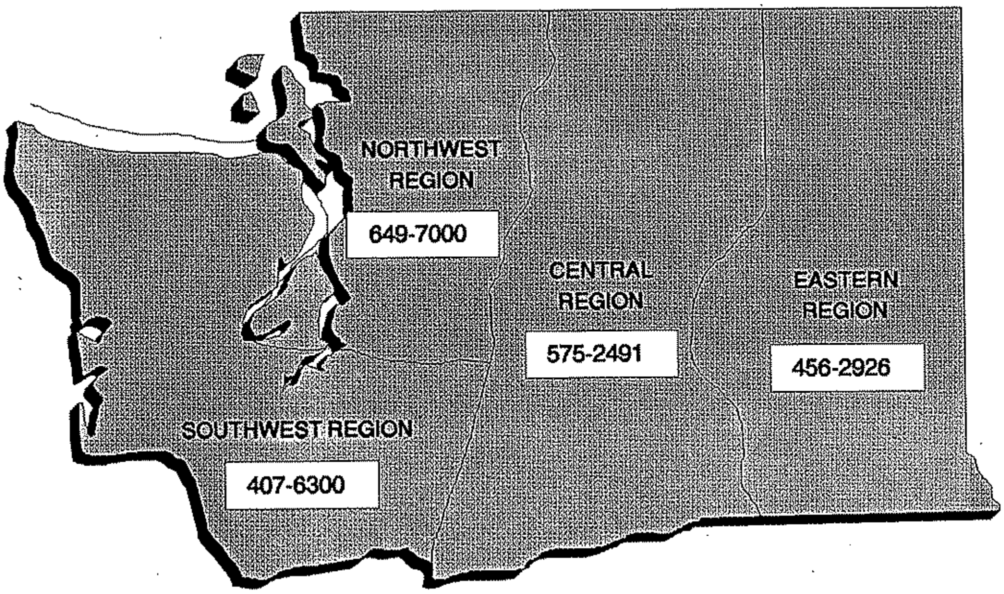
WASHINGTON STATE DEPARTMENT OF ECOLOGY

# An Analysis of the Effect of Discharged Wastewater on the Stillaguamish River at Stanwood

July 1996
Publication No. 96-330

*For additional copies of this report, contact:*

*Department of Ecology*
*Publications*
*P.O. Box 47600*
*Olympia, WA 98504-7600*
*Telephone: (360) 407-7472*




*The Department of Ecology is an equal opportunity agency and does not discriminate on the basis of race, creed, color, disability, age, religion, national origin, sex, marital status, disabled veteran's status, Vietnam Era veteran's status, or sexual orientation.*

*For more information or if you have special accommodation needs, please contact Barbara Tovrea at (206) 407-6696. Ecology Headquarters telecommunications device for the deaf (TDD) number is (206) 407-6006. Ecology Regional Office TDD numbers are as follows:*

*SWRO (TDD) (360) 407-6306*
*NWRO (TDD) (206) 649-4259*
*CRO (TDD) (509) 454-7673*
*ERO (TDD) (509) 458-2055*

# An Analysis of the Effect of Discharged Wastewater on the Stillaguamish River at Stanwood

by
*Norm Glenn*

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Watershed Assessments Section
P. O. Box 47600
Olympia, Washington 98504-7600

Water Body No. WA-05-1010

July 1996
Publication No. 96-330

*Printed on Recycled Paper*

# Table of Contents

# List of Figures



# List of Tables

# List of Appendices

# Abstract

A dye study was conducted in late summer 1992 in a remnant channel of the Stillaguamish River. The purpose of the study was to assess the present impact of the city of Stanwood's intermittent wastewater discharge and the future impact that a continuous discharge might have. This discharge was the only freshwater inflow to the channel, which was actually a tidal bay. Dye injection began on an ebbing tide and continued for one tidal day for the dual purposes of calibrating a mixing zone model and determining far-field accumulation of effluent. The EPA 3PLUMES model was validated for the acute boundary and was calibrated for the chronic boundary by adjusting one coefficient. Dye measurement data from six days and the principle of superposition were used to calculate far-field accumulation.

There were a number of noteworthy findings:

- the ultimate daily maximum concentration of dye within the mixing zone (assuming a continuous discharge) was 10% of the concentration present in effluent;
- flushing time is about three days;
- acute and chronic dilution factors under the present situation are 13:0 and 205.6, respectively;
- the copper criterion is violated at the acute boundary and the ammonia criterion at the chronic boundary;
- in a future scenario which assumes a continuous discharge of higher flow rate, dilution factors will be 16.6 and 41.6;
- the copper criterion will be violated at the acute boundary and ammonia at the chronic; and
- there is a reasonable potential that the chronic criterion for nickel is presently being exceeded--a condition which would continue in the future situation to be joined by lead.

# Introduction

Stanwood is a city of about 2,100 people in Snohomish County (Figure 1). The wastewater treatment plant (WWTP) is located immediately adjacent to an old channel of the Stillaguamish River at about RM 4.1 (Figure 2). Discharge is authorized by National Pollutant Discharge Elimination System (NPDES) permit no. WA-002029-0, which expired in September 1987 but remains in effect. The outfall is an open-ended pipe which terminates 20 feet from shore.

Discharge is intermittent, occurring as infrequently as once every three weeks in the summer, and is not possible when the (Seattle) tide exceeds 10.5 feet because the WWTP has no pumping capability. Discharge times are not restricted by permit conditions (*i.e.*, the operator has the discretion to discharge on incoming as well as outgoing tides).

Although it is still called the Stillaguamish River, most Stillaguamish River flow was diverted out of this channel more than 40 years ago at a point seven miles upstream from the city of Stanwood. The river now travels down Hat Slough except during high flow periods, when some of the river overflows into this remnant channel. As a result, the channel has experienced a build-up of sediment and vegetation and diminished flow over the ensuing years. During low flow periods, it is a tidal bay.

The channel is about 60-200 feet wide at high tide and is contained by levees throughout much of the last 3.5 river miles. It bifurcates at about RM 1.5 (Figure 2). South Pass appears to transport about 80 percent of the flow to and from Port Susan Bay; West Pass carries the remaining flow to and from Skagit Bay.

The purpose of this study is to analyze the effect of Stanwood's discharge on this channel. The analysis will provide information to the permit manager on whether Washington State water quality standards [referred to hereafter as "the standards"] are/will be violated because of this discharge and on the need for effluent limits in a reissued permit.

The study objectives are as follows:

1. Measure background concentrations of pollutants of concern in the receiving water at a time when there is no effluent present from the WWTP;
2. inject effluent with dye and measure concentrations of dye at selected stations in the receiving water for up to nine days;
3. validate a theoretical mixing zone model with field data;
4. determine the portion of effluent which is reintroduced by tidal reversals (far-field accumulation);
5. calculate a flushing time;

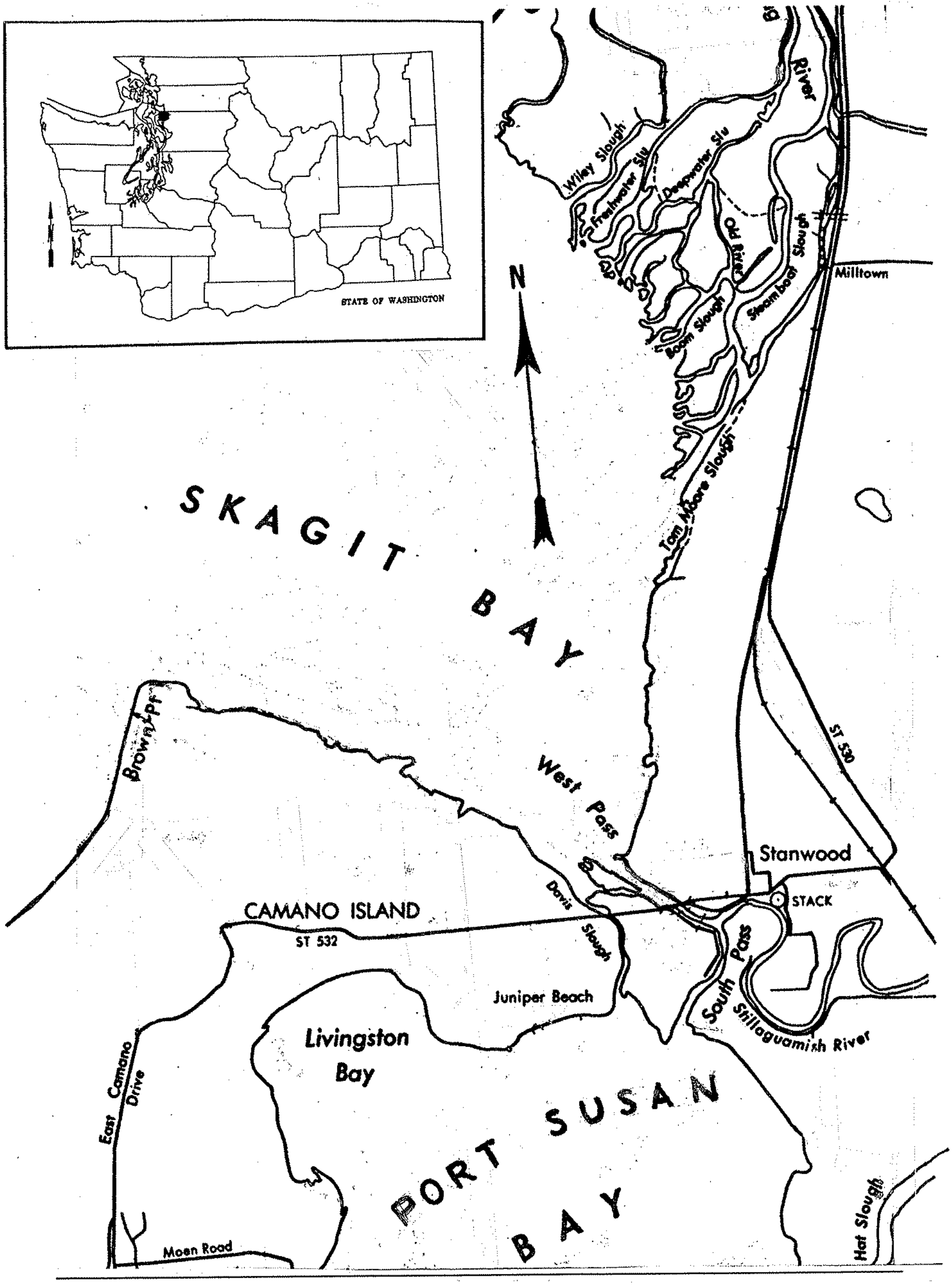
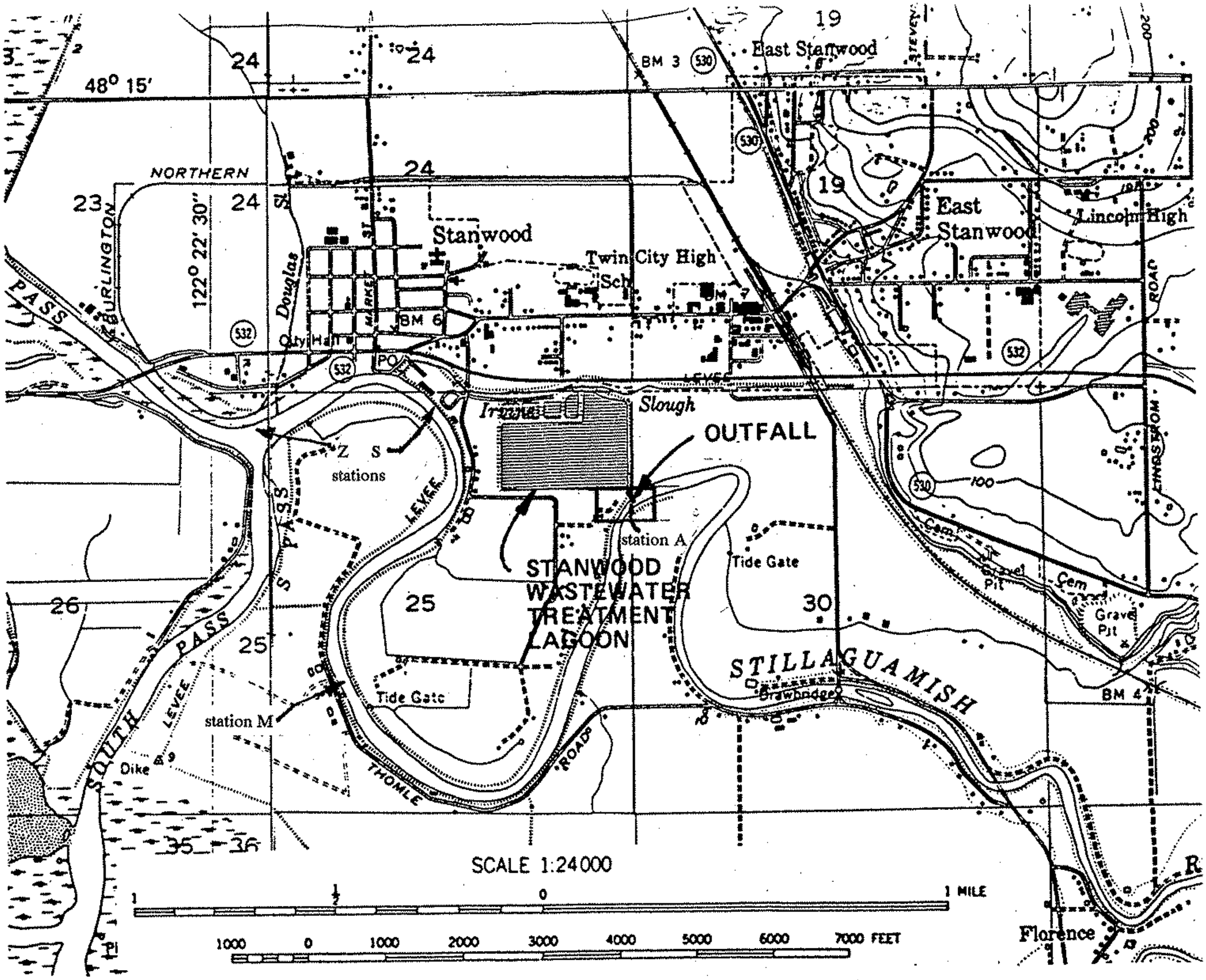





Figure 1. Location Map.



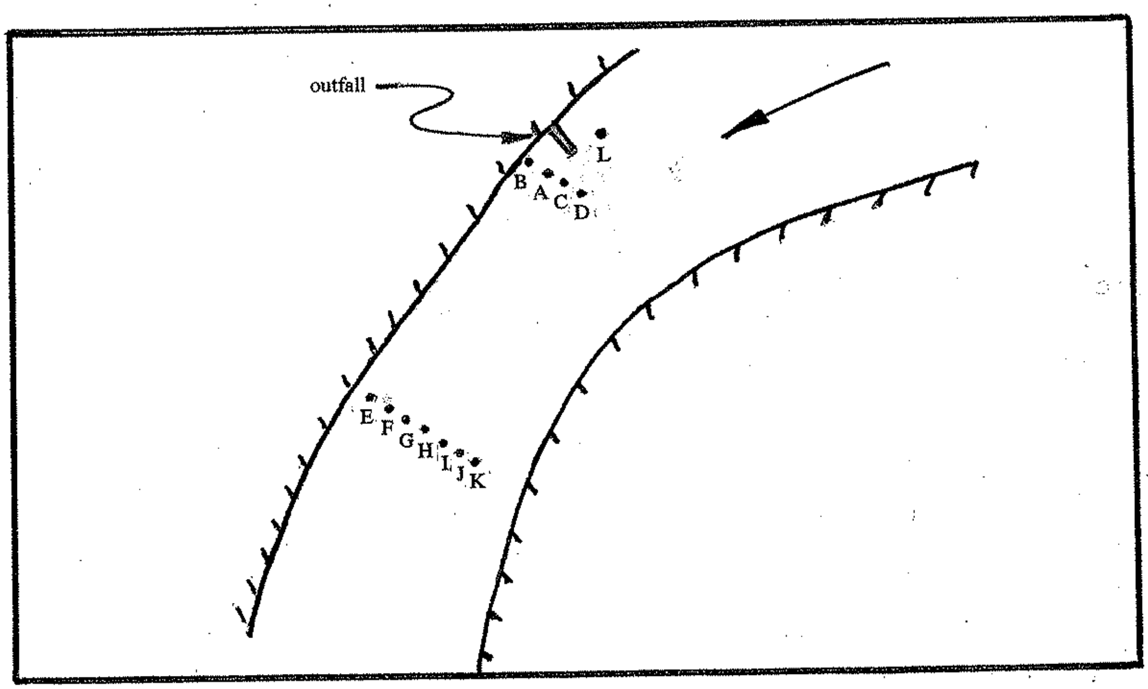




Figure 2. Detail Map.

6. analyze the effect of the present situation involving intermittent discharge by determining whether violations of the standards are occurring; and
7. project receiving water impacts under a critical design scenario where the WWTP is discharging continuously at maximum permitted loads.

Appendix A is a glossary of terms used in this report.

# Methods and Data Quality Assurance

A reconnaissance visit was made to the site on July 30, 1992. Cross-sections were taken in the channel at four locations using a Lowrance® sonar. Plots were created and cross-sectional areas calculated for each location. This information was of assistance in calculating an approximate volume of water in the tidal bay and quantity of dye to use. The plots are shown in Appendix B. A tidal gage plate was secured to a piling in the channel to serve as a relative datum against which to reference time and stage of tidal fluctuations. It was not referenced to a known datum.

A second visit was made to the site on August 18. Field methods and equipment were tested by conducting a one-hour simulated survey. Receiving water was collected, and standards were produced at Ecology's Manchester Environmental Laboratory for calibrating the Turner Model 10® fluorometer (Turner, 1990). Appendix C summarizes pertinent information about the field equipment used during the survey.

On the first day of the survey, taut lines were strung across the bay at locations where downstream edges of the acute and chronic boundaries would be. Stations A, B, C, D, and L were positioned along the acute boundary at 21 feet downstream and upstream from the outfall (Figure 2). (Station L is positioned upstream to monitor the acute boundary during flow reversals). Stations E through K were positioned along the chronic boundary that could be authorized, at 210 feet downstream from the outfall (Figure 2). Positions along these transects were coded on each line to ensure that the same station locations were revisited. Stations M, S, and Z were located 1.2, 2.0, and 2.5 RMs below the outfall, respectively.

Anchors and buoys were deployed at stations A, M, S, and Z. A Unidata® with datalogger continuously monitored depth for about two days at station A. A Hydrolab DataSonde® continuously monitored depth and a variety of water quality parameters at station S.

Several grab samples of receiving water were taken at station A before effluent discharge with dye injection began (one at lower low water [LLW] one at lower high water [LHW]). Receiving water fluorescence was also measured and found to be zero. A 24-hour automatic composite sample of effluent was taken for pollutants of concern, total suspended solids (TSS), and salinity. Results of these samples are shown in Appendix D.

Discharge from the WWTP and dye injection began at 1330 on September 3, 1992, and ceased at 1415 on September 4. Injection was located at the effluent weir to ensure maximum mixing. The pump drew from a solution consisting of 24 liters of 20% Rhodamine WT dye and tap water that had been premixed in two 55 gallon drums. The predetermined rate of 270 mL/minute was maintained throughout the tidal day as confirmed by the fact that both drums were emptied. Flow over the weir was carefully monitored in an attempt to maintain 0.5 million gallons per day (MGD).

Discharge and injection began at the initiation of a small ebb following a LHW. The duration of fall to higher low water (HLW) was about three hours. A drogue was deployed early in the ebbing stage and average current velocity for the stage was measured at 0.8 feet per second.

The Lowrance® was used to create a continuous bottom profile of the centerline of the bay. A fifth cross-sectional profile was taken at station M. The cross-sectional plot for station M is in Appendix B with the other four locations.

Dye concentrations were measured *in situ* during the first four days (several exceptions are noted below). While the first set of measurements was during a small ebb stage (LHW->HLW), it was intended that all remaining measurements be taken on stands of tide--involving 10 of the first 12 stands. The first three sets of measurements were at all of the stations shown on Figure 2; the remainder were at stations A, M, S, and Z only. The first 10 sets were at multiple depths, and the remainder at one foot below the surface because injection had ceased and the dye was vertically mixed.

It was necessary to obtain some dye concentrations by driving to the monitoring station and collecting samples for later analysis. A sill across the channel restricted navigation during lower stands of tide the first three days. Over the next five days, three additional sets of samples were collected during return trips for measurement at Ecology.

Continuous data collected at stations S and A were downloaded and are provided in Appendices E1 and E2, respectively. Gaps in the water level data at station S were supplemented by interpolated water levels, as explained in Appendix E1. Appendix F contains tide time and height information which has been referenced to the Julian date, the tidal gage plate, and the Unidata® depth monitor at station A. Explanations of the correction and normalization processes used are provided in the footnotes to the appendix.

Appendix G1 is a complete chronology of tide information and dye measurements for the nine days of the survey. The raw dye measurements were corrected because fluorescence is dependent upon temperature, time, chlorine, and turbidity. References used were Pritchard and Carpenter (1960), Hetling & O'Connell (1966), and Deaner (1973), respectively. Turbidity was accounted for by creating the calibration standards using receiving water brought back from a reconnaissance trip.

Appendix G2 contains a selected shorter-term group of data from Appendix G1 consisting of dye concentration measurements taken during the small ebb immediately following start of injection. It was used to calibrate the PLUMES model. Appendix G3 contains a selected longer-term group of data from Appendix G1. Each of the dye concentrations is the highest (corrected) value for that particular time at that station. Stand of tide durations are also shown for the purpose of illustrating on which stage of tide the dye measurements actually occurred. This information was useful when attempting to create the dye concentration-over-time curve, which must pass through each data point.

The principle of superposition was used to determine the ultimate daily maximum concentration attributable to far-field accumulation that could potentially occur under the steady-state conditions of a continuous discharge. The principle evolves from Linsley *et al.* (1958) and was later refined for use with dye tracer work by Bailey (1966), Yotsukura (1968), and Hubbard & Stamper (1972). It is explained in detail in Appendix H.

Considerable review of reconnaissance data must go into the selection of sampling stations and times at which the longer-term group of data is collected. In the case of a tidal bay, a pollutant mass discharged will remain centered about the point of discharge, but tidal action causes it to become more elongated with each tidal cycle. After a sufficient number of tidal cycles, the leading edge is flushed into the adjoining sea. Eventually, a steady-state condition develops (if the discharge is continuous).

There is a nearly constant relationship between the peaks of concentration at each sampling station and the rise and fall of the tides. It requires frequent measuring of concentrations at each station until this relationship can be established. It may then be possible to confine monitoring to the stage of tide when the maximum peak occurs; but, it is always better to err on the side of more frequent monitoring. An examination of the stages of tide listed in Appendix G3 confirms that the measurements weren't properly timed. This timing is a critical factor in correctly graphing the concentration-over-time curves and determines the ultimate daily maximum concentrations for each station.

The modified tidal prism method was used to calculate a flushing time. The raw trace data, explanations of how depth to bottom from MHW and MLW were determined, and calculated volumes are contained in Appendix I.

# Results and Discussion

Tidal action can cause far-field accumulation of pollutants. Part of the volume of water that enters during the flood tide can be made up of water that left the estuary on the previous ebb tide (refluxed water). The remainder can be thought of as "new" water that is available for dilution of pollutants inside the estuary. In pure theoretical analyses, far-field accumulation can only be crudely estimated. This is why a dye study becomes valuable. It can be used to determine far-field accumulation and also to develop a farfield diffusivity coefficient for the 3PLUMES model (referred to in the PLUMES User's Manual as the farfield dispersion coefficient).

## Validating the mixing zone model

Dilution factor (DF) is an important conceptual term in mixing zone analyses and water quality-based permitting (Ecology, 1994). If DFs are known for the acute and chronic boundaries of a mixing zone, then comparison of effluent pollutants of concern to receiving water quality criteria contained in the standards becomes a simple mass balance calculation. Appendix J contains a detailed explanation of how DFs are formulated, and of related terminology which appear in this text.

The 3PLUMES model was operating near the limit of its capability at Stanwood. The densimetric Froude number was less than one. When it is less than one the plume has virtually no momentum and is so buoyant that it separates from the bottom of the port orifice allowing ambient water to flow into the diffuser. The receiving water was also well-mixed and shallow, contributing to a rapidly surfacing plume.

Validating the model with dye work was important. The model was best validated using field data from the ebb tide immediately following initiation of dye injection. This is because there was no other time during field work involving dye injection when steady-state conditions prevailed (*i.e.*, a background fluorescence [$C_a$] of zero) Appendix K explains how the dye concentration in effluent ($C_e$) value (3,020 $\mu$g/L) was predetermined.

The objective of the model validation exercise was to compare theoretical to empirical results and make a judgment regarding acceptability of the model results. But first, it was necessary to make a judgment regarding the dye measurements (*i.e.*, which values best represented the concentration in the plume ($C_p$) at the two regulatory boundaries). The measurements taken at stations A - K during this first ebb tide (as shown in Appendix G1) show a dramatic flattening of the surfacing plume--analogous to a waffle cone unfolding into a waffle. It was no longer a plume by the time it reached the two boundaries. Most of the dye was in the top one foot of the water column, and the plume had spread to nearly 30 feet in width at the acute boundary, and 70 feet at the chronic boundary. It was decided to use the single highest reading for each station as most protective - specifically of the microlayer. However, it is suggested that Ecology develop clearer policy(s) regarding the actual point(s) of compliance on the regulatory boundary planes and protection of the microlayer.

Table 1 shows the comparison of theoretical to empirical results. 3PLUMES was not able to simulate this situation involving a rapidly surfacing plume: While the dye plume was nearly 30 feet wide and one foot thick at the acute boundary, the model plume was less than 6 feet in diameter. The dye plume had spread to nearly 70 feet at the chronic boundary and less than three feet thick, but the model indicated that the plume would be 25 feet in diameter. Nevertheless, 3PLUMES was validated for use at the acute boundary because it generated reasonably accurate concentrations at that distance from the discharge. This indicated that all entrainment took place within near-field and that flattening (and widening) of the plume was dramatic once the surface boundary was encountered. Appendix L contains this validating case run, coded Case: 1 of 4.

Concentrations generated by the model at the chronic boundary were significantly higher than those resulting from the dye study, and it was necessary to calibrate it. Two coefficients can be adjusted: the aspiration coefficient and farfield dispersion coefficient, the input cells described by the code names **<asp coeff>**, and **<far dif>**, respectively. The early exit from the near-field algorithm, validation of the model at the acute boundary, and dramatic spreading of the plume on the surface suggested that tuning of the farfield dispersion coefficient was needed in order to make model results at the chronic boundary acceptable. Appendix L contains this calibrating case run, coded Case: 2 of 4. Appendix M gives an explanation of the farfield algorithm.

## Determining far-field accumulation

Tides on the West coast of the United States exhibit a strong semi-diurnal inequality. A tidal day includes an HHW and an LHW, an LLW and an HLW, large ebbs and small ebbs, as well as large floods and small floods. For this reason, all dye studies should include a duration of injection of at least one tidal day.

The dye cloud elongates symmetrically about the point of injection when there is no freshwater inflow. The highest concentration is always at the center of mass (centroid). At a sampling station located near the point of injection, this centroid moves back and forth across the station with each ebbing and flooding stage causing four peaks during a tidal day. This concentration may decrease and then increase depending upon the robustness of ebbing and flooding tides. Stations far-removed longitudinally from the centroid may experience only two peaks. Concentrations can be expected to decrease during the quiescence of slack tides due to vertical and lateral dispersion and diffusion.

**Table 1. Comparison of Empirical and Theoretical Results.**

| Date.Time Number (Julian) (1)* | Sampling Station (2)* | Y coordinate (feet) (3)* | Empirical results Cp (ppb) (4)* | DF** (5) | Plume width*** (feet) (6) | Theoretical results^ Cp (ppb) (7) | DF (8) | Plume width (feet) (9) | Point of comparison (10) |
|---|---|---|---|---|---|---|---|---|---|
| Ebb tide following LHW stand | | | | | | | | | |
| 33850.60 | B | 0 | 185.6 | | | | | | |
| 33850.60 | A | 10 | 232.0 | 13 | 30 | 213 | 14 | 6 | longitudinal acute boundary; (distance = 21 ft). |
| 33850.61 | C | 20 | 157.8 | | | | | | |
| 33850.62 | D | 30 | 0.5 | | | | | | |
| | | | | | | | | | |
| 33850.63 | E | 10 | 52.8 | | | | | | |
| 33850.63 | F | 20 | 39.9 | | | | | | |
| 33850.64 | G | 30 | 39.0 | | | | | | |
| 33850.63 | H | 40 | 36.2 | | | | | | |
| 33850.65 | I | 50 | 44.0 | | | | | | |
| 33850.65 | J | 60 | 58.7 | 51 | 70 | 59 | 51 | 25 | longitudinal chronic boundary; (distance = 210 ft). |
| 33850.65 | K | 70 | 4.6 | | | | | | |

* – Information in columns (1) – (4) has been carried forward from columns (1), (3), (5), and (4), respectively of Appendix G2.
Date.time is a unique number representing the number of days (and fraction of days) since midnight of December 31, 1899.
Y coordinate = distance traversing the channel (along Y–axis) as measured from right bank.

** – Calculated using Equation (3) in Appendix J.

*** – Determined approximately by examining Y coordinates in column (3) and concentrations in column (4).

^ – Generated by 3PLUMES model, Ed. 3.1 (8/7/95). Refer to Case 1 in Appendix L.

The shapes of concentration-over-time curves that can be plotted vary considerably. Some curves display successively lower peak concentrations following cessation of injection. Other curves show successively lower peaks within a tidal day and successively lower maximum peaks from day-to-day, but a maximum peak may be higher than several of the peaks in the previous tidal day. The shape is dictated by: 1) the quantity of freshwater inflow, and 2) the location of the sampling station in relation to the centroid. The key to an accurate determination of far-field accumulation using the superposition approach is to measure the maximum peak in each tidal day.

Station A was chosen because it was obvious that in this tidal bay a station in close proximity to the discharge point was going to have the highest steady-state concentration. The schedule of sampling was devised so that dye measurements were taken during stands of tide. Unfortunately, it was not understood then that peaks occur during the brief period when the centroid of the dye cloud moves through the sampling station and sampling of the centroid likely did not occur. Dye measurement should have been scheduled frequently during the ebb and flood stages of tide.

Figure 3 is a concentration-over-time curve which connects the dye measurements, but it is likely that the curve underestimates the actual peaks in concentration that occurred at the sampling station. This problem could have been avoided by using a newer model digital fluorometer which can read and store dye concentrations continuously. Figure 3 also includes the curve showing tidal action so that the relationship between stage of tide and dye concentration can be seen.

The ultimate daily maximum concentration of dye at station A was determined from Figure 3 by summing the daily maximum peak concentrations - including the peak that occurred during dye injection. The prior-occurring "background fluorescence" in the Stillaguamish River is zero. So, the correct concentration of dye within the mixing zone (assuming a continuous discharge) was:

$$232 + 22 + 20 + 10 + 10 + 5 + 4 + 3 = 306\ \mu g/L,$$

which was 10% of the concentration present in effluent (3,020 $\mu$g/L).

Referring to the dye study results shown in Figure 3 and the information under subheadings Introduction, Definitions, and Mass Balance Equations for Alternative 1 in Appendix N:

$$C_{max} = V = 232\ \mu g/L;$$

$$\mathbb{C}_{max} = \underline{V} = 306\ \mu g/L; \text{ and}$$

$$r_d = 0.24$$

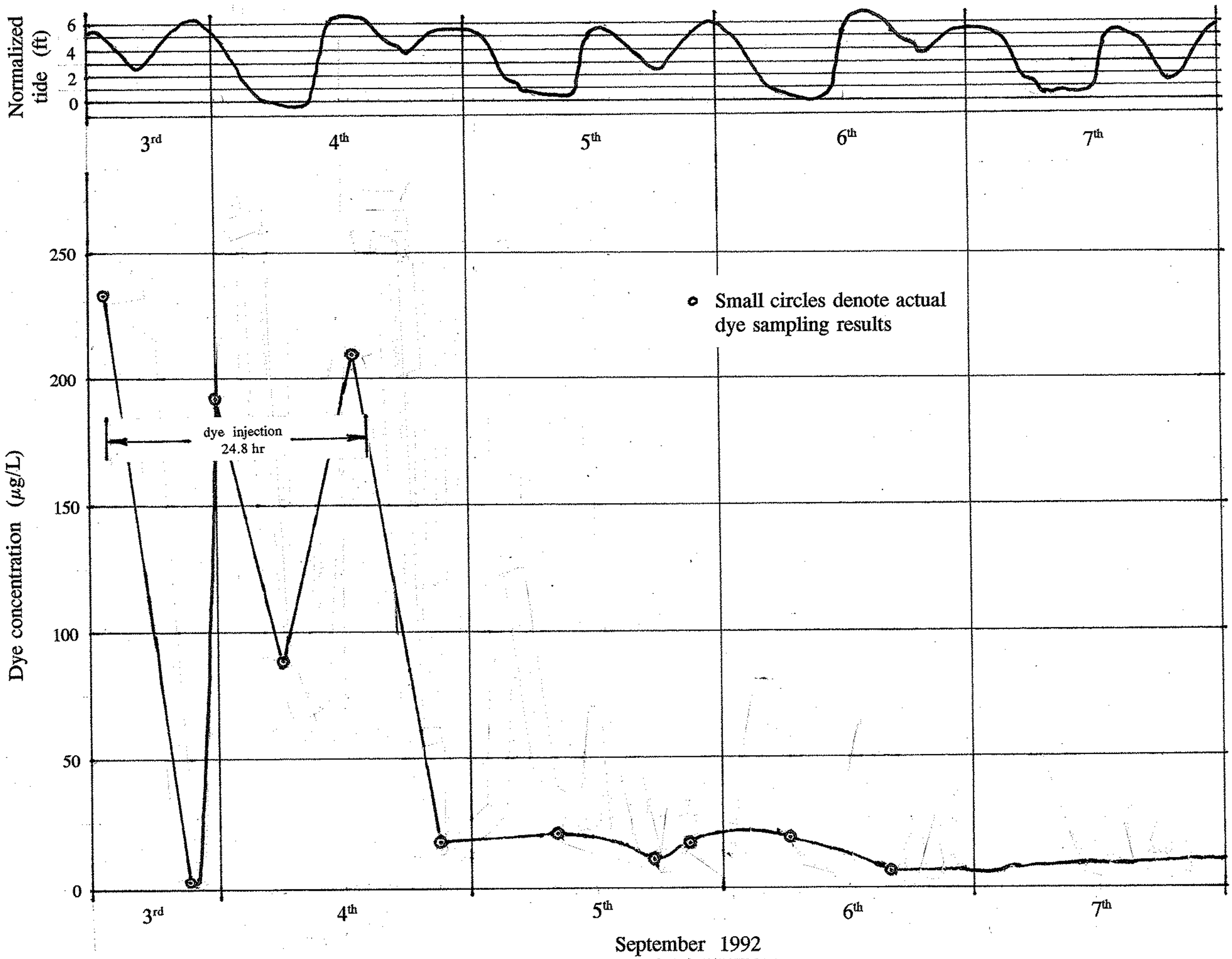



Figure 3. Tidal and Concentration-over-time Curves for Station A.

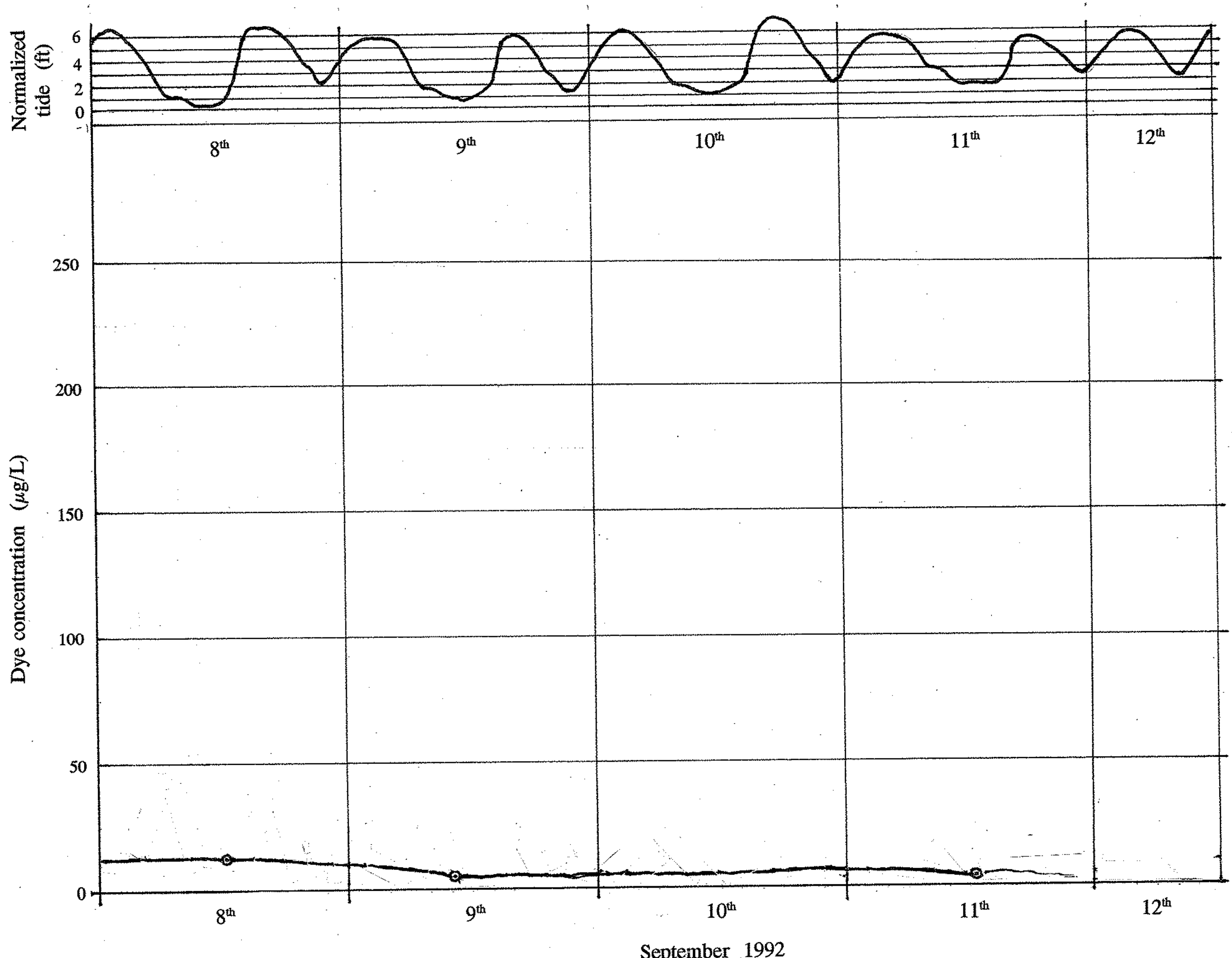



Figure 3. Tidal and Concentration-over-time Curves for Station A (cont'd).

Appendix N refers to a third method for determining far-field accumulation, a default value based on $r_d$, which avoids the expense of a dye study. This Jirka term ($r_d$) was selected as the basis for a default value because enough research has been conducted to provide reliable numbers for several different types of receiving water. Paraphrasing Subsection 2.6.2 in EPA (1992) as it applies at Stanwood:

> The return rate . . . can be expected to vary in the range of $\leq 0.1$ to $\approx 0.5$ (highly conservative estimate). . . . It may be reasonably high (up to 0.5) for shallow water, vertically mixed, discharges in strongly restricted estuaries with weak flushing.

The guidance appears in Ecology's *Permit Writer's Manual* as follows:

> The MZ modeling analysis conducted in the office should simulate an ebbing tide, and then the assumption should be made that far-field accumulation reduces the resultant DFs at acute and chronic boundaries by one-half (Ecology, 1994).

This is equivalent to an $r_d$ of 0.5.

Anytime a dye study is done there are two $r_d$'s from which to choose: the one derived empirically, and the default value. Ordinarily, the empirically derived one is lower and more representative of the discharge location, and should be chosen. It was pointed out earlier that the 0.24 value probably contributes to an overestimation of the dilution factors; but 0.5 is probably conservative, resulting in an underestimation of the dilution factors. The 0.24 value is used in this report.

It would be helpful to permittees if guidance were available on whether to conduct a dye study or accept the default value when addressing the effect of far-field accumulation. Return rate and its closely associated flushing time can vary dramatically from estuary to estuary and are not that easy for the inexperienced person to estimate from observations.

## Determining flushing time

The modified tidal prism method is one of four methods for calculating flushing time which is discussed in Mills *et al.* (1985). The first step in using the method is to divide an estuary into segments. Within each segment the tidal prism is compared to the total segment volume as a measure of the flushing potential of that segment per tidal cycle. The method assumes complete mixing of the incoming tidal prism waters with the subtidal volume as it iterates its way from head waters to mouth through the entire estuary. The method is also capable of reflecting the presence or absence of freshwater inflow.

Figure 4 is a graph of the cumulative intertidal and subtidal volumes in the estuarine portion of the Stillaguamish River established during the study. It was prepared using the calculated water volumes in Appendix I and in accordance with the methodology in Mills *et al* (1985). Table 2 shows that the flushing time calculated using this method is about three days.

## Efficacy of discharging on ebb tides only

Intuitively, it makes good sense to discharge only on ebb tides. Every discharger to tidally-influenced waters should do this as long as the additional storage needed is affordable. That may not always be the case, so this analysis takes a brief look at the factors involved:

- robustness of ebb tide;
- duration of fall of tide;
- relative size of tidal prism; and
- distance to mouth of estuary.

The survey took place during a first-quarter moon with minimal tidal fluctuations (Tide Guide, 1992). Perigean tides, which occur during a new moon, are the most robust.

Appendix F shows that the duration of fall of the ebb tide following the LHW stand was four hours, but that the duration of the ebb following the ensuing HHW was nearly eight hours. The Appendix also indicates that the tide time corrections for the various stands of tide, which are shown for "Stanwood/Stillaguamish" in the Tide Guide (1992), can be off by as much as 1½ hours (*e.g.*, the ebb following the LHW stand was of four hours duration, not six hours as suggested by the Guide).

This tidal bay has a relatively large tidal prism (and correspondingly, a short flushing time). The influence of a large tidal prism becomes more evident when the first two factors are optimized such that a minimal amount of pollutants are refluxed above the discharge point. This is a positive factor for the Stanwood situation.

Longitudinal trace information in Appendix I shows that the discharge point is more than four miles from the mouth. Dye results in Appendix G1 indicate that during an ebb following a LHW stand of tide effluent can reach station M, which is a travel distance of 1.2 miles. So, during the less robust of the two daily ebb tides, effluent travels less than one-third of the distance to the mouth. The ensuing flood tide undoubtedly pushes the entire effluent cloud upstream past the discharge point.

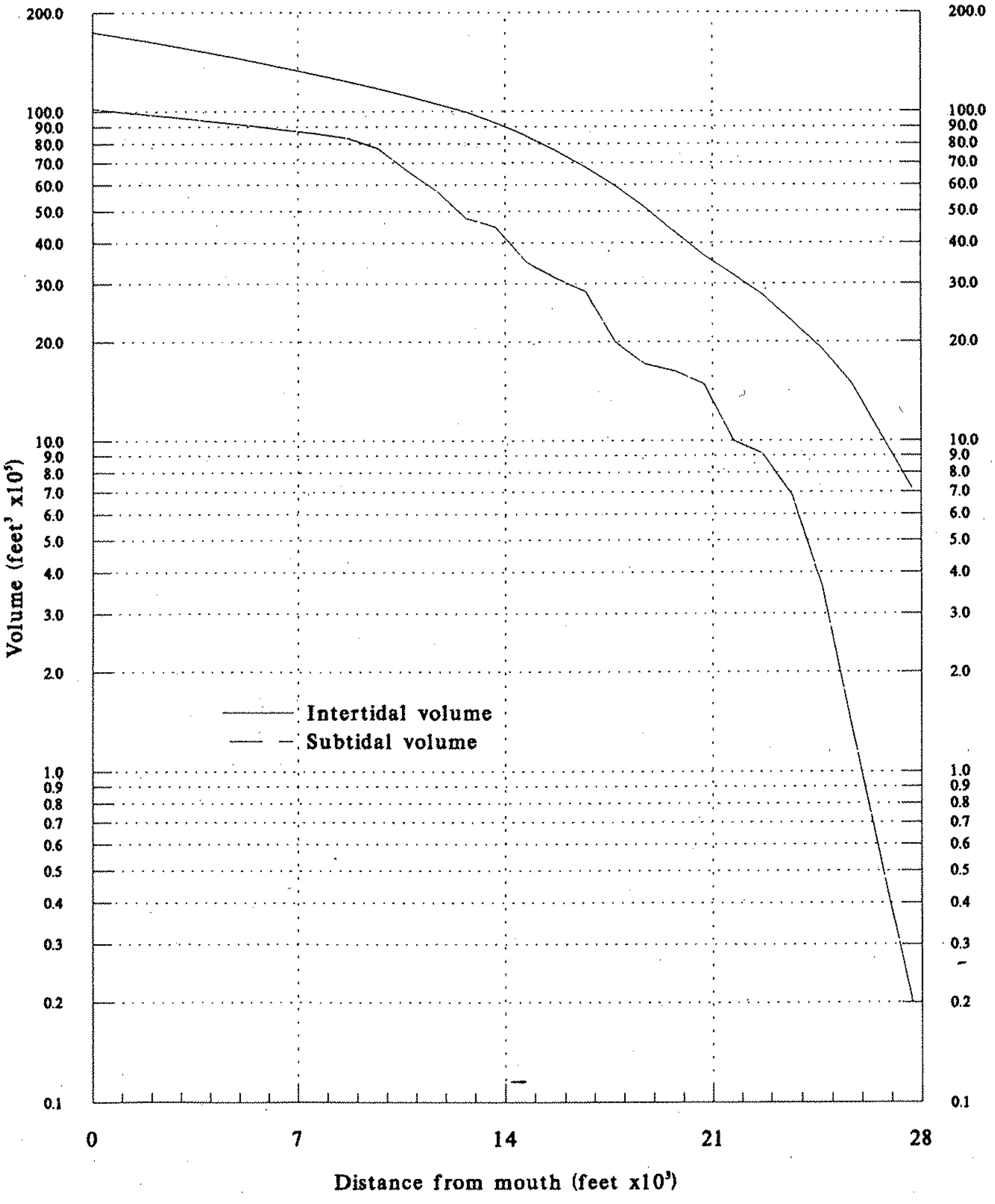



**Figure 4. Cumulative Intertidal and Subtidal Volumes.**

**Table 2. Water Volume Data and Flushing Time Calculations for Lower Stillaguamish River.**

| Segment Dimensions | | | Subtidal Volume per Segment ($ft^3$ x 10 ) | Intertidal Volume per Segment ($ft^3$ x 10 ) | Segment Exchange Ratio | Segment Flushing Time (tidal cycles) |
|---|---|---|---|---|---|---|
| Starts at this distance above mouth (feet) | Stops at this distance above mouth (feet) | Segment length - (feet) | | | | |
| ±32,700 | 32,700 | 0 | 0 | 0 | 0 | 0 |
| 32,700 | 27,700 | 5,000 | 0.2 | 7.1 | 0.97 | 1.03 |
| 27,700 | 23,500 | 4,200 | 7.4 | 16.9 | 0.7 | 1.44 |
| 23,500 | 15,600 | 7,900 | 24.2 | 52.8 | 0.69 | 1.46 |
| 15,600 | 0 | 15,600 | 70.1 | 97.8 | 0.58 | 1.71 |
| | | | | | | 5.64 |
| | | | | | | (3 days) |

Distance of the discharge point from the mouth appears to be an overriding factor. Regardless of the discharge scenario devised, the entire volume of effluent refluxes at least once; but under an optimum scenario the centroid of an intermittent discharge need not reflux above the discharge point. This optimum scenario would limit discharges to the large ebb stages of tide (following HHWs). The large difference between durations of fall and disparity in starting times of ebb tides from the published information (as well as possible effects that lunar and seasonal tide cycles and seasonal freshwater inflow may have on these) suggest the need for a documented discharge schedule. A schedule would show the dates and times of appropriate ebb tides and the allowable duration of discharge. Articles by Webb & Tomlinson (1992) and Duxbury (1988) are excellent references for further inquiry.

## Analysis of present situation

An analysis of the effect on receiving water involves: 1) determining the dimensions of each mixing zone, 2) finding the minimum dilution factors, 3) comparing concentrations of pollutants of concern to the appropriate water quality criteria at each boundary, and 4) establishing waste load allocations (WLAs) for each pollutant. The mixing zone regulations are in Chapter 173-201A-100 WAC (Ecology, 1992). Three places in this subsection discuss dimensions with applicability to the Stanwood situation:

> [(7)(b)(i)] The maximum size of a mixing zone shall . . ."not extend in any horizontal direction from the discharge port for a distance greater than two hundred feet plus the depth of water over the discharge port as measured during mean lower low water; and
>
> [(7)(b)(ii)] "The maximum size of a mixing zone shall . . . not occupy greater than twenty-five percent of the width of the water body as measured during mean lower low water; and
>
> [(8)(b)] "In oceanic and estuarine waters a zone where acute criteria may be exceeded shall not extend beyond ten percent of the distance established in subsection (7)(b) . . . "

The phrase "any horizontal direction" suggests a circular MZ boundary (when the outfall is a single port), but the "width of the water body" stipulation, coupled with a narrow river channel, mandates a more rectangular shape.

The first ebb tide following start of dye injection was more sluggish and the plume's lateral spread was more extensive. This was the appropriate opportunity to focus on plume dimensions and channel width considerations. Dye results shown in Table 1 give quite well-defined dimensions for the plume.

The channel width during mean lower low water (MLLW) was taken from the cross-section for station A which can be found in Appendix B. It is approximately 100 feet. Therefore, a strict interpretation of the regulations mandates dimensions for the boundaries as follows:

| | Y (lateral) dimension | X (longitudinal) dimension |
|---|---|---|
| • acute | 2.5 ft. | 21 ft. |
| • chronic | 25 ft. | 210 ft. |

However, a more liberal interpretation of the regulations is now being used by Ecology. The "ten percent of the distance" requirement for the acute boundary is interpreted as a distance equal to ten percent of the longitudinal dimension of the chronic boundary. This distance may be used as both the lateral and longitudinal dimensions of the acute boundary. So, the acute MZ boundary is taken as 21 feet in both the lateral and longitudinal dimensions:

| | Y (lateral) dimension | X (longitudinal) dimension |
|---|---|---|
| • acute | 21 ft. | 21 ft. |
| • chronic | 25 ft. | 210 ft. |

These are the maximum allowable dimensions for acute and chronic boundaries for Stanwood.

Results in column (6) of Table 1 show that the plume was already 30 feet wide at the acute boundary and had spread to a width of 70 feet at the chronic boundary. So, dye concentrations at both the lateral and longitudinal dimensions must be compared. The higher of the two concentrations (from both the acute and chronic boundaries) is the important one. Column (4) in Table 1 shows that the maximum dye concentrations at the acute and chronic lateral boundaries were approximately 157.8 and 39.0 ppb, respectively. However, there are higher values on the longitudinal boundary--232.0 and 58.7 ppb, respectively. Therefore, the minimum DFs are those shown in column (5) in Table 1:

| | |
|---|---|
| acute | 13.0 |
| chronic | 51.4 |

Chronic criteria assume a continuous exposure duration of four days. The WWTP operator indicated that the intermittent discharge occurs less frequently than once every four days; so, it was necessary to calculate an average--assuming one day of discharge and three days of no-discharge. The chronic DF was time-weighted (51.4, 0.0, 0.0, 0.0) and a harmonic mean DF of 205.6 was calculated. The acute DF was not corrected because acute criteria assume a one-hour duration of exposure.

Neither the chronic nor acute DFs was corrected for far-field accumulation under this condition of an intermittent discharge because a steady-state concentration of dye did not exist in the receiving water at the time short-term measurements (for determining these DFs) were taken. Therefore, the corrected DFs for use in the present situation are:

| | |
|---|---|
| acute | 13.0 |
| chronic | 205.6 |

These are appropriate as long as the frequency of discharge is one-day-in-four or less and the timing of the discharges coincides with large ebb stages of tide.

Table 3 shows the effects on receiving water of the present situation involving an intermittent discharge. Each of the $C_p$'s shown in columns (4) and (5) was calculated in accordance with the explanation and equation (3) given under the subheading Mass Balance Equations for Alternative 1, which is in Appendix N. The Water Quality Criteria shown in columns (6) and (7) are in accordance with the state's standards (Ecology, 1992) or EPA (1989).

The $C_p$'s in column (4) are concentrations calculated for the longitudinal acute boundary. A comparison of each of these values to those in column (6) shows that copper exceeds its acute criterion. $C_p$'s shown in column (5) are for the longitudinal chronic boundary. A comparison of each of the values to those in column (7) shows that ammonia violated its criterion.

All toxic effects testing has some degree of uncertainty associated with it. The more limited the amount of test data available, the larger the uncertainty. Only one sample was collected for each pollutant of concern in effluent and receiving water at Stanwood. EPA has examined a myriad of effluent toxicity data nationwide. A statistical approach has been developed to better characterize the effects of effluent variability and reduce uncertainty in the process of deciding whether to require an effluent limit. It involves the use of a "reasonable potential" multiplier, which is applied to a single value to project an estimated maximum concentration for the effluent.

The "Yes"/"No" information in columns (8) and (9) of Table 3 indicates whether a "reasonable potential" for violation of criteria exists after an appropriate multiplier is applied. The multiplier is from Table 3-2 of EPA (1991); the equation is from Chapter VI of Ecology (1994). This information indicates that a reasonable potential exists for nickel to exceed its chronic criterion under the present situation.

## Table 3. Effects on receiving water of present situation involving an intermittent discharge.

| Pollutant of concern* | Prior Occurring (Ca)** | Effluent (Ce)** | Plume (Cp) at boundaries*** Acute | Plume (Cp) at boundaries*** Chronic**** | Water Quality Criteria^ Acute | Water Quality Criteria^ Chronic | Reasonable potential^^ acute | Reasonable potential^^ chronic | Waste Load Allocation^^^ Acute | Waste Load Allocation^^^ Chronic |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Ammonia | 2,020 | 6,730 | 2,380 | 2,040 | 9,040 | 2,020^^^^ | No | Yes | 93,300 | 2,020 |
| Cadmium | 0 | 0.65 | 0.05 | 0.003 | 37.2 | 8.0 | No | No | 484 | 1,640 |
| Chromium | 3.46 | 2.31 | 3.37 | 3.45 | 1,100 | 50 | No | No | 14,300 | 9,570 |
| Copper | 5.2 | 22.5 | 6.53 | 5.28 | 5.2^^^^ | — | Yes | — | 5.2 | — |
| Lead | 0 | 47.1 | 3.62 | 0.23 | 151.1 | 5.8 | No | No | 1,960 | 1,190 |
| Nickel | 11.0 | 8.7 | 10.8 | 11.0 | 71.3 | 11.0^^^^ | No | Yes | 795 | 11.0 |
| Zinc | 24 | 68.9 | 27.5 | 24.2 | 84.6 | 76.6 | No | No | 812 | 10,800 |

* – All concentrations are in micrograms per liter (ug/L). Ammonia is Total Ammonia as NH3–N.

** – Concentrations have been carried forward from Appendix D.

*** – Determined by using equations (1), (2), and (3) under the subheading Mass Balance Equations for Alternative 1 in Appendix N.

**** – Chronic water quality criteria assume a 4–day duration of exposure. A weighted–average has been applied to the effluent concentration (Ce in column (3)) to reflect fact that discharge is intermittent. Refer to text.

^ – Water Quality Criteria (WQC) are found in WAC 173–201A–040 Toxic Substances (Ecology, 1992b), except Ammonia which is found in EPA, (1989).

^^ – Reasonable potential multiplier equals 6.2 for n=1 and CV=0.6 from Table 3–2 of EPA (1991). Determined by using equation in Chapter VI, section 3.3.10, subpart 4. of Ecology's Permit Writer's Manual.

^^^ – Determined by using equation (4) under the subheading Mass Balance Equations for Alternative 1 in Appendix N.

^^^^ – WAC 173–201A–070(2) states that whenever natural conditions are of a lower quality than the criteria assigned, the natural conditions shall constitute the criteria. Ammonia criterion assigned is 1,360; based on temperature of 19.27, pH of 7.8, and salinity of 14.5. Nickel criterion assigned is 7.9.

The WLAs are shown in columns (10) and (11). The copper WLA (acute) and ammonia WLA (chronic), which are outlined by boxes, reflect the present need for limits on these two pollutants to reduce the concentration in effluent below the amount measured during the field study. The values in bold lettering reflect reasonable potential. The city may be able to avoid an effluent limit on nickel by collecting additional samples in order to reduce the reasonable potential multiplier that is applied.

## Analysis of future situations

The model is used to generate dilution factors for future situations which involve a continuous discharge of effluent. This necessitates changing several of the variables and revisiting the coefficient (discussed under *Validating the mixing zone model*) in the 3PLUMES interface:

1. Effluent flow rate. Effluent flow rate was obtained from the city of Stanwood General Sewer Plan (KCM, 1994), which projected a discharge rate of 0.79 MGD in the year 2015. This is an appropriate number for analyses at the chronic boundary, but the *Permit Writer's Manual* suggests that a peaking factor be applied to this number for analyses at the acute boundary. A factor of 3.0 is used. This variable appears in the PLUMES interface under the cell name **<tot flow>**.

2. Farfield dispersion coefficient (**<far dif>**). The approach to making changes in this coefficient has been explained in Appendix M.

3. Far-field velocity. The only current velocity data is from the one-time drogue release. A minimum velocity is chosen when the analysis is done for the acute boundary. The average of 0.7 feet/second obtained from the drogue release is used for the analysis at the chronic boundary. This variable appears in the interface as **<far vel>**. (The current velocity used by the initial dilution algorithm appears in the interface under the cell name **<current>**; the same values were inserted here).

Case: 3 of 4 and case: 4 of 4 in Appendix L give the minimum DFs for the acute and chronic boundaries, respectively:

| | |
|---|---|
| acute | 21.8 |
| chronic | 54.7 |

Both the chronic and acute DFs must be corrected for far-field accumulation under this condition of a continuous discharge. Therefore, the corrected DFs for use in the future situation are:

| | |
|---|---|
| acute | 16.6 |
| chronic | 41.6 |

Table 4 shows the effects on receiving water of the future situation involving a continuous discharge. It can be understood by employing the same explanation and logic used in reading Table 3. Copper and ammonia again violate their water quality criteria: copper at the acute boundary; ammonia at the chronic boundary. Lead and nickel present a reasonable potential for violation. Additional sampling would increase the number (of samples) in the population and decrease the applicable reasonable potential multiplier. This could change the results as shown in both Tables 3 and 4.

# Conclusions and Recommendations

1. The Stanwood WWTP intermittently discharges treated wastewater into an old channel of the Stillaguamish River at RM 4.1. This channel acts as a tidal bay during the dry season (*i.e.*, there is no freshwater inflow). There is a sill across the channel at RM 3.7 which is exposed during lower low water (LLW).

2. Actual times of some tide stands in the channel differed from published times by as much as 1½ hours.

3. The 3PLUMES model was operating near the limit of its capability when modeling the future situation at Stanwood. Calibrating the model with dye work was important, particularly because of Froude numbers less than 1.

4. Measuring the cyclical peak concentrations of dye is imperative. These peaks occur during the brief periods when the centroid of the dye cloud moves through the sampling station. Many of the peaks were missed at Stanwood, resulting in an incomplete data set. In future mixing zone studies, the reconnaissance survey should be used to establish whether anomalous tidal movements are present - which may then influence the sampling schedule. An alternative approach would involve using a newer model digital fluorometer which can read and store dye concentrations continuously.

5. Anytime a dye study is done there are two return rates ($r_d$) from which to choose: the one derived empirically, and the default value of 0.5 allowed by Ecology. Ordinarily, the empirically derived one is lower and more representative of the discharge location, and should be chosen. The study at Stanwood yielded an empirical $r_d$ of 0.24 at the injection location.

## Table 4. Effects on receiving water of future situation involving a continuous discharge.

| Pollutant of concern* | Prior Occurring (Ca)** | Effluent (Ce)** | Plume (Cp) at boundaries*** | | Water Quality Criteria^ | | Reasonable potential^^ | | Waste Load Allocation^^^ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Acute | Chronic | Acute | Chronic | acute | chronic | Acute | Chronic |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Ammonia | 2,020 | 6,730 | 2,300 | 2,130 | 9,040 | 2,020^^^^ | No | Yes | 118,000 | 2,020 |
| Cadmium | 0 | 0.65 | 0.039 | 0.016 | 37.2 | 8.0 | No | No | 616 | 333 |
| Chromium | 3.46 | 2.31 | 3.39 | 3.43 | 1,100 | 50 | No | No | 18,200 | 1,940 |
| Copper | 5.2 | 22.5 | 6.24 | 5.62 | 5.2^^^^ | — | Yes | — | 5.2 | — |
| Lead | 0 | 47.1 | 2.85 | 1.13 | 151.1 | 5.8 | No | Yes | 2,500 | 241 |
| Nickel | 11.0 | 8.7 | 10.9 | 10.9 | 71.3 | 11.0^^^^ | No | Yes | 1,010 | 11.0 |
| Zinc | 24 | 68.9 | 26.7 | 25.1 | 84.6 | 76.6 | No | No | 1,030 | 2,210 |

* – All concentrations are in micrograms per liter (ug/L). Ammonia is Total Ammonia as NH3–N.

** – Concentrations have been carried forward from Appendix D.

*** – Determined by using equations (1), (2), and (3) under the subheading Mass Balance Equations for Alternative 1 in Appendix N.

^ – Water Quality Criteria (WQC) are found in WAC 173–201A–040 Toxic Substances (Ecology, 1992b), except Ammonia which is found in EPA, (1989).

^^ – Reasonable potential multiplier equals 6.2 for n=1 and CV=0.6 from Table 3–2 of EPA (1991).
Determined by using equation in Chapter VI, section 3.3.10, subpart 4. of Ecology's Permit Writer's Manual.

^^^ – Determined by using equation (4) under the subheading Mass Balance Equations for Alternative 1 in Appendix N.

^^^^ – WAC 173–201A–070(2) states that whenever natural conditions are of a lower quality than the criteria assigned, the natural conditions shall constitute the criteria.
Ammonia criterion assigned is 1,360; based on temperture of 19.27, pH of 7.8, and salinity of 14.5. Nickel criterion assigned is 7.9.

6. The return rate is part of an expression used to adjust an initial dilution factor to a quasi-steady state dilution factor, accounting for far-field accumulation. The percentage of far-field accumulation at Stanwood was underestimated because of the manner in which the field work was conducted, a liberal interpretation of results tending to overestimate dilution factors in favor of Stanwood. On the other hand, the default value would have been conservative, resulting in an underestimation of dilution factors.

7. A flushing time of about three days was calculated using a desk-top approach (modified tidal prism).

8. A liberal interpretation of Ecology's mixing zone regulations would allow a mixing zone to be established with the following dimensions:

| | **Y (lateral) dimension** | **X (longitudinal) dimension** |
|---|---|---|
| acute | 21 ft. | 21 ft. |
| chronic | 25 ft. | 210 ft. |

The lateral dimensions should have been determined prior to initiation of the survey so that two of the shorter-term sampling stations could have been sited at those precise locations.

9. The acute and chronic dilution factors for permitting purposes are as follows:

- present situation with intermittent discharge

| | |
|---|---|
| acute | 13.0 |
| chronic | 205.6 |

- future situation with continuous discharge and far-field accumulation

| | |
|---|---|
| acute | 16.6 |
| chronic | 41.6 |

10. Using the above dilution factors it appears that in both the present and future situations copper and ammonia concentrations measured in Stanwood's effluent cause a violation of the acute and chronic criteria, respectively. This is due, in large measure, to the high background concentrations of these pollutants in the receiving water. There is a reasonable potential for nickel to exceed its chronic criterion. Therefore, the WLAs for these latter two pollutants should also be included as effluent limits in the reissued permit. The permittee may be able to mitigate the

regulation of several of these pollutants through regular monitoring of metals and ammonia in effluent and receiving water. Collecting additional samples will decrease the applicable reasonable potential multiplier, which is presently based on a single sample.

11. A better designed outfall could provide an optimum balance between buoyancy and momentum, and thus more entrainment in the discharge plume. This would be reflected by a Froude number (ratio of buoyancy-to-momentum) between 15 and 30. Model results indicate the Froude number is presently less than one.

12. Data and observations from the study suggest that regardless of the discharge scenario devised, the entire cloud of effluent from an intermittent discharge refluxes at least once. But, under an optimum scenario of discharge during the more robust of the two daily ebb tides, the centroid of the discharge need not reflux above the discharge point. Discharge should be limited to this ebb tide. The large difference between durations of fall and disparity in starting times of ebb tides from the published information (as well as possible effects that lunar and seasonal tide cycles and seasonal freshwater inflow may have on these) suggest the need for a documented discharge schedule. A schedule would show the dates and times of appropriate ebb tides and the allowable duration of discharge.

13. The formulae to be used in deriving WLAs are:

- $\underline{DF} = DF\ (1 - r_d)$, where

  $\underline{DF}$ is DF corrected for far-field accumulation;

- $C_p = C_e\ (1 / \underline{DF}) + C_a\ (1 - (1 / \underline{DF}))$; and

- $WLA = WQC * \underline{DF} - C_a\ (\underline{DF} - 1)$, where

  WQC is the appropriate water quality criterion.

14. The recommended WLAs (in $\mu$g/L) for the present discharge scenario are as follows:

| | **Acute** | **Chronic** |
|---|---|---|
| ammonia | 93,300 | 2,020 |
| copper | 5.2 | -- |
| nickel | 795 | 11.0 |

15. The recommended WLAs (in $\mu g/L$) for a future discharge scenario are as follows:

| | **Acute** | **Chronic** |
|---|---|---|
| ammonia | 118,000 | 2,020 |
| copper | 5.2 | -- |
| lead | -- | 241 |
| nickel | 1,010 | 11.0 |

# References


Bailey, T.E., 1966. *Fluorescent-Tracer Studies of an Estuary*, Journal of Water Pollution Control Federation, December, 1966.

Deaner, D.G., 1973. *Effect of Chlorine on Fluorescent Dyes*, Journal of Water Pollution Control Federation, Volume 45, Number 3, March, 1973.

Duxbury, A.C., 1988. *Understanding Marine Embayments*, University of Washington, draft, October 17.

Ecology, 1992. Chapter 173-201A WAC, *Water Quality Standards for Surface Waters of the State of Washington*, Department of Ecology, Water Quality Program, Olympia WA, December.

Ecology, 1994. *Permit Writer's Manual*, Department of Ecology, Water Quality Program, Olympia WA, as later amended.

EPA, 1989. *Ambient Aquatic Life Water Quality Criteria for Ammonia (Salt Water)*, EPA 440/5-88-004.

EPA, 1991. *Technical Support Document for Water Quality-based Toxics Control*, EPA/505/2-90-001, March.

EPA, 1992. *Draft Technical Guidance Manual for Performing Waste Load Allocations Book III: Estuaries Part 3: Use of Mixing Zone Models in Estuarine Waste Load Allocations*, EPA/823/R-92/004, section 2.6.

EPA, 1993. *Dilution Models for Effluent Discharges (Second Edition)* (User's Manual for PLUMES model interface), EPA/600/R-93/139, July.

Fischer, H.B., E.J. List, R.C.Y. Koh, J. Imberger, and N.H. Brooks, 1979. Mixing in Inland and Coastal Waters, Academic Press, Inc., Harcourt Brace Jovanovich Publishers, New York NY, pp. 126-127.

Hetling, L.J. and O'Connell, R.L., 1966. *A Study of Tidal Dispersion in the Potomac River*, Water Resources Research, volume 2, number 4, pp. 825-841.

Hubbard, E.F. and W.G. Stamper, 1972. *Movement and Dispersion of Soluble Pollutants in the Northeast Cape Fear Estuary, North Carolina*, Water-supply paper 1873-E, U.S. Geological Survey, United States Department of the Interior.

# References (cont'd)


Hydrolab, 1991. *DataSonde® 3 Multiparameter Water Quality Datalogger - Operating Manual*, Hydrolab Corporation, P.O. Box 50116, Austin TX, 78731, Revision B.

KCM, 1994. *City of Stanwood General Sewer Plan*, draft report, prepared by KCM, Inc., 1917 First Avenue, Seattle WA, 98101-1027, March.

Linsley, R.K., M.A. Kohler, and J.L.H. Paulhus, 1958. Hydrology for Engineers, McGraw-Hill Book Company, New York NY, pp. 200-202.

Mills, W.B., D.B. Porcella, M.J. Ungs, S.A. Gherini, K.V. Summers, L.Mok, G.L. Rupp, and G.L. Bowie, 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water--Part II, EPA/600/6-85/002b, pp. 176-184.

Pritchard, D.W. & J.H. Carpenter, 1960. *Measurements of Turbulent Diffusion in Estuarine and Inshore Water*. Bulletin No.20, Association Internationale d'Hydrologie Scientifique, Genibrugge, Belgium, December, pp. 37-50.

Tide Guide, 1992. Seattle District Tide Correction Table, Evergreen Pacific Publishing, Seattle WA, pp. 5.

Turner, G.K., 1990. *Turner Design: Model 10 Fluorometer User's Manual.* Sunnyvale CA, October.

Webb, T. & R.B. Tomlinson, 1992. *Design Procedures for Effluent Discharge to Estuaries during Ebb Tide*, Journal of Environmental Engineering, Volume 118, Number 3, May/June.

Yotsukura, N., 1968. *Discussion of Longitudinal Mixing in Natural Streams*, Journal of Sanitary Engineering Division, American Society of Civil Engineers, volume 94, no. SA3, pp. 568-571.

# APPENDIX A

## Glossary of terms

## Glossary of Terms

The following technical terms are defined in order to clarify their usage in this report.

**Apogean tide.** The lower of the semimonthly neap tides, resulting from the moon being in apogee (farthest from the earth).

**Conservative waste.** A dissolved substance of low degradability.

**Diffusion.** In mixing zone studies, this is the random scattering of particles by turbulent motion. Often defined mathematically by the eddy diffusion coefficient.

**Duration of rise and duration of fall.** The time interval from low water to high water and from high water to low water, respectively.

**Ebb current.** The outgoing current moving down an estuary or tidal bay.

**Estuary.** Where a river meets the sea.

**Flood current.** The incoming current moving up an estuary or tidal bay.

**Flushing time.** The average time required for a particle to travel from a point of injection to the mouth of the estuary (or tidal bay).

**Froude number.** The ratio of inertial to gravity force. More appropriately termed the jet densimetric Froude number when studying the motion of fluids in which there is density stratification; in which case, the ratio is of momentum to buoyancy.

**Initial dilution.** The dilution achieved in a plume due to the combined effects of momentum and buoyancy of the fluid discharged from an orifice, and due to ambient turbulent mixing in the vicinity of the plume.

**Intertidal volume.** The tidal prism, consisting of the volume of water lying between mean high tide and mean low tide.

**Left bank.** The streambank that is on the left when facing downstream or seaward.

**Longitudinal dispersion.** The scattering of particles or a cloud of pollutants (or dye) by the combined effects of shear and diffusion.

**Longitudinal trace.** Measurement of (1) dye distribution and concentration, or (2) depth of water along the centerline of a channel. Measurements are made by moving slowly upstream on a stand of tide taking continuous measurements using the (1) fluorometer at approximate one meter depths, or (2) the Lawrance.

**Mean high water.** Generally speaking, it is considered the arithmetic mean of the high water heights observed over a number of years. Specifically (for this project), it is the mean of <u>all</u> high waters for a three month period (July through September) derived from data contained in Seattle Tides (1992) tables and corrected for Stanwood. This period contains the series of semidiurnal, neap, and spring tides which is appropriate for this study.

**Mean low water.** Generally speaking, it is considered the arithmetic mean of the low water heights observed over a number of years. Specifically (for this project), it is the mean of <u>all</u> low waters for a three month period (July through September) derived from data contained in Tide Guide (1992) tables and corrected for Stanwood. This period contains the series of semidiurnal, neap, and spring tides which is appropriate for this study.

**Mean range of tide.** The difference in height between mean high water and mean low water.

**Mixing zone.** The Washington state Water Quality Standards allow the use of mixing zones for discharges that would otherwise exceed the water quality criteria for aquatic life. Mixing zones are a regulatory recognition that the concentrations and effects of most pollutants diminish rapidly after discharge due to dilution. They are established in a manner which limits the duration of exposure for organisms passing through the effluent plume to minimize the risk from each discharge. The water quality standards for chronic protection must be met at the boundary of this zone and beyond. A smaller zone in which acute criteria may be exceeded can also be authorized. This zone must be small enough to limit exposure times and therefore not cause acute mortalities or interfere with passage of aquatic organisms in the water body. In other words, a mixing zone may be an area that is not suitable as long-term habitat at critical conditions for all aquatic organisms, but those organisms passing through it should not die from the short-term effects of any pollutants". (Ecology, 1992a)

**Neap tides**. Tides of decreased range occurring semimonthly as a result of the moon being in the first or last quarter of its quadrature.

**Perigean tide**. The higher of the semimonthly spring tides, resulting from the moon being in perigee (nearest the earth).

**Range of tide**. The difference in height between consecutive high and low waters.

**Seattle Tides**. Published tables which give daily predictions of times and heights of high and low waters for the Seattle reference station. Some additional information included is: 1) corrections for other locations in the Seattle District, and 2) date of each quarter in the Moon's quadrature.

**Semidiurnal**. A term which describes an event, or cycle, which occurs during half-day intervals. Since tidal cycles in this part of the world cover approximate intervals of one-half day, they are characterized as semidiurnal.

**Shear**. Transport by an imposed current system, resulting from fluid lying in adjacent streamlines that is traveling at different speeds.

**Slack water**. The state of a tidal current when its speed is near zero, especially the moment when a reversing current changes direction and its speed is zero. The term also applies to the entire period of low speed near the time of turning of the current.

**Spring tides**. Tides of increased range occurring semimonthly as a result of the moon being in the new or full quarter of its quadrature.

**Stand of tide**. An interval at high or low water when there is no sensible change in the height of the tide. The stands are (in the most frequent order of occurrence): higher high water (HHW), lower low water (LLW), lower high water (LHW), and higher low water (HLW). In general, the duration of the apparent stand will depend upon the range of tide, being longer for a small range than for a large range.

**Station**. A cross-section of the tidal bay where a series of sampling and measuring activities is conducted.

**Tidal bay**. So little fresh water inflow that there is no measurable dilution.

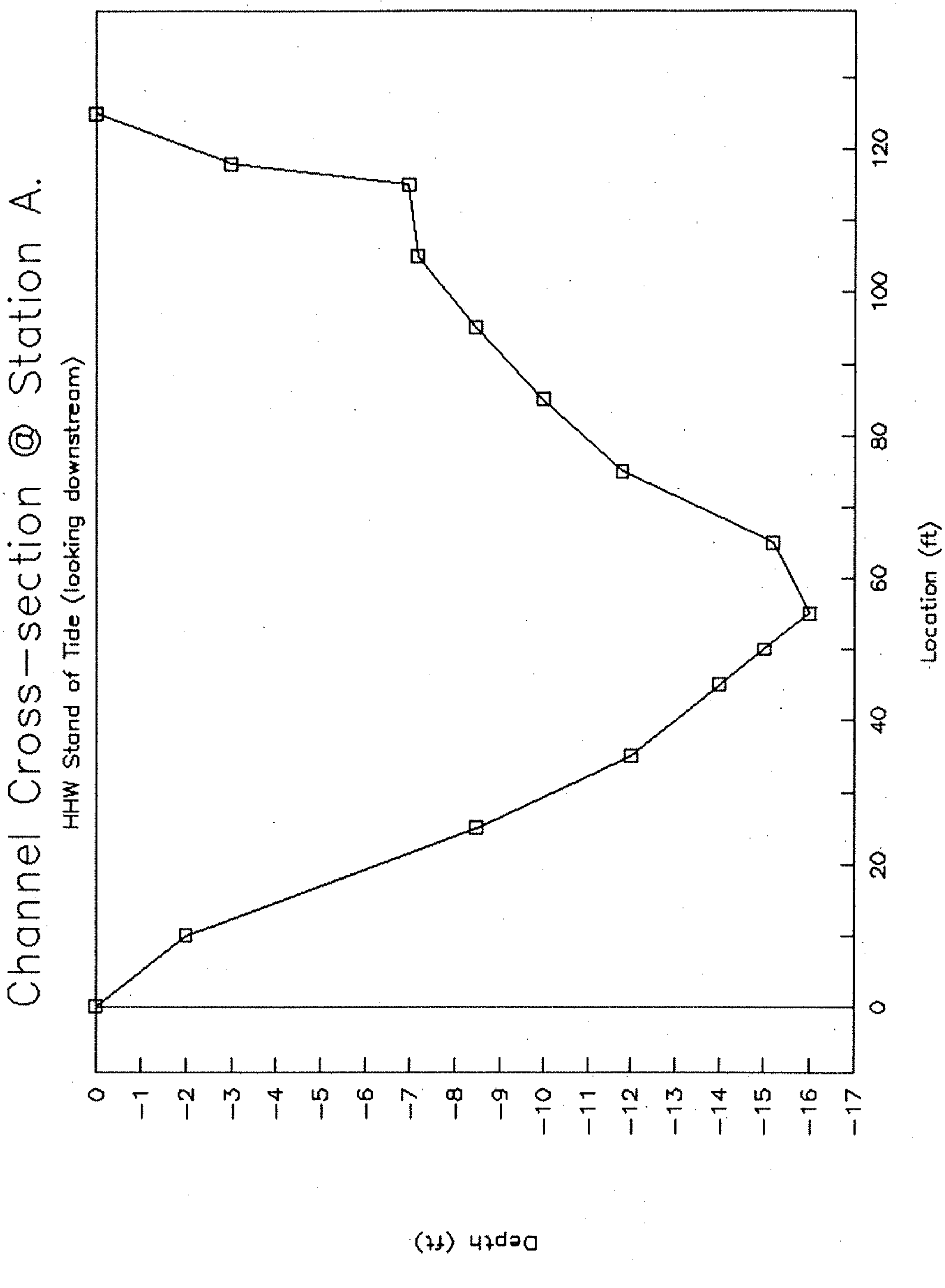
**Tidal day**. Commensurate with a lunar day, *i.e.*, consisting of 24.8 solar hours. On the Pacific Coast it consists of two tidal cycles (four stands of tide).

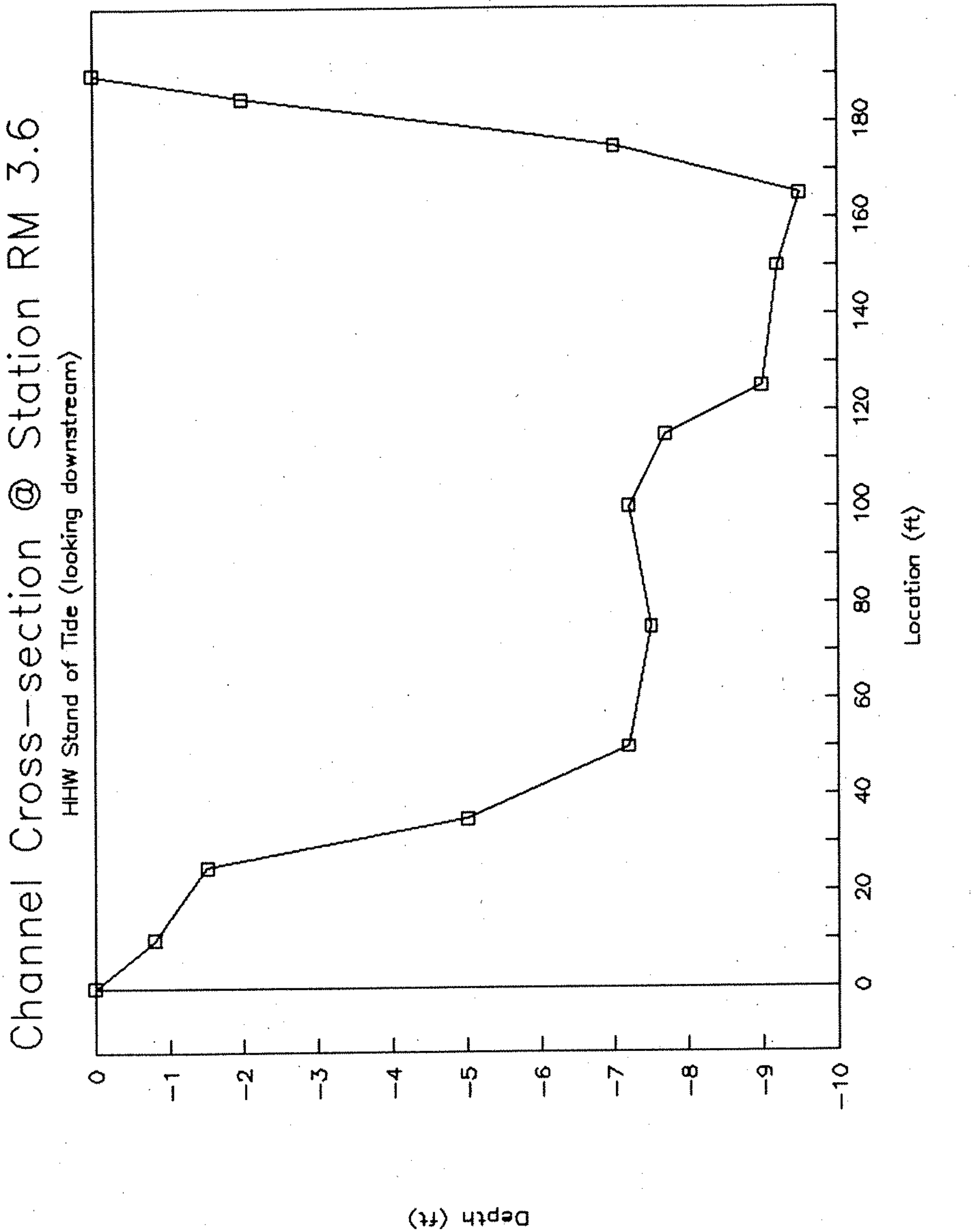
**Tidal excursion**. The net distance a certain particle of water (or a dye cloud) moves during a tidal cycle (12.4 hrs) with reference to some stationary point.

**Tidal prism**. The intertidal volume of water in 1) an entire estuary, or 2) if working with the modified tidal prism approach, a predetermined length (segment) of the estuary.

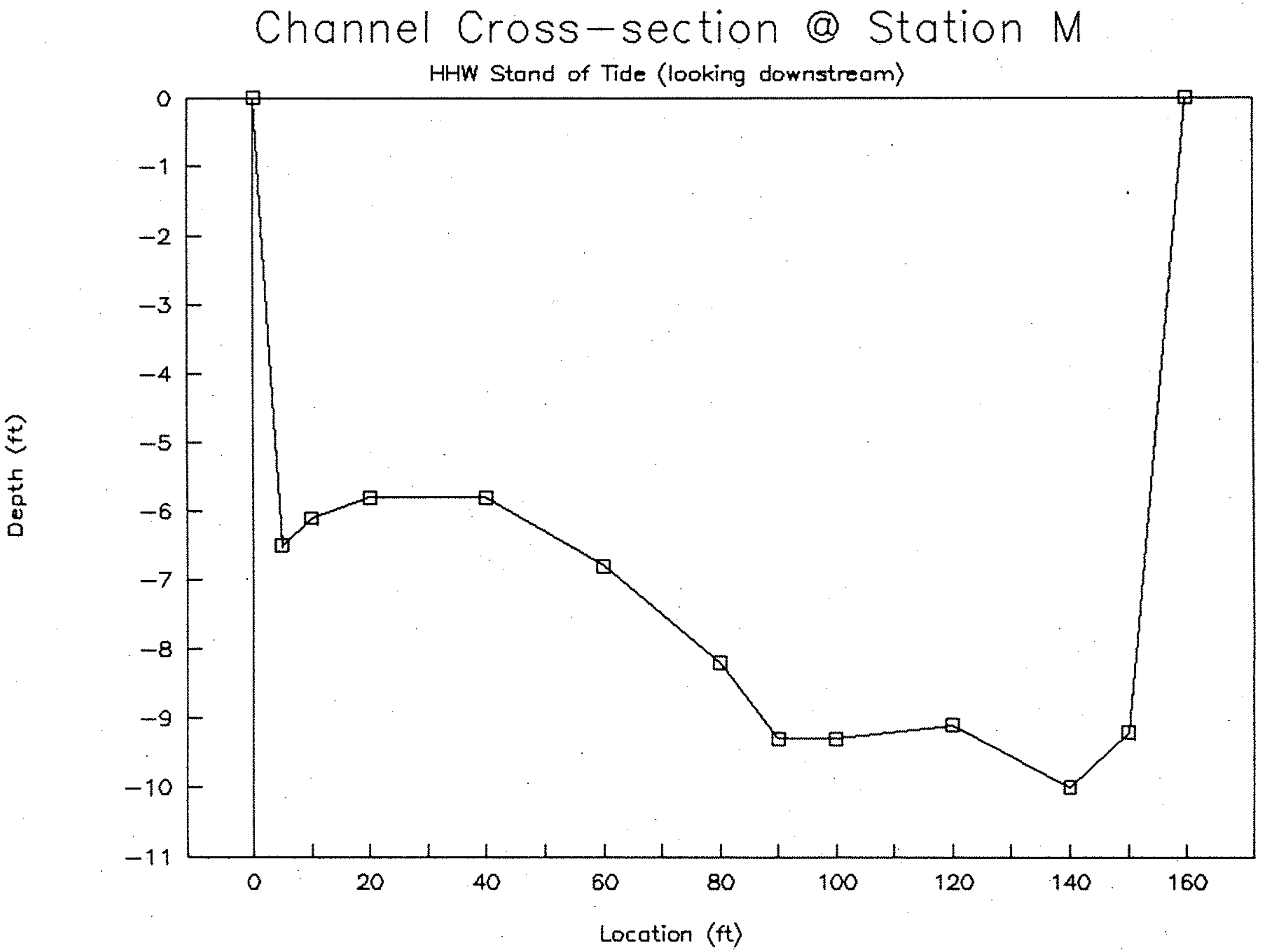
# APPENDIX B

## Channel cross-sections

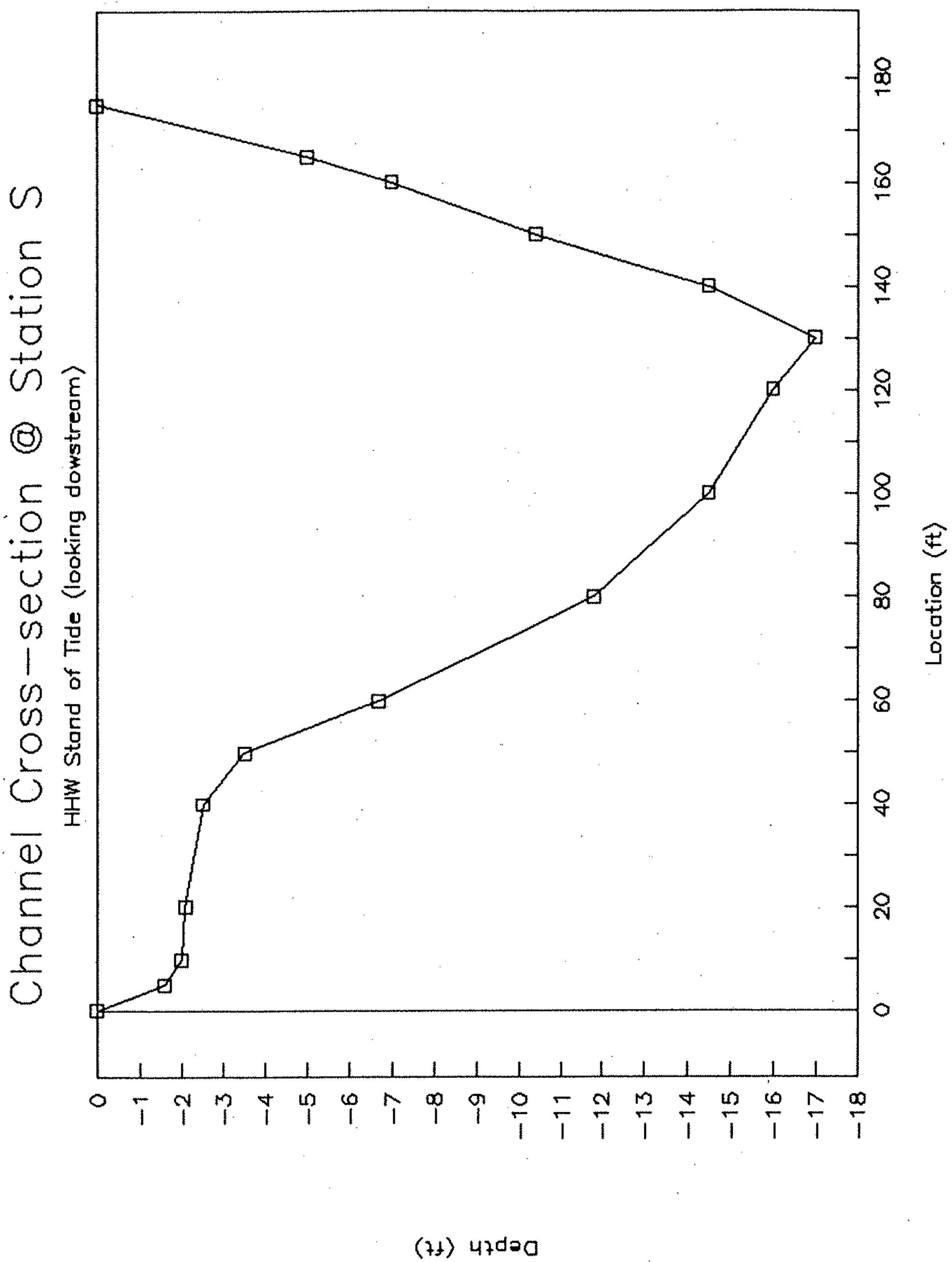

Channel Cross-section @ Station A.
HHW Stand of Tide (looking downstream)
Location (ft)
Depth (ft)
0
20
40
60
80
100
120
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17

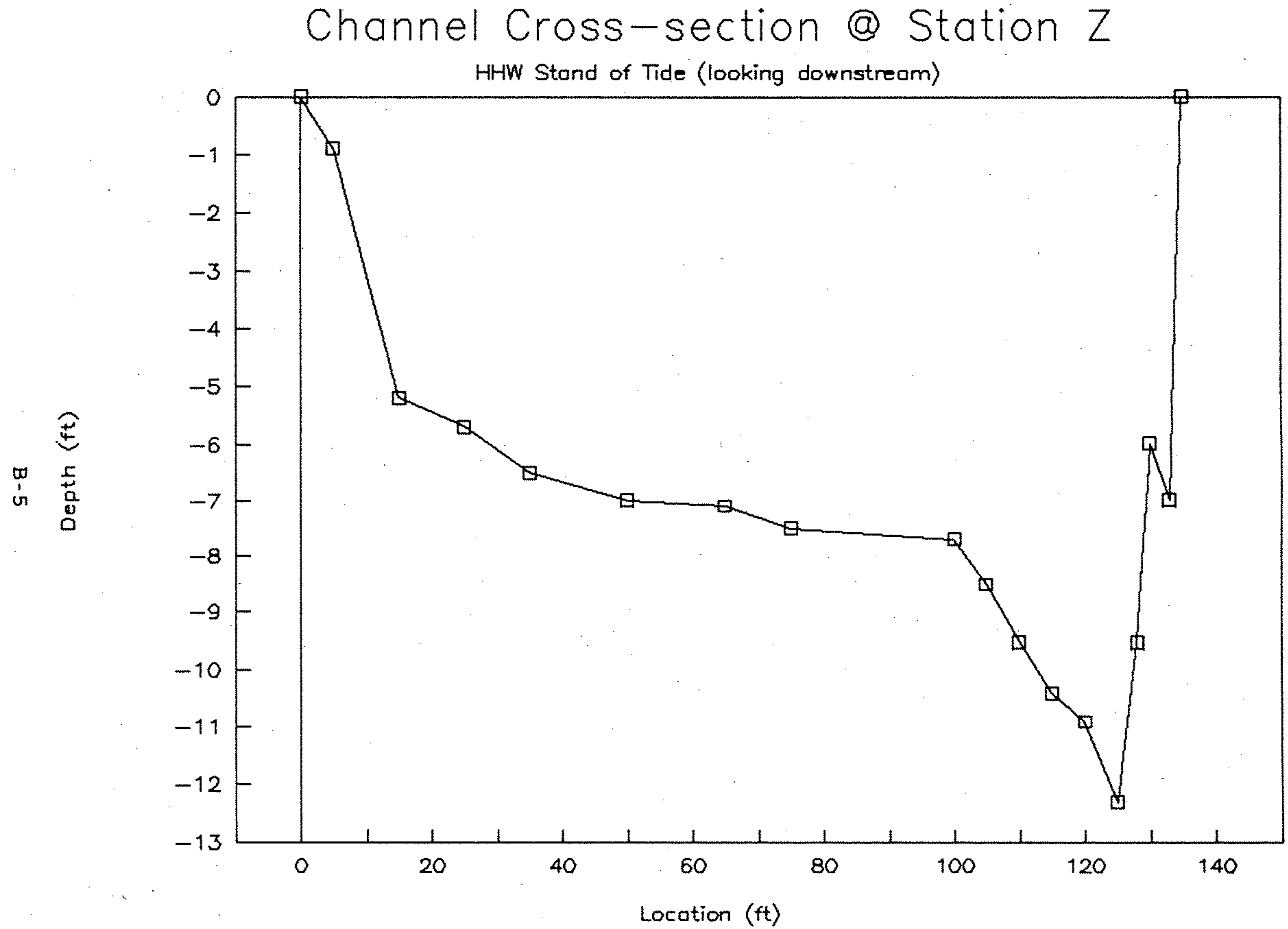


Channel Cross-section @ Station RM 3.6
HHW Stand of Tide (looking downstream)
Depth (ft)
Location (ft)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
0
20
40
60
80
100
120
140
160
180



Channel Cross-section @ Station M
HHW Stand of Tide (looking downstream)
Depth (ft)
Location (ft)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
0
20
40
60
80
100
120
140
160


Channel Cross-section @ Station S
HHW Stand of Tide (looking dowstream)
Location (ft)
Depth (ft)
0
20
40
60
80
100
120
140
160
180
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18



Channel Cross-section @ Station Z
HHW Stand of Tide (looking downstream)
Depth (ft)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
Location (ft)
0
20
40
60
80
100
120
140

# APPENDIX C

## Field equipment used during survey

**Pertinent Information about Field Equipment Used during Survey.**

| Name | Description | Preparation/Calibration Methods | Use |
|---|---|---|---|
| Hydrolab DataSonde™ | Multiparameter Water quality monitoring instrument. | For marine water; in accordance with Operation Manual (Hydrolab, 1991). | Deployed at station S for 48 hours to measure D.O., pH, temp., salinity & depth; results in Appendix E1. |
| Unidata™ | 32K Portable Data Logger (PDL) w/ 5m pressure transducer (PT). | PDL reset using V. 1.8 of Unidata™ software; system checked in fabricated water column; deployed inside a stilling well. | Deployed at station A for 48 hours to continuously record depth; results in Appendix E2. |
| Turner Model 10 | Fluorometer, outfitted w/ a flow-through cuvette system. | In accordance w/ Method A in User's Manual (Turner, 1990); 1, 10, 25, 50, & 100 ppb standards made using 20% dye solution & receiving water; standards kept @ 11.5° C during calibration. | Measured dye concentrations to 1 ppb; temp. coefficient applied to each value in accordance w/ (Pritchard & Carpenter; 1960); results in Appendix G1. |
| Masterflex | variable-speed peristaltic pump. | Curve of pump setting on knob versus flow rate shown in Figure C1. | Metered out a predetermined, constant flowrate of dye solution into effluent. |
| YSI 33 | Handheld monitoring instrument. | Several grab samples taken at same time/location for comparison of results. | Measured temp. & salinity concurrent w/ concentration readings from fluorometer. |
| ISCO | 24-hour automatic composite sampler. | Priority-pollutant cleaned in accordance w/ internal SOP (Glenn, in prep.). | Collected representative samples of pollutants of concern. |
| Lawrence | Sonar depth finder w/ strip chart recorder. | Field calibrated with weighted line. | Generated cross-sections at four stations and longitudinal trace of entire reach. |

# APPENDIX D

## General chemistry and metals analytical results

## General Chemistry and Metals Analytical Results.

| | Location: | A-LLW | A-LHW | EFF-C | Z-HLW | Z-LLW | Z-HHW |
|---|---|---|---|---|---|---|---|
| | Type: | Grab | Grab | Comp | Grab | Grab | Grab |
| | Date: | 9/03 | 9/03 | 9/3-4 | 9/4 | 9/5 | 9/6 |
| | Time: | 0800 | 1200 | 1230-1230 | 2000 | 0815 | 1615 |
| Parameter | Lab Log #: 3780 | -50 | -51 | -52 | -53 | -54 | -55 |
| GENERAL CHEMISTRY | | | | | | | |
| Salinity (ppt) | | 12.0 | 17.0 | 0.5 | 18.0 | 17.0 | 20.0 |
| TSS (mg/L) | | 30 | 25 | 60J | | | |
| $NH_3$-N Total (μg/L) | | 2,020 | 139 | 6,730 | | | |
| METALS (μg/L) | | | | | | | |
| Cadmium | | 0.20U | 0.20U | 0.65 | | | |
| Chromium | | 3.46 | 2.58 | 2.31 | | | |
| Copper | | 5.2P | 3.9P | 22.5 | | | |
| Lead | | 2.0UN | 2.0UN | 47.1N | | | |
| Nickel | | 11 | 7.6P | 8.7P | | | |
| Silver | | 0.86PN | 0.55PN | 0.50UN | | | |
| Zinc | | 24P | 20U | 68.9 | | | |

A - station A; Z - station Z; EFF - Effluent.

LHW - Lower High Water; HLW - Higher Low Water; HHW - Higher High Water; LLW - Lower Low Water; C - Compositor.

U means the analyte was not detected at or above the reported result.

P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.

J means the analyte was positively identified.

N means the spike sample recovery was not within control limits.

# APPENDIX E1

Data logged by DataSonde®

# Data Logged by DataSonde™ Deployed at Station S, with Some Interpolated Water Levels Added.

<u>Data programmed into instrument before departing for field</u>
Log File Name : Stanwood-datasonde
Setup Date (MMDDYY) : 090192
Setup Time (HHMMSS) : 144441
Starting Date (MMDDYY) : 090392
Starting Time (HHMMSS) : 120000
Stopping Date (MMDDYY) : 090592
Stopping Time (HHMMSS) : 120001
Interval (HHMMSS) : 001500
Warmup : Enable

==> Setup Variables and Calibration <==

| Data logged by instrument in the field | | | | | | | | | | | Logged "depths" supplemented by interpolated water levels | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date (MMDDYY) | Time (HHMMSS) | Temp (deg C) | pH (units) | SpCond (mS/cm) | Salin (ppt) | DO (%Sat) | DO (mg/l) | Depth (feet) | Batt (volts) | | Date (MM/DD/YY) | Time (HHMMSS) | Date number | Time number | Date.Time Number^ (Julian) | Water level^^ (feet) |
| 90392 | 120000 | 16.97 | 7.61 | 29.9 | 18.5 | 73.8 | 6.41 | 8.2 | 13.6 | & | 9/3/92 | 120000 | 33850 | 0.5000 | 33850.5 | 8.2 |
| 90392 | 121500 | 16.97 | 7.61 | 29.9 | 18.5 | 71 | 6.17 | 8.6 | 13.6 | & | 9/3/92 | 121500 | 33850 | 0.5063 | 33850.50 | 8.6 |
| 90392 | 123000 | 16.98 | 7.61 | 29.8 | 18.4 | 70.7 | 6.14 | 8.8 | 13.5 | & | 9/3/92 | 123000 | 33850 | 0.5125 | 33850.51 | 8.8 |
| 90392 | 124500 | 16.96 | 7.6 | 29.9 | 18.5 | 70 | 6.08 | 8.8 | 13.4 | & | 9/3/92 | 124500 | 33850 | 0.5188 | 33850.51 | 8.8 |
| 90392 | 130000 | 16.98 | 7.6 | 29.8 | 18.4 | 70.6 | 6.14 | 8.7 | 13.3 | & | 9/3/92 | 130000 | 33850 | 0.5417 | 33850.54 | 8.7 |
| 90392 | 131500 | 16.98 | 7.59 | 29.7 | 18.4 | 69.7 | 6.06 | 8.6 | 13.3 | & | 9/3/92 | 131500 | 33850 | 0.5479 | 33850.54 | 8.6 |
| 90392 | 133000 | 16.98 | 7.6 | 29.7 | 18.3 | 69.8 | 6.07 | 8.5 | 13.3 | & | 9/3/92 | 133000 | 33850 | 0.5542 | 33850.55 | 8.5 |
| 90392 | 134500 | 16.98 | 7.59 | 29.5 | 18.2 | 69.7 | 6.06 | 8.3 | 13.2 | & | 9/3/92 | 134500 | 33850 | 0.5604 | 33850.56 | 8.3 |
| 90392 | 140000 | 16.98 | 7.58 | 29.4 | 18.2 | 69.1 | 6.01 | 8.2 | 13.2 | & | 9/3/92 | 140000 | 33850 | 0.5833 | 33850.58 | 8.2 |
| 90392 | 141500 | 16.97 | 7.57 | 29.3 | 18.1 | 68.1 | 5.93 | 8.1 | 13.2 | & | 9/3/92 | 141500 | 33850 | 0.5896 | 33850.58 | 8.1 |
| 90392 | 143000 | 16.96 | 7.57 | 29.1 | 18 | 68 | 5.93 | 7.8 | 13.1 | & | 9/3/92 | 143000 | 33850 | 0.5958 | 33850.59 | 7.8 |
| 90392 | 144500 | 16.98 | 7.57 | 29 | 17.9 | 67.7 | 5.9 | 7.6 | 13.1 | & | 9/3/92 | 144500 | 33850 | 0.6021 | 33850.60 | 7.6 |
| 90392 | 150000 | 17.05 | 7.57 | 28.6 | 17.6 | 67.9 | 5.93 | 7.4 | 13.1 | & | 9/3/92 | 150000 | 33850 | 0.6250 | 33850.62 | 7.4 |
| 90392 | 151500 | 17.13 | 7.57 | 28.6 | 17.6 | 68.1 | 5.93 | 7.2 | 13.1 | & | 9/3/92 | 151500 | 33850 | 0.6313 | 33850.63 | 7.2 |
| 90392 | 153000 | 17.54 | 7.58 | 28.2 | 17.4 | 69.9 | 6.04 | 6.9 | 13 | & | 9/3/92 | 153000 | 33850 | 0.6375 | 33850.63 | 6.9 |
| 90392 | 154500 | 17.86 | 7.58 | 28.1 | 17.2 | 70.6 | 6.07 | 6.8 | 13 | & | 9/3/92 | 154500 | 33850 | 0.6438 | 33850.64 | 6.8 |
| 90392 | 160000 | 18.11 | 7.58 | 28 | 17.2 | 71.9 | 6.15 | 6.5 | 13 | & | 9/3/92 | 160000 | 33850 | 0.6667 | 33850.66 | 6.5 |
| 90392 | 161500 | 18.31 | 7.57 | 28 | 17.2 | 72.4 | 6.17 | 6.3 | 13 | & | 9/3/92 | 161500 | 33850 | 0.6729 | 33850.67 | 6.3 |
| 90392 | 163000 | 18.38 | 7.57 | 28 | 17.2 | 72.2 | 6.15 | 6 | 12.9 | & | 9/3/92 | 163000 | 33850 | 0.6792 | 33850.67 | 6 |
| 90392 | 164500 | 18.51 | 7.57 | 28 | 17.2 | 72.7 | 6.17 | 6.1 | 12.9 | & | 9/3/92 | 164500 | 33850 | 0.6854 | 33850.68 | 6.1 |
| 90392 | 170000 | 18.73 | 7.58 | 27.9 | 17.1 | 74.1 | 6.26 | 5.9 | 12.9 | & | 9/3/92 | 170000 | 33850 | 0.7083 | 33850.70 | 5.9 |
| 90392 | 171500 | 18.69 | 7.58 | 27.9 | 17.1 | 74.1 | 6.27 | 5.9 | 12.9 | & | 9/3/92 | 171500 | 33850 | 0.7146 | 33850.71 | 5.9 |
| 90392 | 173000 | 18.66 | 7.58 | 27.9 | 17.1 | 74 | 6.26 | 6 | 12.9 | & | 9/3/92 | 173000 | 33850 | 0.7208 | 33850.72 | 6 |
| 90392 | 174500 | 18.57 | 7.58 | 28 | 17.2 | 73.3 | 6.22 | 6.1 | 12.9 | & | 9/3/92 | 174500 | 33850 | 0.7271 | 33850.72 | 6.1 |
| 90392 | 180000 | 18.39 | 7.56 | 28 | 17.2 | 71.4 | 6.08 | 6.3 | 12.9 | & | 9/3/92 | 180000 | 33850 | 0.7500 | 33850.75 | 6.3 |

| Data logged by instrument in the field | | | | | | | | | | | Logged "depths" supplemented by interpolated water levels | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date (MMDDYY) | Time (HHMMSS) | Temp (deg C) | pH (units) | SpCond (mS/cm) | Salin (ppt) | DO (%Sat) | DO (mg/l) | Depth (feet) | Batt (volts) | | Date (MM/DD/YY) | Time (HHMMSS) | Date number | Time number | Date.Time Number* (Julian) | Water level^^ (feet) |
| 90392 | 181500 | 18.11 | 7.57 | 28.1 | 17.2 | 70.3 | 6.01 | 6.5 | 12.8 | & | 9/3/92 | 181500 | 33850 | 0.7563 | 33850.75 | 6.5 |
| 90392 | 183000 | 17.98 | 7.57 | 28.1 | 17.3 | 70.6 | 6.06 | 6.7 | 12.8 | & | 9/3/92 | 183000 | 33850 | 0.7625 | 33850.76 | 6.7 |
| 90392 | 184500 | 17.89 | 7.61 | 28.1 | 17.3 | 73.2 | 6.29 | 7 | 12.8 | & | 9/3/92 | 184500 | 33850 | 0.7688 | 33850.76 | 7 |
| 90392 | 190000 | 17.82 | 7.61 | 28.1 | 17.3 | 73.5 | 6.32 | 7.2 | 12.8 | & | 9/3/92 | 190000 | 33850 | 0.7917 | 33850.79 | 7.2 |
| 90392 | 191500 | 17.7 | 7.63 | 28.2 | 17.3 | 75.1 | 6.47 | 7.5 | 12.8 | & | 9/3/92 | 191500 | 33850 | 0.7979 | 33850.79 | 7.5 |
| 90392 | 193000 | 17.7 | 7.64 | 28.4 | 17.5 | 75.8 | 6.53 | 7.8 | 12.8 | & | 9/3/92 | 193000 | 33850 | 0.8042 | 33850.80 | 7.8 |
| 90392 | 194500 | 17.68 | 7.65 | 28.6 | 17.6 | 76.2 | 6.56 | 8.1 | 12.7 | & | 9/3/92 | 194500 | 33850 | 0.8104 | 33850.81 | 8.1 |
| 90392 | 200000 | 17.72 | 7.65 | 28.6 | 17.6 | 76.3 | 6.56 | 8.3 | 12.7 | & | 9/3/92 | 200000 | 33850 | 0.8333 | 33850.83 | 8.3 |
| 90392 | 201500 | 17.75 | 7.65 | 28.6 | 17.6 | 76.4 | 6.57 | 8.6 | 12.7 | & | 9/3/92 | 201500 | 33850 | 0.8396 | 33850.83 | 8.6 |
| 90392 | 203000 | 17.8 | 7.67 | 28.9 | 17.8 | 78 | 6.69 | 8.7 | 12.7 | & | 9/3/92 | 203000 | 33850 | 0.8458 | 33850.84 | 8.7 |
| 90392 | 204500 | 17.85 | 7.7 | 29.2 | 18 | 80.1 | 6.86 | 8.9 | 12.7 | & | 9/3/92 | 204500 | 33850 | 0.8521 | 33850.85 | 8.9 |
| 90392 | 210000 | 17.97 | 7.73 | 29.6 | 18.3 | 82.7 | 7.05 | 9.1 | 12.7 | & | 9/3/92 | 210000 | 33850 | 0.8750 | 33850.87 | 9.1 |
| 90392 | 211500 | 17.99 | 7.78 | 30 | 18.6 | 86.6 | 7.37 | 9.3 | 12.7 | & | 9/3/92 | 211500 | 33850 | 0.8813 | 33850.88 | 9.3 |
| 90392 | 213000 | 17.97 | 7.81 | 30.2 | 18.7 | 88.2 | 7.5 | 9.4 | 12.6 | & | 9/3/92 | 213000 | 33850 | 0.8875 | 33850.88 | 9.4 |
| 90392 | 214500 | 17.96 | 7.83 | 30.3 | 18.8 | 89.5 | 7.61 | 9.4 | 12.6 | & | 9/3/92 | 214500 | 33850 | 0.8938 | 33850.89 | 9.4 |
| 90392 | 220000 | 17.97 | 7.85 | 30.4 | 18.8 | 90.7 | 7.71 | 9.6 | 12.6 | & | 9/3/92 | 220000 | 33850 | 0.9167 | 33850.91 | 9.6 |
| 90392 | 221500 | 17.97 | 7.87 | 30.4 | 18.8 | 91.6 | 7.78 | 9.6 | 12.6 | & | 9/3/92 | 221500 | 33850 | 0.9229 | 33850.92 | 9.6 |
| 90392 | 223000 | 17.99 | 7.87 | 30.4 | 18.8 | 91.5 | 7.77 | 9.6 | 12.6 | & | 9/3/92 | 223000 | 33850 | 0.9292 | 33850.92 | 9.6 |
| 90392 | 224500 | 17.99 | 7.87 | 30.4 | 18.8 | 91.5 | 7.77 | 9.5 | 12.6 | & | 9/3/92 | 224500 | 33850 | 0.9354 | 33850.93 | 9.5 |
| 90392 | 230000 | 17.97 | 7.86 | 30.4 | 18.8 | 90.5 | 7.69 | 9.4 | 12.6 | & | 9/3/92 | 230000 | 33850 | 0.9583 | 33850.95 | 9.4 |
| 90392 | 231500 | 17.97 | 7.85 | 30.4 | 18.8 | 90 | 7.65 | 9.3 | 12.6 | & | 9/3/92 | 231500 | 33850 | 0.9646 | 33850.96 | 9.3 |
| 90392 | 233000 | 17.96 | 7.83 | 30.3 | 18.8 | 88.8 | 7.55 | 9.2 | 12.5 | & | 9/3/92 | 233000 | 33850 | 0.9708 | 33850.97 | 9.2 |
| 90392 | 234500 | 17.96 | 7.81 | 30.3 | 18.8 | 87.5 | 7.44 | 9 | 12.6 | & | 9/3/92 | 234500 | 33850 | 0.9771 | 33850.97 | 9 |
| 90492 | 0 | 17.97 | 7.78 | 30.2 | 18.7 | 86.1 | 7.32 | 8.8 | 12.5 | & | 9/04/92 | 0 | 33851 | 0.0000 | 33851 | 8.8 |
| 90492 | 1500 | 17.96 | 7.75 | 29.9 | 18.5 | 83.5 | 7.12 | 8.5 | 12.5 | & | 9/04/92 | 1500 | 33851 | 0.0063 | 33851.00 | 8.5 |
| 90492 | 3000 | 17.86 | 7.7 | 29.5 | 18.2 | 79.9 | 6.83 | 8.3 | 12.5 | & | 9/04/92 | 3000 | 33851 | 0.0125 | 33851.01 | 8.3 |
| 90492 | 4500 | 17.69 | 7.64 | 28.9 | 17.8 | 74.7 | 6.42 | 8 | 12.5 | & | 9/04/92 | 4500 | 33851 | 0.0188 | 33851.01 | 8 |
| 90492 | 10000 | 17.58 | 7.61 | 28.5 | 17.5 | 72.5 | 6.26 | 7.8 | 12.5 | & | 9/04/92 | 10000 | 33851 | 0.0417 | 33851.04 | 7.8 |
| 90492 | 11500 | 17.58 | 7.6 | 28.4 | 17.5 | 71.7 | 6.19 | 7.4 | 12.4 | & | 9/04/92 | 11500 | 33851 | 0.0479 | 33851.04 | 7.4 |
| 90492 | 13000 | 17.65 | 7.58 | 28.2 | 17.4 | 70.4 | 6.07 | 7.1 | 12.5 | & | 9/04/92 | 13000 | 33851 | 0.0542 | 33851.05 | 7.1 |
| 90492 | 14500 | 17.75 | 7.56 | 28.1 | 17.3 | 69.2 | 5.96 | 6.7 | 12.5 | & | 9/04/92 | 14500 | 33851 | 0.0604 | 33851.06 | 6.7 |
| 90492 | 20000 | 17.92 | 7.55 | 28.1 | 17.2 | 68.5 | 5.88 | 6.3 | 12.5 | & | 9/04/92 | 20000 | 33851 | 0.0833 | 33851.08 | 6.3 |
| 90492 | 21500 | 18.23 | 7.54 | 27.9 | 17.1 | 68.7 | 5.87 | 5.9 | 12.4 | & | 9/04/92 | 21500 | 33851 | 0.0896 | 33851.08 | 5.9 |
| 90492 | 23000 | 18.53 | 7.54 | 27.6 | 16.9 | 69.3 | 5.89 | 5.5 | 12.4 | & | 9/04/92 | 23000 | 33851 | 0.0958 | 33851.09 | 5.5 |
| 90492 | 24500 | 18.83 | 7.53 | 27.3 | 16.7 | 69.8 | 5.91 | 5.2 | 12.4 | & | 9/04/92 | 24500 | 33851 | 0.1021 | 33851.10 | 5.2 |
| 90492 | 30000 | 19.04 | 7.52 | 26.9 | 16.4 | 69.9 | 5.9 | 4.9 | 12.4 | & | 9/04/92 | 30000 | 33851 | 0.1250 | 33851.12 | 4.9 |
| 90492 | 31500 | 19.21 | 7.51 | 26.5 | 16.2 | 69.5 | 5.85 | 4.6 | 12.4 | & | 9/04/92 | 31500 | 33851 | 0.1313 | 33851.13 | 4.6 |
| 90492 | 33000 | 19.32 | 7.5 | 26.2 | 16 | 68.8 | 5.79 | 4.4 | 12.4 | & | 9/04/92 | 33000 | 33851 | 0.1375 | 33851.13 | 4.4 |
| 90492 | 34500 | 19.4 | 7.49 | 25.9 | 15.8 | 68.1 | 5.73 | 4.1 | 12.4 | & | 9/04/92 | 34500 | 33851 | 0.1438 | 33851.14 | 4.1 |
| 90492 | 40000 | 19.43 | 7.48 | 25.7 | 15.6 | 67.5 | 5.68 | 3.9 | 12.4 | & | 9/04/92 | 40000 | 33851 | 0.1667 | 33851.16 | 3.9 |
| 90492 | 41500 | 19.45 | 7.47 | 25.5 | 15.5 | 66.9 | 5.63 | 3.7 | 12.4 | & | 9/04/92 | 41500 | 33851 | 0.1729 | 33851.17 | 3.7 |
| 90492 | 43000 | 19.45 | 7.46 | 25.2 | 15.3 | 66.3 | 5.59 | 3.4 | 12.4 | & | 9/04/92 | 43000 | 33851 | 0.1792 | 33851.17 | 3.4 |

| Data logged by instrument in the field | | | | | | | | | | | Logged "depths" supplemented by interpolated water levels | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date (MMDDYY) | Time (HHMMSS) | Temp (deg C) | pH (units) | SpCond (mS/cm) | Salin (ppt) | DO (%Sat) | DO (mg/l) | Depth (feet) | Batt (volts) | | Date (MM/DD/YY) | Time (HHMMSS) | Date number | Time number | Date.Time Number* (Julian) | Water level** (feet) |
| 90492 | 44500 | 19.48 | 7.45 | 25.1 | 15.2 | 65.6 | 5.53 | 3.3 | 12.4 | & | 9/04/92 | 44500 | 33851 | 0.1854 | 33851.18 | 3.3 |
| 90492 | 50000 | 19.48 | 7.45 | 24.9 | 15.1 | 65.3 | 5.5 | 3.2 | 12.4 | & | 9/04/92 | 50000 | 33851 | 0.2083 | 33851.20 | 3.2 |
| 90492 | 51500 | 19.5 | 7.44 | 24.7 | 15 | 64.6 | 5.45 | 3.1 | 12.4 | & | 9/04/92 | 51500 | 33851 | 0.2146 | 33851.21 | 3.1 |
| 90492 | 53000 | 19.52 | 7.43 | 24.6 | 14.9 | 63.7 | 5.37 | 3.1 | 12.4 | & | 9/04/92 | 53000 | 33851 | 0.2208 | 33851.22 | 3.1 |
| 90492 | 54500 | 19.54 | 7.43 | 24.4 | 14.7 | 63.6 | 5.37 | 3 | 12.4 | & | 9/04/92 | 54500 | 33851 | 0.2271 | 33851.22 | 3 |
| 90492 | 60000 | 19.55 | 7.42 | 24.2 | 14.7 | 62.8 | 5.3 | 3 | 12.4 | & | 9/04/92 | 60000 | 33851 | 0.2500 | 33851.25 | 3 |
| 90492 | 61500 | 19.55 | 7.41 | 24.1 | 14.6 | 62.8 | 5.3 | 2.9 | 12.4 | & | 9/04/92 | 61500 | 33851 | 0.2563 | 33851.25 | 2.9 |
| 90492 | 63000 | 19.55 | 7.41 | 24 | 14.5 | 62.4 | 5.28 | 2.9 | 12.4 | & | 9/04/92 | 63000 | 33851 | 0.2625 | 33851.26 | 2.9 |
| 90492 | 64500 | 19.55 | 7.4 | 23.8 | 14.4 | 61.8 | 5.22 | 2.9 | 12.3 | & | 9/04/92 | 64500 | 33851 | 0.2688 | 33851.26 | 2.9 |
| 90492 | 70000 | 19.56 | 7.4 | 23.7 | 14.3 | 60.8 | 5.14 | 2.9 | 12.3 | & | 9/04/92 | 70000 | 33851 | 0.2917 | 33851.29 | 2.9 |
| 90492 | 71500 | 19.59 | 7.39 | 23.7 | 14.3 | 60.6 | 5.13 | 2.9 | 12.3 | & | 9/04/92 | 71500 | 33851 | 0.2979 | 33851.29 | 2.9 |
| 90492 | 73000 | 19.5 | 7.38 | 23.6 | 14.2 | 60.3 | 5.11 | 2.9 | 12.4 | & | 9/04/92 | 73000 | 33851 | 0.3042 | 33851.30 | 2.9 |
| 90492 | 74500 | 19.48 | 7.38 | 23.5 | 14.2 | 60.4 | 5.12 | 2.9 | 12.3 | & | 9/04/92 | 74500 | 33851 | 0.3104 | 33851.31 | 2.9 |
| 90492 | 80000 | 19.54 | 7.38 | 23.5 | 14.2 | 60.1 | 5.09 | 2.9 | 12.3 | & | 9/04/92 | 80000 | 33851 | 0.3333 | 33851.33 | 2.9 |
| 90492 | 81500 | 19.57 | 7.38 | 23.5 | 14.2 | 60 | 5.07 | 2.9 | 12.3 | & | 9/04/92 | 81500 | 33851 | 0.3396 | 33851.33 | 2.9 |
| 90492 | 83000 | 19.54 | 7.38 | 23.4 | 14.1 | 59.6 | 5.05 | 2.9 | 12.3 | & | 9/04/92 | 83000 | 33851 | 0.3458 | 33851.34 | 2.9 |
| 90492 | 84500 | 19.5 | 7.37 | 23.4 | 14.1 | 59.6 | 5.05 | 2.9 | 12.3 | & | 9/04/92 | 84500 | 33851 | 0.3521 | 33851.35 | 2.9 |
| 90492 | 90000 | 19.4 | 7.39 | 23.1 | 13.9 | 60.6 | 5.15 | 2.9 | 12.3 | & | 9/04/92 | 90000 | 33851 | 0.3750 | 33851.37 | 2.9 |
| 90492 | 91500 | 19.39 | 7.4 | 23.2 | 14 | 62.1 | 5.28 | 2.9 | 12.3 | & | 9/04/92 | 91500 | 33851 | 0.3813 | 33851.38 | 2.9 |
| 90492 | 93000 | 19.35 | 7.41 | 23.5 | 14.2 | 63.7 | 5.42 | 3.2 | 12.3 | & | 9/04/92 | 93000 | 33851 | 0.3875 | 33851.38 | 3.2 |
| 90492 | 94500 | 19.31 | 7.42 | 24.5 | 14.8 | 62.6 | 5.31 | 4.3 | 12.3 | & | 9/04/92 | 94500 | 33851 | 0.3938 | 33851.39 | 4.3 |
| 90492 | 100000 | 18.86 | 7.49 | | | | | 8.8* | 11.5 | & | 9/04/92 | 100000 | 33851 | 0.4167 | 33851.41 | 5.3 |
| 90492 | 101500 | 18.86 | 7.49 | | | | | 8.8* | 11.5 | & | 9/04/92 | 101500 | 33851 | 0.4229 | 33851.42 | 6.3 |
| 90492 | 103000 | 18.86 | 7.49 | | | | | 8.8* | 11.5 | & | 9/04/92 | 103000 | 33851 | 0.4292 | 33851.42 | 7.3 |
| 90492 | 104500 | 16.55 | 7.66 | | | | | 12.1* | 11.5 | & | 9/04/92 | 104500 | 33851 | 0.4354 | 33851.43 | 8.3 |
| 90492 | 110000 | 15.78 | 7.73 | 26.3 | 16 | 81.9 | 7.41 | 9.3 | 11.7 | & | 9/04/92 | 110000 | 33851 | 0.4583 | 33851.45 | 9.3 |
| 90492 | 111500 | 15.61 | 7.76 | | | | | 13.3* | 11.4 | & | 9/04/92 | 111500 | 33851 | 0.4646 | 33851.46 | 9.5 |
| 90492 | 113000 | 15.68 | 7.78 | 26.7 | 16.3 | 83.6 | 7.56 | 10.1* | 11.7 | & | 9/04/92 | 113000 | 33851 | 0.4708 | 33851.47 | 9.7 |
| 90492 | 114500 | 15.78 | 7.78 | 26.9 | 16.4 | 83.7 | 7.55 | 9.8 | 11.8 | & | 9/04/92 | 114500 | 33851 | 0.4771 | 33851.47 | 9.8 |
| 90492 | 120000 | 15.84 | 7.79 | 27.7 | 17 | 83.9 | 7.53 | 9.8 | 11.8 | & | 9/04/92 | 120000 | 33851 | 0.5000 | 33851.5 | 9.8 |
| 90492 | 121500 | 15.93 | 7.8 | 28.2 | 17.4 | 84 | 7.51 | 9.7 | 11.8 | & | 9/04/92 | 121500 | 33851 | 0.5063 | 33851.50 | 9.7 |
| 90492 | 123000 | 15.99 | 7.81 | 28.5 | 17.5 | 84.3 | 7.52 | 9.7 | 11.8 | & | 9/04/92 | 123000 | 33851 | 0.5125 | 33851.51 | 9.7 |
| 90492 | 124500 | 16.05 | 7.81 | 28.6 | 17.6 | 84.8 | 7.55 | 9.7 | 11.8 | & | 9/04/92 | 124500 | 33851 | 0.5188 | 33851.51 | 9.7 |
| 90492 | 130000 | 16.01 | 7.81 | 28.7 | 17.6 | 84 | 7.49 | 9.7 | 11.8 | & | 9/04/92 | 130000 | 33851 | 0.5417 | 33851.54 | 9.7 |
| 90492 | 131500 | 16.08 | 7.82 | 28.6 | 17.6 | 84.9 | 7.56 | 9.7 | 11.8 | & | 9/04/92 | 131500 | 33851 | 0.5479 | 33851.54 | 9.7 |
| 90492 | 133000 | 16.08 | 7.81 | 28.7 | 17.7 | 84.6 | 7.53 | 9.8 | 11.8 | & | 9/04/92 | 133000 | 33851 | 0.5542 | 33851.55 | 9.8 |
| 90492 | 134500 | 16.09 | 7.82 | 28.6 | 17.6 | 84.9 | 7.55 | 9.7 | 11.8 | & | 9/04/92 | 134500 | 33851 | 0.5604 | 33851.56 | 9.7 |
| 90492 | 140000 | 16.18 | 7.82 | 28.6 | 17.6 | 85.2 | 7.56 | 9.6 | 11.8 | & | 9/04/92 | 140000 | 33851 | 0.5833 | 33851.58 | 9.6 |
| 90492 | 141500 | 16.23 | 7.83 | 28.6 | 17.6 | 85.9 | 7.62 | 9.5 | 11.8 | & | 9/04/92 | 141500 | 33851 | 0.5896 | 33851.58 | 9.5 |
| 90492 | 143000 | 16.23 | 7.82 | 28.6 | 17.6 | 85.1 | 7.55 | 9.4 | 11.8 | & | 9/04/92 | 143000 | 33851 | 0.5958 | 33851.59 | 9.4 |
| 90492 | 144500 | 16.14 | 7.81 | 28.6 | 17.6 | 93.4 | 8.3 | 10.4* | 11.9 | & | 9/04/92 | 144500 | 33851 | 0.6021 | 33851.60 | 9.4 |
| 90492 | 150000 | 16.09 | 7.81 | 3.485 | 1.9 | 83.6 | 8.21 | 9.4 | 11.5 | & | 9/04/92 | 150000 | 33851 | 0.6250 | 33851.62 | 9.4 |

| Data logged by instrument in the field | | | | | | | | | | | Logged "depths" supplemented by interpolated water levels | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date (MMDDYY) | Time (HHMMSS) | Temp (deg C) | pH (units) | SpCond (mS/cm) | Salin (ppt) | DO (%Sat) | DO (mg/l) | Depth (feet) | Batt (volts) | | Date (MM/DD/YY) | Time (HHMMSS) | Date number | Time number | Date.Time Number* (Julian) | Water level** (feet) |
| 90492 | 151500 | 16.09 | 7.8 | | | | | 12.4* | 11.5 | & | 9/04/92 | 151500 | 33851 | 0.6313 | 33851.63 | 9.2 |
| 90492 | 153000 | 16.16 | 7.8 | 28.6 | 17.6 | 84.1 | 7.47 | 9 | 11.7 | & | 9/04/92 | 153000 | 33851 | 0.6375 | 33851.63 | 9 |
| 90492 | 154500 | 16.15 | 7.8 | 28.6 | 17.6 | 83.5 | 7.42 | 8.8 | 11.7 | & | 9/04/92 | 154500 | 33851 | 0.6438 | 33851.64 | 8.8 |
| 90492 | 160000 | 16.1 | 7.79 | 28.2 | 17.3 | 83.5 | 7.44 | 8.6 | 11.7 | & | 9/04/92 | 160000 | 33851 | 0.6667 | 33851.66 | 8.6 |
| 90492 | 161500 | 16.08 | 7.79 | 28.3 | 17.4 | 83.2 | 7.41 | 8.5 | 11.7 | & | 9/04/92 | 161500 | 33851 | 0.6729 | 33851.67 | 8.5 |
| 90492 | 163000 | 16.13 | 7.78 | 27.6 | 17 | 83.2 | 7.43 | 8.3 | 11.7 | & | 9/04/92 | 163000 | 33851 | 0.6792 | 33851.67 | 8.3 |
| 90492 | 164500 | 16.15 | 7.78 | 27.6 | 17 | 83.1 | 7.41 | 8.1 | 11.7 | & | 9/04/92 | 164500 | 33851 | 0.6854 | 33851.68 | 8.1 |
| 90492 | 170000 | 16.16 | 7.77 | 27.7 | 17 | 82.7 | 7.37 | 7.9 | 11.7 | & | 9/04/92 | 170000 | 33851 | 0.7083 | 33851.70 | 7.9 |
| 90492 | 171500 | 16.33 | 7.79 | 26.5 | 16.2 | 85 | 7.59 | 7.7 | 11.7 | & | 9/04/92 | 171500 | 33851 | 0.7146 | 33851.71 | 7.7 |
| 90492 | 173000 | 16.47 | 7.79 | 26.3 | 16 | 86.7 | 7.73 | 7.5 | 11.7 | & | 9/04/92 | 173000 | 33851 | 0.7208 | 33851.72 | 7.5 |
| 90492 | 174500 | 16.48 | 7.78 | 26.4 | 16.1 | 86.1 | 7.67 | 7.3 | 11.7 | & | 9/04/92 | 174500 | 33851 | 0.7271 | 33851.72 | 7.3 |
| 90492 | 180000 | 16.52 | 7.78 | 26.4 | 16.1 | 85.6 | 7.62 | 7.3 | 11.7 | & | 9/04/92 | 180000 | 33851 | 0.7500 | 33851.75 | 7.3 |
| 90492 | 181500 | 16.57 | 7.77 | 26.4 | 16.1 | 85.5 | 7.6 | 7.1 | 11.7 | & | 9/04/92 | 181500 | 33851 | 0.7563 | 33851.75 | 7.1 |
| 90492 | 183000 | 16.68 | 7.77 | 26.4 | 16.1 | 85.8 | 7.61 | 7 | 11.7 | & | 9/04/92 | 183000 | 33851 | 0.7625 | 33851.76 | 7 |
| 90492 | 184500 | 16.72 | 7.77 | 26.4 | 16.1 | 86.1 | 7.62 | 7.1 | 11.6 | & | 9/04/92 | 184500 | 33851 | 0.7688 | 33851.76 | 7.1 |
| 90492 | 190000 | 16.7 | 7.76 | 26.5 | 16.2 | 85.8 | 7.61 | 7.1 | 11.6 | & | 9/04/92 | 190000 | 33851 | 0.7917 | 33851.79 | 7.1 |
| 90492 | 191500 | 16.65 | 7.77 | 26.5 | 16.2 | 85.8 | 7.61 | 7.2 | 11.6 | & | 9/04/92 | 191500 | 33851 | 0.7979 | 33851.79 | 7.2 |
| 90492 | 193000 | 16.5 | 7.77 | 26.5 | 16.2 | 85.1 | 7.57 | 7.4 | 11.6 | & | 9/04/92 | 193000 | 33851 | 0.8042 | 33851.80 | 7.4 |
| 90492 | 194501* | 16.47 | 7.77 | 26.5 | 16.2 | 85.1 | 7.57 | 7.6 | 11.5 | & | 9/04/92 | 194500 | 33851 | 0.8104 | 33851.81 | 7.6 |
| 90492 | 200010* | 16.4 | 7.77 | | | 85.7 | 8.47 | 7.9 | 11.4 | & | 9/04/92 | 200000 | 33851 | 0.8333 | 33851.83 | 7.9 |
| 90492 | 201529* | 16.33 | 7.79 | | | | | 11.2* | 11.4 | & | 9/04/92 | 201500 | 33851 | 0.8396 | 33851.83 | 8 |
| 90492 | 203022* | | | | | | | | | | 9/04/92 | 203000 | 33851 | 0.8458 | 33851.84 | 8.2 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90492 | 204519* | | | | | | | | | | 9/04/92 | 204500 | 33851 | 0.8521 | 33851.85 | 8.3 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90492 | 210023* | 16.2 | 7.81 | | | | | 11.7* | 11.3 | & | 9/04/92 | 210000 | 33851 | 0.8750 | 33851.87 | 8.4 |
| 90492 | 211514* | 16.2 | 7.8 | | | 85.5 | 8.49 | 8.5 | 11.2 | & | 9/04/92 | 211500 | 33851 | 0.8813 | 33851.88 | 8.5 |
| 90492 | 213055* | 16.15 | 7.81 | | | | | 11.8* | 11.2 | & | 9/04/92 | 213000 | 33851 | 0.8875 | 33851.88 | 8.5 |
| 90492 | 215004* | 16.15 | 7.82 | | | 86 | 8.55 | 8.5 | 11 | & | 9/04/92 | 214500 | 33851 | 0.8938 | 33851.89 | 8.5 |
| 90492 | 220230* | | | | | | | | | | 9/04/92 | 220000 | 33851 | 0.9167 | 33851.91 | 8.7 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90492 | 221745* | 16.28 | 7.83 | | | 87.3 | 8.65 | 8.8 | 10.9 | & | 9/04/92 | 221500 | 33851 | 0.9229 | 33851.92 | 8.8 |
| 90492 | 223217* | 16.4 | 7.87 | | | | | 12.4* | 10.9 | & | 9/04/92 | 223000 | 33851 | 0.9292 | 33851.92 | 8.8 |
| 90492 | 224738* | | | | | | | | | | 9/04/92 | 224500 | 33851 | 0.9354 | 33851.93 | 8.8 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90492 | 230249* | | | | | | | | | | 9/04/92 | 230000 | 33851 | 0.9583 | 33851.95 | 8.9 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90492 | 231725* | 16.52 | 7.95 | | | 93.1 | 9.17 | 9 | 10.8 | & | 9/04/92 | 231500 | 33851 | 0.9646 | 33851.96 | 9 |
| 90492 | 233243* | | | | | | | | | | 9/04/92 | 233000 | 33851 | 0.9708 | 33851.97 | 9 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90492 | 234731* | | | | | | | | | | 9/04/92 | 234500 | 33851 | 0.9771 | 33851.97 | 9 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |

| Data logged by instrument in the field | | | | | | | | | | | Logged "depths" supplemented by interpolated water levels | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date (MMDDYY) | Time (HHMMSS) | Temp (deg C) | pH (units) | SpCond (mS/cm) | Salin (ppt) | DO (%Sat) | DO (mg/l) | Depth (feet) | Batt (volts) | | Date (MM/DD/YY) | Time (HHMMSS) | Date number | Time number | Date.Time Number^ (Julian) | Water level^^ (feet) |
| 90592 | 208* | | | | | | | | | | 9/05/92 | 0 | 33852 | 0.0000 | 33852 | 9 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 1630* | | | | | | | | | | 9/05/92 | 1500 | 33852 | 0.0063 | 33852.00 | 8.9 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 3048* | 16.43 | 7.92 | | | 91.2 | 9 | 8.9 | 10.8 | & | 9/05/92 | 3000 | 33852 | 0.0125 | 33852.01 | 8.9 |
| 90592 | 4515* | 16.48 | 7.93 | | | 91.5 | 9.03 | 8.9 | 10.8 | & | 9/05/92 | 4500 | 33852 | 0.0188 | 33852.01 | 8.9 |
| 90592 | 10007* | 16.52 | 7.92 | | | 91.3 | 9 | 8.8 | 10.8 | & | 9/05/92 | 10000 | 33852 | 0.0417 | 33852.04 | 8.8 |
| 90592 | 11514* | 16.47 | 7.89 | | | 89.4 | 8.82 | 8.7 | 10.8 | & | 9/05/92 | 11500 | 33852 | 0.0479 | 33852.04 | 8.7 |
| 90592 | 13000 | 16.28 | 7.82 | 28.2 | 17.4 | 85.9 | 7.62 | 8.5 | 11 | & | 9/05/92 | 13000 | 33852 | 0.0542 | 33852.05 | 8.5 |
| 90592 | 14500 | 16.13 | 7.8 | 27.5 | 16.8 | 84.2 | 7.52 | 8.3 | 10.9 | & | 9/05/92 | 14500 | 33852 | 0.0604 | 33852.06 | 8.3 |
| 90592 | 20000 | 16.07 | 7.78 | 27.2 | 16.7 | 83.3 | 7.45 | 7.9 | 10.9 | & | 9/05/92 | 20000 | 33852 | 0.0833 | 33852.08 | 7.9 |
| 90592 | 21719* | 16.01 | 7.76 | | | | | 11.1 | 10.7 | & | 9/05/92 | 21500 | 33852 | 0.0896 | 33852.08 | 7.6 |
| 90592 | 23336* | | | | | | | | | | 9/05/92 | 23000 | 33852 | 0.0958 | 33852.09 | 7.3 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 24812* | | | | | | | | | | 9/05/92 | 24500 | 33852 | 0.1021 | 33852.10 | 6.9 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 30440* | | | | | | | | | | 9/05/92 | 30000 | 33852 | 0.1250 | 33852.12 | 6.5 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 31729* | | | | | | | | | | 9/05/92 | 31500 | 33852 | 0.1313 | 33852.13 | 6.1 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 33312* | | | | | | | | | | 9/05/92 | 33000 | 33852 | 0.1375 | 33852.13 | 5.7 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 34737* | | | | | | | | | | 9/05/92 | 34500 | 33852 | 0.1438 | 33852.14 | 5.4 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 40251* | | | | | | | | | | 9/05/92 | 40000 | 33852 | 0.1667 | 33852.16 | 5.1 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 41638* | | | | | | | | | | 9/05/92 | 41500 | 33852 | 0.1729 | 33852.17 | 4.8 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 43048* | 17.72 | 7.64 | | | 78.3 | 7.53 | 4.6 | 10.4 | & | 9/05/92 | 43000 | 33852 | 0.1792 | 33852.17 | 4.6 |
| 90592 | 44626* | | | | | | | | | | 9/05/92 | 44500 | 33852 | 0.1854 | 33852.18 | 4.5 |
| ERROR: data could not be acquired | | | | | | | | | | | | | | | | |
| 90592 | 50000 | 17.96 | 7.59 | 25.5 | 15.5 | 75.5 | 6.55 | 4.5 | 10.6 | & | 9/05/92 | 50000 | 33852 | 0.2083 | 33852.20 | 4.5 |
| 90592 | 51500 | 18.02 | 7.57 | 25.2 | 15.3 | 74 | 6.42 | 4.3 | 10.7 | & | 9/05/92 | 51500 | 33852 | 0.2146 | 33852.21 | 4.3 |
| 90592 | 53000 | 18.06 | 7.56 | 25 | 15.2 | 73 | 6.33 | 4.1 | 10.7 | & | 9/05/92 | 53000 | 33852 | 0.2208 | 33852.22 | 4.1 |
| 90592 | 54500 | 18.06 | 7.55 | 24.9 | 15.1 | 72.4 | 6.28 | 4 | 10.7 | & | 9/05/92 | 54500 | 33852 | 0.2271 | 33852.22 | 4 |
| 90592 | 60000 | 18.04 | 7.54 | 24.7 | 15 | 71.9 | 6.24 | 3.9 | 10.7 | & | 9/05/92 | 60000 | 33852 | 0.2500 | 33852.25 | 3.9 |
| 90592 | 61500 | 18.06 | 7.53 | 24.6 | 14.9 | 71 | 6.17 | 3.8 | 10.7 | & | 9/05/92 | 61500 | 33852 | 0.2563 | 33852.25 | 3.8 |
| 90592 | 63000 | 18.09 | 7.51 | 24.5 | 14.9 | 70.1 | 6.09 | 3.8 | 10.7 | & | 9/05/92 | 63000 | 33852 | 0.2625 | 33852.26 | 3.8 |
| 90592 | 64500 | 18.11 | 7.5 | 24.4 | 14.8 | 69 | 5.99 | 3.8 | 10.7 | & | 9/05/92 | 64500 | 33852 | 0.2688 | 33852.26 | 3.8 |
| 90592 | 70000 | 18.13 | 7.49 | 24.3 | 14.7 | 68.5 | 5.94 | 3.6 | 10.7 | & | 9/05/92 | 70000 | 33852 | 0.2917 | 33852.29 | 3.6 |
| 90592 | 71500 | 18.16 | 7.48 | 24.2 | 14.6 | 67.6 | 5.87 | 3.7 | 10.7 | & | 9/05/92 | 71500 | 33852 | 0.2979 | 33852.29 | 3.7 |
| 90592 | 73000 | 18.18 | 7.48 | 24.1 | 14.6 | 66.9 | 5.81 | 3.7 | 10.7 | & | 9/05/92 | 73000 | 33852 | 0.3042 | 33852.30 | 3.7 |

### Data logged by instrument in the field

| Date (MMDDYY) | Time (HHMMSS) | Temp (deg C) | pH (units) | SpCond (mS/cm) | Salin (ppt) | DO (%Sat) | DO (mg/l) | Depth (feet) | Batt (volts) | |
|---|---|---|---|---|---|---|---|---|---|---|
| 90592 | 74500 | 18.23 | 7.47 | 24.1 | 14.5 | 66.3 | 5.75 | 3.6 | 10.7 | & |
| 90592 | 80000 | 18.24 | 7.46 | 24 | 14.5 | 66.1 | 5.73 | 3.5 | 10.7 | & |
| 90592 | 81500 | 18.15 | 7.46 | 24 | 14.5 | 66.2 | 5.75 | 3.6 | 10.6 | & |
| 90592 | 83000 | 18.17 | 7.46 | 24 | 14.5 | 66 | 5.73 | 3.4 | 10.6 | & |
| 90592 | 84500 | 18.18 | 7.45 | 24.1 | 14.6 | 65.7 | 5.7 | 3.4 | 10.6 | & |
| 90592 | 90000 | 18.19 | 7.45 | 24.1 | 14.6 | 65.7 | 5.7 | 3.4 | 10.6 | & |
| 90592 | 91500 | 18.16 | 7.46 | 24 | 14.5 | 65.9 | 5.72 | 3.4 | 10.5 | & |
| 90592 | 93000 | 18.08 | 7.47 | 23.9 | 14.4 | 66.9 | 5.82 | 3.5 | 10.5 | & |
| 90592 | 94500 | 18.1 | 7.47 | 24 | 14.5 | 66.3 | 5.77 | 3.4 | 10.5 | & |
| 90592 | 100000 | 18.09 | 7.47 | 23.8 | 14.4 | 66.5 | 5.79 | 3.4 | 10.5 | & |
| 90592 | 101500 | 18.06 | 7.47 | 23.6 | 14.3 | 67.6 | 5.89 | 3.4 | 10.4 | & |
| 90592 | 103000 | 18.04 | 7.5 | 23.1 | 13.9 | 70.7 | 6.18 | 3.4 | 10.4 | & |
| 90592 | 104500 | 18.06 | 7.52 | 23.2 | 14 | 72.8 | 6.36 | 3.8 | 10.4 | & |
| 90592 | 110000 | 17.99 | 7.48 | 24.1 | 14.6 | 66.8 | 5.82 | 5.2 | 10.4 | & |
| 90592 | 113831* | | | | | | | | | |
| ERROR: data could not be acquired | | | | | | | | | | |
| 90592 | 121921* | 17.9 | 7.61 | | | 78.1 | 7.48 | 8.9 | 8.9 | & |
| 90592 | 121927* | 17.9 | 7.61 | | | 78.1 | 7.48 | 8.9 | 8.9 | & |
| 90592 | 121927* | 17.9 | 7.61 | | | 78.1 | 7.48 | 8.9 | 8.9 | & |

Variable or Calibration changed at 090892 083153 => changes ignored!
Power loss from 090892 090712 to 090892 090712
Power loss from 090892 090713 to 090892 090720
Power loss from 090892 090749 to 090892 090749
Power loss from 090892 090750 to 090892 090750
Power loss from 090892 090751 to 090892 090751
Power loss from 090892 090752 to 090892 090752
Power loss from 090892 090753 to 090892 090753
Power loss from 090892 090754 to 090892 090754
Power loss from 090892 090755 to 090892 090755
Recovery finished at 090892 091554

### Logged "depths" supplemented by interpolated water levels

| Date (MM/DD/YY) | Time (HHMMSS) | Date number | Time number | Date.Time Number^ (Julian) | Water level^^ (feet) |
|---|---|---|---|---|---|
| 9/05/92 | 74500 | 33852 | 0.3104 | 33852.31 | 3.6 |
| 9/05/92 | 80000 | 33852 | 0.3333 | 33852.33 | 3.5 |
| 9/05/92 | 81500 | 33852 | 0.3396 | 33852.33 | 3.6 |
| 9/05/92 | 83000 | 33852 | 0.3458 | 33852.34 | 3.4 |
| 9/05/92 | 84500 | 33852 | 0.3521 | 33852.35 | 3.4 |
| 9/05/92 | 90000 | 33852 | 0.3750 | 33852.37 | 3.4 |
| 9/05/92 | 91500 | 33852 | 0.3813 | 33852.38 | 3.4 |
| 9/05/92 | 93000 | 33852 | 0.3875 | 33852.38 | 3.5 |
| 9/05/92 | 94500 | 33852 | 0.3938 | 33852.39 | 3.4 |
| 9/05/92 | 100000 | 33852 | 0.4167 | 33852.41 | 3.4 |
| 9/05/92 | 101500 | 33852 | 0.4229 | 33852.42 | 3.4 |
| 9/05/92 | 103000 | 33852 | 0.4292 | 33852.42 | 3.4 |
| 9/05/92 | 104500 | 33852 | 0.4354 | 33852.43 | 3.8 |
| 9/05/92 | 110000 | 33852 | 0.4583 | 33852.45 | 5.2 |
| 9/05/92 | 111500 | 33852 | 0.4646 | 33852.46 | 6.4 |
| 9/05/92 | 113000 | 33852 | 0.4708 | 33852.47 | 7.6 |
| 9/05/92 | 114500 | 33852 | 0.4771 | 33852.47 | 8.7 |
| 9/05/92 | 120000 | 33852 | 0.5000 | 33852.5 | 9.6 |

^ - Based on Julian Year.
^^ - Predominance of this data is the "depth" readings logged by the DataSonde™; where instrument indicated that "data could not be acquired"; interpolated water levels were inserted.
* - Outlier

# APPENDIX E2

Data logged by Unidata®

## Data Logged by Unidata™ Deployed at Station A.

| Data logged by instrument in the field | | | Data normalized in office | | | | |
|---|---|---|---|---|---|---|---|
| Date (MM/DD/YY) | Time (HH:MM:SS) | Water level (inches) | Date number | Time number | Date.Time number (Julian) | Water level* (feet) | |
| 09/03/92 | 12:00:00 | 107 | 33850 | 0.5000 | 33850.5 | 5.7 | |
| 09/03/92 | 12:15:00 | 106 | 33850 | 0.5104 | 33850.51041 | 5.6 | |
| 09/03/92 | 12:30:00 | 105 | 33850 | 0.5208 | 33850.52083 | 5.6 | |
| 09/03/92 | 12:45:00 | 103 | 33850 | 0.5313 | 33850.53125 | 5.4 | |
| 09/03/92 | 13:00:00 | 102 | 33850 | 0.5417 | 33850.54166 | 5.3 | |
| 09/03/92 | 13:15:00 | 100 | 33850 | 0.5521 | 33850.55208 | 5.1 | |
| 09/03/92 | 13:30:00 | 99 | 33850 | 0.5625 | 33850.5625 | 5.1 | |
| 09/03/92 | 13:45:00 | 97 | 33850 | 0.5729 | 33850.57291 | 4.9 | |
| 09/03/92 | 14:00:00 | 95 | 33850 | 0.5833 | 33850.58333 | 4.7 | |
| 09/03/92 | 14:15:00 | 93 | 33850 | 0.5938 | 33850.59375 | 4.6 | |
| 09/03/92 | 14:30:00 | 92 | 33850 | 0.6042 | 33850.60416 | 4.5 | |
| 09/03/92 | 14:45:00 | 90 | 33850 | 0.6146 | 33850.61458 | 4.3 | |
| 09/03/92 | 15:00:00 | 87 | 33850 | 0.6250 | 33850.625 | 4.1 | |
| 09/03/92 | 15:15:00 | 84 | 33850 | 0.6354 | 33850.63541 | 3.8 | |
| 09/03/92 | 15:30:00 | 82 | 33850 | 0.6458 | 33850.64583 | 3.6 | |
| 09/03/92 | 15:45:00 | 80 | 33850 | 0.6563 | 33850.65625 | 3.5 | |
| 09/03/92 | 16:00:00 | 77 | 33850 | 0.6667 | 33850.66666 | 3.2 | |
| 09/03/92 | 16:15:00 | 75 | 33850 | 0.6771 | 33850.67708 | 3.1 | |
| 09/03/92 | 16:30:00 | 73 | 33850 | 0.6875 | 33850.6875 | 2.9 | |
| 09/03/92 | 16:45:00 | 72 | 33850 | 0.6979 | 33850.69791 | 2.8 | |
| 09/03/92 | 17:00:00 | 71 | 33850 | 0.7083 | 33850.70833 | 2.7 | |
| 09/03/92 | 17:15:00 | 71 | 33850 | 0.7188 | 33850.71875 | 2.7 | HLW |
| 09/03/92 | 17:30:00 | 71 | 33850 | 0.7292 | 33850.72916 | 2.7 | |
| 09/03/92 | 17:45:00 | 73 | 33850 | 0.7396 | 33850.73958 | 2.9 | |
| 09/03/92 | 18:00:00 | 74 | 33850 | 0.7500 | 33850.75 | 3.0 | |
| 09/03/92 | 18:15:00 | 76 | 33850 | 0.7604 | 33850.76041 | 3.1 | |
| 09/03/92 | 18:30:00 | 79 | 33850 | 0.7708 | 33850.77083 | 3.4 | |
| 09/03/92 | 18:45:00 | 81 | 33850 | 0.7813 | 33850.78125 | 3.6 | |
| 09/03/92 | 19:00:00 | 83 | 33850 | 0.7917 | 33850.79166 | 3.7 | |
| 09/03/92 | 19:15:00 | 86 | 33850 | 0.8021 | 33850.80208 | 4.0 | |
| 09/03/92 | 19:30:00 | 90 | 33850 | 0.8125 | 33850.8125 | 4.3 | |
| 09/03/92 | 19:45:00 | 93 | 33850 | 0.8229 | 33850.82291 | 4.6 | |
| 09/03/92 | 20:00:00 | 95 | 33850 | 0.8333 | 33850.83333 | 4.7 | |
| 09/03/92 | 20:15:00 | 99 | 33850 | 0.8438 | 33850.84375 | 5.1 | |
| 09/03/92 | 20:30:00 | 101 | 33850 | 0.8542 | 33850.85416 | 5.2 | |
| 09/03/92 | 20:45:00 | 103 | 33850 | 0.8646 | 33850.86458 | 5.4 | |
| 09/03/92 | 21:00:00 | 106 | 33850 | 0.8750 | 33850.875 | 5.6 | |

| Data logged by instrument in the field | | | Data normalized in office | | | | |
|---|---|---|---|---|---|---|---|
| Date (MM/DD/YY) | Time (HH:MM:SS) | Water level (inches) | Date number | Time number | Date.Time number (Julian) | Water level* (feet) | |
| 09/03/92 | 21:15:00 | 107 | 33850 | 0.8854 | 33850.88541 | 5.7 | |
| 09/03/92 | 21:30:00 | 110 | 33850 | 0.8958 | 33850.89583 | 6.0 | |
| 09/03/92 | 21:45:00 | 112 | 33850 | 0.9063 | 33850.90625 | 6.1 | |
| 09/03/92 | 22:00:00 | 113 | 33850 | 0.9167 | 33850.91666 | 6.2 | |
| 09/03/92 | 22:15:00 | 113 | 33850 | 0.9271 | 33850.92708 | 6.2 | HHW |
| 09/03/92 | 22:30:00 | 113 | 33850 | 0.9375 | 33850.9375 | 6.2 | |
| 09/03/92 | 22:45:00 | 113 | 33850 | 0.9479 | 33850.94791 | 6.2 | |
| 09/03/92 | 23:00:00 | 112 | 33850 | 0.9583 | 33850.95833 | 6.1 | |
| 09/03/92 | 23:15:00 | 110 | 33850 | 0.9688 | 33850.96875 | 6.0 | |
| 09/03/92 | 23:30:00 | 109 | 33850 | 0.9792 | 33850.97916 | 5.9 | |
| 09/03/92 | 23:45:00 | 107 | 33850 | 0.9896 | 33850.98958 | 5.7 | |
| 09/04/92 | 00:00:00 | 104 | 33851 | 0.0000 | 33851 | 5.5 | |
| 09/04/92 | 00:15:00 | 100 | 33851 | 0.0104 | 33851.01041 | 5.1 | |
| 09/04/92 | 00:30:00 | 98 | 33851 | 0.0208 | 33851.02083 | 5.0 | |
| 09/04/92 | 00:45:00 | 94 | 33851 | 0.0313 | 33851.03125 | 4.6 | |
| 09/04/92 | 01:00:00 | 90 | 33851 | 0.0417 | 33851.04166 | 4.3 | |
| 09/04/92 | 01:15:00 | 86 | 33851 | 0.0521 | 33851.05208 | 4.0 | |
| 09/04/92 | 01:30:00 | 83 | 33851 | 0.0625 | 33851.0625 | 3.7 | |
| 09/04/92 | 01:45:00 | 79 | 33851 | 0.0729 | 33851.07291 | 3.4 | |
| 09/04/92 | 02:00:00 | 75 | 33851 | 0.0833 | 33851.08333 | 3.1 | |
| 09/04/92 | 02:15:00 | 72 | 33851 | 0.0938 | 33851.09375 | 2.8 | |
| 09/04/92 | 02:30:00 | 68 | 33851 | 0.1042 | 33851.10416 | 2.5 | |
| 09/04/92 | 02:45:00 | 65 | 33851 | 0.1146 | 33851.11458 | 2.2 | |
| 09/04/92 | 03:00:00 | 63 | 33851 | 0.1250 | 33851.125 | 2.1 | |
| 09/04/92 | 03:15:00 | 59 | 33851 | 0.1354 | 33851.13541 | 1.7 | |
| 09/04/92 | 03:30:00 | 57 | 33851 | 0.1458 | 33851.14583 | 1.5 | |
| 09/04/92 | 03:45:00 | 55 | 33851 | 0.1563 | 33851.15625 | 1.4 | |
| 09/04/92 | 04:00:00 | 53 | 33851 | 0.1667 | 33851.16666 | 1.2 | |
| 09/04/92 | 04:15:00 | 52 | 33851 | 0.1771 | 33851.17708 | 1.1 | |
| 09/04/92 | 04:30:00 | 50 | 33851 | 0.1875 | 33851.1875 | 1.0 | |
| 09/04/92 | 04:45:00 | 49 | 33851 | 0.1979 | 33851.19791 | 0.9 | |
| 09/04/92 | 05:00:00 | 47 | 33851 | 0.2083 | 33851.20833 | 0.7 | |
| 09/04/92 | 05:15:00 | 46 | 33851 | 0.2188 | 33851.21875 | 0.6 | |
| 09/04/92 | 05:30:00 | 46 | 33851 | 0.2292 | 33851.22916 | 0.6 | |
| 09/04/92 | 05:45:00 | 45 | 33851 | 0.2396 | 33851.23958 | 0.5 | |
| 09/04/92 | 06:00:00 | 44 | 33851 | 0.2500 | 33851.25 | 0.5 | |
| 09/04/92 | 06:15:00 | 43 | 33851 | 0.2604 | 33851.26041 | 0.4 | |
| 09/04/92 | 06:30:00 | 43 | 33851 | 0.2708 | 33851.27083 | 0.4 | |
| 09/04/92 | 06:45:00 | 42 | 33851 | 0.2813 | 33851.28125 | 0.3 | |
| 09/04/92 | 07:00:00 | 42 | 33851 | 0.2917 | 33851.29166 | 0.3 | |
| 09/04/92 | 07:15:00 | 42 | 33851 | 0.3021 | 33851.30208 | 0.3 | |
| 09/04/92 | 07:30:00 | 41 | 33851 | 0.3125 | 33851.3125 | 0.2 | |

| Data logged by instrument in the field | | | Data normalized in office | | | | |
|---|---|---|---|---|---|---|---|
| Date (MM/DD/YY) | Time (HH:MM:SS) | Water level (inches) | Date number | Time number | Date.Time number (Julian) | Water level* (feet) | |
| 09/04/92 | 07:45:00 | 41 | 33851 | 0.3229 | 33851.32291 | 0.2 | |
| 09/04/92 | 08:00:00 | 40 | 33851 | 0.3333 | 33851.33333 | 0.1 | |
| 09/04/92 | 08:15:00 | 40 | 33851 | 0.3438 | 33851.34375 | 0.1 | |
| 09/04/92 | 08:30:00 | 40 | 33851 | 0.3542 | 33851.35416 | 0.1 | |
| 09/04/92 | 08:45:00 | 39 | 33851 | 0.3646 | 33851.36458 | 0.0 | LLW |
| 09/04/92 | 09:00:00 | 39 | 33851 | 0.3750 | 33851.375 | 0.0 | |
| 09/04/92 | 09:15:00 | 39 | 33851 | 0.3854 | 33851.38541 | 0.0 | |
| 09/04/92 | 09:30:00 | 39 | 33851 | 0.3958 | 33851.39583 | 0.0 | |
| 09/04/92 | 09:45:00 | 40 | 33851 | 0.4063 | 33851.40625 | 0.1 | |
| 09/04/92 | 10:00:00 | 44 | 33851 | 0.4167 | 33851.41666 | 0.5 | |
| 09/04/92 | 10:15:00 | 52 | 33851 | 0.4271 | 33851.42708 | 1.1 | |
| 09/04/92 | 10:30:00 | 63 | 33851 | 0.4375 | 33851.4375 | 2.1 | |
| 09/04/92 | 10:45:00 | 73 | 33851 | 0.4479 | 33851.44791 | 2.9 | |
| 09/04/92 | 11:00:00 | 83 | 33851 | 0.4583 | 33851.45833 | 3.7 | |
| 09/04/92 | 11:15:00 | 92 | 33851 | 0.4688 | 33851.46875 | 4.5 | |
| 09/04/92 | 11:30:00 | 98 | 33851 | 0.4792 | 33851.47916 | 5.0 | |
| 09/04/92 | 11:45:00 | 102 | 33851 | 0.4896 | 33851.48958 | 5.3 | |
| 09/04/92 | 12:00:00 | 106 | 33851 | 0.5000 | 33851.5 | 5.6 | |
| 09/04/92 | 12:15:00 | 108 | 33851 | 0.5104 | 33851.51041 | 5.8 | |
| 09/04/92 | 12:30:00 | 109 | 33851 | 0.5208 | 33851.52083 | 5.9 | |
| 09/04/92 | 12:45:00 | 110 | 33851 | 0.5313 | 33851.53125 | 6.0 | |
| 09/04/92 | 13:00:00 | 110 | 33851 | 0.5417 | 33851.54166 | 6.0 | |
| 09/04/92 | 13:15:00 | 112 | 33851 | 0.5521 | 33851.55208 | 6.1 | |
| 09/04/92 | 13:30:00 | 111 | 33851 | 0.5625 | 33851.5625 | 6.1 | |
| 09/04/92 | 13:45:00 | 112 | 33851 | 0.5729 | 33851.57291 | 6.1 | |
| 09/04/92 | 14:00:00 | 110 | 33851 | 0.5833 | 33851.58333 | 6.0 | |
| 09/04/92 | 14:15:00 | 109 | 33851 | 0.5938 | 33851.59375 | 5.9 | |
| 09/04/92 | 14:30:00 | 107 | 33851 | 0.6042 | 33851.60416 | 5.7 | |
| 09/04/92 | 14:45:00 | 106 | 33851 | 0.6146 | 33851.61458 | 5.6 | |
| 09/04/92 | 15:00:00 | 103 | 33851 | 0.6250 | 33851.625 | 5.4 | |
| 09/04/92 | 15:15:00 | 103 | 33851 | 0.6354 | 33851.63541 | 5.4 | |
| 09/04/92 | 15:30:00 | 100 | 33851 | 0.6458 | 33851.64583 | 5.1 | |
| 09/04/92 | 15:45:00 | 98 | 33851 | 0.6563 | 33851.65625 | 5.0 | |
| 09/04/92 | 16:00:00 | 96 | 33851 | 0.6667 | 33851.66666 | 4.8 | |
| 09/04/92 | 16:15:00 | 94 | 33851 | 0.6771 | 33851.67708 | 4.6 | |
| 09/04/92 | 16:30:00 | 91 | 33851 | 0.6875 | 33851.6875 | 4.4 | |
| 09/04/92 | 16:45:00 | 90 | 33851 | 0.6979 | 33851.69791 | 4.3 | |
| 09/04/92 | 17:00:00 | 86 | 33851 | 0.7083 | 33851.70833 | 4.0 | |
| 09/04/92 | 17:15:00 | 84 | 33851 | 0.7188 | 33851.71875 | 3.8 | |
| 09/04/92 | 17:30:00 | 83 | 33851 | 0.7292 | 33851.72916 | 3.7 | |
| 09/04/92 | 17:45:00 | 81 | 33851 | 0.7396 | 33851.73958 | 3.6 | |
| 09/04/92 | 18:00:00 | 80 | 33851 | 0.7500 | 33851.75 | 3.5 | |

| Data logged by instrument in the field | | | Data normalized in office | | | |
|---|---|---|---|---|---|---|
| Date (MM/DD/YY) | Time (HH:MM:SS) | Water level (inches) | Date number | Time number | Date.Time number (Julian) | Water level* (feet) |
| 09/04/92 | 18:15:00 | 79 | 33851 | 0.7604 | 33851.76041 | 3.4 |
| 09/04/92 | 18:30:00 | 78 | 33851 | 0.7708 | 33851.77083 | 3.3 |
| 09/04/92 | 18:45:00 | 78 | 33851 | 0.7813 | 33851.78125 | 3.3 |
| 09/04/92 | 19:00:00 | 79 | 33851 | 0.7917 | 33851.79166 | 3.4 |
| 09/04/92 | 19:15:00 | 80 | 33851 | 0.8021 | 33851.80208 | 3.5 |
| 09/04/92 | 19:30:00 | 80 | 33851 | 0.8125 | 33851.8125 | 3.5 |
| 09/04/92 | 19:45:00 | 83 | 33851 | 0.8229 | 33851.82291 | 3.7 |
| 09/04/92 | 20:00:00 | 85 | 33851 | 0.8333 | 33851.83333 | 3.9 |
| 09/04/92 | 20:15:00 | 86 | 33851 | 0.8438 | 33851.84375 | 4.0 |
| 09/04/92 | 20:30:00 | 88 | 33851 | 0.8542 | 33851.85416 | 4.1 |
| 09/04/92 | 20:45:00 | 90 | 33851 | 0.8646 | 33851.86458 | 4.3 |
| 09/04/92 | 21:00:00 | 91 | 33851 | 0.8750 | 33851.875 | 4.4 |
| 09/04/92 | 21:15:00 | 93 | 33851 | 0.8854 | 33851.88541 | 4.6 |
| 09/04/92 | 21:30:00 | 95 | 33851 | 0.8958 | 33851.89583 | 4.7 |
| 09/04/92 | 21:45:00 | 96 | 33851 | 0.9063 | 33851.90625 | 4.8 |
| 09/04/92 | 22:00:00 | 99 | 33851 | 0.9167 | 33851.91666 | 5.1 |
| 09/04/92 | 22:15:00 | 100 | 33851 | 0.9271 | 33851.92708 | 5.1 |
| 09/04/92 | 22:30:00 | 102 | 33851 | 0.9375 | 33851.9375 | 5.3 |
| 09/04/92 | 22:45:00 | 103 | 33851 | 0.9479 | 33851.94791 | 5.4 |
| 09/04/92 | 23:00:00 | 104 | 33851 | 0.9583 | 33851.95833 | 5.5 |
| 09/04/92 | 23:15:00 | 105 | 33851 | 0.9688 | 33851.96875 | 5.6 |
| 09/04/92 | 23:30:00 | 105 | 33851 | 0.9792 | 33851.97916 | 5.6 |
| 09/04/92 | 23:45:00 | 104 | 33851 | 0.9896 | 33851.98958 | 5.5 |
| 09/05/92 | 00:00:00 | 103 | 33852 | 0.0000 | 33852 | 5.4 |
| 09/05/92 | 00:15:00 | 103 | 33852 | 0.0104 | 33852.01041 | 5.4 |
| 09/05/92 | 00:30:00 | 102 | 33852 | 0.0208 | 33852.02083 | 5.3 |
| 09/05/92 | 00:45:00 | 100 | 33852 | 0.0313 | 33852.03125 | 5.1 |
| 09/05/92 | 01:00:00 | 97 | 33852 | 0.0417 | 33852.04166 | 4.9 |
| 09/05/92 | 01:15:00 | 95 | 33852 | 0.0521 | 33852.05208 | 4.7 |
| 09/05/92 | 01:30:00 | 91 | 33852 | 0.0625 | 33852.0625 | 4.4 |
| 09/05/92 | 01:45:00 | 89 | 33852 | 0.0729 | 33852.07291 | 4.2 |
| 09/05/92 | 02:00:00 | 85 | 33852 | 0.0833 | 33852.08333 | 3.9 |
| 09/05/92 | 02:15:00 | 82 | 33852 | 0.0938 | 33852.09375 | 3.6 |
| 09/05/92 | 02:30:00 | 79 | 33852 | 0.1042 | 33852.10416 | 3.4 |
| 09/05/92 | 02:45:00 | 76 | 33852 | 0.1146 | 33852.11458 | 3.1 |
| 09/05/92 | 03:00:00 | 71 | 33852 | 0.1250 | 33852.125 | 2.7 |
| 09/05/92 | 03:15:00 | 69 | 33852 | 0.1354 | 33852.13541 | 2.6 |
| 09/05/92 | 03:30:00 | 66 | 33852 | 0.1458 | 33852.14583 | 2.3 |
| 09/05/92 | 03:45:00 | 63 | 33852 | 0.1563 | 33852.15625 | 2.1 |
| 09/05/92 | 04:00:00 | 60 | 33852 | 0.1667 | 33852.16666 | 1.8 |
| 09/05/92 | 04:15:00 | 58 | 33852 | 0.1771 | 33852.17708 | 1.6 |
| 09/05/92 | 04:30:00 | 56 | 33852 | 0.1875 | 33852.1875 | 1.5 |

| Data logged by instrument in the field | | | Data normalized in office | | | |
|---|---|---|---|---|---|---|
| Date (MM/DD/YY) | Time (HH:MM:SS) | Water level (inches) | Date number | Time number | Date.Time number (Julian) | Water level* (feet) |
| 09/05/92 | 04:45:00 | 53 | 33852 | 0.1979 | 33852.19791 | 1.2 |
| 09/05/92 | 05:00:00 | 52 | 33852 | 0.2083 | 33852.20833 | 1.1 |
| 09/05/92 | 05:15:00 | 51 | 33852 | 0.2188 | 33852.21875 | 1.0 |
| 09/05/92 | 05:30:00 | 49 | 33852 | 0.2292 | 33852.22916 | 0.9 |
| 09/05/92 | 05:45:00 | 48 | 33852 | 0.2396 | 33852.23958 | 0.8 |
| 09/05/92 | 06:00:00 | 47 | 33852 | 0.2500 | 33852.25 | 0.7 |
| 09/05/92 | 06:15:00 | 46 | 33852 | 0.2604 | 33852.26041 | 0.6 |
| 09/05/92 | 06:30:00 | 45 | 33852 | 0.2708 | 33852.27083 | 0.5 |
| 09/05/92 | 06:45:00 | 44 | 33852 | 0.2813 | 33852.28125 | 0.5 |
| 09/05/92 | 07:00:00 | 43 | 33852 | 0.2917 | 33852.29166 | 0.4 |
| 09/05/92 | 07:15:00 | 43 | 33852 | 0.3021 | 33852.30208 | 0.4 |
| 09/05/92 | 07:30:00 | 42 | 33852 | 0.3125 | 33852.3125 | 0.3 |
| 09/05/92 | 07:45:00 | 42 | 33852 | 0.3229 | 33852.32291 | 0.3 |
| 09/05/92 | 08:00:00 | 42 | 33852 | 0.3333 | 33852.33333 | 0.3 |
| 09/05/92 | 08:15:00 | 41 | 33852 | 0.3438 | 33852.34375 | 0.2 |
| 09/05/92 | 08:30:00 | 41 | 33852 | 0.3542 | 33852.35416 | 0.2 |
| 09/05/92 | 08:45:00 | 41 | 33852 | 0.3646 | 33852.36458 | 0.2 |
| 09/05/92 | 09:00:00 | 40 | 33852 | 0.3750 | 33852.375 | 0.1 |
| 09/05/92 | 09:15:00 | 40 | 33852 | 0.3854 | 33852.38541 | 0.1 |
| 09/05/92 | 09:30:00 | 40 | 33852 | 0.3958 | 33852.39583 | 0.1 |
| 09/05/92 | 09:45:00 | 40 | 33852 | 0.4063 | 33852.40625 | 0.1 |
| 09/05/92 | 10:00:00 | 40 | 33852 | 0.4167 | 33852.41666 | 0.1 |
| 09/05/92 | 10:15:00 | 39 | 33852 | 0.4271 | 33852.42708 | 0.0 |
| 09/05/92 | 10:30:00 | 39 | 33852 | 0.4375 | 33852.4375 | 0.0 |
| 09/05/92 | 10:45:00 | 39 | 33852 | 0.4479 | 33852.44791 | 0.0 |
| 09/05/92 | 11:00:00 | 39 | 33852 | 0.4583 | 33852.45833 | 0.0 |
| 09/05/92 | 11:15:00 | 43 | 33852 | 0.4688 | 33852.46875 | 0.4 |
| 09/05/92 | 11:30:00 | 52 | 33852 | 0.4792 | 33852.47916 | 1.1 |
| 09/05/92 | 11:45:00 | 62 | 33852 | 0.4896 | 33852.48958 | 2.0 |
| 09/05/92 | 12:00:00 | 73 | 33852 | 0.5000 | 33852.5 | 2.9 |
| 09/05/92 | 12:15:00 | 83 | 33852 | 0.5104 | 33852.51041 | 3.7 |
| 09/05/92 | 12:30:00 | 92 | 33852 | 0.5208 | 33852.52083 | 4.5 |
| 09/05/92 | 12:45:00 | 98 | 33852 | 0.5313 | 33852.53125 | 5.0 |
| 09/05/92 | 13:00:00 | 102 | 33852 | 0.5417 | 33852.54166 | 5.3 |
| 09/05/92 | 13:15:00 | 106 | 33852 | 0.5521 | 33852.55208 | 5.6 |
| 09/05/92 | 13:30:00 | 109 | 33852 | 0.5625 | 33852.5625 | 5.9 |
| 09/05/92 | 13:45:00 | 110 | 33852 | 0.5729 | 33852.57291 | 6.0 |
| 09/05/92 | 14:00:00 | 112 | 33852 | 0.5833 | 33852.58333 | 6.1 |
| 09/05/92 | 14:15:00 | 112 | 33852 | 0.5938 | 33852.59375 | 6.1 |
| 09/05/92 | 14:30:00 | 112 | 33852 | 0.6042 | 33852.60416 | 6.1 |
| 09/05/92 | 14:45:00 | 113 | 33852 | 0.6146 | 33852.61458 | 6.2 |
| 09/05/92 | 15:00:00 | 112 | 33852 | 0.6250 | 33852.625 | 6.1 |

| Data logged by instrument in the field | | | Data normalized in office | | | |
|---|---|---|---|---|---|---|
| Date (MM/DD/YY) | Time (HH:MM:SS) | Water level (inches) | Date number | Time number | Date.Time number (Julian) | Water level* (feet) |
| 09/05/92 | 15:15:00 | 110 | 33852 | 0.6354 | 33852.63541 | 6.0 |
| 09/05/92 | 15:30:00 | 110 | 33852 | 0.6458 | 33852.64583 | 6.0 |
| 09/05/92 | 15:45:00 | 108 | 33852 | 0.6563 | 33852.65625 | 5.8 |
| 09/05/92 | 16:00:00 | 107 | 33852 | 0.6667 | 33852.66666 | 5.7 |
| 09/05/92 | 16:15:00 | 105 | 33852 | 0.6771 | 33852.67708 | 5.6 |
| 09/05/92 | 16:30:00 | 103 | 33852 | 0.6875 | 33852.6875 | 5.4 |
| 09/05/92 | 16:45:00 | 102 | 33852 | 0.6979 | 33852.69791 | 5.3 |
| 09/05/92 | 17:00:00 | 99 | 33852 | 0.7083 | 33852.70833 | 5.1 |
| 09/05/92 | 17:15:00 | 97 | 33852 | 0.7188 | 33852.71875 | 4.9 |
| 09/05/92 | 17:30:00 | 95 | 33852 | 0.7292 | 33852.72916 | 4.7 |
| 09/05/92 | 17:45:00 | 93 | 33852 | 0.7396 | 33852.73958 | 4.6 |
| 09/05/92 | 18:00:00 | 90 | 33852 | 0.7500 | 33852.75 | 4.3 |
| 09/05/92 | 18:15:00 | 86 | 33852 | 0.7604 | 33852.76041 | 4.0 |
| 09/05/92 | 18:30:00 | 83 | 33852 | 0.7708 | 33852.77083 | 3.7 |
| 09/05/92 | 18:45:00 | 82 | 33852 | 0.7813 | 33852.78125 | 3.6 |
| 09/05/92 | 19:00:00 | 79 | 33852 | 0.7917 | 33852.79166 | 3.4 |
| 09/05/92 | 19:15:00 | 76 | 33852 | 0.8021 | 33852.80208 | 3.1 |
| 09/05/92 | 19:30:00 | 76 | 33852 | 0.8125 | 33852.8125 | 3.1 |
| 09/05/92 | 19:45:00 | 75 | 33852 | 0.8229 | 33852.82291 | 3.1 |

* – Logged "water level" data normalized to "corrected for Stanwood" relative datum by subtracting 3.2 feet from each reading.

# APPENDIX F

## Corrected and normalized tide information

## Tide Information Corrected for Stanwood and Normalized to a Relative Datum.

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Corrected slack^^^ (feet) | Normalized water levels* (feet) | Stand of tide duration** | Dye reading number*** |
|---|---|---|---|---|---|---|---|---|
| 09/03/92 | 12:00:00 | 33850.5 | | | | 5 | | |
| 09/03/92 | 12:15:00 | 33850.51 | LHW | 1 | 6.0 | 5.4 | | (1) |
| 09/03/92 | 12:30:00 | 33850.52 | | | | 5.6 | \| | |
| 09/03/92 | 12:45:00 | 33850.53 | | | | 5.6 | \| | |
| 09/03/92 | 13:00:00 | 33850.54 | | | | 5.5 | \| | |
| 09/03/92 | 13:15:00 | 33850.55 | | | | 5.4 | | |
| 09/03/92 | 13:30:00 | 33850.56 | | | | 5.3 | | |
| 09/03/92 | 13:45:00 | 33850.57 | | | | 5.1 | | |
| 09/03/92 | 14:00:00 | 33850.58 | | | | 5 | | |
| 09/03/92 | 14:15:00 | 33850.59 | | | | 4.9 | | |
| 09/03/92 | 14:30:00 | 33850.60 | | | | 4.6 | | |
| 09/03/92 | 14:45:00 | 33850.61 | | | | 4.4 | | |
| 09/03/92 | 15:00:00 | 33850.62 | | | | 4.2 | | |
| 09/03/92 | 15:15:00 | 33850.63 | | | | 4 | | |
| 09/03/92 | 15:30:00 | 33850.64 | | | | 3.7 | | |
| 09/03/92 | 15:45:00 | 33850.65 | | | | 3.6 | | |
| 09/03/92 | 16:00:00 | 33850.66 | | | | 3.3 | | |
| 09/03/92 | 16:15:00 | 33850.67 | | | | 3.1 | | |
| 09/03/92 | 16:30:00 | 33850.68 | | | | 2.8 | \| | |
| 09/03/92 | 16:45:00 | 33850.69 | | | | 2.9 | \| | |
| 09/03/92 | 17:00:00 | 33850.70 | | | | 2.7 | \| | |
| 09/03/92 | 17:15:00 | 33850.71 | | | | 2.7 | \| | |
| 09/03/92 | 17:30:00 | 33850.72 | | | | 2.8 | \| | |
| 09/03/92 | 17:45:00 | 33850.73 | | | | 2.9 | | |
| 09/03/92 | 18:00:00 | 33850.75 | | | | 3.1 | | |
| 09/03/92 | 18:15:00 | 33850.76 | | | | 3.3 | | |
| 09/03/92 | 18:30:00 | 33850.77 | | | | 3.5 | | |
| 09/03/92 | 18:45:00 | 33850.78 | HLW | 2 | 1.9 | 3.8 | | (2) |
| 09/03/92 | 19:00:00 | 33850.79 | | | | 4 | | |
| 09/03/92 | 19:15:00 | 33850.80 | | | | 4.3 | | |
| 09/03/92 | 19:30:00 | 33850.81 | | | | 4.6 | | |
| 09/03/92 | 19:45:00 | 33850.82 | | | | 4.9 | | |
| 09/03/92 | 20:00:00 | 33850.83 | | | | 5.1 | | |
| 09/03/92 | 20:15:00 | 33850.84 | | | | 5.4 | | |
| 09/03/92 | 20:30:00 | 33850.85 | | | | 5.5 | | |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Corrected slack^^^ (feet) | Normalized water levels* (feet) | Stand of tide duration** | Dye reading number*** |
|---|---|---|---|---|---|---|---|---|
| 09/03/92 | 20:45:00 | 33850.86 | | | | 5.7 | | |
| 09/03/92 | 21:00:00 | 33850.87 | | | | 5.9 | | |
| 09/03/92 | 21:15:00 | 33850.88 | | | | 6.1 | | |
| 09/03/92 | 21:30:00 | 33850.89 | | | | 6.2 | | |
| 09/03/92 | 21:45:00 | 33850.90 | | | | 6.2 | | |
| 09/03/92 | 22:00:00 | 33850.91 | | | | 6.4 | \| | |
| 09/03/92 | 22:15:00 | 33850.92 | | | | 6.4 | \| | |
| 09/03/92 | 22:30:00 | 33850.93 | HHW | 3 | 6.2 | 6.4 | \| | (3) |
| 09/03/92 | 22:45:00 | 33850.94 | | | | 6.3 | | |
| 09/03/92 | 23:00:00 | 33850.95 | | | | 6.2 | | |
| 09/03/92 | 23:15:00 | 33850.96 | | | | 6.1 | | |
| 09/03/92 | 23:30:00 | 33850.97 | | | | 6 | | |
| 09/03/92 | 23:45:00 | 33850.98 | | | | 5.8 | | |
| 09/04/92 | 00:00:00 | 33851 | | | | 5.6 | | |
| 09/04/92 | 00:15:00 | 33851.01 | | | | 5.3 | | |
| 09/04/92 | 00:30:00 | 33851.02 | | | | 5.1 | | |
| 09/04/92 | 00:45:00 | 33851.03 | | | | 4.8 | | |
| 09/04/92 | 01:00:00 | 33851.04 | | | | 4.6 | | |
| 09/04/92 | 01:15:00 | 33851.05 | | | | 4.2 | | |
| 09/04/92 | 01:30:00 | 33851.06 | | | | 3.9 | | |
| 09/04/92 | 01:45:00 | 33851.07 | | | | 3.5 | | |
| 09/04/92 | 02:00:00 | 33851.08 | | | | 3.1 | | |
| 09/04/92 | 02:15:00 | 33851.09 | | | | 2.7 | | |
| 09/04/92 | 02:30:00 | 33851.10 | | | | 2.3 | | |
| 09/04/92 | 02:45:00 | 33851.11 | | | | 2 | | |
| 09/04/92 | 03:00:00 | 33851.12 | | | | 1.7 | | |
| 09/04/92 | 03:15:00 | 33851.13 | | | | 1.4 | | |
| 09/04/92 | 03:30:00 | 33851.14 | | | | 1.2 | | |
| 09/04/92 | 03:45:00 | 33851.15 | | | | 0.9 | | |
| 09/04/92 | 04:00:00 | 33851.16 | | | | 0.7 | | |
| 09/04/92 | 04:15:00 | 33851.17 | | | | 0.5 | | |
| 09/04/92 | 04:30:00 | 33851.18 | | | | 0.2 | | |
| 09/04/92 | 04:45:00 | 33851.19 | | | | 0.1 | | |
| 09/04/92 | 05:00:00 | 33851.20 | | | | 0 | | |
| 09/04/92 | 05:15:00 | 33851.21 | | | | -0.1 | | |
| 09/04/92 | 05:30:00 | 33851.22 | | | | -0.1 | | |
| 09/04/92 | 05:45:00 | 33851.23 | | | | -0.2 | | |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Corrected slack^^^ (feet) | Normalized water levels* (feet) | Stand of tide duration** | Dye reading number*** |
|---|---|---|---|---|---|---|---|---|
| 09/04/92 | 06:00:00 | 33851.25 | | | | -0.2 | | |
| 09/04/92 | 06:15:00 | 33851.26 | | | | -0.3 | \| | |
| 09/04/92 | 06:30:00 | 33851.27 | | | | -0.3 | \| | |
| 09/04/92 | 06:45:00 | 33851.28 | | | | -0.3 | \| | |
| 09/04/92 | 07:00:00 | 33851.29 | | | | -0.3 | \| | |
| 09/04/92 | 07:15:00 | 33851.30 | | | | -0.3 | \| | |
| 09/04/92 | 07:30:00 | 33851.31 | | | | -0.3 | \| | |
| 09/04/92 | 07:45:00 | 33851.32 | LLW | 4 | 0.1 | -0.3 | \| | (4) |
| 09/04/92 | 08:00:00 | 33851.33 | | | | -0.3 | \| | |
| 09/04/92 | 08:15:00 | 33851.34 | | | | -0.3 | \| | |
| 09/04/92 | 08:30:00 | 33851.35 | | | | -0.3 | \| | |
| 09/04/92 | 08:45:00 | 33851.36 | | | | -0.3 | \| | |
| 09/04/92 | 09:00:00 | 33851.37 | | | | -0.3 | \| | |
| 09/04/92 | 09:15:00 | 33851.38 | | | | -0.3 | \| | |
| 09/04/92 | 09:30:00 | 33851.39 | | | | 0 | | |
| 09/04/92 | 09:45:00 | 33851.40 | | | | 1.1 | | |
| 09/04/92 | 10:00:00 | 33851.41 | | | | 2.1 | | |
| 09/04/92 | 10:15:00 | 33851.42 | | | | 3.1 | | |
| 09/04/92 | 10:30:00 | 33851.43 | | | | 4.1 | | |
| 09/04/92 | 10:45:00 | 33851.44 | | | | 5.1 | | |
| 09/04/92 | 11:00:00 | 33851.45 | | | | 6.1 | | |
| 09/04/92 | 11:15:00 | 33851.46 | | | | 6.3 | | |
| 09/04/92 | 11:30:00 | 33851.47 | | | | 6.5 | \| | |
| 09/04/92 | 11:45:00 | 33851.48 | | | | 6.6 | \| | |
| 09/04/92 | 12:00:00 | 33851.5 | | | | 6.6 | \| | |
| 09/04/92 | 12:15:00 | 33851.51 | | | | 6.5 | \| | |
| 09/04/92 | 12:30:00 | 33851.52 | | | | 6.5 | \| | |
| 09/04/92 | 12:45:00 | 33851.53 | | | | 6.5 | \| | |
| 09/04/92 | 13:00:00 | 33851.54 | | | | 6.5 | \| | |
| 09/04/92 | 13:15:00 | 33851.55 | | | | 6.5 | \| | |
| 09/04/92 | 13:30:00 | 33851.56 | HHW | 5 | 6.0 | 6.6 | \| | (5) |
| 09/04/92 | 13:45:00 | 33851.57 | | | | 6.5 | \| | |
| 09/04/92 | 14:00:00 | 33851.58 | | | | 6.4 | | |
| 09/04/92 | 14:15:00 | 33851.59 | | | | 6.3 | | |
| 09/04/92 | 14:30:00 | 33851.60 | | | | 6.2 | | |
| 09/04/92 | 14:45:00 | 33851.61 | | | | 6.2 | | |
| 09/04/92 | 15:00:00 | 33851.62 | | | | 6.2 | | |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Corrected slack^^^ (feet) | Normalized water levels* (feet) | Stand of tide duration** | Dye reading number*** |
|---|---|---|---|---|---|---|---|---|
| 09/04/92 | 15:15:00 | 33851.63 | | | | 6 | | |
| 09/04/92 | 15:30:00 | 33851.64 | | | | 5.8 | | |
| 09/04/92 | 15:45:00 | 33851.65 | | | | 5.6 | | |
| 09/04/92 | 16:00:00 | 33851.66 | | | | 5.4 | | |
| 09/04/92 | 16:15:00 | 33851.67 | | | | 5.3 | | |
| 09/04/92 | 16:30:00 | 33851.68 | | | | 5.1 | | |
| 09/04/92 | 16:45:00 | 33851.69 | | | | 4.9 | | |
| 09/04/92 | 17:00:00 | 33851.70 | | | | 4.7 | | |
| 09/04/92 | 17:15:00 | 33851.71 | | | | 4.5 | | |
| 09/04/92 | 17:30:00 | 33851.72 | | | | 4.3 | | |
| 09/04/92 | 17:45:00 | 33851.73 | | | | 4.1 | | |
| 09/04/92 | 18:00:00 | 33851.75 | | | | 4.1 | | |
| 09/04/92 | 18:15:00 | 33851.76 | | | | 3.9 | \| | |
| 09/04/92 | 18:30:00 | 33851.77 | | | | 3.8 | \| | |
| 09/04/92 | 18:45:00 | 33851.78 | | | | 3.9 | \| | |
| 09/04/92 | 19:00:00 | 33851.79 | | | | 3.9 | \| | |
| 09/04/92 | 19:15:00 | 33851.80 | | | | 4 | | |
| 09/04/92 | 19:30:00 | 33851.81 | | | | 4.2 | | |
| 09/04/92 | 19:45:00 | 33851.82 | | | | 4.4 | | |
| 09/04/92 | 20:00:00 | 33851.83 | | | | 4.7 | | |
| 09/04/92 | 20:15:00 | 33851.84 | HLW | 6 | 2.1 | 4.8 | | (6) |
| 09/04/92 | 20:30:00 | 33851.85 | | | | 5 | | |
| 09/04/92 | 20:45:00 | 33851.86 | | | | 5.1 | | |
| 09/04/92 | 21:00:00 | 33851.87 | | | | 5.2 | | |
| 09/04/92 | 21:15:00 | 33851.88 | | | | 5.3 | | |
| 09/04/92 | 21:30:00 | 33851.89 | | | | 5.3 | | |
| 09/04/92 | 21:45:00 | 33851.90 | | | | 5.3 | | |
| 09/04/92 | 22:00:00 | 33851.91 | | | | 5.5 | | |
| 09/04/92 | 22:15:00 | 33851.92 | | | | 5.6 | | |
| 09/04/92 | 22:30:00 | 33851.93 | | | | 5.6 | | |
| 09/04/92 | 22:45:00 | 33851.94 | | | | 5.6 | | |
| 09/04/92 | 23:00:00 | 33851.95 | | | | 5.7 | | |
| 09/04/92 | 23:15:00 | 33851.96 | | | | 5.8 | \| | |
| 09/04/92 | 23:30:00 | 33851.97 | LHW | 7 | 5.8 | 5.8 | \| | (7) |
| 09/04/92 | 23:45:00 | 33851.98 | | | | 5.8 | \| | |
| 09/05/92 | 00:00:00 | 33852 | | | | 5.8 | \| | |
| 09/05/92 | 00:15:00 | 33852.01 | | | | 5.7 | | |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Corrected slack^^^ (feet) | Normalized water levels* (feet) | Stand of tide duration** | Dye reading number*** |
|---|---|---|---|---|---|---|---|---|
| 09/05/92 | 00:30:00 | 33852.02 | | | | 5.7 | | |
| 09/05/92 | 00:45:00 | 33852.03 | | | | 5.7 | | |
| 09/05/92 | 01:00:00 | 33852.04 | | | | 5.6 | | |
| 09/05/92 | 01:15:00 | 33852.05 | | | | 5.5 | | |
| 09/05/92 | 01:30:00 | 33852.06 | | | | 5.3 | | |
| 09/05/92 | 01:45:00 | 33852.07 | | | | 5.1 | | |
| 09/05/92 | 02:00:00 | 33852.08 | | | | 4.7 | | |
| 09/05/92 | 02:15:00 | 33852.09 | | | | 4.4 | | |
| 09/05/92 | 02:30:00 | 33852.10 | | | | 4.1 | | |
| 09/05/92 | 02:45:00 | 33852.11 | | | | 3.7 | | |
| 09/05/92 | 03:00:00 | 33852.12 | | | | 3.3 | | |
| 09/05/92 | 03:15:00 | 33852.13 | | | | 2.9 | | |
| 09/05/92 | 03:30:00 | 33852.14 | | | | 2.5 | | |
| 09/05/92 | 03:45:00 | 33852.15 | | | | 2.2 | | |
| 09/05/92 | 04:00:00 | 33852.16 | | | | 1.9 | | |
| 09/05/92 | 04:15:00 | 33852.17 | | | | 1.6 | | |
| 09/05/92 | 04:30:00 | 33852.18 | | | | 1.4 | | |
| 09/05/92 | 04:45:00 | 33852.19 | | | | 1.3 | | |
| 09/05/92 | 05:00:00 | 33852.20 | | | | 1.3 | | |
| 09/05/92 | 05:15:00 | 33852.21 | | | | 1.1 | | |
| 09/05/92 | 05:30:00 | 33852.22 | | | | 0.9 | | |
| 09/05/92 | 05:45:00 | 33852.23 | | | | 0.8 | | |
| 09/05/92 | 06:00:00 | 33852.25 | | | | 0.7 | | |
| 09/05/92 | 06:15:00 | 33852.26 | | | | 0.6 | | |
| 09/05/92 | 06:30:00 | 33852.27 | | | | 0.6 | | |
| 09/05/92 | 06:45:00 | 33852.28 | | | | 0.6 | | |
| 09/05/92 | 07:00:00 | 33852.29 | | | | 0.4 | | |
| 09/05/92 | 07:15:00 | 33852.30 | | | | 0.5 | | |
| 09/05/92 | 07:30:00 | 33852.31 | | | | 0.5 | | |
| 09/05/92 | 07:45:00 | 33852.32 | | | | 0.4 | | |
| 09/05/92 | 08:00:00 | 33852.33 | | | | 0.3 | | |
| 09/05/92 | 08:15:00 | 33852.34 | | | | 0.4 | | |
| 09/05/92 | 08:30:00 | 33852.35 | | | | 0.2 | \| | |
| 09/05/92 | 08:45:00 | 33852.36 | LLW | 8 | 0.2 | 0.2 | \| | |
| 09/05/92 | 09:00:00 | 33852.37 | | | | 0.2 | \| | |
| 09/05/92 | 09:15:00 | 33852.38 | | | | 0.2 | \| | |
| 09/05/92 | 09:30:00 | 33852.39 | | | | 0.3 | \| | |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Corrected slack^^^ (feet) | Normalized water levels* (feet) | Stand of tide duration** | Dye reading number*** |
|---|---|---|---|---|---|---|---|---|
| 09/05/92 | 09:45:00 | 33852.40 | | | | 0.2 | \| | |
| 09/05/92 | 10:00:00 | 33852.41 | | | | 0.2 | \| | |
| 09/05/92 | 10:15:00 | 33852.42 | | | | 0.2 | \| | |
| 09/05/92 | 10:30:00 | 33852.43 | | | | 0.2 | \| | |
| 09/05/92 | 10:45:00 | 33852.44 | | | | 0.6 | | |
| 09/05/92 | 11:00:00 | 33852.45 | | | | 2 | | |
| 09/05/92 | 11:15:00 | 33852.46 | | | | 3.2 | | |
| 09/05/92 | 11:30:00 | 33852.47 | | | | 4.4 | | |
| 09/05/92 | 11:45:00 | 33852.48 | | | | 5.5 | | |
| 09/05/92 | 12:00:00 | 33852.5 | | | | 6.4 | | |
| 09/05/92 | 12:15:00 | 33852.51 | | | | | | |
| 09/05/92 | 12:30:00 | 33852.52 | | | | | | |
| 09/05/92 | 12:45:00 | 33852.53 | | | | | | |
| 09/05/92 | 13:00:00 | 33852.54 | | | | | | |
| 09/05/92 | 13:15:00 | 33852.55 | | | | | | |
| 09/05/92 | 13:30:00 | 33852.56 | | | | | | |
| 09/05/92 | 13:45:00 | 33852.57 | | | | | | |
| 09/05/92 | 14:00:00 | 33852.58 | | | | | | |
| 09/05/92 | 14:15:00 | 33852.59 | | | | | \| | |
| 09/05/92 | 14:30:00 | 33852.60 | | | | | \| | |
| 09/05/92 | 14:45:00 | 33852.61 | HHW | 9 | 6.2 | | \| | (8) |
| 09/05/92 | 15:00:00 | 33852.62 | | | | | \| | |

^ – HHW means Higher High Water; LLW means Lower Low Water; LHW means Lower High Water; HLW means Higher Low Water. Each acronym has been placed in the row which contains the corrected time for this stand based on information in the Tide Guide (1992).

^^ – Stands of tide are numbered consecutively from start of survey @1200 on 9/3/92.

^^^ – Corrected for Stanwood, i.e., time and height of Seattle tide corrected to reflect slack tide at Stanwood:

| | High tide correction Time | High tide correction Height | Low tide correction Time | Low tide correction Height |
|---|---|---|---|---|
| Stanwood/Stillaguamish | add 0:23 | multiply by 0.62 | add 2:14 | multiply by 0.29 |

Each number has been placed in the row which contains the corrected time for this stand based on information in the Tide Guide (1992).

* – "Water level" data from Appendix E1 normalized to "corrected for Stanwood" relative datum by subtracting 3.2 feet from each reading.

** – Duration of each stand at station S as reflected by "water level" data in column headed Normalized water levels.

*** – Those stands of tide when dye readings were taken at the sampling stations are also numbered consecutively from start of survey.

# APPENDIX G1

Raw data from dye measurements

Actual and extrapolated tide information and corrected dye concentrations.

| Date | Time | Date.Time number | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| (MM/DD/YY) | (HH:MM:SS) | (Julian) | | | | | | | |
| 09/03/92 | 12:00:00 | 33850.50 | | | | | | | |
| 09/03/92 | 12:15:00 | 33850.51 | LHW | 1 | | (1) | | | |
| 09/03/92 | 12:30:00 | 33850.52 | | | \| | | | | |
| 09/03/92 | 12:45:00 | 33850.53 | | | \| | | | | |
| 09/03/92 | 13:00:00 | 33850.54 | | | \| | | | | |
| 09/03/92 | 13:15:00 | 33850.55 | | | | | | | |
| 09/03/92 | 13:30:00 | 33850.56 | | | | | | | |
| 09/03/92 | 13:45:00 | 33850.57 | | | | | | | |
| 09/03/92 | 14:00:00 | 33850.58 | | | | | | | |
| 09/03/92 | 14:15:00 | 33850.59 | | | | | | | |
| 09/03/92 | 14:25:00 | 33850.60 | | | | | B | 6 | 0.0 |
| 09/03/92 | 14:25:00 | 33850.60 | | | | | B | 5 | 0.0 |
| 09/03/92 | 14:25:00 | 33850.60 | | | | | B | 4 | 0.0 |
| 09/03/92 | 14:25:00 | 33850.60 | | | | | B | 3 | 31.6 |
| 09/03/92 | 14:25:00 | 33850.60 | | | | | B | 2 | 41.1 |
| 09/03/92 | 14:25:00 | 33850.60 | | | | | B | 1 | 132.0 |
| 09/03/92 | 14:25:00 | 33850.60 | | | | | B | 0.5 | 185.6 |
| 09/03/92 | 14:30:00 | 33850.60 | | | | | A | 6 | 7.0 |
| 09/03/92 | 14:30:00 | 33850.60 | | | | | A | 5 | 3.7 |
| 09/03/92 | 14:30:00 | 33850.60 | | | | | A | 4 | 3.7 |
| 09/03/92 | 14:30:00 | 33850.60 | | | | | A | 3 | 18.6 |
| 09/03/92 | 14:30:00 | 33850.60 | | | | | A | 2 | 13.9 |
| 09/03/92 | 14:30:00 | 33850.60 | | | | | A | 1 | 27.8 |
| 09/03/92 | 14:30:00 | 33850.60 | | | | | A | 0.5 | 232.0 |
| 09/03/92 | 14:40:00 | 33850.61 | | | | | C | 6 | 0.5 |
| 09/03/92 | 14:40:00 | 33850.61 | | | | | C | 5 | 0.5 |
| 09/03/92 | 14:40:00 | 33850.61 | | | | | C | 4 | 0.5 |
| 09/03/92 | 14:40:00 | 33850.61 | | | | | C | 3 | 0.5 |
| 09/03/92 | 14:40:00 | 33850.61 | | | | | C | 2 | 0.5 |
| 09/03/92 | 14:40:00 | 33850.61 | | | | | C | 1 | 27.8 |
| 09/03/92 | 14:40:00 | 33850.61 | | | | | C | 0.5 | 157.8 |
| 09/03/92 | 14:45:00 | 33850.61 | | | | | | | |
| 09/03/92 | 14:50:00 | 33850.62 | | | | | D | 6 | 0.5 |
| 09/03/92 | 14:50:00 | 33850.62 | | | | | D | 5 | 0.5 |
| 09/03/92 | 14:50:00 | 33850.62 | | | | | D | 4 | 0.5 |
| 09/03/92 | 14:50:00 | 33850.62 | | | | | D | 3 | 0.5 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide: identifier^ | Stand of tide: number^^ | Stand of tide: duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/03/92 | 14:50:00 | 33850.62 | | | | | D | 2 | 0.5 |
| 09/03/92 | 14:50:00 | 33850.62 | | | | | D | 1 | 0.5 |
| 09/03/92 | 14:50:00 | 33850.62 | | | | | D | 0.5 | 0.5 |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | | | |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | E | 6 | 0.0 |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | E | 5 | 0.0 |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | E | 4 | 0.0 |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | E | 3 | 46.9 |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | E | 2 | 41.1 |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | E | 1 | 41.1 |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | E | 0.5 | 52.8 |
| 09/03/92 | 15:10:00 | 33850.63 | | | | | F | 6 | 13.0 |
| 09/03/92 | 15:10:00 | 33850.63 | | | | | F | 5 | 11.6 |
| 09/03/92 | 15:10:00 | 33850.63 | | | | | F | 4 | 18.6 |
| 09/03/92 | 15:10:00 | 33850.63 | | | | | F | 3 | 22.3 |
| 09/03/92 | 15:10:00 | 33850.63 | | | | | F | 2 | 28.8 |
| 09/03/92 | 15:10:00 | 33850.63 | | | | | F | 1 | 39.9 |
| 09/03/92 | 15:10:00 | 33850.63 | | | | | F | 0.5 | 36.2 |
| 09/03/92 | 15:15:00 | 33850.64 | | | | | | | |
| 09/03/92 | 15:20:00 | 33850.64 | | | | | G | 6 | 1.9 |
| 09/03/92 | 15:20:00 | 33850.64 | | | | | G | 5 | 0.9 |
| 09/03/92 | 15:20:00 | 33850.64 | | | | | G | 4 | 1.9 |
| 09/03/92 | 15:20:00 | 33850.64 | | | | | G | 3 | 20.4 |
| 09/03/92 | 15:20:00 | 33850.64 | | | | | G | 2 | 32.5 |
| 09/03/92 | 15:20:00 | 33850.64 | | | | | G | 1 | 32.5 |
| 09/03/92 | 15:20:00 | 33850.64 | | | | | G | 0.5 | 39.0 |
| 09/03/92 | 15:30:00 | 33850.65 | | | | | H | 6 | 0.9 |
| 09/03/92 | 15:30:00 | 33850.65 | | | | | H | 5 | 0.9 |
| 09/03/92 | 15:30:00 | 33850.65 | | | | | H | 4 | 0.9 |
| 09/03/92 | 15:30:00 | 33850.65 | | | | | H | 3 | 4.6 |
| 09/03/92 | 15:30:00 | 33850.65 | | | | | H | 2 | 13.0 |
| 09/03/92 | 15:30:00 | 33850.65 | | | | | H | 1 | 23.2 |
| 09/03/92 | 15:00:00 | 33850.63 | | | | | H | 0.5 | 36.2 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | I | 6 | 0.9 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | I | 5 | 0.9 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | I | 4 | 0.9 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | I | 3 | 1.9 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | I | 2 | 20.9 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | I | 1 | 37.1 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | I | 0.5 | 44.0 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | J | 6 | 0.9 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/03/92 | 15:35:00 | 33850.65 | | | | | J | 5 | 0.9 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | J | 4 | 0.9 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | J | 3 | 0.9 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | J | 2 | 23.2 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | J | 1 | 41.8 |
| 09/03/92 | 15:35:00 | 33850.65 | | | | | J | 0.5 | 58.7 |
| 09/03/92 | 15:40:00 | 33850.65 | | | | | K | 6 | 0.9 |
| 09/03/92 | 15:40:00 | 33850.65 | | | | | K | 5 | 0.9 |
| 09/03/92 | 15:40:00 | 33850.65 | | | | | K | 4 | 0.9 |
| 09/03/92 | 15:40:00 | 33850.65 | | | | | K | 3 | 0.9 |
| 09/03/92 | 15:40:00 | 33850.65 | | | | | K | 2 | 4.6 |
| 09/03/92 | 15:45:00 | 33850.66 | | | | | | | |
| 09/03/92 | 15:48:00 | 33850.66 | | | | | M | 6 | 0.04 |
| 09/03/92 | 15:48:00 | 33850.66 | | | | | M | 5 | 0.7 |
| 09/03/92 | 15:48:00 | 33850.66 | | | | | M | 4 | 0.3 |
| 09/03/92 | 15:48:00 | 33850.66 | | | | | M | 3 | 0.4 |
| 09/03/92 | 15:48:00 | 33850.66 | | | | | M | 2 | 0.7 |
| 09/03/92 | 15:48:00 | 33850.66 | | | | | M | 1 | 0.8 |
| 09/03/92 | 15:48:00 | 33850.66 | | | | | M | 0.5 | 0.9 |
| 09/03/92 | 16:00:00 | 33850.67 | | | | | | | |
| 09/03/92 | 16:15:00 | 33850.68 | | | | | | | |
| 09/03/92 | 16:30:00 | 33850.69 | | | \| | | | | |
| 09/03/92 | 16:45:00 | 33850.70 | | | \| | | | | |
| 09/03/92 | 17:00:00 | 33850.71 | | | \| | | | | |
| 09/03/92 | 17:15:00 | 33850.72 | | | \| | | | | |
| 09/03/92 | 17:30:00 | 33850.73 | | | \| | | | | |
| 09/03/92 | 17:45:00 | 33850.74 | | | | | S | 1 | 0.05 |
| 09/03/92 | 18:00:00 | 33850.75 | | | | | | | |
| 09/03/92 | 18:15:00 | 33850.76 | | | | | | | |
| 09/03/92 | 18:30:00 | 33850.77 | | | | | | | |
| 09/03/92 | 18:45:00 | 33850.78 | HLW | 2 | | (2) | | | |
| 09/03/92 | 19:00:00 | 33850.79 | | | | | | | |
| 09/03/92 | 19:15:00 | 33850.80 | | | | | | | |
| 09/03/92 | 19:30:00 | 33850.81 | | | | | | | |
| 09/03/92 | 19:45:00 | 33850.82 | | | | | | | |
| 09/03/92 | 20:00:00 | 33850.83 | | | | | | | |
| 09/03/92 | 20:15:00 | 33850.84 | | | | | | | |
| 09/03/92 | 20:30:00 | 33850.85 | | | | | | | |
| 09/03/92 | 20:45:00 | 33850.86 | | | | | | | |
| 09/03/92 | 21:00:00 | 33850.88 | | | | | | | |
| 09/03/92 | 21:15:00 | 33850.89 | | | | | A | 6 | 1.3 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/03/92 | 21:15:00 | 33850.89 | | | | | A | 5 | 1.4 |
| 09/03/92 | 21:15:00 | 33850.89 | | | | | A | 4 | 1.4 |
| 09/03/92 | 21:15:00 | 33850.89 | | | | | A | 3 | 1.6 |
| 09/03/92 | 21:15:00 | 33850.89 | | | | | A | 2 | 1.6 |
| 09/03/92 | 21:15:00 | 33850.89 | | | | | A | 1 | 1.6 |
| 09/03/92 | 21:15:00 | 33850.89 | | | | | A | 0.5 | 1.6 |
| 09/03/92 | 21:30:00 | 33850.90 | | | | | | | |
| 09/03/92 | 21:45:00 | 33850.91 | | | | | | | |
| 09/03/92 | 22:00:00 | 33850.92 | | | \| | | | | |
| 09/03/92 | 22:15:00 | 33850.93 | | | \| | | | | |
| 09/03/92 | 22:30:00 | 33850.94 | HHW | 3 | \| | (3) | | | |
| 09/03/92 | 22:45:00 | 33850.95 | | | | | | | |
| 09/03/92 | 23:00:00 | 33850.96 | | | | | | | |
| 09/03/92 | 23:15:00 | 33850.97 | | | | | | | |
| 09/03/92 | 23:30:00 | 33850.98 | | | | | | | |
| 09/03/92 | 23:45:00 | 33850.99 | | | | | | | |
| 09/04/92 | 00:00:00 | 33851.00 | | | | | L | 6 | 0.0 |
| 09/04/92 | 00:00:00 | 33851.00 | | | | | L | 5 | 6.3 |
| 09/04/92 | 00:00:00 | 33851.00 | | | | | L | 4 | 6.5 |
| 09/04/92 | 00:00:00 | 33851.00 | | | | | L | 3 | 6.5 |
| 09/04/92 | 00:00:00 | 33851.00 | | | | | L | 2 | 6.7 |
| 09/04/92 | 00:00:00 | 33851.00 | | | | | L | 1 | 6.9 |
| 09/04/92 | 00:00:00 | 33851.00 | | | | | L | 0.5 | 7.4 |
| 09/04/92 | 00:10:00 | 33851.01 | | | | | B | 5 | 13.9 |
| 09/04/92 | 00:10:00 | 33851.01 | | | | | B | 4 | 18.6 |
| 09/04/92 | 00:10:00 | 33851.01 | | | | | B | 3 | 16.2 |
| 09/04/92 | 00:10:00 | 33851.01 | | | | | B | 2 | 58.6 |
| 09/04/92 | 00:10:00 | 33851.01 | | | | | B | 1 | 102.6 |
| 09/04/92 | 00:10:00 | 33851.01 | | | | | B | 0.5 | 208.8 |
| 09/04/92 | 00:15:00 | 33851.01 | | | | | A | 6 | 7.3 |
| 09/04/92 | 00:15:00 | 33851.01 | | | | | A | 5 | 7.3 |
| 09/04/92 | 00:15:00 | 33851.01 | | | | | A | 4 | 7.3 |
| 09/04/92 | 00:15:00 | 33851.01 | | | | | A | 3 | 2.8 |
| 09/04/92 | 00:15:00 | 33851.01 | | | | | A | 2 | 58.7 |
| 09/04/92 | 00:15:00 | 33851.01 | | | | | A | 1 | 114 |
| 09/04/92 | 00:15:00 | 33851.01 | | | | | A | 0.5 | 191.5 |
| 09/04/92 | 00:30:00 | 33851.02 | | | | | C | 6 | 8.4 |
| 09/04/92 | 00:30:00 | 33851.02 | | | | | C | 5 | 8.4 |
| 09/04/92 | 00:30:00 | 33851.02 | | | | | C | 4 | 8.4 |
| 09/04/92 | 00:30:00 | 33851.02 | | | | | C | 3 | 8.4 |
| 09/04/92 | 00:30:00 | 33851.02 | | | | | C | 2 | 8.4 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/04/92 | 00:30:00 | 33851.02 | | | | | C | 1 | 8.4 |
| 09/04/92 | 00:30:00 | 33851.02 | | | | | C | 0.5 | 8.4 |
| 09/04/92 | 00:45:00 | 33851.03 | | | | | | | |
| 09/04/92 | 00:50:00 | 33851.03 | | | | | E | 6 | 0.0 |
| 09/04/92 | 00:50:00 | 33851.03 | | | | | E | 5 | 0 |
| 09/04/92 | 00:50:00 | 33851.03 | | | | | E | 4 | 27 |
| 09/04/92 | 00:50:00 | 33851.03 | | | | | E | 3 | 27 |
| 09/04/92 | 00:50:00 | 33851.03 | | | | | E | 2 | 29.2 |
| 09/04/92 | 00:50:00 | 33851.03 | | | | | E | 1 | 26 |
| 09/04/92 | 00:50:00 | 33851.03 | | | | | E | 0.5 | 28 |
| 09/04/92 | 01:10:00 | 33851.05 | | | | | F | 6 | 20.4 |
| 09/04/92 | 01:10:00 | 33851.05 | | | | | F | 5 | 18.6 |
| 09/04/92 | 01:10:00 | 33851.05 | | | | | F | 4 | 19.5 |
| 09/04/92 | 01:10:00 | 33851.05 | | | | | F | 3 | 20.9 |
| 09/04/92 | 01:10:00 | 33851.05 | | | | | F | 2 | 20 |
| 09/04/92 | 01:10:00 | 33851.05 | | | | | F | 1 | 21.3 |
| 09/04/92 | 01:10:00 | 33851.05 | | | | | F | 0.5 | 23.2 |
| 09/04/92 | 01:15:00 | 33851.05 | | | | | G | 6 | 1.6 |
| 09/04/92 | 01:15:00 | 33851.05 | | | | | G | 5 | 18.6 |
| 09/04/92 | 01:15:00 | 33851.05 | | | | | G | 4 | 16.2 |
| 09/04/92 | 01:15:00 | 33851.05 | | | | | G | 3 | 16.2 |
| 09/04/92 | 01:15:00 | 33851.05 | | | | | G | 2 | 18.6 |
| 09/04/92 | 01:15:00 | 33851.05 | | | | | G | 1 | 23.2 |
| 09/04/92 | 01:15:00 | 33851.05 | | | | | G | 0.5 | 27 |
| 09/04/92 | 01:25:00 | 33851.06 | | | | | H | 6 | 9.7 |
| 09/04/92 | 01:25:00 | 33851.06 | | | | | H | 5 | 9.7 |
| 09/04/92 | 01:25:00 | 33851.06 | | | | | H | 4 | 9.7 |
| 09/04/92 | 01:25:00 | 33851.06 | | | | | H | 3 | 9.7 |
| 09/04/92 | 01:25:00 | 33851.06 | | | | | H | 2 | 9.7 |
| 09/04/92 | 01:25:00 | 33851.06 | | | | | H | 1 | 9.7 |
| 09/04/92 | 01:25:00 | 33851.06 | | | | | H | 0.5 | 9.7 |
| 09/04/92 | 01:30:00 | 33851.06 | | | | | | | |
| 09/04/92 | 01:45:00 | 33851.07 | | | | | | | |
| 09/04/92 | 02:00:00 | 33851.08 | | | | | | | |
| 09/04/92 | 02:15:00 | 33851.09 | | | | | | | |
| 09/04/92 | 02:30:00 | 33851.10 | | | | | | | |
| 09/04/92 | 02:45:00 | 33851.11 | | | | | | | |
| 09/04/92 | 03:00:00 | 33851.13 | | | | | | | |
| 09/04/92 | 03:15:00 | 33851.14 | | | | | | | |
| 09/04/92 | 03:30:00 | 33851.15 | | | | | | | |
| 09/04/92 | 03:45:00 | 33851.16 | | | | | | | |

| Date | Time | Date.Time number | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| (MM/DD/YY) | (HH:MM:SS) | (Julian) | | | | | | | |
| 09/04/92 | 04:00:00 | 33851.17 | | | | | | | |
| 09/04/92 | 04:15:00 | 33851.18 | | | | | | | |
| 09/04/92 | 04:30:00 | 33851.19 | | | | | | | |
| 09/04/92 | 04:45:00 | 33851.20 | | | | | | | |
| 09/04/92 | 05:00:00 | 33851.21 | | | | | | | |
| 09/04/92 | 05:15:00 | 33851.22 | | | | | | | |
| 09/04/92 | 05:30:00 | 33851.23 | | | | | | | |
| 09/04/92 | 05:45:00 | 33851.24 | | | | | | | |
| 09/04/92 | 06:00:00 | 33851.25 | | | | | | | |
| 09/04/92 | 06:15:00 | 33851.26 | | | │ | | | | |
| 09/04/92 | 06:30:00 | 33851.27 | | | │ | | | | |
| 09/04/92 | 06:40:00 | 33851.28 | | | │ | | A | 6 | 3.6 |
| 09/04/92 | 06:40:00 | 33851.28 | | | │ | | A | 5 | 3.6 |
| 09/04/92 | 06:40:00 | 33851.28 | | | │ | | A | 4 | 1.8 |
| 09/04/92 | 06:40:00 | 33851.28 | | | │ | | A | 3 | 1.8 |
| 09/04/92 | 06:40:00 | 33851.28 | | | │ | | A | 2 | 1.8 |
| 09/04/92 | 06:40:00 | 33851.28 | | | │ | | A | 1 | 11.2 |
| 09/04/92 | 06:40:00 | 33851.28 | | | │ | | A | 0.5 | 9 |
| 09/04/92 | 06:45:00 | 33851.28 | | | │ | | | | |
| 09/04/92 | 07:00:00 | 33851.29 | | | │ | | | | |
| 09/04/92 | 07:15:00 | 33851.30 | | | │ | | | | |
| 09/04/92 | 07:30:00 | 33851.31 | | | │ | | | | |
| 09/04/92 | 07:45:00 | 33851.32 | LLW | 4 | │ | (4) | | | |
| 09/04/92 | 08:00:00 | 33851.33 | | | │ | | | | |
| 09/04/92 | 08:15:00 | 33851.34 | | | │ | | | | |
| 09/04/92 | 08:30:00 | 33851.35 | | | │ | | | | |
| 09/04/92 | 08:45:00 | 33851.36 | | | │ | | | | |
| 09/04/92 | 09:00:00 | 33851.38 | | | │ | | | | |
| 09/04/92 | 09:15:00 | 33851.39 | | | | | | | |
| 09/04/92 | 09:20:00 | 33851.39 | | | | | M | 0.5 | 4.5 |
| 09/04/92 | 09:30:00 | 33851.40 | | | | | | | |
| 09/04/92 | 09:40:00 | 33851.40 | | | | | S | 0.5 | 22.4 |
| 09/04/92 | 09:45:00 | 33851.41 | | | | | Z | 0.5 | 9.0 |
| 09/04/92 | 10:00:00 | 33851.42 | | | | | | | |
| 09/04/92 | 10:15:00 | 33851.43 | | | | | | | |
| 09/04/92 | 10:30:00 | 33851.44 | | | | | | | |
| 09/04/92 | 10:45:00 | 33851.45 | | | | | | | |
| 09/04/92 | 11:00:00 | 33851.46 | | | | | | | |
| 09/04/92 | 11:15:00 | 33851.47 | | | | | | | |
| 09/04/92 | 11:30:00 | 33851.48 | | | │ | | | | |
| 09/04/92 | 11:45:00 | 33851.49 | | | │ | | | | |

| Date | Time | Date.Time number | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| (MM/DD/YY) | (HH:MM:SS) | (Julian) | | | | | | | |
| 09/04/92 | 12:00:00 | 33851.50 | | | | | | | |
| 09/04/92 | 12:15:00 | 33851.51 | | | | | | | |
| 09/04/92 | 12:30:00 | 33851.52 | | | | | | | |
| 09/04/92 | 12:45:00 | 33851.53 | | | | | | | |
| 09/04/92 | 13:00:00 | 33851.54 | | | | | | | |
| 09/04/92 | 13:15:00 | 33851.55 | | | | | | | |
| 09/04/92 | 13:30:00 | 33851.56 | HHW | 5 | | (5) | A | 6 | 6.8 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | A | 5 | 6.8 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | A | 4 | 7.7 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | A | 3 | 9.3 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | A | 2 | 10.1 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | A | 1 | 111.2 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | A | 0.5 | 220 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | D | 6 | 6.5 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | D | 5 | 6.4 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | D | 4 | 9 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | D | 3 | 9.1 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | D | 2 | 10.3 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | D | 1 | 90.4 |
| 09/04/92 | 13:30:00 | 33851.56 | | | | | D | 0.5 | 150 |
| 09/04/92 | 13:45:00 | 33851.57 | | | | | | | |
| 09/04/92 | 14:00:00 | 33851.58 | | | | | | | |
| 09/04/92 | 14:05:00 | 33851.59 | | | | | E | 6 | 9 |
| 09/04/92 | 14:05:00 | 33851.59 | | | | | E | 5 | 7.2 |
| 09/04/92 | 14:05:00 | 33851.59 | | | | | E | 4 | 8.1 |
| 09/04/92 | 14:05:00 | 33851.59 | | | | | E | 3 | 7.1 |
| 09/04/92 | 14:05:00 | 33851.59 | | | | | E | 2 | 7 |
| 09/04/92 | 14:05:00 | 33851.59 | | | | | E | 1 | 40 |
| 09/04/92 | 14:05:00 | 33851.59 | | | | | E | 0.5 | 41.7 |
| 09/04/92 | 14:15:00 | 33851.59 | | | | | I | 6 | 6.6 |
| 09/04/92 | 14:15:00 | 33851.59 | | | | | I | 5 | 6.6 |
| 09/04/92 | 14:15:00 | 33851.59 | | | | | I | 4 | 6.8 |
| 09/04/92 | 14:15:00 | 33851.59 | | | | | I | 3 | 7 |
| 09/04/92 | 14:15:00 | 33851.59 | | | | | I | 2 | 18 |
| 09/04/92 | 14:15:00 | 33851.59 | | | | | I | 1 | 41.8 |
| 09/04/92 | 14:15:00 | 33851.59 | | | | | I | 0.5 | 48.7 |
| 09/04/92 | 14:25:00 | 33851.60 | | | | | M | 6 | 0.14 |
| 09/04/92 | 14:25:00 | 33851.60 | | | | | M | 5 | 0.12 |
| 09/04/92 | 14:25:00 | 33851.60 | | | | | M | 4 | 0.12 |
| 09/04/92 | 14:25:00 | 33851.60 | | | | | M | 3 | 0.13 |
| 09/04/92 | 14:25:00 | 33851.60 | | | | | M | 2 | 0.13 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/04/92 | 14:25:00 | 33851.60 | | | | | M | 1 | 0.13 |
| 09/04/92 | 14:25:00 | 33851.60 | | | | | M | 0.5 | 0.15 |
| 09/04/92 | 14:30:00 | 33851.60 | | | | | | | |
| 09/04/92 | 14:45:00 | 33851.61 | | | | | | | |
| 09/04/92 | 15:00:00 | 33851.63 | | | | | | | |
| 09/04/92 | 15:15:00 | 33851.64 | | | | | | | |
| 09/04/92 | 15:30:00 | 33851.65 | | | | | | | |
| 09/04/92 | 15:45:00 | 33851.66 | | | | | | | |
| 09/04/92 | 16:00:00 | 33851.67 | | | | | | | |
| 09/04/92 | 16:15:00 | 33851.68 | | | | | | | |
| 09/04/92 | 16:30:00 | 33851.69 | | | | | | | |
| 09/04/92 | 16:45:00 | 33851.70 | | | | | | | |
| 09/04/92 | 17:00:00 | 33851.71 | | | | | | | |
| 09/04/92 | 17:15:00 | 33851.72 | | | | | | | |
| 09/04/92 | 17:30:00 | 33851.73 | | | | | | | |
| 09/04/92 | 17:45:00 | 33851.74 | | | | | | | |
| 09/04/92 | 18:00:00 | 33851.75 | | | | | | | |
| 09/04/92 | 18:15:00 | 33851.76 | | | | | | | | |
| 09/04/92 | 18:30:00 | 33851.77 | | | | | | | | |
| 09/04/92 | 18:45:00 | 33851.78 | | | | | | | | |
| 09/04/92 | 19:00:00 | 33851.79 | | | | | | | | |
| 09/04/92 | 19:15:00 | 33851.80 | | | | | | | |
| 09/04/92 | 19:30:00 | 33851.81 | | | | | | | |
| 09/04/92 | 19:45:00 | 33851.82 | | | | | Z | 6 | 0.1 |
| 09/04/92 | 19:45:00 | 33851.82 | | | | | Z | 3 | 0.1 |
| 09/04/92 | 19:45:00 | 33851.82 | | | | | Z | 2 | 0.1 |
| 09/04/92 | 19:45:00 | 33851.82 | | | | | Z | 1 | 0.1 |
| 09/04/92 | 19:45:00 | 33851.82 | | | | | Z | 0.5 | 0.1 |
| 09/04/92 | 20:00:00 | 33851.83 | | | | | | | |
| 09/04/92 | 20:13:00 | 33851.84 | | | | | S | 6 | 0.4 |
| 09/04/92 | 20:13:00 | 33851.84 | | | | | S | 5 | 0.4 |
| 09/04/92 | 20:13:00 | 33851.84 | | | | | S | 4 | 0.3 |
| 09/04/92 | 20:13:00 | 33851.84 | | | | | S | 3 | 0.4 |
| 09/04/92 | 20:13:00 | 33851.84 | | | | | S | 2 | 0.4 |
| 09/04/92 | 20:13:00 | 33851.84 | | | | | S | 1 | 0.4 |
| 09/04/92 | 20:13:00 | 33851.84 | | | | | S | 0.5 | 0.4 |
| 09/04/92 | 20:15:00 | 33851.84 | HLW | 6 | | (6) | | | |
| 09/04/92 | 20:30:00 | 33851.85 | | | | | | | |
| 09/04/92 | 20:38:00 | 33851.86 | | | | | M | 6 | 2.7 |
| 09/04/92 | 20:38:00 | 33851.86 | | | | | M | 5 | 2.7 |
| 09/04/92 | 20:38:00 | 33851.86 | | | | | M | 4 | 3.2 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/04/92 | 20:38:00 | 33851.86 | | | | | M | 3 | 3.2 |
| 09/04/92 | 20:38:00 | 33851.86 | | | | | M | 2 | 3.3 |
| 09/04/92 | 20:38:00 | 33851.86 | | | | | M | 1 | 3.3 |
| 09/04/92 | 20:38:00 | 33851.86 | | | | | M | 0.5 | 3.3 |
| 09/04/92 | 20:45:00 | 33851.86 | | | | | | | |
| 09/04/92 | 21:00:00 | 33851.88 | | | | | | | |
| 09/04/92 | 21:02:00 | 33851.88 | | | | | D | 6 | 13.9 |
| 09/04/92 | 21:02:00 | 33851.88 | | | | | D | 5 | 13.9 |
| 09/04/92 | 21:02:00 | 33851.88 | | | | | D | 4 | 13.9 |
| 09/04/92 | 21:02:00 | 33851.88 | | | | | D | 3 | 13.9 |
| 09/04/92 | 21:02:00 | 33851.88 | | | | | D | 2 | 13.9 |
| 09/04/92 | 21:02:00 | 33851.88 | | | | | D | 1 | 13.9 |
| 09/04/92 | 21:02:00 | 33851.88 | | | | | D | 0.5 | 13.9 |
| 09/04/92 | 21:15:00 | 33851.89 | | | | | A | 6 | 13.4 |
| 09/04/92 | 21:15:00 | 33851.89 | | | | | A | 3 | 13.4 |
| 09/04/92 | 21:15:00 | 33851.89 | | | | | A | 1 | 13.4 |
| 09/04/92 | 21:30:00 | 33851.90 | | | | | A | 6 | 15.0 |
| 09/04/92 | 21:30:00 | 33851.90 | | | | | A | 5 | 15.0 |
| 09/04/92 | 21:30:00 | 33851.90 | | | | | A | 4 | 15.0 |
| 09/04/92 | 21:30:00 | 33851.90 | | | | | A | 3 | 15.0 |
| 09/04/92 | 21:30:00 | 33851.90 | | | | | A | 2 | 15.0 |
| 09/04/92 | 21:30:00 | 33851.90 | | | | | A | 1 | 15.0 |
| 09/04/92 | 21:30:00 | 33851.90 | | | | | A | 0.5 | 15.0 |
| 09/04/92 | 21:30:00 | 33851.90 | | | | | | | |
| 09/04/92 | 22:00:00 | 33851.92 | | | | | | | |
| 09/04/92 | 22:15:00 | 33851.93 | | | | | | | |
| 09/04/92 | 22:30:00 | 33851.94 | | | | | | | |
| 09/04/92 | 22:45:00 | 33851.95 | | | | | | | |
| 09/04/92 | 23:00:00 | 33851.96 | | | | | | | |
| 09/04/92 | 23:15:00 | 33851.97 | | | \| | | M | 6 | 1.3 |
| 09/04/92 | 23:15:00 | 33851.97 | | | \| | | M | 5 | 1.3 |
| 09/04/92 | 23:15:00 | 33851.97 | | | \| | | M | 4 | 1.3 |
| 09/04/92 | 23:15:00 | 33851.97 | | | \| | | M | 3 | 1.1 |
| 09/04/92 | 23:15:00 | 33851.97 | | | \| | | M | 2 | 1.1 |
| 09/04/92 | 23:15:00 | 33851.97 | | | \| | | M | 1 | 1.3 |
| 09/04/92 | 23:15:00 | 33851.97 | | | \| | | M | 0.5 | 1.3 |
| 09/04/92 | 23:20:00 | 33851.97 | | | \| | | S | 6 | 0.9 |
| 09/04/92 | 23:20:00 | 33851.97 | | | \| | | S | 5 | 0.9 |
| 09/04/92 | 23:20:00 | 33851.97 | | | \| | | S | 4 | 0.9 |
| 09/04/92 | 23:20:00 | 33851.97 | | | \| | | S | 3 | 0.9 |
| 09/04/92 | 23:20:00 | 33851.97 | | | \| | | S | 2 | 0.9 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/04/92 | 23:20:00 | 33851.97 | | | \| | | S | 1 | 0.9 |
| 09/04/92 | 23:20:00 | 33851.97 | | | \| | | S | 0.5 | 0.9 |
| 09/04/92 | 23:30:00 | 33851.98 | LHW | 7 | \| | (7) | | | |
| 09/04/92 | 23:35:00 | 33851.98 | | | \| | | Z | 6 | 0.9 |
| 09/04/92 | 23:35:00 | 33851.98 | | | \| | | Z | 5 | 0.9 |
| 09/04/92 | 23:35:00 | 33851.98 | | | \| | | Z | 4 | 0.9 |
| 09/04/92 | 23:35:00 | 33851.98 | | | \| | | Z | 1 | 0.9 |
| 09/04/92 | 23:35:00 | 33851.98 | | | \| | | Z | 0.5 | 0.8 |
| 09/04/92 | 23:45:00 | 33851.99 | | | \| | | | | |
| 09/05/92 | 00:00:00 | 33852.00 | | | \| | | | | |
| 09/05/92 | 00:15:00 | 33852.01 | | | | | | | |
| 09/05/92 | 00:30:00 | 33852.02 | | | | | | | |
| 09/05/92 | 00:45:00 | 33852.03 | | | | | | | |
| 09/05/92 | 01:00:00 | 33852.04 | | | | | | | |
| 09/05/92 | 01:15:00 | 33852.05 | | | | | | | |
| 09/05/92 | 01:30:00 | 33852.06 | | | | | | | |
| 09/05/92 | 01:45:00 | 33852.07 | | | | | | | |
| 09/05/92 | 02:00:00 | 33852.08 | | | | | | | |
| 09/05/92 | 02:15:00 | 33852.09 | | | | | | | |
| 09/05/92 | 02:30:00 | 33852.10 | | | | | | | |
| 09/05/92 | 02:45:00 | 33852.11 | | | | | | | |
| 09/05/92 | 03:00:00 | 33852.13 | | | | | | | |
| 09/05/92 | 03:15:00 | 33852.14 | | | | | | | |
| 09/05/92 | 03:30:00 | 33852.15 | | | | | | | |
| 09/05/92 | 03:45:00 | 33852.16 | | | | | | | |
| 09/05/92 | 04:00:00 | 33852.17 | | | | | | | |
| 09/05/92 | 04:15:00 | 33852.18 | | | | | | | |
| 09/05/92 | 04:30:00 | 33852.19 | | | | | | | |
| 09/05/92 | 04:45:00 | 33852.20 | | | | | | | |
| 09/05/92 | 05:00:00 | 33852.21 | | | | | | | |
| 09/05/92 | 05:15:00 | 33852.22 | | | | | | | |
| 09/05/92 | 05:30:00 | 33852.23 | | | | | | | |
| 09/05/92 | 05:45:00 | 33852.24 | | | | | | | |
| 09/05/92 | 06:00:00 | 33852.25 | | | | | | | |
| 09/05/92 | 06:15:00 | 33852.26 | | | | | | | |
| 09/05/92 | 06:30:00 | 33852.27 | | | | | | | |
| 09/05/92 | 06:45:00 | 33852.28 | | | | | Z | 0.5 | 8.7 |
| 09/05/92 | 07:00:00 | 33852.29 | | | | | | | |
| 09/05/92 | 07:15:00 | 33852.30 | | | | | S | 0.5 | 9.1 |
| 09/05/92 | 07:30:00 | 33852.31 | | | | | | | |
| 09/05/92 | 07:45:00 | 33852.32 | | | | | M | 0.5 | 9.1 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/05/92 | 08:00:00 | 33852.33 | | | | | | | |
| 09/05/92 | 08:14:00 | 33852.34 | | | | | A | 0.5 | 19.8 |
| 09/05/92 | 08:15:00 | 33852.34 | | | | | | | |
| 09/05/92 | 08:30:00 | 33852.35 | | | \| | | | | |
| 09/05/92 | 08:45:00 | 33852.36 | LLW | 8 | \| | | | | |
| 09/05/92 | 09:00:00 | 33852.38 | | | \| | | | | |
| 09/05/92 | 09:15:00 | 33852.39 | | | \| | | | | |
| 09/05/92 | 09:30:00 | 33852.40 | | | \| | | | | |
| 09/05/92 | 09:45:00 | 33852.41 | | | \| | | | | |
| 09/05/92 | 10:00:00 | 33852.42 | | | \| | | | | |
| 09/05/92 | 10:15:00 | 33852.43 | | | \| | | | | |
| 09/05/92 | 10:30:00 | 33852.44 | | | \| | | | | |
| 09/05/92 | 10:45:00 | 33852.45 | | | | | | | |
| 09/05/92 | 11:00:00 | 33852.46 | | | | | | | |
| 09/05/92 | 11:15:00 | 33852.47 | | | | | | | |
| 09/05/92 | 11:30:00 | 33852.48 | | | | | | | |
| 09/05/92 | 11:45:00 | 33852.49 | | | | | | | |
| 09/05/92 | 12:00:00 | 33852.50 | | | | | | | |
| 09/05/92 | 12:15:00 | 33852.51 | | | | | | | |
| 09/05/92 | 12:30:00 | 33852.52 | | | | | | | |
| 09/05/92 | 12:45:00 | 33852.53 | | | | | | | |
| 09/05/92 | 13:00:00 | 33852.54 | | | | | | | |
| 09/05/92 | 13:15:00 | 33852.55 | | | | | | | |
| 09/05/92 | 13:30:00 | 33852.56 | | | | | | | |
| 09/05/92 | 13:45:00 | 33852.57 | | | | | | | |
| 09/05/92 | 14:00:00 | 33852.58 | | | | | | | |
| 09/05/92 | 14:15:00 | 33852.59 | | | \| | | | | |
| 09/05/92 | 14:30:00 | 33852.60 | | | \| | | | | |
| 09/05/92 | 14:45:00 | 33852.61 | HHW | 9 | \| | (8) | | | |
| 09/05/92 | 15:00:00 | 33852.63 | | | \| | | | | |
| 09/05/92 | 15:38:00 | 33852.65 | | | | | M | 2 | 0.01 |
| 09/05/92 | 16:00:00 | 33852.67 | | | | | A | 2 | 12.4 |
| 09/05/92 | 16:30:00 | 33852.69 | | | | | M | 9 | 1.1 |
| 09/05/92 | 16:30:00 | 33852.69 | | | | | M | 6 | 0.6 |
| 09/05/92 | 16:30:00 | 33852.69 | | | | | M | 5 | 0.8 |
| 09/05/92 | 16:30:00 | 33852.69 | | | | | M | 4 | 0.8 |
| 09/05/92 | 16:30:00 | 33852.69 | | | | | M | 3 | 0.7 |
| 09/05/92 | 16:30:00 | 33852.69 | | | | | M | 2 | 0.7 |
| 09/05/92 | 16:30:00 | 33852.69 | | | | | M | 1 | 0.6 |
| 09/05/92 | 16:30:00 | 33852.69 | | | | | M | 0.5 | 0.6 |
| 09/05/92 | 16:40:00 | 33852.69 | | | | | S | 6 | 0.1 |

| Date | Time | Date.Time | Stand of tide | | | Dye reading | Sampling | Depth of | Dye |
|---|---|---|---|---|---|---|---|---|---|
| | | number | identifier^ | number^^ | duration^^^ | number* | station** | sampling*** | Concentration |
| (MM/DD/YY) | (HH:MM:SS) | (Julian) | | | | | | (feet) | (ppb) |
| 09/05/92 | 16:40:00 | 33852.69 | | | | | S | 5 | 0.1 |
| 09/05/92 | 16:40:00 | 33852.69 | | | | | S | 4 | 0.1 |
| 09/05/92 | 16:40:00 | 33852.69 | | | | | S | 3 | 0.1 |
| 09/05/92 | 16:40:00 | 33852.69 | | | | | S | 2 | 0.2 |
| 09/05/92 | 16:40:00 | 33852.69 | | | | | S | 1 | 0.1 |
| 09/05/92 | 16:40:00 | 33852.69 | | | | | S | 0.5 | 0.1 |
| 09/05/92 | 16:50:00 | 33852.70 | | | | | H | 4 | 11.5 |
| 09/05/92 | 16:50:00 | 33852.70 | | | | | H | 3 | 13 |
| 09/05/92 | 16:50:00 | 33852.70 | | | | | H | 2 | 13 |
| 09/05/92 | 16:50:00 | 33852.70 | | | | | H | 1 | 13.6 |
| 09/05/92 | 16:50:00 | 33852.70 | | | | | H | 0.5 | 13.8 |
| 09/05/92 | 17:00:00 | 33852.71 | | | | | | | |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 10 | 11.6 |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 8 | 11.6 |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 6 | 11.6 |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 5 | 11.6 |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 4 | 11.6 |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 3 | 11.6 |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 2 | 11.6 |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 1 | 11.6 |
| 09/05/92 | 17:20:00 | 33852.72 | | | | | A | 0.5 | 11.6 |
| 09/05/92 | 17:45:00 | 33852.74 | | | \| | | | | |
| 09/05/92 | 18:45:00 | 33852.78 | | | \| | | | | |
| 09/05/92 | 20:08:00 | 33852.84 | | | | | S | 6 | 2.2 |
| 09/05/92 | 20:08:00 | 33852.84 | | | | | S | 5 | 2.3 |
| 09/05/92 | 20:08:00 | 33852.84 | | | | | S | 4 | 2.3 |
| 09/05/92 | 20:08:00 | 33852.84 | | | | | S | 3 | 2.3 |
| 09/05/92 | 20:08:00 | 33852.84 | | | | | S | 2 | 2.3 |
| 09/05/92 | 20:08:00 | 33852.84 | | | | | S | 1 | 2.3 |
| 09/05/92 | 20:08:00 | 33852.84 | | | | | S | 0.5 | 2.2 |
| 09/05/92 | 20:25:00 | 33852.85 | | | | | Z | 6 | 0.7 |
| 09/05/92 | 20:25:00 | 33852.85 | | | | | Z | 5 | 0.8 |
| 09/05/92 | 20:25:00 | 33852.85 | | | | | Z | 4 | 0.8 |
| 09/05/92 | 20:25:00 | 33852.85 | | | | | Z | 3 | 0.8 |
| 09/05/92 | 20:25:00 | 33852.85 | | | | | Z | 2 | 0.8 |
| 09/05/92 | 20:25:00 | 33852.85 | | | | | Z | 1 | 0.8 |
| 09/05/92 | 20:25:00 | 33852.85 | | | | | Z | 0.5 | 0.8 |
| 09/05/92 | 20:40:00 | 33852.86 | | | | | M | 6 | 10.2 |
| 09/05/92 | 20:40:00 | 33852.86 | | | | | M | 5 | 10.2 |
| 09/05/92 | 20:40:00 | 33852.86 | | | | | M | 4 | 10.4 |
| 09/05/92 | 20:40:00 | 33852.86 | | | | | M | 3 | 10.6 |
| 09/05/92 | 20:40:00 | 33852.86 | | | | | M | 2 | 10.7 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/05/92 | 20:40:00 | 33852.86 | | | | | M | 1 | 10.7 |
| 09/05/92 | 20:40:00 | 33852.86 | | | | | M | 0.5 | 10.7 |
| 09/05/92 | 21:10:00 | 33852.88 | | | | | A | 1 | 15.6 |
| 09/05/92 | 22:00:00 | 33852.92 | HLW | 10 | | (9) | | | |
| 09/05/92 | 23:30:00 | 33852.98 | | | \| | | | | |
| 09/06/92 | 00:15:00 | 33853.01 | | | \| | | | | |
| 09/06/92 | 00:30:00 | 33853.02 | LHW | 11 | | (10) | | | |
| 09/06/92 | 06:40:00 | 33853.28 | | | | | A | 5 | 16.8 |
| 09/06/92 | 06:40:00 | 33853.28 | | | | | A | 4 | 17.7 |
| 09/06/92 | 06:40:00 | 33853.28 | | | | | A | 3 | 17.7 |
| 09/06/92 | 06:40:00 | 33853.28 | | | | | A | 2 | 17.7 |
| 09/06/92 | 06:40:00 | 33853.28 | | | | | A | 1 | 17.7 |
| 09/06/92 | 06:40:00 | 33853.28 | | | | | A | 0.5 | 17.7 |
| 09/06/92 | 07:40:00 | 33853.32 | | | | | M | 4 | 14.6 |
| 09/06/92 | 08:05:00 | 33853.34 | | | | | S | 9 | 12.1 |
| 09/06/92 | 08:05:00 | 33853.34 | | | | | S | 6 | 14 |
| 09/06/92 | 08:05:00 | 33853.34 | | | | | S | 5 | 14 |
| 09/06/92 | 08:05:00 | 33853.34 | | | | | S | 4 | 14 |
| 09/06/92 | 08:05:00 | 33853.34 | | | | | S | 3 | 14 |
| 09/06/92 | 08:05:00 | 33853.34 | | | | | S | 2 | 14 |
| 09/06/92 | 08:05:00 | 33853.34 | | | | | S | 1 | 14 |
| 09/06/92 | 08:05:00 | 33853.34 | | | | | S | 0.5 | 14 |
| 09/06/92 | 08:15:00 | 33853.34 | | | | | | | |
| 09/06/92 | 08:30:00 | 33853.35 | | | | | Z | 0.5 | 13 |
| 09/06/92 | 10:00:00 | 33853.42 | LLW | 12 | | | | | |
| 09/06/92 | 13:45:00 | 33853.57 | | | \| | | | | |
| 09/06/92 | 15:45:00 | 33853.66 | HHW | 13 | \| | (11) | | | |
| 09/06/92 | 15:55:00 | 33853.66 | | | \| | | A | 1 | 5.9 |
| 09/06/92 | 16:00:00 | 33853.67 | | | \| | | M | 1 | 0.4 |
| 09/06/92 | 16:05:00 | 33853.67 | | | | | S | 1 | 0 |
| 09/06/92 | 16:10:00 | 33853.67 | | | | | Z | 1 | 0 |
| 09/06/92 | 23:00:00 | 33853.96 | HLW | 14 | | | | | |
| 09/07/92 | 02:00:00 | 33854.08 | LHW | 15 | | | | | |
| 09/07/92 | 11:00:00 | 33854.46 | LLW | 16 | | | | | |
| 09/07/92 | 16:30:00 | 33854.69 | HHW | 17 | | | | | |
| 09/08/92 | 00:00:00 | 33855.00 | HLW | 18 | | | | | |
| 09/08/92 | 02:45:00 | 33855.11 | LHW | 19 | | | | | |
| 09/08/92 | 10:15:00 | 33855.43 | | | \| | | | | |
| 09/08/92 | 11:45:00 | 33855.49 | LLW | 20 | \| | (12) | | | |
| 09/08/92 | 12:00:00 | 33855.50 | | | \| | | | | |
| 09/08/92 | 12:30:00 | 33855.52 | | | \| | | A | | 10.8 |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide identifier^ | Stand of tide number^^ | Stand of tide duration^^^ | Dye reading number* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 09/08/92 | 12:30:00 | 33855.52 | | | \| | | M | | 13 |
| 09/08/92 | 12:30:00 | 33855.52 | | | \| | | S | | 13 |
| 09/08/92 | 12:30:00 | 33855.52 | | | \| | | Z | | 12.1 |
| 09/08/92 | 12:30:00 | 33855.52 | | | \| | | H | | 7.8 |
| 09/08/92 | 13:00:00 | 33855.54 | | | \| | | | | |
| 09/08/92 | 17:00:00 | 33855.71 | HHW | 21 | | | | | |
| 09/09/92 | 00:30:00 | 33856.02 | HLW | 22 | | | | | |
| 09/09/92 | 03:45:00 | 33856.16 | | | \| | | | | |
| 09/09/92 | 04:00:00 | 33856.17 | LHW | 23 | \| | (13) | | | |
| 09/09/92 | 04:30:00 | 33856.19 | | | \| | | | | |
| 09/9/92 | 10:20:00 | 33856.43 | | | | | A | | 6.1 |
| 09/9/92 | 10:20:00 | 33856.43 | | | | | M | | 7.6 |
| 09/9/92 | 10:20:00 | 33856.43 | | | | | S | | 12.2 |
| 09/9/92 | 10:20:00 | 33856.43 | | | | | Z | | 10.3 |
| 09/09/92 | 12:15:00 | 33856.51 | LLW | 24 | | | | | |
| 09/09/92 | 17:30:00 | 33856.73 | HHW | 25 | | | | | |
| 09/10/92 | 01:00:00 | 33857.04 | HLW | 26 | | | | | |
| 09/10/92 | 04:45:00 | 33857.20 | LHW | 27 | | | | | |
| 09/10/92 | 13:00:00 | 33857.54 | LLW | 28 | | | | | |
| 09/10/92 | 17:45:00 | 33857.74 | HHW | 29 | | | | | |
| 09/11/92 | 01:30:00 | 33858.06 | HLW | 30 | | | | | |
| 09/11/92 | 05:30:00 | 33858.23 | LHW | 31 | | | | | |
| 09/11/92 | 12:40:00 | 33858.53 | | | \| | | A | | 3.9 |
| 09/11/92 | 12:40:00 | 33858.53 | | | \| | | M | | 3.9 |
| 09/11/92 | 12:40:00 | 33858.53 | | | \| | | S | | 9.3 |
| 09/11/92 | 12:40:00 | 33858.53 | | | \| | | Z | | 5.8 |
| 09/11/92 | 12:40:00 | 33858.53 | | | \| | | H | | 1.5 |
| 09/11/92 | 13:00:00 | 33858.54 | LLW | 32 | \| | (14) | | | |
| 09/11/92 | 14:45:00 | 33858.61 | | | \| | | | | |

^ – HHW means Higher High Water; LLW means Lower Low Water; LHW means Lower High Water; HLW means Higher Low Water.

^^ – Stands of tide are numbered consecutively from start of survey @1200 on 9/3/92.

^^^ – Vertical dashes in this column represent duration of each slack at station S as reflected by "water level" data from Appendix E1. Vertical dashes shown in all rows after 33852.50 (Julian) represent durations which are predictions extrapolated from earlier durations.

* – Those stands of tide when dye readings were taken at the sampling stations are also numbered consecutively from start of survey.

** – Location of sampling stations is shown on Figure 2 and described in text of report.

*** – Depth below the water surface. Surface ("Water level") fluctuates with tidal activity.

# APPENDIX G2

Shorter-term dye concentrations

**Shorter-term Dye Concentrations for Use in Calibrating PLUMES Model.**

| Date.Time number (Julian) (1) | Dye reading number* (2) | Sampling station** (3) | Dye Concentration (ppb)*** (4) | Y coordinate on SURFER grid (feet)^ (5) | X coordinate on SURFER grid (feet)^^ (6) |
|---|---|---|---|---|---|
| Ebb tide following LHW stand | | | | | |
| 33850.60 | (1) | B | 185.6 | 0 | 21 |
| 33850.60 | (1) | A | 232.0 | 10 | 21 |
| 33850.61 | (1) | C | 157.8 | 20 | 21 |
| 33850.62 | (1) | D | 0.5 | 30 | 21 |
| 33850.63 | (1) | E | 52.8 | 10 | 210 |
| 33850.63 | (1) | F | 39.9 | 20 | 210 |
| 33850.64 | (1) | G | 39.0 | 30 | 210 |
| 33850.63 | (1) | H | 36.2 | 40 | 210 |
| 33850.65 | (1) | I | 44.0 | 50 | 210 |
| 33850.65 | (1) | J | 58.7 | 60 | 210 |
| 33850.65 | (1) | K | 4.6 | 70 | 210 |
| 33850.66 | (1) | M | 0.9 | 75 | 6400 |
| 33850.74 | (1) | S | 0.05 | 50 | 10700 |

* – Those stands of tide when dye readings were taken at the sampling stations are numbered consecutively from start of survey.

** – Location of sampling stations is shown on Figure 2 and described in text of report.

*** – Each of these values is the single highest reading for this particular sampling station during dye reading number (1).

^ – Distance transversing the channel (along Y–axis) as measured from right bank. For use in SURFER plotting software.

^^ – Distance longitudinally in channel (along X–axis) as measured from outfall. For use in SURFER plotting software.

# APPENDIX G3

Longer-term dye concentrations

Longer-term Dye Concentrations for Use in Developing Concentration-over-time Curves.

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide duration* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) | Stage of tide during sampling |
|---|---|---|---|---|---|---|---|
| 09/03/92 | 12:30:00 | 33850.52 | \| | | | | |
| 09/03/92 | 13:00:00 | 33850.54 | \| | | | | |
| 09/03/92 | 14:30:00 | 33850.60 | | A | 0.5 | 232.0 | small ebb |
| 09/03/92 | 15:48:00 | 33850.66 | | M | 0.5 | 0.9 | small ebb |
| 09/03/92 | 16:30:00 | 33850.69 | \| | | | | |
| 09/03/92 | 17:30:00 | 33850.73 | \| | | | | |
| 09/03/92 | 17:45:00 | 33850.74 | | S | 1 | 0.05 | start of small flood |
| 09/03/92 | 21:15:00 | 33850.89 | | A | 3 | 1.6 | end of small flood |
| 09/03/92 | 22:00:00 | 33850.92 | \| | | | | |
| 09/03/92 | 22:30:00 | 33850.94 | \| | | | | |
| 09/04/92 | 00:15:00 | 33851.01 | | A | 0.5 | 191.5 | large ebb |
| 09/04/92 | 06:15:00 | 33851.26 | \| | | | | |
| 09/04/92 | 06:40:00 | 33851.28 | \| | A | 1 | 11.2 | LLW |
| 09/04/92 | 09:00:00 | 33851.38 | \| | | | | |
| 09/04/92 | 09:20:00 | 33851.39 | | M | 0.5 | 4.5 | start of large flood |
| 09/04/92 | 09:40:00 | 33851.40 | | S | 0.5 | 22.4 | start of large flood |
| 09/04/92 | 09:45:00 | 33851.41 | | Z | 0.5 | 9.0 | start of large flood |
| 09/04/92 | 11:30:00 | 33851.48 | \| | | | | |
| 09/04/92 | 13:30:00 | 33851.56 | \| | A | 0.5 | 220 | HHW |
| 09/04/92 | 13:45:00 | 33851.57 | \| | | | | |
| 09/04/92 | 14:25:00 | 33851.60 | | M | 0.5 | 0.15 | small ebb |
| 09/04/92 | 18:15:00 | 33851.76 | \| | | | | |
| 09/04/92 | 19:00:00 | 33851.79 | \| | | | | |
| 09/04/92 | 19:45:00 | 33851.82 | | Z | 3 | 0.1 | small flood |
| 09/04/92 | 20:13:00 | 33851.84 | | S | 3 | 0.4 | small flood |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide duration* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) | Stage of tide during sampling |
|---|---|---|---|---|---|---|---|
| 09/04/92 | 20:38:00 | 33851.86 | | M | 2 | 3.3 | small flood |
| 09/04/92 | 21:30:00 | 33851.90 | | A | 3 | 15.0 | small flood |
| 09/04/92 | 23:15:00 | 33851.97 | \| | M | 4 | 1.3 | LHW |
| 09/04/92 | 23:20:00 | 33851.97 | \| | S | 3 | 0.9 | LHW |
| 09/04/92 | 23:35:00 | 33851.98 | \| | Z | 4 | 0.9 | LHW |
| 09/05/92 | 00:00:00 | 33852.00 | \| | | | | |
| 09/05/92 | 06:45:00 | 33852.28 | | Z | 0.5 | 8.7 | large flood |
| 09/05/92 | 07:15:00 | 33852.30 | | S | 0.5 | 9.1 | large flood |
| 09/05/92 | 07:45:00 | 33852.32 | | M | 0.5 | 9.1 | large flood |
| 09/05/92 | 08:14:00 | 33852.34 | | A | 0.5 | 19.8 | large flood |
| 09/05/92 | 08:30:00 | 33852.35 | \| | | | | |
| 09/05/92 | 10:30:00 | 33852.44 | \| | | | | |
| 09/05/92 | 14:15:00 | 33852.59 | \| | | | | |
| 09/05/92 | 15:00:00 | 33852.63 | \| | | | | |
| 09/05/92 | 15:38:00 | 33852.65 | | M | 2 | 0.01 | small ebb |
| 09/05/92 | 16:00:00 | 33852.67 | | A | 2 | 12.4 | small ebb |
| 09/05/92 | 16:30:00 | 33852.69 | | M | 4 | 0.8 | small ebb |
| 09/05/92 | 16:40:00 | 33852.69 | | S | 4 | 0.1 | small ebb |
| 09/05/92 | 17:20:00 | 33852.72 | | A | 10 | 11.6 | small ebb |
| 09/05/92 | 17:45:00 | 33852.74 | \| | | | | |
| 09/05/92 | 18:45:00 | 33852.78 | \| | | | | |
| 09/05/92 | 20:08:00 | 33852.84 | | S | 5 | 2.3 | small flood |
| 09/05/92 | 20:25:00 | 33852.85 | | Z | 5 | 0.8 | small flood |
| 09/05/92 | 20:40:00 | 33852.86 | | M | 2 | 10.7 | small flood |
| 09/05/92 | 21:10:00 | 33852.88 | | A | 1 | 15.6 | small flood |
| 09/05/92 | 23:30:00 | 33852.98 | \| | | | | |
| 09/06/92 | 00:15:00 | 33853.01 | \| | | | | |
| 09/06/92 | 06:40:00 | 33853.28 | | A | 4 | 17.7 | large ebb |
| 09/06/92 | 07:40:00 | 33853.32 | | M | 4 | 14.6 | large ebb |
| 09/06/92 | 08:05:00 | 33853.34 | | S | 5 | 14 | large ebb |
| 09/06/92 | 08:30:00 | 33853.35 | | Z | 0.5 | 13 | large ebb |
| 09/06/92 | 13:45:00 | 33853.57 | \| | | | | |

| Date (MM/DD/YY) | Time (HH:MM:SS) | Date.Time number (Julian) | Stand of tide duration* | Sampling station** | Depth of sampling*** (feet) | Dye Concentration (ppb) | Stage of tide during sampling |
|---|---|---|---|---|---|---|---|
| 09/06/92 | 15:55:00 | 33853.66 | \| | A | 1 | 5.9 | HHW |
| 09/06/92 | 16:00:00 | 33853.67 | \| | M | 1 | 0.4 | HHW |
| 09/06/92 | 16:05:00 | 33853.67 | | S | 1 | 0 | HHW |
| 09/06/92 | 16:10:00 | 33853.67 | | Z | 1 | 0 | small ebb |
| | | | | | | | |
| 09/08/92 | 10:15:00 | 33855.43 | \| | | | | |
| 09/08/92 | 12:30:00 | 33855.52 | \| | A | | 10.8 | LLW |
| 09/08/92 | 12:30:00 | 33855.52 | \| | M | | 13 | LLW |
| 09/08/92 | 12:30:00 | 33855.52 | \| | S | | 13 | LLW |
| 09/08/92 | 12:30:00 | 33855.52 | \| | Z | | 12.1 | LLW |
| 09/08/92 | 13:00:00 | 33855.54 | \| | | | | |
| | | | | | | | |
| 09/09/92 | 03:45:00 | 33856.16 | \| | | | | |
| 09/09/92 | 04:30:00 | 33856.19 | \| | | | | |
| | | | | | | | |
| 09/9/92 | 10:20:00 | 33856.43 | | A | | 6.1 | small ebb |
| 09/9/92 | 10:20:00 | 33856.43 | | M | | 7.6 | small ebb |
| 09/9/92 | 10:20:00 | 33856.43 | | S | | 12.2 | small ebb |
| 09/9/92 | 10:20:00 | 33856.43 | | Z | | 10.3 | small ebb |
| | | | | | | | |
| 09/11/92 | 12:40:00 | 33858.53 | \| | A | | 3.9 | LLW |
| 09/11/92 | 12:40:00 | 33858.53 | \| | M | | 3.9 | LLW |
| 09/11/92 | 12:40:00 | 33858.53 | \| | S | | 9.3 | LLW |
| 09/11/92 | 12:40:00 | 33858.53 | \| | Z | | 5.8 | LLW |
| 09/11/92 | 14:45:00 | 33858.61 | \| | | | | |

* – Vertical dashes in this column represent duration of each slack at station S as reflected by "water level" data from Appendix E1. Vertical dashes shown in all rows after 33852.50 (Julian) represent durations which are predictions extrapolated from earlier durations.

** – Location of sampling stations is shown on Figure 2 and described in text of report.

*** – Depth below the water surface. Surface ("Water level") fluctuates with tidal activity.

# APPENDIX H

## The Principle of Superposition

## The Principle of Superposition

The principle of superposition as it applies generally to dye tracing studies and in particular to the Stillaguamish River study can be best understood if the case of discharge into a unidirectional flowing stream is considered first. If a slug of dye is injected instantaneously, the concentrations measured over time at a downstream sampling station will assume a typical bell-shaped curve. If slug injections of the same amount of dye are repeated at uniform, closely spaced time intervals, then there will be a series of overlapping bell-shaped curves. Concentration at this station (or any other downstream sampling station) will build up to some ultimate plateau level.

The assumption can be made that these closely spaced time intervals amount to a continuous discharge. In this way, the series of bell-shaped concentration-over-time curves can be superimposed on each other, as shown in Figure H1, and a cumulative response curve can be graphed. This curve will yield the ultimate daily maximum concentration due to this "continuous" discharge. This ultimate concentration can also be simulated (in unidirectional flow situations only) by numerically integrating the curve produced by a <u>single</u> slug injection. The ultimate concentration will be dependent on the stream discharge and the amount or rate of dye injection.

The portions of estuaries where there are alternating directions of flow are more complex. The concentration-over-time curves resulting from a series of instantaneous slug injections will vary in shape, magnitude, and location, depending on the stage of tide when the injection is made. Thus, each concentration-over-time curve in the series (of slug injections throughout a normal tidal cycle) will be different, <u>i.e.</u>, no two will look alike.

It becomes virtually impossible to create a series of curves using this approach in tidally-influenced waters without simplifying assumptions. The complication can be overcome by assuming a slug injection of one tidal cycle duration. This is reasonable because the conditions during a tidal cycle are quasi-steady-state in relation to the long observation period.

Consider the case of this one-tidal-cycle injection into an estuary which has no freshwater inflow. The set of curves shown in Figure H2 evolve from this single slug injection, when dye concentrations are measured at one-tidal-cycle intervals at the point of injection. These are concentration-over-longitudinal distance curves.* The T = 1$\Delta$t curve shows the concentrations throughout the dye cloud after an elapsed time of $\Delta$t (the end of the injection), when the tidal condition is the same as it was at the beginning of injection. The curve at 2$\Delta$t shows the concentrations due to injection which took place two tidal cycles previous; the curve at 3$\Delta$t is due to injection three tidal cycles ago; and so on. The dye mass remains centered about the point of injection even though it becomes more elongated with each tidal cycle - as depicted by curves T = 2$\Delta$t, T = 3$\Delta$t, and T = 4$\Delta$t. The appearance of each curve as symmetrical about the point of injection, i.e., bell-shaped, is due to the absence of freshwater inflow.

If the injection point is relatively close to the ocean (or Skagit Bay/Port Susan - as is Stanwood's outfall), a part of the dye will reach the ocean within several tidal cycles. This is due to the processes of tidal excursion and longitudinal dispersion. This dye will be flushed out by the large body of dilution water. Such flushing will cause additional attenuation of the seaward side of the cloud, the formation of a nonsymmetrical cloud, and loss of the bell-shape in the curve.

If the tides are asymmetrical, then dye should be injected for two tidal cycles; it makes some difference in the ultimate concentration whether the dye is injected through just the high-high or the low-high cycle. By injecting through both it is possible to choose the combination of peaks that will add up to the largest dye concentration.

The set of concentration-over-longitudinal distance curves in Figure H2 are useful for graphically depicting what happens in an estuary following a slug injection. In theory, the ultimate daily maximum concentration due to a continuous injection at any location, e.g., sampling station A somewhere along the x axis of Figure H2, can be obtained by summing each concentration ($C_1$, $C_2$, $C_3$, ....$C_\infty$) obtained from the y axis at $\Delta$t intervals. This summation is, in essence, the principle of superposition.

The final case is in estuaries where steady freshwater inflow exists. The concentration-over-longitudinal distance curves are shifted seaward, as shown in Figure H3, and the concentrations are reduced by both freshwater and ocean-water dilution. The ultimate daily maximum concentrations that will result at various stations from a continuous injection can still be computed using the superposition principle by summing the curves at each of the stations. The resultant concentrations reflect the affects of freshwater transport, flushing, and longitudinal dispersion; and therefore, depict exactly the concentration distribution of a pollutant of concern having similar characteristics.

---

*[Note: Figure H1 shows the concentration curves for a series of dye injections (each injection of instantaneous duration) developed for a downstream sampling station, while Figure H2 shows the concentration curves for a single dye injection (of one-tidal-cycle duration) developed for the point of injection. Time is the preferred independent variable (units on X-axis) in Figure H1 because of the unidirectional nature of the current, while distance is the preferred independent variable in Figure H2 because of the cyclical nature of the current].

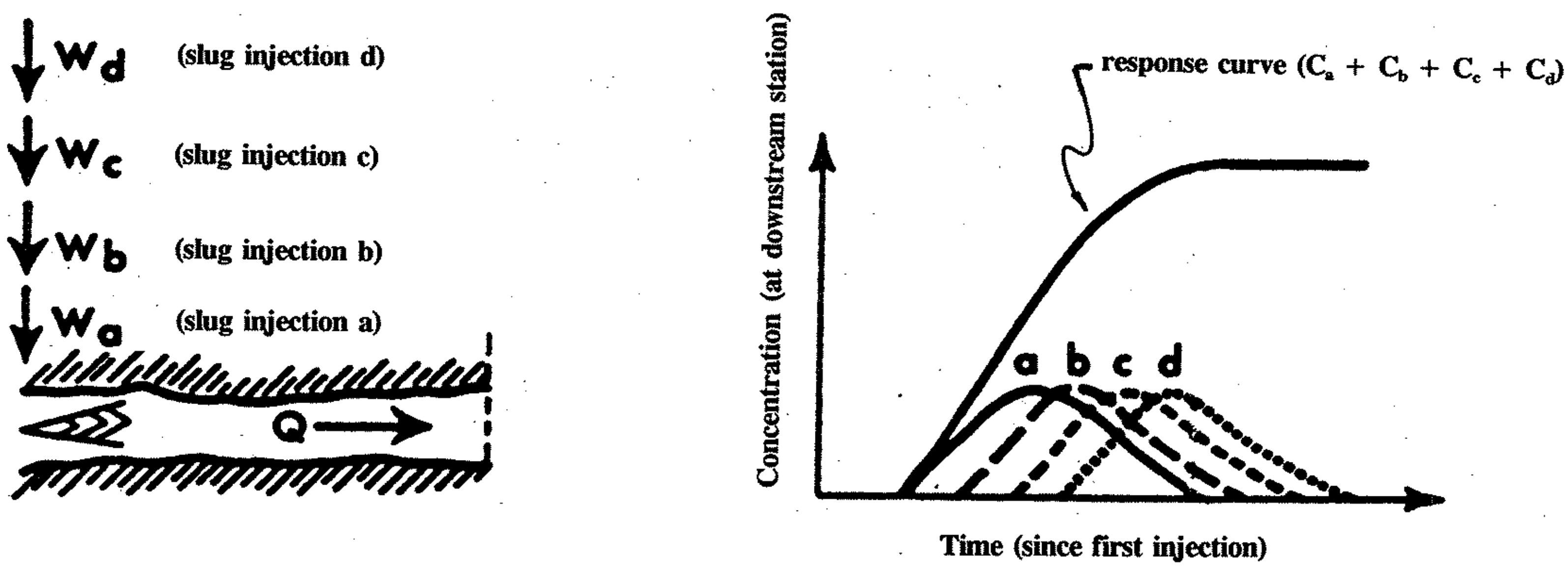
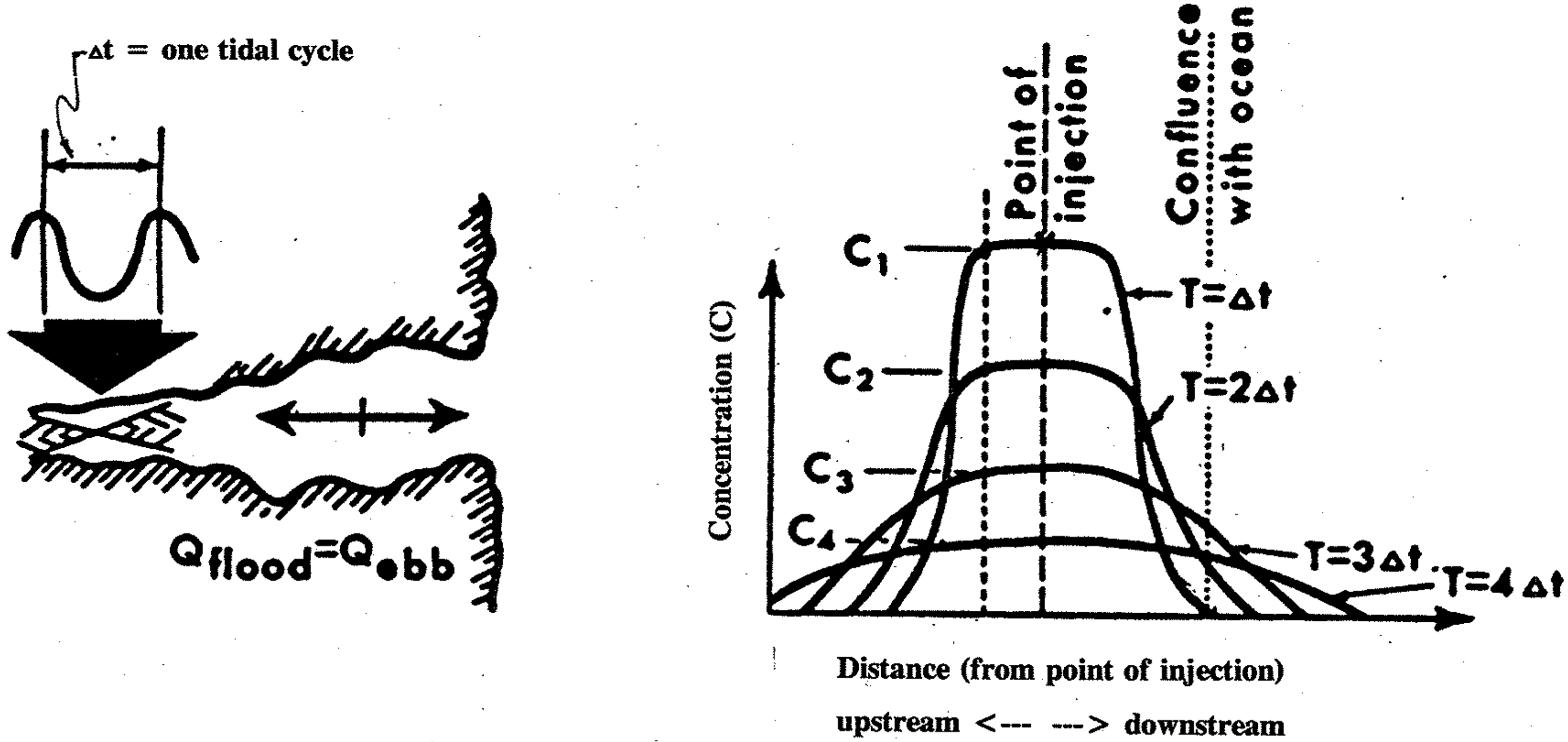

Wd (slug injection d)
Wc (slug injection c)
Wb (slug injection b)
Wa (slug injection a)
Q
response curve ($C_a + C_b + C_c + C_d$)
a b c d
Concentration (at downstream station)
Time (since first injection)

Figure H1



Δt = one tidal cycle
$Q_{flood} = Q_{ebb}$
Point of injection
Confluence with ocean
$C_1$
$C_2$
$C_3$
$C_4$
T=Δt
T=2Δt
T=3Δt
T=4Δt
Concentration (C)
Distance (from point of injection)
upstream <--- ---> downstream


Figure H2

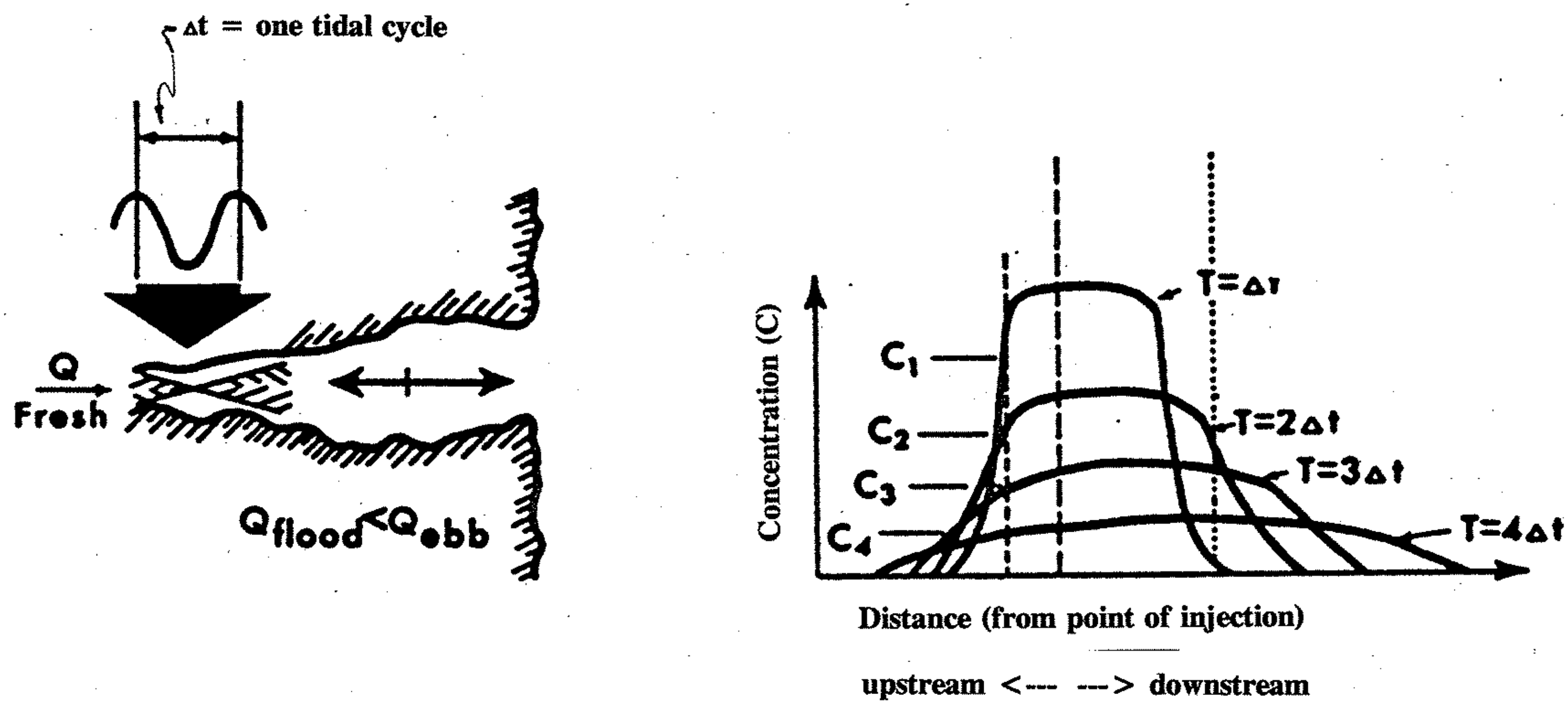

Δt = one tidal cycle
Q
Fresh
Q flood < Q ebb
Concentration (C)
C1
C2
C3
C4
T=Δt
T=2Δt
T=3Δt
T=4Δt
Distance (from point of injection)
upstream <--- ---> downstream

Figure H3

# APPENDIX I

Raw and corrected longitudinal trace data

Calculated intertidal and subtidal water volumes

Longitudinal Trace of Stillaguamish River Channel with Calculated Intertidal and Subtidal Water Volumes.

| Identification Marks | | Distance | Depth to bottom (feet) | | | Calculated Water Volumes (ft³ x $10^5$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | intertidal | | subtidal | |
| Landmarks | Lawrance tape code | from mouth (feet) | actual reading* | from MHW** | from MLW*** | /distance | cumulative | /distance | cumulative |
| Head of tidal bay | | ±32,700 | --- | 0^ | -5.9^ | | | | |
| | | 27,700 | 6.0 | 6.5 | 0.6 | 7.15 | 7.15 | 0.20 | 0.20 |
| | | 26,700 | 6.0 | 6.5 | 0.6 | 3.54 | 10.69 | 0.36 | 0.56 |
| | | 25,700 | 7.0 | 7.5 | 1.6 | 4.13 | 14.82 | 0.77 | 1.33 |
| | | 24,700 | 10.0 | 10.5 | 4.6 | 4.13 | 18.95 | 2.28 | 3.61 |
| | | 23,700 | 10.0 | 10.5 | 4.6 | 4.13 | 23.08 | 3.22 | 6.83 |
| Sharp bend above WWTP | 4 marks | 23,100 | 9.0 | 9.5 | 3.6 | | 23.08 | | 6.83 |
| | | 23,000 | 6.0 | 6.5 | 0.6 | | 23.08 | | 6.83 |
| | | 22,900 | 6.0 | 6.5 | 0.6 | | 23.08 | | 6.83 |
| | | 22,800 | 6.0 | 6.5 | 0.6 | | 23.08 | | 6.83 |
| | | 22,700 | 6.0 | 6.5 | 0.6 | 4.72 | 27.80 | 2.32 | 9.15 |
| | | 22,600 | 6.0 | 6.5 | 0.6 | | 27.80 | | 9.15 |
| | | 22,500 | 5.0 | 5.5 | -0.4 | | 27.80 | | 9.15 |
| | | 22,400 | 4.0 | 4.5 | -1.4 | | 27.80 | | 9.15 |
| | | 22,300 | 4.0 | 4.5 | -1.4 | | 27.80 | | 9.15 |
| | | 22,200 | 6.0 | 6.5 | 0.6 | | 27.80 | | 9.15 |
| | | 22,100 | 7.0 | 7.5 | 1.6 | | 27.80 | | 9.15 |
| | | 22,000 | 6.0 | 6.5 | 0.6 | | 27.80 | | 9.15 |
| | | 21,900 | 10.0 | 10.5 | 4.6 | | 27.80 | | 9.15 |
| | | 21,800 | 6.0 | 6.5 | 0.6 | | 27.80 | | 9.15 |
| Station A (WWTP outfall) | | 21,700 | 12.0 | 12.5 | 6.6 | 4.16 | 31.96 | 0.84 | 9.99 |
| | | 21,600 | 14.0 | 14.5 | 8.6 | | 31.96 | | 9.99 |
| 210 ft. chronic boundary | 4 marks | 21,490 | 14.0 | 14.5 | 8.6 | | 31.96 | | 9.99 |
| | | 21,400 | 14.0 | 14.5 | 8.6 | | 31.96 | | 9.99 |
| | | 21,300 | 13.0 | 13.5 | 7.6 | | 31.96 | | 9.99 |
| | | 21,200 | 12.0 | 12.5 | 6.6 | | 31.96 | | 9.99 |
| | | 21,100 | 12.0 | 12.5 | 6.6 | | 31.96 | | 9.99 |
| | | 21,000 | 10.0 | 10.5 | 4.6 | | 31.96 | | 9.99 |
| | | 20,900 | 8.0 | 8.5 | 2.6 | | 31.96 | | 9.99 |
| | | 20,800 | 8.0 | 8.5 | 2.6 | | 31.96 | | 9.99 |
| | | 20,700 | 7.0 | 7.5 | 1.6 | 4.72 | 36.68 | 4.88 | 14.87 |
| | | 20,600 | 6.0 | 6.5 | 0.6 | | 36.68 | | 14.87 |
| | | 20,500 | 6.0 | 6.5 | 0.6 | | 36.68 | | 14.87 |

| Identification Marks | | Distance | Depth to bottom (feet) | | | Calculated Water Volumes ($ft^3 \times 10^5$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | intertidal | | subtidal | |
| Landmarks | Lawrance tape code | from mouth (feet) | actual reading* | from MHW** | from MLW*** | /distance | cumulative | /distance | cumulative |
| 1st house on lt. bank | 3 marks | 20,400 | 6.0 | 6.5 | 0.6 | | 36.68 | | 14.87 |
| | | 20,300 | 8.0 | 8.5 | 2.6 | | 36.68 | | 14.87 |
| | | 20,200 | 8.0 | 8.5 | 2.6 | | 36.68 | | 14.87 |
| | | 20,100 | 7.0 | 7.5 | 1.6 | | 36.68 | | 14.87 |
| | | 20,000 | 7.0 | 7.5 | 1.6 | | 36.68 | | 14.87 |
| | | 19,900 | 7.0 | 7.5 | 1.6 | | 36.68 | | 14.87 |
| | | 19,800 | 6.0 | 6.5 | 0.6 | | 36.68 | | 14.87 |
| | | 19,700 | 6.0 | 6.5 | 0.6 | 6.49 | 43.17 | 1.43 | 16.30 |
| | | 19,600 | 5.0 | 5.5 | -0.4 | | 43.17 | | 16.30 |
| | | 19,500 | 5.0 | 5.5 | -0.4 | | 43.17 | | 16.30 |
| | | 19,400 | 5.0 | 5.5 | -0.4 | | 43.17 | | 16.30 |
| | | 19,300 | 6.0 | 6.5 | 0.6 | | 43.17 | | 16.30 |
| | | 19,200 | 5.0 | 5.5 | -0.4 | | 43.17 | | 16.30 |
| Station RM3.7 | 2 marks | 19,100 | 6.0 | 6.5 | 0.6 | | 43.17 | | 16.30 |
| | | 19,000 | 7.0 | 7.5 | 1.6 | | 43.17 | | 16.30 |
| | | 18,900 | 7.0 | 7.5 | 1.6 | | 43.17 | | 16.30 |
| | | 18,800 | 7.0 | 7.5 | 1.6 | | 43.17 | | 16.30 |
| | | 18,700 | 6.0 | 6.5 | 0.6 | 8.12 | 51.29 | 0.77 | 17.07 |
| | | 18,600 | 6.0 | 6.5 | 0.6 | | 51.29 | | 17.07 |
| | | 18,500 | 6.0 | 6.5 | 0.6 | | 51.29 | | 17.07 |
| | | 18,400 | 6.0 | 6.5 | 0.6 | | 51.29 | | 17.07 |
| | | 18,300 | 6.0 | 6.5 | 0.6 | | 51.29 | | 17.07 |
| Single houses-lt.& rt. | 1 mark | 18,200 | 7.0 | 7.5 | 1.6 | | 51.29 | | 17.07 |
| | | 18,100 | 8.0 | 8.5 | 2.6 | | 51.29 | | 17.07 |
| | | 18,000 | 9.0 | 9.5 | 3.6 | | 51.29 | | 17.07 |
| | | 17,900 | 11.0 | 11.5 | 5.6 | | 51.29 | | 17.07 |
| | | 17,800 | 14.0 | 14.5 | 8.6 | | 51.29 | | 17.07 |
| | | 17,700 | 12.0 | 12.5 | 6.6 | 8.26 | 59.55 | 2.94 | 20.01 |
| | | 17,600 | 12.0 | 12.5 | 6.6 | | 59.55 | | 20.01 |
| | | 17,500 | 13.0 | 13.5 | 7.6 | | 59.55 | | 20.01 |
| | | 17,400 | 13.0 | 13.5 | 7.6 | | 59.55 | | 20.01 |
| | | 17,300 | 12.0 | 12.5 | 6.6 | | 59.55 | | 20.01 |
| | | 17,200 | 11.0 | 11.5 | 5.6 | | 59.55 | | 20.01 |
| | | 17,100 | 11.0 | 11.5 | 5.6 | | 59.55 | | 20.01 |
| | | 17,000 | 10.0 | 10.5 | 4.6 | | 59.55 | | 20.01 |

| Identification Marks | | Distance | Depth to bottom (feet) | | | Calculated Water Volumes ($ft^3 \times 10^5$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | intertidal | | subtidal | |
| Landmarks | Lawrance tape code | from mouth (feet) | actual reading* | from MHW** | from MLW*** | /distance | cumulative | /distance | cumulative |
| | | 16,900 | 11.0 | 11.5 | 5.6 | | 59.55 | | 20.01 |
| | | 16,800 | 11.0 | 11.5 | 5.6 | | 59.55 | | 20.01 |
| Metal bldg–rt. bank | 2 marks | 16,700 | 9.0 | 9.5 | 3.6 | 8.26 | 67.81 | 8.40 | 28.41 |
| | | 16,600 | 8.0 | 8.5 | 2.6 | | 67.81 | | 28.41 |
| | | 16,500 | 7.0 | 7.5 | 1.6 | | 67.81 | | 28.41 |
| | | 16,400 | 7.0 | 7.5 | 1.6 | | 67.81 | | 28.41 |
| | | 16,300 | 7.0 | 7.5 | 1.6 | | 67.81 | | 28.41 |
| | | 16,200 | 7.0 | 7.5 | 1.6 | | 67.81 | | 28.41 |
| | | 16,100 | 7.0 | 7.5 | 1.6 | | 67.81 | | 28.41 |
| | | 16,000 | 7.0 | 7.5 | 1.6 | | 67.81 | | 28.41 |
| | | 15,900 | 8.0 | 8.5 | 2.6 | | 67.81 | | 28.41 |
| | | 15,800 | 8.0 | 8.5 | 2.6 | | 67.81 | | 28.41 |
| | | 15,700 | 8.0 | 8.5 | 2.6 | 8.26 | 76.07 | 2.80 | 31.21 |
| | | 15,600 | 10.0 | 10.5 | 4.6 | | 76.07 | | 31.21 |
| | | 15,500 | 10.0 | 10.5 | 4.6 | | 76.07 | | 31.21 |
| | | 15,400 | 10.0 | 10.5 | 4.6 | | 76.07 | | 31.21 |
| Station M | 4 marks | 15,300 | 8.0 | 8.5 | 2.6 | | 76.07 | | 31.21 |
| | | 15,200 | 7.0 | 7.5 | 1.6 | | 76.07 | | 31.21 |
| | | 15,100 | 6.5 | 7 | 1.1 | | 76.07 | | 31.21 |
| 1st TCF bldg. | 3 marks | 15,000 | 6.5 | 7 | 1.1 | | 76.07 | | 31.21 |
| | | 14,900 | 7.5 | 8 | 2.1 | | 76.07 | | 31.21 |
| | | 14,800 | 9.0 | 9.5 | 3.6 | | 76.07 | | 31.21 |
| | | 14,700 | 11.0 | 11.5 | 5.6 | 8.26 | 84.33 | 3.78 | 34.99 |
| | | 14,600 | 12.0 | 12.5 | 6.6 | | 84.33 | | 34.99 |
| | | 14,500 | 12.5 | 13 | 7.1 | | 84.33 | | 34.99 |
| | | 14,400 | 13.0 | 13.5 | 7.6 | | 84.33 | | 34.99 |
| | | 14,300 | 13.0 | 13.5 | 7.6 | | 84.33 | | 34.99 |
| | | 14,200 | 14.0 | 14.5 | 8.6 | | 84.33 | | 34.99 |
| | | 14,100 | 13.0 | 13.5 | 7.6 | | 84.33 | | 34.99 |
| | | 14,000 | 13.0 | 13.5 | 7.6 | | 84.33 | | 34.99 |
| | | 13,900 | 11.5 | 12 | 6.1 | | 84.33 | | 34.99 |
| | | 13,800 | 10.0 | 10.5 | 4.6 | | 84.33 | | 34.99 |
| | | 13,700 | 9.0 | 9.5 | 3.6 | 8.26 | 92.59 | 9.66 | 44.65 |
| | | 13,600 | 8.5 | 9 | 3.1 | | 92.59 | | 44.65 |
| | | 13,500 | 8.0 | 8.5 | 2.6 | | 92.59 | | 44.65 |

| Identification Marks | | Distance | Depth to bottom (feet) | | | Calculated Water Volumes ($ft^3 \times 10^5$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lawrance | from mouth | actual | from | from | intertidal | | subtidal | |
| Landmarks | tape code | (feet) | reading* | MHW** | MLW*** | /distance | cumulative | /distance | cumulative |
| | | 13,400 | 8.0 | 8.5 | 2.6 | | 92.59 | | 44.65 |
| | | 13,300 | 8.0 | 8.5 | 2.6 | | 92.59 | | 44.65 |
| | | 13,200 | 7.5 | 8 | 2.1 | | 92.59 | | 44.65 |
| | | 13,100 | 7.5 | 8 | 2.1 | | 92.59 | | 44.65 |
| | | 13,000 | 7.5 | 8 | 2.1 | | 92.59 | | 44.65 |
| | | 12,900 | 7.0 | 7.5 | 1.6 | | 92.59 | | 44.65 |
| | | 12,800 | 7.5 | 8 | 2.1 | | 92.59 | | 44.65 |
| | | 12,700 | 9.0 | 9.5 | 3.6 | 7.08 | 99.67 | 2.88 | 47.53 |
| Top of boat basin | 5 marks | 12,600 | 9.0 | 9.5 | 3.6 | | 99.67 | | 47.53 |
| | | 12,500 | 12.0 | 12.5 | 6.6 | | 99.67 | | 47.53 |
| | | 12,400 | 15.0 | 15.5 | 9.6 | | 99.67 | | 47.53 |
| | | 12,300 | 18.0 | 18.5 | 12.6 | | 99.67 | | 47.53 |
| | | 12,200 | 23.0 | 23.5 | 17.6 | | 99.67 | | 47.53 |
| | | 12,100 | 21.0 | 21.5 | 15.6 | | 99.67 | | 47.53 |
| | | 12,000 | 15.0 | 15.5 | 9.6 | | 99.67 | | 47.53 |
| | | 11,900 | 16.0 | 16.5 | 10.6 | | 99.67 | | 47.53 |
| | | 11,800 | 14.0 | 14.5 | 8.6 | | 99.67 | | 47.53 |
| | | 11,700 | 15.0 | 15.5 | 9.6 | 5.90 | 105.57 | 10.00 | 57.53 |
| | | 11,600 | 12.0 | 12.5 | 6.6 | | 105.57 | | 57.53 |
| | | 11,500 | 12.0 | 12.5 | 6.6 | | 105.57 | | 57.53 |
| | | 11,400 | 15.0 | 15.5 | 9.6 | | 105.57 | | 57.53 |
| | | 11,300 | 15.0 | 15.5 | 9.6 | | 105.57 | | 57.53 |
| | | 11,200 | 16.0 | 16.5 | 10.6 | | 105.57 | | 57.53 |
| | | 11,100 | 15.0 | 15.5 | 9.6 | | 105.57 | | 57.53 |
| Station S | 2 marks | 11,000 | 14.0 | 14.5 | 8.6 | | 105.57 | | 57.53 |
| | | 10,900 | 14.0 | 14.5 | 8.6 | | 105.57 | | 57.53 |
| | | 10,800 | 15.0 | 15.5 | 9.6 | | 105.57 | | 57.53 |
| | | 10,700 | 12.0 | 12.5 | 6.6 | 5.90 | 111.47 | 8.70 | 66.23 |
| | | 10,600 | 12.0 | 12.5 | 6.6 | | 111.47 | | 66.23 |
| | | 10,500 | 13.5 | 14 | 8.1 | | 111.47 | | 66.23 |
| | | 10,400 | 15.0 | 15.5 | 9.6 | | 111.47 | | 66.23 |
| | | 10,300 | 16.0 | 16.5 | 10.6 | | 111.47 | | 66.23 |
| | | 10,200 | 17.0 | 17.5 | 11.6 | | 111.47 | | 66.23 |
| | | 10,100 | 18.0 | 18.5 | 12.6 | | 111.47 | | 66.23 |
| | | 10,000 | 19.0 | 19.5 | 13.6 | | 111.47 | | 66.23 |

| Identification Marks | | Distance | Depth to bottom (feet) | | | Calculated Water Volumes (ft³ x 10⁵) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lawrance | from mouth | actual | from | from | intertidal | | subtidal | |
| Landmarks | tape code | (feet) | reading* | MHW** | MLW*** | /distance | cumulative | /distance | cumulative |
| TCF pipeline | 3 marks | 9,900 | 21.0 | 21.5 | 15.6 | | 111.47 | | 66.23 |
| | | 9,800 | 19.0 | 19.5 | 13.6 | | 111.47 | | 66.23 |
| | | 9,700 | 17.0 | 17.5 | 11.6 | 5.90 | 117.37 | 11.10 | 77.33 |
| | | 9,600 | 14.5 | 15 | 9.1 | | 117.37 | | 77.33 |
| | | 9,500 | 14.5 | 15 | 9.1 | | 117.37 | | 77.33 |
| | | 9,400 | 14.0 | 14.5 | 8.6 | | 117.37 | | 77.33 |
| | | 9,300 | 13.0 | 13.5 | 7.6 | | 117.37 | | 77.33 |
| | | 9,200 | 12.0 | 12.5 | 6.6 | | 117.37 | | 77.33 |
| | | 9,100 | 7.0 | 7.5 | 1.6 | | 117.37 | | 77.33 |
| | | 9,000 | 7.5 | 8 | 2.1 | | 117.37 | | 77.33 |
| | | 8,900 | 8.0 | 8.5 | 2.6 | | 117.37 | | 77.33 |
| | | 8,800 | 8.5 | 9 | 3.1 | | 117.37 | | 77.33 |
| | | 8,700 | 9.0 | 9.5 | 3.6 | 5.90 | 123.27 | 5.60 | 82.93 |
| | | 8,600 | 9.0 | 9.5 | 3.6 | | 123.27 | | 82.93 |
| Station Z | 5 marks | 8,500 | 10.0 | 10.5 | 4.6 | | 123.27 | | 82.93 |
| | | 7,700 | --- | 8.0^ | 2.1^ | 5.90 | 129.17 | 2.80 | 85.73 |
| | | 6,700 | --- | 8.0^ | 2.1^ | 5.90 | 135.07 | 2.10 | 87.83 |
| | | 5,700 | --- | 8.0^ | 2.1^ | 5.90 | 140.97 | 2.10 | 89.93 |
| | | 4,700 | --- | 8.0^ | 2.1^ | 5.90 | 146.87 | 2.10 | 92.03 |
| | | 3,700 | --- | 8.0^ | 2.1^ | 5.90 | 152.77 | 2.10 | 94.13 |
| | | 2,700 | --- | 8.0^ | 2.1^ | 5.90 | 158.67 | 2.10 | 96.23 |
| | | 1,700 | --- | 8.0^ | 2.1^ | 5.90 | 164.57 | 2.10 | 98.33 |
| | | 700 | --- | 8.0^ | 2.1^ | 5.90 | 170.47 | 2.10 | 100.43 |
| Mouth of tidal bay | | 0 | --- | 8.0^ | 2.1^ | 4.13 | 174.60 | 1.47 | 101.90 |

* – As recorded by Lawrance during "stand of tide number" 9 on 9/5/92, which had a "corrected for Stanwood" height of 6.2 feet.

** – The "corrected for Stanwood" MHW was calculated to be 6.7 feet.

*** – The "corrected for Stanwood" MLW was calculated to be 0.8 feet.

^ – Estimated.

# APPENDIX J

Formulation of the term "dilution factor"

**Formulation of the conceptual term "dilution factor".**

The volumetric dilution factor (DF) is defined as

$$DF = (Q_a + Q_e) / Q_e \quad \text{where} \qquad (1)$$

$Q_a$ is the quantity of receiving (ambient) water entrained in the plume from an outfall at some sampling station; and
$Q_e$ is the quantity of effluent in the plume.

It is conceptual because it's easier to visualize than to obtain directly. What <u>can</u> be measured directly in the plume is concentration of a pollutant of concern - or a dye tracer - at a sampling station whose location is a known horizontal distance from the outfall. Call this concentration ($C_p$). (A dye tracer is better because it can be measured *in situ*; and measuring its background concentration in the ambient water ($C_a$) and the concentration being discharged in effluent ($C_e$) is more manageable).

The basic mass balance equation is

$$(Q_a * C_a) + (Q_e * C_e) = (Q_a + Q_e) * C_p \qquad (2)$$

The Q values are difficult to measure at sampling stations in the plume, but they can be factored out of the mass balance equation by algebraic manipulation:

If the % effluent is represented by the term X; then the % ambient water which has been entrained in the plume of effluent that emerged from the outfall must be (1-X), because the sum of the two is 100% of the water in the plume. Substituting (1-X) for $Q_a$ and X for $Q_e$ (and understanding from equation (1) that 1 / X = DF) gives

$$DF = (C_e - C_a) / (C_p - C_a) \qquad (3)$$

A DF calculated using equation (3) is an empirical result for the particular sampling station where the $C_p$ value was measured.

The PLUMES model generates theoretical $C_p$s and DFs during a case run using outfall, steady-state effluent, and steady-state receiving water characteristics supplied to it (including $C_e$ and $C_a$). Each $C_p$ and DF that prints out is for a particular horizontal distance from the outfall. The empirical and theoretical $C_p$s for the same horizontal distance from the outfall can then be compared to establish how well the model is simulating the plume. In this way, a model can be validated for a particular site.

# APPENDIX K

Calculations showing derivation of $C_e$

**Calculations Showing Derivation of $C_e$.**

Quantity of 20% Rhodamine WT dye used: 24 L;

Quantity of 100% dye used: 24 x 0.2 = 4.8 L;

Density of dye: 1.19 kg/L;

Weight of dye: 4.8 L x 1.19 kg/L = 5.71 kg;

$= 5.71 \times 10^{3}$ gm;

Quantity of effluent:

$0.5 \times 10^{6}$ gal x $3.785 \times 10^{-3}$ $m^3/L$ x $10^3$ $L/m^3$

$= 1.89 \times 10^{6}$ L;

Concentration of dye ($C_e$):

$5.71 \times 10^{3}$ gm / $1.89 \times 10^{6}$ L = $3.02 \times 10^{3}$ gm/L

= 3,020 ppb

# APPENDIX L

Printouts from 3PLUMES MZ model

Jun 17, 1996, 17: 9:41 WED PROGRAM PLUMES, Ed 3.1, 8/7/95 Case: 1 of 4

Title Stanwood-Present/Validation,ebb following LHW, station A. nonlinear

| tot flow | # ports | port flow | spacing | effl sal | effl temp | far inc | far dis |
|---|---|---|---|---|---|---|---|
| 0.02191 | 1 | 0.02191 | 1000 | 0.0 | 17 | 6.4 | 6.4 |
| port dep | port dia | plume dia | total vel | horiz vel | vertl vel | asp coeff | print frq |
| 2.652 | 0.5567 | 0.4348 | 0.1476 | 0.1476 | 0.000 | 0.1 | 60 |
| port elev | ver angle | cont coef | effl den | poll conc | decay | Froude # | Roberts F |
| 0.3048 | 0.0 | 0.61 | -1.16146 | 3020 | 0 | 0.6001 | 4755 |
| hor angle | red space | p amb den | p current | far dif | far vel | K:vel/cur | Stratif # |
| 90 | 1000.0 | 13.0040 | 0.2438 | 0.000453 | 0.1 | 0.6053 | 0.0002402 |
| depth | current | density | salinity | temp | amb conc | N (freq) | red grav. |
| 0.0 | 0.1 | 12.9832 | 19.3 | 19.6 | 0 | 0.008704 | 0.1391 |
| 3. | 0.1 | 13.0067 | 19.3 | 19.5 | 0 | buoy flux | puff-ther |
| | | | | | | 3.047E-06 | 0.2414 |
| | | | | | | jet-plume | jet-cross |
| | | | | | | 0.2456 | 0.2332 |
| | | | | | | plu-cross | jet-strat |
| | | | | | | 0.2103 | 2.556 |
| | | | | | | plu-strat | |
| | | | | | | 8.245 | |
| | | | | | | hor dis>= | |
| | | | | | | 6.4 | |

CORMIX1 flow category algorithm is turned off.

0.000453 m2/3/s 0.0001 to 0.0005 m2/3/s range

Help: F1. Quit: <esc>. Configuration:NRC00. FILE: STANWOOD.VAR;

UM INITIAL DILUTION CALCULATION (nonlinear mode)

| plume dep | plume dia | poll conc | dilution | hor dis |
|---|---|---|---|---|
| m | m | | | m |
| 2.652 | 0.4348 | 3020 | 1.000 | 0.000 |
| 2.388 | 0.4239 | 1992 | 1.508 | 0.3006 |
| 2.141 | 0.5199 | 1315 | 2.279 | 0.4553 |
| 1.850 | 0.6573 | 867.3 | 3.447 | 0.6277 |
| 1.508 | 0.8407 | 572.2 | 5.218 | 0.8359 |
| 1.108 | 1.080 | 377.5 | 7.902 | 1.096 |
| 0.6453 | 1.388 | 249.1 | 11.97 | 1.427 |
| 0.4584 | 1.522 | 213.8 | 13.94 | 1.570 -> surface hit |

FARFIELD CALCULATION (based on Brooks, 1960, see guide)

Input wastefield width: 1.52

Farfield dispersion based on wastefield width of 1.520m

| --4/3 Power Law-- | | | --Const Eddy Diff-- | | | | | |
|---|---|---|---|---|---|---|---|---|
| conc | dilution | width | conc | dilution | width | distance | time | |
| | | m | | | m | m | sec | hrs |
| 212 | 14.1 | 1.83 | 213 | 14.0 | 1.80 | 6.40 | 48.3 | 0.013 |

Jun 17, 1996, 17: 7:22 WED PROGRAM PLUMES, Ed 3.1, 8/7/95 Case: 2 of 4

Title Stanwood-Present/Calibration,ebb following LHW/station I. nonlinear

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| tot flow | # ports | port flow | spacing | effl sal | effl temp | far inc | far dis |
| 0.02191 | 1 | 0.02191 | 1000 | 0.0 | 17 | 6.4 | 64. |
| port dep | port dia | plume dia | total vel | horiz vel | vertl vel | asp coeff | print frq |
| 2.652 | 0.5567 | 0.4348 | 0.1476 | 0.1476 | 0.000 | 0.10 | 100 |
| port elev | ver angle | cont coef | effl den | poll conc | decay | Froude # | Roberts F |
| 0.3048 | 0.0 | 0.61 | -1.16146 | 3020 | 0 | 0.6001 | 328.2 |
| hor angle | red space | p amb den | p current | far dif | far vel | K:vel/cur | Stratif # |
| 90 | 1000.0 | 13.0040 | 0.1000 | 0.0022 | 0.1 | 1.476 | 0.0002402 |
| depth | current | density | salinity | temp | amb conc | N (freq) | red grav. |
| 0.0 | 0.1 | 12.9832 | 19.3 | 19.6 | 0 | 0.008704 | 0.1391 |
| 3. | 0.1 | 13.0067 | 19.3 | 19.5 | 0 | buoy flux | puff-ther |
| | | | | | | 3.047E-06 | 0.3249 |
| | | | | | | jet-plume | jet-cross |
| | | | | | | 0.2456 | 0.5686 |
| | | | | | | plu-cross | jet-strat |
| | | | | | | 3.047 | 2.556 |
| | | | | | | plu-strat | |
| | | | | | | 8.245 | |
| | | | | | | hor dis>= | |
| | | | | | | 6.4 | |

CORMIX1 flow category algorithm is turned off.

0.0022 m2/3/s 0.0001 to 0.0005 m2/3/s range

Help: F1. Quit: <esc>. Configuration:NRCO0. FILE: STANWOOD.VAR;

UM INITIAL DILUTION CALCULATION (nonlinear mode)

| plume dep m | plume dia m | poll conc | dilution | hor dis m |
|---|---|---|---|---|
| 2.652 | 0.4348 | 3020 | 1.000 | 0.000 |
| 2.227 | 0.4832 | 1510 | 1.986 | 0.4029 |
| 1.742 | 0.7130 | 755.0 | 3.958 | 0.6923 |
| 1.108 | 1.080 | 377.5 | 7.902 | 1.096 |
| 0.4584 | 1.522 | 213.8 | 13.94 | 1.570 -> surface hit |

FARFIELD CALCULATION (based on Brooks, 1960, see guide)

Input wastefield width: 1.52

Farfield dispersion based on wastefield width of 1.520m

| --4/3 Power Law-- | | | --Const Eddy Diff-- | | | | | |
|---|---|---|---|---|---|---|---|---|
| conc | dilution | width m | conc | dilution | width m | distance m | time sec | hrs |
| 140 | 21.4 | 3.20 | 169 | 17.7 | 2.60 | 6.40 | 48.3 | 0.013 |
| 75.6 | 39.8 | 5.99 | 126 | 23.8 | 3.56 | 12.8 | 112 | 0.031 |
| 48.7 | 61.8 | 9.31 | 105 | 28.7 | 4.31 | 19.2 | 176 | 0.049 |
| 34.7 | 86.8 | 13.1 | 91.3 | 32.9 | 4.95 | 25.6 | 240 | 0.067 |
| 26.3 | 114 | 17.3 | 82.1 | 36.6 | 5.51 | 32.0 | 304 | 0.085 |
| 20.9 | 145 | 21.8 | 75.1 | 40.0 | 6.02 | 38.4 | 368 | 0.10 |
| 17.0 | 177 | 26.7 | 69.7 | 43.1 | 6.50 | 44.8 | 432 | 0.12 |
| 14.3 | 212 | 31.9 | 65.3 | 46.0 | 6.94 | 51.2 | 496 | 0.14 |
| 12.2 | 248 | 37.4 | 61.7 | 48.8 | 7.35 | 57.6 | 560 | 0.16 |
| 10.5 | 287 | 43.2 | 58.6 | 51.4 | 7.74 | 64.0 | 624 | 0.17 |

```
Jun 17, 1996,  17: 7:31  WED PROGRAM PLUMES, Ed 3.1, 8/7/95   Case:    3 of   4
Title   Stanwood-Future/acute boundary/2.37 MGD/min curr/           nonlinear
 tot flow   # ports port flow   spacing  effl sal effl temp   far inc   far dis
  0.1038          1   0.1038      1000      0.0        17       6.4       6.4
 port dep  port dia plume dia total vel horiz vel vertl vel asp coeff print frq
   2.652    0.6096    0.4761    0.5830    0.5830     0.000       0.1        60
port elev ver angle cont coef  effl den poll conc     decay  Froude # Roberts F
  0.3048       0.0      0.61  -1.16146       100         0     2.266     673.2
hor angle red space p amb den p current   far dif   far vel K:vel/cur Stratif #
      90    1000.0   13.0040    0.2134  0.000453    0.0009     2.732 0.0002630
    depth   current   density  salinity      temp  amb conc  N (freq) red grav.
      0.0    0.0009   12.9832      19.3      19.6         0  0.008704    0.1391
       3.    0.0009   13.0067      19.3      19.5         0 buoy flux puff-ther
                                                        0.00001444     1.059
                                                         jet-plume jet-cross
                                                             1.015     1.153
                                                         plu-cross jet-strat
                                                             1.486     5.316
                                                         plu-strat
                                                             12.16
                                                           hor dis>=
                                                               6.4

CORMIX1 flow category algorithm is turned off.
 0.000453 m2/3/s                                   0.0001 to 0.0005 m2/3/s range
Help: F1.  Quit: <esc>.  Configuration:NRCO0.  FILE: STANWOOD.VAR;
UM INITIAL DILUTION CALCULATION (nonlinear mode)
 plume dep plume dia poll conc  dilution   hor dis
        m         m                              m
    2.652    0.4761     100.0     1.000     0.000

    2.567    0.7022     65.98     1.508    0.5919
    2.147    0.9463     43.53     2.279     1.329
    1.293     1.186     28.72     3.447     2.021
   0.2588     1.432     20.17     4.903     2.526 -> surface hit
FARFIELD CALCULATION (based on Brooks, 1960, see guide)

Input wastefield width: 1.43

Farfield dispersion based on wastefield width of      1.430m
      --4/3 Power Law--          --Const Eddy Diff--
    conc dilution     width     conc dilution     width   distance     time
                          m                           m          m      sec     hrs
   0.582      172      69.2     4.57     21.8      8.80     6.40     4300     1.2
```

```
Jun 17, 1996,  17:11:17  WED PROGRAM PLUMES, Ed 3.1, 8/7/95   Case:   4 of   4
Title   Stanwood-Future/chronic boundary/0.79 MGD/mean curr/        nonlinear
 tot flow   # ports port flow   spacing  effl sal effl temp   far inc   far dis
 0.03461          1  0.03461      1000       0.0        17       64.       64.
 port dep  port dia plume dia total vel horiz vel vertl vel asp coeff print frq
   2.652    0.5575    0.4354    0.2324    0.2324     0.000       0.1       100
port elev ver angle cont coef  effl den poll conc     decay  Froude # Roberts F
   0.3048       0.0      0.61  -1.16146       100         0    0.9445      2019
hor angle red space p amb den p current   far dif   far vel K:vel/cur Stratif #
       90    1000.0   13.0040    0.2134    0.0022    0.2134     1.089 0.0002405
    depth   current   density  salinity      temp  amb conc  N (freq) red grav.
      0.0    0.2134   12.9832      19.3      19.6         0  0.008704    0.1391
       3.    0.2134   13.0067      19.3      19.5         0 buoy flux puff-ther
                                                            4.814E-06    0.3979
                                                            jet-plume jet-cross
                                                               0.3872    0.4203
                                                            plu-cross jet-strat
                                                               0.4953     3.210
                                                            plu-strat
                                                                9.244
                                                              hor dis>=
                                                                  6.4
CORMIX1 flow category algorithm is turned off.
 0.0022 m2/3/s                                    0.0001 to 0.0005 m2/3/s range
Help: F1.  Quit: <esc>.  Configuration:NRCO0.  FILE: STANWOOD.VAR;
UM INITIAL DILUTION CALCULATION (nonlinear mode)
 plume dep plume dia poll conc  dilution   hor dis
         m         m                             m
     2.652    0.4354     100.0     1.000     0.000

     2.386    0.5667     50.00     1.986    0.5179
     2.122    0.8208     25.00     3.958    0.9091
     1.781     1.192     12.50     7.902     1.496
     1.324     1.722     6.250     15.79     2.440
    0.9811     2.132     4.152     23.76     3.263 -> surface hit
FARFIELD CALCULATION (based on Brooks, 1960, see guide)

Input wastefield width: 2.13

Farfield dispersion based on wastefield width of      2.130m
       --4/3 Power Law--          --Const Eddy Diff--
     conc dilution       width      conc dilution       width   distance     time
                             m                              m          m      sec     hrs
    0.718        139      17.2      1.82      54.7       6.76      64.0      285   0.079
```

# APPENDIX M

## The UM model in the 3PLUMES interface
## A closer look at the near-field and far-field algorithm

**The UM model in the PLUMES interface**
**A closer look at the near-field and far-field algorithms**

The 3PLUMES interface contains both initial dilution (near-field) and far-field algorithms for predicting performance of the effluent plume. Entrainment of ambient fluid into the effluent plume is simulated in the near-field by the interrelated principles of aspiration and projected area entrainment (PAE). The user can fine-tune aspiration through the interface by adjusting the aspiration coefficient **<asp coeff>**. Adjustments have the biggest effect at the lowest ambient current velocities. The default value is (0.1). PAE cannot be fine-tuned.

The far-field algorithm can also be fine-tuned. Some explanation is provided here. The user's manual (EPA, 1993) should be consulted for a detailed discussion of the algorithm (and the equations (66) through (70)) associated with far-field. The printout from the model shows the output from both algorithms.

There are two equations in the farfield algorithm: (1) the 4/3 Power Law, and (2) the Constant Eddy Diffusion. The former equation is preferred for analyses in open coastal waters; the latter for near shore coastal waters and confined waters - like the Stillaguamish River estuary. Both equations employ a farfield dispersion coefficient, whose units are $m^{2/3}$/sec. Both sets of results are included in the printout from a 3PLUMES case run.

The literature, *e.g.*, Table 5.3 in Fischer *et al* (1979), contains a range of observed values for longitudinal dispersion coefficients for a variety of channels. Typically, the units are $m^2$/sec. Equation (67) in the user's manual expresses the relationship between the longitudinal and farfield coefficients:

$\alpha = \epsilon_o / b^{4/3}$, where (1)

$\epsilon_o$ is a longitudinal dispersion coefficient from the literature;

b is the width of the plume field at the end of initial dilution (in m); and

$\alpha$ is the farfield dispersion coefficient used in 3PLUMES.

A change from the default value for the farfield dispersion coefficient (named **<far dif>** on the interface) appeared to be warranted. Dilutions in the printout under the subheading "**-Const Eddy Diff-**" (results from Equation (66)) weren't close to empirical values. Calibration of the model to field data for use at the chronic boundary was eventually achieved using a farfield dispersion coefficient of 0.0022. This is appropriate as long as the value in **<far vel>** remains approximately the same. This is because dispersion is dependent on ambient velocity, as mentioned above.

The farfield dispersion coefficient is the variable which must be recalculated whenever "b" changes. The "b" value is always present in the message: "Farfield dispersion based on wastefield width of ____m". The recalculated $\alpha$ is entered into the cell <**far dif**>, and the model restarted. If the second digit of the five-digit configuration string (at the bottom of the PLUMES interface) is encoded as an R, then the model will stop following completion of the near field algorithm to allow the modeller to input a "b" of his/her choice.

# APPENDIX N

Mixing zone mass balance calculations

# Mixing Zone Mass Balance Calculations Including Far-Field Accumulation of Effluent and Ambient Background Pollutants

## Introduction

Tidal currents may cause effluent to accumulate in the receiving water surrounding an outfall in a tidal river or estuary. The receiving water may also contain background concentrations of pollutants from sources other than effluent. This discussion presents mass-balance equations to account for far-field accumulation of effluent and background pollutant concentrations in the receiving water for mixing zones that are tidally-influenced. Various methods are available to account for the accumulation of effluent and ambient background sources when determining potential to exceed water quality criteria or estimating waste load allocations.

When dye is used as a tracer of effluent in a mixing zone study, the far-field accumulation of effluent may be estimated based on either of two methods:

- Method 1: the USGS superposition method (Hubbard and Stamper, 1972) may be used by injecting the tracer during one tidal day and measuring continuously at a fixed monitoring station to determine maximum concentrations during succeeding days until the tracer is undetectable; or

- Method 2: the Jirka method (EPA, 1992) may be used by injecting the tracer over several tidal cycles (usually five or more) until a quasi-maximum steady state is reached. Concentrations of the tracer are usually monitored continuously at a fixed monitoring station.

In addition to the two methods of tracer injection, two alternative schemes for locating monitoring stations are acceptable:

- Alternative 1: tracer concentrations are measured in the near-field at the mixing zone boundary in the approximate centerline of the effluent plume; or

- Alternative 2: tracer concentrations are measured in the far-field at some considerable distance from the effluent plume at a position that is representative of the source of dilution water for the plume.

Either the superposition or Jirka method may be used to conduct the tracer studies for both Alternatives 1 and 2. A third method is also proposed if a tracer study is not conducted:

- Method 3: A default correction which can be used as an approximation of far-field accumulation is based on recommendations by EPA (1992).

## Definitions

| | |
|---|---|
| near-field | at the mixing zone boundary in the approximate center-line of the effluent plume. |
| far-field | at some considerable distance from the effluent plume at a position that is representative of the source of dilution water for the plume. |
| $V$ | initial maximum effluent concentration (volume fraction of effluent; *e.g.* 5 percent effluent corresponds to V of 0.05) during first tidal cycle prior to influence of far-field accumulation from previous tidal cycles. |
| $\underline{V}$ | quasi-steady-state maximum effluent concentration (volume fraction of effluent; *e.g.* 5 percent effluent corresponds to $\underline{V}$ of 0.05) after several tidal cycles result in equilibrium with far-field accumulation. |
| $r_d$ | return rate of dye or effluent mass discharged in the previous tidal cycle as defined in EPA, 1992. |
| DF | initial effluent dilution factor (reciprocal of volume fraction of effluent; *e.g.* 5 percent effluent corresponds to DF of 20) during first tidal cycle prior to influence of far-field accumulation from previous tidal cycles. DF may be estimated using a model (e.g. PLUMES or CORMIX) or by near-field tracer measurement. DF is usually determined at critical conditions. |
| $\underline{DF}$ | quasi-steady-state effluent dilution factor (reciprocal of volume fraction of effluent; *e.g.* 5 percent effluent corresponds to DF of 20) after several tidal cycles (usually 5 or more cycles) result in equilibrium with far-field accumulation. $\underline{DF}$ is usually determined at critical conditions. |
| $C_p$ | pollutant concentration in the plume at the mixing zone boundary. |
| $C_e$ | pollutant concentration in effluent before dilution in the mixing zone. |
| $C_a$ | pollutant concentration in upstream ambient receiving water away from the influence of far-field effluent accumulation. |
| WLA | effluent concentration to use for Waste Load Allocation (acute or chronic) for derivation of water quality-based permit limits. |
| WQC | pollutant concentration for water quality criteria (acute or chronic). |

## Mass Balance Equations for Alternative 1

If the tracer monitoring station is located in the near-field (at the mixing zone boundary in the approximate centerline of the effluent plume), then the following mass-balance equations are appropriate:

- calculate Jirka's $r_d$ from near-field $\underline{V}$ and V (based on equation 22 in EPA, 1992:

$$r_d = ( \underline{V} - V ) / \underline{V} \tag{1}$$

- calculate the near-field $\underline{DF}$ (acute or chronic boundary), including the effect of far-field accumulation of effluent, from model or tracer estimates of DF and estimated $r_d$ in the previous step (based on equation 22 in EPA, 1992:

$$\underline{DF} = DF ( 1 - r_d ) \tag{2}$$

- The following equation is appropriate to calculate pollutant concentrations ($C_p$) at the mixing zone boundaries for comparisons with water quality criteria. Near-field $\underline{DF}$ is corrected for far-field accumulation of effluent in the previous step. The following equation incorporates the effect of ambient background ($C_a$) from sources of pollutants other than effluent. Estimates of $C_e$ may also include a reasonable potential multiplier using methods in chapter VI of Ecology's Permit Writer's Manual. Pollutant concentrations ($C_p$) are estimated as follows (based on equation 9 in EPA, 1993:

$$C_p = C_e ( 1 / \underline{DF} ) + C_a ( 1 - ( 1 / \underline{DF} ) ) \tag{3}$$

- calculate acute and chronic WLAs:

$$WLA = WQC * \underline{DF} - C_a ( \underline{DF} - 1 ) \tag{4}$$

**Example:**

**Given**: near-field V = .02 (2 percent effluent); near-field $\underline{V}$ = .07 (7 percent effluent).

**Calculation of near-field $\underline{DF}$ including far-field accumulation of effluent:**
$r_d$=(.07-.02)/.07=.7143; DF=1/.02=50; therefore near-field $\underline{DF}$=50(1-.7143)=14.3.

## Mass Balance Equations for Alternative 2

If the tracer monitoring station is located in the far-field at some considerable distance from the effluent plume at a position that is representative of the source of dilution water for the plume, then the following mass-balance equations are applicable:

- calculate near-field DF, excluding the far-field accumulation of effluent, from a model (*e.g.* PLUMES or CORMIX) or from an additional near-field tracer monitoring station (*e.g.* near-field DF = reciprocal of near-field V)

- calculate the near-field $\underline{DF}$ (acute or chronic boundary), including the effect of far-field accumulation of effluent, by mass balance with near-field DF from the previous step and far-field $\underline{V}$ (based on equation 8 in EPA, 1993:

$$\underline{DF} = DF / ( 1 + \underline{V} ( DF - 1 ) ) \qquad (5)$$

- The following equation is appropriate to calculate pollutant concentrations ($C_p$) at the mixing zone boundaries for comparisons with water quality criteria. Near-field $\underline{DF}$ is corrected for far-field accumulation of effluent in the previous step. The following equation incorporates the effect of ambient background ($C_a$) from sources of pollutants other than effluent. Estimates of $C_e$ may also include a reasonable potential multiplier using methods in chapter VI of Ecology's Permit Writer's Manual. Pollutant concentrations ($C_p$) are estimated as follows (based on equation 9 in EPA,1993:

$$C_p = C_e ( 1 / \underline{DF} ) + C_a ( 1 - ( 1 / \underline{DF} ) ) \qquad (3)$$

- calculate acute and chronic WLAs:

$$WLA = WQC * \underline{DF} - C_a ( \underline{DF} - 1 ) \qquad (4)$$

**Example:**

**Given:** near-field DF=50 from PLUMES model excluding far-field accumulation of effluent; far-field $\underline{V}$=.051 (5.1 percent effluent) from tracer study using super-position method.

**Calculation of near-field $\underline{DF}$ including far-field accumulation of effluent:**
near-field $\underline{DF}$=50/(1+.051(50-1))=14.3.

## Mass Balance Equations for Method 3

If it is decided to use a default correction for far-field accumulation, then the following mass balance equations are applicable:

- estimate default for Jirka's $r_d = 0.5$ from EPA 1992 and Ecology's Permit Writer's Manual.

- calculate the near-field DF (acute or chronic boundary), including the effect of far-field accumulation of effluent, from model or tracer estimates of DF and estimated $r_d$ in the previous step (based on equation 22 in EPA, 1992:

$$\underline{DF} = DF\ (\ 1 - r_d\ ) \qquad (2)$$

- The following equation is appropriate to calculate pollutant concentrations ($C_p$) at the mixing zone boundaries for comparisons with water quality criteria. Near-field DF is corrected for far-field accumulation of effluent in the previous step. The following equation incorporates the effect of ambient background ($C_a$) from sources of pollutants other than effluent. Estimates of $C_e$ may also include a reasonable potential multiplier using methods in chapter VI of Ecology's Permit Writer's Manual. Pollutant concentrations ($C_p$) are estimated as follows (based on equation 9 in EPA, 1993:

$$C_p = C_e\ (\ 1\ /\ \underline{DF}\ ) + C_a\ (\ 1 - (\ 1\ /\ \underline{DF}\ )\ ) \qquad (3)$$

- calculate acute and chronic WLAs:

$$WLA = WQC * \underline{DF} - C_a\ (\ \underline{DF} - 1\ ) \qquad (4)$$

**Example:**

**Given:** $r_d$=0.5; DF=50

**Calculation of DF:** DF=50(1-.5)=25.