OSO BAY

TIDE AND DISCHARGE STUDY

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PURPOSE

In developing a habitat enhancement program for the Blind Oso, consideration has been given to enlarging the direct connection between the Blind Oso and Corpus Christi Bay either through the construction of a bridge and excavated channel or through the construction of larger culverts beneath Ocean Drive. Randy Thompson of Archie Walker Engineering and I have been retained to study the hydrologic effects of such channelization on the water flow and habitats of the Blind Oso.

This particular portion of the analysis applies tide data collected from tide gauges in the Oso and in Corpus Christi Bay along with current measurements at the existing bridge to calibrate a flow equation for the existing channel. This data will then be used to calibrate the HEC II hydrologic model of the Oso on the computer at Archie Walker Engineering.

TIDE GAUGE DATA

The Blucher Institute for Surveying and Science at Corpus Christi State University collects continuous high quality tide level data from numerous automatic tide gauging stations along the Texas coast. They provided data from February 1991 through September 1991 for the gauge in Corpus Christi Bay and for the gauge near Ward Island in Oso Bay. David Pyle, a surveyor for the

City determined the NGVD (National Geodetic Vertical Datum) elevations for the two tide gauges so that we could use them to determine the relative water levels in Oso and Corpus Christi Bays. The tide gauge elevations correlate with cross section and other surface elevations surveyed by the city in Oso Bay and in the Blind Oso.

Refer to APPENDIX A. for monthly graphs presenting the hourly NGVD tide levels for Corpus Christi and Oso Bays. On all graphs, time is UTC (Universal Coordinated Time). The dates are presented on the graphs as the day of the year, not the day of the month. For instance the last day in January is the 31st day of the month and also the 31st day of the year, while February 1 is the 32nd day of the year. Each graph also presents the hourly difference in tide level between the two gauges (DIFFERENCE = OSO LEVEL - CORPUS CHRISTI BAY LEVEL). Note that most of the time, the water level is higher in the Oso than in Corpus Christi Bay (DIFFERENCE greater than zero). This is due to the fact that the Davis power plant discharges about 531 MGD (Millions of Gallons per Day) of saline Laguna Madre water into the Oso. Other non-tidal Oso discharges include the Oso sewage treatment plant, sewage treatment plants upstream in Oso Creek, and rainfall runoff. The inflow into the Oso under the Ocean Drive Bridge is due only to the rise and fall of the tidal level of Corpus Christi Bay. The outflow from the Oso under the Ocean Drive Bridge is the sum of the tidal flow in, the power plant discharge, the sewage discharges, and rainfall runoff from the Oso Creek watershed.

DIURNAL DISCHARGE MEASUREMENTS

On September 28-29, 1991, we measured the cross-section of the channel at the Oso bridge and made hourly current velocity measurements for a 24 hour tidal cycle. These measurements used in conjunction with simultaneous water level measurements made by the

OSO and NAS (Naval Air Station) tide gauges permit the calibration of a flow equation which can be used to compute the long term flow in and out of the Oso under the bridge using only the long term tide level data collected by the two gauges.

The flow equation is the Manning stream flow equation which is expressed as follows:

$$V = 1.49 \times R^{0.666} \times S^{0.5} / n$$

WHERE

V = MEAN FLOW VELOCITY in cubic feet per second,

R = HYDRAULIC RADIUS in feet (cross sectional AREA of the channel divided by the WETTED PERIMETER (width of the submerged bottom and sides of the channel)

S = water surface SLOPE (difference in water level from one end of the channel to the other divided by the length of the channel)

n = MANNING FRICTION FACTOR determined experimentally

The flow through the bridge channel is driven by the relative elevations of the water in the Oso and in Corpus Christi Bay. When the water is at the same level in both bays there is no flow in the channel. The greater the difference in the water levels, the faster the water flows through the channel.

During both slack water periods of the diurnal current measurement, the water level reported by the Oso gauge and corrected to NGVD by the data provided by the city, was 0.24 ft higher that the water level reported in Corpus Christi Bay by the NAS gauge. This indicates that there is a survey error in the elevation of one or both gauges. The error is probably in the level line going to the NAS gauge as it is several miles long. Since we know that the gauges must be at the same level when there is no measured flow under the bridge, we adjusted all of the NAS

gauge data up 0.24 ft. so that the water level difference between the two gauges at no flow is zero. The adjustment was made at the NAS gauge so that the OSO gauge water levels would continue to be on the same datum as the elevation data collected throughout the oso.

MANNING n

For each of the 25 current measurements obtained at the bridge on September 28-29, 1991, the Manning n was computed using the corrected water levels from the NAS and OSO gauges, a channel length of 4000 ft., and the measured cross sectional area and wetted perimeter (See Oso Bridge Channel, APPENDIX B). Values were averaged for flows greater than 0.2 ft./sec. because measurement becomes inaccurate at very low flow velocities. This resulted in a Manning n = 0.0407. This is within the range of values expected for this type of movable bed natural channel.

MEASURED AND CALCULATED DISCHARGE

The results of the discharge and velocity measurements are presented graphically in APPENDIX B. The graph titled SEPT 28-29, 1991 1400 HR TO 1400 HR presents the tidal data gathered by the NAS and OSO gauges for the diurnal discharge measurement period. Note that the difference in water levels (OSO - NAS) is greater during ebb from the Oso into Corpus Christi Bay than during flood from Corpus Christi Bay into the Oso. The much greater ebb flow is due to the non-tidal discharges from the Oso including power plant, sewage plant and Oso Creek discharges.

The figure entitled OSO BAY STUDY, HOURLY VELOCITY AND DISCHARGE (APPENDIX B) shows the velocity and discharge measured during the diurnal study. Note again, that the measured flow out of the Oso is greater than the measured flow into the Oso.

The figure entitled SEPT 28-29 1991 DISCHARGE (APPENDIX B) compares the discharge calculated using the Manning equation with the measured tidal levels with the actual discharge measured at the bridge. The heavy solid line (CALC-Q), the calculated discharge closely follows the heavy dotted line (MEAS-Q) the actual measured discharge. Since the discharge is proportional to the velocity, the velocity trend is similar to the trend of the discharge. Likewise, the tidal differential which drives the flow and which is plotted as three times the tidal differential (TIDE DIFF), also shows a trend similar to the measured and calculated discharges.

This figure demonstrates that the flow calculated with the Manning equation using a Manning n = 0.0407 agrees very closely with the actual measured flow for the same period. Thus, we will be able to use the Manning equation with n = 0.0407 along with the long term tidal differentials measured by the NAS and OSO gauges to compute the flow into and out of the Oso through the bridge channel for the entire duration of data collected by both tide gauges.

COMPUTED HOURLY DISCHARGE

The tidal difference (NAS - OSO), a channel length of 4000 ft., a Manning n = 0.0407, the measured cross sectional area and the wetted perimeter of the bridge channel adjusted for water level were used to compute the hourly flow under the bridge from the middle of February, 1991 to the end of September, 1991. The results are presented as a series of monthly graphs in APPENDIX C.

On each of the monthly graphs, the heavy dotted line is the computed hourly discharge under the bridge. Values greater than zero are for flow from the Oso out into Corpus Christi Bay while values less than zero are for flows from Corpus Christi Bay into the Oso. As expected, most of the flow is out of the Oso, since the non-tidal flows greatly exceed the tidal flows. The calculated

flow velocities and measured tidal differentials are also presented.

COMPUTED DAILY DISCHARGE

The hourly discharge rate was used to compute the daily flows in MGD (Millions of Gallons per Day) into and out of the Oso from Corpus Christi Bay. This was computed only for days with 24 hours of hourly tidal data. Incomplete days were omitted. These data are presented as a series graphs in APPENDIX D. All of these data for the period from February through September are presented on the first graph entitled DAILY DISCHARGE. Note that most of the time the flow out of the Oso greatly exceeds the flow into the Oso. As before, flow out of the Oso (OSO gauge higher than NAS gauge) is presented as a positive number, and flow into the Oso is presented as a negative number.

The second figure, NET DAILY DISCHARGE, shows the net flow out of the Oso for the entire period. Note that there were only a few days when flow into the Oso (negative values) exceeded flow out of the Oso. Note also, that the net daily discharge fluctuates around values somewhat above 500 MGD. Finally, the remainder of the graphs presented in APPENDIX D show the daily flow through the bridge channel as a series of monthly graphs.

MEAN DAILY DISCHARGE

For the period from February through September, 1991, the daily mean flow (tidal) from Corpus Christ Bay into the Oso is 147 MGD, the daily mean flow out of the Oso is 720 MGD. This results in a daily computed net flow out of the Oso of 573 MGD. This is the non-tidal flow out of the Oso which is composed of the sewage plant discharges, the power plant discharges, rainfall runoff and other flow down Oso Creek from the Oso Creek watershed.

Non-tidal discharges from the OSO can be estimated as follows:

Barney Davis Power Plant	531 MGD (maximum)
Oso Sewage Treatment Plant	15 MGD
Upstream Sewage Plants	4 MGD
Mean Daily Runoff for 1991	33 MGD
TOTAL	583 MGD

Thus we see that the long term computed net flow out of the Oso of 573 MGD compares very closely with the estimated non-tidal net flow out of the Oso of 583 MGD. In fact, since the power plant flow used for the estimate was the maximum flow, and some days the power plant flow is lower while some generating units are not on line, the estimate compares very closely with the computed flow.

CONCLUSIONS

Hourly tidal data provided by the Blucher Institute for Surveying and Science collected by gauges in Corpus Christi Bay and in Oso Bay used in conjunction with the Manning flow equation with a Manning friction factor determined by a diurnal discharge study at the Oso bridge enabled the long term computation of hourly and daily flows into and out of the Oso through the Oso bridge channel. These computed results are believed to be highly accurate since the computed values for the 24 hour diurnal discharge agree closely with the measured values for that period and since the long term computed net flow out of the Oso corresponds closely with the estimated known elements of the non-tidal net flow out of the Oso. Likewise the computed flow into the Oso accurately represents the tidal exchange between Oso and Corpus Christi Bays.

These data are being used to calibrate and test the HEC II flow model which is being used to estimate the effect of proposed new openings between the Blind Oso and Corpus Christi Bay.

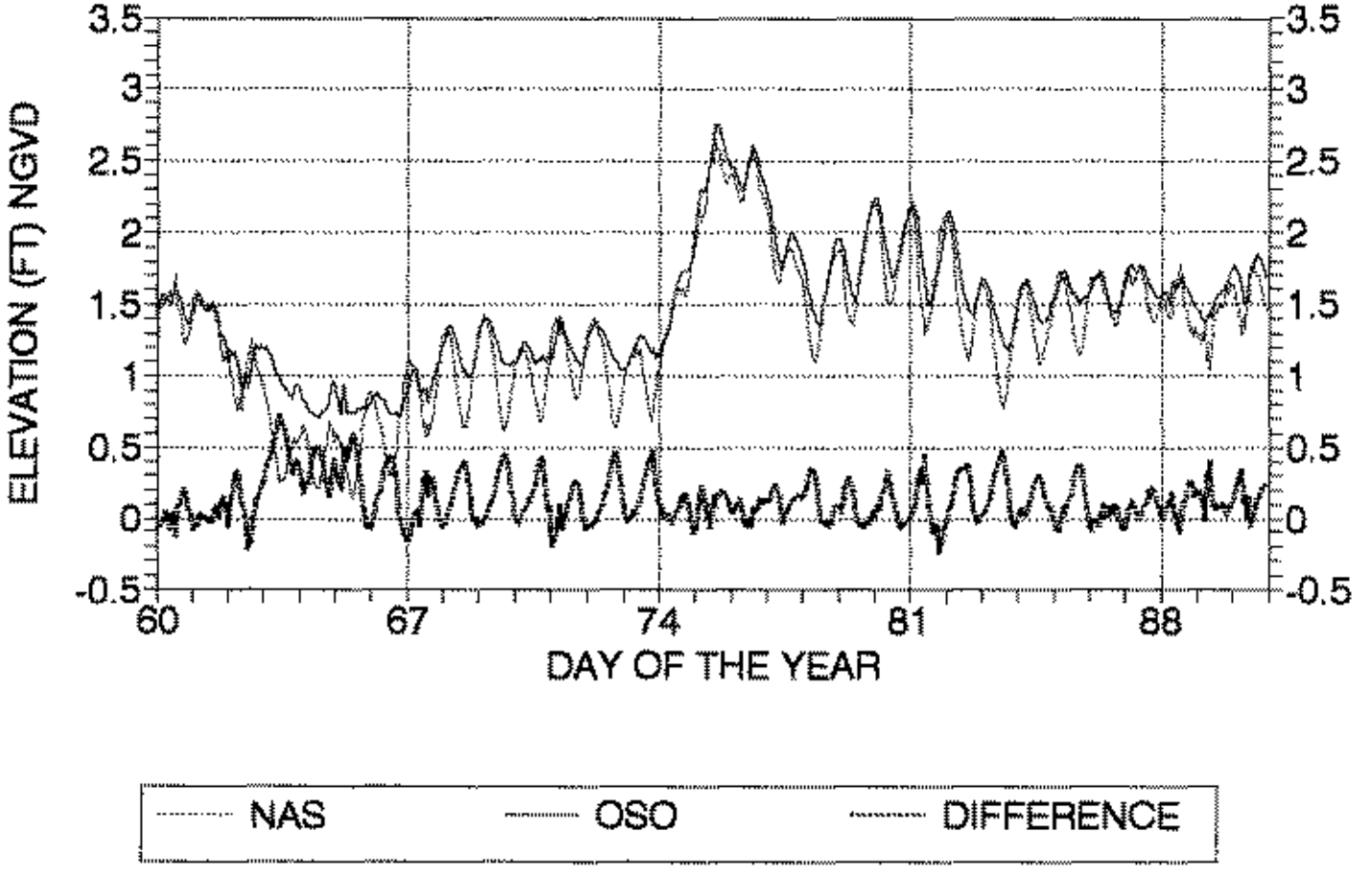
APPENDIX A

OSO AND NAS

TIDE LEVELS

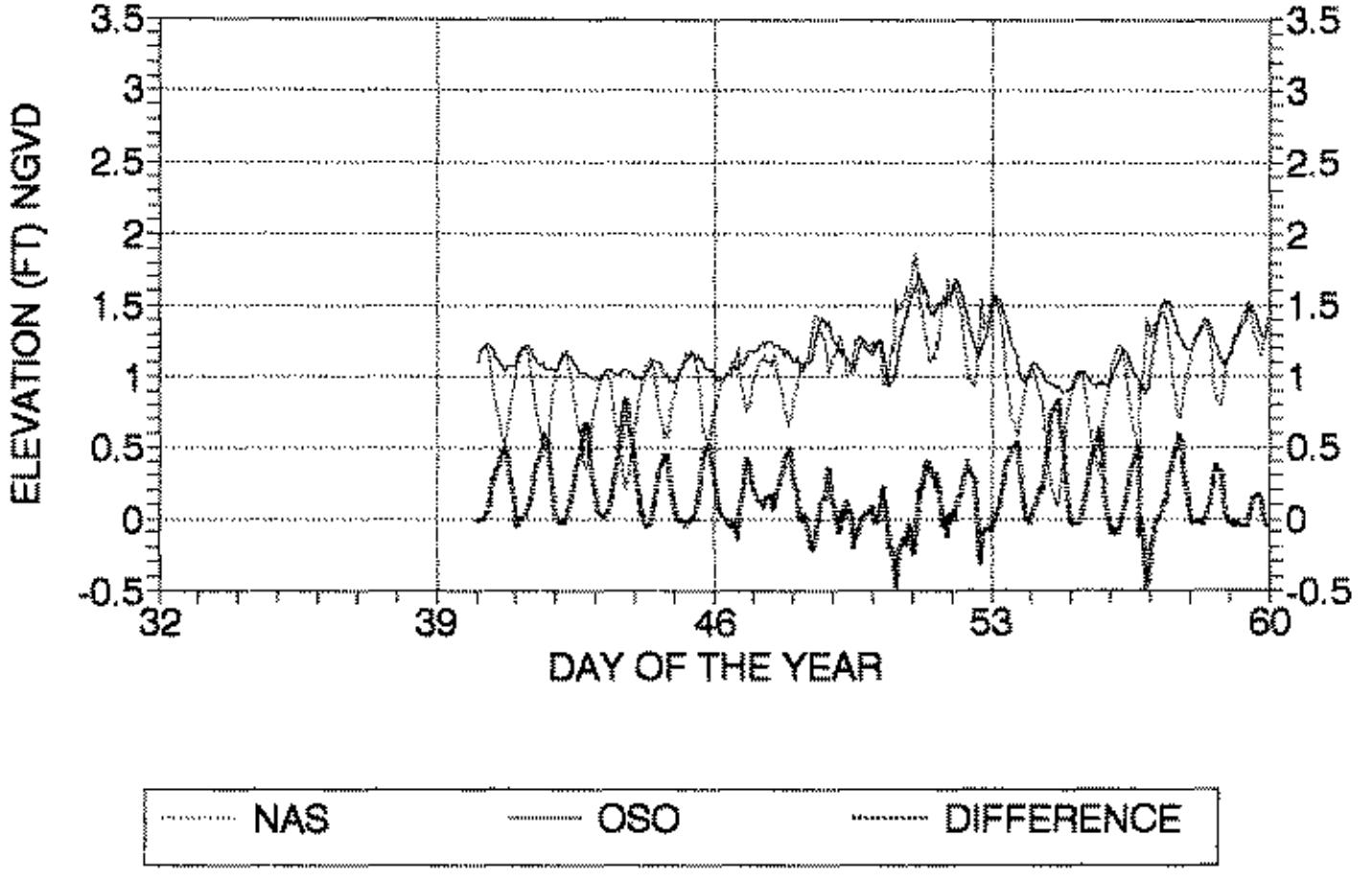
MARCH 1991

NAS NGVD ADJUSTED UP 0.24 FT



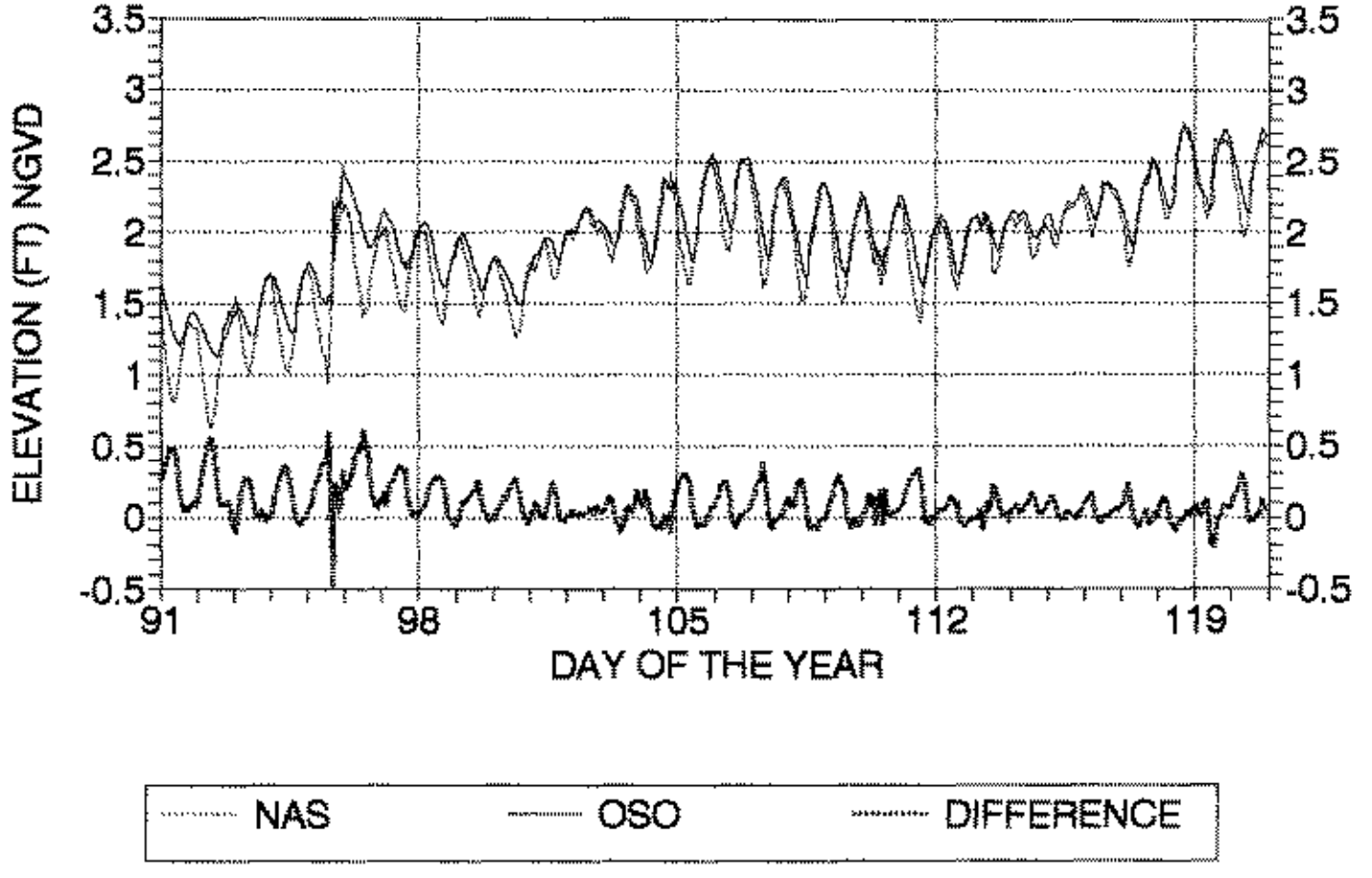
FEBRUARY 1991

NAS NGVD ADJUSTED UP 0.24 FT



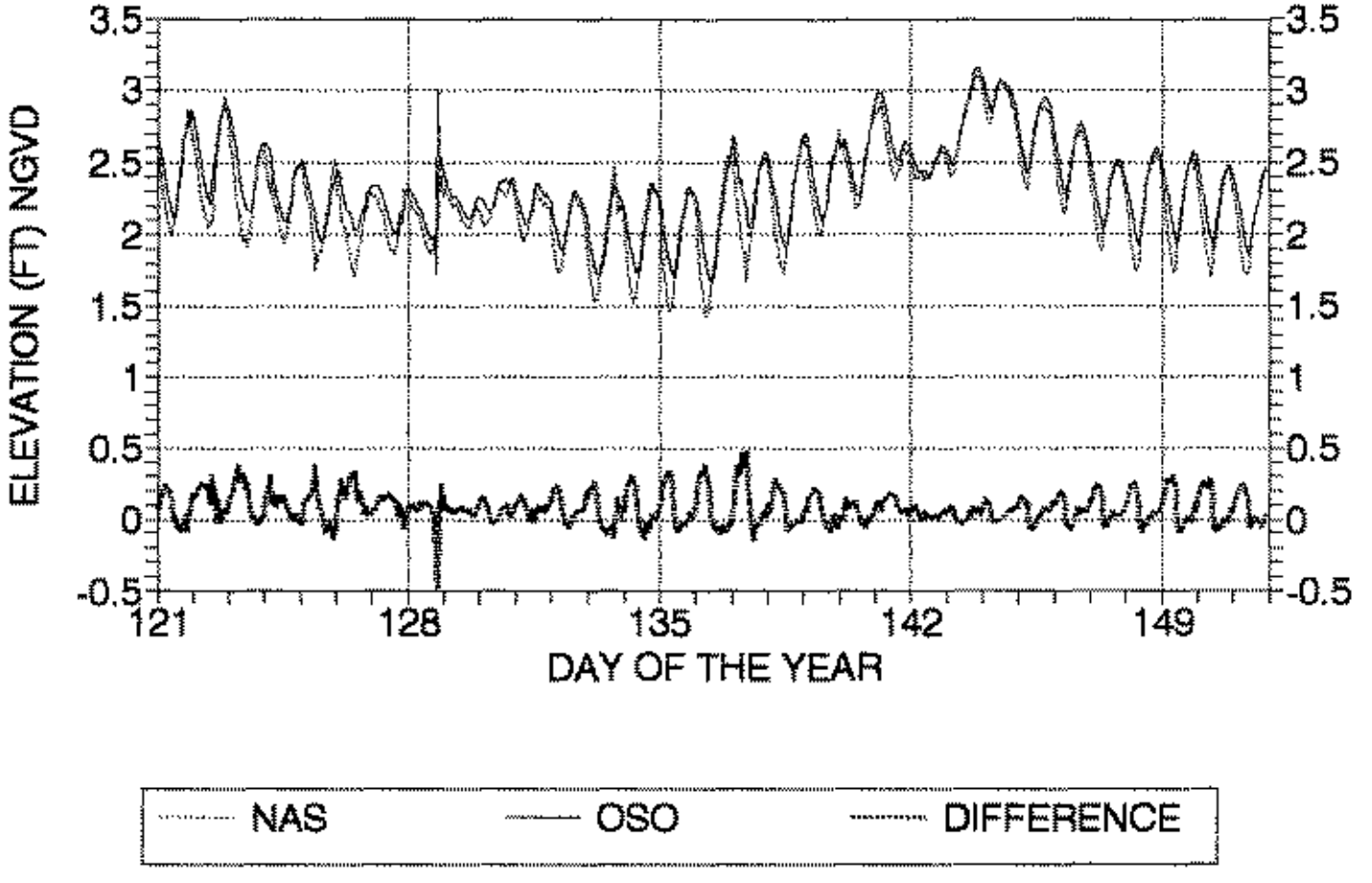
APRIL 1991

NAS NGVD ADJUSTED UP 0.24 FT



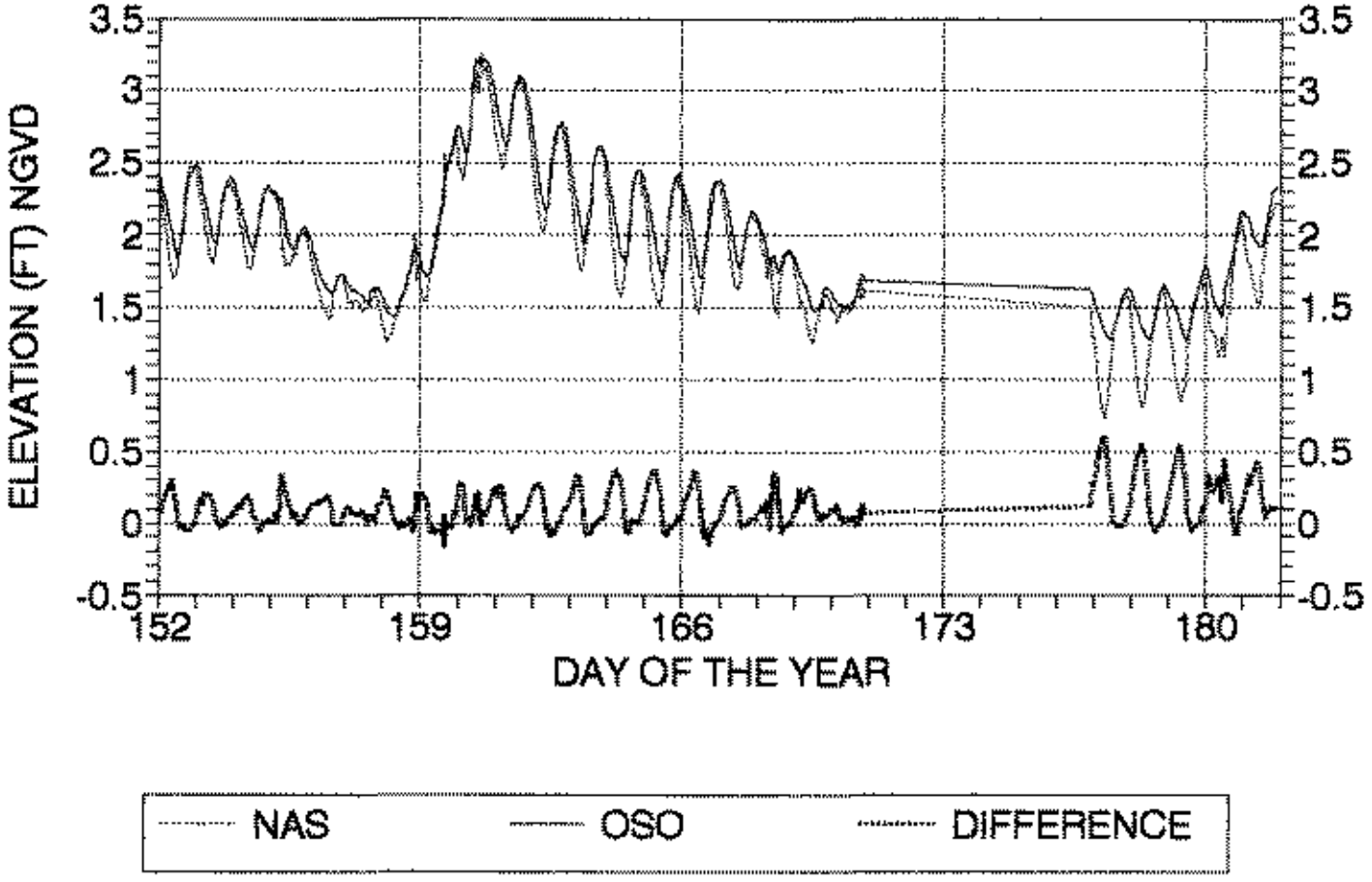
MAY 1991

NAS NGVD ADJUSTED UP 0.24 FT



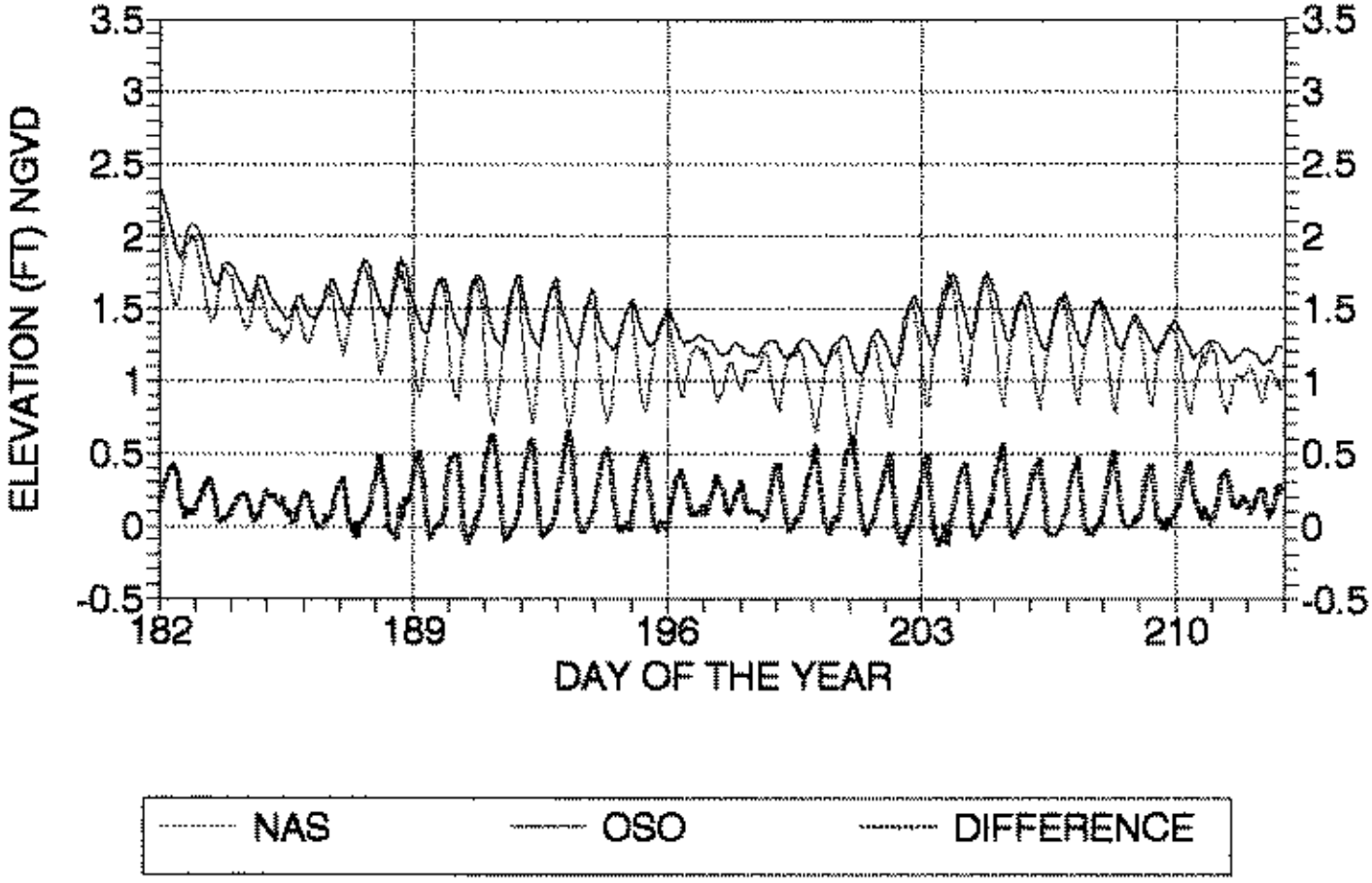
JUNE 1991

NAS NGVD ADJUSTED UP 0.24 FT



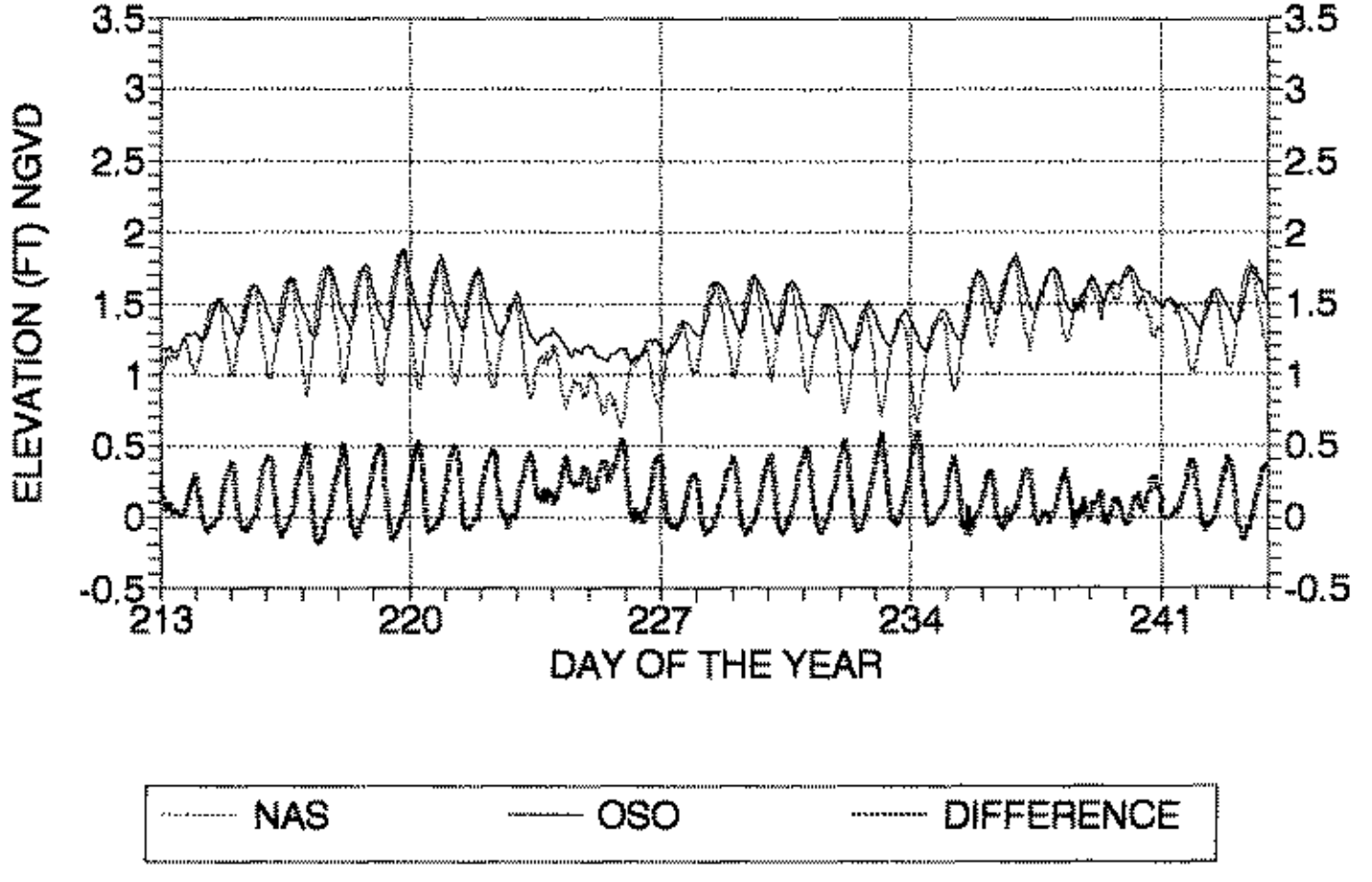
JULY 1991

NAS NGVD ADJUSTED UP 0.24 FT



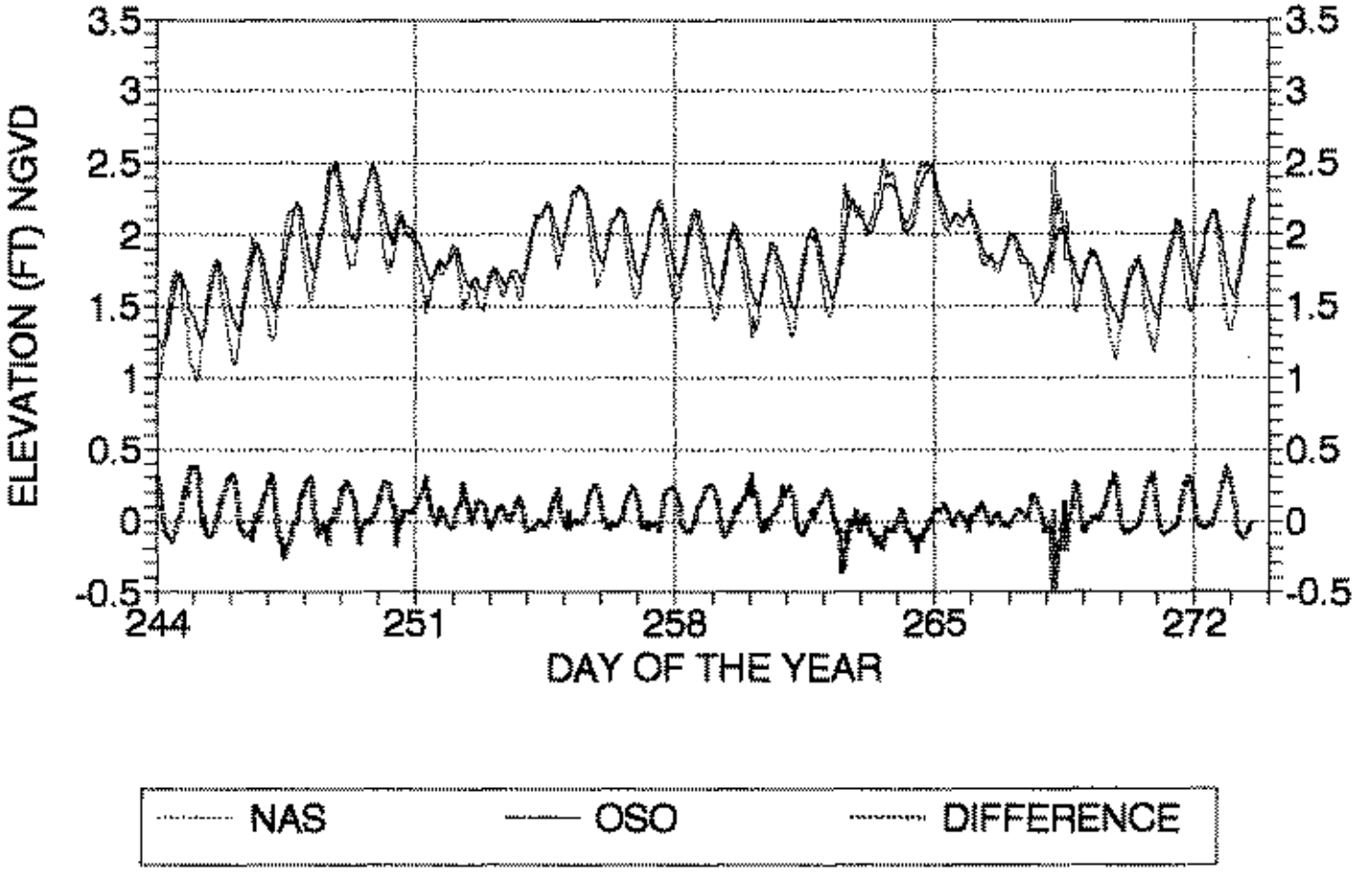
AUGUST 1991

NAS NGVD ADJUSTED UP 0.24 FT



SEPTEMBER 1991

NAS NGVD ADJUSTED UP 0.24 FT



APPENDIX B

MEASURED

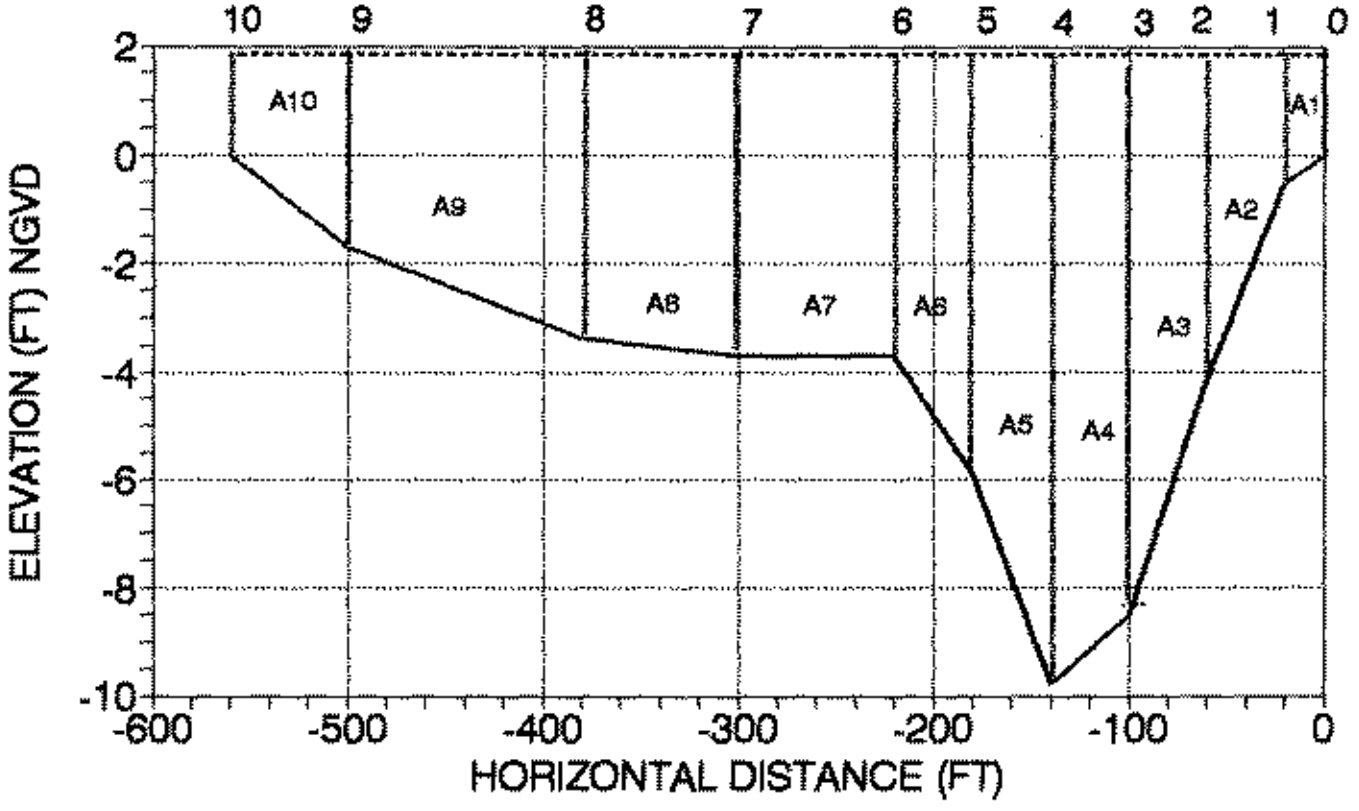
DISCHARGE

AND

MISCELLANEOUS

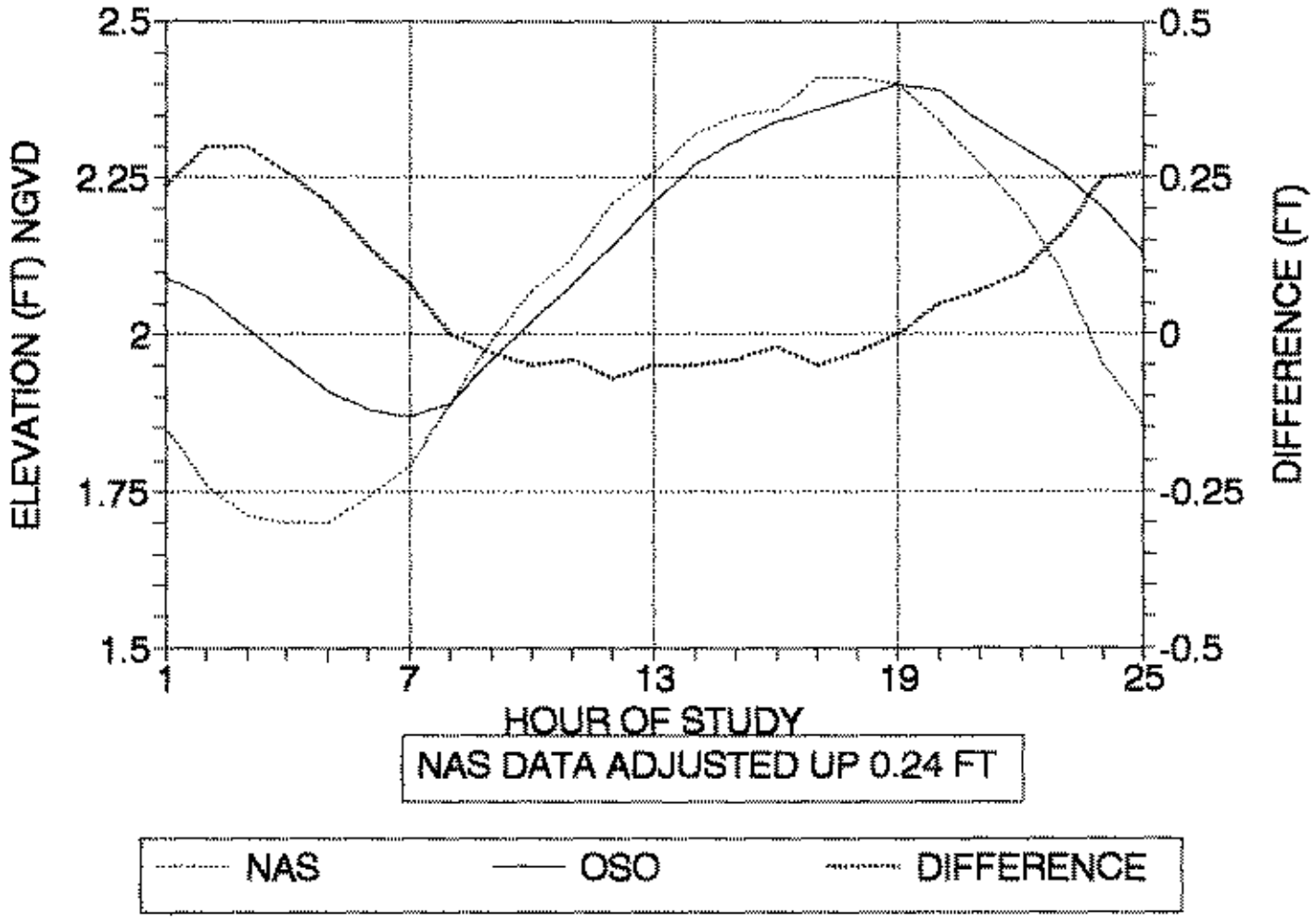
GRAPHS

OSO BRIDGE CHANNEL



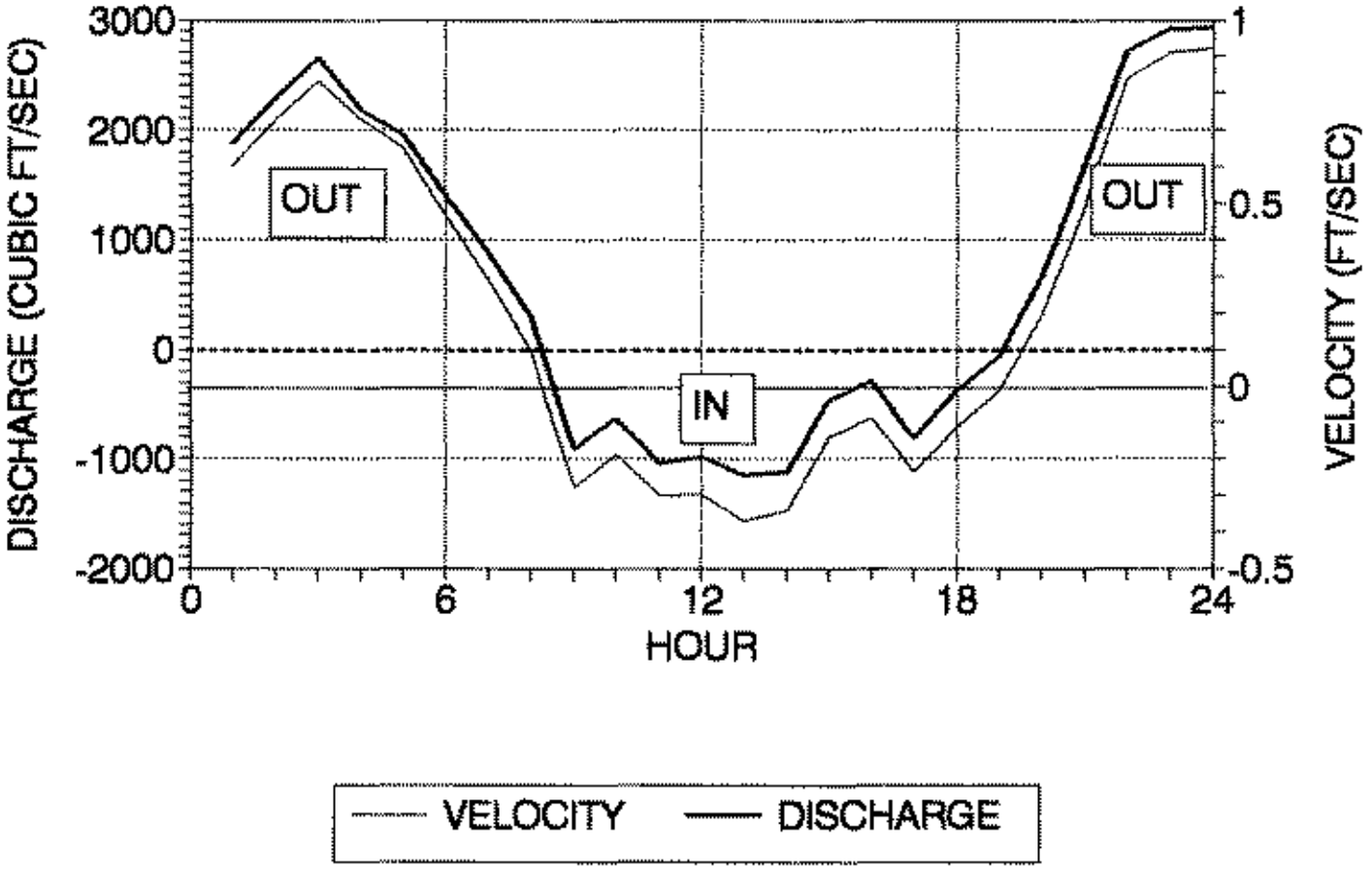
—— CHANNEL BOTTOM ------ 1ST WATER LEVEL

SEPT 28-29, 1991 1400 HR TO 1400 HR



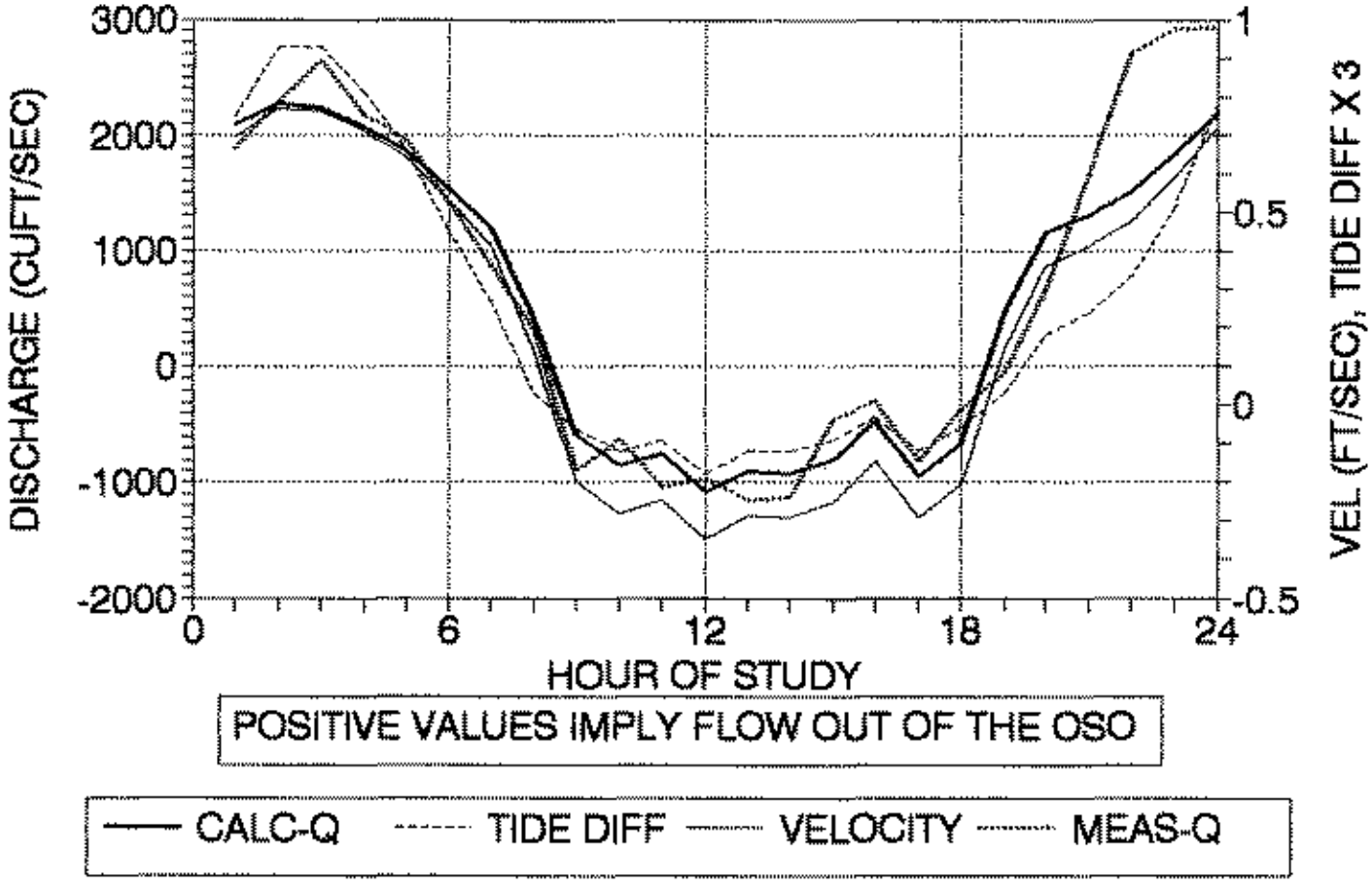
OSO BAY STUDY

HOURLY VELOCITY AND DISCHARGE



SEPT 28-29 1991 DISCHARGE

NAS NGVD ADJUSTED UP 0.24 FT

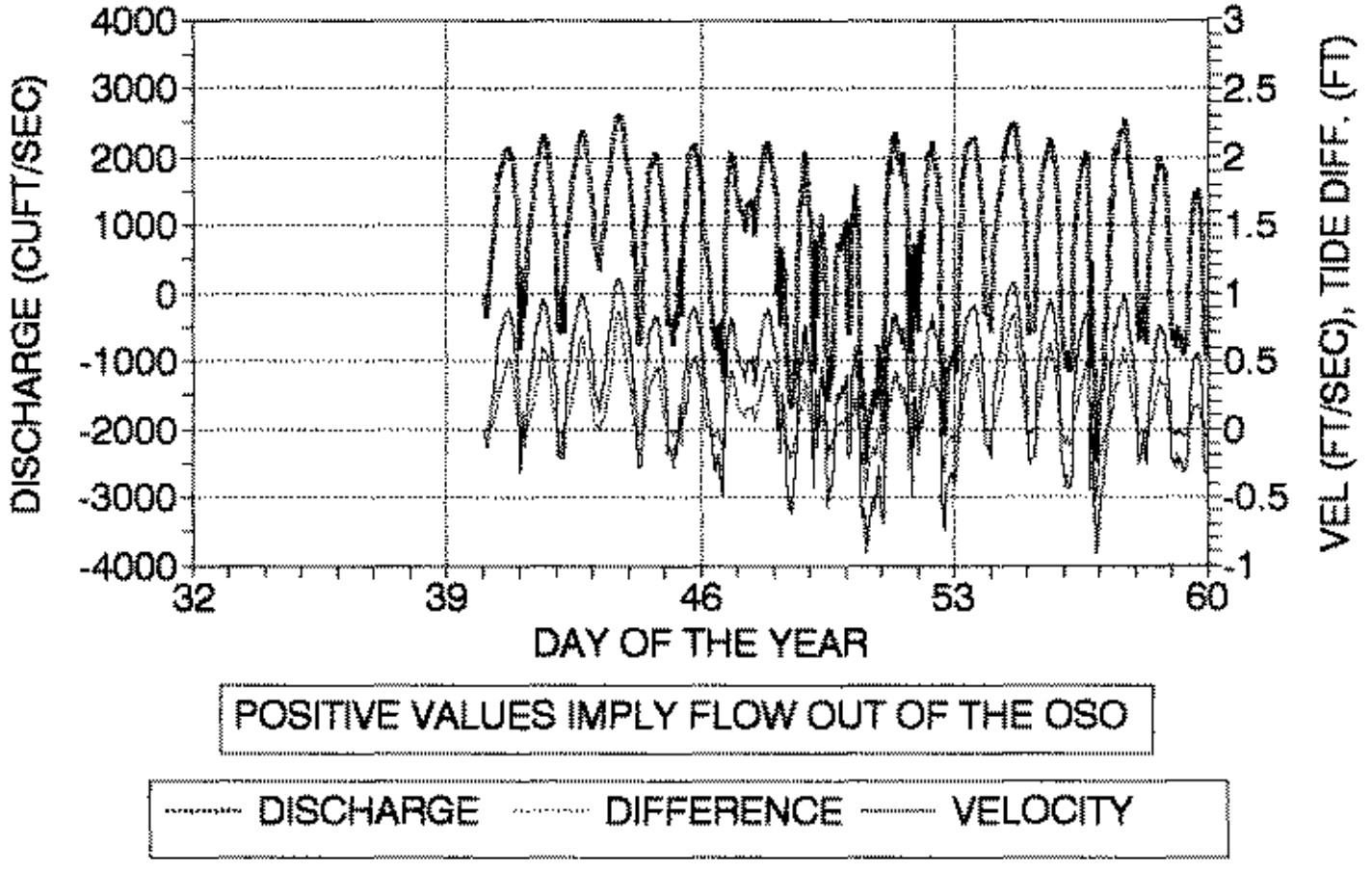


APPENDIX C

COMPUTED HOURLY DISCHARGE GRAPHS

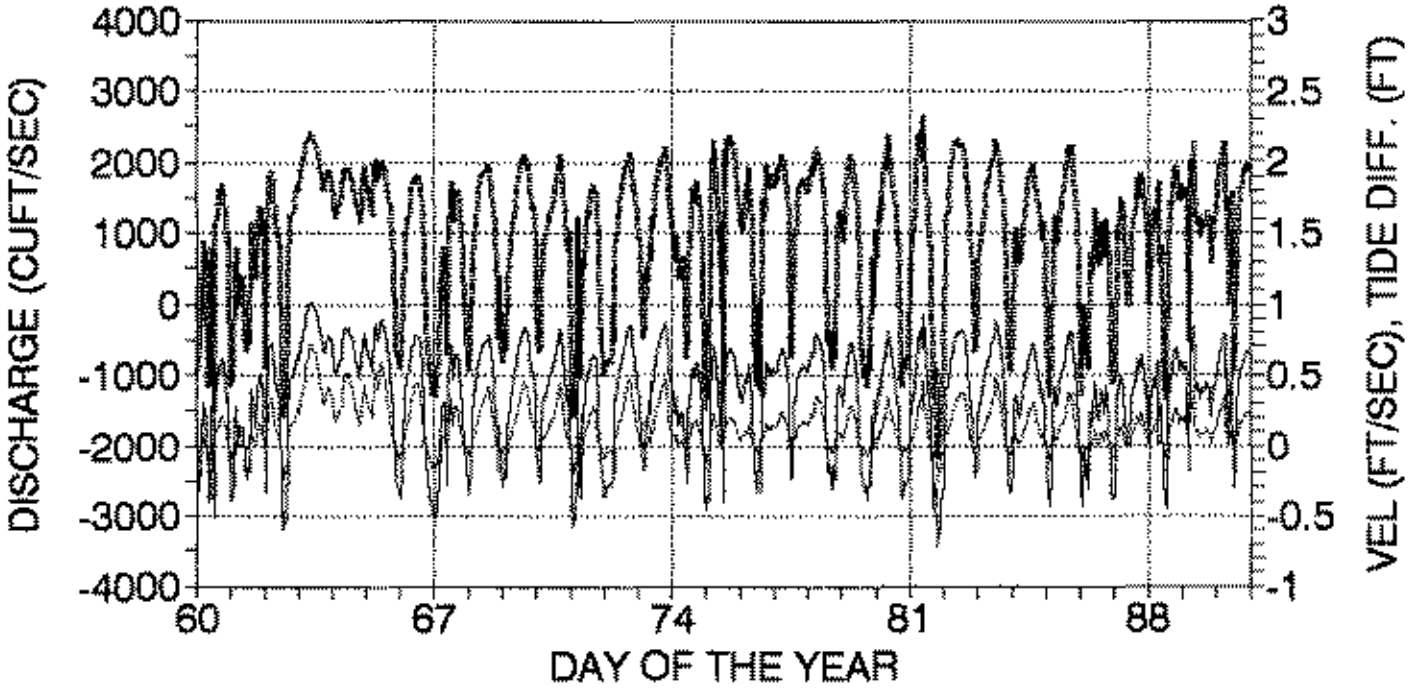
FEBRUARY 1991 DISCHARGE

NAS NGVD ADJUSTED UP 0.24 FT



MARCH 1991 DISCHARGE

NAS NGVD ADJUSTED UP 0.24 FT

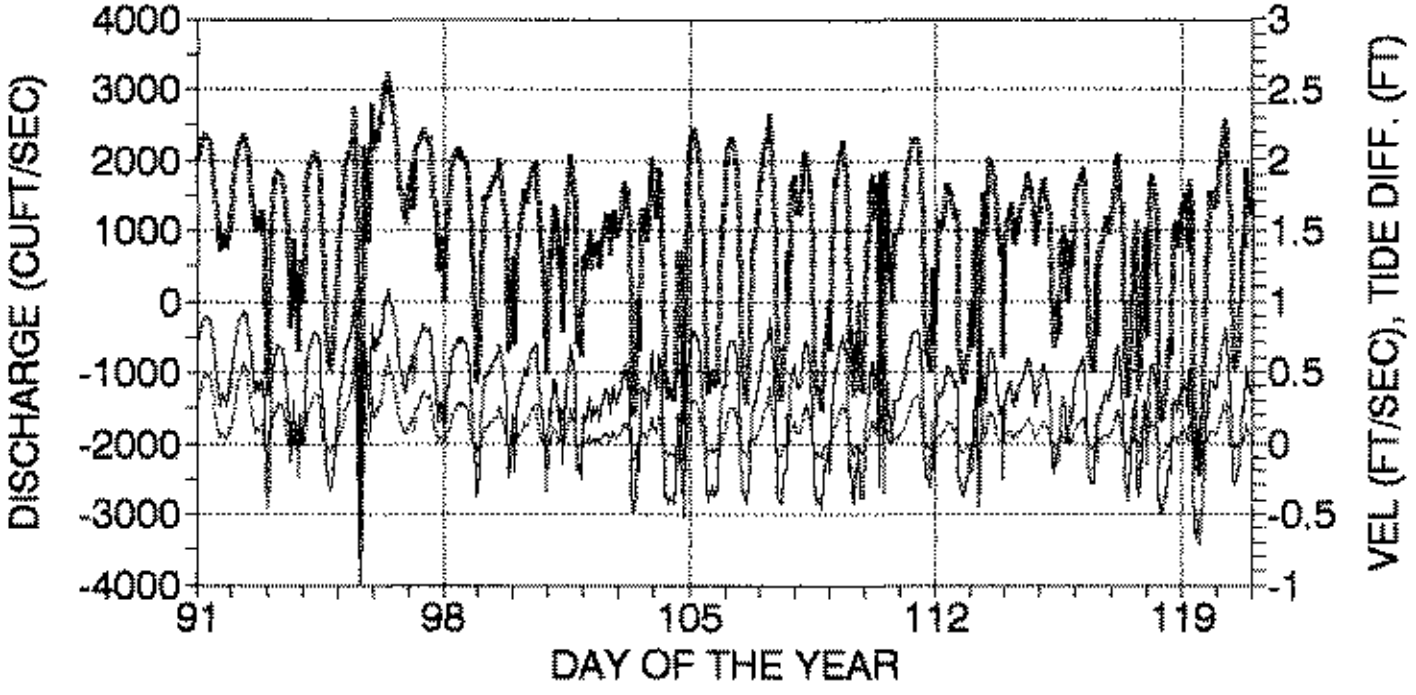


POSITIVE VALUES IMPLY FLOW OUT OF THE OSO

DISCHARGE DIFFERENCE VELOCITY

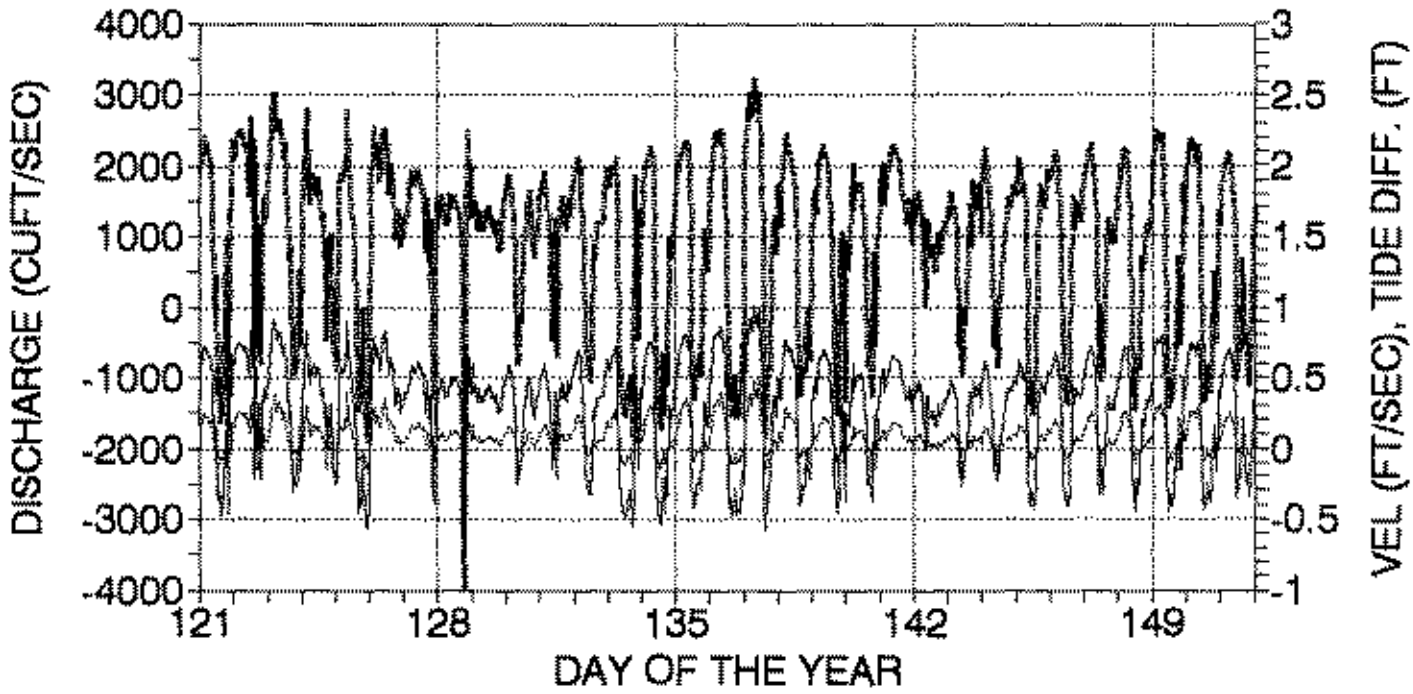
APRIL 1991 DISCHARGE

NAS NGVD ADJUSTED UP 0.24 FT



MAY 1991 DISCHARGE

NAS NGVD ADJUSTED UP 0.24 FT

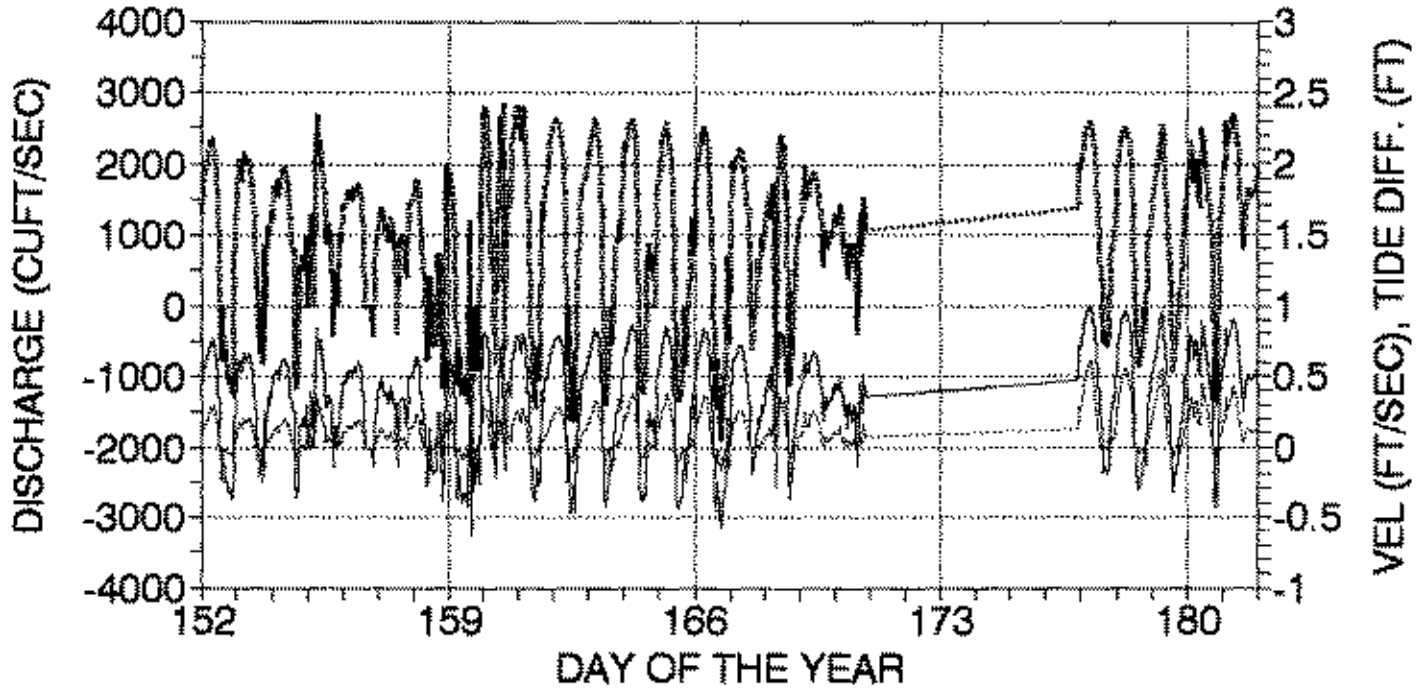


POSITIVE VALUES IMPLY FLOW OUT OF THE OSO

DISCHARGE DIFFERENCE VELOCITY

JUNE 1991 DISCHARGE

NAS NGVD ADJUSTED UP 0.24 FT



POSITIVE VALUES IMPLY FLOW OUT OF THE OSO

DISCHARGE DIFFERENCE VELOCITY

JULY 1991 DISCHARGE

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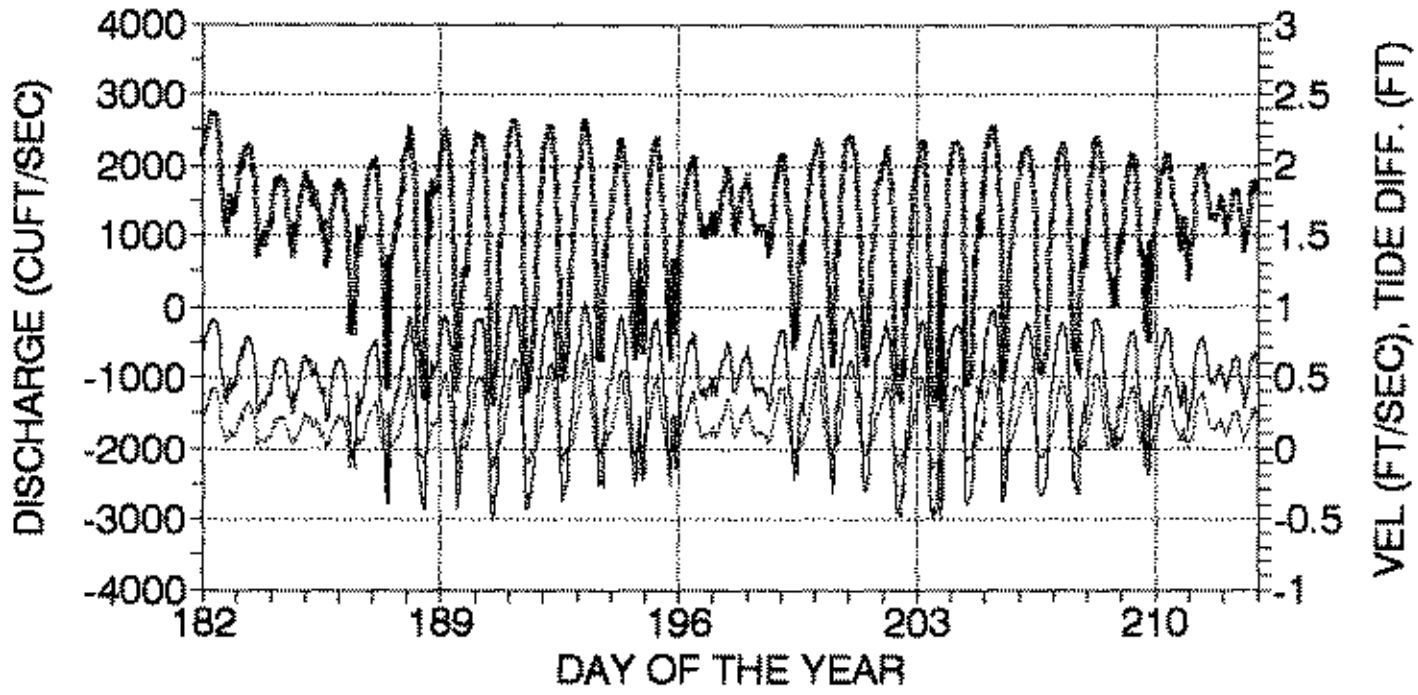

AUGUST 1991 DISCHARGE

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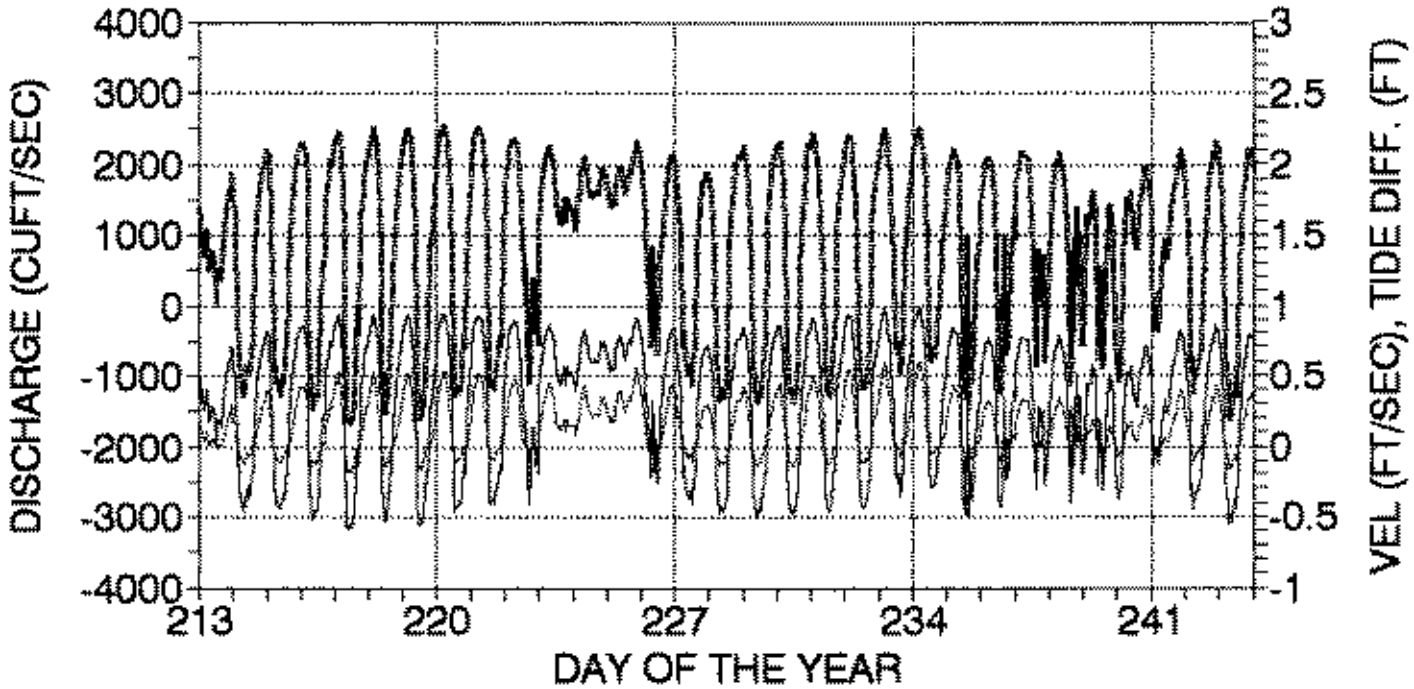
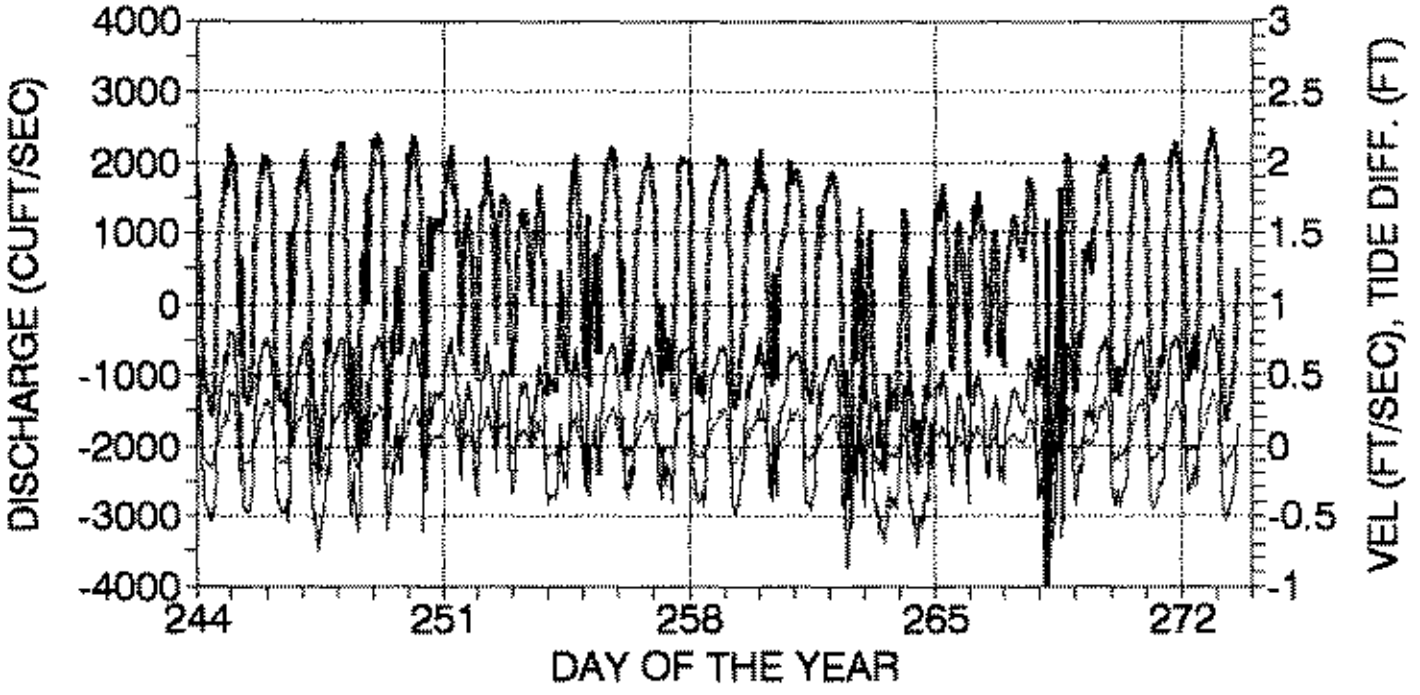


POSITIVE VALUES IMPLY FLOW OUT OF THE OSO

DISCHARGE DIFFERENCE VELOCITY

SEPTEMBER 1991 DISCHARGE

NAS NGVD ADJUSTED UP 0.24 FT



POSITIVE VALUES IMPLY FLOW OUT OF THE OSO

DISCHARGE DIFFERENCE VELOCITY

APPENDIX D

COMPUTED

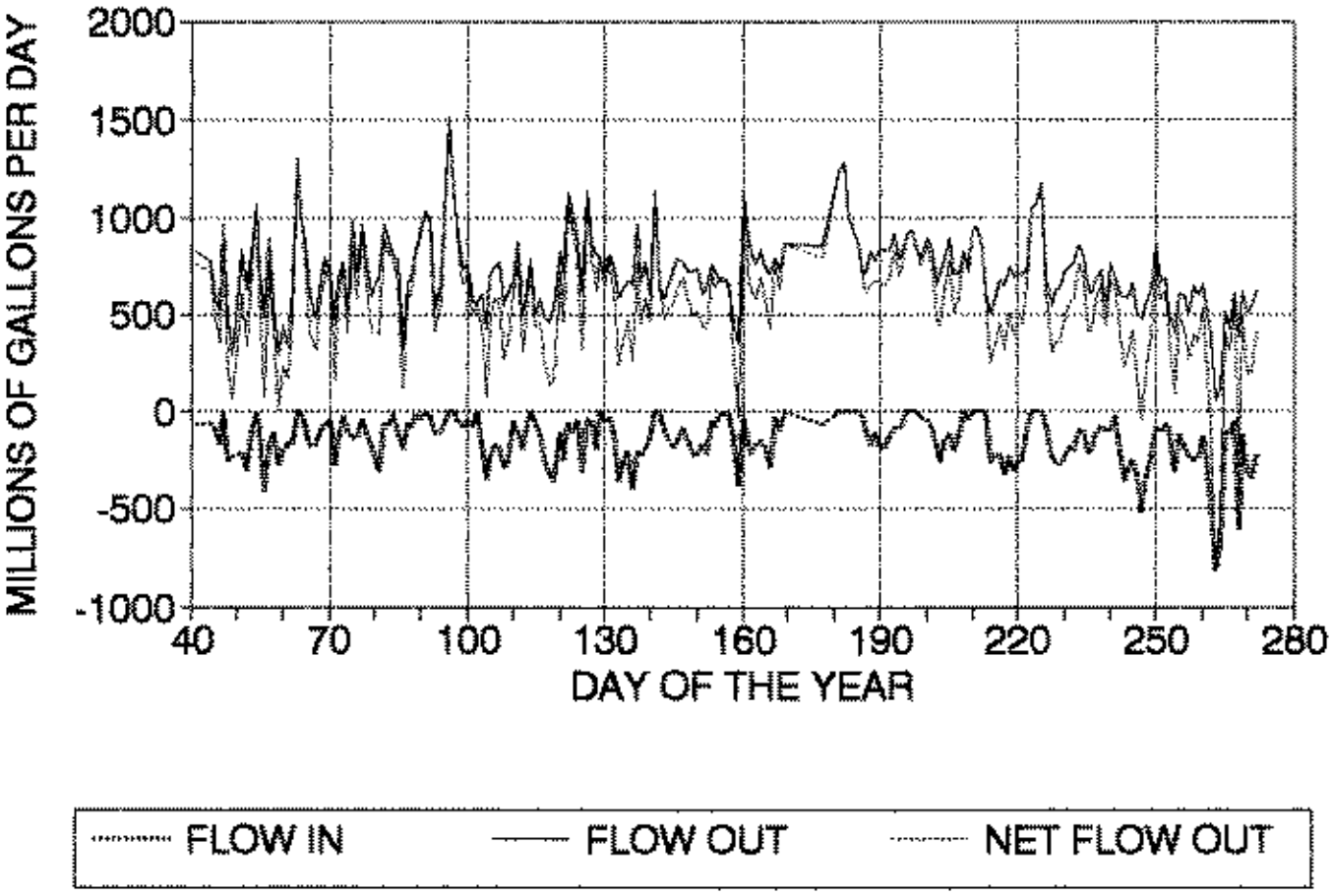
DAILY

DISCHARGE

GRAPHS

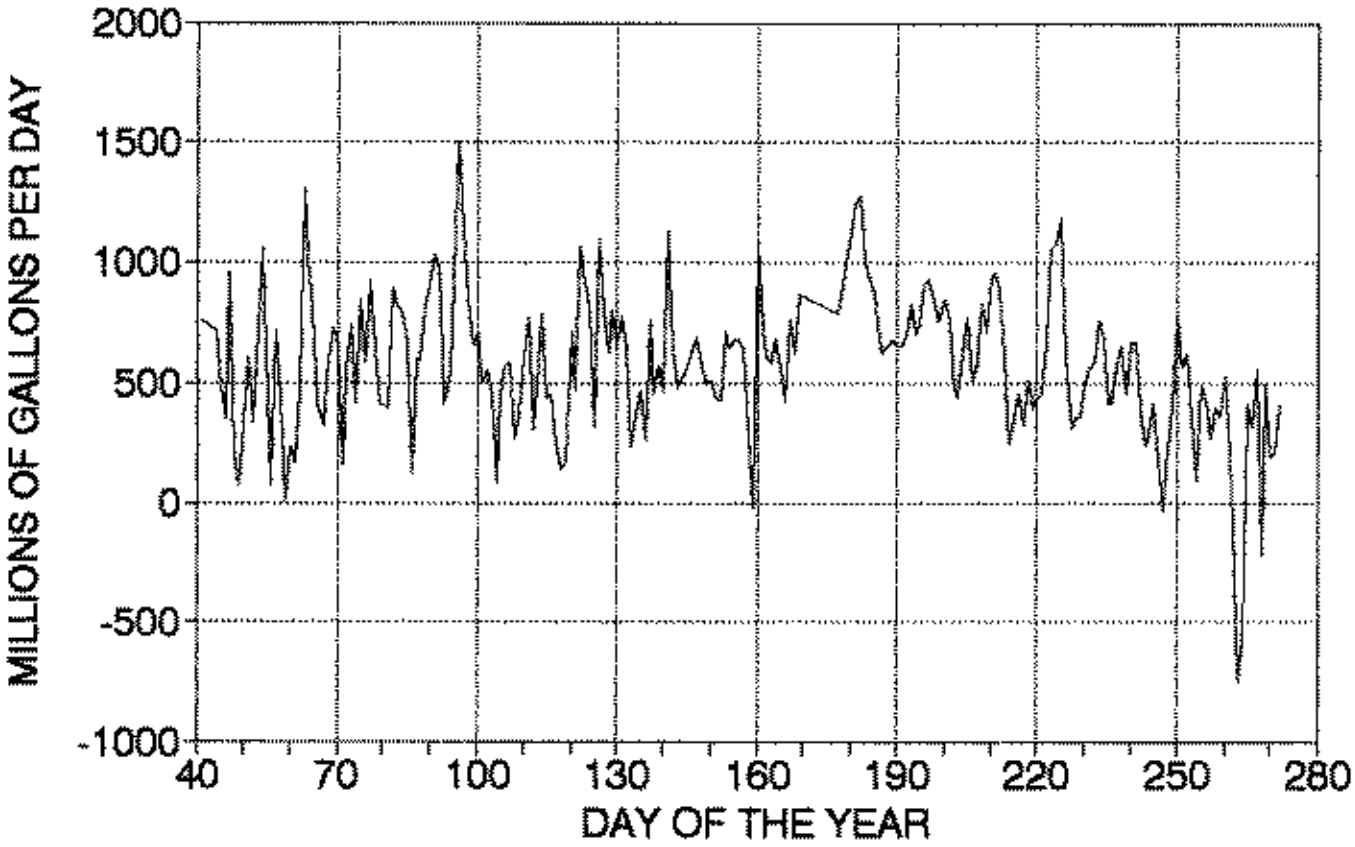
DAILY DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



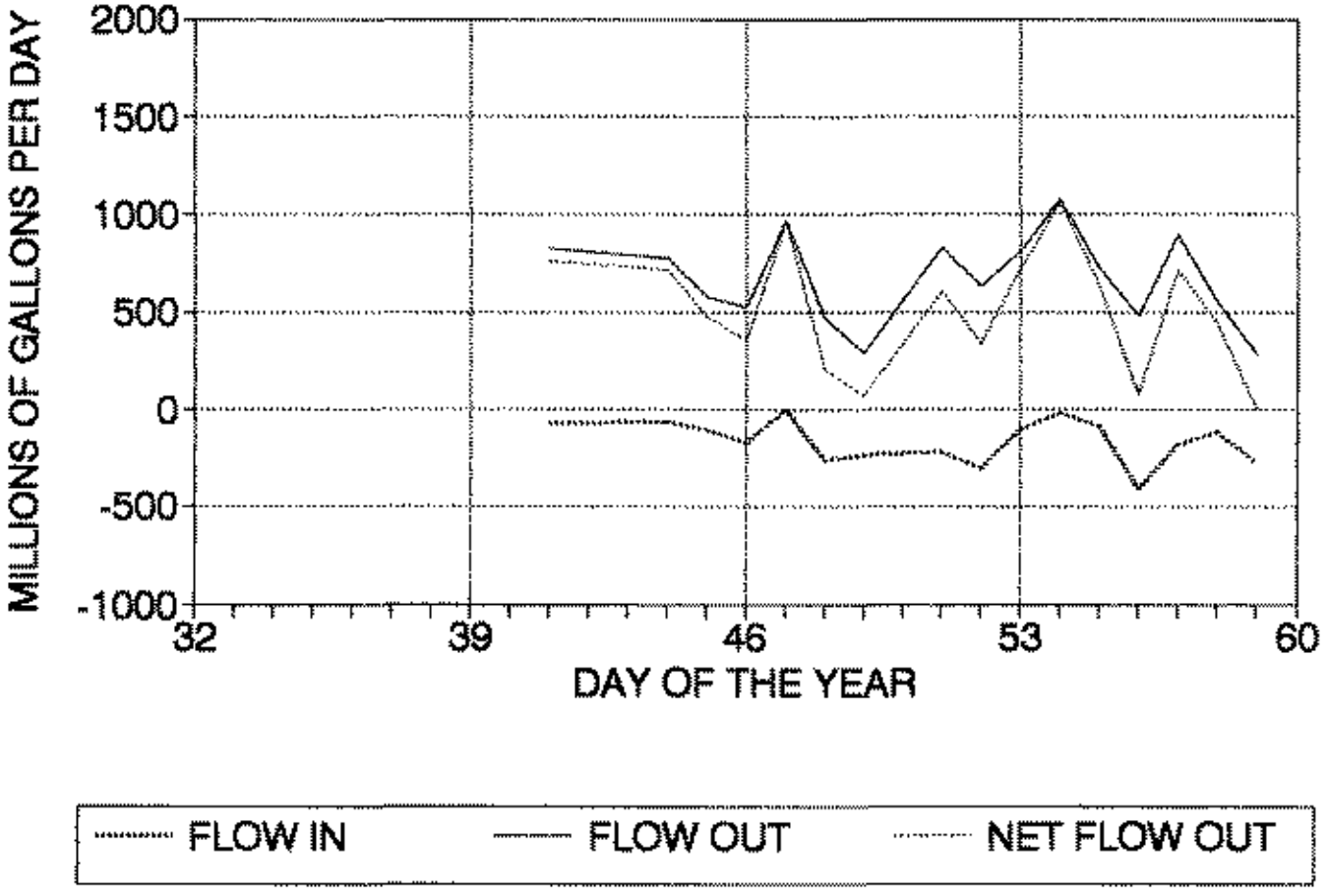
NET DAILY DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



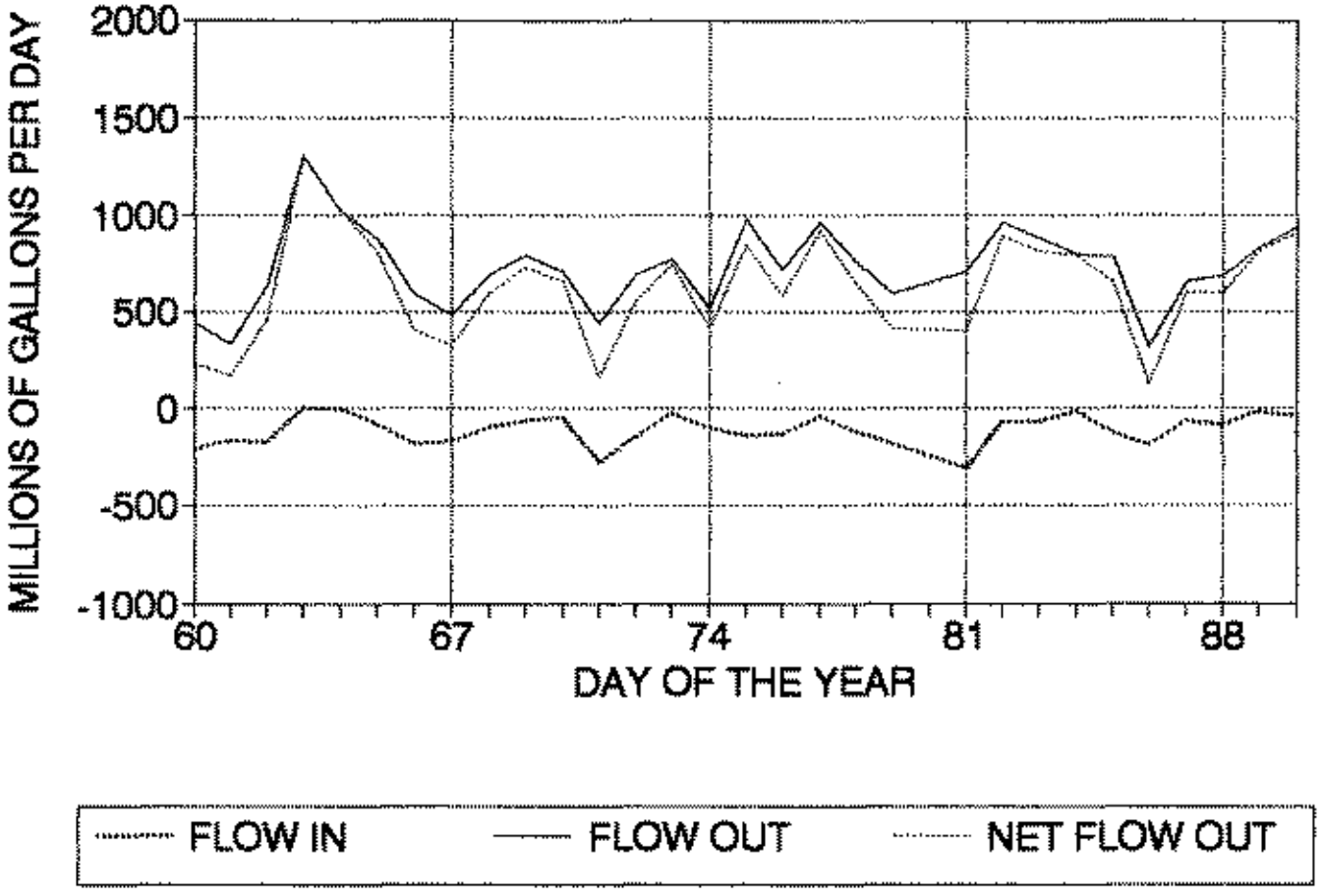
FEBRUARY DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



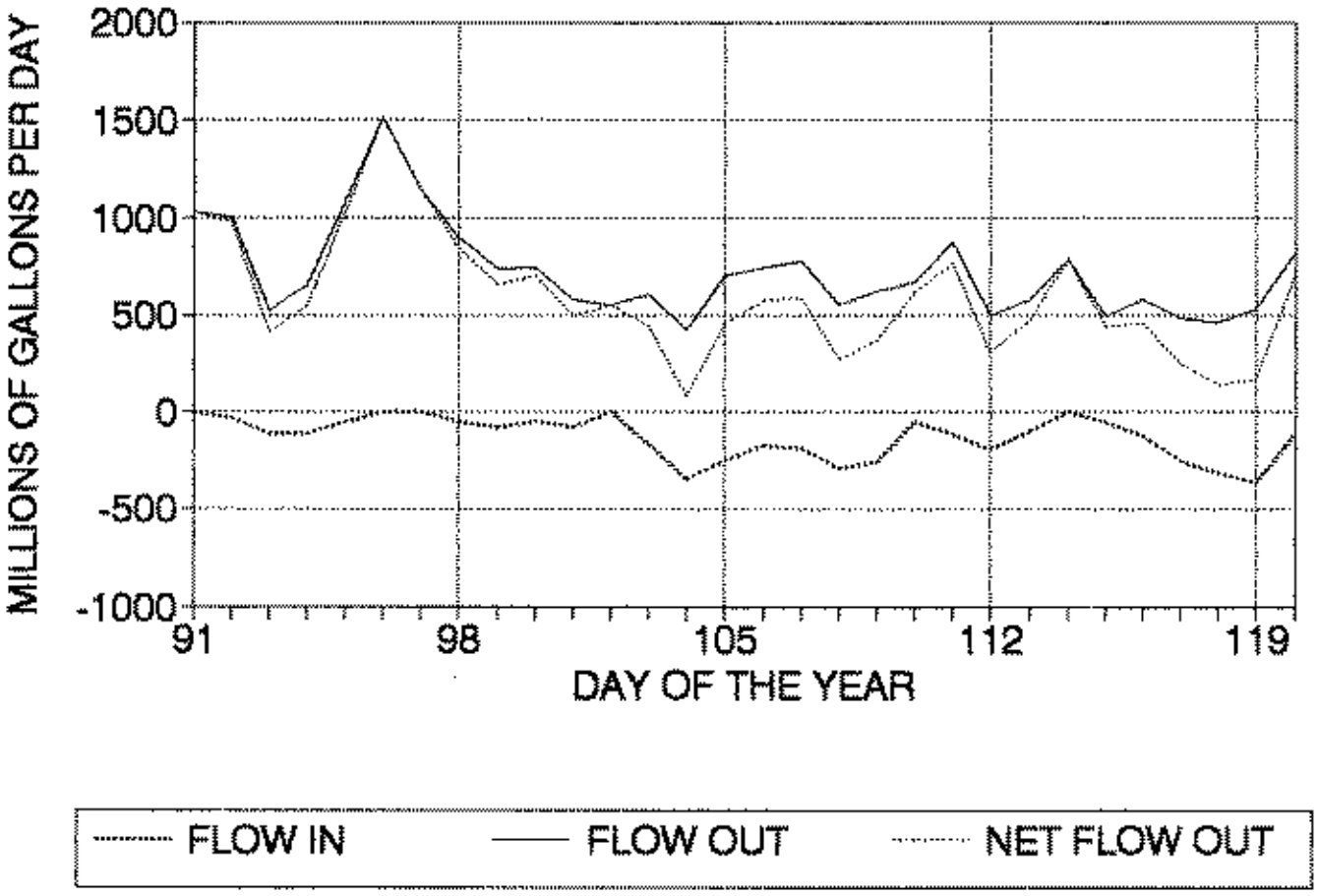
MARCH DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



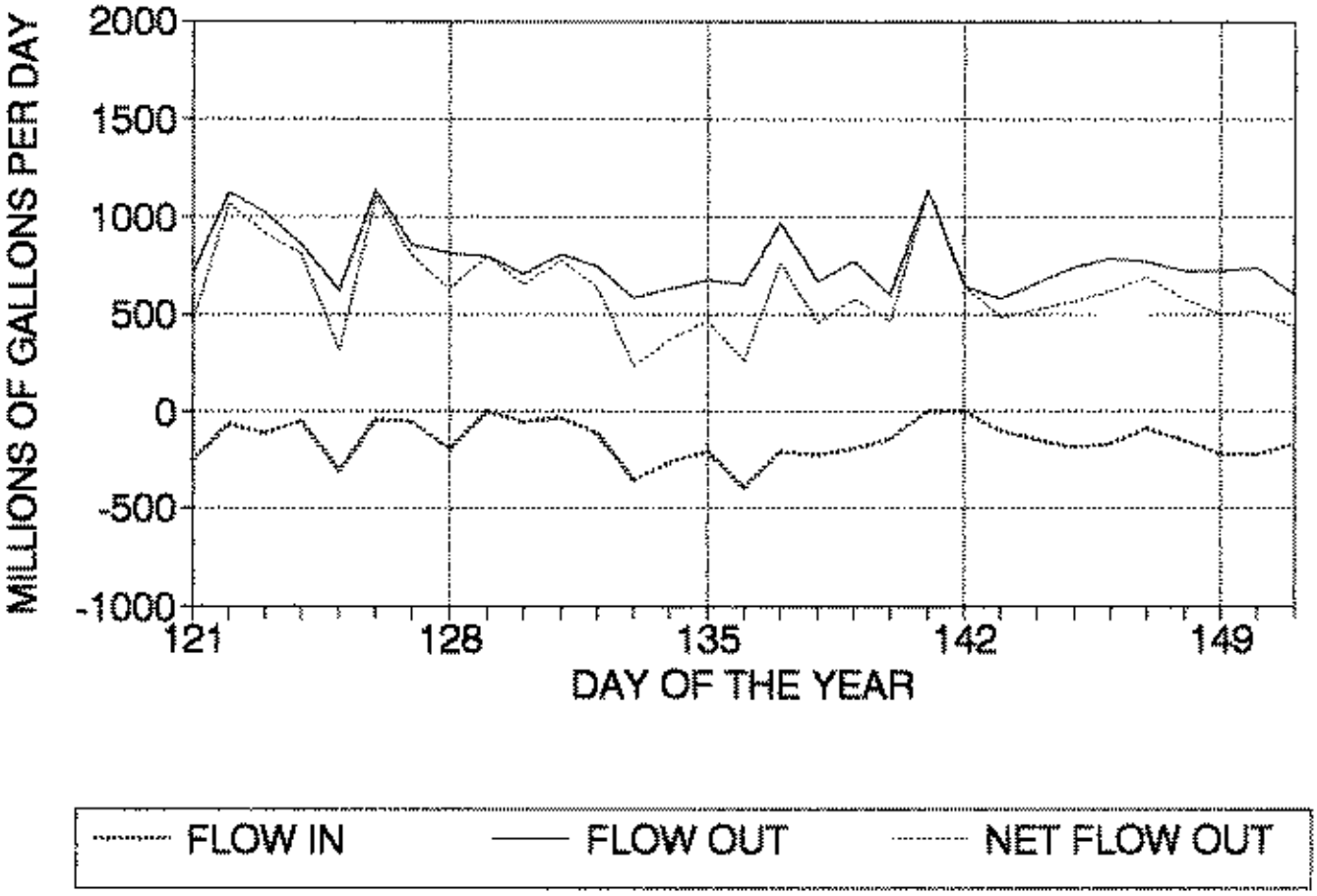
APRIL DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



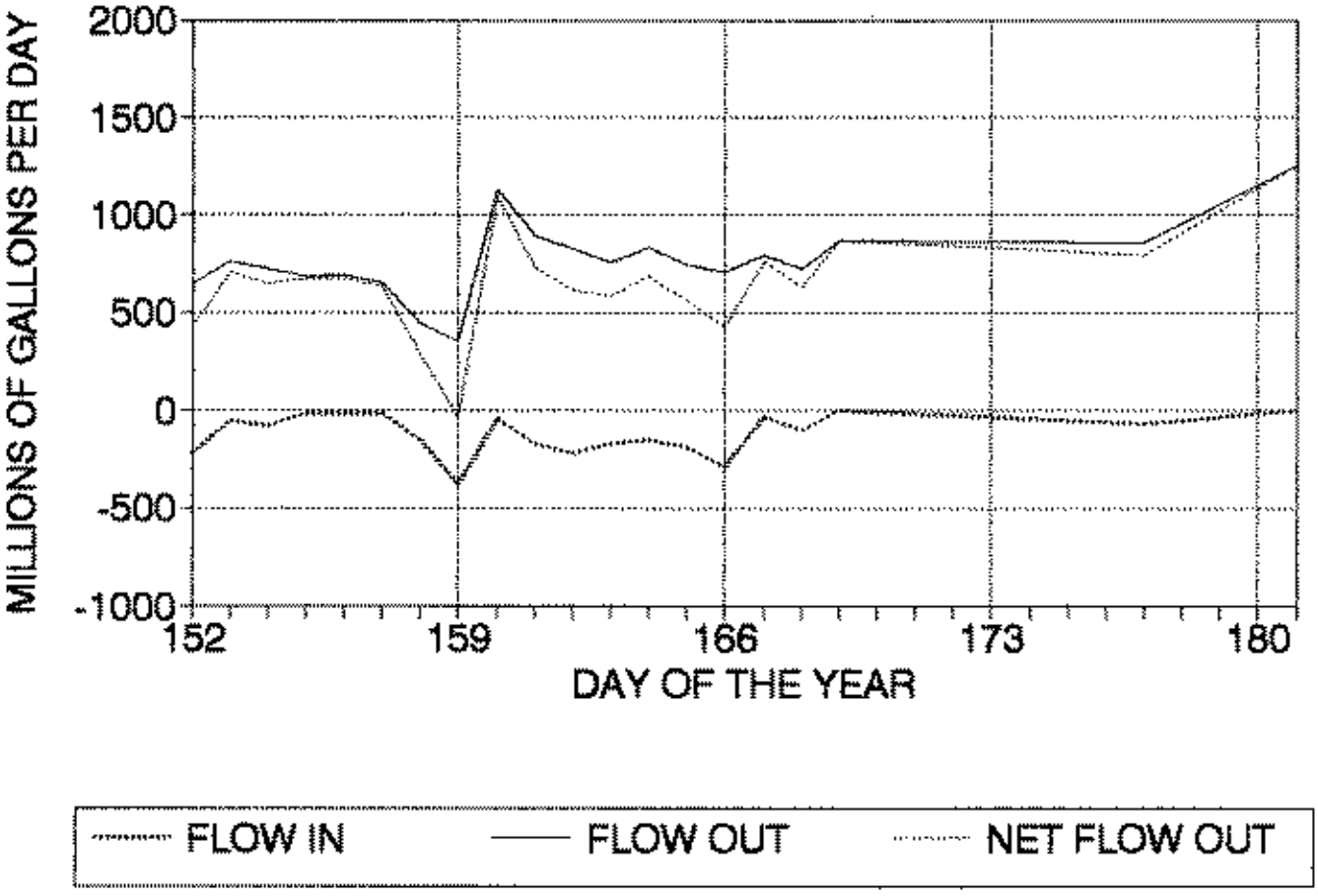
MAY DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



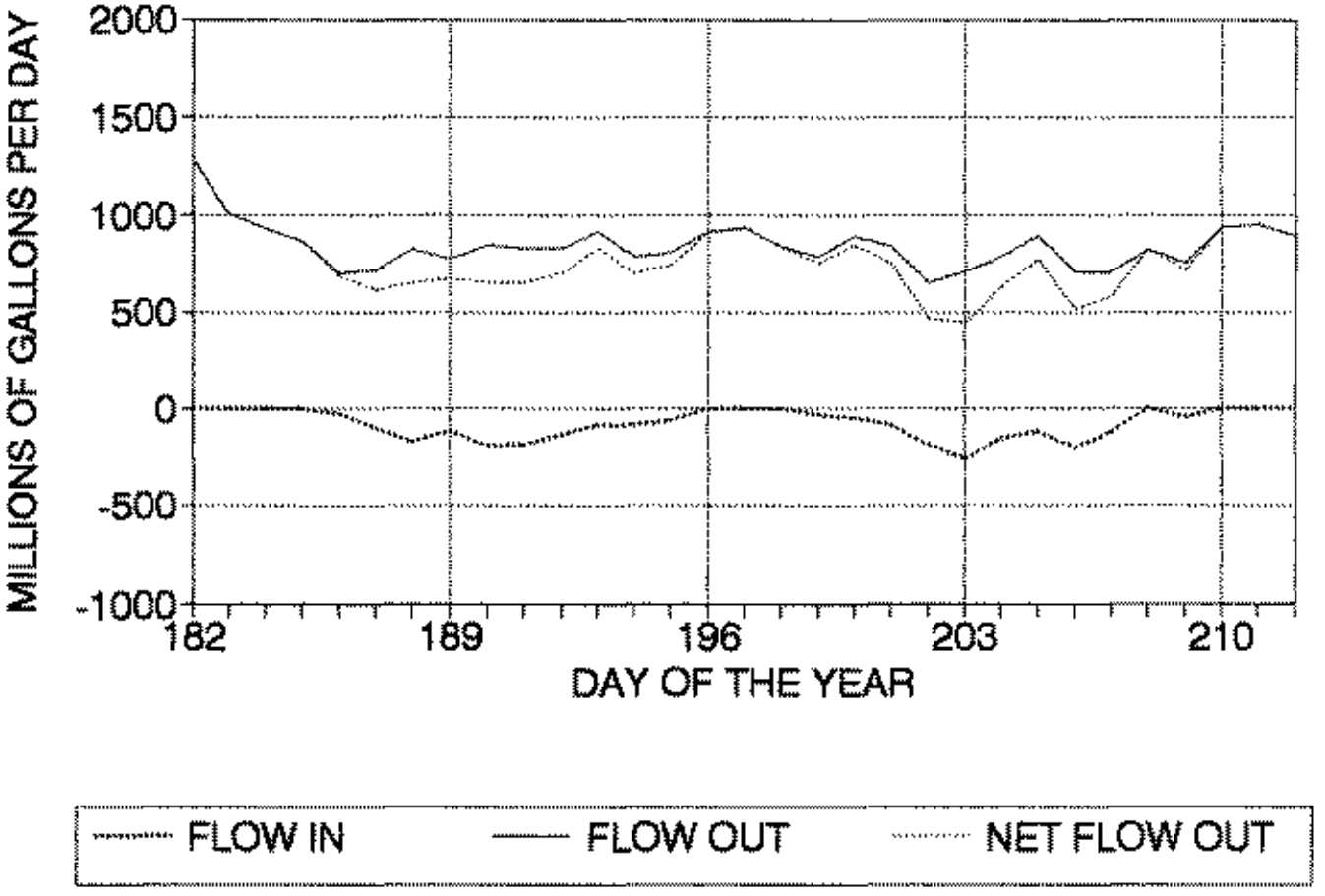
JUNE DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



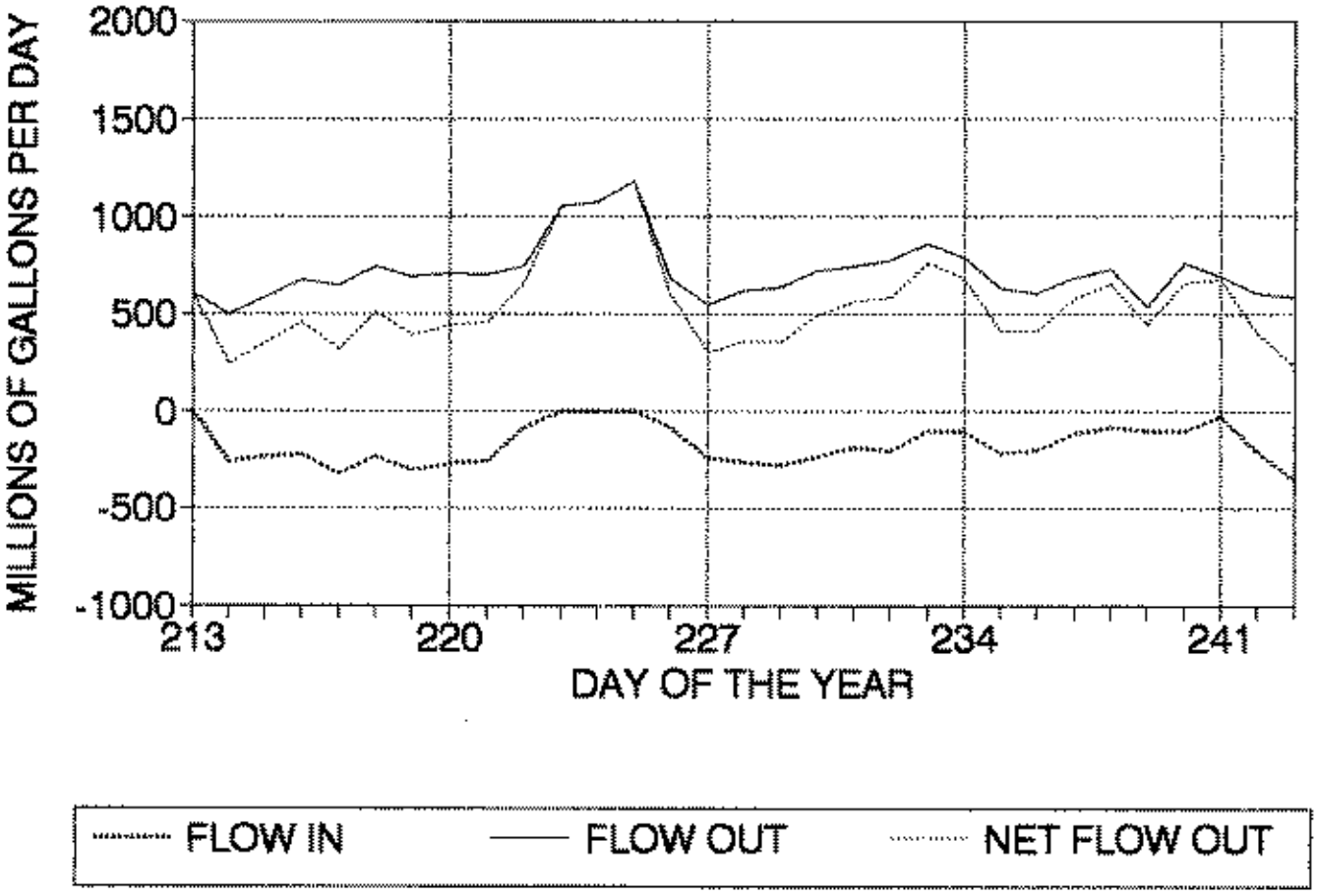
JULY DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



AUGUST DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO



SEPTEMBER DISCHARGE

POSITIVE IMPLIES FLOW OUT OF OSO