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## Development of Risk-Based Comparison Levels for Chemicals in Agricultural Irrigation Water

April 2016

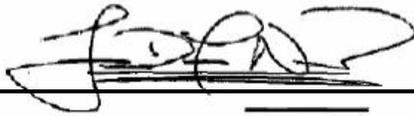
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# Development of Risk-Based Comparison Levels for Chemicals in Agricultural Irrigation Water

April 2016

Project No. 0306920



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Luis Navarro  
*Partner*



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Mark Jones  
*Program Director*



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Sandra Mulhearn  
*Senior Toxicologist*

ERM-West, Inc.  
5001 California Avenue, Suite 205  
Bakersfield, California 93309  
T: 661-437-3090  
F: 661-326-6775

## **PEER-REVIEWER**

Dr. Jay Gan  
Professor of Environmental Chemistry  
Department of Environmental Sciences  
University of California, Riverside

## TABLE OF CONTENTS

<b>LIST OF FIGURES</b>	<b><i>iii</i></b>
<b>LIST OF TABLES</b>	<b><i>iv</i></b>
<b>EXECUTIVE SUMMARY</b>	<b>ES-1</b>
<b>1.0 INTRODUCTION</b>	<b>1-1</b>
<b>1.1 REPORT ORGANIZATION</b>	<b>1-1</b>
<b>1.2 BACKGROUND</b>	<b>1-2</b>
<b>1.3 PROJECT OBJECTIVES</b>	<b>1-3</b>
<b>1.4 CONCEPTUAL MODEL</b>	<b>1-4</b>
<b>1.5 METHODS AND GUIDANCE</b>	<b>1-4</b>
<b>2.0 IDENTIFICATION OF CHEMICALS AND CROPS OF INTEREST</b>	<b>2-1</b>
<b>2.1 CHEMICALS OF INTEREST</b>	<b>2-1</b>
2.1.1 <i>Essential Nutrients</i>	2-1
2.1.2 <i>Persistent, Bioaccumulative, and Toxic Chemicals</i>	2-2
2.1.3 <i>Comparison to Drinking Water Screening Levels</i>	2-2
2.1.4 <i>Summary of Selection of Chemicals of Interest</i>	2-2
<b>2.2 CROPS OF INTEREST</b>	<b>2-3</b>
<b>3.0 EXPOSURE ASSESSMENT</b>	<b>3-1</b>
<b>3.1 POTENTIAL RECEPTORS</b>	<b>3-2</b>
<b>3.2 POTENTIAL EXPOSURE PATHWAYS</b>	<b>3-2</b>
<b>3.3 EXPOSURE POINT CONCENTRATIONS</b>	<b>3-2</b>
3.3.1 <i>Irrigation Rate</i>	3-3
3.3.2 <i>Soil Concentration</i>	3-4
3.3.3 <i>Plant Concentration</i>	3-6
<b>3.4 EXPOSURE FACTORS</b>	<b>3-9</b>

3.5	<i>QUANTIFICATION OF EXPOSURE</i>	3-10
4.0	<i>TOXICITY ASSESSMENT</i>	4-1
4.1	<i>NON-CARCINOGENIC HEALTH EFFECTS</i>	4-1
4.2	<i>TOTAL PETROLEUM HYDROCARBONS FRACTIONATION APPROACH</i>	4-2
4.3	<i>CARCINOGENIC HEALTH EFFECTS</i>	4-2
5.0	<i>RISK CHARACTERIZATION</i>	5-1
5.1	<i>METHOD FOR ASSESSING CANCER RISKS</i>	5-1
5.2	<i>METHOD FOR ASSESSING NON-CANCER HEALTH EFFECTS</i>	5-1
5.3	<i>RISK-BASED COMPARISON LEVELS</i>	5-2
6.0	<i>UNCERTAINTY ANALYSIS</i>	6-1
7.0	<i>CONCLUSIONS</i>	7-1
8.0	<i>REFERENCES</i>	8-1

*APPENDIX A – ABBREVIATIONS AND ACRONYMS*

*APPENDIX B – GLOSSARY*

*APPENDIX C – SENSITIVITY ANALYSIS*

**LIST OF FIGURES**

*(Figures immediately follow the text)*

*Figure 1      Conceptual Model for Human Exposure*

*Figure 2      Cawelo Water District and North Kern Water Storage District*

## LIST OF TABLES

*(Tables immediately follow the figures)*

<i>Table 1</i>	<i>Identification of Chemicals of Interest</i>
<i>Table 2</i>	<i>COI-Specific Physical-Chemical Properties</i>
<i>Table 3</i>	<i>Annual Evapotranspiration and Irrigation Rates for Crops of Interest in Kern County</i>
<i>Table 4</i>	<i>Chemicals of Interest Loss Factors</i>
<i>Table 5</i>	<i>Soil-to-Plant Bioaccumulation Factor Summary</i>
<i>Table 6</i>	<i>Soil-to-Plant Bioaccumulation Factor for TPH and Ethylene Glycol</i>
<i>Table 7</i>	<i>Exposure Factors – Consumers</i>
<i>Table 8</i>	<i>Non-Carcinogenic Toxicity Criteria</i>
<i>Table 9</i>	<i>Carcinogenic Toxicity Criteria</i>
<i>Table 10</i>	<i>RBC Level Calculations for Tree Nuts</i>
<i>Table 11</i>	<i>RBC Level Calculations for Grapes</i>
<i>Table 12</i>	<i>RBC Level Calculations for Citrus</i>
<i>Table 13</i>	<i>RBC Level Calculations for Carrots</i>
<i>Table 14</i>	<i>RBC Level Calculations for Potatoes</i>
<i>Table 15</i>	<i>Summary of RBC Levels</i>
<i>Table 16</i>	<i>Recommended Irrigation Water RBC Levels</i>

## EXECUTIVE SUMMARY

Underground hydrocarbon-bearing formations contain commingled water, called produced water, which is lifted to the surface in the process of producing oil and natural gas. For decades, the State of California has approved the use of reclaimed produced water from certain oil and natural gas fields as a best practice to augment irrigation water supplies. After separation and treatment, the reclaimed produced water is delivered to agricultural water districts for blending with their surface and ground water sources into irrigation water. The State requires both the reclaimed produced water and the blended irrigation water to meet specific water quality criteria, extensive monitoring and other permit conditions that are established for each participating field and water district to protect public health and the environment. Given California's severe and persistent drought, reclaimed produced water is recognized as a key source of water for beneficial use that can be expanded to supplement fresh surface and ground water resources. To achieve this objective, risk assessment tools can be applied to rapidly identify oil and natural gas fields with produced water quality that is suitable for blending into irrigation water.

This study presents the results of a human health risk assessment performed to establish risk-based comparison (RBC) levels of chemicals of interest (COIs) in irrigation water containing reclaimed produced water. A screening process was conducted to identify particular COIs on the basis of their potential toxicological significance, with other COIs added at the request of the California Regional Water Quality Control Board, Central Valley Region (RWQCB), the state regulatory agency that approves the use of reclaimed produced water for irrigation. These RBC levels are intended for use as benchmarks for rapidly assessing the acceptability and suitability of reclaimed produced water from oil and natural fields for blending and use in agricultural irrigation.

Accordingly, this assessment derived the recommended RBC levels for blended irrigation water using the most stringent target risk thresholds applied by the United States Environmental Protection Agency (USEPA) and the State of California – a theoretical upper-bound incremental cancer risk of  $1 \times 10^{-6}$  (one in one million) – which is 100 times lower than the upper end of the acceptable risk range applied by the USEPA and other agencies – and an acceptable daily intake for theoretical non-cancer effects (i.e., a hazard quotient of 1).

The recommended RBC levels for a given crop represent the concentrations of COIs in irrigation water that satisfy this risk threshold.

Concentrations above the recommended RBC levels in irrigation water would warrant further assessment to determine whether they fall within the acceptable risk range of the USEPA and other agencies. RBC levels for these COIs were developed specifically for irrigation water for six primary crops grown in the Cawelo Water District and North Kern Water Storage District (the Water Districts): almonds, pistachios, citrus, grapes, potatoes, and carrots.

The risk assessment was performed in accordance with health risk assessment procedures established by the USEPA, the California Department of Toxic Substances Control, and the California Office of Environmental Health Hazard Assessment. In keeping with standard risk assessment practices, the assessment was a deterministic, reverse-based assessment with the objective of deriving health-protective RBC levels for the COIs. Several analytical models were employed to assess the disposition and transport of the COIs in the agricultural environment and to estimate reasonable maximum exposures to the crops.

The exposure assessment step of the risk assessment identifies the potential receptors, and ways in which these receptors could come into contact with COIs. The exposure assessment quantifies the intake of COIs by the potential receptors. The methods used to estimate potential daily dosages of COIs to receptors via each of the theoretical exposure pathways are based on standard regulatory guidance. The exposure pathway upon which the RBC levels are based is the ingestion of crops grown using irrigation water blended with reclaimed, treated produced water. Regulatory-derived toxicity criteria (*i.e.*, reference dosages for theoretical non-cancer health effects, cancer slope factors for theoretical cancer risks) for each of the COIs are used.

The risk assessment is not intended to determine actual risks to an individual receptor associated with exposure to COIs. Rather, risk assessment is a means of estimating the upper bound probability that an adverse health effect may occur in a receptor at some point in the future as a result of the nature and magnitude of exposure assumed in the assessment. Because a multitude of conservative assumptions were used in the process, the recommended RBC levels are likely to be more restrictive (lower) than the actual threshold limits that would be protective of crop consumers.

The results of the risk assessment are recommended RBC levels for irrigation water blended with reclaimed, treated produced water for the identified COIs, applying the most stringent USEPA and State target risk thresholds.

Recommended Irrigation Water Risk-Based  
Comparison (RBC) Levels (mg/L)

Inorganics		Organics	
Arsenic	0.1	Acetone	20,000
Barium	2,000	Benzene	0.7
Boron	70	Ethylbenzene	6
Cadmium	70	Ethylene Glycol	5,000
Chromium (VI)	0.4	Methylene Chloride	2
Fluoride	700	Naphthalene	200
Mercury	20	PAHs	0.02
Thallium	10	Toluene	500
Zinc	2,000	Total Petroleum Hydrocarbons	200
		Trimethylbenzene	200
		Xylenes	1,000

mg/L = Milligrams per liter

Data available from the RWQCB's dataset in fall 2015 show that measured concentrations of the COIs in blended irrigation water are all below the recommended RBC levels, indicating that the crops are suitable for human consumption under the regulatory agency recommended target risk thresholds. Concentrations of COIs in irrigation water measured above the RBC levels would warrant further evaluation to determine whether they fall within the acceptable risk range of the USEPA and other agencies without additional treatment of the reclaimed produced water.

## 1.0

### *INTRODUCTION*

ERM-West, Inc. (ERM), sponsored by California Resources Corporation (CRC), conducted this evaluation on the use of reclaimed produced water for agricultural irrigation water. Current use of reclaimed produced water for agricultural irrigation water is in accordance with specific water quality criteria, monitoring and other permit conditions established by the California Regional Water Quality Control Board, Central Valley Region (RWQCB), for each participating field and water district to protect public health and the environment. Oil and natural gas producers and water districts are seeking to expand the beneficial use of reclaimed produced water from oil and gas production to augment fresh surface and ground water resources, particularly during California's persistent and severe drought. This risk assessment study was conducted to develop risk-based comparison (RBC) levels of chemicals of interest (COIs) in blended irrigation water that could be used to rapidly evaluate the acceptability and suitability of the water for irrigating crops for human consumption.

The quantitative approach and methods employed in the risk assessment are consistent with those of the United States Environmental Protection Agency (USEPA), the California Department of Toxic Substances Control (DTSC), and the California Office of Environmental Health Hazard Assessment (OEHHA). Due to uncertainties and variability inherent in the risk assessment process, a conservative approach is applied throughout to provide for the protection of human health. The RBC levels developed in this study are for the treated, blended irrigation water prior to delivery to the crops, not for direct application of the reclaimed produced water itself.

## 1.1

### *REPORT ORGANIZATION*

This study is composed of the following sections:

- Section 1 – A presentation and discussion of the background, objectives, and conceptual model for the overall project.
- Section 2 – Identification of the COIs and crops of interest, to focus the risk assessment.
- Section 3 – Summary of the human exposure assessment step of the risk assessment, including a discussion of potential human receptors, exposure pathways, exposure routes, and exposure concentrations.
- Section 4 – Summary of the toxicity assessment component of the risk assessment, including an explanation of the methods used to derive

toxicity criteria for carcinogenic and non-carcinogenic effects, as well as relevant toxicity criteria used to calculate the risks associated with each estimated exposure level.

- Section 5 – A presentation of the methods for deriving the RBC levels and the results of the derivation.
- Section 6 – Discussion of the uncertainties associated with the risk assessment development process. Associated with each risk assessment is some degree of uncertainty, which is a function of the exposure and toxicity information, the modeling approaches, and data used in the evaluation.
- Section 7 – Summary of the RBC levels and an explanation of RBC usage.
- Section 8 – References cited.

Figures and tables immediately follow the text. Appendix A presents a list of acronyms used in this study. Appendix B provides a glossary to the terms used in this study. Appendix C presents a sensitivity analysis for a number of the parameters used in the development of RBC levels.

## 1.2

### **BACKGROUND**

Produced water is defined herein as water that is trapped in underground formations and brought to the surface during oil and gas exploration and production. Due to its commingling within the hydrocarbon formation, produced water has some chemical characteristics of the underground formation. Produced water is the largest volume byproduct stream associated with oil and natural gas exploration and production. Reclaimed produced water has been used throughout the western United States for decades, with beneficial uses including crop irrigation, livestock watering, streamflow augmentation, and municipal and industrial uses (Bureau of Reclamation 2011). Given the large volumes of produced water generated in the western United States and the growing need for new water supplies, reclaimed produced water may serve as an important water source for augmenting conventional water supplies and for groundwater recharge.

The use of reclaimed produced water for agricultural irrigation has been recognized and permitted by the RWQCB as a sustainable best practice since the early 1980s. Produced water contains many natural substances from the hydrocarbon formation, including trace elements (e.g., arsenic), salts, and petroleum-related organic compounds (e.g., benzene, toluene).

While this produced water is not suitable for drinking water, the RWQCB and other agencies apply specific water quality criteria to ensure that it is suitable, after separation and treatment, for use in irrigation water.

Oil and natural gas producers separate produced water from the produced oil and gas. Produced water on the eastside of the Southern San Joaquin is generally low in salinity and suitable for irrigation. Statewide, most of the produced water is recycled in a closed loop by reinjection into mature oil and gas reservoirs as part of improved or enhanced oil recovery operations. The remaining produced water is either treated and supplied to agricultural water districts for irrigation or disposed of via reinjection into approved zones. Of particular note is that produced water is treated by oil and natural gas producers and the resulting reclaimed water is then blended with other fresh water sources (at least an equal amount or more) by water districts prior to use as agricultural irrigation water. Treatment processes include oil water separators, solids removal, flotation cells, and aeration ponds. The RBC levels developed in this evaluation are for agricultural irrigation water that contains reclaimed produced water, not for direct application of the reclaimed produced water prior to treatment and blending.

### **1.3 PROJECT OBJECTIVES**

The objective of the project was to develop RBC levels for particular COIs in irrigation water containing reclaimed produced water, applying the most stringent USEPA and State target risk thresholds to rapidly evaluate the acceptability and suitability of the water for irrigating crops grown for human consumption. These RBC levels were developed based on the concept of acceptable plant tissue levels and the back-calculation to irrigation water RBC levels.

In keeping with standard risk assessment practices, the development of RBC levels was based on a reverse, deterministic, and prospective risk assessment. This approach allowed for the derivation of health-protective RBC levels for COIs in irrigation water. The recommended RBC levels indicate that if concentrations of the COIs are below these levels in irrigation water used for agriculture, the crops are suitable for consumption under standard regulatory agency recommended risk thresholds.

## 1.4

### CONCEPTUAL MODEL

A conceptual model is a tool used in risk assessment to describe relationships between chemicals and potentially exposed human receptor populations, thereby delineating the relationships between the identified sources of chemicals, the mechanisms by which the chemicals might transport in the environment, and the means by which the receptors could come in contact with the chemicals. The conceptual model for the project establishes the exposure pathways considered in the development of RBC levels and ensures that exposure scenarios most likely to contribute to risk are evaluated. The conceptual model for the project is presented in Figure 1. The conceptual model comprises the following elements:

- The source of certain of the COIs; that is, the produced water from the Kern Front;
- Various water treatment and blending (that is, mixing with water from other sources) operations that occur prior to use of the water for agricultural irrigation;
- Application of blended irrigation water for agriculture; and
- Uptake of chemicals from blended irrigation water into plants that are consumed as produce by the human population.

The development of RBC levels also includes consideration of the following inter-media transfers:

- Irrigation rates for specific crops were used to estimate the transfer and accumulation of the COIs from water to soil based on deposition rates; and
- Translocation of COIs was modeled from soil into plants grown in areas that use reclaimed produced water.

The conceptual model in Figure 1 presents graphically the life-cycle of the produced water from extraction through treatment, blending and application to fields by irrigation. This conceptual model also identifies potential exposure pathways for which RBC levels were developed.

## 1.5

### METHODS AND GUIDANCE

The methods used in the risk assessment follow standard USEPA guidance. Specifically, the methods used in the risk assessment followed basic procedures outlined in the USEPA's *Risk Assessment Guidance for*

*Superfund: Volume I – Human Health Evaluation Manual* (USEPA 1989).

Other guidance documents consulted include:

- *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual. Supplemental Guidance: Standard Default Exposure Factors* (USEPA 1991);
- *Guidelines for Exposure Assessment* (USEPA 1992)
- *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (USEPA 2005); and
- *Exposure Factors Handbook: 2011 Edition* (USEPA 2011a).

In addition, California guidance was also consulted:

- *Preliminary Endangerment Assessment Guidance Manual* (DTSC 2015);  
and
- Various DTSC Human Health Risk Assessment notes (DTSC 2016).

The risk assessment is a deterministic risk assessment, meaning that single values based on conservative assumptions are used for all modeling, exposure parameters, and toxicity criteria. In addition, this assessment applied the most stringent USEPA and State target risk thresholds. These conservative estimates compound each other so that the calculated RBC levels likely overestimate potential risks, and therefore, are considered protective of human health. Concentrations of COIs in blended irrigation water exceeding the RBC levels may warrant further evaluation to determine if they fall within the acceptable risk range of USEPA and other agencies without further treatment of the water.

## 2.0 IDENTIFICATION OF CHEMICALS AND CROPS OF INTEREST

This section describes how chemicals and crops were identified for further evaluation in the risk assessment. This process helps to focus the risk assessment on those chemicals and crops of greatest interest.

### 2.1 CHEMICALS OF INTEREST

The dataset used to select COIs was created from data compiled by the RWQCB. At the RWQCB's request, more than 120 chemicals have been analyzed at various monitoring points along the life-cycle of the produced water from extraction through separation, treatment, blending into irrigation water, and delivery to farmers. To ensure that the RBC level development process focuses on those chemicals that would contribute to the overall potential risk (USEPA 1989), the following procedures were used when determining whether or not analytes should be retained as COIs for quantitative evaluation in the risk assessment:

- Chemicals that are considered essential nutrients were excluded;
- Chemicals that are considered by USEPA to be persistent, bioaccumulative, and toxic were retained, unless not detected; and
- Chemicals with maximum measured concentrations above risk-based screening levels (i.e., USEPA [2015] tap (drinking) water regional screening levels or California Public Health Goals [OEHHA 2016]), were retained.

Each of these procedures is discussed below.

#### 2.1.1 *Essential Nutrients*

An essential nutrient is a chemical required for normal body functioning that either cannot be synthesized by the body at all, or cannot be synthesized in amounts adequate for good health, and thus must be obtained from a dietary source. USEPA (1989) states that "Chemicals that are (1) essential human nutrients, (2) present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and (3) toxic only at very high doses (i.e., much higher than those that could be associated with contact in consumed crops) need not be considered further in the quantitative risk assessment. Examples of such chemicals are calcium, iron, magnesium, potassium, and sodium." Consistent with guidance and

standard practices, no further quantitative evaluations are required for these essential nutrients.

### 2.1.2 *Persistent, Bioaccumulative, and Toxic Chemicals*

USEPA (2011b) has developed a list of persistent, bioaccumulative, and toxic chemicals. If detected, persistent, bioaccumulative, and toxic chemicals were retained even if the maximum detected concentration was less than the drinking water risk-based screening levels. This applied to only one detected chemical, mercury, which was found in irrigation water below drinking water screening levels. All other persistent, bioaccumulative, and toxic chemicals on the analyte list were either retained based on comparison to drinking water screening levels or not retained because they were not detected in the available data.

### 2.1.3 *Comparison to Drinking Water Screening Levels*

Irrigation water is recognized and accepted to be of a different quality than drinking water. The USEPA and California drinking water screening levels are based upon direct exposure to drinking water (ingestion, dermal contact, and inhalation of volatiles). Since the reclaimed produced water will be used for irrigation of crops, not for drinking or other domestic use, a comparison to screening levels based on direct exposures associated with drinking water is considered a conservative initial screen. If the maximum detected concentration (for all samples collected anywhere along the produced water life-cycle) for a chemical is less than the drinking water screening level(s), then no further quantitative evaluation was conducted for that chemical. The chemicals that exceeded drinking water screening levels were the following:

- Arsenic
- Cadmium
- Hexavalent chromium
- Zinc
- Naphthalene
- Ethylbenzene
- Barium
- Fluoride
- Thallium
- Benzo(b)fluoranthene
- Benzene
- Total petroleum hydrocarbons (TPH)

### 2.1.4 *Summary of Selection of Chemicals of Interest*

The results of the identification of COIs are presented in Table 1. The resulting COIs for agricultural irrigation water are shown above. In

addition, the following chemicals were included as COIs in this assessment at the request of the RWQCB. These include:

- Boron
- Acetone
- Toluene
- Xylenes
- Trimethylbenzenes
- Ethylene glycol
- Methylene chloride

Note also that because benzo(b)fluoranthene is considered a carcinogenic polycyclic aromatic hydrocarbon (PAH), all similar PAHs (which include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene) were retained as COIs and evaluated as a class, not individually.

## 2.2 *CROPS OF INTEREST*

The San Joaquin Valley, including Kern County, is one of the most productive agricultural regions in the world. More than 250 crops are cultivated in the valley. Similar to identifying COIs, particular crops of interest were also selected for further evaluation in the risk assessment. The process for the selection of crops of interest is based on identifying those crops that are grown in the greatest acreage within the Water Districts. Crop acreages in 2014 for Kern County were used for this selection process. Crop acreages were identified using the Kern County Agriculture and Measurements Standards spatial dataset (Kern County 2015).

Based on a geospatial analysis of the crop acreage data, only crops associated with direct human consumption were included in the selection process. For example, crops such as alfalfa were excluded from the dataset. There are approximately 700,000 acres of crops grown for direct human consumption in Kern County. There are approximately 93,000 acres of these crops grown within the Water Districts (Figure 2). Of these 93,000 acres, six crops account for over 95 percent of the total acreage. These crops are:

- Almonds (over 47,500 acres, 51 percent of total acreage within the Water Districts);
- Pistachios (over 11,900 acres, 13 percent of total acreage within the Water Districts);

- Citrus (over 10,800 acres, 12 percent of total acreage within the Water Districts);
- Grapes (over 10,800 acres, 12 percent of total acreage within the Water Districts, primarily table grapes);
- Carrots (over 2,200 acres, 2 percent of total acreage within the Water Districts); and
- Potatoes (over 1,300 acres, 1 percent of total acreage within the Water Districts).

Other crops are grown in lesser amounts in the Water Districts. Note also that this does not reflect totals for Kern County, but only for the Water Districts that are receiving reclaimed produced water for blending into irrigation water. Therefore, the risk assessment focuses the evaluation on these six crops. These crops can also serve as 'indicators' for other crops should crops or agricultural practices change in the future.

In a risk assessment, the possible exposures of populations are examined to determine if the chemicals could affect the health of identified human populations of interest, such as consumers (i.e., receptors). The risk associated with exposure to chemicals depends not only on the concentration of the chemicals in the media, but also on the duration and frequency of exposure to the media. Potential health effects from chemicals in a medium can occur via one or more exposure pathways. The exposure assessment step of a risk assessment combines information regarding affected media (in this case, the crops identified in Section 2) with assumptions about the people who could come into contact with these media. The result is an estimation of a person's potential rate of contact with the affected media. The intake rates are evaluated in the risk characterization step to estimate the risks they could pose.

Whereas a traditional risk assessment is a forward calculation in which exposure information is combined with measured concentrations of chemicals to provide upper-bound estimates of health risk, derivation of RBC levels is a reverse calculation, solving for a concentration in environmental media (i.e., irrigation water) that is protective of human populations of interest. This approach involves combining exposure information with the most stringent USEPA and State target risk thresholds (e.g., one in one million [1,000,000] theoretical upper-bound incremental cancer risk) to derive COI-specific RBC levels.

Presented and discussed in this section are the various methods, assumptions, and data used to estimate the relationship between long-term irrigation water applications, soil concentrations of COIs accumulated over time, receptor exposure point concentrations, and receptor-specific exposure factors. All of these parameters are combined in the risk characterization step (Section 5) to derive the RBC levels.

The following exposure variables are identified and discussed:

- *Potential human receptors.* RBC levels protective of consumers of food crops grown with blended irrigation water containing reclaimed produced water.
- *Potential exposure pathways.* Pathways by which potential human receptors might be exposed to COIs in irrigation water.
- *Potential exposure point concentrations.* Estimated concentrations of COIs corresponding to the recommended target risk level under accepted

agricultural practices, using modeling of the disposition, transport, and uptake of COIs to derive these estimates.

- *Potential receptor exposure factors.* Assumed biological (*e.g.*, body weight) and non-biological (*e.g.*, crop ingestion rates) factors associated with potential human receptors and exposure pathways.

### 3.1 **POTENTIAL RECEPTORS**

The RBC levels are developed specifically for members of the general population who are end consumers of crops grown using blended irrigation water containing reclaimed produced water. Notably, crops potentially consumed by most members of the general public will originate from many different geographical regions, including regions where reclaimed produced water is not used. This is discussed further in Section 3.4 below.

### 3.2 **POTENTIAL EXPOSURE PATHWAYS**

The exposure pathway upon which the RBC levels are based is the consumption of produce, specifically the six crops identified in Section 2.2: almonds, pistachios, citrus, grapes, carrots, and potatoes. RBC levels based on these crops are likely to result in values that are protective of exposures resulting from consumption of other crops grown in lesser amounts.

### 3.3 **EXPOSURE POINT CONCENTRATIONS**

Exposure point concentrations are COI-specific concentrations at a specific point of exposure (*e.g.*, concentrations in edible plant parts). Exposure point concentrations are dependent directly on a wide range of chemical, physical, and biological factors that are known to influence the behavior of the COIs in various media (*e.g.*, soil, plants), including:

- The physical and chemical properties of the individual COIs;
- The physical and chemical properties of the soil; and
- Other environmental factors such as temperature, field slopes, and precipitation.

The net effect of these environmental factors is a time-dependent reduction (or loss) of COI concentrations per unit volume of soil in

conjunction with long-term irrigation water application. In addition, these factors also dictate the nature and extent that the COIs move within each medium (*e.g.*, volatilization, leaching) and between media (*i.e.*, translocation from soil into plants via the root system).

It is standard practice to use agency-recognized mathematical models, which provide a way to quantify intra-medium and inter-media movement of COIs, to estimate exposure point concentrations for direct exposure pathways. These estimates are the quantitative link between long-term application of blended irrigation water, soil concentrations of COIs, and exposure point concentrations. The COI-specific physical-chemical properties used in running the fate and transport models are presented in Table 2. The models incorporated into the RBC level risk assessment calculations are discussed in the following subsections.

### 3.3.1 *Irrigation Rate*

Since the crops are irrigated, the first value that must be derived is the deposition rate of COIs in water to soil. The deposition rate methodology shown here reflects an irrigation rate over a unit area. In accordance with USEPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (Human Health Combustor Guidance; USEPA, 2005), this is later combined with the water concentration and a soil loss constant to derive a soil concentration.

$$DR = IR_c \times CF$$

Where the deposition rate is calculated as follows:

- DR = Deposition rate (liter per square meter [L/m<sup>2</sup>]-year)
- IR<sub>c</sub> = Irrigation rate – crop specific (inch/year)
- CF = Conversion factor – 25.4 (meter/inch x liter per cubic meter [L/m<sup>3</sup>])

The irrigation rate is derived from the water needs of each individual crop. The State of California collects data for use in determining the irrigation needs around the state. Evapotranspiration is the sum of evaporation from soil and transpiration from the plant leaves. Evapotranspiration is a term used to describe the water use by plants over a period of time. The evapotranspiration rate for each crop was identified for Kern County from the California Irrigation Management Information System and compiled by University of California Cooperative Extension - Kern County (UC Extension 2015). The calculation of the irrigation rate is as follows:

$$IR_c = ET_c - P$$

Where:

- IR<sub>c</sub> = Irrigation rate – crop specific (inch/year)
- ET<sub>c</sub> = Evapotranspiration rate – crop specific (inch/year)
- P = Precipitation (6.45 inch/year; Bakersfield [US Climate Data 2015])

Irrigation rates for each crop type are shown in Table 3.

### 3.3.2 *Soil Concentration*

A crop-specific soil concentration based on the unit water concentration was derived using Equation 5-1A of USEPA’s Human Health Combustor’s Guidance (USEPA 2005) where the deposition is derived from the calculation in Section 3.3.1.

$$C_s = \frac{100 \times C_w \times DR \times [1 - ks \times tD]}{Z_s \times BD \times ks}$$

Where:

- C<sub>s</sub> = Soil concentration (milligrams per kilogram [mg/kg])
- 100 = Units conversion factor (mg-m<sup>2</sup>/kg-cm<sup>2</sup>)
- C<sub>w</sub> = Water concentration (grams per liter [g/L])
- DR = Deposition rate (L/m<sup>2</sup>-year)
- Ks = COI soil loss constant due to degradation and runoff (year<sup>-1</sup>)
- tD = Time period over which deposition occurs (26 years; equal to the exposure duration [USEPA 2015])
- Z<sub>s</sub> = Soil mixing zone depth (38 centimeters (cm) to account for chiseling and subsoiling as described in United States Department of Agriculture [USDA; 2009])
- BD = Soil bulk density (1.5 grams per cubic centimeter [g/cm<sup>3</sup>]; USEPA [2005] default)

#### *Soil Loss Constant*

The Human Health Combustor’s Guidance (USEPA 2005) recognizes COI loss through biotic and abiotic degradation, runoff, erosion, leaching, and volatilization. Erosion, leaching, and volatilization were minimally or not included as they are likely minimized through strict water management used in California or may be dependent upon the irrigation method

employed (i.e., drip irrigation, sprinkler, etc.). While volatilization may be significant for the more volatile components (e.g., benzene, toluene, ethylbenzene, xylenes, and light fraction TPH), it may be considered to be negligible for COIs such as inorganics. It must be noted that the exclusion of specific COI loss pathways leads to lower, or more protective, RBC levels. For the purposes of this evaluation, only degradation and runoff were considered.

$$ks = ksg + ksr$$

Where:

- ks = COI soil loss constant due to degradation and runoff (year<sup>-1</sup>)
- ksg = COI soil loss constant due to degradation (year<sup>-1</sup>)
- ksr = COI soil loss constant due to runoff (year<sup>-1</sup>)

Soil loss calculations are presented in Table 4.

#### *Biotic and Abiotic Degradation*

The biotic and abiotic degradation constants are available for most COIs using the database in the Human Health Combustor's Guidance (USEPA 2005). However, per Appendix A of that guidance, the value for ksg can be derived using the half-life of the COI in soil as shown:

$$ksg = \frac{0.693}{t_{1/2}}$$

The value for ethylene glycol was derived using a half-life in soil provided by the Agency for Toxic Substances and Disease Registry (2007). Surrogate values for COIs lacking ksg's were identified as follows: based on chemical structure similarities, xylenes were determined to be a suitable surrogate for 1,3,5-trimethylbenzene. The mean values for benzene, ethylbenzene, toluene, and xylenes were used for C<sub>5</sub>-C<sub>8</sub> aliphatics and C<sub>6</sub>-C<sub>8</sub> aromatics. The mean values for carcinogenic PAHs were used for C<sub>9</sub>-C<sub>16</sub> aromatics, C<sub>9</sub>-C<sub>18</sub> aliphatics, C<sub>17</sub>-C<sub>32</sub> aromatics, and C<sub>19</sub>-C<sub>32</sub> aliphatics. Section 4.2 presents a discussion on the TPH fractionation approach.

#### *Runoff*

USEPA's Human Health Combustor's Guidance (USEPA 2005) provides an equation to estimate runoff, as shown below:

$$ksr = \frac{RO}{\theta_{sw} \times Z_s} \times \left( \frac{1}{1 + (Kd_s \times BD / \theta_{sw})} \right)$$

Where:

- ks = ksr = COI soil loss constant due to runoff (year<sup>-1</sup>)
- RO = Average annual surface runoff from pervious areas (2.54 cm/year; U.S. Geological Survey 1987)
- $\theta_{sw}$  = Soil volumetric content (milliliter (ml) water/cm<sup>3</sup> soil; USEPA [2005] default)
- Kd<sub>s</sub> = Soil/water partition coefficient (ml water/g soil; chemical-specific)
- BD = Soil bulk density (1.5 g/cm<sup>3</sup>; USEPA [2005] default)

### 3.3.3 *Plant Concentration*

The plant concentration was estimated for aboveground crops using the bioaccumulation factors (BAFs) identified using the following hierarchy (in order of preference) for selecting soil-to-plant BAFs:

1. Pacific Northwest National Laboratory (2014) – This document identifies BAFs specific to fruit trees and grapes for arsenic, barium, chromium, and zinc. No values from any source were identified specific to hexavalent chromium, and therefore, soil-to-plant BAF for total chromium was used as a surrogate.
2. USEPA Ecological Soil Screening Levels (Eco-SSLs; 2007) – USEPA’s Eco-SSLs provides a comprehensive review of soil-to-plant bioaccumulation models.
3. Oak Ridge National Laboratory (ORNL; Bechtel Jacobs 1998) – ORNL’s study was limited to metals of interest.
4. USEPA’s Human Health Combustor’s Guidance (USEPA 2005) – The database provides soil-to-plant BAFs for above- and below ground crops and the guidance provides equations for deriving BAFs for additional chemicals.
5. Baes *et al.* (1984) – For above- and below ground crops, Baes *et al.* identified soil-to-plant BAFs for metals.

Crop-specific BAFs were preferred, but not readily available for all the crops and COIs assessed. USEPA Eco-SSLs (2007) have been rigorously reviewed and were identified as a secondary source. The Eco-SSLs also draw from the ORNL document (Bechtel-Jacobs 1998), but not all of the ORNL metals were included in the Eco-SSL study. USEPA’s Human

Health Combustor's Guidance (USEPA 2005) was used for thallium and a number of the organics. Lastly, Baes *et al.* (1984) was applied for the remainder of the metals. A summary of the soil-to-plant BAFs used and their sources is provided in Table 5.

For those COIs where the BAF is a point estimate, the plant concentration is calculated as follows:

$$C_{plant} = C_s \times BAF$$

Where:

- $C_{plant}$  = Plant concentration (mg/kg)
- $C_s$  = Soil concentration (mg/kg)
- BAF = Bioaccumulation factor (mg/kg plant/mg/kg soil)

For those COIs where the soil-to-plant BAF is based on a linear regression, the plant concentration is calculated as follows:

$$\ln(C_{plant}) = \ln(C_s) \times B1 + B0$$

Where:

- $C_{plant}$  = Plant concentration (mg/kg)
- B1 = Slope (unitless)
- B0 = Intercept (unitless)

For TPH and ethylene glycol, soil-to-plant BAFs were estimated using equations for aboveground and belowground crops listed in USEPA's Human Health Combustor's Guidance (USEPA 2005). The calculations are presented in Table 6.

The estimated BAFs for aboveground crops were identified by Travis and Arms (1988), the generally accepted reference, as follows:

$$\log Br_{ag} = 1.588 - 0.578 \times (\log K_{ow})$$

Where:

- $Br_{ag}$  = Plant-soil bioconcentration factor for aboveground crops (unitless)
- $K_{ow}$  = Octanol-water partition coefficient (liter per kilogram [L/kg])

For belowground crops, an equation identified by Briggs et al. (1982) was utilized, as follows:

$$Br_{root} = \frac{RCF}{Kd_s}$$

Where:

- Br<sub>root</sub> = Plant-soil bioconcentration factor for belowground crops (unitless)
- RCF = Root concentration factor (unitless)
- Kd<sub>s</sub> = Soil-water partition coefficient (L/kg)

The root concentration factor is estimated as follows for COIs with a logK<sub>ow</sub> value of 2.0 or higher (USEPA 2005):

$$\log(RCF) = 0.77 \times \log K_{ow} - 0.52$$

For COIs with logK<sub>ow</sub> values less than 2.0, the equation is modified as shown (USEPA 2005):

$$\log(RCF - 0.82) = 0.77 \times \log K_{ow} - 0.52$$

Where:

- RCF = Root concentration factor (unitless)
- K<sub>ow</sub> = Octanol-water partition coefficient (L/kg)

It should be noted that Briggs *et al.* (1982) derived the relationship using compounds with logK<sub>ow</sub> values ranging from -0.57 to 4.6. Additional validation studies were performed on logK<sub>ow</sub> values ranging from 6.0 to 8.2 (Muller *et al.* 1994). Only one of the COIs shown in Table 6 has a logK<sub>ow</sub> outside (below) the range of -0.57 to 8.2. As suggested in USEPA's Human Health Combustor's Guidance (USEPA 2005), a value of -0.57 was substituted for the logK<sub>ow</sub> in the root concentration factor calculation.

For belowground crops, an additional unitless correction factor is applied (0.01 for COIs with a log K<sub>ow</sub> greater than 4 and 1.0 for COIs with a log K<sub>ow</sub> less than 4; from USEPA 2005).

$$C_{plant} = C_s \times VG_{rootveg} \times BAF \text{ (or regression calculation)}$$

Where:

- $C_{\text{plant}}$  = Plant concentration (mg/kg)
- $C_s$  = Soil concentration (mg/kg)
- $VG_{\text{rootveg}}$  = Correction factor for belowground crops
- BAF = Bioaccumulation factor (mg/kg plant/mg/kg soil)

### 3.4 EXPOSURE FACTORS

To derive RBC levels, exposure factors, representing a wide range of population variables, are used to quantitatively define each receptor's exposure (*e.g.*, ingestion rate, exposure frequency, body weight). The average daily dose (ADD) associated with a target non-carcinogenic level, which is a hazard index of 1, is calculated using exposure factors that define each exposure pathway and each receptor for each non-carcinogenic effect. Similarly, the lifetime average daily dose (LADD) associated with a theoretical upper-bound incremental target cancer risk level, which is  $1 \times 10^{-6}$  (one in million; 1,000,000), is also calculated using exposure factors that define the exposure pathway for the receptor for the potential effect. A main difference between the assumed carcinogenic and non-carcinogenic exposure is the length of the averaging time. The averaging time for non-carcinogenic effects is the length of actual or assumed exposure, while the averaging time for carcinogenic effects is a receptor's expected lifetime. Many of the assumptions regarding the magnitude of exposure are default factors developed by USEPA's Superfund program. Default values were modified to reflect site-specific conditions, where possible.

Ingestion rates of crops were obtained for both children and adults. The food commodities intake database (USEPA 2016a) provides ingestion rates for each age-class for each of the crops. The calculations required that various age classes be combined to create the 0 to 5 and 6 to 50+ classes. The weighting factors are therefore used in order to accurately represent each sub-group's contribution to the ingestion of an age-class. Table 7 presents each of the exposure parameters used in the risk assessment.

The acreages of almonds/pistachios, citrus, and grapes constitute 20 percent of the acreage within Kern County. The acreages for carrots and potatoes are approximately 5 percent of the acreage within Kern County. Therefore, a fraction of crops grown within the Water Districts was included in the risk assessment. A factor of 20 percent (0.2) was used for all crops. This is considered to be a conservative assumption as an individual is likely to consume crops grown from a wide geographic area,

not just within the Water Districts, nor Kern County, over the duration considered in this assessment. As an example, assuming a 20-percent consumption rate for potatoes, instead of the 5-percent rate of acreage usage, decreased the recommended RBC level for several of the compounds by a factor of four.

### 3.5 QUANTIFICATION OF EXPOSURE

In this section, the concentrations of COIs at the points of potential human exposure are combined with assumptions about the behavior of the populations of interest to estimate the dose of COIs that may be taken in by the exposed individuals. Later, in the RBC level development step of the assessment, the doses are combined with toxicity parameters for COIs to estimate calculated intake levels that meet the most stringent target risk thresholds applied by the USEPA and the State.

The method used to estimate the ADD of the COIs via each of the complete exposure pathways is based on USEPA (1989, 1992) guidance. For carcinogens, LADD estimates are based on chronic lifetime exposure, extrapolated over the estimated average lifetime (assumed to be 70 years). This establishes consistency with cancer slope factors (CSFs), which are based on chronic lifetime exposures. For non-carcinogens, ADD estimates are averaged over the estimated exposure period. ADDs and LADDs were calculated for each exposure scenario listed above using the following generic equation:

$$ADD \text{ or } LADD \text{ (mg/kg - day)} = \frac{C_{plant} \times IR \times EF \times ED \times MC \times BIO \times IPF}{AT \times CF}$$

where:

- $C_{plant}$  = COI concentration (*e.g.*, mg/kg dry weight)
- IR = Ingestion rate; the amount of the crop item ingested per body weight (*e.g.*, mg/kg-body weight/day)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- MC = Moisture content (Dry to wet weight)
- BIO = Bioavailability (percent; arsenic only)
- IPF = Impacted plant fraction (percent)
- AT = Averaging time; the time over which the exposure is averaged (days)

Since the consumer receptor exposure is cumulative over child- and adult-ages, and ingestion rates (*i.e.*, crop consumption) vary with the age of the receptor, the exposure equation must account for these age-class differences. To accomplish this, age-adjusted exposure parameters are used. These are related to the age-class of the receptor, the duration of time spent within each age-class (adult/child), and the body weight of that age-class. The age-weighted exposures are used to evaluate carcinogens. The generic equation for age-weighted exposure parameters ( $IR_{twa}$ ) is:

$$IR_{twa} = IR_{child} \times ED_{child} + IR_{adult} \times ED_{adult}$$

In the case where age-adjusted exposure parameters are used, the parameters used (that is, ingestion rates and exposure durations) are removed from the generic ADD/LADD equation shown above. The assumptions about behavior leading to potential exposure to the ingestion of crops (*i.e.*, ADDs and LADDs) are presented in Table 7.

From scientific studies, it is known that the concentration of a chemical that is measured in the environment is not entirely bioavailable. However, to be conservative, the relative oral bioavailability of all COIs was assumed to be 100 percent, except for arsenic. An arsenic oral relative bioavailability of 87 percent is used based upon a human ingestion study presented in USEPA's *Compilation and Review of Data on Relative Bioavailability of Arsenic in Soil* (USEPA 2012).

Exposure levels of potentially carcinogenic and non-carcinogenic chemicals are calculated separately because different exposure assumptions apply (*i.e.*, ADD for non-carcinogens and LADD for carcinogens).

## 4.0

### *TOXICITY ASSESSMENT*

This section describes the potential toxicity of the COIs studied in this assessment. Numerical toxicity values were developed for use in the calculation of the hazard quotients (HQs; for non-carcinogens) and risks (for carcinogens). Toxicity values, when available, are published by the USEPA in its regional screening levels tables (USEPA 2015). These tables follow the hierarchy of human health toxicity criteria established by USEPA (2003). The primary source for toxicity criteria is USEPA's Integrated Risk Information System (USEPA 2016b).

CSFs (in units of milligrams per kilogram per day [mg/kg-d]<sup>-1</sup>) are chemical-specific and experimentally derived potency values that are used to calculate the risk of cancer resulting from exposure to potentially carcinogenic chemicals. A higher value implies a more potent carcinogenic potential. Reference dosages (RfDs) are experimentally derived "no-effect" levels used to quantify the extent of toxic effects other than cancer due to exposure to chemicals (in units of mg/kg-d). With RfDs, a lower value implies a more potent toxicant. These criteria are generally developed by USEPA risk assessment work groups and listed in the USEPA risk assessment guidance documents and databases, as noted above.

## 4.1

### *NON-CARCINOGENIC HEALTH EFFECTS*

For non-carcinogenic health effects, USEPA assumes that a dose threshold exists, below which adverse effects are not expected to occur. A chronic RfD of a chemical is an estimate of a lifetime daily dose to humans that is likely to be without appreciable adverse non-carcinogenic health effects. To derive an RfD, a series of professional judgments is made to assess the quality and relevance of the human or animal data and to identify the critical study and the most critical toxic effect. Data typically used in developing the RfD are the highest no-observable-adverse-effect-levels (NOAELs) for the critical studies on effects of the non-carcinogen. For each factor representing a specific area of uncertainty inherent in the extrapolation from the available data, an uncertainty factor is applied. Uncertainty factors generally consist of multiples of 10, although values less than 10 are sometimes used.

Four major types of uncertainty factors are typically applied to NOAELs in the derivation of RfDs. Uncertainty factors of 10 are used to (1) account for the variability between humans; (2) extrapolate from animals to

humans; (3) account for a NOAEL based on a subchronic study instead of a chronic study; and (4) extrapolate from a lowest-observed-adverse-effect-level to a NOAEL, if necessary. In addition, a modifying factor can be used to account for adequacy of the database. Typically, the modifying factor is set equal to one.

To obtain the RfD, all uncertainty factors associated with the NOAEL are multiplied together, and the NOAEL is divided by the total uncertainty factor. Therefore, the NOAEL can be reduced (made more protective) by several orders-of-magnitude to derive a health protective RfD. An understanding of the uncertainties associated with RfDs is important in evaluating the significance of the RBC levels calculated in the risk characterization portion of the risk assessment. The RfDs used in this evaluation are presented in Table 8.

#### 4.2 *TOTAL PETROLEUM HYDROCARBONS FRACTIONATION APPROACH*

To evaluate petroleum hydrocarbons, a fractionation approach, in which the total mass of petroleum hydrocarbons is separated into aromatic and aliphatic fractions, was used. For each quantifiable analytical fraction, a “reference” toxicity value is assigned to represent the toxicity of that fraction. The utility of the fractionation approach is its applicability to all forms of petroleum products, whether fresh or weathered. Because the petroleum associated with produced water is unrefined, fractionation information for TPH as crude was used. For TPH as crude, carbon-range fractions were developed based on composition data presented by the TPH Criteria Working Group (TPHCWG), Volume 2 (Table 14 from TPHCWG 1998), which is distilled into the following:

C <sub>5</sub> -C <sub>8</sub> Aliphatics	40%
C <sub>6</sub> -C <sub>8</sub> Aromatics	10%
C <sub>9</sub> -C <sub>18</sub> Aliphatics	29%
C <sub>9</sub> -C <sub>16</sub> Aromatics	15%
C <sub>19</sub> -C <sub>32</sub> Aliphatics	6%
C <sub>17</sub> -C <sub>32</sub> Aromatics	0.10%

#### 4.3 *CARCINOGENIC HEALTH EFFECTS*

USEPA develop CSFs from chronic animal studies or, where possible, epidemiological data. Because animal studies use much higher doses over shorter periods of time than the exposures generally expected for humans,

the data from these studies are adjusted, typically using a linearized multi-stage mathematical model. To ensure protectiveness, CSFs are typically derived from the 95th percentile Upper Confidence Limit of the slope, and thus the actual risks are unlikely to be higher than those predicted using the CSF, and may be considerably lower. The CSFs used in this evaluation are presented in Table 9.

## 5.0 RISK CHARACTERIZATION

In the last step of a risk assessment, the estimated rate at which a receptor intakes a chemical is compared with information about the toxicity of that COI to estimate the potential risks posed by exposure to the COI. This step is known as risk characterization. The methods used for assessing cancer risks and non-cancer adverse health effects are discussed below to provide perspective on how the RBC levels are derived.

### 5.1 METHOD FOR ASSESSING CANCER RISKS

In the risk characterization, carcinogenic risk is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to chemicals. Carcinogenic risks for chemicals were evaluated by multiplying the estimated average exposure rate (i.e., LADD calculated in the exposure assessment) by the chemical's CSF. The CSF converts estimated daily doses averaged over a lifetime to incremental risk of an individual developing cancer. Because cancer risks are averaged over a person's lifetime, longer-term exposure to a carcinogen results in higher risks than shorter-term exposure to the same carcinogen, if all other exposure assumptions are constant. Theoretical risks associated with low levels of exposure in humans are assumed to be directly related to an observed cancer incidence in animals associated with high levels of exposure during laboratory testing. According to USEPA (1989), this approach is appropriate for theoretical upper-bound incremental lifetime cancer risks (ILCRs) of less than  $1 \times 10^{-2}$ . The following equations were used to calculate COI-specific risks:

$$ILCR = LADD \times CSF$$

Where:

ILCR = Incremental lifetime cancer risk (unitless)  
LADD = Lifetime average daily dose (mg/kg-d)  
CSF = Cancer slope factor (mg/kg-d)<sup>-1</sup>

### 5.2 METHOD FOR ASSESSING NON-CANCER HEALTH EFFECTS

Non-cancer adverse health effects are estimated by comparing the estimated average exposure rate (i.e., ADDs estimated in the exposure assessment) with an exposure level at which no adverse health effects are

expected to occur for a long period of exposure (e.g., the RfDs). ADDs and RfDs are compared by dividing the ADD by the RfD to obtain the ADD:RfD ratio, as follows:

$$HQ = \frac{ADD}{RfD}$$

Where:

HQ = Hazard quotient  
ADD = Average daily dose (mg/kg-d)  
RfD = Reference dose (mg/kg-d)

The ADD-to-RfD ratio is known as an HQ. If a person's average exposure is less than the RfD (i.e., if the HQ is less than 1), the chemical is considered unlikely to pose a non-carcinogenic health effect to individuals under the given exposure conditions. Unlike carcinogenic risk estimates, an HQ is not expressed as a probability. Therefore, while both cancer and non-cancer risk characterizations indicate a relative potential for adverse effects to occur from exposure to a chemical, a non-cancer adverse health effect estimate is not directly comparable with a cancer risk estimate.

### 5.3 RISK-BASED COMPARISON LEVELS

The goal of the RBC levels determination is to establish COI levels that are protective of human health, that are acceptable to regulatory agencies (e.g., RWQCB) and the public, and that are practical and based on good science. RBC levels are based on the relationship between chemical concentration and estimated risk for each COI. The RBC levels define the HQ and ILCR concentration equivalents of a particular constituent.

USEPA has defined an acceptable cancer risk range of  $10^{-6}$  to  $10^{-4}$ . Therefore, for individual carcinogens, RBC levels are calculated using a target risk of  $10^{-6}$  to  $10^{-4}$ . DTSC considers  $10^{-6}$  to be the initial consideration for decision making. For non-carcinogens, a target HQ of unity (1) was used as the acceptable level.

For those equations where the exposure, risk calculations, and bioaccumulation models used are linear, the following equation was used to establish RBC levels:

$$RBC = \frac{C_w \times RISK_{target}}{RISK_{unit}}$$

Where:

- RBC = COI-specific RBC (milligrams per liter [mg/L])  
C<sub>w</sub> = Water concentration; for those with a linear bioaccumulation model a unit value of 1 g/L was used to back-calculate to the RBC levels (1,000 mg/L)  
RISK<sub>target</sub> = Target risk level (1 for non-carcinogens; 10<sup>-6</sup> for carcinogens)  
RISK<sub>unit</sub> = Unit risk level (based on the unit water concentration)

For those COIs evaluated using regression-based bioaccumulation models, this approach could not be used. The values had to be calculated iteratively by adjusting the water concentration until the target risk levels were met. The calculations and RBC levels are presented in Tables 10 through 14 and the RBC levels summarized in Table 15.

The RBC levels were calculated for specific crops, and vary significantly depending on the crop and the COI, applying the most stringent target risk thresholds of the USEPA and the State of California. It is noted that the RBC levels do not account for the potential that an individual may consume all the different crop types grown in the Water Districts. One of the principles of risk assessment is the evaluation of reasonable maximum exposures. Given the conservative approach inherent in the risk assessment process, derivation of RBC levels based on the consumption of multiple crops was considered an unreasonable assumption. Therefore, the recommended RBC levels for irrigation water blended with reclaimed, treated produced water are the lowest of the crop-specific RBC levels, as shown in Table 16.

These RBC levels indicate that concentrations of the COIs below these levels in blended irrigation water satisfy the USEPA and State-recommended risk thresholds, and that this water is suitable to use for agricultural irrigation of crops grown for human consumption. Concentrations of COIs in blended irrigation water above the recommended RBC levels would warrant further assessment to determine whether they fall within the acceptable risk range of the USEPA and other agencies.

Note that the RBC levels are based strictly on health risk thresholds and do not take into consideration the chemical/physical characteristics of the COIs, such as water solubility limit. Therefore, in some cases the calculated RBC levels are greater than a concentration that would be physically possible in the irrigation water. For example, several of the calculated RBC levels for ethylene glycol exceed 1,000,000 mg/L, which would be pure ethylene glycol. These high RBC levels are due to a number

of factors, including the chemical's toxicity, degradation rate, and plant uptake.

The use of the recommended RBC level is illustrated for arsenic. The recommended RBC level for irrigation water for arsenic is 0.1 mg/L. The maximum measured arsenic concentration from the RWQCB's fall 2015 dataset in the Cawelo Water District's blended irrigation water was 0.02 mg/L, which is below the recommended RBC level of 0.1 mg/L, showing for this COI that the water is acceptable and suitable for irrigating crops for human consumption. The measured arsenic concentration in reclaimed produced water at CRC's Section 23 treatment facility – before it is blended into irrigation water – is 0.076 mg/L, which is also less than the recommended RBC level for arsenic of 0.1 mg/L in irrigation water, meaning that this reclaimed produced water would also be acceptable and suitable for irrigating crops directly with respect to this COI.

To put these RBC levels in perspective, for example, the maximum contaminant level (MCL) for arsenic in drinking water is 0.01 mg/L (or 10 µg/L). The MCL is a level established to protect consumers against the effects of long-term, chronic exposure to arsenic in drinking water (and that maximizes health risk reduction benefits at a cost that is justified by the benefits). The recommended RBC level for irrigation water for arsenic is 0.1 mg/L (or 100 µg/L). Given drinking water exposures are a more direct and higher level of exposure than those associated with ingestion of crops grown in irrigation water, it is reasonable that levels for irrigation water would be higher than those for drinking.

Uncertainties are inherent at every step in the risk assessment process and are evaluated to provide an indication of the relative degree of confidence in the findings of the development of RBC levels. This section presents a qualitative discussion of the uncertainties associated with the overall risk assessment process, so that the RBC levels generated can be interpreted in the proper perspective.

Risk assessments are not intended to determine actual risks to an individual receptor associated with exposure to COIs in the environment. In fact, determining actual risks is impossible because of the variability in the exposed or potentially exposed populations. Therefore, risk assessment is a means of estimating the upper bound probability that an adverse health effect may occur in a receptor at some point in the future as a result of the nature and magnitude of exposure assumed in the assessment. Because there are a multitude of conservative assumptions used in the process, and this assessment applied the most stringent target risk thresholds of the USEPA and the State, the RBC levels are more restrictive than alternative higher threshold values that would still be considered protective of human health.

Concentrations of COIs in blended irrigation water above the RBC levels would warrant further evaluation to determine whether they fall within the acceptable risk range of the USEPA and other agencies without additional treatment of the reclaimed produced water. The RBC levels presented in this study are calculated by combining a wide range of factors that are used to quantitatively estimate the individual steps in the pathways relating target levels of carcinogenic and non-carcinogenic risk with concentrations in irrigation water applied to farmland in the Water Districts.

The uncertainties in the development of the RBC levels can be grouped into three main categories: uncertainties in assumptions concerning fate and transport modeling (inter-media transfers), exposure scenarios (*e.g.*, activity patterns), and uncertainties in toxicity data and dose-response extrapolations. The table below presents the results of the qualitative uncertainty analysis conducted for the RBC health risk assessment. The table lists many of the uncertainties that could not be modeled or quantitatively accounted for, and discusses the potential effect these sources of uncertainty may have on the results. Three possible effects on the RBC levels are listed:

- May underestimate risk (RBC levels should be lower, or more restrictive, than those developed);
- May overestimate risk (RBC levels should be higher, or less restrictive, than those developed); and
- May under- or overestimate risk (the uncertainty could result in RBC levels that are either more or less restrictive than developed, depending on the situation).

The degree (low, moderate, and high; likely affecting the results by less than one, between one and two, and more than two orders of magnitude, respectively) to which these uncertainties could affect the outcomes (RBC levels) is also presented. In evaluating the overall effect these individual parameters may have, one can compare the number and severity of overestimation and underestimation, and temper these with the parameters that could affect the results either way. A brief discussion of each of the major types of uncertainties in the RBC risk assessment is presented below.

Source of Uncertainty	May Underestimate Risk	May Overestimate Risk	May Under or Overestimate Risk
<b>Fate and Transport Modeling</b> Fate and transport modeling did not account for reduction or increase in uptake resulting from presence of other elements in soils.			Moderate
Soil mixing depth in the model is set according to assumed tillage depth and may vary from crop to crop and farm to farm.			Low
Soil accumulation model used irrigation rates based on mid-range crop-specific estimates from the literature.			Moderate
Soil accumulation model did not account for varying soil geochemistry.			Moderate
Soil accumulation model did not account for COI removal from soils by plant uptake.		Low	
Soil accumulation model did not account for loss due to volatilization.		Moderate	
Soil accumulation model loss factors are based on annual averages of past weather conditions.			Low

Source of Uncertainty	May Underestimate Risk	May Overestimate Risk	May Under or Overestimate Risk
Soil-to-plant uptake factors are based on data incorporating a wide variety of soil textures, pH, and chemistry parameters.		Moderate	
Soil-to-plant uptake factors are generally based on generic non-specific plant values intended to represent a broad range of plant types.		Moderate	
Where Kern County-specific parameters in the soil accumulation model were not available, default values from USEPA were used (e.g. bulk density).			Low
Reductions in COI concentrations during food processing are not accounted for in the model.		High	
<p><b>Exposure Assumptions</b></p> <p>Only crop consumption pathway is evaluated. Other pathways are not assessed.</p>	Low		
Exposure values are combined to arrive at the ADD and LADD estimates. There is a low probability that all of the various upper-bound assumptions used in the exposure assessment would occur simultaneously.		Moderate	
Activities and pathways resulting in media intakes are assumed to be constant over time.			Low
Crop ingestion rates are on a per capita basis, based on a range of United States values that may not represent a limited specific subpopulation.	Low		
<p>The plant fraction ingested from crops grown with reclaimed produced water was set at 20 percent to reflect the percentage of crop land within the Water Districts in Kern County. However, the crops from this area may be consumed across the county and individuals would likely consume crops from other areas during the course of the exposure duration. Therefore, consumption of crops grown in the Water Districts is likely to be less than 20 percent of an individual's diet.</p>		High	

Source of Uncertainty	May Underestimate Risk	May Overestimate Risk	May Under or Overestimate Risk
Bioavailability of COIs other than arsenic is not accounted for in the exposure models.		Moderate	
<b>Toxicological Data</b> RfDs are derived and extrapolated from laboratory studies exposing animals to relatively high intakes. Conservative assumptions are inherent in extrapolation of data from animals to humans, from high to low doses, and from one exposure route to another.		Moderate	
RfDs used to estimate non-carcinogenic health effects are derived from NOAELs based on sensitive endpoints in sensitive species. As a result, extrapolation of toxicity data from animals to humans is uncertain.		Moderate	
New evidence suggests that the arsenic CSF, based on a zero-tolerance model, requires reconsideration to account for an apparent threshold in its carcinogenic potential.		High	
Conversion of arsenic from the toxic inorganic form to the non-toxic organic form is not accounted for in the model.		High	
The concentration and soil chemistry-dependency of metal bioavailability is not accounted for in the model.			Low

Uncertainties from different sources are compounded in the risk assessment. For example, if a person's daily intake rate for a chemical is compared to an RfD to determine potential health risks, the uncertainties in the exposure assumptions and toxicities are all expressed in the result. Because the exposure assumptions and toxicity criteria are considered conservative, and this evaluation applied the most stringent target risk thresholds of the USEPA and the State, the RBC levels developed in this risk assessment are considered to be more restrictive than concentrations of COIs that would be protective of crop consumers.

In addition to the qualitative uncertainty analysis presented above, a semi-quantitative sensitivity analysis was also performed. The purpose of the sensitivity analysis was to identify and rank important sources of variability and uncertainty in the development of the RBC levels. This sensitivity analysis is presented in Appendix C, and summarized below.

A number of parameters were identified with alternative values, and that may have a large effect on the RBC levels. These parameters are summarized in Table C-1. All crops were evaluated in the sensitivity analysis, and all analytes with the exception of those calculated using regression-based plant uptake values (cadmium, mercury, zinc [carrots and potatoes only], benzo[a]anthracene, benzo[a]pyrene, benzo[k]fluoranthene, and chrysene). The sensitivity analysis was focused on discrete variables on an individual basis. Therefore, the cumulative effect of multiple variable changes was not evaluated. The effect is presented as a fold-change in the tornado plots.

A tornado plot is a type of bar chart that is useful in providing a visual sense of the relative importance of different variables and is particularly useful in a sensitivity analysis. The tornado plots were developed using the R statistical program. The tornado plots are presented in Appendix C.

The plots indicate that the most sensitive parameter is target risk for carcinogens, for which this assessment applied the most stringent target risk thresholds used by the USEPA and the State. The affected plant fraction is also a sensitive parameter. Crop consumption rates and soil mixing depth for the tree nuts, citrus and grapes are also sensitive parameters. The remaining parameter changes result in a comparatively minimal variation in RBC levels. Most of the changes would result in an increase of the RBC levels, reflecting the protective nature of the study.

Every effort was made throughout the RBC level development risk assessment to ensure that the resultant RBC levels for the COIs are not less restrictive than what would normally be considered protective of human health by regulatory agencies. Therefore, actual incremental risks associated with the COIs in irrigation water below these concentrations are likely lower than the acceptable levels used in this assessment.

The purpose of this study was to develop RBC levels for COIs in irrigation water containing reclaimed produced water by applying the most stringent USEPA and State target risk thresholds to rapidly evaluate the acceptability and suitability of the water for irrigating crops grown for human consumption. These RBC levels developed based on the concept of acceptable plant tissue levels apply to concentrations of COIs in blended irrigation water that is applied to the crops.

The risk assessment used to develop the RBC levels evaluated the potential for human health effects from potential exposure to COIs in crops as a result of deposition from irrigation water into soil, and subsequent uptake from the soil into plant tissues. It is noted that the RBC levels are crop specific. The results could be applied to the individual crop by comparing the concentrations of the COIs measured in irrigation water to the RBC levels for the individual crop. To enable more rapid screening, the recommended RBC level in this assessment was selected as the lowest RBC level of any of the six crops. Therefore, the recommended RBC levels for irrigation water blended with reclaimed, treated produced water are the lowest of the crop-specific RBC levels shown in Table 16.

The RWQCB dataset from fall 2015 included irrigation water monitoring data from the Cawelo Water District. Comparison of these data in Table 16 with the recommended RBC levels show that measured concentrations of the COIs in irrigation water blended with reclaimed produced water were below the recommended RBC levels for all COIs and all crops, indicating that the blended irrigation water is acceptable and suitable for irrigation of crops grown for human consumption. Table 16 also compares the recommended RBC levels to the measured concentrations in the RWQCB dataset for the reclaimed produced water at CRC's Section 23 treatment facility – before it is blended into irrigation water. The measured COI concentrations in the reclaimed produced water are less than the recommended RBC levels for all COIs and all crops. This illustrates that the reclaimed produced water could be applied directly to irrigate these crops grown for human consumption and achieve the most stringent target risk thresholds of the USEPA and the State of California. This further illustrates the acceptability and suitability of the blended irrigation water containing reclaimed produced water for irrigating crops grown for human consumption.

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## *Figures*

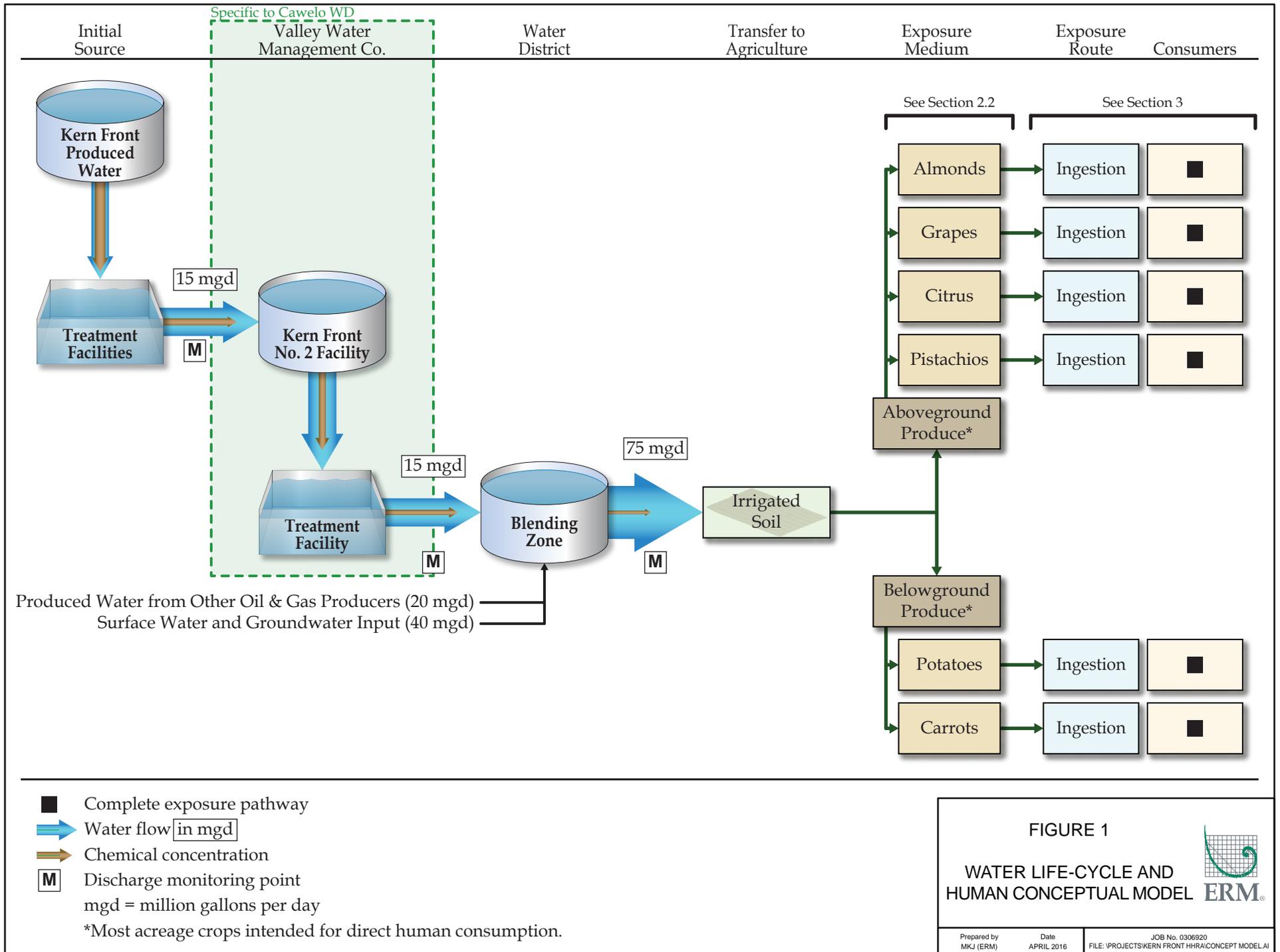
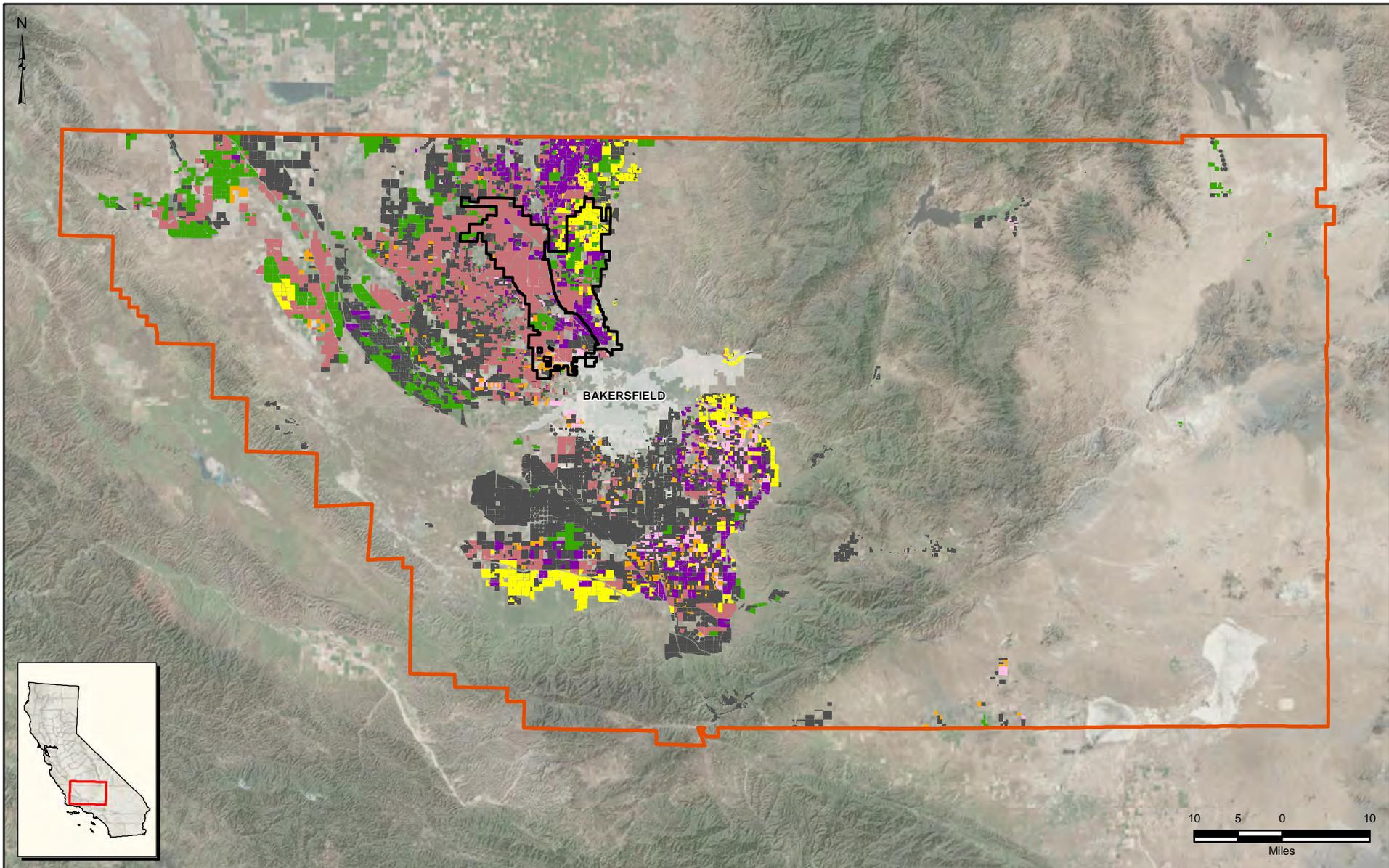


FIGURE 1  
 WATER LIFE-CYCLE AND HUMAN CONCEPTUAL MODEL

ERM<sup>®</sup>

Prepared by MKJ (ERM) Date APRIL 2016 JOB No. 0306920 FILE: \PROJECTS\KERN FRONT\HRA\CONCEPT MODEL.A1



Kern County  
 Cawelo WD/North Kern WSD

**Crop Type (2014 Data)**

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #c44e52; margin-right: 5px;"></span> Almond</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #ff9900; margin-right: 5px;"></span> Carrot</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #800080; margin-right: 5px;"></span> Grape</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #ffff00; margin-right: 5px;"></span> Citrus</li> </ul> | <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #008000; margin-right: 5px;"></span> Pistachio</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #ff99cc; margin-right: 5px;"></span> Potato</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #333333; margin-right: 5px;"></span> Other Crops</li> </ul> |
|---|--|

FIGURE 2  
 WATER DISTRICTS  
 AND KERN COUNTY  
 CROP TYPES



## *Tables*

**Table 1**  
**Identification of Chemicals of Interest**

Chemical	Units	Maximum Detect	Minimum Screening Level	Screening Level	Chemical of Interest Y/N?
<b>Inorganics</b>					
Alkalinity as CaCO <sub>3</sub>	mg/L	250	--	--	N
Ammonia	mg/L	0.5	--	--	N
Antimony	mg/L	0.0024	0.0078	USEPA RSL	N
Arsenic	mg/L	0.17	0.000004	Cal/EPA PHG	Y
Barium	mg/L	20	2	Cal/EPA PHG	Y
Beryllium	mg/L	ND (<0.001)	0.025	USEPA RSL	N
Bicarbonate	mg/L	320	--	--	N
Boron	mg/L	2	4	USEPA RSL	Y (D)
Bromide	mg/L	1.1	--	--	N
Cadmium	mg/L	0.0011	0.00004	Cal/EPA PHG	Y
Calcium	mg/L	29	--	--	N
Carbonate	mg/L	ND (<4.0)	--	--	N
Chloride	mg/L	250	--	--	N
Chromium	mg/L	ND (<0.01)	22	USEPA RSL	N
Cobalt	mg/L	ND (<0.01)	--	--	N
Copper	mg/L	0.0088	0.3	Cal/EPA PHG	N
Fluoride	mg/L	1	0.8	USEPA RSL	Y
Hexavalent Chromium	mg/L	0.0013	0.00002	Cal/EPA PHG	Y
Hydroxide Alkalinity	mg/L	ND (<4.0)	--	--	N
Iron	mg/L	2.2	14	USEPA RSL	N
Lead	mg/L	ND (<0.005)	0.015	USEPA RSL	N
Lithium	mg/L	0.096	40	USEPA RSL	N
Magnesium	mg/L	6.3	--	--	N
Manganese	mg/L	0.085	0.43	USEPA RSL	N
Mercury	mg/L	0.00024	0.0012	Cal/EPA PHG	Y (PBT)
Molybdenum	mg/L	0.043	0.1	USEPA RSL	N
Nickel	mg/L	0.0041	0.012	Cal/EPA PHG	N
Nitrate	mg/L	0.12	10	Cal/EPA PHG	N
Potassium	mg/L	6.4	--	--	N
Selenium	mg/L	0.016	0.03	Cal/EPA PHG	N
Silicon	mg/L	83	--	--	N
Silver	mg/L	ND (<0.01)	0.094	USEPA RSL	N
Sodium	mg/L	280	--	--	N
Strontium	mg/L	0.41	12	USEPA RSL	N
Sulfate	mg/L	250	--	--	N
Thallium	mg/L	0.0091	0.0001	Cal/EPA PHG	Y
Total Dissolved Solids	mg/L	800	--	--	N
Vanadium	mg/L	ND (<0.005)	0.086	USEPA RSL	N
Zinc	mg/L	0.015	6	USEPA RSL	Y (D)

**Table 1**  
**Identification of Chemicals of Interest**

Chemical	Units	Maximum Detect	Minimum Screening Level	Screening Level	Chemical of Interest Y/N?
<b>Total Petroleum Hydrocarbons</b>					
TPH	mg/L	32000	0.8	USEPA RSL	Y
Methane	ug/L	7.5	--	--	N
Oil&Grease	mg/L	57	--	--	N
Organic Carbon	mg/L	12	--	--	N
Gasoline Range Hydrocarbons	mg/L	250	0.033	USEPA RSL	Y
Motor Oil Range Hydrocarbons	mg/L	22.5	0.8	USEPA RSL	Y
Diesel Range Hydrocarbons	mg/L	14.8	0.0055	USEPA RSL	Y
<b>Radionuclides</b>					
Gross Alpha	pCi/L	9.3	--	--	N
Gross Beta	pCi/L	6.39	--	--	N
Uranium	ug/L	ND (<1)	60	USEPA RSL	N
Radium-226	pCi/L	0.813	5	Cal/EPA MCL	N
Radium-228	pCi/L	1.2	5	Cal/EPA MCL	N
<b>Polynuclear Aromatic Hydrocarbons</b>					
Acenaphthene	ug/l	0.82	530	USEPA RSL	N
Acenaphthylene	ug/l	0.19	530	surrogate: Acenaphthene	N
Anthracene	ug/l	ND (<0.2)	--		N
Benzo(a)anthracene	ug/l	ND (<0.2)	--		Y (cPAH)
Benzo(a)pyrene	ug/l	ND (<0.2)	--		Y (cPAH)
Benzo(b)fluoranthene	ug/l	0.049	0.034	USEPA RSL	Y
Benzo(g,h,i)perylene	ug/l	ND (<0.2)	--		N
Chrysene	ug/l	0.15	3.4	USEPA RSL	Y (cPAH)
Dibenzo(a,h)anthracene	ug/l	ND (<0.2)	--		Y (cPAH)
Fluoranthene	ug/l	ND (<0.2)	--		N
Fluorene	ug/l	2.1	290	USEPA RSL	N
Indeno(1,2,3-cd)pyrene	ug/l	ND (<0.2)	--		Y (cPAH)
Naphthalene	ug/l	0.84	0.17	USEPA RSL	Y
Phenanthrene	ug/l	1.1	120	surrogate: Pyrene	N
Pyrene	ug/l	0.18	120	USEPA RSL	N
<b>Volatile Organic Compounds</b>					
Acetone	ug/l	160	14000	USEPA RSL	Y (D)
Benzene	ug/l	1.2	0.15	Cal/EPA PHG	Y
Bromobenzene	ug/l	ND	--		N
Bromochloromethane	ug/l	ND	--		N
Bromodichloromethane	ug/l	ND	--		N
Bromoform	ug/l	ND	--		N
Bromomethane	ug/l	ND	--		N
2-Butanone (MEK)	ug/l	7.8	5600	USEPA RSL	N
Carbon tetrachloride	ug/l	ND	--		N
Chlorobenzene	ug/l	ND	--		N
Chloroethane	ug/l	ND	--		N
Chloroform	ug/l	ND	--		N

**Table 1**  
**Identification of Chemicals of Interest**

Chemical	Units	Maximum Detect	Minimum Screening Level	Screening Level	Chemical of Interest Y/N?
Chloromethane	ug/l	ND	--		N
2-Chlorotoluene	ug/l	ND	--		N
4-Chlorotoluene	ug/l	ND	--		N
cis-1,2-Dichloroethene	ug/l	ND	--		N
cis-1,3-Dichloropropene	ug/l	ND	--		N
Dibromochloromethane	ug/l	ND	--		N
1,2-Dibromo-3-Chloropropane	ug/l	ND	--		N
1,2-Dibromoethane (EDB)	ug/l	ND	--		N
Dibromomethane	ug/l	ND	--		N
1,3-Dichlorobenzene	ug/l	ND	--		N
1,2-Dichlorobenzene	ug/l	ND	--		N
1,4-Dichlorobenzene	ug/l	ND	--		N
Dichlorodifluoromethane	ug/l	ND	--		N
1,1-Dichloroethane	ug/l	ND	--		N
1,2-Dichloroethane	ug/l	ND	--		N
1,1-Dichloroethene	ug/l	ND	--		N
1,2-Dichloropropane	ug/l	ND	--		N
2,2-Dichloropropane	ug/l	ND	--		N
1,3-Dichloropropane	ug/l	ND	--		N
1,1-Dichloropropene	ug/l	ND	--		N
Ethanol	ug/l	ND	--		N
Ethylbenzene	ug/l	9.1	1.5	USEPA RSL	Y
Ethyl-t-butyl ether (ETBE)	ug/l	ND	--		N
2-Hexanone	ug/l	ND	--		N
Isopropylbenzene	ug/l	ND	--		N
Isopropyl Ether (DIPE)	ug/l	ND	--		N
Methylene Chloride	ug/l	ND	--		Y (D)
4-Methyl-2-pentanone (MIBK)	ug/l	ND	--		N
Methyl-t-Butyl Ether (MTBE)	ug/l	ND	--		N
m,p-Xylene	ug/l	4.4	190	USEPA RSL	N
n-Butylbenzene	ug/l	ND	--		N
n-Propylbenzene	ug/l	ND	--		N
o-Xylene	ug/l	3.2	190	USEPA RSL	N
p-Isopropyltoluene	ug/l	ND	--		N
sec-Butylbenzene	ug/l	ND	--		N
Styrene	ug/l	ND	--		N
Tert-amyl-methyl ether (TAME)	ug/l	ND	--		N
tert-Butyl alcohol (TBA)	ug/l	ND	--		N
tert-Butylbenzene	ug/l	ND	--		N
1,1,2,2-Tetrachloroethane	ug/l	ND	--		N
1,1,1,2-Tetrachloroethane	ug/l	ND	--		N
Tetrachloroethene	ug/l	ND	--		N
Toluene	ug/l	7.5	150	Cal/EPA PHG	N
trans-1,2-Dichloroethene	ug/l	ND	--		N
trans-1,3-Dichloropropene	ug/l	ND	--		N
1,2,4-Trichlorobenzene	ug/l	ND	--		N

**Table 1**  
**Identification of Chemicals of Interest**

Chemical	Units	Maximum Detect	Minimum Screening Level	Screening Level	Chemical of Interest Y/N?
1,2,3-Trichlorobenzene	ug/l	ND	--		N
1,1,1-Trichloroethane	ug/l	ND	--		N
1,1,2-Trichloroethane	ug/l	ND	--		N
Trichloroethene	ug/l	ND	--		N
Trichlorofluoromethane	ug/l	ND	--		N
1,2,3-Trichloropropane	ug/l	ND	--		N
1,2,4-Trimethylbenzene	ug/l	0.68	15	USEPA RSL	N
1,3,5-Trimethylbenzene	ug/l	ND	--		Y (D)
Vinyl chloride	ug/l	ND	--		N
Total Xylenes	ug/l	22	190	USEPA RSL	N
1,1,2-Trichloro-1,2,2-Trifluoroethar	ug/l	ND	--		N
2-Chloroethylvinyl ether	ug/l	ND	--		N
4-Isopropyltoluene	ug/l	ND	--		N
Acrolein	ug/l	ND	--		N
Acrylonitrile	ug/l	ND	--		N
Carbon disulfide	ug/l	20.8	810	USEPA RSL	N
Ethyl acetate	ug/l	ND	--		N
Hexachlorobutadiene	ug/l	ND	--		N
Iodomethane	ug/l	ND	--		N
Vinyl acetate	ug/l	ND	--		N
Ethylene glycol	--	NS	--		Y (D)

USEPA RSL = Regional Screening Level for Tap Water (USEPA 2015a).

Cal/EPA PHG = Public Health Goal for Drinking Water (OEHHA 2015)

Cal/EPA MCL = Maximum Contaminant Level (combined for radium-226 and -228)

COI = chemical of interest

ND = not detected; (<max detection limit) detection limits are provided where available

NS = not sampled

mg/L = milligram per liter

ug/L = microgram per liter

Y = Yes

N = No

(PBT) = Selected because chemical was detected and is considered Persistent, Bioaccumulative and Toxic

(D) = Discretionary selection at the request of the RWQCB; chemical was less than the screening value or not detect.

(cPAH) = Selected because one carcinogenic PAH exceeded the screening value.

**Table 2**  
**COI-Specific Physical-Chemical Properties**

<b>Chemical</b>	<b>K<sub>d</sub> (L/kg)</b>	<b>log K<sub>ow</sub> (L/kg)</b>	<b>K<sub>oc</sub> (L/kg)</b>
Boron	3	1.16	--
Fluoride	150	--	--
Arsenic	29	0.68	--
Barium	790	0.23	--
Cadmium	75	-0.07	--
Hexavalent Chromium	19	--	--
Mercury	52	0.62	--
Thallium	71	0.23	--
Zinc	62	-0.47	--
Benzo (a) Anthracene	1061	5.8	176900
Benzo (a) Pyrene	3524	6.1	587400
Benzo (b) Fluoranthene	3596	5.8	599400
Benzo (k) Fluoranthene	3524	6.1	587400
Chrysene	1083	5.8	180500
Dibenz (a,h) Anthracene	11472	6.8	1912000
Indeno (1,2,3-c,d) Pyrene	11706	6.7	1951000
Naphthalene	9.3	3.3	1544
1,3,5-Trimethylbenzene	3.6	3.4	600
Acetone	0.014	-0.24	2.4
Toluene	1.4	2.7	234
Xylenes	2.3	3.2	383
Benzene	0.87	2.13	146
Ethylbenzene	2.7	3.15	446
Ethylene Glycol	0.006	-1.4	1
Methylene Chloride	0.13	1.25	22
<b>Total Petroleum Hydrocarbons</b>			
C4-C12			
C5-C8 Aliphatics	0.79	3.9	132
C6-C8 Aromatics	0.87	2.1	146
C13-C22			
C9-C16 Aromatics	12	3.6	2011
C9-C18 Aliphatics	4.8	5.7	796
C23-C32			
C17-C32 Aromatics	333	5.2	55450
C19-C32 Aliphatics	29	6.1	4818

**Notes:**

Source: Regional Screening Level Tables (USEPA 2015a)

K<sub>d</sub>s - soil water partition coefficient

K<sub>ow</sub> = Octanol-water partition coefficient

K<sub>oc</sub> = Soil organic carbon-water partition coefficient

For organics, K<sub>d</sub> = K<sub>oc</sub> \* f<sub>oc</sub> (default 0.006)

**Table 3**  
**Annual Evapotranspiration and Irrigation Rates for**  
**Crops of Interest in Kern County**

<b>Crop</b>	<b>Annual Evapotranspiration Rate inches/year</b>	<b>Annual Irrigation Rate inches/year</b>
Tree Nuts	52.34	45.89
Grapes	45.78	39.33
Citrus	39.54	33.09
Carrots	16.09	9.64
Potatoes	20.85	14.4

Notes:

The annual evapotranspiration rate was provided by UC Cooperative Extension:  
 Kern County

The Annual irrigation rate is estimated by subtracting the average annual  
 precipitation (6.45 in/year) from the annual evapotranspiration rate.

**Table 4**  
**Chemicals of Interest Loss Factors**

Chemical	Kd <sub>s</sub> (L/kg)	COI Loss due to Biotic and Abiotic Degradation	COI Loss due to Surface Runoff	Total COI Loss
		ksg 1/yr	ksr 1/yr	ks 1/yr
Boron	3.0 E+0	0	1.4 E-2	1.4 E-2
Fluoride	1.5 E+2	0	3.0 E-4	3.0 E-4
Arsenic	2.9 E+1	0	1.5 E-3	1.5 E-3
Barium	7.9 E+2	0	5.6 E-5	5.6 E-5
Cadmium	7.5 E+1	0	5.9 E-4	5.9 E-4
Hexavalent Chromium	1.9 E+1	0	2.3 E-3	2.3 E-3
Mercury	5.2 E+1	0	8.5 E-4	8.5 E-4
Thallium	7.1 E+1	0	6.3 E-4	6.3 E-4
Zinc	6.2 E+1	0	7.2 E-4	7.2 E-4
Benzo (a) Anthracene	1.1 E+3	3.7 E-1	4.2 E-5	3.7 E-1
Benzo (a) Pyrene	3.5 E+3	4.8 E-1	1.3 E-5	4.8 E-1
Benzo (b) Fluoranthene	3.6 E+3	4.1 E-1	1.2 E-5	4.1 E-1
Benzo (k) Fluoranthene	3.5 E+3	1.2 E-1	1.3 E-5	1.2 E-1
Chrysene	1.1 E+3	2.5 E-1	4.1 E-5	2.5 E-1
Dibenz (a,h) Anthracene	1.1 E+4	2.7 E-1	3.9 E-6	2.7 E-1
Indeno (1,2,3-c,d) Pyrene	1.2 E+4	3.5 E-1	3.8 E-6	3.5 E-1
Naphthalene	9.3 E+0	5.3 E+0	4.7 E-3	5.3 E+0
1,3,5-Trimethylbenzene	3.6 E+0	9.0 E+0	1.2 E-2	9.0 E+0
Acetone	1.4 E-2	3.6 E+1	3.0 E-1	3.6 E+1
Toluene	1.4 E+0	1.2 E+1	2.9 E-2	1.2 E+1
Xylenes	2.3 E+0	9.0 E+0	1.8 E-2	9.0 E+0
Benzene	8.7 E-1	1.6 E+1	4.4 E-2	1.6 E+1
Ethylbenzene	2.7 E+0	2.5 E+1	1.6 E-2	2.5 E+1
Ethylene Glycol	6.0 E-3	2.1 E+1	3.2 E-1	2.1 E+1
Methylene Chloride	1.3 E-1	9.0 E+0	1.7 E-1	9.2 E+0

**Table 4**  
**Chemicals of Interest Loss Factors**

Chemical	Kd <sub>s</sub> (L/kg)	COI Loss due to	COI Loss due to	Total
		Biotic and Abiotic Degradation	Surface Runoff	COI Loss
		ksg 1/yr	ksr 1/yr	ks 1/yr
<b>Total Petroleum Hydrocarbons</b>				
C4-C12				
C5-C8 Aliphatics	7.9 E-1	1.5 E+1	4.8 E-2	1.5 E+1
C6-C8 Aromatics	8.7 E-1	1.5 E+1	4.4 E-2	1.5 E+1
C13-C22				
C9-C16 Aromatics	1.2 E+1	9.4 E-1	3.7 E-3	9.5 E-1
C9-C18 Aliphatics	4.8 E+0	9.4 E-1	9.1 E-3	9.5 E-1
C23-C32				
C17-C32 Aromatics	3.3 E+2	9.4 E-1	1.3 E-4	9.4 E-1
C19-C32 Aliphatics	2.9 E+1	9.4 E-1	1.5 E-3	9.5 E-1

Notes:

ksg - soil loss constant due to biotic and abiotic degradation (USEPA 2005a) (see calculation in text)

ksr - soil loss constant due to runoff (see calculation in text)

ks - combined soil loss constant

1/yr - loss per year

	Value	Units	Parameter description	Source
RO	2.54	cm/yr	runoff rate	USGS 1987
thetasw	0.2	ml/cm <sup>3</sup>	soil volumetric water content	USEPA 2005
Zs	38	cm	soil mixing depth	USDA 2009
Kds see Table 2			soil/water partition coefficient	
BD	1.5	g/cm <sup>3</sup>	bulk density	USEPA 2005
P	16.4	cm/yr	precipitation	US Climate Data 2015

**Table 5**  
**Soil-to-Plant Bioaccumulation Factor Summary**

Chemical	All Plants				Aboveground		Belowground				Nuts		Grapes		Citrus	
	BAF	B1	B0	Source	BAF	Source	BAF	B1	B0	Source	BAF	Source	BAF	Source	BAF	Source
Boron	--	--	--	--	4	a	2	--	--	b	--	--	--	--	--	--
Fluoride	--	--	--	--	0.06	a	6.00E-03	--	--	b	--	--	--	--	--	--
Arsenic	--	--	--	--	--	--	0.0352	--	--	c	0.024	g	0.064	i	0.034	j
Barium	--	--	--	--	--	--	0.156	--	--	c	0.005	h	0.004	i	0.004	j
Cadmium	--	0.546	-0.475	c	--	--	--	--	--	--	--	--	--	--	--	--
Hexavalent Chromium	--	--	--	--	--	--	0.041	--	--	c	0.028	h	0.012	i	0.011	j
Mercury	--	0.544	-0.966	f	--	--	--	--	--	--	--	--	--	--	--	--
Thallium	--	--	--	--	8.58E-04	d	4.00E-04	--	--	e	--	--	--	--	--	--
Zinc	--	--	--	--	--	--	--	0.544	1.575	c	0.118	h	0.144	i	0.137	j
Benzo (a) Anthracene	--	0.5944	-2.7078	c	--	--	--	--	--	--	--	--	--	--	--	--
Benzo (a) Pyrene	--	0.975	-2.0615	c	--	--	--	--	--	--	--	--	--	--	--	--
Benzo (b) Fluoranthene	0.31	--	--	c	--	--	--	--	--	--	--	--	--	--	--	--
Benzo (k) Fluoranthene	--	0.8595	-2.1579	c	--	--	--	--	--	--	--	--	--	--	--	--
Chrysene	--	0.5944	-2.7078	c	--	--	--	--	--	--	--	--	--	--	--	--
Dibenz (a,h) Anthracene	0.13	--	--	c	--	--	--	--	--	--	--	--	--	--	--	--
Indeno (1,2,3-c,d) Pyrene	0.11	--	--	c	--	--	--	--	--	--	--	--	--	--	--	--
Naphthalene	12.2	--	--	c	--	--	--	--	--	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	--	--	--	--	0.49	d	16.3	--	--	e	--	--	--	--	--	--
Acetone	--	--	--	--	8.38	d	74.2	--	--	e	--	--	--	--	--	--
Toluene	--	--	--	--	1.07	d	77.4	--	--	e	--	--	--	--	--	--
Xylenes	--	--	--	--	0.548	d	83.5	--	--	e	--	--	--	--	--	--
Benzene	--	--	--	--	2.37	d	80.1	--	--	e	--	--	--	--	--	--
Ethylbenzene	--	--	--	--	0.625	d	77.6	--	--	e	--	--	--	--	--	--
Ethylene Glycol	--	--	--	--	--	--	calculated - see Table 6				--	--	--	--	--	--
Methylene Chloride	--	--	--	--	6.86	d	359	--	--	e	--	--	--	--	--	--
<b>Total Petroleum Hydrocarbons</b>							calculated - see Table 6									

Notes:

BAF - bioaccumulation factor

B1 and B0 - slope and intercept for regression calculation

a - Baes, 1984. Bv

b - Baes, 1984. Br

c - USEPA 2007. EcoSSL Att 4-1

d - USEPA 2005. HH Combustor's Database; aboveground

e - USEPA 2005. HH Combustor's Database; belowground

f - ORNL 1998.

g - PNNL 2014. (pistaschio)

h - PNNL 2014. (almond)

i - PNNL 2014. (grapes)

j - PNNL 2014. (generic fruit)

**Table 6**  
**Soil-to-Plant Bioaccumulation Factor for TPH and Ethylene Glycol**

	log Kow (L/kg)	RCF (unitless)	Koc (L/kg)	Kd (L/kg)	Brroot (unitless)	log Brag (unitless)	Brag (unitless)
Ethylene Glycol	-1.4	0.0016638	1	0.006	0.2772993	2.3972	249.57438
C5-C8 Aliphatics	3.9	30	131.5	0.789	38.541002	-0.6662	0.2156751
C6-C8 Aromatics	2.1	1.3	145.8	0.8748	1.4291941	0.3742	2.3670095
C9-C16 Aromatics	3.6	18	2011	12.066	1.4805964	-0.4928	0.3215141
C9-C18 Aliphatics	5.7	740	796	4.776	154.85873	-1.7066	0.0196517
C17-C32 Aromatics	5.2	305	55450	332.7	0.9161091	-1.4176	0.0382296
C19-C32 Aliphatics	6.1	1503	4818	28.908	51.997439	-1.9378	0.0115398

**Key:**

Kow = Octanol-water partition coefficient (USEPA 2005)

RCF = Root concentration factor

Koc = Soil organic carbon-water partition coefficient (USEPA 2005)

Kd = Soil-water partition coefficient

Brroot = Plant-soil bioconcentration factor for below-ground produce

Brag = Plant-soil bioconcentration factor for above-ground produce

$$\log \text{RCF} = 0.77 \times \log \text{Kow} - 1.52$$

If the  $\log \text{Kow} < 2.0$ ,  $\log (\text{RCF}-0.82) = 0.77 \times \log \text{Kow} - 1.52$ . If the  $\log \text{Kow} < -0.57$ , then the  $\log \text{Kow}$  value was set to  $-0.57$ .

$$\text{Kd} = \text{Koc} * \text{foc} \text{ (default } 0.006)$$

$$\text{Brroot} = \text{RCF}/\text{Kd}$$

$$\log \text{Brag} = 1.588 - (0.578 \times \log \text{Kow})$$

**Table 7**  
**Exposure Factors – Consumers**

Parameter	Abbrev.	Value	Units	Reference
Averaging time, carcinogenic	AT <sub>c</sub>	70	years	USEPA 2015
Averaging time, non-carcinogenic	AT <sub>nc</sub>	26	years	Based on ED
Exposure frequency	EF <sub>r</sub>	350	days/year	USEPA 2015
Exposure duration - Adult	ED <sub>r,a</sub>	20	years	USEPA 2015
Exposure duration - Child	ED <sub>r,c</sub>	6	years	USEPA 2015
Affected plant fraction	APF	0.2	percent	see text Section 3.4
Dry weight to fresh weight - Carrots	CFwd	0.1171	dry/wet weight	Table 9-37, USEPA 2011b
Dry weight to fresh weight - Tree nuts	CFwd	0.93	dry/wet weight	<a href="http://ucanr.edu/datastoreFiles/234-2753.pdf">http://ucanr.edu/datastoreFiles/234-2753.pdf</a>
Dry weight to fresh weight - Grapes	CFwd	0.187	dry/wet weight	Table 9-37, USEPA 2011b
Dry weight to fresh weight - Citrus	CFwd	0.1325	dry/wet weight	Table 9-37, USEPA 2011b; oranges
Dry weight to fresh weight - Potatoes	CFwd	0.1842	dry/wet weight	USEPA 2016a
Adult ingestion rate - Carrots	IR <sub>s,a</sub>	130	mg/kg-day	USEPA 2016a
Child ingestion rate - Carrots	IR <sub>s,c</sub>	360	mg/kg-day	USEPA 2016a
Adult ingestion rate - Tree nuts	IR <sub>s,a</sub>	20	mg/kg-day	USEPA 2016a
Child ingestion rate - Tree nuts	IR <sub>s,c</sub>	20	mg/kg-day	USEPA 2016a
Adult ingestion rate - Grapes	IR <sub>s,a</sub>	100	mg/kg-day	USEPA 2016a
Child ingestion rate - Grapes	IR <sub>s,c</sub>	560	mg/kg-day	USEPA 2016a
Adult ingestion rate - Citrus	IR <sub>s,a</sub>	140	mg/kg-day	USEPA 2016a
Child ingestion rate - Citrus	IR <sub>s,c</sub>	530	mg/kg-day	USEPA 2016a
Adult ingestion rate - Potatoes	IR <sub>s,a</sub>	510	mg/kg-day	USEPA 2016a
Child ingestion rate - Potatoes	IR <sub>s,c</sub>	990	mg/kg-day	USEPA 2016a

**Key:**

mg/kg-day = milligram per kilogram per day

USEPA = United States Environmental Protection Agency

USDA = United States Department of Agriculture

**Table 8**  
**Non-Carcinogenic Toxicity Criteria**

Chemical	Oral - Chronic (mg/kg-d)		Oral BIO
	Value	Reference	
<b>Non-Carcinogenic</b>			
Acetone	9.0 E-1	USEPA 2015	1.0
1,3,5-Trimethylbenzene	1.0 E-2	USEPA 2015	1.0
Benzene	4.0 E-3	USEPA 2015	1.0
Ethylbenzene	1.0 E-1	USEPA 2015	1.0
Ethylene Glycol	2.0 E+0	USEPA 2015	1.0
Methylene Chloride	6.0 E-3	USEPA 2015	1.0
Naphthalene	2.0 E-2	USEPA 2015	1.0
Toluene	8.0 E-2	USEPA 2015	1.0
Xylenes	2.0 E-1	USEPA 2015	1.0
Benzo (a) Anthracene	NA		1.0
Benzo (a) Pyrene	NA		1.0
Benzo (b) Fluoranthene	NA		1.0
Benzo (k) Fluoranthene	NA		1.0
Chrysene	NA		1.0
Dibenz (a,h) Anthracene	NA		1.0
Indeno (1,2,3-c,d) Pyrene	NA		1.0
Arsenic	3.0 E-4	USEPA 2015	0.87
Barium	2.0 E-1	USEPA 2015	1.0
Boron	2.0 E-1	USEPA 2015	1.0
Cadmium	1.0 E-3	USEPA 2015	1.0
Fluoride	4.0 E-2	OEHHA 2015	1.0
Hexavalent Chromium	3.0 E-3	USEPA 2015	1.0
Mercury	3.0 E-4	USEPA 2015	1.0
Thallium	1.0 E-5	USEPA 2015	1.0
Zinc	3.0 E-1	USEPA 2015	1.0
C9-C16 Aromatics	4.0 E-3	USEPA 2015	1.0
C6-C8 Aromatics	4.0 E-3	USEPA 2015	1.0
C5-C8 Aliphatics	1.0 E-2	C9-C18 aliphatics	1.0
C9-C18 Aliphatics	1.0 E-2	USEPA 2015	1.0
C17-C32 Aromatics	4.0 E-2	USEPA 2015	1.0
C19-C32 Aliphatics	3.0 E+0	USEPA 2015	1.0

**Key:**

BIO = bioavailability (assumed to be 100% unless specific USEPA value reported)

mg/kg-d = Milligrams per kilogram per day

NA = Not applicable. Data either not applicable (*e.g.*, not carcinogenic), not available, or chemical not assessed for this pathway.

OEHHA = Office of Environmental Health Hazard Assessment

USEPA = United States Environmental Protection Agency

**Table 9**  
**Carcinogenic Toxicity Criteria**

Chemical	Oral (mg/kg-d <sup>-1</sup> )		Oral BIO
	Value	Reference	
<b>Carcinogenic</b>			
Acetone	NA		1.0
1,3,5-Trimethylbenzene	NA		1.0
Benzene	5.5 E-2	USEPA 2015	1.0
Ethylbenzene	1.1 E-2	OEHHA 2015	1.0
Ethylene Glycol	NA		1.0
Methylene Chloride	2.0 E-3	USEPA 2015	1.0
Naphthalene	NA		1.0
Toluene	NA		1.0
Xylenes	NA		1.0
Benzo (a) Anthracene	7.3 E-1	USEPA 2015	1.0
Benzo (a) Pyrene	7.3 E+0	USEPA 2015	1.0
Benzo (b) Fluoranthene	7.3 E-1	USEPA 2015	1.0
Benzo (k) Fluoranthene	7.3 E-2	USEPA 2015	1.0
Chrysene	7.3 E-3	USEPA 2015	1.0
Dibenz (a,h) Anthracene	7.3 E+0	USEPA 2015	1.0
Indeno (1,2,3-c,d) Pyrene	7.3 E-1	USEPA 2015	1.0
Arsenic	1.5 E+0	USEPA 2015	0.87
Barium	NA		1.0
Boron	NA		1.0
Cadmium	NA		1.0
Fluoride	NA		1.0
Hexavalent Chromium	5.0 E-1	USEPA 2015	1.0
Mercury	NA		1.0
Thallium	NA		1.0
Zinc	NA		1.0
C9-C16 Aromatics	NA		1.0
C5-C8 Aliphatics	NA		1.0
C6-C8 Aromatics	NA		1.0
C9-C18 Aliphatics	NA		1.0
C17-C32 Aromatics	NA		1.0
C19-C32 Aliphatics	NA		1.0

**Key:**

BIO = bioavailability (assumed to be 100% unless specific USEPA value reported)

mg/kg-d = Milligrams per kilogram per day

NA = Not applicable. Data either not applicable (*e.g.*, not carcinogenic), not available, or chemical not assessed for this pathway.

OEHHA = Office of Environmental Health Hazard Assessment

USEPA = United States Environmental Protection Agency

**Table 10**  
**RBC Level Calculations for Tree Nuts**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m2-yr	Soil Concentration (mg/kg)	Soil to Plant Uptake			Plant Tissue Concentration <sup>b</sup> (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-	Cancer-Based
				BCF	B1	B0								RBC Level	Water RBC Level
Boron	1	1166	4.4 E+4	4			1.8 E+5	6.3 E-1	2.4 E-1	2.0 E-1	NA	3	NA	315	NA
Fluoride	1	1166	5.3 E+4	0.06			3.2 E+3	1.1 E-2	4.2 E-3	4.0 E-2	NA	0	NA	3529	NA
Arsenic	1	1166	5.2 E+4	0.024			1.3 E+3	3.9 E-3	1.4 E-3	3.0 E-4	1.5 E+0	13	2E-03	77	0.46
Barium	1	1166	5.3 E+4	0.005			2.7 E+2	9.5 E-4	3.5 E-4	2.0 E-1	NA	0.00	NA	211062	NA
Cadmium	1.375	1166	7.3 E+4		0.546	-0.475	2.8 E+2	1.0 E-3	3.7 E-4	1.0 E-3	NA	1	NA	1375	NA
Hexavalent Chromium	1	1166	5.2 E+4	0.028			1.4 E+3	5.2 E-3	1.9 E-3	3.0 E-3	5.0 E-1	2	1E-03	582	1.04
Mercury	0.3877	1166	2.0 E+4		0.544	-0.966	8.4 E+1	3.0 E-4	1.1 E-4	3.0 E-4	NA	1	NA	387.7	NA
Thallium	1	1166	5.3 E+4	8.58E-04			4.5 E+1	1.6 E-4	6.0 E-5	1.0 E-5	NA	16	NA	62.0	NA
Zinc	1	1166	5.3 E+4	0.118			6.2 E+3	2.2 E-2	8.2 E-3	3.0 E-1	NA	0	NA	13530	NA
Benzo (a) Anthracene	0.036	1166	2.0 E+2		0.5944	-2.7078	1.6 E+0	5.5 E-6	2.1 E-6	NA	7.3 E-1	NA	1E-06	NA	36.0
Benzo (a) Pyrene	0.00028	1166	1.2 E+0		0.975	-2.0615	1.5 E-1	5.4 E-7	2.0 E-7	NA	7.3 E+0	NA	1E-06	NA	0.280
Benzo (b) Fluoranthene	1	1166	5.0 E+3	0.31			1.5 E+3	5.5 E-3	2.0 E-3	NA	7.3 E-1	NA	1E-03	NA	0.67
Benzo (k) Fluoranthene	0.018	1166	2.9 E+2		0.8595	-2.1579	1.5 E+1	5.4 E-5	2.0 E-5	NA	7.3 E-2	NA	1E-06	NA	18.0
Chrysene	56	1166	4.6 E+5		0.5944	-2.7078	1.5 E+2	5.5 E-4	2.0 E-4	NA	7.3 E-3	NA	1E-06	NA	56000
Dibenz (a,h) Anthracene	1	1166	7.6 E+3	0.13			9.8 E+2	3.5 E-3	1.3 E-3	NA	7.3 E+0	NA	1E-02	NA	0.105
Indeno (1,2,3-c,d) Pyrene	1	1166	5.8 E+3	0.11			6.4 E+2	2.3 E-3	8.5 E-4	NA	7.3 E-1	NA	6E-04	NA	1.61
Naphthalene	1	1166	3.9 E+2	12.2			4.7 E+3	1.7 E-2	6.2 E-3	2.0 E-2	NA	1	NA	1192	NA
1,3,5-Trimethylbenzene	1	1166	2.3 E+2	0.49			1.1 E+2	4.0 E-4	1.5 E-4	1.0 E-2	NA	0.0	NA	25213	NA
Acetone	1	1166	5.6 E+1	8.38			4.7 E+2	1.7 E-3	6.2 E-4	9.0 E-1	NA	0.00	NA	536546	NA
Toluene	1	1166	1.8 E+2	1.07			1.9 E+2	6.8 E-4	2.5 E-4	8.0 E-2	NA	0.01	NA	118169	NA
Xylenes	1	1166	2.3 E+2	0.548			1.2 E+2	4.4 E-4	1.6 E-4	2.0 E-1	NA	0.00	NA	451212	NA
Benzene	1	1166	1.3 E+2	2.37			3.1 E+2	1.1 E-3	4.1 E-4	4.0 E-3	5.5 E-2	0	2E-05	3666	45
Ethylbenzene	1	1166	8.1 E+1	0.625			5.0 E+1	1.8 E-4	6.7 E-5	1.0 E-1	1.1 E-2	0.00	7E-07	555287	1359
Ethylene Glycol	1	1166	9.6 E+1	249.574			2.4 E+4	8.5 E-2	3.2 E-2	2.0 E+0	NA	0.0	NA	23508	NA
Methylene Chloride	1	1166	2.2 E+2	6.86			1.5 E+3	5.5 E-3	2.0 E-3	6.0 E-3	2.0 E-3	1	4E-06	1099	247
<b>Total Petroleum Hydrocarbons</b>															
<b>C4-C12</b>															
C5-C8 Aliphatics	1	1166	1.3 E+2	0.216			2.9 E+1	1.0 E-4	3.8 E-5	1.0 E-2	NA	0.01	NA	98194	NA
C6-C8 Aromatics	1	1166	1.3 E+2	2.367			3.1 E+2	1.1 E-3	4.2 E-4	4.0 E-3	NA	0	NA	3578	NA
<b>C13-C22</b>															
C9-C16 Aromatics	1	1166	2.2 E+3	0.322			6.9 E+2	2.5 E-3	9.2 E-4	4.0 E-3	NA	0.6	NA	1616	NA
C9-C18 Aliphatics	1	1166	2.1 E+3	0.020			4.2 E+1	1.5 E-4	5.6 E-5	1.0 E-2	NA	0.02	NA	66469	NA
<b>C23-C32</b>															
C17-C32 Aromatics	1	1166	2.2 E+3	0.038			8.3 E+1	3.0 E-4	1.1 E-4	4.0 E-2	NA	0.01	NA	135389	NA
C19-C32 Aliphatics	1	1166	2.2 E+3	0.012			2.5 E+1	8.9 E-5	3.3 E-5	3.0 E+0	NA	0.0000	NA	33689046	NA

**Table 10**  
**RBC Level Calculations for Tree Nuts**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m <sup>2</sup> -yr	Soil Concentration (mg/kg)	Soil to Plant Uptake			Plant Tissue Concentration <sup>b</sup> (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-Based Water RBC Level mg/L	Cancer-Based Water RBC Level mg/L
				BCF	B1	B0									

**Key:**

ADD = Average daily dose

BCF = Bioconcentration factor

CSF = Cancer slope factor

g/cm<sup>3</sup> = Grams per cubic centimeter

g/L = Grams per liter

HI = Hazard index

ILCR = Incremental lifetime cancer risk

in/yr = Inches per year

Kow = Octanol water partition coefficient

L/m<sup>2</sup>-yr = Liters per square meters per year

LADD = Lifetime average daily dose

mg/kg = Milligram per kilogram

mg/kg-day = Milligram per kilogram per day

mg/L = Milligrams per liter

NA = Not applicable. Data either not applicable (e.g., not carcinogenic), not available, or chemical not assessed for this pathway.

RBC = Risk-based concentration

RfD = Reference dose

**Notes:**

The soil and plant concentrations and ADD and LADD values presented are calculated from the unit water concentration (1 g/L) and are therefore 'placeholders' and are used to calculate a risk-based water concentration based upon a HQ = 1 or ILCR = 1x10<sup>-6</sup>.

<sup>a</sup> - For COIs that are evaluated with a linear bioaccumulation model, the water concentration is 1 g/L. For COIs using a regression model, the water concentration was changed to achieve either an HQ = 1 or an ILCR = 1x10<sup>-6</sup>.

**Table 11**  
**RBC Level Calculations for Grapes**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m2-yr	Soil Concentration (mg/kg)	Soil to Plant Uptake			Plant Tissue Concentration (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-	Cancer-Based
				BCF	B1	B0								RBC Level	Water RBC Level
														mg/L	mg/L
Boron	1	999	3.8 E+4	4			1.5 E+5	3.1 E+0	4.2 E-1	2.0 E-1	NA	15	NA	65	NA
Fluoride	1	999	4.5 E+4	0.06			2.7 E+3	5.5 E-2	7.5 E-3	4.0 E-2	NA	1	NA	731	NA
Arsenic	1	999	4.5 E+4	0.064			2.9 E+3	5.0 E-2	6.8 E-3	3.0 E-4	1.5 E+0	167	1E-02	6.0	0.10
Barium	1	999	4.6 E+4	0.004			1.8 E+2	3.7 E-3	5.0 E-4	2.0 E-1	NA	0.02	NA	54676	NA
Cadmium	0.068	999	3.1 E+3		0.546	-0.475	5.0 E+1	1.0 E-3	1.4 E-4	1.0 E-3	NA	1	NA	68	NA
Hexavalent Chromium	1	999	4.4 E+4	0.012			5.3 E+2	1.1 E-2	1.5 E-3	3.0 E-3	5.0 E-1	4	7E-04	282	1.4
Mercury	0.019	999	8.5 E+2		0.544	-0.966	1.5 E+1	3.0 E-4	4.1 E-5	3.0 E-4	NA	1	NA	19	NA
Thallium	1	999	4.5 E+4	8.58E-04			3.9 E+1	7.8 E-4	1.1 E-4	1.0 E-5	NA	78	NA	13	NA
Zinc	1	999	4.5 E+4	0.144			6.5 E+3	1.3 E-1	1.8 E-2	3.0 E-1	NA	0.4	NA	2298	NA
Benzo (a) Anthracene	0.012	999	5.7 E+1		0.5944	-2.7078	7.4 E-1	1.5 E-5	2.0 E-6	NA	7.3 E-1	NA	1E-06	NA	12
Benzo (a) Pyrene	0.00015	999	5.5 E-1		0.975	-2.0615	7.1 E-2	1.4 E-6	1.9 E-7	NA	7.3 E+0	NA	1E-06	NA	0.15
Benzo (b) Fluoranthene	1	999	4.3 E+3	0.31			1.3 E+3	2.7 E-2	3.6 E-3	NA	7.3 E-1	NA	3E-03	NA	0.38
Benzo (k) Fluoranthene	0.0091	999	1.3 E+2		0.8595	-2.1579	7.4 E+0	1.5 E-4	2.0 E-5	NA	7.3 E-2	NA	1E-06	NA	9
Chrysene	19	999	1.3 E+5		0.5944	-2.7078	7.4 E+1	1.5 E-3	2.0 E-4	NA	7.3 E-3	NA	1E-06	NA	19000
Dibenz (a,h) Anthracene	1	999	6.5 E+3	0.13			8.4 E+2	1.7 E-2	2.3 E-3	NA	7.3 E+0	NA	2E-02	NA	0.059
Indeno (1,2,3-c,d) Pyrene	1	999	5.0 E+3	0.11			5.5 E+2	1.1 E-2	1.5 E-3	NA	7.3 E-1	NA	1E-03	NA	0.91
Naphthalene	1	999	3.3 E+2	12.2			4.0 E+3	8.1 E-2	1.1 E-2	2.0 E-2	NA	4	NA	247	NA
1,3,5-Trimethylbenzene	1	999	1.9 E+2	0.49			9.5 E+1	1.9 E-3	2.6 E-4	1.0 E-2	NA	0.2	NA	5225	NA
Acetone	1	999	4.8 E+1	8.38			4.0 E+2	8.1 E-3	1.1 E-3	9.0 E-1	NA	0.009	NA	111195	NA
Toluene	1	999	1.5 E+2	1.07			1.6 E+2	3.3 E-3	4.5 E-4	8.0 E-2	NA	0.04	NA	24490	NA
Xylenes	1	999	1.9 E+2	0.548			1.1 E+2	2.1 E-3	2.9 E-4	2.0 E-1	NA	0.01	NA	93510	NA
Benzene	1	999	1.1 E+2	2.37			2.6 E+2	5.3 E-3	7.2 E-4	4.0 E-3	5.5 E-2	1	4E-05	760	25
Ethylbenzene	1	999	6.9 E+1	0.625			4.3 E+1	8.7 E-4	1.2 E-4	1.0 E-1	1.1 E-2	0.009	1E-06	115079	765
Ethylene Glycol	1	999	8.2 E+1	249.574			2.0 E+4	4.1 E-1	5.6 E-2	2.0 E+0	NA	0.2	NA	4872	NA
Methylene Chloride	1	999	1.9 E+2	6.86			1.3 E+3	2.6 E-2	3.6 E-3	6.0 E-3	2.0 E-3	4	7E-06	228	139
<b>Total Petroleum Hydrocarbons</b>															
<b>C4-C12</b>															
	C5-C8 Aliphatics	1	999	1.1 E+2	0.216		2.4 E+1	4.9 E-4	6.7 E-5	1.0 E-2	NA	0.05	NA	20350	NA
	C6-C8 Aromatics	1	999	1.1 E+2	2.367		2.7 E+2	5.4 E-3	7.4 E-4	4.0 E-3	NA	1	NA	741	NA
<b>C13-C22</b>															
	C9-C16 Aromatics	1	999	1.8 E+3	0.322		5.9 E+2	1.2 E-2	1.6 E-3	4.0 E-3	NA	3.0	NA	335	NA
	C9-C18 Aliphatics	1	999	1.8 E+3	0.020		3.6 E+1	7.3 E-4	9.9 E-5	1.0 E-2	NA	0.073	NA	13775	NA
<b>C23-C32</b>															
	C17-C32 Aromatics	1	999	1.9 E+3	0.038		7.1 E+1	1.4 E-3	1.9 E-4	4.0 E-2	NA	0.04	NA	28	NA
	C19-C32 Aliphatics	1	999	1.9 E+3	0.012		2.1 E+1	4.3 E-4	5.9 E-5	3.0 E+0	NA	0.0001	NA	6981780	NA

**Table 11**  
**RBC Level Calculations for Grapes**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m <sup>2</sup> -yr	Soil Concentration (mg/kg)	Soil to Plant Uptake			Plant Tissue Concentration (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-Based Water RBC Level mg/L	Cancer-Based Water RBC Level mg/L
				BCF	B1	B0									

**Key:**

ADD = Average daily dose

BCF = Bioconcentration factor

CSF = Cancer slope factor

g/cm<sup>3</sup> = Grams per cubic centimeter

g/L = Grams per liter

HI = Hazard index

ILCR = Incremental lifetime cancer risk

in/yr = Inches per year

Kow = Octanol water partition coefficient

L/m<sup>2</sup>-yr = Liters per square meters per year

LADD = Lifetime average daily dose

mg/kg = Milligram per kilogram

mg/kg-day = Milligram per kilogram per day

mg/L = Milligrams per liter

NA = Not applicable. Data either not applicable (e.g., not carcinogenic), not available, or chemical not assessed for this pathway.

RBC = Risk-based concentration

RfD = Reference dose

Grapes irrigation rate	39.33 in/yr	see Table 3
Zs	38 cm	USDA 2009
BD	1.5 g/cm <sup>3</sup>	USEPA 2005a

**Notes:**

The soil and plant concentrations and ADD and LADD values presented are calculated from the unit water concentration (1 g/L) and are therefore 'placeholders' and are used to calculate a risk-based water concentration based upon a HQ = 1 or ILCR = 1x10<sup>-6</sup>.

<sup>a</sup> - For COIs that are evaluated with a linear bioaccumulation model, the water concentration is 1 g/L. For COIs using a regression model, the water concentration was changed to achieve either an HQ = 1 or an ILCR = 1x10<sup>-6</sup>.

**Table 12**  
**RBC Level Calculations for Citrus**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m2-yr	Soil Concentration (mg/kg)	Soil to Plant Uptake			Plant Tissue Concentration (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-	Cancer-Based
				BCF	B1	B0								RBC Level	Water RBC Level
														mg/L	mg/L
Boron	1	840	3.2 E+4	4			1.3 E+5	1.7 E+0	2.8 E-1	2.0 E-1	NA	9	NA	116	NA
Fluoride	1	840	3.8 E+4	0.06			2.3 E+3	3.1 E-2	5.0 E-3	4.0 E-2	NA	0.8	NA	1296	NA
Arsenic	1	840	3.8 E+4	0.034			1.3 E+3	1.5 E-2	2.4 E-3	3.0 E-4	1.5 E+0	50	4E-03	20	0.28
Barium	1	840	3.8 E+4	0.004			1.5 E+2	2.1 E-3	3.3 E-4	2.0 E-1	NA	0.010	NA	96909	NA
Cadmium	0.17	840	6.4 E+3		0.546	-0.475	7.4 E+1	1.0 E-3	1.6 E-4	1.0 E-3	NA	1	NA	168	NA
Hexavalent Chromium	1	840	3.7 E+4	0.011			4.1 E+2	5.5 E-3	8.9 E-4	3.0 E-3	5.0 E-1	2	4E-04	544	2.3
Mercury	0.047	840	1.8 E+3		0.544	-0.966	2.2 E+1	3.0 E-4	4.8 E-5	3.0 E-4	NA	1	NA	47	NA
Thallium	1	840	3.8 E+4	8.58E-04			3.3 E+1	4.4 E-4	7.1 E-5	1.0 E-5	NA	44	NA	23	NA
Zinc	1	840	3.8 E+4	0.137			5.2 E+3	7.0 E-2	1.1 E-2	3.0 E-1	NA	0.2	NA	4281	NA
Benzo (a) Anthracene	0.021	840	8.4 E+1		0.5944	-2.7078	9.3 E-1	1.2 E-5	2.0 E-6	NA	7.3 E-1	NA	1E-06	NA	21
Benzo (a) Pyrene	0.00024	840	7.4 E-1		0.975	-2.0615	9.5 E-2	1.3 E-6	2.1 E-7	NA	7.3 E+0	NA	1E-06	NA	0.24
Benzo (b) Fluoranthene	1	840	3.6 E+3	0.31			1.1 E+3	1.5 E-2	2.4 E-3	NA	7.3 E-1	NA	2E-03	NA	0.57
Benzo (k) Fluoranthene	0.014	840	1.6 E+2		0.8595	-2.1579	9.3 E+0	1.2 E-4	2.0 E-5	NA	7.3 E-2	NA	1E-06	NA	14
Chrysene	34	840	2.0 E+5		0.5944	-2.7078	9.4 E+1	1.3 E-3	2.1 E-4	NA	7.3 E-3	NA	1E-06	NA	34000
Dibenz (a,h) Anthracene	1	840	5.5 E+3	0.13			7.1 E+2	9.6 E-3	1.5 E-3	NA	7.3 E+0	NA	1E-02	NA	0.09
Indeno (1,2,3-c,d) Pyrene	1	840	4.2 E+3	0.11			4.6 E+2	6.2 E-3	1.0 E-3	NA	7.3 E-1	NA	7E-04	NA	1.4
Naphthalene	1	840	2.8 E+2	12.2			3.4 E+3	4.6 E-2	7.4 E-3	2.0 E-2	NA	2	NA	438	NA
1,3,5-Trimethylbenzene	1	840	1.6 E+2	0.49			8.0 E+1	1.1 E-3	1.7 E-4	1.0 E-2	NA	0.11	NA	9261	NA
Acetone	1	840	4.0 E+1	8.38			3.4 E+2	4.6 E-3	7.4 E-4	9.0 E-1	NA	0.005	NA	197083	NA
Toluene	1	840	1.3 E+2	1.07			1.4 E+2	1.8 E-3	3.0 E-4	8.0 E-2	NA	0.02	NA	43406	NA
Xylenes	1	840	1.6 E+2	0.548			9.0 E+1	1.2 E-3	1.9 E-4	2.0 E-1	NA	0.006	NA	165738	NA
Benzene	1	840	9.3 E+1	2.37			2.2 E+2	3.0 E-3	4.8 E-4	4.0 E-3	5.5 E-2	0.7	3E-05	1347	38
Ethylbenzene	1	840	5.8 E+1	0.625			3.6 E+1	4.9 E-4	7.9 E-5	1.0 E-1	1.1 E-2	0.005	9E-07	203967	1150
Ethylene Glycol	1	840	6.9 E+1	249.574			1.7 E+4	2.3 E-1	3.7 E-2	2.0 E+0	NA	0.12	NA	8635	NA
Methylene Chloride	1	840	1.6 E+2	6.86			1.1 E+3	1.5 E-2	2.4 E-3	6.0 E-3	2.0 E-3	2	5E-06	404	209
<b>Total Petroleum Hydrocarbons</b>															
<b>C4-C12</b>															
C5-C8 Aliphatics	1	840	9.5 E+1	0.216			2.1 E+1	2.8 E-4	4.5 E-5	1.0 E-2	NA	0.028	NA	36069	NA
C6-C8 Aromatics	1	840	9.5 E+1	2.367			2.3 E+2	3.0 E-3	4.9 E-4	4.0 E-3	NA	0.8	NA	1314	NA
<b>C13-C22</b>															
C9-C16 Aromatics	1	840	1.6 E+3	0.322			5.0 E+2	6.7 E-3	1.1 E-3	4.0 E-3	NA	1.7	NA	594	NA
C9-C18 Aliphatics	1	840	1.5 E+3	0.020			3.0 E+1	4.1 E-4	6.6 E-5	1.0 E-2	NA	0.041	NA	24415	NA
<b>C23-C32</b>															
C17-C32 Aromatics	1	840	1.6 E+3	0.038			6.0 E+1	8.0 E-4	1.3 E-4	4.0 E-2	NA	0.02	NA	50	NA
C19-C32 Aliphatics	1	840	1.6 E+3	0.012			1.8 E+1	2.4 E-4	3.9 E-5	3.0 E+0	NA	0.00008	NA	12374601	NA

**Table 12**  
**RBC Level Calculations for Citrus**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m <sup>2</sup> -yr	Soil Concentration (mg/kg)	Soil to Plant Uptake			Plant Tissue Concentration (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-Based Water RBC Level mg/L	Cancer-Based Water RBC Level mg/L
				BCF	B1	B0									

**Key:**

ADD = Average daily dose

BCF = Bioconcentration factor

CSF = Cancer slope factor

g/cm<sup>3</sup> = Grams per cubic centimeter

g/L = Grams per liter

HI = Hazard index

ILCR = Incremental lifetime cancer risk

in/yr = Inches per year

Kow = Octanol water partition coefficient

L/m<sup>2</sup>-yr = Liters per square meters per year

LADD = Lifetime average daily dose

mg/kg = Milligram per kilogram

mg/kg-day = Milligram per kilogram per day

mg/L = Milligrams per liter

NA = Not applicable. Data either not applicable (e.g., not carcinogenic), not available, or chemical not assessed for this pathway.

RBC = Risk-based concentration

RfD = Reference dose

Citrus irrigation rate	33.09 in/yr	see Table 3
Zs	38 cm	USDA 2009
BD	1.5 g/cm <sup>3</sup>	USEPA 2005a

**Notes:**

The soil and plant concentrations and ADD and LADD values presented are calculated from the unit water concentration (1 g/L) and are therefore 'placeholders' and are used to calculate a risk-based water concentration based upon a HQ = 1 or ILCR = 1x10<sup>-6</sup>.

<sup>a</sup> - For COIs that are evaluated with a linear bioaccumulation model, the water concentration is 1 g/L. For COIs using a regression model, the water concentration was changed to achieve either an HQ = 1 or an ILCR = 1x10<sup>-6</sup>.

**Table 13**  
**RBC Level Calculations for Carrots**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m2-yr	Soil Concentration (mg/kg)	log Kow (L/kg)	Correction Factor for Belowground Produce (V <sub>grootveg</sub> ) (unitless)	Soil to Plant Uptake			Plant Tissue Concentration (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-Based Water RBC Level mg/L	Cancer-Based Water RBC Level mg/L
						BCF	B1	B0									
Boron	1	245	9.3 E+3	1.2 E+0	1.0 E+0	2			1.9 E+4	1.5 E-1	2.9 E-2	2.0 E-1	NA	0.8	NA	1325	NA
Fluoride	1	245	1.1 E+4		1.0 E+0	6.0E-03			6.7 E+1	5.4 E-4	1.0 E-4	4.0 E-2	NA	0.01	NA	74116	NA
Arsenic	1	245	1.1 E+4	6.8 E-1	1.0 E+0	0.0352			3.9 E+2	2.7 E-3	5.1 E-4	3.0 E-4	1.5 E+0	9	8E-04	111	1.3
Barium	1	245	1.1 E+4	2.3 E-1	1.0 E+0	0.156			1.7 E+3	1.4 E-2	2.7 E-3	2.0 E-1	NA	0.07	NA	14209	NA
Cadmium	1.5	245	1.6 E+4	-7.0 E-2	1.0 E+0		0.546	-0.475	1.2 E+2	1.0 E-3	1.9 E-4	1.0 E-3	NA	1	NA	1463	NA
Hexavalent Chromium	1	245	1.1 E+4		1.0 E+0	0.041			4.4 E+2	3.6 E-3	6.8 E-4	3.0 E-3	5.0 E-1	1	3E-04	835	2.9
Mercury	0.41	245	4.5 E+3	6.2 E-1	1.0 E+0		0.544	-0.966	3.7 E+1	3.0 E-4	5.7 E-5	3.0 E-4	NA	1	NA	410	NA
Thallium	1	245	1.1 E+4	2.3 E-1	1.0 E+0	4.0E-04			4.4 E+0	3.6 E-5	6.8 E-6	1.0 E-5	NA	4	NA	279	NA
Zinc	1254	245	1.4 E+7	-4.7 E-1	1.0 E+0		0.544	1.575	3.7 E+4	3.0 E-1	5.7 E-2	3.0 E-1	NA	1	NA	1254427	NA
Benzo (a) Anthracene	310	245	3.6 E+5	5.8 E+0	1.0 E-2		0.5944	-2.7078	1.3 E+0	1.1 E-5	2.0 E-6	NA	7.3 E-1	NA	1E-06	NA	310000
Benzo (a) Pyrene	0.13	245	1.2 E+2	6.1 E+0	1.0 E-2		0.975	-2.0615	1.3 E-1	1.1 E-6	2.0 E-7	NA	7.3 E+0	NA	1E-06	NA	130
Benzo (b) Fluoranthene	1	245	1.0 E+3	5.8 E+0	1.0 E-2	0.31			3.2 E+0	2.6 E-5	5.0 E-6	NA	7.3 E-1	NA	4E-06	NA	276
Benzo (k) Fluoranthene	15	245	5.1 E+4	6.1 E+0	1.0 E-2		0.8595	-2.1579	1.3 E+1	1.0 E-4	2.0 E-5	NA	7.3 E-2	NA	1E-06	NA	15000
Chrysene	490000	245	8.4 E+8	5.8 E+0	1.0 E-2		0.5944	-2.7078	1.3 E+2	1.1 E-3	2.1 E-4	NA	7.3 E-3	NA	1E-06	NA	490000000
Dibenz (a,h) Anthracene	1	245	1.6 E+3	6.8 E+0	1.0 E-2	0.13			2.1 E+0	1.7 E-5	3.2 E-6	NA	7.3 E+0	NA	2E-05	NA	43
Indeno (1,2,3-c,d) Pyrene	1	245	1.2 E+3	6.7 E+0	1.0 E-2	0.11			1.3 E+0	1.1 E-5	2.1 E-6	NA	7.3 E-1	NA	2E-06	NA	665
Naphthalene	1	245	8.1 E+1	3.3 E+0	1.0 E+0	12.2			9.9 E+2	8.0 E-3	1.5 E-3	2.0 E-2	NA	0.4	NA	2504	NA
1,3,5-Trimethylbenzene	1	245	4.8 E+1	3.4 E+0	1.0 E+0	16.3			7.8 E+2	6.3 E-3	1.2 E-3	1.0 E-2	NA	0.6	NA	1592	NA
Acetone	1	245	1.2 E+1	-2.4 E-1	1.0 E+0	74.2			8.7 E+2	7.1 E-3	1.3 E-3	9.0 E-1	NA	0.008	NA	127274	NA
Toluene	1	245	3.7 E+1	2.7 E+0	1.0 E+0	77.4			2.9 E+3	2.3 E-2	4.4 E-3	8.0 E-2	NA	0.3	NA	3431	NA
Xylenes	1	245	4.8 E+1	3.2 E+0	1.0 E+0	83.5			4.0 E+3	3.2 E-2	6.1 E-3	2.0 E-1	NA	0.2	NA	6220	NA
Benzene	1	245	2.7 E+1	2.1 E+0	1.0 E+0	80.1			2.2 E+3	1.8 E-2	3.3 E-3	4.0 E-3	5.5 E-2	4	2E-04	228	5.5
Ethylbenzene	1	245	1.7 E+1	3.2 E+0	1.0 E+0	77.6			1.3 E+3	1.1 E-2	2.0 E-3	1.0 E-1	1.1 E-2	0.11	2E-05	9394	45
Ethylene Glycol	1	245	2.0 E+1	-1.4 E+0	1.0 E+0	1.00			2.0 E+1	1.6 E-4	3.1 E-5	2.0 E+0	NA	0.00008	NA	12322938	NA
Methylene Chloride	1	245	4.7 E+1	1.3 E+0	1.0 E+0	359			1.7 E+4	1.4 E-1	2.6 E-2	6.0 E-3	2.0 E-3	23	5E-05	44	19
<b>Total Petroleum Hydrocarbons</b>																	
<b>C4-C12</b>																	
C5-C8 Aliphatics	1	245	2.8 E+1	3.9	1.0 E+0	38.54			1.1 E+3	8.7 E-3	1.6 E-3	1.0 E-2	NA	0.9	NA	1154	NA
C6-C8 Aromatics	1	245	2.8 E+1	2.1	1.0 E+0	1.43			4.0 E+1	3.2 E-4	6.1 E-5	4.0 E-3	NA	0.08	NA	12446	NA
<b>C13-C22</b>																	
C9-C16 Aromatics	1	245	4.5 E+2	3.6	1.0 E+0	1.48			6.7 E+2	5.4 E-3	1.0 E-3	4.0 E-3	NA	1.4	NA	737	NA
C9-C18 Aliphatics	1	245	4.5 E+2	5.7	1.0 E-2	154.86			7.0 E+2	5.6 E-3	1.1 E-3	1.0 E-2	NA	0.56	NA	1772	NA
<b>C23-C32</b>																	
C17-C32 Aromatics	1	245	4.6 E+2	5.2	1.0 E-2	0.92			4.2 E+0	3.4 E-5	6.4 E-6	4.0 E-2	NA	0.0008	NA	1187	NA
C19-C32 Aliphatics	1	245	4.5 E+2	6.1	1.0 E-2	52.00			2.4 E+2	1.9 E-3	3.6 E-4	3.0 E+0	NA	0.0006	NA	1570368	NA

**Table 13**  
**RBC Level Calculations for Carrots**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m <sup>2</sup> -yr	Soil Concentration (mg/kg)	log Kow (L/kg)	Correction Factor for Belowground Produce (V <sub>grootveg</sub> ) (unitless)	Soil to Plant Uptake			Plant Tissue Concentration (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-Based Water RBC Level mg/L	Cancer-Based Water RBC Level mg/L
						BCF	B1	B0									

**Key:**

- ADD = Average daily dose
- BCF = Bioconcentration factor
- CSF = Cancer slope factor
- g/cm<sup>3</sup> = Grams per cubic centimeter
- g/L = Grams per liter
- HI = Hazard index
- ILCR = Incremental lifetime cancer risk
- in/yr = Inches per year
- Kow = Octanol water partition coefficient
- L/m<sup>2</sup>-yr = Liters per square meters per year
- LADD = Lifetime average daily dose
- mg/kg = Milligram per kilogram
- mg/kg-day = Milligram per kilogram per day
- mg/L = Milligrams per liter
- NA = Not applicable. Data either not applicable (e.g., not carcinogenic), not available, or chemical not assessed for this pathway.
- RBC = Risk-based concentration
- RfD = Reference dose

**Notes:**

The soil and plant concentrations and ADD and LADD values presented are calculated from the unit water concentration (1 g/L) and are therefore 'placeholders' and are used to calculate a risk-based water concentration based upon a HQ = 1 or ILCR = 1x10<sup>-6</sup>.

<sup>a</sup> - For COIs that are evaluated with a linear bioaccumulation model, the water concentration is 1 g/L. For COIs using a regression model, the water concentration was changed to achieve either an HQ = 1 or an ILCR = 1x10<sup>-6</sup>.

**Table 14**  
**RBC Level Calculations for Potatoes**

Chemical	Water Concentration <sup>a</sup> g/L	Deposition Rate L/m2-yr	Soil Concentration (mg/kg)	log Kow (L/kg)	Correction Factor for Belowground Produce (Vg <sub>rootveg</sub> ) (unitless)	Soil to Plant Uptake			Plant Tissue Concentration (mg/kg)	ADD (mg/kg-day)	LADD (mg/kg-day)	RfD (mg/kg-day)	CSF (mg/kg-day) <sup>-1</sup>	HQ (unitless)	ILCR (unitless)	Non-Cancer-Based Water RBC Level mg/L	Cancer-Based Water RBC Level mg/L
						BCF	B1	B0									
Boron	1	366	1.4 E+4	1.2 E+0	1.0 E+0	2			2.8 E+4	9.8 E-1	2.3 E-1	2.0 E-1	NA	5	NA	205	NA
Fluoride	1	366	1.7 E+4		1.0 E+0	6.00E-03			1.0 E+2	3.5 E-3	8.1 E-4	4.0 E-2	NA	0.1	NA	11470	NA
Arsenic	1	366	1.6 E+4	6.8 E-1	1.0 E+0	0.0352			5.8 E+2	1.8 E-2	4.1 E-3	3.0 E-4	1.5 E+0	58	6E-03	17	0.16
Barium	1	366	1.7 E+4	2.3 E-1	1.0 E+0	0.156			2.6 E+3	9.1 E-2	2.1 E-2	2.0 E-1	NA	0.5	NA	2199	NA
Cadmium	0.067	366	1.1 E+3	-7.0 E-2	1.0 E+0		0.546	-0.475	2.9 E+1	1.0 E-3	2.3 E-4	1.0 E-3	NA	1.0	NA	1000	NA
Hexavalent Chromium	1	366	1.6 E+4		1.0 E+0	0.041			6.6 E+2	2.3 E-2	5.4 E-3	3.0 E-3	5.0 E-1	7.7	3E-03	129	0.37
Mercury	0.019	366	3.1 E+2	6.2 E-1	1.0 E+0		0.544	-0.966	8.6 E+0	3.0 E-4	7.0 E-5	3.0 E-4	NA	1.0	NA	19	NA
Thallium	1	366	1.7 E+4	2.3 E-1	1.0 E+0	4.0E-04			6.6 E+0	2.3 E-4	5.4 E-5	1.0 E-5	NA	23	NA	43	NA
Zinc	57	366	9.4 E+5	-4.7 E-1	1.0 E+0		0.544	1.575	8.6 E+3	3.0 E-1	7.0 E-2	3.0 E-1	NA	1	NA	56861	NA
Benzo (a) Anthracene	12	366	2.1 E+4	5.8 E+0	1.0 E-2		0.5944	-2.7078	2.5 E-1	8.6 E-6	2.0 E-6	NA	7.3 E-1	NA	1E-06	NA	12000
Benzo (a) Pyrene	0.016	366	2.1 E+1	6.1 E+0	1.0 E-2		0.975	-2.0615	2.5 E-2	8.8 E-7	2.1 E-7	NA	7.3 E+0	NA	1E-06	NA	16
Benzo (b) Fluoranthene	1	366	1.6 E+3	5.8 E+0	1.0 E-2	3.1E-01			4.9 E+0	1.7 E-4	4.0 E-5	NA	7.3 E-1	NA	3E-05	NA	35
Benzo (k) Fluoranthene	1.5	366	7.7 E+3	6.1 E+0	1.0 E-2		0.8595	-2.1579	2.5 E+0	8.8 E-5	2.1 E-5	NA	7.3 E-2	NA	1E-06	NA	1500
Chrysene	19000	366	4.9 E+7	5.8 E+0	1.0 E-2		0.5944	-2.7078	2.5 E+1	8.7 E-4	2.0 E-4	NA	7.3 E-3	NA	1E-06	NA	19000000
Dibenz (a,h) Anthracene	1	366	2.4 E+3	6.8 E+0	1.0 E-2	0.13			3.1 E+0	1.1 E-4	2.5 E-5	NA	7.3 E+0	NA	2E-04	NA	5.4
Indeno (1,2,3-c,d) Pyrene	1	366	1.8 E+3	6.7 E+0	1.0 E-2	0.11			2.0 E+0	7.1 E-5	1.6 E-5	NA	7.3 E-1	NA	1E-05	NA	83
Naphthalene	1	366	1.2 E+2	3.3 E+0	1.0 E+0	12.2			1.5 E+3	5.2 E-2	1.2 E-2	2.0 E-2	NA	3	NA	388	NA
1,3,5-Trimethylbenzene	1	366	7.1 E+1	3.4 E+0	1.0 E+0	16.3			1.2 E+3	4.1 E-2	9.5 E-3	1.0 E-2	NA	4	NA	246	NA
Acetone	1	366	1.8 E+1	-2.4 E-1	1.0 E+0	74.2			1.3 E+3	4.6 E-2	1.1 E-2	9.0 E-1	NA	0.05	NA	19697	NA
Toluene	1	366	5.6 E+1	2.7 E+0	1.0 E+0	77.4			4.3 E+3	1.5 E-1	3.5 E-2	8.0 E-2	NA	2	NA	531	NA
Xylenes	1	366	7.1 E+1	3.2 E+0	1.0 E+0	83.5			5.9 E+3	2.1 E-1	4.8 E-2	2.0 E-1	NA	1	NA	963	NA
Benzene	1	366	4.0 E+1	2.1 E+0	1.0 E+0	80.1			3.2 E+3	1.1 E-1	2.6 E-2	4.0 E-3	5.5 E-2	28	1E-03	35	0.69
Ethylbenzene	1	366	2.5 E+1	3.2 E+0	1.0 E+0	77.6			2.0 E+3	6.9 E-2	1.6 E-2	1.0 E-1	1.1 E-2	0.7	2E-04	1454	5.7
Ethylene Glycol	1	366	3.0 E+1	-1.4 E+0	1.0 E+0	0.28			8.3 E+0	2.9 E-4	6.8 E-5	2.0 E+0	NA	0.0001	NA	6877247	NA
Methylene Chloride	1	366	7.0 E+1	1.3 E+0	1.0 E+0	359			2.5 E+4	8.8 E-1	2.0 E-1	6.0 E-3	2.0 E-3	146	4E-04	6.8	2.4
<b>Total Petroleum Hydrocarbons</b>																	
<b>C4-C12</b>																	
C5-C8 Aliphatics	1	366	4.2 E+1	3.9	1.0 E+0	38.54			1.6 E+3	5.6 E-2	1.3 E-2	1.0 E-2	NA	6	NA	179	NA
C6-C8 Aromatics	1	366	4.2 E+1	2.1	1.0 E+0	1.43			5.9 E+1	2.1 E-3	4.8 E-4	4.0 E-3	NA	0.5	NA	1926	NA
<b>C13-C22</b>																	
C9-C16 Aromatics	1	366	6.8 E+2	3.6	1.0 E+0	1.48			1.0 E+3	3.5 E-2	8.2 E-3	4.0 E-3	NA	9	NA	114	NA
C9-C18 Aliphatics	1	366	6.7 E+2	5.7	1.0 E-2	154.86			1.0 E+3	3.6 E-2	8.5 E-3	1.0 E-2	NA	3.6	NA	274	NA
<b>C23-C32</b>																	
C17-C32 Aromatics	1	366	6.8 E+2	5.2	1.0 E-2	0.92			6.2 E+0	2.2 E-4	5.1 E-5	4.0 E-2	NA	0.005	NA	184	NA
C19-C32 Aliphatics	1	366	6.8 E+2	6.1	1.0 E-2	52.00			3.5 E+2	1.2 E-2	2.9 E-3	3.0 E+0	NA	0.004	NA	243025	NA

**Table 14**  
**RBC Level Calculations for Potatoes**

Chemical	Water Concentration <sup>a</sup>	Deposition Rate	Soil Concentration	log Kow	Correction Factor for Belowground Produce ( $V_{g_{rootveg}}$ )	Soil to Plant Uptake			Plant Tissue Concentration	ADD	LADD	RfD	CSF	HQ	ILCR	Non-Cancer-Based Water RBC Level	Cancer-Based Water RBC Level
	g/L	L/m <sup>2</sup> -yr	(mg/kg)	(L/kg)	(unitless)	BCF	B1	B0	(mg/kg)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day) <sup>-1</sup>	(unitless)	(unitless)	mg/L	mg/L

**Key:**

ADD = Average daily dose	potato irrigation rate	14.4 in/yr	see Table 3
BCF = Bioconcentration factor	Zs	38 cm	USDA 2009
CSF = Cancer slope factor	BD	1.5 g/cm <sup>3</sup>	USEPA 2005a

g/cm<sup>3</sup> = Grams per cubic centimeter  
g/L = Grams per liter  
HI = Hazard index  
ILCR = Incremental lifetime cancer risk  
in/yr = Inches per year  
Kow = Octanol water partition coefficient  
L/m<sup>2</sup>-yr = Liters per square meters per year  
LADD = Lifetime average daily dose  
mg/kg = Milligram per kilogram  
mg/kg-day = Milligram per kilogram per day  
mg/L = Milligrams per liter  
NA = Not applicable. Data either not applicable (e.g., not carcinogenic), not available, or chemical not assessed for this pathway.  
RBC = Risk-based concentration  
RfD = Reference dose

**Notes:**

The soil and plant concentrations and ADD and LADD values presented are calculated from the unit water concentration (1 g/L) and are therefore 'placeholders' and are used to calculate a risk-based water concentration based upon a HQ = 1 or ILCR = 1x10<sup>-6</sup>.  
<sup>a</sup> - For COIs that are evaluated with a linear bioaccumulation model, the water concentration is 1 g/L. For COIs using a regression model, the water concentration was changed to achieve either an HQ = 1 or an ILCR = 1x10<sup>-6</sup>.

**Table 15**  
**Summary of RBC Levels**

Chemical	Tree Nuts			Citrus			Grapes			Carrots			Potatoes		
	Risk-Based Comparison (RBC) Level			Risk-Based Comparison (RBC) Level			Risk-Based Comparison (RBC) Level			Risk-Based Comparison (RBC) Level			Risk-Based Comparison (RBC) Level		
	Non-Cancer Based (mg/L)	Cancer Based (mg/L)	Minimum (mg/L)	Non-Cancer Based (mg/L)	Cancer Based (mg/L)	Minimum (mg/L)	Non-Cancer Based (mg/L)	Cancer Based (mg/L)	Minimum (mg/L)	Non-Cancer Based (mg/L)	Cancer Based (mg/L)	Minimum (mg/L)	Non-Cancer Based (mg/L)	Cancer Based (mg/L)	Minimum (mg/L)
<b>Inorganics</b>															
Boron	300	NA	300	100	NA	100	70	NA	70	1000	NA	1000	200	NA	200
Fluoride	4000	NA	4000	1000	NA	1000	700	NA	700	70000	NA	70000	10000	NA	10000
Arsenic	80	0.5	0.5	20	0.3	0.3	6	0.1	0.1	100	1	1	20	0.2	0.2
Barium	200000	NA	200000	100000	NA	100000	50000	NA	50000	10000	NA	10000	2000	NA	2000
Cadmium	1000	NA	1000	200	NA	200	70	NA	70	1000	NA	1000	1000	NA	1000
Hexavalent Chromium	600	1	1	500	2	2	300	1	1	800	3	3	100	0.4	0.4
Mercury	400	NA	400	50	NA	50	20	NA	20	400	NA	400	20	NA	20
Thallium	60	NA	60	20	NA	20	10	NA	10	300	NA	300	40	NA	40
Zinc	10000	NA	10000	4000	NA	4000	2000	NA	2000	1000000	NA	1000000	60000	NA	60000
<b>Polynuclear Aromatic Hydrocarbons</b>															
Benzo (a) Anthracene	NA	40	40	NA	20	20	NA	10	10	NA	300000	300000	NA	10000	10000
Benzo (a) Pyrene	NA	0.3	0.3	NA	0.2	0.2	NA	0.2	0.2	NA	100	100	NA	20	20
Benzo (b) Fluoranthene	NA	0.7	0.7	NA	0.6	0.6	NA	0.4	0.4	NA	300	300	NA	30	30
Benzo (k) Fluoranthene	NA	20	20	NA	10	10	NA	9	9	NA	20000	20000	NA	2000	2000
Chrysene	NA	60000	60000	NA	30000	30000	NA	20000	20000	NA	500000000	500000000	NA	20000000	20000000
Dibenz (a,h) Anthracene	NA	0.1	0.1	NA	0.09	0.09	NA	0.06	0.06	NA	40	40	NA	5	5
Indeno (1,2,3-c,d) Pyrene	NA	2	2	NA	1	1	NA	0.9	0.9	NA	700	700	NA	80	80
Naphthalene	1000	NA	1000	400	NA	400	200	NA	200	3000	NA	3000	400	NA	400
<b>Volatile Organic Compounds</b>															
1,3,5-Trimethylbenzene	30000	NA	30000	9000	NA	9000	5000	NA	5000	2000	NA	2000	200	NA	200
Acetone	500000	NA	500000	200000	NA	200000	100000	NA	100000	100000	NA	100000	20000	NA	20000
Toluene	100000	NA	100000	40000	NA	40000	20000	NA	20000	3000	NA	3000	500	NA	500
Xylenes	500000	NA	500000	200000	NA	200000	90000	NA	90000	6000	NA	6000	1000	NA	1000
Benzene	4000	40	40	1000	40	40	800	30	30	200	5	5	40	0.7	0.7
Ethylbenzene	600000	1000	1000	200000	1000	1000	100000	800	800	9000	50	50	1000	6	6
Ethylene Glycol	20000	NA	20000	9000	NA	9000	5000	NA	5000	10000000	NA	10000000	7000000	NA	7000000
Methylene Chloride	1000	200	200	400	200	200	200	100	100	40	20	20	7	2	2
TPH-Crude															
<b>Total Petroleum Hydrocarbons</b>															
C4-C12															
C5-C8 Aliphatics	100000	NA	100000	40000	NA	40000	20000	NA	20000	1000	NA	1000	200	NA	200
C6-C8 Aromatics	4000	NA	4000	1000	NA	1000	700	NA	700	10000	NA	10000	2000	NA	2000
C13-C22															
C9-C16 Aromatics	2000	NA	2000	600	NA	600	300	NA	300	700	NA	700	100	NA	100
C9-C18 Aliphatics	70000	NA	70000	20000	NA	20000	10000	NA	10000	2000	NA	2000	300	NA	300
C23-C32															
C17-C32 Aromatics	100000	NA	100000	50	NA	50	30	NA	30	1000	NA	1000	200	NA	200
C19-C32 Aliphatics	30000000	NA	30000000	10000000	NA	10000000	7000000	NA	7000000	2000000	NA	2000000	200000	NA	200000

**Key:**

mg/L = Milligrams per liter

NA = Not applicable. Data either not applicable (e.g., not carcinogenic) or not available.

**Table 16**  
**Recommended Irrigation Water RBC Levels**

Chemical	Irrigation Water Risk-Based Comparison (RBC) Level (mg/L)					Lowest Irrigation Water RBC Level (mg/L)	Cawelo WD Blended Reclaimed Water Conc. (mg/L)	CRC Section 23 Facility Reclaimed Water Conc. (Pre-Blended) (mg/L)
	Nuts	Citrus	Grapes	Carrots	Potatoes			
<b>Inorganics</b>								
Arsenic	0.5	0.3	0.1	1	0.2	0.1	0.02	0.076
Barium	200,000	100,000	50,000	10,000	2,000	2,000	0.078	0.034
Boron	300	100	70	1,000	200	70	0.67	1.2
Cadmium	1000	200	70	1,000	1000	70	ND	ND
Chromium (VI)	1	2	1	3	0.4	0.4	ND	ND
Fluoride	4000	1,000	700	70,000	10,000	700	0.4	0.58
Mercury	400	50	20	400	20	20	ND	0.00016
Thallium	60	20	10	300	40	10	0.0085	ND
Zinc	10,000	4,000	2,000	1,000,000	60,000	2,000	ND	ND
<b>Organics</b>								
Acetone	500,000	200,000	100,000	100,000	20,000	20,000	ND	ND
Benzene	40	40	30	5	0.7	0.7	ND	0.0012
Ethylbenzene	1000	1,000	800	50	6	6	ND	ND
Ethylene Glycol	20,000	9,000	5,000	10,000,000	7,000,000	5,000	--	--
Methylene Chloride	200	200	100	20	2	2	ND	ND
Naphthalene	1000	400	200	3,000	400	200	ND	ND
PAHs	0.02	0.07	0.04	30	3	0.02	ND	0.00015
Toluene	100,000	40,000	20,000	3,000	500	500	ND	0.0051
TPH-Crude	8,000	3000	2000	1,000	200	200	0.08	20
Trimethylbenzene	30,000	9,000	5,000	2,000	200	200	ND	ND
Xylenes	500,000	200,000	90,000	6,000	1000	1,000	ND	0.021

ND = Not detected.

*Appendix A*  
*Abbreviations and Acronyms*

## **ABBREVIATIONS AND ACRONYMS**

ADD	Average daily dose
BAF	Bioaccumulation factor
cm	Centimeter
COI	Chemical of interest
CRC	California Resources Corporation
CSF	Cancer slope factor
DTSC	California Department of Toxic Substances Control
Eco-SSL	Ecological Soil Screening Level
ERM	ERM-West, Inc.
g/cm <sup>3</sup>	Grams per cubic centimeter
g/L	Grams per liter
HQ	Hazard quotient
ILCR	Incremental lifetime cancer risk
kg	Kilogram
L	Liter
L/m <sup>2</sup>	Liter per square meter
L/m <sup>3</sup>	Liter per cubic meter
LADD	Lifetime average daily dose
m <sup>2</sup>	Square meter
MCL	Maximum contaminant level
mg/kg	Milligrams per kilogram
mg/kg-d	Milligrams per kilogram per day
mg/L	Milligrams per liter
ml	Milliliter
NOAEL	No-observable-adverse-effect-level
OEHHA	California Office of Environmental Health Hazard Assessment
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic aromatic hydrocarbon
RBC	Risk-based comparison

RfD	Reference dose
RWQCB	Regional Water Quality Control Board
TPH	Total petroleum hydrocarbons
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency

*Appendix B*  
*Glossary*

## GLOSSARY

**ABSORPTION** – The process by which a substance is taken into and included within another substance (*e.g.*, intake of water by soil, or intake of gases, water, nutrients or other substances by plants and animals). In toxicology, a substance is considered absorbed once it has gained access to the circulatory system (*e.g.*, blood stream).

**ACCEPTABLE RISK** – A risk that is judged by society to be outweighed by corresponding benefits or one that is of such a degree that is considered to pose no significant potential for adverse effects.

**ADSORPTION** – The increased concentration of molecules or ions at a surface, including exchangeable cations and anions on soil particles.

**AVERAGE DAILY DOSE (ADD)** – Dose rate averaged over a specific period of exposure expressed as a daily dose on a per-unit-body-weight basis. The ADD is used for exposure to chemicals with non-carcinogenic health effects.

**BASELINE HEALTH RISK ASSESSMENT** – Generally a prospective assessment of health risk based on existing conditions.

**BIOAVAILABILITY** – The fraction of a substance in the surrounding environment available for uptake or absorption into an organism.

**BULK DENSITY** – The ratio of the mass of water-free soil to its bulk volume. Bulk density is expressed in pounds per cubic foot or grams per cubic centimeter. When expressed in grams per cubic centimeter, bulk density is numerically equal to apparent specific gravity or volume weight.

**CARCINOGEN** – A substance capable of causing or producing cancer in mammals, including humans. A chemical is considered to be a carcinogen if: (1) it has been evaluated by the International Agency for Research on Cancer (IARC) and found to be a known or potential carcinogen; (2) it is listed as a known or potential carcinogen in the *Annual Report on Carcinogens* published by the National Toxicology Program (NTP) (latest edition); or (3) it is listed as a carcinogen by the California Office of Environmental Health Hazard Assessment.

**CARCINOGENICITY** – The ability to produce cancer.

**CHRONIC EXPOSURE** – Long-term contact with a substance. In humans as applied to exposure duration, generally considered a period greater than 7 years.

**CHRONIC TOXICITY** – Toxic effects resulting from repeated doses or exposures of greater than 67 percent of the lifetime in laboratory animals, or greater than 1 year in humans.

**COMPLETE EXPOSURE PATHWAY** – A pathway that has (1) a source and mechanism of release to the environment; (2) an environmental transport medium; (3) a point of potential human contact (or ‘exposure point’); and (4) an exposure route and intake by a human receptor at the exposure point.

**CONCENTRATION** – The relative amount of a substance when combined or mixed with other substances. For example, the amount of a metal in soil, fertilizer, or water. Usually measured in parts per million, or milligrams of metal per kilogram of soil (or fertilizer) or milligrams of metal per liter of water.

**CONSERVATIVE** – Where assumptions are used that tend to maximize the estimated exposures and resultant risks.

**DEFAULT ASSUMPTIONS** – As applied to risk assessment, default assumptions are generally accepted values placed on parameters when site-specific values are lacking. Typically, regulatory agencies derive default values.

**DETERMINISTIC ANALYSIS** – A risk assessment approach that uses single point values for individual parameters that yields a single-value result. All population and environmental parameters are assumed to be constant and accurately specified; a contrasting approach is probabilistic risk assessment.

**DIRECT EXPOSURE** – Direct contact with a medium containing a substance that may be available for absorption into an organism (*e.g.*, ingestion of food containing a substance).

**DOSE** – The amount (usually expressed in milligrams per kilogram body weight per day [mg/kg-d]) of a metal or chemical that is ingested, inhaled, or absorbed through the skin.

**DOSE-RESPONSE ASSESSMENT** – A step in the risk-assessment process that attempts to characterize the relationship between the dose of a

chemical administered to a population of animals or humans and the incidence or proportion experiencing a given adverse effect. It frequently involves mathematical modeling techniques to extrapolate from the high-dose effects observed in test animals or humans exposed occupationally to estimate the effects expected from exposure to the typically low doses in the environment that may be encountered by humans.

**ENVIRONMENT** – All external conditions that may act upon an organism or soil to influence its development, including sunlight, temperature, moisture, and other conditions.

**ENVIRONMENTAL FATE** – The disposition of a substance in various environmental media or locations as a result of transport, partitioning, uptake, and degradation.

**ENVIRONMENTAL MEDIUM** – A distinguishable component of the physical environment (*e.g.*, soil, sediment, water, air, food).

**ENVIRONMENTAL TRANSPORT** – The movement of contaminants from their point of release through various environmental media to locations where exposure is assumed to occur.

**EQUILIBRIUM** – The condition in which all acting influences are canceled by others, resulting in a stable, balanced, or unchanging system.

**EROSION** – The wearing away of the land surface by detachment and transport of soil and rock materials through the action of moving water, wind, or other geological agents.

**EVAPOTRANSPIRATION** – The loss of water from a soil by evaporation and plant transpiration.

**EXPOSURE** – Contact of an organism with a chemical or physical agent; exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (*e.g.*, skin, lungs, gut) and available for absorption.

**EXPOSURE ASSESSMENT** – A component of risk assessment that attempts to estimate the magnitude, frequency, duration, and route of human exposure to a substance in the environment or in the workplace.

**EXPOSURE DURATION** – Defines how long exposure occurs in years.

**EXPOSURE EVENT** – An incident of contact with a chemical or physical agent. An exposure event can be defined by time (*e.g.*, day, hour) or by the incident (*e.g.*, eating a single meal of contaminated fish).

**EXPOSURE FACTOR** – A factor that quantitatively defines a single variable in exposure assessment (*e.g.*, human body weight, human inhalation rate).

**EXPOSURE FREQUENCY** – Defines how often exposure occurs (*e.g.*, hours per day, days per year).

**EXPOSURE PATHWAY** – The course a substance takes from a source to an exposed organism (see ‘complete pathway’). An exposure pathway describes a unique mechanism by which an individual or population is exposed to substance at or originating from a source.

**EXPOSURE POINT** – The point at which a receptor is assumed to come into direct contact with a substance (*e.g.*, point where dermal contact with soil occurs).

**EXPOSURE POINT CONCENTRATION** – The concentration of a substance at a specific exposure point.

**EXPOSURE ROUTE** – The way a chemical or physical agent comes into contact with an organism; also, a route of entry (*i.e.*, absorption) into a biological organism (*e.g.*, ingestion route, inhalation route, dermal route).

**EXTRAPOLATION** – The process of estimating or inferring something by extending or projecting known information.

**FOOD CHAIN TRANSFER** – Translocation of hazardous substances from the environment via food into human receptors (*e.g.*, uptake of metals from soil into parts of plants ingested by people).

**FORWARD-BASED RISK ASSESSMENT** – Unlike a reverse-based health risk assessment, a forward-based assessment estimates the likelihood of adverse health impacts in conjunction with a defined set of existing conditions (*e.g.*, defined exposure pathways, defined exposure point concentrations).

**HAZARD IDENTIFICATION** – The process of determining whether exposure to a substance can cause an adverse health effect and whether the adverse health effect is likely to occur in humans.

**HAZARD INDEX** – Generally calculated by summing the individual hazard quotients for multiple substances in multiple media (*e.g.*, water, air, soil, food) and/or for multiple substances with similar toxic effects (*e.g.*, liver toxicants).

**HAZARD QUOTIENT** – Generally calculated by dividing either a dosage (mg/kg-day) or environmental concentration (mg/kg) of a substance by the target dosage (*e.g.*, reference dose as mg/kg-day) or concentration (mg/kg).

**HEALTH RISK** – The probability of adverse health effects occurring to humans.

**INCREMENTAL RISK** – The additional or extra risk incurred by exposure to a substance over the lifetime of an individual (for carcinogens) or period of exposure (for non-carcinogens).

**INGESTION** – Entry of a substance into the body via the mouth.

**INORGANIC** – Substances occurring as minerals in nature or obtainable from them by chemical means. Refers to all matter except the compounds of carbon, but includes carbonates.

**LEACHING** – The removal of materials in solution by the passage of water through the soil.

**LIFETIME AVERAGE DAILY DOSE (LADD)** – Dose rate averaged over a lifetime expressed as a daily dose on a per-unit-body-weight basis. The LADD is used for exposure to chemicals with carcinogenic effects.

**LOWEST-OBSERVED-ADVERSE-EFFECT-LEVEL** – The lowest exposure level at which a statistically or biologically significant adverse effect is observed.

**MODELING** – Use of mathematical equations to simulate and predict real events and processes.

**NO-OBSERVED-ADVERSE-EFFECT-LEVEL** – The highest exposure level at which no statistically or biologically significant adverse effects are observed. Some effects may be produced at this level, but they are not considered adverse, or precursors to adverse effects.

**ORGANIC** – Compounds of carbon other than the inorganic carbonates.

**PARTS PER MILLION** – A notation for indicating small amounts of materials. The expression gives the number of units by weight of the substance per million weight units of another substance, such as soil. For water, parts per million is equivalent to milligrams per liter.

**pH** – A numerical designation of acidity and alkalinity. Technically, pH is the common logarithm of the reciprocal of the hydrogen ion concentration of a solution. A pH of 7.0 indicates precise neutrality; higher values indicate increasing alkalinity, and lower values indicate increasing acidity.

**POTENCY** – The power of a substance to cause a toxic effect; refers to the relative dosage required to produce the toxic effect (*i.e.*, a potency is inversely related to dosage).

**PRODUCED WATER** – Water that comes from the process of lifting oil and natural gas from underground formations to the surface.

**PROSPECTIVE** – Where exposures are modeled forward in time from the present to some future point in time.

**REASONABLE MAXIMUM EXPOSURE** – A term referring to the lower portion of the upper bound of the exposure, dose, or risk distribution.

**RECEPTOR** – A biological recipient (*e.g.*, human being) of exposure (or potential exposure) to a chemical or physical agent.

**REFERENCE DOSE (RfD)** – Same as the term ‘acceptable daily intake’; a level of exposure considered acceptable for non-carcinogenic health effects. RfDs are generally established by regulatory agencies (notably the United States Environmental Protection Agency), and are exposure route specific (*e.g.*, oral, inhalation) and time specific (*e.g.*, chronic, subchronic).

**REVERSE-BASED RISK ASSESSMENT** – Unlike a forward-based risk assessment, a reverse-based assessment estimates a level of exposure (*e.g.*, a concentration of a substance in an environmental medium) that would not pose an unacceptable health risk (*e.g.*,  $1 \times 10^{-5}$  theoretical upper-bound incremental cancer risk) under a defined set of existing conditions.

**RISK** – The uncertainty or variability in the outcome of some event or decision. In human health risk, it is the probability that an adverse effect

will occur under specified conditions (*e.g.*, a level of exposure to a substance).

**RISK ASSESSMENT** – The process by which the form, nature, extent, and characteristics of a risk are estimated. In regards to human health risk assessment, it is the characterization of the types of health effects expected from exposure to a substance, and estimation of the probability (risk) of occurrence of adverse effects. Reverse risk assessment is employed to derive an acceptable concentration of a substance in an environmental medium (*e.g.*, air, water, food, soil).

**RISK-BASED CONCENTRATION** – Concentration of a substance (*e.g.*, metal) in a medium (*e.g.*, irrigation water) that is considered health protective at a given risk threshold and a particular type of exposure.

**RISK MANAGEMENT** – Refers to the complex of judgments and analyses that uses the results of risk assessment to produce a decision; it is distinguished from risk assessment in that political, economic, and social aspects are included in the decision-making process.

**SAFETY** – The practical certainty that adverse health effects will not result from a substance when used in the quantity and in the manner approved for its use.

**SUBSTANCE** – A chemical, physical, mineralogical, or biological entity that may have adverse effects in an organism after the organism is exposed to it.

**THRESHOLD** – The dose or exposure level below which an adverse effect is not expected.

**TOXICITY** – The amount or dosage of a substance that causes toxic effects (*e.g.*, mg/kg body weight or parts per million in diet).

**TOXICITY ASSESSMENT** – Characterization, quantification, and documentation of the toxicological properties and effects of a substance, including all aspects of its absorption, metabolism, distribution, excretion, and mechanism of action, with special emphasis on establishment of dose-response characteristics; the process involves hazard identification and dose-response assessment.

**TOXICOLOGY** – The study of substances and their adverse effects on living systems.

**UNCERTAINTY** – Uncertainty represents a lack of knowledge about specific factors, parameters, or models affecting exposure or risk and can lead to inaccurate or biased estimates of exposure.

**UNCERTAINTY FACTOR** – A number that reflects the degree or amount of uncertainty that must be considered when toxicological data are used to establish acceptable levels of exposure.

**UPPER BOUND** – An estimate of the plausible upper limit to the true value of the quantity; a level of risk not likely to be lower than the true risk.

**UPPER-BOUND RISK** – A plausible estimate of the individual risk for those persons at the upper end of the risk distribution, conceptually above the 90<sup>th</sup> percentile, but not higher than the individual in the population with the highest risk.

**VARIABILITY** – Refers to observed differences attributable to true heterogeneity or diversity in a population or exposure parameter.

*Appendix C*  
*Sensitivity Analysis*

## *SENSITIVITY ANALYSIS*

A number of parameters for the development of RBC levels were identified with alternative values. These parameters and alternative values are identified in Table C-1. The sensitivity analysis focused on discrete variables on an individual crop/COI basis. The effect is presented as a fold-change in the tornado plots on the following figures, with the alternative values that would result in a higher (or less restrictive) RBC level in irrigation water represented in the light blue bars that extend to the right of the recommended RBC level, while the alternative values that would lead to a lower (or more restrictive) RBC level are shown in the dark blue bars on the left of the recommended RBC level:

- Figure C-1 Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Carrots
- Figure C-2 Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Citrus
- Figure C-3 Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Grapes
- Figure C-4 Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Potatoes
- Figure C-5 Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Tree Nuts
  
- Figure C-6 Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Carrots
- Figure C-7 Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Citrus
- Figure C-8 Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Grapes
- Figure C-9 Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Potatoes
- Figure C-10 Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Tree Nuts

- Figure C-11 Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Carrots
- Figure C-12 Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Citrus
- Figure C-13 Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Grapes
- Figure C-14 Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Potatoes
- Figure C-15 Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Tree Nuts
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- Figure C-16 Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Carrots
- Figure C-17 Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Citrus
- Figure C-18 Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Grapes
- Figure C-19 Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Potatoes
- Figure C-20 Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Tree Nuts
- 
- Figure C-21 Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Carrots
- Figure C-22 Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Citrus
- Figure C-23 Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Grapes
- Figure C-24 Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Potatoes
- Figure C-25 Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Tree Nuts

- Figure C-26 Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Carrots
- Figure C-27 Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Citrus
- Figure C-28 Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Grapes
- Figure C-29 Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Potatoes
- Figure C-30 Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Tree Nuts
- 
- Figure C-31 Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Carrots
- Figure C-32 Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Citrus
- Figure C-33 Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Grapes
- Figure C-34 Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Potatoes
- Figure C-35 Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Tree Nuts
- 
- Figure C-36 Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Carrots
- Figure C-37 Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Citrus
- Figure C-38 Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Grapes
- Figure C-39 Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Potatoes
- Figure C-40 Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Tree Nuts

- Figure C-41 Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Carrots
- Figure C-42 Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Citrus
- Figure C-43 Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Grapes
- Figure C-44 Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Potatoes
- Figure C-45 Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Tree Nuts
- Figure C-46 Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Carrots
- Figure C-47 Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Citrus
- Figure C-48 Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Grapes
- Figure C-49 Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Potatoes
- Figure C-50 Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Tree Nuts
- Figure C-51 Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Carrots
- Figure C-52 Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Citrus
- Figure C-53 Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Grapes
- Figure C-54 Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Potatoes
- Figure C-55 Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Tree Nuts

- Figure C-56 Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Carrots
- Figure C-57 Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Citrus
- Figure C-58 Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Grapes
- Figure C-59 Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Potatoes
- Figure C-60 Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Tree Nuts
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- Figure C-61 Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Carrots
- Figure C-62 Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Citrus
- Figure C-63 Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Grapes
- Figure C-64 Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Potatoes
- Figure C-65 Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Tree Nuts
- 
- Figure C-66 Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Carrots
- Figure C-67 Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Citrus
- Figure C-68 Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Grapes
- Figure C-69 Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Potatoes
- Figure C-70 Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Tree Nuts

- Figure C-71 Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Carrots
- Figure C-72 Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Citrus
- Figure C-73 Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Grapes
- Figure C-74 Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Potatoes
- Figure C-75 Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Tree Nuts
- 
- Figure C-76 Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Carrots
- Figure C-77 Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Citrus
- Figure C-78 Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Grapes
- Figure C-79 Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Potatoes
- Figure C-80 Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Tree Nuts
- 
- Figure C-81 Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Carrots
- Figure C-82 Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Citrus
- Figure C-83 Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Grapes
- Figure C-84 Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Potatoes
- Figure C-85 Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Tree Nuts

**FIGURE C-1**

**Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Carrots**

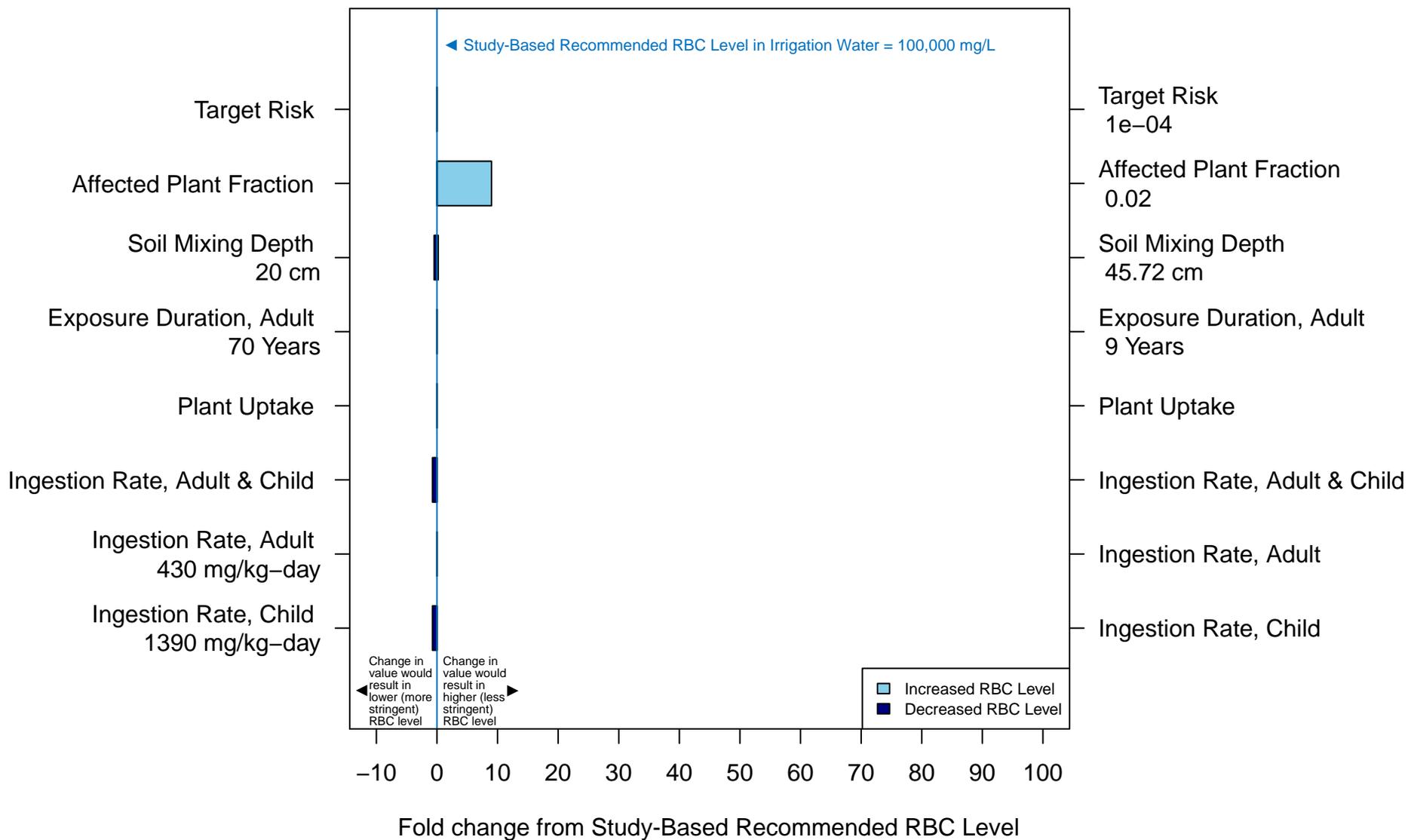
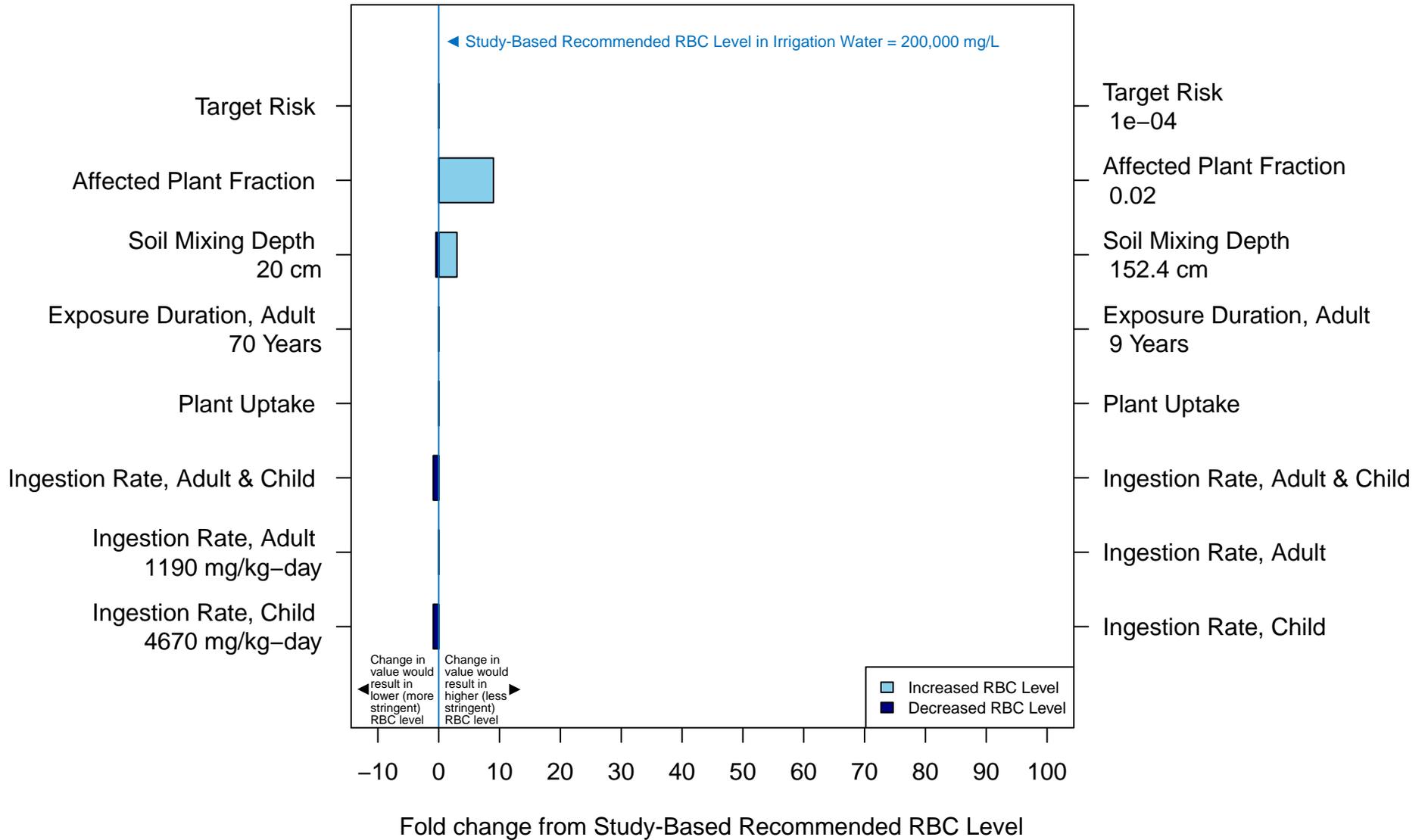


FIGURE C-2

Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Citrus



**FIGURE C-3**

**Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Grapes**

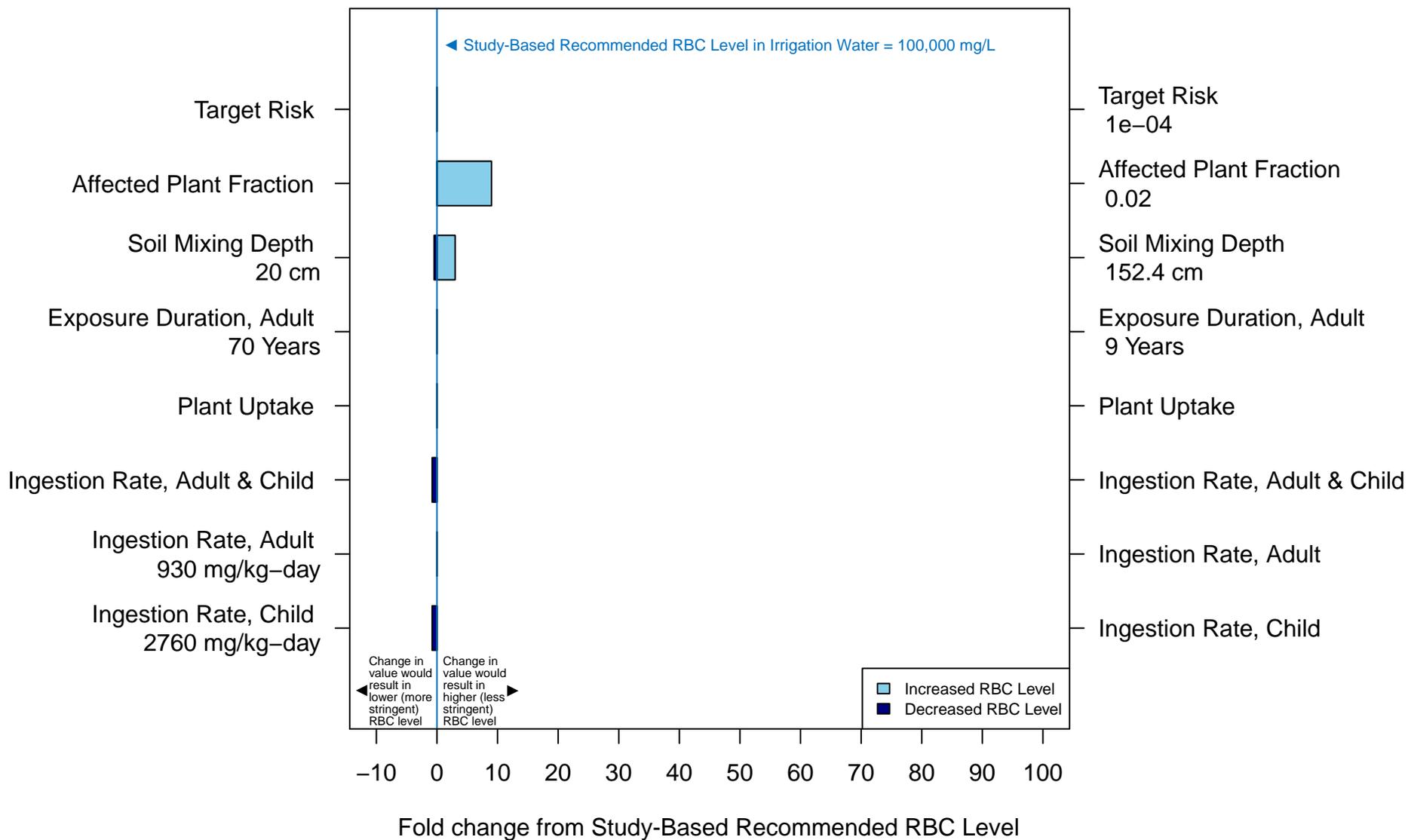


FIGURE C-4

Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Potatoes

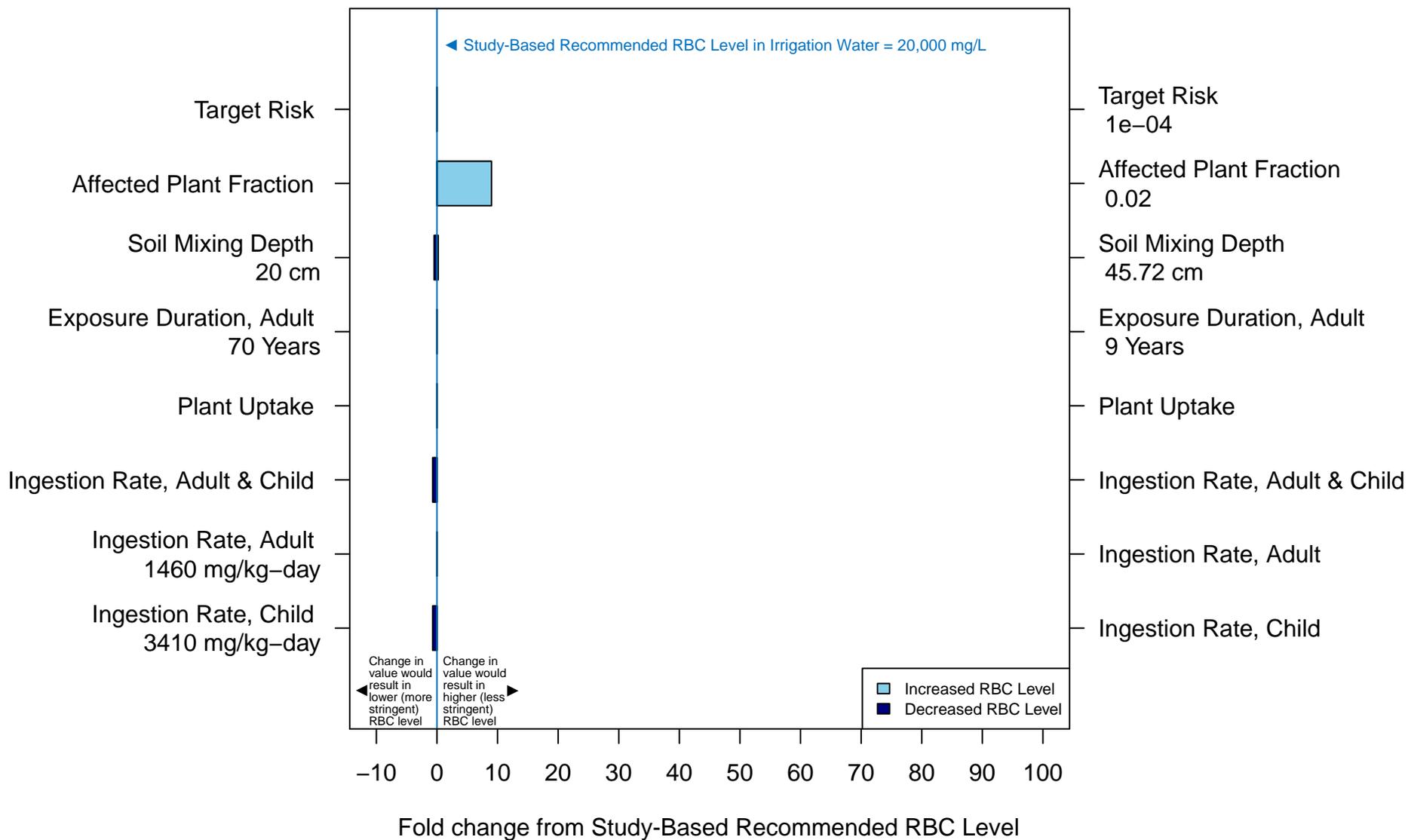


FIGURE C-5

Sensitivity of Recommended RBC Level of Acetone in Irrigation Water Applied for Tree Nuts

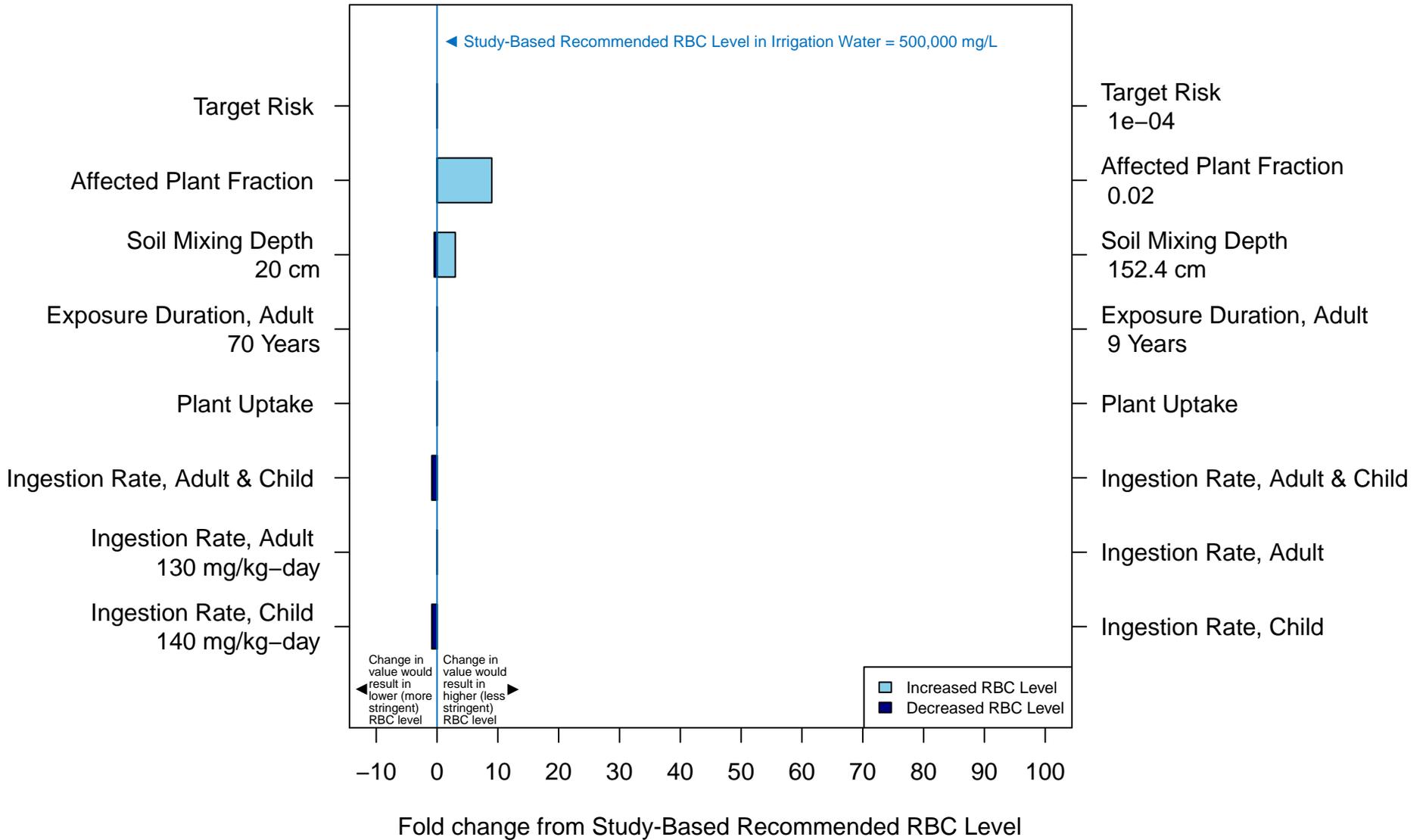
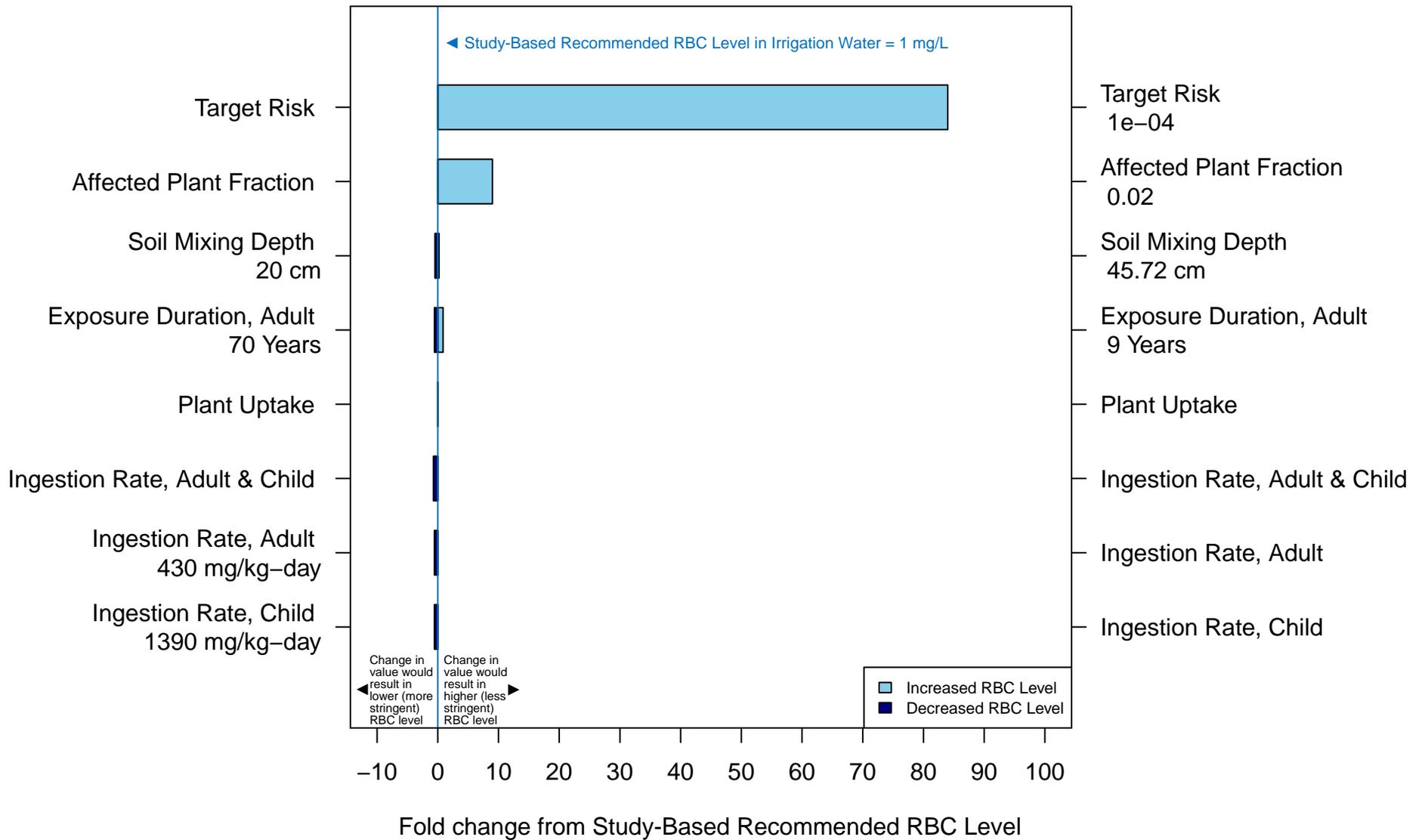


FIGURE C-6

Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Carrots



**FIGURE C-7**

**Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Citrus**

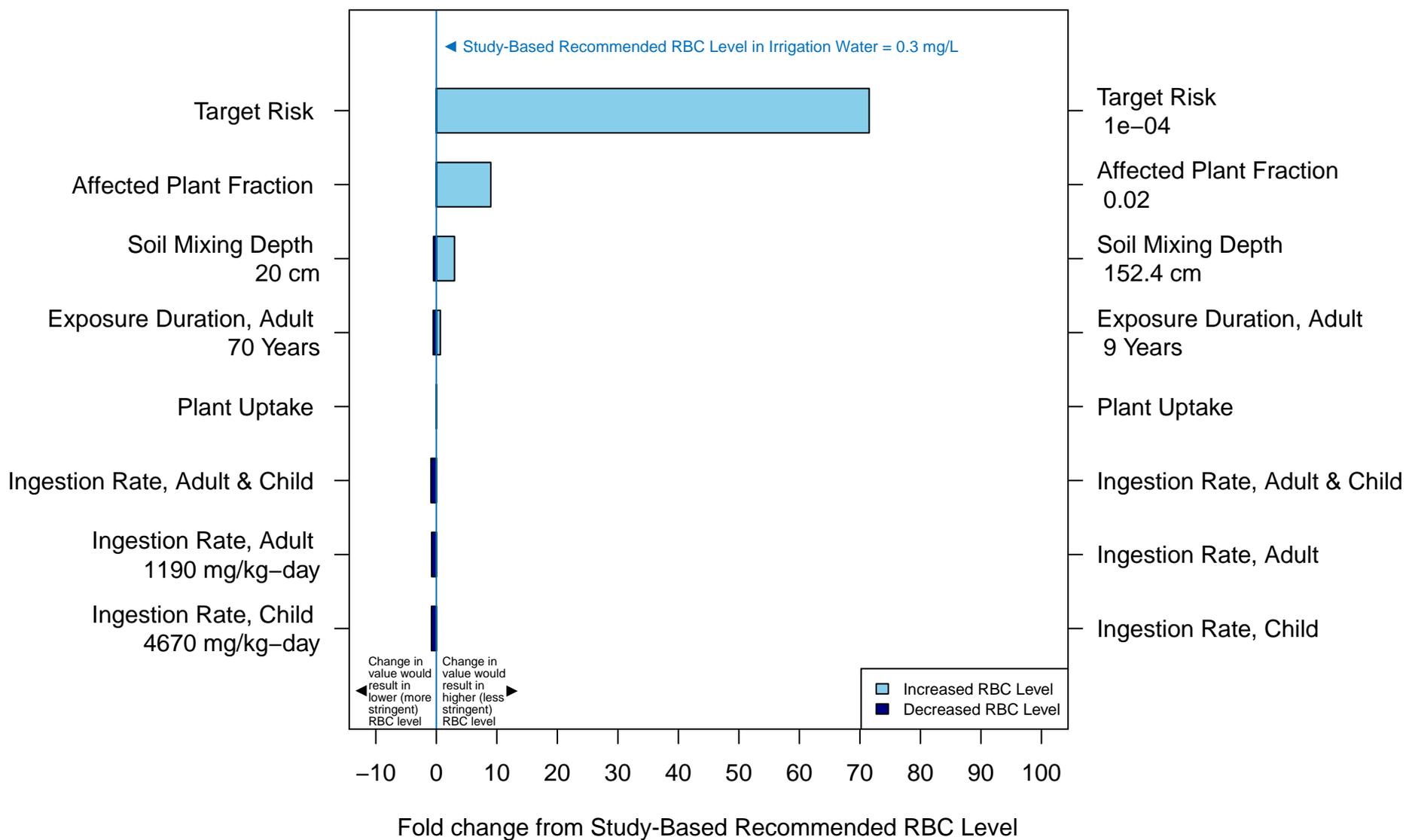
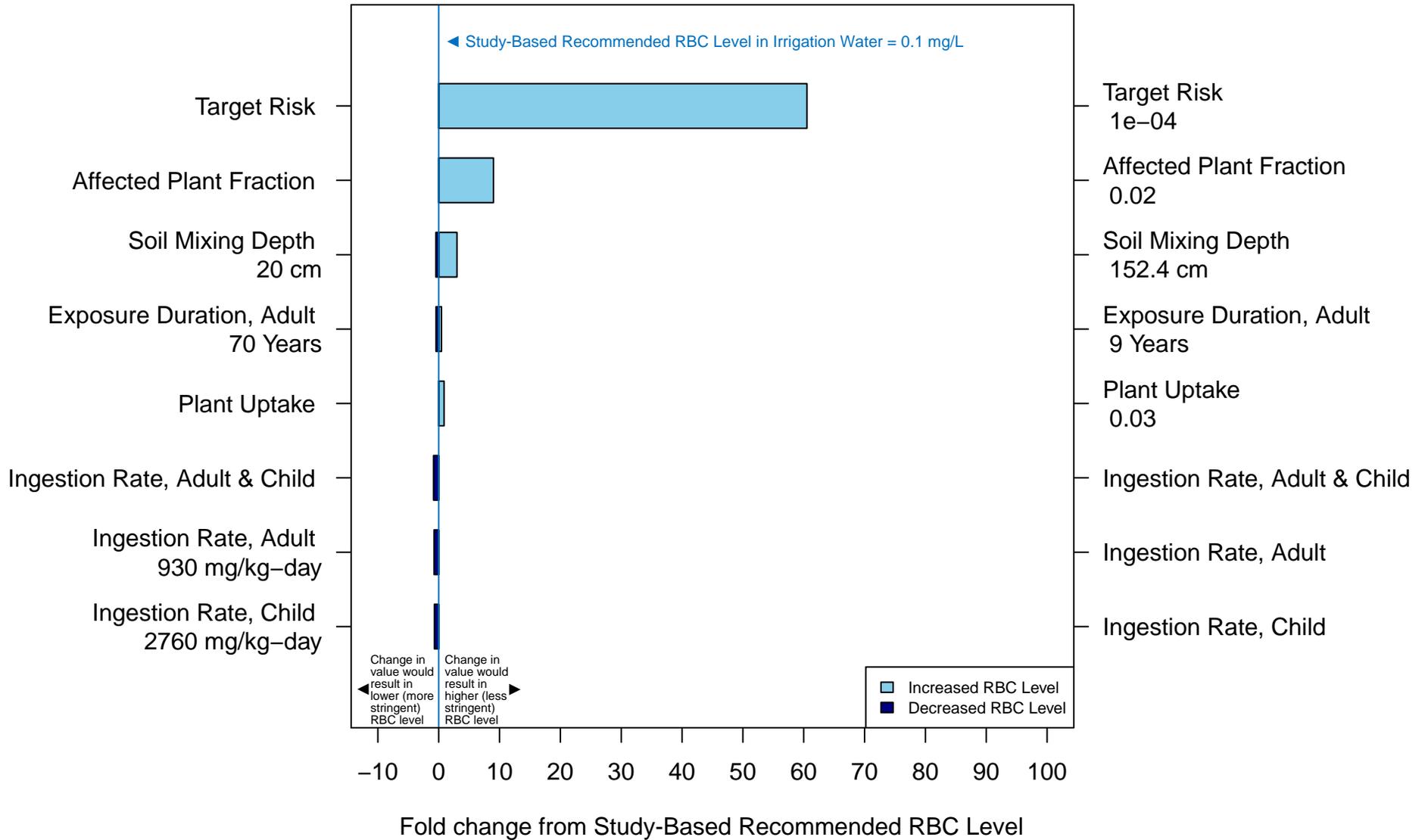


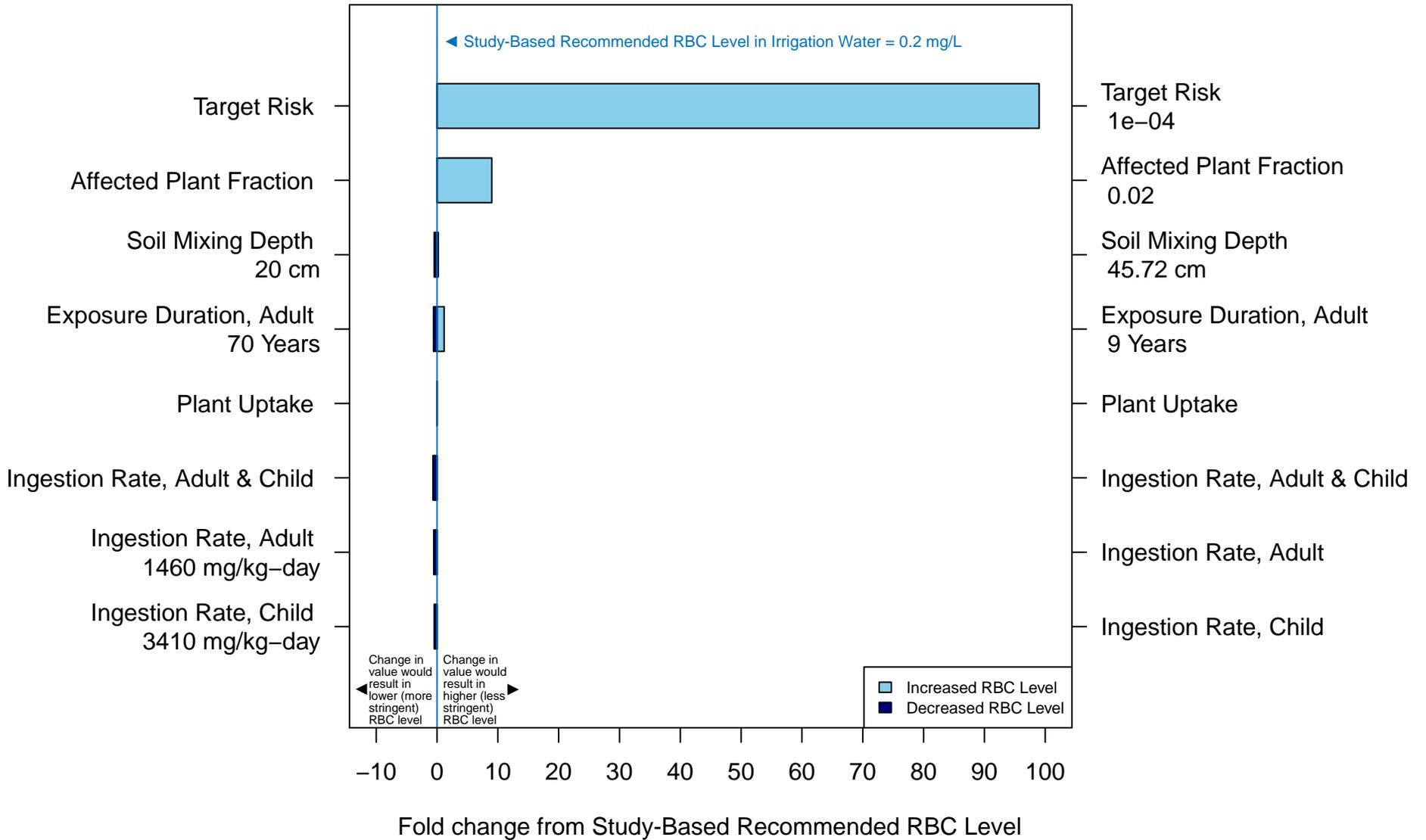
FIGURE C-8

Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Grapes



**FIGURE C-9**

**Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Potatoes**



**FIGURE C-10**

**Sensitivity of Recommended RBC Level of Arsenic in Irrigation Water Applied for Tree Nuts**

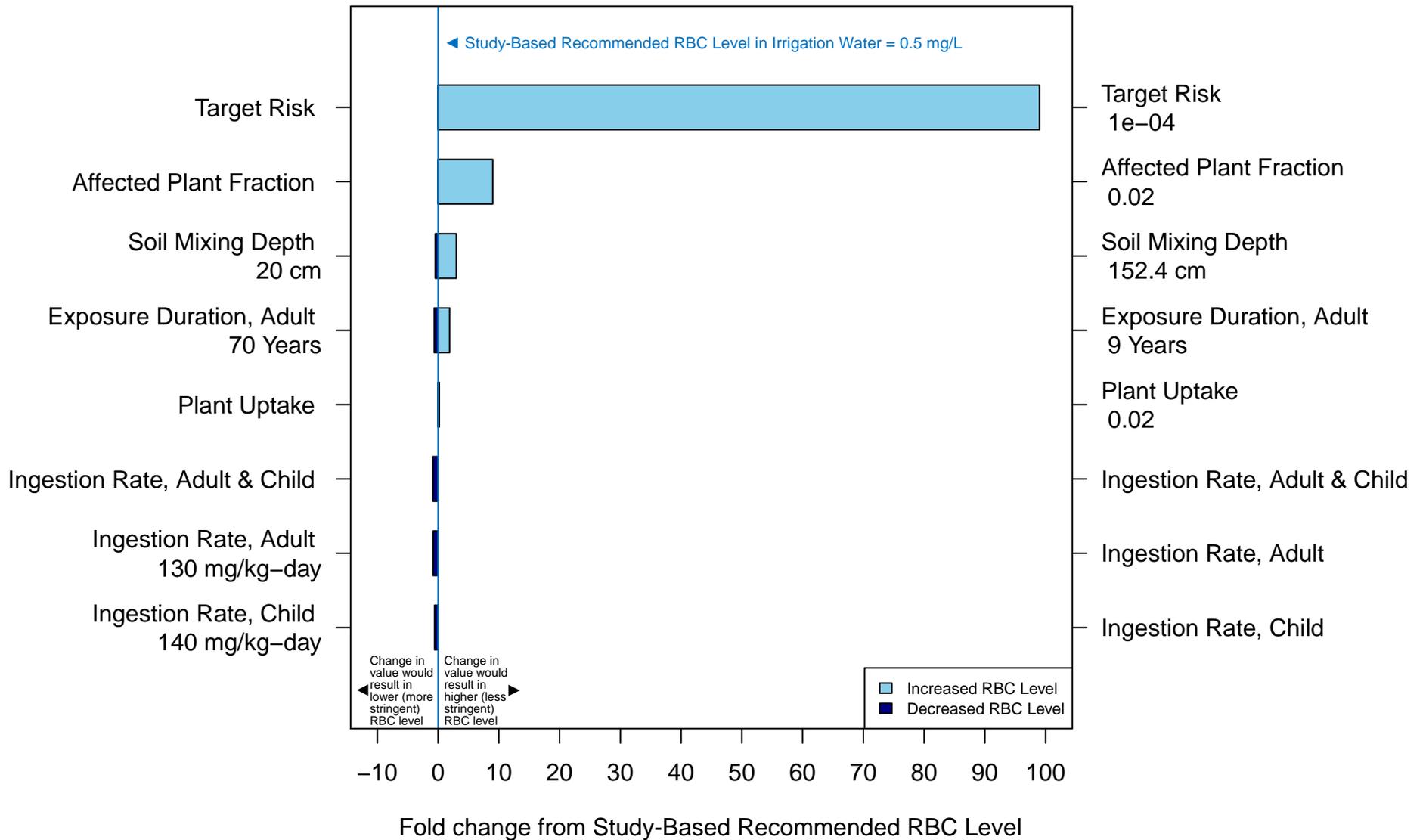


FIGURE C-11

Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Carrots

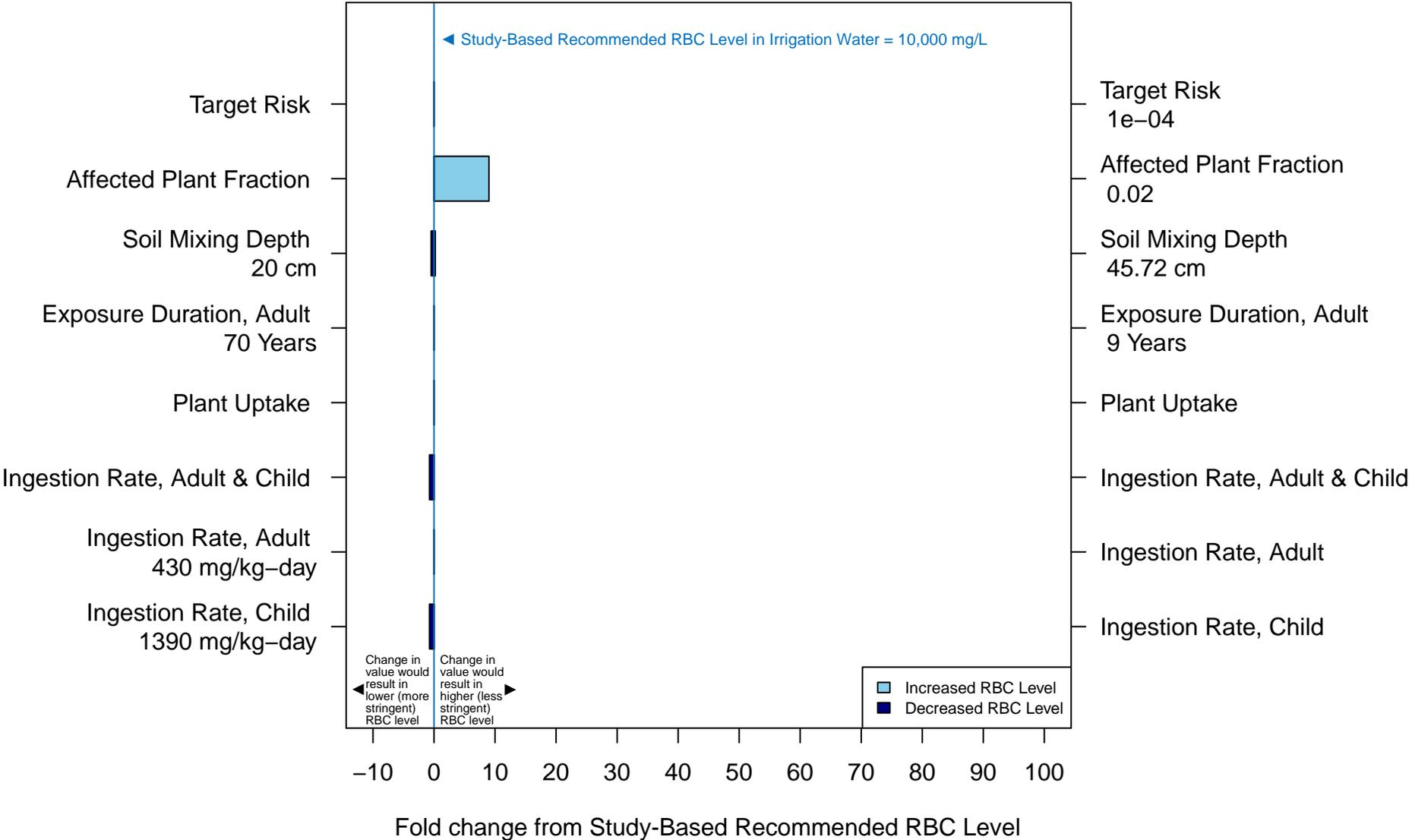
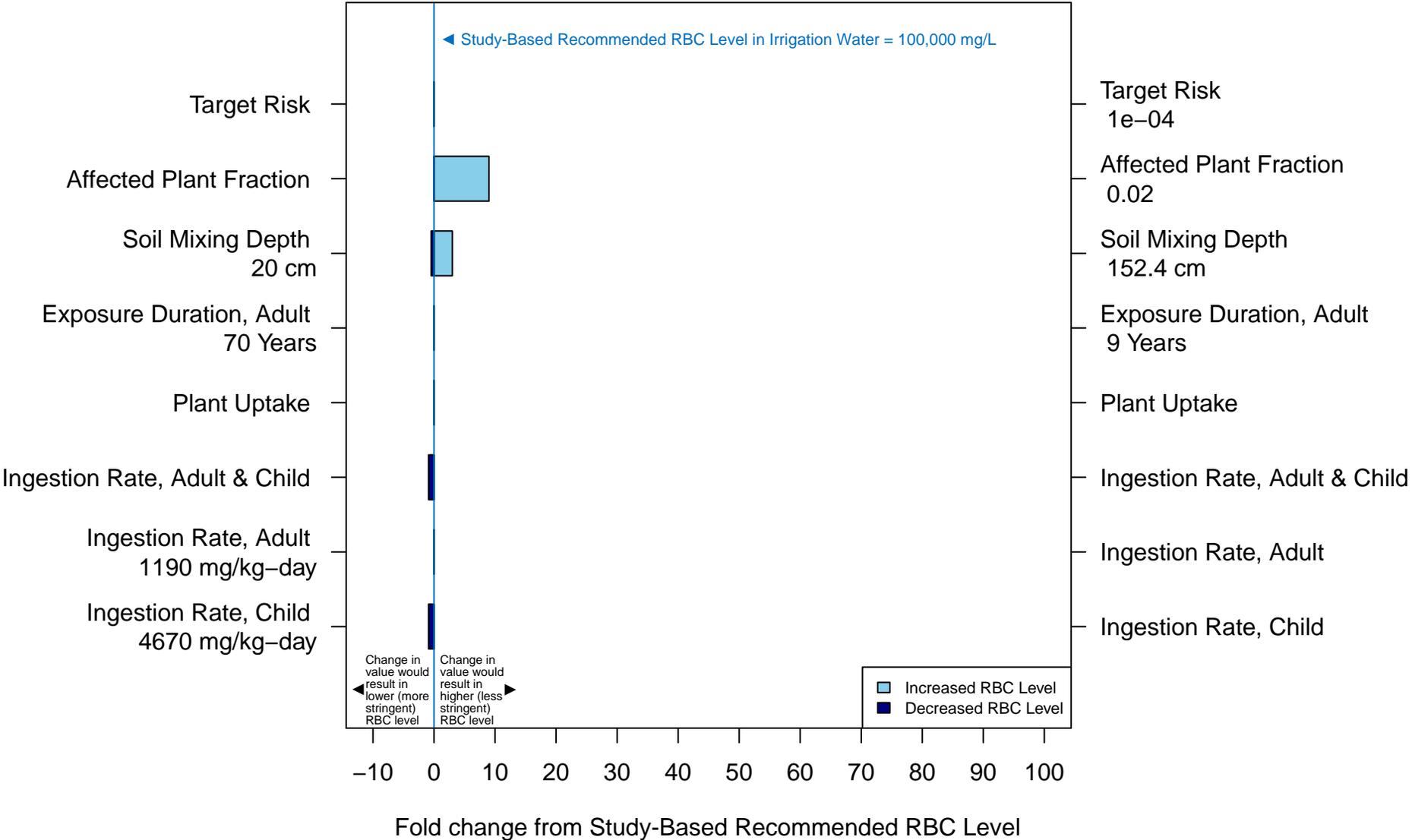


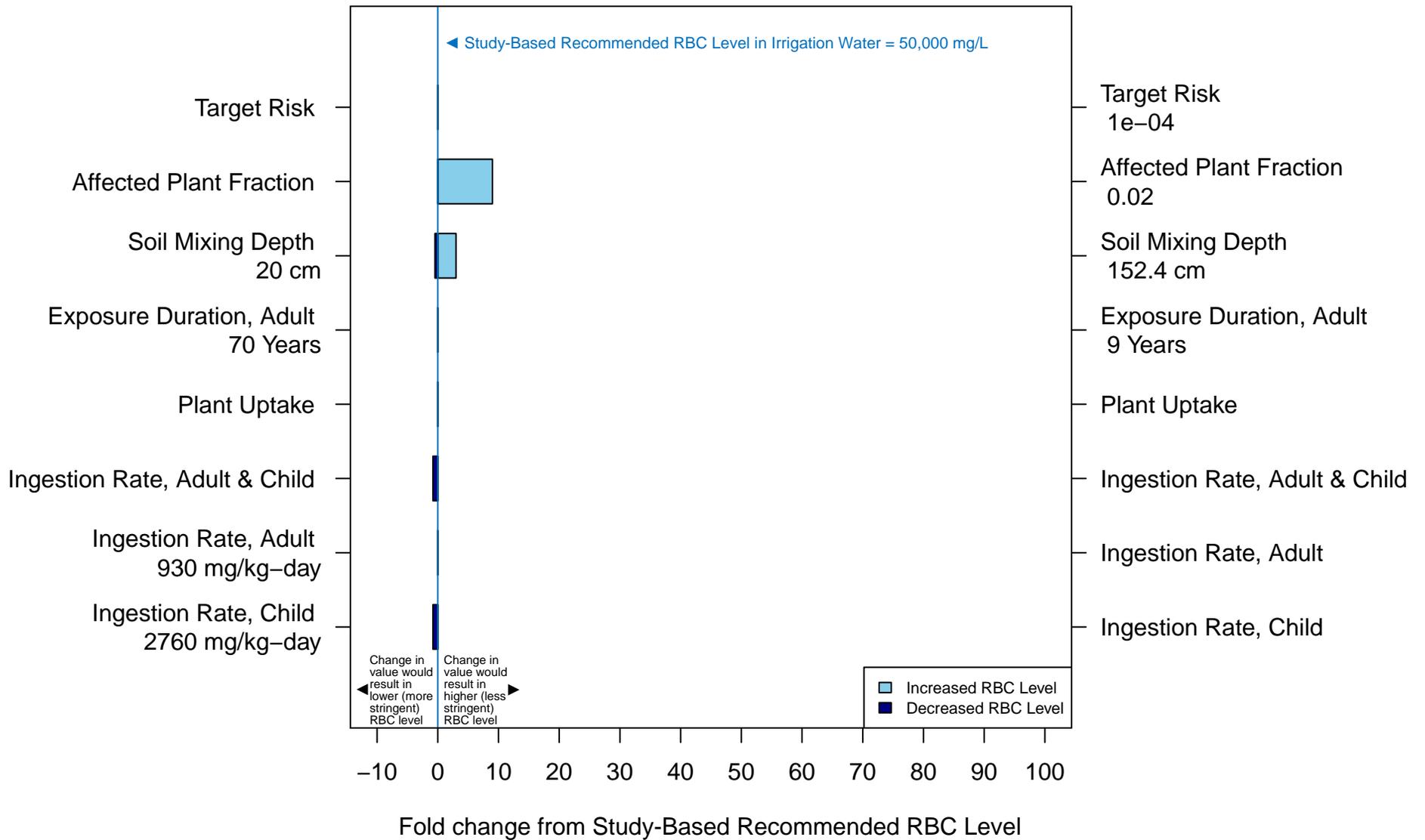
FIGURE C-12

Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Citrus



**FIGURE C-13**

**Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Grapes**



**FIGURE C-14**

**Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Potatoes**

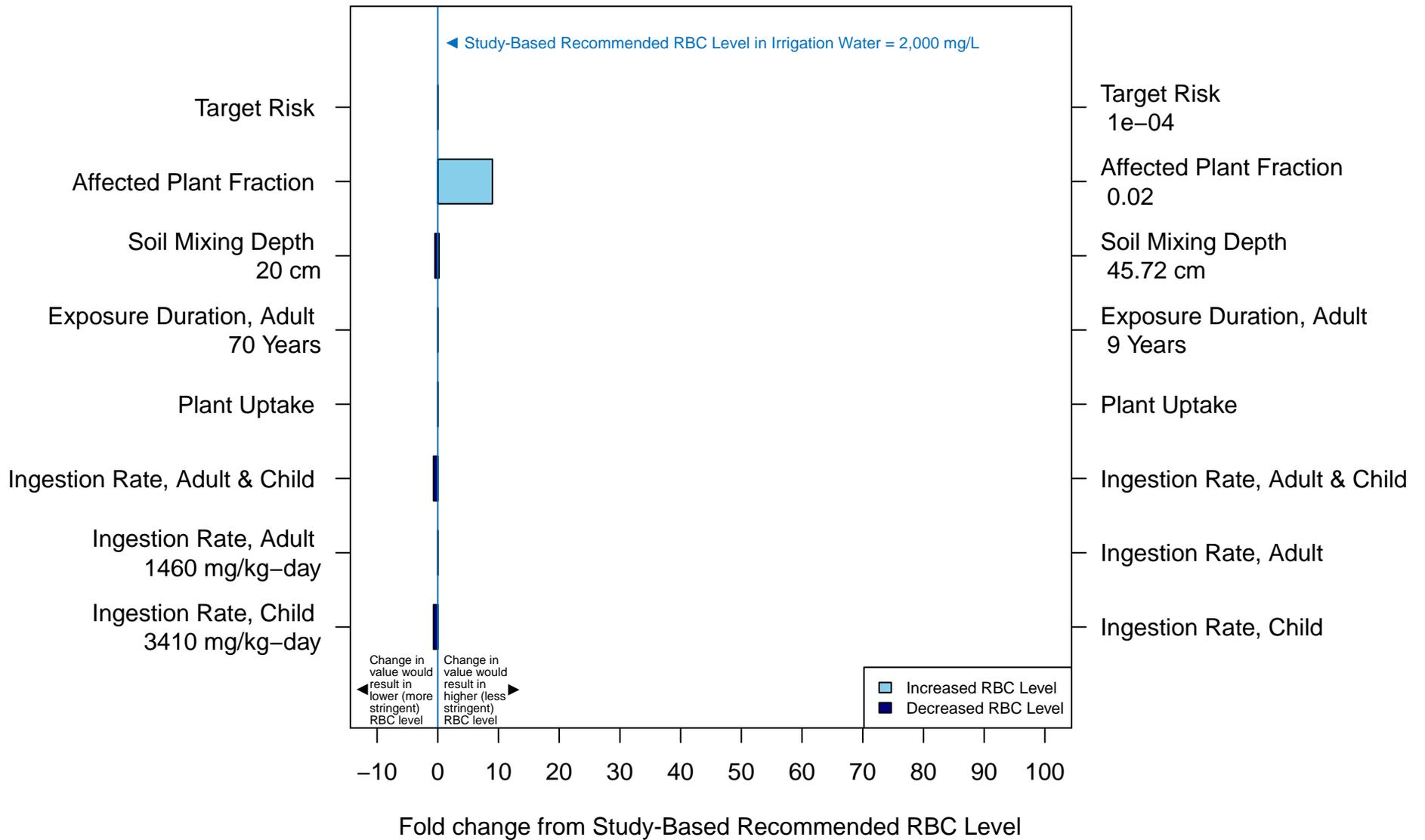
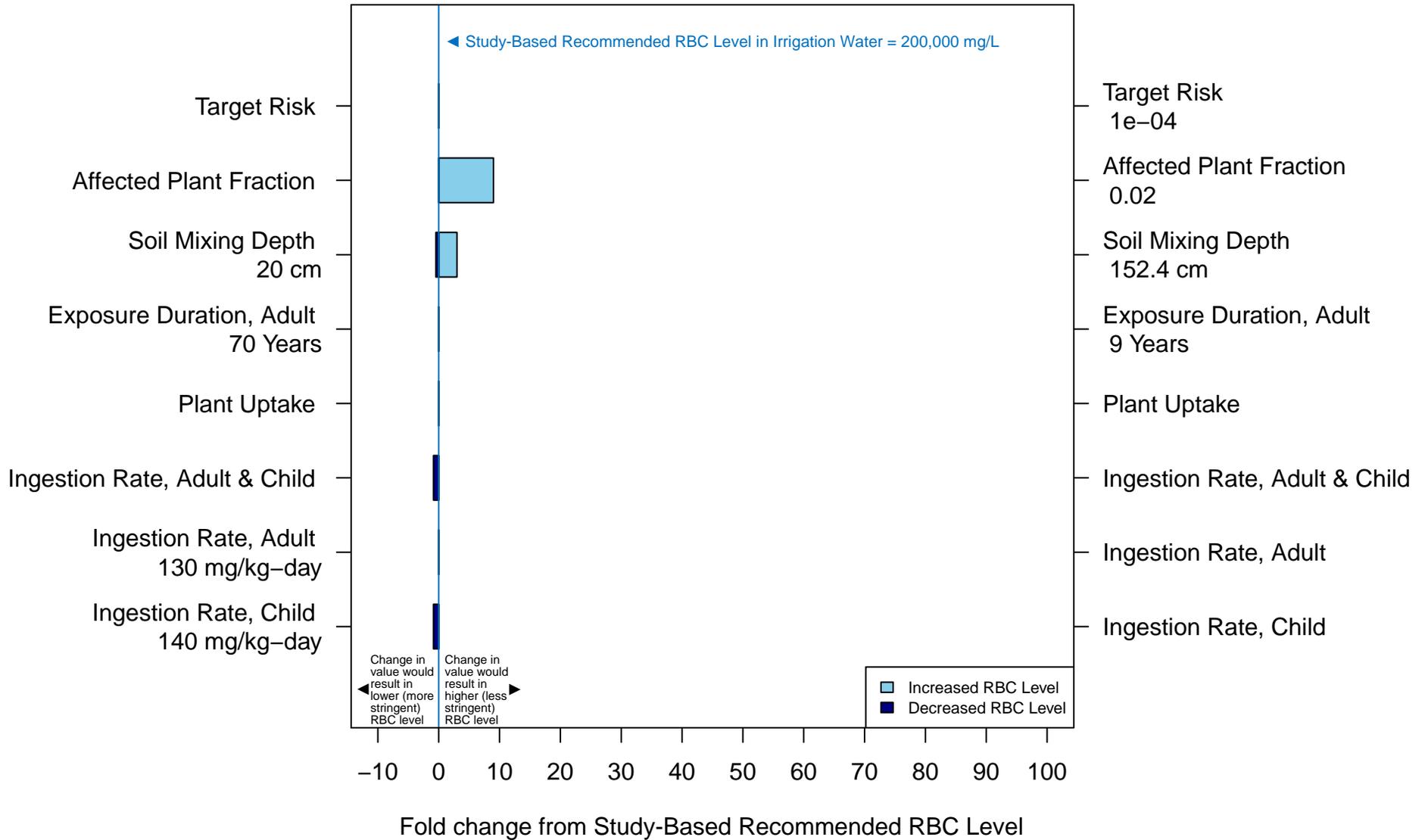


FIGURE C-15

Sensitivity of Recommended RBC Level of Barium in Irrigation Water Applied for Tree Nuts



**FIGURE C-16**

**Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Carrots**

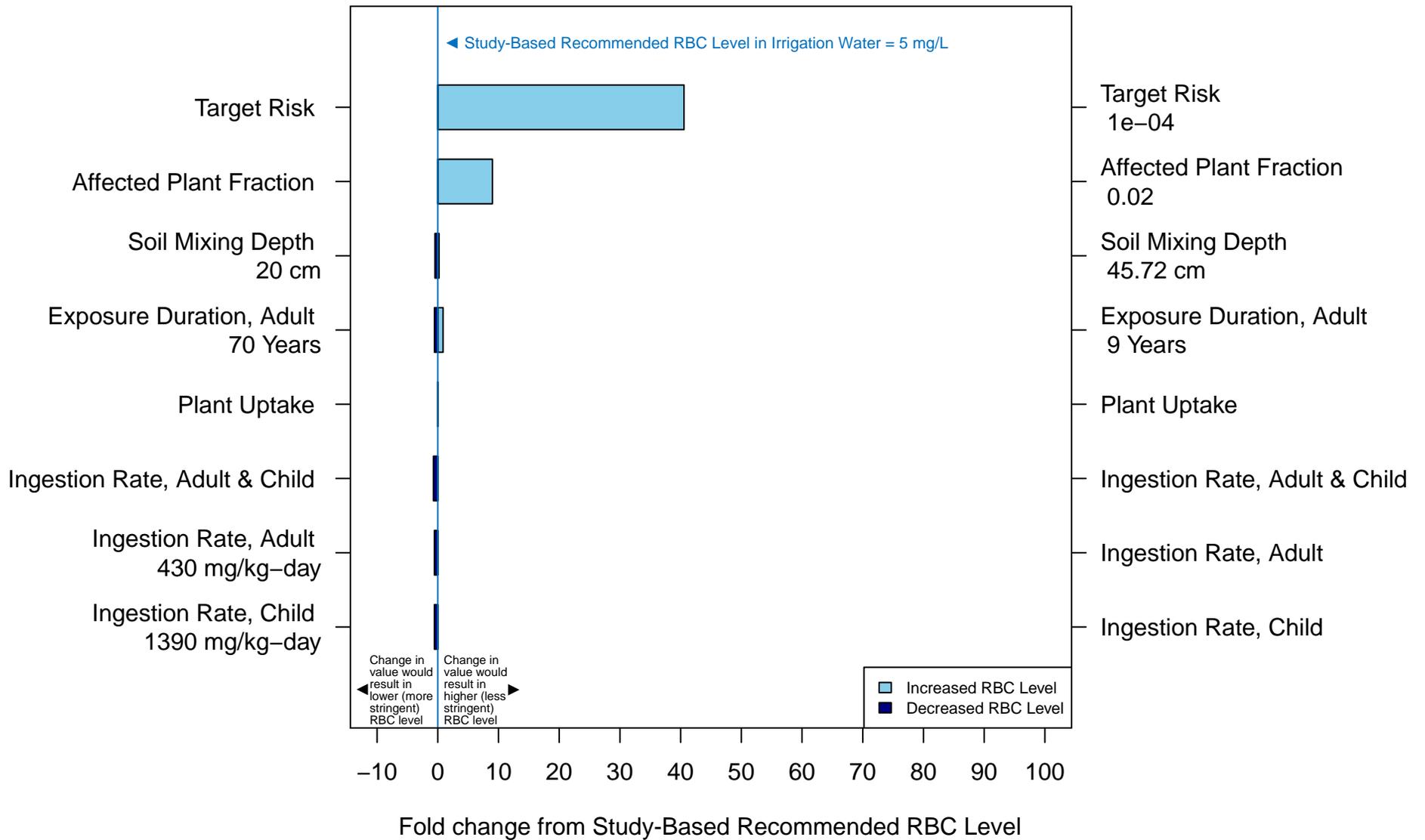
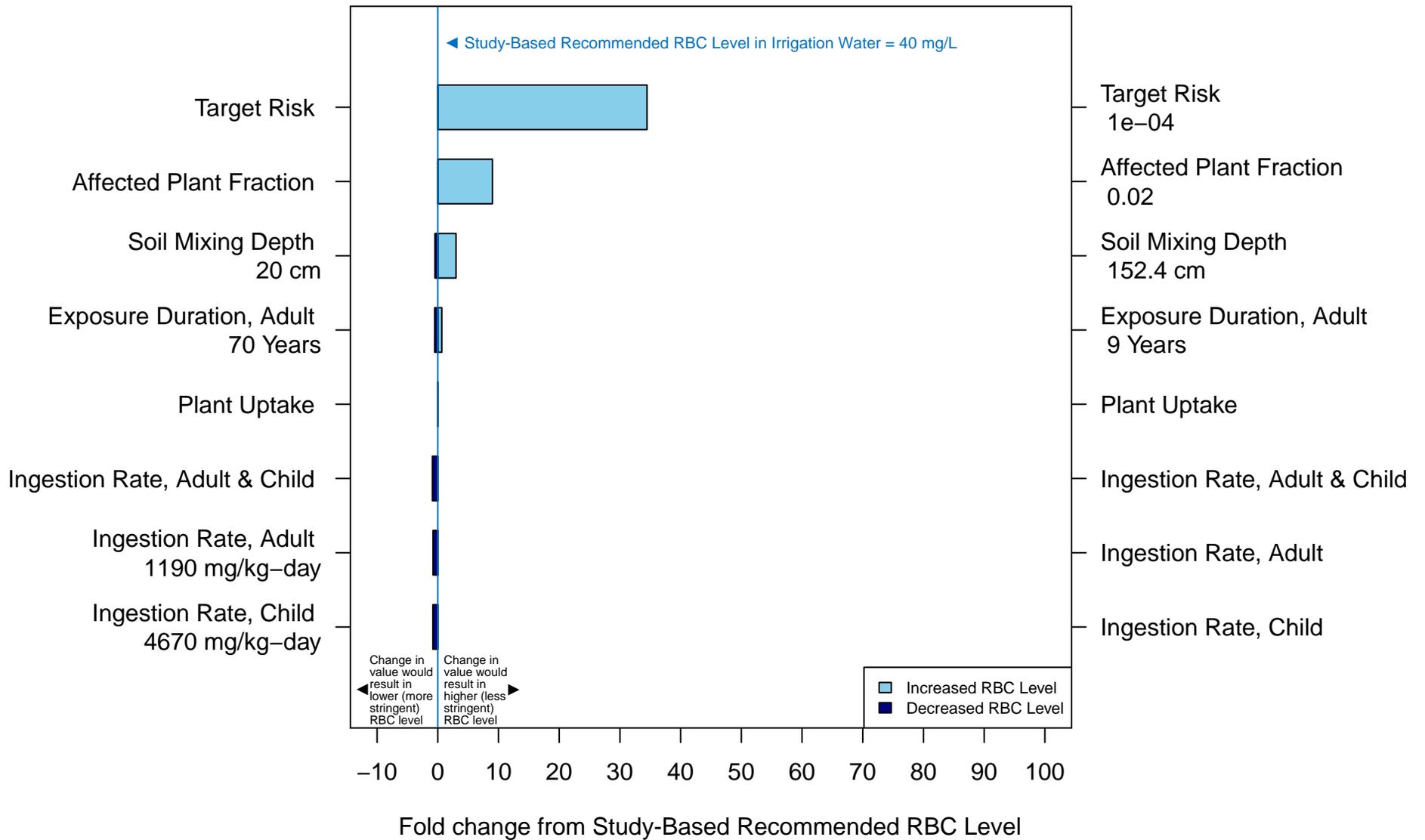


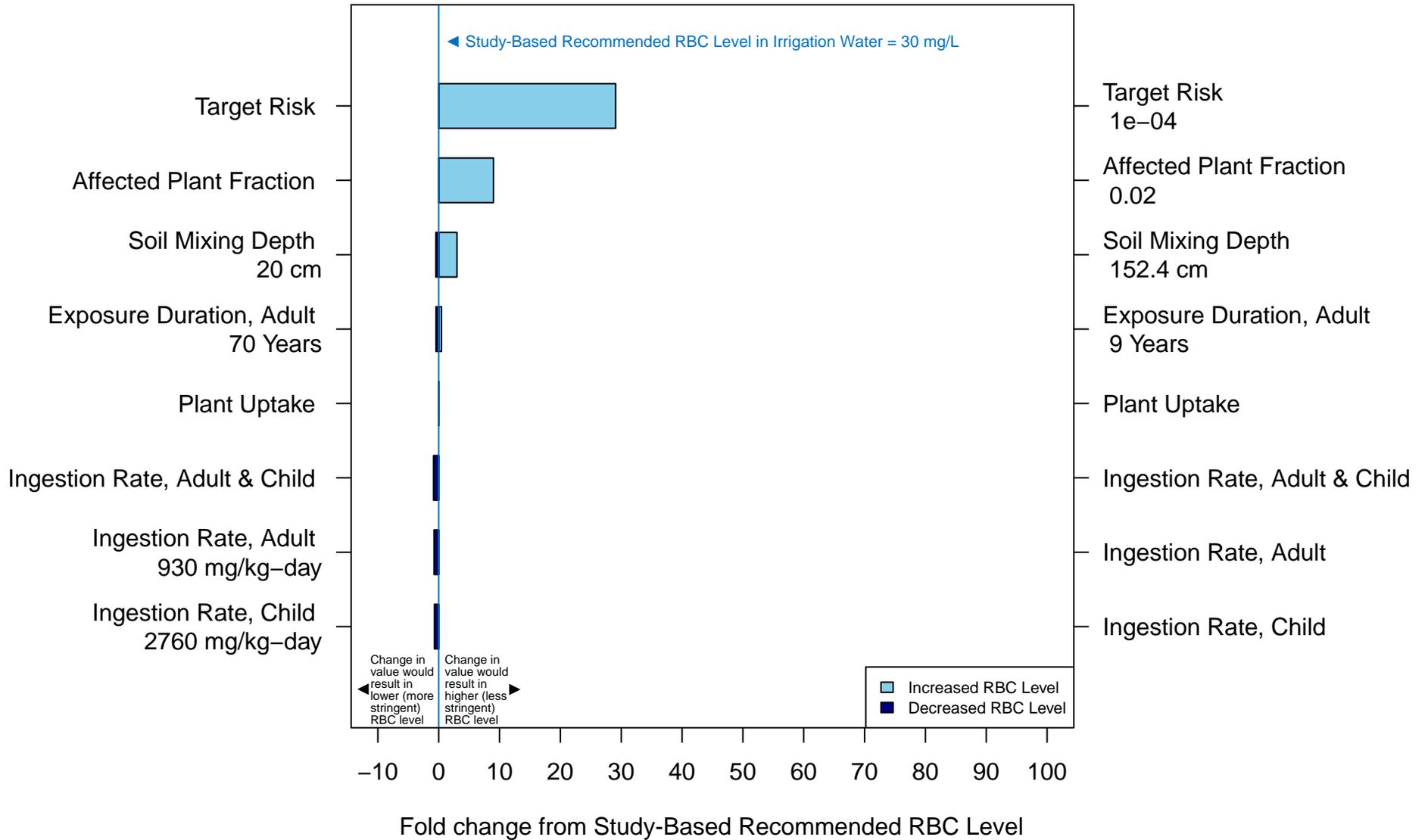
FIGURE C-17

Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Citrus



**FIGURE C-18**

**Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Grapes**



**FIGURE C-19**

**Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Potatoes**

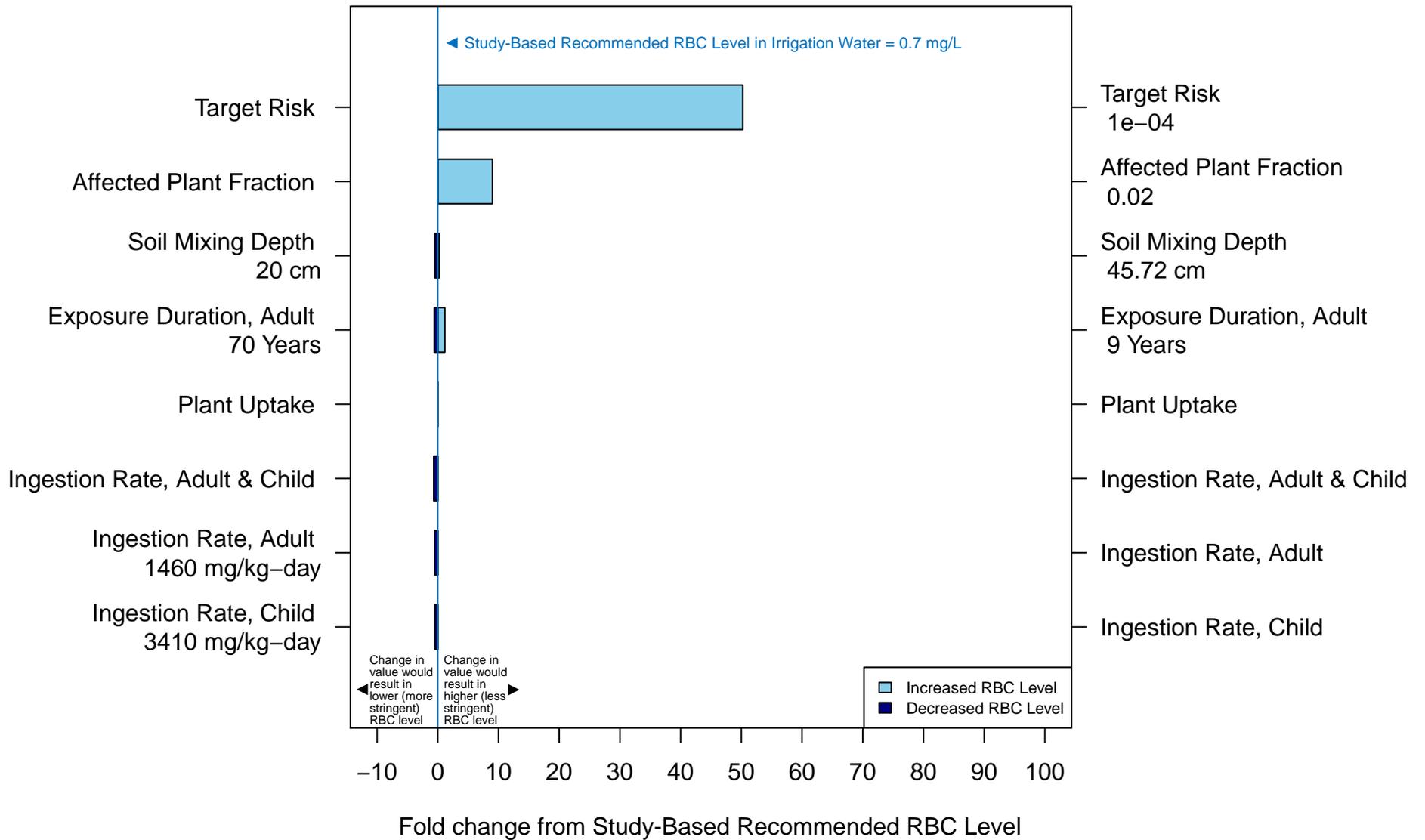


FIGURE C-20

Sensitivity of Recommended RBC Level of Benzene in Irrigation Water Applied for Tree Nuts

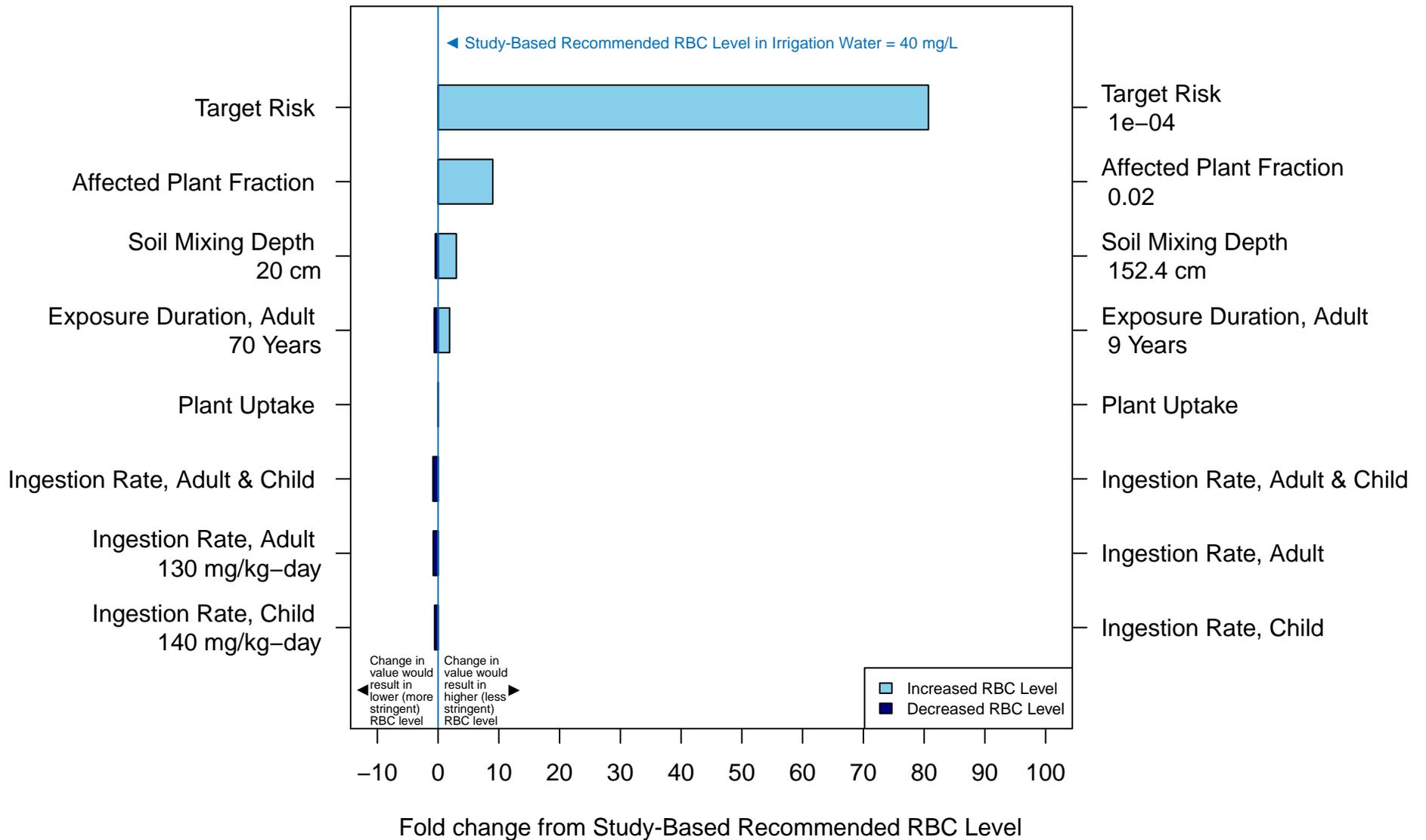


FIGURE C-21

Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Carrots

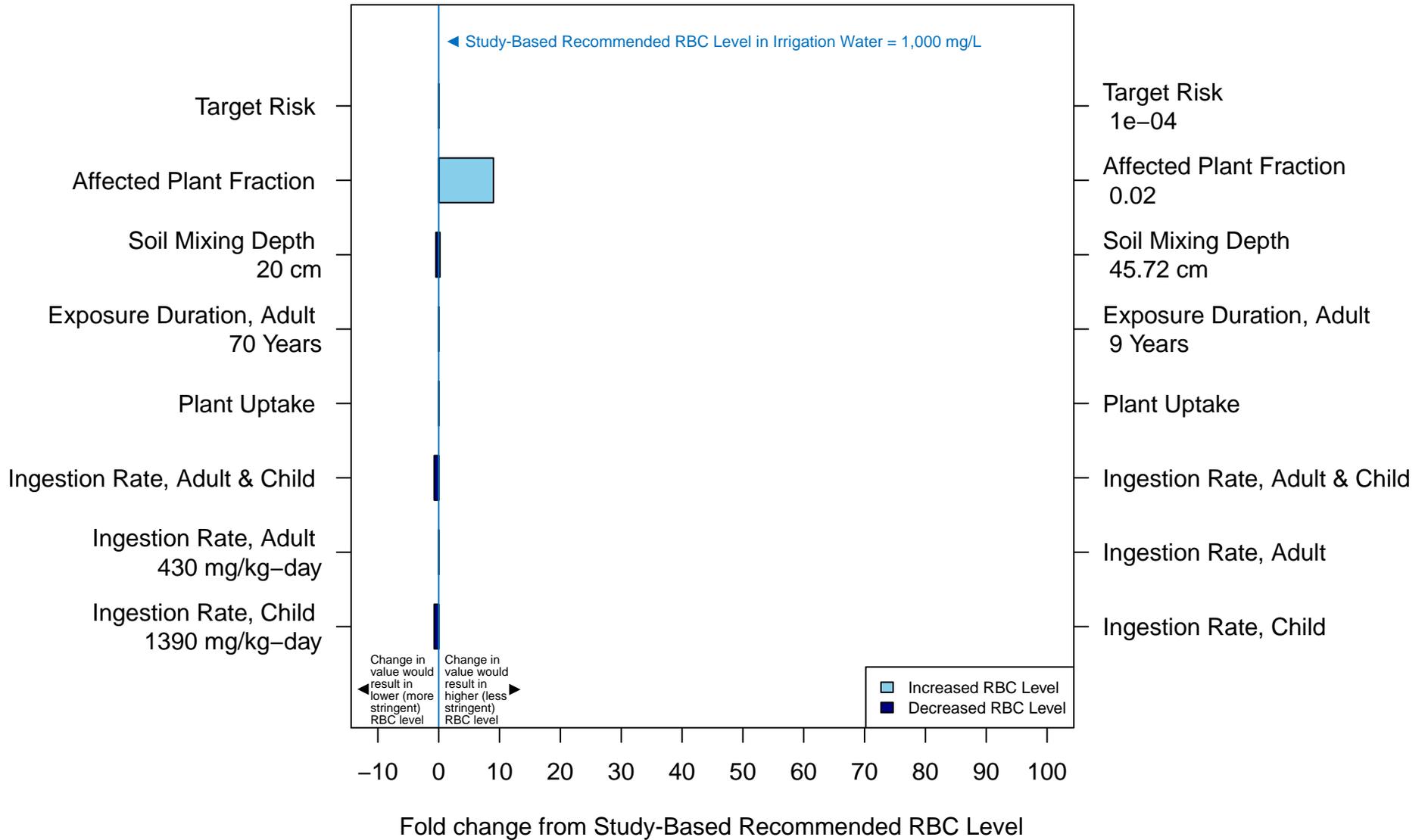
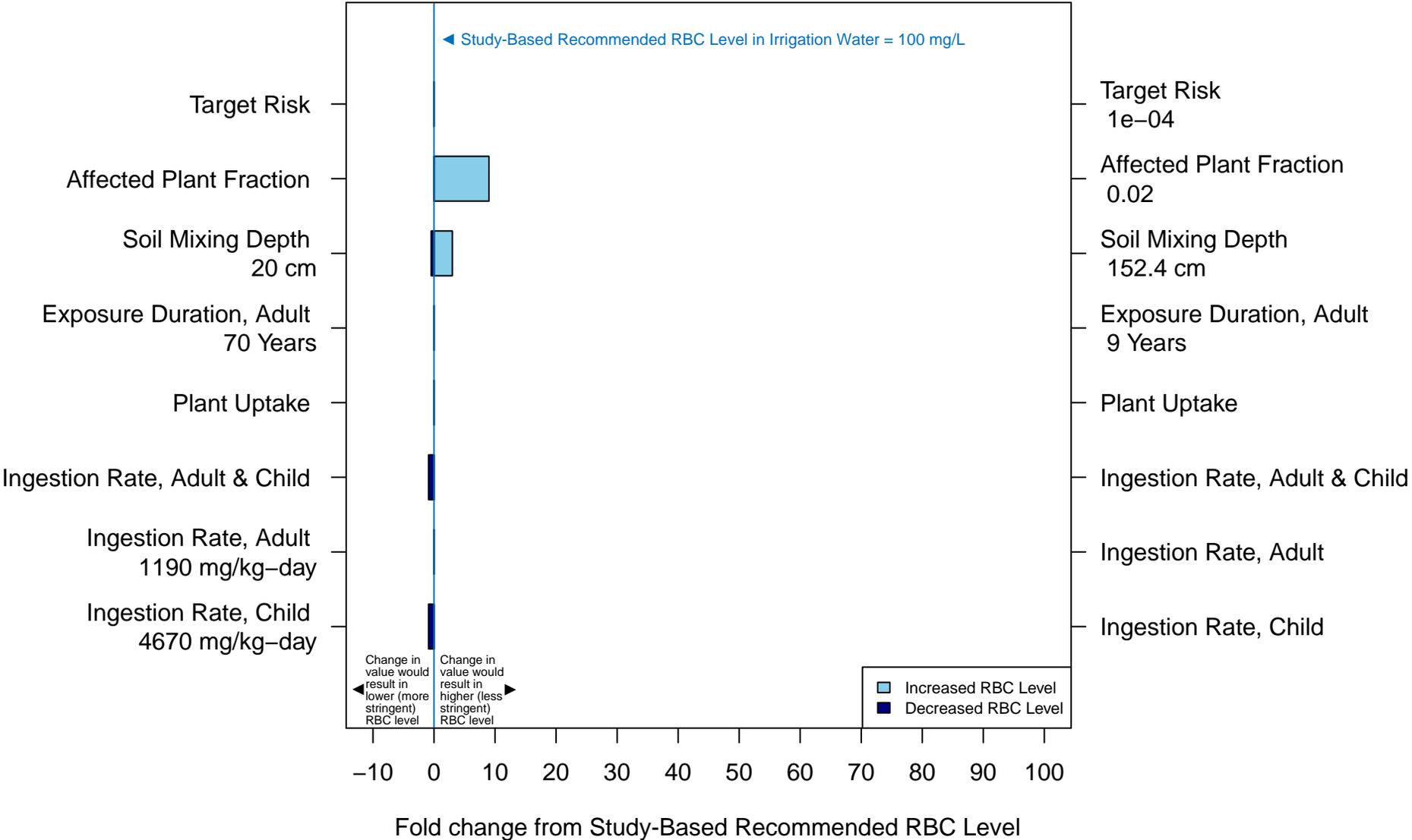


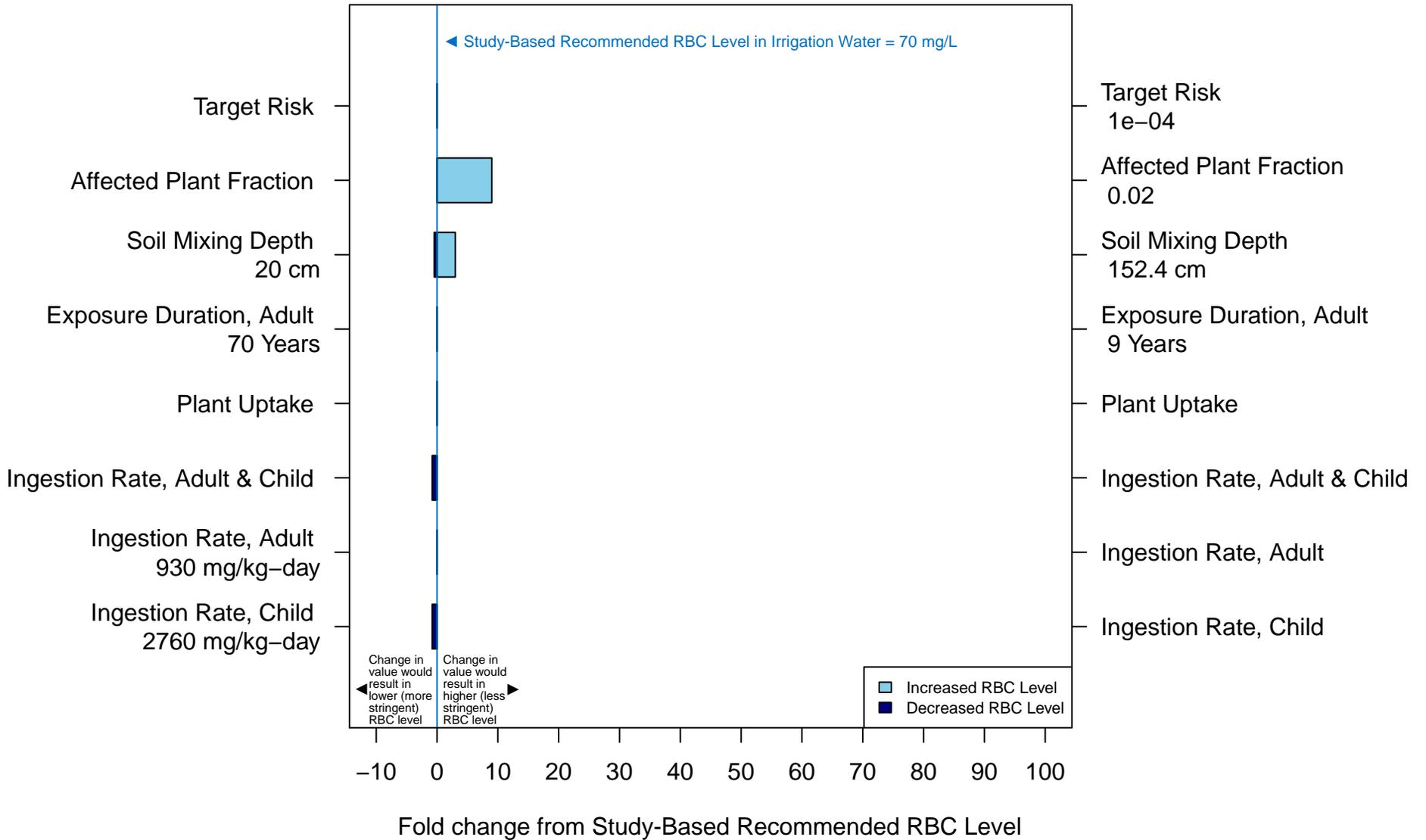
FIGURE C-22

Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Citrus



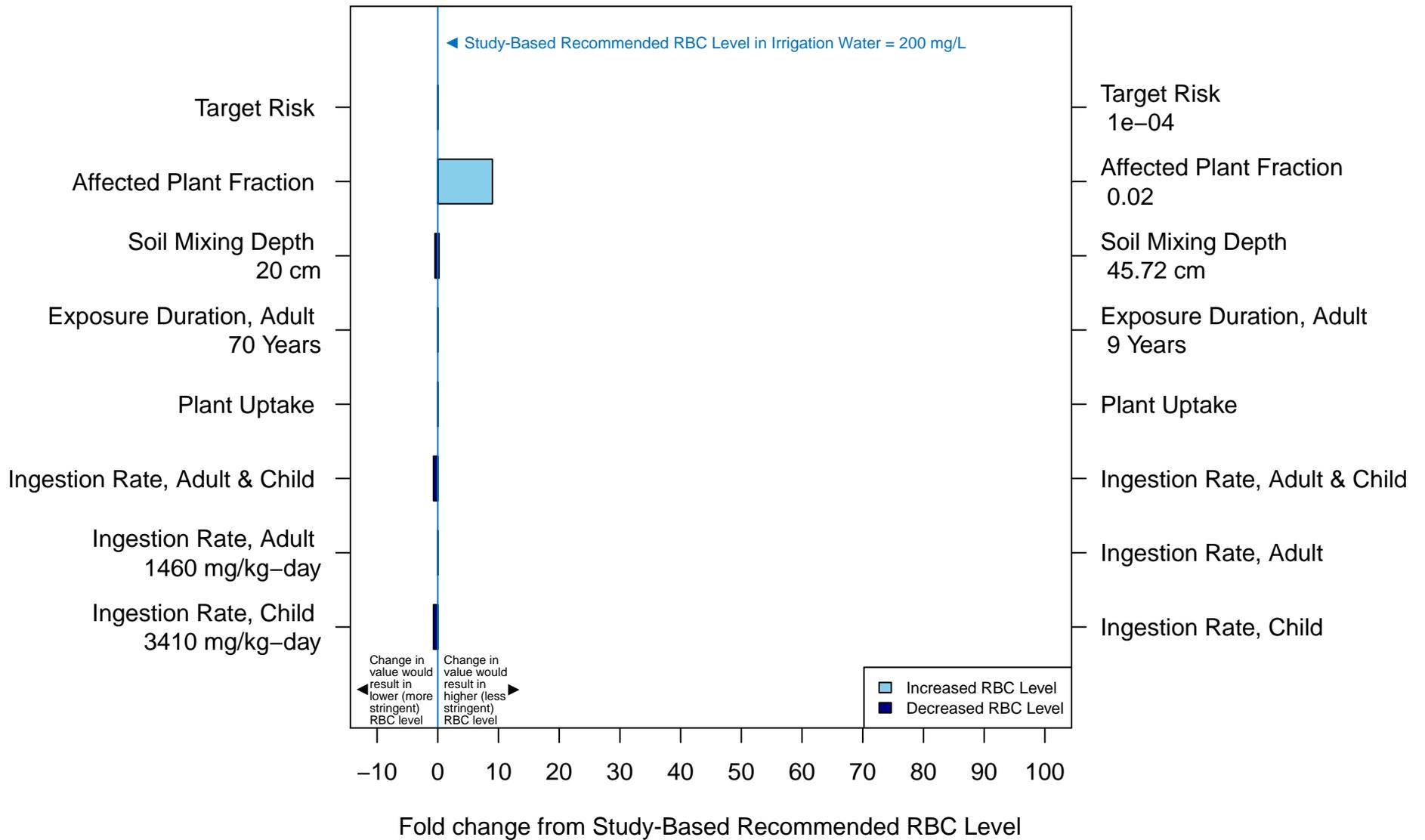
**FIGURE C-23**

**Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Grapes**



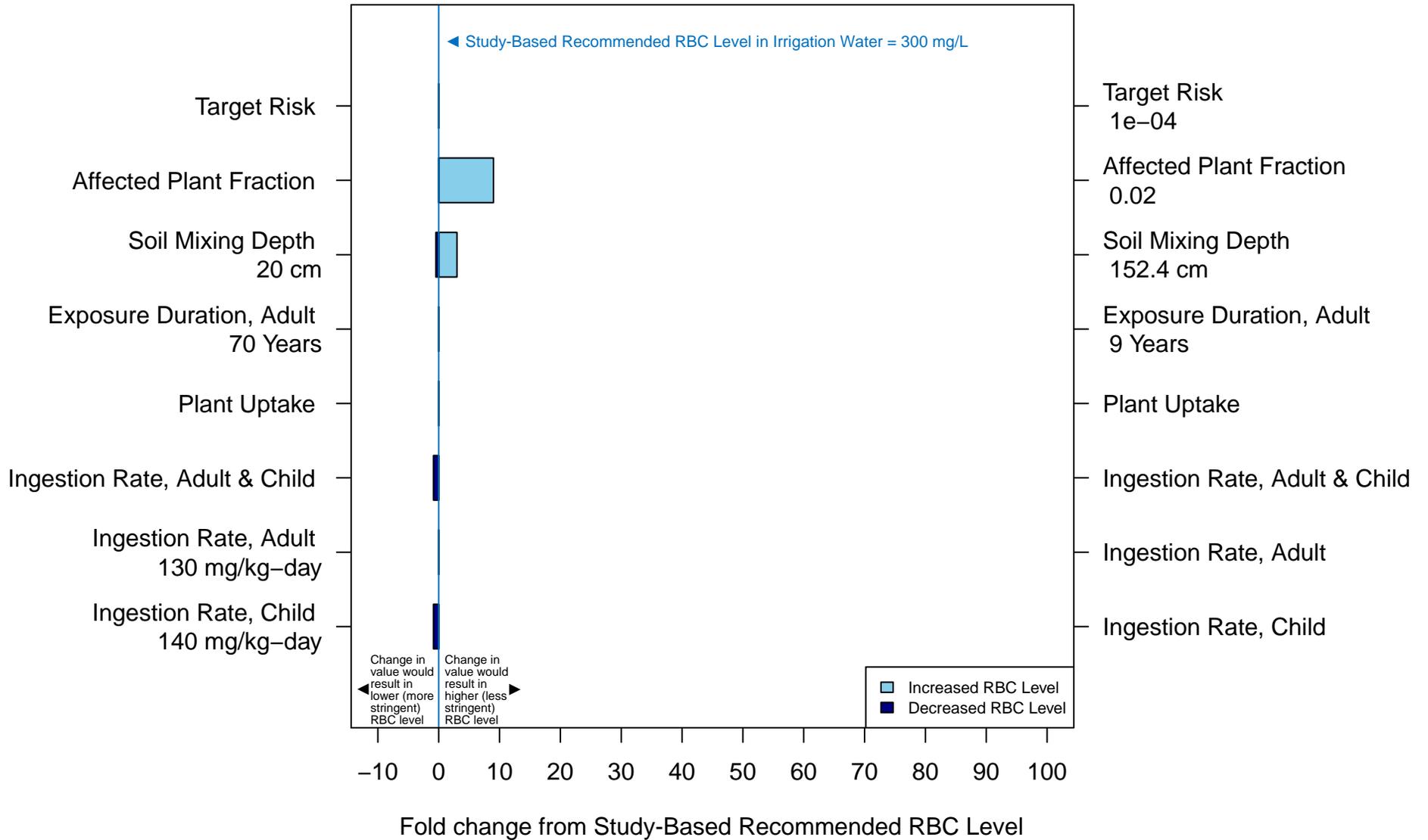
**FIGURE C-24**

**Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Potatoes**



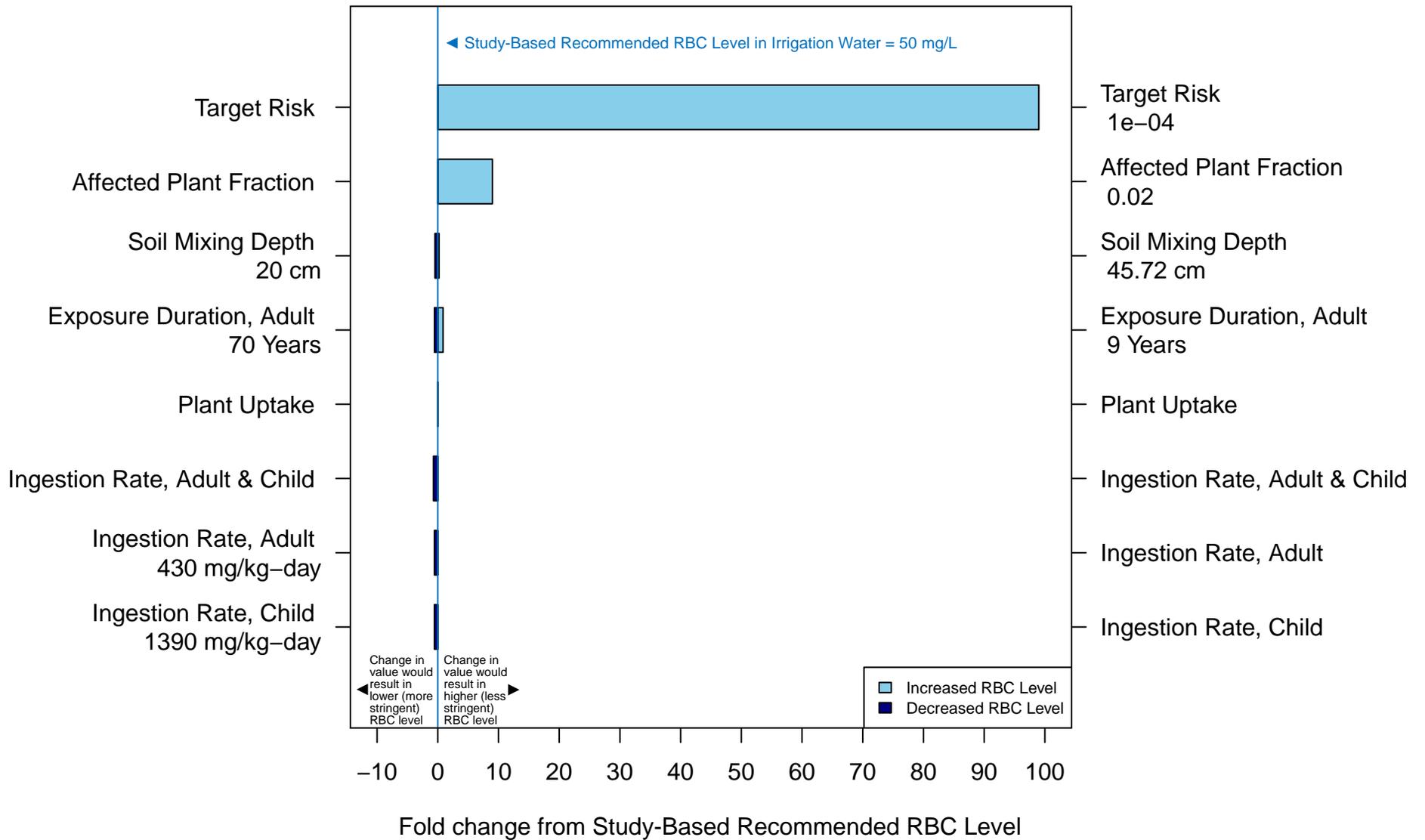
**FIGURE C-25**

**Sensitivity of Recommended RBC Level of Boron in Irrigation Water Applied for Tree Nuts**



**FIGURE C-26**

**Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Carrots**



**FIGURE C-27**

**Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Citrus**

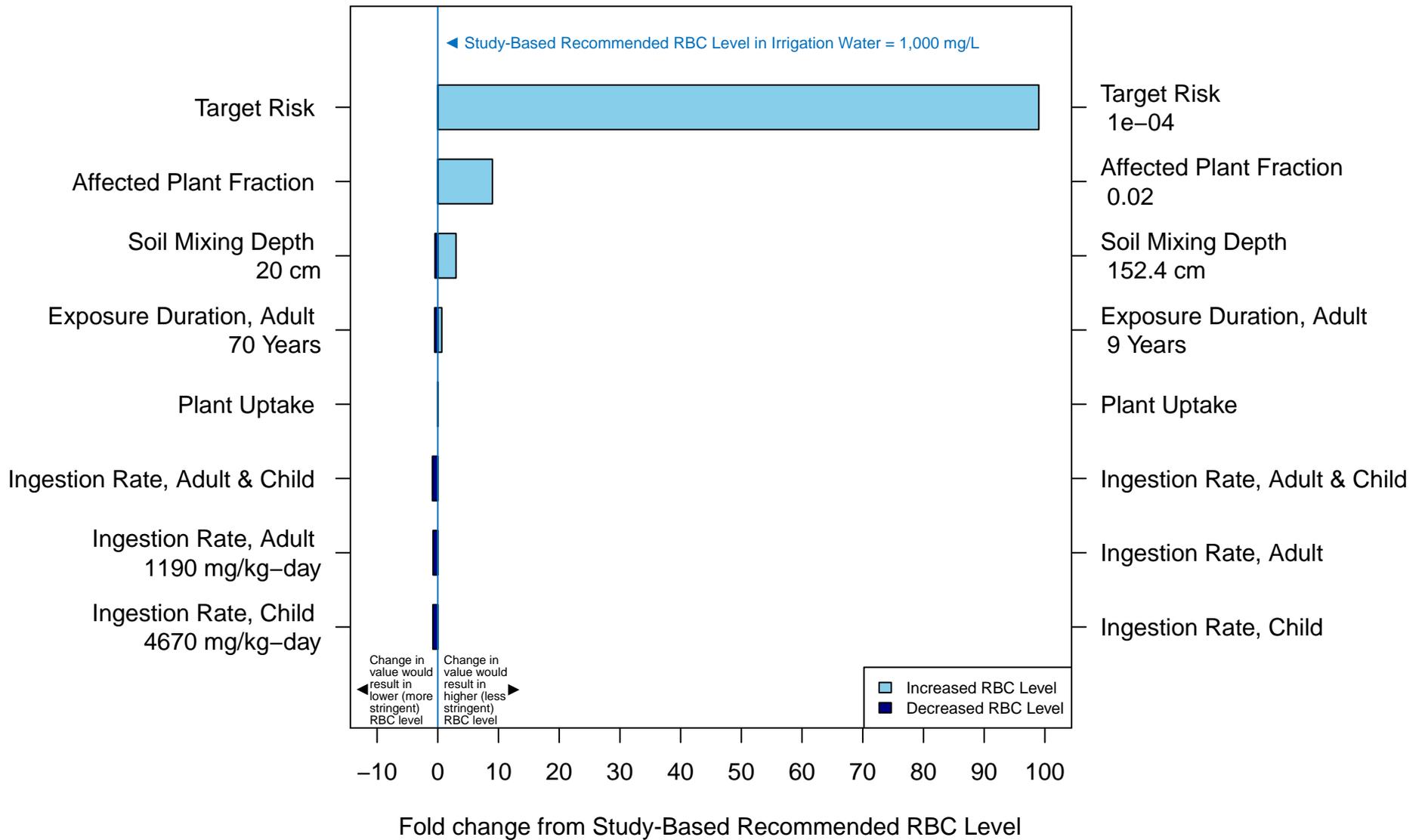


FIGURE C-28

Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Grapes

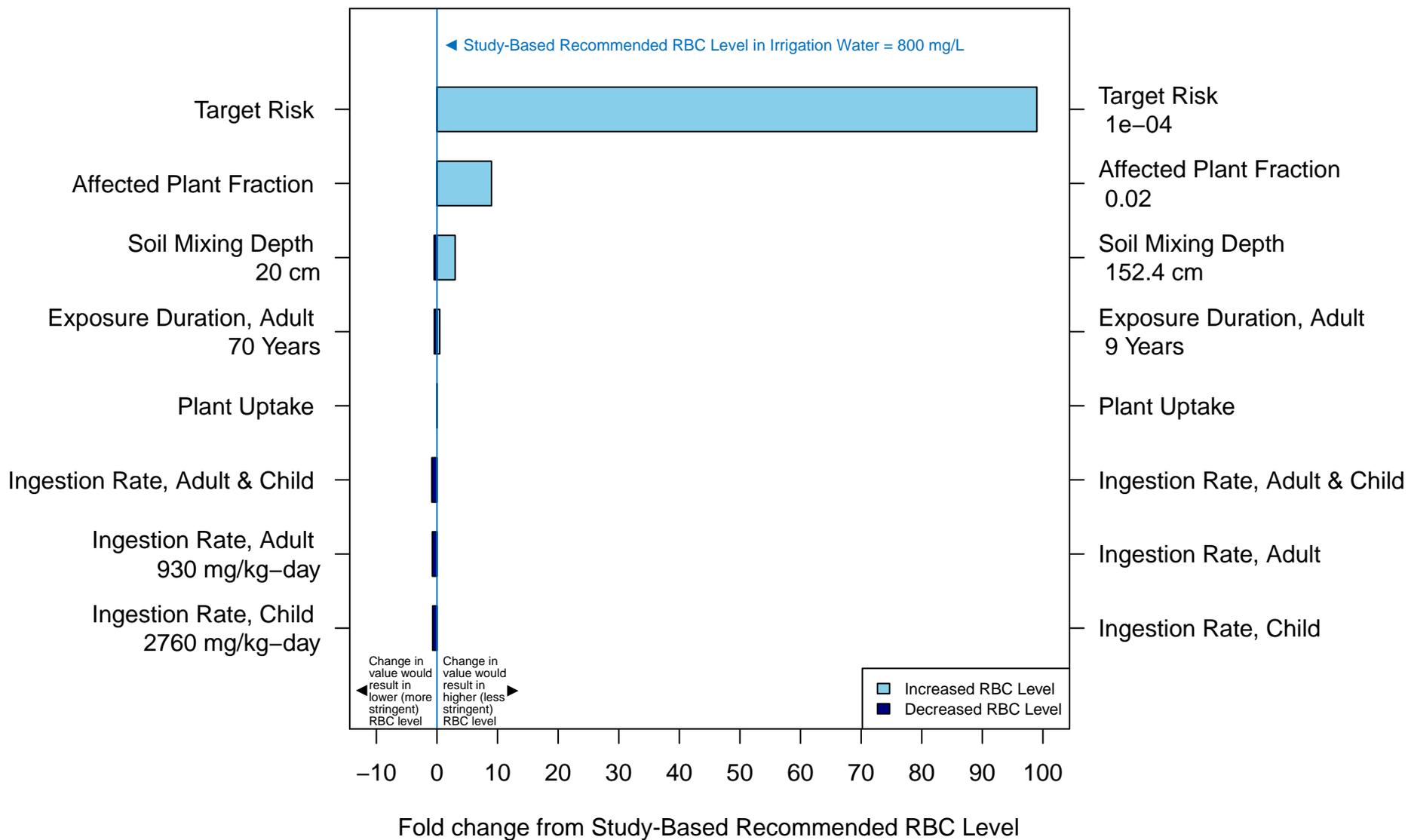
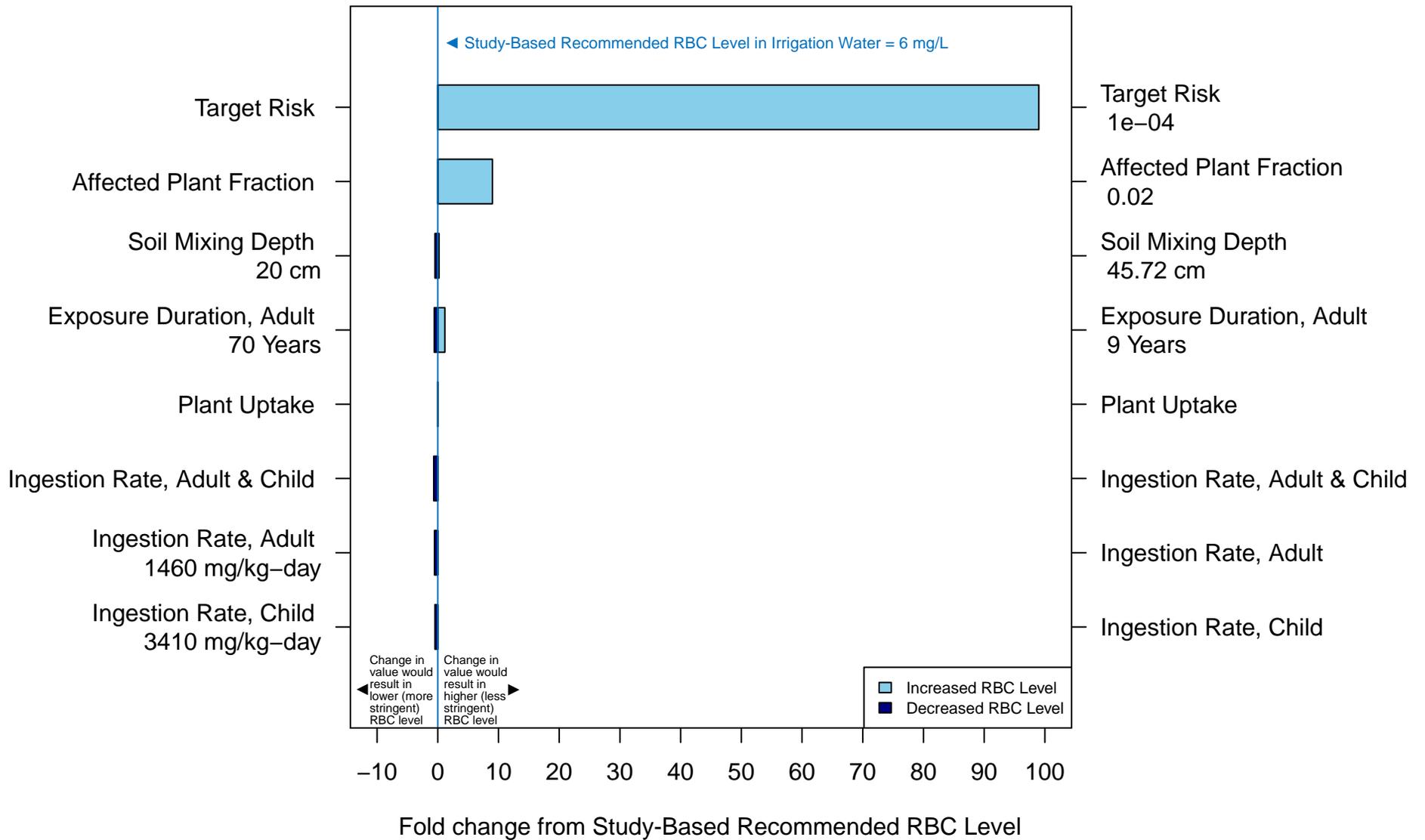


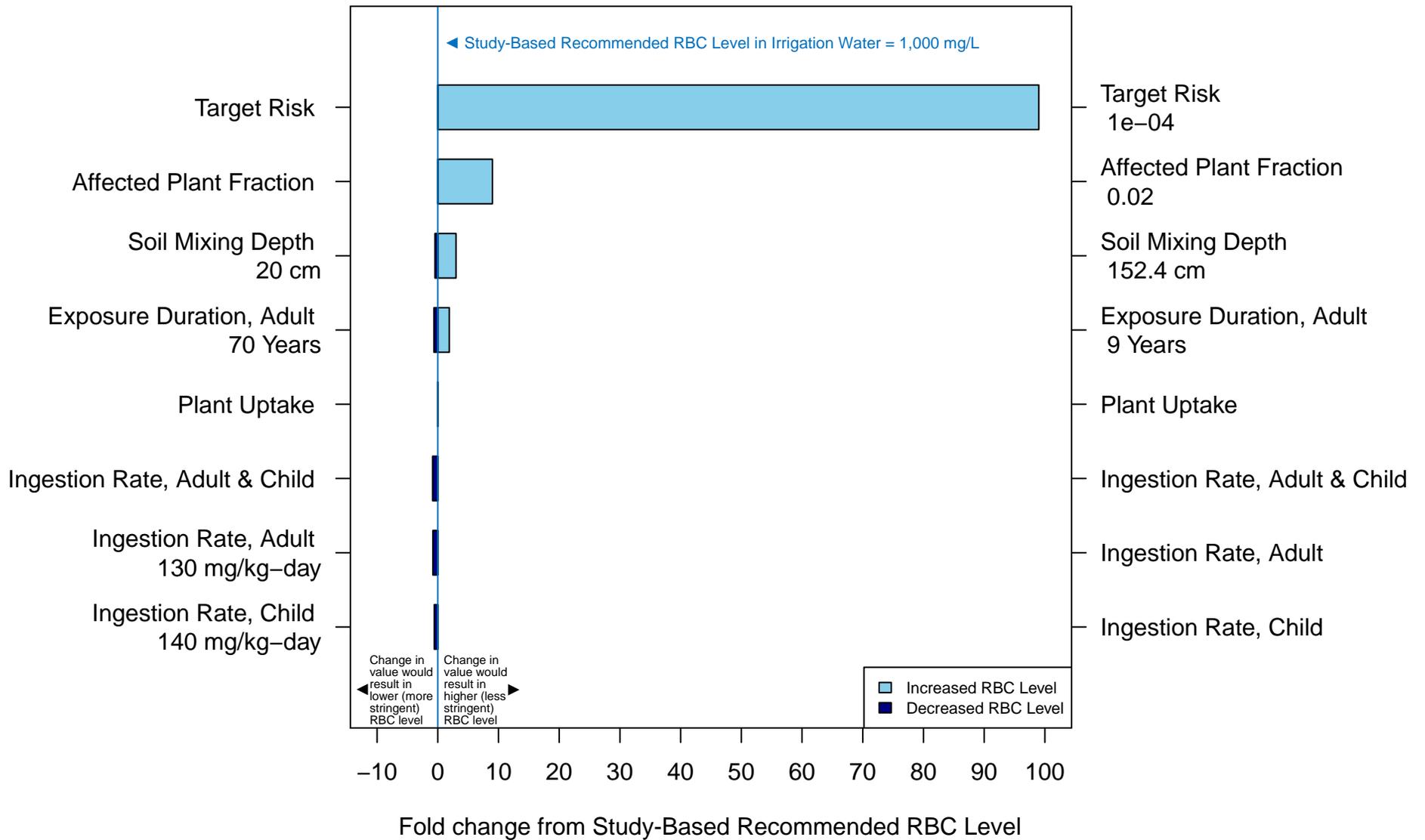
FIGURE C-29

Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Potatoes



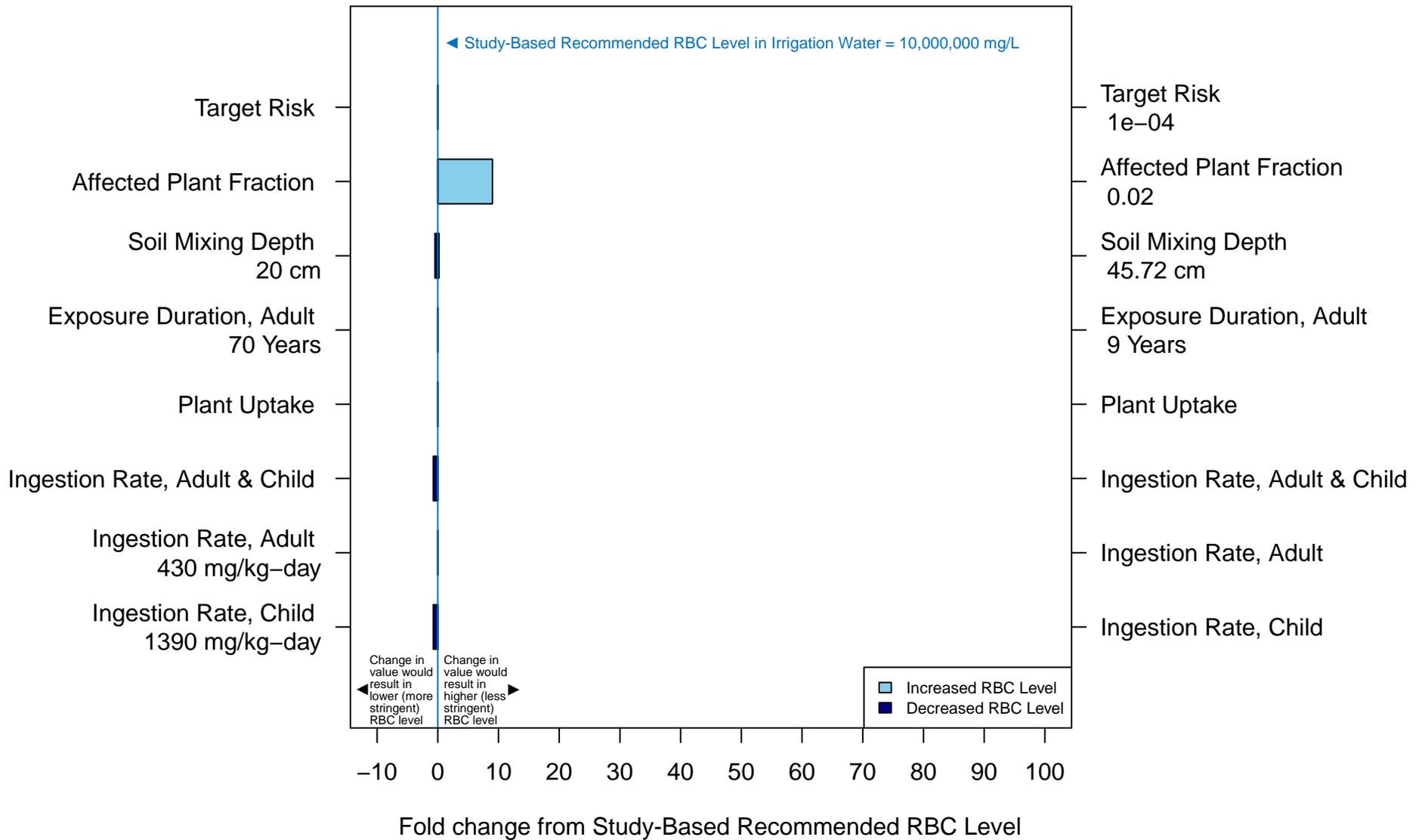
**FIGURE C-30**

**Sensitivity of Recommended RBC Level of Ethylbenzene in Irrigation Water Applied for Tree Nuts**



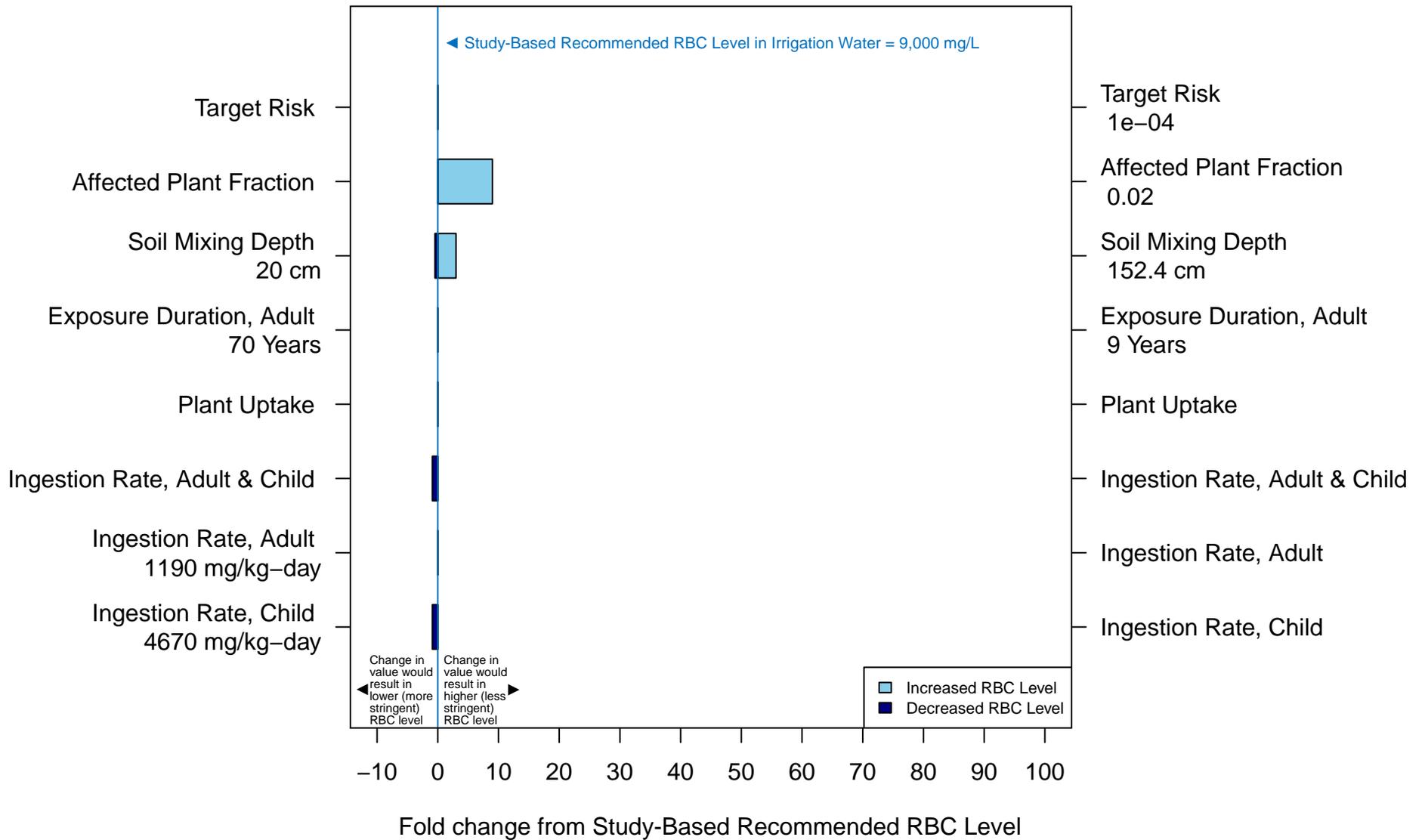
**FIGURE C-31**

**Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Carrots**



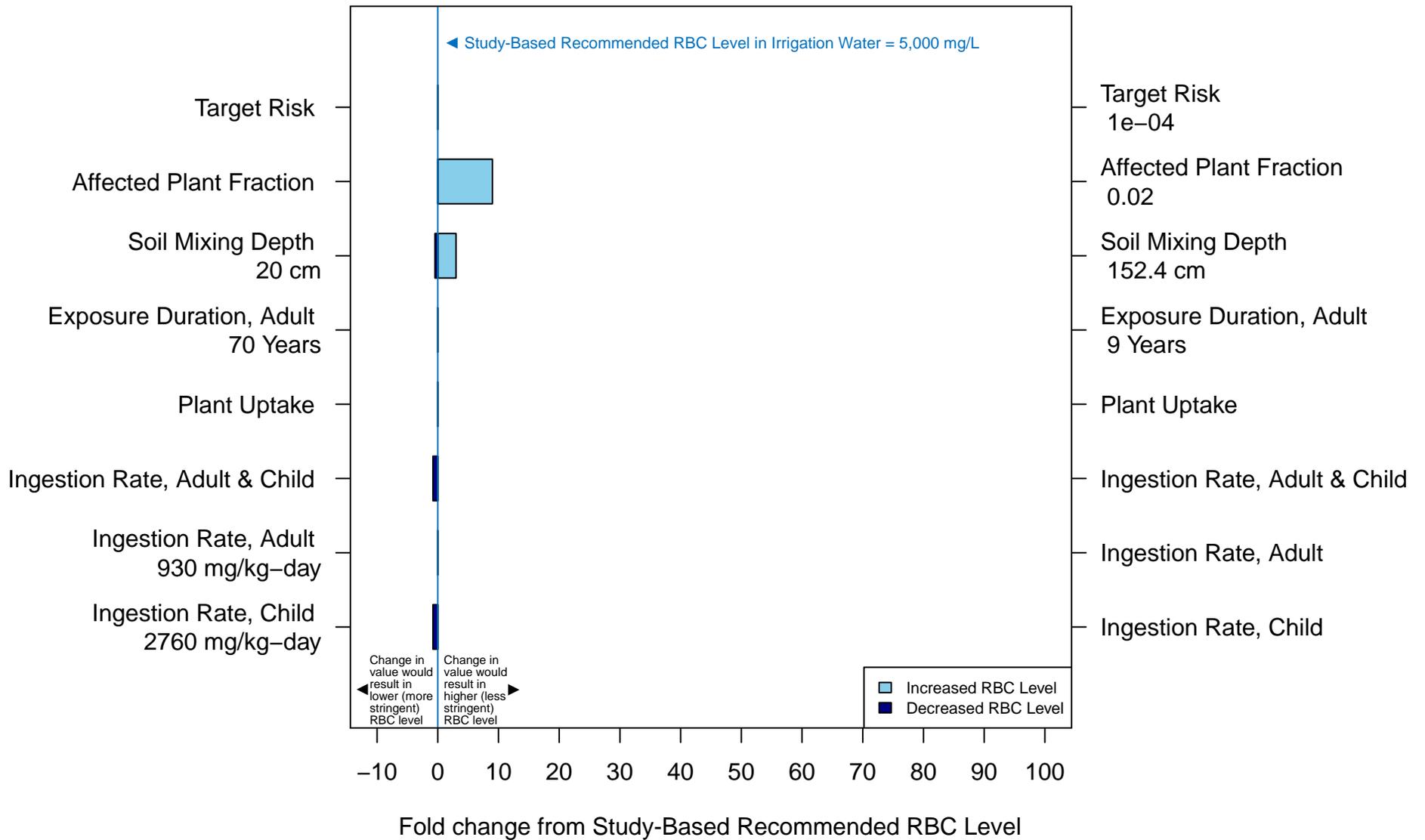
**FIGURE C-32**

**Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Citrus**



**FIGURE C-33**

**Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Grapes**



**FIGURE C-34**

**Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Potatoes**

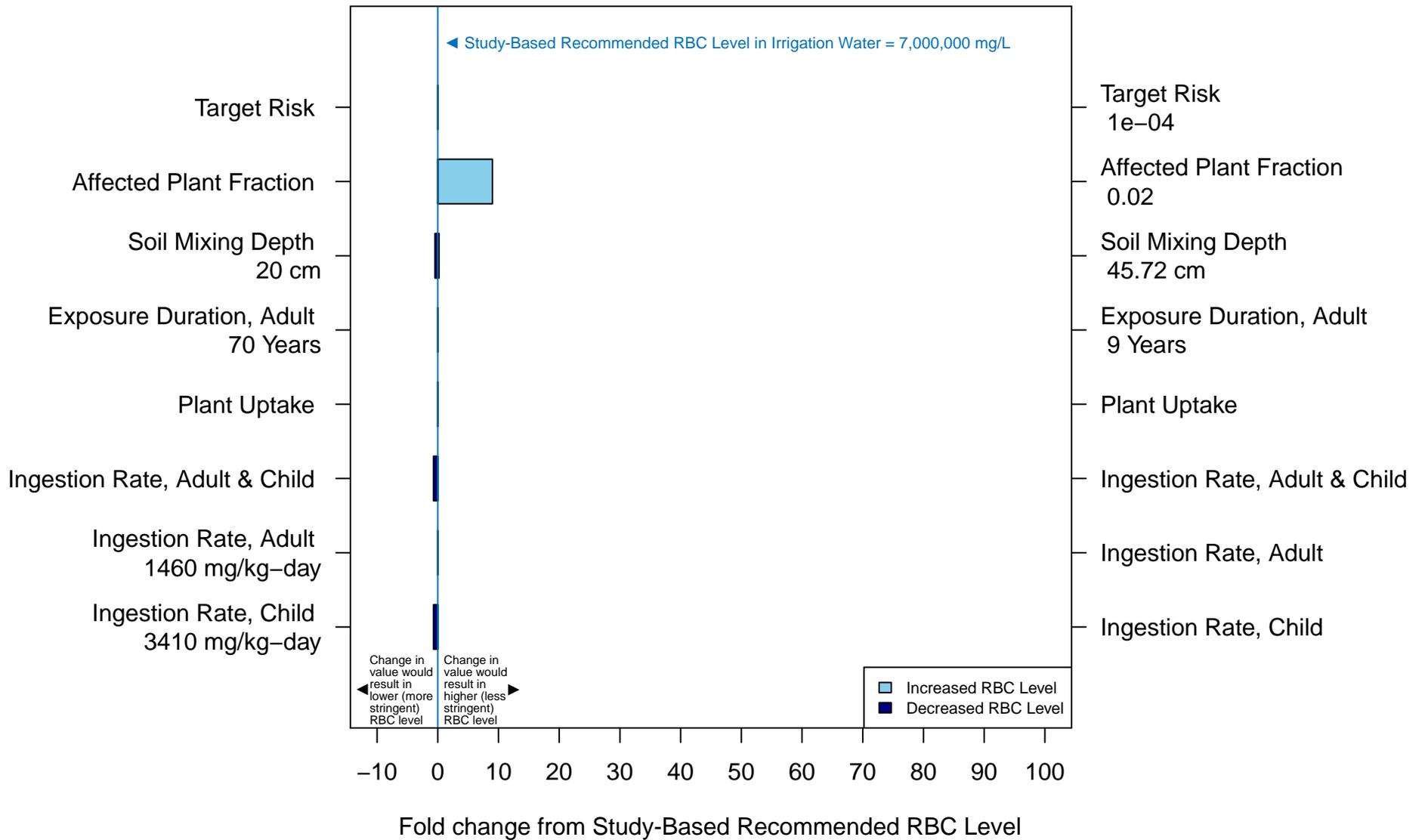


FIGURE C-35

Sensitivity of Recommended RBC Level of Ethylene Glycol in Irrigation Water Applied for Tree Nuts

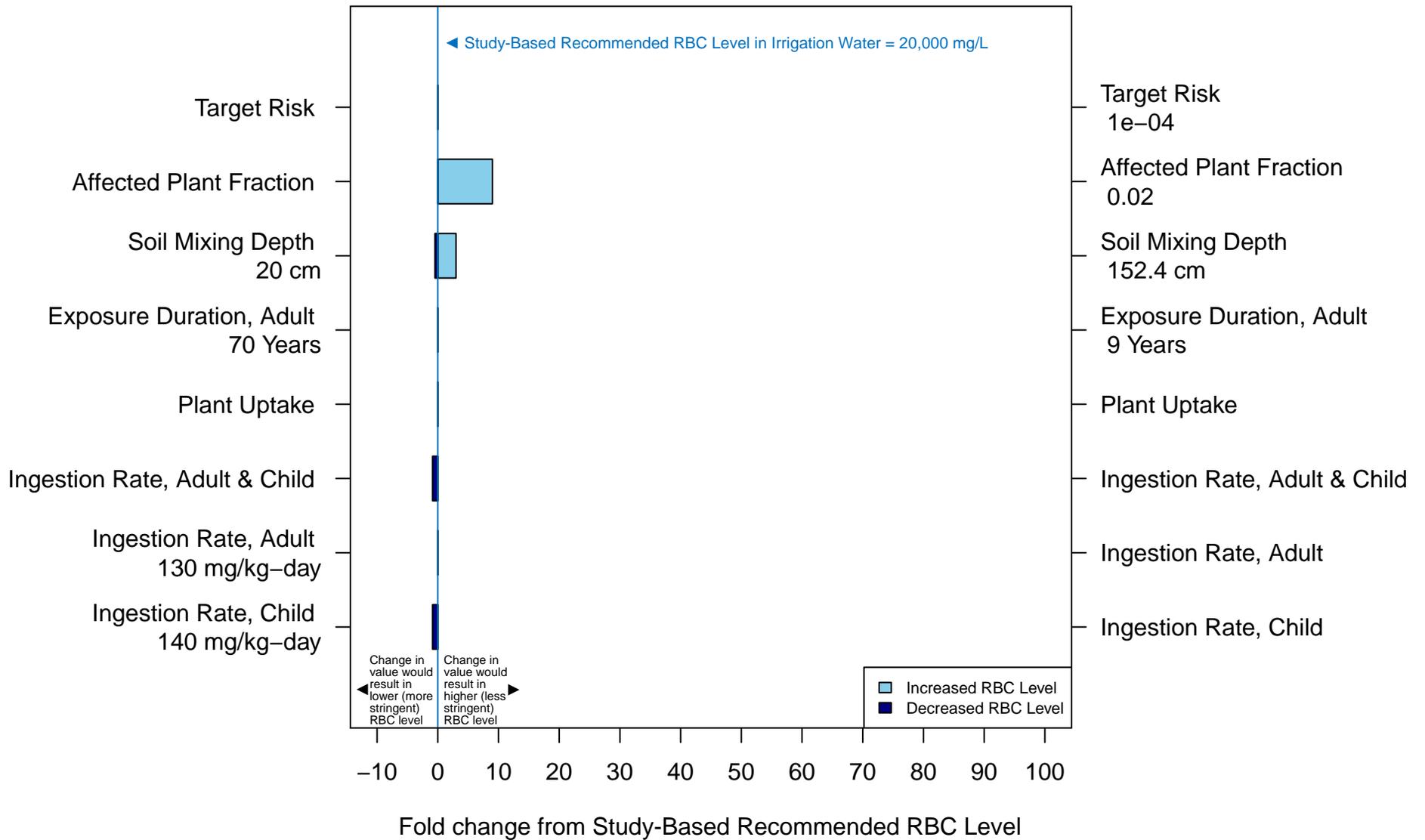
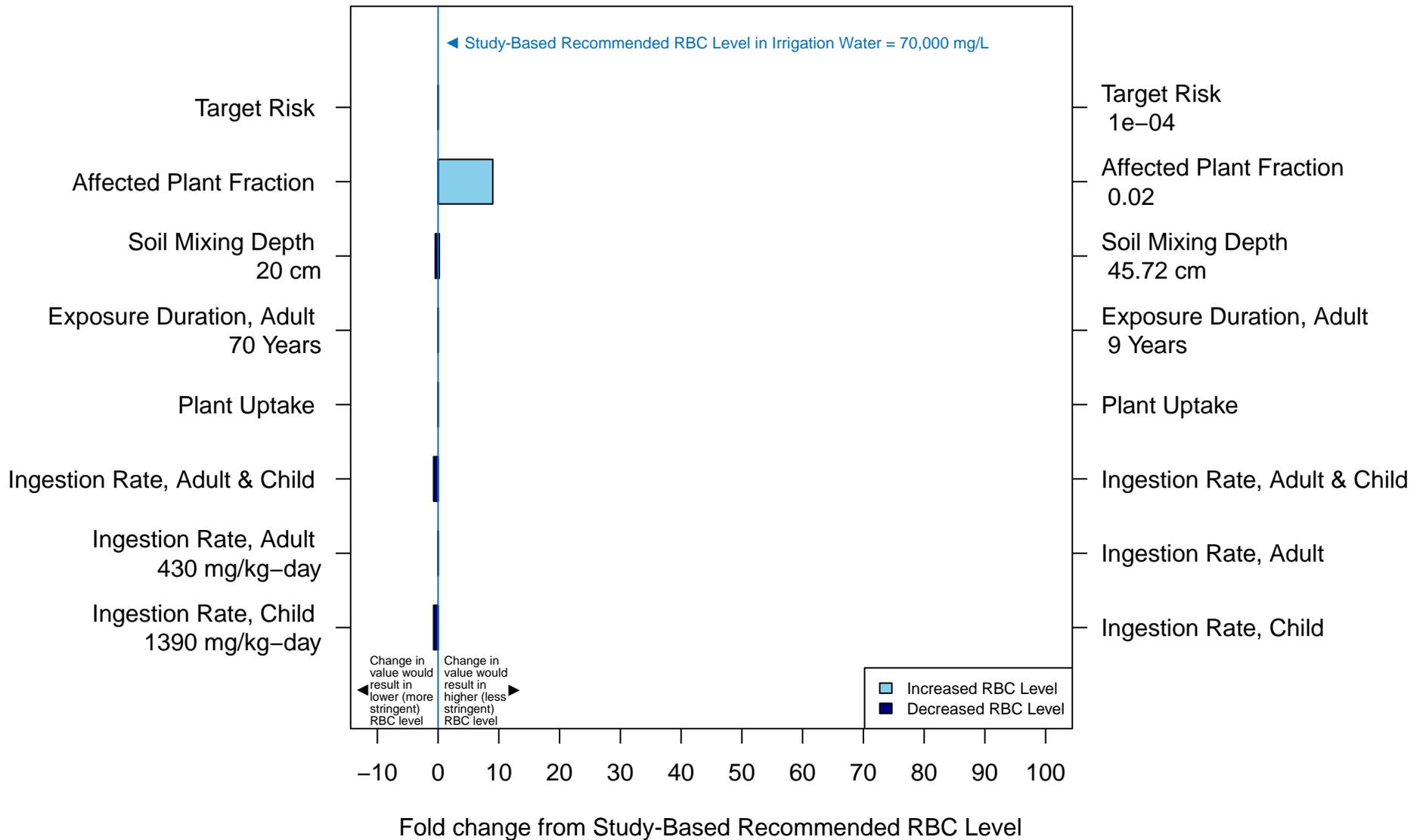


FIGURE C-36

Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Carrots



**FIGURE C-37**

**Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Citrus**

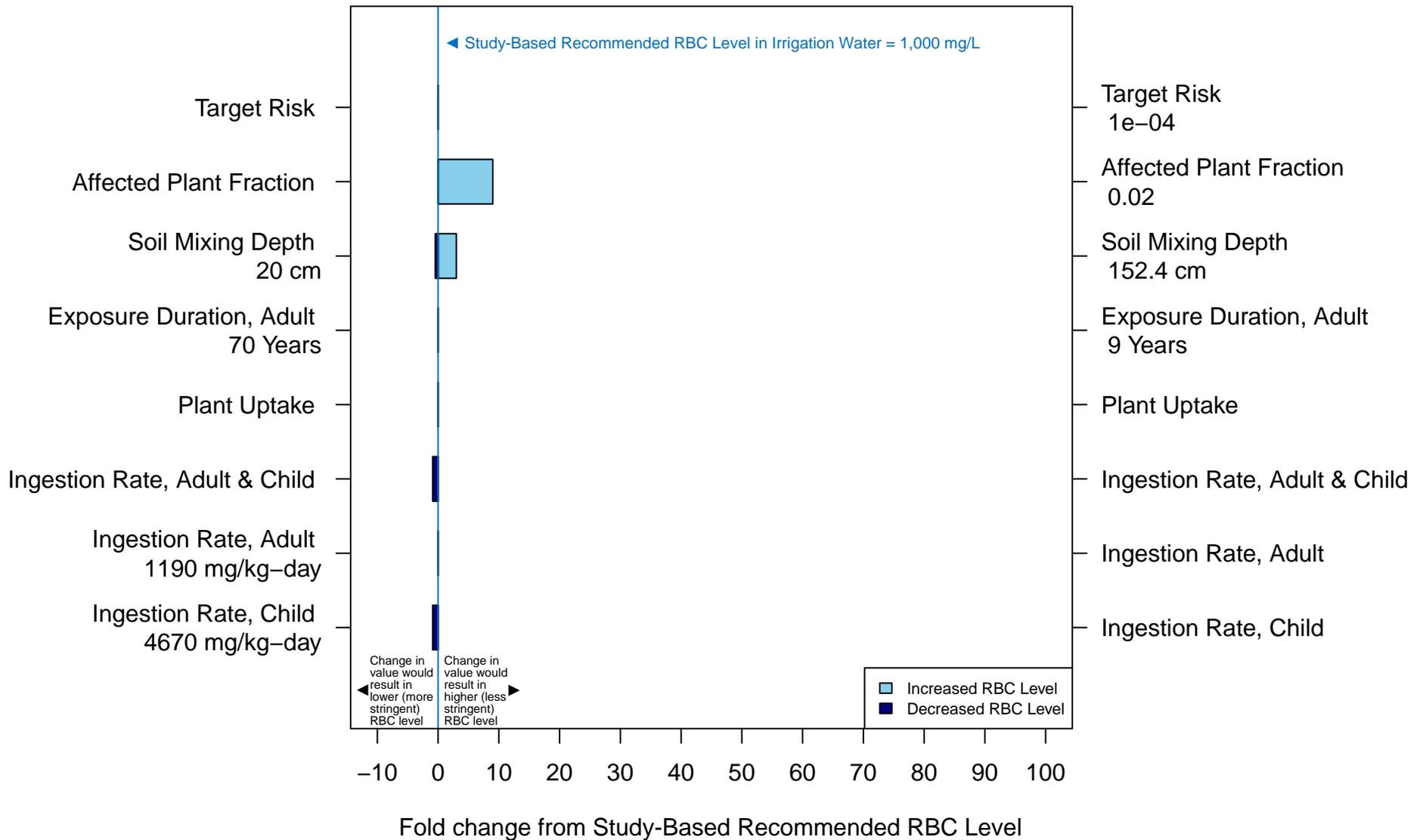
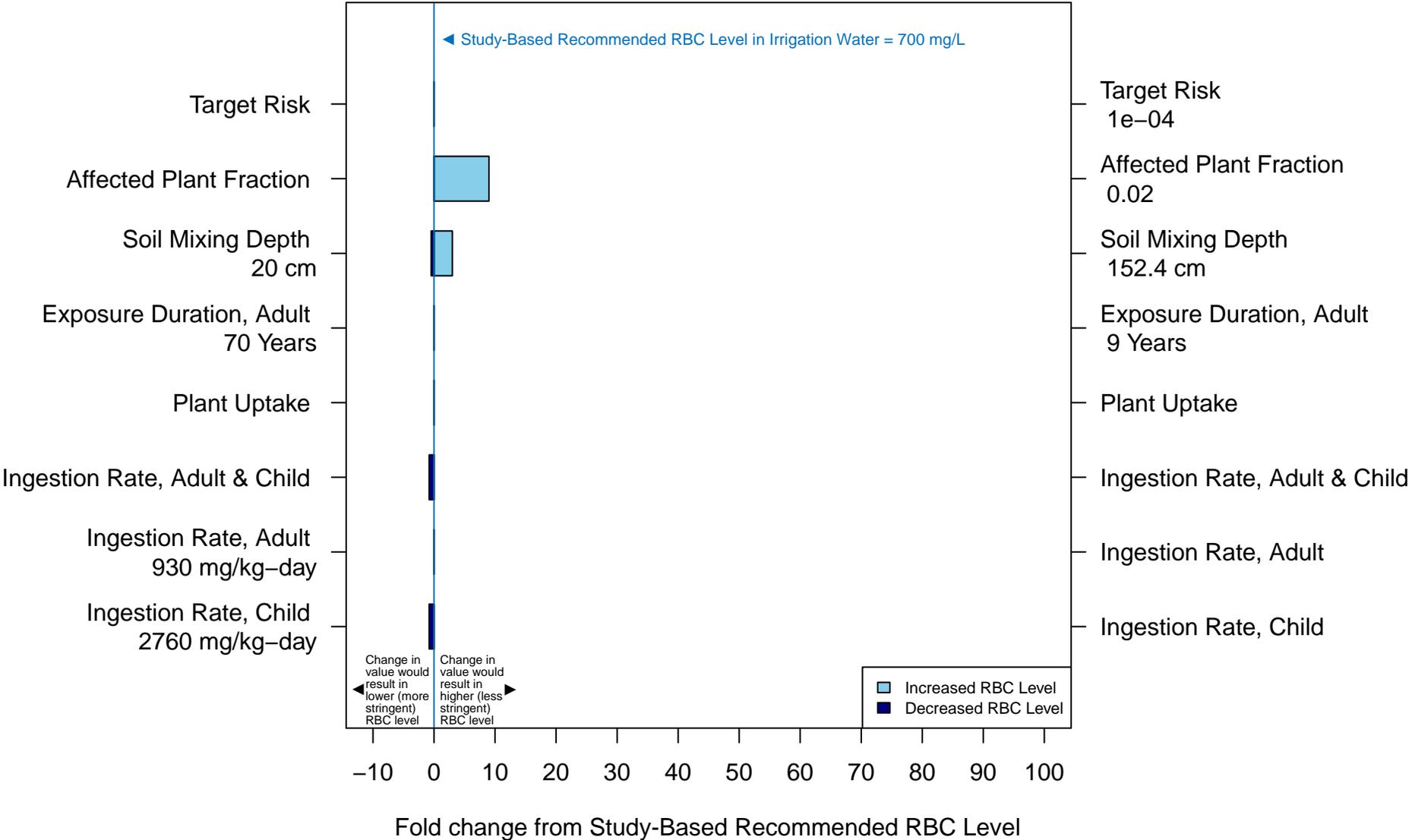


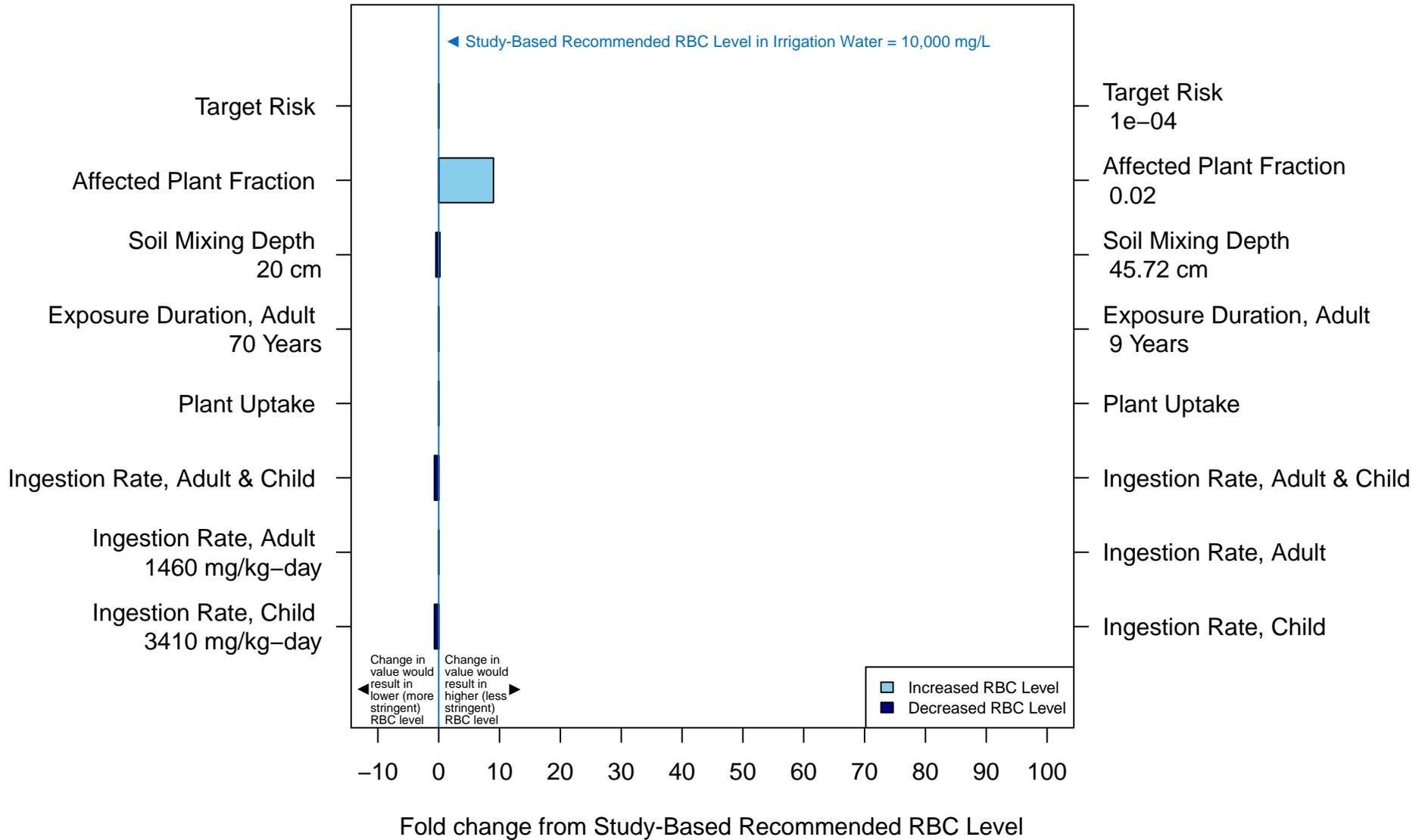
FIGURE C-38

Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Grapes



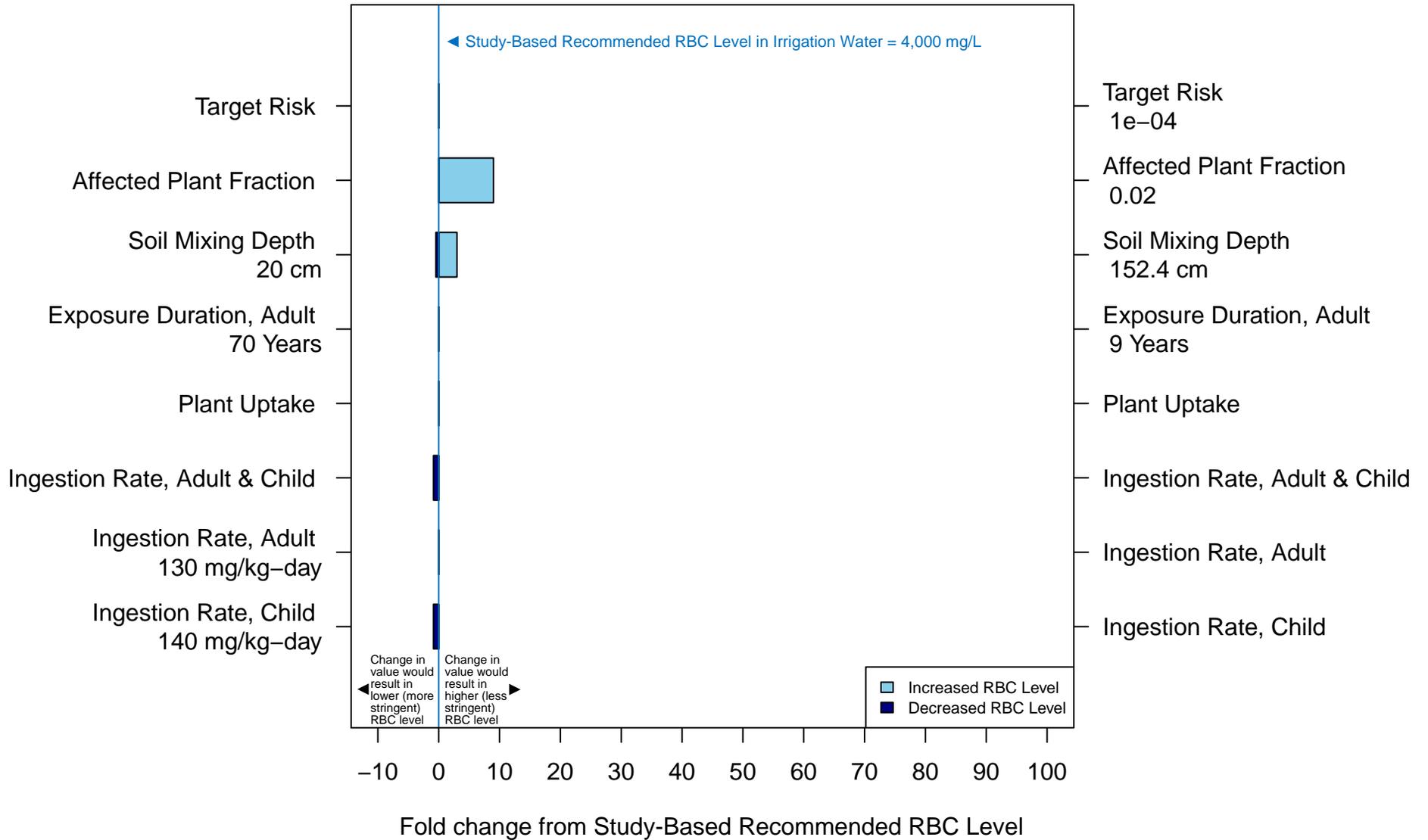
**FIGURE C-39**

**Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Potatoes**



**FIGURE C-40**

**Sensitivity of Recommended RBC Level of Fluoride in Irrigation Water Applied for Tree Nuts**



**FIGURE C-41**

**Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Carrots**

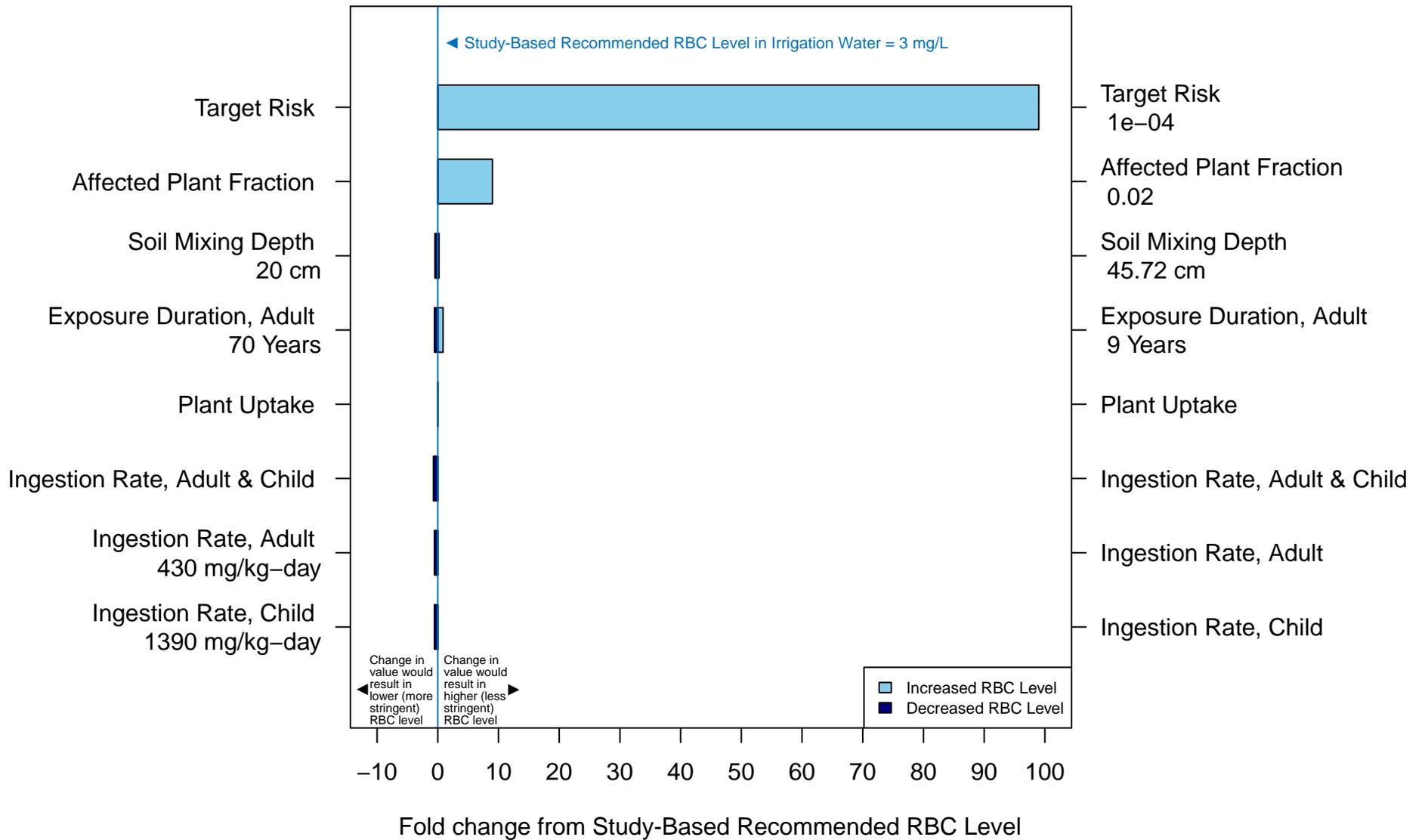
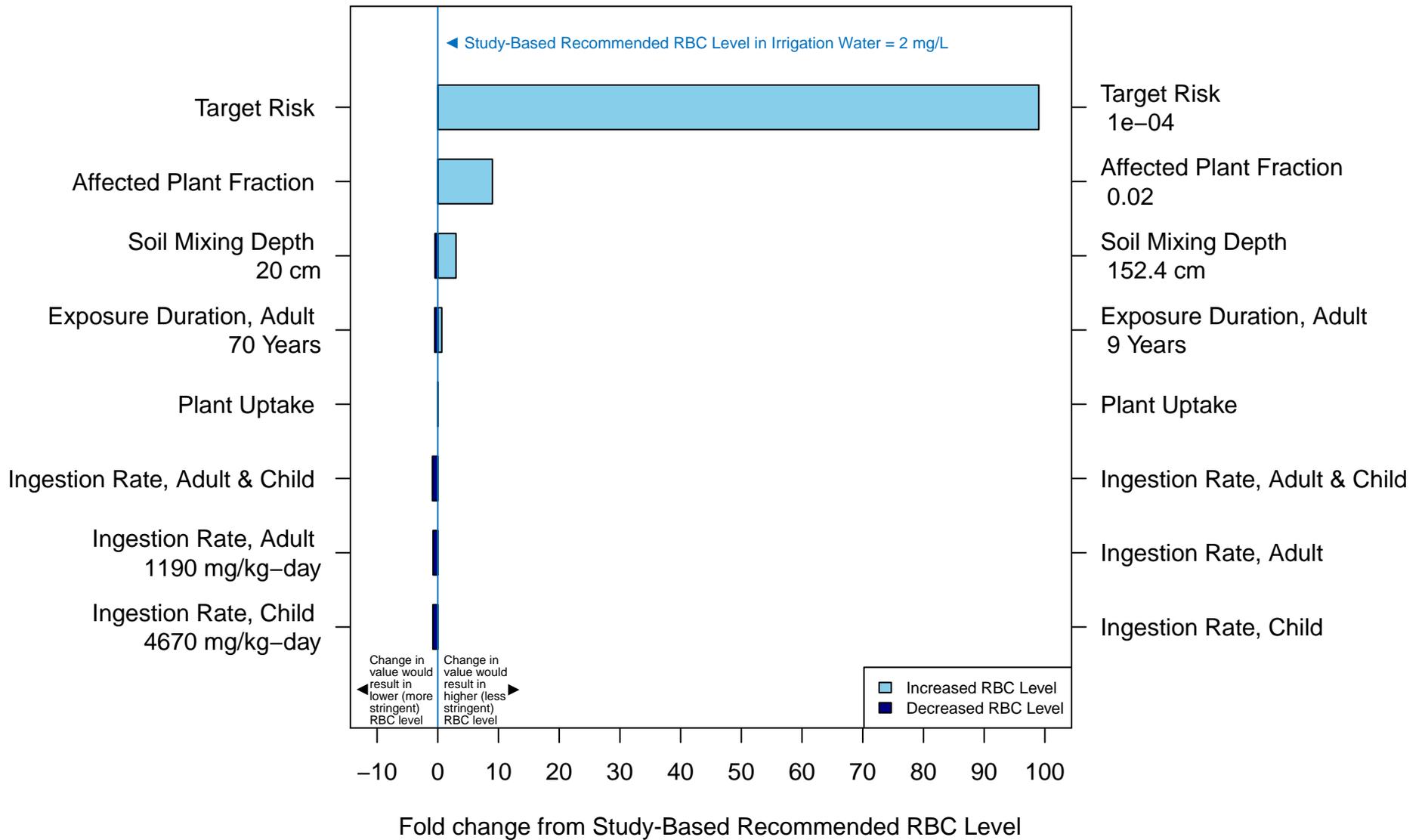


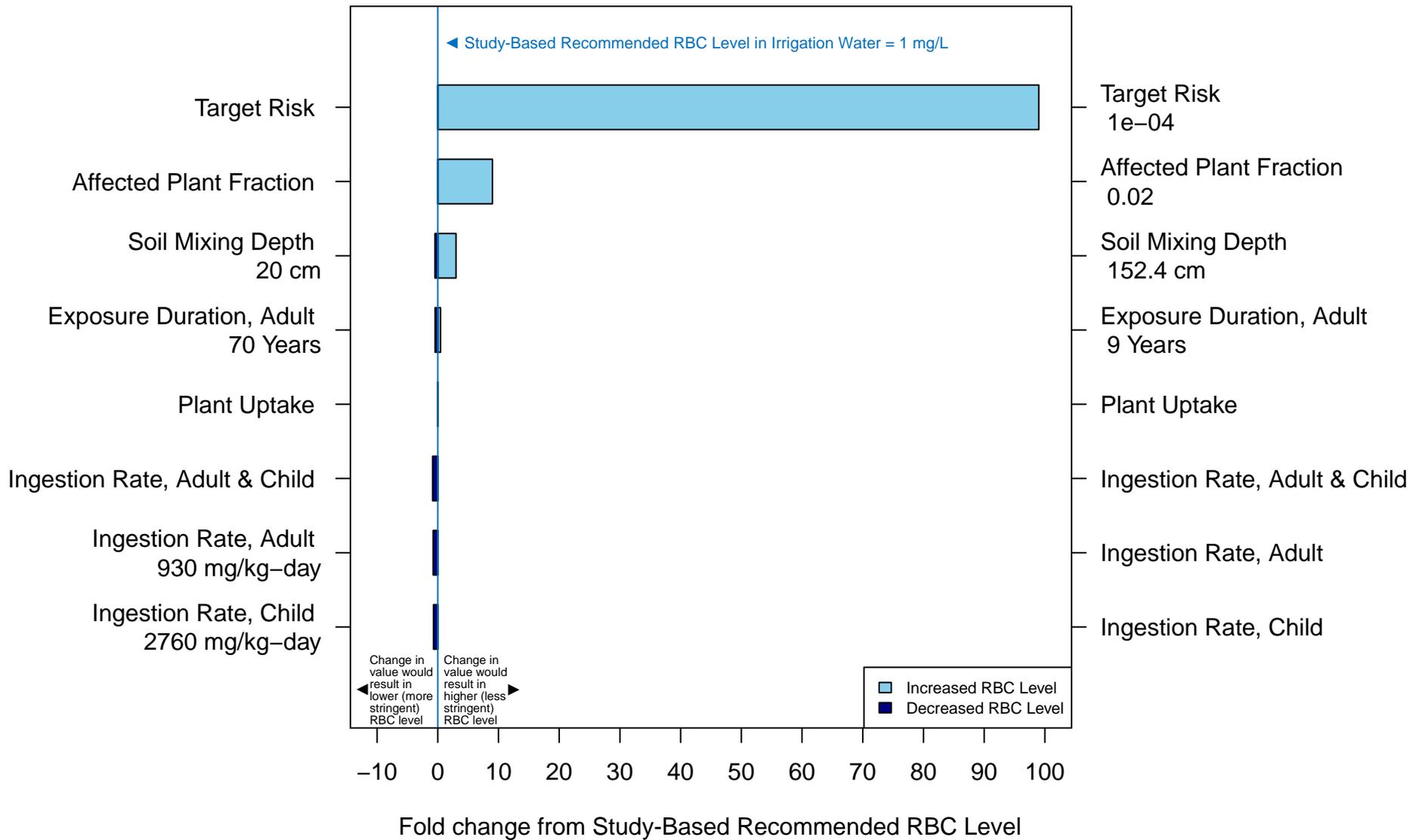
FIGURE C-42

Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Citrus



**FIGURE C-43**

**Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Grapes**



**FIGURE C-44**

**Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Potatoes**

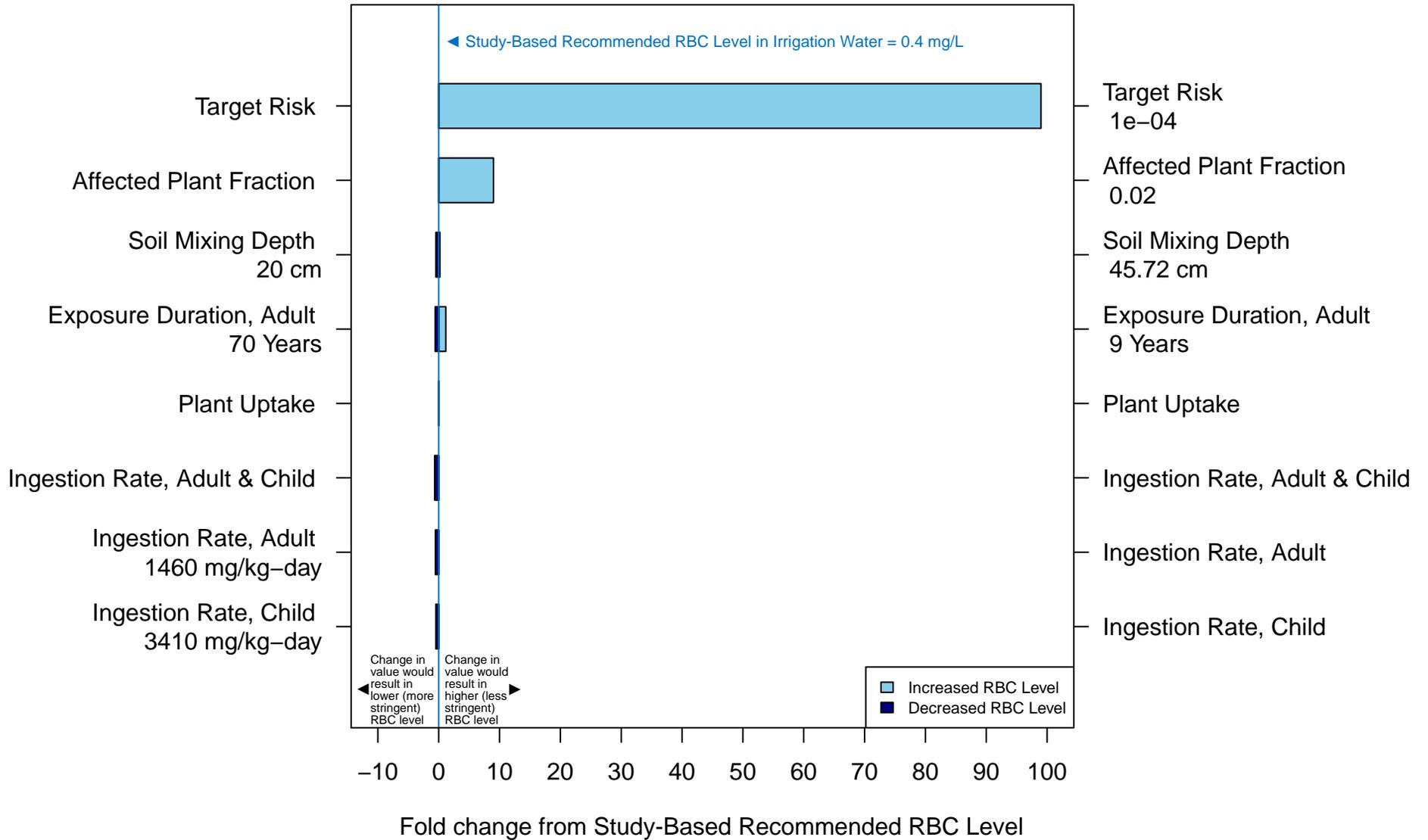
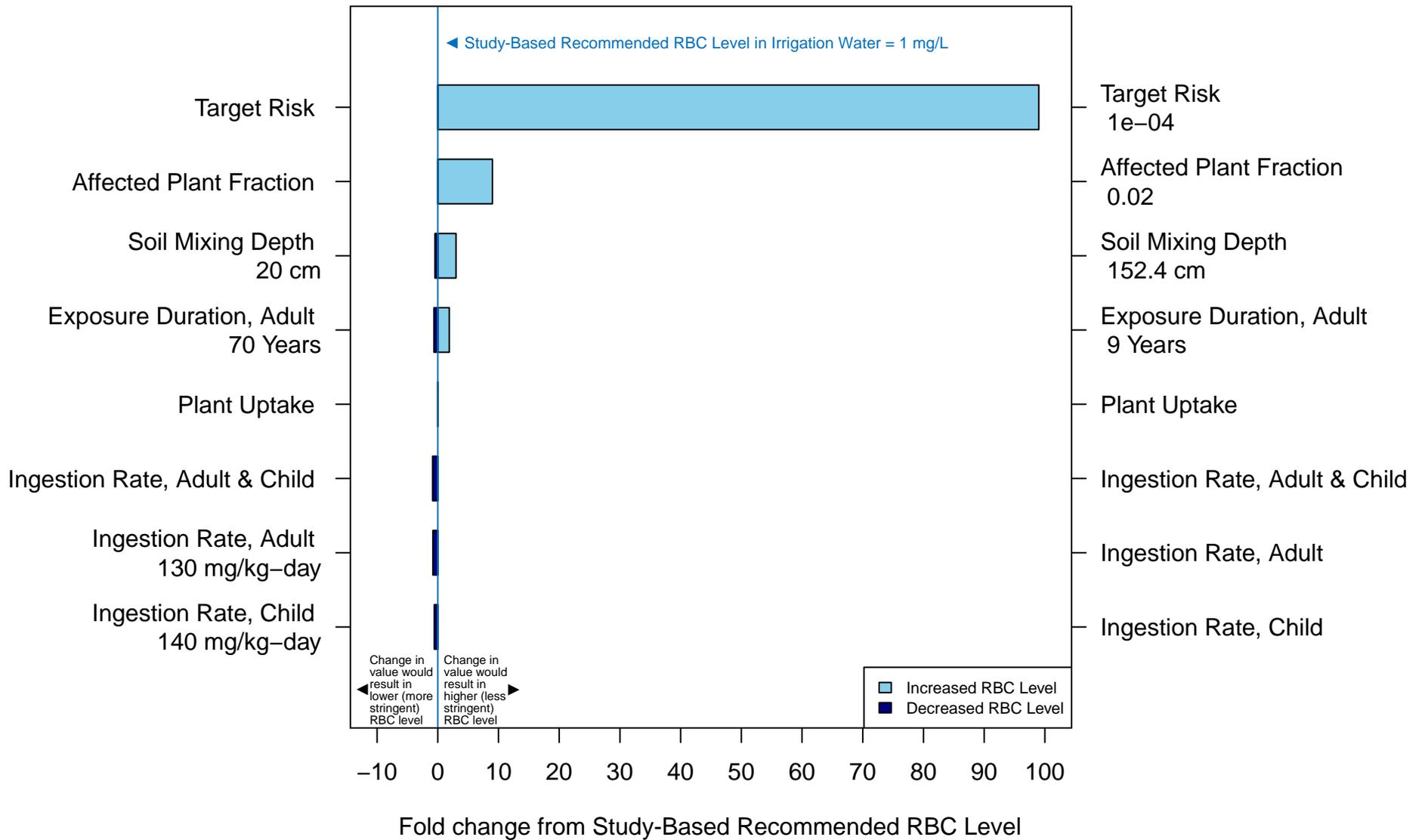


FIGURE C-45

Sensitivity of Recommended RBC Level of Hexavalent Chromium in Irrigation Water Applied for Tree Nuts



**FIGURE C-46**

**Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Carrots**

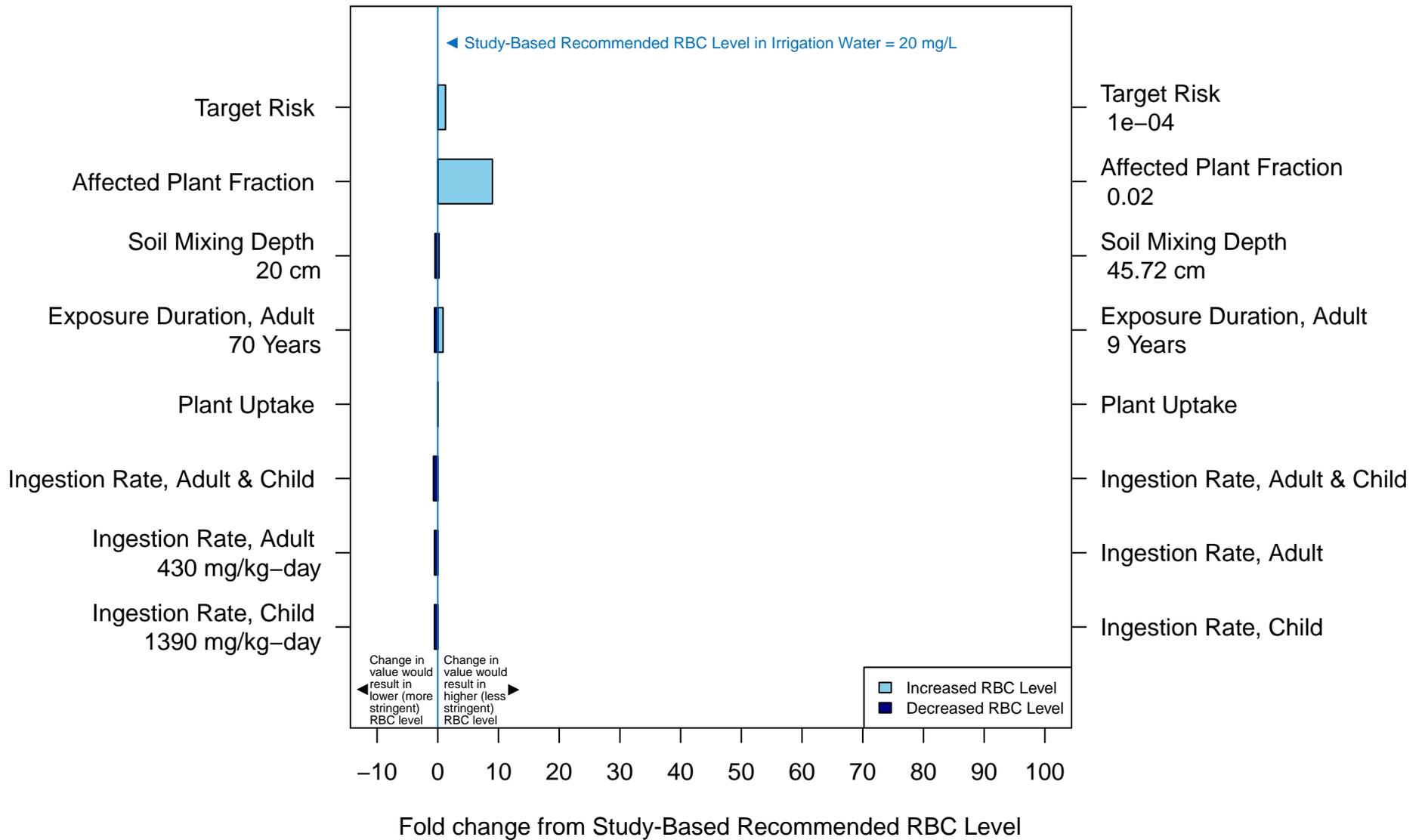
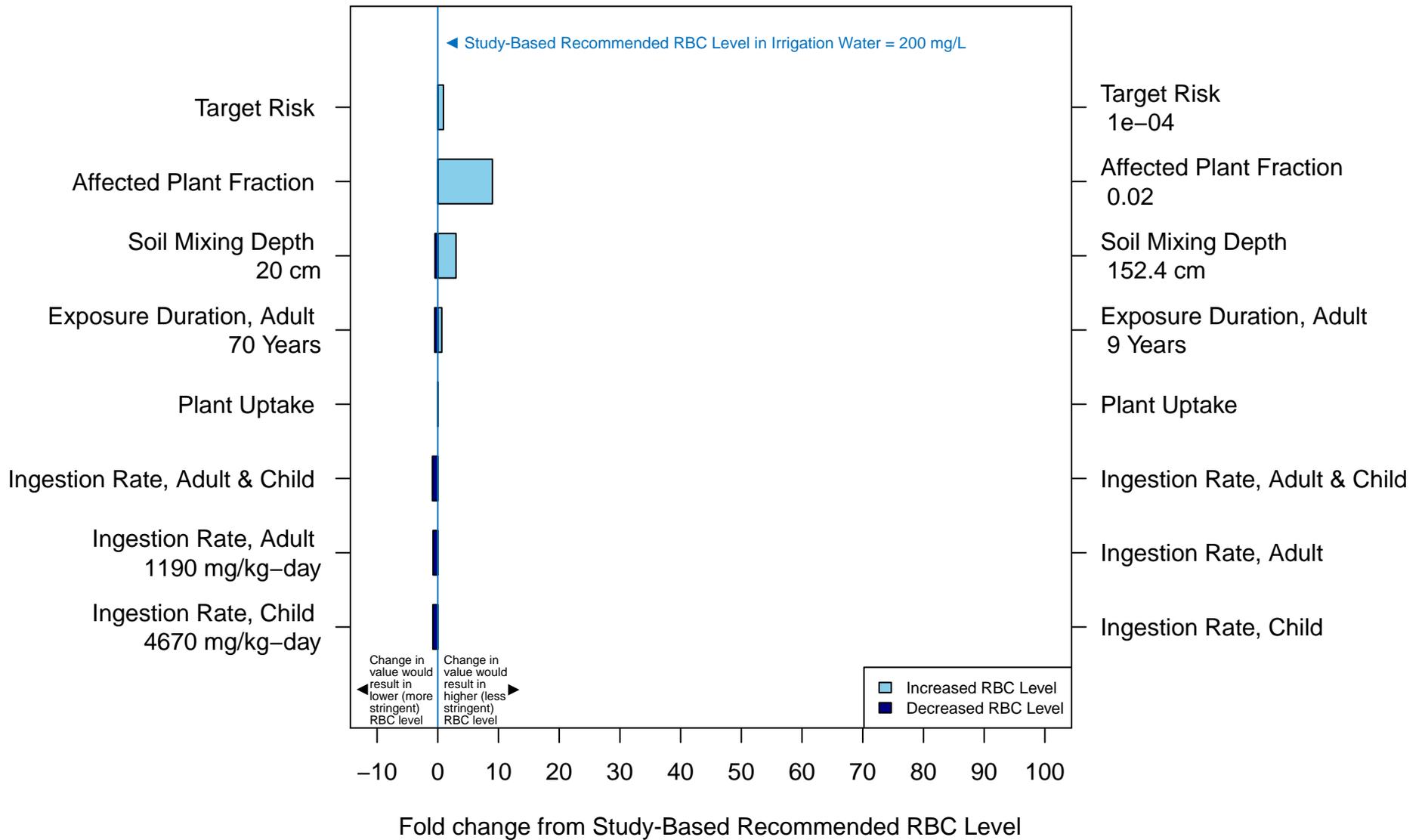


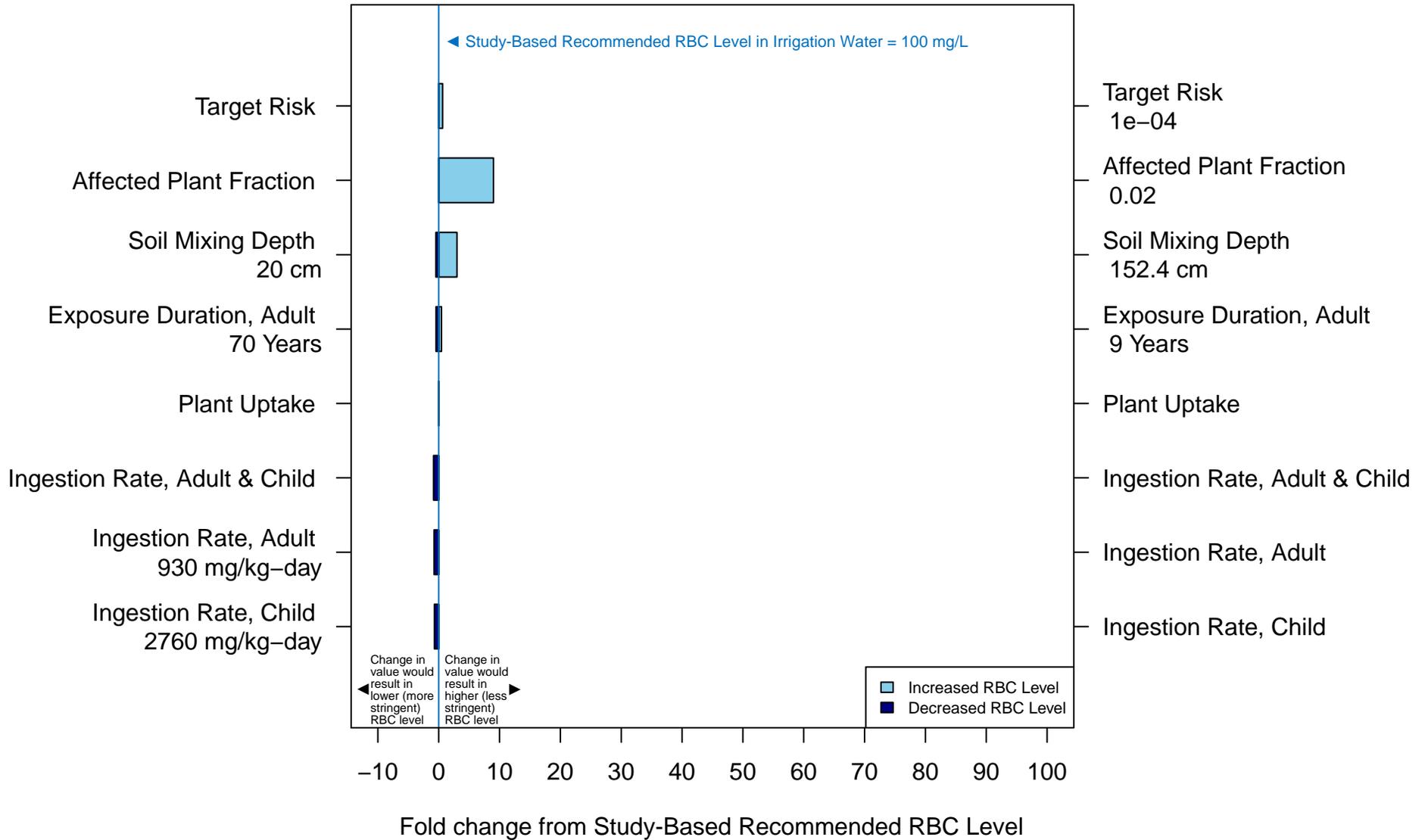
FIGURE C-47

Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Citrus



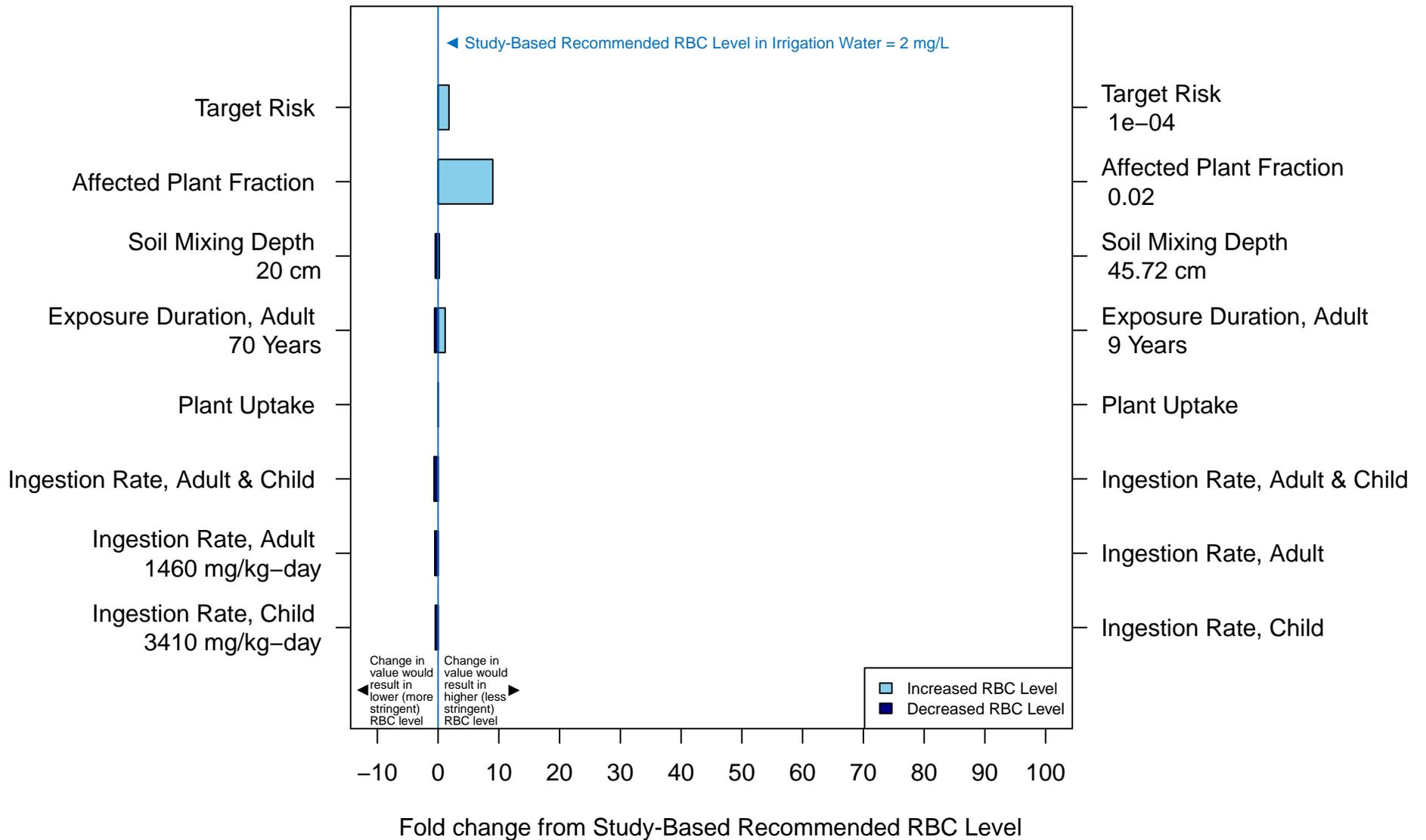
**FIGURE C-48**

**Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Grapes**



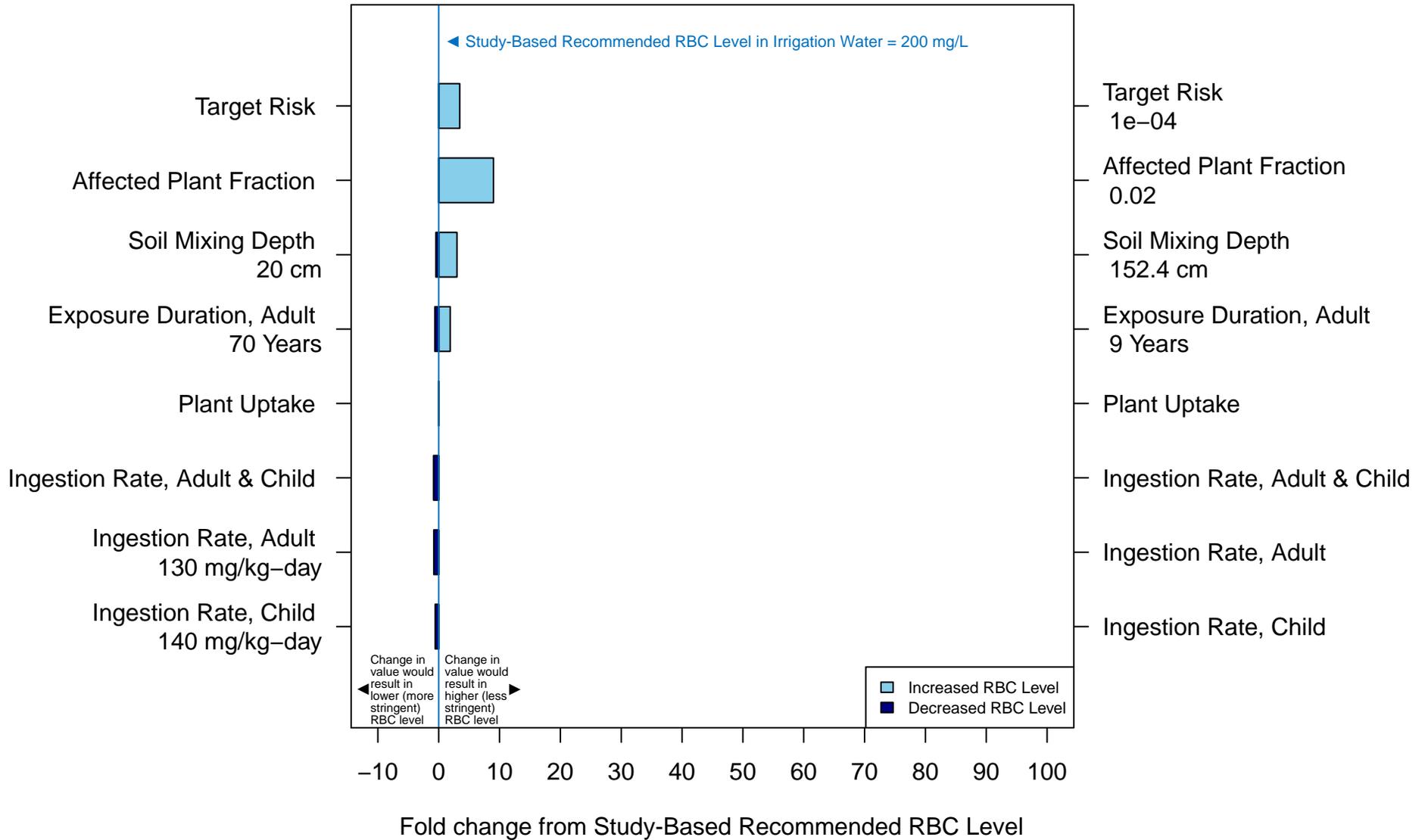
**FIGURE C-49**

**Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Potatoes**



**FIGURE C-50**

**Sensitivity of Recommended RBC Level of Methylene Chloride in Irrigation Water Applied for Tree Nuts**



**FIGURE C-51**

**Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Carrots**

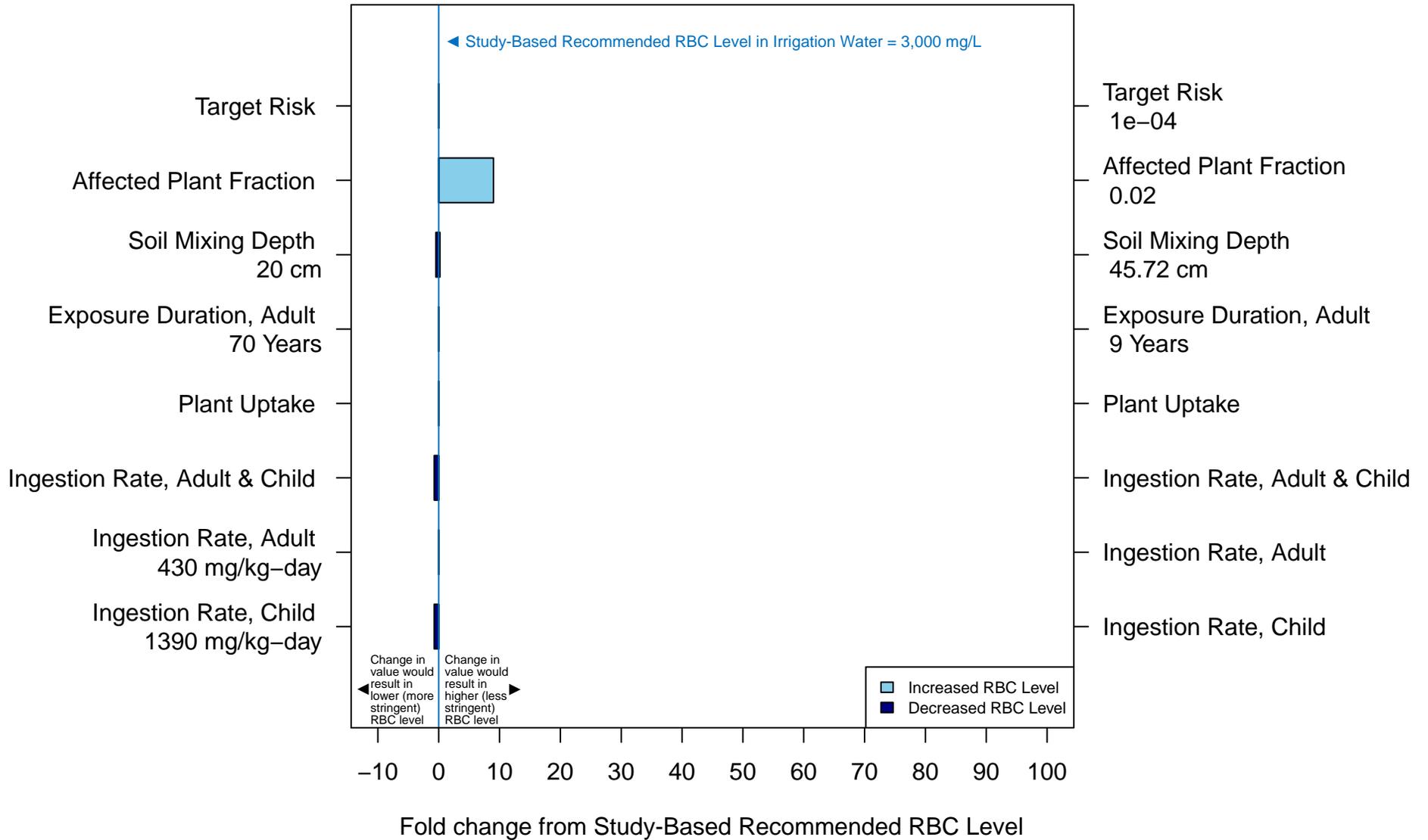


FIGURE C-52

Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Citrus

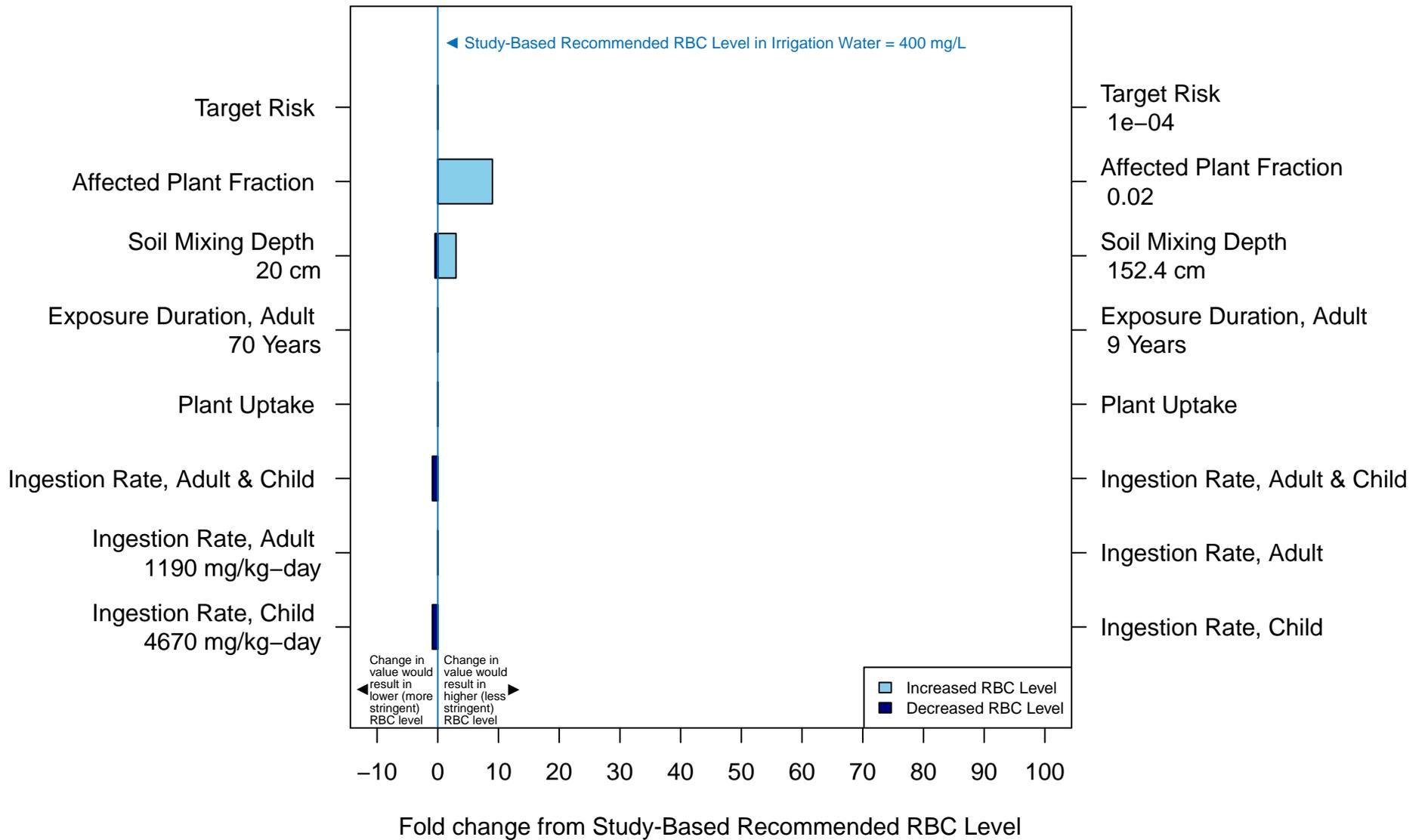
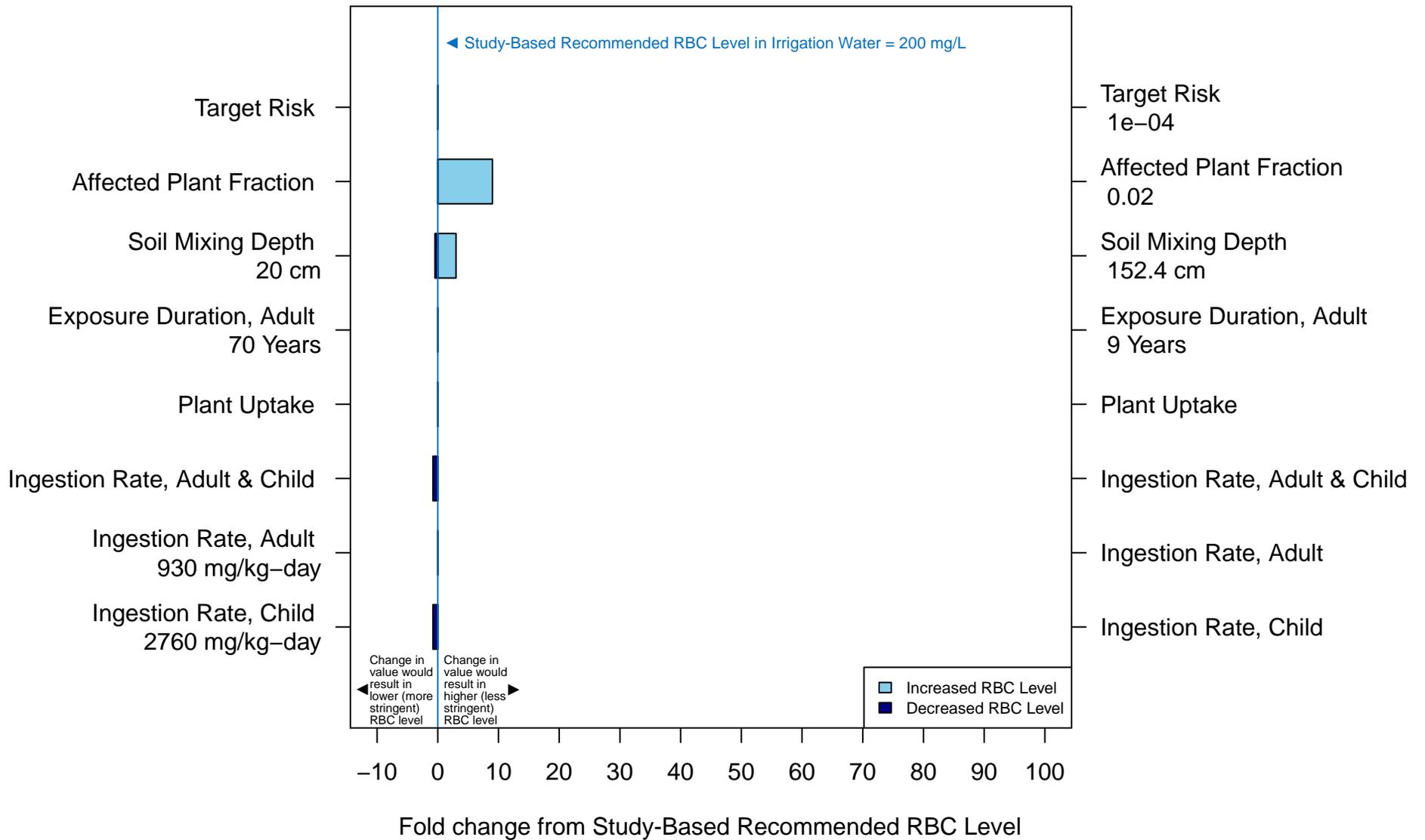


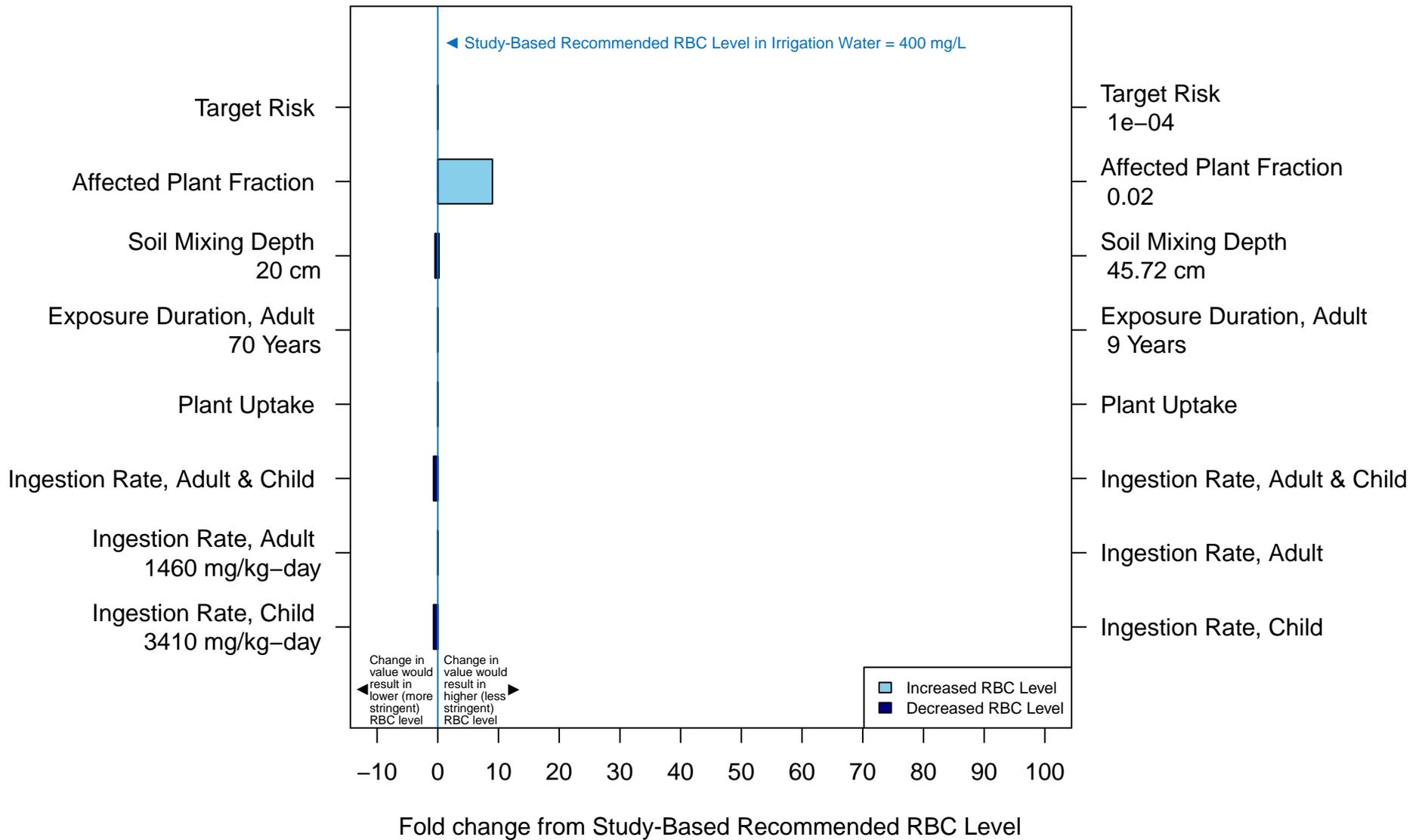
FIGURE C-53

Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Grapes



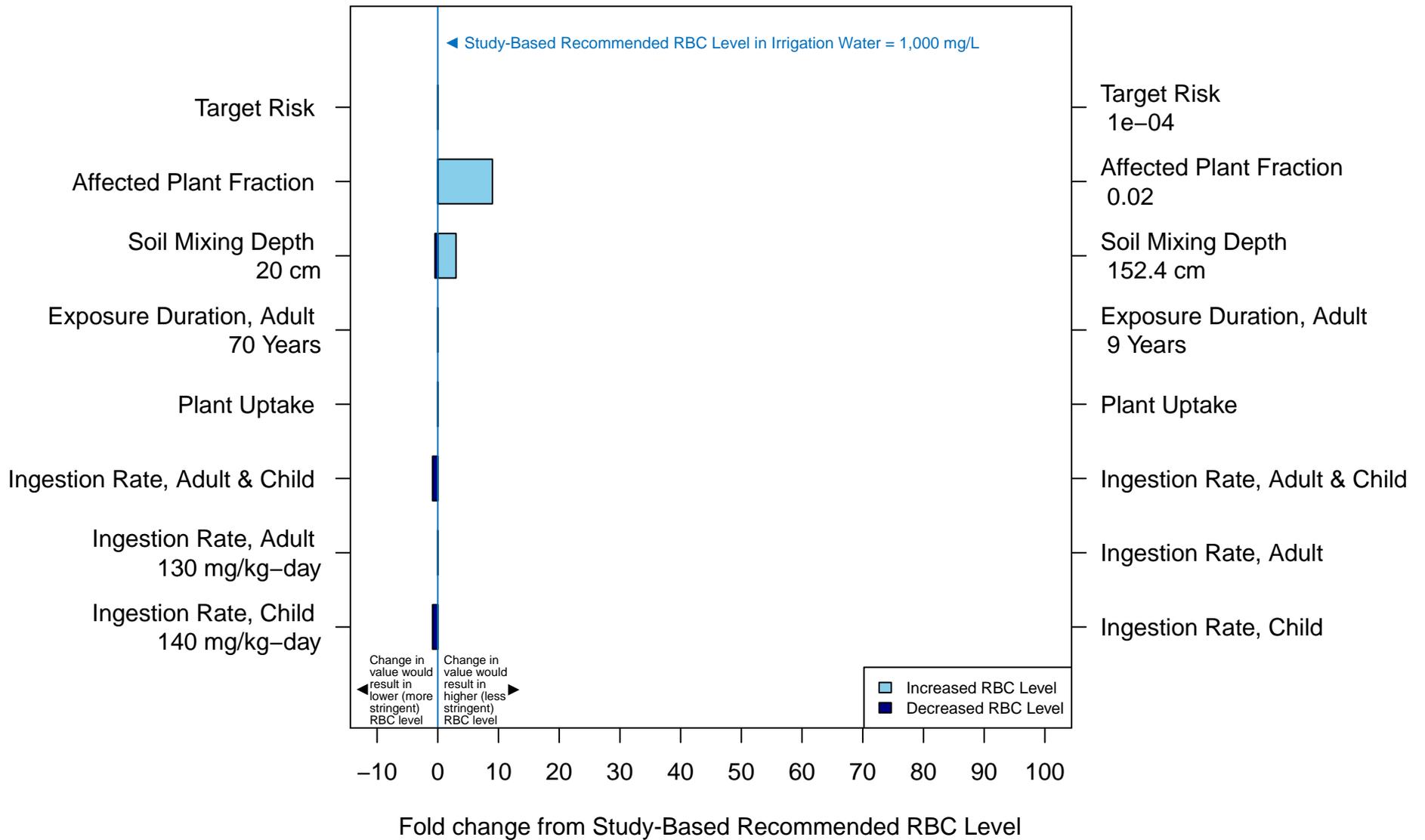
**FIGURE C-54**

**Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Potatoes**



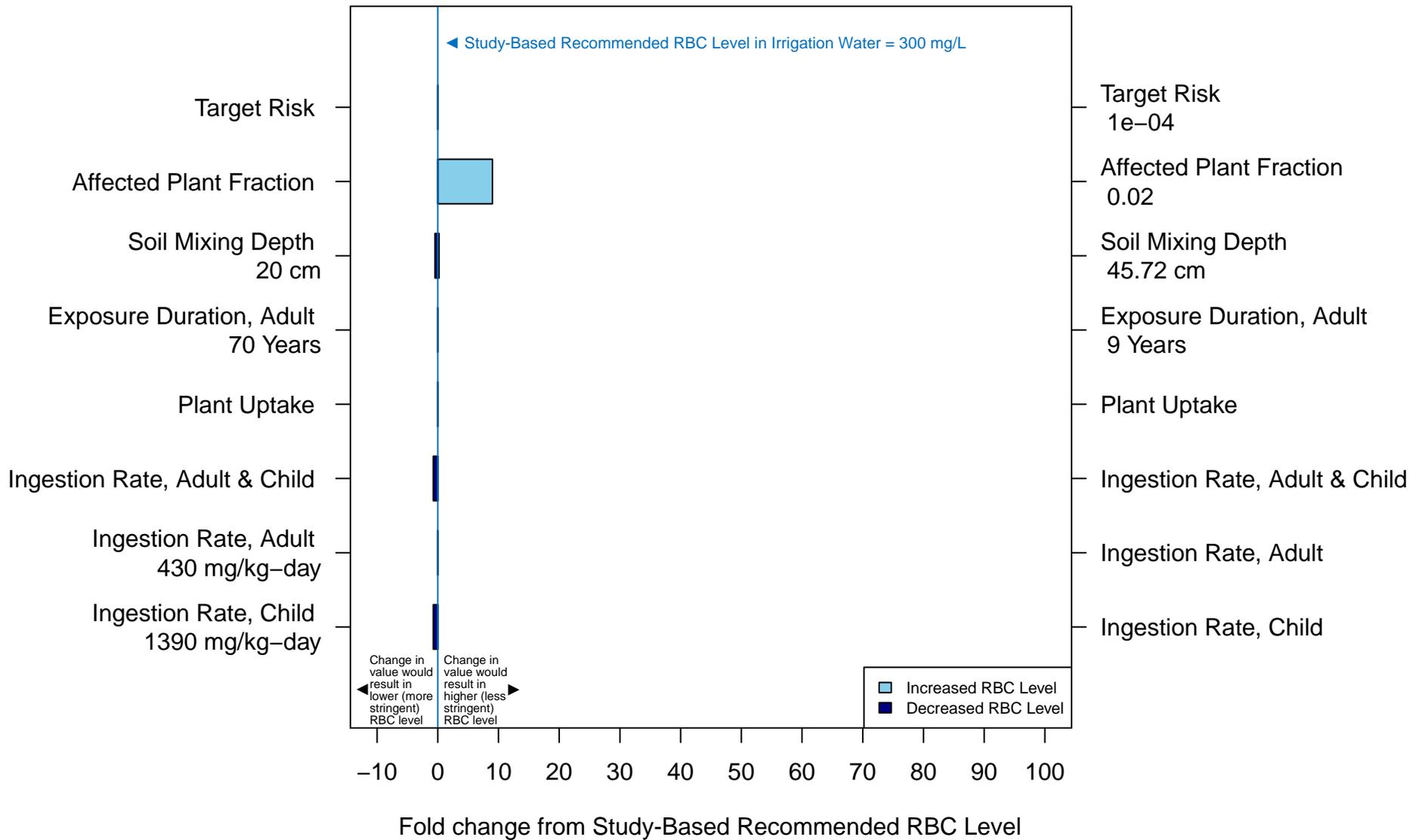
**FIGURE C-55**

**Sensitivity of Recommended RBC Level of Naphthalene in Irrigation Water Applied for Tree Nuts**



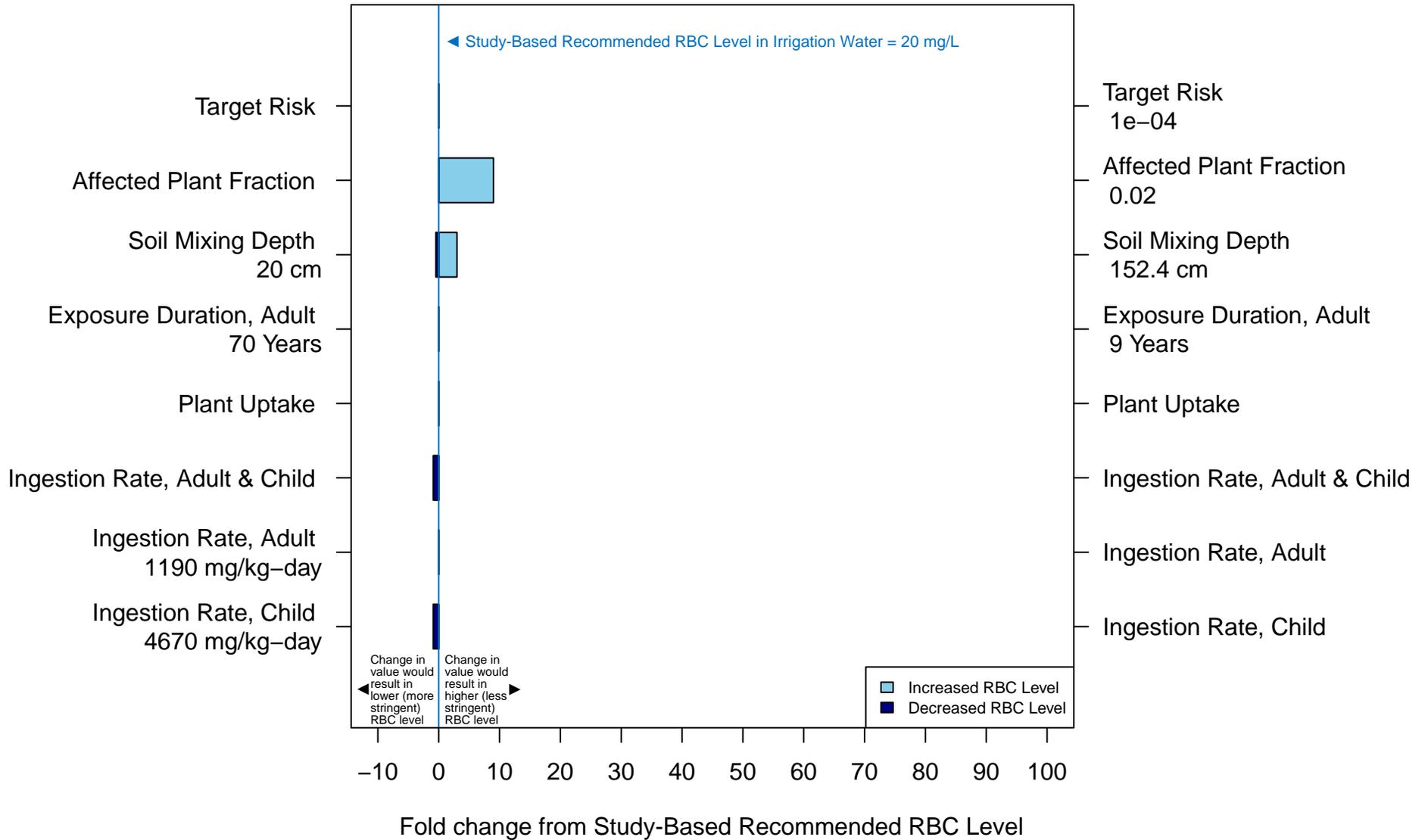
**FIGURE C-56**

**Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Carrots**



**FIGURE C-57**

**Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Citrus**



**FIGURE C-58**

**Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Grapes**

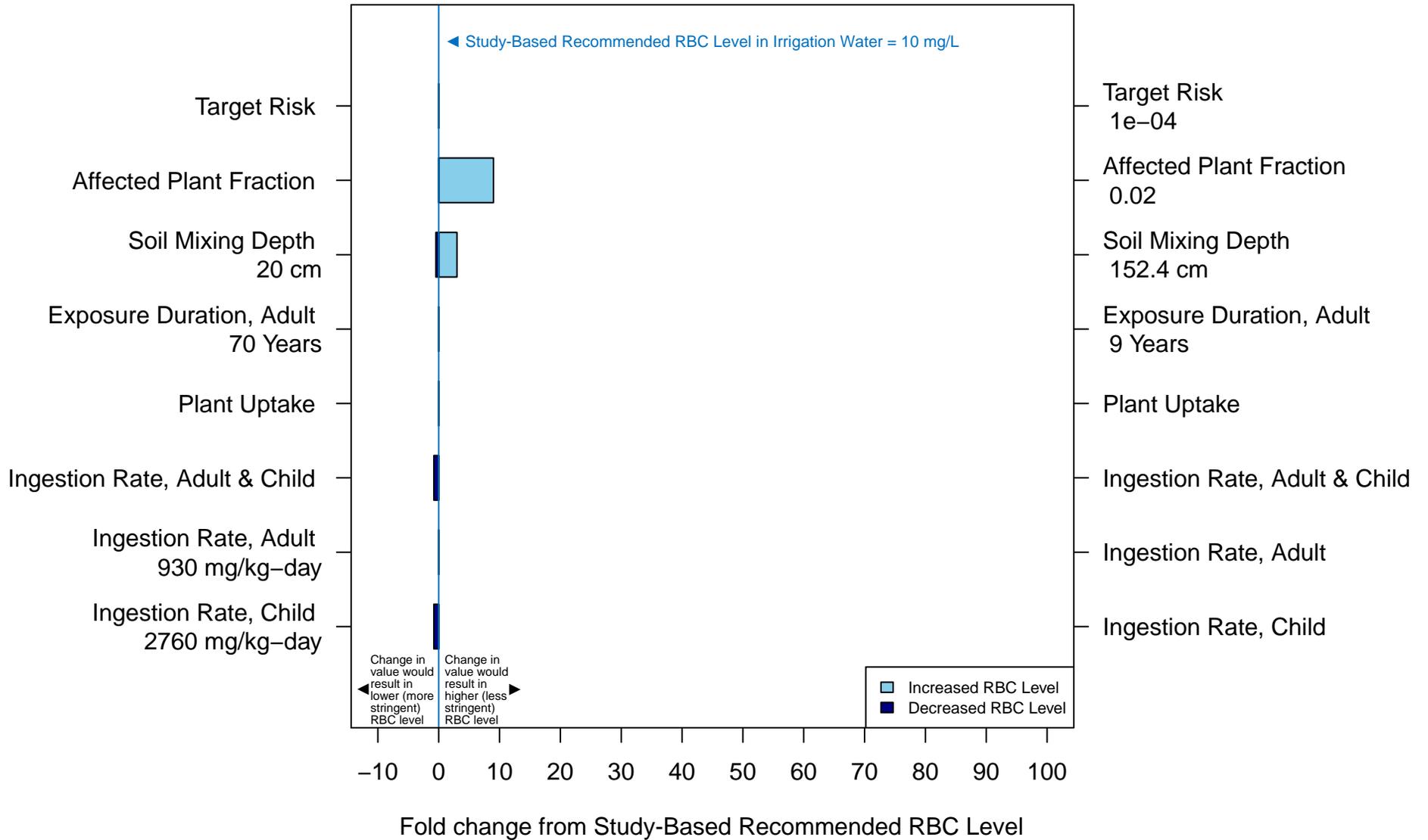
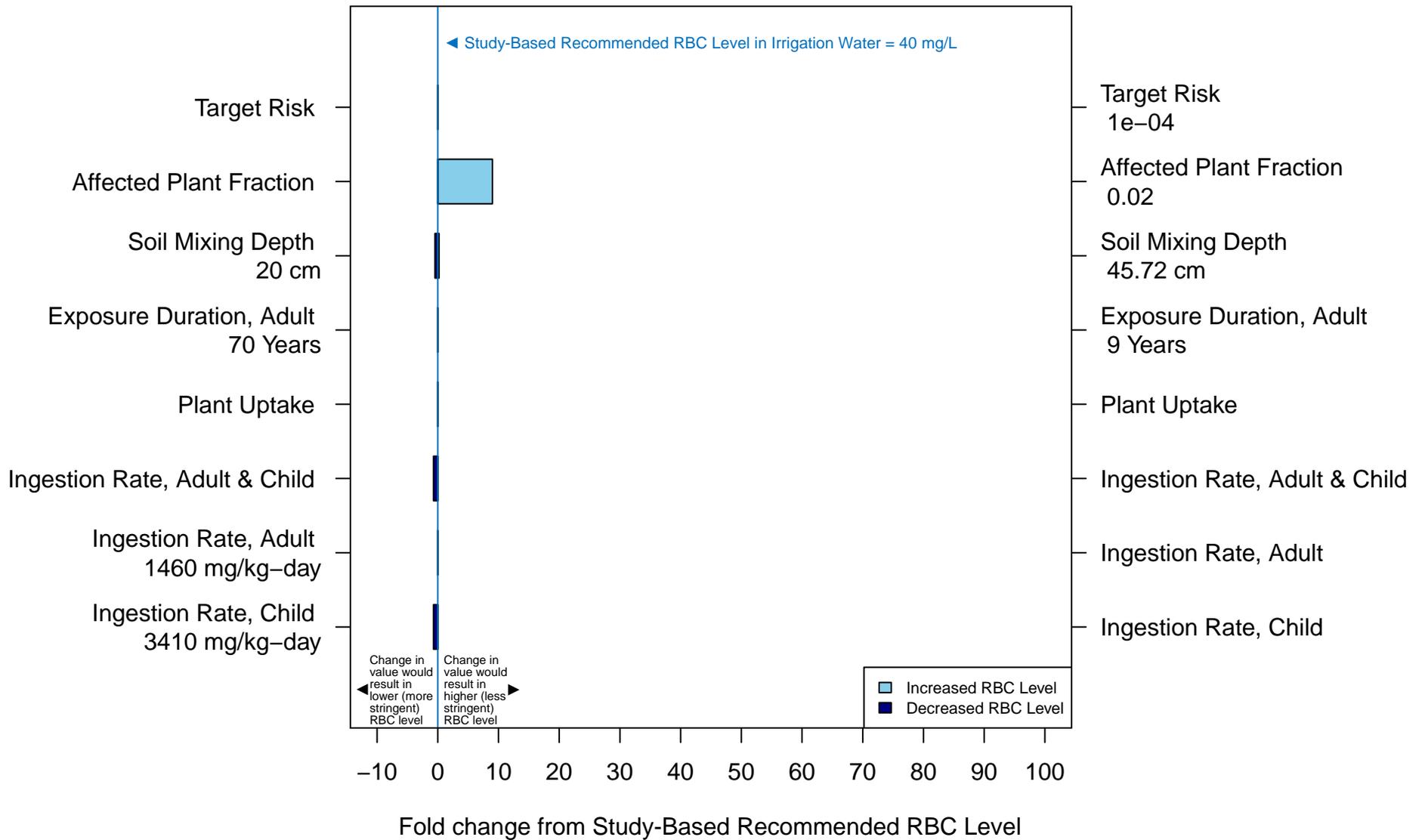


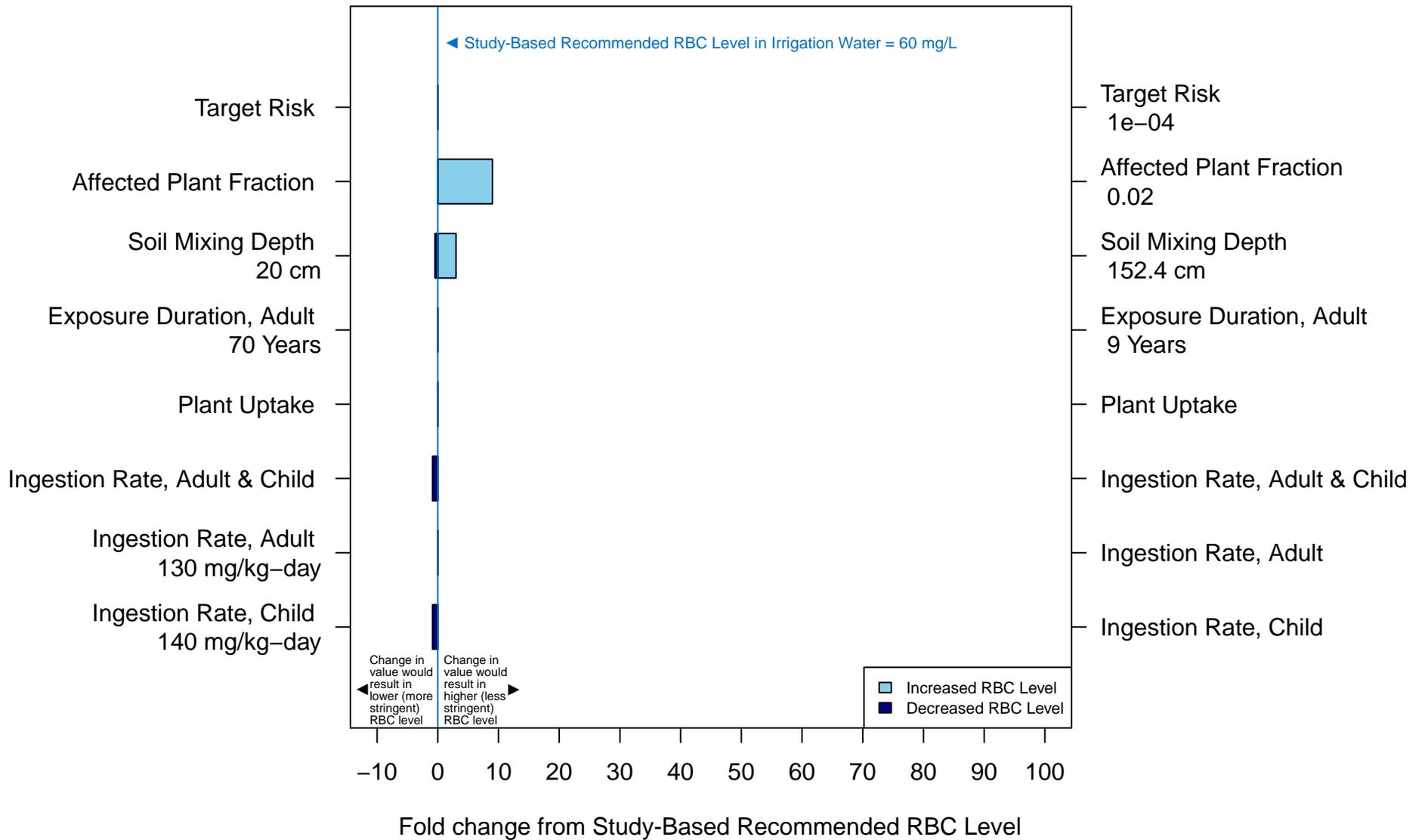
FIGURE C-59

Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Potatoes



**FIGURE C-60**

**Sensitivity of Recommended RBC Level of Thallium in Irrigation Water Applied for Tree Nuts**



**FIGURE C-61**

**Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Carrots**

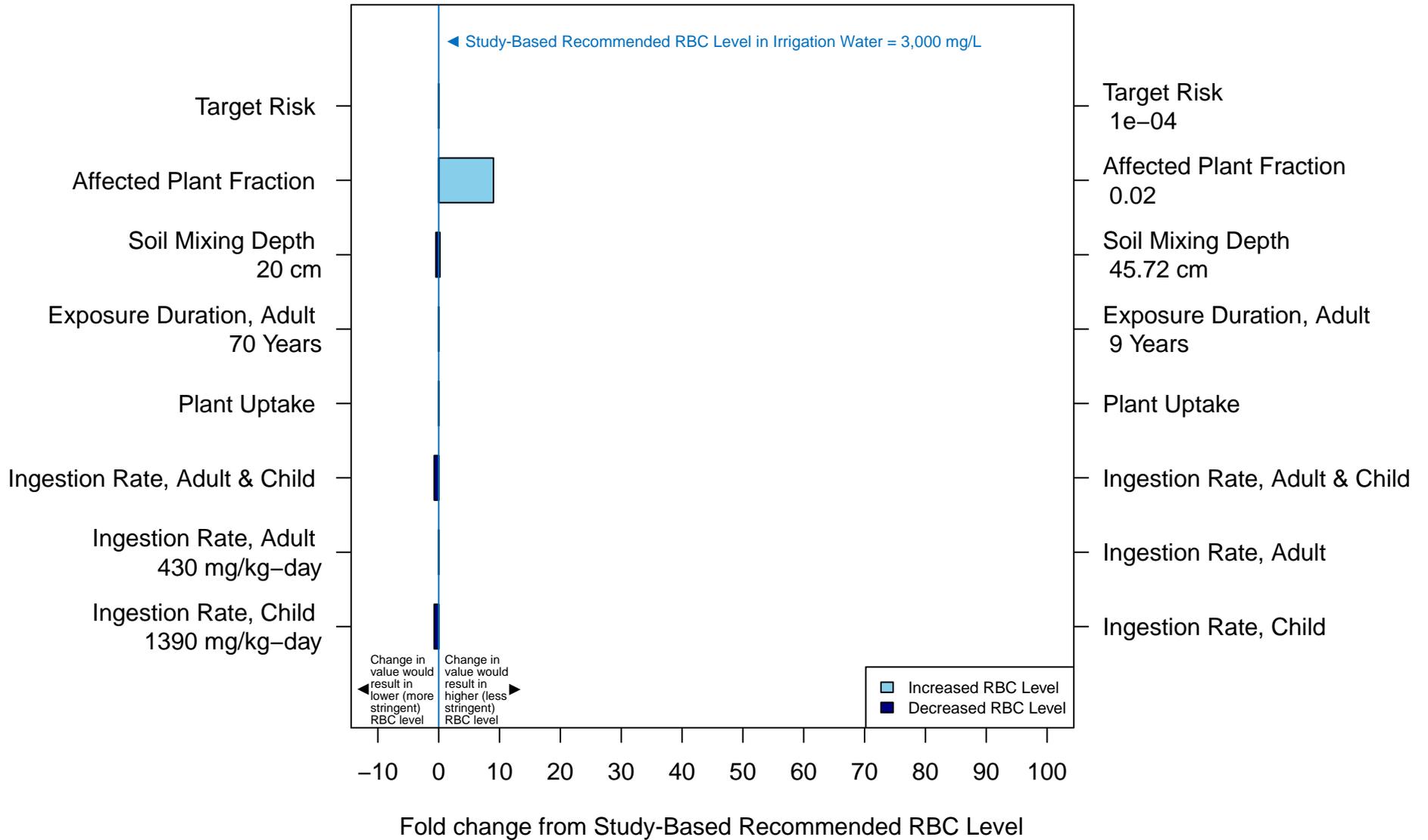


FIGURE C-62

Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Citrus

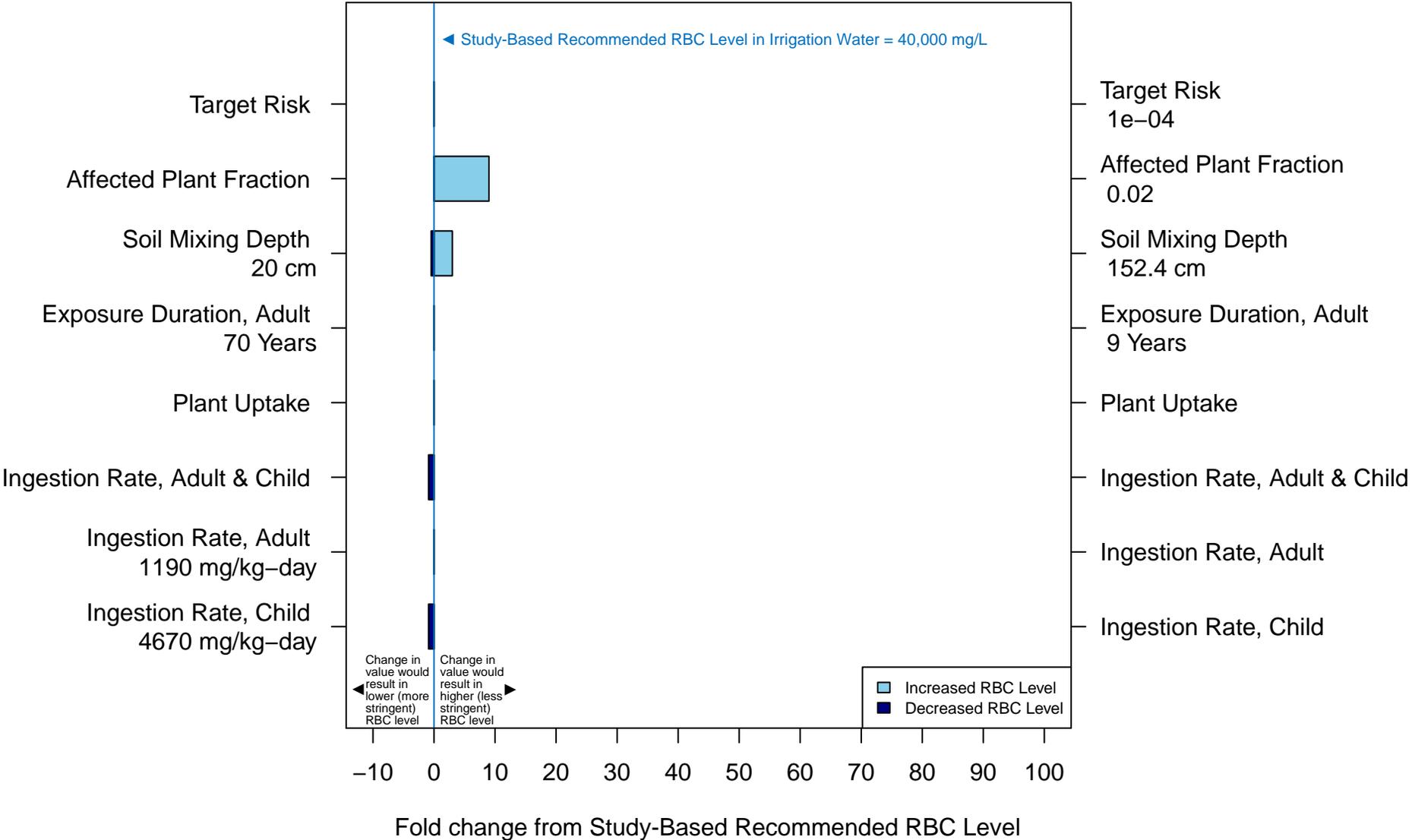
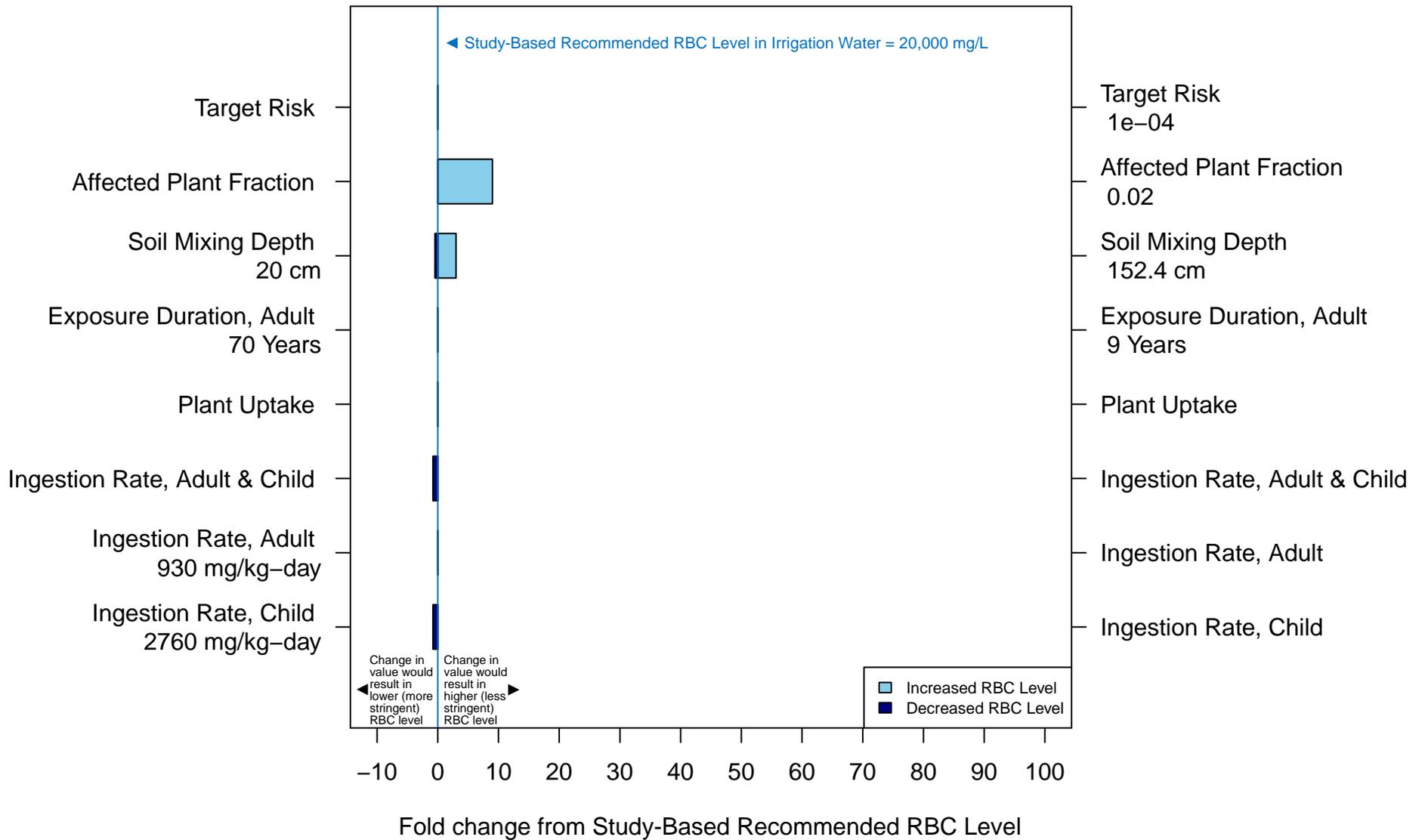


FIGURE C-63

Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Grapes



**FIGURE C-64**

**Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Potatoes**

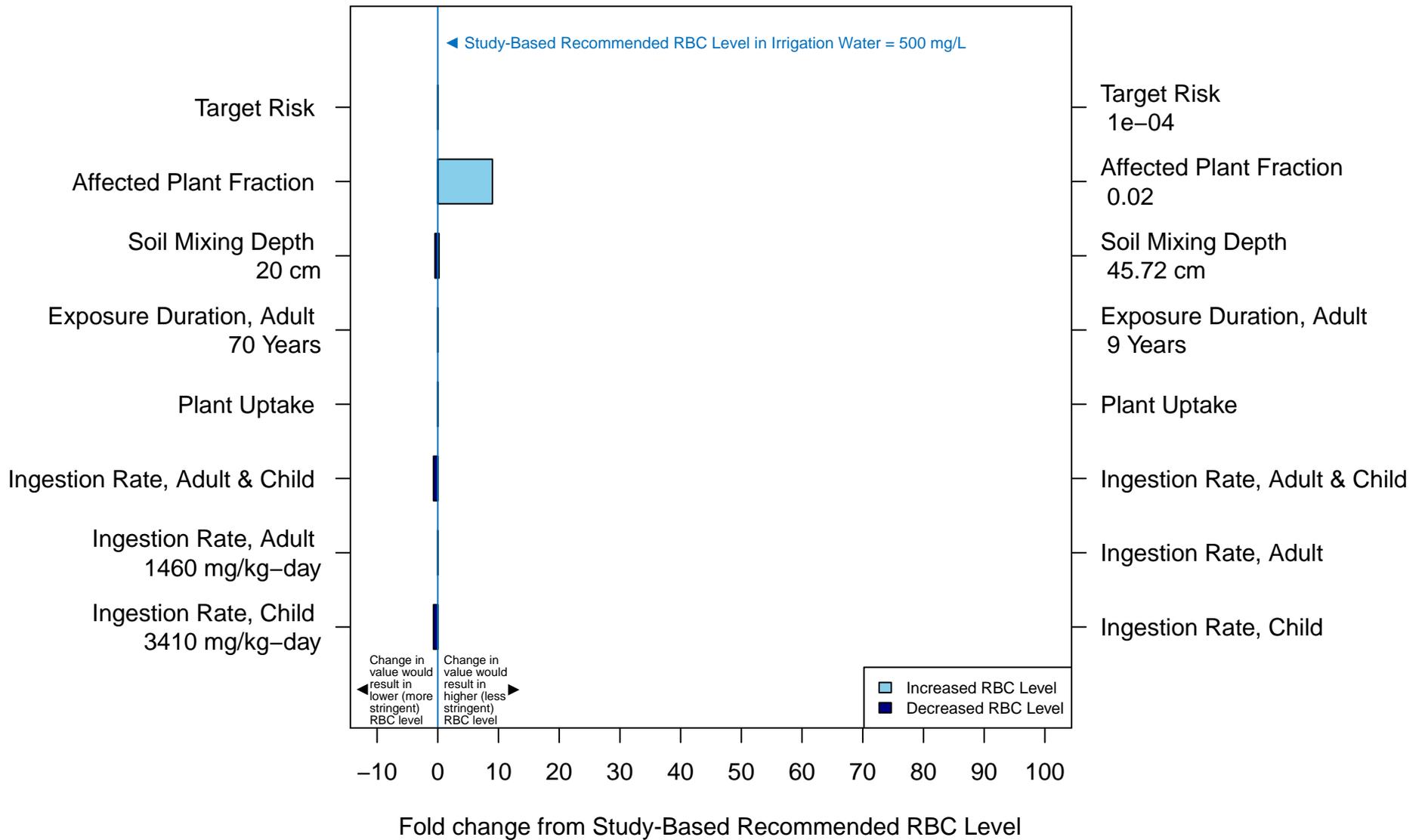
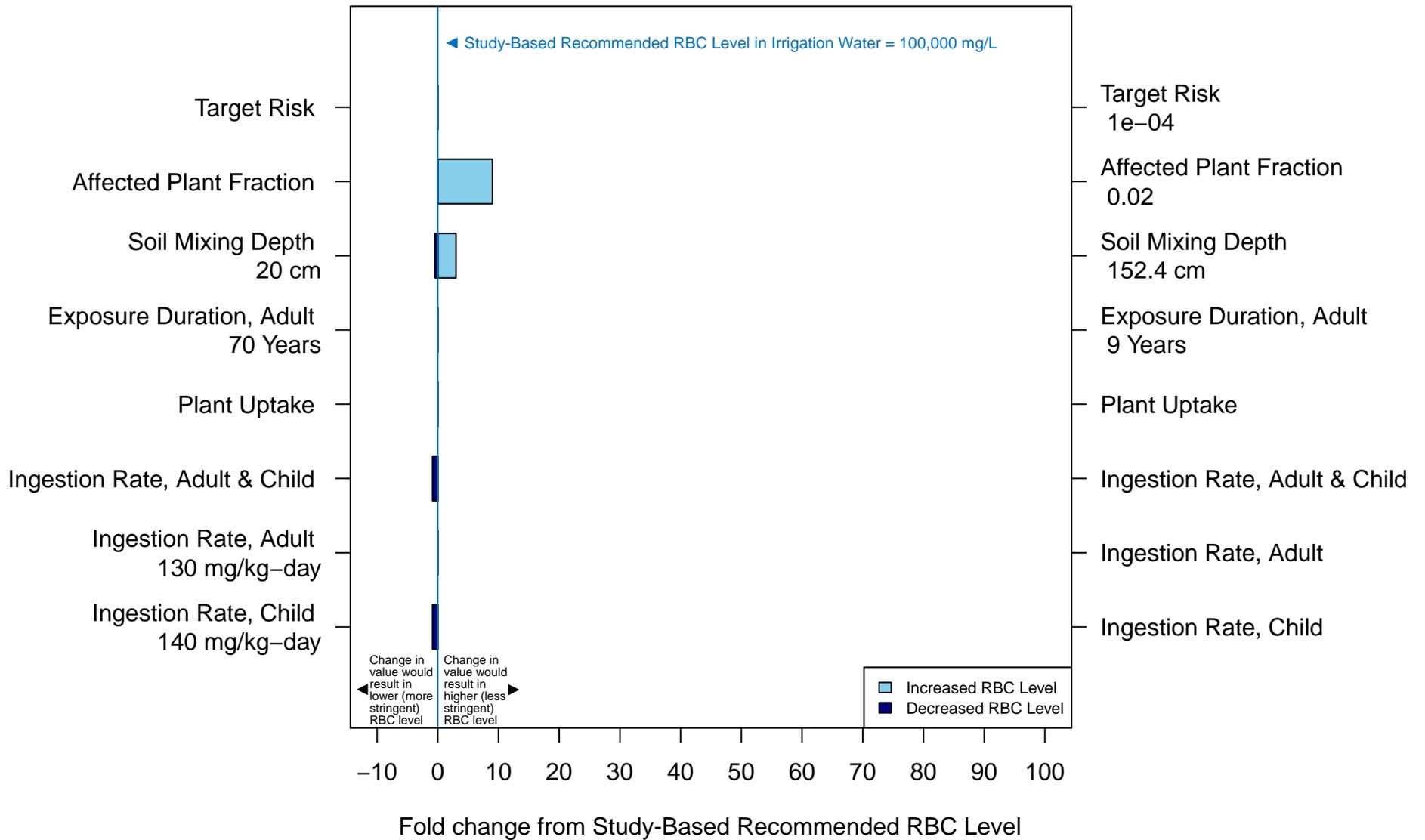


FIGURE C-65

Sensitivity of Recommended RBC Level of Toluene in Irrigation Water Applied for Tree Nuts



**FIGURE C-66**

**Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Carrots**

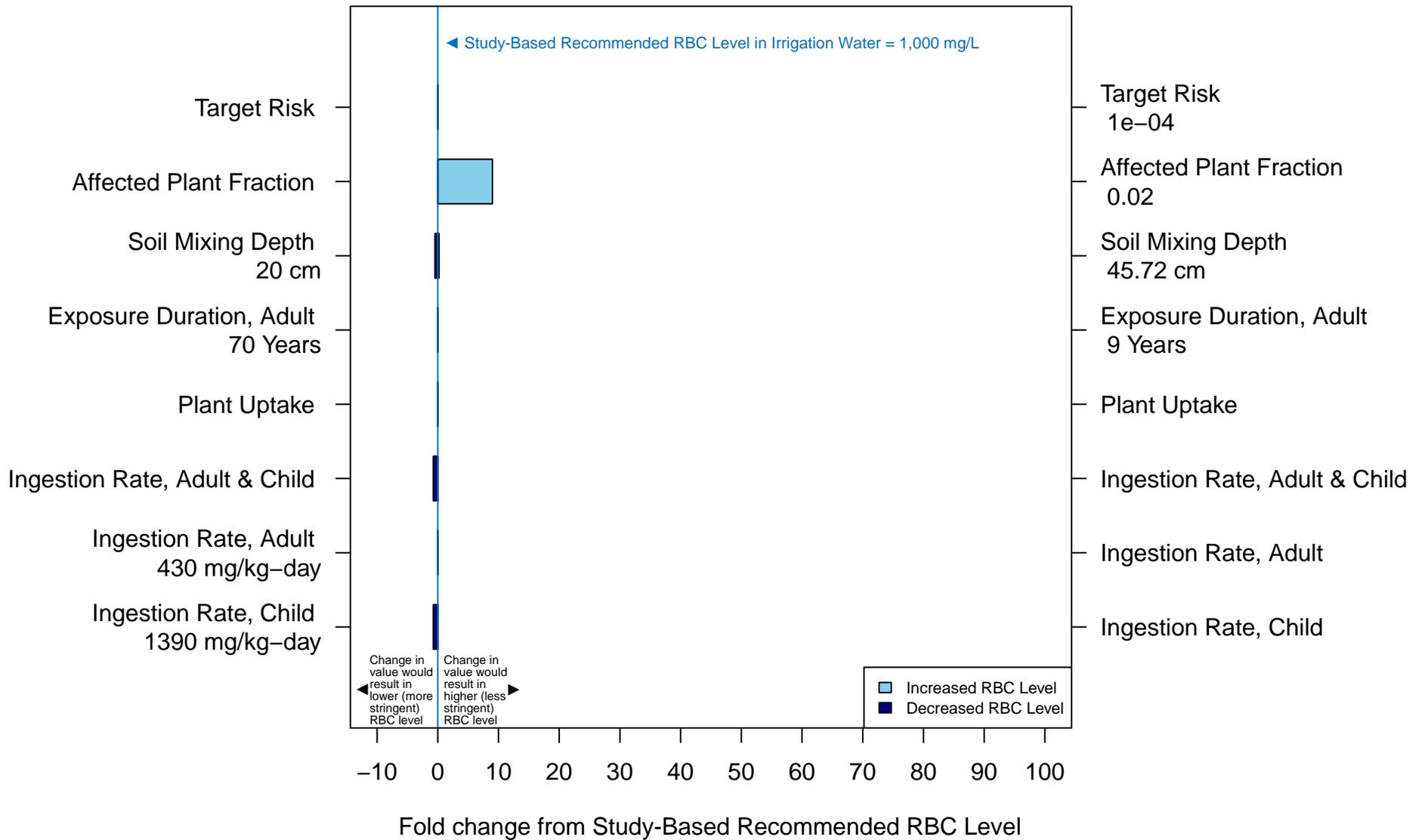


FIGURE C-67

Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Citrus

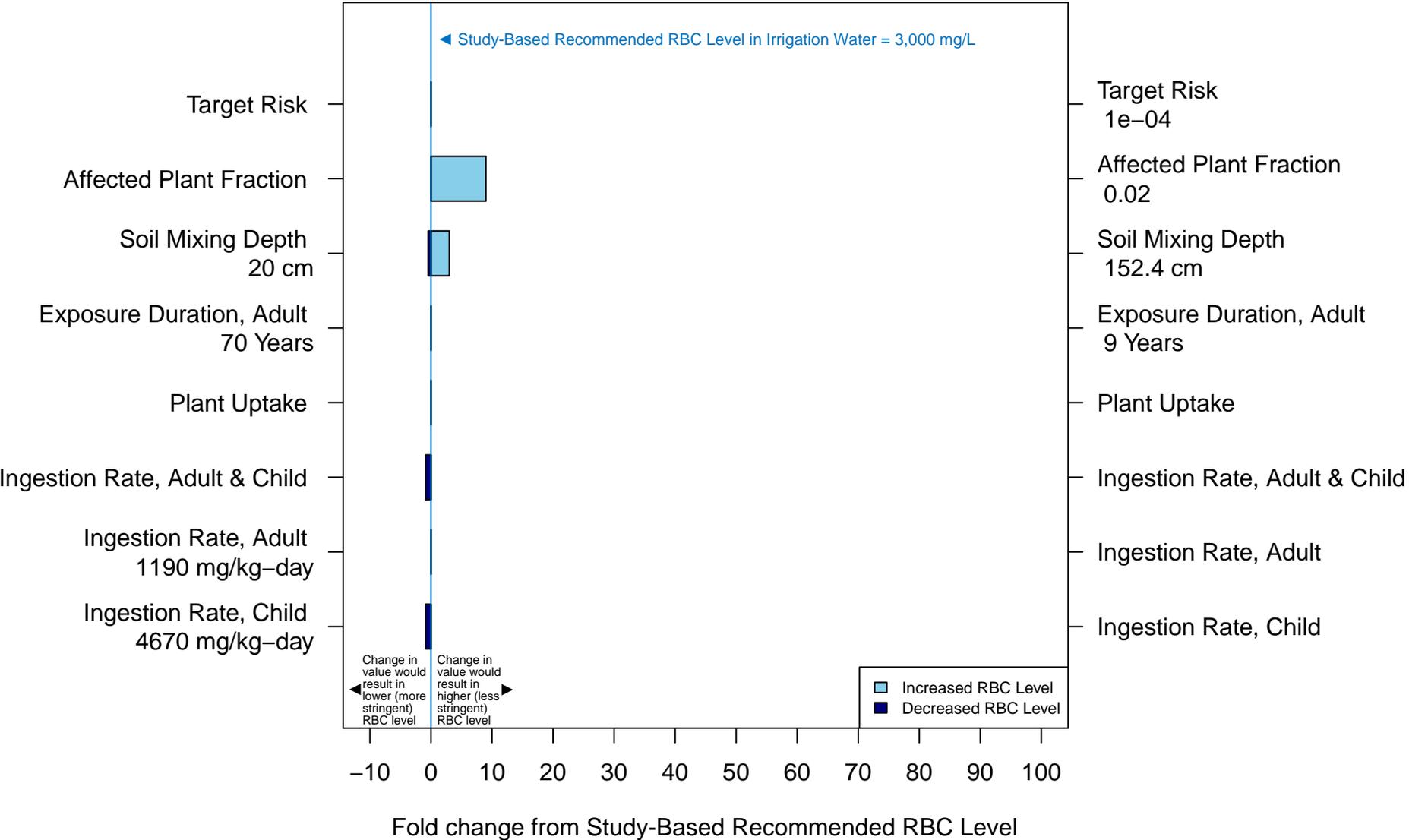


FIGURE C-68

Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Grapes

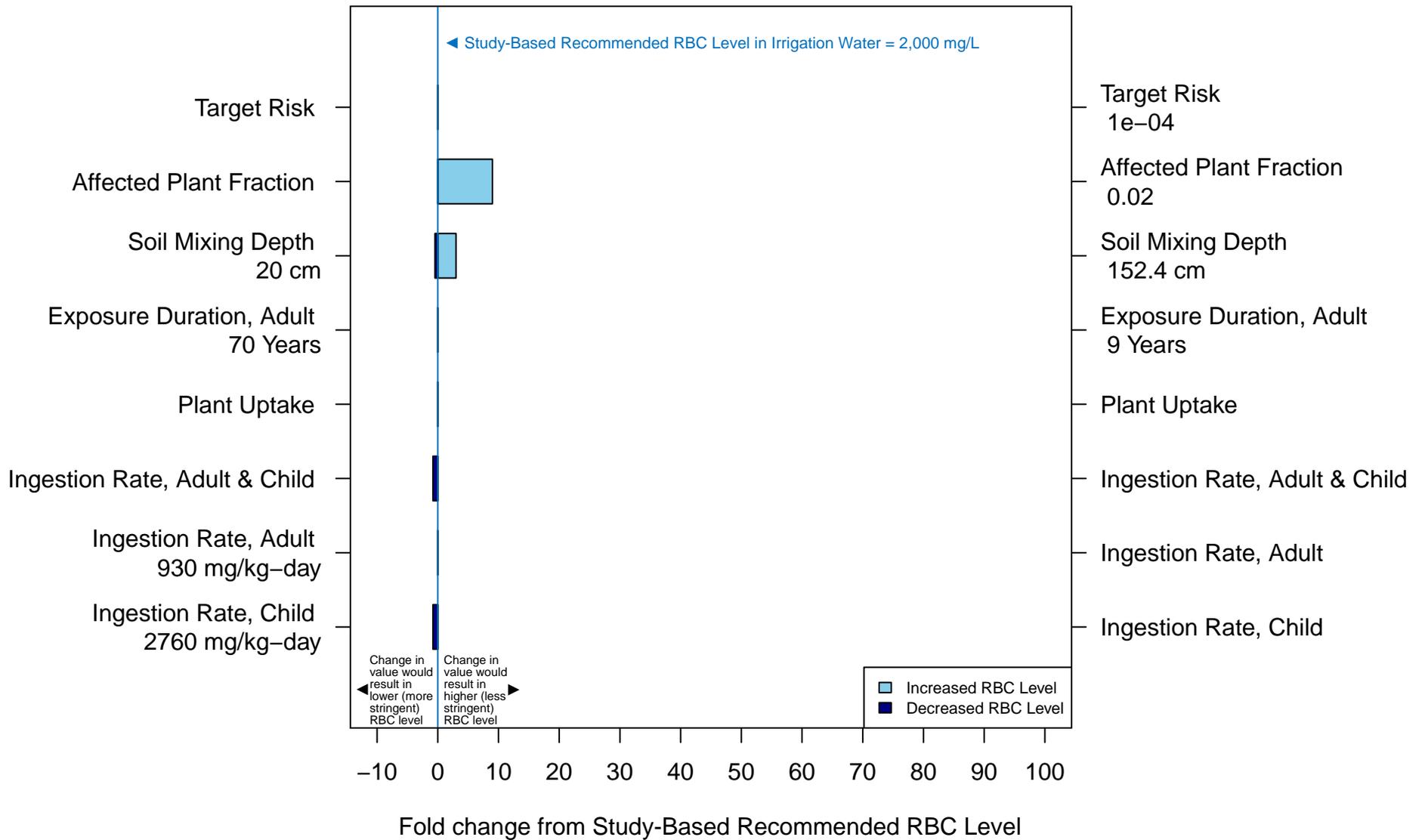


FIGURE C-69

Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Potatoes

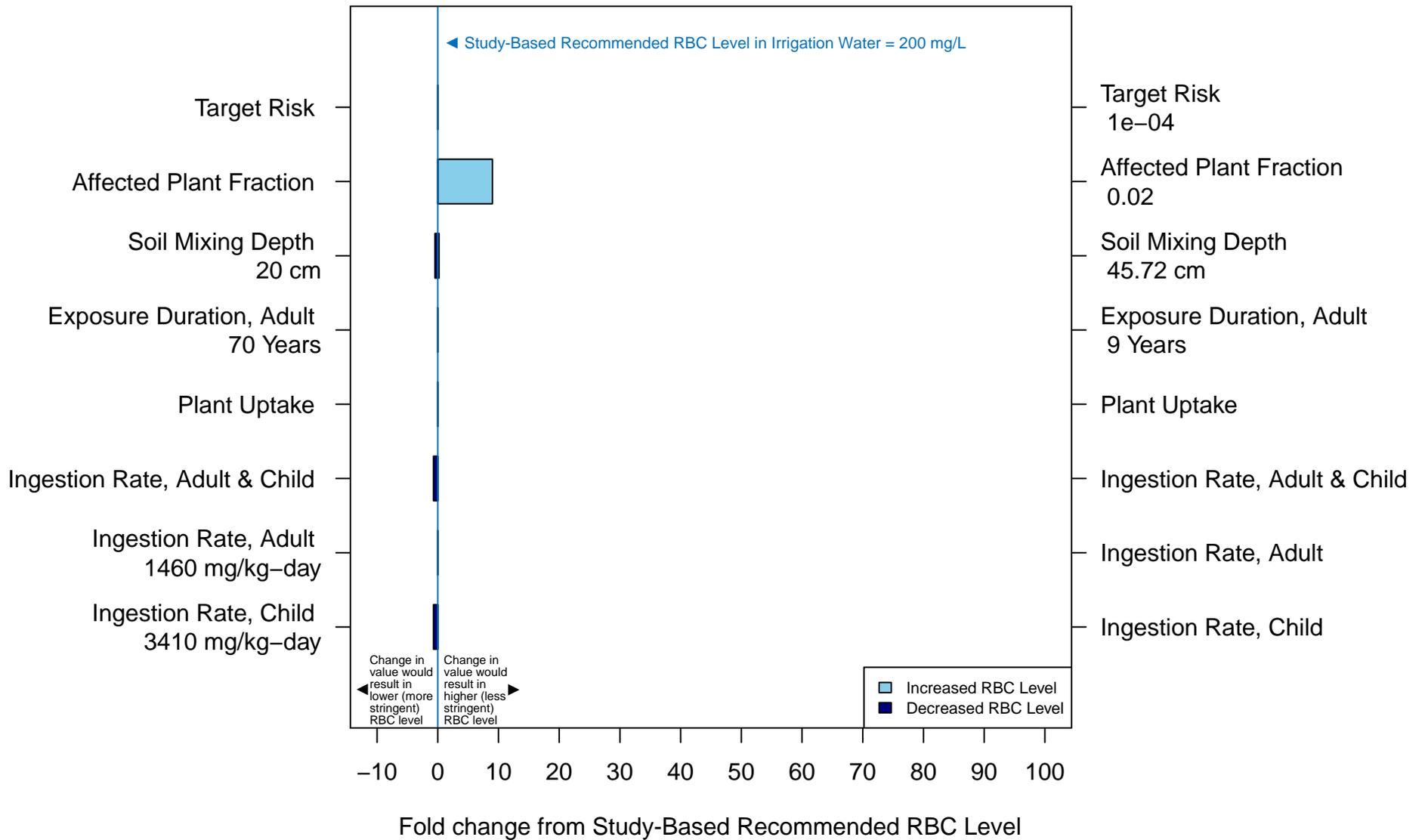


FIGURE C-70

Sensitivity of Recommended RBC Level of TPH-Crude in Irrigation Water Applied for Tree Nuts

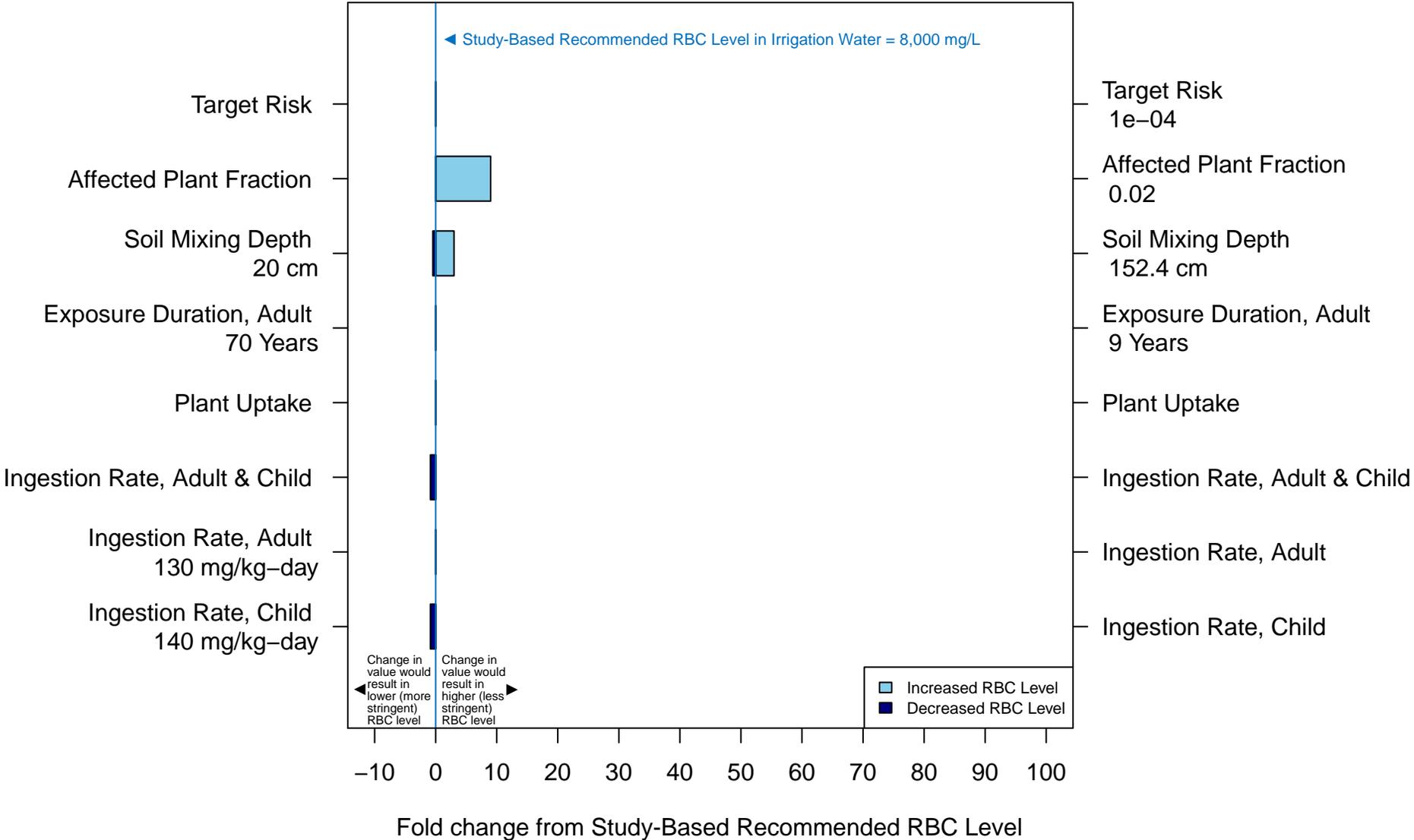


FIGURE C-71

Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Carrots

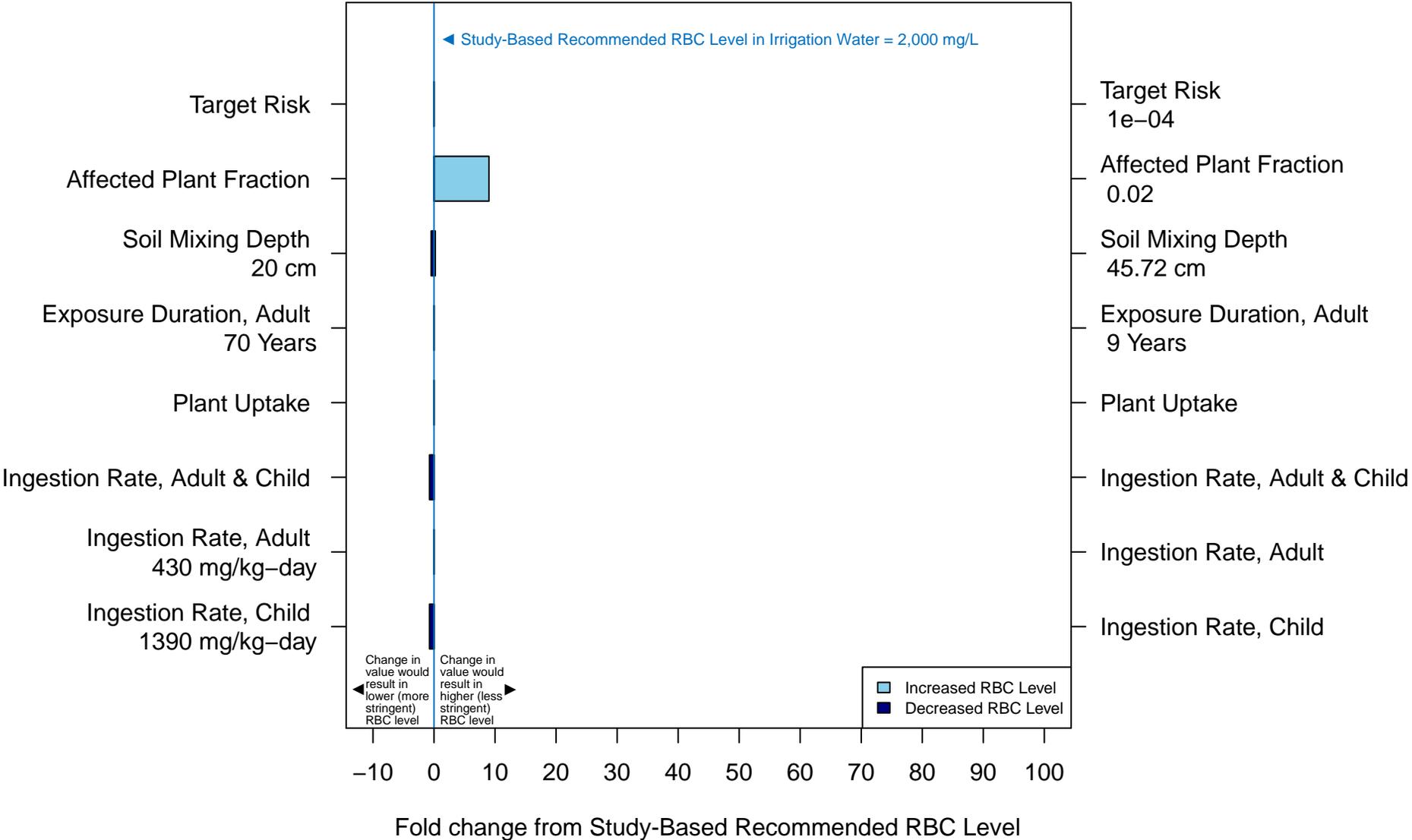


FIGURE C-72

Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Citrus

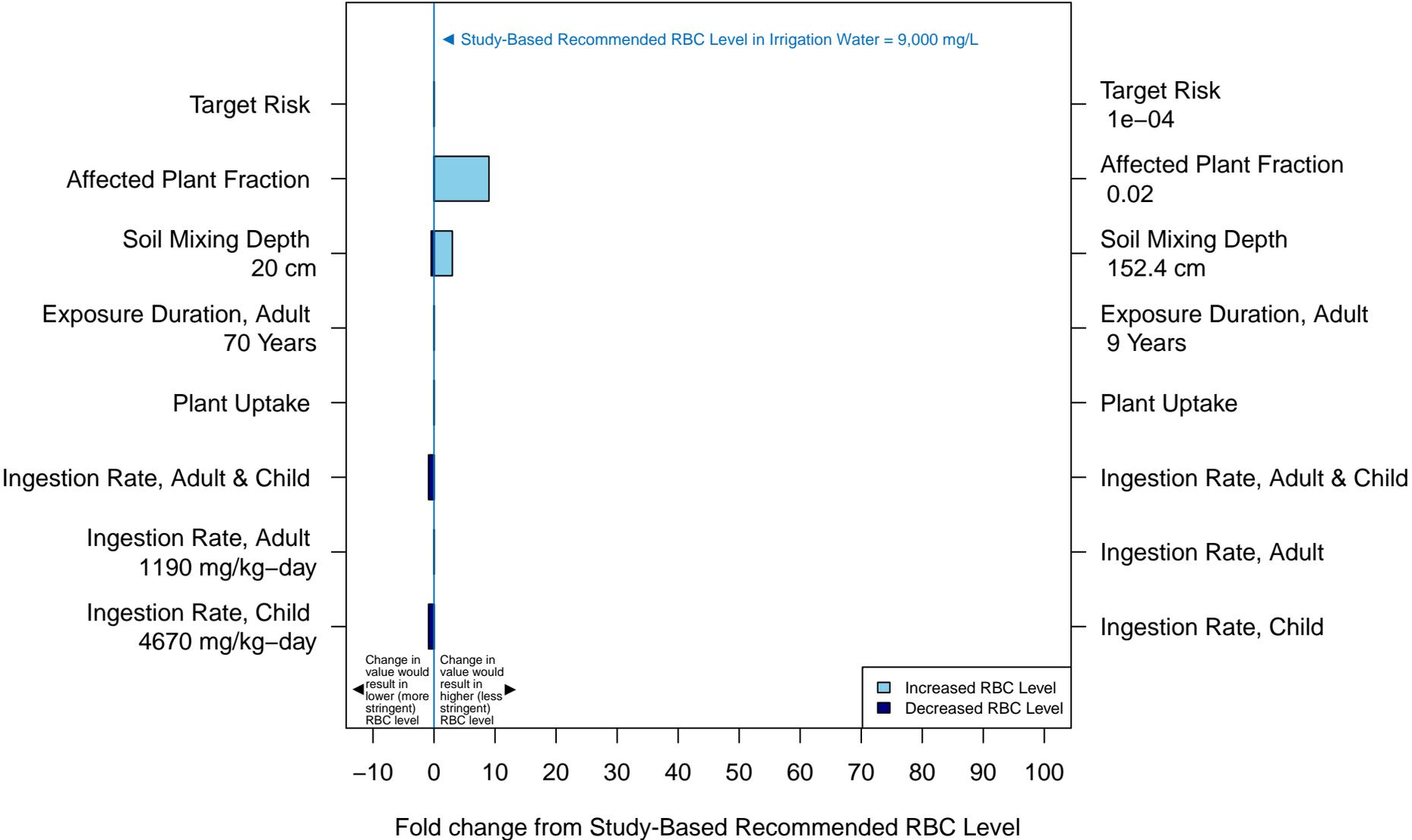
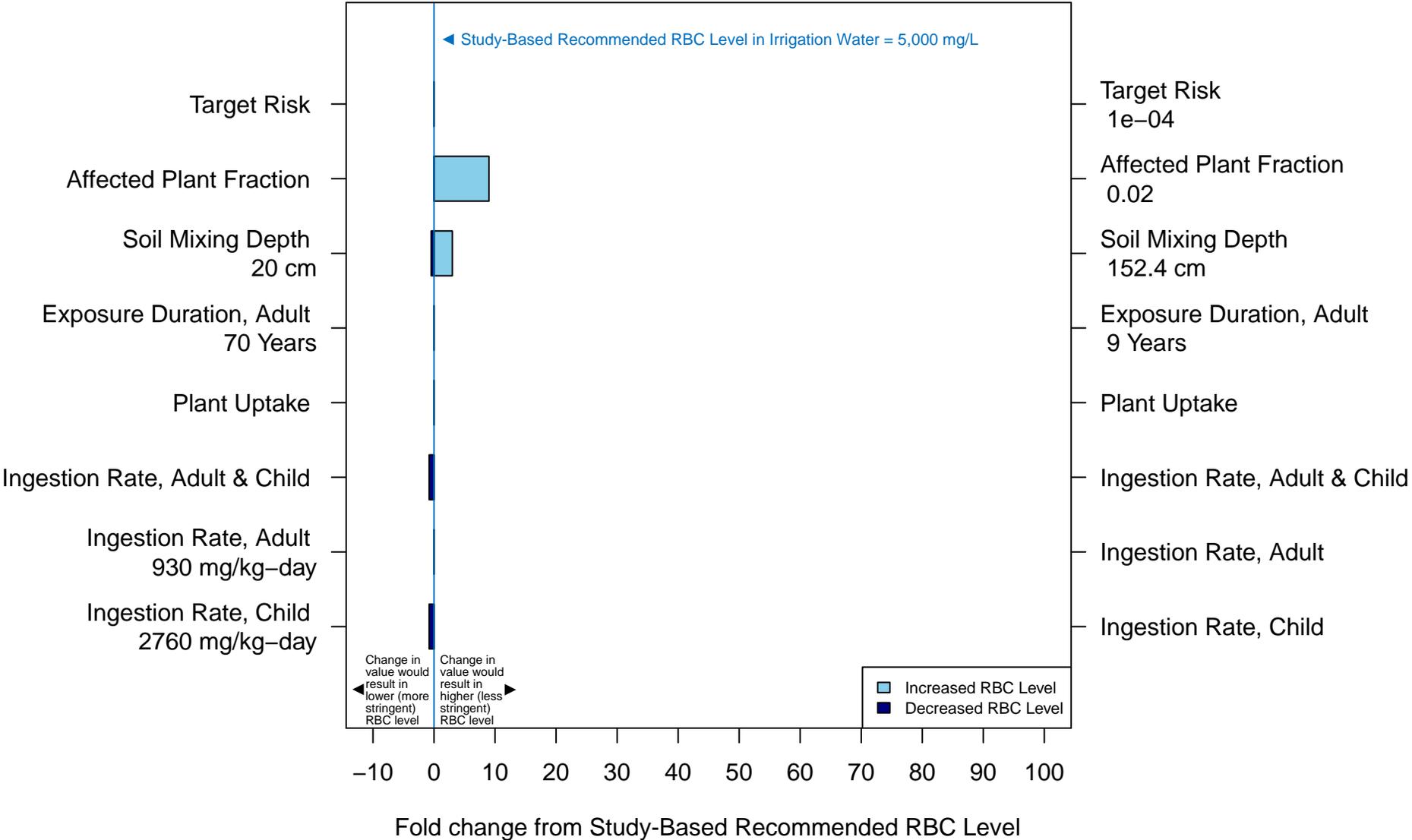


FIGURE C-73

Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Grapes



**FIGURE C-74**

**Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Potatoes**

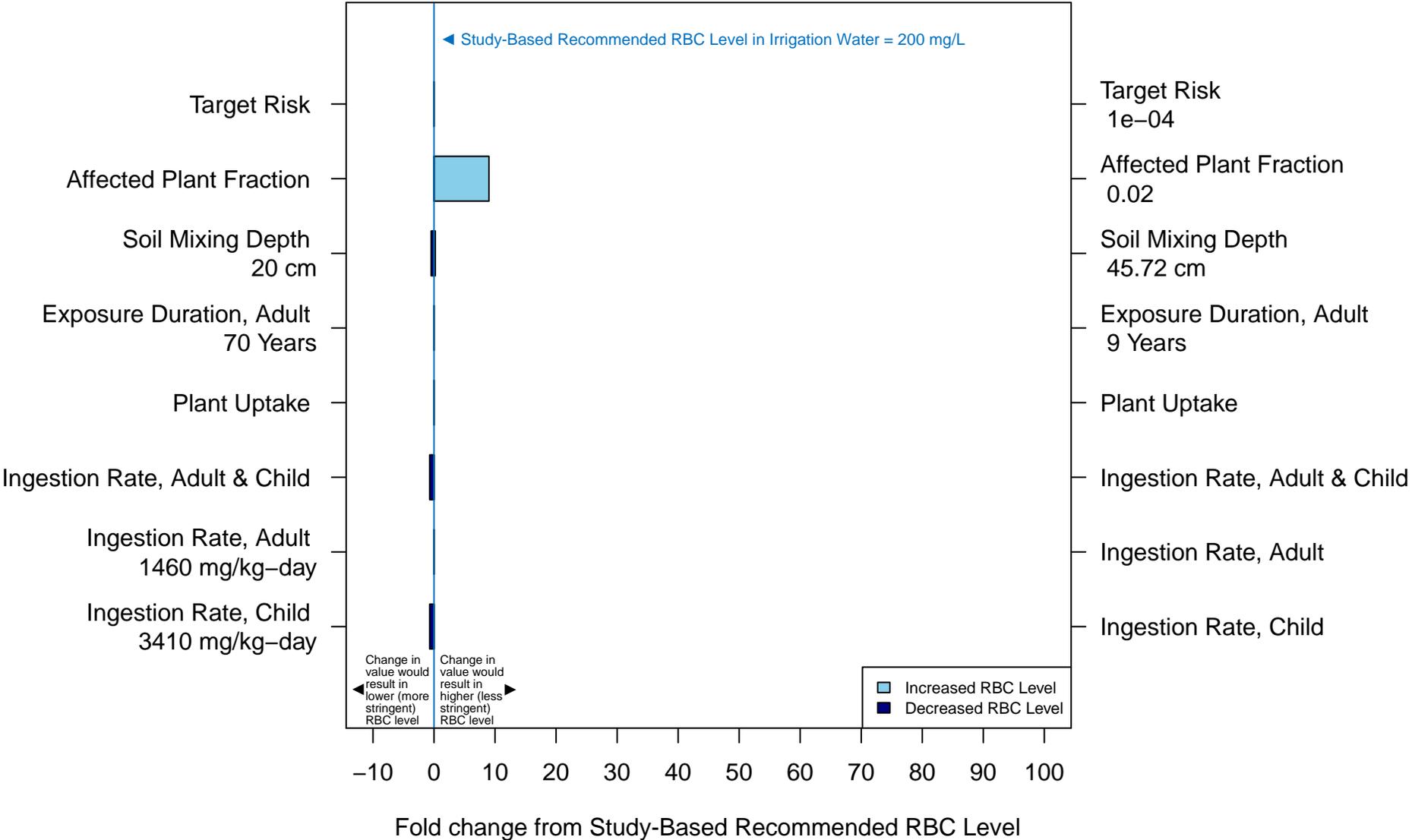
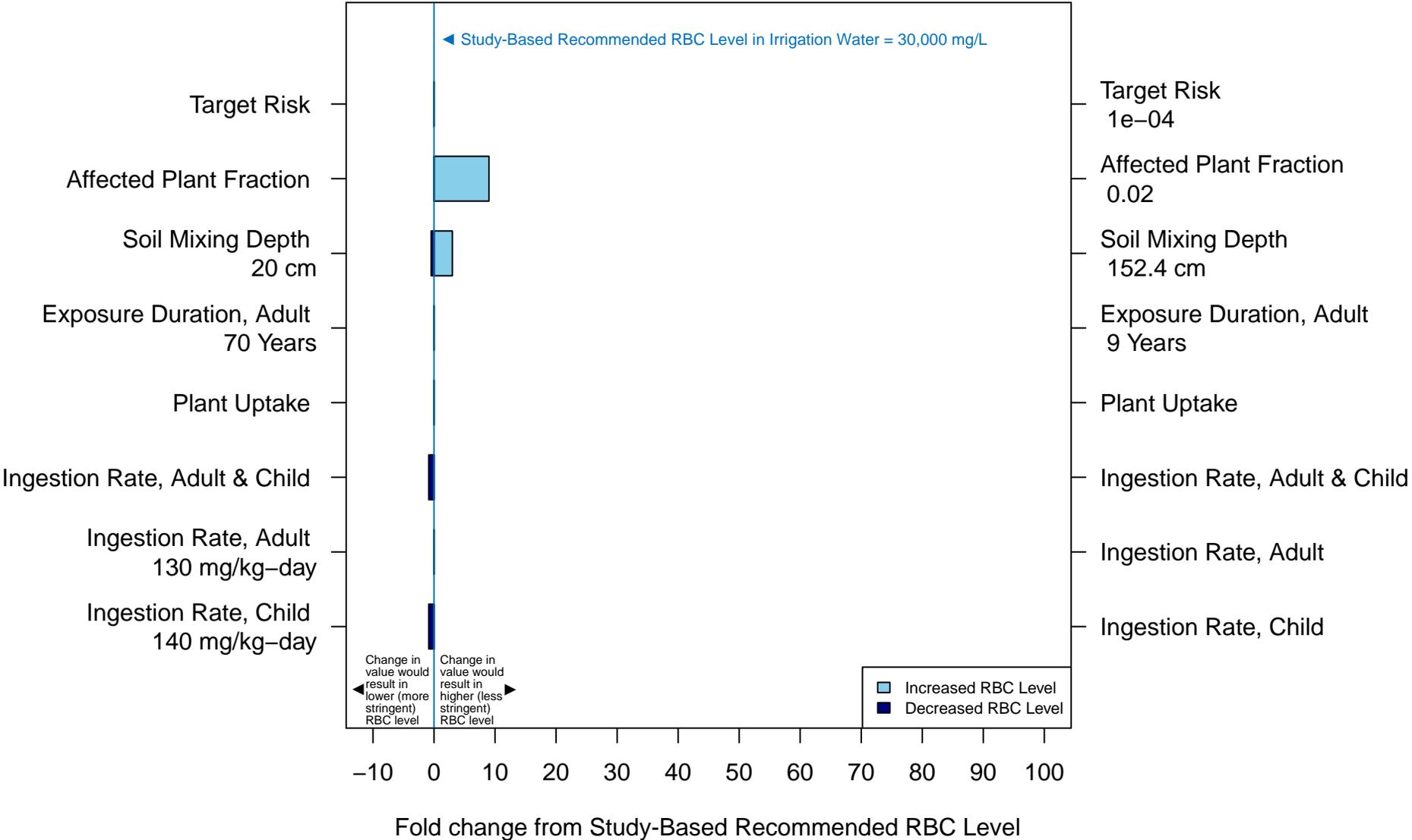


FIGURE C-75

Sensitivity of Recommended RBC Level of 1,3,5-Trimethylbenzene in Irrigation Water Applied for Tree Nuts



**FIGURE C-76**

**Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Carrots**

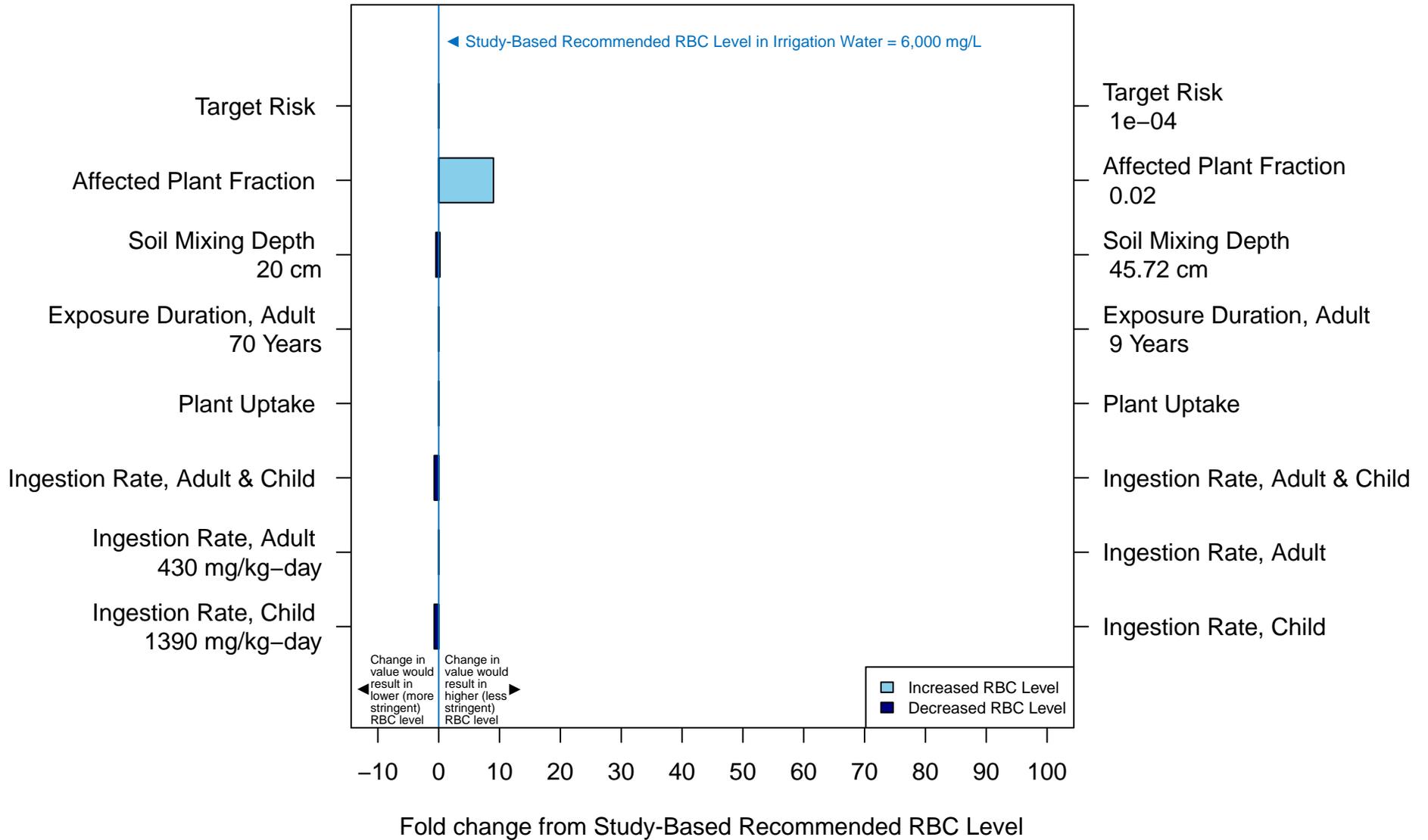


FIGURE C-77

Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Citrus

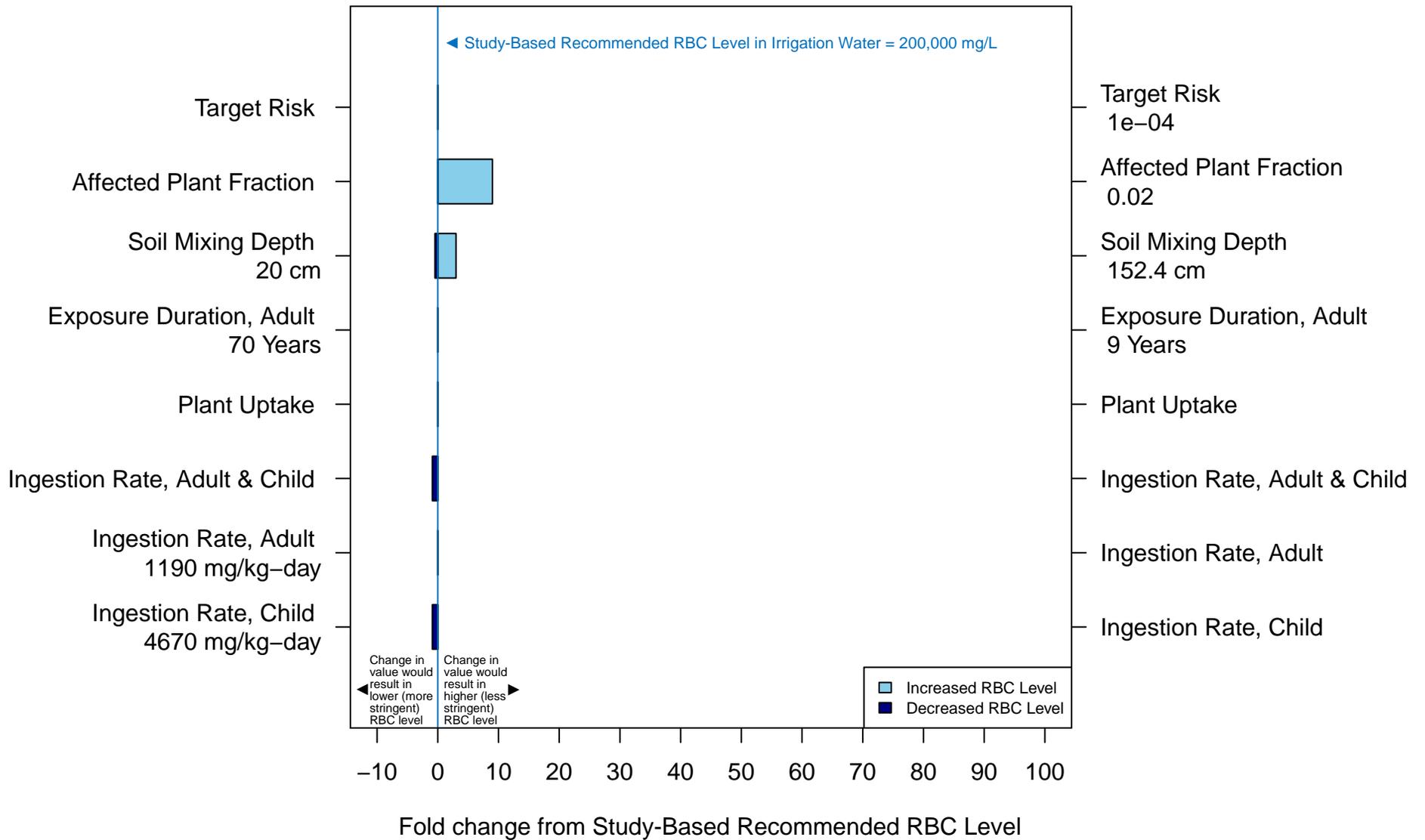


FIGURE C-78

Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Grapes

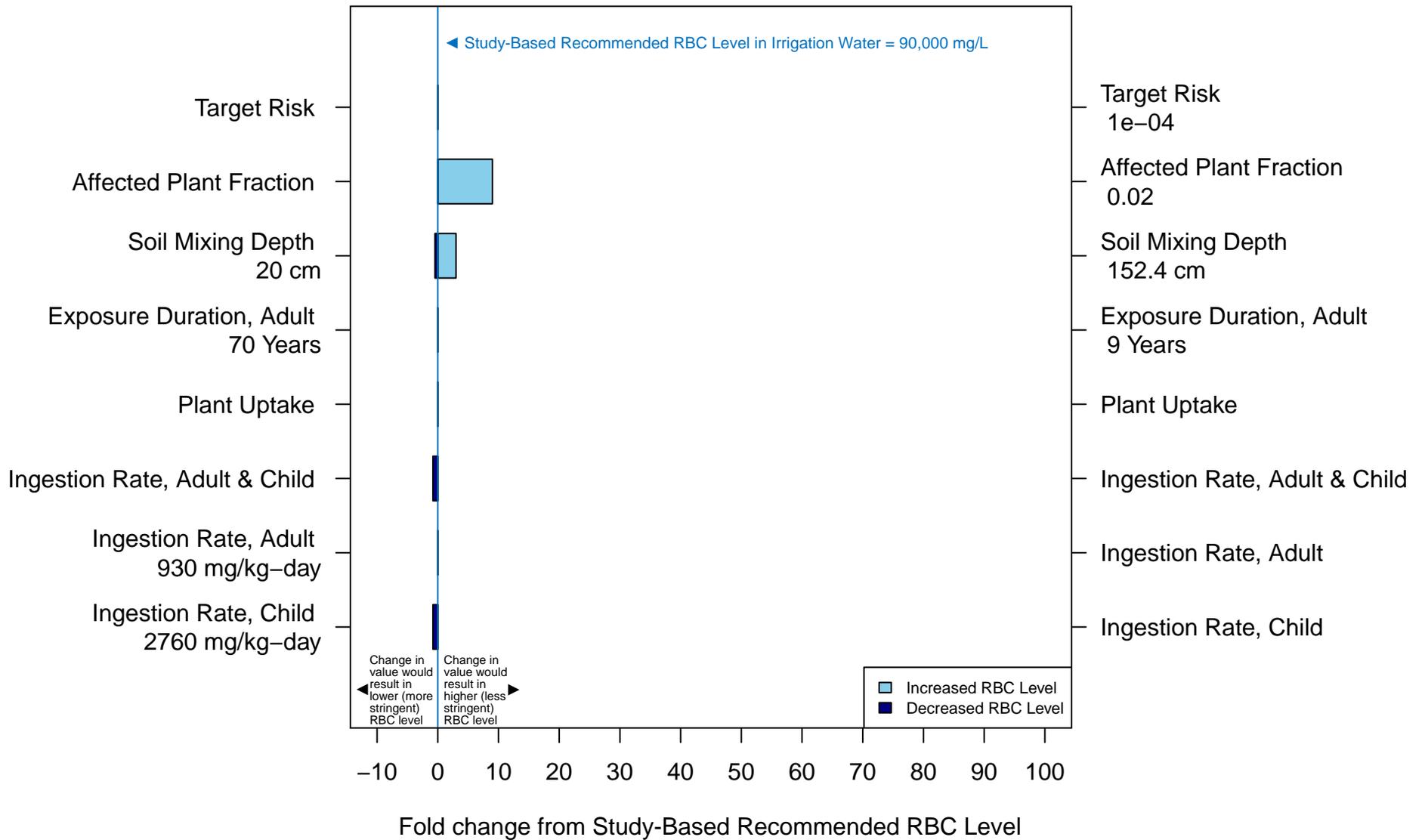


FIGURE C-79

Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Potatoes

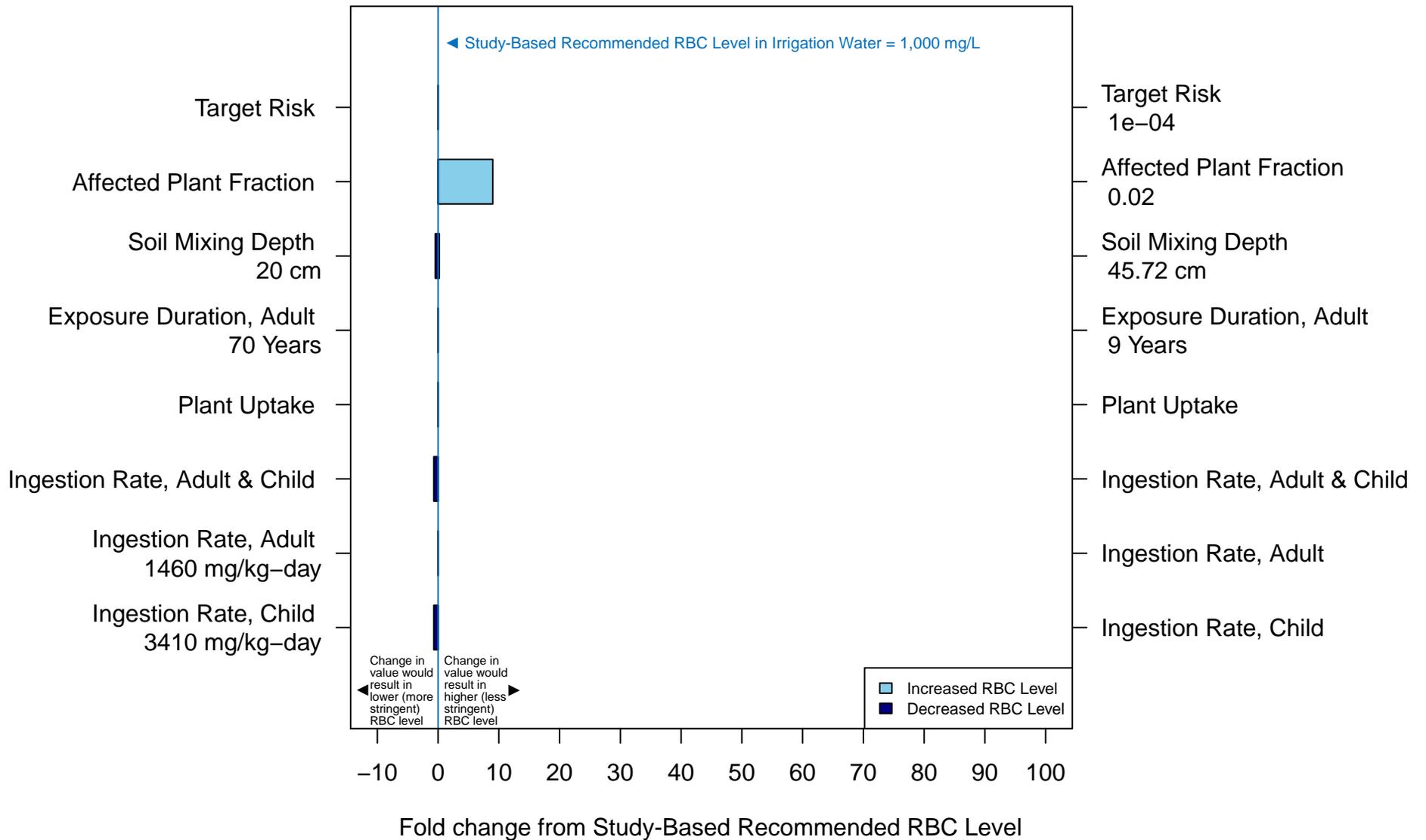


FIGURE C-80

Sensitivity of Recommended RBC Level of Xylenes in Irrigation Water Applied for Tree Nuts

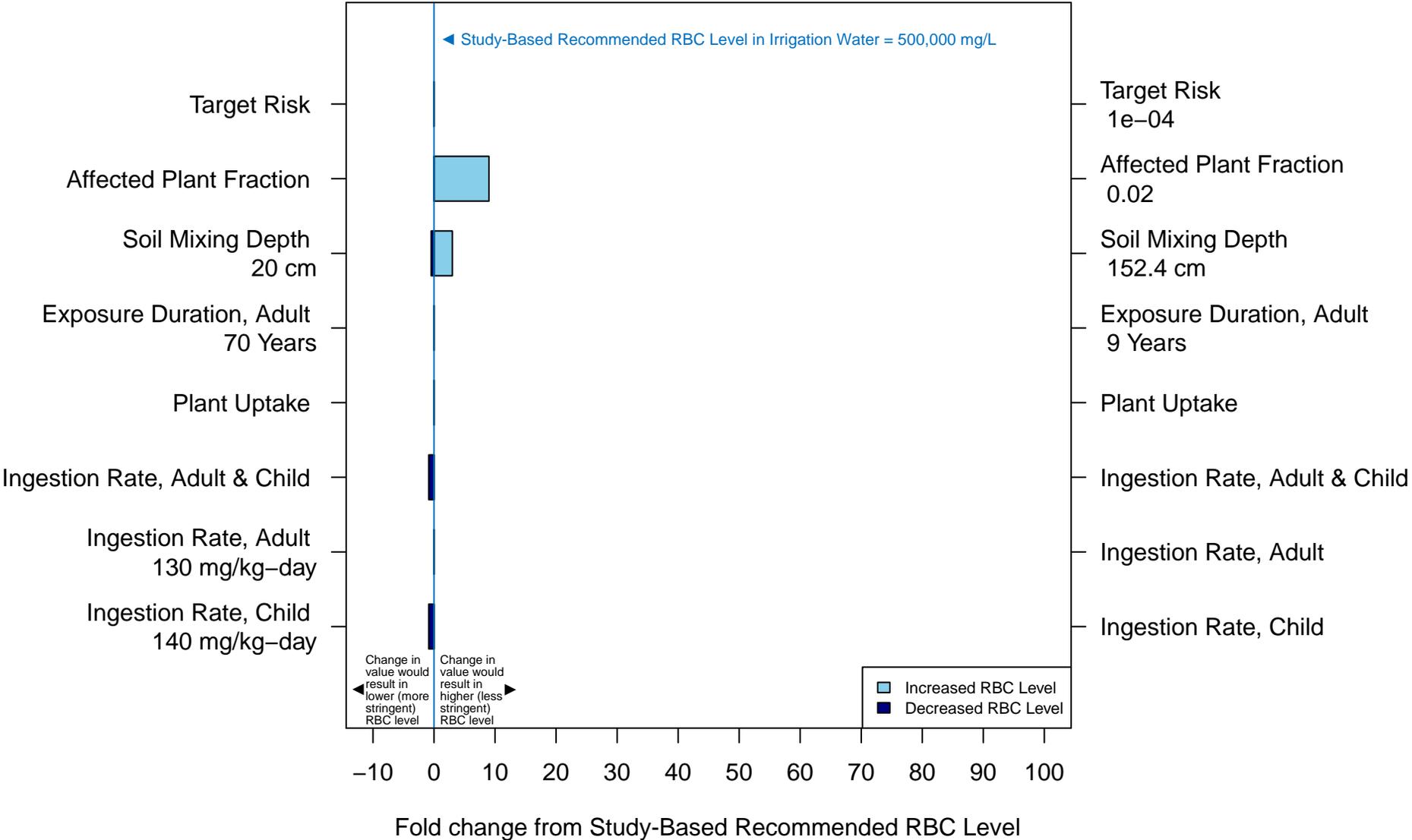
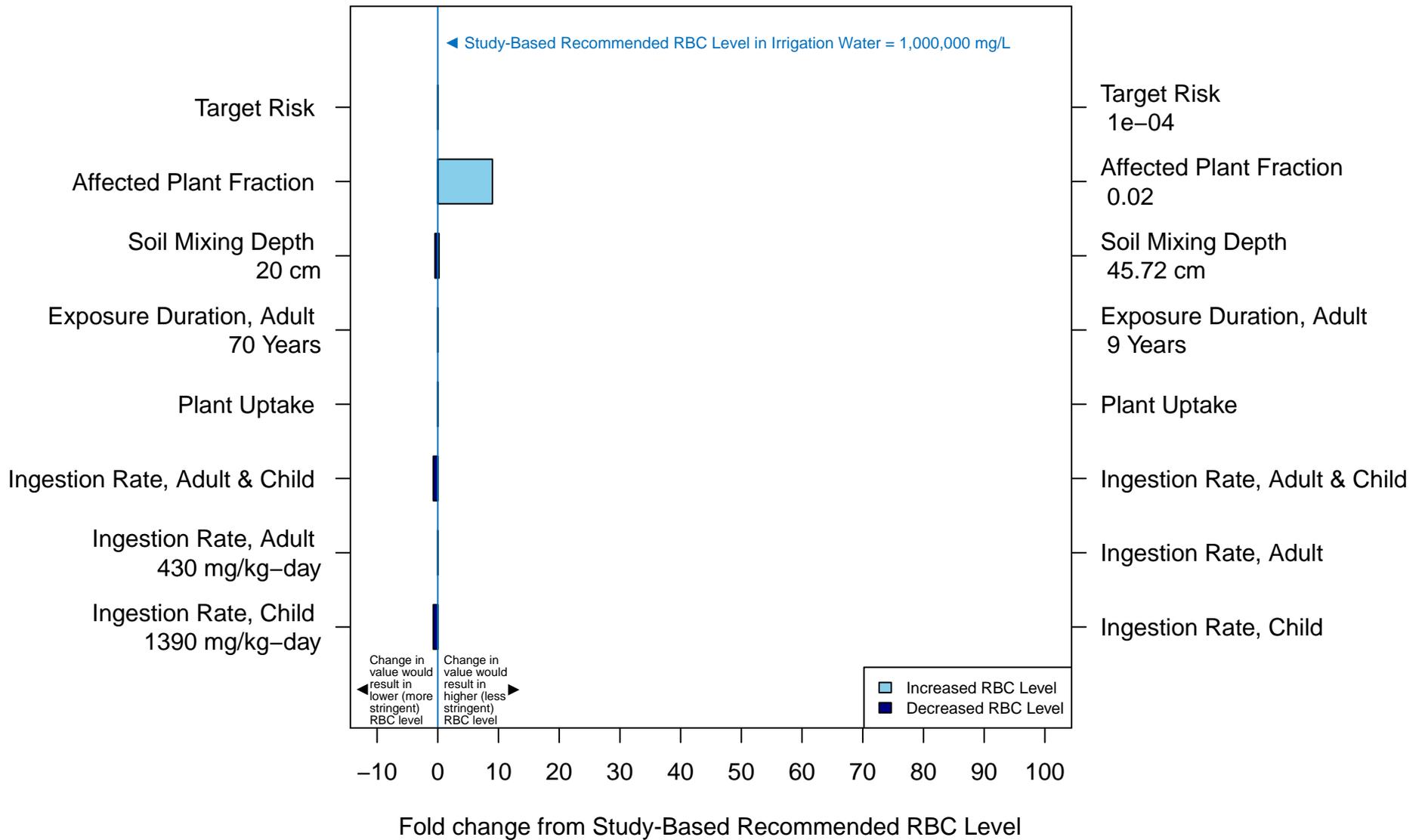


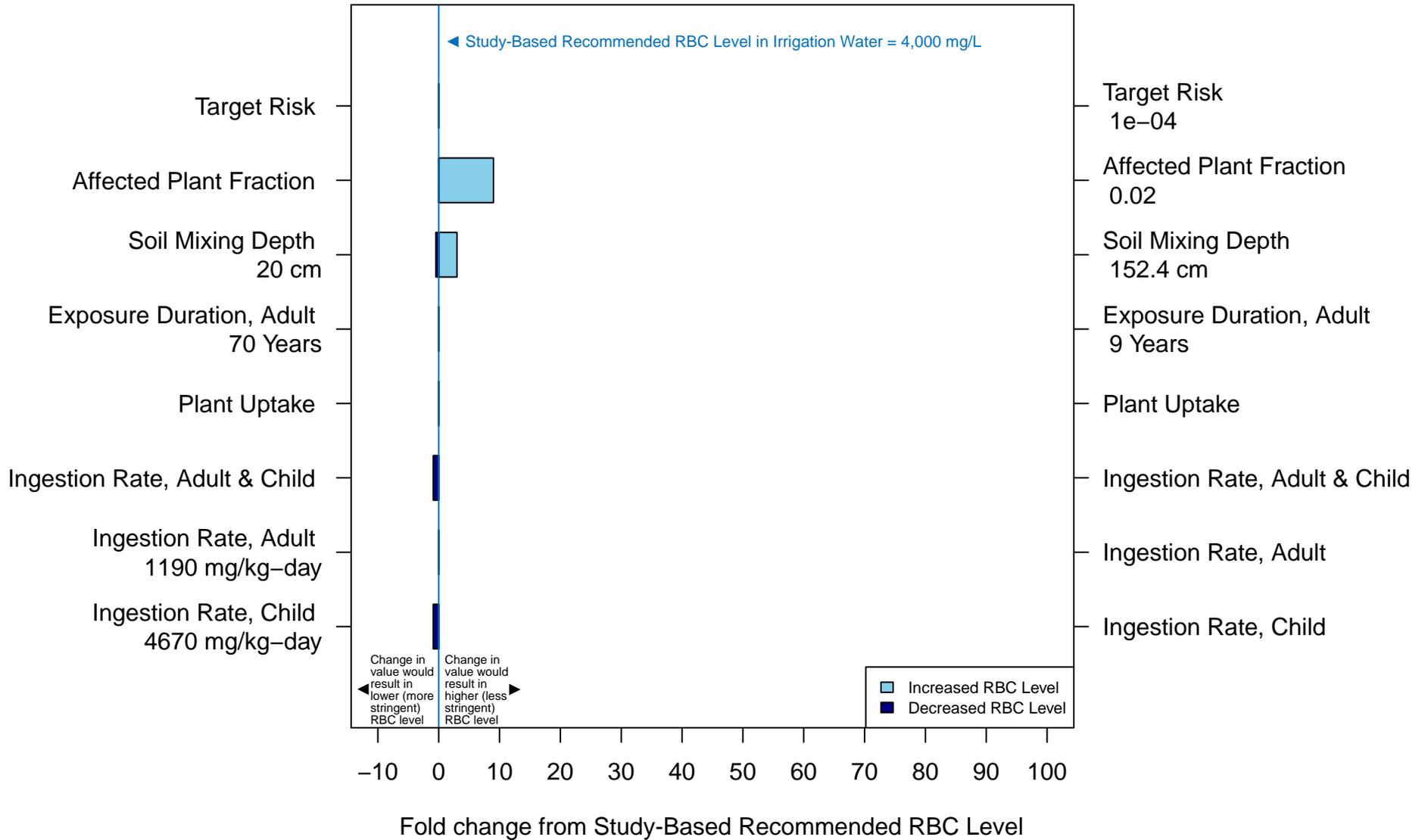
FIGURE C-81

Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Carrots



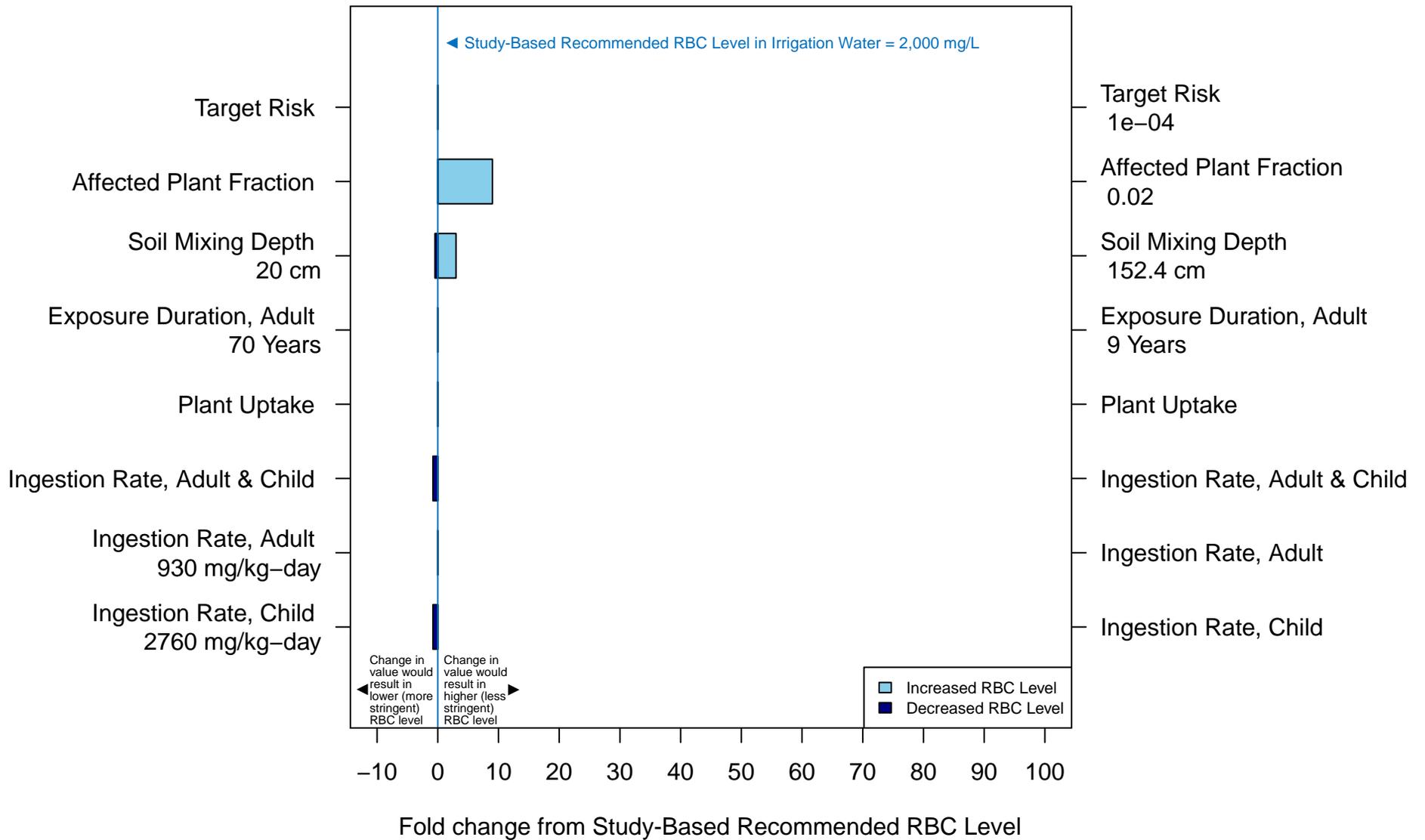
**FIGURE C-82**

**Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Citrus**



**FIGURE C-83**

**Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Grapes**



**FIGURE C-84**

**Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Potatoes**

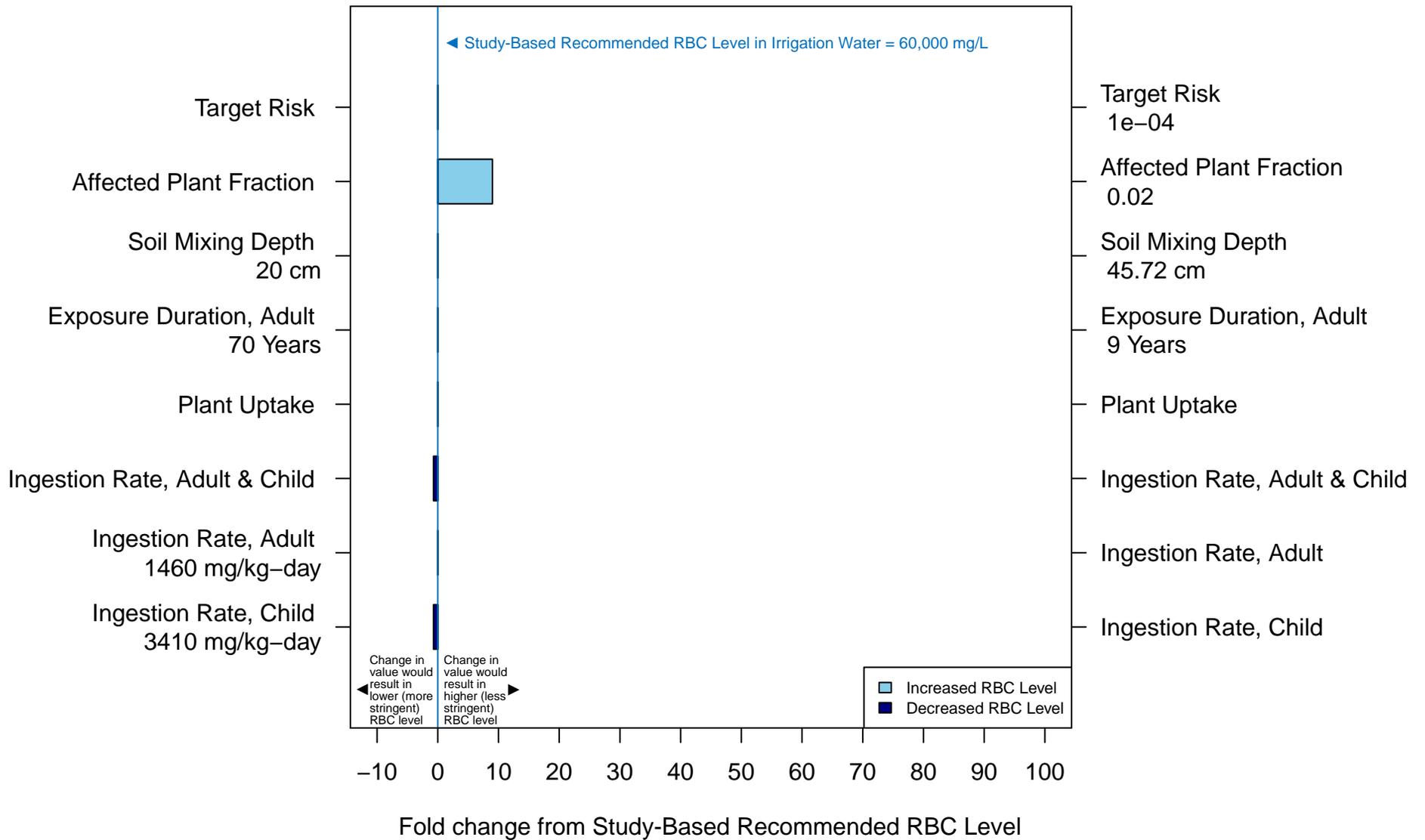


FIGURE C-85

Sensitivity of Recommended RBC Level of Zinc in Irrigation Water Applied for Tree Nuts

