

A REPORT TO THE TEXAS WATER QUALITY BOARD
ON GALVESTON BAY PROJECT PROBLEM AREAS

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ABSTRACT

This report addresses the Problem Areas Section (Task II-B-4) of the Gulf Coast Waste Disposal Authority-Texas Water Quality Board Contract.

Primary Problem Area data was obtained from the Marine Science Institute in the form of reports by Copeland and ^{Bechtel} Eruh, Some Environmental Limits of Six Important Galveston Bay Species and Parker, Proposed Environmental Limits for Galveston Bay with additional information supplied by conversations with Dr. Neal Armstrong. Data was also obtained from Texas Parks and Wildlife Department Coastal Fisheries Report and the Texas Water Quality Board Standards. Espey-Huston and Associates supplied the computer model read-out for present and predicted dissolved oxygen and salinity in the Galveston Bay System.

The data was qualified and parameter comparisons of TWQB Standards and MSI Environmental Limits with the Espey-Huston model read-outs were attempted to determine Problem Areas. It was found that of the dissolved oxygen, temperature, salinity, and nutrient parameters, only the dissolved oxygen had adequate data available to accomplish a proper comparison. Problem Areas that were indicated by the dissolved oxygen comparison are delineated in Part IV - Comparison of Data and Definition of Problem Areas.

Model predictions of dissolved oxygen were compared with TWQB Water Quality Standards indicating Problem Areas where predicted levels of DO (Dissolved Oxygen) were less than those

standards for each segment using model condition A and C (Appendix A), segment 1005 had deficiencies below the TWQB DO Standards ranging from 0.2 to 0.5 mg/l. Segments 1006 and 1007 indicated deficiencies below the TWQB DO Standards under conditions A, B, C, D, I, and K (Appendix A) ranging from 0.7 to 2.0 mg/l for 1006 and 0.1 to 1.0 mg/l in 1007. Segment 2429 (Scott Bay) was deficient under conditions A and C (Appendix A) ranging from 0.2 to 0.5 mg/l. Segment 2430 (Burnett Bay) indicated deficiencies with conditions A, B, C, D, and K (Appendix A) ranging from 0.1 to 2.9 mg/l.

Other Problem Areas were included in the form of comments presented during discussions with Marine Science Institute personnel and an additional listing of problems were included from discussions with Bernard Johnson Incorporated personnel.

This report is a prelude to the final Gulf Coast Waste Disposal Authority's input to the Galveston Bay Project which is Task IV - Recommended Procedures for Implementation, scheduled for completion on October 31, 1974.

I. Introduction

This report on the Galveston Bay Project Problem Areas fulfills Task II, B-4 of the contract between the Texas Water Quality Board and the Gulf Coast Waste Disposal Authority. Problem Areas have been defined by Texas Water Quality Board personnel for this task as any deficiency that results from the comparisons of computer model predictions for the bay under varying conditions against the Texas Water Quality Board Standards and the Marine Science Insitute Environmental Limits as well as the limitations of the technical problem solving tools and the critical assumptions that must be made based on the limited data available. Other specific problems concerning the present and future Galveston Bay System are presented to be included in the overall development of alternative corrective measures.

The scope of this report includes four areas of discussion. Section II describes the computer models which were chosen for this study, and their limitations as predictive tools. Section III describes the Environmental Limits proposed by the Marine Science Insitute of the University of Texas, and their limitations. Section IV contains the actual comparisons of the Dissolved Oxygen information and lists the indicated Problem Areas with respect to Dissolved Oxygen deficiencies both present and predicted. These deficiencies indicate Problem Areas that will be detrimental to the propogation and maintenance of aquatic life in the Galveston Bay System. Section VI contains comments

on several problems in the Galveston Bay System by scientists at the Marine Science Insitute and a listing of other problems that were discussed with Bernard Johnson Incorporated personnel.

II. Limitation of Galveston Bay Project Study Tools

To prepare a study of this nature and scope, about the complex esturine system of the Houston Ship Channel (HSC) and Galveston Bay the scientists and engineers involved had to make some basic decisions on how to perform the study. The collection of as much water quality data as necessary was one of the first steps in the Galveston Bay Project (GBP). A prevailing question remained as to what "tools" and procedures could be used to optimize the voluminous amount of material collected. A tool was needed that could compare data, vary real and theoretical water quality conditions, and make predictions of segment water quality under the various input conditions. Computer water quality models, although not meeting the requirements perfectly were decided to be the best tool available to develop the necessary criteria.

Water quality models have been in use for several years and some pioneering efforts in modeling⁰¹ were done for the GBP. The mode used by Espey-Huston and Associates, Inc. (EHA) for the prediction of segment water quality under varied conditions is a combination of two models⁰².

A model that was developed by Dr. Donald O'Connor⁰³ was used for predictions in the HSC from the turning basin to a point approximately 3½ miles above Morgan's Point. The rest of the Galveston Bay Esturine System water quality segments under consideration in this study were modeled

by a two dimensional steady state model. The O'Connor model was proved to have a greater reliability in the HSC and the two dimensional steady state model was proved better for use in the rest of the Galveston Bay System⁰⁴. The model verifications were done by EHA and TWQB personnel.

There are several factors which limit the reliability of the computer model output. These factors may be divided into two categories; model weaknesses, and input data inaccuracy.

The Tracor Galveston Bay model, and the O'Connor model both contain weaknesses and programmed assumptions which limit their accuracy. These weaknesses and assumptions will be addressed in the report being prepared by EHA⁰⁵.

The reliability of any model output is also dependent upon the accuracy of the loading data. It is necessary therefore, to qualify certain aspects of the loading data.

- 1.) Future theoretical conditions were approximated by using the appropriate EPA guidelines. These guidelines may change before 1990 and nullify the present predictions of the 1990 conditions.
- 2.) The present loading data is based on the TWQB Self-Reporting System and the data has been supported by correspondence with the discharges involved.⁰⁶
- 3.) Large non-point sources of organic loading such as urban run off and tidal marsh inflow are not considered in the loading data.

III. Environmental Limits Discussion

The initial concept for the designation of Environmental Limits relied on the existence of easily obtainable historical data relating to the water quality of the Galveston Bay System. This was to be supplemented with toxicity studies⁰⁷ and additional research on existing water quality. Scientists hoped to establish trends in the water quality parameters being studied, and with engineering and modeling support establish Environmental Limits on the Galveston Bay System.

This initial concept was not realized for two reasons. First, no "easily obtainable" historical data on the Galveston Bay System was acquired⁰⁸, and second, loss of Federal funding for the engineering and modeling efforts restricted that supporting effort.⁰⁹ Because of the loss of these important aspects of the research, Environmental Limits were established in a different manner utilizing only the data and interpretive manpower which was available.

Due to the lack of obtainable historical data, the Environmental Limits discussed below are generally based on single sets of data gathered in one period from 1969-1973.¹⁰ The data sets are supported by previous research performed in Galveston Bay and other areas. They are also supported by data from agencies¹¹ doing research related to establishing Environmental Limits.

The limits as presently established probably do not represent the optimal environmental situation for the

Galveston Bay System. Insufficient data was available to establish this. However, these limits are tolerable conditions and represent limits which have contributed to the historically high productivity of Galveston Bay.¹²

The following subsections describe each of the proposed limits, and how they were derived.

IIIA. Nutrient Levels

Nutrients described in this study represent primarily Nitrogen and Phosphorous loading in the Bay system. The Environmental Limit has been set at a level "equal to or less than the 1970 mass emission rates". Although accurate quantitative estimates do not exist, this limit is generally higher than the guideline set by the National Academy of Sciences (N.A.S.) of 0.362 mg/l for inorganic N. and 0.05 mg/l for P.¹³ However, the N.A.S. guidelines are set for coastal (marine) and not estuarine waters. Further, the Galveston Bay system has shown a tolerance for these higher levels and has maintained a high productivity level.¹⁴ There are several reasons why this Environmental Limit may not represent the optimal nutrient loading condition for the Bay.

First and most importantly, the data base which led to the establishment of this limit is weak, and more information on nutrient loads and the resulting phytoplankton productivity is necessary to achieve optimal nutrient loads for the Bay.

Second, there is no real deliniation for nuisance levels

of phytoplankton in estuarine waters.¹⁵ In freshwater there is some definitive information related to certain water conditions. Phytoplankton blooms create slimes and other undesirable conditions which provide an index for nuisance definition. These undesirable conditions are not so evident or consistent in estuarine systems.

Third, insufficient data is available to ascertain the affect of nutrient levels to stimulate biologically detrimental phytoplankton blooms.¹⁶ Much more detailed research will be needed to expose the affect of nutrients in this situation.

Fourth, accurate quantitative information describing non-point discharges, non-permitted discharges and natural nutrient input from marsh areas is necessary before an actual loading figure can be defined for the Galveston Bay System.¹⁷ Once this data is gathered, decisions to eliminate certain discharges or decrease input from others can be considered. Those decisions cannot be made based on the presently available data.

IIIB. Dissolved Oxygen

Dissolved Oxygen (DO) limits for segments 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), and 2424 (West Bay) have been set at 5 mg/l except where depressions occur due to natural causes. Dissolved oxygen limitations for the remainder of the Bay System have not been suggested because insufficient data was available to characterize those areas.¹⁸

DO limits were calculated using the National Academy of Sciences equation for characterizing aquatic systems requiring

a moderate¹⁹ level of protection. The following equation was used:

$$\text{DO Criterion} = 1.08M - 0.0415M^2 - 0.202$$

M = the established natural seasonal minimum of Dissolved Oxygen Saturation levels.

The dissolved oxygen limit is well supported with data from the Galveston Bay system and other areas. In addition, research into minimum DO requirements has been performed by the Environmental Protection Agency, the National Academy of Sciences, and the Texas Water Quality Board. There is also significant information on the DO requirements for individual species in the Galveston Bay system.²⁰

The weakness inherent in the proposed Dissolved Oxygen limit relates to the designation of only a "moderate" level of protection for this Bay system, and hence only a 5 mg/l requirement.²¹ Six mg/l of Dissolved Oxygen may be more environmentally responsive than the present limit and future research may indicate the need to raise it.²²

IIIIC. Temperature

Maximum temperature limits of 95°F (35°C) were established for Galveston Bay (WQS 2421), Trinity Bay (WQS 2422), East Bay (WQS 2423), and West Bay (WQS 2424). In addition during the Summer and Fall months of June through September the maximum temperature increase from thermal discharges should be only 1.5°F (0.8°C) above ambient. During other months of

the year a 4°F (2.2°C) temperature increase is tolerable.²³

This limit is supported by a study performed by Copeland and Bechtel (1971) on the Environmental Limits of six important species. The proposed limit is also very close to the standards set by both the Environmental Protection Agency and Texas Water Quality Board.²⁴

The only limiting factor related to this designation involves a partial reliance on data from other fresh and salt water systems and the need for further research to substantiate the temperature limit.²⁵

IIID. Salinity

Insufficient data is available concerning the Environmental Requirements for salinity in the Galveston Bay system. Therefore, it was proposed that the existing salinity regime for Galveston Bay be maintained until such time as data is available to define specific requirements²⁶. The logic which led to this designation relies on the fact that the biotic community is existing within, and is acclimated to the present salinity regime. There is also high productivity in the Galveston Bay system²⁷.

Since freshwater inflow is the single most important salinity controlling factor, it must be maintained at its present volume. This inflow must include several high volume surges per year to protect the oyster fisheries by dropping salinity in the lower Bay. These inflow requirements

are supported by several researchers²⁸.

The limitations on this proposed environmental requirement are related to the lack of data. Future research may indicate that higher salinities can be tolerated without a significant loss of productivity.

As demand for freshwater increases, competition by users for that which is available will increase. For this reason the bay's minimal requirement must be established and safeguards installed to insure that it will receive the freshwater it needs to remain a balanced productive ecosystem²⁹.

IV. Comparison of the Data and Definition of Problem Areas

This section addresses Problem Areas delineated by the comparison of the EHA model readouts, with the TWQB standards³⁰, and MSI Environmental Limits³¹. The comparison is limited in several respects.

No comparative data exists for nutrient levels in the Galveston Bay System. The Environmental Limits proposed by MSI are not quantified but relate to the present conditions³². No TWQB standards are set for nutrient levels, and the computer model does not predict nutrient levels.

No comparative data exists for BOD levels in the Galveston Bay System. Although the computer model has predicted BOD levels for Galveston Bay, neither the MSI Environmental Limits or the TWQB standards address themselves to acceptable levels of this parameter.

No comparative data was provided for the analysis of temperature levels for the Galveston Bay System. Both the TWQB standards and the MSI Environmental Limits set temperature limits, but the model run provided did not predict temperature levels.

Salinity data for Galveston Bay is not presently comparable because the MSI Environmental Limits propose that the present salinity regime be maintained in the Galveston Bay System. The Texas Parks and Wildlife Department has salinity data for more than 15 years on the

major Bays in the Galveston Bay system³³, but the present average salinity regime has not been formulated. There is also no TWQB standard salinity regime, so there is no basis for comparison with the model.

There is comparable data for Dissolved Oxygen (DO) concentrations in the Galveston Bay Project Area. The MSI Environmental Limits for DO are listed only for Galveston Bay (WQS 2421), Trinity Bay (WQS 2422), East Bay (WQS 2423), and West Bay (WQS 2424). However, the side bays along the Houston Ship Channel (HSC) were not addressed by the model readout but were included in the comparison. The following rationale was used: it was assumed that the DO in a side bay, would be at least as high as the DO indicated by the model readout at the corresponding mile point in the HSC. The comparisons of Dissolved Oxygen were made based on the above mentioned qualifications.

V. Dissolved Oxygen Problem Area Summary

Comparison of the dissolved oxygen predictions and Texas Water Quality Board Water Quality Standards indicated Problem Areas in several segments where the predicted DO (Dissolved Oxygen) level was less than the prescribed standard level for each individual segment. Using model conditions A and C (Appendix A), segment 1005 (Houston Ship Channel - lower) had deficiencies of DO (Dissolved Oxygen) ranging from 0.2 to 0.5 mg/l. Segments 1006 (Houston Ship Channel - upper) and 1007 (Houston Ship Channel - Turning Basin) indicated deficiencies below the Texas Water Quality Board DO (Dissolved Oxygen) Standards under conditions A, B, C, D, I, and K (Appendix A) ranging from 0.7 to 2.0 mg/l for segment 1006 and 0.1 to 1.0 mg/l in segment 1007. Segment 2429 (Scott Bay) was deficient under conditions A and C (Appendix A) ranging from 0.2 to 0.5 mg/l. Segment 2430 (Burnett Bay) indicated deficiencies with conditions A, B, C, D, and K (Appendix A) ranging from 0.1 to 2.9 mg/l.

All other segments in the study area indicated no deficiencies in dissolved oxygen when model conditions (Appendix A) were compared with the Texas Water Quality Board Water Quality Standards.

VI. Other Problem Areas

The following comments on Problem Areas of the Galveston Bay System were presented in discussion with Dr. William B. Brogden, Dr. Chase Van Baalen and Dr. Carl Oppenheimer. While these draft comments do not represent any official position of the Marine Science Institute, they are opinions of experts in the field of marine sciences and the problems presented must be considered in any corrective alternative measures concerning the Galveston Bay System.

1) Baseline Data Inadequacies: An effective management effort will require a stronger effort to acquire and maintain baseline data. The present data base should be expanded to include more quantitative biological data such as that can be collected by Parks and Wildlife. There should be more emphasis on the establishment of critical parameters to be measured, maintenance of uniform sampling and analysis procedures, and scheduling sampling efforts to more accurately characterize the bay system.

Standard sampling and analysis accomplished as part of the self-reporting system of the industries needs to be more rigidly controlled, with special attention to metals and other suspected toxicants. For some industries, continuous bioassay may be appropriate.

In the past, methods used to sample the bay and ship channel waters has not included adequate diurnal sampling. This may give an inaccurate picture of conditions such as dissolved oxygen

productivity, organic carbon etc. It is now technically feasible to continuously monitor such important parameters as oxygen, salinity, temperature, pH, chlorophyll-a fluorescence, ATP and a variety of specific ions or molecules. Consideration should be given to continuous monitoring of these parameters at critical points within the ship channel and bay with direct readout for anticipation of adverse effects.

2) 5-day BOD Parameter Weakness: The BOD₅ test has limitations with respect to characterizing industrial effluents and the bay system. BOD₅ should be supplemented with analysis of total organic carbon, dissolved organic carbon, and long-term BOD₄₅.

3) Deleted Portions of the Project: During the course of the Galveston Bay Project, many of the original concepts of the research required were modified or deleted due to financial problems. It is possible to recover much useful information from the data which is available but not interpreted. In particular, the USCG data on inflow of heavy metals could be interpreted in terms of the heavy metal budget of the bay.

4. The Houston Ship Channel as a Special Area: Additional time and effort should be put into re-thinking of the environmental goals for the Houston Ship Channel and the potential effect of the channel on Galveston Bay as a whole. Some suggested potential problems in the system are discussed below:

A) "Natural" anaerobic conditions in the Houston Ship Channel: Because of the channel's high nutrient level, depth, reduced flow, and restricted surface area, we speculate that the

channel could exhibit periodic and sometimes continuous anaerobic conditions even if all BOD loadings were removed. Photosynthesis at the present may be suppressed by discharged toxicants, when these discharges are stopped, natural photosynthesis and respiration in the channel may become large enough to cause anaerobic conditions. Recent studies in the Corpus Christi Inner Harbor (TWQB-preliminary report) have implicated both benthic oxygen demand and algal photosynthesis and respiration as major causes for low oxygen conditions.

B) Impact of the present ship channel sediments: In addition to the problem of benthic oxygen demand, the sediments can continue to act as a reservoir of nutrients and toxicants for many years after discharges have been controlled. Future dredging operations will probably be required to dispose of spoil on land, with precautions taken to prevent the subsequent release of toxic materials to the environment.

C) Pulse discharges: No adequate study has been made of the consequences of "pulse" discharges of toxic waters into the bay from the ship channel or other sources, caused by flooding. This could be studied both by modeling and by continuous monitoring. The consequences of the periodic extra high tides and low tides would also be evaluated with respect to discharges and mixing of toxic waters.

5. Nutrients and Eutrophication: Assuming that the toxicity and dissolved oxygen problems are solved, there will still be the necessity for management of nutrient inflows into Galveston Bay. On one hand, it will be necessary to avoid nuisance

algae blooms due to excessive nutrients, on the other hand, the natural sources of nutrients for the bay are being altered by man and it may be necessary to supplement these natural sources with controlled nutrient discharges to maintain productivity. Making these management decisions will require a better understanding of nutrient cycles in the bay, and may require a more sophisticated computer model than is presently available.

6. Consideration should be given to the establishment of in situ bioassay points at areas where effluents may affect the living organisms in the bay. Bioassay tests are available for such purposes and it is recommended that the shrimp and mullet be used as representative organisms for the bioassay. Tests should be established on an annual basis.

7. The economic value of the bay estuarine area to industry and the general public should be established. This value can then be related to the effort devoted to understanding the bay for management purposes. Most industrial organizations devote a certain portion of their profits to R&D. Such a philosophy should apply to the Bay system as the system is directly related to the economics of industrial operations. For example, if the total economic industrial annual base is five billion dollars, a 0.1 percent investment in bay research would be five million dollars. Such analogy would provide the means to implement the research need items mentioned in this Galveston Bay Planning Project Report.

An additional listing was compiled in discussions with Bernard Johnson Incorporated personnel. These problems are mentioned here and will be documented and taken into consideration by Bernard Johnson Incorporated as they develop the alternative corrective measures for the Galveston Bay System.

- 1) There is presently an overloading of many of the municipal treatment facilities, especially in Harris County, thereby increasing the loading in their respective receiving waters.
- 2) Accuracy of the 1990 projected data has not been determined.
- 3) There is no criteria for the level or availability of the technology required of municipal treatment facilities after the 1983 and 1990 requirements.
- 4) The effect of fewer but larger discharges resulting from regionalization of treatment facilities must be evaluated.
- 5) The effect of recycle and reuse implementation on flow patterns and salinity should be considered.
- 6) There is a variation of treatment of nitrogen on all models used in water quality predictions.
- 7) There will be limitations on the use of alternative disposal due to urbanization.
- 8) A geographic limit exists when considering the recycle and reuse of water.

- 9) There is a possible change in cooling water volume and requirements for its discharge that will require consideration.
- 10) Benthic loads may be altered due to advanced wastewater treatment techniques.

VII. Methodology

The comparison of dissolved oxygen in the Galveston Bay System was accomplished by collection of the available data from the Texas Water Quality Board Water Quality Standards, Model runs from Espey-Huston & Associates, and the University of Texas Marine Science Institute.

Determination of water quality segments displayed on the Espey-Huston data printouts was made by construction of an overlay corresponding to the one nautical mile grid system used by Espey-Huston. Using the land boundaries with the grid system, and the TWQB segment definition maps, the water quality segments were delineated for the Galveston Bay system.

The ranges of the dissolved oxygen were then taken in each of the segments and compared, by segment, with the Texas Water Quality Board Water Quality Standards and the proposed Environmental Limits established by the Marine Science Institute. In comparing dissolved oxygen in the Houston Ship Channel, values were extrapolated from the BOD and DO profile graphs for the ship channel. These values were compared with the TWQB Water Quality Standards.

Any deficiencies of dissolved oxygen in either the Galveston Bay System or the Houston Ship Channel comparisons were then noted as Problem Areas.

END NOTES

- 1.) Ward, G., Personal Conversation with T.M. Samson, (July 12, 1974).
- 2.) Ibid.
- 3.) Ibid.
- 4.) Ibid.
- 5.) Ibid.
- 6.) Anonymous, Domestic and Industrial Loading Tables for the GBP, Gulf Coast Waste Disposal Authority, 1973.
- 7.) Anonymous, Toxicity Studies of the Galveston Bay Project, Texas Water Quality Board, (1973).
- 8.) Armstrong, N.E., Personal Conversation with W.G. Stullken, (July 12, 1974).
- 9.) Ibid.
- 10.) Armstrong, N.E., Personal Conversation with W.G. Stullken, (July 12, 1974).
- 11.) Texas Water Quality Board, Texas Parks and Wildlife Department, Environmental Protection Agency, National Academy of Sciences-National Technical Advisory Committee.
- 12.) Armstrong, N.E., Personal Conversation with W.G. Stullken, (July 12, 1974).
- 13.) In Situ Study, National Academy of Sciences (in press).
- 14.) Armstrong, N.E., Personal Conversation with W.G. Stullken, (July 12, 1974), (Re: Parker, P.L., Et. al, Proposed Environmental Limits for Galveston Bay, TWQB), Contract IAC-(72-73)-1180. (1974).
- 15.) Armstrong, N.E., Personal Conversation with W.G. Stullken, (July 12, 1974).
- 16.) Ibid.
- 17.) Ibid.
- 18.) Ibid.

- 19.) "Moderate" is the third of 4 water protection categories set by the National Academy of Sciences. This level is applicable in areas where fisheries and important industries exist, with fisheries accepting some decreases in production in favor of urban economic development.
- 20.) Copeland, ^BS.J. and ^{Bechtel}Fruh, E.G., Some Environmental Limits of Six Important Galveston Bay Species, (1970).
- 21.) Parker, P.L., Et. al, Proposed Environmental Limits for Galveston Bay, TWQB Contract IAC-(72-73)-1180, (1974).
- 22.) Armstrong, N.E., Personal Conversation with W.G. Stullken, (July 12, 1974).
- 23.) Parker, P.L., Et. al, Proposed Environmental Limits for Galveston Bay, TWQB Contract IAC-(72-73)-1180, (1974).
- 24.) Ibid.
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- 26.) Parker, P.L., Et.al, Proposed Environmental Limits for Galveston Bay, TWQB Contract IAC-(72-73)-1180. (1974).
- 27.) Armstrong, N.E., Personal Conversation with W.G. Stullken, (July 12, 1974), Re: Odum, Et. al, Publication of the Institute of Marine Sciences, Vol. IX, 1963.
- 28.) Copeland and Bechtel, 1971, Armstrong and Hinson, 1973.
- 29.) Armstrong, N.E., Personal Conversation with W.G. Stullken, (July 12, 1974).
- 30.) Anonymous, Texas Water Quality Board Standards, (1973).
- 31.) Parker, P.L., Et. al, Proposed Environmental Limits for Galveston Bay, TWQB Contract IAC-(72-73)-1180, (1974).
- 32.) Ibid.
- 33.) Anonymous, Coastal Fisheries Reports, Texas Parks and Wildlife Department, (1962-1971), (1972-1973 in publication).

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Copeland, S. J. and Fruh, E. G., Some Environmental Limits of Six Important Galveston Bay Species, (1970).

Parker, P. L., Et. al, Proposed Environmental Limits for Galveston Bay, TWQB Contract IAC-(72-73)-1180, 1974.

APPENDIX A
MODEL CONDITIONS INDEX

- A) Present Conditions, BPCT, Low Flow, with Nitrogenous Demand.
- B) Present Conditions, BAT, Low Flow, with Nitrogenous Demand.
- C) 1990 Conditions, BPCT, Low Flow, with Nitrogenous Demand.
- D) 1990 Conditions, BAT, Low Flow, with Nitrogenous Demand.
- E) Present Conditions, BPCT, Low Flow, without Nitrogenous Demand.
- F) Present Conditions, BAT, Low Flow, without Nitrogenous Demand.
- G) 1990 Conditions, BPCT, Low Flow, without Nitrogenous Demand.
- H) 1990 Conditions, BAT, Low Flow, without Nitrogenous Demand.
- I) Present Conditions, BPCT, Normal Flow, with Nitrogenous Demand.
- J) Present Conditions, BAT, Normal Flow, with Nitrogenous Demand.
- K) 1990 Conditions, BPCT, Normal Flow, with Nitrogenous Demand.
- L) 1990 Conditions, BAT, Normal Flow, with Nitrogenous Demand.
- M) Present Conditions, BPCT, Normal Flow, without Nitrogenous Demand.
- N) Present Conditions, BAT, Normal Flow, without Nitrogenous Demand.
- O) 1990 Conditions, BPCT, Normal Flow, without Nitrogenous Demand.
- P) 1990 Conditions, BAT, Normal Flow, without Nitrogenous Demand.
- Q) 1990 Conditions, BAT, Low Flow, 12°C, without Nitrogenous Demand.
- R) 1990 Conditions, BAT, Low Flow, 12°C, with Nitrogenous Demand.

S) 1990 Conditions, BAT, Low Flow, 22°C, without Nitrogenous Demand.

T) 1990 Conditions, BAT, Low Flow, 22°C, with Nitrogenous Demand.

I. Model Conditions - A

Present BPCT , Low Flow with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be attained in segments 1107 (Chocolate Bayou Tidal), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2431 (Moses Bay), and 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model loading conditions (Appendix A) indicate that DO Problem Areas would exist in the following water quality segments: 1005 (Houston Ship Channel-Morgan's Point to San Jacinto Monument), 1006 (Houston Ship Channel-San Jacinto River Confluence), 1007 (Houston Ship Channel-Turning Basin), 2429 (Scott Bay), and 2430 (Burnett Bay).

<u>Segment No.</u>	<u>Predicted Min. DO (mg/l)</u>	<u>Required Min. DO (mg/l)</u>	<u>Δ (mg/l)</u>
1005	3.8	4.0	-0.2
1006	0.0*	2.0	-2.0
1007	1.0	1.5	-0.5
2429	3.8	4.0	-0.2
2430	1.3	4.0	-2.7

* HSC-mile 6 from Morgan's Point to Turning Basin.

DO Comparison - Galveston Bay System

Model Conditions Present BPCT Low Flow with N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.4 - 6.4	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	3.8 - 5.5	-
1006	2.0	0.0 - 3.6	-
1007	1.5	1.0*	-
2421	4.0	6.0 - 6.6	5.0
2422	4.0	6.6 - 6.6	5.0
2423	4.0	6.5 - 6.6	5.0
2424	4.0	6.3 - 6.4	5.0
2425	4.0	6.6**	-
2426	4.0	5.2 - 5.7	-
2427	4.0	4.4 - 4.8	-
2428	4.0	5.5 - 6.3	-
2429	4.0	3.8***	-
2430	4.0	1.3 - 2.0	-
2431	4.0	6.5 - 6.5	-
2432	4.0	6.4 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - B

Present BAT , Low Flow with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO Standards set by the TWQB and the DO Environmental Limits set by the MSI would be met in segments 1107 (Chocolate Bayou Tidal), 1005, Houston Ship Channel-Morgan's Point to San Jacinto Monument), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2431 (Moses Bay), and 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model loading conditions (Appendix A) indicate that DO Problem Areas would exist in the following segments: 1006 (Houston Ship Channel-San Jacinto River Confluence), 1007 (Houston Ship Channel-Turning Basin), and 2430 (Burnett Bay).

<u>Segment No.</u>	<u>Predicted Min. DO (mg/l)</u>	<u>Required Min. DO (mg/l)</u>	<u>Δ (mg/l)</u>
1006	1.2*	2.0	-0.8
1007	1.3	1.5	-0.2
2430	3.8	4.0	-0.2

* The DO at mile 13 from Morgan's Point to the Turning Basin is below TWQB standards.

DO Comparison - Galveston Bay System

Model Conditions Present BAT Low Flow with N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.4 - 6.4	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	5.2 - 6.1	-
1006	2.0	1.2 - 5.0	-
1007	1.5	1.3*	-
2421	4.0	6.2 - 6.6	5.0
2422	4.0	6.6 - 6.6	5.0
2423	4.0	6.6 - 6.6	5.0
2424	4.0	6.4 - 6.4	5.0
2425	4.0	6.6**	-
2426	4.0	5.9 - 6.2	-
2427	4.0	5.5 - 5.7	-
2428	4.0	5.9 - 6.3	-
2429	4.0	5.2***	-
2430	4.0	3.8 - 4.2	-
2431	4.0	6.5 - 6.5	-
2432	4.0	6.4 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - C

1990' BPCT , Low Flow with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2431 (Moses Bay), and 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model loading conditions (Appendix A) indicate that DO Problem Areas would exist in the following segments: 1005 (Houston Ship Channel-Morgan's Point to San Jacinto Monument), 1006 (Houston Ship Channel-San Jacinto River Confluence), 1007 (Houston Ship Channel-Turning Basin), 2429 (Scott Bay), and 2430 (Burnett Bay).

<u>Segment No.</u>	<u>Predicted Min. DO (mg/l)</u>	<u>Required Min. DO (mg/l)</u>	<u>Δ mg/l</u>
1005	3.5	4.0	-0.5
1006	0.0*	2.0	-2.0
1007	0.9	1.5	-0.6
2429	3.5	4.0	-0.5
2430	1.1	4.0	-2.9

* The DO at mile 5 from Morgan's Point to the Turning Basin is below the TWQB standards.

DO Comparison - Galveston Bay System

Model Conditions 1990 BPCT Low Flow with N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.4 - 6.4	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	3.5 - 5.5	-
1006	2.0	0.0 - 3.0	-
1007	1.5	0.9*	-
2421	4.0	5.8 - 6.9	5.0
2422	4.0	6.9 - 7.0	5.0
2423	4.0	6.7 - 6.8	5.0
2424	4.0	6.4 - 6.4	5.0
2425	4.0	6.8**	-
2426	4.0	5.1 - 5.7	-
2427	4.0	4.1 - 4.6	-
2428	4.0	5.1 - 5.9	-
2429	4.0	3.5***	-
2430	4.0	1.1 - 1.8	-
2431	4.0	6.7 - 6.7	-
2432	4.0	6.4 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - D

1990 BAT , Low Flow with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (Houston Ship Channel-Morgan's Point to San Jacinto Monument), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model loading conditions (Appendix A) indicate that DO Problem Areas would exist in the following segments: 1006 (Houston Ship Channel-San Jacinto River Confluence), 1007 (Houston Ship Channel-Turning Basin), and 2430 (Burnett Bay).

<u>Segment No.</u>	<u>Predicted Min. DO (mg/l)</u>	<u>Predicted Min. DO (mg/l)</u>	<u>Δ mg/l</u>
1006	1.3*	2.0	-0.7
1007	1.4	1.5	-0.1
2430	3.9	4.0	-0.1

* The DO at mile 14 from Morgan's Point to the Turning Basin is below the TWQB standards.

DO Comparison - Galveston Bay System

Model Conditions 1990 BAT Low Flow with N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.4 - 6.4	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	5.3 - 6.3	-
1006	2.0	1.3 - 5.3	-
1007	1.5	1.4*	-
2421	4.0	6.3 - 6.9	5.0
2422	4.0	6.9 - 7.0	5.0
2423	4.0	6.8 - 6.8	5.0
2424	4.0	6.4 - 6.4	5.0
2425	4.0	6.9**	-
2426	4.0	6.1 - 6.4	-
2427	4.0	5.6 - 5.9	-
2428	4.0	6.1 - 6.5	-
2429	4.0	5.3***	-
2430	4.0	3.9 - 4.3	-
2431	4.0	6.7 - 6.7	-
2432	4.0	6.4 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - E

Present BPCT , Low Flow without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions Present BPCT Low Flow Without N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.4 - 6.4	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	5.4 - 6.1	-
1006	2.0	2.4 - 5.3	-
1007	1.5	2.5*	-
2421	4.0	6.3 - 6.6	5.0
2422	4.0	6.6 - 6.6	5.0
2423	4.0	6.6 - 6.6	5.0
2424	4.0	6.4 - 6.4	5.0
2425	4.0	6.6**	-
2426	4.0	6.0 - 6.2	-
2427	4.0	5.6 - 5.8	-
2428	4.0	6.0 - 6.3	-
2429	4.0	5.4***	-
2430	4.0	4.2 - 4.5	-
2431	4.0	6.5 - 6.5	-
2432	4.0	6.4 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - F

Present BAT , Low Flow without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions Present BAT Low Flow Without N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.4 - 6.4	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	5.5 - 6.2	-
1006	2.0	3.0 - 5.5	-
1007	1.5	3.1*	-
2421	4.0	6.3 - 6.6	5.0
2422	4.0	6.6 - 6.6	5.0
2423	4.0	6.6 - 6.6	5.0
2424	4.0	6.4 - 6.4	5.0
2425	4.0	6.6**	-
2426	4.0	6.1 - 6.3	-
2427	4.0	5.8 - 5.9	-
2428	4.0	6.1 - 6.4	-
2429	4.0	5.5***	-
2430	4.0	4.6 - 4.8	-
2431	4.0	6.5 - 6.5	-
2432	4.0	6.4 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - G

1990 BPCT , Low Flow , without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BPCT Low Flow Without N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.4 - 6.4	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	5.5 - 6.3	-
1006	2.0	2.5 - 5.4	-
1007	1.5	2.7*	-
2421	4.0	6.3 - 6.9	5.0
2422	4.0	6.9 - 7.0	5.0
2423	4.0	6.8 - 6.8	5.0
2424	4.0	6.4 - 6.4	5.0
2425	4.0	6.9**	-
2426	4.0	6.2 - 6.4	-
2427	4.0	5.8 - 6.0	-
2428	4.0	6.2 - 6.5	-
2429	4.0	5.5***	-
2430	4.0	4.3 - 4.6	-
2431	4.0	6.7 - 6.7	-
2432	4.0	6.4 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - H

1990 BAT , Low Flow without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BAT Low Flow Without N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.4 - 6.4	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	5.7 - 6.5	-
1006	2.0	3.4 - 5.8	-
1007	1.5	3.6*	-
2421	4.0	6.3 - 7.0	5.0
2422	4.0	7.0 - 7.1	5.0
2423	4.0	6.8 - 6.8	5.0
2424	4.0	6.4 - 6.4	5.0
2425	4.0	6.9**	-
2426	4.0	6.4 - 6.5	-
2427	4.0	6.0 - 6.2	-
2428	4.0	6.3 - 6.6	-
2429	4.0	5.7***	-
2430	4.0	4.8 - 5.2	-
2431	4.0	6.7 - 6.7	-
2432	4.0	6.4 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - I

Present BPCT , Normal Flow with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI will be attained in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's point to San Jacinto Monument), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), and 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions (Appendix A) indicate that DO Problem Areas would exist in the following segments: 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin).

<u>Segment No.</u>	<u>Predicted Min. DO (mg/l)</u>	<u>Required Min. DO (mg/l)</u>	<u>Δ (mg/l)</u>
1006	1.2*	2.0	-0.8
1007	1.3	1.5	-0.2

* The DO at mile 14 from Morgan's Point to the Turning Basin is below TWQB standards.

DO Comparison - Galveston Bay System

Model Conditions Present BPCT Normal Flow With N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.5 - 6.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	5.6 - 6.6	-
1006	2.0	1.2 - 5.3	-
1007	1.5	1.3*	-
2421	4.0	6.4 - 7.5	5.0
2422	4.0	7.5 - 7.5	5.0
2423	4.0	7.3 - 7.4	5.0
2424	4.0	6.4 - 6.5	5.0
2425	4.0	7.5**	-
2426	4.0	6.4 - 6.8	-
2427	4.0	5.9 - 6.1	-
2428	4.0	6.4 - 6.9	-
2429	4.0	5.6***	-
2430	4.0	4.4 - 4.7	-
2431	4.0	7.2 - 7.2	-
2432	4.0	6.5 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - J

Present BAT , Normal Flow with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions Present BAT Normal Flow With N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.5 - 6.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	6.2 - 6.9	-
1006	2.0	3.9 - 6.3	-
1007	1.5	4.0*	-
2421	4.0	6.4 - 7.5	5.0
2422	4.0	7.5 - 7.5	5.0
2423	4.0	7.3 - 7.4	5.0
2424	4.0	6.4 - 6.5	5.0
2425	4.0	7.4**	-
2426	4.0	6.8 - 7.1	-
2427	4.0	6.5 - 6.6	-
2428	4.0	6.8 - 7.1	-
2429	4.0	6.2***	-
2430	4.0	5.6 - 5.8	-
2431	4.0	7.2 - 7.2	-
2432	4.0	6.5 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - K

1990 BPCT , Normal Flow with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO Environmental Limits set by MSI would be attained in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2431 (Moses Bay), and 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model loading conditions (Appendix A) indicate that DO problem areas would exist in the following segments: 1006 (HSC-San Jacinto Confluence), 1007 (HSC-Turning Basin) and 2430 (Burnett Bay).

<u>Segment No.</u>	<u>Predicted Min. DO (mg/l)</u>	<u>Required Min. DO (mg/l)</u>	<u>Δ(mg/l)</u>
1006	0.5*	2.0	-1.5
1007	0.5	1.5	-1.0
2430	3.6	4.0	-0.4

* The DO at mile 11 from Morgan's Point to the Turning Basin is below TWQB standards.

DO Comparison - Galveston Bay System

Model Conditions 1990 BPCT Normal Flow With N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.5 - 6.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	4.8 - 6.2	-
1006	2.0	0.5 - 4.8	-
1007	1.5	0.5*	-
2421	4.0	6.5 - 7.4	5.0
2422	4.0	7.4 - 7.4	5.0
2423	4.0	7.2 - 7.3	5.0
2424	4.0	6.4 - 6.6	5.0
2425	4.0	7.3**	-
2426	4.0	6.0 - 6.4	-
2427	4.0	5.2 - 5.6	-
2428	4.0	5.9 - 6.6	-
2429	4.0	4.8***	-
2430	4.0	3.6 - 3.9	-
2431	4.0	7.1 - 7.1	-
2432	4.0	6.5 - 6.5	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - L

1990 BAT , Normal Flow with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BAT Normal Flow With N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.5 - 6.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	6.0 - 6.8	-
1006	2.0	3.9 - 6.0	-
1007	1.5	4.0*	-
2421	4.0	6.5 - 7.4	5.0
2422	4.0	7.4 - 7.5	5.0
2423	4.0	7.1 - 7.3	5.0
2424	4.0	6.4 - 6.5	5.0
2425	4.0	7.4**	-
2426	4.0	6.7 - 6.9	-
2427	4.0	6.3 - 6.5	-
2428	4.0	6.7 - 7.0	-
2429	4.0	6.0***	-
2430	4.0	5.5 - 5.7	-
2431	4.0	7.1 - 7.1	-
2432	4.0	6.5 - 6.5	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute -- Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - M

Present BPCT , Normal Flow without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bayou).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

I. Model Conditions- N

Present BAT , Normal Flow without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bayou).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions Present BAT Normal Flow Without N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.5 - 6.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	6.5 - 7.1	-
1006	2.0	4.8 - 6.7	-
1007	1.5	4.9*	-
2421	4.0	6.3 - 7.5	5.0
2422	4.0	7.5 - 7.5	5.0
2423	4.0	7.3 - 7.4	5.0
2424	4.0	6.5 - 6.5	5.0
2425	4.0	7.5**	-
2426	4.0	7.0 - 7.2	-
2427	4.0	6.7 - 6.8	-
2428	4.0	7.0 - 7.2	-
2429	4.0	6.5***	-
2430	4.0	6.1 - 6.3	-
2431	4.0	7.2 - 7.2	-
2432	4.0	6.5 - 6.5	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - O

1990 BPCT , Normal Flow without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BPCT Normal Flow Without N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.5 - 6.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	6.1 - 6.9	-
1006	2.0	4.3 - 6.1	-
1007	1.5	4.4*	-
2421	4.0	6.4 - 7.4	5.0
2422	4.0	7.4 - 7.5	5.0
2423	4.0	7.2 - 7.3	5.0
2424	4.0	6.4 - 6.5	5.0
2425	4.0	7.4**	-
2426	4.0	6.8 - 7.0	-
2427	4.0	6.4 - 6.6	-
2428	4.0	6.7 - 7.1	-
2429	4.0	6.1***	-
2430	4.0	5.6 - 5.8	-
2431	4.0	7.1 - 7.1	-
2432	4.0	6.5 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - P

1990 BAT , Normal Flow without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BAT Normal Flow Without N Demand

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	6.5 - 6.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	6.4 - 7.0	-
1006	2.0	4.8 - 6.6	-
1007	1.5	5.0*	-
2421	4.0	6.4 - 7.4	5.0
2422	4.0	7.4 - 7.5	5.0
2423	4.0	7.2 - 7.3	5.0
2424	4.0	6.5 - 6.5	5.0
2425	4.0	7.4**	-
2426	4.0	6.9 - 7.1	-
2427	4.0	6.6 - 6.7	-
2428	4.0	6.9 - 7.1	-
2429	4.0	6.4***	-
2430	4.0	5.9 - 6.0	-
2431	4.0	7.1 - 7.1	-
2432	4.0	6.5 - 6.6	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - Q

1990 BAT Low Flow Winter 12°C with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BAT Low Flow Winter 12°C With N

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	8.5 - 8.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	8.4 - 9.0	-
1006	2.0	6.0 - 8.3	-
1007	1.5	6.2*	-
2421	4.0	7.4 - 9.6	5.0
2422	4.0	9.6 - 9.7	5.0
2423	4.0	9.3 - 9.4	5.0
2424	4.0	8.2 - 8.7	5.0
2425	4.0	9.5**	-
2426	4.0	8.9 - 9.1	-
2427	4.0	8.6 - 8.7	-
2428	4.0	8.9 - 9.2	-
2429	4.0	8.4***	-
2430	4.0	7.3 - 7.6	-
2431	4.0	9.2 - 9.2	-
2432	4.0	7.7 - 8.5	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - R

1990 BAT , Low Flow Winter 12°C without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BAT Low Flow Winter 12°C Without N

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	8.5 - 8.5	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	8.9 - 9.3	-
1006	2.0	7.8 - 9.0	-
1007	1.5	8.1*	-
2421	4.0	7.4 - 9.6	5.0
2422	4.0	9.6 - 9.7	5.0
2423	4.0	9.3 - 9.4	5.0
2424	4.0	8.4 - 8.8	5.0
2425	4.0	9.5**	-
2426	4.0	9.3 - 9.4	-
2427	4.0	9.1 - 9.2	-
2428	4.0	9.2 - 9.4	-
2429	4.0	8.9***	-
2430	4.0	8.3 - 8.5	-
2431	4.0	9.2 - 9.3	-
2432	4.0	7.7 - 8.5	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - S

1990 BAT , Low Flow , Spring, Autumn 22°C without Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BAT Low Flow Spring Autumn 22°C Without N

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	7.2 - 7.2	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	7.1 - 7.6	-
1006	2.0	5.4 - 7.2	-
1007	1.5	5.6*	-
2421	4.0	6.7 - 7.9	5.0
2422	4.0	7.9 - 8.0	5.0
2423	4.0	7.7 - 7.8	5.0
2424	4.0	7.1 - 7.3	5.0
2425	4.0	7.8**	-
2426	4.0	7.5 - 7.7	-
2427	4.0	7.3 - 7.4	-
2428	4.0	7.5 - 7.7	-
2429	4.0	7.1***	-
2430	4.0	6.3 - 6.6	-
2431	4.0	7.6 - 7.7	-
2432	4.0	7.2 - 7.2	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

I. Model Conditions - T

1990 BAT , Low Flow , Spring, Autumn 22°C with Nitrogenous Demand

II. Congruent Water Quality Segments

The DO (Dissolved Oxygen) levels shown by the above model loading conditions (Appendix A) indicate that the DO standards set by the TWQB and the DO Environmental Limits set by MSI would be met in segments: 1107 (Chocolate Bayou Tidal), 1005 (HSC-Morgan's Point to San Jacinto Monument), 1006 (HSC-San Jacinto River Confluence), 1007 (HSC-Turning Basin), 2421 (Galveston Bay), 2422 (Trinity Bay), 2423 (East Bay), 2424 (West Bay), 2425 (Clear Lake), 2426 (Tabbs Bay), 2427 (San Jacinto Bay), 2428 (Black Duck Bay), 2429 (Scott Bay), 2430 (Burnett Bay), 2431 (Moses Bay), 2432 (Chocolate Bay).

III. Problem Areas

The DO levels shown by the above model conditions indicates that DO Problem Areas would not exist in any of the segments that were considered by the model.

DO Comparison - Galveston Bay System

Model Conditions 1990 BAT Low Flow Spring, Autumn 22°C With N

<u>Segment #</u>	<u>Standards¹</u>	<u>EHA Model²</u>	<u>Environmental Limits³</u>
1101	4.0	-	-
1102	5.0	-	-
1103	4.0	-	-
1104	5.0	-	-
1107	4.0	7.2 - 7.2	-
901	4.0	-	-
902	5.0	-	-
1001	4.0	-	-
1005	4.0	6.6 - 7.3	-
1006	2.0	3.5 - 6.5	-
1007	1.5	3.7*	-
2421	4.0	6.7 - 7.9	5.0
2422	4.0	7.9 - 8.0	5.0
2423	4.0	7.7 - 7.8	5.0
2424	4.0	7.1 - 7.3	5.0
2425	4.0	7.8**	-
2426	4.0	7.2 - 7.4	-
2427	4.0	6.8 - 7.0	-
2428	4.0	7.2 - 7.5	-
2429	4.0	6.6***	-
2430	4.0	5.4 - 5.7	-
2431	4.0	7.6 - 7.6	-
2432	4.0	7.0 - 7.2	-

1. Texas Water Quality Standards, TWQB, October, 1973.

2. Epsey-Huston & Associates, Inc., Model Runs, June, 1974.
The segments that are not considered on the model readout are denoted by dashes.

3. University of Texas Marine Science Institute - Proposed Environmental Limits For Galveston Bay, June 28, 1974.
The segments that are not given specific DO concentrations by MSI are denoted by dashes.

* This model does not include the section above the HSC Turning Basin in segment 1007.

** This model does not include the section above the Seabrook Channel in segment 2425.

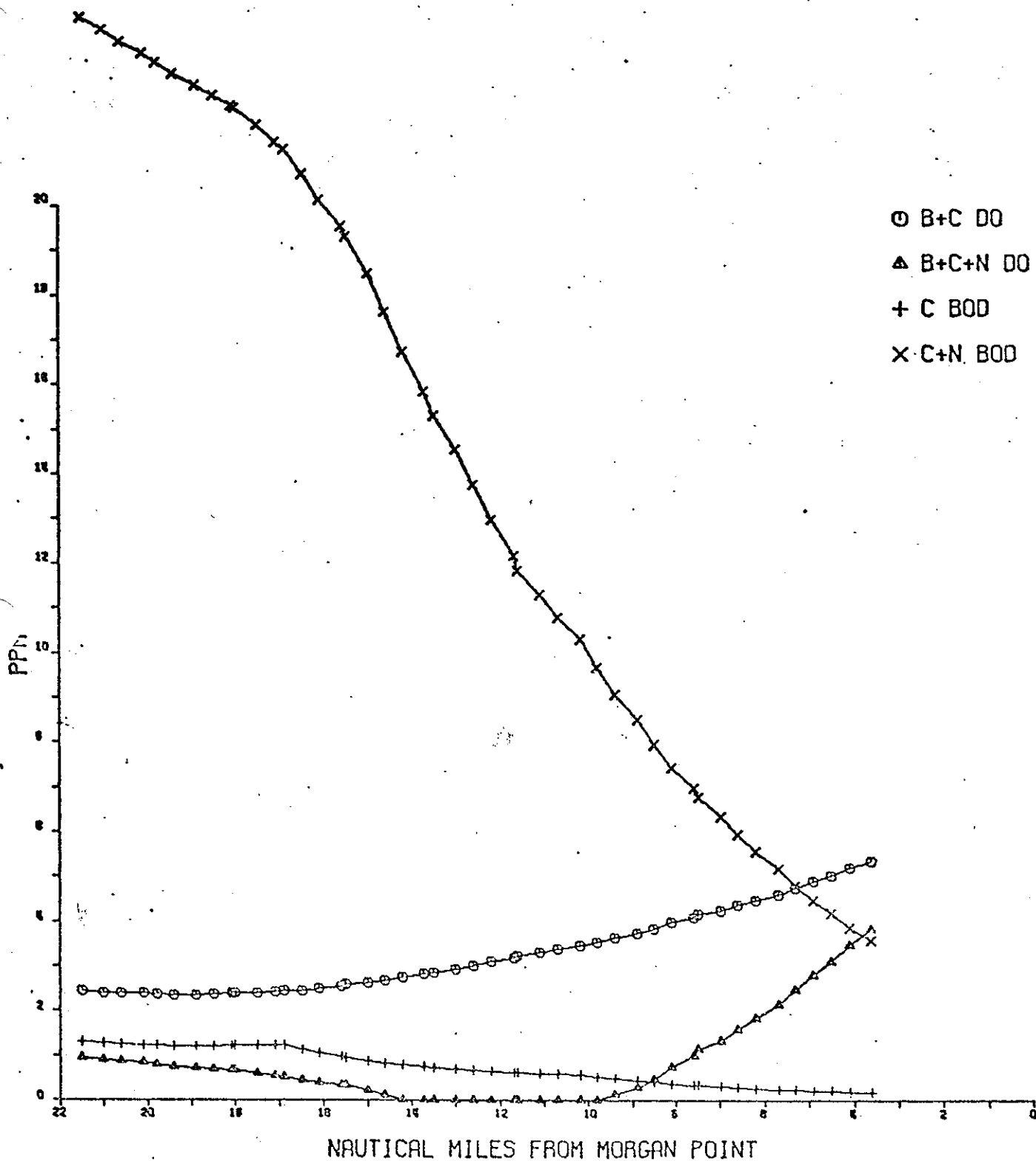
*** This model does not record more than one reading in the vicinity of Scott's Bay (segment 2429).

APPENDIX B

This Appendix contains the raw data for the following model loading conditions:

- 1.) Present Conditions, BPCT, Low Flow, with Nitrogenous Demand.
- 2.) Present Conditions, BAT, Low Flow, with Nitrogenous Demand.
- 3.) 1990 Conditions, BPCT, Low Flow, with Nitrogenous Demand.
- 4.) 1990 Conditions, BAT, Low Flow, with Nitrogenous Demand
- 5.) Present Conditions, BPCT, Low Flow, without Nitrogenous Demand.
- 6.) Present Conditions, BAT, Low Flow, without Nitrogenous Demand.
- 7.) 1990 Conditions, BPCT, Low Flow, without Nitrogenous Demand.
- 8.) 1990 Conditions, BAT, Low Flow, without Nitrogenous Demand.
- 9.) Present Conditions, BPCT, Normal Flow, with Nitrogenous Demand.
- 10.) Present Conditions, BAT, Normal Flow, with Nitrogenous Demand.
- 11.) 1990 Conditions, BPCT, Normal Flow, with Nitrogenous Demand
- 12.) 1990 Conditions, BAT, Normal Flow with Nitrogenous Demand.
- 13.) Present Conditions, BPCT, Normal Flow, without Nitrogenous Demand.
- 14.) Present Conditions, BAT, Normal Flow, without Nitrogenous Demand.
- 15.) 1990 Conditions, BPCT, Normal Flow, without Nitrogenous Demand.

- 16.) 1990 Conditions, BAT, Normal Flow, without Nitrogenous Demand.
- 17.) 1990 Conditions, BAT, Low Flow, 12°C, without Nitrogenous Demand.
- 18.) 1990 Conditions, BAT, Low Flow, 12°C, with Nitrogenous Demand.
- 19.) 1990 Conditions, BAT, Low Flow, 22°C, without Nitrogenous Demand
- 20.) 1990 Conditions, BAT, Low Flow, 22°C, with Nitrogenous Demand.



BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL BPCT PRESENT LOW FLOWS


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***** 6.4 6.4*****
***** 6.4 6.4 6.3*****
***** 6.3 6.3 6.3*****
***** 6.3 6.3 6.3*****
***** 6.3 6.3*****
***** 6.3 6.3 6.3*****
***** 6.3 6.3 6.3*****
***** 6.3 6.3 6.3*****
***** 6.3 6.3*****
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***** 6.3 8.3*****
***** 6.3 6.3 6.3 6.3***** 6.6*****

***** 6.3 6.3 6.3 6.3***** 6.5 6.5**** 6.5***** 6.6 6.6 6.6*****

***** 6.3 6.3 6.3 6.3 6.3 6.3 6.5 6.5***** 6.5 6.5 6.5***** 6.5 6.5 6.5 6.5 6.5*****
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***** 6.6 6.6 6.6 6.6 ***** 6.6 6.6 6.6 6.6 6.6 6.6 6.6 6.6 *****

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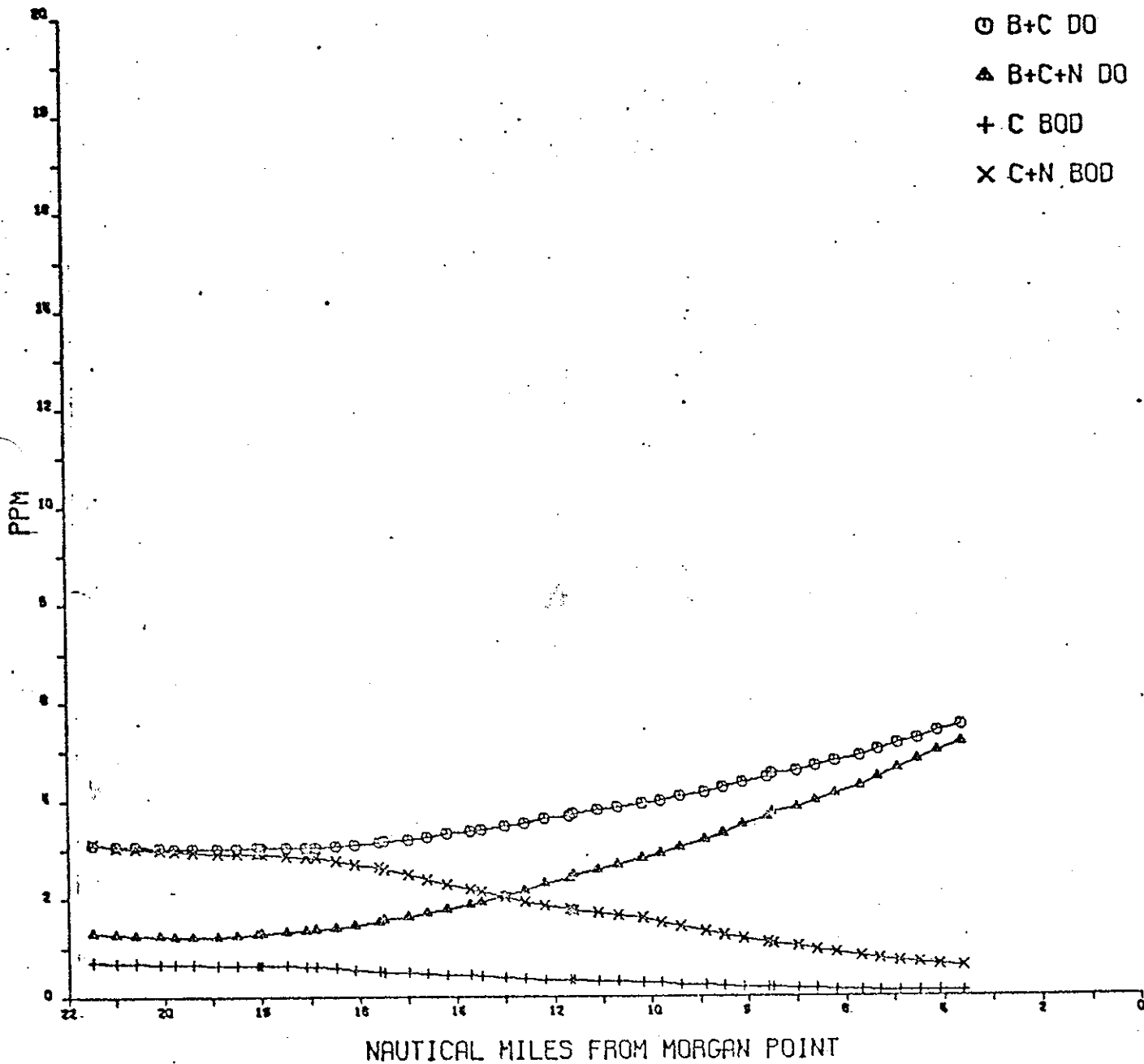
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4

***** 6.6 *****

***** 6.6 *****



BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL AT PRESENT LOW FLOWS

ESPEY, HUSTON & ASSOCIATES, INC.

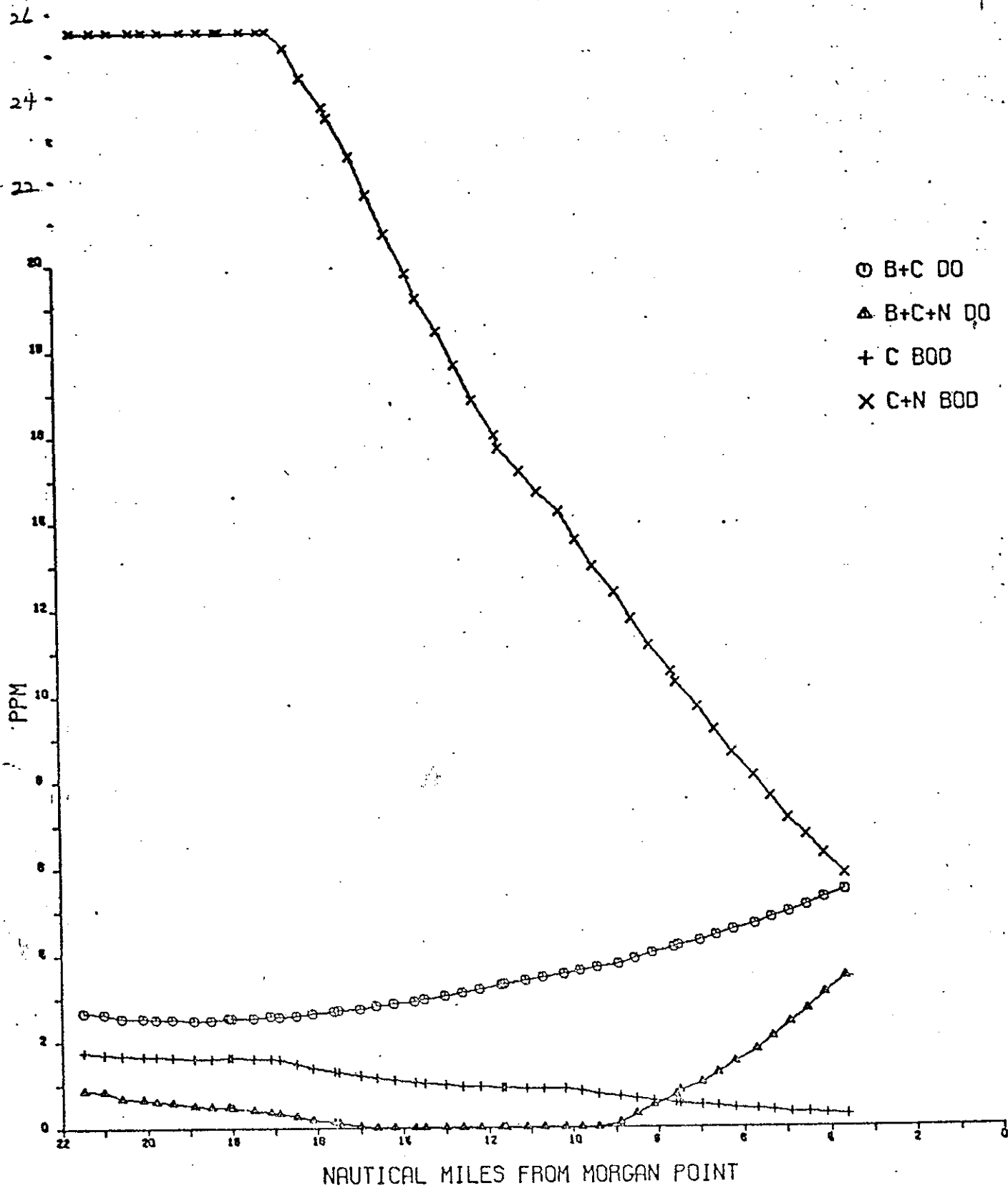
Environmental Consultants
500 WEST 16TH • AUSTIN, TEXAS 78701

Dissolved Oxygen
for
Load Set # 2
Present Condition - BAT
Low Flow
With Nitrogenous Demand

ESPEY, HUSTON & ASSOCIATES, INC.

Environmental Consultants
500 WEST 16TH • AUSTIN, TEXAS 78701

Dissolved Oxygen
for
Load Set # 6
Present Conditions - BAT
Low Flow
Without Nitrogenous Demand

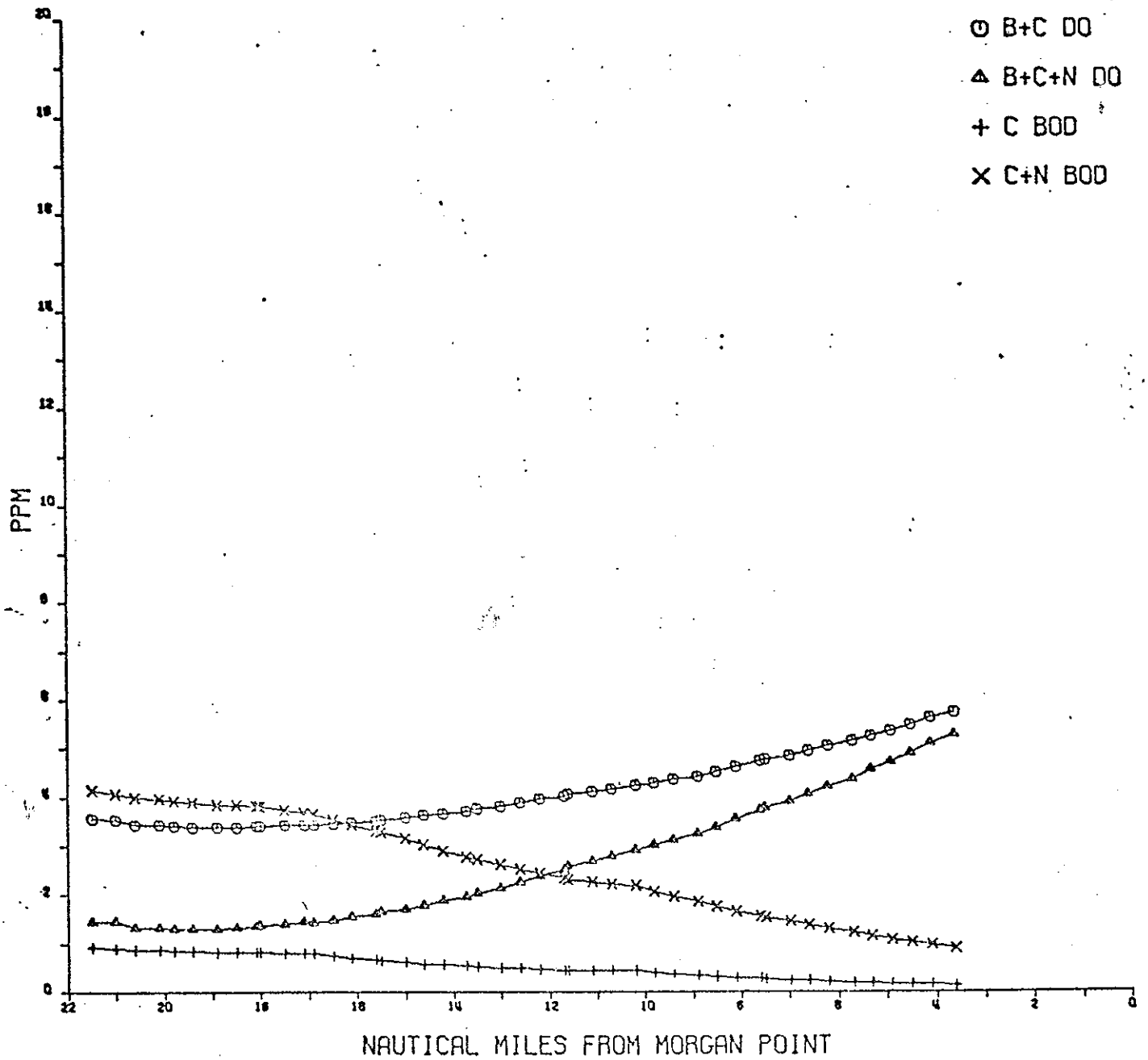


BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL 1990 BPCT LOW FLOWS

Dissolved Oxygen
for
Load Set # 3
1990 Conditions ~ BPCT
Low Flow
With Nitrogenous Demand

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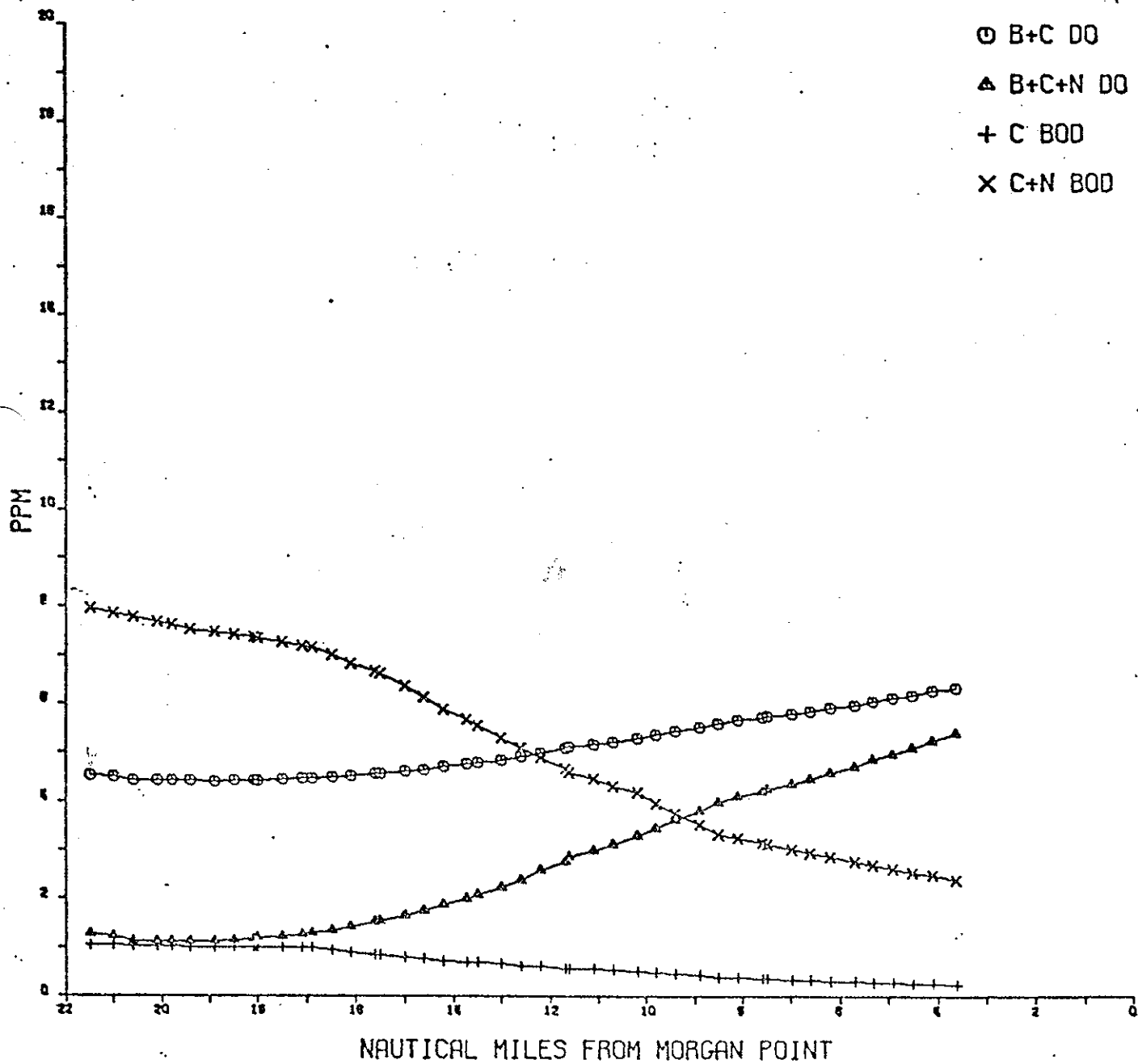
Load Set # 7
1990 Conditions - BPCT
Low Flow
Without Nitrogenous Demand



BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL 1990 BAT LOW FLOWS

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14

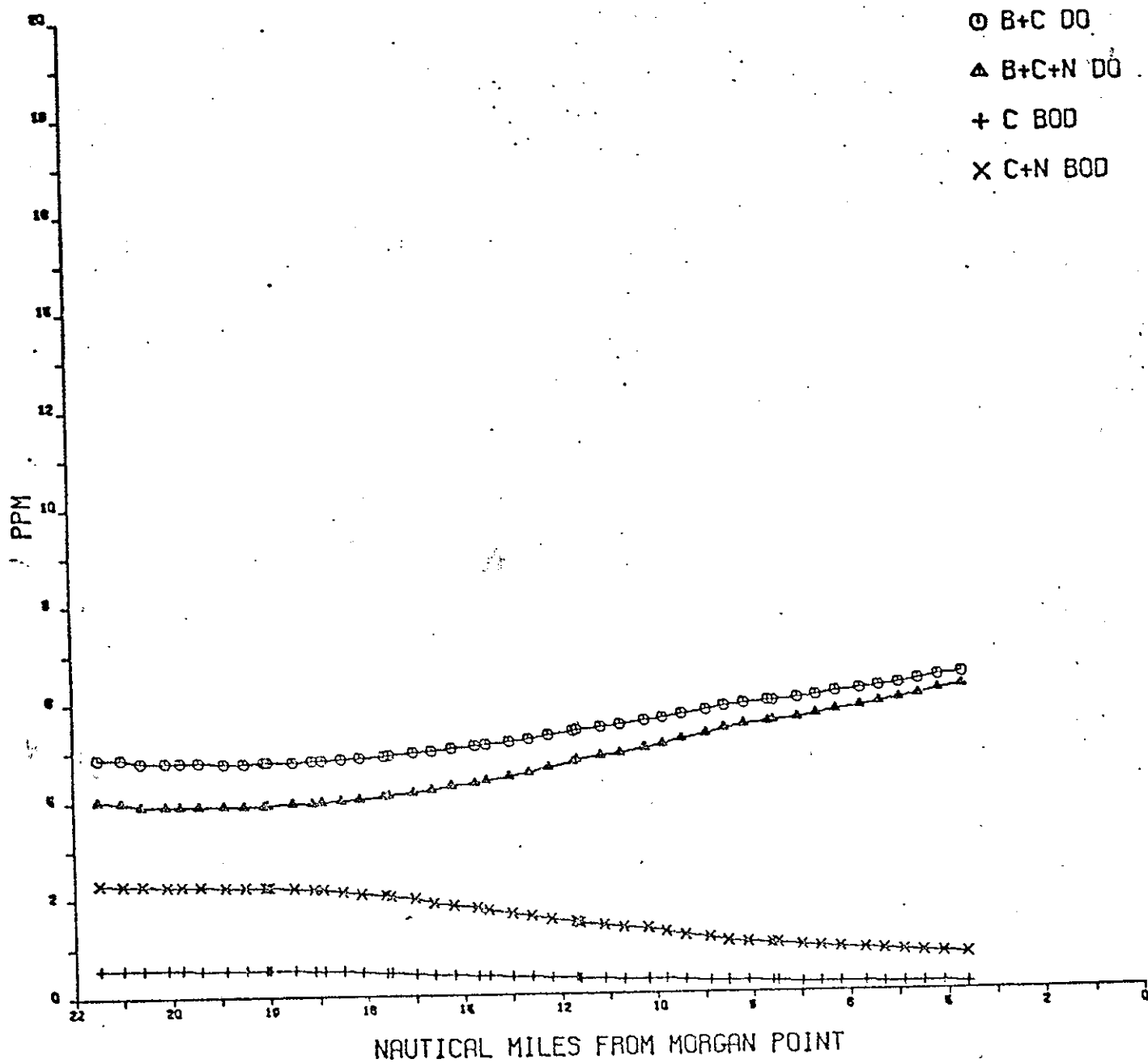


BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL BPCT PRESENT NORMAL FLOWS

[illegible]

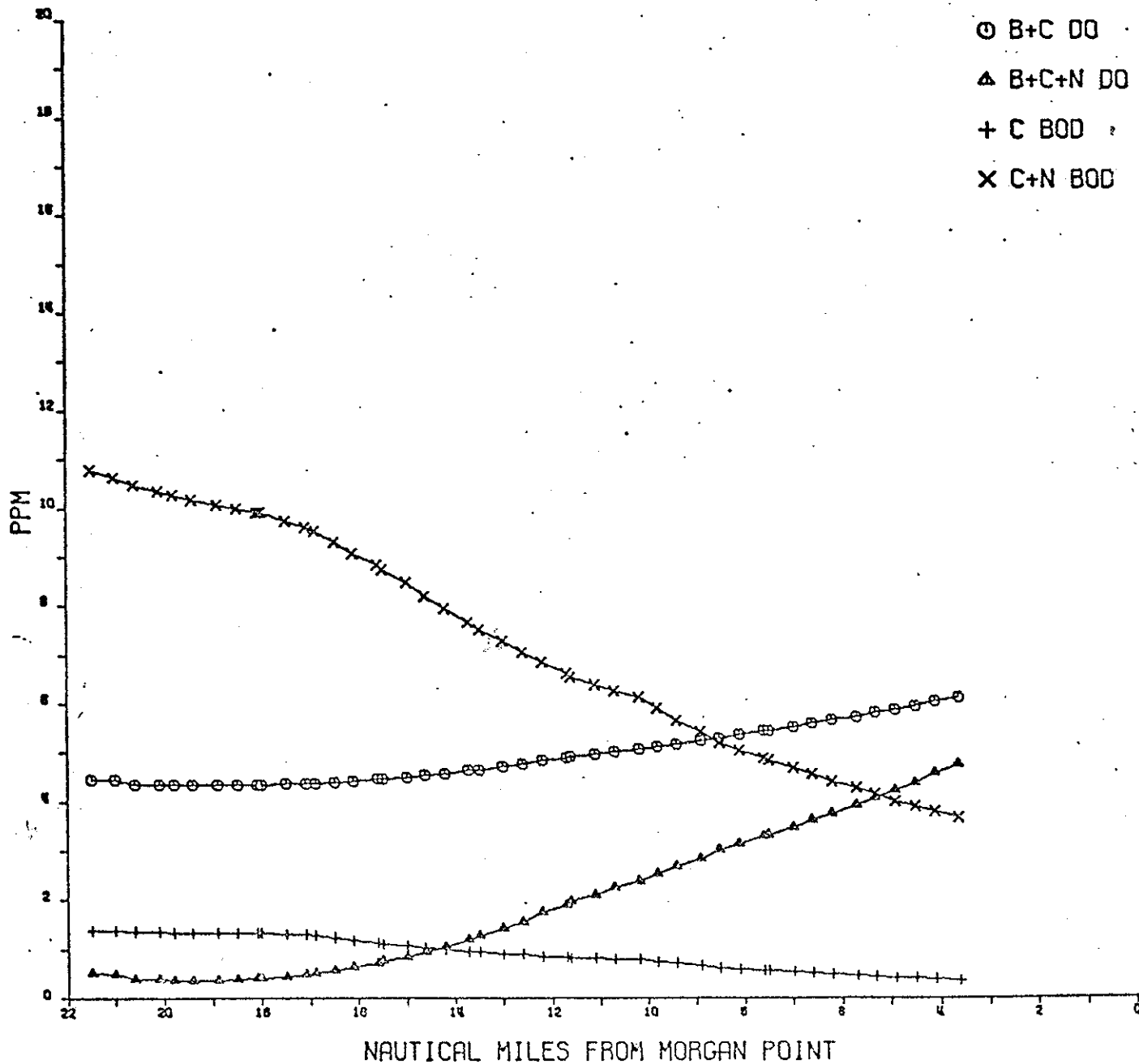
Dissolved Oxygen
for
Load Set # 13
Present Conditions - BPCT
Normal Flow
Without Nitrogenous Demand

17



BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL BAT PRESENT NORMAL FLOWS

[illegible]



BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL 1990 BPCT NORMAL FLOWS

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Dissolved Oxygen

for

Load Set # 11

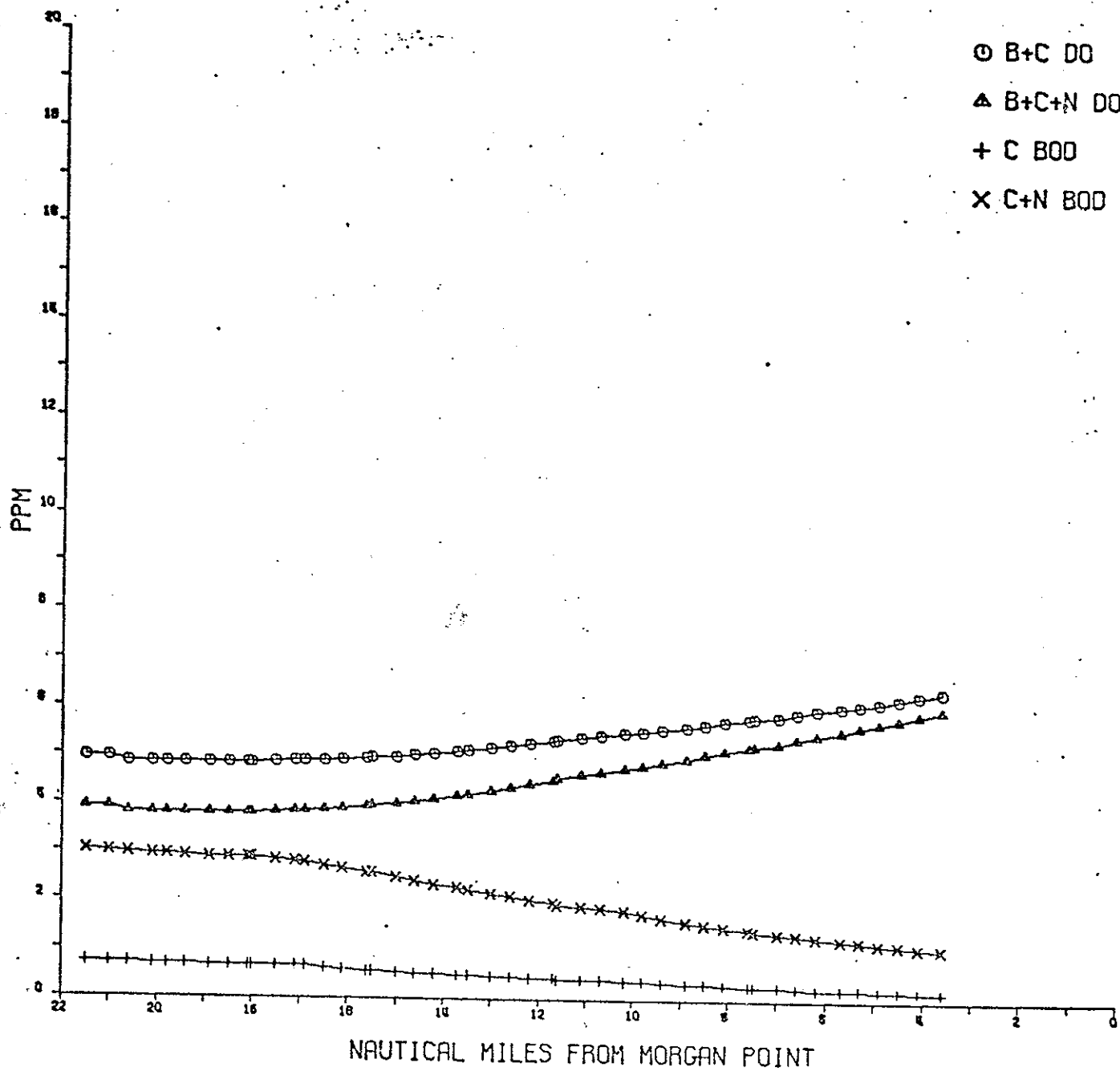
1990 Conditions - BPCT

Normal Flow

With Nitrogenous Demand

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Environmental Consultants
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Dissolved Oxygen
for
Load Set # 15
1990 Conditions - BPCT
Normal Flow
Without Nitrogenous Demand



BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL 1990 BAT NORMAL FLOWS

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Dissolved Oxygen

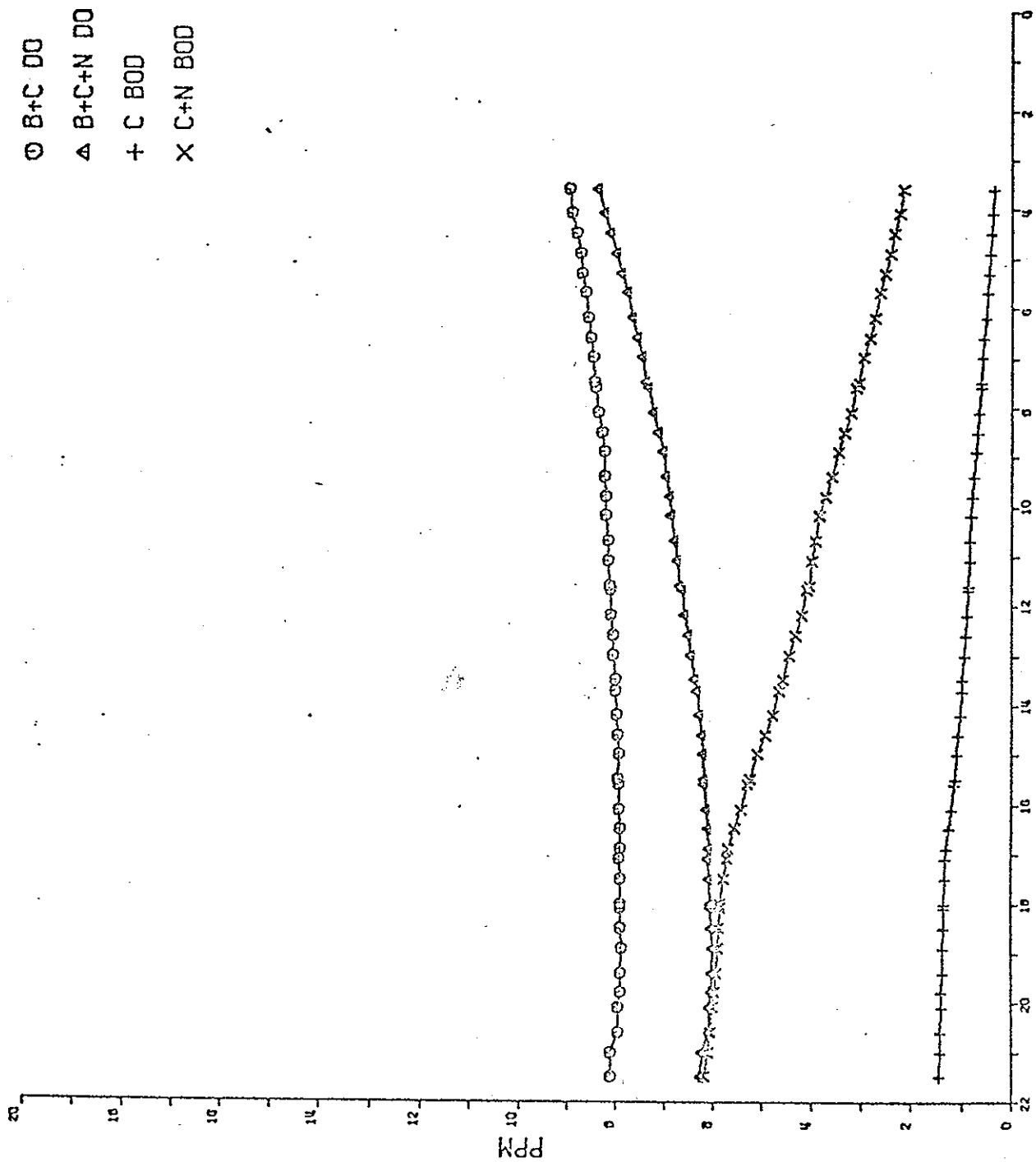
for

Load Set # 12

1990 Conditions - BAT

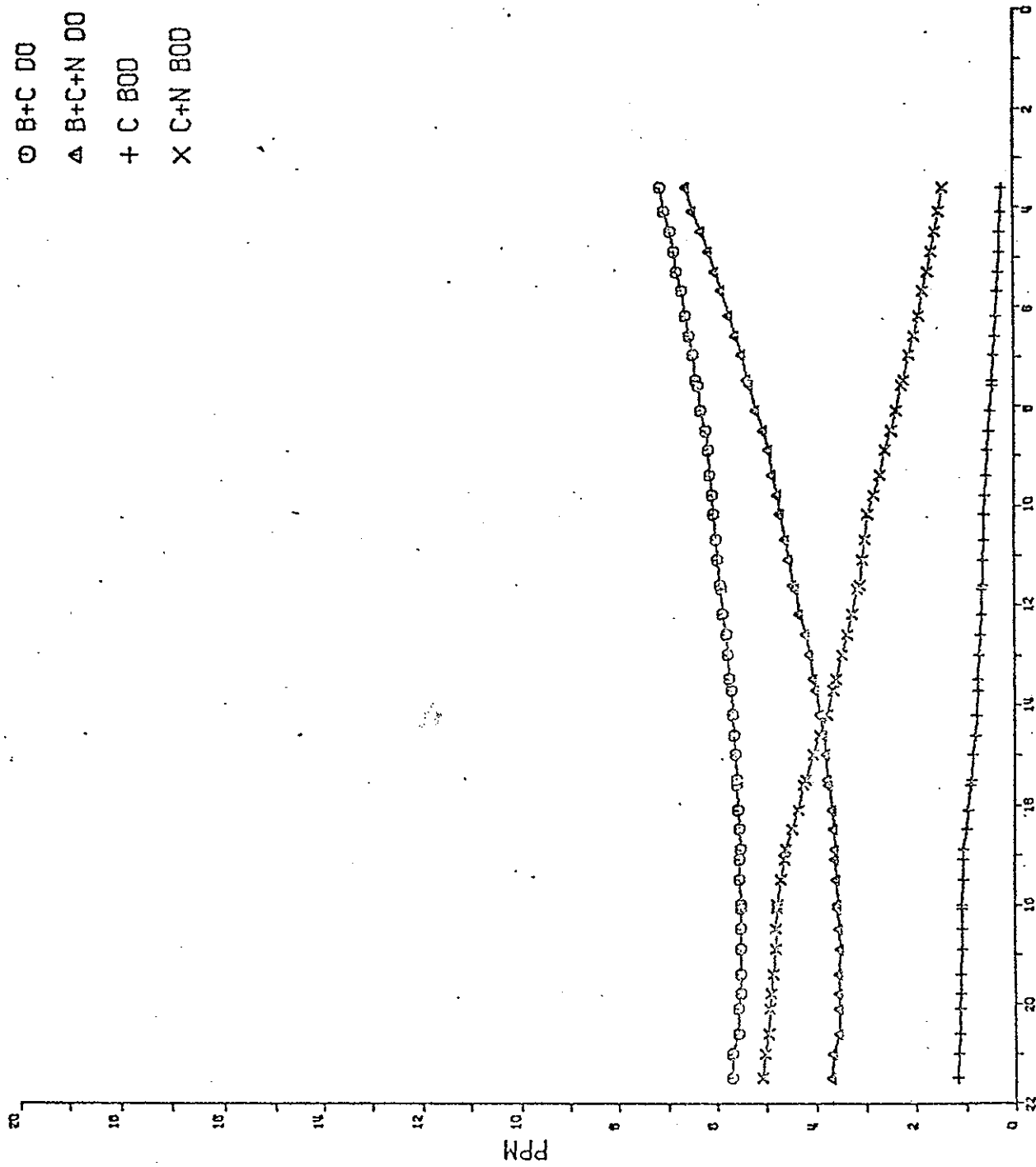
Normal Flow

With Nitrogenous Demand



NAUTICAL MILES FROM MORGAN POINT

BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL BAT 1990 LOW FLOW (12 C)



NAUTICAL MILES FROM MORGAN POINT

BOD AND DO PROFILES FOR THE HOUSTON SHIP CHANNEL BAT 1990 LOW FLOW (22 C)

ESPEY, HUSTON & ASSOCIATES, INC.
Environmental Consultants
500 WEST 16TH • AUSTIN, TEXAS 78701

1990 BAT Loading
Low Flow
Spring, Autumn Temperature (22 C)
Dissolved Oxygen
(w/o Nitrogenous)

