SDMS DocID 2050630

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103

SUBJECT: Bally: Preliminary Evaluation of 1,4-Dioxane Concentration

FROM: Jennifer Hubbard, Toxicologist
Technical Support Section (3HS41)

TO: Mitch Cron, RPM
Western PA Remedial Section (3HS22)

DATE: 2/19/2003

This memo is to evaluate a preliminary concentration of 1,4-dioxane reported in the effluent from an air stripper at the Bally site. This water reportedly undergoes chlorination before being distributed to residences for drinking and other domestic purposes.

The result for 1,4-dioxane did not undergo third-party validation and is therefore subject to change. Furthermore, this positive detection occurred in a single sample, and the average concentration over time is not currently known. However, if confirmed, the reported concentration of 53.7 ug/L could be associated with the risks described below.

1,4-Dioxane is classified by EPA as a Group B2 ("probable human") carcinogen. This means that there is evidence in animals, but insufficient evidence in humans, of cancer causation. The EPA consensus oral Cancer Slope Factor (CSF) is 1.1E-2 per mg/kg/day, as listed on EPA's Integrated Risk Information System database. EPA has no consensus toxicity values for non-cancer effects. Using the CSF, a potential cancer risk of approximately 9E-6 (or 9 in a million) can be estimated for chronic users of this water, under Superfund default exposure assumptions. (These assumptions are described in more detail below.) According to the National Contingency Plan, acceptable exposure levels for Superfund sites are generally those that represent an excess cancer risk between 1E-4 and 1E-6, with 1E-6 as the point of departure. The risk from this preliminary result is within that range.

The concentration associated with a 1E-6 cancer risk would be approximately 6 ug/L, using the assumptions described below. For 70-year lifetime exposure, the 1E-6 risk would be at approximately 3 ug/L. The 1E-4 cancer risk levels would be at 600 ug/L and 300 ug/L, respectively, depending upon exposure duration. While a lifetime is generally assumed to be approximately 70 years, the Superfund program uses 30 years as the default exposure duration because that is the 90th percentile for time spent at a single household.

I have also brought this information to ATSDR, as discussed with you earlier today. I have asked for assistance with 1) determining whether this concentration (or concentrations obtained from the upcoming sampling event) would pose an acute hazard; 2) determining

whether there are other health-based values for 1,4-dioxane that should be considered for the estimation of chronic risk. ATSDR has also been coordinating with PaDOH. I will update you on information from these health agencies as information comes in.

If you have any questions concerning this memo, please contact me at 215-814-3328.

Supporting Documentation for EPA Risk Assessment

The attached spreadsheets document the equations and assumptions used in generating the preliminary risks. The oral equations are from EPA's 1989 Risk Assessment Guidance for Superfund, Volume I Part A. The dermal equations are from EPA's 2001 Draft Risk Assessment Guidance for Superfund, Volume I Part E ("RAGS E"). The inhalation equations (showering exposure was estimated for adults only, since children are assumed to take baths) are from Foster and Chrostowski, 1987.

The water ingestion rate, breathing rate, body weight, exposure frequency, and exposure duration are from EPA's 1991 "Standard Default Exposure Factors" directive. The child's water ingestion rate is derived from EPA's 1997 Exposure Factors Handbook. The skin surface area, Kp, B, tau, and t* were obtained from RAGS E. The showering and bathing times were approximately 50th percentile values from the Exposure Factors Handbook. Most of the other showering input values were from Foster and Chrostowski, 1987, except that the showering flow rate was based on professional judgment.

The oral CSF was used for dermal and inhalation exposure also. While there is uncertainty associated with this assumption, it was considered preferable to assuming a "zero" exposure for these routes. This is believed to be a conservative approach, although the bias could theoretically be in either direction.

Attachments

cc: Trish Taylor (3HS43)
Helen Duteau (3HS43)
Bernice Pasquini (3HS41)
Eric Johnson (3HS41)
Kathy Davies (3HS41)
Tom Stukas (ATSDR; 3HS00)

DRINKING WATER EXPOSURE
SITE: Bally
RECEPTOR: Child resident

ORAL EXPOSURE FROM GROUNDWATER

EQUATIONS:

D = C x IR x ED x EF / BW x AT

D = ORAL DOSE (MG/KG/DAY)
C = CONCENTRATION IN WATER (MG/L)
IR = INGESTION RATE (L/DAY)
ED = EXPOSURE DURATION (YRS)
EF = EXPOSURE FREQUENCY (DAYS/YR)
BW = BODY WEIGHT (KG)
AT = AVERAGING TIME (DAYS)

HQ = D / RFD

HQ = HAZARD QUOTIENT
D = NONCARCINOGENIC DOSE (MG/KG/DAY)
RFD = REFERENCE DOSE (MG/KG/DAY)

CR = 1 - EXP(-CSF x D)

CR = CANCER RISK
CSF = CARCINOGENIC SLOPE FACTOR (1/MG/KG/DAY)
D = CARCINOGENIC (TIME-WEIGHTED) DOSE (MG/KG/DAY)

INPUTS		ADULT RESIDENT	CHILD RESIDENT	ADULT WORKER
IR	1	2	1	1
EF	350	350	350	250
ED	6	24	6	24
BW	15	70	15	70
AT-NC	2190	8760	2190	8760
AT-C	25550	25550	25550	25550

CHEMICAL	C (MG/L)	RFD	CSF	HQ	CR
1,4-dioxane	0 0537		1 1E-002	N/A	3.2E-006
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
TOTALS/ORAL DRINK WATER				0 0E+000	3 2E-006

DERMAL EXPOSURE FROM GROUNDWATER

EQUATIONS:

INORGANICS DA = KP x CV x t x CF

DA = DOSE ABS. PER UNIT AREA (MG/CM2)
KP = PERMEABILITY COEFF. FROM WATER (CM/HR)
CV = CONCENTRATION IN WATER (MG/L)
t = DURATION OF EVENT (HRS)
CF = CONVERSION FACTOR (L/CM3: 1E-3)

ORGANICS IF t<=t* DA = 2 x CFx FA x KP x CV x SQRT (6 x TAU x t / PI)
IF t>t* DA = KPx FA x CV x CF x [t/(1+B) + (2 x TAU x (1+3B+3B^2)/((1+B)^2))]

TAU = LAG TIME (HRS)
B = PARTITIONING CONSTANT
t* = TIME (HRS)

DAD = (DA x EF x ED x A) / (BW x AT)

DAD = DERMALLY ABSORBED DOSE (MG/KG/DAY)
A = SKIN SURFACE AREA AVAILABLE FOR CONTACT (CM2)

INPUTS		ADULT RESIDENT	CHILD RESIDENT	ADULT WORKER
A	6600	18000	6600	
EF	350	350	350	250
ED	6	24	6	24
BW	15	70	15	70
AT-NC	2190	8760	2190	8760
AT-C	25550	25550	25550	25550
t	0 33	0.2	0 33	

FOR INORGANICS, SET Do = 0; FOR ORGANICS, SET Di = 0

CHEMICAL	C (MG/L)	Di	Do	KP	t*	B	TAU	FA	t<t*	t>t*	1+B	1+3B
1,4-dioxane	0 0537	0.00E+000	1 62E-008	3.3E-004	0.8	0 0012	0 33	1	1.62E-008	1 76E-008	1 0012	1 0036
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0.00E+000	0 00E+000						0	0	1	1
----------		0 00E+000	0.00E+000						0	0	1	1
----------		0 00E+000	0 00E+000						0	0	1	1

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CHEMICAL	DA	RFD	CSF	HQ	CR
1,4-dioxane	1 62E-008		1.1E-002	N/A	6.4E-009
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0 0E+000
TOTALS/DERM DRINK WATER				0 0E+000	6 4E-009

INHALATION EXPOSURE

EQUATIONS:

kg = kH x SQRT (MW H / MW)

kg = GAS-FILM MASS TRANSFER COEFFICIENT (CM/HR)
kH = kg FOR WATER (CM/HR: 3000)
MW H = MOLEC. WT. FOR WATER (G/MOL: 18)
MW = MOLECULAR WT. (G/MOL)

kl = kC x SQRT (MW C / MW)

kl = LIQUID-FILM MASS TRANSFER COEFFICIENT (CM/HR)
kC = kl FOR CARBON DIOXIDE (CM/HR: 20)
MW C = MOLEC WT. FOR CARB DIOXIDE (G/MOL 44)

KL = 1 / [(1 / kl) + ((R x T) / (H x kg))]

KL = MASS TRANSFER COEFFICIENT (CM/HR)
R = GAS CONSTANT (ATM M3/MOL K. 8 2E-5)
T = ABSOLUTE TEMP. (K: 293)
H = HENRY'S LAW CONSTANT (ATM M3/MOL)

KaL = KL / SQRT [(T1 x US) / (TS x U1)]

KaL = ADJUSTED OVERALL MASS TRANS COEFF. (CM/HR)
T1 = CALIB. WATER TEMP OF KL (K)
TS = SHOWER WATER TEMP. (K)
U1 = WATER VISCOSITY AT T1 (CP)
US = WATER VISCOSITY AT TS (CP)

CWD = C x CF x (1 - EXP [(-KaL x ts) / (60 x d)])

CWD = CONC LEAVING SHOWER DROPLET AFTER TIME ts (UG/L)
C = CONCENTRATION IN WATER (MG/L)
CF = CONVERSION FACTOR (UG/MG: 1E3)
ts = SHOWER DROPLET TIME (SEC)
d = SHOWER DROPLET DIAMETER (MM)

S = CWD x FR / SV

S = INDOOR VOC GENERATION RATE (UG/M3/MIN)
FR = SHOWER FLOW RATE (L/MIN)
SV = SHOWER ROOM AIR VOLUME (M3)

D = [(VR x S) / (BW x Ra x 1E6)] x Q

D = INHALATION DOSE (MG/KG/SHOWER)
VR = VENTILATION RATE (L/MIN)
BW = BODY WEIGHT (KG)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
Ra = RATE OF AIR EXCHANGE (1/MIN)

Q = Ds + [(EXP(-Ra x Dt)) / Ra] - [(EXP(Ra x (Ds-Dt))) / Ra]

Ds = DURATION OF SHOWER (MIN)

INPUTS

T1	293	VR	0
TS	318	BW	70
U1	1.002	EF	350
US	0.596	ED	24
d	1	AT-NC	8760
ts	2	AT-C	25550
FR	20		
SV	6		
Ds	12	Q	2.4819173
Dt	20		
Ra	0.01667		

CHEMICAL	C (MG/L)	MW	H	kg	kl	KL	KaL	CWD	S	D
1,4-dioxane	0 0537	88 1	4 8E-006	1356.0308	14.134107	0.2658177	0.359066	0.6388971	2.1296571	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0

CHEMICAL	D	RFD	CSF	HQ	CR
1,4-dioxane	0 00E+000		1.1E-002	N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0 0E+000
TOTALS/INHAL				0.0E+000	0 0E+000
TOTAL THIS RECEPTOR				0.0E+000	3.2E-006

AR100011

RISKS BY CHEMICAL

CHEMICAL	HAZARD INDEX	CANCER RISK
1,4-dioxane	0.0E+000	3.2E-006
----------	0.0E+000	0.0E+000
----------	0.0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0.0E+000	0 0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0 0E+000
----------	0.0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0.0E+000	0.0E+000
----------	0.0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0 0E+000
----------	0 0E+000	0.0E+000
----------	0.0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0.0E+000	0 0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0.0E+000	0 0E+000
----------	0.0E+000	0.0E+000
----------	0 0E+000	0 0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0 0E+000
----------	0.0E+000	0.0E+000
----------	0 0E+000	0 0E+000
----------	0.0E+000	0 0E+000
----------	0 0E+000	0 0E+000
----------	0 0E+000	0 0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0 0E+000
----------	0.0E+000	0.0E+000
----------	0.0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0 0E+000
----------	0 0E+000	0 0E+000
----------	0.0E+000	0.0E+000
----------	0.0E+000	0 0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0.0E+000
----------	0 0E+000	0 0E+000
----------	0 0E+000	0 0E+000
TOTAL	0 0E+000	3 2E-006

DRINKING WATER EXPOSURE
SITE: Bally
RECEPTOR: Adult resident

ORAL EXPOSURE FROM GROUNDWATER

EQUATIONS:

D = C x IR x ED x EF / BW x AT

D = ORAL DOSE (MG/KG/DAY)
C = CONCENTRATION IN WATER (MG/L)
IR = INGESTION RATE (L/DAY)
ED = EXPOSURE DURATION (YRS)
EF = EXPOSURE FREQUENCY (DAYS/YR)
BW = BODY WEIGHT (KG)
AT = AVERAGING TIME (DAYS)

HQ = D / RFD

HQ = HAZARD QUOTIENT
D = NONCARCINOGENIC DOSE (MG/KG/DAY)
RFD = REFERENCE DOSE (MG/KG/DAY)

CR = 1 - EXP(-CSF x D)

CR = CANCER RISK
CSF = CARCINOGENIC SLOPE FACTOR (1/MG/KG/DAY)
D = CARCINOGENIC (TIME-WEIGHTED) DOSE (MG/KG/DAY)

INPUTS		ADULT RESIDENT	CHILD RESIDENT	ADULT WORKER
IR	2	2	1	1
EF	350	350	350	250
ED	24	24	6	24
BW	70	70	15	70
AT-NC	8760	8760	2190	8760
AT-C	25550	25550	25550	25550

CHEMICAL	C (MG/L)	RFD	CSF	HQ	CR
1,4-dioxane	0.0537		1 1E-002	N/A	5.5E-006
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
----------				N/A	0.0E+000
----------				N/A	0 0E+000
----------				N/A	0 0E+000
TOTALS/ORAL DRINK WATER				0 0E+000	5 5E-006

DERMAL EXPOSURE FROM GROUNDWATER

EQUATIONS:

INORGANICS DA = KP x CV x t x CF

DA = DOSE ABS. PER UNIT AREA (MG/CM2)
KP = PERMEABILITY COEFF. FROM WATER (CM/HR)
CV = CONCENTRATION IN WATER (MG/L)
t = DURATION OF EVENT (HRS)
CF = CONVERSION FACTOR (L/CM3: 1E-3)

ORGANICS IF t<=t* DA = 2 x CFx FA x KP x CV x SQRT (6 x TAU x t / PI)
IF t>t* DA = KPx FA x CV x CF x [t/(1+B) + (2 x TAU x (1+3B+3B^2)/((1+B)^2))]

TAU = LAG TIME (HRS)
B = PARTITIONING CONSTANT
t* = TIME (HRS)

DAD = (DA x EF x ED x A) / (BW x AT)

DAD = DERMALLY ABSORBED DOSE (MG/KG/DAY)
A = SKIN SURFACE AREA AVAILABLE FOR CONTACT (CM2)

INPUTS		ADULT RESIDENT	CHILD RESIDENT	ADULT WORKER
A	18000	18000	6600	
EF	350	350	350	250
ED	24	24	6	24
BW	70	70	15	70
AT-NC	8760	8760	2190	8760
AT-C	25550	25550	25550	25550
t	0 2	0.2	0 33	

FOR INORGANICS, SET Do = 0, FOR ORGANICS, SET Di = 0

CHEMICAL	C (MG/L)	Di	Do	KP	t*	B	TAU	FA		t<t*	t>t*	1+B	1+3B
1,4-dioxane	0 0530611	0 00E+000	1.24E-008	3.3E-004	0.8	0 0012	0.33		1	1.24E-008	1.51E-008	1 0012	1 0036
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0.00E+000	0.00E+000							0	0	1	1
----------		0.00E+000	0.00E+000							0	0	1	1
----------		0.00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0.00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0.00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0.00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0.00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0.00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1
----------		0.00E+000	0 00E+000							0	0	1	1
----------		0 00E+000	0.00E+000							0	0	1	1
----------		0.00E+000	0.00E+000							0	0	1	1
----------		0.00E+000	0.00E+000							0	0	1	1
----------		0 00E+000	0 00E+000							0	0	1	1

CHEMICAL	DA	RFD	CSF	HQ	CR
1,4-dioxane	1 24E-008		1.1E-002	N/A	1 2E-008
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
TOTALS/DERM DRINK WATER				0.0E+000	1.2E-008

INHALATION EXPOSURE

EQUATIONS:

kg = kH x SQRT (MW H / MW)

kg = GAS-FILM MASS TRANSFER COEFFICIENT (CM/HR)
kH = kg FOR WATER (CM/HR: 3000)
MW H = MOLEC. WT FOR WATER (G/MOL: 18)
MW = MOLECULAR WT. (G/MOL)

kl = kC x SQRT (MW C / MW)

kl = LIQUID-FILM MASS TRANSFER COEFFICIENT (CM/HR)
kC = kl FOR CARBON DIOXIDE (CM/HR: 20)
MW C = MOLEC. WT. FOR CARB DIOXIDE (G/MOL: 44)

KL = 1 / [(1 / kl) + ((R x T) / (H x kg))]

KL = MASS TRANSFER COEFFICIENT (CM/HR)
R = GAS CONSTANT (ATM M3/MOL K: 8.2E-5)
T = ABSOLUTE TEMP. (K 293)
H = HENRY'S LAW CONSTANT (ATM M3/MOL)

KaL = KL / SQRT [(T1 x US) / (TS x U1)]

KaL = ADJUSTED OVERALL MASS TRANS COEFF. (CM/HR)
T1 = CALIB. WATER TEMP OF KL (K)
TS = SHOWER WATER TEMP (K)
U1 = WATER VISCOSITY AT T1 (CP)
US = WATER VISCOSITY AT TS (CP)

CWD = C x CF x (1 - EXP [(-KaL x ts) / (60 x d)])

CWD = CONC LEAVING SHOWER DROPLET AFTER TIME ts (UG/L)
C = CONCENTRATION IN WATER (MG/L)
CF = CONVERSION FACTOR (UG/MG: 1E3)
ts = SHOWER DROPLET TIME (SEC)
d = SHOWER DROPLET DIAMETER (MM)

S = CWD x FR / SV

S = INDOOR VOC GENERATION RATE (UG/M3/MIN)
FR = SHOWER FLOW RATE (L/MIN)
SV = SHOWER ROOM AIR VOLUME (M3)

D = [(VR x S) / (BW x Ra x 1E6)] x Q

D = INHALATION DOSE (MG/KG/SHOWER)
VR = VENTILATION RATE (L/MIN)
BW = BODY WEIGHT (KG)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
Ra = RATE OF AIR EXCHANGE (1/MIN)

Q = Ds + [(EXP(-Ra x Dt)) / Ra] - [(EXP(Ra x (Ds-Dt))) / Ra]

Ds = DURATION OF SHOWER (MIN)

INPUTS:

T1	293	VR	14
TS	318	BW	70
U1	1.002	EF	350
US	0.596	ED	24
d	1	AT-NC	8760
ts	2	AT-C	25550
FR	20		
SV	6		
Ds	12	Q	2.4819173
Dt	20		
Ra	0.01667		

CHEMICAL	C (MG/L)	MW	H	kg	kl	KL	KaL	CWD	S	D
1,4-dioxane	0.0537	88.1	4.8E-006	1356 0308	14 134107	0 2658177	0.359066	0.6388971	2.1296571	0.0000634
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0
----------				N/A	N/A	N/A	0	0	0	0

CHEMICAL	D	RFD	CSF	HQ	CR
1,4-dioxane	6.34E-005		1.1E-002	N/A	2.3E-007
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0.00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0.0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0.00E+000			N/A	0 0E+000
----------	0 00E+000			N/A	0 0E+000
TOTALS/INHAL				0.0E+000	2.3E-007
TOTAL THIS RECEPTOR				0.0E+000	5.8E-006

RISKS BY CHEMICAL

CHEMICAL	HAZARD INDEX	CANCER RISK
1,4-dioxane	0.0E+000	5.8E-006
----------	0.0E+000	0.0E+000
----------	0.0E+000	0.0E+000
----------	0.0E+000	0.0E+000