	0.59	0.50	0.09	1.49	1.43	1.42	1.962	2.431	4.021	0.605	198.675	1.979	2.462	4.057	0.607	201.741	0.727	0.015	0.075	0.677
2004-09-15	1.65	0.38	0.34	0.04	1.28	1.24	1.22	1.758	2.040	3.604	0.566	159.500	1.778	2.080	3.645	0.571	163.542	0.624	0.005	0.035	0.526
2004-09-16	1.53	0.35	0.31	0.04	1.25	1.18	1.19	1.730	1.982	3.547	0.559	153.720	1.723	1.967	3.531	0.557	152.196	0.610	0.004	0.036	0.513
2004-09-22	2.20	0.40	0.36	0.04	1.30	1.27	1.24	1.777	2.078	3.643	0.570	163.341	1.808	2.140	3.707	0.577	169.577	0.634	0.008	0.032	0.715
2004-10-07	0.72	0.22	0.20	0.02	1.12	1.13	1.06	1.609	1.730	3.298	0.525	128.650	1.672	1.863	3.428	0.543	141.825	0.546	0.001	0.019	0.352
2004-10-12	1.04	0.18	0.16	0.02	1.08	1.07	1.03	1.572	1.652	3.222	0.513	121.011	1.611	1.734	3.302	0.525	129.054	0.527	0.003	0.017	0.572
2004-10-21	7.76	0.94	0.71	0.23	1.84	1.60	1.75	2.354	2.998	4.825	0.621	249.556	2.162	2.757	4.431	0.622	229.692	0.898	0.047	0.183	0.820

Table 9. Determination of coefficient of discharge for Culvert 77

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-08-05	4.87	0.52	0.33	0.19	1.29	1.16	1.23	1.798	2.018	3.597	0.561	156.917	1.728	1.884	3.457	0.545	143.624	0.645	0.047	0.143	0.854
2004-08-20	3.12	0.37	0.25	0.12	1.14	1.07	1.08	1.654	1.737	3.308	0.525	129.187	1.638	1.705	3.276	0.520	126.072	0.570	0.027	0.093	0.747
2004-08-26	2.47	0.31	0.21	0.10	1.08	1.04	1.02	1.592	1.613	3.184	0.507	117.203	1.610	1.649	3.220	0.512	120.636	0.538	0.019	0.076	0.679
2004-09-15	3.52	0.35	0.25	0.10	1.12	1.07	1.06	1.635	1.699	3.270	0.520	125.488	1.644	1.717	3.288	0.522	127.239	0.560	0.035	0.065	1.003
2004-10-20	5.18	0.59	0.44	0.15	1.36	1.27	1.29	1.867	2.146	3.734	0.575	169.611	1.844	2.104	3.688	0.570	165.444	0.680	0.043	0.105	0.947

Table 10. Determination of coefficient of discharge for Culvert 89

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-09-16	3.40	0.31	0.10	0.22	1.04	0.97	0.99	1.559	1.547	3.118	0.496	110.811	1.543	1.515	3.086	0.491	107.757	0.520	0.044	0.171	0.676
2004-09-23	2.75	0.24	0.10	0.14	0.97	0.94	0.92	1.492	1.414	2.984	0.474	98.226	1.506	1.441	3.012	0.478	100.756	0.485	0.034	0.106	0.731
2004-10-06	2.28	0.21	0.06	0.15	0.94	0.90	0.89	1.464	1.357	2.927	0.464	92.936	1.470	1.369	2.939	0.466	94.044	0.470	0.027	0.123	0.590
2004-10-13	2.37	0.15	0.02	0.13	0.88	0.87	0.84	1.406	1.244	2.812	0.442	82.587	1.439	1.310	2.879	0.455	88.539	0.440	0.034	0.096	0.728
2004-10-20	3.24	0.41	0.27	0.14	1.14	1.10	1.08	1.649	1.727	3.298	0.524	128.262	1.670	1.768	3.340	0.529	132.307	0.568	0.028	0.107	0.698
2004-11-05	1.65	0.11	-0.02	0.13	0.84	0.83	0.79	1.363	1.160	2.725	0.426	75.061	1.404	1.240	2.808	0.442	82.231	0.418	0.020	0.110	0.499

Table 11. Determination of coefficient of discharge for Culvert 108

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-08-12	0.37	-0.100	-0.120	0.020	0.95	1.01	0.90	1.440	1.411	2.989	0.472	97.848	1.544	1.634	3.204	0.510	119.186	0.458	0.001	0.019	0.203
2004-08-19	0.80	-0.090	-0.130	0.040	0.96	1.00	0.91	1.450	1.431	3.008	0.476	99.693	1.535	1.613	3.184	0.507	117.163	0.463	0.002	0.038	0.320
2004-08-26	0.51	-0.100	-0.140	0.040	0.95	0.96	0.90	1.440	1.411	2.989	0.472	97.848	1.496	1.530	3.104	0.493	109.143	0.458	0.001	0.039	0.212
2004-09-16	2.99	0.230	0.160	0.070	1.28	1.13	1.22	1.744	2.059	3.618	0.569	161.673	1.663	1.889	3.451	0.547	144.459	0.617	0.017	0.053	0.858
2004-09-23	2.38	0.180	0.140	0.040	1.23	1.10	1.17	1.697	1.962	3.522	0.557	151.824	1.632	1.822	3.386	0.538	137.833	0.593	0.012	0.028	0.978
2004-10-06	1.90	0.165	0.110	0.055	1.22	1.10	1.15	1.684	1.933	3.493	0.553	148.867	1.630	1.818	3.382	0.538	137.420	0.586	0.008	0.047	0.600
2004-10-13	1.54	0.110	0.070	0.040	1.16	1.04	1.10	1.633	1.825	3.388	0.538	138.040	1.568	1.686	3.254	0.518	124.269	0.559	0.006	0.034	0.622
2004-11-05	0.74	0.060	0.030	0.030	1.11	1.03	1.05	1.587	1.726	3.293	0.524	128.258	1.564	1.675	3.244	0.516	123.250	0.535	0.002	0.028	0.327

Table 12. Determination of coefficient of discharge for Culvert 118

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-08-12	0.21	-0.080	-0.090	0.010	0.61	0.59	0.58	1.130	0.760	2.284	0.333	41.709	1.142	0.779	2.307	0.338	43.192	0.302	0.001	0.009	0.353
2004-08-19	0.36	-0.090	-0.100	0.010	0.60	0.57	0.57	1.120	0.743	2.262	0.328	40.385	1.120	0.743	2.262	0.328	40.385	0.297	0.004	0.006	0.755
2004-08-26	0.28	-0.110	-0.120	0.010	0.58	0.55	0.55	1.099	0.708	2.220	0.319	37.792	1.098	0.706	2.218	0.319	37.658	0.287	0.002	0.008	0.562
2004-09-23	1.69	0.22	0.17	0.050	0.91	0.84	0.86	1.421	1.300	2.871	0.453	87.615	1.405	1.267	2.837	0.446	84.561	0.448	0.017	0.033	0.922
2004-10-13	0.84	0.15	0.12	0.035	0.84	0.81	0.80	1.359	1.177	2.746	0.429	76.519	1.366	1.191	2.760	0.432	77.754	0.416	0.005	0.030	0.508
2004-11-04	0.69	0.09	0.06	0.025	0.78	0.81	0.74	1.296	1.056	2.619	0.403	65.913	1.368	1.195	2.764	0.432	78.107	0.384	0.004	0.021	0.495

Table 13. Determination of coefficient of discharge for Culvert 143

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-08-19	0.12	-0.105	-0.130	0.025	0.515	0.29	0.49	1.007	0.613	2.116	0.290	30.673	0.761	0.289	1.599	0.181	10.555	0.245	0.002	0.023	0.354
2004-08-26	0.09	-0.120	-0.150	0.030	0.500	0.28	0.48	0.991	0.588	2.082	0.282	28.912	0.748	0.275	1.570	0.175	9.814	0.238	0.001	0.029	0.238
2004-09-16	0.95	0.26	0.20	0.060	0.880	0.62	0.84	1.366	1.286	2.868	0.448	86.072	1.149	0.855	2.413	0.354	48.917	0.419	0.010	0.050	0.615
2004-09-23	0.58	0.19	0.14	0.050	0.810	0.56	0.77	1.300	1.150	2.731	0.421	73.838	1.085	0.741	2.279	0.325	40.093	0.386	0.005	0.045	0.462
2004-10-06	0.57	0.185	0.145	0.040	0.805	0.55	0.76	1.296	1.140	2.721	0.419	72.988	1.074	0.723	2.256	0.320	38.695	0.383	0.005	0.035	0.525
2004-11-04	0.34	0.07	0.025	0.045	0.690	0.45	0.66	1.186	0.923	2.490	0.371	54.473	0.963	0.544	2.021	0.269	25.937	0.329	0.004	0.041	0.383

Table 14. Determination of coefficient of discharge for Culvert 170

Date	Flow	Head water	Tail water	Head – Tail	h_1	h_4	$h_2 - z$ ($h_2 = 0.95\ h_1$)	Θ_2	A_2	P_2	R_2	K_2	Θ_3	A_3	P_3	R_3	K_3	h_1/D	$h_{f2,3}$	$h_1 - h_4 - h_{f2,3}$	C_{d3}
	(ft^3/s)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)	(rad)	(ft^2)	(ft)	(ft)	(ft^3/s)		(ft)	(ft)	
2004-07-30	0.20	0.100	0.090	0.010	0.730	0.68	0.69	1.241	0.983	2.545	0.386	59.573	1.228	0.957	2.516	0.380	57.388	0.356	0.001	0.009	0.262
2004-09-16	0.27	0.28	0.27	0.010	0.910	0.83	0.86	1.414	1.323	2.898	0.456	89.626	1.379	1.253	2.828	0.443	83.246	0.444	0.000	0.010	0.275
2004-09-23	0.20	0.27	0.26	0.010	0.900	0.83	0.86	1.404	1.303	2.879	0.453	87.855	1.379	1.253	2.828	0.443	83.246	0.439	0.000	0.010	0.203
2004-09-30	2.17	0.52	0.485	0.035	1.150	1.03	1.09	1.637	1.789	3.355	0.533	134.415	1.579	1.667	3.236	0.515	122.413	0.561	0.013	0.022	1.087
2004-10-06	0.26	0.28	0.27	0.010	0.910	0.82	0.86	1.414	1.323	2.898	0.456	89.626	1.369	1.233	2.807	0.439	81.424	0.444	0.000	0.010	0.267
2004-10-13	0.73	0.38	0.37	0.010	1.010	0.911	0.96	1.507	1.516	3.089	0.491	107.834	1.459	1.417	2.992	0.474	98.432	0.493	0.002	0.008	0.734
2004-10-20	0.55	0.395	0.385	0.010	1.025	0.932	0.97	1.521	1.545	3.118	0.496	110.633	1.480	1.460	3.034	0.481	102.478	0.500	0.001	0.009	0.502

RATING EQUATIONS AND CALIBRATION

From the calculation results shown in the above tables, we relate the coefficient of discharge C_d with h_1/D. The ratio h_1/D is that of upstream water level above the inlet invert to the culvert diameter. Under SR 9336 in ENP, the culverts are used to connect water on both sides of the road so that natural flow is not blocked. The difference of elevation of culvert inverts on both sides is minimal. So, h_1/D is close to $(h_1 - z)/D$. z = inlet invert elevation - outlet invert elevation.

We find that C_d exhibits a linear relationship with h_1/D and it increases with h_1/D. The characteristic of C_d being increasing with h_1/D is related to how Manning's roughness coefficient changes with depth of water in culvert. According to Lindeburg's citation (Lindeburg, 2003), the Manning's roughness coefficient, n, varies with depth. The ratio of n to n_{full} (the n value when culvert is full) has a maximum value of about 1.28 when relative depth of water d/D in culvert is between 0.2 and 0.3. When d/D is larger than 0.3, n/n_{full} decreases gradually. When the culvert is full (d/D = 1), n/n_{full} is back to 1. Most flow measurements of this study conducted in the Everglades correspond to d/D > 0.3. With h_1/D increases, d/D increases and thus the roughness coefficient, n, decreases. This makes the barrel friction become less important and the discharge coefficient C_d become larger.

Using the rated discharge coefficients, we calculate flows using observed head water and tail water. Displaying calculated and measured flows in a plot shows the quality of rating analyses. The following figures display the relationships of C_d versus h_1/D and the difference between calculated and measured flows. It should be noted that all measured flows are compared with the corresponding calculated ones even though they may not be used to estimate discharge coefficients. The figures show a reasonably good match between measured and calculated flows.

Culvert 11

Only one calculation can be conducted on C_d. No plot of C_d versus h_1/D is drawn.

Culvert 24

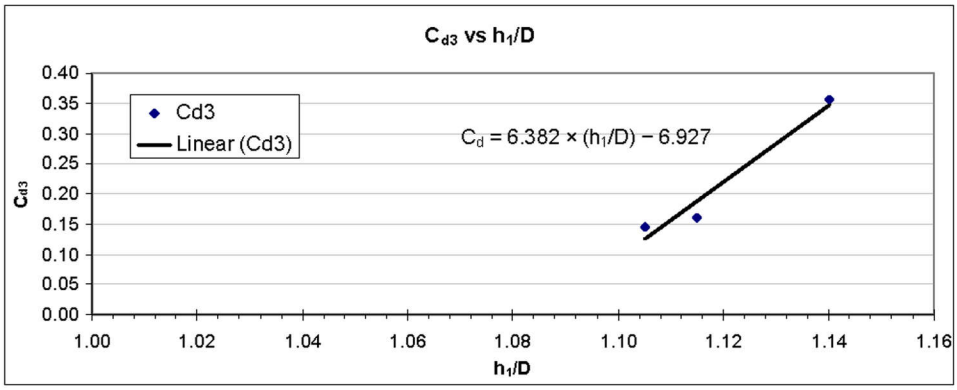

Figure 4. C_d versus h_1/D for Culvert 24

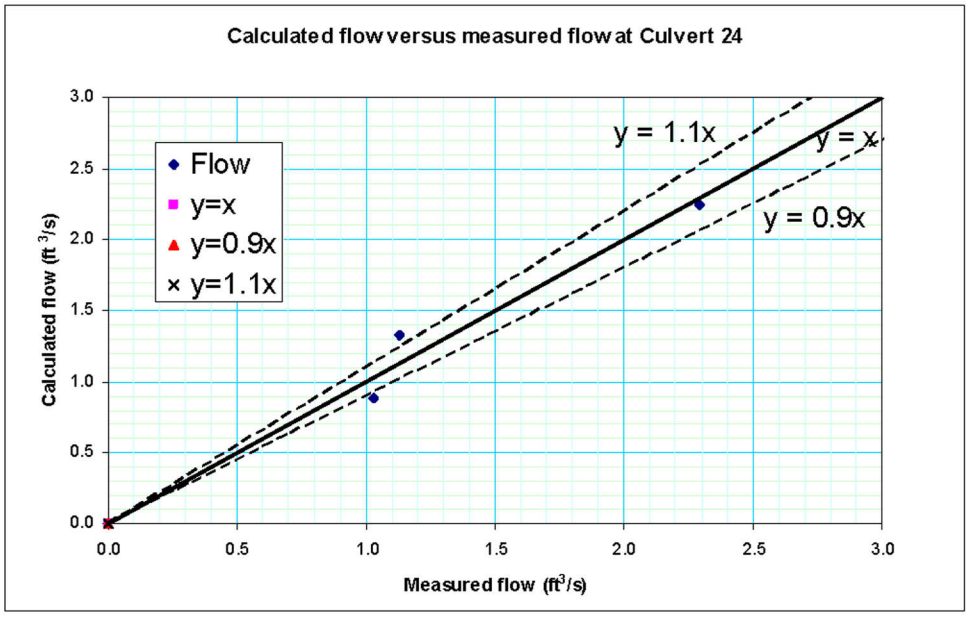

Figure 5. Calculated and measured flows for Culvert 24

Culvert 30

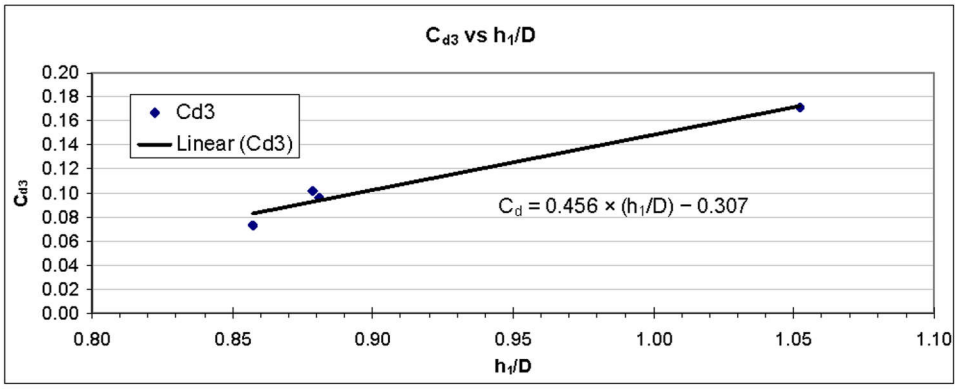

Figure 6. C_d versus h_1/D for Culvert 30

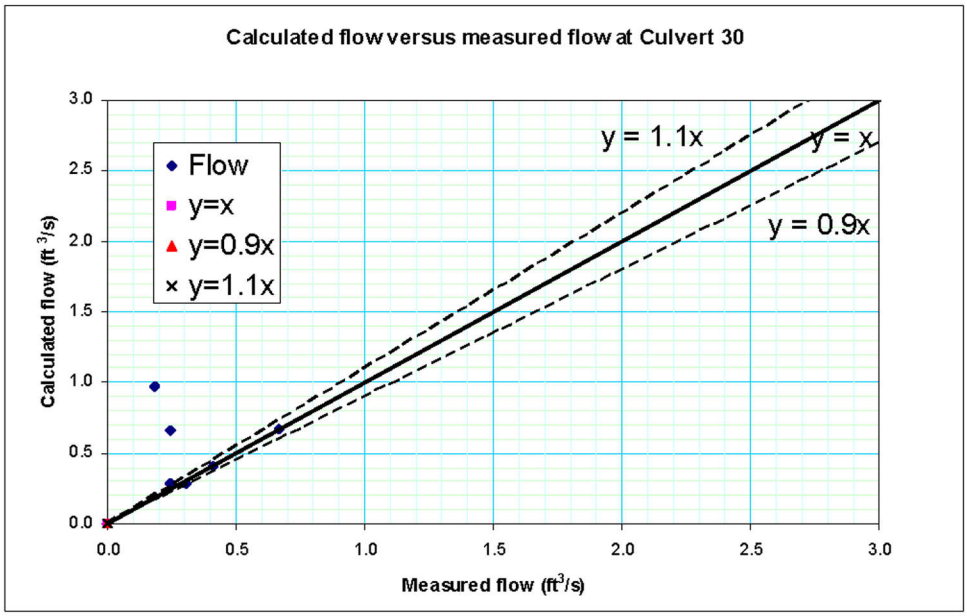

Figure 7. Calculated and measured flows for Culvert 30

Culvert 34

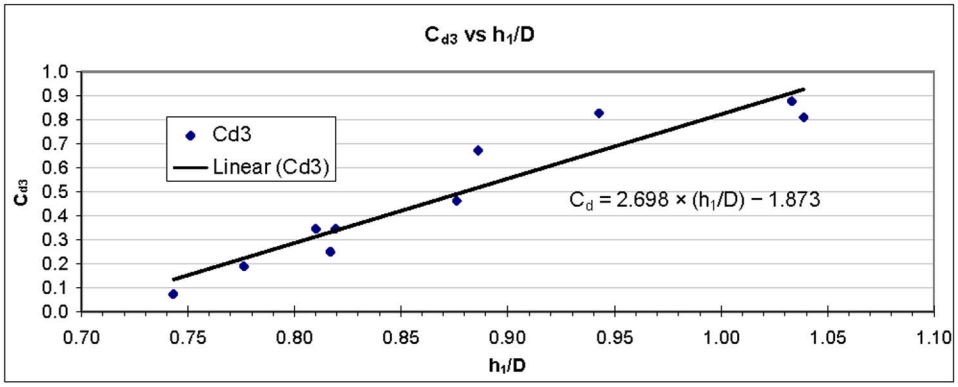

Figure 8. C_d versus h_1/D for Culvert 34

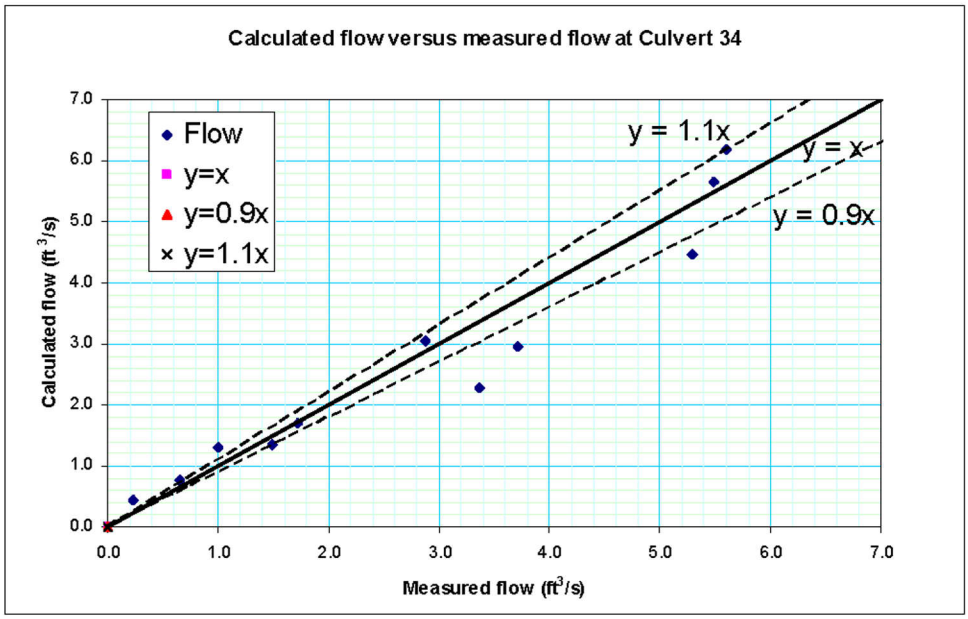

Figure 9. Calculated and measured flows for Culvert 34

Culvert 43

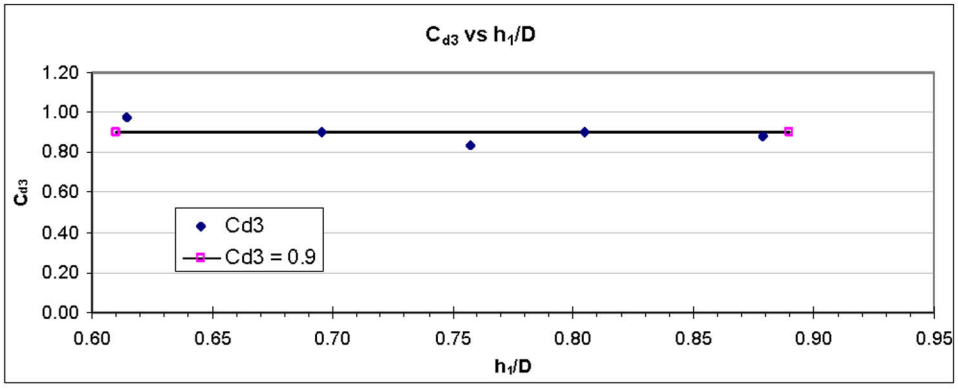

Figure 10. C_d versus h_1/D for Culvert 43

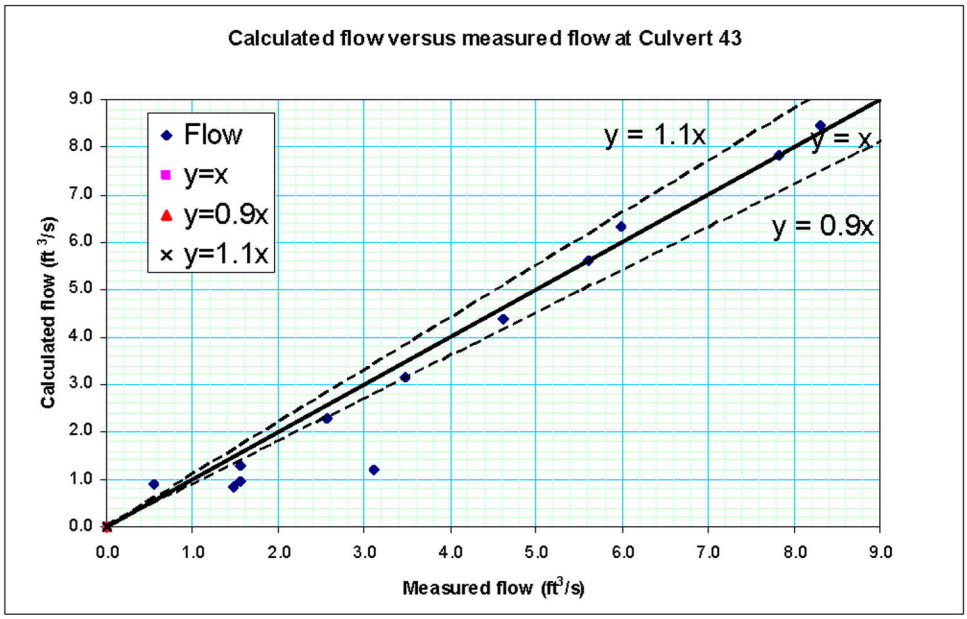

Figure 11. Calculated and measured flows for Culvert 43

Culvert 59

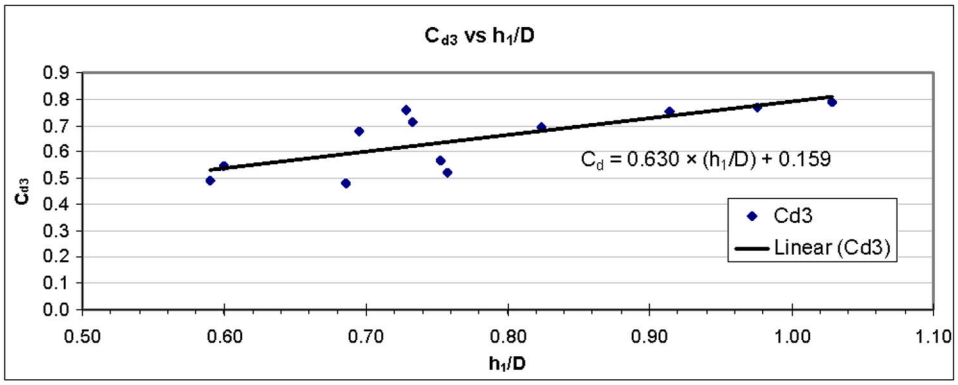

Figure 12. C_d versus h_1/D for Culvert 59

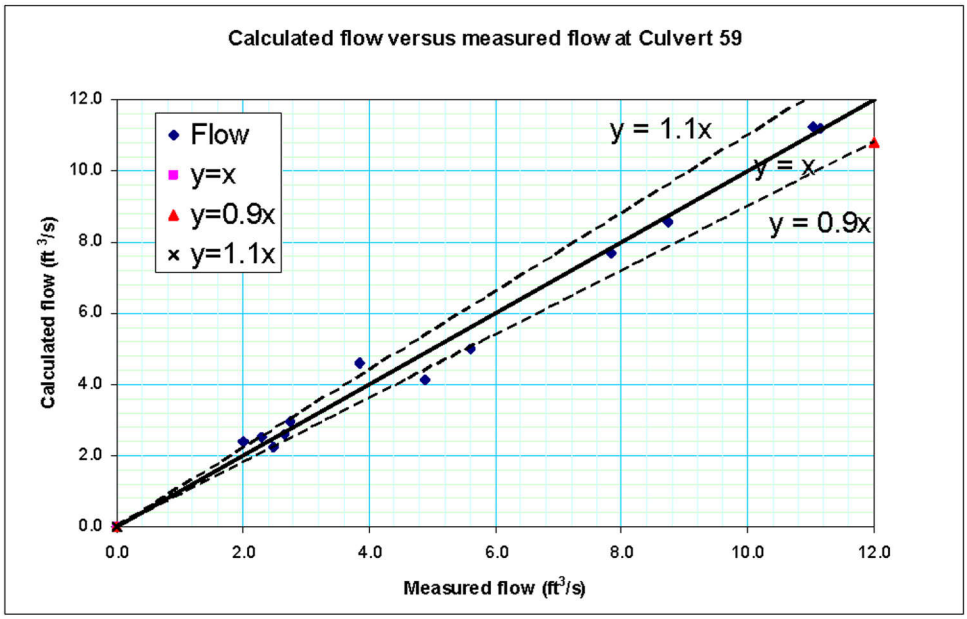

Figure 13. Calculated and measured flows for Culvert 59

Culvert 69

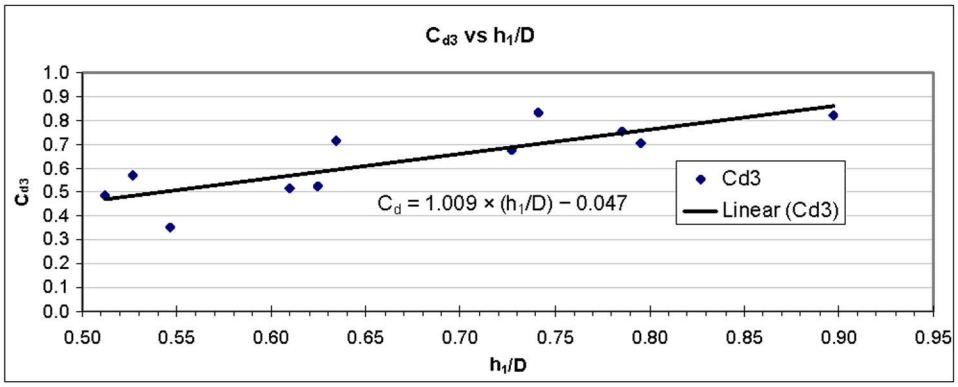

Figure 14. C_d versus h_1/D for Culvert 69

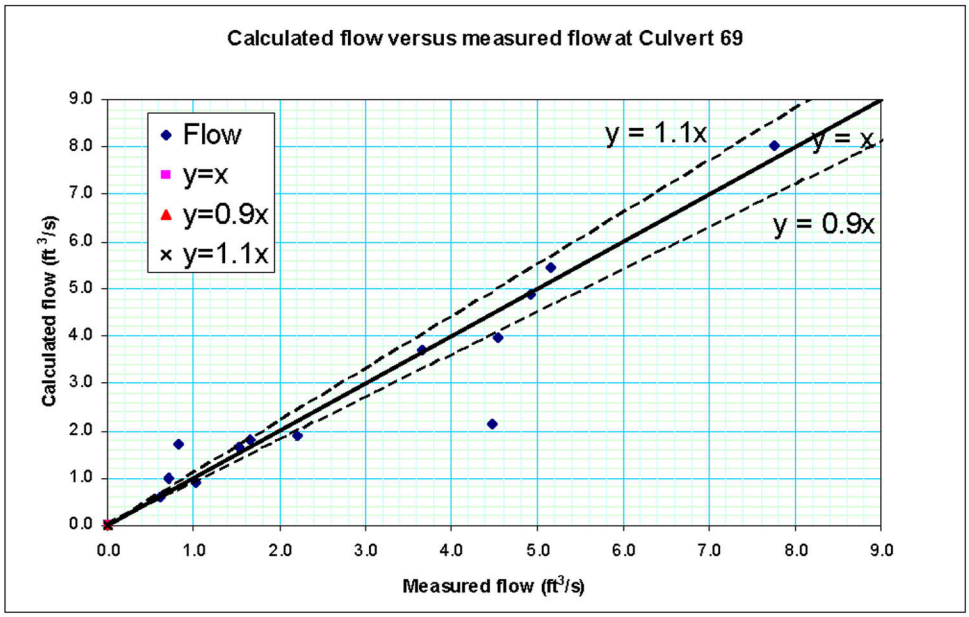

Figure 15. Calculated and measured flows for Culvert 69

Culvert 77

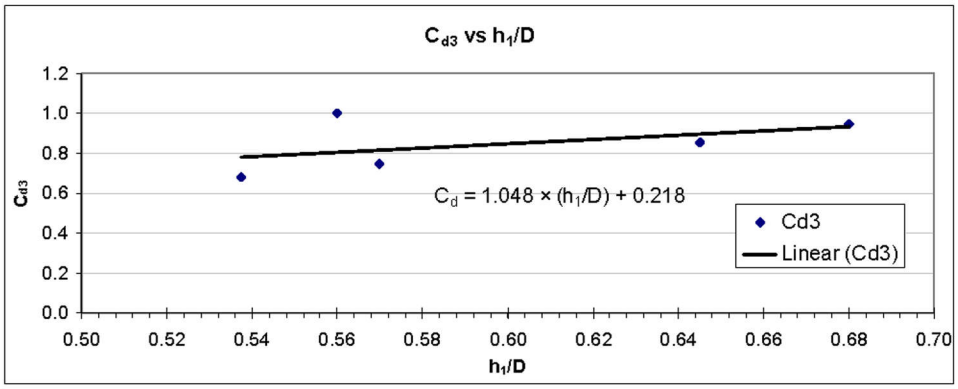

Figure 16. C_d versus h_1/D for Culvert 77

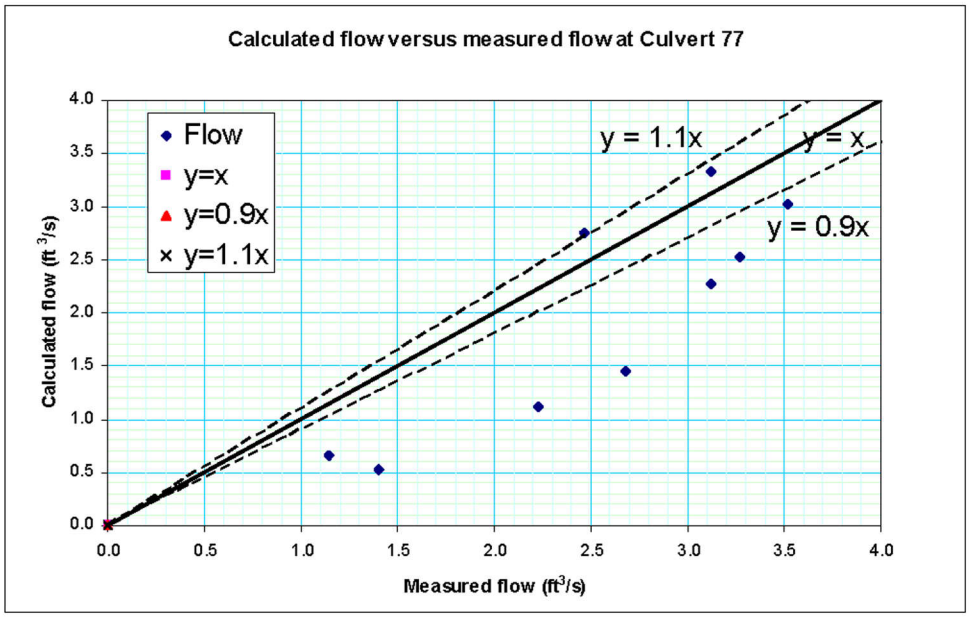

Figure 17. Calculated and measured flows for Culvert 77

Culvert 89

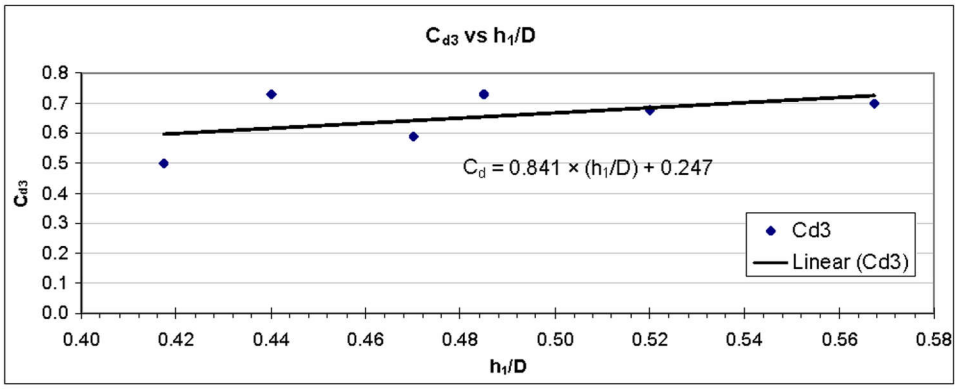

Figure 18. C_d versus h_1/D for Culvert 89

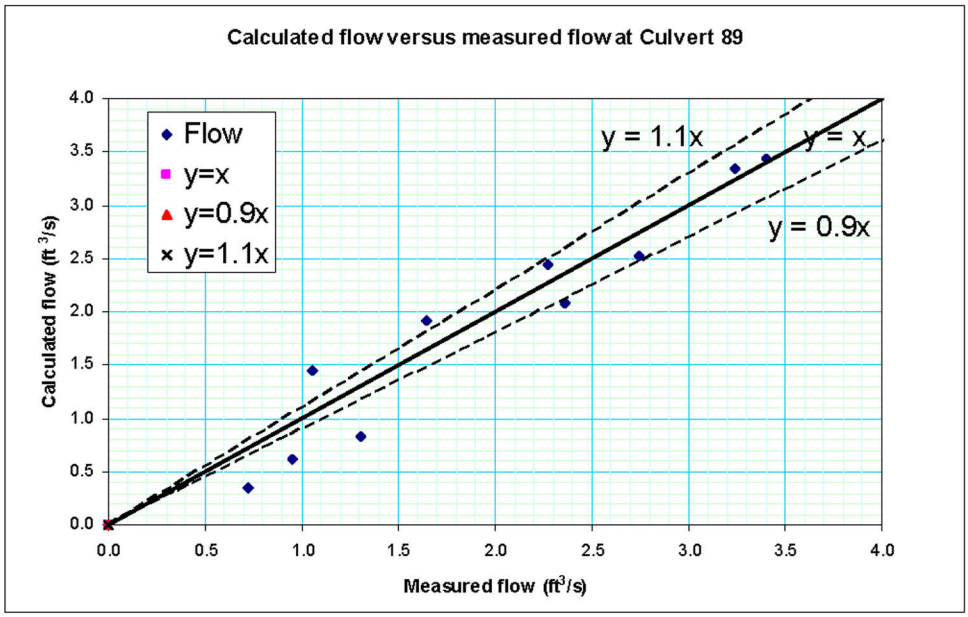

Figure 19. Calculated and measured flows for Culvert 89

Culvert 108

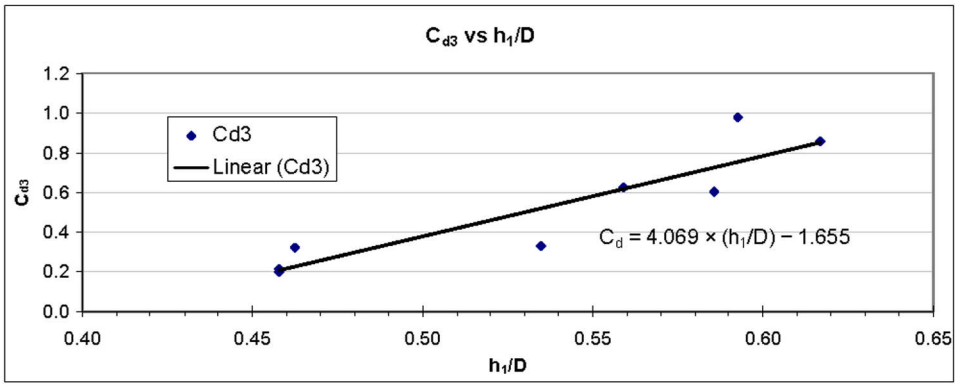

Figure 20. C_d versus h_1/D for Culvert 108

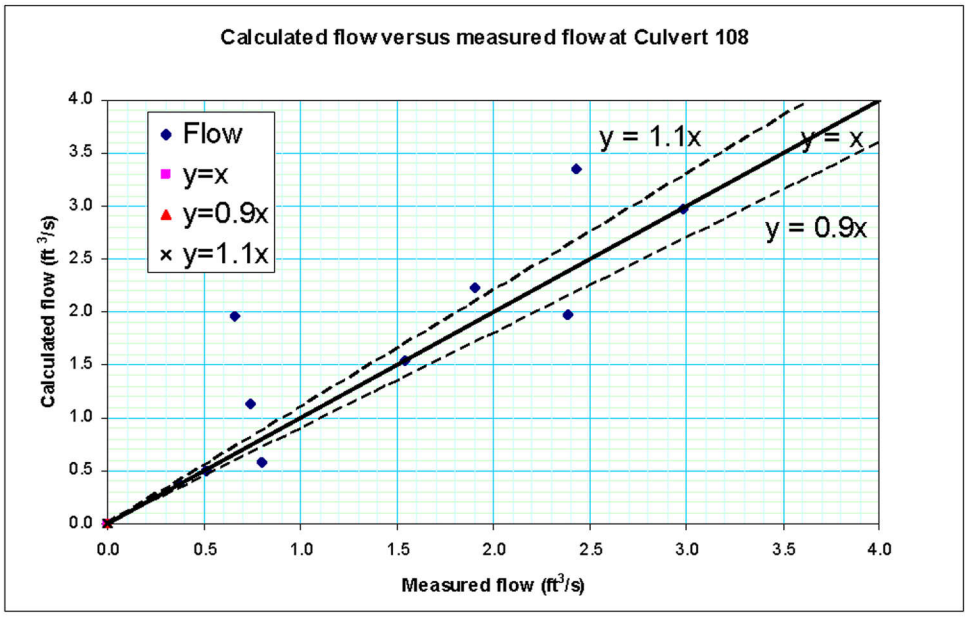

Figure 21. Calculated and measured flows for Culvert 108

Culvert 118

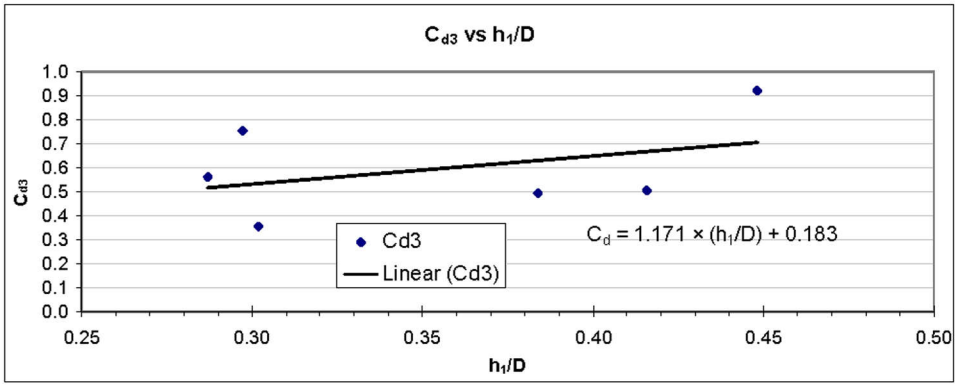

Figure 22. C_d versus h_1/D for Culvert 118

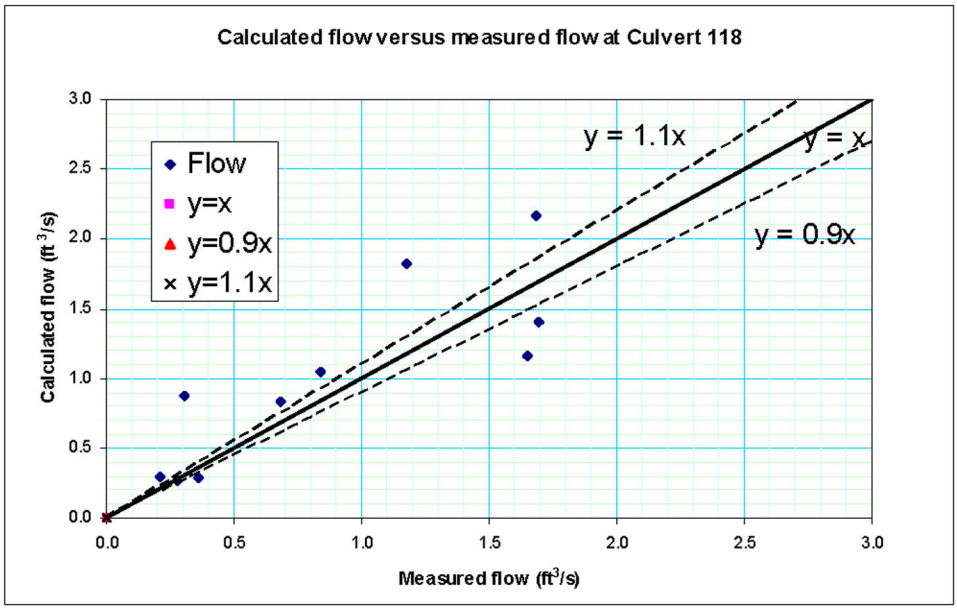

Figure 23. Calculated and measured flows for Culvert 118

Culvert 143

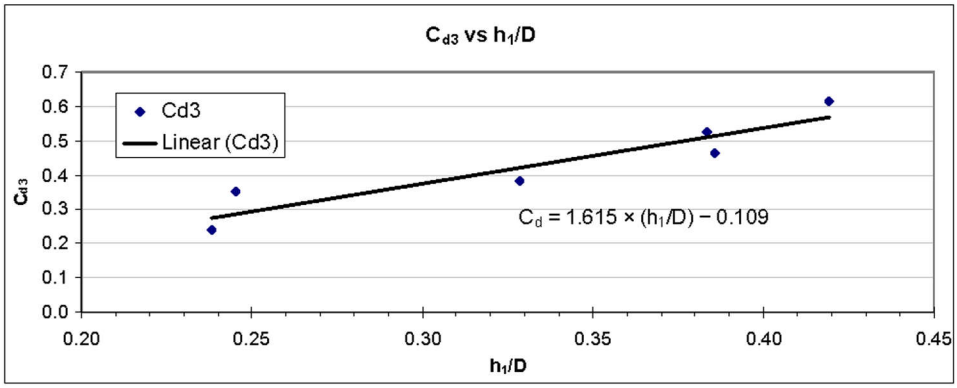

Figure 24. C_d versus h_1/D for Culvert 143

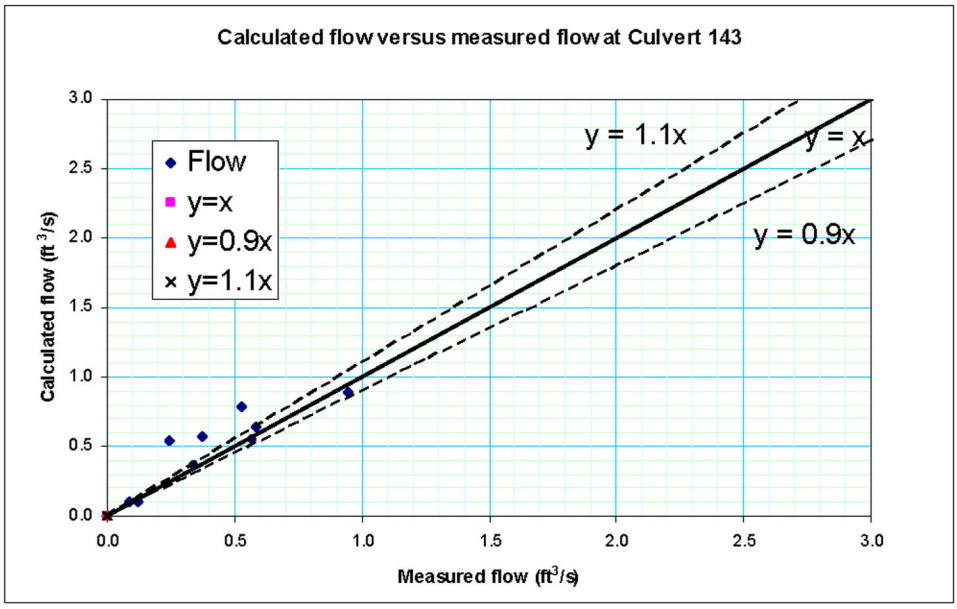

Figure 25. Calculated and measured flows for Culvert 143

Culvert 170

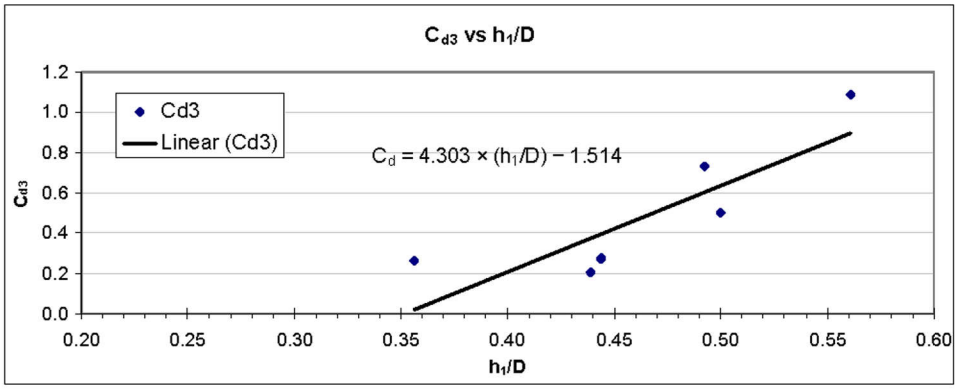

Figure 26. C_d versus h_1/D for Culvert 170

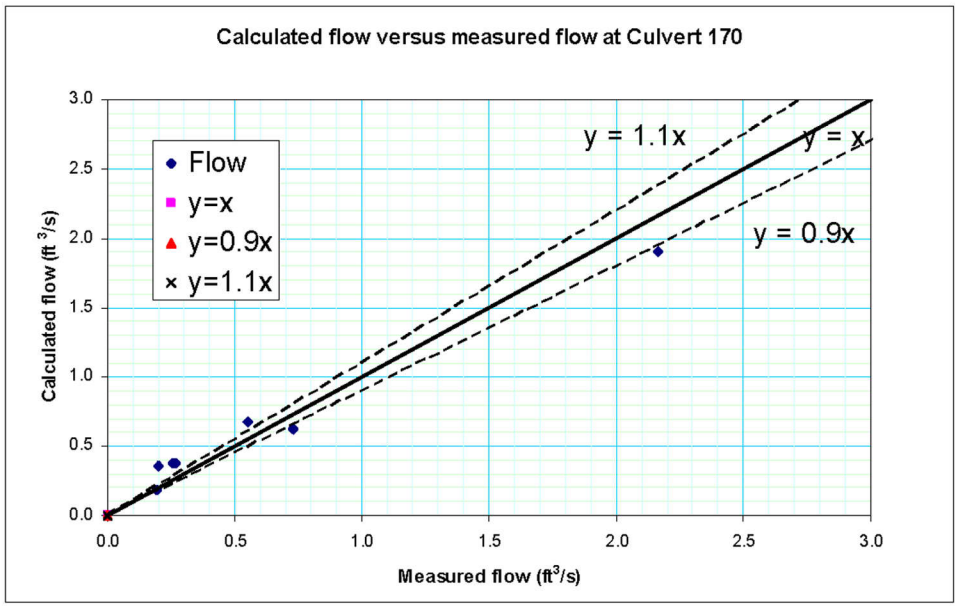

Figure 27. Calculated and measured flows for Culvert 170

Table 15 lists the linear regression equations of discharge coefficients for 13 representative culverts. We use the results shown in the table to estimate the remaining 165 culverts. Due to the large number of flow structures along SR 9336 and the complexity of site conditions, this attempt gave approximate results and needs to be refined based on further site study and flow monitoring. Further study is needed to examine how well the proposed rating relationships and coefficients can be used to estimate flows for all culverts across SR 9336. Further rating equations can be developed depending on the data collected.

Table 15. Discharge coefficients for 13 representative culverts and estimation for the rest sites

Culvert No	C_d	Limits of C_d	Culverts with same C_d
11	$C_d = 0.7$		1 to 17, 20, 21.
24	$C_d = 6.382 \times (h_1/D) - 6.927$	C_d (min) = 0.15 C_d (max) = 1.0	22 to 28
30	$C_d = 0.456 \times (h_1/D) - 0.307$	C_d (min) = 0.1 C_d (max) = 1.0	29 to 33
34	$C_d = 2.698 \times (h_1/D) - 1.873$	C_d (min) = 0.15 C_d (max) = 1.0	34 to 42
43	$C_d = 0.9$		43 to 54
59	$C_d = 0.630 \times (h_1/D) + 0.159$	C_d (min) = 0.15 C_d (max) = 1.0	55 to 63
69	$C_d = 1.009 \times (h_1/D) - 0.047$	C_d (min) = 0.15 C_d (max) = 1.0	64 to 73

77	$C_d = 1.048 \times (h_1/D) + 0.218$	C_d (min) = 0.15 C_d (max) = 1.0	74 to 85
89	$C_d = 0.841 \times (h_1/D) + 0.247$	C_d (min) = 0.15 C_d (max) = 1.0	86 to 100
108	$C_d = 4.069 \times (h_1/D) - 1.655$	C_d (min) = 0.15 C_d (max) = 1.0	101 to 114
118	$C_d = 1.171 \times (h_1/D) + 0.183$	C_d (min) = 0.15 C_d (max) = 1.0	115 to 135
143	$C_d = 1.615 \times (h_1/D) - 0.109$	C_d (min) = 0.15 C_d (max) = 1.0	136 to 160
170	$C_d = 4.303 \times (h_1/D) - 1.514$	C_d (min) = 0.20 C_d (max) = 1.0	161 to 178

Notes:
Culverts 18, 19 are replaced by the new bridges;
C_d: discharge coefficient describing culvert flow;
h_1: depth of water above the culvert invert in the upstream side;
D: diameter of a culvert barrel;
If the calculated discharge coefficient from the above equation is less than the defined minimum C_d, then C_d is set to C_d(min). If the calculated discharge coefficient is larger than the defined maximum C_d, then C_d is set to C_d(max).

CONCLUSIONS

Flow data was collected at 13 representative culvert sites along SR 9336 in ENP. Rating analyses show that discharge coefficients have a linear relationship with the head water level. By using rated discharge coefficients, we calculate flows and compare them with the measurements. The results show a good match between calculated and measured flows.

Discharge coefficient can vary significantly from site to site or under different flow conditions. It is recommended that further flow monitoring and field study be conducted to examine how well the proposed rating relationships can be applied to estimate flows through the remaining 165 culverts.

REFERENCES

1. Bodhaine, G.L. (1968). Measurement of Peak Discharge at Culverts by Indirect Methods. Techniques of Water Resources Investigations of the United States Geological Survey, Book 3, Applications of Hydraulics.

2. Buchanan, T.J., Somers, W.P. (1969). Discharge Measurements at Gaging Stations. Techniques of Water Resources Investigations of the United States Geological Survey, Book 8, Applications of Hydraulics.

3. Lindeburg, M.R. (2003). Civil Engineering Reference Manual for the PE Exam, Ninth Edition, Professional Publications Inc, Belmont, CA.

4. MGD Technologies Inc. (2000). ADFM Acoustic Doppler Flow Meter Technical Manual.

5. MGD Technologies Inc. Web site: http://www.mgdinc.com/products.htm as of March 31, 2005.

6. Wu, Q., Imru, M. (2005). Rating Development for Flow through Culverts under SR9336 in the Everglades National Park I: Concepts and Methods, South Florida Water Management District, West Palm Beach, FL.

APPENDIX I – SITE CONDITIONS OF 178 CULVERTS ALONG SR 9336
(Field study conducted in December 2003 & January 2004)

Culvert No.	Tags/ NGVD 29 (ft)	Observation	Conditions for flow monitoring
		Locating the first culvert: When driving along SR 9336 to the Everglades National Park, one can see an "L-31W" sign just in front of a bridge. A canal is under the bridge. Passing the bridge, there is a "GLEN GARRETT MEMORIAL PARK" sign on the left hand side of the road (south side). Then just 100 feet in the front, there is an "EVERGLADES NATIONAL PARK" sign on the right hand side (north side). Then IMMEDIATELY passing a stretch of road with lots of bushes and trees on both sides, it is culvert 1.	
1	Yes 3.99	Open on the north side; bushes face the culvert on the south side. One staff gauge on each side of the road. Pipeline type culvert. No water/no flow	Poor[3]
		There is one box culvert between culvert 1 & 2. Newly constructed. Still water/no flow	
2	Yes 4.25	Both sides are open. Pipeline type culvert. Shallow water/no flow	Good
3	No 4.50	Both sides are open. Pipeline type culvert. No water/no flow	Good
4	Yes[1] 4.77	The culvert is long due to the division of SR 9336 into the road to the visitor center. On the visitor center side, there is a big pond; on the other side, it is open grass land. Pipeline type culvert.	Poor
5	Yes 4.79	Right face the visitor center. Pipeline type culvert. Both sides are dry/no flow.	Acceptable
6	No 4.05	On the visitor center side, there are lots of bushes and trees; on the other side, it is open. Pipeline type culvert. No water/no flow	Poor

7	5.10	Can not be seen due to thick vegetation	Poor
8	4.26	Located before the entrance gate to the park (around 100 feet). On the south side, culvert is half buried in the soil; on the north side, it can not be seen due to thick vegetation. Long/useless culvert. Pipeline type culvert.	Poor
9	Yes[1] 4.33	First culvert after the park entrance. Right after the Sign: "Campground – Long Pine Key 6 miles (10km) – Flamingo 38 miles (61km)" Culvert buried in woods. Longer than usual. Pipeline type culvert. Both sides are dry. No water/no flow	Poor
10	No 4.73	Pipeline type culvert. Both sides are dry. No water/no flow	Acceptable
11	No 4.87	Pipeline type culvert. Both sides are dry. No water/no flow	Acceptable
12	Yes[1] 4.84	Pipeline type culvert. Both sides are dry. No water/no flow	Acceptable
13	Yes[1] 4.75	Pipeline type culvert. Both sides are dry. No water/no flow There are some grasses around the culvert on the south side	Acceptable
14	Yes 5.07	Pipeline type culvert. Both sides are dry. No water/no flow	Acceptable
15	Yes 4.75	Pipeline type culvert. Both sides are dry. No water/no flow	Acceptable
16	No 4.69	Pipeline type culvert. Little water on both sides. No flow.	Acceptable
17	Yes 4.03	1st culvert before the 1st bridge along SR 9336. On the north side, lots of grass around culvert; on the south side, less grass. This is a 3 feet culvert. Pipeline type culvert. Culvert is 90% full with water. No flow.	Acceptable
		1st bridge	
18	5.03	Destroyed due to the bridge being built.	
19	5.11	Destroyed due to the bridge being built.	
		There is one box culvert/tunnel after the 1st bridge from the park entrance. There are 2 staff gauges just after the box culvert. Flow is slow inside the box culvert.	

		Then it's the 2nd bridge (Taylor Slough Bridge). There is a staff gauge on each side of the bridge.	
		There is a box culvert just after the 2nd bridge. Flow is slow in north to south direction.	
		Then there is a "Royal Palm Turn Off – ¼ mile (0.4 km)" Sign	
20	Yes 4.37	Pipeline type culvert. Flow is in north to south direction	Good
		Then around 100 feet down the road, there is a box culvert. Flow is slow. There are 2 staff gauges after this box culvert (60 feet down the road after the box culvert). There is a benchmark K432 on the north side of the road (15 feet after the staff gauges).	
21	Yes 4.25	Pipeline type culvert. Almost no flow	Acceptable
		Then there is a Sign: "Royal Palm – ← Anhinga Trail – Gumbo Limbo Trail – Flamingo 36 mi ↑"	
22	Yes 4.25	Too many grasses and trees around the culvert. Pipeline type culvert. No flow	Poor
23	Yes 5.51	Lots of trees around the culvert. Pipeline type culvert. Culvert half full/no flow	Poor
24	Yes 5.43	There is a staff gauge on the south side. A groundwater table recorder on the north side. Pipeline type culvert. No flow	Good
		Then there is a Sign: "← Long Pine Key – Flamingo 34 mile"	
25	No 5.48	First culvert after the road to Long Pine Key. Culvert top broken on the south side. Tag fallen from the culvert and picked up from the site. Lots of grasses and trees around the culvert. Pipeline type culvert. Culvert is dry/no flow.	Poor
26	Yes[1] 5.48	Culvert structural condition is good. Pipeline type culvert. Culvert is dry/no flow.	Good
27	Yes 5.55	Culvert structural condition is good. Lots of trees on the south side. Pipeline type culvert. Culvert is dry/no flow.	Poor
		Then there is a Sign: "Pine Land → – Flamingo 32 mile"	

28	Yes[1] 5.80	Culvert is just after the above "Pine Land" sign. Culvert structural condition ok. There are small palm trees on the north side and large pine trees on the south side. Pipeline type culvert. Culvert is dry/no flow.	Poor
29	Yes 6.00	Both sides are open. Pipeline type culvert. Culvert is dry/no flow.	Good
30	No 5.60	Pipeline type culvert. Culvert is dry/no flow.	Acceptable
31	No 5.60	There are many trees just in front of the culvert mouth on the north side. The area is open on the south side. Pipeline type culvert. Culvert is dry/no flow.	Poor
32	Yes 5.17	On the north side, the area is ok. On the south side, there is a bunch of trees just facing the culvert. Pipeline type culvert. Both sides are dry. No flow in the culvert.	Poor
33	No 5.34	Pipeline type culvert. Both sides are dry. No flow in the culvert.	Acceptable
34	No 4.22	On the north side, culvert top is broken. The culvert is right before the "Rock Reef Pass" sign. Pipeline type culvert. There is water on both sides, but no flow in the culvert.	Acceptable
		Then there is a Sign: "Rock Reef Pass – Elevation 3 feet – 0.9 meter"	
35	Yes 4.21	Located right after the "Rock Reef Pass" sign. There are some trees on both sides. Water can not flow very freely. Pipeline type culvert. Still water/no flow.	Acceptable
36	No 4.25	The culvert is just in front of a wood stairway outlook. Some grasses and trees on the north side. Open on the south side. Tag fallen from the culvert and picked up from the site. Pipeline type culvert. Still water/no flow.	Acceptable
37	Yes 4.33	Culvert top broken on the south side. Pipeline type culvert. Still water/no flow.	Poor
38	Yes[1] 4.25	Some grasses and trees on the north side. Open on the south side. Pipeline type culvert. Still water/no flow.	Good

39	No 4.41	Culvert top broken on the north side. South side can be selected for flow monitoring. Pipeline type culvert. Slow water flows from north to south.	Acceptable
40	No 4.48	Pipeline type culvert. There is water on both sides. Water flows slowly/half full in north to south direction.	Good
41	Yes 3.94	Open on the south side; ok on the north side. Pipeline type culvert. Still water/no flow.	Good
42	No 4.29	Just before the Pahayokee Overlook. North side open; trees face the culvert on the south side. Pipeline type culvert. Still water/no flow.	Good
		Then there is a Sign: "Pa-hay-okee" pointing to the Pahayokee Road.	
43	Yes 4.22	First culvert after Pahayokee Road. There is one staff gauge on each side of the road. Pipeline type culvert. Culvert half full/no flow.	Good
44	No 2.38	Culvert is buried deep beneath the highway. Culvert top broken. Pipeline type culvert. Culvert is totally submerged. Still water/no flow.	Poor
45	No 2.52	Culvert is buried deep beneath the highway. One tree fallen down on the west side. Sand and gravel inside culvert. Pipeline type culvert. Culvert submerged. Still water/no flow.	Poor
46	No 2.55	Culvert is buried deep beneath the highway. Culvert top broken on the west side. A tree grows just in the mouth of culvert on the east side. Sand and gravel inside culvert. Pipeline type culvert. Culvert submerged. Still water/no flow.	Poor
47	No 2.61	Culvert is buried deep beneath the highway. Culvert top broken on the west side. Sand and gravel inside culvert. Pipeline type culvert. Culvert submerged. Still water/no flow.	Acceptable

48	No 2.66	Culvert is buried deep beneath the highway. Sand and gravel inside culvert. Pipeline type culvert. Culvert submerged. Still water/no flow.	Good
49	No 2.68	Culvert is buried deep beneath the highway. Easily accessible on the west side. Hard to access on the east side due to being surrounded by bushes and trees. Pipeline type culvert. Culvert submerged. Still water/no flow.	Acceptable
50	No 2.28	Just in front of the "Dwarf Cypress Forest" sign. Culvert is buried deep beneath the highway. Sand and gravel inside culvert. Open on both sides. Overall, a bad site. Pipeline type culvert. Still water/no flow.	Poor
		Then there is the sign "Dwarf Cypress Forest – Elev. 4ft (1.2m)".	
51	No 2.60	Culvert is buried deep beneath the highway. A big tree just outside the culvert on the east side. On the west side, there are trees but the flow is ok. Pipeline type culvert. Still water/no flow.	Poor
52	No 2.16	Culvert is buried deep beneath the highway. On the west side, there are lots of trees that the culvert can not be seen. Ok on the east side. Pipeline type culvert. Still water/no flow.	Poor
53	No 2.26	Culvert is buried deep beneath the highway. On the west side, a tree grows right from the side of the culvert mouth. Site is clear on the east side, but the culvert top is broken on this side. Pipeline type culvert. Culvert submerged. Still water/no flow.	Poor
54	No 2.16	Culvert is buried deep beneath the highway. On the east side, culvert is covered by thick grasses and bushes. Culvert mouth is far away from road side. Situation better on the west side, but still not very visible. Pipeline type culvert. Still water/no flow.	Poor

55	No 2.94	Both sides are totally surrounded by thick woods. Pipeline type culvert. Still water/no flow.	Very poor
56	Yes 3.32	On both sides, trees are growing right in front of the culvert. Pipeline type culvert. Still water/no flow.	Poor
57	No 3.82	Both sides are open. Pipeline type culvert. Still water/no flow.	Good
		0.2 mile after Culvert 57, there is a groundwater table recorder on each side of the road.	
58	No 3.24	There are some bushes growing on the bank beside the culvert. Other than that, the site is ok. Pipeline type culvert. Still water/no flow.	Acceptable
59	Yes 3.10	On the west side, there are many trees, which are away from the culvert. There is a staff gauge on this side. Open on the east side. There exists a tube to measure the water level, which should be a staff gauge. Pipeline type culvert. Should be selected for the continuity of previous monitoring work.	Good
60	Yes 3.75	Culvert top broken on the east side. Pipeline type culvert. Shallow slow water flow from east to west.	Acceptable
61	No 3.14	Open on the east side. Top of culvert is broken. On the west side, a small tree is beside the culvert. Pipeline type culvert. Shallow slow water flow from east to west.	Acceptable
62	No 3.04	On the east side, there are trees just in the course of water way. The situation is ok on the west side. Pipeline type culvert. Shallow slow water flow from east to west.	Poor
63	Yes 3.04	Open on the east side. 2 trees just out facing the culvert on the west side. Pipeline type culvert.	Acceptable
64	No 2.78	Both sides are high pine tree forest. East side, bushes growing right on top of the culvert. Pipeline type culvert. No water/no flow.	Poor
65	No 2.94	Both sides are open. There is a snake on the west side. Pipeline type culvert. No water/no flow.	Acceptable

		Then down the road less than 0.1 mi, there is a Sign: "Mahagany Hammock → – Flamingo 18 mi ↑"	
66	Yes 3.15	Culvert is just after the "Speed Limit 55" Sign. Open on the east side. Far away is pine tree forest. West side, pine trees not far away. Pipeline type culvert. Both sides are dry/no flow.	Acceptable
67	Yes 3.08	Open on the east side. A tree growing right on top of the culvert on the west side. Pipeline type culvert. No water/no flow.	Poor
68	Yes 2.76	Open on both sides. West side, trees are a little bit around the culvert. Pipeline type culvert. No water/no flow.	Acceptable
69	Yes 3.03	Both sides are open. Pipeline type culvert. Shallow water inside culvert/no flow.	Very good
70	Yes 3.02	East side: open. West side: bushes and grasses around the culvert. Pipeline type culvert. Almost still water/no flow.	Acceptable
71	Yes 2.86	East side: open. West side: basically ok. There are just some trees around. Pipeline type culvert. No water/no flow.	Acceptable
72	No 2.86	East side: open. West side: lots of big trees just in front of the culvert. Pipeline type culvert. Still water/no flow.	Poor
73	Yes 2.76	East side: not very visible. West side: bushes and grasses are around the culvert. Pipeline type culvert. Still water/no flow.	Poor
74	Yes 2.96	Both sides are heavily surrounded by trees; worse on the west side. Pipeline type culvert. Still water/no flow.	Poor
75	Yes 3.06	After 75, the road is becoming very straight like a line. Both sides are surrounded by trees; worse on the east side. Pipeline type culvert. Still water/no flow.	Poor

76	No 3.67	West side: it is a land with many trees growing. East side: open. Culvert is constructed inside the reinforced concrete body. It is stronger than the pipeline type culvert, but shorter in length. Still water/no flow.	Acceptable
77	No 3.66	West side: surrounded by trees. But flow can move smoothly. East side: open. Concrete type culvert. Still water/no flow.	Good
78	No 3.55	West side: Some trees around. East side: Open outside but bushes beside the culvert. Concrete type culvert. Still water/no flow.	Acceptable
79	No 3.58	West side: a bush growing right beside the culvert. East side: open. Concrete type culvert. Shallow water/no flow.	Poor
80	Yes 3.67	West side: grasses and a palm tree around. East side: open out in the field. Grasses and bushes around the culvert. Concrete type culvert. Still water/no flow.	Poor
81	No 3.99	Both sides are covered by thick woods and grasses. Concrete type culvert. Still water/no flow.	Poor
82	Yes 3.53	West side: lots of grass around the culvert. East side: a tree just beside the culvert. Open out in the field. Concrete type culvert. Still water/no flow.	Poor
83	Yes 3.72	Tag can not be accessed. West side: a big tree is growing right from the center of the culvert. East side: a palm tree beside the culvert. Concrete type culvert. Still water/no flow.	Very Poor
84	Yes 3.75	West side: open. East side: trees growing beside the culvert. Concrete type culvert. Slow water flow from east to west.	Poor

85	Yes[1] 3.47	West side: open. East side: 2 trees growing just inside the culvert blocking the water flow. Concrete type culvert. Still water/no flow.	Poor
86	No 3.78	West side: small trees growing beside the culvert. East side: open. Concrete type culvert. Shallow slow water flows from east to west.	Acceptable
87	Yes 3.50	West side: grasses around the culvert. East side: open. Concrete type culvert. Shallow slow water flows from east to west.	Acceptable
88	No 3.56	Both sides are covered by tall thick trees; even worse on the west side. Concrete type culvert. Shallow slow water flows from east to west.	Poor
89	Yes 3.81	Right before the "Paurotis Pond" Sign. West side: thick trees beside and inside the water way. East side: clear and open except that a small palm tree is beside the culvert. A staff gauge is just outside the culvert on each side. Trees must be cleared off to some extent for proper ADFM flow measurement. Concrete type culvert. Shallow water flows from east to west.	Acceptable
		Then there is a Sign: "Paurotis Pond – Flamingo 14 mi ↑".	
90	Yes 3.66	Both sides are clear just in the close vicinity of the culvert. Lots of trees are outside in the front. Concrete type culvert. Slow flow from east to west.	Poor
91	Yes 3.53	West side: trees grow right from the culvert mouth. East side: about 6 feet away, trees grow in front of the culvert blocking the flow. Concrete type culvert. Still water/no flow.	Poor
92	Yes 3.53	Both sides are similar. Culvert is visible, but heavy trees block the flow path. Concrete type culvert. Still water/no flow.	Poor
93	No 3.65	Water flow is visible, but there are trees growing in front of or around the culvert. Concrete type culvert. Shallow water flows slowly from east to west.	Acceptable

94	No 3.58	Both sides are similar. Palm trees beside the culvert. Water flow is visible, but there are lots of trees 10 feet away outside. Stones at the bottom of the culvert. Concrete type culvert. Shallow water flows slowly from east to west.	Acceptable
95	Yes 3.68	Trees grow in the water way. Flow visible. Concrete type culvert. Shallow water flows slowly from east to west.	Acceptable
96	Yes 3.41	Lots of trees around and in front of the culvert on both sides. East side more visible than west side. Concrete type culvert. Shallow still water/no flow.	Poor
97	Yes 3.71	Lots of grasses and trees on both sides. Flow almost invisible. Concrete type culvert. Almost dry/no flow.	Poor
98	Yes 3.31	West side: a tree grows right in front of the culvert. Lots of grass around. East side: Too many grasses and trees to make the culvert totally invisible. Concrete type culvert. Still water/no flow.	Very poor
99	Yes[1] 3.62	Each side has a palm tree beside the culvert. East side is more visible than west side. Concrete type culvert. Still water/no flow.	Poor
100	No[2] 3.57	West side: almost invisible due to grass and palm trees. East side: better. But a small tree beside the culvert. Concrete type culvert. Still water/no flow.	Poor
101	No[2] 3.80	West side: better than the east. But there are grass and trees beside the culvert. East side: trees face the culvert 6 feet away in the front. Flow visible on both sides. Concrete type culvert. Slow flow east to west.	Acceptable
102	Yes 3.71	Both sides are heavily covered by grass and woods. Water is little visible. Concrete type culvert. Still water/no flow.	Poor
103	Yes 3.48	Lots of tall grasses, some bushes on both sides. More visible on the east side than the west side. Concrete type culvert. Shallow water/slow flow east to west.	Poor

104	No[2] 3.54	West side: a big bush makes the culvert invisible. East side: better. Concrete type culvert. Slow flow east to west.	Poor
105	No[2] 3.64	Both sides are similar. Water visible, but heavy trees in front of the culvert about 6 feet away. Impossible to set up staff gauges at this site. Concrete type culvert. Shallow water flows east to west.	Poor
106	No 4.13	Heavy grass and woods on both sides. Water little visible. Concrete type culvert. Still water/no flow.	Poor
107	Yes[1] 3.71	East side is better than west side: more visible, less grass. 10 feet away, lots of trees on both sides. Can conduct ADFM flow measurement by some efforts, but hard to set up staff gauges. Concrete type culvert. Still water/no flow.	Poor
108	No[2] 3.46	Just before the "Nine Mile Pond" sign. West side is better than east side: more visible, less trees around culvert. Can conduct ADFM flow measurement on the west side. Concrete type culvert. Still water/no flow.	Acceptable
		Then it is the sign "← Nine Mile Pond – Flamingo 11 mi".	
109	No 3.78	Both sides are heavily covered by grass and trees. Water and culvert totally invisible. Concrete type culvert.	Very poor
110	No[2] 3.82	Heavily covered by trees on both sides. West side: culvert like a concrete type. East side: culvert like a pipeline type. Culvert is dry/no flow.	Poor
111	No[2] 3.24	West side: Heavily covered by a big tree and its roots. East side: visible around culvert. But not far away, lots of trees in the front. Looking north, we can feel the road is changing direction. This observation can be used to verify the correctness of the GIS map. Concrete type culvert. Still water/no flow.	Poor

112	Yes 3.46	West side: a middle size tree grows right at the culvert mouth. Lots of grass around. Little visible. East side: condition ok around the culvert. Concrete type culvert. Still water/no flow.	Poor
113	Yes 3.04	Lot of grass around culvert on both sides. Lots of large trees and branches in front of culvert. Situation is a little better on the east side. Concrete type culvert. Almost dry/no flow.	Poor
114	Yes[1] 3.48	West side: covered with grasses. If cleared off, can be used for flow monitoring. East side: grass, trees are even closer to the culvert. Concrete type culvert. Culvert totally dry/no flow.	Poor
115	Yes 3.72	East side more open than west side. About 4 feet away, lots of trees on both sides. Concrete type culvert. Still water/no flow.	Poor
116	No[2] 3.79	Both sides are open. Clear only within 4 feet from the culvert. East side is a little better than west side. Can be a site for ADFM flow measurement, but hard to put the staff gauge. Concrete type culvert. Culvert is dry/no flow.	Acceptable
117	Yes[1] 3.57	West side: it is tree land about 6 feet away. East side: grass land about 9 feet away. More visible on this side. Can be a site for ADFM flow measurement, but hard to put the staff gauge. Concrete type culvert. Not that strong. Still water/no flow.	Acceptable
118	Yes[1] 3.72	Both sides are similar. 6 feet away, it is tree land. East side is less dense than west side. A little hard to put staff gauges, especially in the west side. Concrete type culvert. Still water/no flow.	Good
119	No 2.10	Both sides are clear. Water can be seen out in the front. If grass is cleared off around the culvert, the site can be used for ADFM flow monitoring. A benchmark point is close to the culvert. Pipeline type culvert. Still water/no flow.	Acceptable

120	No 2.83	West side is more visible than east side. Pipeline type culvert. Still water/no flow.	Acceptable
121	Yes 2.90	Even though visible, both sides are surrounded by heavily growing trees, which block the flow. Pipeline type culvert. Still water/no flow.	Poor
122	No 2.87	Same situations as Culvert 121. Pipeline type culvert. Still water/no flow.	Poor
123	No 2.81	Both sides are heavily covered by trees and tree roots. Culvert almost invisible. Pipeline type culvert. Still water/no flow.	Very poor
124	No 2.97	West side: big trees on the side of culvert. East side: tree roots in front of culvert. Visible on both sides, with better situation on the west side. Relatively easy to put staff gauges on this side. Pipeline type culvert. Shallow water/slow flow east to west.	Acceptable
125	No 2.94	West side: open, but lots of trees very close to culvert (< 2 feet). Situation better on the west side. Pipeline type culvert. Shallow water/slow flow east to west.	Poor
126	No 2.96	West side: heavily covered by trees. East side: visible. Pipeline type culvert. Shallow still water/no flow.	Poor
127	No 3.05	East side: visible and conditions ok. Trees are out around the culvert. West side: bad. Can conduct flow measurement if this side is cleared off a little bit. Pipeline type culvert. Slow flow east to west.	Poor
128	No 2.98	West side: covered by lots of trees. Little visible. East side: visible, open. Generally ok. Pipeline type culvert. Still water/no flow.	Poor
		Then it is the Sign "← Noble Hammock".	
129	No 2.70	About 300 feet down the road from the "Noble Hammock" sign. Both sides totally covered by heavy trees. Hardly visible. Pipeline type culvert. Still water/no flow.	Very Poor

130	No 2.82	West side: totally covered by trees and grasses. East side: visible, but lots of trees in front of the culvert. Pipeline type culvert. Shallow still water/no flow.	Poor
131	No[2] 2.91	West side: covered by heavy trees and bushes. East side: outside water visible. Pipeline type culvert. Shallow still water/no flow.	Poor
132	No 2.44	West side: covered by lots of trees and grasses. Culvert top broken. East side: outside water visible, site accessible. Pipeline type culvert. Still water/no flow.	Poor
		Then it is the "Hell's Bay" sign.	
133	Yes[1] 2.46	Site visible on both sides. Some grasses around the culvert. 6 feet away, there are lots of tree roots. A relatively good site for flow monitoring in this part of the road. Pipeline type culvert. Still water/no flow.	Good
134	No 2.60	West side: tree roots right in the middle of culvert. Lots of trees surrounding the culvert outside. East side: visible and accessible. Pipeline type culvert. Still water/no flow.	Poor
135	No 2.54	West side: lots of grasses and trees around the culvert. East side: visible and accessible. Pipeline type culvert. Still water/no flow.	Poor
136	Yes[1] 2.67	East side: visible and accessible. Lots of tree roots 6 feet away from the culvert. West side: less favorable than the other side. Grasses and trees in the vicinity of the culvert. Ok to measure flow, but hard to put staff gauges. Pipeline type culvert. Still water/no flow.	Acceptable
137	No 2.81	West side: almost invisible and inaccessible. Totally covered by high trees. East side: visible and accessible. But about 6 feet outside, it is tall tree forest. Pipeline type culvert. Still water/no flow.	Poor

138	No 2.59	East side: more open and visible than the other side. West side: efforts required to measure flow. Pipeline type culvert. Still water/no flow.	Acceptable
139	Yes[1] 2.72	West side: big tree roots just outside the culvert. East side: visible, but lots of trees in the vicinity of the culvert. Pipeline type culvert. Still water/no flow.	Poor
140	No 2.58	Both sides have many trees just in front of the culvert blocking the flow. West side more accessible than east side. Pipeline type culvert. No water/no flow.	Poor
141	No 3.32	Culvert in good conditions. No stones/gravels, etc inside. West side: a big tree is in the front with some branches hanging over. East side: medium dense grasses around. Acceptable site for flow measurement, but hard to put staff gauges. Pipeline type culvert. No water/no flow.	Poor
142	No 3.43	Culvert in good situations. Both sides have trees out in the front. West side: open and accessible. East side: grasses around culvert. Pipeline type culvert. No water/no flow.	Acceptable
143	No 3.50	Culvert in good conditions. West side: accessible and open to the road, but there are trees and grasses in the very front (3 feet away) blocking the flow. East side: grasses around. Lots of trees 6 feet away in the front. Pipeline type culvert. Culvert is dry/no flow.	Acceptable
144	No 2.82	Accessible on both sides, but not very open. Lots of trees around. Acceptable to measure flow, but hard to put staff gauges. Pipeline type culvert. Shallow water/no flow.	Acceptable

145	No 2.48	West side: heavy trees and tree roots inside, beside and outside the culvert blocking the flow. East side: Lots of grass around the culvert. Dense trees outside. Pipeline type culvert. Culvert is dry/no flow.	Poor
146	No 1.80	West side: dense trees and tree roots blocking the flow. East side: better than the west side, but still big trees very close surrounding the culvert. Pipeline type culvert. Culvert is dry /no flow.	Poor
147	No 2.41	West side: dense trees and tree roots around and facing the culvert, blocking the flow. East side: better than the other side just in the sense that trees are a little away from the culvert. Pipeline type culvert. No water/no flow.	Poor
148	No 2.73	Both sides are similar. Lots of tree roots, sand inside culvert. Also lots of trees just outside blocking the flow. Pipeline type culvert. No water/no flow.	Poor
149	No 2.69	West side: culvert top broken. Lots of sand deposit and dead tree roots inside culvert. Many trees and tree roots very close to culvert blocking the flow. East side: very dense bushes and trees outside the culvert (< 3 feet away). Pipeline type culvert. No water/no flow.	Poor
150	No 2.28	Heavily dense trees cover the culvert on both sides, making the culvert almost invisible and inaccessible. Pipeline type culvert. No water/no flow.	Poor
151	No 2.68	West side: very dense trees making the culvert almost invisible and inaccessible. Very big tree roots growing right from the culvert, almost blocking the whole culvert. East side: accessible from the road. But just in front of the culvert, dense large trees block the flow. Pipeline type culvert. Still water/no flow.	Very poor
152	No 2.39	Trees growing inside culvert on both sides. Lots of dense trees also outside the culvert. Culvert almost invisible. Pipeline type culvert. Still water/no flow.	Poor

153	No 2.46	West side more accessible than east side. Site is ok in terms of visibility. West side: thick tree roots 2 ~ 3 feet away in front of the culvert. East side: trees growing from and around the culvert. Impossible to put staff gauges. Pipeline type culvert. Culvert is dry/no flow.	Poor
154	No 2.37	Site is visible and easily accessible. But there are thick trees and tree roots around the culvert. Both sides are very close to outside large water bodies. Acceptable for flow measurement, but hard to put staff gauges. Pipeline type culvert. Culvert is dry/no flow.	Acceptable
155	No 3.56	Both sides are open and accessible. 5~6 feet away is the tall thick forest. The site is good for measuring flow, but hard to put staff gauges. Pipeline type culvert. Culvert is dry/no flow.	Acceptable
		Then about 100 feet ahead, it is the Sign: "← West Lake – Flamingo 7 mi ↑"	
156	No 2.35	West side: culvert hidden inside woods. Hardly seen. East side: better than the other side. But trees are just in front of culvert. Pipeline type culvert. Culvert is dry/no flow.	Poor
157	No 2.48	West side: trees surround and cover the culvert. East side: similar, just a little more accessible. Pipeline type culvert. Culvert is dry/no flow.	Poor
158	No 3.68	Visible and accessible on both sides. 5~6 feet away, it is dense tree forest. Can well conduct flow monitoring, just a little hard to put staff gauges. Pipeline type culvert. Culvert is dry/no flow.	Acceptable
159	No 2.47	Culvert visible on both sides. But big tree trunks are over the culvert. Accessibility just so-so. Pipeline type culvert. Culvert is dry/no flow.	Poor

160	No 3.87	West side: culvert top broken. Site open and visible. East side: covered by grasses. 5~6 feet away, it is forest land on both sides. Ok to measure flow, but hard to put staff gauges. Pipeline type culvert. Culvert is dry/no flow.	Acceptable
161	No[2] 3.34	West side: covered by thick trees. Hardly visible and accessible. East side: some grasses growing inside and around culvert. 5~6 feet away, lots of trees around. Situations better than the west side. Pipeline type culvert. Culvert is dry/no flow.	Poor
162	Yes 4.48	There are open areas on both sides. But just 5~6 feet away, it is dense forest land. Can conduct flow measurement, but hard to put staff gauges. Concrete type culvert. Culvert is dry/no flow.	Acceptable
163	No 4.13	Both sides are open and easily accessible. 8~9 feet away, it is tree forest land. Easy to measure flow, ok to set up staff gauges. Concrete type culvert. Culvert is dry/no flow.	Good
164	No[2] 4.14	Both sides are open and accessible. Even better on east side. Can easily conduct flow monitoring. About setting up staff gauge, West side: acceptable; east side: good. Concrete type culvert. Culvert is dry/no flow.	Good
165	Yes[1] 3.83	West side: 2~3 feet away, big tree roots face the culvert, blocking the flow. East side: site open and accessible. Very good for setting up the staff gauge. Concrete type culvert. Culvert is dry/no flow.	Acceptable
166	No 4.02	West side: 5~6 feet away, it is tree forest. A little bit hard to set up staff gauge. East side: 8~9 feet away, it is tree forest. Easy to install staff gauge. Good for flow measurement. Concrete type culvert. Culvert is dry/no flow.	Acceptable

167	No 3.43	West side: open and accessible. Trees are 3 feet away from the culvert. Good to measure flow; a little hard to install staff gauge. East side: open and accessible. It is forest land 8~9 feet away, but trees are not that thick in the flow way as on the other side. Concrete type culvert. Culvert is dry/no flow.	Acceptable
168	No 3.86	East side: open and accessible. 5~6 feet away, it is tree forest land. West side: similar to east side. Grass inside & around culvert. 6 feet away, big tree roots face the culvert, a little bit blocking the flow. Conditions to install staff gauge: just so-so. Concrete type culvert. Culvert is dry/no flow.	Acceptable
169	Yes[1] 3.36	West side: totally covered by big tree trunks. Inaccessible. East side: open, visible and accessible. Trees are 6 feet away. Concrete type culvert. Still water/no flow.	Poor
170	No 3.87	Both sides are open and accessible. Trees are not very dense. Relatively easy to install staff gauges. It is clean inside culvert. Concrete type culvert. Culvert is dry/no flow.	Good
171	No[2] 3.77	West side: visible and accessible, though there are big tree trunks over in front of the culvert (5~6 feet away). Space to measure flow and flow path are ok. East side: more open and accessible than the other side. Relatively easy to install staff gauge. Overall, a good site, but not as good as Culvert 170. Concrete type culvert. Culvert is dry/no flow.	Good
172	No 3.63	East side: open and accessible. Good for both measuring flow and installing staff gauge. West side: less favorable than east side, but still ok. Tree roots twisted in the front. The flow direction will change to some extent due to the setting around the culvert. Measuring flow: ok. Installing staff gauge: so-so. Concrete type culvert. Culvert is dry/no flow.	Acceptable

173	Yes[1] 3.84	Both sides are open and accessible. Around 6~9 feet away from the road, it is tree forest land. Good site to conduct flow measurement. Regarding installing staff gauge: West side: ok (place covered with water) East side: a little hard (moderately dense trees) Concrete type culvert. Culvert is dry/no flow.	Good
174	No 3.78	West side: very hard to access. Tree branches block the culvert. East side: open and accessible. Around 8~9 feet away, it is tree forest. Overall, a bad site. Concrete type culvert. Still dead water inside culvert/no flow.	Poor
175	Yes[1] 3.37	East side: lots of tree branches growing down in the water way to the culvert, blocking the flow. Dense trees in front of the culvert. West side: better conditions than East side. But 5~6 feet away, there are dense trees. Concrete type culvert. Culvert is dry/no flow.	Poor
		Around 0.1 mile ahead, it is the "Mrazek Pond" Sign.	
176	No 2.92	West side: totally covered by tree branches. Poor accessibility. East side: open and accessible. Culvert directly connected to Mrazek Pond. Concrete type culvert. Culvert is dry/no flow.	Poor
177	No 4.02	East side: totally covered by trees. West side: a little better, but still heavily covered by trees. Poor accessibility on both sides. Concrete type culvert. Culvert is dry/no flow.	Poor

178	No 3.20	West side: 5~6 feet away, big tree roots in front of the culvert, blocking the flow. Far away, it is forest land with dense tall big tree roots, forming very special scenery not seen in other places along SR 9336. East side: 8~9 feet away, big tree roots in the front. Far away, it is forest land with dense tall big tree roots, which is similar to the other side. Flow monitoring: ok. Relatively hard to put staff gauge, especially on the west side. Concrete type culvert. Still water inside culvert/no flow.	Acceptable
		Then just down the road, it is the "Coot Bay Pond →" Sign.	

Notes:

1: Tag is actually found in the field, which is however incorrectly recorded as "No" on an old GIS map.
2: Tag can not found in the field, which is however incorrectly recorded as "Yes" on an old GIS map.
3: Condition "Good" means that it is a favorable site to conduct ADFM flow measurement and minor vegetation clearing-off may be required to install staff gauges on the site. Condition "Acceptable" means some efforts may be required in conducting flow measurement or some vegetation clearing-off may be required in installing staff gauges or both. Condition "Poor" means it is not a favorable site to conduct ADFM flow measurement. Major efforts and vegetation clearing-off are required if the site is chosen for flow measurement.

APPENDIX II – BASIC INFORMATION ON CULVERTS ALONG SR 9336 IN ENP

Table 16. Location and geometric properties of 178 culverts along SR 9336 in ENP

CUL_ NO	X_ COORD	Y_ COORD	MILES	TAGS	TAG ELEV_*	CUL_ DIAM_	CUL_ TYPE	REMARKS	Locating culvert by Landmark
1	542458.95	2808668.63	0.25	Yes	3.99	24	B1	Next to R158	After "EVERGLADES NATIONAL PARK" sign
2	542337.57	2808611.48	0.33	Yes	4.25	24	B1		
3	542196.02	2808555.64	0.42	No	4.50	24	B1	Before entrance station	
4	542065.67	2808512.33	0.51	Yes	4.77	24	B1	This culvert is twice as long due to split in road after entrance station.	
5	541947.57	2808483.35	0.59	Yes	4.79	24	B1	Has a double culvert on NE side. In front of Visitor center.	
6	541797.01	2808458.07	0.68	No	4.05	24	B1	Visitor center	
7	541419.01	2808467.96	0.95	No	5.10	24	B1	Culvert thick with vegetation	
8	541253.43	2808467.63	1.04	No	4.26	24	B2	Culvert is buried on North side, useless	First culvert after the park entrance
9	541107.33	2808514.58	1.12	Yes	4.33	24	B1	Long culvert cannot see through	
10	540851.84	2808610.54	1.29	No	4.73	24	B1	A Taylor Slough Culvert	
11	540716.68	2808681.43	1.38	No	4.87	24	B1	A Taylor Slough Culvert	
12	540583.75	2808756.71	1.48	Yes	4.84	24	B1	A Taylor Slough Culvert	
13	540462.92	2808825.18	1.56	Yes	4.75	24	B1	A Taylor Slough Culvert	
14	540321.29	2808906.19	1.67	Yes	5.07	24	B1	A Taylor Slough Culvert	
15	540184.77	2808982.53	1.76	Yes	4.75	24	B1	A Taylor Slough Culvert	
16	540052.84	2809057.79	1.86	No	4.69	24	B1	A Taylor Slough Culvert	
17	539921.02	2809132.76	1.95	Yes	4.03	36	B1	A Taylor Slough Culvert	1st culvert before the 1st bridge along SR 9336
18	539703.47	2809254.08	2.11	No	5.03	24	C1	A Taylor Slough Culvert	Destroyed due to the bridge built
19	539257.76	2809505.56	2.43	No	5.11	24	C2	A Taylor Slough Culvert	Destroyed due to the bridge built
20	539100.15	2809596.34	2.54	Yes	4.37	36	B1	A Taylor Slough Culvert	After "Royal Palm Turn Off – ¼ mile (0.4 km)" sign
21	538994.22	2809656.82	2.61	Yes	4.25	36	B1	A Taylor Slough Culvert	
22	538758.08	2809796.10	2.78	Yes	4.25	24	B2	A Taylor Slough Culvert	After "Royal Palm – ← Anhinga Trail" sign
23	537489.40	2810509.70	3.69	Yes	5.51	24	B2	A Taylor Slough Culvert. After road to Royal Palm.	
24	536202.74	2811021.52	4.59	Yes	5.43	24	B2	Next to Nts14. A year 94' BM next to culvert	
25	535137.33	2810983.43	5.18	No	5.48	24	B2	After road to Long Pine Key	After "← Long Pine Key – Flamingo 34 mile" sign
26	533859.40	2810967.83	6.02	Yes	5.48	24	B2		
27	532586.63	2811349.75	6.85	Yes	5.55	24	B2		
28	532199.98	2811588.06	7.13	Yes	5.80	24	B2		After "Pine Land → – Flamingo 32 mile" sign
29	530217.24	2813096.87	8.65	Yes	6.00	24	B2		
30	529445.83	2813200.77	9.12	No	5.60	24	B2		
31	528659.15	2813100.16	9.65	No	5.60	24	B2		

CUL_ NO	X_ COORD	Y_ COORD	MILES	TAGS	TAG ELEV_*	CUL_ DIAM_	CUL_ TYPE	REMARKS	Locating culvert by Landmark
32	527107.12	2812782.49	10.66	Yes	5.17	24	B2	After old road to P-44	
33	525835.24	2812710.56	11.47	No	5.34	24	B2		
34	525275.50	2812775.18	11.81	No	4.22	24	B2	Right before Rock Reef sign	
35	525115.16	2812795.30	11.91	Yes	4.21	24	B2		After "Rock Reef Pass – Elevation 3 feet – 0.9 meter" sign
36	524810.50	2812804.05	12.18	No	4.25	24	B2		
37	524506.63	2812784.00	12.37	Yes	4.33	24	B2		
38	524174.43	2812726.50	12.59	Yes	4.25	24	B2		
39	523909.87	2812649.24	12.76	No	4.41	24	B2		
40	523600.70	2812522.40	12.85	No	4.48	24	B2		
41	523357.44	2812393.78	13.04	Yes	3.94	24	B2		
42	523104.33	2812221.28	13.16	No	4.29	24	B2	Before Pahayokee vista area	
43	522872.21	2812026.20	13.42	Yes	4.22	24	B2	After Pahayokee	After "Pa-hay-okee" sign
44	522655.03	2811805.27	13.61	No	2.38	24	B2		
45	522471.75	2811570.90	13.79	No	2.52	24	B2		
46	522304.32	2811309.76	13.98	No	2.55	24	B2		
47	522180.17	2811083.63	14.16	No	2.61	24	B2		
48	522029.56	2810820.82	14.34	No	2.66	24	B2		
49	521857.91	2810533.84	14.53	No	2.68	24	B2		
50	521694.93	2810276.63	14.73	No	2.28	24	B2		
51	521525.23	2810023.61	14.92	No	2.60	24	B2		After "Dwarf Cypress Forest – Elev. 4ft (1.2m)" sign
52	521349.12	2809776.30	15.11	No	2.16	24	B2		
53	521162.31	2809534.38	15.30	No	2.26	24	B2		
54	520969.88	2809297.20	15.49	No	2.16	24	B2		
55	520768.27	2809063.84	15.68	No	2.94	24	B2		
56	519864.96	2808099.38	16.50	Yes	3.32	24	B2	After Sisal Pond	
57	519171.62	2807212.96	17.20	No	3.82	24	B2		
58	518690.92	2806431.05	17.77	No	3.24	24	B2		
59	518340.06	2805689.48	18.28	Yes	3.10	24	B2		
60	518087.15	2805000.68	18.74	Yes	3.75	24	B2		
61	517981.81	2803830.98	19.49	No	3.14	24	B2		
62	518060.77	2803502.00	19.68	No	3.04	24	B2		
63	518166.09	2803231.09	19.86	Yes	3.04	24	B2		
64	518342.25	2802923.66	20.08	No	2.78	24	B2		
65	518497.62	2802703.55	20.25	No	2.94	24	B2		
66	518714.16	2802484.67	20.44	Yes	3.15	24	B1	Right after Mahogoney Hammock vista area	After "Mahagany Hammock → – Flamingo 18 mi ↑" sign
67	518947.57	2802293.71	20.63	Yes	3.08	24	B1		

CUL_ NO	X_ COORD	Y_ COORD	MILES	TAGS	TAG ELEV_*	CUL_ DIAM_	CUL_ TYPE	REMARKS	Locating culvert by Landmark
68	519216.34	2802140.05	20.82	Yes	2.76	24	B1		
69	519441.25	2802014.31	20.98	Yes	3.03	24	B1		
70	519715.09	2801800.74	21.20	Yes	3.02	24	B1		
71	519920.99	2801576.79	21.39	Yes	2.86	24	B1		
72	520080.96	2801326.29	21.54	No	2.86	24	B1		
73	520184.13	2801068.98	21.75	Yes	2.76	24	B1		
74	520254.57	2800772.84	21.94	Yes	2.96	24	B1		
75	520269.47	2800505.88	22.11	Yes	3.06	24	B1		After 75, the road is becoming very straight like a line
76	520267.96	2800152.84	22.33	No	3.67	24	A1	Culvert is right after old pump house road.	
77	520266.79	2799864.66	22.51	No	3.66	24	A1		
78	520269.10	2799557.98	22.70	No	3.55	24	A1		
79	520269.56	2799251.39	22.88	No	3.58	24	A1		
80	520267.84	2798946.87	23.07	Yes	3.67	24	A1		
81	520269.41	2798643.62	23.26	No	3.99	24	A1		
82	520268.32	2798336.80	23.45	Yes	3.53	24	A1		
83	520268.61	2798032.88	23.64	Yes	3.72	24	A1	BM 94 NL. side	
84	520267.91	2797729.95	23.83	Yes	3.75	24	A1		
85	520265.71	2797418.11	24.02	Yes	3.47	24	A1		
86	520272.82	2797119.41	24.21	No	3.78	24	A1		
87	520269.01	2796816.69	24.40	Yes	3.50	24	A1	Has a 71' BM at culvert	
88	520270.36	2796507.03	24.59	No	3.56	24	A1		
89	520268.97	2796200.18	24.78	Yes	3.81	24	A1	Has a '71 BM at culvert	
90	520271.45	2795896.44	24.97	Yes	3.66	24	A1	Right after Paurotis Pond	After "Paurotis Pond – Flamingo 14 mi ↑" sign
91	520268.63	2795596.02	25.16	Yes	3.53	24	A1		
92	520268.84	2795421.61	25.26	Yes	3.53	24	A1		
93	520270.82	2795293.85	25.35	No	3.65	24	A1		
94	520270.07	2795137.61	25.44	No	3.58	24	A1		
95	520270.79	2794989.21	25.54	Yes	3.68	24	A1		
96	520270.96	2794835.35	25.64	Yes	3.41	24	A1		
97	520271.13	2794681.48	25.73	Yes	3.71	24	A1		
98	520269.63	2794538.26	25.82	Yes	3.31	24	A1		
99	520270.12	2794377.55	25.92	Yes	3.62	24	A1		
100	520269.91	2794205.20	26.02	No	3.57	24	A1		
101	520270.12	2794080.53	26.11	No	3.80	24	A1		
102	520269.49	2793920.97	26.20	Yes	3.71	24	A1		
103	520269.75	2793771.53	26.29	Yes	3.48	24	A1		

CUL_ NO	X_ COORD	Y_ COORD	MILES	TAGS	TAG ELEV_*	CUL_ DIAM_	CUL_ TYPE	REMARKS	Locating culvert by Landmark
104	520269.28	2793616.48	26.39	No	3.54	24	A1		
105	520266.65	2793439.97	26.50	No	3.64	24	A1		
106	520270.82	2793281.96	26.60	No	4.13	24	A1		
107	520270.49	2793125.87	26.69	Yes	3.71	24	A1		
108	520266.66	2793011.22	26.76	No	3.46	24	A1		
109	520270.64	2792868.07	26.85	No	3.78	24	A1		After "← Nine Mile Pond – Flamingo 11 mi" sign
110	520274.82	2792732.69	26.94	No	3.82	24	A1		
111	520268.39	2792569.57	27.04	No	3.24	24	A1	After nine mile pond	Road direction is changing to south west
112	520237.51	2792402.63	27.15	Yes	3.46	24	A1		
113	520184.98	2792261.53	27.24	Yes	3.04	24	A1		
114	520108.59	2792133.35	27.34	Yes	3.48	24	A1		
115	520008.37	2792012.94	27.43	Yes	3.72	24	A1		
116	519891.74	2791918.79	27.53	No	3.79	24	A1		
117	519765.08	2791834.20	27.63	Yes	3.57	24	A1		
118	519637.29	2791749.40	27.71	Yes	3.72	24	A1		
119	519505.31	2791661.09	27.81	No	2.10	24	B2		
120	519360.64	2791565.26	27.90	No	2.83	24	B1		
121	519271.20	2791499.81	27.99	Yes	2.90	24	B1		
122	519092.97	2791384.47	28.13	No	2.87	24	B1		
123	518954.48	2791287.98	28.23	No	2.81	24	B2		
124	518890.40	2791247.67	28.27	No	2.97	24	B1		
125	518753.61	2791154.82	28.38	No	2.94	24	B1		
126	518664.10	2791096.97	28.44	No	2.96	24	B1		
127	518542.86	2791013.44	28.54	No	3.05	24	B1		
128	518361.12	2790890.48	28.67	No	2.98	24	B2		
129	518240.43	2790810.94	28.77	No	2.70	24	B2		After "← Noble Hammock" sign
130	518176.07	2790767.44	28.81	No	2.82	24	B2		
131	518054.26	2790688.31	28.90	No	2.91	24	B2		
132	517875.20	2790566.61	29.04	No	2.44	24	B2		
133	517730.74	2790471.68	29.14	Yes	2.46	24	B2	After Hells Bay canoe trail.	After "Hell's Bay" sign
134	517626.95	2790400.29	29.26	No	2.60	24	B2		
135	517490.36	2790304.74	29.32	No	2.54	24	B2		
136	517378.72	2790230.55	29.41	Yes	2.67	24	B2		
137	517237.27	2790136.26	29.51	No	2.81	24	B2		
138	517108.86	2790050.13	29.61	No	2.59	24	B2		
139	516984.47	2789969.92	29.70	Yes	2.72	24	B2		

CUL_ NO	X_ COORD	Y_ COORD	MILES	TAGS	TAG ELEV_*	CUL_ DIAM_	CUL_ TYPE	REMARKS	Locating culvert by Landmark
140	516855.64	2789882.73	29.80	No	2.58	24	B2		
141	516742.27	2789802.04	29.88	No	3.32	24	B1		
142	516624.18	2789724.69	29.97	No	3.43	24	B1		
143	516476.62	2789625.41	30.08	No	3.50	24	B2		
144	516352.67	2789540.40	30.18	No	2.82	24	B2		
145	516227.61	2789452.73	30.27	No	2.48	24	B1		
146	516098.82	2789369.15	30.37	No	1.80	24	B2		
147	515975.32	2789284.55	30.46	No	2.41	24	B2		
148	515846.05	2789200.77	30.56	No	2.73	24	B2		
149	515720.35	2789115.92	30.65	No	2.69	24	B2		
151	515469.53	2788943.95	30.75	No	2.28	24	B2		
150	515594.33	2789028.71	30.84	No	2.68	24	B2		
152	515339.36	2788860.70	30.93	No	2.39	24	B2		
153	515157.57	2788735.55	31.07	No	2.46	24	B2		
154	515101.71	2788700.80	31.12	No	2.37	24	B2		
155	514936.85	2788588.42	31.24	No	3.56	24	B1		
156	514759.11	2788469.24	31.37	No	2.35	24	B1		After "← West Lake – Flamingo 7 mi 1" sign
157	514683.38	2788417.54	31.43	No	2.48	24	B1		
158	514582.11	2788350.61	31.50	No	3.68	24	B2		
159	514456.44	2788266.11	31.60	No	2.47	24	B2		
160	514331.17	2788180.20	31.69	No	3.87	24	B2		
161	514203.64	2788095.86	31.79	No	3.34	24	A1		
162	514078.59	2788010.48	31.88	Yes	4.48	24	A1		
163	513825.23	2787839.00	32.07	No	4.13	24	A1		
164	513571.15	2787671.07	32.26	No	4.14	24	A1		
165	513317.27	2787501.81	32.45	Yes	3.83	24	A1		
166	513065.77	2787329.77	32.64	No	4.02	24	A1		
167	512819.68	2787149.68	32.83	No	3.43	24	A1		
168	512572.61	2786973.64	33.02	No	3.86	24	A1		
169	512324.96	2786795.17	33.21	Yes	3.36	24			
170	512074.35	2786622.30	33.40	No	3.87	24	A2		
171	511826.99	2786446.79	33.59	No	3.77	24	A1		
172	511575.67	2786273.88	33.78	No	3.63	24	A1		
173	511323.66	2786098.26	33.96	Yes	3.84	24	A1		
174	511100.26	2785895.13	34.15	No	3.78	24	A1		
175	510883.22	2785680.20	34.34	Yes	3.37	24	A1		

CUL_ NO	X_ COORD	Y_ COORD	MILES	TAGS	TAG ELEV_+	CUL_ DIAM_	CUL_ TYPE	REMARKS	Locating culvert by Landmark
176	510677.73	2785449.72	34.53	No	2.92	24	A1	Before Mrazek Pond	
177	510482.94	2785220.05	34.72	No	4.02	24	A1		
178	510304.97	2785012.90	34.91	No	3.20	24	A2		

Notes:

+: TAG ELEV_ (Tag Elevation) means the elevation where the tag is placed. The tag is flat round metal placed either on the top of the culvert or on the top of the vertical headwall above the culvert.

APPENDIX III – CULVERT TAG ELEVATION VERSUS MILEAGE ALONG SR 9336 IN ENP

Table 17. Elevation where the tag is punched onto the top of each of 178 culverts along SR 9336[+]

Culvert No.	Tags	Mileage (mi)	Culvert Tag Elevation in NGVD29 Datum (ft)	Culvert No.	Tags	Mileage (mi)	Culvert Tag Elevation in NGVD29 Datum (ft)
1	Yes	0.25	3.99	38	Yes	12.59	4.25
2	Yes	0.33	4.25	39	No	12.76	4.41
3	No	0.42	4.5	40	No	12.85	4.48
4	Yes	0.51	4.77	41	Yes	13.04	3.94
5	Yes	0.59	4.79	42	No	13.16	4.29
6	No	0.68	4.05	43	Yes	13.42	4.22
7	No	0.95	5.1	44	No	13.61	2.38
8	No	1.04	4.26	45	No	13.79	2.52
9	Yes	1.12	4.33	46	No	13.98	2.55
10	No	1.29	4.73	47	No	14.16	2.61
11	No	1.38	4.87	48	No	14.34	2.66
12	Yes	1.48	4.84	49	No	14.53	2.68
13	Yes	1.56	4.75	50	No	14.73	2.28
14	Yes	1.67	5.07	51	No	14.92	2.6
15	Yes	1.76	4.75	52	No	15.11	2.16
16	No	1.86	4.69	53	No	15.30	2.26
17	Yes	1.95	4.03	54	No	15.49	2.16
18	Culvert no longer exists	2.11	5.03	55	No	15.68	2.94
19	Culvert no longer exists	2.43	5.11	56	Yes	16.50	3.32
20	Yes	2.54	4.37	57	No	17.20	3.82
21	Yes	2.61	4.25	58	No	17.77	3.24
22	Yes	2.78	4.25	59	Yes	18.28	3.1
23	Yes	3.69	5.51	60	Yes	18.74	3.75
24	Yes	4.59	5.43	61	No	19.49	3.14
25	No	5.18	5.48	62	No	19.68	3.04
26	Yes	6.02	5.48	63	Yes	19.86	3.04
27	Yes	6.85	5.55	64	No	20.08	2.78
28	Yes	7.13	5.8	65	No	20.25	2.94
29	Yes	8.65	6	66	Yes	20.44	3.15
30	No	9.12	5.6	67	Yes	20.63	3.08
31	No	9.65	5.6	68	Yes	20.82	2.76
32	Yes	10.66	5.17	69	Yes	20.98	3.03
33	No	11.47	5.34	70	Yes	21.20	3.02
34	No	11.81	4.22	71	Yes	21.39	2.86
35	Yes	11.91	4.21	72	No	21.54	2.86
36	No	12.18	4.25	73	Yes	21.75	2.76
37	Yes	12.37	4.33	74	Yes	21.94	2.96

Culvert No.	Tags	Mileage (mi)	Culvert Tag Elevation in NGVD29 Datum (ft)	Culvert No.	Tags	Mileage (mi)	Culvert Tag Elevation in NGVD29 Datum (ft)
75	Yes	22.11	3.06	118	Yes	27.71	3.72
76	No	22.33	3.67	119	No	27.81	2.1
77	No	22.51	3.66	120	No	27.90	2.83
78	No	22.70	3.55	121	Yes	27.99	2.9
79	No	22.88	3.58	122	No	28.13	2.87
80	Yes	23.07	3.67	123	No	28.23	2.81
81	No	23.26	3.99	124	No	28.27	2.97
82	Yes	23.45	3.53	125	No	28.38	2.94
83	Yes	23.64	3.72	126	No	28.44	2.96
84	Yes	23.83	3.75	127	No	28.54	3.05
85	Yes	24.02	3.47	128	No	28.67	2.98
86	No	24.21	3.78	129	No	28.77	2.7
87	Yes	24.40	3.5	130	No	28.81	2.82
88	No	24.59	3.56	131	No	28.90	2.91
89	Yes	24.78	3.81	132	No	29.04	2.44
90	Yes	24.97	3.66	133	Yes	29.14	2.46
91	Yes	25.16	3.53	134	No	29.26	2.6
92	Yes	25.26	3.53	135	No	29.32	2.54
93	No	25.35	3.65	136	Yes	29.41	2.67
94	No	25.44	3.58	137	No	29.51	2.81
95	Yes	25.54	3.68	138	No	29.61	2.59
96	Yes	25.64	*3.41*	139	Yes	29.70	2.72
97	Yes	25.73	3.71	140	No	29.80	2.58
98	Yes	25.82	3.31	141	No	29.88	3.32
99	Yes	25.92	3.62	142	No	29.97	3.43
100	No	26.02	3.57	143	No	30.08	3.5
101	No	26.11	3.8	144	No	30.18	2.82
102	Yes	26.20	3.71	145	No	30.27	2.48
103	Yes	26.29	3.48	146	No	30.37	1.8
104	No	26.39	3.54	147	No	30.46	2.41
105	No	26.50	3.64	148	No	30.56	2.73
106	No	26.60	4.13	149	No	30.65	2.69
107	Yes	26.69	3.71	150	No	30.75	2.28
108	No	26.76	3.46	151	No	30.84	2.68
109	No	26.85	3.78	152	No	30.93	2.39
110	No	26.94	3.82	153	No	31.07	2.46
111	No	27.04	3.24	154	No	31.12	2.37
112	Yes	27.15	3.46	155	No	31.24	3.56
113	Yes	27.24	3.04	156	No	31.37	2.35
114	Yes	27.34	3.48	157	No	31.43	2.48
115	Yes	27.43	3.72	158	No	31.50	3.68
116	No	27.53	3.79	159	No	31.60	2.47
117	Yes	27.63	3.57	160	No	31.69	3.87

Culvert No.	Tags	Mileage (mi)	Culvert Tag Elevation in NGVD29 Datum (ft)	Culvert No.	Tags	Mileage (mi)	Culvert Tag Elevation in NGVD29 Datum (ft)
161	No	31.79	3.34	170	No	33.40	3.87
162	Yes	31.88	4.48	171	No	33.59	3.77
163	No	32.07	4.13	172	No	33.78	3.63
164	No	32.26	4.14	173	Yes	33.96	3.84
165	Yes	32.45	3.83	174	No	34.15	3.78
166	No	32.64	4.02	175	Yes	34.34	3.37
167	No	32.83	3.43	176	No	34.53	2.92
168	No	33.02	3.86	177	No	34.72	4.02
169	Yes	33.21	3.36	178	No	34.91	3.2

Notes:
+: The tag is placed either on the top of the culvert or on the top of the vertical headwall above the culvert.

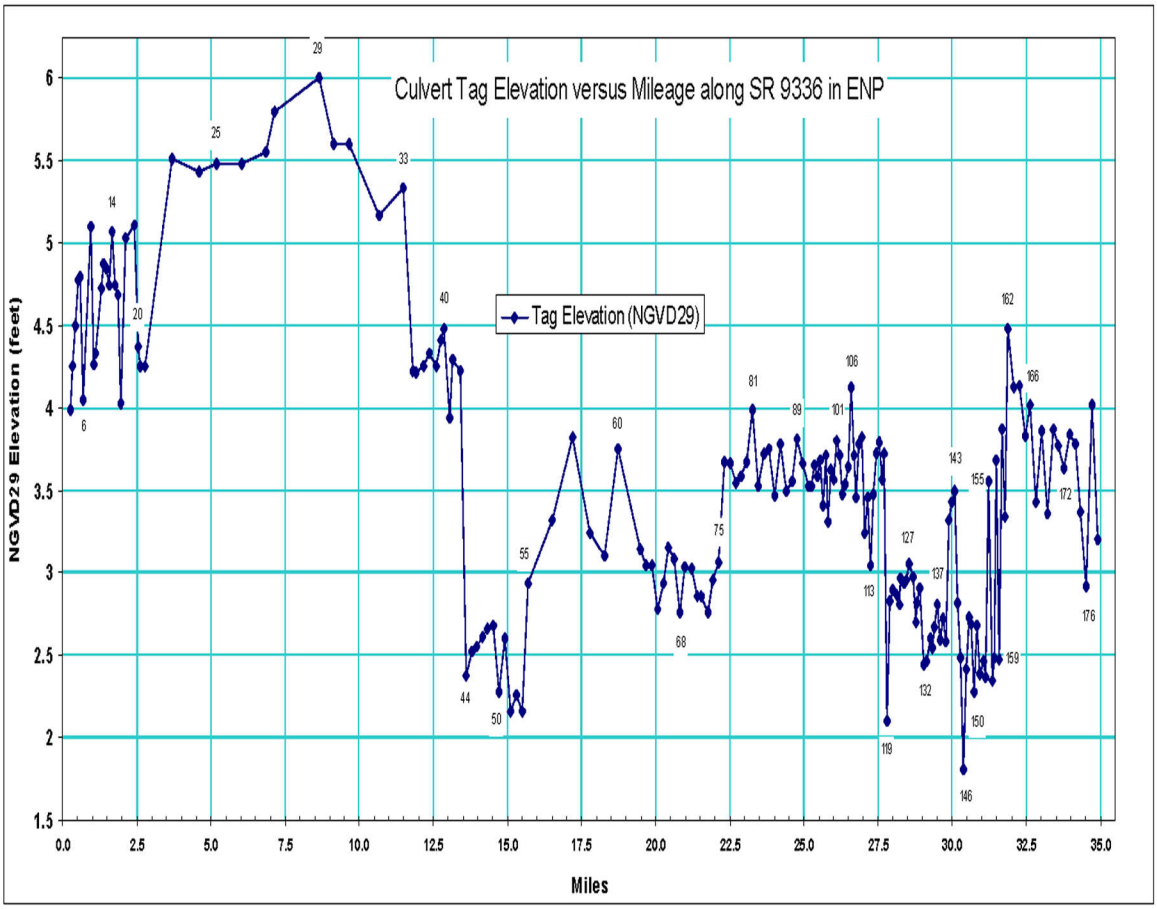

Figure 28. Culvert tag elevation versus mileage along SR 9336 in ENP+

Notes:

+: Culvert tag elevation refers to the notes in Appendix II.

APPENDIX IV – SURVEY SUPPORT FOR STAFF GAUGE INSTALLATION ALONG SR 9336 IN THE EVERGLADES NATIONAL PARK

Introduction

To support the RECOVER and CERP projects, the South Florida Water Management District (District) has initiated a flow monitoring project in the Everglades National Park (ENP), which is undertaken by Hydrogage, Inc. The flow measurement outcomes will be used to establish rating curves and relationships for flow across the culverts along the main park road in ENP.

US Geological Survey (USGS) in Miami also has monitoring needs in ENP to support its modeling efforts. It has been identified that some staff gauges need to be installed along the main park road. Thus corresponding survey work is required to support this task. USGS has taken the role to install the gauges.

Scope of Work

The staff gauges are to be installed at the close vicinity of selected culvert sites. Survey work is to be started from the closest benchmark point of a culvert site. The survey will provide baseline elevation reference to install one staff gauge on each side of the road. In addition to this, 4 elevation readings will be taken for each culvert: 2 invert elevation values and 2 culvert top height readings. The culvert invert point and top point are in the same vertical line. The culvert top points to be surveyed are to be marked by paint before the survey work is started. The following two tables contain some of basic information needed for the survey work.

Table 18. Staff gauge sites and closest benchmarks

Culvert No.	Staff Gauge	Benchmark to be used for survey work	Observation & Comment
11	Proposed site of new staff gauge pair	H432 It is just around 20 feet away from culvert 13 on the east side. GPS position readings: W 80°35'50.8" N 25°23'50.9"	To be used to monitor the water level in the upper reach of SR 9336
24	South side: gauge condition is good. North side: gauge pole is there. We may need to put a gauge on the pole.	M432 It is just beside the culvert on north side.	There is a groundwater transducer on north side.

Culvert No.	Staff Gauge	Benchmark to be used for survey work	Observation & Comment
30	Proposed site of new staff gauge pair	R432 It is between culvert 29 & 30 on the north side of road, about 300 feet down the road from culvert 29. GPS position readings: W 80°42'00.4" N 25°26'11.7"	To be used to monitor the water level in the upper reach of SR 9336
34	Proposed site of new staff gauge pair	Supposed benchmark: U432 To be identified	
43	A pair of gauges have been installed	V432 It is located inside the intersection triangle lot of the main park road and Pahayokee road.	West side: gauge is eroded. The numbers and markings on the gauge have faded. A replacement for this is needed. East side: gauge is normal.
59	There is only one staff gauge on the west side of the road. Another staff gauge needs to be installed on the east side of the road.	A433 It is located on the west side of road, about 6 feet down the road from culvert 59.	The analysis on the flow data of this site shows that head water – tail water difference and flow rate exhibits a good relationship.
69	Proposed site of new staff gauge pair	D433 It is located between culvert 69 and 70, about 20 ft in the north from Culvert 70.	To be used to monitor the water level in the middle reach of SR 9336
77	Proposed site of new staff gauge pair	Supposed benchmark: E433 Need to be identified.	To be used to monitor the water level in the middle reach of SR 9336
89	A pair of gauges have been installed	Supposed benchmark: G433 Need to be identified.	Staff gauge readings faded. Gauges need to be replaced on both sides.

Culvert No.	Staff Gauge	Benchmark to be used for survey work	Observation & Comment
108	Proposed site of new staff gauge pair	Supposed benchmark: H433 Need to be identified.	
118	Proposed site of new staff gauge pair	Supposed benchmark: FLGPS THOMPSON 1989 or FLGPS THOMPSON AZ M Need to be identified.	To be used to monitor the water level in the lower reach of SR 9336
143	Proposed site of new staff gauge pair	Supposed benchmark: K433 Need to be identified.	To be used to monitor the water level in the lower reach of SR 9336
170	Proposed site of new staff gauge pair	Supposed benchmark: N433 Need to be identified.	To be used to monitor the water level in the lower reach of SR 9336
P1	Pa-Hay-Okee visitor vista road staff gauge pair. W 80°46.544 N 25°265.895	V432 It is located inside the intersection triangle lot of the main park road and Pahayokee road	To help document the influence of the Pay-Hay-Okee road on flows across SR9336
S1 and SR2	ENP gauges along SR9336 . Located north of Culvert 59	Supposed benchmark: Z432 Need to be identified.	To be used to help verify ENP water levels and in conjunction with USGS marsh flow meters.

Table 19. Benchmarks along SR 9336 in the Everglades National Park

ID	EASTING	NORTHING	LONGITUDE	LATITUDE	MARKER	NAVD 88 (ft)
1	542969.81	2808912.50	80:34:22.1W	25:23:52.3N	lame az mk 1961/197	
2	542464.50	2808670.50	80:34:40.2W	25:23:44.5N	F432 1994	4.55
3	541214.25	2808516.75	80:35:25.0W	25:23:39.6N	G432	4.81
4	540466.38	2808822.25	80:35:51.7W	25:23:49.6N	H432	3.92
5	539463.94	2809387.25	80:36:27.5W	25:24:08.1N	J432	6.13
6	538998.38	2809652.25	80:36:44.1W	25:24:16.7N	K432	4.41
7	537645.75	2810421.00	80:37:32.5W	25:24:41.9N	L432	4.53
8	536205.25	2811020.25	80:38:24.0W	25:25:01.5N	M432	5.37
9	534638.06	2810966.50	80:39:20.1W	25:24:59.9N	N432	4.4
10	533022.38	2811157.50	80:40:17.9W	25:25:06.2N	P432	4.85
11	531755.25	2811958.50	80:41:03.2W	25:25:32.3N	Q432	4.99
12	530129.00	2813119.75	80:42:01.3W	25:26:10.2N	R432	5.35

ID	EASTING	NORTHING	LONGITUDE	LATITUDE	MARKER	NAVD 88 (ft)
13	528078.63	2812980.25	80:43:14.7W	25:26:05.8N	S432	4.59
14	526345.13	2812701.50	80:44:16.8W	25:25:56.9N	T432	4.47
15	524778.19	2812806.00	80:45:12.9W	25:26:00.4N	U432	3.45
16	523010.16	2812155.75	80:46:16.2W	25:25:39.3N	V432	4.98
17	522031.03	2810822.50	80:46:51.4W	25:24:56.0N	W432	3.32
18	521141.28	2809507.00	80:47:23.3W	25:24:13.3N	X432	3.45
19	520037.69	2808283.50	80:48:02.9W	25:23:33.6N	Y432	3.41
20	519026.28	2806987.25	80:48:39.1W	25:22:51.5N	Z432	2.92
21	518344.34	2805689.25	80:49:03.6W	25:22:09.3N	A433	2.87
22	517950.13	2804144.50	80:49:17.8W	25:21:19.1N	B433	2.82
23	518615.66	2802572.25	80:48:54.0W	25:20:28.0N	C433	3.5
24	519712.44	2801806.75	80:48:14.8W	25:20:03.0N	D433	2.65
25	520268.72	2800179.75	80:47:55.0W	25:19:10.1N	E433	2.25
26	520278.69	2798041.75	80:47:54.8W	25:18:00.6N	F433	2.58
27	520278.47	2796140.25	80:47:54.9W	25:16:58.8N	G433	2.3
28	520279.50	2794087.00	80:47:55.0W	25:15:52.0N	H433	2.18
29	520036.25	2792020.25	80:48:03.8W	25:14:44.9N	PINKS 1961	
30	519996.00	2791987.75	80:48:05.2W	25:14:43.8N	FLGPS THOMPSON 1989	2.69
31	519514.94	2791651.25	80:48:22.4W	25:14:32.9N	FLGPS THOMPSON AZ M	1.68
32	517788.13	2790492.25	80:49:24.2W	25:13:55.3N	J433	1.84
33	516317.31	2789503.50	80:50:16.8W	25:13:23.2N	K433	2.05
34	514868.38	2788523.75	80:51:08.6W	25:12:51.4N	L433	1.77
35	513087.75	2787337.25	80:52:12.3W	25:12:12.9N	M433	2.32
36	512225.97	2786718.50	80:52:43.1W	25:11:52.8N	N433	2.5
37	510999.25	2785782.75	80:53:27.0W	25:11:22.4N	P433	2.45
38	510307.72	2785015.25	80:53:51.7W	25:10:57.5N	872 3644 N TIDAL	1.58
39	510300.88	2784951.75	80:53:52.0W	25:10:55.4N	872 3644 L TIDAL	1.29
40	509358.00	2783884.25	80:54:25.7W	25:10:20.7N	Q433	2.5
41	508771.31	2782441.75	80:54:46.7W	25:09:33.8N	R433	3.11
42	508061.38	2781491.75	80:55:12.1W	25:09:02.9N	872 3644 K TIDAL	1.38
43	507785.25	2781260.75	80:55:21.9W	25:08:55.4N	MARKED 17.36	15.04
44	507784.38	2781249.25	80:55:22.0W	25:08:55.1N	FCE 3803	
45	507679.41	2780591.00	80:55:25.7W	25:08:33.7N	MLW G	
46	507681.88	2780648.50	80:55:25.6W	25:08:35.5N	872 3644 TIDAL 1	2.79

Notes:
NAVD 88 values are excerpted from the web site of the National Geodetic Survey http://www.ngs.noaa.gov/

APPENDIX V – SURVEY SUMMARY SHEET FOR CULVERTS ALONG SR 9336 IN ENP

Table 20. Survey summary for the culverts and staff gauge tubes in the selected monitoring sites

	NAVD88 elevation								GPS position reading							
	Staff gauge tube		Top of pipe		Invert of pipe		Top - Invert		Top of pipe				Invert of pipe			
Culvert	North/	South/	North/	South/	North/	South/	North/	South/	North/West side coordinate		South/East side coordinate		North/West side coordinate		South/East side coordinate	
No.	West	East	West	East	West	East	West	East	Northing	Easting	Northing	Easting	Northing	Easting	Northing	Easting
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
11	4.71	4.9	3.52	3.74	1.26	1.47	2.26	2.27	386448.9	789878.7	386403.5	789854.8	386449.6	789879.2	386403.6	789855.2
24	5.73	6.02	4	3.97	1.75	1.72	2.25	2.25	394130.5	775059	394079.9	775060.9	394129.3	775060.2	394079.1	775061.1
30	5.71	5.26	4.12	4.23	1.86	1.99	2.26	2.24	401282.1	752883	401231.4	752884.4	401281.7	752884.3	401232.1	752884.6
34	4.06	5.01	2.65	2.53	0.4	0.29	2.25	2.24	399879.3	739197.9	399832.8	739192.1	399878.4	739198.4	399832.6	739192.7
43	3.06	2.96	2.62	2.71	0.19	0.4	2.43	2.31	397429.6	731301.9	397394.9	731336.3	397434	731297.7	397392.2	731339.2
59	1.66	1.14	1.43	1.45	-0.84	-0.82	2.27	2.27	376623.1	716438.8	376608.8	716481.3	376624	716436	376605.9	716485.3
69	0.91	2.14	1.4	1.35	-0.86	-0.9	2.26	2.25	364563.7	720041.3	364605.5	720067.3	364561.1	720039.7	364611.1	720068.8
77	2.34	2.67	1.22	1.32	-0.77	-0.77	1.99	2.09	357500.1	722768	357500.3	722809.7	357500.3	722766	357500.8	722809.8
89	2.83	2.55	2.38	2.16	-0.58	-0.73	2.96	2.89	345494.2	722766.7	345491.6	722811	345492.7	722768.1	345491.7	722808.1
108	1.47	1.44	0.92	1.01	-1.08	-1.05	2	2.06	335017.9	722770.8	335017.1	722813.1	335019.2	722772.3	335019.6	722810.9
118	2.4	1.91	2.26	2.28	-0.65	-0.69	2.91	2.97	330873.5	720693.2	330841	720716.4	330874.1	720693.2	330841.4	720716.6
143	1.45	1.29	1.87	1.64	-0.39	-0.62	2.26	2.26	323905.3	710321.4	323870	710347.5	323906.1	710319.2	323868.3	710347.7
170	1.7	2.88	2.2	2.14	-0.55	-0.63	2.75	2.77	314055.6	695863	314024.9	695888.6	314056.9	695863.2	314024.2	695887.6

APPENDIX VI – COMPARISON OF ELEVATION VALUES ON THE CULVERT TAGS WITH LAND SURVEY RESULTS OF THIS PROJECT

Originally when the culverts were buried under SR 9336 in ENP, a tag was placed at each culvert site. It is either on the top of the pipe or on the top of the vertical headwall above the pipe. Table 17 contains the elevation where each tag is placed. When the staff gauges were to be installed in 2004, a survey work was conducted in 13 representative culvert sites. Elevations of the culvert inverts and tops were surveyed. Listed below in Table 21 are the comparison of the above two sources, surveyed in different years.

Table 21. Comparison of elevation values on the culvert tags with the results of survey in 2004

Culvert No.	Elevation of point where culvert tag is placed (see Table 17)	Results from the survey conducted in 2004 for the project	Comparison
	NAVD 29 (ft)	NAVD 29 (ft)	
(1)	(2)	(3)	(4)
11	4.87	Top of culvert: Northern: 5.11 Southern: 5.33	Columns (2) & (3) should be close. But actually the difference is significant.
24	5.43	Top of culvert: Northern: 5.59 Southern: 5.56	Columns (2) & (3) should be close. But actually the difference is distinguishable.
30	5.6	Top of culvert: Northern: 5.71 Southern: 5.82	Columns (2) & (3) should be close. But actually the difference is distinguishable.
34	4.22	Top of culvert: Northern: 4.24 Southern: 4.12	Column (2) and the value for the northern side of column (3) have little difference.
43	4.22	Top of culvert: North/West: 4.21 South/East: 4.30	Column (2) and the value for the North/West side of column (3) are almost the same.
59	3.1	Top of culvert: West: 3.02 East: 3.04	Columns (2) & (3) should be close. But actually the difference is distinguishable.
69	3.03	Top of culvert: North/East: 2.57 South/West: 2.62	Columns (2) & (3) should be close. But actually the difference is significant.

77	3.66	Top of culvert: West: 2.81 East: 2.91	This culvert has vertical headwall at its entrance. The tag is on the top of the headwall. So the tag elevation is higher than that of the culvert top. Columns (2) & (3) can not be compared.
89	3.81	Top of the headwall: West: 3.60 East: 3.38	This culvert has vertical headwall at its entrance. The tag is on the top of the headwall in the west side. The difference between Column (2) and the value for the West side of column (3) is significant.
108	3.46	Top of culvert: West: 2.60 East: 2.51	This culvert has vertical headwall at its entrance. The tag is on the top of the headwall. So the tag elevation is higher than that of the culvert top. Columns (2) & (3) can not be compared.
118	3.72	Top of the headwall: North/West: 3.85 South/East: 3.87	This culvert has vertical headwall at its entrance. The tag is on the top of the headwall. The difference between Columns (2) and (3) is distinguishable.
143	3.5	Top of culvert: North/West: 3.46 South/East: 3.23	Column (2) and the value for the North/West side of column (3) have a small difference.
170	3.87	Top of the headwall: North/West: 3.79 South/East: 3.73	This culvert has vertical headwall at its entrance. The tag is on the top of the headwall. The difference between Columns (2) and (3) is distinguishable.

From the comparison in Table 21, it is seen that significant or distinguishable differences exist between the tag elevations listed in Table 17 and the elevations surveyed in 2004. The survey conducted in 2004 was based on the Vertical Control Marks (benchmarks) installed by the National Geodetic Survey in 1994, which is accurate. Data in Table 17 was based on an old datum system, which is less accurate. So when we use the data in Table 17 to represent elevations of the culverts along SR 9336 for monitoring or modeling purposes, discretions must be employed. If accurate elevation data is required, then a new survey based on the Vertical Control Marks of 1994 is preferred.

APPENDIX VII – FLOW MEASUREMENT RECORDS FOR CULVERTS ALONG SR 9336 IN ENP

Table 22. Flow measurement records at Culvert 11

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-08-04	13:40 to 14:10	3.321	1.399	2.45	1.356	North to south	2.95	2.88
2004-10-19	11:58 to 12:35	4.400	1.463	2.576	1.708	North to south		2.96
2004-10-21	12:56 to 13:40	4.331	1.479	2.606	1.662	North to south		2.975
2004-11-03	15:50 to 16:51	0.750	1.201	2.046	0.367	North to south		2.69
2004-11-04	15:41 to 16:21	0.635	1.201	2.046	0.311	North to south		2.675
2004-11-05	12:52 to 13:26	0.931	1.166	1.974	0.472	North to south		2.665

Table 23. Flow measurement records at Culvert 24

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-08-04	14:55 to 15:27	2.290	1.96	3.127	0.733	North to south	4.03	3.96
2004-08-18	14:10	1.031	2.24	3.142	0.328	North to south	3.96	3.88
2004-08-25	12:45	0.314	2.13	3.142	0.1	North to south	3.86	3.8
2004-09-01	12:00	0	2.06	3.142	0	North to south	3.78	3.74
2004-10-19	13:15	1.128	2.24	3.142	0.359	North to south	3.98	3.9

Table 24. Flow measurement records at Culvert 30

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-08-04	16:05 to 16:35	0.607	1.926	3.326	0.183	North to South	3.91	3.84
2004-08-11	12:15	1.247	1.73	3.053	0.409	North to South	3.71	3.68
2004-08-18	15:20	2.307	2.09	3.462	0.666	North to South	4.07	4.05
2004-08-27	11:35	0.724	1.67	2.954	0.245	North to South	3.66	3.64
2004-09-01	14:00	0.921	1.72	3.036	0.303	North to South	3.705	3.69
2004-09-16	17:45	0.000	1.36	2.373	0		3.36	3.34
2004-09-24	11:00	0.000	1.46	2.570	0		3.46	3.45
2004-10-01	13:50		1.52	2.685			3.5	3.5
2004-10-05	14:00		1.3	2.252			3.28	3.29
2004-10-14	11:50		1.34	2.333			3.34	3.34
2004-10-19	14:10 to 14:58	0.793	1.854	3.236	0.245	North to South	3.86	3.82
2004-11-04	15:15		1.36	2.373			3.35	3.34

Table 25. Flow measurement records at Culvert 34

Date	Time	Flow	Depth of	Area of	Mean velocity	Flow direction	Head water	Tail water

			water	flow				
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-28	13:30	2.021	1.9	3.296	0.613	North to South	3.16	3.16
2004-08-06	10:15	5.289	2.05	3.442	1.537	North to South	2.38	2.31
2004-08-11	14:36 to 15:10	6.097	1.959	3.362	1.814	North to South	2.26	2.21
2004-08-11	14:36 to 15:10	3.706	1.959	3.363	1.102	North to South	2.26	2.21
2004-08-18	16:15	5.483	2.25	3.464	1.583	North to South	2.57	2.5
2004-08-27	10:55	3.361	2	3.403	0.987	North to South	2.3	2.275
2004-09-01	14:58 to 15:43	8.134	1.886	3.278	2.482	North to South	2.24	2.18
2004-09-01	16:00	2.871	1.93	3.332	0.862	North to South	2.24	2.18
2004-09-16	17:15	0.236	1.66	2.937	0.081	North to South	1.96	1.94
2004-09-23	16:40	1.490	1.81	3.175	0.469	North to South	2.1	2.07
2004-10-01	13:10	1.715	1.83	3.203	0.536	North to South	2.12	2.08
2004-10-05	14:45	0.656	1.74	3.068	0.214	North to South	2.03	2.01
2004-10-14	11:20	0.0	1.79	3.145	0.0		2.08	2.07
2004-10-19	15:30	5.603	2.23	3.464	1.617	North to South	2.582	2.5
2004-11-05	12:15	1.007	1.83	3.203	0.314	North to South	2.115	2.09

Table 26. Flow measurement records at Culvert 43

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-28	15:00	4.622	1.25	2.149	2.151	South/East to North/West	1.69	1.58
2004-08-06	11:06 to 11:31	5.613	1.291	2.233	2.513	South/East to North/West	1.86	1.7
2004-08-12	17:27 to 18:00	3.481	1.216	2.078	1.676	South/East to North/West	1.7	1.64
2004-08-20	13:02 to 13:30	7.831	1.405	2.461	3.182	South/East to North/West	2.09	1.84
2004-08-26	16:22 to 16:53	5.984	1.434	2.518	2.377	South/East to North/West	1.99	1.83
2004-09-15	12:49 to 13:41	3.117	1.168	1.978	1.576	South/East to North/West	1.58	1.57
2004-09-16	16:30	1.478	1.18	2.004	0.737	South/East to North/West	1.55	1.545
2004-09-22	12:59 to 13:44	2.565	1.24	2.129	1.205	South/East to North/West	1.690	1.66
2004-09-29	16:51 to 17:08	1.550	1.234	2.114	0.733	South/East to North/West	1.63	1.64
2004-10-05	15:50 to 16:51	1.560	1.269	2.186	0.713	South/East to North/West	1.685	1.68
2004-10-12	11:49 to 12:50	0.542	1.232	2.111	0.257	South/East to North/West	1.645	1.64
2004-10-19	15:55 to 16:31	8.310	1.588	2.809	2.958	South/East to North/West	2.245	2.02

Table 27. Flow measurement records at Culvert 59

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-06-16	16:55	2.748	1.204	2.054	1.338	East to west	0.4	0.27
2004-07-23	10:25	2.657	1.198	2.041	1.302	East to west	0.42	0.32
2004-07-28	16:00	5.206	1.5	2.647	1.967	East to west	1.04	0.51
2004-08-06	12:09	7.825	1.467	2.583	3.029	East to west	0.89	0.54
2004-08-12	16:14	5.609	1.45	2.55	2.2	East to west	0.7	0.52
2004-08-20	11:54	11.146	1.677	2.965	3.759	East to west	1.21	0.76

2004-08-26	15:22	8.741	1.709	3.017	2.897	East to west	1.08	0.8
2004-09-15	14:11	4.877	1.465	2.579	1.891	East to west	0.69	0.57
2004-09-22	14:13	3.855	1.471	2.59	1.488	East to west	0.75	0.61
2004-10-01	11:38	2.296	1.527	2.697	0.851	East to west	0.74	0.7
2004-10-06	15:16	2.487	1.428	2.507	0.992	East to west	0.62	0.58
2004-10-12	14:09	2.015	1.396	2.445	0.824	East to west	0.6	0.55
2004-10-21	10:41	11.023	1.769	3.112	3.542	East to west	1.32	0.93

Table 28. Flow measurement records at Culvert 69

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-23	12:00	0.607	1.03	1.661	0.365	North/East to South/West	0.15	0.14
2004-07-29	10:21 to 11:10	4.543	1.426	2.447	1.857	North/East to South/West	0.62	0.52
2004-08-05	15:40 to 15:55	4.919	1.399	2.396	2.053	North/East to South/West	0.71	0.57
2004-08-12	15:18 to 15:40	4.476	1.27	2.144	2.088	North/East to South/West	0.41	0.36
2004-08-19	14:39 to 15:08	5.147	1.498	2.581	1.994	North/East to South/West	0.73	0.58
2004-08-26	14:28 to 14:56	3.662	1.432	2.459	1.489	North/East to South/West	0.59	0.50
2004-09-15	15:28 to 16:08	1.650	1.236	2.077	0.795	North/East to South/West	0.38	0.34
2004-09-16	15:45	1.526	1.18	1.967	0.776	North/East to South/West	0.35	0.31
2004-09-22	15:24 to 16:04	2.201	1.266	2.138	1.029	North/East to South/West	0.4	0.36
2004-09-30	16:16 to 16:51	0.832	1.3	2.204	0.378	North/East to South/West	0.43	0.4
2004-10-07	10:14 to 11:10	0.719	1.129	1.860	0.387	North/East to South/West	0.22	0.2
2004-10-12	15:17 to 16:01	1.035	1.066	1.733	0.597	North/East to South/West	0.18	0.16
2004-10-21	11:34 to 12:16	7.755	1.596	2.752	2.817	North/East to South/West	0.94	0.71

Table 29. Flow measurement records at Culvert 77

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-22	15:30	0.000	0.65	0.885	0.0	East to west	-0.17	-0.19
2004-07-29	11:45	3.125	0.95	1.471	2.124	East to west	0.3	0.22
2004-08-05	14:21 to 14:52	4.872	1.157	1.884	2.585	East to west	0.52	0.33
2004-08-12	14:24 to 14:37	3.271	1.007	1.586	2.063	East to west	0.27	0.18
2004-08-20	11:01 to 11:25	3.119	1.067	1.705	1.829	East to west	0.37	0.25
2004-08-26	13:43 to 14:01	2.468	1.039	1.648	1.497	East to west	0.305	0.21
2004-09-15	16:32 to 17:15	3.523	1.073	1.717	2.052	East to west	0.35	0.25
2004-09-23	15:18 to 15:51	2.679	1.012	1.596	1.779	East to west	0.26	0.23
2004-09-30	15:30 to 15:48	2.230	1.204	1.976	1.129	East to west	0.38	0.38
2004-10-07	11:36 to 12:52	1.403	0.969	1.509	0.93	East to west	0.17	0.165
2004-10-14	10:30	1.140	0.9	1.371	0.832	East to west	0.13	0.12
2004-10-20	15:07 to 15:30	5.178	1.27	2.104	2.461	East to west	0.59	0.442

Table 30. Flow measurement records at Culvert 89

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-22	12:30	0.333	0.3	0.295	1.128	West to east	-0.18	-0.28
2004-07-29	13:00	0.500	0.35	0.369	1.355	West to east	-0.13	-0.22
2004-08-05	13:30	1.178	0.8	1.173	1.004	West to east	0.26	0.22
2004-08-12	12:50	0.725	0.65	0.885	0.819	East to west	-0.03	-0.03
2004-08-20	10:00	1.308	0.63	0.848	1.542	East to west	0	-0.06
2004-08-26	11:55	0.951	0.6	0.793	1.200	East to west	-0.05	-0.09
2004-09-16	14:25 to 15:03	3.399	0.972	1.514	2.244	East to west	0.31	0.095
2004-09-23	14:09 to 14:45	2.748	0.935	1.442	1.906	East to west	0.24	0.1
2004-09-30	14:09 to 14:40	1.057	1.137	1.846	0.573	East to west	0.365	0.340
2004-10-06	14:12 to 14:48	2.275	0.899	1.370	1.661	East to west	0.21	0.060
2004-10-13	14:39 to 15:20	2.365	0.869	1.309	1.808	East to west	0.15	0.020
2004-10-20	14:10 to 14:44	3.242	1.099	1.769	1.834	East to west	0.405	0.270
2004-11-05	10:00 to 10:39	1.649	0.834	1.240	1.330	East to west	0.105	-0.025

Table 31. Flow measurement records at Culvert 108

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-29	14:00	0.591	0.78	1.162	0.509	West to east	-0.27	-0.42
2004-08-05	12:15	1.166	0.98	1.572	0.742	West to east	-0.05	-0.08
2004-08-12	12:15	0.371	1.01	1.634	0.227	East to west	-0.1	-0.12
2004-08-19	12:00	0.803	1	1.613	0.498	East to west	-0.09	-0.13
2004-08-26	11:00	0.513	0.96	1.530	0.335	East to west	-0.1	-0.14
2004-09-16	12:57 to 13:55	2.987	1.133	1.887	1.583	East to west	0.23	0.160
2004-09-23	12:49 to 13:39	2.383	1.101	1.822	1.308	East to west	0.18	0.140
2004-09-30	13:06 to 13:42	0.657	1.329	2.285	0.288	East to west	0.34	0.325
2004-10-06	12:50 to 13:45	1.900	1.099	1.817	1.045	East to west	0.165	0.110
2004-10-13	13:31 to 14:14	1.544	1.035	1.685	0.916	East to west	0.11	0.070
2004-10-20	13:08 to 13:46	2.427	1.265	2.158	1.125	East to west	0.33	0.280
2004-11-05	11:00 to 11:31	0.742	1.03	1.675	0.443	East to west	0.06	0.030

Table 32. Flow measurement records at Culvert 118

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-29	15:00	0.410	0.42	0.482	0.849	West to east	-0.220	-0.26
2004-08-05	11:15	0.930	0.58	0.761	1.223	West to east	-0.070	-0.14
2004-08-12	10:45	0.209	0.59	0.779	0.268	East to west	-0.09	-0.090
2004-08-19	11:15	0.360	0.57	0.743	0.485	East to west	-0.09	-0.100
2004-08-26	10:20	0.277	0.55	0.706	0.392	East to west	-0.11	-0.120
2004-09-16	11:30 to 12:26	1.684	0.906	1.392	1.210	East to west	0.28	0.190
2004-09-23	11:41 to 12:20	1.692	0.843	1.267	1.335	East to west	0.215	0.165

2004-09-30	11:52 to 12:40	0.307	1.01	1.591	0.193	East to west	0.36	0.350
2004-10-06	11:26 to 12:22	1.648	0.804	1.188	1.387	East to west	0.195	0.155
2004-10-13	12:11 to 13:07	0.837	0.805	1.191	0.703	East to west	0.15	0.115
2004-10-20	11:59 to 12:45	1.176	1.001	1.583	0.743	East to west	0.345	0.300
2004-11-04	13:53 to 14:41	0.686	0.807	1.195	0.574	East to west	0.085	0.060

Table 33. Flow measurement records at Culvert 143

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-30	10:30	0.262	0.56	0.741	0.353	West to East	-0.04	-0.07
2004-08-05	10:30	0.348	0.59	0.798	0.436	West to East	-0.01	-0.05
2004-08-19	10:30	0.124	0.29	0.289	0.429	East to West	-0.105	-0.13
2004-08-26	9:45	0.089	0.28	0.275	0.324	East to West	-0.12	-0.15
2004-09-16	11:00	0.947	0.62	0.855	1.108	East to West	0.26	0.2
2004-09-23	10:50	0.583	0.56	0.741	0.786	East to West	0.19	0.14
2004-09-30	11:10	0.243	0.77	1.151	0.211	East to West	0.365	0.355
2004-10-06	11:00	0.568	0.55	0.723	0.786	East to West	0.185	0.145
2004-10-13	11:30	0.372	0.5	0.632	0.588	East to West	0.155	0.095
2004-10-20	11:30	0.527	0.7	1.011	0.521	East to West	0.315	0.285
2004-11-04	13:00	0.340	0.45	0.544	0.625	East to West	0.07	0.025

Table 34. Flow measurement records at Culvert 170

Date	Time	Flow	Depth of water	Area of flow	Mean velocity	Flow direction	Head water	Tail water
(yyyy-mm-dd)	(hh:mm to hh:mm)	(ft^3/s)	(ft)	(ft^2)	(ft/s)		(ft)	(ft)
2004-07-30	11:30	0.196	0.68	0.957	0.205	East to West	0.09	0.09
2004-09-16	10:10	0.270	0.83	1.253	0.216	East to West	0.27	0.27
2004-09-23	10:10	0.201	0.83	1.253	0.161	East to West	0.27	0.26
2004-09-30	10:04 to 10:38	2.165	1.033	1.665	1.300	East to West	0.52	0.485
2004-10-06	10:10	0.259	0.82	1.233	0.210	East to West	0.265	0.27
2004-10-13	10:16 to 11:03	0.733	0.911	1.415	0.518	East to West	0.37	0.37
2004-10-20	9:56 to 10:52	0.551	0.932	1.457	0.378	East to West	0.375	0.385
2004-11-04	12:30	0.0	0.66	0.918	0.0		0.09	0.09

APPENDIX VIII – WATER LEVEL MEASUREMENT RECORDS AT REPRESENTATIVE CULVERTS ALONG SR 9336 IN ENP

Table 35 to Table 48 are water level data for each field trip. The data was collected at representative culverts along SR 9336 in a period of three days. Since the water level changes gradually in ENP most of the time, each table provides a profile of the water level distribution along SR 9336, an important cross section to monitor the hydrological conditions in the Everglades. Figure 29**Error! Reference source not found.** to Figure 42**Error! Reference source not found.** are the corresponding graphical representation of water level distribution along SR 9336. Figure 43**Error! Reference source not found.** to Figure 52**Error! Reference source not found.** display the water level distribution of different dates in on one plot, which shows how water level changes temporally.

Table 35. Water level versus mileage along SR 9336 in ENP (Observation 1)

Date	Culvert No.	Mileage (mile)	North/West# Side NAVD88 (ft)	South/East# Side NAVD88 (ft)
	11	1.38		
	24	4.59		
	30	9.12		
	34	11.81		
	43	13.42		
7/23/2004	59	18.28	0.32	0.42
7/23/2004	69	20.98	0.14	0.15
7/22/2004	77	22.51	-0.19	-0.17
7/22/2004	89	24.78	-0.18	-0.28
	108	26.76		
	118	27.71		
	143	30.08		
	170	33.4		

Notes:

#: The orientation of North/West and South/East is unambiguously identifiable for all culverts except Culvert 69. For Culvert 69, North/West and South/East should be comprehended as West and East side of the main park road. This peculiarity is seen in Figure 1**Error! Reference source not found.**. This convention applies to all the tables and graphs that follow.

Table 36. Water level versus mileage along SR 9336 in ENP (Observation 2)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
	11	1.38		
	24	4.59		

	30	9.12		
7/28/2004	34	11.81	3.16	3.16
7/28/2004	43	13.42	1.58	1.69
7/28/2004	59	18.28	0.51	1.04
7/29/2004	69	20.98	0.52	0.62
7/29/2004	77	22.51	0.22	0.3
7/29/2004	89	24.78	-0.13	-0.22
7/29/2004	108	26.76	-0.27	-0.42
7/29/2004	118	27.71	-0.22	-0.26
7/30/2004	143	30.08	-0.04	-0.07
7/30/2004	170	33.4	0.09	0.09

Table 37. Water level versus mileage along SR 9336 in ENP (Observation 3)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
8/4/2004	11	1.38	2.95	2.88
8/4/2004	24	4.59	4.03	3.96
8/4/2004	30	9.12	3.91	3.84
8/6/2004	34	11.81	2.38	2.31
8/6/2004	43	13.42	1.7	1.86
8/6/2004	59	18.28	0.54	0.89
8/5/2004	69	20.98	0.57	0.71
8/5/2004	77	22.51	0.33	0.52
8/5/2004	89	24.78	0.22	0.26
8/5/2004	108	26.76	-0.05	-0.08
8/5/2004	118	27.71	-0.070	-0.14
8/5/2004	143	30.08	-0.01	-0.05
	170	33.4		

Table 38. Water level versus mileage along SR 9336 in ENP (Observation 4)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
	11	1.38		
	24	4.59		
8/11/2004	30	9.12	3.71	3.68
8/11/2004	34	11.81	2.26	2.21
8/12/2004	43	13.42	1.64	1.7

8/12/2004	59	18.28	0.52	0.7
8/12/2004	69	20.98	0.36	0.41
8/12/2004	77	22.51	0.18	0.27
8/12/2004	89	24.78	-0.03	-0.03
8/12/2004	108	26.76	-0.12	-0.1
8/12/2004	118	27.71	-0.090	-0.09
	143	30.08		
	170	33.4		

Table 39. Water level versus mileage along SR 9336 in ENP (Observation 5)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
	11	1.38		
8/18/2004	24	4.59	3.96	3.88
8/18/2004	30	9.12	4.07	4.05
8/18/2004	34	11.81	2.57	2.5
8/20/2004	43	13.42	1.84	2.09
8/20/2004	59	18.28	0.76	1.21
8/19/2004	69	20.98	0.58	0.73
8/20/2004	77	22.51	0.25	0.37
8/20/2004	89	24.78	-0.06	0
8/19/2004	108	26.76	-0.13	-0.09
8/19/2004	118	27.71	-0.100	-0.09
8/19/2004	143	30.08	-0.13	-0.105
	170	33.4		

Table 40. Water level versus mileage along SR 9336 in ENP (Observation 6)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
	11	1.38		
8/25/2004	24	4.59	3.86	3.8
8/27/2004	30	9.12	3.66	3.64
8/27/2004	34	11.81	2.3	2.275
8/26/2004	43	13.42	1.83	1.99
8/26/2004	59	18.28	0.8	1.08
8/26/2004	69	20.98	0.5	0.59
8/26/2004	77	22.51	0.21	0.305

8/26/2004	89	24.78	-0.09	-0.05
8/26/2004	108	26.76	-0.14	-0.1
8/26/2004	118	27.71	-0.120	-0.11
8/26/2004	143	30.08	-0.15	-0.12
	170	33.4		

Table 41. Water level versus mileage along SR 9336 in ENP (Observation 7)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
	11	1.38		
9/1/2004	24	4.59	3.78	3.74
9/1/2004	30	9.12	3.705	3.69
9/1/2004	34	11.81	2.24	2.18
	43	13.42		
	59	18.28		
	69	20.98		
	77	22.51		
	89	24.78		
	108	26.76		
	118	27.71		
	143	30.08		
	170	33.4		

Table 42. Water level versus mileage along SR 9336 in ENP (Observation 8)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
	11	1.38		
	24	4.59		
9/16/2004	30	9.12	3.36	3.34
9/16/2004	34	11.81	1.96	1.94
9/15/2004	43	13.42	1.57	1.58
9/15/2004	59	18.28	0.57	0.69
9/15/2004	69	20.98	0.34	0.38
9/15/2004	77	22.51	0.25	0.35
9/16/2004	89	24.78	0.095	0.31
9/16/2004	108	26.76	0.16	0.23
9/16/2004	118	27.71	0.19	0.28

9/16/2004	143	30.08	0.2	0.26
9/16/2004	170	33.4	0.27	0.27

Table 43. Water level versus mileage along SR 9336 in ENP (Observation 9)

Date	Culvert No.	Mileage	North/West Side	South/East Side
		(mile)	NAVD88 (ft)	NAVD88 (ft)
	11	1.38		
	24	4.59		
9/24/2004	30	9.12	3.46	3.45
9/23/2004	34	11.81	2.1	2.07
9/22/2004	43	13.42	1.66	1.69
9/22/2004	59	18.28	0.61	0.75
9/22/2004	69	20.98	0.36	0.4
9/23/2004	77	22.51	0.23	0.26
9/23/2004	89	24.78	0.1	0.24
9/23/2004	108	26.76	0.14	0.18
9/23/2004	118	27.71	0.165	0.215
9/23/2004	143	30.08	0.14	0.19
9/23/2004	170	33.4	0.26	0.27

Table 44. Water level versus mileage along SR 9336 in ENP (Observation 10)

Date	Culvert No.	Mileage	North/West Side	South/East Side
		(mile)	NAVD88 (ft)	NAVD88 (ft)
	11	1.38		
	24	4.59		
10/1/2004	30	9.12	3.5	3.5
10/1/2004	34	11.81	2.12	2.08
9/29/2004	43	13.42	1.64	1.63
10/1/2004	59	18.28	0.7	0.74
9/30/2004	69	20.98	0.4	0.43
9/30/2004	77	22.51	0.38	0.38
9/30/2004	89	24.78	0.34	0.365
9/30/2004	108	26.76	0.325	0.34
9/30/2004	118	27.71	0.35	0.36
9/30/2004	143	30.08	0.355	0.365
9/30/2004	170	33.4	0.485	0.52

Table 45. Water level versus mileage along SR 9336 in ENP (Observation 11)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
	11	1.38		
	24	4.59		
10/5/2004	30	9.12	3.28	3.29
10/5/2004	34	11.81	2.03	2.01
10/5/2004	43	13.42	1.68	1.685
10/6/2004	59	18.28	0.58	0.62
10/7/2004	69	20.98	0.2	0.22
10/7/2004	77	22.51	0.165	0.17
10/6/2004	89	24.78	0.06	0.21
10/6/2004	108	26.76	0.11	0.165
10/6/2004	118	27.71	0.155	0.195
10/6/2004	143	30.08	0.145	0.185
10/6/2004	170	33.4	0.27	0.265

Table 46. Water level versus mileage along SR 9336 in ENP (Observation 12)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
	11	1.38		
	24	4.59		
10/14/2004	30	9.12	3.34	3.34
10/14/2004	34	11.81	2.08	2.07
10/12/2004	43	13.42	1.64	1.645
10/12/2004	59	18.28	0.55	0.6
10/12/2004	69	20.98	0.16	0.18
10/14/2004	77	22.51	0.12	0.13
10/13/2004	89	24.78	0.02	0.15
10/13/2004	108	26.76	0.07	0.11
10/13/2004	118	27.71	0.115	0.15
10/13/2004	143	30.08	0.095	0.155
10/13/2004	170	33.4	0.37	0.37

Table 47. Water level versus mileage along SR 9336 in ENP (Observation 13)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)

10/19/2004	11	1.38		2.96
10/19/2004	24	4.59	3.98	3.9
10/19/2004	30	9.12	3.86	3.82
10/19/2004	34	11.81	2.582	2.5
10/19/2004	43	13.42	2.02	2.245
10/21/2004	59	18.28	0.93	1.32
10/21/2004	69	20.98	0.71	0.94
10/20/2004	77	22.51	0.442	0.59
10/20/2004	89	24.78	0.27	0.405
10/20/2004	108	26.76	0.28	0.33
10/20/2004	118	27.71	0.3	0.345
10/20/2004	143	30.08	0.285	0.315
10/20/2004	170	33.4	0.385	0.375

Table 48. Water level versus mileage along SR 9336 in ENP (Observation 14)

Date	Culvert No.	Mileage (mile)	North/West Side NAVD88 (ft)	South/East Side NAVD88 (ft)
11/5/2004	11	1.38		2.665
	24	4.59		
11/4/2004	30	9.12	3.35	3.34
11/5/2004	34	11.81	2.115	2.09
	43	13.42		
	59	18.28		
	69	20.98		
	77	22.51		
11/5/2004	89	24.78	-0.025	0.105
11/5/2004	108	26.76	0.03	0.06
11/4/2004	118	27.71	0.06	0.085
11/4/2004	143	30.08	0.025	0.07
11/4/2004	170	33.4	0.09	0.09

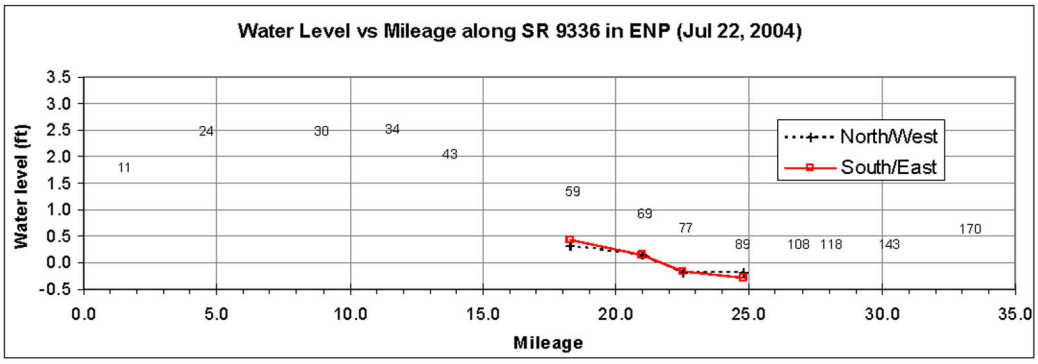

Figure 29. Water level versus mileage along SR 9336 in ENP (Observation 1)

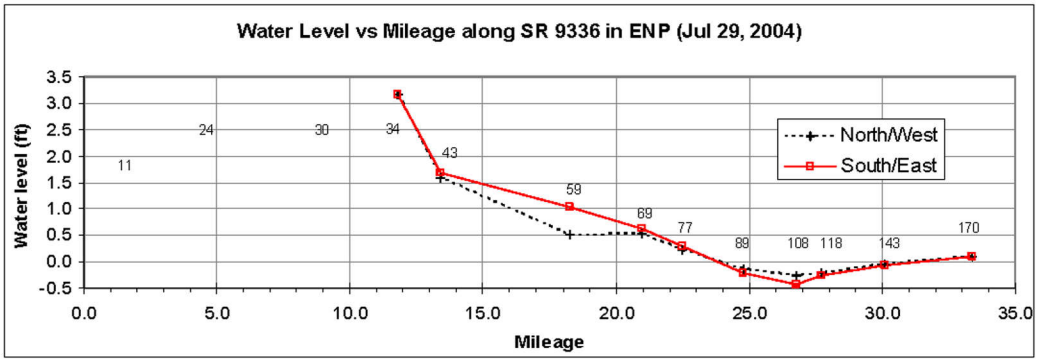

Figure 30. Water level versus mileage along SR 9336 in ENP (Observation 2)

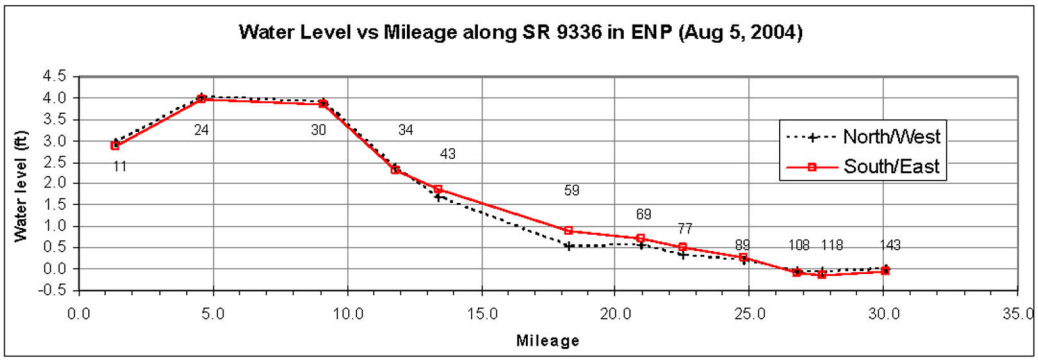

Figure 31. Water level versus mileage along SR 9336 in ENP (Observation 3)

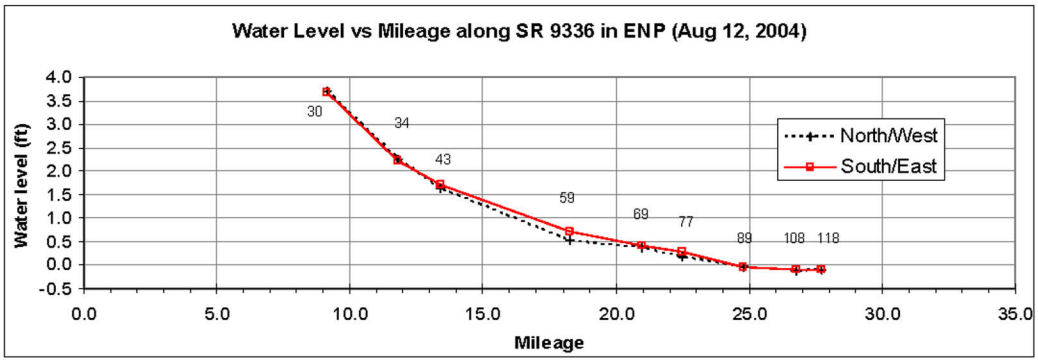

Figure 32. Water level versus mileage along SR 9336 in ENP (Observation 4)

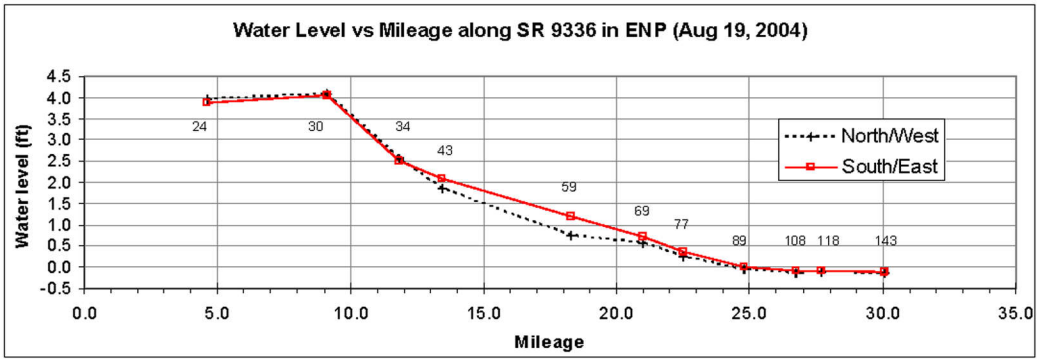

Figure 33. Water level versus mileage along SR 9336 in ENP (Observation 5)

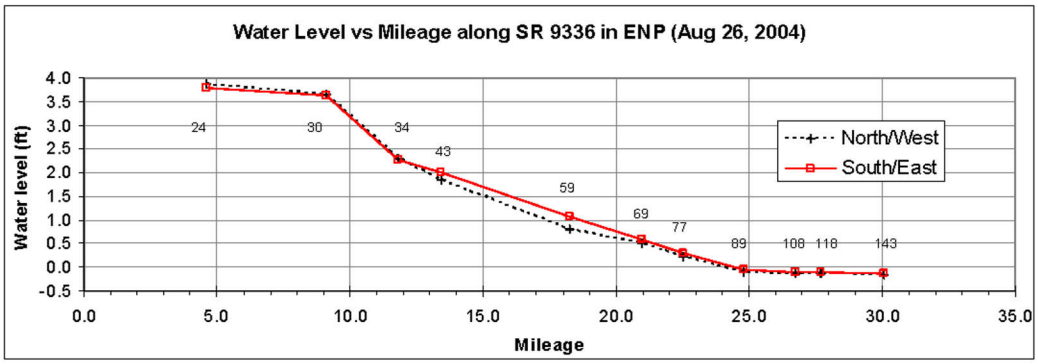

Figure 34. Water level versus mileage along SR 9336 in ENP (Observation 6)

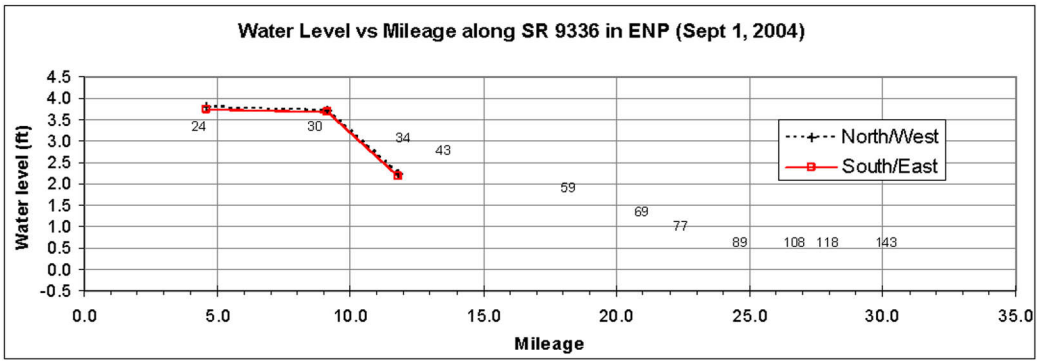

Figure 35. Water level versus mileage along SR 9336 in ENP (Observation 7)

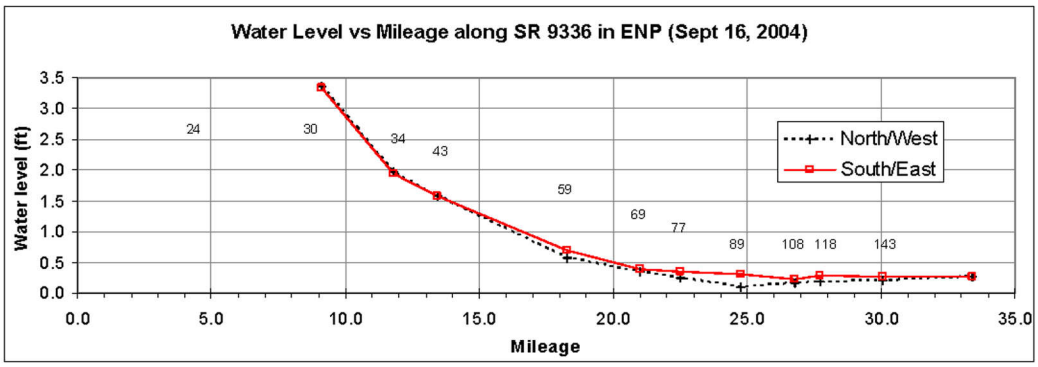

Figure 36. Water level versus mileage along SR 9336 in ENP (Observation 8)

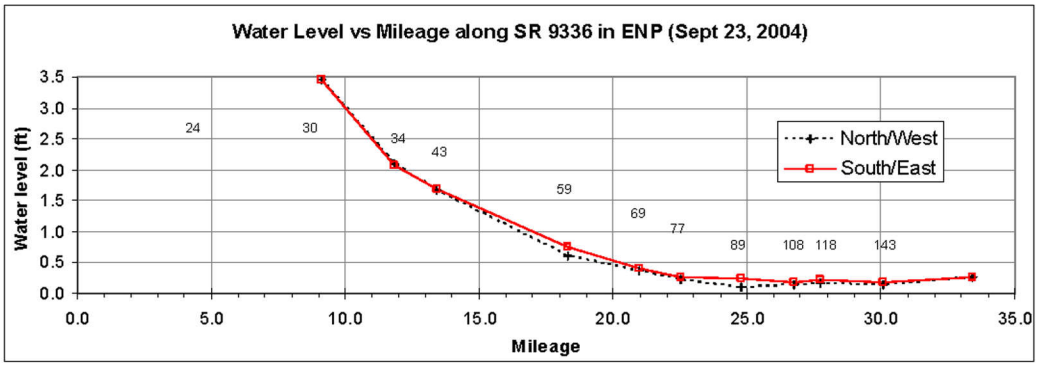

Figure 37. Water level versus mileage along SR 9336 in ENP (Observation 9)

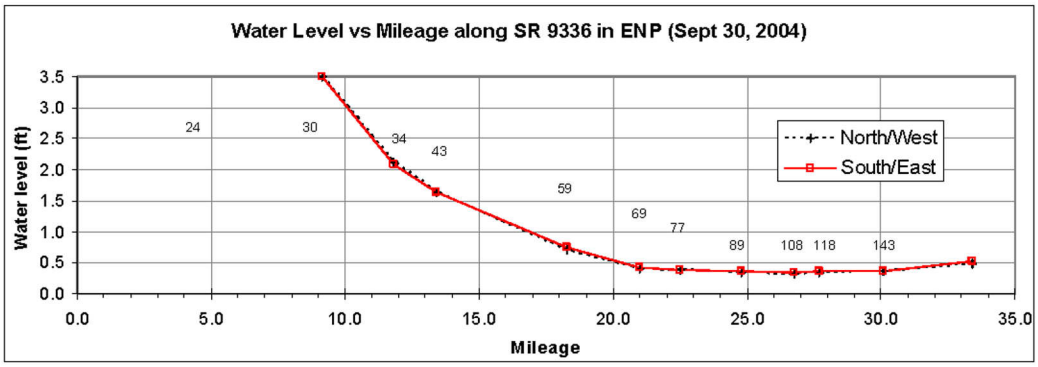

Figure 38. Water level versus mileage along SR 9336 in ENP (Observation 10)

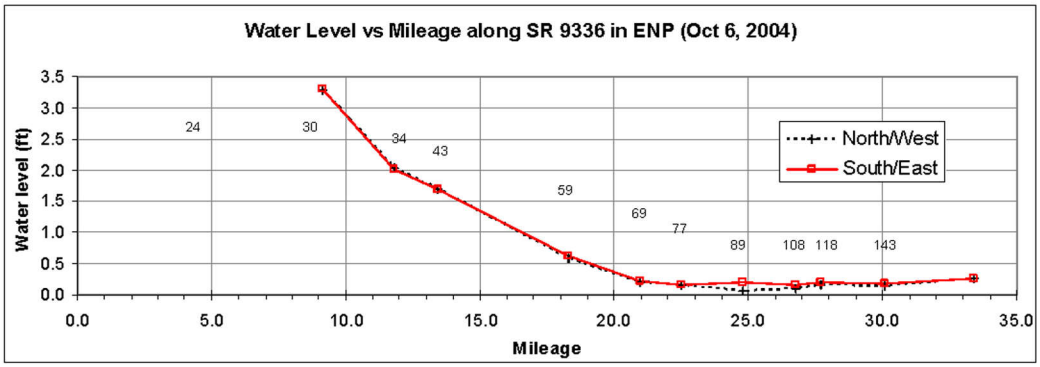

Figure 39. Water level versus mileage along SR 9336 in ENP (Observation 11)

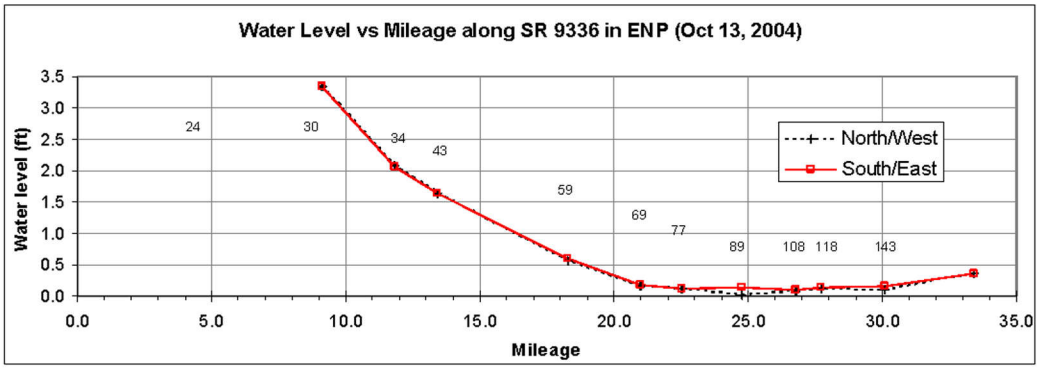

Figure 40. Water level versus mileage along SR 9336 in ENP (Observation 12)

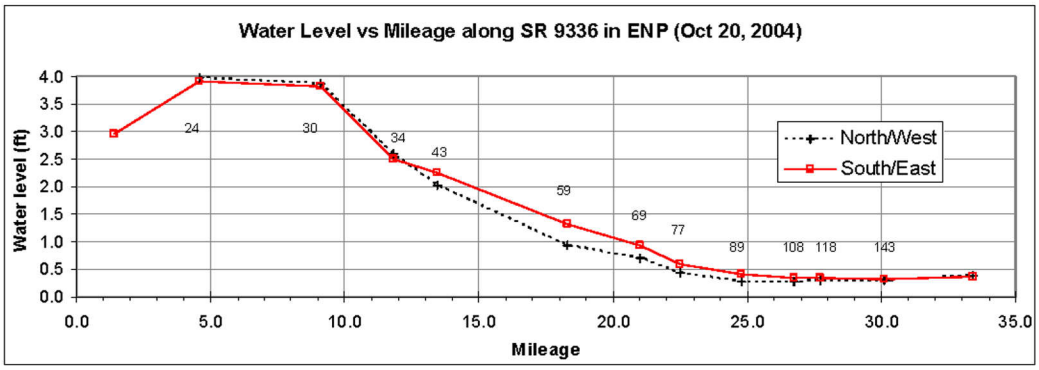

Figure 41. Water level versus mileage along SR 9336 in ENP (Observation 13)

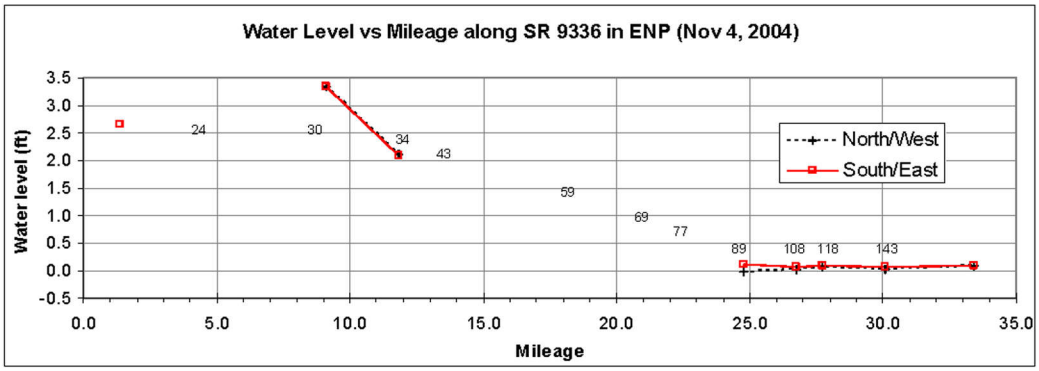

Figure 42. Water level versus mileage along SR 9336 in ENP (Observation 14)

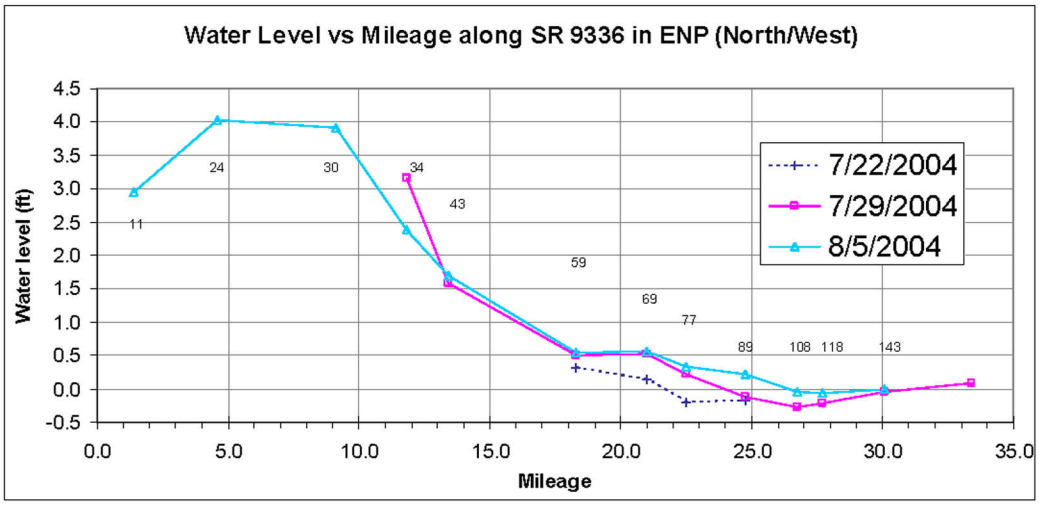

Figure 43. Water level distribution along SR 9336 in different dates in ENP (Comparison 1)

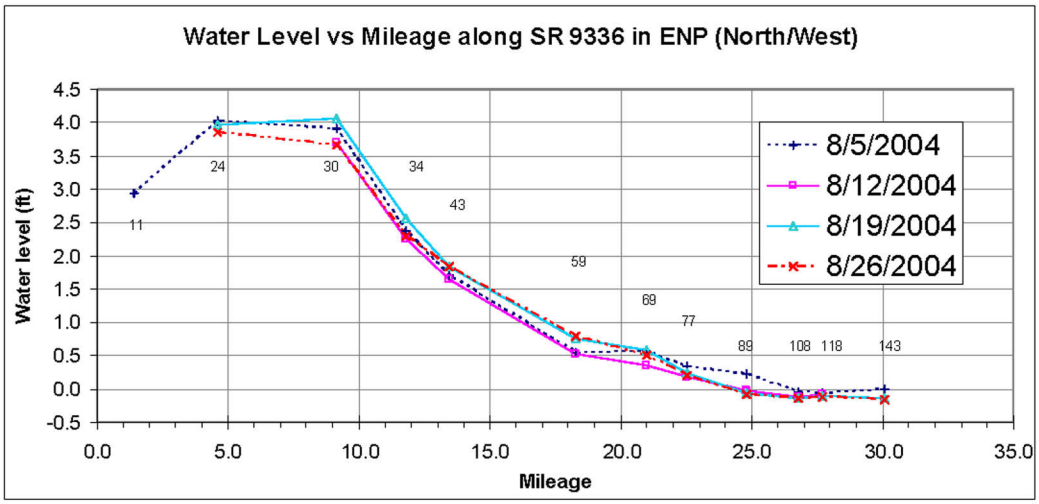

Figure 44. Water level distribution along SR 9336 in different dates in ENP (Comparison 2)

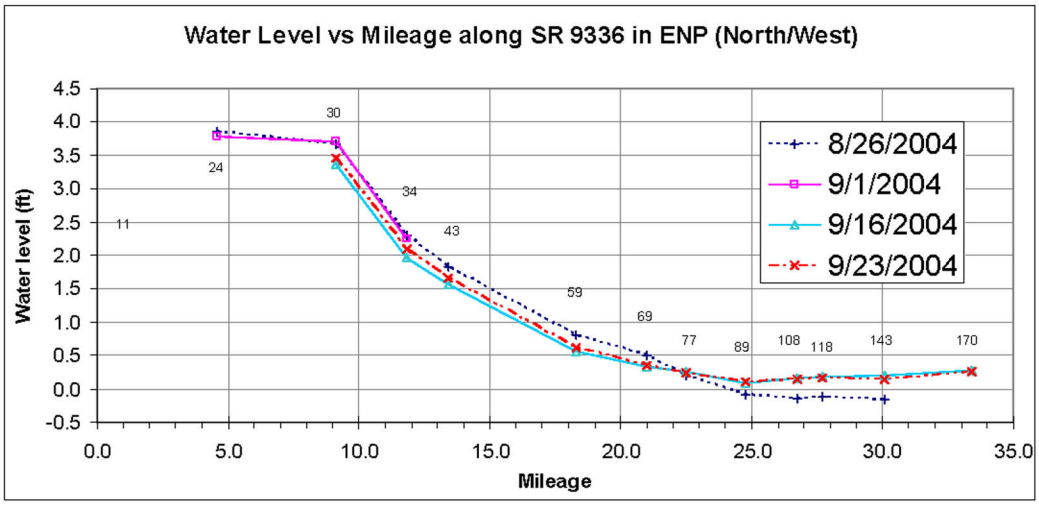

Figure 45. Water level distribution along SR 9336 in different dates in ENP (Comparison 3)

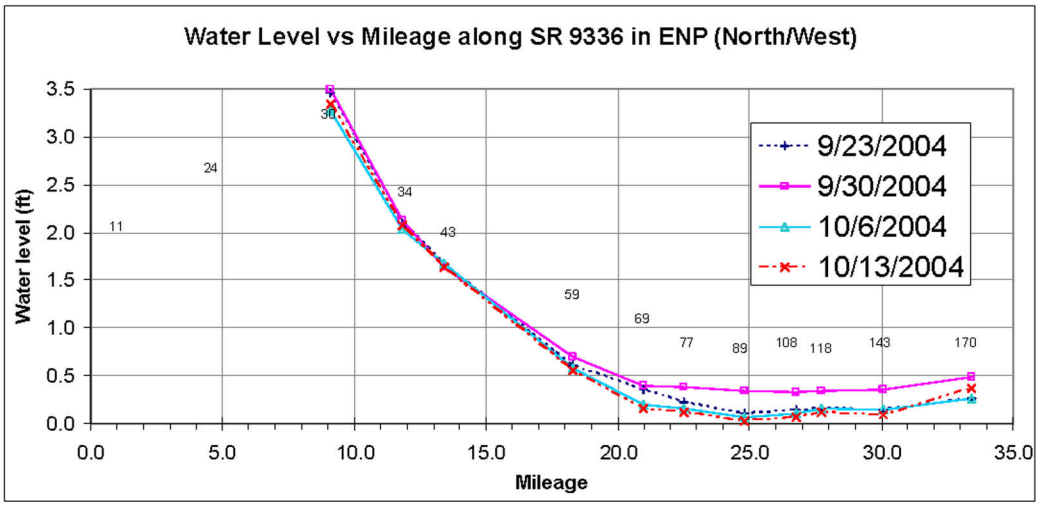

Figure 46. Water level distribution along SR 9336 in different dates in ENP (Comparison 4)

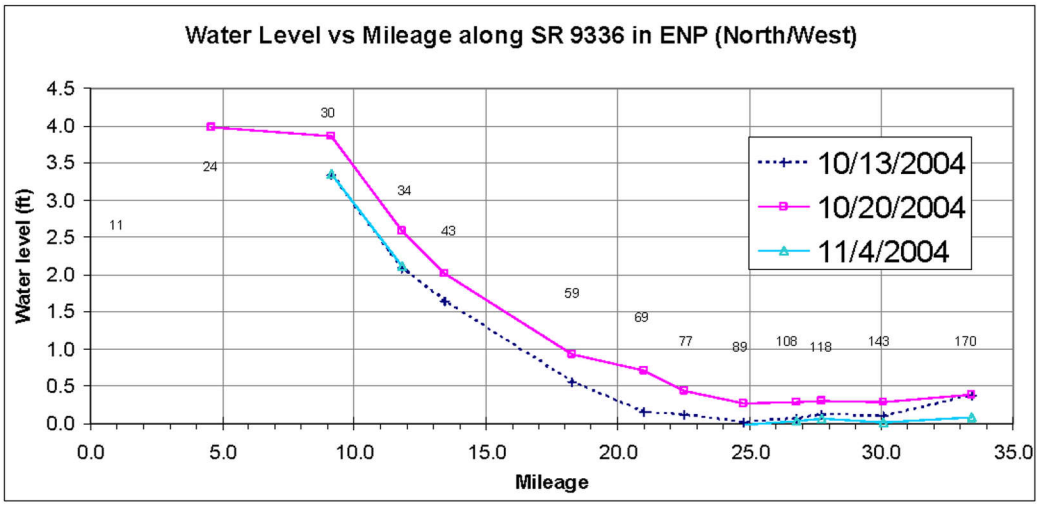

Figure 47. Water level distribution along SR 9336 in different dates in ENP (Comparison 5)

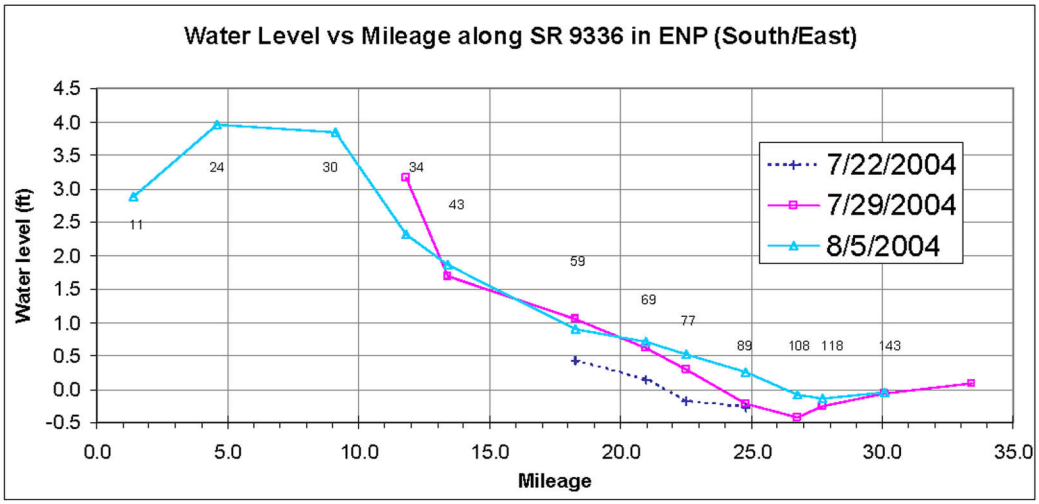

Figure 48. Water level distribution along SR 9336 in different dates in ENP (Comparison 1)

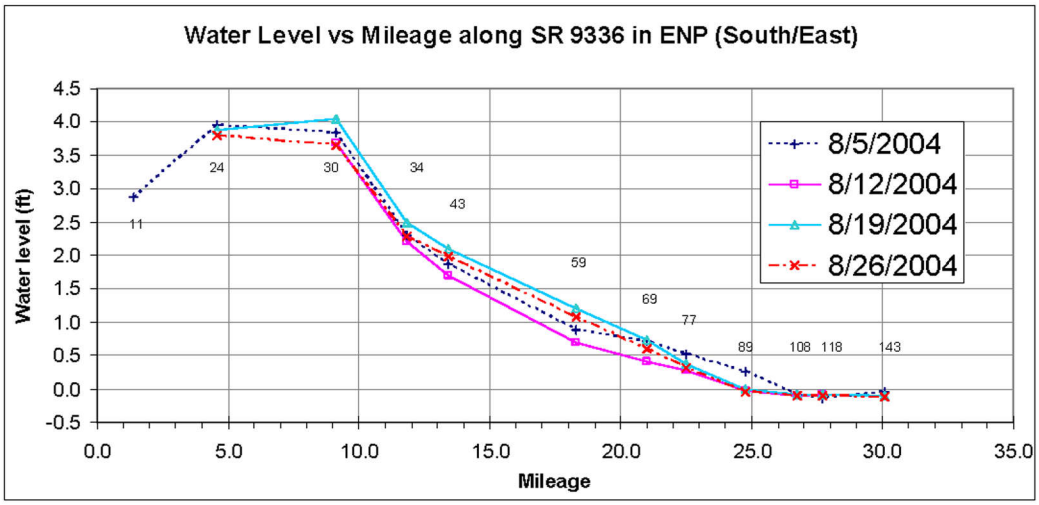

Figure 49. Water level distribution along SR 9336 in different dates in ENP (Comparison 2)

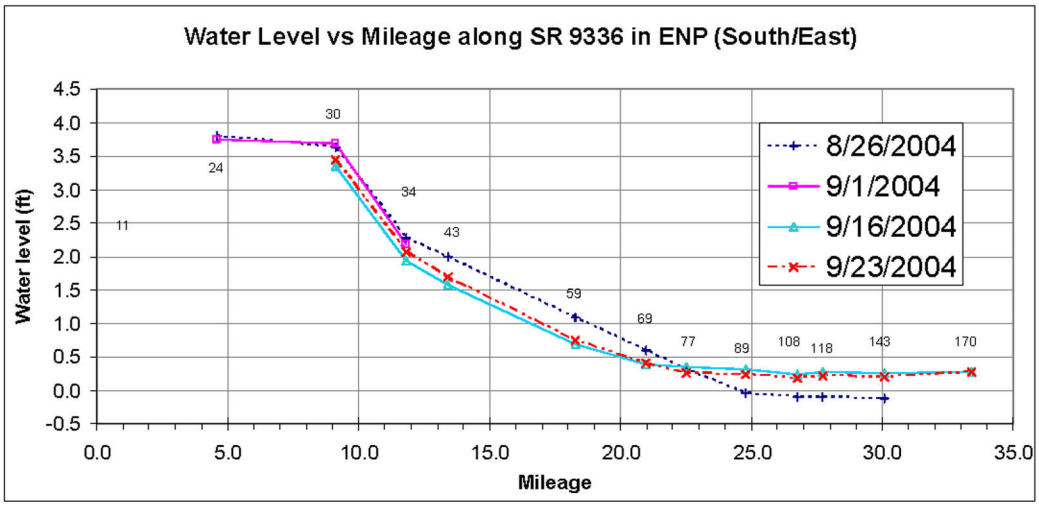

Figure 50. Water level distribution along SR 9336 in different dates in ENP (Comparison 3)

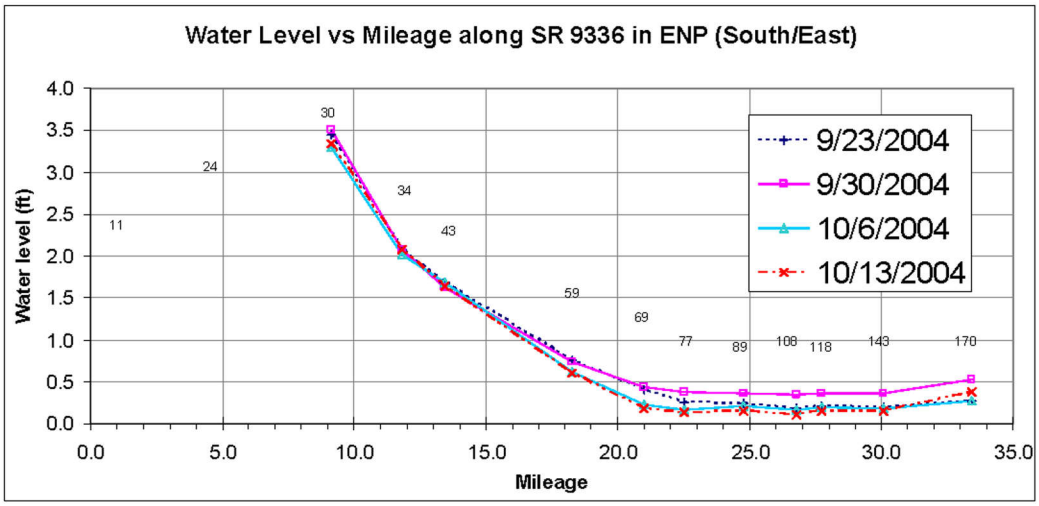

Figure 51. Water level distribution along SR 9336 in different dates in ENP (Comparison 4)

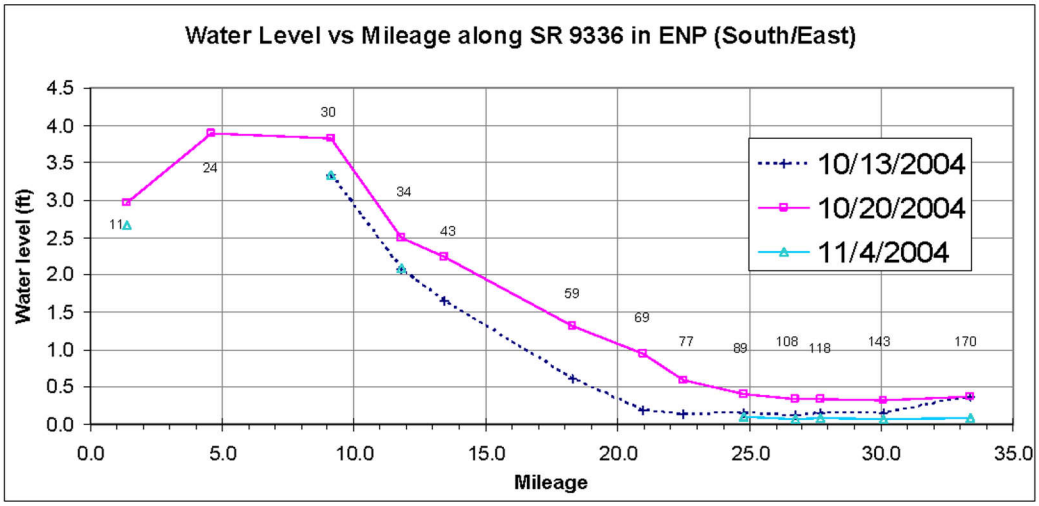

Figure 52. Water level distribution along SR 9336 in different dates in ENP (Comparison 5)

It is seen from the above figures that the major water level drop occurs in the stretch from Culvert 30 to 89. This coincides with the fact that the major flow occurs in this section.

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