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June 14, 1999

Reference No. 7431

Via U.S. Mail

Mr. Ken Marcy (ECL-117)
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
1200 Sixth Avenue
Seattle, WA 98101

Dear Mr. Marcy:

Re: Area 5106 Removal Action
Response to HCC/POT Comments on CLT Evaluation Report

OCC Tacoma has completed the sensitivity analysis simulations outlined in the responses (dated May 11, 1999) to the Hylebos Cleanup Committee (HCC) and Port of Tacoma (POT) comments on the Area 5106 Sediment Column Leach Test (CLT) Evaluation Report. The results of the sensitivity analysis simulations confirm that the boundary sediment material may be placed in a confined disposal facility such as Slip 1 without treatment.

Please find enclosed for your review, two (2) copies of the Conestoga-Rovers & Associates memorandum presenting the results of the sensitivity analyses. Upon completion of your review, OCC Tacoma will submit the memorandum to the HCC and POT.

Should you have any questions concerning the analyses, please contact the undersigned at 716-297-2160.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

James W. Singer, P.E.
Project Manager

JWS/js/20
Encl.
c.c.: R. Bakemeier, PLLC (w/o attachment)
F.A. Meek, GSHI (w/o attachment)
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DRAFT MEMORANDUM

TO:	Jim Singer/Jack Michels	REF. NO.:	7431
FROM:	Steve Harris/17	DATE:	June 14, 1999
RE:	**Sensitivity Analysis Simulation Work** ***Column Leach Test Evaluation Report*** **Area 5106 Removal Action** **Former OCC Tacoma Facility** **Tacoma, Washington**		

Introduction

This memorandum documents the simulation work conducted to address the comments received on the hydrogeologic modeling presented in the report entitled, "Column Leach Test Evaluation Report, Area 5106 Removal Action, Former OCC Tacoma Facility, Tacoma, Washington" (Leach Test Report) (CRA, April 1998). The comments pertain to demonstrating the sensitivity of the model results presented in the Leach Test Report to adjustments in the various model input parameters that were applied. The sensitivity simulations conducted to address the comments are presented herein.

One comment pertained to the observed effective tidal amplitude in Commencement Bay being closer to 8 feet rather than the tidal amplitude of 12 feet applied in the Leach Test Report. To address this comment, water level data measured within Commencement Bay were applied to develop the variable constant hydraulic head boundary condition specified at the seaward face of the berm, rather than the sinusoidal cycle applied in the Leach Test Report. This boundary condition was input into the model described in the Leach Test Report, and the simulations presented in the Leach Test Report were repeated. All other model input parameters were specified as described in the Leach Test Report. The results from the revised model form the base case to which the results of the sensitivity simulations, presented herein, are compared.

The development of the variable hydraulic head boundary condition at the seaward face of the berm from the observed Commencement Bay water level data, and the results of the revised base case model, are described below. The sensitivity simulations and the associated results for each then are presented.

Variable Constant Hydraulic Head Boundary Condition Development

Measured water level data from April 22, 1996 to February 28, 1999 were available for the boundary condition development. The observed data consists of continuous water level measurements obtained on an approximate 30-minute frequency from a pressure transducer located in Commencement Bay. Several gaps exist in the measured water level data which extend over several hours to several days. The complete water level data set is presented on Figure 1. The least amount of data gaps exist in the time period extending from February 6, 1997 to February 6, 1998. The water level data measured within this time period is presented on Figure 2. The data gaps that exist within this time period, which extend over a time

period greater than 8 hours, were filled by inserting data measured prior to each data gap such that the pattern of water level fluctuations observed surrounding each data was preserved. The February 6, 1997 to February 6, 1998 water level data, with data gaps filled, are presented on a monthly basis on Figures 3 to 14. This annual data set reasonably reflects seasonal water level fluctuations in Commencement Bay, and was applied to develop the variable constant hydraulic head boundary condition (i.e., a constant hydraulic head was specified per time step) at the seaward face of the berm. The annual data set was reduced in size such that the minimum time between consecutive water level measurements is 60 minutes. The total number of time steps in the reduced annual data set is 5,826, with an average time step duration of 90 minutes and a maximum time step duration of 8 hours (only two 8-hour time step durations occur, on October 7,1997 and October 29, 1997). The 8-hour time steps occurring on October 7, 1997 and October 29, 1997 are indicated on Figure 11, and it is apparent on Figure 11 that the observed pattern in water level fluctuations is preserved over the two 8-hour time steps. The two 8-hour time steps, therefore, have no significant implications with respect to the boundary condition representation. The February 6, 1997 to February 6, 1998 annual data (with data gaps filled) set was repeated for the number of years required for steady-state conditions to be achieved, as described below.

Results of Revised Base Case Model

The annual data set was repeated over a 4-year time period to achieve steady-state conditions in terms of the predicted relative concentrations discharging to Commencement Bay. The simulated tide induced water level fluctuations throughout the length of the berm and sediments is presented in Figure 15. The contaminant transport simulation for the base case was conducted using a maximum time step size of 20 minutes. A constant concentration of 1 was specified from 90 to 500 feet away from the seaward face of the berm (representing a 20-foot buffer zone as applied in the Leach Test Report). The predicted relative concentration profile at the seaward face of the berm over the 4-year time period is presented on Figure 16. The variations in the concentration profile stabilize near the end of the 4-year time period demonstrating that steady-state conditions essentially are achieved. The steady-state peak relative concentration (C_{peak}) and the steady-state average relative concentration (C_{avg}) of 0.0382 and 0.0192, respectively, at the seaward face of the berm are presented on Figure 17. The peak tidal dispersion factor (TDF_{peak}) and average tidal dispersion factor (TDF_{avg}) for the base case are determined from:

$$TDF_{peak} = 1.0 / C_{peak} \qquad TDF_{avg} = 1.0 / C_{avg}$$

The TDFs for the revised base case are 26.2 and 52.6 for the peak and average relative concentrations, respectively. Applying these peak and average TDFs in Table 4.1 of the Leach Test Report for the revised base case does not result in any exceedances of the acute or chronic water quality criteria (WQC) for Commencement Bay.

Sensitivity of Contaminant Transport Time Step Size

An initial sensitivity analysis was conducted to assess the impact of the contaminant transport time step size on the predicted peak and average relative concentrations. The sensitivity of the contaminant transport time step size was assessed by applying a 5-minute time step size and repeating the contaminant transport simulation for the base case presented above. The predicted relative concentration profile at the seaward face of the berm over the 4-year time period using a 5-minute time step size is presented on Figure 18. The

steady-state peak relative concentration and the steady-state average relative concentration of 0.0388 and 0.0192, respectively, at the seaward face of the berm using a 5-minute time step size are presented on Figure 19. The peak and average relative concentrations using a 5-minute time step size are not significantly different from those determined using a 20-minute time step size. Therefore, a 20-minute time step size was applied to conduct the remaining sensitivity simulations described below.

Sensitivity of Buffer Zone Length

The sensitivity of the peak and average TDFs to the buffer zone length was assessed for the revised base case. The contaminant transport simulations for the revised base case were repeated for buffer zone lengths of 15 feet, 10 feet, 5 feet, and 0 feet. The predicted relative concentration profiles at the seaward face of the berm over a 4-year time period are presented on Figures 20, 22, 24, and 26 for the buffer zone lengths of 15 feet, 10 feet, 5 feet, and 0 feet, respectively. The steady-state peak relative concentrations and the steady-state average relative concentrations at the seaward face of the berm are presented on Figures 21, 23, 25, and 27 for the buffer zone lengths of 15 feet, 10 feet, 5 feet, and 0 feet, respectively. A summary of the average and peak TDFs determined from the steady-state peak relative concentrations and the steady-state average relative concentrations at the seaward face of the berm for each buffer zone length is presented on Figure 28. A minimum TDF_{peak} value of 8.26 and a minimum TDF_{avg} value of 16.46 result for the 0-foot buffer zone length. To satisfy the acute WQC for all compounds listed in Table 4.1 of the Leach Test Report, a minimum TDF_{peak} value of 12.4 is required (based on the source concentration divided by the acute WQC for tetrachlorobutadiene). To satisfy the chronic WQC for all compounds listed in Table 4.1 of the Leach Test Report, a minimum TDF_{avg} value of 4.95 is required (based on the source concentration divided by the chronic WQC for vinyl chloride). Therefore, consistent with the modeling approach presented herein, which does not account for any attenuation process other than tidal dispersion, a buffer zone length of 8.5 feet is required to satisfy the acute WQC (determined by applying linear interpolation between the TDF_{peak} values presented on Figure 28 for the buffer lengths of 5 feet and 10 feet), and no buffer zone is required to satisfy the chronic WQC.

Description of Sensitivity Analysis Simulations

Based on the comments on the modeling work presented in the Leach Test Report, a total of 11 sensitivity simulations were conducted to address the sensitivity of the TDFs to the physical input parameters applied in the model. For each sensitivity simulation, only one input parameter was adjusted while all other input parameters were left as specified for the base case. Table 1 presents a description of the model input parameter adjustment applied in each sensitivity simulation.

Results of Sensitivity Analysis Simulations

The results of the sensitivity simulations are summarized in Table 2. For sensitivity simulations 1 to 11, Table 2 indicates the following:

- figure presenting the tide induce water level fluctuations;
- figure presenting the predicted relative concentration at the seaward face of the berm;
- figure presenting the predicted relative concentration at the seaward face of the berm expanded scale;
- simulated peak and average relative concentrations; and

- calculated peak and average TDFs.

For sensitivity simulations 1 to 11, the peak and average TDFs presented in Table 2 are applied in Table 3 to determine the peak and average seepage concentrations discharging to Commencement Bay. The peak and average seepage concentrations are compared in Table 3 to their respective acute and chronic WQC, or estimated WQC, for Commencement Bay. As indicated in Table 3, only sensitivity simulation 10 results in a minor exceedance of the acute WQC for tetrachlorobutadiene.

For sensitivity simulations 1 to 11, a qualitative description of the impact of the physical input parameter changes to the simulated peak and average seepage concentrations follows:

- Sensitivity Simulation 1: the increase in the regional gradient increases the amount of groundwater and groundwater flow velocities discharging to Commencement Bay, and the peak and average seepage concentrations increase correspondingly;
- Sensitivity Simulation 2: the decrease in the regional gradient has the opposite affect of sensitivity simulation 1. The affect of increasing/decreasing the regional hydraulic conductivity applied in the model would have the same impact as the regional gradient increase/decrease;
- Sensitivity Simulation 3: the increase in the buffer fill/sediment fill hydraulic conductivity increases groundwater flow velocities discharging to Commencement Bay, and the peak and average seepage concentrations increase correspondingly;
- Sensitivity Simulation 4: the decrease in the buffer fill/sediment fill hydraulic conductivity has the opposite affect of sensitivity simulation 3;
- Sensitivity Simulation 5: the decrease in the buffer fill/sediment porosity increases groundwater flow velocities in the buffer fill/sediment fill. However, the groundwater flow velocities discharging to Commencement Bay largely are controlled by the lower berm porosity of 35 percent, and the buffer fill/sediment fill porosity decrease results in only a marginal increase in the peak and average concentrations;
- Sensitivity Simulation 6: the increase in the berm hydraulic conductivity increases the groundwater flow velocities discharging to Commencement Bay, and the peak and average seepage concentrations increase correspondingly;
- Sensitivity Simulation 7: the decrease in the berm hydraulic conductivity has the opposite affect of sensitivity simulation 7;
- Sensitivity Simulation 8: the increase in the berm/buffer fill/sediment fill specific yield increases the amount of groundwater released from storage in the case of a hydraulic head decline (i.e., low tide condition) and increases the amount of groundwater uptake in the case of a hydraulic head increase (i.e., high tide condition). The net result of the specific yield increase is that hydraulic head changes are damped by releases from and uptakes to storage which reduces groundwater flow velocities discharging to Commencement Bay, and the peak and average seepage concentrations decrease correspondingly;
- Sensitivity Simulation 9: the decrease in the berm/buffer fill/sediment fill specific yield has the opposite affect of sensitivity simulation 8;
- Sensitivity Simulation 10: the increase in the longitudinal dispersivity increases the amount of solute spreading in the direction of groundwater flow toward Commencement Bay, and the peak and average seepage concentrations increase correspondingly; and

- Sensitivity Simulation 11: this sensitivity simulation was conducted to address solute transport through the peninsula between Slip 1 and Slip 5. The decrease in the berm hydraulic conductivity to reflect the regional hydraulic conductivity value, such as for the peninsula between Slip 1 and Slip 5, decreases the groundwater flow velocities discharging to Commencement Bay, and the peak and average seepage concentrations decrease correspondingly. For this sensitivity simulation, the reduction in the berm hydraulic conductivity reduces the groundwater discharge to Commencement Bay to the extent that the groundwater flow and contaminant transport simulations were extended to a 20-year duration to achieve steady-state relative concentrations at the seaward face of the berm.

The hydrogeologic input parameter values applied in the base case model are considered to reasonably reflect the average hydrogeologic conditions expected at the confined disposal facility (CDF). The revised base case analysis demonstrates that the placement of boundary sediment within the CDF without treatment is acceptable. The hydrogeologic input parameter adjustments applied in the sensitivity simulations are considered representative of the upper and lower bounds of the variability in the hydrogeologic conditions expected at the CDF. Of the 11 sensitivity simulations conducted to address the physical input parameters, only sensitivity simulation 10 (an order of magnitude increase in the longitudinal dispersivity value applied in the base case) results in a minor exceedance of the acute WQC for tetrachlorobutadiene. Therefore, the sensitivity analysis confirms that boundary sediment placement in the CDF is acceptable.

The acceptability of placing boundary sediment within the CDF without treatment is strengthened when further consideration is given to the conservative nature of the source condition applied in the modeling approach presented herein. The source condition was represented in the model as a constant aqueous phase concentration for all time. In reality, the initial compound concentrations adsorbed to the sediment, which leach to groundwater and create the aqueous phase concentrations, will decline in time by biodegradation processes in the sorbed phase and by flushing from non-impacted upgradient groundwater flow. Once leached to groundwater, the compounds will be subject to further reductions by aqueous phase biodegradation processes. In addition, the modeling approach applied herein did not represent solute retardation due to adsorption onto soil particles. For significantly sorptive compounds, such as hexachlorobutadiene and tetrachlorobutadiene, the mobility of these solutes is substantially limited by retardation processes which will further reduce concentrations discharging to Commencement Bay. The reduced mobility of the more sorptive compounds increases the likelihood that these compounds will be substantially biodegraded before reaching Commencement Bay.

To demonstrate the conservative nature of not representing retardation and biodegradation, sensitivity simulation 12 was conducted considering vinyl chloride migration to Commencement Bay with retardation and biodegradation. Vinyl chloride was selected for this purpose for the following reasons:

- vinyl chloride is the least sorptive of the compounds considered in this work;
- vinyl chloride potentially may biodegrade at the slowest rate of the compounds considered in this work; and
- vinyl chloride is the daughter product of several other compounds detected in the column leach tests (CLTs), such as tetrachloroethene (PCE), trichloroethene (TCE), and 1,2-dichloroethene (1,2-DCE).

The details and results of sensitivity simulation 12 are presented below.

Vinyl Chloride Migration with Retardation and Biodegradation

For sensitivity simulation 12 which considers vinyl chloride migration with retardation and biodegradation, all physical model input parameters were left as specified for the revised base case. Retardation was represented using a linear isotherm and biodegradation was represented through a first-order approximation. The retardation/biodegradation simulation required the following input:

- compound-specific adsorption partitioning coefficient k_d equal to the product of the compound-specific organic carbon partitioning coefficient K_{oc} and the soil-specific fraction of organic carbon content f_{oc};
- soil-specific dry bulk density;
- compound-specific half-life $t_{1/2}$ used to determine the compound-specific first-order biodegradation rate constant λ through the relationship $\lambda=\ln(2)/t_{1/2}$; and
- compound-specific source concentration.

The retardation/biodegradation input parameters applied for sensitivity simulation 12 are presented in Table 1.

For the source condition, consideration was given to the amount of vinyl chloride that may be produced from the degradation of parent compounds detected in the CLTs. Vinyl chloride may be produced by the sequential anaerobic biodegradation of PCE to TCE to cis-1,2-dichloroethene (c-1,2-DCE) to vinyl chloride. Under anaerobic conditions, vinyl chloride then may be biodegraded to ethene. Anaerobic groundwater conditions are expected to prevail within the CDF. The maximum anaerobic half-lives for these compounds reported in Howard et al. (1991[1]) are as follows:

- 4.5 years for PCE;
- 4.5 years for TCE;
- 2 years for c-1,2-DCE; and
- 2 years for vinyl chloride.

The sequential parent compound degradation and potential vinyl chloride production may be estimated by applying sequential first order kinetics as follows:

$$C_{PCE}(t_i)=C_{PCE}(t_{i-1})-\lambda_{PCE}\times C_{PCE}(t_{i-1})\times dt$$

$$C_{TCE}(t_i)=C_{TCE}(t_{i-1})-\lambda_{TCE}\times C_{TCE}(t_{i-1})\times dt+M_{TCE}/M_{PCE}\times\lambda_{PCE}\times C_{PCE}(t_{i-1})\times dt$$

$$C_{TCE}(t_i)=C_{TCE}(t_{i-1})-\lambda_{TCE}\times C_{TCE}(t_{i-1})\times dt+M_{TCE}/M_{PCE}\times\lambda_{PCE}\times C_{PCE}(t_{i-1})\times dt$$

$$C_{VC}(t_i)=C_{VC}(t_{i-1})-\lambda_{VC}\times C_{VC}(t_{i-1})\times dt+M_{VC}/M_{DCE}\times\lambda_{DCE}\times C_{DCE}(t_{i-1})\times dt$$

where;

C concentration [micrograms per liter (µg/L)];

λ first order decay rate (days^{-1}) equal to the value of ln(2) divided by the compound half-life;

M molecular weight [gram per mole (g/mole)];

[1] Howard, P.H., R.S., Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko, 1991, Handbook of Environmental Degradation Rates, Lewis Publishers, Chelsea, Michigan.

t_i current time step;
t_{i-1} previous time step; and
dt time step increment (days).

The above approximation reasonably reflects a first order reaction if a small value is applied for *dt*. The potential production of vinyl chloride was estimated using a *dt* of 0.0005 days. Initial concentrations for the above compounds were taken as the maximum concentrations of 700 µg/L, 830 µg/L, and 2,600 µg/L for PCE, TCE, and vinyl chloride, respectively, detected in the CLTs as presented in Tables 3.4 to 3.7 of the Leach Test Report. The maximum concentration of 48 µg/L reported in Tables 3.4 to 3.7 of the Leach Test Report for trans-1,2-dichloroethene was applied as the initial concentration for c-1,2-DCE. The maximum anaerobic half-lives reported in Howard et al. (1991) were applied for PCE, TCE, and c-1,2-DCE. An anaerobic half-life of 20 years was applied for vinyl chloride as a conservative approach. Figure 60 presents the estimated concentration profiles over a 16-year time period for PCE, TCE, c-1,2-DCE, and vinyl chloride using the sequential first order kinetics approach. The concentrations of all compounds decline over this time period and vinyl chloride levels do not increase above the initial concentration. Therefore, for sensitivity simulation 12, a constant source concentration of 2,600 µg/L was specified for vinyl chloride from 90 to 500 feet away from the seaward face of the berm. The constant source concentration specification is conservative since the source concentrations are expected to decline with time as described above.

For sensitivity simulation 12, Table 2 indicates the following:

- figure presenting the predicted concentration at the seaward face of the berm;
- figure presenting the predicted concentration at the seaward face of the berm expanded scale; and
- simulated peak and average concentrations.

The peak and average vinyl chloride seepage concentrations discharging to Commencement Bay presented in Table 2 are compared to the acute and chronic WQC for Commencement Bay in Table 3. The acute and chronic WQC for vinyl chloride are not exceeded by the simulated seepage concentrations. The simulated acute vinyl chloride seepage concentration is lower than that predicted for the revised base case. Therefore, the results of the vinyl chloride migration simulation considering retardation and limited biodegradation confirm that if attenuation processes such as retardation and biodegradation are considered in the modeling, in addition to tidal dispersion attenuation process represented in the revised base case, then the resultant predicted concentrations at the seaward face of the berm would be less than the predicted concentrations presented in Table 3 for the revised base case. Therefore, sensitivity simulation 12 confirms the conservative nature of the modeling approach applied in the revised base case.

TABLE 1

DESCRIPTION OF GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODEL SENSITIVITY SIMULATIONS
CLT EVALUATION
AREA 5106 REMOVAL ACTION
FORMER OCC TACOMA FACILITY

Sensitivity Simulation	*Adjusted Model Input Parameter*	*Model Input Parameter Applied in Revised Base Case*		*Model Input Parameter Adjustment*	*Model Input Parameter Applied in Sensitivity Simulation*	
		Value	*Units*		*Value*	*Units*
1	Regional Hydraulic Gradient	0.004	feet/foot	multiplied by 2	0.008	feet/foot
2	Regional Hydraulic Gradient	0.004	feet/foot	divided by 2	0.002	feet/foot
3	Buffer Fill/Sediment Fill Hydraulic Conductivity	0.0006	cm/s	multiplied by 2	0.0012	cm/s
4	Buffer Fill/Sediment Fill Hydraulic Conductivity	0.0006	cm/s	divided by 2	0.0003	cm/s
5	Buffer Fill/Sediment Fill Porosity	77	percent	reduced to minimum value expected due to consolidation	40	percent
6	Berm Hydraulic Conductivity	0.03	cm/s	multiplied by 2	0.06	cm/s
7	Berm Hydraulic Conductivity	0.03	cm/s	divided by 2	0.015	cm/s
8	Berm/Buffer Fill/Sediment Fill Specific Yield	0.1	ft^3/ft^3	multiplied by 2	0.2	ft^3/ft^3
9	Berm/Buffer Fill/Sediment Fill Specific Yield	0.1	ft^3/ft^3	divided by 2	0.05	ft^3/ft^3
10	Berm/Buffer Fill/Sediment Fill Longitudinal Dispersivity [1]	3.281	ft	multiplied by 10	32.81	ft
11	Berm Hydraulic Conductivity	0.03	cm/s	reduced to the regional hydraulic conductivity value	0.0006	cm/s
12	Base Case with Vinyl Chloride (VC) Retardation [2] and Biodegradation [3]	-	-	VC K_{oc}	70	mL/g
				VC $t_{1/2}$	20	years
				VC Initial Source Concentration [4]	2,600	µg/L

Note:

[1] Transverse longitudinal and transverse vertical dispersivity values equal to 10 percent and 1 percent of the longitudinal dispersivity value were specified, however the transverse longitudinal and transverse vertical dispersivity values do not have a role in the 1-dimensional model applied in this analysis.

[2] Retardation was represented using a linear isotherm and the sorbed/aqueous phase partitioning coefficient $k_d = f_{oc} * K_{oc}$ where the organic carbon partitioning coefficients K_{oc} values indicated above for each compound were applied along with the fraction of organic carbon content f_{oc} values of 0.001 and 0.0111 were applied for the berm and buffer/sediment fill, respectively. The K_{oc} values consistent with the Area 5106 Dredging Modeling were applied. Retardation factors were determined from $R = 1 + k_d * \rho_{bd}/n$ where the dry bulk soil density ρ_{db} of 2.6 g/cm^3 was applied for the berm and buffer fill material and the ρ_{db} value of 2.75 g/cm^3 was applied for the sediment fill material.

[3] Biodegradation was not represented for vinyl chloride to conservatively account for the production of vinyl chloride from the biodegradation of tetrachloroethene and trichloroethene.

[4] The initial source concentration taken to be the peak leachate concentration from the CLTs.

[5] Biodegradation was represented using a first order approximation using the half-life $t_{1/2}$ reported above.

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TABLE 2

PEAK AND AVERAGE TIDAL DILUTION FACTORS
GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODEL SENSITIVITY SIMULATIONS
CLT EVALUATION
AREA 5106 REMOVAL ACTION
FORMER OCC TACOMA FACILITY

Sensitivity Simulation	*Figure Presenting Tide Induced Water Level Fluctuations*	*Figure Presenting Predicted Concentration at Seaward Face of Berm*	*Figure Presenting Predicted Concentration at Seaward Face of Berm (Expanded Scale)*	*Simulated Peak Relative Concentration*	*Simulated Average Relative Concentration*	TDF_{peak} (1)	TDF_{avg} (2)
Revised Base Case	Figure 15	Figure 16	Figure 17	0.0382	0.0192	26.18	52.03
1	Figure 29	Figure 30	Figure 31	0.0463	0.0233	21.60	42.90
2	Figure 32	Figure 33	Figure 34	0.0345	0.0174	28.99	57.64
3	Figure 35	Figure 36	Figure 37.	0.0596	0.0295	16.78	33.86
4	Figure 38	Figure 39	Figure 40	0.0211	0.0109	47.39	92.00
5	-	Figure 41	Figure 42	0.0389	0.0194	25.71	51.65
6	Figure 43	Figure 44	Figure 45	0.0442	0.0202	22.62	49.43
7	Figure 46	Figure 47	Figure 48	0.0297	0.0168	33.67	59.45
8	Figure 49	Figure 50	Figure 51	0.0159	0.0067	62.89	150.38
9	Figure 52	Figure 53	Figure 54	0.0674	0.0408	14.84	24.53
10	-	Figure 55	Figure 56	0.0811	0.0587	12.33	17.04
11	Figure 57	Figure 58	Figure 59	0.0361	0.0280	27.70	35.71
				C_{peak} (3) ($\mu g/L$)	C_{avg} (4) ($\mu g/L$)		
12	-	Figure 61	Figure 62	93.2	54.8		

Note:

(1) Peak Tidal Dispersion Factor (TDF_{peak}) based on the peak relative concentration simulated at the seaward face of the berm once approximate steady-state conditions were achieved.

(2) Average Tidal Dispersion Factor (TDF_{avg}) based on the average relative concentration simulated at the seaward face of the berm once approximate steady-state conditions were achieved.

(3) Peak concentration simulated at the seaward face of the berm after achieving approximate steady-state conditions.

(4) Average concentration simulated at the seaward face of the berm after achieving approximate steady-state conditions.

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TABLE 3

PREDICTED SEEPAGE CONCENTRATIONS [1]
GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODEL SENSITIVITY SIMULATIONS
CLT EVALUATION
AREA 5106 REMOVAL ACTION
FORMER OCC TACOMA FACILITY

COMPARISON TO ACUTE WATER QUALITY CRITERIA

Sensitivity Simulation	TDF_{peak} [3]	Predicted Peak Concentration C_{peak} per Chemical of Concern [2]: Tetrachloroethene (µg/L)	Hexachlorobutadiene (µg/L)	Vinyl Chloride (µg/L)	Dichlorobutadiene (µg/L)	Trichlorobutadiene (µg/L)	Tetrachlorobutadiene (µg/L)	Pentachlorobutadiene (µg/L)
Source Concentration [4]		700	42	2,600	870J	870J	2,500J	100J
	Acute WQC	10,200	31	nc	282 [5]	192 [5]	121 [5]	67 [5]
Revised Base Case	26.18	26.7	1.6	99.3	33.2	33.2	57.3	3.8
1	21.60	32.4	1.9	120.4	40.3	40.3	69.5	4.6
2	28.99	24.2	1.4	89.7	30.0	30.0	51.8	3.5
3	16.78	41.7	2.5	154.9	51.8	51.8	89.4	6.0
4	47.39	14.8	0.9	54.9	18.4	18.4	31.7	2.1
5	25.71	27.2	1.6	101.1	33.8	33.8	58.3	3.9
6	22.62	30.9	1.9	114.9	38.5	38.5	66.3	4.4
7	33.67	20.8	1.2	77.2	25.8	25.8	44.6	3.0
8	62.89	11.1	0.7	41.3	13.8	13.8	23.9	1.6
9	14.84	47.2	2.8	175.2	58.6	58.6	101.1	6.7
10	12.33	56.8	3.4	210.9	70.6	70.6	121.7	8.1
11	27.70	25.3	1.5	93.9	31.4	31.4	54.2	3.6
12	-	-	-	93.2	-	-	-	-

COMPARISON TO CHRONIC WATER QUALITY CRITERIA

Sensitivity Simulation	TDF_{avg} [6]	Predicted Average Concentration C_{avg} per Chemical of Concern [7]: Tetrachloroethene (µg/L)	Hexachlorobutadiene (µg/L)	Vinyl Chloride (µg/L)	Dichlorobutadiene (µg/L)	Trichlorobutadiene (µg/L)	Tetrachlorobutadiene (µg/L)	Pentachlorobutadiene (µg/L)
Source Concentration [4]		700	42	2,600	870J	870J	2,500J	100J
	Chronic WQC	450	nc	525 [8]	nc	nc	nc	nc
Revised Base Case	52.03	13.5	0.8	50.0	16.7	16.7	28.8	1.9
1	42.90	16.3	1.0	60.6	20.3	20.3	35.0	2.3
2	57.64	12.1	0.7	45.1	15.1	15.1	26.0	1.7
3	33.86	20.7	1.2	76.8	25.7	25.7	44.3	3.0
4	92.00	7.6	0.5	28.3	9.5	9.5	16.3	1.1
5	51.65	13.6	0.8	50.3	16.8	16.8	29.0	1.9
6	49.63	14.2	0.8	52.6	17.6	17.6	30.3	2.0
7	59.45	11.8	0.7	43.7	14.6	14.6	25.2	1.7
8	150.38	4.7	0.3	17.3	5.8	5.8	10.0	0.7
9	24.53	28.5	1.7	106.0	35.5	35.5	61.1	4.1
10	17.04	41.1	2.5	152.6	51.1	51.1	88.0	5.9
11	35.71	19.6	1.2	72.8	24.4	24.4	42.0	2.8
12	-	-	-	54.8	-	-	-	-

4-24-03;11:33AM;CRA BATHURST MAIN ;5197251354 # 12/ 75

Notes:

[1] Based on a 20-foot Buffer Zone between the upland face of the berm and the dredged boundary sediments.

[2] Predicted peak seepage concentration at the point of compliance equal to the source concentration divided by TDF_{peak}.

[3] Peak Tidal Dispersion Factor (TDF_{peak}) presented in Table 2.

[4] Source concentration taken to be the peak leachate concentration from the CLTs.

[5] Estimated WQC based on human health criterion.

[6] Predicted average seepage concentration at the point of compliance equal to the source concentration divided by TDF_{avg}.

[7] Average Tidal Dispersion Factor (TDF_{avg}) presented in Table 2.

[8] Estimated WQC based on USEPA ECOSAR computer program.

[ ] Excedance of acute or chronic WQC.

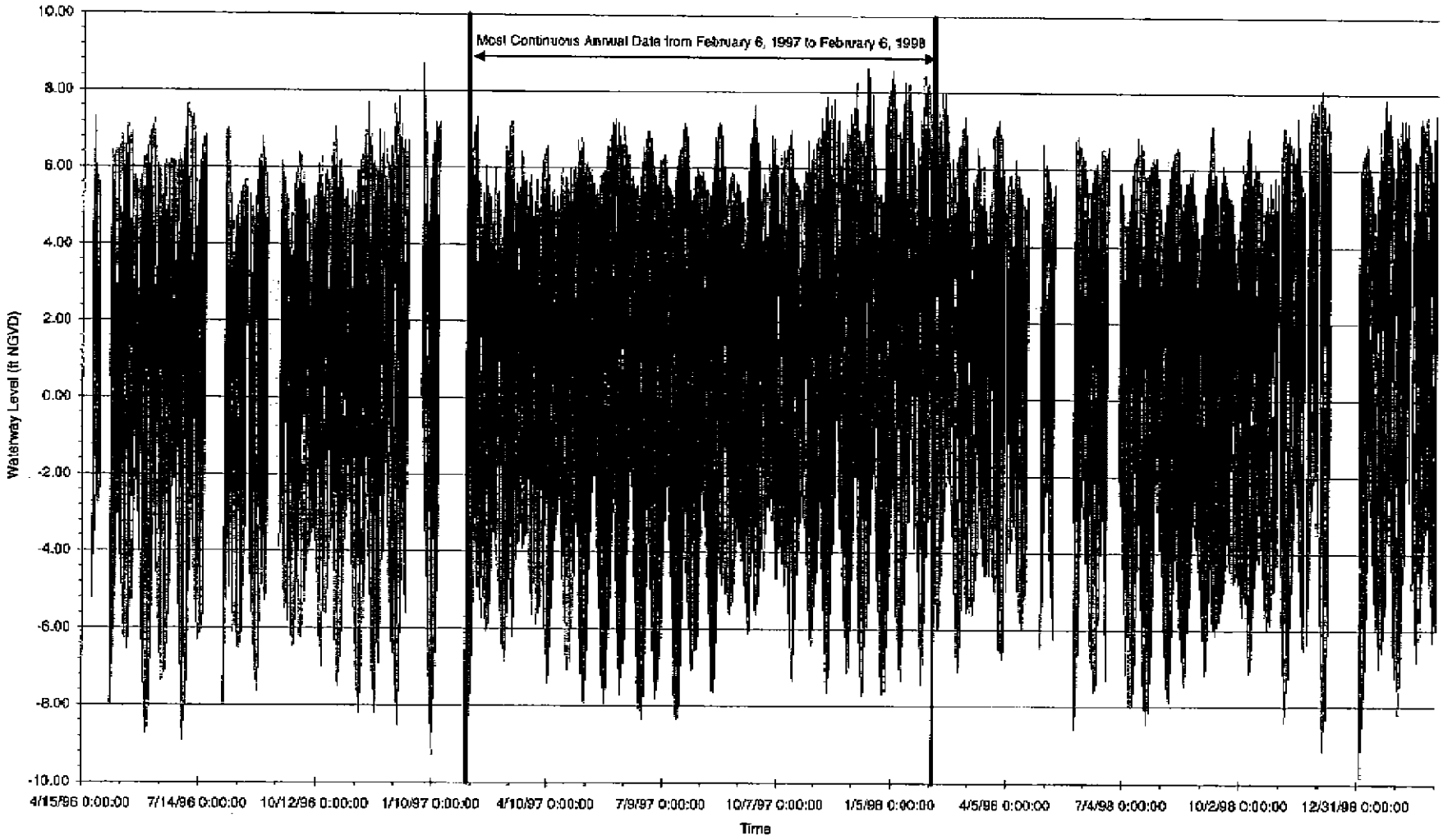

figure 1
APRIL 1996 TO FEBRUARY 1999
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017)GN-W-HYD (n:\hag\7431\cd\model5\baylev\waterway.xls) May 15/99

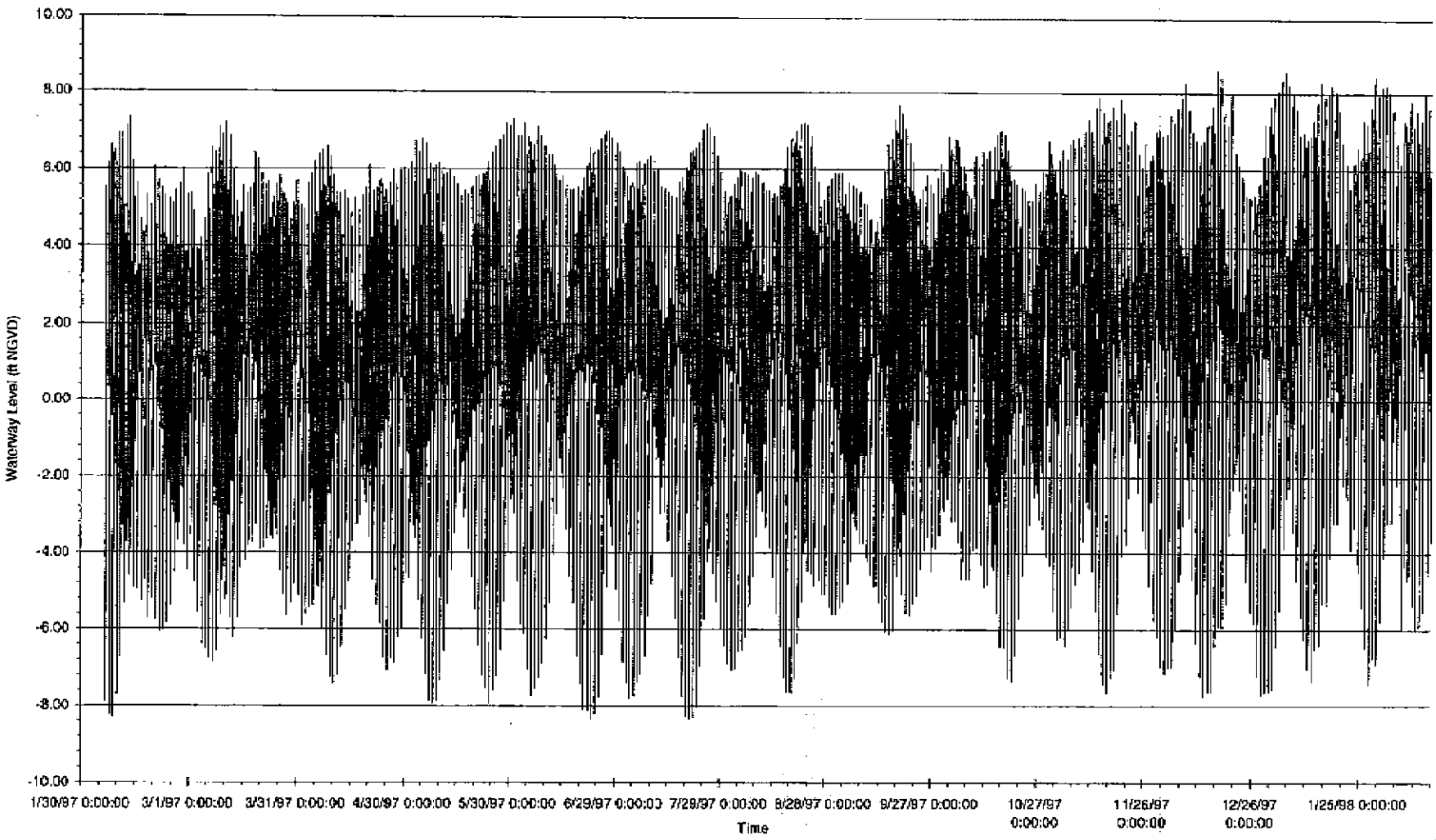

figure 2
FERUARY 6, 1997 TO FEBRUARY 6, 1998
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo#17)GN-W-HYD (n:\heg\7431\cdf\model6\bayfev\waterway.xls) May 19/99

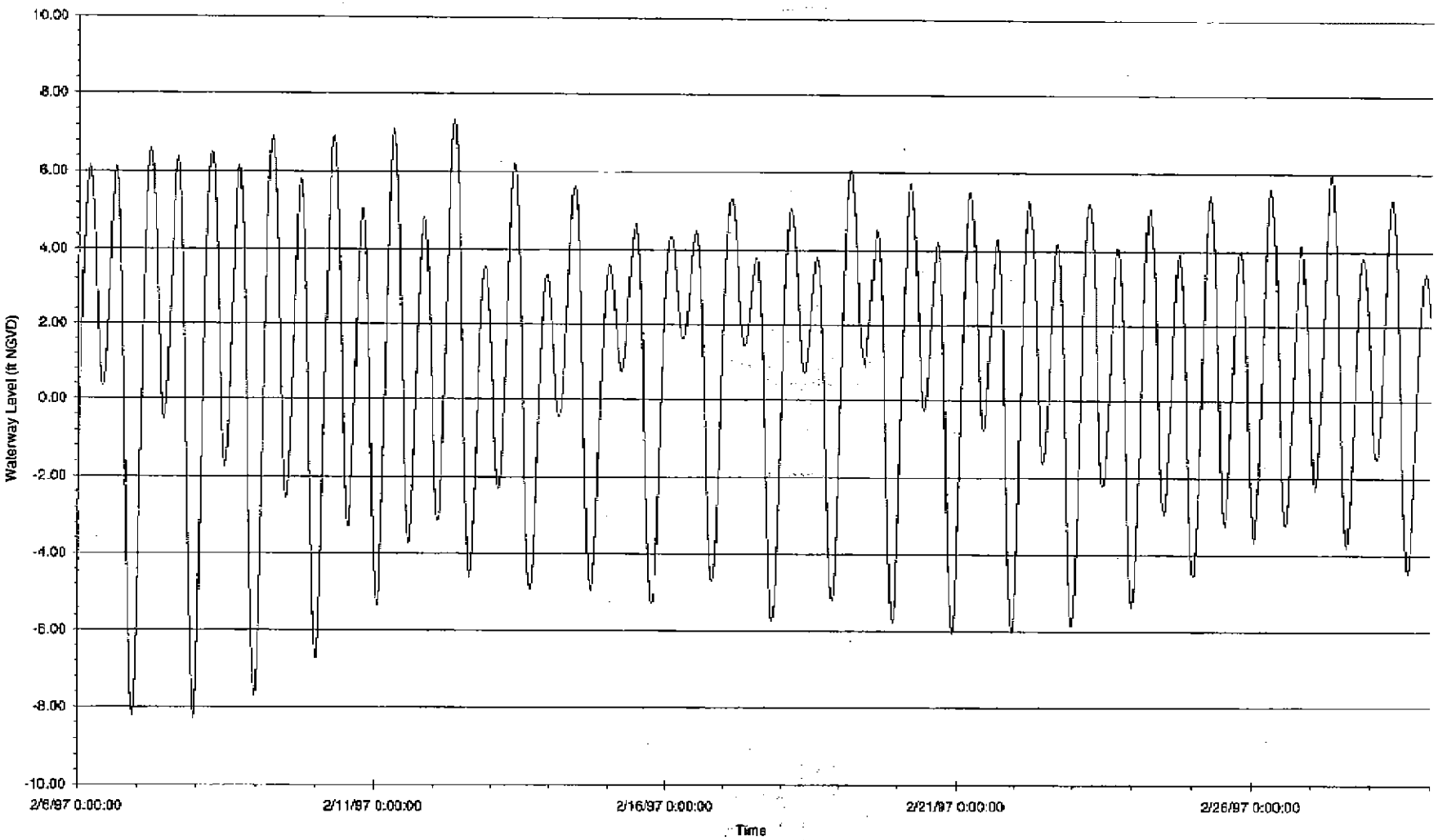

figure 3
FEBRUARY 6, 1997 TO MARCH 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017)GN-W-HYD (n:\hsg\7431\cdf\model6\bayley\waterway.xls) May 19/99

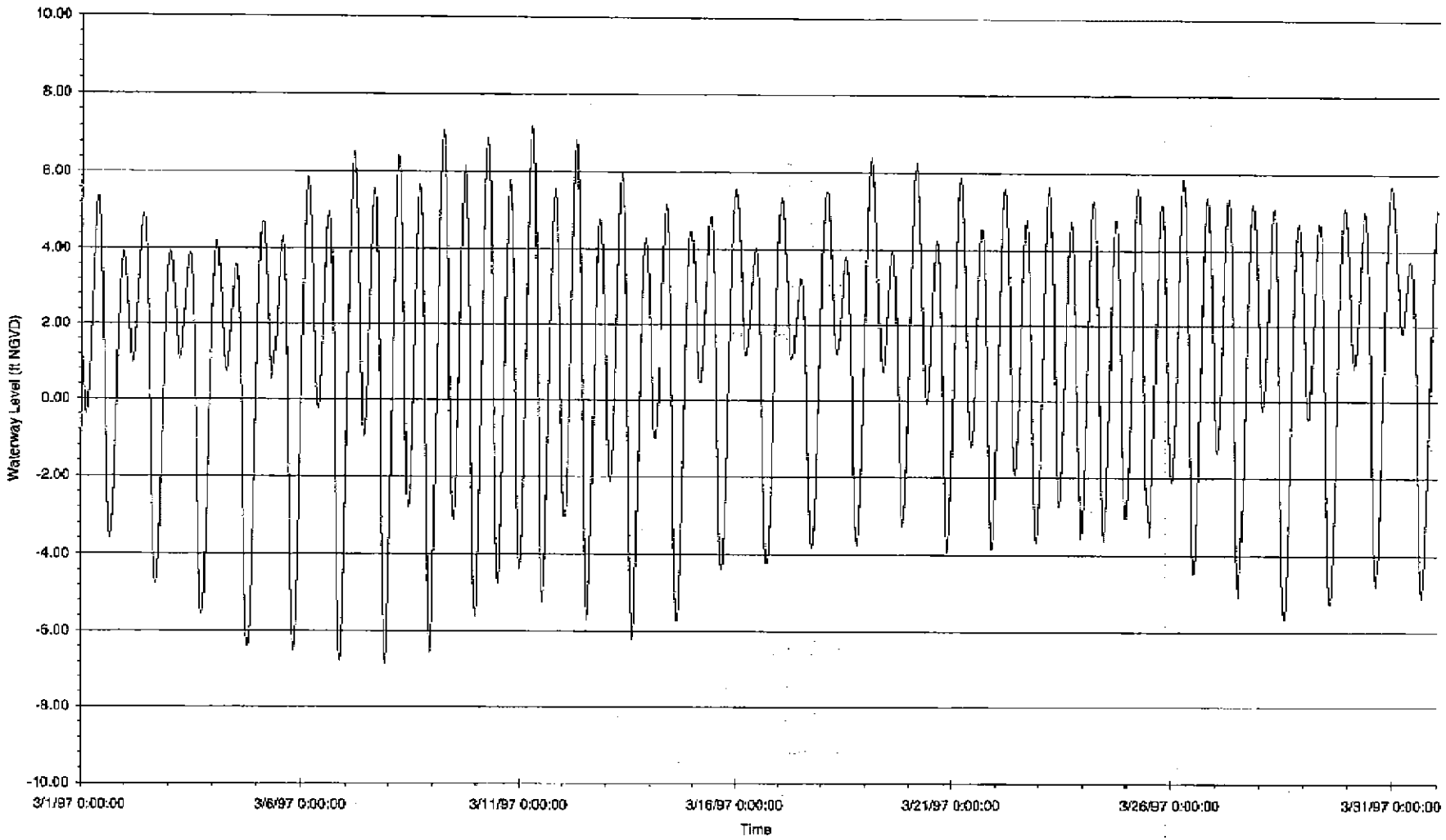

figure 4
MARCH 1, 1997 TO APRIL 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

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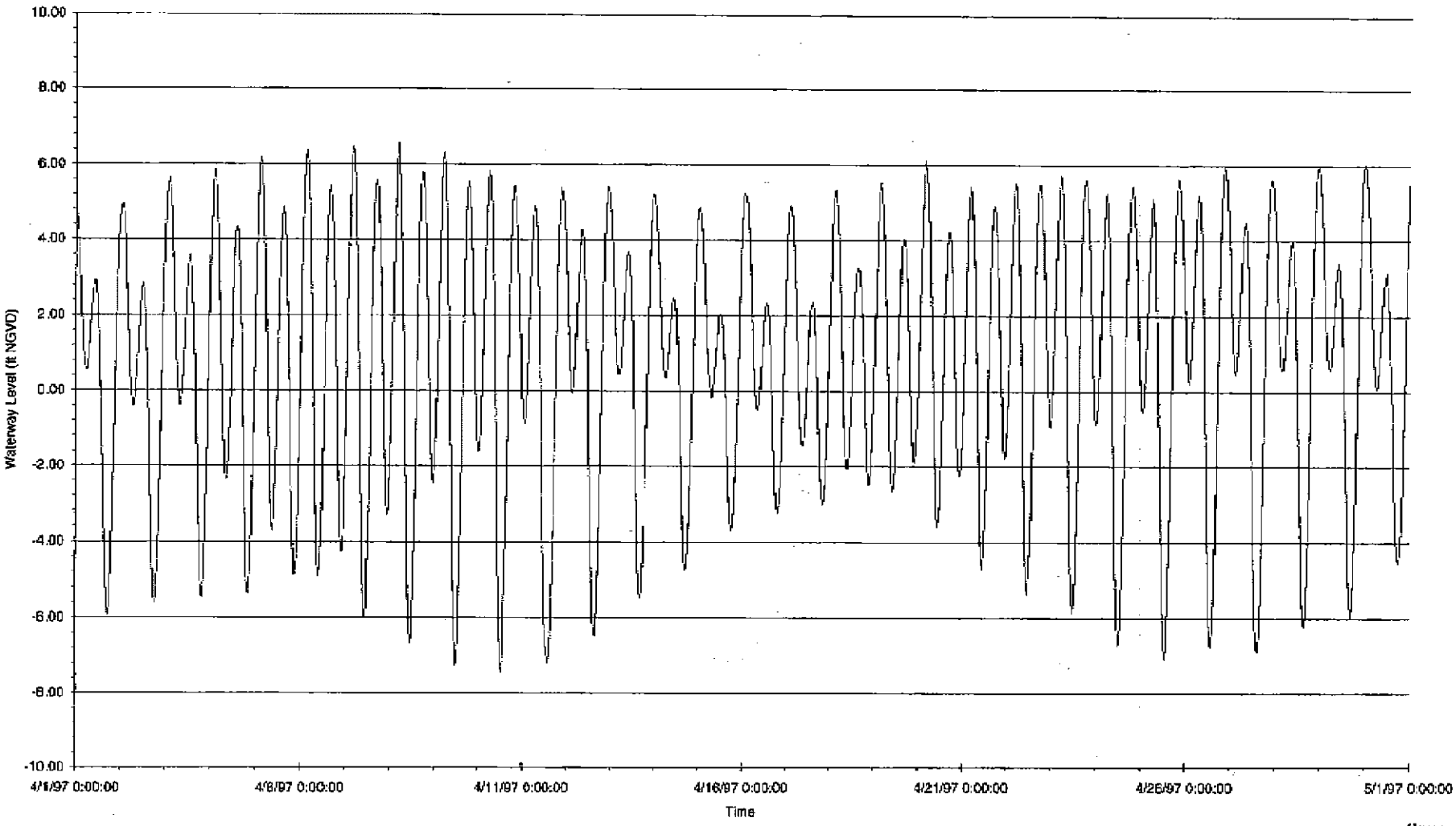

figure 5
APRIL 1, 1997 TO MAY 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017)GN-W-HYD [n:\heg\7431\cdf\model6\bayles\waterway.xls] May 18/99

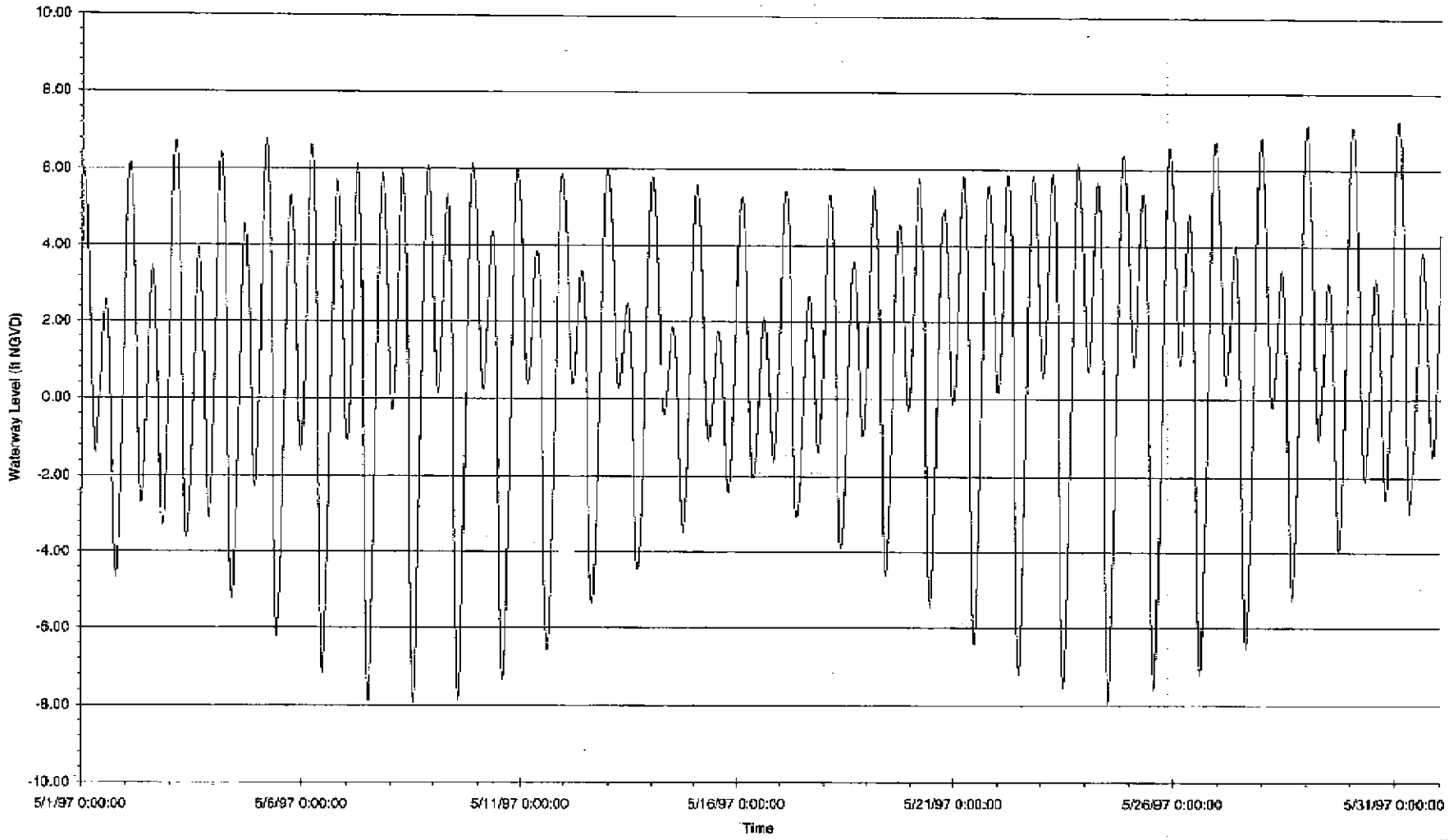

figure 6
MAY 1, 1997 TO JUNE 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00[memo017]GN-W-HYD (n:\heg\7431\cdf\model6\baylev\waterway.xls) May 19/99

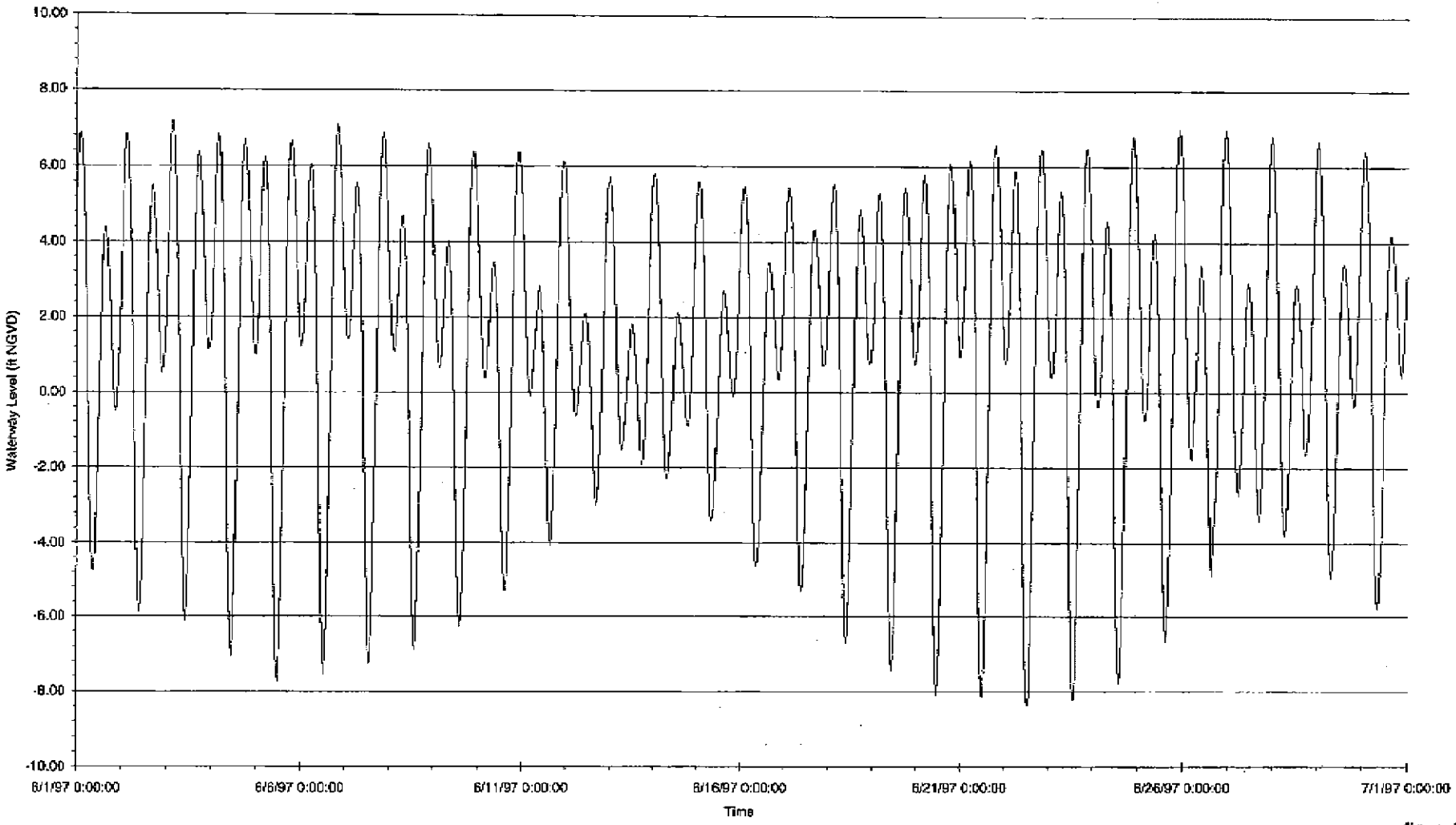

figure 7
JUNE 1, 1997 TO JULY 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00[memo017]GN-W-HYD (n:\heg\7431\cdf\model8\baylav\waterway.xls) May 19/99

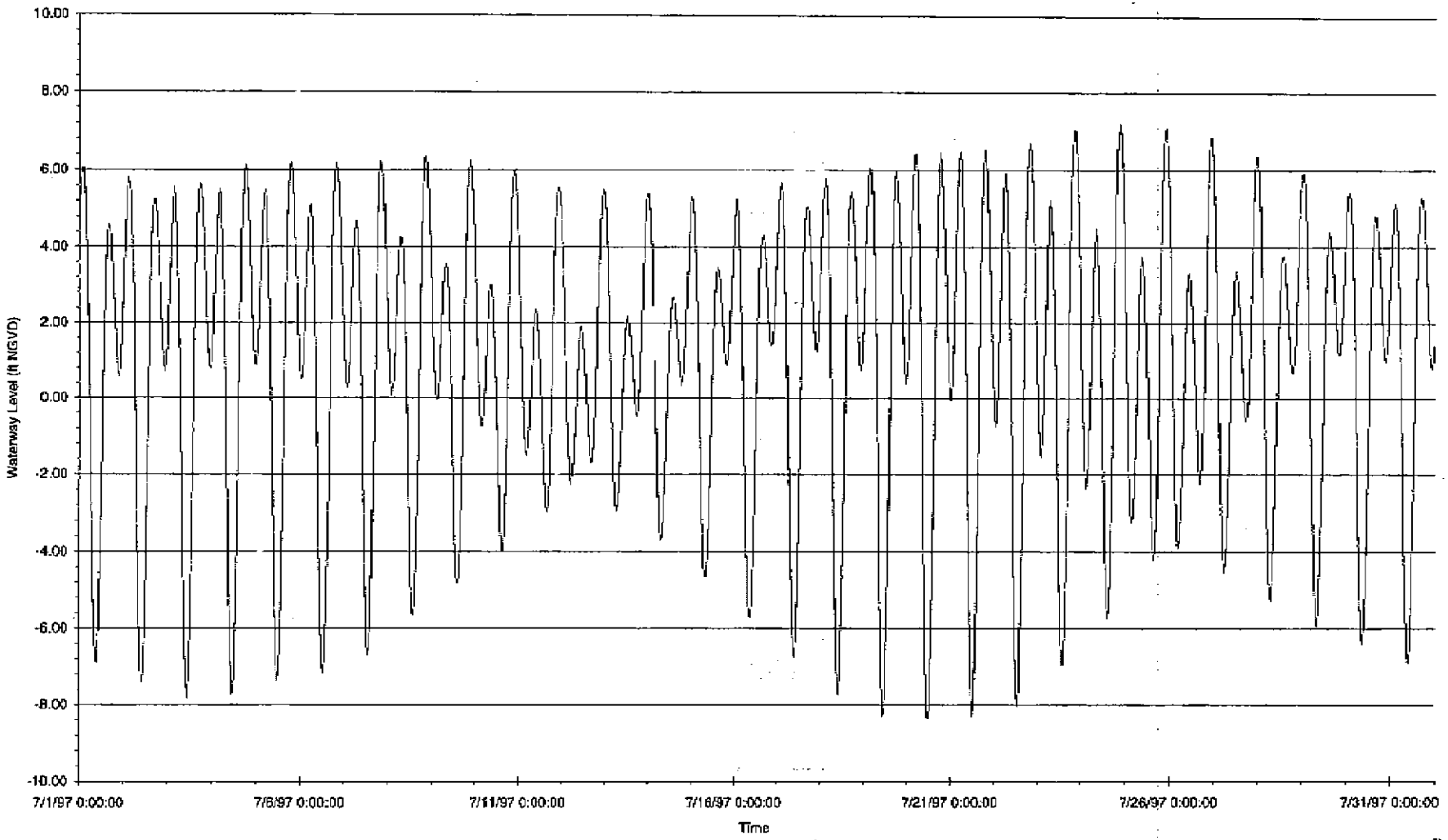

figure 8
JULY 1, 1997 TO AUGUST 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00[memo017]GM-W-HYD (n:\hcg\7431\cdf\model6\bayley\waterway.xls) May 19/99

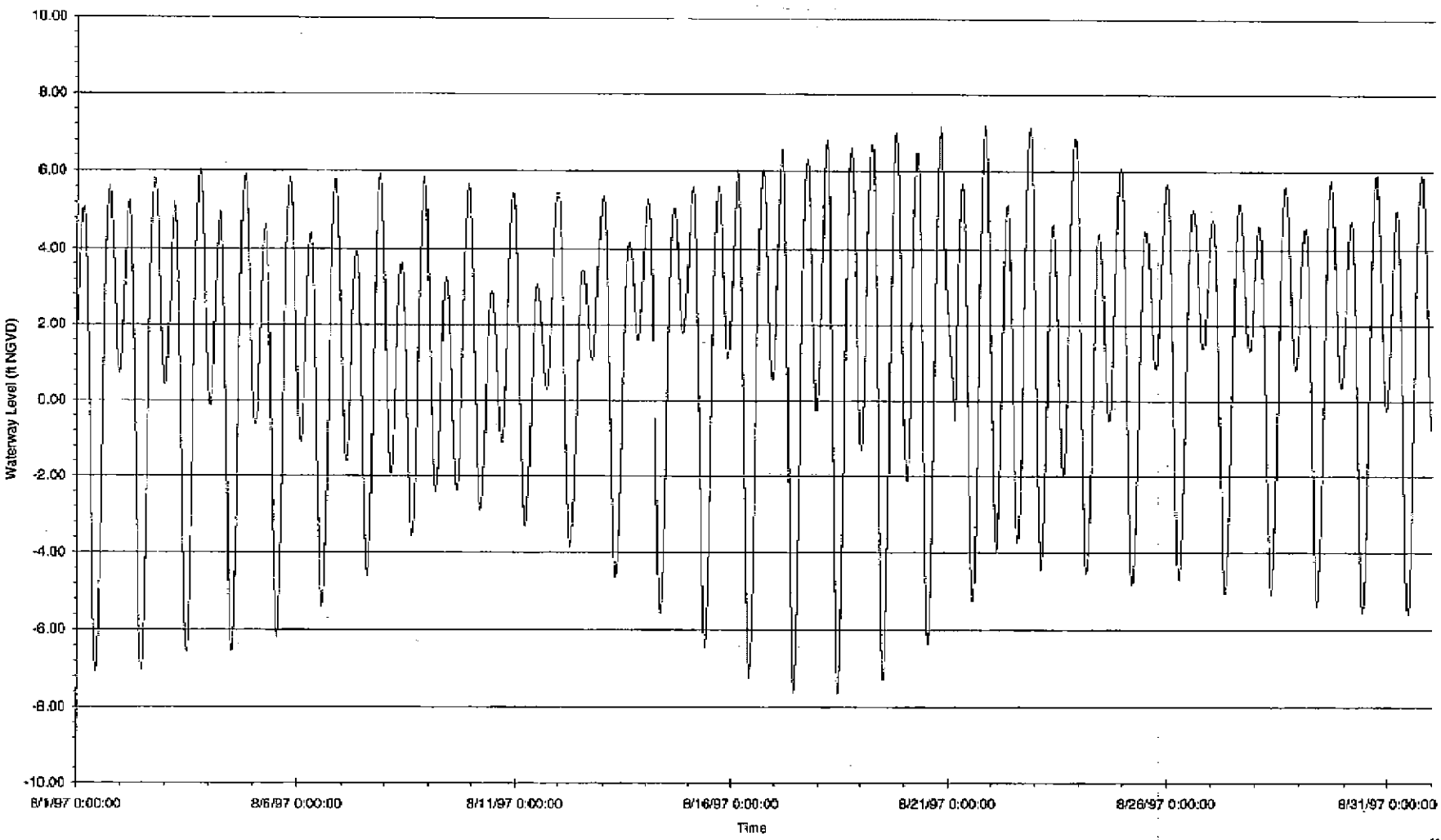

figure 9
AUGUST 1, 1997 TO SEPTEMBER 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017)GN-W-HYD (n:\hag\7431\cdh\model6\bayley\waterway.xls) May 19/99

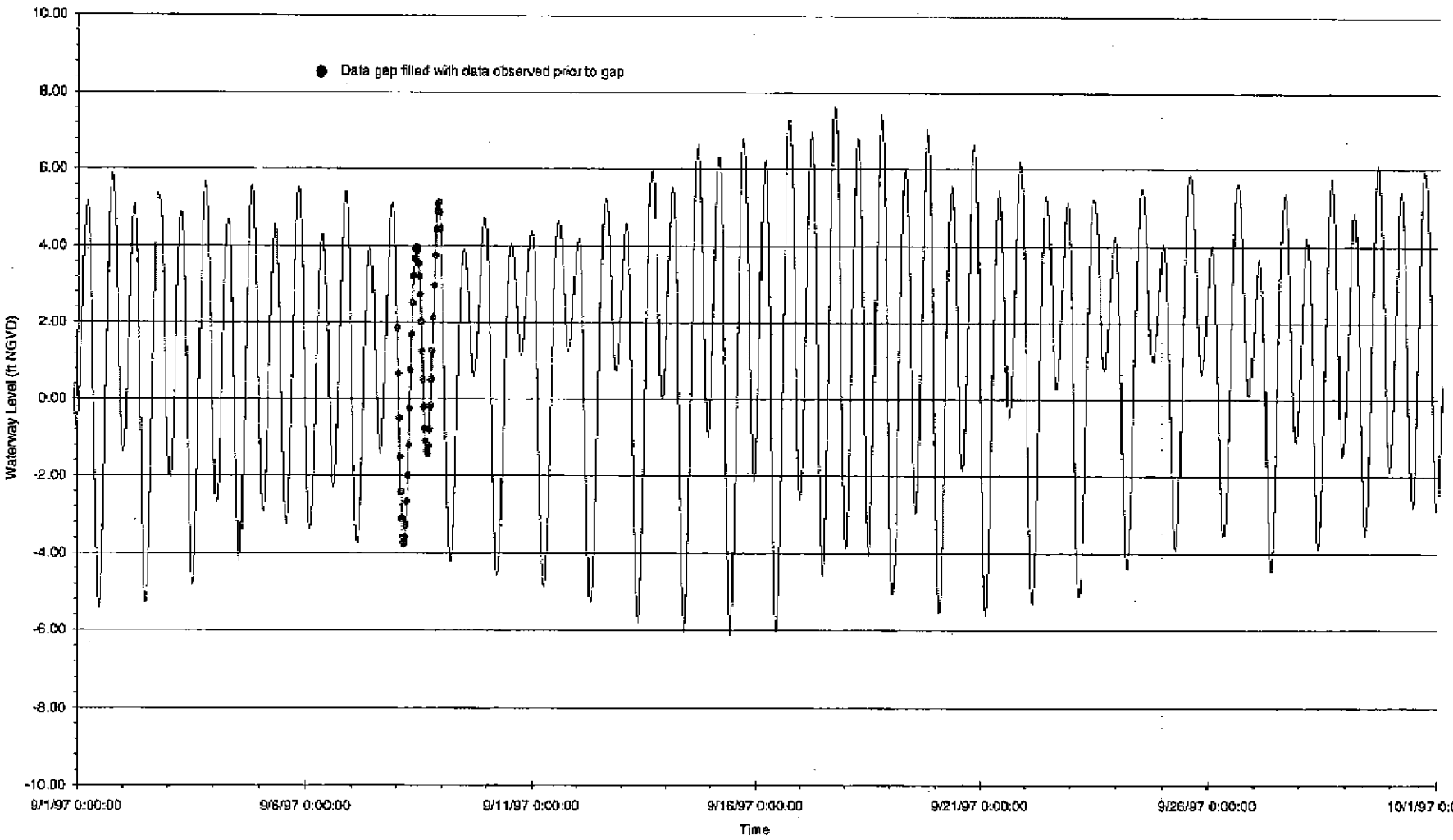

figure 10
SEPTEMBER 1, 1997 TO OCTOBER 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

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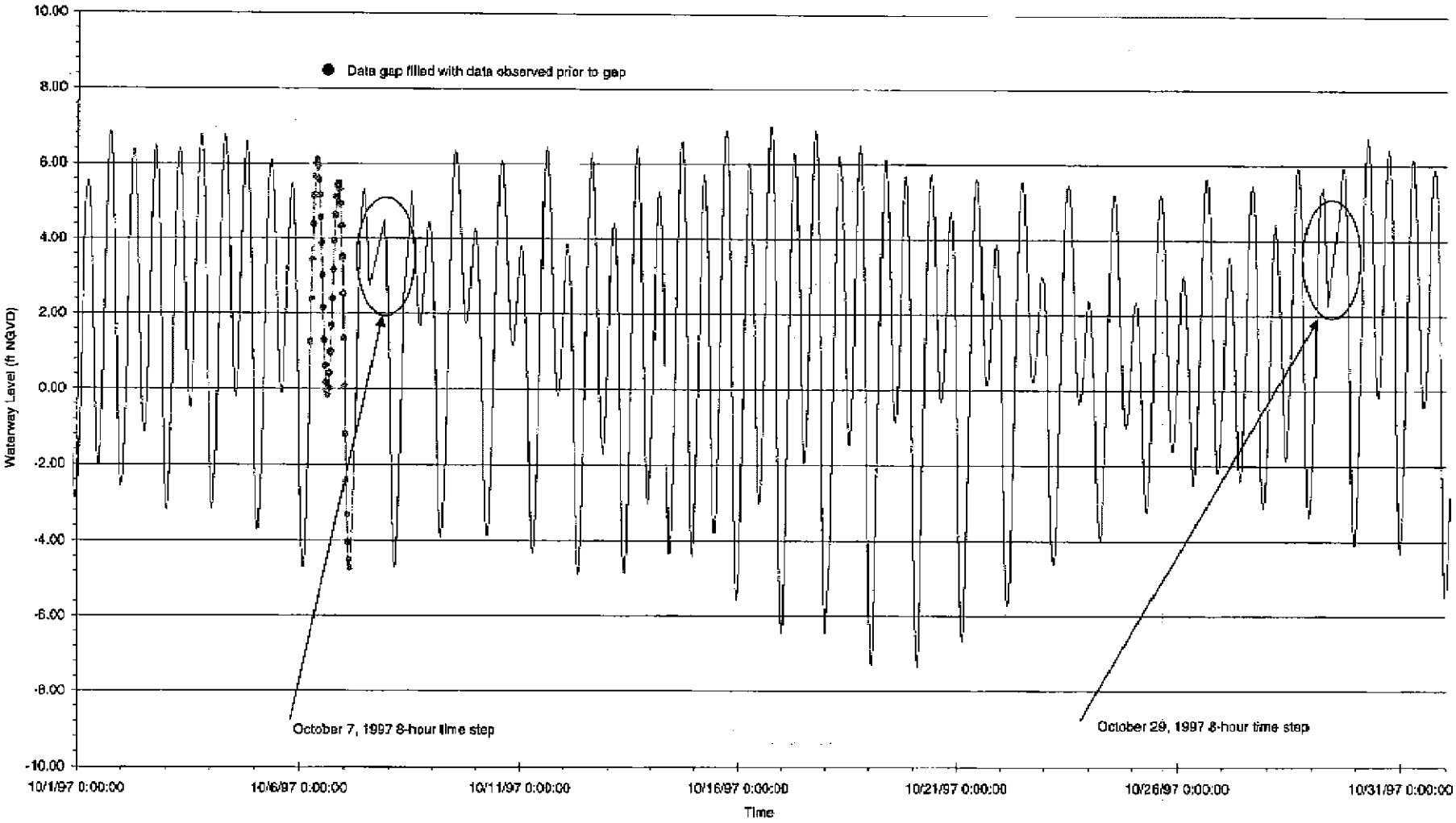

figure 11
OCTOBER 1, 1997 TO NOVEMBER 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017)GN-W-HYD (n:\reg\07431\cd\models\bayew\waterway.xls) May 18/99

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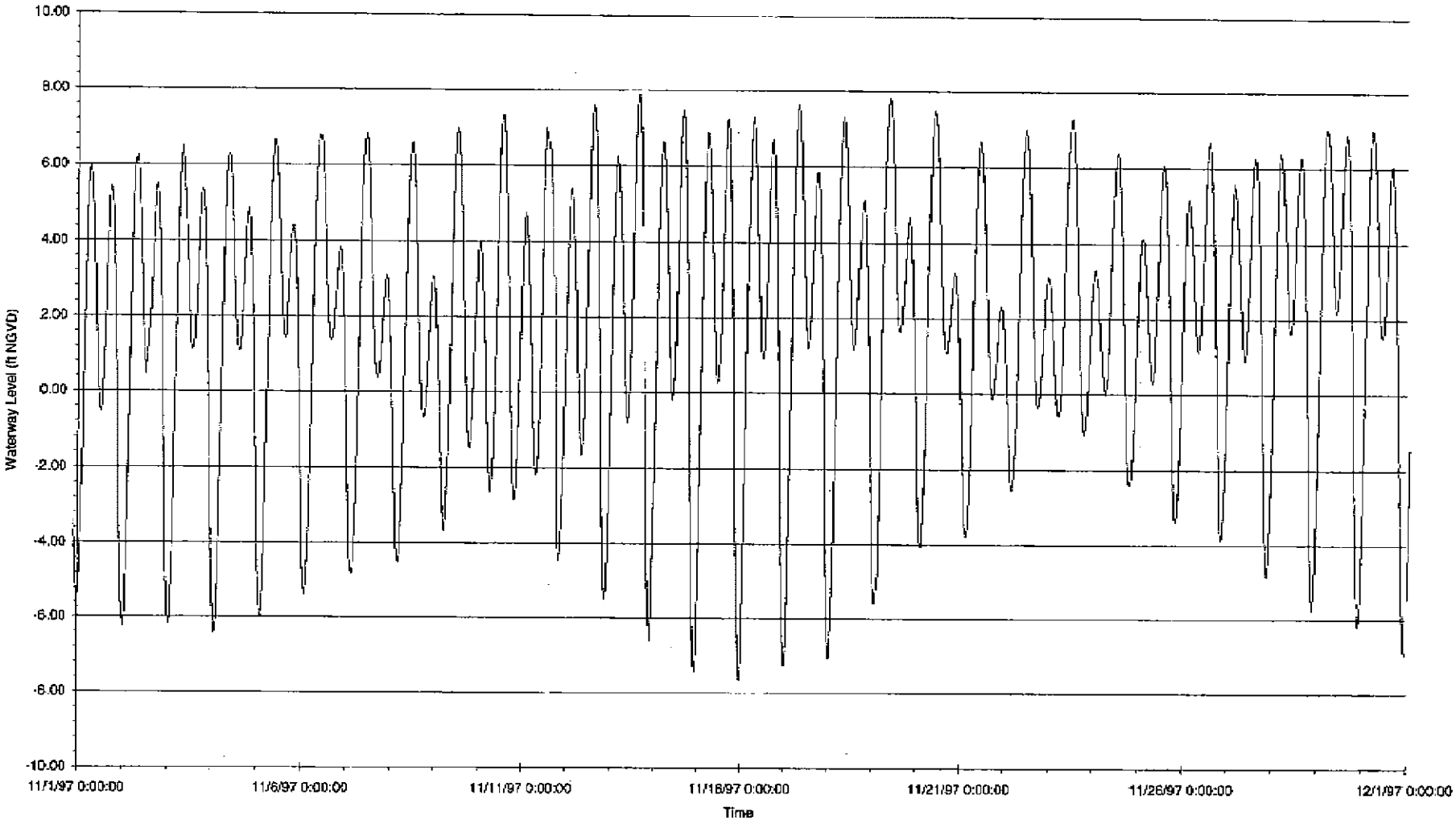

figure 12
NOVEMBER 1, 1997 TO DECEMBER 1, 1997
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017)GN-W-HYD (n:\neg\7431\cdf\model6\bayley\waterway.xls) May 18/98

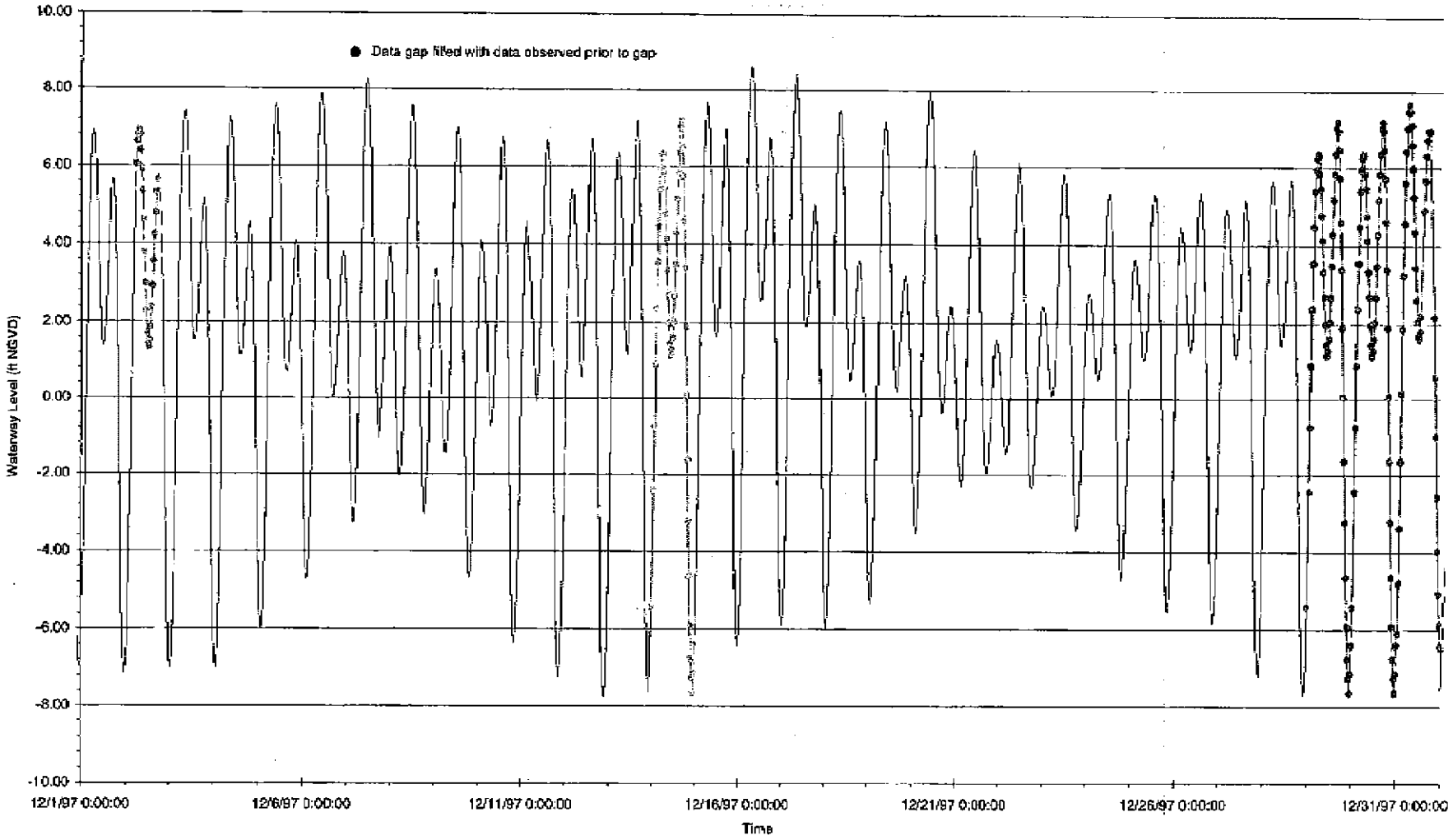

figure 13
DECEMBER 1, 1997 TO JANUARY 1, 1998
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017)GN-W-HYD (n:\reg\7431\cdf\model6\bayla\waterway.xls) May 18/99

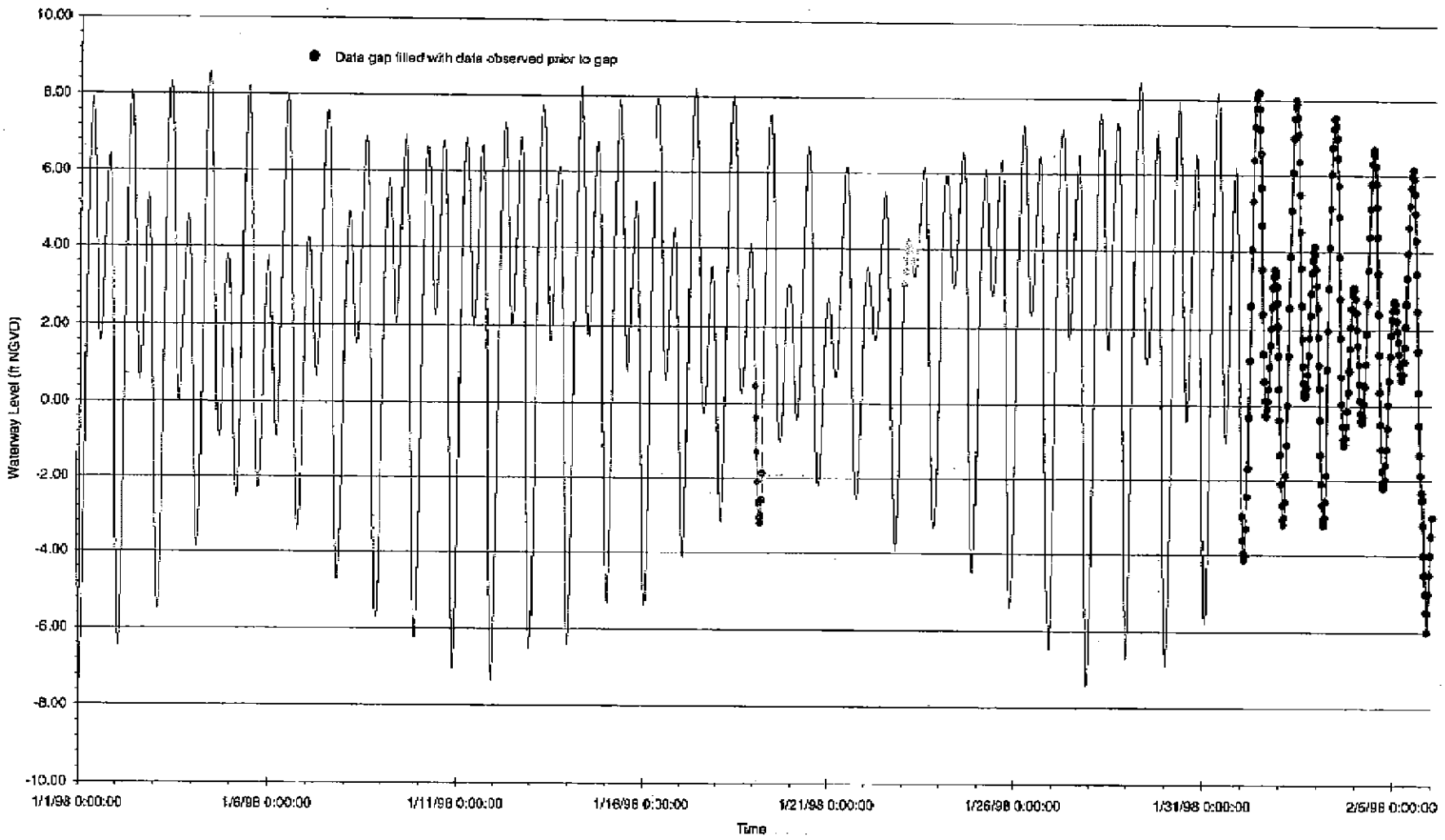

figure 14
JANUARY 1, 1997 TO FEBRUARY 6, 1998
MEASURED WATER LEVELS IN COMMENCEMENT BAY
OCC TACOMA
Tacoma, Washington

CRA

07431-0+G7330|memo017|GN-W-HYD (n:\heg\7431\cdf\model6\bayley\waterway.xls) May 18/99

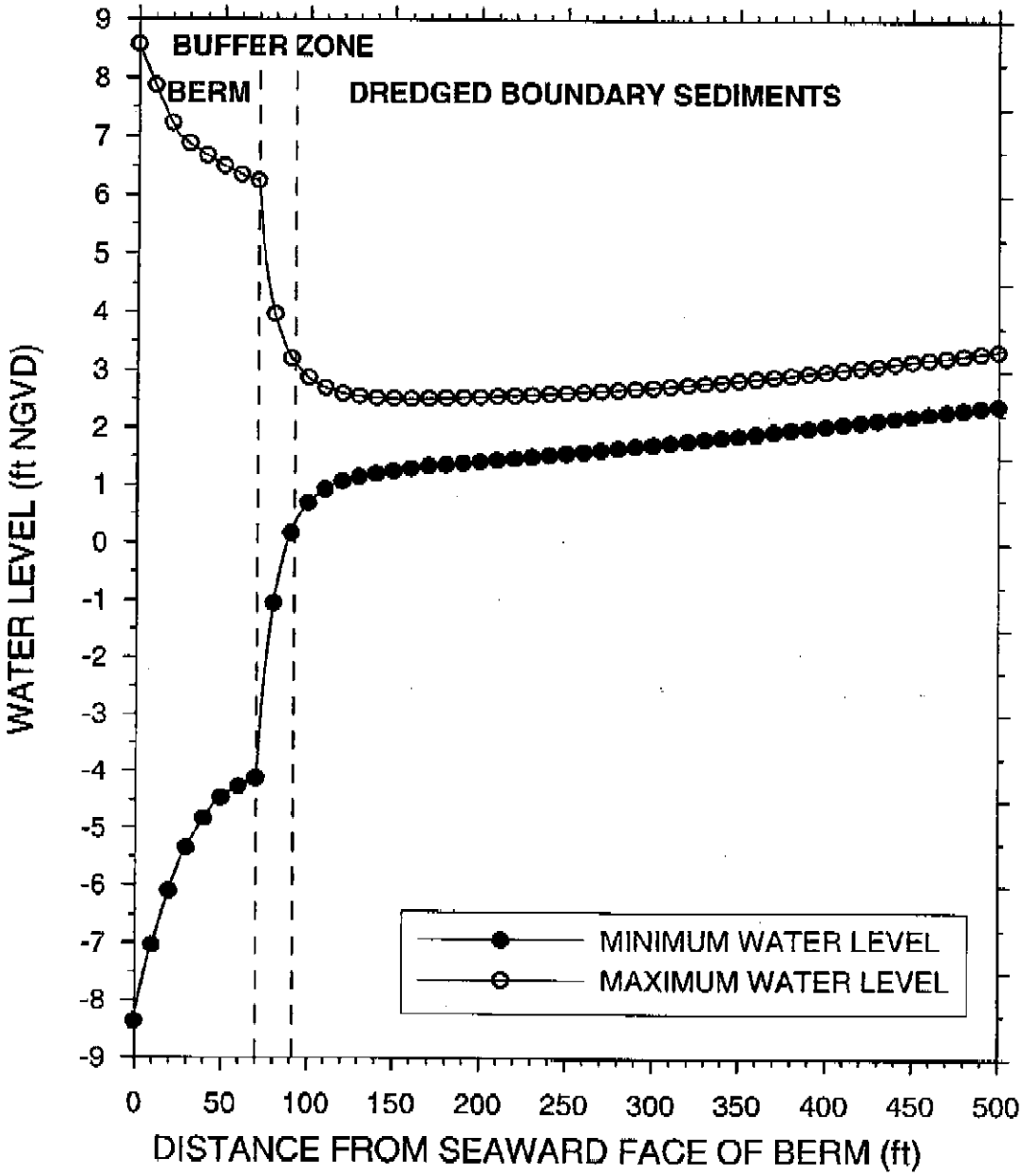

figure 15
REVISED BASE CASE
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

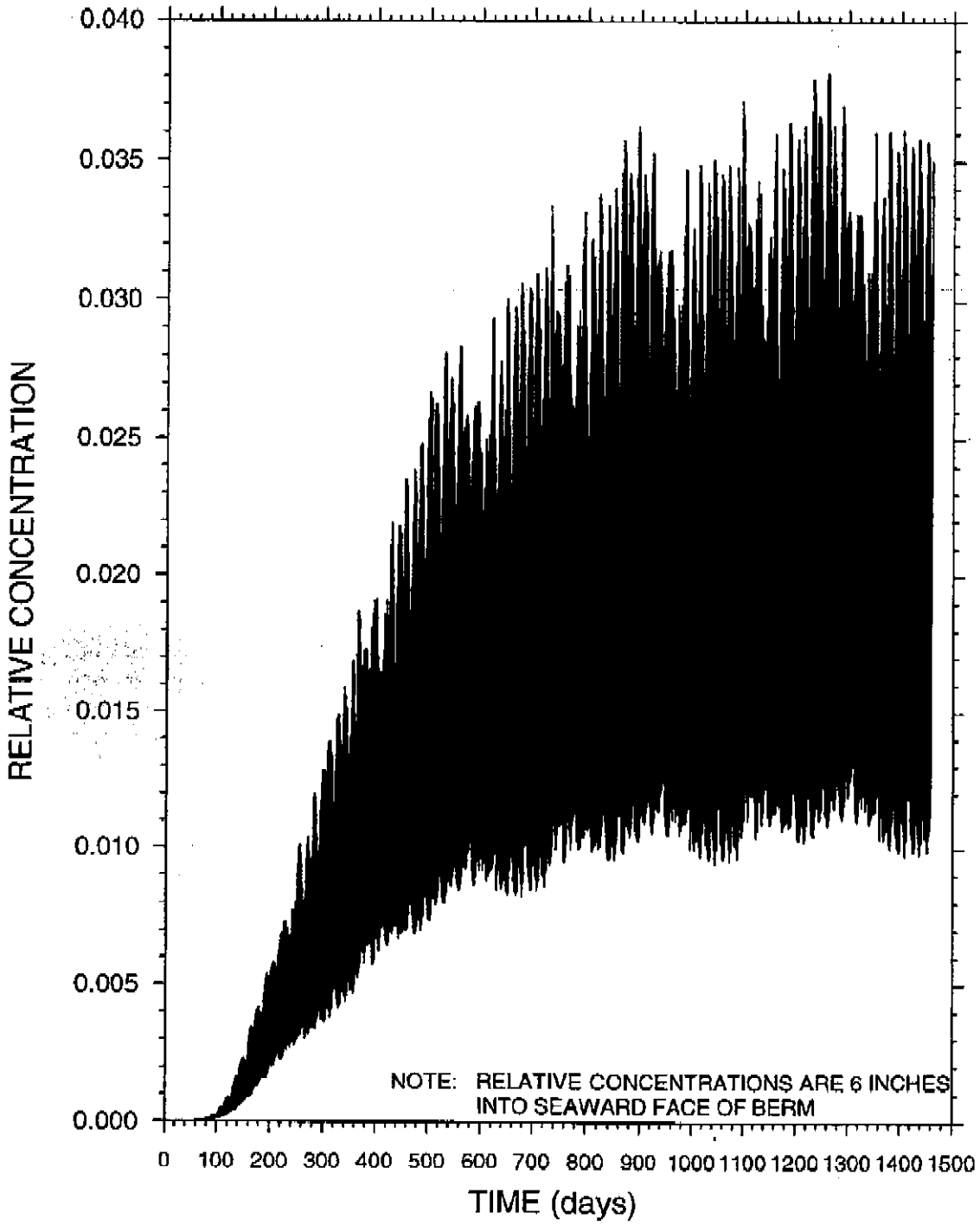

figure 16
REVISED BASE CASE
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8baset-figure44.grf) MAY 19/99

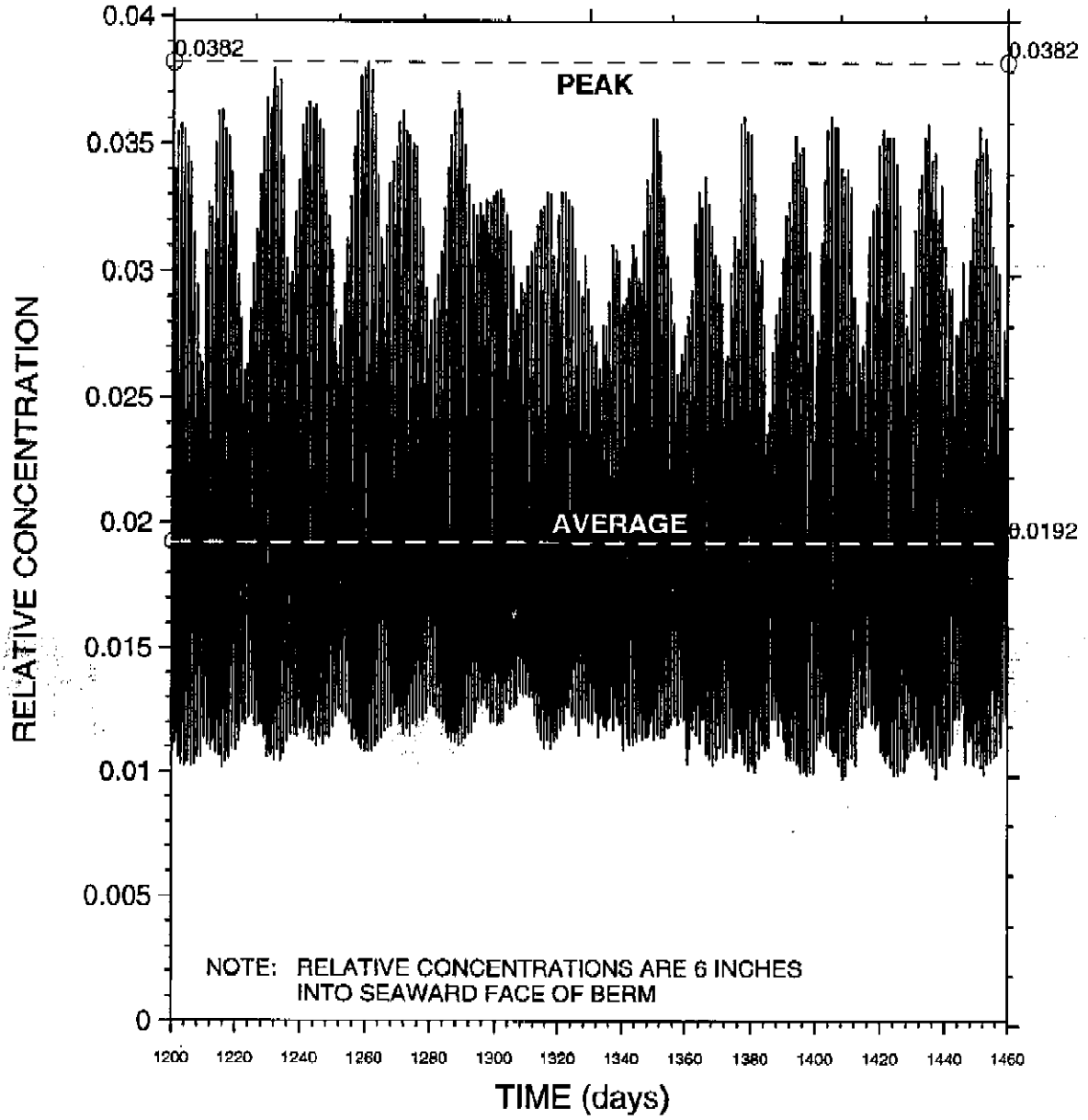

figure 17
REVISED BASE CASE
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8baset-figure45.grf) MAY19/99

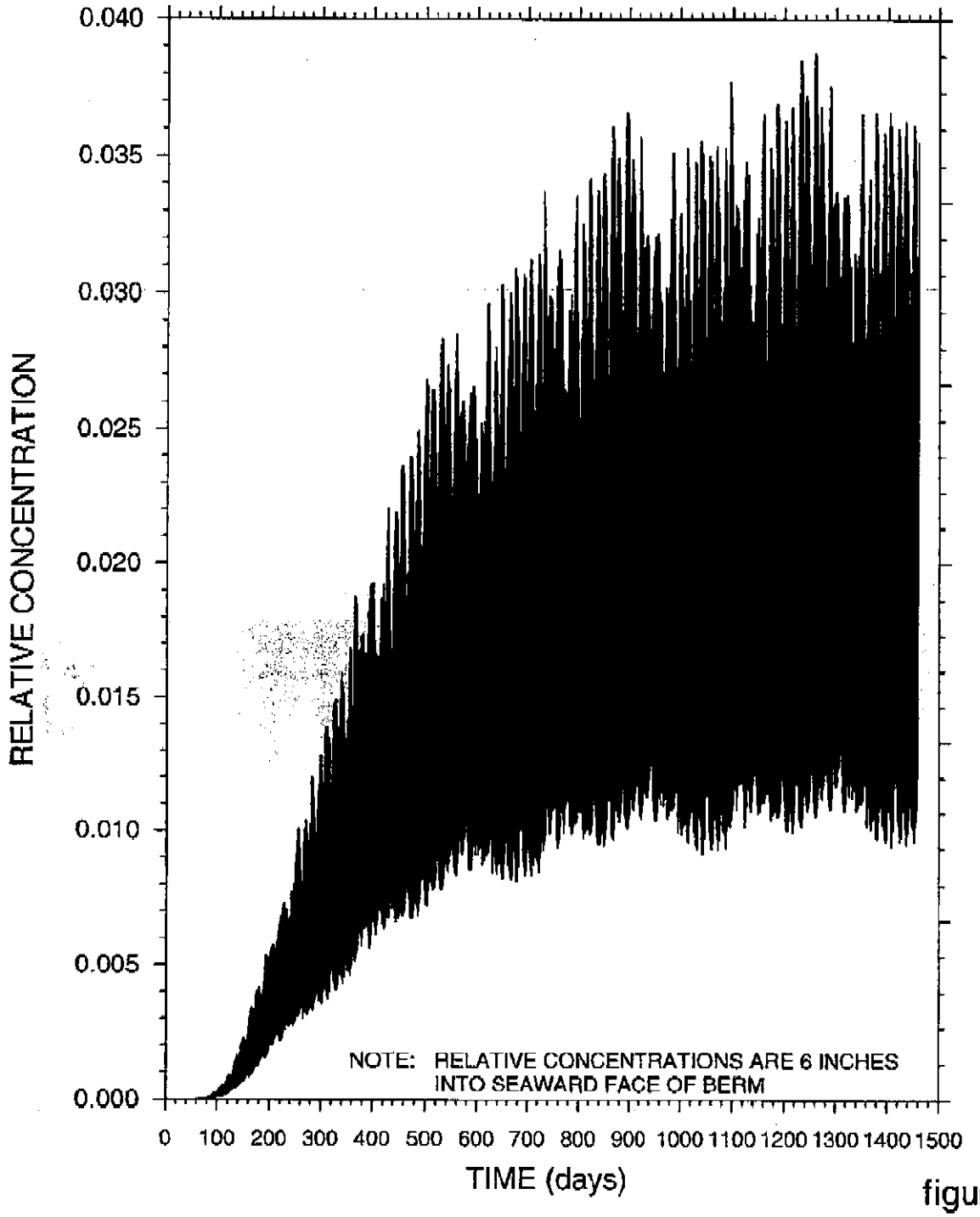

figure 18

REVISED BASED CASE
TRANSPORT TIME STEP OF 5 MINUTES
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen1t-figure44.grf) MAY 20/99

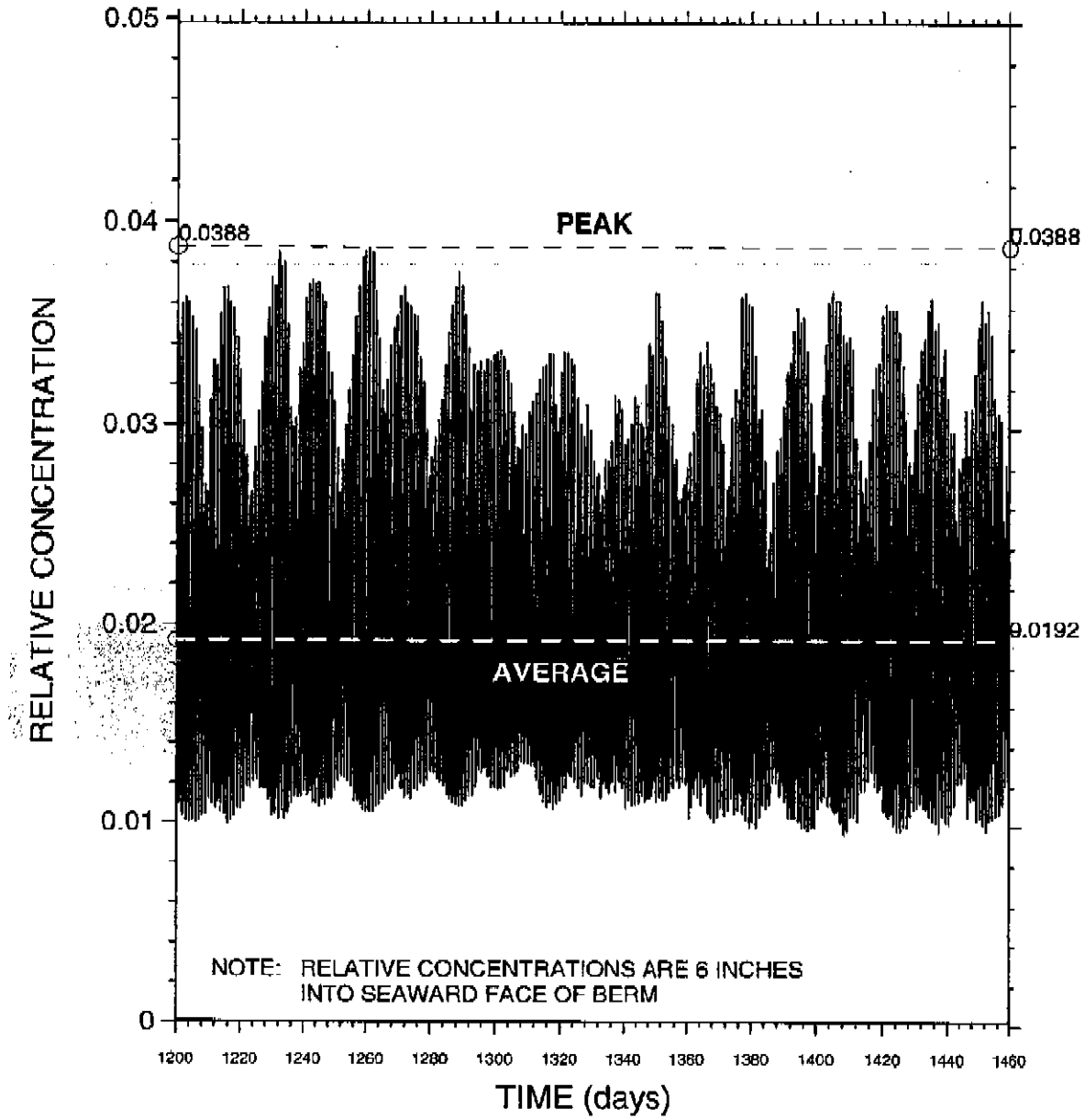

figure 19
REVISED BASE CASE
TRANSPORT TIME STEP OF 5 MINUTES
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

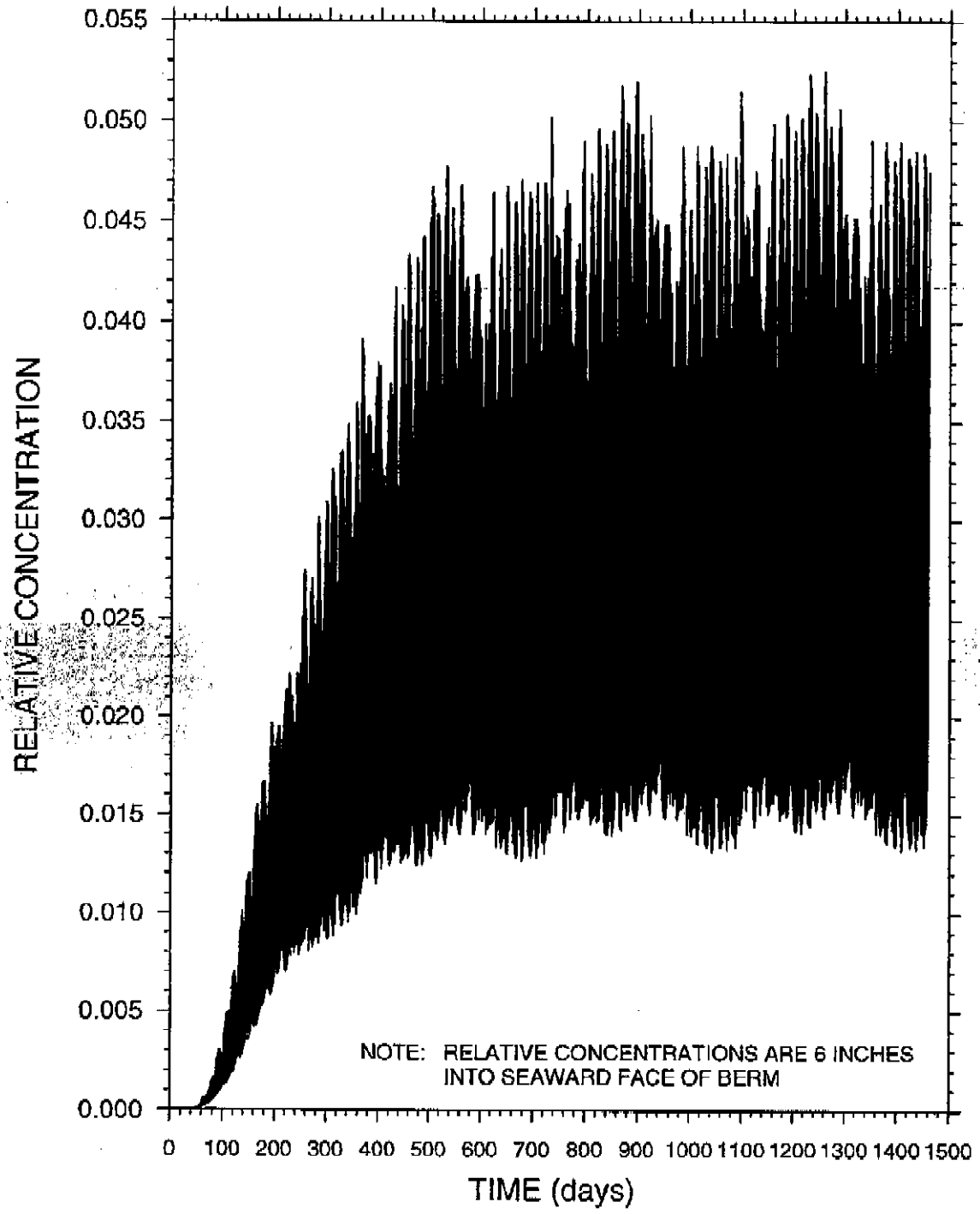

figure 20
REVISED BASE CASE
BUFFER ZONE LENGTH OF 15 FEET
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\buff\buff15-figure44.grf) MAY 19/99

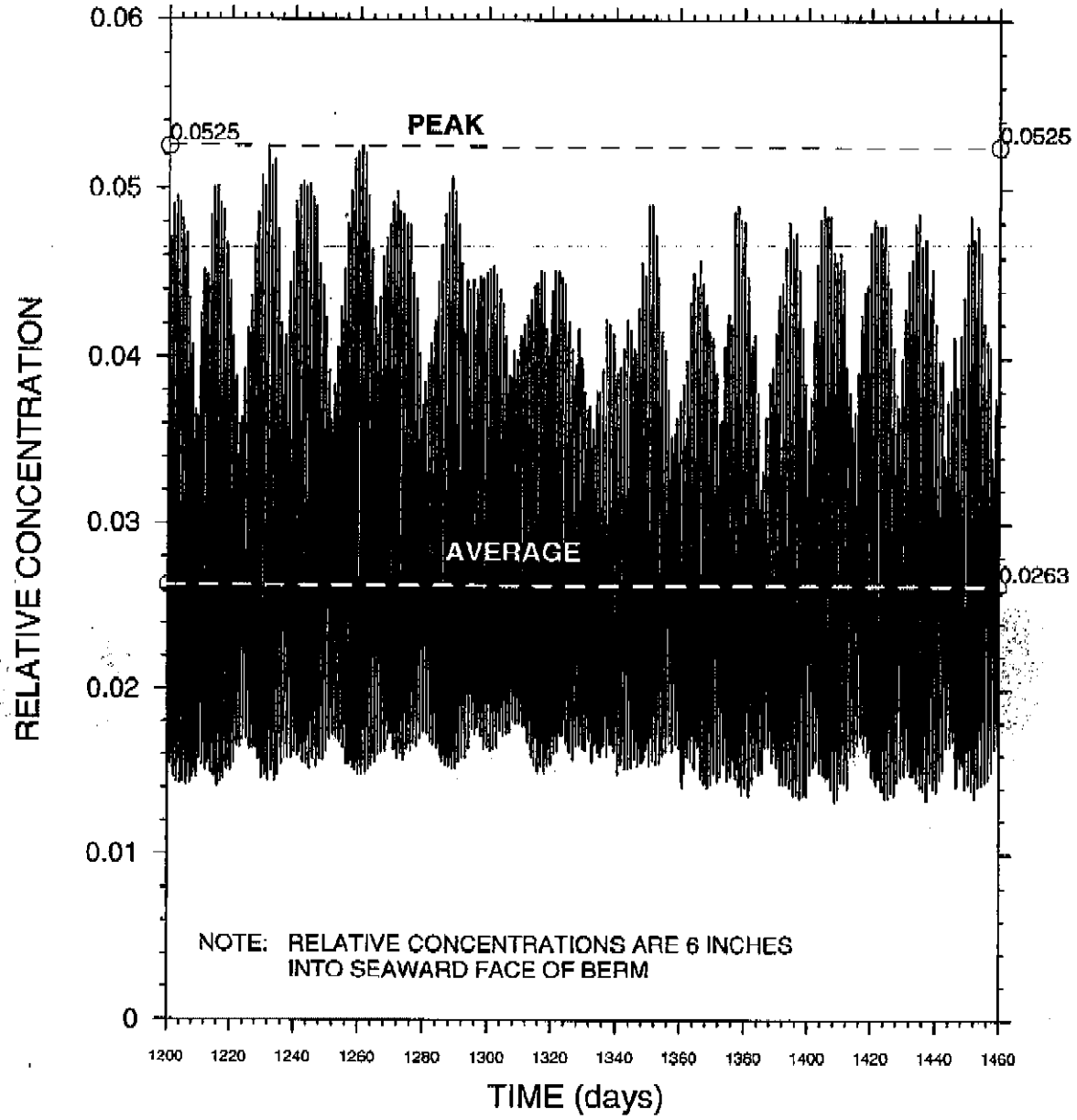

figure 21
REVISED BASE CASE
BUFFER ZONE LENGTH OF 15 FEET
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\buff\buff15-figure45.grf) MAY 19/99

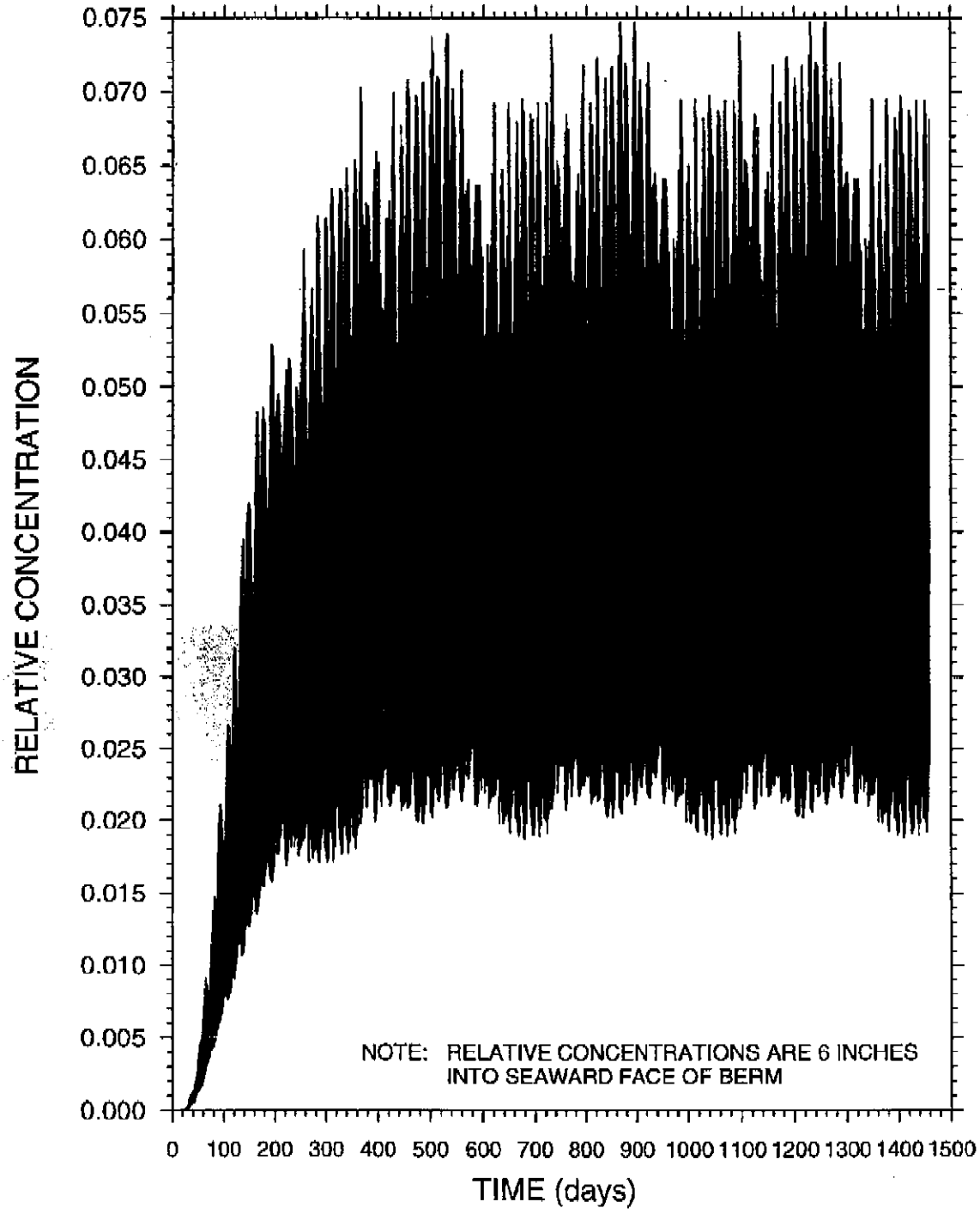

figure 22
REVISED BASE CASE
BUFFER ZONE LENGTH OF 10 FEET
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\buff\buff10-figure44.grf) MAY 19/99

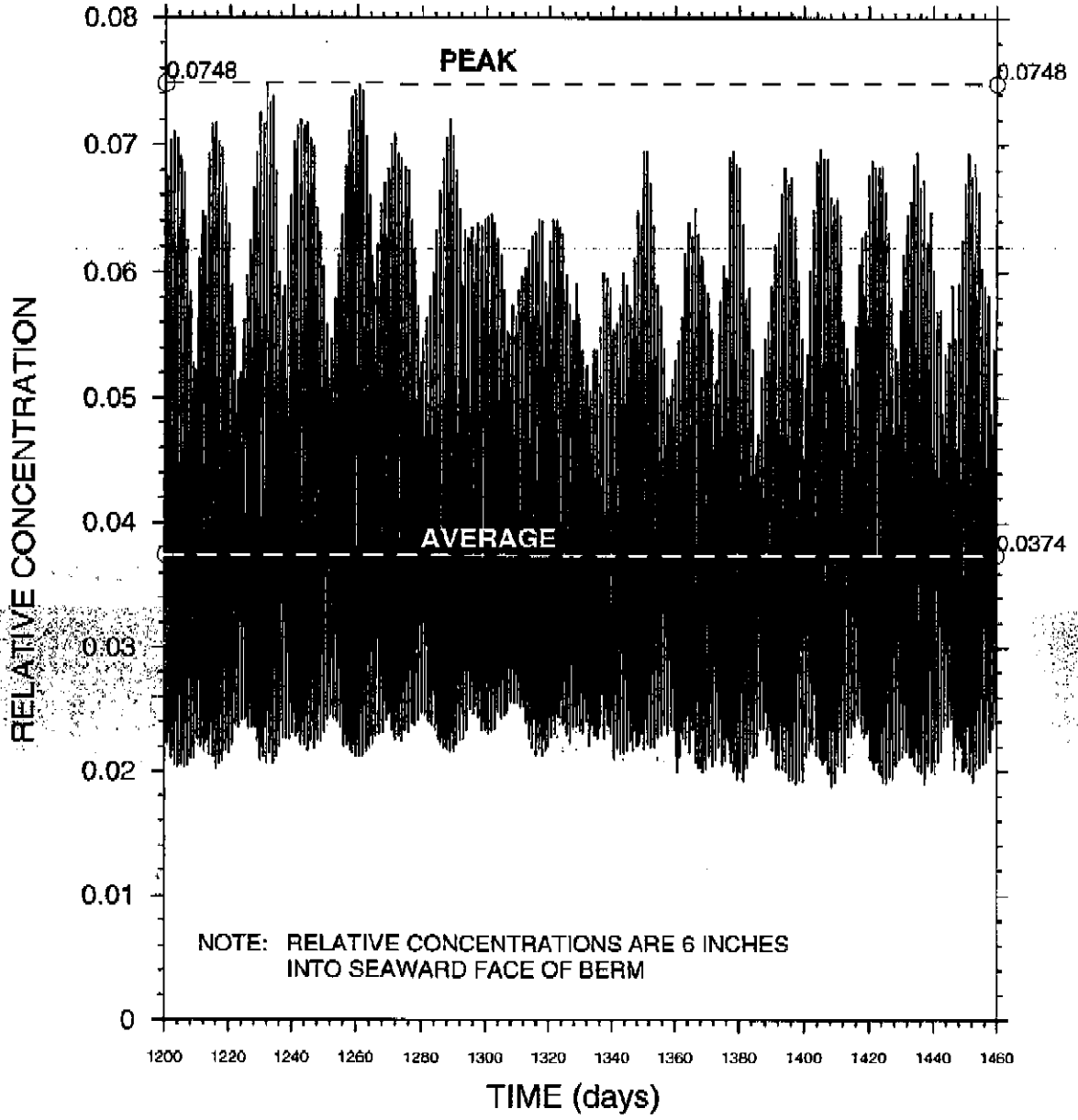

figure 23
REVISED BASE CASE
BUFFER ZONE LENGTH OF 10 FEET
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\buff\buff10-figure45.grf) MAY 19/99

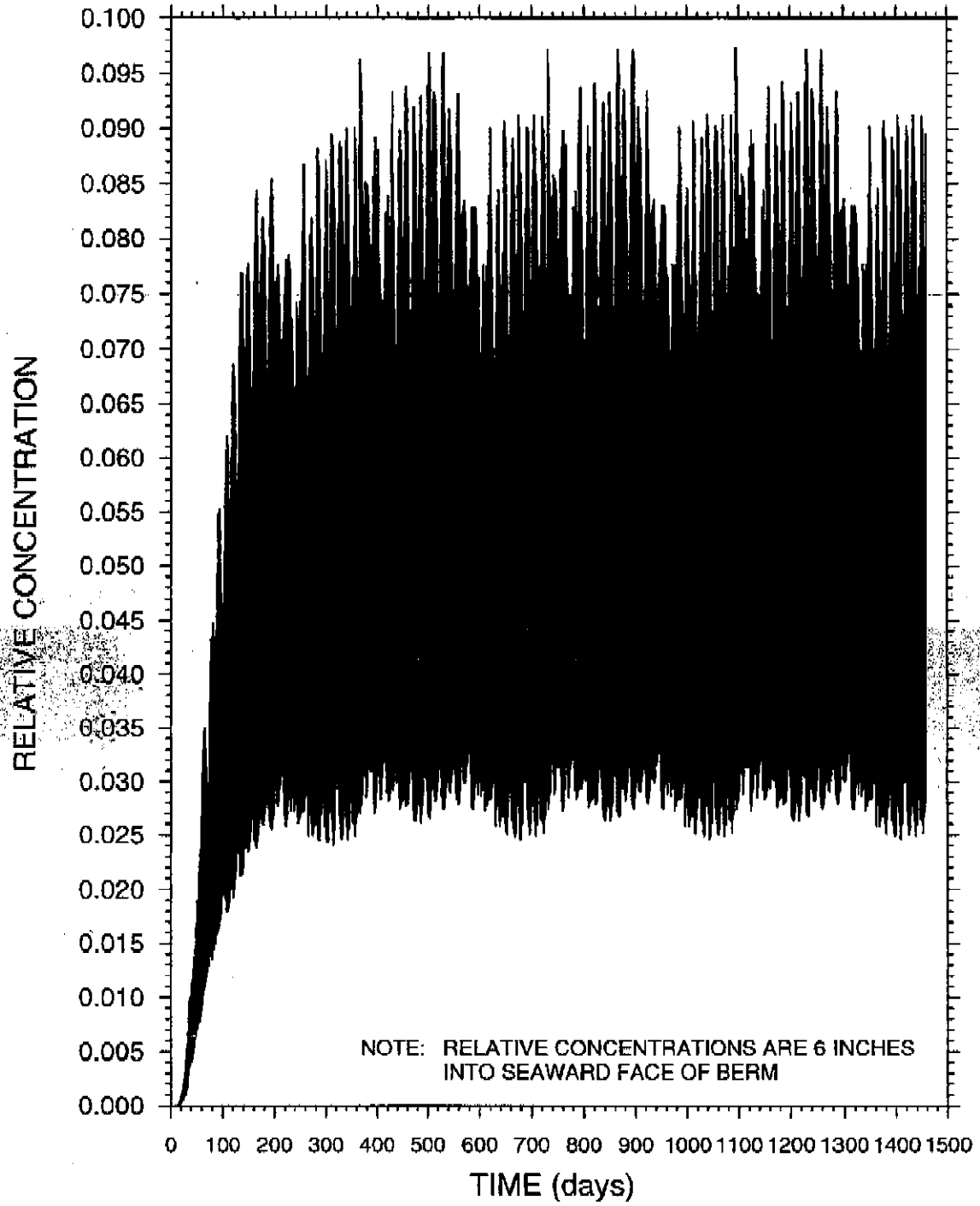

figure 24
REVISED BASE CASE
BUFFER ZONE LENGTH OF 5 FEET
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\buff\buff5-figure44.grf) MAY 19/99

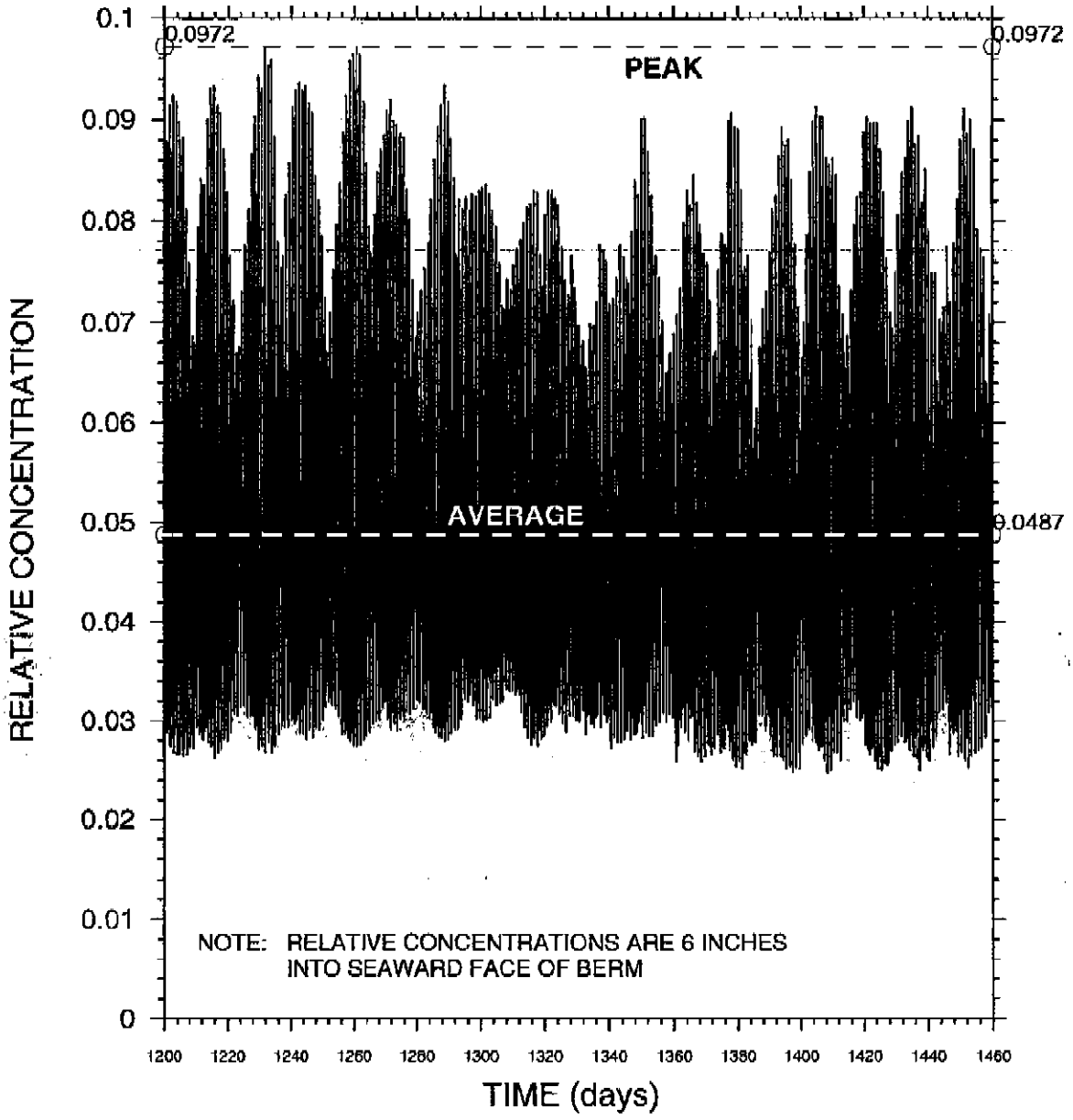

figure 25
REVISED BASE CASE
BUFFER ZONE LENGTH OF 5 FEET
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\buff\buff5-figure45.grf) MAY 19/99

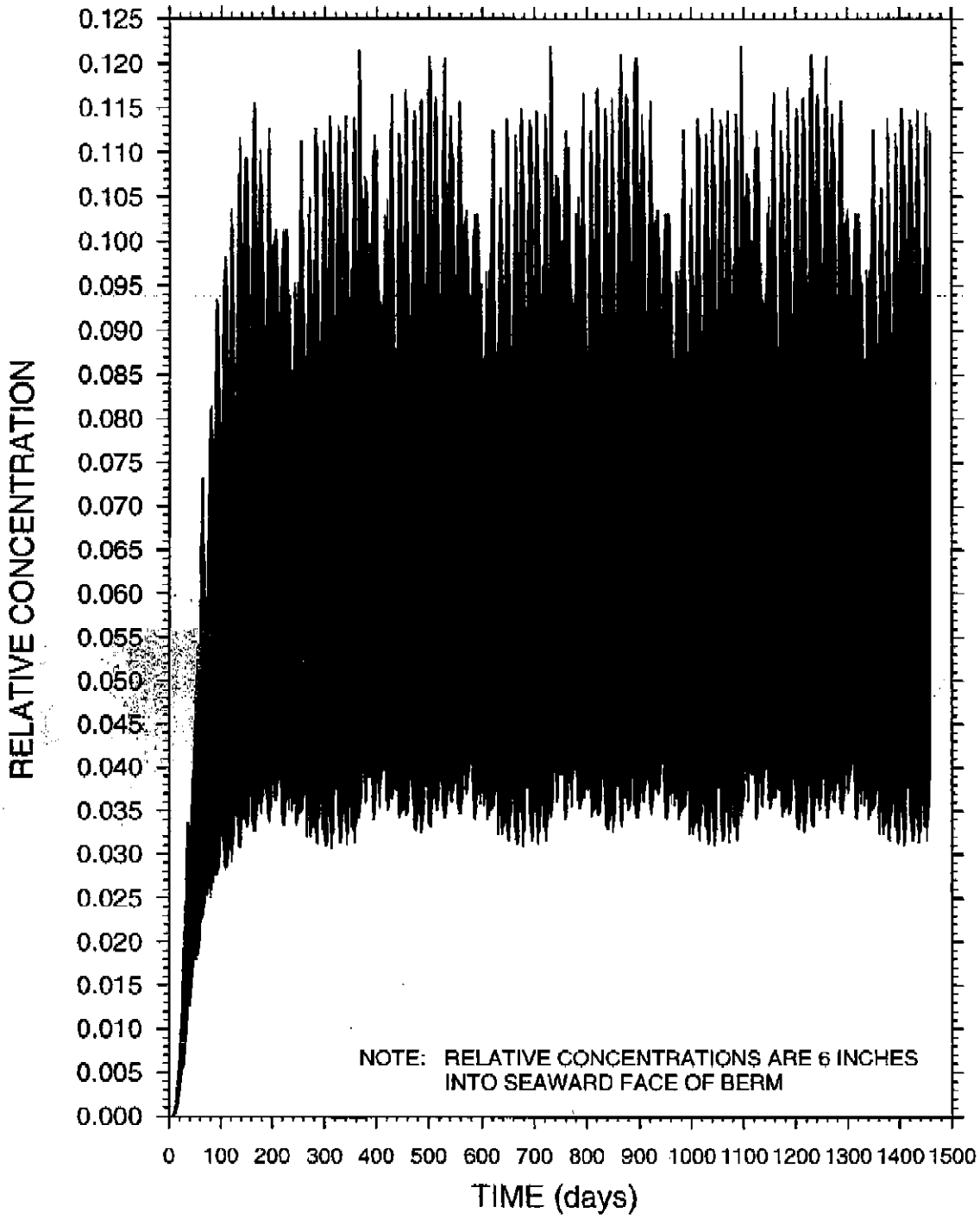

figure 26
REVISED BASE CASE
BUFFER ZONE LENGTH OF 0 FEET
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\buff\buff0-figure44.grf) MAY 19/99

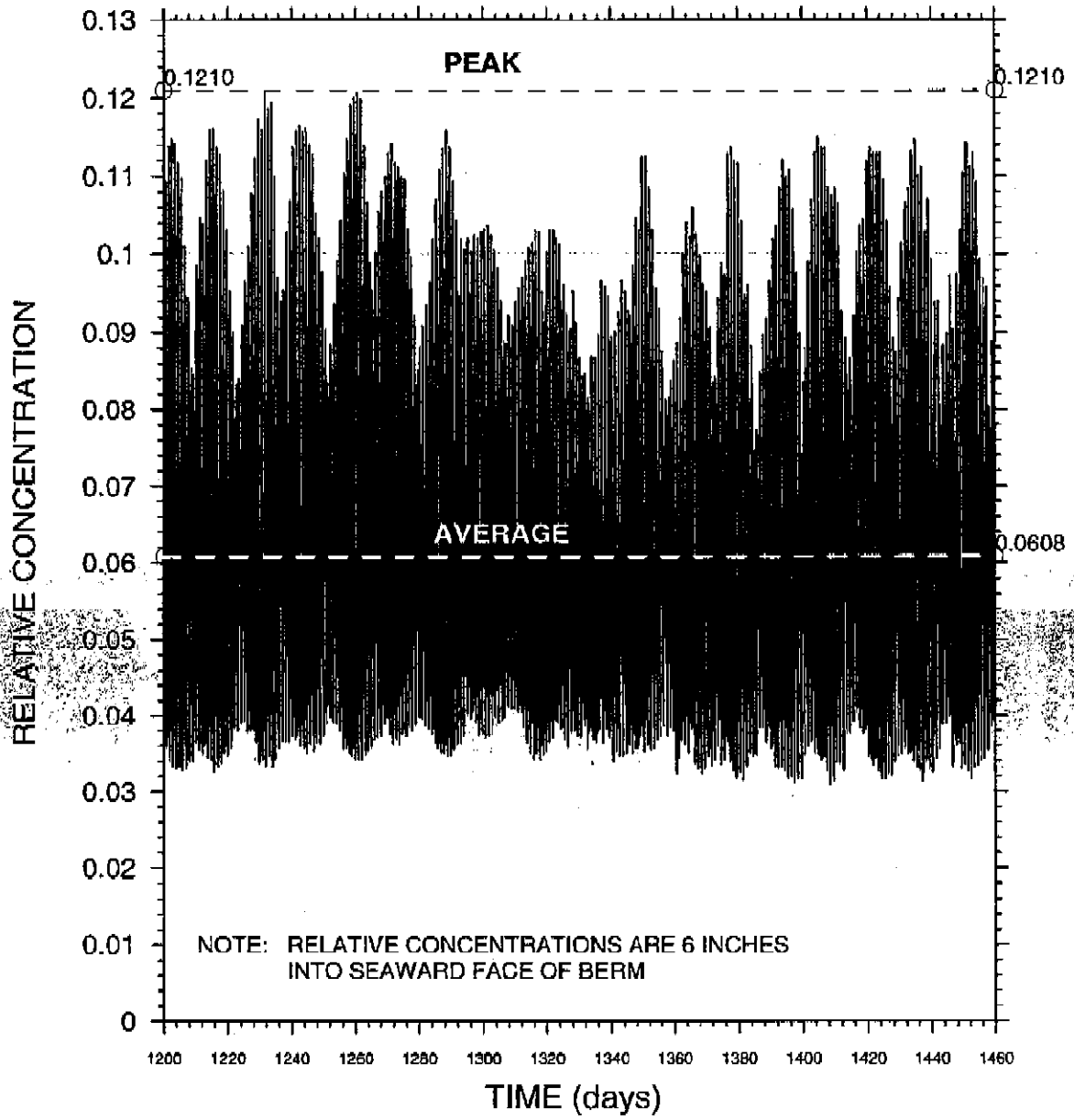

figure 27
REVISED BASE CASE
BUFFER ZONE LENGTH OF 0 FEET
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\buff\buff0-figure45.grf) MAY 19/99

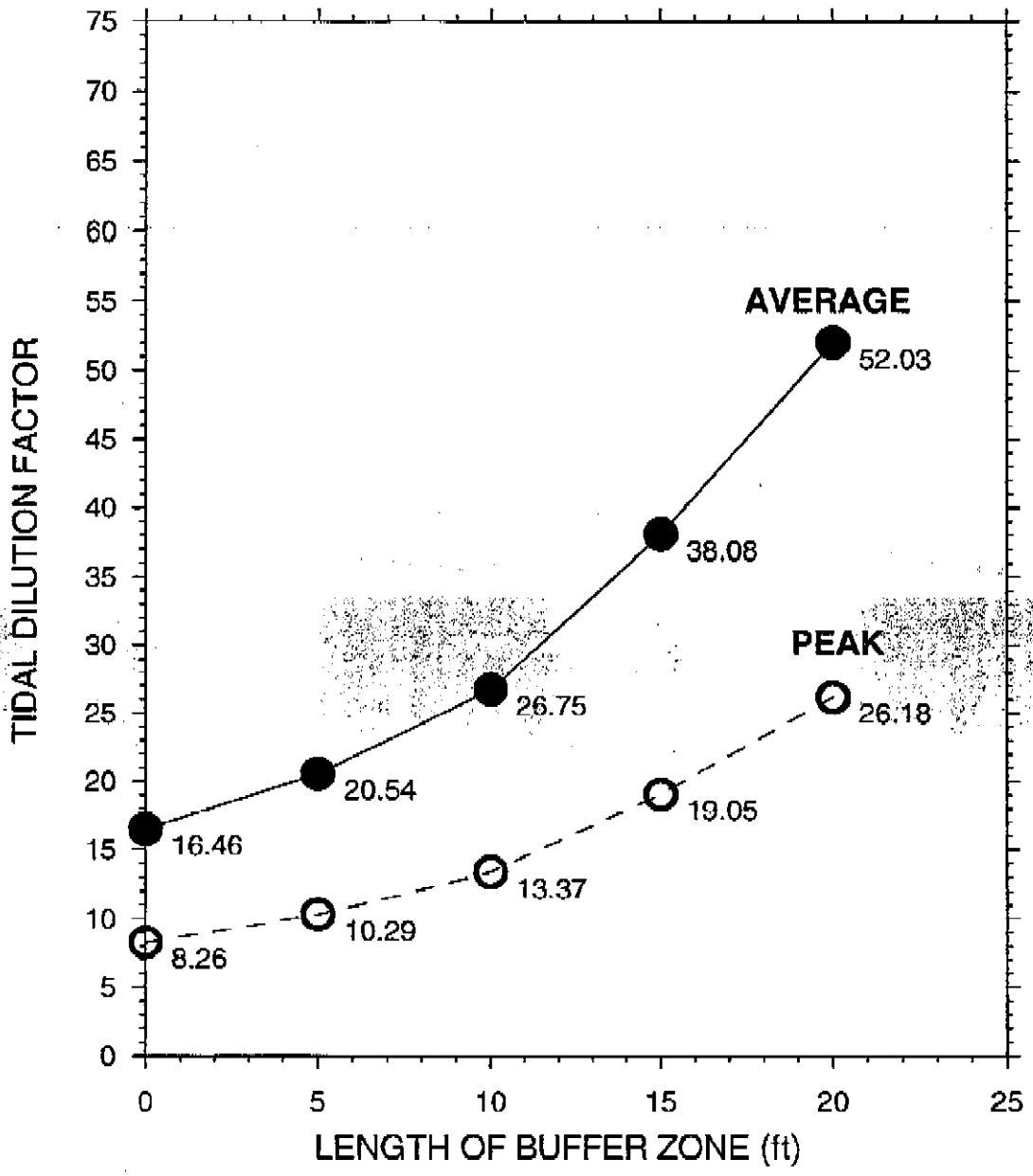

figure 28
REVISED BASE CASE
SENSITIVITY OF TIDAL DILUTION FACTORS
WITH BUFFER LENGTH
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

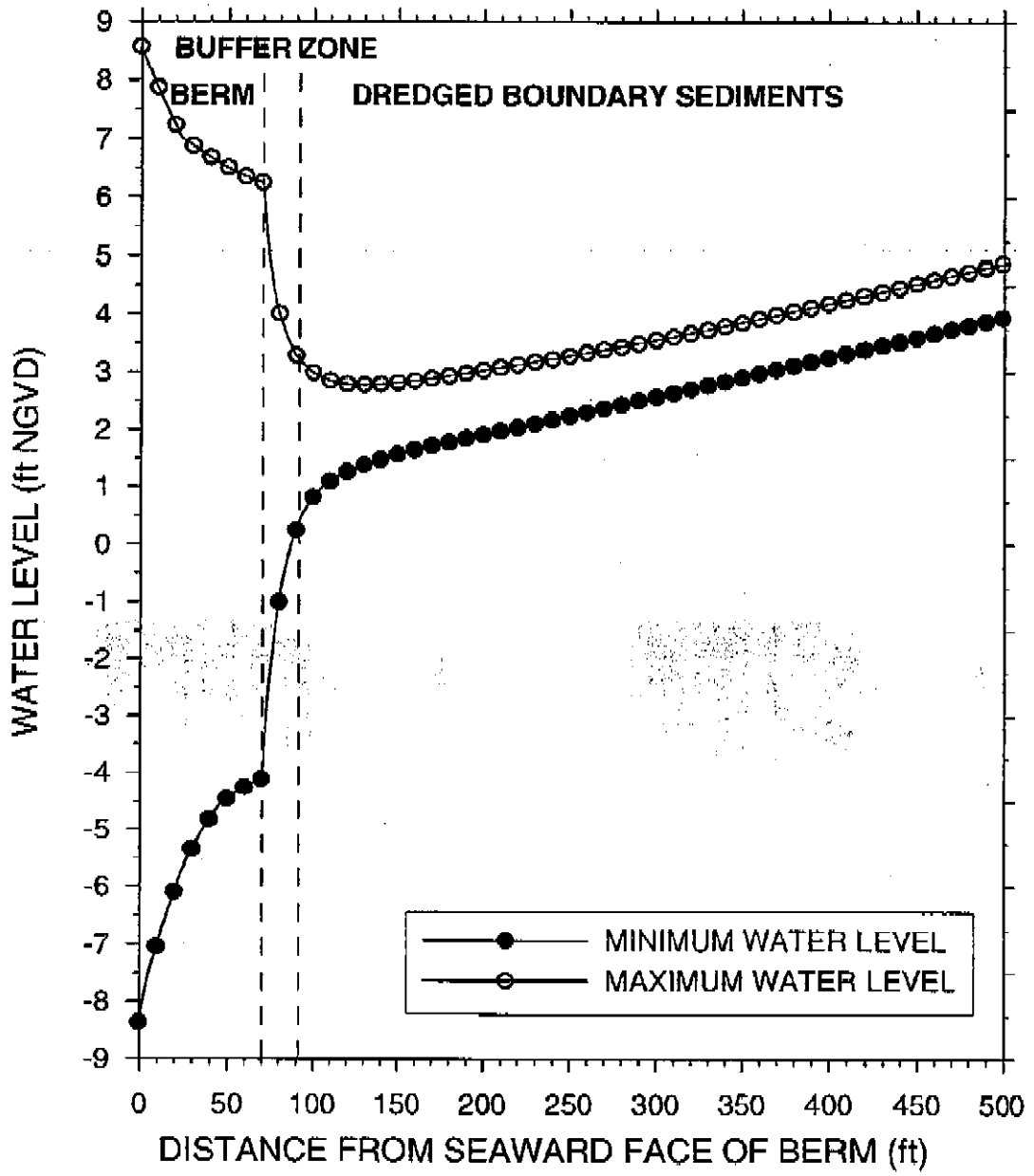

figure 29
REVISED BASE CASE
REGIONAL GRADIENT MULTIPLIED BY 2
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen2-figure42.grf) MAY 19/99

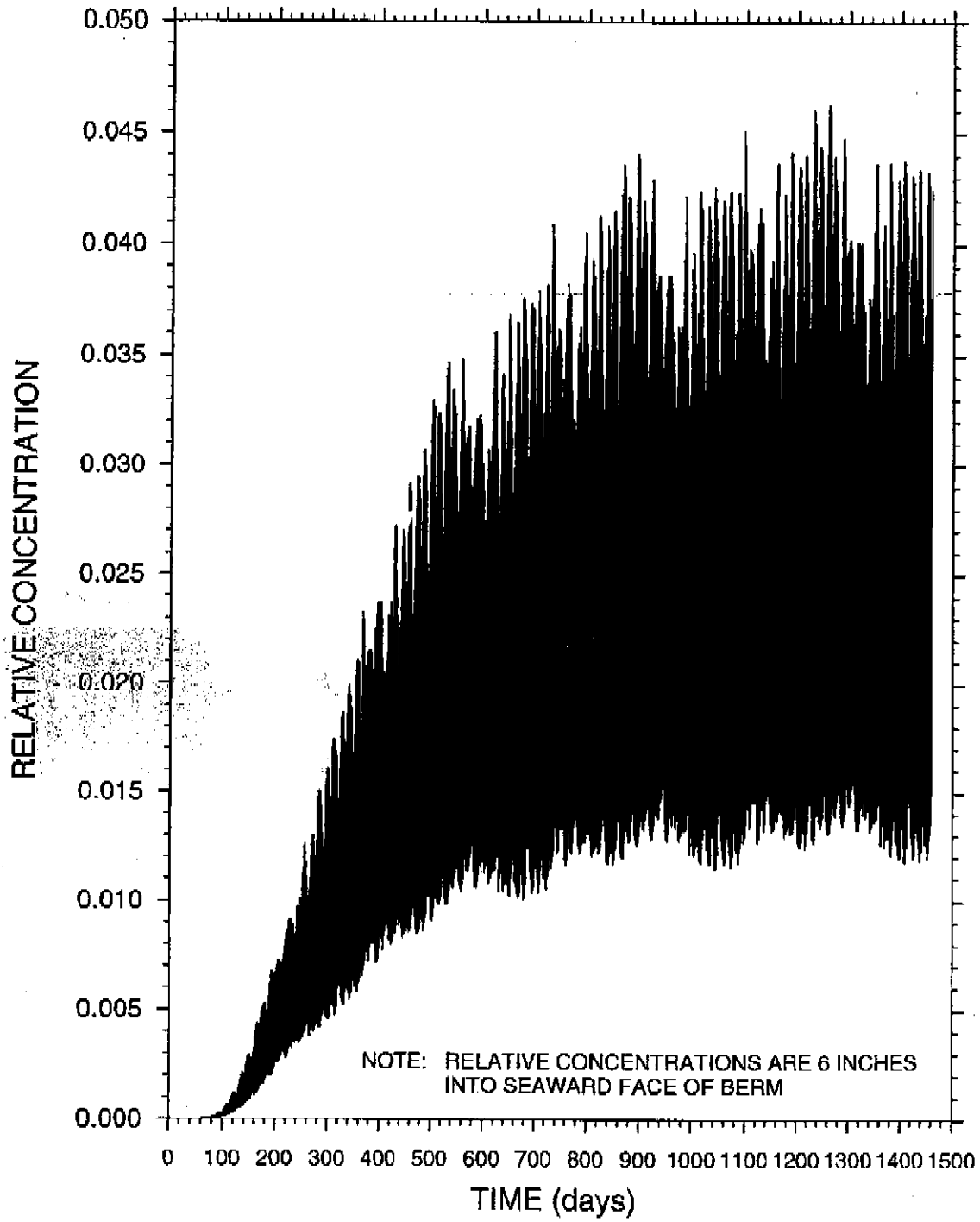

figure 30
REVISED BASE CASE
REGIONAL GRADIENT MULTIPLIED BY 2
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen2t-figure44.grf) MAY 19/99

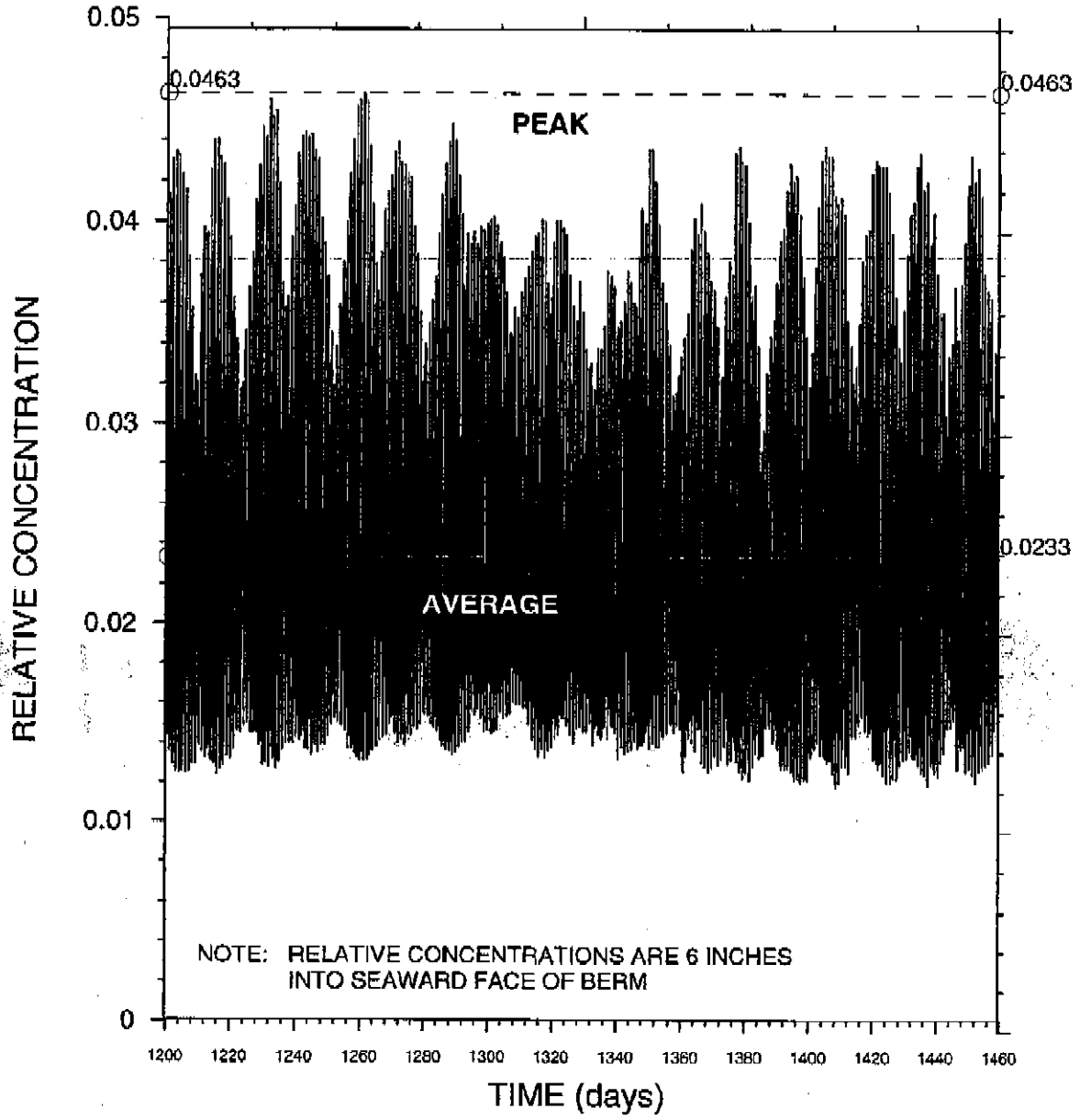

figure 31
REVISED BASE CASE
REGIONAL GRADIENT MULTIPLIED BY 2
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen2t-figure45.grf) MAY19/99

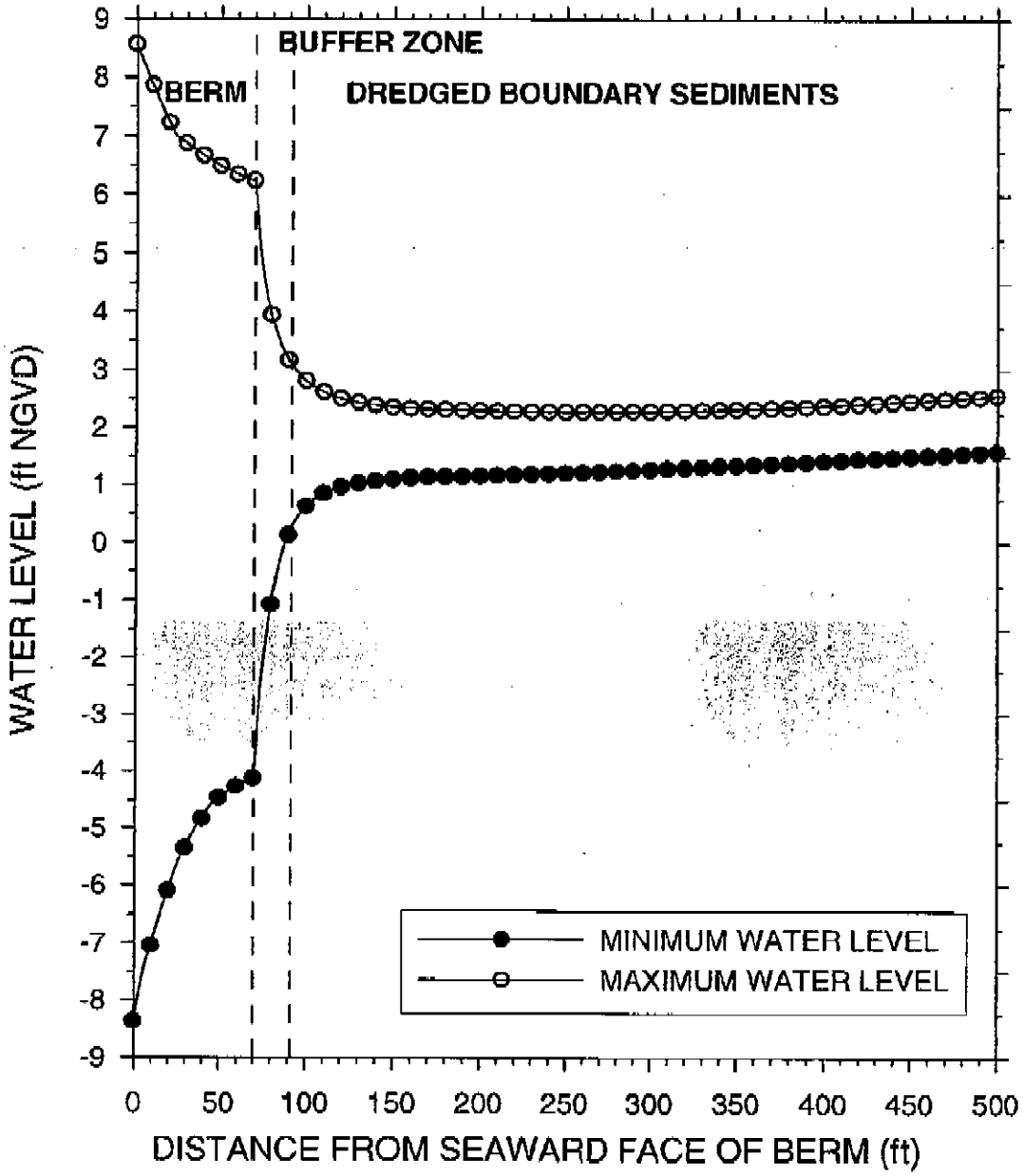

figure 32
REVISED BASE CASE
REGIONAL GRADIENT DIVIDED BY 2
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

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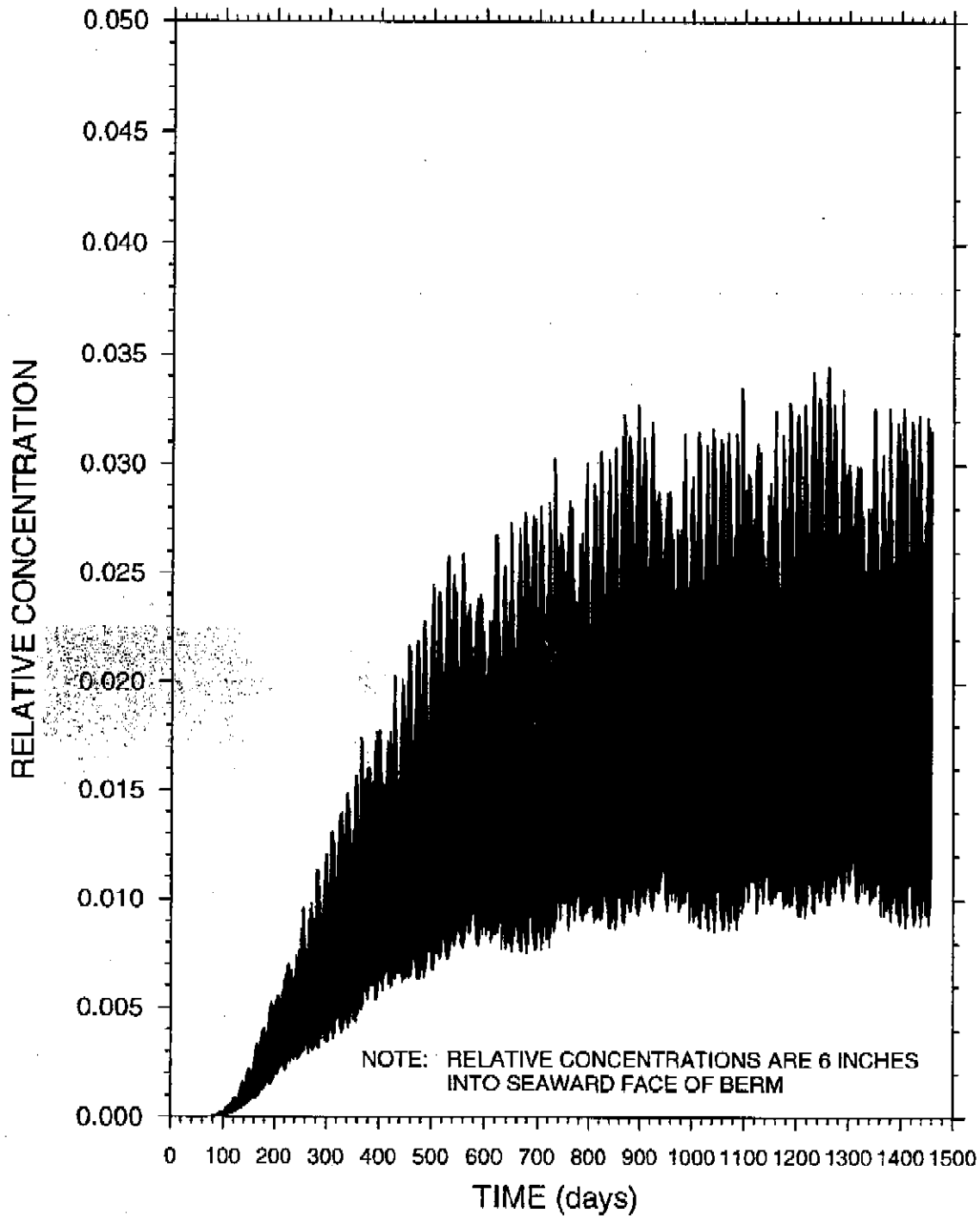

figure 33
REVISED BASE CASE
REGIONAL GRADIENT DIVIDED BY 2
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

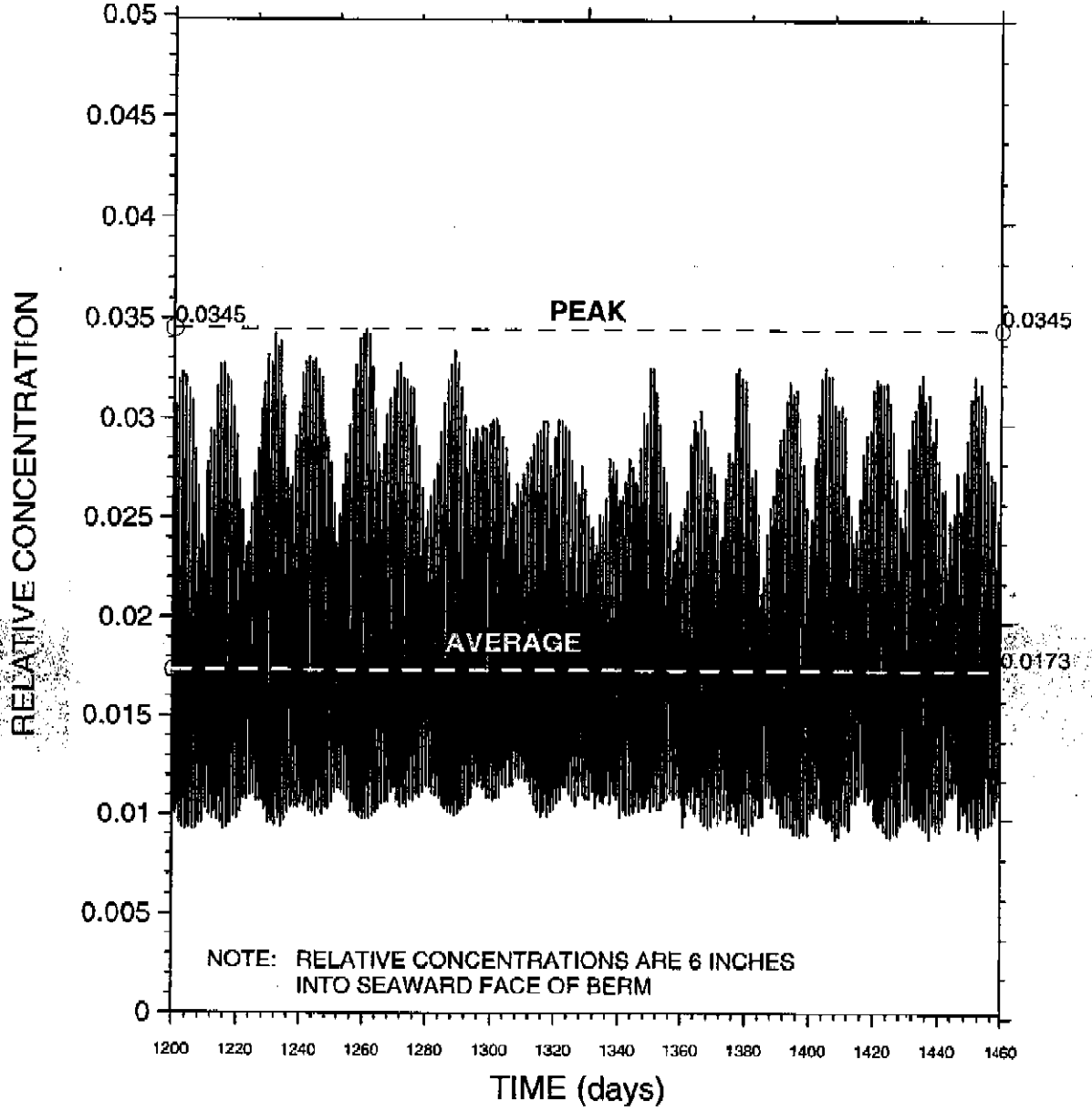

figure 34
REVISED BASE CASE
REGIONAL GRADIENT DIVIDED BY 2
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen3t-figure45.grf) MAY19/99

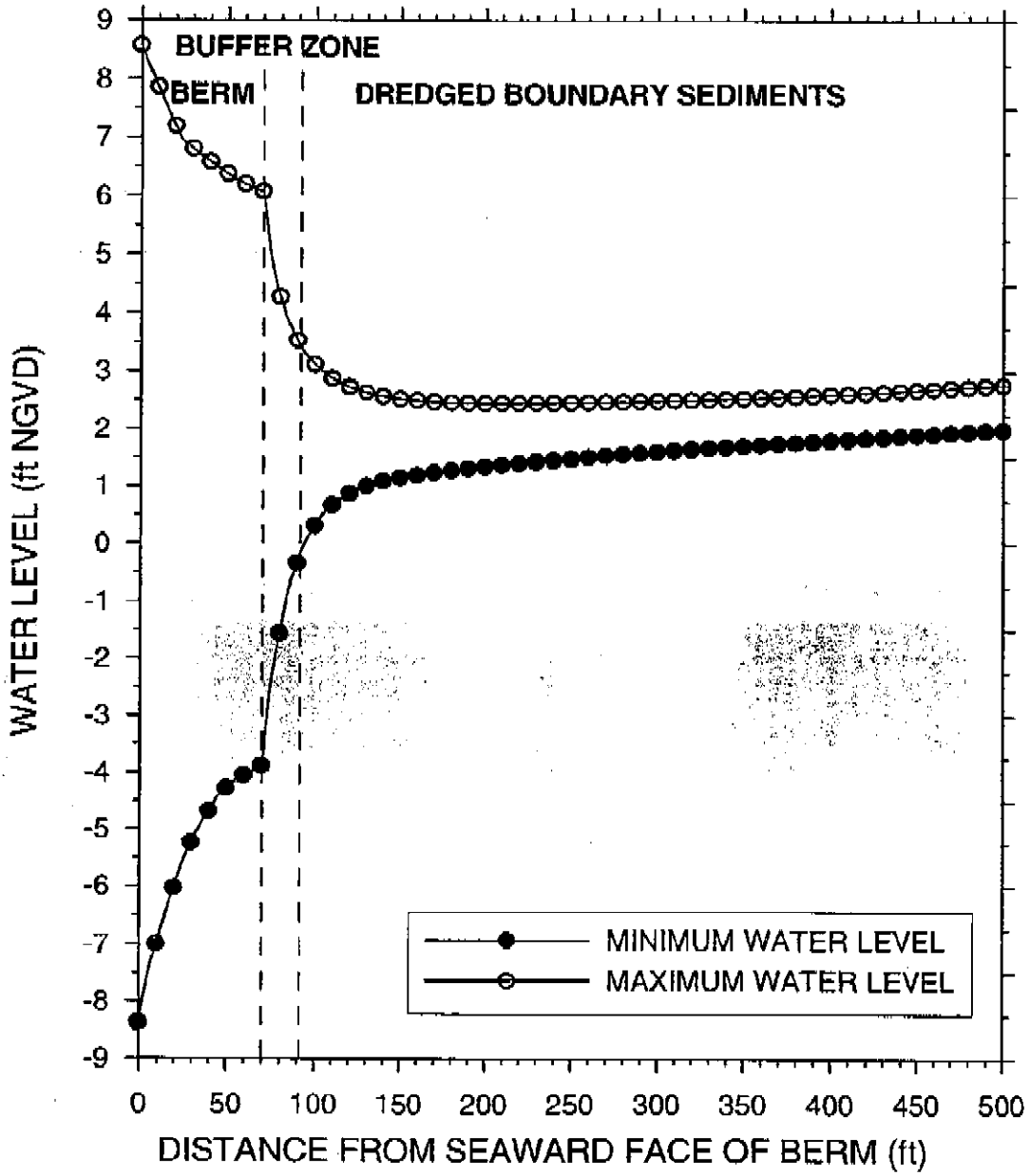

figure 35
REVISED BASE CASE
BERM/SEDIMENT FILL K MULTIPLIED BY 2
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

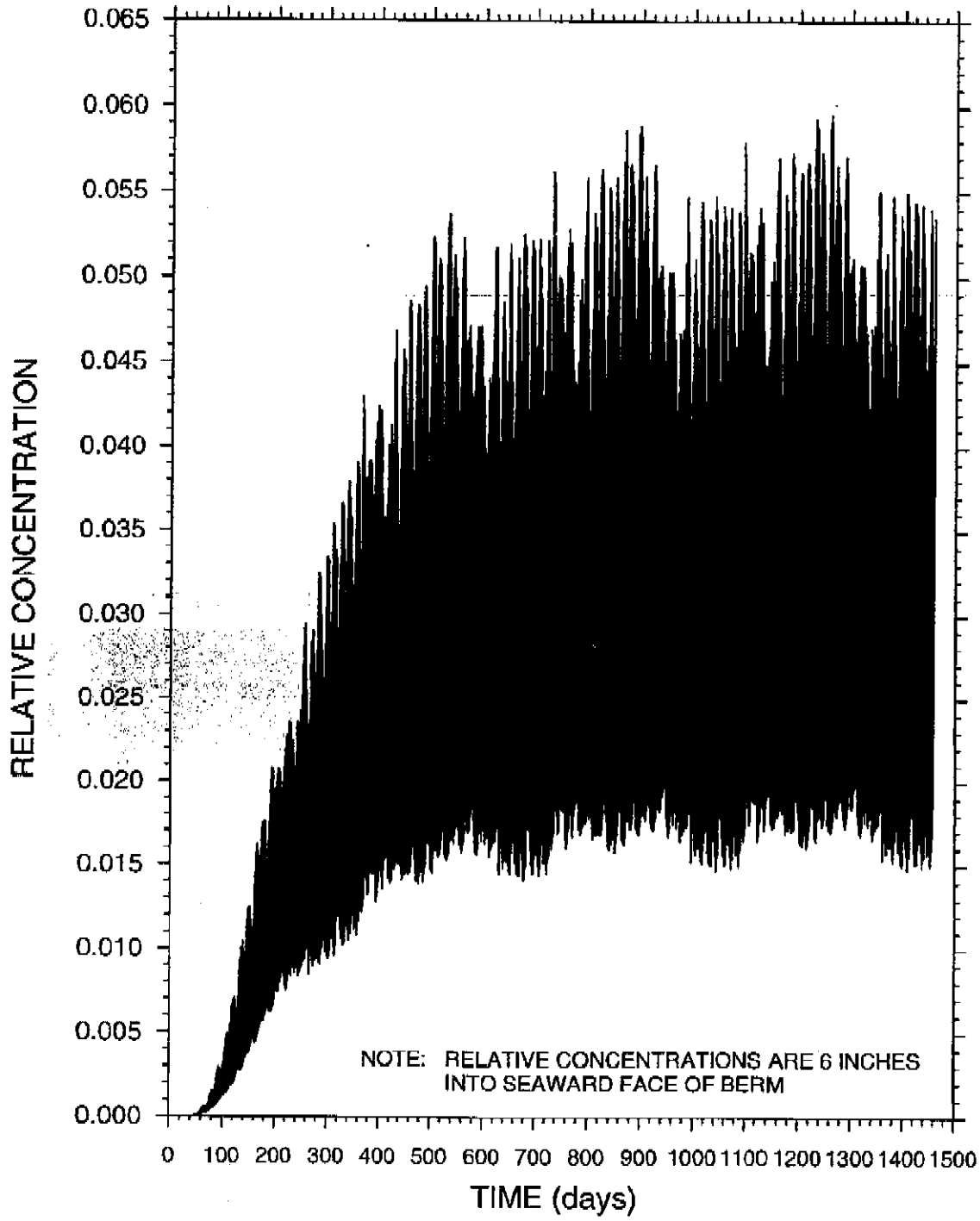

figure 36
REVISED BASE CASE
BERM/SEDIMENT K MULTIPLIED BY 2
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen4t-figure44.grf) MAY 19/99

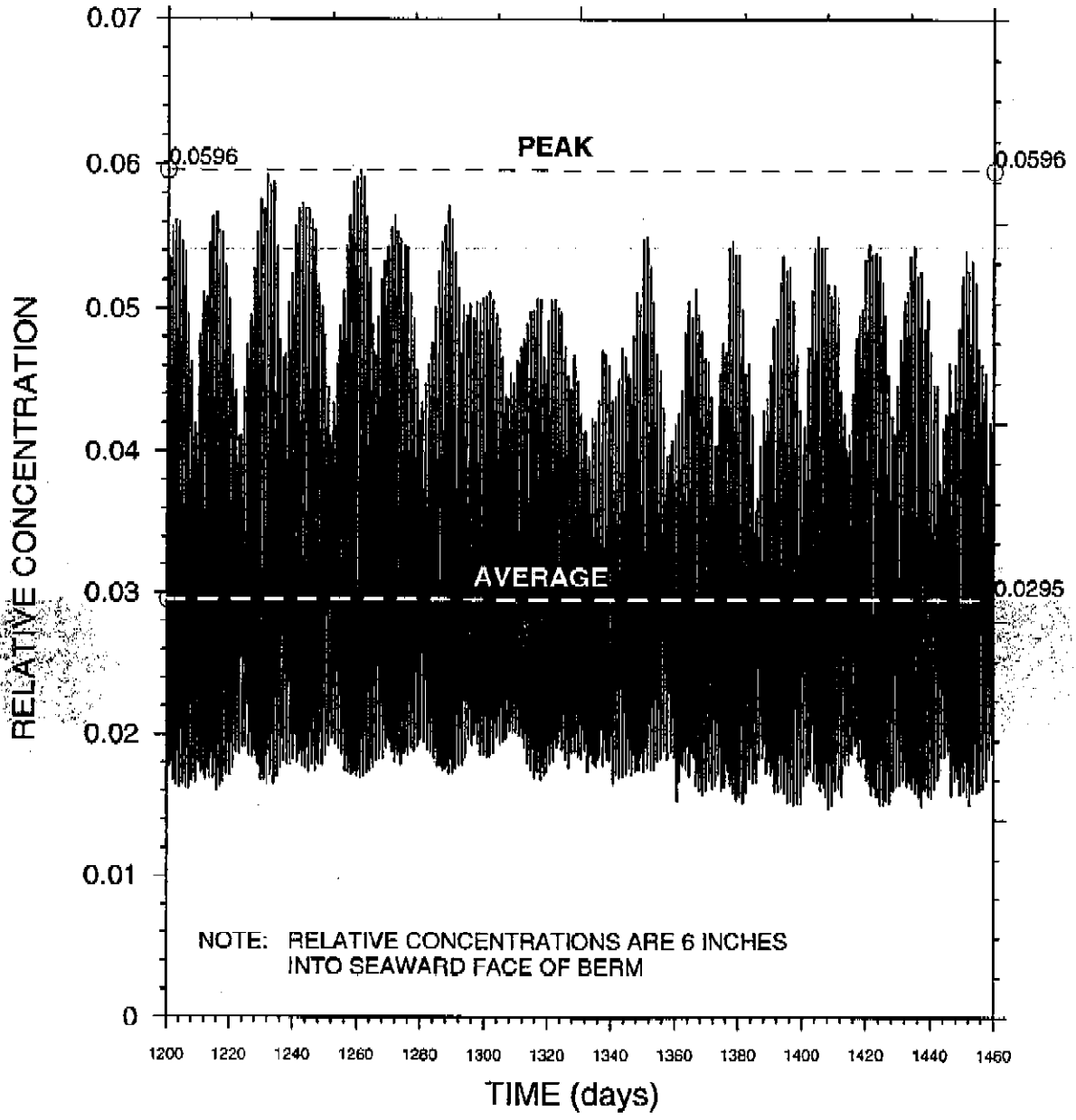

figure 37
REVISED BASE CASE
BERM/FILL K MULTIPLIED BY 2
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

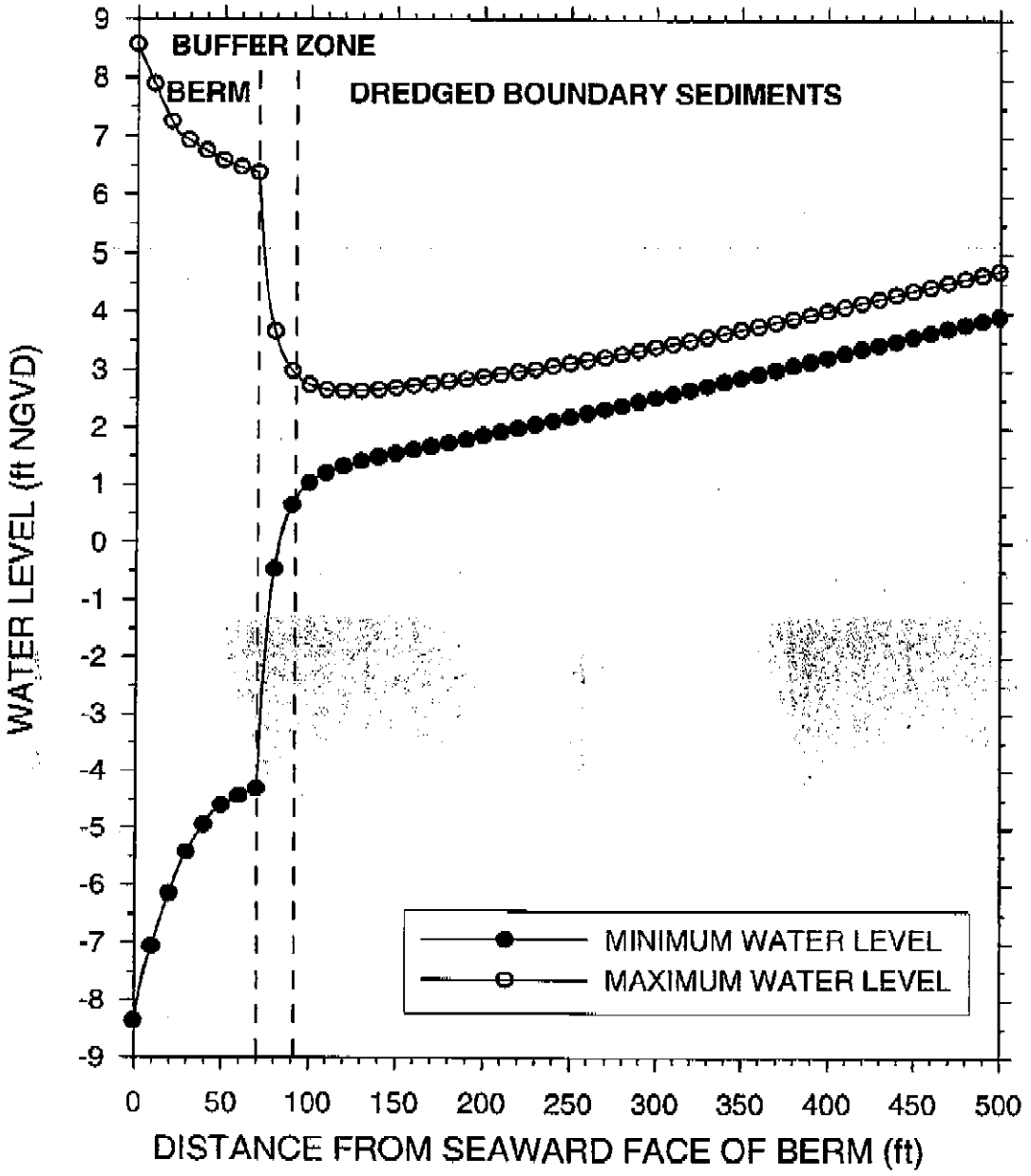

figure 38
REVISED BASE CASE
BUFFER FILL/SEDIMENT FILL K DIVIDED BY 2
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

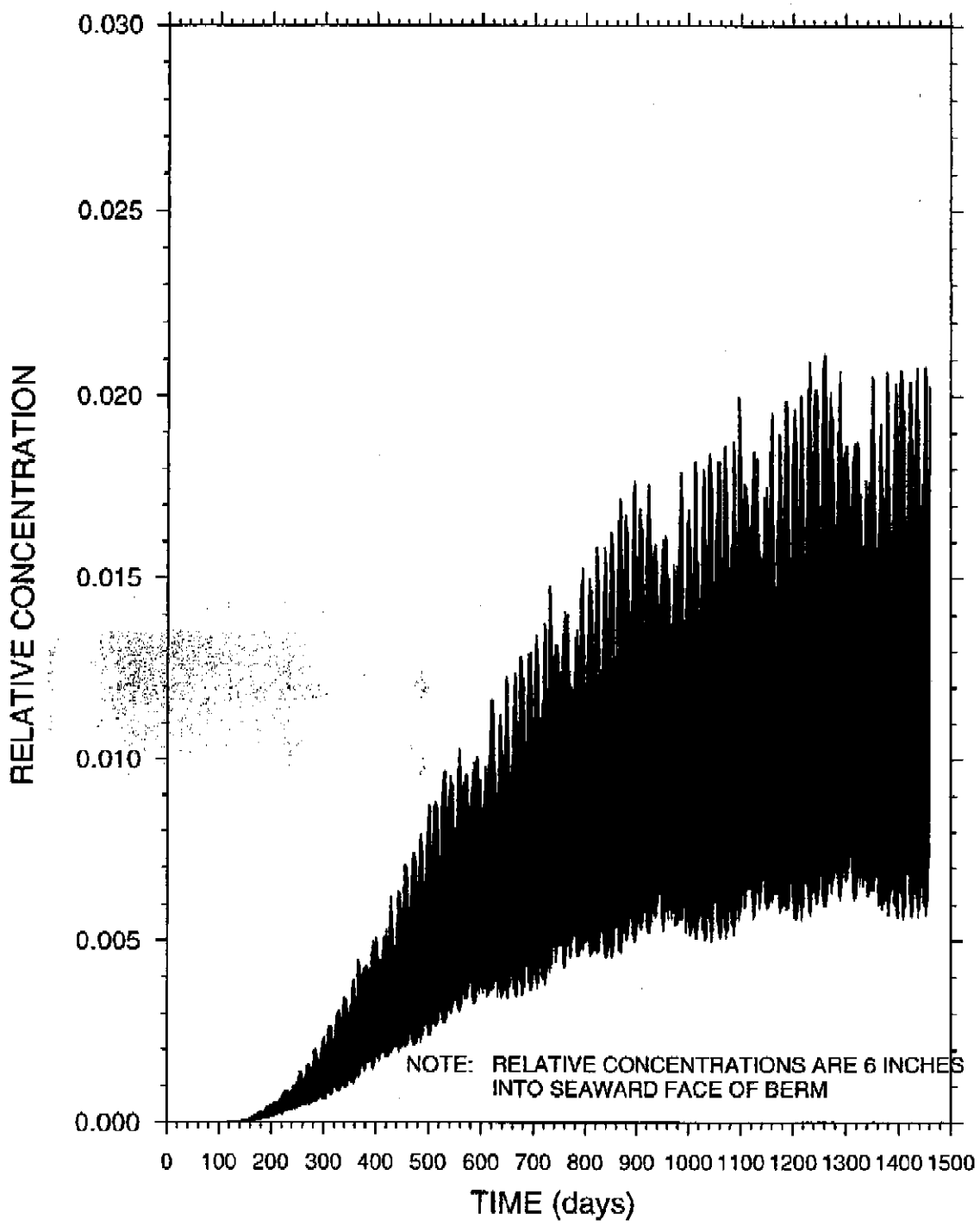

figure 39

REVISED BASE CASE
BUFFER FILL/SEDIMENT FILL K DIVIDED BY 2
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen5t-figure44.grf) MAY 19/99

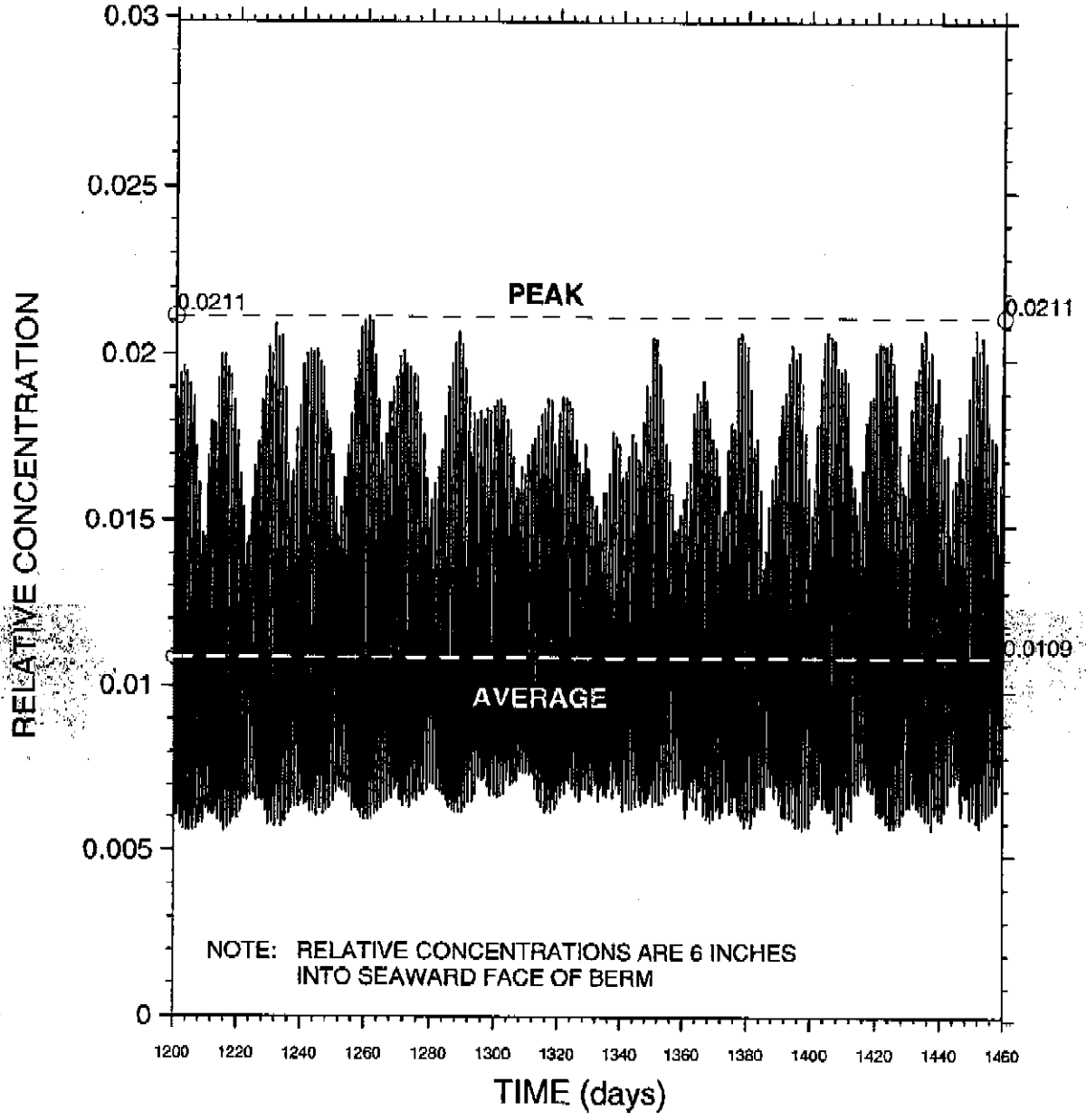

figure 40
REVISED BASE CASE
BUFFER FILL/SEDIMENT FILL K DIVIDED BY 2
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

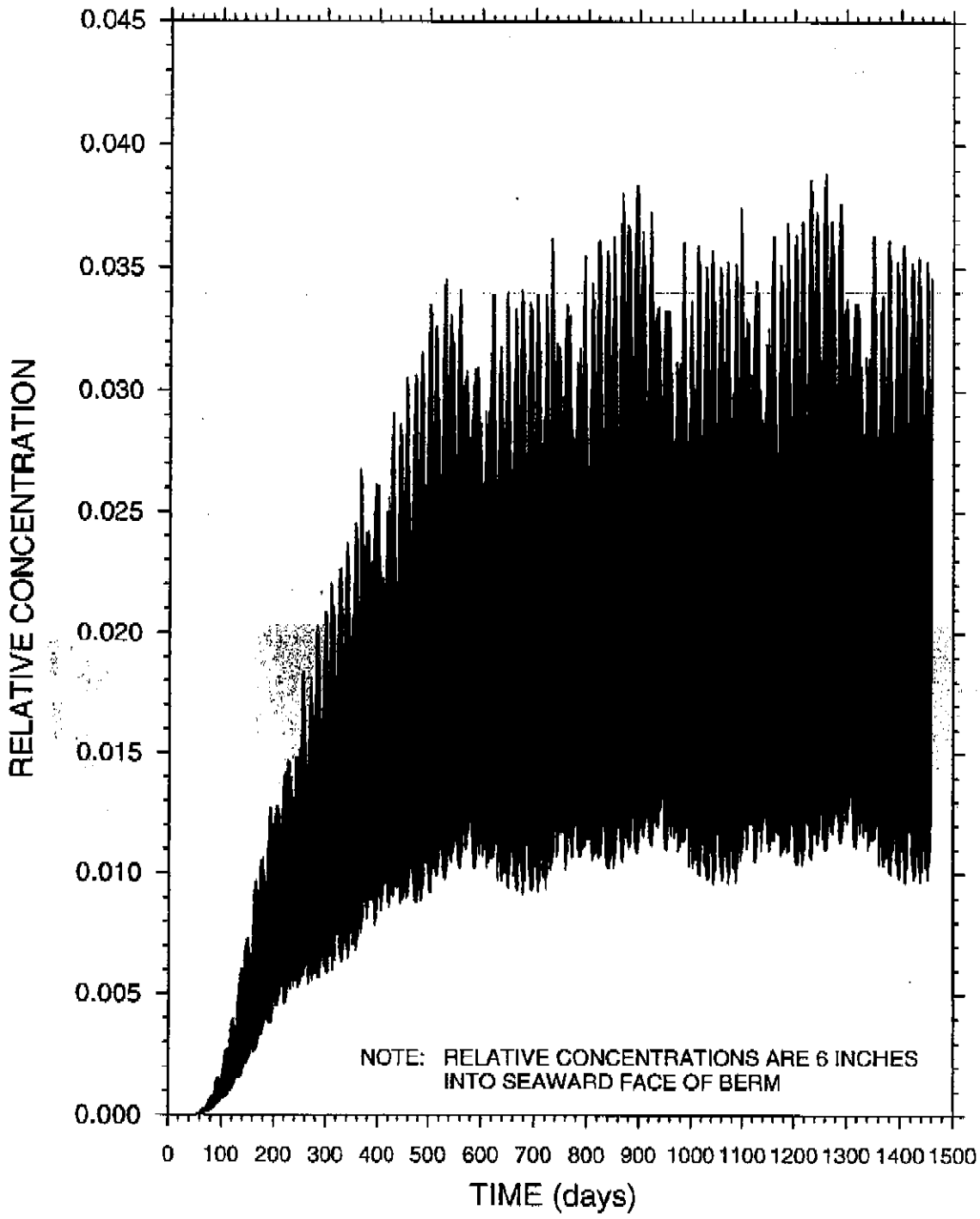

figure 41
REVISED BASE CASE
BUFFER FILL/SEDIMENT FILL POROSITY OF 40%
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen6t-figure44.grf) MAY 19/99

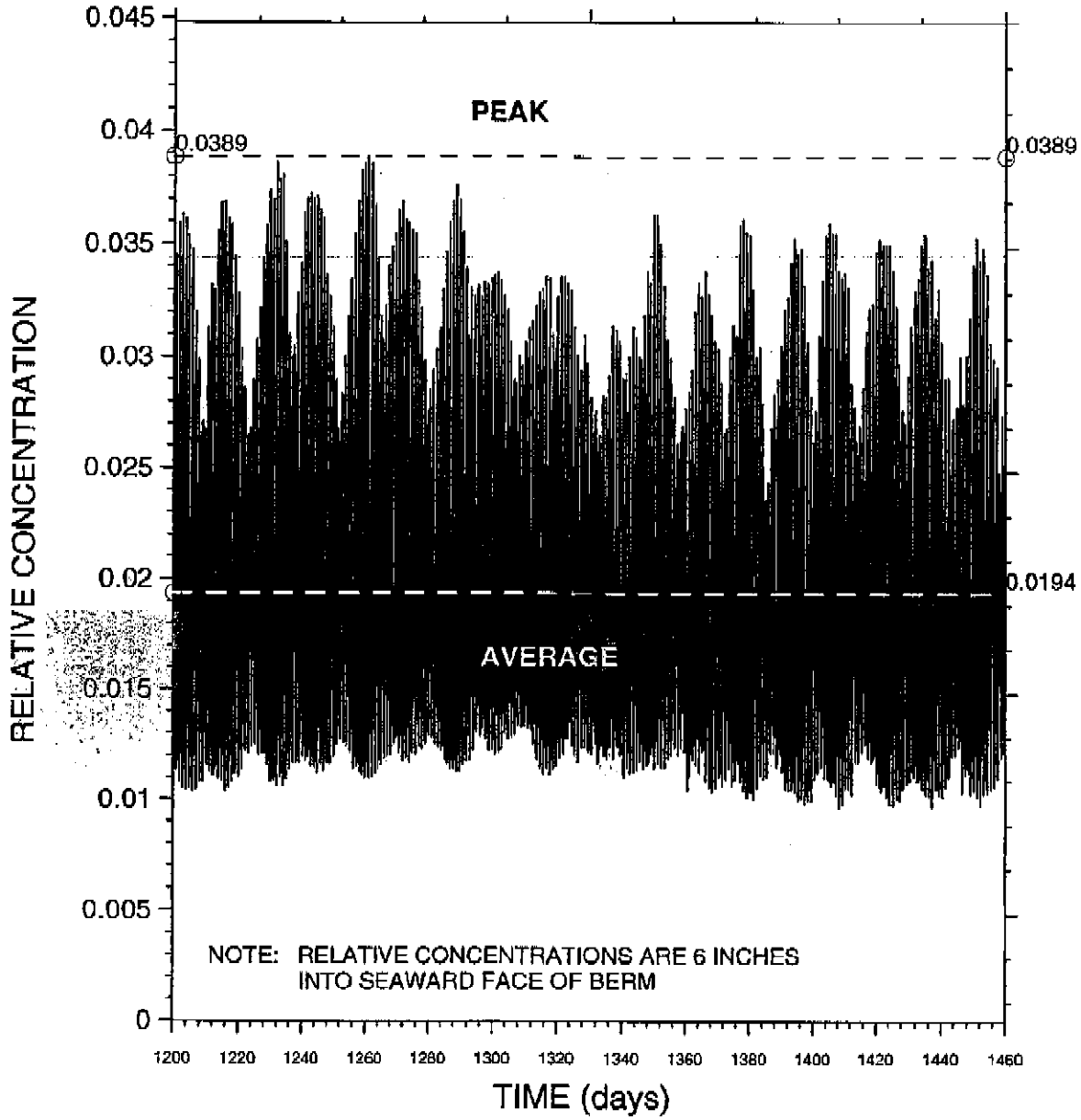

figure 42
REVISED BASE CASE
BUFFER FILL/SEDIMENT POROSITY OF 40%
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen6t-figure45.grf) MAY19/99

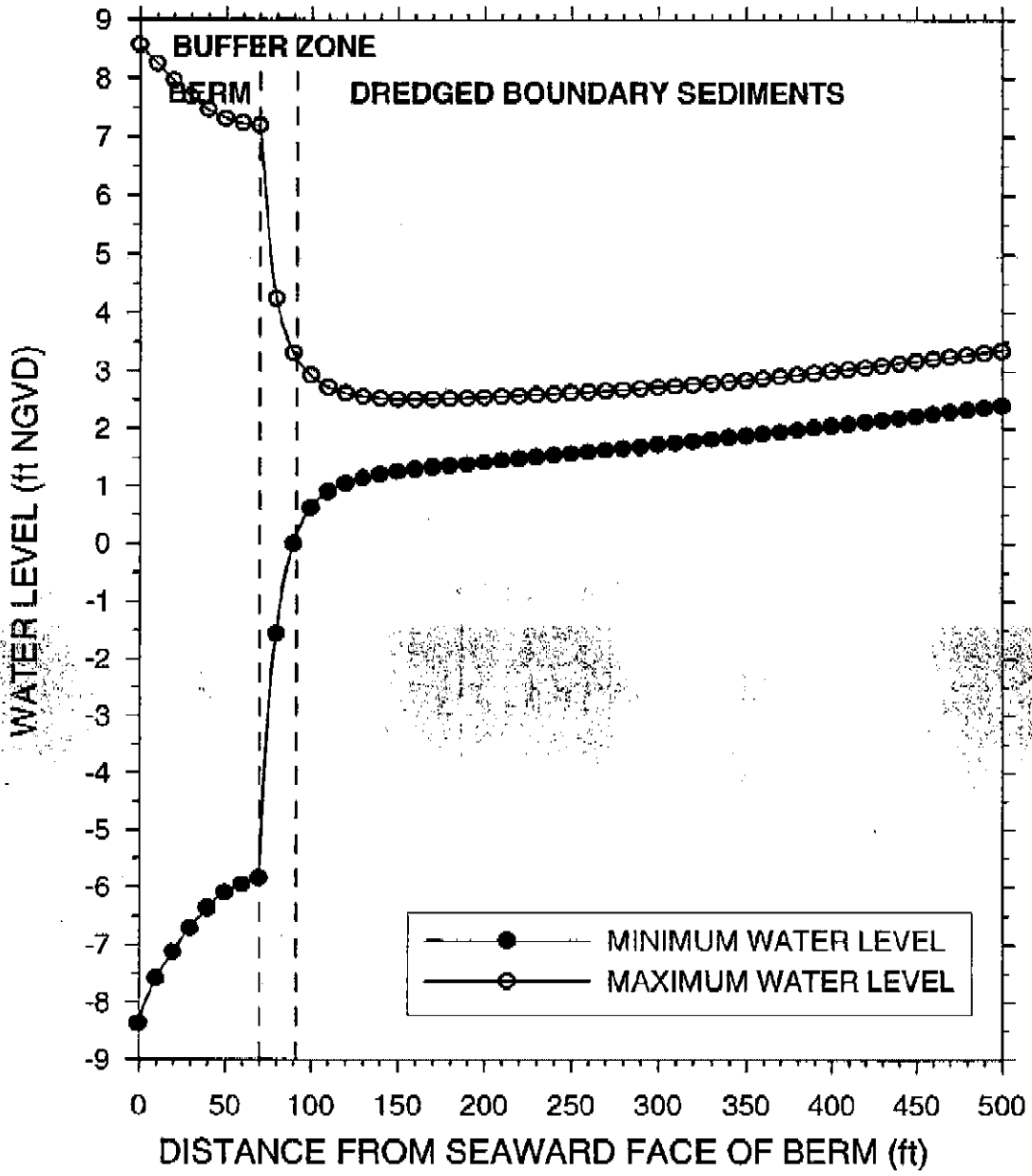

figure 43
REVISED BASE CASE
BERM K MULTIPLIED BY 2
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen8-figure42.grf) MAY 19/99

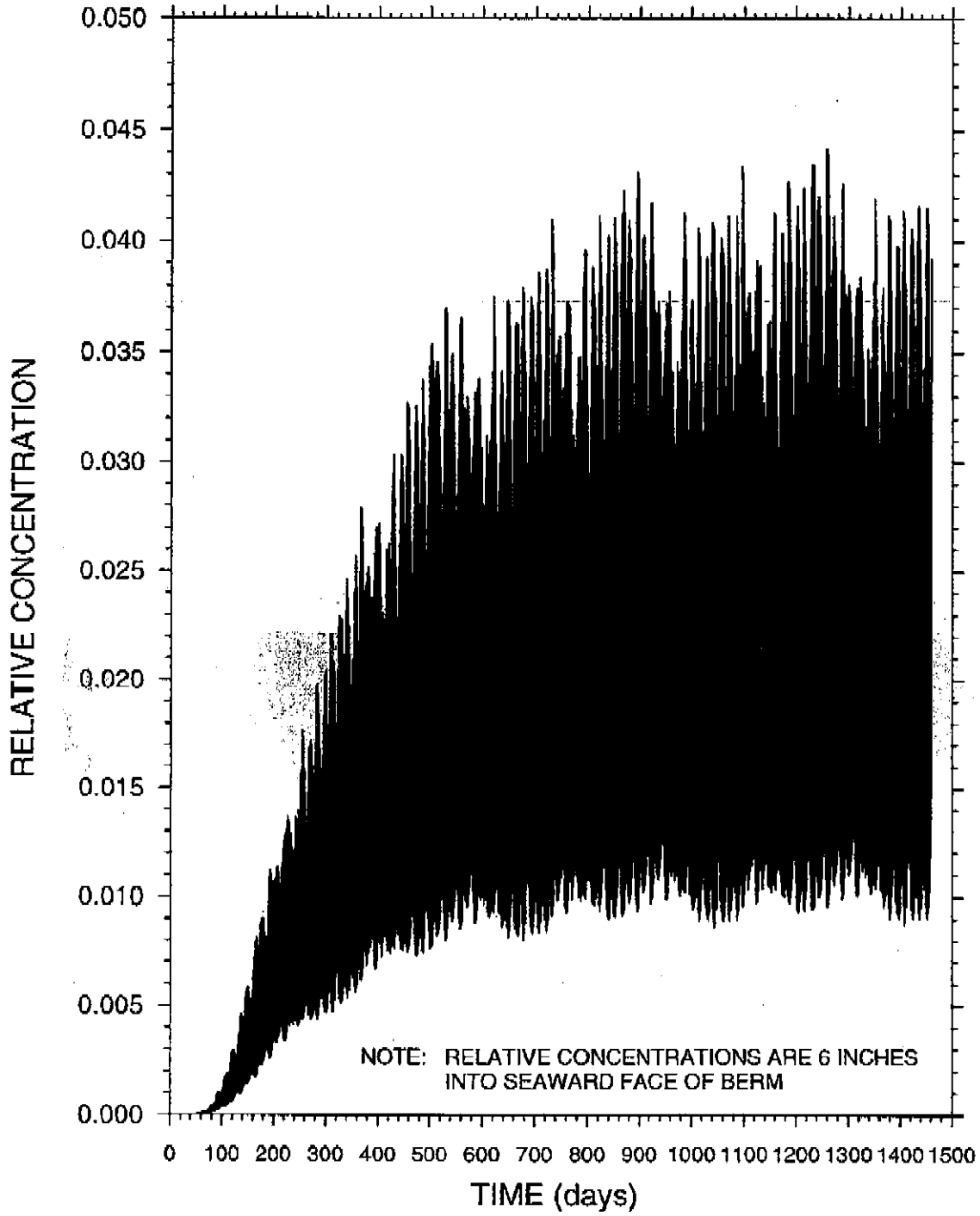

figure 44
REVISED BASE CASE
BERM K MULTIPLIED BY 2
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

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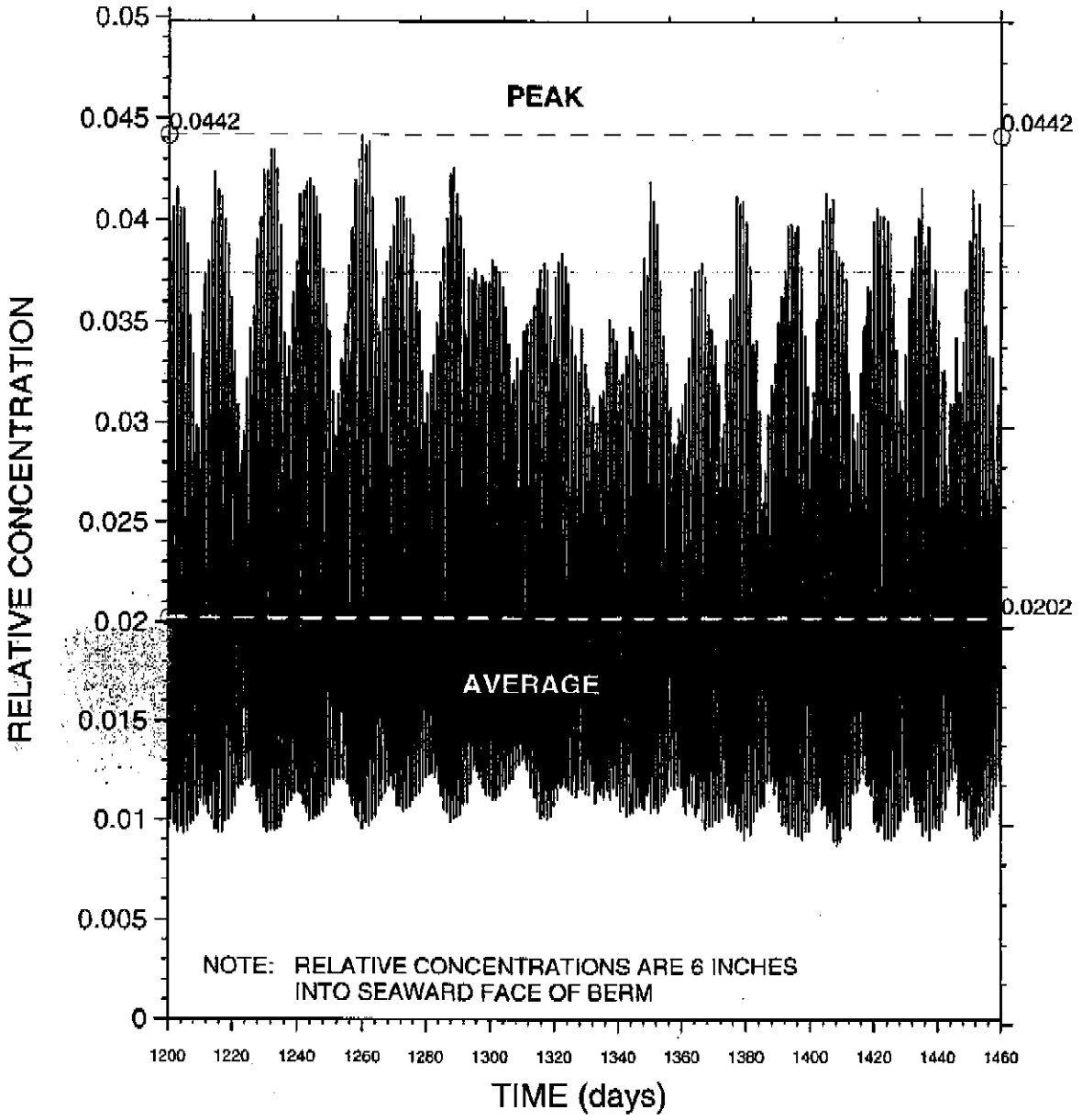

figure 45
REVISED BASE CASE
BERM K MULTIPLIED BY 2
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

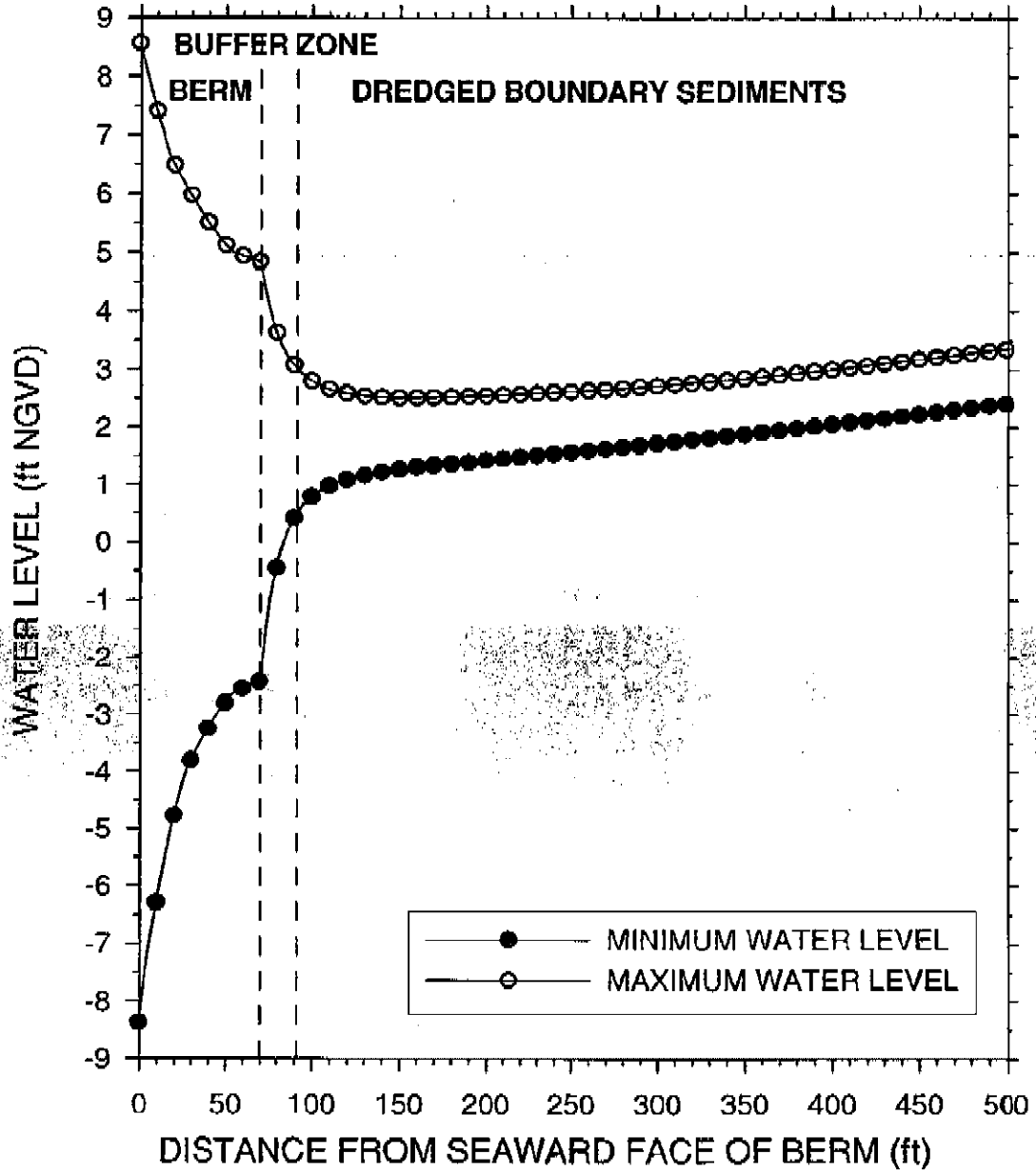

figure 46
REVISED BASE CASE
BERM K DIVIDED BY 2
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

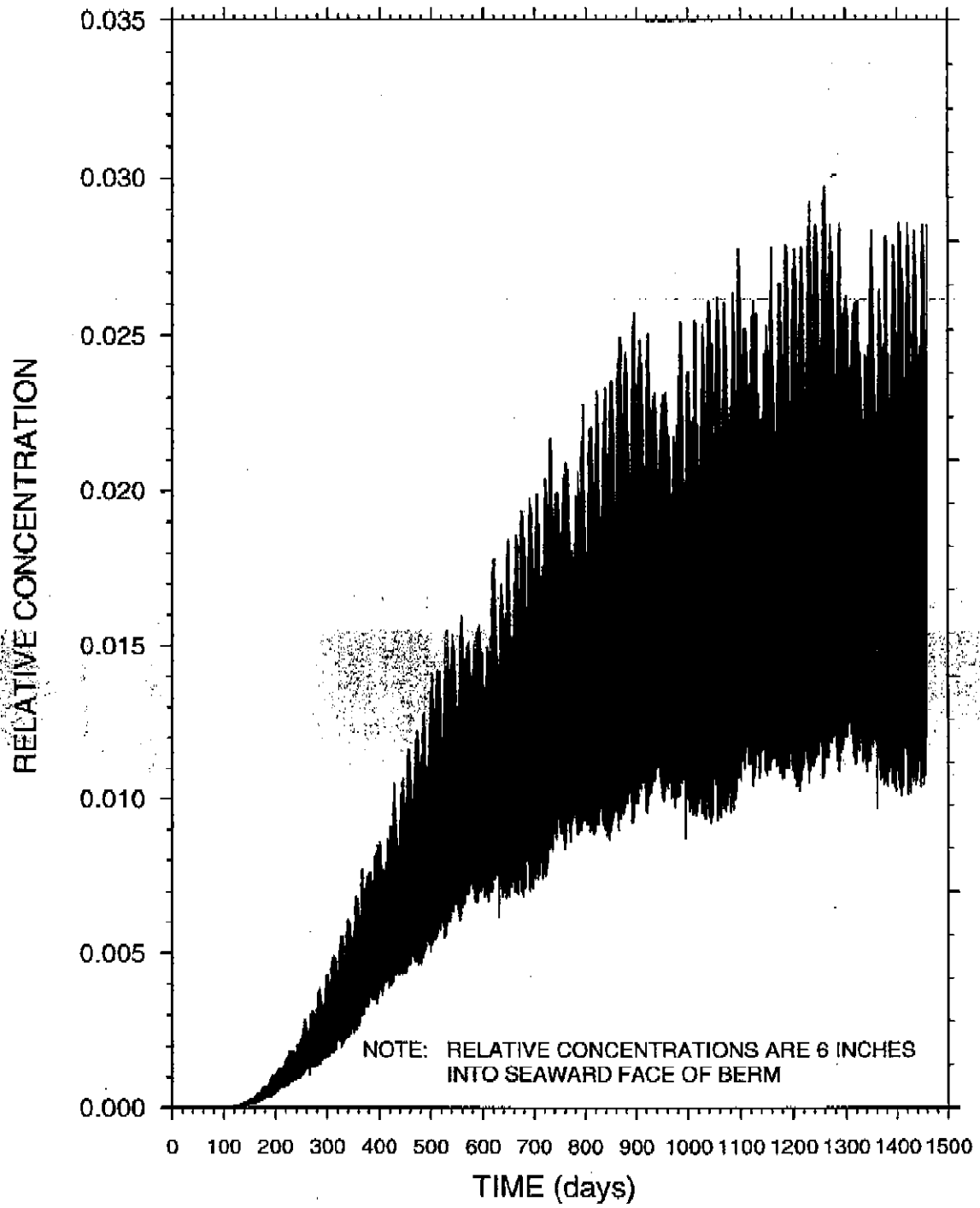

figure 47
REVISED BASE CASE
BERM K DIVIDED BY 2
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen9t-figure44.grf) MAY 19/99

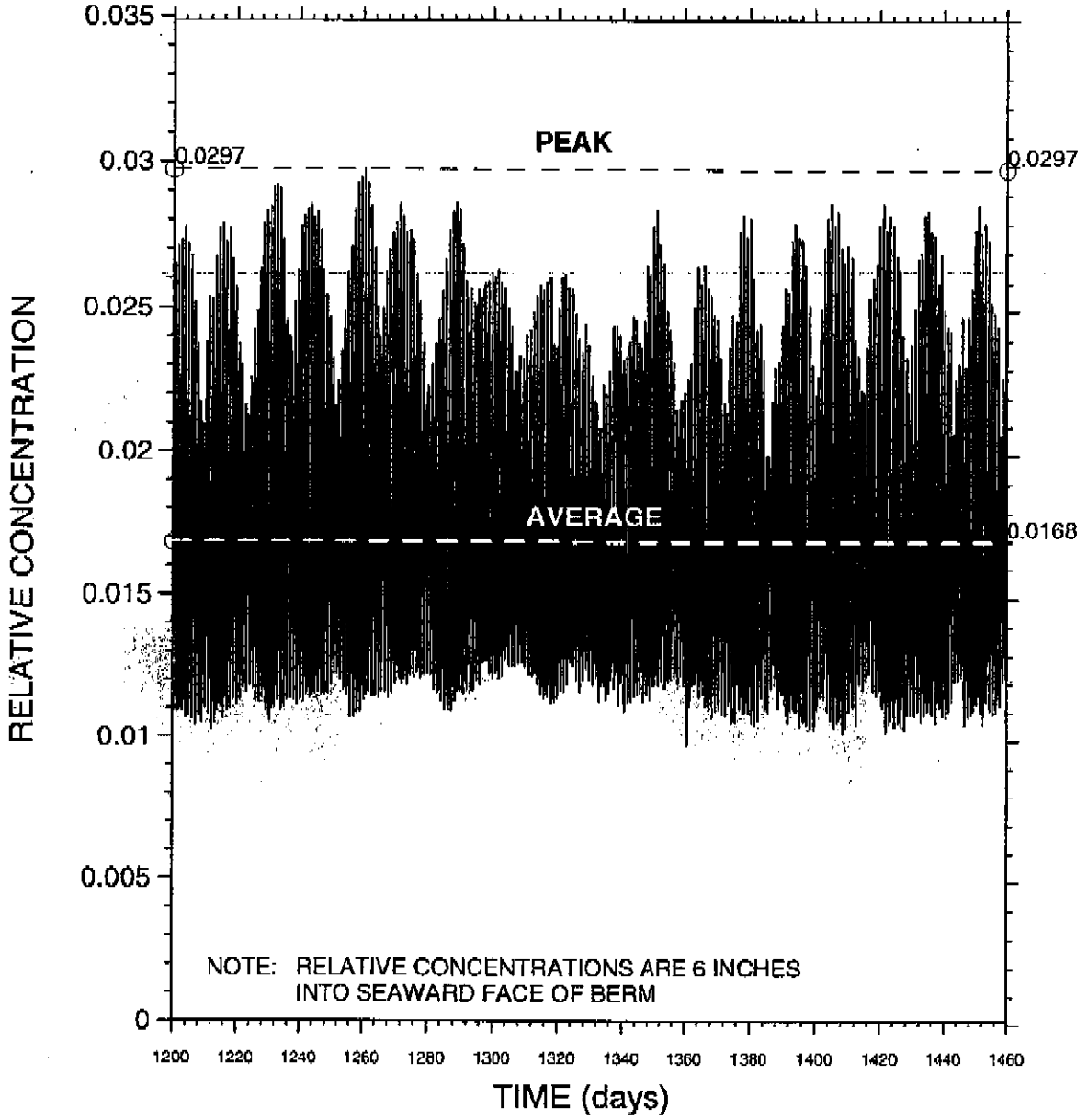

figure 48
REVISED BASE CASE
BERM K DIVIDED BY 2
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

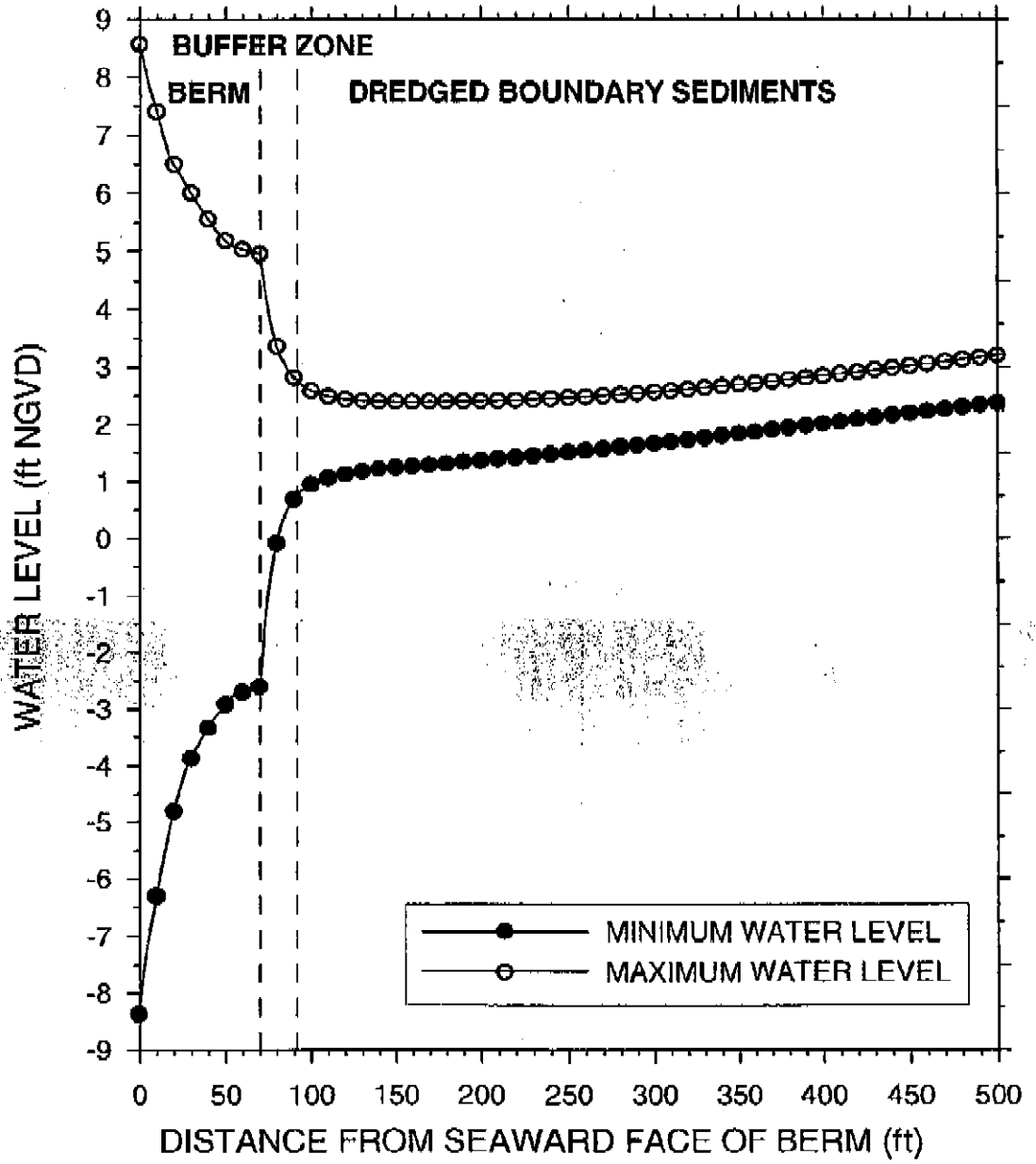

figure 49
REVISED BASE CASE
BERM/BUFFER FILL/SEDIMENT FILL Sy MULTIPLIED BY 2
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen10-figure42.grf) MAY 19/99

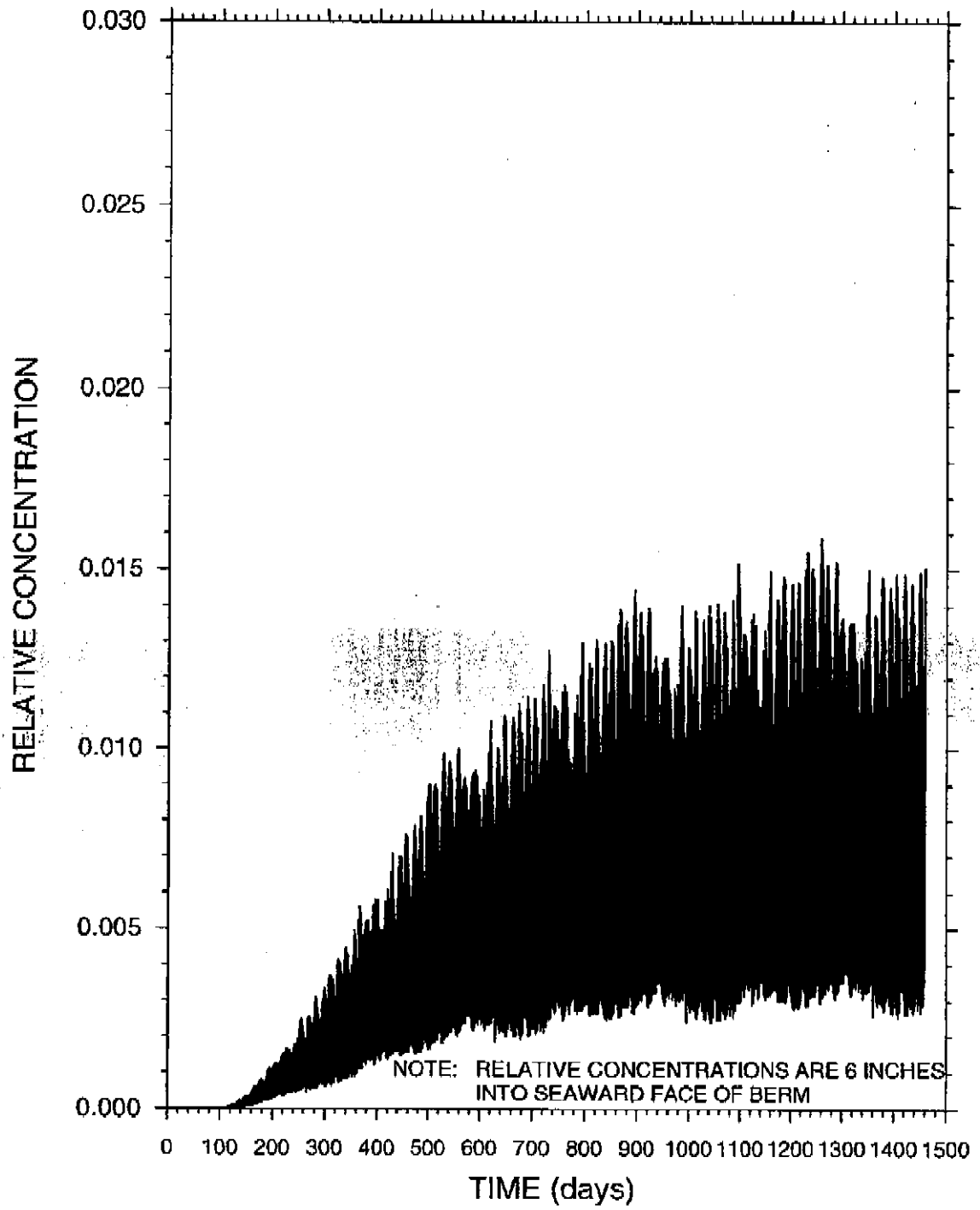

figure 50
REVISED BASE CASE
BERM/BUFFER FILL/SEDIMENT FILL Sy MULTIPLIED BY 2
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

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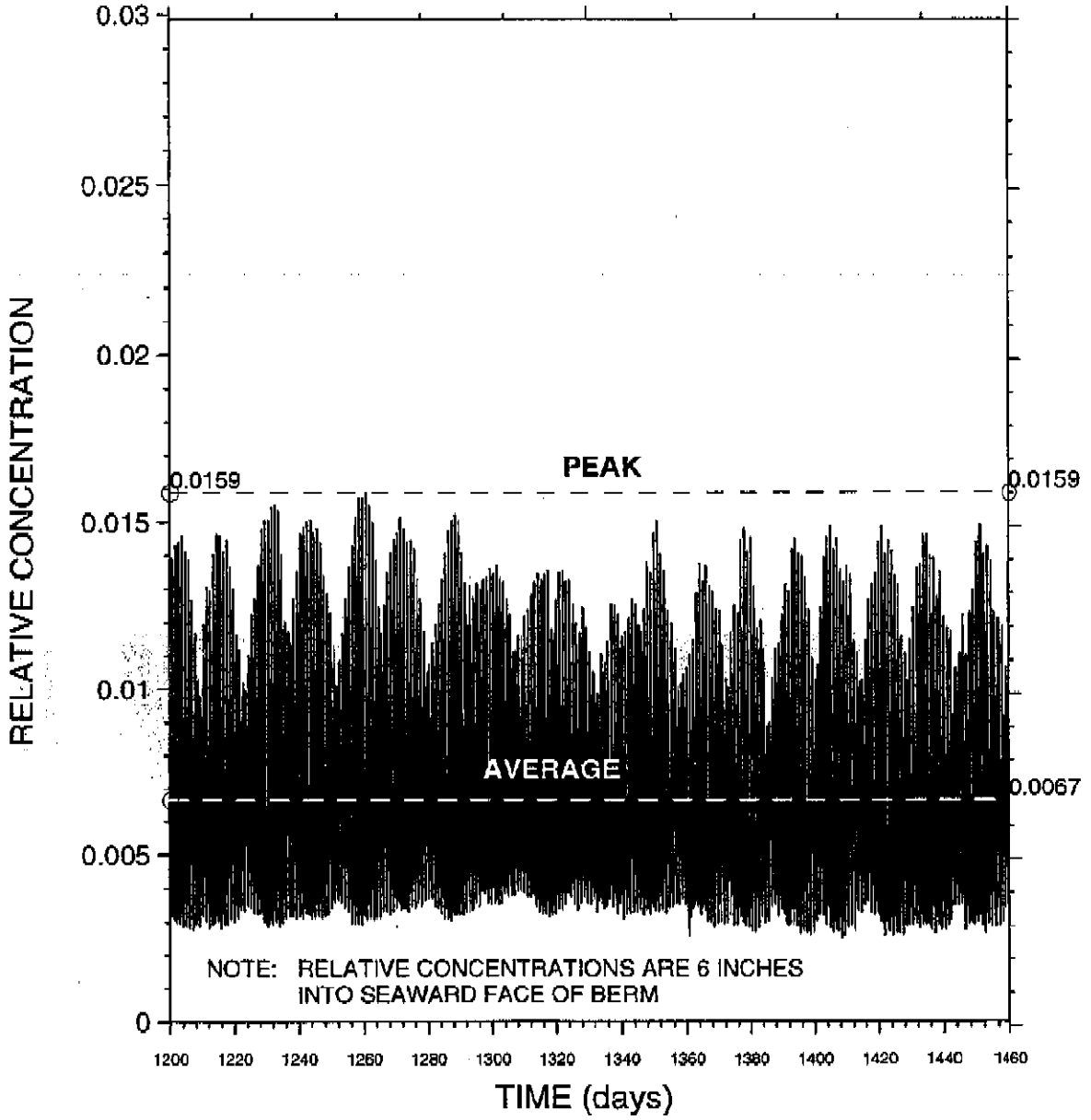

figure 51
REVISED BASE CASE
BERM/BUFFER FILL/SEDIMENT FILL MULTIPLIED BY 2
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

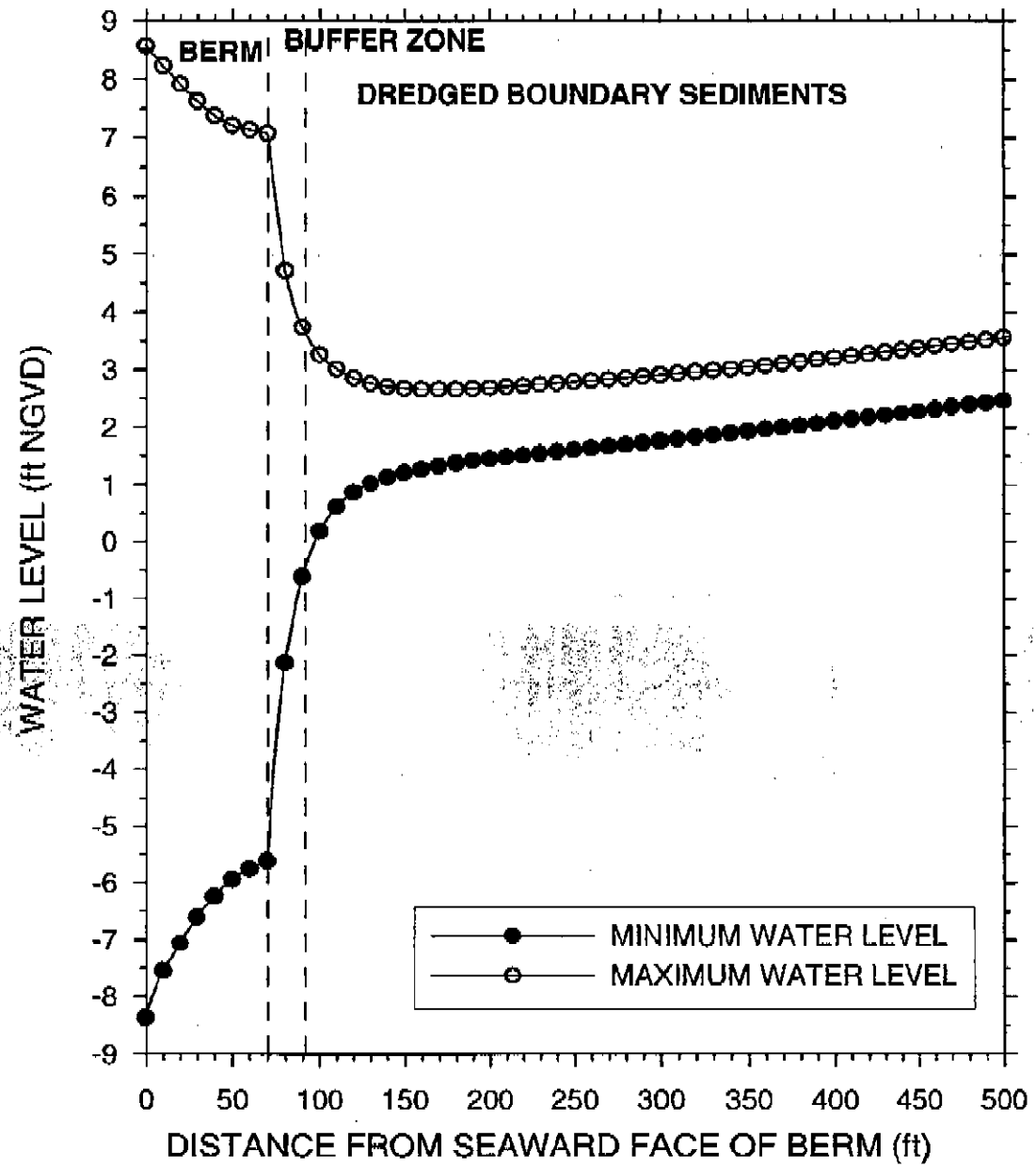

figure 52
REVISED BASE CASE
BERM/BUFFER FILL/SEDIMENT FILL Sy DIVIDED BY 2
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen11-figure42.grf) MAY 19/99

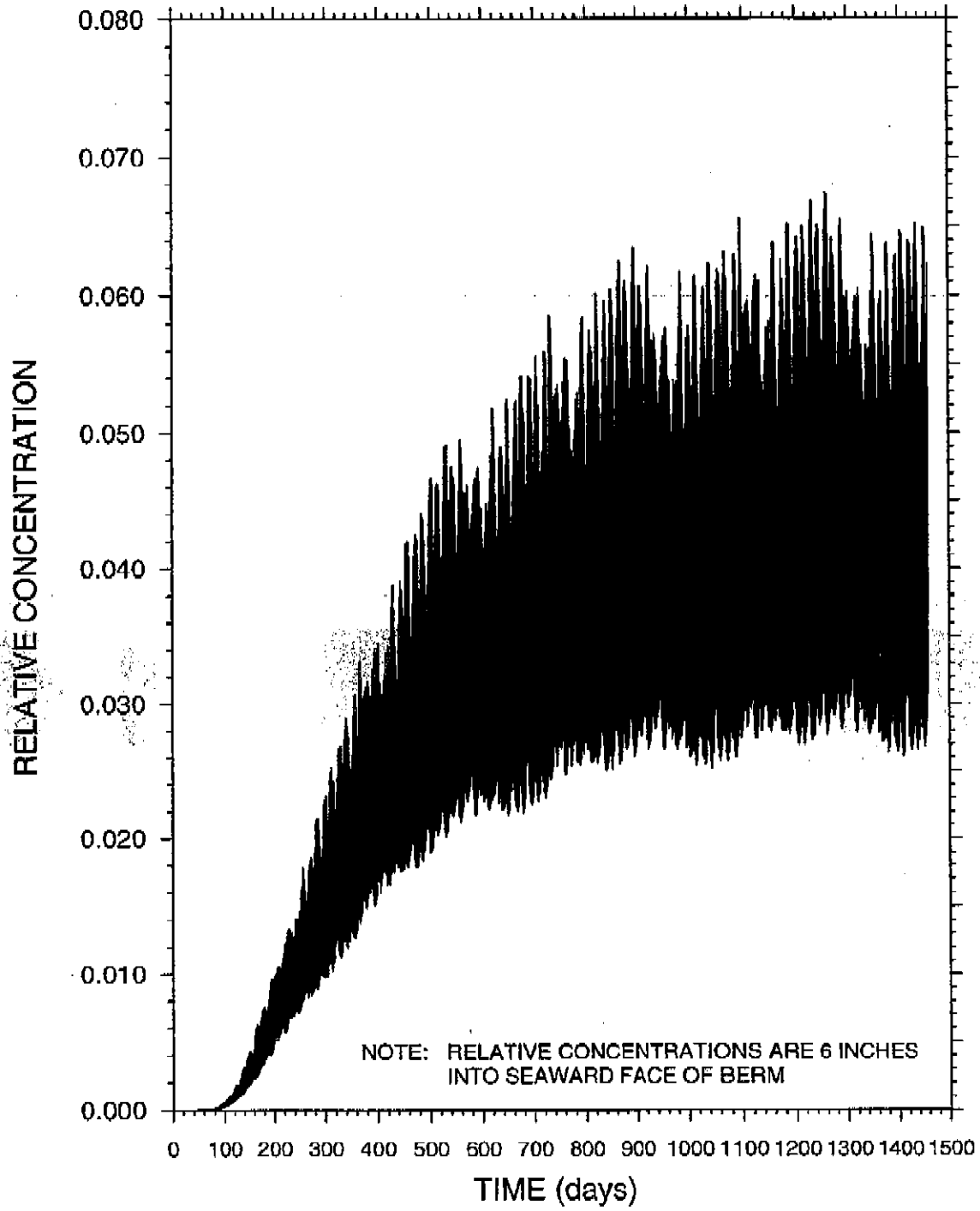

figure 53
REVISED BASE CASE
BERM/BUFFER FILL/SEDIMENT FILL Sy DIVIDED BY 2
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

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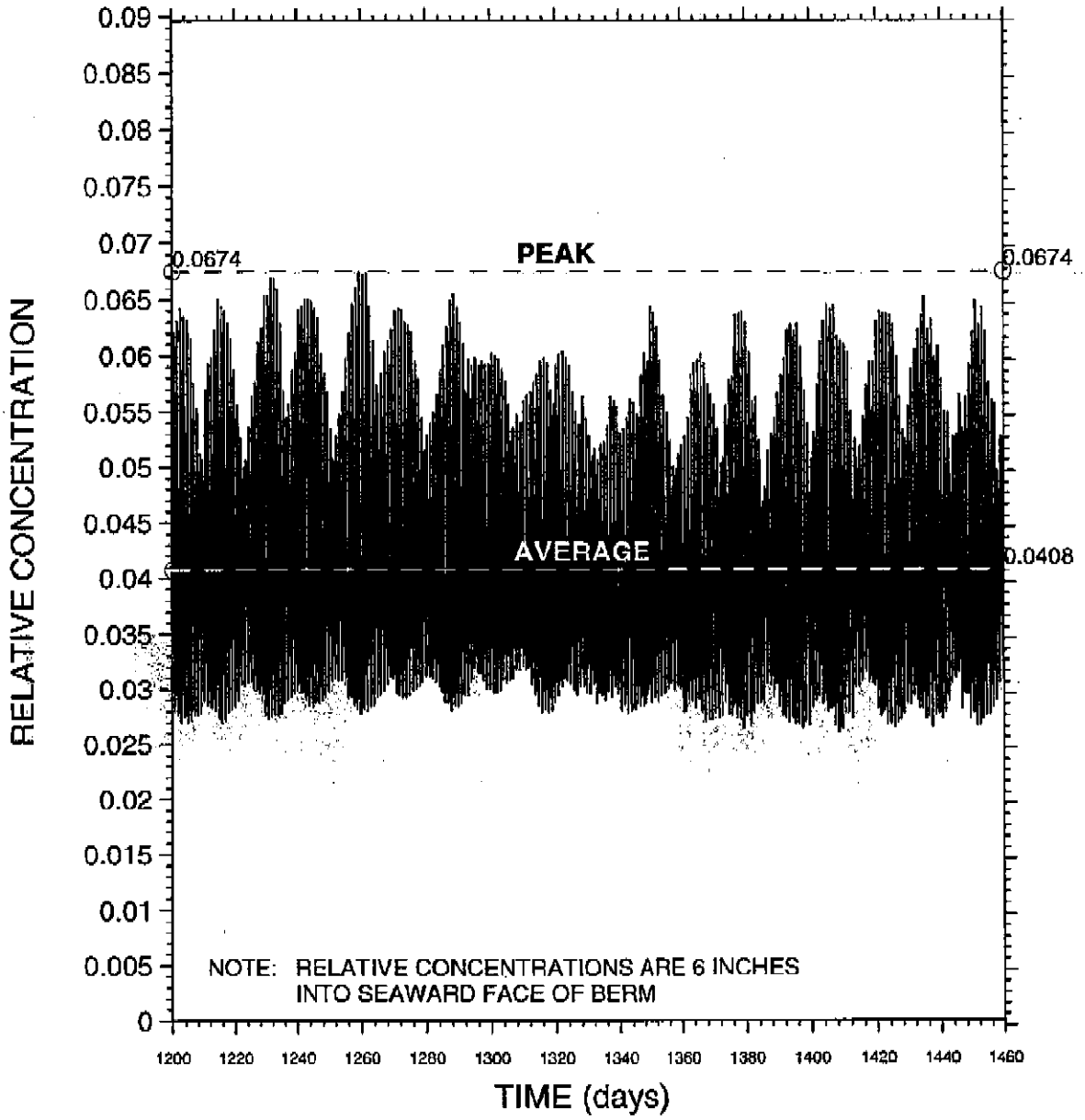

figure 54
REVISED BASE CASE
BERM/BUFFER FILL/SEDIMENT FILL Sy DIVIDED BY 2
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

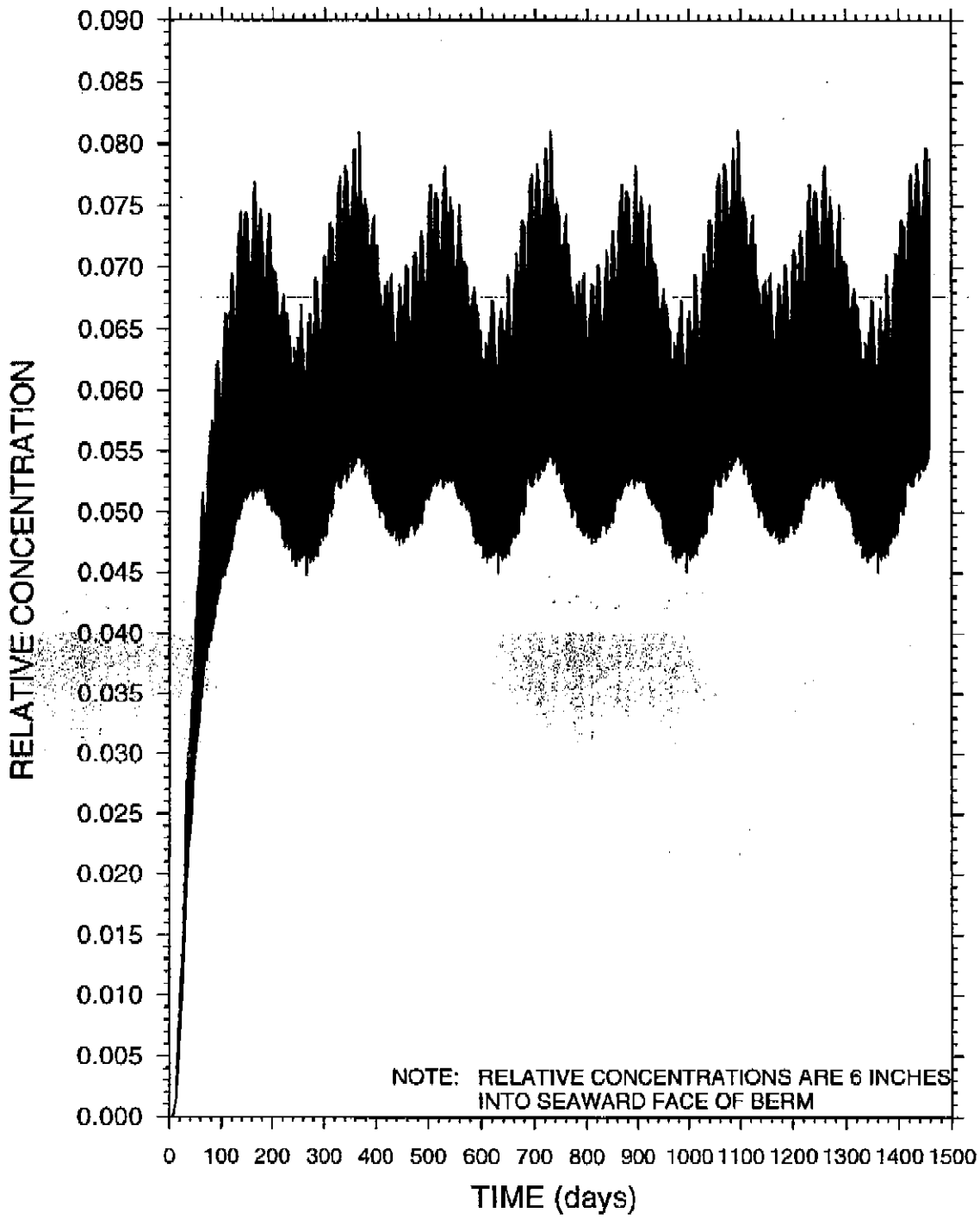

figure 55
REVISED BASE CASE
LONGITUDINAL DISPERSIVITY MULTIPLIED BY 10
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen13t-figure44.grf) MAY 19/99

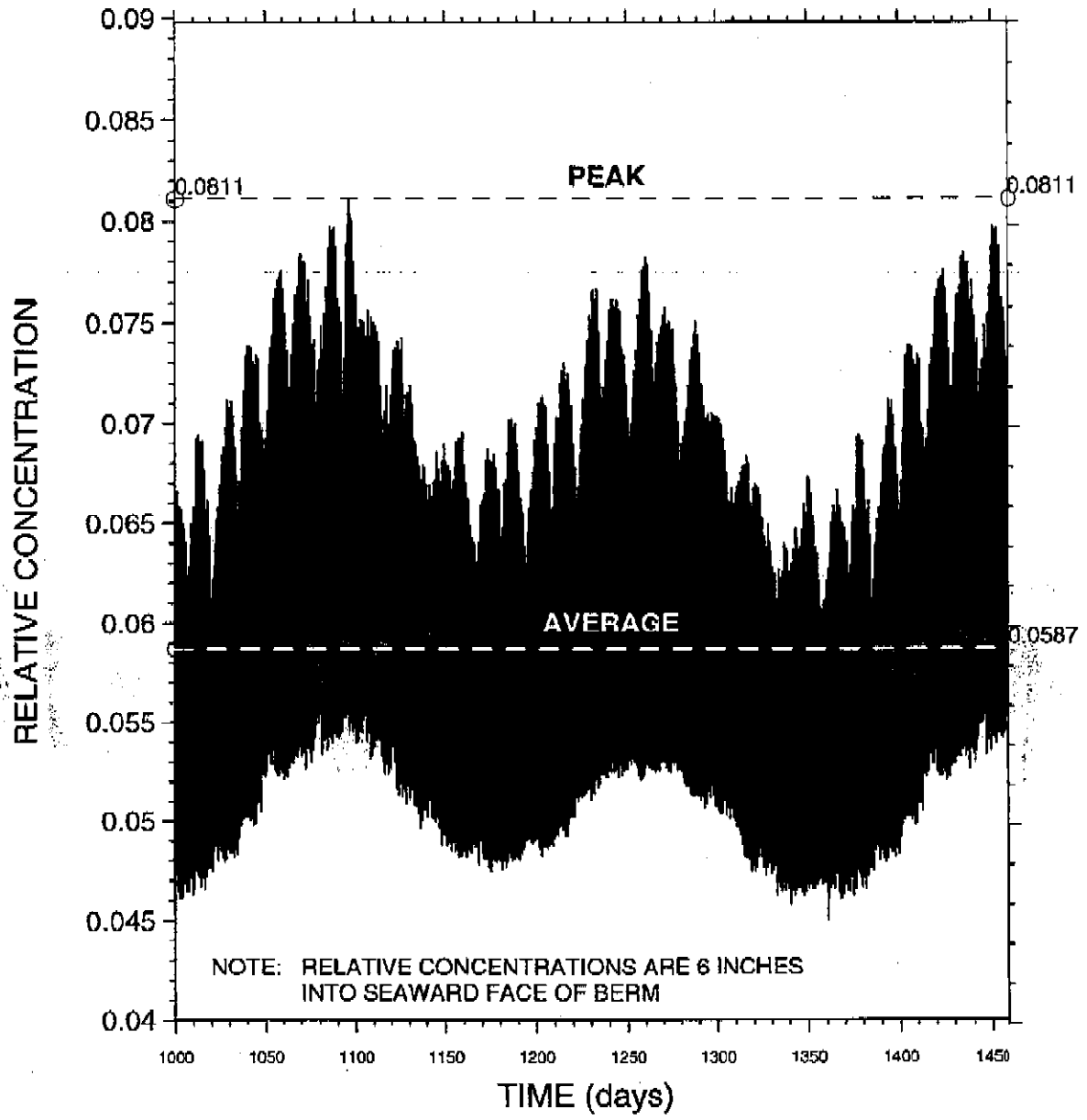

figure 56
REVISED BASE CASE
LONGITUDINAL DISPERSIVITY MULTIPLIED BY 10
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen13t-figure45.grf) MAY19/99

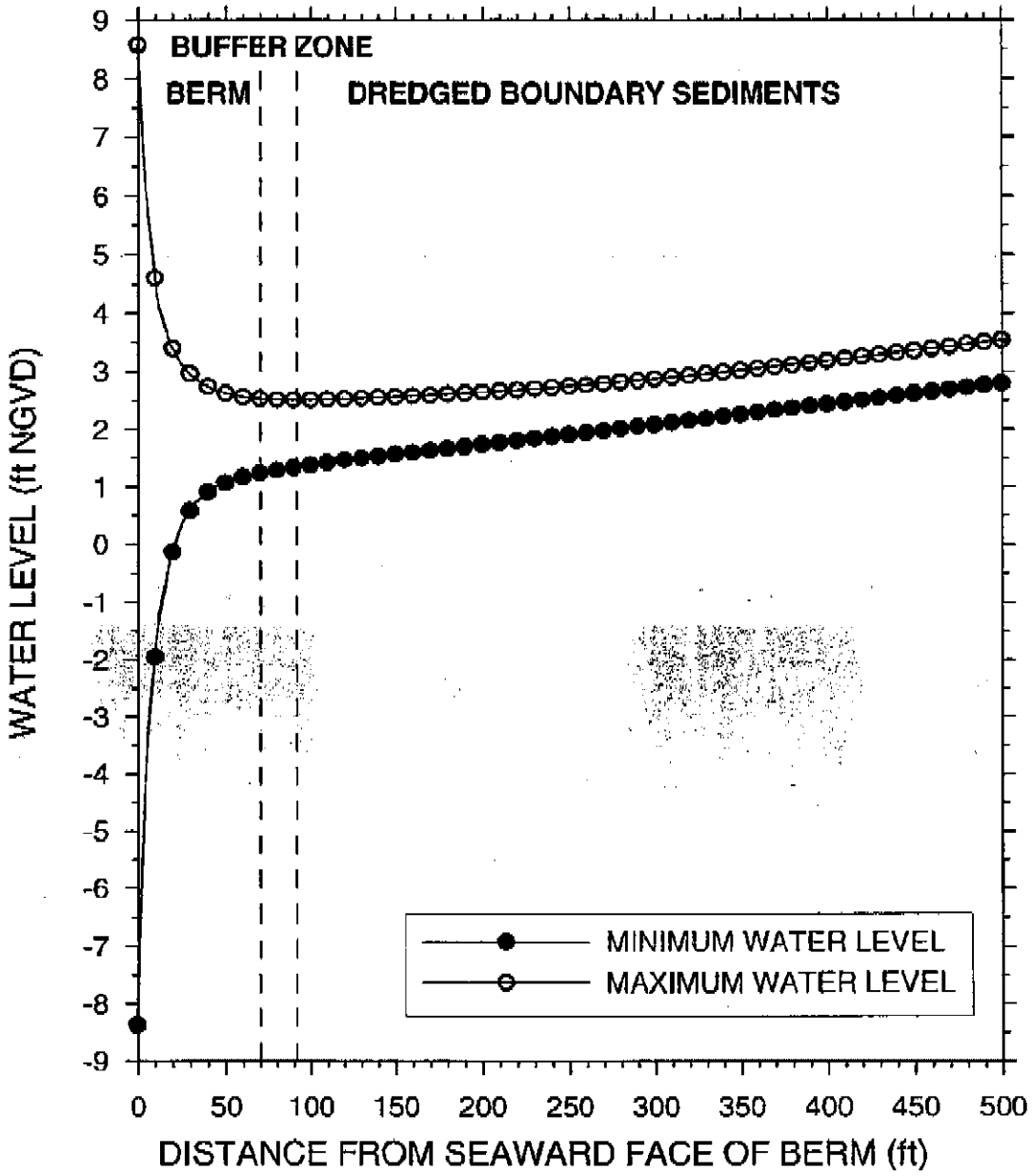

figure 57
REVISED BASE CASE
BERM K REDUCED TO REGIONAL K
PREDICTED TIDE INDUCED WATER LEVEL FLUCTUATIONS
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

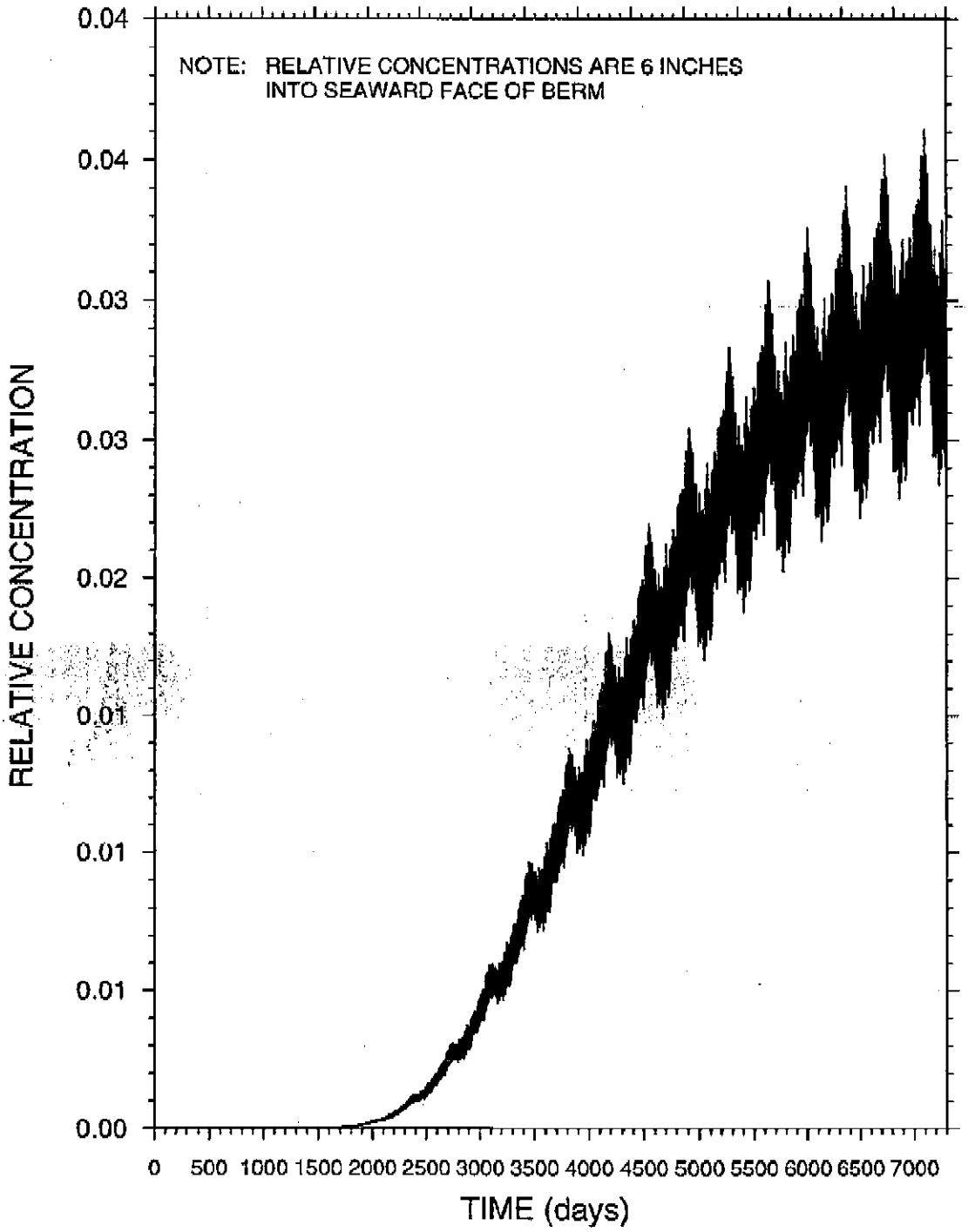

figure 58
REVISED BASE CASE
BERM K REDUCED TO REGIONAL K
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

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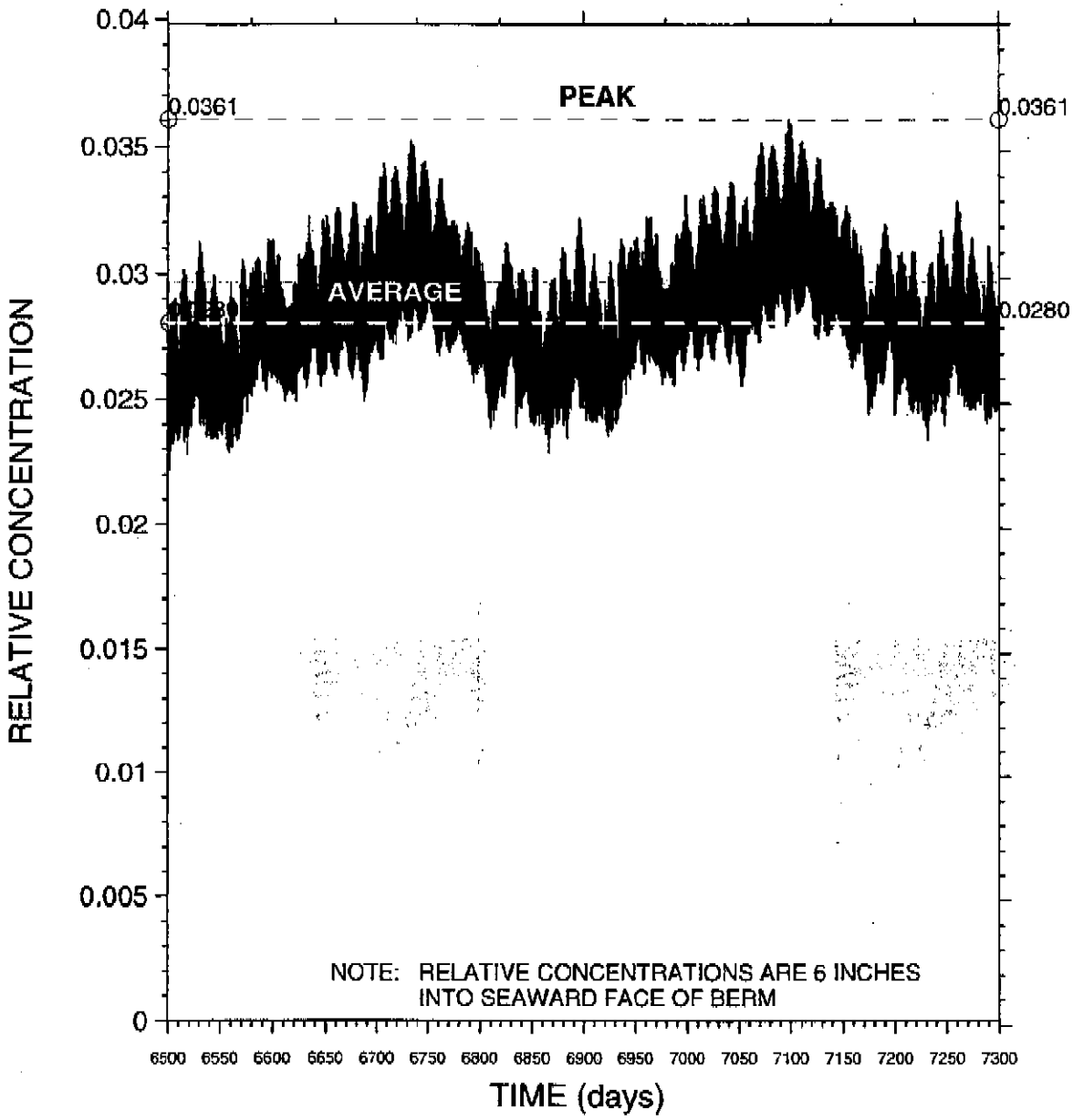

figure 59
REVISED BASE CASE
BERM K REDUCED TO REGIONAL K
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(memo017) WA-HYD (N:\HEG\7431\cdf\model6\r8base\r8sen14-figure45.grf) MAY20/99

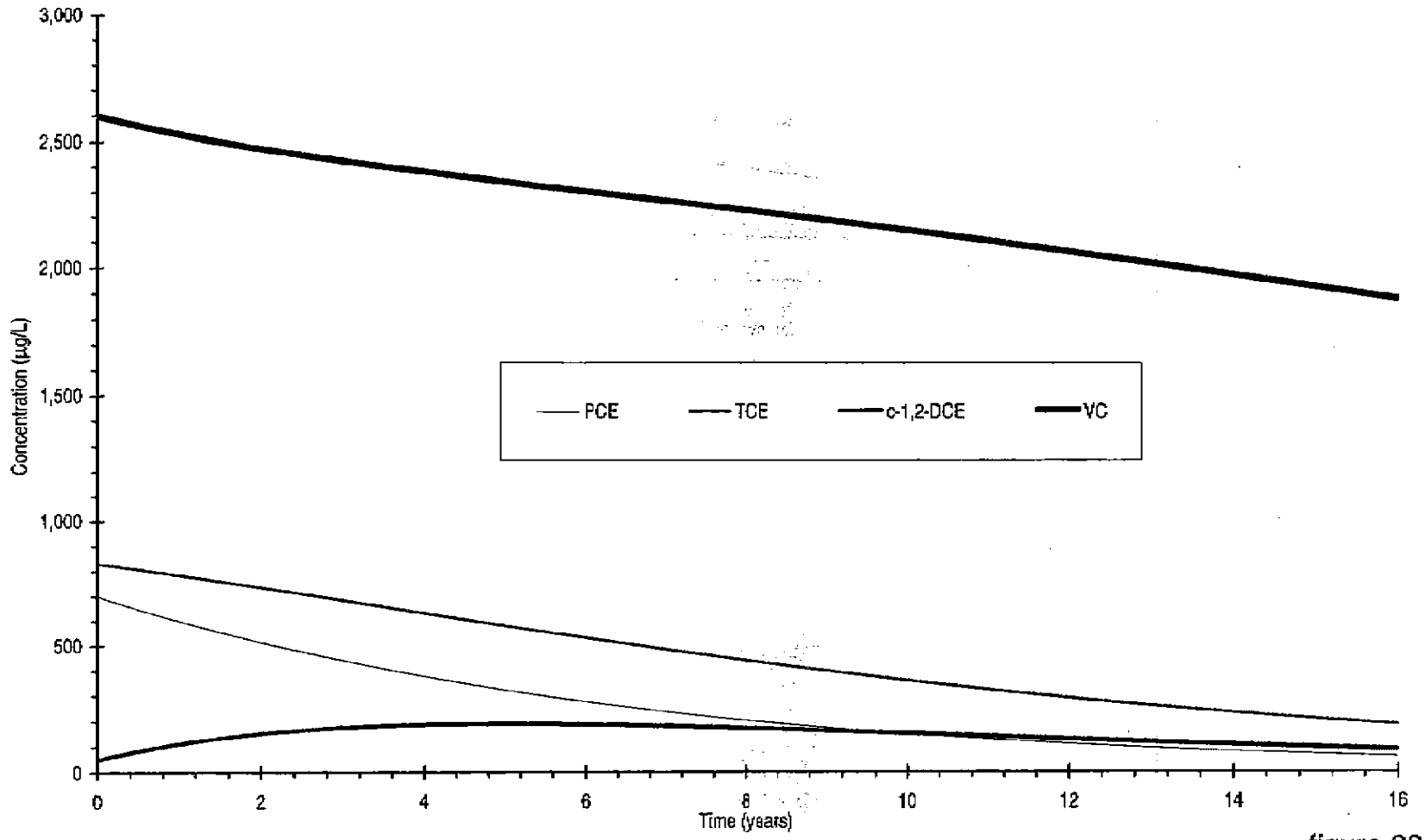

figure 60

FIRST ORDER BIODEGRADATION OF PCE TO TCE TO c-1,2-DCE TO VC

CDF MODELING

OCC TOCOMA

Tacoma, Washington

CRA

07431-00(MEMO017)GN-W-HYD (n:\hegi\7431\cdf\model6\r8base\7431-firstorder-pce-tce-cdce-vc.xls) MAY 19/99

4-24-03;11:33AM;CRA BATHURST MA N ;5197251394 # 73/ 75

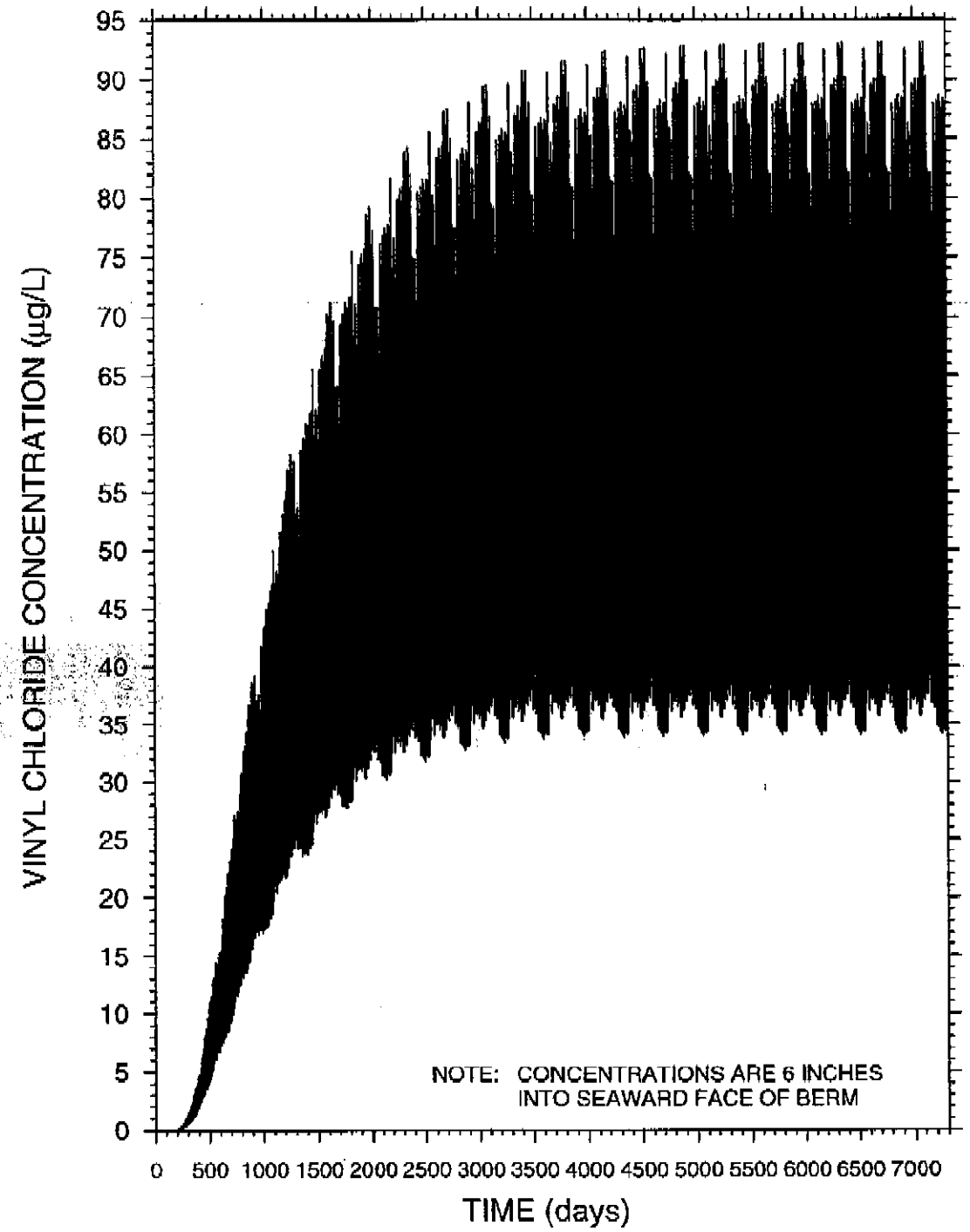

figure 61

REVISED BASE CASE
20-YEAR VINYL CHLORIDE MIGRATION WITH RETARDATION AND BIODEGRADATION
BUFFER ZONE LENGTH OF 20 FEET
PREDICTED CONCENTRATION AT SEAWARD FACE OF BERM
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA

07431-00(MEMO017) WA-HYD (N:\HEG\7431\cdf\model6\ret-biodeg\r8vc200Y-figure44.grf) MAY 18/99

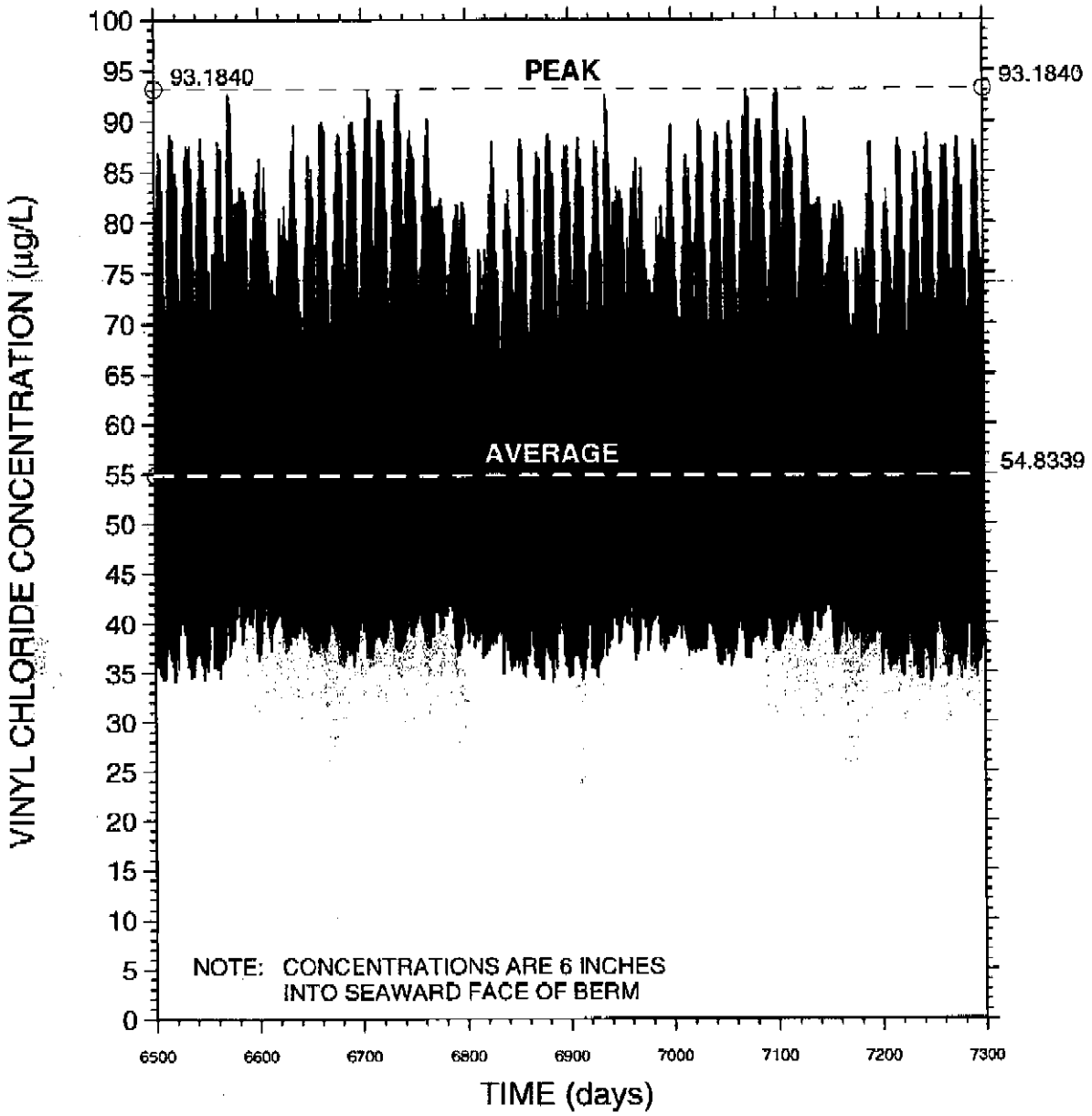

figure 62

REVISED BASE CASE
20-YEAR VINYL CHLORIDE MIGRATION WITH RETARDATION AND BIODEGRADATION
CONCENTRATION AT SEAWARD FACE (EXPANDED SCALE)
CDF MODELING
OCC TACOMA
Tacoma, Washington

CRA