Screening Assessment for the Challenge

(Benzenamine, *N*-phenyl-, Reaction Products with Styrene and 2,4,4-Trimethylpentene)

Chemical Abstracts Service Registry Number 68921-45-9

Environment Canada
Health Canada

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Synopsis

Pursuant to section 74 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), the Ministers of the Environment and of Health have conducted a screening assessment of benzenamine, *N*-phenyl-, reaction products with styrene and 2,4,4-trimethylpentene (BNST) Chemical Abstracts Service Registry Number 68921-45-9. This substance was identified as a high priority for screening assessment and was included in the Challenge because it was found to meet the ecological categorization criteria for persistence, bioaccumulation potential and inherent toxicity to non-human organisms and is believed to be in commerce in Canada.

The substance BNST was not considered to be a high priority for assessment of potential risks to human health, based upon application of the simple exposure and hazard tools developed by Health Canada for categorization of substances on the Domestic Substances List. Therefore, this assessment focuses on information relevant to the evaluation of ecological risks.

BNST is an organic substance that is not naturally produced in the environment. Between 100 001 and 1 000 000 kg of BNST was imported into Canada in 2006, and between 1 000 000 and 10 000 000 kg was manufactured in 2006. The quantity of BNST that is manufactured and imported into Canada, along with the dispersive uses of this substance, indicate that significant quantities could be released into the Canadian environment.

The majority of BNST that is manufactured in Canada is exported. Of the amount imported and used in Canada it is estimated that 98.3% is chemically transformed, combusted, incinerated or re-used during use and following disposal. Small proportions are estimated to be released during use to sewer (0.9%) and soil (0.6%). A total of 0.2% is expected to end up in waste disposal sites. Approximately 0.2% is expected to be released to sewers during cleaning of containers used to transport additive packages containing BNST.

BNST has very low solubility in water, has low volatility and has a tendency to partition to particles and lipids (fat) of organisms because of its hydrophobic nature. For these reasons, BNST will likely be found mostly in soil and sediments. It is not expected to be present in large amounts in other media. It is also not expected to be subject to long-range atmospheric transport.

Based on its physical and chemical properties, BNST is not anticipated to degrade quickly in the environment. It is expected to be persistent in water, soil and sediments. BNST also has the potential to accumulate in organisms and may biomagnify in trophic food chains. The substance has been determined to meet the persistence and bioaccumulation criteria as set out in the *Persistence and Bioaccumulation Regulations*. In addition, acute aquatic toxicity estimates indicate that the substance may be moderately to highly hazardous to aquatic organisms.

Given that long-term risks associated with persistent and bioaccumulative substances cannot at present be reliably predicted, quantitative risk estimates have limited relevance. Furthermore, since accumulations of such substances may be widespread and are difficult to reverse, a conservative response to uncertainty is justified.

Based on the information presented in this screening assessment, it is concluded that BNST is entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity.

This substance will be included in the upcoming *Domestic Substances List* inventory update initiative. In addition and where relevant, research and monitoring will support verification of assumptions used during the screening assessment and, where appropriate, the performance of potential control measures identified during the risk management phase.

Based on the information available, it is concluded that BNST meets one or more of the criteria set out in section 64 of CEPA 1999. BNST is persistent and bioaccumulative in accordance with the regulations, its presence in the environment results primarily from human activity, and it is not a naturally occurring radionuclide or a naturally occurring inorganic substance.

Introduction

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada 1999) requires the Minister of the Environment and the Minister of Health to conduct screening assessments of substances that have met the categorization criteria set out in the Act to determine whether these substances present or may present a risk to the environment or human health. Based on the results of a screening assessment, the Ministers can propose to take no further action with respect to the substance, to add the substance to the Priority Substances List (PSL) for further assessment, or to recommend that the substance be added to the List of Toxic Substances in Schedule 1 of the Act and, where applicable, the implementation of virtual elimination.

Based on the information obtained through the categorization process, the Ministers identified a number of substances as high priorities for action. These include substances that

- met all of the ecological categorization criteria, including persistence (P), bioaccumulation potential (B) and inherent toxicity to aquatic organisms (iT), and were believed to be in commerce in Canada; and/or
- met the categorization criteria for greatest potential for exposure (GPE) or presented an intermediate potential for exposure (IPE), and had been identified as posing a high hazard to human health based on classifications by other national or international agencies for carcinogenicity, genotoxicity, developmental toxicity or reproductive toxicity.

The Ministers therefore published a notice of intent in the *Canada Gazette*, Part I, on December 9, 2006 (Canada 2006), that challenged industry and other interested stakeholders to submit, within specified timelines, specific information that may be used to inform risk assessment, and to develop and benchmark best practices for the risk management and product stewardship of those substances identified as high priorities.

The substance BNST was identified as a high priority for assessment of ecological risk as it was found to be persistent, bioaccumulative and inherently toxic to aquatic organisms and is believed to be in commerce in Canada during the categorization of the DSL. The Challenge for this substance was published in the *Canada Gazette* on November 17, 2007 (Canada 2007). A substance profile was released at the same time. The substance profile presented the technical information available prior to December 2005 that formed the basis for categorization of this substance. As a result of the Challenge, submissions of information pertaining to the uses, composition and hazard of the substance were received.

Although BNST was determined to be a high priority for assessment with respect to the environment, it did not meet the criteria for GPE or IPE and was not identified as posing a high hazard to human health based on classifications by other national or international agencies for carcinogenicity, genotoxicity, developmental toxicity or reproductive

toxicity. Therefore, this assessment focuses principally on information relevant to the evaluation of ecological risks.

Under CEPA 1999, screening assessments focus on information critical to determining whether a substance meets the criteria for defining a chemical as toxic as set out in section 64 of the Act, where

> "64. [...] a substance is toxic if it is entering or may enter the environment in a quantity or concentration or under conditions that
>
> (*a*) have or may have an immediate or long-term harmful effect on the environment or its biological diversity;
>
> (*b*) constitute or may constitute a danger to the environment on which life depends; or
>
> (*c*) constitute or may constitute a danger in Canada to human life or health."

Screening assessments examine scientific information and develop conclusions by incorporating a weight-of-evidence approach and precaution.

This screening assessment includes consideration of information on chemical properties, hazards, uses and exposure, including the additional information submitted under the Challenge. Data relevant to the screening assessment of this substance were identified in original literature, review and assessment documents, stakeholder research reports and from recent literature searches, up to March 25 2009. Key studies were critically evaluated; modelling results may have been used to reach conclusions. When available and relevant, information presented in hazard assessments from other jurisdictions was considered. The screening assessment does not represent an exhaustive or critical review of all available data. Rather, it presents the most critical studies and lines of evidence pertinent to the conclusion.

This screening assessment was prepared by staff in the Existing Substances Programs at Health Canada and Environment Canada and incorporates input from other programs within these departments. This assessment has undergone external written peer review/consultation. Additionally, a draft of this screening assessment was subject to a 60-day public comment period. While external comments were taken into consideration, the final content and outcome of the screening risk assessment remain the responsibility of Health Canada and Environment Canada. The critical information and considerations upon which the assessment is based are summarized below.

Substance Identity

Benzenamine, *N*-phenyl-, reaction products with styrene and 2,4,4-trimethylpentene (CAS RN 68921-45-9; BNST) is a UVCB (Unknown or Variable Composition, Complex Reaction Products, or Biological Materials). BNST is a reaction product of diphenylamine substitution with a blend of styrene and isooctane (also known as di-isobutylene) (Environment Canada 2009a). The reaction product is a mixture of diphenylamines (the mixture differs by the type and extent of substitution of the phenyl group), the nature of which may be variable depending on the ratio of styrene to di-isobutylene used during the manufacture. There may also be monoalkylated species formed, where either a styrene or a di-isobutylene unit are added (Environment Canada 2009a).

For the purposes of this assessment, BNST will be evaluated based on two structures that are representative of the UVCB. As it is not a discrete chemical, BNST may be characterized by multiple structures in order to provide a range of properties of the mixture and thus the best possible characterization for assessment purposes. Information on BNST is provided in Table 1a. The selected representative structures are shown in Tables 1b and 1c. Information concerning sources, uses and releases are described in terms of BNST, as the data submitted under the Challenge was in reference to CAS RN 68921-45-9. However, evaluation of properties and risk are based on the identified representative structures.

Structure 1 is one of eight members of the substituted diphenylamines category that were submitted by the American Chemistry Council, Rubber and Plastic Additives (RAPA) Panel as part of the US EPA screening level hazard characterization for high production volume chemicals (US EPA 2008). This structure (Table 1b) provides a more hazardous profile possibility for the mixture representing CAS RN 68921-45-9, but its weight percent in the mixture that is CAS number 68921-45-9, is unknown.

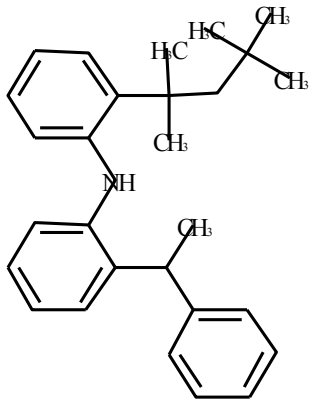
Structure 2 is the major component of the UVCB N-phenyl-, reaction products with 2,4,4-trimethylpentene (CAS RN 68411-46-1). This mono substituted diphenylamine is analogous to the major component of BNST. This representative structure does not contain styrene which would increase the hydrophobicity and potentially the bioaccumulation of the substance.

Table 1a. Substance identity for BNST

Chemical Abstracts Service Registry Number (CAS RN)	**68921-45-9**
Domestic Substances List (DSL) Name	**Benzenamine, *N*-phenyl-, reaction products with styrene and 2,4,4-trimethylpentene**
National Chemical Inventories (NCI) names[1]	*Benzenamine,* N-*phenyl-, reaction products with styrene and 2,4,4-trimethylpentene* (TSCA, EINECS, ENCS, AICS, PICCS, ASIA-PAC, NZIoC)
Other names	*Diphenylamine reaction product with styrene and diisobutylene* *Reaction product of* N-*phenylbenzenamine, ethenylbenzene, and diisobutylene* *Amines*
Chemical group	UVCB
Major chemical class or use	Diphenyl amines

[1] National Chemical Inventories (NCI). 2006: AICS (Australian Inventory of Chemical Substances); ASIA-PAC (Asia-Pacific Substances Lists); EINECS (European Inventory of Existing Commercial Chemical Substances); ENCS (Japanese Existing and New Chemical Substances); NZIoC (New Zealand Inventory of Chemicals); PICCS (Philippine Inventory of Chemicals and Chemical Substances); and TSCA (Toxic Substances Control Act Chemical Substance Inventory).

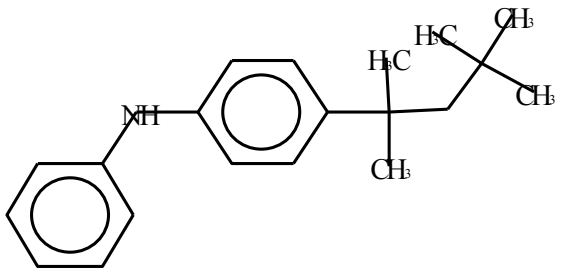
Table 1b. Substance identity for representative Structure 1

Representative Chemical formula	$C_{28}H_{35}N$
Representative chemical structure used to run estimation models	
SMILES[1] used to run estimation models	CC(C1=CC=CC=C1NC2=CC=CC=C2C(C)(C)CC(C)(C)C)3=CC=CC=C3

Molecular mass	385.60 g/mol

1 Simplified Molecular Line Input Entry System

Table 1c. Substance identity for representative Structure 2

Representative Chemical formula	$C_{20}H_{27}N$
Representative chemical structure used to run estimation models	
SMILES[1] used to run the estimation model	CC(C)(CC(C)(C)C)C1=CC=C(NC2=CC=CC=C2)C=C1
Molecular mass	281.44

1 Simplified Molecular Line Input Entry System

Physical and Chemical Properties

No experimental data are available for the two structures selected to represent BNST.

Tables 2a and 2b contain modelled physical and chemical properties for the representative structures.

Table 2a. Physical and chemical properties of Structure 1

Property	Type	Value[1]	Temperature (°C)	Reference
Melting point (ºC)	Modelled	180.83		MPBPWIN 2000
Boiling point (ºC)	Modelled	462.34		MPBPWIN 2000
Density (kg/m^3)	Unknown	1010	15.6	R. T. Vanderbilt 2007
Vapour pressure (Pa)	Modelled	$7.71x10^{-7}$ ($5.78x10^{-9}$ mm Hg)	25	MPBPWIN 2000
Henry's Law constant ($Pa\ m^3/mol$)	Modelled	$1.01x10^{-1}$ ($9.869x10-^{7}$)		HENRYWIN 2000
Log K_{ow} (Octanol-water partition coefficient) (dimensionless)	Modelled	9.21		KOWWIN 2000
Log K_{oc} (Organic carbon-water partition coefficient) (dimensionless)	Modelled	5.97		PCKOCWIN 2000
Water solubility (mg/L)	Modelled	$5.11x10^{-5}$	25	WSKOWWIN 2000
pK_a (Acid dissociation constant) (dimensionless)	Modelled	2.14		ACD/pK_aDB 2005

[1] Values and units in parentheses represent those originally reported by the authors or estimated by the models.

Table 2b. Physical and chemical properties of Structure 2

Property	Type	Value[1]	Temperature (°C)	Reference
Melting point (ºC)	Modelled	120.09		MPBPWIN 2000
Boiling point (ºC)	Modelled	361.98		MPBPWIN 2000
Density (kg/m^3)	Unknown	1010 (1.01 g/mL)	15.6	R. T. Vanderbilt 2007
Vapour pressure (Pa)	Modelled	$1.04x10^{-3}$ (7.8×10^{-6} mm Hg)	25	MPBPWIN 2000
Henry's Law constant ($Pa\ m^3/mol$)	Modelled	$8.54x10^{-1}$ (8.42×10^{-6} atm m^3/mol)		HENRYWIN 2000
Log K_{ow} (Octanol-water partition coefficient) (dimensionless)	Modelled	7.05		KOWWIN 2000
Log K_{oc} (Organic carbon-water partition coefficient) (dimensionless)	Modelled	4.78		PCKOCWIN 2000
Water solubility (mg/L)	Modelled	0.014	25	WSKOWWIN 2000
pK_a (Acid dissociation constant) (dimensionless)	Modelled	1.39		ACD/pK_aDB 2005

[1] Values and units in parentheses represent those originally reported by the authors or estimated by the models.

Sources

Neither BNST nor its selected representative structures are reported to be naturally produced in the environment.

Information submitted as part of the Challenge indicates that fewer than five companies manufactured between 1 000 000 and 10 000 000 kg and fewer than five companies imported between 100 001 and 1 000 000 kg in Canada in the year 2006 (Environment Canada 2008a). One company reported importing 405 600 kg for miscellaneous chemical product and preparation manufacturing. A total of 12 companies indicated stakeholder interest in this substance.

Based on the information received, the petroleum and chemical manufacturing sector is the primary industrial sector involved with BNST (Environment Canada 2008a)

The quantity reported to be manufactured, imported into or in commerce in Canada during the 1986 calendar year was between 100 000 and 1 000 000 kg (Environment Canada 1986). The number of notifiers for the 1984 to 1986 calendar years was fewer than five.

Elsewhere, BNST has been identified as a High Production Volume (HPV) chemical under the HPV Challenge Program of the U.S. Environmental Protection Agency (US EPA). In the United States, according to the information collected by the US EPA, in the years 1990, 1994 and 2002, BNST was imported or used in quantities between 450 000 kg to 45 million kg per year (US EPA 2006). According to the Substances in Preparations in Nordic Countries database (SPIN 2006), this chemical was used in Sweden and Denmark in the years 1999–2004.

Uses

Information submitted in response to the Challenge (Environment Canada 2008a) indicates that BNST is used in Canada as a lubricating agent/lubricant additive. These uses can be dispersive.

During the calendar year 1986, when between 100 000 and 1 000 000 kg of BNST were in commerce in Canada, fewer than five notifiers reported the following uses: antioxidant/corrosion inhibitor/tarnish inhibitor/scavenger/antiscaling agent; lubricating agent/lubricant additive/mould release agent; organic chemicals, industrial.

Elsewhere, BNST is a U.S. Environmental Protection Agency (US EPA) High Production Volume chemical. Norway, Sweden and Denmark reported use from 1999 to 2005. Norway reported use as a lubricant and additive (SPIN 2006).

The primary end-use application of BNST is as an antioxidant in vehicle engine oils. It also has a minor use as an antioxidant in commercial/industrial lubricants. Antioxidants are added to stabilize lubricating oils and prevent polymerization that leads to the formation of engine-fouling residues. A technical study completed for Environment Canada by MTN Consulting Associates (Environment Canada 2009a) indicated that BNST is present in vehicle engine oils and commercial and industrial lubricating oils at levels between 0.20% and 0.25%.

Releases to the Environment

Mass Flow Tool

To estimate potential releases of a substance to the environment at different stages of its life cycle, a Mass Flow Tool was developed (Environment Canada 2008b. Empirical data concerning releases of specific substances to the environment are seldom available. Therefore, for each identified type of use of the substance, the proportion and quantity of releases to the different environmental media are estimated, as is the proportion of the substance chemically transformed or sent for waste disposal.

Assumptions and input parameters used in making the release estimates are based on information obtained from a variety of sources, including responses to regulatory surveys, Statistics Canada, manufacturers' websites, technical databases and documents. Of particular relevance are emission factors, which are generally expressed as the fraction of a substance released to the environment, particularly during its manufacture, processing, and use associated with industrial processes. Sources of such information include emission scenario documents, often developed under the auspices of the OECD, and default assumptions used by different international chemical regulatory agencies. Information received from companies during the public comment period under the Challenge were also considered in the application of certain assumptions. The level of uncertainty in the mass of substance and quantity released to the environment generally increases toward the end of the life cycle.

Table 3. Estimated releases and losses of BNST to environmental media, chemical transformation and transfer to waste disposal sites, based on the Mass Flow Tool

Fate	Proportion of the mass (%)[1]	Major life cycle stage[2]
Releases to receiving media:		
Soil/Sewer[3]	1.3	Commercial and consumer use, disposal of used lubricants
Air	0.0	
Sewer[3]	0.2	Disposal of container cleaning residues
Chemically transformed, combusted or incinerated	98.3	Use as commercial or consumer product. BNST is consumed by design during its function in lubricants.
Waste disposal	0.2	Disposal of used lubricants

[1] For BNST, information from OECD emission scenario documents was used to estimate releases to the environment and distribution of the substance. Specific assumptions used in derivation of these estimates are summarized in Environment Canada (2009b).
[2] Applicable stage(s): production, formulation, industrial use, consumer use, service life of article/product, waste disposal.
[3] Wastewater before any form of treatment.

Results of the Mass Flow Tool (Environment Canada 2009b) indicate that the majority of BNST can be expected to be chemically transformed (98.3%). This value includes combustion, chemical transformation, incineration and re-use of BNST. The fraction transferred to waste disposal sites is relatively low (0.2% for landfill). Based largely on information contained in OECD emission scenario documents on processing and uses associated with this type of substance, and new information from the public comment period (Environment Canada 2009b), it is estimated that 1.5% of BNST may be released to sewer and soil, amounting to over 7 000 kg per year in total. This 1.5% loss consists of 1.0% due to leaks and spills during commercial and consumer use, 0.3% as a result of improper disposal and 0.2% resulting from the process of cleaning containers used to transport lubricant additives.

It is assumed that there are very minimal releases from manufacturing and lubricant blending operations, as it is assumed that existing on-site wastewater treatments are highly efficient in removing BNST. Unless specific information on the rate or potential for release of the substance from landfills and incinerators is available, the Mass Flow Tool does not quantitatively account for release to the environment from disposal.

Environmental Fate

Based on their physical and chemical properties (Tables 2a and 2b), the results of Level III fugacity modelling (Table 4a and 4b) suggest that Structures 1 and 2 will predominantly reside in soil and/or sediment, depending on the compartment of release.

Table 4a. Results of the Level III fugacity modelling for Structure 1 (EQC 2003)

	Fraction of substance partitioning to each medium (%)			
Substance released to	**Air**	**Water**	**Soil**	**Sediment**
Air (100 %)	1	0	80	19
Water (100 %)	0	2	0	98
Soil (100 %)	0	0	100	0

Table 4b. Results of the Level III fugacity modelling for Structure 2 (EQC 2003)

	Fraction of substance partitioning to each medium (%)			
Substance released to	**Air**	**Water**	**Soil**	**Sediment**
Air (100 %)	31	2	21	46
Water (100 %)	0	4	0	96
Soil (100 %)	0	1	100	0

The relatively low ionization constants (pKa) of 1.39 and 2.14 (Table 2a and 2b) for the two structures indicates that ionization of these bases is insignificant. In aqueous environments at environmentally relevant pHs (6–9), these substances will be treated as non-ionizing substances which exist in the environment in their neutral form only.

Structures 1 and 2 are characterized by negligible water solubility (5.11×10^{-5} and 0.014 mg/L, respectively), low vapour pressure (7.71×10^{-7} Pa and 0.001 Pa), high log K_{oc} (5.97 and 4.78) and low Henry's Law constant (1.01×10^{-1} Pa m^3/mol to 8.54×10^{-1} Pa m^3/mol), respectively. Thus, partitioning to each of the soil and sediment compartments is potentially significant, depending on the compartment of release and the rates of partitioning relative to other fate processes, such as advection and degradation.

If released to soil, Structures 1 and 2 are expected to have high adsorptivity to soil (i.e., expected to be relatively immobile) based upon their estimated log K_{oc}s. Little volatilization from moist soil surfaces will occur, based on their estimated Henry's Law constants. These chemicals are not likely to volatilize significantly from dry soil surfaces based upon their vapour pressure. Therefore, if released to soil, both substances represented by Structures 1 and 2 will partition solely to this environmental compartment, as illustrated by the results of the Level III fugacity modelling (see Tables 4a and 4b).

If released into water, Structures 1 and 2 are expected to strongly adsorb to sediment based upon high estimated log K_{ow} of 9.21 and 7.05, log K_{oc} values of 5.97 and 4.78 and low water solubility. Little volatilization from water surfaces is expected based on the compounds' estimated Henry's Law constant. Thus, if water is a receiving medium, both substances are expected to partition mainly to sediment and to a limited extent remain in water (see Tables 4a and b).

If released to air, Structure 1 is not expected to remain in air (see Table 4a). Based upon the very low vapour pressure of Structure 1 (7.71×10^{-7}Pa) and low Henry's Law constant

of $1.01x10^{-1}$ Pa m^3/mol, Structure 1 has low volatility. Therefore, if it is released solely to air, Structure 1 will not remain in this compartment; the major compartments to which this substance will partition will be soil and sediment (~ 100%; see Table 4a).

Moderate amounts of Structure 2 are expected to remain in air (see Table 4b). Based on the moderate vapour pressure and low Henry's law constant ($8.54x10^{-1}$ Pa m^3/mol), this substance is semi-volatile. Although moderate amounts will remain in air if released solely to air, the remainder will partition to soil and sediment (67%).

Persistence and Bioaccumulation Potential

Environmental Persistence

No experimental degradation data for Structures 1 and 2 have been identified. Tables 5a and 5b summarize the results of available quantitative structure-activity relationship (QSAR) models for degradation in various environmental media.

Table 5a. Modelled data for degradation of Structure 1

Fate Process	Model and model basis	Model Output	Expected Half-life (days)
AIR			
Atmospheric oxidation	AOPWIN 2000	$t_{1/2}$ = 0.052 days	< 2
Ozone reaction	AOPWIN 2000	n/a[1]	n/a
WATER			
Hydrolysis	HYDROWIN 2000	n/a	n/a
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 3: Expert Survey (ultimate biodegradation)	1.73	> 182
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 4: Expert Survey (primary biodegradation)	2.8	> 182
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 5: MITI linear probability	-0.308	> 182
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 6: MITI non-linear probability	0.001	> 182
Biodegradation (aerobic)	TOPKAT 2004 Probability	n/a	n/a
Biodegradation (aerobic)	CATABOL c2004-2008 % BOD (biological oxygen demand)	0.7	> 182

[1] Model does not provide an estimate for this type of structure.

Table 5b. Modelled data for degradation of Structure 2

Fate Process	Model and model basis	Model Output	Expected Half-life (days)

AIR			
Atmospheric oxidation	AOPWIN 2000	$t_{1/2}$ = 0053 days	< 2
Ozone reaction	AOPWIN 2000	n/a[1]	n/a
WATER			
Hydrolysis	HYDROWIN 2000	n/a)	n/a
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 3: Expert Survey (ultimate biodegradation)	2.04	> 182
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 4: Expert Survey (primary biodegradation)	3.03	~ 182
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 5: MITI linear probability	-0.02	> 182
Biodegradation (aerobic)	BIOWIN 2000 Sub-model 6: MITI non-linear probability	0.01	> 182
Biodegradation (aerobic)	TOPKAT 2004 Probability	n/a	n/a
Biodegradation (aerobic)	CATABOL c2004-2008 % BOD (biological oxygen demand)	1.0	> 182

[1] Model does not provide an estimate for this type of structure.

In air, predicted atmospheric oxidation half-life values of 0.052 and 0.053 days (see Tables 5a and b) for Structures 1 and 2 demonstrate that these substances are likely to be rapidly oxidized. There are no estimates for the reaction half-lives of these substance with other photooxidative species in the atmosphere, such as ozone. Therefore, it is expected that reactions with hydroxyl radicals will be the most important fate process in the atmosphere for Structures 1 and 2. With half-lives of 0.052 and 0.053 hours, via reactions with hydroxyl radicals, respectively, Structures 1 and 2 are considered not persistent in air.

Structures 1 and 2 do not contain functional groups expected to undergo hydrolysis.

As shown in Table 5a, all three ultimate degradation models (BIOWIN 3, 5 and 6) suggest that Structures 1 and 2 do not biodegrade rapidly. Results for BIOWIN 4 with a threshold of 3.0 suggest that primary biodegradation of Structure 2 is on or around 182 days. Another ultimate degradation probability model (CATABOL) predicts that Structures 1 and 2 do not undergo mineralization in a 28-day time frame, with a probability or extent of biodegradation in the range of very persistent chemicals. CATABOL predicted 0.7% biodegradation for Structure 1 and 1.0% for Structure 2 based on the OECD 301 ready-biodegradation test (percentage biochemical oxygen demand [BOD]); this rate has been suggested to mean "likely persistent" (Aronson and Howard 1999) and having a half-life in water of > 182 days. A reliable estimate from the TOPKAT model could not be obtained.

Diphenylamine (DPA, Chemical Abstracts Service Registry Number 122-39-4) is another relatively close analogue of BNST. There are experimental biodegradation data for DPA (NITE 2002) and they show that DPA has 0–7% biodegradation for the OECD 301C test, i.e., it does not biodegrade quickly. BNST is expected to be less biodegradable than DPA because it is a larger substance, more hydrophobic, and has more molecular groups that could structurally impede biodegradation.

When the results of all models and empirical analogue test data are considered, there is a consistent line of evidence to suggest that the representative structures of BNST do not undergo a rapid rate of biodegradation in water or sewage sludge. Most of the model predictions and analogue data are in the very slow range of the biodegradation spectrum for ultimate degradation (i.e., <10% in 28 days) and the slow range for primary biodegradation. These results are consistent with structural features of chemicals that are known to be persistent (i.e., presence of terminal branched alkyl tert-butyl groups, benzene ring with more than two non-hydroxy substituents and high $\log K_{ow}$). Thus there is a sufficient and consistent weight of evidence to conclude that the biodegradation half-life in water is > 182 days.

Using an extrapolation ratio of 1:1:4 for a water:soil:sediment biodegradation half-life (Boethling et al. 1995), the biodegradation half-life in soil is also > 182 days and the half-life in sediments is > 365 days. This indicates that both Structures 1 and 2 are expected to be persistent in soil and sediment.

The Transport and Persistence Level III Model (TaPL3) (TaPL3 2000) was used to estimate the characteristic travel distance (CTD), defined as the maximum distance traveled in air by 63% of the substance. Beyer et al. (2000) have proposed CTDs of > 2000 km as representing high long-range atmospheric transport potential (LRATP), 700–2000 km as moderate LRATP, and < 700 km as low LRATP. Based on the CTD estimates of 56.3 and 13.3 km, respectively, the long-range atmospheric transport potentials of Structures 1 and 2 are considered to be low. This means that although the partitioning behaviour suggests that lower molecular weight components of this mixture could reside in the atmosphere (e.g. Structure 2), because of the expected rapid rate of photodegradation, neither structure is expected to be transported through the atmosphere significant distances from its emission sources.

Based on the modelled and representative structure data (see Tables 5a and b), BNST, as represented by Structures 1 and 2, meets the persistence criteria in water, soil and sediment (half-lives in soil and water ≥ 182 days and half-life in sediment ≥ 365 days), but does not meet the criterion for air (half-life in air ≥ 2 days), as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Potential for Bioaccumulation

According to the *Persistence and Bioaccumulation Regulations* (Canada 2000), measures of BAF are the preferred metric for the assessment of the bioaccumulation potential of substances. This is because BCF does not adequately account for the bioaccumulation potential of substances via the diet, which predominates for substances with log K_{ow} greater than ~ 4.0 (Arnot and Gobas 2003). The modelled log K_{ow} values for Structures 1 and 2 of 9.2 and 7.0, respectively suggest that these chemicals could have a high potential to bioaccumulate in higher in organisms biota via the diet (i.e. not via the water), if not substantially metabolized. The log K_{ow} of both structures is within the log K_{ow} range where the worst case via the diet is expected (log Kow 7-9) and which is explained via the BAF (Arnot and Gobas 2006).

Since no experimental bioaccumulation factor (BAF) and/or bioconcentration factor (BCF) data for the two structures were available, a predictive approach was applied using available BAF and BCF models, as shown in Tables 6a and 6b.

A mass-balance (kinetic) model and QSAR (structural fragment) model were used to estimate the bioaccumulation potential of Structures 1 and 2. The mass-balance approach is based on first principles of mechanistic action. As such, a chemical must satisfy the mechanistic principle of the model which is passive diffusion. Structures 1 and 2, as neutral organics, satisfy this domain and are expected to be taken up and accumulated in organisms as a function of hydrophobicity and lipophylicity. This means bioaccumulation can be predicted using logK_{ow}. In addition, the representative structures for BNST do not contain structural fragments that are outside the domain of the mass-balance model (e.g., ionizing groups). The molecular weight and maximum cross-sectional diameters of these structures are also not expected to be outside the domain of the model (<1000 g/mol, D_{max} < 2.0 nm). However, there have been few chemicals analyzed for bioaccumulation potential with logK_{ow} > 9 (Arnot and Gobas 2006). The estimated log K_{ow} for Structure 1 is 9.2 and thus predictions are considered more uncertain for this Structure compared with those for Structure 2. At higher logK_{ow} values (>8), low assimilation efficiency can limit passive diffusion of a chemical from the gut of a fish to lypophilic tissues (Kelly et al. 2004). No dietary assimilation efficiency information is available for the representative structures and thus cannot be considered in the mass-balance model. Because metabolic transformation potential is low and molecular size will not restrict passive diffusion, dietary assimilation is likely still high and may be approximately equal to the default model value of ~50-60%.

The QSAR approach for bioaccumulation models uses a structural fragment addition method to account for features of a chemical that are associated with bioaccumulation and biotransformation. The principle domain of these models is the structural domain. Examination of Structures 1 and 2 reveals that there are no structural fragments considered to be outside the domain of the BCFWIN or Dimitrov models. In other words, these two chemicals are considered to be well represented in the training sets and

fragment sets of the models. These models only predict bioconcentration from the water phase which is expected to be limited. For substances with higher log Kow values (e.g., >8), BCF values are expected to underestimate the potential body burden of BNST for reasons already mentioned. There is likely some uncertainty in the BCF predictions for Structure 1 given a log K_{ow} of 9.2 but predictions of low bioconcentration potential are in agreement with what would be expected for chemicals with low aqueous solubility.

Tables 6a and 6b show the results of bioaccumulation modeling corrected for any potential metabolism. Metabolic rate constants were calculated using a structural fragment-based approach using the QSAR BCFBAF v3.00 (see EPIsuite 2009) using the 10g fish output.

Table 6a. Fish BAF and BCF predictions for Structure 1 corrected for metabolic rate

Test organism	Log Kow	Metabolic Rate (1/days)	Endpoint	Value wet weight (L/kg)	Reference
Fish	9.2	n/a	BCF	1098	BCFWIN 2000
Fish	9.2	0.004	BAF	207 491	Gobas BAF middle trophic level with k_M of 0.004316) (Arnot and Gobas 2003)
Fish	9.2	0.004	BCF	197	Gobas BCF middle trophic level with k_M of 0.004316) (Arnot and Gobas 2003)
Fish	9.2	n/a	BCF	40	Baseline BCF Model with mitigating factors (Dimitrov et al. 2005)

Table 6b. Fish BAF and BCF predictions for Structure 2 corrected for metabolic rate

Test organism	Log Kow	Metabolic Rate (1/days)	Endpoint	Value wet weight (L/kg)	Reference
Fish	7.0	n/a	BCF	12589	BCFWIN 2000
Fish	7.0	0.04	BAF	182 810	Gobas BAF middle trophic level with kM of (Arnot and Gobas 2003)
Fish	7.0	0.04	BCF	2409	Gobas BCF middle trophic level with kM of (Arnot and Gobas 2003)
Fish	7.0	0.04	BCF	1000	Baseline BCF Model with mitigating factors (Dimitrov et al. 2005)

Metabolism rates of 0.004 (Structure 1) and 0.04 (Structure 2) which equal half-lives in fish of approximately 17 to 173 days were used instead of the default of zero metabolism potential. These rates are reasonable given the representative structures, and are considered to equal a moderate to very slow rate of biotransformation in fish.

Mass-balance model results for Structure 1 for the middle trophic level fish give a BCF of 197 and a BAF of 207491. Using QSAR models, BCFWIN (in EPIsuite 2009) produced a BCF result of 1098 and the Dimitrov BCF model produced a BCF result of 40. The Dimitrov model (Dimitrov et al. 2005) accounts for factors that mitigate bioaccumulation potential, including biotransformation. Biotransformation pathways analysis from this model suggests that BNST representatives could be eliminated via N-glucuonidation which is a phase II reaction. The probability of this biotransformation occurring was estimated at only 22% suggesting that the metabolism correction in this model may be uncertain. The BCF excluding metabolism is 251, which is in general agreement with the other BCF predictions. In conclusion, the expected high log K_{ow} of Structure 1 indicates bioavailability from the water column is limited resulting in predicted BCF values well below 5000. Nonetheless, the high log Kow also suggests that significant uptake via the diet is likely which results in a predicted BAF >5000.

Mass-balance model results for Structure 2 with metabolism considered for middle trophic levels produced a BCF of 2409 L/kg and BAF of 182 810 L/kg. For QSAR Results, BCFWIN produced a BCF value of 12 589 L/kg wet weight but this model cannot consider biotransformation potential and thus may overestimate the BCF. The Dimitrov BCF model gives a result of log BCF of 3.0 (BCF = 1000) incorporating metabolism considerations. This model also suggests that this substance could be eliminated via N-Glucuonidation which is a Phase II reaction. However, the metabolism pathway has only a 22% probability of occurring suggesting that the metabolism correction in this model may be uncertain. The log BCF excluding metabolism is 3.9 (BCF = 7943 L/kg wet weight). The moderately high log Kow of Structure 2 does not fully limit bioavailability in the water column so predicted BCF values are thus only below 5000 when biotransformation potential is considered. Significant uptake via the diet suggests that the BAF is >5000 even when biotransformation is considered.

BAF is considered the critical metric for bioaccumulation assessment for substances with high log K_{ow} values (e.g., Gobas and Arnot 2006). The BAF values generated incorporating reasonable mitigating factors, such as biotransformation, are > 5000 and are considered consistent with the structures representing BNST. Therefore, based on the modeled values as well as structural and property considerations, there is sufficient and consistent evidence that BNST, as represented by Structures 1 and 2, meets the bioaccumulation criteria (BCF or BAF > 5000) as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Potential to Cause Ecological Harm

Ecological Effects Assessment

A - In the Aquatic Compartment

Experimental aquatic toxicity results range from 0.36 to 920 mg/L for a number of analogues of Structures 1 and 2 (Tables 7a, b). Results from a 48-hour immobilization study with Daphnia magna were reported during the public comment period (Study Submission 2009a). Because this is a water accommodated fraction (WAF) study and thus subject to Raoult's Law[1], loading level becomes important for explaining the aqueous solubility and thus bioavailability of a chemical mixture. Raoult's Law says that the solubility of individual components is dependent on the mole fraction and vapour pressure of each constituent in the mixture which in turn is influenced by the loading level. This of course can influence the exposure in an aquatic toxicity test. However, it is difficult to determine if observed effects are the result of exposure to the WAF and if the WAF contains a micro dispersion of insoluble constituents that may adsorb to the gills of water breathing organisms and thus cause "indirect" effects. Insufficient detail was available in the Study Submission to determine this. While natural surface water rich in particulate organic carbon (POC) may mitigate this type of indirect effect by providing an alternative adsorption surface, it is uncertain to what degree the observed effects would be mitigated and what POC levels are to be expected in Canadian receiving waters (i.e., the opportunity for waters low in POC exists). Therefore, the observed effects reported according to the measured water concentrations (i.e., EC50, EC100) of BNST were deemed preferable because these concentrations can be associated with an internal body burden expected to cause cell narcosis (narcotic mode of action), while the loading level cannot.

Aquatic toxicity data for benzenamine, N-phenyl-, styrenated (CAS no. 68442-68-2) considered an acceptable analogue of benzenamine, N-phenyl-, reaction products with 2,4,4-trimethyl-pentene (CAS no 68411-46-1) (Structure 2), submitted to the US EPA (2008), indicated that there were effects at or below the water solubility limit of 0.41 mg/L. The sponsor (the American Chemistry Council, Rubber and Plastic Additives [RAPA] Panel also reported a 96-h LC50 of 920 mg/L for CAS no 68442-68-2, however, the US EPA indicated that the results of this test were difficult to interpret as the substance was tested above its water solubility limit.

A range of aquatic toxicity predictions were also obtained from QSAR models for Structures 1 and 2. Most of the predictions are below the potential aqueous solubility of BNST (according to the WAF study) but some are unreliable because the logKow values input into the models are out of the model domain. The suggested Log Kow domain limit for acute predictions in ECOSAR is ~5.0 and for chronic toxicity is ~8.0 indicating that there are no neutral organics in the training set above these cut-offs. In addition, chronic

[1] See http://en.wikipedia.org/wiki/Raoult's_law

toxicity predictions below 1 ug/L were not considered to be reliable as these are simply generated based on logKow correlations and are likely beyond practical toxicity testing methodologies. Also, there are no acute values below 1 ug/L in the ECOSAR training set for neutral organics for most of the neutral organic SARs. Therefore, only chronic aquatic toxicity predictions for Structure 2 were considered. The OASIS QSAR model for acute fish (fathead minnow) toxicity using base surface narcotics produced model results within model structural domains, and was thus considered more reliable. No predicted results were accepted for Structure 1 as it was considered out of acute and chronic toxicity model domains for all models.

Table 7a. Empirical data for aquatic toxicity for BNSTand its analogues.

Test organism	Test substance	Type of test	Endpoint	Loading Rate (mg/L)	Value (mg/L)	Reference
Daphnia magna	Analogue mixture	Acute (48-hour)	Immobilization: 0% 30% 100%	 10 46 100	 0.32[1] 0.63[1] 0.36[1]	Study Submission 2009a
Mysid shrimp	68921-45-9	Acute (96-hour)	LC_{50}[2]	n/a	2.3	Study Submission 2009b
Zebrafish	68442-68-2	Acute (96-hour)	LC_{50}	n/a	920	US EPA 2008
Zebrafish	68442-68-2	Acute (96-hour)	LC_{50}	n/a	≤0.41	US EPA 2008

[1] Mean measured concentration
[2] LC_{50} – The concentration of a substance that is estimated to be lethal to 50% of the test organisms.

Table 7b. Modelled data for aquatic toxicity for Structure 2

Test organism	Test Duration	Endpoint	Value (mg/L)	Reference
Algae	96 hr[1]	EC_{50}[2] and ChV[3]	0.035-0.039	ECOSAR 2004 (neutral organics)
Daphnid	16 days	ChV	0.002	ECOSAR 2004 (neutral organics)
Fish	30 days	ChV	0.001	ECOSAR 2004 (neutral organics)
Fish	96 hr	LC_{50}[4]	0.19 ± 0.13	(OASIS) Mekenyan et al 2005 (Baseline Narcotic Amine)

[1] Algal 96hr test can be considered chronic tests as they are multiple generation tests
[2] EC_{50} – The concentration of a substance that is estimated to cause some toxic sublethal effect on 50% of the test organisms.
[3] ChV – Chronic toxicity value

[4] LC_{50} – The concentration of a substance that is estimated to be lethal to 50% of the test organisms.

Results of empirical testing with WAFs and model predictions are in general agreement. Invertebrates appear to be the most sensitive to BNST based on this limited dataset. Observable effects for invertebrates are of the order of 0.1 to low mg/L range and are considered to be the most reliable acute results of those available in the above tables when structure and property values are considered. This could be the result of indirect effects, but available study details cannot confirm this. Predicted chronic results for invertebrates are approximately a factor of 100-200 lower than observed acute data but are within the reported range of ACRs (acute to chronic ratios) for many narcotic chemicals (see Chapman 1998). Fish may be as or less sensitive to BNST than invertebrates. Some fish tests with nominal concentrations cannot confirm actual exposure levels and so cannot easily be compared with predicted values or other measured concentrations. It is likely the transition from acute to chronic effects is not as drastic as the ACRs would suggest; because only a representative structure for chronic toxicity modeling could be used. It is likely that longer term exposures with BNST as a mixture would provide a greater opportunity for effects at thermodynamic equilibrium to be expressed, resulting in adverse effects closer to the range of acute effects. Nonetheless if released to the aquatic environment, there is sufficient and consistent evidence to suggest that BNST can cause a high level of ecological harm from short and long term exposures.

B - In Other Environmental Compartments

No experimental or predicted-effects data for sediment or soil dwelling organisms were identified for Structures 1 and 2 or other analogous substances.

C – Predatory Wildlife

BNST is considered to be persistent in the environment and is estimated to have significant bioaccumulation and likely significant biomagnification potential. Therefore, exposures to both terrestrial and aquatic wildlife predators (e.g., mink, osprey, fox) via the food web may be significant, as trophic dilution is not expected given the relatively slow rate of biotransformation and overall elimination rate. Mammalian oral dose toxicity is therefore highly relevant for substances such as BNST, because a potential exists for exposure to predatory ecological receptors via the diet.

Acute oral dose LD50 and chronic and sub-chronic repeated oral dose rodent toxicity data were provided to the USEPA for the category screening level hazard characterization of substituted diphenylamines for the High Production Volume Challenge Program (US EPA 2008). Data for CAS# 68921-45-9 and other comparable structures were summarized in this report. The acute LD50 (median concentration of a toxicant that will kill 50% of the test animals within a designated period) data generally reflect a low level of observed effects at the median level (i.e., >500 mg/kg bw), but these data only reflect mortality and not more subtle endpoints. The repeated oral dose data, which better reflect subtle chronic effects, shows that significant non-adaptative adverse effects (e.g.,

development and reproductive toxicity), were observed in rodents exposed to this category of chemicals in the range of 25 mg/kg bw/day to 125 mg/kg bw/day and at 5 mg/kg bw/day to 25 mg/kg bw day (biochemical changes). Female rodents appear to be more sensitive than males in the available studies. Specific to CAS# 68921-45-9, the US EPA report cites that *"diffuse hepatic degeneration was observed in all animals, the severity of which was not treatment-related. The degenerative changes in the liver were described as diffuse cloudy swellings and fatty metamorphosis of the cytoplasm of the hepatocytes".* The study LOAEL (Lowest Observed Adverse Effect Level) was established at ~ 125 mg/kg-bw/day (based on growth retardation in females and effects on the liver), but as this was the lowest test concentration used, no NOAEL (No-Observed-Adverse-Effect Level) could be established and it is therefore considered unbounded (i.e. somewhere < 125 mg/kg bw/day).

Using a read-across approach from the US EPA High Production Volume (HPV) amine categorical data, an approximate threshold for non-adaptative adverse effects can be established for mammalian wildlife. Using endpoints for reproductive and developmental toxicity as more certain non-adaptative adverse effects than biochemical changes, multiple studies in the USEPA report cited a NOAEL of 25 mg/kg bw/day and a LOAEL of 125 mg/kg bw/day. The geometric mean of these values, 56.0 mg/kg bw day, can be used to estimate the threshold for the onset of effects. Body weight transformation of this threshold value must be performed to approximate effects in a wildlife species (see Sample et al. 1996). The body weights of test rodents are unknown, therefore a reference body weight of 0.35 kg was assumed in accordance with Sample et al. (1996). Given an upper body weight limit of 1.1 kg for a mink (as an example focal species), this yields a body weight normalized value of ~19.0 mg/kg bw/day. Applying an uncertainty factor of 10 for interspecies variation and extrapolation to field conditions, results in a value of ~ 2.0 mg/kg bw/day for mammalian piscivores. This value is considered in the high range of mammalian toxicity (< 10 mg/kg bw/day).

Therefore it is concluded that a significant potential exists for BNST to cause ecological harm to wildlife predators as a function of oral exposure (i.e., diet).

Ecological Exposure Assessment

No monitoring data on the presence of BNST in environmental media (air, water, soil, sediment) have been found.

Characterization of Ecological Risk

Evidence that a substance is highly persistent and bioaccumulative as defined in the *Persistence and Bioaccumulation Regulations* of CEPA 1999 (Canada 2000), when taken together with the potential for environmental release or formation and the potential for toxicity to organisms, provides a significant indication that the substance may be entering the environment under conditions that may have harmful long-term ecological effects . Substances that are persistent remain in the environment for a long time after being

released, increasing the potential magnitude and duration of exposure. Substances that have long half-lives in mobile media (air and water) and partition into these media in significant proportions have the potential to cause widespread contamination. Releases of small amounts of bioaccumulative substances may lead to high internal concentrations in exposed organisms. Highly bioaccumulative and persistent substances are of special concern, since they may biomagnify in food webs, resulting in very high internal exposures, especially for top predators.

The relatively large quantities of BNST manufactured in Canada and imported into Canada, along with its dispersive uses, indicate potential for releases into the Canadian environment. Because of its resistance to degradation, BNST will remain in water, sediment and soil for long periods after it is released. Because of its lipophilic character, it is expected to bioaccumulate while it remains in the environment and it could be biomagnified in trophic food chains. The ecotoxicity data indicate that BNST can cause harm to aquatic organisms at low concentrations. In addition, the potential for ecological harm to terrestrial wildlife predators as, a result of oral exposure is significant as, BNST is considered to be persistent and biomagnify. Taken together, the above information indicates that BNST has the potential to cause ecological harm in Canada.

Uncertainties in Evaluation of Ecological Risk

There is uncertainty regarding the risk that BNST may pose now or in the future. Typically, quantitative risk estimates (i.e., risk quotients or probabilistic analyses) are important lines of evidence when evaluating a substance's potential to cause environmental harm. However, when risks for persistent and bioaccumulative substances such as BNST are estimated using such quantitative methods, the estimated risks are highly uncertain and are likely to be underestimated. Given that long-term risks associated with persistent and bioaccumulative substances cannot at present be reliably predicted, quantitative risk estimates have limited relevance. Since accumulations of such substances may be widespread and are difficult to reverse, a conservative response to uncertainty is justified.

All modelling of the substance's physical and chemical properties and P, B and iT characteristics is based on chemical structures. As this substance is a UVCB, it cannot be represented by a single, discrete chemical structure. Therefore, for the purposes of modelling, "representative structures" that provide realistic conservative estimates, were identified and these structures were used to assess the fate and hazard properties of BNST. More than one representative structure may be derived for the same UVCB; therefore, structure-related uncertainties exist for BNST.

The predicted concentrations, associated with toxicity for aquatic organisms, may have an additional source of uncertainty when these concentrations exceed the solubility of the chemical in water (either experimental or predicted). Given that concentrations for both the toxicity and water solubility are often uncertain, toxicity values that exceed solubility estimates may in some cases be accepted.

Regarding ecotoxicity, based on the predicted partitioning behaviour of this chemical, the significance of soil and sediment as important media of exposure is not well addressed by the effects data available. Toxicity data for terrestrial and aquatic wildlife predators are available and are represented by acute oral rodent toxicity studies. While some uncertainty exists with the extrapolation of rodent toxicity data to a mammalian predator in the mustelidae family (i.e., mink), this is a generally well accepted practice for chemical assessment that is also used for human toxicological assessment. The application of an uncertainty factor of 10 is expected to account for general toxicological uncertainty under laboratory conditions and intra and inter species variation. Also, body weight normalization lowers the rat LOAEL by a factor of approximately three which in itself can be considered an uncertainty factor for species differences.

The resulting PNEC for predatory wildlife is based on repeated oral dose experimental results and is considered reflective of the potential for effects given an expected daily exposure. Consequently, the PNEC may not account for very long-term effects realized from the slow accumulation of BNST in the tissues of wildlife predators as a function of biomagnification.

Because the available rodent repeated oral dose toxicity data report "hypothesis-based" values (NOAEL, LOAEL) are produced from simple statistical variation and the test concentrations selected, some uncertainty exists regarding the "true" point of departure from a dose response curve where adverse effects commence. Also, some test results report effects at all test concentrations and therefore no possible NOAEL which adds to experimental error and lower robustness of test results. Accordingly, only studies reporting both unbounded NOAEL and LOAEL were used. Also, in place of a dose-response curve, the geometric mean of the NOAEL and LOAEL is used as the best estimate of the threshold of effects.

Conclusion

Based on the information presented in this screening assessment, it is concluded that BNST is entering or may be entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity.

It is concluded that the BNST meets the definition of toxic as set out in paragraph 64(a) of CEPA 1999. Additionally, BNST meets the criteria for persistence and bioaccumulation potential as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

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Appendix I - Robust Study Summary

Study Submission 2009a

Robust Study Summaries Form and Instructions: Aquatic iT					
No	**Item**	**Weight**	**Yes/No**	**Specify**	**Instructions**
1	Reference: Acute toxicity of TK 12430 (IRGANOX L57) to Daphnia magna in a 48-hour immobilization test				Title of the study, authors, year, journal/book, volume, pages, and other information.
2	Substance identity: CAS RN	n/a	y		Chemical Abstracts Service Registry Number.
3	Substance identity: chemical name(s)	n/a	y		At least one chemical name from a recognized nomenclature.
4	Chemical composition of the substance	2	n		Yes or No. Chemical composition (%) of the substance (major and secondary components, by-products, impurities). Especially important for UVCBs and polymers. May be considered as "non-applicable", if the test substance is a discrete high-purity chemical (see item 5).
5	Chemical purity	1	n		Yes or No. Purity may be reported as % and/or chemical grade designations (e.g. A.C.S., Reagent, etc.). May be not applicable for some UVCBs (e.g. CAS 128683-25-0 - crude oil; CAS 65996-72-7 - steelmaking dust; etc).
6	Persistence/stability of test substance in aquatic solution reported?	1	Y		Yes or No. Information on whether the substance is stable or unstable (i.e. volatile, hydrolysable, photodegradable, polymerizable, readily biodegradable, etc.) in water.
Method					
7	Reference	1	y		Yes or No. Reference in respect to the method used.
8	OECD, EU, national, or other standard method?	3	y		Yes or No.
9	Justification of the method/protocol if not a standard method was used	2		Not applicable	Yes or No. When "Yes", method justification (which is not a synonym of the "method description") should be provided. Not applicable, if a standard protocol (see item 8) was used.
10	GLP (Good Laboratory Practice)	3	y		Yes or No. "Yes" - whenever GLP was applied. "No" - if the study was conducted after 1997 and GLP was not implemented. If the study completed before 1997 and GLP was not implemented, the item can be considered as not applicable.
Test organism					
11	Organism identity: name	n/a	y		Names (common and/or scientific) as reported in the study.
12	Latin or both Latin & common names reported?	1	y		Yes or No.

13	Life cycle age / stage of test organis	1	y		Yes or No. Item may not be negatively answered if other items (e.g. item 15) give indirect, but clear information on the age or stage of the organism (for example, if the weight/size of the specific fish species is given, an assumption on the life stage can be easily made).
14	Length and/or weight	1	n		Yes or No. Not applicable in some cases (e.g. for algae or very small invertebrates such as *Daphnia magna)*.
15	Sex	1	n		Yes or No. Not applicable in some cases (e.g. algae). If the item is applicable for an organism, but the organism is very young and small, for example 1-3 cm long fathead minnow or rainbow trout (e.g. see OECD Guidelines No. 203), this item can also be considered as non-applicable.
16	Number of organisms per replicate	1	y		Yes or No. Specify number of organisms per replicate
17	Organism loading rate	1	y		Yes or No. Specify loading rate for the organisms (e.g.: 0.8 g/L).
18	Food type and feeding periods during the acclimation period	1	n		Yes or No.
Test design / conditions					
19	Test type (acute or chronic	n/a	y	Acute	Yes or No. Specify test type.
20	Experiment type (laboratory or field	n/a	y	Laboratory	Yes or No. Specify test type.
21	Exposure pathways (food, water, both)	n/a	y	Water	Yes or No. Specify exposure pathways.
22	Exposure duration	n/a	y	48 hours	Yes or No. Specify exposure duration.
23	Negative or positive controls (specify)	1	y	Potassium dichromate once/yr	Yes or No. Specify which controls were used.
24	Number of replicates (including controls)	1	y	Four	Yes or No. Specify number of replicates.
25	Nominal concentrations reported?	1	y	Four	Yes or No. Specify number of nominal concentrations.
26	Measured concentrations reported?	3	y	Analytical measured concentration (WAFs)	Yes or No. May be considered as not applicable for some substances such as UVCBs (e.g. CAS 128683-25-0 - crude oil). However, if reliable alternative measurements, which can reflect the amount of the substance in the test solution (e.g. dissolved organic carbon level which can be theoretically converted to the substance's concentration) are presented, they can be conditionally considered as "measured" (i.e. weight = 3 points). **Note:** "reliable alternative measurements" wording means that the appropriate instrument - e.g. TOC analyzer with low MDL - was used (or in other words, the difference between the TOC levels in the control and the treatments should be statistically significant considering the actual measurements and MDLs).
27	Food type and feeding periods during the long-term tests	1	n		Yes or No. Not applicable for acute tests as organisms are not normally fed in short-term tests.

28	Were concentrations measured periodically (especially in the chronic test)?	1	y		Yes or No. When answered "Yes": chronic tests - at least three measurements; acute tests - at least two measurements (in both cases, actual concentrations at the end of the test have to be presented).
29	Were the exposure media conditions relevant to the particular chemical reported? (e.g., for the metal toxicity - pH, DOC/TOC, water hardness, temperature)	3	y		Yes or No.
30	Photoperiod and light intensity	1	y		Yes or No.
31	Stock and test solution preparation	1	y		Yes or No.
32	Was solubilizer/emulsifier used, if the chemical was poorly soluble or unstable?	1	n		Yes or No. Applicable for poorly soluble / unstable substances only, especially when toxicity value is above the chemical's water solubility.
33	If solubilizer/emulsifier was used, was its concentration reported?	1	n		Yes or No.
34	If solubilizer/emulsifier was used, was its ecotoxicity reported?	1	n		Yes or No. It's allowed to present toxicity values from another similar tests.
35	Monitoring intervals (including observations and water quality parameters) reported?	1	y		Yes or No.
36	Statistical methods used	1	y		Yes or No.
Information relevant to the data quality					
37	Was the endpoint directly caused by the chemical's toxicity, not by organism's health (e.g. when mortality in the control >10%) or physical effects (e.g. 'shading effect')?	n/a	y		Yes or No. When answered "No", submit all the considerations/concerns in the "Comments" box below; most likely, the study will be rejected.
38	Was the test organism relevant to the Canadian environment?	3	y		Yes or No.
39	Were the test conditions (pH, temperature, DO, etc.) typical for the test organism?	1	y		Yes or No.
40	Does system type and design (static, semi-static, flow-through; sealed or open; etc.) correspond to the substance's properties and organism's nature/habits?	2	y		Yes or No. "No" - when, for example, the chemical was volatile, and open (not sealed) static-system tanks were used.
41	Was pH of the test water within the range typical for the Canadian environment (6 to 9)?	1	y	5.1-6.2	Yes or No. Specify actual pH range.
42	Was temperature of the test water within the range typical for the Canadian environment (5 to 27°C)?	1	y		Yes or No. Specify actual temperature range.

43	Was toxicity value below the chemical's water solubility?	3	n		Yes or No. Experimental WS results are preferred over predicted WS data. The difference between WS and toxicity value is considered as negligible when it is within one order of magnitude, and if beyond that, the difference is considered as meaningful. The item might not be applicable if WAF (Water Accommodated Fractions) protocol has been used.
Results					
44	Toxicity values (specify endpoint and value)	n/a	y	48-h EC50 = 51 mg/L	Specify endpoint and value (e.g. 48-h LC50=70 mg/L)
45	Other endpoints reported - e.g. BCF/BAF, LOEC/NOEC (specify)?	n/a	y	48-h NOEC = 10 mg/L	Yes or No. Specify endpoint and value (e.g. 28-d NOEC=70 mg/L; BCF=1200 L/kg)
46	Other adverse effects (e.g. carcinogenicity, mutagenicity) reported?	n/a	n		Yes or No. Specify other adverse effects (if any)
47	***Score*: ... %**	***72.3***			
48	***EC Reliability code*:**	***2***			
49	***Reliability category (high, satisfactory, low)*:**	***Satisfactory Confidence***			
50	***Comments***				

Appendix I - Robust Study Summary

Study Submission 2009b

Robust Study Summaries Form and Instructions: Aquatic iT					
No	**Item**	**Weight**	**Yes/No**	**Specify**	**Instructions**
1	Acute invertebrate 96-h toxicity. Springborn Laboratories, Inc. Report #89-11-3144 (January 10, 1990)				Title of the study, authors, year, journal/book, volume, pages, and other information.
2	Substance identity: CAS RN	n/a	Y		Chemical Abstracts Service Registry Number.
3	Substance identity: chemical name(s)	n/a	Y		At least one chemical name from a recognized nomenclature.
4	Chemical composition of the substance	2	Y		Yes or No. Chemical composition (%) of the substance (major and secondary components, by-products, impurities). Especially important for UVCBs and polymers. May be considered as "non-applicable", if the test substance is a discrete high-purity chemical (see item 5).
5	Chemical purity	1	Y		Yes or No. Purity may be reported as % and/or chemical grade designations (e.g. A.C.S., Reagent, etc.). May be not applicable for some UVCBs (e.g. CAS 128683-25-0 - crude oil; CAS 65996-72-7 - steelmaking dust; etc).
6	Persistence/stability of test substance in aquatic solution reported?	1	N		Yes or No. Information on whether the substance is stable or unstable (i.e. volatile, hydrolysable, photodegradable, polymerizable, readily biodegradable, etc.) in water.
Method					
7	Reference	1	Y		Yes or No. Reference in respect to the method used.
8	OECD, EU, national, or other standard method?	3	Y		Yes or No.
9	Justification of the method/protocol if not a standard method was used	2	N		Yes or No. When "Yes", method justification (which is not a synonym of the "method description") should be provided. Not applicable, if a standard protocol (see item 8) was used.
10	GLP (Good Laboratory Practice)	3	Y		Yes or No. "Yes" - whenever GLP was applied. "No" - if the study was conducted after 1997 and GLP was not implemented. If the study completed before 1997 and GLP was not implemented, the item can be considered as not applicable.
Test organism					
11	Organism identity: name	n/a	Y		Names (common and/or scientific) as reported in the study.
12	Latin or both Latin & common names reported?	1	N		Yes or No.
13	Life cycle age / stage of test organism	1	N		Yes or No. Item may not be negatively answered if other items (e.g. item 15) give indirect, but clear information on the age or stage of the organism (for example, if the weight/size of the specific fish species is given, an assumption on the life stage can be easily made).

14	Length and/or weight	1	N		Yes or No. Not applicable in some cases (e.g. for algae or very small invertebrates such as *Daphnia magna)*.
15	Sex	1	N		Yes or No. Not applicable in some cases (e.g. algae). If the item is applicable for an organism, but the organism is very young and small, for example 1-3 cm long fathead minnow or rainbow trout (e.g. see OECD Guidelines No. 203), this item can also be considered as non-applicable.
16	Number of organisms per replicate	1	N		Yes or No. Specify number of organisms per replicate
17	Organism loading rate	1	N		Yes or No. Specify loading rate for the organisms (e.g.: 0.8 g/L).
18	Food type and feeding periods during the acclimation period	1	N		Yes or No.
Test design / conditions					
19	Test type (acute or chronic)	n/a	Y	acute	Yes or No. Specify test type.
20	Experiment type (laboratory or field)	n/a	Y	lab	Yes or No. Specify test type.
21	Exposure pathways (food, water, both)	n/a	Y	water	Yes or No. Specify exposure pathways.
22	Exposure duration	n/a	Y	96-h	Yes or No. Specify exposure duration.
23	Negative or positive controls (specify)	1	Y	2 control vessels containing dilution water but no test material	Yes or No. Specify which controls were used.
24	Number of replicates (including controls)	1	N		Yes or No. Specify number of replicates.
25	Nominal concentrations reported?	1	Y	6	Yes or No. Specify number of nominal concentrations.
26	Measured concentrations reported?	3	Y		Yes or No. May be considered as not applicable for some substances such as UVCBs (e.g. CAS 128683-25-0 - crude oil). However, if reliable alternative measurements, which can reflect the amount of the substance in the test solution (e.g. dissolved organic carbon level which can be theoretically converted to the substance's concentration) are presented, they can be conditionally considered as "measured" (i.e. weight = 3 points). **Note:** "reliable alternative measurements" wording means that the appropriate instrument - e.g. TOC analyzer with low MDL - was used (or in other words, the difference between the TOC levels in the control and the treatments should be statistically significant considering the actual measurements and MDLs).
27	Food type and feeding periods during the long-term tests	1			Yes or No. Not applicable for acute tests as organisms are not normally fed in short-term tests.

28	Were concentrations measured periodically (especially in the chronic test)?	1	Y		Yes or No. When answered "Yes": chronic tests - at least three measurements; acute tests - at least two measurements (in both cases, actual concentrations at the end of the test have to be presented).
29	Were the exposure media conditions relevant to the particular chemical reported? (e.g., for the metal toxicity - pH, DOC/TOC, water hardness, temperature)	3	N	low soluble chemicals, the solublity not stated	Yes or No.
30	Photoperiod and light intensity	1	N		Yes or No.
31	Stock and test solution preparation	1	Y		Yes or No.
32	Was solubilizer/emulsifier used, if the chemical was poorly soluble or unstable?	1	N		Yes or No. Applicable for poorly soluble / unstable substances only, especially when toxicity value is above the chemical's water solubility.
33	If solubilizer/emulsifier was used, was its concentration reported?	1			Yes or No.
34	If solubilizer/emulsifier was used, was its ecotoxicity reported?	1			Yes or No. It's allowed to present toxicity values from another similar tests.
35	Monitoring intervals (including observations and water quality parameters) reported?	1	Y		Yes or No.
36	Statistical methods used	1	Y		Yes or No.
Information relevant to the data quality					
37	Was the endpoint directly caused by the chemical's toxicity, not by organism's health (e.g. when mortality in the control >10%) or physical effects (e.g. 'shading effect')?	n/a	n	mortality in control not provided	Yes or No. When answered "No", submit all the considerations/concerns in the "Comments" box below; most likely, the study will be rejected.
38	Was the test organism relevant to the Canadian environment?	3	Y		Yes or No.
39	Were the test conditions (pH, temperature, DO, etc.) typical for the test organism?	1	N	not provided	Yes or No.
40	Does system type and design (static, semi-static, flow-through; sealed or open; etc.) correspond to the substance's properties and organism's nature/habits?	2	Y	low water solubility and no solubility provided	Yes or No. "No" - when, for example, the chemical was volatile, and open (not sealed) static-system tanks were used.
41	Was pH of the test water within the range typical for the Canadian environment (6 to 9)?	1	N	no pH	Yes or No. Specify actual pH range.
42	Was temperature of the test water within the range typical for the Canadian environment (5 to 27°C)?	1	N	no temperature provided	Yes or No. Specify actual temperature range.

43	Was toxicity value below the chemical's water solubility?	3	N		Yes or No. Experimental WS results are preferred over predicted WS data. The difference between WS and toxicity value is considered as negligible when it is within one order of magnitude, and if beyond that, the difference is considered as meaningful. The item is not applicable if WAF (Water Accommodated Fractions) protocol has been used.
Results					
44	Toxicity values (specify endpoint and value)	n/a	96-h LC50		Specify endpoint and value (e.g. 48-h LC50=70 mg/L)
45	Other endpoints reported - e.g. BCF/BAF, LOEC/NOEC (specify)?	n/a			Yes or No. Specify endpoint and value (e.g. 28-d NOEC=70 mg/L; BCF=1200 L/kg)
46	Other adverse effects (e.g. carcinogenicity, mutagenicity) reported?	n/a			Yes or No. Specify other adverse effects (if any)
47	***Score*: ... %**	***52.2***			
48	***EC Reliability code*:**	***3***			
49	***Reliability category (high, satisfactory, low)*:**	***Low Confidence***			
50	***Comments***				

Appendix II – PBT Model Inputs Summary Table

	Phys-Chem/Fate	**Fate**	**Fate**	**Fate**	**Fate**	**Fate**	**PBT Profiling**	**Ecotoxicity**
Model Input Parameters	EPIWIN Suite (all models, including: AOPWIN, KOCWIN, BCFWIN BIOWIN and ECOSAR)	STP (1) ASTreat (2) SimpleTreat (3) (required inputs are different depending on model)	EQC (required inputs are different if Type I vs. Type II chemical)	TaPL3 (required inputs are different if Type 1 vs. Type 2 chemical)	OECD POPs Tool	Arnot-Gobas BCF/BAF Model	Canadian-POPs (including: CATABOL, BCF Mitigating Factors Model, OASIS Toxicity Model)	Artificial Intelligence Expert System (AIES)/ TOPKAT/ ASTER
SMILES Code	Structure 1 : CC(C1=CC=CC=C1NC2=CC=CC=C2C(C)(C)CC(C)(C)C)C3=CC=CC=C3 Structure 2 : CC(C)(CC(C)(C)C)C1=CC=C(NC2=CC=CC=C2)C=C1	Structure 1 : CC(C1=CC=CC=C1NC2=CC=CC=C2C(C)(C)CC(C)(C)C)C3=CC=CC=C3 Structure 2 : CC(C)(CC(C)(C)C)C1=CC=C(NC2=CC=CC=C2)C=C1	Structure 1 : CC(C1=CC=CC=C1NC2=CC=CC=C2C(C)(C)CC(C)(C)C)C3=CC=CC=C3 Structure 2 : CC(C)(CC(C)(C)C)C1=CC=C(NC2=CC=CC=C2)C=C1	Structure 1 : CC(C1=CC=CC=C1NC2=CC=CC=C2C(C)(C)CC(C)(C)C)C3=CC=CC=C3 Structure 2 : CC(C)(CC(C)(C)C)C1=CC=C(NC2=CC=CC=C2)C=C1		Structure 1 : CC(C1=CC=CC=C1NC2=CC=CC=C2C(C)(C)CC(C)(C)C)C3=CC=CC=C3 Structure 2 : CC(C)(CC(C)(C)C)C1=CC=C(NC2=CC=CC=C2)C=C1	Structure 1 : CC(C1=CC=CC=C1NC2=CC=CC=C2C(C)(C)CC(C)(C)C)C3=CC=CC=C3 Structure 2 : CC(C)(CC(C)(C)C)C1=CC=C(NC2=CC=CC=C2)C=C1	Structure 1 : CC(C1=CC=CC=C1NC2=CC=CC=C2C(C)(C)CC(C)(C)C)C3=CC=CC=C3 Structure 2 : CC(C)(CC(C)(C)C)C1=CC=C(NC2=CC=CC=C2)C=C1

Molecular weight (g/mol)	Structure 1: 385.6 Structure 2: 281.44	Structure 1: 385.6 Structure 2: 281.44 (1)	Structure 1: 385.6 g/mol Structure 2: 281.44(I)	Structure 1: 385.6 g/mol Structure 2: 281.44 (I)	x	Structure 1: 385.6 g/mol Structure 2: 281.44 (I)	Structure 1: 385.6 g/mol Structure 2: 281.44 (I)	Structure 1: 385.6 g/mol Structure 2: 281.44 (I)
Melting point (ºC)	*Structure 1: 180.83 Structure 2: 120.09	*Structure 1: 180.83 Structure 2: 120.09	Structure 1: 180.83 Structure 2: 120.09 (I)	Structure 1: 180.83 Structure 2: 120.09 (I)				
Boiling point (ºC)	*Structure 1: 462.34 Structure 2: 361.98	Structure 1: 462.34 Structure 2: 361.98						
Temperature (ºC)	Structure 1: 25 Structure 2: 25	Structure 1: 20 Structure 2: 20	Structure 1: 20 Structure 2: 20	Structure 1: 20 Structure 2: 20				
Density (kg/m^3)	Structure 1: not available Structure 2: 1010	x (2)						
Vapour pressure (Pa)	*Structure 1: $7.71x10^{-7}$ Structure 2: $1.04x10^{-3}$	Structure 1: $7.71x10^{-7}$ Structure 2: $1.04x10^{-3}$ (1)	Structure 1: $7.71x10^{-7}$ Structure $21.4x10^{-3}$ (I)	Structure 1: $7.71x10^{-7}$ Structure $21.4x10^{-3}$ (I)				
Henry's Law constant ($Pa·m^3/mol$)	*Structure 1: $1.01x10^{-1}$ Structure 2: $8.54x10^{-1}$	Structure 1: $1.01x10^{-1}$ Structure 2: $8.54x10^{-1}$ (3)						
Log K_{aw} (Air-water partition	Structure 1: $1.62x10^{9}$ Structure 2:				x			

coefficient; dimensionless)	$3.44x10^{-4}$							
Log K_{ow} (Octanol-water partition coefficient; dimensionless)	*Structure 1: 9.21 Structure 2: 7.05	Structure 1: 9.21 Structure 2: 7.05 (1)	Structure 1: 9.21 Structure 2: 7.05 (I)	Structure 1: 9.21 Structure 2: 7.05 (I) (I)	x	Structure 1: 9.21 Structure 2: 7.05 (I) (I)	Structure 1: 9.21 Structure 2: 7.05 (I) (I)	
K_{ow} (Octanol-water partition coefficient; dimensionless)	Structure 1: $1.6218x10^{9}$ Structure 2: $1.1220x10^{7}$	Structure 1: $1.6218x10^{9}$ Structure 2: $1.1220x10^{7}$						
Log K_{oc} (Organic carbon-water partition coefficient – L/kg)	Structure 1: 5.97 Structure 2: 4.78							
Water solubility (mg/L)	*Structure 1: $5.11x10^{-5}$ Structure 2: 0.014	Structure 1: $5.11x10^{-5}$ Structure 2: 0.014 (1)	Structure 1: $5.11x10^{-5}$ Structure 2: 0.014(I)	Structure 1: $5.11x10^{-5}$ Structure 2: 0.014(I)				
Log K_{oa} (Octanol-air partition coefficient; dimensionles	Structure 1; 13.6 Structure 2; 10.52=1							

s)								
Soil-water partition coefficient (L/kg)[1]			x (II)	x (II)				
Sediment-water partition coefficient (L/kg)[1]			x (II)	x (II)				
Suspended particles-water partition coefficient (L/kg)[1]		x (2)	x (II)	x (II)				
Fish-water partition coefficient (L/kg)[2]			x (II)	x (II)				
Aerosol-water partition coefficient; dimensionless[3]			x (II)	x (II)				
Vegetation-water partition coefficient; dimensionless[1]				x (II)				
Enthalpy				-20 (3)				

(K_{ow})								
Enthalpy (K_{aw})				55 (3)				
Half-life in air (days)	Structure 1: Structure 2: 0.105		Structure 1: 0.052 Structure 2: 0.053(I)	Structure 1: 0.052 Structure 2: 0.053(I)	x			
Half-life in water (days)			Structure 1: 360 Structure2: 120(I)	Structure 1: 360 Structure2: 120(I)	x		CATABOL Structure 1: >182 Structure 2: >182	
Half-life in sediment (days)			Structure 1: 1440 Structure 2: 480(I)	Structure 1: 1440 Structure 2: 480(I)				
Half-life in soil (days)			Structure 1: 360 Structure 2: 120(I)	Structure 1: 360 Structure 2: 120(I)	x			
Half-life in vegetation (days)[4]				x (I,II)				
Metabolic rate constant (1/days)						*Structure 1: 0.004 Structure 2: 0.04		
Biodegradation rate constant (1/days) or (1/hr) - specify		Structure 1: 0.78 (l/days) Structure 2: 0.67 (1/days)						

Biodegradation half-life in primary clarifier ($t_{1/2-p}$) (hr)		Structure 1: Structure 2: 248 (1)						
Biodegradation half-life in aeration vessel ($t_{1/2-s}$) (hr)		Structure 1: Structure 2: 24.8 (1)						
Biodegradation half-life in settling tank ($t_{1/2-s}$) (hr)		Structure 1: Structure 2: 24.8 (1)						

[1] derived from $\log K_{oc}$
[2] derived from BCF data
[3] default value
[4] derived from half-life in water