Washington State Department of
Labor & Industries

Final Cost-Benefit Analysis & Significant Legislative Rule Analysis

Chapter 296-62 WAC, General Occupational Health Standards, Part J-1
WAC 296-62-095, Outdoor Heat Exposure
Chapter 296-307 WAC, Safety Standards for Agriculture, Part G-1
WAC 295-307-097, Outdoor Heat Exposure

Contact: Kerwin Julien (Kerwin.Julien@Lni.wa.gov)
Research and Data Services

Contact: Teri Neely (Teri.Neely@Lni.wa.gov)
DOSH Standards and Technical Services
Washington State Department of Labor & Industries

June 2023

Table of Contents

Chapter 1: Background

1.1 Requirements of the Administrative Procedure Act (APA)

The Administrative Procedure Act (APA; Chapter 34.05 RCW) requires that, before adopting a significant legislative rule, the Department of Labor & Industries (L&I) must analyze the probable costs and benefits of the rule, and determine that the "benefits are greater than its probable costs, taking into account both the qualitative and quantitative benefits and costs." [RCW 34.05.328(1)(d)] .

Under certain circumstances, a rule or rule component is exempt from this requirement. These exemption criteria are listed in RCW 34.05.328(5)(b) including:

- Emergency rules adopted under RCW 34.05.350;
- Rules relating only to internal governmental operations that are not subject to violation by a nongovernment party;
- Rules adopting or incorporating by reference without material change federal statutes or regulations, Washington state statutes, rules of other Washington state agencies, shoreline master programs other than those programs governing shorelines of statewide significance, or, as referenced by Washington state law, national consensus codes that generally establish industry standards, if the material adopted or incorporated regulates the same subject matter and conduct as the adopting or incorporating rule;
- Rules that only correct typographical errors, make address or name changes, or clarify language of a rule without changing its effect;
- Rules the content of which is explicitly and specifically dictated by statute;
- Rules that set or adjust fees under the authority of RCW 19.02.075 or that set or adjust fees or rates pursuant to legislative standards, including fees set or adjusted under the authority of RCW 19.80.045.

This cost-benefit analysis has been prepared in compliance with the APA for the requirements in the chapter 296-62 WAC and chapter 296-307 WAC, Part G-1 that do not fall under the exemptions described above.

1.2 Introduction & Background of This Rulemaking

1.2.1 Legal Authority

The Washington State Constitution mandates that "[t]he legislature shall pass laws for the protection of persons working in mines, factories, and other employments dangerous to life or deleterious to health." In enacting ch. 49.17 RCW, Washington Industrial Safety and Health Act (WISHA), the Washington Legislature found "that personal injuries and illnesses arising out of conditions of employment impose a substantial burden upon employers and employees in terms of lost production, wage loss, medical expenses, and payment of benefits under the industrial insurance act. Therefore, in the public interest for welfare of the people of the state of Washington and in order to assure, insofar as may be reasonably possible, safe and healthful working conditions for every man and woman working in the state of Washington, the legislature…in keeping with the mandates of Article II, section 35 of the state Constitution, declares its purpose by the provisions of this chapter to create, maintain, continue, and enhance the industrial safety and health program of the state…"

WISHA mandates that the Director of L&I shall "[p]rovide for the promulgation of health and safety standards and the control of conditions in all work places concerning…harmful physical agents which shall set a standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity."

In *Rios v. Dept. of L&I*[1], the Washington Supreme Court concluded that L&I must consider rulemaking for recognized work place hazards.

1.2.2 Health Effects of Outdoor Heat Exposure

There are multiple effects of heat exposure on the health of workers. Individuals working under heat stress can experience heat strain and heat-related illnesses, which include heat stroke, heat exhaustion, heat syncope (fainting), rhabdomyolysis, and heat cramps (NIOSH 2016). Heat stroke is a failure to maintain a normal core body temperature and is characterized by elevated body temperature greater than 40°C (104°F). Heat stroke can cause death even in workers who are young and otherwise healthy (Gubernot 2015, NOISH 2016). Heat exhaustion is caused by the inability of the body to fully respond to the demands of work while maintaining a normal body temperature and is often associated with dehydration (ACGIH 2022). Symptoms and signs of heat exhaustion include lightheadedness, nausea, fatigue, and diminished performance. Heat syncope, or fainting, is caused by dilation of blood vessels for cooling and is worsened by dehydration. Rhabdomyolysis is caused by skeletal muscle breakdown and can lead to kidney damage. Heat exposure has been reported to be associated with traumatic injuries (e.g., from falls) (Spector 2016, Calkins 2019, Fatima 2021) and acute kidney injury (Moyce 2017, Shi 2022) among outdoor workers.

In addition to heat-related illnesses, injuries, and acute kidney injury, there are several other effects of heat exposure on health. Occupational heat stress may lead to adverse birth outcomes

[1] *Rios v. Dep't of Lab. & Indus.*, 145 Wn.2d 483, 491-92, 39 P.3d 961 (2002)

among heat-exposed pregnant individuals (Keuhn 2017) and can influence the absorption, distribution, and metabolism of chemicals (Leon 2008). Physical activity in the heat is associated with reduced physical and cognitive performance on complex tasks (Piil 2017). Heat exposure can worsen underlying chronic disease. Diabetes mellitus is associated with impairments in heat loss during exercise (Carter 2014). General population studies in King County, Washington State, have reported increased risk of death with increasing heat exposure for all-cause, non-traumatic, circulatory, cardiovascular, cerebrovascular, and diabetes causes of death (Isaksen 2016). Studies have also reported an increase in cardiovascular mortality rates in the contiguous United States on extreme heat days (Khatana 2022). There is also emerging evidence of the effect of heat exposure on mental health. In the general population, extreme heat and rising temperatures has been linked to increased hospitalizations for mood and behavioral disorders and an increased risk of suicide (Ebi 2021).

1.2.3 Explanation of Rulemaking Goals and Alternatives to Rulemaking

The rulemaking goals were to ensure clear and enforceable requirements that, based on the best available evidence, adequately protect workers from outdoor heat exposure (OHE). Alternatives to rulemaking considered included expanding guidance tools, such as model programs and training material, and increasing awareness and outreach campaigns.

L&I reviewed peer-reviewed research to understand the current best evidence on heat exposure hazards and controls, including studies regarding the relationship between OHE and traumatic injuries, such as falls from ladders. Information on heat-related illness and injuries, including Washington workers' compensation claim heat-related illness and injury claims data, were also reviewed.

The current rules were also evaluated. Under the framework of the 2008 OHE rule, there are no minimum preventive requirements for the employer's OHE elements to be addressed in the written Accident Prevention Program other than drinking water. Under the Division of Occupational Safety and Health's (DOSH) accident prevention plan requirement, the program must be tailored to the needs of an employer's particular workplace or operation and to the types of hazards involved. In addition, employers must establish, supervise and enforce their accident prevention program in a manner that is effective in practice. However, the most common citation is failure to include a heat stress prevention program in the employer's accident prevention program, suggesting a level of general noncompliance with employer's addressing hazardous heat exposures.

As such, it was determined that rulemaking to provide clear and enforceable requirements to include more specific minimum requirements and preventative measures, and to provide protective measures are lower temperatures.

1.2.4 Description of Current Regulation

In 2008, L&I adopted a rule for the control of OHE for all employers with employees performing work in an outdoor environment. The 2008 OHE rules adopted under chapter 296-62 WAC, General Occupational Health Standards, were the result of the need for more specific rules to prevent the recognized workplace hazards posed by OHE. Washington's OHE rulemaking effort

began following a farmworker death from heat stroke in 2005. It was informed by review of Washington workers' compensation injury and illness data from 1995 to 2010, which found an additional worker death from heat stress and approximately 450 injury and illness claims for heat-related illness (HRI). This was tragically punctuated by two additional worker deaths due to heat-related illness in 2006 following the adoption of the first of two emergency rules.[2]
In 2009, DOSH incorporated the rules into the Safety Standards for Agriculture under chapter 296-307 WAC as requested by stakeholders. The current rules require employers with employees working outdoors to: address outdoor heat exposures as part of their written accident prevention program, ensure that drinking water is readily accessible in sufficient quantity for workers to drink at least one quart of water per hour, respond to signs and symptoms of heat-related illness, and provide training to employees and supervisors. The current rules, in effect annually from May 1 through September, apply when the temperature is at or above 89°F (degrees Fahrenheit) with lower temperature thresholds of 77°F for work in double-layer woven clothes and 52°F non-breathing clothes. Double-layer woven clothing includes coveralls, jackets and sweatshirts, and non-breathing clothes includes vapor barrier clothing or Personal Protective Equipment (PPE) such as chemical resistant suits.

1.2.5 History of This Rulemaking

On June 28, 2021, in the midst of a record-breaking heat wave in the Pacific Northwest, DOSH received a petition to add more specific preventative requirements to prevent heat-related illness, including when there is extreme heat, and requested emergency rules be adopted .The petitioner referenced requirements under California OSHA's (Cal/OSHA) outdoor rules that require more preventative steps be taken by employers, such as the requirement that shade be provided at 80°F and rest breaks. L&I accepted the petition, recognizing the need to reexamine the agency's 2008 OHE rules, especially in light of information suggesting the occurrence of heat-related illnesses below the current trigger temperatures and the increasing temperatures experienced in Washington State since the rule was first established.

To address the immediate need, L&I adopted emergency rules on July 9, 2021 (WSR 21-15-017) to take effect on July 13, 2021, to address extreme high heat procedures when the temperature is 100°F. Under the emergency rule, sufficient shade at all times and mandatory paid preventative cool-down rest periods of at least ten minutes every two hours were required when the temperatures were at or exceeded 100°F. The emergency rules also affirmatively stated that preventative cool-down rest at the temperature action level (89°F in most cases) was allowed and encouraged as needed by workers to prevent themselves from overheating, clarified that drinking water must be suitably cool, and employees and supervisors be trained on the emergency rule requirements. This emergency rule expired on November 6, 2021.

DOSH's robust education and outreach efforts to provide assistance to employers and inform workers were then focused on amplifying the emergency and existing rules requirements, and the updated tools available help employers and employees address heat exposure hazards. Efforts included updates to the model prevention plans, training materials available in English and Spanish, and heat prevention awareness campaigns to reflect the emergency rule requirements.

On August 17, 2021, DOSH initiated the permanent rulemaking process (WSR 21-17-135). This effort includes consideration of occupational heat exposure hazards from high ambient temperatures in all industries, including outdoor and indoor exposures, and considered requirements for, but not limited to: trigger temperatures or another measure of environmental conditions, time frames for when the rule is in effect, preventative measures (such as water, shade or other cooling means, and rest time/breaks), emergency response measures, training, and planning.

In February 2022, DOSH conducted an outdoor heat exposure survey, asking 10 scoping questions around the following topics: ambient heat exposure, environmental monitoring; rest breaks, work pace, and hydration; acclimatization; training; responding to signs and symptoms of heat-related illness; current standard and 2021 emergency standard; and PPE. The survey was sent to several DOSH electronic email distribution lists and also posted on social media in English and Spanish. Responses were received from employers, employees, safety professionals, employer associations, and labor advocates. A wide range of industries were represented in the responses, including, but not limited to: Agriculture; Construction; Government; Manufacturing; Transportation; and Utilities.

On March 11, 2022, L&I received a communication regarding the ongoing permanent rule process and the need to protect workers given the expiration of the 2021 emergency rules which was treated as petition for emergency rules

A virtual stakeholder meeting was held on March 17, 2022 with over 110 in attendance. The meeting included presentations from L&I's Safety & Health Assessment & Research for Prevention (SHARP) Program on health effects, risk factors, and trends for outdoor workers exposed to heat. This meeting also included an overview of the rulemaking process, next steps, and information from the survey.

A second virtual stakeholder meeting was held on May 4, 2022. An update was provided on ongoing development of a permanent rule for outdoor heat, including the continued research and consideration of appropriate options to protect workers that are evidence-based, feasible, and the least burdensome on employers. As the development of the adopted rule for permanent changes was still in process, the intention to adopt a second emergency rule to address the hazard of outdoor heat and the gaps identified in the current rule was discussed. Adoption of second emergency rules was also requested under a petition sent in March 2022, which focused on the gaps in the current rules and the 2021 emergency rules, the ongoing permanent rule process and the need to protect workers given the expiration of the 2021 emergency rules. Draft emergency rule language was reviewed and feedback requested. Second emergency rules were adopted on June 1, 2022 (WSR 22-12-095). The emergency rules required sufficient shade at all times when the temperature was at or exceeded one of the three temperature action levels under the rule and specific preventative measures for mandatory cool-down rest periods, maintaining effective communication, and close observation of employees when the temperatures were at or exceeded 89°F. The mandatory cool mandatory cool-down rest periods were to be at least 10 minutes every two hours. The emergency rules again included language affirmatively stating preventative cool-down rest was allowed and encouraged as needed by workers to prevent themselves from overheating, clarified that drinking water must be suitably cool, and employees and supervisors

be trained on the emergency rule requirements. This emergency rule expired on September 29, 2022.

A third virtual stakeholder meeting was held on August 4, 2022, with over 150 public stakeholders in attendance and was aired on TVW. The presentation included information on items being considered as part of the upcoming permanent rule. Staff reviewed the hazards of high ambient heat and the effects on the body such as heat strain and heat-related illness. Topics discussed included trigger temperatures, preventative measures such as water, shade or other cooling means, rest/time breaks, high heat procedures, emergency response measures, acclimatization and training. Staff requested feedback on the draft rule language presented.

A fourth virtual stakeholder meeting was held on August 31, 2022, with over 260 public stakeholders in attendance and also aired on TVW. The staff presentation covered topics that were included in the emergency rules as well as new language added, based on comments from previous stakeholder meetings. Staff provided clarity regarding incidental exposure to heat, noting this is not a change from the 2008 rule. Topics included added definitions, employer and employee responsibilities, access to shade and suitably cool drinking water, acclimatization, responding to signs and symptoms of heat-related illness, high heat procedures, information and training. Staff requested feedback on the draft rule language presented.

All virtual meetings included simultaneous interpretation in Spanish and the meeting materials were available in English and Spanish.

Proposed rules were filed on March 21, 2023. In-person public hearings were held in Bellingham, Tukwila, Spokane, Kennewick, Vancouver and Yakima. One virtual public hearing was also held. Written comments were accepted through May 11, 2023.

1.2.6 Description of Rule Amendments

The amended rules will improve workplace safety conditions for outdoor workers. The following describes the changes:

- **Amends and adds definitions under WAC 296-62-09520 to clarify and improve understanding of the chapter.**

- **Amends the scope, WAC 296-62-09510, to be applicable year-round when workers are exposed to outdoor heat**. The occurrence of hot days and heat waves is not restricted to May 1 through September 30. Continuing to apply this time-frame restriction would does not provide the protection under the rule for employees covered by the 52°F action on days outside of May-September that are at or above the action level. It also provides protections for employees covered by the 80°F action level when those days occur outside of May-September. While these days historically are uncommon, the number of hot days is expected to increase with climate change.[3]

[3] The length of the "frost free season", the number of days between the last spring occurrence and the first fall occurrence of a minimum temperature at or below 32°F, has been increasing nationally since the 1980s. During

- **Continues to keep ambient temperature as measure for the temperature action levels now under WAC 296-62-09530 and 296-307-09730.**
Under L&I's 2008 OHE rule, there are three outdoor temperature action levels, based on ambient air temperature, dependent on the general types of clothing or personal protective equipment each employee is required to wear:

Outdoor Temperature Action Levels

All other clothing	89°F
Double-layer woven clothes including coveralls, jackets and sweatshirts	77°F
Nonbreathing clothes including vapor barrier clothing or PPE such as chemical resistant suits	52°F

The ambient air temperature action levels in the 2008 rules were derived using Web Bulb Globe Temperature (WBGT) in consultation with Dr. Thomas Bernard, PhD, a national expert in heat stress and then Chair of the American Conference of Governmental Industrial Hygienist (ACGIH) Physical Hazards Committee.[4] The WBGT takes into account air temperature, humidity, wind, and solar radiation (e.g., sun) and is used by the ACGIH and NIOSH as the heat stress assessment metric. (NIOSH 2016, ACGIH 2022) The WBGT assesses more factors relevant to human health than the Heat Index or Humidex, which only consider temperature and humidity. Dr. Bernard's approach was to determine the temperature corresponding to the ACGIH action limit, assuming moderate metabolic rate work in the sun.[5] A review of humidity for Washington State, as assessed by dew point temperatures, identified little variability in humidity, and a dew point of 50°F was assumed. With these assumptions, the outdoor temperature action levels for different types of clothing were determined.

Dew point observations were not expected to change substantially since the prior assessment, and more recent dew point data from across Washington State indicated that a dew point of 50° F remains a reasonable assumption. As such, L&I decided to continue using these assumptions to develop ambient temperature triggers for the rule. In addition, maintaining the use of ambient air is easier for employers and employees to use and removes the burden of employers having to used specialized equipment (WBGT), separately consider humidity levels, and conduct complex calculations.

1991-2011, the average frost-free season was about 10 days longer than during 1901-1960. The largest increases for this period occurred in the western U.S. https://cig.uw.edu/learn/climate-change/

[4] The research is documented in L&I's 2008 Outdoor Heat Exposure Concise Explanatory Statement Section II "Outdoor Heat Exposure Policy Rationale", available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.163.89&rep=rep1&type=pdf.

[5] *Id*.

- **Amends the outdoor temperature action levels that apply to different sections of the rule, WAC 296-62-09530 and 296-307-09730**. The adopted rule has two outdoor temperature action levels:

Nonbreathable clothes including vapor barrier clothing or PPE such as chemical resistant suits	52°F
All other clothing	80°F

In determining the temperature action level, L&I reviewed the best available evidence on heat-related illness environmental conditions, and traumatic injury risk. This included the following:

  - Research on heat-related illness State Fund workers' compensation claims in Washington State showed 918 confirmed heat-related illness claims between 2006 and 2017, with 654 claims accepted. The data included both indoor and outdoor workers. For the accepted claims, the maximum daytime temperature was below the 2008 OHE rule temperature action level of 89°F for 45% of accepted heat-related illness claims (Hesketh et al 2020).
  - Research on federal Occupational Safety and Health Administration (OSHA) outdoor heat-related illness investigations from 2011-2016 found heat stress was below a Heat Index of 89°F[6] in 32% cases (Tustin et al 2018).
  - Research on Washington State Fund traumatic injury workers' compensation claims from 2000-2012 found a 14% increased odds (risk) of traumatic injury at temperatures of 76-82°F[7] (Humidex of 25-29°C), compared to temperatures <76°F*[8] (Humidex <25°C) in agriculture in Central/Eastern Washington (Spector et al 2016) and a 0.7% increase odds (risk) of traumatic injury for each degree Celsius increase in temperature in outdoor construction from March-October (Calkins et al 2019).
  - The American Conference of Governmental Industrial Hygienists' (ACGIH) 2022 Threshold Limit Value (TLV) for heat stress indicates that an evaluation process for heat stress should be started if heat stress is expected, such as when the Heat Index or air temperature is 80°F[9].
  - Under California OSHA's outdoor heat exposure rule, first adopted in 2005, prevention protections go into effect at 80°F (ambient temperature).[10] Under Oregon OSHA indoor and outdoor heat exposure rules[11], adopted in 2022, with emergency rules adopted in 2021[12], prevention protections go into effect

[6] A Heat Index of 89°F is equivalent to an air temperature of 89°F at 40% relative humidity.
[7] Assuming 35% relative humidity.
[8] Assuming 35% relative humidity.
[9] Equivalent to air temperature 80°F at 40% relative humidity.
[10] California Code of Regulations, Title 8, § 3395. Heat Illness Prevention in Outdoor Places of Employment.
[11] Oregon Administrative Order 3-2022, OAR 437-002-0156 and OAR 437-004-1131, Heat Illness Prevention.
[12] Oregon Administrative Order 8-2021, Temporary Amendment OAR 437-004-1120 to Address High Ambient Temperatures in Labor Housing

at a Heat Index of 80°F[13]. While federal OSHA does not currently have a specific rule for heat exposure[14], OSHA guidance provides that days when the Heat Index exceeds 80°F will be considered heat priority days and enforcement efforts will be increased on heat priority days for a variety of indoor and outdoor industries.[15]

- Recommendations for using a heat index of 80°F[16] as triggering hazard awareness and protective action for at-risk outdoor industries based on analysis of WBGT and heat index and heat-related illnesses and fatalities. (Morris 2019; Maung 2020).

In consideration of this best available evidence, including also the data described above, DOSH made the determination that the temperature action level of 89°F was to too high to provide protection from workers overheating. In addition, in lowering the 89°F temperature action level, the separate temperature action level for double-layer clothing of 77°F could be repealed and incorporated into one action level (80°F).

- **Amends requirements for the written outdoor heat exposure safety program under WAC 296-62-09530(1) and 296-307-09730(1).** The current rules require employers address their outdoor exposure safety program in their written Accident Prevention Plan, however the rules do not contain any minimum required elements for the written program. The adopted rules under specifies the written program include, at a minimum, procedures addressing all elements of the adopted rules. In addition, the adopted rules clarify that the written program needs to be in a language understood by employees and that a copy of the written program be made available to employee and their authorized representatives. Under L&I DOSH's Accident Prevention Plan Requirements, the program must be tailored to the needs of an employer's particular workplace or operation and to the types of hazards involved.[17] In addition, employers must implement their Accident Prevention Plans, including establishing, supervising and enforcing it in a manner that is effective in practice.[18] The intent behind explicitly stating the minimum required elements for the outdoor exposure safety plan is to remove ambiguity and thus help employers better comply with the rule and to ensure employees have access to the written program.

- **Amends the employer requirements under WAC 296-62-09530(1)(e) and 296-307-09730(1)(e) to encourage and allow employees to take preventative cool-down rests periods when needed.** Under the adopted rules, employers are to

[13] Equivalent to air temperature 80°F at 40% relative humidity.
[14] OSHA filed an Advance Notice of Proposed Rulemaking on October 27. 2021, initiating rulemaking to protect indoor and outdoor workers from hazardous heat. 86 FR 59309.
[15] Occupational Safety and Health Administration (OSHA). (2021, September 1). Inspection Guidance for Heat-Related Hazards. (OSHA, September 1, 2021)
[16] Equivalent to air temperature 80°F at 40% relative humidity.
[17] WAC 296-800-140, WAC 296-307-030
[18] WAC 296-307-018, WAC 296-800-140.

encourage and allow employees to allow employees to take a preventative cool-down rest period when they feel the need to do so to protect themselves from overheating and to reduce the risk from traumatic injuries due heat exposure. The preventative cool-down rest period must be paid unless taken during a meal period. This requirements applies when the temperature is at or above the action levels in the adopted rules. Given the variability in environmental factors and personal factors, ensuring workers understand they have the right to take preventative cool-down rest periods when needed and that those rest periods will be paid unless during meal periods will help prevent overheating or recover from being overheated, in particular in situations where employees may be motivated to skip breaks or otherwise adjust the pace of their work such as piece rate or where the employees fear of retaliation and discrimination.

- **Creates WAC 296-62-09535 and 296-307-09735 Access to shade.** The current rules require employers have shade, or an alternative means to cool body temperature, readily available for first-aid response when heat-related illness is already being experienced. There are not provision in the current rules regarding shade or other cooling methods as preventative measures to reduce the amount of heat exposure. The adopted rules address this gap requiring shade be provided at all times when employees are exposed to temperatures at or above the action levels. The adopted rules specify that the shade be to the air or provided with ventilation or cooling, not adjoining a radiant heat source such as machinery or a concrete structure, and be located as close as practicable to the areas where employees are working. In addition, the amount of shade is to be large enough to accommodate all employees on a meal or rest break to sit in a normal position. The use of other cooling methods is permitted in lieu of shade. The adopted rules define the term "shade" as blockage of direct sunlight with a purpose to allow the body to cool. The adopted change ensures clarity on and removes ambiguity as to what is considered appropriate shade and where it should be provided. Additionally, the section is intended to require employers to proactively provide a means to reduce body temperature during meals or rest periods, including preventative rest periods and mandatory rest periods under the adopted rules, and not solely as a first-aid response when heat-related illness is already being experienced.

- **Amends WAC 296-62-09540 and 296-307-09740 Drinking water.** This amendment clarifies the existing requirement to explicitly state that drinking water needs to be suitably cool in temperature such that it will not discourage employees to drink water. This is consistent with DOSH's long standing application of the existing requirement as "drinking water" is defined as potable water or other appropriate beverages that are "suitable to drink." As discussed in DOSH Directive 10.15, "suitable" includes ensuring that water is cool enough to be readily drinkable. In addition, the general requirement for drinking water in under WAC 296-307-09512(7) specifically addresses the need to provide suitably cool potable drinking water.

- **Creates requirements for acclimatization, WAC 296-62-09545 and 296-307-09745.** The adopted rules requires close observation for 14 days for signs and symptoms of heat-related illness for employees newly assigned and employees returning from an absence of seven days or more when the temperatures are at or above the action levels. Close observation of all employees working during a heat wave is also required. A "heat wave" is defined any day in which the predicted high temperature for the day will at or above the action levels and at least 10°F higher than the average high daily temperature in the preceding five days. This definition of a "heat wave" is consistent with California OSHA's definition of a heat wave.[19] This definition is also consistent with NIOSH's definition of a heat wave.[20]

  Building tolerance to working in the heat is an important factor for reducing the risk of heat-related illness. Acclimatization consists of changes in the body, or physiological adaptations that occur with work in the heat, that allow the body to better withstand working in hot conditions. (NIOSH 2016; Périard 2015). Acclimatization provides protection from about 2.5-3°C (degrees Celsius) WBGT additional exposure to heat, can take up to 14 days to develop, and can be lost after a week away from working in the heat. (NIOSH 2016; ACGIH 2022) The acclimatization section was created to establish requirements addressing this important factor. The adopted requirements focus on the times during which employees are most vulnerable to heat-related illness: when they are new or returning to working in the heat, and during a sudden temperature increase (e.g., heat wave) that does not allow for acclimatization to occur. (NIOSH 2016) Close observation of employees at these higher-risk times is the only requirement in this section, with the intent to quickly identify and respond to employees who may begin showing signs and symptoms of heat-related illness.

- **Creates WAC 296-62-09547 and 296-307-09747 High heat procedures.** These new sections require mandatory cool-down rest periods and close observation of employees to help identify employees who may begin showing signs and symptoms of heat-related illness. The intent of this section is to address additional protections during high heat. Rest periods can reduce the risk of heat-related illness by allowing the body to cool by moving out of direct sunlight to shade and reducing the metabolic heat, or internal heat, generated from physical labor. Using ACGIH methods, similar to the methods described above and employed in determination of the 2008 rule triggers,[21] the high heat threshold was derived using WBGT. The approach was to

[19] California Code of Regulations, Title 8, § 3395. Heat Illness Prevention in Outdoor Places of Employment.
[20] NIOSH's Criteria for a Recommended Standard for Occupational Exposure to Heat and Hot Environments, defines a "heat wave", for the purposes of a Heat Alert Program, as when the daily maximum temperature exceeds 95°F or when the daily maximum temperature exceeds 90°F and is 9°F or more above the maximum temperature reached on the preceding days. Under a Heat Alert Program, additional preventative measures are to be implemented when a heat wave occurs, including measures such as: postponing non-urgent tasks; increasing workers on a team to reduce each worker's heat exposures; introduce new workers gradually to allow acclimatization; increase rest allowances; check workers' core temperature during their most severe heat-exposure period; and exercise additional caution on the first day of a shift to address any acclimatization lost over the weekend or days off. (NIOSH 2016)
[21] L&I's 2008 Outdoor Heat Exposure Concise Explanatory Statement

determine the temperature corresponding to the ACGIH threshold limit value, assuming moderate metabolic rate work in the sun at a dew point of 50°F for acclimatized workers working in double layer clothing (since double layer and all other clothing categories were combined). With these assumptions, L&I calculated a high heat threshold temperature of 90°F at which such additional protections are required.

When the temperature is at 90°F but less than 100°F, mandatory cool-down rest periods are required every two hours. This is consistent with requirements adopted or currently required by the California OSHA and Oregon OSHA. When the temperature is at or above 100°F, a mandatory cool-down rest periods of 15 minutes every hour is required. This is consistent with Oregon OSHA, which based rest breaks on National Institute for Occupational Safety and Health's (NIOSH) Criteria for a Recommended Standard for Occupational Exposure to Heat and Hot Environments. (NIOSH 2016) The mandatory cool-down rest periods can be taken concurrently with any meal or rest period required under L&I's Employment Standards rules[22] and must be paid unless taken during a meal period.

The final rules create an exemption from the requirement for mandatory cool-down rest periods for emergency response operations related to aiding firefighting, protecting public health and safety, or maintaining safe and reliable operation of critical infrastructure. Employees under this exemption must still be permitted to take preventative cool-down rest periods when they think they need to.

- **Amends WAC 296-62-09550 and 296-307-09750 Responding to signs and symptoms of heat-related illness.** Under the current rules, employees showing signs or demonstrating symptoms of heat-related illness must be relieved from duty and provided with a sufficient means to reduce body temperature and monitored to determine whether medical attention is necessary. The amendment clarifies the current requirement to explicitly state employers must ensure effective means of communication, whether voice, observation, or electronic means, is maintained so that employees at the work site and their supervisor can contact each other to report are available to report and respond to heat-related illness. Effective means of communication is necessary for employers to meet the existing requirement to respond to employees showing signs or demonstrating symptoms of heat-related illness.

- **Amends WAC 296-62-09560 and 296-307-09760 Information and training.** Training provisions are now required when there might be an employee exposure to outdoor heat, rather than when an outdoor temperature action level has been reached. Training provisions are also amended to reflect the new and amended sections of the rule.

[22] WAC 296-126-092, Meal period-Rest periods, applies to all employers accept agricultural employers. WAC 296-131-020, Meal and rest period, applies to agriculture employers.

1.3 Description of the affected Businesses and Workers

1.3.1 Affected Workers

In order to identify the occupations that are exposed to outdoor heat and estimate the number of workers in these occupations that are likely affected by the adopted rule, L&I relies on the outdoor exposure data from BLS' Occupational Requirements Survey (ORS) and the outdoor, exposed to weather data from O*Net database.[23] L&I believes these are the best outdoor exposure data available for the purpose of identifying affected workers.

More specifically, L&I looked at the distribution of workers in each occupation by outdoor exposure level (no presence, seldom, occasionally, frequently, and constantly[24]) from the ORS data in the last few years (2018, 2021, and 2022) and a similar distribution of data from the O*Net database to distinguish the affected occupations from those not affected. The occupations that did not have outdoor work presence were first excluded from the affected population. For the affected occupations in which a specific exposure level was available, L&I estimates that about 25% of the workers who indicated they were exposed to the outdoors occasionally[25] and all of the workers who were exposed to the outdoors frequently or constantly will be affected by the adopted rule. For the rest of the occupations, L&I used the reported percent of workers who said they were exposed to outdoors every day from O*Net as the share of affected workers in each of those occupations.

Based on the share of likely affected workers in each occupation estimated from the previous step and the most recent occupational employment data,[26] L&I estimates that overall, a total of 396,551 workers, or 11.8% of Washington's workforce, perform outdoor work activities at some point in time and therefore may be potentially affected by the rule. **Table 1.1** below shows both the top 20 occupations with the largest share of workers potentially affected and the resultant number of potentially affected workers. It is also worth mentioning that the estimated number of affected workers for each requirement analyzed in Chapter 2 may only be a small proportion of this affected population, which will be explained in each specific section.

Table 1.1. Top occupations with the largest share and number of affected workers

SOC	Job Title	% of workers affected	SOC	Job Title	Number of affected workers
435041	Meter Readers, Utilities	100.0%	452092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	41,852

[23] More details about these data can be found on these websites: ORS Database: U.S. Bureau of Labor Statistics (bls.gov) and Work Context - Outdoors, Exposed to Weather (onetonline.org).
[24] Defined in the survey as no exposure, exposed to outdoors up to 2 percent of the workday, 2 percent and up to 1/3 of the workday, 1/3 up to 2/3 of the workday, and 2/3 or more of the workday respectively.
[25] Given the exemption of the workers who only have incidental outdoor exposure (workers who are not required to perform a work activity outdoors for more than 15 minutes in any 60-minute period).
[26] Occupations-Industry Matrices, 2022, ESD.

472151	Pipe layers	100.0%	537062	Laborers and Freight, Stock, and Material Movers, Hand	30,451
475013	Service Unit Operators, Oil and Gas	100.0%	472061	Construction Laborers	28,302
475071	Roustabouts, Oil and Gas	100.0%	373011	Landscaping and Grounds keeping Workers	21,102
373011	Landscaping and Grounds keeping Workers	99.6%	472031	Carpenters	15,607
499051	Electrical Power-Line Installers and Repairers	99.5%	471011	First-Line Supervisors of Construction Trades and Extraction Workers	12,538
475011	Derrick Operators, Oil and Gas	99.1%	499071	Maintenance and Repair Workers, General	12,277
333041	Parking Enforcement Workers	99.0%	339032	Security Guards	11,354
454023	Log Graders and Scalers	98.5%	472111	Electricians	10,180
472072	Pile Driver Operators	98.4%	533032	Heavy and Tractor-Trailer Truck Drivers	7,082
475012	Rotary Drill Operators, Oil and Gas	97.1%	472073	Operating Engineers and Other Construction Equipment Operators	5,994
537073	Wellhead Pumpers	97.0%	533033	Light Truck Drivers	5,086
472021	Brick masons and Block masons	96.8%	472181	Roofers	5,033
339091	Crossing Guards and Flaggers	96.0%	272022	Coaches and Scouts	4,399
474061	Rail-Track Laying and Maintenance Equipment Operators	95.5%	372011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	4,044
474071	Septic Tank Servicers and Sewer Pipe Cleaners	94.6%	452093	Farmworkers, Farm, Ranch, and Aquacultural Animals	3,805
454021	Fallers	94.4%	333051	Police and Sheriff's Patrol Officers	3,638
339011	Animal Control Workers	93.5%	111021	General and Operations Managers	3,503

373012	Pesticide Handlers, Sprayers, and Applicators, Vegetation	92.6%	472051	Cement Masons and Concrete Finishers	3,479
472181	Roofers	91.9%	537061	Cleaners of Vehicles and Equipment	3,367

1.3.2 Affected Industries and Businesses

The adopted rule applies to all employers with employees who are exposed to outdoor heat environments. Using the number of affected workers in each occupation estimated in Section 1.3.1 and their employment by each industry, L&I was able to estimate the number of businesses in each industry that are likely affected by this adopted rule.[27] The share and number of affected businesses in each industry are presented in Table 1.2. It shows Agriculture, Forestry, Fishing and Hunting has the largest share of affected businesses (53.3%), but Construction is the top industry in terms of the number of employers affected by the rule (12,744). Altogether, more than 31,000 employers may be affected by this adopted rule.

Table 1.2. Share and number of businesses that are likely affected in each industry

NAICS	Sector	Share of affected businesses	Number of affected businesses
11	Agriculture, Forestry, Fishing and Hunting	53.3%	3,482
21	Mining, Quarrying, and Oil and Gas Extract	22.2%	29
22	Utilities	16.8%	38
23	Construction	45.1%	12,744
31-33	Manufacturing	6.8%	527
42	Wholesale Trade	12.5%	1,544
44-45	Retail Trade	5.9%	841
48-49	Transportation and Warehousing	21.8%	1,098
51	Information	3.2%	186
52	Finance and Insurance	3.1%	201
53	Real Estate and Rental and Leasing	16.5%	1,196
54	Professional, Scientific, and Technical Services	2.8%	910
55	Management of Companies and Enterprises	2.0%	14
56	Administrative, Support and Waste Management	25.1%	3,352
61	Educational Services	5.7%	217
62	Health Care and Social Assistance	2.8%	1,747
71	Arts, Entertainment, and Recreation	12.8%	392
72	Accommodation and Food Services	4.1%	623
81	Other services except public administration	9.2%	1,845
99	State and Local Governments	14.5%	290

[27] Assuming the share of affected workers in a certain industry is similar to that of affected businesses in that industry.

	Total	**11.8%**	**31,274**

Chapter 2: Costs of Adopted Rule

The estimated costs in this analysis represent only the new costs of complying with the adopted rules for the affected parties, excluding realized potential costs associated with or originating from the current practices, or "baseline" standards under existing laws, rules or national consensus standards. Therefore, the costs that can be attributed to or are insignificantly different from these baseline standards are not analyzed or factored into our estimates.
This chapter assesses each of the adopted rule components that have been identified to have a probable cost implication. The chapter concludes by summarizing the total identified probable costs.

2.1 Cost Estimates by Provision

2.1.1 Cost of Employer and Employee Responsibility
The amended subsections under WAC 296-62-09530 and 296-307-09730 will now require employers with exposed employees to (a) address their outdoor heat exposure safety program (OHESP) in a language that employees understand; (b) ensure a minimum set of six elements are included in their OHESP; (c) ensure a copy of the OHESP is made available to employees and their authorized representatives; and (d) encourage and allow employees to take paid preventative cool-down rest periods when needed.

The approach to estimating the new requirements requires (1) estimating the number of impacted businesses; (2) estimating the cost of translating the updated OHESP document; (3) estimating the administrative time needed to update the OHESP with the minimum required elements; and (4) the cost of providing copies to the employees and their representatives.
The adopted amendment affects all employers of outdoor workers exposed at or above the temperature thresholds specified in this adopted rule. Table 1.2 in Chapter 1 shows the number of affected businesses in each industry.

In order to estimate the cost to the impacted firms L&I relied upon a few assumptions:

- The distribution of workers with limited English proficiency across all impacted industries is not known. While the Agriculture, Forestry, Fishing and Hunting, and Construction would have workers who do not understand English and would need language translation services, not all businesses in these sectors will need translation services. For the purposes of this analysis, we assumed all businesses in these two sectors, about 52% of total impacted businesses, would need translation to address employers across all industries.

- Employers would use digital methods to provide electronic copies of the OHESP to employees and their authorized representatives. Employers can easily provide digital copies to any common electronic device such as a mobile phone or tablet.

- Employers would not incur any cost encouraging employees to take cool-down rest periods. This assumption is based several factors, including: the expectation many cool-down rest periods under this provisions will be done in conjunction with the existing requirements that an employer ensure employees have an opportunity to drink at least

one quart of drinking water per hour; variability across employees on the need to take the rest periods; reduced impact from the inclusion of mandatory cool-down rest periods at 90°F and 100°F under the adopted rules; ability of some employers to move an employee's work to a location below the temperature action level, such as working in an indoor environment, when the employee indicates they are starting to overheat; and an employee who feels they need to rest to avoid overheating may be starting to show signs and symptoms of heat-related illness such as excessive sweating and action is already required in those circumstances under the current rules.

L&I makes available on its website a template of the OHESP document that includes the new minimum required elements, which employers could use to update their own OHESP.[28] As a result, employers may not need to create this document anew but simply need a small amount of administrative time to update the document. L&I estimates that it would take approximately 15 to 30 minutes to perform this task. Based on the estimated labor time, the hourly compensation for a competent person to do so, and the number of impacted businesses, the total one-time cost of updating the OHESP amounts to $628,321-$1,256,642. Assuming this adopted rule stays effective for at least 9 years after its adoption and employers don't need to do this again over that period of time, the annual cost would be $84,189 to $168,378 (see Table 2.1).

Table 2.1. Administrative cost to update OHESP

Cost Factors	
Average time to update OHESP	15-30 minutes
Hourly labor cost (wage and benefits)	$80.36
Average cost per business	$20.09 - $40.18
Number of impacted businesses	31,274
Total cost	$628,321 - $1,256,642
Annualized cost[29]	$84,189 - $168,378

The adopted rule also requires that employers provide the OHESP in a language understood by the employee. As stated above, for the purpose of this analysis we assume all the Agriculture, Forestry, Fishing and Hunting, and the Construction sectors would need the OHESP translated into one or more languages. As such, about 16,225 businesses may be affected by this requirement. Using the average cost of $20 to $75 for translation services for each affected business, L&I estimates this requirement will impose a one-time cost of $324,508 to $1,216,906, or $43,481 to $163,054 each year[30] to all these affected businesses (see Table 2.2).

[28] View the "Outdoor Heat APP Addendum" at Accident Prevention Program (APP) (wa.gov)
[29] The 5% discount rate is used to convert the total cost over 9-year period to the net present value and annualize it for this section and all other sections as well.
[30] Using the same method as in the cost analysis for updating OHESP.

Table 2.2. Translation costs

Cost Factors	
Industries needing translation services: - Agriculture, Forestry, Fishing & Hunting - Construction	Number of businesses 3,428 12,744
Average cost of translation services per business	$20.00 - $75.00
Total translation costs – one time	$324,508 - $1,216,906
Annualized cost	$43,481 - $163,054

Given the cost of updating the OHESP and translating the documents, L&I estimates this adopted requirement will impose approximately a cost of $127,670 to $331,432 on impacted businesses each year (see Table 2.3).

Table 2.3. Total compliance costs

Cost Factor	
Updating OHESP	$628,321 - $1,256,642
Translation services	$324,508 - $1,216,906
Total one-time cost	$952,829 - $2,473,548
Annualized cost	**$127,670 - $331,432**

2.1.2 Access to Shade

The adopted rule under WAC 296-62-09535 and 296-307-09735 require employers to (1) provide and maintain one or more areas of ventilated or cooled shade as close as possible to the worksite at all times; (2) ensure that this shade be large enough to accommodate employees on a meal or rest break so they can sit in a normal posture, and; (3) use other equally or more effective means to reduce body temperatures in lieu of shade. This could include misting stations, cooling vests, or air conditioned areas, among others.

This is a new requirement which would impose a cost on impacted businesses. To estimate this cost L&I relied upon the following assumptions:

- A typical employer would choose pop-up canopies for shade;
- The average time to set up a simple pop-up canopy is 5 minutes;

- Only a proportion of workers would be working outdoors at any single point in time, and of those who are out, some would avoid exposure to outdoor heat as a result of engineering or administrative controls, so they do not require shade.

To estimate the number of employees who would need shade, L&I assumes that around 75% of workers in Agriculture, Forestry, Fishing and Hunting, and Mining, Quarrying, and Oil and Gas Extraction would be out at any single point in time, and around 90% of these workers would require shade. These shares are estimated at 75% and 70% for Construction workers, and even lower at 25% and 40% respectively for all other industries. This resulted in an estimate of 116,536 workers in year one for whom employers would need to provide shade. The number of canopies needed for the future years would be based on the number of newly impacted employees.[31] Therefore, employers would encounter a higher upfront cost but only marginal costs in future years as their workforce increases.

To estimate the cost, L&I first determined a 10'x10' and 12'x12' canopy which holds 8 and 12 individuals respectively, with a chair and table included, would be some of the most likely options employers choose. Based on the number of person these canopies hold comfortably and the current as well as projected affected workers over a 9-year period, approximately 15,957 10'x10' tents or 10,638 12'x12' tents would be needed. Using an average of 10-minutes for the set-up and disassemble time for each tent, the total labor cost amounts to $876,529 to $1,314,794. Given the average cost of $43.56 to $106.82 for a 10'x10' tent and $80.66 to $217.99 for a 12'x12' one,[32] the total cost would be $1,734,602 to $3,195,528 over the entire period, or $208,724 to $401,354 every year (see Table 2.4).

Table 2.4. Cost of providing 10'x10' and 12'x12' shade canopies

Cost Factors	
Total number of affected workers over 9 years	127,658
10'x10' canopies	
Number of canopies needed	15,957
Cost of each canopy	$43.56 - $106.82
Total set-up cost	$1,314,794
Total cost in 9 years	$2,009,832 - $3,019,343
Annualized cost	$235,018 - $368,127
12'x12' canopies	

[31] The number of new employees was calculated using Employment and Security Department growth rates for workers in the various industries.

[32] Based on the market prices of these tents from Amazon, Target, Lowes, Walmart, Home Depot and Costco. All are after-tax prices. Prices were adjusted for inflation to estimate future costs.

Number of canopies needed	10,638
Cost of each canopy	$80.66 - $217.99
Total set-up cost	$876,529
Total cost in 9 years	$1,734,602 - $3,195,528
Annualized cost	$208,724 - $401,354

The adopted rule also allows employers to use other effective body temperature reducing options such as misting vests. Based on the average cost of $10.89-$21.67 per unit and the number of units needed for all impacted workers, L&I estimates the total cost of this option to be $1,390,077 to $2,766,240 over the entire period, or $183,289 to $364,743 per year (see Table 2.5).

Table 2.5. Cost of body temperature reduction option

Cost Factor	
Total number of devices needed	127,658
Cost range of typical devices	$10.89 - $21.67
Total cost over the entire period	$1,390,077 - $2,766,240
Annualized	$183,289 - $364,743

Considering a mix of the options available for employers to comply with this adopted section, L&I estimates a total cost of $1,390,077 - $3,195,528 over the entire period or $183,289 - $401,354 per year to impacted businesses (see Table 2.6).

Table 2.6. Total cost of providing shade

Cost Factor	
10'x10' canopies	$2,009,832 - $3,019,343
12'x12' canopies	$1,735,602 - $3,195,528
Body temp. reducing options	$1,390,077 - $2,766,240
Total cost range	$1,390,077 - $3,195,528
Annualized cost	$183,289 - $401,354

2.1.3 Drinking Water

Under existing WAC 296-62-09540 and 296-307-09740 employers are required to provide and keep workers hydrated with drinking water of at least one quart per hour for each employee, but this requirement only applies to the period of May through September. While adopted changes to these section does not have any cost impact, amendments to preceding sections do. For instance, amendments to WAC 296-62-09510(2) and 296-307-09710(2) now require that the water provided be provided year round whereas previous it was only required from May through September. In addition, the temperatures at which drinking water is required has been adjusted from 89°F to 80°F for workers wearing all other clothing (i.e. clothes other than non-breathable material which includes vapor barrier clothing or PPE such as chemical resistant suits).

These changes all have implications to the drinking water requirement. First, drinking water now also needs to be provided for some hours and days between October and April when the temperature is at or above certain thresholds for the affected workers. Secondly, the trigger temperature for providing drinking water for workers between May and September is now lowered from 89°F to 80°F, which means water needs to be provided for more hours and days during these months as well.

In order to estimate the cost of these adopted changes L&I needs to determine the amount of drinking water to be provided for the new period of October to April when the temperature is at or above 52°F for workers who wear non-breathable clothing and when the temperature is at or above 80°F for all other workers. L&I then needs to determine the amount of drinking water that would need to be provided between 80°F to 89°F for May through September.

For this estimation L&I relied upon the following assumptions:

- The average number of annual hours when the trigger temperatures (52°F and 80°F) are met would remain relatively unchanged in the immediate future. While measured temperatures (from historical data) have been trending upwards the unpredictability of weather makes it difficult to precisely forecast future temperature changes and all the number of hours when a certain trigger temperature is met.

- Due to the impact of seasonality where outdoor work activities are significantly reduced for many industries during the colder months of October to April, we assume that the number of impacted workers requiring water would be reduced to a certain degree during this period.

An analysis of historical temperature data for the trigger temperatures for the period of October to April over the past 10 years shows that Washington state experienced an average of 9 hours per day for at least 76 business days a year when the temperature was 52°F or higher, and 3 hours per day for about 1 day a year with temperatures of at least 80°F. There were also about 2 hours per day for an average of 23 business days during May through September when the temperature was between 80°-89°F. These represent the additional occasions / times when employers need to provide drinking water to their exposed workers.

Factoring in the second assumption above L&I estimates that only 89,677 of workers would be impacted by this requirement during the months of October to April, among which 3,659 workers are those wearing non-breathable clothing and subject to a much lower trigger temperature. In contrast, L&I estimates that 403,220 workers would be impacted each you over the entire 9-year period by the trigger temperature change during May to September (from 89°F to 80°F).[33]

To estimate a reasonable range of cost for this requirement, L&I considered two cost scenarios: a upper bound cost scenario which assumes that businesses would provide bottled water for all additional drinking water required by the rule, and a lower bound cost scenario assuming that around 70% of employers would provide drinking water from an existing water source, like water from the office or a nearby faucet, with the remaining 30% providing bottled water.

Based on the above approach L&I determines that the cost of this adopted requirement would impose approximately $2.5 million to $8.0 million each year over a 9-year period (see Table 2.7).

Table 2.7. Cost of providing drinking water

Cost Factors	
Average number of affected workers in Oct.-Apr. per year	89,677
Average number of affected workers in May-Sept. per year	403,220
Average number of gallons of water required in Oct.-Apr. per year	667,612
Average number of gallons of water required in May-Sept. per year	4,721,923
Cost per gallon of water- bottled water[34]	$1.29
Cost per gallon of water- using existing water source[35]	$0.01
Total cost of drinking water per year	
Low-cost scenario: 30% of bottled water and 70% other options	$2,456,145
High-cost scenario: 100% bottled water	$8,041,270

2.1.4 Acclimatization

WAC 296-62-09545 and 296-307-09745 are new sections which require employers to closely observe employees for signs and symptoms of heat-related illness for (1) a total of 14 days who

[33] Employers are already required to provide drinking water to employees at 52°F during May to September and so this group is not factored into the cost analysis for this period.

[34] Based on the recent market prices from large grocery stores such as Safeway, Fred Myers, Walmart, and Costco (after-tax prices). The prices in future years are inflation adjusted.

[35] Based on the 2022 average water rate per CCF (748 gallons) of water for commercial use in selected large cities across Washington State.

are (a) newly assigned to outdoor work at the trigger temperatures, and (b) who are returning to work after a 7 day absence, and exposed to outdoor heat at the trigger temperatures; and (2) during a heat wave, as defined by the rule, through a mix of either (i) regular communication,[36] (ii) a mandatory buddy system, or (iii) some other effective means.
These requirements are new and would impose a cost upon impacted businesses. To determine the probable total cost L&I analyzed the cost of each of the requirements using the first two options – regular communication and the mandatory buddy system. L&I did not analyze cost of a third option due to data and time limitations. L&I relies upon the following major assumptions in the analysis of this section:

- On average around 6% of employees would be working alone in outdoor exposure conditions. This figure would vary in the colder months of October to April where the percent of exposed workers would be reduced.

- On average around 5% of employees working alone would be in remote locations which require long range radio signal for communication. This figure would vary depending on the time of year.

- On average two devices would be needed for each employee who needs long range communication.

- Observation time is on average about 2 minutes meaning in some cases it may be longer and in others shorter. For instance, when the observer and the employee already work in close proximity there is likely the opportunity for ongoing visual and verbal assessment to be conducted while simultaneously carrying out normal work duties. This time may also vary depending on a number of variables, including whether or not the individual is showing any signs or symptoms of HRI, the individual's location, the size of the worksite, etc.

14-day observation of newly assigned employees
To estimate the cost of observing newly assigned employees L&I needs to determine the number of newly assigned workers. Using the employment growth rates for new workers entering the workforce from Employment and Security Department,[37] the total number of newly assigned workers subject to this rule are estimated at 45,131 for the next 8 years, or 5,641 each year.[38]
The regular communication option has a two part component – an equipment cost for those workers who work alone, and a labor cost for the observation times. Analyzing the cost of this option requires, first, determining how many employees would be working alone and needing regular communication, then estimating the cost of any devices needed for that communication process, followed by estimating the cost of observation based on the time it takes to observe each employee. For determining the number of employees who would trigger a device cost, L&I

[36] The regular communication option is intended to be used and applied to workers who are working alone via means such as a radio or cellular phone, (See WAC 296-62-09547(2)(a)).
[37] ESDWAGOV - Projections
[38] L&I used an 8-year period for this assessment because new employees would not count in the base year but in year 1 of the forecast period.

considered the likely number of employees working alone and determined that among those a certain number would be within cellular range and others would require longer/remote range devices, like a radio. L&I assumes that all impacted workers within cellular range would have a cellular phone for communication and so there would be no equipment cost. Equipment cost would therefore apply only to those workers working in remote areas and who require longer/remote range devices. The number of devices needed for communication would be twice that number – one for the employee and one for the supervisor, assuming a one-to-one relationship.

To estimate the number of employees working alone, L&I applied a sector modifier to the total number of impacted employees. It was determined that based on the number of new employees entering the workforce and the nature of the industry, on average about 6% would be working alone.[39] This number was further broken down to identify those workers working alone and remotely where cellular service was not possible so radios, due to their long range, would be needed. L&I determined these workers accounted for approximately 5% of all workers working alone.[40] During the days and times when trigger temperatures are met and employees need to be observed, L&I estimates that the typical observation time of an employee for heat-related illnesses is approximately 2 minutes.[41]

From the above approach L&I estimates that the cost of observing newly assigned employees for 14 days using regular communication to be approximately $17,435 in equipment cost and $5,566,237 in observation cost for a total of $5,583,673 in the whole period. The mandatory buddy system can be seen as simply each worker checking and observing another at the same worksite for signs and symptoms of HRI. This option impacts all exposed workers and does not have any equipment cost. Based on the total number of impacted workers, the cost of the buddy system was estimated at $5,566,237 for the entire period. Therefore the total cost of this requirement is $662,720 to $664,800 per year (see Table 2.8).

[39] L&I's modifier was applied across all industries with Agriculture, Forestry, Fishing and Hunting, and Construction having the greatest proportion of employees likely working alone. While the average for individual industries varies, the overall average across all examined industries was approximately 6%.
[40] L&I applied a modifier across all industries. While the impact across the examined industries varied, the overall average across all industries was approximately 5%.
[41] On average it is estimated that a typical observation of an employee would take about 2 minutes. However, this may vary depending on a number of variables, for instance whether or not the individual is showing signs/symptoms, the individual's location, size of the worksite, etc.

Table 2.8. Cost of observing newly assigned employees

Cost Factors		
Regular Communication	Total number of workers to be observed in 8 years	45,131
	Number of workers needing devices	124
	Total device cost	$17,435
	Observation costs	$5,566,237
	Total cost in 8 years	$5,583,673
Buddy system	Number of workers to be observed in 8 years	45,131
	Total cost in 8 years	$5,566,237
Overall	Total cost range in 8-year period	$5,566,237 - $5,583,673
	Annual cost	$662,720 - $664,800

14-day observation of return-to-work employees

To estimate the cost of workers returning to work after a 7-day absence L&I needs to determine the number of these workers. To estimate this number L&I relies upon the average national absentee rate of 3.2%[42], which results in approximately 120,901 affected workers in a 9-year period, or 13,433 annually. Analyzing the observation cost using regular communication which requires estimating both a device cost based on the number of employees working remotely and alone, and the total number of employees impacted, L&I estimated the cost to be approximately $44,569 for communication devices and $14,822,571 for observation costs, for a total of $14,867,141 in 9 years. Using the same total number of impacted employees and the average observation time of 2 minutes, L&I estimates the total cost of the buddy system option to be approximately $14,822,571 over the forecast period. The total estimated 14-day observation cost of employees returning to work is approximately $1,614,901 to $1,619,768 per year (see Table 2.9).

[42] Absences from work of employed full-time wage and salary workers by occupation and industry: U.S. Bureau of Labor Statistics (bls.gov). The initial rate used in this calculation was 3.2%, but the rate shown on BLS's website may vary due to BLS updates.

Table 2.9. Cost of observing return-to-work employees

Cost Factors		
Regular Communication	Number of workers to be observed based on 3.2% absentee rate	120,901
	Number of workers needing devices	319
	Total device cost	$44,569
	Observation cost	$14,822,571
	Total cost	$14,867,141
Buddy system	Number of workers to be observed	120,901
	Total cost	$14,822,571
Overall	Total cost range	$14,822,571 - $14,867,141
	Annualized cost	$1,614,901 - $1,619,768

Observation during a heat wave

The third requirement under these sections is for the observation of employees during a heat wave.[43] Based on the definition of a heat wave for this rule, there are two temperature triggers at which a heatwave is assessed and during which employees exposed to outdoor heat must be observed for signs and symptoms of heat-related illnesses: 52°F and 80°F.
Examination of historical data over the 10-year period 2011-2020, shows that heat waves satisfying this definition would have occurred for approximately 14 business days and 7 business days each year at the 52°F and 80°F respectively. In assessing this requirement L&I estimated the cost when utilizing (i) the regular communications (along with any equipment cost), and (ii) the mandatory buddy system.

Analysis of the former reveals that impacted businesses would need to monitor approximately 3,030 employees over the 9-year period who would be working alone remotely, for a total device cost of around $423,170. Using the estimated 2-minute observation time, an average hourly wage of $47.05, the estimated numbers of heat wave days, and an average of 122,430 affected workers every year, L&I estimates the cost of observing employees for heat waves from this method to be approximately $116,135,084. The total cost of this option is thus $116,558,254. The cost of the buddy system is similar to the cost of the observation method without the additional equipment cost. This is estimated to be approximately $116,135,084 for the whole period. Therefore the total cost of compliance with this requirement is approximately $116,135,084 to $116,558,254 in the entire period, or $12,664,029 to $12,710,284 each year (see Table 2.10).

[43] For purposes of this rule a "heat wave" is defined as any day in which the predicted high temperature for the day will be at least the temperatures listed in Table 1 of WAC 296-62-09530 and at least 10°F higher than the average high daily temperature in the preceding 5 days.

Table 2.10. Cost of observation during heat waves

Cost Factors		
Regular Communication	Number of workers to be observed each year Number of workers needing devices	122,430 3,030
	Total device cost in 9 years	$423,170
	Total observation cost in 9 years	$116,135,084
	Total cost in 9 years	$116,558,254
Buddy system	Number of workers to be observed each year	122,430
	Total cost in 9 years	$116,135,084
Overall	Total cost range in 9 years Annual cost	$116,135,084 - $116,558,254 $12,664,029 - $12,710,284

Summing the cost of the individual requirements from these adopted sections related to acclimatization, L&I estimates that the total cost is $14,941,650 to $14,994,852 per year on the impacted businesses.

2.1.5 High Heat Procedures

WAC 296-62-09547 and 296-307-09747 requires employers to implement high heat procedures when the temperature is at or above 90°F, unless they can utilize engineering or administrative controls, such as changing work schedules or the use of air-conditioning, to lower the employees' exposure to below 90°F. In particular, this adopted section has two main parts. First, employers must ensure employees take at minimum the mandatory cool-down rest periods of (i) 10 minutes every 2 hours when the temperature is 90-100°F, and (ii) 15 minutes every hour when the temperature is at least 100F. Employers also have the option of implementing additional more protective rest periods per the National Institute for Occupational Safety & Health (NIOSH) or the American Conference of Governmental Industrial Hygienists (ACGIH) methods.[44] L&I intends to review the work-rest periods within 3 years of the rule going into effect, which includes but not limited to HRI claims, and inspections, amongst others. Secondly, employers must closely observe employees for signs and symptoms of HRI by implementing one or more of either (a) regular communication with employees working alone, (b) a mandatory buddy system, or (c) other effective means of observation.

[44] See note under section WAC 296-62-09547 for more details.

Mandatory cool-down rest period at 90°F

Analysis of weather data for the period 2011-2020 shows that temperatures between 90°F to 100°F lasted on average 1.2 hours per day for an average of 7 business days per year.[45] L&I estimates that the average number of workers impacted at this temperature range would be about 122,430 each year. Therefore approximately 516,674 ten-minute rest periods would be required each year by all impacted employees. Using the starting weighted average hour wage (plus benefits) of $47.05 for the base year and adjusted for wage inflation over future years, L&I estimates the total cost to impacted businesses for the mandatory 10-minute rest periods to be about $4,842,223 each year (see Table 2.11).

Table 2.11. Cost of mandatory cool-down rest periods at 90° - 100°F

Cost Factor	
Average number of workers impacted over 9 years	122,430
Average number of affected hours per day	1.2
Average number of affected days per year	7
Average number of 10-minute rest periods per year	516,647
Total cost over 9 years	$44,405,457
Annualized cost	**$4,842,233**

Mandatory cool-down rest periods for 100°F temperatures

This rest period requires exposed employees to take a 15-minute rest period each hour when the temperature is at least 100°F or greater. Using the same historical weather data, the average number of hours per day when the temperature was at least 100°F was about 0.4 for an average of at least one business day. In determining the cost to impacted businesses L&I assumes no significant change to this historical weather pattern. It is reasonable to assume that at this high temperature businesses would implement additional engineering or administrative controls which would reduce the number of workers actually outdoors and exposed to this temperature level. To account for this L&I adjusted the number of impacted workers down by 25% to reflect a number closer to what would actually be impacted. This results in an average of 91,822 annually who would be exposed to outdoor work temperatures of at least 100°F. Using the same adjusted weighted hourly wage above, L&I estimates the annual cost of this requirement to be $10,895,002 (see Table 2.12).

[45] While the 1.2 daily rate is below the 2 hour threshold, there were days when the daily hours did exceed the 2-hour threshold.

Table 2.12. Cost of mandatory cool-down rest periods at 100°F

Cost Factor	
Average number of workers impacted over 9 years	91,822
Average number of affected hours per day	0.4
Average number of affected days per year	1
Average number of 15-minute rest periods per year	774,970
Total cost over 9 years	$99,912,278
Annualized cost	**$10,895,002**

Close observations at or above 90°F

As mentioned in the section introduction, employers with employees exposed to outdoor heat temperature of at least 90°F must closely observe these employers for HRI using one or more of 3 options. To determine the likely cost of this requirement L&I analyzed the first two options – regular communication and mandatory buddy system. Similar to the analysis above which required these options, L&I did not analyze the third option for cost given the wide variety of choices an employer could make.

The method used to estimate the cost of the regular communications option is the same as described in section 2.4. Analysis here resulted in an estimate of approximately 3,030 workers in a 9-year period who are likely working alone and need communication equipment for close observation. The number of devices needed for communication would be twice that number – one for the employee and one for the supervisor assuming a one-to-one relationship. Based on the average price of $59.21 for a typical radio and adjusted for inflation over time, L&I estimates the total device cost to be $423,170. These workers combined with the others working together totals about 1.1 million combined across all industries. Using the average observation time of about 2 minutes, and the starting weighted average hourly wage (adjusted over time for wage changes), L&I estimates the observation cost to be approximately $26,755,119. This observation cost combined with the equipment costs would impose a total cost of $27,178,289 over the entire period, or $2,963,785 each year, on impacted businesses.

The mandatory buddy system can be seen as simply each worker checking in and observing another for signs and symptoms of HRI. Using the same number of impacted employees, observation time and starting weighted hourly wage, this option is expected to impose approximately $26,755,119 for the total cost, or $2,917,530 annualized cost, on impacted businesses (see Table 2.13).

Table 2.13. Close observation cost at or above 90°F

Cost Factors		
Regular Communication	Number of workers to be observed each year Number of workers needing devices	122,430 3,030
	Total device cost in 9 years	$423,170
	Total observation cost in 9 years	$26,775,119
	Total cost in 9 years	$27,178,289
Buddy system	Number of workers to be observed each year Total cost in 9 years	122,430 $26,775,119
Overall	Total cost range in 9 years Annual cost	$26,775,119 - $27,178,289 $2,917,530 - $2,963,785

2.1.6 Responding to Signs and Symptoms of Heat-Related Illness

WAC 296-62-09550 and 296-307-09750 have been amended to require employers to ensure that an effective means of communication is maintained in order to facilitate communication between employees at worksites and their supervisors to report any signs and symptoms of HRI which needs attention. These communication devices would likely be a cellular phone or radio.

This requirement is in line with or supplements existing WAC 296-800-15020 which requires employers to ensure first-aid personnel are available for quick response, and WAC 296-800-140(2) for Accident Prevention Program (APP) and safety orientation that address how and when to report injuries and unsafe conditions, and what to do during emergencies. As a result of being consistent with these existing WACs, it is believed that all impacted employers would already have the necessary communication system in place to ensure workers can communicate with their supervisors about any HRI. As a result, this requirement is not expected to impose any new device cost upon impacted businesses.

2.1.7 Information and Training

WAC 296-62-09560 and 296-307-09760 require employees and supervisors to be trained prior to outdoor work where occupational exposure to heat may occur, and annually thereafter. Employees must be trained on acclimatization and the importance of taking preventative cool-down rest periods, among other topics. Supervisors must now be trained on the importance of considering the use of engineering or administrative controls in order to reduce employees' exposure to heat.

The updates to the employee and supervisor training section would have a cost implication to impacted businesses. First, employers would need to update their training material to include the new information to which employees and supervisors must be trained. While annual training is

not a new requirement, the adopted amendments would add additional time to training and so add an administrative cost. In order to estimate the cost of this requirement L&I relies upon the following assumptions:

- Updating the training material would take approximately 1-2 hours of administrative time.
- Training on the new components would add approximately 10-15 minutes of training time.
- There is no cost of training material.

Updating the training content with the new material is a one-time cost which would be incurred by all impacted businesses. Using a starting weighted hourly rate of $80.17 (and adjusted for wage changes over time) for an employee most likely updating the material, L&I estimates this would impose approximately $335,941 - $671,881 each year (see Table 2.14).

Table 2.14. Cost of updating training content

Cost factor	
Average time to update training material	1 to 2 hours
Hourly labor cost (wage and benefits)	$80.17
Average cost of updating training material per business	$80.17 - $160.34
Number of impacted businesses	31,274
Estimated one-time cost to update training material	$2,507,196 - $5,014,392
Annualized cost	$335,941 - $671,881

WAC 296-62-09560(2) and 296-307-09760(2) made amendments to the employee training requirements. Under subsection (e) for instance, employees must now be trained on the concept of acclimatization. The adjustments to this requirement would add approximately 10 to 15 minutes of additional training time to employee training each year. Using a starting weighted hourly employee wage of $47.05 (and adjusted for wage inflations over time) and the starting weighted hourly wage of a trainer of $80.17 (also adjusted over time), L&I estimates the total cost of this additional training time to be $3,919,791 to $5,909,687 each year (see Table 2.15)

Table 2.15. Cost of employee training

Cost factor	
Average number of impacted employees per year	420,371
Average time for new training	10-15 minutes
Hourly labor cost for an employee	$47.05
Hourly labor cost for a trainer	$80.17
Total cost of employee training over 9-year period	$36,153,020 - $54,229,530
Annualized cost	$3,939,791 - $5,909,687

The cost of supervisor training to impacted businesses is similarly expected to impose additional cost. Under the adopted section supervisors would now be required to be trained on the importance of considering the use of engineering or administrative controls in order to reduce employees' exposure to heat. This training too is expected to add about 10 to 15 minutes of additional time to existing training. Using a starting weighted hourly wage of supervisor of $56.76 (and adjusted for changes over time) plus a similar weighted hourly wage of a trainer, L&I estimates this requirement would impose approximately $50,497 to $75,746 each year (see Table 2.16).

Table 2.16. Cost of supervisor training

Cost factor	
Average number of impacted supervisors per year	4,468
Average time for new training	10-15 minutes
Hourly labor cost for a supervisor	$56.73
Hourly labor cost for a trainer	$80.17
Total cost of supervisor training in 9 years	$463,487 - $695,230
Annualized cost	$50,497 - $75,746

The total cost of the adopted information and training amendments would impose approximately $4,326,229 - $6,657,314 each year.

2.2 Summary of Compliance Cost of Adopted Rule

Overall the adopted rule amendments are estimated to impose $40.7 million - $49.1 million of cost on all impacted businesses each year (see Table 2.17).

Table 2.17. Summary of total cost

Requirement	**Cost range**
Employer and employee responsibility	$127,670 - $331,432
Access to shade	$183,289 - $401,354
Drinking water	$2,456,145 - $8,041,270
Acclimatization	$14,941,650 - $14,994,852
High heat procedures	$18,654,756 - $18,701,011
Employee training and information	$4,326,229 - $6,657,314
Total	**$40,689,738 - $49,127,233**

Chapter 3: Benefits of Adopted Rule

3.1 Methods and Data Sources for Benefit Analysis

3.1.1 Estimate of the Effectiveness of Washington's 2023 Occupational Heat Exposure Rule Update

Implementation of Washington's occupational heat exposure rule is likely to reduce the number of occupational HRI cases and heat associated traumatic injuries. Our method for estimating the proportion of cases prevented by Washington's updated occupational heat exposure rule is as follows:

- Using published studies describing the effectiveness of heat-related illness prevention programs, establish an upper and lower bound estimate for the reduction of HRI cases with implementation of Washington occupational heat exposure rule.

- Adjust the effectiveness estimates by comparing Washington's occupational heat exposure rule interventions to program components in published intervention studies.

Using published intervention studies to reduce heat-related illnesses and heat associated traumatic injuries, establish an upper and lower bound estimate for the reduction of HRI cases for Washington's adopted occupational heat exposure rule.

> **Three studies summarized below demonstrate that heat illness prevention programs can eliminate or nearly eliminate the occurrence of heat-related illness. These studies represent the upper bound effectiveness of the OHE rule.**

Minard (1967) reported the development and implementation of heat casualty prevention program at Marine Corps Recruit Depot Parris Island. The program was directed towards new male US Marine Corps recruits. The program also included liberal water and salt intake during hot weather, indoctrination of recruits and drill instructors in hot weather hygiene, a "breaking in period for new recruits, rational clothing practices, and special conditioning platoons for obese recruits and others substandard in physical fitness." The program also included modifying activity levels, based on Wet Bulb-Globe Temperature Index (WBGT) and whether recruits had been acclimatized, as follows:

- At WBGT 85 strenuous exercises are curtailed for non-acclimatized trainees.

- At WBGT 88 trainees who have had less than 10 weeks of training in the geographic area cease vigorous drills and exercises.

- At WBGT 90 fully acclimatized personnel cease training.

Following development and implementation of the program, HRI cases decreased from a weekly incidence of 39.5 per 10,000 recruits in 1952-53 to less than 0.52 per 10,000 recruits in 1962, an almost 99% reduction in prevalence. The reduction occurred in the setting of similar annual measures of mean temperatures and WBGT indices.

Stonehill (1961) reported an intervention to prevent heat illness during recruit training at Lackland Air Force Base in Texas during the summers of 1957 and 1958. The 1957 intervention consisted of provision of adequate water and salt intake, training of instructors and troops regarding heat illnesses and its prevention, scheduling training times during cooler parts of the day and discontinuation of training when temperatures exceeded 95°F (dry bulb), using clothing with more ventilation, and use of helmet liners to block direct sunlight. In 1957, the rate of heat casualties was 39/45,095 exposed troops or 8.65 cases/10,000 troops. In 1958, cessation of training activities were guided by the use of the WBGT index, with cessation of activities at WBGT of 88°F and there was a subsequent reduction of heat casualties to 2/42,112 troops or 0.47 cases/10,000 troops, or a 95% reduction in prevalence.

McCarthy et al. (2019) developed and implemented a Heath Stress Awareness Program (HSAP) for municipal workers in a mid-size, central Texas city. The HSAP was similar to guidelines outlined in *OSHA's Heat Stress Technical Manual* and *NIOSH's Criteria for a Standard, Occupational Exposure to Heat and Hot Environments*. The program included unlimited access to cool water or cold sports drinks close to the work site; training for supervisors and employees on the signs and symptoms of heat stress and heat illness, and first aid and emergency response procedures; access to shade and rest; preferences for breathable clothing, establishing provisions for acclimatization schedule for new workers or established workers returning from an absence during the hot season; and work/rest procedures so that exposure time to high temperatures and/or the work rate is decreased. A medical monitoring program was established to identify individual HRI risk factors and higher risk individuals were provided individualized HRI prevention counseling. Supervisors were notified of worker's ability to perform essential job requirements with or without accommodation in a heat stress environment.

Pre-intervention rates of heat-related illness, in CY 2009 of 27/1000 workers and CY 2010 of 24/1000 workers, decreased following the implementation of the program to no cases in CY 2016 and 2017, thus reporting the elimination of HRI in this working population following HSAPs implementation.

> **Two studies summarized below report on limited programmatic interventions to prevent heat-related illness or heat associated traumatic injury risk. The studies suggest an intervention effectiveness of an approximately 50% reduction in heat-related illness or heat associated traumatic injury risk.**

Kerstein (1986) reported on a heat casualty prevention program among infantry reservists that relied on an educational program on the importance of hydration, training on the use of a 'Botsball device' – a portable monitoring device that measures WBGT index, and a special briefing for commanding officers. A second group received only the 'normal advice and direction on hydration' and served as controls. Training was matched and parallel (concurrent) for the two infantry groups, however the training for the intervention group was guided by WBGT 'leadings.'

The efficacy of the intervention, essentially the training on the use of a portable environmental monitoring device and modification of training activities at the discretion of the commanding officer, led to a 54% reduction in the prevalence of heat casualties. The heat casualty rate in the

intervention group was 9.1 per 100 reservists as compared to the rate in the control group of 4.2 per 100 reservists.

Park (2021) assessed Cal/OSHA heat exposure regulations on the reduction of the excess number of occupational injuries associated with heat exposure. California initially adopted regulations for 'Heat Illness Prevention in Outdoor Places of Employment in 2005, with subsequent revisions in 2015. Cal/OSHA regulations (California Code of Regulation, Title 8, Chapter 4,§3395) require: employee access to sufficient quantities of potable drinking water, training on the prevention and identification of heat illnesses, employee access to shade, allowing employees 5-minute preventative cool-down rest periods, employer's close observation and monitoring of employees newly assigned to high heat areas or all employees when exposed to a heat wave, inclusion of high heat procedures when temperatures reach 95°F, which include observing, monitoring and communicating with exposed employees at all times, having emergency response procedures coupled with a mandatory 10 minute rest period every two hours in agricultural employers.

Park estimated the magnitude of the decline in injuries: '[for] the difference in implied annual injury burden due to heat in the period prior to and after 2005, … We find that hotter temperature caused approximately 6100 injuries per year in the period 2001-2005, versus approximately 4250 injuries per year in the period 2006-2018, suggesting a significant decline of approximately 30 percent.' Of note, the estimated decline occurred in the context of incomplete employer compliance with the heat exposure regulations, suggesting that if all employers had complied with the regulation, the decline in injuries is likely greater than estimated by Park. For example a 50% non-compliance estimate for the California heat regulation,[46] as provided by Cal/OSHA, would translate into a 60% decline in heat associated traumatic injury if all employers had complied with the regulation. Further California revised their heat illness prevention rule in 2015 and adopted greater heat-related illness protections for workers, suggesting that the estimate provided by Park would be underestimated.[47]

Estimate the effectiveness of Washington's adopted occupational heat exposure rule by comparing it to the program components in the published intervention studies above, and consider any adjustments based on differences in the working populations.

The intervention studies described above took place in either military recruits/reservists or within civilian working populations. In interpreting these studies we must consider the likely workloads experienced by the study populations and the underlying health and fitness level of the workers. Military recruits during training likely experience higher workloads and possibly more stringent PPE requirements than many workers in the civilian workforce. Heavier workloads and non-breathable clothing increase the risk for heat-related illness. However, we would interpret the military recruit population as a younger, healthier working population where individuals with significant underlying health conditions are excluded or are not placed in positions of high

[46] California Department of Industrial Relations Memo. October 18, 2007. Cal/OSHA investigations of Heat-Related Illness 2006. Available at https://www.dir.ca.gov/dosh/heatillnessinvestigations-2006.pdf; accessed January 20, 2022.

[47] California Department of Industrial Relations. (2015). Heat Illness Prevention Regulation Amendments. Guidance for Employers and Employees on the New Requirements, May 14, 2015.

exertion in the heat. The prevalence of health conditions that place workers at risk for heat-related illness, e.g. heart disease, diabetes, is likely higher in the civilian population, suggesting the estimates of effectiveness of the military intervention studies may be lower in the civilian population. (Chao, 2013; Webber, 2023; O'Donnell, 2018)

We assume that interventions have the potential to reduce heat-related illness similarly in different populations. In other words, the proportion of heat illnesses prevented through HRI prevention programs with common elements in both military and civilian populations would be similar across the two working populations. However, while many of the specific control measures for preventing heat-related illness are the same across military and civilian populations, programmatic adjustments to account for underlying disease morbidity, varying physical fitness levels and other factors in civilian populations likely are necessary. Further, due to the nature of the military workplace, there may be greater compliance with heat control policies, specifically with hydration, clothing ensembles, workload levels, and rest period utilization than civilian workplaces. Therefore, in estimating the potential benefit of Washington's adopted occupational heat exposure rule, we will focus on the intervention studies to control HRI or heat-related injury in civilian working populations. Specifically, these are the Heat Stress Awareness by McCarthy (2019) and the California Division of Occupational Safety and Health regulation[48]for control of occupational heat exposure.

All considered intervention programs through rule or voluntary programs include hydration, training programs for supervisors and workers on HRI risks, prevention and symptoms. Generally the primary differences between the researched civilian programs and policies are: McCarthy's (2019) implementation of the Heat Stress Awareness Program (HSAP) has program elements that may be more effective in reducing HRI and heat associated traumatic injury than Washington's adopted OHE rule; specifically, acclimatization processes, work/rest procedures, and medical monitoring programs.

In McCarthy, the design of the HSAP preceded federal guidance documents but had acclimatization programs with graduated increases in the percentage of time working in a hot environment with adjustments for whether the worker is new to the job tasks or returning to the job following an absence. The Washington rule has an expectation of observing and monitoring these employees in the first 14 days of employment and during heat waves but does not have any programmatic increase in exposure times in the first several days of employment. The impact of this difference suggests the HSAP to be more effective than Washington's adopted rule. An analysis of Washington's State Fund workers' compensation claims reveal that ~16% of HRI claims occur in the first two weeks of employment.[49] However, the HSAP publication did not appear to have acclimatization procedures in the context of temperature changes, i.e. 'heat waves,' but communication with the study author (R. McCarthy, 1/13/2023) reflected supervisor's acting to shift work to earlier parts of the day, more emphasis on hydration, and increased breaks.

[48] California Code of Regulation, Title 8, Chapter 4,§3395 Heat Illness Prevention in Outdoor Places of Employment.

The HSAP also included mitigation of metabolic heat load through work/rest schedules or moderation of work intensity, all of which the supervisor could modify at their discretion likely resulting in more effective HRI reduction than Washington's adopted rule. Within the Washington State data more than 50% of claims are occurring at maximum daytime temperatures greater than 90°F. While the adopted rule in Washington state is less protective than published recommendations for work-rest cycles, inclusion of the mandatory periodic rest periods at 90°F (10 min every 2 hours) and at 100°F (15 minutes per hour) coupled to an employee determined preventative cool-down period, likely provides partial protection relative to the generally accepted published work-rest cycles. A secondary benefit of structured rest periods may be the facilitation of the recognition of the risk of HRI to workers and work initiated preventative measures (e.g., shade, hydration). Third, mandatory rest periods likely diminish 'motivational' heat-related illness cases – a subset of HRI cases caused by motivations to skip breaks such as piece rate pay.

The third element of the HSAP that may lead to more effective reduction in HRI cases than Washington's adopted rule is the medical monitoring program, which involves individual evaluation of HRI risk factors and provisions of work accommodations when the medical conditions created risk. While there is no requirement for medical monitoring in Washington's rule, there exists specific training requirements for workers and supervisors on the medical conditions that create risk for HRI, training on the symptoms and emergency response procedures for HRI cases and also monitoring requirements during high heat environments. The second study comparable to Washington's adopted occupational heat exposure standard is the evaluation of the impact of California's Heat Illness Prevention in Outdoor Places of Employment regulation. As mentioned above, the regulation was updated in 2015 to be more protective.

Washington's adopted occupational heat exposure rule is similar to California's current regulations. The primary difference between California's current rule and Washington's adopted rule is in regard to work-rest cycles. According to California's rule, workers in agriculture only, are entitled to a 10 minute rest period for every 2 hours worked when air temperatures exceed 95°F. The adopted Washington rule includes for **all** outdoor workers, a 10 minute rest period every 2 hours when temperatures exceed 90°F, and 15 minute rest period for every hour worked when temperatures exceed 100°F.

In estimating the benefit of Washington's adopted Occupational Heat Exposure rule, the range would be between 50% to 100% effectiveness in reducing cases of heat-related illness. Given the relative robustness of the HSAP's acclimatization schedules and work-rest cycles, and the medical monitoring with accommodations for those workers with risk factors for HRI, Washington's adopted rule is likely at the lower end of this range. California's rule was estimated to reduce HRI cases by 50%. However, this estimate of effectiveness accounted for significant levels of employer non-compliance, as well as covering a period when a much less stringent rule was in place. Given this, a reasonable estimate of the potential reductions in HRI and heat associated traumatic injury for Washington's rule would be approximately 55-65%.

3.1.2 Washington Regional Threshold Exceedances and Heat Wave Days

Weather data from 1/1/11-12/31/2020 (10 years) were downloaded from NOAA/NCEI's U.S. Local Climatological Data product.[50] Twenty-seven surface weather observation stations (ASOS/AWOS) across 21 Washington State (WA) counties that had available maximum daily temperature (dry bulb temperature) and hourly temperature data were included in the analysis. Eastern WA (E. WA) and Western WA (W. WA) regions were defined using county borders nearest the Cascade Ridge line.[51] For the analysis, daily maximum temperature (T_{max}) values from each weather station were first averaged within a county. The average daily T_{max} in that county on that day was then determined to: 1) be at or above temperature thresholds (≥52, 80, 90, 100°F) or not; and 2) be a heat wave day (≥52°F or ≥80°F AND T_{max} ≥10°F higher than average T_{max} over past 5 days) or not. Next, the number of days at or above thresholds and heat wave days were tabulated over the entire year and for May-September and October-April periods of each year for each county to yield the total number of days during each period within each county. Then, the mean total number of days across E. WA and W. WA counties was computed for that period. Finally, this total number of days was averaged across all of the included years (2011-2020) to yield the results in the Table 3.1.

This approach *did not* count up days for which *at least one* county or weather station in E. or W. WA was at or above a threshold (or met the definition of a heat wave) in a given period, which would produce higher estimates (e.g., if only one county in E. WA met the definition of a heat wave on a particular day, all of E. WA would be designated to have a heat wave day on that day, even if the majority of E. WA did not meet the definition of a heat wave on that day). Rather, the number of days in each county during each period were averaged together to produce summary metrics for the typical yearly heat exposure experience across E. and W. WA. This daily-level analysis did not take into account day of the week (i.e., no assumptions were made about which days of the week workers work), future climate projections, or the hours of the day that workers may be working (i.e., T_{max} may occur after the end of the work shift for certain workers who end work early on hot days).

Table 3.1 Yearly regional summary of days at or above thresholds and heat wave days

	≥52°F	≥80°F	≥90°F	≥100°F	≥52°F & 'heat wave'*	≥80°F & 'heat wave'*
E. WA						
Annual	248	92	40	7	28	15
May-Sept	151	90	40	7	15	13
Oct-Apr	97	3	0	0	13	1
W. WA						
Annual	254	25	4	0	17	8
May-Sept	150	24	4	0	11	8
Oct-Apr	104	1	0	0	6	0

*'Heat wave' = T_{max} ≥10°F higher than average T_{max} over past 5 days *Note: May-Sept and Oct-Apr numbers may not add up to Annual numbers due to rounding (to nearest day) and regional calculation procedure*

[50] https://www.ncei.noaa.gov/access/search/data-search/local-climatological-data
[51] https://wsdot.wa.gov/sites/default/files/2021-10/Env-Wet-EastWestBoundary.pdf

3.1.3 Indirect Cost Estimates for Employers

Workers compensation costs for medical and wage-replacement benefits and the associated costs to administer these claims are the direct costs that employers bear for HRI and injury claims. However, research has shown that there are sizable injury and injury-related costs that are not covered by workers compensation insurance, which nonetheless are borne by the employer. These costs are commonly referred to as uninsured or indirect costs. Indirect costs include productivity losses due to an injured workers absence and reduction in coworkers' productivity following the injured workers' return to work. Also included in the indirect cost category are the additional recruitment and training efforts for replacement workers and additional company administrative costs for dealing with the injury episode, including accident investigations, recordkeeping and reporting. A company with a high level of claims may need to hire additional staff in order to maintain production levels. Researchers using a variety of methods and definitions of indirect costs have estimated the magnitude of indirect costs to employers in several industries, with a broad range of results. Estimates of the size of indirect costs range from 10 to 2000% of direct costs (Andreoni, 1986). This wide range is due to both the large variances of indirect costs across industry groups, the size of the direct costs, and the inclusiveness of the researcher's investigation of indirect costs.

H.W. Heinrich evaluated both the indirect and direct costs of workplace injuries from a large number of industrial accidents from the 1920s through the 1940s and estimated an indirect to direct cost ratio of 4:1 (Heinrich, 1959). More recently, a review study suggested indirect costs could range from 1.6 to 20 times direct costs, with a median of 4.1 (Andreoni, 1986). Another study, based upon work conducted by the Stanford University Department of Civil Engineering, found that the size of indirect costs is inversely related to the seriousness of the injury, i.e. the less serious the injury the higher the ratio of indirect costs to direct costs (Levitt et al., 1981). Levitt's estimates of indirect losses to employers from workplace injuries include the following:

- Any wages paid to injured workers for absences not covered by workers' compensation;
- The wage costs related to time lost through work stoppage associated with the worker injury;
- The overtime costs necessitated by the injury;
- Administrative time spent by supervisors, safety personnel, and clerical workers after an injury;
- Training costs for a replacement worker;
- Lost productivity related to work rescheduling, new employee learning curves, presenteeism, and accommodation of injured employees; and
- Clean-up, repair, and replacement costs of damaged material, machinery, and property.

It should be noted that certain possible kinds of indirect costs are not included in these estimates, including:

- The costs of OSHA fines and any associated legal action;
- Third-party liability and legal costs;
- Worker pain and suffering; and
- Loss of good will from bad publicity.

Levitt's study includes the following table which provides a summary of the indirect cost amounts to be expected for each level of direct claim cost. Note that these cost intervals have been adjusted for inflation from their original 1981 levels to 2022 dollars:

For lost-time claims with direct costs of the following amounts:	Direct: Indirect Cost Ratio
0 - $8999	1:4.1
$9000-$15999	1:1.6
$16000-$31999	1:1.2
+$32000	1:1.1
No lost time	
0-$649	1:4.2
$650-$1300	1:5.1

Source: Raymond E. Levitt, Henry W. Parker, Nancy Morse Samuelson (1981): Improving Construction Safety Performance: The User's Role. Volume 260 of Technical Report. Department of Civil Engineering, Stanford University. Department of Civil Engineering.
Note: Dollar intervals were adjusted from 1981$ to 2022$ using the BLS-CPI.

Given that the weighted average cost of a HRI claim is $5,508; while that of a non-work-related musculoskeletal disorders (WMSD) injury claim that could result from heat stress is $19,558, the above table of typical indirect-direct cost ratios would suggest a choice of 4.1 as a reasonable measure of the indirect costs of HRI claims borne by employers. A ratio of 1.6 would be the appropriate measure of indirect costs for non-WMSD claims. We have accordingly adopted these ratios to estimate the costs of injuries borne by employers and not recoverable through insurance coverage.

3.2 Quantitative Benefits

3.2.1 Benefits of Preventing Occupational Heat-Related Illnesses

The best means L&I has for capturing and quantifying this anticipated benefit in dollars was to look at past State Fund Workers' Compensation (WC) claims costs associated with HRI. The Safety & Health Assessment & Research (SHARP) group within L&I provided data on HRI WC claims costs for 2006-2021. SHARP summarized HRI WC claims from 2006-2017 and has published the results (Hesketh, 2020) and supplemented these results with the HRI claims from 2018-2021 (SHARP, 2022). The methods for identifying suspected cases and confirming them as HRI WC claims are described in detail in Hesketh, et al. 2020. Briefly, SHARP researchers queried L&I's administrative Data Warehouse and identified claims with either ICD-9/10 or Occupational Injury or Illness Classification codes suggesting occupational heat exposure and occupational HRI with dates of injury for the time frame under study. Next, the researchers extracted the worker, physician, and employer electronic claim text fields describing the injury from the Report of Industrial Injury and Occupational Disease (RIIOD), also known as the Report of Accident (ROA) form. Two researchers then independently reviewed the text fields in the RIIOD to determine whether or not the claim appeared to be consistent with HRI. In cases where the information in the text fields was inconclusive, the researchers reviewed the medical records for the claims in question. When the two reviewers did not initially agree, they reviewed the text fields and medical records again to arrive at a consensus (Bonauto, 2007; Hesketh, 2020).

Once the researchers had determined that a case was indeed an HRI claim, they estimated costs on an annual basis using the "actuary incurred total" field. This provides an estimate of future expenses for open claims (by the case reserve unit), in addition to the actual paid to date costs for closed claims. It includes the costs of time loss, pensions, and medical treatment. In order to get a case reserve estimate of future expenses, a claim must be open for about nine months. In cases where the claim has already been closed, the actuary incurred total estimate is equivalent to the paid to date expenses for that claim and is unlikely to change unless the claim is reopened. Additional claim review determined if the claim was unlikely to be an outdoor claim, and each claim was assigned a daytime maximum temperature for the day of injury (Hesketh, 2020). We adjusted medical and all other costs separately to 2022 dollars using the BLS Consumer Price Index-medical and -excluding medical, respectively, to account for inflation.

Table 3.2: Case Counts of Heat-related Illness Claims[1] with Daytime Tmax <80ºF[2] and/or Indoor Work Environment, WA State Fund, 2006-2021

	All Claims Filed	**Accepted Claims**	**Rejected Claims**
	Number (%)	Number (%)	Number (%)
Total Claims	1317 (100)	850 (100)	467 (100)
Day Tmax <80ºF	269 (20.4)	153 (18)	116 (24.8)
Unlikely Outdoor Work Environment	217 (16.5)	110 (12.9)	107 (22.9)

Both Daily Tmax <80ºF and Unlikely Outdoor Work Environment	63 (4.8)	28 (3.3)	35 (7.5)
Either Daily Tmax <80ºF or Unlikely Outdoor Work Environment	423 (32.1)	235 (27.6)	188 (40.3)
Claims with Daily Tmax ≥80ºF and NOT Unlikely Outdoor Work Environment	894 (67.9)	615 (72.4)	279 (59.7)
[1] Case identification methods per Hesketh, AJIM 2020.			
[2]13 claims excluded due to inability to identify location for temperature assessment			

Table 3.3: Outdoor HRI State Fund Workers Compensation Claims and Costs Occurring with Tmax on Date of Injury ≥ 80ºF, in Washington State, 2006-2021, costs adjusted for inflation to 2022 dollars

Year	# Accepted Claims	Accepted Claim Costs ($)	# Rejected Claims	Rejected Claim Costs ($)
2006	37	66,206	9	5,320
2007	43	62,134	2	2,964
2008	24	38,199	5	1,631
2009	49	162,215	14	14,566
2010	40	1,625,521	5	15,382
2011	25	38,978	6	8,381
2012	33	55,533	9	12,364
2013	38	73,295	16	19,211
2014	62	99,874	13	13,336
2015	42	47,362	21	21,743
2016	26	20,266	17	15,152
2017	53	65,883	28	32,463
2018	40	52,916	40	50,387
2019	15	117,074	32	29,566
2020	25	21,239	16	12,225
2021	63	854,037	46	73,932
Total	**615**	**3,400,733**	**279**	**328,623**

Using these figures we excluded claims that were unlikely to having occurred outdoors and when the daytime maximum temperature was less than 80ºF (Table 3.2). The number of eligible claims by year and annual costs are described in Table 3.3. For eligible accepted claims over a 16-year period (2006-2021), L&I estimated the average annual cost of accepted HRI claims as $212,546 per year. L&I also rejected a number of WC claims filed for HRI during this time frame, but still had expenses related to those claims. Using the figures above, an average annual cost of rejected

HRI claims was $20,539. Thus the total annual average WC claim costs for all HRI claims, accepted and rejected, was $233,085.

Since the Washington State Fund only provides workers' compensation insurance for approximately 75% of workers in Washington State with the remainder working for employers who self-insure (SI), the number of HRI claims and their costs are underestimated. Assuming self-insured HRI accepted claim rates and costs are similar to the Washington State Fund, the annual estimated costs for all accepted HRI claims, State Fund plus SI, in Washington is **$283,394 [$212,546/0.75].** Similarly, the annual average WC claims costs for rejected HRI claims, State Fund plus SI, is **$27,385 [$20,539/0.75]**.

One limitation of using WC claims data is that a substantial proportion of workers experiencing work-related illness and injuries are known to not report these conditions to the WC system (Fan, 2006; Boden, 2008; Anderson, 2022). Under-reporting of work-related injuries and illness to WC insurers is recognized to impact all WC systems (Azaroff, 2002; National Academies, 2018). For the purposes of estimating the likely extent to which work-related HRIs have not been reported to Washington State WC systems, several studies are relevant (Fan, et al., 2006; CDC, 2010; Anderson, 2022). The study by Fan and colleagues employed data from a statewide 2002 telephone survey conducted through the Centers for Disease Control and Prevention (CDC) known as the Behavioral Risk Factor Surveillance System (BRFSS). From the 2,612 Washington respondents who were working adults at the time of the survey and who were not self-employed, 321 reported having experienced (or been diagnosed as having) a work-related injury or doctor diagnosed occupational illness in the past 12 months. Of those 321 respondents reporting a workplace injury or doctor diagnosed occupational illness, 52% had filed WC claims. Of those who did *not* file a WC claim, 20% reported that their medical costs were paid for through another means (e.g., employer, public health insurance programs, etc.), while 80% reported that their costs were paid by private insurance, family, or there was no payment/no treatment.

Subsequent estimates of underreporting or non-payment of worker injuries and/or occupational illnesses support the estimates in the study by Fan et al. A second statewide survey using BRFSS in 2007, similarly estimated non-payment of ~40% of occupational injuries by WC. In contrast to the study by Fan, this survey was restricted to occupational injuries only and did not inquire about physician diagnosed occupational illnesses (CDC, 2010). Further, in a survey of janitorial workers, a low-wage working population, only 45% of those with a work-related injury or doctor diagnosed occupational illness initiated a WC claim (Anderson, 2022).

A limitation associated with using these BRFSS data to estimate the underreporting of work-related heat-related illness is the survey's requirement that the occupational illness is diagnosed by a healthcare provider. Heat-related illnesses likely occur without a visit to a healthcare provider or result in a visit to a healthcare provider but do not lead to recognition by the healthcare provider or worker that work was the cause of the illness. Evidence suggests a relatively high percentage of work-related illnesses not being reported to workers compensation. From Pransky (1999), only 5% of workers had officially reported a work-related injury or illness during the past year, while over 85% experienced work-related symptoms, 50% had persistent work-related problems, and 30% reported either lost time from work or work restrictions from their ailment. An estimate of significant underreporting to workers compensation of cases of

work-related musculoskeletal disorders has been reported by others, in particular in Connecticut (Morse, 1998), where approximately 5.5 to 7.9% of cases of work-related musculoskeletal disorders were reported to workers compensation.

In estimating the number of HRIs cases that likely *should* have been reported as workers' compensation claims, but were not, L&I, after considering research in detail and in understanding particular issues with reporting occupational illnesses it is reasonable to think that between 5 to 50% of heat-related illness cases result in a workers' compensation claim. After review, a reasonable estimate for this CBA is that only 25% of heat-related illness cases are reported and accepted by Washington workers compensation.

Conservatively, for heat-related illness, it seems possible that the severity of unreported cases may be less than those for reported claims. We have not included the additional costs of rejected heat-related illness claims in the Washington workers' compensation data (Table 3.3). As discussed in Hesketh (2020), these claims often presented as heat-related illness, were treated and resolved; so although work likely caused the heat-related illness, the claim was rejected since treatment resolved the illness. Considering these rejected claims as possibly representative of cases that may not have entered into the workers compensation system, we will use these costs for unreported cases –or approximately 10% of the cost of accepted cases. The total estimated costs of reported HRI claims and unreported heat-related illness weighted using the ratio of 1 claim to 3 unreported cases provides an estimated annual cost for HRI in Washington at **$365,549 [$283,394 + 3 ($27,385)]**

Finally, the annualized costs need to be adjusted for the estimated effectiveness of the occupational heat exposure rule. As provided elsewhere, our lower estimate of effectiveness of the occupational heat exposure rules suggests a reduction of 55% of heat-related illness cases and an upper bound estimate of 65% reduction of heat-related illness cases. Applying the lower bound estimate for effectiveness, the estimated savings/benefit in adopting the occupational heat exposure rule based on accepted claims only ranges from **$201,052 [$365,549 x 0.55]**. Applying the upper estimate for effectiveness, the estimated savings/benefit in adopting the occupational heat exposure rule for accepted claims is from **$237,607 [$365,549 x 0.65]**.

These cases are not without additional costs borne by workers, employers and society. As described above, the estimation of the indirect costs associated with HRI are a ratio of 4.1 dollars of indirect costs to 1 dollar of direct costs. Thus the lower bound costs for HRI cases is **$1,025,365** and the upper bound costs are **$1,211,796**.

L&I believes these to be conservative estimates for three reasons. First, Fan et al. (2006: 919) also found that workers in two industry sectors—agriculture, forestry, fishing; and construction "ranked comparatively higher in stating they had had work-related injury or illness and lower in WC claim filing." Similarly, the authors found that by occupation, "farming/forestry/fishing ranked the highest in having had a work-related injury or illness and second lowest in WC claim filing" (Fan, et al., 2006: 919). Both findings are significant given that, together, agriculture/forestry/fishing and construction are recognized as having many workers in an outdoor environment (Spector, 2014; NIOSH, 2016). Secondly, the authors reported that two factors that emerge in the peer-reviewed academic literature as being related to underreporting of

WC claims are work in a non-manufacturing sector and work in small firms. Both factors are at play for workers exposed to HRIs in the outdoor environment. Finally, another study identified problems with data on HRI that are also relevant to this analysis: (1) data were only available for severe cases involving hospital admissions, (2) mild HRIs were not recorded despite their effect on performance, (3) medical providers did not have a good understanding of the criteria for diagnosing HRI, and (4) because HRI and fatalities occur seasonally, their apparent significance can be underestimated by a tendency to focus on annual rates of occurrence (Kerstein, et al., 1986).

In addition to the aforementioned factors, there are at least two limitations of the data that lead L&I to believe these benefits are underestimated: (1) by using time loss payments to estimate the amount of time workers were away from work, it underestimates lost wages, lost days, benefits, and taxes because compensable (time loss) claims do not compensate workers at 100% of their lost wages or for all lost workdays (i.e., there is a waiting period of three days before a workers is eligible wage replacement benefits, and (2) it is likely that medical billing for claims is incomplete (Asfaw, 2013). In review of individual claim costs associated with accepted state fund HRI claims, 22/615 (3.5%) had zero dollar claim costs and an additional 19/615 had claims costs less than $100. And while the field in L&I's administrative data that was used to capture claims costs does include a reserve set aside for open claims, this is only currently relevant for one claim in these data. In all other cases, the claims are closed such that the reserve amount is equivalent to the total paid-to-date amount. In sum, L&I believes using WC claims data alone leads to a downwardly biased estimate of the benefits of preventing HRI.

3.2.2 Reduction of Occupational Heat Exposure Mortality

In additional to the spectrum heat-related illnesses, excess heat exposure causes increased all-cause and cardiovascular mortality (Rahmnan, 2022; Liu, 2022). Excess heat exposure with resultant heat strain likely places those with underlying diseases, e.g. cardiovascular disease, diabetes, obesity, skin disease at risk for fatal and non-fatal outcomes. Excess attributable deaths due to heat exposure at work may be prevented by the rule. The approach to quantify the potential benefits of the adopted Washington heat rule is described below.

Value of a Statistical Life

An anticipated benefit of the adopted HRI rule is that it will help prevent work-related fatalities. Over the twenty-five-year period from 1997 to 2022, there were six documented fatalities where heat exposure caused occupational heat stroke or was recognized as a contributing cause of a worker's death. L&I considers each fatality to be an unnecessary tragedy, the scope and magnitude of which is impossible to quantify in dollars. Nevertheless, there is much precedent in both tort law and regulatory cost-benefit analyses for doing so as a means of either attempting to compensate for the loss, on the one hand, or to prevent future losses, on the other (Posner and Sunstein, 2005).

One particularly rigorous study improves upon previous attempts to estimate what economists refer to as the "Value of a Statistical Life," or VSL (Viscusi, 2004). The VSL is the value to a person of the incremental reduction in the risk of a fatality. Viscusi (2004) underscores the importance of estimating this value for different segments of the population, namely blue- and

white-collar workers, as well as women and men. In differentiating in this fashion, Viscusi (2004) arrives at a VSL estimate for blue-collar male workers that ranges from $7.8 million to $9.7 million in 2000 dollars, with a mean value of $8.75 million. Since all six fatalities occurred to male workers, the male blue-collar VSL was deemed most appropriate. It is worth noting that this results in a more conservative estimate than using the female blue-collar VSL or taking the average between the two. This is because Viscusi (2004) found the female blue-collar worker VSL to be higher for women than for men, ranging from $8.8 million to $15.5 million in 2000 dollars, with a mean value of approximately $12.2 million. The estimate included in this analysis adjusts the male blue-collar worker VSL upward to $15,002,401 to account for inflation using an online calculator (https://www.bls.gov/data/inflation_calculator.htm).

Benefit of Reducing Excess Deaths due to Occupational Heat Exposure

Khitana (2022) estimated the increase in all-cause mortality related exposure to extreme heat days. Extreme heat days are defined with an absolute component, i.e. a heat index greater than or equal to 90 °F (32.2 °C), and a relative component, a day in the 99th percentile of the maximum heat index in the baseline period for each county. The authors of the work calculated the number of extreme heat days meeting this definition annually from 2008-2017, for all US counties. Annual estimates were defined as the five month period from May through September. At our request the data, the authors provided the data for all Washington counties. Using these data we calculated the average annual number of extreme heat days for Eastern (4.215 extreme heat event days/year) and Western Washington (2.311 extreme heat event days/year). The geographic separation of Eastern and Western Washington followed the county borders on the Cascade ridgeline.

For 20 to 64 year olds, the primary working age population, each additional extreme heat day per month was associated with an excess mortality of 0.04 death per 100,000 individuals. The estimate has to be modified for mortality risk differences between those employed and unemployed – the healthy worker effect. We estimated this conservatively to be a 25% reduction in risk for employed workers (Steenland, 1991; Chowdhury, 2017). Modifying the estimate above for the healthy worker effect, provides an estimate that for each additional extreme heat day per month, there is an excess mortality of 0.03 deaths per 100,000 individuals.
The number of outdoor workers in Eastern and Western Washington, (116,080 workers/288,861 workers) has been estimated previously. Since the number of months defined in a year was five (May through September), we multiplied by 0.03 deaths per 100,000 individuals per one extreme heat day/month by five. This product was multiplied by the number of extreme heat events per year (above), with a resultant estimate of 0.734 excess deaths per year in Eastern Washington and 1.04 deaths per year in Western Washington or 1.735 deaths per year in Washington State. Applying an estimate of the effectiveness of the Washington update occupational heat exposure rule of 55 – 65%, we would expect a lower bound estimate of 0.954 deaths prevented per year and an upper bound estimate of 1.128 prevented deaths per year. Using the value of a statistical life at $15,002,401, the estimated benefit of the Washington OHE rule ranges from $14,312,291 to $16,922,708.

This is an extremely conservative estimate since it represents increased deaths only during extreme heat days. Extreme heat days represent only a fraction of the risk presented by exposure to heat. Alternative scenarios would suggest increasing risk of heat associated mortality as heat

exposure increases. Finally, while the definition of an extreme heat event uses of 90°F heat index, there is no situation where a heat index of 90°F is excluded from coverage under the Washington occupation heat exposure rule.

3.2.3 Heat-Related Traumatic Injury Prevention Benefits

The anticipated benefit in dollars of the adopted Washington State (WA) occupational heat rule on traumatic injuries (distinct from heat-related illnesses Section 3.2.1) can be quantified by estimating the cost of traumatic injury workers' compensation claims that may be attributable to heat that may be prevented by the rule.

Working in the heat may cause fatigue, dehydration, and changes in balance, concentration, and behavior that may increase the risk of traumatic injuries (e.g., falls). Published research in outdoor agriculture (Spector 2016) and outdoor construction (Calkins 2019) in WA has examined the relationship between ambient heat exposure and occupational traumatic injury workers' compensation claims from 2000-2012. The WA studies evaluated the relationship between injury and Humidex (a real-feel metric that is a combination of ambient temperature and humidity) at the location of injury, comparing heat exposure on the day of injury with other days in the same month on the same day of the week at the same location. These studies found an increased risk of traumatic injury in warm conditions. Subsequent research, summarized in a recent study (Fatima 2021), examined the relationship between ambient heat exposure and traumatic injuries across different locations and industries. Fatima 2021 reported a pooled risk of 1.006, 95% CI: 1.004–1.007 for studies conducted in warm Mediterranean climates, including the WA studies described above, and an **overall increased risk of occupational injuries of 1% per 1°C increase in ambient temperature.**

The approach to quantify the potential benefits of the adopted WA heat rule is described below. First, all accepted WA workers' compensation injury claims from May-Sept 2011-2020 were identified by industry and region (Eastern versus Western WA). The May-Sept time-frame was chosen because approximately 95% of HRI claims typically occur during these warmer months. Restricting to warmer months allows capture of injury data most likely relevant to heat exposure and leads to a conservative (lower) estimate of potential benefits, as the adopted rule is in effect all year, and injuries may occur outside the May-Sept window. Eastern WA (E. WA) and Western WA (W. WA) regions were analyzed separately given their relatively different climates and industry distributions. E. WA and W. WA and were defined using county borders nearest the Cascade Ridge line.[52] The location of injury claims was determined from the county of the injury location, and, if missing, the business location county.

Work-related musculoskeletal disorders (WMSDs), which are typically soft tissue disorders that develop gradually over time,[53] were excluded from injury estimates because there has not been specific research examining the relationship between heat exposure and WMSDs. If heat exposure does increase the risk of WMSDs, this exclusion leads to a conservative (lower) estimate of potential benefits. Since information for defining WMSDs is limited for Self-Insured claims that are medical only (do not results in wage replacement or death or disability benefits),

[52] https://wsdot.wa.gov/sites/default/files/2021-10/Env-Wet-EastWestBoundary.pdf
[53] https://www.lni.wa.gov/safety-health/safety-research/ongoing-projects/wmsd-claim-tracking

versus compensable, the ratio of medical only to compensable claims by industry and region was assumed to be the same as for WA State Fund workers' compensation claims and was used to impute the number of medical only WMSD Self-Insured claims. Medical only and compensable WMSD claims were subtracted from all injury claims to obtain non-WMSD injury claims. The average daily number of non-WMSD injury claims was obtained by dividing the total number of non-WMSD injury claims during the 2011-2020 period, by industry and region, by 1,530 (the number of days between May 1st and September 30th [153] times 10 years). It was assumed that there was no variation in injuries over time within the period, even though ambient conditions and work activities may change over the period. The average daily number of injury claims, by industry and region, was then multiplied by the estimated percent of outdoor workers by industry (see methods in Section 1.3). It was assumed that there is a not a difference in injuries among indoor versus outdoor workers and that the percentage of workers outdoors corresponds to the % of injuries outdoors. This yielded the average number of outdoor injury claims per day, by industry and region (Table 3.4).

Table 3.4. Average number of injury claims per day, proportion outdoor, and average number of outdoor injury claims per day by industry and region, May-Sept 2011-2020

Industry	E. WA avg # injury claims/d	E. WA prop. out-door	E. WA avg # outdoor injury claims/d	W. WA avg # injury claims/d	W. WA prop. Outdoor	W. WA avg # outdoor injury claims/d
Agriculture, Forestry, Fishing and Hunting	19.93	0.54	10.80	3.40	0.50	1.69
Mining, Quarrying, and Oil and Gas Extraction	0.15	0.19	0.03	0.27	0.23	0.06
Utilities	0.39	0.22	0.09	0.64	0.15	0.10
Construction	7.31	0.46	3.38	23.55	0.45	10.56
Manufacturing	7.85	0.09	0.72	18.70	0.06	1.20
Wholesale Trade	4.56	0.17	0.76	7.09	0.11	0.81
Retail Trade	6.89	0.07	0.46	18.28	0.06	1.04
Transportation and Warehousing	2.39	0.30	0.72	7.95	0.28	2.20
Information	0.36	0.12	0.04	1.12	0.03	0.03
Finance and Insurance	0.24	0.03	0.01	0.77	0.03	0.02
Real Estate and Rental and Leasing	1.02	0.17	0.18	3.29	0.16	0.54
Professional, Scientific, and Technical Services	1.28	0.04	0.05	5.00	0.03	0.14
Management of Companies and Enterprises	0.02	0.03	0.00	0.33	0.02	0.01
Administrative and Support and Waste Management and Remediation Services	3.75	0.29	1.08	11.94	0.24	2.91
Educational Services	3.51	0.06	0.20	8.79	0.06	0.50
Health Care and Social Assistance	7.74	0.03	0.21	18.80	0.03	0.54
Arts, Entertainment, and Recreation	0.54	0.15	0.08	2.47	0.12	0.31
Accommodation and Food Services	5.32	0.04	0.23	16.91	0.04	0.68
Other Services (except Public Administration)	2.12	0.12	0.25	7.12	0.09	0.62
Public Administration	4.67	0.18	0.84	12.03	0.14	1.69

Estimates of the yearly number of days in temperature ranges corresponding to the adopted WA heat rule thresholds of 80, 90, and 100°F by region (Table 3.5) were derived from the procedure outlined in Section 3.1.2. 110°F was used as the upper bound of the highest temperature range to maintain consistent 10°F intervals in each category. 109°F was the 99th percentile of mean within-WA county maximum daily temperature observations at or above 100°F within the 2011-2020 exposure data analyzed to generate ambient heat exposure estimates in Section 3.1.2. No injuries occurred on days above a maximum daily temperature of 108°F in the Spector 2016 study.

Table 3.5. Yearly number of May-Sept days in temperature ranges in WA regions, 2011-2020

Temperature range	# days E. WA	# days W. WA
80-<90°F	50	20
90-<100°F	33	4
100-<110°F	7	0

The yearly number of days in each temperature range was then multiplied by the average number of outdoor injury claims per day to yield the average yearly May-Sept number of outdoor injury claims by industry, region, and temperature range, as shown in Table 3.6. This estimate is conservative, as we do not assume an increasing frequency and severity of temperature extremes as is projected with climate change. Nor do we assume an increase in the number of workers in the future.

Table 3.6. Average yearly May-Sept number of outdoor injury claims by industry, region, and temperature range, 2011-2020

	E. WA			W. WA		
Industry	**80-<90°F**	**90-<100°F**	**100-<110°F**	**80-<90°F**	**90-<100°F**	**100-<110°F**
Agriculture, Forestry, Fishing and Hunting	540.2	356.5	75.6	33.8	6.8	0.0
Mining, Quarrying, and Oil and Gas Extraction	1.4	0.9	0.2	1.2	0.2	0.0
Utilities	4.4	2.9	0.6	2.0	0.4	0.0
Construction	168.9	111.4	23.6	211.3	42.3	0.0
Manufacturing	36.2	23.9	5.1	24.0	4.8	0.0
Wholesale Trade	37.8	24.9	5.3	16.3	3.3	0.0
Retail Trade	23.1	15.3	3.2	20.7	4.1	0.0
Transportation and Warehousing	36.2	23.9	5.1	44.1	8.8	0.0
Information	2.2	1.5	0.3	0.6	0.1	0.0
Finance and Insurance	0.4	0.2	0.1	0.5	0.1	0.0
Real Estate and Rental and Leasing	8.9	5.9	1.2	10.8	2.2	0.0
Professional, Scientific, and Technical Services	2.5	1.6	0.3	2.7	0.5	0.0
Management of Companies and Enterprises	0.0	0.0	0.0	0.1	0.0	0.0
Administrative and Support and Waste Management and Remediation Services	54.2	35.8	7.6	58.3	11.7	0.0
Educational Services	10.2	6.8	1.4	10.0	2.0	0.0
Health Care and Social Assistance	10.4	6.9	1.5	10.8	2.2	0.0
Arts, Entertainment, and Recreation	3.9	2.6	0.5	6.1	1.2	0.0
Accommodation and Food Services	11.7	7.7	1.6	13.7	2.7	0.0
Other Services (except Public Administration)	12.5	8.3	1.8	12.4	2.5	0.0
Public Administration	42.2	27.8	5.9	33.7	6.7	0.0

For the injury claims identified above, the average cost per claim of non-WMSD injury claims, by industry and region, was estimated based on the cost of the State Fund injury claims' "actuary incurred total" cost field, which provides an estimate of future expenses for open claims in addition to the actual paid to date costs for closed claims. It includes the costs of time-loss, pensions, and medical treatment. In order to get a case reserve estimate of future expenses, a claim must be open for about nine months. In cases where the claim has already been closed, the actuary incurred total estimate is equivalent to the paid to date expenses for that claim and is unlikely to change unless the claim is reopened. We adjusted medical and all other costs separately to 2022 dollars using the BLS Consumer Price Index-medical and -excluding medical, respectively, to account for inflation. Average costs per claim are shown in Table 3.7. It was assumed that the average cost for injury claims was the same for indoor and outdoor claims and for claims occurring at different ambient temperature levels.

These estimates are conservative (likely underestimates) for the following reasons: (1) by using time loss payments to estimate the amount of time workers were away from work, it underestimates lost wages, lost days, benefits, and taxes because compensable (time loss) claims do not compensate workers at 100% of their lost wages or for all lost workdays (i.e., there is a waiting period of three days before a workers is eligible wage replacement benefits); and (2) it is likely that medical billing for claims is incomplete (Asfaw 2013).

Table 3.7. Average costs per claim for non-WMSD injury claims by industry and region, May-Sept 2011-2020

Industry	E. WA average cost per claim	W.WA average cost per claim
Agriculture, Forestry, Fishing and Hunting	$ 10,437	$ 21,010
Mining, Quarrying, and Oil and Gas Extraction	$ 21,894	$ 13,363
Utilities	$ 20,506	$ 12,852
Construction	$ 14,869	$ 19,204
Manufacturing	$ 8,113	$ 9,199
Wholesale Trade	$ 9,804	$ 11,200
Retail Trade	$ 6,818	$ 8,261
Transportation and Warehousing	$ 18,447	$ 18,081
Information	$ 10,759	$ 14,061
Finance and Insurance	$ 15,400	$ 13,410
Real Estate and Rental and Leasing	$ 9,254	$ 12,004
Professional, Scientific, and Technical Services	$ 5,971	$ 6,933
Management of Companies and Enterprises	$ 18,534	$ 11,402
Administrative and Support and Waste Management and Remediation Services	$ 9,130	$ 12,878
Educational Services	$ 5,244	$ 8,227
Health Care and Social Assistance	$ 7,850	$ 9,330
Arts, Entertainment, and Recreation	$ 11,525	$ 7,084
Accommodation and Food Services	$ 3,624	$ 5,482

Other Services (except Public Administration)	$ 9,231	$ 8,951
Public Administration	$ 14,911	$ 16,594

The average cost per injury claim by industry and region was then multiplied by the average yearly May-Sept number of outdoor injury claims by industry and region from above and multiplied by corresponding injury risk multipliers for each temperature range. Injury risk multipliers were derived from the 1% increase in relative risk per 1°C increase in temperature relationship from the aforementioned published research, as shown in Appendix A**,** and summarized in Table 3.8. It was assumed that injury risk is linear with increasing temperature, the same risk profile exists across all industries, and injury is a rare outcome (Fatima 2021). This calculation yielded the raw yearly May-Sept *heat-attributable* injury costs by industry and region. Research on the relationship between heat exposure and occupational traumatic injuries has used different reference temperatures above which increases in risk have been observed. These are used to generate lower- and upper-bound estimates of the increase in injury risk attributable to heat for each 10°F interval. Lower bound estimates included risk estimates calculated based on a reference temperature of <77°F from Spector 2016. Upper bound estimates considered the mean reference temperature of 70°F from the research studies included in Fatima 2021.

Table 3.8. Injury risk estimates and multipliers in each temperature range

		Ambient temperature range		
Reference temperature		**≥ 80 to < 90°F**	**≥ 90 to < 100°F**	**≥ 100 to 110°F**
<77°F from Spector 2016 (for lower bound estimates)	Risk estimate	3%-8% (mid: ~5.5%)	8-14% (mid: ~11%)	14-19% (mid: ~16.5%)
	Risk multiplier	0.055/1.055	0.11/1.11	0.165/1.165
70°F from Fatima 2021 (for upper bound estimates)	Risk estimate	6%-11% (mid: ~8.5%)	11-17% (mid: ~14%)	17-22% (mid: ~19.5%)
	Risk multiplier	0.085/1.085	0.14/1.14	0.195/1.195

Raw cost estimates were then adjusted for under-reporting (multiplied by 1/0.25=4) (Section 3.2.1). Raw estimates were additionally multiplied by an anticipated adopted heat rule effectiveness multiplier (Section 3.2.2). Lower bound estimates assumed 55% anticipated rule effectiveness and multiplied raw estimates by 0.55, and upper bound estimates assumed 65% anticipated rule effectiveness and multiplied raw estimates by 0.65. Estimates were then summed over all three temperature ranges, E. and W. WA regions, and all industries to yield the total yearly anticipated benefit.

The lower bound (assuming reference temperature of <77°F in risk estimates and 55% adopted WA heat rule effectiveness) total annual monetized benefit for outdoor occupational injuries was $4,707,198.86 ($3,429,894.82 (E. WA) + $1,277,304.04 (W. WA)). The upper bound (assuming reference temperature of 70°F in risk estimates and 65% adopted WA heat rule effectiveness) total annual monetized benefit for outdoor occupational injuries was $7,536,500.79 ($5,377,640.62 (E. WA) + $2,158,860.16 (W. WA)).

Applying a ratio of 1.6 indirect-to-direct costs to estimate the costs of injuries borne by employers and not recoverable through insurance coverage (Section 3.1.3), the final total annual monetized benefit for outdoor occupational injuries in WA was $12,238,717.03 (lower bound) to $19,594,902.04 (upper bound).

3.2.4 Heat-Related Productivity Benefits

The anticipated benefit in dollars of the adopted Washington State (WA) occupational heat rule on productivity can be quantified by estimating the cost of productivity loss that may be prevented by the rule.

Increasing heat exposure is a well-studied contributor to reduced physical work capacity in laboratory settings (Foster 2021) and real-world populations (Romanello 2021). In laboratory settings, models suggest reductions in physical work capacity that vary from 10% with mild heat stress (Wet Bulb Globe Temperature (WBGT) = 64°F) to 78% in extreme heat conditions (WBGT = 104°F) (Foster 2021). Hot ambient temperatures cause the temperature of human skin to rise, which is ultimately associated with increased skin blood flow that may detract from the ability for muscles to perform physical work (Sawka 2012). Insufficient hydration reduces blood volume and worsens this effect of heat on productivity. Improvements in hydration resulting from the adopted WA heat rule are therefore the focus of this heat-related productivity benefit analysis. Although research studies have reported improvements in work capacity and productivity in shaded versus sunny conditions (Morabito 2021, Foster 2022) and with heat acclimatization (Benjamin 2019), these factors were not directly considered in productivity benefits analyses, as the adopted WA heat rule does not require shade during work periods or procedures to induce acclimatization prior to work in the heat, though the latter are recommended.

The approach to quantify the potential benefits of the adopted WA heat rule on productivity via hydration is described below. In this analysis, it was assumed that preventive and mandatory cool-down rest periods required in the adopted WA heat rule will increase opportunities for, and enhance, worker hydration. It was also assumed that preventive cool-down rest periods starting at 80°F will reduce the chance of dehydration at or above 90°F when the maximum temperature of a work-shift is at or above 90°F. Dehydration refers to the process of losing body water, and hypo-hydration refers to the state of body water content deficits. Three percent of total body water deficit corresponds to ~2% body weight deficit and a urine specific gravity (USG) of > 1.020 (Sawka 2007). Dehydration >2% body weight is reported in the scientific literature to be associated with performance decrements (Sawka 2007).

First, the yearly number of outdoor workers was estimated (Table 3.9). The number of outdoor workers by industry in Eastern and Western WA regions was estimated using (Section 1.3.1). Eastern WA (E. WA) and Western WA (W. WA) regions were analyzed separately given their relatively different climates and industry distributions. E. WA and W. WA and were defined using county borders nearest the Cascade Ridge line.[54]

[54] https://wsdot.wa.gov/sites/default/files/2021-10/Env-Wet-EastWestBoundary.pdf

Table 3.9. Yearly number of outdoor workers and hourly loaded wages by industry and WA regions

	Eastern Washington		Western Washington	
Industry	**# outdoor workers**	**hourly loaded wage**	**# outdoor workers**	**hourly loaded wage**
Agriculture, Forestry, Fishing and Hunting	43,843	$24.58	10,027	$32.05
Mining, Quarrying, and Oil and Gas Extract	43	$56.34	338	$50.72
Utilities	249	$69.68	562	$74.25
Construction	18,658	$42.43	80,932	$53.30
Manufacturing	3,169	$41.29	12,496	$61.74
Wholesale Trade	4,193	$45.24	11,400	$70.16
Retail Trade	5,005	$26.24	18,222	$59.27
Transportation and Warehousing	5,547	$34.66	26,524	$51.69
Information	683	$52.92	4,198	$193.97
Finance and Insurance	548	$63.76	2,441	$92.22
Real Estate and Rental and Leasing	1,545	$30.00	8,004	$52.76
Professional, Scientific, and Technical Services	892	$60.05	5,390	$91.27
Management of Companies and Enterprises	133	$78.10	733	$95.01
Administrative and Support and Waste Management	8,061	$41.76	33,183	$43.42
Educational Services	4,426	$34.24	12,580	$33.60
Health Care and Social Assistance	2,910	$37.62	10,242	$42.99
Arts, Entertainment, and Recreation	1,328	$17.67	5,707	$30.42
Accommodation and Food Services	2,306	$16.95	7,539	$20.39
Other services except public administration	2,404	$26.42	8,611	$37.98
Governments	10,137	$50.04	29,732	$60.18

Not all outdoor workers are subject to equal conditions, such as regular physical work activity, which may increase the risk of dehydration and the benefit of hydration. Research among agricultural workers in 2014-2015 (3-minute maximum WBGT during data collection 86.5°F) in California, which has an occupational heat rule that includes hydration provisions,[55] indicates that 10.6% of workers lost 1.5% or more body mass during their work-shifts (Moyce 2020). A study of North American utility workers reported that 75% of workers post-shift and 62% pre-shift had a USG of ≥ 1.020 (difference 13%) (Meade 2015). A study of agricultural workers in Florida (mean ambient daytime temperature 83°F, average relative humidity 77%) reported that 81% of workers post-shift and 53% pre-shift had a urine specific gravity ≥ 1.020 (difference 28%), and 13% post-shift and 3% pre-shift had a urine specific gravity > 1.030 (difference 10%) (Mix 2018). In accordance with this literature, a lower bound estimate of 10% of outdoor workers at risk for dehydration in the absence of the adopted rule was used (based on the reported difference between post- and pre-shift hydration measurements). An upper bound estimate (based on post-shift dehydration) of 13% was used, assuming that workplace hydration due to the adopted WA heat rule would support better hydration status the following workday.

[55] https://www.dir.ca.gov/title8/3395.html

The latter is a conservative estimate, as the aforementioned literature has reported higher percentages of dehydration post-shift. These proportions were multiplied by the number of outdoor workers to yield the number of workers at risk for dehydration by industry and region.

The number of workers at risk for hypo-hydration-associated productivity declines by industry and region was multiplied by the mean number of days in temperature ranges corresponding to the adopted WA heat rule thresholds of 80, 90, and 100°F by region (80-<90°F, 90-<100°F, 100-<110°F) (**Table 3.10**) (Section 3.1.2). 110°F was used as the upper bound of the highest temperature range to maintain consistent 10°F intervals in each category. 109°F was the 99th percentile of mean within-WA county maximum daily temperature observations at or above 100°F within the 2011-2020 exposure data analyzed to generate ambient heat exposure estimates [Section 3.1.2]. The result was the number of at-risk (for dehydration) outdoor worker-days by industry, region, and temperature category. This estimate is conservative, as we do not assume an increasing frequency and severity of temperature extremes as is projected with climate change. Nor do we assume an increase in the number of workers in the future.

Table 3.10. Yearly number of annual days in temperature ranges in WA regions, 2011-2020

Temperature range	# days E. WA	# days W. WA
80-<90°F	53	21
90-<100°F	33	4
100-<110°F	7	0

Next, the number of hours in an eight hour work-shift a worker without sufficient hydration may be dehydrated was estimated. Research underlying sports medicine guidelines, which are applicable to workers performing physical tasks, suggests that hydration is necessary by the fourth hour of activity to prevent dehydration (defined as >2% body mass) for 50-90 kg individuals exercising in conditions with 0.5 L/hr sweat loss (Cheuvront 2021). In the present analysis, an upper bound of four hours was used as the number of hours that could realize productivity benefits from hydration in an eight-hour work-shift. This is conservative, as a study among acclimatized military personnel indicates that workers doing easy work (defined as 250 Watt) at WBGT 78-82°F should receive some hydration before four hours to sustain performance for four hours of work (Montain 1999). A lower bound estimate assumes three hours. Not all hours in a day may be at or above temperature thresholds. In WA, between 2011-2020 from May-September, the average number of hours at or above 80°F on days with a maximum temperature at or above 80°F was about 6 hours and 15 min [Section 3.1.2]. Two and a quarter of these hours (6 hrs and 15 min – 4 hrs = 2 hrs and 15 min) could therefore, on average, realize productivity benefits of hydration at or above 80°F. However, insufficient hydration prior to 80°F, as the temperature rises, could shorten the overall amount of productive time and increase the amount of time that could realize productivity benefits of hydration, so the lower bound is three rather than two hours. The number of at-risk (for dehydration) outdoor worker-days by industry and region was multiplied by the number of hours in a shift a worker without sufficient hydration may be dehydrated. This yielded the number of at-risk (for dehydration) outdoor worker-hours by industry and region. This was multiplied by the hourly wage by industry and region loaded with benefits [Section 1.3] (Table 3.9), as an estimated monetary measure of productivity per hour, to yield the total dollar amount subject to decrements from productivity loss by dehydration by industry, region, and temperature category.

Finally, the expected decrement in productivity was determined for each ambient temperature category corresponding to the adopted WA heat rule thresholds of 80, 90, and 100°F (80-<90°F, 90-<100°F, and 100-<110°F). The relationship between ambient temperature (Ta) and skin temperature (Tsk) has been described to be linear (Adams 1977; Tsk = 20.27+0.40*Ta with no sun and Tsk=22.77+0.35*Ta with sun) among athletes. The relationship between Tsk and productivity has also been described to be linear above a skin temperature of about 27°C = 80°F (Sawka 2015), with approximately a 1.3% decline in aerobic performance for each 1°C elevation in Tsk (% impairment in performance = 26.37-1.26*Tsk) when hypo-hydrated at 3-4% body mass among participants undergoing exercise timed trials lasting for less than an hour. Assuming linearity of these functions in the temperature ranges of interest (Appendix B), a proportion of productivity decrement was calculated for each temperature range (Table 3.11). Conditions without sun, which could include cloudy conditions, were considered in the lower bound estimate, and conditions with sun were considered in the upper bound benefits estimate.

Table 3.11. Dehydration risk estimates and multipliers in each temperature range

		Ambient temperature range		
Sun assumption		**≥ 80 to < 90°F**	**≥ 90 to < 100°F**	**≥ 100 to 110°F**
Without sun (for lower bound estimates)	Risk estimate	-0.13 to -0.15 (mid: ~-0.14)	-0.15 to -0.18 (mid: ~-0.165)	-0.18 to -0.21 (mid: ~-0.195)
	Risk multiplier	14.0%	16.5%	19.5%
With sun (for consideration in upper bound estimates)	Risk estimate	-0.14 to -0.16 (mid: ~-0.15)	-0.16 to -0.19 (mid: -0.175)	-0.19 to -0.21 (mid: ~-0.13)
	Risk multiplier	15.0%	17.5%	20.0%

The risk estimates are conservative estimates, as the function relating heat exposure and productivity is based primarily on laboratory studies, while a real-world study of Nicaraguan sugar cane workers (mean ambient temperature 88°F, mean relative humidity 52%) found up to a 45% increase in productivity among optimally hydrated workers after a hydration intervention, though there was no comparison group (Cortez 2009). Further, it is unlikely that all outdoor workers at risk for dehydration are sufficiently acclimatized. A 1995-2005 WA workers' compensation claims analyses suggested that claims occurring within one week of employment, when a worker is less likely to be acclimatized, were more than four times more frequent for HRIs than for workers suffering from injuries from all causes (Bonauto 2007). In addition, this analysis does not take into account non-breathable clothing and personal protective equipment, which can increase skin temperature and decrease exercise time (Carballo-Leyenda 2018). Also, these analyses don't take into account longer durations of exposure, yet physical work capacity is lower with longer work durations (Smallcombe 2022).

The productivity decrements by temperature category were then multiplied by the total dollar amount subject to decrements from productivity loss by industry, region, and temperature category, which was then summed across industry, region, and temperature category to yield the total benefit. Lower bound estimates assumed three hours of potential dehydration in conditions

without sun, with 10% of outdoor workers in each industry and region at risk for dehydration-associated productivity declines. Upper bound estimates assumed four hours in conditions with sun, with 13% of outdoor workers in each industry and region at risk for dehydration-associated productivity declines. The lower bound total annual monetized benefit for productivity was $33,569,027.46 ($16,843,344.49 (E. WA) + $16,725,682.97 (W. WA)). The upper bound total annual monetized benefit for productivity was $62,035,827.17 ($31,031,366.69 (E. WA) + $31,004,460.47 (W. WA)).

3.2.5 Total Estimated Benefits

Summary of Benefits

Benefit	Lower Bound Estimate	Upper Bound Estimate
Preventing heat-related illness cases and claims	$1,025,365	$1,211,796
Preventing heat associated traumatic injury	$12,238,717	$19,594,902
Preventing excess heat associated deaths	$14,312,291	$16,922,708
Improving productivity	$33,569,027	$62,035,827
Total Quantitative Benefit	$61,145,400	$99,765,233

3.3 Qualitative Benefits

CLARIFICATION OF SAFE WORKPLACE REQUIREMENTS

One qualitative benefit of the rule is that, in the interest of worker safety, the adopted rule clarifies existing standards related to heat stress hazards so that employers know what is expected of them, especially at high heat. This translates to a benefit for both workers and employers. Outdoor workers benefit because they are more likely to be protected from heat stress. Employers benefit because they will be less likely to receive citations and fines for violations of standards that they may not have realized applied to them. Moreover, employers will have a better understanding of what they need to do to be in compliance with health and safety standards related to heat stress. Ultimately, this will also save businesses, as well as L&I and tax payers, from the cost of appeals and legal fees resulting from citations that are challenged due to rule language that is unclear.

PAIN AND SUFFERING OF DECEASED WORKERS' FAMILY AND FRIENDS

In comparing the practice of monetizing the value of preventing and compensating fatalities in administrative regulations and tort law respectively, Posner (2005) recommend that government agencies move in the direction of the courts and take into account factors such as dependents' pain and suffering, dread, emotional distress, and other general welfare losses. They suggest, "These changes would make a dramatic difference for administrative practice, replacing the crude current effort to use a single value for statistical lives." The authors note that courts tend to

award “noneconomic” damages for the deceased’s pain and suffering prior to his or her death, as well as the emotional distress and loss suffered by dependents (Posner 2005).

PREVENTING LONG-TERM HEALTH PROBLEMS

In the period from 2006 to 2021, Washington workers compensation received 25 workers claims for an emergent inpatient hospitalization for heat-related illness. This is significant given that there are a number of long-term health problems that individuals might experience after having suffered from severe HRI. For instance, one study found that Army personnel hospitalized for severe HRI had a 40% increased risk of mortality from other causes later in life when compared to personnel who had been hospitalized with appendicitis (Wallace 2007). In addition, reports suggest that severe HRI (and heat stroke, in particular) can cause acute and irreversible damage to the heart, lungs, kidneys, and liver which could in turn contribute to cardiovascular disease, ischemic heart disease, chronic liver disease, and renal failure (Wallace 2007, Garcia-Rubira 1995, Rubel 1983). Workers exposed to hot working environments may also have an increased risk of non-malignant digestive disease (Redmond 1977), and chronic heat stress exposure may increase the risk of kidney stones (Borghi 1993). Individuals who have experienced HRI are likely to have reduced tolerance to future heat exposure (Wallace 2007). Rapid cooling of individuals with heat stroke, as supported by timely recognition and emergency response procedures, has been shown to reduce heat stroke mortality (Filep 2020, Pease 2009).

PREVENTING EXACERBATIONS OF CHRONIC DISEASE

Heat exposure can worse underlying chronic disease. Diabetes mellitus is associated with impairments in heat loss during exercise (Carter 2014). General population studies in King County, Washington State, have reported increased risk of death with increasing heat exposure for all-cause, non-traumatic, circulatory, cardiovascular, cerebrovascular, and diabetes causes of death (Isaksen 2016). Studies have also reported an increase in cardiovascular mortality rates in the contiguous United States on extreme heat days (Khatana 2022). There is also emerging evidence of the effect of heat exposure on mental health. In the general population, extreme heat and rising temperatures has been linked to increased hospitalizations for mood and behavioral disorders and an increased risk of suicide (Ebi 2021). Reduction in workplace heat stress may reduce exacerbations of chronic disease, including cardiovascular disease and diabetes, and certain mental health conditions.

REDUCING INEQUITIES

Another benefit of the adopted HRI rule is that it will likely provide protection for certain marginalized workers who are particularly at risk for having the signs and symptoms of HRI go unrecognized and unaddressed. Working populations with the most social and economic disadvantage are often disproportionally exposed to hazards and may also lack adequate means to identify and address exposures and health effects (Marsh 2015). For example, a Washington State workers’ compensation 2006-2017 HRI claims analysis estimated that Latinx workers were overrepresented in HRI claims (Hesketh 2020). An analysis of 2001-2018 California workers’ compensation claims identified a higher risk of heat-related injuries among workers at the lower income distribution (Park 2021). A study of heat-related fatalities in North Carolina between 1977 and 2001 reported that 45% of the workplace fatalities occurred among farmworkers and that many of their deaths went unnoticed and without medical attention (Mirabelli 2005). These inequities may be reduced with clarification of expectations for employers related to HRI

prevention and, specifically, by allowing and encouraging preventative rest periods, requirements for inclusion of HRI training in a language and manner that employees understand, and provision of a written copy of the heat accident prevention plan in a language the employees understand.

REDUCING THE BURDEN OF CLIMATE CHANGE

Climate change is resulting hotter days occurring more frequently. Heat waves will be more frequent and longer. Instituting a protective occupational heat exposure rule will mitigate some of the impact these climate changes on workers and society, as described below.

PREVENTING SOCIETAL COSTS

Beyond the direct loss of income suffered while recovering from their injury or illness, workers with severe cases also may face impairment of their quality of life in the form of continuing physical limitations, increased usage of medical services, fear of future re-injury, and reduced capacity to perform family and social roles (Shapiro et al., 1979; Dembe, 2001; Strunin and Boden, 2004). In addition, there are losses borne by society as a whole such as impacts to state disability and welfare systems, loss of tax revenues, and the loss of the worker's contribution to community life (Brown, et al., 2007; Leigh, 2011). Consequences of injury-related work absence may also include loss of pre-injury job, loss of seniority or loss of investment in job-specific skills. Workers may also face discrimination from potential employers following periods of injury-related absence (Strunin and Boden, 2004). Such workers may fear they will be regarded by employers or co-workers as being "injury prone" or "unreliable" and that they will have more difficulty finding future employment.

Household economic losses

A large amount of costs borne by workers could not be quantified in the cost-benefit analysis. Economists recognize that household production, although unremunerated, creates immense value and meets important needs. Household work, including cooking, cleaning, washing, yard work, household improvements and repairs creates value. Disability due to long-term consequences from heat-related illness and heat-related injuries can interfere with the ability to create value through home production. Rather than spending time in productive household activities, injured workers often spend their time in self-maintenance and in administrative efforts in order to secure payment for medical bills and insurance benefits. Although L&I recognizes the important role of household production to the economic and social fabric, these considerations were not included in this estimated benefit of preventing HRI or heat-related injuries.

Community Effects

When workers are injured or ill, communities suffer as well. Workers are not compensated for the full wages and benefits lost, therefore the loss of disposable income, or the portion of income that is used for consumption of goods and services, has an impact on the local and state economy. The loss of their spending and sales tax revenues has multiplier effects in the local and state economy that were not considered in the cost-benefit ratio.

Prior to their illnesses and injuries, many workers are contributing members to their local communities. The value of healthy workers' volunteering and participating in committees at work, churches, schools, homeless shelters and other contributions to society could not be enumerated as financial benefits to the heat rule.

In some cases, HRI is severe enough to lead to long-term health effects, as described above, including long-term kidney and cardiovascular damage. In such cases, the unquantified losses to local economies and to community participation may be substantial.

Although these qualitative losses of heat-related illness and injury could not be quantified and added the measured benefits of the adopted rule, L&I emphasizes that the full costs of HRIs to workers and their families is much greater than the dollar value expressed in this analysis. Benefits from the prevention of HRIs to workers and to the State's economy as a whole of keeping workers as productive members of society are at least as important as the monetary benefits that could be quantified.

Chapter 4: Cost-Benefit Determination

As mentioned in the cost and benefit sections, L&I estimates that the total probable annual cost of the adopted rule to $40,689,738 to $49,127,233 for the affected business community. The total probable benefit to the entire society that can be quantified is estimated at $61,145,400 to $99,765,233 per year. In addition to quantifiable benefits, there are additional qualitative benefits as described in Section 3.3. Based on these results, L&I concludes that the probable benefit of the adopted rule outweighs the probable cost. Therefore, the adopted rules are economically feasible.

Chapter 5: Least Burdensome Analysis

L&I must determine whether a rule being adopted is the least burdensome of the alternative requirements that still achieves the goals and objectives of the authorizing statutes.[56] The authorizing statute is the WISHA, and its goals and objectives are to assure, as may reasonably be possible, safe and healthful working conditions for every man and woman working in the state of Washington[57]. Specific to harmful physical agents, including outdoor heat exposure, WISHA mandates L&I "[p]rovide for the promulgation of health and safety standards and the control of conditions in all work places concerning… which shall set a standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity."[58] L&I assessed the alternatives to elements of the adopted rules, and determined whether they met these goals and objectives. Of those that met the goals and objectives, L&I determined that the adopted rules were the least burdensome version of the rule for those who are required to comply, given the goals and objectives of the law.

WAC 296-62-09510 & 296-307-09710 *Amending the scope to apply year-round.*
Under the current rules, the applicability of OHE rules were restricted from May 1 to September 30 at specified temperature action levels. It was amended to apply year-round to outdoor work environments when employees are exposed to outdoor heat, with specific requirements of the rules applying only when the temperature actions levels are met or exceeded. Continuing to apply this time-frame restriction does not protect employees covered under the temperature action level of 52°F outside of May-September. As such, discussed in the cost section 2.1.3, the temperature was 52°F or higher for an average of 9 hours per day for at least 76 business days a year. While historically uncommon, the current rule also does not protect employees exposed to days at the higher temperature action level. As such, changing the rules to apply year round is the least burdensome alternative that serves the goals and objectives of the statute.

WAC 296-62-09530(1) and 296-307-09730(1)
Table 1 - Temperature Action Levels.
Keeping ambient temperature as measure for the temperature action level. As discussed in Section 1.2.6, the temperature action levels in the current rule were set at ambient temperatures derived from using the American Conference of Governmental Industrial Hygienists (ACGIH) action limit using a calculation for the Wet Bulb Globe Temperature (WBGT). As the underlying assumptions for the decision to use ambient temperature were not expected to change since the assessment when the 2008 rule was adopted, the use of ambient temperature was maintained. The use of ambient temperature is the least burdensome alternative for the temperature action level measurement as it removes the burden the burden of employers having to used specialized equipment (WBGT), separately consider humidity levels, and conduct complex calculations.

[56] RCW 34.05.328(1)(e).
[57] RCW 49.17.010.
[58] RCW 49.17.050(4)

Setting the temperature action level at 80°F for all other clothing except nonbreathable clothing. As discussed in Section 1, L&I reviewed the best available evidence, including peer reviewed research, workers' compensation claim data, research on federal OSHA investigations, and action levels used by other enforcement agencies to determine the appropriate action level. Based on this review, it was determined that 89°F was to too high to provide protection from workers overheating and that preventative measures needed to be occurring at lower temperatures. As such, the proposal lowers the current action level of 89°F to 80°F. At the 80°F temperature action level compliance with certain preventative protection measures is required: access to shade; providing specific quantities of sufficiently cool drinking water; and encouraging and allowing employees to take preventative cool-down rest periods when they feel the need to do so to protect themselves from overheating. As lowering the temperature to 80°F is supported by the best available evidence is feasible, maintaining the current threshold is not consistent with the goals and objectives of WISHA. However, in lowering the temperature action level, L&I determined maintaining the separate temperature action level for double-layer clothing of 77°F would present a burden to employers to follow both requirements, so the least burdensome alternative was to repeal the action level at 77°F and incorporate it into one action level (80°F).

WAC 296-62-09530 and 296-307-09730 *Employer and employee responsibility*
Requiring specific elements be addressed in the written outdoor exposure safety program and be in a language understood by employees. The current rules require employers address their outdoor exposure safety program in their written Accident Prevention Plan, however the rules do not contain any minimum required elements for the written program. The adopted rules specify the written program include, at a minimum, procedures addressing all elements of the adopted rules. In addition, the adopted rules clarify that the written program needs to be in a language understood by employees. As the adopted rules include specific preventative measures, ensuring all the elements under the rule are addressed in the written outdoor exposure safety program, including the specific ways the employer will be addressing the requirements where there are options, will help employers better comply and help with employees training. These requirements reduce inequities for workers marginalized due to language, especially where they have overlapping characteristics such as immigration status, race, or class. (NIOSH, ASSE 2015) Ensuring the written program is in a language understood by employees and that a copy is made available to employees and employee representatives will help make the written plan more accessible and reduce inequities.

Requiring employers encourage and allow employees to take preventative cool-down rests periods when needed and that the preventative cool-down rest periods be paid unless taken during a meal break. Environmental factors, such as workload or work duration can vary across worksites and across activities at an individual worksite. Personal factors, such a physical fitness or acclimatization, similarly vary across employees at different worksites and at individual worksites. Overheating puts employees at risk of both heat-related illness and traumatic injuries. Taking a rest when needed to prevent overheating is a critical administrative control for heat exposure. While the adopted rule includes mandatory cool-down rest periods under the high heat procedures starting when the temperature is at or exceeds 90°F, this provision in the adopted rules applies when the temperature is at the action levels. In addition, ensuring employees understand their right to take preventative cool-down rests periods when needed and that the

preventative cool-down rest periods are paid unless taken during a meal break will help in situations where employees may be motivated to skip breaks or otherwise adjust the pace of their work such as piece rate or where the employees fear of retaliation and discrimination. Marginalized workers, such as those socially and economically disadvantaged due to race, ethnicity, immigration status, language, class, low wage work, or work arrangements such as contingent work or other insecure or precarious employment, are often at risk of having their workplace rights denied or lack the capacity or means to secure them, or have difficulties accessing government services.[59] Given the variability in the environmental and personal risk factors and the need to protect marginalized workers, ensuring employees can take the rest when they feel they need to prevent overheating anytime the temperature is above 80°F is the least burdensome alternative that meets the goals and objectives of WISHA.

WAC 296-62-09535 and 296-307-09735 *Access to shade.*
Access when exposure to outdoor heat occurs. L&I considered requiring provisions of shade whenever employee exposure to outdoor heat occurs rather than when action level temperatures are reached. Establishing temperatures at which an employer is required to provide shade removes some of the burden for employers determining on when it is necessary to provide shade. Requiring shade at the temperature actions level in the adopted rule is the least burdensome alternative that meets the goals and objectives of WISHA.

Vegetation. Adequacy of shade provided by vegetation and crops can vary depending on the amount of shade coverage, the humidity level from irrigation, and presence of insects and animals. Consequently, L&I considered not allowing for vegetation or crops to be used as a source of shade. However, given the potential restrictions an employer might face providing shade, removing vegetation as a shade source would increase burden. As such, L&I addressed the adequacy of shade, including the use of vegetation as shade, in the definition of shade. The definition of shade under the adopted rules is a "blockage of direct sunlight" and "may be provided by any natural or artificial means…". Allowing vegetation that meets the definition is the least burdensome alternative.

Specified distance to shade from work areas. L&I considered specifying the exact distance between employees' work area and shade. If the shade is too far away, it can deter or discourage both the access and use. Depending on the characteristics of the worksite, installing shade at a specified distance might not be feasible, or might be burdensome and costly As such, the adopted rules require shade be located as close as practicable to the areas where employees are working.

WAC 296-62-09545 and 296-307-09745 *Acclimatization.*
Acclimatization for employees newly assigned. The adopted requirements for close observation for 14 newly assigned employees was determined to be the least burdensome alterative that meets the purpose and goals of the WISHA. The other option considered was to require employers to follow an acclimatization schedule based on the National Institute for Occupational Safety and Health's (NIOSH) Criteria for a Recommended Standard for Occupational Exposure to Heat and Hot Environments. According to the acclimatization schedule, an employer would slowly increase the amount of work and employee performs in the heat over the course of 4-5

[59] *Id.*

days depending on whether the employee is new or returning to working in the heat. However, the duration of the benefits gained from acclimatization depends on the length of the initial acclimatization period. (Periard, 2015) The benefits of a four to five day short-term acclimatization period may be lost more quickly than if acclimatization was done during a longer period. Additionally, the overall scientific literature shows that the extent to which an individual acclimatizes not only depends on the amount of work performed in the heat, but on individual characteristics including but not limited to age, physical fitness, medications taken, and level of hydration. An acclimatization schedule was not included in the adopted rules due to the potential false sense of security stakeholders might experience from a short-term acclimatization schedule; and the impact that employers would experience tracking each employee's percentage of work performed in the heat for up to 5 days.

Acclimatization for employees returning to work after an absence of seven days or more. The adopted requirements for close observation for employees returning from work after an absence of seven days or more was determined to be the least burdensome alterative that meets the purpose and goals of the WISHA. In the alternative, consideration was given to the requirement for an acclimatization schedule versus close observation and this not included as discussed above. It was considered to establish that an absence of five workdays would classify an employee as one "returning to work," requiring close observation. However, based on the variability of work schedules an employer might have, tracking this would increase burden.

Acclimatization for all employees in a heat wave
The adopted requirements for close observation for employees during a heat wave was determined to be the least burdensome alterative that meets the purpose and goals of the WISHA. The alternative option of employers implement work-rest cycles based on ACGIH or NIOSH or requiring employer's implement a Heat Alert Program based on NIOSH was rejected as too burdensome.

WAC 296-62-09547 and 296-307-09747 *High heat procedures.*
The adopted requirements for mandatory cool-down rest periods and close observation of employees was determined to be the least burdensome that the purpose and goals of the WISHA. There is an exemption from the mandatory cool-down rest periods for certain emergency response activities included in the final rules. The following options were considered and determined to be more burdensome:

Work-rest periods starting at 85°F. Some stakeholders requested mandatory cool-down rest periods at 85°F. Using ACGIH methods, L&I calculated that additional protections would be warranted at 90°F, at which mandatory cool-down rest periods are established. This higher trigger temperature for high heat procedures reduces the time employers need to implement additional protections and provides a relief for cost and burden.

Prescribed cool-down rest periods at 90°F, 95°F, 100°F and 105°F. It was considered to require employers to follow prescribed mandatory cool-down rest periods calculated at four different temperature using the AGCIH methods, using assumptions for workload, sun coverage, relative humidity, air movement, personal protective equipment, and acclimatization status. This prescribed method would not allow employers to adjust to shorter cool-down rest periods when

work and environmental conditions permit. Estimating the specific factors to be considered for worker (workload, sun coverage, etc.) would add additional burden and provide less clarity to individual workers on their rights regarding cool-down rest periods.

Two work-rest tables: Vapor barrier clothing and all other clothing. L&I considered including two separate tables with mandatory cool-down rest periods at 90°F, 95°F, 100°F and 105°F, one table for non-breathable clothing and one for all other clothing. The non-breathable table would be more restrictive than the table for all other clothing adding additional cost and burden.

Employer-established work-rest schedules based on NIOSH and ACGIH. L&I considered requiring employers to establish their own work/rest schedules based either on ACGIH methods or on NIOSH's Criteria for a Recommended Standard for Safety and Health. In addition to the impact this would have on employee worktime, employers would be required to determine several work factors (workload, sun coverage, temperature, relative humidity, clothing) in order to calculate rest time per work hour or to follow work-rest tables. Since ACGIH methods are based on wet-bulb globe temperatures, employers would also potentially need to purchase and learn how to use a (WBGT) thermometer, increasing cost, training and overall burden.

Close observation of employees
Prescribed check-in time intervals. L&I considered requiring employers to check-in on their lone workers at specified time-intervals. However, this was deemed to be burdensome to employers and would not allow the flexibility needed for employers to establish appropriate time-intervals appropriate for their workforce and the work tasks performed.

WAC 296-62-09560 and 296-307-09760 *Information and training.*
Under the adopted rules, the training provisions are now required when there might be an employee exposure to outdoor heat, rather than when an outdoor temperature action level has been reached and the training provisions ae also amended to reflect the new and amended sections of the rule. Ensuring employees are trained before exposed to temperature at or above the actions level under the adopted rule and that the training includes all requirement under the rule is the least burdensome option that meets the purpose and goals of the WISHA.

Chapter 6: Federal & Local Jurisdiction

Does this rule require those to whom it applies to take an action that violates requirements of another federal or state law?

☐ Yes. *(provide citation)*

☒ No.

Does this rule impose more stringent performance requirements on private entities than on public entities? RCW 34.05.328(1)(g)

☐ Yes.

☒ No.

If yes, explain whether the requirements justified by state or federal law. *(provide citation)*

Do other federal, state, or local agencies have the authority to regulate this subject?

☐ Yes *(describe below)* ☒ No

Is this rule different from any federal regulation or statute on the same activity or subject?

☐ Yes *(describe below)* ☒ No

If yes, check all that apply. The difference is justified based on the following:

☐ A state statute *(provide a citation)*

☐ There is substantial evidence that the difference is necessary to achieve the general goals and objectives of the statute as described above.

RCW 34.05.328(1)(h)

Explain how the rule has been coordinated, to the maximum extent practicable, with other federal, state, and local laws applicable to the same activity or subject matter. RCW 34.05.328(1)(i)

A comparison document of the state and federal rules will be provided to OSHA following the final rule adoption.

Chapter 7: Appendices

Appendix B. Injury risk estimates at corresponding ambient temperatures

Temp	Increase in risk relative risk for lower bound estimates[1]	Increase in risk relative risk for upper bound estimates[2]
27°C= 80°F	3%	6%
28°C	4%	7%
29°C	5%	8%
30°C	6%	9%
31°C	7%	10%
32°C = 90°F	8%	11%
33°C	9%	12%
34°C	10%	13%
35°C	11%	14%
36°C	12%	15%
37°C	13%	16%
38°C = 100°F	14%	17%
39°C	15%	18%
40°C	16%	19%
41°C	17%	20%
42°C	18%	21%
43°C = 110°F	19%	22%

[1]Based on a reference of < 25°C = 77 °F from Spector 2016
[2]Based on the mean reference of 21°C = 70°F from Fatima 2021

Appendix A. Correspondence between ambient temperature, skin temperature, and productivity decline

	Outdoors (no sun)		Outdoors (sun)	
Ambient temp (°C)	**Skin temp (°C)[1]**	**Productivity decline[3]**	**Skin temp (°C)[2]**	**Productivity decline[3]**
27=80°F	31.07	-0.13	32.22	-0.14
28	31.47	-0.13	32.57	-0.15
29	31.87	-0.14	32.92	-0.15
30	32.27	-0.14	33.27	-0.16
31	32.67	-0.15	33.62	-0.16
32=90°F	33.07	-0.15	33.97	-0.16
33	33.47	-0.16	34.32	-0.17
34	33.87	-0.16	34.67	-0.17
35	34.27	-0.17	35.02	-0.18
36	34.67	-0.17	35.37	-0.18
37	35.07	-0.18	35.72	-0.19
38=100°F	35.47	-0.18	36.07	-0.19
39	35.87	-0.19	36.42	-0.20
40	36.27	-0.19	36.77	-0.20
41	36.67	-0.20	37.12	-0.20
42	37.07	-0.20	37.47	-0.21
43=110°F	37.47	-0.21	37.82	-0.21

[1]Skin temperature (°C) = 20.27+0.40*ambient temperature (°C), with no sun (Adams 1977)
[2]Skin temperature (°C) =22.77+0.35*ambient temperature (°C), with sun (Adams 1977)
[3]Impairment in performance = (26.37-1.26*skin temperature)/100 (Sawka 2015)

Chapter 8: References

Adams W. (1977). Influence of exercise mode and selected ambient conditions on skin temperature. *Annals of the New York Academy of Sciences*. *301*(1):110–127.

ACGIH. (2022). *Heat Stress and Strain: TLV® Physical Agents*. American Conference of Governmental Industrial Hygienists.

Anderson N, Smith C, Foley M. (2022). Work-related injury burden, workers' compensation claim filing, and barriers: Results from a statewide survey of janitors. *Am J Ind Med.* 65(3):173-195.

Andreoni, D. Review of methodologies for estimating the financial costs of occupational injuries. The Costs of Occupational Accidents and Diseases. Geneva: International Labor Office; 1986.

Asfaw A, Rosa R, Mao R. (2013). Do zero-cost workers' compensation medical claims really have zero cost? The impact of workplace injury on group health insurance utilization and costs. *J Occ Env Med*. 55(12):1394-1400.

Azaroff L, Levenstein C, Wegman D. (2002) Occupational injury and illness surveillance: Conceptual filters explain underreporting. *Am J Pub Health*. 92(9):1421-1429.

Benjamin C, Sekiguchi Y, Fry L, and Casa, D. (2019). Performance Changes Following Heat Acclimation and the Factors That Influence These Changes: Meta-Analysis and Meta-Regression. *Frontiers in Physiology*. 10: 1448.

Boden L, Ozonoff A. (2008) Capture-recapture estimates of nonfatal workplace injuries and illnesses. *Ann Epi*. 18(6):500-506.

Bonauto D, Anderson R, Rauser E, Burke B. (2007) Occupational Heat Illness in Washington State, 1995-2005. *Am J Ind Med*. 50(12):940-950.

Brown J, Shannon H, Mustard C, McDonough P. (2007). Social and economic consequences of workplace injury: a population-based study of workers in British Columbia, Canada. *Am J Ind Med*. 50(9): 633-645.

California Code of Regulations. Title 8, Chapter 4,§3395.

Calkins M, Bonauto D, Hajat A, Lieblich M, Seixas N, Sheppard L, Spector JT. (2019) A case-crossover study of heat exposure and injury risk among outdoor construction workers in Washington State. *Scand J Work Environ Health*. 45(6):588-599.

Carballo-Leyenda B, Villa J, López-Satué J, Collado P, Rodríguez-Marroyo J. (2018). Fractional contribution of wildland firefighters' personal protective equipment on physiological strain. *Frontiers in Physiology*. 9:1139.

Carter M, McGinn R, Barrera-Ramirez J, Sigal R, Kenny G. (2014). Impairments in local heat loss in type 1 diabetes during exercise in the heat. *Medicine and Science in Sports and Exercise*. 46(12): 2224–2233.

Centers for Disease Control and Prevention. (2010). Proportion of workers who were work-injured and payment by workers' compensation systems – 10 states, 2007. *MMWR*. 59(29):897-900.

Chao S, Zarzabal L, Walker S, Herzog C, Eilerman PA, Luce BK, Carnahan DH. (2013). Estimating diabetes prevalence in the Military Health System population from 2006 to 2010. *Military Medicine*. 178(9):986-993.

Cheuvront S, & Kenefick R. (2021). Personalized fluid and fuel intake for performance optimization in the heat. *Journal of Science and Medicine in Sport*. 24(8): 735–738.

Chowdhury R, Shah D, Payal A. (2017). Healthy Worker Effect Phenomenon: Revisited with an Emphasis on Statistical Methods – A Review. *Indian J Occ Env Med.* 21(1):2-8.

Cortez, O. D. (2009). Heat stress assessment among workers in a Nicaraguan sugarcane farm. *Global Health Action*. 2(1).

Dembe, A. (2001). The social consequences of occupational injuries and illnesses. *Am J Ind Med.* 40(4): 403-417.

Ebi K, Vanos J, Baldwin J, Bell J, Hondula D, Errett N, Hayes K, Reid C, Saha S, Spector J, Berry P. (2021). Extreme Weather and Climate Change: Population Health and Health System Implications. *Annual Review of Public Health*. 42: 293–315.

Fan Z, Bonauto D, Foley M, Silverstein B. (2006) Underreporting of work-related injury and illness to workers compensation: industry and illness factors. *J Occ Env Med*. 48(9):914-922.

Fatima SH, Rothmore P, Giles LC, Varghese BM, Bi P. (2021). Extreme heat and occupational injuries in different climate zones: A systematic review and meta-analysis of epidemiological evidence. *Environ Int.* 148:106384.

Filep E, Murata Y, Endres B, Kim G, Stearns R, Casa D. (2020). Exertional Heat Stroke, Modality Cooling Rate, and Survival Outcomes: A Systematic Review. *Medicina (Kaunas, Lithuania)*. 56(11): 1–24.

Foster J, Smallcombe J, Hodder S, Jay O, Flouris A, Nybo L, Havenith G. (2021). An advanced empirical model for quantifying the impact of heat and climate change on human physical work capacity. *International Journal of Biometeorology*. 65(7): 1215–1229.

Foster J, Smallcombe J, Hodder S, Jay O, Flouris A, Nybo L, Havenith G. (2022). Quantifying the impact of heat on human physical work capacity; part III: the impact of solar radiation varies with air temperature, humidity, and clothing coverage. *International Journal of Biometeorology*. 66(1): 175–188.

García-Rubira J, Aguilar J, Romero D. (1995). Acute myocardial infarction in a young man after heat exhaustion. *International Journal of Cardiology.* 47(3): 297–300.

Gubernot D, Anderson G, Hunting K. (2015). Characterizing occupational heat-related mortality in the United States, 2000-2010: An analysis using the census of fatal occupational injuries database. *American Journal of Industrial Medicine.* 58(2): 203–211.

Hesketh, M., Wuellner, S., Robinson, A., Adams, D., Smith, C., & Bonauto, D. (2020). Heat related illness among workers in Washington State: A descriptive study using workers' compensation claims, 2006-2017. *American Journal of Industrial Medicine*. 63(4): 300–311.

Isaksen, T. B., Fenske, R. A., Hom, E. K., Ren, Y., Lyons, H., & Yost, M. G. (2016). Increased mortality associated with extreme-heat exposure in King County, Washington, 1980-2010. *International Journal of Biometeorology*. 60(1): 85–98.

Kerstein M, Wright D, Connelly J, Hubbard R. (1986) Heat illness in hot/humid environment. *Military Medicine.* 151(6): 308-311

Khatana S, Werner R, Groeneveld P. (2022).Association of Extreme Heat With All-Cause Mortality in the Contiguous US, 2008-2017. *JAMA Network Open*. May 2; 5(5).

Khatana SAM, Werner RM, Groeneveld PW. (2022) Association of Extreme Heat and Cardiovascular Mortality in the United States: A County-Level Longitudinal Analysis From 2008 to 2017. *Circulation*. 146(3): 249-261.

Kuehn L, McCormick S. (2017) Heat Exposure and Maternal Health in the Face of Climate Change. *Int J Environ Res Public Health*. 14(8):853.

Leigh, J. P. (2011). Economic burden of occupational injury and illness in the United States. *Milbank Q* 89(4): 728-772.

Leon L. (2008). Thermoregulatory responses to environmental toxicants: the interaction of thermal stress and toxicant exposure. *Toxicology and Applied Pharmacology.* 233(1): 146–161.

Levitt R, Parker H, Morse Samuelson N (1981): Improving Construction Safety Performance: The User's Role. Volume 260 of Technical Report. Department of Civil Engineering, Stanford University. Department of Civil Engineering.

Liu J, Varghese B, Hansen A, Hansen A, Zhang Y, Driscoll T, Morgan G. (2022) Heat exposure and cardiovascular health outcomes: a systematic review and metaanalysis. *The Lancet; Planetary Health* 6(6):E484-E495.

Marsh B, Milofsky C, Kissam E, Arcury TA. (2015) Understanding the Role of Social Factors in Farmworker Housing and Health. *New Solut*. 25(3): 313-33.

Maung, Z., & Tustin, A. W. (2020). The Heat Death Line: Proposed Heat Index Alert Threshold for Preventing Heat-Related Fatalities in the Civilian Workforce. *New solutions: a journal of environmental and occupational health policy*: NS, 30(2), 138–145. https://doi.org/10.1177/1048291120933819

McCarthy R. (2019). Outcomes of a Heat Stress Awareness Program on Heat-Related Illness in Municipal Outdoor Workers. *J Occ Env Med*. 61(9):724-728

Meade D, Lauzon M, Poirier M, Flouris A, Kenny G. (2015). An Evaluation of the Physiological Strain Experienced by Electrical Utility Workers in North America. *Journal of Occupational and Environmental Hygiene.* 12(10): 708–720.

Minard D. (1967). Studies and Recent Advances in Military Problems of Heat Acclimatization. *Military Med.* 132(4):306-315.

Mirabelli M, Richardson D. (2005). Heat-Related Fatalities in North Carolina. *American Journal of Public Health.* 95(4): 635.

Mix J, Elon L, Vi Thien Mac V, Flocks J, Economos E, Tovar-Aguilar A. Stover Hertzberg V. McCauley L. (2018). Hydration Status, Kidney Function, and Kidney Injury in Florida Agricultural Workers. *Journal of Occupational and Environmental Medicine*. 60(5): e253–e260.

Montain S, Latzka W, Sawka M. (1999). Fluid Replacement Recommendations for Training in Hot Weather. *Military Medicine.* 164(7): 502–508.

Morris, C. E., Gonzales, R. G., Hodgson, M. J., & Tustin, A. W. (2019). Actual and simulated weather data to evaluate wet bulb globe temperature and heat index as alerts for occupational heat-related illness. *Journal of occupational and environmental hygiene*, 16(1), 54–65.

Morse T, Dillon C, Kenta-Bibi E, Weber J, Warren D. (2005) Trends in work-related musculoskeletal disorder reports by year, type, and industrial sector: A capture-recapture analysis. *Am J Ind Med*. 48(1):40-49.

Moyce S, Armitage T, Mitchell D, Schenker M. (2020). Acute kidney injury and workload in a sample of California agricultural workers. *American Journal of Industrial Medicine.* 63(3), 258–268.

Moyce S, Mitchell D, Armitage T, Tancredi D, Joseph J, Schenker M. (2017) Heat strain, volume depletion and kidney function in California agricultural workers. *Occup Environ Med.* 74(6):402-409.

National Academies of Sciences, Engineering, and Medicine. (2018). *A Smarter National Surveillance System for Occupational Safety and Health in the 21st Century*. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/24835

NIOSH, ASSE [2015]. Overlapping vulnerabilities: the occupational safety and health of young workers in small construction firms. By Flynn MA, Cunningham TR, Guerin RJ, Keller B, Chapman LJ, Hudson D, Salgado C. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2015- 178

NIOSH. NIOSH criteria for a recommended standard: occupational exposure to heat and hot environments. By Jacklitsch B, Williams WJ, Musolin K, Coca A, Kim J-H, Turner N. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 2016-106.

O'Donnell F, Stahlman S, Oetting A. (2018). Incidence rates of diagnoses of cardiovascular diseases and associated risk factors, active component, U.S. Armed Forces, 2007-2016. *MSMR.* 25(3):12-18.

Park RJ, Pankratz N, Behrer AP. IZA DP No. 14560 Temperature, Workplace Safety and Labor Market Inequality. IZA Institute of Labor Economics. Bonn, Germany, 2021.

Pease S, Bouadma L, Kermarrec N, Schortgen F, Régnier B, Wolff M. (2009). Early organ dysfunction course, cooling time and outcome in classic heatstroke. *Intensive Care Medicine.* 35(8), 1454–1458.

Périard, J. D., Racinais, S., & Sawka, M. N. (2015). Adaptations and mechanisms of human heat acclimation: Applications for competitive athletes and sports. *Scandinavian Journal of Medicine and Science in Sports*, *25*(S1), 20–38. https://doi.org/10.1111/sms.12408

Piil J, Lundbye-Jensen J, Trangmar S, Nybo L. (2017). Performance in complex motor tasks deteriorates in hyperthermic humans. *Temperature*. 4: 1–9.

Posner E and Sunstein C. (2005). Dollars and death. *University of Chicago Law Review*. 72(2):537-598.

Pransky G, Snyder T, Dembe A, Himmelstein J. (1999). Underreporting of work-related disorders in the workplace: A case study and review of the literature. *Ergonomics.* 42(1): 171–182.

Rahman M, McConnell R, Schlaerth H, et al. (2022) The Effects of Coexposure to Extreme Heat and Particulate Air Pollution on Mortality in California: Implications for Climate Change. *Am J Resp Critical Care Med*. 206(9).

Redmond C, Emes J, Mazumdar S, Magee P, Kamon E. (1979). Mortality of steelworkers employed in hot jobs. *J Environ Pathol Toxicol.* 2(5):75-96.

Romanello M, McGushin A, di Napoli C, Drummond P, Hughes N, Jamart L, et. al. (2021). The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future. *The Lancet.* 398(10311), 1619–1662.

Rubel L, Ishak K. (1983). The liver in fatal exertional heatstroke. *Liver.* 3(4), 249–260.

Sawka M, Burke L, Eichner E, Maughan R, Montain S, Stachenfeld N. (2007). American College of Sports Medicine position stand. Exercise and fluid replacement. *Medicine and Science in Sports and Exercise*, 39(2), 377–390.

Shapiro Y, Magazanik A, Udassin R, Ben-Baruch G, Shvartz E, Shoenfeld Y. (1979). Heat intolerance in former heatstroke patients. *Ann Intern Med*. 90(6):913-6.

SHARP. SHARP Stats: Heat-related Illness. Technical Report 76-30-2022. Washington State Department of Labor and Industries, SHARP Program, Olympia, WA. 2022.

SHARP. SHARP Stats: Heat-related Illness in New Workers. Technical Report 76-31-2022. Washington State Department of Labor and Industries, SHARP Program, Olympia, WA. 2022.

Shi D, Weaver V, Hodgson M, Tustin A. (2022). Hospitalized heat-related acute kidney injury in indoor and outdoor workers in the USA. *Occ Environ Med.* 79(3):184–191.

Smallcombe J, Foster J, Hodder S, Jay O, Flouris A, Havenith G. (2022). Quantifying the impact of heat on human physical work capacity; part IV: interactions between work duration and heat stress severity. *International Journal of Biometeorology*. 66(12).

Spector J, Krenz J, Rauser E, Bonauto D. (2014). Heat-related illness in Washington State agriculture and forestry sectors. *Am J Ind Med*. 57:881-895.

Spector J, Bonauto D, Sheppard L, Busch-Isaksen T, Calkins M, Adams D, Lieblich M, Fenske R. (2016). A Case-Crossover Study of Heat Exposure and Injury Risk in Outdoor Agricultural Workers. *PLoS One*. 11(10):e0164498.

Steenland K, Stayner L. (1991). The Importance of Employment Status in Occupational Cohort Studies. *Epidemiology.* 2(6):418-423.

Stonehill R, Keil P. (1961) Successful Preventive Medical Measures against Heat Illness at Lackland Air Force Base. *AJPH*. 51(4):586-590.

Strunin L, Boden L. (2004). Family consequences of chronic back pain. *Soc Sci Med*. 58(7): 1385-1393.

Viscusi K. (2004). The Value of Life: Estimates with Risks by Occupation and Industry. *Economic Inquiry*. 42(1): 29-48.

Wallace R, Kriebel D, Punnett L, Wegman D, Amoroso P. (2007). Prior heat illness hospitalization and risk of early death. *Environmental Research*. 104(2): 290–295.

Webber B, Bornstein D, Deuster P, O'Connor F, Park S, Rose K, Whitfield G. (2023) BMI and Physical Activity, Military-Aged U.S. Population 2015-2020. *AJPM*. 64(1):66-75.