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Conclusions

The ASDM model can be used to identify potential sources or sinks of contaminants among three compartments (air, water, and sediment), and to quantify contaminant loading rates from air/ water diffusion, dry deposition, wet deposition, water/ sediment diffusion, suspended solid settling, sediment resuspension and burial in the river system. The major sources for Mercury in the Detroit River water column are upstream input (50%), CSOs (43%), and the DWWTP (5%). The major sinks for Mercury in the Detroit River water column are downstream output (94%) deposition to sediment (4%), and volatilization to air (2%). So the Detroit River water column is a source of Mercury for Lake Erie, river sediment, and air. In addition, the Detroit River water column overall mercury mass balance showed that the total input is equal to the total output. So the ASDM model is a mass conservation model.

The ASDM can also be used to predict water, sediment, suspended solid, plankton, fish, porewater and benthos phase contaminant concentration profiles in the river aquatic and sediment systems. The steady state model results showed that all Detroit River water mercury concentrations exceed Michigan's Rule 57(2) Criteria (0.6 ng/l); the UGLCC study also found the same results. In addition, regression analysis for steady state sediment mercury give a general indication of goodness of fit (Regression Line Slope =1.3, Regression Line Intercept= 0, Regression Coefficient= 0.6). The steady state model outputs also showed that most of large fish mercury concentrations are above the OME Criterion, similar to the fish mercury concentrations in Lake St. Clair.

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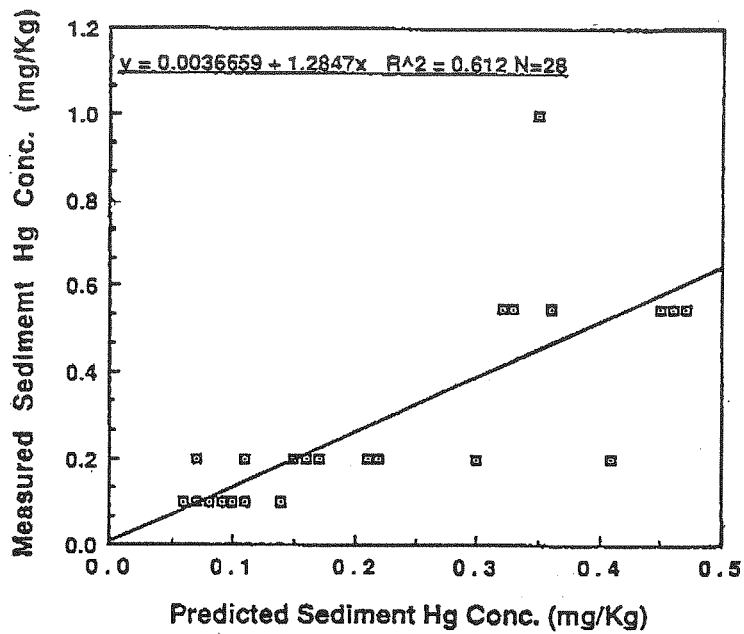[8] O'Connor, D.J.; Connolly, J.P., 1980, Water

Figure 5. Comparison of Predicted and Measured Sediment Mercury Concentrations (Sediment Flow, 1982-1991 Predicted CSO
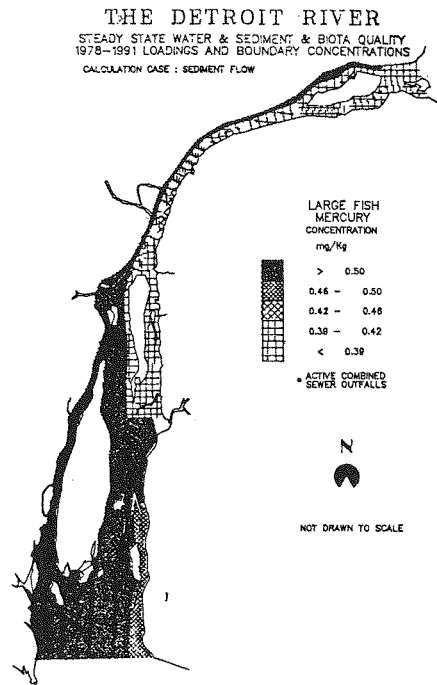
Flow Rates)

Figure 6. Steady State Large Fish methyl Mercury Concentration Profiles (1982-1991 Predicted

CSO Flow Rates)

THE DETROIT RIVER

STEADY STATE WATER & SEDIMENT & BIOTA QUALITY
1978—1991 LOADINGS AND BOUNDARY CONCENTRATIONS

CALCULATION CASE : SEDIMENT FLOW

SEDIMENT
MERCURY
CONCENTRATION
mg/Kg

>   0.20

0.16 —   0.20

0.12 —   0.16

0.09 —   0.12

<   0.09

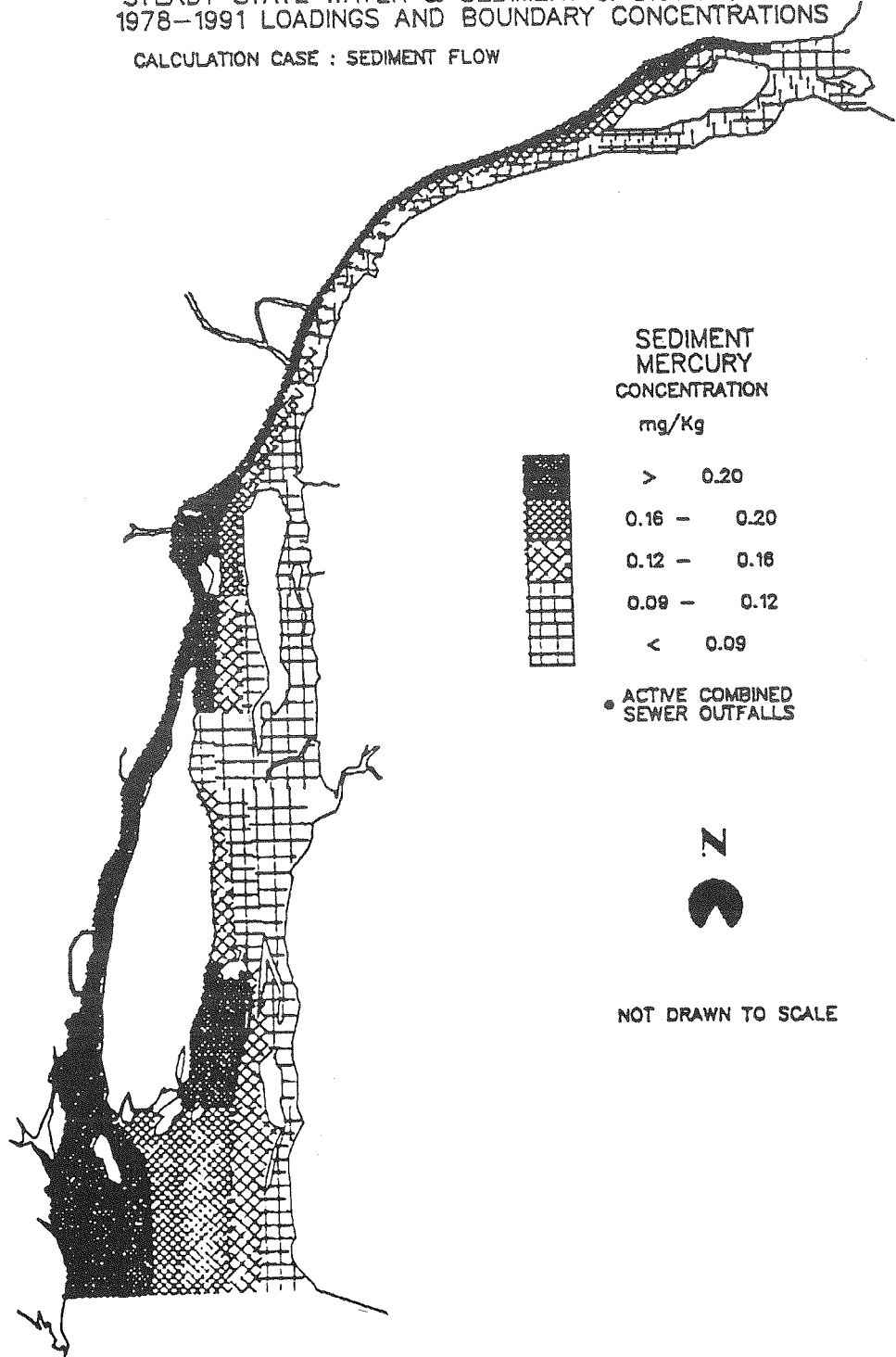ACTIVE COMBINED
SEWER OUTFALLS

N

NOT DRAWN TO SCALE

Figure. 4. Steady State sediment Mercury Concentration Profiles (1982-1991 Predicted CSO Flow Rates)

THE DETROIT RIVER

STEADY STATE WATER & SEDIMENT & BIOTA QUALITY
1978—1991 LOADINGS AND BOUNDARY CONCENTRATIONS
CALCULATION CASE : SEDIMENT FLOW

WATER
MERCURY
CONCENTRATION
ng/L

>   0.60

ACTIVE COMBINED
SEWER OUTFALLS
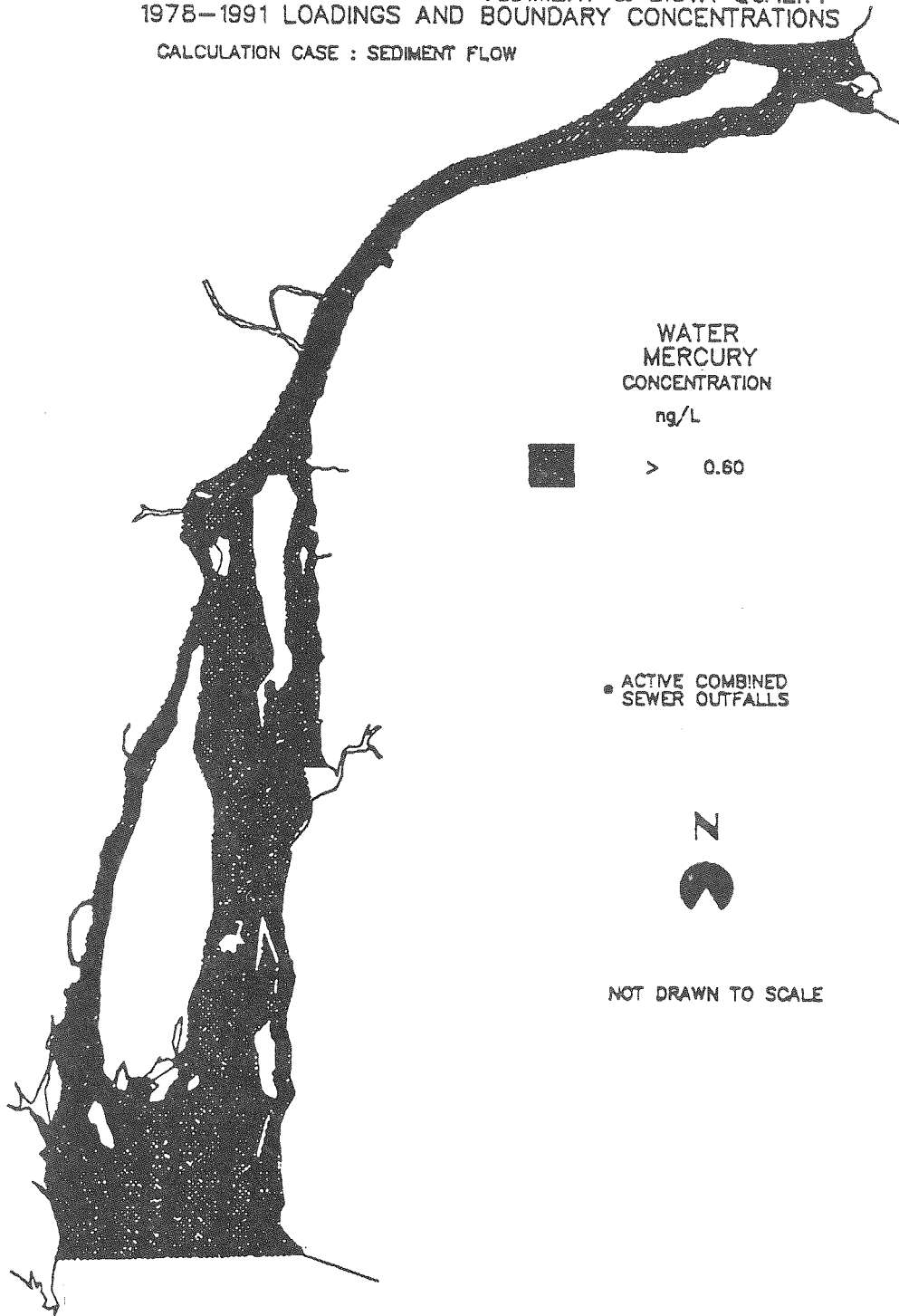
N

NOT DRAWN TO SCALE

Figure 3. Steady State Water Mercury Concentration Profiles (1982-1991 Predicted CSO Flow Rates)

Steady State Mercury Concentration Profiles in the Detroit River

The equation of continuity for the water column can be simplified to steady state when considering long residence times (about 19 to 21 hours). Because the Detroit River is well- mixed from top to bottom, we can consider two dimensional flow, and if we consider a source/ sink transport model with no reaction, because we will consider a balance on total Hg.

$$1/A_{WX} \{ \partial [- Q_{WX} (C_W + C_{ss}) +$$
$$E_{wx}A_{wx} (\partial (C_W + C_{ss}) /\partial x)] / \partial x\} +$$
$$1/A_{Wy} \{ \partial [- Q_{Wy} (C_W + C_{ss}) +$$
$$E_{wy}A_{wy} (\partial (C_W + C_{ss})/\partial y)] / \partial y\} + s_W = 0 \qquad (17)$$

Water Mercury

The UGLCC study [2] employing methodology with low detection levels, determined that all Detroit River water mercury concentrations exceed Michigan's Rule 57(2) Criteria (0.6 ng/l). The model simulation also predicted that entire the Detroit River water mercury concentrations exceed 0.6 ng/l (See Figure 3).

Sediment Mercury

The US EPA (1980-1987) reported that mercury concentrations in the Detroit River sediments were less than EPA Dredge Criteria (Heavily Polluted Value 1.0 mg/Kg) with the exception of the Michigan shoreline between Monguagon Creek and Elizabeth Park; the majority of the Ontario and mid-river sediments contained less than Toxicity Characteristic Rule concentration (0.2 mg/Kg) [1]; similar to the model simulation output (See Figure 4). The regression analysis (See Figure 5) gives a good fit (Regression Line Slope=1.3, Regression Line Intercept= 0.0, Regression Coefficient= 0.6) except at the upper Trenton Channel where simulation data are higher than measured data, at the middle Trenton Channel where simulation data are lower than measured data. For this regression analysis, the slope of the regression analysis line is over one, so the model simulation results are underestimation due to no complete loading data.

Fish Mercury (Methyl Mercury Form)

Fish are highly migratory, so the trends of contaminants in the fish collected from the Detroit River area must relate to the contiguous water bodies of Lake Erie and Lake St. Clair. The Ontario MOE (1988-1989) [1] found that most of Lake St. Clair large walleye mercury concentrations were over the OME Criterion (0.5 mg/Kg); similar results are predicted in simulation Figure 6.

Upstream input
6.95

Volatilization   Wet deposition Dry deposition
0.287 6.09×10^{-4} 2.92×10^{-4}

US
Industrial and
Municipal sources
1.52×10^{-1}
DWWTP 0.74

CSOs 5.824

Tributary
7.25×10^{-2}

Stormwater
1.4×10^{-2}

Detroit

River

Water
Column

CANADA
Industrial and
Municipal Sources
8.73×10^{-3}

CSOs
5.48×10^{-4}

Tributaries
8.23×10^{-3}

Stormwater
2.33×10^{-3}

6.387

1.982
Water/Sediment diffusion

Suspended solid settling
3.887
Sediment resuspension

12.978
Downstream output

PS. : Unit (Kg/Day)
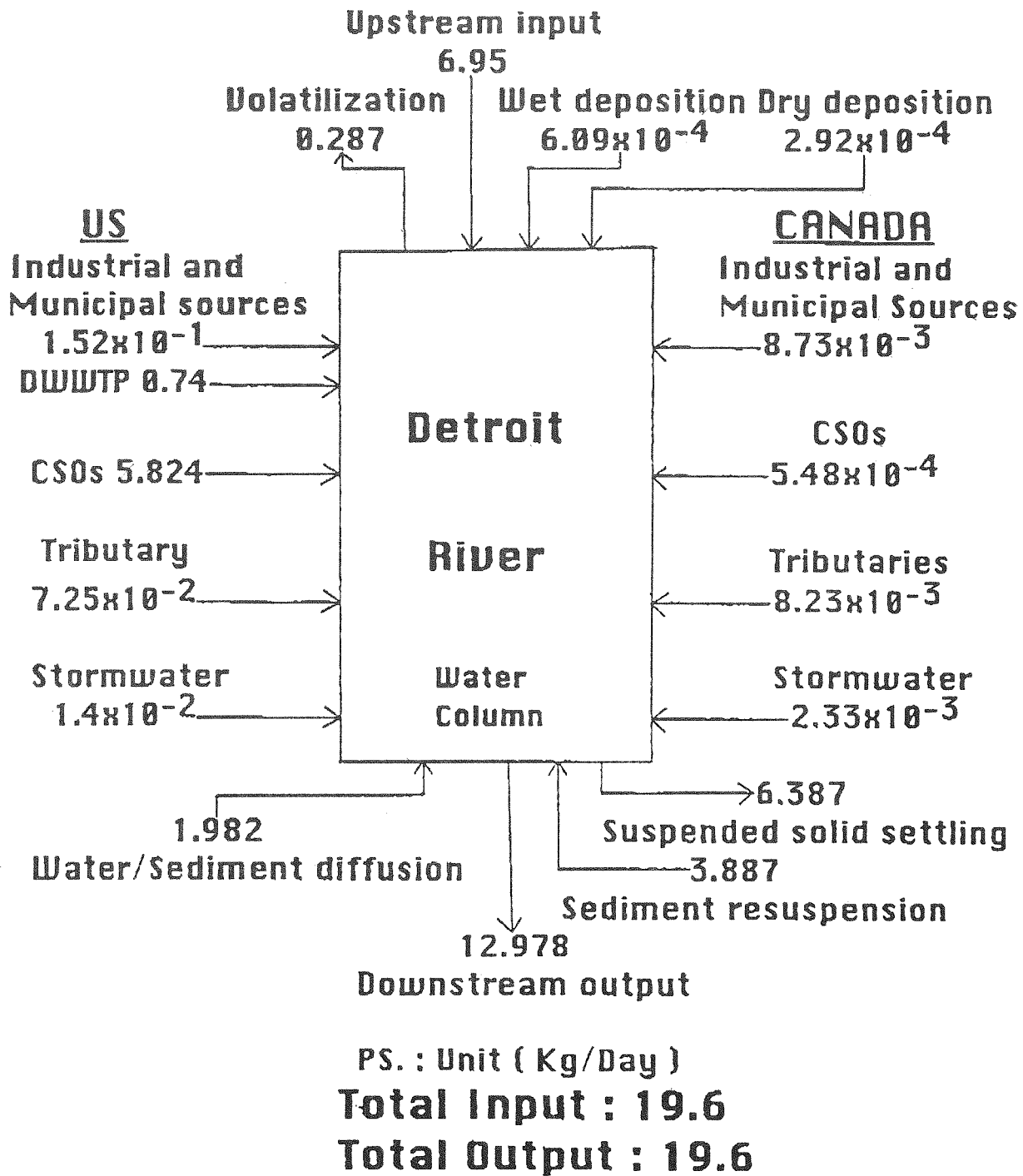Total Input : 19.6
Total Output : 19.6

Figure 2. Detroit River Water Column (Water and Suspended Solid Phases)

Mercury Mass Balance Result (Sediment Flow, 1982-1991 Predicted CSO Flow Rates)

Sediment Burial

The flux of contaminant burial is able to be calculated by the following equation [13].

$$F_B = 3.6 \times 10^9 \, C_{Sed} \, C_{MS} \, V_{BSed} +$$
$$3.6 \times 10^6 \, C_{PW} \, V_{BPW} \qquad (16)$$

where,

F_B (ng/ hr - m^2) is the flux of contaminant burial. 3.6×10^9 and 3.6×10^6 are the unit conversion factors.

C_{Sed} (mg/ Kg) is the concentration of contaminants in the sediment

C_{MS} (Kg/m^3) is the sediment concentration.

V_{BSed} (m/s) is the sediment contaminant burial rate.

C_{PW} (ng/l) is the concentration of contaminants in the porewater.

V_{BPW} (m/s) is the porewater contaminant burial rate.

Model Calibration and Verification
Detroit River Water Column Mercury Mass Balance

The plankton and fish phases are assumed stationary (Exposure Model) due to lack of available data. The mercury mass accumulated in the plankton and fish phases are assumed to be small by comparing with the mercury mass accumulated in the water and suspended solid phases. First, let us consider an overall water and suspended solid phase mercury mass balance approach in the Detroit River water column assuming a steady state one- box model when considering long residence times (about 19 to 21 hours), and it equated total sources/ sinks and reactions of Mercury. The water and suspended solid mercury inflow (main flow, tributary, municipal discharge, industrial discharge, CSOs, and stormwater) rates and outflow rates are known [1,2,14,15,16]. The mercury source/ sink fluxes can be calculated from the Atmospheric and Sediment Deposition Model (ASDM). The reaction rates are assumed zero when considering a total mercury balance. The Detroit River water column (water and suspended solid phases) mercury mass balance result (See Figure 2) suggests that in the steady state, the overall Detroit River water column (water and suspended solid phases) is a potential source (volatilization > dry and wet deposition, suspended solid settling > sediment resuspension and sediment diffusion to water) of Mercury. The total input is equal to the total output in the Detroit River water column (water and suspended solid phases) mercury mass balance (See Figure 2). So the Atmospheric and Sediment Deposition Model (ASDM) is a mass conservation model.

depends to a large degree on particle size and characteristics, wind speed, receptor surface and micrometerorological conditions. In a simplified case, the following equation is most commonly used to calculate particulate fluxes [12].

$$F_D = 3600 \, V_D C_P \qquad (12)$$

where,

F_D (ng/ hr - m^2) is dry particle contaminant flux. 3600 is the unit conversion factor.

V_D (m/s) is the dry deposition velocity.

C_P (ng/ m^3) is the concentration of contaminants in the particle phase.

Wet Deposition of Vapor and Particle

The flux of contaminant wet deposition from the atmosphere to surface water by rain and snow can be determined from the equation [12].

$$F_W = F_v + F_p = W_V \, C_A \, J \, /24 + W_P \, C_P \, J \, /24 = C_T$$
$$W_T \, J \, /24 = C_L \, J \, /24 \qquad (13)$$

where,

F_W (ng/ hr - m^2) is the flux of contaminant wet deposition.

F_V and F_P (ng / hr - m^2) are the fluxes of vapor and particle contaminant wet deposition, respectively.

J (m/ day) is the precipitation intensity.

C_L (ng/ m^3) is the concentration of contaminants in the rain and snow.

$C_T = C_A + C_P$

$W_T = W_V \, (1 - \psi) + W_P \, \psi = C_L \, / \, C_T$

$\psi = C_P \, / \, C_T$

W_V is the vapor washout ratio.

W_P is the particle washout ratio.

24 is the unit conversion factor.

Suspended Solid Settling and Sediment Resuspension

Suspended Solid Settling

The flux of suspended solid contaminant deposition at the water- sediment interface can be calculated by the following equation.

$$F_s = 36000 \, C_{ss} \, C_M \, V_s \qquad (14)$$

where,

F_S (ng / hr - m^2) is the flux of suspended solid contaminant settling.

36000 is the unit conversion factor.

C_{ss} (mg / Kg) is the concentration of contaminants in the suspended solid.

C_M (mg/l) is the suspended solid concentration.

V_S (cm/s) is the suspended solid settling velocity.

Sediment Resuspension

The flux of sediment contaminant resuspension at the water- sediment interface also can predicted by the following equation.

$$F_R = 10^7 \, C_{Sed} \, F_{RS} \qquad (15)$$

where,

F_R (ng / hr - m^2) is the flux of sediment contaminant resuspension. 10^7 is the unit conversion factor.

C_{Sed} (mg/ Kg) is the concentration of contaminants in the sediment.

F_{RS} (g/hr - cm^2) is the flux of sediment resuspension.

Air/ Water and Water/ Sediment Diffusion

Air/ Water Diffusion

The air-water diffusion equations are developed from the two- film model. The two-film model assumes that interfacial resistance is negligible and there is a sharp transition between a stagnant film and a well- mixed fluid in which concentration gradients are negligible with the main resistance to gas transfer coming from the gas and liquid phase interfacial layers [10].

Assuming that the transport of gas across the interface is a steady- state process, it follows that

$$F_{AW} = K_A (C_A RT - HC_W) = K_W [(C_A RT/H) - C_W] \quad (6)$$

where,

$$1/ k_A = (RT/ K_A) + (H / k_W) \quad (7)$$

$$1/ k_W = (1/ K_W) + [RT / (Hk_A)] \quad (8)$$

F_{AW} (ng/ hr-m^2) is the flux of air- water gas contaminant diffusion through each boundary layer.

K_A (mol/ hr- atm- m^2) and K_W (m/hr) are contaminant overall mass transfer coefficients in the air and water at the air- water interface, respectively.

k_A and k_w (m/hr) are contaminant mass transfer coefficients in the air and water at the air- water interface, respectively.

C_A (ng/m^3) and C_W (ng/l) are concentrations of contaminants in the air and water, respectively.

R (atm- m^3 / mol- ° K) is the gas constant.

T (°C) is the water temperature.

H (atm- m^3 / mol) is the contaminant Henry's law constant.

Because the overall mass transfer coefficient (K) is dependent on the Henry's law constant (H), a small value of H ($<5 \times 10^{-6}$ atm- m^3 /mole) results in gas phase controlled absorption and large values of H ($>5 \times 10^{-3}$ atm- m^3 / mole) result in liquid phase controlled volatilization [6].

Water/ Sediment Diffusion

The water- sediment diffusion equation also can be developed from the two- film model. The results are [11]:

$$F_{WP} = K'_W (C_W - K_{WP} C_{PW}) = K_{PW} (C_W / K_{WP} - C_{PW}) \quad (9)$$

where,

$$1/ K'_W = (1/k'_W) + (K_{WP} / K_{PW}) \quad (10)$$

$$1/ K_{PW} = (1/k_{PW}) + [1 / (K_{WP} K'_W)] \quad (11)$$

F_{WP} (ng/ hr- m^2) is the flux of water- sediment contaminant diffusion.

K'_W and K_{PW} (m/hr) are the contaminant overall mass transfer coefficients in the water and porewater at the water- sediment interface.

K'_W and K_{PW} (m/hr) are the contaminant mass transfer coefficients in the water and porewater at the water- sediment interface.

K_{WP} is the partition coefficient of contaminant between water and porewater.

C_{PW} (ng/l) is the concentration of contaminants in the porewater.

Particle Dry Deposition

The atmospheric flux of particle contaminants

($°C^{-1}$) have the relative values of (k_5: $3.58×10^{-5}$; $1.33×10^{-4}$; $3.16×10^{-3}$), (k_6: 0.769;0.781; 0.764), (k_7: 0.335; 0.129; -0.76) for the three temperature ranges (0-6.7°C; 6.7-14.9°C; higher than 14.9°C).

d_w (ft) is the depth of the water column.

d_p (ft) is the depth of the surface sediment.

Fish absorb toxic contaminants both from water and porewater through the gills and from their food (plankton, benthos or small fish). The following equilibrium mass balance, assumed steady-state due to lack of available time variable date, is used to describe sorption [9].

$$k_3 C_{DF} / 10^3 + A \text{ (food, } C_{PBF}) - EC_F = 0 \qquad (5)$$

where,

$k_3 = (0.07 \log K_{ow} - 0.02) RV/W$

$K_{ow} = B_{cf} / 0.048$ (octanol- water partition coefficient)

B_{cf} is the bioconcentration factor of contaminants between the water and fish.

$W = 0.005$ Kg (W_{SF} for the small fish like smelt).

$= 3.180$ Kg (W_{LF} for the large fish like trout).

RV (m^3 / hr) is the filtration rate (RV= $k_4 T W^{0.8}$).

$k_4 = 6.45$ m^3 / ($Kg^{0.8}$ °C hr) (for the small fish).

$= 10.3$ m^3 / ($Kg^{0.8}$ °C hr) (for the large fish).

$C_{DF} = $ (ng/l) is the fish intake concentration of contaminants from the water and porewater through the gills

($C_{DF} = d_w C_w / (d_w + d_p) + d_p C_{pw} / (d_w + d_p)$).

10^3 is the unit conversion factor.

A (food, C_{PBF}) with the unit mg/ Kg-hr is the assimilation rate from the plankton and benthos for the small fish, or from the plankton, benthos and small fish for the large fish (A(food, C_{PBF}) = $K_5 W^{k_6} e^{(k_7 T)} C_{PBF}$).

k_5 (1/ ($Kg_{predator}^{k_6}$ hr), k_6 (dimensionless), k_7 ($°C^{-1}$) have the relative values of (k_5: $3.58×10^{-5}$; $1.33×10^{-4}$; $3.16×10^{-3}$), (k_6: 0.769;0.781; 0.764), (k_7: 0.335; 0.129; -0.76) for the three temperature ranges (0-6.7°C; 6.7-14.9°C; higher than 14.9°C).

$C_{PBF} = d_w C_{pl} / (d_w + d_p) + d_p C_{Ben} / (d_w + d_p)$ (for the small fish, unit mg/Kg).

$= (1-0.2) d_w C_{pl} / (d_w + d_p) + (1-0.2) d_p C_{Ben} / (d_w + d_p) + 0.2 C_{SF}$

(20% of the assimilation rate is from the small fish for the large fish, unit mg/Kg).

E (hr^{-1}) is the excretion rate (E=12.8214$W^{-0.75}$ / K_{ow}).

12.8214 ($Kg^{0.75}$ hr^{-1}) is an empirical scaling constant.

C_F (mg/ Kg) is the concentration of contaminants in the small fish (C_{SF}) or large fish (C_{LF}).

Finally, the concentration of contaminants in the plankton (C_{pl}), the concentration of contaminants in the benthos (C_{Ben}), the concentration of contaminants in the small fish (C_{SF}) and the concentration of contaminants in the large fish (C_{LF}) can be solved from 4 equations which include equation (4) for the plankton and benthos, and equation (5) for the small fish and large fish.

10^6 is the unit conversion factor.

C_{ss} (mg/Kg) is the concentration of contaminants in the suspended solid.

C_w (ng/l) is the concentration of contaminants in the water.

The partition coefficient in surface sediments is linearly related to the organic carbon fraction, and the organic carbon fraction seems to be the most important factor in determining the partition coefficient of contaminants between the porewater and the sediment [7,8]. If the organic carbon content of the suspended solid and sediment, and the partition coefficient (K_{ws}) of contaminants between water and suspended solid are known, then the partition coefficient (K_{ps}) of contaminants between porewater and sediment can be estimated by linear proration equation [5,9].

$$K_{ps} = K_{ws}f_{ocs} / f_{ocss} = C_{sed} / C_{pw} \qquad (3)$$

where,

K_{ps} (l/Kg) is the partition coefficient of contaminants between porewater and sediment.

f_{ocs} is the organic carbon fraction in the sediment.

f_{ocss} is the organic carbon fraction in the suspended solid.

The partition coefficient also can be used in modeling the uptake of toxic contaminants by plankton (phytoplankton and zooplankton) or benthos from water or porewater; the only

difference is that excretion is temperature dependent [9]. The following equilibrium mass balance is assumed steady- state due to lack of available time variable data.

$$k_1 (K_{ws} f_{ocpb} / f_{ocss}) C_D / 10^6 - K_2 f(T) C_{PB} - A (\text{food}, C_{PB}) = 0 \qquad (4)$$

where,

$k_1 (K_{ws} f_{ocpb} / f_{ocss}) C_D / 10^6$ is the adsorption process from water to plankton or from porewater to benthos.

$k_2 f (T) C_{PB}$ is the desorption process from plankton to water or from benthos to porewater.

k_1 and k_2 are parameters whose respective values are 4.56×10^{-7} hr^{-1} and 1.14×10^{-4} hr^{-1}.

10^6 is the unit conversion factor.

f_{ocpb} is the organic carbon fraction in the plankton (f_{ocp}) or benthos (f_{ocb}). $f(T)$ is 1.024^T (T°C) [9].

C_{PB} (mg/Kg) is the concentration of contaminants in the plankton (C_{pl}) or benthos (C_{Ben}).

$A(\text{food}, C_{PB}) = k_5 W^{k6} e^{(k-T)} C_{PB}$ with units of mg/Kg-hr, is the uptake of toxic contaminants in the plankton or benthos by the small and large fish

$W^{k6} = d_w (W_{SF}{}^{k6} + W_{LF}{}^{k6}) / (d_w + d_p)$ for the plankton.

$\quad = d_p (W_{SF}{}^{k6} + W_{LF}{}^{k6}) / (d_w + d_p)$ for the benthos.

$W = 0.005$ Kg (W_{SF} for the small fish like smelt).

$\quad = 3.180$ Kg (W_{LF} for the large fish like trout).

k_5 (1/ (Kg$_{predstor}{}^{k6}$ hr), k_6 (dimensionless), and k_7

$$1/A_z \{ \partial [- Q_z (C_D + C_B) +$$

$$E_z A_z (\partial (C_D + C_B) / \partial z)] / \partial z \} +$$

where (1)

C_D (ng/l) is the mean concentration of contaminants in the water (C_w) or porewater (C_{pw}).

C_B (mg/Kg) is the mean concentration of contaminants in the suspended solid (C_{SS}) or sediment (C_{Sed}). ($C_B = K C_D$)

A_x, A_y, A_z are the local areas (ft^2) for the water column or surface sediment in a plane normal to the given axis at a point.

Q_x, Q_y, Q_z are the flows (ft^3 /s) for the water column or surface sediment in the x,y,z directions, respectively.

E_x, E_y, E_z are the eddy diffusivities (ft^2 / hr) for the water column or surface sediment in the coordinate directions.

s (ng/ hr- 1) is the time averaged source/ sink rate in the water column or surface sediment.

The equations of continuity for the water column and the surface sediment can be transformed by the finite difference method and solved by the Crank- Nicolson method [3]. Then, these two equations for water column and surface sediment can be solved by using Gaussian elimination with partial pivoting and backsubstitution [4], and iteration method simultaneously.

Partitioning Processes

The partition coefficient is highly dependent on the characteristics and the relative amount of each particulate phase. In general, for a particulate phase with an organic carbon fraction >0.5%, the organic carbon appears to be the predominant influence on the partition coefficient; the increasing partition coefficient with increasing organic carbon fraction is due to the high cation exchange capacity [8]. The partition coefficient also varies inversely with the concentration of the particulate phase because a solid- solid interaction may be mediating the adsorption and desorption process [7,8]. Other environmental variables such as pH, temperature, hardness, alkalinity, and redox potential also will affect the partition coefficient [7].

The partition coefficients are very highly correlated with the suspended solid concentration in almost cases. So the following regression equation is useful for estimating contaminant partition coefficients for specific river systems where actual field data are not available [7,8].

$$K_{ws} = K_{wso} C_M^a = 10^6 C_{ss} / C_w \quad (2)$$

where,

K_{ws} (l/Kg) is the partition coefficient of contaminants between water and suspended solid.

K_{wso} (l/Kg) is the partition coefficient constant which is dependent on pH, temperature, hardness, alkalinity, and redox potential.

C_M (mg/l) is the suspended solid concentration. a is the partition coefficient exponential constant.

porewater and sediment phases. The equation of continuity in orthogonal curvilinear coordinates for stream flow is [3,5,6]

$$\partial(C_D + C_B)/\partial t = 1/A_x \{ \partial [-Q_x (C_D + C_B) +$$

$$E_x A_x (\partial (C_D + C_B)/\partial x)]/\partial x \} +$$

$$1/A_y \{ \partial [-Q_y (C_D + C_B) +$$

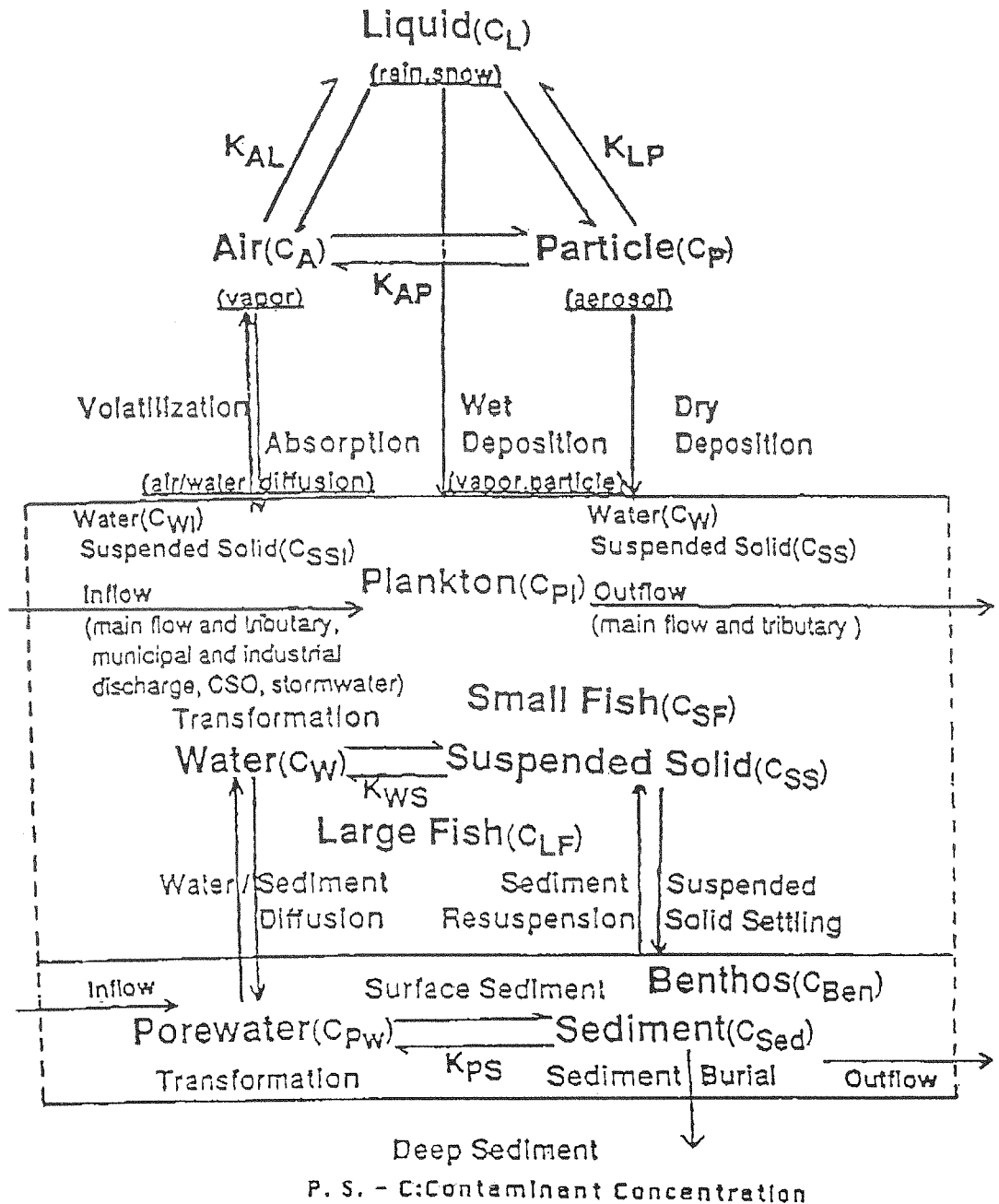$$E_y A_y (\partial (C_D + C_B)/\partial y)]/\partial y\} +$$

Figure 1. Transport & Partitioning & Transformation Processes

water and sediment environment. In order to understand and predict the transport and partitioning of Mercury in the Detroit River, a Atmospheric and Sediment Deposition Model (ASDM) based on the unsteady state finite difference model [3] was developed. The model includes water column and surface sediment contaminant advection and dispersion, multimedia contaminant transport processes (air/ water diffusion, water/ sediment diffusion, dry and wet deposition, suspended solid settling, sediment resuspension and burial), and intermedia contaminant partitioning processes (water/ suspended solid sorption, porewater/ sediment sorption, water/ plankton sorption, porewater/ benthos sorption, and fish sorption).

Three compartment (air, water and sediment) contaminant interaction source/ sink rates, and contaminant sorption effect of water and porewater exposure to suspended solids, plankton, fish, sediment and benthos can be calculated from this model and applied to the water and sediment equations of continuity in one, two and three dimensions for both steady state and transient conditions. Two equations of continuity for water column and surface sediment can be solved by the Finite Difference Method, Crank- Nicolson Method [3], and Iteration Method. The model computer program USSMPX [4] is run on a SUN work station and MTS (Michigan Terminal Systems) utilizing databases.

Model Theory

The Atmospheric and Sediment Deposition Model (ASDM) assumes a well- mixed state in each water column segment and in each surface sediment segment due to very thin surface sediment and very high porosity (See Figure 1).

The original finite difference model which is finite difference solution to the equation of continuity by Roginski [3] forms the basis for this model. The source sink rates can be calculated from atmospheric and sediment deposition model (ASDM) and applied to the equation of continuity. The concentration of contaminants in the suspended solid or sediment can be expressed by the concentration of contaminants in the water or porewater from the equation (2) or (3), and also applied to the equation of continuity. Concentrations which are given at the head and mouth of the river from measured data are the boundary conditions for the equation of continuity.

Equation of Continuity

The plankton, benthos, and fish phases are assumed stationary (Exposure Model) due to lack of available data. The contaminant mass accumulated in the plankton, benthos, and fish phases are assumed to be small by comparing with the contaminant mass accumulated in the water, porewater, suspended solid, and sediment phases. So the equation of continuity only includes water and suspended solid phases or

Modelling A Two Dimensional River

Incorporating Sediment Flow

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ABSTRACT:

The International Joint Commission (IJC) has identified 43 Areas of Concern (AOC) on the Great Lakes. The Detroit River, a binational waterway, is one such AOC with impaired uses (restrictions on fish consumption, degradation of benthic communities, and restrictions on dredging activities) documented in the Stage I Remedial Action Plan (RAP). The authors modeled the Detroit River as part of the Stage II RAP process and developed a Wayne State University's Atmospheric and Sediment Deposition Model (ASDM). The model is a temporal and spatial transport, partitioning, and transformation model for predicting water, sediment, fish, suspended solid, plankton, porewater, and benthos contaminant concentration profiles attributed to contaminant source/ sink rates among three compartments (air, water, and sediment) and multiple point source contaminant discharges (municipal and industrial sources, tributaries, stormwater, and combined sewer overflows). Most of Mercury concentrations in the Detroit River sediment phase which are less than the Environmental Protection Agency's (EPA) Dredge Criteria (Heavily Polluted Value 1.0 mg/Kg) are comparable to the simulation results (Regression Line Slope: 1.3, Regression Line Intercept: 0.0, Regression Coefficient: 0.6).

INDEX WORDS: Mathematical models, Mercury, Detroit River, transport and partitioning, water column and surface sediment, and model studies.

Introduction

The Detroit River flows from Lake St. Clair to Lake Erie. Fish contaminant monitoring programs in the Detroit River have found elevated levels of Mercury in some species of fish like Walleye. Degraded benthic communities have been noted along the Michigan shoreline from the Rouge River to the mouth of the Detroit River and the Detroit River sediments have been classified as heavily and moderately polluted with a number of metals, including Mercury.

Because hydrophobic contaminants like Mercury are strongly associated with particulate matter, suspended and settled sediments play a key role in determining their transport and partitioning. Practical and accurate modelling must appropriately trace both dissolved and particulate hydrophobic contaminants in the