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OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

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Memorandum

SUBJECT: Sodium Bromide: Residential and Dietary Antimicrobial Uses (Pools, Spas, Sugar Beets, and Fruit & Vegetable Wash). PC Code 013907, DP Barcode 321793.

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Attached is a review of the antimicrobial residential and dietary uses of sodium bromide (excluding food contact sanitizers). The assessment of the food contact sanitizer use is presented in USEPA 2005a.

EXECUTIVE SUMMARY

The scope of the assessment of the residential and dietary antimicrobial uses of sodium bromide includes swimming pools, spas, fruit & vegetable wash (a petition to establish a tolerance exemption is needed), and sugar beet wash. No toxicological endpoints of concern have been identified for sodium bromide, so there are no risks of concern with direct exposure to sodium bromide. Therefore, the sugar beets and fruit & vegetable wash uses have not be quantified. There are some uses of sodium bromide that result in the formation of bromate ion, which is a known human carcinogen and poses a concern. Given the labeled uses of sodium bromide, the formation of bromate ion is a concern when the product is used in the presence of UV light and oxidizers (i.e., outdoor swimming pools).

Cancer risks of concern have been identified for the formation of bromate ion in outdoor swimming pools. There are inadequate data available on the concentration of bromate ion in pools such to definitively characterize the risks. However, there are sufficient data to cause concern. Based largely on a 6(a)2 submission, the US Environmental Protection Agency (EPA) has presented a range of cancer risks associated with incidental ingestion of pool water at various concentrations of bromate ion. These risks range up to 10^{-4}. Additional water sampling of outdoor swimming pool water at the labeled application rate for sodium bromide would more accurately characterize the risks. Regulatory conclusions are out of the scope of this document.

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1.0 INTRODUCTION

The Antimicrobials Division (AD) received a 6(a)2 submission indicating potential risks associated with the use of bromine-based sanitizers and HOBr/Br$^-$, specifically BCDMH and DBDMH (Arch 2005). However, the pool water samples presented in this submission associated with high levels of bromate ion were taken from pools treated with an exaggerated sodium bromide application. In compiling the information provided in the 6(a)2 along with the chemistry of sodium bromide (e.g., oxidation and presence of UV light forms bromate ion) the risk assessment was developed. Note: The food sanitizer uses of sodium bromide are qualitatively assessed in a separate memo (USEPA 2005a).

1.1 Chemical Identification

Two chemicals are considered in this document: sodium bromide and bromate (sodium). Table 1 presents the chemical identification information for the two chemicals.

Table 1. Chemical Identification Information for Sodium Bromate and Sodium Bromide

	Bromate[a]	Sodium Bromide
OPP Chemical Code	NA	013907
CAS Number	7789-38-0[a]	7647-15-6
Molecular Formula	$NaBrO_3$	NaBr

[a] The source of bromate is sodium bromate salt, and hence the CAS# of sodium bromate is provided.

1.2 Physical/Chemical Properties

The physical and chemical properties of sodium bromide and bromate are provided in Table 2. The sodium bromide applied to swimming pool will result in swimmers being exposed to bromate ion in outdoor uses.

Table 2. Physical/Chemical Properties of Sodium Bromate and Sodium Bromide

Property	Sodium Bromate	Sodium Bromide
Molecular Weight	150.89 g/mol[2]	102.89 g/mol
Melting Point	314.4 ° C[2]	313°C
Boiling Point	717.95° C[2]	716°C

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Table 2. Physical/Chemical Properties of Sodium Bromate and Sodium Bromide		
Property	Sodium Bromate	Sodium Bromide
Physical State	Solid powder	White crystals, granules or powder
Vapor Pressure	4.19×10^{-18} mm Hg[2]	3.58×10^{-17} mm Hg
Solubility (water)	364 g/L[2]	0.24 g/L
Log K_{ow}	-7.17 [2]	-0.37 (estimated by EPI Suite)
Henry's Law Constant	8.319×10^{-25} atm-m^3/mol[2]	2.03×10^{-23} atm-m^3/mole

EPI Suite Version 3.11, USEPA, 2003.
USEPA, 2005b.

2.0 USE INFORMATION

2.1 Formulation Types and Percent Active Ingredient

Concentrations of sodium bromide in registered products range from 6.9% to 98%. Formulations containing sodium bromide are available as tablets, liquids and granules.

2.2 Summary of Use Pattern and Formulations

Sodium bromide is an active ingredient in numerous products used in the control of bacteria, fungi, and algal slimes. At this time, products containing sodium bromide are intended for industrial and residential use. Industrial uses include treatments of recirculation cooling water systems, once-through cooling water systems, air washer water systems, pulp and paper mill water systems, wastewater treatment systems, fruit and vegetable wash, sugar beets, and pasteurizer/cannery cooling water systems. Residential uses include disinfection of swimming pools, hot tubs, spas, decorative fountains, and non-potable water. Only the swimming pool use is quantitatively assessed in this memorandum. Table 3 provides a listing of the sodium bromide uses for pools, spas, and fruits & vegetables. References to the fruit & vegetable wash are included in this memorandum because during this assessment it was noticed that there are no pesticidal claims and no tolerances for this use.

Table 3. Label Summary for Residential and Public Access for Sodium Bromide			
Uses	Method of Application	Registration Number Associated with Maximum Potential Exposure	Application Rate
Swimming Pools[a]	Feeder/tablets	935-75 (6.9% sodium bromide)	0.0274 lbs a.i/tablet [0.397 lbs (weight of one tablet) x 6.9% a.i.][b]
	Liquid Pour	3377-76 (50% sodium bromide)	Initial and maintenance rate: 0.0000261 lbs a.i./gal (8 oz product/10,000 gal x 50% a.i. x 1 gal/128 fl. oz x 8.34 lb/gal assuming product has the density of water) Winterizing rate: 0.0000521 lbs a.i./gal (16 oz product/10,000 gal x 50% a.i. x conversion factor oz/gal x 8.34 lb/gal assuming product has the density of water)
	Solid pour (granular)	45337-8 (88.8% sodium bromide)	0.0000880 lbs a.i./gal (2 lbs product/20,000 gallons x 88.8% a.i.)
Spas/hot tubs	Feeder/tablets	935-73 (6.9% sodium bromide)	0.0274 lbs a.i/tablet [0.397 lbs (weight of one tablet) x 6.9% a.i.)[b]
	Liquid Pour	54998-9 (35% sodium bromide)	0.000456 lbs a.i/gal (5 oz product/250 gal x 35% a.i. x 1 gal/128 fl. oz x 8.34 lb/gal, assuming product has the density of water)
	Solid pour (granular)	45337-9 (48.5% sodium bromide)	0.0000909 lbs a.i./gal (1.5 oz product/500 gal x 48.5% a.i.)
Fruit & Vegetable Wash	Solid pour into flume water system	1706-181 Applied on sugar beets	Sodium bromide is the active (42.8%); 1:1 sodium bromide to an oxidant ratio; no information on the expected residues ; potable water rinse suggested before slicing the sugar beets

Table 3. Label Summary for Residential and Public Access for Sodium Bromide			
Uses	Method of Application	Registration Number Associated with Maximum Potential Exposure	Application Rate
	Solid pour into the potable water system.	1448-345 Fruits and vegetable washes	Sodium bromide (40%); rate of application: 55 ppm; residue levels: 0.5 to 5 ppm 5 minutes after the application; no validation method suggested for the residue determination
	Solid pour into flume water system or potable water system	5185-451 Fruits and vegetable washes	Sodium bromide (40%); rate of application: max.55 ppm; residue level 5 minutes after the application: 5 ppm; no validation method suggested for residue determination.

[a] Some labels restrict to only indoor pools (e.g., 935-75) while other labels have no restriction (e.g., 3377-53).

[b] The label for product # 935-75 is unclear in its description of how to apply the product. It appears that the product is to be used in conjunction with another product (perhaps a product containing 2-dichloro-s-triazinetrione) and that the application rate should be measured in terms of available chlorine, not bromine. On the other hand, the label for product # 935-73 only indicates the level of residual bromine that should be maintained in the pools and spas (6 ppm).

3.0 SUMMARY OF TOXICITY CONCERNS RELATING TO EXPOSURES

3.1 Acute Toxicology

Acute toxicity values and toxicity categories for sodium bromide are presented in Table 4. The data indicate that sodium bromide is of low acute oral and dermal toxicity and causes mild eye and skin irritation (USEPA, 2005c).

Table 4. Acute Toxicity Categories for Sodium Bromide				
Guideline No.	Study Type	MRID #	Results	Tox. Cat.
§81-1 (OPPTS870.1100)	Acute Oral sodium bromide 99.23%	40670804	LD_{50} 4.5 g/kg Male LD_{50} 3.9 g/kg Female LD_{50} 4.2 g/kg combined	III
§81-2 (OPPTS 870.1200	Acute Dermal sodium bromide 46%	46083032	LD_{50} >2.0 g/kg	III
§81-3	Acute Inhalation	study not available		

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§81-4 (OPPTS 870.2400)	Primary Eye Irritation sodium bromide 46%	46083033 40670806	mild conjuctival irritation found in 6/6 animals, which persisted for 72 hr in 1/6 animals. No effects at 96 hr.	III
§81-5 (OPPTS 870.2500)	Primary Dermal Irritation sodium bromide 46%	46083034	very mild erythema on 1/6 animals, cleared by 24 hr. No irritation fount at other times. P.I.I. = 1.0	IV
§81-6 (OPPTS 870.2600	Dermal Sensitization	study not available		
§81-8 (OPPTS 870.6200)	Acute and Subchronic Neurotoxicity	study not available		

3.2 Summary of Toxicity Concerns Relating to Exposures

Bromine/Bromide - Report of the Antimicrobials Division Toxicity Endpoint Selection Committee (USEPA, 2005c) indicates that there are no toxicological endpoints of concern for sodium bromide. However, there are circumstances where applications of sodium bromide form bromate ion. Bromate is a known human carcinogen. The cancer slope factor selected for bromate is listed in Table 5.

Table 5. Bromate Toxicology Endpoints

Exposure Scenario	Cancer Slope Factor	Study and Toxicological Endpoints
Bromate Cancer Slope Factor	0.7 $(mg/kg/day)^{-1}$	USEPA 2001, Kurokawa et al1986a, Kurokawa et al 1986b, and DeAngelo 1998

4.0 RESIDENTIAL EXPOSURE AND RISK ESTIMATES

Sodium bromide is an active ingredient in numerous products used in the control of bacteria, fungi, and algal slimes. Residential applications include disinfection of hot tubs, spas, decorative fountains, non-potable water, and fruits and vegetables. Sanitizer uses are assessed in USEPA 2005a.

4.1 Dietary Exposure/Risk Pathway

No toxicological endpoints of concern were identified for sodium bromide. Therefore, exposure/risk estimates for the dietary pathway are not of concern and are not quantified.

During the development of this assessment, labels were identified (i.e., 1448-345 and 5185-451) that list a commercial fruit & vegetable wash. These two labels make no pesticidal claims for the wash. In addition, there are no tolerances for this use. EPA considers the fruit &

vegetable wash to be a food use, and therefore a tolerance exemption is required. Prior to submitting a petition to establish a tolerance exemption, the registrant needs to determine a pesticidal claim for this use (Note: some pesticidal claims require efficacy data).

4.2 Residential Exposure/Risk Pathway

Residential uses of sodium bromide products include use in swimming pools and hot tubs/spas. Since there are no toxicological endpoints identified for sodium bromide, handler exposures and risks were not calculated. At the time of application the formation of bromate is not expected to have occurred. Therefore, there are no applicator risks of concern. However, there are postapplication exposures associated with use of sodium bromide products in swimming pools and spas. EPA has concerns for uses of sodium bromide that potentially generate bromate ion in outdoor swimming pools. Bromate is a known human carcinogen with a cancer slope factor of 0.7 $(mg/kg/day)^{-1}$ (USEPA 2001, Kurokawa et al1986a, Kurokawa et al 1986b, and DeAngelo 1998).

4.2.1 Formation of Bromate Ion In Outdoor Swimming Pool

The potential for bromate ion formation in outdoor swimming pools occurs in the presence of UV light and oxidizers (Dionex, 1995). There is a relationship between UV light and the oxidizer when forming bromate from sodium bromide applications. However, EPA has insufficient data to develop a trend on the conversion rate of sodium bromide to bromate ion.

EPA received a 6(a)2 submission that indicated high concentrations of bromate in outdoor swimming pools when applying sodium bromide activated with $Ca(OCl)_2$ to produce hypobromous acid ($HOBr/OBr^-$) (Arch 2005). However, the data in this submission were based on exaggerated application rates of sodium bromide (i.e., 250 mg/L which is also 250 ppm) in comparison to the labeled application rate of 6 ppm and are not useful in assessing risks. Nonetheless, based on the chemistry, EPA is concerned with the generation of bromate ion in outdoor swimming pools. *Note: Some sodium bromide labels restrict the product to indoor pools only (e.g., EPA Reg. No. 935-75) while other labels have no restrictions, and in fact, recommend the product for above ground pools (e.g., EPA Reg. No. 3377-53).* At this time, EPA only has concerns for exposure in outdoor swimming pools. EPA is not concerned at this time with indoor/outdoor spas because incidental ingestion is expected to be negligible. In addition, EPA is not concerned with indoor swimming pools at this time because the formation of bromate ion is expected to be minimal without the presence of UV light.

The basis for the bromate ion concentration in pool water used in this assessment is based on information provided in the labels (6 ppm or 6 mg bromine/liter based on the maintenance rate listed in EPA Reg. No. 935-75). The available monitoring data for bromate ion concentrations in swimming pools are very limited and are based on exaggerated application rates of sodium bromide. Therefore, to present regulatory risk managers with a range of potential risk estimates, the swimmer risks are based on 100 percent conversion to bromate (i.e., 6 ppm), a 50 percent conversion to bromate (i.e., 3 ppm), and a "back-calculated" concentration

of bromate in pool water that represents the lifetime cancer risk of 1E-6. The 50 percent conversion to bromate estimate (i.e., 3 ppm) is based on data in the 6(a)2 submission where the highest conversion to bromate was 50 percent (Arch 2005).

It is important to note that there is the potential for bromate concentrations to accumulate over time (i.e., greater than 6 ppm). The concern for increasing bromate concentration over time is based on the studies conducted by Navy in 1994 (MRID Nos. 436637-01 and 437461-01, and USEPA 2005d) on the conversion of bromide into bromate at high ionic strength with pH 7 and above and at constant temperature. In these experiments, which were not conducted in the presence of sunlight, no oxidants were present. At the freely available bromine level of 5 ppm, the amount of bromate formed, over a period of 4 days, was 0.009 ppm. Arch's study indicates that the conversion of bromide to bromate is much higher in the presence of sunlight and oxidants.

4.2.2 Exposure Route and Input Parameters for Swimming

EPA's concern for bromate ion is based on the oral route of exposure. The dermal and inhalation exposure routes are not of concern because the bromate ion will not penetrate the skin (i.e., low permeability constant (Kp)) and it has a very low vapor pressure (estimated ~10^{-18} mm Hg). Oral exposure from incidental ingestion occurs while swimming but is expected to be negligible while sitting in a spa/hot tub (i.e., head is above water line). Therefore, the cancer risk assessment for bromate is limited to incidental oral exposure to swimmers in outdoor swimming pools.

The SWIMODEL 3.0 was developed by EPA as a screening tool to conduct exposure assessments of pesticides found in swimming pools (Versar, 2003). The SWIMODEL uses screening exposure assessment equations to calculate the high end exposure for swimmers expressed as a mass-based intake value (mg/event). The model focuses on potential chemical intakes only and does not take into account metabolism or excretion of the chemical of concern. Detailed information and the downloadable executable file are available at http://www.epa.gov/oppad001/swimodel.htm. Although, the actual model was not used in this assessment, the same equations as provided in the SWIMODEL User's Manual (version 3.0) were used in a spreadsheet format to estimate postapplication incidental oral exposures to bromate ion when applying sodium bromide to outdoor swimming pools.

The input parameters for ingestion exposure while swimming are presented in Table 6. Exposure time and frequency for non-competitive swimmers are based on the summary statistics from the National Human Activity Pattern Survey (NHAPS) (USEPA, 1996) whereas competitive swimmer exposure time and frequency data are based on the Agency's review of the American Chemistry Council (ACC) study (ACC, 2002).

Table 6. Parameters for Swimming Ingestion Exposure						
Age	Adult		Child 7-10 yrs		Child 11-14 yrs	
Type of Swimmer	Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.
Cw (mg/L)	6.0	6.0	6.0	6.0	6.0	6.0
IR (L/hr)	0.0125	0.0125	0.05	0.05	0.025	0.05
ET(hr/day)	3	mean=0.93	1	mean=1.47	2	mean=1.37
		90th%=2		90th %=3		90th%=2.6
EF (events/year)	238	88	65	102	189	82
BW(kg)	70	70	30	30	48	48

Where: Cw is chemical concentration in pool water, IR is ingestion rate of pool water, ET is exposure time, EF is exposure frequency, and BW is body weight.

4.2.3 Cancer Risks

The potential cancer risks resulting from incidental oral exposure of bromate ion in outdoor swimming pools treated with sodium bromide are estimated from the following two equations:

(1) LADD = Cw x IR x ET x EF x ED / BW x AT x 365 d/yr

where:

LADD = Lifetime average daily dose (mg/kg/day);
Cw = Chemical concentration in pool water (mg/L);
IR = Ingestion rate of pool water (L/hour);
ET = Exposure time (hours/day);
EF = Exposure frequency (events/year);
ED = Exposure duration (years);
BW = Body weight; and
AT = Averaging time (70 year lifetime).

(2) Cancer Risk = LADD (mg/kg/day) x Cancer Slope Factor of 0.7 $(mg/kg/day)^{-1}$

In addition to estimating the LADD, EPA's new Cancer Assessment Guidelines and Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens recommend that additional safety factors for various age groups are warranted for mutagens (USEPA 2005e and 2005f). Bromate is a mutagen, as noted in the following IRIS discussion (the reader is referred to IRIS, http://www.epa.gov/iris/subst/1002.htm, for a listing of the primary citations noted below):

> *"The genotoxicity of bromate has been evaluated in a variety of in vitro and in vivo systems. It has tested positive in the Salmonella typhimurium assay in the presence of metabolic activation and in an in vitro test for chromosomal aberrations that uses Chinese hamster fibroblasts (Ishidate et al., 1984). Dose-dependent*

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increases in the number of aberrant metaphase cells were observed following single oral doses of potassium bromate to Long-Evans rats (Fuji et al., 1988). Bromate caused significant increases in the number of micronuclei following either i.p. injection (Hayashi et al., 1988; Awogi et al., 1992) or gavage dose (Hayashi et al., 1989; Nakajima et al., 1989) in mice. Also, i.p. injection of bromate in F344 rats resulted in significantly increased micronuclei in reticulocytes (Sai et al., 1992a). Bromate was cytotoxic, increased the frequency of cells with micronuclei, increased the number of chromosome aberrations, and increased DNA migration in a series of assays that used V79 Chinese hamster cells (Speit et al., 1999). Furthermore, potassium bromate clearly induced gene mutations at the HPRT locus of V79 Chinese hamster cells (Speit et al., 1999)."

The additional safety factors or age-dependent adjustment factors (ADAFs) recommended in the EPA guidance include:

Age Group	Safety Factor or Age-Dependent Adjustment Factor (ADAF)
0 to 2 years olds	10x
2 to 16 year olds	3x
16 to 70 year olds	1x

To estimate potential cancer risk, the safety factors have been applied to the risk estimates for each of the specific age groups (e.g., 0 to 2 year olds LADD mg/kg/day x CSF x 10). Cancer risks for the 5 age groups are then summed to estimate the potential lifetime cancer risk.

The estimated LADDs and potential cancer risks for competitive and non competitive swimmers using the age-dependent adjustment factors (ADAF or safety factor) are presented in Table 7. The cancer risks are presented for various age groups with the total risk representing a "lifetime" of swimming.

Based on these assumptions, the cancer risks range up to 8.8E-4 for competitive and 9.2E-4 for non competitive swimmers at the 6 ppm bromate ion concentration. Cancer risks are also provided in this memorandum to illustrate the differences in risks when the ADAFs are not applied. For comparison (Table 8), the lifetime cancer risks without the additional safety factors at 6 ppm are 4.8E-4 and 4.1E-4 for competitive and non competitive swimmers, respectively. A back-calculated concentration of less than 0.01 ppm bromate ion in swimming pools corresponds to a cancer risk of E-6 for both approaches.

Table 7. Swimmer Bromate Cancer Risks Resulting From Outdoor Applications of Sodium Bromide to Pools (SF Applied).

Age Group (years) (a)	SF (b)	LADD (mg/kg/day) (c)						Cancer Risk (d)					
		0.01 ppm		3 ppm		6 ppm		0.01 ppm		3 ppm		6 ppm	
		Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.
0 to 2	10x	NA	2E-7	NA	6.0E-5	NA	1.2E-4	NA	1.4E-6	NA	4.2E-4	NA	8.4E-4
3 to 6	3x	NA	6E-7	NA	1.9E-4	NA	3.8E-4	NA	1.3E-6	NA	4.0E-4	NA	7.9E-4
7 to 10	3x	2E-7	4E-7	5.1E-5	1.2E-4	1.0E-4	2.3E-4	3.6E-7	8.2E-7	1.1E-4	2.5E-4	2.1E-4	4.9E-4
11 to 15	3x	3E-7	2E-7	9.2E-5	6.7E-5	1.8E-4	1.3E-4	6.4E-7	4.7E-7	1.9E-4	1.4E-4	3.8E-4	2.8E-4
16 to 70	1x	1E-6	4E-7	2.0E-4	1.1E-4	4.0E-4	2.1E-4	4.7E-7	2.5E-7	1.4E-4	7.4E-5	2.8E-4	1.5E-4
Lifetime	--							1.5E-6	1.5E-6	4.4E-4	4.6E-4	8.8E-4	9.2E-4

a Age groups are based on the SWIMODEL and the cancer assessment guidelines.

b Safety factor (SF) values are based on the recommendations in the cancer assessment guidelines. The SF are used in the calculation of the cancer risk estimates. The SF are not included in the calculation/presentation of the LADD.

c Lifetime average daily dose (LADD) (mg/kg/day) = LADD = Cw x IR x ET x EF x ED / BW x AT x 365 d/yr.

Where Cw=Chemical concentration in pool water (mg/L); IR=Ingestion rate of pool water (L/hour);
ET=Exposure time (hours/day); EF=Exposure frequency (events/year); ED=Exposure duration (years);
BW=Body weight; and AT=Averaging time (70 year lifetime).

d Cancer Risk = age group specific LADD (mg/kg/day) x Cancer Slope Factor of 0.7 $(mg/kg/day)^{-1}$ x age group specific SF. Lifetime risk is the sum of the 5 age group risks.

Table 8. Swimmer Bromate Cancer Risks Resulting From Outdoor Applications of Sodium Bromide to Pools (No SF Applied).

Age Group (years) (a)	SF (b)	LADD (mg/kg/day) (c)						Cancer Risk (d)					
		0.01 ppm		3 ppm		6 ppm		0.01 ppm		3 ppm		6 ppm	
		Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.	Comp.	Non-Comp.
0 to 2	1x	NA	2E-7	NA	6.0E-5	NA	1.2E-4	NA	1.4E-7	NA	4.2E-5	NA	8.4E-5
3 to 6	1x	NA	6E-7	NA	1.9E-4	NA	3.8E-4	NA	4.4E-7	NA	1.3E-4	NA	2.6E-4
7 to 10	1x	2E-7	4E-7	5.1E-5	1.2E-4	1.0E-4	2.3E-4	1.2E-7	2.7E-7	3.6E-5	8.2E-5	7.1E-5	1.6E-4
11 to 15	1x	3E-7	2E-7	9.2E-5	6.7E-5	1.8E-4	1.3E-4	2.1E-7	1.6E-7	6.4E-5	4.7E-5	1.3E-4	9.4E-5
16 to 70	1x	1E-6	4E-7	2.0E-4	1.1E-4	4.0E-4	2.1E-4	4.7E-7	2.5E-7	1.4E-4	7.4E-5	2.8E-4	1.5E-4
Lifetime	--							8.0E-7	6.8E-7	2.4E-4	2.0E-4	4.8E-4	4.1E-4

a Age groups are based on the SWIMODEL and the cancer assessment guidelines.

b Safety factor (SF) values are not used in these estimates (i.e., SF = 1).

c Lifetime average daily dose (LADD) (mg/kg/day) = LADD = Cw x IR x ET x EF x ED / BW x AT x 365 d/yr.

Where Cw=Chemical concentration in pool water (mg/L); IR=Ingestion rate of pool water (L/hour);
ET=Exposure time (hours/day); EF=Exposure frequency (events/year); ED=Exposure duration (years);
BW=Body weight; and AT=Averaging time (70 year lifetime).

d Cancer Risk = LADD (mg/kg/day) x Cancer Slope Factor of 0.7 $(mg/kg/day)^{-1}$

4.4 Data Limitations/Uncertainties

There are several data limitations and uncertainties associated with the postapplication cancer exposure/risk assessment. These uncertainties include:

$ Calculation for the swimming pool scenarios rely on the use of SWIMODEL, a model which has the following limitations:

S SWIMODEL focuses on potential chemical intakes only. It does not account for metabolism or excretion of the chemical of concern.

S SWIMODEL does not predict or calculate chemical concentration values in exhaled air or blood. Therefore, biological monitoring results cannot be directly compared or related to SWIMODEL outputs.

S SWIMODEL assumes 100% absorption of ingested chemical.

$ The concentration of bromate ion in swimming pools has not been adequately characterized. This assessment provides risk estimates at various bromate ion concentrations based on available data in the 6(a)2 submission and assumptions made based on the information available. Additional sampling would better characterize the risk estimates.

$ Arch (2005) did not provided details of the sampling and analysis methods. No QA/QC data were included in the submission.

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