Impact Analysis of Trans Mountain Pipeline Extension: Social and Environmental Assessment of Potential Leak

> GEOB 270 Moca Nimmervoll Samuel Chua Paul Li

1. Abstract

The existing Trans Mountain Pipeline from Alberta to Westridge Marine Terminal on the South shore of Burnaby, B.C has been operating since 1953. In June of 2019, the federal government of Canada approved an expansion project of this pipeline, a second pipeline running approximately parallel to the existing one. This project analyzes the risks on the natural environment and human infrastructure in the event of a leak with a 100-metre' leak risk zone' around the pipeline. To perform this analysis, data was acquired about features of the natural and built environment with the pipeline buffer overlayed to perform an intersect analysis. Our results showed that there are many factors that need to be considered when planning a large scale project such as a pipeline.

2. Description of the Project

The approved Expansion Project of this pipeline, a "twinning" of the original one, has been a controversial topic because of the tremendous effects the pipeline will have on the neighbouring communities and the environment. Although Trans Mountain assures the pipeline will be safe, residents of Burnaby are highly concerned about the impacts of this project. The Major of Burnaby, Mike Hurley, believes that the pipeline "poses an unacceptably high risk to local residents" (Scott), and is concerned about public safety and the environmental threats that the project will pose. After being approved on June 18, 2019 by the Federal Government, construction has started without the approval of the City of Burnaby.

This project assesses the impacts of a potential leak along the expansion project pipeline within the Municipality of Burnaby. With the sole focus being on built infrastructure and the environment, the analysis takes into account residential areas, civic areas, conservation areas and waterways. With two maps to support our analysis, one visualizes the areas of population that are at immediate risk in the event of a leak, while the other assesses how a leak would impact the natural environment. Since a pipeline leak varies in severity depending on a number of factors, our estimates on the areas around the pipelines that are in high-risk zones in the event of a leak are based on the previous oil spill that occurred in 2007 in Burnaby (Granger).

3. Methodology

As the methodology was different for each of our assessments, here we will show the steps that were taken in order to create the human impact assessment map and the environmental assessment map.

a. Acquire

Environmental Impact Assessment

Trans Mountain Website:

- Existing and extended pipelines, referenced from website map

Data BC:

- Oceans
- Lakes

City of Burnaby Open Data Portal:

- Waterways
- Metro Vancouver Open Data Catalogue:
 - 2011 Generalized Land Use Classification
- BC Marine Conservation Analysis:
 - Rockfish Conservation Areas

Human Impact Assessment

Trans Mountain Website

- Existing and extended pipelines, referenced from website map

Metro Vancouver Open Catalogue:

- Metro Vancouver municipal boundaries
- City of Burnaby open data portal:
 - Burnaby civic places

DMTI CanMap:

- Metro Vancouver roads

Canadian Census Analyzer (University of Toronto CHASS):

- Population of Dissemination Areas (DAs) (2016 Census)

b. Parse Filter

Environmental Impact Assessment

- 1) Create geodatabase for all data used in environmental impact map named EnviroImpactPipeline
- 2) Add and rename layers
 - a) Light Grey Canvas Basemap from GIS defaults
 - b) "waterway', "TransMountain_extension" and "TransMountain_pipeline"
 - c) "AdminBoundary" renamed "MunicipalBoundaries"
 - d) "Bmca_hu_commercialfish_rcas_data" renamed " Commercial_rockfish"
 - e) "ihy_000c16a_e" renamed "Lakes", "ihy_00h16a_e" renamed "Oceans"
 - f) "LandUse2011" renamed "Burnaby_Land_Use"
- 3) Projected all layers into NAD 1983 UTM Zone 10 through projection tool

Human Impact Assessment

- 1) Create geodatabase for all data used in human impact map: HumanImpactPipeline
- 2) Add and rename layers
 - a) Light Grey Canvas Basemap from GIS defaults
 - b) "TransMountain_extension" and "TransMountain_pipeline"
 - c) "AdminBoundary" renamed "MunicipalBoundaries"
 - d) "CivicPlaces", "Roads", "MetroVanDA" and "PopulationDA"
- 3) Reproject all layers to NAD 1983 UTM Zone 10 through projection tool
- 4) Join Dissemination Area population data (DBF file) to Dissemination Area shapefiles (Spatial Join)
 - a) Joins and Relates -> Joins
 - b) Field: DAUID
 - c) Table: PopulationDA
 - d) Field in table: COL0
 - e) Keep only matching records
- 5) Create roads layer by clipping Metro Vancouver roads with Burnaby boundary layer

c. Mine/Analysis

Environmental Impact Assessment

- 1) Create Burnaby boundary layer through select by attribute
 - a) Query select by attribute: "MunicipalBoundaries" FullName = Burnaby
 - b) Create new layer from selection \rightarrow "Burnaby_Boundary"
- 2) Create Conservation Area from "Burnaby_Land_Use" layer through select by attribute
 - a) Query select by attribute: LU-CodeDes= Open Space and Protected Natural Areas → New layer from selection: "BurnabyLand_Conservation"
- 3) Create buffer of Extension Pipeline
 - a) Analysis Tool \rightarrow Proximity \rightarrow Buffer
 - b) Input feature "TransMountain_extension"; 100m buffer → New Layer "TransMountain_extension100"
- 4) Use intersect to determine conservation land at risk in the event of a leak
 - a) Geoprocessing \rightarrow Intersect "BurnabyLand_Conservation" and
 - "TransMountain_extension100" \rightarrow New layer "conservation_risk"
- 5) Use Select by Location to determine waterways at risk in the event of a leak
 - a) Query Select by Location → "waterway" intersect with "TransMountain_extension100" → new layer from selected feature "Waterway Risk"

Human Impact Assessment

1) Create Burnaby boundary layer through select by attribute

- a) Query select by attribute: "MunicipalBoundaries" FullName = Burnaby
- b) Create new layer from selection \rightarrow "BurnabyBorder"
- 2) Calculate population density of all Burnaby Dissemination Areas
 - a) Remove all zeros from Dissemination Areas (Select by attribute: Population > 0)
 - i) Create new layer from selection \rightarrow "DAProjectPopulatedBurnaby"
 - Add a field named "PopDensity" in the attribute table of "PopulationDA" (value field: float)
 - c) Using field calculator divide Dissemination Area population by Dissemination Areas to get population density
- 3) Create separate roads layer from existing Metro Vancouver "Roads" layer through select by attributes
 - a) Select by attributes: Road type = "Expressways" and "highways"
 - b) Create new layer from selection \rightarrow "Express_and_high"
 - c) Select by attributes: Road type = "Major_Roads"
 - d) Create new layer from selection \rightarrow "Major_Roads"
- Buffer "TransMountain_extension" by 100 metres and calculate affected areas by potential leak
 - a) Using buffer tool create 100 metre buffer around pipeline
 - b) Intersect "Pipeline_Buffer100" and "DAProjectPopulatedBurnaby" shapefiles
 - c) View new intersect layer attribute table (shape area field → statistics) to find total area of buffer within Burnaby Dissemination Areas
 - As shown in Fig. 1, to calculate the areas of high and dense population (2613-37826 people per km²) that the pipeline is in contact with, these polygon areas have been selected to create a new layer and then intersected with the extended pipeline

d. Represent

Our project consists of two maps to visualize the risks of a potential leak from the Trans Mountain Expansion project. One map assesses the environmental impact, and the other assesses the human impact.

Environmental Impact Assessment

- 1) Add light gray base map
- 2) Following layers are added:
 - a) "Burnaby_Boundary"
 - b) "BurnabyLand_Conservation"
 - c) "Conservation_risk"
 - d) "waterway"
 - e) "Waterway_Risk"

- f) "Commercial_rockfish"
- g) "TransMountain_extension" and "TransMountain_pipeline"
- h) "Ocean" and "Lake"
- 3) Zoom in to include zone of commercial rockfish and entirety of the pipeline
 - a) Add inset map to provide a frame of reference of the map
- 4) Alter colours and transparency to provide better visuals to support analysis
- 5) Add scale, north arrow, data source, credentials and legend

Human Impact Assessment

- 1) Add light gray base map
- 2) Following layers are added:
 - a) "BurnabyBorder"
 - b) "Pipeline_Buffer100"
 - c) "Pipeline"
 - d) "existing_pipeline"
 - e) "CivicPlaces_Project"
 - f) "Express_and_high"
 - g) "Major_Roads"
 - h) "DAProjectPopulatedBurnaby"
- 3) Zoom to "Pipeline_Buffer100" layer (focus on areas most affected by pipeline)
 - a) Add inset map to provide a frame of reference of the map
- 4) Make symbology of "TransMountain_extension" bright red (as it is focus of project) and "Pipeline_Buffer100" buffer around it hollow to allow for view of features underneath.
- 5) Make symbology in "Express_and_high" layer a thicker black line and "Major_Roads" layer a dotted thin line to create visual hierarchy
- 6) Classify population density by quantile classification method
 - a) Accept the default values for break points
 - b) Accept the default number of classes (5 classes)
- 7) Add scale, north arrow, data source, credentials and legend

e. Table of dataset

Layer/Datafile name	Source	Uses	Entity/data model	Attributes	Modifications
"AdminBoundary" Renamed: "Municipal Boundaries"	Metro Vancouver Open Data Catalogue	Burnaby Municipal Boundary	Shapefile	FullName = Name of Municipality	Project to NAD 1983 UTM ZONE 10. Query Select by Attribute to only get municipal boundary of Burnaby
"Roads" Renamed: "express_highway " and "major_roads"	CanMap	Roads in Metro Vancouver	Line	Road_type: 1 = Expressway 2= Primary Highway 4= Major Road	Project to NAD 1983 UTM ZONE 10. Clipped to Burnaby_Boundary Query Select by Attribute: 1. Select 1 and 2 to make layer express_highway 2. Select 4 to make layer major_roads
"PopulationDA" Renamed: "PopulationDensit yDA"	CHASS Data Centre (2016)	Population Density in City of Burnaby	Tabular	COLO as the identifier of DAs (from DBF File) that match the DAUID (in the shapefile of metro Vancouver DAs)	Project to NAD 1983 UTM ZONE 10. Heading of COL1 (in the DBF file) changed to Population. Used in the population density calculation, 0 values excluded
"CivicPlaces"	City of Burnaby Open Data Portal	Schools, Libraries, Community Centres	Points		Project to NAD 1983 UTM ZONE 10

"LandUse2011" Renamed: "Burnaby_Land_U se"	Metro Vancouver	Recreation, Open Space and Protected Natural Areas	Shapefile	LU-CodeDes= Different land use classifications	Project to NAD 1983 UTM ZONE 10. Query Select by Attribute: Recreation, Open Space and Protected Natural Areas for conservation areas
"waterway"	City of Burnaby Open Data Portal	Waterways that may intersect with the pipeline	Line	WATERWAYNA = Names of waterways in Burnaby	Project to NAD 1983 UTM ZONE 10
"Ihy_000c16a_e" Renamed: "Lakes"	Census Canada Cartographic Boundary	Lakes in Burnaby	Shapefile	NAME = name of hydrography	Project to NAD 1983 UTM ZONE 10
"Ihy_000h16a_e" Renamed: "Ocean"	Census Canada Cartographic Boundary	Ocean	Shapefile	Name = Name of hydrography	Project to NAD 1983 UTM ZONE 10
"TransMountain_e xtension" And "TransMountain_p ipeline"	Drawn by hand	Existing for reference, and extension for creating buffer	Shapefile		
"Bmca_hu_comm ercialfish_rcas_dat a" Renamed: "Commercial_rock fish"	BC Marine Conservation Analysis	(Commercial) Rockfish Conservation Areas	Shapefile		Project to NAD 1983 UTM ZONE 10

4. Discussion and Results

Overview

The Trans Mountain Pipeline transports crude and refined oil from Edmonton, Alberta to Burnaby, BC. Indirectly owned by the Government of Canada, it currently transports around 300,000 barrels a day (Trans Mountain, "Expansion Project"). The proposed expansion of the pipeline adds a second pipeline running approximately parallel to the current one and would nearly triple the amount of oil transported each day to around 900,000 barrels.

Supporters of the pipeline have cited the economy as the largest reason for expanding Canada's oil transporting capacity. More oil being transported translates to greater tax revenue and the creation of more jobs, both direct and indirect. As Canada's main current buyer of oil is the United States, connection to the coast is important as it allows for access to Asian markets. Canada would be able to reach more buyers while at the same time receive a better price per barrel. If oil is to be transported, pipelines are considered to be the safest alternative versus other methods such as rail (Leavitt et al.).

Critics of the pipeline argue the social and environmental impacts of the expansion outweigh the economic benefits. Canadian government modelling from 2017 shows that even without the pipeline expansion, currently, the country is not on track to meet its Paris Agreement targets (Leavitt et al.). If built, the expansion would contribute an additional 13 - 15 megatons of greenhouse gasses, approximately 2% of Canada's total emissions in 2016 (Leavitt et al.). Many First Nations groups are also opposed to the pipeline, in particular, Coast Salish nations in coastal BC near where the proposed expansion reaches the water. Opposition from First Nations groups, local governments, and environmentalist have materialized as protests and even legal challenges.

One major concern of expansion of the pipeline, which has particular relevance to this project, is an increased risk of leakage and spill. The current Trans Mountain pipeline has reported 84 spills since 1961 with 9 of these spills exceeding the reporting threshold of 1.5 cubic metres (Trans Mountain, "Spill History"). Burnaby itself has experienced a large spill in 2007 in which spillage of around 230 cubic metres of crude oil forcing the evacuation of around 225 residents (Granger). The greatest damage from the pipeline spillage occurred in the "Red Zone", a 100 m radius from the rupture origin. In the event of spillage, there is a significant impact on both people and the environment.

Environmental Impact Assessment Results

The Trans Mountain pipeline extension is proposed to be constructed through some key environmental components in Burnaby B.C. The 100m buffer from the pipeline extension highlights conservation areas and creeks that are at risk in the event of a leak. Figure 2 has areas that include recreation, open space and natural protected areas of conservation zones and highlights the 0.7 km² that is within the 100m risk zone of a spill. One of the biggest concerns that residents in Burnaby have is the effects that this pipeline will have on the Burnaby Mountain Conservation Area and the Brunette River Conservation Area (City of Burnaby).

In addition, there are many waterways within the municipality of Burnaby that can be affected by a spill. Spills into creaks can be extremely detrimental as when oil enters the water, it affects the entirety of the creek that runs downstream from where it was originally contaminated. Figure 3 lists the major creeks that run through the buffer zone of the pipeline, putting them within the risk zone along with the conservation areas. Fig. 2 also highlights the Commercial Rockfish habitat in the Eastern Burrard Inlet. It can be seen that this habitat, although not directly within the 'risk' zone that this project proposes, sits very close to the terminal in which the pipeline ends. In addition to the pipeline extension, the Trans Mountain Corporation has planned to extend the Westridge Marine Terminal on the Burrard Inlet Shore along with the installation of 14 new tanks at the Burnaby Terminal (Trans Mountain "Expansion Project"). These additional features of the project also increase risk, along with ecological destruction to existing environmental components from the construction process that will be discussed later in the *further research/recommendations* section of this paper.

Human Impact Assessment Results

1. Population

As shown in Figure 1 and "Human Impact Assessment" (Analysis 4c), the total area of the leak risk zone (100 m) from the Trans Mountain Pipeline Extension is calculated to be approximately 1.69 km². By looking at Fig 1, the pipeline seems to be avoiding most areas that are densely populated (2613 - 37826 people per km²). However, the extended pipeline is still in contact with some areas where there is a higher population density (2613 - 37826 people per km²), mostly in the south-east region. This highly populated area consists of 0.39 km² that falls within the leak risk zone of the pipeline expansion.

The classification method of quantile was chosen in grouping and classifying population density (by DAs) as it fits the most for our purposes. Quantile classification ensures each class has the same number of data points. As population density in Burnaby is skewed to lower

densities with some higher density DAs, quantile method could best represent areas of higher density distinctly. From the histogram distribution of population density, breakpoints/values set by quantile method corresponds the most with the skewed distribution of population density (towards the left or lower density areas).

2. Civic Places

As in Fig. 1, the potential leak from the leak risk zone encloses one civic place which is Burnaby Mountain Secondary School which could potentially pose a significant socio-economic risk to areas around the school district and the school itself.

3. Infrastructure (transportation route types)

As in Fig. 1, the leak risk zone intersects with parts of the transportation routes including Inlet Drive, Burnaby Mountain Parkway, Gaglardi Way, Barnet Highway, Lougheed Highway and Trans-Canada Highway from all types of expressways, highways and major roads.

Conclusion

To holistically assess the viability of the Trans Mountain proposed expansion, it is important to look not only at economic benefits but also the negative physical impacts on both the natural environment and human infrastructure. Burnaby is a heavily urbanized area that also contains many natural conservation and recreation areas and creeks. The proposed pipeline, in the event of completion, would go under many populated areas and vital infrastructure like a school and major highways and roads. A spill would cause much infrastructural disruption and pose potential health risk to residents in the vicinity. The risk of environmental damage is equally significant, with the pipelines intersecting many natural features. With such a large presence of urban and natural space, the Trans Mountain expansion has large potential to cause direct harm to the City of Burnaby.

5. Error and Uncertainty

Analyzing data and producing maps always come with margins of error whether it is from the data, the analysis or the interpretation of the information provided. With risk assessments, one of the biggest factors of error and uncertainty comes from the inability to determine how a crisis would play out in real life. In the case of this project, this means that the "risk zone" of 100m that we determined has margins of error as in the case of a leak, the 100m zone used is based on the research we gathered to create that hypothesis. If a leak were to occur anywhere along with the pipeline extension, areas outside the zone could be affected as well and should not be ignored when doing extensive analysis. Throughout the analysis, population density should be smooth and continuous data because a choropleth map of population density by Dissemination Areas does not best illustrate the pattern (Fig. 1). Thus, a heat map should be used but only with sufficient data on the distribution of populations throughout the city of Burnaby (the data deficiency issue is present here). There are also smaller DAs that have highest population density due to the property of a DA being an apartment building where residents or populations are living at a vertical scale (in the high-rise apartments) rather than spread out across the DAs, leading to the modifiable areal unit problem (MAUP). Census Tracts (CTs) could be used instead due to their larger area sizes (data aggregated over larger areas of CTs) and fewer divisions than DAs, to address the MAUP and distorted or skewed values of population density in smaller DAs that are comprised mostly of apartment buildings.

In terms of civic places in the 'Human Impact Assessment' map, they are in point forms which could be adjusted to polygons only with a dataset on the polygons of the civic places such as schools and hospitals (presence of data deficiency here), which allows more spatial accuracy of data. A more detailed view of the civic polygon areas (e.g. school districts) affected by leak risk zone could be produced from adjusting points to polygons.

Another error comes with the analysis of the creeks that intersect within the leak risk zone. DEM should be taken into account when looking at the waterways since if a leak were to happen, oil would not be able to run upstream. With this being said, it is an error that each creek is entirely highlighted as at risk for oil contamination.

There is also uncertainty with the pipeline layers as they were drawn by hand. Although it was drawn carefully in reference to the visual from the Trans Mountain Website, there is no guarantee that the pipeline is the exact locations that it will be in real life. This in turn effects analysis that has been based on it such as the buffers and intersects analysis.

6. Further Research/Recommendations

Due to the limitations that come with this project, listed below are suggestions on how one could further research this topic to complete a deeper analysis.

- Include the proposed extension of the Westridge Marine Terminal and Burnaby Terminal to further analyze the risk of this project.
- Complete an extensive marine spill analysis about the damage that could be caused to the Burrard Inlet if a spill were to occur by the pipeline terminal

- Along with a leak risk assessment, a construction impact assessment could be completed in order to get a larger scale view of the damages that this pipeline will pose on the natural environment
- Complete a larger scale impact assessment from Burnaby to Alberta as this project solely focused on the municipality of Burnaby.

7. Appendices

Figure 1: Human Impact Assessment





Potential Leak Assessment of Trans Mountain Pipeline Project

Assessment of Ecologically Sensitive or Affected Areas in Burnaby

Samuel Chua, Paul Li, Moca Nimmervoll UBC Geography Dec 3, 2019

City of Burnaby, BC Marine Conservation Analysis

Figure 3: Major Creeks

Waterway Name	Waterway Length (m)	OWNER
Silver Trib.1	953.705211	CITY
Eagle Trib.6-1	264.648213	CITY
Eagle Trib.6-1-1	927.371016	CITY
Lost Creek	754.548628	CITY
Eagle Trib.3-1	95.506397	
Stoney Trib.1	2922.056441	CITY
Stoney Creek	3263.651363	CITY
Holmes Creek	520.305328	CITY
Eagle Trib.3	2302.509309	CITY
Eagle Trib.5	1246.691609	CITY
Eagle Trib	883.023796	
Silver Creek	3622.614872	CITY
Eagle Trib.6	1410.106079	CITY
Eagle Trib	622.385791	CITY



Figure 4: Flowchart for Environmental Impact Map



Figure 5: Flowchart for Human Assessment Map

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