California Multimedia Evaluation of Gasoline Containing up to 15 percent Ethanol (E15)

Staff Written Summary

December 2025

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List of Acronyms and Abbreviations

ATDS	Automotive Testing and Development Services, Inc.
BTEX	Benzene, Toluene, Ethylbenzene, m/p Xylenes, o-Xylenes
CalEPA	California Environmental Protection Agency
CARB	California Air Resources Board
CARBOB	California Reformulated Gasoline Blendstock for Oxygenate Blending
CaRFG	California Phase 3 Reformulated Gasoline
CCR	California Code of Regulations
CEPC	California Environmental Policy Council
CE-CERT	University of California Bourns College of Engineering - Center for Environmental Research and Technology
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DPR	Department of Pesticide Regulation
DTSC	Departement of Toxic Substance Control
E0	Gasoline without Ethanol
E10	Gasoline-Ethanol Fuel Blend of 10 Percent by Volume Ethanol
E15	Gasoline-Ethanol Fuel Blend of 15 Percent by Volume Ethanol
EPA	U.S. Environmental Protection Agency
GDI	Gasoline Direct Injection
GHG	Greenhouse Gas
HSC	Health and Safety Code
MMWG	Multimedia Working Group
MMP	Misfueling Mitigation Plan
MY	Model Year
N_2O	Nitrous Oxide
NH_3	Ammonia
NMHC	Non-Methane Hydrocarbons
NOx	Oxides of Nitrogen
OEHHA	Office of Environmental Health Hazard Assessment
PAH	Polycyclic Aromatic Hydrocarbon
PFI	Port Fuel Injection
PM	Particulate Matter
THC	Total Hydrocarbons
UST	Underground Storage Tanks
VOC	Volatile Organic Compounds

1. Staff Written Summary

A. INTRODUCTION

CARB is authorized to adopt standards, rules and regulations to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish California's attainment of the state and federal ambient air quality standards at the earliest practicable date. Before regulations establishing new fuel specifications can be adopted, California Health and Safety Code (HSC) section 43830.8 requires a multimedia evaluation to be conducted and reviewed by the California Environmental Policy Council (CEPC).[1] The purpose of the multimedia evaluation is to develop information on the potential impacts of new fuels on environmental and human health.

Growth Energy and the Renewable Fuels Association (RFA) prepared a multimedia evaluation of gasoline-ethanol blends based on the addition of 10.5 to 15 percent by volume denatured fuel ethanol with California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB) approved for use under the California Reformulated Gasoline Regulations (CaRFG), referred to as E15. The Multimedia Working Group (MMWG), an interagency staff team described below, was established to oversee the multimedia evaluation process and make recommendations to the CEPC regarding the acceptability of new fuel specifications proposed for use in the State.

This Staff Written Summary was developed by the MMWG and includes: an assessment of the E15 multimedia evaluation prepared by Growth Energy and the Renewable Fuels Association. The Written Summary includes an analysis of potential significant adverse impacts on public health and the environment and the conclusions and recommendations of the MMWG for consideration by the CEPC. A draft version of the Staff Written Summary was provided to Scientific Peer Reviewers as described in section A.1.c. below. This final version incorporates comments from the Peer Reviewers, where appropriate, and the introductory sections and format were edited from the draft version for clarity and concision and to ensure the format supports distribution.

1. Multimedia Evaluation

HSC section 43830.8 defines "multimedia evaluation" as the identification and evaluation of any significant adverse impact on public health or the environment, including air, water, or soil, that may result from the production, use, or disposal of the motor vehicle fuel that may be used to meet the state board's motor vehicle fuel specifications.[2]

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[1] Health & Saf. Code, § 43830.8.

[2] Health & Saf. Code, § 43830.8(b).

The multimedia evaluation must address:

- Emissions of air pollutants, including ozone forming compounds, particulate matter, toxic air contaminants, and greenhouse gases.
- Contamination of surface water, groundwater, and soil.
- Disposal or use of the byproducts and waste materials from the production of the fuel.

a. Overview of the Multimedia Evaluation Process

A multimedia evaluation consists of three tiers conducted by the fuel applicants seeking approval of the proposed fuel and overseen by the MMWG with CARB leading coordination between parties. In Tier I, a report is developed summarizing what is known about the fuel and identifying the information needed for the impact and risk assessment, currently available information and key knowledge gaps, if any exist. The Tier I report also establishes a scope and plan for additional evaluation and experiments needed to address any identified knowledge gaps. Tier II includes the development and review of analyses and experiments to address any knowledge gaps identified during Tier I and culminates in a Tier II experimental report. The MMWG reviews the Tier II report and all experiments and analyses conducted. The next step in the multimedia evaluation is the completion and review of the Tier III Multimedia Risk Assessment according to the agreed upon protocol developed through Tiers I and II. A final Tier III report, which incorporates the Tier I and Tier II reports, is produced and used as the basis for MMWG review and development of recommendations by the MMWG to the CEPC. At this point, the MMWG prepares a draft Staff Written Summary with recommendations to the CEPC. The draft Staff Written Summary Tier III report and Tier reports with all supporting documentation undergo independent peer review. Following the peer review, the MMWG reviews and prepares responses to all peer reviewer comments and develops a Final Staff Written Summary, incorporating peer review comments where appropriate.

Figure 1 below provides a graphical overview of the MME process. The process is described in its entirety in the 2016 MME guidance document[3] on CARB's website.

[3] https://ww2.arb.ca.gov/sites/default/files/2019-11/fuels_multimedia_guidance_mar2016.pdf

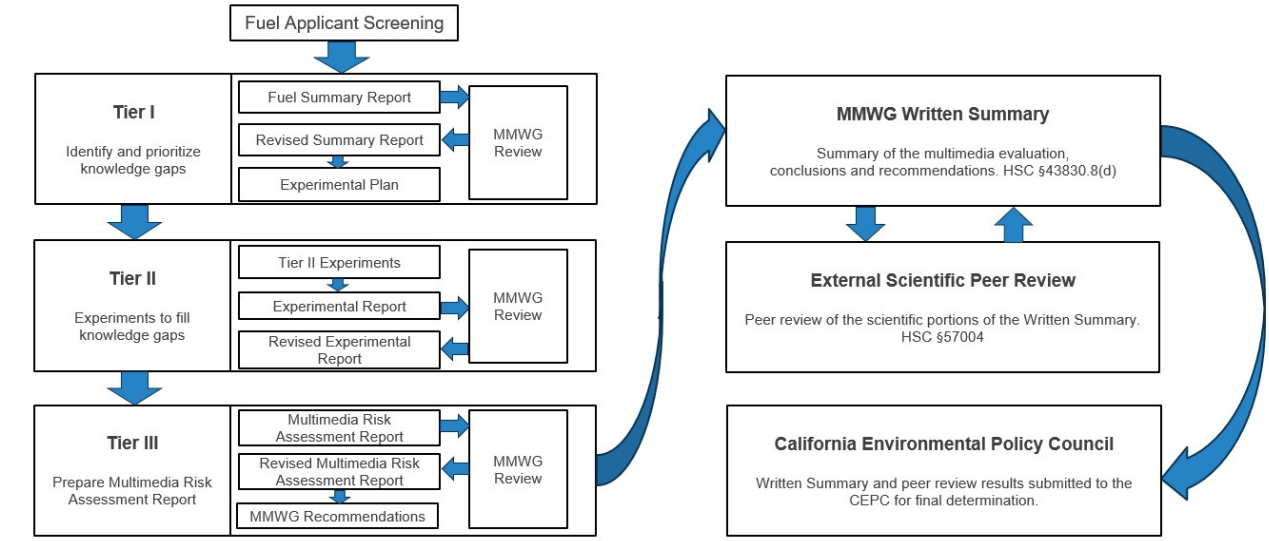

Figure 1. Multimedia Evaluation Process

For the E15 multimedia evaluation, the Tier I and Tier II Reports are available as individual reports, however, the Tier III Report incorporates the Tier I and Tier II Reports as appendices and therefore the Tier III Report provides all multimedia evaluation materials. The Tier III Report, including the Tier I and Tier II reports, is included as Appendix A to this document. All reports are also available on *CARB's Fuels Multimedia Evaluation of E15 webpage*.

b. Multimedia Working Group

The California Environmental Protection Agency (CalEPA) formed the interagency MMWG to oversee the multimedia evaluation process and make recommendations to the CEPC. The MMWG is composed of representatives from CalEPA boards department and offices, including CARB, the State Water Resources Control Board (State Water Board), the Office of Environmental Health Hazard Assessment (OEHHA), the Department of Toxic Substances Control (DTSC), and the Department of Pesticide Regulation (DPR). The MMWG also consults with other agencies, such as the State Fire Marshal, as needed.

For the MMWG analysis of the E15 multimedia evaluation, CARB staff was responsible for the air quality impact assessment and overall coordination of the multimedia evaluation process. OEHHA staff was responsible for evaluating potential public health impacts, State Water Board staff was responsible for evaluating potential surface water and groundwater quality impacts, and DTSC staff was responsible for evaluating potential hazardous waste and soil impacts.

c. External Scientific Peer Review

HSC section 43830.8(d) requires an external scientific peer review of the multimedia evaluation be conducted pursuant to HSC section 57004. The purpose of the peer

review is to determine whether the scientific portions of the MMWG Written Summary are based upon "sound scientific knowledge, methods, and practices."[4] The CalEPA External Scientific Peer Review Program manages the processes CalEPA boards, departments and offices use to comply with HSC section 57004 when a formal external scientific peer review is required.[5]

For the E15 multimedia evaluation, CARB coordinated with the CalEPA External Scientific Peer Review Program to complete the scientific peer review and the materials from that review including individual peer reviewer reports and agency responses to comments are included in Appendix C.

d. California Environmental Policy Council

Pursuant to Public Resources Code section 71017(b), the CEPC is comprised of the Secretary for Environmental Protection; the Chairpersons of CARB and the State Water Board; and the Directors of OEHHA, DTSC, DPR, and the Department of Resources Recycling and Recovery. As noted above, HSC section 43830.8 requires that CARB may not adopt any regulation that establishes a specification for motor vehicle fuel unless that regulation, and a multimedia evaluation is reviewed by the CEPC.

If the CEPC determines that the use of fuels according to the proposed regulation will cause a significant adverse impact on public health or the environment, or that alternatives exist that would be less adverse, the CEPC shall recommend alternative measures that CARB or other state agencies may take to reduce the adverse impact on public health or the environment. According to HSC section 43830.8(e), the CEPC is required to complete its review of the multimedia evaluation and proposed regulation within 90 calendar days following CARB providing a draft proposed regulation and notice of intent to adopt the regulation.

In the case of the E15 multimedia evaluation, CARB has not yet developed proposed regulatory language. When completed, the proposed regulations will be provided to the CEPC to support their final review of all materials.

2. E15 Fuel Information

Title 40, Code of Federal Regulations, section 1090.80 defines E15 as gasoline that contains more than 10 and no more than 15 volume percent ethanol. The CaRFG Regulations currently permit the sale of gasoline with up to 10 percent ethanol by volume (E10). As noted in the introduction, the E15 test fuels evaluated under this multimedia evaluation were composed of fuel grade denatured ethanol, pursuant to

[4] Health & Safety Code, §57004(d)(2).

[5] State Water Resources Control Board. *External Scientific Peer Review* website. *https://www.waterboards.ca.gov/resources/peer_review/#stay-informed*.

ASTM D4806[6] and California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB).[7]

a. Federal Considerations

In 2011, the U.S. Environmental Protection Agency (EPA) granted partial waivers that allow E15 use for light-duty conventional vehicles of model year (MY) 2001 and newer, subject to certain conditions.[8] These waivers do not apply in California. EPA placed two types of conditions on the waivers for E15 use in other states:

1) Fuel quality conditions:
   - Ethanol used for E15 must meet ASTM International D4806-10.
   - Reid Vapor Pressure is limited to 9.0 pound per square inch during the summertime.
2) Misfuelling mitigation conditions:

   Fuel and fuel additive manufacturers subject to the waivers must submit to EPA a misfuelling mitigation plan (MMP), for EPA's approval, and must fully implement the EPA-approved MMP prior to introduction of E15. Reasonable precautions in an MMP must include, but are not limited to, the following conditions:
   - Labels must be placed on E15 retail dispensers indicating that E15 use is only for MY 2001 and new motor vehicles.
   - Product Transfer Documents must accompany all transfers of fuels for E15 use.
   - Parties involved in the manufacture of E15 must participate in a survey of compliance at fuel retail dispensing facilities.
   - Any other reasonable measures EPA determines are appropriate.[9]

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[6] ASTM International. *ASTM D4806. Standard Specification for Denatured Fuel Ethanol Blending with Gasoline for Use as an Automotive Spark-Ignition Engine Fuel*. Oct 19, 2021.

[7] , Cal. Code of Regs., tit. 17 § 2250-2273.5.

[8] U.S. Environmental Protection Agency. *Final Rule: Regulation to Mitigate the Misfueling of Vehicles and Engines with Gasoline Containing Greater than Ten Volume Percent Ethanol.* *https://www.epa.gov/gasoline-standards/final-rule-regulation-mitigate-misfueling-vehicles-and-engines-gasoline*.

[9] U.S. Environmental Protection Agency. *Regulation History of the E15 Partial Waivers Under the Clean Air Act. EPA-420-F-15-044.* *https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100QJTU.pdf*. September 2015.

Nationwide, outside of California, over 3,000 gasoline stations sell E15, accounting for about 2% of all gasoline stations across the country.[10,11] Currently, those retail stations offering E15 outside of California utilize a separate underground storage tank (UST) to accommodate E15.

B. MMWG E15 MULTIMEDIA EVALUATION SUMMARIES

This section provides summaries of the evaluations and analyses prepared by CARB, the State Water Board, OEHHA and DTSC. The evaluations are based on the relative differences between E10 that meets CaRFG Regulations and E15 as described above. The complete evaluations and supporting documentation are provided as appendices of this report.

1. California Air Resources Board Evaluation

CARB staff completed an air quality assessment of E15. The evaluation includes a description of the E15 emissions test programs and impact analyses on air emissions, including regulated emission, toxic air contaminants and evaporative emissions. The complete report is provided in Appendix B. Staff's assessment is based on the data and information provided for the E15 multimedia evaluation, including the fuel applicants' multimedia reports (Final Tier I, Tier II, and Tier III Reports); and the studies in the Tier II report including the "*Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15*" (Exhaust Emissions Study)[12] by the University of California Bourns College of Engineering - Center for Environmental Research and Technology (CE-CERT); and the "*Comparison of Evaporative Emissions Between E10 CaRFG and Splash Blended E15*" (Evaporative Emissions Study)[13] by Automotive Testing and Development Services, Inc. (ATDS).

Exhaust and evaporative emissions testing were conducted to determine the emissions impacts of E15 compared to E10 gasoline meeting CaRFG Regulations. The baseline E10 fuel used for testing was a summer-grade CaRFG sourced from four different refineries. The E10 fuels were blended in four equal parts to create the final E10 fuel. The E15 test fuel was created by splash blending denatured ASTM D4806 fuel grade ethanol with the final E10 fuel. CE-CERT supplied the same E10 and E15

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[10] U.S. Department of Energy. Alternative Fuels Data Center. *E15*. *https://afdc.energy.gov/fuels/ethanol-e15*.

[11] API. America's *Service Station FAQs*. *https://www.api.org/oil-and-natural-gas/consumer-information/consumer-resources/service-station-faqs.aspx*.

[12] Karavalakis, G., Durbin T.D., & Tang, T. *Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15*. June 2022. *https://ww2.arb.ca.gov/sites/default/files/2022-07/E15_Final_Report_7-14-22_0.pdf*.

[13] Automotive Testing and Development Services, Inc. *Comparison of Evaporative Emissions Between E10 CaRFG and Splash Blended E15*. January 2022.

fuels that were used in the Exhaust Emissions Study to ATDS for the Evaporative Emissions Study.[14,15]

Exhaust emissions testing was performed on twenty light-duty vehicles that were selected to provide a wide range of makes, models, technology standards, and sizes. The test matrix included eleven vehicles with gasoline direct injection (GDI), six vehicles with port fuel injection (PFI) and two PFI+GDI fuel systems that are representative of the current California gasoline fleet. One hybrid electric vehicle equipped with a PFI engine was also used. All vehicles were equipped with three-way catalysts.[16] Evaporative emissions testing was conducted on a subset of the vehicles tested in the Exhaust Emissions Study, including a 2016 Nissan Rogue, 2020 Jeep Cherokee, 2020 Jeep Compass, 2019 RAV4, and a 2021 Hyundai Accent.[17]

a. Health-Relevant Air Emissions

Emissions testing conducted as part of the Exhaust Emissions Study focused primarily on regulated emissions, including nitrogen oxides (NOx), carbon monoxide (CO), total hydrocarbons (THC), nonmethane hydrocarbons, carbon dioxide (CO_2), methane (CH_4), and particulate matter (PM). More extensive testing, including toxics analyses, was completed as part of the study.[18]

Results generally found that most regulated emissions from E15 are reduced compared to E10, including PM, CO and THC. Weighted PM, CO and THC emissions showed a statistically significant reduction of 18%, 17% and 5%, respectively, for E15 compared to E10 across the entire fleet of 20 vehicles. NOx did not show any statistically significant difference between the fuels.[19] Results are considered "statistically significant" if the associated p-values are less than 0.05, which represent a 95 percent confidence level. Results are considered "marginally statistically significant" if the associated p-values are greater than or equal to 0.05 and less than 0.1.

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[14] Karavalakis, G., Durbin T.D., & Tang, T. *Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15.* June 2022. *https://ww2.arb.ca.gov/sites/default/files/2022-07/E15_Final_Report_7-14-22_0.pdf*.

[15] Automotive Testing and Development Services, Inc. *Comparison of Evaporative Emissions Between E10 CaRFG and Splash Blended E15.* January 2022.

[16] Karavalakis, G., Durbin T.D., & Tang, T. *Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15.* June 2022. *https://ww2.arb.ca.gov/sites/default/files/2022-07/E15_Final_Report_7-14-22_0.pdf*.

[17] Automotive Testing and Development Services, Inc. *Comparison of Evaporative Emissions Between E10 CaRFG and Splash Blended E15.* January 2022.

[18] Karavalakis, G., Durbin T.D., & Tang, T. *Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15.* June 2022. *https://ww2.arb.ca.gov/sites/default/files/2022-07/E15_Final_Report_7-14-22_0.pdf*.

[19] Karavalakis, G., Durbin T.D., & Tang, T. *Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15.* June 2022. *https://ww2.arb.ca.gov/sites/default/files/2022-07/E15_Final_Report_7-14-22_0.pdf*., page vi.

Toxics emissions tests were conducted for various carbonyl compounds and hydrocarbon species, including benzene, toluene, ethylbenzene, m/p-xylenes, o-xylenes (BTEX), 1,3-butadiene, formaldehyde, acetaldehyde and ethanol emissions. Toxics results show statistically significant reductions in ethylbenzene (11%) and increases in acetaldehyde (32%) and ethanol (77%). As expected, acetaldehyde and ethanol emissions were consistently higher for E15 compared to E10 as acetaldehyde emissions are a function of ethanol content. Cumulative BTEX emissions results for benzene and toluene did not show any statistically significant differences between E10 and E15. For m/p-xylenes and o-xylene emissions, E15 showed marginally statistically significant reductions of 10% and 9%, respectively. 1,3-butadiene and formaldehyde emissions results did not show any statistically significant difference between E10 and E15.[20]

b. Climate-Relevant Air Emissions

Gases that trap heat in the atmosphere are called greenhouse gases (GHGs). GHG emissions are primarily CO_2, CH_4, nitrous oxide (N_2O), and hydrofluorocarbons.[21] Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years.[22] GHG emissions from the use of fuels are primarily CO_2.[23]

Weighted CO_2 emission results from the study did not show any statistically significant differences between E10 and E15. In general, any increase in CO_2 emissions would not necessarily suggest that the fuel leads to an overall increase in carbon emissions. Most THC and CO convert to CO_2 in the atmosphere, so total CO_2 produced by the combustion process is determined by direct CO_2 emissions, as well as THC and CO. As previously stated, weighted CO and THC emissions showed a statistically significant reduction of 17% and 5%, respectively, for E15 compared to E10 across the entire fleet of 20 vehicles.[24]

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[20] Karavalakis, G., Durbin T.D., & Tang, T. *Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15.* June 2022. *https://ww2.arb.ca.gov/sites/default/files/2022-07/E15_Final_Report_7-14-22_0.pdf*. Page 44.

[21] California Air Resources Board. *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles.* August 6, 2004. Page i.

[22] United States Environmental Protection Agency. *Overview of Greenhouse Gases* website. *https://www.epa.gov/ghgemissions/overview-greenhouse-gases*. Accessed November 20, 2024.

[23] California Air Resources Board. *Proposed Re-Adoption of the Low Carbon Fuel Standard. Staff Report: Initial Statement of Reasons.* December 2014, ES-2. *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2015/lcfs2015/lcfs15isor.pdf*.

[24] Karavalakis, G., Durbin T.D., & Tang, T. *Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15.* June 2022. *https://ww2.arb.ca.gov/sites/default/files/2022-07/E15_Final_Report_7-14-22_0.pdf*. Page 54.

c. Secondary Air Pollutants

Secondary pollutants form in the atmosphere through chemical and photochemical reactions from other primary pollutants. An example includes ozone, which is formed when hydrocarbons and NOx combine in the presence of light. Its precursor components are primarily the result of road traffic. Unlike many of the other GHGs, ozone is a short-lived gas that is found in regionally varying concentrations.

Both THC and NOx emissions determine ozone concentrations. As previously stated, THC emissions showed statistically significant reductions. NOx did not show any statistically significant difference between E10 and E15.

2. State Water Resources Control Board Evaluation

State Water Board staff have completed the evaluation of potential surface water and groundwater impacts from E15 fuel. Staff based their assessment on the information provided in the multimedia evaluation reports (Final Tier I, Tier II and Tier III Reports). The multimedia evaluation and State Water Board assessment of environmental impacts is specific to the difference between E15 and E10. The complete evaluation is provided in Appendix B.

a. Water Impacts

State Water Board staff reviewed the exposure data comparing the effects of E15 and E10. Human and ecological risks associated with E15 blends would not be significantly different than those present from the widespread use of E10.

b. Underground Storage Tank Material Compatibility and Leak Detection

California statutes require underground storage tank systems to be compatible with the substance stored, and the leak detection equipment to be able to function appropriately with the substance stored. Incompatibility increases the risk of unauthorized releases.

UST regulations require the storage of substances not certified as compatible by an independent testing organization, typically Underwriters Laboratories (UL), if the manufacturer of the components provides affirmative statements of compatibility. Fiberglass USTs manufactured before April 1, 1990 (Xerxes) and July 1, 1990 (Owens Corning) cannot be certified by UL and both manufacturers only will certify compatibility with fuel blends containing 10 percent ethanol or methanol.

California maintains approximately 35,000 secondarily contained USTs, of which 5,100 USTs and (estimated) 2,000 additional piping systems are not compatible with E15. Additionally, UST system upgrades require local agency permitting and review, and typically also require additional property improvements associated with local planning and fire code.

c. Biodegradability and Fate and Transport

Researchers provided data on the impacts of fate and transport properties of E15 compared to E10. Fate and transport, as well as biodegradability, are not expected to be significantly different given the similar chemical composition of E15 and E10.

d. Waste Discharge from Manufacturing

Chemicals used in, and byproducts created by, the production of the fuel are required to comply with hazardous waste laws and regulations. No significant areas of concern have been identified by staff when comparing the waste streams of E15 to E10.

3. Office of Environmental Health Hazard Assessment Evaluation

OEHHA staff evaluated potential public health impacts from the use of E15 based on review of the Tier Reports and focused on the comparison of toxicity between E15 and E10. The evaluation includes a brief description of OEHHA's previous assessment on health risks of ethanol in fuel, a summary of findings on comparative toxicity from the Tier I Report, and a summary of findings on comparative exposure from the Tier I and II Reports. The complete evaluation is provided in Appendix B.

a. OEHHA's previous assessment on the health risks of ethanol in gasoline

OEHHA previously assessed the potential health risks of ethanol in fuel, as an alternative oxygenate to methyl tertiary-butyl ether. In general, the addition of ethanol to fuel did not present significant risks to public health. The health risks associated with fuel stemmed primarily from the hydrocarbon portion of the fuel, including BTEX, its combustion byproducts (e.g., acetaldehyde, formaldehyde, and 1,3-butadiene), and secondary transformation products that may form in the atmosphere.

These compounds remain a concern with E15 fuels; although, the increase in the percent volume of ethanol from 10% to 15% leads to a percent volume decrease of some of the other constituents of the fuel.

b. Summary of findings on comparative toxicity

The Tier I Report summarized the results of a literature review of studies comparing the toxicity of ethanol blended fuels, including gasoline without ethanol (E0) and blends up to E85. The Tier I Report included studies published through early 2018. OEHHA reviewed the summaries of these studies in the Tier I Report, as well as several additional toxicological/mechanistic studies published since 2018. While most of the available studies did not compare E15 and E10 fuels directly, the inclusion of fuels with a wide range of ethanol concentrations in the studies as a whole allowed for quantitative comparisons that enabled the estimation of the toxicity of any blend.

Based on sub-acute studies in experimental animals, E15 does not appear to be more toxic than E10 in relation to maternal, behavioral, immunological, physiological, or cognitive outcomes. Subchronic studies with inhalation exposure to E0 or gasoline

combined with ethanol suggest that evaporative emissions of E15 may not increase health hazard compared to E10, but more comprehensive evaluations are warranted. *In vitro* experiments in human cell lines suggest E15 would not be more potent than E10 in inducing cytotoxic, pro-inflammatory, oxidative stress, mutagenic, or DNA-damage effects. While outside the scope of this study, future studies that are focused on low-dose toxicity assessments and mechanistic toxicity evaluations may be helpful to better understand the potential health risks of E15 versus E10.

Overall, the Tier I Report concludes that the use of gasoline-ethanol blends in the E11 – E15 range would not result in any human public health impacts different from those that already occur with existing E10 fuels. The additional studies do not change the conclusion from the Tier I Report regarding public health impact of E15 compared to E10.

c. Summary of findings on comparative exposure

Exposure scenarios for E15 are expected to be similar to those for E10, and include inhalation, oral ingestion, and dermal contact routes. Inhalation exposure can result from tailpipe emissions and evaporative emissions from vehicles, evaporation of volatile compounds during fuel handling, and vapors from contaminated soil and soil vapor. Dermal exposure can occur during fuel handling and from contact with contaminated soil. Oral exposures can occur through contamination of drinking water supplies. The increased ethanol content in E15 results in a proportional decrease in the hydrocarbon portion of the fuel, resulting in a slight decrease in exposure to key chemicals of concern.

E15 significantly reduces tailpipe emissions of, thereby reducing inhalation exposure to PM, CO, THC, non-methane hydrocarbons (NMHC), and some volatile organic compounds (VOCs), with no increase in NOx or carbon dioxide emissions. There are no statistically significant differences in emissions of several toxic air contaminants compared to E10. While E15 reduces exposure to many pollutants, emissions of ethanol and acetaldehyde were increased compared to E10. However, the increased ethanol concentrations are expected to have no impact on health due to ethanol's low anticipated health risk relative to other fuel-related chemicals of concern and low amount anticipated to be inhaled given the likely outdoor exposure.

Besides tailpipe emissions, inhalation exposure resulting from the evaporation of volatile compounds can occur with vehicle refueling, fuel spills, and fuel transport. Evaporative emissions resulting from the volatilization of compounds from within the fuel system are not expected to differ since E15 and E10 have similar vapor pressures, as described in the Tier I Report. Evaporative emissions testing, detailed in the Tier II Report, found no statistically significant difference between E15 and E10. Exposure can also occur with vapor intrusion from contaminated soil and soil vapor into the indoor air of a building. According to the Tier I Report, the benzene component of E11–15 ethanol-gasoline blends is the primary risk driver for long-term vapor intrusion due to potential preferential degradation of ethanol over BTEX constituents. However,

the report did not specify the duration of "long-term", which may be on the order of years, depending on environmental conditions and the amount of fuel released. The applicability of currently accepted vapor intrusion vertical screening distances to E15 releases is unknown and requires validation, as the distances are based on risk data from E0–E10 fuels.

Oral and dermal exposures are unlikely to differ significantly between E15 and E10. While there is an increase in ethanol content, it is highly volatile and unlikely to contribute additional risk via these exposure routes. The risks associated with exposures to the other constituents of the fuel do not change appreciably and remain similar to the risk associated with E10.

Overall, the Tier I Report concludes that the use of gasoline-ethanol blends in the E11 – E15 range would not result in any release scenarios or environmental impacts different from those that already occur with existing fuels.

4. Department of Toxic Substances Control Evaluation

DTSC staff assessed potential impacts to human health and the environment from the production and use of E15. Staff's evaluation focused on: (1) hazardous waste generation during production, use, and storage of E15 in California, and (2) cleanup of contaminated sites in cases of spills of E15. Please refer to Appendix B for DTSC's complete evaluation.

Today, virtually all gasoline sold in California is E10. E15 has been approved at the federal level. Allowing E15 to replace E10 is one way in which California can make progress towards achieving its goals regarding greenhouse gas emissions. Other potential benefits include, but are not limited to, reduced dependence on petroleum and reductions in several air pollutants.

Production of the increased ethanol that would be necessary to produce E15 is centered around fermentation of renewable organic feedstocks (e.g., sugar crops, corn, sorghum, and grasses) along with certain sugar-containing waste streams such as brewery and dairy wastes. Most ethanol currently consumed in California is derived from corn starch, with smaller amounts from sorghum. The primary co-product of the fermentation process is carbon dioxide. It can be expected that, in order to generate the increased amount of ethanol needed to produce E15, more carbon dioxide will be produced and potentially released. Regulated hazardous wastes are not a byproduct of ethanol production.

Transportation of ethanol used to create E15 blends would be conducted by the existing system of trucks, railcars, or waterborne vessels (e.g., ethanol from Brazil). Ethanol is then stored in dedicated tanks to be blended with petroleum and produced as a finished product for delivery to retail stations. Storage of E15 blends can be conducted in pre-existing approved infrastructure, such as tanks. Storage tanks may be above ground or below ground, with provisions for tank maintenance and monitoring, along with secondary containment, pursuant to 40 Code of Federal

Regulations sections 112 and 280. State regulations for underground storage tanks are also overseen by the SWRCB, see California Code of Regulations, title 23, chapter 16. Tanker truck roadway accidents, which may lead to fuel tank punctures must also be considered, although the likelihood of these accidents is not greater than existing probabilities for E10. As such, the transportation and storage of E15 do not represent an increased risk of hazardous waste generation compared to E10.

The most significant pollutants in surface or subsurface releases of gasoline-ethanol blends are BTEX. Because BTEX pollutants come from the petroleum fraction of E15, a higher concentration of ethanol would reduce the amounts of BTEX potentially being released. Ethanol increases the solubility of BTEX in water. However, via ethanol competition for electron acceptors, the increased ethanol concentration will reduce the rate of biodegradation of BTEX in the environment upon release.[25]

In the event of a release of E15 into soil, modeling efforts suggest that increased ethanol content leads to a significant elongation effect on benzene plume lengths, with this effect most pronounced for E10-E20 blends. However, similar modeling indicates that the difference between baseline E10 plumes compared to potential E15 plumes is a fraction of a percent. Furthermore, the plume degradation time is inversely correlated with ethanol content in fuel blends. As such, the natural attenuation time for an E15 release is expected to be less than for a similar volume release of E10. A 2009 underground storage tank leak in Minnesota which had been used to store E85 detected the following:

- Consistent detection of benzene in onsite and offsite wells, with offsite migration of the benzene plume past 2015; and
- Rapidly dropping ethanol concentrations in onsite monitoring wells, with final detection in 2012.[26]

Ethanol release and subsequent degradation is also associated with increased microbial activity, leading to the production of methane. Higher concentrations of ethanol, if released, have the potential to generate significant quantities of methane; studies of historical groundwater impacts after sudden (neat) ethanol releases demonstrate that methane can be expected to develop and persist in groundwater.[27] In general, the time to ethanol cleanup varied, with cleanups occurring between 27-60 months, when documented. Increased monitoring for methane in soil and

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[25] National Response Team (NRT), NRT Quick Reference Guide: Fuel Grade Ethanol Spills (including E85). 2010.

[26] Pinnacle Engineering, Inc (Pinnacle), *Minnesota Pollution Control Agency Annual Monitoring Report, Miller & Holmes, Inc. Convenience Store, 1402 Vermillion Street, Hastings, Minnesota, Leak 17529*. (2015).

[27] Spalding, R. F., Toso, M. A., Exner Spalding, M., Hattan, G., Higgins, T.M., Sekely, A.C., et al., *Long-Term Groundwater Monitoring Results at Large, Sudden Denatured Ethanol Releases*. (2011). *https://doi.org/10.1111/j.1745-6592.2011.01336.x*.

groundwater in areas where there is potential for E15 spills may be needed due to the potential for explosions in the case of advective methane flow.

Finally, E15 has the same potential as E10 to be released into the environment, potentially affecting soil, surface water, and groundwater. Typically, the half-life of ethanol in the environment is 0.5-5 days (quicker in soil, longer in sewers), with possibly faster degradation in surface waters, due to the presence of aerobic microorganisms in the environment.[28] However, sensitive and other receptors may still be impacted through exposure via routes such as inhalation, ingestion, and dermal exposure. The primary human carcinogen found in fuel, benzene, would be expected to decrease in concentration as the proportion of ethanol increases. The human and ecological risks associated with E15 are largely similar to those associated with the current widespread use of E10.

C. Conclusions

This section provides the conclusions of each of the evaluations conducted by CARB, the State Water Board, OEHHA and DTSC. The conclusions on the impacts of E15 on public health and the environment are summarized below:

1. Conclusions on Air Emissions Impact

Based on the relative comparison between E10 and E15, CARB staff concludes that with fuel requirements, E15, as evaluated in this multimedia evaluation, does not pose a significant adverse impact on public health or the environment from potential air quality impacts.

Staff also makes the following general conclusions:

- E15 reduces PM, THC and CO exhaust emissions.
- No statistically significant difference in NOx emissions compared to E10.
- E15 increases acetaldehyde and ethanol exhaust emissions.

2. Conclusions on Water Impact

State Water Board staff conclude that given the current information and the similarities between E15 and E10, there are minimal additional risks to the beneficial uses of California waters posed by E15 as compared to current fuel blend of E10. The State Water Board supports the multimedia evaluation of E15 which meets the ASTM fuel specifications and the finding of no significant adverse impacts on public health or the environment.

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[28] Pinnacle Engineering, Inc (Pinnacle), *Minnesota Pollution Control Agency Annual Monitoring Report, Miller & Holmes, Inc. Convenience Store, 1402 Vermillion Street, Hastings, Minnesota, Leak 17529*. (2015).

3. Conclusions on Public Health Impact

As stated in the Tier Reports, there are risks to human health and the environment inherent in the use of gasoline-ethanol blends that are related primarily to the complex mixture of volatile hydrocarbons that make up the gasoline blendstock. The public health impacts resulting from E15 are not expected to differ from those of E10. As with E10, there is the potential for release of E15 into the environment, resulting in potential exposures to humans through inhalation, oral ingestion, and dermal contact. However, release and exposure scenarios for E15 are similar to those of E10 and are not expected to present an increased risk to human health.

Based on the information presented in the E15 multimedia evaluation, the substitution of E15 for E10 shows a general decrease in levels of ozone-forming compounds, particulate matter, some VOCs, and other contaminants of concern to human health. However, E15 use may increase tailpipe emissions of a few VOCs, such as ethanol and acetaldehyde.

Toxicological studies of gasoline blended with various levels of ethanol in laboratory animals do not indicate potential for different health hazards regarding maternal, behavioral, immunological, physiological, or cognitive outcomes. Studies using cultured human cells suggest that E15 will not be more potent than E10 in terms of its cytotoxic, pro-inflammatory, oxidative stress, mutagenic, or DNA-damage effects.

Overall, OEHHA did not find evidence of significant adverse impacts on human health from the use of E15 compared to E10. The Tier Reports support the approval of E15, based on significant environmental benefits, reduced greenhouse gas emissions, and no expected significant new public health risks compared to E10.

4. Conclusions on Soil and Hazardous Waste Impact

Based on available data, DTSC staff concludes that E15, if improperly released, may lead to an elongated subsurface benzene plume. However, this subsurface plume would overall also biodegrade more quickly due to the higher ethanol content compared to E10. BTEX contaminants from petroleum may also biodegrade less quickly in the event of an E15 release into the environment. Improper release of E15 may also result in increased generation and release of methane.

D. Recommendations

Based on the E15 multimedia evaluation and the information provided in the Final Tier I, Tier II and Tier III reports, the MMWG determined that the use of E15, as evaluated in this multimedia evaluation, does not pose a significant adverse impact on public health or the environment compared to E10.

The Multimedia Working Group recommends that the CEPC:

1. Find the use of E15 fuel in California, as evaluated in this multimedia evaluation, does not pose a significant adverse impact on public health or the environment compared to E10.
2. Condition the finding on the following:
    a. Any hazardous substances and hazardous waste used in production, storage and transportation of E15 will be handled in compliance with applicable California and federal laws and regulations.
    b. Fuel formulations not included within the scope of this multimedia evaluation must be reviewed by the MMWG for consideration of appropriate action.
    c. Through existing programs CARB staff will continue to monitor acetaldehyde and ethanol emissions. In the event that emissions data indicates the potential for significant risks to public health CARB will take appropriate action under its authority.
    d. In the event that any relevant available information indicates the potential for significant risks to public health or the environment, the specific use of E15 will be reviewed by the MMWG for appropriate action.