# Paving the Way to a Sustainable Future: The City of Russell's Transportation Reconstruction Plan

## Benefit Cost Analysis Project Technical Memo

## USDOT 2021 RAISE Discretionary Transporation Grant Program

# Benefit Cost Analysis Project Summary Matrix

| Current Status/Baseline & Problem to be Addressed | Change to Baseline/ Alternatives | Type of Impacts | Population Affected by Impacts | Economic Benefit |
|---|---|---|---|---|
| Aging pavement Streets dangerous to travel for vehicles, and bicyclists slowing down traffic | Replace existing streets | Reduce wear and tear on vehicles, reduce travel time and make it safer for bicyclists | Number of drivers with reduced wait time & number of accidents & injuries per year | Monetized value of reduced travel times, emissions, and accident costs |
| Aging pavement or no pavement for Sidewalks, pedestrians walking in the streets, not all sidewalks are ADA Compliant | Replace existing sidewalks and add sidewalks where needed make sidewalks ADA Compliant | Improves accessibility to multimodal travel, jobs, and activity areas for all community members | Number of pedestrians able to walk in a safer environment | Pavement Repair Savings |
| Travel time delays due to timed cycle length of stop lights | Replace existing stop lights | Reduce Wait time for vehicles | Number of drivers with reduced wait time | Personal time saved |
| Pedestrian crossings inadequate on Main Street | Add curb extensions | Reduce crossing time for pedestrians and accessibility to multimodal travel, jobs, and activity areas for all community members | Number of pedestrians able to cross in a safer environment | Greater foot traffic into local businesses |

# Benefit Cost Analysis Summary of Benefits

| | | | | Maintenance Cost | | | | VTTS Savings | Accidents | CO2 Emissions | Remaining Capital Value | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calendar Year | Project Year | Alternative Construction Costs | Discounted Construction costs at 7% | Base Case | Discounted Base Case at 7% | Alternative | Discounted Alternative at 7% | Value of Travel Time Savings Discounted 7% | Discounted Base Case at 7% | Value of CO2 Savings Discounted 3% | Base Case | Alternative |
| 2023 | 0 | $ 2,375,000 | $ 2,375,000 | $ 107,840 | $ 104,253 | $ - | $ - | $ - | $ - | | $ - | $ - |
| 2024 | 1 | $ 4,097,746 | $ 3,829,669 | $ 107,840 | $ 97,433 | $ - | $ - | $ - | $ - | | $ - | $ - |
| 2025 | 2 | $ 4,097,746 | $ 3,579,130 | $ 2,207,840 | $ 1,864,267 | $ - | $ - | $ - | $ - | | $ - | $ - |
| 2026 | 3 | $ 4,097,746 | $ 3,344,981 | $ 107,840 | $ 85,101 | $ - | $ - | $ - | $ - | | $ - | $ - |
| 2027 | 4 | $ 4,097,746 | $ 3,126,151 | $ 107,840 | $ 79,534 | $ - | $ - | $ - | $ - | | $ - | $ - |
| 2028 | 5 | $ 4,097,746 | $ 2,921,636 | $ 107,840 | $ 74,331 | $ - | $ - | $ - | $ - | | $ - | $ - |
| 2029 | 6 | $ 4,097,746 | $ 2,730,501 | $ 107,840 | $ 69,468 | $ - | $ - | $ 25,241,575 | $ 86,852 | $ 200,775 | $ - | $ - |
| 2030 | 7 | $ - | $ - | $ 107,840 | $ 64,923 | $ - | $ - | $ 23,614,121 | $ 81,170 | $ 198,857 | $ - | $ - |
| 2031 | 8 | $ - | $ - | $ 2,207,840 | $ 1,242,240 | $ - | $ - | $ 22,091,574 | $ 75,860 | $ 196,410 | $ - | $ - |
| 2032 | 9 | $ - | $ - | $ 107,840 | $ 56,707 | $ - | $ - | $ 20,667,175 | $ 70,897 | $ 193,942 | $ - | $ - |
| 2033 | 10 | $ - | $ - | $ 107,840 | $ 52,997 | $ - | $ - | $ 19,334,596 | $ 66,259 | $ 191,458 | $ - | $ - |
| 2034 | 11 | $ - | $ - | $ 107,840 | $ 49,530 | $ - | $ - | $ 18,087,922 | $ 61,924 | $ 191,845 | $ - | $ - |
| 2035 | 12 | $ - | $ - | $ 107,840 | $ 46,290 | $ - | $ - | $ 16,921,614 | $ 57,873 | $ 189,255 | $ - | $ - |
| 2036 | 13 | $ - | $ - | $ 107,840 | $ 43,261 | $ - | $ - | $ 15,830,494 | $ 54,087 | $ 186,659 | $ - | $ - |
| 2037 | 14 | $ - | $ - | $ 2,207,840 | $ 827,757 | $ - | $ - | $ 14,809,716 | $ 50,548 | $ 184,059 | $ - | $ - |
| 2038 | 15 | $ - | $ - | $ 107,840 | $ 37,786 | $ - | $ - | $ 13,854,745 | $ 47,242 | $ 181,458 | $ - | $ - |
| 2039 | 16 | $ - | $ - | $ 107,840 | $ 35,314 | $ - | $ - | $ 12,961,340 | $ 44,151 | $ 178,857 | $ - | $ - |
| 2040 | 17 | $ - | $ - | $ 107,840 | $ 33,004 | $ - | $ - | $ 12,125,533 | $ 41,263 | $ 176,259 | $ - | $ - |
| 2041 | 18 | $ - | $ - | $ 107,840 | $ 30,845 | $ - | $ - | $ 11,341,344 | $ 38,563 | $ 173,665 | $ - | $ - |
| 2042 | 19 | $ - | $ - | $ 107,840 | $ 28,827 | $ - | $ - | $ 10,612,102 | $ 36,040 | $ 173,374 | $ - | $ - |
| 2043 | 20 | $ - | $ - | $ 2,207,840 | $ 551,569 | $ - | $ - | $ 9,927,755 | $ 33,683 | $ 170,730 | $ 542,680 | $ 4,129,689 |
| Totals | | $ 26,961,476 | $ 21,907,069 | $ 10,664,640 | $ 5,475,436 | $ - | $ - | $ 247,421,604 | $ 846,410 | $ 2,787,602 | $ 542,680 | $ 4,129,689 |

| | Option 1 <Build> | Option 2 <No Build> |
|---|---|---|
| Appraisal period (years) | 20 | 20 |
| Capital Costs | $26,961,478 | $0 |
| Whole of Life Costs | $27,177,158 | $588,948,099 |
| Cost-benefit analysis of monetary costs and benefits at the Public Sector Discount Rate | | |
| Present Value of Benefits | $251,055,617 | $21,609,855 |
| Present Value of Costs | $22,108,756 | $248,231,891 |
| Benefit Cost Ratio | 11.36 | 0.09 |
| Net Present Value | $228,946,861 | -$226,622,035 |

## Assumptions and Methodology

A baseline of no build was compared to a build scenario. The baseline of no build assumed that repairs would be made each year using the average cost of repairs from 2016 to 2020 and dividing that by the total length of all streets to get a price per foot and multiplying that by the total length of the project. The baseline also assumed that an overlay of the concrete and asphalt streets would occur in 2025 and every five years. The benefits assumed in the baseline assumption, is the cost of not building the roadways and sidewalks. The cost of the baseline assumption was maintenance each year and travel time savings, accident savings and emission savings of the build scenario.

The build scenario assumed that repairs would take place in 2023 and 2024 until the project started in 2024. The cost of the project was split between six years. The first year, 2023, the cost of the design engineering was calculated and then the cost of construction was split evenly between the next six years. The build assumption included benefits of time savings and accident savings and emission savings.

## Benefit-Cost Analysis Period

For this BCA, a 20-year period was used that starts in the year construction begins. This represents a period during which the long-term impacts can be confidently forecasted.

The initial costs of construction are applied over the years' that construction will take place. Construction is assumed to take up to six years and start in 2024. Project benefits are assumed to take place in 2029 when the project has been completed.

It is expected that the service life of the major infrastructure elements will exceed the analysis period and as a conservative measure, a residual value has been calculated based on the service life of twenty-five years for the surface and forty years for the subbase and base.

All costs and benefits were estimated in year 2019 dollars and are based on the recommended values provided in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs. A discount rate of 7 percent was applied to the calculated values to convert future year dollars into today's dollars without inflation and 3 percent for CO2 emissions.

## BCA Spreadsheet Format

Two different spread sheets were used in the Benefit Cost Analysis (BCA). The first BCA Spreadsheet is split into seven tabs: Summary, Residual Value, Yearly Cost of Repairs, Emissions, VTTS (Value of Travel Time Savings), Accidents, and Accident break down.

The summary tab ties five tabs together presenting the conclusion of the BCA. The residual value tab calculates the value the project will retain in twenty years. The yearly cost of repairs tab calculates the cost of repairs related to the baseline scenario. The emissions tab calculates the savings in carbon dioxide emissions. The value of travel time savings calculates the value of time saved by drivers. The accident tab calculates the value of accident savings, and the accident breakdown tab breaks down the accidents by type.

The second spreadsheet compares a build scenario to a no build scenario, the baseline. The build scenario takes the cost of construction and compares it with the benefits of the value of travel time savings, the savings from accidents and savings of carbon dioxide emissions. The no build scenario uses the costs of repairs and overlays, the value of travel time savings, the savings from accidents and savings of carbon dioxide emissions as the cost and the cost of the construction of the build scenario as a benefit.

## Residual Value

The calculation for the residual value to reconstruct the streets and sidewalks assumed that the preliminary engineering, removal of current pavement, engineering and the traffic signals would have no value after twenty years. The surface is projected to have a twenty-five-year life. The subbase and base are projected to have a forty-year life. The residual value of the reconstruction project at the end of twenty years is projected to be $4,129,689.

The residual value for the baseline was calculated assuming that an asphalt overlay would take place every five years. In 2043 an asphalt overlay is projected to be done leaving the residual value to be $542,679. This figure was calculated by taking $2,100,000 of the cost of the overlay and discounting it to year twenty with a seven percent discount rate.

When completing the residual value for the construct scenario, the surface was projected to last for twenty-five years. The cost of maintenance was insignificant and not calculated.

## Yearly Cost of Repairs

The BCA compares the baseline scenario to the reconstruction of the streets. The baseline scenario is simply the repair costs annually, which assumes an overlay of asphalt every five years. The overlay does not include the brick streets. The baseline scenario assumes no maintenance of sidewalks from the city, except for a possible cost sharing of replacement of existing sidewalks. The owner of each parcel is ultimately responsible to replace or construct a new sidewalk at their expense in the City's right of way.

The cost of repairs every year is an average of the repairs to the streets done in 2016 through 2020 based on a price per foot and total length of the project. The cost of the overlay was projected by Bartlett & West, the City of Russell's engineers.

The alternate construction scenario is the total reconstruction of streets and sidewalks including replacement of twelve stoplights, one pedestrian cross light and adding curb extensions to the downtown district.

The total repairs and maintenance done assuming the baseline scenario is $5,774,109, which is discounted to 7 percent.

The analysis shown in the table below shows the maintenance cost each year starting in 2024 if the construction scenario is not done. The cost of maintenance each year was discounted by 7% to convert future year dollars into what it costs today without inflation.

| Calendar Year | Project Year | Pavement Maintenance Savings | Discounted to 7% |
|---|---|---|---|
| 2024 | 0 | $ 107,840 | $ 104,253.02 |
| 2025 | 1 | $ 2,207,840 | $ 1,994,766.02 |
| 2026 | 2 | $ 107,840 | $ 91,058.62 |
| 2027 | 3 | $ 107,840 | $ 85,101.52 |
| 2028 | 4 | $ 107,840 | $ 79,534.13 |
| 2029 | 5 | $ 107,840 | $ 74,330.96 |
| 2030 | 6 | $ 107,840 | $ 69,468.19 |
| 2031 | 7 | $ 2,207,840 | $ 1,329,196.83 |
| 2032 | 8 | $ 107,840 | $ 60,676.21 |
| 2033 | 9 | $ 107,840 | $ 56,706.73 |
| 2034 | 10 | $ 107,840 | $ 52,996.95 |
| 2035 | 11 | $ 107,840 | $ 49,529.86 |
| 2036 | 12 | $ 107,840 | $ 46,289.59 |
| 2037 | 13 | $ 2,207,840 | $ 885,699.97 |
| 2038 | 14 | $ 107,840 | $ 40,431.12 |
| 2039 | 15 | $ 107,840 | $ 37,786.09 |
| 2040 | 16 | $ 107,840 | $ 35,314.10 |
| 2041 | 17 | $ 107,840 | $ 33,003.84 |
| 2042 | 18 | $ 107,840 | $ 30,844.71 |
| 2043 | 19 | $ 2,207,840 | $ 590,179.29 |
| 2044 | 20 | $ 107,840 | $ 26,940.96 |
| Total | | $ 10,664,643 | $ 5,774,109 |

## Reduction in Emissions

The reduction of carbon dioxide was considered by the length of time a vehicle was on the road. The speed limits for the project are no more than 30 mph and emissions do not increase until a vehicle reaches a speed above 50 mph. Therefore, the assumption was the less time a vehicle spends on the city's roads the fewer the carbon dioxides are emitted into the air. Using the recommended values from the BCA guidance for discretionary grant programs, the social cost of carbon for a metric ton of carbon dioxide is $60 in 2029 and increases up to $76 in 2043. The savings was based on a per gallon of gasoline idling rate for the savings by traveling time by10 mph and spending less time on the roads. A second calculation was done based on replacing the stop lights from an old light that cycled 37 seconds through yellow and red to a stop light with a sensor to sense vehicles approaching and turning green or staying green to let them pass which creates less idling time. Since motorists usually do not stop a soon as the yellow light turns, 6 seconds was taken off the calculation to account for that. The total savings for a 20-year period amounted to $2,787,602.

The analysis shown in the table below shows the cost savings of carbon dioxide emissions each year when a vehicle can spend 10 mph less on the road by speeding up the safe drivable speed limit and saving 31 seconds at a stoplight.

To compute the cost savings, an estimation of the traffic on each of the thirteen streets was calculated. The assumption of the traffic for each street varied depending on if there were industry, businesses, schools and housing on the streets. The calculation of streets with schools on them included the number of staff and students per building with each arriving and leaving school two times a day. 15th Street included the number of semi-trucks coming in and out of the ethanol-gluten facility. Any blocks with housing had a calculation of 1.3 vehicles per household and 1.67 persons per vehicle leaving two times a day from their home. The figures per household and vehicle came from the BCA guidance for discretionary grant programs. The major collectors and major business streets were calculated based on the population of the city. The idling savings of fuel was based on research from http://www.transportation.anl.gov. A chart, attached to the end of this technical memo, of how many gallons of fuel each type of vehicle and gasoline type was used per hour of idling came from this website. All streets in the project see all vehicle types, and because of that an average gallon per hour idling for all types was calculated. This average equaled .59 gallons per hour of idling. The miles per street was divided by a 10-mph savings and multiplied by the average gallon of idling fuel used per hour and then multiplied by the metric tons of carbon dioxide that a gallon of gas produces. That figure is the amount of carbon dioxide produced by idling. To figure the carbon dioxide produced per idling at each stop light, the average idling fuel use per gallon per second was figured and then multiplied by an average 31 seconds times three stoplights. Then these figures were multiplied by the calculation of each vehicle per year multiplied by the dollar figure for the year.

| Calendar Year | Project Year | Value of CO2 Savings | Discounted Value of CO2 Savings at 3% |
|---|---|---|---|
| | | | |
| 2029 | 6 | $ 239,735.99 | $ 200,775.12 |
| 2030 | 7 | $ 244,569.44 | $ 198,857.34 |
| 2031 | 8 | $ 248,805.90 | $ 196,409.68 |
| 2032 | 9 | $ 253,050.73 | $ 193,942.31 |
| 2033 | 10 | $ 257,303.92 | $ 191,458.28 |
| 2034 | 11 | $ 265,558.28 | $ 191,844.95 |
| 2035 | 12 | $ 269,832.39 | $ 189,255.01 |
| 2036 | 13 | $ 274,114.87 | $ 186,658.89 |
| 2037 | 14 | $ 278,405.72 | $ 184,058.98 |
| 2038 | 15 | $ 282,704.94 | $ 181,457.54 |
| 2039 | 16 | $ 287,012.52 | $ 178,856.72 |
| 2040 | 17 | $ 291,328.48 | $ 176,258.52 |
| 2041 | 18 | $ 295,652.80 | $ 173,664.86 |
| 2042 | 19 | $ 304,011.75 | $ 173,373.65 |
| 2043 | 20 | $ 308,356.99 | $ 170,729.79 |
| Total | | $ 4,100,444.72 | $ 2,787,601.63 |

## Value of Travel Time Savings Calculation

The value of travel time savings calculation was calculated using the recommended hourly value of travel time savings provided in the BCA guidance for discretionary grant programs. The amount used was $17.90 per person per hour for business and private vehicle travel combined. For the ethanol plant the amount used for commercial trucks was $30.80 per truck per hour.

The city streets are so deteriorated that vehicles cannot safely travel at the posted speed limit of 30 mph. Being conservative, the assumption used was a safe travel speed of 20-mph which is high for some parts of the project. The 10-mph savings in dollars is $3.04, which is calculated by dividing 10 minutes by 60 minutes and multiplying that figure by $17.90 and $5.24 for the ethanol plant multiplying the figure by $30.80.

The assumption of traffic for each street varied depending on if there were industry, businesses, schools, and housing on the streets. The calculation of streets with schools on them included the number of staff and students per building with each arriving and leaving school two times a day. Any blocks with housing had a calculation of 1.3 vehicles per household and 1.67 persons per vehicle leaving two times a day from their home. 15th Street included the number of semi-trucks coming in and out of the ethanol-gluten facility. The figures per household and vehicle came from the BCA guidance for discretionary grant programs. The major collectors and major business streets were calculated on the population of the city.

It is concluded that $247,421,604 will be saved in travel time if the city proceeds with the construction scenario instead of the baseline scenario. The value of time was discounted at 7 percent. The year of savings started at 2029 when the complete project will be finished.

| Calendar Year | Project Year | Value of Travel Time Savings | Discounted Travel Time Savings at 7% |
|---|---|---|---|
| | | | |
| 2029 | 6 | $ 37,880,797.72 | $ 25,241,574.99 |
| 2030 | 7 | $ 37,919,117.69 | $ 23,614,120.76 |
| 2031 | 8 | $ 37,957,437.67 | $ 22,091,574.31 |
| 2032 | 9 | $ 37,995,757.65 | $ 20,667,174.66 |
| 2033 | 10 | $ 38,034,077.63 | $ 19,334,596.44 |
| 2034 | 11 | $ 38,072,397.60 | $ 18,087,921.84 |
| 2035 | 12 | $ 38,110,717.58 | $ 16,921,614.38 |
| 2036 | 13 | $ 38,149,037.56 | $ 15,830,494.31 |
| 2037 | 14 | $ 38,187,357.54 | $ 14,809,715.64 |
| 2038 | 15 | $ 38,225,677.51 | $ 13,854,744.66 |
| 2039 | 16 | $ 38,263,997.49 | $ 12,961,339.80 |
| 2040 | 17 | $ 38,302,317.47 | $ 12,125,532.81 |
| 2041 | 18 | $ 38,332,973.65 | $ 11,341,343.71 |
| 2042 | 19 | $ 38,378,957.42 | $ 10,612,101.54 |
| 2043 | 20 | $ 38,417,277.40 | $ 9,927,754.52 |
| Total | | $ 572,227,899.58 | $ 247,421,604.36 |

The table below shows the value of travel time savings each year based on driving 10 mph faster after construction is completed. The savings is discounted to 7 percent to show the cost at today's value without inflation.

## Motor Vehicle Accidents

Motor vehicle accident data was calculated for the period of January 1, 2013, through May 1, 2021, and then averaged to come up with an accident rate per year. The value of accidents was calculated using the recommended value from the BCA guidance for discretionary grant programs. The only type of accidents that occurred on the streets of the project was property damage only accidents and minor injury accidents.

Data was computed by the police department for a six-year time span. The number of accidents that occurred in each category was averaged over the six-year time span. The average amount of accidents then was multiplied by the value recommended in the BCA guidance for discretionary grant programs. The accident savings was then discounted at 7 percent. The total number of savings of accidents if the project is completed will be $592,967.

The table below shows the savings of the cost of the average accidents per year when construction is completed. The cost is discounted by 7 percent to show the value in today's dollars without inflation.

| Calendar Year | Project Year | Accident Savings | Discounted at 7% |
|---|---|---|---|
| | | | |
| 2029 | 6 | $ 91,313 | $ 60,845.37 |
| 2030 | 7 | $ 91,313 | $ 56,864.84 |
| 2031 | 8 | $ 91,313 | $ 53,144.71 |
| 2032 | 9 | $ 91,313 | $ 49,667.95 |
| 2033 | 10 | $ 91,313 | $ 46,418.64 |
| 2034 | 11 | $ 91,313 | $ 43,381.91 |
| 2035 | 12 | $ 91,313 | $ 40,543.84 |
| 2036 | 13 | $ 91,313 | $ 37,891.44 |
| 2037 | 14 | $ 91,313 | $ 35,412.56 |
| 2038 | 15 | $ 91,313 | $ 33,095.85 |
| 2039 | 16 | $ 91,313 | $ 30,930.70 |
| 2040 | 17 | $ 91,313 | $ 28,907.20 |
| 2041 | 18 | $ 91,313 | $ 27,016.07 |
| 2042 | 19 | $ 91,313 | $ 25,248.67 |
| 2043 | 20 | $ 91,313 | $ 23,596.89 |
| Total | | $ 1,369,688 | $ 592,966.65 |

## Qualitative Benefits

The benefits that are not able to be shown as a quantitative figure include: safer travel of pedestrians, alternative modes of transportation for citizens with no vehicles, safer travel for bicycles, and the cost of maintenance on vehicles due to the road condition.

Constructing new sidewalks will provide safer travel for pedestrians. The baseline scenario provides no maintenance of sidewalks. It is up to the parcel owners to provide sidewalks in the city right of way. The City of Russell has a cost sharing program for sidewalk replacement program for existing sidewalks only. The proposed project area is in a low-income area where many of the residents cannot afford the cost sharing program. The new sidewalks will provide a means of transportation for the low-income individuals and handicap people who cannot afford other means of transportation. It will connect them to local businesses, schools, and health care.

The baseline scenario in its current state does not allow for safe travel for all modes of transportation. The sidewalks are uneven, disconnected or do not exist leaving pedestrians to walk in the streets. The streets are cracked or uneven which does not allow for safe travel by bicycle.

Connecting the sidewalks in the main corridor will allow citizens with no vehicles a safe way to travel to school, employment, recreation, and health care. With the baseline scenario, there is no easy way to travel throughout the main corridor of the city without walking in the streets or through yards. Children who walk to school have no connecting sidewalks and therefore find themselves walking in the streets.

Walking has health benefits that are not quantifiable. By connecting the sidewalks throughout the corridor, it will give citizens an alternative to driving to and from work, school and other activities. By walking, citizens will gain a healthier lifestyle that will increase their life expectancy.

The condition of the streets causes many alignment and maintenance problems for vehicles. This costs consumers more money for repairs. By doing nothing in the baseline scenario causes vehicle owners a lot of money.

It is rough travel for bicyclists within the main corridor. The City is not bicycle friendly due to the condition of the streets. Bicycling is an alternative mode of transportation that focuses on a healthier lifestyle increasing a longer life. Without safe travel for bicyclists throughout the streets, many citizens do not travel by bicycle.

## Benefit Cost Ratio and Net Present Value

As shown in the summary table below, the Build option has a positive net present value of $228,946,861 and the no build option has a negative net present value of $226,622,035. The benefit cost ratio for the build option is 11.36 and the no build option is .09. This makes the build option a much stronger option.

| | Option 1 <Build> | Option 2 <No Build> |
|---|---|---|
| Appraisal period (years) | 20 | 20 |
| Capital Costs | $26,961,478 | $0 |
| Whole of Life Costs | $27,177,158 | $588,948,099 |
| Cost-benefit analysis of monetary costs and benefits at the Public Sector Discount Rate | | |
| Present Value of Benefits | $251,055,617 | $21,609,855 |
| Present Value of Costs | $22,108,756 | $248,231,891 |
| Benefit Cost Ratio | 11.36 | 0.09 |
| Net Present Value | $228,946,861 | -$226,622,035 |

The assumptions used in the build option were, capital costs of $26,961,478 split between six years and repairs for the roads in 2023 and 2024 in the amount of $215,680 before construction is ready to start. These costs were then converted to present value using a 7 percent discount rate.

The benefits of the build scenario included the value of travel time savings that totaled $247,421,604 over a 15-year period starting after construction is complete. This figure was converted to net present value using a 7 percent discount rate. Also, another benefit used was savings of accident costs. The total savings for 15 years assuming no savings until after the project is complete total $592,967 which was converted to net present value using a 7 percent discount rate. The cost of carbon dioxide emissions was included and totaled $2,787,602 and then converted to net present value using a 3 percent discount rate.

The no build assumptions used a cost of repairs and asphalt overlays done every five years starting in 2024. The total cost of repairs and overlays amounted to $5,774,109 which was converted to net present value using a 7 percent discount rate. Benefits in this scenario included the cost savings of the construction cost of $26,961,476, which was also discounted at 7 percent.

The benefit cost ratio in both scenarios was calculated by taking the present value of benefits and dividing it by the present value of costs.

## Conclusion

After evaluating the different costs through the benefit analysis and the existing condition of the pavement, the build option is the best option. The concrete pavement will last considerably longer with less maintenance costs than the asphalt overlay in the no build option. Concrete has a 30-year life span with minimal maintenance costs. There will be minimal maintenance for the next 5-10 years. The local economy will benefit by improved roadways and better access to services. The appearance of the community will greatly improve. During winter, snow removal will be easier with a smother surface; especially since most of the roadways in this project are primary snow routes.

With the no build option, the current street conditions will continue to worsen at an increasing rate and the future cost of replacement will be more than the current cost of reconstruction now. Construction costs will continue to increase, plus the longer that roadway improvements are delayed the worse shape that the subgrade and roadway base will be and will require additional subgrade reconstruction under the roadway.