Appendix A. Climate Change Assessment

BLACK & VEATCH CORPORATION
Lincoln Water System **B&V Project Number 401472**
2020 Facilities Master Plan Update **January 31, 2020**
Climate Change Projections

To: File
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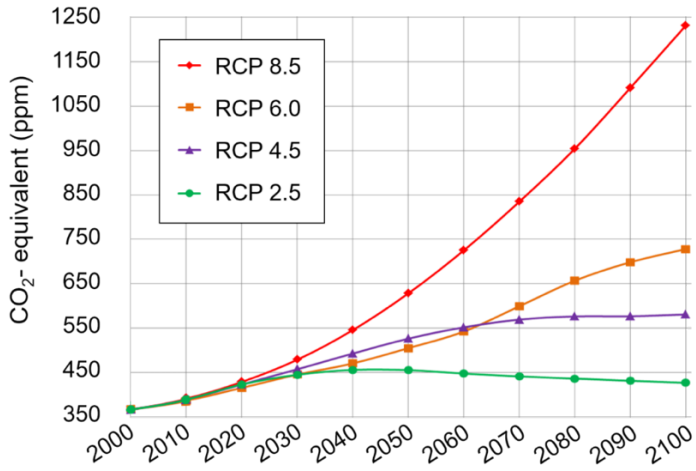
Central and Eastern Nebraska Mid-century Climate Projections (2041-2070)

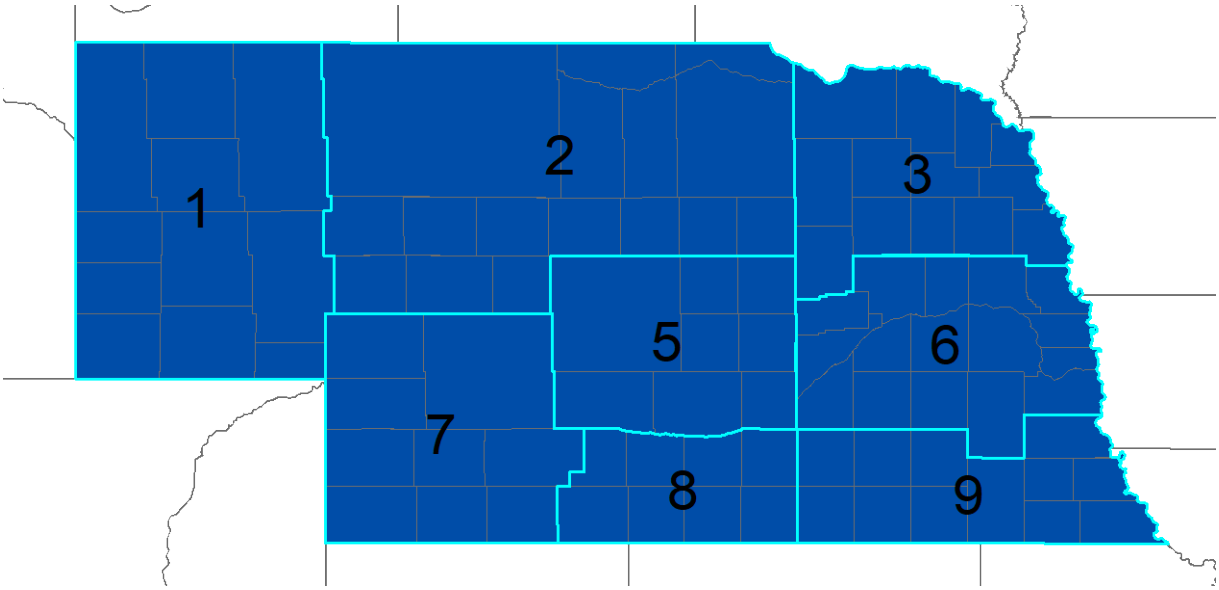
A set of global climate models are used to predict the influence of future atmospheric carbon dioxide (CO_2) concentrations on temperature and precipitation patterns. The model ensemble CMIP5 and the RCP 8.5 scenario were used in this project to assess climate change impacts to central and eastern Nebraska. CMIP5 is the Coupled Model Intercomparison Project Phase 5. Its main objectives are to analyze how realistic the models are in simulating the past climate, provide projections for mid and late twenty-first century, and to better understand the components responsible for differences in model projections like feedback between the clouds and the carbon cycle. The CMIP5 facilitates the strengths and weaknesses of climate models to enhance the focus of the development of future models. RCP is the Representative Concentration Pathway, which is a greenhouse gas concentration future trajectory. It has a wide range of outcomes based on four different model simulations (see figure A-1).

The RCP 8.5 scenario, used in the images and data tables, has the highest increase in CO_2 emissions and therefore has the most extreme climate projections compared to the other RCP model runs. If energy generation does not change and business as usual continues, the future CO_2 concentrations could look like the RCP 8.5 If actions are taken towards a cleaner and more renewable energy source, one of the less extreme models runs could occur causing the future climate changes to be less extreme. The hatched areas on the below images represent areas with more than 50 percent of the models showing a significant change and more the 67 percent agreeing on the sign change. These scenarios are widely accepted and utilized in international and national climate assessment reports, such as the recent U.S. National Climate Assessment (www.globalchange.gov/nca4).

This report outlines annual and seasonal changes in temperature and precipitation for Nebraska. The mid-century projection represents an average over the 30-year timeframe from 2041 to 2070 minus the 1971 – 2000 climate normal average. Changes are provided in degrees F for temperature and percentage for precipitation. The eight climate divisions in the state (figure A-2) are identified in the graphics and tables.



Global carbon dioxide concentration emissions scenarios used in the CMIP5 climate model projections. RCP 8.5 is termed the 'business as usual' approach and was the one chosen for this project. It assumes little to no mitigative action and follows the current rate of CO_2 increase.



Represented here are the eight climate divisions in Nebraska; 1 – Panhandle, 2 – Northcentral, 3 – Northeast, 5 – Central, 6 – East central, 7 – Southwest, 8 – Southcentral, 9 - Southeast. Seasonal climate projections are summarized based on these regions.

Winter

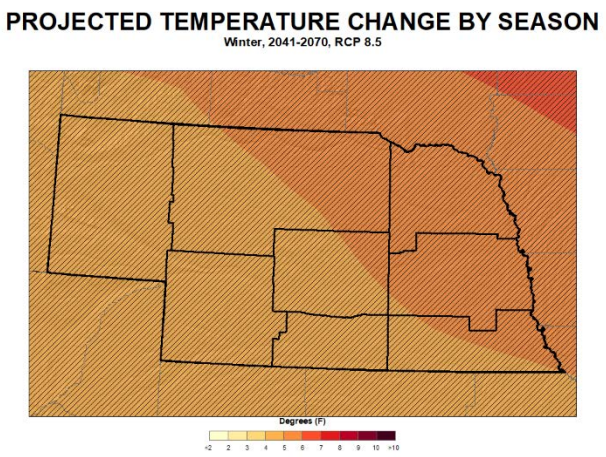
The average winter (Dec-Jan-Feb) temperature shows a projected increase (compared to the 1971 – 2000 average) by mid-century with high confidence. This increase has not always been a trend historically. The most recent 30-years (1987 - 2016) shows a decrease of 0.09-1.5°F while the 100-year trend (1895 - 2016) shows an increase of 2.1-3.6°F. The increase of 4-5°F by mid-century is a rate greater than previously experienced.

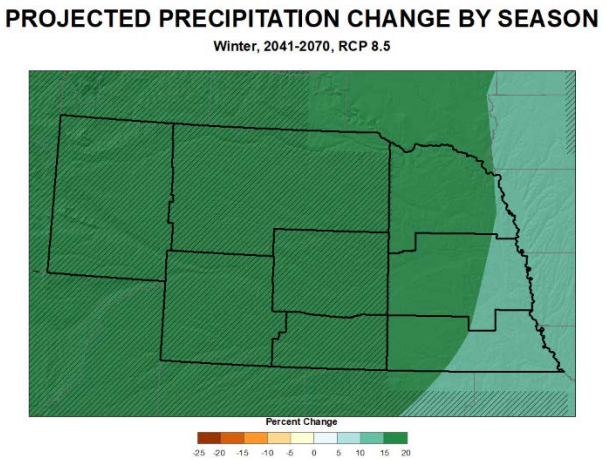
Winter shows the largest projected increase, in percent change, in precipitation when compared to the other seasons. Conversely, it is the smallest increase in liquid-equivalent precipitation out of the four seasons. The eastern part of the state shows a smaller percent increase along with lower confidence. Although, the eastern part of the state receives the most precipitation during the winter the increase in liquid-equivalent precipitation will be the greatest in amount. On average, winter precipitation averages are 1.6-2.5 inches, with the lower totals found for the central climate divisions.

Table A-1 Projected Temperature and Precipitation Change by Mid-Century

Climate Division	Temperature Increase
Northcentral	5°F
Northeast	5°F
Central	4°F
East Central	5°F
Southcentral	4°F
Southeast	4-5°F

Climate Division	Precipitation Increase	
Northcentral	15-20%	0.24-0.32”
Northeast	15-20%	0.33-0.44”
Central	15-20%	0.26-0.34”
East Central	10-20%	0.23-0.46”
Southcentral	15-20%	0.26-0.34”
Southeast	10-20%	0.25-0.5”





Spring

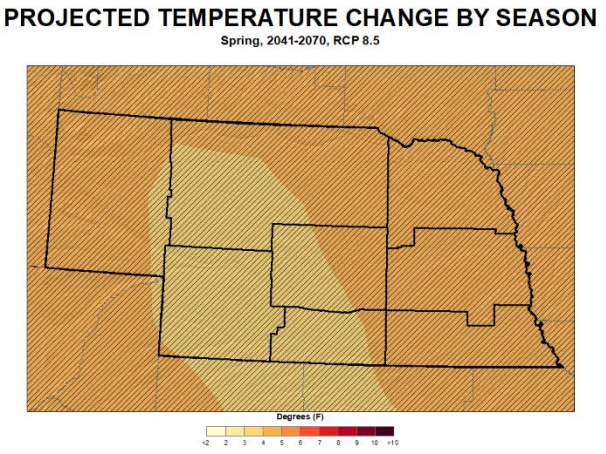
The average spring (Mar-Apr-May) temperature shows a projected increase (compared to the 1971 – 2000 average) by mid-century with high confidence. The increase continues the general historic trend of warming. The most recent 30-years (1987 - 2016) shows an increase of 0.39-0.72°F while the 100-year trend (1895 - 2016) shows an increase of 1.5-2.5°F. The coming decades could experience a 3-4°F increase in temperature, which is double the historic 100-year trend.

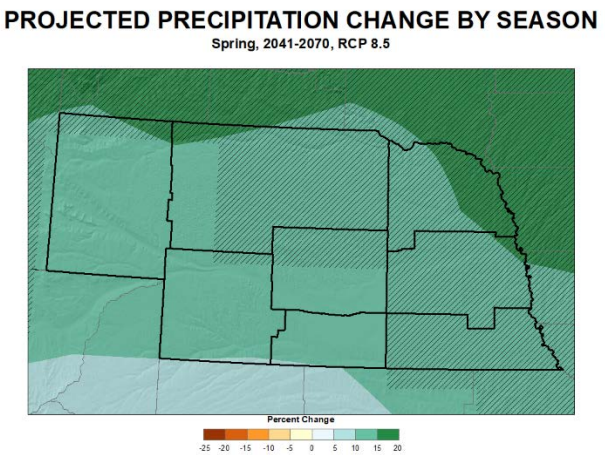
Spring shows the second largest projected increase, in percent change, in precipitation when compared to the other seasons. However, spring will have the largest increase (in terms of amount) in liquid equivalent precipitation. The northeast part of the state will experience the greatest percent change. The eastern part of the state will experience that largest increase in liquid equivalent precipitation with high confidence. On average, spring precipitation totals are 6.9-8.7 inches, with the lower totals found for the central climate divisions. The 30-year historic trends range from a 2-17 percent increase with the higher totals coming from the southeastern climate divisions. The historic 100-year trend ranges from a 13-25 percent increase with the increase coming from the southern climate divisions.

Table A-2 Projected Temperature and Precipitation Change by Mid-Century

Climate Division	Temperature Increase
Northcentral	4°F
Northeast	4°F
Central	3-4°F
East Central	4°F
Southcentral	3°F
Southeast	4°F

Climate Division	Precipitation Increase	
Northcentral	10-15%	0.68-1.0”
Northeast	10-20%	0.8-1.6”
Central	10-15%	0.74-1.1”
East Central	10-15%	0.84-1.25”
Southcentral	10-15%	0.74-1.1”
Southeast	10-15%	0.87-1.3”





Summer

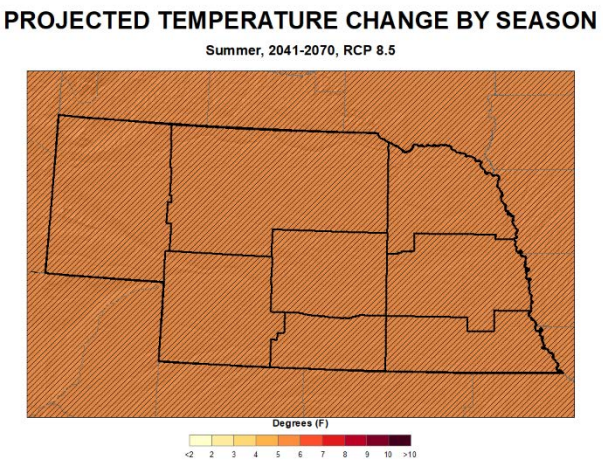
The average summer (June-July-Aug) temperature shows a projected increase by mid-century with high confidence. The increase has been a historic trend. The 30-year (1987 - 2016) historic trend shows an increase of 0.28-1.12°F while the historic 100-year (1895 - 2016) trend shows and increase of .03-0.96°F. The increase of 5°F by mid-century is several degrees higher than previously experienced in past climate.

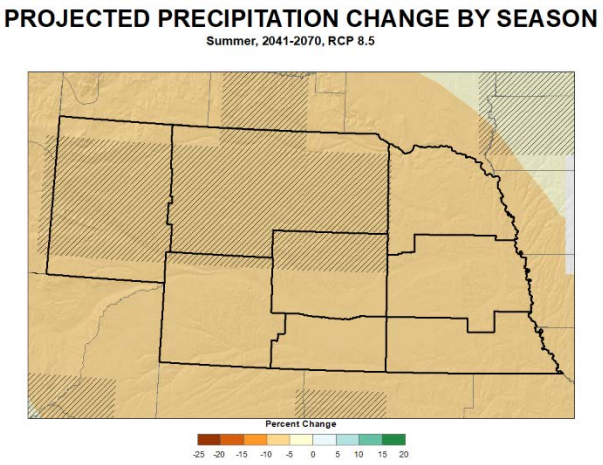
Summer is the only season that has a projected decrease in precipitation. The whole state could experience a 5-10 percent decrease in precipitation by mid-century. Even though it is a small percentage decrease, summer has the highest precipitation totals, on average, compared to other seasons. This will mostly affect the eastern and southern parts of the state. On average, summer precipitation totals are 8.8-11.8 inches, with the lower totals found for the central climate divisions. The 30-year historic trends range from a 10 percent decrease to an 11 percent increase with the higher totals found for the northern climate divisions. The historic 100-year trend ranges from a 5 percent decrease to a 13 percent increase with the increase occurring for the northcentral climate division.

Table A-3 Projected Temperature and Precipitation Change by Mid-Century

Climate Division	Temperature Increase
Northcentral	5°F
Northeast	5°F
Central	5°F
East Central	5°F
Southcentral	5°F
Southeast	5°F

Climate Division	Precipitation Decrease	
Northcentral	15-20%	0.44-0.88”
Northeast	15-20%	0.53-1”
Central	15-20%	0.5-1”
East Central	10-20%	0.57-1.13”
Southcentral	15-20%	0.5-1”
Southeast	10-20%	0.6-1.2”





Fall

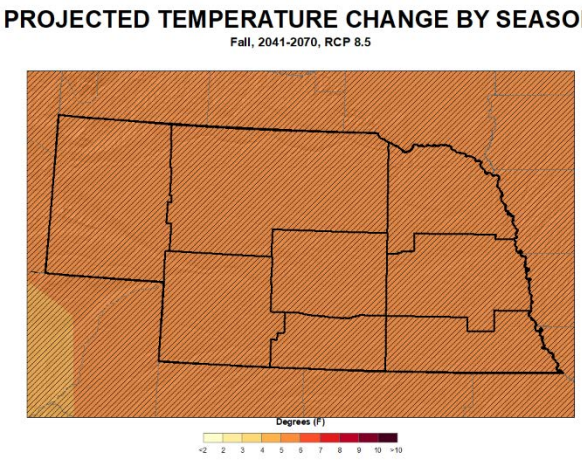
The average fall (Sep-Oct-Nov) temperature shows a projected increase by mid-century with high confidence. The increase has been a historic trend especially in the recent decades. The 30-year (1987 - 2016) historic trend shows an increase of 2.5-3°F while the historic 100-year (1895 - 2016) trend shows and increase of 0.2-0.8°F. The next few decades could experience a 5°F increase in temperature which is double the 100-year trend.

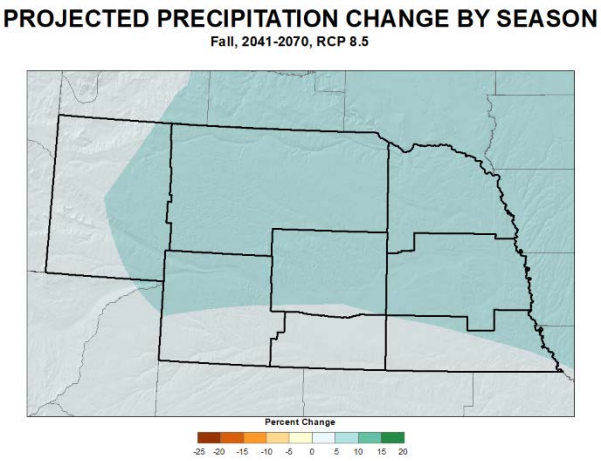
Fall shows a small projected increase, in percent change, in precipitation when compared to the other seasons. The greatest increase in liquid equivalent precipitation will occur in the northern climate divisions. There is lower confidence on the changes in the fall compared to the other seasons. On average, fall precipitation averages are 3.85-6.65 inches, with the lower totals found for the central climate divisions. The 30-year historic trends range from a 12 percent decrease to a 6 percent increase with the higher totals coming from the south and central climate divisions. The historic 100-year trends range from a 1 percent decrease to a 30 percent increase with the increase coming from the northern climate divisions.

Table A-4 Projected Temperature and Precipitation Change by Mid-Century

Climate Division	Temperature Increase
Northcentral	5°F
Northeast	5°F
Central	5°F
East Central	5°F
Southcentral	5°F
Southeast	5°F

Climate Division	Precipitation Increase	
Northcentral	5-10%	0.2-0.38”
Northeast	5-10%	0.28-0.56”
Central	5-10%	0.23-0.46”
East Central	5-10%	0.3-0.6”
Southcentral	0-5%	0-0.24”
Southeast	0-5%	0-0.33”





Annual

The annual average temperature shows a projected increase by mid-century with high confidence. The magnitude of the increase is in the 4° to 5°F range for central and eastern Nebraska, when compared to the 1971 – 2000 average. Historically, temperatures have increased in the state by approximately 1.5°F over the past 100 years (1895 – 2016). The rate of increase has at least doubled (eastern climate divisions), and in the central divisions has increased by a factor of four. Annual total precipitation is expected to increase by approximately 5 percent, compared to the 1971 – 2000 average. Historically, precipitation on an annual basis has increased over the long-term (by 5 percent - 10 percent). That trend has accelerated in recent decades (1987 – 2016), particularly for the central and northern divisions.