APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT (33 CFR 325)	OMB APPROVAL NO. 0710-0003 EXPIRES: 31 August 2012

(ITEMS 1 THRU 4 TO BE FILLED BY THE CORPS)

1. APPLICATION NO.	2. FIELD OFFICE CODE	3. DATE RECEIVED	4. DATE APPLICATION COMPLETE

(ITEMS BELOW TO BE FILLED BY APPLICANT)

5. APPLICANT'S NAME:	8. AUTHORIZED AGENT'S NAME AND TITLE (an agent is not required)
First - Larry Middle - L. Last - Laine	First - Michael Middle - E. Last - Trudnak
Company - Texas General Land Office	Company - Taylor Engineering, Inc.
E-mail Address - larry.laine@glo.state.tx.us	E-mail Address - mtrudnak@taylorengineering.com
6. APPLICANT'S ADDRESS:	9. AGENT'S ADDRESS
Address - 1700 North Congress Avenue, Suite 935	Address - 10151 Deerwood Park Boulevard, Building 300, Suite 300
City - Austin State - Texas Zip - 78701 Country - USA	City - Jacksonville State - Florida Zip - 32256 Country - USA
7. APPLICANT'S PHONE NOs. W/AREA CODE	10. AGENT'S PHONE NOs. W/AREA CODE
a. Residence b. Business (512) 936-1927 c. Fax (512) 463-5248	a. Residence b. Business (904) 731-7040 c. Fax (904) 731-9847

STATEMENT OF AUTHORIZATION

11. I hereby authorize, Taylor Engineering, Inc. to act in my behalf as my agent in the processing of this application and to furnish, upon request, supplemental information in support of this permit application.

APPLICANT'S SIGNATURE

11/24/09
DATE

NAME, LOCATION, AND DESCRIPTION OF PROJECT OR ACTIVITY

12. PROJECT NAME OR TITLE (see instructions)

Rollover Pass Closure

13. NAME OF WATERBODY, IF KNOWN (if applicable)	14. PROJECT STREET ADDRESS (if applicable)
Gulf of Mexico, Rollover Pass, Rollover Bay, GIWW, East Galveston Bay	Address State Highway 87 between Bauer St & N. Bauer Lane
15. LOCATION OF PROJECT	
Latitude: °N 29° 30' 30" Longitude: °W 94° 30' 30"	City - Gilchrist State - Texas Zip - 77617

16. OTHER LOCATION DESCRIPTIONS, IF KNOWN (see instructions)

State Tax Parcel ID R178060   Municipality Galveston County

Section -   Township -   Range -   Legal Description - ABST 64 PAGE 6 E FRANKS SUR TR 112 11.407 ACRS

17. DIRECTIONS TO THE SITE

Approximately 19 miles east of Port Bolivar via SH 87 or approximately 7 miles west of High Island via SH 87.

18. Nature of Activity (Description of project, include all features)

The project will fill Rollover Pass to elevations matching the surrounding grade with material from one or a combination of three potential dredge material sources: local DMPAs, Rollover Bay (SWG-21755 and amendments) or GIWW annual dredging. The TxDOT bridge at Rollover Pass (SH 87) and all utilities that currently cross the pass will remain. For full details, see the attached project narrative.

19. Project Purpose (Describe the reason or purpose of the project, see instructions)

The project (Rollover Pass closure) will reduce USACE maintenance dredging requirements of the GIWW and will alleviate the accelerated beach erosion caused by the pass. For additional details, see the attached project narrative.

USE BLOCKS 20-23 IF DREDGED AND/OR FILL MATERIAL IS TO BE DISCHARGED

20. Reason(s) for Discharge

A hydraulic dredge will excavate and pump material from one or a combination of three potential dredge material sources (local DMPAs, Rollover Bay (SWG-21755 and amendments) or GIWW annual dredging) to Rollover Pass via floating pipeline (except for a submerged pipeline segment crossing the GIWW) for the purpose of closing the pass.

21. Type(s) of Material Being Discharged and the Amount of Each Type in Cubic Yards:

Type Amount in Cubic Yards	Type Amount in Cubic Yards	Type Amount in Cubic Yards
Sand: approximately 120,000 - 140,000 cy		

22. Surface Area in Acres of Wetlands or Other Waters Filled (see instructions)

Acres Approximately 11 acres
Or
Liner Feet

23. Description of Avoidance, Minimization, and Compensation (see instructions)

The project will impact local recreational fishing . Potential construction of a recreational fishing pier would compensate for impacts. See the attached project narrative for more details.

24. Is Any Portion of the Work Already Complete? Yes ☐ No ☑ IF YES, DESCRIBE THE COMPLETED WORK

25. Addresses of Adjoining Property Owners, Lessees, Etc., Whose Property Adjoins the Waterbody (If more than can be entered here, please attach a supplemental list).

Address – Gulf Coast Rod, Reel, & Gun Club. 148 South Dowlen Road, # 704

City – Beaumont State – Texas Zip – 77707

26. List of Other Certifications or Approvals/Denials Received from other Federal, State, or Local Agencies for Work Described in This Application.

AGENCY	TYPE APPROVAL*	IDENTIFICATION NUMBER	DATE APPLIED	DATE APPROVED	DATE DENIED
TCEQ	NEPA Coordination	TRACS #9778 (attached)	July 28, 2009	October 16, 2009	
NRCS	NEPA Coordination	(attached)	July 28, 2009	August 17, 2009	
THC - SHPO	NEPA Coordination	(attached)	July 28, 2009	August 6, 2009	
GLO - CCC	NEPA Coordination	(attached)	July 28, 2009	August 19, 2009	

* Would include but is not restricted to zoning, building, and flood plain permits

27. Application is hereby made for a permit or permits to authorize the work described in this application. I certify that the information in this application is complete and accurate. I further certify that I possess the authority to undertake the work described herein or am acting as the duly authorized agent of the applicant.

		[signature]	1/12/10
SIGNATURE OF APPLICANT	DATE	SIGNATURE OF AGENT	DATE

The application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in block 11 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up any trick, scheme, or disguises a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statements or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.

Rollover Pass Closure
Project Narrative
Supplement to the Department of the Army Permit Application

Project Overview

Rollover Pass, an artificial inlet created in 1955 to enhance recreational fishing opportunities, lies on the Bolivar Peninsula in Galveston County, Texas about 30 km (19 miles) northeast of the Galveston Bay entrance. The pass provides a tidal connection between the Gulf of Mexico and Rollover Bay in the southeastern portion of East Bay (Figure 1). Immediately after construction, Rollover Pass accelerated adjacent beach erosion rates by trapping littoral sediments, increased maintenance dredging requirements of the Gulf Intracoastal Waterway (GIWW) — which separates Rollover Bay from East Bay — by transporting littoral sediments from the gulf into the bay system, and affected environmental resources in the bay by increasing salinity levels. The proposed Rollover Pass Closure project will alleviate the above adverse impacts and return the project site to a more natural state by completely filling in the pass, from the gulf shoreline to the bay shoreline.

The proposed project will use a hydraulic dredge connected to a floating pipeline (except for a short submerged segment across the GIWW) to pump fill material from the borrow source(s) to Rollover Pass. The project may use up to three potential sources including a nearby upland dredge material placement area (DMPA), the permitted Rollover Bay sand source (Galveston County, SWG 21755 and amendments), or the GIWW in the Rollover Pass vicinity in coordination with annual maintenance dredging conducted by the U.S. Army Corps of Engineers (USACE). Heavy equipment will grade the infill to meet the elevations of adjacent lands. The specified construction methodology will use a combination of permanently installed steel sheet pile walls and geotextile bags to close the pass while minimizing water quality impacts and structural impacts to the existing bridge and utilities. The existing State Highway 87 bridge, maintained by the Texas Department of Transportation (TxDOT), and all utilities that currently cross Rollover Pass will remain intact. Demolition and/or removal of the existing steel and concrete walls throughout the pass will occur after stabilization of the fill.

Rollover Pass, a well-known fishing destination, provides recreational fishing opportunities that will no longer exist after project construction. To help compensate for the lost recreational benefits, the Texas General Land Office (GLO) intends to construct a recreational fishing pier. GLO plans to submit a separate permit application to address the pier.

Project Authorization

The 81st Texas Legislature, through Senate Bill 2043, has appropriated $5.85 million, available from September 1, 2009 through August 31, 2011, to the Texas GLO for the closure of any man-made pass that is causing negative effects, both environmental and/or erosional, to the adjacent land. The GLO plans to use this appropriation to close Rollover Pass. Notably, the GLO has also applied for a FEMA 404 Hazard Mitigation Grant Program (HMGP) grant through the Texas Governor's Division of Emergency Management (DEM) to help defray the cost of closing Rollover Pass. The federal share for this grant would equal approximately $4.4 million, with a $1.45-million state match from the 81st Texas Legislature appropriation. If FEMA approves the 404 HMGP application, the remaining $4.4 million of the 81st Texas Legislature appropriation will become available for any additional costs to close Rollover Pass and the construction of a pier and/or any other recreational activities seen fit by the GLO, Galveston County, and the local community.

Note: FEMA has informed the GLO that approval of the HMGP will not occur until the USACE issues a permit for the project. The GLO has sent NEPA coordination letters for this grant application to the following State and Federal Agencies: Texas Historical Commission (THC) for the State Historical Preservation Officer (SHPO), Natural Resources Conservation Service (NRCS), Texas Commission on Environmental Quality (TCEQ), GLO on behalf of the Coastal Coordination Council (CCC), Texas Parks and Wildlife Department (TPWD), and USACE. Texas DEM contacted US Fish and Wildlife Service directly concerning this grant. The GLO has received responses from four of the six agencies listed above: GLO-CCC, NRCS, TCEQ, and THC-SHPO. Attachment A contains the responses.

Supporting Studies

Texas GLO contracted Taylor Engineering, Inc. to evaluate the historical impacts of Rollover Pass, evaluate the potential effects of pass closure on inland water hydraulics and salinity, develop an engineering plan to close the pass, and prepare a draft Environmental Assessment to support permitting of pass closure. Taylor Engineering continues to work towards completion of the above supporting analyses. However, due to funding restrictions (i.e., the August 31, 2011 appropriation deadline), Taylor Engineering submits this incomplete application to initiate the permitting process and engage the regulatory and commenting agencies.

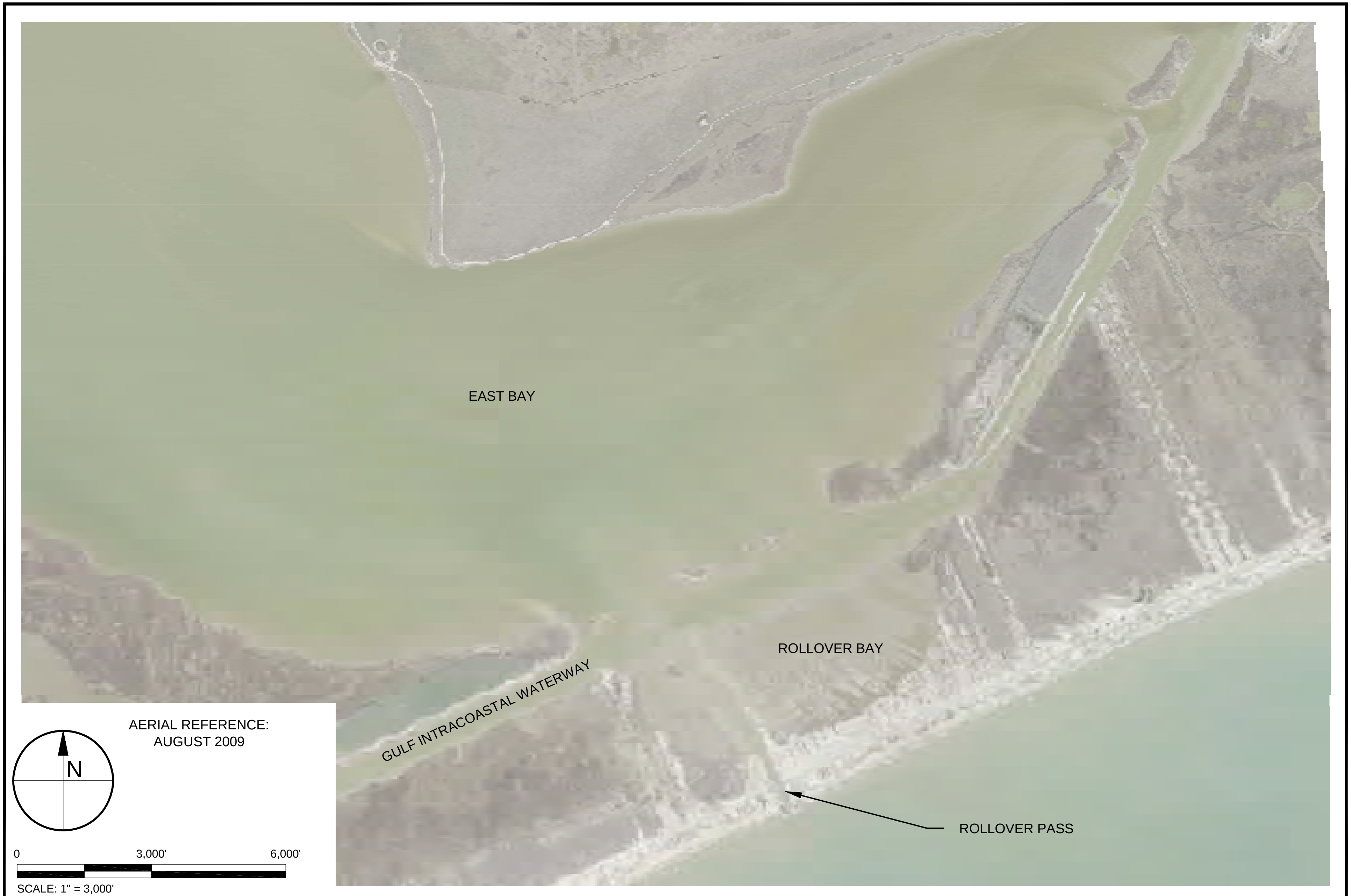
Taylor Engineering will submit the results of the above studies upon availability as Attachments B – F to this project narrative. To date, Attachment B contains a coastal processes analysis that supports project justification, Attachment C contains a preliminary closure plan that addresses methods (e.g., turbidity control measures and discharge pipeline routing) to minimize direct environmental effects of project construction, and Attachment D contains the results of a hydrodynamic and salinity modeling study. Attachment E, expected complete by January 22, 2010, will contain a draft Environmental Assessment. Finally, Attachment F, which may not be completed until February or March 2010 due to contractor availability, will include a geotechnical data analysis of the existing beach sediments and the proposed fill material.

Project Meetings

Maintaining open lines of communication is critical during the permitting process. To date, GLO has held several meetings and teleconferences between appropriate federal, state, and local agencies to discuss the proposed project. Table 1 lists the dates, forums, and attendees of completed and scheduled meetings/teleconferences. GLO will continue to attend meetings and teleconferences as necessary during the permitting process.

Table 1 List of Project Meetings

Date	Forum	Attendees
August 18, 2009	Joint Evaluation Meeting, Galveston	USACE, GLO, Taylor Engineering, TPWD, NMFS, USFWS, Galveston County
August 21, 2009	Teleconference	USACE, GLO, Taylor Engineering
September 22, 2009	Meeting at TxDOT, Houston	TxDOT, GLO, Taylor Engineering
October 20, 2009	Galveston County Coordination Meeting	Galveston County, GLO
November 6, 2009	Teleconference with USACE	USACE, GLO
November 18, 2009	Galveston County Commissioners Court Workshop	Galveston County Commissioners Court, GLO
November 24, 2009	Teleconference with TxDOT	TxDOT, GLO, Taylor Engineering
December 15, 2009	Galveston County and Local Coordination Meeting	Galveston County, GLO, TPWD, GCRRGC, GCA, and Bolivar Chamber of Commerce
February 6, 2010 (Scheduled)	Gilchrist Community Association Monthly Meeting (discussion of Rollover Pass and recreational options)	GLO, GCA, GCRRGC



TAYLOR ENGINEERING INC.
10151 DEERWOOD PARK BLVD.
BLDG. 300, SUITE 300
JACKSONVILLE, FL 32256

FIGURE 1
LOCATION MAP
ROLLOVER PASS CLOSURE PROJECT
GALVESTON COUNTY, TEXAS

PROJECT	C2009-063
DRAWN BY	AF
SHEET	1 OF 1
DATE	NOV 2009

Attachment A
NEPA Coordination Responses

Coastal Coordination Council

P.O. Box 12873 ♦ Austin, Texas 78711-2873 ♦ (800) 998-4GLO ♦ FAX (512) 475-0680

August 19, 2009

Ms. Kayleigh Rust
Texas General Land Office
Coastal Resources
PO Box 12873
Austin Texas 78711-2873

Re: NEPA Review Request for FEMA 404 HGMP (DR-1791-TX)
Application for the Closure of Rollover Pass

Dear Ms. Rust:

Based on information provided to the Texas Coastal Management Program on the above project, it has been determined that it will likely not have adverse impacts on coastal natural resource areas (CNRAs) in the coastal zone. However, siting and construction should avoid and minimize impacts to CNRAs. If a U. S. Army Corps of Engineers permit is required, it will be subject to consistency review under the Texas Coastal Management Program.

If you have any questions or concerns, please contact me at (512) 463-9212 or at tammy.brooks@glo.state.tx.us.

Sincerely,

Tammy Sue Mon

Tammy S. Brooks
Coastal Coordination Council Secretary
Consistency Review Coordinator
Texas General Land Office

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
101 South Main
Temple, TX 76501-7602

August 17, 2009

Ms. Kayleigh Rust
Natural Resource Specialist
Texas General Land Office
P. O. Box 12873
Austin, TX 78711-2873

Dear Ms. Rust:

We have reviewed the project information pertaining to the application to the Texas Governor's Division of Emergency Management (DEM) for Federal Emergency Management Agency (FEMA) 404 Hazard Mitigation Grant Program (HMGP) funds for the closure of Rollover Pass on Bolivar Peninsula.

This project should have no significant adverse impact on the environment or natural resources in the area. We do not require any permits, easements, or approvals for activities such as this.

Thank you for the opportunity to review this proposed project.

Sincerely,

For DONALD W. GOHMERT
State Conservationist

TEXAS HISTORICAL COMMISSION

real places telling real stories

August 6, 2009

Ms. Kayleigh Rust
Natural Resource Specialist
Coastal Protection Division
Texas General Land Office
1700 North Congress Ave.
Austin, TX 78701

Re: Project review under Section 106 of the National Historic Preservation Act of 1966 and the Antiquities Code of Texas
Closure of Rollover Pass, Galveston County
GLO

Dear Ms. Rust

Thank you for your correspondence describing the above referenced project. This letter serves as comment on the proposed federal undertaking from the State Historic Preservation Officer, the Executive Director of the Texas Historical Commission. As the state agency responsible for administering the Antiquities Code of Texas, these comments also provide recommendations on compliance with state antiquities laws and regulations.

The review staff, led by State Marine Archeologist Steven D. Hoyt, has completed its review. The closure of Rollover Pass will have no adverse impact on submerged historic resources in the area. However, the vicinity of the pass, both in the Gulf and in East Bay, is considered high probability for the presence of historic shipwrecks. The illustrations provided give only an "approximate location of borrow area." We need to see a more accurate location of where the borrow area will be before we can determine if a marine archeological survey is needed in that area. Considerable survey has already been completed in the bay by the US Army Corps of Engineers, Galveston District. Your borrow area may fall within that previous survey and already be cleared for cultural resource purposes or you may be able to adjust you borrow area to fall within the previously surveyed area. Please provide the additional information on the location of the borrow area so that we may appropriately review the project impacts.

We look forward to further consultation with your office and hope to maintain a partnership that will foster effective historic preservation. Thank you for your cooperation in this federal and state review process, and for your efforts to preserve the irreplaceable heritage of Texas. **If you have any questions concerning our review or if we can be of further assistance, please contact Steve Hoyt at 512/927-7882.**

Sincerely,

Steven D. Hoyt
for
Mark Wolfe, State Historic Preservation Officer

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

October 16, 2009

Ms. Kayleigh Rust
Natural Resource Specialist
Texas General Land Office
PO Box 12873
Austin, TX 78711-2873

Re: TCEQ Grant and Texas Review and Comment System (TRACS) #9778, FEMA 404 HMGP (DR-1791-TX), Application for the Closure of Rollover Pass

Dear Ms. Rust,

The Texas Commission on Environmental Quality (TCEQ) has reviewed the above-referenced project and offers following comments:

A review of the project for General Conformity impact in accordance with 40 CFR Part 93 and Title 30, Texas Administrative Code § 101.30 indicates that the proposed project is located in Galveston County, which is currently classified as a severe ozone nonattainment area. Therefore, General Conformity rules apply.

The two criteria pollutants of concern as precursors to ozone formation are volatile organic compounds (VOCs) and nitrogen oxides (NO_x). An increase of 100 tons per year for VOCs or NO_x, resulting from the proposed project, could trigger general conformity analysis. However, the emissions from the proposed project are expected to be well below the 25 tons per year significance level. Therefore, a general conformity analysis will not be required.

Although any demolition, construction, rehabilitation or repair project will produce dust and particulate emissions, these actions should pose no significant impact upon air quality standards. Any minimal dust and particulate emissions should be easily controlled by the construction contractors using standard dust mitigation techniques.

We do not anticipate significant long term environmental impacts from this project as long as construction and waste disposal activities are completed in accordance with applicable local, state, and federal statutes and regulations. We agree with a finding of no significant impact and have no objection to the release of funds for this project. We recommend that best management practices to control runoff from construction sites be utilized to prevent impact to surface and groundwater.

Re: TCEQ Grant and Texas Review and Comment System (TRACS) #9778, FEMA 404 HMGP (DR-1791-TX), Application for the Closure of Rollover Pass

Thank you for the opportunity to review this project. If you have any questions, please call Ms. Glenda Thorn at (512) 239-1980.

Sincerely,

Katherine Nelson

Katherine Nelson, Manager
Planning & Implementation Section
Water Quality Planning Division

Attachment B
Analysis of Rollover Pass Impacts to
Adjacent Beaches and the Littoral System

Analysis of Rollover Pass Impacts to Adjacent Beaches and the Littoral System

Galveston County, TX

January 12, 2010

10151 Deerwood Park Blvd., Bldg. 300, Suite 300, Jacksonville, FL 32256
(904) 731-7040 ~ www.taylorengineering.com

Analysis of Rollover Pass Impacts

to Adjacent Beaches and the Littoral System

Prepared for

Texas General Land Office

by

Taylor Engineering, Inc.
10151 Deerwood Park Blvd., Bldg. 300, Suite 300
Jacksonville, Florida 32256
(904) 731-7040

C2009-063

January 12, 2010

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1.0 INTRODUCTION

The Closure of Rollover Pass will immediately help reduce the rates of beach erosion along Bolivar Peninsula, reduce the required frequency and costs of Gulf Intracoastal Waterway (GIWW) maintenance dredging, and help improve the effectiveness of future beach restoration projects. The results of numerous studies — documenting the changes to the littoral system and their adverse impacts caused by Rollover Pass — from 1958 to the present support the above statement. This report summarizes the results of several past studies and introduces new data to demonstrate the Pass' adverse impacts and to support the stated project benefits. This report also develops a 1999 – 2008 sediment budget that summarizes beach volume changes and the sediment transport magnitudes and pathways, both natural and artificial, near Rollover Pass for the recent pre-Hurricane Ike period.

2.0 ADVERSE IMPACTS

Rollover Pass' adverse impacts on the coastal system began immediately after construction in 1955 and continue today. The impacts — namely, accelerated beach erosion and increased deposition in the GIWW — arise primarily from the Pass' flood-dominant characteristics that transport and deposit sediments into the Rollover and East Galveston bays and effectively diminish the natural sediment supply to the adjacent beaches. This process starves the beaches of the sand volume required to maintain the natural beach conditions; without this sand, erosion increases. Erosion also results from the trapping of littoral sediments against the Pass' updrift side and through ebb tidal effects. Similar to the above flood tidal process, the Pass' ebb tidal currents disrupt the natural longshore sediment transport by directing sediment offshore where they deposit in an ebb tidal shoal. Though the numerous studies disagree on impact quantities, the studies without exception acknowledge that Rollover Pass traps sediment that would normally reach the adjacent beaches, and consequently causes significant beach erosion and increases GIWW dredging requirements. The following sections discuss the initial effects of the Pass' construction, the trapping effect of the Pass' flood dominant characteristics, and beach erosion.

2.1 Initial Effects

The Texas Game and Fish Commission (now the Texas Parks and Wildlife Department) constructed Rollover Pass through a natural wash-over area, periodically breached during high tides and hurricanes, to improve local fishing conditions. The original Rollover Pass channel design included an 80-foot (ft) bottom width, an 8-ft depth, and sloping earthen sides throughout except for a steel sheet pile bulkhead along the southwest side. Unanticipated tidal currents through the Pass caused extensive erosion as construction neared completion; the Gulf entrance widened to about 500 ft and the channel bottom scoured to a depth of 30 ft under the Highway 87 bridge. Immediate protection measures included additional pilings to protect the bridge abutments, groins along the northeast side of the Pass to stop erosion, and a protective cover of shell, broken concrete, stone and other rubble along all exposed banks (Prather and Sorensen, 1972). Subsequent erosion during unusually high tides in spring and summer of 1955 caused additional problems. The shoreline, extending approximately one mile southwest of the Pass, receded landward and undermined some houses, which were subsequently moved. Along the northeast side of the inlet; the Highway 87 bridge showed indications of possible scour damage. In November 1955, in an effort to stop erosion, a steel sheet pile wall, or sill, was constructed across the Pass 40 ft south of the bridge to close the Pass temporarily. Shortly thereafter, alternative piles of the sill were driven 2 ft below mean sea level to reopen a portion of the Pass. The Pass remained partially open until inlet stabilization measures were enacted in 1958 – 1959 based on U.S. Army Corps of Engineers (USACE, 1958) recommendations. Today, although the Pass remains open and various structural improvements have stabilized the inlet, chronic erosion problems still persist.

The beach and channel erosion that occurred immediately after construction of Rollover Pass demonstrate the Pass' significant sediment transport capability and its disruptive effect on the natural littoral system. The USACE, in 1958, authored the first of many reports aimed at correcting or managing the Pass' adverse impacts. The following sections cite relevant published data regarding the Pass' effects on the adjacent beaches and waterways.

2.2 Sediment Transport into Rollover Pass

Sediment transport directed into Rollover Pass represents the crux of the Pass' adverse impacts. Field measurements and analytical conclusions reported in several past studies (e.g., Bales and Holley [1985], Mason [1981], and Prather and Sorensen [1972]) document the flood-dominant characteristics of the Pass. The strong flood tidal currents intercept the natural longshore sediment transport and carry the sediment predominantly through the inlet into Rollover Bay and then into the deeper waters of the GIWW where the majority of sediment is deposited. This process directly increases adjacent beach erosion and the frequency and hence increases costs to the USACE to dredge the GIWW navigation channel in this area. Several studies have calculated the sediment transport rate into Rollover Pass. Although the estimates vary widely, the studies without exception agree that Rollover Pass adversely affects adjacent beach areas significantly by funneling sediments through the Pass into the adjacent Rollover Bay and GIWW areas.

Table 1 contains previously published estimates of sediment transport rates into Rollover Pass. The estimates, based on various calculation methods, range from 3,800 cy/yr to 290,000 cy/yr. Bales and Holley (1989) conducted a thorough analysis using three different methods. Bales and Holley acknowledged the limitations of all three calculation methods, and they considered the results based on longshore transport rates to be the least reliable due to the uncertainties in such rates and the results based on dredging records — "substantiated by limited direct measurements and by conditions in East Bay and Rollover Bay" — to be the most reliable. The dredging data presented in Bales and Holley document a dramatic increase in dredging requirements coinciding with the construction of Rollover Pass as shown in Figures 1 and 2. Notably, the Figure 2 data, which indicate a 290,000 cy/yr dredged-volume increase after Pass construction, include dredging volumes between GIWW stations 1900+00 and 2450+00. A more conservative estimate that includes only the portion of the GIWW within the confines of Rollover Bay indicates an 80,000 cy/yr increase in Rollover Pass dredging requirements (Bales and Holley, 1989).

Table 1 Estimates of the Sediment Transport Rate into Rollover Pass

Source	Estimated Sediment Transport Rate (cy/yr)	Basis of Estimation
USACE (1958)	18,000	Beach erosion rates
Bales and Holley (1989)	3,800 – 29,000	Percentage (i.e., 5 – 25%) of the longshore sediment transport rate
Bales and Holley (1989)	9,000 – 26,000	Beach erosion rates
Bales and Holley (1989)	240,000 – 290,000	GIWW dredging records
Bales and Holley (1989)	80,000	GIWW dredging records
Parchure (2000)	15,400	GIWW dredging records
Pacific International Engineering (2002)	>150,000	November 2000 – June 2001 bathymetric survey comparisons

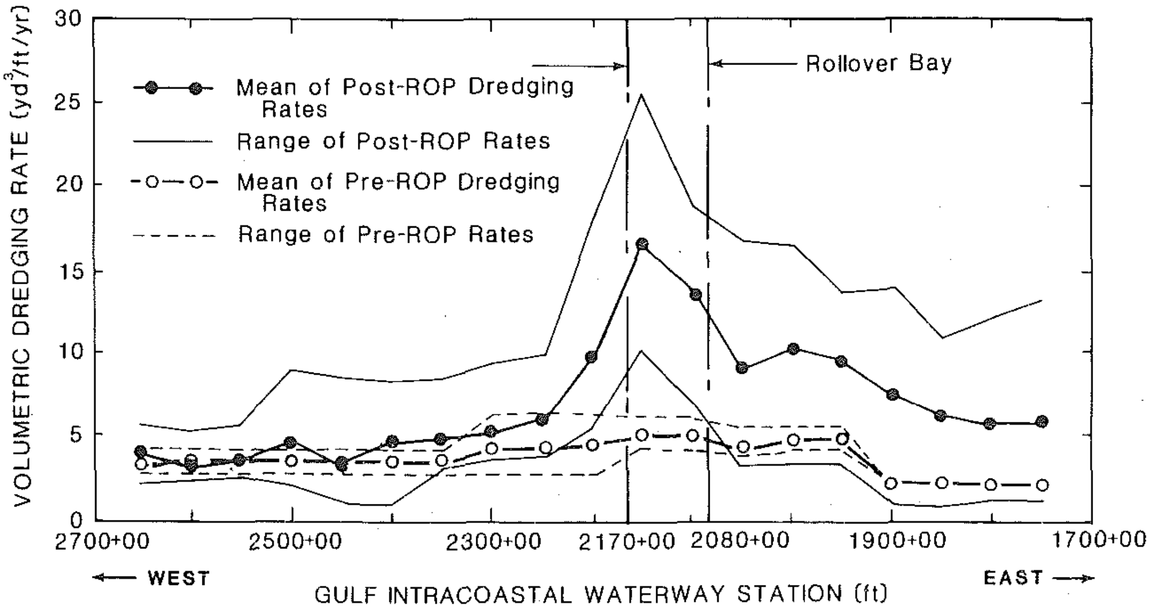

Figure 1 Observed Mean and Extreme Intracoastal Waterway Dredging Rates, Station 1700+00 to Station 2700+00, 1943–1980 (Source: Bales and Holley, 1989)

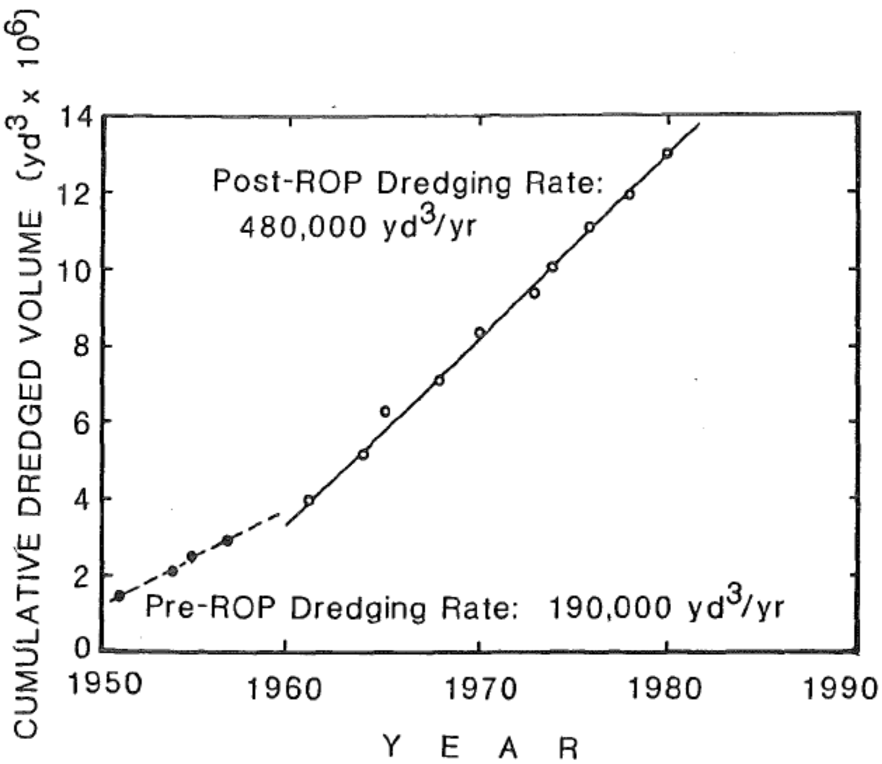

Figure 2 Cumulative Volume Dredged from Gulf Intracoastal Waterway, Station 1900+00 to Station 2450+00 (Source: Bales and Holley, 1989)

2.3 Beach Erosion

The beaches in the Rollover Pass vicinity would naturally experience background erosion absent the effects of Rollover Pass. However, as discussed above, Rollover Pass causes accelerated beach erosion by reducing the natural sediment supply to adjacent beaches. Numerous studies have documented such effects in terms of shoreline and beach volume change rates.

USACE (1958), as cited in Lockwood et al. (1974), calculated an average shoreline recession rate of 5 ft/yr from 1850 – 1956 (i.e., the data period selected by the study authors to represent pre-construction conditions). Subsequently, the USACE (as cited in Lockwood et al, 1974) documented an increased shoreline recession rate of 8.5 ft/yr from 1956 – 1974 within the first mile (5,280 feet) southwest of the Pass compared to a recession rate of 3 – 4 ft/yr over the next 10 miles (mi). In separate studies, Morton (1975) and the USACE, as cited in Mason (1981), found that shoreline recession rates varied between 15 – 25 ft/yr and between 7 – 14 ft/yr, respectively. Through analysis of beach profile changes, Mason (1981) estimated that Rollover Pass causes an additional 26,080 cy/yr of beach volume loss (i.e., erosion) over a 14,000-ft-long shoreline segment southwest of the Pass. Through analysis of aerial photographs of the beach within 6,900 ft of each side of the Pass, Bales and Holley (1989) estimated the Pass causes an additional 9,000 cy/yr of erosion within their study area southwest of the Pass. The above estimates clearly indicate that Rollover Pass has increased the shoreline recession and beach volume loss rates of the nearby beaches. Figure 3 illustrates the effect of adjacent erosion, indicated by the landward retreat of the beach contours (6.0 ft, 2.5-ft, and -2-ft contours shown) southwest of the Pass relative to the contours northeast of the Pass.

Recent studies by the USACE (2006) and Galveston County (2008) document beach changes without specifying the level of erosion caused by the Pass versus that caused by background conditions. The USACE (2006) calculated erosion rates of 42,500 cy/yr over an area extending 6,300 meters (m) (20,670 ft) southwest of the Pass and 36,000 cy/yr over an area extending 4,300 m (14,108 ft) northeast of the Pass. Galveston County (2008) analyzed 1999 – 2008 beach profile data to monitor beach changes associated with geotextile tube shore protection projects. The data, covering a 7-mile stretch of shoreline centered at the Pass, indicates the shoreline southwest of Rollover Pass receded 22.6 ft (2.5 ft/yr) on average and the northeast shoreline receded 4.5 ft (0.5 ft/yr). Though the above shoreline and volume changes do not specifically quantify the erosion caused by the Pass, the data clearly shows the southwestern (i.e. downdrift) beach suffers significantly more erosion than the northeastern beach.

Additionally, this erosion occurs despite the significant infusion of sand from beach and dune nourishment projects further discussed below.

Notably, the Bales and Holley and USACE (2006) volume change estimates originate from shoreline changes. Bales and Holley applied a sediment-volume conversion factor, developed by USACE (1984), of 0.7 cy per square foot of beach eroded to convert shoreline change to volume change. USACE calculated volumes changes by translating beach profiles (surveyed in 2002) by appropriate shoreline change distances (based on analysis of 1974, 1982, 1995 aerials and 2000 LIDAR topography by the University of Texas Bureau of Economic Geology). The USACE (2006) results correspond to conversion factors of 0.784 cy per square foot of beach eroded southwest of the Pass and 0.659 cy per square foot of beach eroded northeast of the Pass. The current study applied the conversion factors derived from USACE to the shoreline changes presented in Galveston County (2008) to calculate 1999 – 2008 beach volume changes extending 3.5 miles southwest and northeast of the Pass. The results indicate approximately 36,167 cy/yr of sand erode from the beach southwest of the Pass and 6,053 cy/yr erode northeast of the Pass within the monitoring area.

Figure 3 2008 Beach Contours near Rollover Pass (adapted from Galveston County, 2008)

3.0 1999 – 2008 SEDIMENT BUDGET

A sediment budget delineates sediment transport magnitudes and pathways and tallies sediment gains and losses within a specified domain. A 1999 – 2008 sediment budget for Rollover Pass provides an update to historic analyses cited above and helps evaluate the recent effects of the Pass. The sediment budget divides the Rollover Pass vicinity into three cells. These cells, illustrated in Figure 4, represent the beach extending 3.5 mi northeast of the Pass (cell 1), the beach extending 3.5 mi southwest of the Pass (cell 2), and the GIWW and Rollover Bay channel (cell 3). The following sections discuss the sediment budget input data — including beach volume changes, sediment transport rates, and beach nourishment and dredging data — and the sediment budget results.

3.1 Beach Volume Changes

As discussed above, Taylor Engineering calculated beach volume changes within cells 1 and 2. The volume estimates, based on shoreline change data reported in Galveston County (2008) and sediment volume conversion factors derived from USACE (2006) data, indicate erosion of 6,053 cy/yr in cell 1 and 36,167 cy/yr in cell 2. Notably, the conversion factors correspond to beach volume changes extending to -4 m (-13 ft) NAVD 88, the depth of closure as determined by the USACE (2006). Thus, the above erosion volumes theoretically represent volume changes to the same depth. Also of note, preferable volume changes based on direct comparison of beach profile surveys extending to the depth of closure are unavailable; however, the above estimates appear reasonable based on historic estimates similar in magnitude.

3.2 Longshore Sediment Transport Rates

Estimated in numerous studies, the longshore sediment transport rate near Rollover Pass is a critical component of the sediment budget. Bales and Holley (1989) reported previous estimates including 96,000 cy/yr (USACE, 1984), 75,000 cy/yr (Prather and Sorensen, 1972), 58,000 cy/yr (Mason 1981), and 54,000 cy/yr (Hall, 1976). All estimates represent a net southwesterly transport direction. The estimates of Mason and Hall include only wave-induced transport, whereas those of USACE and Prather and Sorensen include both wave and wind-current induced transport. Considering a separate USACE (1984) wind-induced transport estimate of 57,000 cy/yr, Bales and Holley (1989) present a possible 75,000 cy/yr – 115,000 cy/yr range of total longshore transport. In their study, the authors assume that addition of the independent wave- and wind-induced transport rates (i.e., addition of the 57,000 cy/yr wind-induced transport rate to the wave-induced rates estimated by Mason [1981] and Hall [1976]) reasonably represent the total rate. Recently, King (2007) applied numerical modeling techniques to simulate longshore sediment transport along Bolivar Peninsula. The sediment budget, which specifies the rate at the northeast boundary of cell 1, applies a transport rate of 91,600 cy/yr obtained from King.

3.3 Sediment Transport into Rollover Pass

As cited above, previous research led to a wide range of sediment transport estimates varying by an order of magnitude from 3,800 cy/yr to 290,000 cy/yr. This study selected a midrange of 80,000 cy/yr – 150,000 cy/yr based on data reported in Bales and Holley (1989) and PIE (2002). Notably, without any published data specifying the proportion of sand entering the inlet from the updrift and downdrift sides, this sediment budget assumes that 60% originates from the updrift beach. Notably, the 60% value corresponds to the southwesterly-directed proportion of gross sediment transport derived from King (2007). Numerical model results presented in King (2007) indicate gross sediment transport of roughly 650,000 cy/yr and net southwesterly sediment transport of roughly 133,500 cy/yr at the Pass. This data suggests the southwesterly-directed component of gross transport equals 391,750 cy/yr (or 60% of the gross transport) and the northeasterly-directed component equals 258,250 (or 40% of the gross transport).

3.4 Beach and Dune Nourishment and Dredging History

The sediment budget includes an average annual artificial placement of 64,675 cy/yr and 155,901 cy/yr of material onto the beaches northeast (cell 1) and southwest (cell 2) of Rollover Pass and removal of 185,668 cy/yr from the GIWW and Rollover Bay channel (cell 3) from 1999 – 2008. Taylor Engineering derived these quantities from annual beach and dune nourishment data (i.e., volumes, placement locations, and sand sources) from Galveston County (2008) and Texas General Land Office (personal communications) as presented in Table 2. Notably, cell 3 of the sediment budget corresponds to the reach associated with the dredging events documented in Table 2. Also, this analysis excludes a 2008 project that placed 134,700 cy southwest of the Pass; this nourishment event occurred after the 2008 survey used by Galveston County (2008) to determine shoreline changes.

3.5 Sediment Budget Results

Figures 5 and 6 illustrate alternative sediment budgets with differences that stem from different sediment transport rates entering the Pass. Alternative 1 (Figure 5) includes 80,000 cy/yr entering the Pass, and Alternative 2 (Figure 6) includes 150,000 cy/yr entering the Pass. Both alternatives specify the longshore transport rate (91,600 cy/yr) entering the domain cell 1 at the northeast boundary, the artificial transport (i.e. dredging and beach nourishment) magnitudes, and the proportions of transport entering the

Pass from updrift (60%) and downdrift (40%). All other transport rates — including transport into the GIWW from interior waters and longshore transport rates at the Pass (i.e. from cell to cell) and at the southwest domain boundary of cell 2— represent a balance of volumes such that the transport volume exiting a cell equals the sum of volumes entering the cell and volume changes within the cell. Both alternatives assume the net change within cell 3 equals zero (i.e., dredging rates equal deposition rates); thus, the sediment transport entering from interior bay waters equals the difference between the dredging rate and the sediment transport entering the Pass from offshore. Both alternatives assume zero offshore transport through the beach cell boundaries.

Comparison of Alternatives 1 and 2 provide insight into sediment transport as follows:

- Alternative 1 and Alternative 2 indicate that approximately 114,300 cy/yr and 72,300 cy/yr travel from the northeast beach cell (cell 1) to the southwest beach cell (cell 2). The greater transport into the Pass (Alternative 2), which diminishes sediment supply downdrift, accounts for the volume difference.

- Alternative 1 and Alternative 2 indicate that approximately 274,400 cy/yr and 204,400 cy/yr exit downdrift of the southwest beach cell (cell 2). Both estimates appear higher than previously estimated rates; the assumption of zero offshore transport and a possible underestimation of the transport into Rollover Bay could account for the higher than expected rates.

- Alternative 1 and Alternative 2 indicate 105,700 cy/yr and 35,700 cy/yr deposit into cell 3 via siltation from interior waters. The Alternative 1 estimate represents about 57% of the dredged volume. The Alternative 2 estimate represents about 19% of the dredged volume. Historic dredging records discussed above show evidence of increased deposition after construction of Rollover Pass, and several studies hypothesize that sediment transported from the beach rather than the bay region comprise the majority of deposited sediments. As such, the above results suggest that the 80,000 cy/yr transport of Alternative 1 underestimates the actual transport rate into the Pass.

Table 2 1999 – 2008 Sediment Budget Nourishment Data and Dredging Volumes

Year	Nourishment Type	Volume (cy)	Sand Source
Northeast Shoreline Nourishments (Cell 1)			
2000	Beach	300,000	Rollover Bay[3] (dredge placement)
2000	Dune	22,000[2]	Upland source (truck haul)
2001	Dune	17,800	Upland source (truck haul)
2003	Beach	104,000	GIWW (dredge placement)
2004	Beach	74,274	GIWW (dredge placement)
2005	Dune	64,000	Upland source (truck haul)
Total	-	582,074	-
1999 – 2008 annual average	-	64,675	-
Southwest Shoreline Nourishments (Cell 2)			
1999	Beach	175,000	GIWW (dredge placement)
2000	Beach	138,400	GIWW (dredge placement)
2000	Dune	22,000[2]	Upland source (truck haul)
2001	Beach	126,000	GIWW (dredge placement)
2001	Dune	6,600	Upland source (truck haul)
2002	Beach	119,000	GIWW (dredge placement)
2004	Beach	102,523	Upland source (truck haul)
2004	Dune	8,247	Upland source (truck haul)
2005	Beach	361,000	GIWW (dredge placement)
2005	Dune	71,000	Upland source (truck haul)
2006	Beach	87,737	GIWW (dredge placement)
2007	Beach	185,600	GIWW (dredge placement)
Total	-	1,403,107	-
1999 – 2008 annual average[1]	-	155,901	-
Dredging Volumes (Cell 3)			
1999 – 2008 Total[1]	-	1,371,011	GIWW
	-	300,000	Rollover Bay channel[3]
	-	1,671,011	Cell 3 total
1999 – 2008 annual average[1]	-	152,335	GIWW
		33,333	Rollover Bay channel[3]
		185,668	Cell 3 total

[1]The data excludes a 2008 nourishment of the southwest shoreline that placed 134,700 cy of GIWW dredged material; this event occurred after the 2008 survey that defines the sediment budget period.
[2]Event included placement of 44,000 cy southwest and northeast of the Pass, but the placement distribution is unknown to the study authors. Thus, the data presented above assumes equal distribution to both sides of the Pass.
[3]The 2000 dredging event removed sediment from the permitted borrow area located along the Rollover Bay channel.

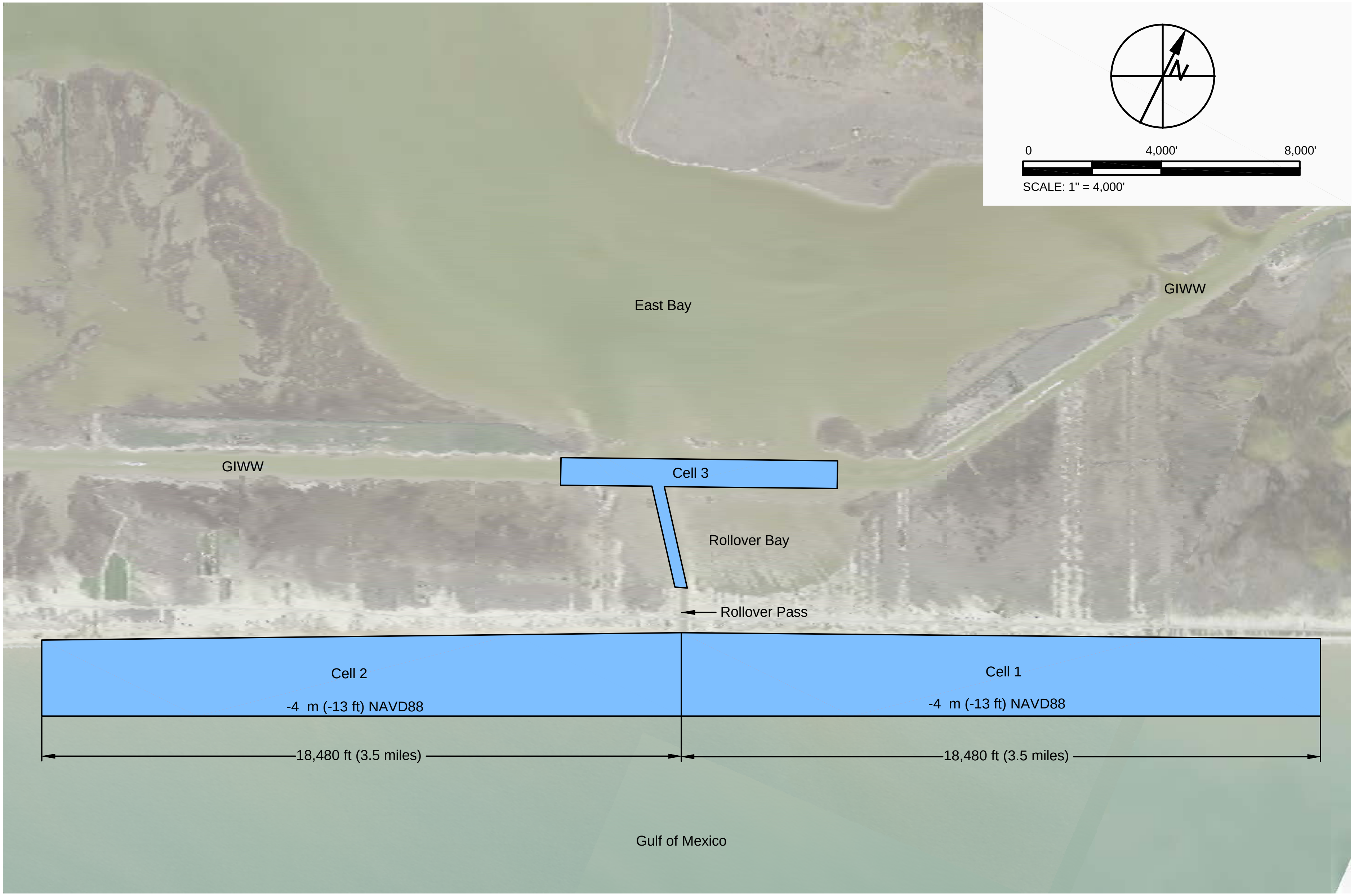

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Figure 4
Sediment Budget Cells

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DRAWN BY	JCH
DATE	NOV 2009

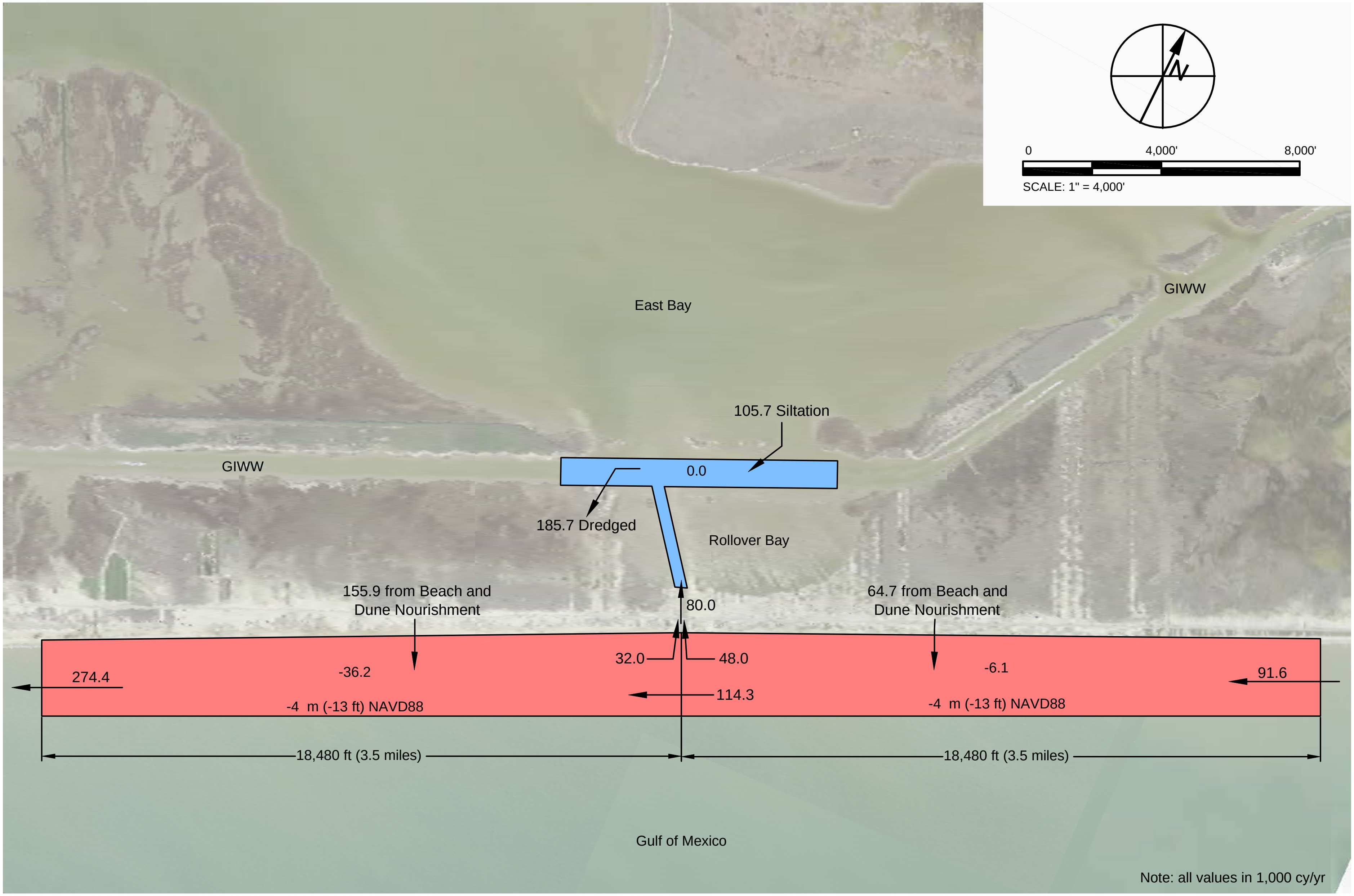

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Figure 5
Sediment Budget Alternative 1

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DATE	NOV 2009

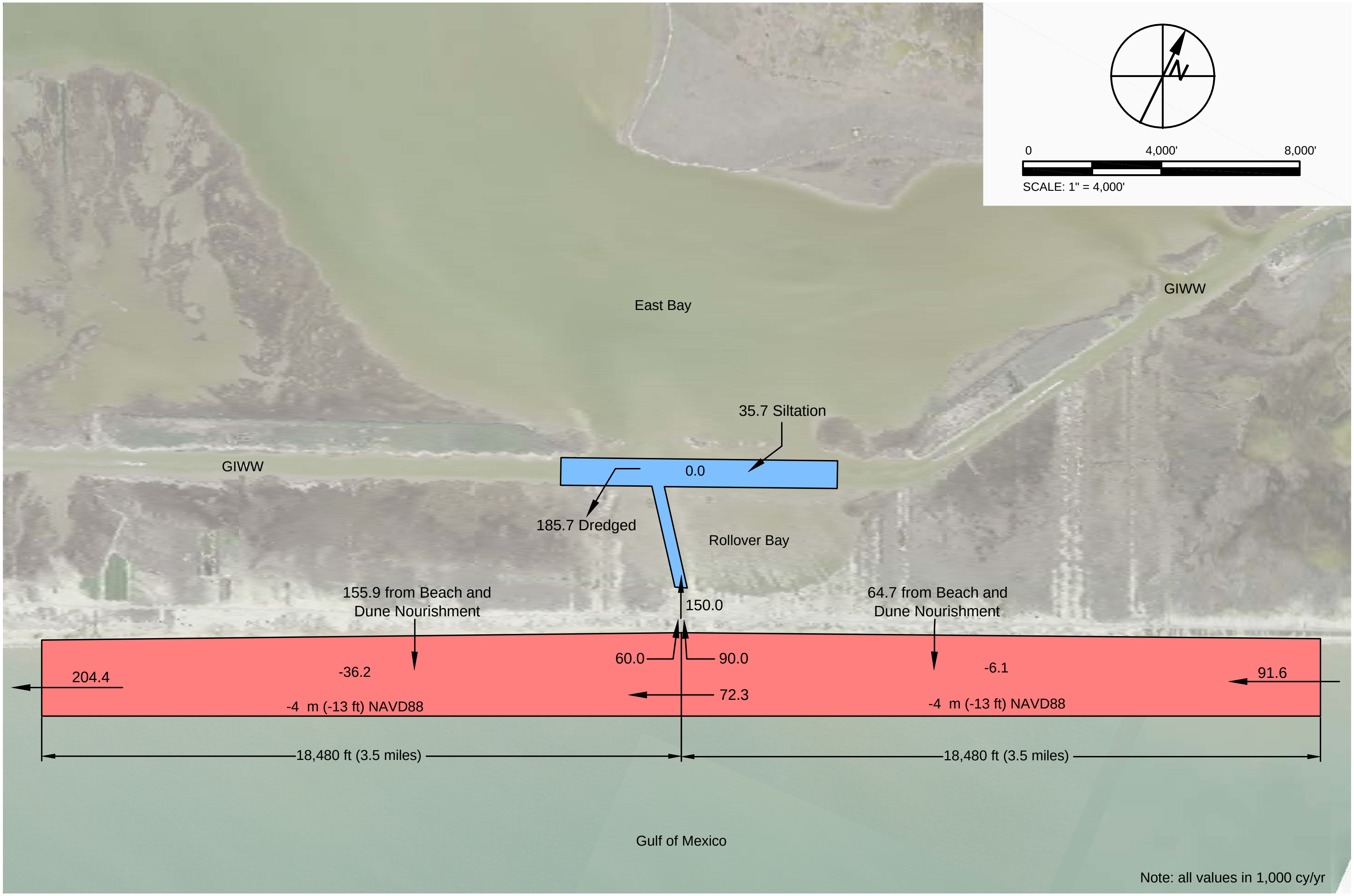

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Figure 6
Sediment Budget Alternative 2

PROJECT	C2009-063
DRAWN BY	JCH
DATE	NOV 2009

In summary, the sand transport rate into Rollover Pass remains debatable, but the sediment budget results suggest rates of 150,000 cy/yr or more are likely. Closing Rollover Pass would eliminate this sediment transport pathway and return the littoral system to a more natural state. In effect, the longshore transport will feed the beaches as naturally intended and alleviate the accelerated erosion rates caused by the Pass. Eliminating the sediment pathway into the Pass will also reduce deposition in the GIWW and Rollover Bay and help decrease the high dredging frequency currently required to maintain the GIWW. Additionally, future beach restoration projects, subject only to background erosion rates rather than the accelerated rates from the Pass, should perform more effectively.

4.0 CONCLUSION

This report cited numerous studies from 1958 to the present that indicate Rollover Pass causes significant erosion of the adjacent beaches and increases the frequency and, hence, costs to dredge the GIWW. Such adverse impacts arise primarily from the Pass' flood dominant characteristics that transport material from the natural littoral zone into the Pass interior. This report also developed an alternative 1999 – 2008 sediment budgets that summarize the beach volume changes and the sediment transport magnitudes and pathways, both natural and artificial, near Rollover Pass for the recent pre-Hurricane Ike period. The sediment budget alternatives suggest that a sediment transport rate of 150,000 cy/yr or more into Rollover Pass appears likely. Collectively, the results of this study justify closure of Rollover Pass to help reduce erosion of the adjacent beaches, reduce the required frequency and costs of GIWW maintenance dredging, and help improve the effectiveness of future beach restoration projects.

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Attachment C
Preliminary Rollover Pass Closure Work Plan

Preliminary Rollover Pass Closure Work Plan

Introduction

Rollover Pass, an artificial inlet created in 1955 to enhance recreational fishing opportunities, lies on the Bolivar Peninsula in Galveston County, Texas about 30 km (19 miles) northeast of the Galveston Bay entrance. The Pass, which provides a tidal connection between the Gulf of Mexico and Rollover Bay in the southeastern portion of East Bay, causes beach erosion, increases the frequency and, hence, costs to dredge the Gulf Intracoastal Waterway (GIWW), and increases the salinity levels within interior waters. The proposed Rollover Pass Closure project will alleviate the above adverse impacts and return the project site to a more natural state by completely infilling the pass from the Gulf to the bay shoreline.

The Texas General Land Office (GLO) requested Taylor Engineering, Inc. to develop the procedure to close Rollover Pass. This document details the preliminary work plan to complete this project objective.

Project Overview

The proposed project will use a hydraulic dredge connected to a floating pipeline (except for a short submerged segment across the GIWW) to pump fill material from the borrow source(s) to Rollover Pass. The project may use up to three potential fill sources including a nearby upland dredge material placement area (DMPA), the permitted Rollover Bay sand source (Galveston County, SWG 21755 and amendments), or the GIWW in the Rollover Pass vicinity. Material fill removal from the GIWW would coincide with annual maintenance dredging conducted by the U.S. Army Corps of Engineers (USACE). Heavy equipment will grade the infill to meet the elevations of adjacent lands. The specified construction methodology will use a combination of permanently installed steel sheet pile walls and geotextile bags to close the Pass. Implementing this methodology will minimize water quality impacts and structural impacts to the existing bridge and utilities. The existing State Highway 87 bridge, maintained by the Texas Department of Transportation (TxDOT), and all utilities that currently cross Rollover Pass will remain intact. Demolition and/or removal of the existing steel and concrete walls throughout the pass will occur after the fill stabilizes.

Work Plan

The project will include two or more separate operation sites. Rollover Pass comprises one operation site and the borrow area(s) comprises the additional operation site(s). As mentioned above, the project may use up to three potential fill sources. The Texas GLO is currently collecting geotechnical data at various DMPAs along Bolivar Peninsula. Upon receipt of the geotechnical reports (expected in early December 2009), Taylor Engineering will evaluate the DMPA sediment’s suitability for pass closure. If project construction coincides with the USACE’s maintenance dredging of the GIWW, the GLO will coordinate with the USACE to obtain and evaluate geotechnical data of the GIWW sediments. GLO will evaluate the permitted Rollover Bay sand source if the other sources cannot provide suitable material. Taylor Engineering will update this work plan as new data becomes available. Currently, this preliminary work plan describes construction methods at the Rollover Pass operation center and at a potential DMPA operation center.

Preliminary Rollover Pass Work Plan

Rollover Pass closure will involve three sequential construction phases, as detailed in Sheet 1 of the attached plans. Phase 1 will stop the tidal flow through the Pass by installing steel sheet pile walls adjacent to the steel sheet pile weirs on both sides of the State Highway 87 bridge. This step also isolates the bridge to minimize the risk of impacts to the piles and other utilities or structural components.

Phase 2 will infill the southern portion (Gulf side) of the Pass including the bridge section isolated in Phase 1. The first step installs two geotextile tubes (200-ft long and 20-ft in diameter) across the Pass to create cells. The attached plans illustrate the geotextile tube locations. The contractor will first create a stable bracket for each tube by driving numerous 30-ft long wooden piles into the pass bottom. The contractor will then fill the geotextile tubes — first, by pumping in seawater to establish their location between the brackets, and then by pumping in low quality material from the sand source. The second step of Phase 2 fills the cells created by the sheet pile walls and geotextile tubes. The contractor will begin filling the section under the bridge between the sheet pile walls and will dewater the section with a mechanical pump as necessary. The contractor will direct outflow from dewatering operations toward the Gulf (i.e., into the adjacent cell). The geotextile tube of the adjacent cell will help contain the outflow and, thus, help control turbidity. The contractor will fill the remaining cells from north to south. During this process, the geotextile tubes will continue to help contain outflow to minimize turbidity impacts. Additionally, the contractor will use turbidity screens as necessary to further minimize turbidity and erosion. The contractor will also screen and remove debris from the dredged slurry during pumping operations if required.

To help stabilize the fill, the contractor will compact the fill in 6 in. lifts once the fill reaches an elevation of approximately 1.0 ft NAVD88. However, to minimize potential risk to the bridge piles, the contractor will not compact material placed within the bridge cell. Once the fill has stabilized, the contractor will begin complete removal of the existing concrete and steel sheet pile walls south of the bridge. The contractor will use suitable concrete rubble and metal materials to fill the large scour hole on the bayside of the sheet pile weir north of the bridge in Phase 3 (discussed below); the contractor will truck all other demolished materials away from the site to an appropriate disposal location. Notably, the fill material used for the bottom of the cells may not meet beach quality criteria. However, the top layer above approximately 1.0 ft NAVD88 and the seaward portion of the fill will include only beach quality material.

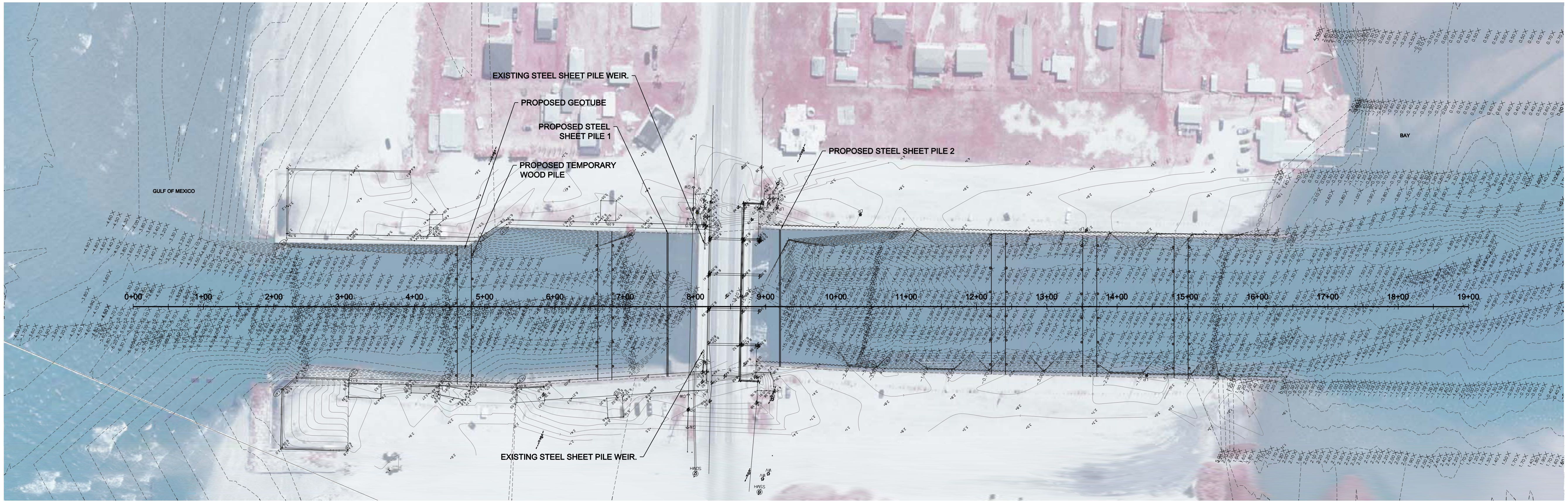
Phase 3 fills in the northern portion of the Pass. In the same manner described above in Phase 2, the contractor will install three geotextile tubes to create fill cells. The contractor will fill the cells beginning near the bridge and progressing northward towards Rollover Bay. The contractor will use any suitable material from the demolition activities of Phase 2 to fill the large scour hole on the bayside of the sheet pile weir north of the bridge. Again, the contractor will use turbidity screens as necessary to minimize turbidity impacts and erosion. The contractor will also compact all cells in 6 in. lifts once the fill reaches approximately 1.0 ft NAVD88. Once the fill has stabilized, the contractor will begin demolition of the existing sheet pile walls that line the Pass; the contractor will cut the walls 2 ft below the surrounding grade and remove the top portions.

Preliminary DMPA Sand Source Work Plan

The contractor will use mechanical loaders to segregate beach quality, high quality, and low quality material within the DMPA site. The contractor, in coordination with the USACE and the GLO, will create an excavation transfer point where the hydraulic dredge can excavate the DMPA material. Mechanical loaders will move material into the transfer point from within the DMPA. The hydraulic dredge, securely moored and enclosed within multiple turbidity barriers, will pump the excavated slurry through a floating pipeline (except for a short submerged segment across the GIWW) to the Rollover Pass operation site. The location of the transfer point may dictate the use of several booster pumps to move the slurry through the pipeline. Sheet 2 illustrates a possible pipeline route originating from DMPA 36, a potential sand source. The pipeline route will minimize impacts to any environmentally sensitive areas. The contractor will follow the site's Stormwater Pollution Prevention Plan (SWPP).

Final Design Considerations

Final design of the closure plan requires coordination with Texas Department of Transportation (TxDOT) and other entities (i.e., Bolivar Peninsula Special Utility District [BPSUD], Camden Communications, and Entergy Texas) that currently maintain utilities across Rollover Pass. Such communications are necessary to prevent unintended impacts to existing utilities and to incorporate possible utility improvements into the project design. In addition to maintaining the State Highway 87 bridge over Rollover Pass, TxDOT maintains four stormwater pipes that currently open into Rollover Pass. Final design of the pass will require development of a drainage design that incorporates the existing pipes. BPSUD maintains a waterline attached to the bridge; final design could involve relocation or burial of the pipeline. Camden Communications maintains fiber optic lines bored underneath the pass, and Entergy Texas maintains electric lines above the pass.

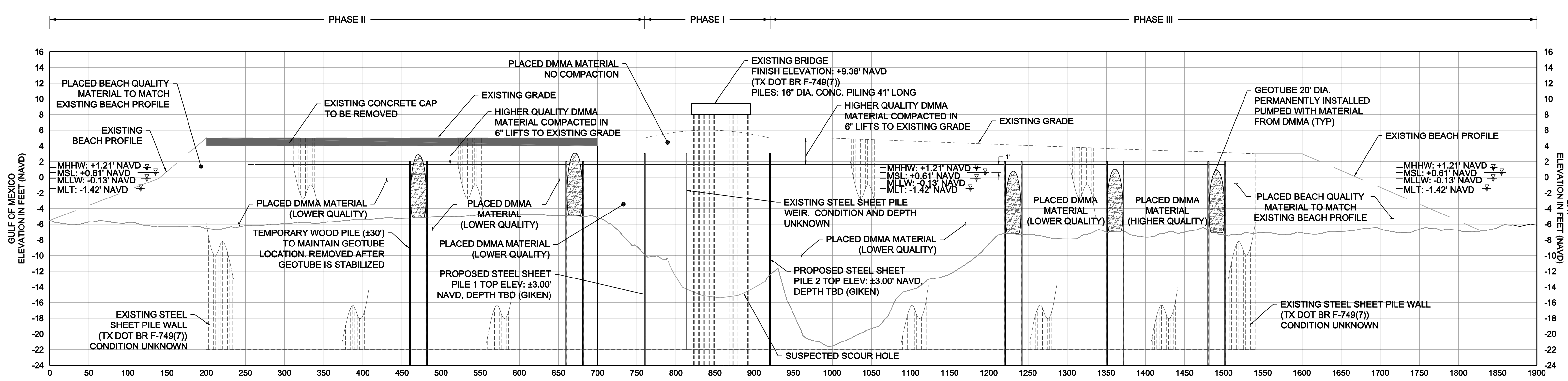


0 80' 160' 320'
GRAPHIC SCALE
22X34: 1" = 80'
11X17: 1" = 160'

N

PRELIMINARY CLOSURE PLAN

22X34: 1" = 80'
11X17: 1" = 160'
0 80' 160'



PRELIMINARY CLOSURE PROFILE

22X34: 1" = 80'
11X17: 1" = 160'
0 80' 160'
X10 VERTICAL EXAGGERATION

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SEAL

MICHAEL E. TRUDNAK P.E.# 58200

PROJECT TITLE

ROLLOVER PASS CLOSURE STUDY
GALVESTON COUNTY, TEXAS

TEXAS ONE CALL SYSTEM — STOP - CALL BEFORE YOU DIG!

PRELIMINARY DRAWINGS
THESE DRAWINGS ARE NOT IN FINAL FORM, BUT ARE BEING TRANSMITTED FOR AGENCY REVIEW.

NO	ZONE	REVISIONS / SUBMISSIONS	DATE
1	C2	REMOVE GULF SIDE GEOTUBE	10/13/09

PROJECT NO	C2009-063
DATE	11-17-09
DESIGNED	MPW
DRAWN	AF
CHECKED	
REVIEWED	
SCALE	AS SHOWN

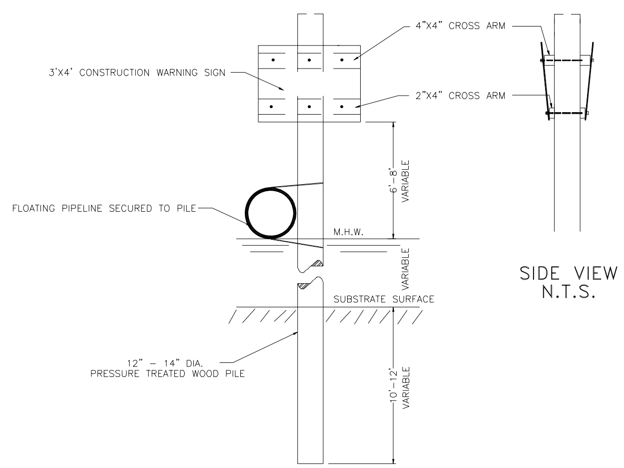
DRAWING TITLE

PRELIMINARY CLOSURE PLAN

W-1

SHEET 1 OF 2

TEMPORARY PILING AND SIGN PLACEMENT



FRONT VIEW – TEMPORARY PILING AND SIGN
N.T.S.

GRAPHIC SCALE
22X34: 1" = 800'
11X17: 1" = 1,600'

NOTES:
1. CONTRACTOR TO SECURE FLOATING PIPELINE WITH TEMPORARY PILES AND SIGNAGE AS APPROPRIATE ALONG SOUTH SIDE OF CHANNEL.
2. LOCATION OF PIPELINE IS APPROXIMATE, CONTRACTOR TO MAINTAIN FLOATING PIPELINE WITHIN CHANNEL BOUNDARIES, AND AVOID ENVIRONMENTAL IMPACTS DURING PLACEMENT OF PIPELINE AND TEMPORARY PILES.
3. BOOSTER PUMP LOCATIONS ARE APPROXIMATE. CONTRACTOR WILL SELECT THE ACTUAL NUMBER AND LOCATION OF BOOSTER PUMPS.
4. AERIAL REFERENCE: USDA 2004

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CERTIFICATE OF AUTHORIZATION # 4815

SEAL

MICHAEL E. TRUDNAK P.E.# 58200

PROJECT TITLE

ROLLOVER PASS CLOSURE STUDY
GALVESTON COUNTY, TEXAS

PRELIMINARY DRAWINGS
THESE DRAWINGS ARE NOT IN FINAL FORM, BUT ARE BEING TRANSMITTED FOR AGENCY REVIEW.

REVISIONS / SUBMISSIONS — NO | ZONE | DATE

PROJECT NO	C2009-063
DATE	01-08-10
DESIGNED	MPW
DRAWN	RJD
CHECKED	
REVIEWED	
SCALE	AS SHOWN

DRAWING TITLE

FLOATING PIPELINE LOCATION

W-2

SHEET 2 OF 2

Attachment D
The Effects of Rollover Pass Closure on Hydrodynamics and Salinity

The Effects of Rollover Pass Closure on Hydrodynamics and Salinity

Galveston County, TX

January 2010

The Effects of Rollover Pass Closure on Hydrodynamics and Salinity

Prepared for

Texas General Land Office

by

Taylor Engineering, Inc.
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Jacksonville, Florida 32256
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C2009-063

January 2010

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1.0 INTRODUCTION

Rollover Pass, an artificial inlet created in 1955 to enhance recreational fishing opportunities, lies on the Bolivar Peninsula in Galveston County, Texas about 30 km (19 miles) northeast of the Galveston Bay entrance. The Pass, which provides a tidal connection between the Gulf of Mexico and Rollover Bay in the southeastern portion of East Bay, causes beach erosion, increases the frequency and, hence, costs to dredge the Gulf Intracoastal Waterway (GIWW), and increases the salinity levels within interior waters. The proposed Rollover Pass Closure project will alleviate the above adverse impacts and return the project site to a more natural state by completely infilling the pass from the Gulf to the bay shoreline.

The Texas General Land Office (GLO) requested Taylor Engineering, Inc. to evaluate the potential affects of the closure of Rollover Pass on inland water hydraulics and salinity. This report discusses a numerical modeling effort conducting by Taylor Engineering to analyze such affects of Pass closure. Following this brief introduction, Chapter 2 describes the general modeling procedures, the study area, and the model calibration. Chapter 3 presents the study methodology and model results. Chapter 4 contains a brief summary of the study's findings.

2.0 STUDY AREA, MODELING PROCEDURES, AND CALIBRATION

2.1 Overview

The study area lies on the northwestern side of the Gulf of Mexico and includes Rollover Pass, Rollover Bay, and Galveston Bay. Galveston Inlet and Rollover Pass connect the bays directly to the Gulf. Tides in the Gulf of Mexico generate tidal currents through these connections which exchange water between the bays and the Gulf. The tidal currents draw highly saline water into the bays from the Gulf of Mexico and expel saline water mixed with freshwater from the bays. Additionally, tidally controlled water level changes generate currents internal to the bays. These currents mix saline water from the Gulf with freshwater continuously entering the system through rivers and bayous. This study examines the affects of closing Rollover Pass, the primary conduit for water interchange, on the salinity concentration of waters in Rollover Bay and Galveston Bay.

Tidal and river circulations in and around inlets, rivers, and bays control the introduction and mixing of saline ocean waters with freshwater from streams and rivers. Hydrodynamic models provide engineers a means to describe and study these circulations. Such models simulate flow by solving the governing equations for the fluid dynamic processes at a given location under specific water level and flow boundary conditions.

This study employed two U.S. Army Corps of Engineers (USACE) two-dimensional finite element models (RMA2 and RMA4) to determine water conditions which would result from closing Rollover Pass. RMA2 computes water surface elevations and horizontal velocity components in two-dimensional flow fields based on tidal or riverine flow data. RMA4 applies the hydrodynamic solution from RMA2 to simulate the advection-diffusion transport process of saline and freshwater through the system.

Resource Management Associates, Inc. of Davis, California developed the hydrodynamic model RMA2 in 1973. Continuing modification and improvement by researchers at the USACE Waterways Experiment Station (WES) has resulted in a robust, well-established model. RMA2 solves the two-dimensional transient, depth-averaged, fluid dynamic governing equations in a finite element scheme with specifications for roughness coefficients to describe bed friction, turbulent exchange coefficients for turbulence closure, and both flow and free surface boundary conditions. Additional capabilities include treatments for wetting and drying, Coriolis acceleration, wind stress, dynamic bed friction assignment by depth, Peclet number definition of turbulent exchange coefficients, and one-dimensional storage and flow structures.

RMA4, another Resource Management Associates program modified and improved by researchers at WES, applies the hydrodynamic solutions from RMA2 to simulate depth-averaged advection-diffusion transport processes. RMA4 can simulate the fate of constituents as conservative or non-conservative with a first order decay. Successful applications include investigating the physical processes of migration and mixing of a soluble substance in reservoirs, rivers, bays, estuaries, and coastal zones; defining horizontal salinity distributions; tracing temperature effects from power plants; calculating residence times of harbors or basins; optimizing the placement of outfalls; identifying potential critical areas for oil spills or other contaminant spread; evaluating turbidity plume extent; and monitoring other water quality criterion within game and fish habitats.

The RMA2 model, calibrated with especially collected tidal stage and tidal velocity data, provides the hydrodynamic solution for the RMA4 model. The RMA4 model, calibrated with salinity data collected coincident with the tide data, estimates the salinity of the bays.

2.2 Study Area and Model Domain

Figure 2.1 shows the extent of the model domain. As noted, Galveston Inlet and Rollover Pass connect the bays directly to the Gulf of Mexico and provide the source of saline water in the bays. Trinity River provides 60 – 70% of the freshwater entering the study area with Buffalo Bayou, San Jacinto River, and Cedar Bayou providing the majority of the remaining freshwater input to the system.

The model domain applied in this study derives from the TxBLEND (Matsumoto et al., 2005). Taylor Engineering converted this model to RMA2, added details of Rollover Bay, and updated Rollover and East Bays with bathymetric data collected by Naismith Marine Services from August 6 to 21, 2009 (Figure 2.2). Figure 2.3 shows the bathymetry and model mesh in Rollover and East Bay, near Rollover Pass.

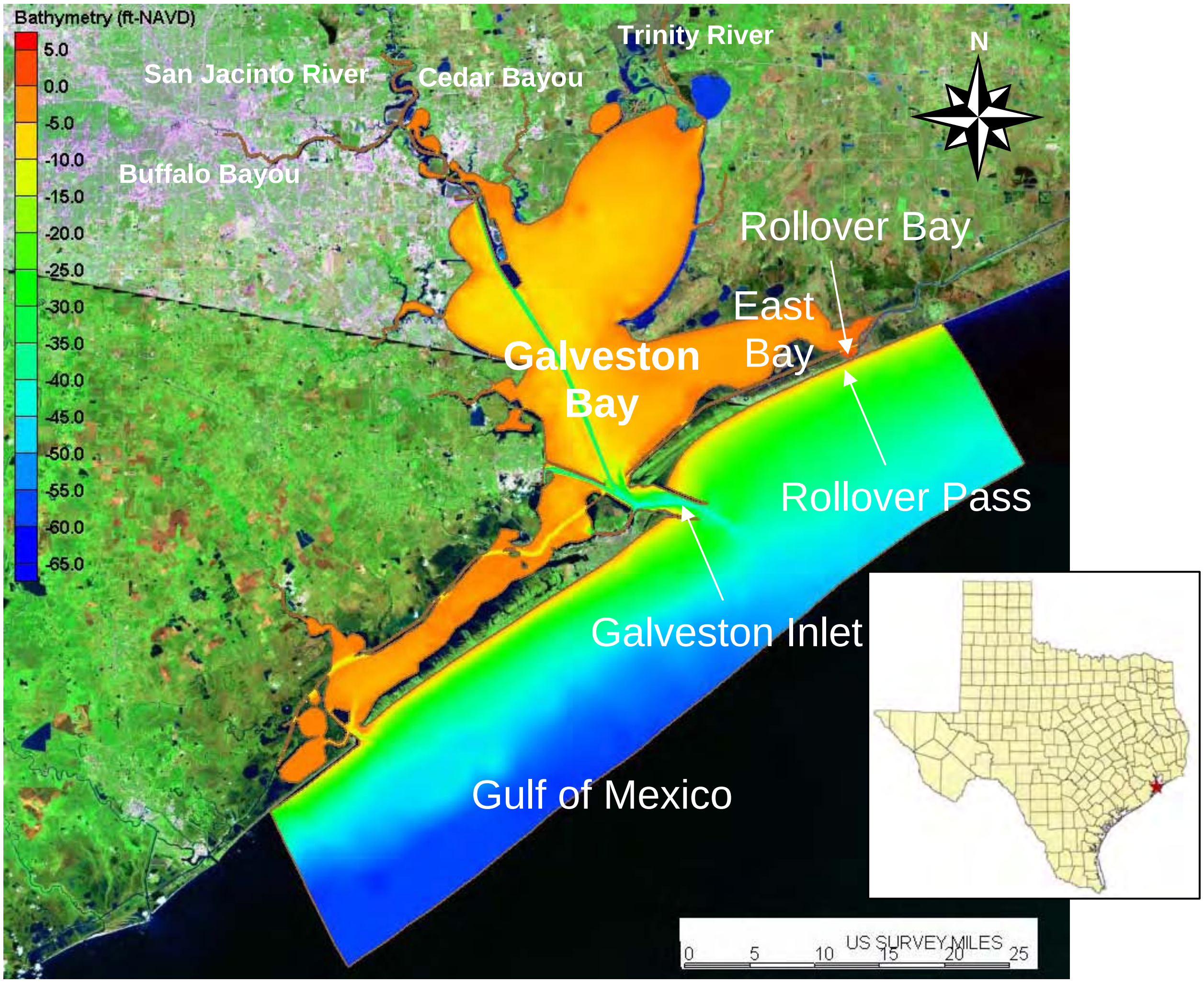

Figure 2.1 Model Domain

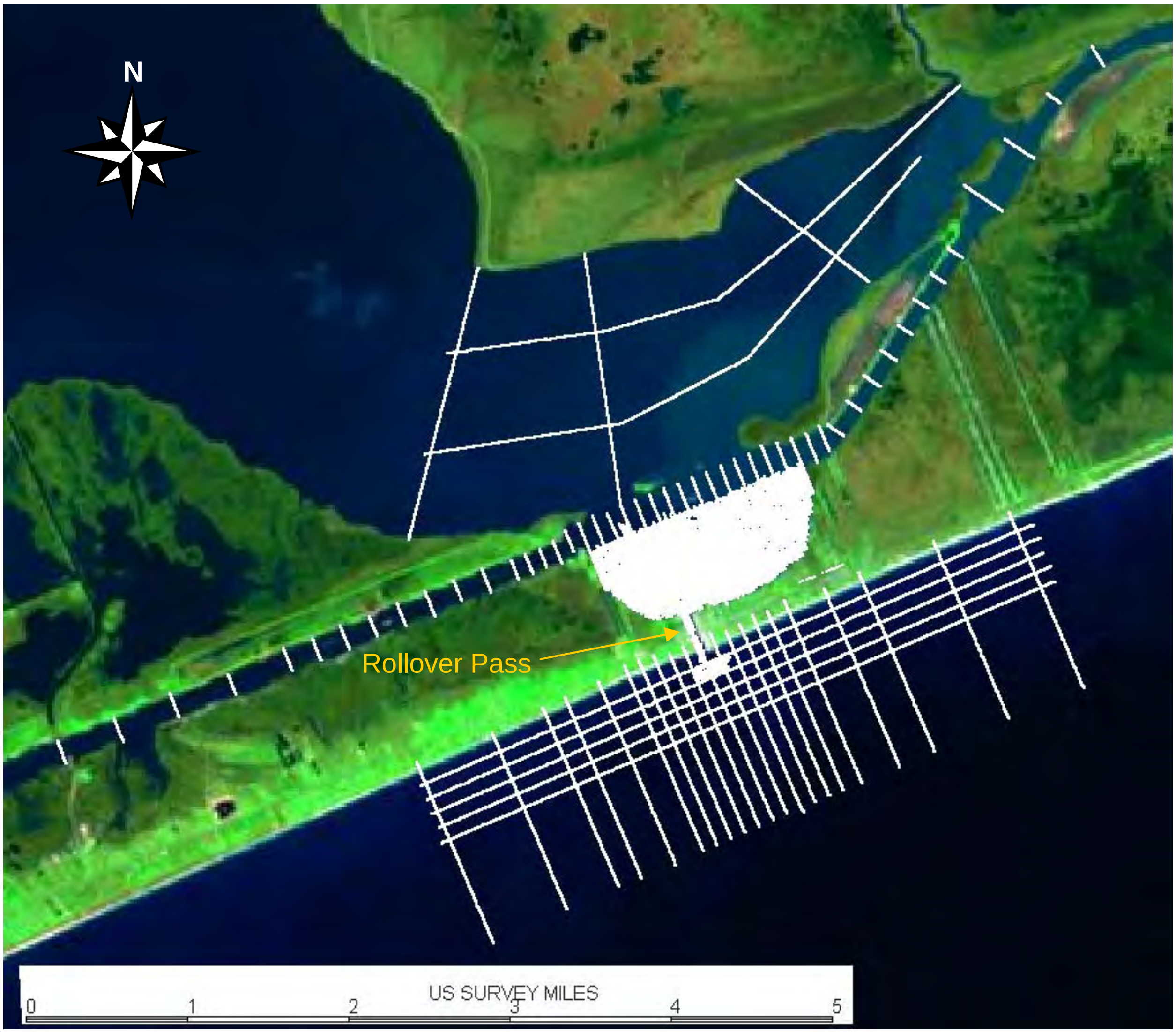

Figure 2.2 Extent of New Bathymetric Survey Data near Rollover Pass

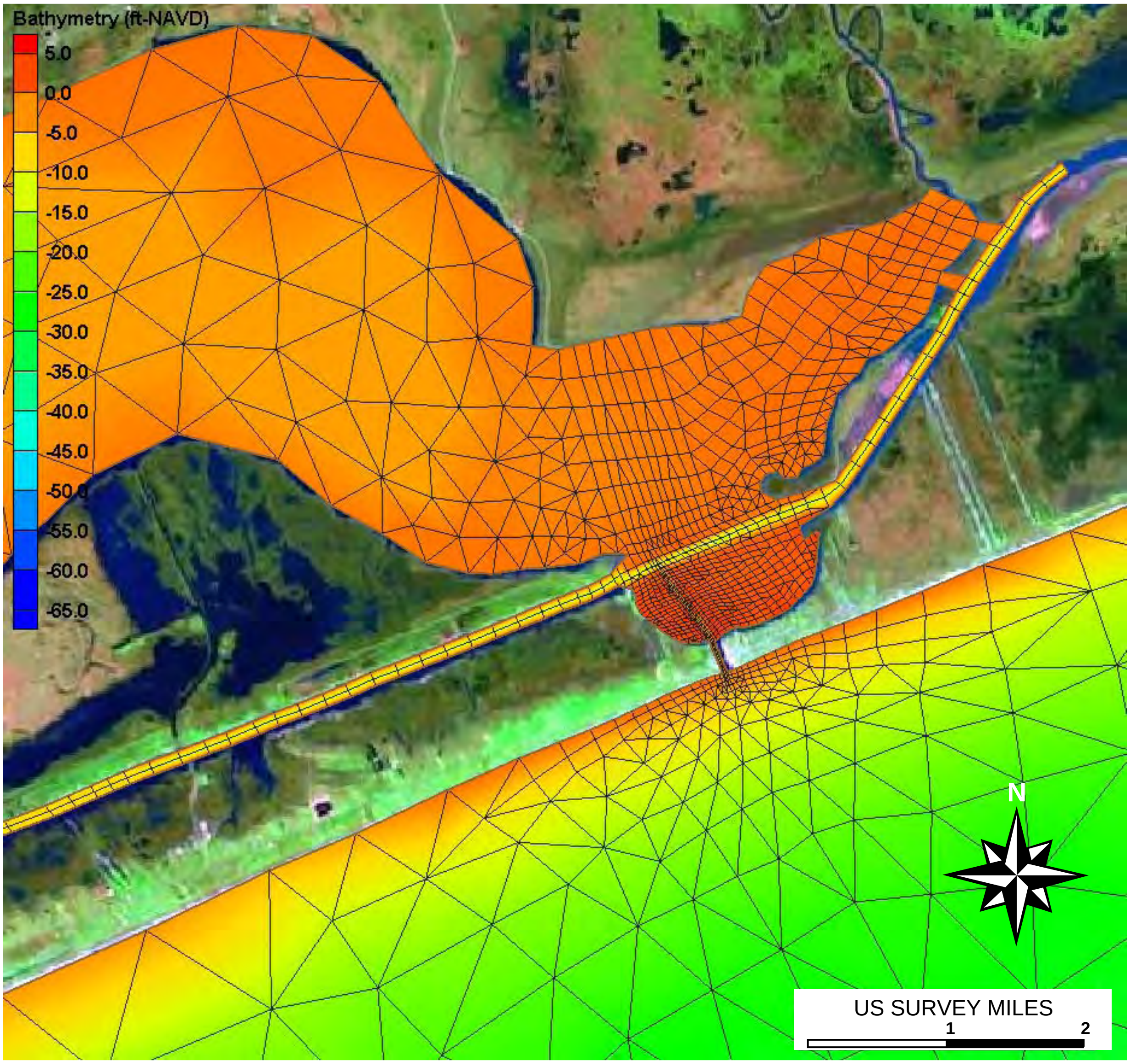

Figure 2.3 Mesh and Bathymetry near Rollover Pass

2.3 Hydrodynamic Model Calibration Data Collection and Tidal Characteristics

Gauges at six stations located in the project area (Figure 2.4) provided tidal stage and velocity data. Two stations provided only tidal stage data, three stations provided only velocity data, and one station in Rollover Pass provided both tidal stage and velocity data. One additional station in the Gulf Intracoastal Waterway east of the project area provided tidal stage data for model boundary conditions. The tide gauges supplied continuous water level data from July 28 to September 3, 2009. Taylor Engineering collected velocity data over the water column with an Acoustic Doppler Current Profiler (ADCP) during discrete intervals (lasting at least five minutes) on July 29 and September 3, 2009. This data provided the required information for hydrodynamic model calibration.

Figure 2.4 Model Calibration Points

Notably, collected salinity data only covers the late summer, early fall period. Time constrains did not allow data collection over an extended period. To predict the absolute value of salinity with any accuracy over several years requires calibration with salinity data for each season. Therefore, the model may not accurately predict absolute salinity values, but should reliably predict relative salinity between simulations with the Pass open and closed.

National Oceanic and Atmospheric Administration (NOAA) stations 8771510 at Galveston Pleasure Pier and 8770971 Rollover Pass provided long-term tidal stage information. Table 2.1 summarizes the tidal data from these stations.

Table 2.1 NOAA Tide Data

Tide Data	STA 8771510, Galveston Pleasure Pier (ft-NAVD)	STA 8770971, Rollover Pass (ft-NAVD)
Mean Higher High Water (MHHW)	1.43	1.21
Mean High Water (MHW)	1.24	1.13
Mean Tide Level (MTL)	0.51	0.61
Mean Sea Level (MSL)	0.50	0.61
Mean Low Water (MLW)	-0.22	0.03
Mean Lower Low Water (MLLW)	-0.61	-0.13
Mean Tide Range (ft) (MHW – MLW)	1.46	1.10
Diurnal Tide Range (ft) (MHHW – MLLW)	2.04	1.34

2.4 Hydrodynamic Model Parameters and Boundary Conditions

A Manning's roughness coefficient (Manning's *n*) value ranging from 0.015 to 0.035 provided the bed friction boundary condition within the model. The USACE recommends n = 0.02 – 0.025 for sand channels and 0.075 – 0.150 for winding or overgrown channels (Donnell et al., 2005); Chow (1959) recommends n = 0.035 for rivers, and the U.S. Geological Survey (USGS) recommends n = 0.012 – 0.026 (Arcement and Schneider, 1989).

A turbulent exchange coefficient value of 30 – 70 lb-sec/ft^2 controlled the turbulence closure for the hydrodynamic model. This value falls within the 20 – 100 lb-sec/ft^2 range the model developers recommend for flow in tidal estuaries (Donnell et al., 2005).

The model calibration applied time-varying free surface water level boundary conditions from July 28 to September 3, 2009 offshore and on the Intracoastal Waterway east of the area of interest. NOAA tide measurements from Galveston Pleasure Pier provided the offshore water level boundary conditions for the model while measured tide data in the Intracoastal Waterway provided the water level boundary at that site.

USGS stream flow data from July to September 2009 provided freshwater input discharge data for model calibration. Taylor Engineering compiled the daily mean stream flow data for Trinity River, Cedar Bayou, San Jacinto River, and Buffalo Bayou for the calibration period and applied the data as time-varying freshwater input flows to the hydrodynamic model. An absence of data for Oyster Bayou precluded their inclusion in the model; however, because Trinity River contributes 60 – 70% of the freshwater to the system, the absence of Oyster Bayou freshwater input should have no significant affect on the study. Figure 2.5 indicates the boundary input locations for the time-varying freshwater input flows and water level boundary conditions.

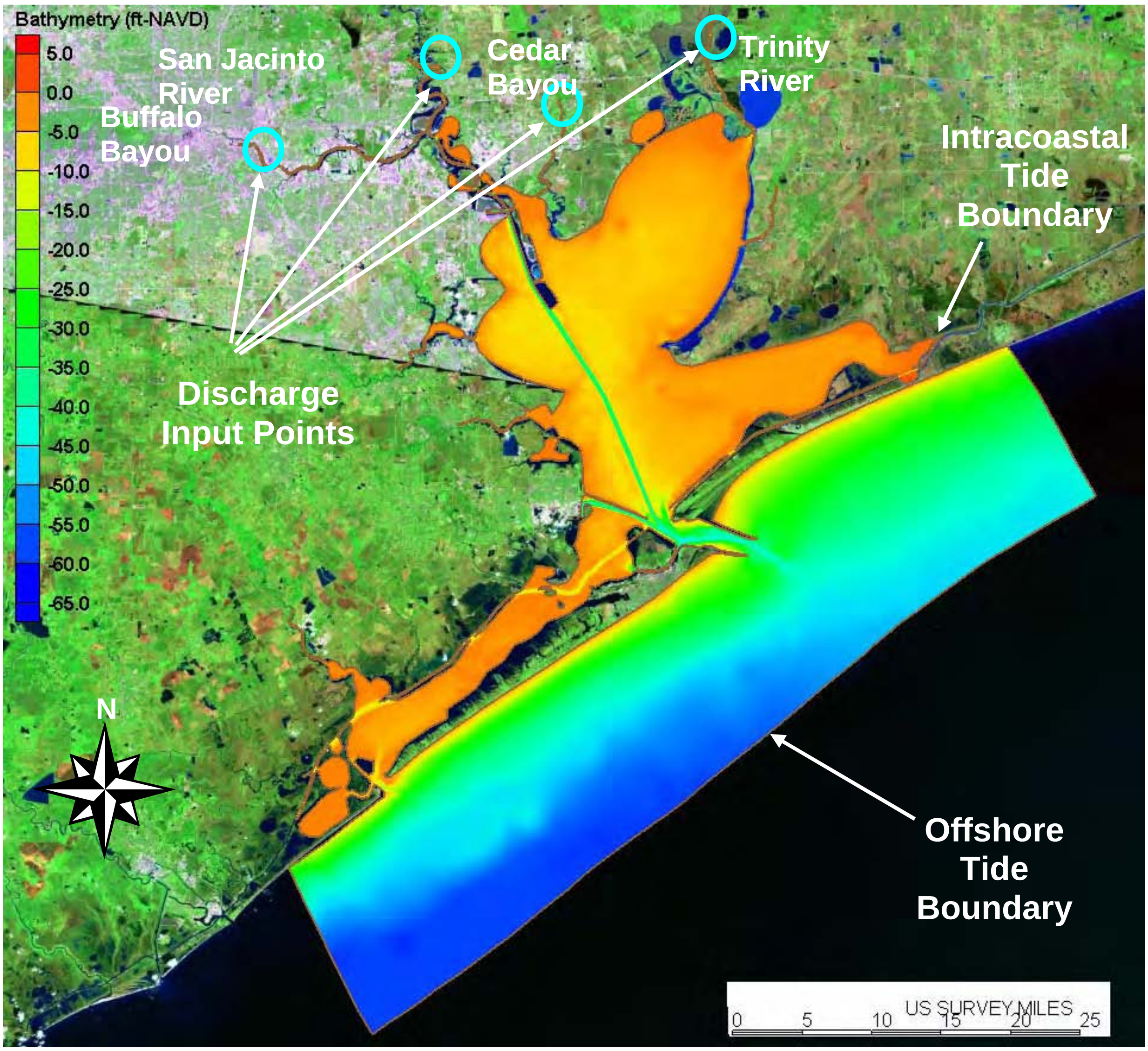

Figure 2.5 Hydrodynamic Model Boundary Condition Points

2.5 Hydrodynamic Model Calibration Results

A model's calibration demonstrates its capability to reproduce observed hydrodynamic conditions. The correlation coefficient (the ratio of the covariance of two data sets to the product of the variance of the data sets) provides a statistical measure of the correspondence of two data sets. Two coincident data sets have a correlation coefficient of 1.0 (i.e., the data sets match), while correlation coefficients approaching zero indicate less correspondence between the data sets.

The mean error (E = the average of the difference of between two data sets) provides another measure of the difference of two data sets. A positive value for the mean error indicates that the model overestimates the measured data, while a negative value indicates the model underestimates the data.

Finally, the root-mean-square error (E_{rms} = the square-root of the average of the square of the difference of between two data sets) indicates the absolute error of the compared data sets. Table 2.2 gives the formulas for each of the error measurements. In Table 2.2, x = measured data, y = model data, N = total number of data points, σ_x^2 = variance of the measured data, σ_y^2 = variance of the model data, and σ_{xy}^2 = covariance of the measured and model data.

Table 2.2 Error Measurement Formulas

	Symbol	**Formula**
Correlation coefficient	r^2	$r^2 = \frac{\sigma_{xy}^2}{\sigma_x^2 \sigma_y^2}$
Mean Error	E	$E = \frac{\sum_1^N (y-x)}{N}$
Root-Mean-Square Error	E_{rms}	$E_{rms} = \sqrt{\frac{\sum_1^N (y-x)^2}{N}}$

Figures 2.6 – 2.8 compare the modeled tidal stage with the measured tidal stage data at the three tide stations shown in Figure 2.4. The figures show only a representative portion of the complete model calibration period from July 28 to September 3, 2009; however, the indicated correlation coefficient (r^2) applies to the entire calibration period. Table 2.3 summarizes the tidal stage error measurements for each tide station over this period. Figures 2.6 – 2.8 and Table 2.3 indicate reasonable agreement between the modeled and measured tide water levels.

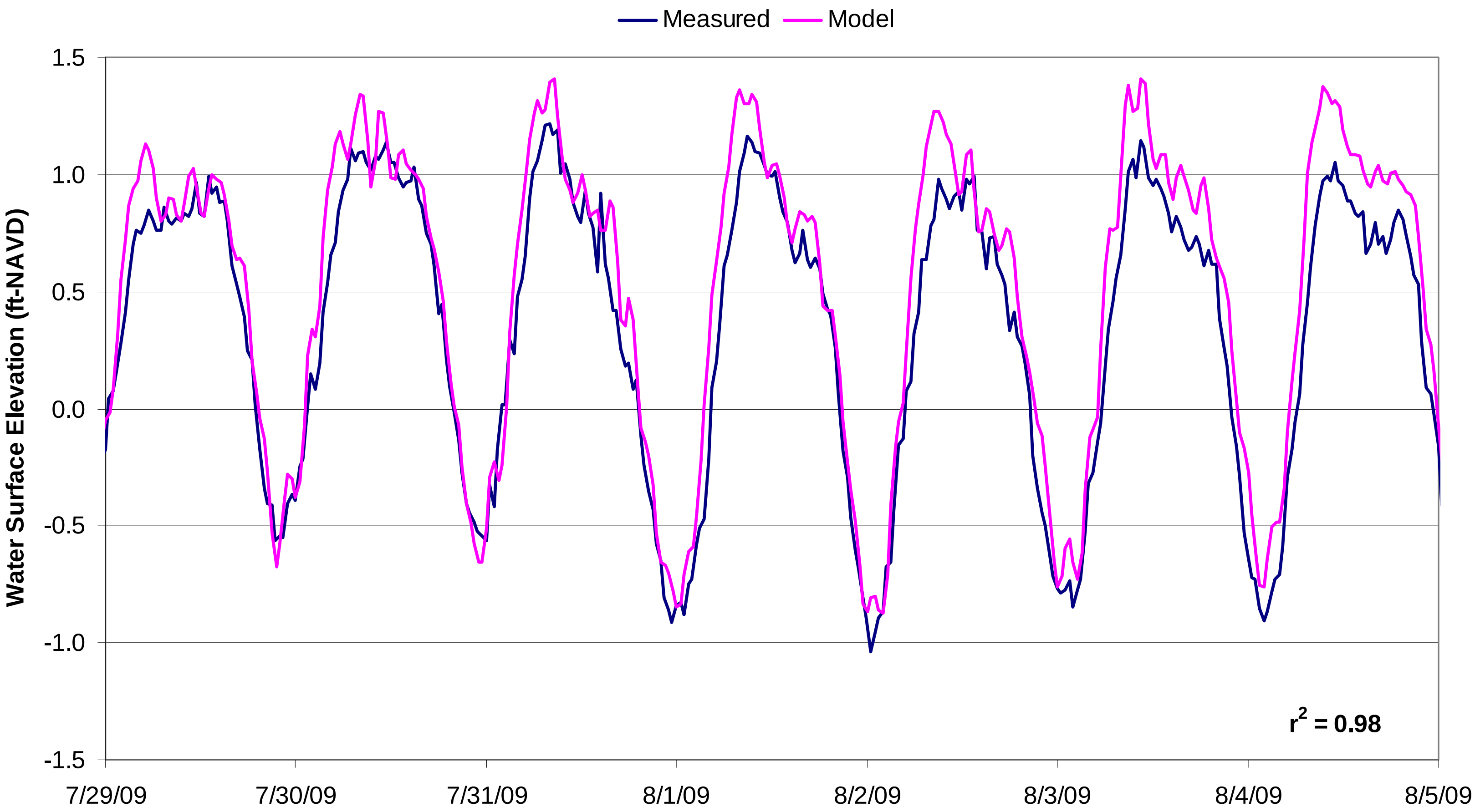

Figure 2.6 Sample Model Calibration Results at Tide Station 1

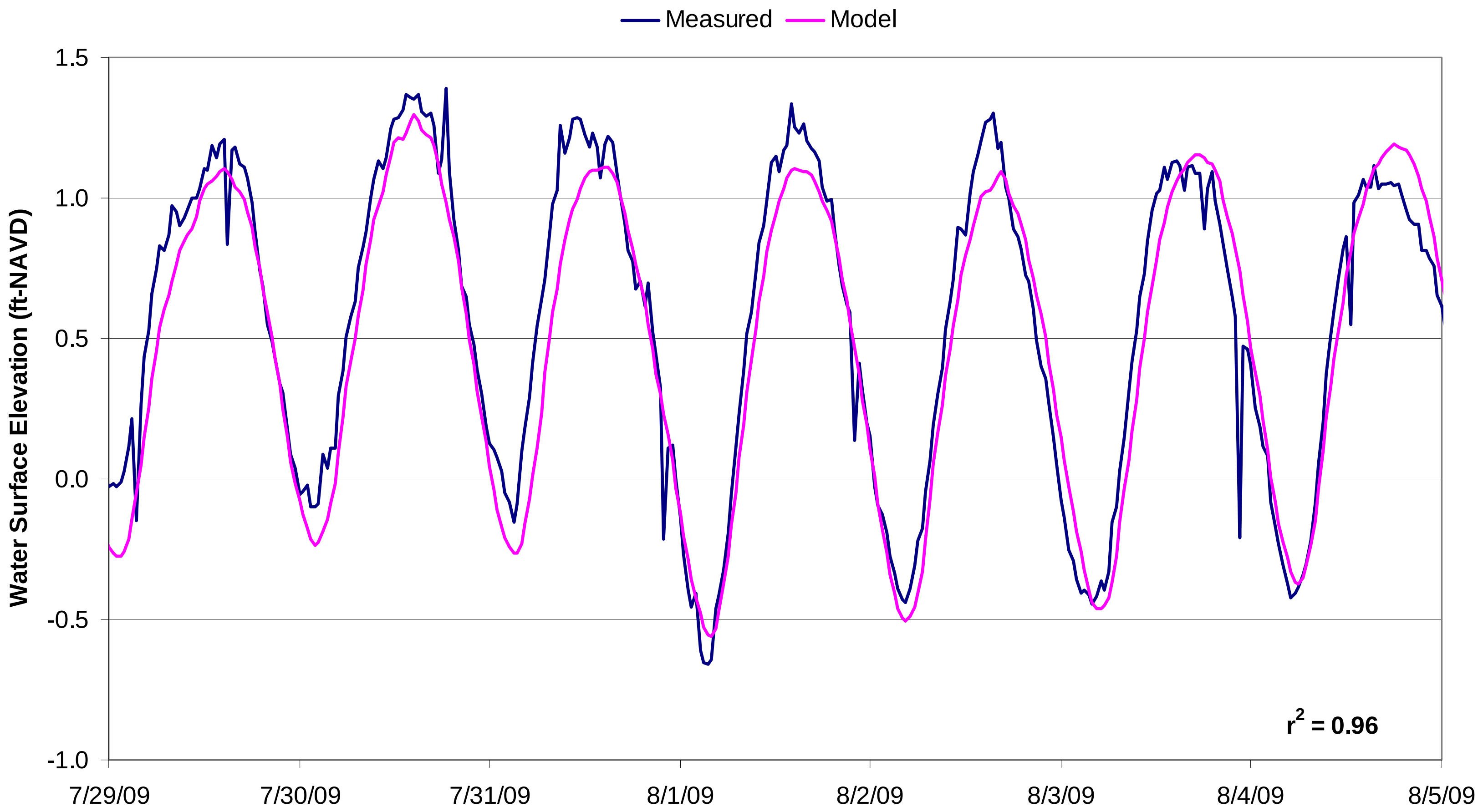

Figure 2.7 Sample Model Calibration Results at Tide Station 2

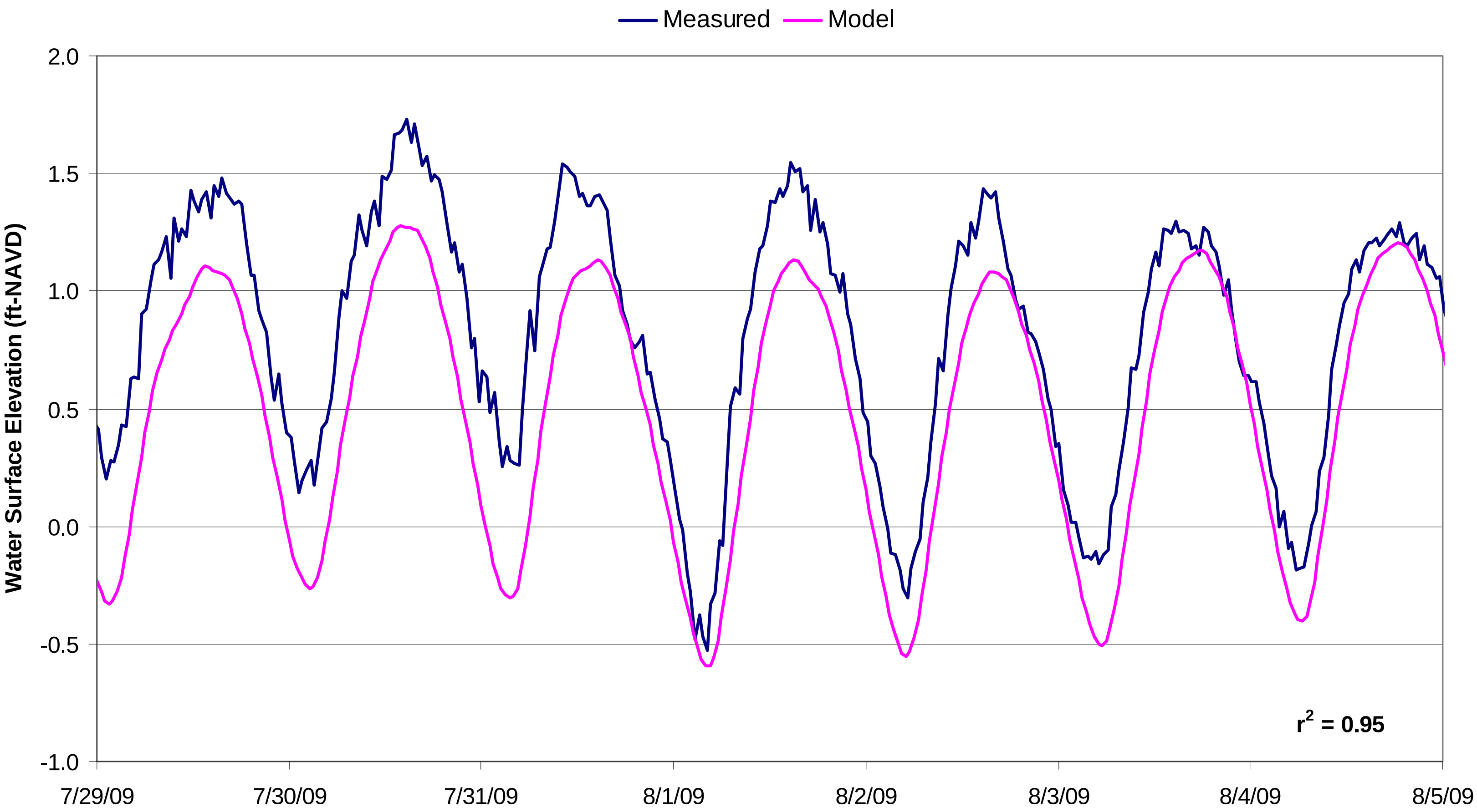

Figure 2.8 Sample Model Calibration Results at Tide Station 3

Table 2.3 Tide Station Error Measurement Summary

	Tide Station 1	Tide Station 2	Tide Station 3
Correlation coefficient	0.98	0.96	0.95
Mean Error	0.27	0.04	-0.15
Root-Mean-Square Error	0.30	0.16	0.23

Figures 2.9 – 2.16 show plots of the measured velocities against the RMA2 model depth-averaged velocities. The figures show two periods for each of the four velocity stations — one in July 2009 and one in September 2009. Each figure displays the continuous model output and discrete point values for the measured data. The ADCP recorded velocity profiles over the water column. Analysis of the measured data converted the ADCP data to depth-averaged velocities. During the velocity data collection, field personnel noted high wind conditions which may have caused velocity variations the model failed to capture. The effect of wind on the water surface layer was notable in several data sets, particularly the July readings at Station 4.

The discrete nature of the velocity measurements (i.e., non-continuous data) precludes the computation of the error estimates obtained for the tidal stage data. Tables 2.4 and 2.5 compare the average measured and modeled velocities at each location for the two data collection periods. The figures and table show adequate agreement between depth-averaged model velocities and ADCP velocities converted to depth-averaged velocities. Notably, the velocity stations in Rollover Pass and Rollover Bay — locations with the most up-to-date bathymetric data — showed the closest agreement.

Table 2.4 Velocity Station Mean Velocity Comparison, Data Period 1

	Velocity Station 1	Velocity Station 2	Velocity Station 3	Velocity Station 4
Measured Mean Velocity (ft/s)	1.75	1.21	0.60	0.69
Modeled Mean Velocity (ft/s)	1.99	1.18	0.62	0.42
Difference (ft/s)	+0.24	-0.03	+0.02	-0.27

Table 2.5 Velocity Station Mean Velocity Comparison, Data Period 2

	Velocity Station 1	Velocity Station 2	Velocity Station 3	Velocity Station 4
Measured Mean Velocity (ft/s)	0.75	0.38	0.17	0.29
Modeled Mean Velocity (ft/s)	0.87	0.27	0.93	0.26
Difference (ft/s)	+0.12	-0.11	+0.76	-0.03

Overall, the comparison of measured and model data indicate that the model satisfactorily reflects the physical processes in the study area.

Figure 2.9 Model Calibration Results at Velocity Station 1, Data Period 1

Figure 2.10 Model Calibration Results at Velocity Station 1, Data Period 2

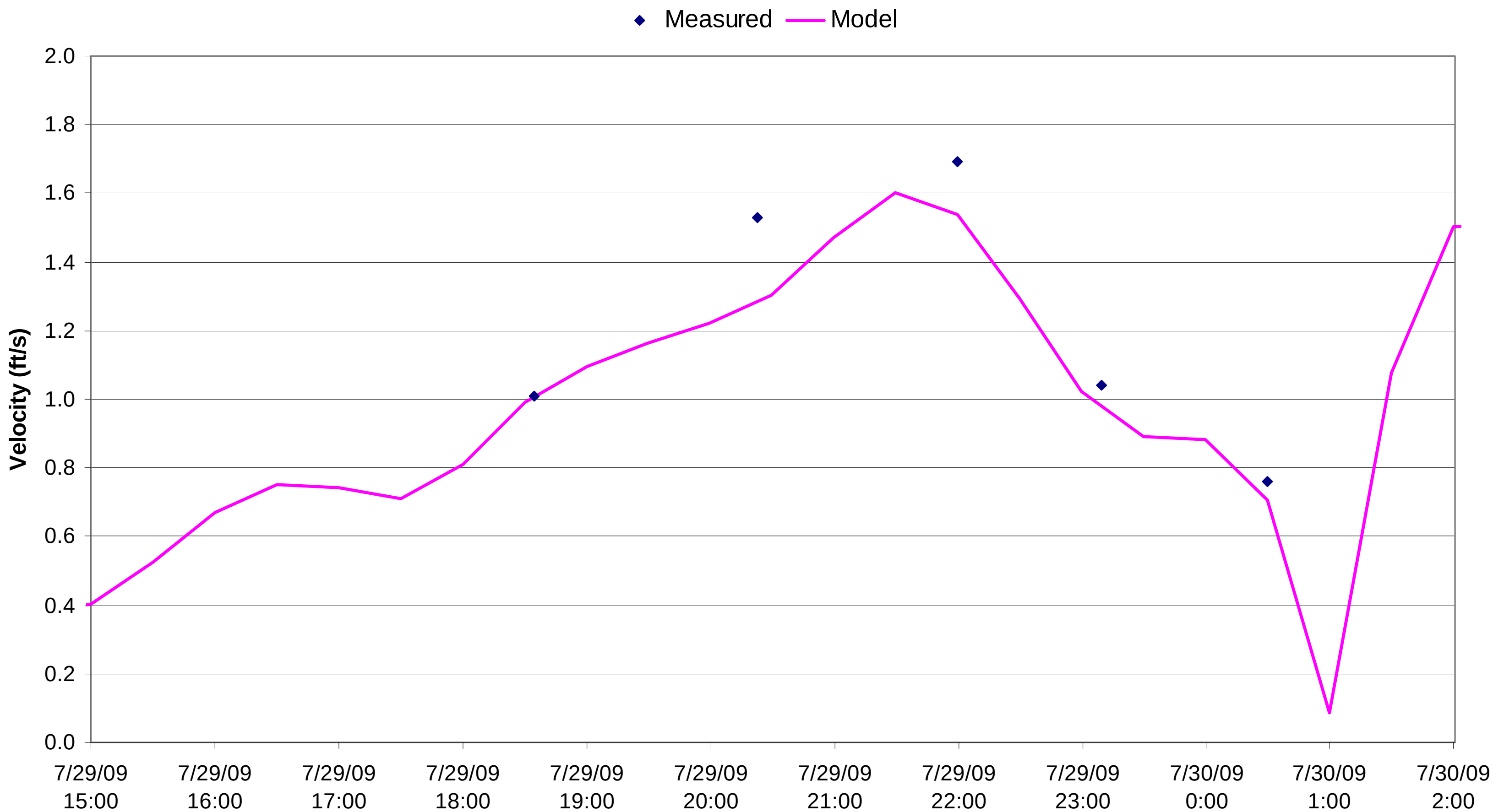

Figure 2.11 Model Calibration Results at Velocity Station 2, Data Period 1

Figure 2.12 Model Calibration Results at Velocity Station 2, Data Period 2

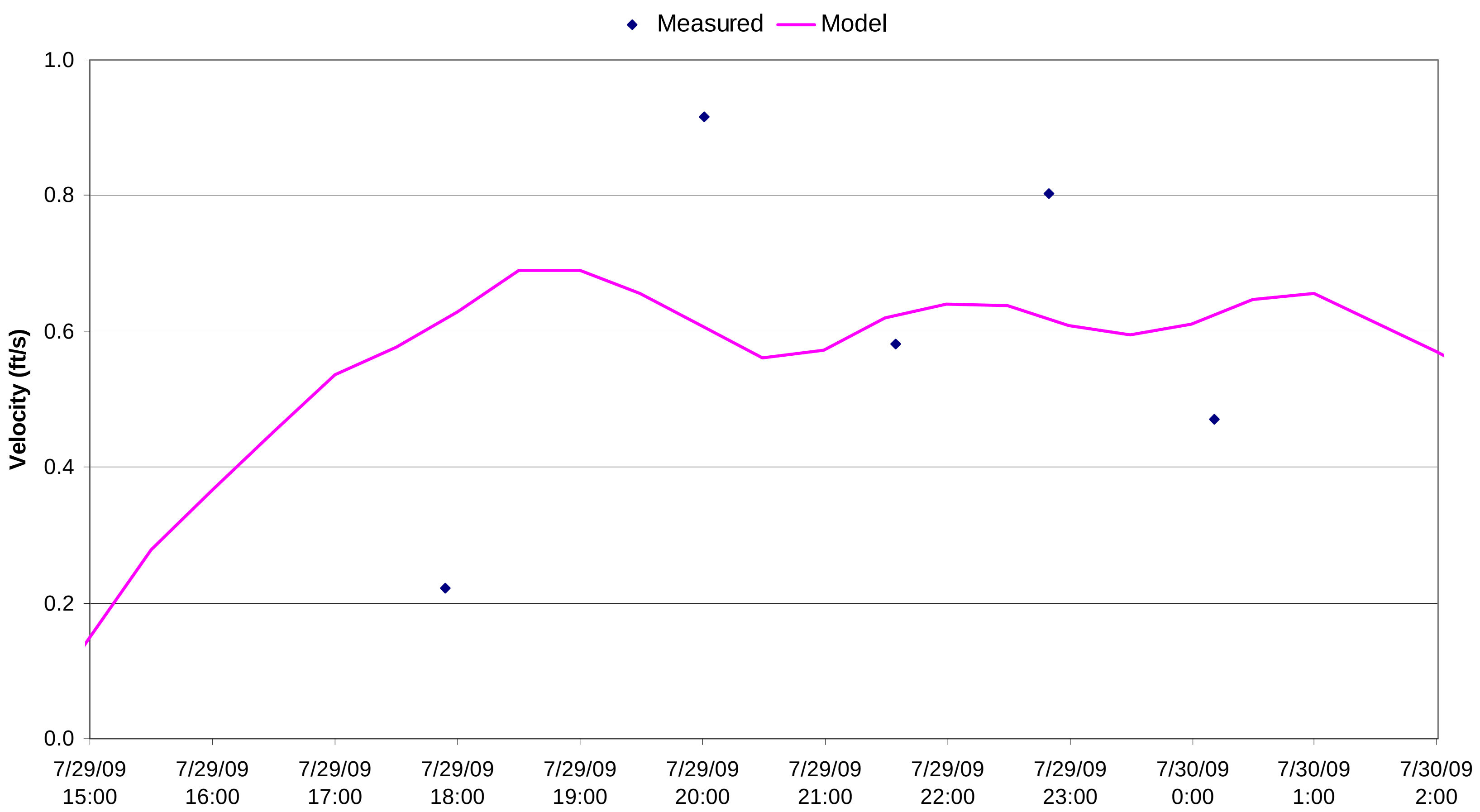

Figure 2.13 Model Calibration Results at Velocity Station 3, Data Period 1

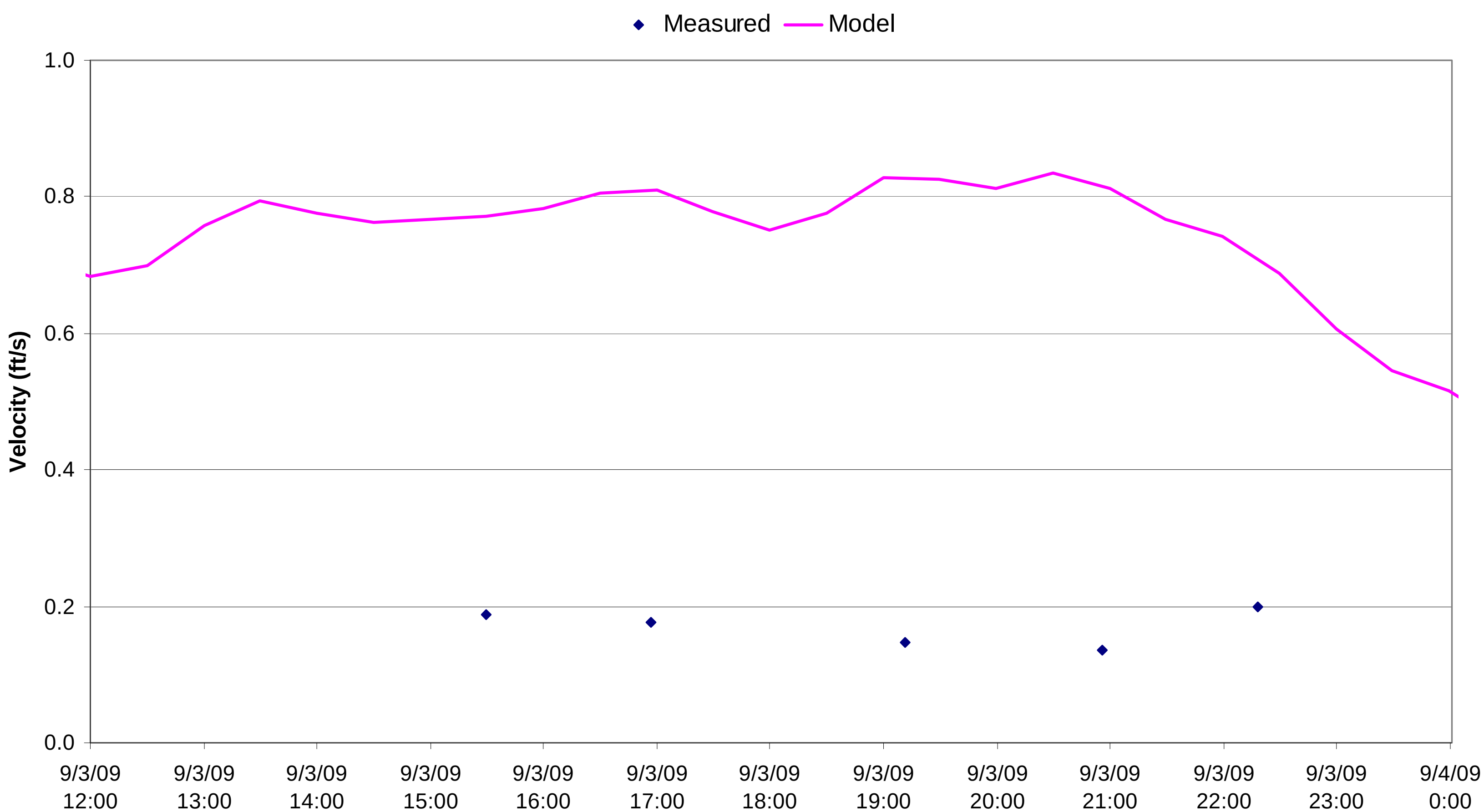

Figure 2.14 Model Calibration Results at Velocity Station 3, Data Period 2

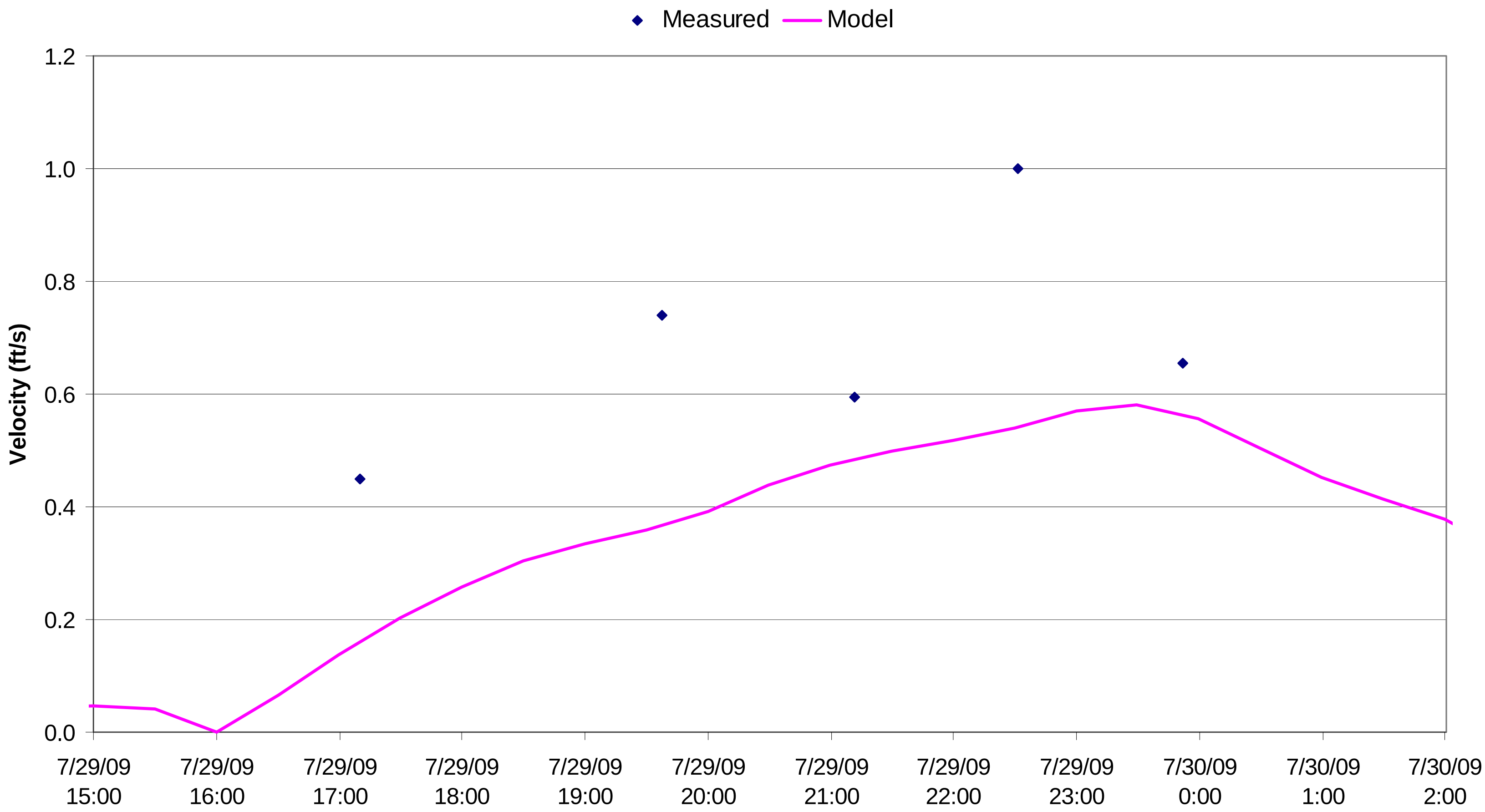

Figure 2.15 Model Calibration Results at Velocity Station 4, Data Period 1

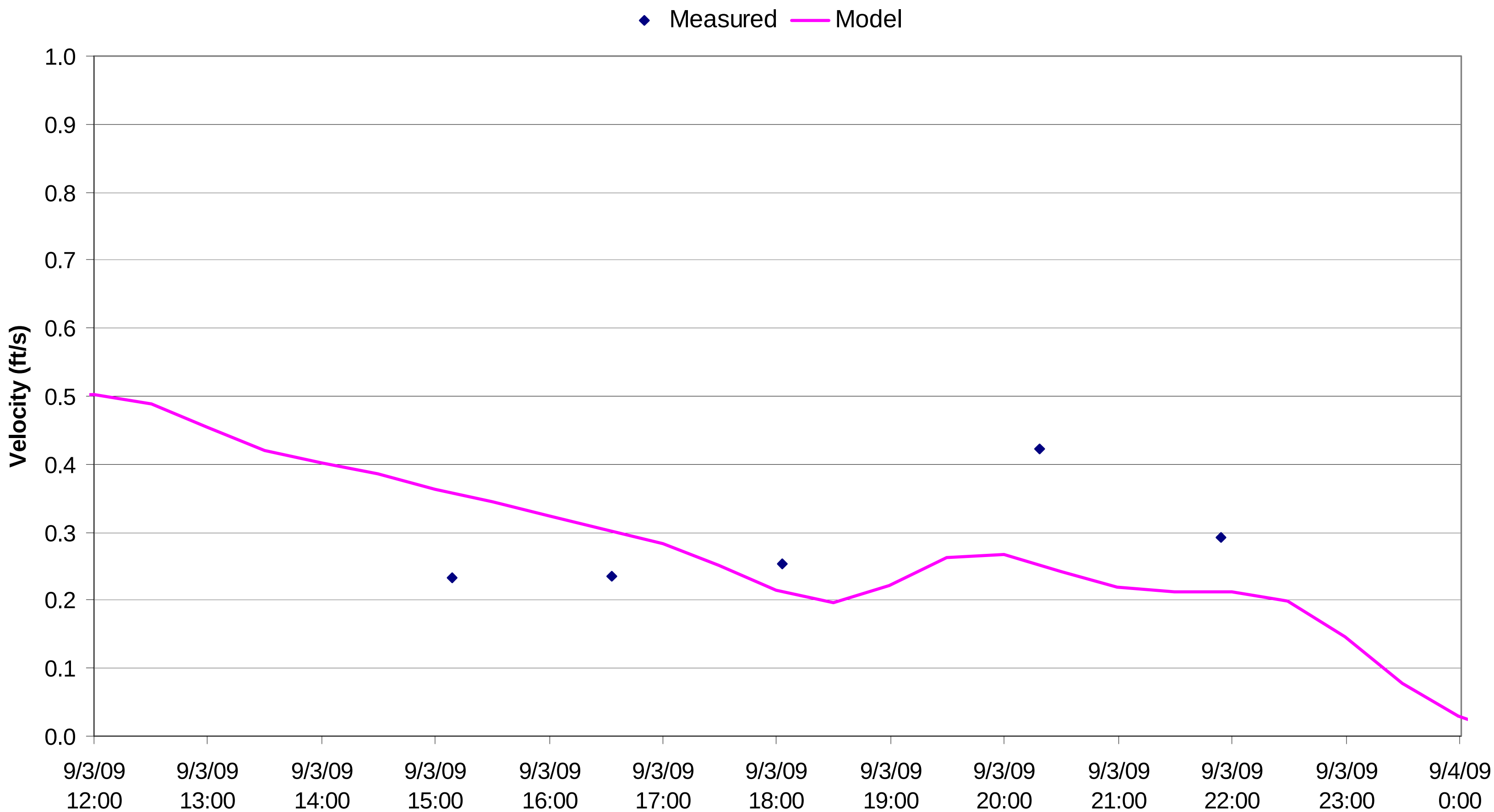

Figure 2.16 Model Calibration Results at Velocity Station 4, Data Period 2

2.6 Transport Model Calibration Data, Parameters and Boundary Conditions

Taylor Engineering collected salinity data on August 4, 5, 12, and 13, 2009 at the eight locations shown in Figure 2.17. As with the velocity data, salinity data reflect discrete time periods and depths over the water column at the various locations. Analysis of the data provided depth-averaged values.

Peclet number control automatically assigned the model diffusion coefficient for the transport model with a Peclet number equal to 20 throughout the model. The earliest measured data provided the initial salinity values throughout the system.

Figure 2.17 Salinity Data Collection Stations

2.7 Transport Model Calibration Results

Figures 2.18 – 2.25 compare the modeled and measured salinity results. The figures show reasonable agreement between the modeled and the measured salinity. The data set contains 59 data points recorded between August 4 and 13, 2009. The model produced salinities within 2 parts per thousand (ppt) for 52 of the 59 measured data points or 88%. All model results fall within about 8 ppt of the measured data. Table 2.6 shows the mean measured salinity, mean modeled salinity, and the difference between the modeled and measured means at each station over the collection period. On average, the mean model and measured salinities differed by only 1 – 2 ppt.

Table 2.6 Salinity Station Mean Salinity Comparison

	Station 1	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 7**	**Station 8**
Measured Mean Salinity (ppt)	25	24	26	30	27	30	33	37
Modeled Mean Salinity (ppt)	26	25	28	30	26	31	32	36
Difference (ppt)	+1	+1	+2	0	-1	+1	-1	-1

Overall, the comparison of measured salinity and model output indicate that the transport model satisfactorily reflects the processes in the study area.

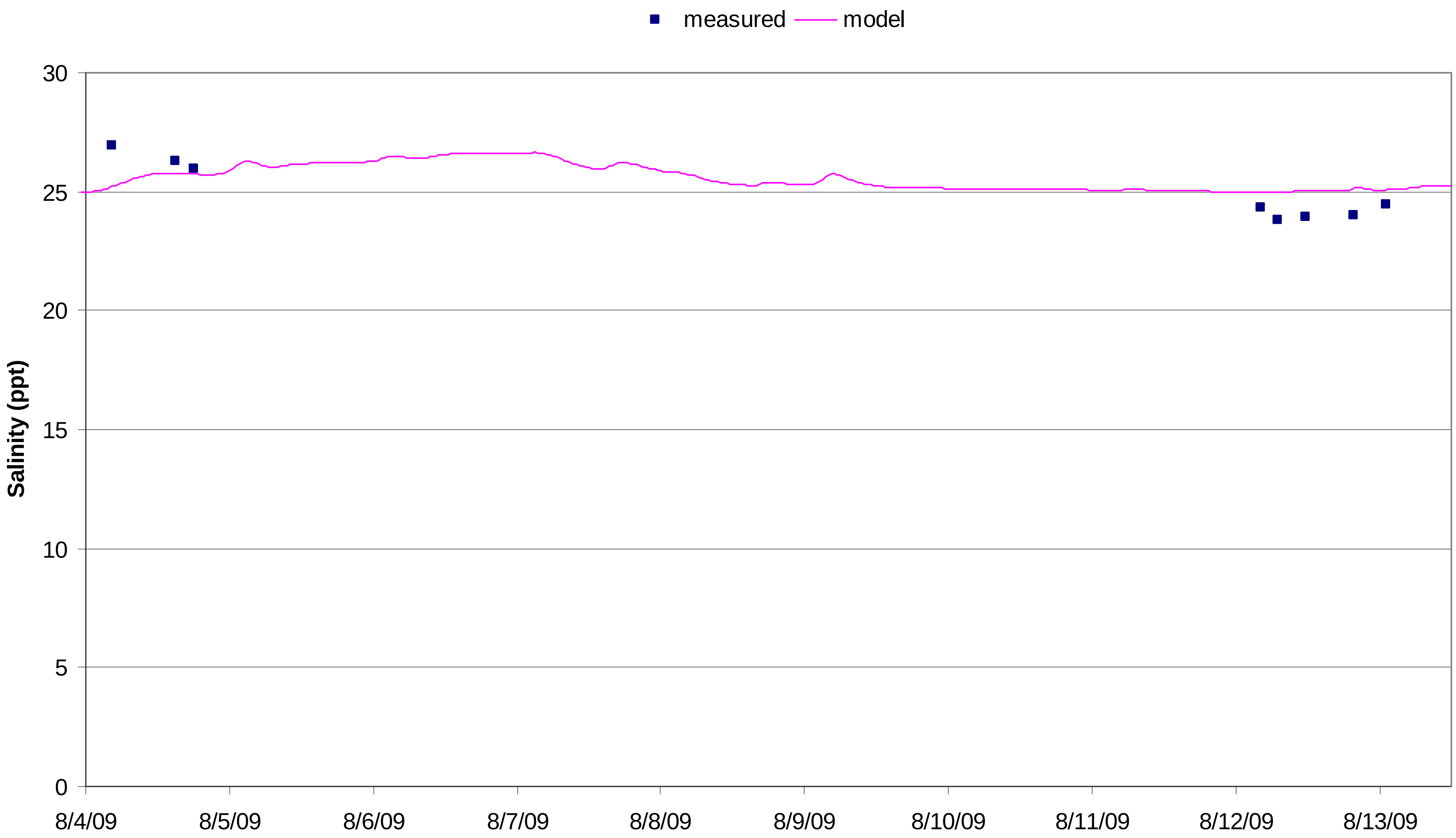

Figure 2.18 Transport Model Calibration Results, Salinity Station 1

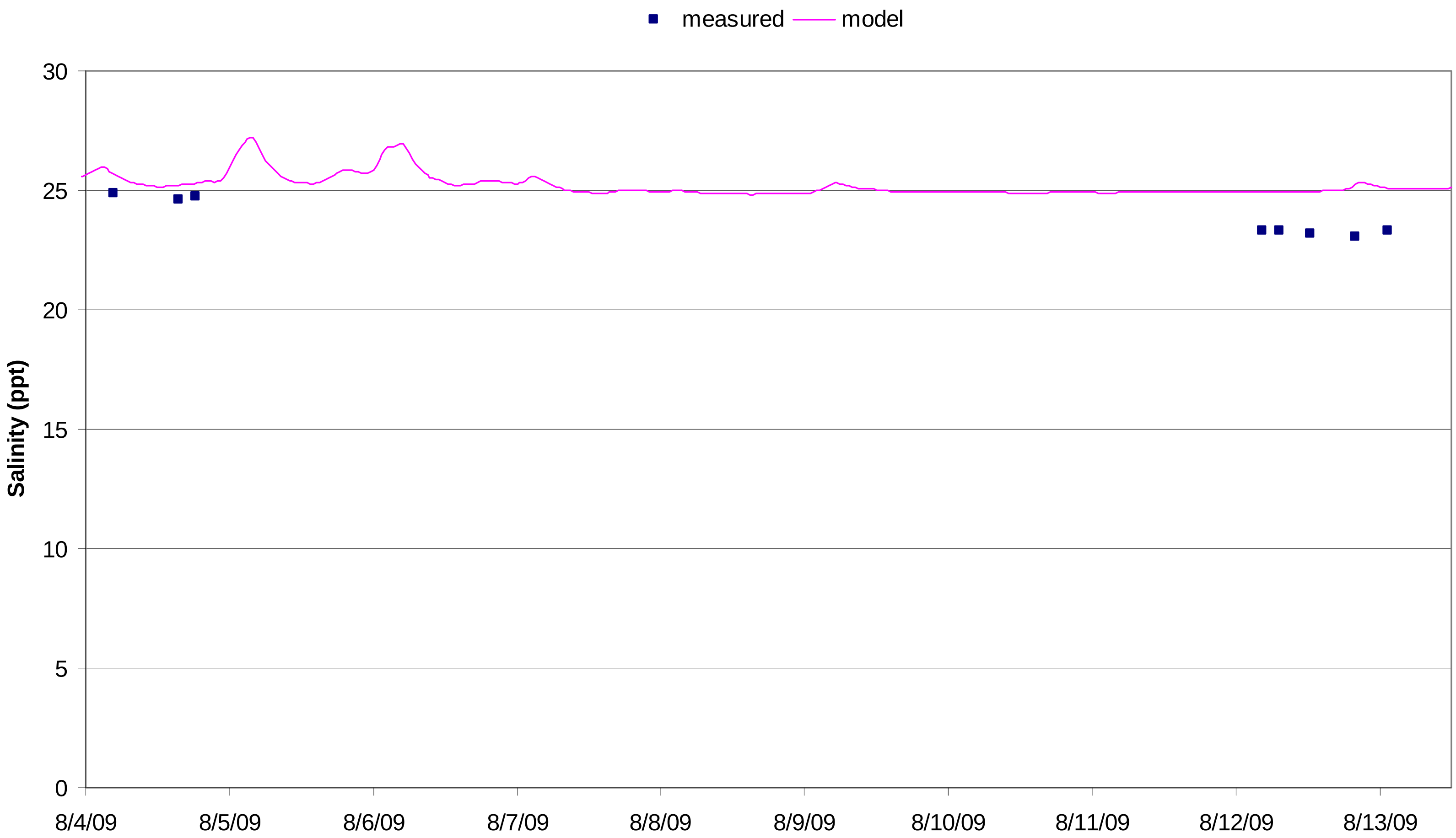

Figure 2.19 Transport Model Calibration Results, Salinity Station 2

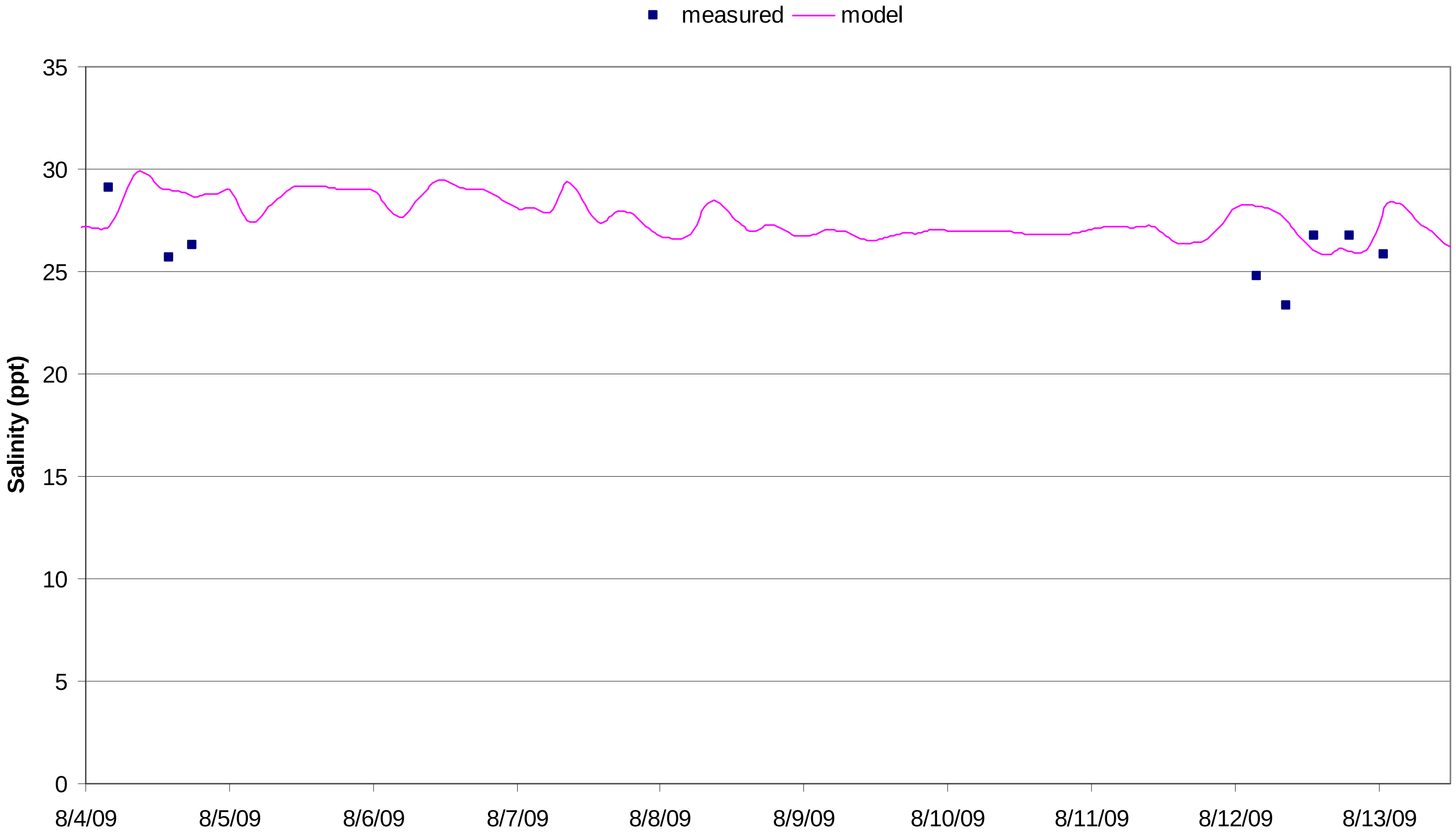

Figure 2.20 Transport Model Calibration Results, Salinity Station 3

Figure 2.21 Transport Model Calibration Results, Salinity Station 4

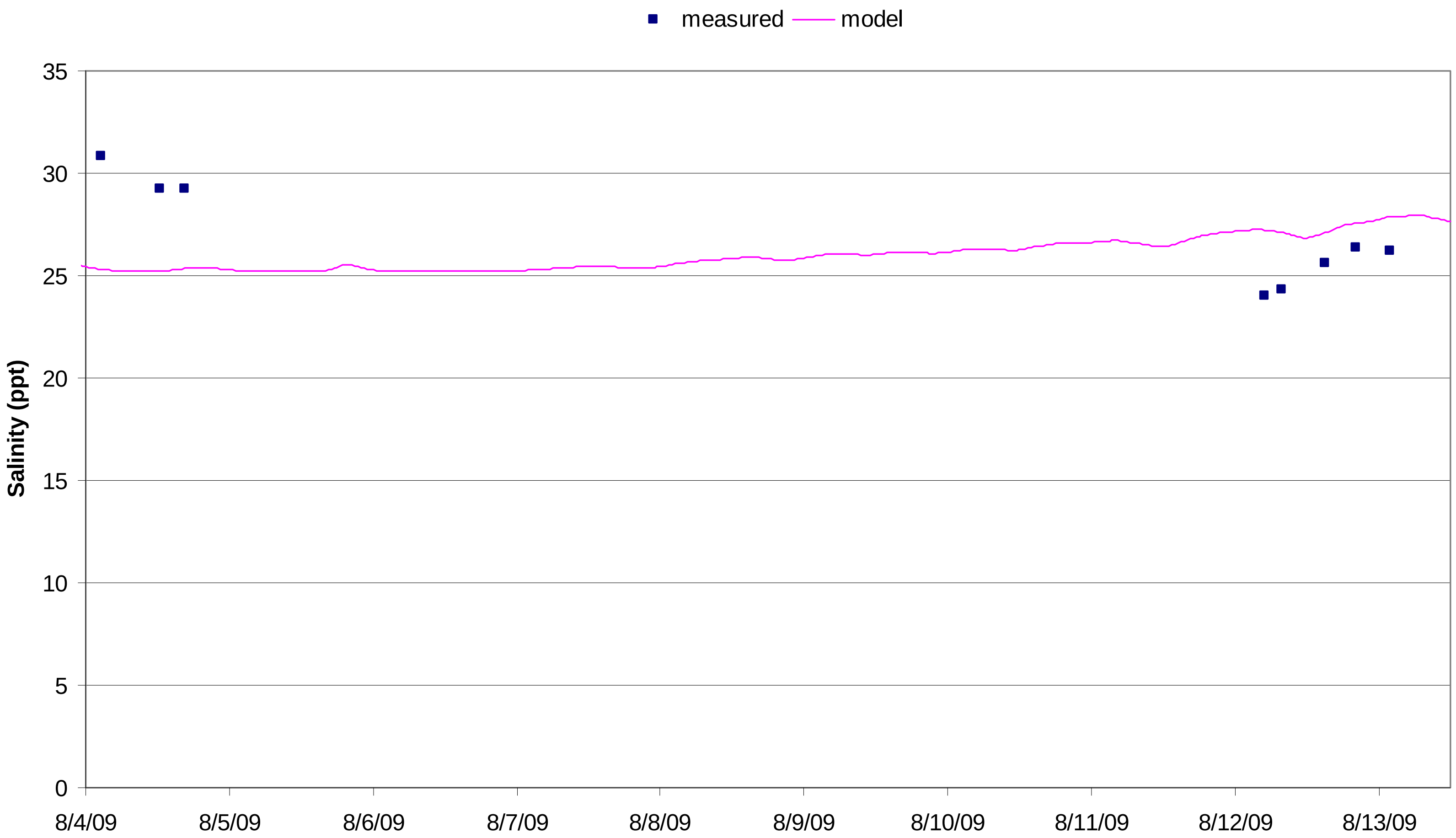

Figure 2.22 Transport Model Calibration Results, Salinity Station 5

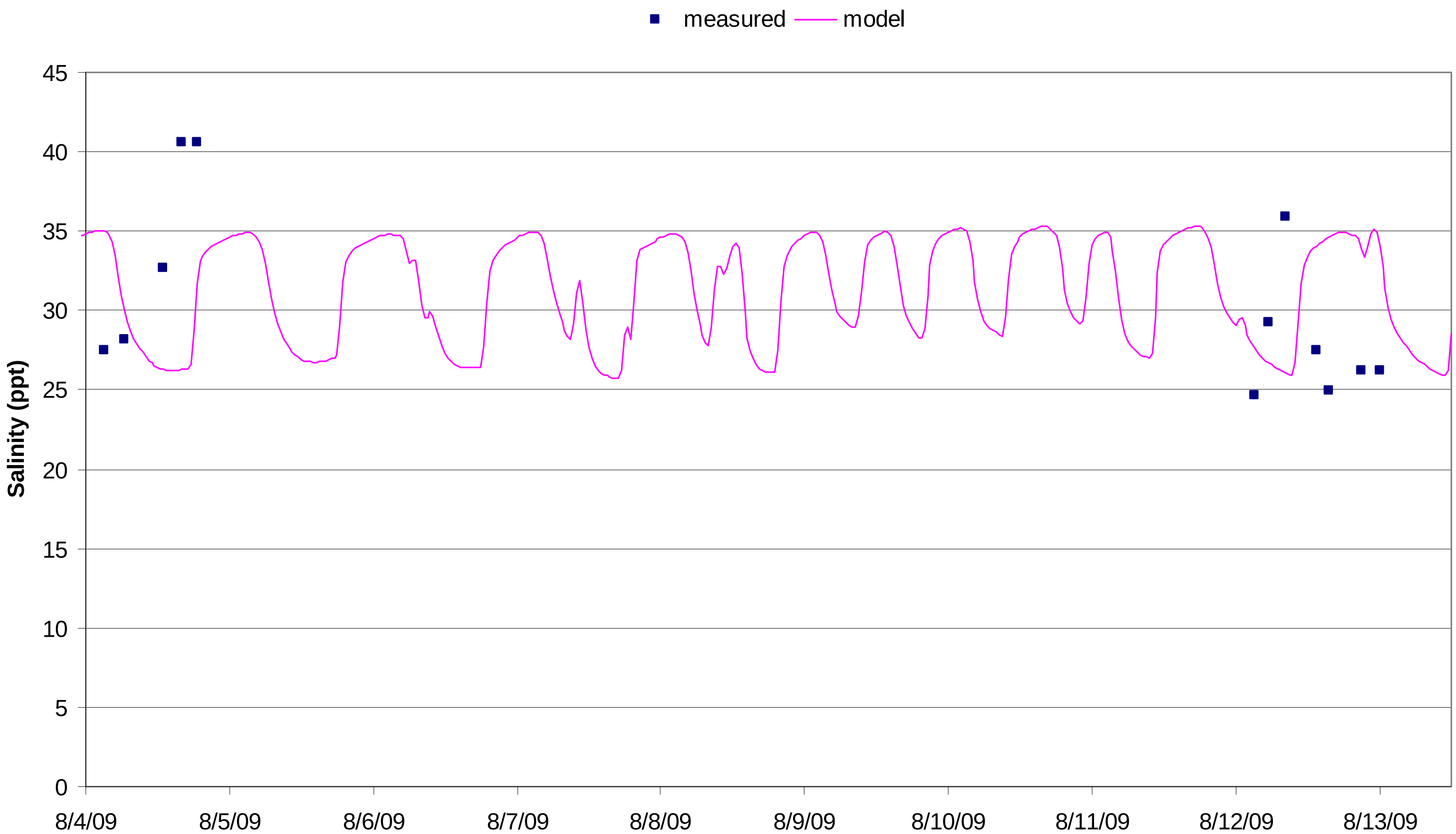

Figure 2.23 Transport Model Calibration Results, Salinity Station 6

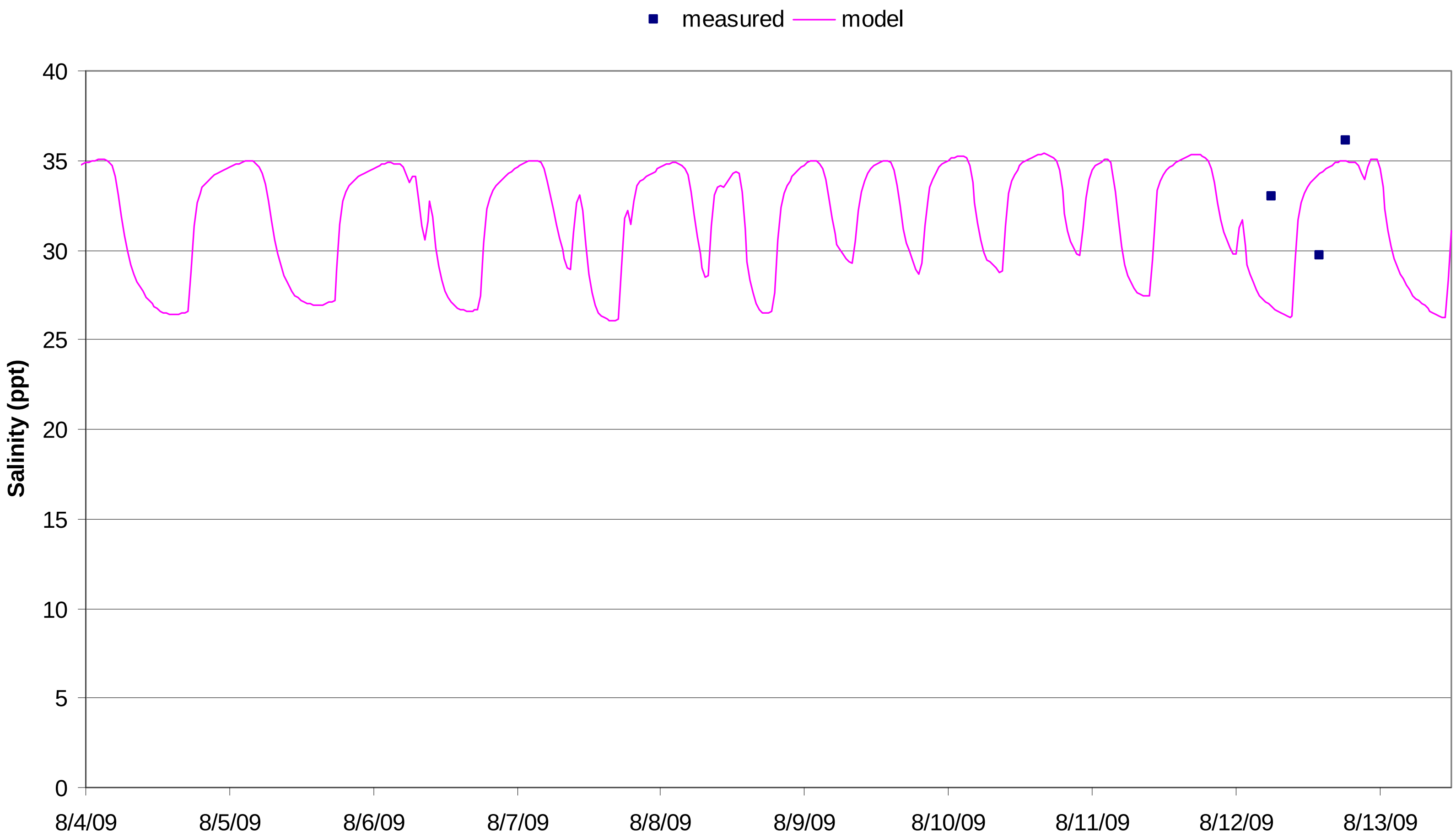

Figure 2.24 Transport Model Calibration Results, Salinity Station 7

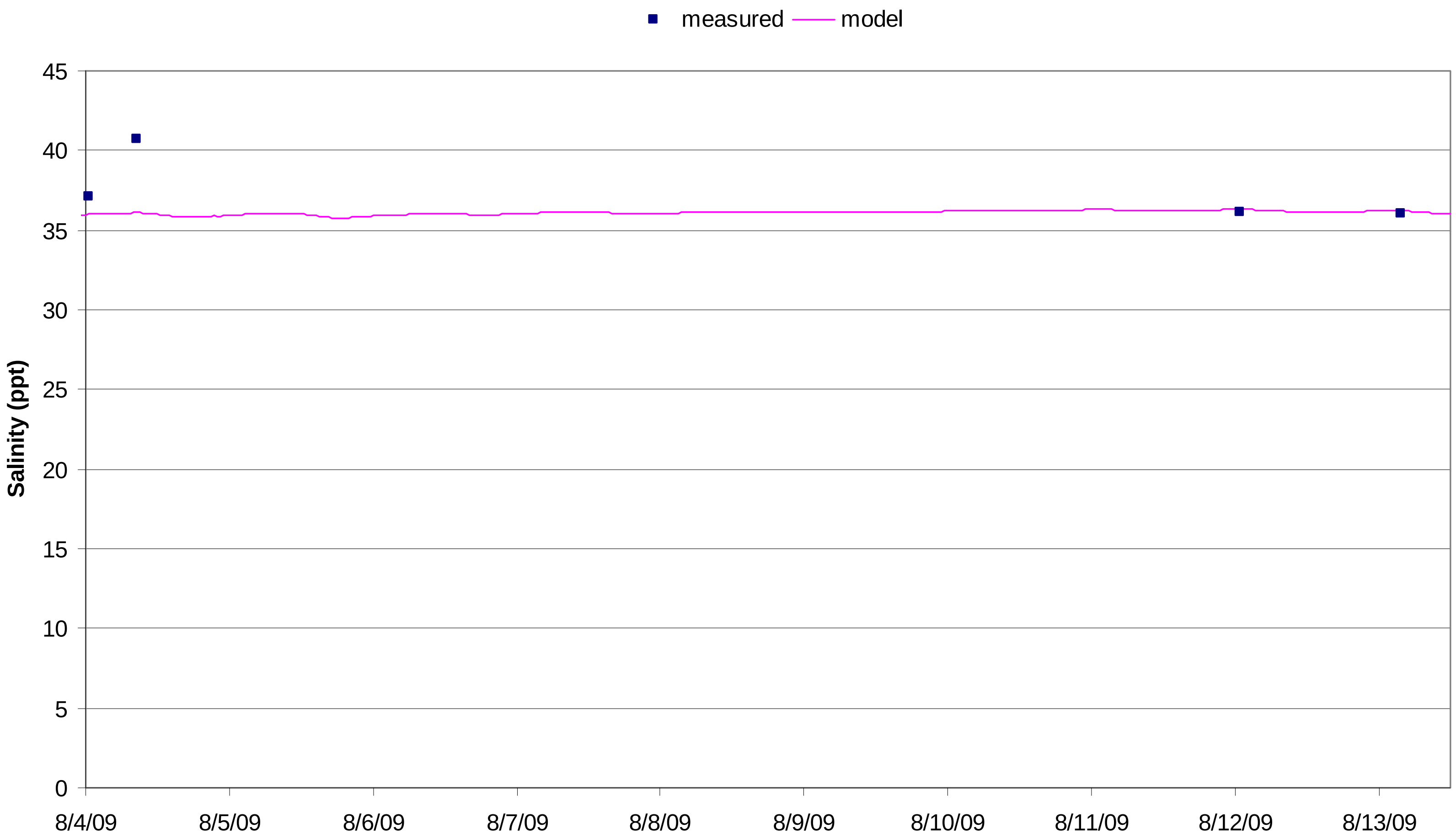

Figure 2.25 Transport Model Calibration Results, Salinity Station 8

3.0 LONG-TERM MODELING OF THE CLOSURE OF ROLLOVER PASS

3.1 Methodology Overview and Boundary Conditions

This study examines the effect of closing Rollover Pass on salinity in Rollover, East, and Galveston Bays. To accomplish this, the study needs to simulate salinity in the system over several years for the existing and proposed physical conditions of the study area (i.e., Rollover Pass open and Rollover Pass closed).

Hydrodynamic models such as RMA2 generally command very high computational costs — in the form of prohibitively long model run times and large solution file sizes — to simulate extended time periods (i.e., multiple years). These high computational costs make such long-term hydrodynamic simulations impractical without the use of expensive high performance computing facilities running multi-processor clusters and parallelized hydrodynamic and transport models.

However, an analysis of historic (1936 – 2009) daily stream flow records indicated generally consistent seasonal variations in the freshwater entering the bays. This analysis suggested that representative month-long hydrodynamic simulations with seasonally varying freshwater input would provide a computationally cost-effective method to simulate long-term hydrodynamic conditions. The less computationally expensive transport model (RMA4) can draw on the hydrodynamic model solutions representing the appropriate season and provide a numerical description of salinity transport processes spanning several years.

Analysis of the stream flow records at Trinity River, Cedar Bayou, San Jacinto River, and Buffalo Bayou from 1936 to 2009 showed seasonally varying stream flow values roughly corresponding to spring, summer, fall, and winter. As noted in Chapter 2, no data exists for Oyster Bayou. Figure 3.1 combines stream flow data from 1936 to 2009 and shows the average daily stream flow statistics over a representative year. Figure 3.2 compares the total stream flow statistics to representative constant seasonal flows applied as model boundary conditions. Table 3.1 lists the model input stream flow values and the period of the stream flow record analyzed at each input location.

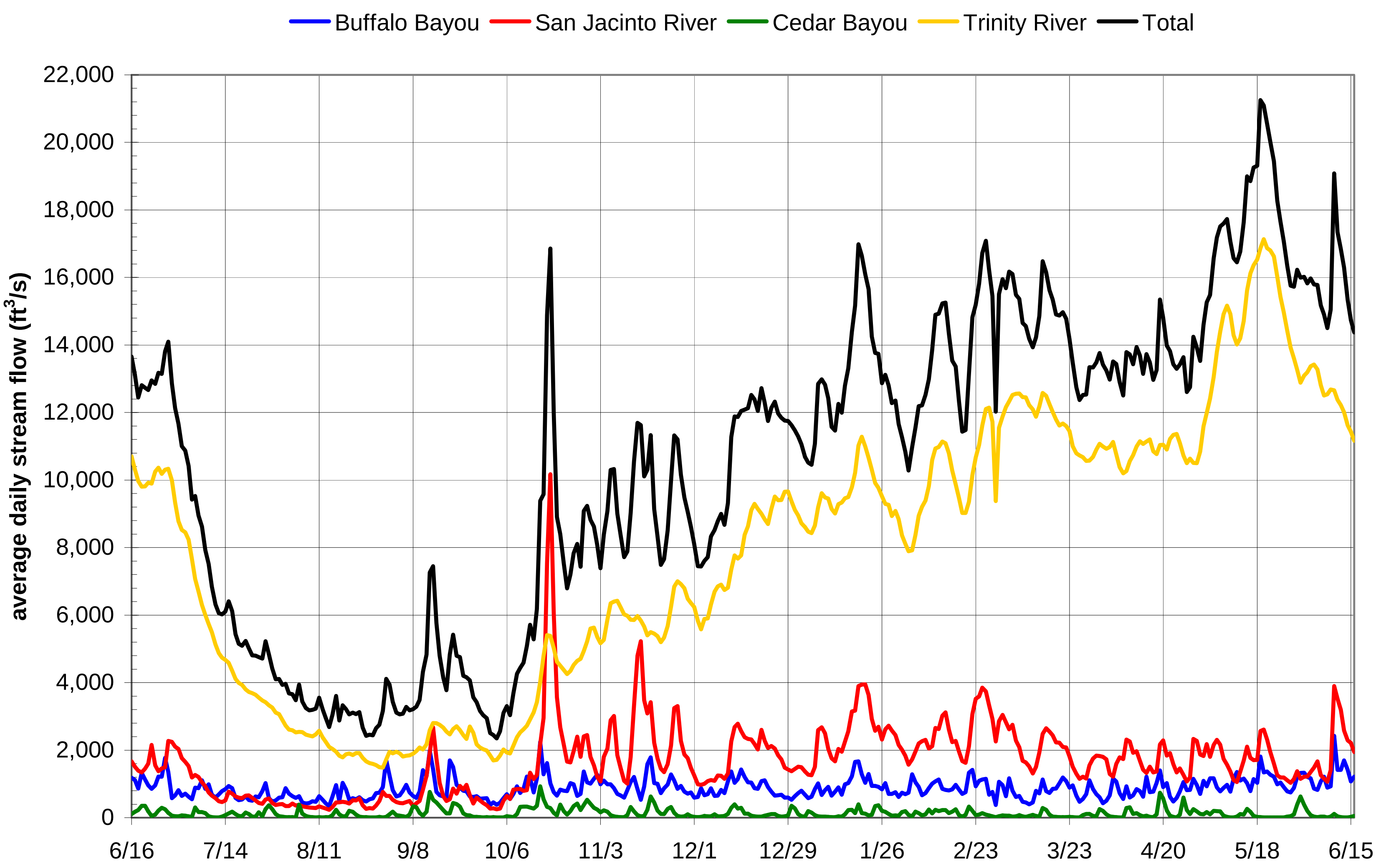

Figure 3.1 Representative Annual Daily Stream Flow Statistics at Model Input Location

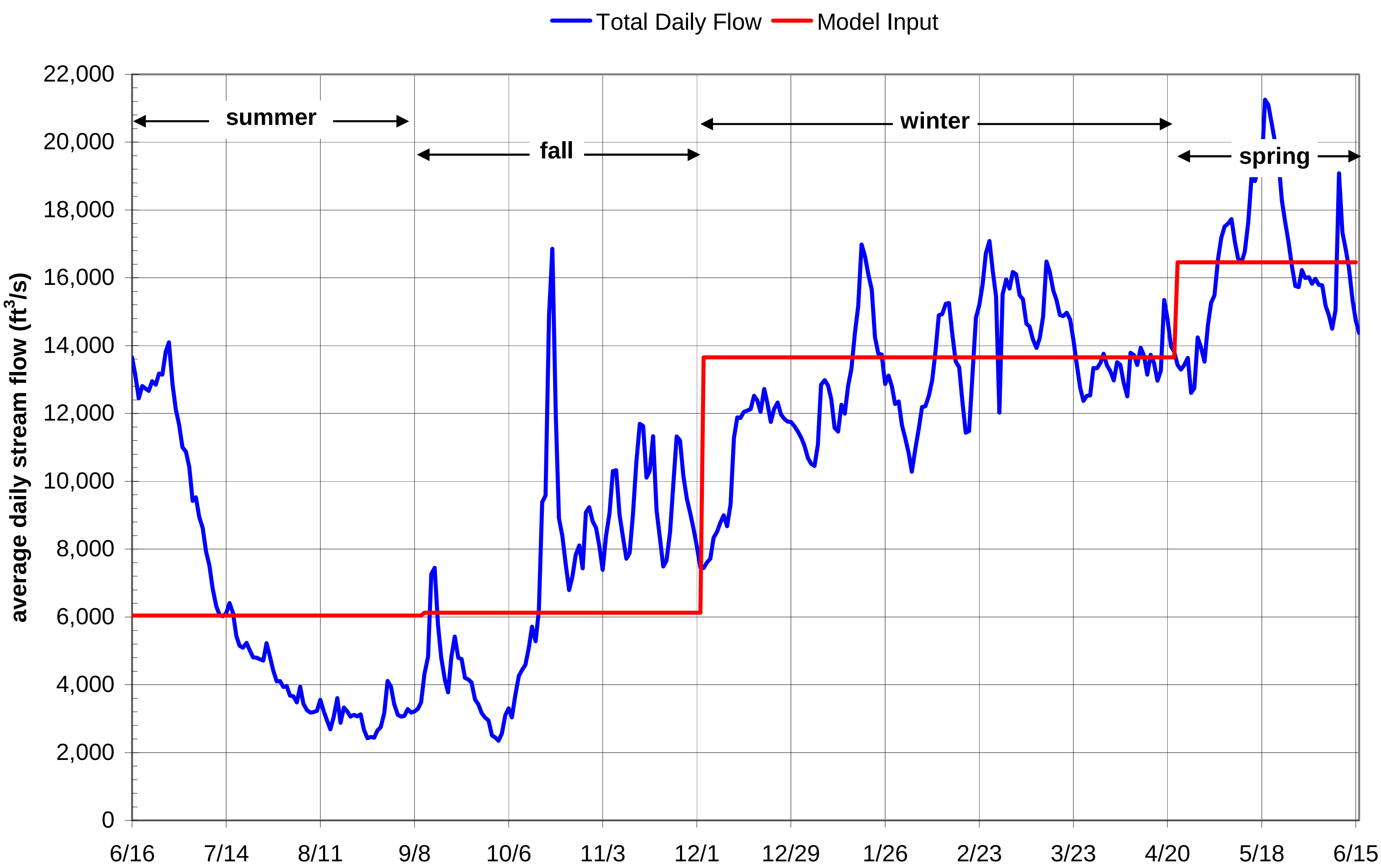

Figure 3.2 Representative Annual Total Daily Stream Flow and Constant Model Input Stream Flow

Table 3.1 Model Stream Flow Input

Input Location	Winter Flow (cfs)	Spring Flow (cfs)	Summer Flow (cfs)	Fall Flow (cfs)	Record Period
Trinity River	10,500	13,507	4,427	3,347	1936 – 2009
Cedar Bayou	114	105	102	232	2001 – 2009
San Jacinto River	2,189	1,747	755	1,611	1939 – 2009
Buffalo Bayou	855	1,098	755	932	1936 – 2009
Total	13,658	16,457	6,039	6,122	–

Similarly, an analysis of the tidal record at Galveston Pleasure Pier from 2004 to 2009 developed representative tidal characteristics for each season. Figure 3.3 shows the weekly mean, high, and low water levels from the analysis period plotted against the model input water level. Figure 3.4 compares the month-long (28-day) model input tide boundary conditions applied to each season. Figure 3.3 shows that the representative tide follows the general pattern of mean high and low tide over the typical year. Additionally, the model input tide captures the higher mean tide levels seen in the late summer through fall months. Figure 3.4 shows that the representative 28-day periods capture typical spring and neap tides, and successive model periods do not introduce large discontinuities into the model water levels. Notably, a reduced tide range accompanies the higher mean tide levels in the late summer through fall months.

3.2 Model Procedure

The hydrodynamic simulations developed in this study consisted of four seasonally representative one-month (28-day) simulations on each of the two model domains (Rollover Pass open and Rollover Pass closed). Each simulation applied time varying tidal inputs (Figures 3.3 and 3.4) and constant freshwater inputs (Figure 3.2) to model a full lunar cycle (28 days) and yield a solution representative of a given season.

Properly sequenced, the month-long seasonal simulations generate representative hydrodynamic conditions over multiple years. The transport model applied these hydrodynamic conditions to determine the circulation and mixing of saline water and freshwater throughout the system. The transport model applied a constant offshore boundary salinity of 37 ppt and 0 ppt at the stream flow input locations throughout the simulation. This boundary derived from the measured data collected from July – September 2009.

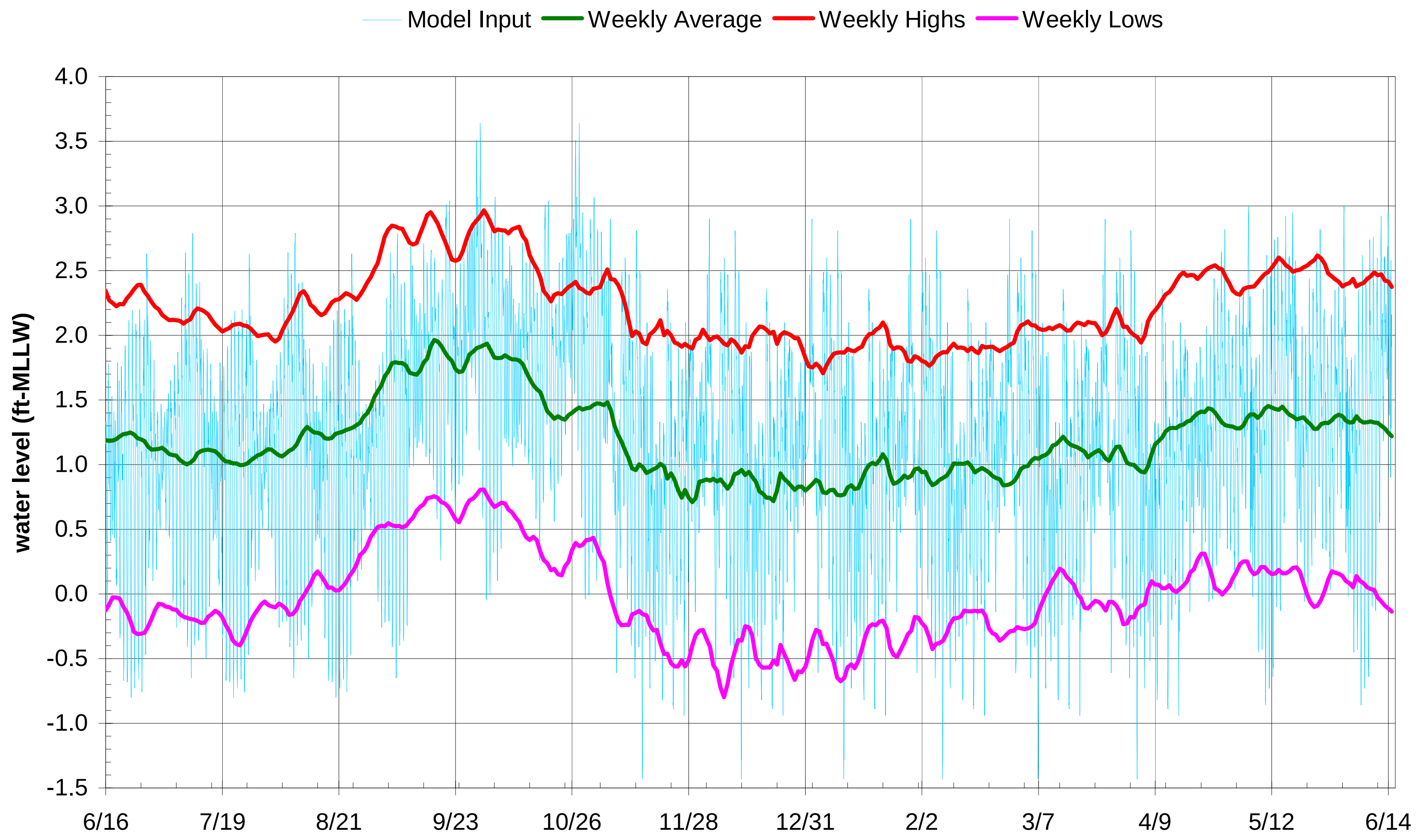

Figure 3.3 Model Tide Input vs. Measured Mean, High, and Low Tide Levels

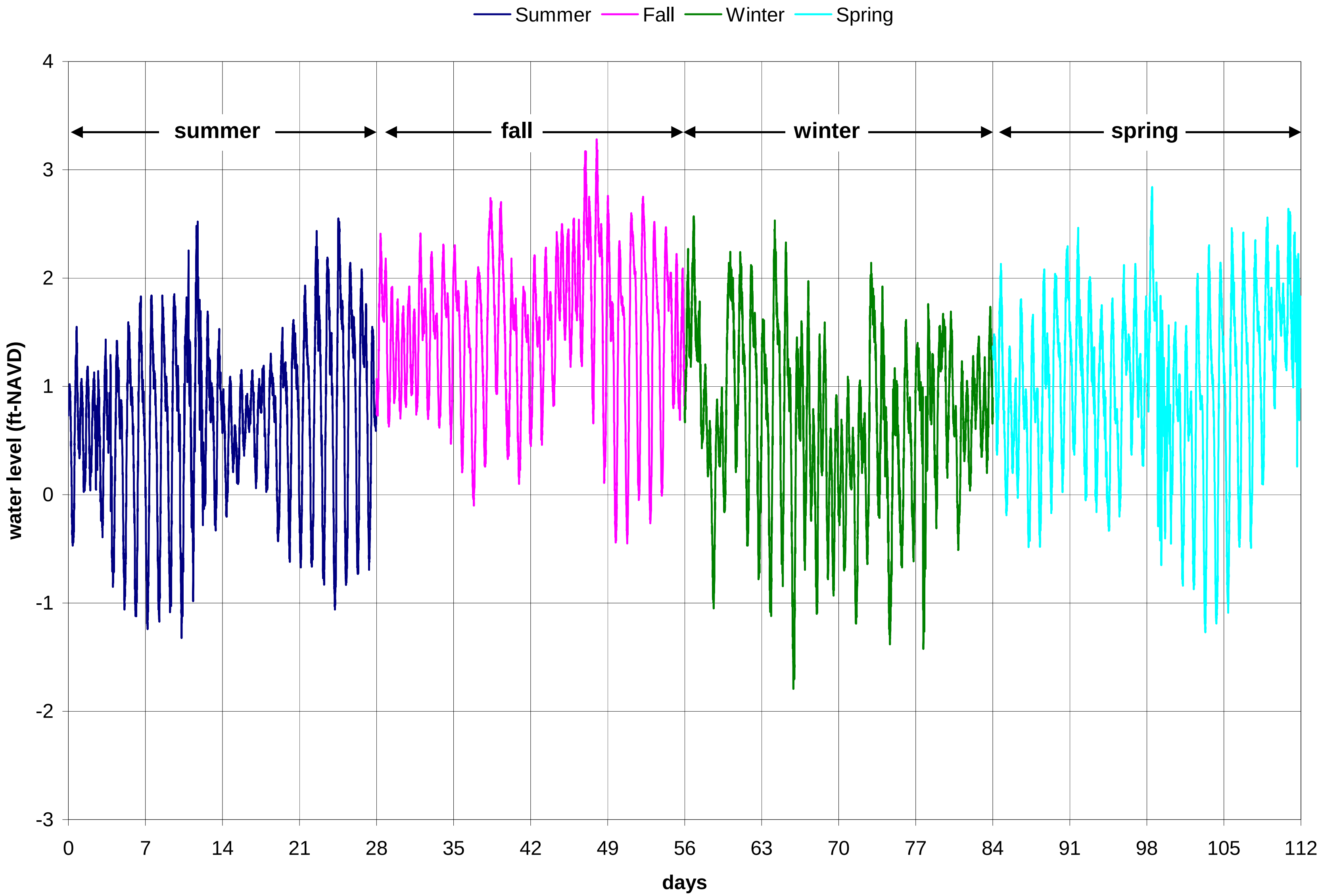

Figure 3.4 Model Tide Input vs. Measured Mean, High, and Low Tide Levels

Table 3.2 lists the one-month seasonal simulations applied for each calendar period. Notably, each hydrodynamic simulation covers 28 days with a full year requiring thirteen 28-day months.

Table 3.2 Simulation Periods and Corresponding Hydrodynamic Simulations

Calendar Period	Number of 28-day Calendar Months	Hydrodynamic Simulation (One-month Tide and Stream Flow Conditions)
June – August	3	Summer
September – November	3	Fall
December – March	5	Winter
April – May	2	Spring

The transport model applied the initial salinity conditions of July 2009 from the calibration model to establish the initial salinity throughout the system. An initial "spin-up" simulation period of one-month (28-day) applied the summer hydrodynamic solution to the transport model and allowed the salinity throughout the model to stabilize before beginning the model production runs. Following this spin-up period, control programs scheduled the appropriate seasonal hydrodynamic solution files as input to the transport model as described in Table 3.2. The final transport model solution describes the salinity throughout the system with Rollover Pass open and closed over a typical three-year period. The model does not include episodic events such as hurricanes or other storms.

Both the Rollover Pass open and closed models applied exactly the same boundary conditions throughout the simulation. The study assumes that closing Rollover Pass would not change the model parameters determined during the calibration process (i.e., bed roughness and eddy viscosity). The application of consistent conditions (i.e., bed roughness, eddy viscosity, stream flow, tide, boundary salinity) to both models should counter any unaccounted variability in boundary data (e.g., offshore salinity). The comparison of the models should remain consistent regardless of actual boundary conditions.

3.3 Model Results

Figures 3.5 and 3.6 show circulation patterns in Rollover and East Bays during typical winter tides and freshwater stream flows with Rollover Pass open and closed. The figures indicate that closing Rollover Pass reduces the flows along the channel in Rollover Bay, but does not appreciably affect the circulation in the rest of the Bay.

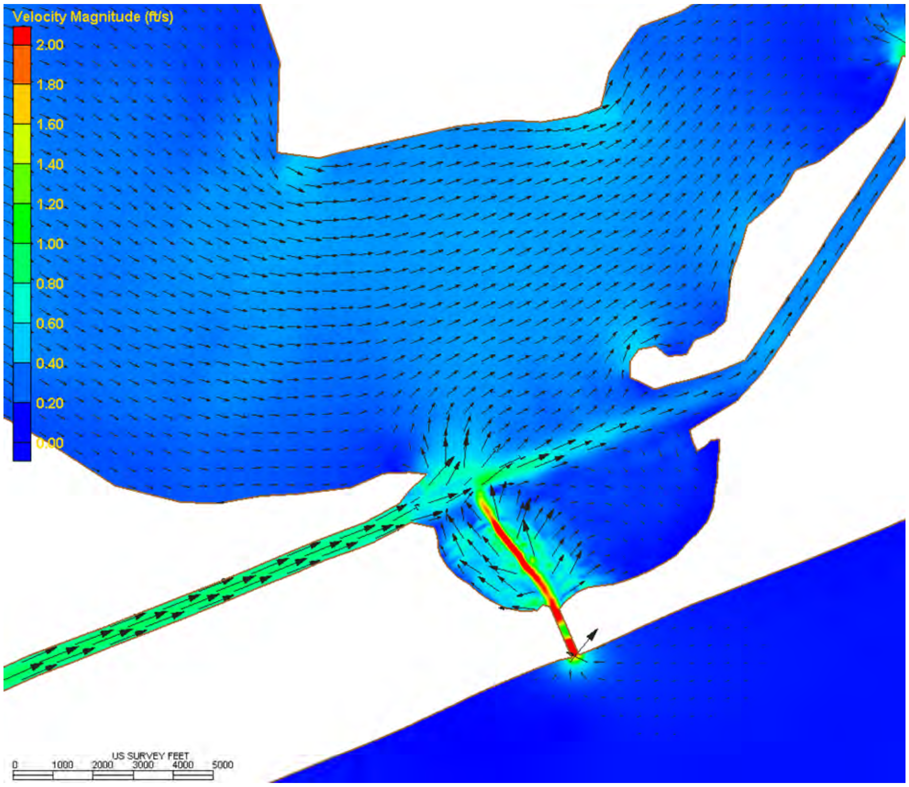

Figure 3.5 Winter Circulation in Rollover and East Bay with Rollover Pass Open

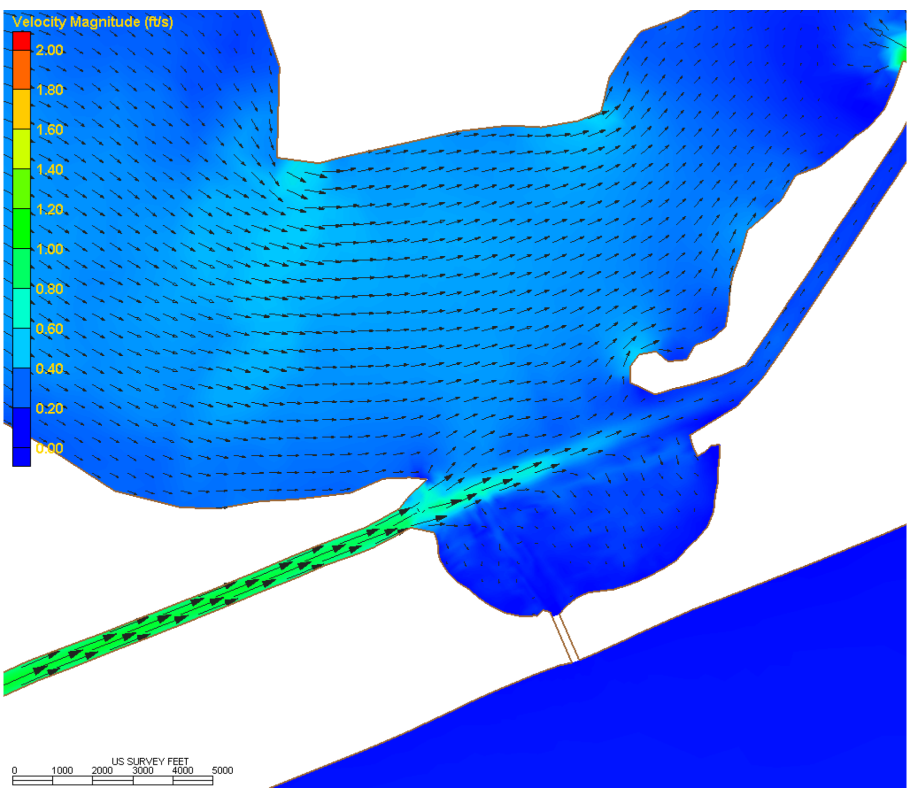

Figure 3.6 Winter Circulation in Rollover and East Bay with Rollover Pass Closed

The transport model determined the salinity at each model grid point at half-hour intervals over three years. Post-simulation analysis of the model results examined time-varying salinity data at various stations (Figure 3.7) near Rollover Pass and determined seasonal average salinity throughout the model domain.

Figures 3.8 – 3.16 show the time-varying salinity results for each of the three simulation years at three typical sample stations (Stations 4, 3, and 11). Appendix A contains similar plots for each station shown in Figure 3.5. Each plot compares the salinity for Rollover Pass the open and closed condition over the given simulation year and also plots the total freshwater input to the model during each season. Plot annotations indicate the average, maximum, and minimum salinity in ppt for each season with Rollover Pass open and closed.

High salinities at the start of Year 1 derive from the initial salinity conditions applied to the models. These initial conditions reflect salinity levels more representative of the end of the summer season rather than the beginning. The models eliminate this effect by the end of the Year 1 fall season.

Comparison of the plots at each sample station demonstrates that simulation Year 3 essentially duplicates Year 2, and the model reached an equilibrium condition after the first simulation year. Simulations beyond Year 3 should show no appreciable change. Tables 3.3 and 3.4 list maximum, average, minimum salinity with the Pass open and closed by season for simulation Year 2 at all sample stations (Figure 3.7).

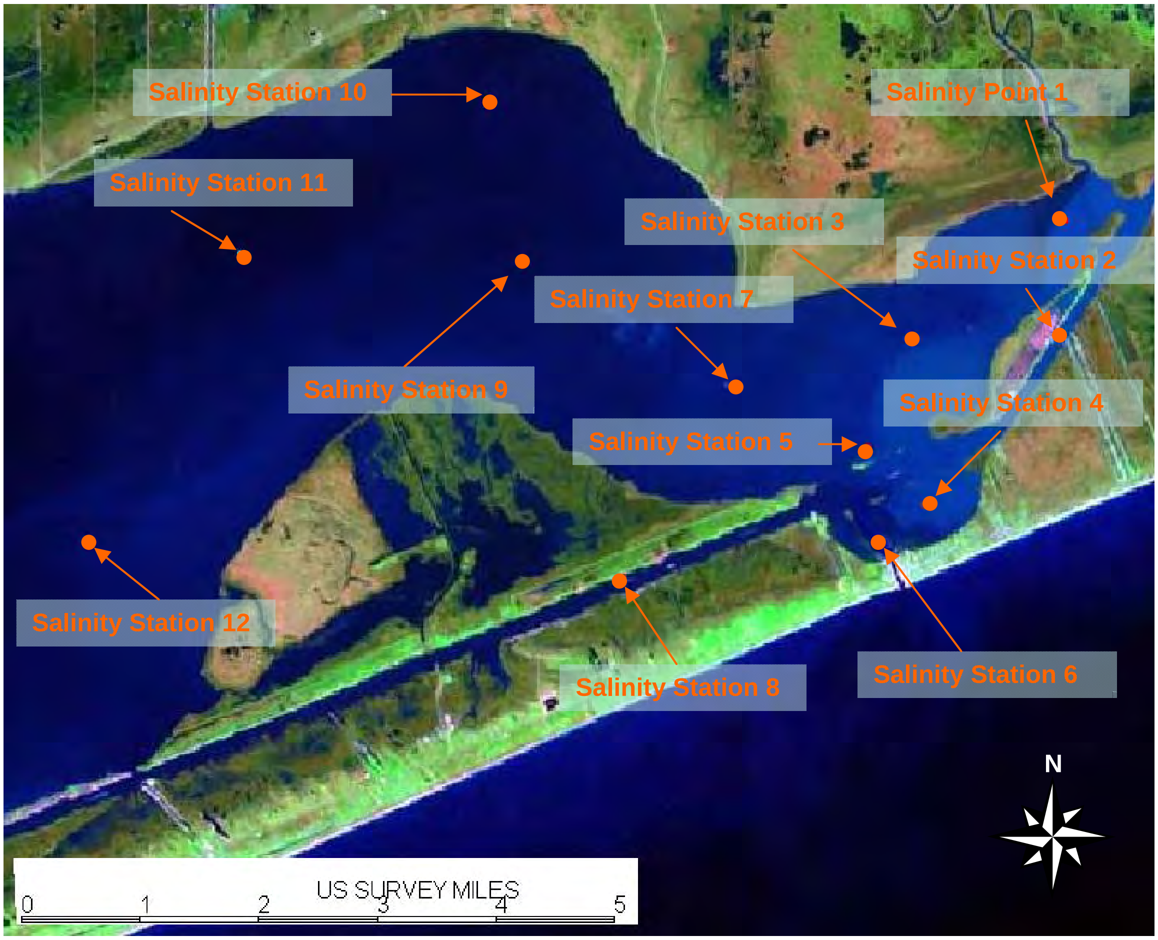

Figure 3.7 Production Run Salinity Sample Points

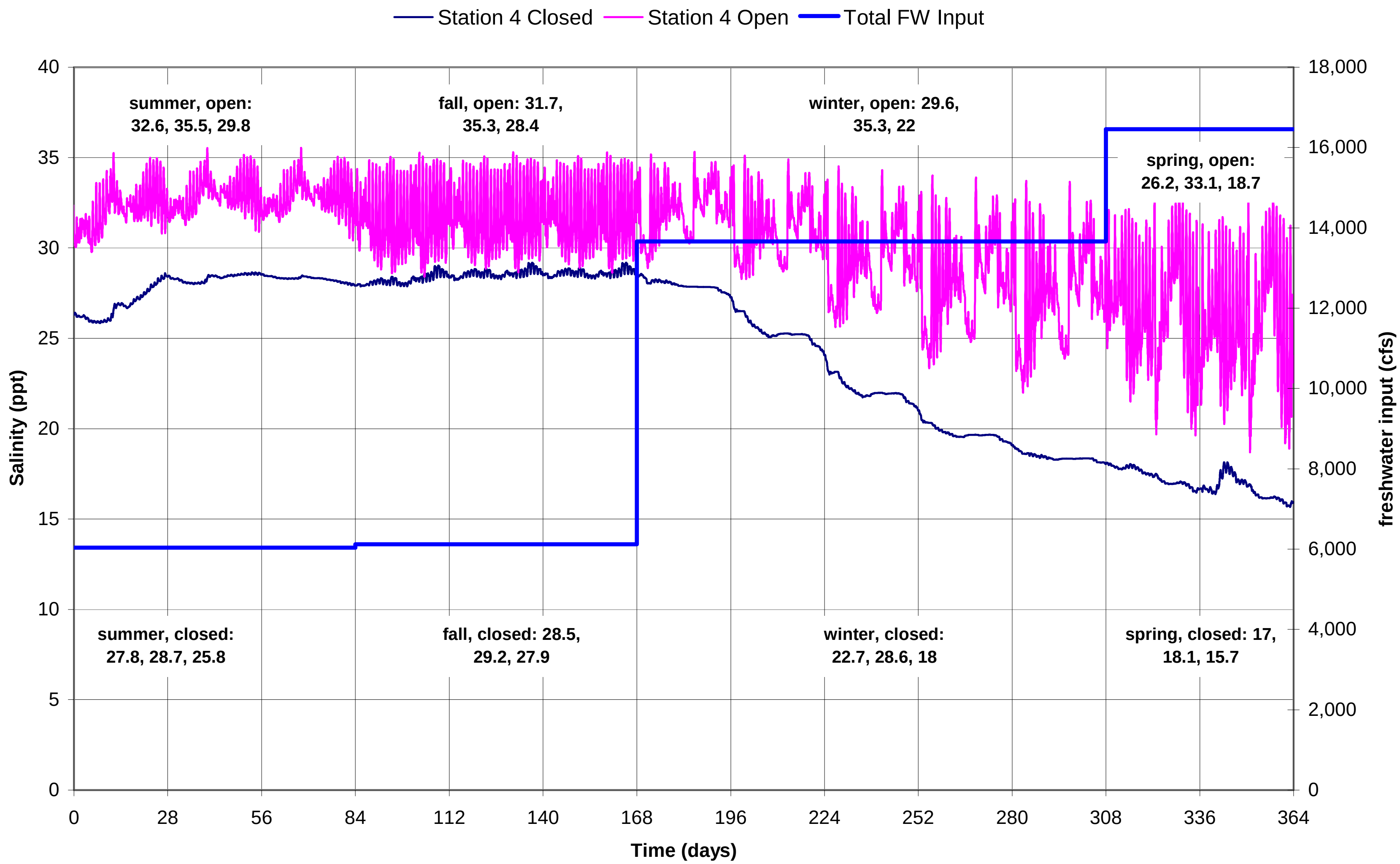

Figure 3.8 Salinity Variation with Time, Station 4, Year 1

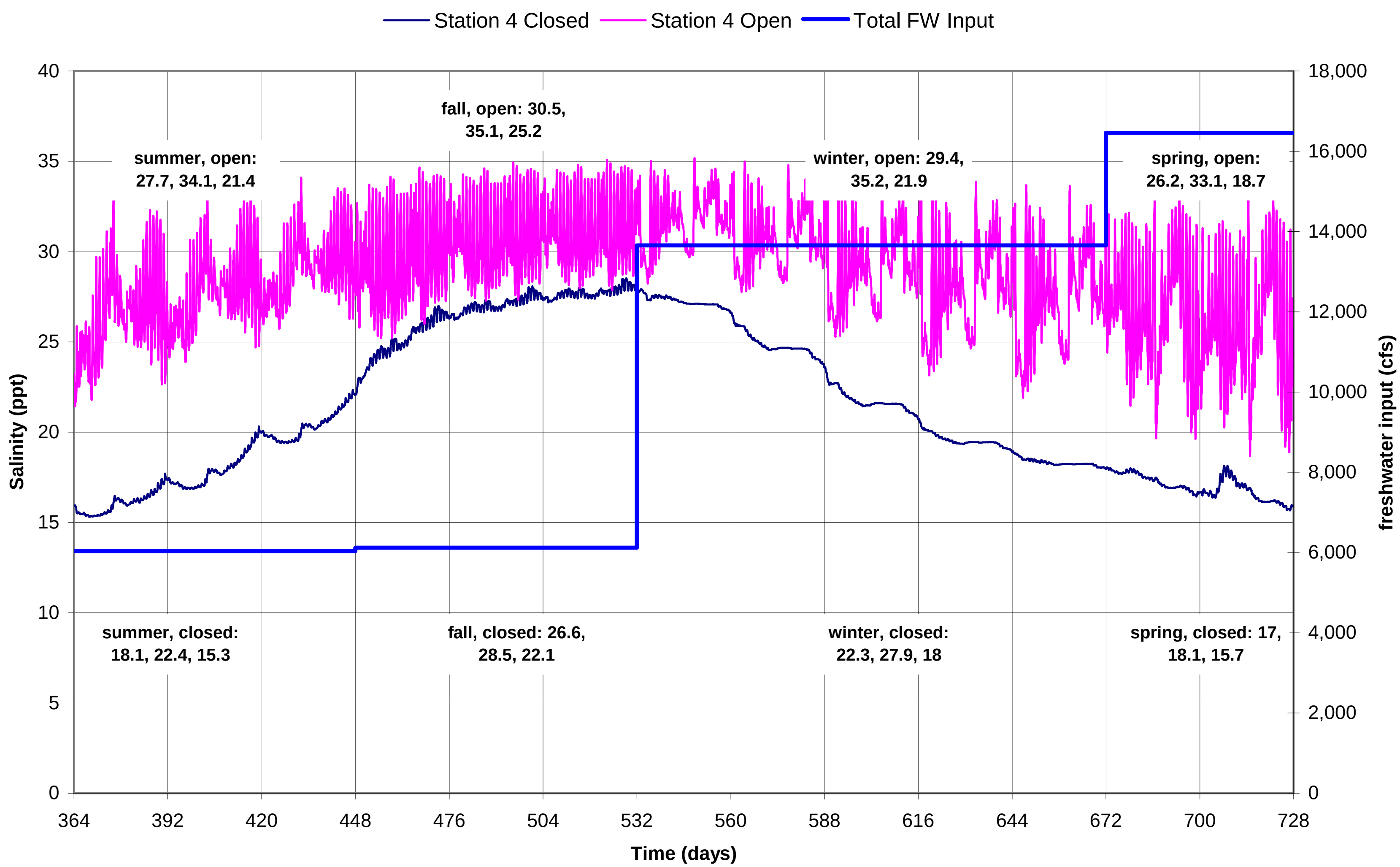

Figure 3.9 Salinity Variation with Time, Station 4, Year 2

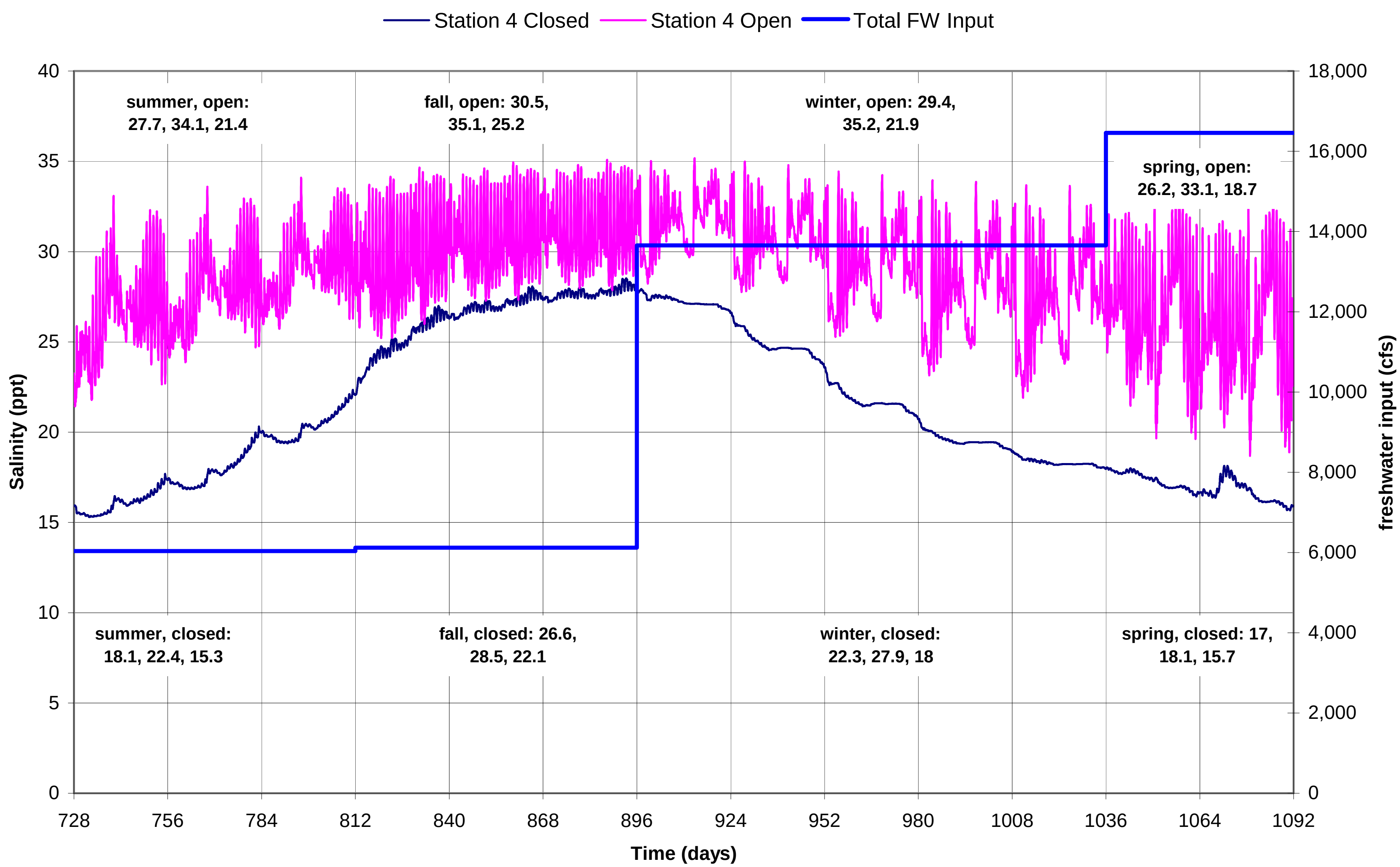

Figure 3.10 Salinity Variation with Time, Station 4, Year 3

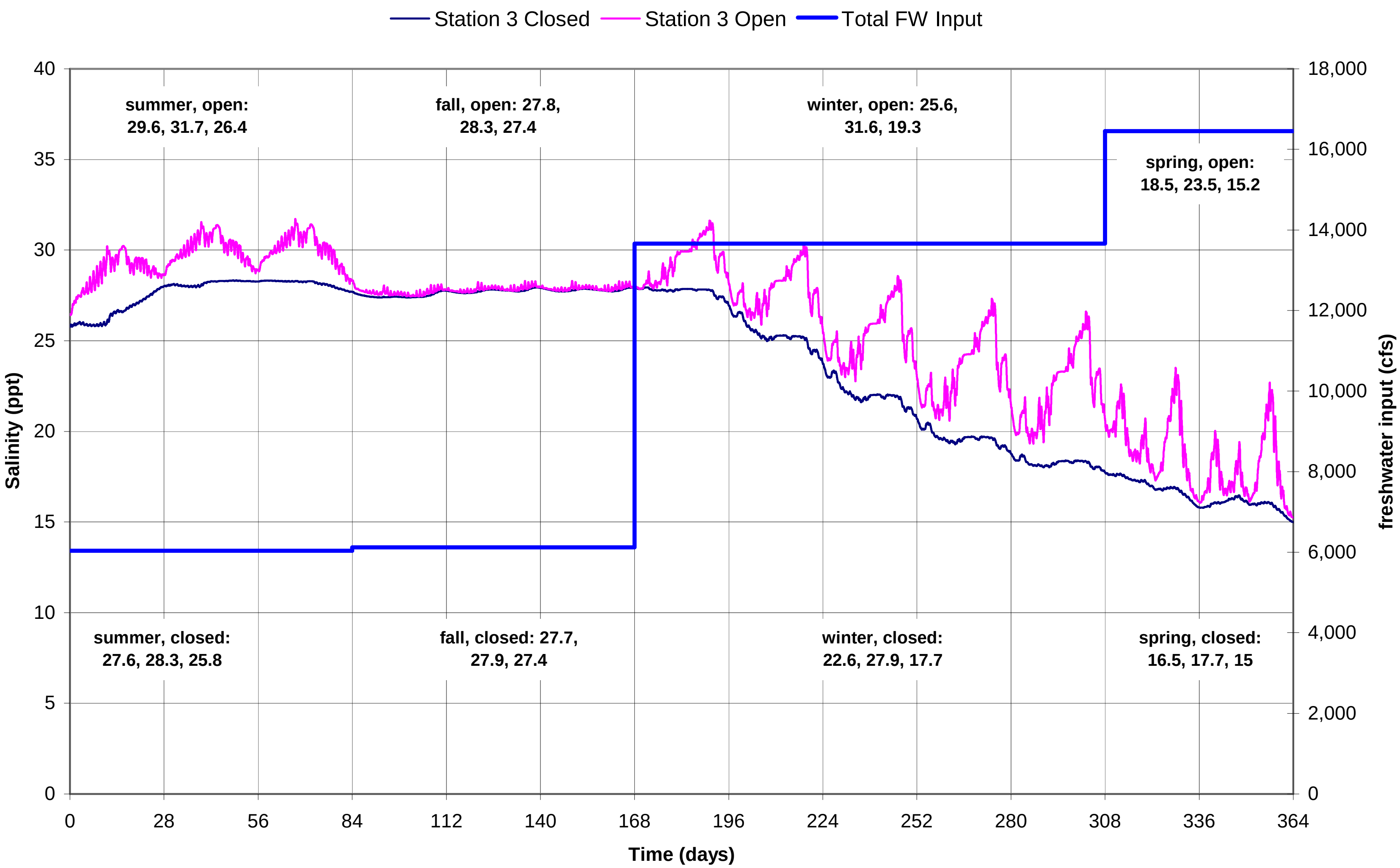

Figure 3.11 Salinity Variation with Time, Station 3, Year 1

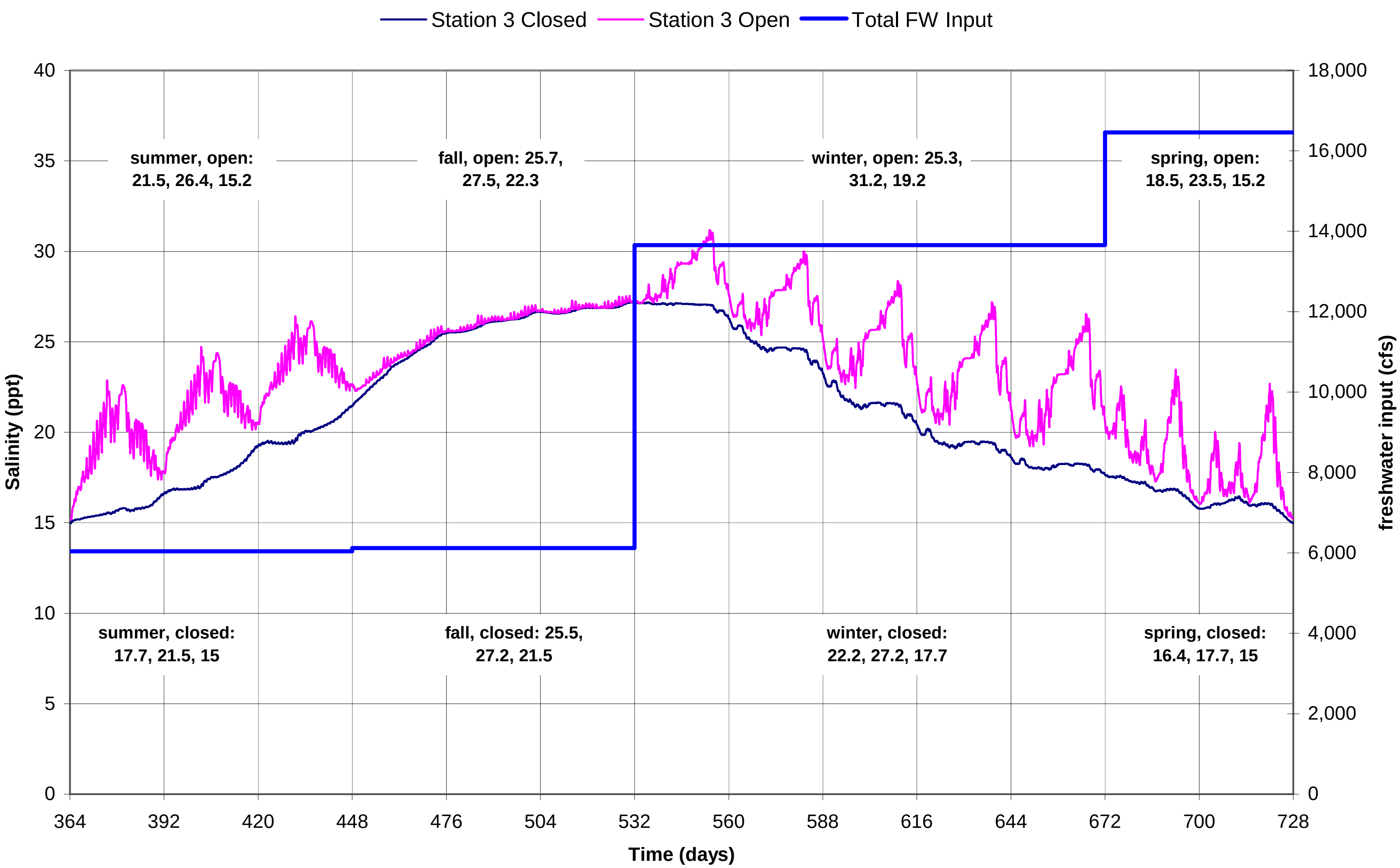

Figure 3.12 Salinity Variation with Time, Station 3, Year 2

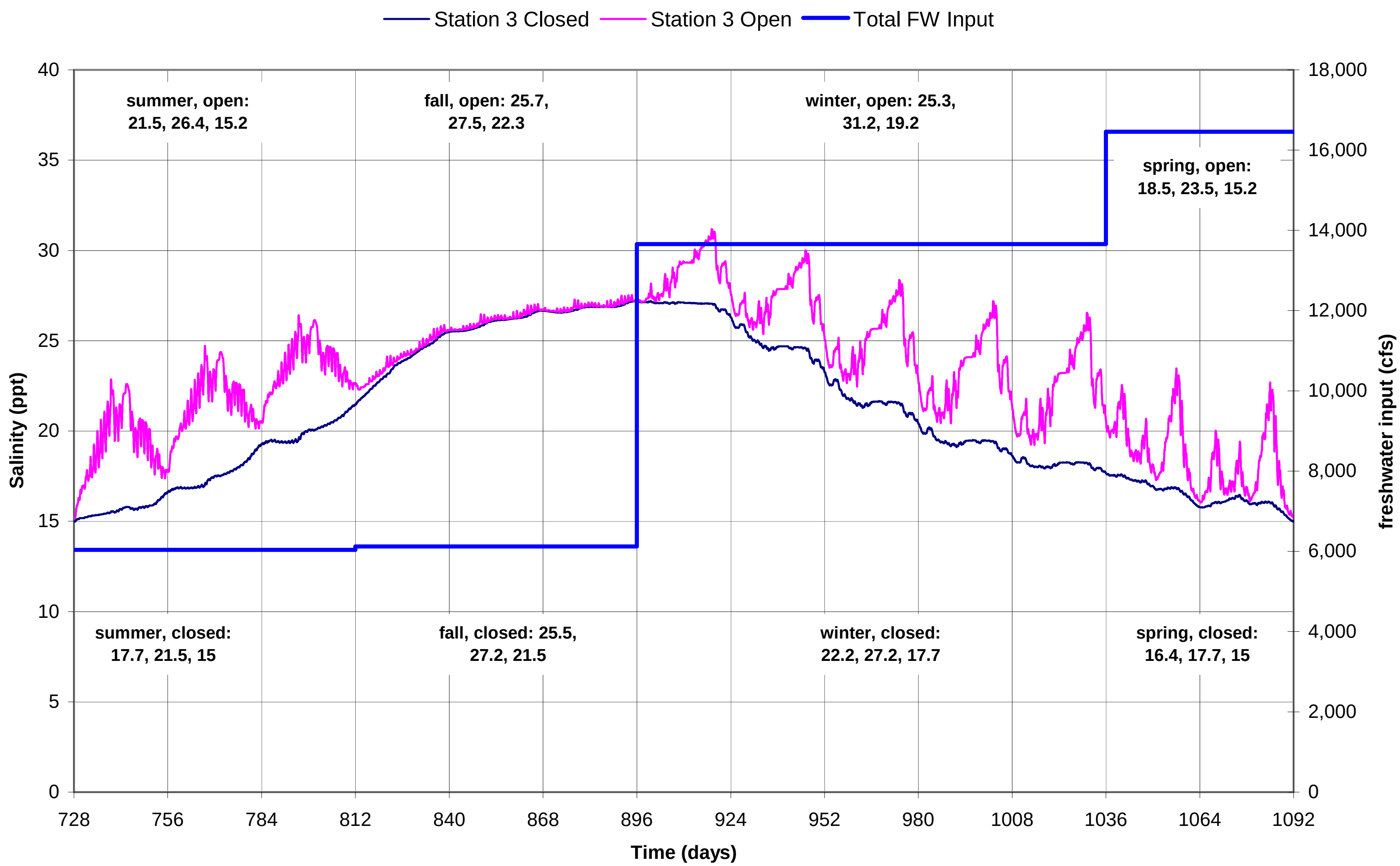

Figure 3.13 Salinity Variation with Time, Station 3, Year 3

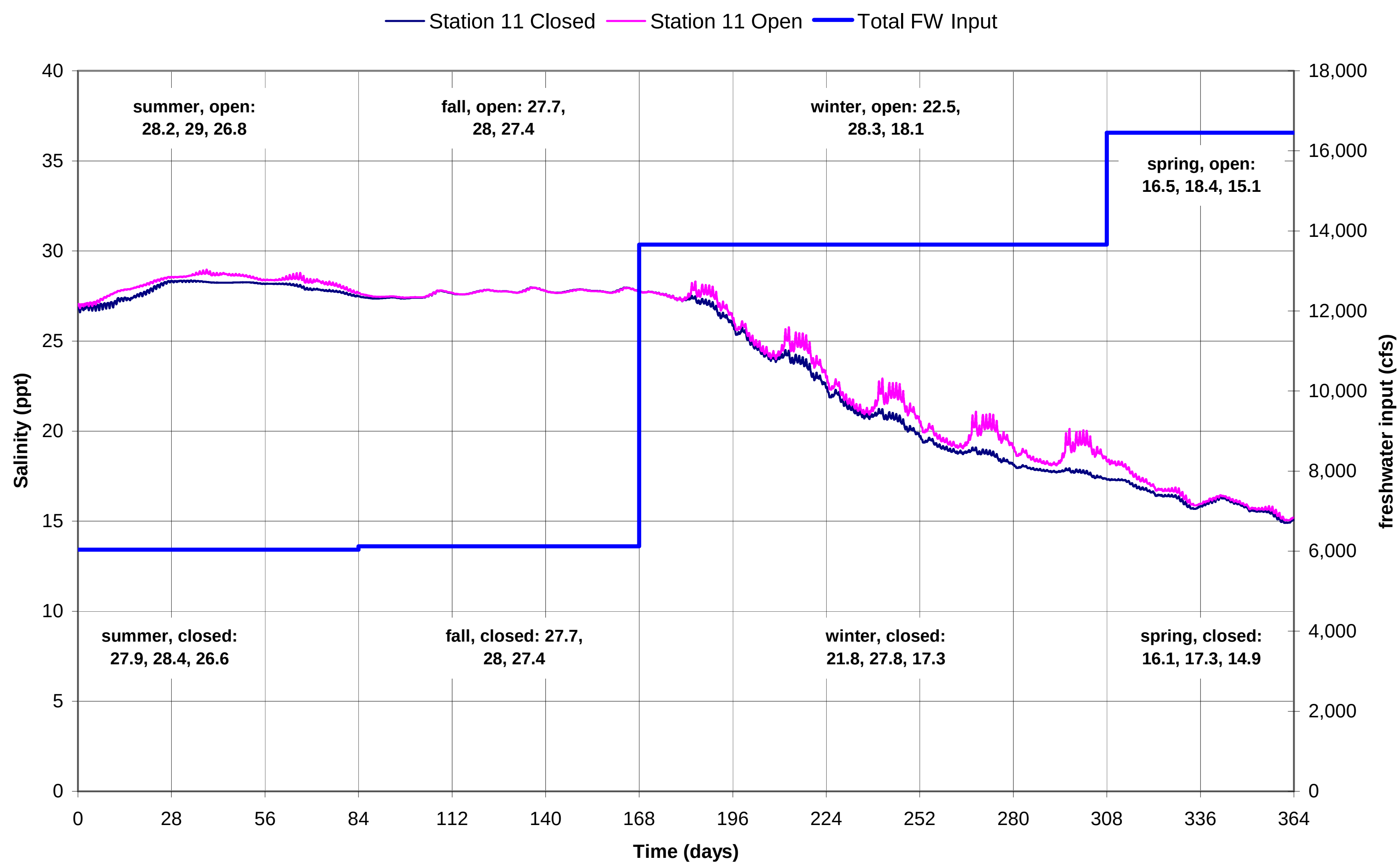

Figure 3.14 Salinity Variation with Time, Station 11, Year 1

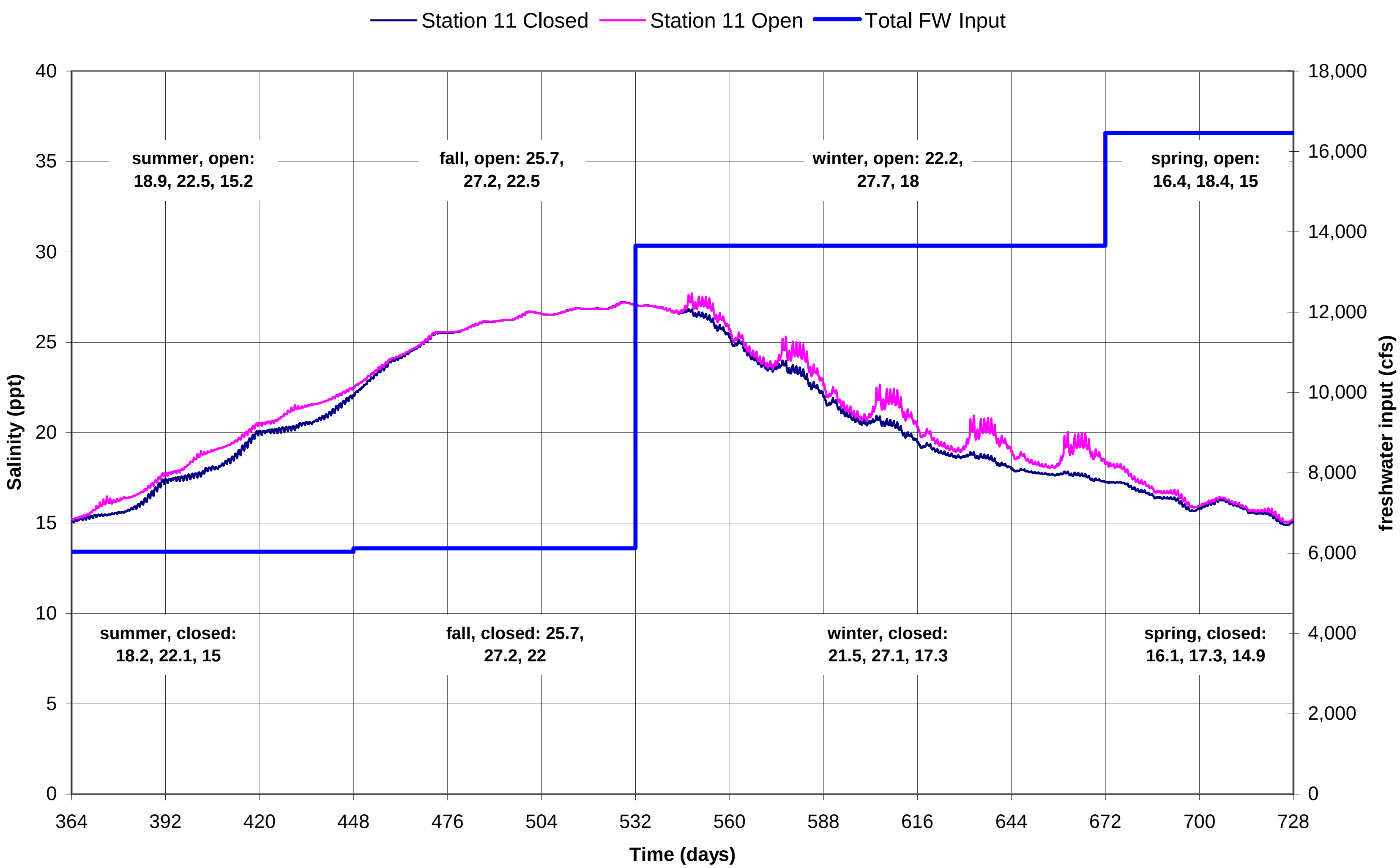

Figure 3.15 Salinity Variation with Time, Station 11, Year 2

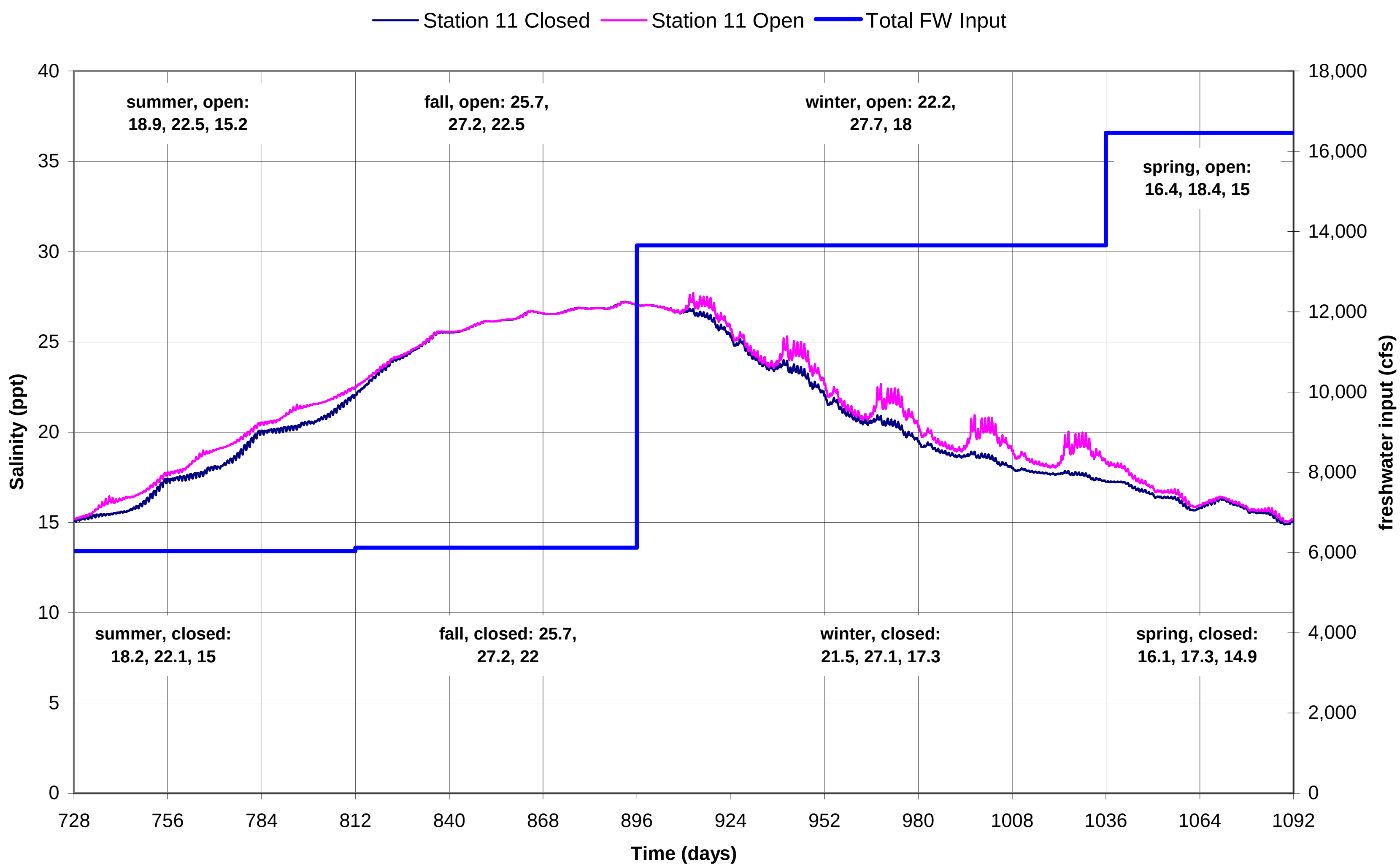

Figure 3.16 Salinity Variation with Time, Station 11, Year 3

Table 3.3 Summer and Fall Salinity Values

Station	Pass Condition	Summer, Year 2			Fall, Year 2		
		Maximum Salinity (ppt)	**Average Salinity (ppt)**	**Minimum Salinity (ppt)**	**Maximum Salinity (ppt)**	**Average Salinity (ppt)**	**Minimum Salinity (ppt)**
1	Open	26.7	21.9	15.4	27.6	25.8	22.3
	Closed	21.5	17.7	15	27.2	25.5	21.4
2	Open	31	23.4	16.3	32.2	27.8	23.3
	Closed	22.1	17.9	15.2	27.9	26.1	21.9
3	Open	26.4	21.5	15.2	27.5	25.7	22.3
	Closed	21.5	17.7	15	27.2	25.5	21.5
4	Open	34.1	27.7	21.4	35.1	30.5	25.2
	Closed	22.4	18.1	15.3	28.5	26.6	22.1
5	Open	31.5	23.9	15.4	30.5	26.4	22.3
	Closed	21.9	18	15.1	27.4	25.7	21.8
6	Open	35	28.3	17.1	35.5	30.9	23.4
	Closed	22.4	18.3	15.5	28.7	27	22.3
7	Open	25.5	20.2	15.1	27.2	25.6	22.2
	Closed	21.6	17.8	15	27.2	25.5	21.5
8	Open	26.5	21.4	16.8	29.7	27.7	24.2
	Closed	24	20	15.8	29.7	27.6	24
9	Open	22.4	19.1	15.1	27.2	25.7	22.3
	Closed	21.8	17.9	15	27.2	25.6	21.7
10	Open	22.3	18.9	15.1	27.2	25.6	22.3
	Closed	21.7	18	15	27.2	25.6	21.7
11	Open	22.5	18.9	15.2	27.2	25.7	22.5
	Closed	22.1	18.2	15	27.2	25.7	22
12	Open	22.7	19	15.4	27.3	25.9	22.7
	Closed	22.4	18.6	15.3	27.3	25.8	22.4

Table 3.4 Winter and Spring Salinity Values

Station	Pass Condition	Winter, Year 2			Spring, Year 2		
		Maximum Salinity (ppt)	Average Salinity (ppt)	Minimum Salinity (ppt)	Maximum Salinity (ppt)	Average Salinity (ppt)	Minimum Salinity (ppt)
1	Open	31.1	25.8	19.9	23.8	19.3	15.4
	Closed	27.2	22.3	17.8	17.8	16.6	15
2	Open	32.9	26.8	20.6	29.4	21.7	16.4
	Closed	27.5	22.3	17.9	17.9	16.7	15.4
3	Open	31.2	25.3	19.2	23.5	18.5	15.2
	Closed	27.2	22.2	17.7	17.7	16.4	15
4	Open	35.2	29.4	21.9	33.1	26.2	18.7
	Closed	27.9	22.3	18	18.1	17	15.7
5	Open	33.6	26.4	19	29.5	20.1	15.3
	Closed	27.5	22.2	17.7	17.7	16.6	15.1
6	Open	35.8	30.3	19.6	34.3	26.1	16.4
	Closed	28.2	22.4	18.1	18.5	17.2	15.9
7	Open	30.6	24.3	18.5	21	17.2	15.1
	Closed	27.2	22.1	17.6	17.5	16.3	15
8	Open	31.1	24.5	19.1	22.2	18.3	16.1
	Closed	28.5	22.3	18.1	20.6	17.8	15.9
9	Open	29	23.1	18.3	19	16.7	15.1
	Closed	27.1	21.8	17.4	17.4	16.2	14.9
10	Open	28.3	22.9	18.3	19	16.7	15.1
	Closed	27.1	21.8	17.4	17.4	16.2	14.9
11	Open	27.7	22.2	18	18.4	16.4	15
	Closed	27.1	21.5	17.3	17.3	16.1	14.9
12	Open	27	21.6	17.8	17.9	16.3	15
	Closed	27	21.1	17.2	17.2	16.1	14.8

A seasonal rise and fall of salinity evidenced in all plots corresponds to the fall increase in mean water levels shown in Figure 3.3. Higher offshore water levels combine with low freshwater input to increase salinity within the system. Salinity falls when water levels return to their normal winter-spring-summer levels and freshwater inputs rise during the winter and spring. Lower freshwater inputs in summer cause salinities to rise — slowly during summer and more rapidly when high water levels return in fall.

Figures 3.11 – 3.16 exhibit an episodic — several times monthly — rise and fall in salinity with Rollover Pass open at Stations 3 and 11 from winter through summer. Low salinities at these stations nearly reach the Pass closed salinity levels during these episodes. These patterns reflect salinity oscillations at Station 4 (Figures 3.8 – 3.10) near Rollover Pass, and follow the monthly spring-neap tide sequence illustrated in Figure 3.4. As spring tide approaches, more saline water enters the bays and salinity rises. As spring tide approaches less saline water enters the bays and salinity falls under the influence of freshwater input from the rivers and bayous. Higher mean tide levels and smaller tidal ranges during fall months (Figure 3.4) suppress this pattern at Stations 3 and 11.

The response of Stations 3 and 11 indicates the closure of Rollover Pass should not appreciably affect salinity levels outside of Rollover Bay during the fall months — when the area experiences no salinity oscillations. During the winter through summer months, closure of the Pass eliminates the monthly salinity fluctuations and stabilizes salinity near Pass open low levels.

Tables 3.3 and 3.4 indicate the largest change in seasonally-averaged salinity occurs in summer. Closing the Pass reduces seasonally-averaged salinity up to 10 ppt near the Pass (Station 6) and less than 2 ppt about four miles from the Pass (Station 7). Peak salinity drops 16 ppt near the Pass and less than 4 ppt about four miles from the Pass.

Figures 3.17 – 3.24 plot contours of the seasonally-averaged salinity in Rollover Pass and East Bay for simulation Year 2. The figures show seasonally-averaged salinity contours with the Pass open, followed by contours with the Pass closed for each season. Figures 3.25 – 3.28 show contours of change in salinity (Pass closed minus Pass open) for each season. As noted in Chapter 2, the model calibration excluded multi-seasonal data comparisons and, thus, may not accurately predict absolute salinity values (Figures 3.17 – 3.24) but should reliably predict relative changes in salinity due to closing Rollover Pass (Figures 3.25 – 3.28).

Figures 3.25 – 3.28 indicate seasonally-averaged salinity changes due to closing the Pass increase with proximity to the Pass. Closing the Pass minimally affects seasonally-averaged salinity (less than 2 ppt change) beyond five miles from the Pass. In Rollover Bay, seasonally-averaged salinity may drop as much as 8 – 12 ppt during spring, summer, and fall and about 5 ppt during winter.

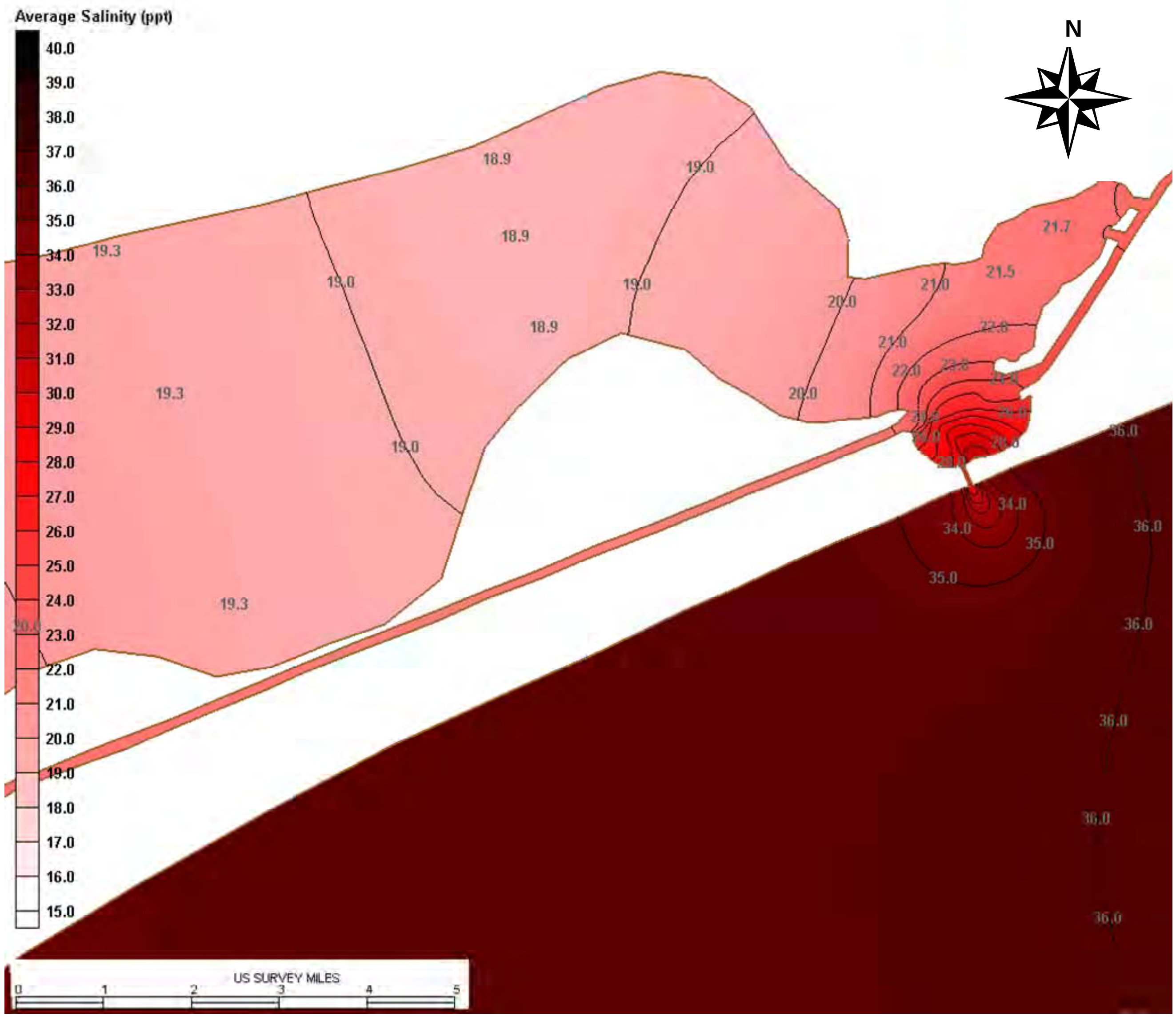

Figure 3.17 Average Salinity Contours, Rollover Pass Open, Summer Year 2

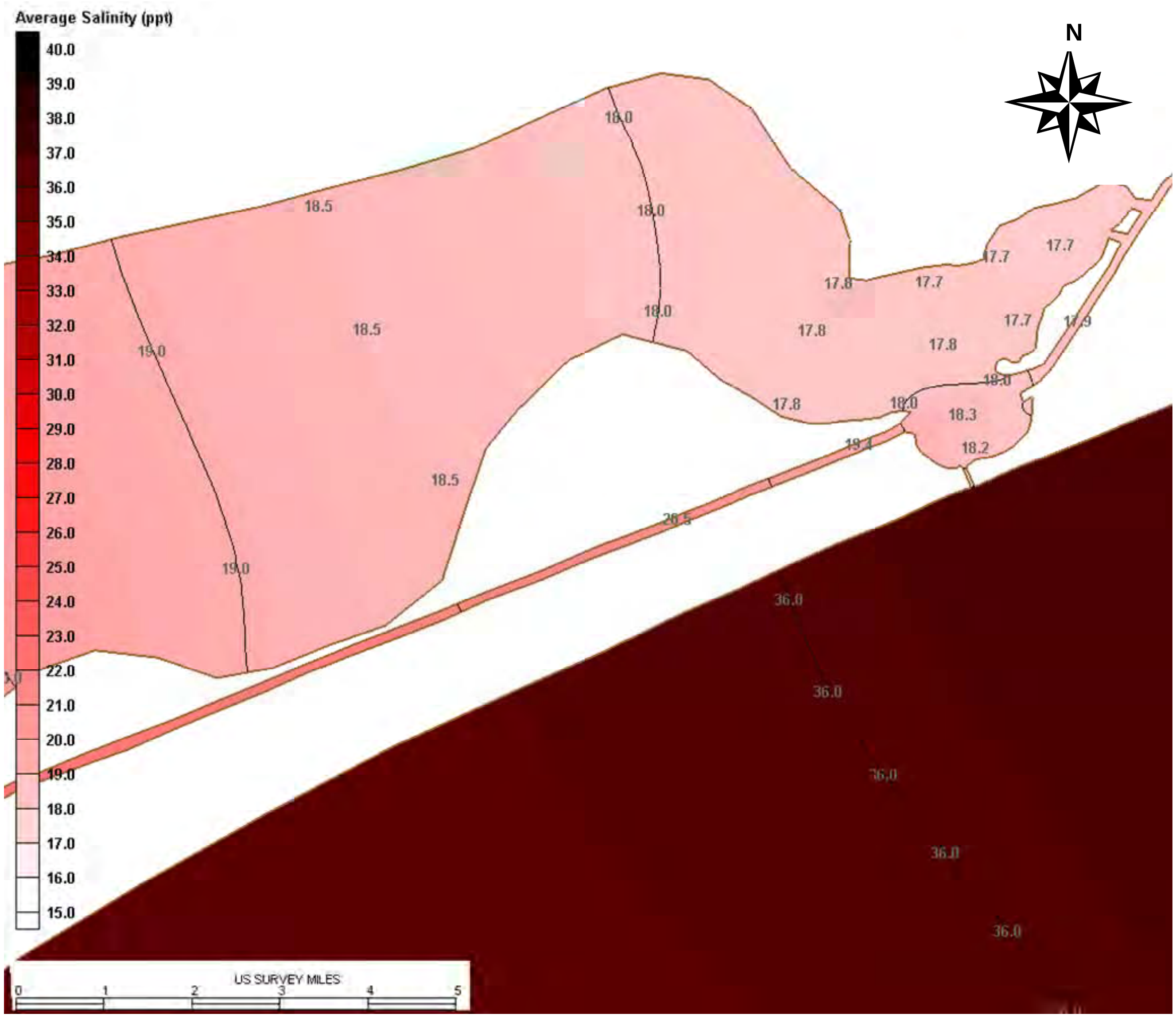

Figure 3.18 Average Salinity Contours, Rollover Pass Closed, Summer Year 2

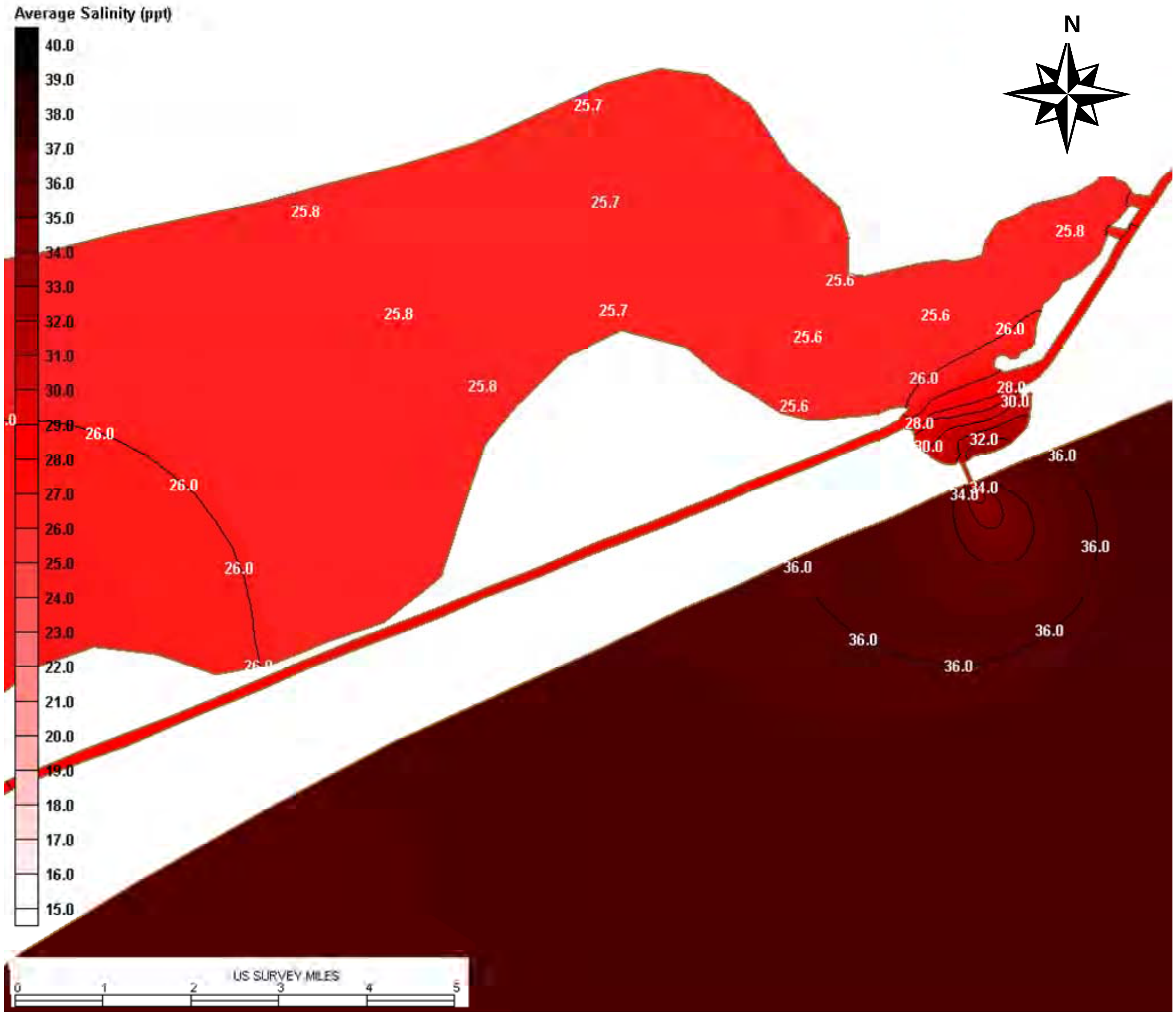

Figure 3.19 Average Salinity Contours, Rollover Pass Open, Fall Year 2

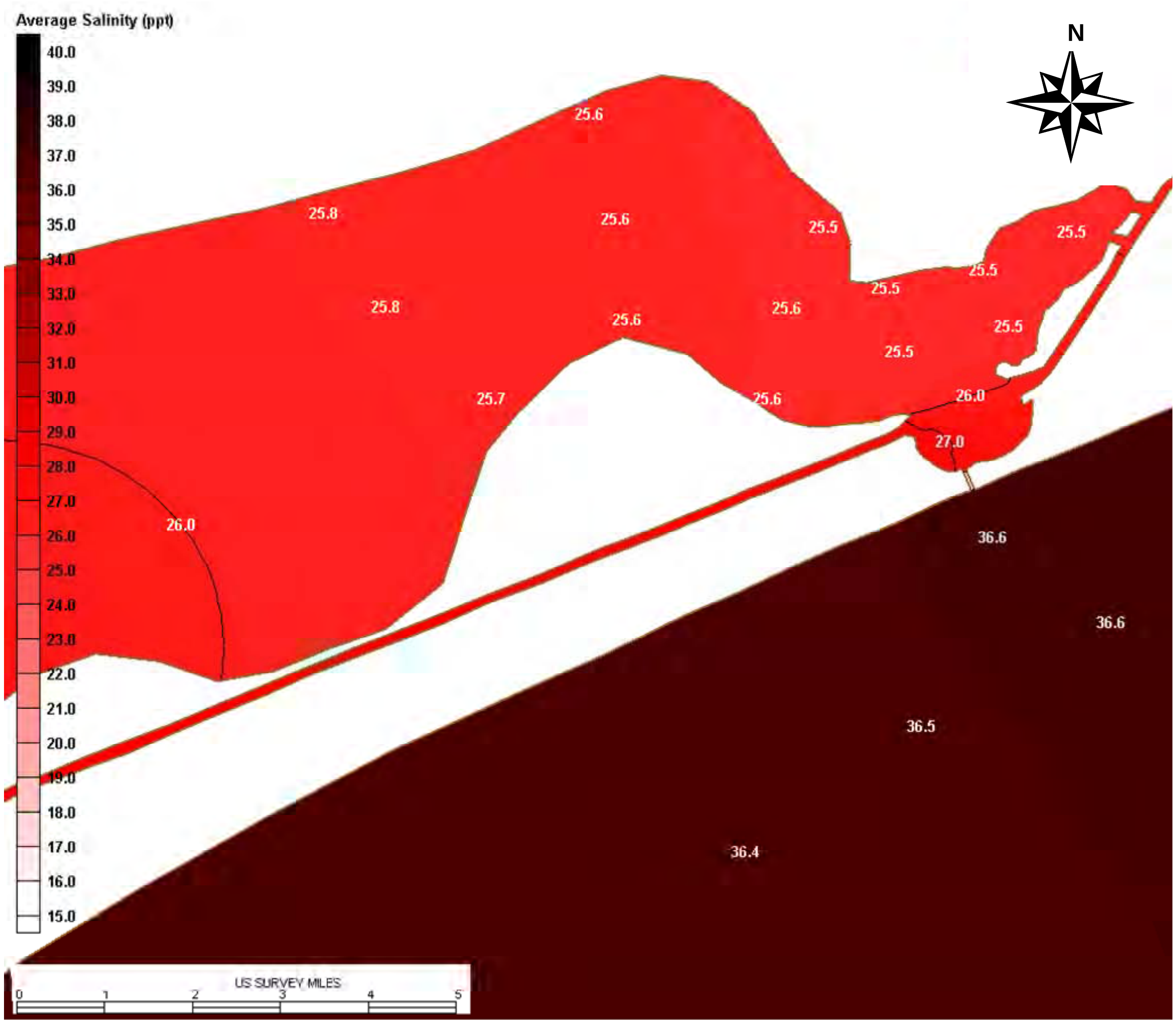

Figure 3.20 Average Salinity Contours, Rollover Pass Closed, Fall Year 2

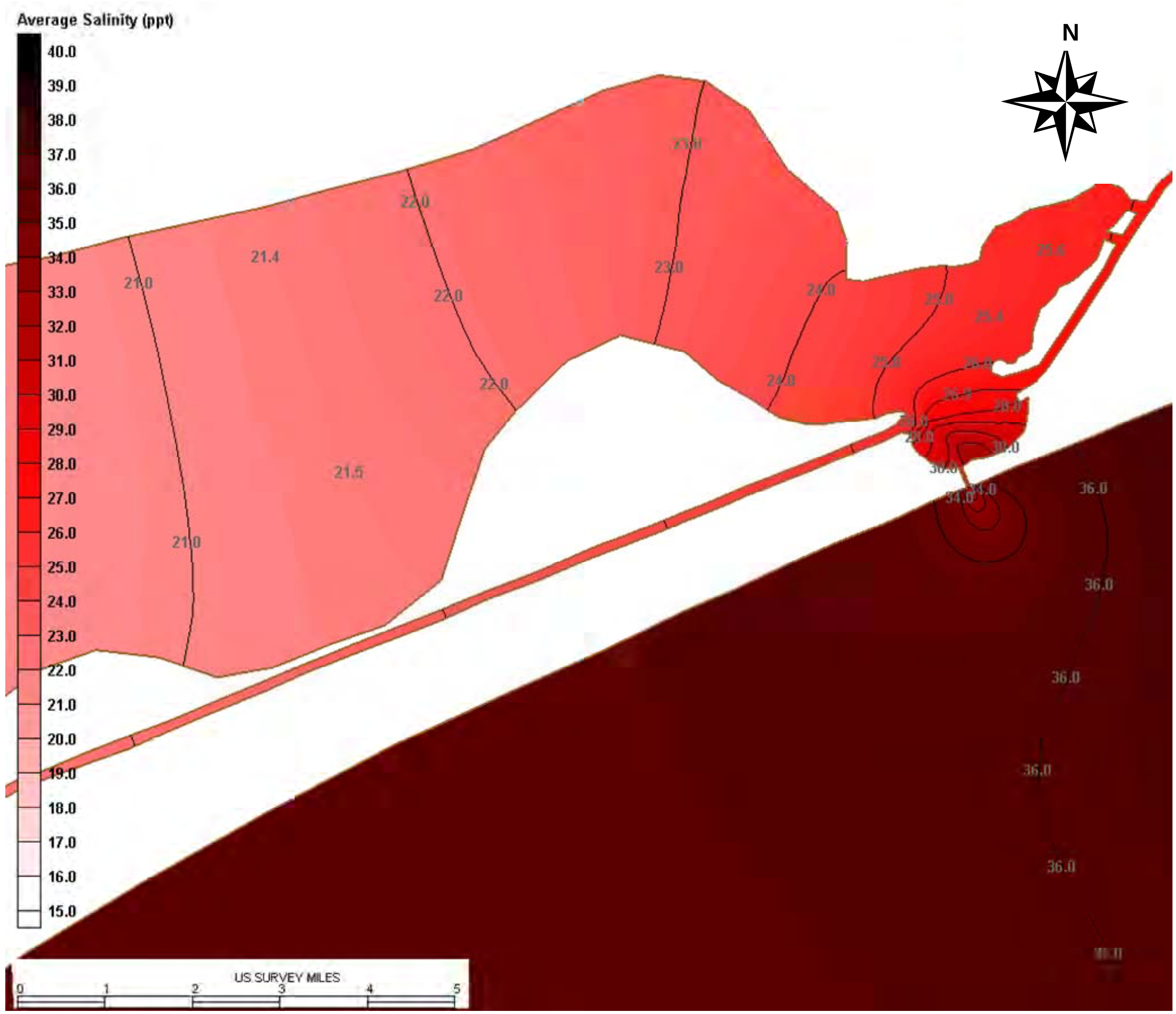

Figure 3.21 Average Salinity Contours, Rollover Pass Open, Winter Year 2

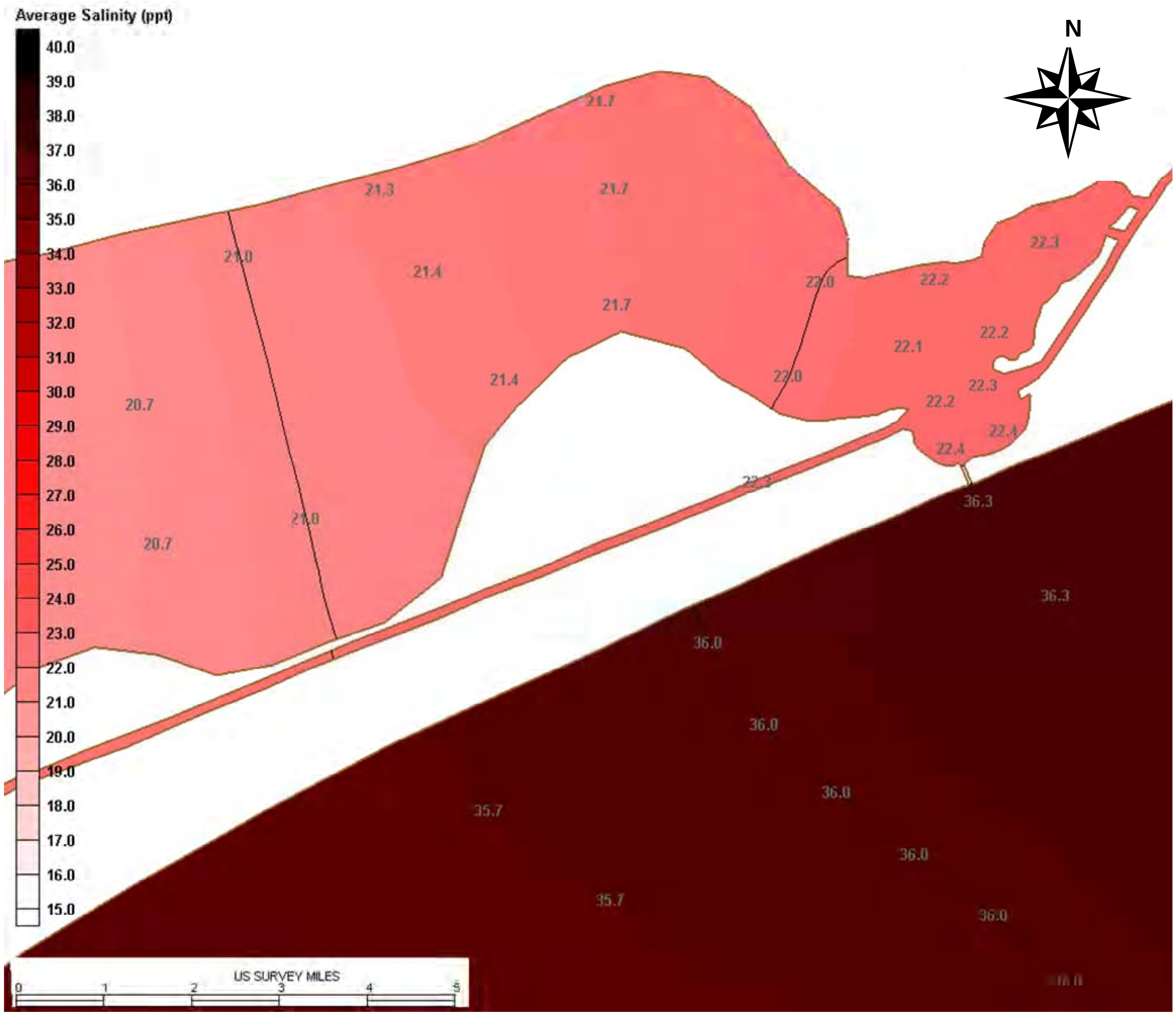

Figure 3.22 Average Salinity Contours, Rollover Pass Closed, Winter Year 2

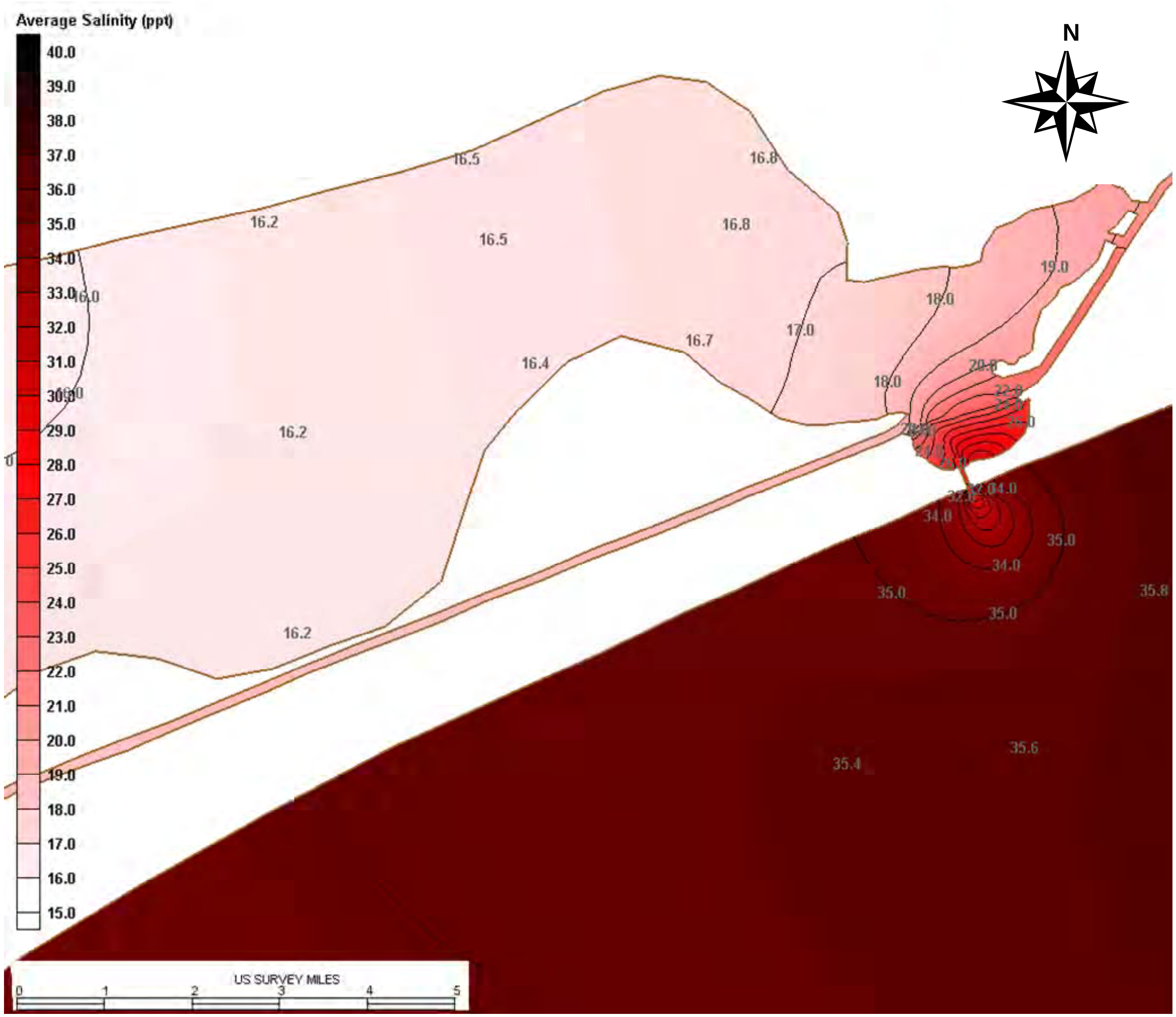

Figure 3.23 Average Salinity Contours, Rollover Pass Open, Spring Year 2

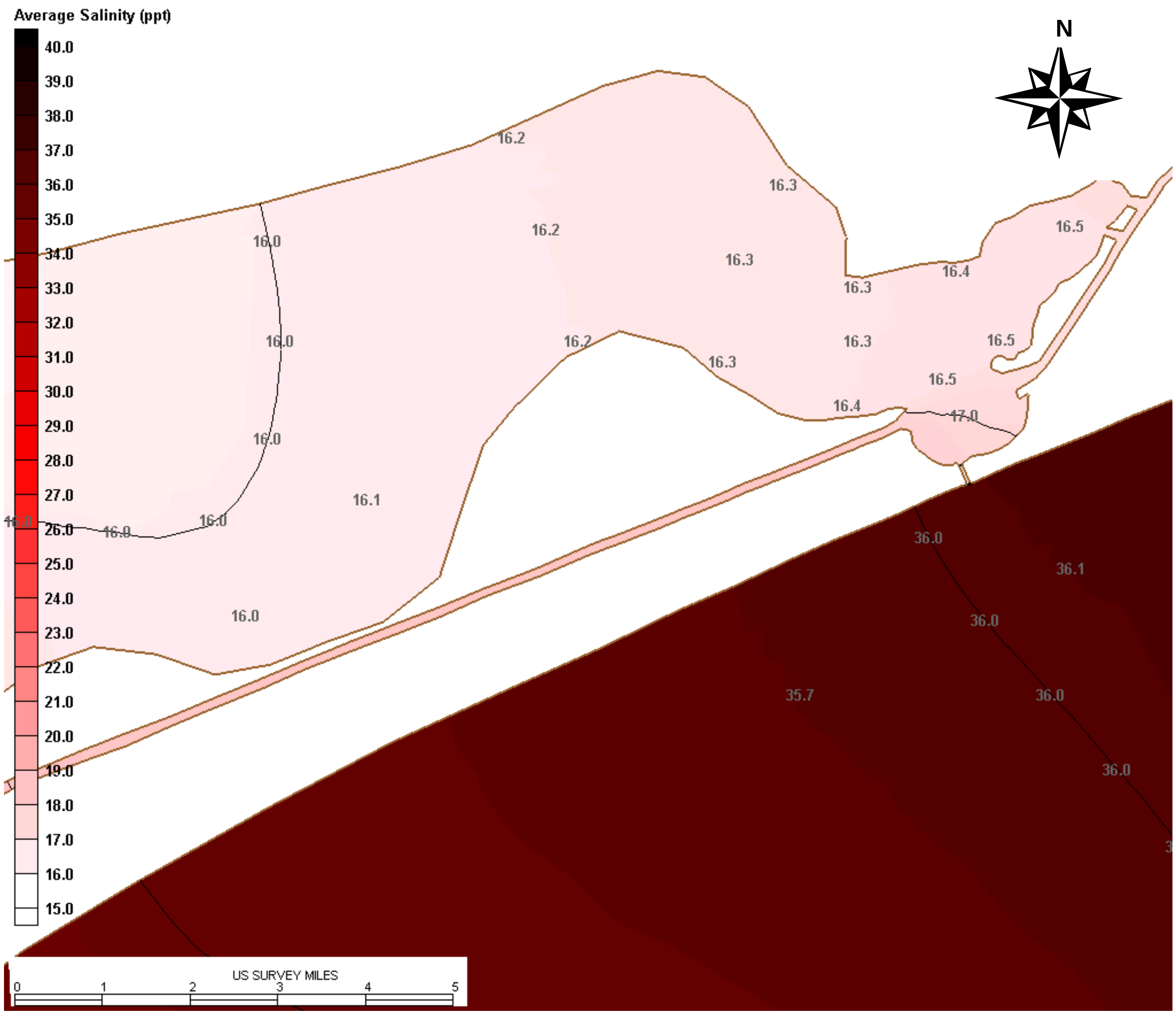

Figure 3.24 Average Salinity Contours, Rollover Pass Closed, Spring Year 2

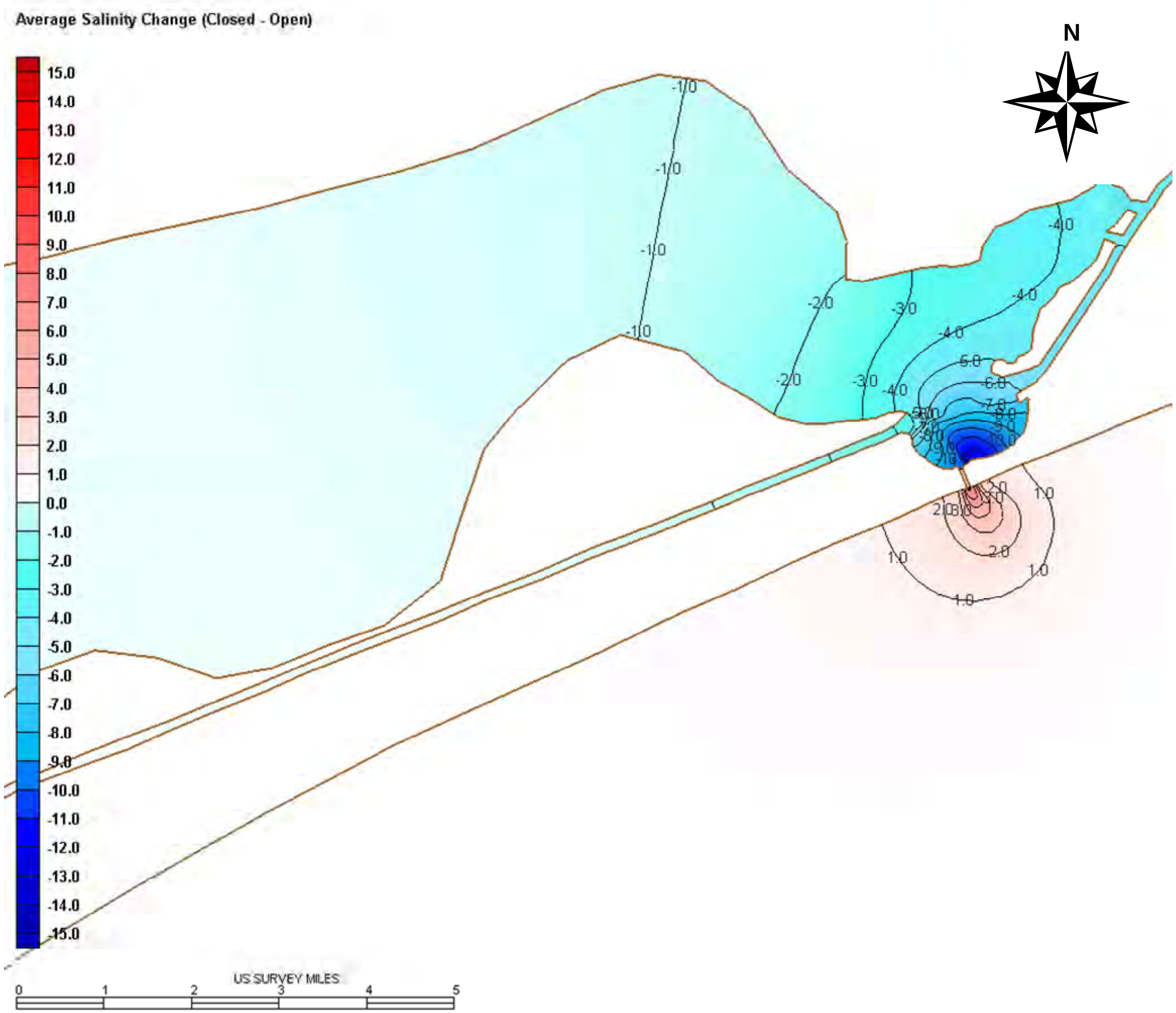

Figure 3.25 Contours of Average Salinity Change, Summer Year 2

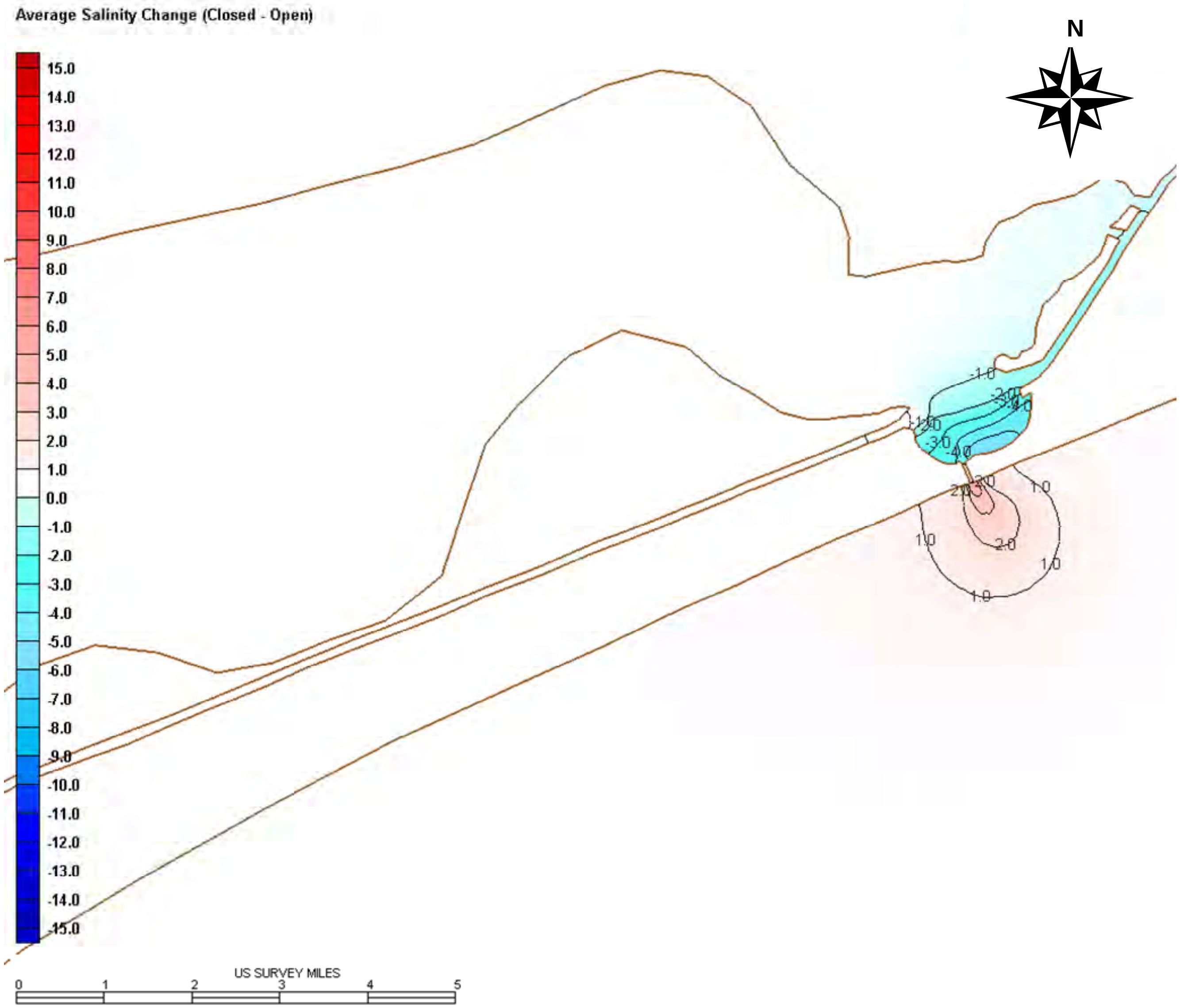

Figure 3.26 Contours of Average Salinity Change, Fall Year 2

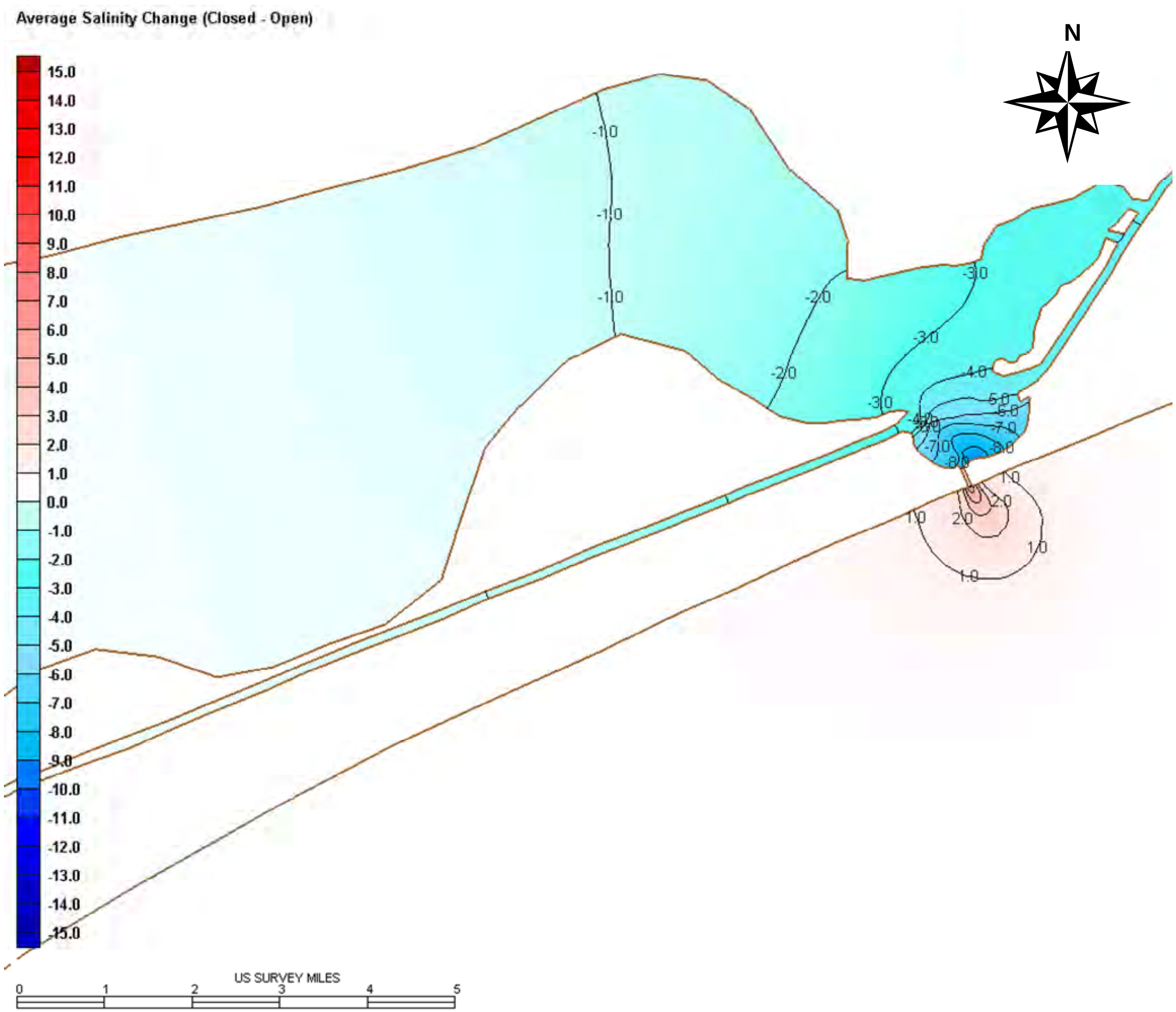

Figure 3.27 Contours of Average Salinity Change, Winter Year 2

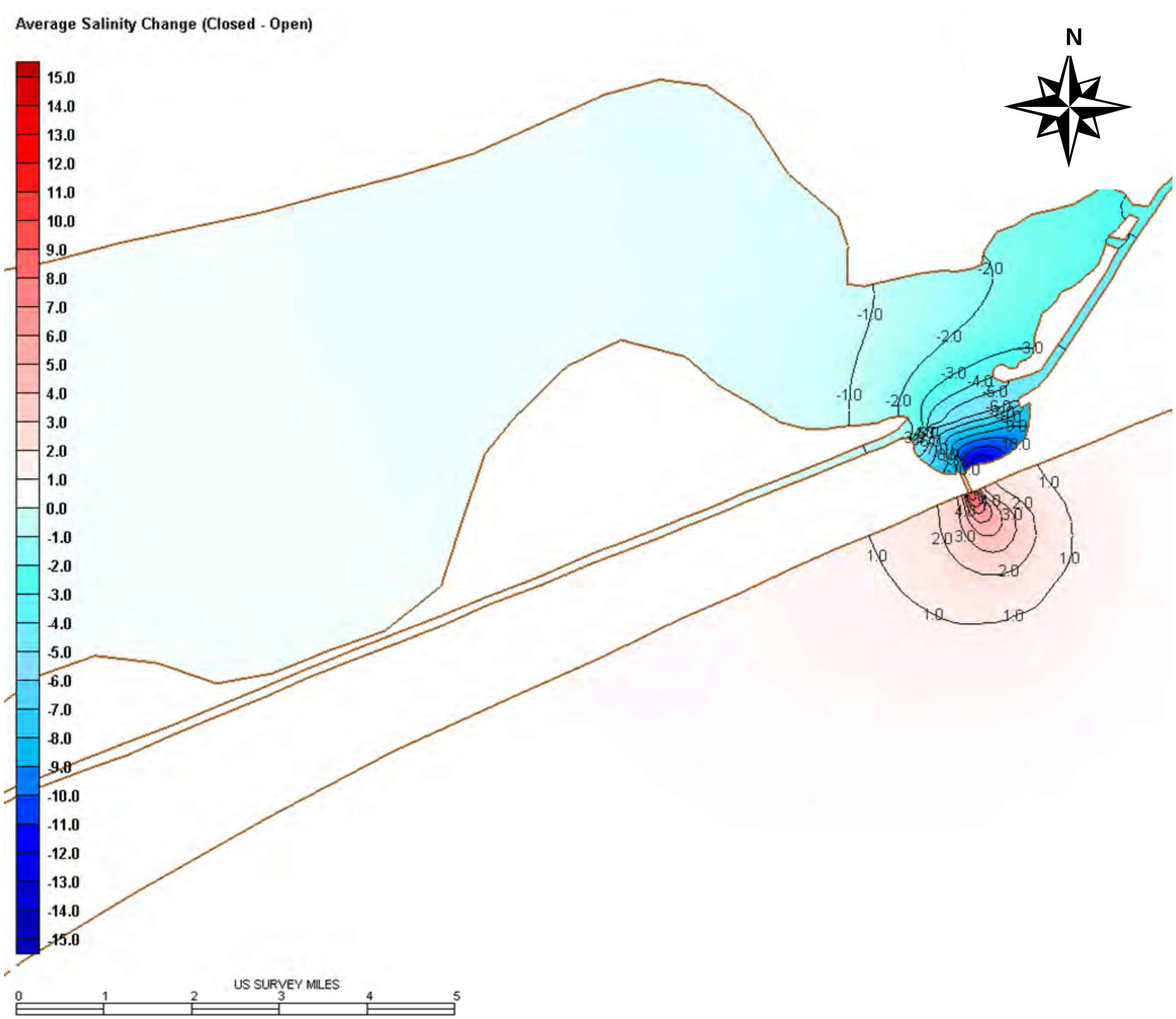

Figure 3.28 Contours of Average Salinity Change, Spring Year 2

4.0 SUMMARY

Overall, the effects on salinity of closing Rollover Pass appear greatest within Rollover Bay. Seasonally-averaged salinity in the Bay may drop as much as 9 – 10 ppt from existing conditions during most of the year. Rollover Bay should experience at least a 3 – 4 ppt drop in seasonally-averaged salinity throughout the year.

Within two miles of Rollover Bay, seasonally-averaged salinity may drop up to 2 – 4 ppt, but may experience no change from existing conditions during some portions of the typical year. Areas more than five – six miles from Rollover Pass should experience minimal changes (less than 2 ppt) in seasonally-averaged salinity.

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Chow, V. T. 1959. *Open-Channel Hydraulics.* McGraw-Hill, Inc. New York.

Donnell, Barbara P., Letter, Joseph V., MacAnaaly, William H., and Thomas, William A. 2005. *Users Guide to RMA2 Version 4.5*. U.S. Army, Engineer Research and Development Center, Waterways Experiment Station, Coastal and Hydraulics Laboratory. Vicksburg, MS.

Donnell, Barbara P., Letter Joseph V. 2003. *Users Guide to RMA4 Version 4.5*. U.S. Army, Engineer Research and Development Center, Waterways Experiment Station, Coastal and Hydraulics Laboratory. Vicksburg, MS.

Matsumoto, J., Powell, G.L., Brock, D.A., and Paternostro, C. 2005. *Effects of Structures and Practices on the Circulation and Salinity Patterns of Galveston Bay, Texas.* Report to the Texas Water Development Board, Austin, Texas, February, 2005.

APPENDIX A

Salinity Variation with Time Plots

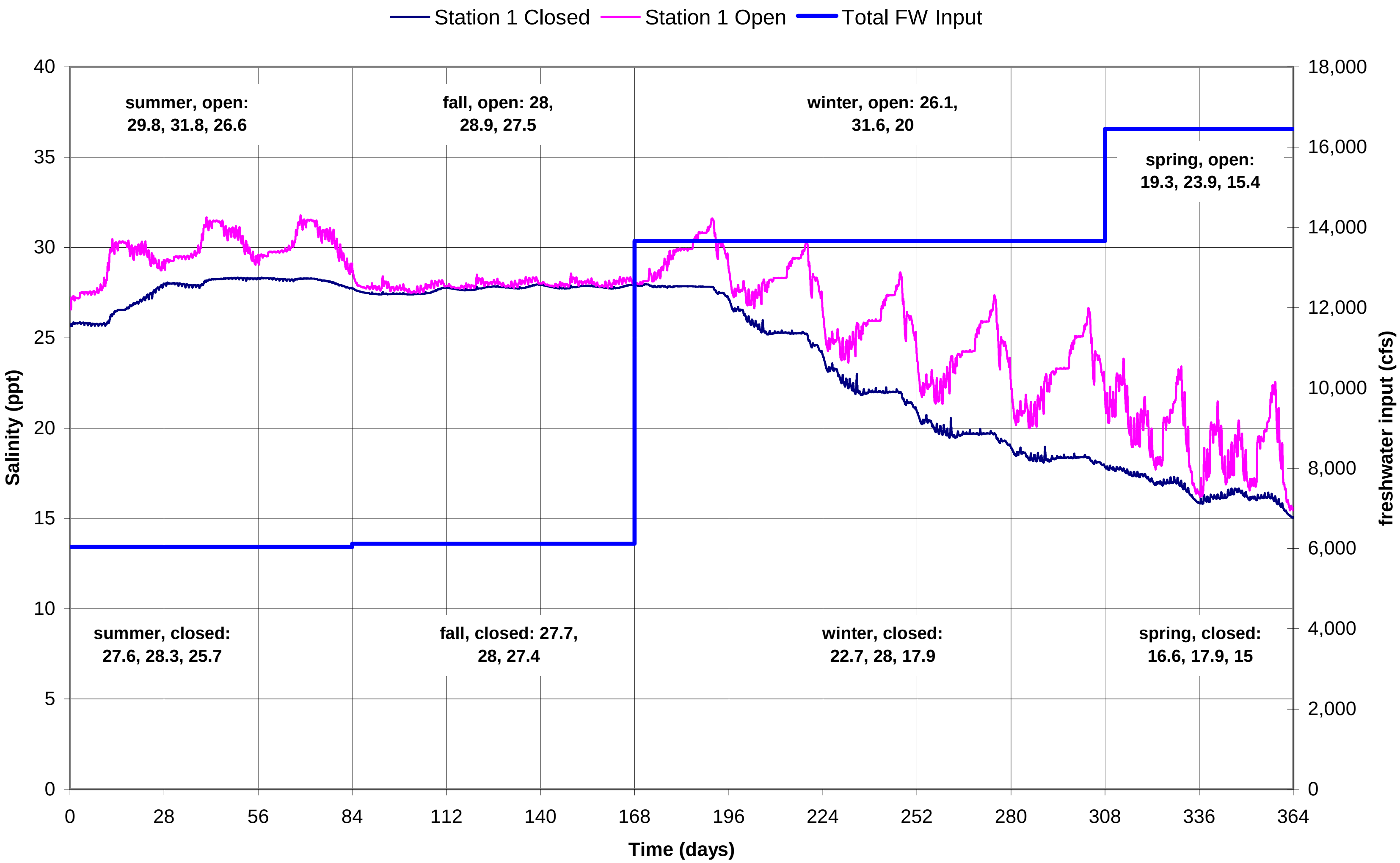

Figure A1 Salinity Variation with Time, Station 1, Year 1

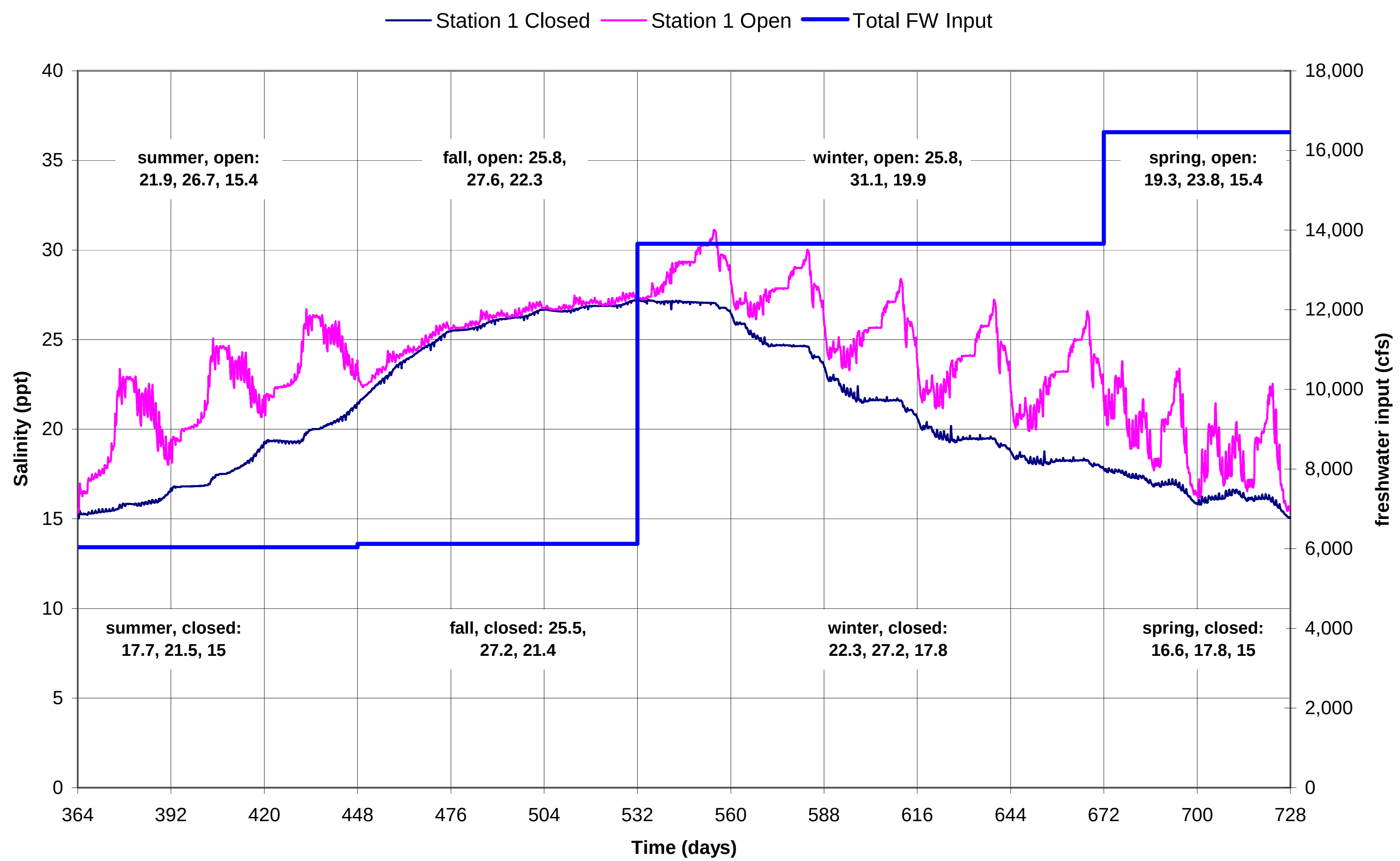

Figure A2 Salinity Variation with Time, Station 1, Year 2

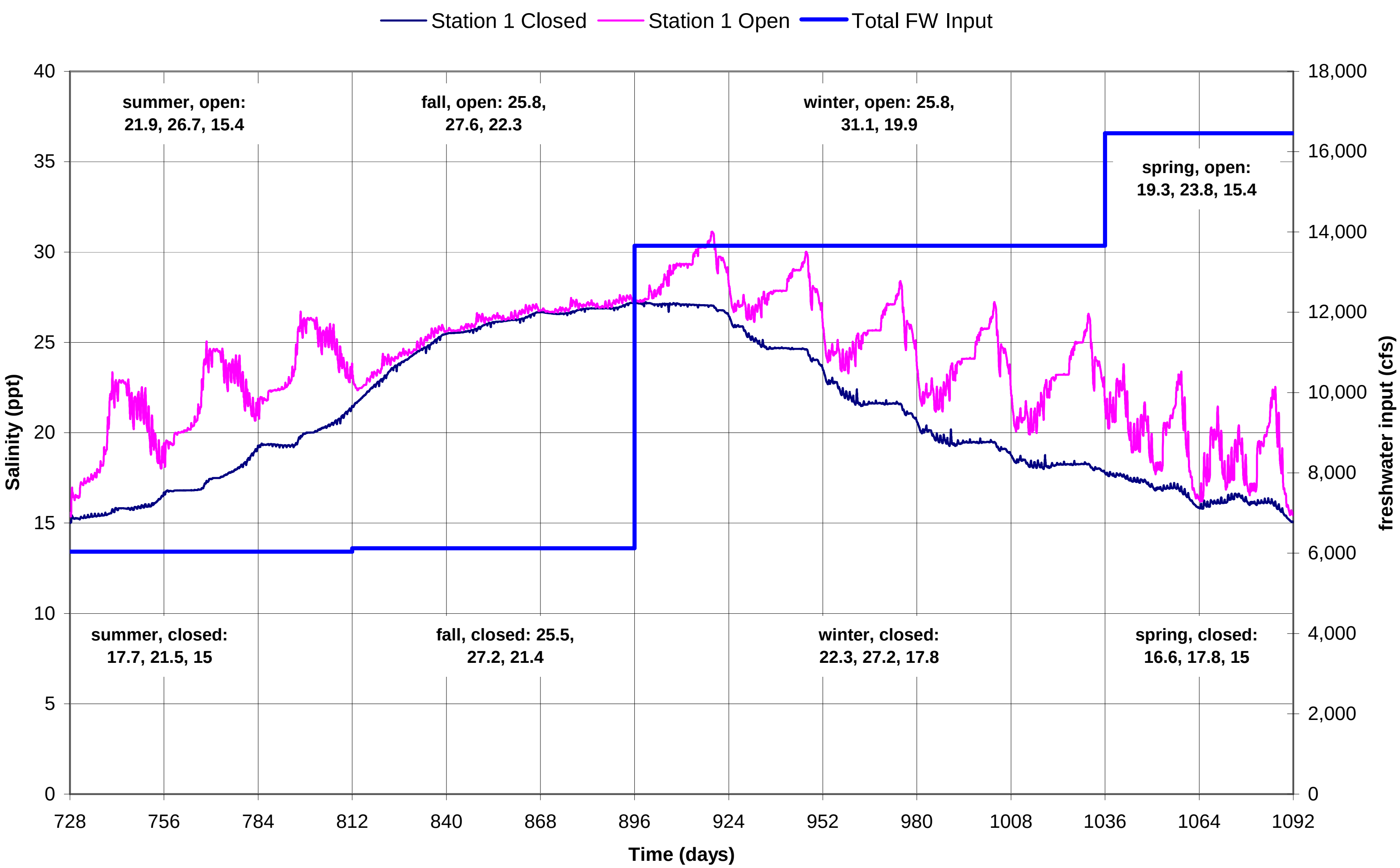

Figure A3 Salinity Variation with Time, Station 1, Year 3

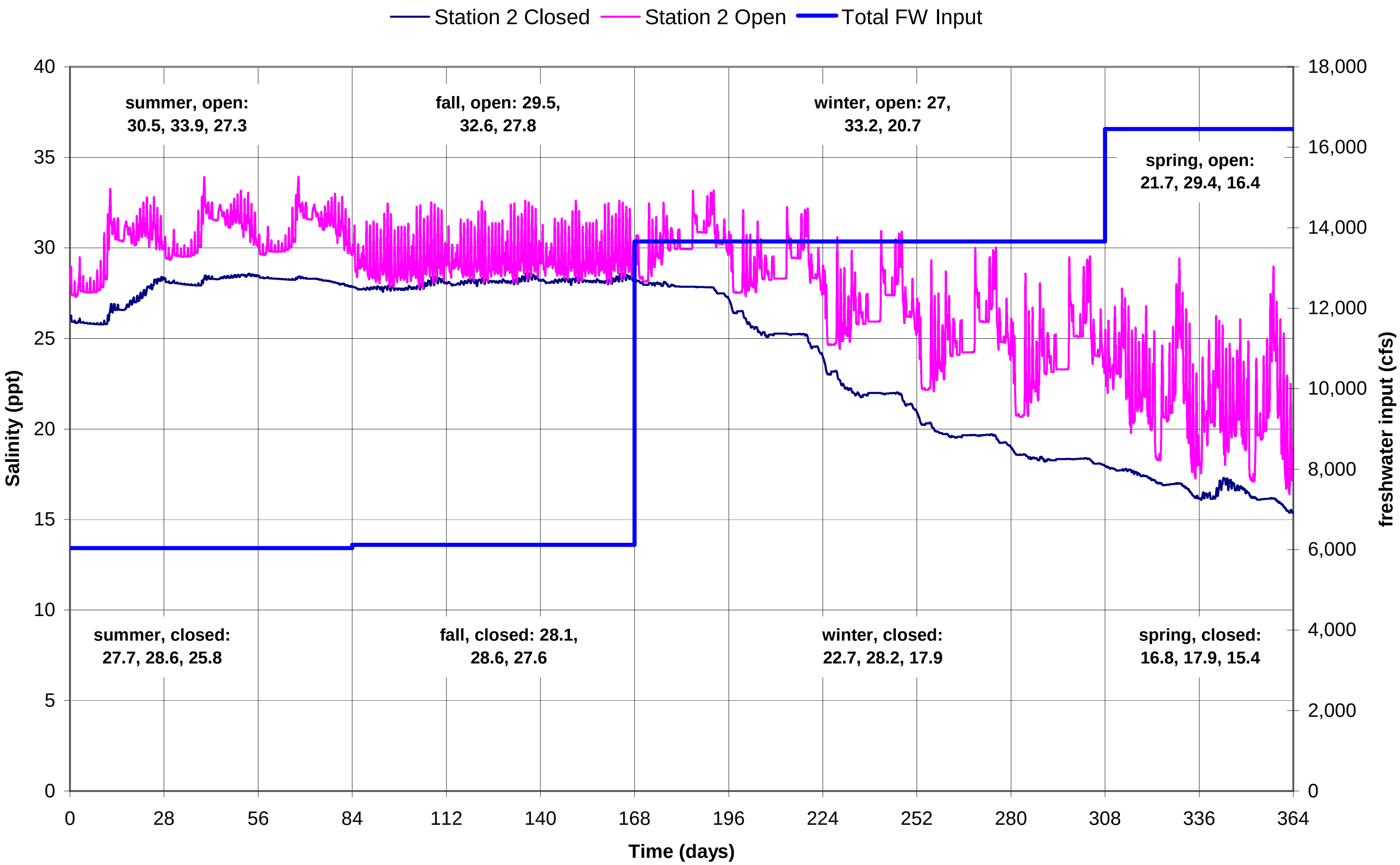

Figure A4 Salinity Variation with Time, Station 2, Year 1

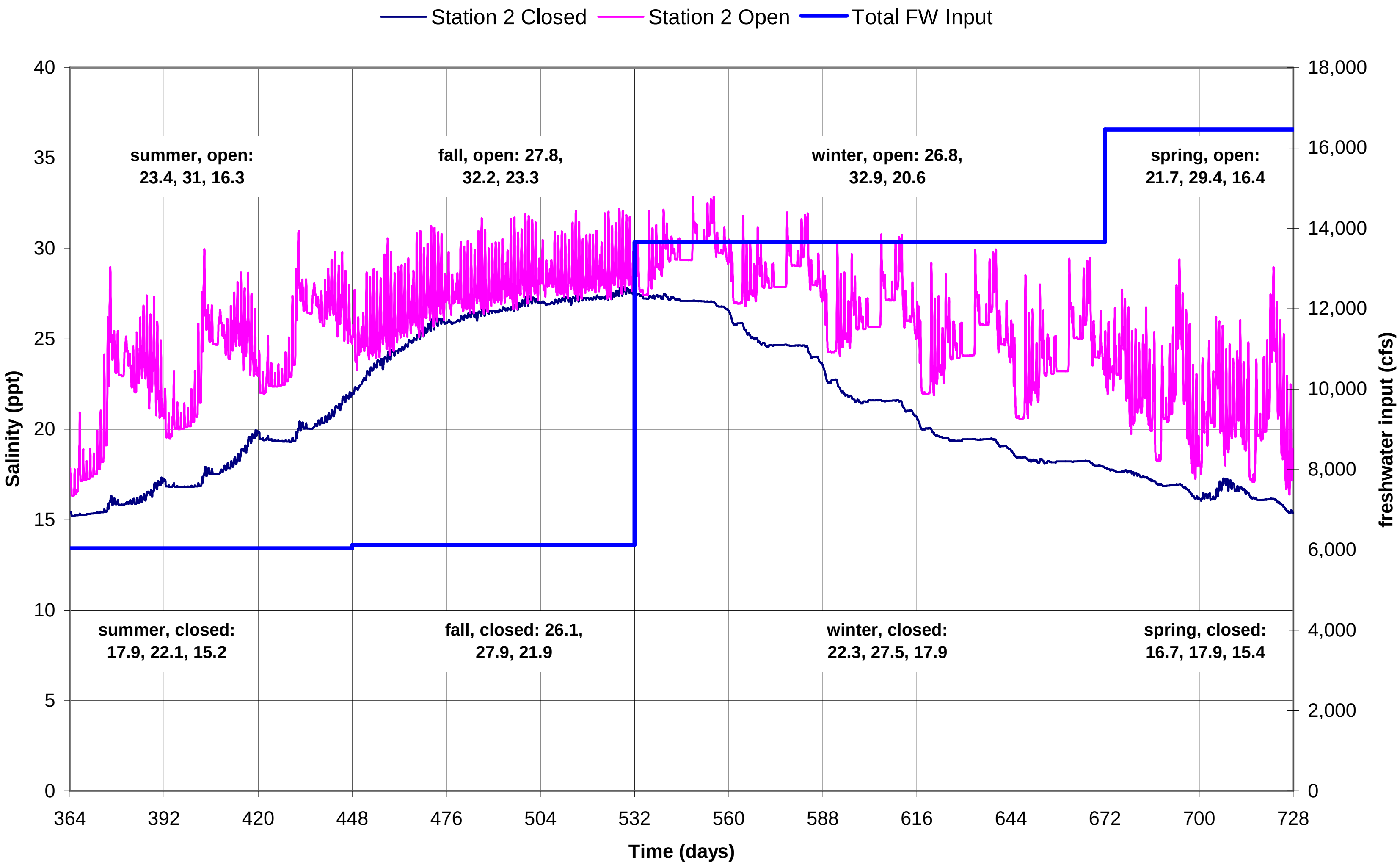

Figure A5 Salinity Variation with Time, Station 2, Year 2

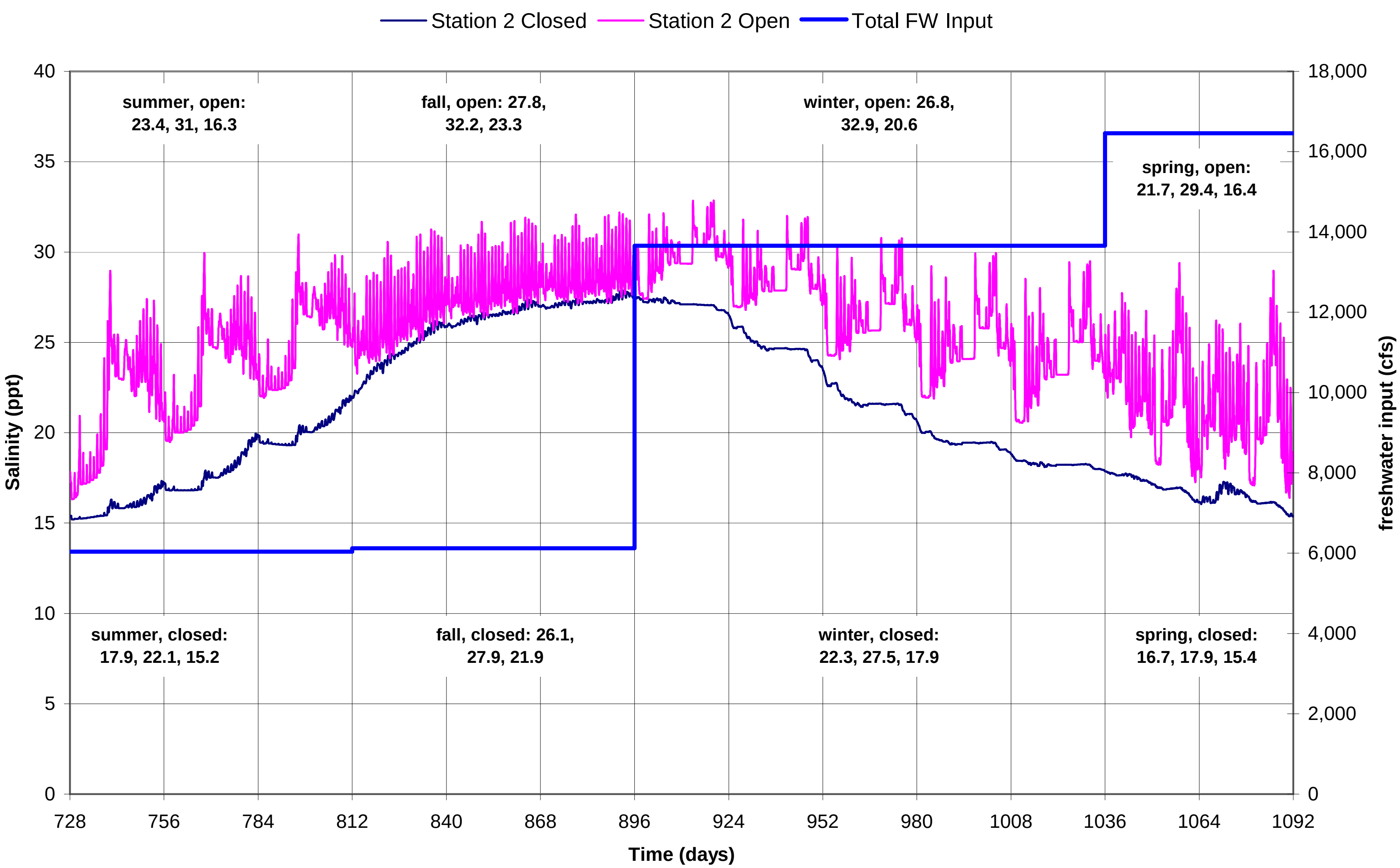

Figure A6 Salinity Variation with Time, Station 2, Year 3

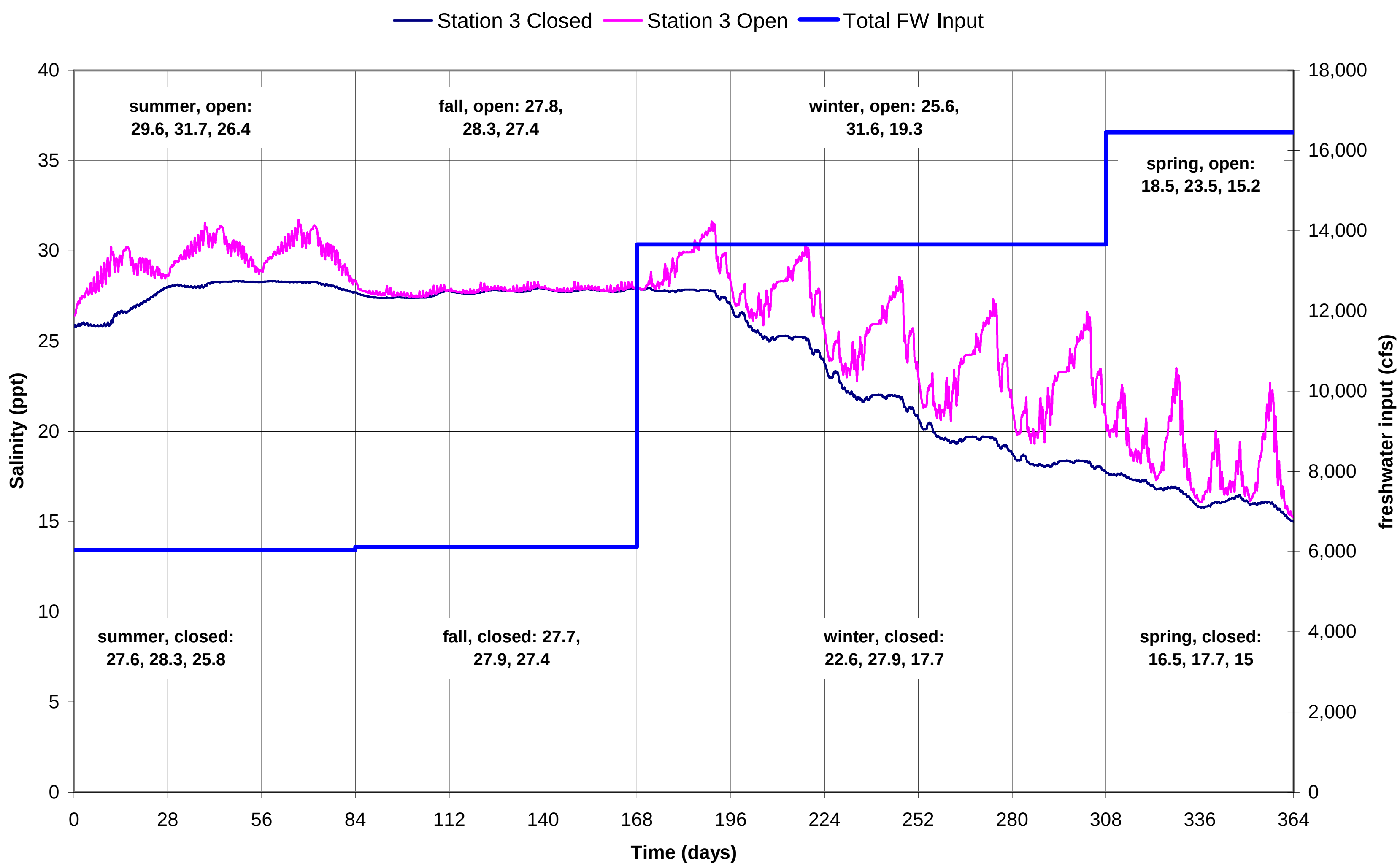

Figure A7 Salinity Variation with Time, Station 3, Year 1

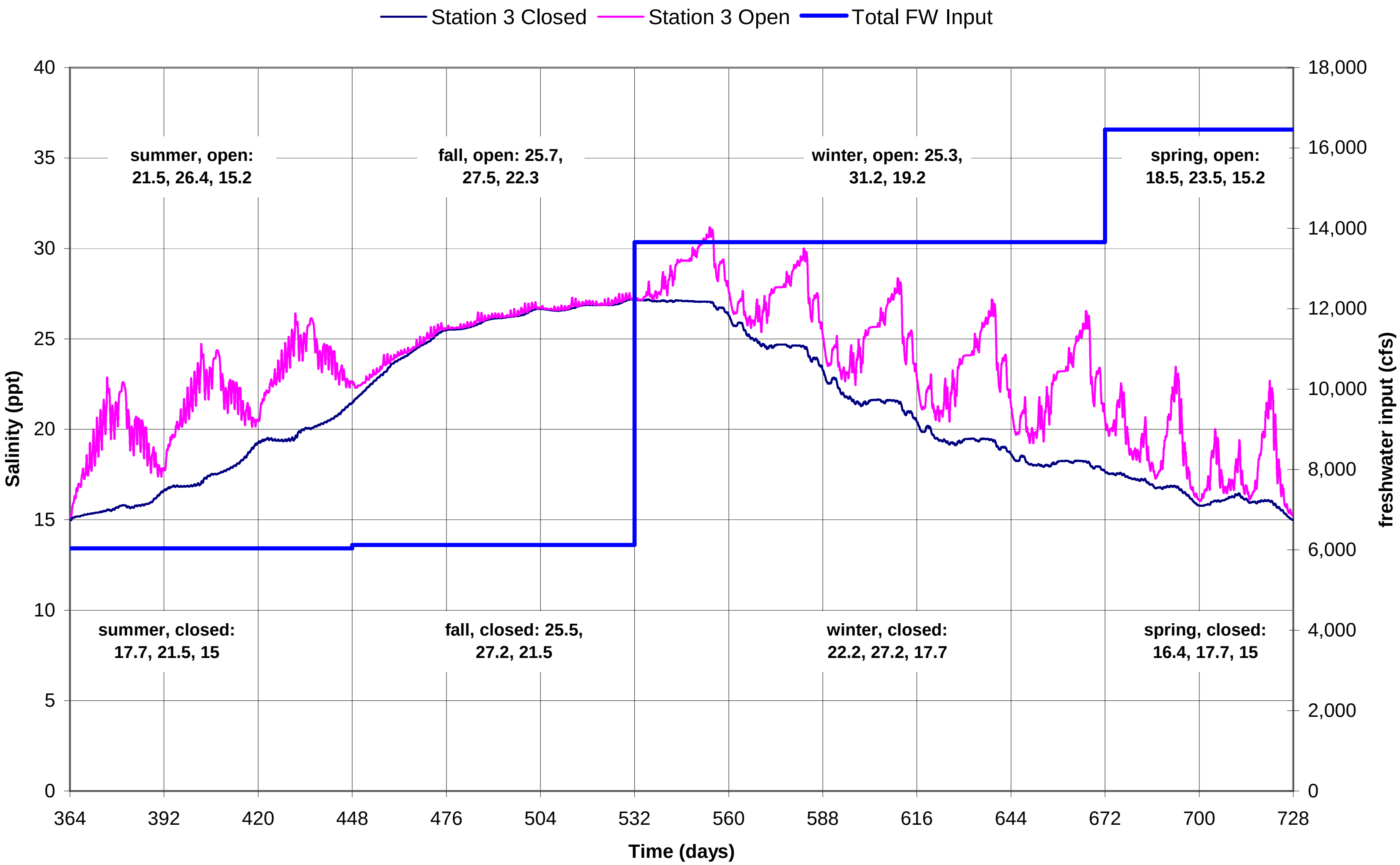

Figure A8 Salinity Variation with Time, Station 3, Year 2

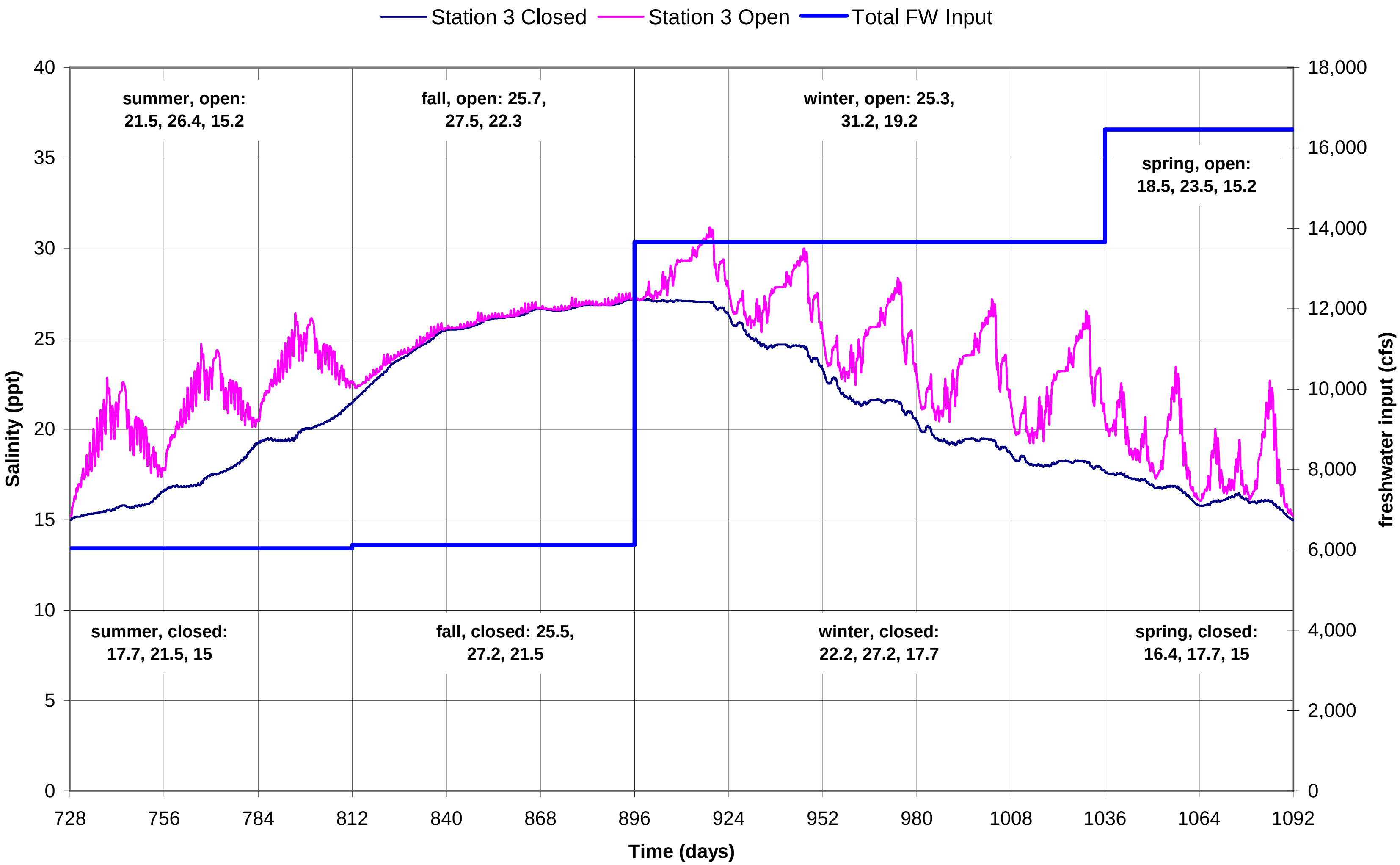

Figure A9 Salinity Variation with Time, Station 3, Year 3

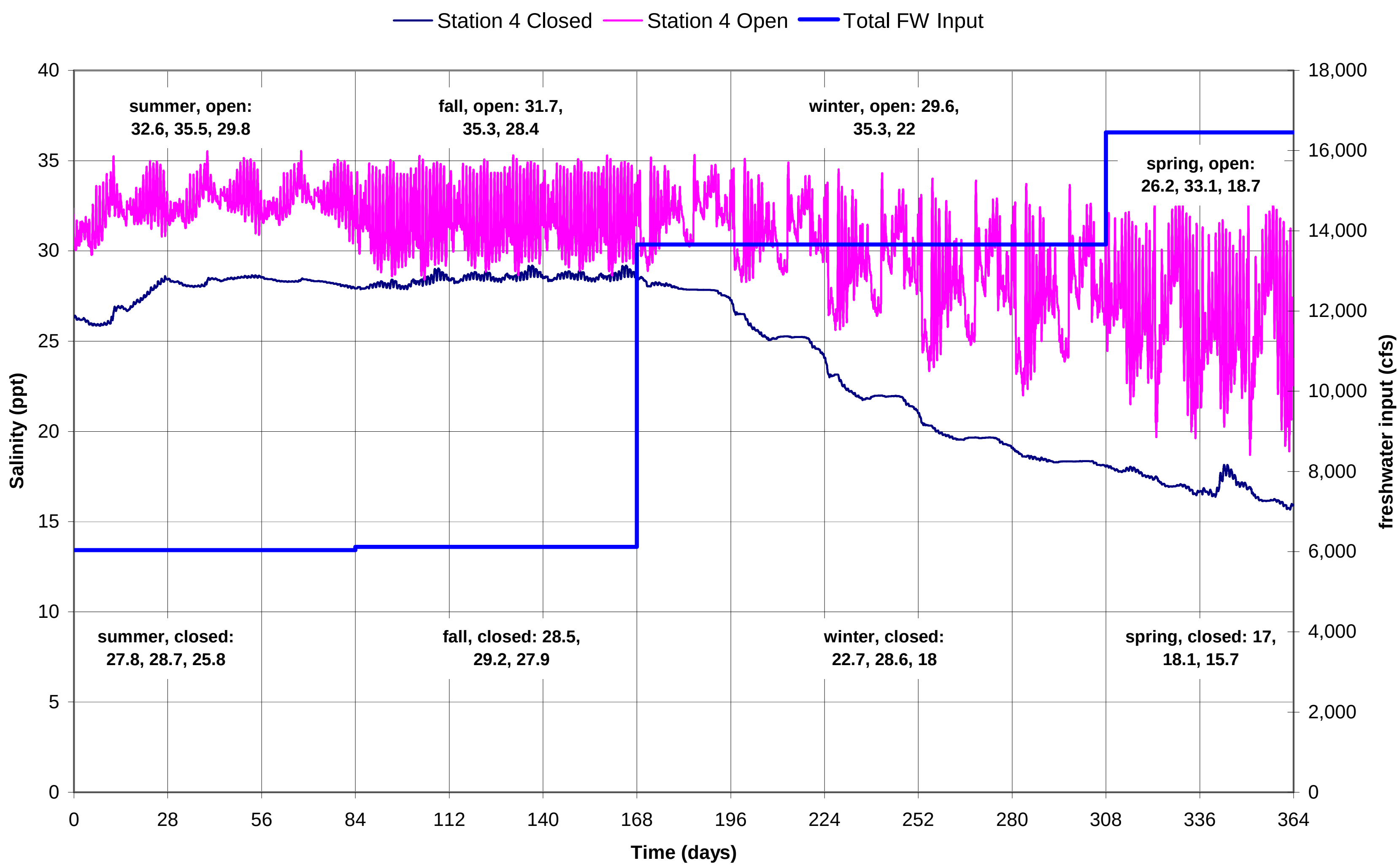

Figure A10 Salinity Variation with Time, Station 4, Year 1

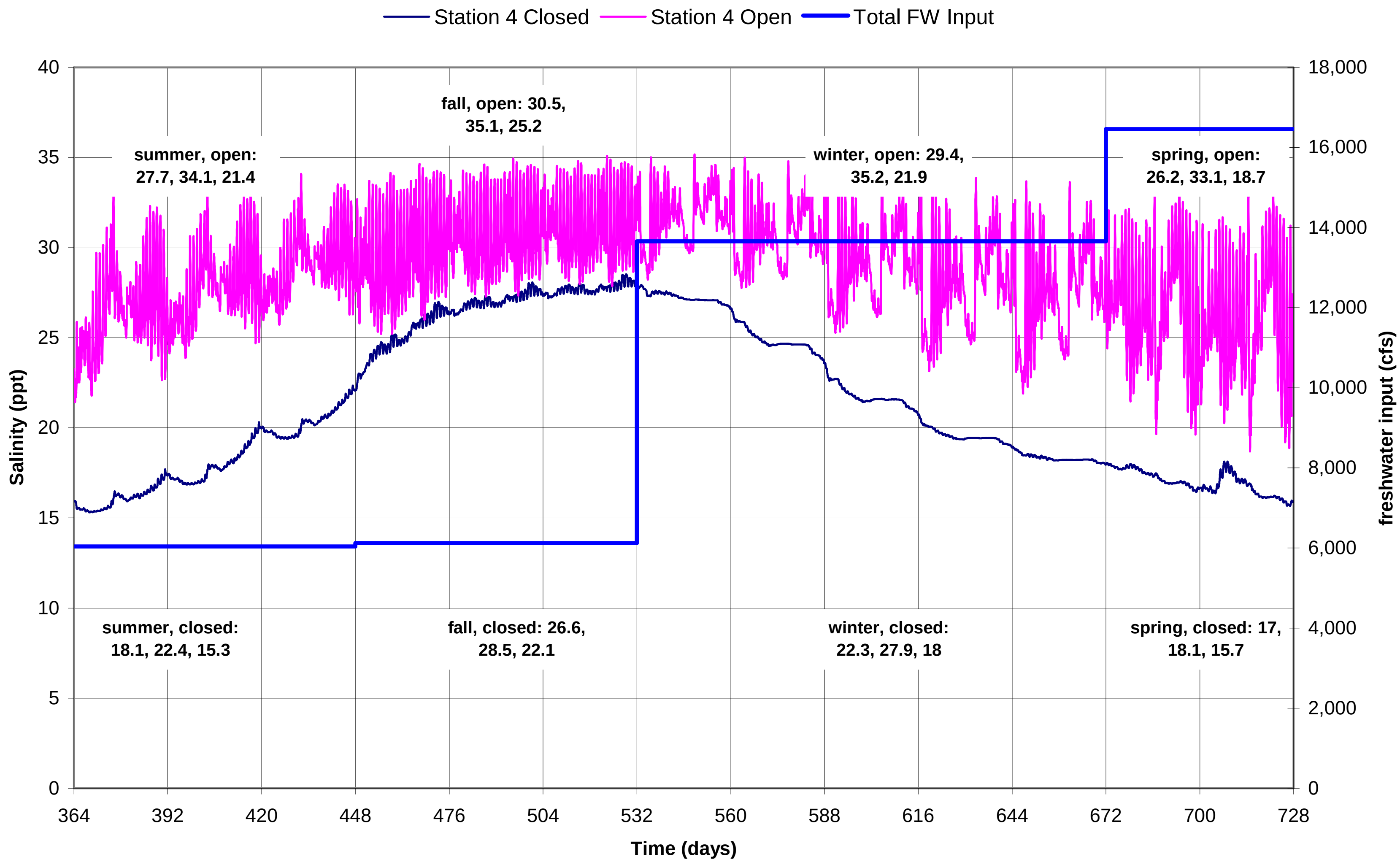

Figure A11 Salinity Variation with Time, Station 4, Year 2

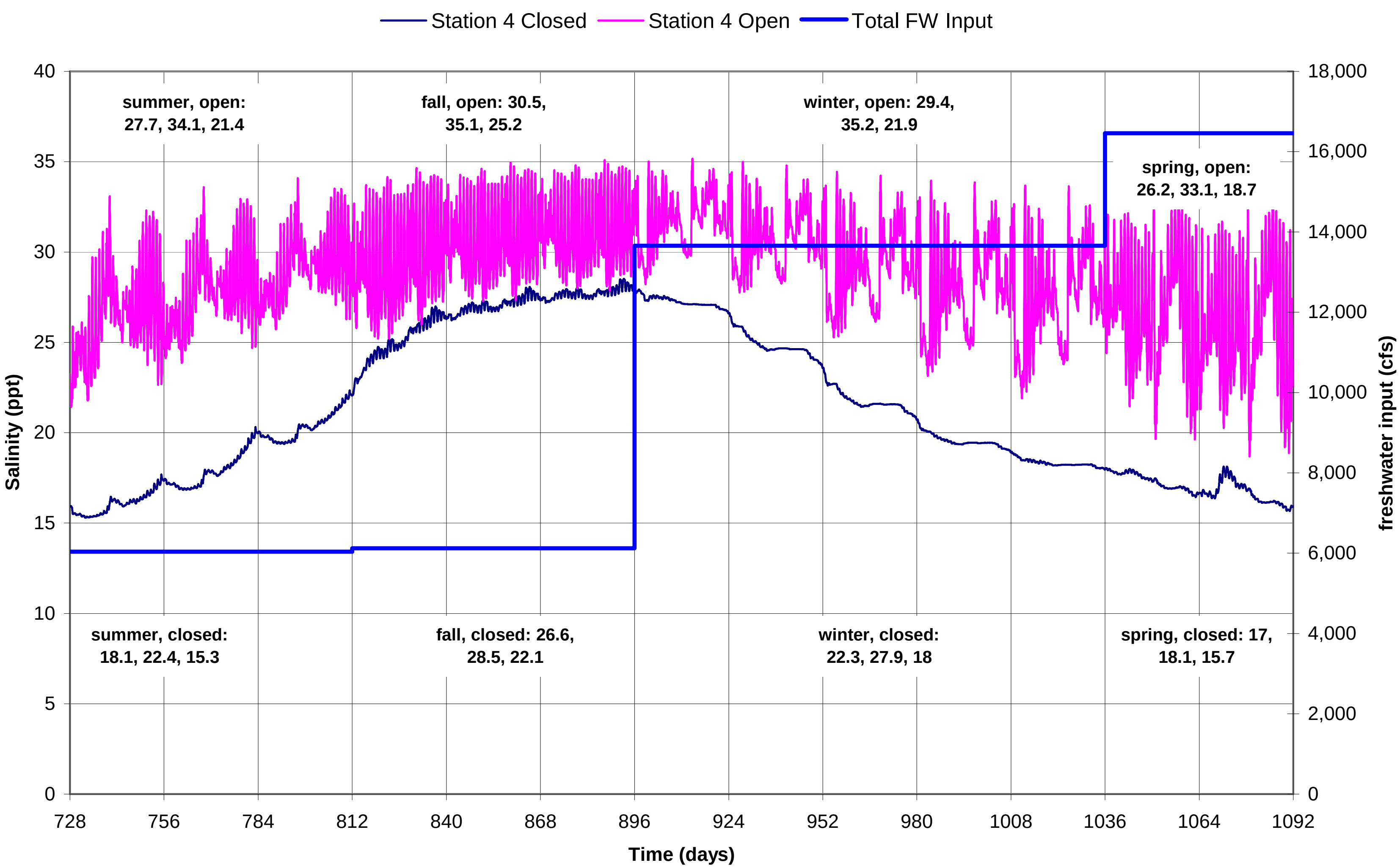

Figure A12 Salinity Variation with Time, Station 4, Year 3

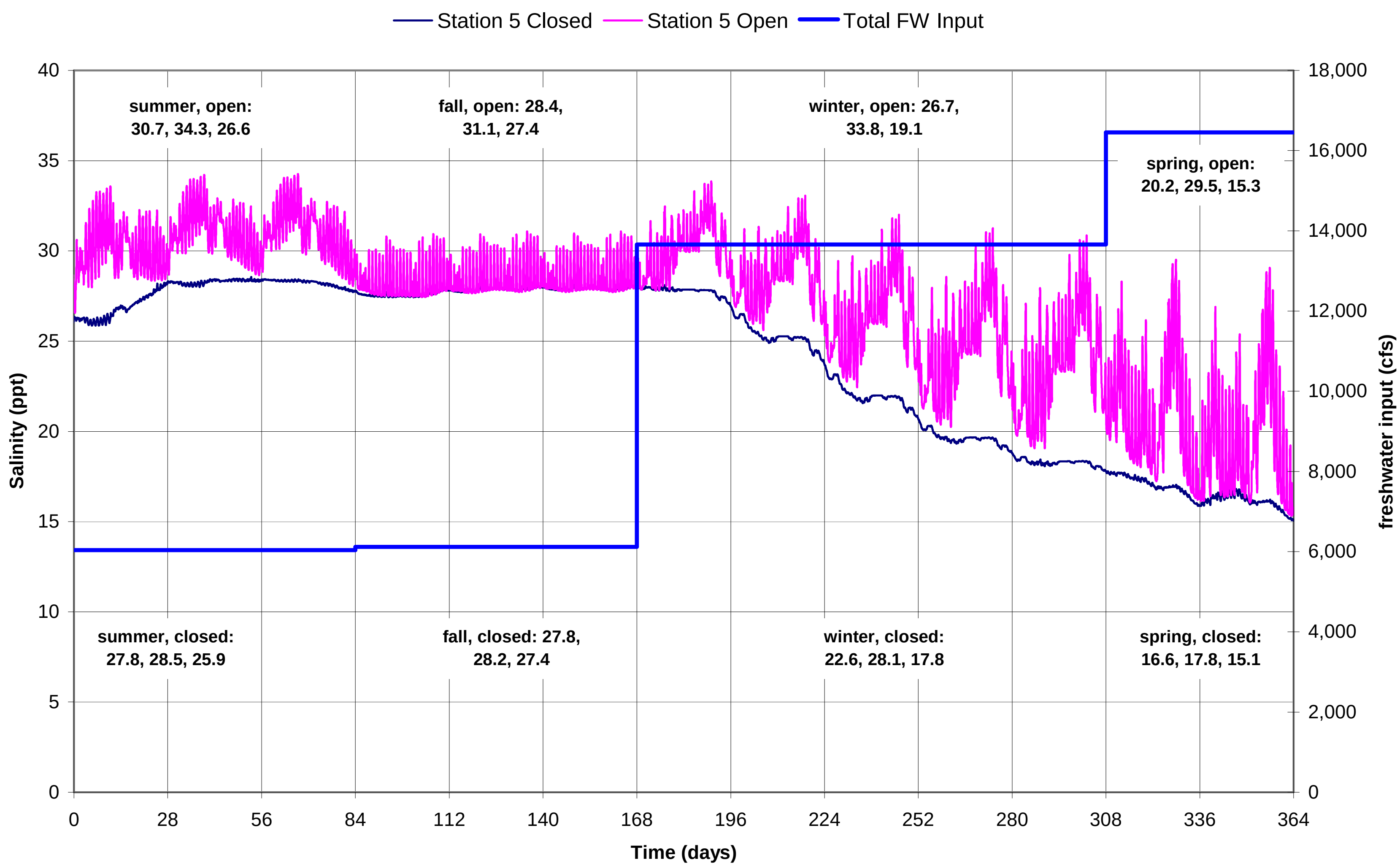

Figure A13 Salinity Variation with Time, Station 5, Year 1

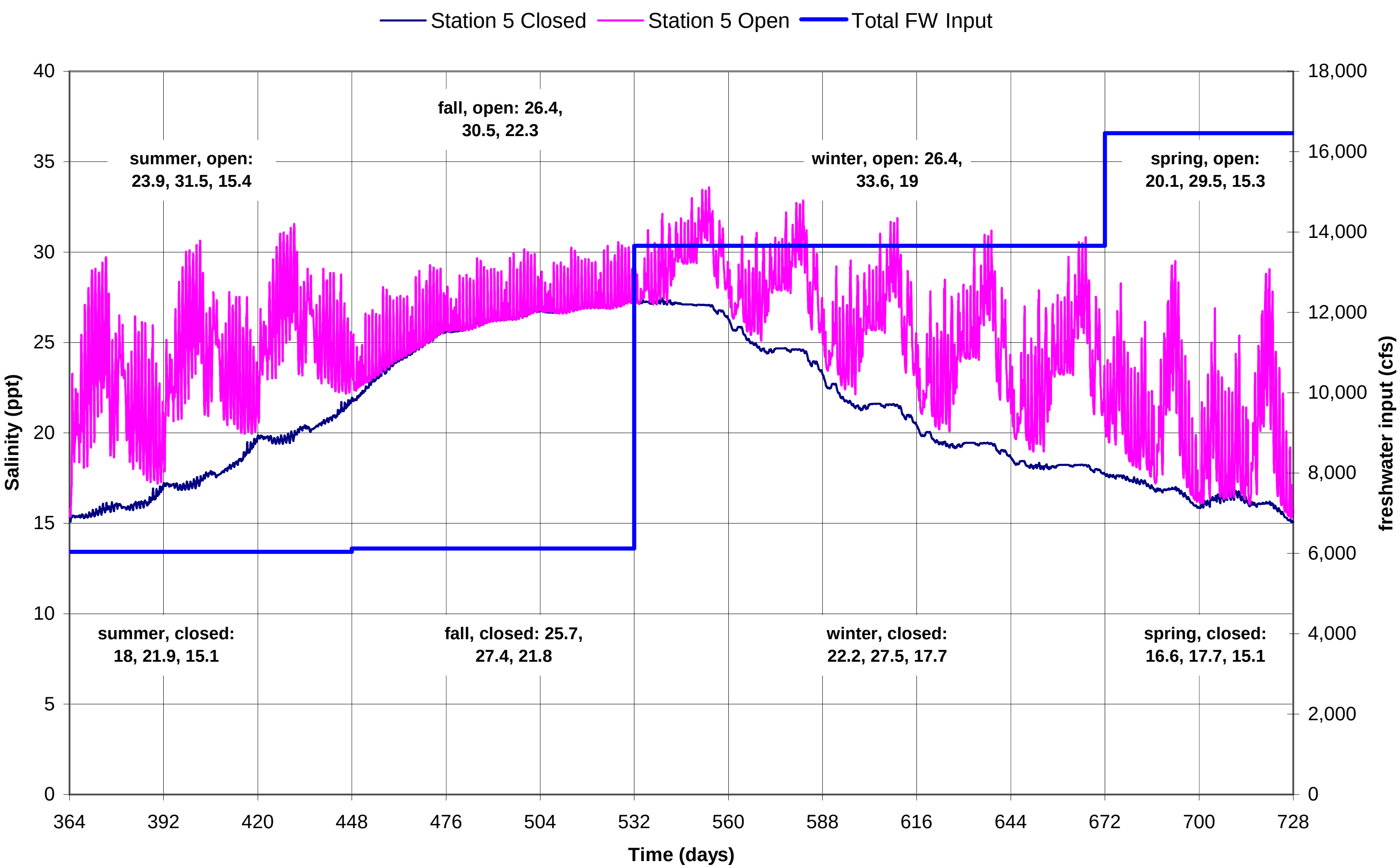

Figure A14 Salinity Variation with Time, Station 5, Year 2

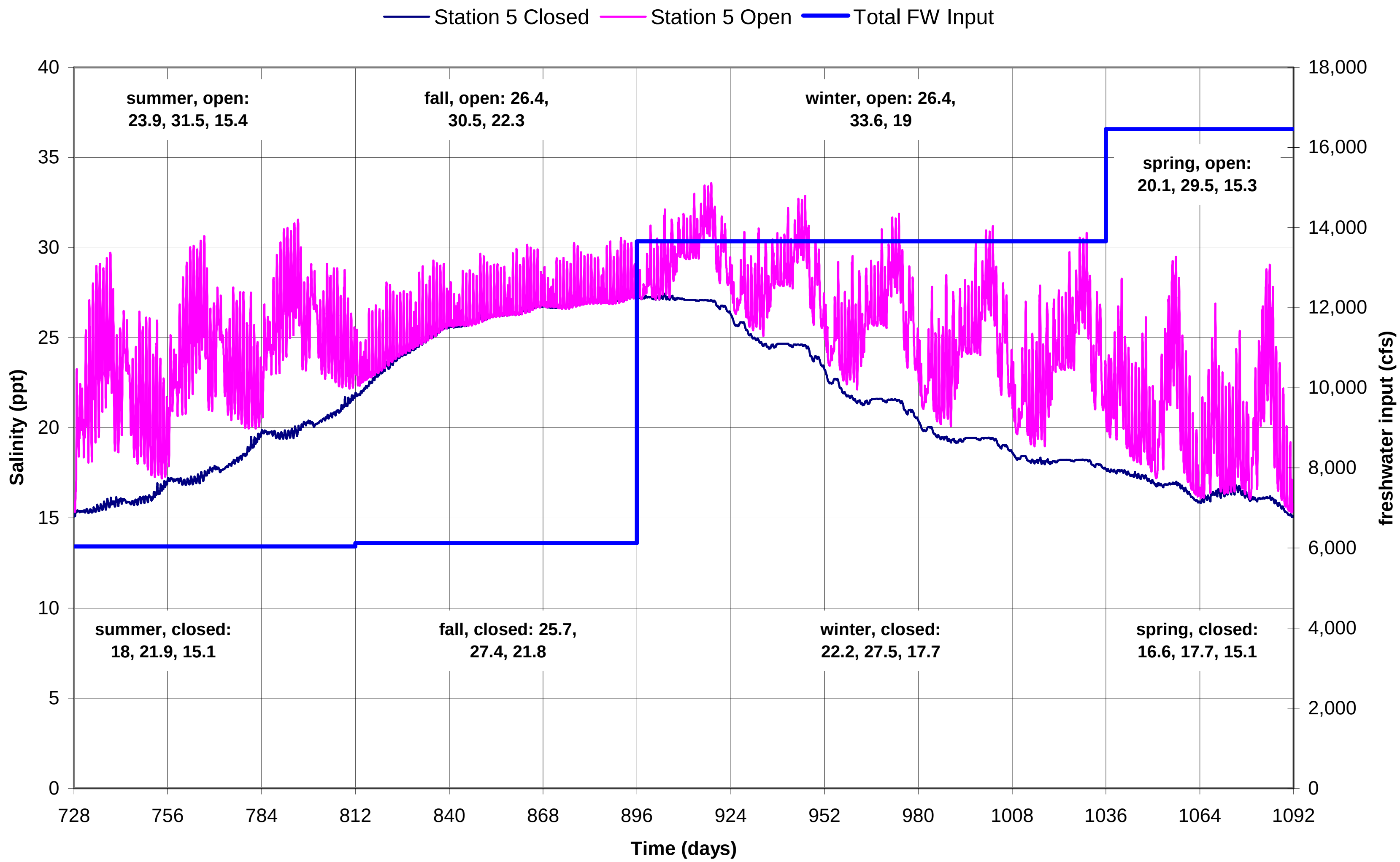

Figure A15 Salinity Variation with Time, Station 5, Year 3

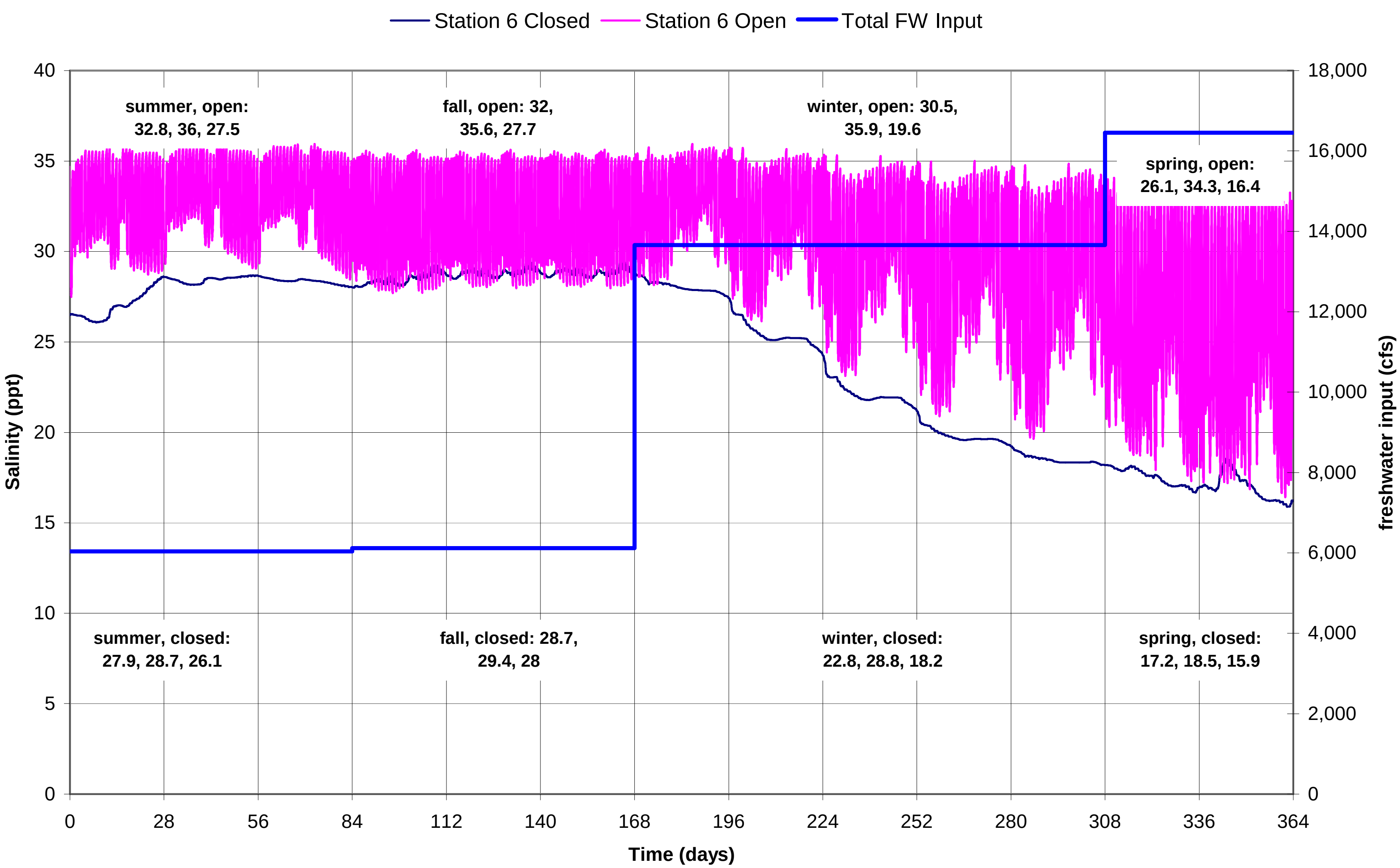

Figure A16 Salinity Variation with Time, Station 6, Year 1

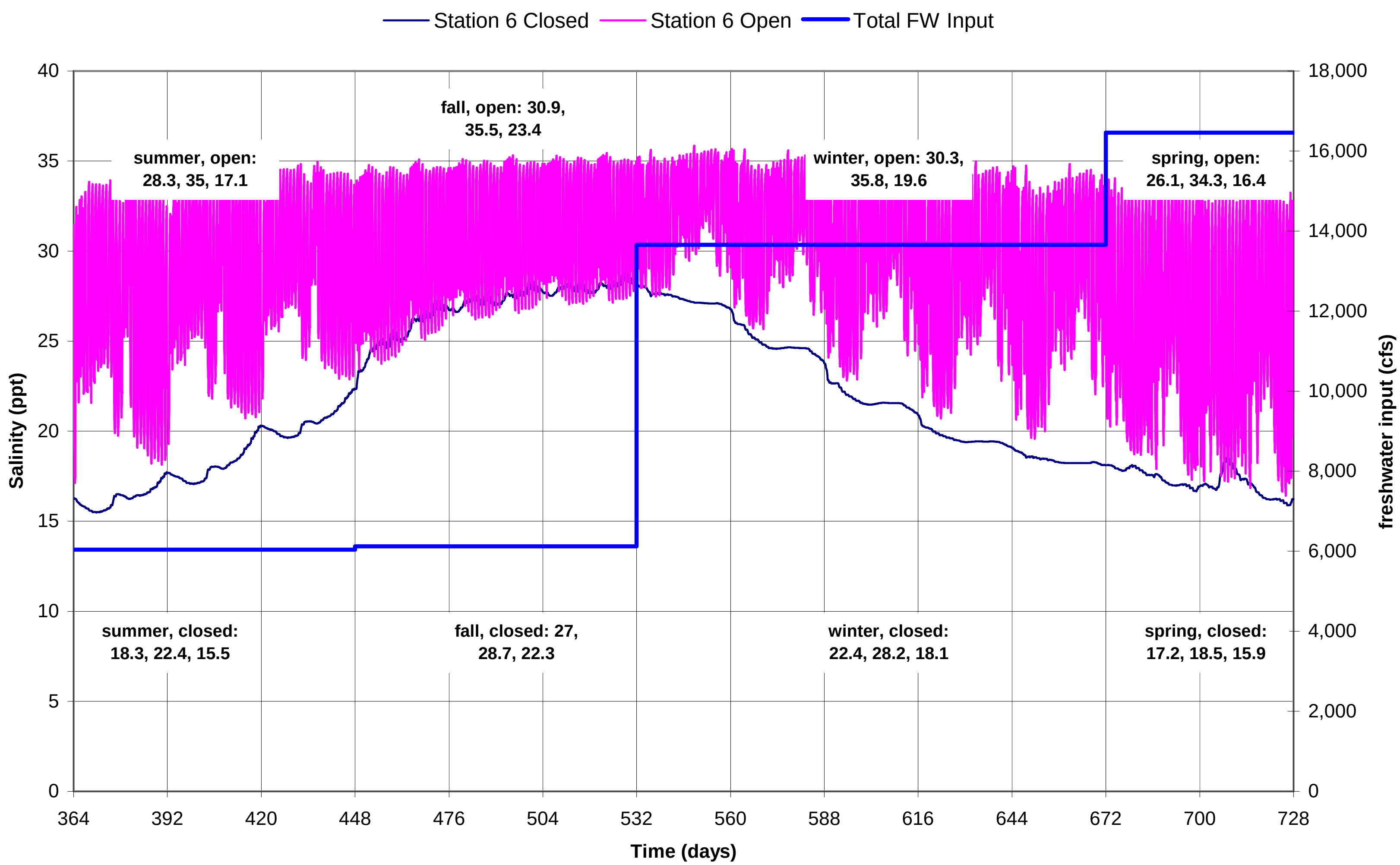

Figure A17 Salinity Variation with Time, Station 6, Year 2

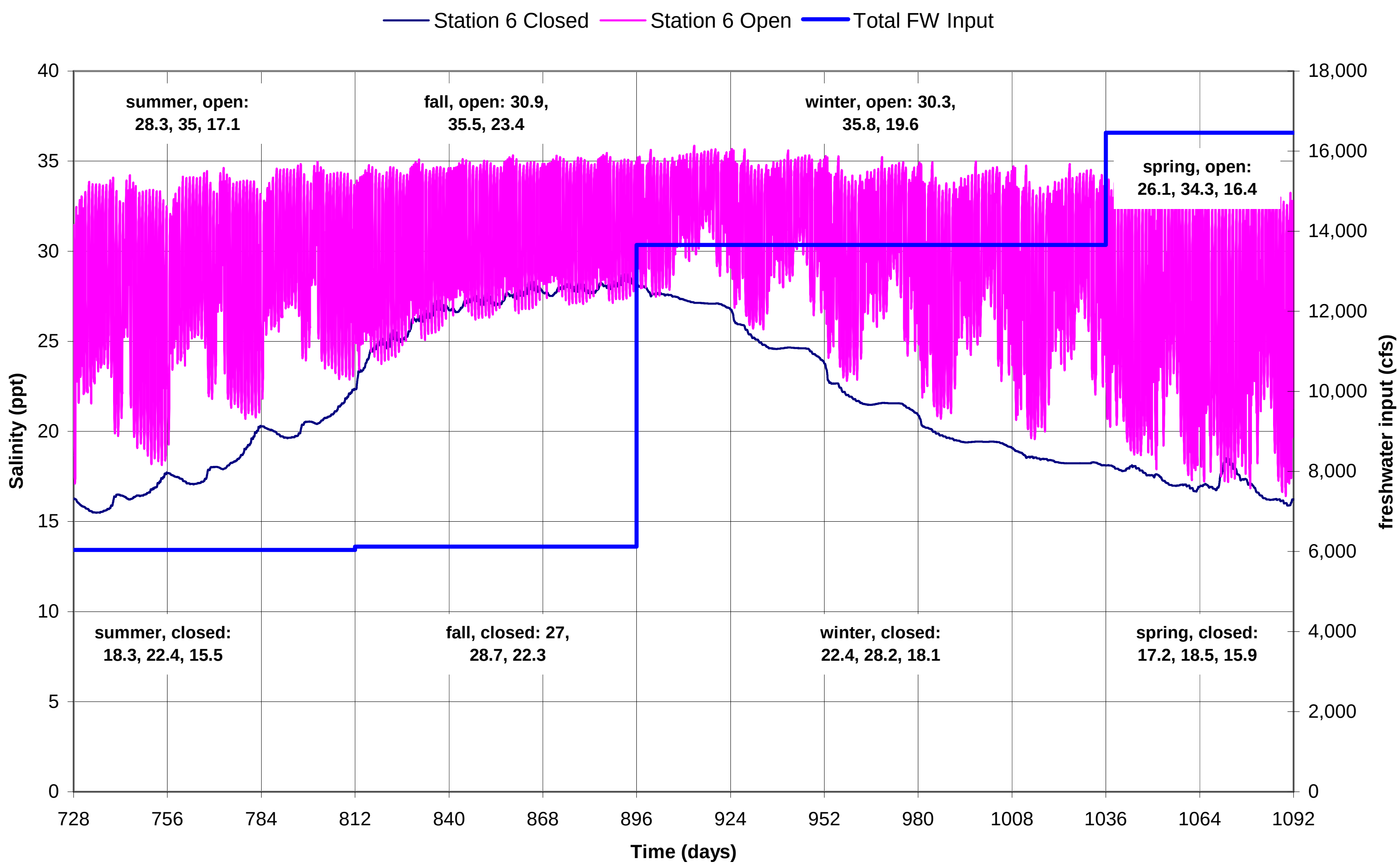

Figure A18 Salinity Variation with Time, Station 6, Year 3

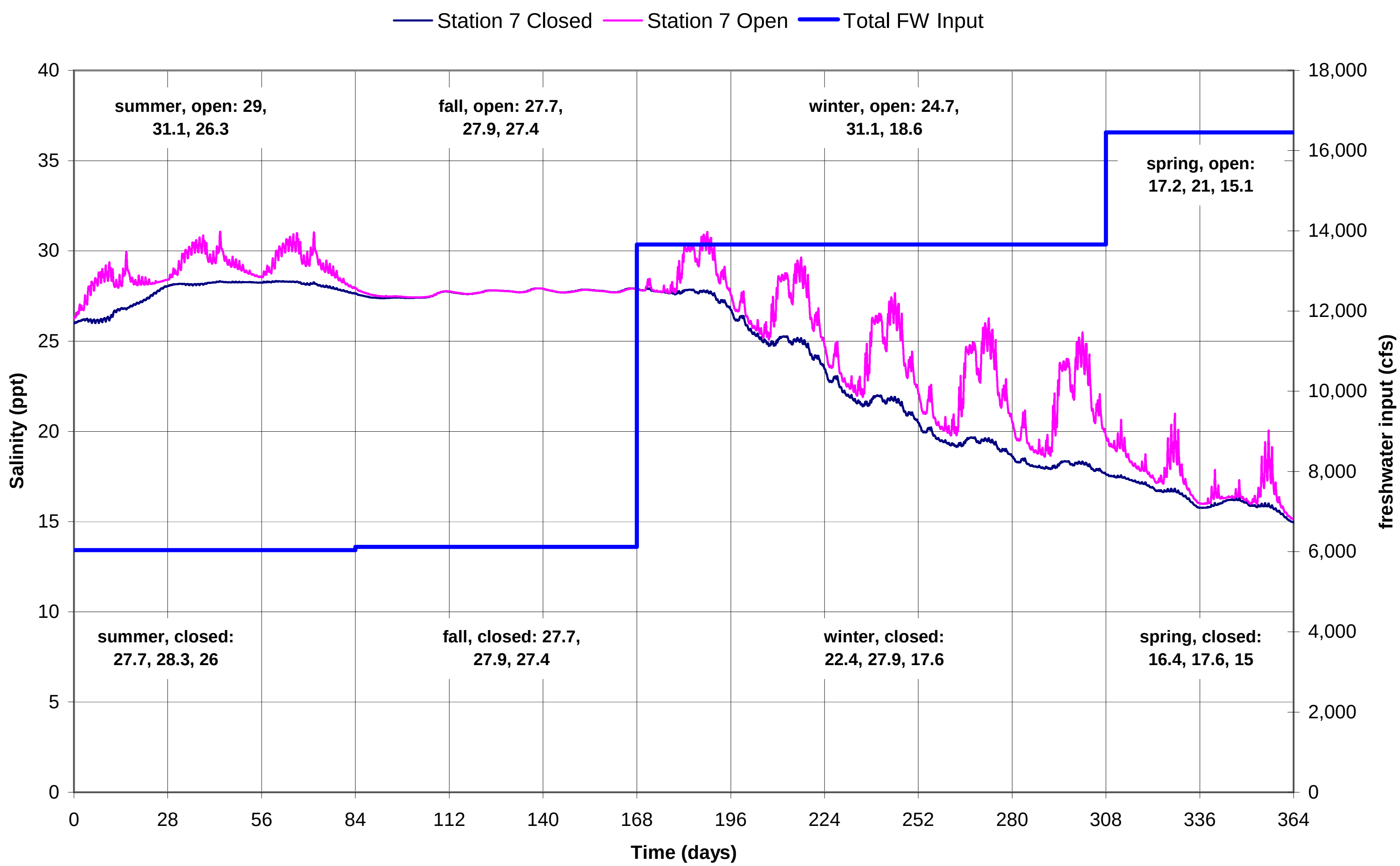

Figure A19 Salinity Variation with Time, Station 7, Year 1

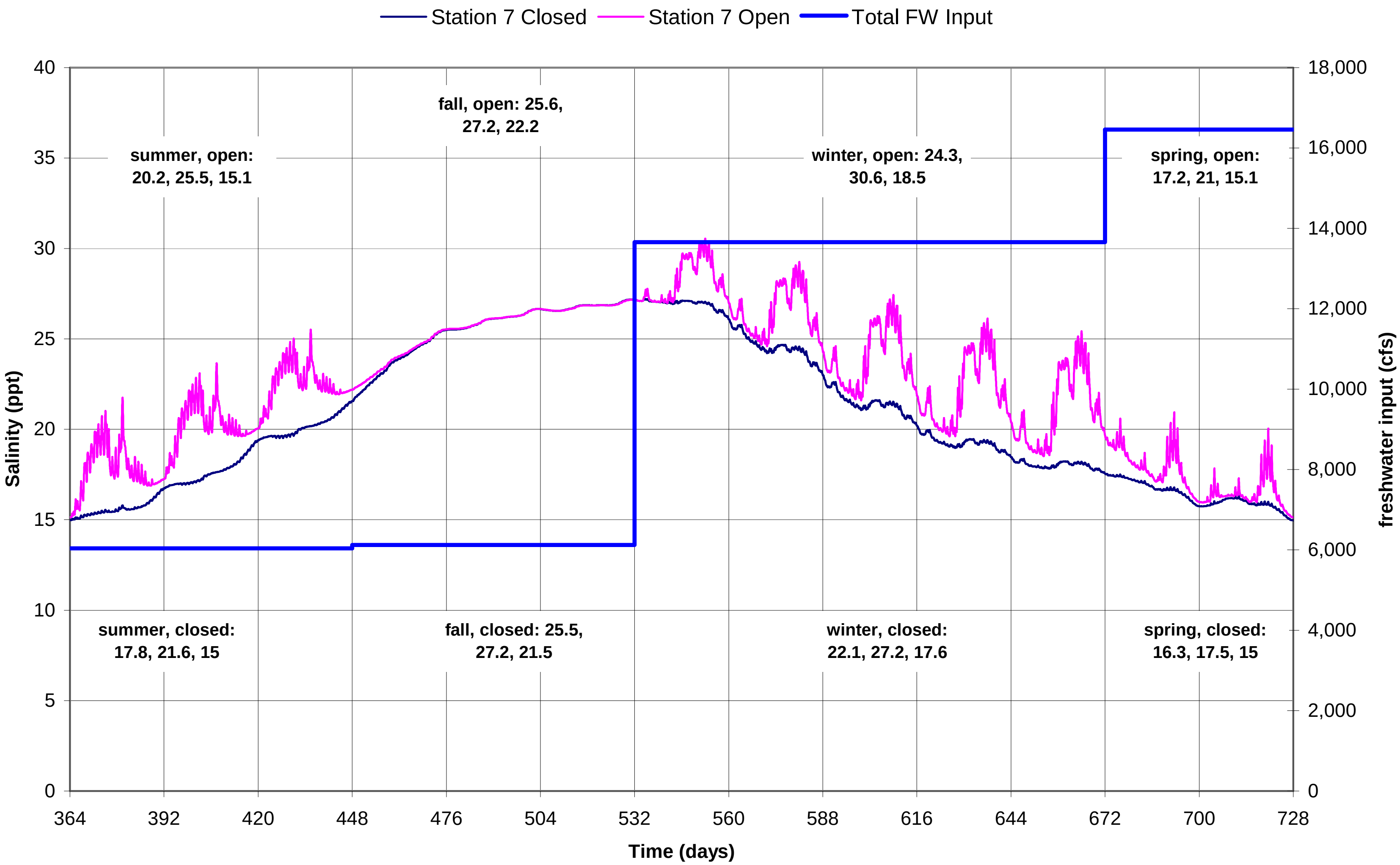

Figure A20 Salinity Variation with Time, Station 7, Year 2

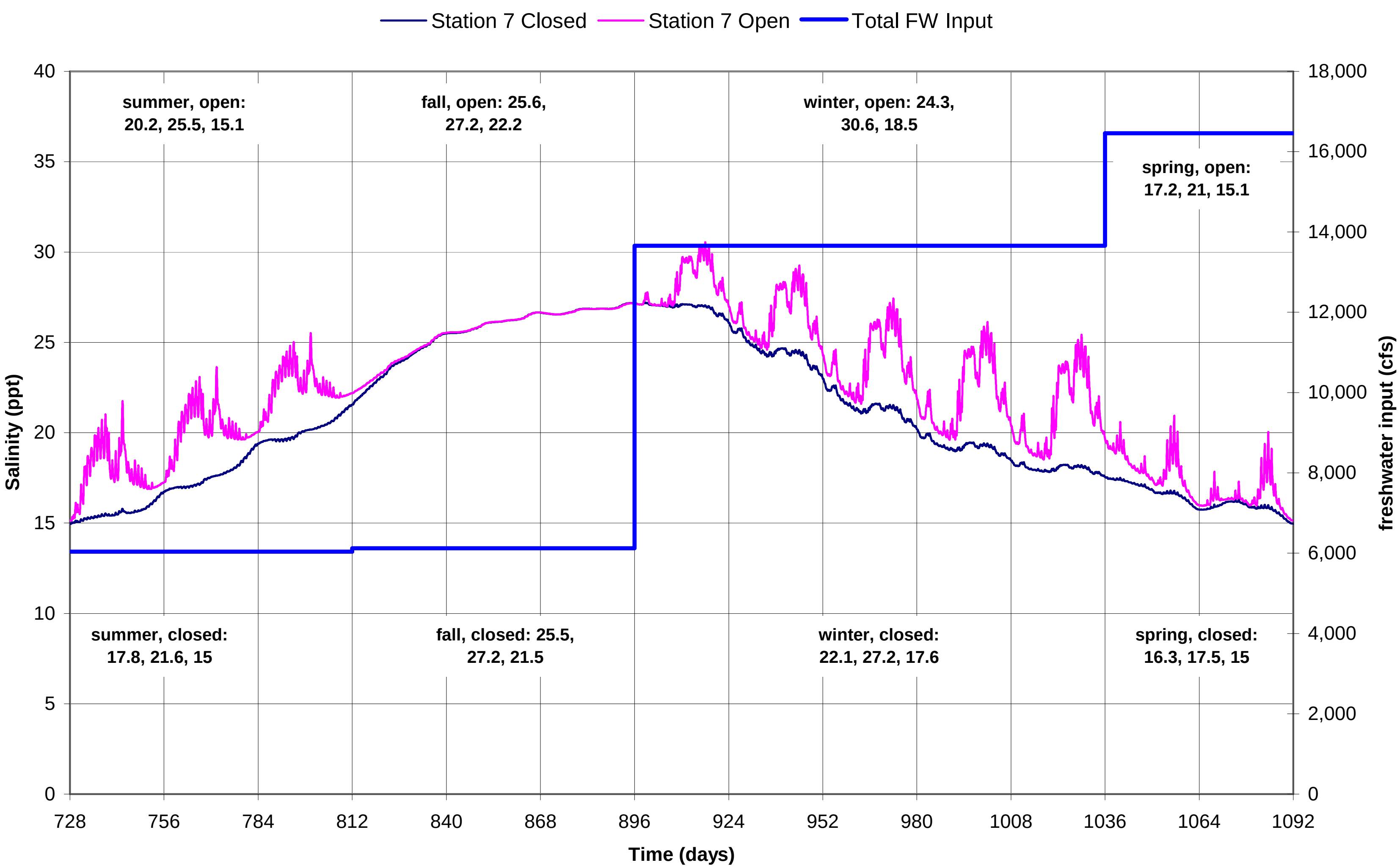

Figure A21 Salinity Variation with Time, Station 7, Year 3

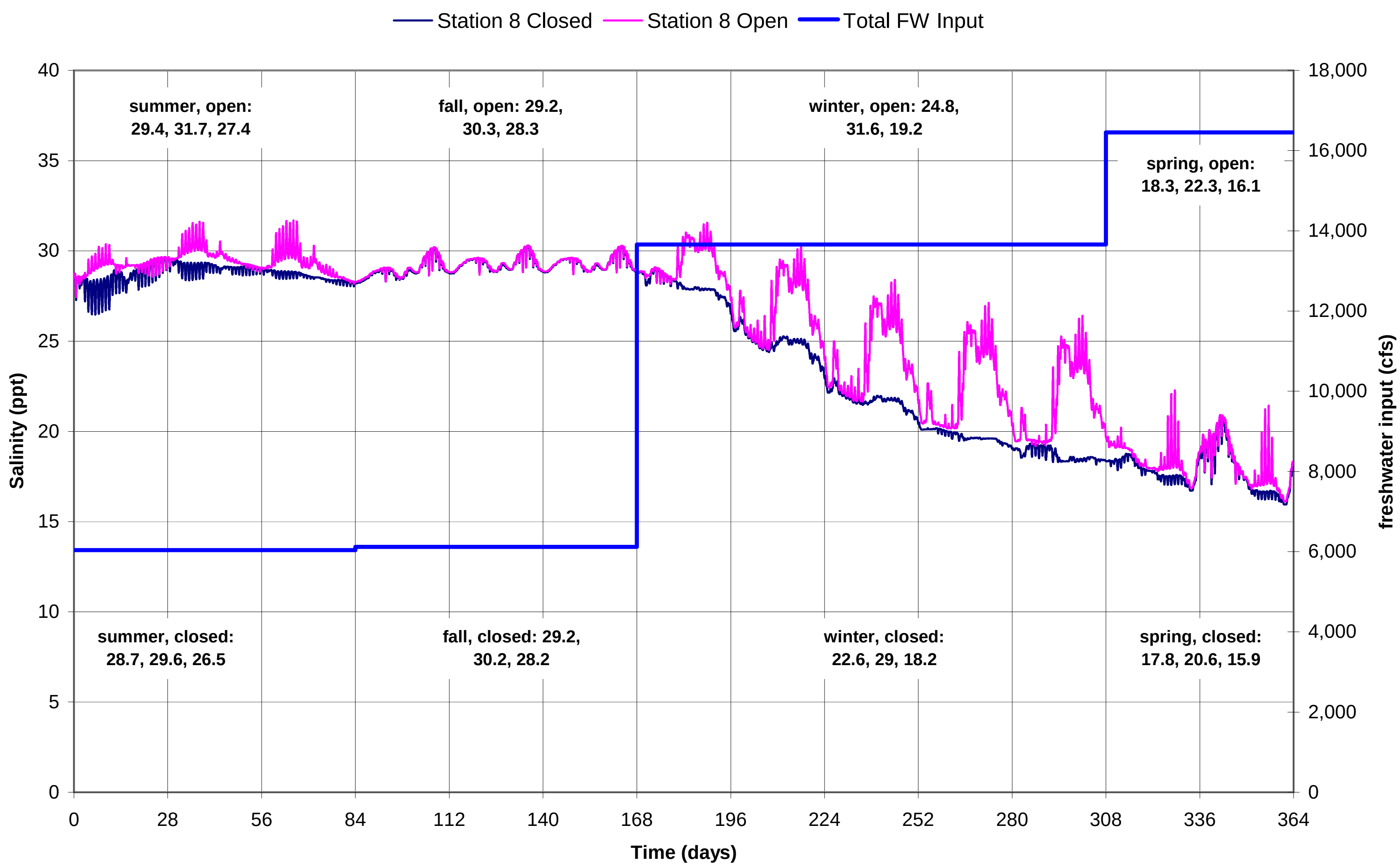

Figure A22 Salinity Variation with Time, Station 8, Year 1

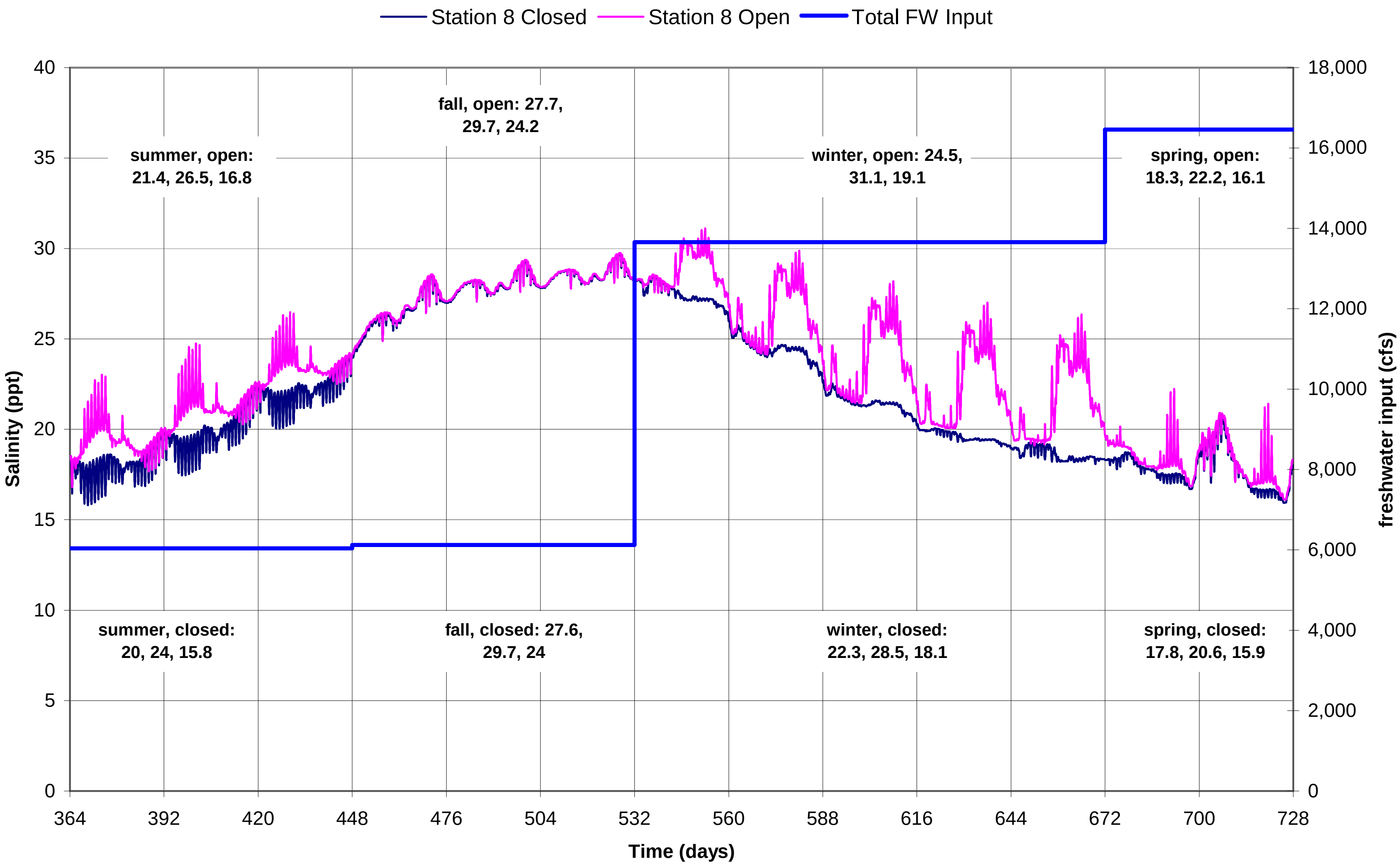

Figure A23 Salinity Variation with Time, Station 8, Year 2

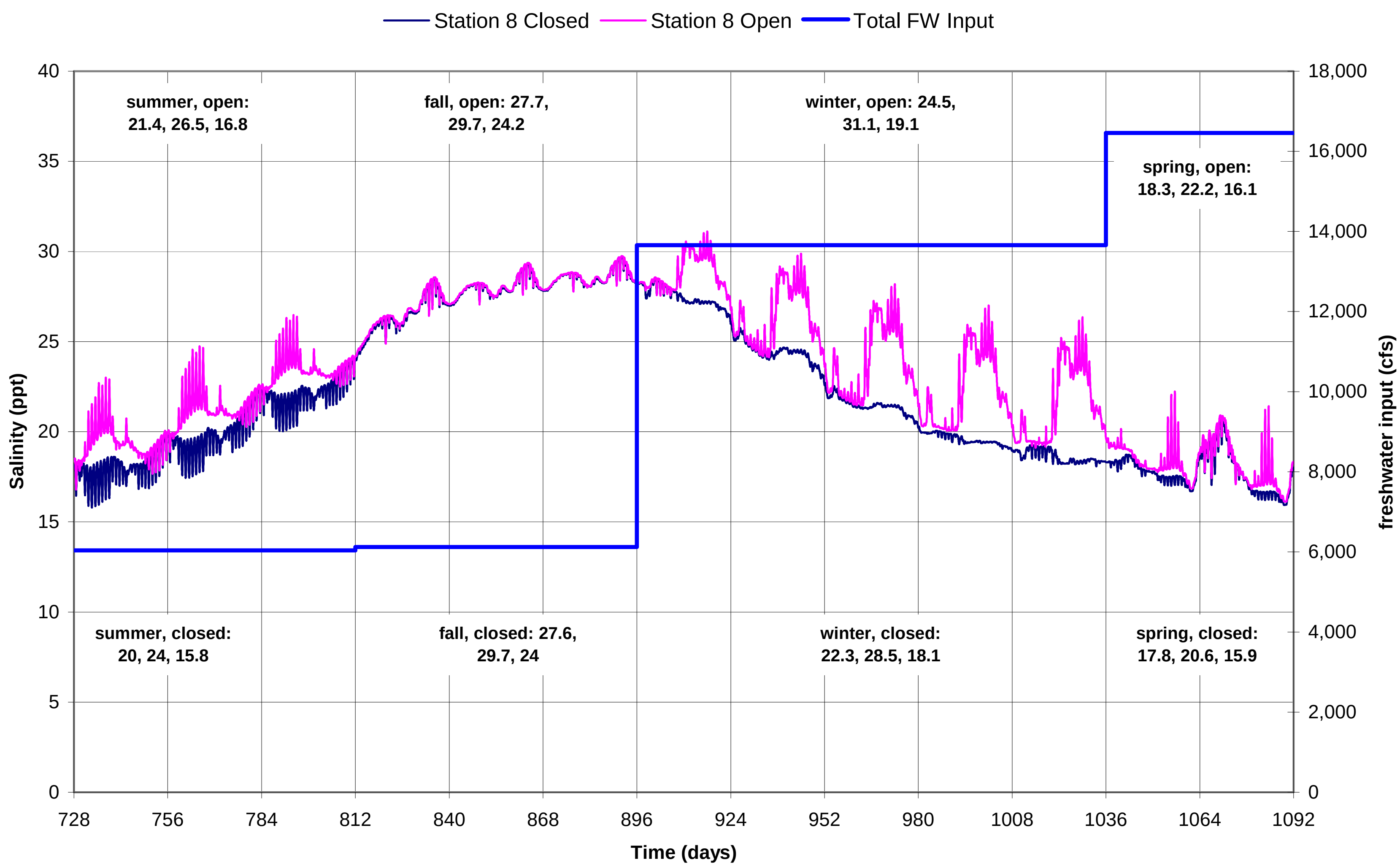

Figure A24 Salinity Variation with Time, Station 8, Year 3

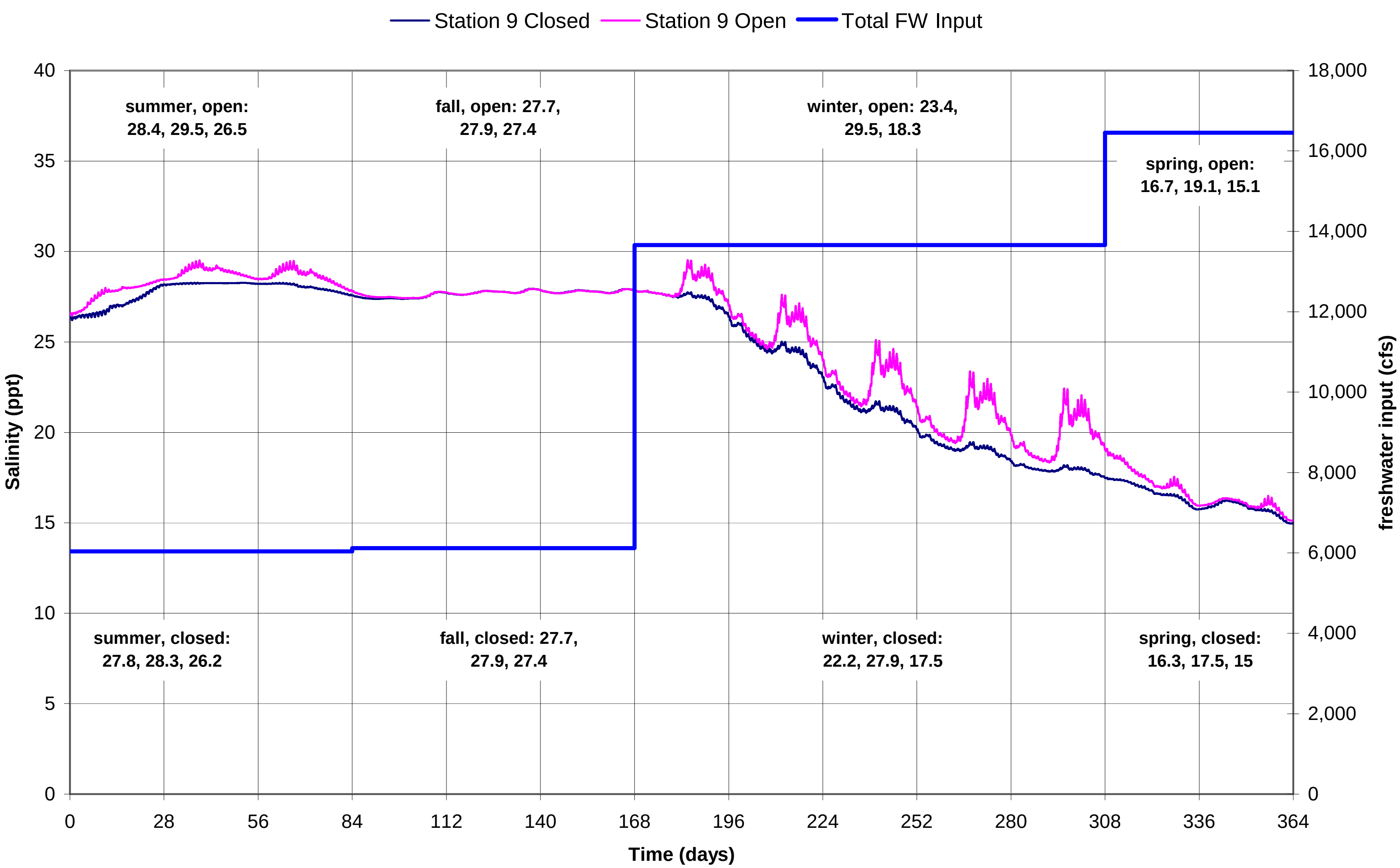

Figure A25 Salinity Variation with Time, Station 9, Year 1

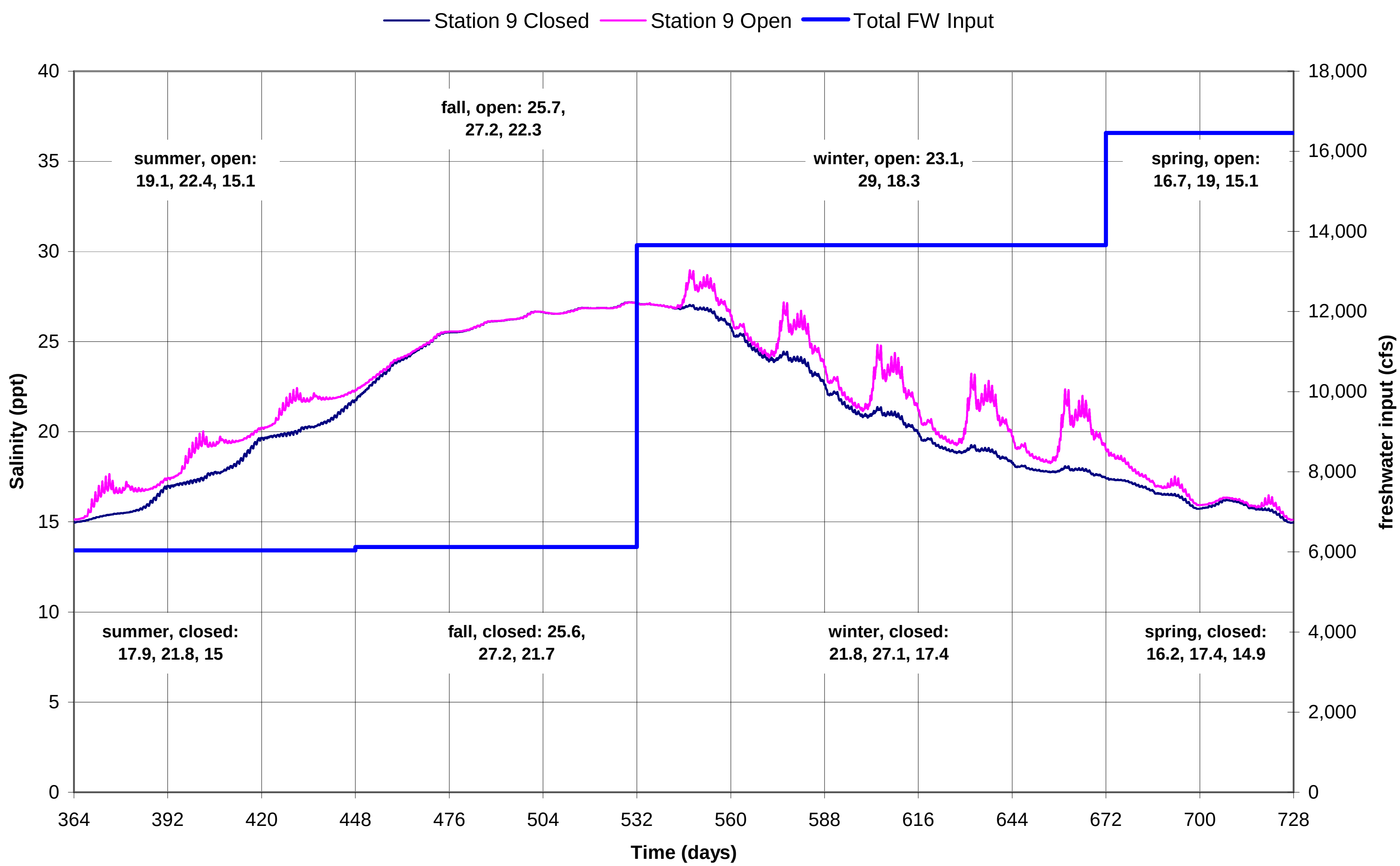

Figure A26 Salinity Variation with Time, Station 9, Year 2

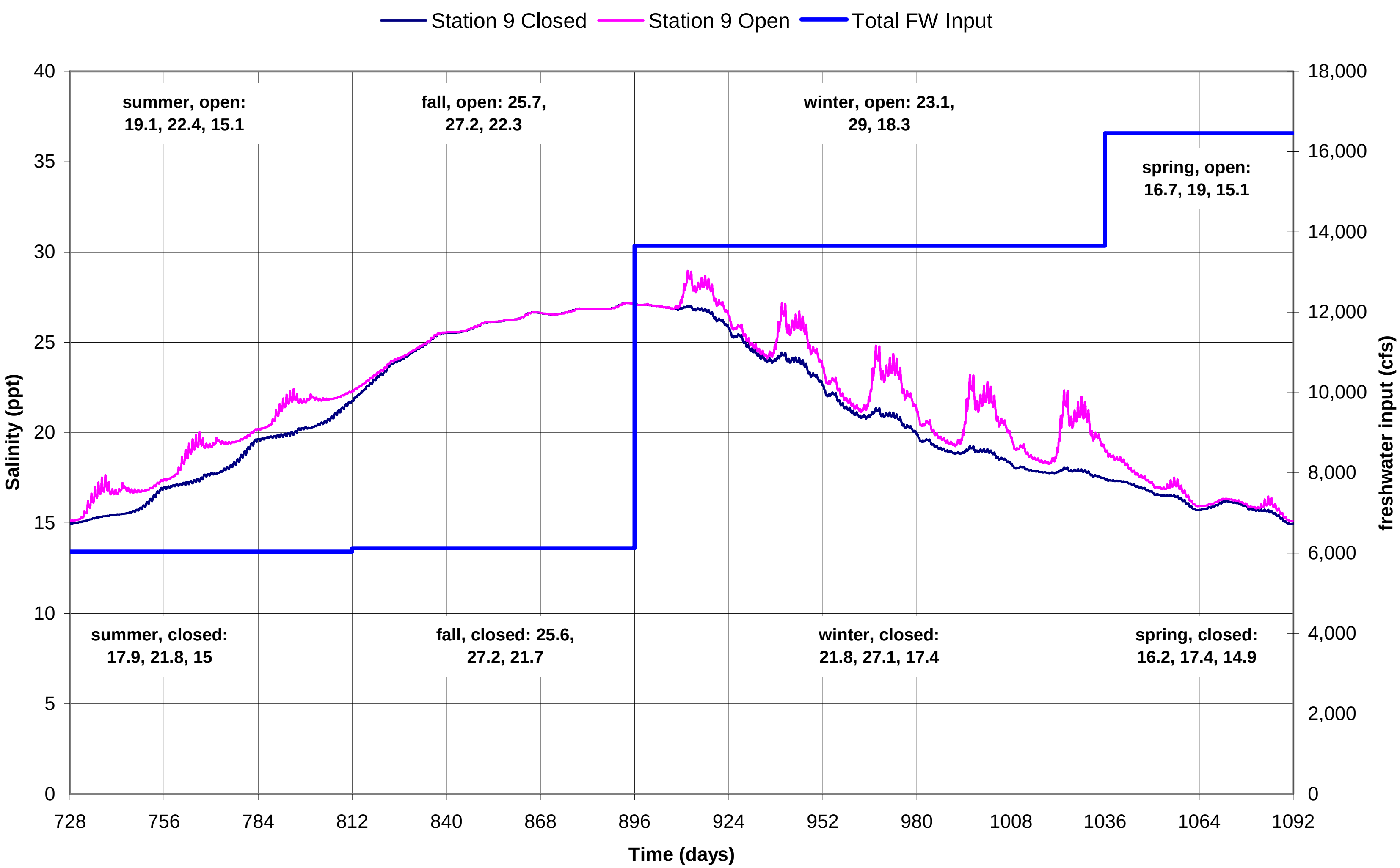

Figure A27 Salinity Variation with Time, Station 9, Year 3

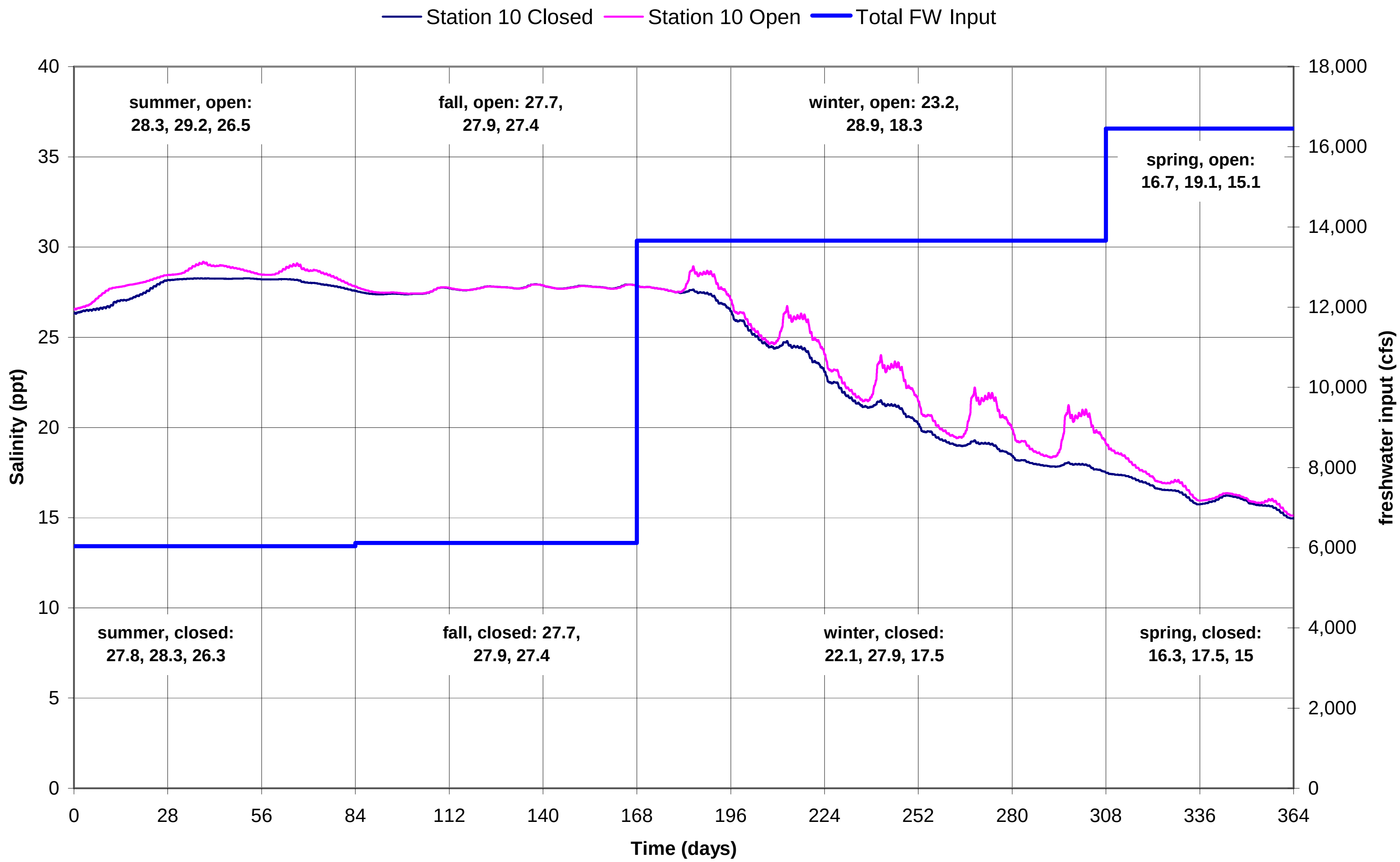

Figure A28 Salinity Variation with Time, Station 10, Year 1

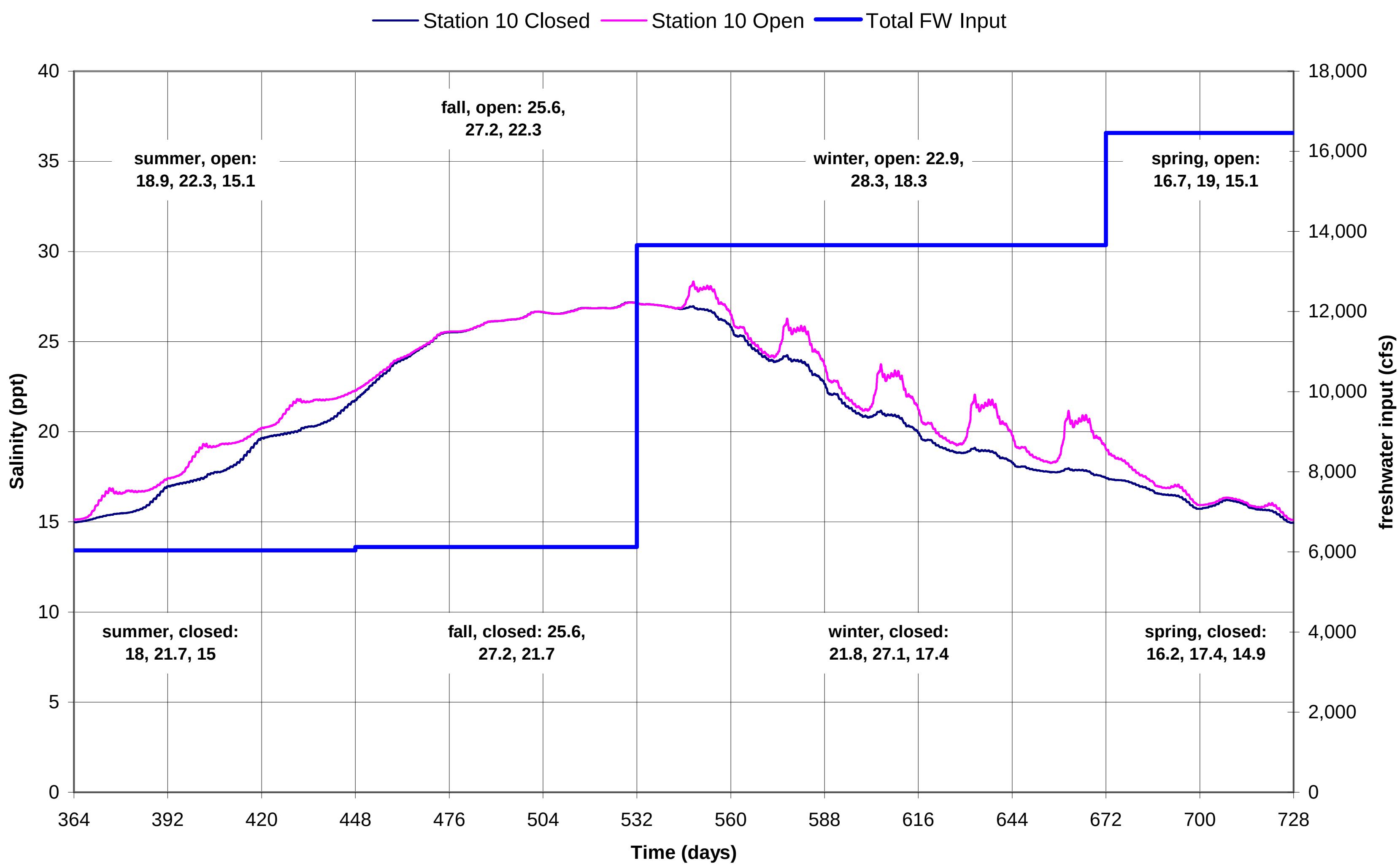

Figure A29 Salinity Variation with Time, Station 10, Year 2

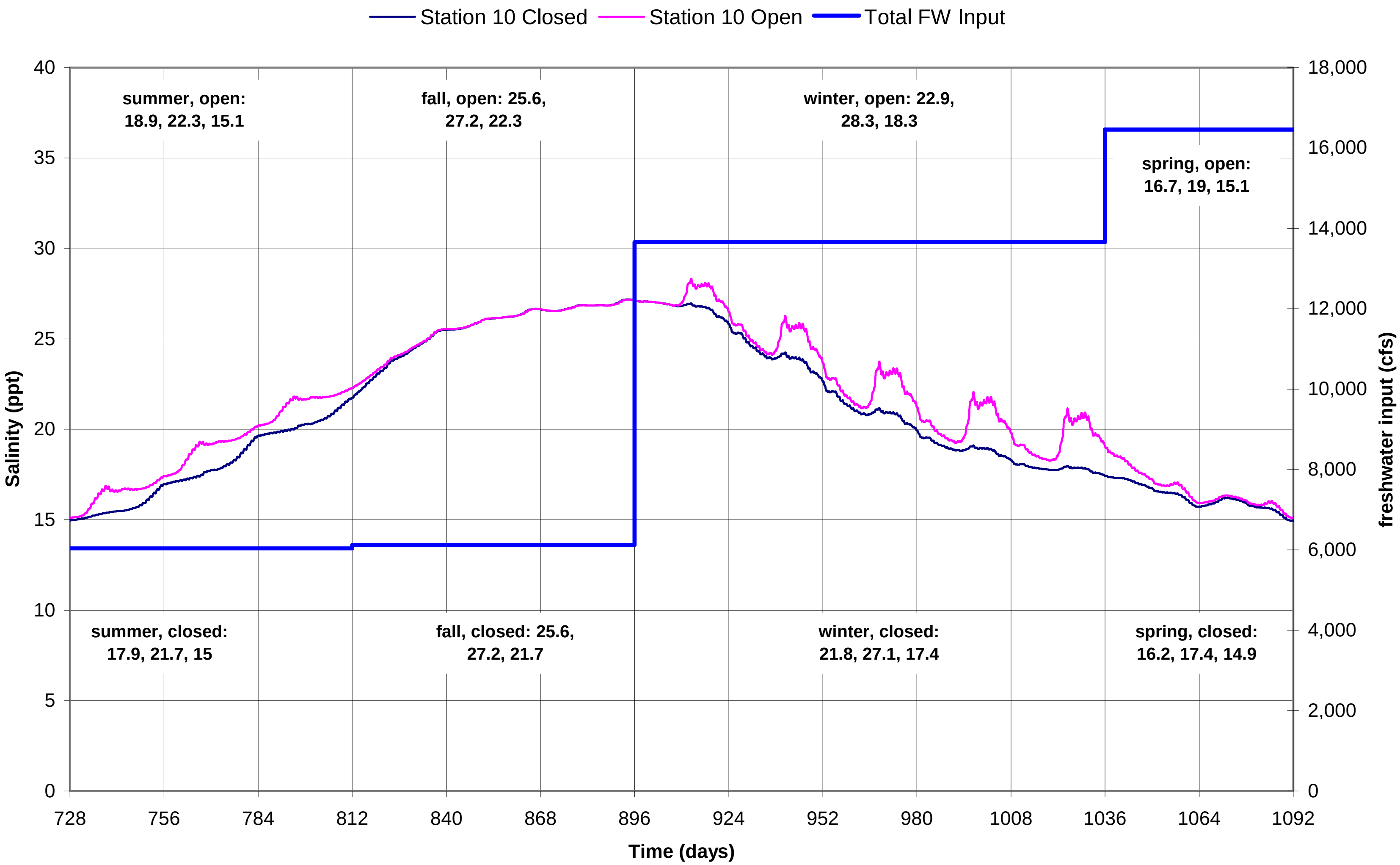

Figure A30 Salinity Variation with Time, Station 10, Year 3

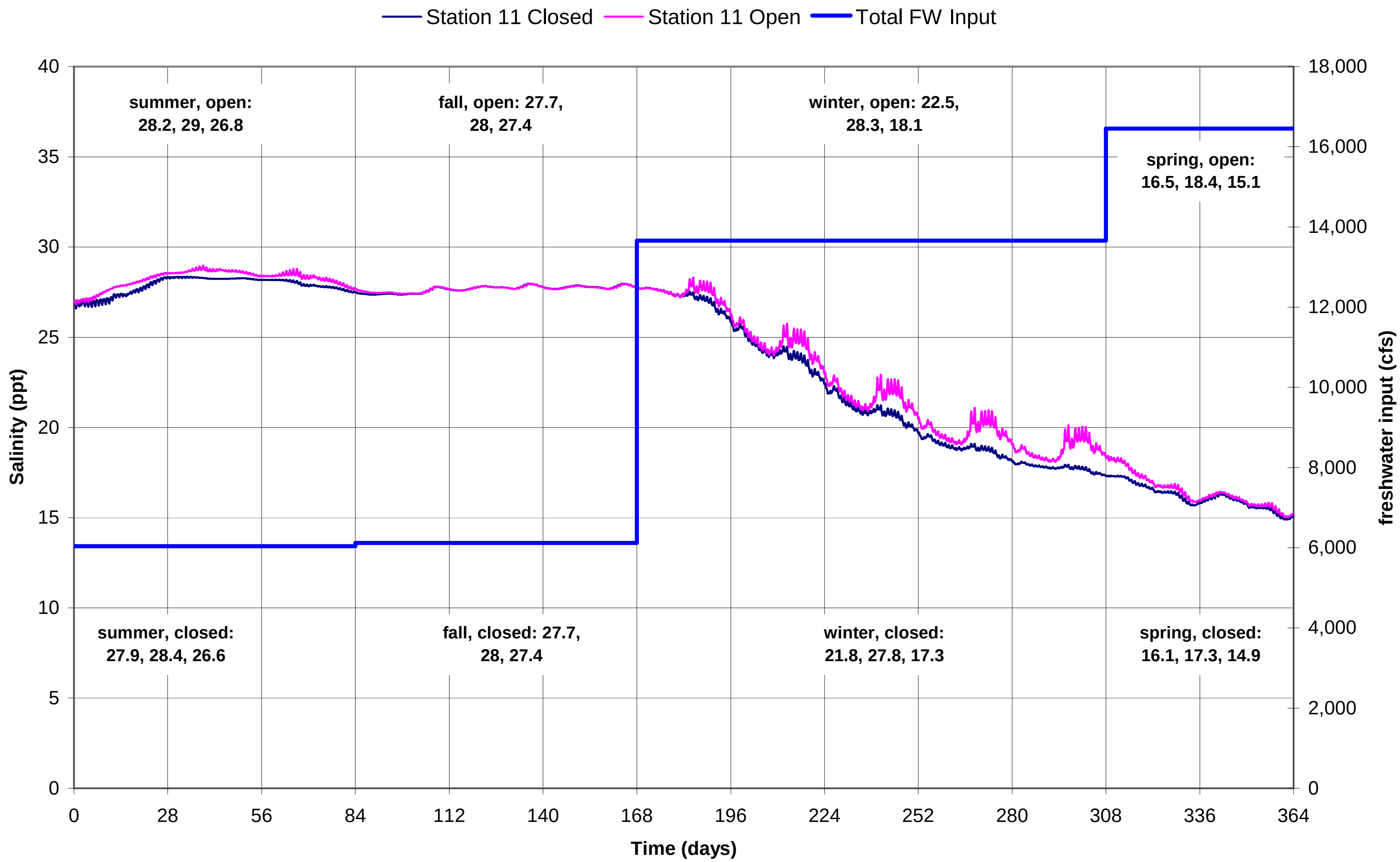

Figure A31 Salinity Variation with Time, Station 11, Year 1

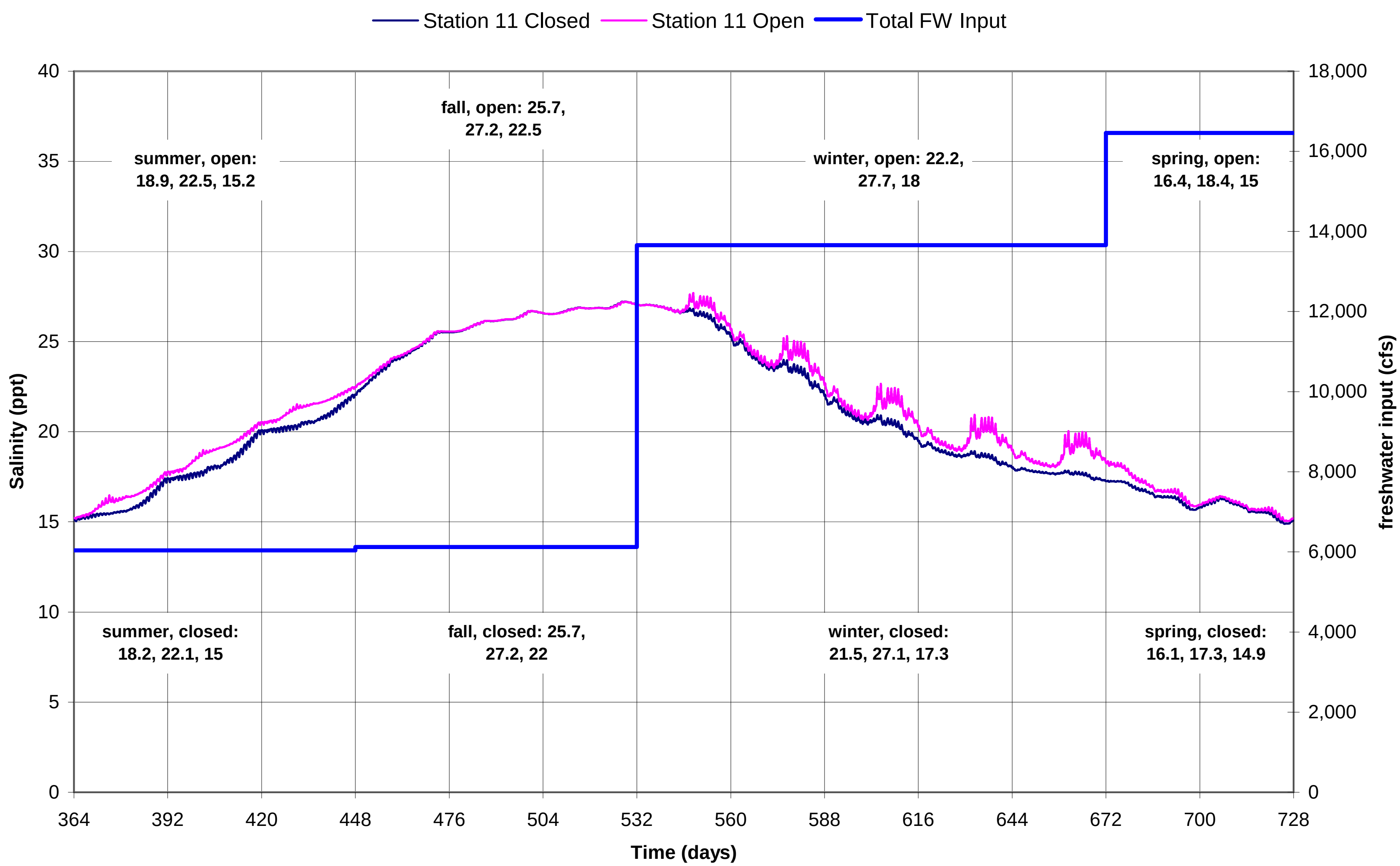

Figure A32 Salinity Variation with Time, Station 11, Year 2

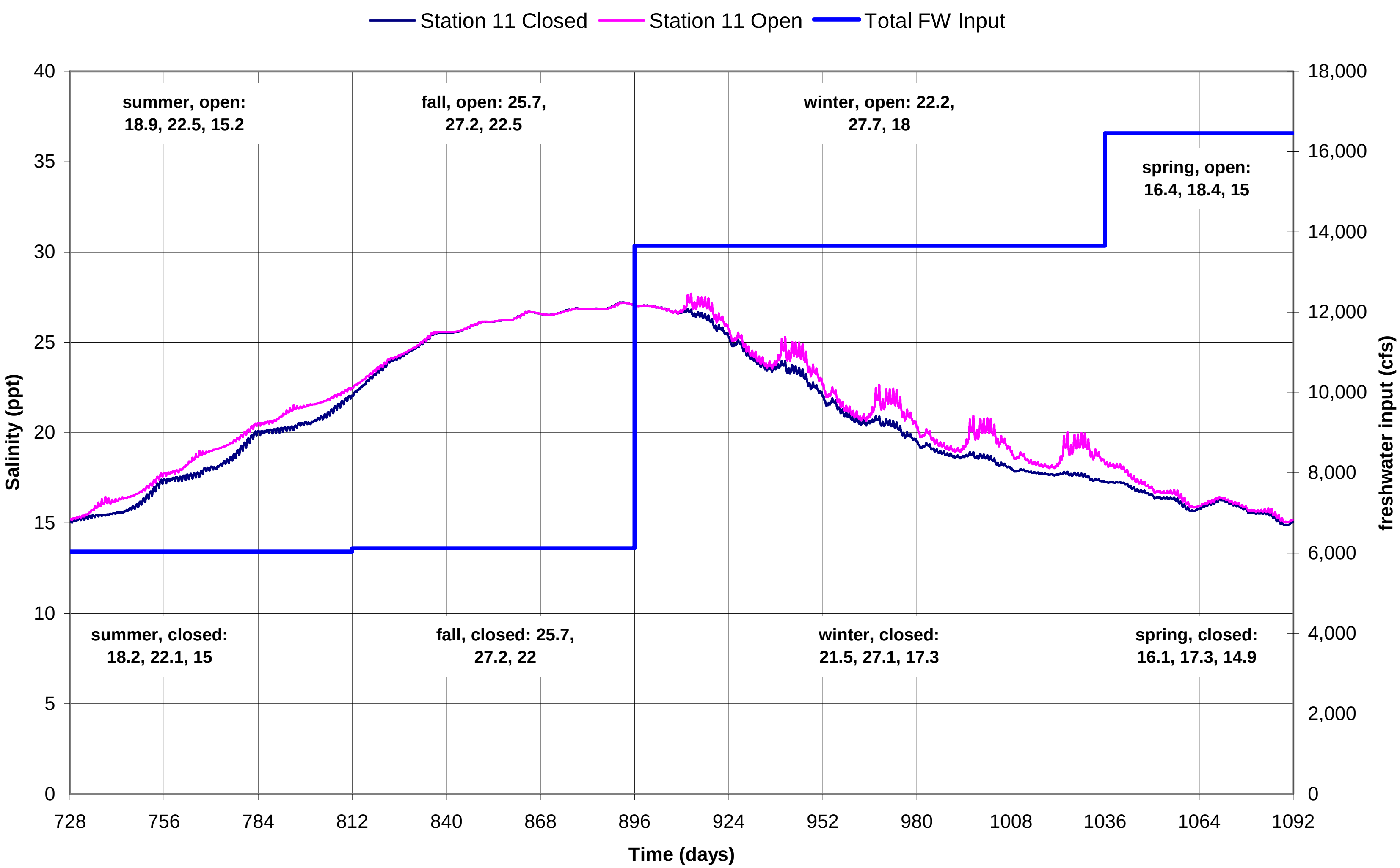

Figure A33 Salinity Variation with Time, Station 11, Year 3

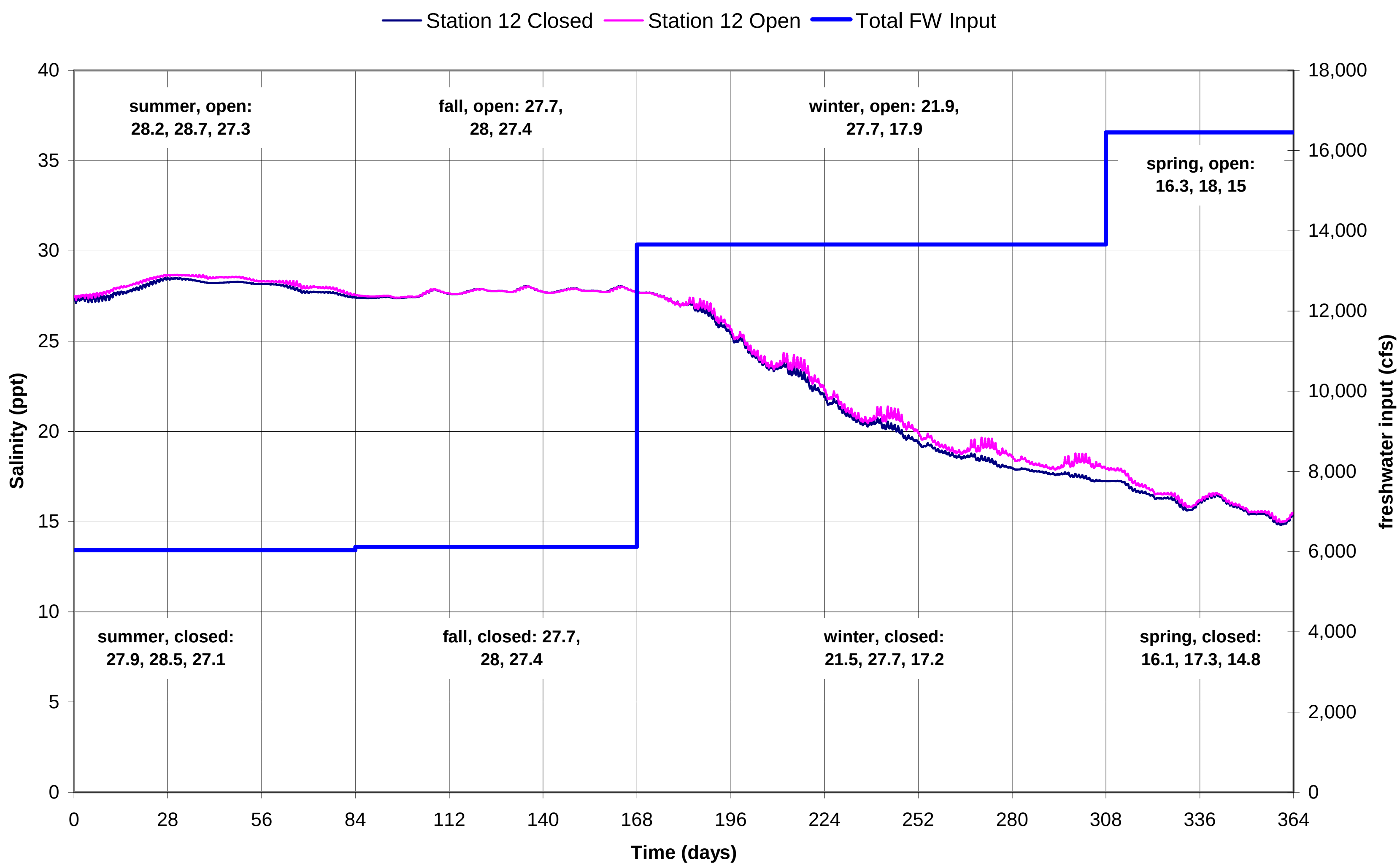

Figure A34 Salinity Variation with Time, Station 12, Year 1

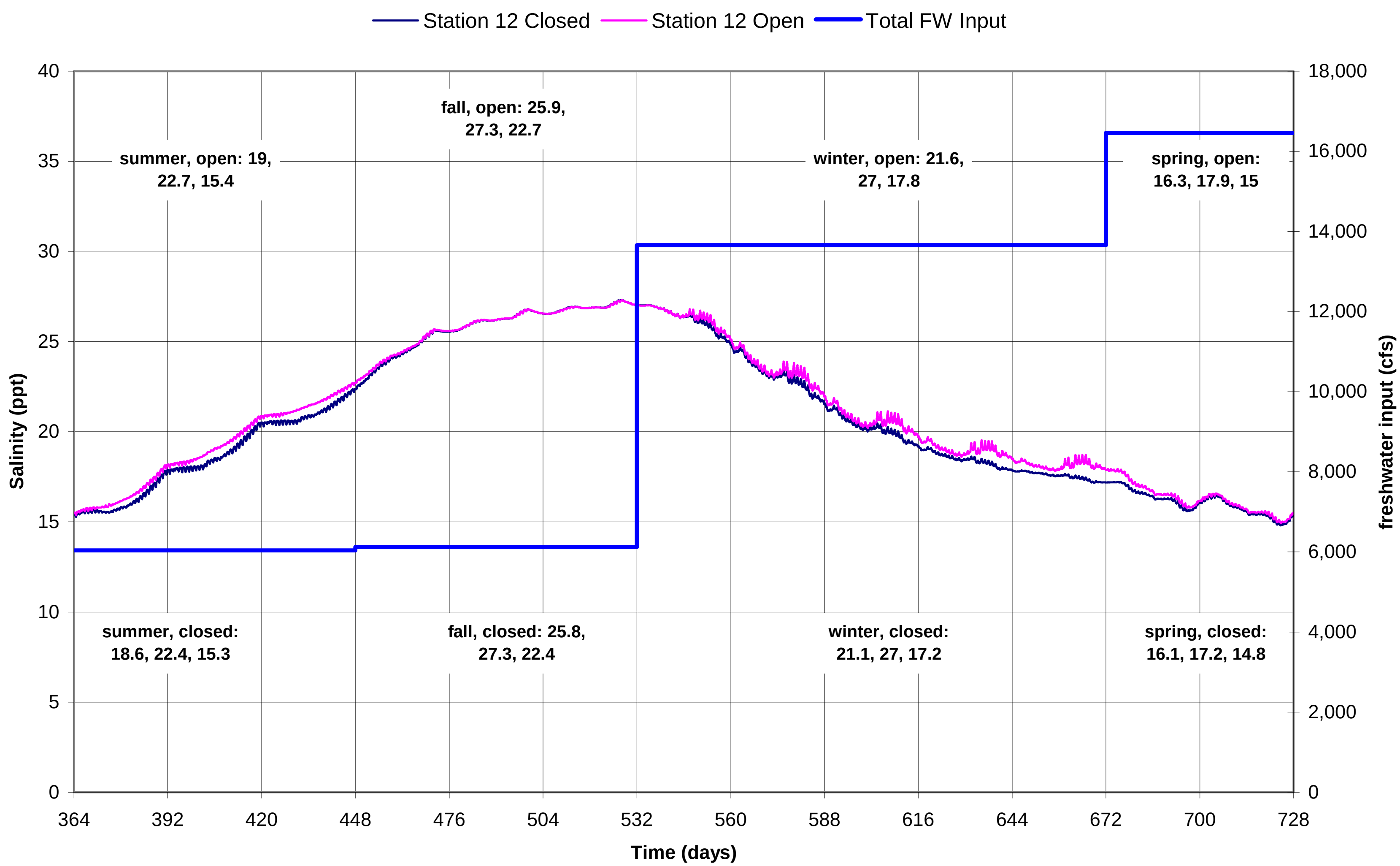

Figure A35 Salinity Variation with Time, Station 12, Year 2

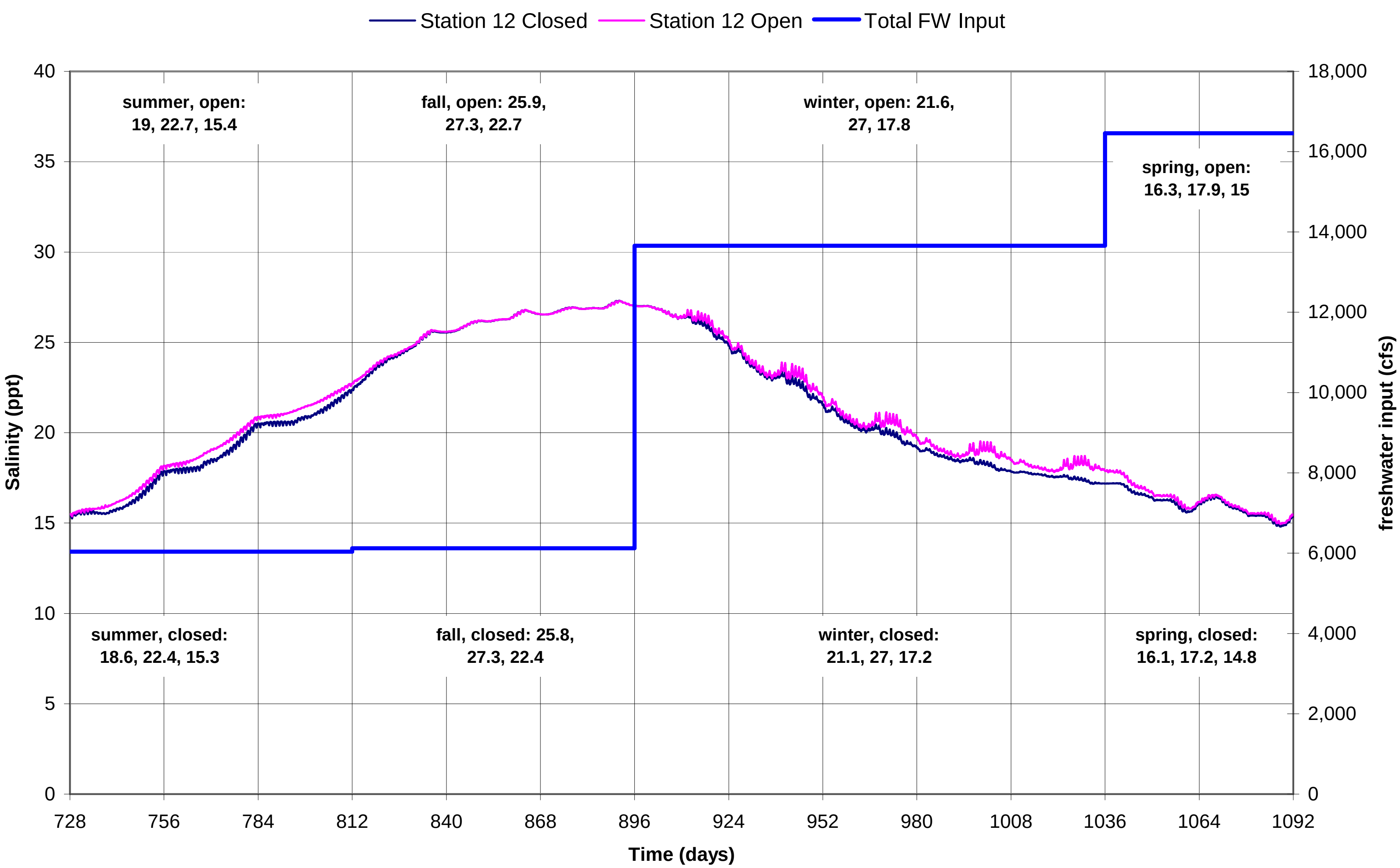

Figure A36 Salinity Variation with Time, Station 12, Year 3

Attachment E
Draft Environmental Assessment

Taylor Engineering expects to submit the draft environmental assessment by January 22, 2010.

Attachment F
Geotechnical Analysis

Taylor Engineering expects to submit the geotechnical analysis report by March 2010.