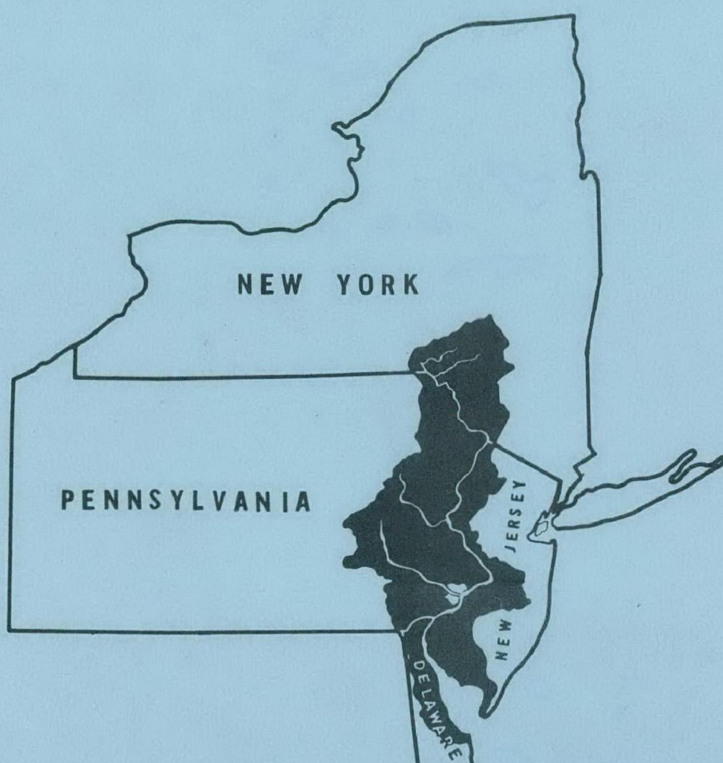
THE EFFECT OF CHANNEL DREDGING ON WATER QUALITY IN THE DELAWARE ESTUARY



DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMININISTRATION
NEW YORK, NEW YORK

MAY 1966

I. INTRODUCTION

Request

This study was requested by the District Engineer, U. S. Army Engineer District, Philadelphia, Pennsylvania, by letter dated June 30, 1965. The letter requested that the Public Health Service* study the effect of widening and deepening the navigation channel on salinity in the Delaware Estuary.

Purpose and Scope

The purpose of this study is to determine the effect of several dredging schemes for widening and deepening the navigation channel from Philadelphia, Pa. to the sea on salinity in the estuary. In addition, the effect of channel dredging on dissolved oxygen has been investigated since this parameter is of utmost importance in present and future pollution abatement studies. The area of detailed study is limited to the main stem of the Delaware River between Liston Point, Delaware and Trenton, N. J., since the effect on the Delaware Bay is considered to be negligible and the tidal influence ends at the Trenton rapids.

This study was carried out concurrently with the Delaware Estuary Comprehensive Study and the Water Quality Control Study, Tocks Island

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*Water pollution control activities of the Public Health Service were assigned to the Federal Water Pollution Control Administration by the Water Quality Control Act of 1965 (PL 89-234)

Reservoir, Delaware River Basin. Much of the data used in this report was developed in connection with these other studies, and the reports on these projects should be consulted for more detailed information.

Five schemes for improving the channel from Philadelphia to the sea were studied. These schemes are as follows:

a) increase channel depth to 45 feet, maintain present width.

b) increase channel depth to 45 feet, maintain present width, add anchorage improvements.

c) increase channel depth to 50 feet, maintain present width.

d) increase channel depth to 50 feet, maintain present width, add anchorage improvements.

e) increase channel depth to 50 feet, widen channel, add anchorage improvements.

II. FINDINGS AND CONCLUSIONS

1. The following three dredging schemes would have little or no effect on the chlorides concentration in the estuary: a) the 45 foot deep channel, b) the 45 foot deep channel including proposed anchorage improvements, and c) the 50 foot deep channel.

2. The 50 foot channel including anchorage improvements would result in an increase in the chloride concentration at the intake to Philadelphia's Torresdale Water Treatment Plant (Section 7 in Figure 1)

to greater than 50 ppm in late autumn with present assured flows. Based on the added flow necessary to maintain the average chloride concentration at mile 80 (Section 18 in Figure 1) at or below 250 ppm compared to present channel depths, the 50 foot channel and anchorages would result in a damage to water quality of approximately $900,000/year.

3. A fifty foot deep channel with the proposed anchorage improvements plus widening the channel to proposed dimensions would increase the chloride concentration at the Torresdale intake to approximately 85 ppm in late fall with present assured flows. Based on the cost of providing the added flow required to maintain the chloride concentration at mile 80 (Section 18) at or below 250 ppm, as compared to the present channel, this channel would result in damages of approximately $1,300,000/year.

4. A 45 foot deep channel would cause a small decrease in the dissolved oxygen concentration in the estuary equivalent to the addition of a waste load of 214,000 population equivalents. As a measure of the damages this would cause, secondary treatment to remove a load of this magnitude would cost approximately $650,000/year based on a 20-year economic life, an interest rate of 3-1/8%, and including operation and maintenance costs.

5. A 50 foot deep channel would have a larger effect on the dissolved oxygen, increasing the deficit by about 13%. This effect is equivalent to an additional 428,000 population equivalents. A load

this size would cost approximately $1,150,000/year to remove, based on a 20 year economic life, an interest rate of 3-1/8%, and including operation and maintenance costs.

6. Because of a lack of information on available spoils deposition areas, all of the calculations on which the above conclusions were based contained the assumption that the dredging spoils would be removed entirely from the river. It may be possible through careful choice of deposition areas that the salinity intrusion might be somewhat reduced. As indicated, greater channel deepening will cause larger increases on the salinity intrusion and correspondingly greater damages; thus, efforts to plan spoils disposal areas to minimize this intrusion could reduce the damages. However, it is important that organic sludge which is to be found in many areas of the river bottom not be redeposited in the river. Because of the high oxygen demand that this material would exhibit when dispersed in the water, care should be taken at the disposal site so that there is no chance of drainage back to the river.

7. The dredging operations should be carried out at times of low temperatures so that the effects of increased turbidity and disruption of organic deposits that inevitably occur will be minimized.

8. Disposal areas in Delaware Bay should be selected so that oyster beds are not damaged by silting.

III. NAVIGATION IMPROVEMENTS PROPOSED

The Delaware River presently has a navigation channel maintained by the Corps of Engineers at a nominal depth of 40 feet from the sea to Philadelphia, Pa., (Section 10) and a nominal depth of 30 feet from Philadelphia, Pa. to Trenton, New Jersey.

Five different dredging schemes for improving the navigation channel to Philadelphia have been proposed. All five configurations were used for the evaluation of the effects on salinity, as follows:

a. 45 foot channel - This configuration assumes an increase nominal depth of channel from Philadelphia to the sea of 5 feet, with no other changes.

b. 45 foot channel with anchorages - This configuration assumes an increase in nominal depth of 5 feet in the channel as well as in the present anchorages. In addition, anchorages at Reedy Pt., Pea Patch Island, Cherry Island, Marcus Hook, and Hog Island would be added or enlarged to proposed dimensions.

c. 50 foot channel - This configuration assumes an increase in the nominal depth of the channel of 10 feet, with no other changes.

d. 50 foot channel with anchorages - This configuration assumes an increase in nominal depth of 10 feet in the channel and present anchorages. In addition, the new or enlarged anchorages cited in configuration b) would be incorporated.

e. Optimum channel - This configuration assumes that all modifications made in configuration d) would be incorporated as well as widening the channel to the proposed new dimensions.

IV. METHOD OF ANALYSIS

A time varying model of the estuary was used for evaluating the changes in salinity in the estuary. The flow regime for the last half of the 1964 record at Trenton, which has a recurrence interval of about fifty years, was used as a basis for analysis. The conclusions on the dissolved oxygen effects are based on investigation of configurations, a) and c), above. These investigations used a steady state flow approximation of 3300 cfs which is approximately equal to a 90 day average summer flow with a recurrence interval of 3 years, and is in the order of the assured flow expected with presently proposed development.

V. RESULTS

The effect on D.O. is primarily due to a decrease in reaeration rate which is considered to be inversely proportional to the average depth. Therefore, the configurations which have larger average depths associated with them, result in increased deficits.

The steady state solution for the effect of Configuration a) showed that in the area between Section 7 and Section 12, the dissolved oxygen deficit was increased by an average of .1 ppm. An increase in deficit of .2 ppm was seen from Section 12 to Section 18 with the effect tapering off to zero between there and Section 29. This represents an overall increase in D.O. depletion of about 6%. The actual magnitude of change is not great but it is equivalent to an increase in BOD load of about 214,000 population equivalents which would cost approximately $650,000/year to remove by treatment in a secondary plant based on a 20 year economic life, an interest rate of 3-1/8%, and including operation and maintenance costs.

Configuration c) gave effects that were almost exactly double those under configuration a) at each point along the estuary. The dissolved oxygen deficit was increased by .2 ppm from Section 7 to Section 12, and by .4 ppm from there to Section 18, an overall increase of 13%. This increase is equivalent to the effect of an additional 428,000 population equivalents which would cost approximately $1,150,000/year to remove by treatment.

The effect on salinity is primarily due to an increase in the eddy exchange coefficient and a decrease in the net velocity brought about an increase in the cross-sectional area of the river.

The salinity study, accomplished on a time varying, digital computer model, yielded the following results with the percentage change at any one point on the estuary remaining essentially constant throughout the year:

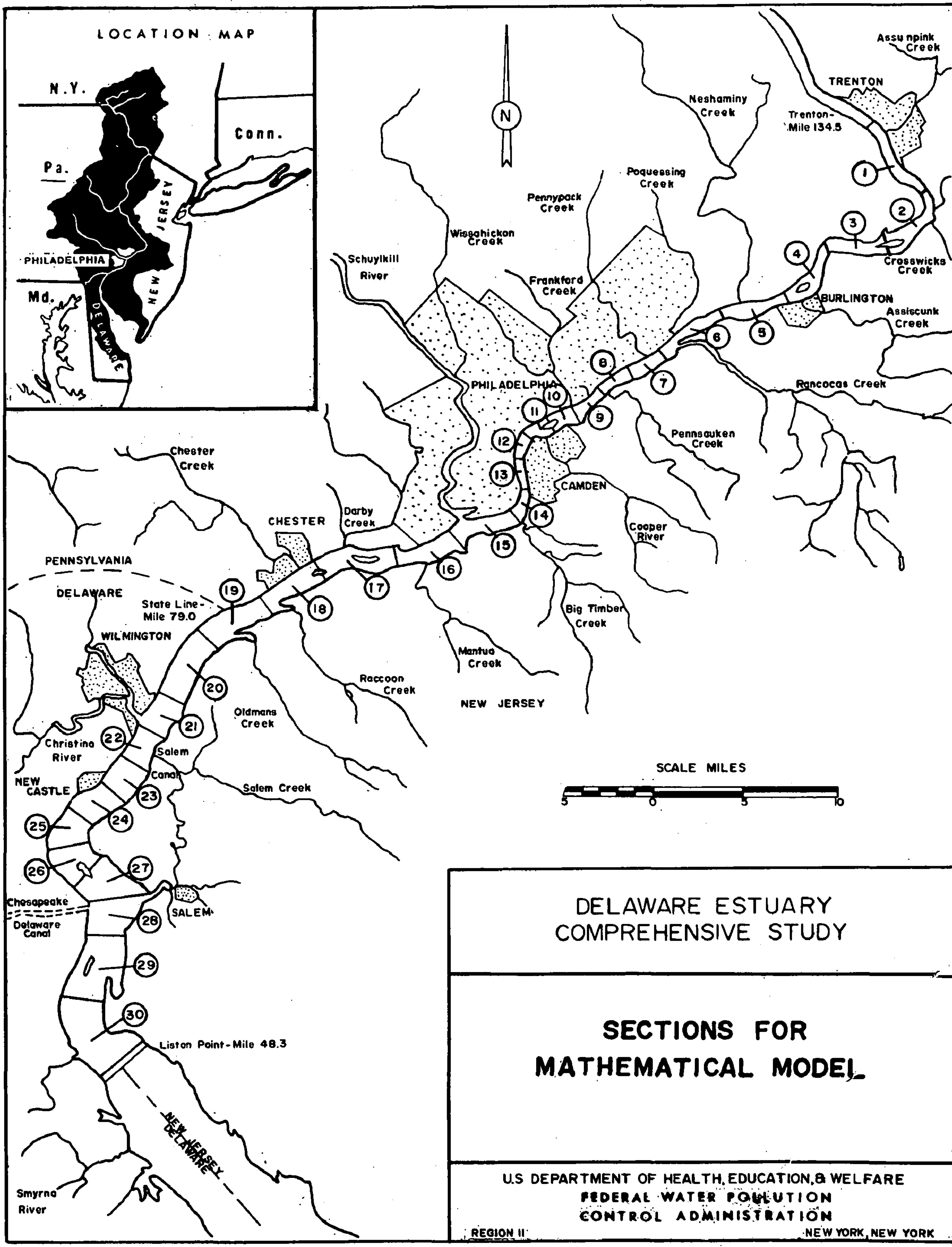
Configuration a) showed an increase in chlorides of about 14% from Section 1 to Section 10. The actual magnitude of chloride concentration in this region is relatively small so the effect is not as large as might be presumed from the percentage change. As the magnitude of the chlorides rose from Section 10 to Section 19, the percentage change dropped from 12% to about 3%. Below Section 19, the change in chlorides amounted to about 2%.

Configuration b) and c) were very similar with an increase of about 25% in chloride concentration from Section 1 to Section 10, decreasing from there to about 5% at Section 19. The river below Section 19 showed a 4% increase in chlorides.

In Configuration d) the chlorides between Section 1 and Section 10 were increased by almost 50%, dropped to 6% at Section 19. This increase was sufficient to yield an average chloride concentration in excess of 50 ppm at the Philadelphia water intake (Section 7) in late Autumn. In order to maintain the average chloride level at mile 80 (Section 18), at 250 ppm, an increase of about 400 cfs at Trenton over the present requirement of 6200 cfs would be necessary. In order to supply this additional flow, it was calculated that a single purpose dam would require an added draft on storage of 133,000 acre feet. Using an economic life of 50 years and 3-1/8% interest, the annual added cost for this additional storage would be $900,000/year including operation and maintenance. The damages which would result from allowing intrusion past Chester based on some recent benefit surveys carried out by the DECS in connection with the Tocks Island report would be $471,500/year to the industries and municipalities between Chester and Philadelphia.

The added cost to maintain the 250 ppm average chloride level at the mouth of the Schuylkill River would be approximately the same.

Configuration e) yielded an increase of approximately 90% in the estuary above Section 10. The increase in chlorides below Section 10 drops to 25% at Section 19 and zero at Section 29. At the Torresdale intake, the average chloride concentration in lage Autumn in increased to approximately 85 ppm. An additional flow of 600 cfs above the present requirement of 6200 cfs at Trenton would be required to maintain the average chlorides at mile 80 (Section 18) at 250 ppm. The additional cost to provide the necessary 250,000 acre feet added annual draft on storage for a single purpose reservoir would be approximately $1,300,000/year. The quantifiable portion of the damages due to the loss of water use benefits to the industries and municipalities between Philadelphia and Chester would be $671,500/year.



DELAWARE ESTUARY COMPREHENSIVE STUDY

SECTIONS FOR MATHEMATICAL MODEL

U.S DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
REGION II — NEW YORK, NEW YORK