



Rationale Document for Motor Vehicle Tires Containing Zinc

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ABOUT THIS DOCUMENT

The Department of Toxic Substances Control's (DTSC) Safer Consumer Products (SCP) regulations allow any person to petition the DTSC to add a product-chemical combination to the Priority Product List. In May 2018, the California Stormwater Quality Association (CASQA) petitioned DTSC to list motor vehicle tires with tire tread containing zinc as a Priority Product. In May 2019, CASQA submitted supplemental information to its original petition to address questions and gaps identified by DTSC in its merits review of the petition. For the purposes of this document, the term "petition" includes both the original petition and the supplemental information. This document provides an overview of DTSC's determination that the petition provides sufficient information to meet the key prioritization criteria for listing a Priority Product (California Code of Regulations, title 22, section 69503.2(a)):

- (1) There must be potential public and/or aquatic, avian, or terrestrial animal or plant organism exposure to the Candidate Chemical(s) in the product; and
- (2) There must be the potential for one or more exposures to contribute to or cause significant or widespread adverse impacts.

This document relies almost entirely on resources presented in the petition but incorporates other findings made by DTSC during its evaluation of the petition, as appropriate.

1. RATIONALE FOR GRANTING THE PETITION

Based on the criteria in the SCP regulations, DTSC has determined the petition meets the criteria for quality and comprehensiveness specified in section 69504.1 of title 22 of the California Code of Regulations. Specifically, DTSC has determined that the petition has demonstrated the potential for exposure of aquatic organisms to zinc found in motor vehicle tires, and for those exposures to contribute to or cause significant and widespread adverse impacts.

Zinc is added to tire rubber (typically as zinc oxide) to encourage the vulcanization process. Vulcanization strengthens the rubber and allows tire manufacturers to mold tire rubber into the precise shapes found in tire treads and other tire components. This zinc remains part of the matrix of the tire. Small pieces of tires, commonly referred to as tire wear particles (TWP), are generated as tires roll along the road. TWP can be deposited on roads and surrounding areas, where it can be carried by stormwater into waterways. Additionally, TWP can be transported through the air and deposited onto hard surfaces, such as roofs, where it is also subject to transport to the aquatic environment via stormwater.

Once released into the environment, including local waterways, zinc can and does leach out of TWP. TWP represents a significant source of zinc in stormwater runoff, which is a significant source of zinc introduced to the aquatic environment. Aquatic organisms in California's streams, rivers, and lakes may be adversely impacted by exposure to zinc. The U.S. Environmental Protection Agency (U.S. EPA) and the State Water Resources Control Board (State Water Board) have developed water quality criteria for zinc to assist in this determination.

In more urbanized parts of the state, TWP-containing stormwater runoff represents a major source of zinc contamination. Especially in the southern part of the state, California waterways have been found to exceed zinc water quality criteria, including at the point of stormwater discharge. Many of California's municipal stormwater agencies, which are responsible for adhering to permit requirements designed to protect local waterways, report challenges complying with permits due to these exceedances.

Some California waterways have been classified as impaired under the provisions of section 303(d) of the Clean Water Act due to zinc contamination. In laboratory studies, water samples collected from impacted waterways induced toxic effects in native marine organisms, which have been attributed to their zinc content. Advanced stormwater treatment (referred to as "special handling" in the SCP regulations) is required to mitigate the adverse impacts of zinc exposure on aquatic organisms; however, such treatment is often prohibitively expensive or technically infeasible.

2. PRODUCT DEFINITION AND SCOPE

This section describes the product that forms the basis for the proposed product-chemical combination.

The petition describes the product-chemical combination as "motor vehicle tires with tire-tread containing zinc" and observes that the "main categories of tires are passenger, light truck, and medium/heavy truck."

DTSC proposes to list motor vehicle tires containing zinc as a Priority Product. DTSC further proposes to define "tire" as *any product that can be described or observed as a covering for a wheel, usually made of rubber reinforced with cords of nylon, fiberglass, or other material, whether filled with compressed gas (such as air or nitrogen), solid, or non-pneumatic (airless)*. This definition is based on the GS1 Global Product Classification (GPC) standard's tire definition (GS1 2020).

This proposal encompasses all parts of new tires (tread, sidewalls, etc.) and tire tread material (circular or linear precured tread and raw rubber for use in mold cure retreading) intended for use on passenger cars (including sport utility vehicles (SUVs) and pickups); motorcycles; motor homes; light-, medium-,

and heavy-duty trucks; buses; and trailers (including trailer coaches, park trailers, and semitrailers). This proposal excludes tires intended for use in off-road vehicles including:

- aircrafts;
- vehicles intended exclusively for off-road (e.g. dirt, track) use;
- construction and agricultural equipment such as excavators, paving equipment, tractors, combines, bulldozers, and skidders (but not farm labor vehicles); and
- industrial equipment such as forklifts, airport service equipment, and ice-grooming machines.

3. CANDIDATE CHEMICAL DEFINITION AND PROPERTIES

This section introduces the Candidate Chemical (or Chemicals) in the proposed product-chemical combination.

Reference: California Code of Regulations, title 22, section 69503.3(a)(1)(D).

Zinc (Zn) is element number 30 on the periodic table (PubChem 2021) It has an atomic weight of 65.38 and a density of 7.134 grams per cubic centimeter (PubChem 2021). It is a heavy metal that is abundant in the earth's crust (PubChem 2021). Zinc is used in a wide variety of commercial applications including rust prevention, and in alloys such as brass and bronze (PubChem 2021). Zinc, typically as zinc oxide (ZnO) particles, is added to tire rubber to aid in the vulcanization process, which creates chemical bonds (cross-links) among individual rubber polymer molecules to improve rubber performance.

Because zinc is an element, it cannot break down in the environment; it can only form different compounds. Zinc's toxicity depends on its bioavailability—the fraction of zinc in the immediate environment that can be taken in by an organism. For a chemical to be bioavailable, it must reach the site (e.g., a protein or other biotic ligand) in a biological system (e.g., an organism or cell) where it exerts its effect. The bioavailability of zinc is strongly influenced by factors such as pH, the amounts and types of other dissolved minerals, and the amounts and types of dissolved and suspended organic material available to bind zinc.

The petition notes that “the dominant fate of zinc in the freshwater aquatic environment appears to be sorption [to particles],” and these particles may remain suspended in the water column or be deposited in underlying sediment. In general, zinc that is dissolved in the water column is more bioavailable than zinc compounds in sediments; however, the petition also states that zinc in sediments “may be a problem at higher concentrations or if re-suspended.”

The petition states that zinc from tire wear can contribute to aquatic toxicity, and studies have shown that zinc exposure can adversely affect the reproduction, development, and survival of wildlife in aquatic environments. According to the petition, zinc's toxicity may result from its disruption of aquatic

organisms' ability to regulate the concentration of calcium across cell membranes (calcium homeostasis). This may be a particular issue for aquatic species whose reproductive strategy involves external fertilization and development. For example, studies indicate that dissolved zinc can impair the viability of purple sea urchin sperm, resulting in decreased reproductive success (Schiff et al. 2002; Schiff et al. 2003). Zinc can also impair the uptake and accumulation of calcium during sensitive stages of embryonic and larval sea urchin development; this may lead to developmental malformations including delayed or stunted growth, skeletal abnormalities, and atrophy (Tellis et al. 2014; Rouchon and Phillips 2017; Nogueira et al. 2020). In addition to sublethal effects, zinc can also cause mortality in sea urchin and mussel embryos (Nadella et al. 2013).

U.S. EPA's ambient water quality criteria for zinc derive from a model that predicts zinc's bioavailability in a given body of water based on the water's hardness. However, it is now recognized that other characteristics of natural waters, especially the concentration(s) of colloidal or dissolved natural organic matter, can significantly affect the bioavailability—and hence the toxicity—of metals like zinc. This knowledge has led to the development of more sophisticated models for predicting metals' bioavailability, such as the Biotic Ligand Model (DeForest and Van Genderen 2012; Adams et al. 2020). However, to date, U.S. EPA has not revised its water quality criteria for zinc to incorporate these newer estimation techniques.

4. POTENTIAL FOR EXPOSURES TO ZINC FROM TIRES

Reference: California Code of Regulations, title 22, section 69503.3(b)(2).

The petition highlights many lines of evidence to suggest the potential for exposure of aquatic organisms to zinc from motor vehicle tires. These include:

- the presence of zinc in motor vehicle tires;
- scenarios describing how zinc can be released from tires into stormwater during the use and end-of-life of stages of their lifecycle;
- estimates of the amount of zinc released into stormwater from tires; and
- environmental monitoring data indicating the presence of zinc from tires in California stormwater in concentrations that:
 - exceed regulatory thresholds for zinc;
 - may result in violations of permits issued to California municipalities responsible for managing stormwater streams; and
 - require the expenditure of public funds to mitigate potential adverse impacts.

Presence of the Candidate Chemical in the Product

The petition includes data from laboratory studies analyzing the zinc content in tires. The data show that rubber in car tires contains approximately 1 percent zinc. Tires for heavier vehicles may have higher concentrations, up to 1.7 percent (CASQA 2015).

Potential Exposures to Zinc During the Life Cycle of Tires

Use

The petition identifies the movement of TWP from roads into nearby waterways—often via stormwater—as the primary means by which tires can expose aquatic organisms to zinc (see Figure 1). As vehicles are driven, tire tread slowly wears off, creating TWP. Over a tire’s lifetime, more than 10 percent of its mass wears away onto road surfaces (CASQA 2015). A significant percentage of these particles remain on or near the road, where they may be washed off by rain or enter stormwater drainage systems where they can be discharged to streams, rivers, or the ocean (CASQA 2015). Testing has found that zinc leaches from TWP and into the water column where aquatic species can be exposed (Degaffe and Turner 2011). A significant portion of the zinc from TWP is eventually deposited in sediments at the bottom of the streams, rivers, lakes, and the ocean.

Estimates of the frequency, extent, level, and duration of exposure

CASQA identifies TWP and galvanized metal surfaces as two major sources of zinc in urban stormwater in California, estimating tires discharge over 500,000 pounds of zinc to stormwater in Los Angeles County each year (CASQA 2015).

The frequency, extent, and amount of zinc released to the aquatic environment by stormwater depends on the weather. During dry weather, TWP build up on roads and nearby surfaces. During the first storm after a dry period, commonly referred to as the first flush, significant amounts of TWP can be washed away, resulting in high levels of zinc in stormwater. The petition states that this is particularly significant in California for two reasons. First, California experiences longer periods between storms than many other parts of the country, increasing the potential for more particles to build up and be discharged to waterbodies when it does rain. Second, many California waterways have little or no flow during summer months, reducing the dilution of stormwater when it is discharged. In some cases, wet-weather zinc plumes from inland waterways have been shown to extend more than two miles into the ocean (Bay et al. 1999).

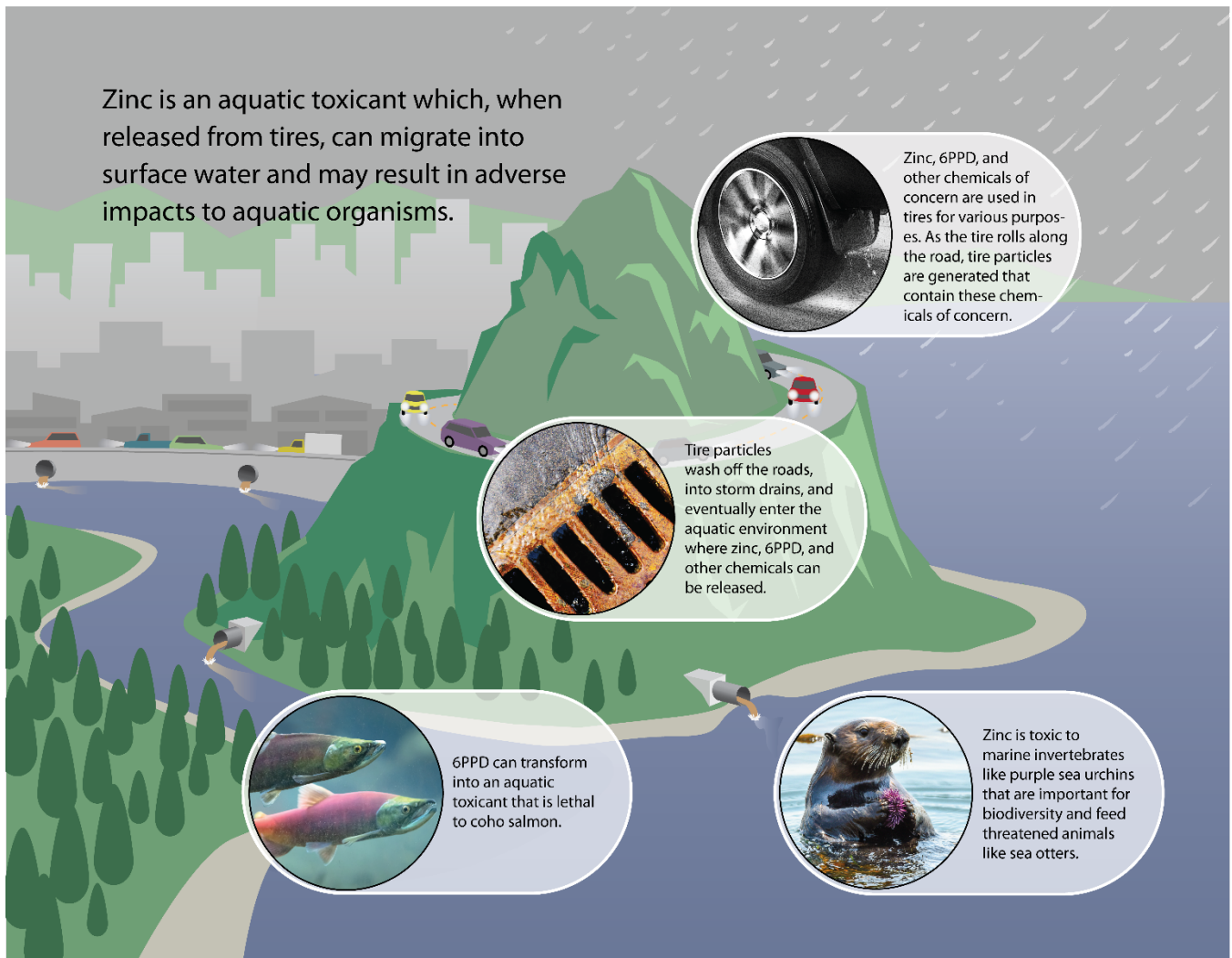


Figure 1. Environmental release of tire-related chemicals and their impacts on sensitive aquatic ecosystems.

Indicators of potential exposures

The petition includes environmental monitoring data demonstrating the presence of zinc in California stormwater in concentrations that may cause or contribute to exceedances, in receiving waters, of water quality standards established by U.S. EPA and the State Water Board. Waterbodies in California with ongoing exceedances of water quality standards can be listed as impaired under the Clean Water Act (CWA). The most recent update of the CWA 303(d) list identifies 37 waterbodies, spanning 17 counties across the state, as impaired due to zinc; these numbers do not include exceedances attributable to mining activities (State Water Board 2021).

The petition asserts that compliance with water quality requirements can require the expenditure of significant amounts of public funds but does not present specific cost estimates or examples, only stating that high costs make treating stormwater to remove zinc generally infeasible. During its review of the petition, DTSC found evidence supporting this claim. For example, the Enhanced Watershed Management Programs for Ballona Creek and Upper Los Angeles River watersheds estimate the total capital costs of projects required to meet applicable zinc limits to be in excess of \$5.8 billion and the total operations and maintenance costs to exceed \$249 million per year (BC WMG 2016; ULAR WMG 2016).

End-of-Life

The petition cites two studies from Texas showing substantially higher zinc levels in stormwater runoff from asphalt formulated with tire rubber than without. Recycled tires are also used in other applications, notably playgrounds and athletic fields. However, the relative contributions of these sources to zinc concentrations in stormwater are likely to be minor.

5. POTENTIAL FOR SIGNIFICANT OR WIDESPREAD ADVERSE IMPACTS

This section integrates the information provided in the petition to demonstrate how the key prioritization principles, as identified in the SCP regulations, are met.

Reference: California Code of Regulations, title 22, section 69503.2(a).

Zinc released from motor vehicle tires may contribute to significant and widespread adverse impacts to aquatic organisms in California. As outlined above, TWP can contribute significant quantities of zinc to stormwater, which represents a major source of zinc to aquatic environments. The petition indicates that studies have found tire leachate is toxic to aquatic organisms and that this toxicity is attributable both to zinc and to organic compounds (Wik et al. 2009).

The petition outlines three lines of evidence for the potential for significant or widespread impacts to aquatic organisms from zinc in motor vehicle tires:

- exceedances of regulatory water quality standards;
- lab studies on the effects of stormwater-influenced water samples on aquatic organisms; and
- special handling efforts required of California stormwater agencies to attempt to mitigate adverse impacts of zinc in stormwater.

Water Quality Standard Exceedances

U.S. EPA and the State Water Board set water quality standards to ensure protection of aquatic species and beneficial uses of waterbodies (State Water Board 2017). Per the SCP regulations, exceedances of water quality standards are an indicator of exposure as well as adverse environmental impacts (California Code of Regulations, title 22, section 69501.1(a)(4) and 69501.1(a)(58)). There are 37 California waterbodies listed as impaired on the CWA 303(d) list due to exceedances of zinc water quality standards (State Water Board 2021). These exceedances indicate the potential for significant adverse impacts to aquatic organisms in these waterbodies. The petition states that the number of waterbodies listed as impaired may increase as monitoring is expanded.

Lab Studies with Contaminated Environmental Media

The petition highlights several instances where researchers have assessed the toxicity of stormwater, receiving water, or discharge plumes to aquatic organisms. In these experiments, researchers expose organisms—often the purple sea urchin (*Strongylocentrotus purpuratus*)—to samples they have collected to assess their toxicity. Further investigation can pinpoint the compound(s) responsible for this toxicity.

Several studies conducted in Southern California, using samples collected at the point of stormwater discharge and in receiving waters, indicate that zinc has either caused or contributed to toxicity to local aquatic organisms (Bay et al. 1999; Schiff et al. 2002; Schiff et al. 2003). In some instances, these toxic effects continue to be observed even when test organisms are exposed to samples that have been diluted ten to one with clean water (Bay et al. 1999). Even in larger waterbodies, evidence of aquatic toxicity can be observed long distances from stormwater discharges, despite dilution. One study found that stormwater collected from a plume that extended over 2 kilometers offshore from the mouth of Ballona Creek exhibited aquatic toxicity due to its zinc content (Bay et al. 1999), while another study estimated a 2.25 square-kilometer area of San Diego Bay is contaminated with toxic levels of zinc from stormwater released from Chollas Creek (Schiff et al. 2003).

The petition indicates that the first storms of the rain season result in particularly toxic stormwater as accumulated TWP and other chemicals and debris are washed off roads. This runoff has been shown to be between two and 10 times more toxic than stormwater from later storms (Bay et al. 1999). As

detailed above, this is particularly relevant in Southern California, which can go months with no rain, resulting in a large amount of TWP accumulation on the roads (Schiff et al. 2003).

Studies using the purple sea urchin fertilization bioassay provide some of the strongest evidence for the toxicity of zinc in stormwater (Bay et al. 1999; Schiff et al. 2003). As a native organism, the purple sea urchin is a standard representative model for marine ecotoxicological screens in California (U.S. EPA 1995; Phillips et al. 1998; OEHHA 2004). Developmental and reproductive endpoints such as fertilization are commonly used in ecotoxicological screens because they are sensitive to contaminants and are ecologically relevant (Hudspith et al. 2017). The purple sea urchin and many other marine species reproduce through broadcast spawning (external fertilization), and previous studies have linked exposure of metals in marine systems with the potential to disrupt fertilization in broadcast spawning invertebrates (Hudspith et al. 2017; Han et al. 2019). Such effects may impair population recruitment and maintenance. Stormwater exposure would be expected to occur when purple sea urchins spawn in the late fall and winter (Pearse et al. 1986). The evidence for stormwater toxicity toward sea urchin fertilization demonstrates the potential for adverse population effects in other broadcast spawners as well.

The toxicity of zinc in stormwater may have ecological consequences beyond the impacts to purple sea urchin development. Purple sea urchins serve as ecosystem engineers that regulate algae growth and are a food source for threatened animals, including sea stars and otters. Sunflower stars, which are listed as critically endangered by the International Union for Conservation of Nature due to the effects of sea star wasting syndrome, preferentially feed on purple sea urchins (McGaw and Twitchit 2012; Burt et al. 2018). Southern sea otters, listed as a threatened species by the U.S. Fish and Wildlife Service, consume purple sea urchins frequently enough that their teeth often exhibit a purple discoloration known as echinochrome staining (Winer et al. 2013). A recent census suggested a correlation between sea urchin abundance and southern sea otter population (USGS and DOI 2019). Thus, zinc-induced toxicity in sea urchins could adversely affect sea otter recovery efforts.

Special Handling to Mitigate Adverse Impacts

Zinc from motor vehicle tires also contributes to adverse impacts as evidenced by the special handling needed by stormwater agencies to mitigate the impacts of zinc to the aquatic environment. This is of particular concern given that the special handling needed to reduce zinc contamination of stormwater is not always financially or technically feasible. Per the petition, some of these efforts are already in place (e.g., street sweeping), yet ongoing zinc contamination of stormwater indicates that they are insufficient. Physical treatment of stormwater through filtration and other approaches is expensive and infeasible in some parts of California due to the infrastructure needed to capture and store runoff. Additionally, redirection of stormwater for infiltration into groundwater requires significant land availability and may also require storage and treatment before discharge. Ultimately, as the petition

highlights, source control of zinc is a far more effective option to mitigate zinc contamination of California aquatic ecosystems.

6. OTHER REGULATORY PROGRAMS

Reference: California Code of Regulations, title 22, section 69503.2(b)(2).

When deciding whether to list a product-chemical combination as a Priority Product, DTSC must consider other California and federal laws that regulate the product or the Candidate Chemical in the product and the extent to which these other regulations provide adequate protections with respect to the same exposures and adverse impacts. If the exposures or impacts are regulated by another entity, DTSC may only list a product-chemical combination as a Priority Product if it determines that doing so would meaningfully enhance protection of public health or the environment.

DTSC has assessed all applicable state and federal laws and regulations and international treaties or agreements with the force of domestic law related to the proposed Priority Product and the Candidate Chemical in the product. The results of these assessments are summarized below. DTSC has determined that these programs do not overlap or conflict with this proposal to list motor vehicle tires containing zinc as a Priority Product, nor with any subsequent regulatory response that may result from such listing.

Regulations Addressing the Same Exposures and Impacts

The CWA prohibits the discharge of stormwater containing pollutants without a National Pollutant Discharge Elimination System (NPDES) permit. U.S. EPA delegates this federal permitting program to the state of California. California's Municipal Storm Water Program manages NPDES permits for municipalities and the statewide permit for the California Department of Transportation. These permits are intended to address the same potential exposures and impacts described in the petition. In its petition, CASQA asserts these requirements do not provide adequate protection.

DTSC has determined that listing motor vehicle tires containing zinc as a Priority Product could meaningfully enhance protection to the environment through requiring manufacturers to conduct an Alternatives Analysis to determine if there is a substitute for zinc that is safe for the environment and public health while still meeting performance and safety requirements.

Regulations Addressing the Safety and Performance of Tires

The National Highway Traffic Safety Administration (NHTSA) regulates the safety of tires. NHTSA has established a number of Federal Motor Vehicle Safety Standards setting safety and performance requirements for tires (*Code of Federal Regulations, title 49, subtitle B, chapter V, part 571, subpart B*), including:

- Standard No. 109; New pneumatic and certain specialty tires.
- Tire selection and rims and motor home/recreation vehicle trailer load carrying capacity information for motor vehicles with a gross vehicle weight rating (GVWR) of 4,536 kilograms (10,000 pounds) or less.
- Standard No. 119; New pneumatic tires for motor vehicles with a GVWR of more than 4,536 kilograms (10,000 pounds) and motorcycles.
- Tire selection and rims and motor home/recreation vehicle trailer load carrying capacity information for motor vehicles with a GVWR of more than 4,536 kilograms (10,000 pounds).
- Standard No. 139; New pneumatic radial tires for light vehicles.

DTSC has determined that these regulations do not overlap or conflict with the proposal to list motor vehicle tires containing zinc, as they do not address the potential exposures or adverse impacts under consideration. If motor vehicle tires containing zinc were listed as a Priority Product, they would still be required to meet the same standards for safety and performance. The SCP regulations do not require the evaluation or use of alternatives to a Chemical of Concern that would compromise a Priority Product's compliance with health and safety requirements.

Regulations Addressing the Recycling, Reuse, and Disposal of Tires

Current laws and regulations require people who store, stockpile, accumulate, or discard waste tires to comply with tire storage and disposal standards and to obtain a waste tire facility permit. The California Department of Resources Recycling and Recovery (CalRecycle) is responsible for administering waste tire programs in California and has established technical standards and a permitting program for waste tire facilities (CalRecycle 2021).

DTSC has determined that these regulations do not overlap or conflict with the proposal to list motor vehicle tires containing zinc, as they do not address the potential exposures or adverse impacts under consideration. CalRecycle's waste tire and storage and disposal standards primarily address preventing fires and the breeding of mosquitoes, rodents, and other pests. If motor vehicle tires containing zinc were listed as a Priority Product, they would still be subject to the same requirements.

7. POTENTIAL ALTERNATIVES

Reference: California Code of Regulations, title 22, section 69503.2(b)(3).

This section summarizes information available to DTSC regarding alternatives that may or may not be safer than the Candidate Chemical. DTSC does not need to ensure that these alternatives are safer and may summarize their associated hazards to illustrate readily available information. The sections below may include information such as how readily available an alternative is, product functions addressed by the alternative, and implications for manufacturers using the alternative (e.g., use limitations, product reformulation, different equipment needs).

The CASQA petition observes, “Safer alternatives are tires containing less zinc or no zinc. Materials used to replace zinc would also need to not present a risk to water quality or public health.” The vulcanization process apparently involves formation of intermediate zinc complexes and suggests that other metals could be used instead of zinc (Mostoni et al. 2019). Alternatives such as cadmium, lead, and mercury are unsuitable due to their toxicity. The petition refers to one published study that discusses magnesium as a possible substitute for some, if not all, of the zinc used in tires; however, the ramifications of this substitution for tire performance and human and environmental health are unclear. Strategies to use less zinc focus on making it more available to participate in the chemical reactions involved in vulcanization. Technologies that enhance the dispersion of zinc in rubber during vulcanization and thereby improve the efficiency of the process may allow tire manufacturers to use less zinc without diminishing the quality of the finished product (Mostoni et al. 2019). The Alternatives Analysis required by the SCP regulations is designed to answer the question of whether such technologies are available and feasible.

8. CONCLUSIONS

The presence of zinc in motor vehicle tires and its release from TWP expose aquatic organisms in California waterways to this toxic metal. TWP contribute to exceedances of water quality regulatory thresholds for zinc and violations of stormwater permits. Exposures to zinc from TWP can cause or contribute to significant and widespread adverse impacts to aquatic organisms in California. Lab studies have documented these adverse impacts, and local governments have had to spend public funds to implement special handling measures to mitigate them. Based on its evaluation of CASQA’s petition and the factors discussed above, DTSC has concluded that there is sufficient information regarding potential exposures and adverse impacts from motor vehicle tires containing zinc to designate this as a Priority Product.

ACRONYMS AND ABBREVIATIONS

CalRecycle	California Department of Resources Recycling and Recovery
CASQA	California Stormwater Quality Association
CWA	Clean Water Act
DTSC	Department of Toxic Substances Control
GVWR	Gross Vehicle Weight Rating
GPC	GS1 Global Product Classification
NHTSA	National Highway Traffic Safety Administration
NPDES	National Pollutant Discharge Elimination System
NAICS	North American Industry Classification System
SCP	Safer Consumer Products
State Water Board	State Water Resources Control Board
SUV	Sport Utility Vehicle
TWP	Tire wear particles
U.S. EPA	United States Environmental Protection Agency
Zn	Zinc
ZnO	Zinc oxide

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APPENDIX A: POTENTIAL RELEVANT FACTORS

Non-exhaustive list of adverse impact factors that may be relevant to this proposed Priority Product

Relevant factors are used in SCP's Alternatives Analysis (AA) to make a focused and meaningful comparison of adverse impacts during the product's life cycle between the Product Profile and alternative. This Profile has identified adverse impacts in the following categories:

- Adverse environmental impacts
- Adverse waste and end-of-life effects
- Environmental fate
- Associated exposure pathways and life cycle segments
 - Use
 - Operation and maintenance
 - Waste generation and management
 - Reuse and recycling
 - End-of-life disposal

At a minimum, all AAs submitted for this product-chemical combination must include a discussion of these impacts and how they compare between the Priority Product and whatever alternative(s) have been identified at the appropriate point in the lifecycle. This list is not intended to be comprehensive. Also, alternatives evaluated in the AA report will likely have additional adverse impacts that don't apply to the Priority Product; these will also need to be assessed in the AA report. Product performance and economics are generally not evaluated in the Profile.

APPENDIX B: REPORT PREPARATION

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