1957 SURVEY OF ARTHUR KILL WATERS

INTERSTATE SANITATION COMMISSION

New York

New Jersey

Connecticut

1957 SURVEY OF ARTHUR KILL WATERS*

*Excerpted from
1958 Annual Report
of the
Interstate Sanitation Commission

SURVEY OF ARTHUR KILL WATERS

GENERAL

The Arthur Kill is an interstate waterway and a partial boundary between the States of New York and New Jersey, separating Richmond County in New York State from Union and Middlesex Counties in the State of New Jersey. It is a tidal stream approximately thirteen miles in length and averages roughly one half mile in width.

In recent years, the Arthur Kill has become one of the busiest waterways in the Metropolitan Area. This has been brought about primarily by concentration and further development of the chemical and petroleum industries. There has been increased industrial activity and expansion, and our industrial waste survey reflects the potentiality of the area as a source of present and future pollution. The industrial areas bordering the Arthur Kill are in general lightly populated by residential groups; however large amounts of domestic wastes are now brought into treatment plants in this area by trunk sewers from inland communities. After treatment these plants discharge into the Arthur Kill. In view of reported degradation of the Arthur Kill by different investigators, the Interstate Sanitation Commission planned and conducted an intensive five week survey of these waters to determine accurately the conditions existing throughout the length of the Kill.

PROCEDURE

The map on the following page, "Arthur Kill Survey Sampling Stations", shows the entire Arthur Kill waterway and the eighteen sampling stations used. (A description of each sampling station is also included on Pages 3 and 4.)


NORTH
STATEN ISLAND
ARTHUR KILL
Port Reading
Tottenville
Kreischerville
Rossville
Smoking Pt.
Fresh Kills
Bloomfield
Chelsea
Travis
Rahway R.
Tremley Pt.
Carteret
Sewaren
Great Kills
Eltingville
Annadale
Huguenot Beach
Princess Bay
Pleasant Plains
Richmond Valley
Red Bank
Arlington
Port Richmond
Elizabethport
STATEN ISLAND F 251H
GREAT KILLS HARBOR CHANNEL
Depth of 10 feet was available for width of 120 feet May 1954.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
ARTHUR KILL SURVEY
SAMPLING STATIONS
0
1
NAUTICAL MILE
INTERSTATE SANITATION COMMISSION
NEW YORK NEW JERSEY CONNECTICUT
1957
Authorized reproduction of U.S.C.&G.S. Map.
Not for use in navigation.
BOUNDARY BEACON

The Commission had classified, after public hearings, the waters from Raritan Bay up to the Outerbridge Crossing, which is just north of sampling station #17, as Class "A", and the remainder of the waterway from the Outerbridge Crossing to Newark Bay as Class "B". The Compact of the Interstate Sanitation Commission requires that in Class "A" waters an average dissolved oxygen content be maintained in the waters, at a depth of about 5 feet below the surface, of not less than fifty percent (50%) saturation during any week of the year, and in Class "B" waters not less than thirty percent (30%) saturation during any week of the year. Previous work done by this Commission indicated that there was no evidence of horizontal or vertical stratification at any particular cross section. All samples, during the five week survey, were taken at a depth of 5 feet below the surface using a Foerst Water Sampler.

Two boats were used in this survey with each covering approximately one half of the waterway. Over 900 samples were taken in the survey with time of observation, dissolved oxygen, chlorides, pH and temperature being determined on each sample. The temperature and dissolved oxygen determinations were made aboard the boats. All pH and chloride determinations were made in the Commission's laboratory.

ANALYSIS OF DATA

This survey was started on June 17, 1957 and terminated on July 18, 1957. There were 18 stations which were spaced throughout the length of the Kill. Each station was sampled three times a day and four days a week for five weeks.

There were 50 samples or more taken at each of the 18 stations. Chlorides, temperature, pH and dissolved oxygen determinations were made on each of these samples. The percent saturation of dissolved oxygen was then calculated for each of the samples and plotted as a graph of Percent Saturation vs. Degrees.

DESCRIPTION OF SAMPLING STATIONS
in the
ARTHUR KILL SURVEY

STATION #1	Intersection of center of channel in the Elizabethport Reach and the Elizabeth Ferry course which runs from Howland Hook to Elizabethport.
STATION #2	At center of the mouth of the Elizabeth River and the west side of channel in the Elizabethport Reach.
STATION #3	At center of and on the north side of the Baltimore & Ohio Railroad Bridge.
STATION #4	Mid-channel in the Gulfport Reach and midway between Morse and Piles Creek.
STATION #5	Pralls Island Reach, at mid-channel, directly opposite the north bank of the mouth of Pralls Creek.
STATION #6	Middle of channel and directly opposite the Black Can Buoy #25. This is also opposite Pralls Island.
STATION #7	Middle of mouth of the Rahway River and in line with the shore line along Tremley Reach.
STATION #8	In mid-channel and directly opposite the Flashing Green, Black Buoy #19.
STATION #9	Opposite Carteret in the center of Fresh Kills Reach and 200 yards south of the ferry run.
STATION #10	In the center of the Fresh Kills Reach and opposite the center of the mouth of the Great Fresh Kills.

STATION #11 In mid-channel and directly opposite the Quick Flashing Red Buoy #18. Also, it is north of Rossville.

STATION #12 In mid-channel directly opposite the Flashing Red Buoy #16.

STATION #13 In mid-channel between Flashing Red Buoy #12 and Flashing Green, Black Buoy #11.

STATION #14 At the west edge of channel in the Port Socony Reach and opposite the center of the mouth of Smith Creek.

STATION #15 At the confluence of Woodbridge Creek and Port Socony Reach. The point is halfway between center of the mouth of the Creek and the west side of the channel.

STATION #16 In mid-channel and directly opposite the Flashing Red Buoy #4.

STATION #17 In mid-channel directly opposite Flashing Red Buoy #2.

STATION #18 Mid-channel of Ward Point Bend (west) and opposite Perth Amboy ferry slip.

The variation of the observed percent saturation values during a current cycle and for a particular station was best described by a sinusoidal curve for some stations but as a straight line of best fit for others.

The curves or lines of best fit are determined by the method of "least squares" and a regression analysis is made to determine the significance of these lines of best fit. A discussion of the mathematics used in the derivation of equations and analysis of data are included as Appendix B in the 1958 Annual Report.

DISCUSSION

General

The survey of the Arthur Kill waters was an intensive sampling program from which the Interstate Sanitation Commission hoped to determine the actual conditions of these waters during the hot summer season. The Commission would then have positive data upon which further studies and recommendations could be based.

The Arthur Kill is a tidal waterway which joins the Raritan Bay on the south and Newark Bay on the north. Due to this tidal influence the percent saturation values were found to vary depending on the particular stage of the ebbing or flooding current which happened to be sampled. When the Raritan Bay is flooding, its waters flow northerly into the Arthur Kill. These waters were higher in dissolved oxygen than those of the Kill and resulted in raising the dissolved oxygen content at most of the stations within the influence of the flood phase of the cycle. When the Raritan Bay is ebbing, the waters in the Arthur Kill flow southerly into the Raritan Bay. With the flow going in this direction, some of the waters from Newark Bay were drawn into the Arthur Kill.

Table I on the following page shows the observed weighted mean percent saturation of

Table I

WEIGHTED MEAN PERCENT SATURATION OF DISSOLVED OXYGEN

STATION	WEIGHTED MEAN % SATURATION
1	31.2
2	29.3*
3	27.6
4	22.0
5	16.7
6	13.7
7	6.5
8	11.3
9	16.8
10	21.7
11	23.2
12	28.3
13	36.7
14	44.0
15	37.5*
16	53.0
17	58.3
18	65.6

* Values not used in % Saturation Profiles

dissolved oxygen for each of the 18 sampling stations during the five week period for a complete tidal cycle including both ebb and flood. These are determined as explained in the preceding section. Plate I shows a mean percent saturation (of dissolved oxygen) profile of the Arthur Kill. The horizontal scale has the sampling stations running from #1 through #18. The red line shows the Compact requirements of 30% of saturation in Class "B" and 50% in Class "A" waters. The black line shows the variation of the percent saturation throughout the Kill during the survey period. The values of Stations #2 and #15 are not plotted on the percent saturation profile since they are not representative of the principal tidal movement of the Kill. This is due to the fact that they were not located in the Channel of the Kill (see description of stations). It is highly significant to notice how the black line curve slopes downward from both sides toward Station #7. The dissolved oxygen content falls below the Interstate Sanitation Commission Compact requirements starting at a point between Stations #2 and #3 and it continues to drop to a minimum of 6.5% at Station #7. It starts to rise again and continues to rise until Compact requirements are met again at a point between Stations #12 and #13. There is, therefore, a section in Class "B" waters about 6.4 miles in length where the mean percent saturation drops below the 30% minimum for Compact requirements. The mean of 50% saturation for the section of Class "A" waters was met.

Ebb Current Phase

Plate II shows the observed hourly variations of percent saturation of dissolved oxygen during the ebb current phase. The dashed line marked "O" indicates approximately the conditions prevailing in the Arthur Kill when the ebbing current has just started at each of the stations. The dashed line marked "1" shows the conditions existing one hour later. The dashed line marked "2" shows the conditions two hours later and so

WEIGHTED MEAN PERCENT SATURATION OF DISSOLVED OXYGEN

1957 ARTHUR KILL SURVEY

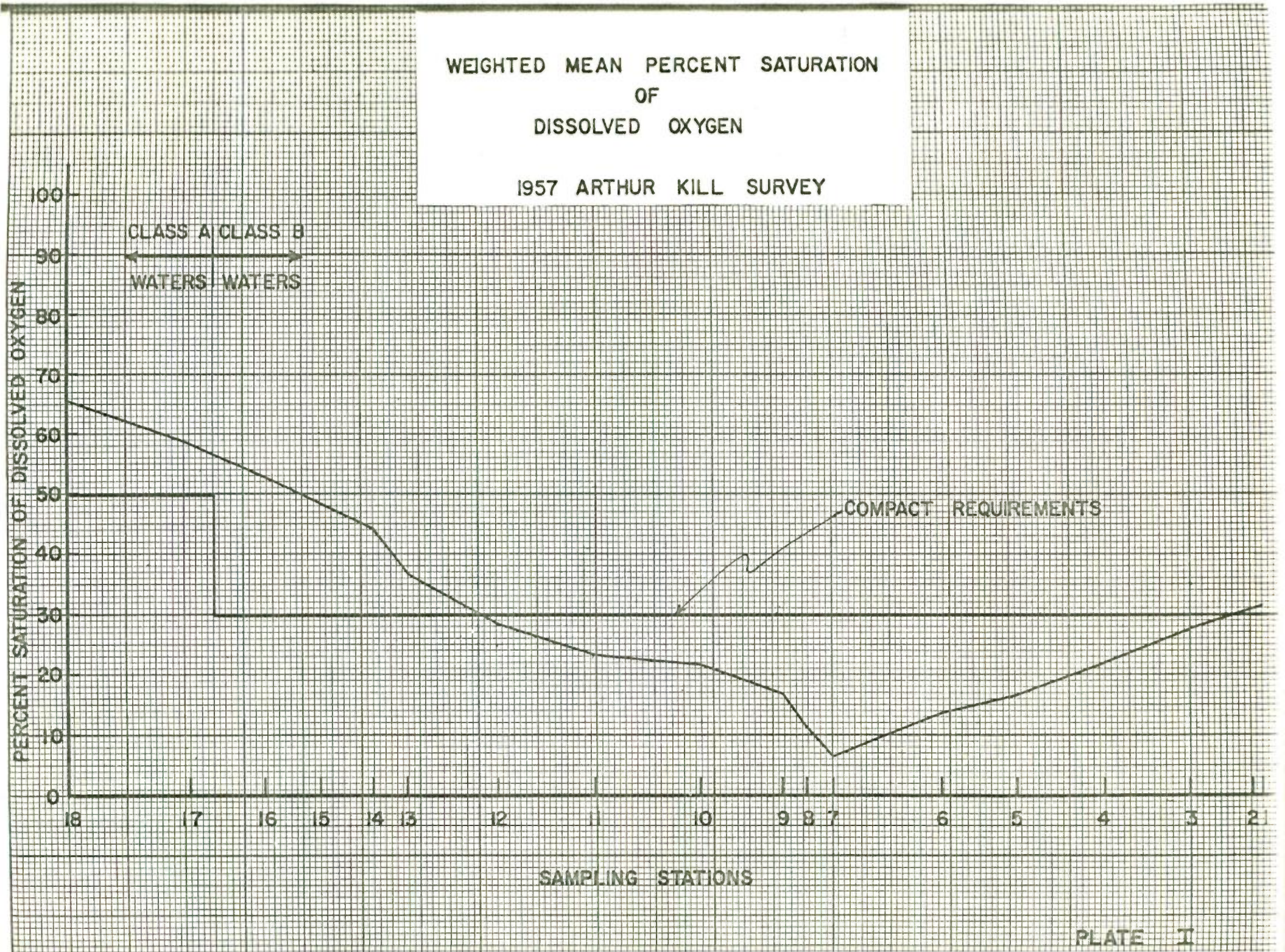
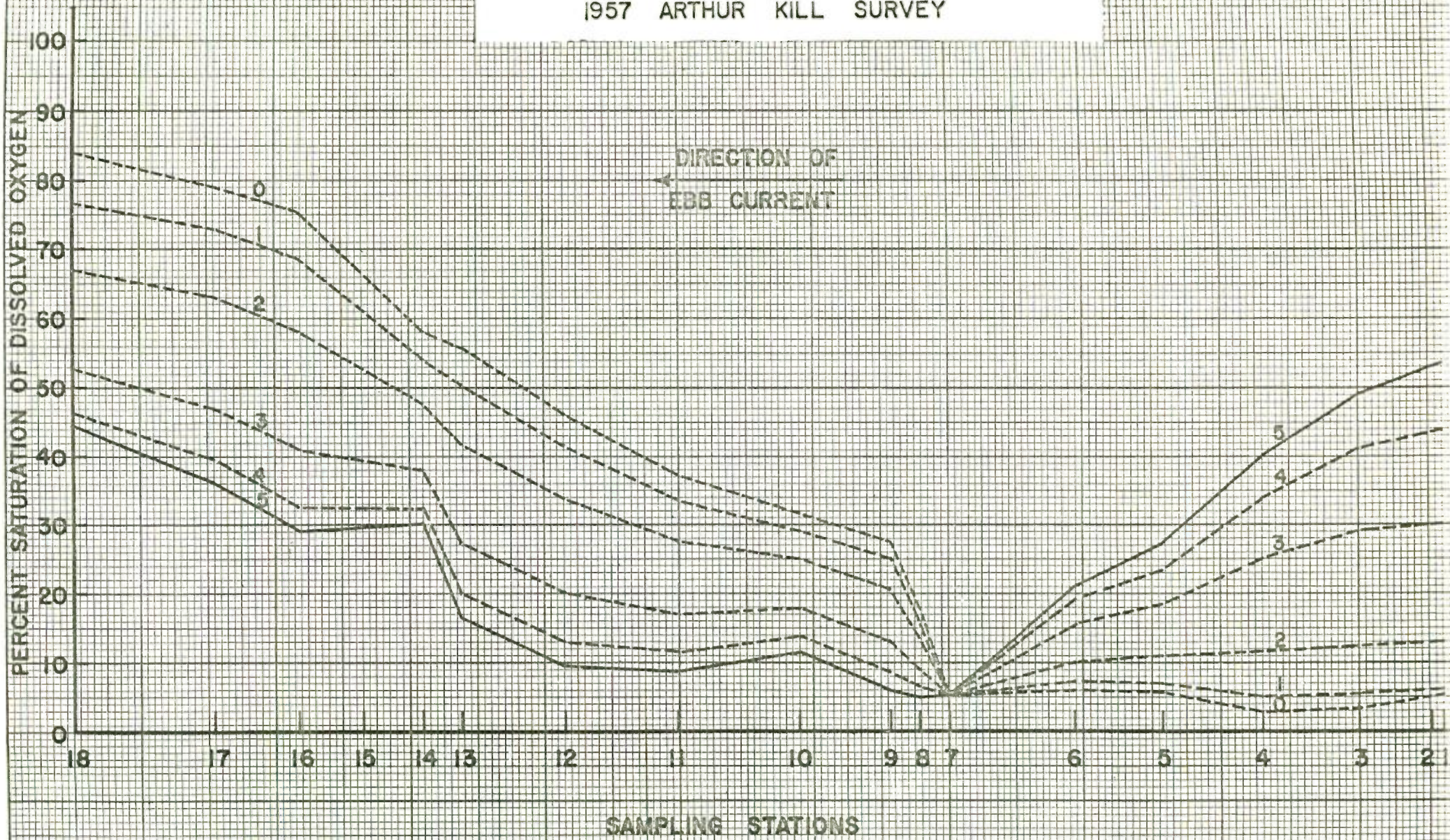


PLATE II

OBSERVED HOURLY VARIATION OF PERCENT SATURATION OF DISSOLVED OXYGEN - EBB CURRENT PHASE - 1957 ARTHUR KILL SURVEY



forth. The line marked "5" shows the percent saturation profile five hours later and just before the tidal flooding starts in the Kill.

Attention is called again to the dashed line marked "0". It can be seen that the percent saturation of dissolved oxygen is highest at Station #18 and decreases to Station #9 where it decreases sharply to 5.1% at Station #7. From Station #7 through #1 it remains very low and ranges from a high of 6% at Station #6 to a low of 2.8% at Station #4. It is very interesting to note the rapid drop in this line between Stations #9 and #7 and how it remains low and almost flat from Stations #7 through #1. This indicates that during this part of the ebb current phase the worst conditions were from Stations #9 through #1 and seem to outline a somewhat constant volume or "slug" of badly polluted water.

Looking at the dashed line marked "1" on the same Plate II, we can see the observed conditions one hour after the conditions shown by the dashed line marked "0". The current was ebbing and flowing from north to south (from Newark Bay past our Station #1, down past our Station #18 and into the Raritan Bay). The percent saturation of dissolved oxygen at Station #18 was 76.9%, a drop of 7.1%. It is further shown that an hour of ebbing produced a lowering of the percent saturation at all of the stations from #18 through #8 inclusive. Station #7 remained unchanged, while Stations #6 through #1 improved or the observed percent saturation of dissolved oxygen increased. This latter increase was small but, nevertheless, a definite increase. The dashed line "2" shows the observed conditions two hours later. The velocity of the ebbing current increased and produced a greater change in percent saturation during the additional hour. The percent saturation at Station #18 dropped to 67.0% or a drop of 17.0% in two hours. The "2" line shows that the percent saturation is continuing to

drop at an increasing rate at all stations from #18 through #8. Station #7 still remains unchanged. Stations #6 through #1 were improving at a faster rate than before and show higher percent saturation values.

The greatest observed hourly change is shown between the "2" and "3" hour lines. This is because the ebbing current velocities reach a maximum during this time and produce the greatest movement of pollution and corresponding reductions in the percent saturation. It should be noted here how the sharp drop in the percent saturation between Stations #9 and #7 gradually started to level off and approach the horizontal. This indicates that the heavy suppression of dissolved oxygen was being gradually moved by the ebbing current from Stations #7 through #1 towards Stations #13 and #14. The southernmost point to which the section of badly polluted water, as measured by percent saturation of dissolved oxygen traveled, was Stations #13 and #14. The slope or break in the percent saturation profile for line "5" closely resembles the break produced between Stations #9 to #7 for the line "0". The fifth hour, solid line, marked "5" indicates the percent saturation profile for the Arthur Kill near the end of the ebb current phase. This line "5" shows a drop at Station #18 from 84.0% for the "0" line to 44.5% for the fifth hour or an overall drop of 39.5% in five hours. However, at Station #1 the percent saturation increased from 5.2% at the zero hour to 53.4% at the fifth hour or an overall increase of 48.2%. Thus, the observations clearly show that the ebbing current moved the "slug" of oxygen depleted waters southward and as these waters moved past Station #7 towards #18 the percent saturation values were lowered. The lowest values were recorded at those stations within the main "slug" of pollution.

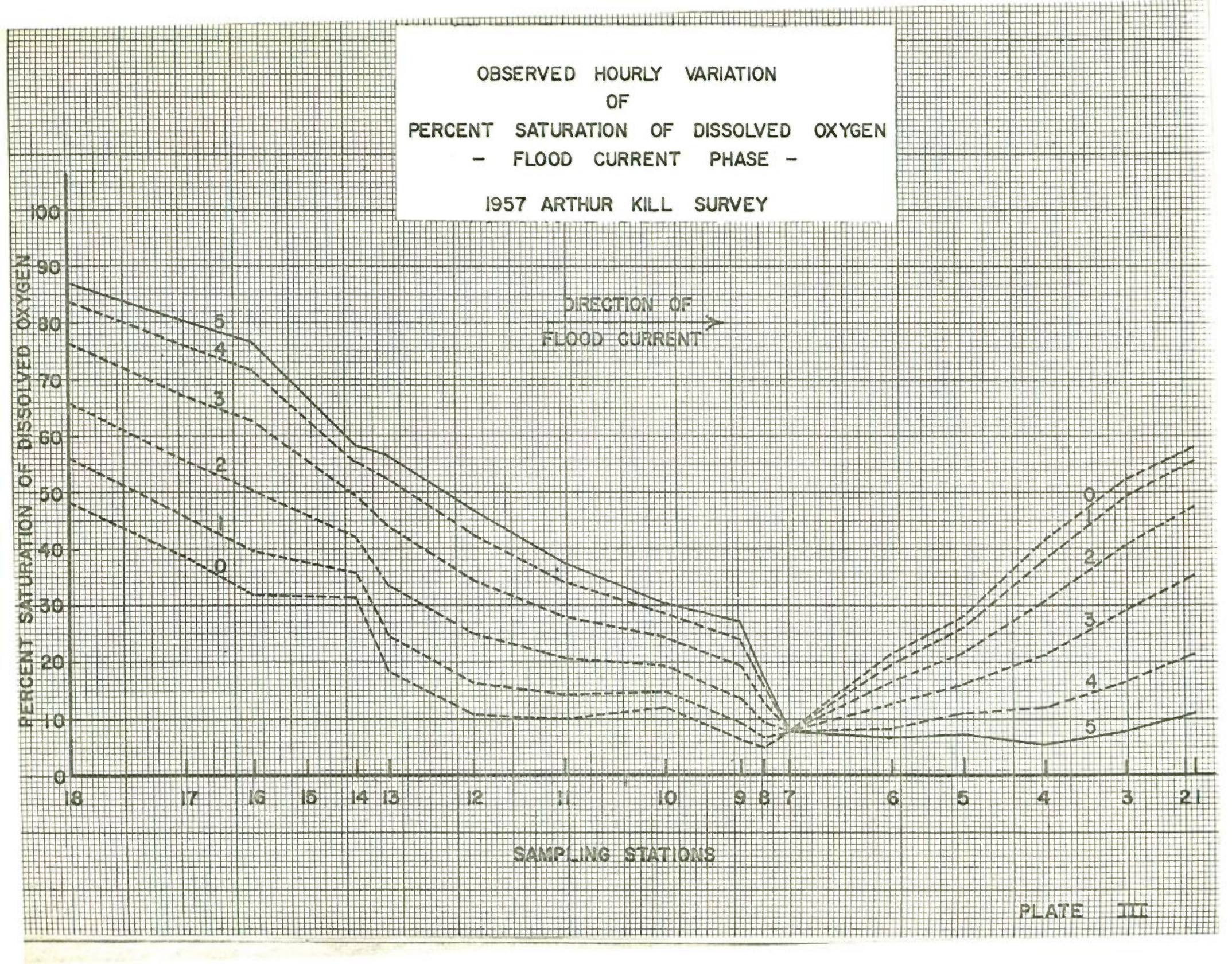
Flood Current Phase

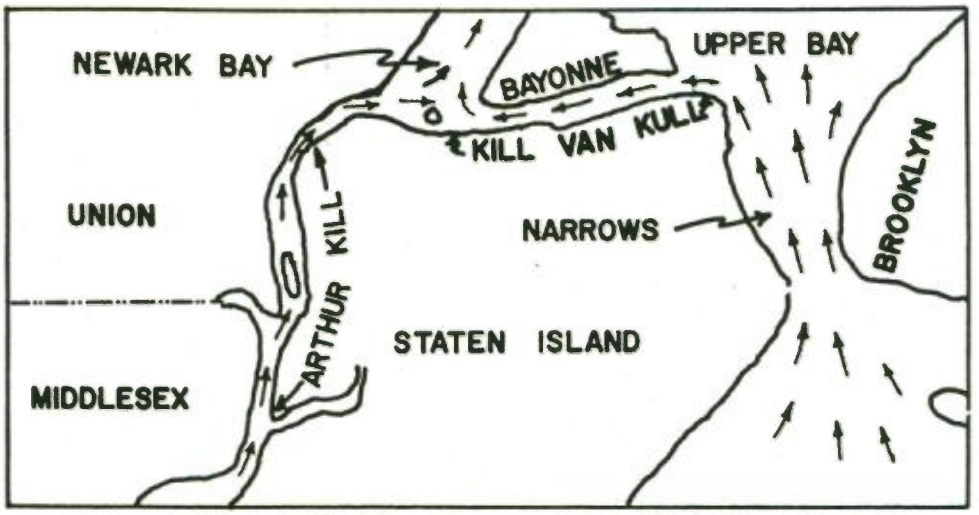
A similar percent saturation profile was

prepared for the flood phase and is shown on Plate III. The dashed line marked "0" here occurs one hour after line "5" on Plate II. This one hour interval allows for the transition of flow in the Arthur Kill from ebb to flood. The dashed line marked "0" on Plate III indicates the percent saturation profile in the Kill when the waters started flooding or flowing northerly from Station #18 to Station #1. At this time, the waters in Raritan Bay were flowing up into the Kill. The line marked "0" on Plate III, then, is very close to that of line "5" of Plate II and it can be seen from Plate III that as the flood current brought in the waters from Raritan Bay the percent saturation rose at all of the stations from #18 through #7 and dropped at all of the stations from #6 through #1. This was caused by the "slug" of pollution being "pushed" northward toward Station #1. The amount dropped during the hourly intervals of the flood current is shown by the lines marked "0", "1", "2", "3" and "4". The solid line, line "5", shows the percent saturation observed near the end of the flood phase. Line "5" also shows how the lower end of the section of heavy pollution or "slug" had been pushed from Stations #14 and #13 to Stations #9, #8 and #7. The upper end of this "slug" extended past Station #1 and into the lower end of Newark Bay.

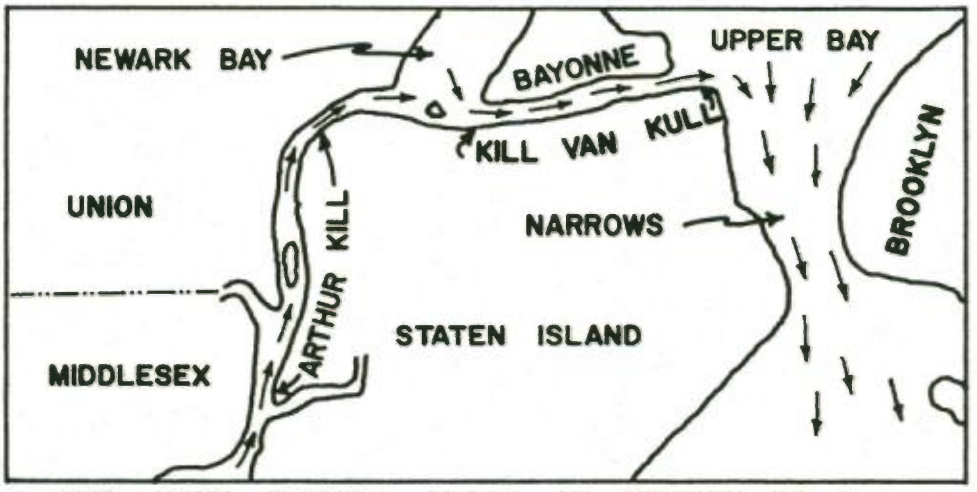
Movement of "Slug"

By studying Plates II and III it becomes apparent that the "slug" of polluted waters moves back and forth in the Kill. The southernmost point to which this "slug" of pollution extended was Station #14. At the northerly end, an investigation of tidal currents (see Figure I) showed that the flood current carries Kill waters northerly into the lower end of Newark Bay for approximately six hours during the flood stage During the last hour of this flood current, at Station #1 in the Arthur Kill, the waters were also being pushed across the southerly or lower end of Newark Bay easterly into the Kill Van

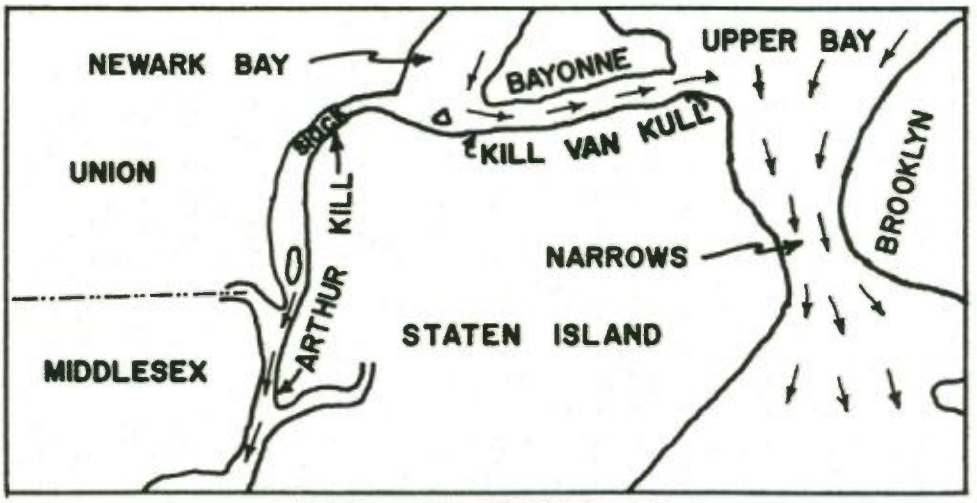

OBSERVED HOURLY VARIATION
OF
PERCENT SATURATION OF DISSOLVED OXYGEN
- FLOOD CURRENT PHASE -
1957 ARTHUR KILL SURVEY
PERCENT SATURATION OF DISSOLVED OXYGEN
100
90
80
70
60
50
40
30
20
10
0
DIRECTION OF
FLOOD CURRENT
5
4
3
2
1
0
0
1
2
3
4
5
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
SAMPLING STATIONS
PLATE III



TWO HOURS BEFORE SLACK AT STATION NO. 1



ONE HOUR BEFORE SLACK AT STATION NO. 1



SLACK AT STATION NO. 1

DIRECTION OF TIDAL CURRENTS

1957 ARTHUR KILL SURVEY

FIG. I

Kull. The waters in the lower end of Newark Bay were also at this time ebbing out through the Kill Van Kull and into the Upper Bay. Conditions were made more favorable for channelizing part of the "slug" of pollution into the Kill Van Kull and out into the Upper Bay because of the main ship channel running across the lower end of Newark Bay and dike along the northern side of this channel. Other investigations conducted by the Commission have also indicated the passage of polluted water during ebb currents through the Kill Van Kull. If part of this "slug" of pollution was carried over into the Kill Van Kull during the first part of its ebb current, as described, then there remained sufficient time during ebb in the Kill Van Kull to carry it out into the Upper Bay. This may also include any part of polluted waters previously pushed up into the lower Newark Bay during an earlier part of the flood current in the Arthur Kill. Evidently, the "slug" of pollution in the Arthur Kill was restricted or controlled by this continual "sloughing off" of its northern end through the Kill Van Kull to balance off the pollution which is continually discharged. An examination of Plates II and III suggests that no part of the concentrated "slug" of pollution passed "intact" out of the Arthur Kill into Raritan Bay. There appeared to be limited mixing at the southern end of the "slug". This is substantiated by comparing the percent saturation curve marked "O" on Plate II, between Stations #7 and #12, with Stations #13 and #18 on Curve "5". These portions of the curves show approximately the same percent saturation values and definite outlining of the "slug" of pollution. Thus, if you were to move this part of curve "O" horizontally, it would approximately match the comparable part of Line "5". The slope of Line "5" between Stations #13 and #14 is the same as the slope of Line "O" between Stations #8 and #9. The percent saturation values, however, extend or drop to a lower value at Station #7 than at Stations #12 and #13. This is probably due to

the fact that more pollution enters the Arthur Kill at Station #7 than between Stations #12 and #13 and also, that the "slug" never really clears or leaves Station #7.

Plate II shows how the northern end of the "slug" covered Station #7 at the end of the ebb flow and Plate III shows how the southern end of the "slug" covers it at the end of the flood flow. Thus, Station #7 appeared to be the pivotal point about which these variations revolved and it did not attain higher percent saturation values at any time because of the continual presence of the "slug" of pollution. The observed "slug" of pollution appeared to move back and forth with a relatively constant strength of pollution.

SUMMARY AND CONCLUSIONS

(1) The Interstate Sanitation Commission Compact requirements for Class "B" waters are not being met from a point near Station #2 to a point between Stations #12 and #13.

(2) The waters at Station #7 contain the greatest pollution.

(3) There is a "slug" of pollution in the Arthur Kill about 6.4 miles in length, having 30% or less saturation of dissolved oxygen, and it moves to and fro with the ebb and flood of the tide.

(4) Station #7 is the only station continually under the influence of the "slug" of pollution.

(5) A method for analyzing the observed data in tidal waters was determined.

(6) Hourly variations of the percent saturation (of dissolved oxygen) profiles for the length of the Arthur Kill were found to be more valuable than the variations at a single station.