Model Alternatives Assessment

PRELIMINARY ALTERNATIVES ASSESSMENT REPORT

Deca Bromodiphenyl Ether
in External Computer Housings

As Required under
Division 4.5, Title 22, California Code of Regulations
Chapter 55. Safer Consumer Products

October 7, 2013

Acknowledgements

While staff at Hewett-Packard (HP) took the lead on this report, it benefited greatly from collaborations made possible through the BizNGO Alternatives Assessment Work Group, especially the expertise of Cheri Peele. This report is intended to contribute to the growth and development of the field of alternatives assessment and should be used for demonstration and educational purposes only.

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Acronyms and Abbreviations

ABS	acrylonitrile butadiene styrene
BAF	bioaccumulation factor
BCF	bioconcentration factor
BFR	brominated flame retardant
CFR	chlorinated flame retardant
COC	chemical of concern
Deca-BDE	decabromodiphenyl ether
DfE	US Environmental Protection Agency Design for the Environment Program
DTSC	California Department of Toxics Substances Control
ECJ	European Court of Justice
EEE	Electrical and Electronic Equipment
EIC	European Information Center
EPDM	ethylene propylene diene monomer
EU	European Union
EVA	ethylene vinyl acetate
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
HBCDD	hexabromocyclododecane
HIPS	high impact polystyrene
IEC	International Electrotechnical Commission
NFPA	National Fire Protection Association
NOEC	no observed effect concentration
PBDE	polybrominated diphenyl ether
PBT	persistent, bioaccumulative toxic
PBT	polybutylene terephthalate
PET	polyethylene terephthalate
PC	personal computer
PC	polycarbonate
PE	polyethylene
PINFA	Phosphorus Inorganic & Nitrogen Flame Retardants Association
PP	polypropylene
PPO-PS	polyphenylene oxide - polystyrene
RoHS	Restriction on Hazardous Substances
TFA	UK Textiles Finishers Association
TPU	thermoplastic polyurethane
UL	Underwriters Laboratory, Inc.
VECAP	Voluntary Emissions Control Action Program
vPvB	very high persistence and very high bioaccumulation
vPT	very high persistence and toxic
vBT	very high bioaccumulation and toxic

About this Report

In 2008, The California legislature passed the California Green Chemistry Initiative. The Law authorized the California Department of Toxic Substances and Control (DTSC) to enact regulations that identify and prioritize chemicals in consumer products that have the potential to cause adverse impacts to human health and the environment, and that establish a process for evaluating safer alternatives. These Safer Consumer Product (SCP) regulations are the first of its kind in the U.S. to require an alternatives analysis. Alternatives analysis – commonly referred to as alternatives assessment – is a systematic approach for identifying, comparing and selecting safer alternatives to chemicals of concern (including those in materials, processes or technologies) on the basis of their hazards, performance, and economic viability.

As DTSC was drafting the SCP regulations, requirements for the alternatives analysis process as incorporated into early versions of the regulations were very different than those historically used by alternatives assessment experts. In order to better inform comments to DTSC on the draft regulations and guidance documents, the BizNGO alternatives assessment working group – a collaboration of leaders in business, environmental groups, academia and government working together to advance alternatives assessment for the evaluation and selection of safer chemicals and sustainable materials – undertook a demonstration project to pilot test the alternatives analysis requirements as outlined in Article 5 of the draft SCP regulations.

The demonstration project focused on decabromodiphenyl ether (Deca-BDE) in external computer housings. Deca-BDE is already restricted in commerce by the European Union's Restriction of Hazardous Substance Directive (RoHS). The BizNGO working group thought it useful to explore the draft analysis of alternatives approach for a chemical of concern used in an *article or assembled product*, thus the focus on flame retardants used in external computer housings. The purpose of the demonstration project was to test the SCP alternatives analysis *process,* rather than to identify new safer alternatives to Deca-BDE. As such, the project focused on using existing data, rather than on generating new data and new results regarding alternatives. Over the course of two years, the BizNGO alternatives assessment working group convened and discussed methodological approaches and worked through challenges that emerged as the analysis progressed. This report is the result of this collaborative effort.

The report is divided into two main sections, which follow the Stage 1 and Stage 2 CA SCP draft regulatory requirements. Stage 1 includes an examination of the product's and chemical of concern's function and performance requirements; identification of candidate alternatives; identification of relevant comparison factors (for example, environmental, human health, and physicochemical properties); assessment of human and environmental health hazards of concern; and a work plan and associated timeline relevant to completion and submission of the Stage 2 assessment. Stage 2 includes a broader assessment of lifecycle impacts not addressed in Stage 1 as well as an assessment of economic and technical feasibility. In practice, these two stages would be submitted as separate reports to DTSC. The report concludes with a reflection of lessons learned from this demonstration project.

This report should be used for educational purposes only; it was not developed for legal advice. This report is the result of a collaboration of many stakeholders and therefore should not be attributed to a single individual or organization. **This project predates final regulations and guidance materials adopted by the DTSC. As such, future alternative analyses should follow final compliance guidance found on DTSC's Safer Consumer Products program website: http://www.dtsc.ca.gov/scp/.**

A webinar reporting on this project was hosted on March 14, 2014 and can be viewed at: http://www.biznGO.org/resources/entry/california-safer-product-regulations.

EXECUTIVE SUMMARY

This alternatives assessment completes Stage I and 2 of a model alternatives assessment for Deca Bromodiphenyl ether (Deca-BDE) in electronics housings.

Deca-BDE is used as a flame retardant in a range of consumer products, including furniture upholstery fabric, polypropylene drapery, synthetic carpets, and housings for television and other electronic housings. The scope of this assessment is limited to applications where the external electronics housing also functions as the fire enclosure.

Industry wide flammability standards have been adopted by electronics manufacturers to promote the development of safe products. Fire safety standards have been developed by the National Fire Protection Association (NFPA) in conjunction with the Underwriters Laboratory Inc. (UL) in the U.S. and California and by the International Electrotechnical Commission (IEC) worldwide. The NFPA and UL standards are adapted from the IEC standards for use in the US and Canada. The UL94 standard includes the '20 mm Vertical Burning Test,' a performance-based test used to qualify plastics for flammability ratings. The most stringent rating under this test is V-0. The standards DO NOT specify the use of any particular flame retardant.

There are few explicit legal requirements regarding flammability standards for electronics. However, NFPA standards, while voluntary, are often cited as a definitive source for fire and combustion related technical information. For this reason, any alternative selected must achieve a V-0 rating to be acceptable and to mitigate any liability risk.

Deca-BDE is added to plastic during the molding process at 10-15 percent of total by weight, enabling the plastic to meet a V-0 flammability rating. It is important to note that not all electronics housings are plastic or use Deca-BDE. However, in products where the electronic housing itself is the fire enclosure, that housing is typically a plastic that contains Deca-BDE.

Alternatives to Deca-BDE vary by application due to the varied nature of materials used and differing flammability requirements. An initial list of 106 potential alternatives was to Deca-BDE in electronics enclosures was developed based on three well known sources that represent a cross-section of stakeholders from industry, government, scientific consultancy and academia: 1.) "Flame retardants product selector and regulatory information" published by the group Phosphorus Inorganic & Nitrogen Flame Retardants Association (PINFA)[1], 2.) "An alternatives assessment for the flame retardant decabromodiphenyl ether (Deca-BDE)" U.S. EPA Design for Environment[2] and 3). "Study on Hazardous Substances in Electrical and Electronic Equipment, Not Regulated by the RoHS Directive" Oko Institut.

In the initial screening, potential alternatives were "binned" as unacceptable for these reasons, in addition to the following:

- Lack of a complete hazard assessment
- Halogenated: When plastic containing halogenated flame retardants is burned, dioxins are formed, which pose significant adverse health and environment problems.[3]

[1] http://www.pinfa.org/component/content/article/8.html (accessed March 9, 2013).
[2] http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/aa-for-deca-full-version.pdf (accessed March 9, 2013).
[3] Weber, Kuch, Environmental International, 29 (6), 2003, 699. (Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated–chlorinated dibenzodioxins and dibenzofurans).

- Brominated flame retardant (BFR) synergist: BFR synergists will only work in the presence of a BFR. As BFRs are halogenated and all halogenated alternatives were binned, BFR synergists were also binned.
- Inability or unknown ability to function adequately as a flame retardant in an electronic enclosure
- Low production

Alternatives that with similar chemical structures were grouped, with one representative selected to go through the rest of the assessment.

Toward the goal of identifying potential alternatives that are less hazardous than Deca-BDE, each of the remaining 20 potential alternatives was evaluated against hazard endpoints listed in Table 1. Hazard cutoff criteria are provided in the Table and are largely based upon GHS classification. While the screening criteria are based very closely on the GreenScreen™ for Safer Chemicals v1.2,[4] the evaluations performed for this assessment do not constitute validated GreenScreen assessments.

Table A: Hazard Evaluation Endpoints and Cutoff Criteria

Hazard endpoint	**Criteria Cutoff**	
Group I Human	High	
Carcinogenicity	GHS Category 1A (Known) or 1B (Presumed)	
Mutagenicity/Genotoxicity	GHS Category 1A (Known) or 1B (Presumed)	
Reproductive Toxicity	GHS Category 1A (Known) or 1B (Presumed)	
Developmental Toxicity	GHS Category 1A (Known) or 1B (Presumed)	
Endocrine Activity	Evidence of endocrine activity	
Group II Human	Very High	High
Acute toxicity	GHS Category 1 or 2	GHS Category 3
Systemic Toxicity/Organ Effects and Neurotoxicity; single exposure	GHS Category 1	GHS Category 2
Systemic Toxicity/Organ Effects and Neurotoxicity; repeated exposure*		GHS Category 1
Skin Sensitization*		GHS Category 1A
Respiratory Sensitization*		GSH Category 1A
Skin Irritation	GHS Category 1 (Corrosive)	GHS Category 2 (Irritant)
Eye Irritation	GHS Category 1 (Irreversible)	GHS Category 2A (Irritating)
Ecotoxicity		
Acute Aquatic Toxicity	GHS Category 1	GHS Category 2
Chronic Aquatic Toxicity	NOEC < 1.0 mg/L	NOEC < 1.0 mg/L
Fate	Very High	High
Persistence (P)	Days: Soil: $t_{1/2}$>180 Water: $t_{1/2}$>60 Air: $t_{1/2}$>50	Days Soil: 60 < $t_{1/2}$ < 180 Water: 40 < $t_{1/2}$ < 60 Air: 2 < $t_{1/2}$ < 5
Bioaccumulation (B)	BAF/BCF > 5000; Log K_{ow} > 5.0	1000 < BAF/BCF < 5000 4.5 < Log K_{ow} < 5.0
Reactivity	Equally or less reactive than chemical of concern	
Flammability	Equally or less flammable than chemical of concern	

Designates a Group II hazard endpoint—generally hazard endpoints that are dependent upon multiple exposures.

[4] Clean Production Action. The GreenScreen™ for Safer Chemicals v1.2. http://www.cleanproduction.org/Greenscreen.v1-2.php (accessed March 27, 2013).

Alternatives and their transformation products exhibiting the following hazard profiles did not advance to the next step of the alternative assessment process:

a. PBT = High P + High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
b. vPvB = very High P + very High B
c. vPT = very High P + [very High T (Ecotoxicity or Group II Human) or High T (group I or I* Human)]
d. vBT = very High B + [very High T (Ecotoxicity or group II Human) or High T (group I or II* Human)]
e. High T (group I Human)

Using the decision logic from above as criteria the alternatives BDP and Zinc Borate were deselected for advancement to the second stage assessment. The 18 remaining alternatives shown in green in Table 2 will be assessed in the second stage assessment for the final alternatives assessment report.
The focus of the second stage analysis will be on the prevention of unintended consequences or burden shifting negative impacts from one environmental or human health concern to another. The analysis will consist of multimedia life cycle assessments, product function and performance assessments and economic impact assessments.

Table B. Alternatives Selection for Second Stage Assessment

Chemical Name	CAS #	Selection Criteria
Monomeric N-alkoxy hindered amine	191680-81-6	DfE Hazard Table
Polyphosphonate oligomers	68664-06-2	DfE Hazard Table
APP Ammonium Polyphosphate	68333-79-9	DfE Hazard Table, Known Alternative
ATH - Aluminium tri-hydroxide	21645-51-2	DfE Hazard Table, Known Alternative
BDP - Bisphenol-A bis(diphenyl phosphate)	181028-79-5, 5945-33-5	DfE Hazard Table, Known Alternative
Diethylphosphinate, aluminium salt	225789-38-8	DfE Hazard Table, Known Alternative
MDH - Magnesium di-hydroxide	13760-51-5, 1309-42-8	DfE Hazard Table, Known Alternative
Melamine Cyanurate	37640-57-6	DfE Hazard Table, Known Alternative
Melamine Polyphosphate	218768-84-4, 56386-64-2	DfE Hazard Table, Known Alternative
P/N based intumescent systems piperazine pyrophosphate	66034-17-1	DfE Hazard Table, Known Alternative
Polcarbonate-Polyphosphonate copolymer	77226-90-5	DfE Hazard Table, Known Alternative
RDP Resorcinol bis (diphenyl phosphate)	57583-54-7, 125997-21-9	DfE Hazard Table, Known Alternative
TPP - triphenyl phosphate	115-86-6	DfE Hazard Table, Known Alternative
Zinc Borate	138265-88-0, 1332-07-6, 12767-90-7	DfE Hazard Table, Known Alternative
Aluminum housing material		Material Change
Magnesium alloy housing material		Material Change
Added sheet metal fire enclosure		Material Change
High PC content PC/ABS		Material Change

Chemical Name	CAS #	Selection Criteria
Tris-(2-ethylhexyl) phosphate	78-42-2	Representative--Alkyl Phosphate Group
silicon dioxide	112945-52-5, 7631-86-9	Representative--Filler Group
ZnHS - Zinc Hydroxystannate	12027-96-2	BFR Synergist
ZnS - Zinc Stannate	12036-37-2	BFR Synergist
Antinomy trioxide	1309-64-4	BFR Synergist
APP Ammonium Polyphosphate (coated)	68333-79-9	Duplicate
APP Ammonium Polyphosphate (with synergists)	68333-79-9	Duplicate
Diethylphosphinate, aluminium salt (with synergists)	225789-38-8	Duplicate
Polyphosphonate homopolymer	68664-06-2	Duplicate
Boehmite (Aluminium oxide hydroxide)	1318-23-6	Group--Aluminum tri-hydroxide
DEEP - Diethylethane phosphonate	78-38-6, 150103-83-6	Group--Alkyl Phosphate
Expandable graphite	7782-42-5	Group—Filler
Diphenyl (2-ethylhexyl) phosphate	1241-94-7	Group--Alkyl Phosphate
DMMP - Dimethyl methyl phosphonate	756-79-9	Group--Alkyl Phosphate
DMPP - Dimethyl propane phosphonate	242-555-3	Group--Alkyl Phosphate
TEP - Triethyl phosphate	78-40-0	Group--Alkyl Phosphate
TXP - Trixylyl phosphate	68952-33-0	Group--Alkyl Phosphate
Poly(m-phenylene methylphosphonate)	63747-58-0	Group--Alkyl Phosphate
silicon dioxide	14808-60-7	Group—Filler
Melamine	108-78-1	Group--Melamine
Melamine Borate	53587-44-3	Group--Melamine
Melamine Phosphate	41583-09-9	Group--Melamine
Zinc Oxide	1314-13-2	Group—Zinc
Tris(tribromophenoxy) triazine, Tris(tribromophenyl) cyanurate	25713-60-4	Halogenated
Dechlorane plus - Bis (hexachlorocyclopentadieno) cyclooctane	13560-89-9	Halogenated
DBDPE	84852-53-9	Halogenated
HBCDD, Hexabromocyclododecane	25637-99-4, 3194-55-6	Halogenated
Deca-BDE, Decabromodiphenyl ether	1163-19-5	Halogenated
Poly(2,6-dibromo-phenylene oxide)	69882-11-7	Halogenated
Tetra-decabromo-diphenoxy-benzene	58965-66-5	Halogenated
1,2-Bis(2,4,6-tribromo-phenoxy) ethane	37853-59-1	Halogenated
3,5,3’,5’-Tetrabromo-bisphenol A (TBBA)	79-94-7	Halogenated
TBBA, unspecified	30496-13-0	Halogenated
TBBA-epichlorhydrin oligomer	40039-93-8	Halogenated
TBBA-TBBA-diglycidyl-ether oligomer	70682-74-5	Halogenated

Chemical Name	CAS #	Selection Criteria
TBBA carbonate oligomer	28906-13-0	Halogenated
TBBA carbonate oligomer, phenoxy end capped	94334-64-2	Halogenated
TBBA carbonate oligomer, 2,4,6-tribromo-phenol terminated	71342-77-3	Halogenated
TBBA-bisphenol A-phosgene polymer	32844-27-2	Halogenated
Brominated epoxy resin end-capped with tribromophenol	139638-58-7	Halogenated
Brominated epoxy resin end-capped with tribromophenol	135229-48-0	Halogenated
TBBA-(2,3-dibromo-propyl-ether)	21850-44-2	Halogenated
TBBPA glycidyl ether & polymers	68928-70-1	Halogenated
TBBA bis-(2-hydroxy-ethyl-ether)	4162-45-2	Halogenated
TBBA-bis-(allyl-ether)	25327-89-3	Halogenated
TBBA-dimethyl-ether	37853-61-5	Halogenated
Tetrabromo-bisphenol S	39635-79-5	Halogenated
TBBS-bis-(2,3-dibromo-propyl-ether)	42757-55-1	Halogenated
2,4-Dibromo-phenol	615-58-7	Halogenated
2,4,6-tribromo-phenol	118-79-6	Halogenated
Pentabromo-phenol	608-71-9	Halogenated
2,4,6-Tribromo-phenyl-allyl-ether	3278-89-5	Halogenated
Tribromo-phenyl-allyl-ether, unspecified	26762-91-4	Halogenated
Bis(methyl)tetrabromo-phtalate	55481-60-2	Halogenated
Bis(2-ethylhexyl)tetrabromo-phtalate	26040-51-7	Halogenated
2-Hydroxy-propyl-2-(2-hydroxy-ethoxy)-ethyl-TBP	20566-35-2	Halogenated
TBPA, glycol-and propylene-oxide esters	75790-69-1	Halogenated
N,N'-Ethylene –bis-(tetrabromo-phthalimide)	32588-76-4	Halogenated
Ethylene-bis(5,6-dibromo-norbornane-2,3-dicarboximide)	52907-07-0	Halogenated
2,3-Dibromo-2-butene-1,4-diol	2/4/3234	Halogenated
Dibromo-neopentyl-glycol	3296-90-0	Halogenated
Dibromo-propanol	96-13-9	Halogenated
Tribromo-neopentyl-alcohol	36483-57-5	Halogenated
Poly tribromo-styrene	57137-10-7	Halogenated
Tribromo-styrene	61368-34-1	Halogenated
RP Red phosphorus	7723-14-0	Incompatible
RP Red phosphorus (concentrates)	7723-14-0	Incompatible
RP Red phosphorus (dispersions)	7723-14-0	Incompatible
EDAP, Ethylenediamine-o-phosphate	14852-17-6	Low production
Cyclic Phosphonate	proprietary	Proprietary

Chemical Name	CAS #	Selection Criteria
Modified Guanidine Phosphate	proprietary	Proprietary
New phosphonate 1 (new substance)	proprietary	Proprietary
New phosphonate 2 (new substance)	proprietary	Proprietary
other P/N based intumescent system	proprietary	Proprietary
Phosphonic acid, organic salt	proprietary	Proprietary
Phosphorus polyol	proprietary	Proprietary
Hypohosphite, calcium salt	7789-79-9	Unknown Functionality
Hypohosphite, calcium salt (with synergists)	7789-79-9	Unknown Functionality
Hypophosphite, aluminium salt (with synergists)	7784-22-7	Unknown Functionality
Inorganic, mineral based FR synergist	68953-58-2	Unknown Functionality
IPPP - Isopropylated phenol phosphate	68937-41-7	Unknown Functionality
Mixtures of esters of phophoric acid	1003300-73-9	Unknown Functionality
Polyphosphoric Acid	8017-16-1	Unknown Functionality
resorcinol bis dixylenyl phosphate	139189-30-3	Unknown Functionality
Potassium 3-(phenylsulfonyl)benzenesulfonate	63316-43-8	Unknown Functionality
2,2'-Oxybis[5,5-dimethyl-1,3,2-dioxaphosphorinane]2,2'disulphide	4090-51-1	UnsuiTable
CDP - Cresyldiphenyl phosphate	26444-49-5	UnsuiTable
DOPO, 9,10-Dihydro-9-oxa-10-phosphaphenanthren-10-oxide	35948-25-5	UnsuiTable
N,N-(bis)-hydroxyethyl-aminomethane phosphonic acid diethyl ester	2781-11-5	UnsuiTable
TCP - Tricresyl phosphate	1330-78-5, 78-30-8	UnsuiTable

Legend

- **Material Change**—A material or design change that accomplishes the desired flame rating without a chemical substitute for Deca-BDE. Example: Using a metal housing instead of plastic.
- **UnsuiTable**—Alternatives that are typically used for other applications or purposes and are not anticipated to be used as replacements for Deca-BDE in electronics housings. Example: CDP is typically used as a plasticizer for PVC and not as a flame retardant for plastic housing materials.
- **Known Alternative**—Alternatives that are known to have been used as flame retardants in plastics. Example: BDP is currently used in some electronics housings.
- **Low Production**—These materials are only available in low production volumes and are therefore not practical alternatives at this time.
- **Proprietary**—The CAS number was not provided for this material therefore a hazard assessment cannot be completed. The hazard assessment is essential to the alternative assessment process so these alternatives were deselected.
- **Incompatible**—Alternatives that are not compatible with the resins of interest. Example: red phosphorus causes corrosion in electronic equipment and is therefore not suiTable for electronics housings.

- **Alkyl Phosphate**—Alternatives that are part of the alkyl phosphate family of chemicals. Rather than assess each alkyl phosphate individually it was determined that the group of alkyl phosphates will be represented by tris-(2-ethylhexyl) phosphate.
- **Halogenated**—Alternatives that contain bromine or chlorine. Other halogens, such as fluorine and iodine, are not in scope. The halogenated alternatives were deselected due to the potential health implications and waste stream pollution from burning plastics containing halogenated flame retardants. The issue is that halogenated flame retardants, when burned, form dioxins which pose significant adverse health and environment problems.[5] Based on hazard alone, with the volume of information on the hazard of these substances, halogenated flame retardants were eliminated from further consideration.
- **BFR Synergist**—A synergistic chemical that is only effective when used in combination with a BFR. Since halogenated flame retardants were deselected there is no reason to evaluate synergists.
- **DfE Hazard Table**—Alternatives listed in the report "An alternatives assessment for the flame retardant decabromodiphenyl ether (Deca-BDE)" published by the U.S. EPA.[6] All of these alternatives were selected to progress in the assessment process.
- **Duplicate**—An alternative that has the same CAS number as another chemical in the Table that is being considered.
- **Group**—An alternative that is represented by a similar chemical, such as the alkyl phosphate group, or is similar to another material already being considered. For example, boehmite is expected to have a similar hazard profile to ATH.
- **Representative**—An alternative that is being used as a proxy for other chemicals in the Table. Example: tris-(2-ethylhexyl) phosphate for the alkyl phosphates.

[5] Weber, Kuch, Environmental International, 29 (6), 2003, 699. (Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated–chlorinated dibenzodioxins and dibenzofurans).

[6] U.S. EPA. An Alternatives Assessment for the Flame Retardant Decabromodiphenyl Ether (Deca-BDE). http://www.epa.gov/dfe/pubs/projects/Deca-BDE/deca_fullreport.pdf (accessed March 27, 2013).

Table C: Alternatives to Deca-BDE in Electronic Enclosures Summary Table

	Raw Materials		Manufacture			Transportation[7]	Use		End-of-Life	
Material	Raw Materials Extraction	Resource Inputs and Other Resource Consumption	Intermediate Materials Processes	Manufacture	Waste Generation and Management	Packaging Transportation and Distribution	Use	Operation and Maintenance[8]	Reuse and Recycling	End-of-Life Disposal
Deca-BDE	L[9]		$H_{B, C, E}$	L	M	L	$M_{B, D}$	L	$\mathbf{H_{A, B, C, D, E, F}}$	$\mathbf{H_{A, B, C, D, F}}$
Monomeric N-alkoxy hindered amine	$M_{A,B,D, E, F}$		H_B	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Polyphosphonate oligomers	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
APP Ammonium Polyphosphate	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
ATH - Aluminium tri-hydroxide	$H_{A,B,D, E, F}$		$H_{B, C, E}$	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Diethylphosphinate, aluminium salt	$H_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
MDH - Magnesium di-hydroxide	$H_{A,B,D, E, F}$		$H_{B, C, E}$	M_X	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Melamine Cyanurate	$M_{A,B,D, E, F}$		H_B	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Melamine Polyphosphate	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
P/N based intumescent systems piperazine pyrophosphate	$M_{A,B,D, E, F}$		H_F	L	M	L	$M_{B, D}$	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Polcarbonate-Polyphosphonate copolymer	$M_{A,B,D, E, F}$		H_B	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
RDP Resorcinol bis (diphenyl phosphate)	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
TPP - triphenyl phosphate	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Aluminum housing material	$H_{A,B,D, E, F}$		$H_{B, C, E}$	H_X	L	L	L_D	L	$\mathbf{L_X}$	L

[7] The material density differences are not expected to significantly change the weight of the finished housing, therefore the transportation impact is expected to be the same for all of the alternatives.

[8] Operation and maintenance is expected to be similar for all alternatives.

[9] Brominated flame retardant raw materials are relatively more easily extracted using mining process that have lower impact than other mining techniques.

	Raw Materials		Manufacture			Transportation[7]	Use		End-of-Life	
Material	Raw Materials Extraction	Resource Inputs and Other Resource Consumption	Intermediate Materials Processes	Manufacture	Waste Generation and Management	Packaging Transportation and Distribution	Use	Operation and Maintenance[8]	Reuse and Recycling	End-of-Life Disposal
Magnesium alloy housing material	$H_{A,B,D,E,F}$		$H_{B,C,E}$	H_X	*L*	*L*	L_D	*L*	**L_X**	*L*
Added sheet metal fire enclosure	$H_{A,B,D,E,F}$		$H_{B,C,E}$	H_X	*L*	*L*	L_D	*L*	**L_X**	*L*
High PC content PC/ABS	$M_{A,B,D,E,F}$		H_B	*L*	*M*	*L*	L_D	*L*	$M_{A,B,C,D,E,F}$	$M_{A,B,C,D,F}$
Tris-(2-ethylhexyl) phosphate	$M_{A,B,D,E,F}$		H_F	*L*	*M*	*L*	L_D	*L*	$M_{A,B,C,D,E,F}$	$M_{A,B,C,D,F}$
silicon dioxide	$M_{A,B,D,E,F}$		H_B	M_X	*M*	*L*	L_D	*L*	$M_{A,B,C,D,E,F}$	$M_{A,B,C,D,F}$

Legend:

Relevant Factor
Non-Relevant Factor
Unknown

Bold font indicates empirical data

Italic font indicates lower confidence estimate based professional judgment.

A	Adverse Environmental Impacts
B	Adverse Public Health Impact
C	Adverse Waste and End-of-Life Effects
D	Environmental Fate
E	Materials and Resource Consumption Impacts
F	Physical Chemical Hazards
G	Physicochemical Properties
X	Energy-Alternative may result in higher energy consumption. Depending on the energy source there may be impacts in areas A through F.

To determine the relevant factors for comparison of the alternatives, a review of available Life Cycle Assessment (LCA) resources was undertaken. The review revealed that that available LCA data for the alternatives is strongly energy and emission focused. Midpoints such as chemical toxicity can be undervalued, but LCA provides a contrasting perspective to the hazard evaluation in Stage 1. The midpoints addressed by LCA correspond to the adverse environmental impact areas described in the Safer Consumer Products regulation. Since the hazard evaluation eliminated alternatives with environmental or human health hazards in Stage 1, understanding the LCA of the remaining alternatives can provide a different perspective and help identify burden shifting.

LCA results for a complete notebook computer can provide perspective to the values obtained for the alternatives. The primary study chosen for comparison was *LCA of an Ecolabeled Notebook* prepared by GreenDeltaTC for Belgium's Federal Public Planning Service Sustainable Development.[10] The study examined the life cycle impacts of a notebook supplied by AsusTek using standard LCA procedures and guidelines. The results show that the relevant impacts are in climate change (human health and ecosystems), human toxicity, particulate matter formation and fossil depletion, with a minor contribution from metal depletion. Furthermore, the environmental impacts are dominated by the production phase with a much smaller secondary contribution from the use phase. The results are consistent with LCAs performed elsewhere although some studies conclude that the use phase has the greatest impact.

It is useful to compare the most extreme alternatives to Deca-BDE. Switching to an aluminum or magnesium housing material requires more energy and produces more CO_2 emissions than Deca-BDE. Silicon Dioxide, on the other hand, results in much lower emissions and energy requirements. Energy and emissions associated with magnesium are highly dependent on the process and raw materials used to refine the metal. Emission values were widely ranging. Thus uncertainty of the emission values makes it difficult to select one alternative over another based on emission calculations.

The contribution of the choice of flame retardant is an extremely small part of the overall energy and emission profile of a laptop computer. The uncertainty associated with life cycle inventory data, due to measurement error and significantly different manufacturing processes, makes it difficult to definitively show a difference between the alternatives. Nevertheless, selecting some alternatives may lead to a small increase in energy and emissions but this insignificant compared to benefits of lower toxicity.

For the purposes of this report it was assumed that the recyclability of the alternative is not a significant factor because of the limited recycling of e-waste to new electronics housings. It is unlikely that plastics used in electronics housings would be reused for electronics housings but rather lower grade products.

The useful life of an electronic housing is anticipated to be greater than the useful life of the computer. None of the alternative flame retardants or alternative materials are expected to decrease the useful life of the electronics housing.

To determine the function and **performance of potential alternatives** Finite Element Analysis was used to compare alternatives and provide basic information on the viability of alternatives. Key material properties were obtained from datasheets for resins containing the flame retardant alternatives being analyzed as well as two of metal alternatives that do not require added flame retardants. Ultimately, the adequacy of the final housing material will be determined through experimentation with prototypes, which is beyond the scope of

[10] Ciroth, Andreas and Franze, Juliane. LCA of an Ecolabeled Notebook: Consideration of Social and Environmental Impacts Along the Entire Life Cycle. Berlin 2011.

this report. For the purposes of this report it is assumed that functionally acceptable housings can be manufactured with any of the alternatives.

The economic feasibility of the alternatives is difficult to evaluate because the direct costs are considered confidential business information, will depend on volumes and are likely to change over time. In 2006, the Washington State Department of Ecology (Ecology) evaluated the potential costs of a statewide ban on the use of Deca-BDE in electronics enclosures compared with associated human health benefits. The analysis calculated an initial benefit of $80 per person to a ban on Deca-BDE in electronics enclosures. This figure was based on avoided health impacts and does not take into account health impacts that may be caused by a replacement for Deca-BDE.

In order to calculate the economic impact on human health or the environment for any of the alternatives being considered, it would be necessary to understand the human health and environmental impacts of each of the alternatives and the exposure resulting from use in electronic equipment. Economic values would be placed on each impact, for example, the cost of liver cancer for an individual for one year. This unit cost would then be multiplied by the number of individuals impacted, that is, the number exposed. Data gaps make this difficult to estimate in absolute terms. However, impacts are possible to estimate in relative terms and displayed in Table E. Routes of exposure will remain unchanged whether Deca-BDE or another alternative is utilized in electronics housings. Relative economic impacts can therefore be estimated based on hazard. Less hazardous alternatives with the same exposure routes will result in lower economic impact. All potential alternatives as hazardous or more hazardous than Deca-BDE have been screened from consideration. As the remaining alternatives are less hazardous than Deca-BDE, we predict that overall economic impact will be less.

Promoting a list of multiple alternatives will allow the market to determine the most economically viable alternative. The multiple alternatives approach also leaves suppliers the freedom to choose an alternative based on multiple criteria rather than just the cheapest option. Although the costs are not known it is anticipated that all of the alternatives will be more expensive than Deca-BDE, at least initially.

We do not anticipate any change in the handling of electronics enclosures at end of life due to a change in flame retardants. Theoretically, resin manufacturers incorporating some percent of recycled content may adjust the volume of flame retardant added based on the volume of flame retardant already present in the recycled content. In practice, however, this does not happen. As a result, we do not anticipate a cost impact due to recycling or end of life practices.

Table D. Estimated Economic Impact of Potential Alternatives Relative to Deca-BDE

Alternative	CAS #	Increased (+) or Decreased (-) Cost Relative to Deca-BDE		
		Public Health	Environment	Gov't Agencies & Non-Profits*
Monomeric N-alkoxy hindered amine	191680-81-6	-	-	-
Polyphosphonate oligomers	68664-06-2	-	-	-
APP Ammonium Polyphosphate	68333-79-9	-	-	-
ATH - Aluminium tri-hydroxide	21645-51-2	-	-	-
BDP - Bisphenol-A bis(diphenyl phosphate)	181028-79-5, 5945-33-5	-	-	-
Diethylphosphinate, aluminium salt	225789-38-8	-	-	-
MDH - Magnesium di-hydroxide	13760-51-5, 1309-42-8	-	-	-

Alternative	CAS #	Increased (+) or Decreased (-) Cost Relative to Deca-BDE		
		Public Health	Environment	Gov't Agencies & Non-Profits*
Melamine Cyanurate	37640-57-6	-	-	-
Melamine Polyphosphate	218768-84-4, 56386-64-2	-	-	-
P/N based intumescent systems piperazine pyrophosphate	66034-17-1	-	-	-
Polcarbonate-Polyphosphonate copolymer	77226-90-5	-	-	-
RDP Resorcinol bis (diphenyl phosphate)	57583-54-7, 125997-21-9	-	-	-
TPP - triphenyl phosphate	115-86-6	-	-	-
Zinc Borate	138265-88-0, 1332-07-6, 12767-90-7	-	-	-
Aluminum housing material		-	-	-
Magnesium alloy housing material		-	-	-
Added sheet metal fire enclosure		-	-	-
High PC content PC/ABS		-	-	-
Tris-(2-ethylhexyl) phosphate	78-42-2	-	-	-
silicon dioxide	112945-52-5, 7631-86-9	-	-	-

* Governmental agencies and non-profit organizations that manage waste, oversee environmental cleanup and restoration efforts, and/or are charged with protecting natural resources, water quality, and wildlife.

No single alternative was determined "best" in this analysis of alternatives. The eighteen alternatives shown in Table F did not reveal high-level human or environmental health hazards, did not demonstrate life cycle or economic impacts what were sufficient to warrant their exclusion, and it was determined that functionally acceptable housings can be manufactured with any of the alternatives.

Promoting a list of multiple alternatives will allow component manufacturers – those entities manufacturing and supplying the computer housings in the assembled product – to have a range of options for selecting the most economically viable alternative in a specific application. Such a list also better supports the performance evaluation of alternatives to Deca-BDE in computer housings under real-world production processes for component manufacturers that electronic suppliers such as Hewlett Packard cannot directly control.

Table F: Final Menu of Alternatives

Chemical Name	CAS #
Monomeric N-alkoxy hindered amine	191680-81-6
Polyphosphonate oligomers	68664-06-2
APP Ammonium Polyphosphate	68333-79-9
ATH - Aluminium tri-hydroxide	21645-51-2
Diethylphosphinate, aluminium salt	225789-38-8
MDH - Magnesium di-hydroxide	13760-51-5, 1309-42-8
Melamine Cyanurate	37640-57-6
Melamine Polyphosphate	218768-84-4, 56386-64-2
P/N based intumescent systems piperazine pyrophosphate	66034-17-1
Polcarbonate-Polyphosphonate copolymer	77226-90-5
RDP Resorcinol bis (diphenyl phosphate)	57583-54-7, 125997-21-9
TPP - triphenyl phosphate	115-86-6
Aluminum housing material	
Magnesium alloy housing material	
Added sheet metal fire enclosure	
High PC content PC/ABS	
Tris-(2-ethylhexyl) phosphate	78-42-2
Silicon dioxide	112945-52-5, 7631-86-9

STAGE 1: ALTERNATIVES ANALYSIS

Specific guidance for all future assessment should follow the CA DTSC alternatives analysis guide: http://www.dtsc.ca.gov/scp/

Stage 1 of the analysis of alternatives per CA SCP regulations included in this report include the following components.

- Identify the product requirements and function of the chemical of concern. Specific considerations include:
    - identify functional, performance, and legal requirements; identify the role of the chemical of concern; determine the requirements/necessity of the chemical of concern, including its possible elimination (if appropriate).
- Identify candidate alternatives. Specific considerations include:
    - identify and consider a broad range of alternatives; research and evaluate viable alternatives for consideration.
- Consideration of additional information.
- A work plan and associated timeline relevant to completion and submission of the Stage 2 assessment.

Preparer Information

Preparer Data

Name	***
Organization	***
Address	***
Telephone	***
Email	***

Responsible Entity Data

Organization	***
Representative	***
Address	***
Telephone	***
Email	***

Other Involved Parties

Name	Organization	Role
***	***	***

Comment Process

This document has been posted on the website of the California Department of Toxic Substances Control (DTSC) at [URL]. It is available for public review and comment for a period of 45 days beginning [date]. Comments may be submitted in writing or electronic form to the person named in "Preparer Data" above. All comments submitted to the preparer shall be simultaneously submitted to the DTSC by [method] at [location].

Certification and Signatures

“I certify that this document and all attachments were prepared or compiled under my direction or supervision to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person(s) directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that submitting false information or statements is a violation of law.”

Responsible Entity Signature *** Date ***

Responsible Entity	Signature	***	Date	***
Preparer	Signature	***	Date	***

Responsible Entity and Supply Chain Information

Manufacturer Data

Manufacturer	***
Headquarters Address	***
Responsible Representative	***
Address	***
Telephone	***
Email	***
Website	***

Importer Data

Importer	***
Headquarters Address	***
Responsible Representative	***
Address	***
Telephone	***
Email	***
Website	***

California Customer Identification
[repeat Table as needed for all direct customers within the last 12 months]

Organization	***
Contact Person	***
Address	***
Telephone	***
Email	***

Direct Outlet Identification

[repeat Table as needed to identify all manufacturer outlets in California]

Organization	***
Contact Person	***
Address	***
Telephone	***
Email	***

1. Priority Product Information

Brand Names and/or Product Names	***
Products in Which Priority Product is Used as a Component	External electronics housings
Chemical of Concern	Deca bromodiphenyl ether (Deca-BDE)
Material Safety Data Sheet Reference	http://icl-ip.com/wp-content/uploads/2012/01/8426_enFR-12101.pdf

1.1 Functional Requirements

Deca-BDE is used as a flame retardant in a range of consumer products, including furniture upholstery fabric, polypropylene drapery, synthetic carpets, and housings for television and other electronic housings. Flame retardants generally achieve effectiveness through three basic mechanisms: inhibition of oxidation, barrier formation, or as fillers. Inhibition of oxidation occurs when the gaseous reactive species that are formed during combustion are quenched by available free radical species. Halogenated flame retardants (including Deca-BDE) operate in this way by providing a ready source of free radical halogen species to inhibit oxidation during combustion. Barrier flame retardants form a non-flammable coating over the burning polymer which prevents oxidants from reaching the polymer surface to continue the combustion. Filler flame retardants are usually inert inorganic solids incorporated into the polymer that will absorb heat and conduct it away from the polymer. Fillers also may release waters of hydration which further cools the burning polymer.

The scope of this assessment is limited to applications where the external electronics housing also functions as the fire enclosure. A fire enclosure is designed to prevent the spread of fire from within the enclosure to the outside of the enclosure. An enclosure may provide multiple types of protection including electrical enclosure, fire enclosure and mechanical enclosure, and certain enclosures may provide multiple functions. In some devices an internal fire enclosure may separate potential ignition sources within the device by a protective fire barrier or separation distance from combustible materials. By containing the potential ignition sources in an internal fire enclosure (such as a metal chassis in desktop computers) the need for flame retardancy in the external housing is greatly reduced and in most cases will not require addition of a chemical flame retardant. The scope of this assessment is limited to applications that currently use chemical flame retardants to achieve sufficient fire protection, such as plastic laptop housings.

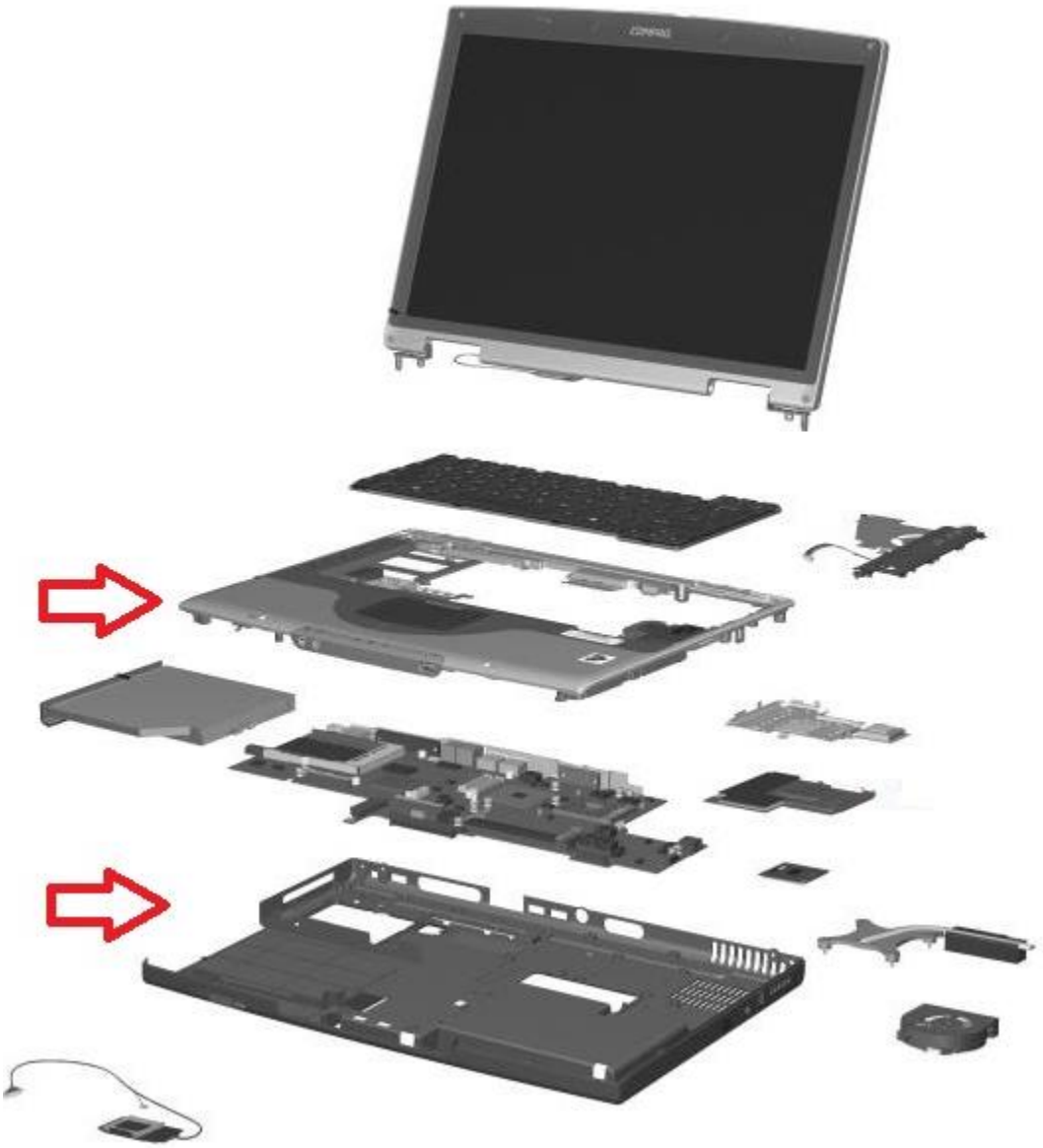

Figure 1. In laptops, the external housing also functions as the fire enclosure. The red arrows indicate fire enclosures.

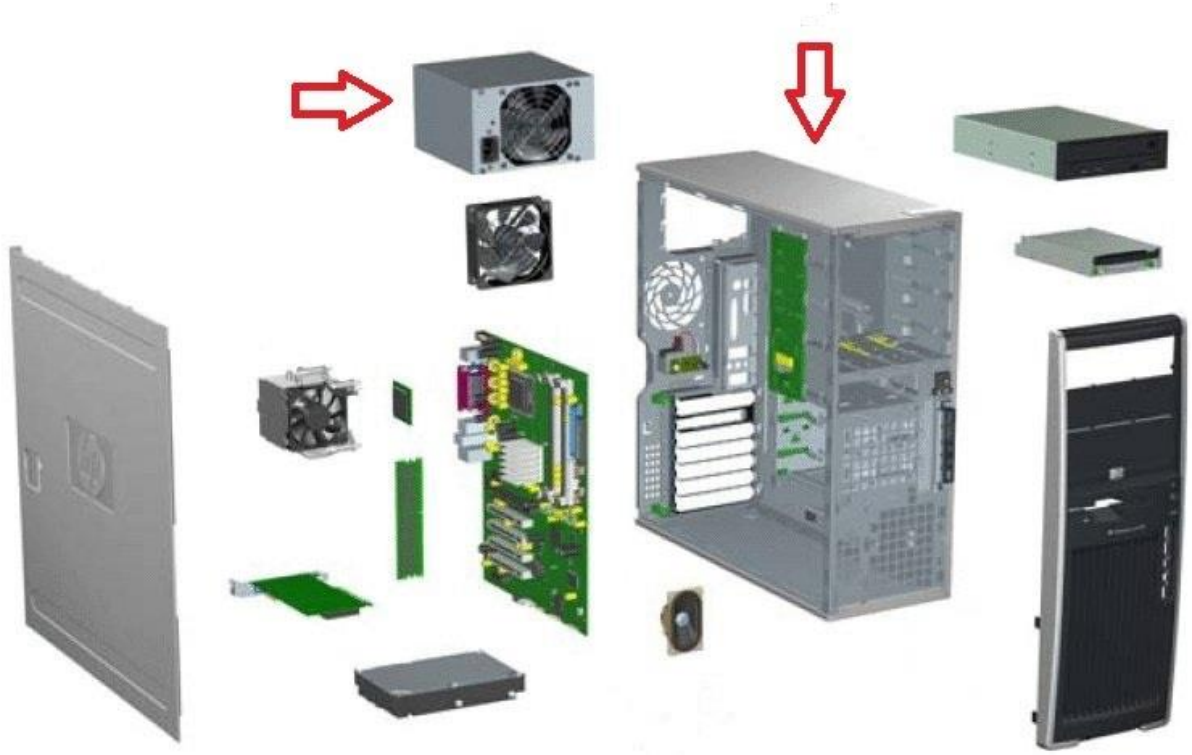

Figure 2. Example of a desktop computer where the fire enclosures are metal and do not typically require chemical flame retardants. The red arrows indicate fire enclosures.

1.2 Performance Requirements

Industry wide standards have been adopted by electronics manufacturers to minimize product liability concerns. Flammability standards consider two things when setting requirements: the type of the ignition source and the path between the source and other combustible materials. This path may be blocked by a fire resistant enclosure. Each requirement is then based upon a material rating. (*vide infra*)

Fire safety standards have been developed by the National Fire Protection Association (NFPA) in conjunction with the Underwriters Laboratory Inc. (UL) in the U.S. and California and by the International Electrotechnical Commission (IEC) worldwide. The NFPA and UL standards are adapted from the IEC standards for use in the US and Canada. The current document is IEC 623681 Ed 1.0: Audio/video, information and communication technology equipment – Part 1: Safety requirements.

The UL94 standard includes several tests that quantify the ability of plastics to withstand combustion. One of these, the *'20 mm Vertical Burning Test*', is used to qualify plastics for the V-0 rating. In this test, five pieces of plastic are twice subjected to an open flame. Discrete information is collected on how long the plastic continues to burn and smolder after the flame is removed. In addition, the combustion of the plastic is observed. It is noted if the plastic burns down to the clamp and if cotton placed beneath the plastic catches fire due to dripping, burning plastic[11].

[11] From WA Dept. of Ecology and Dept. of Health Alternatives to Deca-BDE in Televisions and Computers and Residential Upholstered Furniture, 2008: https://fortress.wa.gov/ecy/publications/publications/0907041.pdf

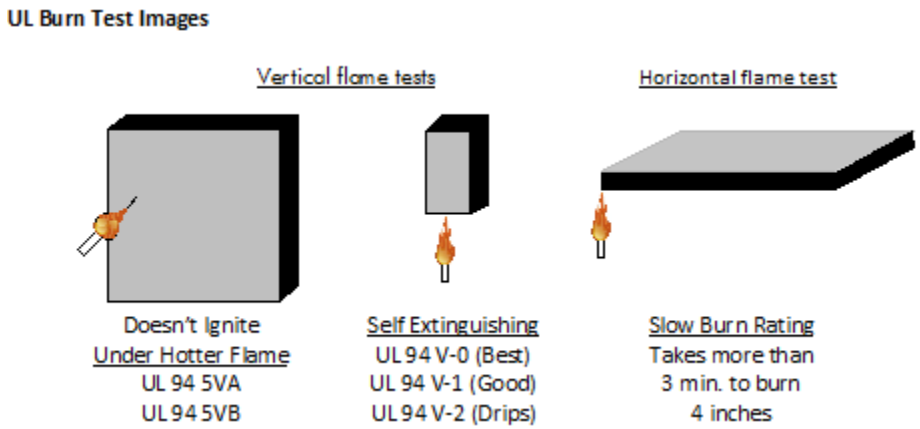

Figure 3: UL Burn Test Images

As illustrated in Figure 3, above:

Table 1: UL Burn Tests

Burn Test	Description
5VA Surface Burn	Burning stops within 60 seconds after five applications of five seconds each of a flame (larger than that used in Vertical Burn testing) to a test bar. Test specimens MAY NOT have a burn-through (no hole). This is the highest (most flame retardant) UL94 rating.
5VB Surface Burn	Burning stops within 60 seconds after five applications of five seconds each of a flame (larger than that used in Vertical Burn testing) to a test bar. Test specimens MAY HAVE a burn-through (a hole).
V-0 Vertical Burn	Burning stops within 10 seconds after two applications of ten seconds each of a flame to a test bar. NO flaming drips are allowed.
V-1 Vertical Burn	Burning stops within 60 seconds after two applications of ten seconds each of a flame to a test bar. NO flaming drips are allowed.
V-2 Vertical Burn	Burning stops within 60 seconds after two applications of ten seconds each of a flame to a test bar. Flaming drips ARE allowed.
H-B Horizontal Burn	Slow horizontal burning on a 3mm thick specimen with a burning rate is less than 3"/min or stops burning before the 5" mark. H-B rated materials are considered "self-extinguishing". This is the lowest (least flame retardant) UL94 rating.

The vertical ratings also indicate whether the test specimen dripped flaming particles that ignited a cotton indicator located below the sample. UL 94 also describes a method in which the test flame is applied for up to five applications in testing for a 5VA or 5VB classification. These small-scale tests measure the propensity of a material to extinguish or spread flames once it becomes ignited[12].

These safety standards are based on worldwide IEC guidance, which has been adapted by various countries and regions. In general, all of these standards have flammability requirements, but they are performance based, that is, they meet a specific flammability classification or allow testing to demonstrate that there is no fire

[12] From UL 94, the Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing: http://www.ul.com/global/eng/pages/offerings/industries/chemicals/plastics/testing/flame/

hazard. The standards DO NOT specify the use of any particular flame retardant. An example is that all connectors in electronic products meet the UL94 V-0 rating – often without the addition of flame retardants. Additionally, some materials are considered to compliant without testing (for example, PTFE and ceramic).

1.3 Legal Requirements

There are few explicit legal requirements regarding flammability standards for electronics; industry wide standards have been adopted by manufacturers to ensure development of safe products. It is important to note that safety standards are set at the product level and not at the material level. Manufacturers may specify material level requirements in order to ensure that the product level requirements are met. Flammability requirements are usually just one part of an overall product safety standard that may include safety requirements designed to prevent bodily injury or electric shock for instance. While product safety standards may not be legal requirements they are fundamental requirements for most products.

The National Electric Code (NEC) provides the umbrella standard for electronic products. The National Fire Protection Association (NFPA) standards exist under the NEC umbrella and are voluntary, but they are often cited as a definitive source for fire and combustion related technical information. The NFPA standards are developed in conjunction with the Underwriters Laboratory Inc. (UL) in the U.S. and California and by the International Electrotechnical Commission (IEC) worldwide. At the materials level, electronics enclosures using materials with Deca-BDE meet the UL Method 94 Vertical flammability rating V-0. The UL94 standard includes the '20 mm Vertical Burning Test,' a performance-based test used to qualify plastics for flammability ratings. Possible ratings include V-0, V-1, and V-2, with V-0 being the most resistant to combustion. Manufacturers may specify a V-0 rating in order to meet the NFPA and NEC requirements at the product level. The standards DO NOT specify the use of any particular flame retardant. In general, any Deca-BDE alternative will need to achieve the same flammability rating to ensure product level compliance.

Local jurisdictions have specific flammability standards that must be met. For example, Orange County, California has fire standards that must be taken into consideration in product development. International standards, such as the European Union's Restriction of Hazardous Substances Directive (RoHS) must be considered for manufacturers that ship product internationally. The RoHS directive restricts the use of polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs). Deca-BDE is a PBDE and is therefore restricted by RoHS in the EU along with the 209 congeners which share similar chemical structures. The RoHS restriction of PBDEs eliminates them from consideration as alternatives to Deca-BDE. In most cases it is not practical to develop products for specific jurisdictions; most products are designed to meet all worldwide standards.

1.4 Role of Chemical of Concern in Meeting Product Requirements

Deca-BDE enables a wide variety of materials to meet high fire safety standards. Deca-BDE is added to plastic during the molding process at 10-15 percent of total by weight. Used at this level, the plastic will meet the UL V-0 flammability rating.

It is important to note that not all electronics housings are plastic or use Deca-BDE. In cases where electronic products have a metal chassis encasing their electronic components, the metal chassis itself serves as the fire enclosure – thus, there is no need for plastic housing containing Deca-BDE. Many desktop computers and printers have a sheet metal box that serves as fire enclosure (with ABS polymer as an outer skin). However, some products do not have such a metal chassis and for many laptop computers and other mobile devices, the

electronic housing itself is the fire enclosure—typically a plastic that contains Deca-BDE. This alternatives analysis report serves as a guide for assessing viable alternatives for this application.

2. Scope and Comparison of Alternatives

Although concerned regulatory agencies and guidance (the European Court of Justice (ECJ), EIC, RoHS) all agree alternatives to Deca-BDE exist, all agree that none of the alternatives has gone through a risk assessment as extensive as that for Deca-BDE-- for this substance, more scientific data are available than for any other alternative flame retardant. It is unclear if the negative environmental, health and/or consumer safety impacts caused by substitution are likely to outweigh the environmental, health and/or consumer benefits.

2.1 Identification of Alternatives

Alternatives to Deca-BDE vary by application due to the varied nature of materials used and differing flammability requirements. This assessment focuses specifically on alternatives to Deca-BDE in electronics housings. Most electronic housings for personal computers (PCs) and printers are made out of molded plastic, typically High Impact Polystyrene (HIPS). Other possible polymers or materials include:

- Polyolefins
    - Polypropylene (PP)
    - Polyethylene (PE)
    - Ethylene vinyl acetate (EVA)

- Styrenics
    - High-impact polystyrene (HIPS)
    - Acrylonitrile butadiene styrene (ABS)
    - Polyphenylene oxide – polystyrene (PPO-PS)

- Engineering thermoplastics
    - Polyesters
        - Polybutylene terephthalate (PBT)
        - Polyethylene terephthalate (PET)
    - Polyamides (e.g. nylon)
    - Polycarbonate (PC) and polycarbonate blends, e.g. PC-ABS
    - Polyimides

- Thermosets
    - Unsaturated polyesters
    - Epoxy (electronics, building and aerospace applications)
    - Melamine[13]

- Elastomers
    - Ethylene Propylene Diene Monomer (EPDM) rubber
    - Thermoplastic polyurethanes (TPUs)
    - Ethylene vinyl acetate (EVA)

[13] Note - melamine is not a polymer.

- Waterborne emulsions and coatings – including but not limited to those designed for textile backcoatings such as:
    - Acrylic emulsions
    - Polyvinyl chloride emulsions
    - Ethylene vinyl chloride emulsions
    - Urethane emulsions

Table 2, in section 2.3, is a "best effort" assessment of known alternatives to Deca-DBE. While it attempts to list every known alternative, it may not be comprehensive. Significant effort was applied to identify potential alternatives, but the Table does not exclude the possibility of other alternatives, particularly those that are newly developed and have not been reviewed by government or industry sources. The potential alternatives listed in Table 2 were Deca-BDE taken from three well known sources that represent a cross-section of stakeholders from industry, government, scientific consultancy and academia: 1.) "Flame retardants product selector and regulatory information" published by the group Phosphorus Inorganic & Nitrogen Flame Retardants Association (PINFA)[14], 2.) "An alternatives assessment for the flame retardant decabromodiphenyl ether (Deca-BDE)" U.S. EPA Design for Environment[15] and 3). "Study on Hazardous Substances in Electrical and Electronic Equipment, Not Regulated by the RoHS Directive" Oko Institut.[16]. These three studies are the most comprehensive reviews available of potential alternatives to Deca-BDE and were developed by an industry association, government, and an independent research institution. In summary, 106 possible substances that in principle are alternatives to Deca-BDE were identified.

2.2: Identification of Relevant Comparison Factors

For external computer housings the exposure is expected to be the same regardless of the flame retardant alternative used. Since exposure is assumed to be constant, the public health and environmental risk (a function of exposure and hazard) can be reduced through a reduction in chemical hazard.[17] The hazard profile of each alternative will form the foundation of this alternatives assessment as this is the best way to reduce adverse public health and environmental impacts. It is not anticipated that the choice of alternative will influence the market presence of the product in terms of sales volumes; units shipped or intended use patterns.

End of life considerations are relevant comparison factors due to the potential for halogenated flame retardants to form dioxins during combustion.[18] The high concern for end of life impacts associated with Deca-BDE necessitates the need for careful consideration of end of life impacts of the alternatives. End of life scenarios will be considered to determine the suitability of alternatives in both the first and second stages of the assessment.

Studies are emerging demonstrating exposure to PBDEs during the use phase. Stapleton et al. analyzed hand wipes and determined that exposure to household dust and hand-to-mouth contact is an important exposure

[14] http://www.pinfa.org/component/content/article/8.html (accessed March 9, 2013).
[15] http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/aa-for-deca-full-version.pdf (accessed March 9, 2013).
[16] http://ec.europa.eu/environment/waste/weee/pdf/hazardous_substances_report.pdf (accessed March 9, 2013).
[17] Emma T. Lavoie, Lauren G. Heine, Helen Holder, Mark S. Rossi, Robert E. Lee, II, Emily A. Connor, Melanie A. Vrabel, David M. DiFiore, and Clive L. Davies. Chemical Alternatives Assessment: Enabling Substitution to Safer Chemicals. *Environmental Science & Technology* 2010 44 (24), 9244-9249.
[18] Weber, Kuch, Environmental International, 29 (6), 2003, 699. (Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated–chlorinated dibenzodioxins and dibenzofurans).

route for PBDEs.[19] Wu et al. found a positive correlation between PBDE concentrations in breast milk and household dust supporting the hypothesis that the indoor environment is an important source of exposure to PBDEs.[20] Some alternatives may require higher loading levels, the amount of flame retardant used to achieve the desired flame retardancy, which could increase the potential for exposure during use. In the first stage the relative amounts of the alternative does not affect the hazard profile, so loading level will not be a consideration. In the second stage assessment the loading level will be factor in product function and performance and economic considerations.

Certain flame retardants have the potential to be used in a reacted form that is bound to the polymer that forms the resin. However, in external computer housings it is anticipated that most of the alternatives will be the additive type. Use of a reactive flame retardant could reduce the potential for exposure and will be considered a relevant comparison factor. Other factors including raw material extraction, manufacturing and transportation will be examined using life cycle assessment tools in the second stage assessment but are anticipated to be less important than use and end of life.

2.3 Preliminary Evaluation and Screening of Alternative Replacement Chemicals

In Table 2, the initial list of 106 potential alternatives was narrowed for the reasons shown in gray (see the legend at the end of the Table for further explanation). The deselected alternatives were placed into a "bin" to be given consideration for further work only if other options are not viable. Finally, the materials that were selected for further consideration in this assessment were indicated in green.

Initial screening of the alternatives was based on the hazard profile of the chemical under consideration. For example, 41 brominated and chlorinated flame retardants were "binned" due to concerns about the formation of dioxins resulting from improper disposal. [21]

Hazards data gaps posed a challenge when considering whether a potential alternative should progress to Phase 2. Fortunately, the U.S. EPA Design for Environment Deca-BDE Alternatives project provided complete, relatively recent hazard data for many of the potential alternatives. A potential alternative's inclusion in the EPA report became a primary criterion for its progression to Phase 2. Alternatives not included in the report lacked adequate, reliable, recent hazard information and were binned.

After the binning process, the list of 106 alternatives from Table 2 was reduced to the 20 alternatives shown in Table 3. The 20 alternatives will proceed to the next step in the process, and the remaining alternatives will only be reconsidered if viable options are not identified from the 20 alternatives.

[19] Stapleton, H. M., S. M. Kelly, J. G. Allen, M. D. McClean and T. F. Webster. Measurement of Polybrominated Diphenyl Ethers on Hand Wipes: Estimating Exposure from Hand-to-Mouth Contact. *Environmental Science &Technology* 2008 42, 3329-3334.

[20] Wu, N., T. Herrmann, O. Paepke, J. Tickner, R. Hale, E. Harvey, M. La Guardia, M. D. McClean and T. Webster. Human Exposure to PBDEs: Associations of PBDE Body Burdens with Food Consumption and House Dust Concentrations. *Environmental Science & Technology* 2007 (41) 1584-1589.

[21] Weber, Kuch, Environmental International, 29 (6), 2003, 699. (Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated–chlorinated dibenzodioxins and dibenzofurans).

Table 2. Alternatives Selection

Chemical Name	CAS #	Selection Criteria
Monomeric N-alkoxy hindered amine	191680-81-6	DfE Hazard Table
Polyphosphonate oligomers	68664-06-2	DfE Hazard Table
APP Ammonium Polyphosphate	68333-79-9	DfE Hazard Table, Known Alternative
ATH - Aluminium tri-hydroxide	21645-51-2	DfE Hazard Table, Known Alternative
BDP - Bisphenol-A bis(diphenyl phosphate)	181028-79-5, 5945-33-5	DfE Hazard Table, Known Alternative
Diethylphosphinate, aluminium salt	225789-38-8	DfE Hazard Table, Known Alternative
MDH - Magnesium di-hydroxide	13760-51-5, 1309-42-8	DfE Hazard Table, Known Alternative
Melamine Cyanurate	37640-57-6	DfE Hazard Table, Known Alternative
Melamine Polyphosphate	218768-84-4, 56386-64-2	DfE Hazard Table, Known Alternative
P/N based intumescent systems piperazine pyrophosphate	66034-17-1	DfE Hazard Table, Known Alternative
Polcarbonate-Polyphosphonate copolymer	77226-90-5	DfE Hazard Table, Known Alternative
RDP Resorcinol bis (diphenyl phosphate)	57583-54-7, 125997-21-9	DfE Hazard Table, Known Alternative
TPP - triphenyl phosphate	115-86-6	DfE Hazard Table, Known Alternative
Zinc Borate	138265-88-0, 1332-07-6, 12767-90-7	DfE Hazard Table, Known Alternative
Aluminum housing material		Material Change
Magnesium alloy housing material		Material Change
Added sheet metal fire enclosure		Material Change
High PC content PC/ABS		Material Change
Tris-(2-ethylhexyl) phosphate	78-42-2	Representative--Alkyl Phosphate Group
silicon dioxide	112945-52-5, 7631-86-9	Representative--Filler Group
ZnHS - Zinc Hydroxystannate	12027-96-2	BFR Synergist
ZnS - Zinc Stannate	12036-37-2	BFR Synergist
Antinomy trioxide	1309-64-4	BFR Synergist
APP Ammonium Polyphosphate (coated)	68333-79-9	Duplicate
APP Ammonium Polyphosphate (with synergists)	68333-79-9	Duplicate
Diethylphosphinate, aluminium salt (with synergists)	225789-38-8	Duplicate
Polyphosphonate homopolymer	68664-06-2	Duplicate
Boehmite (Aluminium oxide hydroxide)	1318-23-6	Group--Aluminum tri-hydroxide
DEEP - Diethylethane phosphonate	78-38-6, 150103-83-6	Group--Alkyl Phosphate
Expandable graphite	7782-42-5	Group--Filler
Diphenyl (2-ethylhexyl) phosphate	1241-94-7	Group--Alkyl Phosphate

Chemical Name	CAS #	Selection Criteria
DMMP - Dimethyl methyl phosphonate	756-79-9	Group--Alkyl Phosphate
DMPP - Dimethyl propane phosphonate	242-555-3	Group--Alkyl Phosphate
TEP - Triethyl phosphate	78-40-0	Group--Alkyl Phosphate
TXP - Trixylyl phosphate	68952-33-0	Group--Alkyl Phosphate
Poly(m-phenylene methylphosphonate)	63747-58-0	Group--Alkyl Phosphate
silicon dioxide	14808-60-7	Group--Filler
Melamine	108-78-1	Group--Melamine
Melamine Borate	53587-44-3	Group--Melamine
Melamine Phosphate	41583-09-9	Group--Melamine
Zinc Oxide	1314-13-2	Group--Zinc
Tris(tribromophenoxy) triazine, Tris(tribromophenyl) cyanurate	25713-60-4	Halogenated
Dechlorane plus - Bis (hexachlorocyclopentadieno) cyclooctane	13560-89-9	Halogenated
DBDPE	84852-53-9	Halogenated
HBCDD, Hexabromocyclododecane	25637-99-4, 3194-55-6	Halogenated
Deca-BDE, Decabromodiphenyl ether	1163-19-5	Halogenated
Poly(2,6-dibromo-phenylene oxide)	69882-11-7	Halogenated
Tetra-decabromo-diphenoxy-benzene	58965-66-5	Halogenated
1,2-Bis(2,4,6-tribromo-phenoxy) ethane	37853-59-1	Halogenated
3,5,3',5'-Tetrabromo-bisphenol A (TBBA)	79-94-7	Halogenated
TBBA, unspecified	30496-13-0	Halogenated
TBBA-epichlorhydrin oligomer	40039-93-8	Halogenated
TBBA-TBBA-diglycidyl-ether oligomer	70682-74-5	Halogenated
TBBA carbonate oligomer	28906-13-0	Halogenated
TBBA carbonate oligomer, phenoxy end capped	94334-64-2	Halogenated
TBBA carbonate oligomer, 2,4,6-tribromo-phenol terminated	71342-77-3	Halogenated
TBBA-bisphenol A-phosgene polymer	32844-27-2	Halogenated
Brominated epoxy resin end-capped with tribromophenol	139638-58-7	Halogenated
Brominated epoxy resin end-capped with tribromophenol	135229-48-0	Halogenated
TBBA-(2,3-dibromo-propyl-ether)	21850-44-2	Halogenated
TBBPA glycidyl ether & polymers	68928-70-1	Halogenated
TBBA bis-(2-hydroxy-ethyl-ether)	4162-45-2	Halogenated
TBBA-bis-(allyl-ether)	25327-89-3	Halogenated
TBBA-dimethyl-ether	37853-61-5	Halogenated

Chemical Name	CAS #	Selection Criteria
Tetrabromo-bisphenol S	39635-79-5	Halogenated
TBBS-bis-(2,3-dibromo-propyl-ether)	42757-55-1	Halogenated
2,4-Dibromo-phenol	615-58-7	Halogenated
2,4,6-tribromo-phenol	118-79-6	Halogenated
Pentabromo-phenol	608-71-9	Halogenated
2,4,6-Tribromo-phenyl-allyl-ether	3278-89-5	Halogenated
Tribromo-phenyl-allyl-ether, unspecified	26762-91-4	Halogenated
Bis(methyl)tetrabromo-phtalate	55481-60-2	Halogenated
Bis(2-ethylhexyl)tetrabromo-phtalate	26040-51-7	Halogenated
2-Hydroxy-propyl-2-(2-hydroxy-ethoxy)-ethyl-TBP	20566-35-2	Halogenated
TBPA, glycol-and propylene-oxide esters	75790-69-1	Halogenated
N,N'-Ethylene –bis-(tetrabromo-phthalimide)	32588-76-4	Halogenated
Ethylene-bis(5,6-dibromo-norbornane-2,3-dicarboximide)	52907-07-0	Halogenated
2,3-Dibromo-2-butene-1,4-diol	2/4/3234	Halogenated
Dibromo-neopentyl-glycol	3296-90-0	Halogenated
Dibromo-propanol	96-13-9	Halogenated
Tribromo-neopentyl-alcohol	36483-57-5	Halogenated
Poly tribromo-styrene	57137-10-7	Halogenated
Tribromo-styrene	61368-34-1	Halogenated
RP Red phosphorus	7723-14-0	Incompatible
RP Red phosphorus (concentrates)	7723-14-0	Incompatible
RP Red phosphorus (dispersions)	7723-14-0	Incompatible
EDAP, Ethylenediamine-o-phosphate	14852-17-6	Low production
Cyclic Phosphonate	proprietary	Proprietary
Modified Guanidine Phosphate	proprietary	Proprietary
New phosphonate 1 (new substance)	proprietary	Proprietary
New phosphonate 2 (new substance)	proprietary	Proprietary
other P/N based intumescent system	proprietary	Proprietary
Phosphonic acid, organic salt	proprietary	Proprietary
Phosphorus polyol	proprietary	Proprietary
Hypohosphite, calcium salt	7789-79-9	Unknown Functionality
Hypohosphite, calcium salt (with synergists)	7789-79-9	Unknown Functionality
Hypophosphite, aluminium salt (with synergists)	7784-22-7	Unknown Functionality
Inorganic, mineral based FR synergist	68953-58-2	Unknown Functionality
IPPP - Isopropylated phenol phosphate	68937-41-7	Unknown Functionality

Chemical Name	CAS #	Selection Criteria
Mixtures of esters of phophoric acid	1003300-73-9	Unknown Functionality
Polyphosphoric Acid	8017-16-1	Unknown Functionality
resorcinol bis dixylenyl phosphate	139189-30-3	Unknown Functionality
Potassium 3-(phenylsulfonyl)benzenesulfonate	63316-43-8	Unknown Functionality
2,2'-Oxybis[5,5-dimethyl-1,3,2-dioxaphosphorinane]2,2'disulphide	4090-51-1	UnsuiTable
CDP - Cresyldiphenyl phosphate	26444-49-5	UnsuiTable
DOPO, 9,10-Dihydro-9-oxa-10-phosphaphenanthren-10-oxide	35948-25-5	UnsuiTable
N,N-(bis)-hydroxyethyl-aminomethane phosphonic acid diethyl ester	2781-11-5	UnsuiTable
TCP - Tricresyl phosphate	1330-78-5, 78-30-8	UnsuiTable

Legend

- **Material Change**—A material or design change that accomplishes the desired flame rating without a chemical substitute for Deca-BDE. Example: Using a metal housing instead of plastic.
- **UnsuiTable**—Alternatives that are typically used for other applications or purposes and are not anticipated to be used as replacements for Deca-BDE in electronics housings. Example: CDP is typically used as a plasticizer for PVC and not as a flame retardant for plastic housing materials.
- **Known Alternative**—Alternatives that are known to have been used as flame retardants in plastics. Example: BDP is currently used in some electronics housings.
- **Low Production**—These materials are only available in low production volumes and are therefore not practical alternatives at this time.
- **Proprietary**—The CAS number was not provided for this material therefore a hazard assessment cannot be completed. The hazard assessment is essential to the alternative assessment process so these alternatives were deselected.
- **Incompatible**—Alternatives that are not compatible with the resins of interest. Example: red phosphorus causes corrosion in electronic equipment and is therefore not suiTable for electronics housings.
- **Alkyl Phosphate**—Alternatives that are part of the alkyl phosphate family of chemicals. Rather than assess each alkyl phosphate individually it was determined that the group of alkyl phosphates will be represented by tris-(2-ethylhexyl) phosphate.
- **Halogenated**—Alternatives that contain bromine or chlorine. Other halogens, such as fluorine and iodine, are not in scope. The halogenated alternatives were deselected due to the potential health implications and waste stream pollution from burning plastics containing halogenated flame retardants. The issue is that halogenated flame retardants, when burned, form dioxins which pose significant adverse health and environment problems.[22] Based on hazard alone, with the volume of information on the hazard of these substances, halogenated flame retardants were eliminated from further consideration.
- **BFR Synergist**—A synergistic chemical that is only effective when used in combination with a BFR. Since halogenated flame retardants were deselected there is no reason to evaluate synergists.

[22] Weber, Kuch, Environmental International, 29 (6), 2003, 699. (Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated–chlorinated dibenzodioxins and dibenzofurans).

- **DfE Hazard Table**—Alternatives listed in the report "An alternatives assessment for the flame retardant decabromodiphenyl ether (Deca-BDE)" published by the U.S. EPA.[23] All of these alternatives were selected to progress in the assessment process.
- **Duplicate**—An alternative that has the same CAS number as another chemical in the Table that is being considered.
- **Group**—An alternative that is represented by a similar chemical, such as the alkyl phosphate group, or is similar to another material already being considered. For example, boehmite is expected to have a similar hazard profile to ATH.
- **Representative**—An alternative that is being used as a proxy for other chemicals in the Table. Example: tris-(2-ethylhexyl) phosphate for the alkyl phosphates.

2.4 Consideration of Additional Information

Toward the goal of identifying potential alternatives that are less hazardous than Deca-BDE, each of the remaining 20 potential alternatives was evaluated against hazard endpoints listed in Table 3. Hazard cutoff criteria are provided in the Table and are largely based upon GHS classification. Hazard evaluation relies upon data availability. Some hazard endpoints are divided into both High and Very High classifications. These are noted in the Table. While the screening criteria are based very closely on the GreenScreen® for Safer Chemicals v1.2,[24] the evaluations performed for this assessment do not constitute validated GreenScreen assessments.

The initial screening of alternatives will deselect alternatives that are either more hazardous than the chemical of concern or equally hazardous as the chemical of concern. However, there may be cases where an alternative may be more hazardous in one category and less hazardous in the other category. To address this issue, a decision logic framework is used to deselect chemicals that have a certain combination of hazards:

Alternatives and their transformation products exhibiting the following hazard profiles did not advance to the next step of the alternative assessment process:

f. PBT = High P + High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
g. vPvB = very High P + very High B
h. vPT = very High P + [very High T (Ecotoxicity or Group II Human) or High T (Group I or I* Human)]
i. vBT = very High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
j. High T (Group I Human)

[23] U.S. EPA. An Alternatives Assessment for the Flame Retardant Decabromodiphenyl Ether (Deca-BDE). http://www.epa.gov/dfe/pubs/projects/Deca-BDE/deca_fullreport.pdf (accessed March 27, 2013).
[24] Clean Production Action. The GreenScreen™ for Safer Chemicals v1.2. http://www.cleanproduction.org/Greenscreen.v1-2.php (accessed March 27, 2013).

Table 3: Hazard Evaluation Endpoints and Cutoff Criteria

Hazard endpoint	**Criteria Cutoff**	
Group I Human	High	
Carcinogenicity	GHS Category 1A (Known) or 1B (Presumed)	
Mutagenicity/Genotoxicity	GHS Category 1A (Known) or 1B (Presumed)	
Reproductive Toxicity	GHS Category 1A (Known) or 1B (Presumed)	
Developmental Toxicity	GHS Category 1A (Known) or 1B (Presumed)	
Endocrine Activity	Evidence of endocrine activity	
Group II Human	Very High	High
Acute toxicity	GHS Category 1 or 2	GHS Category 3
Systemic Toxicity/Organ Effects and Neurotoxicity; single exposure	GHS Category 1	GHS Category 2
Systemic Toxicity/Organ Effects and Neurotoxicity; repeated exposure*		GHS Category 1
Skin Sensitization*		GHS Category 1A
Respiratory Sensitization*		GSH Category 1A
Skin Irritation	GHS Category 1 (Corrosive)	GHS Category 2 (Irritant)
Eye Irritation	GHS Category 1 (Irreversible)	GHS Category 2A (Irritating)
Ecotoxicity		
Acute Aquatic Toxicity	GHS Category 1	GHS Category 2
Chronic Aquatic Toxicity	NOEC < 1.0 mg/L	NOEC < 1.0 mg/L
Fate	Very High	High
Persistence (P)	Days: Soil: $t_{1/2}$>180 Water: $t_{1/2}$>60 Air: $t_{1/2}$>50	Days Soil: 60 < $t_{1/2}$ < 180 Water: 40 < $t_{1/2}$ < 60 Air: 2 < $t_{1/2}$ < 5
Bioaccumulation (B)	BAF/BCF > 5000; Log K_{ow} > 5.0	1000 < BAF/BCF < 5000 4.5 < Log K_{ow} < 5.0
Reactivity	Equally or less reactive than chemical of concern	
Flammability	Equally or less flammable than chemical of concern	

Designates a Group II hazard endpoint—generally hazard endpoints that are dependent upon multiple exposures.

Using the decision logic from above as criteria the alternatives BDP, and Zinc Borate were deselected for advancement to the second stage assessment. The 18 remaining alternatives shown in Table 3 will be assessed in the second stage assessment for the final alternatives assessment report.

Chemical (for relevant trade names see the synonym section of the individual profiles in Section 4.8)	CASRN	Human Health Effects											Aquatic Toxicity		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Organic Phosphorus or Nitrogen Flame Retardants (PFRs or NFRs) Alternatives																
Discrete PFR, NFR and P/NFR Alternatives																
Substituted Amine Phosphate Mixture [1]	Confidential	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*M*	*M*[§]	*M*[§]	*VH*	*M*	*L*	*H*	*L*
Triphenyl Phosphate	115-86-6	L	*M*	L	L	L	L	M	L		L	VL	VH	VH	L	M
Polymeric PFR and NFR Alternatives																
Bisphenol A bis-(diphenyl phosphate), BAPP	181028-79-5	L	*L*	L	*L*	*L*[§]	L	L	L		L	L	L	L	H	*H*[◊]
Melamine Cyanurate [1]	37640-57-6	*L*	*M*	*M*	*M*[§]	*M*[§]	*L*	H	*L*		*L*	*L*	*L*	*L*	VH	*L*
Melamine Polyphosphate [1]	15541-60-3	L	*M*	*M*	*L*[§]	*L*	*L*[§]	*M*	L		L	VL	L	L	*H*	*L*
N-alkoxy Hindered Amine Reaction Products	191680-81-6	L	*M*	L	*H*	*H*	*L*	*H*	L		L	VL	*H*	*H*	H	*H*[‡]
Phosphonate Oligomer	68664-06-2	L	*M*	*L*[§]	*L*[¥]	*L*[¥]	*M*[‡]	*L*[§¥]	*L*[§¥]		*M*[¥‡]	*M*[‡]	L[¥]	*H*[‡]	*VH*	*H*[‡]
Polyphosphonate	68664-06-2	L	*L*	*L*	*L*	*L*	*L*	*M*[d]	*L*		*L*	*L*	*L*	*L*	*VH*	*L*
Poly[phosphonate-co-carbonate]	77226-90-5	L	*L*	*L*	*L*	*L*	*L*	*M*[d]	*L*		*L*	*L*	*L*	*L*	*VH*	*L*
Resorcinol bis-diphenylphosphate	125997-21-9	L	*M*[§]	L	L	VL	*M*[§]	M	*L*		L	VL	VH	*H*[‡]	M	*H*[‡]

[1] Hazard designations are based upon the component of the salt with the highest hazard designation, including the corresponding free acid or base.

Figure 4. Hazard Tables for several alternatives from U.S. EPA alternatives assessment for the flame retardant decabromodiphenyl ether (Deca-BDE).[25]

Chemical (for relevant trade names see the synonym section of the individual profiles in Section 4.8)	CASRN	Human Health Effects											Aquatic Toxicity		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Inorganic Flame Retardant Alternatives																
Aluminum Diethylphosphinate	225789-38-8	L	*L*	L	*L*	*M*	*M*	L	L		L	VL	M	M	*H*[R]	*L*
Aluminum Hydroxide	21645-51-2	L	*L*	L	*L*	L	M	L	L		VL	VL	*M*	*M*	*H*[R]	*L*
Ammonium Polyphosphate	68333-79-9	L	*L*	*L*	*L*	*L*	*L*	*M*[d]	L		VL	L	*L*	*L*	*VH*	*L*
Antimony Trioxide [1]	1309-64-4	L	L*	L	*L*	*L*	*L*	M*	L		L	M	M	M	*H*[R]	*L*
Magnesium Hydroxide	1309-42-8	L	L	L	*L*	*L*	*L*	L	*L*		M	*M*	*L*	*L*	*H*[R]	*L*
Red Phosphorus	7723-14-0	VH	*L*	*M*	*L*	*L*	*L*	*L*	L		M	H	L	L	H	*L*
Zinc Borate	1332-07-6	L	*L*	*H*	*M*	*M*	*H*	*L*	L		L	L	*H*	*H*	H[R]	*L*

[1] This compound is included in the ongoing EPA Work Plan evaluation for Antimony and Compounds

Figure 5. Hazard Tables for several alternatives from U.S. EPA alternatives assessment for the flame retardant decabromodiphenyl ether (Deca-BDE).[26]

[25] U.S. EPA. An Alternatives Assessment for the Flame Retardant Decabromodiphenyl Ether (Deca-BDE). http://www.epa.gov/dfe/pubs/projects/Deca-BDE/deca_fullreport.pdf (accessed March 27, 2013).

[26] U.S. EPA. An Alternatives Assessment for the Flame Retardant Decabromodiphenyl Ether (Deca-BDE). http://www.epa.gov/dfe/pubs/projects/Deca-BDE/deca_fullreport.pdf (accessed March 27, 2013).

3. Selected Alternative(s)

The list of alternatives identified in Table 4 below will be advanced to the second stage of the alternative assessment. Comments and guidance on the list of alternatives from the department will be incorporated into the second stage analysis. The focus of the second stage analysis will be on the prevention of unintended consequences or burden shifting negative impacts from one environmental or human health concern to another. The analysis will consist of multimedia life cycle assessments, product function and performance assessments and economic impact assessments. A first pass assessment of the impact in each of these three areas will be performed to eliminate unacceptable alternatives and identify areas where a deeper assessment is needed. A second iteration of the impact in these three areas will follow, if necessary.

Table 4. Alternatives for Second Stage Assessment

Chemical Name	CAS #	Hazard Table
Monomeric N-alkoxy hindered amine	191680-81-6	*DfE Deca-BDE*
Polyphosphonate oligomers	68664-06-2	*DfE Deca-BDE*
APP Ammonium Polyphosphate	68333-79-9	*DfE Deca-BDE*
ATH - Aluminium tri-hydroxide	21645-51-2	*DfE Deca-BDE*
Diethylphosphinate, aluminium salt	225789-38-8	*DfE Deca-BDE*
MDH - Magnesium di-hydroxide	13760-51-5, 1309-42-8	*DfE Deca-BDE*
Melamine Cyanurate	37640-57-6	*DfE Deca-BDE*
Melamine Polyphosphate	218768-84-4, 56386-64-2	*DfE Deca-BDE*
P/N based intumescent systems piperazine pyrophosphate	66034-17-1	*DfE Deca-BDE*
Polcarbonate-Polyphosphonate copolymer	77226-90-5	*DfE Deca-BDE*
RDP Resorcinol bis (diphenyl phosphate)	57583-54-7, 125997-21-9	*DfE Deca-BDE*
TPP - triphenyl phosphate	115-86-6	*DfE Deca-BDE*
Aluminum housing material		
Magnesium alloy housing material		
Added sheet metal fire enclosure		
High PC content PC/ABS		
Tris-(2-ethylhexyl) phosphate	78-42-2	
silicon dioxide	112945-52-5, 7631-86-9	DfE PCB

Table 5: Alternatives to Deca-BDE in Electronic Enclosures Summary Table

	Raw Materials		Manufacture			Transportation[27]	Use		End-of-Life	
Material	**Raw Materials Extraction**	**Resource Inputs and Other Resource Consumption**	**Intermediate Materials Processes**	**Manufacture**	**Waste Generation and Management**	**Packaging Transportation and Distribution**	**Use**	**Operation and Maintenance[28]**	**Reuse and Recycling**	**End-of-Life Disposal**
Deca-BDE	L[29]		$H_{B, C, E}$	L	M	L	$M_{B, D}$	L	$H_{A, B, C, D, E, F}$	$H_{A, B, C, D, F}$
Monomeric N-alkoxy hindered amine	$M_{A,B,D, E, F}$		H_B	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Polyphosphonate oligomers	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
APP Ammonium Polyphosphate	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
ATH - Aluminium tri-hydroxide	$H_{A,B,D, E, F}$		$H_{B, C, E}$	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Diethylphosphinate, aluminium salt	$H_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
MDH - Magnesium di-hydroxide	$H_{A,B,D, E, F}$		$H_{B, C, E}$	M_X	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Melamine Cyanurate	$M_{A,B,D, E, F}$		H_B	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Melamine Polyphosphate	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
P/N based intumescent systems piperazine pyrophosphate	$M_{A,B,D, E, F}$		H_F	L	M	L	$M_{B, D}$	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Polcarbonate-Polyphosphonate copolymer	$M_{A,B,D, E, F}$		H_B	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
RDP Resorcinol bis (diphenyl phosphate)	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
TPP - triphenyl phosphate	$M_{A,B,D, E, F}$		H_F	L	M	L	L_D	L	$M_{A, B, C, D, E, F}$	$M_{A, B, C, D, F}$
Aluminum housing material	$H_{A,B,D, E, F}$		$H_{B, C, E}$	H_X	L	L	L_D	L	L_X	L

[27] The material density differences are not expected to significantly change the weight of the finished housing, therefore the transportation impact is expected to be the same for all of the alternatives.

[28] Operation and maintenance is expected to be similar for all alternatives.

[29] Brominated flame retardant raw materials are relatively more easily extracted using mining process that have lower impact than other mining techniques.

	Raw Materials		Manufacture			Transportation[27]	Use		End-of-Life	
Material	**Raw Materials Extraction**	**Resource Inputs and Other Resource Consumption**	**Intermediate Materials Processes**	**Manufacture**	**Waste Generation and Management**	**Packaging Transportation and Distribution**	**Use**	**Operation and Maintenance[28]**	**Reuse and Recycling**	**End-of-Life Disposal**
Magnesium alloy housing material	$H_{A,B,D,\ E,\ F}$		$H_{B,\ C,\ E}$	H_X	*L*	*L*	L_D	*L*	**L_X**	*L*
Added sheet metal fire enclosure	$H_{A,B,D,\ E,\ F}$		$H_{B,\ C,\ E}$	H_X	*L*	*L*	L_D	*L*	**L_X**	*L*
High PC content PC/ABS	$M_{A,B,D,\ E,\ F}$		H_B	*L*	*M*	*L*	L_D	*L*	$M_{A,\ B,\ C,\ D,\ E,\ F}$	$M_{A,\ B,\ C,\ D,\ F}$
Tris-(2-ethylhexyl) phosphate	$M_{A,B,D,\ E,\ F}$		H_F	*L*	*M*	*L*	L_D	*L*	$M_{A,\ B,\ C,\ D,\ E,\ F}$	$M_{A,\ B,\ C,\ D,\ F}$
silicon dioxide	$M_{A,B,D,\ E,\ F}$		H_B	M_X	*M*	*L*	L_D	*L*	$M_{A,\ B,\ C,\ D,\ E,\ F}$	$M_{A,\ B,\ C,\ D,\ F}$

Legend:

Relevant Factor

Non-Relevant Factor

Unknown

Bold font indicates empirical data

Italic font indicates lower confidence estimate based professional judgment.

A Adverse Environmental Impacts

B Adverse Public Health Impact

C Adverse Waste and End-of-Life Effects

D Environmental Fate

E Materials and Resource Consumption Impacts

F Physical Chemical Hazards

G Physicochemical Properties

X Energy-Alternative may result in higher energy consumption. Depending on the energy source there may be impacts in areas A through F.

4. Final Alternatives Assessment Work Plan and Proposed Implementation Schedule

Second Stage

1. Multimedia Life Cycle Assessment

Completion: 20 weeks after approval of Phase 1 AA

The multimedia life cycle assessment will be performed using existing literature sources. Where life cycle assessment is lacking, data for proxy chemicals may be used as a substitute. SimaPro LCA software will also be used to generate life cycle data as needed. In order to evaluate the alternatives on the SimaPro software, an alternative may need to be broken down into its precursor or constituent chemicals. Using the life cycle information an assessment will be completed identifying potential areas of burden shifting. Alternatives with significant burden shifting will be eliminate from further consideration.

Milestones:
Step 1: Literature search for life cycle data and information.
Step 2: SimaPro LCA Software evaluation.
Step 3: Eliminate potential alternatives associated with significant burden shifting.

Output:
Potential alternatives associated with significant burden shifting after evaluation using the life cycle thinking module will be removed from further consideration.

2. Product Function & Performance

Completion: 29 weeks after approval of Phase 1 AA

Product function and performance will be evaluated by identifying the key performance parameters of an existing housing material and determining the range of acceptable values for those parameters. The focus of the product function and performance evaluation will be on preventing burden shifting in the form of decreased safety. The alternatives must provide the same level of safety as Deca-BDE flame retarded materials. Alternatives that do not meet the same level of safety will be removed from further consideration.

Milestones:
Step 1: Identify key performance parameters.
Step 2: Evaluate the alternatives against the key performance parameters.
Step 3: Eliminate potential alternatives that do not meet the same level of safety as Deca-BDE.

Output:
Potential alternatives will be identified that are expected to meet safety and performance standards.

3. Economic Impact

Completion: 29 weeks after approval of Phase 1 AA

It is anticipated that one or more of the alternatives will be selected for substitution of the chemicals of concern; therefore, the economic impacts are expected to be positive from a burden shifting perspective.

Because the alternatives are inherently less hazardous the indirect cost impacts, such as waste management, are expected to be cost neutral or lower cost. The direct costs will be more difficult to evaluate because they are considered confidential business information, will depend on volumes and are likely to change over time. Promoting a list of multiple alternatives will allow the market to determine the most economically viable alternative. The multiple alternatives approach also leaves suppliers the freedom to choose an alternative based on multiple criteria rather than just the cheapest option. To help identify areas of economic impact the economic impact assessment checklist shown in Appendix B will be completed for each alternative.

Milestones:
Step 1: Complete economic impact assessment checklist.
Step 2: Identify potential externalities.
Step 3: Eliminate potential alternatives that result in significant burden shifting.

Output:
Potential alternatives associated with significant burden shifting will be removed from further consideration.

STAGE 2 ALTERNATIVES ANALYSIS

Specific guidance for all future assessment should follow the CA DTSC alternatives analysis guide: http://www.dtsc.ca.gov/scp/

Stage 2 of the alternatives assessment per CA SCP regulations in this report include the following components:

- Evaluation of Other Relevant Factors Not Addressed in Stage 1. Specific considerations include:
    - adverse impacts and multimedia life cycle impacts;
    - product function and performance; and
    - economic impacts.
- Compare the Priority Product to Alternatives. Specific considerations include:
    - performance of alternatives with respect to all relevant factors included in the assessment (e.g., hazard, consideration of exposure pathways, multimedia life cycle impacts, performance, economic feasibility).
- Additional Considerations
- Alternative Selection Decision

5. Evaluation of Other Relevant Factors Not Addressed in Stage 1

To determine the relevant factors for comparison of the alternatives a review of available Life Cycle Assessment (LCA) resources was undertaken. LCA was chosen because of the wide range of endpoints assessed to evaluate the ultimate environmental impact in a comprehensive manner. LCA evaluates environmental impact of the complex system of extraction, manufacturing, use and end-of-life which can identify the hot-spots or areas where the environmental impact is greatest. For instance, the environmental impact of electricity use is strongly related to energy sources, such as coal, and LCA can inform the impact of burning coal based on electricity usage. For simplicity LCA results are typically aggregated to a one-dimensional index, such as energy, based on weighting indices that convert midpoints like eutrophication potential into units of energy[30]. The result of this process is that LCA is strongly energy and emission focused. Midpoints such as chemical toxicity can be undervalued, but LCA provides a contrasting perspective to the hazard evaluation in Stage 1. The midpoints addressed by LCA correspond to the adverse environmental impact areas described in the Safer Consumer Products regulation, see appendix 1 for details. Since the hazard evaluation eliminated alternatives with environmental or human health hazards in Stage 1, understanding the LCA of the remaining alternatives can provide a different perspective and help identify burden shifting.

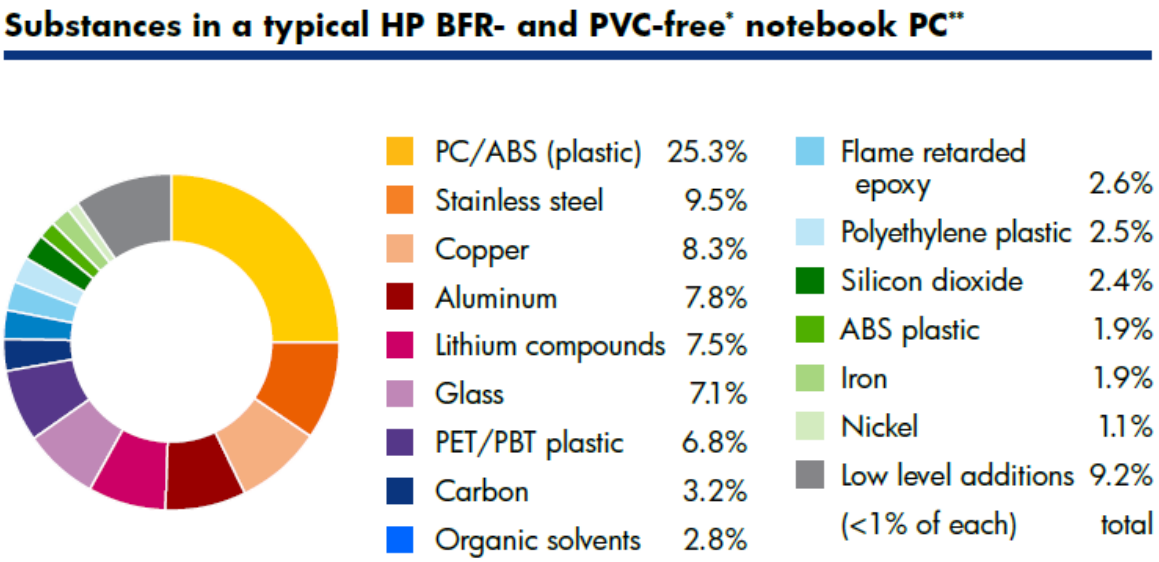

Figure 6: Content Model of a Typical Notebook PC[31].

The figure above shows that a typical notebook contains 25.3% PC/ABS plastic which translates to 0.5kg of PC/ABS in a typical 2kg notebook. The amount of flame retardant in this plastic, known as the loading level, will vary depending on the alternative chosen and is an important factor in calculating the life cycle impact that can be attributed to each alternative. An important reason for the popularity of brominated flame retardants are the low loading levels required to meet flame standards compared with the mineral type solutions. The loading level is an important factor in determining the flame retardant's contribution to the overall notebook life cycle impact. Table 1 below shows several flame retardants and the typical loading levels found in the literature.

[30] Baumann, Henrikke and Anne-Marie Tillman. 2004. The hitch hiker's guide to LCA: An orientation in life cycle assessment methodology and application. Lund, Sweden: Studentlitteratur AB.

[31] Hewlett-Packard Global Citizenship Report 2010. http://www.hp.com/hpinfo/globalcitizenship/pdf/hp_fy10_gcr.pdf

Table 5. Typical Loading Levels of Flame Retardants

Type of Flame Retardant	Loading Range[32] (wt %)	Typical Loading in Polycarbonates[33] (wt %)
Bromine-based	2 to 25%	10%
Aluminum Hydroxide	13 to 60%	
Magnesium Hydroxide	53 to 60%	
Chlorophosphates	9 to 10%	
Organophosphorus	5 to 30%	15%

The life cycle inventory for Deca-BDE was not available, however an article by Hu et al compares the energy and emission requirements of 9,10-Dihydro-9-oxa-10-phosphaphenanthrene 10-oxide (DOPO) and tetrabromobisphenol-A (TBBPA) which are suiTable proxies[34]. DOPO is representative of the organophosphorus alternatives and TBBPA is representative Deca-BDE. The study determined that TBBPA requires between 29,900 and 39,200 MJ/tonne of primary energy and has between 1,900 and 2400 CO2e/tonne emissions. DOPO requires 30,700 to 38,600 MJ/tonne of primary energy to manufacture, and the total emissions of CO2 are between 2,400 and 2880 kg CO2e/tonne. To simplify the calculations the average values of 34550 MJ/tonne and 2150 CO2e/tonne will be used for TBBPA and 34650 MJ/tonne and 2640 CO2e/tonne will be used for DOPO. Values for the other alternatives were obatained from Ecoinvent. In most cases the life cycle inventory for the exact alternative was not available so a suiTable proxy was chosen and is shown in Table 2. Details of the calculations and values used to generate the results in Table 2 are available in the appendix.

[32] Weil, E. D. and S. V. Levchik (2009). Flame Retardants for Plastics and Textiles: Practical Applications, Hanser.

[33] Weil, E. D. and S. V. Levchik (2006). Flame Retardants in Commercial Use or in Advanced Development in Polycarbonates and Polycarbonate Blends. Journal of Fire Sciences. Vol. 24 March.

[34] Hu, Z., M. R. Overcash and M. J. Realff. "Process based Greenhouse gas inventory of representative flame," Electronics Goes Green 2012+ (EGG), 2012 , vol., no., pp.1,5, 9-12 Sept. 2012

Table 6. Energy and Emission Results

Alternative	Representative Material	Primary Energy for 0.5kg (MJ)	Emissions for 0.5kg (kg CO_2)
Deca-BDE (Baseline)	PC/ABS + TBBPA (10% Loading)	46.3	2.57
Monomeric N-alkoxy hindered amine	PC/ABS + Melamine (60% Loading)	47.9	2.62
Polyphosphonate oligomers	PC/ABS + DOPO (15% Loading)	44.7	2.52
APP Ammonium Polyphosphate	PC/ABS + DOPO (15% Loading)	44.7	2.52
ATH - Aluminium tri-hydroxide	PC/ABS + Aluminum (60% Loading)	57.9	4.76
Diethylphosphinate, aluminium salt	PC/ABS + DOPO (15% Loading)	44.7	2.52
MDH - Magnesium di-hydroxide	PC/ABS + Magnesium (60% Loading)	48.8	23.2
Melamine Cyanurate	PC/ABS + Melamine (60% Loading)	47.9	2.62
Melamine Polyphosphate	PC/ABS + Melamine (60% Loading)	47.9	2.62
P/N based intumescent systems piperazine pyrophosphate	PC/ABS + Melamine (60% Loading)	47.9	2.62
Polcarbonate-Polyphosphonate copolymer	PC/ABS + DOPO (15% Loading)	44.7	2.52
RDP Resorcinol bis (diphenyl phosphate)	PC/ABS + DOPO (15% Loading)	44.7	2.52
TPP - triphenyl phosphate	PC/ABS + DOPO (15% Loading)	44.7	2.52
Aluminum housing material	Aluminum	63.5	6.1
Magnesium alloy housing material	Magnesium	48.3	36.9
Added sheet metal fire enclosure	Steel		
High PC content PC/ABS	Polycarbonate	57.5	3.35
Tris-(2-ethylhexyl) phosphate	DOPO (15% Loading)	44.7	2.52
silicon dioxide	Silicon Dioxide (60% Loading)	19.9	1.1

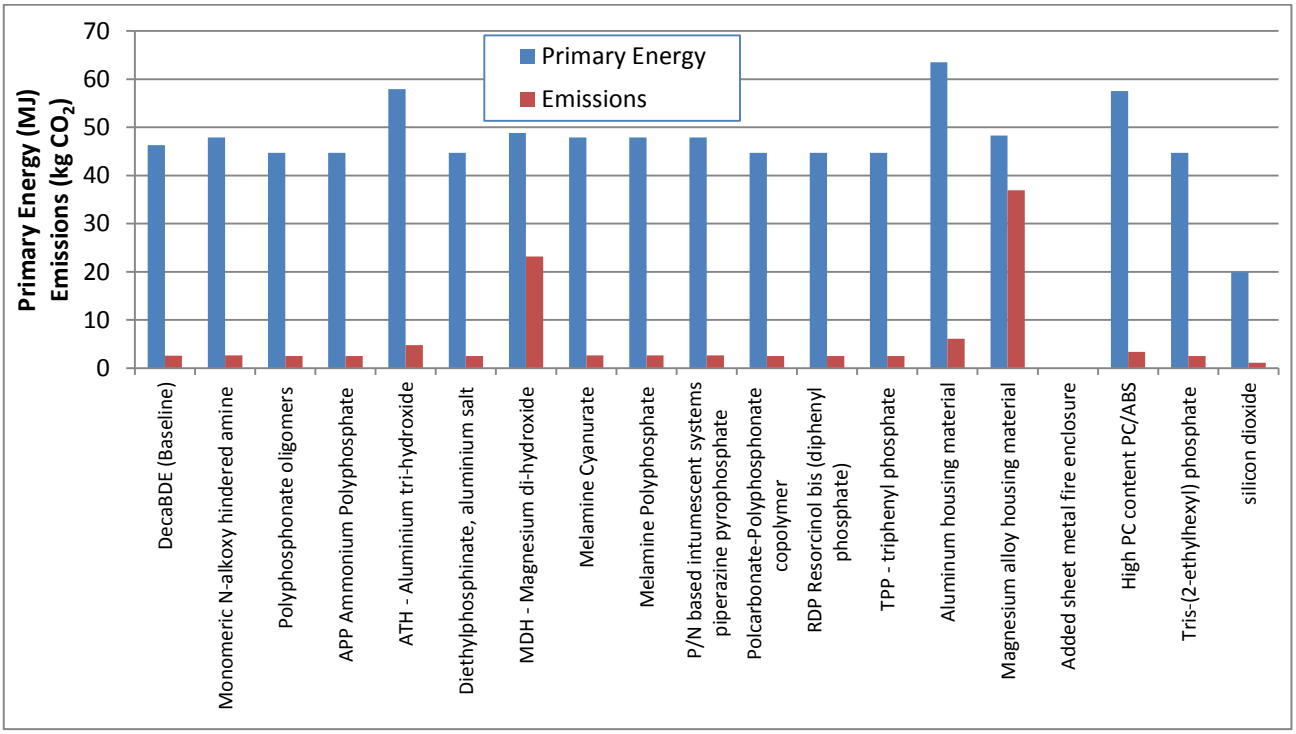

Figure 7: Energy and Emission Results.

LCA results for a complete notebook computer can provide perspective to the values obtained for the alternatives. The principle study chosen for comparison was *LCA of an Ecolabeled Notebook* prepared by GreenDeltaTC for Belgium's Federal Public Planning Service Sustainable Development.[35] The study examined the life cycle impacts of a notebook supplied by AsusTek using standard LCA procedures and guidelines. This study was chosen to inform this report because the product, a notebook computer, is representative of the products that are the subject of the department notice. Also, the study was conducted on behalf of a government agency rather than a manufacturer eliminating potential bias. The LCA was performed based on the ISO 14040 and ISO 14044 standards (p. 15).

The AsusTek notebook LCA used normalization to identify environmental hot spots in the life cycle. Through normalization the results of the impact assessment are related to a total environmental load of a region (p. 109). The normalized results are shown in figure 3. The results show that the relevant impacts are in climate change (human health and ecosystems), human toxicity, particulate matter formation and fossil depletion, with a minor contribution from metal depletion. Furthermore, the environmental impacts are dominated by the production phase with a much smaller secondary contribution from the use phase.

[35] Ciroth, Andreas and Franze, Juliane. LCA of an Ecolabeled Notebook: Consideration of Social and Environmental Impacts Along the Entire Life Cycle. Berlin 2011.

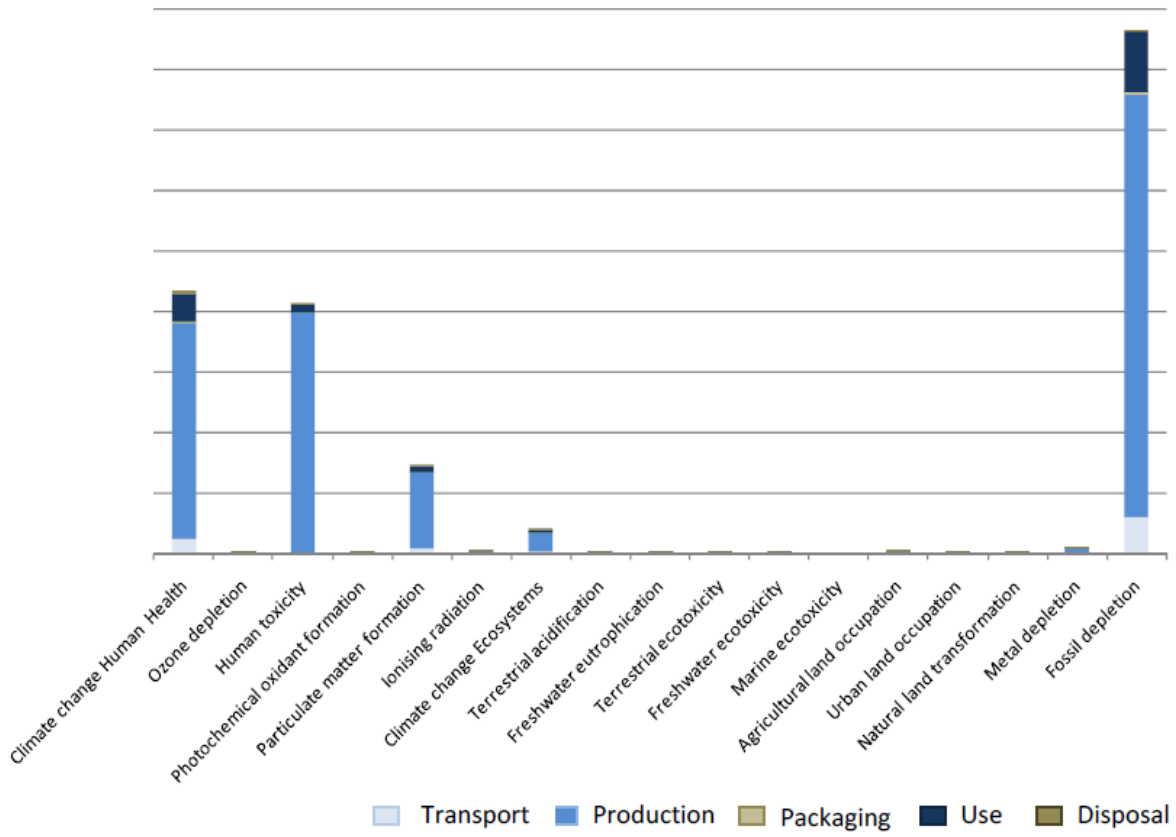

Figure 8: AsusTek Notebook LCA Normalized Midpoint Assessment

The results of AsusTek LCA are consistent with LCAs performed elsewhere although some studies conclude that the use phase has the greatest impact. Yao et al of Intel Corporation summarized the findings of commonly cited LCAs on electronic products.[36] They found between 1997 and 2010 the majority of published studies determined that the use phase contributes most to the life cycle energy demand with a handful of studies suggesting the manufacturing phase has the largest impact. Similarly, Andrae and Anderson conclude that recycling and other end-of-life processes have a tiny share of the total impact of electronic products.[37] The Yao et al article presented total energy impact of three hybrid LCA studies of desktop computers as 5600, 7300 and 6400 MJ and total fossil fuels as 240, 290 and 260 kg CO2. An LCA performed by Deng et al reported total energy use of a Dell laptop as 4790 to 6120 MJ and emissions of 386 to 429 kg CO_2[38]. For the purposes of this study the Deng et al article most closely matches the laptop model used in this review, "mainstream, high volume product used by individual in the U.S. residential sector." The lower values of 4790 MJ and 386 kg CO_2 were chosen for this comparison to provide the most conservative comparison.

It is useful to compare the most extreme alternatives to Deca-BDE. Switching to an aluminum or magnesium housing material requires more energy and produces more emissions than Deca-BDE. Silicon Dioxide, on the other hand, results in much lower emissions and energy requirements. For energy, the most extreme case is

[36] Yao, Marissa A., Higgs, Tim G., Cullen, Michael J., Stewart, Scott and Brady, Todd A. Comparative Assessment of Life Cycle Assessment Methods Used for Personal Computers. Environmental Science and Technology (44) 2010. 7335-7346.
[37] Andrae, Anders S. G. and Andersen, Otto. Life Cycle Assessments of Consumer Electronics-Are They Consistent? International Journal of Life Cycle Assessment (15) 2010. 827-836.
[38] Deng, L., C. W. Babbitt, E. D. Williams. Economic-balance hybrid LCA extended with uncertainty analysis: case study of a laptop computer. Journal of Cleaner Production 19 (2011) 1198-1206.

using an aluminum housing (63.5 MJ) compared to Deca-BDE (46.3 MJ), a difference of 17.2 MJ. This difference is 0.36% of the primary energy of a notebook computer identified by Deng et al. Using silicon dioxide results in a decrease of 26.4 MJ or 0.55% of the total energy of the notebook. For emissions silicon dioxide results in a decrease in emissions of 1.47 kg CO2 or 0.38% of total emissions. Switching to a magnesium housing provides the most extreme increase of 36.9 kg CO2 which is 8.9% of the total emissions of the notebook.

Energy and emissions associated with magnesium are highly dependent on the process and raw materials used to refine the metal. Emission values range from 73,700 kgCO2/tonne from the Ecoinvent database down to 42,000 kgCO2/tonne for the China Pidgeon process to a low of 9,100 kg/CO2/tonne for the Gossan-Zuliani process,[39] resulting in emissions for a notebook computer ranging from 36.9 to 4.6 as shown in figure 4 below. The lowest value associated with the Gossan-Zuliani process is on par with the emissions associated with most of the other alternative flame retardants. The uncertainty of the emission values makes it difficult to select one alternative over another based on emission calculations.

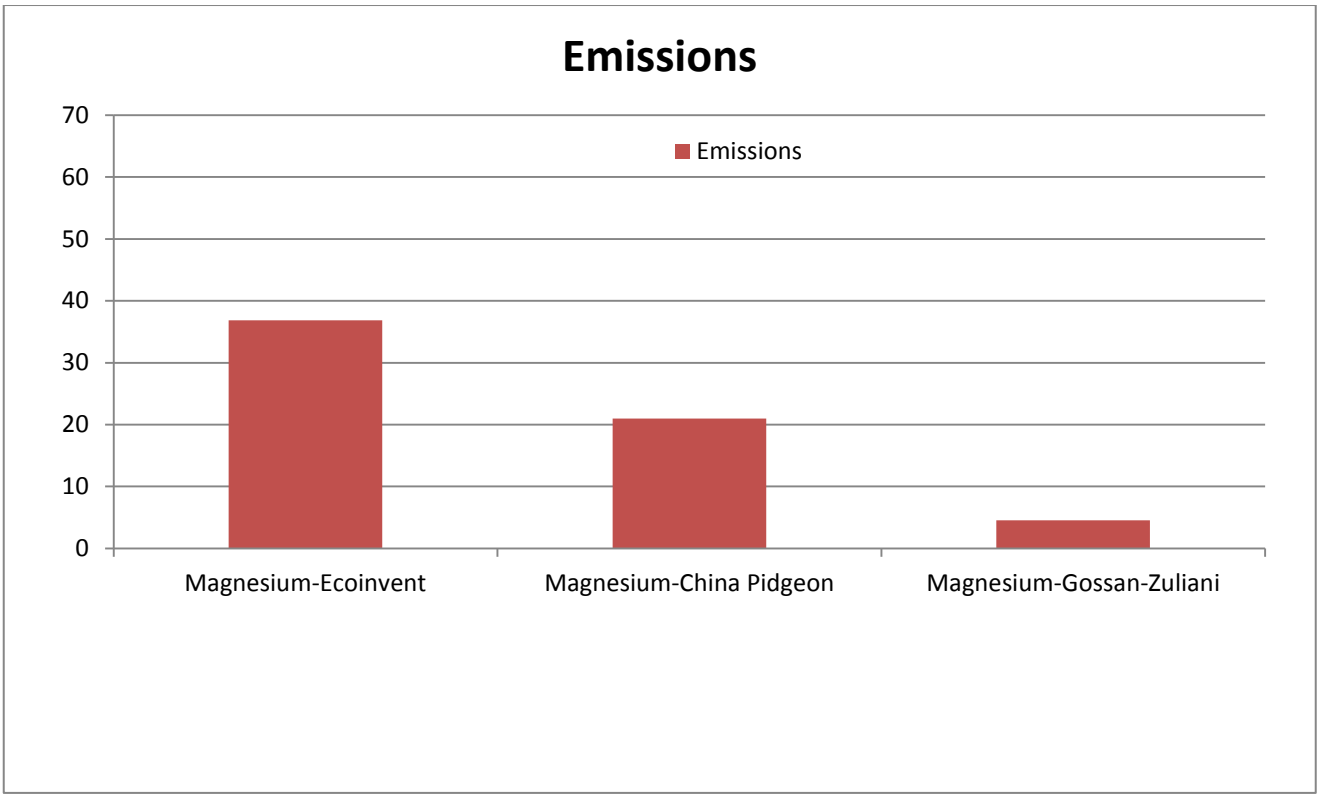

Figure 9: Magnesium CO2 Emissions by Extraction Process.

The contribution of the choice of flame retardant is an extremely small part of the overall energy and emission profile of a laptop computer. The uncertainty associated with life cycle inventory data, due to measurement error and significantly different manufacturing processes, makes it difficult to definitively show a difference between the alternatives. Nevertheless, selecting some alternatives may lead to a small increase in energy and emissions but this insignificant compared to benefits of lower toxicity. As highlighted above a magnesium housing may result in an increase in CO2 emissions but magnesium offers a much improved hazard profile compared to Deca-BDE. Furthermore, the impacts can be mitigated to some degree by selecting manufacturing

[39] Process Research Ortech, Inc. Lowering of CO2 Emission for Magnesium Production by Gossan-Zuliani Process. http://www.gossan.ca/projects/pdf/MgGHGReport.pdf (accessed June 13, 2013).

processes that minimize energy use and emissions. In conclusion no significant burden shifting was identified by LCA for any of the alternatives.

The recyclability of low-halogen alternatives compared to BFRs such as Deca-BDE has been discussed in the literature. Imai et al. found that plastics containing BFRs performed much better than their low-halogen counterparts in both mechanical properties and flame retardancy after multiple recycling cycles.[40] However, the negative environmental impacts associated with BFRs have led plastics recyclers to avoid introducing plastics containing BFRs into their recycling streams. Plastics recyclers tend to avoid and/or test incoming e-waste because of the high proportion of bromine they contain. For this reason plastic from e-waste is mostly used for the low-value markets and is almost never used to build new electronics parts.[41] For the purposes of this report it was assumed that the recyclability of the alternative is not a significant factor because of the limited recycling of e-waste to new electronics housings. It is unlikely that plastics used in electronics housings would be reused for electronics housings but rather lower grade products.

[40] Imai, Takaretu, Stephan Hamm and Klaus P. Rothenbacher. Comparison of the Recyclability of Flame-Retarded Plastics. Environmental Science and Technology (37) 2003. 652-656.

[41] Schut, Jan H. Recycling E-Plastics New Material Brings Its Own Set of Problems. Plastics Technology. August 2007.

6. Product Function and Performance

The useful life of an electronic housing is anticipated to be greater than the useful life of the computer. None of the alternative flame retardants or alternative materials are expected to decrease the useful life of the electronics housing. To determine the function and performance of potential alternatives Finite Element Analysis was used to compare alternatives. Key material properties were obtained from datasheets for resins containing the flame retardant alternatives being analyzed as well as two of metal alternatives that do not require added flame retardants. An example of some of the key resin properties are shown in Table 7.

Table 7. Key Material Properties

	Mold shrinkage (1/1000), 3.2mm	Flexural Modulus (Mpa)	Notched Izod Impact (J/m)	Melt Flow Rate (g/10min)
PC/ABS + Brominated FR[42]		2675.9	656.3	9.4 (260C/2.16kg)
PC/ABS + Phosphorus FR[43]	4-6	2620	550	21.5 (260C/2.16kg)
Polcarbonate-Polyphosphonate copolymer[44]		2800	500	

The resin properties were entered into the Ansys Finite Element Analysis software. The example housing chosen for this simulation was a printer housing. This particular part can be exposed to large forces if the user attempts to move the printer by lifting on the scan fixture. For this simulation a force of 211N was applied to each side of the unit while fixed at the points of attachment to the printer. An example of the output is shown in figure 5 below. The red areas indicate the areas with the highest deflection. The maximum deflection ranged from 0.036 to 0.903 mm, all within an acceptable range given the requirements for this product. The professional judgment of the engineer performing this analysis was that the small differences in resin properties would not be detrimental to the electronics housing design. Finite element analysis was not performed on all of the alternatives because the material properties were not available, however it is anticipated that all of the alternatives would perform acceptably in this simulation.

[42] Great Lakes Solutions a Chemtura Business, Emerald Innovation 1000 datasheet
[43] SABIC Innovative Plastics Cycoloy C6600 datasheet
[44] FRX Polymers Nofia CO3000 datasheet

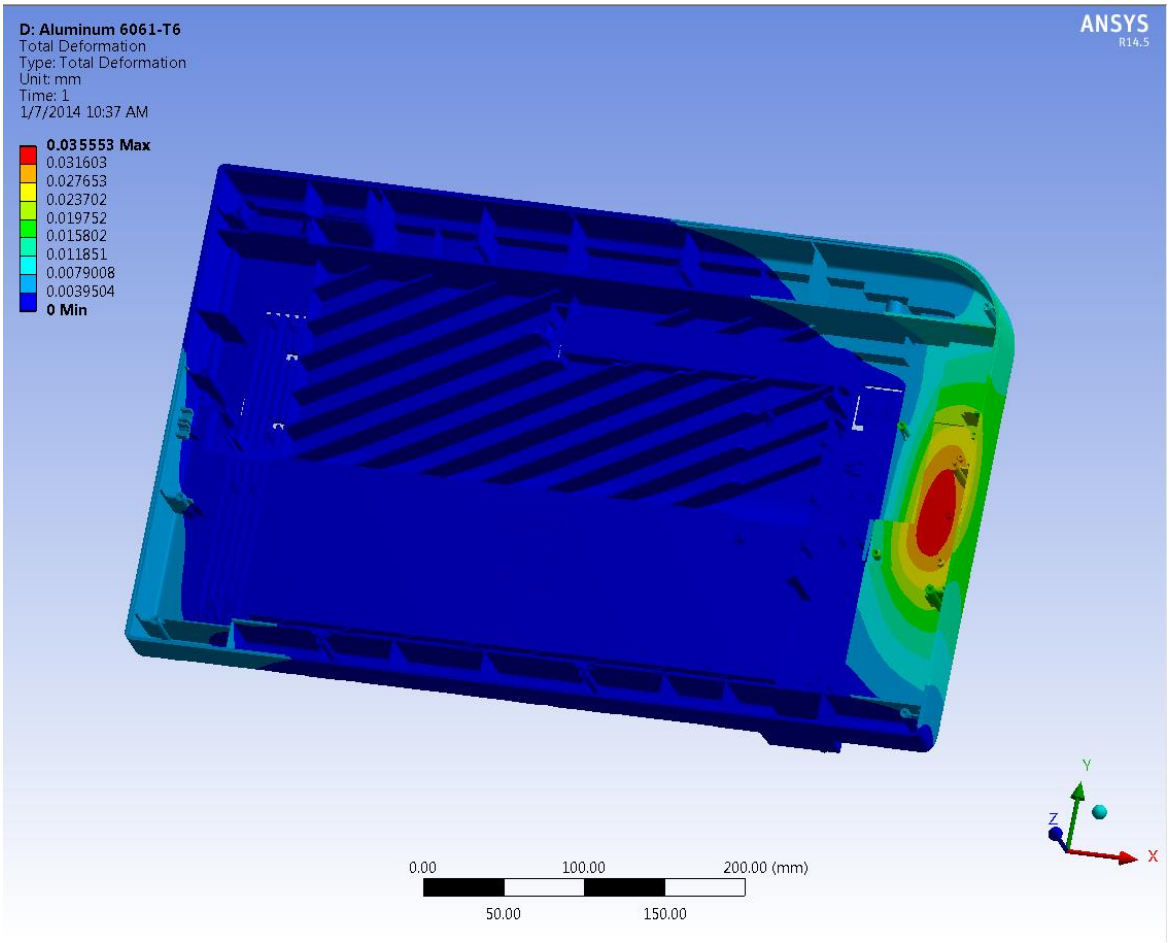

Figure 10: Aluminum Housing Finite Element Analysis

The Finite Element Analysis provides basic information on the viability of alternative materials. Ultimately, the adequacy of the final housing material will be determined through experimentation with prototypes, which is beyond the scope of this report. For the purposes of this report it is assumed that functionally acceptable housings can be manufactured with any of the alternatives.

7. Economic Impacts

The economic feasibility of the alternatives is difficult to evaluate because the direct costs are considered confidential business information, will depend on volumes, and are likely to change over time. Promoting a list of multiple alternatives will allow the market to determine the most economically viable alternative. The multiple alternatives approach also leaves suppliers the freedom to choose an alternative based on multiple criteria rather than just the cheapest option. Although the costs are not known, it is anticipated that all of the alternatives will be more expensive than Deca-BDE, at least initially.

In 2006, the Washington State Department of Ecology (Ecology) evaluated the potential costs of a statewide ban on the use of Deca-BDE in electronics enclosures compared with associated human health benefits. The analysis calculated an initial benefit of $80 per person to a ban on Deca-BDE in electronics enclosures. This figure was based on avoided health impacts and does not take into account health impacts that may be caused

by a replacement for Deca-BDE. However, Ecology found that efforts to finalize the analysis were hindered by three factors:

1. Limited information on health effects, exposures and conditions,
2. Differences in sensitivity to Deca-BDE exposures and business responses to changing regulatory requirements, and
3. Emerging information on toxicity, exposure, and economic issues.

Ecology reported: "Given these limitations, it is important to recognize that there is a high degree of uncertainty surrounding estimated expenditures and health benefits and those estimates are highly sensitive to assumptions on future economic conditions, exposure, and health risks. Ecology believes that these sources of uncertainty and variability complicate the interpretation and use of the study results."[45] Ecology's analysis did not include calculating the benefit to the environment of a ban on Deca-BDE in electronic equipment.

In order to calculate the economic impact on human health or the environment for any of the alternatives being considered, it would be necessary to understand the human health and environmental impacts of each of the alternatives and the exposure resulting from use in electronic equipment. Economic values would be placed on each impact, for example, the cost of liver cancer for an individual for one year. This unit cost would then be multiplied by the number of individuals impacted, that is, the number exposed. As with the analysis by Ecology, data gaps make this difficult to estimate in absolute terms. However, impacts are possible to estimate in relative terms and the result of this assessment is shown in Table 8.

Routes of exposure will remain unchanged whether Deca-BDE or another alternative is utilized in electronics housings. Relative economic impacts can therefore be estimated based on hazard. Less hazardous alternatives with the same exposure routes will result in lower economic impact. All potential alternatives either as hazardous or more hazardous than Deca-BDE have been screened from consideration. As the remaining alternatives are less hazardous than Deca-BDE, we predict that overall economic impact will be less.

We do not anticipate any change in the handling of electronics enclosures at end of life due to a change in flame retardants. Theoretically, resin manufacturers incorporating some percent of recycled content may adjust the volume of flame retardant added based on the volume of flame retardant already present in the recycled content. In practice, however, this does not happen. As a result, we do not anticipate a cost impact due to recycling or end of life practices.

[45] Washington State Department of Ecology and Washington State Department of Health, "Washington State Polybrominated Diphenyl Ether (PBDE) Chemical Action Plan: Final Plan" January 19, 2006, p. 73.

Table 8: Estimated Economic Impact of Potential Alternatives Relative to Deca-BDE

Alternative	CAS #	Increased (+) or Decreased (-) Cost Relative to Deca-BDE		
		Public Health	Environment	Gov't Agencies & Non-Profits*
Monomeric N-alkoxy hindered amine	191680-81-6	-	-	-
Polyphosphonate oligomers	68664-06-2	-	-	-
APP Ammonium Polyphosphate	68333-79-9	-	-	-
ATH - Aluminium tri-hydroxide	21645-51-2	-	-	-
BDP - Bisphenol-A bis(diphenyl phosphate)	181028-79-5, 5945-33-5	-	-	-
Diethylphosphinate, aluminium salt	225789-38-8	-	-	-
MDH - Magnesium di-hydroxide	13760-51-5, 1309-42-8	-	-	-
Melamine Cyanurate	37640-57-6	-	-	-
Melamine Polyphosphate	218768-84-4, 56386-64-2	-	-	-
P/N based intumescent systems piperazine pyrophosphate	66034-17-1	-	-	-
Polcarbonate-Polyphosphonate copolymer	77226-90-5	-	-	-
RDP Resorcinol bis (diphenyl phosphate)	57583-54-7, 125997-21-9	-	-	-
TPP - triphenyl phosphate	115-86-6	-	-	-
Zinc Borate	138265-88-0, 1332-07-6, 12767-90-7	-	-	-
Aluminum housing material		-	-	-
Magnesium alloy housing material		-	-	-
Added sheet metal fire enclosure		-	-	-
High PC content PC/ABS		-	-	-
Tris-(2-ethylhexyl) phosphate	78-42-2	-	-	-
Silicon dioxide	112945-52-5, 7631-86-9	-	-	-

* Governmental agencies and non-profit organizations that manage waste, oversee environmental cleanup and restoration efforts, and/or are charged with protecting natural resources, water quality, and wildlife.

8. Final Comparison of Priority Product and Alternatives

Eighteen alternatives were included the Stage 2 assessment as the GreenScreen® hazard assessment did not reveal high-level hazards to support exclusion. Life cycle impacts, economic impacts and performance were considered in this Stage 2 assessment.

While available data for magnesium alternatives showed an increase in energy use and emissions, these impacts were not large enough to warrant excluding these alternatives, especially given the substantially reduced hazard profile of magnesium alternative compared to Deca-BDE. Regarding the performance assessment, it is assumed that functionally acceptable housings can be manufactured with any of the alternatives. Despite a lack of quantitative data available for the economic assessment, a qualitative review of the socio-economic cost categories for each alternative compared to Deca-BDE did not reveal notably higher costs.

While the additional factors of life cycle impacts, costs and performance will certainly inform decision making, no alternative demonstrated significant impacts or limitations – all eighteen alternatives are deemed feasible candidates for future prototype development and testing.

9. Alternatives Selection Decision

No single alternative was determined "best" in this alternatives analysis. The 18 alternatives shown in Table 9 neither revealed high-level hazards nor life cycle or economic impacts of significant concern to warrant exclusion. It was determined that functionally acceptable housings can be manufactured with any of the alternatives.

Promoting a list of multiple alternatives will enable component manufacturers of computer housings for our assembled products to have a range of options for selecting the most economically viable alternative in a specific application. Such a list also better supports the performance evaluation of alternatives to Deca-BDE in computer housings under real-world production processes for component manufacturers, which cannot be directly controlled by suppliers such as Hewlett Packard.

Table 9: Final Menu of Alternatives

Chemical Name	CAS #
Monomeric N-alkoxy hindered amine	191680-81-6
Polyphosphonate oligomers	68664-06-2
APP Ammonium Polyphosphate	68333-79-9
ATH - Aluminium tri-hydroxide	21645-51-2
Diethylphosphinate, aluminium salt	225789-38-8
MDH - Magnesium di-hydroxide	13760-51-5, 1309-42-8
Melamine Cyanurate	37640-57-6
Melamine Polyphosphate	218768-84-4, 56386-64-2
P/N based intumescent systems piperazine pyrophosphate	66034-17-1
Polcarbonate-Polyphosphonate copolymer	77226-90-5
RDP Resorcinol bis (diphenyl phosphate)	57583-54-7, 125997-21-9
TPP - triphenyl phosphate	115-86-6
Aluminum housing material	
Magnesium alloy housing material	
Added sheet metal fire enclosure	
High PC content PC/ABS	
Tris-(2-ethylhexyl) phosphate	78-42-2
Silicon dioxide	112945-52-5, 7631-86-9

SUMMARY OF RESULTS AND LESSONS LEARNED FROM THIS DEMONSTRATION PROJECT

Summary of Results

This demonstration project pilot tested the alternatives analysis requirements outlined under the draft California SCP regulations. The project focused on Deca-BDE in external computer housings – a chemical of concern already restricted in commerce by the European Union's Restriction of Hazardous Substance Directive (RoHS). Publicly available data were used for this assessment to focus on testing the alternatives analysis process elements outlined in the SCP draft regulations.

Over 100 potential alternatives were originally included into the analysis. At the end of Stage 2 assessment having assessed human and environmental health impacts across high-impact lifecycle segments for these chemicals, and having considered performance and economic impacts, eighteen alternatives were identified as safer and feasible. Identifying a menu of alternatives will allow component manufacturers for this assembled product to have a range of options for selecting the most economically viable alternative based on the particular characteristics of their production process and facility.

Lessons Learned

1. Time tables under the regulation are workable, but it may be difficult for DTSC to adhere to its review timelines. The draft SCP regulations outline specific timelines and deadlines for the alternatives analysis requirements. For example, if an enterprise is required to conduct an alternatives analysis, the draft regulations stipulate that a completed Stage 1 assessment is required to be submitted to DTSC within 180 days. DTSC has then 60 days to review the submitted report. Once reviewed and DTSC approves an applicant to begin conducting a Stage 2 assessment, a final report to DTSC is due within 365 days of such date. One key question pursued in this demonstration project was whether these timeTables prescribed in the draft SCP regulations were feasible. In this project, both Stage 1 and Stage 2 reports were submitted to a mock DTSC review panel well before the various deadlines. However, the mock DTSC review panel took much longer than their 60 days to review the Stage 1 report. This demonstration project found that for chemicals of concern where there are known alternatives (as was the case of this project) the SCP regulatory timelines for the analysis of alternatives are easily achievable for affected enterprises. However, even under such circumstances, it may be difficult for DTSC to meet the review deadlines for each application.

2. Alternatives analyses benefit from stakeholder collaborations. By working through the BizNGO alternatives assessment working group, this demonstration project mimicked the workings of a consortium. The benefits of this experience underscored the importance of encouraging affected enterprises to work through a consortium, for at least the technical portion of the assessment.

In practice, each enterprise will be responsible for submitting its own final assessment to DTSC. However, experience conducting alternatives analyses has revealed that the most useful, most well conducted assessments are those completed under the auspices of stakeholder collaboration. Conducting the technical portions of an alternatives analysis requires multiple areas of expertise: toxicology, ecology, engineering, economics to name just a few. The process is data intensive and also requires decisions to be made at multiple points during the assessment. Thus, establishing a consortium (for example under the auspices of a trade or professional association) can create a useful collaborative mechanism in which entities that share the same problem and questions can leverage expertise, data and differing perspectives.

3. The requirement of "relevant factors" and the process for consideration and evaluation is unclear and problematic. The draft SCP regulations state that only "relevant factors" are to be analyzed in the alternatives analysis. The draft regulations include a four-part test for determining if a factor is relevant. A factor is relevant if: (1) there is an exposure pathway in (2) a particular life cycle segment; if the factor (3) makes a material contribution to one or more adverse impact areas; and (4) there is a material difference in the factor's impact between alternatives. During this project, the question emerged as to whether the draft SCP regulations required entities to consider every possible impact factor across each life cycle segment. To help better define this question, we produced a Table that identified over 80 possible human and environmental health impact factors and 12 lifecycle segments that are required for consideration in the Stage 1 assessment. It quickly became evident that is was simply impossible to assess each impact factor and each life cycle segment for each of the 130 alternatives.

There was a significant amount of delay in this project to determine a more feasible method for determining relevant factors. Rather than recreating methods to identify sentinel impact factors out of the list of 80, we opted to adopt U.S. EPA Design for Environment's (DfE) findings that informed their hazard assessment methods, and which was also incorporated into the GreenScreen® hazard assessment methodology. U.S. EPA DfE and the GreenScreen®, identified 18 sentinel human and environmental health impacts factors. We used these impact factors and applied life cycle thinking and professional judgment across the 12 lifecycle stages to determine the list of relevant factors. However, it remains unclear whether DTSC will consider this process "sufficient" in practice for determining relevant factors.

A summary matrix of the relevant factors is also required, and much work went into developing the colorful, data-rich matrix that concludes the Stage 1 Assessment, "Table 5: Alternatives to Deca-BDE in Electronic Enclosures, Summary Table." While this matrix is an attempt to display the necessary information and reasoning for determining relevant factors for the analysis, again, it remains unclear whether it would be reviewed by DTSC as having sufficiently substantiated the rationale for these decisions.

4. Consider the importance of a menu of final alternatives rather than a single option. From the perspective of companies such as Hewlett Packard, it is important that results of an alternatives assessment identify a range of viable alternatives to offer the supply chain, rather than a single alternative. This is especially true of alternatives for chemicals of concern in assembled products. Contract component manufacturers often need to test the performance of alternatives in their real-world circumstances and these manufacturing and production line process are often unknown to companies further up the supply chain that are required to comply with the CA SCP regulations.

5. The "externalized" economic assessment requirements are deeply problematic: methodological and data gaps abound. The final component of the Stage 2 assessment is the consideration of economic impacts. The draft SCP regulations require a comparison of both internalized costs and externalized costs. Internalized costs include those most familiar to and feasible for business financial accountants such as quantifying manufacturing costs, marketing costs, capital expenditures and resource consumption costs. The externalized costs include both public health and environmental costs as well as costs to governmental agencies and NGOs that manage waste, oversee environmental clean-up and restoration efforts, and/or are charged with protecting natural resources, water quality, and wildlife.

For externalized costs, neither data nor socioeconomic assessment methodologies were available. We tried several strategies, including examining county-level data for areas with e-waste treatment facilities. However, there was simply insufficient data available to adequately quantify economic impacts. A report commissioned by the Washington Department of Ecology on the human and environmental health costs of Deca-BDE and conducted by economists noted similar methodological and data complications, "There is a high degree of

uncertainty surrounding estimated expenditures and health benefits and those estimates are highly sensitive to assumptions on future economic conditions, exposures and health risks." Rather than pursuing a quantitative economic assessment, our approach focused on using professional judgment to qualitatively assess the cost impact of the alternatives compared to Deca-BDE.

While externalized cost analyses are required for all assessments, is it necessary for future DTSC guidance documents make clear the types of methods that should be used for externalized cost assessments and the available economic data sources. Although requiring socio-economic analyses will ultimately force identifying solutions to current methodological and data challenges, there will likely be extreme growing pains during the early years of conducting economic assessments as part of the SCP alternatives assessment requirements.

Conclusion

CA SCP regulations address the critical need to reduce toxic chemicals in consumer products – chemicals that are responsible for known human health and environmental harms. The requirements to conduct an alternatives analysis is crucial for assuring that chemicals of concern are replaced with safer alternatives that are not likely to be later regretted. This demonstration project highlighted several lessons learned – what worked and what was particularly challenging. We hope these lessons will inform implementation of the SCP regulations. The BizNGO Alternatives Assessment Work Group looks forward to working with multiple sectors as they begin the process of assessing their options for safer, feasible substitutes.

Appendix 1: Energy and Emission Calculations

The energy and emission values used in the calculations for this report were obtained from literature sources and the Ecoinvent database, shown in Table A-1. For simplicity it was assumed that the base polymer used consisted of equal parts polycarbonate and ABS. Where available typical loading values were used, when a range was given the highest loading level was used to provide the most conservative estimates. For alternative materials that do not use the PC/ABS matrix, such as an aluminum housing, the energy and emissions of 0.5kg was calculated by multiplying the in Table A-1 by 0.0005 (tonnes). Calculations for alternatives in a PC/ABS matrix accounted for the contribution of PC and ABS as shown in figure A-1.

Table A-1. Energy and Emission Values Used in Calculations

	Primary Energy	**Emissions**
	MJ/tonne	**kgCO_2/tonne**
TBBPA	34550	2150
DOPO	34650	2640
Aluminum	127000	12200
Magnesium	96500	73700
Silicon Dioxide	301	21
Melamine	93600	5070
ABS Plastic	83000	4250
PC Plastic	115000	6700

0.5kg PC/ABS with 10% TBBPA	**Energy** (MJ/tonne)		
45% ABS	83000	x 0.0005 * 45%=	18.675
45% PC	115000	x 0.0005 * 45%=	25.875
10% TBBPA	34550	x 0.0005 * 10%=	1.7275
		Total Energy (MJ)	**46.2775**

Figure A-1. Example Energy Calculation of PC/ABS Blend

Appendix 2: Correlation of LCA Midpoints with Adverse Impact Factors

The environmental impact midpoints used in *LCA of an Ecolabeled Notebook* are typical of LCA studies.[46] The environmental impacts were calculated using the "ReCiPe (H)" life cycle inventory assessment method algorithm, one of the most recent methods and the method recommended by LCA experts (p. 47). The algorithms used by the LCA studies in this report used midpoints consistent with the ReCiPe midpoints as well. The LCA midpoints address the adverse impact factors identified by the Safer Consumer Products regulation. The following Table shows the correlation of adverse impact factors with the LCA midpoints:

Human Health and Environmental Concerns	**LCA (ReCiPe) Midpoint**	**Safer Consumer Products Adverse Impact Factor**
	Climate Change Human Health	Adverse Public Health Impacts
	Ionizing Radiation	Adverse Public Health Impacts
(A) Carcinogenicity	Human Toxicity	Adverse Public Health Impacts
(B) Developmental Toxicity	Human Toxicity	Adverse Public Health Impacts
(C) Reproductive Toxicity	Human Toxicity	Adverse Public Health Impacts
(D) Cardiovascular Toxicity	Human Toxicity	Adverse Public Health Impacts
(E) Dermatotoxicity	Human Toxicity	Adverse Public Health Impacts
(F) Endocrine Toxicity	Human Toxicity	Adverse Public Health Impacts
(G) Epigenetic Toxicity	Human Toxicity	Adverse Public Health Impacts
(H) Genotoxicity	Human Toxicity	Adverse Public Health Impacts
(I) Hematotoxicity	Human Toxicity	Adverse Public Health Impacts
(J) Hepatotoxicity	Human Toxicity	Adverse Public Health Impacts
(K) Digestive System Toxicity	Human Toxicity	Adverse Public Health Impacts
(L) Immunotoxicity	Human Toxicity	Adverse Public Health Impacts
(M) Musculoskeletal Toxicity	Human Toxicity	Adverse Public Health Impacts
(N) Nephrotoxicity and Other Toxicity to the Urinary System	Human Toxicity	Adverse Public Health Impacts
(O) Neurodevelopmental Toxicity	Human Toxicity	Adverse Public Health Impacts

[46] Ciroth, Andreas and Franze, Juliane. LCA of an Ecolabeled Notebook: Consideration of Social and Environmental Impacts Along the Entire Life Cycle. Berlin 2011.

Emissions of CA Toxic Air Contaminants# including: Benzene, Ethylene Dibromide (1,2-dibromoethane), Ethylene Dichloride (1,2-dichloroethane), Hexavalent chromium, Asbestos, Dibenzo-p-dioxins and Dibenzofurans chlorinated in the 2,3,7 and 8 positions and containing 4,5,6 or 7 chlorine atoms, Cadmium (metallic cadmium and cadmium compounds), Carbon Tetrachloride(tetrachloromethane), Ethylene Oxide (1,2-epoxyethane), Methylene Chloride (Dichloromethane), Trichloroethylene (Trichloroethene), Chloroform, Vinyl chloride (Chloroethylene), Inorganic Arsenic, Nickel (metallic nickel and inorganic nickel compounds), Perchloroethylene (Tetrachloroethylene), Formaldehyde, 1,3-Butadiene, Inorganic Lead, Particulate Emissions from Diesel-Fueled Engines	Human Toxicity	Adverse Environmental Impacts
Emissions of GHGs, including: Carbon dioxide, Hydrofluorocarbons, Methane, Nitrogen trifluoride, Nitrous oxide, Perfluorocarbons, Sulfur hexafluoride, or Gases that exhibit the global warming potential hazard trait, as specified in section 69405.4;	Climate Change Ecosystems	Adverse Environmental Impacts
Emissions of nitrogen oxides;	Terrestrial Acidification	Adverse Environmental Impacts
Emissions of particulate matter that exhibits the particle size or fiber dimension hazard trait, as specified in section 69405.7;	Particulate Matter Formation	Adverse Environmental Impacts
Emissions of chemical substances that exhibit the stratospheric ozone depletion potential hazard trait, as specified in section 69405.8;	Ozone Depletion	Adverse Environmental Impacts
Emissions of sulfur oxides; or	Terrestrial Acidification	Adverse Environmental Impacts
Emissions of tropospheric ozone-forming compounds, including compounds that exhibit the ambient ozone formation hazard trait, as specified in section 69405.1.	Photochemical Oxidant Formation	Adverse Environmental Impacts
(B) Adverse ecological impacts;	Freshwater Ecotoxicity	Adverse Environmental Impacts
Acute or chronic toxicity;	Marine Ecotoxicity	Adverse Environmental Impacts
Changes in population size, reductions in biodiversity, or changes in ecological communities; and	Marine Ecotoxicity	Adverse Environmental Impacts
The ability of an endangered or threatened species to survive or reproduce;	Marine Ecotoxicity	Adverse Environmental Impacts
Deterioration or loss of environmentally sensitive habitats;	Terrestrial Ecotoxicity	Adverse Environmental Impacts
Impacts that contribute to or cause vegetation contamination or damage; and	Terrestrial Ecotoxicity	Adverse Environmental Impacts

Adverse impacts on environments that have been designated as impaired by a California State or federal regulatory agency;	Terrestrial Ecotoxicity	Adverse Environmental Impacts
Biological or chemical contamination of soils; or	Terrestrial Ecotoxicity	Adverse Environmental Impacts
Domesticated Animal Toxicity	Freshwater Ecotoxicity	Adverse Environmental Impacts
Eutrophication	Freshwater/Marine Eutrophication	Adverse Environmental Impacts
Loss of Genetic Diversity, Including Biodiversity	Agricultural Land Occupation	Adverse Environmental Impacts
Phytotoxicity	Terrestrial Ecotoxicity	Adverse Environmental Impacts
Wildlife Developmental Impairment	Freshwater Ecotoxicity	Adverse Environmental Impacts
Wildlife Growth Impairment	Freshwater Ecotoxicity	Adverse Environmental Impacts
Wildlife Reproductive Impairment	Freshwater Ecotoxicity	Adverse Environmental Impacts
Wildlife Survival Impairment	Freshwater Ecotoxicity	Adverse Environmental Impacts
Soil Compaction or other structural changes	Terrestrial Ecotoxicity	Adverse Environmental Impacts
Soil Erosion	Natural Land Transformation	Adverse Environmental Impacts
Soil Loss of organic matter	Natural Land Transformation	Adverse Environmental Impacts
Soil sealing	Natural Land Transformation	Adverse Environmental Impacts
Increase in biological oxygen demand;	Freshwater Eutrophication	Adverse Environmental Impacts
Increase in chemical oxygen demand;	Freshwater Eutrophication	Adverse Environmental Impacts
Increase in temperature;	Freshwater Eutrophication	Adverse Environmental Impacts
Increase in total dissolved solids; or	Freshwater Eutrophication	Adverse Environmental Impacts
Introduction of, or increase in, any of the following:	Freshwater Ecotoxicity	Adverse Environmental Impacts
1. CWA 303(c) pollutants# for CA including:	Freshwater Ecotoxicity	Adverse Environmental Impacts

chromium III, cyanide, antimony, thallium, asbestos, acrolein, acrylonitrile, carbon tetrachloride, chlorobenzene, 1,2-dichloroethane, 1,1-dichloroethylene, 1,3-dichloropropylene, ethylbenzene, 1,1,2,2-tetrachloroethane, tetrachloroethylene, 1,1,2-trichloroethane, trichloroethylene, vinyl chloride, 2,4-dichlorophenol, 2-methyl-4,6-dinitrophenol, 2,4-dinitrophenol, benzidine, bis(2-chloroethyl)ether, bis(2-ethylhexyl)phthalate, 3,3-dichlorobenzidine, diethyl phthalate, dimethyl phthalate, di-n-butyl phthalate, 2,4-dinitrotoluene, 1,2-diphenylhydrazine, hexachlorobutadiene, hexachlorocyclopentadiene, hexachloroethane, isophorone, nitrobenzene, n-nitrosodimethylamine, n-nitrosodiphenylamine.	Freshwater Ecotoxicity	Adverse Environmental Impacts
2. CWA 303(d) pollutants# for CA including:	Freshwater Ecotoxicity	Adverse Environmental Impacts
Arsenic, Cadmium, Chromium VI, Copper, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Zinc, Boron and Chloride salts, PCBs.	Freshwater Ecotoxicity	Adverse Environmental Impacts
3. Safe Drinking Water Act pollutants with MCLs including:#	Freshwater Ecotoxicity	Adverse Environmental Impacts
Antimony, Arsenic, Asbestos, Barium, Beryllium, Cadmium, Chromium, Copper, free Cyanide, Fluoride, Lead, Mercury (inorganic), Nitrate (measured as Nitrogen), Nitrite (measured as Nitrogen), Selenium, Thallium, Acrylamide, Benzene, Benzo(a)pyrene (PAHs), Carbofuran, Carbon tetrachloride, Chlorobenzene, o-Dichlorobenzene, p-Dichlorobenzene, 1,2-Dichloroethane, 1,1-Dichloroethylene, cis-1,2-Dichloroethylene, trans-1,2-Dichloroethylene, Dichloromethane, 1,2-Dichloropropane, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthalate, Dioxin (2,3,7,8-TCDD), Epichlorohydrin, Ethylbenzene, Ethylene dibromide, Polychlorinated biphenyls (PCBs), Styrene, Tetrachloroethylene, Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, Trichloroethylene, Vinyl chloride, Xylenes	Freshwater Ecotoxicity	Adverse Environmental Impacts
4. CA HSC 116455 with Notification Levels including:#	Freshwater Ecotoxicity	Adverse Environmental Impacts

Boron, n-Butylbenzene, sec-Butylbenzene, tert-Butylbenzene, Carbon disulfide, Chlorate, 2-Chlorotoluene, 4-Chlorotoluene, Dichlorodifluoromethane (Freon 12), 1,4-Dioxane, Ethylene glycol, Formaldehyde, HMX, Isopropylbenzene, Manganese, Methyl isobutyl ketone (MIBK), Naphthalene, N-Nitrosodiethylamine (NDEA), N-Nitrosodimethylamine (NDMA), N-Nitrosodi-n-propylamine (NDPA), n-Propylbenzene, RDX, Tertiary butyl alcohol (TBA), 1,2,3-Trichloropropane (1,2,3-TCP), 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, 2,4,6-Trinitrotoluene (TNT), Vanadium	Freshwater Ecotoxicity	Adverse Environmental Impacts
5. CA Safe Drinking Water Act with public health goals# including:	Freshwater Ecotoxicity	Adverse Environmental Impacts
1,1-Dichloroethane, 1,1-Dichloroethylene, 1,1,1-Trichloroethane, 1,2-Dibromo-3-chloropropane, 1,2-Dichloroethane, 1,2-Dichloroethylene, cis, 1,2-Dichloroethylene, trans, 1,2-Dichloropropane, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,2,3-Trichloropropane, 1,2,4-Trichlorobenzene, 1,2-Dichlorobenzene, 1,4-Dichlorobenzene, 2,4-Dichlorophenoxyacetic acid, Aluminum, Antimony, Arsenic, Asbestos, Barium, Benzene, Benzo[a]pyrene, Beryllium, Bromate, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorite, Chlorobenzene, Hexavalent Chromium, Copper, Cyanide, Dichloromethane, Diethylhexyl adipate, Diethylhexylphthalate (DEHP), Ethylbenzene, Ethylene dibromide, Fluoride, Gross Alpha or Beta Particle Activity, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury (inorganic), Methyl tertiary butyl ether (MTBE), N-Nitrosodimethylamine, Nickel, Nitrate, Nitrate and Nitrite, Nitrite, Perchlorate, Polychlorinated Biphenyls (PCBs), Radium-226, Radium-228, Selenium, Strontium-90, Styrene, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), Tetrachloroethylene, Thallium, Toluene, Trichloroethylene, Trichlorofluoromethane (Freon 11), Trichlorotrifluoroethane (Freon 113), Tritium, Uranium, Vinyl Chloride, Xylene	Freshwater Ecotoxicity	Adverse Environmental Impacts
(E) Exceedance of an enforceable California or federal regulatory standard relating to the protection of the environment.	Freshwater Ecotoxicity	Adverse Environmental Impacts
Impairment of Waste Management Organisms	Natural Land Transformation	Adverse Waste and End-of-Life Effects
(A) Aerobic and anaerobic half-lives;	Terrestrial Ecotoxicity	Environmental Fate
(B) Aqueous hydrolysis half-life;	Marine Ecotoxicity	Environmental Fate

(C) Atmospheric oxidation rate;	Terrestrial Ecotoxicity	Environmental Fate
(D) Bioaccumulation;	Terrestrial Ecotoxicity	Environmental Fate
(E) Biodegradation;	Terrestrial Ecotoxicity	Environmental Fate
(F) Mobility in environmental media, as specified in section 69405.6;	Terrestrial Ecotoxicity	Environmental Fate
(G) Persistence; and	Terrestrial Ecotoxicity	Environmental Fate
(H) Photodegradation.	Terrestrial Ecotoxicity	Environmental Fate
	Urban Land Occupation	Materials and Resource Consumption
	Metal Depletion	Materials and Resource Consumption
	Fossil Depletion	Materials and Resource Consumption
(A) Combustion Facilitation		Physical Chemical Hazards
(B) Explosivity		Physical Chemical Hazards
(C) Flammability		Physical Chemical Hazards
(A) Physical state;		Physicochemical Properties
(B) Molecular weight;		Physicochemical Properties
(C) Density;		Physicochemical Properties
(D) Vapor pressure and saturated vapor pressure;		Physicochemical Properties
(E) Melting point;		Physicochemical Properties
(F) Boiling point;		Physicochemical Properties
(G) Water solubility;		Physicochemical Properties
(H) Lipid solubility;		Physicochemical Properties
(I) Octanol-water partition coefficient, octanol-air partition coefficient, organic carbon partition coefficient;		Physicochemical Properties
(J) Diffusivity in air and water;		Physicochemical Properties
(K) Henry's Law constant;		Physicochemical Properties
(L) Sorption coefficient for soil and sediment;		Physicochemical Properties
(M) Redox potential;		Physicochemical Properties
(N) Photolysis rates;		Physicochemical Properties
(O) Hydrolysis rates;		Physicochemical Properties
(P) Dissociation constants; or		Physicochemical Properties
(Q) Reactivity including electrophilicity		Physicochemical Properties

Appendix C: Administrative Compliance

The Safer Consumer Product Regulations are comprised of 11 articles, of which one - Article 5: Alternatives Analysis - is specifically pertinent to this document. The following Tables document each requirement of that article and where in the PAA that requirement is complied with.

Compliance with Section 69505: Guidance Materials

COMPLIANCE LOCATION	TEXT
NA	(a) Guidance Materials. Before finalizing the initial list of Priority Products, the Department shall make available on its website guidance materials to assist persons in performing AAs under this article. The Department shall periodically revise and update the guidance materials.
NA	(b) Sample Alternatives Analyses. The Department shall also post on its website examples of AAs that are available in the public domain at no cost. The posting must indicate, for each AA, the name of the person or entity that prepared the AA.

Compliance with Section 69505.1: General Provisions

COMPLIANCE LOCATION	TEXT
NA	(a) Applicability. This article does not apply to a product for which the notification requirements of section 69505.2 or section 69505.3 have been fully and timely met.
Entire document	(b) AA Requirements.
Entire document	(1) Except as otherwise provided in subsection (a) above and subsections (b), (c) and (d) of section 69505.4, a responsible entity for a Priority Product shall conduct an AA for the Priority Product and shall comply with all applicable requirements of this article.
Entire document	(2) A responsible entity subject to the requirements of paragraph (1) shall prepare, sign, and submit to the Department AA Reports as follows:
NA	(A) Except as provided in subsection (c), a responsible entity shall submit the Preliminary AA Report to the Department no later than 180 days after the date the product is listed on the final Priority Products list posted on the Department's website, unless the Department specifies a different due date in the Priority Products list.
NA	(B) Except as provided in subsection (c), a responsible entity shall submit the Final AA Report no later than twelve (12) months after the date the Department issues a notice of compliance for the Preliminary AA Report, unless the responsible entity requests and the Department approves an extended due date.
NA	(C) For a product that is first placed into the stream of commerce in California after the date the product is listed on the Priority Products list, the due date for the Preliminary AA Report shall be 180 days after the product is first placed into the stream of commerce in California, unless the Department specifies a different due date in the Priority Products list.
Entire document	(3) The requirements of this article applicable to a responsible entity may be fulfilled entirely or in part by the responsible entity, and/or entirely or in part by a person acting on behalf of or in the stead of the responsible entity. This paragraph does not apply to sections 69505.2 and 69505.3.
NA	(c) AA Report Due Date Extension.
NA	(1) A responsible entity may request, and the Department may grant, a one-time extension of up to ninety (90) days to the submission deadline for the AA Report or Alternate Process AA Work Plan if the extension request is based on circumstances that could not reasonably be anticipated or controlled by the responsible entity. The extension request must be received at least sixty (60) days before the applicable due date.
NA	(2) The extension request must include:
NA	(A) The name of, and contact information for, the person filing the extension request;
NA	(B) The name of, and contact information for, the responsible entity(ies) on whose behalf the AA Reports will be submitted;
NA	(C) If different from subparagraphs (A) and (B), the name of, and contact information for, the manufacturer(s) and importer(s) of the product;
NA	(D) Information identifying and describing the responsible entity's Priority Product, and the brand name(s) and product name(s) under which the Priority Product is placed into the stream of commerce in California, and, if the Priority Product is a component of one or more assembled products, a description of the known product(s) in which the component is used;

COMPLIANCE LOCATION	TEXT
NA	(E) The due date for the AA Report;
NA	(F) The amount of additional time requested; and
NA	(G) The reason the extension is needed, including an explanation as to why the circumstances necessitating the extension could not reasonably be anticipated or controlled by the responsible entity.
NA	(3) The Department shall approve or deny the extension request in whole or in part and provide notice to the person submitting the extension request of the decision within thirty (30) days of receipt of the extension request. Failure by the Department to issue a decision within thirty (30) days does not constitute an approval of the extension request.
NA	(d) Consideration of Information. A responsible entity conducting an AA shall consider all relevant information made available on the Department's website, and any additional information or technical assistance the Department may provide regarding alternatives analysis. The responsible entity shall summarize these efforts in the Final AA Report or final Abridged AA Report, whichever is applicable.
NA	(e) Compliance Status. Notwithstanding any other provision of this chapter, failure of the Department to make a compliance determination for an AA Report or Alternate Process AA Work Plan within the applicable timeframe specified in section 69505.9, or failure of the Director or the Department to respond to an appeal or Request for Review submitted under article 7 within sixty (60) days, shall not cause an AA Report or Alternate Process AA Work Plan to be deemed compliant with this article.

Compliance with Section 69505.2: Removal/Replacement Notifications in Lieu of Alternatives Analysis

COMPLIANCE LOCATION	TEXT
NA	(a) Applicability.
	(1)
NA	(A) The requirements of this article do not apply to a responsible entity's Priority Product if the manufacturer of the Priority Product submits one of the following notifications to the Department no later than the due date for submitting the Preliminary AA Report:
NA	1. A Chemical Removal Intent and/or Confirmation Notification that complies with subsections (b) and (c);
NA	2. A Product Removal Intentand/or Confirmation Notification that complies with subsections (b) and (d); or
NA	3. A Product-Chemical Replacement Intent and/or Confirmation Notification that complies with subsections (b) and (e)
NA	(B) If only a Chemical Removal, Product Removal, or Product-Chemical Replacement Intent Notification is submitted to the Department by the date specified in subparagraph (A), within ninety (90) days of the submission date, or by the due date for the Preliminary AA Report, whichever is later, the manufacturer shall submit one of the following to the Department:
NA	1. A removal or replacement Confirmation Notification; or
NA	2. A Preliminary AA Report, Abridged AA Report, or Alternate Process AA Work Plan.
	(2)
NA	(A) If a Preliminary AA Report or Alternate Process AA Work Plan has already been submitted to the Department, the requirements of this article pertaining to performance of a second stage AA and submission of a Final AA Report do not apply if one of the notifications specified in paragraph (1)(A) is submitted to the Department prior to the due date for submitting the Final AA Report.
NA	(B) If only a Chemical Removal, Product Removal, or Product-Chemical Replacement Intent Notification is submitted to the Department by the date specified in subparagraph (A), the manufacturer shall submit a removal or replacement Confirmation Notification or a Final AA Report by the later of the following dates:
NA	1. Ninety (90) days after the Intent Notification is submitted; or
NA	2. The due date for the Final AA Report.
NA	(3) A manufacturer is not in compliance with section 69505.1(b), if the manufacturer submits a notification under this section, in lieu of submitting the otherwise required AA Report(s), and that notification is not submitted by the applicable due date or does not fully meet the applicable content requirements specified in subsections (b) through (e).
NA	(b) Content Requirements for Intent and Confirmation Notifications. Chemical Removal, Product Removal, and Product-Chemical Replacement Intent and Confirmation Notifications must include:
NA	(1) The name of, and contact information for, the person submitting the notification.
NA	(2) The name of, and contact information for, any known responsible entity(ies).

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NA	(3) If different from paragraphs (1) and (2), the name of, and contact information for, the manufacturer(s) and importer(s) of the product.
NA	(4) The name of, and contact information for, all persons in California, other than the final purchaser or lessee, to whom the manufacturer directly sold the Priority Product within the prior twelve (12) months.
NA	(5) Identification and location of the manufacturer's retail sales outlets where the manufacturer sold, supplied, or offered for sale the Priority Product in California, if applicable.
NA	(6) Information identifying and describing the Priority Product and the reformulated product, if applicable, and the brand name(s) and labeling information under which the Priority Product and the reformulated product, if applicable, are/were placed into the stream of commerce in California, and, if the product is a component of one or more assembled products, a description of the known product(s) in which the component is used.
NA	(7) The intended uses, and targeted customer base(s), for the Priority Product and the reformulated product, if applicable.
NA	(8) The measures the manufacturer will take, or has taken, to:
NA	(A) If applicable, provide information regarding the reformulated product to persons selling or distributing the Priority Product in California; and
NA	(B) Cease fulfilling orders for the Priority Product from persons selling or distributing the Priority Product in California.
NA	(9) For Chemical Removal Notifications and/or Product-Chemical Replacement Notifications, the Chemical(s) of Concern that will be or have been removed from the product and, as applicable, the following information:
NA	(A) Information explaining the rationale and the factors considered in deciding to reformulate the product;
NA	(B) Laboratory analytical testing methodology and quality control and assurance protocols used or that will be used to confirm that the Chemical(s) of Concern has/have been removed, and identification of the testing laboratory;
NA	(C) Information demonstrating that the Chemical(s) of Concern has/have been removed from the product that was a Priority Product;
NA	(D) The name of the replacement chemical(s), the concentration of each replacement chemical in the reformulated product, and the hazard traits and/or environmental or toxicological endpoints known to be associated with the replacement chemical(s);
NA	(E) Laboratory analytical testing methodology and quality control and assurance protocols used or that will be used to measure the concentration of the replacement chemical(s) in the product, and identification of the testing laboratory; and
NA	(F) Information demonstrating that the replacement chemical(s) meet one of the following criteria:
NA	1. The replacement chemical(s) is/are not on the list of Candidate Chemicals; or
NA	2. The replacement chemical(s) is/are Candidate Chemical(s) that is/are already in

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	use to manufacture the same product, in lieu of the Chemical(s) of Concern, by the same or a different responsible entity. For purposes of this subsection, "same product" means a product that has the same or similar product description as the Priority Product; has the same intended use(s) and targeted customer base(s) as the Priority Product; and fulfills the functional, performance, and legal requirements of the Priority Product.
NA	(10) The certification statement specified in subsection (c),(d) or (e), as applicable.
NA	(c) Chemical Removal Notification Certification Statements. Chemical Removal Intent and Confirmation Notifications must include whichever of the following certification statements is applicable:
NA	(1) Chemical Removal Intent Notifications must include a statement certifying that the manufacturer intends to do all of the following within ninety (90) days of the date the notification is submitted to the Department:
NA	(A) Remove the Chemical(s) of Concern from the Priority Product without the use of one or more replacement chemicals or otherwise adding other chemicals to the product;
NA	(B) Provide information regarding the reformulated product to persons selling or distributing the Priority Product in California;
NA	(C) Cease fulfilling orders for the Priority Product from persons selling or distributing the Priority Product in California; and
NA	(D) Submit a Chemical Removal Confirmation Notification to the Department for the Priority Product.
NA	(2) Chemical Removal Confirmation Notifications must include a statement certifying that:
NA	(A) The Chemical(s) of Concern has/have been removed from the product that was a Priority Product without the use of one or more replacement chemicals or otherwise adding other chemicals to the product;
NA	(B) Information regarding the reformulated product has been provided to persons selling or distributing the Priority Product in California; and
NA	(C) The manufacturer has ceased, and will not resume, fulfilling orders for the Priority Product from persons selling or distributing the Priority Product in California.
NA	(d) Product Removal Notification Certification Statements. Product Removal Intent and Confirmation Notifications must include whichever of the following certification statements is applicable:
NA	(1) Product Removal Intent Notifications must include a statement certifying that the manufacturer intends to do both of the following within ninety (90) days of the date the notification is submitted to the Department:
NA	(A) Cease fulfilling orders for the Priority Product from persons selling or distributing the Priority Product in California; and
NA	(B) Submit a Product Removal Confirmation Notification to the Department for the product.
NA	(2) Product Removal Confirmation Notifications must include a statement certifying that the manufacturer has ceased, and will not resume, fulfilling orders for the Priority Product from persons selling or distributing the Priority Product in California.

COMPLIANCE LOCATION	TEXT
NA	(e) Product-Chemical Replacement Notification Certification Statements. Product-Chemical Replacement Intent and Confirmation Notifications must include whichever of the following certification statements is applicable:
NA	(1) Product-Chemical Replacement Intent Notifications must include a statement certifying that the manufacturer intends to do all of the following within ninety (90) days of the date the notification is submitted to the Department:
NA	(A) Remove the Chemical(s) of Concern from the Priority Product;
NA	(B) Provide information regarding the reformulated product to persons selling or distributing the Priority Product in California;
NA	(C) Cease fulfilling orders for the Priority Product from persons selling or distributing the Priority Product in California; and
NA	(D) Submit a Product-Chemical Replacement Confirmation Notification to the Department for the Priority Product.
NA	(2) Product-Chemical Replacement Confirmation Notifications must include a statement certifying that:
NA	(A) The Chemical(s) of Concern has/have been removed from the product that was a Priority Product;
NA	(B) The replacement chemical(s) meet the criteria specified in subparagraph 1. or subparagraph 2. of subsection (b)(9)(F);
NA	(C) Information regarding the reformulated product has been provided to persons selling or distributing the Priority Product in California; and
NA	(D) The manufacturer has ceased, and will not resume, fulfilling orders for the Priority Product from persons selling or distributing the Priority Product in California.

Compliance with Section 69505.3: Alternatives Analysis Threshold Notification in Lieu of Alternatives Analysis

COMPLIANCE LOCATION	TEXT
NA	(a) Notification Requirements. This article does not apply to a responsible entity's Priority Product for which the manufacturer submits an Alternatives Analysis Threshold Notification to the Department concurrently with the Priority Product Notification, or by the due date for the Preliminary AA Report for the Priority Product. Each notification must include:
NA	(1) The name of, and contact information for, the person submitting the notification;
NA	(2) The name of, and contact information for, any known responsible entity(ies);
NA	(3) If different from paragraphs (1) and (2), the name of, and contact information for, the manufacturer(s) and importer(s) of the Priority Product;
NA	(4) (A) A statement certifying that the Chemical(s) of Concern is/are present in the manufacturer's Priority Product only as contaminants and the concentration of each Chemical of Concern does not exceed the PQL for that chemical; or
NA	(B) A statement certifying that the Chemical(s) of Concern does/do not exceed the Alternatives Analysis Threshold(s) specified by the Department under section 69503.5(c) for the Chemical(s) of Concern.
NA	(5) If applicable, identification of the PQL for each Chemical of Concern in the Priority Product, and the information and method used to determine the PQL;
NA	(6) The source of the Chemical(s) of Concern in the Priority Product;
NA	(7) Information identifying and describing the Priority Product, the brand name(s) and labeling information under which the Priority Product is placed into the stream of commerce in California, and, if the Priority Product is a component of one or more assembled products, a description of the known product(s) in which the component is used;
NA	(8) Laboratory analytical testing methodology and quality control and assurance protocols used to measure each Chemical of Concern in the Priority Product, and identification of the testing laboratory; and
NA	(9) A demonstration and certification that the manufacturer meets and will continue to meet the criteria and conditions that are the basis for the exemption in this section.
NA	(b) Burden of Proof. The manufacturer bears the burden of proof to demonstrate that the concentration of the Chemical(s) of Concern in its Priority Product does not exceed the applicable Alternatives Analysis Threshold.
NA	(c) Notification Revisions. If any of the information listed in subsection (a) changes significantly, the manufacturer shall submit to the Department a revised Alternatives Analysis Threshold Notification within thirty (30) days of the change.
NA	(d) Change in Product's Exemption Status. If the Priority Product no longer meets the criteria for an Alternatives Analysis Threshold exemption, the manufacturer shall notify the Department of this change within thirty (30) days of the change, and shall submit to the Department a Preliminary AA Report or an applicable Intent and/or Confirmation Notification under section 69505.2 within 180 days of the change.
NA	(e) Determination of Exemption Eligibility. The exemption in subsection (a) does not apply if the

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	Department notifies the person who submitted the Alternatives Analysis Threshold Notification that the information contained in the notification is inaccurate or inadequate to support an Alternatives Analysis Threshold exemption.

Compliance with Section 69505.4: Alternatives Analysis Process and Options

COMPLIANCE LOCATION	TEXT
Entire Report	(a) AA Stages.
Entire Report	(1) An AA must be conducted in two stages.
Entire Report	(2) The responsible entity shall initially complete the first stage of the AA, and submit a Preliminary AA Report that complies with sections 69505.1(b)(2)(A) and 69505.7.
Entire Report	(3) The responsible entity shall next complete the second stage of the AA, and submit a Final AA Report that complies with sections 69505.1(b)(2)(B) and 69505.7.
NA	(b) Abridged AA Reports. After completing the first five (5) steps of the first stage of the AA under subsections (a) through (e) of section 69505.5, a responsible entity that determines a functionally acceptable and technically feasible alternative is not available may prepare and submit an Abridged AA Report, in lieu of the Preliminary and Final AA Reports, if:
NA	(1) The responsible entity summarizes in the Abridged AA Report the first stage AA findings in compliance with the applicable requirements of section 69505.7;
NA	(2) The responsible entity summarizes in the Abridged AA Report its findings with respect to section 69505.6(a) in compliance with the applicable requirements of section 69505.7;
NA	(3) The responsible entity submits an Abridged AA Report to the Department by the due date specified in section 69505.1(b)(2)(A); and
NA	(4) The responsible entity includes an implementation plan in the Abridged AA Report that specifies the milestones and dates for implementation of proposed regulatory responses, which shall, at a minimum, include the regulatory responses required under sections 69506.3 and 69506.8.
NA	(c) Alternate Process AA.
NA	(1) A responsible entity may use an AA process that differs from the process specified in sections 69505.5 and 69505.6, if:
NA	(A) The responsible entity's alternate process provides the information needed to prepare a Final AA Report that substantially complies with section 69505.7.
NA	(B) The responsible entity's alternate process compares the Priority Product and the alternatives under consideration using, at a minimum, the same relevant factors and, when applicable, associated exposure pathways and life cycle segments specified in sections 69505.5 and 69505.6.
NA	(C) The responsible entity submits an Alternate Process AA Work Plan to the Department with sufficient information to demonstrate that the alternate process complies with subparagraphs (A) and (B), and sufficient information for the Department to specify an appropriate due date for submittal of the Final AA Report.
NA	1. The Alternate Process AA Work Plan shall include the information specified in subsections (c), (d), and (e) of section 69505.7.
NA	2. If the Alternate Process AA Work Plan includes information for which trade secret protection is claimed, the responsible entity shall also submit a redacted copy of the work plan that excludes that information.
NA	3. The Alternate Process AA Work Plan shall be accompanied by an executive summary organized in conformance with the organization of the work plan that is sufficient to convey to the public a general understanding of the work plan, and

COMPLIANCE LOCATION	TEXT
	that excludes any information for which trade secret protection is claimed. If the Department subsequently rejects a trade secret claim, the responsible entity shall, at the Department's request, submit a revised executive summary within thirty (30) days of the request to add any information for which a trade secret claim is rejected and which the Department specifies must be included in the executive summary.
NA	(D) The Alternate Process AA Work Plan is submitted to the Department no later than the due date for the Priority Product Notification for the product.
NA	(E)
NA	1. The responsible entity timely submits a Final AA Report to the Department that substantially complies with section 69505.7.
NA	2. The due date for the Final AA Report is eighteen (18) months after the date the Department issues a notice of compliance for the Alternate Process AA Work Plan, unless the responsible entity requests and receives Department approval of an extended due date using the procedures specified for Preliminary AA Reports in section 69505.7(k)(1)(B), or the Department otherwise approves an extended due date under section 69505.9(b)(4)(A). If the Department approves an extended due date, the responsible entity shall provide a yearly progress report until the Final AA Report is submitted. Each progress report must provide all of the information specified in subparagraphs 1. through 6. of section 69505.7(k)(1)(A).
NA	(2) If the Alternate Process AA Work Plan is disapproved by the Department under section 69505.9(b)(3), the responsible entity shall submit a Preliminary AA Report to the Department within 180 days after the Department issues the notice of disapproval.
NA	(d) Previously Completed AAs. A responsible entity may comply with section 69505.1(b) by submitting to the Department a report for a previously completed AA for the Priority Product, if the Department determines that the report is substantially equivalent to the Final AA Report requirements of section 69505.7 and contains sufficient information for the Department to determine any necessary regulatory response(s) under article 6. The previously completed AA may be either an AA conducted or obtained by the responsible entity or a publicly available AA.
NA	(1) A responsible entity submitting a report underthis subsection shall submit the report no later than the deadline for submitting a Preliminary AA Report, except that a one-time extension may be requested under section 69505.1(c).
NA	(2) A responsible entity submitting an existing report under this subsection may supplement the report with additional information to render the report substantially equivalent to the Final AA Report requirements of section 69505.7.
NA	(e) Revised Alternative Selection Decision.
NA	(1) If after submitting the Final AA Report, the responsible entity selects one or more alternatives that differ from the alternative(s) identified as the selected alternative(s) in the Final AA Report, the responsible entity shall submit a revised Final AA Report to the Department at least sixty (60) days prior to placing the newly selected alternative product(s) into the stream of commerce in California. The revised Final AA Report must explain the differences from the original Final AA Report, identify the information used to support the revisions to the Final AA Report, and describe the rationale for selecting the different alternative(s). The Department shall review and make a compliance determination with respect to the revised Final AA Report in accordance with the procedures and criteria set forth in section 69505.9.
NA	(2) Paragraph (1) also applies if:

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NA	(A) The selection decision in the original Final AA Report was to retain the Priority Product, and the responsible entity later decides to select an alternative to replace the Priority Product; or
NA	(B) The responsible entity later decides to retain the Priority Product in lieu of a previously selected alternative product.
NA	(3) The requirements of this subsection only apply for three (3) years after the date the original Final AA Report is approved by the Department.
NA	(f) Reformulation. Except as provided in section 69505.2, if prior to submitting the Final AA Report for a Priority Product the responsible entity removes, or reduces the concentration of, the Chemical of Concern(s) and uses one or more replacement Candidate Chemical(s), the Alternatives Analysis evaluation and comparison shall include consideration of both the Priority Product and the reformulated product.

Compliance with Section 69505.5: Alternatives Analysis: First Stage

COMPLIANCE LOCATION	TEXT
	The first stage of the AA shall include the six (6) steps described below:
Section 1.1	(a) Step 1, Identification of Product Requirements and Function(s) of Chemical(s) of Concern.
Sections 1.1, 1.2, 1.3	(1) The responsible entity shall identify the functional, performance, and legal requirements of the Priority Product that must also be met by the alternatives under consideration.
Section 1.1	(2) The responsible entity shall identify the role(s), if any, of the Chemical(s) of Concern in meeting the Priority Product's requirements identified under paragraph (1).
Section 1.4	(3) (A) The responsible entity shall determine if the Chemical(s) of Concern or alternative replacement chemical(s) is/are necessary to meet the Priority Product's requirements identified under paragraph (1).
NA	(B) If the responsible entity determines that neither the Chemical(s) of Concern nor alternative replacement chemical(s) is/are necessary to meet the Priority Product's requirements identified under paragraph (1), the responsible entity shall evaluate removal of the Chemical(s) of Concern from the Priority Product without the use of any replacement chemical(s) as one of the alternatives to the Priority Product. Alternatively, the responsible entity may submit Chemical Removal Intent and/or Confirmation Notifications to the Department in lieu of completing the Alternatives Analysis and submitting the required AA Reports.
Section 2.1	(b) Step 2, Identification of Alternatives.
Section 2.1	(1) (A) In addition to any alternative identified under subsection (a)(3)(B), the responsible entity shall identify and consider alternatives that meet the definition of "alternative" under section 69501.1 and meet the Priority Product's requirements identified under subsection (a)(1).
Section 2.1	(B) The responsible entity shall research and evaluate available information that identifies existing possibly viable alternatives for consideration in the AA. This research and evaluation shall include, but is not limited to, information posted on the Department's website. The responsible entity shall consider any identified alternative in the AA, or explain in the AA Report why such an alternative is not viable for consideration.
NA	(2) Alternatives that do not involve the use of one or more replacement chemicals, or otherwise adding chemicals to the product, do not require compliance with subsection (c).
Section 2.2	(c) Step 3, Identification of Factors Relevant for Comparison of Alternatives.
Section 2.2	(1) A factor listed in paragraph (2), in conjunction with an associated exposure pathway and life cycle segment, if applicable, is relevant if:
Section 2.2	(A) The factor makes a material contribution to one or more adverse public health impacts, adverse environmental impacts, adverse waste and end-of-life effects, and/or materials and resource consumption impacts associated with the Priority Product and/or one or more alternatives under consideration; and
Section 2.2	(B) There is a material difference in the factor's contribution to such impact(s) between the Priority Product and one or more alternatives under consideration and/or between two or more alternatives.
Section 2.2	(2) The responsible entity shall use available quantitative information and analytical tools,

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	supplemented by available qualitative information and analytical tools, to identify the factors listed below and the associated exposure pathways and life cycle segments, if applicable, that are relevant for the comparison of the Priority Product and the alternatives under consideration:
Section 2.2	(A) Adverse environmental impacts;
Section 2.2	(B) Adverse public health impacts;
Section 2.2	(C) Adverse waste and end-of-life effects;
Section 2.2	(D) Environmental fate;
Section 2.2	(E) Materials and resource consumption impacts;
Section 2.2	(F) Physical chemical hazards; and
Section 2.2	(G) Physicochemical properties.
Section 2.2	(3) The responsible entity's identification of relevant exposure pathways shall consider both of the following:
Section 2.2	(A) Chemical quantity information:
Section 2.2	1. Quantities of the Chemical(s) of Concern or alternative replacement chemical(s) necessary to manufacture the Priority Product and each alternative under consideration; and
Section 2.2	2. Estimated volume and/or mass of the Chemical(s) of Concern or alternative replacement chemical(s) that is/are or would be placed into the stream of commerce in California as a result of the Priority Product and each alternative under consideration.
Section 2.2	(B) Exposure factors specified in section 69503.3(b).
Section 2.3	(d) Step 4, Initial Evaluation and Screening of Alternative Replacement Chemicals.
Sections 2.3, 2.4	(1) For those alternatives under consideration that involve removing or reducing the concentration of the Chemical(s) of Concern and using one or more alternative replacement chemicals, or otherwise adding chemicals to the product, the responsible entity shall use available quantitative information and analytical tools, supplemented by available qualitative information and analytical tools, to evaluate and compare each of the alternative replacement chemicals under consideration with the Chemical(s) of Concern in the Priority Product with respect to each of the following factors to the extent relevant:
Section 2.3	(A) Adverse environmental impacts;
Section 2.3	(B) Adverse public health impacts;
Section 2.3	(C) Environmental fate;
Section 2.3	(D) Physical chemical hazards; and
Section 2.3	(E) Physicochemical properties.
NA	(2) The responsible entity may eliminate from further consideration in the AA any alternative replacement chemical(s) that it determines has/have the potential to pose adverse impacts

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		equal to or greater than those posed by the Chemical(s) of Concern.
Section 2.4	(e)	Step 5, Consideration of Additional Information. In the first stage of the AA, the responsible entity may consider pertinent factors and information not specifically identified in this section. This may include, but is not limited to, consideration of the factors and information specified in section 69505.6. A responsible entity may eliminate an alternative from further consideration based on the additional factors and information as long as the reason for its elimination is explained in the Preliminary AA Report and there are alternatives remaining to be evaluated in the second AA stage.
Entire Report	(f)	Step 6, Preliminary AA Report Preparation.
Section 4	(1)	The responsible entity shall prepare, for inclusion in the Preliminary AA Report, a work plan and proposed implementation schedule for completion of the second AA stage and preparation and submittal of the Final AA Report.
Entire Report	(2)	The responsible entity shall prepare and submit to the Department a Preliminary AA Report as specified in section 69505.7.

Compliance with Section 69505.6: Alternatives Analysis: Second Stage

COMPLIANCE LOCATION	TEXT
NA	After receiving approval of the Preliminary AA Report from the Department, the responsible entity shall compare the Priority Product with the alternatives still under consideration. The second stage of the AA shall include the five (5) steps described below:
NA	(a) Step 1, Identification of Factors Relevant for Comparison of Alternatives.
NA	(1) Adverse Impacts and Multimedia Life Cycle Impacts. The responsible entity may use available quantitative information and analytical tools, supplemented by available qualitative information and analytical tools, to re-evaluate the identification of factors and the associated exposure pathways and life cycle segments, if applicable, determined to be relevant under section 69505.5(c) for the comparison of the Priority Product and the alternatives still under consideration after completion of the first AA stage. In addition to the factors determined to be relevant under this paragraph and/or section 69505.5(c), the factors specified in paragraphs (2) and (3) are relevant for all comparisons of the Priority Product and the alternatives.
NA	(2) Product function and performance. The responsible entity shall identify the principal manufacturer-intended use(s) or application(s), the functional and performance attributes, and the applicable legal requirements for the Priority Product. The responsible entity shall, at a minimum, evaluate:
NA	1. The useful life of the Priority Product, and that of the alternatives under consideration;
NA	2. The function and performance of each alternative relative to the Priority Product and other alternatives under consideration; and
NA	3. Whether an alternative exists that is functionally acceptable, technically feasible, and economically feasible.
NA	(3) Economic impacts.
NA	1. The responsible entity shall evaluate, monetize, and compare for the relevant exposure pathways and life cycle segments the following impacts of the Priority Product and the alternatives:
NA	a. Public health and environmental costs; and
NA	b. Costs to governmental agencies and non-profit organizations that manage waste, oversee environmental cleanup and restoration efforts, and/or are charged with protecting natural resources, water quality, and wildlife.
NA	2. If the responsible entity's alternative selection decision is to retain the Priority Product based in whole or in part on internal cost impacts, this decision must be explained in the Final AA Report. The Final AA Report must include a quantified comparison of the internal cost impacts of the Priority Product and the alternatives, including manufacturing, marketing, materials and equipment acquisition, and resource consumption costs.
NA	(b) Step 2, Comparison of the Priority Product and Alternatives. The responsible entity shall use available quantitative information and analytical tools, supplemented by available qualitative information and analytical tools, to evaluate and compare the Priority Product and each of the alternatives under consideration with respect to each relevant factor and associated exposure pathways and life cycle segments, if applicable, identified under subsection (a) above and section 69505.5(c). The responsible entity shall compare each alternative with the Priority Product and with each of the other alternatives under consideration.

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NA	(c) Step 3, Consideration of Additional Information. As part of the second stage of the AA, the responsible entity may also consider other pertinent information not specifically identified in this section. This may include, but is not limited to, reconsideration of the factors and information identified in section 69505.5.
NA	(d) Step 4, Alternative Selection Decision. The responsible entity shall select the alternative(s) that will replace the Priority Product, unless the decision is to retain the existing Priority Product. The selection of an alternative or the decision to retain the Priority Product shall be based on and supported by the comparative analysis conducted under subsections (b) and (c).
NA	(e) Step 5, Final AA Report Preparation. The responsible entity shall prepare and submit to the Department a Final AA Report as specified under section 69505.7.

Compliance with Section 69505.7: Alternatives Analysis Reports

COMPLIANCE LOCATION	TEXT
	(a) General Requirements.
Entire Report	(1) Preliminary and Final AA Reports and Abridged AA Reports must each include all of the applicable information specified in subsections (b) through (k).
	(2) The responsible entity shall include in the AA Reports sufficient information for the Department to determine:
Appendix B	(A) Compliance with the substantive and administrative requirements of this article; and
NA	(B) The appropriate due date for submission of the Final AA Report, and the appropriate due date for any regulatory response (s) required under article 6.
NA	(3) The responsible entity shall identify and explain in the Final AA Report all differences in the information and analyses presented in the Preliminary AA Report and the Final AA Report. The responsible entity must identify in the Final AA Report the information sources used to support changes from the Preliminary AA Report to the Final AA Report.
Entire Report	(4) The responsible entity shall maximize the scope of information in the AA Report that can be made available to the public, while maintaining protection of legitimate trade secrets.
NA	(A) If the AA Report contains information claimed by the responsible entity to be a trade secret, a separate publicly available AA Report shall be submitted to the Department that excludes claimed trade secret information only to the extent necessary to protect its confidential nature.
NA	(B) If the Department subsequently rejects a trade secret claim and/or the nature and/or extent of redaction, the responsible entity shall, at the Department's request, submit a revised publicly available AA Report and executive summary within thirty (30) days of the request to add any information for which a trade secret claim or redaction is rejected.
Page 1	(b) Executive Summary. AA Reports must include a publicly available executive summary sufficient to convey a general understanding of the scope and results of the AA and the rationale for the AA selection decision. The executive summary must be organized in conformance with the organization of the AA Report and must include for each section of the AA Report a detailed summary of the information presented. Information for which trade secret protection is claimed must not be included in the executive summary.
Page 4	(c) Preparer Information. This section of the AA Report must include:
Page 4	(1) The name of, and contact information for, the person submitting the AA Report;
Page 4	(2) If applicable, the name of, and contact information for, all responsible entities on whose behalf the AA Report is being submitted; and
Page 4	(3) The names of the parties that were involved in funding, directing, overseeing, preparing, and/or reviewing the AA.
Page 5	(d) Responsible Entity and Supply Chain Information. This section of the AA Report must include:
Page 5	(1) The name of, contact information for, and headquarters location of the manufacturer(s) and importer(s), if applicable, and, if the AA Report is prepared on behalf of a consortium of manufacturers or other persons in the Priority Product's supply chain, a list of the participants along with their contact information;

COMPLIANCE LOCATION	TEXT
Page 5	(2) The name of, and contact information for, any person(s) identified on the Priority Product label as the manufacturer, importer, or distributor;
Page 5	(3) The name of, and contact information for, all persons in California other than the final purchaser or lessee to whom the manufacturer or importer directly sold the Priority Product within the prior twelve (12) months; and
Page 5	(4) Identification and location of the manufacturer's and/or importer's retail sales outlets where the manufacturer and/or importer sold, supplied, or offered for sale the Priority Product in California, if applicable.
Section 1	(e) Priority Product Information. This section of the AA Report must include:
Section 1	(1) The brand name(s) and product name(s) under which the Priority Product is placed into the stream of commerce in California;
Section 1	(2) If the Priority Product is a component of one or more assembled products, a description of the known product(s) in which the component is used;
Section 1	(3) Identification of the Chemical(s) of Concern for the Priority Product;
Section 1	(4) Any Material Safety Data Sheets and/or Safety Data Sheets related to the Priority Product; and
	(5) The information specified in paragraphs (1) and (2) of section 69505.5(a).
Section 2.2	(f) Scope of Relevant Comparison Factors. Each AA Report must identify which factors and, when applicable, associated exposure pathways and life cycle segments were determined to be relevant, under sections 69505.5(c) and 69505.6(a), for evaluation and comparison of the Priority Product and its alternatives. For each factor, and exposure pathway and life cycle segment, if applicable, determined not to be relevant, the AA Report must explain the rationale and identify, and explain the pertinent findings of, the supporting information for this determination.
Section 2.3	(g) Scope and Comparison of Alternatives. The AA Reports must identify and describe the alternatives chosen to be evaluated and compared, and explain the rationale for selecting and screening out specific alternatives at each stage of the alternatives comparison process. For any alternative that is screened out because it is determined that its adverse impacts are equal to or greater than those of the Priority Product, the responsible entity shall describe in the AA Report the method used to determine equal or greater adverse impacts, including the method used to compare the multiple factors associated with the impacts, and the rationale for any trade-offs made among the factors.
Section 2.3	(1) Each Preliminary AA Report and Abridged AA Report must include the information collected and the comparison conducted under section 69505.5 for the Chemical(s) of Concern and the alternative replacement chemical(s). This must include a matrix, or other summary format, that provides a clear visual comparison that summarizes the information collected regarding the relevant adverse impacts, and their associated relevant exposure pathways and life cycle segments, for the Chemical(s) of Concern and each alternative replacement chemical being considered, and the comparative results of evaluating this information.
NA	(2) The Final AA Report must include the information collected and the comparison conducted under sections 69505.5 and 69505.6 for the Priority Product and its alternatives, including:
NA	(A) A matrix, or other summary format, that provides a clear visual comparison that summarizes the information collected regarding the relevant comparison factors, and their associated relevant exposure pathways and life cycle segments, for the Priority Product and each alternative considered, and the comparative results of evaluating this

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	information; and
NA	(B) Identification and description of how any relevant safeguards provided by other federal and California State regulatory programs were considered in the AA.
NA	(3) The responsible entity shall demonstrate in the Final AA Report that all of the requirements of section 69505.6 have been met.
Section 2.3	(h) Methodology. The AA Report shall identify and describe the analytical tools, models, and software used to conduct the AA, and discuss any of their limitations. The AA Report shall also identify any published methodologies and/or guidelines used, and any deviations from those methodologies and/or guidelines.
Entire Report	(i) Supporting Information.
NA	(1) All information used as supporting information in performance of the AA and preparation of the AA Reports must be cited in the AA Reports and made available to the Department upon request. The AA Reports must include a brief summary of the information reviewed and considered under section 69505.1(d).
NA	(2) The Final AA Report must identify information that is not currently available but, if it were available, could be used to:
NA	(A) Validate information used for purposes of sections 69505.5 and 69505.6; and/or
NA	(B) Address any uncertainties in the analyses conducted under sections 69505.5 and 69505.6.
Section 3	(j) Selected Alternative(s).
Section 3	(1) The Preliminary AA Report must identify and describe the alternatives selected for further evaluation in the second stage of the AA, and explain the rationale for the selection decision.
NA	(2) The Final AA Report must identify and describe the alternative(s), if any, selected to replace the Priority Product. The description of the selection decision must include an analysis that evaluates and compares the selected alternative(s) against the Priority Product and a detailed list and explanation of the reasons for the selection decision, or, alternatively, for the decision not to select and implement an alternative to the Priority Product. The Final AA Report must also include:
NA	(A) The product function and performance information specified in section 69505.6(a)(2) for the selected alternative(s). If no alternative is selected, this information must be provided in the Final AA Report or Abridged AA Report, as applicable, for each alternative considered.
NA	(B) An explanation of the rationale for retaining the Chemical(s) of Concern or using the alternative replacement chemical(s), if section 69505.5(a)(3)(B) applies, and one or more selected alternatives retains the Chemical(s) of Concern or uses one or more replacement chemicals.
NA	(C) A list of all chemicals known, based on available information, to be in the selected alternative(s) that are Chemicals of Concern, that differ from the chemicals in the Priority Product, or that are present in the selected alternative(s) at a higher concentration than in the Priority Product relative to other chemicals in the Priority Product other than the Chemical(s) of Concern. The following information, to the extent available, must be provided for those chemicals:

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NA	1. Environmental fate;
NA	2. Hazard trait and environmental and toxicological endpoint information that has not already been provided to the Department under this chapter;
NA	3. Information about the chemical purity, meaning the relative absence of extraneous matter, and identification of known impurities and additives in the chemical;
NA	4. Physicochemical properties; and
NA	5. Substance identification information, including all of the following that are applicable:
NA	a. Chemical abstract services number;
NA	b. Structural formula;
NA	c. Molecular weight;
NA	d. Synonyms;
NA	e. International Union of Pure and Applied Chemistry name;
NA	f. European Commission number;
NA	g. Registry of Toxic Effects of Chemical Substances number;
NA	h. International Union of Biochemistry and Molecular Biology number;
NA	i. Japan Ministry of International Trade and Industry number;
NA	j. Number assigned by the United Nations Experts on the Transport of Dangerous Goods;
NA	k. North America Department of Transportation number;
NA	l. European Inventory of Existing Commercial Chemical Substances number;
NA	m. European List of Notified Chemical Substances number;
NA	n. European Commission Directive 67/548/EEC No Longer Polymers number; and
NA	o. Other commonly recognized substance identification system numbers.
Section 4	(k) Next Steps.
Section 4	(1) Work plan. The Preliminary AA Report must include the work plan and proposed implementation schedule for completion of the second AA stage required to be prepared under section 69505.5(f)(1).
Section 4	(A) The work plan and implementation schedule must specify the proposed submission date for the Final AA Report and must ensure that the Final AA Report or progress report, if applicable, will be submitted to the Department no later than twelve (12) months after the Department issues a notice of compliance for the Preliminary AA Report. If the Department approves an extended due date under section 69505.9(b)(4)(A), the responsible entity shall provide a yearly progress report until the Final AA Report is submitted. The first yearly progress report shall be submitted no later than twelve (12) months after the Department issues a notice of compliance for the Preliminary AA Report. Each progress report must include:
NA	1. Preparer information specified in subsection (c);
NA	2. Priority Product information specified in subsection (e);
NA	3. A summary of achievements since the last progress report;
NA	4. A summary and discussion of issues that have arisen and their resolutions;
NA	

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	5. A summary of work that is pending; and
NA	6. An assessment of whether the milestones in the schedule set forth in the Preliminary AA Report or Alternate Process AA Work Plan are anticipated to be completed on time and any contingency plans to ensure timely completion.
NA	(B) The responsible entity may request an extended due date for submittal of the Final AA Report. Any requested extension shall not exceed twenty-four (24) months from the date the Department issues a notice of compliance for the Preliminary AA Report, unless additional time is needed to conduct regulatory safety and/or performance testing on multiple alternatives prior to making an AA selection decision, in which case the requested extension shall not exceed thirty-six (36) months. The extended due date request must include a detailed explanation of why additional time is needed.
NA	(2) Implementation of selected alternatives. The Final AA Report must include a detailed plan for implementing any selected alternative(s).
NA	(A) The implementation plan must include key milestones and dates for implementing the selected alternative(s), if applicable, and identify steps that will be taken to ensure compliance with applicable federal, state, and/or local laws.
NA	(B) The implementation plan may also include the identification of and implementation plan(s) for any regulatory response(s) that the responsible entity wishes to propose that would best limit exposure to, or reduce the level of adverse impacts or adverse waste and end-of-life effects posed by, any Chemical(s) of Concern or replacement Candidate Chemical(s) that will be in the selected alternative(s) or the Chemical(s) of Concern that is/are in the Priority Product if the decision resulting from the AA is to retain the Priority Product.

Compliance with Section 69505.8: Public Comments on AA Reports

COMPLIANCE LOCATION	TEXT
NA	(a) Public Notice of Opportunity for Comment. Upon receipt of a Final AA Report or an Abridged AA Report, the Department shall post on its website, and send to persons on the electronic mailing list(s) that the Department establishes related to this chapter, a notice regarding the availability for public review and comment of the Final AA Report or Abridged AA Report. The notice shall include the last day for the public to submit written comments to the Department, the method(s) for submitting comments, and a link to the location on the Department's website where a copy of the Final AA Report or Abridged AA Report may be viewed. The last day for submission of public comments shall be no sooner than forty-five (45) days from the date the notice of availability of the Final AA Report or Abridged AA Report is posted on the Department's website or the date the notice is sent to persons on the electronic mailing list(s), whichever is the later date.
NA	(b) Department Review of Public Comments. No later than thirty (30) days after the close of the public comment period established under subsection (a), the Department shall review the public comments received and notify the person that submitted the Final AA Report or Abridged AA Report of those issues that the Department determines must be addressed in an AA Report Addendum. The notice shall include the due date by which the person must submit an AA Report Addendum to the Department under subsection (c). In determining the due date for the AA Report Addendum, the Department shall take in to consideration the scope and complexity of the issues the Department is requiring the person to address.
NA	(c) AA Report Addendum. A person that receives a notice under subsection (b) shall prepare, and submit to the Department by the due date specified under subsection (b), an AA Report Addendum that addresses the issues identified by the Department as requiring further attention. The AA Report Addendum shall also include any revisions to the Final AA Report or Abridged AA Report determined necessary based on consideration of the issues identified by the Department.

Compliance with Section 69505.9: Department Review and Determinations for AA Reports and Work Plans

COMPLIANCE LOCATION	TEXT
NA	(a) Review Criteria. In reviewing AA Reports and Alternate Process AA Work Plans for compliance
NA	with the substantive and administrative requirements of this article, the Department shall consider:
NA	(1) Whether the AA Report or Alternate Process AA Work Plan was submitted timely;
NA	(2) Whether, and to what extent, the responsible entity considered and addressed all applicable provisions of this article pertaining to the preparation and submittal of an AA Report or Alternate Process AA Work Plan, whichever is applicable;
NA	(3) Whether, and to what extent, the responsible entity demonstrated that the conclusions of the AA were based on reliable information, when applicable; and
NA	(4) Whether, and to what extent, the responsible entity demonstrated that the conclusions of the AA Report were determined using reliable information.
NA	(b) Preliminary AA Reports and Alternate Process AA Work Plans.
NA	(1) Within sixty (60) days of receiving a Preliminary AA Report or Alternate Process AA Work Plan, the Department shall review the report or work plan for compliance with this article, and issue a notice of compliance, notice of deficiency, notice of disapproval, or notice of ongoing review.
NA	(2) Notice of Deficiency.
NA	(A) The Department shall specify in a notice of deficiency the areas of deficiency, the information required to cure the deficiency(ies), and the due date for submitting the necessary information, which may not exceed sixty (60) days from the date the notice of deficiency is issued. The responsible entity shall submit a revised report or work plan, whichever is applicable, by the due date specified, and address the areas of deficiency.
NA	(B) Within thirty (30) days of receipt of the additional information requested in the notice of deficiency, the Department shall issue a notice of compliance, a notice of disapproval, or a 28 notice of ongoing review for the report or work plan.
NA	(3) Notice of Disapproval. If the revised report or work plan does not fully address the identified areas of deficiency, the Department shall issue a notice of disapproval. The Department shall also issue a notice of disapproval if a revised report or work plan is not submitted by the due date specified under paragraph (2)(A). If the report or work plan is disapproved, the Department shall explain the basis for the disapproval. A disapproved report or work plan is not in compliance with section 69505.1(b).
NA	(4) Notice of Compliance. The Department shall specify in a notice of compliance for a Preliminary AA Report or Alternate Process AA Work Plan the due date for submitting the Final AA Report. The Department shall specify a due date twelve (12) months from the date the Department issues the notice of compliance, except that the Department may specify an extended due date for submission of the Final AA Report if it determines based on information in the Preliminary AA Report or Alternate Process AA Work Plan that more time is needed. The Department may also specify an extended due date for submission of the Final AA Report if the responsible entity submits a request under section 69505.7(k)(1)(B).
NA	
NA	(c) Final AA Reports and Abridged AA Reports.

COMPLIANCE LOCATION	TEXT
	(1) Within sixty (60) days of receiving an AA Report Addendum, the Department shall review the Final AA Report or Abridged AA Report, including the AA Report Addendum, for compliance with this article, and shall issue a notice of compliance, notice of deficiency, notice of disapproval, or notice of ongoing review. If no AA Report Addendum is required under section 69505.8, the Department shall complete its review of the Final AA Report or
NA	Abridged AA Report within sixty (60) days of whichever of the following dates is applicable:
NA	(A) The close of the public comment period,if no public comments are received; or
	(B) Thirty (30) days after the close of the public comment period, if the Department determines after reviewing the public comments that there are no issues that need to
NA	be addressed in an AA Report Addendum.
NA	(2) Notice of Deficiency.
	(A) The Department shall specify in a notice of deficiency the areas of deficiency, the information required to cure the deficiency(ies), and the due date for submitting the necessary information to complete the Final AA Report or Abridged AA Report, which may not exceed sixty (60) days from the date of the notice of deficiency. The responsible entity shall submit a revised Final AA Report or revised Abridged AA Report by the due date specified, and address all areas of deficiency. The responsible entity may request and the Department may approve, under section 69505.1(c), a one-time extension of not more than ninety (90) days for submission of the revised Final AA
NA	Report or revised Abridged AA Report to correct the deficiencies.
	(B) Within sixty (60) days of receipt of the requested additional information, the Department shall issue a notice of compliance, a second notice of deficiency, or a
NA	notice of ongoing review.
	1. If the Department issues a second notice of deficiency, the Department may grant
NA	no more than thirty (30) days for submission of the requested information.
	2. Within sixty (60) days of receipt of the additional information requested in the second notice of deficiency, the Department shall issue a notice of compliance, a notice of disapproval, or a notice of ongoing review for the Final AA Report or
NA	Abridged AA Report.
	(3) Notice of Disapproval. If the Final AA Report or Abridged AA Report does not fully address the areas of deficiency identified in the second notice of deficiency, the Department shall issue a notice of disapproval. The Department shall also issue a notice of disapproval if a revised Final AA Report or revised Abridged AA Report is not submitted by the due date specified under paragraph (2)(A) or paragraph (2)(B)1., whichever is applicable. If the Final AA Report or Abridged AA Report is disapproved, the Department shall explain the basis for the disapproval. A disapproved Final AA Report or Abridged AA Report is not in compliance
NA	with section 69505.1(b).
	(d) Notice of Ongoing Review. The Department shall specify in a notice of ongoing review the estimated date by which the Department expects to issue a notice of compliance or notice of deficiency, which shall be based on its available resources and the complexity of the document
NA	under review.
	(e) Issuance of Notices. All notices issued by the Department under this section shall be issued to the person who submitted the document, and a copy of the notice shall be sent by the Department to all persons identified in the document under subsections (c)(2) and (c)(3) of section 69505.7.

Additional References

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Danish Ministry of the Environment (2007). Health and Environmental Assessment of Alternatives to Deca-BDE in Electrical and Electronic Equipment. Environmental Protection Agency.

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Oregon Legislative Assembly (2009). Relating to decabrominated diphenyl ether; creating new provisions; and amending ORS 453.005, 453.025 and 453.085. Senate Bill 596.

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Washington (2006). An act relating to brominated flame retardant. House Bill (HB) 1488/Senate Bill (SB) 5515.

Washington State Department of Health (2008). Alternatives to Deca-BDE in Televisions and Residential Upholstered Furniture. Department of Ecology. Olympia, WA.