Chapter 10 – Greenhouse Gas Emissions

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Chapter 10 Greenhouse Gas Emissions

This chapter is based on the background information and technical analysis documented in Appendix M, *Greenhouse Gas Emissions Technical Appendix*, which includes additional information on greenhouse gases (GHGs) and technical analysis of the effects of each alternative.

10.1 Affected Environment

Global warming is the name given to the increase in the average temperature of the Earth's near-surface air and oceans since the mid-twentieth century and its projected continuation. Warming of the climate system is now considered to be unequivocal (International Panel on Climate Change 2023) with global surface temperature increasing approximately 1.1 degrees Celsius (°C) above 1850-1900 in 2011-2020. Continued warming is projected to likely increase global average temperature above 1.5°C during the 21st century.

Observed warming since 1850 is human-caused, with warming from GHGs dominated by carbon dioxide (CO_2) and methane (CH_4). Increases in GHG concentrations in the Earth's atmosphere since around 1750 are unequivocally caused by GHG emissions from human activities (International Panel on Climate Change 2023). GHGs naturally trap heat by impeding the exit of solar radiation that has hit the Earth and is reflected back into space. Some GHGs occur naturally and are necessary for keeping the Earth's surface inhabitable. However, increases in the concentrations of these gases in the atmosphere have decreased the amount of solar radiation that is reflected back into space, intensifying the natural greenhouse effect and resulting in the increase of global average temperature. (International Panel on Climate Change 2023).

Warming of the atmosphere has broad implications for the environment. In California, one of the effects of climate change could be increases in temperature that could affect the timing and quantity of precipitation. Over the past century, the precipitation mix between snow and rain has shifted in favor of more rainfall and less snow, and snowpack in the Sierra Nevada is melting earlier in the spring (California Department of Water Resources 2010). The average early spring snowpack in the Sierra Nevada has decreased by about 10% during the last century, a loss of 1.5 million acre-feet of snowpack storage. These changes have significant implications for water supply, flooding, aquatic ecosystems, energy generation, and recreation throughout the state (California Department of Water Resources 2010).

Total gross statewide GHG emissions in 2021 were estimated to be 381.3 metric tons per year of CO_2e (California Air Resources Board 2023). The two largest sectors contributing to emissions in California are transportation (38%) and industrial (19%). The agricultural sector represents 10% of the total gross statewide emissions. The agricultural sector includes manure management, enteric fermentation, agricultural residue burning, and soils management.

10.2 Effects of the Alternatives

The impact analysis considers changes in greenhouse gas emissions related to changes in CVP and SWP operation under the alternatives as compared with the No Action Alternative.

The No Action Alternative is based on 2040 conditions. Changes that would occur over that time frame without implementation of the action alternatives are not analyzed in this chapter. However, the changes related to greenhouse gases that are assumed to occur by 2040 under the No Action Alternative are summarized in this section.

The changes to GHGs that are assumed to occur by 2040 under the No Action Alternative conditions would be different from existing conditions because of the following factors:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of the Sacramento Valley

Under the No Action Alternative, Reclamation would continue with the current operation of the CVP, as described in the 2020 Record of Decision and subject to the 2019 Biological Opinions. The 2020 Record of Decision for the CVP and the 2020 Incidental Take Permit for the SWP represent current management direction or intensity pursuant to 43 CFR Section 46.30.

The No Action Alternative, thus, is expected to result in potential changes in GHG emissions from potential changes in emissions from fossil-fueled power plants, hydropower generation, and groundwater pumping. These changes were described and considered in the 2020 Record of Decision.

10.2.1 Impacts from potential changes in GHG emissions from fossil-fueled power plants (hydropower generation)

For the purposes of this analysis, the changes in operations and flows are linked to changes in greenhouse gas emissions because changes in operations and flows affect the amount of power the hydroelectric facilities in the system can generate. Where flows increase on rivers that have hydroelectric facilities then hydropower generation could increase. The additional hydroelectric power is expected to displace power that must be purchased from suppliers connected to the regional electric system (grid). To the extent that the displaced power would have been generated by fossil-fueled power plants, emissions of GHGs from these plants would decrease. Conversely, if hydropower generation decreases, the decrease must be offset by purchased power from the grid to meet demand for power. To the extent that the additional purchased power would have been generated by fossil-fueled power plants, GHG emissions from these plants would increase.

The action alternatives would change operations of the CVP and SWP, which change river flows and reservoir levels. These changes could affect the amount of hydroelectric energy generated, as well as the amount of energy used for operations and pumping, at CVP and SWP facilities. Net energy is the difference between energy generated and energy used. When net energy is positive the CVP and SWP sell the excess to the grid, and GHG emissions from power plants decrease.

When net energy is negative the CVP and SWP purchase power from the grid, and GHG emissions from power plants (to the extent fossil-fueled) supplying that power increase.

With alternatives 1, 2 (all four phases), and 4, net energy would decrease compared to the No Action Alternative (decreases of long-term averages from 6% to 47% for SWP and increases of 2% to decreases of 4% for CVP), and as a result GHG emissions would increase. The increases would be largest with Alternative 1, less with Alternative 4, and least with Alternative 2 (all four phases). With Alternative 3 net energy would increase compared to the No Action Alternative (increases of long-term averages of 86% for SWP and 21% for CVP), and as a result GHG emissions would decrease.

Table 10-1 shows the estimated emissions from fossil-fueled grid power plants associated with net generation. Figure 10-1 and Figure 10-2 show the emissions of each GHG for grid power generation and the changes compared to the No Action Alternative, respectively.

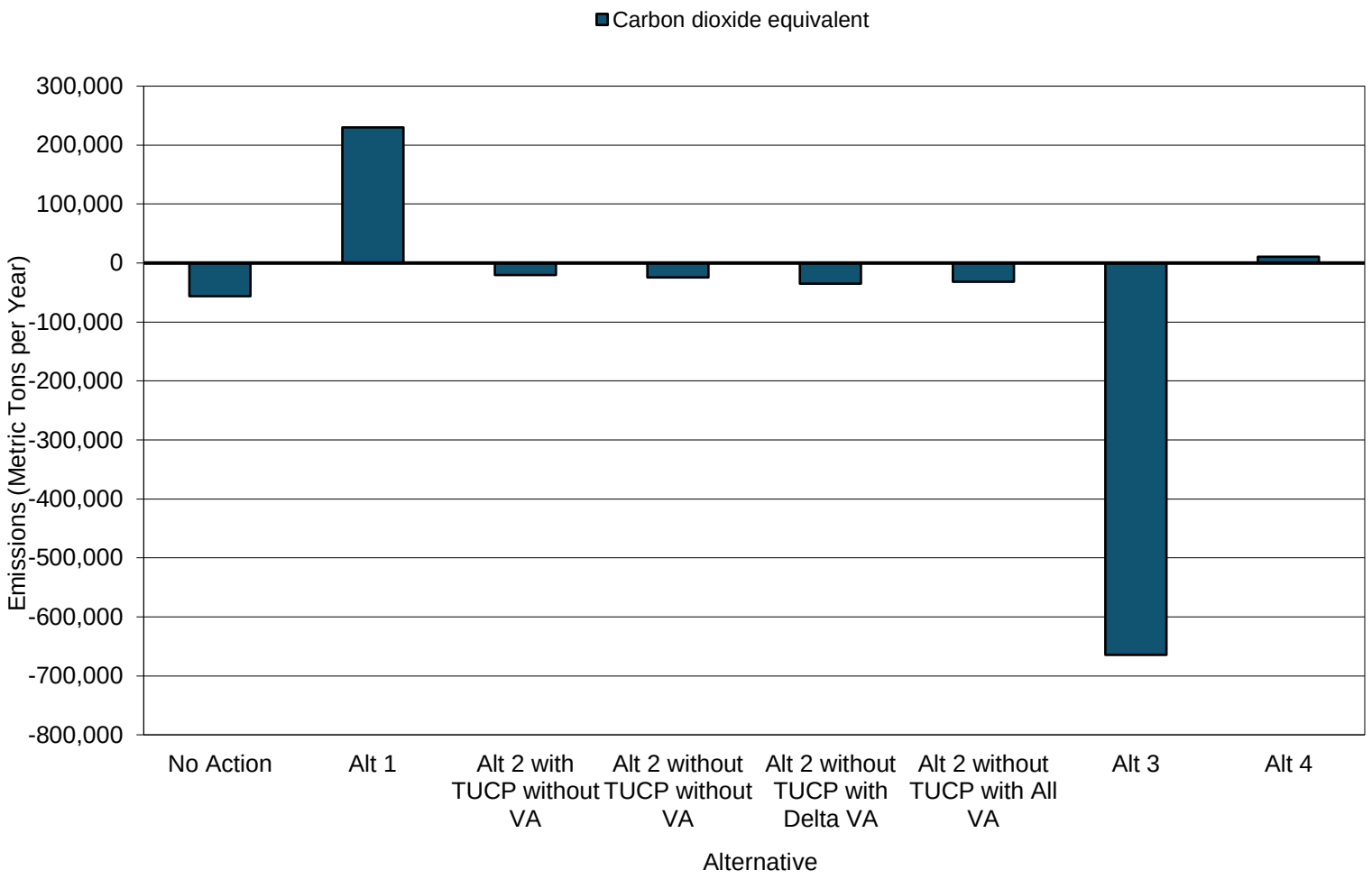
Table 10-1. GHG Emissions from Net Generation.

	GHG Emissions (metric tons per average year)							
GHG	**No Action**	**Alt 1**	**Alt 2 with TUCP without VA**	**Alt 2 without TUCP without VA**	**Alt 2 without TUCP with Delta VA**	**Alt 2 without TUCP with All VA**	**Alt 3**	**Alt 4**
CO_2	-56,252	229,352	-19,854	-23,990	-34,537	-31,849	-662,412	10,754
CH_4	-3.208	13.079	-1.132	-1.368	-1.969	-1.816	-37.774	0.613
N_2O	-0.370	1.509	-0.131	-0.158	-0.227	-0.210	-4.359	0.071
CO_2e	-56,443	230,129	-19,921	-24,071	-34,654	-31,957	-664,655	10,791

Notes:

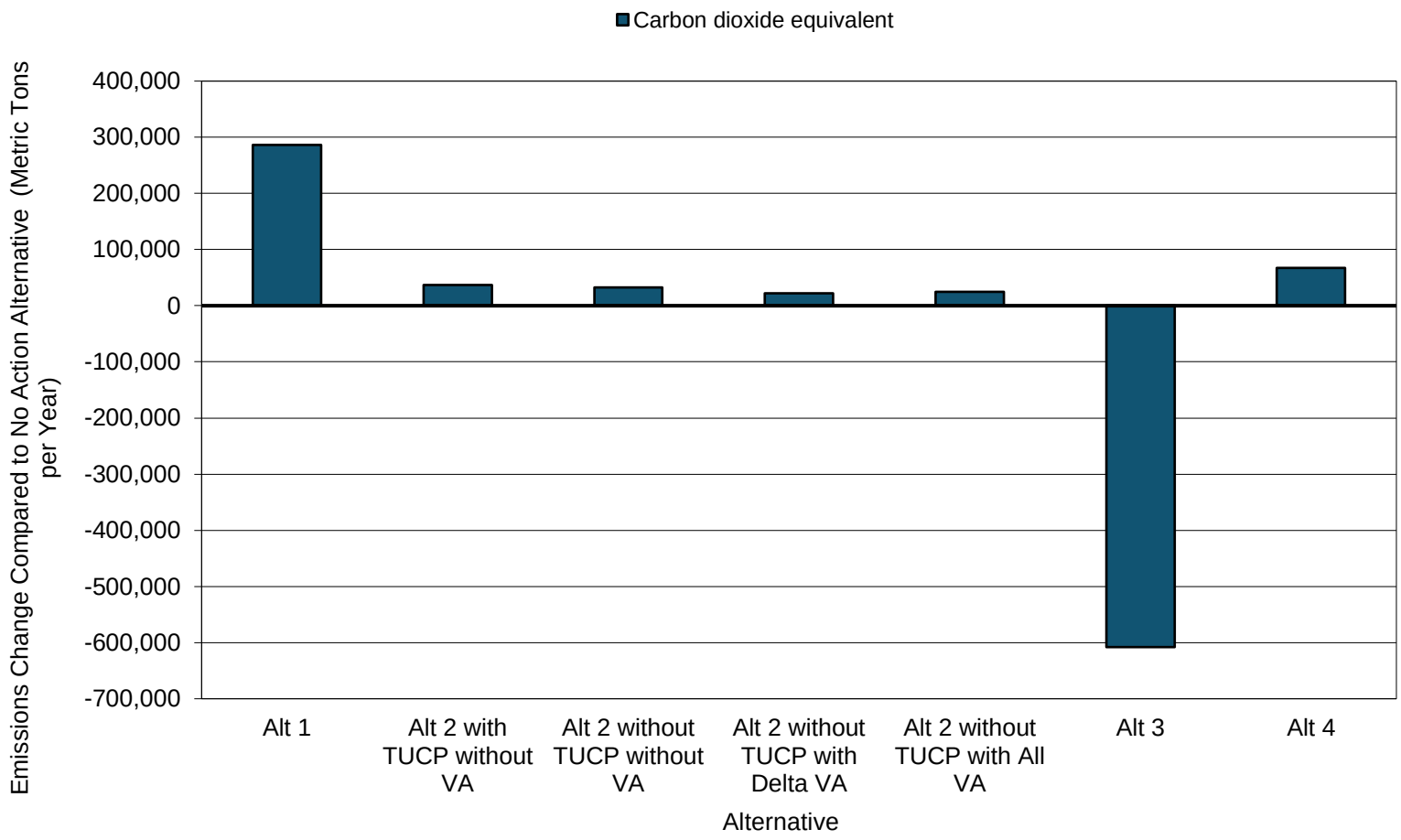
Values represent the emissions effects of net generation, i.e., CVP/SWP hydropower generation minus CVP/SVP energy use. Emissions of zero would indicate that CVP/SWP hydropower generation exactly equals CVP/SWP energy use. Negative emission values indicate decreases in emissions because net generation is positive and displaces grid power; positive emission values indicate increases in emissions because net generation is negative and CVP/SWP purchases the needed power from the grid.

CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; N_2O = nitrous oxide; CO2e = carbon dioxide equivalent; Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements, < = less than



Notes: Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements

Figure 10-1. GHG Emissions from Grid Power Generation.



Notes: Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements
Emissions for the No Action Alternative are not shown because they are the baseline to which changes under the action alternatives are compared. These baseline emissions are indicated by the No Action bar in Figure 10-1.

Figure 10-2. Changes in GHG Emissions from Grid Power Generation Compared to the No Action Alternative.

10.2.2 Impacts from potential changes in GHG emissions from fossil-fueled power plants (groundwater pumping)

The action alternatives would change operation of the CVP and SWP, which could change river flows and reservoir levels. These changes could affect the amount of water available for agricultural irrigation. If surface water availability decreases, farmers could make up the difference in water supply by increasing groundwater pumping. To the extent that the additional purchased power would be generated by fossil-fueled power plants, GHG emissions from these plants could increase. Conversely, if surface water availability increases, farmers could decrease the amount of groundwater they pump, which could lead to a decrease in GHG emissions.

GHG emissions resulting from changes in groundwater pumping were evaluated on a project-wide basis in terms of emissions from the fossil-fueled power plants (for electrically-powered pumps) and from engines (for engine-powered pumps). For the details of the groundwater modeling on which the GHG analysis was based and the project-wide quantities of water pumped, see Appendix I, *Groundwater Technical Appendix*. Table 10-2 shows the estimated emissions from groundwater pumping. Figure 10-3 and Figure show the GHG emissions and the changes compared to the No Action Alternative for groundwater pumping, respectively.

Table 10-2. GHG Emissions from Groundwater Pumping GHG Emissions from Groundwater Pumping.

GHG	Emissions (metric tons per average year)							
	No Action	Alt 1	Alt 2 with TUCP without VA	Alt 2 without TUCP without VA	Alt 2 without TUCP with Delta VA	Alt 2 without TUCP with All VA	Alt 3	Alt 4
ELECTRIC PUMPS								
CO_2	1,990,165	1,971,247	1,993,417	1,992,974	1,998,886	1,996,077	2,082,690	1,987,948
CH_4	113	112	114	114	114	114	119	113
N_2O	13	13	13	13	13	13	14	13
CO_2e	1,996,905	1,977,922	2,000,168	1,999,723	2,005,655	2,002,837	2,089,743	1,994,680
DIESEL PUMPS								
CO_2	1,231,405	1,219,699	1,233,417	1,233,143	1,236,801	1,235,063	1,288,654	1,230,033
CH_4	50	49	50	50	50	50	52	50
N_2O	11	11	11	11	11	11	11	11
CO_2e	1,235,879	1,224,131	1,237,899	1,237,623	1,241,295	1,239,551	1,293,337	1,234,503
TOTAL PUMPING EMISSIONS [1]								
CO_2	3,221,570	3,190,946	3,226,834	3,226,116	3,235,686	3,231,141	3,371,344	3,217,981
CH_4	163	162	164	164	164	164	171	163
N_2O	24	24	24	24	24	24	25	24
CO_2e	3,232,784	3,202,053	3,238,066	3,237,346	3,246,949	3,242,388	3,383,079	3,229,183

Notes: CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; N_2O = nitrous oxide; CO2e = carbon dioxide equivalent; Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements, < = less than; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements

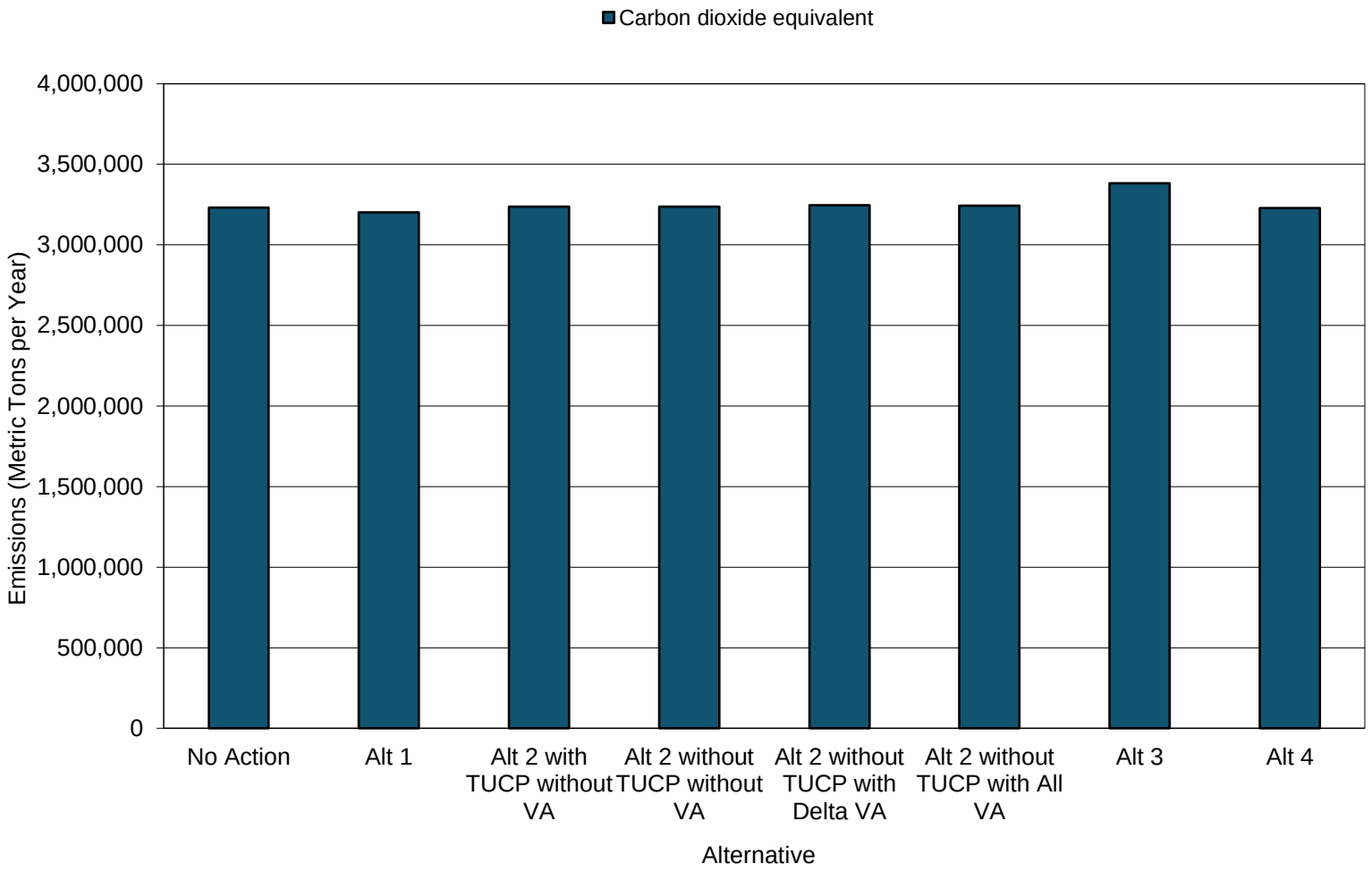
[1] Sum of individual values may not equal total due to rounding.

10.2.3 Impacts from combined potential changes in GHG emissions

The total GHG emissions associated with the project are the sum of the emissions from net generation (Table 10-1) and groundwater pumping (Table 10-2). Table 10-3 shows the estimated total project emissions for a long-term average year. Figure 10-5 and Figure 10-6 show the GHG emissions for all emission sources, and the changes in emissions compared to the No Action Alternative, respectively.

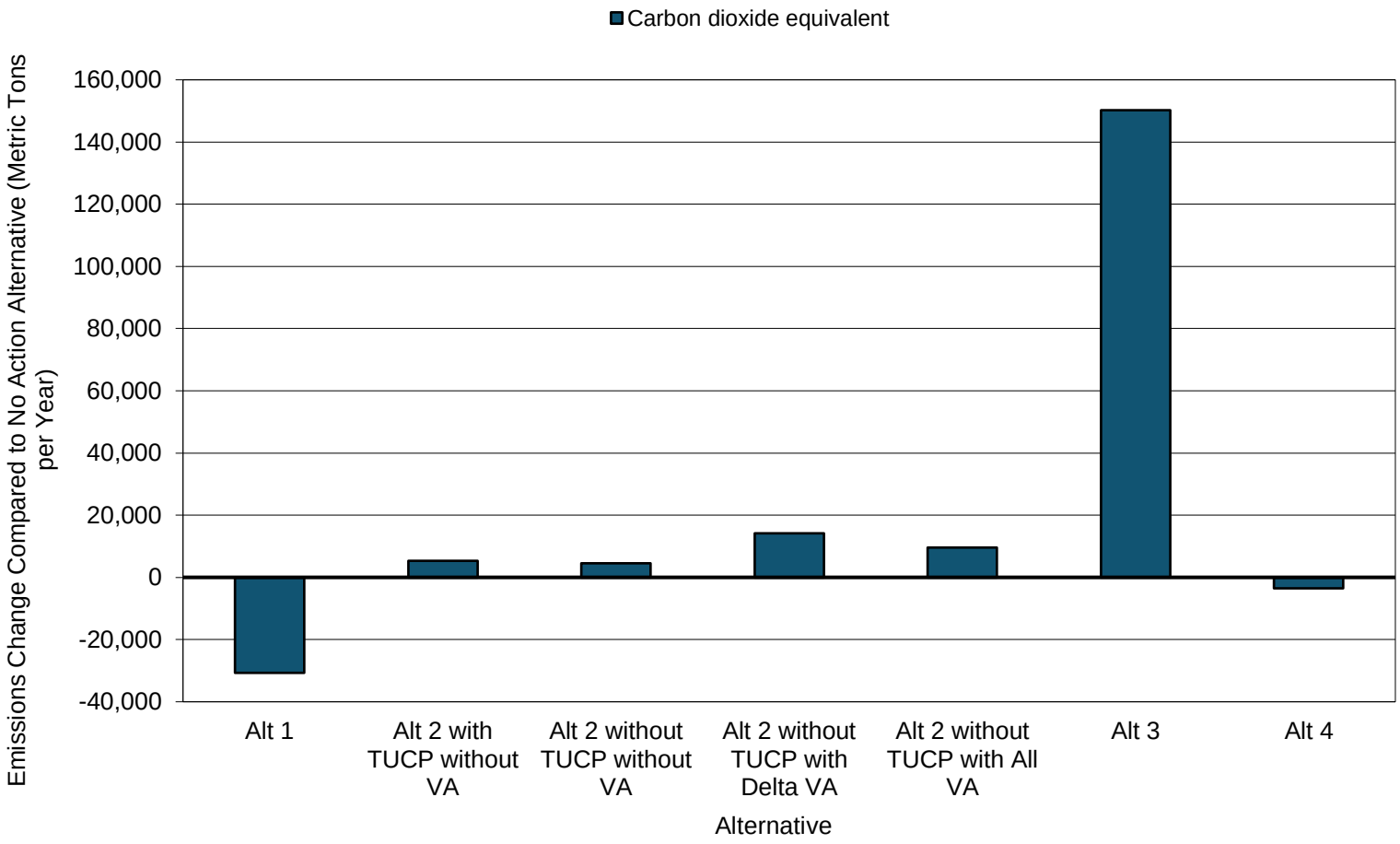
Alternative 1 would lead to an increase in CO_2e emissions compared to the No Action Alternative by 8.1%. Alternative 2, including all four phases, would lead to increases in CO_2e emissions compared to the No Action Alternative by 1.0% to 1.3%. Alternative 3 would lead to a

decrease in CO_2e emissions compared to the No Action Alternative by 14.4%. Alternative 4 would lead to an increase in CO_2e emissions compared to the No Action Alternative by 2.0%.



Notes: Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements

Figure 10-3. GHG Emissions from Groundwater Pumping.



Notes: Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements
Emissions for the No Action Alternative are not shown because they are the baseline to which changes under the action alternatives are compared. These baseline emissions are indicated by the No Action bar in Figure 10-3.

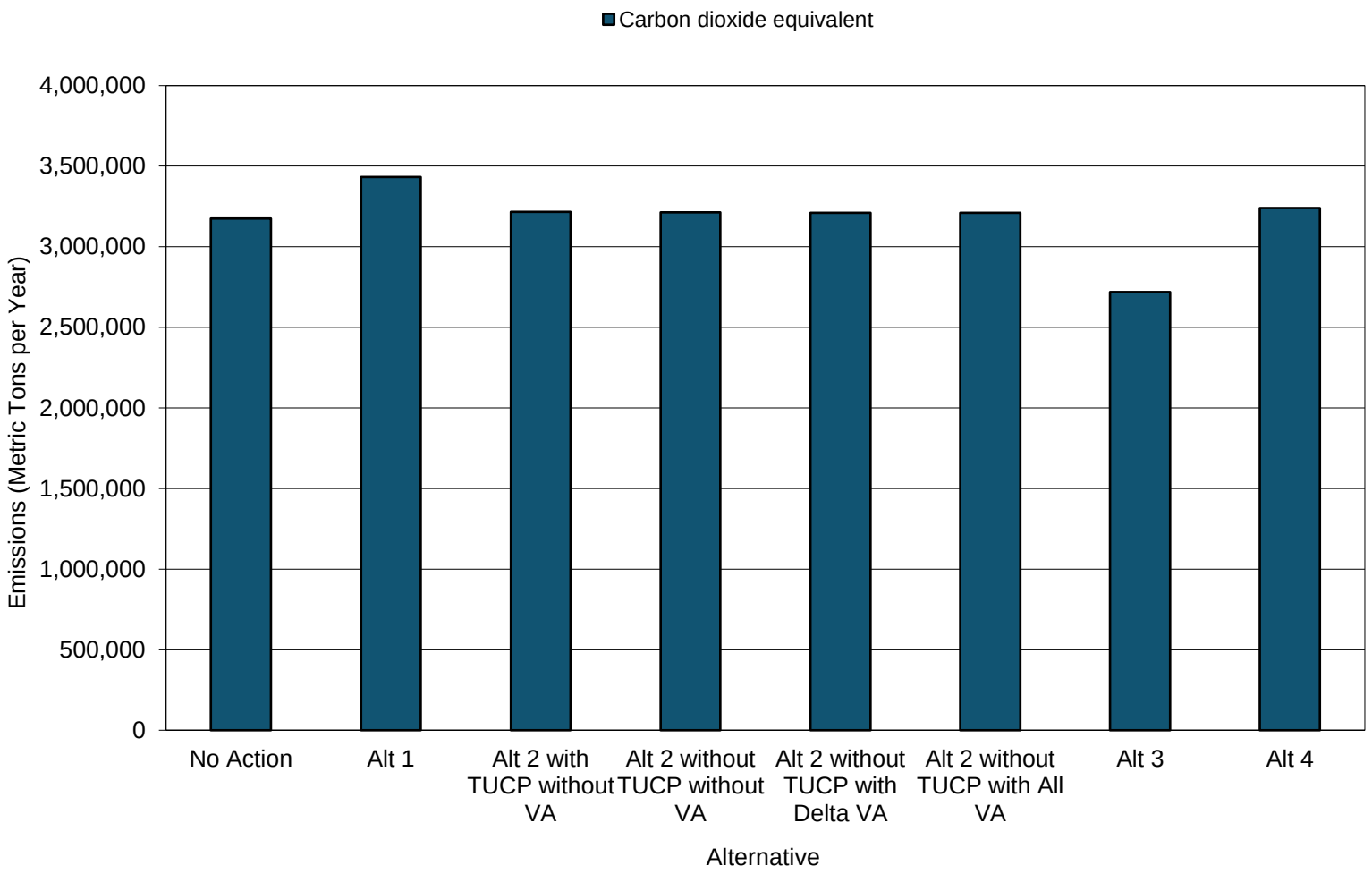
Figure 10-4. Changes in GHG Emissions from Groundwater Pumping Compared to the No Action Alternative

Table 10-3. Total Project GHG Emissions

GHG	Emissions (metric tons per average year)							
	No Action	**Alt 1**	**Alt 2 with TUCP without VA**	**Alt 2 without TUCP without VA**	**Alt 2 without TUCP with Delta VA**	**Alt 2 without TUCP with All VA**	**Alt 3**	**Alt 4**
CO_2	3,165,318	3,420,298	3,206,980	3,202,126	3,201,149	3,199,292	2,708,932	3,228,736
CH_4	160	175	162	162	162	162	133	164
N_2O	24	25	24	24	24	24	21	24
CO_2e	3,176,341	3,432,182	3,218,145	3,213,275	3,212,295	3,210,431	2,718,424	3,239,973

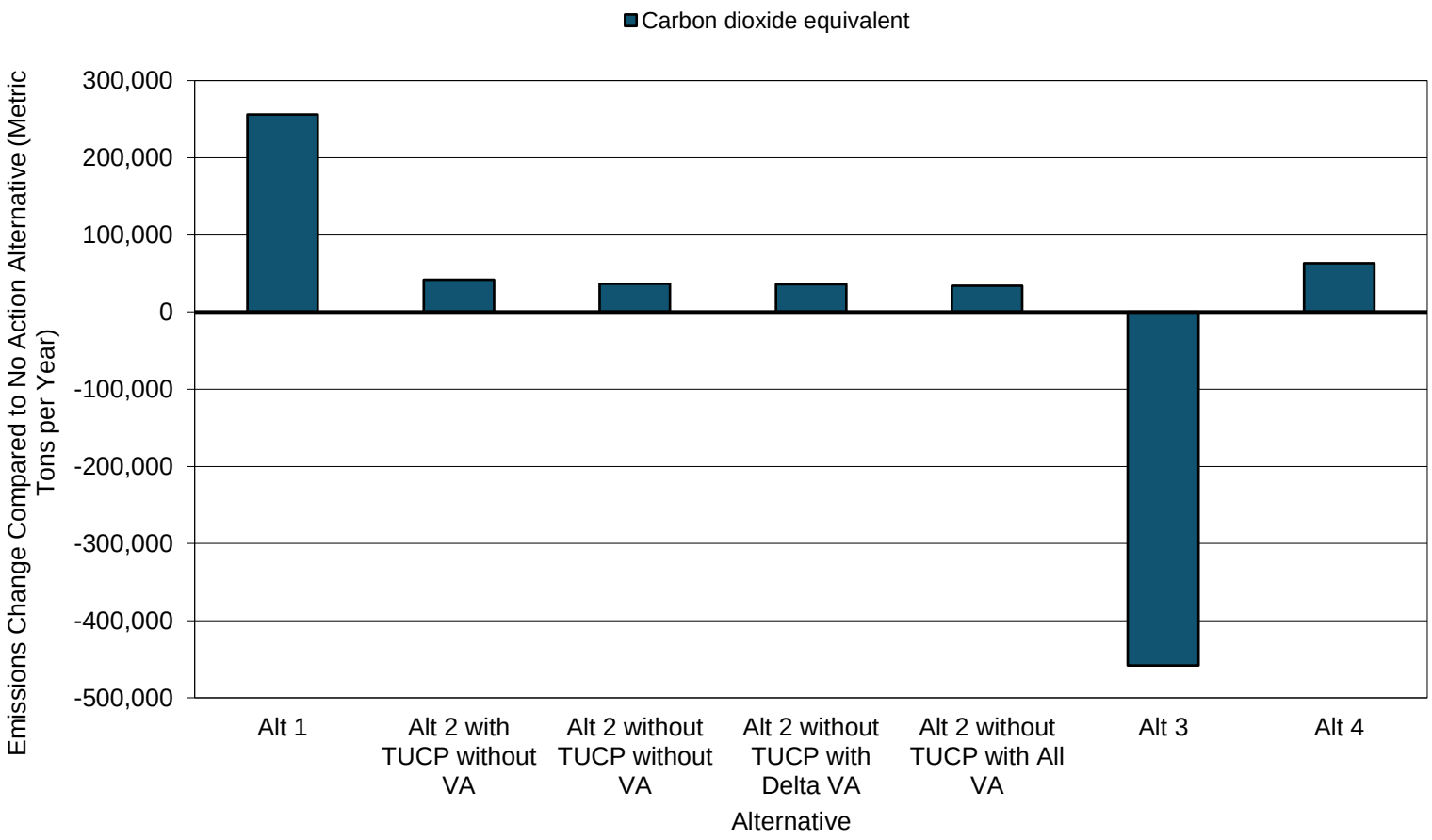
Notes: Values represent the sum of emissions from fossil-fueled power plants (for CVP/SWP purchases of grid power and for electrically-powered groundwater pumps) and emissions from diesel engines (for engine-powered groundwater pumps).

CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; N_2O = nitrous oxide; CO2e = carbon dioxide equivalent; Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements, < = less than; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements



Notes: Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements

Figure 10-5. GHG Emissions from All Sources.



Notes:
Emissions for the No Action Alternative are not shown because they are the baseline to which changes under the action alternatives are compared. These baseline emissions are indicated by the No Action bar in Figure 10-5.
Alt = Alternative; TUCP = Temporary Urgency Change Petition; VA = Voluntary Agreements

Figure 10-6. Changes in GHG Emissions from All Sources Compared to the No Action Alternative.

10.3 Mitigation Measures

No avoidance and minimization measures or mitigation measures have been identified for greenhouse gas emissions.

10.4 Cumulative Impacts

The No Action Alternative would continue with the current operation of the CVP and may result in potential changes to greenhouse gas emissions from fossil-fueled powerplant emissions from hydropower generation and groundwater pumping. The action alternatives will result in changes to greenhouse gas emissions from fossil-fueled powerplant emissions from hydropower generation and groundwater pumping. The magnitude of the changes is dependent on alternative and water year type. Therefore, the No Action Alternative and action alternatives may contribute to cumulative changes to greenhouse gas emissions as described in Appendix M, *Greenhouse Gas Emissions* and Appendix Y, *Cumulative Impacts Technical Appendix*.