

# **Salinity Changes in the Northwest Fork of the Loxahatchee River Resultant from the Re-Establishment of Meandering Flow Patterns**

**Richard C. Dent  
Loxahatchee River District**

**March 1997**

## **Introduction**

A common characteristic of rivers flowing through a flat terrain is that they tend to meander and braid, resulting in multiple channels and the existence of large bends or oxbows. Given time, some of the major bends join at their narrow base, open a new channel and provide a 'short cut' for the water flow. In the northwest fork of the Loxahatchee River, meandering and braiding have occurred over the past centuries and are evident today in a reach situated from five to ten miles upstream of the Jupiter Inlet. In at least four locations along this reach, a new channel or 'gap' has been created at the base of significant river bends. It is believed that the creation of these gaps was accelerated by the activities of man: initially having been cut by canoeists and later by operators of motorized craft, to shorten the boat trip up and down the Loxahatchee.

While these new flow ways were a convenience to boating enthusiasts, they created environmental problems in at least two ways. First, with much of the water moving through the new channel, the volume and velocity of water flowing in the old channel was greatly reduced. Water quality problems associated with this change are being evaluated and may be the subject of a separate report. Second, and of importance to this evaluation, the gaps contributed to the problem of salt water intrusion by shortening the path of saline waters from the inlet and estuary to the historically freshwater reaches of the river system.

Since the middle of the century, several man-induced activities had worked to decrease the flow of freshwater to the northwest fork of the Loxahatchee River and to increase the influence of tidal action and salt. A number of measures to retard saline intrusion were analyzed in the 1970's; however, the closure of the gaps in the meandering portion of the river was not given serious consideration at that time. Then, in 1991, investigation of environmental mitigation potentials in the estuary and associated freshwater river reaches was undertaken by Law Environmental, Inc. for the Jupiter Inlet District. This study assigned a high priority to the closure of the existing gaps. Funding was allocated and design work commenced to construct rock and earthen barriers to close the gaps. The Loxahatchee River District was requested to provide a monitoring program to detect and evaluate changes in water quality. The

purpose of this paper is to present the findings of salinity monitoring conducted before and after the closure of the two major gaps. The working hypothesis was one of the closures serving to lessen the upstream extent of salt water due to the longer travel distance once the 'short cut' gaps were eliminated.

### **Monitoring Program and Results**

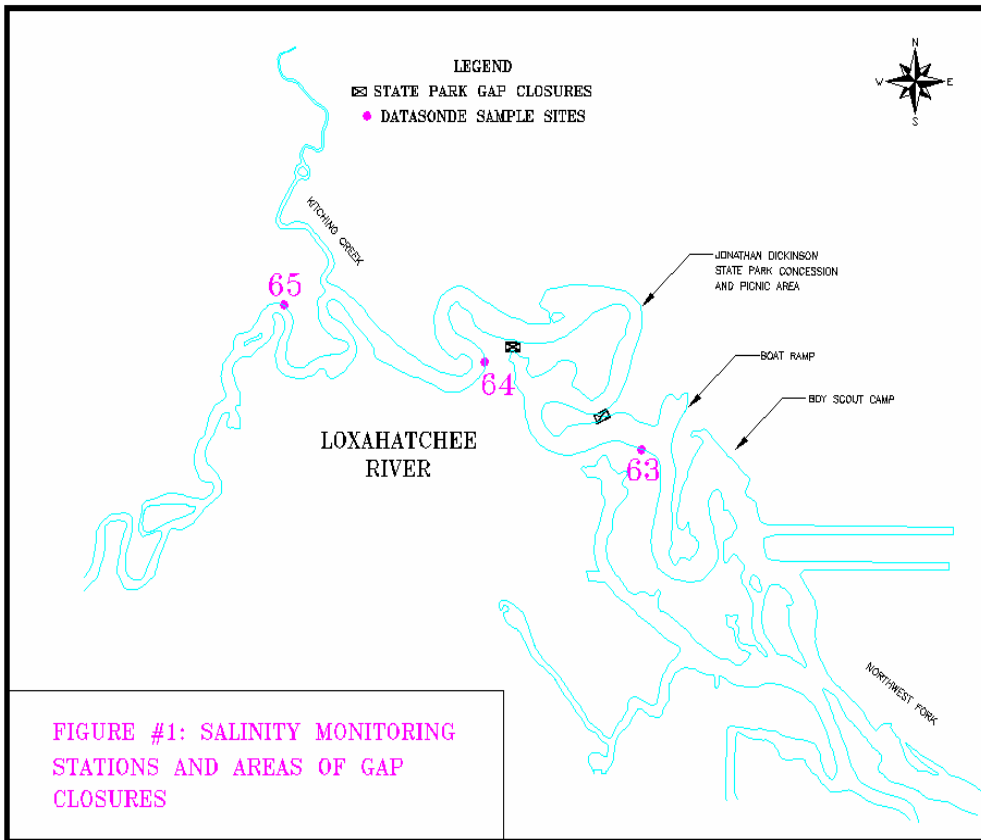
Figure #1 is a map showing the middle reach of the northwest fork of the Loxahatchee River. The two major gaps and three sampling stations are identified. Station #63 is located between mid channel and the southern shore at approximately river mile 6.5 in the vicinity of the south boat ramp in Jonathan Dickinson State Park. This location is downstream of the two gaps and exhibits a depth of about 3.0 meters. The station had been occupied previously by both the U.S. Geological Survey and the South Florida Water Management District for salinity studies. Additionally, the site is in close proximity to a long-term water quality monitoring station sampled by the Loxahatchee River District and other agencies. Station #64 is located at river mile 7.3, approximately 0.8 mile upstream of Station #63. It should be noted that this distance is calculated by employing the short cut provided by the gaps in the river flow way. Reinstatement of the historic flow channel would add approximately 0.7 river miles to the existing distances. Station #64 is upstream of the two gaps and is located near the eastern shore on the outside of a river bend where the depth exceeds 4.0 meters. The final sampling site, Station #65, is located at river mile 8.1 above the confluence of Kitching Creek with the Northwest fork or about 0.8 mile upstream of Station #64. The depth at this station is 3.5 meters and sampling was conducted near the northern shore where the deepest portion of the channel is located. The specific sampling point at each site was located approximately one meter above the channel bottom and each site was marked by permanent buoy.

The equipment used consisted of three Hydrolab Datasonde Model #3 monitoring probes. These devices are capable of providing readings for salinity, dissolved oxygen, depth and other parameters a number of times during the day. With the probes set for half hour sampling intervals, 48 salinity readings were recorded each day for each station. The data are stored in the unit until the unit is retrieved and the information downloaded. Under normal operating conditions, the probes were placed on station for a period from 10 to 30 days, then removed for a few days to a week to download the data and calibrate and service the equipment. The high and low salinity readings for each day were used for analysis.

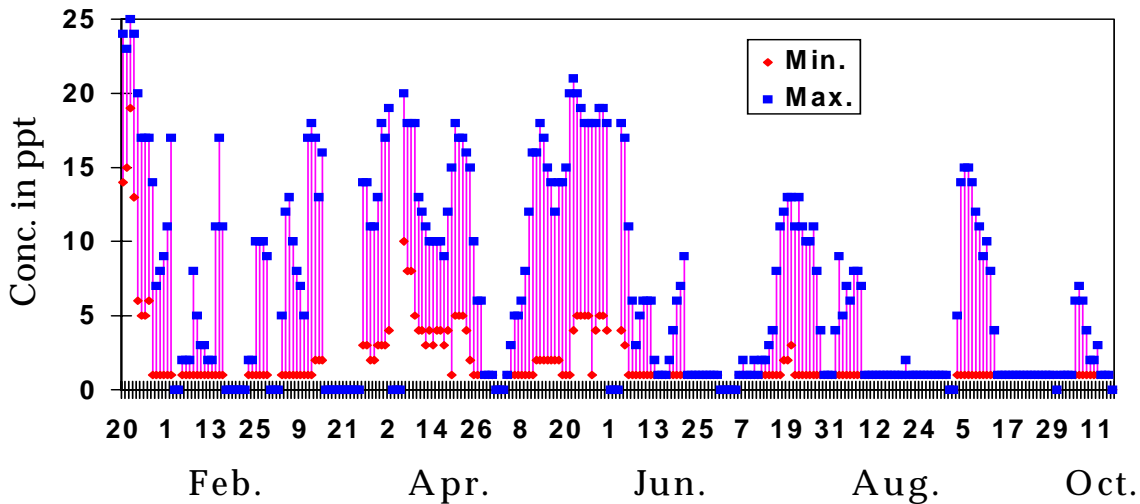
As relates to time, the study was designed to provide 'before' and 'after' data sets for comparison; therefore, the testing time was divided into two periods: an approximate nine month period prior to the construction closing the gaps and a second nine month period subsequent to the closure. The initial two monitoring units were installed in late 1993, calibrated and placed into official operation in February of 1994, a full two years before the gaps were closed. Owing to equipment limitations, only two probes were operative during the 'before' portion of the monitoring. From February through October of 1994, the probes were in service at Station #63 and Station #64 for a total of 227 days. Observed salinity ranged from less than 1 part per thousand (ppt) at

both stations to over 20 ppt at the downstream location. Figure #2 shows the minimum and maximum daily salinities recorded for the 1994 period of study at Station #63.

**Figure #1 Salinity Monitoring Stations in the NW Fork of the Loxahatchee River**



**Figure #2: Minimum and Maximum Daily Bottom Salinities at Station #63 before the Closure of the Gaps - 1994**

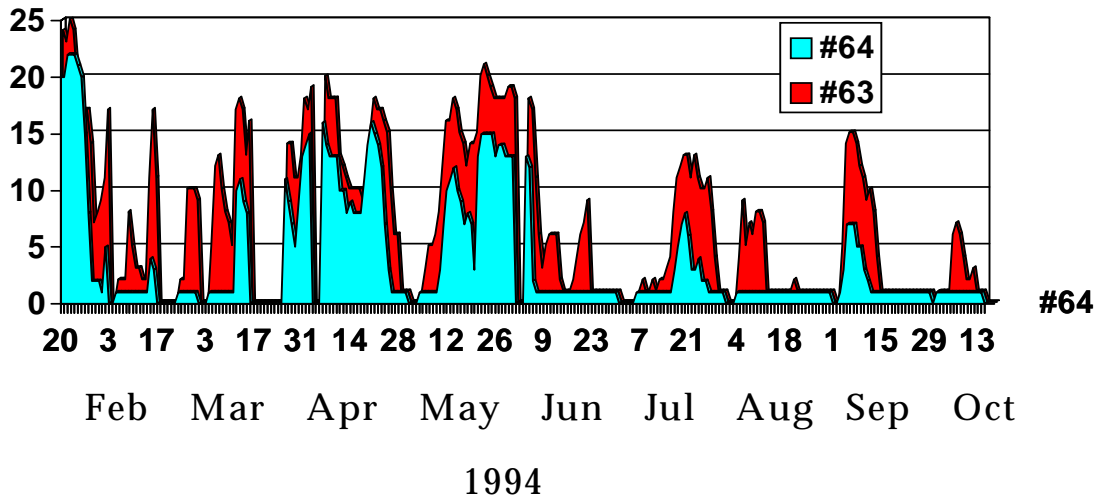


While evaluations of the salinity changes during a typical 24-hour period are not elaborated upon here, the diurnal tidal changes were readily observable in both the salinity and depth data. The heavier saline water formed a 'wedge' that could be observed to move upstream on the incoming tide and downstream as the tide retreated. Daily salinity changes from zero to over 10 ppt were frequent at this station.

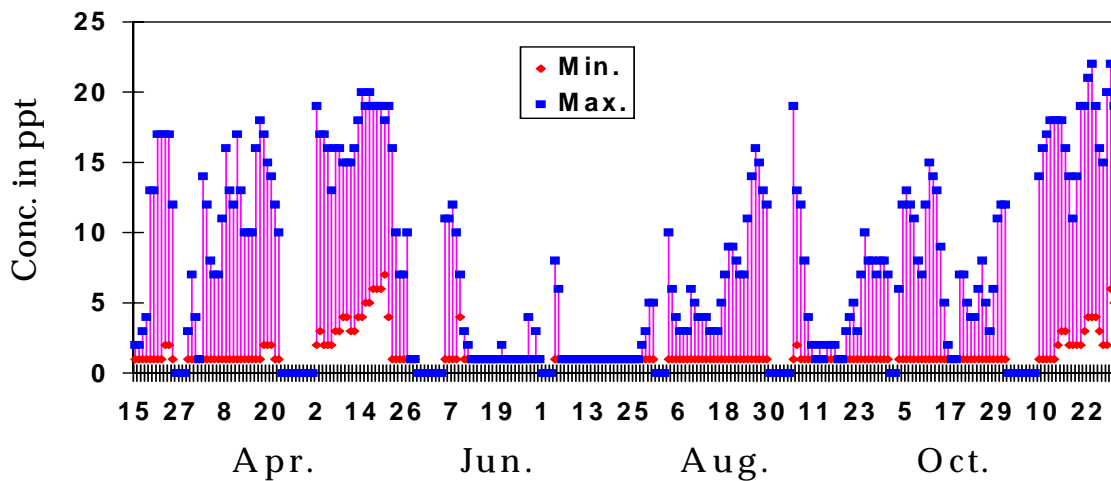
Figure #3 shows the relationship of maximum bottom salinities between Station #63 and Station #64. The upstream station typically ranged from a few ppt to nearly 10 ppt lower in salinity than Station #63 with an average variance of about 6 ppt. Further, it was observed that when the salt water moved upstream beyond Station #63, in reaction to reduced fresh water flows, seasonally high tides or other factors, the salinity at Station #64 reacted in a corresponding fashion by increasing within a one or two day time frame.

The gaps were closed in January of 1996 and the monitoring equipment was redeployed at Station #63 and Station #64. In addition, a new probe was placed at Station #65 for this second monitoring period. The probes were maintained on station, with periodic removal for data acquisition and servicing, from March through November of 1996. Salinity concentrations were recorded every half hour for 220 days during this period. Figure #4 is provided to exhibit the minimum and maximum salinities at Station #63. Salt water was present at this site during the 1996 monitoring period in similar frequency patterns and concentration ranges as observed in the 1994 period.

**Figure #3: Relationship of Maximum Daily Bottom Salinities at Stations #63 & #64 before the Closure of Gaps**



**Figure #4: Minimum and Maximum Daily Bottom Salinities at Station #63 after the Closure of the Gaps - 1996**



A comparison of the maximum salinities observed in 1996 at each of the three stations is presented in Figure #5. The comparison of maximum bottom salinities recorded at Station #63 and Station #64 shows that the difference between the two was greater, typically by only 2 or 3 ppt but higher under certain conditions, than observed before the gaps were closed. This observation tends to support the premise that the longer flow routing of intruding salt water results in lesser concentrations of salt water upstream. In addition, the response time for the upstream station to display an increase in salinity previously observed at the downstream station tended to be from three to six days in comparison to the one or two day reaction observed before the structures were put into place.

**Figure #5: Relationship of Maximum Daily Bottom Salinities at Stations #63, #64 & #65 after Closure of Gaps**

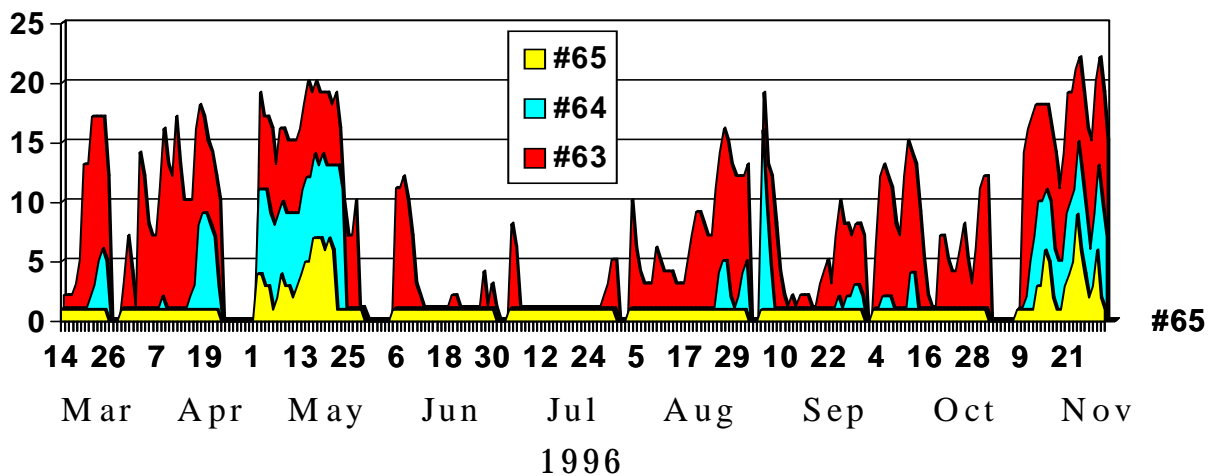
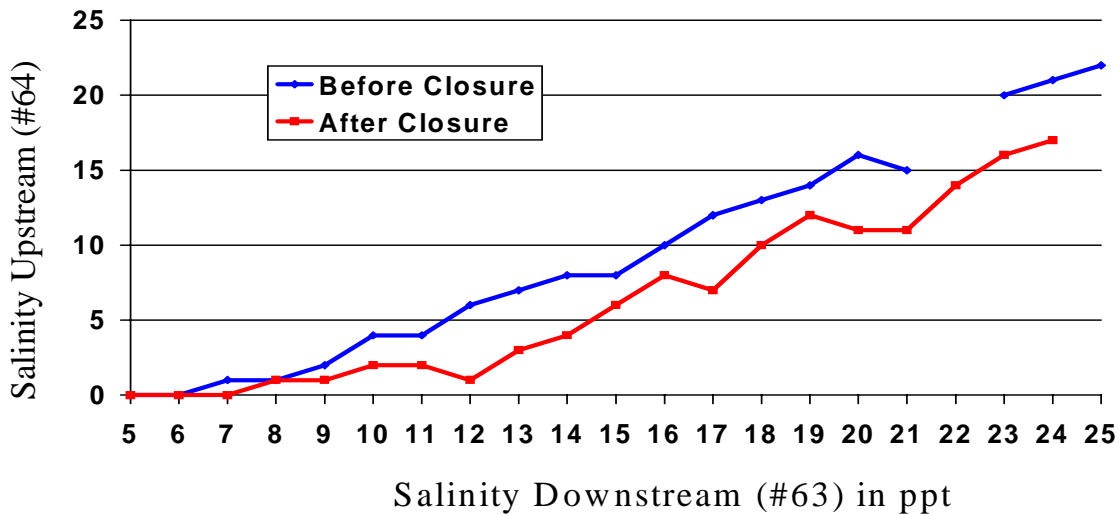


Figure #6 shows the relationship of a given salinity at Station #63 to the salinities observed at Station #64 for conditions prior to and after the closure of the gaps. A reduction in the upstream extent of saline water is apparent. Given equal concentrations of salinity at Station #63, the salinity at Station #64 after the barrier construction was several ppt less than it was prior to the gap closure. Additionally, a review of the maximum daily salinities for the periods 'before' and 'after' the construction reveals the following relationships that are important to maintaining salinity concentrations at or below a halosaline condition of 7 ppt at Station #64. Before the closures, when salinity at Station #63 exceeded 13 ppt, the concentration upstream would exceed 7 ppt. After the closures, the salinity at Station #63 needed to reach 18 ppt or higher before halosaline conditions were exceeded at the upstream monitoring point.

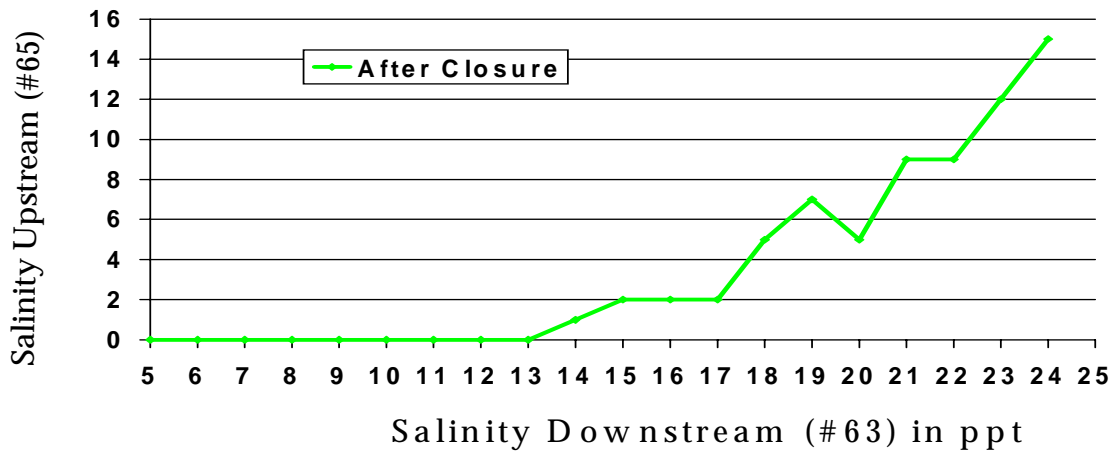
**Figure #6: Relationship of Maximum Bottom Salinities at Station #63 to Concentrations at Station #64 both Before and After the Closure of Gaps**



With no data for Station #65 before the closure, no direct comparisons can be drawn. However, Figure #7 shows the relationship between Station #63 and Station #65 for the 1996 sampling period. It is interesting to note that the salinity at Station #63 must reach 21 ppt before the 7 ppt level is exceeded at Station #65. A second, and perhaps more appropriate goal for Station #65, was set at 2 ppt in previous research. This freshwater condition was observed during much of the 1996 sampling period and correlated to a concentration of less than 18 ppt at Station #63. Since neither monitoring period contained a full dry season, it is difficult to calculate annualized percentages. However, if salinity at station #63 was assumed to have been 18 ppt or greater for a majority of the December, January and February time frame, then the 'success' rate of keeping salt concentrations at or below 2 ppt above Kitching Creek would approach 70%.

Again, without data from Station #65 prior to the gap closure, it is difficult to quantify a degree of improvement at this upstream site; however, improvement is believed to have resulted. It should also be noted that no attempt herein has been made to relate the salinity data generated during this study period to freshwater flows from upstream. This important issue is the subject of ongoing evaluation by the Loxahatchee River District, the South Florida Water Management District and others.

**Figure #7: Relationship of Maximum Bottom Salinities at Station #63 to Concentrations at Station #65 After Gap Closure**



**Conclusion**

In early 1996, the construction of two rock and earthen dams was completed and effectively closed off channels that had been providing a ‘short cut’ for water flow up and down the northwest fork of the Loxahatchee River. By re-directing all flow to the historic, meandering oxbow sections of the river, approximately 0.7 river miles were added to the distance required for saline waters from the inlet and estuary to intrude upon the freshwater reaches of the river. The added distance was anticipated to reduce the impact of salt water on upstream stations.

A salinity monitoring program was conducted for two nine-month periods, one prior to the construction and the second after construction. Maximum daily bottom salinities from two primary sampling stations, one above and the other below the location of the construction, were used for comparison. It was found that, given fixed concentrations of salinity at a location downstream of the closures, the salinity at the station upstream was of a lower concentration after the closure than was recorded prior to the construction. Additionally, after the construction, it was observed that it took longer for the upstream station to experience an increase in salinity in response to increases at the downstream station.