J. Kej. Awam Jil. 7 Bil. 2 1994

SHORT-TERM SALINITY PREDICTIONS IN BACK BAY OF BILOXI, MISSISSIPPI

by

Noor Baharim Hashim
Dept. of Hydraulic and Hydrology
Faculty of Civil Engineering
Universiti Teknologi Malaysia

ABSTRACT

In the development of a water quality model for Back Bay of Biloxi, the Water Quality Analysis Simulation-5 (WASP5) was used. The model is calibrated to a set of field data acquired on Back Bay of Biloxi, during June 14 - 16, 1977 and is verified with another set of field data taken in the Bay, during July 28 - August 2, 1972. The transport mechanisms of the estuary are modeled in each of the 376 segments of two-dimensional vertically mixed system by simulating salinity as a conservative tracer. Comparisons of the predicted and observed salinity data are made qualitatively by using spatial and temporal comparisons and quantitatively by statistical comparisons. The response of model prediction calculations is consistent with trends of the observed salinity data ranges, but not with absolute values in all cases. The results indicate that the model can accurately predict the concentration of salinity in the range of observed data taken at low and high tide conditions.

INTRODUCTION

In the development of a water quality model for Back Bay of Biloxi, the Water Quality Analysis Simulation Program-5 (WASP5) was used (Ambrose et. al., 1993). This model is capable of interpreting and predicting water quality responses to natural phenomena and man-made pollution.

The WASP5 system consists of three stand-alone computer programs, DYNHYD5, EUTRO5, and TOXI5 that can be run in conjunction or separately. The hydrodynamic program, DYNHYD5 simulates the movement of water by solving the one-dimensional equations of continuity and momentum, while the water quality program, EUTRO5, simulates the movement and interaction of pollutants within the water (Ambrose, et al., 1993). WASP5 is supplied with two kinetic sub-models to simulate two of the major classes of water quality problems: conventional pollution and toxic pollution. EUTRO5 can be operated at various levels of complexity to simulate some or all of the related variables and interactions.

While TOXI5 can simulate the transport and transformation of one to three chemicals and one to three types of solids classes, its application to the Back Bay of Biloxi is limited to the simulation of salinity as a conservative tracer.

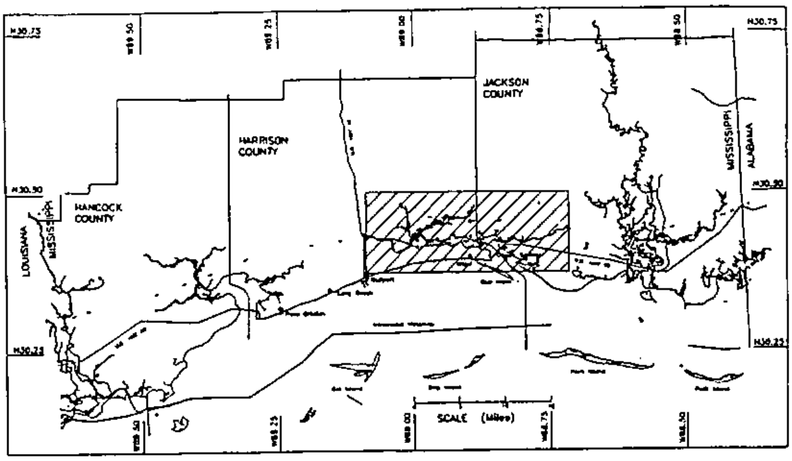


Figure 1 : Location of the Study Area

The study area of this research was located along the Mississippi Gulf Coast and adjacent to Jackson and Hancock Counties shown in Figure 1. Included in the study were the metropolitan areas of Biloxi, Gulfport, and Ocean Springs.

DESCRIPTION OF THE STUDY AREA

The Back Bay of Biloxi study area used in this research is shown in Figure 1. Back Bay of Biloxi is a subsystem of the Mississippi Sound estuarine system. Its geological origin is that of an incompletely sediment-filled drowned river valley (Eleuterius, 1973). The Biloxi Bay estuarine water body is defined as that area contained on the mainland side of Deer Island, bounded on the west by a line projected due north from the western tip of Deer Island, on the east by a line projected with a heading of 30° from the eastern tip of Little Deer Island, including all bayous and slews and rivers as far upriver as salinity intrusion is measurable.

Back Bay of Biloxi extends 7.5 miles eastward from Big Lake to Biloxi Bay. Its width varies from a quarter of a mile to one mile. Depths outside of channels areas range from one to 10 feet with most areas less than three feet. There is a dredged channel from Biloxi Bay to the Back Bay of Biloxi near Big Island and Little Island with a natural channel extending through the remainder of the Back Bay of Biloxi to Big Lake.

Biloxi Bay proper, that is, excluding all tributaries, is approximately 13.5 miles (21.7 km) in length and at mean low water (MLW) has a wet surface area of 16.52 square miles (42.7868 sq km); an average depth, including channels, of 4.31 feet (1.31 m); and a water volume of 73,7517,612 cubic yards (56,208,247 cubic meter). The estuarine subsystem receives fresh water via direct runoff and the discharges of the Biloxi and Tchoutacabouffa Rivers with drainage basins of 271 and 242 square miles (701.9 sq km and 626.8 sq km) respectively. Tchoutacabouffa River discharges at the average rate of 463.57 cfs (13.13 cms) with record extremes of 4.19 cfs (0.81 cms) and 46,357 cfs (1312.68 cms). Biloxi River has an average discharge of 465.9 cfs (657.31 cms). Also draining directly into the Bay are the following bayous : Poito, Old Fort, Week's, Grand, Auguste, Keegan, La Porte, Bernard, Brasher, Biglin, Ravine Canne, Ditch, Davis, St. Martin, Heron, and Brodie. Tributary bayous exist also of those mentioned above.

SEGMENTATION OF BACK BAY OF BILOXI

A segmentation of Back Bay of Biloxi was established for the water quality modeling study, as illustrated by Figure 2. This particular segmentation scheme was selected mainly to accommodate the requirement of the hydrodynamic model being developed by Center for Ocean & Atmospheric Modeling (COAM), University of Southern Mississippi and in consideration of the goemetry and existing water quality data for the Back Bay of Biloxi. The present model segmentation scheme does not include vertical resolution. While there are indications of vertical variations in transport, the data reviewed to date does not include sufficient information to either establish the boundaries or to estimate exchanges between vertical layers. In the survey of June 14 - 16, 1977, vertical variation of dissolved oxygen was indicated at most of the twelve sampling sites. However, vertical stratification of specific conductance, pH, and water temperature was only evident at two sampling sites (USGS, 1978). Furthermore, other available historical data are inconclusive to support the establishment of multi-layer segmentation. Finally, benthic layers were not incorporated into this effort due to the unavailability of data needed to simulate the eutrophication with benthos. Thus, the model application will be for two-dimensional vertically mixed system.

This two-dimensional segmentation was also selected in order to represent the spatial heterogeneity of the water bodies in longitudinal and lateral directions. By using approximately equal surface areas, this type of segmentation is capable of representing the physical shape of the water system.

The simulation reported here was limited to the Back Bay of Biloxi proper. The tributaries were excluded because of the lack of data. Segmentation for the hydrodynamic model DYNHYD5, the Back Bay of Biloxi was divided into 392 segments, including thirteen downstream segment boundaries where the Biloxi Bay junctions with the Mississippi sound, and three upstream segment boundaries at Bernard Bayou, the Biloxi River, and Old

Fort Bayou. While for the water quality model EUTRO5, the Back Bay of Biloxi was divided into 376 segments (Figure 3), including thirteen downstream segments boundaries junctions with Mississippi Sound, two upstream boundaries at Bernard Bayou, and one upstream boundary each at Biloxi River and Old Fort Bayou.

MODEL CALIBRATION/VERIFICATION

Database

Water quality in Biloxi Bay and Back Bay has been monitored for over 2 decades. Since the criteria for selecting an appropriate calibration/verification dataset are adequate temporal and spatial coverage, and available data for the eight state variables considered in the EUTRO5 computation, two studies were selected for use in model calibration and verification. The two studies were selected because of the availability of a comprehensive set of data and adequate description of the conditions surrounding the studies. An intensive survey conducted in June 14 - 16, 1977 was considered as a calibration data set, while the second intensive survey conducted in July 28-August, 1972 was considered as verification data set.

Specific Conductance data were taken at 12 sampling sites under high and low tides on June 14 and 15, 1977. Measurements during the period of calibration data set were taken vertically every 5 feet and about 1 foot below the water surface and 1 foot above the bottom. Chlorides data were taken at high tides on July 28, 29, and 30, 1972 and low tides on July 31, August 1 and 2, 1972. Measurements during the period of verification data set were taken vertically at mid-depth or 5 ft below water surface and/or 1 foot above the bottom.

Model Calibration/Verification Input Parameters

The initial input parameters of the hydrodynamic model DYNHYD5 included estimation of junctions (nodes), channel (links), freshwater inflow, downstream boundary, and wind. Initial input parameters for the water quality model TOXI5 included estimation of environment, transport, boundaries, and transformations. All of the parameters incorporated in the model are either temporally or spatially variable mentioned above on an hourly basis, they are approximated by a series of piecewise linear functions. The piecewise linear functions or approximations used in this model consist of a series of variables and breakpoints usually on high and low tide conditions time interval or daily interval dependent on the type of the variable and availability of data.

Junction Parameters

The input parameters associated with junctions in DYNHYD5 are initial surface elevation (head), surface area, and bottom elevations. Segment volumes and mean depths are calculated internally by using the above parameters. These parameters for verification are assumed to be the same as used in calibration phase.

Figure 2: Overall Segmentation Map of the Back Bay of Biloxi

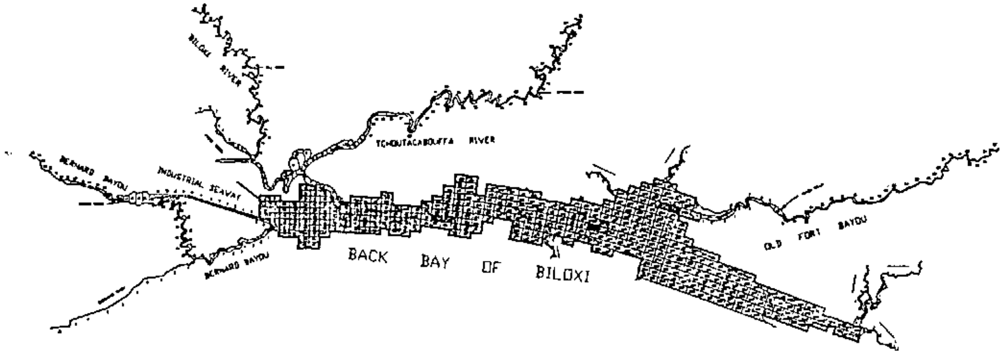
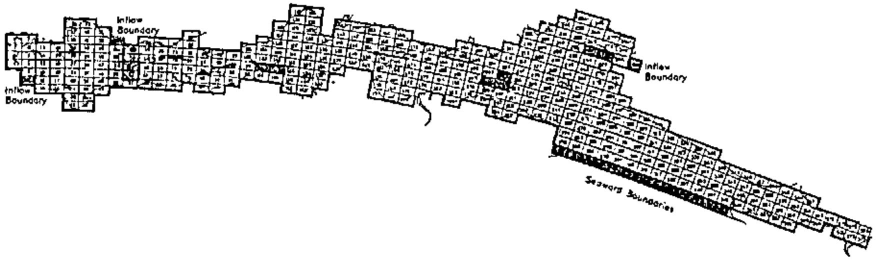


Figure 3: EUTRO5 Segmentation Map of Back Bay of Biloxi



Channels Parameters

The input parameters associated with channels in DYNHYD5 are characteristic length, width, hydraulic radius or depth, channel orientation, initial velocity, and Manning's roughness coefficient. These parameters for verification are assumed to be the same as used in calibration phase.

Inflow Parameters

The major freshwater inflows to Back Bay of Biloxi enter at Biloxi River, Bernard Bayou, and Old Fort Bayou. Rather than input the daily flow hydrographs into the model, constant inflows of 0.42 cms (14.83 cfs), 2.83 cms (99.94 cfs), and 0.24 cms (8.48 cfs) are used at at Bernard Bayou, Biloxi River, and Old Fort Bayou, respectively. These inflow parameters for verification are assumed to be the same as used in calibration phase (under low-flow condition).

Downstream Boundary Parameters

The downstream boundaries are specified by surface elevations (tidal function). The surface elevations at thirteen downstream boundaries are specified by a variable tidal function. Variable tidal patterns are simulated by specifying the high and low tidal heights versus time for multiple tidal cycles. In the calibration/verification phase, simulation starts at low tide condition. So, the downstream boundary parameters also start at low tide condition.

Wind Parameters

The input parameters associated with wind acceleration are wind speed, wind direction, and channel orientation. The wind speed and direction for verification are assumed to be the same as used in calibration phase. Constant wind speed and direction of 2.82 m/sec and 20^{o} from true north, respectively are used in the model. These values were chosen based on the average wind speed in the study period and the most frequent wind direction. The wind parameters are based on the data taken from Keesler Air Force Base (U.S Department of Commerce et al., 1972) during the period of July 28 - August 2, 1972.

Transport Parameters

This group of parameters defines the adjective and dispersive transport of simulated model variables. Input parameters include advective flows, dispersion coefficients, cross-sectional areas, and characteristic lengths. Hydrodynamic results from DYNHYD5 are used in the simulations. Flows from DYNHYD5 are used and flow continuity is automatically maintained.

The number of exchange fields between segments is 625. The cross-sectional areas are specified for each dispersion coefficient, reflecting the area through which mixing occurs. The characteristic missing lengths are also specified for each dispersion coefficient, reflecting the characteristic length over which mixing occurs. The initial estimates of the dispersion coefficients are determined from dye studies (USGS, 1978) and plots of chlorides or salinity distribution as a conservative tracer.

Boundary Parameters

This group of parameters includes boundary concentrations and initial conditions. Boundary concentrations are specified for three upstream boundaries at Bernard Bayou, Biloxi River, and Old Fort Bayou and for downstream (seaward) boundaries junctions with Mississippi Sound at Biloxi Bay. Time-variable concentrations are specified for salinity at each boundary. Boundary concentrations for low or high tide conditions that were not available in the two studies were input as the average of the available low or high tide conditions. The salinity variable boundary concentrations are input as a series of piecewise linear functions versus time. For the calibration data set of June 14 - 16, 1977, the upstream boundary concentrations at Bernard Bayou are extrapolated from the nearby sampling stations. For the verification data set of July 28-August, 1972, the upstream boundary concentrations at Biloxi River are also extrapolated from the nearby sampling stations. The downstream boundary concentrations in calibration phase at Biloxi Bay are also extrapolated from the sampling site at Memorial Bridge.

Initial conditions include initial concentrations as well as solids transport field for each solid and the dissolved fraction in each segment. For dynamic simulations where the transient concentration response is desired, initial concentrations are input closely reflecting the measured values at the beginning of the simulation. Initial conditions reflecting low tide condition were used since the simulation begin from low tide condition. Longitudinal linear interpolations were made between available sampling sites for determining the initial concentrations throughout the water quality segments.

RESULTS

Calibration

Spatial and temporal profiles of specific conductance that was used as a conservative tracer to arrive at a value for the dispersion coefficient are shown in Figures A.1 through A.6. As previously stated, during the calibration phase several dispersion coefficients were used in order to test the sensitivity of the model to variations in the dispersion coefficient. As shown in Figures A.1 through A.6, the model reproduces the observed specific conductance data very well both under the low and high tide conditions, at dispersion coefficients ranging from 1 to 40 m^2/sec. A reasonably good fit of the specific conductance clearly indicates that the model reproduces the principal transport mechanisms of the estuary. However, results of several simulation using dispersion coefficients ranging from 1 to 40 m^2/sec revealed the insensitivity of TOXI5 to changes in the dispersion coefficients.

Verification

Spatial and temporal profiles of chlorides used as a conservative tracer to arrive at a value for the dispersion coefficient in the verification phase are shown in Figures A.11 through A.16. As previously stated, during the calibration phase several dispersion coefficients were used in order to test the sensitivity of the model to variations in the dispersion coefficient. As shown in Figures A.1 through A.6, the model reproduces the observed specific conductance data very well both under the low and high tide conditions, at dispersion coefficients ranging from 1 to 40 m^2/sec. This was confirmed during the verification phase, as shown in the spatial and temporal profiles of chlorides under the low and high tide conditions in Figures A.11 through A.16. A reasonably good fit of the chlorides data clearly indicates that the model reproduces the principal transport mechanisms of the estuary. Furthermore, simulation of chlorides definitely revealed the insensitivity of the model to variations in the dispersion coefficient. Therefore, a constant dispersion coefficient of 1 square meter per second is used in all segments for both the calibration and verification phases.

STATISTICAL ANALYSIS

In the previous section qualitative comparisons between observed salinity data and model computations were presented. Although the comparisons as shown in Figures A.1 through A.16 indicate that the model can reproduce the observed data of the two studies, a more specific measure of model performance is desirable. Therefore, extensive statistical comparisons were made of the two studies, to further quantify the degree to which the model successfully reproduced the observed data.

Three statistical tests are used to compare observed data and model output. These are:

1. a square of the product-moment coefficient of correlation (r^2).
2. mean error
3. relative error

The coefficient of correlation (r), as computed from (Sokal and Fohlf, 1969)

$$\frac{\Sigma OP - \dfrac{\Sigma O \Sigma P}{n}}{\left(\Sigma O^2 - \dfrac{(\Sigma O)^2}{n}\right)\left(\Sigma P^2 - \dfrac{(\Sigma P)^2}{n}\right)} \qquad (1)$$

provides an indication of the degree of correlation between the observed (O) and predicted (P) data, for a given number of observations (n).

The mean error, computed from

$$ME = \frac{\Sigma(O - P)}{n} \tag{2}$$

represents the average difference between predictions and observations, normalized by the magnitude of the observations.

Graphical comparisons of model predictions to the observed field data by using the three statistical analysis mentioned above are presented in Figures 4 through 5. Observed data of chlorides and specific conductance at several sites within the model segment were averaged spatially for comparisons with model results since the observed data for the two studies were taken at various depths and the model is two-dimensional vertically mixed system.

Comparisons between predicted and observed chlorides and specific conductance for both verification and calibration phases are illustrated in Figures 4 and 5, respectively. A square of the product-moment coefficient of correlation (r^2) for the entire Back Bay of Biloxi are 0.998 for low tide condition and 0.996 for high tide condition verification phase. While the r^2 for collaboration phase are 0.997 and 0.995 for low and high tide conditions, respectively. The mean errors in verification phase are 1782.1 and 2036.9 for low and high tide conditions respectively, while the mean errors in calibration phase are -252.3 and 451.1 for low and high tide conditions respectively. The relative errors in verification phase are 0.194 and 0.199 for low and high tide condition respectively. The relative errors in calibration phase are 0.017 and 0.025.

CONCLUSION

The response of model prediction calculations is consistent with trends of the observed salinity data ranges, but not with absolute values in all cases. The results indicate that the model can accurately predict the concentration of salinity in the range of observed data taken at low and high tide conditions. A reasonable good fit of the chlorides data clearly indicates that the model reproduces the principal transport mechanisms of the estuary. The results of several simulations using dispersion coefficients ranging from 1 to 40 m^2/sec revealed the insensitivity of TOXI5 to changes in the dispersion coefficients.

REFERENCES

[1] Ambrose, R.B. and S.E. Roesch, Dynamic Estuary Model Performance, American Society of Civil Engineerings, Journal of the Environmental Engineering Division, Proceedings of ASCE, Vol. 108, No. EE1, February 1982.

[2] Ambrose, R.B., T.A. Wool, J.L. Martin, WASP5, A Hydrodynamic and Water Quality Model-Model Theory, User's Manual, and Programmers Guide. U.S. Environmental Protection Agency, Athens, GA, 1993.

[3] Bierman, V.J. and D.M. Dolan, "Modeling of Phytoplankton in Saginaw Bay: I. Calibration Phase", American Society of Civil Engineers, Journal of the Environmental Engineering Division, Proceedings of ASCE, Vol. 112, No. 2, April 1986.

[4] Bierman, V.J. and D.M. Dolan, "Modeling of Phytoplankton in Saginaw Bay: II. Post-Audit Phase", American Society of Civil Engineers, Journal of the Environmental Engineering Division, Proceedings of ASCE, Vol. 112, No. 2 April 1986.

[5] Bowie, G.L., W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopf, G.L. Rupp, K.M. Johnson, P.W.H. Chan, S.A. Gherini and C.E. Chamberlain, "Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling". Second Edition. U.S. Environmental Protection Agency Athens, GA., 1985.

[6] COAM, Personal communication, Center of Ocean and Atmospheric Modeling, University of Southern Mississippi, Mississippi.

[7] Eleuterius, C.K. Hydrography of Biloxi Bay, Gulf Coast Researcg Laboratory, Ocean Spring, Mississippi, 1973.

[8] Eleuterius, C.K. and G.A. Criss,. "Biloxi Bay: A Compendium of Data" Physical Oceanography Section, Gulf Coast Research Laboratory, University of Southern Mississippi, Ocean Springs, Mississippi, 1993.

[9] Fischer, H.B., E.J. List, R.C.Y. Koh, J. Imberger, and N.H. Brooks. Mixing in Inland and Coastal Waters, Academic P, New York, 1979.

[10] Gaines, J.L. V.E. Carr, J. F. Musselman, and L.A. Chandler, Comprehensive Sanitary Survey of Biloxi Bay and the Back Bay of Biloxi". Northeast Technical Services Unit, Shellfish Sanitation Branch, 1987.

[11] Gulf Regional Planning Commission, Areawide Water and Sanitary Sewerage Systems for Waterworks, Sanitary Sewerage, Solid Waste Management, Storm Drainage, and Flood Plain Management, Volume II, Gulfport, Mississippi, 1972.

[12] MSDEQ, Personal communication, Mississippi Department of Environmental Quality, Mississippi.

[13] O'Connor. D.J. and R.V. Thomann, Water Quality Models: Chemical, Physical and Biological Constituents. In: Estuarine Modeling: An Assessment. EPA Water Pollution Control Research Series 16070 DZV, Section 702/71, 1972.

[14] SAS Institute Inc., SAS/STAT User's Guide, Release 6.03 Edition. Cary, NC: SAS Institute Inc., 1988.

[15] Shindala, Adnan, D.D. Truax, and K.R. Jin. Development of a Water Quality Model for the Upper Tennessee-Tombigbee Waterway. Department of Civil engineering, Mississippi State University, 1991.

[16] Sokal, R.R., F.J. Rohlf. Biometry: The principles and practice of statistics in biological research. W.H. Freeman and Company, San Francisco, 1969.

[17] Tharpe, E.J. Low Flow Characteristics of Mississippi Steams, Mississippi Board of Water Commissioners Bulletin 75-1, 1975.

[18] Thomann, R.V. and J.J. Fitzpatrick. Calibration and Verification of a Mathematical Model of the Eutrophication of the Potomac Estuary. Prepared for Department of Environmental Services, Government of the District of Colombia, Washington, D.C., 1982.

[19] Thomann, Robert V. Verification of Water Quality Models, American Society of Civil Engineers, Journal of the Environmental Engineering Division, Proceedings of ASCE, Vol. 108, No. EE!, October 1982.

[20] Thomann, R.V. and J.A Mueller. Principles of Surface Water Quality Modeling and Control, Harper and Row Publishing Co., New York, NY, 1987.

[21] USEPA, Waste Source and Water Quality Studies, Mississippi Gulf Coast. Environmental Protection Agency, Surveillance and Analysis Division, Athens, Georgia, 1973.

[22] U.S. Department of Commerce, Bureau of Census, Census of Population, Number of Inhabitants, Mississippi, U.S. Government Printing Office, 1970.

[23] U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Station, Mississippi, July-August, 1972.

[24] USGS, Quality of Water and Dye Dispersion Characteristics in the Back Bay of Biloxi, Harrison County, Mississippi. Prepared in Cooperation with Mississippi Air and Water Pollution Control Commission, 1978.

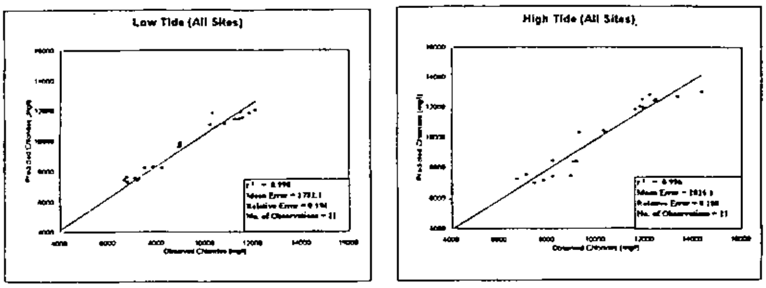


Figure 4: Comparison between Predicted and Observed Chlorides at Back Bay of Biloxi (July 28-August 2, 1972, USEPA Region 4)

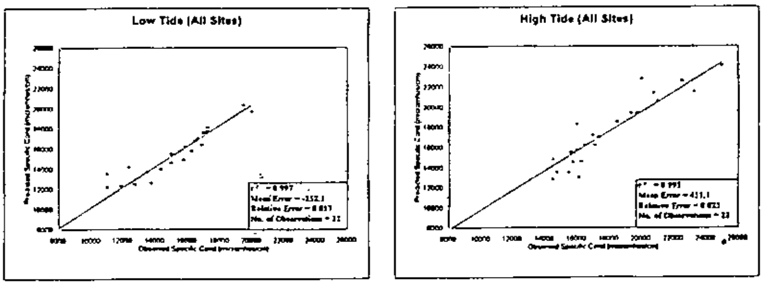


Figure 5: Comparison between Predicted and Observed Specific Conductance at Back Bay of Biloxi (June 14-16, 1977, USGS)

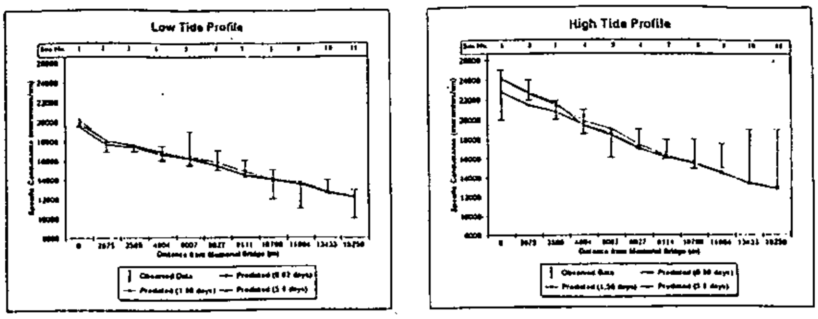


Figure A.1: Spatial Specific Conductance Profiles at Back Bay of Bilòxi with Dispersion Coefficient E = 1 m^2/s (June 14-16, 1977, USGS)

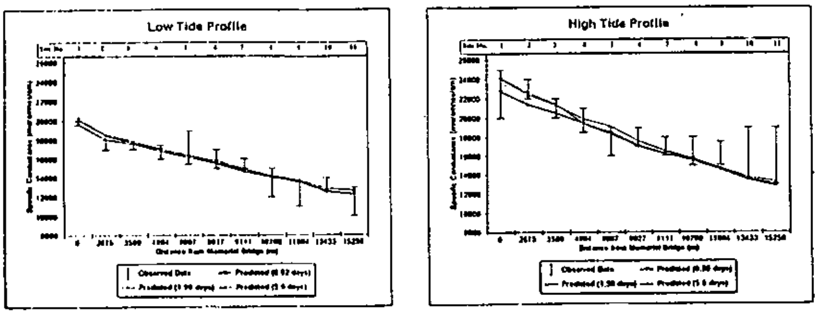
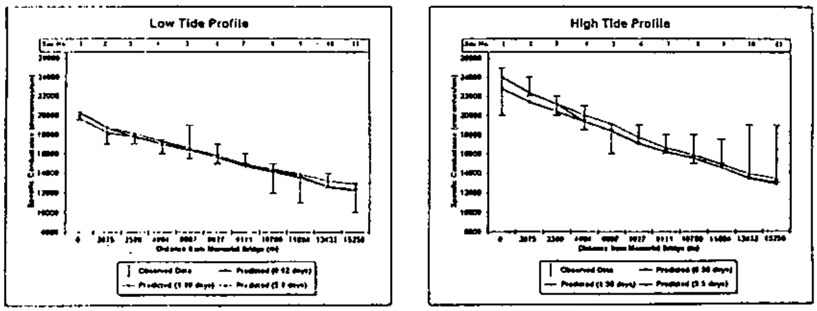


Figure A.2: Spatial Specific Conductance Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 10 m^2/s (June 14-16, 1977, USGS)



Site No	1	2	3	4	5	6	7	8	9	10	11
Segment No	283	223	202	180	168	140	113	99	78	57	56
Station No	02481300	302438088520900	302450088524900	02481279	302528088540000	302518088551100	302500088560000	302513088564400	302508088573200	02481270	302534088564600

Figure A.3: Spatial Specific Conductance Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 20 m^2/s (June 14-16, 1977, USGS)

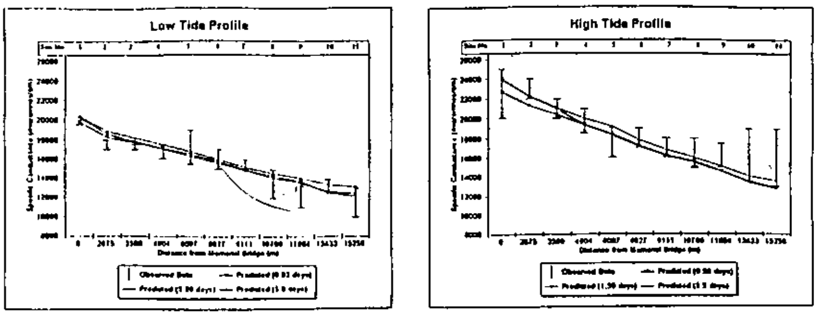
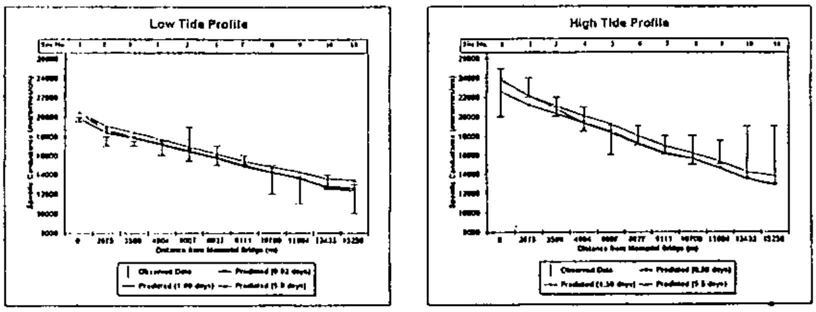
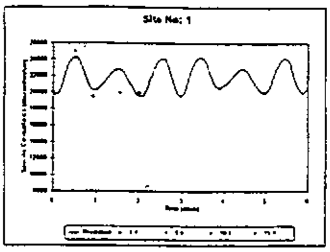


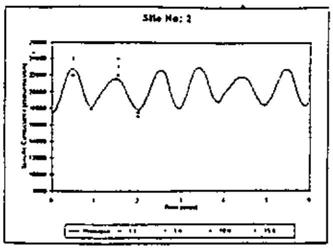
Figure A.4: Spatial Specific Conductance Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 30 m²/s (June 14-16, 1977, USGS)

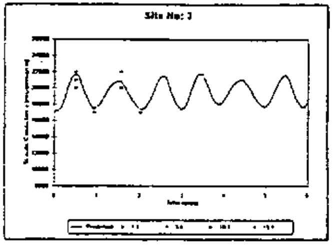


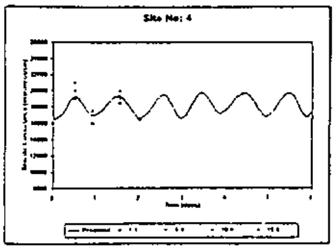
Site No	1	2	3	4	5	6	7	8	9	10	11
Segment No	263	223	202	188	168	140	113	99	79	57	36
Station No	02481300	302439088520900	302450088524900	02481278	302520088540000	302519088551100	302500088580000	302513088594400	302506088573200	02481270	302534088584800

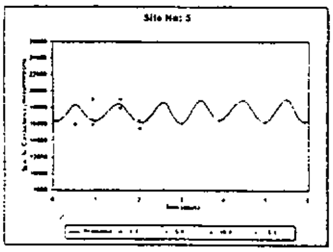
Figure A.5: Spatial Specific Conductance Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 40 m²/s (June 14-16, 1977, USGS)

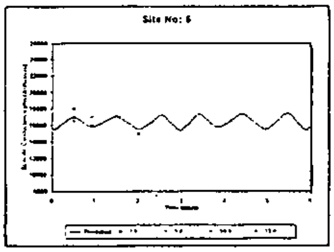

Site No: 1
0
1
2
3
4
5
6


Site No: 2
0
1
2
3
4
5
6


Site No: 3
0
1
2
3
4
5
6


Site No: 4
0
1
2
3
4
5
6


Site No: 5
0
1
2
3
4
5
6


Site No: 6
0
1
2
3
4
5
6

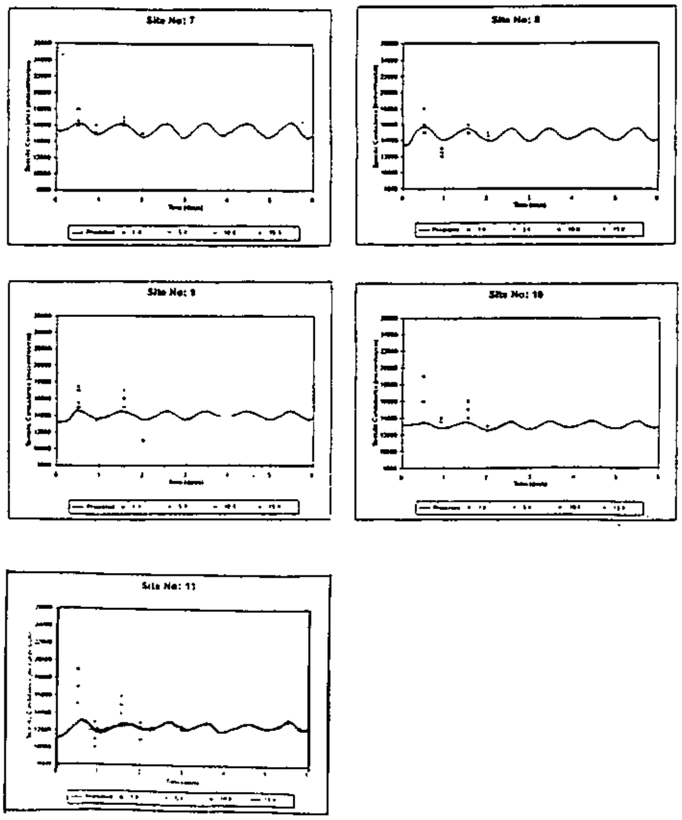


Figure A.6: Temporal Specific Conductance Profile at Back Bay of Biloxi with Dispersion Coefficient E = 1 m^2/s (June 14-16, 1977, USGS)

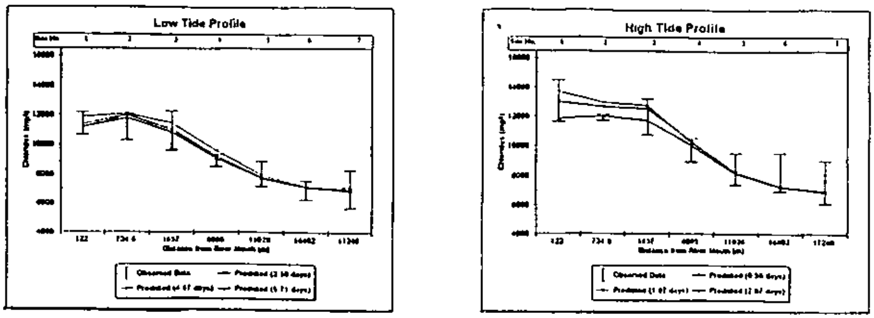


Figure A.11: Spatial Chlorides Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 1 m^2/s (July 28-August 2, 1972, USEPA Region 4)

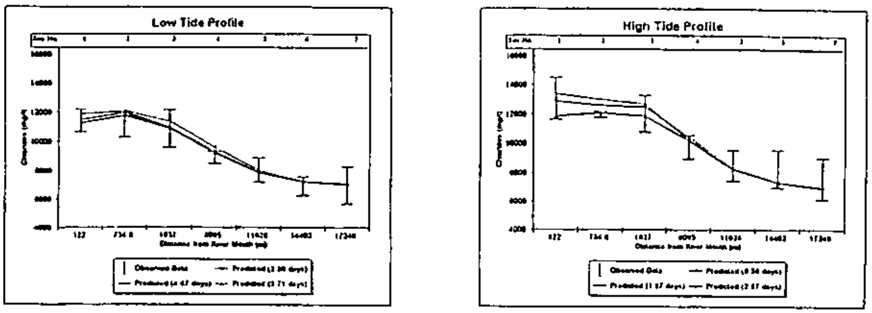
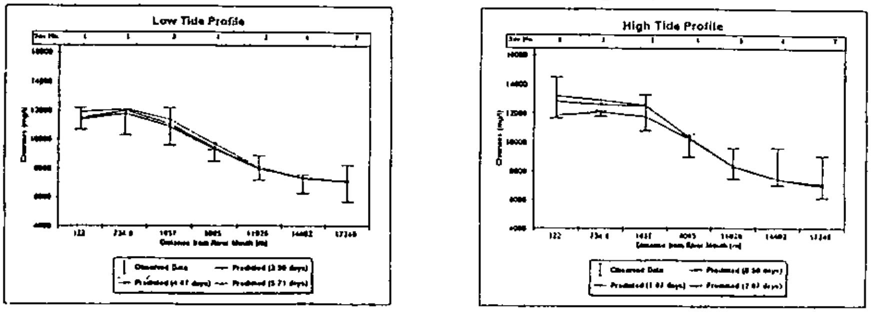


Figure A.12: Spatial Chlorides Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 10 m^2/s (July 28-August 2, 1972, USEPA Region 4)



Site No	1	2	3	4	5	6	7
Segment No	305	318	283	184	102	57	11
Station No	780226	780270	780224	780220	780218	780140	780216
EPA Station No	PAS-WQ-38	PAS-WQ-39	PAS-WQ-37	PAS-WQ-35	PAS-WQ-34	PAS-WQ-33	PAS-WQ-31

Figure A.13: Spatial Chlorides Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 20 m^2/s (July 28-August 2, 1972, USEPA Region 4)

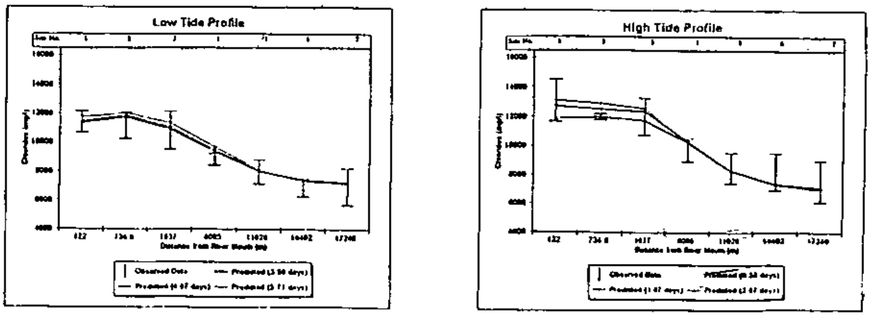
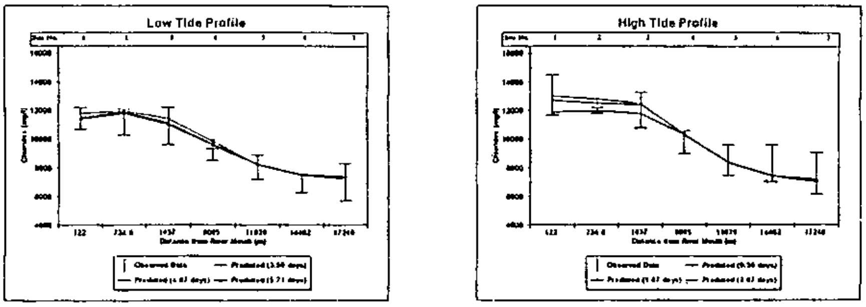


Figure A.14: Spatial Chlorides Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 30 m²/s (July 28-August 2, 1972, USEPA Region 4)



Site No	1	2	3	4	5	6	7
Segment No.	305	318	263	186	102	57	11
Station No	780721	780226	780724	780270	780216	780140	780214
EPA Station No	PAS-WQ-38	PAS-WQ-39	PAS-WQ-37	PAS-WQ-35	PAS-WQ-34	PAS-WQ-33	PAS-WQ-31

Figure A.15: Spatial Chlorides Profiles at Back Bay of Biloxi with Dispersion Coefficient E = 40 m²/s (July 28-August 2, 1972, USEPA Region 4)

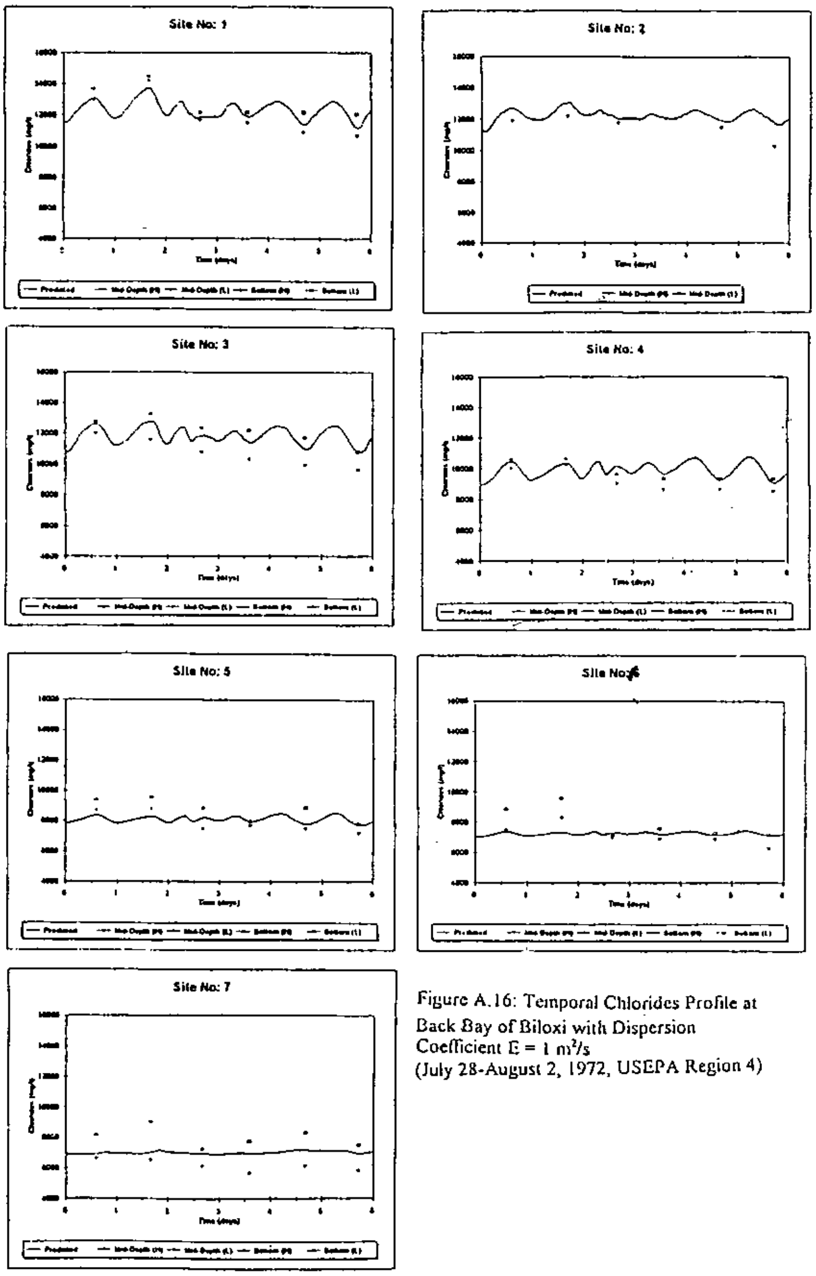


Figure A.16: Temporal Chlorides Profile at Back Bay of Biloxi with Dispersion Coefficient E = 1 m^2/s (July 28-August 2, 1972, USEPA Region 4)