Shoreline Change Rate Estimates

Duval County

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FOREWORD

This report was prepared to provide shoreline change rate estimates to assist in regulatory programs and beach management planning efforts. In particular, there is a need to assist project managers within the Office of Beaches and Coastal Systems in ranking proposed beach management projects for State of Florida funding support. Efforts were made in developing the rate estimates to consider and take into account the influences of coastal structures and sand fill placements on shoreline change. However, these influences can be very complex and extensive analysis and consideration of such influences was beyond the scope of this work.

Shoreline change analyses performed for other specific purposes, such as for establishing 30-year erosion projections pursuant to paragraph 161.053(6), F.S., should be developed in accordance with appropriate and applicable procedures for that specific purpose, although these reports may be relevant in that regard.

This report was prepared by Emmett Foster, P. E., of the Office of Beaches and Coastal Systems and Darren Spurgeon and Jenny Cheng of the Beaches and Shores Resource Center. The shoreline change rate estimates are based on the best available data at the time of report preparation. Updates to the report will be performed as new data becomes available and as staff workload allows.

APPROVED BY

Alfred B. Devereaux, Jr., Director
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TABLE OF CONTENTS

1 EXECUTIVE SUMMARY 1

2 INTRODUCTION 2

3 REGIONAL SETTING 3

3.1 Study Area 3

3.2 Coastal Setting 3

3.2.1 Waves and Tides 3
3.2.2 Longshore Transport 5
3.2.3 Storms 5

3.3 Inlets 5

3.3.1 Nassau Sound 5
3.3.2 Ft. George Inlet 6
3.3.3 St. Johns River Entrance 6

3.4 Engineering Projects 6

3.4.1 Beach Nourishments 6
3.4.2 Structures 7
3.4.3 Dredging 7

4 METHODS 9

5 SHORELINE CHANGE 10

6 SUMMARY 16

7 REFERENCES 17

8 APPENDICES 19

8.1 Appendix A: Shoreline Change Rate Estimates 20
8.2 Appendix B: Stack Plots 24
8.3 Appendix C: Profile Plots 44

LIST OF FIGURES

Figure 1. Study area showing Duval County, Florida 4
Figure 2. Beach nourishment projects in Duval County, Florida 8
Figure 3. Shoreline rate of change estimates for Duval County, Florida 12
Figure 4. Plan view map, North, comparing years 1924 through 1999 13
Figure 5. Plan view map, South, comparing years 1858, 1924, and 1958 14
Figure 6. Plan view map, South, comparing years 1958 to 1999 15

LIST OF TABLES

Table A-1. Shoreline change rate estimates for Duval County, Florida. 21

1 EXECUTIVE SUMMARY

The stabilization of St. Johns River Entrance has had a tremendous impact on beaches to both sides of the inlet. The results include the forced migration of Ft. George Inlet northward, the corresponding reorientation of Little Talbot Island's shoreline, and a highly variable pattern of erosion that makes future predictions uncertain at best on Little Talbot Island. To the south of the jetties, a southward progressive erosion pattern developed, which since 1963 has been held in check by numerous beach nourishment projects.

Rate of change estimates on Little Talbot Island range from +112.5 to -85.5 ft/yr. However, these extremes lie within Nassau Sound and Ft. George Inlet, respectively. Rates on the ocean side of the island have ranged from -19.5 ft/yr to +18.5 ft/yr, indicating that a reorientation of the island is occurring. The beaches between Nassau Sound and the St. Johns River Entrance north jetty have been net accretional in the long term, but highly erosional or accretional locally over short time periods. The relationship between beaches on both sides of Ft. George Inlet indicates that the inlet is migrating northward, driven by sediment buildup on the updrift side of the jetty. The A1A bridge abutment and road revetment on the southwestern corner of Little Talbot Island provide an anchoring point that will likely limit the extent of future northward inlet migration and possibly create a new cyclic migration pattern.

The shoreline south of St. Johns River Entrance has been erosional throughout the historical record. The pre-nourishment era erosion rate estimates here are on the order of -5.5 ft/yr in the northern reaches and taper off gradually to about zero at the extreme southern end of the county. However, the data is meager in extent and possibly was influenced by coastal armoring.

2 INTRODUCTION

This work is part of an ongoing project to develop up-to-date shoreline erosion rate estimates for the Florida sandy beach coastline. The shoreline referred to is the approximate Mean High water (MHW) elevation contour. The information compiled and analyses conducted are intended to provide quantitative and qualitative information on a county-by-county basis that may be used to assist in beach management planning, coastal regulation, and general shoreline analysis work.

Quantitative erosion information will be focused on providing erosion estimates relative to currently active coastal processes in those places where no renourishment projects exist. Where renourishment or other similar sand fill projects of size exist, erosion rate estimates for the pre-project conditions will be attempted where possible. It is beyond the scope of these reports to analyze renourishment project performance. In such cases, erosion is a combination of initial onshore-offshore adjustments, lateral diffusion, structural interaction, and the "background erosion" process. Because the conditions that affect erosion are being frequently altered (e.g. inlets, shoals, and armoring additions/subtractions), pre-project erosion estimates are useful primarily in a historical sense and in showing what led to the need for the artificial nourishment.

The data used for this analysis is from the Office of Beaches and Coastal Systems Historical Shoreline Database. The database includes beach and offshore profile field surveys, digitized historical shoreline and bathymetric maps, aerial photographs from the Office files, and numerous graphical representations of the data, all within a common set of horizontal and vertical controls. This database was developed and quality controlled by engineers in the Research, Analysis and Policy Section and is continually updated as time and workload allows. Beach profiles were surveyed by the Coastal Data Acquisition Section and, in some cases, by private firms, the latter usually related to the monitoring of coastal erosion control projects.

It is beyond the scope of this report to investigate possible actions that may be necessary to prevent or curb shoreline erosion. Where appropriate, however, recommended actions may be suggested or previous, failed attempts may be pointed out in an effort to help guide the reader towards a better understanding of the dynamics of the coastline and future trends in shoreline change.

3 REGIONAL SETTING

3.1 Study Area

Duval County is located in northeast Florida about 20 mi (32 km) south of the Florida-Georgia border (Figure 1). The length of the ocean shoreline is about 16 mi (25.7 km), of which 10 mi (16 km) lies south of the St. Johns River Entrance. Two barrier islands exist in Duval County, separated by Ft. George Inlet and the St. Johns River Entrance. The first is Little Talbot Island, an island about 4.3 mi (7 km) in length and 0.9 mi (1.5 km) in width. It is a state-owned park. Immediately southward is a small island referred to as Wards Bank. It is a county park.

South of the St. Johns River Entrance jetties is a less obvious and possibly older barrier island, now seperated from the mainland by a low tidal marsh and lagoon and the Intracoastal Waterway. Several coastal communities, including the Mayport U.S. Naval Station, Hanna Park, Seminole Beach, Atlantic Beach, Neptune Beach, and Jacksonville Beach are located in this part of the county. The communities and municipalities south of Hanna Park are highly developed.

There are 80 sequentially numbered DEP survey reference points, generally referred to as "R" monuments, spaced approximately 1,000 ft (300 m) apart. This report uses these reference points to locate various items within the study area.

3.2 Coastal Setting

3.2.1 Waves and Tides

Tides for this area are semidiurnal. The mean tide range near Jacksonville is 5.5 ft (1.7 m), with a sping tide range of 6.1 ft (1.9 m) along Little Talbot Island (National Ocean Service–NOAA, 1988).

The mean significant wave height for 10 m depth offshore Duval County is 2.1 ft (0.6 m) (Jensen–USACE, 1983). The dominant wave direction is out of the northeast, which corresponds to the dominant wind direction.

During the winter months, waves for north Florida and south Georgia have a dominant direction out of the northeast with higher wave heights and longer wave periods. In the summer months, however, waves approach mainly from the

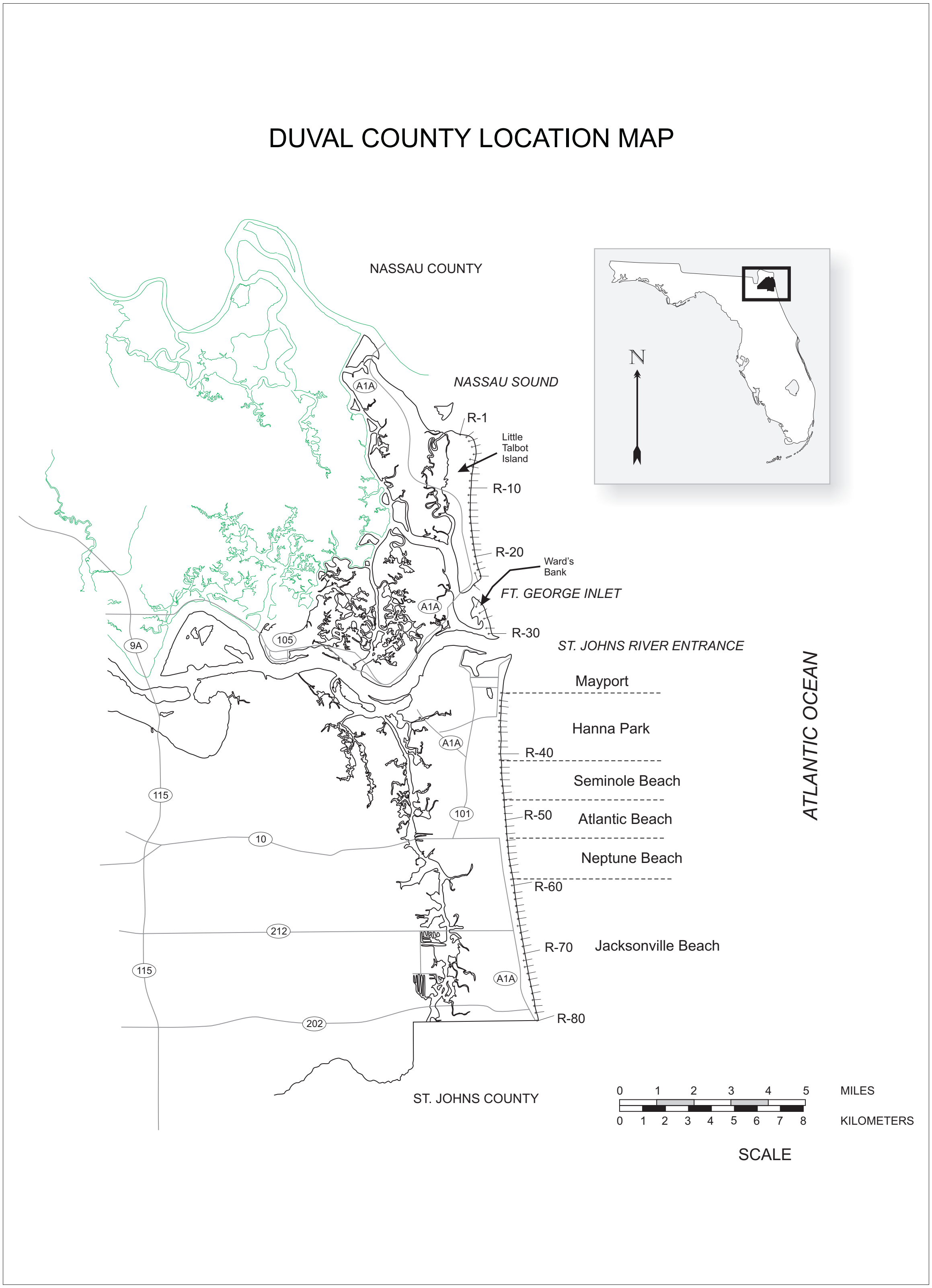

Figure 1. Study area showing Duval County, Florida.

southeast, having relatively smaller wave heights and a combination of shorter and longer periods. Wave energy in the Duval County area is moderate.

3.2.2 *Longshore Transport*

The direction of net littoral transport is from north to south. Strong evidence for this exists in the long-term accretionary pattern north of the St. Johns River Entrance jetties and the long-term erosion pattern south of the jetties, which will be discussed in a later section of this report. There are several widely varying estimates of net longshore sediment transport, ranging from about 110,000 yd^3/yr to 480,000 yd^3/yr (Penland, 1979; Dean and O'Brien, 1987; USACE, 1990).

3.2.3 *Storms*

There have been numerous hurricanes and northeaster storms that have affected northeast Florida. Hurricane Dora in 1964, and northeasters in the 1960's and in November 1984 were probably the most intense in recent history. In general, winter storms or northeasters are thought to have a greater impact on shoreline change than hurricanes in this county because these winter storms occur with greater frequency and can remain in the area for longer periods of time. However, storms are just peaks in the total normal wind and wave climate record. Experience and observations indicate that severe storms can temporarily disrupt or obscure the longer term erosion pattern, perhaps for up to a decade. In some situations, if a major factor such as the sand supply is altered, or if an inlet is significantly changed, the coastal process and erosion pattern can be permanently changed by a storm. There is no obvious evidence of a fundamental change caused by storms in the Duval study area.

3.3 Inlets

3.3.1 *Nassau Sound*

The seaward mouth of Nassau Sound is over two miles wide and contains an ever-changing complex system of shoals and channels. Because Nassau Sound is not a navigational channel, there are no jetties associated with it and there is no maintained dredged channel to the open ocean. There is channel dredging of the Intracoastal Waterway (ICW) nearby. Dredged sand from ICW maintenance has been placed on the south end of Amelia Island.

3.3.2 Ft. George Inlet

Ft. George Inlet is a natural, ebb-dominated, highly migratory inlet located between Little Talbot Island and Wards Bank. The throat of the inlet is about 1,000 ft (300 m) wide or less. This inlet's history has been irregular but continuous northward migration since about 1934 (USACE, 1992). In recent decades, this process has threatened the bridge spanning across Ft. George River, which connects Little Talbot Island to the mainland, and has significantly eroded the south end of Little Talbot Island.

Several researchers have discussed this inlet's migratory process, including Kojima and Mehta (1979), Penland (1979), Mehta and Marino (1987), Marino et al. (1990), and USACE (1992). Essentially, it appears that the long-term accumulation of sand against the north jetty of the St. Johns River Entrance has forced the inlet to migrate northward in order to remain open. This is the conclusion readily obtained from the information in the DEP Historic Shoreline Database, and this will be illustrated in a later section.

3.3.3 St. Johns River Entrance

The St. Johns River Entrance was stabilized by jetties in the 1880s. This inlet, being an important navigational channel, is dredged quite frequently, and has been one of the main sand sources for numerous beach nourishment projects to the south.

3.4 Engineering Projects

3.4.1 Beach Nourishments

There have been numerous nourishment projects in Duval County on the beaches south of the St. Johns River Entrance. This nourishment program began as early as 1963, when dredge material from the St. Johns River Entrance and Jacksonville Harbor was placed in front of the U. S. Mayport Naval Station (between the south jetty and R-31), on Neptune Beach, and on Jacksonville Beach. Since that time, there have been at least fifteen nourishment projects in Duval County from Mayport south to R-80. Figure 2 gives an overview of the numerous fills placed on Duval County's beaches through March, 1999. This is not necessarily a complete listing, in particular with regard to fill placements from channel maintenance dredging. It is a complete listing of all projects noted in the source references.

3.4.2 Structures

Construction began in 1879-1880 and 1882 on the south and north St. Johns River Entrance jetties, respectively. Since that time, the north and south jetties have been extended to 14,200 ft (4,328 m) and 11,192 ft (3,411 m). These parallel jetties are 1,600 ft (490 m) apart. Historically, the north jetty has been porous to varying degrees as a result of miscellaneous repairs and modifications. The south jetty appears to have historically been more sand tight.

Timber bulkheads were erected throughout the county in the 1920s, only to be repaired numerous times after severe storms, most notably in 1925. Many of these bulkheads were replaced altogether when armoring methods shifted to seawall construction in the 1930s. Seawalls were added to Jacksonville Beach, Atlantic Beach, and Neptune Beach in 1932, 1934-1935, and 1936, respectively. Until 1963, most bulkheads and seawalls damaged by storms were replaced by local efforts. After a severe 1962 storm, federal funding provided for a 7,000 ft (2,130 m) granite revetment at Jacksonville and Neptune Beach in 1963. Further damage to Duval's coastline by Hurricane Dora in 1964 prompted the construction of a nearly continuous granite revetment along 25,750 ft (7,850 m) of shore for Jacksonville Beach, Neptune Beach, Atlantic Beach, and the developed area north of Atlantic Beach (USACE, 1975, 1984, 1990).

In response to Little Talbot Island's erosion problem (namely the Ft. George Inlet migration), a rubble revetment was constructed in the late 1970s along the shoreline west of the Highway A1A/SR-105 bridge spanning Ft. George River. This revetment has been extended eastward over time to protect a larger portion of the road.

3.4.3 Dredging

Dredging in Duval County has been active at least since 1925, when sediment was removed from both Wards Bank and the St. Johns River Entrance. With the exception of a 1927-1929 project, most of this was disposed of offshore until the 1963 nourishment project. Since then, dredge material from the St. Johns River Entrance and Jacksonville Harbor has been one of the main sources of sediment for nourishment projects along with, more recently, offshore borrow areas.

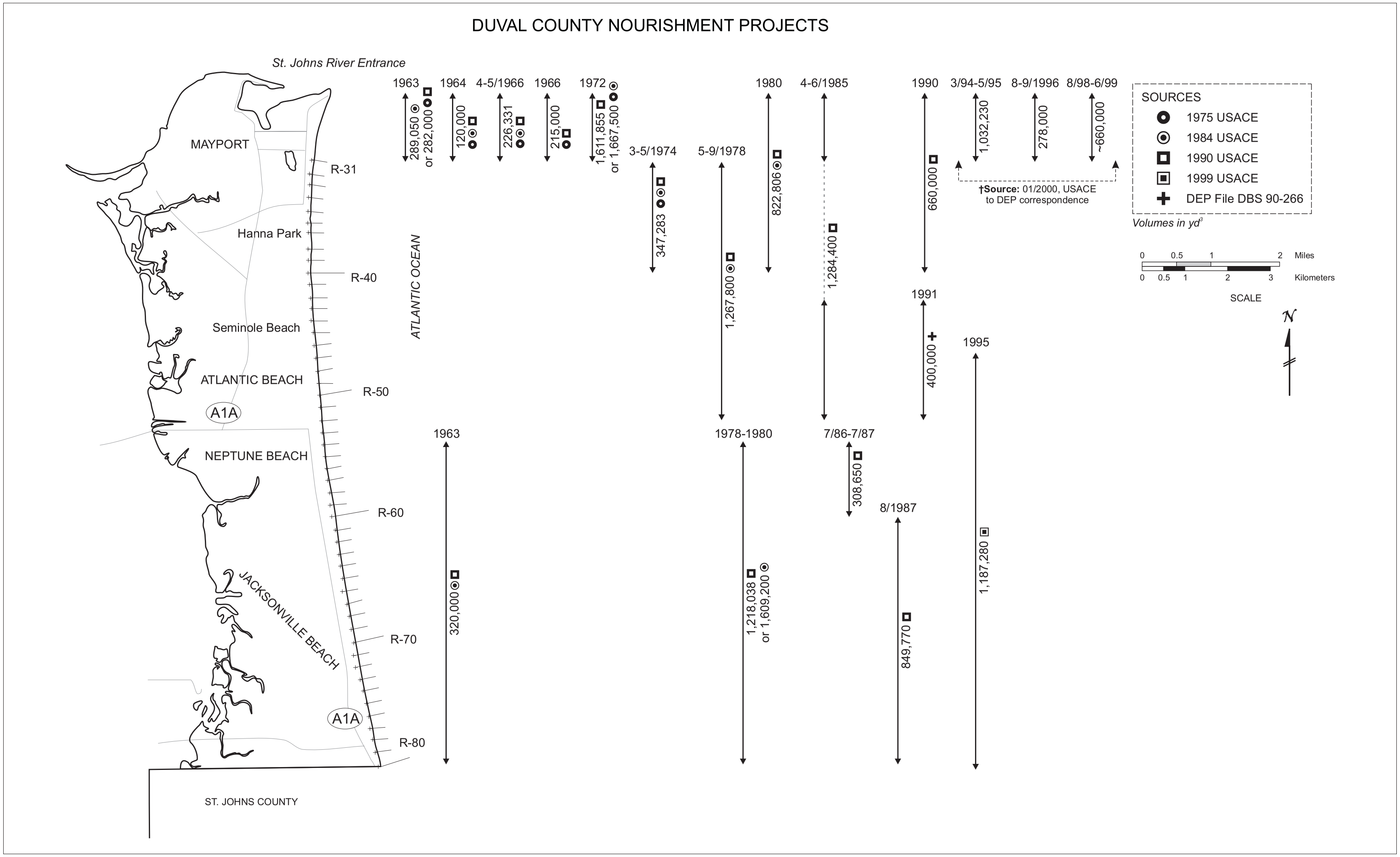

Figure 2. Beach nourishment projects in Duval County, Florida.

4 METHODS

A shoreline change analysis to satisfy the report objectives was performed using the methodology initially developed by Foster and Savage (1989) and Foster (1992). In brief, within the often nonlinear record of shoreline change versus time by reference points, segments are identified, consistent with observed coastal processes, in which the erosion is relatively constant or can reasonably be approximated as such. Three different rate calculation methods are applied to these approximately linear shoreline change versus time segments: the rate averaging, least squares, and end-point methods. These results are first averaged alongshore and then averaged across the three calculation methods to achieve a consensus average, not dependent on any single rate calculation method. This is because each calculation method has relative advantages and disadvantages. If time segments are selected reasonably well, the differences between rate methods will be minimal. In certain simplified situations it may be better to use a single rate calculation method, such as the end-point method, as necessity and reason dictate. If the averaging is done properly it will achieve results representative of the unaveraged data but will not be overly affected by individual point variability.

In many cases rates from longer and shorter time periods are calculated for comparison purposes (e.g., to show possible progression of an erosion pattern over time or to show that the use of more recent data, which is generally of higher accuracy, yields essentially the same results as the data in a comparative longer time period).

Visual tools used for analysis generally include plan views of shorelines oriented and scaled to emphasize shoreline width changes as well as sometimes subtle but important shoreline orientation differences or geologic features within a county or reach. This analysis is also dependent on the shoreline location versus time plots with overlapping axes, known as "stack plots" because several data plots are stacked in sequence to better see a pattern in the data (Appendix B). There are also representative beach profile plots (Appendix C).

5 SHORELINE CHANGE

Shoreline (mhw) change rate estimates are provided in Figure 3 and Table A-1 (Appendix A). These estimates are intended to reflect pre-nourishment conditions where such projects exist and otherwise reflect current averaged conditions. For each area, approximately linear time segments were identified in the distance versus time "stack" plots, as shown in Appendix B, consistent with observed primary coastal processes. Rate estimates were calculated for the selected, approximately linear time segments.

Collectively, the three inlets within the study area are a driving force in shaping the shoreline; and, at least with respect to Little Talbot Island and Ward's Bank, these changes have been dramatic.

Rates along Little Talbot Island are the most extreme in the study area. For the Atlantic side of the island, rates progress from -19.5 ft/yr (R-4) at the north end to +18.5 ft/yr (R-19) at the south end, with the changeover from erosion to accretion occurring in the vicinity of R-10. However, rates on both inlet sides of the island are even more extreme, reaching +112.5 ft/yr (R-1) and -85.5 ft/yr (R-25) for the north and south ends, respectively. It must be pointed out, though, that the shoreline in this area has exhibited extreme variability in its erosion/accretion pattern, and the rate estimates reflect averaged changes over the recent past only. Consequently, the shoreline change rate estimates may not be useful predictors of how the shoreline will progress in the future, particularly in the north and south parts of the island, inlet and Atlantic sides. Only in the central region, approximately R-7 to R-16, are the rate estimates likely to be useful as predictive values.

The result of all this change appears to be a reorientation of Little Talbot Island's shoreline. This is readily observable in plan view (Figure 4), where the southeast tip of the island appears to be migrating northward as Fort George Inlet also migrates in that same direction. At the same time, the northernmost Atlantic side of Little Talbot Island is eroding back, while the adjacent shoreline abutting Nassau Sound is accreting. The northward migration of Ft. George Inlet will likely be hampered to a significant degree by the existing revetment near R-25. Based on recent field observations, the shoreline has already eroded back to the revetment and it appears likely that erosion will continue on the adjacent, unprotected shoreline seaward of the structure.

A probable future scenario is that the inlet will continue to move northward by eroding away the seaward face of Little Talbot Island with a corresponding northward growth of the spit extending from Wards Bank. At some point, the extended inlet channel will become hydraulically inefficient due to its length, and the spit will be breached, relocating the inlet southward again. This scenario would then be repeated indefinitely. Without the anchor point of the bridge abutment and revetment near R-25, the inlet would likely erode through at least the entire southern third of LIttle Talbot Island and very possibly farther.

On the southern side of Ft. George Inlet, along Wards Bank, accretion appears to be consistent throughout the record—a consequence of sediment build-up updrift of the St. Johns River Entrance north jetty. This has led to the slow but steady northward migration of Ft. George Inlet, as evidenced in plan view. Shoaling within the inlet is readily observable in the field and is just one indication that there is an abundant sediment supply being trapped updrift of the St. Johns River Entrance north jetty, facilitating accretion on the beaches of Ward's Bank.

Indeed, the entire Nassau Sound to St. Johns River Entrance shoal and shoreline complex may be thought of in terms of progressive accumulations of sediment updrift of a large littoral barrier, with Ft. George Inlet having an effect similar to a movable permeable groin being pushed northward by the pressure of the accumulated sediment. The entire complex has been net accretional overall, but highly erosional or accretionary in localized areas at different times.

The erosion pattern south of the St. Johns River Entrance south jetty is consistent with theoretical expectations, as discussed by Foster (1995). There is a refraction-induced northeast wave sheltered zone immediately south of and in the lee of the south jetty, followed by a sand deficit induced erosion pattern that progressed southward through the county (Figure 5). Pre-nourishment erosion rate estimates here are estimated to be on the order of -5.5 ft/yr in the northern part (outside the sheltered zone) and taper off gradually to zero at the extreme end of the county. Note that the available data is very limited here for the post-jetty, pre-nourishment time period. In addition, the rates may be lower than what was actually occurring due to possible interference by coastal armoring.

A plan view comparing the pre-nourishment 1957/58 shoreline with the latest DEP 1-2/1999 nourished shoreline is provided in Figure 6 primarily to show the cumulative positive effect of the many projects.

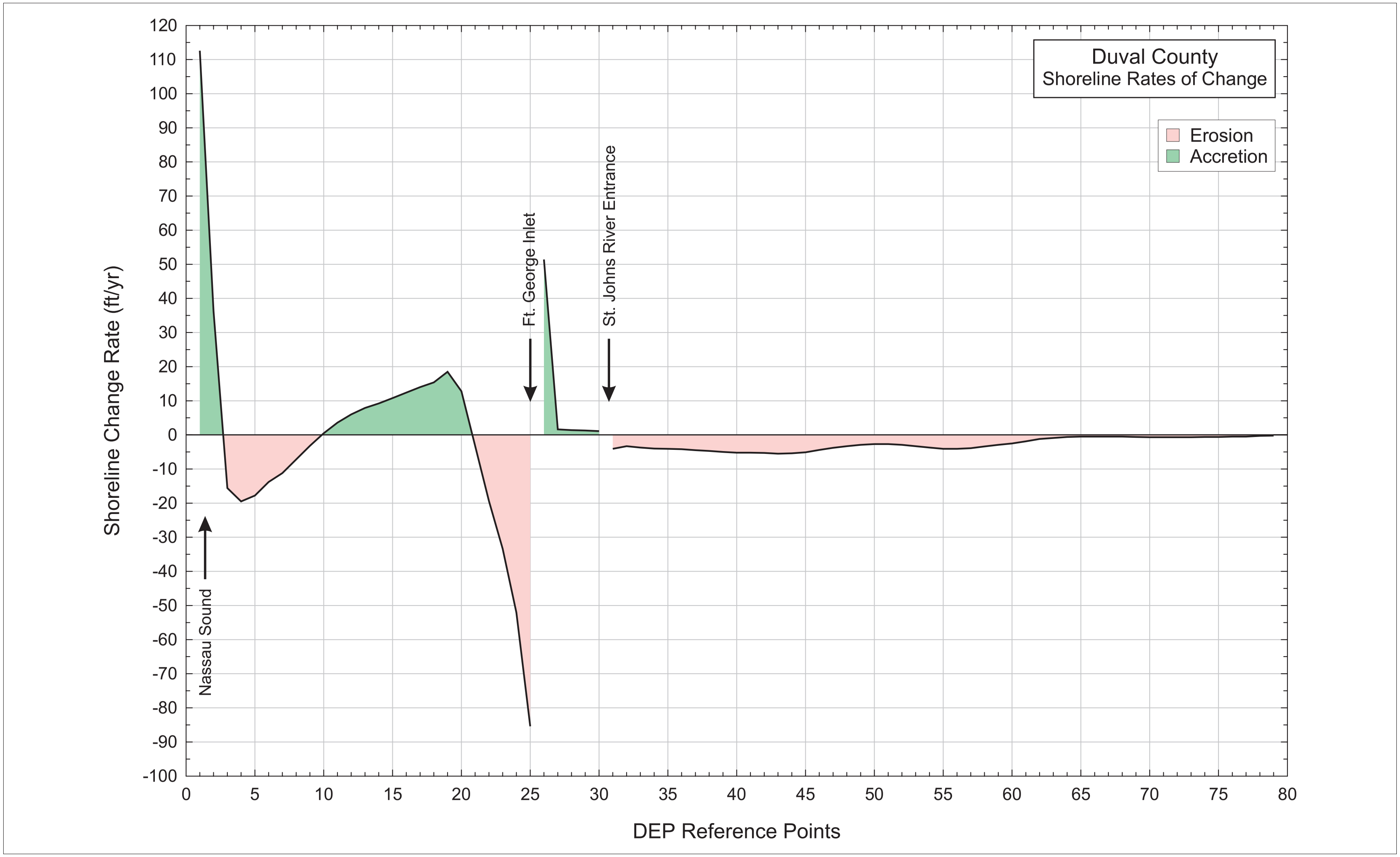

Figure 3. Shoreline rate of change estimates for Duval County, Florida.

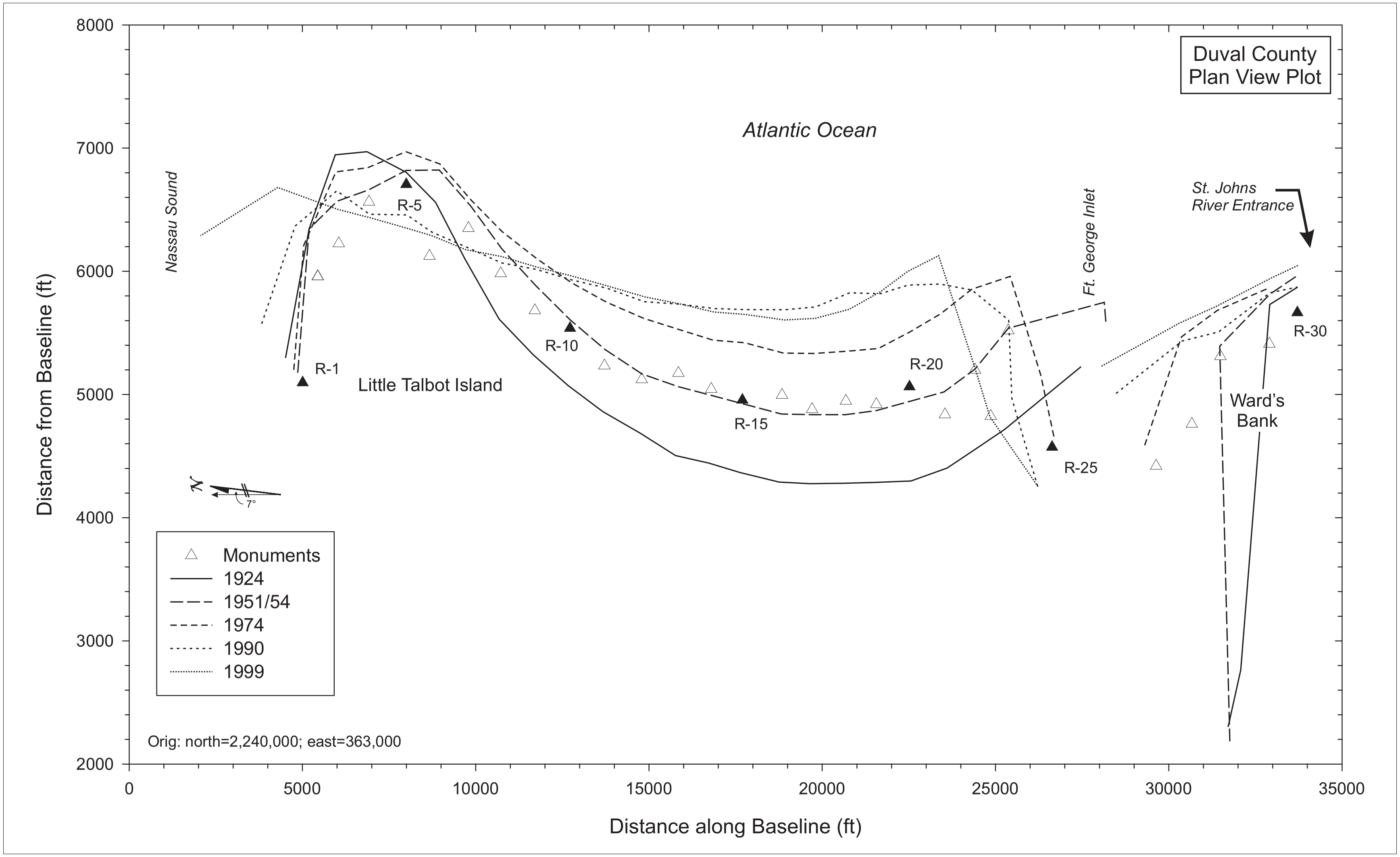

Figure 4. Plan view map of Duval County, Florida, North, comparing years 1924 through 1999.

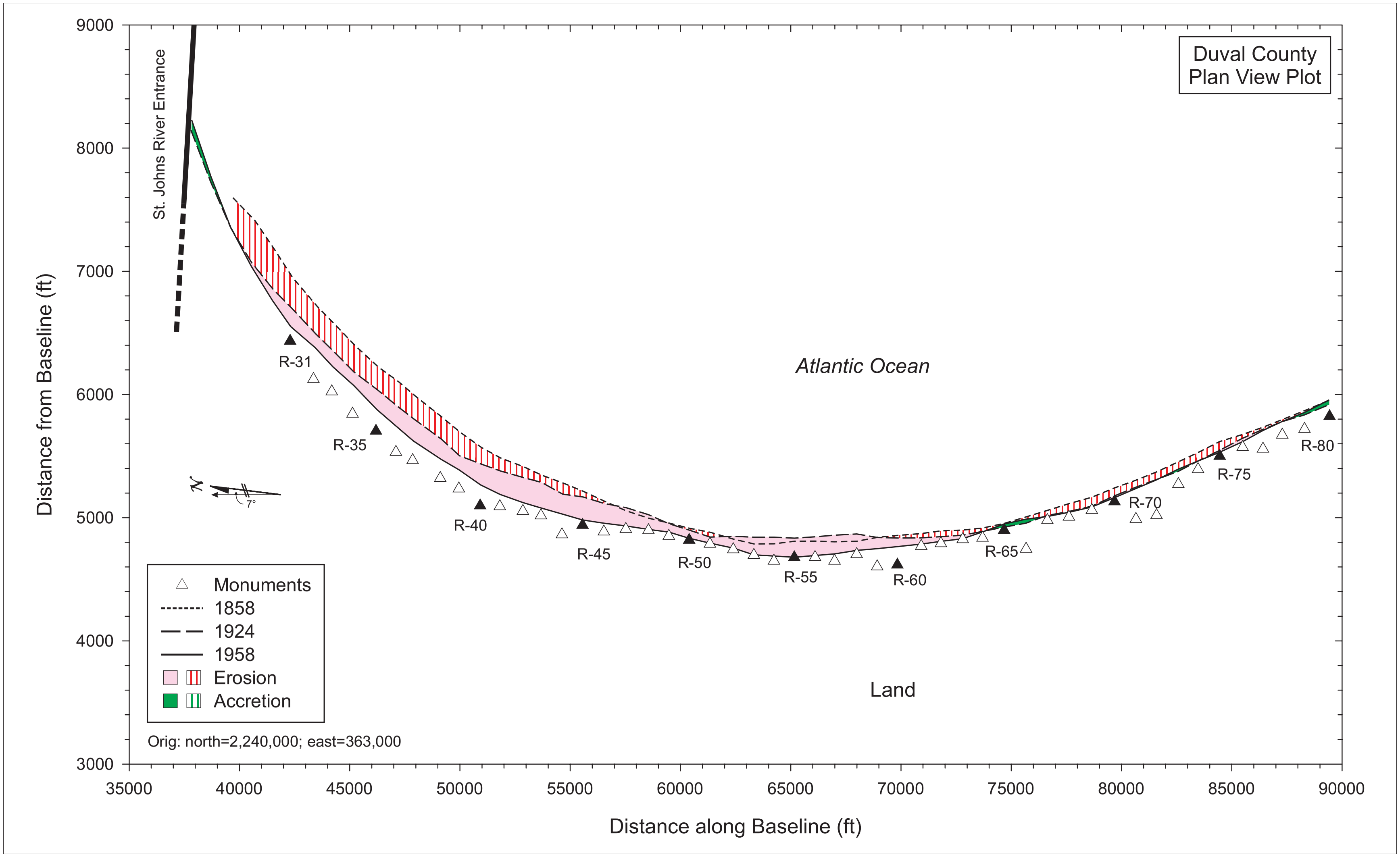

Figure 5. Plan view map of Duval County, Florida, South, comparing years 1858, 1924, and 1958.

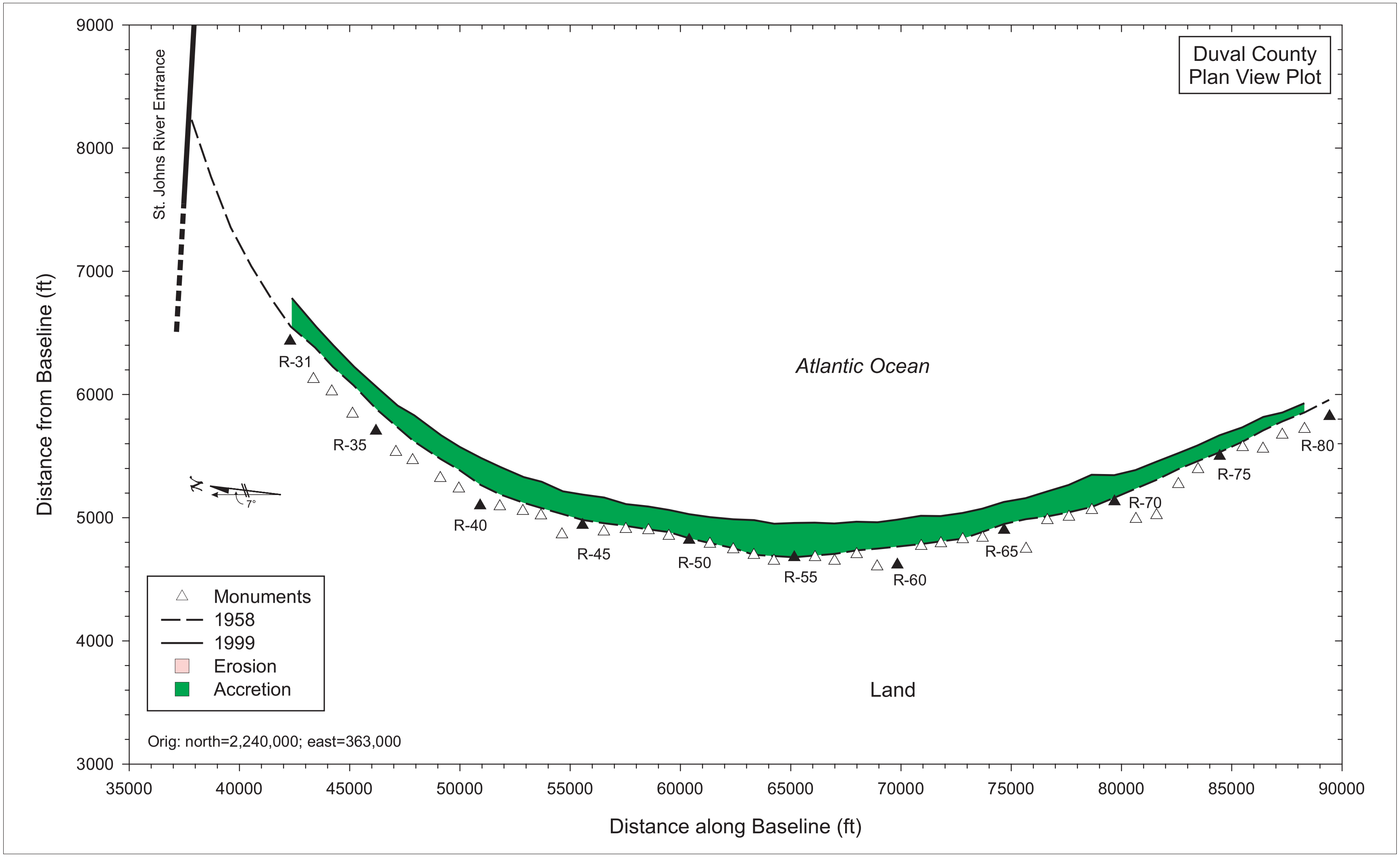

Figure 6. Plan view map of Duval County, Florida, South, comparing years 1958 to 1999.

6 SUMMARY

Little Talbot Island and Wards Bank, in the northern third of the county, are in a constant state of change with localized areas of high erosion and accretion. Long-term accumulation of sediment updrift of the St. Johns River Entrance jetties has resulted in the northward migration of Ft. George Inlet and reorientation of Little Talbot Island.

South of the St. Johns River Entrance jetties, there was a progressively southward spreading erosion pattern that has essentially been held in check by numerous beach nourishments since 1963.

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8 APPENDICES

8.1 Appendix A: Shoreline Change Rate Estimates

Table A-1: This table and accompanying figure provide rates based on the method described in Section 4.

Table A-1. Shoreline change rate estimates for Duval County, Florida.

Range	Year	Method			Consensus Rate Average Estimates	
		RA	LS	EP	Rate (ft/yr)	Comments
Nassau Sound						
1	1974-1999	109.7	112.0	116.2	112.5	no averaging
2	1974-1999	39.9	33.5	35.4	36.5	no averaging
3	1973/75-1999	-15.2	-16.5	-15.2	-15.5	no averaging
4	1973/75-1999	-18.7	-22.5	-22.6	-19.5	3pt average
5	1980-1999	-21.3	-21.8	-21.6	-18.0	5pt average
6	1980-1999	-17.5	-16.4	-17.8	-14.0	7pt average ↓
7	1980-1999	-12.7	-13.2	-13.1	-11.0	
8	1980-1999	-4.2	-4.8	-4.6	-7.0	
9	1973/75-1999	-3.6	-2.8	-2.9	-3.0	
10	1973/75-1999	3.0	2.7	2.3	0.5	
11	1973/75-1999	5.6	6.7	5.6	3.5	
12	1973/75-1999	8.0	8.4	5.4	6.0	
13	1973/75-1999	8.5	9.3	6.2	8.0	
14	1973/75-1999	9.8	10.6	7.0	9.0	
15	1973/75-1999	13.4	13.4	9.3	11.0	
16	1973/75-1999	8.4	13.5	8.9	12.5	
17	1973/75-1999	9.9	14.6	10.1	14.0	
18	1973/75-1999	19.6	18.5	13.0	15.5	5pt average
19	1973/75-1999	17.1	20.9	17.3	18.5	3pt average ↓
20	1973/75-1999	17.7	22.1	20.1	13.0	
21	1985-1999	-0.4	3.2	-3.3	-3.0	
22	1990-1999	-30.4	-28.3	-29.0	-19.5	
23	1974-1999	-38.9	-24.0	-23.6	-33.5	
24	1980-1999	-38.1	-39.2	-49.2	-52.0	
25	1974-1980	-89.5	-84.2	-82.6	-85.5	no averaging
Ft. George Inlet						
26	1963/64-1999	48.3	52.8	53.0	51.5	no averaging
27	1963/64-1999	0.6	0.2	4.0	1.5	no averaging
28	1958-1999	-0.7	-2.1	2.2	1.5	3pt average
29	1951/54-1999	2.9	2.9	2.8	1.5	3pt average
30	1963/64-1999	0.3	1.2	1.8	1.0	no averaging
St. Johns River Entrance						

Table A-1. Shoreline change rate estimates for Duval County, Florida.

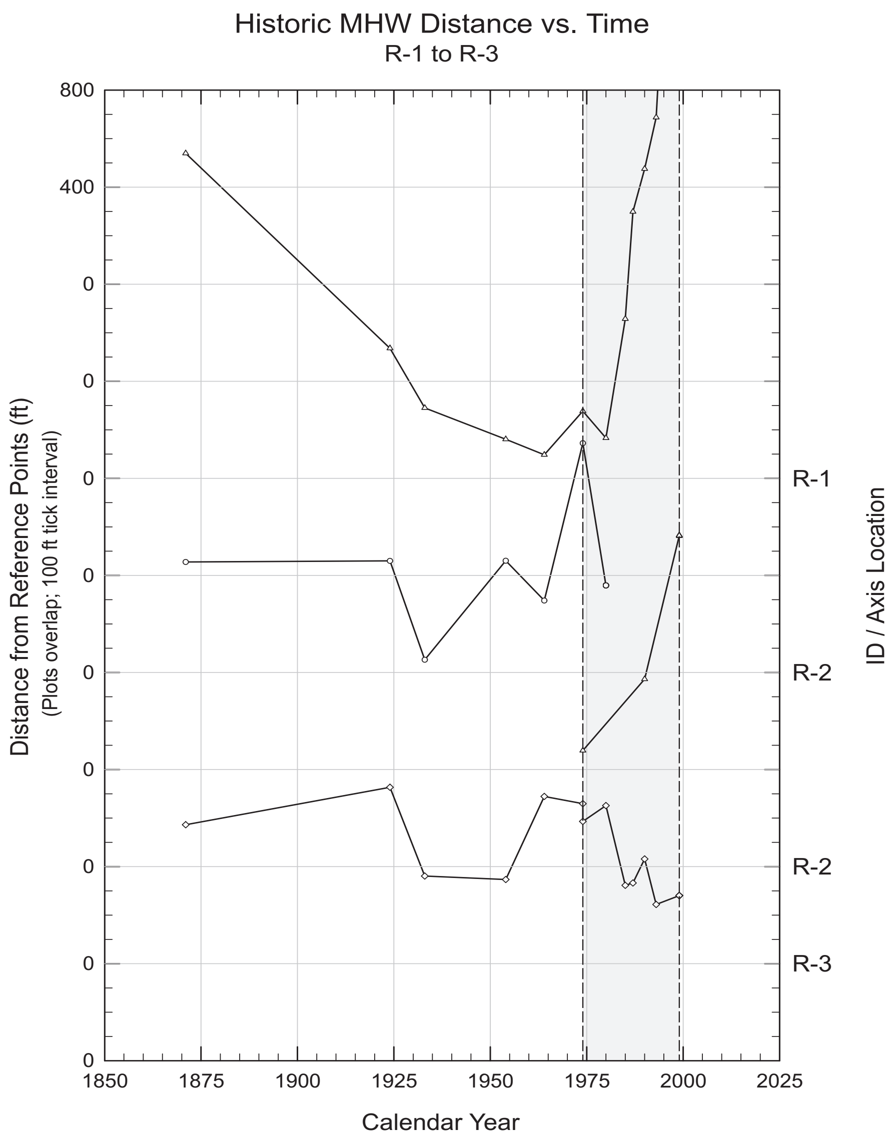
Range	Year	Method			Consensus Rate Average Estimates	
		RA	LS	EP	Rate (ft/yr)	Comments
31	1924-1958	-3.5	-4.1	-4.6	-4.0	no averaging
32	1924-1958	-1.9	-2.8	-3.4	-3.5	3pt average
33	1924-1958	-2.7	-3.3	-3.8	-3.5	5pt average
34	1924-1958	-3.8	-3.4	-3.2	-4.0	7pt average
35	1924-1958	-4.9	-4.4	-4.8	-4.0	↓
36	1924-1958	-5.0	-4.3	-5.0	-4.0	
37	1924-1958	-5.3	-4.7	-5.3	-4.5	
38	1924-1958	-4.7	-4.7	-4.8	-4.5	
39	1924-1958	-3.5	-3.5	-3.4	-5.0	
40	1924-1958	-4.9	-5.2	-5.0	-5.0	
41	1924-1958	-5.6	-5.7	-5.6	-5.0	
42	1924-1958	-6.8	-5.7	-6.0	-5.5	
43	1924-1958	-6.5	-6.0	-6.2	-5.5	
44	1924-1958	-5.4	-4.6	-4.8	-5.5	
45	1924-1958	-6.0	-5.3	-5.5	-5.0	
46	1924-1958	-5.1	-4.6	-4.7	-4.5	
47	1924-1958	-4.6	-4.3	-4.4	-4.0	
48	1924-1958	-3.3	-3.4	-3.5	-3.5	
49	1924-1958	-1.5	-1.8	-2.0	-3.0	
50	1924-1958	-1.4	-1.7	-1.9	-2.5	
51	1924-1958	-1.5	-1.1	-1.5	-2.5	
52	1924-1958	-2.5	-2.7	-2.8	-3.0	
53	1924-1958	-3.6	-4.0	-4.2	-3.5	
54	1924-1958	-4.7	-4.4	-4.5	-3.5	
55	1924-1958	-4.6	-4.5	-4.6	-4.0	
56	1924-1958	-3.8	-4.7	-4.5	-4.0	
57	1924-1958	-3.9	-4.7	-4.5	-4.0	
58	1924-1958	-5.0	-4.3	-3.9	-3.5	
59	1924-1958	-2.9	-2.8	-2.7	-3.0	
60	1924-1958	-2.2	-2.1	-2.1	-2.5	
61	1924-1958	-1.5	-1.5	-1.5	-2.0	
62	1924-1958	-1.1	-1.1	-1.1	-1.0	
63	1858-1958	-0.7	-0.7	-0.7	-1.0	

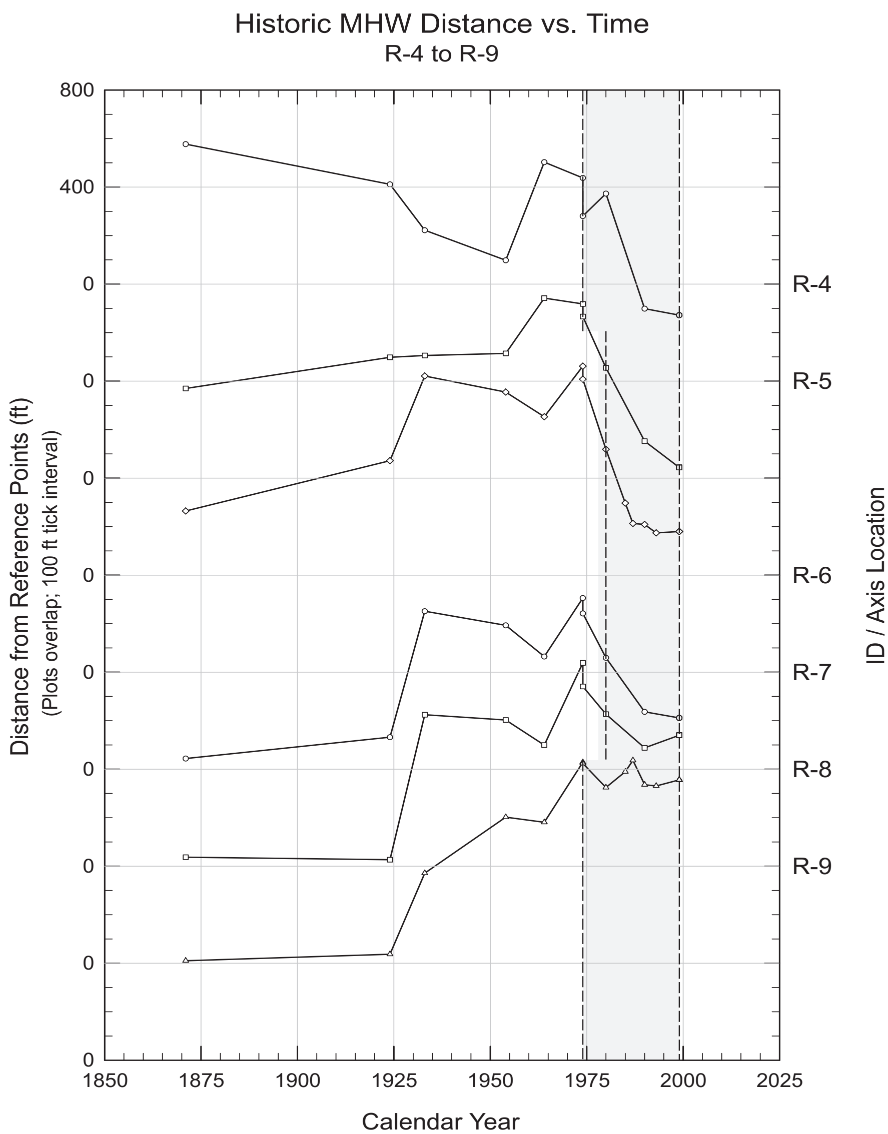
Table A-1. Shoreline change rate estimates for Duval County, Florida.

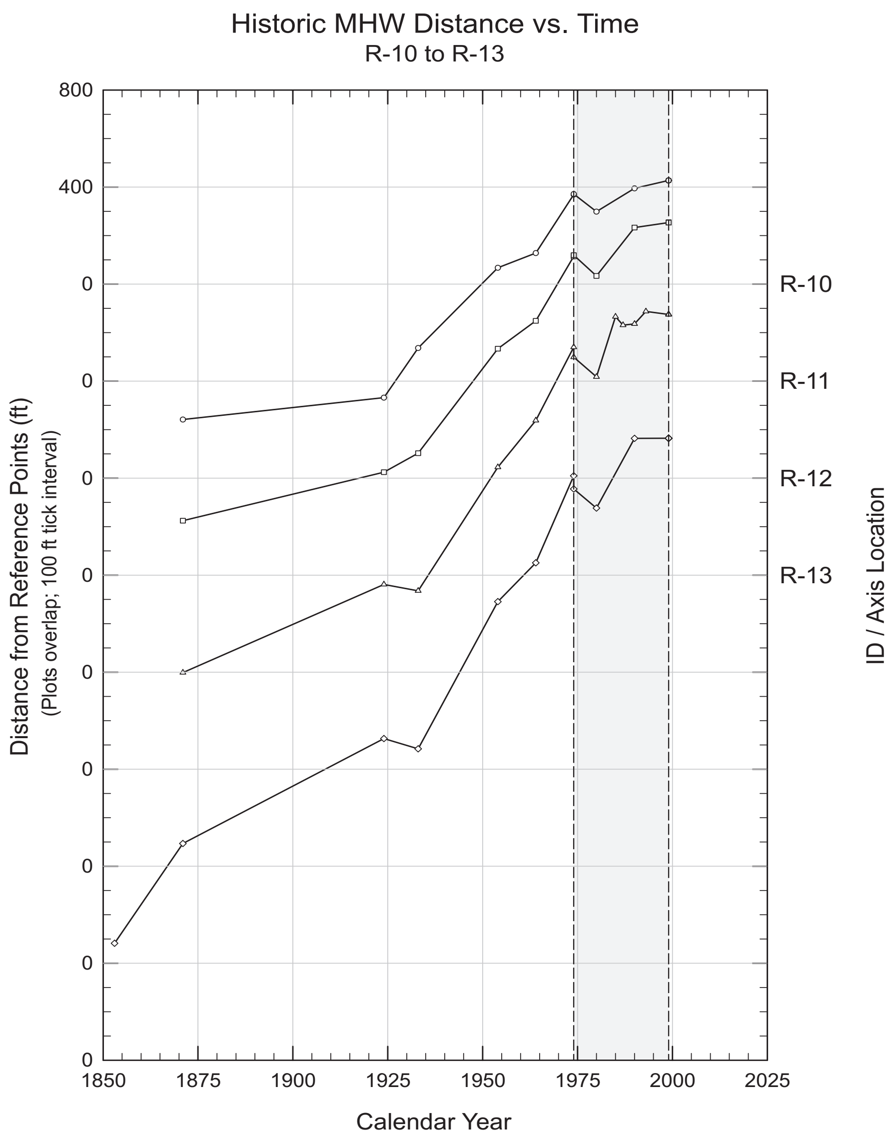
Range	Year	Method			Consensus Rate Average Estimates	
		RA	LS	EP	Rate (ft/yr)	Comments
64	1858-1958	-0.4	-0.5	-0.3	-0.5	
65	1858-1958	0.0	-0.1	0.0	-0.5	
66	1858-1958	-0.2	-0.2	-0.2	-0.5	
67	1858-1958	-0.5	-0.5	-0.5	-0.5	
68	1858-1958	-0.7	-0.6	-0.7	-0.5	
69	1858-1958	-0.7	-0.6	-0.8	-0.5	
70	1858-1958	-0.8	-0.7	-0.8	-0.5	
71	1858-1958	-0.7	-0.6	-0.7	-0.5	
72	1858-1958	-0.6	-0.6	-0.6	-0.5	
73	1858-1958	-0.6	-0.6	-0.6	-0.5	
74	1858-1958	-0.7	-0.6	-0.7	-0.5	
75	1858-1958	-1.0	-1.0	-0.9	-0.5	
76	1858-1958	-0.7	-0.6	-0.6	-0.5	↑
77	1858-1958	-0.3	-0.4	-0.3	-0.5	7pt average
78	1858-1958	-0.2	-0.5	-0.2	-0.5	5pt average
79	1858-1958	-0.1	-0.5	-0.1	0.0	3pt average
80	1858-1958	0.0	-0.4	0.0	0.0	no averaging

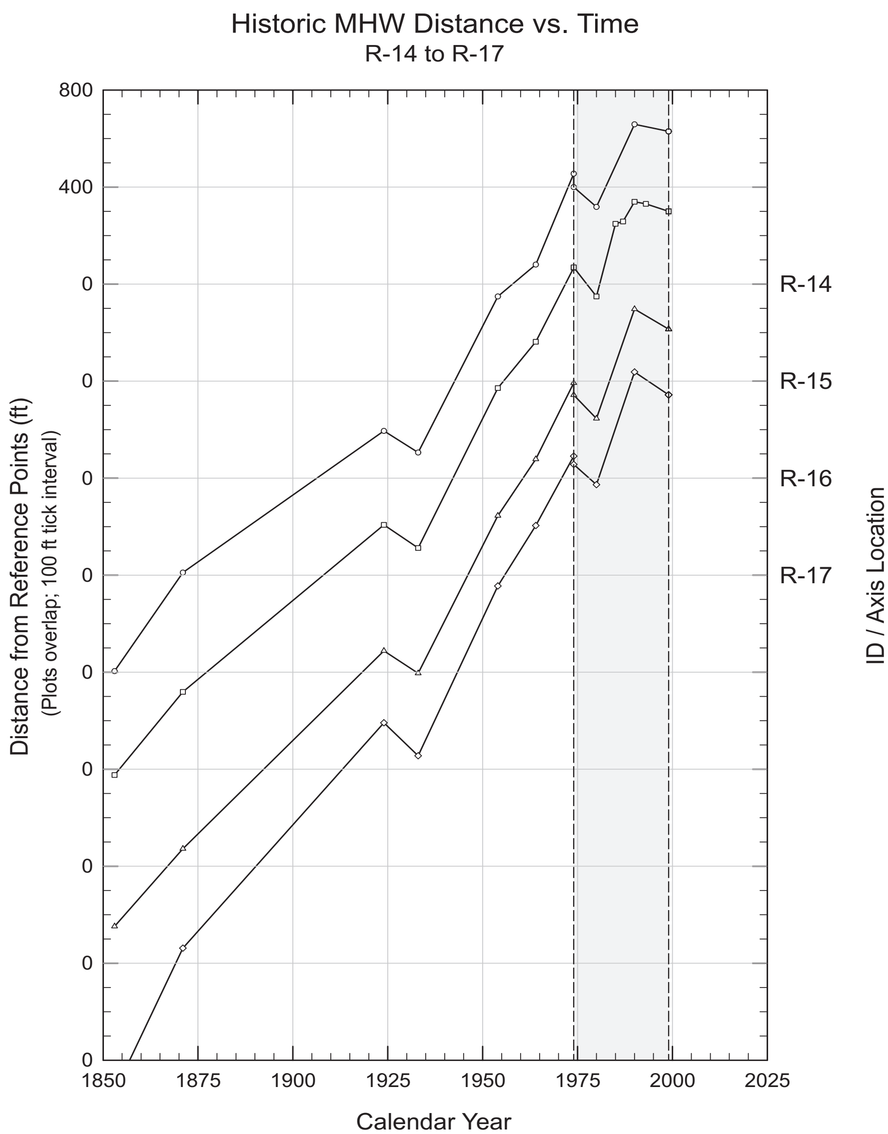
8.2 Appendix B: Stack Plots

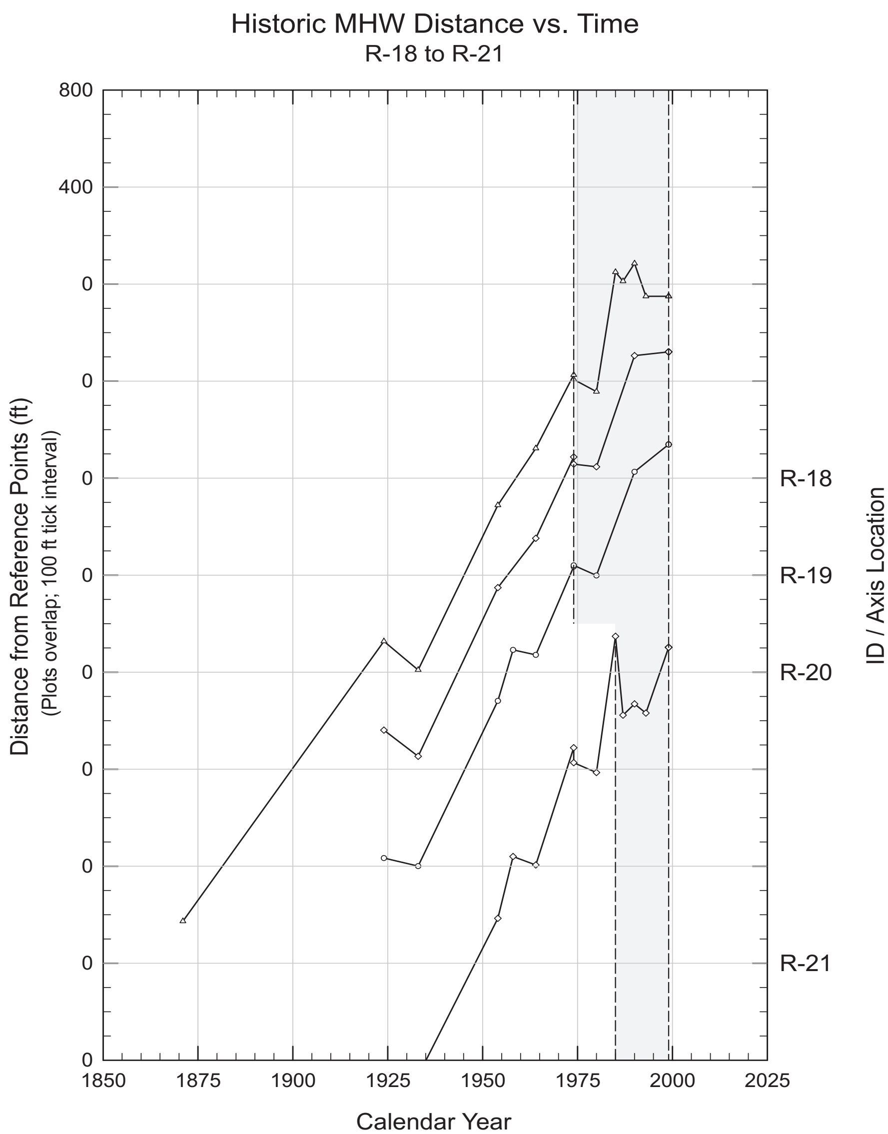
Stack plots from Historic Shoreline Database, Florida Department of Environmental Protection, Office of Beaches and Coastal Systems; slightly modified by authors.


Historic MHW Distance vs. Time
R-1 to R-3
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
R-1
R-2
R-2
R-3
ID / Axis Location

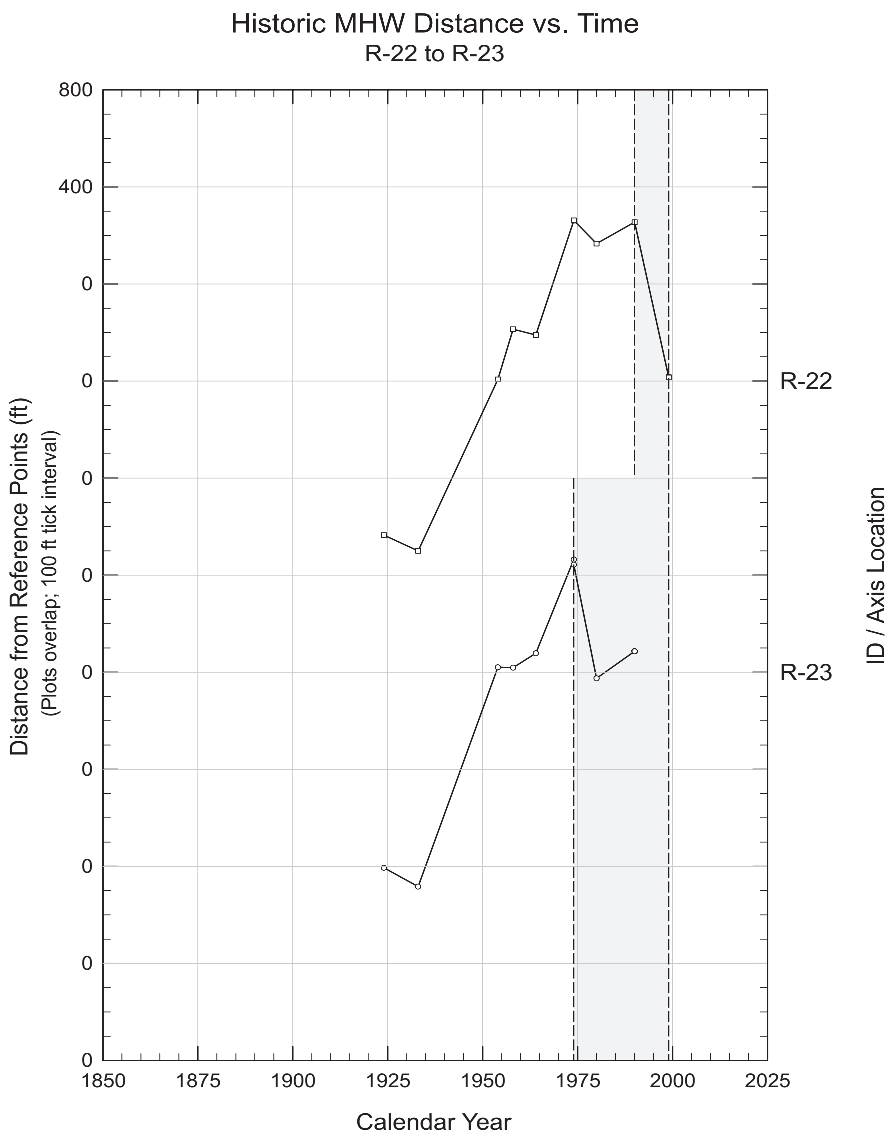

Historic MHW Distance vs. Time
R-4 to R-9
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-4
R-5
R-6
R-7
R-8
R-9
ID / Axis Location

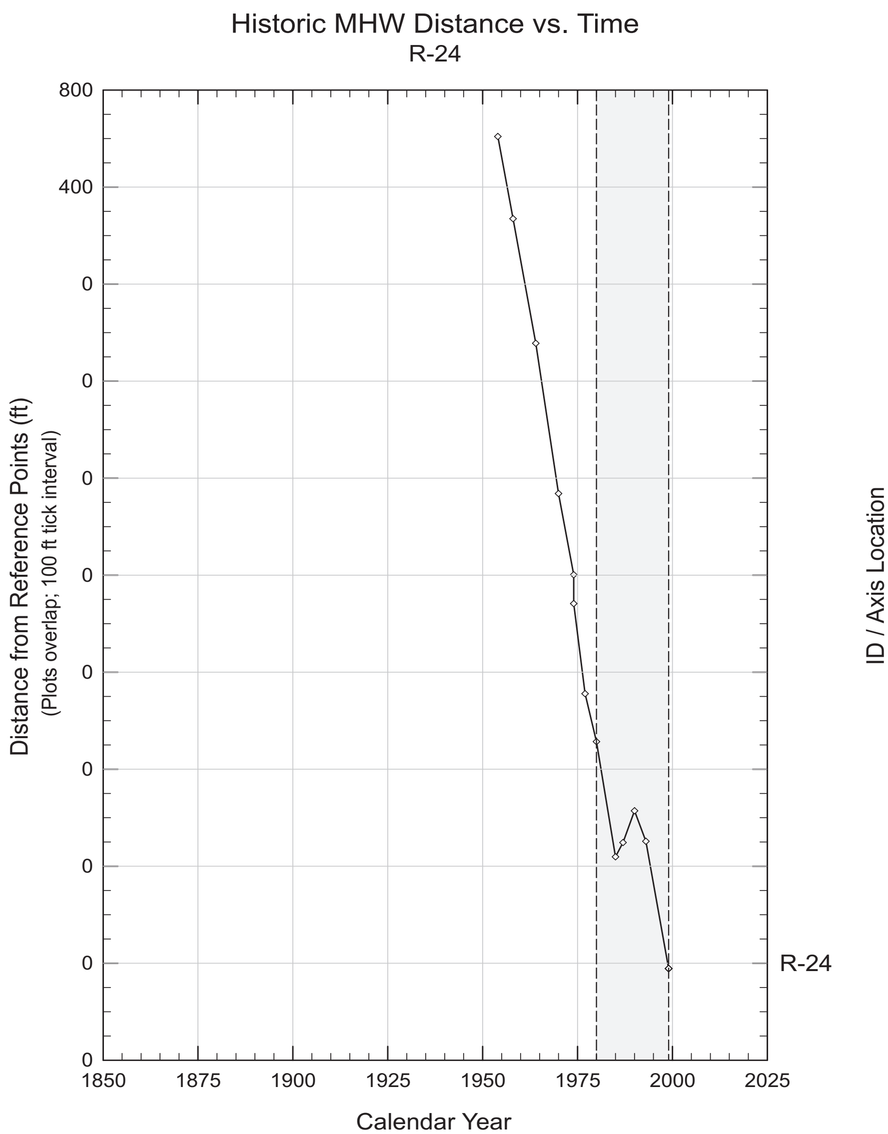

Historic MHW Distance vs. Time
R-10 to R-13
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-10
R-11
R-12
R-13
ID / Axis Location

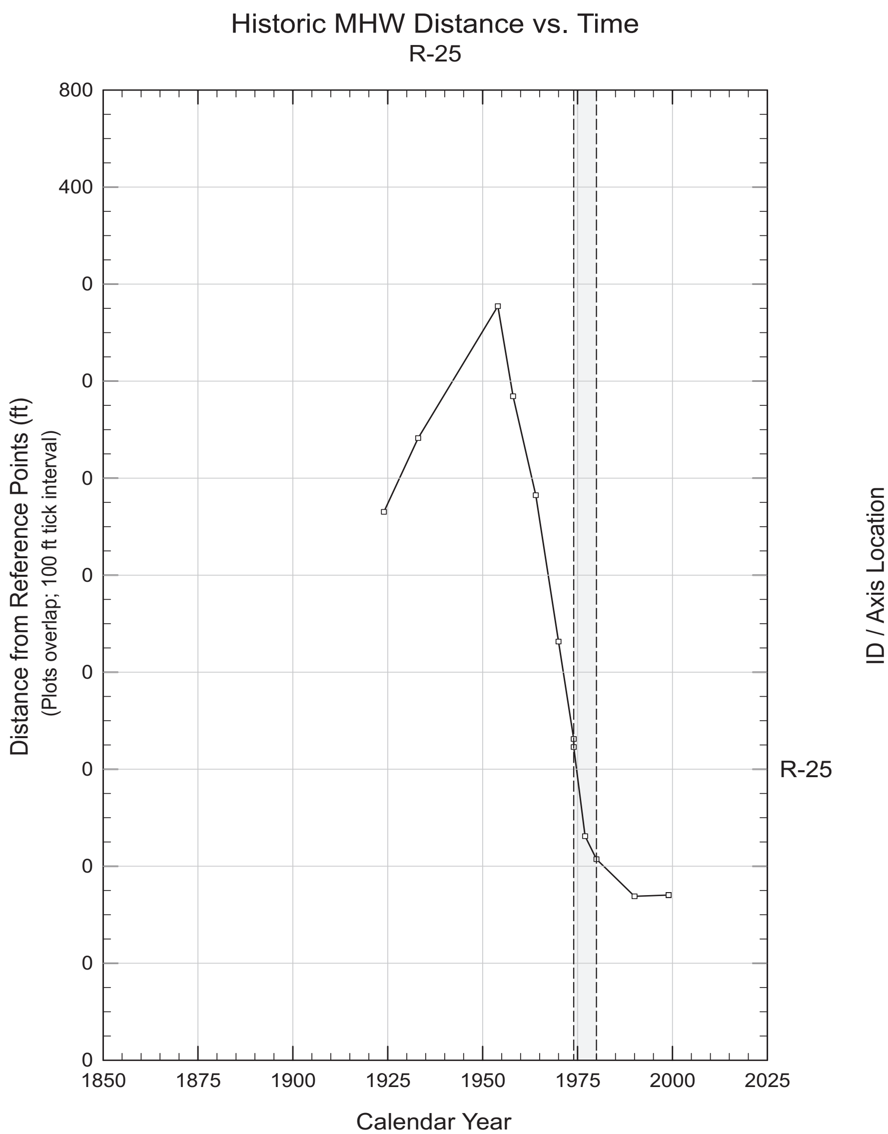

Historic MHW Distance vs. Time
R-14 to R-17
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
R-14
R-15
R-16
R-17
ID / Axis Location



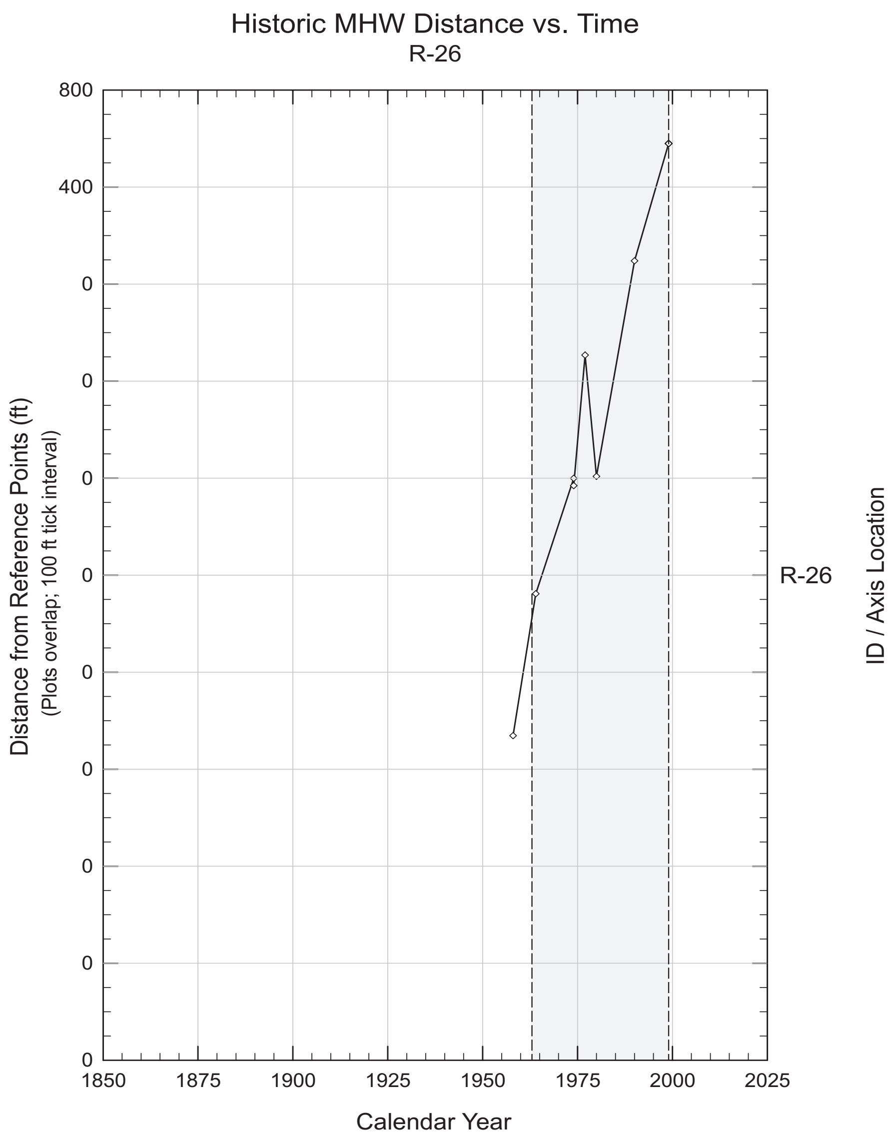
Historic MHW Distance vs. Time
R-18 to R-21
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-18
R-19
R-20
R-21
ID / Axis Location


Historic MHW Distance vs. Time
R-22 to R-23
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-22
R-23
ID / Axis Location

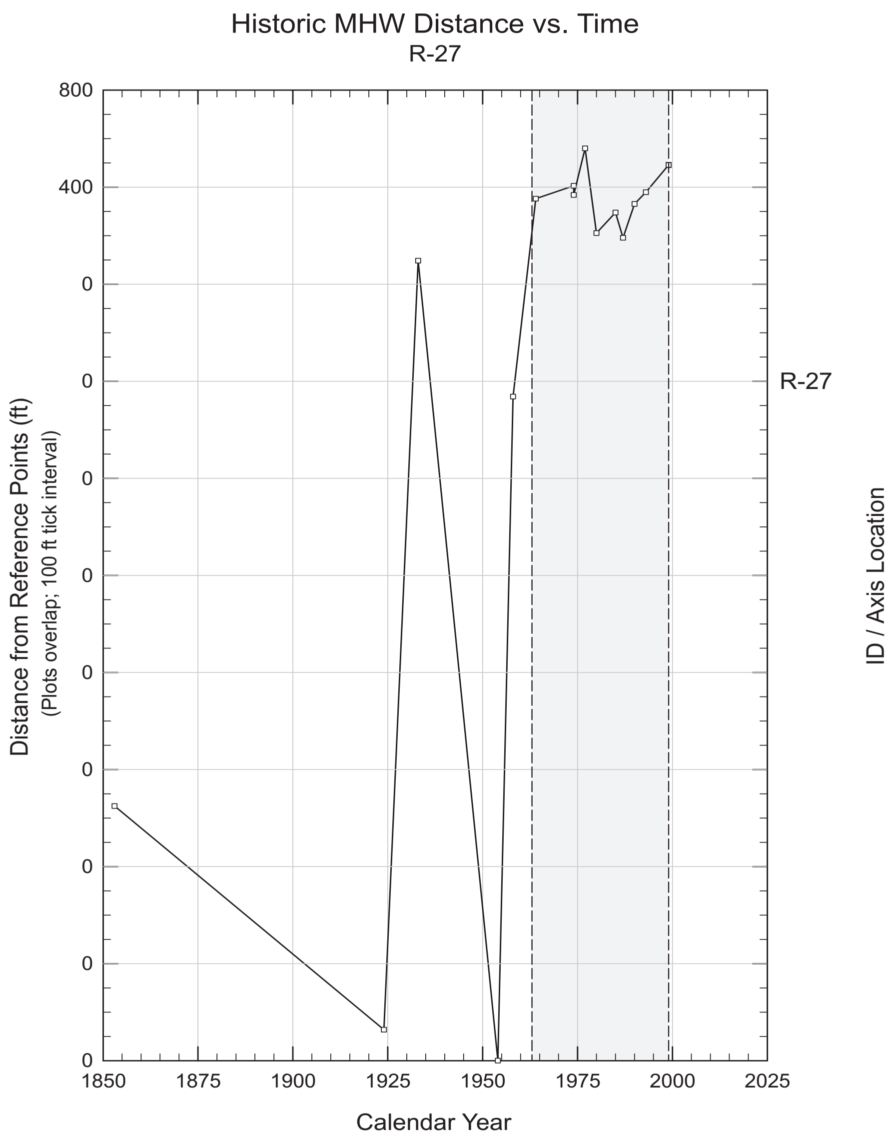

Historic MHW Distance vs. Time
R-24
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
ID / Axis Location
R-24

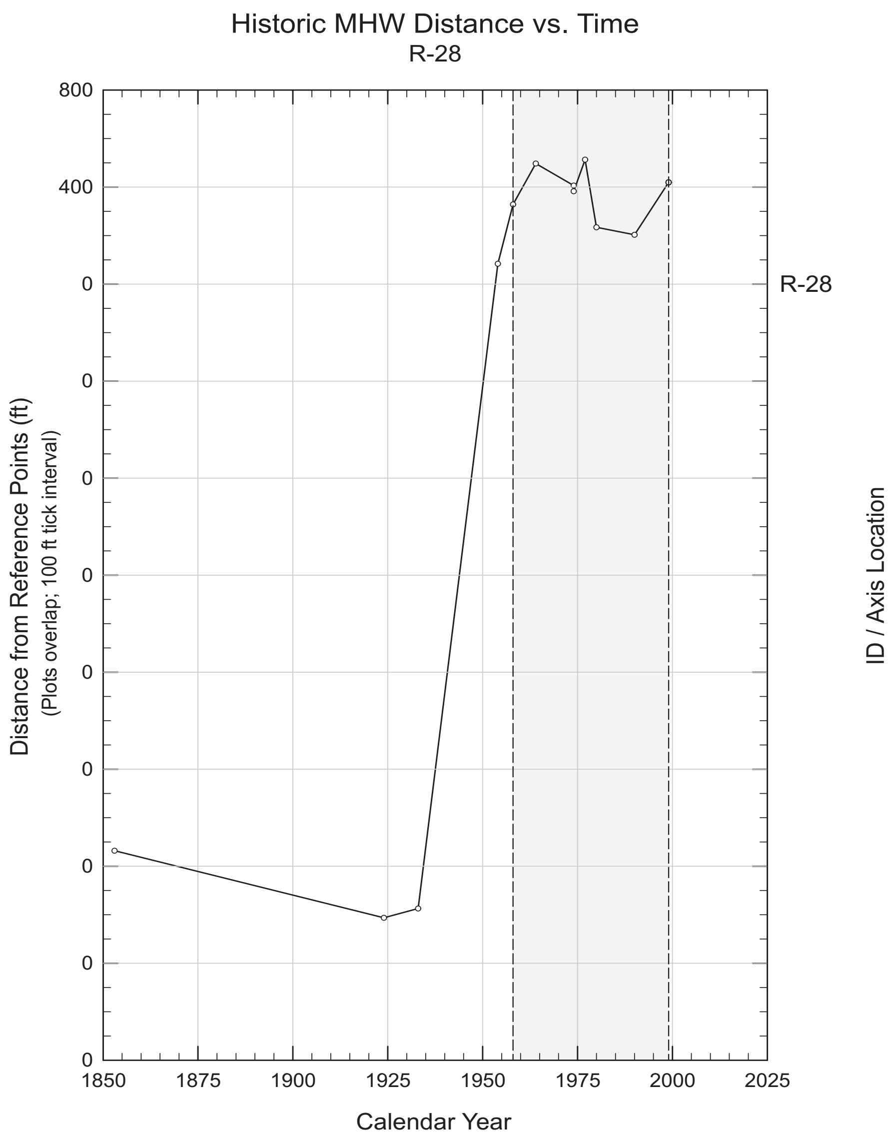


Historic MHW Distance vs. Time
R-25
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
ID / Axis Location
R-25

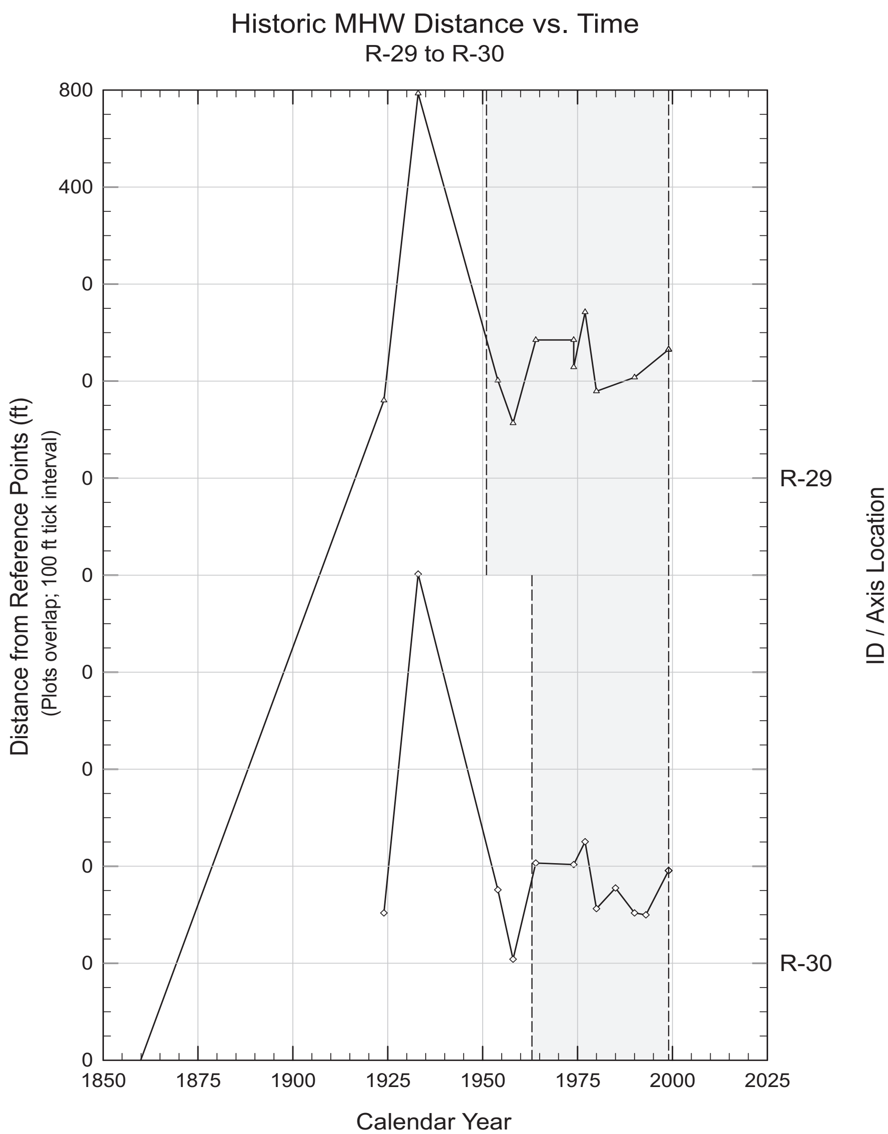


Historic MHW Distance vs. Time
R-26
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-26
ID / Axis Location

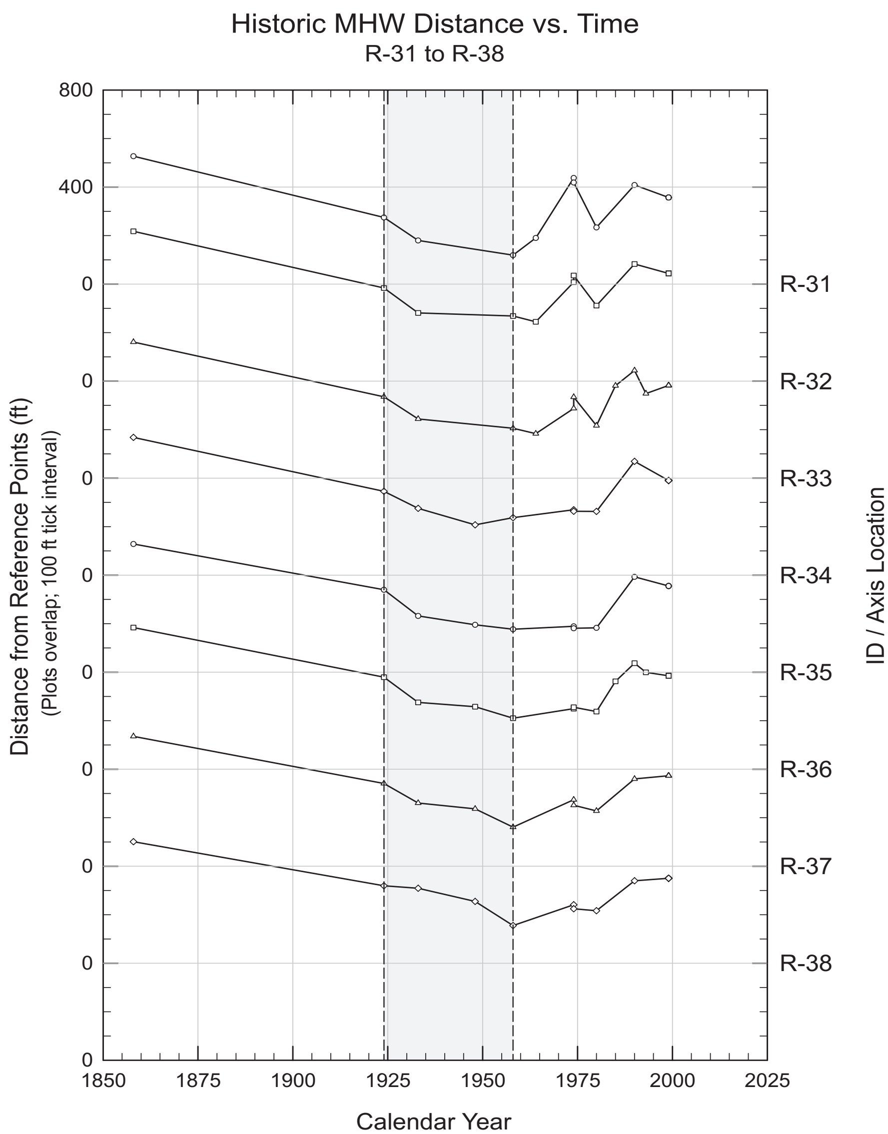

Historic MHW Distance vs. Time
R-27
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-27
ID / Axis Location

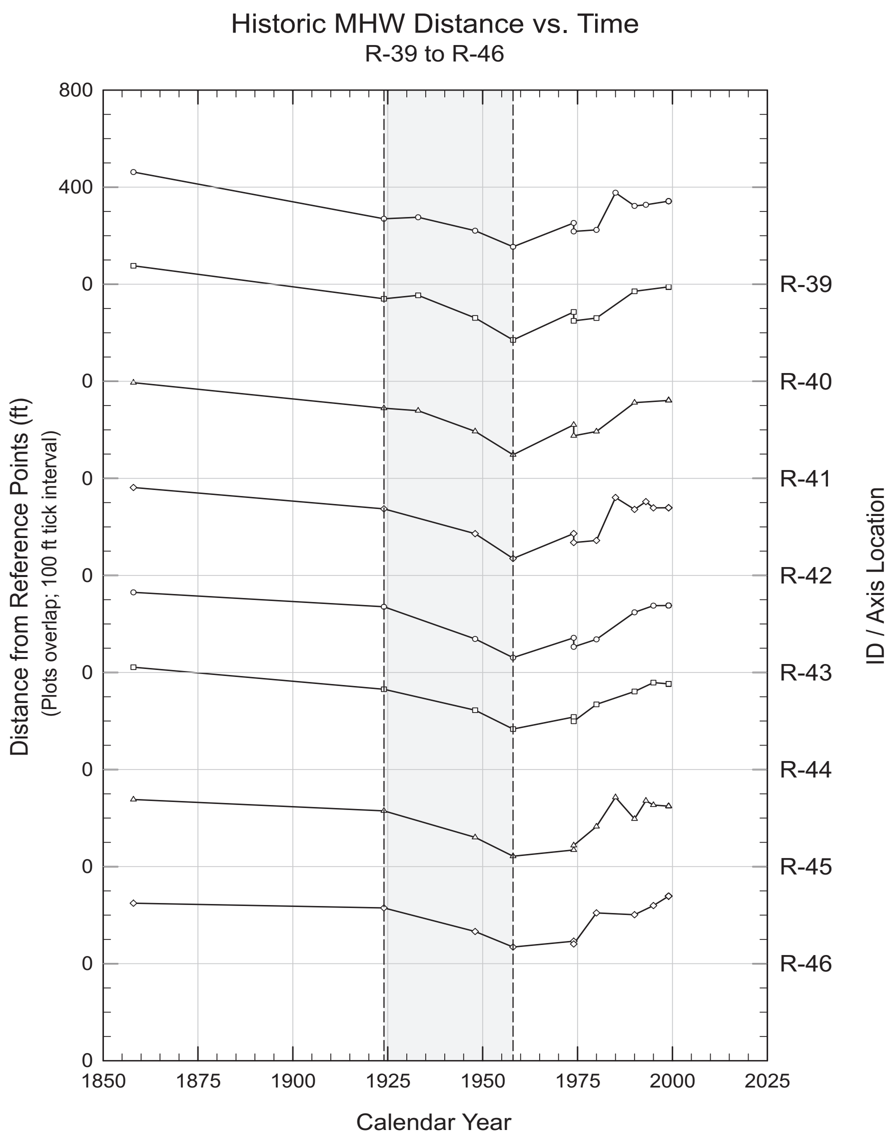


Historic MHW Distance vs. Time
R-28
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-28
ID / Axis Location

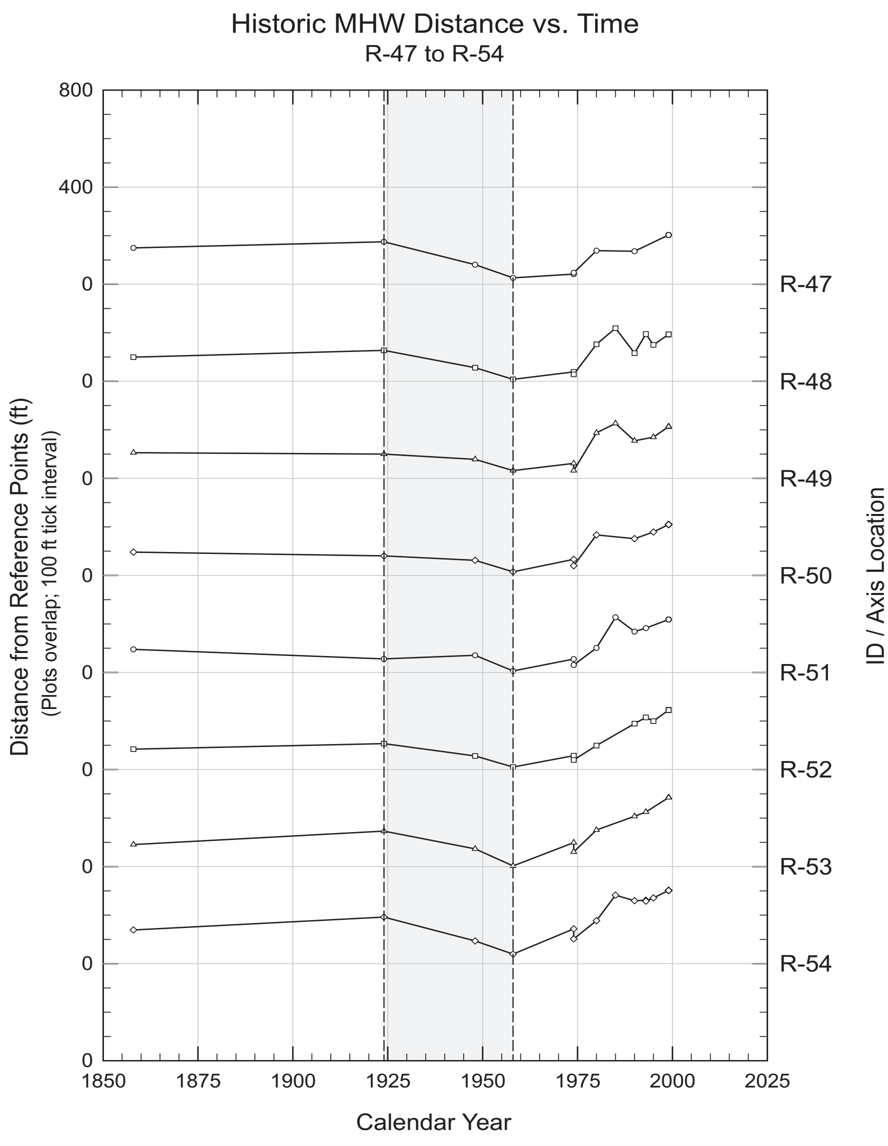


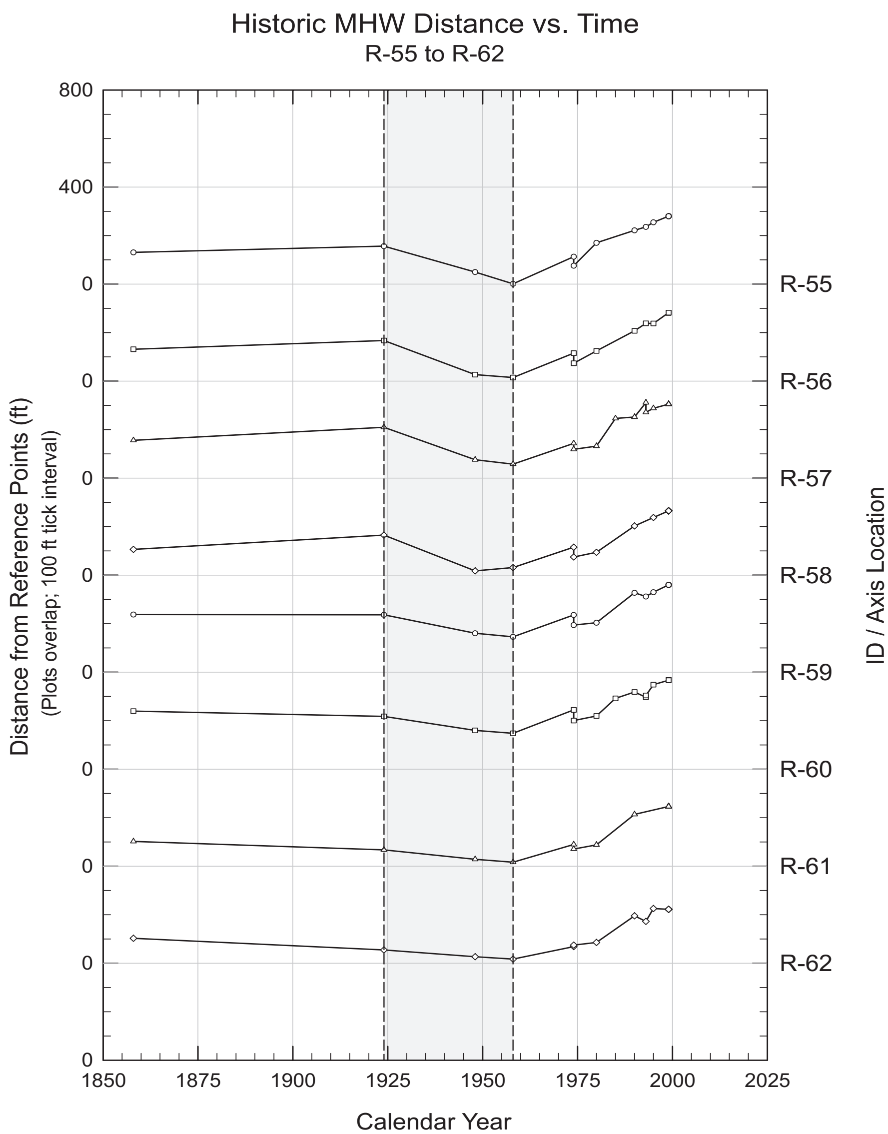
Historic MHW Distance vs. Time
R-29 to R-30
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-29
R-30
ID / Axis Location


Historic MHW Distance vs. Time
R-31 to R-38
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
R-31
R-32
R-33
R-34
R-35
R-36
R-37
R-38
ID / Axis Location

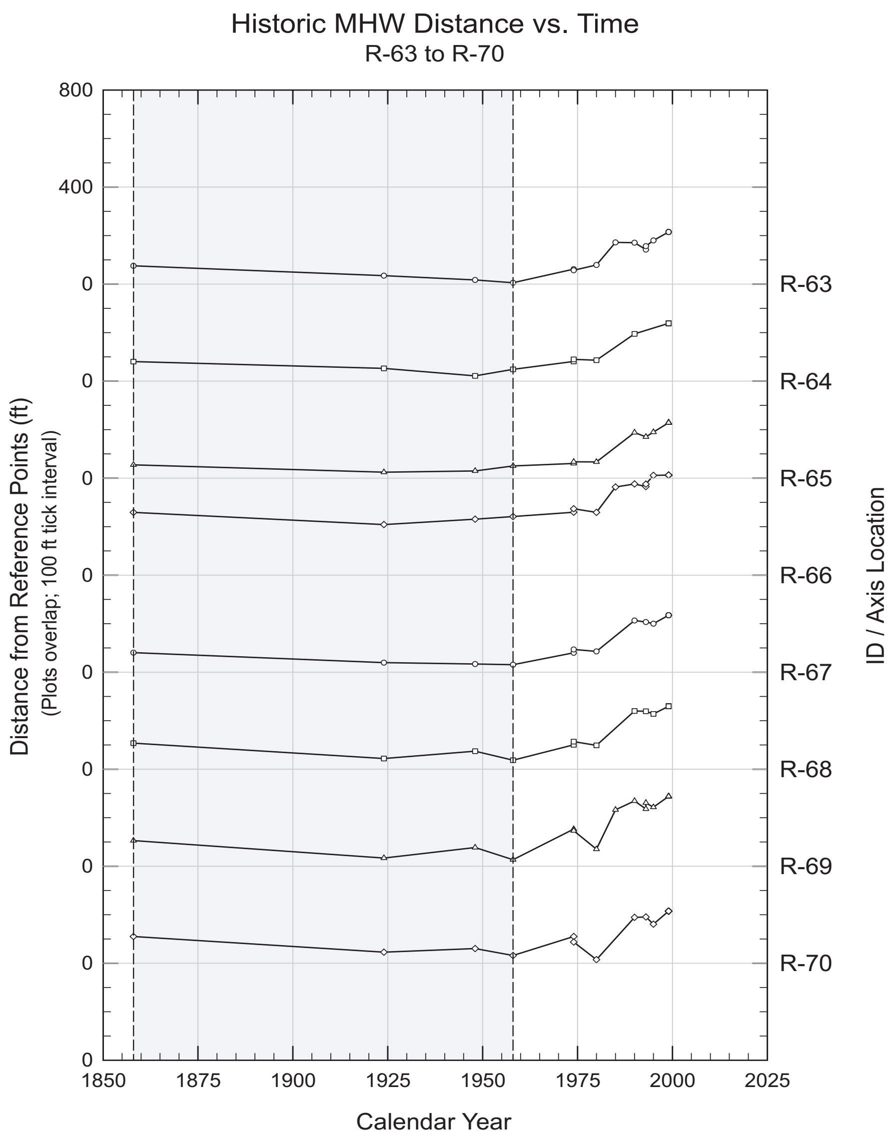


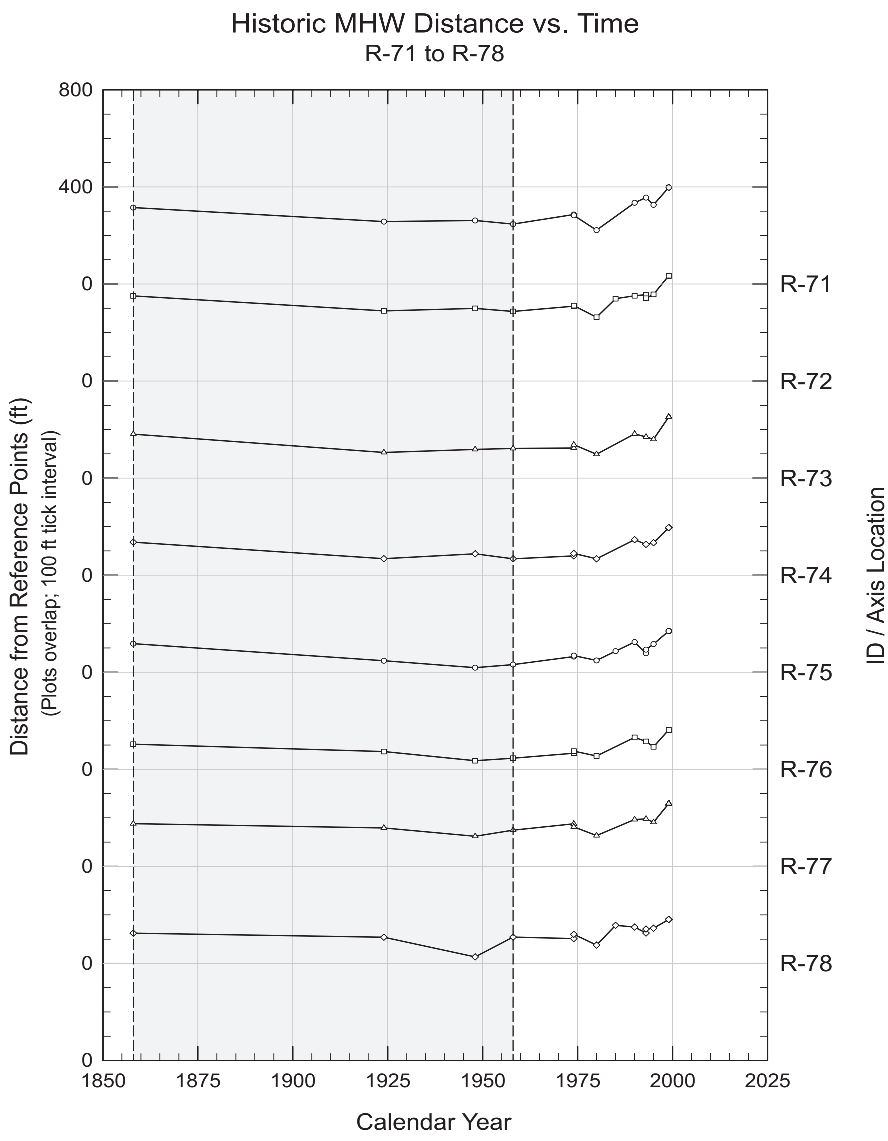
Historic MHW Distance vs. Time
R-39 to R-46
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-39
R-40
R-41
R-42
R-43
R-44
R-45
R-46
ID / Axis Location

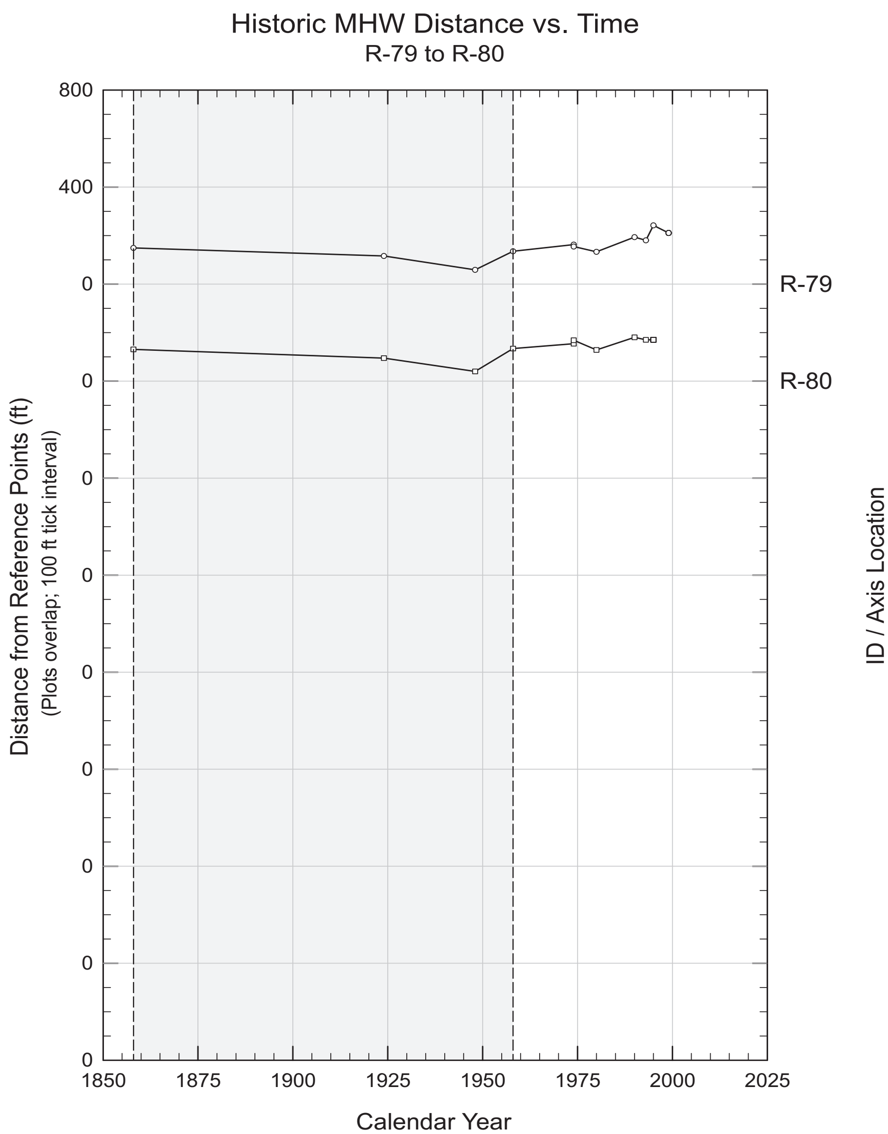

Historic MHW Distance vs. Time
R-47 to R-54
800
400
0
0
0
0
0
0
0
0
0
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-47
R-48
R-49
R-50
R-51
R-52
R-53
R-54
ID / Axis Location
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year



Historic MHW Distance vs. Time
R-55 to R-62
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
R-55
R-56
R-57
R-58
R-59
R-60
R-61
R-62
ID / Axis Location

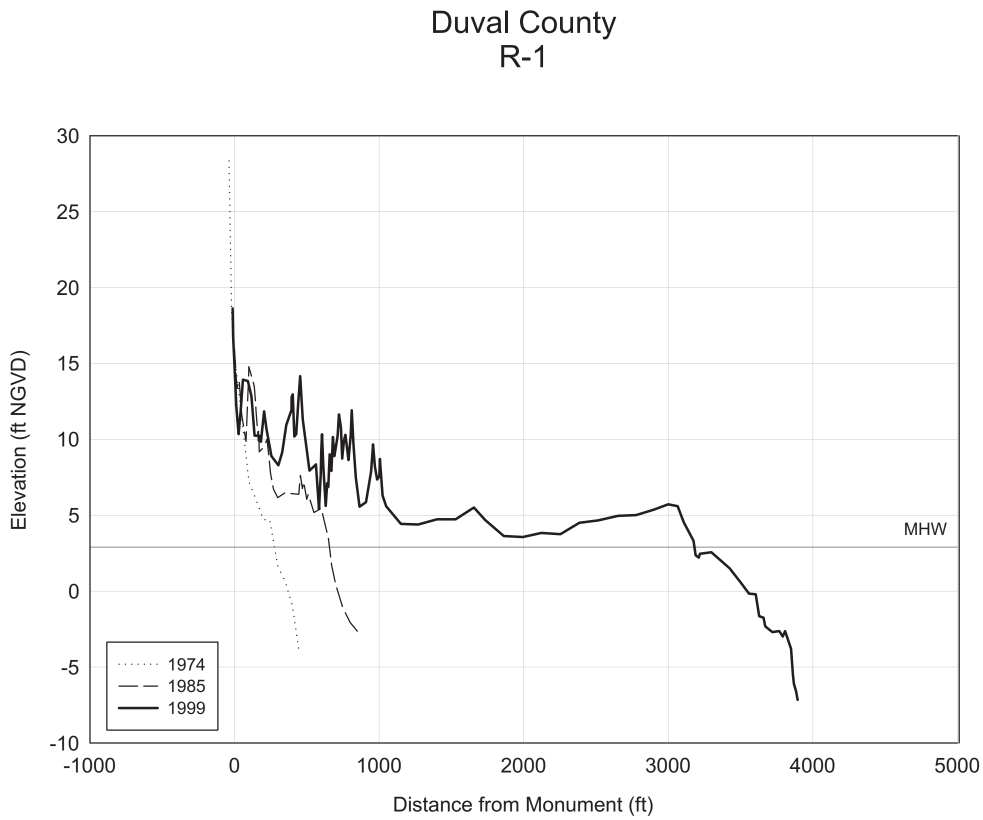

Historic MHW Distance vs. Time
R-63 to R-70
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-63
R-64
R-65
R-66
R-67
R-68
R-69
R-70
ID / Axis Location

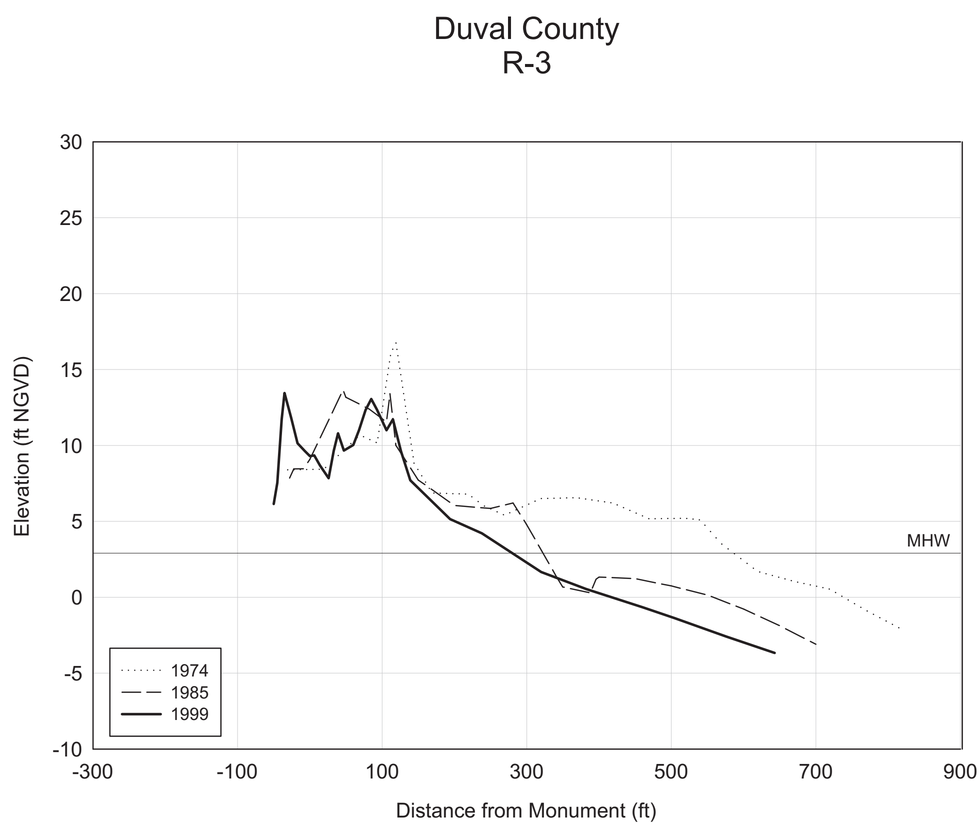

Historic MHW Distance vs. Time
R-71 to R-78
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
800
400
0
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
R-71
R-72
R-73
R-74
R-75
R-76
R-77
R-78
ID / Axis Location



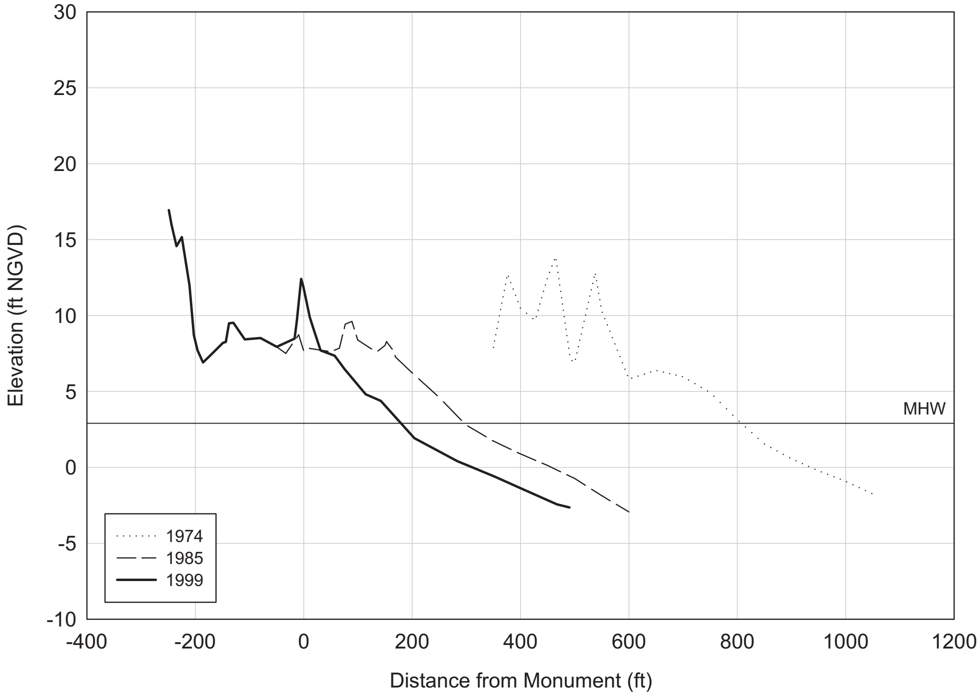
Historic MHW Distance vs. Time
R-79 to R-80
800
400
0
0
0
0
0
0
0
0
0
1850
1875
1900
1925
1950
1975
2000
2025
Calendar Year
Distance from Reference Points (ft)
(Plots overlap; 100 ft tick interval)
R-79
R-80
ID / Axis Location

8.3 Appendix C: Profile Plots

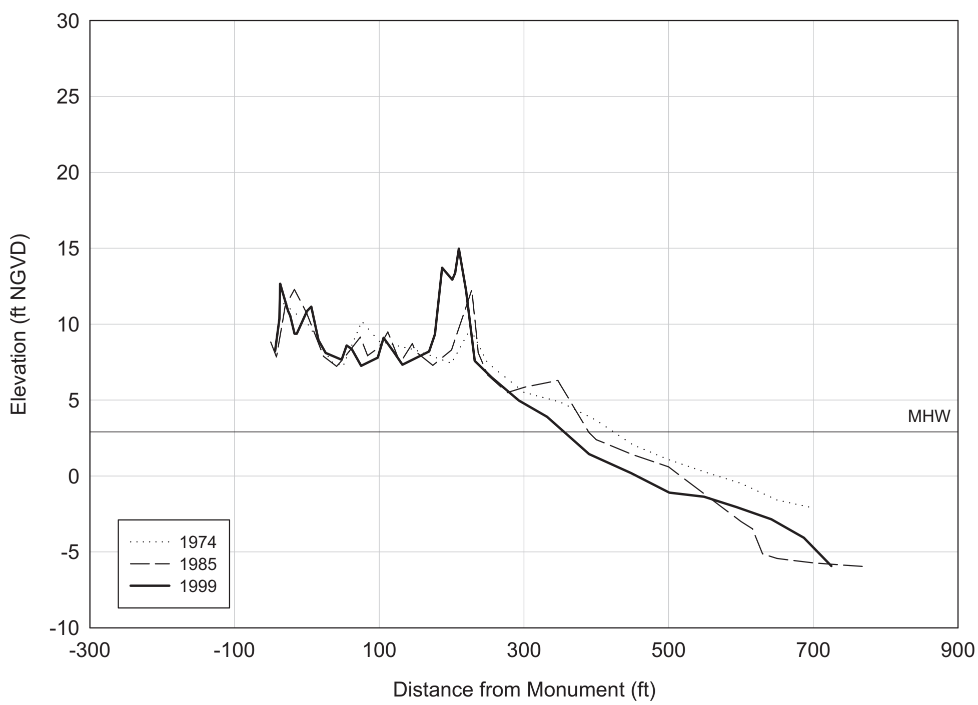

Duval County
R-1
Elevation (ft NGVD)
Distance from Monument (ft)
MHW
1974
1985
1999
30
25
20
15
10
5
0
-5
-10
-1000
0
1000
2000
3000
4000
5000


Duval County
R-3
Elevation (ft NGVD)
Distance from Monument (ft)
MHW
1974
1985
1999
30
25
20
15
10
5
0
-5
-10
-300
-100
100
300
500
700
900

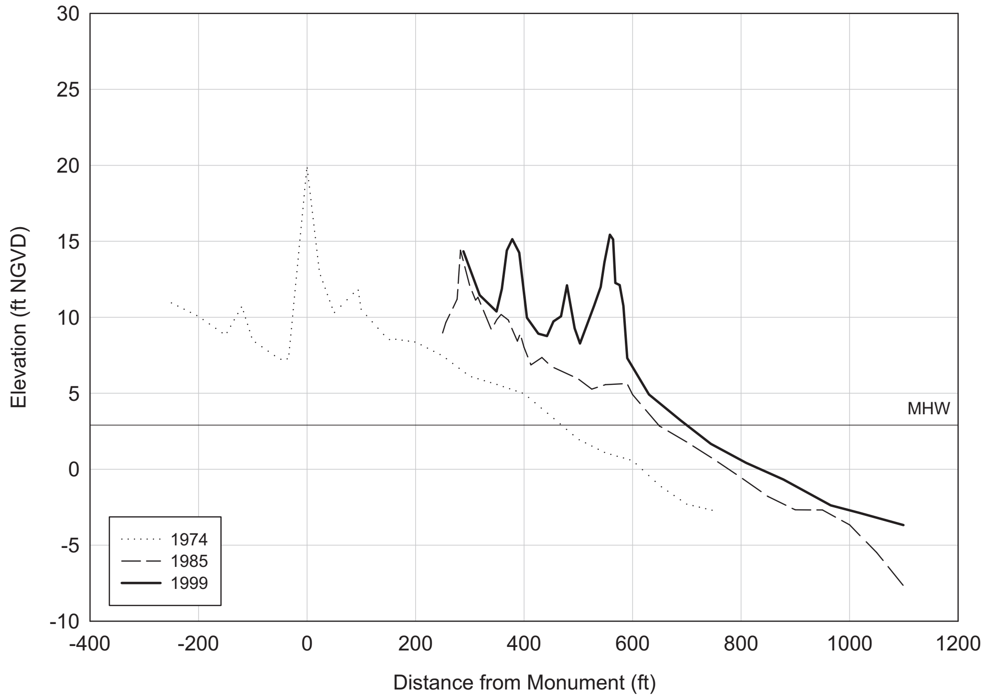
Duval County
R-6



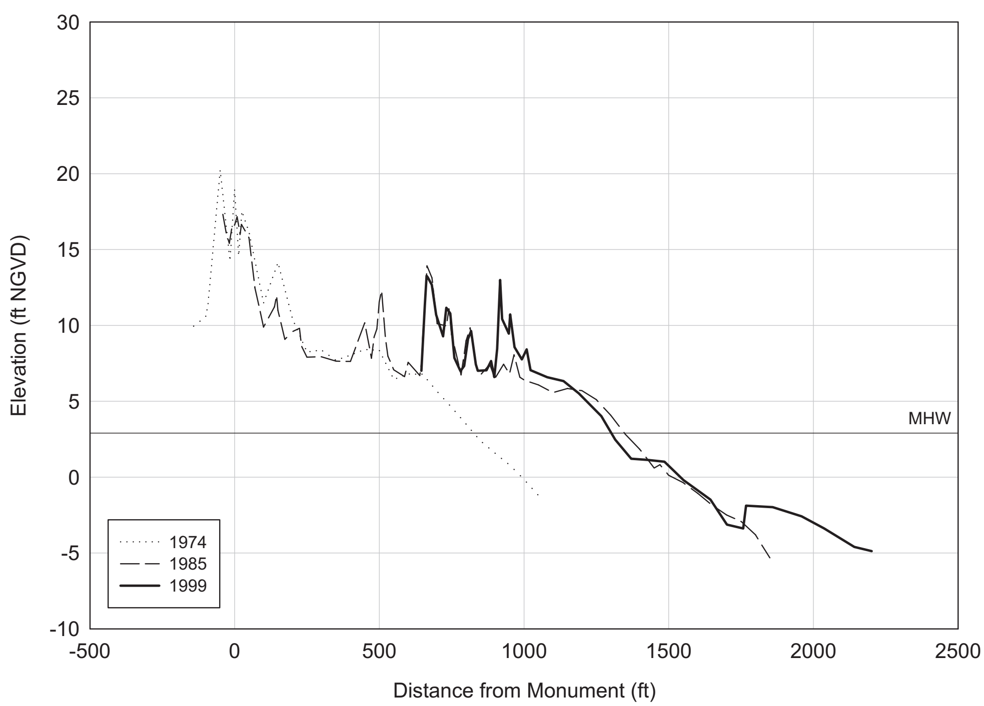
Duval County
R-9



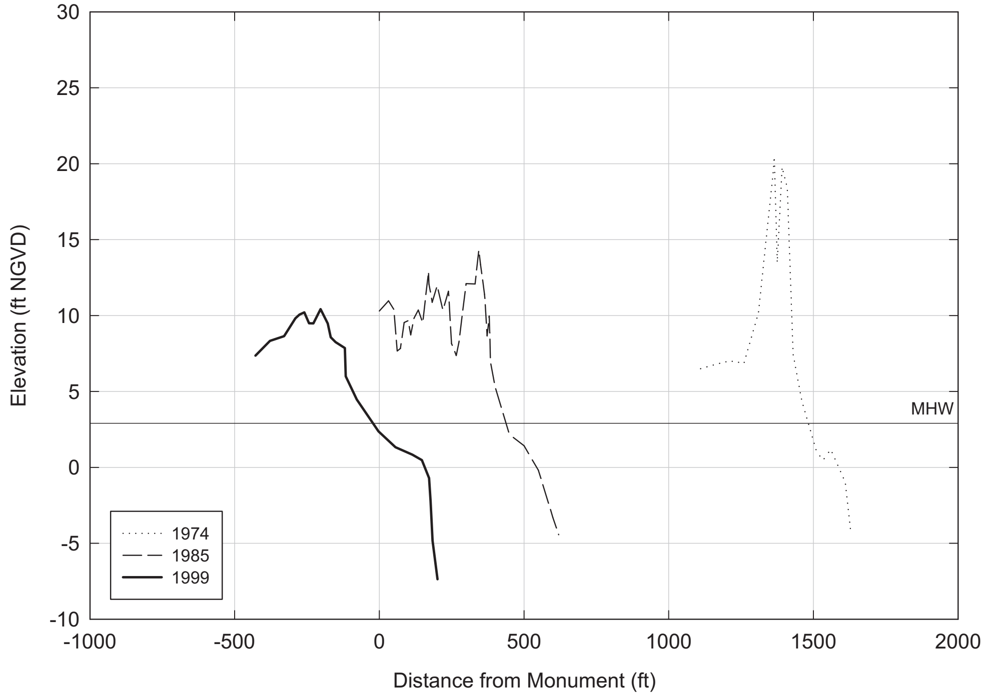
Duval County
R-15



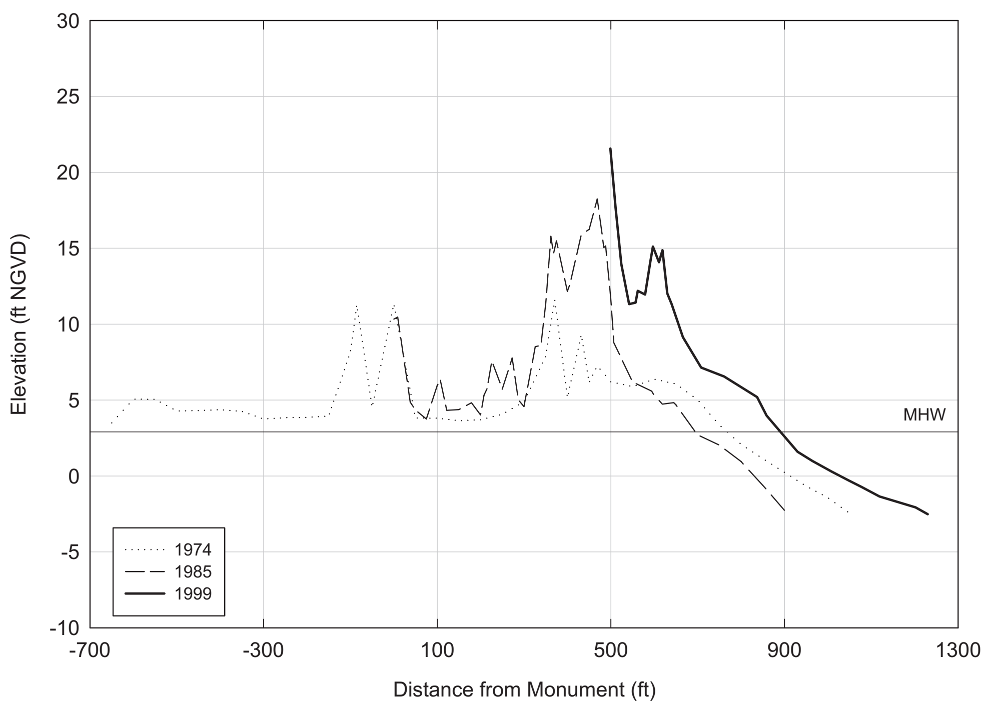
Duval County
R-21



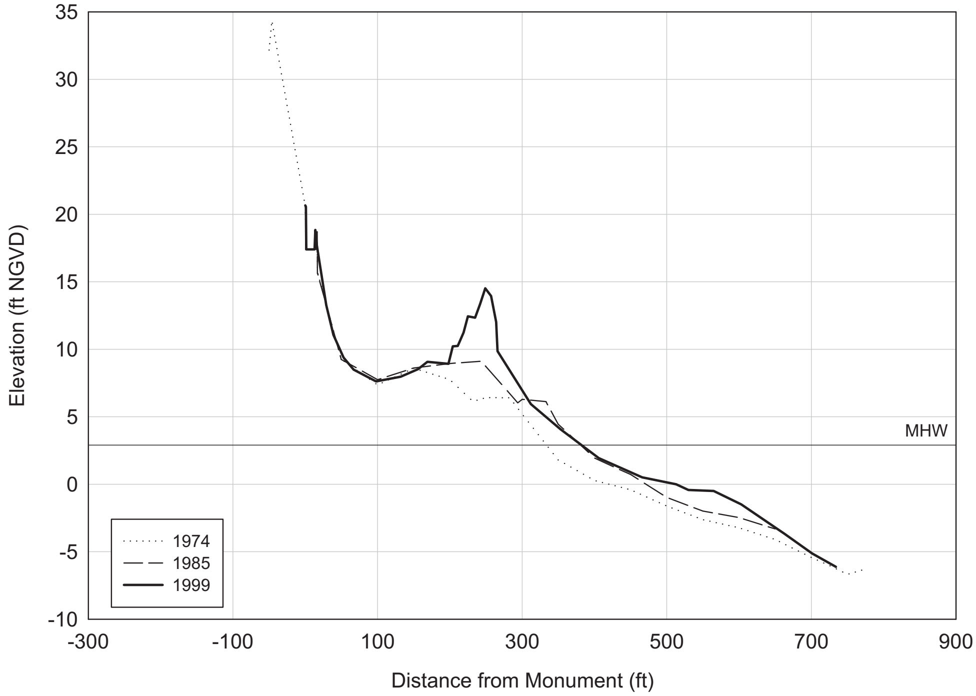
Duval County
R-24



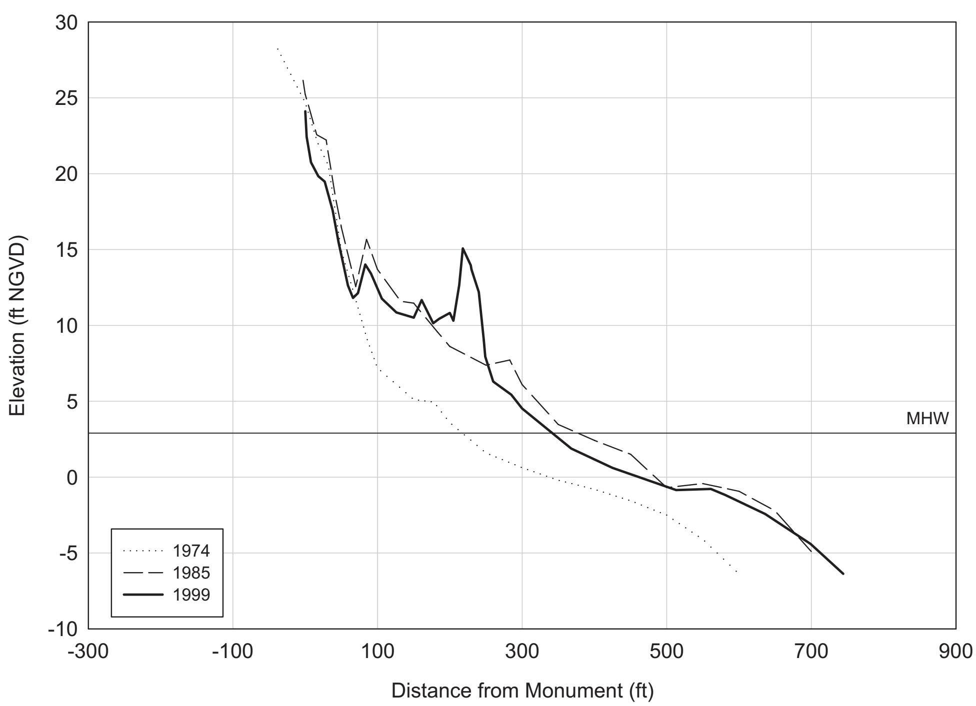
Duval County
R-27



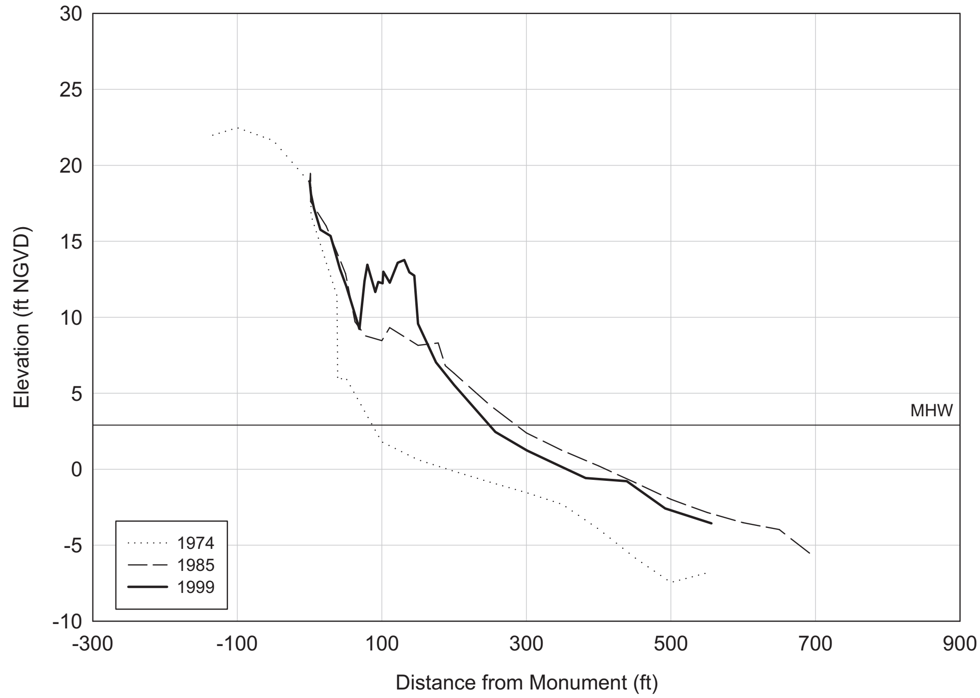
Duval County
R-33



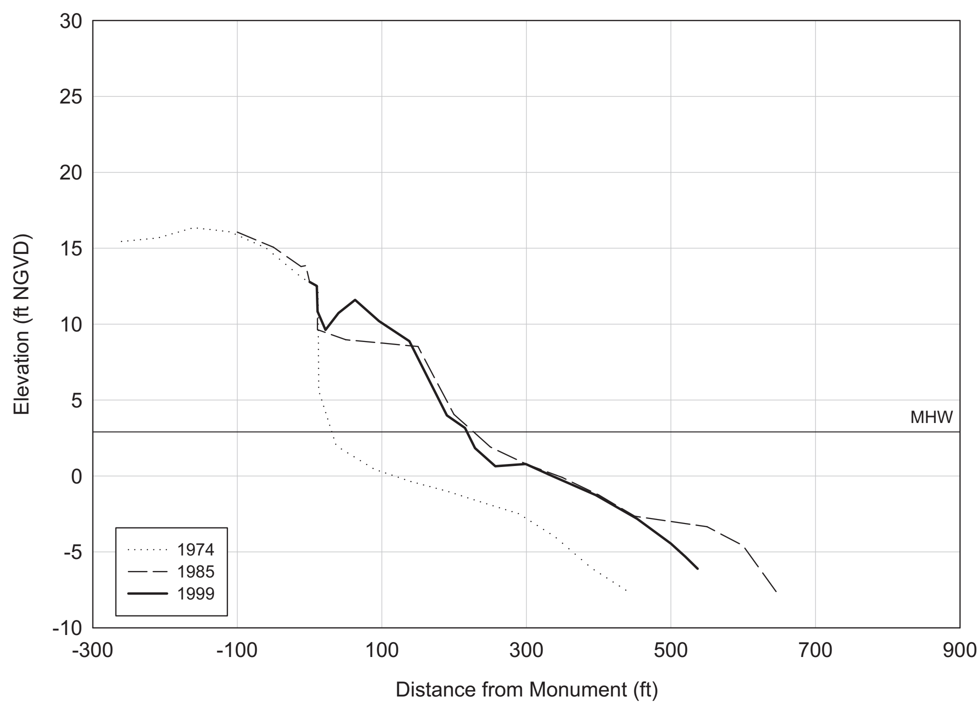
Duval County
R-39



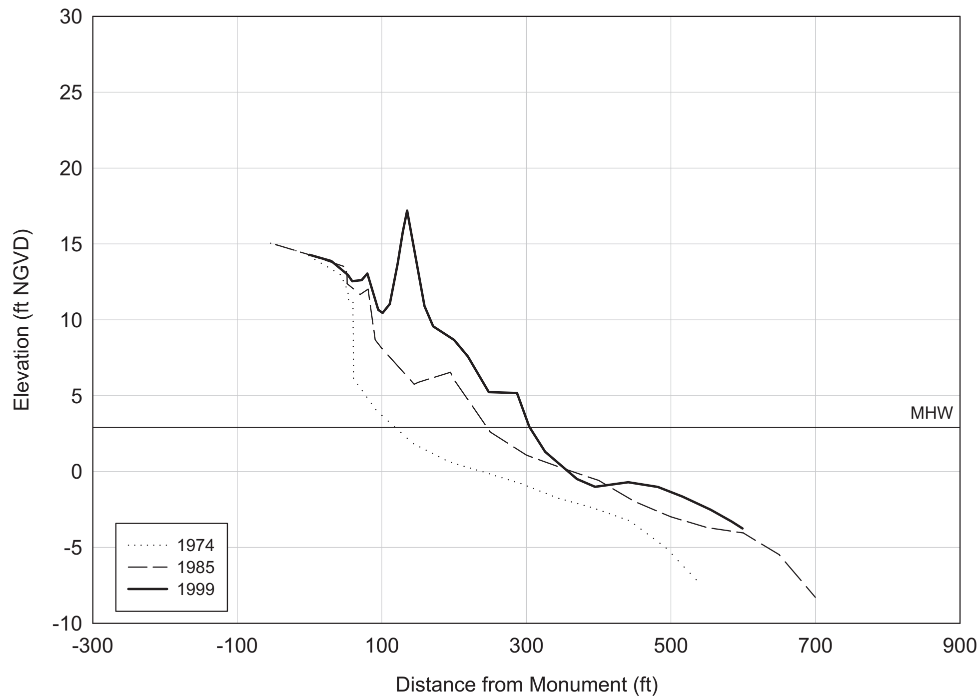
Duval County
R-45



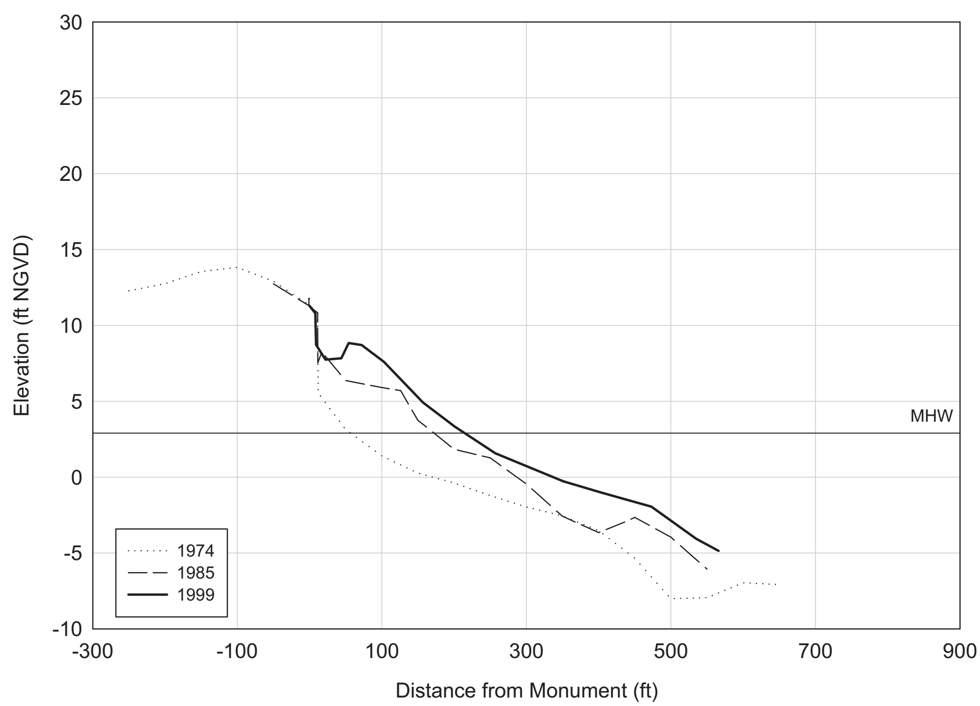
Duval County
R-51



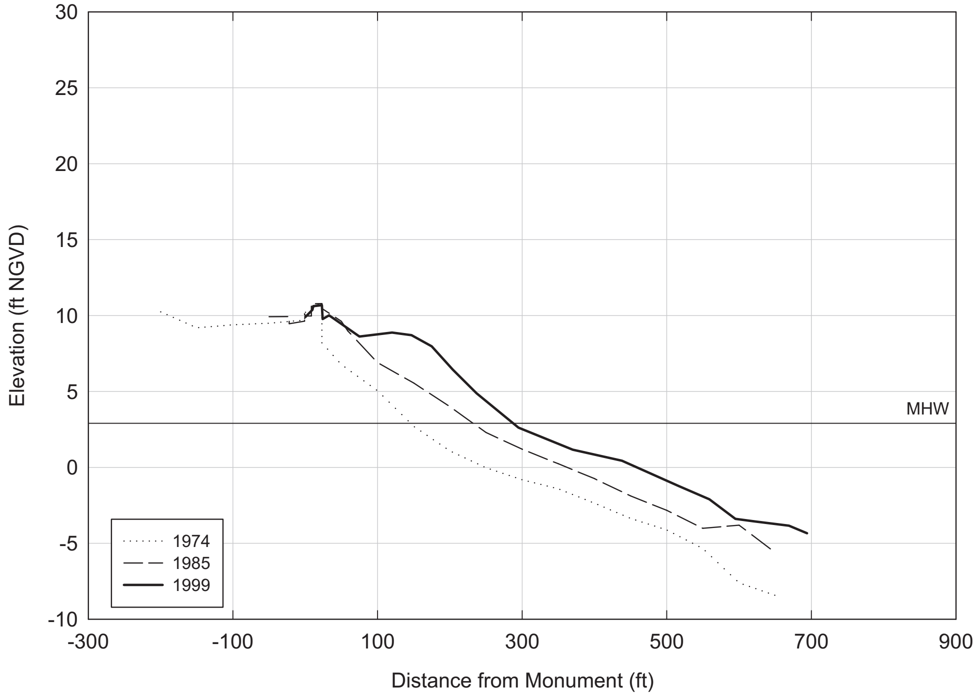
Duval County
R-57



Duval County
R-63



Duval County
R-69



Duval County
R-78