4.14 CLIMATE CHANGE IMPACTS ON THE PROPOSED PROJECT

The Supplemental Environmental Impact Statement (Supplemental EIS) evaluates the relationship between climate change and the proposed Project in several ways. First, the potential contributions of the proposed Project to greenhouse gas emissions are addressed in the air quality analysis found in Section 3.12 and Section 4.12. Second, the potential impact of climate change effects (such as temperature and precipitation changes in the proposed Project area) on the construction and operation of the proposed Project itself is described in this section. Finally, Section 4.15, Cumulative Effects Assessment, presents information and analysis regarding indirect cumulative impacts and life-cycle greenhouse gas emissions including the potential impact of further development of the oil sands on climate change.

This section has been structured to present both the setting and context of climate change, and then an analysis of the potential impacts on the construction and operation of the proposed Project. There is no corresponding section in Chapter 3, Affected Environment.

The setting is discussed first, followed by an analysis of the potential impacts of climate change on the construction and operation of the proposed Project.

4.14.1 Setting and Context

4.14.1.1 Historical Climate Trends

Changes to the global climate have been observed over the past century. Between 1895 and 2009, the annual average global temperature has increased, and the states in which the proposed Project would be constructed and operated are, on average, warmer than they have been in the past. The northern states (i.e., Montana and North Dakota) have experienced relatively greater warming compared to southern states (U.S. Bureau of Reclamation [USBR] 2011a). In addition, more of that warming has been observed in the winter. In North Dakota, the average temperature in the winter increased by 5 degrees Fahrenheit (˚F) between 1895 and 2009, while in Nebraska there was only a 1.8°F increase over the same period. The historical changes in temperature are presented for each of the proposed Project states in Table 4.14-1. These historical climate trends are expected to continue and to intensify according to greenhouse gas emissions levels (both man-made and natural) and the associated climate change projections (Intergovernmental Panel on Climate Change [IPCC] 2007 and 2012).

Table 4.14-1 Historical Changes in Temperature by State (1895-2009)

State	Annual Average Increase (°F)	Summer Average Increase (°F)	Winter Average Increase (°F)
Montana[a]	1.6	1.0	1.7
North Dakota[b]	2.9	1.8	5.0
South Dakota[b]	2.2	1.6	3.9
Nebraska[b]	1.2	0.7	1.8
Kansas[b]	1.1	0.6	2.0

[a] Source: Breckner 2012.
[b] Source: High Plains Regional Climate Center (HPRCC) 2012.

4.14.1.2 Projected Climate Change Effects

Climate changes can produce a range of effects, such as direct effects that include increases/decreases in temperature and precipitation on a seasonal basis, as well as indirect effects including increases in freeze-thaw cycles along with increased occurrences of flooding/drought and wind erosion of soil. It can also lead to broader effects such as changes to the natural environment (e.g., vegetation changes).

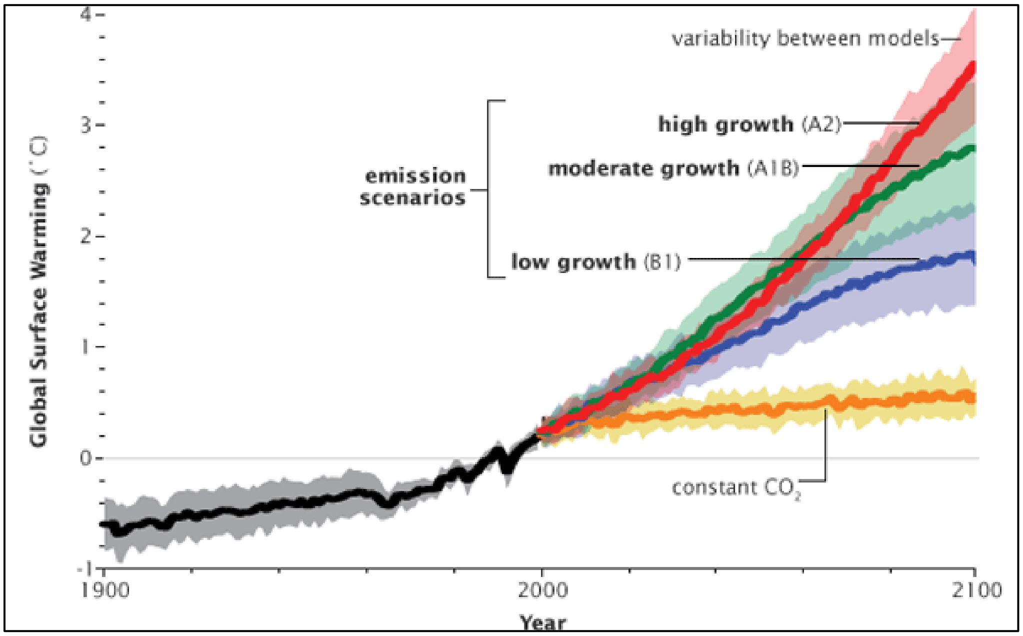
As part of preparation of this Supplemental EIS, an analysis was performed to evaluate the potential impacts of climate change on the proposed Project construction and operations. The analysis identified available, credible information on the projected climate change effects and the time horizons of these changes, to identify potential impacts. The climate projections examined as part of this analysis were "downscaled" from general circulation models for North America. Downscaling disaggregates and refines climate modeling results from a global to a regional scale of relevant interest, or to a finer scale. Since this analysis relied on the downscaled model results reported by existing studies, less information was available on the possible extreme conditions and, by extension, the "worst-case" scenarios. There is, however, general consensus among the downscaled general circulation models[1] about future climate change effects.

A number of sources were reviewed and cited as part of this analysis. The recent IPCC report (IPCC 2012) reviews existing studies, multiple global climate models, and multiple regional climate models and generates non-numerical confidence levels for heat waves and extreme weather events for North America. The High Resolution Interpolation of Climate Scenarios for the Conterminous United States and Alaska Derived from General Circulation Model Simulations study (Joyce et al. 2011) downscaled four global climate models and averaged the model results for eight climate regions in the United States. Of the sources reviewed, it was determined that this study provides the most complete set of data available for application to the proposed Project across all the climate regions. However, due to the averaging of all the models, it likely underestimates the possible climate extremes. Where possible, other studies such as those from the United States Global Change Research Program (USGCRP 2009) and the USBR (2011a and 2011b) were referenced to obtain further detail on the possible extremes. Cumulatively, these studies covered the proposed Project areas with respect to projected climate effects.

Climate change projections have been included for a range of future carbon emissions scenarios. The IPCC developed several future scenarios for greenhouse gas emissions; these were dependent on population and economic growth, as well as technology for fuel use and fuel production (IPCC 2007). These scenarios are used to project the degree and severity of climate change effects.

[1] The term 'downscaled general circulation models' is generally applied to models and studies where future climate predictions are downscaled from the global to regional level.

The emissions scenarios examined for this Supplemental EIS included a high (A2) scenario, a medium (A1B) scenario, and a low (B1) scenario.[2] These emissions scenarios are presented in Figure 4.14.1-1.



Source: IPCC 2007.

Figure 4.14.1-1 Emissions Scenarios

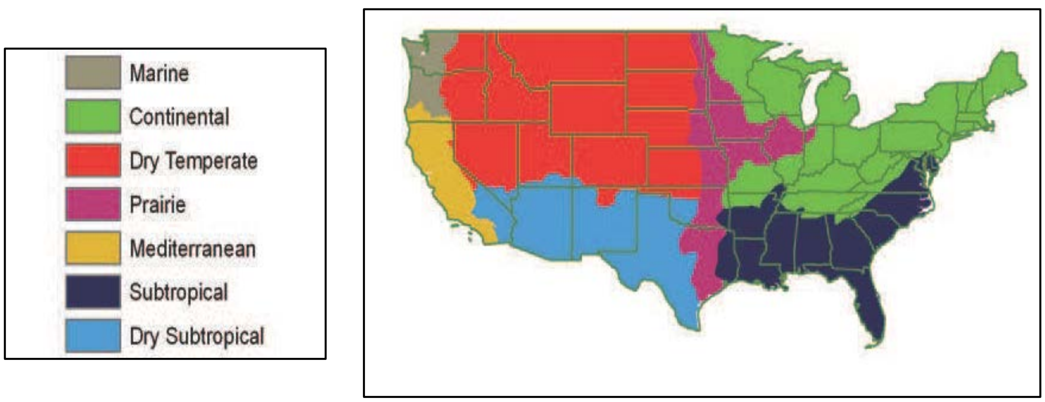
It should be noted that the global climate model results reviewed used a baseline level for carbon dioxide (CO_2) of 350 parts per million (ppm), the level cited in the Kyoto Protocol for Greenhouse Gas Emissions. The actual annual average ambient levels of baseline CO_2 in the atmosphere in 2010 and 2011 (as recorded at the Mauna Loa Observatory, Hawaii) were 390 ppm and 392 ppm, respectively; accordingly, the projected future climate change effects described herein may be greater than those predicted in the IPCC modeling results. Calendar year 1997 was the last year the annual average CO_2 level was less than 350 ppm (Tans 2012), the level cited in the Kyoto Protocol for Greenhouse Gas Emissions. Acknowledging that actual CO_2 levels are currently higher than what was projected in the IPCC models, this analysis has taken a precautionary approach by using the worst-case projections (A2 scenario) to ensure potential

[2] The three selected scenarios are described in the 2007 IPCC report as follows: The A2 scenario is a heterogeneous world with rapid population growth and slow economic development and technological innovation rates. The A1B scenario assumes rapid economic growth and a world population that peaks around 2050. Technological innovation and adoption of energy-efficient technologies is balanced and does not rely on any one energy source. The B1 scenario assumes very rapid economic growth, a world population that peaks around 2050, and a very fast innovation and adoption of energy-efficient technologies. The economy makes rapid changes toward services and information.

impacts and outcomes are not underestimated. The climate change effects examined as part of this study can be broadly grouped into two categories: temperature and precipitation.

The proposed pipeline route crosses through Montana, South Dakota, and Nebraska, with ancillary facilities in North Dakota and Kansas. These areas correspond to the Dry Temperate and Prairie climate regions referenced in Joyce et al. 2011. These region designations are specific to this section on climate change impacts, and do not correspond with region designations discussed in other sections of the Supplemental EIS. The proposed pipeline route is primarily in the Dry Temperate climate region and crosses into the Prairie climate region toward the southern end of the route.

In general, A2 scenario modeling results for each of these two climate regions show the same overall trends in temperature and precipitation, with some variation in the magnitude of the change. Therefore, for each category of climate effect, general changes for the United States are summarized below prior to a review of the projections for each climate region. A map further detailing the locations of the climate regions relative to the states is presented in Figure 4.14.1-2.



Source: Joyce et al. 2011.

Figure 4.14.1-2 Climate Regions of the United States

The climate projection data for the two climate regions (from Joyce et al. 2011) are presented in Appendix T, Literature Review. Further summaries and analysis of these data are presented by climate effect category in the following sections. Given that the proposed Project has a nominal operating life of 50 years, from 2015 to 2065, the most relevant of the data are in the 2010–2039 and 2040–2069 timeframes. However, projected data from 2070-2099 are also included because historically pipelines have been known to remain in service longer than 50 years.

Temperature

By 2040–2069, the national average annual temperature is predicted to increase above the baseline of 1980 to 2009[3] by between 2.8°F and 6.6°F, depending on the model and the emissions scenario evaluated (USGCRP 2009). These changes would modify the seasonal patterns such that spring arrives earlier and summer lasts longer and is generally hotter, both in terms of its average and peak temperatures. Winters have already experienced and are expected to continue to experience the greatest degree of change from historical norms and these changes would result in the winter season becoming shorter and warmer than in the recent past (USGCRP 2009).

For western and central North America, multiple general circulation models predict, with high confidence in the opinion of IPCC, that heat waves and warm spells will likely be more frequent, more intense, and longer in duration (IPCC 2012). Increased temperature over a shortened time span would be expected to have a number of implications included increase in the likelihood of soil contraction, a shorter cool season, a shorter duration of frost periods, and more freeze-thaw cycles. The predicted average incremental temperature increases in the two climate regions for the three scenarios referenced above are presented in Table 4.14-2. Predicted temperatures for the two regions are discussed below.

Table 4.14-2 Projected Changes in Average Mean Daily Maximum Temperatures (2010-2099)

		Climate Regions					
Temperature Changes		**Dry Temperate**			**Prairie**		
		High Emissions A2	**Medium Emissions A1B**	**Low Emissions B1**	**High Emissions A2**	**Medium Emissions A1B**	**Low Emissions B1**
Annual Mean Daily Max Temp Δ[a] from 1980-2009 (°F)	Baseline	59.2	59.2	59.1	65.8	66.0	66.0
	2010-2039	1.8	2.4	2.0	2.1	2.4	1.8
	2040-2069	4.6	4.6	3.3	4.6	4.6	3.1
	2070-2099	7.7	6.4	4.4	7.8	6.4	4.1
Winter Mean Daily Max Temp Δ from 1980-2009 (°F)	Baseline	36.3	36.3	36.2	41.2	41.1	41.1
	2010-2039	1.3	1.8	1.3	1.5	2.1	1.2
	2040-2069	3.8	3.9	3.0	4.0	4.4	3.1
	2070-2099	6.3	5.4	4.1	6.9	6.3	4.2
Summer Mean Daily Max Temp Δ from 1980-2009 (°F)	Baseline	82.4	82.4	82.5	87.7	88.2	88.3
	2010-2039	2.6	3.0	2.3	2.7	2.7	2.1
	2040-2069	5.5	5.5	3.5	5.2	4.7	2.7
	2070-2099	8.8	7.4	4.5	8.6	6.5	3.9

Source: Joyce et al. 2011.

[a] **Δ =** change.

[3] A lengthy period of climate data is used as a baseline because for long term climate modeling, a single baseline year is typically not used. A time period of historical data is used for long term climate modeling, since these will show the historical trend line as a starting point.

Dry Temperate Climate Region

Under the A2 scenario, by 2040–2069, the annual maximum mean daily summer temperature is projected to increase by as much as 5.5°F in the Dry Temperate climate region (Joyce et al. 2011). This would result in a new daily mean summer maximum temperature of 88°F. This would also mean that the temperature extremes for the region would be expected to be greater than historical extremes. The Dry Temperate climate region is expected to have more frequent, longer, and more extreme (intense) events including days with extreme cold and frosts (HPRCC 2012).

Prairie Climate Region

For the Prairie climate region, the A2 scenario predicts an annual maximum mean daily summer temperature increase of as much as 5.2°F for the region by 2040–2069. The inter-annual temperature variability[4] is projected to increase by 15 to 40 percent under the A2 scenario (Joyce et al. 2011) suggesting that although temperature is expected to rise, it could vary widely between seasons.

Precipitation

Annual precipitation is expected to increase across most of the climate regions from the 1980-2009 baseline depending on the emissions scenario. More of the precipitation is predicted to be associated with severe storm events (USGCRP 2009), which are projected to increase in frequency over future time periods. The model projections also indicate a greater inter-annual variability, suggesting that there might be more variability between seasons, for example, periods of drought interspersed by heavy precipitation events.

Increased rainfall in a shortened time span increases the likelihood of flooding, soil submersion, heavy snow, runoff, sinkholes, riverbed scour, washouts, landslides, and (in mountain regions) avalanches (USGCRP 2009). The predicted precipitation changes in the two climate regions for the three scenarios referenced above are presented in Table 4.14-3. Predicted precipitation for the two regions is discussed below.

Table 4.14-3 Projected Changes in Precipitation by Climate Region (2010-2099)

Precipitation		Climate Regions: Dry Temperate			Climate Regions: Prairie		
		High Emissions A2	**Medium Emissions A1B**	**Low Emissions B1**	**High Emissions A2**	**Medium Emissions A1B**	**Low Emissions B1**
Annual Precipitation Δ in inches from 1980-2009	Baseline	16.7	16.7	16.7	35.1	34.7	34.7
	2010-2039	0.5	0.2	0.3	0.2	0.2	0.0
	2040-2069	0.5	0.9	1.0	0.6	0.8	1.8
	2070-2099	0.9	0.9	0.9	0.6	1.7	1.3

Source: Joyce et al. 2011.

[4]Inter-annual temperature variability is the relative change in temperature that occurs between years.

Dry Temperate Climate Region

Precipitation increases are expected between 2010 and 2099. Under the A2 scenario, the increase in average annual precipitation for the Dry Temperate climate region by 2040–2069 is projected to be 0.5 inch. For parts of the Dry Temperate climate region in the Missouri River Basin, by 2050, the projected increases in temperature will offset increases in precipitation, in that evapotranspiration is predicted to result in a net loss in the water balance. The net loss in the water balance would be further compounded by less snowpack accumulation and more precipitation falling as rain earlier in the season. Though there is less certainty around this prediction, this phenomenon could result in more acute runoff events. An increase in the intensity of precipitation events is also predicted with each successive decade (USBR 2011b).

Prairie Climate Region

Precipitation increases are also expected between 2010 and 2099. Under the A2 emissions scenario, the increase in average annual precipitation for the Dry Temperate climate region by 2040–2069 is projected to be 0.6 inch. The studies examined did not include an evaluation of the net impact upon the water balance in this portion of the Missouri River Basin.

4.14.2 Impacts on the Proposed Project

This section discusses the potential for impacts to construction and operation of the proposed Project from the expected future climate changes described above.

The climate modeling results described above show that there are relatively small differences between projected temperature changes across the two climate regions. For precipitation, the relative differences are greater, mainly due to the differences in the baseline precipitation rates for the two climate regions.

The sections below present the potential impacts of climate change on construction and operation of the proposed Project.

4.14.2.1 Construction

The construction of the proposed pipeline is planned to occur in 2015; if construction occurs on that schedule, climate conditions during the 1- to 2-year construction period would not be expected to differ much from current conditions, even under worst-case modeling scenarios. TransCanada Keystone Pipeline, LP (Keystone) has confirmed that the measures identified in the Construction, Mitigation, and Reclamation Plan (Appendix G) are sufficient to deal with any potential predicted effects as described above (Keystone 2012).

4.14.2.2 Operation

From a temperature perspective, projections suggest warmer winter temperatures, a shorter cool season, a shorter duration of the time period that frost occurs and more freeze-thaw cycles per year, which could lead to an increased number of episodes of soil contraction and expansion. In summer, warmer summer temperatures, increased number of hot days, increased number of consecutive hot days and longer summers are predicted, which could lead to impacts associated with heat stress and wildfire risks. Keystone has confirmed that the proposed Project is designed in accordance with U.S. Department of Transportation (USDOT) regulations and the PHMSA 57 Special Conditions (Appendix B), and that these design standards are sufficient to accommodate an increased number of hot days or consecutive hot days. Keystone has also stated that because the proposed pipeline would be buried to at least 4 feet of cover to the top of the pipe, it would be below most surface temperature impacts, including wild fires and frequent freezing and thawing (Keystone 2012).

With respect to precipitation, the potential for increased winter and spring precipitation with increase in frequency of heavy precipitation events, could result in increased runoff and stream flow; increased potential for flooding, erosion, washouts, and hydraulic scour in streambeds, as well as increased periods of soil saturation and increased risk of subsidence. The potential for increased severity, frequency, and duration of droughts, could lead to an increase in episodes of soil contraction and movement. Keystone has confirmed that the design of the proposed Project in accordance with USDOT regulations and the 57 Special Conditions (Appendix B) is sufficient to accommodate the effects of increased precipitation and increased drought. In addition, Keystone has confirmed that the design of pipeline crossings of all waterbodies is required (through these design standards in conjunction with the state permit conditions) to accommodate lateral stream migration and scour. In addition, areas where subsidence is known to be present will be designed accordingly (Keystone 2012).

4.14.3 References

Breckner, Michelle, and Western Regional Climate Center. "Historical Average Temperature Data for Montana." 12 October, 2012. E-mail.

High Plains Regional Climate Center (HPRCC). 2012. Climate Change on the Prairie: A Basic Guide to Climate Change in the High Plains Region. NOAA, University of Nebraska. Website: http://www.hprcc.unl.edu. Accessed October 2, 2012.

HPRCC. See High Plains Regional Climate Center.

IPCC. See Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

_________. 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, J.K. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Joyce, L.A., D.T. Price, D.W. McKenney, R.M Siltanen, P. Papadopol, K. Lawrence, and D.P. Coulson. 2011. High Resolution Interpolation of Climate Scenarios for the Conterminous USA and Alaska Derived from General Circulation Model Simulations. Gen. Tech. Rep. RMRS-GTR-263. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Keystone. See TransCanada Keystone Pipeline, LP.

Tans, Pieter. 2012. NOAA ESRL DATA. NOAA, September 5, 2012. Website: ftp://ftp.cmdl.noaa.gov/ccg/co2/trends/co2_annmean_mlo.txt. Accessed October 5, 2012.

TransCanada Keystone Pipeline, LP (Keystone). 2012. Response to United States Department of State, Data Request 4.0. October 24, 2012.

United States Bureau of Reclamation (USBR). 2011a. Technical Service Center. *West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections*. Denver: US Department of the Interior, 2011. Print. 86-68210–2011-01.

________. 2011b. Alexander, P., L. Brekke, G. Davis, S. Gangopadhyay, K. Grantz, C Hennig, C. Jerla, D. Llewellyn, P. Miller, T. Pruitt, D. Raff, T. Scott, M. Tansey, and T. Turner. Reclamation, SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, Report to Congress. Publication. U.S. Department of the Interior and Bureau of Reclamation, April 2011. Website: http://www.usbr.gov/climate/SECURE/docs/SECUREWaterReport.pdf. Accessed October 4, 2012.

United States Global Change Research Program (USGCRP). 2009. Global Climate Change Impacts in the U.S.

USBR. See United States Bureau of Reclamation.

USGCRP. See United States Global Change Research Program.

-Page Intentionally Left Blank-