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Calgary Green Line LRT
Stage 1 Business Case

City of Calgary

July 2020 Update

Calgary Green Line LRT Stage 1 Business Case

This document is the July 2020 update of the Green Line LRT Business Case that was approved by the Green Line Committee in June 2020. This updated version includes:

- Additional strategic and economic case analysis on the relative benefits of the Stage 1 Green Line LRT proposed in this business case compared to other potential Green Line variants that was presented to the Green Line LRT Committee and City Council in June 2020

- Economic case content on the potential impact of COVID-19 on the Green Line that was presented to the Green Line Committee and City Council in June 2020

- Minor text and graphical changes to improve readability and comprehension

Disclaimer

Readers should note that this Business Case was completed between January 2020 to July 2020 and this report has been drafted based on available data collected prior to the spread of COVID 19 across the world.
This analytic models used in this report do not model the impact or likely outcomes of COVID 19. There is currently insufficient data or information available to allow the models employed in this study to reasonably analyze the impact of the COVID 19 outbreak on this project or for the models to be used to comment on the expected changes in the forecasts described in this report. Efforts have been made to explore potential impacts of COVID 19, however the specific impacts have not been forecast. As of the date of distribution of this report, the COVID 19 outbreak has had a material impact on global economic and political affairs, and readers of this report should consider the findings in the context of their own assessment of the outbreak and its impact on this project.

Contents

Executive summary

I. Introduction

This document is the City of Calgary's Business Case for Stage 1 of the Green Line Light Rail Transit (LRT) Program – a Program that will ultimately run for 46 kilometers, from 160 Ave in the north to Seton in the south.

Building the Green Line is the next step towards completing Calgary's transit network as described in *RouteAhead: A Strategic Plan for Transit in Calgary*. Along with the new MAX bus rapid transit lines, Calgarians will have fast, frequent and reliable transit service that strategically connects communities, employment hubs (including those outside downtown like Quarry Park) and key destinations across the city. Stage 1 of the Green Line LRT Program from 16 Avenue N to Shepard is a strategic investment that will build the core of the project while preparing for the future, allowing for incremental expansion of the LRT north and south and providing best value for tax dollars.

The purpose of this document is to:

- Articulate the case for developing and delivering Stage 1 of the Green Line LRT Program.

- Define the benefits and rationale for Stage 1, as well as the financial and delivery requirements to successfully deliver it.

- Support evidence-based decision making and ongoing planning and design of Stage 1 in advance of procurement and delivery.

This executive summary provides an overview of the key findings of the Business Case document, including:

- The Case for Change – what key issues does the Green Line LRT aim to address?

- Stage 1 Scope – what is in scope for Stage 1?

- Business Case Summary – what are the key findings across the four evaluation dimensions of project performance?

Business Case Overview

The City of Calgary has updated the 2016 Business Case for the Green Line LRT using a revised approach to transportation investment analysis and benefits management.

This approach draws on robust analysis previously completed by The City and is informed by best practices applied in Canada and internationally that support analysts, planners, decision makers, and stakeholders to understand how a proposed investment performs against four crucial dimensions of performance:

- **Strategic Case** – does the investment support the broader policy and planning goals of The City?

- **Economic Case** – what level of socio-economic benefit is generated by the investment?

- **Financial Case** – what are the funding and financing requirements to successfully deliver the investment?

- **Deliverability and Operations Case** – what are the technical and governance requirements to procure, deliver, and operate the investment?

II. The Case for Change

Problem Statement: Calgary's transportation network in the north and southeast does not meet the current mobility needs of the City and its people and is unable to support planned and forecast growth while maintaining a high quality of life, economic competitiveness, and environmental sustainability.

Today, The City of Calgary is an economic and cultural centre and is frequently ranked as one of the most livable cities in North America to live, work, and play in. Over the past decades the City has grown at a rapid pace which has led to increased prosperity but has also brought challenges of increased congestion and travel times and reduced journey time reliability. Combined, these issues will reduce quality of life, prosperity, and environmental quality as more people spend more time travelling on an increasingly congested, crowded, and unreliable network. Without strategic investment, this problem will grow over time and will become more acute due to two key issues.

1. The current transportation network cannot provide quality mobility options for all future travellers – in the near future, demand in the north will exceed capacity resulting in longer travel times and buses on Centre Street exceeding capacity. In southeast Calgary, population is anticipated to increase by almost 70,000 by 2028, and population is forecast to double over the next 30 years. The resulting transportation demand will exceed what can be accommodated with the current 302 bus service, local bus network, and regional roads. There is a clear need for affordable and attractive transit that can provide faster and more reliable mobility.

2. Travel times and congestion will limit the potential to develop great places in which to live, work, and play – land use and development will be impeded if congestion and crowding issues are not addressed, which in turn will reduce Calgary's competitiveness compared to peer cities. The corridor running from southeast Calgary, through the downtown core, and to 16 Avenue N has been identified for redevelopment – with a focus on developing Transit Oriented Developments (TOD) at key sites on the corridor. However, the existing transit network does not provide fast and reliable service or connectivity between these sites.

Stage 1 of the Green Line LRT was developed to directly respond to these issues by enacting the following vision statement:

Vision Statement: Green Line LRT Stage 1 will support the vision of the full Green Line LRT Program and be a city-shaping transit service that improves mobility in north and southeast Calgary, connecting people and places and enhancing the quality of life in the city.

LRT has been proposed as a solution to this problem based on its ability to:

- Improve mobility choices by providing a high-quality transit service that is fast, frequent, and reliable.

- Enhance connectivity between people and places including connections to communities, employment hubs and key destinations across the city.

- Provide flexible capacity for a growing city.

The Green Line LRT is the next step for completing Calgary's rapid transit network, providing seamless connectivity with the existing Red and Blue LRT lines and four MAX transit lines adding 20km to the existing 59km LRT system.

Why Focus on Green Line LRT?

Other solutions were explored to address the problems, but these will not fully and adequately solve them:

Road expansion/widening is unlikely to be a long-term solution as new capacity has historically been taken up by increased auto demand. In addition, further investment in the road network will not provide expanded choice for segments of the population and workforce that rely on transit or choose transit as their primary mode.

Creating an enhanced bus service beyond what it is today (for example, BRT lines 301 in the north, and 302 in the southeast) that will effectively / reliably service the needs of these growing communities may work in the short term, but will be less effective than a LRT solution over the long-term. For example, Centre Street North has evolved into the busiest bus corridor in the city (approximately 30,000 Calgarians transported per day), and regularly exceeds capacity during the morning and evening rush hours.

III. Stage 1 Program Scope

Green Line Program Overview and Stage 1 Focus

The long-term vision for the Green Line LRT project is to serve and connect the growing populations in north central and southeast Calgary with a frequent, reliable and high quality transit system. These communities are growing quickly and, over the next 30 years, the population in the north is expected to increase by over 50% from 170,000 to over 250,000 people and in the southeast, the population will increase from 135,000 to over 242,000 residents.

The level of resources and technical requirements required to fully realize this vision have led the City to deliver it in stages.

This approach allows difficult and complex elements of the program to be delivered first and allows Calgarians to realize the benefits of a partial program in the short-term. In the future, the remainder of the program can be delivered with minimal disruptions to transit users.

This is aligned with how Calgary has historically expanded its LRT network. Stage 1 provides a strong foundation of LRT service while completing the most technically complex and capital intensive aspects of the long-term vision. This foundational core project will best facilitate future extensions and demonstrates The City's commitment to implementing the long-term vision for the Green Line LRT.

Figure E.1: Green Line LRT Stage 1 Scope

Developing Stage 1

In June 2017, Council approved a Stage 1 alignment from 16 Avenue N to Shephard with a tunnel under the Bow River and through the downtown. In summer 2019, the Green Line LRT project team advised members of Council of the need to re-evaluate the Segment 2 alignment for reasons related to construction risk, user experience associated with deep underground stations and the Program's capital cost; reporting that the approved Stage 1 alignment could not be delivered within the approved funding.

City Council directed Administration to review the Green Line program to ensure the Program's recommendation meets the objectives set by Council and delivers the best possible outcomes for Calgarians within the approved budget threshold. This review resulted in a revised version of the approved Stage 1 alignment that continues to serve 16 Avenue N to Shepard. The revised Stage 1 alignment includes the LRT running on surface on Centre Street north of the Bow River to a new bridge over the river and shallower downtown tunnels and stations. Figure E.1 shows the updated Stage 1 Green Line project which is evaluated in the remainder of this Business Case.

Improvements to the north BRT line along Centre Street are being investigated as part of Stage 1 to support increased transit use while a design for the North Centre Street stage of the Green Line is finalized. The next step being recommended is to undertake a functional plan to further investigate BRT improvements to implement.

Stage 1 Scope

Table E.1 summarizes the overall scope for Stage 1 based on the four layers of project design and delivery for the overarching Green Line LRT Program. Layers 1 and 2 are the focus of Stage 1, while layers 3-4 will be enabled by Stage 1 delivery.

Table E.1 Stage 1 Scope

Layer	Description	Key Stage 1 Program Elements
Layer 1: Transit Infrastructure	Physical infrastructure required to operate the Green Line LRT	• 20 km of LRT track • 15 stations – including 11 transit hubs with 4 MAX BRT connections • 2½ km Centre City tunnel from Eau Claire to 4 Street SE • Additional tunnel (CN/Highfield) • Ten bridges • 1.8 km of elevated track • Park and ride facilities with a total of approximately 1,900 stalls • One Maintenance and Storage Facility north of 126 Avenue SE (Shepard)
Layer 2: Connections to Stations	Supportive infrastructure that enables the Green Line LRT to integrate with communities and support multi-modal access	• Improvements to urban realm to support station access- including multi-use pathways along the alignment at critical choke points in the walking and cycling network • Pathways across bridges at both Bow River crossings, Deerfoot Trail, and Blackfoot Trail • New road and bus connections to station areas
Layer 3: TOD Supportive Infrastructure	Supportive infrastructure and design features that enable the Green Line LRT to facilitate TOD	• Six station areas targeted for further TOD planning and design based on significant study of TOD opportunities along the corridor
Layer 4: City Shaping	Supportive infrastructure and design features that enable the Green Line LRT to facilitate The City's broader plans for the corridor and adjacent areas	• Embedded principles and strategies for implementing City Shaping initiatives along the Green Line LRT to create a series of well-planned, connected, accessible, affordable and vibrant communities

IV. Business Case Summary

The Green Line LRT Stage 1 Program was analyzed using best practices applied in Canada and internationally for Business Case Analysis.

This approach uses a four dimension analysis to identify the benefits, costs, trade-offs and risks of Stage 1.

This assessment will be used to inform final planning, design, and delivery of Stage 1 and will be used as a platform for further planning of potential expansions.

Strategic Case Summary

Stage 1 of the Green Line LRT will generate significant benefit for Calgarians across four key policy areas, as shown in Table E.2.

Table E.2 – 10 Reasons Calgary Will Benefit from the Green Line LRT Stage 1

Transportation

1. Meeting the needs of daily travel for work and play

Stage 1 will serve 55,000-65,000 transit users a day in 2028 with a fast, frequent, reliable and direct transit service, saving Calgarians over 10,000 hours a day to work and play

2. Needed capacity for today and tomorrow

Stage 1 will provide capacity to meet demand and provide customers an exceptional customer service in 2028 with opportunities to expand capacity without significant expenditure into the future

3. Faster travel times for Calgarians

Travellers who use the Green Line LRT will save up to 20-25 minutes, while auto users will benefit from reduced journey times of up to 10%, due to decongestion

4. Financial efficiency

Stage 1 will increase the financial efficiency of the Calgary Transit network and will generate enough revenue to cover 70%-84% of the Green Line LRT operating costs per user

Quality of Life

5. A more accessible city

in 2028, 68,000 people will live within walking distance and over 900 community, educational, social service, recreational, or commercial activity centres can be reached using the Green Line LRT

6. A safer and healthier city

Over its first 30 years, the Green Line LRT will take cars off the road and lead to 2,300 fewer collisions and an additional 1.6 million km walked per year

7. Fostering TOD and shaping Calgary's growth

Direct connection to 6 high priority TOD areas including future potential for over 1 million sq metres of new residential development and 160,000 sq metres of new office and retail space

Prosperity

8. Connecting people to jobs and businesses to business to catalyze economic development

in 2028, nearly 200,000 jobs will be within walking distance of the Green Line LRT

9. Generating jobs and supporting economic development

12,000 direct and 8,000 supporting jobs are forecast to be created by Stage 1 alone

Sustainability

10. Reducing emissions to mitigate climate change and provide cleaner air

by taking cars off the road, Stage 1 will save up to 30,000 tonnes of GHG emissions a year in support of municipal, provincial, and federal environmental goals

Economic Case Summary

A socio-economic benefit cost analysis of the Green Line was conducted, as defined in Table E.3, which answers the question *'what level of benefit is generated by investing in the Green Line LRT?'* This table defines the range of resources (costs) required to deliver Stage 1, the benefits it will generate to users (travellers), and the broader city.

The economic analysis identified the following conclusions:

- Stage 1 has the potential to generate $1.84 billion (combined travel time, amenity, crowding, and reliability benefits) in benefit for transit riders over the next 30 years, which when combined with external benefits (such as GHG reductions and safer streets) leads to a combined $2.26 billion in benefit to the City as a whole

- There are key opportunities to improve the economic performance of the Green Line LRT through future stages of design, planning, and delivery including identifying opportunities to optimize bus and multimodal connections, improving travel times, and reduce costs through value engineering or phasing

- In the long run, continued expansion of the Green Line LRT can generate an additional $1.5 billion in benefits based on a preliminary high-level estimates – this allows the capital intensive investment included in Stage 1 to generate benefits as the network is expanded in line with the long-term vision for the Green Line LRT

- The Benefit-Cost-Ratio (BCR) is consistent with, or exceeds, other LRT projects in delivery in Canada

Table E.3 – Economic Case Summary

	Economic Consideration	Value ($2020 PV)
Costs	Incremental capital costs	$3,680m
	Incremental operating and maintenance costs	$350m
	Total Cost	**$4,030m**
User Benefits	Travel time savings	$1,750m
	Auto operating cost savings	$70m
	Amenity	$20m
	Crowding	$50m
	Reliability	$20m
External Benefits	Collision cost savings	$30m
	Benefit/disbenefit of GHG emission changes	$10m
	Health Benefits	$110m
	Wider Economic Benefits	$200m
	Total Benefits	**$2,260m**
Net Present Value	NPV (Benefit – Cost)	**-$1,770m**
Cost-Effectiveness	BCR	**0.56**
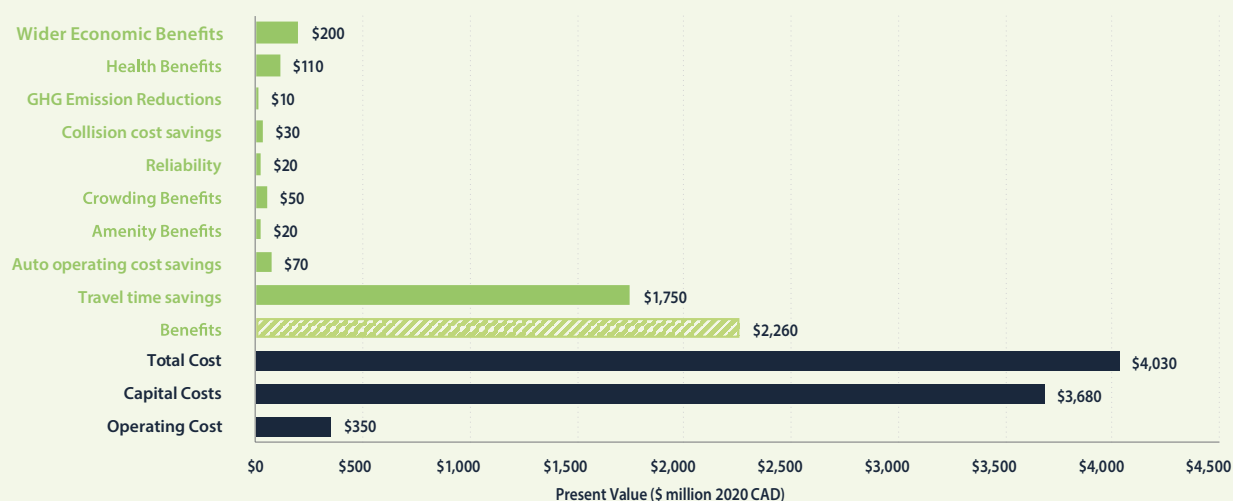
Financial Case Summary

The Financial Case for Stage 1 of the Green Line LRT reviews the anticipated construction, renewal, and operating and maintenance costs. This case also defines the funding strategy for the Program and identifies its potential revenues. Table E.4 provides an overview of the Financial Case Chapter.

Table E.4 – Financial Case Summary

Cost Category	Value (nominal dollars)
Indirect Costs	$805m
Direct Costs	$4,098m
Total Construction Costs	**$4,903m**
Illustrative Annual Financial Impact	
2028 Incremental Operating and Maintenance Costs (LRT only)	$26.9m (2018$)
2028 Incremental Revenue (LRT only)	$6.5m (2018$)
2028 Net Incremental Operating and Maintenance Cost (LRT only)	**$20.4m (2018$)**
Funding Sources	
Government of Canada	• **$1,530m** – Investing in Canada Infrastructure Plan (Public Transit and Green Infrastructure) • **$111m** – Public Transit Infrastructure Fund (Phase I)
Province of Alberta	• **$1,530m** – Ultimate Recipient Agreement • **$55m** – Public Transit Infrastructure Fund (Phase I) • **$117m** – GreenTRIP and prior grants
City of Calgary	• **$52m (per year for 30 years)** – 2013 Tax Room (2015 to 2044) • **$23.7m (per year for 27 years)** – 2017 Tax Room (2018 to 2044)

Deliverability and Operations Case Summary

The Deliverability and Operations Case provides an overview of the approach used to procure the Program and realize its intended benefits.

Socio-Economic and Environmental Considerations

The Program continues to consider how best to align the City and contractor responsibilities for a range of key socio-economic and environmental considerations that will be managed for the life of the Program. These include the allocation of responsibility for regulatory issues, including managing environmental assessment certificate compliance and permitting. It also includes key considerations around the assignment of responsibility for managing external relations, including consultation with Indigenous communities and public engagement processes.

Risks

The Program continues to monitor and actively maintain a risk registry and a recent interdisciplinary review identified the following seven key risks:

- Affordability

- Governance and decision making

- Procurement and market (from multiple procurements)

- Contract interfaces

- Segment 2 design and constructability

- Coordination with CN and CP railways

- Impacts from COVID 19

The Program Delivery Team continues to develop and refine mitigation strategies for the key risks and continues to take a proactive approach to risk identification, management, and mitigation as the Program progresses.

Response and mitigation measures include:

- cost management

- procurement schedule management

- resource and capacity augmentation

- improving/streamlining decision-making

To further reduce risk, the Program Delivery Team is actively managing three key dependencies to ensure the Program continues to meet its planned schedule: completion of early works package; finalization of any required funding agreement amendments; and securing executive sponsorship and Council approvals.

Procurement Strategy and Approach

The procurement strategy is founded on a core set of principles that are intended to support the long-term success and viability of the Program for the City of Calgary. Assessments of market feasibility have been conducted at various stages of the Program to ensure that the procurement model is strategically aligned with key market considerations, feasibility and competition. These assessments have concluded that using an early contractor involvement model with two design-build-finance (DBF) contracts or the main project construction – one for Segment 1 for southern Shepard Phase and one for Segment 2 in the Centre City – with separate contracts for the Light Rail Vehicles (LRV) and enabling works would present the best mix of value, competition and schedule certainty for the Program.

Governance

An effective system of project governance will be integral to the success of the Program. The governance systems and structures will incorporate leading best practice in project governance while also meeting the unique needs of the Program. The governance model for the Program is under development at the time of writing to ensure effective alignment with the outcomes of the procurement process.

The delivery and management of the Program will be supported by a tailored Program Delivery Team model. The organizational chart for the Program Delivery Team is under refinement at the time of writing to ensure effective alignment with the outcomes of the procurement process.

Operations and Maintenance

Operations and maintenance components have been excluded from the procurement model at this stage, as The City is not pursuing a long-term P3 model for the Program with all operations and maintenance planned to be undertaken by Calgary Transit supported by The City's other departments and divisions.

Benefits Management

The City expects a range of benefits to be realized in both the construction and operational phases of the Program and, at the time of writing this Business Case, work is underway to better undestand project benefits to develop a benefits management plan.

V. Business Case Conclusions

The Business Case for Stage 1 of the Green Line LRT Program draws on over five years of planning, stakeholder engagement, and design to present an optimized investment for the City of Calgary. This investment will have a significant benefit on mobility and urban development for the City of Calgary by 2028 and beyond.

Improving mobility choices

Providing fast, frequent and reliable transit services that strategically connect communities, employment hubs and key destinations will save Calgarians time travelling to work and recreational activities

Laying Foundations

Delivering the most complex elements of the overall Green Line Program first, Stage 1 enables future extensions further north and further south.

Catalyzing development

The Green Line LRT serves 10 station areas (of 15 stations) that are identified by Calgary's Municipal Development Plan (MDP) as priorities for investment and development.

Integrated and cost-effective transit service

The Green Line will connect people to where they want to go on a new LRT that can be delivered and operated in a cost-effective manner.

Connecting the city

The Green Line is the next step for completing Calgary's rapid transit network providing seamless connectivity with the existing Red and Blue LRT lines and four MAX transit lines.

Next Steps

Upon review of this Business Case and other supporting materials, the following next steps have been identified for Stage 1:

- Procure LRVs.

- Advance the P3 delivery of Segment 1 from Shepard to Ramsay/Inglewood.

- Continue the design and development of Segment 2 from 4 Street to 16 Avenue N and continue to plan BRT improvements for Centre Street in advance of future expansions.

- Conduct further planning, design, and development of Centre Street N and southern expansions for the Green Line LRT Program.

1

Introduction

1.1   Background

The City of Calgary is regarded as one of North America's best places to live, visit, and do business. It is one of Canada's largest cultural and economic centres and has a well educated and entrepreneurial population working across multiple industries. As a result, the city has undergone significant population and employment growth over previous decades and is forecast to double its population by 2076.

The southeast and north of the city are anticipated to grow faster than any other area.

In particular, the southeast will close to double its population in the next 30 years, resulting in nearly 15,000 new trips during the busiest hour of the day and over 115,000 daily trips. Centre Street North has evolved into the busiest BRT corridor in the city. The demand along this corridor regularly exceeds the capacity of the current BRT system during the morning and evening rush hours.

Without changes to the transit network, 90% of this new demand will use the road network and increase congestion and travel times while reducing reliability.

Investment in infrastructure is essential to maintain a high quality of life, a prosperous and competitive economic advantage, and a sustainable environment. This Business Case outlines a key infrastructure investment to meet this need: Stage 1 of the Green Line LRT Program. This investment will expand mobility choices to improve travel times and journey reliability by connecting southeast, downtown, and north Calgary to meet the needs of the city's present and future population.

1.2 Role of the Calgary Green Line Business Case

This Business Case has been developed as an update to the 2016 Business Case for the Green Line LRT program, and has been updated to reflect Council approvals on 16 June 2020. Since 2016, the design and planning work for a first stage (Stage 1) of the Green Line LRT from Shepard through to 16 Avenue North via downtown has advanced significantly, with an aim to initiate procurement for Segment 1 of the Program in 2020. This Business Case has been developed to advance the Green Line LRT project by:

• Leveraging previous planning studies and Business Cases to define the Green Line LRT project.

• Communicating the central challenges and issues the city will face in coming decades and the role of transportation investment in general and the Green Line in specific, in preparing the city to double its population by 2076.

• Defining the range of benefits the Green Line LRT Stage 1 will realize and set out processes to manage and realize them.

This Business Case has been prepared by applying international best practice to achieve these three aims in a transparent and accountable manner that enhances project delivery and decision making.

1.3 Document Structure

Introduction

The remainder of this document includes the following chapters:

Chapter	Role in Business Case	Relevance to Other Chapters
2 – Case for Change	Defines a 'solution agnostic' problem and defines why Stage 1 of the Green Line LRT is an appropriate investment to address the problem and realize benefits for the city and region	• Chapter 3 – provides goals and objectives to inform the design of options • Chapters 4-7 – provide goals and benefits to inform option evaluation
3 – Green Line Concept	Defines the specific Green Line LRT Program options included in the Business Case evaluation (Chapters 4-7) and key design assumptions to inform next steps	• Chapters 4-7 – scope, (changes to network) costs and model outputs to inform evaluation
4 – Strategic Case	Assesses the benefits of the Green Line LRT Program to Calgarians, the city, and the broader region	• Chapter 5 – provides key strategic benefits to be monetized in Chapter 5 • Chapter 8 – supports conclusions
5 – Economic Case	Monetizes strategic benefits and compares them to the resource costs to deliver the Calgary Green Line LRT to assess overall value to the city and region in economic terms	• Chapter 8 – supports conclusions
6 – Financial Case	Provides a financial and funding assessment of the Green Line LRT	• Chapter 8 – supports conclusions
7 – Deliverability and Operations Case	Defines the procurement approach and requirements (technical and regulatory) to successfully deliver the options and provides an overview of key risks	• Chapter 8 – supports conclusions
8 – Conclusion	Summarizes the Business Case evaluation (Chapters 4-7) and provides key insights and recommendations	• Decision making and procurement planning

GC2020-0583 Attachment 6

2

Case for Change

This chapter outlines the central problems and opportunities that will be addressed by investing in the Program defined in this Business Case. This chapter draws upon municipal, provincial, and federal plans, policies, and goals to define the case for changing the transportation network to meet the needs of the city and its people.

The Problem
An overview of the central issues that define the need for investment in the transportation network.

The Solution
An overview of why the Green Line LRT has been proposed as an essential transformation to the Calgary transportation network to address this problem.

2.1 The Problem

Problem Statement: Calgary's transportation network in the north and southeast does not meet the current mobility needs of the city and its people and is unable to support planned and forecast growth while maintaining a high quality of life, economic competitiveness, and environmental sustainability.

Today, the City of Calgary is an economic and cultural centre and is frequently ranked as one of the most liveable cities in North America to live, work, and play in. Over the past decades the city has grown at a rapid pace which has led to increased prosperity but has also brought challenges of increased travel times and reduced transportation reliability. Combined, these challenges will reduce quality of life, prosperity, and environmental as more people spend more time travelling on an increasingly congested, crowded, and unreliable network. Without investment, this problem will grow over time and will become more acute due to two key issues:

- **The current transportation network in the north and southeast cannot provide quality mobility options for all future travellers**- today demand in the north exceeds capacity, while the rapidly growing southeast does not have complete rapid transit coverage. There is a clear need for affordable and attractive transit that can provide faster and more reliable mobility.

- **Travel times and congestion will limit the potential to develop great places in which to live, work, and play** - the corridor running from southeast Calgary, through the downtown core, and to 16 Avenue N has been identified for redevelopment – with a focus on developing TOD at key sites on the corridor. However, the existing transit network does not provide fast and reliable connectivity between these sites and will suppress their development potential.

What happens if this problem is not addressed?

Table 2.1 defines the central consequences to the city and broader region if this problem is not addressed.

Table 2.1: Consequences and Risks of Inaction if Problem Statement is Not Addressed

Risks	Consequences	Impacts
As the region's population increases, existing transit and roadways will see a continued increase in congestion, lowering the overall efficacy (e.g. speed, reliability) of transportation networks and services	The transportation network will not manage the level of growth, and the quality of life and environment will decrease	People will spend more time travelling, leading to a decline in socio-economic and environmental health and well-being
Increased travel times will make it harder for people and businesses to access economic activity centres across the north and southeast. This will have an impact on the attractiveness of Calgary as a place for businesses to work, invest, and innovate	The transportation network will hinder further development and economic growth	Population and employment growth will be constrained which may hinder investment and development that can help foster the creation of 'complete' communities
Increased population will lead to increasing demands for mobility, which in turn will mean more fuel and energy used every day if sustainable options are not provided	The transportation network will be more resource and pollution intensive	If trips are made on vehicles with lower energy efficiency, the transportation system will produce more pollution that impacts both human and environmental health

2.2 Understanding the Need for Investment

This sub section provides an in-depth review of the factors that shape the issues identified in the problem statement.

Issue 1

The current transportation network cannot provide quality mobility options for all future travellers.

Preparing for the Future – Calgary's Population Will Double by 2076.

Calgary is a large and dynamic City with a population of more than 1.3m people[1] and 720,000 jobs[2], a young and highly educated population, a cluster of highly competitive businesses, and an exceptional quality of life. These advantages inform long-range population growth projections to 2076 that suggest Calgary's population will double, bringing 1.3m new residents to the city.

More specifically, the city expects significant growth in its northern and southeastern communities, with the population of its northern communities estimated to reach 340,000 by 2076 (up from 165,000 in 2014), and population in its southeastern communities estimated to reach 365,000 by 2076 (up from 120,000 in 2014). Importantly, Calgary's southeast quadrant is one of the fastest growing urban areas in the city and is forecast to nearly double over the next 30 years. Figure 2.1 and Figure 2.2 present the distribution of population across the Calgary in 2015 and 2076.

These figures illustrate that:

- Communities such as Inglewood, Ramsay, and Quarry Park have achieved densities of 1,000-5,000 people per square kilometre, which is a similar level of density to the Calgary's older communities adjacent to the core and in line with municipal plans and policies to develop denser, more complete communities.

- Key development areas within the southeast of Calgary are planned for significantly higher densities, such as parts of Quarry Park and Riverbend that will increase to 2,000-10,000 people per square kilometre.

- Areas north of downtown Calgary are also high density and are anticipated to remain so in the future.

1. City of Calgary. (2019). 2019 Civic Census Results. Retrieved from: https://www.calgary.ca/CA/City-clerks/ Documents/Election-and-information-services/ Census2019/2019_CensusResultsBook.pdf

2. City of Calgary. (2020). January 2020 Labour Market Review:

Employment forecasts and economic development plans call for an expanded role for Southeast and North Calgary

This increase in population and population density presents the following potential challenges for the city:

- Existing southeastern transportation infrastructure was developed for lower densities (fewer people within an area means fewer trips exiting and entering an area) and lower populations (fewer people within an area also means lower overall volumes).

- Transportation in the north is already congested - every day the bus routes along Centre Street are exceeding passenger capacity, resulting in an increasing number of passengers unable to board services.

Without investment, denser areas may lead to bottlenecks in the network where travellers exit their community and using major arterials or transit routes, while increased volumes may lead to congestion and increased travel times for all travellers.

Alongside population growth, the City forecasts an additional 100,000 new jobs in north and southeast Calgary over the next 25-30 years, which will position the southeast as an important employment destination[3]. This growth, projected to 2076, estimates there will be:

- Over 100,000 jobs in the north (up from 40,000 in 2014); and

- Over 210,000 jobs in the southeast (up from 100,000 in 2014).

Additionally, by 2033, jobs are forecast to grow by over 50% to 145,000 and and 60,000 in the southeast and north respectively. Figure 2.3 and Figure 2.4 present the distribution of jobs across Calgary in 2015 and 2076.

3. Employment growth may vary from forecasts due to changes in the broader economy at a municipal, provincial, and federal level.

Figure 2.1: Population per Square Kilometer (2015)

Green Line LRT

⬤━ C-Train Red Lne
⬤━ C-Train Blue Line
┈┈ Other rail line
Population density 2015 (residents/km²)

- 0
- 1 - 100
- 101 - 500
- 501 - 1,000
- 1,000 - 5,000
- 5,001 - 10,000
- > 10,000

N

0 1 2 3 4 5 km

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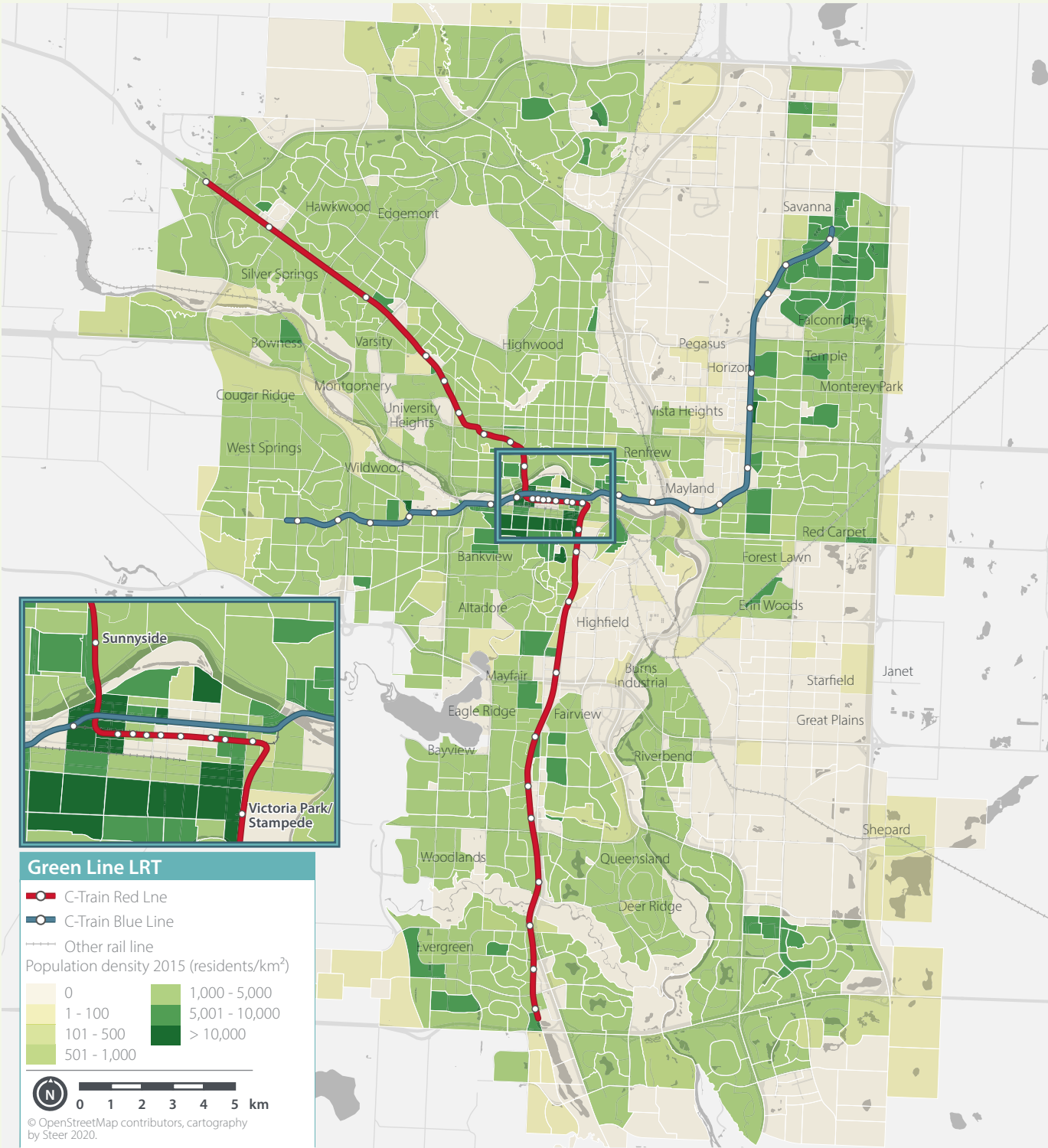
Figure 2.2: Population per Square Kilometer (2076)

Green Line LRT

— C-Train Red Lne
— C-Train Blue Line
Other rail line
Population density 2076 (residents/km²)

0	1,000 - 5,000
1 - 100	5,001 - 10,000
101 - 500	> 10,000
501 - 1,000	

0 1 2 3 4 5 km

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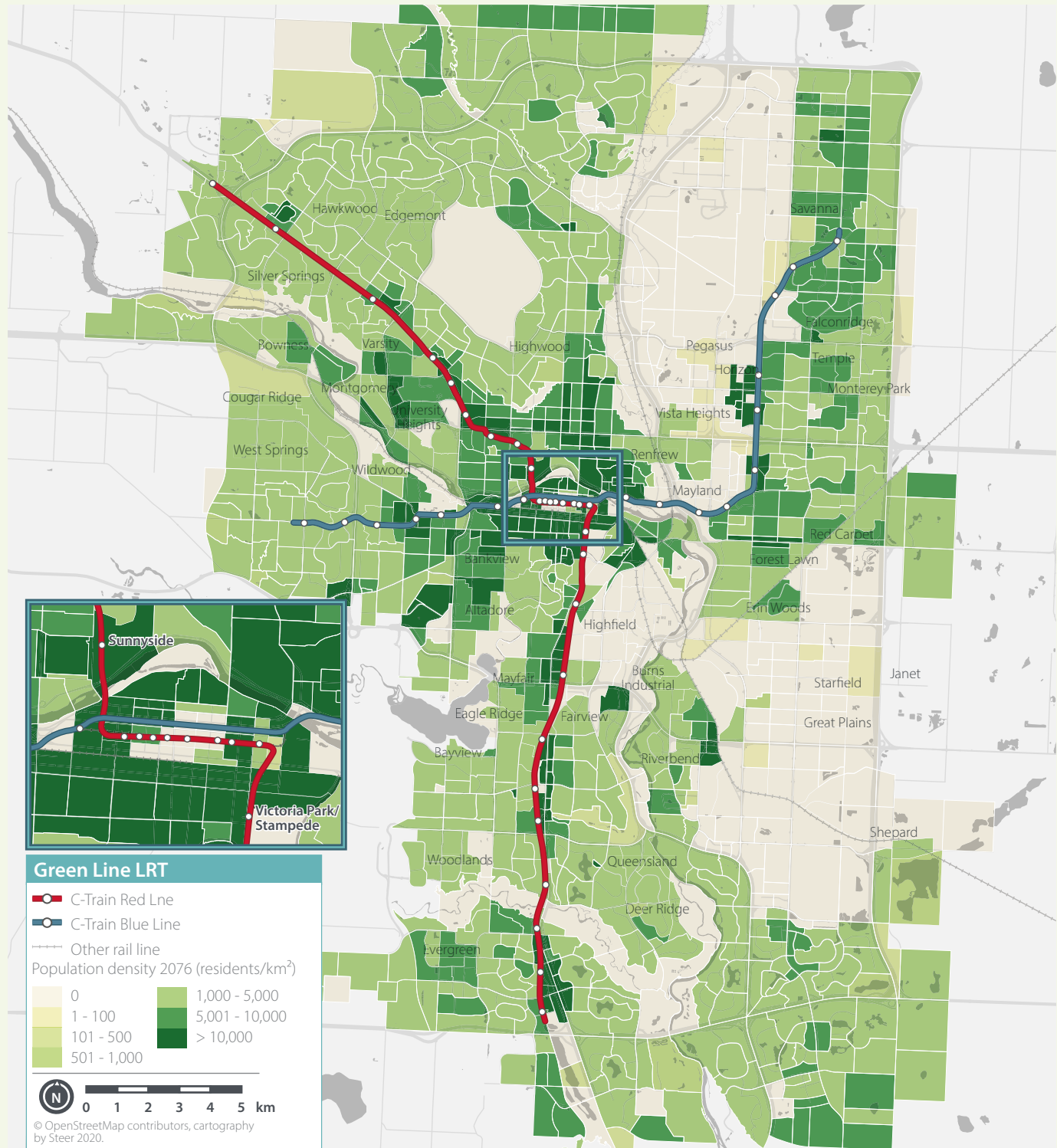
**Figure 2.3: Employment per Square
Kilometre (2015)**

Green Line LRT

—●— C-Train Red Lne

—●— C-Train Blue Line

······· Other rail line

Employment density 2015 (employees/km²)

0	1,000 - 5,000
1 - 100	5,001 - 10,000
101 - 500	> 10,000
501 - 1,000	

0 1 2 3 4 5 km

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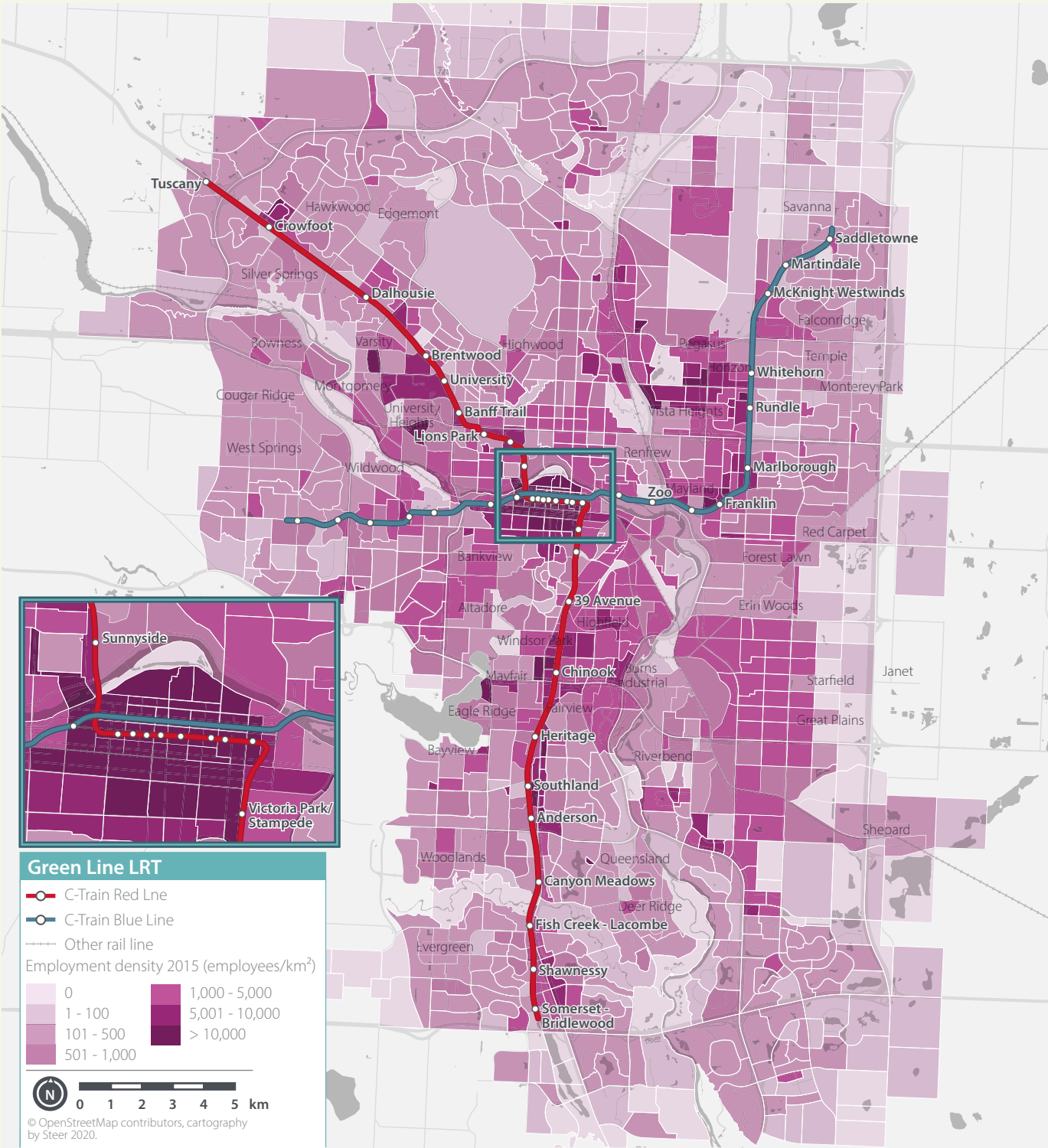
Figure 2.4: Employment per Square Kilometre (2076)

Green Line LRT

— C-Train Red Lne
— C-Train Blue Line
·········· Other rail line

Employment density 2076 (employees/km²)

0	1,000 - 5,000
1 - 100	5,001 - 10,000
101 - 500	> 10,000
501 - 1,000	

0 1 2 3 4 5 km

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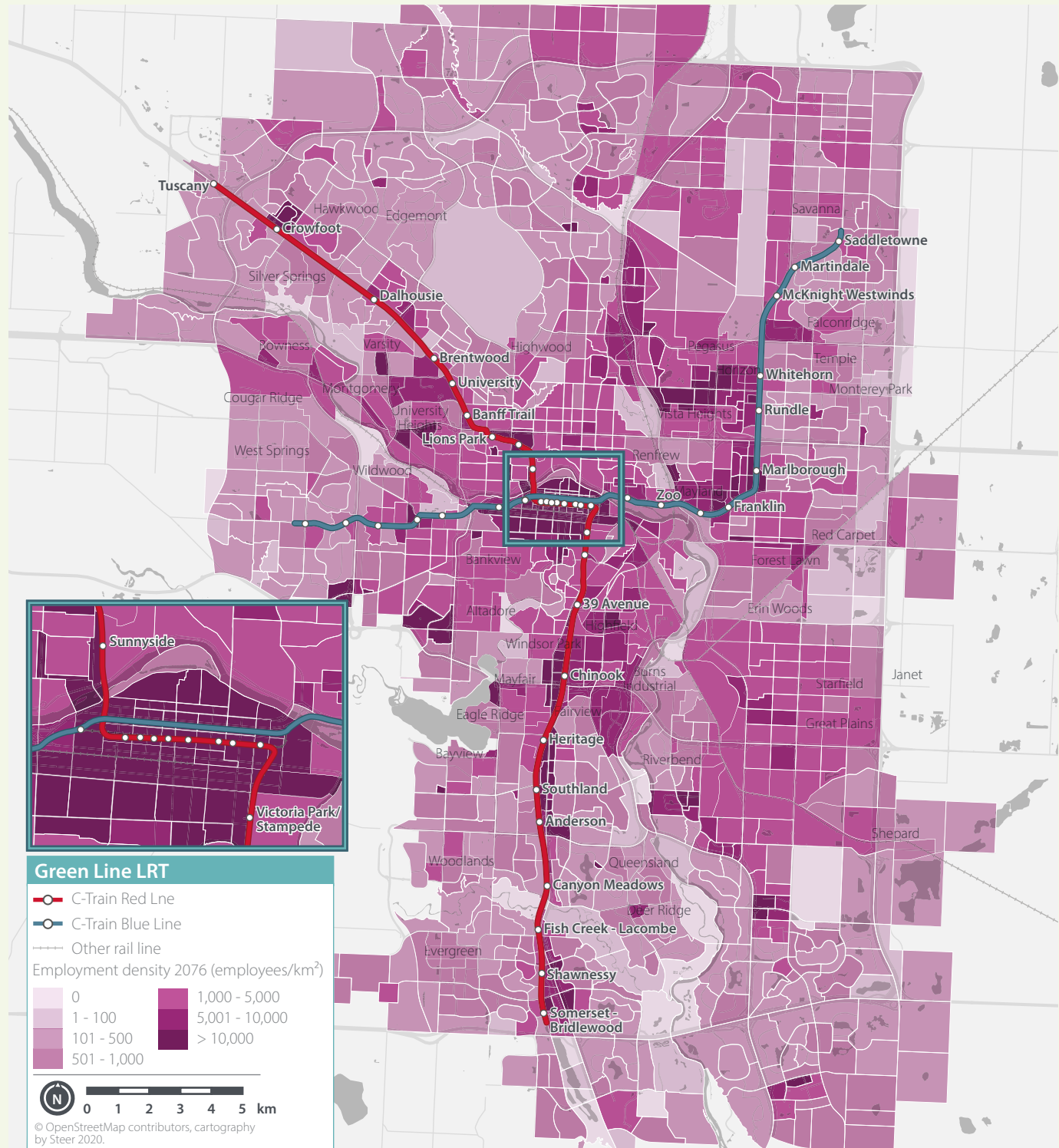
Impact of population and employment growth on transportation network

This significant growth in population and employment will have multiple impacts on the way people travel in the city:

1. **Number of trips** – increased volume of trips as the population and employment grow.

2. **Destination of trips** – as new origin destination pairs emerge, the places where people live and work will change based on urban development (e.g. Calgary is in the process of evolving from a downtown focused City, where most transit users live in suburban communities and work downtown, to one which is more polycentric, where there is a multitude of high-density hubs).

3. **Trip purpose and time of travel** – changed trip patterns as demographics and economic activity influence how people live, work, and play.

4. **Modes used** – people will make use of different transportation modes based on the combined influence of factors 1-3.

Over the past five decades, factors 1-3 have led to increased demand on the cty's transit network. For example, in terms of trips to work between 2001 and 2011, there was a 34% increase in the share of people who took transit to work, from 13.9% to 18.7%[4] of all trips, which demonstrated increased demand for public transit use by commuters. Cordon counts conducted by the City show that the typical AM modal share for transit for trips to the downtown core is 40-50%, which further illustrates the strength of the transit market.

Figure 2.5 illustrates how citywide travel demand has inceased over time by nearly 575,000 trips. Of these trips, approximately 90% were conducted by auto (523,600 trips; vehicle or vehicle passenger), and the remaining 10% by transit (52,400 trips).

4. City of Calgary. (2013). Changing Travel Behavior in the Calgary Region. Retrieved from: https://www.calgary.ca/Transportation/TP/Documents/forecasting/Changing%20Travel%20Behaviour%20in%20the%20Calgary%20Region_Vol2_v07_FOR_WEB.pdf?noredirect=1

Figure 2.5: Historic Calgary Travel Demands

Source: City of Calgary, Changing Travel Behaviour in the Calgary Region (2013)
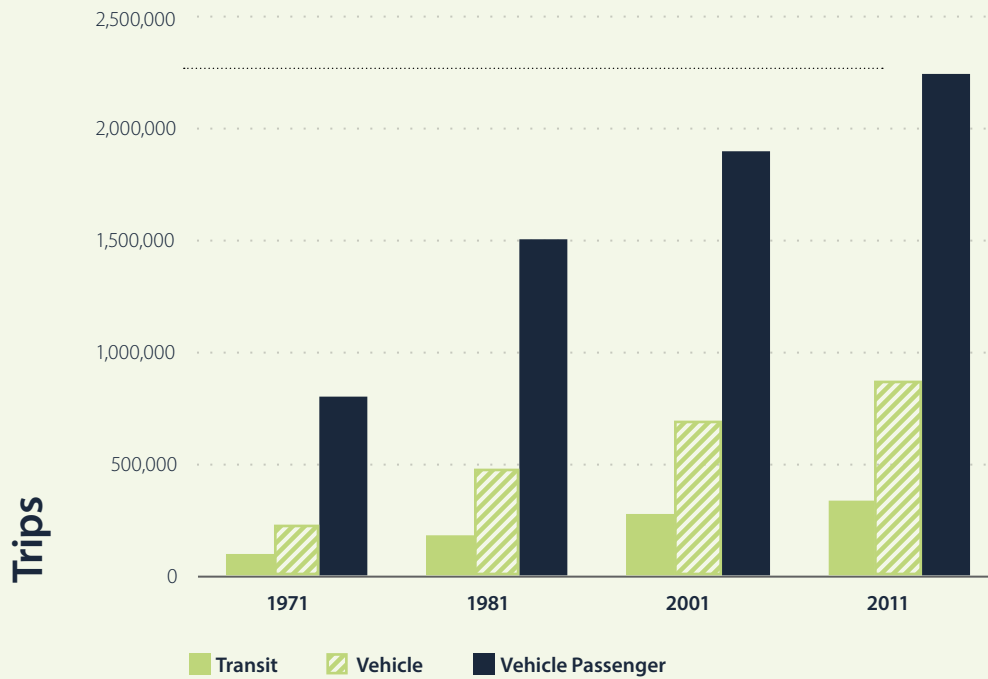
Annual Transit Ridership (millions)
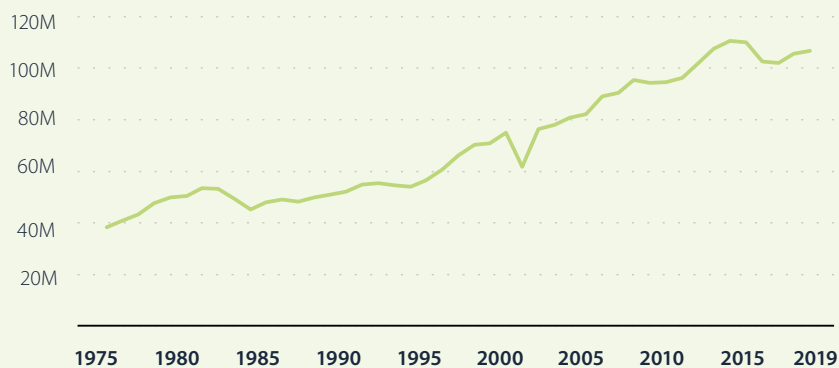
Table 2.2: Future Market Demand (Busiest Hour of the Day)

2028 Forecast	Southeast	Southwest	Northwest	Northeast	CBD	Region	Total
	Destination						
Origin Southeast	5%	10%	30%	8%	33%	0%	**11%**
Southwest	6%	10%	28%	24%	45%	0%	**20%**
Northwest	8%	17%	12%	10%	45%	0%	**17%**
Northeast	6%	31%	22%	9%	54%	1%	**18%**
CBD	11%	17%	25%	23%	20%	5%	**19%**
Region	0%	3%	6%	1%	18%	0%	**2%**
% Growth (2015-2018)	Southeast	Southwest	Northwest	Northeast	CBD	Region	Total
	Destination						
Origin Southeast	93%	47%	54%	58%	27%	47%	**65%**
Southwest	42%	33%	40%	18%	10%	18%	**27%**
Northwest	15%	34%	24%	7%	-3%	68%	**17%**
Northeast	17%	15%	26%	22%	4%	80%	**19%**
CBD	39%	26%	30%	25%	14%	16%	**21%**
Region	36%	27%	64%	32%	2%	80%	**56%**

The City's Regional Transportation Model (RTM), which is informed by these trends, was used to forecast demand between the quadrants of the city and the downtown core to illustrate the level of demand the future network will need to accommodate (noted in Table 2.2).

Table 2.2 notes the following key findings:

- By 2028, demand originating in southeast Calgary will have grown by 65% (the largest growth in the city)– this is a net increase of nearly 15,000 trips, of which 13,500 are made by car.

- This equates to nearly seven lanes of additional peak period demand, which highlights how the road network cannot handle increased demand without significant congestion and delays.

- To attain a similar mode share to the downtown core as other markets, the transit network would need to accommodate an additional 3,000 passengers during the AM peak (equivalent to over 30 buses per hour and one bus every two minutes to the downtown core). Route 302 BRT does not have sufficient operating capacity to meet this demand, presenting significant operational challenges to the transit network.

- Aside from Route 302 BRT, some travellers in the southeast use the Red Line LRT, which is increasingly crowded and at capacity during the busiest hours of the day. This level of crowding impacts customer experience and limits ability to grow transit mode share in the Red Line corridor.

- As demand exceeds the existing transit network's capacity, travel times, user experience, and overall reliability will decrease, which will limit traveller choice to access the downtown core, other employment sites, and a range of recreational sites in Calgary.

- Transit demand from the north will remain high, emphasizing the need for additional transit capacity on core corridors - such as Centre Street.

4. Assuming each lane can carry 2000 vehicles per hour per direction

Impacts of Issue 1

This increase in demand has the following ramifications for the transportation network:

- Increased transit use has put a strain on the bus and LRT networks, with multiple services experiencing significant crowding during the busiest hours of the morning and evening periods.

- Due to a circuitous road network, transit travel times in the southeast take up to 40 minutes longer than a private vehicle, while bus demand in the north leads to overloaded buses by 16 Avenue N.

- Unreliable transit results in long wait times, long travel times, and inconsistent service.

- Increased auto trips have led to worsening road congestion on arterial and local streets, in particular in the southeast, where increased auto ownership is paired with inadequate transit services that do not provide people with an alternative to driving.

Combined, these factors create a vicious cycle – poor travel times and reliability lead to reduced use of transit and increased congestion.

Issue 2

Travel times and congestion will limit the potential to develop great places to live, work, and play.

Issue 1 discussed how increased growth in the city – and in particular in the southeast – will increase congestion on the roadways and exceed the ability of current bus-based transit options to deliver a positive user experience and reliable travel times. Issue 2 focuses on the impact of congestion on the viability of urban development – including municipal and economic developments – and the city's overall ability to provide quality places to live, work, and play in the southeast for Calgarians of today and tomorrow.

The Role of Mobility in Reshaping Southeast and North Calgary

City plans and policies call for a change in urban form as the Calgary's population and employment bases grow. Historically, the city's development has focused on:

- Centralized employment in the downtown core or CBD.

- Lower employment densities throughout the city with a focus on retail and manufacturing, with some service/knowledge-based industries relocating outside of the CBD.

- Higher density residential developments near the CBD with single family home and lower-density developments outside of the core.

This approach to development poses key challenges for the long-term quality of life and prosperity of the city:

- With employment concentrated in the CBD and low-density development outside the core, many commuters travel long distances, with increasing travel times as congestion worsens.

- Industrial lands alongside key transport corridors are ready for redevelopment but are not as accessible as employment sites in and within proximity of the CBD.

- Land use patterns in the southeast are auto-oriented, meaning travellers cannot complete many trips – including work and recreational trips – without an automobile.

- Some communities lack a range of employment and recreation opportunities and amenities, which means people travel great distances for a range of trip purposes.

In response to these challenges, the City of Calgary has made significant investments and long-range policy commitments to tackle this challenge through the use of public transportation infrastructure and encouraging development that supports transit use. The *City's MDP* calls for a revised approach to new development and densification in built-up areas that allows for fewer long-distance trips and increased transit trips.

One of the key goals discussed in the *City's MDP* is as follows:

Direct future growth of the City in a way that fosters a more compact efficient use of land, creates complete communities, allows for greater mobility choices and enhances vitality and character in local neighbourhoods[5]

The City notes four key land use elements that shape the relationship between mobility, growth, and urban form:

Distance
Locating the right uses close to transit.

Design
Creating a quality pedestrian environment.

Diversity
Mixing land uses.
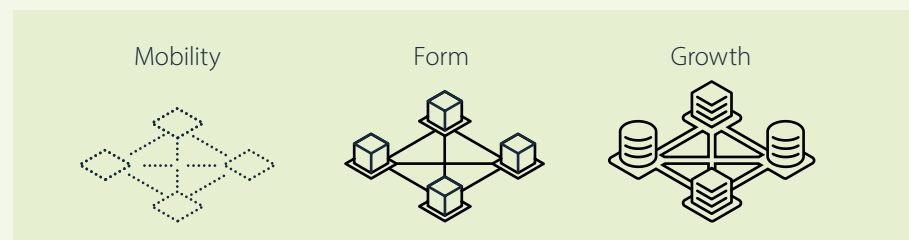
Density
The intensity of people living or working in the area.

Figure x.x:

Mobility   Form   Growth

5. City of Calgary. (2009). The City of Calgary Municipal Development Plan (Office Consolidation 2018)

The transformation to complete and efficient communities cannot be delivered without providing improved connectivity with highly reliable, fast, and frequent rapid transit.

Redevelopments and developments in southeast Calgary have been planned with these principles, however, there is a missing link: rapid transit that provides fast travel times across the southeast, the north, and the broader city. Without rapid transit development, policy frameworks that prioritize dense and mixed use communities will have reduced impact due to high levels of congestion (reduced accessibility) and significantly higher parking requirements.

The Role of Mobility in Safeguarding Economic Activity

Mobility challenges in Calgary impact economic development prospects in a similar way to how they impact urban development prospects. Calgary plays a key role in the economy of Alberta, and has gained global recognition as a highly liveable city with significant economic opportunity. The city is home to more than 720,000 employees and has one of the highest levels of productivity in Canada, at $84,630 per capita (compared to a national average of $52,266)[6] . Calgary is home to a large financial and professional services sector, a highly innovative economy and access to a wealth of natural resources. However, in order to ensure that Calgary realizes its full potential, new investment in infrastructure that will meet the needs of the city's workforce both today and in the future is required. High quality transit is a necessity for cities to grow, to be attractive to a talented workforce, and to be a competitive economic centre.

In particular, infrastructure investment is needed that enables access from high population areas to job rich employment centres, while also using investment in infrastructure to generate jobs. This need is being driven by population growth (and resulting employment growth) and changes in the way people desire to travel across the city.

6. Calgary Economic Development, based on 2019 data from Conference Board of Canada (2019) and Statistics Canada (March 2019)

The City's ten-year economic development plan[7] has an explicit focus on mobility, which can be summarized as follows:

A public transit network that connects the City's major employment and residential areas is required in order to secure Calgary as the City of choice in Canada for the world's best entrepreneurs and maintain high levels of economic productivity.

Effective integration of public transit and providing enhanced transit connectivity will deliver socio-economic value for the city's residents and workers, by:

- Serving Calgarians by connecting major activity, employment and industrial centres within downtown Calgary and across the wider urban area.

- Connecting economic centres with residential housing areas to provide better connections for people to access their workplaces.

- Encouraging businesses and their employees to travel across the city by transit rather than by car.

- Unlocking new development sites to support Calgary in the growth of its key sectors.

Prolonged congestion and current levels of transit service will limit Calgary's potential

As the city's population and employment grows, road congestion will become an increasing issue for the city and its people. Worsening road congestion can be attributed to consistent growth in population alongside auto-dependent land uses with inadequate transit services that do not provide people with an alternative to driving. These issues will in turn impact the ability of the city to realize its growth targets and policy aims.

In order to achieve policy commitments for municipal and economic development, the City of Calgary must work towards improving transit services and infrastructure so that land use and development goals can be effectively met. The development of 'complete' communities can help justify and support the development of new (and improvement of old) transit services. Essentially, by failing to provide adequate transportation services, the city will be limited in its ability to develop complete communities that enable a type of lifestyle that does not depend on car use.

---

7. City of Calgary, Calgary in the New Economy, 2018

The attractiveness and feasibility of new complete community development will diminish without the provision of transit connections through southeast Calgary.

Impacts of Issue 2

The existing transportation network in southeast and north Calgary does not align with policy goals that call for transportation to support land use and economic development, nor does this network enable through connectivity to the downtown core and beyond to north Calgary:

- Travellers have limited mode choice and transit will struggle to compete with private automobiles based on speed and reliability.

- Buses travelling through the southeast are often delayed due to the high volume of vehicles commuting on this route. Transit service includes the BRT Route 302, currently operating every 10 minutes in peak hours and every 30 minutes during off-peak hours. The low frequency of this route often leads to long wait times and an inconsistent service. This means for many trips, automobile is the only choice for travellers.

- Buses from the north are often caught in a bottleneck entering the downtown area on Centre Street, which reduces connectivity between homes and jobs along this dense corridor and limits its attractiveness as a place to invest in and develop.

- Auto dependency will overwhelm existing road capacity and will increase congestion across the southeast of the city and the downtown core.

The Solution

Delivering a Cost-Effective LRT Corridor that unlocks Citywide Potential.

2.3

Delivering a Cost-Effective LRT Corridor that Unlocks Citywide Potential

This Business Case proposes the delivery of an LRT spanning southeast to north Calgary (referred to as 'the Green Line LRT Stage 1') to address the key issues identified in the problem statement: provide sufficient mobility options to prepare the city for the future and shape the transportation network to meet urban development plans.

As part of Stage 1, this LRT will be connected to an improved BRT line on Centre Street, which can be replaced by further LRT expansions in future stages.

Chapter 3 provides an overview of the proposed Green Line LRT concept, while this section provides an overview of the rationale for focusing on LRT as the solution to this problem.

Proposed Solution: Develop the Green Line LRT

The Green Line LRT has been identified as Calgary's next LRT line and will eventually run from a southern terminus at Seton in the southeast, through the downtown core, and north on Centre Street to a northern terminus at 160 Avenue N. This project has undergone significant study, development, engagement, and design and has been selected as a solution to the problem statement due to the following benefits:

- **Improve mobility** – the Green Line LRT will increase capacity to accommodate current and future travel demand in a way that is fiscally responsible and supporting of broader goals for quality of life, environmental protection, and economic productivity.

- **Enhance urban growth and development** – the Green Line LRT can provide a missing link between major development centres and the downtown core with a high quality transportation choice that is aligned with urban growth plans that anticipate the delivery of new rapid transit.

- **Connects people and places** – the Green Line LRT will improve the mobility and accessibility of all people, connecting them to/from places where they can live, work, and play in a way that is safe, healthy, and cost-effective.

Green Line LRT Vision

The Green Line LRT Project Vision was established following a broad-based public engagement process led by the City of Calgary and was reconfirmed by Calgary Council on January 13, 2020 as:

"A City-shaping transit service that improves mobility in north and southeast Calgary, connecting people and places and enhancing the quality of life in the City."

Defining the role of the Green Line LRT in southeast, downtown and north central Calgary

While the full Green Line LRT project will benefit Calgary as a whole, this Business Case for Stage 1 is focused on southeast, downtown, and north central Calgary.

Stage 1 provides a strong foundation of connected LRT service while completing the most technically complex and capital intensive aspects of the long-term vision. This foundational core project will best facilitate future extensions and demonstrates The City's commitment to implementing the long-term vision for the Green Line LRT.

This problem is an initial priority for investment because it has the highest anticipated population and employment in Calgary. This growth will lead to travel demand growth in two key markets:

- Demand from the growing communities in the southeast of Calgary to the downtown core.

- Demand between new developments and economic growth centres across southeast, downtown, and north Calgary.

Today, these markets are served by two primary modes:

- **Highways and roadways** that experience worsening road congestion.

- **Rapid bus service** that is either well-used but over capacity (north Calgary), or inefficient and unreliable (southeast Calgary). Currently, the 301 North and 302 Southeast BRT lines service the north and southeast communities of Calgary.

Table 2.3 reviews three potential solution types for the issues explored within the problem statement. These include: auto network expansion, focused investment in the 302 and other bus corridors, and the development of a new LRT system.

Why Focus on Green Line LRT?

As discussed in Table 2.3, at a high level, LRT has a greater policy alignment and greater overall potential to address the problem statement:

- Auto expansion is unlikely to be a long-term solution as new capacity has historically been taken up by increased auto demand, in addition further investment in the road network will not provide expanded choice for segments of the population and workforce that rely on transit or choose transit as their primary mode.

- Creating an enhanced bus service beyond what it is today (for example, BRT lines 301 in the north, and 302 in the south) that will effectively / reliably service the needs of these growing communities may work in the short term, but will be less effective than an LRT solution over the long term. For example, Centre Street North has evolved into the busiest bus corridor in the city (approximately 30,000 Calgarians transported per day), and regularly exceeds capacity during the morning and evening rush hours.

The core advantages of LRT over these modes are:

- **Flexible capacity for a growing region** – a new lane of highway could move 2,000 cars per hour per direction while an LRT can carry 4,000-6,000 passengers per hour per direction depending on vehicle type and frequency.

- **Cost efficiency compared to bus** – compared to bus and BRT alternatives, each LRV in an LRT network can carry significantly more customers. This means reduced cost per customer carried and a lower required frequency.

- **Integration with urban development** – the city has a successful track record of integrating LRT stations into urban development, while freeways to move increased demands by automobile would require significant expansion which would impact urban realm. Parking lots required at destinations would reduce the amount of land available for development.

- **Improved mobility choice with fast, frequent, and reliable transit** – a grade separated LRT can achieve average corridor speeds of over 40 km/hour during the peak period, which is significantly higher than automobiles and buses that share congested road space. This allows LRT to achieve and maintain high frequencies to meet demand reliably.

- **Network expansion and public acceptability**– the city has significant experience delivering LRT systems over time to meet changing Calgarian needs. LRT lines in Calgary have seen stable and consistent ridership growth as a mode of choice for a range of trip purposes.

- **Regional connections for a regionally integrated economy** – the Red and Blue lines of the LRT network strengthen Calgary's role in the regional economy, with up to 10% of daily demand at terminal stations coming from neighbouring communities.

- **Providing the next step for completing Calgary's rapid transit network** – providing seamless connectivity with the existing Red and Blue LRT lines and four MAX transit lines adding 20km to the existing 59km LRT system as shown in Figure 2.8.

Table 2.3: Comparing how different modes could address the problem statement

Issue	Solution: Roadways	Solution: Bus Rapid Transit	Solution: Light Rail Transit
Issue 1 The Current Transportation Network Cannot Provide Quality Travel Options for All Future Travellers	Roadways are already congested and the principle of induced demand and evidence from other Calgary projects suggests adding new lanes will not address congestion issues in the long term.	Early planning suggests BRT removes some personal vehicles from the road, but still contributes to traffic if not operating in a fully separated right of away. Enhanced bus service with improved efficiency measures (fewer stops, higher frequency) can accommodate some of the anticipated future demand, but not all without technically challenging and cost prohibitive operating concepts (e.g. a frequency of over 30 buses per hour). In order to ensure that Calgary realizes its full potential as a global city, it is crucial to invest in infrastructure that will not only meet the needs of Calgarians today, but will continue to service future generations.	Removes more personal vehicles from the road and does not contribute to traffic congestion. LRT can provide high capacity transit with a more affordable and technically feasible operating concept than bus-based modes.
Issue 2 Congestion will limit the potential to develop great places to live, work, and play	Construction of new roadways causes severance and leads to significant 'access point congestion' and reduced land available for development due to the need to provide parking. In the short-term, congestion may decrease, but in the long-term it is anticipated that road-only solutions will lead to increased congestion that in turn will lead to increased travel times (reduced quality of life and economic competitiveness) and increased emissions.	Bus services can provide connectivity between employment locations, however, they also require high frequencies and therefore higher emissions to meet anticipated demand. The road network in the southeast is restricted with geography constraints (rivers, rail lines, and interchanges), thus it is the most difficult area of the City to provide on-street bus service. The circuitous and limited road network in the southeast results in longer travel time, delay and schedule adherence problems.	LRT can provide connectivity; be integrated with economic centres; maximize the amount of space for development. LRT is fully electric, nearly all downstream emissions are offset. It is also the most effective / reliable service, which has the greatest potential to reduce car travel, saving money and time. LRT avoids the circuitous road network and travels 'almost as the crow flies' to downtown and beyond from the southeast.
Suitability	Not appropriate	Partial solution	More complete solution

<div style="writing-mode: vertical-lr">Case for Change</div>

1981
Red Line Core

- 12.9km of track
- 15 new stations
- 1 maintenance and storage facility

1985
Blue Line Core

- 9.8km of track
- 7 new stations
- 1 storage facility (Haysboro)

1987
Red Line Extension

- 5.8km of track
- 5 new stations

1990
Red Line Extension

- 0.8km of track
- 1 new station

2001
Red Line Extension

- 3.4km of track
- 2 new stations

2003
Red Line Extension

- 3.0km of track
- 1 new station

2004
Red Line Extension

- 3.0km of track
- 2 new stations

2007
Blue Line Extension

- 2.8km of track
- 1 new station
- 1 maintenance and storage facility

2008
Red Line Extension
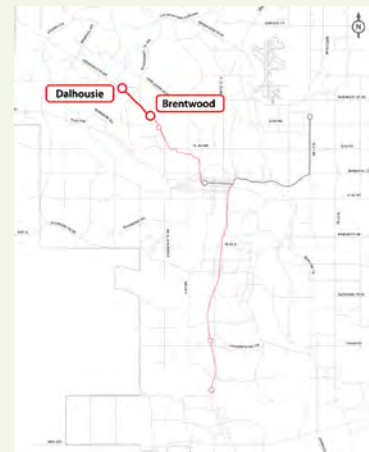
- 3.6km of track
- 1 new station
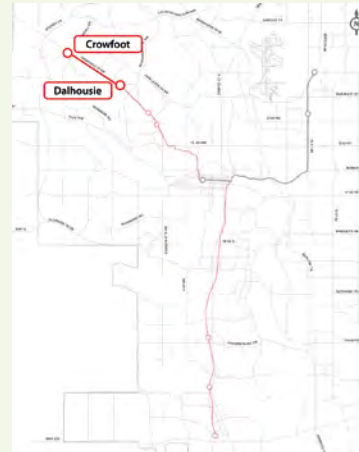
2012
Blue Line Extension

- 2.9km of track
- 2 new stations

2012
Blue Line Extension

- 8.2km of track
- 7 new stations

2014
Red Line Extension

- 2km of track
- 1 new station
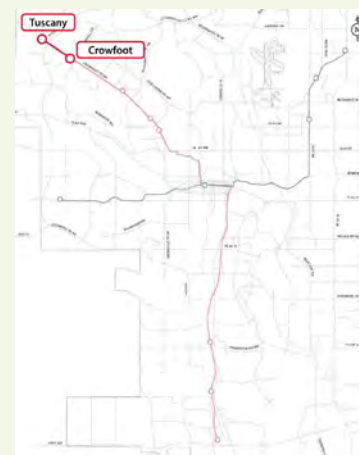
The City's strategic transit plan *RouteAhead*, identified several projects for the expansion of Calgary's rapid transit network, including LRT, BRT, Rapid Transit, and Transitway projects. The Green Line LRT concept was included in this plan as a north-south corridor that interfaces and intersects with multiple BRT and local bus routes and urban development priority areas. Stage 1 of Green Line LRT will offer connections to all four of Calgary's recently implemented MAX BRT lines.

The Green Line LRT – benefits and evaluation framework

The strategic benefits of solving the problem with the Green Line LRT span four outcome areas: connectivity; quality of life; economic prosperity; and environmental protection. These proposed benefits (shown in Table 2.4) are directly realized by acting on the problem statement and illustrate the case for changing the City's transportation network.

Figure 2.7: Intermodal Connections and the southeast Rapid Transit Corridor

Table 2.4: The Benefits of the Green Line LRT

Benefit	Outcomes		Link to problem statement
Frequent, reliable and comfortable connections The Green Line will provide new capacity and a high quality of service that will serve part of Calgary's growing transportation demands	1. Provide new rapid transit connections that generate new ridership		The Green Line will result in a more resilient, efficient, and effective transportation network that can support forecast levels of demand with increased reliability and faster travel times.
	2. Accommodates growth by providing capacity for transit ridership in the near term and long term		
	3. Improve the customer experience by providing frequent, reliable services with reduced travel times		
	4. An affordable mobility option that has cost efficiencies compared to the BRT		
High quality of life The Green Line will help to maintain and enhance the quality of life as Calgary grows	5. Improve travel across the region and reduce congestion by connecting passengers to places they want to go with fast and convenient transit service.		The Green Line will connect travellers across to destinations across Calgary, while reducing the negative impacts of congestion and auto dependency: time spent travelling and reduced health and well-being.
	6. Lead to a safer transportation network (with fewer automobile collisions) that supports a healthy region		
	7. Support the development of mixed-use communities that offer a range of lifestyles to Calgarians		
Economic prosperity The Green Line will support Calgary's development and prosperity	8. Unlock economic development and activity along the LRT corridor		The Green Line will provide alternative commute options and connections to major jobs centres while stimulating the economy through new jobs.
	9. Generate jobs to support an active economy		
Environmental protection The Green Line will lead to a more sustainable transportation network	10. Reduce the environmental impact of Calgary's transportation network		The Green Line will reduce congestion resulting in cleaner air and reduced climate change impacts.

The remainder of this Business Case demonstrates how the Green Line LRT achieves these benefits and what is required to successfully deliver the program.

A roadmap, shown in Table 2.5, has been developed to illustrate the Green Line LRT program, what is required to deliver it, and the outcomes it can generate. This roadmap also outlines where evaluation information is included in the remainder of this Business Case.

Table 2.5: Business Case Road-map

	Inputs Resources required to deliver the Green Line LRT	Actions (means) The core changes to the transportation network	Outputs Measurable changes to network performance	Outcomes (ends) The broader value of the Green Line LRT
Core question	What level of investment is required?	What will the Program provide?	What are the direct effects of the investment on regional travel?	What is the wider benefit of the investment?
What is included?	• Costs (capital and operational expenditure) • Organizational capacity	• Infrastructure and service changes	• Change in travel times, frequencies, reliability	• Indicators for project support for quality of life, environmental sustainability and economic prosperity (Table 2.4)
Success Measures	• Cost efficiency • Jobs created • Stakeholder participation	• On time delivery • Design that meets environmental, safety, and accessibility requirements • Minimize stakeholder impacts	• Meeting on-time performance, target travel times, and desired frequencies	• Ridership • Revenue • Change in automobile vehicle kilometers travelled • Investment in urban development delivered before, during, and after LRT delivery
Role in Business Case				
Chapter 3 – Green Line LRT Program Overview	• Costs are defined	• Program scope • Process to deliver program with guiding principles: safety, stakeholders, regulatory, environment, schedule, cost and risk	• Target runtimes and frequencies	• N/A
Chapter 4 – Strategic Case	• Jobs created (Benefit 9)	• Overview of how program scope realizes benefits	• Overview of how target runtimes and frequencies realize benefits	• Benefits 1-8, 10
Chapter 5 – Economic Case	• Resource costs in real terms			• Monetized user and external benefits from Strategic Case
Chapter 6 – Financial Case	• Costs in nominal terms	• Key financial risks during delivery	• Key financial risks during operation	• Revenues and cost efficiencies (Benefit 4)
Chapter 7 – Deliverability and Operations Case	• Project resource plan	• Project delivery plan and regulatory/ environmental reviews • Procurement plan	• Operating plan	• Benefits management framework

3

Option Development

This chapter provides an overview of the Green Line LRT Program that has been developed to address the problem statement described in Chapter 2. The technical program described in this chapter is a reference concept design for the proposed Green Line LRT, which is intended to:

- Define a scope including all functional capital and operating elements that can be used to estimate costs, benefits, risks, and impacts in Chapters 4-7

- Provide the basis for future detailed design and procurement work

3.1 Program Background and Definition

Option Development

History of Green Line LRT Development

The long-term plan for the Green Line LRT project is to serve and connect the growing populations in north central and southeast Calgary with a fast, frequent and reliable, high quality transit system. These communities are growing quickly and, over the next 30 years, the population in the north central is expected to increase by over 50% from 170,000 to over 250,000 people and in the southeast, the population will double from 135,000 to almost 270,000 residents. The full project is shown in Figure 3.1 and will ultimately be 46km in length, serve Calgarians in more than 27 communities with 29 planned stations and eventually carry over 200,000 trips a day.

The Green Line LRT project is included in the Council's 2013 approved transit plan – RouteAhead: A Strategic Plan for Transit in Calgary and is a key element in successfully meeting the long-term Municipal Development Plan and Calgary Transportation Plan goals. The Green Line LRT will improve mobility choices, connect people and places and enhance the quality of life of the communities that it connects. It will deliver high quality transit service to Calgarians in the north central and southeast and is a key part in the future transit network in the City. Along with the new MAX bus rapid transit routes, Calgarians will have fast, frequent and reliable transit service that strategically connects communities, employment hubs, and key destinations across the City.

Figure 3.1: Vision for the Green Line LRT – 160 Ave N to Seton

Green Line LRT Development Process

In 2015, the Green Line LRT Program received nearly $5B in funding from a combination of the Federal, Provincial and City governments and recognising that, like the Red and Blue Lines, the Green Line LRT would need to be delivered in stages, the Program team considered a range of initial options for the first stage of the line (Stage 1). A detailed evaluation was completed to compare and contrast the numerous options recognising that all options needed to meet the following pre-requisites to be considered:

- **Network Connections** – To support opening day and projected ridership growth, the core project must connect to the Centre City and provide seamless connectivity with the existing Red and Blue lines. Network connectivity could be further enhanced by providing integrated connections to the MAX rapid transit routes.

- **Maintenance and Storage Facility** – Provision of a light rail vehicle facility to clean, repair and protect from the environment when parked.

- **Expandability** – The ability to implement the long-term vision in stages when further investments are made. This positions the City to deliver future affordable and achievable expansions.

Eight preliminary options were identified, four of which were considered above the $5B funding available. Of the remaining four options, two provided considerably less benefit in terms of their network connections and expandability and were dropped from further consideration. The remaining two options – 16 Avenue N-Shepard and 96 Avenue N to 4 Street southeast – were both viewed as providing similar benefits however, the 16 Avenue N-Shepard option was significantly more advanced in terms of project readiness, in part due to earlier planning work for the SETWAY BRT project, and was much less complex to deliver from a land assembly perspective and was therefore selected as the Stage 1 project. This evaluation and sifting process is illustrated in Figure 3.2.

In June 2017, Council approved a Stage 1 alignment from 16 Avenue N to Shephard with a tunnel under the Bow River and through the Downtown. However, in early 2019, concerns were raised related to the Program capital cost as well as the impacts on the customer experience resulting from the deep underground stations, and in June 2019 Administration reported that the approved Stage 1 alignment could not be delivered within the approved funding.

City Council directed Administration to review the Green Line LRT program to ensure the Program continued to meet the original objectives set by Council and that the Program would deliver the best possible outcomes for Calgarians within the approved budget threshold. As part of that review, the Green Line LRT project team has undertaken an Alignment Options Review of the existing project as well as a range of potential options.

Following this assessment, a revised version of the approved Stage 1 alignment was presented to Council in early 2020 that continues to serve 16 Avenue N to Shepard but includes surface running on Centre Street north of the Bow River to a new bridge over the river and shallower Downtown tunnels and stations in an underground alignment on 11 Avenue S. Figure 3.3 shows the updated Stage 1 Green Line LRT project which is evaluated in the remainder of this Business Case. Improvements to the Bus Rapid Transit (BRT) line along Centre Street will also be provided as part of Stage 1 to support increased transit use while a design for the North Centre Street stage of the Green Line is finalized. These BRT improvements are currently under development.

Figure 3.2: Stage 1 Selection Process

Option Development

Part of a long-term vision

7 Avenue SW to Shepard	2 Avenue SW to McKenzie Towne	16 Avenue N to Shepard	96 Avenue to 4 Street SE
40 Avenue N to Shepard	16 Avenue N to McKenzie Towne	Beddington to Shepard	40 Avenue N to McKenzie Towne

Within expected funding

7 Avenue SW to Shepard	2 Avenue SW to McKenzie Towne	16 Avenue N to Shepard	96 Avenue to 4 Street SE

Meets pre-requisites

16 Avenue N to Shepard	96 Avenue to 4 Street SE

Provides benefits

16 Avenue N to Shepard	96 Avenue to 4 Street SE

Project readiness

16 Avenue N to Shepard

**Figure 3.3: Green Line
LRT – Stage 1 Alignment**

160 AVENUE N

144 AVENUE N

NORTH POINTE

96 AVENUE N

BEDDINGTON

64 AVENUE N

McKNIGHT BOULEVARD

40 AVENUE N

28 AVENUE N

16 AVENUE N   16 AVENUE N

9 AVENUE N   9 AVENUE N

2 AVENUE S

2 AVENUE SW   6 AVENUE S

7 AVENUE SW   4 STREET SE

CENTRE STREET S   RAMSAY/INGLEWOOD

26 AVENUE SE

HIGHFIELD

LYNNWOOD/MILLICAN

OGDEN

SOUTH HILL

QUARRY PARK

DOUGLAS GLEN

Maintenance and
Storage Facility

SHEPARD

**North
Central BRT
Improvements**

**Segment 2
(revised
alignment and
new station)**

**Segment 1
(no change)**

3.2

Green Line LRT – A Layered Approach to Design

The purpose of the Green Line LRT is more than just moving people between destinations – it is intentionally planning for future growth with the goal of providing more choices to the way people move, live, work and play. The Program has been designed to be both a transit system and a platform for development and City Shaping; a system that not only provides efficient service and connections to destinations throughout the City, but creates areas where people can live affordably with access to amenities, services and sustainable mobility options.

Through collaboration with all City departments, external partners, industry and all orders of government, a layered approach to the integration of core transit infrastructure, connections to stations, Transit Oriented Development (TOD) supportive infrastructure, and City shaping connections to services and local and regional destinations has been agreed.

By adopting this layered approach, the outcomes of the Green Line LRT project will not only meet the increasing demand for transit in Calgary, but also integrate the economic, social, environmental, and cultural needs of a growing City. Table 3.1 provides a summary of the layers, their key features and how they link back to the objectives of the RouteAhead transit network plan.

Current funding for the Green Line LRT will enable the implementation of Layer 1 (transit infrastructure) and essential components of Layer 2 (connections to transit stations). Future project developments and partnerships with key stakeholders are anticipated to deliver the remaining layers. Together, all four layers will support the creation and evolution of well-planned, connected, accessible, affordable, and vibrant communities that support the use of transit in the community.

Table 3.1: Green Line LRT – A Layered Approach to Design

Route Ahead Objectives & Criteria	Layer	Green Line Design Features
Project Characteristics • Serves High Ridership Corridor • Contributes to Lifecycle Maintenance and Asset Management • Improves Overall Mobility of the Transportation Network **Customer Experience** • Increases Travel Time Advantage • Overcomes Issues of Reliability and Delay • Increases Passenger Capacity	**Layer 1** Transit Infrastructure	• 20 km of LRT track • 15 stations – including 11 transit hubs with 4 MAX BRT connections • 2½ km Centre City tunnel from Eau Claire to 4 Street SE • Additional tunnel (CN/Highfield) • Ten bridges • 1.8 km of elevated track • Park and ride facilities with a total of approximately 1900 stalls • One Maintenance and Storage Facility north of 126 Avenue SE (Shepard)
Land Use • Supports Activity Centres and Corridors • Primary Transit Network Connectivity and Alignment • Population and Jobs Intensity	**Layer 2** Connections to Stations	• Improvements to urban realm to support station access- including multi use pathways along the alignment at critical choke points in the walking and cycling network • Pathways across bridges at both Bow River crossings, Deerfoot Trail, and Blackfoot Trail • New road and bus connections to station areas
	Layer 3 TOD Supportive Infrastructure	• Connects to six station areas targeted for further TOD planning and design and 10 activity centres and corridors identified in Calgary's Municipal Development Plan
	Layer 4 City Shaping	• Establishes the principles and strategies for implementing City Shaping initiatives along the Green Line to create a series of well-planned, connected, accessible, affordable and vibrant communities

Layer 1: Transit infrastructure

Option Development

Serves High Ridership Corridor

Contributes to Lifecycle Maintenance and Asset Management

Improves Overall Mobility of the Transportation Network

Layer 1 includes all of the physical infrastructure that is needed to operate and maintain the Green Line LRT, however, in contrast to existing LRT in Calgary, the Green Line LRT will use modern low-floor light rail vehicle (LRV) technology that better integrates into the community through curb level, less obtrusive station and platform infrastructure. Key infrastructure elements are described in Table 3.1. Stage 1 of the Green Line LRT is the most technically complex and capital intensive stage of the overall Green Line LRT Program. This foundational core project is intended to facilitate future affordable and incremental expansions and demonstrates the commitment to implementing the long-term vision for the Green Line LRT. Stage 1 completes the 4 key Downtown stations that are critical to both ridership from the north and the south, while delivering key supporting facilities (such as the maintenance and storage facility) required to operate the line.

15
new stations, of which 10 are in the Municipal Development Plan

1
MSF north of 126 Avenue SE

10
bridges

1
2.5km Centre City tunnel from Eau Claire to 4 Street SE

1
additional tunnel (CN/Highfield)

20 kilometers of LRT track

1.8 kilometers of elevated track

20-25 minutes journey time saving with 10% journey time reduction due to decongestion

1,900 parking stalls provided through Park & Ride facility
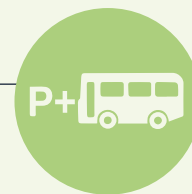
Two-way, all-day service with a peak frequency of every 5-8 minutes

Layer 2: Connections to Stations

Supportive infrastructure that enables the Green Line LRT to integrate with communities and support multi-modal access

Layer 2 of the Green Line LRT project focuses on infrastructure that will support connecting customers to stations. This includes integration of pedestrian, cycling, bus, and road connections to the Green Line LRT ensuring that stations are safe and convenient to access. Essential components of Layer 2 that are included in the Program are the areas directly adjacent to stations where there is missing or unsafe infrastructure which would inhibit pedestrian as well as bus and car access to the station area. Other components of mobility networks such as bicycle pathways, walkways and road works will be addressed through other programs and initiatives.

Pathways across

4

bridges at two Bow River crossings, Deerfoot Trail and Blackfoot Trail

Improvements to urban realm, including multi-use pathways
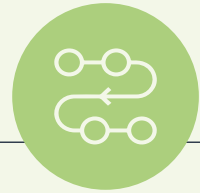
New road and bus connections to station areas

Improvements to critical choke points along walking and cycling network

Connections to the

4 MAX

rapid transit routes, and seamless connectivity to Red and Blue lines
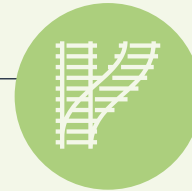
Layer 3: TOD Supportive Infrastructure

Supportive infrastructure and design features that enable the Green Line LRT to facilitate TOD

Six stations are targeted for planning and design based upon extensive research into TOD potential

The City of Calgary has made significant investments and long-range policy commitments to optimize the use of public transportation infrastructure by encouraging development that supports transit use. TOD focuses on future growth and development close to transit stations. The result is the provision of affordable and active lifestyles that support the use of transit in the community.

TOD plays a key role in developing complete communities that help achieve the City's vision for the future as outlined in the City of Calgary's Municipal Development Plan and the Calgary Transportation Plan. Six stations sites along Green Line LRT have been selected as TOD priority sites based on an assessment of geospatial data, market analysis, long term development plans, and stakeholder input (community, developers, and subject matter experts). Figure 3.4 provides a summary of each TOD station including the forecast developable area broken down by residential, office and retail development space.

Layer 4: City Shaping

Supportive infrastructure and design features that enable the Green Line LRT to facilitate the City's broader plans for the corridor and adjacent areas

Embedded principles and strategies to create well-planned, connected, accessible, affordable and vibrant communities

The City Shaping layer is about leveraging Calgary's investment in the Green Line LRT to strengthen and support the social needs of communities along the alignment. It is indicative of the City's effort to create a series of well-planned, connected, accessible, affordable, and vibrant communities, starting from Green Line LRT construction and evolving into the future. City Shaping is about investing in people, places and programs that are near high quality transit service, making it easy and convenient for Calgarians to access them.

Option Development

The implementation of the layers will help redirect the growth patterns of the City towards places and destinations connected by transit. In addition, the Green Line LRT will offer the opportunity for the City to re-prioritize and potentially accelerate other initiatives to leverage the investment in transit infrastructure as a catalyst for community integration and connectivity. Led by the City's Community Services Department, work on Layer 4 will establish the principles and strategies for implementing City Shaping initiatives along the Green Line LRT.

Figure 3.4
TOD Priority Sites

Station					
16 Avenue Station	Inglewood / Ramsay Station	26 Avenue Station	Lynnwood/ Millican Station	Ogden Station	South Hill Station

Development potential					
High	High	High	Medium	High	Medium

Opportunities					
Good street connectivity High land value	Good street connectivity High land value	Presence of underutilized land Presence of large parcels	Presence of underutilized land Presence of large parcels	Good street connectivity Proximity to major arterial/ freeway network	Proximity to arterial/freeway network Public land ownership Presence of development parcels

Possible development areas						
Residential	300,000 m²	87,000 m²	357,000 m²	32,000 m²	95,000 m²	280,000 m²
Retail	31,400 m²	8,800 m²	20,000 m²	0 m²	5,600 m²	14,000 m²
Office	12,000 m²	2,100 m²	8,400 m²	0 m²	3,900 m²	52,500 m²

3.3

Summary of the Design Process and Assumptions

Overview

This section defines the process and assumptions used to develop the alignment and station designs. These assumptions were set out based on significant analysis and design conducted by the City from 2015-2019. This section includes:

- Business as Usual Definition

- Design Assumptions

Business as Usual Definition

Business as Usual (BAU) refers to the future state of Calgary's transportation network without the Green Line LRT. The BAU is the comparator against which the incremental costs and benefits of building and operating the Green Line LRT are measured to understand the overall value of and case for the Program. Generally, the BAU scenario has been defined to include only those investments and service enhancements that are presently funded and:

- Were planned or committed prior to or independently of the Green Line LRT;

- Would be required to meet underlying demand growth, following the bus and transit network service design used by Calgary Transit;

- Would be required as provision for other committed or proposed projects; or

- Would be required if the Green Line LRT was not built to maintain acceptable levels of comfort, safety, and reliability of the transit system.

Table 3.2 summarises the major assumptions and investments included in the 2048 BAU scenario.

Table 3.2: Assumptions and Investments Included in the BAU

Investments included in the BAU

Bus Network

- Approximately 200,000 to 230,000 new annual bus service hours (including MAX expansion) to reflect growth in the population and employment

Transitway and BRT investments including:

- MAX Yellow
- MAX Purple
- MAX Teal
- MAX Orange

Road Network

- Southwest and West Ring Road
- NE and southeast Ring Road –widened to 6 lanes

Design Assumptions

A set of working assumptions was used to develop, model, and test a Reference Concept Design for the Business Case. These assumptions are based on:

- Nearly 40 years of Calgary Transit's LRT operating and capital delivery experience

- Historic Calgary Transit LRT project delivery and performance

- International best practice.

These assumptions are central to determining the overall feasibility of the Green Line LRT as well as estimating its potential costs and benefits. This sub section summarises these assumptions and their influence on the Green Line LRT RCD development process. Assumptions include:

- Customer Experience

- Modelling and Forecasting

- Operating Concept

- Operating Cost Estimate Capital Cost Estimate

Customer Experience

This Business Case assumes that the Green Line LRT project will improve and optimize customer experience building on the framework developed through the RouteAhead planning process. The Green Line LRT:

- **Creates a Transit Travel Time Advantage** – end-to-end journey times on the LRT will be nearly 50% faster than today's BRT service and services will operate approximately three times as frequently in the peak periods.

- **Increases Passenger Capacity** – a two-car LRT train can carry nearly five times more people than an articulated bus and, when combined with the increase in service frequency, the Green Line LRT can carry nearly 15 times more people than the BRT.

- **Overcomes Issues of Reliability and Delay** – running in a dedicated right-of-way with very few at-grade intersection crossings, the Green Line LRT will be able to provide customers with not only a fast service, but one that is able to deliver a consistent and reliable journey time.

- **Improves the Overall Transit Network** – Green Line LRT infrastructure allows for a direct connection to Downtown by increasing the LRT network by over 30% to 80km of total service. The Green Line LRT also allows for an optimized and cost-effective bus network as more buses can play a 'feeder' role rather than service longer distances.

The specifications that will be included in the final contracts for design and construction will ensure that the customer experience elements are implemented across the network in the areas of architecture; site and landscape architecture; universal accessibility; and sustainable, interior and industrial design which includes integrated art and harmonized wayfinding. Primarily qualitative, these influences can have an impact on ridership by improving customer experience.

A key element of the customer experience is the use of low floor LRT, which is characterized by its ability to operate in a variety of environments such as City streets or grade separated rights of way. Key characteristics are its flexibility, compatibility with adjacent vehicular traffic, and passenger capacity.

Passenger boarding takes place at dedicated stations with platform heights that are much lower than the current LRT platforms used in Calgary to allow for easier integration of the stations into the surrounding land uses and sidewalk and path systems. Low floor vehicles were chosen over high-floor LRT vehicles because low-floor platforms allow for stations that are less expensive to build and easier to integrate into buildings and/or sidewalk systems.

Modelling and Forecasting

The City of Calgary's Regional Transportation Forecasting Model (RTMv2) was used to support the optimization of the Green Line Stage 1 Program and creation of this Business Case document. The modelled outputs included ridership, economic, and financial forecasts (peak ridership, time-savings benefits, revenue). The model also provides a robust process for testing scenarios and sensitivities to inputs (for example, service frequencies, travel times, additional stations) to fully explore characteristics of the Program and to mitigate potential risks to performance.

Both 2028 and 2048 horizon years were forecast to inform the design and development of the Green Line. Two key parameters were used to inform operational planning: the level of demand at the busiest hour and the level of demand at the line's busiest point (peak point loading used to design for sufficient system capacity). These forecasts are outlined in Table 3.3. These forecasts reflect Stage 1 - ongoing design and planning work for 2048 are informed by additional forecasts for a full build Green Line LRT Program.

Table 3.3: Ridership Summary for Planning Purposes

Period	2028	2048
Busiest AM Hour (boardings)	6,300-9,500	7,800 -11,800
Peak Point Loading (passengers per hour)	3,700-4,400	4,200-5,800
Daily (boardings)	55,000-65,000	

LRT Operating Concept

An operating concept was developed which included assumptions for:

- Travel speed and overall runtime for the line

- Frequency (number of services provided an hour)

- Train size

The Program is committed to providing a journey time of approximately 37 minutes end to end in both directions, however, for the purposes of this Business Case analysis, an assumed operating concept was developed using a more detailed OpenTrack[9] model to estimate the station-to-station run times including dwell times at stations for customer boardings and alightings. The detailed results of the model for the AM Peak period that were used to inform the design and development of the Program are:

- Northbound 35:45 minutes

- Southbound: 34:27 minutes

The operating concept for the Green Line LRT Business Case assumed five to eight minute frequencies in the peak, 10 minute frequencies in the early morning/mid-day/evening, and 15 minute frequencies in the late evening.

With a peak frequency of 5 minutes and an end-to-end runtime of nearly 37 minutes, the Green Line LRT will require 18 two car trains in service (assuming a 5 minute layover/recovery at each terminus). Assuming these will be run as two-car trains, 36 will be needed to operate the system plus a further six LRVs as spares – for a total fleet requirement of 42 LRVs. If an 8-minute headway is used then 28 LRVs (including spares) will be required with 11 two-car trains in service in the peak.

A number of changes to the surrounding and supporting bus network have been assumed for the purposes of this Business Case. Note that these changes are not intended as a commitment or a detailed service plan (as that work will be undertaken in the years prior to Green Line LRT operations), but rather, are a reasonable scenario as an input to the Business Case.

9. OpenTrack is an industry standard, light rail and railway simulation tool that was originally developed by the Swiss Federal Institute of Technology. The software allows designers to simulate operations and calculate headways, runtimes, fleet requirements, develop timetables and calculate power requirements.

The bus network changes assumed include:

- Removal of duplicate service with local service at minimum policy level maintained – particularly important given that the LRT alignment largely follows a new route which would have left some communities without service if all parallel services were removed; and

- Express services in-corridor would be eliminated.

These changes result in a reduction of bus service hours of approximately 40,000 hours annually (from the BAU) once the Green Line LRT begins operating.

The BAU assumes that there is a 200,000 to 230,000 net increase of bus service hours (including MAX expansion) in southeast Calgary. This required increase is not directly caused by Green Line and represents the need to catch-up to service levels provided in other areas of Calgary and to keep up with ongoing population and employment growth. With the Green Line LRT Stage 1, there will only be a need for 160,000 to 190,000 hours in 2028 as some bus service is replaced by the Green Line.

Concept

Rapid travel times

- <37 minutes end to end
- Northbound 35:45
- Southbound 34:27

Frequent services

- 5 - 8 minutes at peak times
- 15 minutes at night
- 10 minutes early morning, midday and evening

Capacity and demand

- 42 Light Rail Vehicles
- 28-36 in operation
- 6 spare LRV's available

Operating Cost Estimate

An estimated annual operating cost for the Program has been calculated based on the preceding operating concept. These costs are the incremental costs over and above the BAU and account for the costs of operating and maintaining the LRT system as well as the savings from changes to the surrounding and supporting bus network (in other words, they are the incremental transit network costs of the Green Line project). Cost estimates for this concept are:

- $30 to $35 million per year for Green Line LRT Stage 1 operating costs ($32.1 is used as the basis for evaluation)

- -$5.2 million per year for bus optimization (operating cost saving)

Capital Cost Estimate

The Green Line cost estimate (shown in Table 3.4) was developed using bottom-up approach drawing on quantities derived from the designs multiplied by standard labour, equipment, and material rates. Contingency and escalation were then applied to these totals with the contingency estimated through a Quantitative Risk Assessment (QRA) in which costs and durations are ranged and subjected to Monte Carlo analysis and escalation estimated using City of Calgary corporate standard rates. Given the varying level of design certainty across the Program – generally with greater level of detail known in the southern portion of the Program – the cost is currently a mix of Class 3 and Class 5 estimates.

The Green Line Executive Steering Committee set the program risk tolerance at a P80-P90 level of confidence. This means that contingency is evaluated for the entire program and allocated to the party that retains the risk with the final risk allocation still to be established through contractual agreements. The timing of the Program spend was then estimated based on the Program schedule at the time of calculation.

Table 3.4: Green Line Capital Cost Estimate

Cost Category	Recommended Alignment
Program	$805m
Enabling Works	$225m
Land	
Segment 1	$218m
Segment 2	$171m
Infrastructure (Rail, utilities, structures, contingency)	
Segment 1	$1,567m
Segment 2	$1,918m

Program Interdependencies

As noted at the beginning of this chapter, the Green Line LRT is one of a number of investments planned for Calgary's transportation network with many of the supporting and parallel investments included in the BAU scenario. For the purposes of this Business Case assessment, there has not been any explicit sensitivity testing in regard to the performance of the Green Line relative to each of these specific investments.

However, as with any large transit investment, ridership on the system would increase if competing road network capacity increases were limited in parallel corridors.

4

Strategic Case

The Strategic Case describes how the Green Line LRT options address the problem statements and benefits defined in Chapter 2 – The Case for Change. The Strategic Case evaluation uses the benefits framework defined in Table 4.1 to assess the extent to which each option supports the City's broader policy goals and compares each option's relative performance to support investment decision making.

Ten key benefits the Calgary Green Line LRT will realize

Investments

Transit infrastructure

TOD Supportive Infrastructure
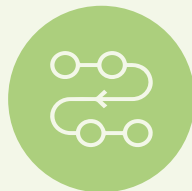
Connections to Stations

City Shaping

Benefits

Transportation

1. Meeting the needs of daily travel for work and play

Stage 1 will serve 55,000-65,000 transit users a day in 2028 with a fast, frequent, reliable and direct transit service, saving Calgarians over 10,000 hours a day to work and play

2. Needed capacity for today and tomorrow

Stage 1 will provide capacity to meet demand and provide customers an exceptional customer service in 2028 with opportunities to expand capacity without significant expenditure into the future

3. Faster travel times for Calgarians

Travellers who use the Green Line LRT will save up to 20-25 minutes, while auto users will benefit from reduced journey times of up to 10%, due to decongestion

4. Financial efficiency

Stage 1 will increase the financial efficiency of the Calgary Transit network and will generate enough revenue to cover 70%-84% of the Green Line LRT operating costs per user

Quality of Life

5. A more accessible city

in 2028, 68,000 people will live within walking distance and over 900 community, educational, social service, recreational, or commercial activity centres can be reached using the Green Line LRT

6. A safer and healthier city

Over its first 30 years, the Green Line LRT will take cars off the road and lead to 2,300 fewer collisions and an additional 1.6 million km walked per year

7. Fostering TOD and shaping Calgary's growth

Direct connection to 6 high priority TOD areas including future potential for over 1 million sq metres of new residential development and 160,000 sq metres of new office and retail space

Prosperity

8. Connecting people to jobs and businesses to business to catalyze economic development

in 2028, nearly 200,000 jobs will be within walking distance of the Green Line LRT

9. Generating jobs and supporting economic development

12,000 direct and 8,000 supporting jobs are forecast to be created by Stage 1 alone

Sustainability

10. Reducing emissions to mitigate climate change and provide cleaner air

by taking cars off the road, Stage 1 will save up to 30,000 tonnes of GHG emissions a year in support of municipal, provincial, and federal environmental goals

**Table 4.1: Ten core strategic
benefits of the Green Line LRT**

Strategic Case

Theme	#	Benefit		Key performance Indicators
Transportation	1	Provide new rapid transit connections that attract and retain transit ridership		Total transit ridership
	2	Accommodates growth by providing capacity for transit ridership in the near term and long term		Level of crowding on Green Line LRT
	3	Improve the customer experience by providing frequent, reliable services with reduced travel times		Improvements to reliability, travel time, and frequency
	4	An affordable mobility option that has cost efficiencies compared to the BRT		Operating cost recovery
Quality of Life	5	Improve travel across the region, and reduce congestion by connecting passengers to places they want to go with fast and convenient transit service		Population within access distance of the LRT Points of interest within access distance of the LRT
	6	Lead to a safer transportation network that supports a healthy region		Reduction in auto collisions and increased walking
	7	Support the development of mixed-use communities that offer a range of lifestyles to Calgarians		Transit-oriented development sites on corridor
Economic Prosperity	8	Reduce commuting times leading to increased productivity		Average change in commute times and jobs accessible by the Green Line LRT
	9	Generate jobs to support an active economy		Jobs created by delivering nad operating the Green Line LRT
Environmental Sustainability	10	Reduce the environmental impact of Calgary's transportation network		Reduction in GHG emissions

4.1 Transportation benefits

The Green Line LRT aims to deliver significant transportation benefits to Calgarians by expanding mobility choice and providing rapid and direct connections between employment and population centres in southeast, downtown, and north Calgary. The key transportation benefits realized by this project are:

- **Benefit 1**
  Provide new rapid transit connections that generate new ridership

- **Benefit 2**
  Accommodates growth by providing capacity for transit ridership in the near term and long term

- **Benefit 3**
  Improve customer experience by providing frequent, reliable services with reduced travel times

- **Benefit 4**
  An affordable mobility option that has cost efficiencies compared to the BRT or exceeding current operating cost recovery

Strategic Case

Benefit 1
Provide new rapid transit connections that generate new ridership.

The Green Line LRT has the potential to serve 55,000-65,000 trips each day, which will increase LRT network usage by 13.5% by 2028. With the Green Line LRT, the LRT network will continue to be one of the busiest LRT systems in the world.

Benefit Overview

The Green Line LRT is intended to provide new rapid transit connectivity between southeast Calgary and the downtown core through to 16 Avenue in the north. The Green LRT has been planned to provide fast, frequent, and reliable transit for the rapidly growing southeast quadrant of the City. Ridership is reviewed from two perspectives: total boardings and change in LRT network ridership. This analysis assesses the extent to which Stage 1 realizes this benefit based on ridership forecasting with a low forecast and a high forecast, which reflects optimized user experience and connectivity.

Benefit Analysis

Table 4.2 outlines the anticipated boardings for the Green Line LRT in 2028. This analysis suggests that the Green Line LRT will move 55,000 to 65,000 passengers daily.

This ridership range is used in this Business Case to reflect the level of design in Segment 2, slight variance of LRT service levels, and the influence of the background bus network.

With further design, the station access locations will be defined, the North BRT run times will be confirmed and more detailed modelling will be undertaken to inform the detail of the system design and operations.

The 55,000-65,000 travellers are predominantly commuters moving from residential areas along the corridor to employment either in the downtown core or at employment sites along the corridor, but will also include a significant number of recreational trips

Figure 4.1 shows how this demand is distributed by station. Figure 4.2 illustrates forecast LRT (LRT Network) ridership in Calgary through to 2048 and Figure 4.3 compares the Calgary LRT system, with and without the Green Line LRT, to other LRT systems in North America.

Table 4.2: Green Line LRT Daily Ridership in 2028

Demand Scenario	Daily Boardings
Low	55,000
High	65,000

Figure 4.1:
Transit Demand by Station – 2028
Green Line AM Crown Boardings

Green Line LRT

- Green Line LRT Proposed
- C-Train Red Lne
- C-Train Blue Line
- Other rail line

New passengers using each station
Daily high

700 → 23,300

0 1 2 3 4 5 km

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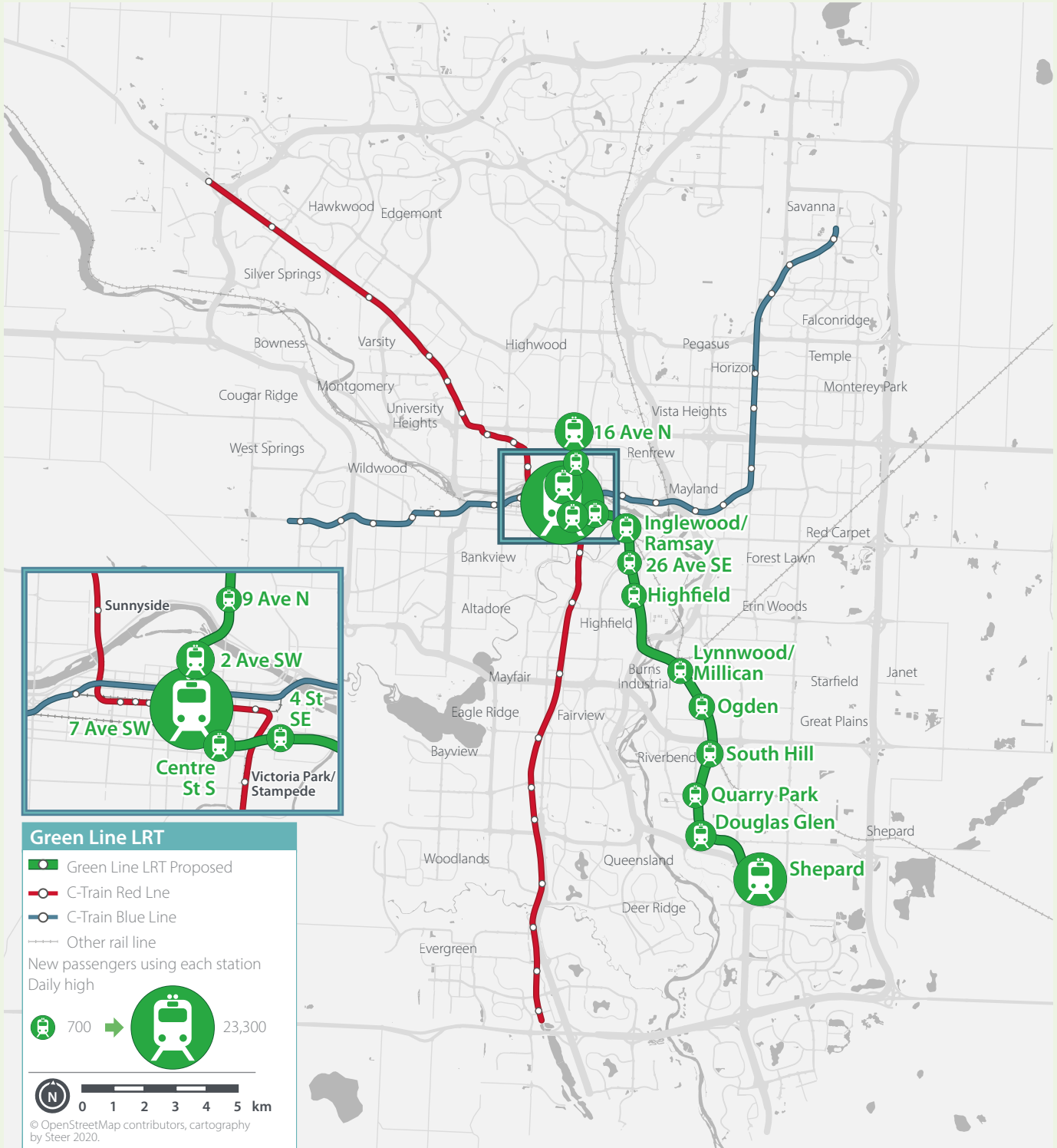
Figure 4.2: LRT Daily Ridership With and Without the Green Line
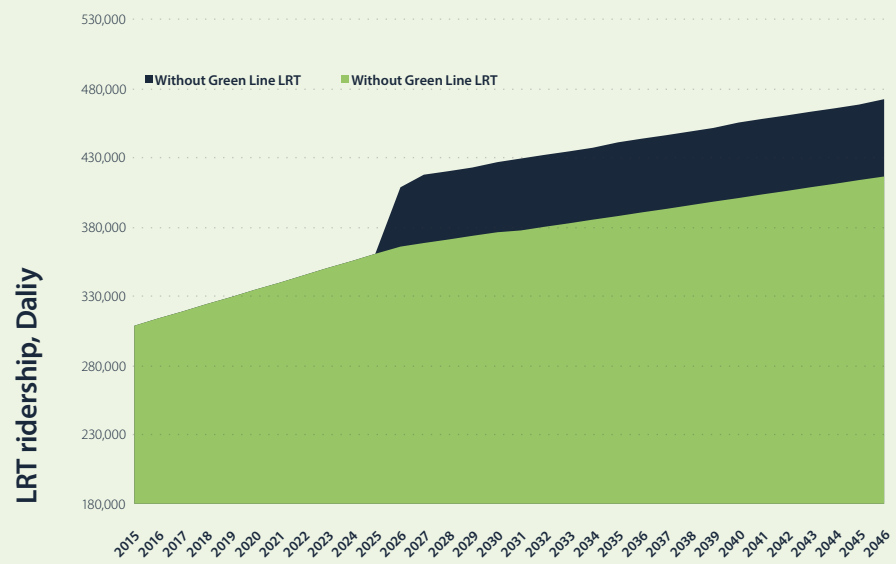
Figure 4.3: Comparison of LRT Network Annual Ridership in North America
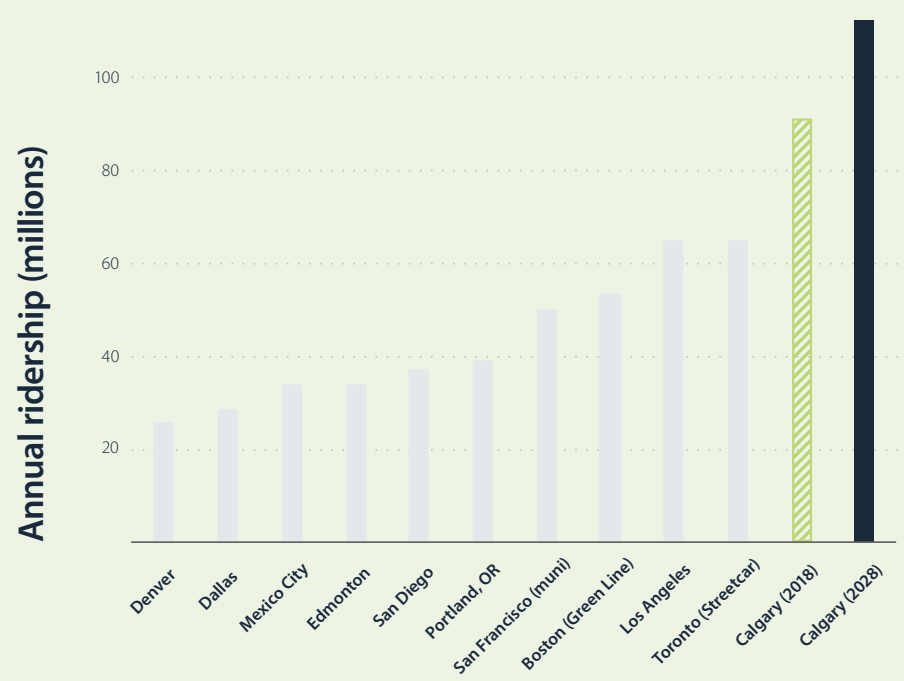
Benefit Analysis Findings

The analysis presented in Table 4.2 and Figures 4.1-4.3 indicates that:

- The Green Line will provide an improved rapid transit service for 55,000-65,000 riders each day(Table 4.1).

- The Green Line will increase total LRT network boardings by 13.5% and will allow travellers to make use of the Blue Line, Red Line, and Green Line (alongside the BRT and bus network) to travel across the City.

- With the Green Line, the Calgary LRT network will remain the busiest LRT system in Canada and the USA and will exceed 120 million boardings per year by 2028 (Figure 4.3) – by 2028 the LRT system will carry over 110 million people a year. This is significantly more than other LRT systems and comparable to heavy rail systems, such as the Bay Area Rapid Transit (BART) system in San Francisco, which serves a region of over 7.75 million people.

How is the benefit realized?

This benefit is realized by:

- Delivering a positive customer experience and designing stations to maximize accessibility along the corridor, including connections with bus, MAX BRT, and active modes.

- Providing seamless connectivity to the Red and Blue lines in the Centre City and further enhancing the rapid transit network by providing integrated connections to the four MAX rapid transit routes recently implemented.

- Connections are further enhanced with the provision for 11 transit hubs that will connect transit customers to local and City-wide destinations including direct connections to ten of the Municipal Development Plans activity centres.

- Ensuring ease of transfer between Red Line, Blue Line, Green Line through the design of an effective interchange at 7th Ave.

- Ensuring that travel times, frequency, and reliability are maximized along the corridor, including providing competitive travel times with the existing bus network and maintaining a 5-8 minute frequency in the peak period.

Comparing the Proposed Stage 1 Project to other Green Line LRT Variants

As discussed in Chapter 3, the Green Line LRT has undergone years of planning, design, and development. This planning process identified the proposed Stage 1 alignment as the optimal variant for delivering new rapid transit connectivity between north and southeastern Calgary via downtown.

Due diligence was conducted as part of the business case analysis to confirm the Stage 1 alignment remains the optimal project, including an analysis of:

- Stage 1 variants with different termini – including terminating the line south of 16 Avenue or extending it further south

- Variants that stop in the Beltline

- An extended Green Line LRT, which reflects the wider ridership potential of the project

Key Findings

- Approximately 25-30% of all boardings for all options are new transit riders

- The 16 Avenue N to Shepard option generates more ridership than any options with moved termini or Beltline focussed options

- Terminating at 7 Avenue SW without extending south leads to 20-25% lower ridership compared to Stage 1

- Terminating at the Beltline and extending further south is forecast to have 25-30% lower ridership compared to Stage 1

- Extending the network can increase ridership by 30-35%

Figure 4.4: Green Line LRT Variant Analysis

Strategic Case
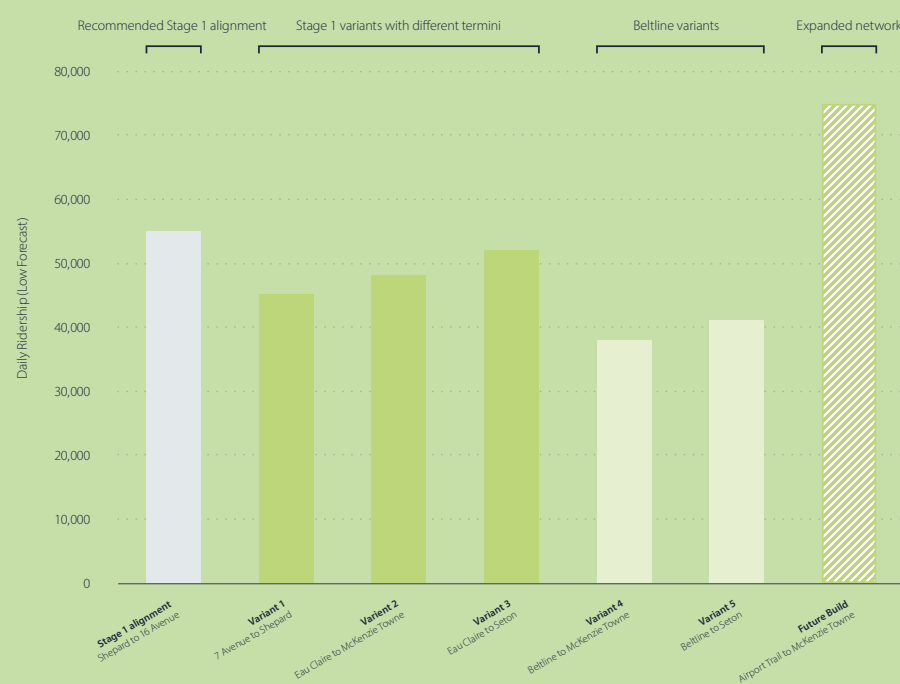
Benefit 2
Accommodates growth by providing capacity in the near term and long term.

The Green Line LRT will provide customers with an LRT service that meets demand in 2028 and can be expanded to provide a high level of service over future decades without need for major capital expansion.

Benefit Overview

This benefit focuses on the LRT's ability to manage a key issue identified in Chapter 2: providing effective capacity for a growing City and managing potential crowding. Benefit 2 explores this issue by assessing the ability of the Green Line LRT options to provide capacity to meet demand in 2028 and into the long term by assessing demand at the busiest point on the line in the busiest hour of travel and comparing it to the level of capacity scoped in Chapter 2.

Benefit Analysis

Forecasts were completed that noted demand on the line at its busiest point during the day will be 3,700 (low demand) to 4,400 (high demand) passengers per direction These forecasts were then compared to the design for the Green Line, which has been designed to accommodative up to a three minute headway. Table 4.3 illustrates the level of crowding on the Green Line in 2028 based on two scenarios: a five minute headway and an eight minute headway. Maximum capacity (AW2) refers to four standing passengers per square metre of floor space, which provides a quality of service commensurate with peer jurisdictions.

In practice, 75% to 90% of AW2 is the maximum demand the LRT network can serve while maintaining seamless operations.

Benefit Analysis Findings

The preceding analysis indicates that the Green Line LRT can accommodate demand on opening day, with some flexibility to grow, with a five minute headway solution. A lower frequency solution could be utilized in the near term to optimize operating costs, while gradually scaling up frequency to meet demand. If demand is aligned with the 'high level demand forecasts' the peak point will be 4,400 passengers per hour per direction and a higher frequency solution will be required earlier in the Program's lifecycle. This flexibility allows the Green Line LRT to be scaled over time to meet the needs of customers without delivering further expensive capital changes to stations, track, or systems.

In addition, the Green Line is expected to also draw demand from the 301 on Centre Street and the Red Line, both of which experience significant peak crowding. This additional capacity will improve the user experience of travellers on these lines and provide room for growth over time.

This highlights that the Green Line investment can be delivered to ensure customers in Calgary will have access to quality travel choices beyond 2028, without need for significant changes to infrastructure.

Table 4.3: 2028 Green Line Capacity and Demand – Northbound AM Peak Demand

Frequency	AW2 Capacity	0.75 AW2 Capacity	0.9 AW2 Capacity	Peak Load/ 0.90 AW2 Capacity (low demand)	Peak Load/ 0.90 AW2 Capacity (high demand)
5 Minutes	6,624	4,968	5,962	62%	74%
8 Minutes	4,140	3,105	3,726	99%	118%

How is the benefit realized?

This benefit is realized by delivering a system that can accommodate 80m (2 x 40m) LRV train sets at a five to eight-minute headway in the peak period.

Strategic Case

Benefit 3
Improve the customer experience by providing frequent, reliable services with reduced travel times.

**The Green Line
LRT will reduce
travel times for
transit users
by up to 20-25
minutes compared
to existing bus
service and by
5-10% for drivers
by taking cars
off the road.**

Benefit Overview

This benefit assesses how the Green
Line LRT will improve travel experience
for trips starting in southeast Calgary.
Travel experience is broadly defined as a
combination of factors related to journey
amenity, travel time on the LRT, time
spent travelling to an LRT station, time
spent waiting for the LRT to arrive, and
reliability. Combined, these factors are
represented in transportation forecasting
as 'Generalized Journey Time', which
converts all elements of a passenger
trip into units of minutes based on how
travellers perceive each component of
the trip.

This benefit uses changes in Generalized
Journey Time (GJT) for transit passengers
and auto travellers to illustrate how
the Green Line LRT will improve
travel times for a range of travellers in
southeast Calgary. Travel time to the
downtown core is used as an illustrative
example as the majority of trips using
the LRT will be to the downtown.

Benefit Analysis

Figure 4.4 shows the change in average
GJT by transit from geographic areas on
the Green Line corridor to the downtown
core, while Figure 4.5 shows the change
in average GJT for auto travellers. Figure
4.6 illustrates how the Green Line will
improve customer experience and
journey time for a set of example trips.

Figure 4.4: Change in Journey Time by to Downtown Calgary by Transit after Green Line is Implemented (2028, AM Crown)

Green Line LRT

⊶ Green Line LRT Proposed
⊶ C-Train Red Lne
⊶ C-Train Blue Line
⊬ Other rail line

Improvement in travel time (mins) by transit to the Calgary CBD after Green Line implementation (2028, AM Crown)

<2.5	7.5 - 9.9
2.5 - 4.9	10 - 14.9
5 - 7.4	>=15

0 1 2 3 4 5 km

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Strategic Case
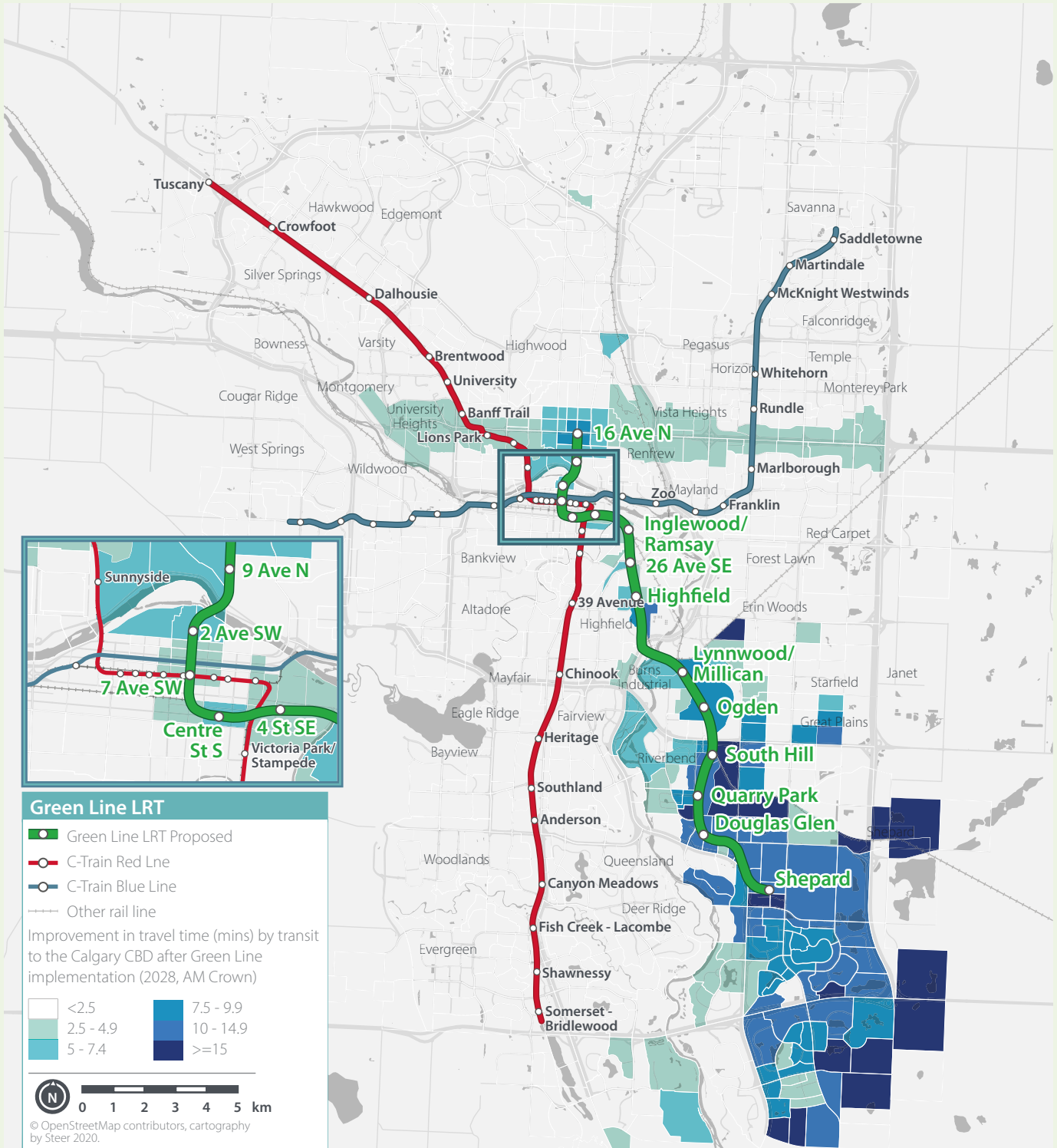
Figure 4.5: Change in Journey Time by to Downtown Calgary by Car after Green Line is Implemented (2028, AM Crown)
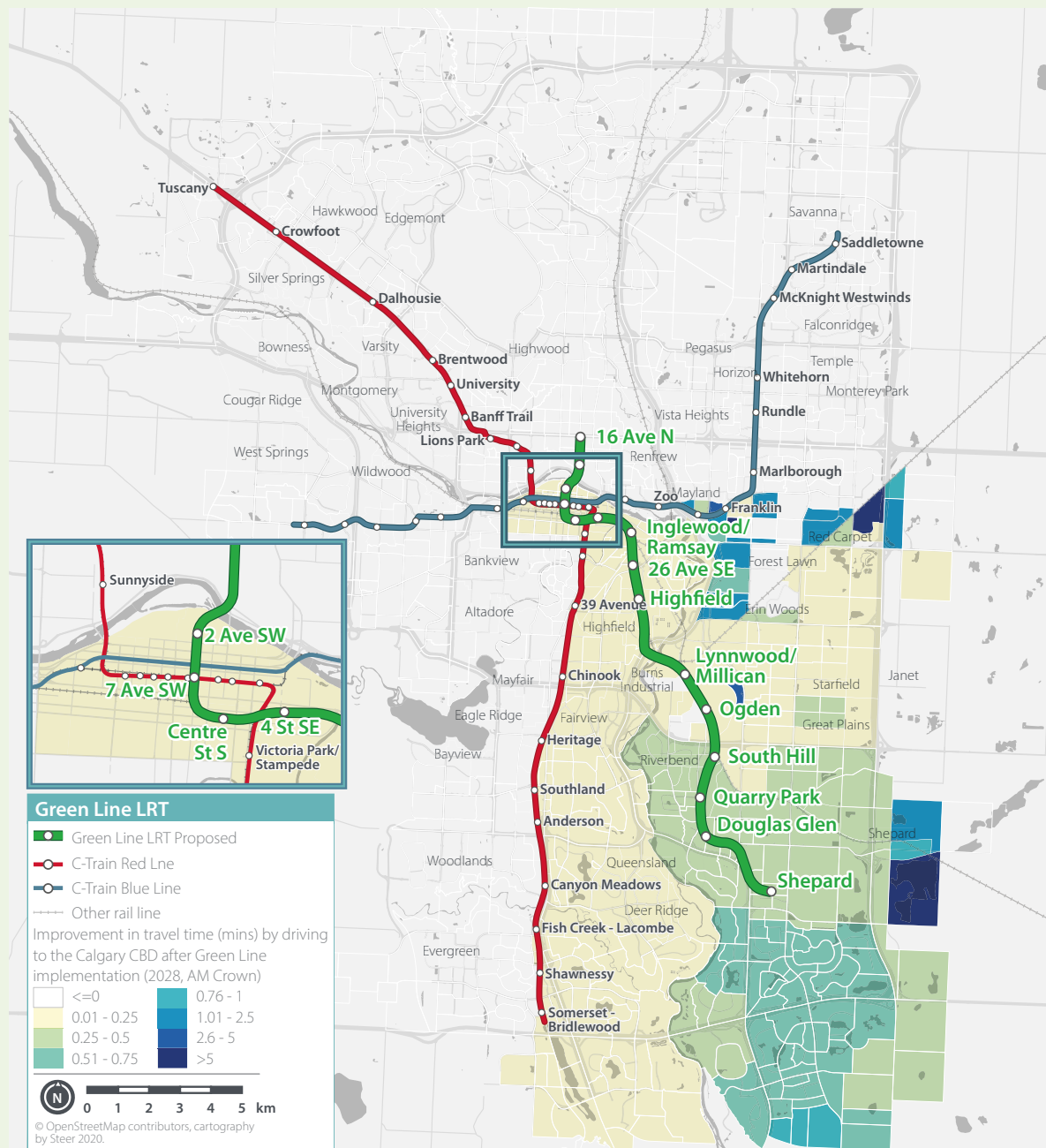
Benefit Analysis Findings

The analysis presented in Figures 4.4 and 4.5 Indicates that:

- On average, transit users on the corridor will save an average of 10 minutes per trip, with most customers saving over 4 minutes (inclusive of all destinations).

- Travellers to the downtown core could save up to 25 minutes.

- Drivers using Deerfoot Trail or other major roads could save up to 4 minutes (10% of a typical 40 minute commute) due to decongestion

How is the benefit realized?

This benefit is realized by ensuring that travel times, frequency, and reliability are maximized along the corridor, including providing competitive travel times with the existing bus network and maintaining a 5-8 minute frequency in the peak period. Figure 4.6 provides an example of how travel times can be improved by the Green Line LRT.

Figure 4.6: Example Journeys on Green Line (Douglas Glen to 7 Avenue SW)

Today's challenge

- Unreliability: traffic, weather, delays due to Heavy Rail crossing
- Driving cost: gas, maintenance, parking

Current		55-60 min
Driving		30-45 min
Green Line		20-25 min

Strategic Case

Benefit 4
An affordable mobility option that has cost efficiencies compared to the BRT.

By 2028, the Green Line has the potential to cover 70-84% of its operating expenditure with fare revenue, which allows for resources to be invested in other transit services and priorities in the City.

Benefit Overview

Today, Calgary Transit operates with a revenue to operating ratio of 0.4 to 0.45. One of the benefits of LRT is its ability to move more passengers with a lower operating cost per passenger trip. This benefit analysis section assesses the extent to which these cost efficiencies are realized by the Green Line in order to promote a more resilient network, allowing the operating subsidy to be spent more effectively in other parts of the City.

Benefit Analysis

Table 4.4 provides a summary of the net ridership, revenue, operating costs, and cost recovery for the Green Line in 2028 for low and high ridership forecasts. The Green Line scope also assumes some bus service operated in the Business as Usual (BAU) scenario will no longer be required after the Green Line is delivered. This mitigated expenditure is included to calculate a cost recovery including bus operating cost savings.

Note – this analysis assumes that up to 50% of all Green Line LRT trips make use of another Calgary Transit service. For these trips, revenue is shared between these additional services and the Green Line.

Table 4.4: Green Line LRT Fare Revenue and Operating Costs in 2028

Factors	Low Ridership	High Ridership
Ridership	16,000,000	19,200,000
Fare Revenue	$18.75M	$22.5M
Operating Costs	$32.1M	$32.1 M
Annual Bus Savings (mitigates bus expenditure)	$5.2M	$5.2M
Cost Recovery for Green Line users	58%	70%
Cost Recovery for Green Line users Including Mitigated Bus Costs	70%	84%
Cost Recovery for new Calgary Transit users including Mitigated Bus Costs	32%	38%

Benefit Analysis Findings

The analysis presented in Table 4.4 suggests that the Green Line LRT can recover 58% to 70% of its costsper Green Line user. If mitigated bus costs are considered, the revenue recovery ratio increases to 70% to 84% per Green Line user or 32% to 38% if considering all new Calgary Tranit users.

How is the benefit realized?

This benefit is realized by:

- Providing customer service, travel times, frequency, and reliability that attracts and retains transit ridership

- Ensuring fare collection (including potential changes to contactless technology) and enforcement systems are deployed to protect revenue corrections

- Periodically review operating costs and service delivery to maximize efficiency and mitigate unforeseen operating expenditure

4.2   Quality of life benefits

As the City's population continues to grow, so too will transportation demand. Without new transportation options, demand will outpace supply leading to an increase in transportation network congestion. As a result, quality of life risks being negatively impacted.

To ensure the City can provide and maintain its growing population with a high quality of life, it is imperative that the transportation network provides high quality connections, as well as safe, fast, convenient, frequent, and reliable service.

Calgary's Green Line will help to transform the City's transportation system by accommodating its current and projected population while maintaining a high quality of life. It will do so by realizing three benefits:

- **Benefit 5**
  Improve travel across the City and region, and reduce congestion by connecting passengers to places they want to go with fast and convenient transit service

- **Benefit 6**
  Lead to a safer transportation network that supports a healthy region

- **Benefit 7**
  Support the development of mixed-use communities that offer a range of lifestyles to Calgarians

Strategic Case

Benefit 5
Improve travel across the city and region, and reduce congestion by connecting passengers to places they want to go with fast and convenient transit service.

Once delivered, over 325,000 Calgarians will live within a 15 minute bus trip of the Green Line, allowing them to access over 900 community, recreational, shopping, social service, or education destinations.

Benefit Overview

Without the Green Line, Calgary is not fully equipped to serve the needs of its current and future populations. Southeast Calgary is currently under served by rapid transit, while demand frequently exceeds capacity in the north. In particular, buses travelling on the southeast road network are often delayed due to the high volume of vehicles commuting on this route. Transit service includes the BRT Route 302, currently operating every 10 minutes in peak hours and every 25-30 minutes during off-peak hours. The Green Line will support improved quality of life on the corridor by offering travellers alternatives to the bus and road network, which are measured by:

- The number of people who live near the Green Line LRT

- The number of destinations that can be reached using the Green Line LRT

Benefit Analysis

Figure 4.7 provides an estimate of the number of people who could walk, cycle, or take the bus to a Green Line station based on typical access distances and Figure 4.8 shows the range of key destinations (such as schools, museums, parks, social services, health care, and shopping centres) that can be readily reached on the Green Line.

Combined, these figures demonstrate the range of uses and total number of people who can make use of the Green Line for their day-to-day travel including visiting friends and family, trips for educational purposes, and recreational travel.

Figure 4.7: Number of People Living Within 15 Minutes of Access Time to the Green Line LRT

Figure 4.8: Key Destinations Accessible by the Green Line LRT
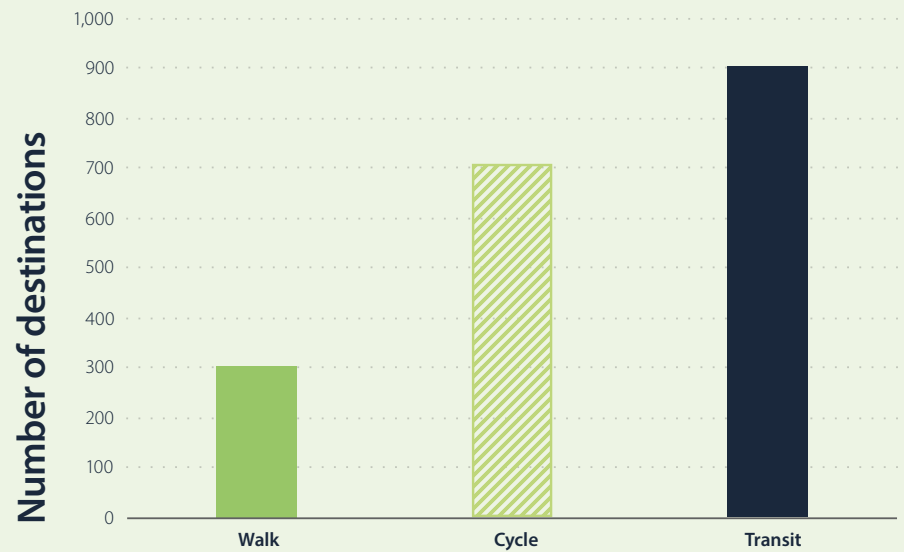
Benefit Analysis Findings

Figures 4.7 to 4.8 suggest that:

- The Green Line will greatly augment transit connectivity in southeast Calgary with more than 325,000 people (as shown in Figure 4.7) living within a 15-minute bus ride of a Green Line station and 68,000 people living within walking distance of a station.

- Over 900 key destinations will be accessible within a 15 minute bus ride of a Green Line station (Figure 4.8).

In addition, investments in transit service like the Green Line will provide transit service for:

- Families that cannot afford to purchase another vehicle for their driving-age children to get to school or their part-time job.

- Parents who work $15 an hour and cannot afford to pay $10 an hour for parking.

- Seniors who live on a fixed income, whose health may not afford them the ability to drive.

- Up to 2,300 affordable housing units.

The Green Line LRT will also promote transit use for a range of educational uses in line with institutional and school board plans to promote use of Calgary Transit and reduce bus provision costs.

Combined, these benefits demonstrate how the Green Line will transform mobility for the City's population by 2028.

How is the benefit realized?

This benefit is realized by:

- Facilitating the provision of walking and cycling access to Green Line stations, including providing bicycle lockers or other storage facilities

- Providing frequent and accessible local bus transit connections to Green Line stations

- Integrating Green Line stations with residential and commercial urban forms

Strategic Case

Benefit 6
Lead to a safer transportation network that supports a healthy region.

The Green Line will lead to nearly 2,300 fewer auto collisions that result in property damage, injury, or death over the next 30 years, while also increasing the distance walked by Calgarians by up to 1.6 million km a year, the equivalent to about 180 people walking across Canada.

Benefit Overview

The Green Line can help improve the health of City residents by providing a safer transportation network that sees a reduction in accidents by decreasing the number of automobile trips and by enabling more people to travel safely using active modes such as walking and cycling. Transit users on average have been found to walk approximately 300m per trip in major metropolitan areas. Increased walking has also been found to have a net health benefit compared to driving (see Economic Case), which in turn allows travellers to have healthier lives and can reduce expenditures on health care.

Benefit Analysis

Table 4.5 provides an overview of the collision reduction potential of the Green Line Project and Table 4.6 provides an estimate of the level of increased walking and cycling that results from mode shift to transit.

Benefit Analysis Findings

The analysis in Tables 4.5 and 4.6 suggests that the Green Line can contribute significant benefits to the health and well-being of Calgarians, including:

- A reduction in collisions of nearly 2,300, which means reduced deaths, injuries, and property damage
- Up to 1.6 million more kms walked a year in the region, which supports improved health and wellbeing

How is the benefit realized?

These benefits are realized by:
- Ensuring the Green Line remains competitive with the automobile to encourage mode shift
- Delivering station infrastructure that is readily accessible and well integrated with the urban realm to facilitate walking and bike access

Table 4.5: Reduction in Auto Collisions

	Fatal Collision	Injury Collision	Property Damage Only	TOTAL
16 Avenue to Shepard	-5	-350	-1,945	-2,300

Table 4.6: Increased Transit and Active Mode Use

	Health Benefit
Net New Transit Ridership (shift from Auto)	5,350,000
Estimated Annual Increase in Walking and Active Mode Use	1.6 million km

Strategic Case

Benefit 7
Support the development of mixed-use communities that offer a range of lifestyles to Calgarians.

The Green Line LRT will be constructed within a variety of communities including some of Calgary's oldest and newest, established and developing. Planning for the right type of development for each area will help ensure communities are set up for future growth.

Benefit Overview

This benefit explores how the Green Line LRT can be delivered to provide high quality transit connections between communities and sites targeted for TOD in southeast Calgary. LRT can be used as a catalyst for increased development; it could either increase the total volume of development or accelerate the delivery of new development along the corridor.

Benefit Analysis

Figure 4.9 provides an overview of the TOD sites that will be well served by the Green Line LRT.

Figure 4.9: Green Line LRT and TOD Access
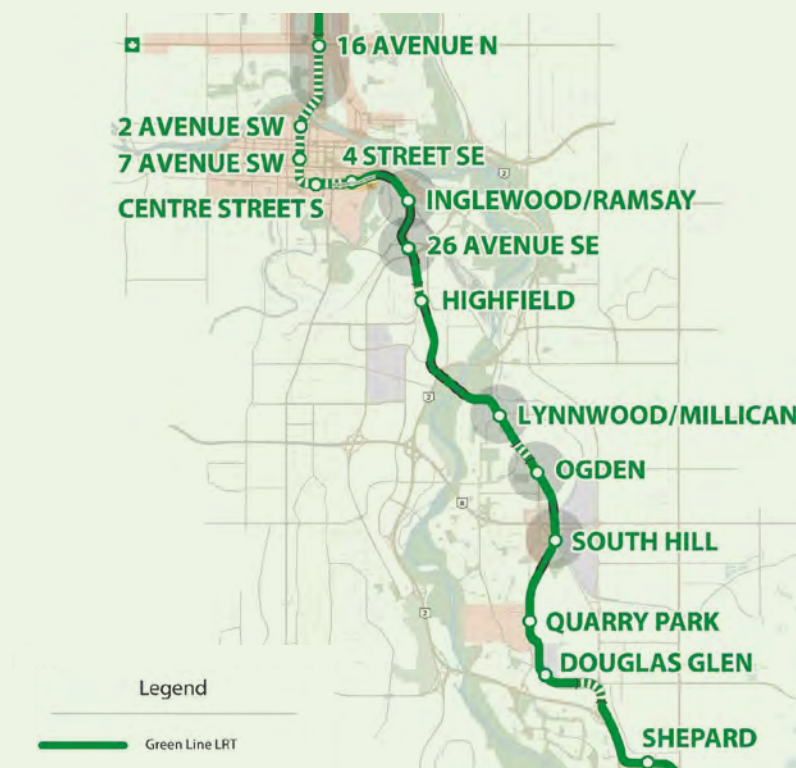
Benefit Analysis Findings

The Green Line LRT will support the delivery of the City's TOD strategy, including:

- Direct connect to four high-potential TOD sites (Ramsay/Inglewood, 26 Avenue, Ogden, 16 Ave) and two medium potential sites (Lynnwood/ Millican and South Hill).

- Catalyzing over 1 million sq metres of residential development, nearly 80,000 sq metres of new retail, and an additional 80,000 sq metres of office development.

- Increased connectivity along the high potential 16 Ave corridor between Centre Street and the Red Line.

- The north limit of the core project at 16 Avenue N has the highest population within walking distance of the station (outside of downtown), has the highest job population on opening day of all northern stations (outside of Downtown) and is expected to see the second highest LRT boarding's (outside of the downtown) on opening day. This station site is also one of the highest ranked TOD sites along the line and demonstrates the potential and value of connecting to north Calgary with the Green Line LRT.

How is the benefit realized?

This benefit is realized by:

- Developing partnerships to co-deliver Green Line LRT infrastructure and new developments

- Designing Green Line LRT stations and infrastructure to integrate with the urban form and support longer term regeneration and TOD (see Chapter 3 layers of the Green Line LRT program).

- Area Redevelopment Plans (ARPs) and Station Area Plans (SAPs) are being developed for several communities, to provide rules and guidance for future development along the Green Line LRT. An ARP provides rules and guidance for the type of development that makes sense in a given area – how to complement the local character, what level of density makes sense and how to transition from high to low density, or residential to commercial. It includes policies on land uses, building forms and densities, buildings heights, parks, transportation, contamination and housing.

4.3 Economic prosperity benefits

As outlined in the City's **_ten-year economic development plan_**[11] , in order to secure Calgary as the City of choice in Canada for the world's best entrepreneurs and maintain high levels of economic productivity, a public transit network to connect the City's major employment and residential development areas is crucial.

With over 100,000 new jobs expected in the City's north and southeastern communities, the City must ensure that these communities and activity centres are well connected with a fast, frequent, and reliable transportation network. This will further help to ensure that this expected growth is realized by attracting investment and talent to the region, and ensuring people can access employment opportunities across the region.opportunities across the region.

The Green Line LRT will support the City's ability to both accommodate employment growth and increase prosperity by:

- **Benefit 8**
  Unlock economic development along the new LRT corridor.

- **Benefit 9**
  Generate employment and economic activity.

11. City of Calgary, Calgary in the New Economy, 2018

Strategic Case

Benefit 8
Reduce commuting times leading to increased productivity.

The Green Line LRT will support economic productivity by providing access to nearly 450,000 (nearly 30% of all jobs) within a fifteen minute bus ride of a Green Line LRT station.

Benefit Overview

This benefit assesses the ability of the Green Line LRT to connect travellers to jobs in support of a more productive economy. Today, workers are dependent on the bus network to access the downtown core and other job centres on transit. One of the proposed benefits of the Green Line LRT is providing customers with direct access to high employment areas either using just the LRT or using the LRT as part of a complete transit network.

Benefit Analysis

Figure 4.10 shows the number of homes that could connect to the downtown core, Calgary's largest employment centre, within 30 - 45 minutes of transit travel time. Figure 4.11 shows the number of jobs that can be accessed by walking, cycling, and transit from Green Line LRT stations.

Strategic Case

Figure 4.10: Population that can access the downtown core using the Green Line LRT (2028)

Legend:
- Green Line Only
- Green Line with Bus Feeder
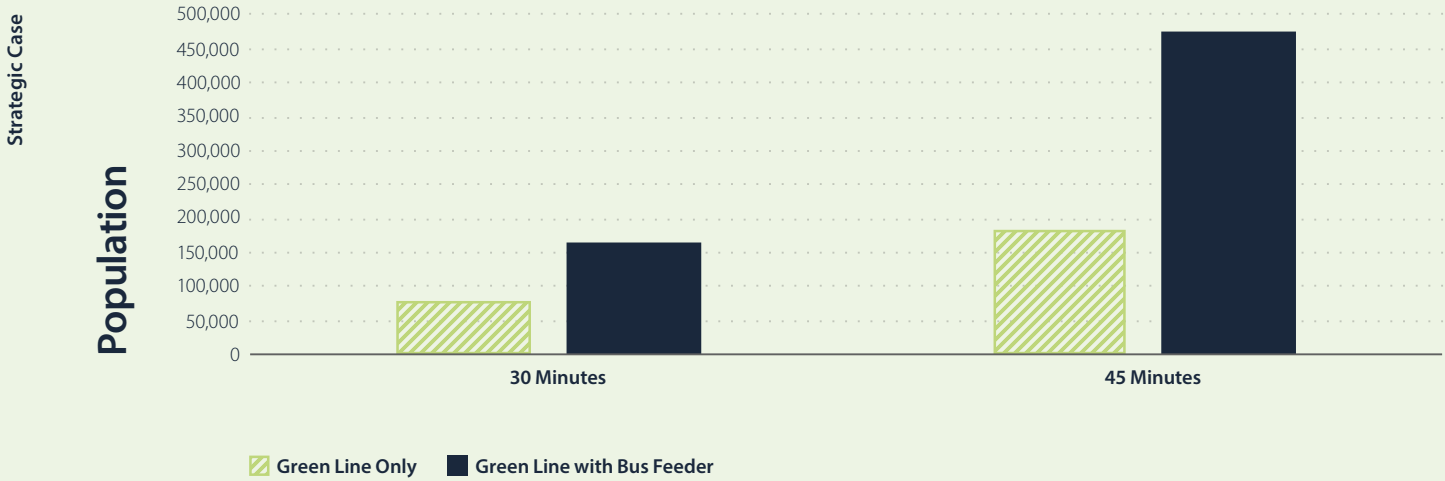
Figure 4.11: Jobs within 15 minutes of Walking, Cycling, and Bus Access from Green Line LRT Stations
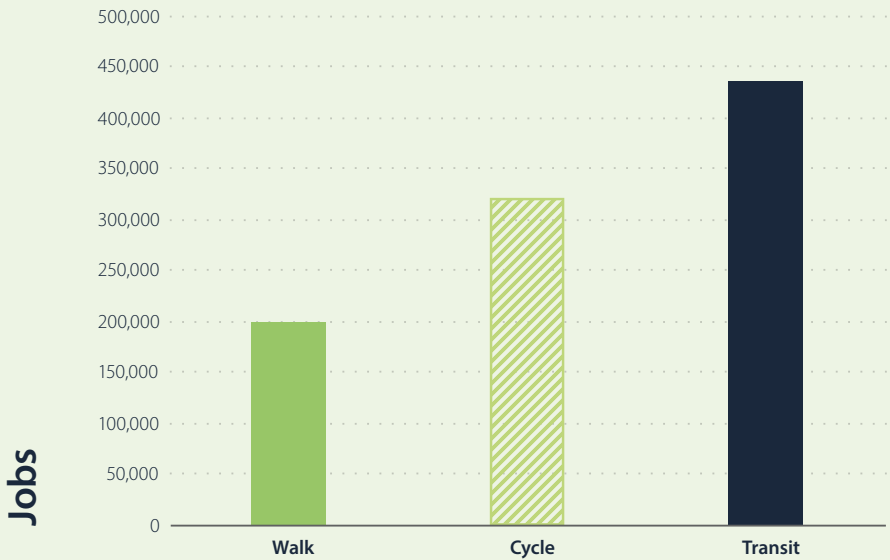
Benefit Analysis Findings

The analysis presented in Figures 4.10 and 4.11 notes that in 2028:

- Over 180,000 people can access the downtown core in 30 minutes when using the bus and LRT network, while nearly 80,000 homes can access the downtown core using LRT alone in 30 minutes.

- Nearly 45,000 jobs are accessible within a 15-minute bus ride of a Green Line LRT station, and nearly 200,000 jobs are within walking distance of Green Line LRT stations which allows transit to be used for commuting and business purposes alike.

This analysis highlights the Green Line LRT's role in supporting movement of workers to help develop a robust municipal and provincial economy.

How is the benefit realized?

This benefit is realized by:

- Delivering the stations as planned and ensuring service is delivered within the planned travel times and frequencies.

- Providing direct walking links or local transit connections between Green Line LRT stations and major employment centres.

- Connecting directly to nine activity centres that are identified by Calgary's **MDP** as an activity centre or corridor – these areas are a priority for intensification and fast, frequent, reliable transit service.

- Co-delivering new development intended for commercial use alongside the Green Line LRT to improve station and urban realm integration.

Strategic Case

Benefit 9
Generate jobs to support an active economy.

The Green Line LRT is a significant investment in the future of Calgary that will not only shape the southeast and northern parts of the city, but will also generate 12,000 direct jobs and 8,000 supporting jobs during construction and operations.

Benefit Overview

This benefit reflects the level of employment and economic activity generated during the construction and operation of the Green Line LRT. This benefit is used to understand how investing in the Green Line LRT can create new jobs, support the development of new industries, and support the economic prosperity of the Calgary community.

Benefit Analysis

The City conducted input-output modelling to determine the level of employment generated to deliver the Green Line LRT program. This modelling estimates the number of jobs major infrastructure projects can generate based on historic changes in employment from comparable projects.

Benefit Analysis Findings

The input output modelling for Stage 1 of the Green Line LRT suggests that:

- 12,000 jobs will be generated based on direct investment in the Program (jobs related to the construction and operation of the line).

- 8,000 indirect jobs will be generated – these jobs are created due to the investment and will be created in parallel and supporting industries.

These jobs are anticipated to be generated in a range of disciplines including construction, engineering, architecture, and professional services and support the diversification of the Calgary economy, which is a key goal of the ***Calgary Economic Development Strategy.***

How is this benefit realized?

This benefit is realized through the delivery and operation of the Green Line LRT based on the assumed capital and operating profiles used in this Business Case. Exact employment levels generated will vary based on construction approach and operating model used for the line.

4.4

Environmental Protection Benefits

As a major source of GHG emissions, the city's transportation network is one of the largest climate change contributors. Additionally, the transportation system is resource intensive – every day the transport system requires significant resources – such as fuel, materials, and electricity to maintain operations.

The Green Line LRT realizes a key sustainability benefit – moving more people while reducing the city's transport-related environmental footprint through a reduction in GHG emissions, energy spent, and resources extracted.

Strategic Case

Benefit 10
Reduce the environmental impact of Calgary's transportation network.

The Green Line LRT can promote a more sustainable environment by reducing transportation related GHG emissions by nearly 30,000 tonnes per year.

Benefit Overview

This benefit assesses how the Green Line LRT can reduce the transportation network's impact on air quality and climate change. It is assessed by estimating the number of vehicles that will be taken off the road as more customers choose public transit after the Green Line LRT is delivered. This in turn will reduce GHG, which contribute to climate change.

Benefit Analysis

Table 4.7 outlines the reduction in GHG forecast for the Green Line LRT.

Benefit Analysis Findings

Table 4.7 notes that the Green Line LRT will support Council's broader environmental policy goals by removing nearly 900,000 tonnes of GHGs over the first 30 years of operations.

How is the benefit realized?

This benefit is realized by:

- Continuing to use renewable energy to power LRT infrastructure – including wind power.

- Delivering the required travel times, frequencies, and reliabilities on the Green Line LRT and connecting bus service to reduce automobile use.

Table 4.7: GHG Reductions

Description	Tonnes
GHG Removed in 2028	30,000 tonnes
GHG Removed Over Lifecycle	900,000 tonnes

4.5

Strategic Case Conclusions

This Strategic Case reviewed the Green Line LRTs potential to benefit Calgarians, transit users, and the broader city and region across four policy themes: transportation, quality of life, economic prosperity, and environmental sustainability.

This analysis outlined wide ranging benefits can be realized by delivering the Green Line LRT by 2028, including those summarized in Table 4.8.

Table 4.8: Strategic Case Conclusions

Theme	#	Benefit		Metric	16 Avenue N - Shepard
Transportation	1	Provide new rapid transit connections that attract and retain transit ridership		Daily ridership	55,000-65,000 riders per day
	2	Accommodates growth by providing capacity for transit ridership in the near-term and long-term		Year demand exceeds loading standard	Stage 1 will provide capacity to meet demand and provide customers an exceptional customer service in 2028 with opportunities to expand capacity without significant expenditure into the future
	3	Improve the customer experience by providing frequent, reliable services with reduced travel times		Average time saved	LRT users save an average of 10 minutes, with drivers saving up to 10% of their trip
	4	An affordable mobility option that has cost efficiencies compared to the BRT		Revenue/Operating cost ratio	70- 84% operating cost recovery
Quality of life	5	Improve travel across the region, and reduce congestion by connecting passengers to places they want to go with fast and convenient transit service		Population within 30 minutes of travel time	68,000 people will live within walking distance and over 900 community, educational, social service, recreational, or commercial activity centres can be reached using the Green Line LRT
	6	Lead to a safer transportation network that supports a healthy region		Reduced automobile collisions and increase in active travel	2,300 fewer collisions and 1.6 million km more walked per year
	7	Support the development of mixed-use communities that offer a range of lifestyles to Calgarians		TOD sites served by Green Line LRT	Direct connection to 6 TOD sites with over 1 million sq metres of new residential development and 160,000 sq metres of new office and retail space
Economic prosperity	8	Unlock economic development and activity along the LRT corridor		Jobs within 30 minutes of travel time by LRT	Over 350,000 jobs can be reached within a 30 minute trip on the Green Line LRT
	9	Generate jobs to support an active economy		Jobs created	12,000 direct and 8,000 supporting jobs
Environmental Sustainability	10	Reduce the environmental impact of Calgary's transportation network		Reduction in GHG	30,000 tonnes per year of GHG emission reductions

5
Economic Case

The Economic Case enables decision makers, project planners, and wider stakeholders to understand the socio-economic performance of the Green Line LRT. Socio-economic performance assesses the value of resources required to deliver the Program (costs) and the monetized value of the benefits the Program can realize. Many of these benefits are reflected in Chapter 4 – Strategic Case.

The Economic Case chapter of the Business Case provides robust estimates of the costs and benefits that will be generated by implementing the Calgary Green Line LRT Stage 1 alignment and demonstrates the value that can be generated for travellers, the City, and the broader region. A comparator analysis outlining the incremental benefits of the entire Green Line LRT Program has also been included in this analysis. The assumptions used in the economic evaluation are defined in Table 5.1.

Investment

The Calgary Green Line LRT is composed of four layers. These layers include:

Transit infrastructure
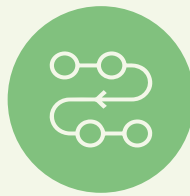
Connections to Stations

TOD Supportive Infrastructure

City Shaping

Combined, these layers generate new benefits to the region that estimated to exceed $2 billion over the first 30 years of operations

Calgary Green Line LRT Economic Summary - Network

The benefits and costs of the Calgary Green Line LRT program are defined below:

Category	Present Value ($ million 2020 CAD)
Wider Economic Benefits	$200
Health Benefits	$110
GHG Emission Reductions	$10
Collision cost savings	$30
Reliability	$20
Crowding Benefits	$50
Amenity Benefits	$20
Auto operating cost savings	$70
Travel time savings	$1,750
Benefits	$2,260
Total Cost	$4,030
Capital Costs	$3,680
Operating Cost	$350

Present Value ($ million 2020 CAD)
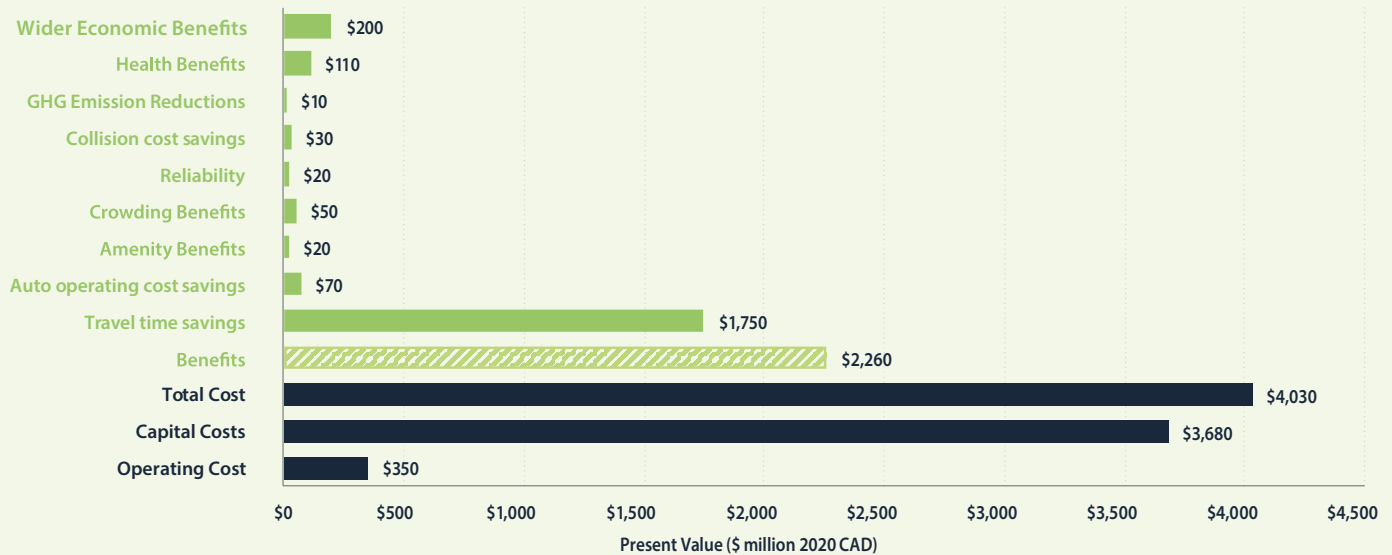
Economic Benchmarking suggests that the Stage 1 alignment has the greatest benefit relative to costs of all potential Green Line LRT Variants (for example, terminating south of the Bow River) and lays the foundation for an expanded Green Line LRT that could generate over $1 billion in additional benefit.

Table 5.1: Economic Evaluation Assumptions

Economic Case

Factor	Definition	Assumption
Social Discount Rate	Over time, the value of a cost or benefit will decrease – as a result, a social discount rate is applied. The social discount rate reflects society's time preference for money – this means that costs and benefits incurred today are more impactful than if they were incurred in a future year	4.00%/year
Evaluation Period	The duration of the analysis included in the economic case	30 years after operations commence
		Operations from 2028-2057
Value of Time (2019 $/hour)	The value of an hour of perceived travel time saved by investment in the transportation network	$23.10 (no value of time growth is assumed in this analysis)

5.1 Economic Costs

The estimated costs required for Calgary Green Line LRT Stage 1 are presented in this section. The costs are broken down into two categories:

- **Capital and Renewal Costs** - these comprise one-time fixed costs incurred to build the required infrastructure (stations, track, signal, electric systems, maintenance depots and fleet)to deliver the service. This also includes costs incurred to renew or replace major elements of the system once they have reached the end of their lifecycle.

- **Operating and Maintenance Costs -** these comprise on-going costs required to operate the service and provide daily maintenance including labour costs, fuel/energy costs, vehicle maintenance costs, facilities (stops, stations, and depots), maintenance and administration costs. Operating costs also include a reduction in bus operating costs compared to the BAU scenario. Approximately 200,000 to 230,000 additional hours of bus service (including MAX expansion) are required in southeast Calgary without the Green Line LRT – with the Green Line LRT only 160,000 to 190,000 are required. This saving is reflected in the economic analysis.

Costs have been assessed based on an assumed expenditure profile for capital, renewal, and operating costs that has been informed by peer LRT projects and historic expenditure on the Blue Line and Red Line. The Green Line LRT will be delivered as a Public Private Partnership (P3) project, which means the realized cost profile may vary in magnitude and timing from the assumptions included in this Business Case.

5.2 Economic Benefits

The socio-economic benefits of transit investments are divided into two categories: user impacts (direct benefits to travellers) and external benefits (reductions to the transportation network's negative impacts to society). Benefits are realized via the logic model in Figure 5.1, which illustrates how:

- Resource investments (economic costs) act as inputs to deliver the Green Line LRT.

- The Green Line LRT is composed of a set of actions or 'program scope layers' (see chapter 3) that directly change the performance of the city's transportation system by improving travel time (project outputs) – some elements of the program are directly delivered in Stage 1, while others will be enabled through broader municipal plans and policies.

- Changes in travel time benefit existing transit users, enable more travellers to make use of transit, who in turn save money on auto operating costs and are healthier due to increased walking.

- Customers who switch to transit decrease the amount of vehicle kilometers travelled (VKT) by automobiles, which in turn reduces the emissions and collisions.

These benefits are further defined in Table 5.2.

Figure 5.1 : Economic Case Logic Framework

Inputs	Actions	Outputs
Economic costs required to deliver the Green Line: • Capital Costs • Renewal Costs • Operating Costs • Labour	Deliver the Green Line Project • Layer 1 – Transit Infrastructure • Layer 2 – Connections to Stations • Layer 3 – TOD Supportive Infrastructure • Layer 4 – City Shaping	Reduced transit travel time • Shorter in vehicle travel time • Improved reliability and frequency • Improved off-peak service

Outcomes and Economic Benefits

Travel time savings for existing transit users

Wider Economic Benefits (shorter travel times between job centres)

Travel time savings for new transit users

Auto operating cost savings

Reduced auto trips and automobile VKT

Improved health from increased walking to transit

Decreased Collisions Resulting in Death or Injury

Decreased emissions

Decongestion (road user travel time savings)

User Benefits

External Benefits

Table 5.2: Cost Benefits Analysis Summary

Category	Benefit	Description	Estimation Approach
User Benefits	Transit Travel Time Savings	Time savings for new and existing users, including reduced vehicle travel time and improved travel experience (increased frequency, amenity, reliability)	Estimated from change in travel time from RTM alongside estimates of improved reliability
	Automobile operating cost savings	Travellers who switch to transit will no longer pay for automobile operating costs	$0.12 per reduction in auto VKT
	Decongestion	Auto travellers will benefit from peak period decongestion due to a reduction of cars on the road network	Estimated from change in travel time for auto users from RTM
External Benefits	Safety Benefits	As travellers switch from automobile to transit there will be fewer cars using the road network and fewer collisions resulting in death or injury	$0.05 per reduction in auto VKT
	GHG Reductions	As travellers switch from automobile to transit, there will be reduced auto vkt and therefore reduced GHG emissions	Auto CO_2 equiv: 2030: 201 g/km; 2045: 164 g/km Average cost of CO_2: 2030: $64.4/tonne; 2045: $69.3/tonne
	Health Benefits	As travellers switch to transit they will realize health benefits due to increased walking	Assumed 300 m walked per new transit trip and 3.85 km walked
	Wider Economic Benefits	Benefits associated with increasing productivity by increasing agglomeration economies	Benchmarked against peer LRT projects
	Agglomeration	Agglomeration refers to the propensity for economic activity to increase as proximity between employment centres (measured in travel time) increases	

Benefits Estimation Method

Travel time savings and change in automobile vehicle kolimetres travelled (VKT) are estimated using the RTMv2 based on forecast years 2028 and 2048. The RTMv2 models a BAU scenario and the option scenarios that includes the Calgary Green Line LRT and bus integration changes. Key metrics and incremental differences are then extracted from the AM Crown (the busiest AM hour) scenario and annualized and monetized for economic evaluation.

Annual estimates are then interpolated and extrapolated from the two forecast years resulting in the annual profile of the evaluation period.

The model estimates that in 2028 the Green Line LRT will reduce VKT travelled by automobiles by up to 37 million km, while on average travellers will save 10 minutes in journey time on the Green Line LRT.

5.3 Economic Case Analysis

Overview

Table 5.3 summarises all the cost and benefits as discussed in this chapter. All values in the table are discounted to present value (2020$) from an assumed 30 year profile in order to assess and compare benefits and costs.

The key economic metrics in this table are:

- **Benefit Cost Ratio (BCR)** – a comparison of total benefits to the resource costs required to deliver the Program.

- **Net Present Value (NPV)** – benefits minus costs, which illustrates the net impact to the region in economic terms.

Table 5.3: Cost Benefits Analysis Summary

	Economic Value	Value ($Million 2020 PV)
Costs	Incremental capital costs	$3,580
	Incremental renewal costs	$100
	Incremental operating and maintenance costs	$350
	Total Cost	$4,030
User Benefits	Travel time savings	$1,750
	Auto operating cost savings	$70
	Amenity	$20
	Crowding	$50
	Reliability	$20
External Benefits	Collision cost savings	$30
	GHG Reductions	$10
	Health Benefits	$110
	Wider Economic Benefits	$200
Total Benefits	Total Benefits	$2,260
Net Present Value	NPV (Benefit – Cost)	-$1,770
Cost-Effectiveness	Benefit : Cost Ratio	0.56

Analysis Summary

The analysis outlined in Table 5.3 notes the following:

- The Program's benefits are largely derived from benefits to existing transit users (75% of total benefits), who currently use one or more buses to complete their trip. With the Green Line LRT, their travel time decreases, and reliability increases, resulting in up to $1.7 billion in economic benefits.

- The external benefits realized through reduced automobile use are equal to 23% of total benefits, suggesting that the Green Line LRT's most significant economic impact is for existing transit users – however, the Program still generates nearly $500 million of benefit to the broader city and region.

- Capital costs are the most significant cost category and make up nearly 90% of total costs.

- The BCR for the project is 0.56. This means for every dollar invested there is $0.56 return based on benefits that can be directly monetized in socio-economic analysis.

Comparator analysis was conducted on the potential benefits of a complete Green Line LRT project (see Chapter 3), which would extend north on Centre Street and further south beyond Shepard. Preliminary analysis suggests that:

- Expansions can generate an additional $1.5 billion in lifecycle value compared to Stage 1 if the extension is finished by 2038 – this is a preliminary analysis and the magnitude of benefits may evolve as the Program scope is refined.

- These benefits are primarily realized by extending the line along Centre Street.

Stage 1 includes the most complex and costly element of the program: the tunnel through the downtown core and connection to 16 Avenue north of downtown. Once complete, this section of the line will form the core of the line and can act as a key enabler of future expansion to realize the incremental benefits of the broader Green Line LRT.

5.4

Economic Case Conclusions

The Economic Case for the Green Line LRT notes the following key conclusions:

- While benefits are lower than costs, the Program has the potential to generate $1.84 billion in benefit for transit riders over the next 30 years, which when combined with external benefits (such as GHG reductions and safer streets), leads to a combined $2.26 billion in benefit to the city as a whole.

- There are key opportunities to improve the economic performance of the line through future stages of design, planning and delivery including:

  - identifying opportunities to optimize bus and multi-modal connections

  - improve travel times

  - reduce costs through value engineering or phasing

- In the long run, continued expansion of the Green Line LRT can generate an additional $1.5 billion in benefits based on current estimates.

Comparing the Proposed Stage 1 Project to other Green Line LRT Variants

Stage 1 includes the most complex and costly element of the program: the tunnel through the Downtown Core and connection to 16 Avenue North of Downtown. Once complete, this section of the line will form the core of the line and can act as a key enabler of future expansion. As discussed in Chapters 3 and 4, this alignment was developed after years of planning and design.

Due diligence was conducted as part of the business case analysis to confirm the Stage 1 alignment remains the optimal project, including an analysis of:

- Stage 1 variants with different termini – including terminating the line south of 16 Avenue or extending it further south

- Variants that stop in the Beltline

- An extended Green Line LRT, which reflects the wider ridership potential of the project

1.

Significant Benefits Come from Connecting to 16 Avenue

Truncating the line on the north end reduces benefit significantly, and may lose up to $3.00 in benefit for every dollar saved (see variant 1)

Truncating the Line with Southern Extensions Produce Less Benefit than Connecting to 16 Ave

Extending the line further south first (before finishing the downtown segment and expanding across the Bow River) could lose up to $3.50 of benefit for every dollar saved (see variant 2)

2.

Beltline Options Save Costs, But Lose Significant Benefits – Even if Extended Further South

The BCR of Beltline options range from 0.43 to 0.46 and loses between $850-$970 million in benefit compared to Stage 1

3.

Expanding the Stage 1 Alignment North of 16 Ave and South of Shepard creates a higher value project

Once built, Stage 1 provides a foundation for realizing over $1.2 billion in new benefit– this means an extended Green Line could realize $1.00 of benefit for every dollar spent above and beyond the Stage 1 Alignment, and could generate a overall BCR of 1.0 under peer jurisdiction appraisal approaches

Benchmarking and Sensitivity Analysis

Figure 5.2 provides a comparison of BCR for a range of recent Canadian LRT projects. The benchmarking exercise notes the Stage 1 alignment has a comparable BCR to other LRT projects in development (example: Toronto Eglinton Crosstown) and outperforms other peer projects from an economic analysis perspective.

It should be noted that projects considered in this benchmarking analysis include a range of assumptions for value of time, discount rate, evaluation period (30 vs 60 years) and types of benefits included. For example, if a 60 year lifecycle was applied to the Green Line LRT (consistent with peer practice), the BCR is estimated to increase to 0.7.

While each Business Case used different assumptions, this analysis can still be used to identify areas for consideration as the Green Line LRT is progressed to future stages of development and delivery.

The Business Case analyzed the Green Line LRT using standard transportation economic appraisal with a 4% discount rate and a 30 year lifecycle.

This analysis notes that the Green Line LRT has higher value for money than projects appraised with a 60 year lifecycle and a 3.5% discount.

Option A

If the Green Line LRT was assessed using similar standards to other projects, its performance would increase significantly

Option B

Preliminary analysis suggests if a large buildout was considered using Ontario Standards, the benefits of the project could meet its costs

Figure 5.2: Economic Comparison of Green Line Variants

Costs and Benefits (million 2018$ - assumes 4% discount rate over 30 years)

	Benefit Cost Ratio (BCR)	Cost & Complexity to Expand North
Stage 1 Alignment -S hepard to 16 Avenue	0.56	Low
Variant 1 -7 Avenue to Shepard	0.34	High
Variant 2 -E au Claire to McKenzie Towne	0.46	Medium-High
Variant 3 -E au Claire to S eton	0.43	High
Variant 4 -B eltline to McKenzie Towne	0.46	High
Variant 5 -B eltline to Seton	0.43	Medium-high
Future Build - Airport Trail to McKenzie Towne	0.66	Low

■ Discounted Lifecycle Benefits   ■ Discounted Lifecycle Costs

Legend

Negative Performance	Moderate Performance	Positive Performance

Figure 5.3: LRT BCR Benchmarking

■ Comparator Projects (3.5% discount, 60 years)

■ Green Line Options Using Ontario Standards (3.5% discount, 60 years)

Project	BCR
Eglinton Crosstown West Extension	0.3
Toronto Eglinton Crosstown	0.43
Calgary Green Line (Shepard to 16th)	0.56
Scarborough Subway	0.60
Surrey SNG LRT	0.74
A — Calgary Green Line (Shepard to 16th)	0.88
Ottawa Confederation Line	0.99
B — Calgary Green Line (Airport Trail to…)	1.00
Calgary Green Line (Beddington to…)	1.02
Mississauga Hurontario-Main LRT	1.24

Economic Case
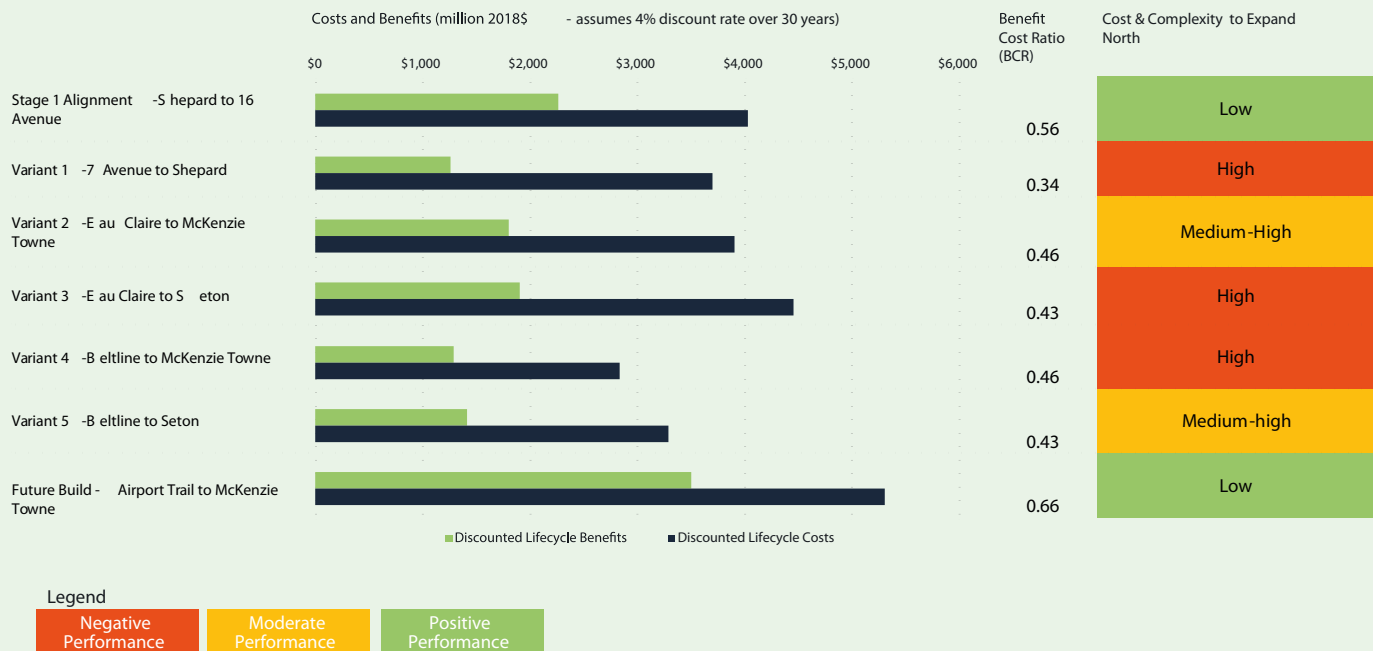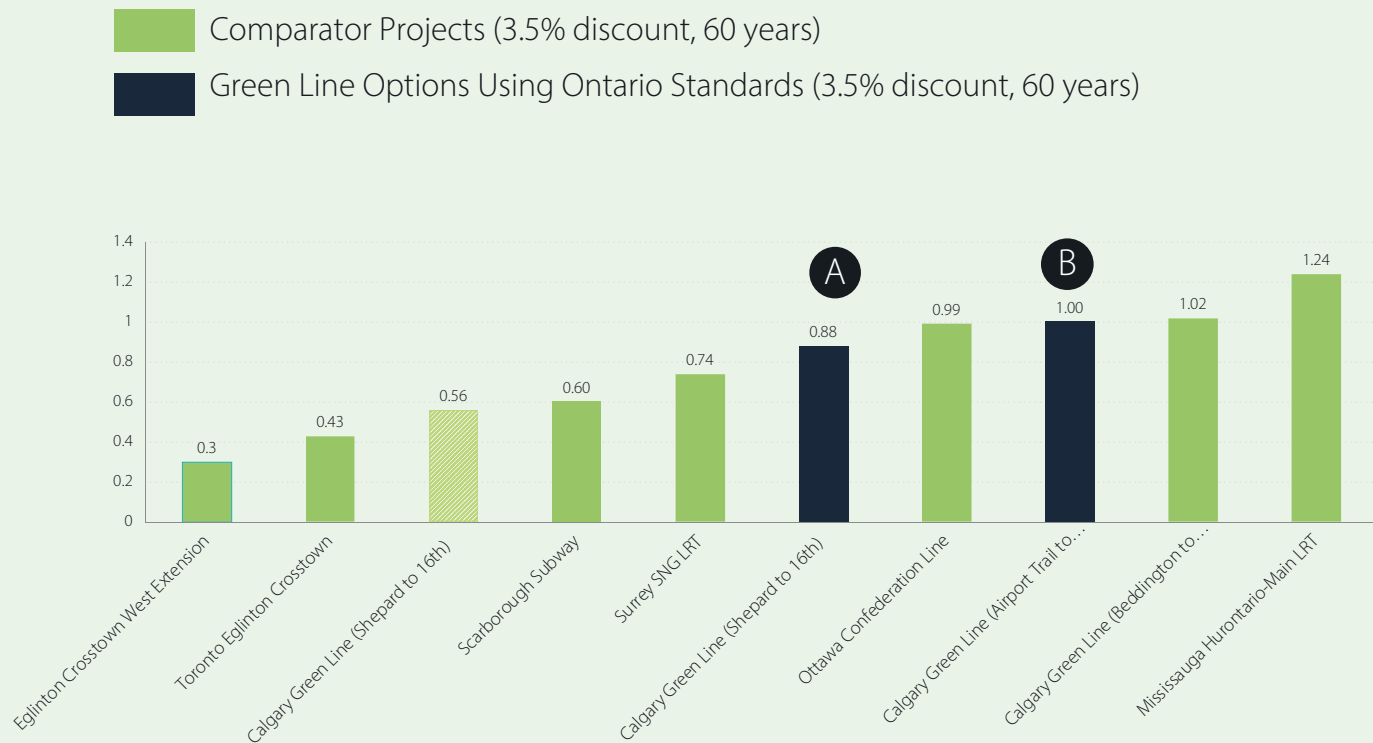
COVID19 and
Economic Sensitivity Tests

Sensitivity and scenario analysis are used in business cases to support decision makers in understanding how external factors could impact project performance. Scenarios have been set out to communicate how changes to economic activity and the current pandemic could impact the ridership and benefits of the Green Line LRT. Figure 5.4 outlines the range of factors considered in these scenarios.

Five scenarios were developed to 'stress test' the Green Line LRT based on these factors, as defined in Figure 5.5.

These scenarios include the four scenarios to the right and one 'no-recovery' scenario. Each scenario considers when the CTrain will reach it's next 'peak' and the level of demand at this peak relative to 2019. Figure 5.6 illustrates the impact on Green Line LRT ridership of benefits from each scenario, while Figure 5.7 provides a summary of the overall impact of each scenario on the case for the project.

Note – these scenarios were developed with a conservative assumption that Calgary transit ridership would recover to 20% by end of 2020. As of June 8 2020 the average weekday LRT ridership in Calgary was over 20% of pre-pandemic levels.

Figure 5.4 : Scenario Factors

Ridership Recovery and Growth			
Economic factors related to COVID 19	Incremental capital costs	Ridership factors related to COVID 19	Time for transit to be seen as safe and acceptable to the general travelling public
	Time for employment to recover		Ability to right size service provision to incentivize demand

Figure 5.5: Scenario Overview

% of 2019 Ridership post stabilization

Rapid return to business as usual

- Economic disruption is minimal, economy and employment rebounds
- Travelling public does not have aversion to transit
- Service can be ramped back up to meet demand

Slow return to business as usual

- Some economic disruption that impacts the commuter market in the short-medium term; and/or
- The travelling public has an aversion to using transit; and/or
- Service takes longer to recover and be right sized to demand

Rapid ridership growth that peaks at lower ridership than 2019

- Some industries rebound quickly, but others have major productivity or job losses
- The travelling public does not have aversion to using transit
- Service can be ramped up to meet demand

Slow ridership growth that peaks at lower ridership than 2019

- Major economic slow down that lasts beyond the pandemic; and/or
- The travelling public has a new aversion to using transit; and/or
- Service cannot be ramped up to meet growing demand

Time to stabilize

Figure 5.2 : Recovery Scenario Sensitivity Analysis
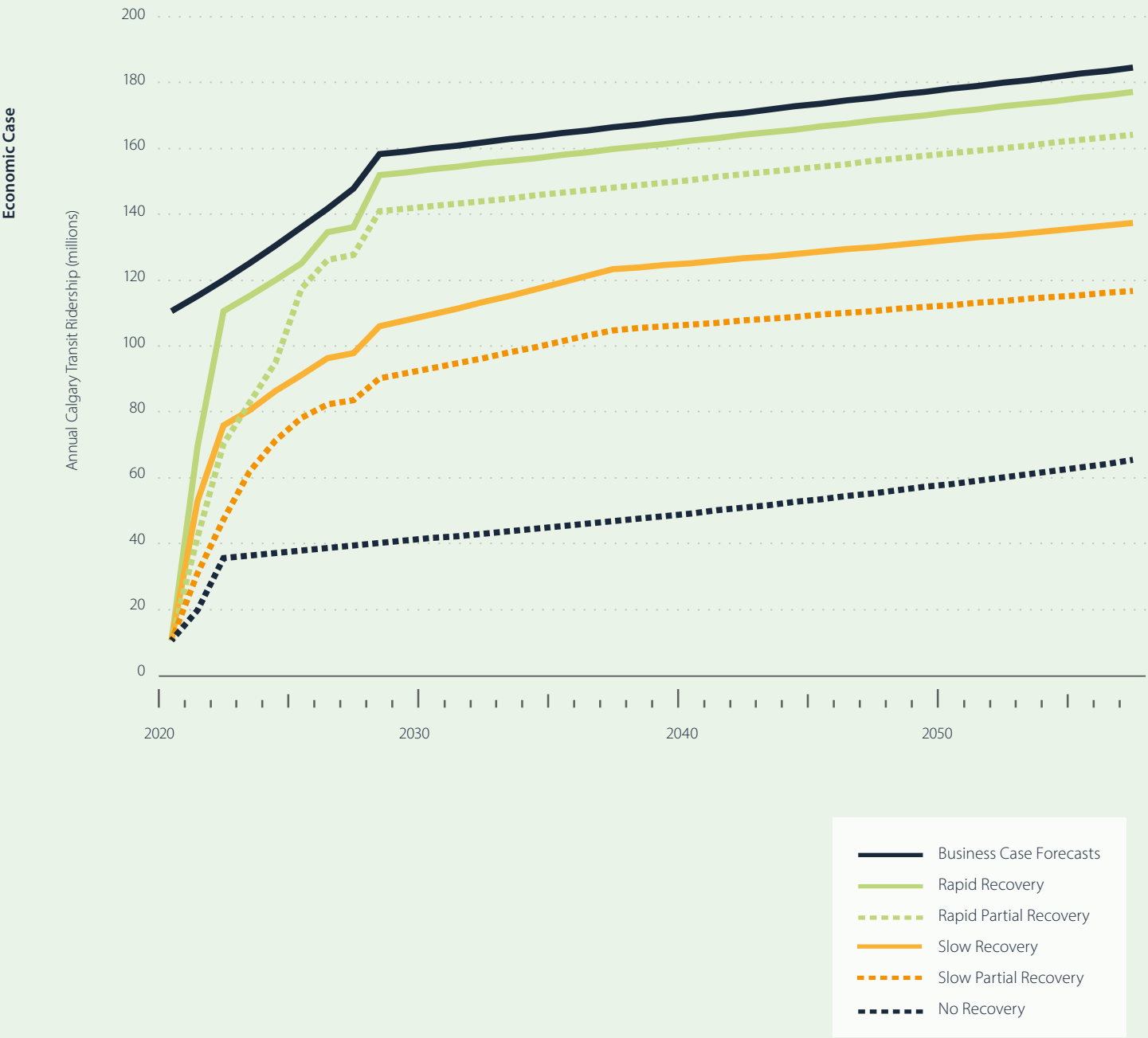
Figure 5.3 Scenario Sensitivity Test Results

	Benefit: Cost ratio	Daily ridership in 2028	Peak point demand
Business Case	0.56	55,000	4,400
Rapid recovery	0.54	53,000	4,200
Rapid partial recovery	0.51	49,000	3,000
Slow recovery	0.38	38,000	3,900
Slow partial recovery	0.32	33,000	2,800
No recovery	0.16	16,500	1,500

Implications for Green Line and Required Level of Service

The following key findings were noted from this analysis:

- Under either of the rapid recovery scenarios, the Green Line LRT's BCR and ridership only have marginal impacts. Higher impact scenarios suggest lower value for money and lower overall ridership.

- Because the Green Line LRT will not be open for several years, there are opportunities to optimize delivery based macro-economic changes and the progression of the pandemic.

- Under all scenarios, the peak point demand is anticipated to exceed the capacity that could be served by a bus line. Under the slow partial recovery scenario, a downtown bound bus would be required every 2 minutes in the peak to meet opening year demand High performance bus lines can carry approximately 2,000 passengers per hour per direction. This level service may be challenging to deliver due to the road configuration in the SE and Downtown.

6

Financial Case

The purpose of this Financial Case is to provide an overview of the Green Line LRT Program's finances and how the Program will be funded. This overview includes a breakdown of the Program's costs and funding alongside a description of how potential program risks will be mitigated and managed.

The costs to deliver the Program will be refined as it progresses through planning, procurement and delivery; therefore, this section focuses on the current estimates of the capital, renewal and operating costs of the Program.

All analysis contained in the Financial Case is incremental to the BAU scenario as described in Chapter 3. This means that all cost and revenue impacts only consider those directly related to the Green Line LRT Stage 1 above and beyond existing forecast spending.

Financial Case

Program Layers ⟶ ## Financial Impacts
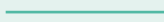
Transit infrastructure
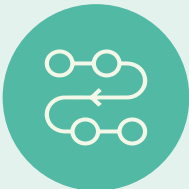
Connections to Stations

TOD Supportive Infrastructure

City Shaping

Incremental Capital Costs:

$4,903 million

Incremental Operating Costs:

$26.9 million per year

Incremental Revenue:

$6.5 million per year

Calgary Green Line LRT Stage 1 Business Case

Funding Strategy

How will the Calgary Green Line LRT be funded?

Federal government support has been confirmed for: $1.6 billion of the Calgary Green Line LRT program

The Province of Alberta has committed $1.53 billion

The City will contribute $52m per year from 2015-2044 and $23.7m from 2018 to 2044

6.1 Capital Costs

Green Line LRT Stage 1 Construction Costs

Capital costs for the Program include all direct and indirect capital expenditures associated with the construction of the Green Line LRT Stage 1 project. Total capital costs for the Program are anticipated to be approximately $4.903 billion (nominal dollars), excluding financing costs during construction.

Capital costs are subdivided into two categories:

- **Direct Capital Investment (DCI)** – direct capital costs such as Design-Build-Finance (DBF) costs (including engineering), LRVs, land, commissioning, owner supplied materials, enabling works construction, utility relocations, plus all escalation and contingency related to these costs.

- **Indirect Capital Investment (ICI)** – indirect capital costs such as staffing, owner engineering, permits, advisor fees, plus all escalation and contingency related to these costs.

The estimated capital costs presented are based on a contingency approach developed to reflect risk tolerance and other assumptions the City has for the Program. The total construction cost of the Program is shown in Table 6.1.

Major Rehabilitation and Renewal Costs

Major rehabilitation and renewal costs refer to all expenditures associated with future lifecycle improvements of the Green Line LRT Stage 1 assets. A rehabilitation and renewal assessment will be made of program assets and could require one or more major maintenance events or even replacement within the program's lifecycle. This includes all expenditures associated with capital improvements that will increase the useful life of the infrastructure.

An assessment completed in 2018 had a renewal cost estimate of $296.2 million (2016 $) - this estimate will be reviewed as the design of Stage 1 progresses. Renewal costs will be expended over a 30 year operations period. Future major rehabilitation and renewal costs do not have an identified funding source, which is standard practice for projects at this stage of development. These costs are anticipated to be included in future capital plans.

Table 6.1: Green Line LRT Stage 1 Construction Costs ($ millions)

Cost Category	Value ($)
Indirect	$805m
Direct Costs	$4,098m
Total Construction Costs	$4,903m

6.2

Operating and Maintenance Costs

Operating and maintenance costs refer to all expenditures associated with the continued operation of the Program. This includes all additional administration and staff support for operation of the expanded infrastructure, as well as parts and materials, contract and services and other costs required to deliver routine operations and maintenance over time.

Program incremental operations and maintenance costs for the Green Line LRT are currently estimated at $32.1 million (2018$) starting in 2028.

Green Line LRT Stage 1 operations and maintenance costs do not currently have an identified funding source from the City of Calgary. An ongoing funding source will need to be approved in advance of the revenue service date.

Operating costs will be reviewed by Calgary Transit during the current One Calgary budget cycle (2019 to 2022). Refinements and updates will be finalized in a future business plan and budget cycle (2027 to 2031) to align with a currently anticipated revenue service date.

Bus Operating Cost Savings

With the Green Line LRT there is a need for a net increase of bus service hours in southeast Calgary of between 160,000 to 190,000 hours (the requirement would be 200,000 to 230,000 hours [including MAX expansion] without Green Line LRT). This required increase is not directly caused by the Green Line LRT, rather it represents the need to catch up to service levels provided in other areas of Calgary and to keep up with ongoing population and employment growth. With the Green Line LRT Stage 1, fewer new bus services hours will be required, which will amount to savings of $5.2 million per year (2018$) and result from the bus network requiring 40,000 fewer hours of service.

Table 6.2 Operations & Maintenance Costs to Deliver Green Line LRT Stage 1 (2018$ millions)

Annual Operating and Maintenance Costs	Value
Green Line LRT Stage 1 Incremental LRT Operating Costs	$32.1m
Trunk Bus Service Operating Cost Savings	-$5.2m
Total Annual Operating Cost Impact	$26.9m

6.3   Financing Costs

Financing costs for the Stage 1 Project include all interest costs and any financing fees associated with:

- The City of Calgary executing the Stage 1 debt program to:

  - 1. Meet its payment obligations for any owners' costs and third party contractors generally relating to enabling works, LRV supply, and Segment 1 and Segment 2 DBF contracts.

  - 2. Service any long-term City debt financing with an anticipated 2044 maturity that will be fully repaid when the City of Calgary's long-term capital contribution for the Program ends.

- The design and construction period for the Segment 1 and Segment 2 contracts that the City of Calgary will reimburse to the Program companies and contractors.

The City of Calgary has approved up to $640 million of financing cost funding (or $23.7 million funded annually for 27 years (2018-2044) for the Stage 1 Program. The City's $1.56 billion capital funding and $640 million financing funding streams can be optimized over time to best meet Project expenditures in a given period.

6.4 Revenue Impacts

The revenue assessment considers total and incremental revenues generated by the Program. The Green Line LRT is anticipated to generate incremental revenues of $6.5 million (2018$) per year starting in 2028. While these annual revenues will change over time as ridership increases, current forecasts estimate revenues will change as demand changes over the first 30 years of operations.

Current forecasts estimate that the Program will generate $270 million in incremental revenue over this time period.

6.5 Funding Sources

The Green Line LRT Stage 1 Program funding strategy has been designed to cover capital costs and financing costs for the Program. The total capital funding for this program is provided over a 30 year time period, with funding being provided by all three levels of government: federal, provincial and the City.

The federal portion is scheduled to be received throughout the construction period, the provincial portion is weighted towards the latter years of the construction period and the City portion will be provided equally over a 30-year period commencing in 2028. Approximately $900 million of City funding for capital costs will be received from property tax dollars following the construction period. As a result of the mismatch in Program expenditures and funding, the Program will require debt financing and incur interest to ensure the $4.903 billion capital cost of the Stage 1 Program can be delivered prior to the receipt of all capital funding contributions.

The debt financing program during the design and construction phase of the Program will optimize the use of City financial resources and contemplates the issuance of a series of short-term and long-term debt instruments to ensure financing costs are minimized, A maximum of $639.9 million of City funding is available to cover all financing costs associated with the Program.

Funding has been secured from multiple sources, including a range of federal and provincial government grant programs. These government grant programs provide the Program with a reliable and stable source of funding for its capital investments. These programs are also accompanied by an oversight model that provides transparency around the allocation and use of funds for the Program.

In additional to the funding provided through federal and provincial funding programs, the City of Calgary has also allocated $2.2B (approximately 40% of Project funding) through municipal taxation. Table 6.3 provides a detailed breakdown of the capital funding received for the Program.

The funding received from the federal and provincial government will be governed under the Grant Agreement: Public Transit and Green Infrastructure Project (often referred to as the Ultimate Recipient Agreement or "URA") between the Government of Alberta and the City of Calgary. This agreement establishes governance structures and systems of oversight that will help to ensure that funding is allocated in alignment with the priorities identified by the Investing in Canada Infrastructure Program ("ICIP"). There are also strict audit requirements set out in this agreement to ensure that the funding has been administered appropriately.

Government of Canada Funding

The Government of Canada has provided funding for the Program through two streams: the Public Transit Infrastructure Fund (Phase I) and the ICIP. This funding can be used to fund up to 40% of total project expense assuming they are eligible costs.

Ineligible costs for Government of Canada ICIP funding are generally limited to costs incurred prior to the original ICIP project approval in principal (i.e. April 19, 2018), land acquisition costs, specified owners' costs and City of Calgary financing costs. Federal ineligible costs will be funded by the City and/or Government of Alberta (if an eligible expenditure).

Government of Alberta Funding

The Government of Alberta has provided funding through a variety of programs, including GreenTRIP and prior grants, Public Transit Infrastructure Fund (Phase I), and the URA.

The Province will fund up to 40% of eligible expenditures of the Program with a detailed description of the Alberta Contribution profile set out in the URA. The Province's Public Transit and Green Infrastructure Act's Alberta Regulation 189/2019, lays out the annual contributions from the Province as noted in Table 6.4.

Ineligible costs for Alberta funding are generally limited to costs incurred prior to the original ICIP project approval in principal (i.e. April 19, 2018), specified owners' costs and financing costs. Provincial ineligible costs will be funded by the City of Calgary.

Table 6.3: Stage 1 Capital Funding Summary

Funding Partner	Funding Amount (billions)	Funding Source (billions, unless otherwise stated)
Government of Canada	**$1.641**	$1.530 – Investing in Canada Infrastructure Plan (Public Transit and Green Infrastructure) $0.111 – Public Transit Infrastructure Fund (Phase I)
Province of Alberta	**$1.702**	$1.530 – Ultimate Recipient Agreement $0.055 – Public Transit Infrastructure Fund (Phase I) $0.117 – GreenTRIP and prior grants
City of Calgary	**$2.200**	$52 million (per year for 30 years) – 2013 Tax Room (2015 to 2044) $23.7 million (per year for 27 years) – 2017 Tax Room (2018 to 2044)
Total Capital Funding (including financing funding)	**$5.543**	

Financial Case

City of Calgary Funding

The City of Calgary has approved $2.20 billion or approximately 40% of the Program's Stage 1 funding through two streams of long-term capital funding for the Program:

- 2013 Tax Room of $1.56 billion (or $52 million per year for 30 years - 2015 to 2044); and

- 2017 Tax Room of $0.64 billion (or $23.7 million per year for 27 years - 2018 to 2044).

The 2017 Tax Room was initially approved to fund Project financing costs up to $639.9 million through the construction period and operations period ending in 2044. the City's two funding streams can be combined to optimize funding through either Program capital costs or financing costs during any given year.

For the initial grant funding agreements for the Program, the City is required to fund 33.3% of GreenTRIP eligible expenditures and 25% of PTIF eligible expenditures to support enabling works activities. City funding will also be used for all remaining Stage 1 Project expenditures and any federal and provincial ineligible costs, including all debt financing costs for the Stage 1 project.

Green Line LRT Connection to Funding Partner Goals

The Program's envisioned benefits are aligned to the Province of Alberta and Government of Canada's goals and priorities as shown in Table 6.5.

Table 6.4: Schedule of Government of Alberta Contributions

Date	Stage 1 Capital Funding (millions)
2018-19	-
2019-20	-
2020-21	-
2021-22	25
2022-23	50
2023-24	291
2024-25	291
2025-26	291
2026-27	291
2027-28	291
TOTAL	1,530

**Table 6.5: Project Alignment
With Funding Partner Goals**

Financial Case

Project benefit theme	Provincial priorities	Federal priorities
Meeting needs of a growing city	**Transportation Business Plan (2016-19) –** *"reliable, multi-model transportation network… that supports Alberta's potential, fosters innovation a supports Alberta's growing population."*	**Federal Budget 2016 –** *"Investing in infrastructure creates good, well-paying jobs that can help the middle class grow and prosper today. And by making it easier to move people and products, well-planned infrastructure can deliver sustained economic growth for years to come."* **Federal Budget 2019 –** *"More efficient transportation corridors mean that businesses can get their goods to customers more quickly."*
Support a growing economy	**Transportation Business Plan (2018-21) –** *"Smart investments in the transportation system help to create jobs, and contribute to economic resiliency and stability."*	**Federal Budget 2019 –** *"Investing in infrastructure creates good, well-paying middle class jobs today, and sets the stage for long-term economic growth that benefits everyone."* **Community Employment Benefits Program 2018 -** *"The Government of Canada has committed to providing sustained economic growth: building stronger, more inclusive communities, and creating meaningful jobs for more Canadians"*
Connecting Calgarians with more destinations	**Infrastructure Business Plan (2016-19) –** *"Infrastructure investments can help stimulate the economy by creating jobs while ensuring Albertans have access to necessary health, learning and government facilities."* **Transportation Business Plan (2018-21) –** *"Alberta's public transportation system will provide seamless, integrated connections between transportation modes and communities, including regional, urban, rural and Indigenous communities."*	**Federal Budget 2016 –** *"Canadians need immediate investments in their communities' public transit systems, so that they can get to work on time, and back home at the end of a long day."* **Federal Budget 2019 –** *"Not only do Canadians require the right kind of homes to be built, things like the accessibility of schools and daycare, and the proximity to public transit are also factors municipal planners must take into consideration when designing sustainable communities that work well."*
Providing opportunities for future development	**Ministry Business Plan (2019-23) –** *"Enhance access and mobility for transportation users, and support routes connecting major and high-load corridors and hubs."*	
Increasing environmental efficiency	**Culture and Tourism Business Plan (2016-19) –** *"The quality of life of any society is often measured by the social and economic well-being of its citizens. Inclusive communities that foster active participation are better equipped to tackle social issues related to a growing population."* **Transportation Business Plan (2018-21) –** *"Transportation is also developing and supporting policies and programs that focus on reducing greenhouse gas emissions across the transportation sector and protecting transportation infrastructure from future climate change impacts."* **Ministry Business Plan (2019-23) –** *"Alberta's transportation system supports economic growth while balancing the need to reduce negative environmental impacts, including identifying barriers and opportunities to reduce passenger and freight-related emissions."*	**Federal Budget 2016 –** *"A clean environment and a strong economy go hand-in-hand. The government is committed to leaving future generations of Canadians a sustainable and prosperous country"* **Infrastructure Canada- Climate Lens (2019)-** *"The Climate Lens is intended to incent behavioral change and consideration of climate impacts into the planning of infrastructure projects with a view to implementing Canada's mid-century goals of a clean growth low carbon economy"*

6.6

Financial Case Summary

The capital, operating, and renewal costs for the Green Line LRT Stage 1 are shown in Table 6.6, alongside revenue impacts. This represents the current estimate of financial impact for Stage 1.

Table 6.6: Financial Case Summary

Cost Category	Value (million $)
Indirect Costs	$805 (Nominal dollars)
Direct Costs	$4.098 (Nominal dollars)
Total Construction Costs	**$4.903 (Nominal dollars)**
Illustrative Annual Financial Impacts *	
2028 Incremental Operating and Maintenance Costs (LRT Only)	$26.9 (2018$)
2028 Incremental Revenue (LRT Only)	$6.5 (2018$)
2028 Net Incremental Operating and Maintenance Cost (Green Line LRT Only)	**$20.4 (2018$)**

7

Deliverability and Operations Case

The Deliverability and Operations Case provides an overview of the approach used to procure the Program and realize its intended benefits.

Since the 2016 Business Case, The City conducted further analysis to determine if the Program can still be expected to deliver on the intended scope within the committed funding ($5.543 billion). This analysis found that the City will be unable to deliver the full scope of underground tunnelling and stations originally planned for the downtown portion of the Program, given the high costs of geotechnical work and drilling. The City is now conducting design and development tasks, including stakeholder engagement for the downtown portion of the Program prior to advancing it to procurement.

Rather than delay the procurement process to accommodate the expected one year of planning, rhe Stage 1 contracting strategy was approved in July 2019. Under this strategy, the City opted to split the DBF contract into two segments. It was determined that the market had insufficient capacity and risk appetite to pursue one large DBF contract.

As such, the City will be putting Segment 1 for the Shepard Phase out to market while concurrently working to finalize the scope and routing of Segment 2. The delivery and management of the Program will be supported by a strong system of governance and the implementation of rigorous project controls. These systems are still under development at the time of writing (July 2020) to ensure that they align with contracting and commercial arrangements. Project charters have been developed for the Program which outline scope, governance, and program milestones, among others.

7.1 Socio-Economic and Environmental Considerations

The Program will have a number of key socio-economic and environmental considerations that will be managed through the contracting process. This includes the allocation of responsibility for regulatory issues, including managing environmental assessment, certificate compliance and permitting. It also includes key considerations around the assignment of responsibility for managing external relations, including consultation with indigenous communities and public engagement processes.

Environmental Management

The Program continues to manage numerous environmental disciplines and will do so for the life of the Program. These include:

- tracking both the federal and provincial assessment processes

- obtaining required federal, provincial and municipal environmental permits, licenses and approvals

- comprehensive construction environmental management to achieve compliance

- production of GHG Mitigation Assessments, Climate Lens and Resilience Reports

- management of contaminated sites, application of sustainability processes

- maintaining a Risk Registry and conducting work required within specific environmental disciplines.

Both federal and provincial reporting will continue alongside internal senior Project Management Team reporting.

Indigenous Relations

To maintain continuity throughout the life of the Green Line LRT project, consultation and engagement activities with First Nations will continue, as necessary, in order to satisfy both federal and provincial requirements. The City will maintain the lead role in identifying the requirements and responsibilities to consult during the Program, and these will also be identified during the contracting process. In addition, the City continues to explore ways to maintain ongoing relationships with First Nations.

Community Relations

With a mandate to help stakeholders prepare for and manage the impacts of construction, the desired outcome of all communication and community relations activities is to ensure transparency, timely access to project and construction-related information, and responsiveness to citizen needs and concerns in order to successfully construct the Green Line LRT with public support and to achieve the project vision. Clear roles and responsibilities will be assigned to ensure that both contractor and City staff are focused on achieving this outcome.

7.2 Risk Management

Risk management protects taxpayer dollars and supports proactive management and decision making for capital projects. Understanding risk and developing measures to either accept or mitigate risk involves the development and continuous improvement of three primary risk management components:

- **A Risk Management Plan**: a clear plan for identifying, assessing, and managing risks as well as communicating status and potential implications.

- **A Risk Register**: a comprehensive register of risks and thorough analysis of their impacts, and a repository for response strategies.

- **Ongoing Risk Management**: identifying and responding to risk through a proactive and empowered risk-aware culture.

Based upon the risk assessment completed to date, the Green Line LRT Stage 1 Program risk exposure is at the high end of the typical range of other major LRT projects at this stage. The program holds risk in all of the typical categories of an LRT megaproject, but higher risk than is typical has been identified in the following risk areas:

- Scope additions and uncertainty.

- Governance and decision making.

- Procurement and market conditions.

- Contract interfaces (i.e. due to the use of multiple DBF contracts plus a separate LRV procurement).

- Canadian National/Canadian Pacific railway coordination.

- Scope and technical risks associated with Segment 2 (from north of Inglewood Station to 16 Avenue N).

- Current impacts of COVID 19.

The Green Line LRT Program Team is acutely aware of the need to continue to prioritize effort on proactively mitigating these risks. There are significant actions the Green Line LRT Program Team has and is taking to respond to these risks, including:

- Finalizing planning details.

- Streamlined, risk informed decision making.

- Meeting established procurement timelines.

- Clearly projecting support for the Green Line LRT Program.

- Finalizing Segment 2.

- Resourcing.

- Cost savings measures.

Monitoring and updating risks and risk response strategies will continue as the Program progresses. With team effort directed toward managing and controlling risk on the Green Line LRT, the risk profile should continue to reduce over time. The risk assessment will be refined and updated to accurately reflect the evolution in affordability, schedule and program risks as key milestones are reached.

7.3 Procurement Strategy and Approach

The procurement strategy is based on a foundational set of principles that are intended to drive towards positive commercial outcomes for the Program. These principles have been used to develop an approach to procurement that is best suited to Project circumstances and requirements. They will also be applied throughout the contracting process to ensure the commercial success of the Program.

Procurement Principles

The procurement strategy is founded on a core set of principles that are intended to support the long-term success and viability of the Program for the City of Calgary (See Table 7.1). The City will not be pursuing a long-term P3 model and operations and maintenance (O&M) components will not be included in the proposed procurement model.

Table 7.1: Procurement Strategy Principles

Schedule – Cost of Delay
Schedule delays pose a significant financial risk to the Program. The procurement process will seek to minimize the risk of schedule delays and increase opportunities for earlier involvement of prospective contractors in the design process.

Cost Certainty
Any uncertainties in cost pose a significant risk to the Program. The design of the procurement process will seek to create cost certainty and minimize potential financial risks wherever possible.

Risk Management
Appropriate risk allocation is a central pillar of the procurement process. Consistent efforts will be made throughout the procurement process to pro-actively identify risks and optimize risk allocation.

Market Attractiveness

The attractiveness of the Program is essential to creating a competitive bid process. Efforts will be made throughout the procurement process to involve contractors early in planning and design to help increase the market attractiveness of the Program.

Contractor Opportunity for Innovation

Innovation has the potential to minimize cost and mitigate risk for both the contractor and Project owner. The procurement process will incentivize contractor innovation, particularly as it relates to Project design.

Impact on Lifecycle Cost
Contractor expertise is a valuable asset in designing a project with minimized lifecycle costs. The procurement process will create opportunities for that expertise to be integrated earlier in the process to allow contractors to work collaboratively with City representatives throughout the design process.

Industry capacity to deliver

Assessments of market feasibility have been conducted at various stages of the Program to ensure that the procurement model is strategically aligned with key market considerations. Early assessments of market feasibility identified that the Program would face competition with other major rapid transit projects across Canada, including Surrey-Langley Skytrain Extension (B.C), Edmonton Valley Line Stage 2 (Alberta) and Broadway Subway (B.C) projects.

The overlapping procurement timelines for these projects suggest that the Program may face high levels of competition when attracting leading firms to submit a bid due to market saturation.

Preliminary procurement models for the Program took into consideration the market assessment findings and the initial model – a single DBF contract, with a separate contract for LRV, and multiple smaller contracts for enabling works – was proposed as an attractive option for the market. Although the levels of competition have not lessened since initial market feasibility assessments were conducted, changing factors in the City of Calgary and the evolution of the LRT market have added further complexity to the assessment of market feasibility. These factors have been critically influential in the development of the current procurement model with two separate DBF contracts for the two segments of the line.

Procurement Approach

The Program is striving for early contractor involvement in project design. Following the issuance of a Request for Proposals (RFP) with an accompanying Project Agreement (PA), pre-qualified bidders will be invited to participate in an iterative design review process and provide input to a revised PA. Following the design review process and amendments to the PA, proponents will be asked to submit a technical and financial proposal for the review of the selection committee. Bid evaluation will consider a number of key factors and is likely to include certain values-based evaluation factors.

The core procurement principles described in Table 7.1 have been applied to design a procurement model that will maximize positive commercial outcomes for the City. The procurement model proposed for the Program has evolved over time as the Program scope continues to be refined and market circumstances have changed. City Council initially approved the following procurement model on March 19, 2018:

- **DBF** - a type of P3 contract for:

  - 1. the tunnel.

  - 2. all underground, at grade and elevated stations, track and systems.

  - 3. MSF.

- **DB - a** contract for the LRV.

- **DBB - a** contract for enabling infrastructure work such as utility relocation.

Since that time, the DBF has been separated into two DBF contracts that are split geographically – DBF for the Shepard Phase (Segment 1) and a DBF for the Centre City Phase (Segment 2).

7.4 Governance

An effective system of project governance will be integral to the success of the Program. The governance systems and structures will incorporate leading best practice in project governance while also meeting the unique needs of the Program. The governance model for the Program is under development at the time of writing to ensure effective alignment with the outcomes of the procurement process.

The Program is currently managed by the City of Calgary, with support from external advisors assisting in strategic and technical aspects. A Technical Risk Committee (TRC) was also set up in August 2019 to conduct technical due diligence on the Program's deliverability and management.

The delivery and management of the Program will be supported by a tailored Program Delivery Team model. The organizational chart for the Program Delivery Team is under refinement at the time of writing to ensure effective alignment with the outcomes of the procurement process.

A Project Management Plan (PMP) is under development at the time of developing this Business Case. A project readiness plan outlining key milestones has been developed and is being updated.

7.5 Operations and Maintenance

Operations and maintenance components have been excluded from the procurement model at this stage, as the City is not pursuing a long-term P3 model for the Program. Long-term operational planning is underway at the time of writing.

Upon completion of constructing and commissioning the Program, Calgary Transit, is expected to take over operation and maintenance responsibilities of the system. This will include:

- **LRV and BRT operation** – operating LRVs on the southeast portion of the alignment, and BRT along the north alignment.

- **LRV and bus vehicle maintenance** – regular and ongoing maintenance including safety checks, mechanical maintenance, and system maintenance.

- **Track, right of way, and other system infrastructure maintenance** – overseeing and providing necessary seasonal, and periodic recurring maintenance and upgrades to track and any access or right of ways for the LRV and BRT system.

- **Station upkeep** – including lighting, landscaping, snow removal, and ongoing maintenance of bus and light rail station shelters.

- **Maintenance facility upkeep** – ensuring appropriate building envelop maintenance and upgrades housing light rail and bus vehicles during maintenance and storage period.

- **Signalling and traffic management for the light rail alignment** – managing and determining signalling priorities for at-grade light rail alignments and interface with roadway vehicle traffic management.

Roadways for the BRT component of the Program will be maintained by the City of Calgary's Roads department. Roadway maintenance includes snow removal, tree clearing and foliage removal, general upkeep (paving, re-paving, re-surfacing), traffic management and safety management (such as vehicle speed designation and safety signage).

7.6 Benefits Management

At the time of developing this Business Case, work is underway to more comprehensively map project benefits to develop a benefits management plan. The City expects a range of benefits to be realized in both the construction and operational phases of the Program. At a high level, the City is contemplating the examples of performance measures in Table 7.2 to help track and demonstrate realization of benefits.

It is expected that appropriate performance metrics will be selected, methodologies for measuring be refined, and that a benefits realization plan will be developed as the Program progresses its planning.

**Table 7.2: Benefits Management
Performance Indicators**

Construction Phase Performance	
Aim	**Indicator**
Job creation and GDP contribution to provincial and national economies	Direct-hires by contractors and approximated using the Stats Can I/O model for capital expenditures incurred
GHG reduction through sustainable construction methods	Modelled GHG reduction estimation based on construction method compared to traditional construction methods
Public art and cultural vibrancy	Public art installation at stations

Operations Phase Performance	
Aim	**Indicator**
Increased ridership	Comparing public transit ridership under similar growth assumptions
Travel time savings per ride and network-wide	Travel time per rider for standard trips, and aggregated travel time savings
GHG emission reduction through ridership conversion	Riders converted from personal vehicle to public transit
Increased transit-oriented development	Number of development permits applied, or change in density and multi-use developments within walking distance of stations

8

Conclusion

This chapter provides a summary of the Business Case
for Stage 1 of the Green Line LRT Program.

8.1

Stage 1 Green Line LRT Business Case Summary

The Business Case for Stage 1 of the Green Line LRT Program draws on over five years of planning, stakeholder engagement, and design to present an optimized investment for the City of Calgary. This project was developed to achieve the following vision:

"A city shaping transit service that improves mobility in north and southeast Calgary, connecting people and places, and enhancing the quality of life in the city."

This investment will have a significant benefit to mobility and urban development in Calgary by 2028 and beyond, including:

- **Improving mobility choices by providing a high-quality transit service that is fast, frequent and reliable–** travelers will spend less time travelling for work, school, and recreation.

- **Laying foundations** – by delivering the most complex elements of the overall Green Line LRT Program first, Stage 1 enables future expansions further north and further south.

- **Catalyzing development –** the Green Line LRT serves 10 station areas (of 15 stations) that are identified by Calgary's **MDP** as an activity centre or corridor – these areas are a priority for intensification and fast, frequent, reliable transit service.

- **Integrated and cost-effective transit service –** the Green Line LRT will connect people to where they want to go using a new LRT that can be delivered and operated in a cost-effective manner.

- **Connecting the city** – the Green Line LRT is the next step for completing Calgary's rapid transit network providing seamless connectivity with the existing Red and Blue LRT lines and four MAX transit lines.

**Table 8.2 Summary of Green Line
LRT Stage 1's performance.**

Strategic Case	**Transportation Benefits**	
	Up to 65,000 riders served each day with up to 25 minutes of journey time saved per trip. The Green Line LRT will provide capacity for 2028 and beyond and collect revenue that covers 70-84% of its operating costs.	
	Quality of Life Benefits	
	68,000 people will live within walking distance of a Green Line LRT station, while 900 key destinations can be walked to from the Green Line LRT. The Green Line LRT will lead to 2,300 fewer automobile collisions in its first 30 years of service and support increased health from increased walking. It will catalyze development of complete communities by directly connecting to 6 high priority TOD areas.	
	Economic Prosperity Benefits	
	An estimated 20,000 jobs will be created to deliver and operate the Green Line LRT. Nearly 200,000 jobs will be within walking distance of Green Line LRT stations.	
	Environmental Sustainability Benefits	
	By taking cars off the road, Stage 1 will save up to 30,000 tonnes of GHG emissions per year in support of municipal, provincial, and federal environmental goals.	
Economic Case	$2.260 billion in economic benefit over its first 30 years of operations.	
	BCR of 0.56, which is comparable or higher than other Canadian LRTs that have been delivered or are planned for delivery.	
Financial Case	$4.903 billion in capital costs funded by The City of Calgary ($2.2 billion), the Province of Alberta ($1.702 billion), and the Government of Canada ($1.641 billion).	
Deliverability and Operations Case	Delivered in two segments using separate P3 procurement processes.	
	Operated by Calgary Transit.	
	Utilized a robust risk management process throughout all stages of project planning, design, and delivery.	

8.2 Next Steps

Conclusion

Upon review of this Business Case and other supporting materials, the following next steps have been identified for Stage 1:

- Procure Light Rail Vehicles.

- Advance the P3 delivery of Segment 1 from Shepard to Ramsay/Inglewood.

- Continue the design and development of Segment 2 from 4 Street to 16 Avenue N and continue to plan BRT improvements for Centre Street in advance of future expansions.

- Conduct further planning, design, and development of Centre Street N and southern expansions for the Green Line LRT Program.

Glossary

Term	Acronym	Definition
Area Redevelopment Plans	**ARP**	One of the tools the City uses to regulate development. It sets high-level requirements that future development will have to meet for an area. The APR outlines general rules such as: • Where certain sizes and types of buildings should be located. • Where amenity space and other public infrastructure should be located. • How the land can be used in a general sense (commercial, residential, retail, etc.) • What improvements to infrastructure are needed to accommodate any changes.
Added Weight 2	**AW2**	A standard for train capacity, defined as the number of passengers that fill all the seats, and fill the passenger standing area at a density of 4 standing passengers per square metre.
Business As Usual	**BAU**	Refers to the future state of Calgary's transportation network without the Green Line LRT. The BAU is the comparator against which the incremental costs and benefits of building and operating the Green Line LRT are measured to understand the overall value of and case for the Program. Generally, the BAU scenario has been defined to include only those investments and service enhancements that are presently funded.

Benefit Cost Ratio	BCR	An economic indicator that reflects the relationship between benefits and costs of an investment. A BCR greater than 1 indicates the projects benefits exceed costs.
Business Case	-	The primary purpose of business cases is to facilitate good decision making for capital project funding. This Business Case has been prepared by applying international best practice to achieve the project objectives in a transparent and accountable manner that enhances project delivery and decision making.
Bus Rapid Transit	BRT	Bus services that leverage a range of infrastructure and service improvements to provide high speed and high capacity travel options. Infrastructure improvements can include: separate right of way, queue jump lanes, signal priority, and off bus ticketing.
Calgary Transportation Plan	CTP	A long-range plan that provides policy direction for how the City of Calgary will deliver transportation options to Calgarians for the next 60 years.
Calgarian	-	Resident of the City of Calgary.
Capital and Renewal Costs	-	These comprise one-time fixed costs incurred to build the required infrastructure (stations, track, signal, electric systems maintenance depots, and fleet) to deliver the service as well as costs incurred to renew or replace major elements of the system, such as the LRV fleet once they have reached the end of their lifecycle.

Central Business District	CBD	Typically categorized by higher density residential developments and centralized employment. Calgary's CBD (Downtown Commercial Core, is City of Calgary's official name for it) is defined as the area from 9 Street SW to 31 Street SE (behind Municipal Building) and from 9 Avenue SW to the 4 Avenue SW. It is about 1.3 km x 6 km in size and excludes Eau Claire, Chinatown or East Village. Also referred to as 'downtown core' in this report.
COVID 19	-	Coronavirus disease (COVID 19) is an infectious disease caused by a newly discovered coronavirus that spread across the globe throughout 2020.
Criteria Air Contaminants	CAC	Pollutants that contribute to smog, acid rain, and human health impacts.
Deliverability and Operations Case	-	Provides an overview of the approach used to procure the Program and realize its intended benefits.
Design Build	DB	A method of project delivery where the design and construction are tendered/let to a single entity.
Design Bid Build	DBB	A traditional method of construction where separate contracts are tendered/let for the design and construction phases.
Design Build Finance	DBF	A type of Public Private Partnership (P3) contract for (1) the tunnel, (2) all underground, at grade and elevated stations, track and systems, and (3) the MSF in this particular context.

Direct Capital Investment	-	Direct capital costs such as DBF costs (including engineering), LRV supply, land, commissioning, owner supplied materials, enabling works construction, utility relocations, plus all escalation and contingency related to these costs.
Economic Case	-	Enables decision makers, project planners, and wider stakeholders to understand socio-economic performance of the Green Line LRT. Socio-economic performance assesses the value of resources required to deliver the Program (costs) and the monetized value of the benefits the Program can realize.
Expandability	-	The ability to implement the long-term vision in stages when further investments are made. This positions the City of Calgary to deliver future affordable and achievable expansions.
Financial Case	-	Provides an overview of the Green Line LRT program's finances and how it will be funded. This overview includes a breakdown of the Program's cost and funding alongside a description of how potential program risks will be mitigated and managed.
Generalized Journey Time	GJT	Converts all elements of a passenger trip into units of minutes based on how travellers perceive each component of the trip.

Grant Agreement: Public Transit and Green Infrastructure Project/ Ultimate Recipient Agreement	URA	Agreement between the Government of Alberta and the City of Calgary. This agreement establishes governance structures and systems of oversight that will help to ensure that funding is allocated in alignment with the priorities identified by the Investing in Canada Infrastructure Program (ICIP). There are also strict audit requirements set out in this agreement to ensure that the funding has been administered appropriately.
Greenhouse Gases	GHG	Emissions that contribute to climate change.
Green Line LRT	-	The LRT system planned to run in its entirety from Seton in the Southeast to 160 Avenue in the North. The system will provide seamless connectivity to the Red and Blue lines in the City Centre and further enhance the rapid transit network by providing integrated connections to the four MAX rapid transit routes recently implemented.
Indirect Capital Investment	-	Indirect capital costs such as staffing, owner engineering, permits, advisor fees, plus all escalation and contingency related to these costs.
Investing in Canada Infrastructure Program	ICIP	The federal government's program designed to create long-term economic growth, build inclusive, sustainable and resilient communities and support a low-carbon economy, through which Alberta is receiving $3.65 billion over the next 10 years (2018-28). These projects will be cost-shared with the Alberta government, municipalities and other partners.

Light Rail Transit	**LRT**	Transit infrastructure and services consisting of LRV running in an exclusive right-of-way, fully separated from traffic, typically with transit signal priority measures in place and longer spacing between stops than conventional transit routes (typically 500 metres to 1 kilometre) to maintain higher average speeds and ensure reliability of the service.
Light Rail Vehicle	**LRV**	Part of an LRT network which can carry significantly more customers than BRT/bus alternatives. This means reduced cost per customer carried and a lower required headway. Typically operate in trains of one to five cars and use an overhead source for their electrical power.
Maintenance and Storage Facility	**MSF**	A dedicated facility used to house unused LRVs (e.g. at night) with adjacent facilities, tools, and personnel to maintain, clean, and fix the LRVs and wayside equipment used by the LRT system.
Municipal Development Plan	**MDP**	City of Calgary's vision for how Calgary grows and develops over the next 30 to 60 years. Calgary is expected to grow by another 1.3 million people over that time, so it is important to plan for the city's future.
Mode share	**-**	The percentage of person-trips made by one mode of travel relative to the total number of trips made by all modes.
Net Present Value	**NPV**	The total economic value of a project. Determined by subtracting project costs from its total benefits. A positive Net Present Value indicates that the project's benefits exceed its costs.

Operations and maintenance	O&M	Administration and staff support for operation of the expanded infrastructure, as well as parts and materials, contract and services and other costs required to deliver routine operations and maintenance over time.
Operations and maintenance costs	-	Refers to all expenditures associated with the continued operations and maintenance of the Program.
Public Private Partnership	P3/PPP	Arrangement whereby design and delivery responsibility and risk will be shared with a private partner.
Quantitative Risk Assessment	QRA	Method where costs and durations are ranged and subjected to Monte Carlo analysis and escalation estimated using City of Calgary corporate standard rates.
Rapid transit	-	Rapid transit / mass rapid transit, also known as heavy rail, metro, LRT, subway, tube, U-Bahn or underground, is a type of high-capacity public transport generally found in urban areas.
Reference Concept Design	RCD	Illustrates how an investment be delivered. This reference concept design is used to estimate costs, ridership, and benefits resulting from the Green Line LRT based on working assumptions and design work.
Regional Transportation Model	RTMv2	City of Calgary transportation forecasting model used in this business case to models a BAU scenario for 2028 and 2048 and the option scenarios that include the Calgary Green Line LRT and bus integration changes.

Station Development Plans	SDP	
Strategic Case	-	Evaluation uses a defined framework to assess the extent to which each scheme option supports the City's broader policy goals and compares each option's relative performance to support investment decision making.
Transitway	-	Another term for a segregated Bus Rapid Transit (BRT) system.
Transit Oriented Development	TOD	Developments that are planned and designed to integrate with transit in order to encourage increased ridership and compact mixed-use developments.
Vehicle Kilometers Travelled	VKT	A measure of roadway use, commonly used in estimating congestion, that reflects the distance that an individual drives, or, more typically, the cumulative distance driven by all vehicles in an urban region during a specified period of time. VKT can reflect the link between land use and transportation. Land uses that are further away from each other result in longer trip lengths, more traffic on roadways and more vehicle kilometers travelled, for example.
Wider Economic Benefits	WEBs	Benefits from investing in transportation that lead to a more productive region. Typically these benefits include agglomeration (enabling increased innovation, collaboration, and productivity) and labour supply benefits (increased job access for employee and a larger labour pool for employers).

Calgary Green Line LRT Business Case

City of Calgary   July 2020