ALASKA CANADA RAIL LINK PROJECT

FEASIBILITY STUDY REPORT

1. RAILROAD ALIGNMENT WITHIN ALASKA

1.1 OVERVIEW

There only two feasible railroad alignments within Alaska that could be used to connect the Alaska Railroad to a railroad in Canada with further connection to the contiguous United States (lower 48). Both of these alignments begin in Fairbanks and follow the Richardson Highway to Delta Junction, and then continue along the Alaska Highway to Tanacross. From Tanacross one route crosses the highway and continues along the Alcan Highway to the Alaskan/Canadian border where it would connect with a Canadian alternative.

The other Alaskan alternative would remain on the east side of the Alcan Highway then veer away from the highway in the vicinity of Tok in an easterly direction. After bridging the Tanana River the route would climb at maximum grade to the headwaters of the Ladue River and then follow the river to the Alaskan/Canadian border where it would also connect with a Canadian alternative.

For the purpose of this analysis, the railroad was considered to begin at Delta Junction. An ongoing study by the Alaska Railroad is currently considering the route between Fairbanks and Delta Junction as a stand alone project.

The all-highway route is 198 miles long and estimated to cost $1.2 billion. The highway/Ladue River route is 190 miles long and estimated to cost $1.0 billion.

1.2 Design Criteria

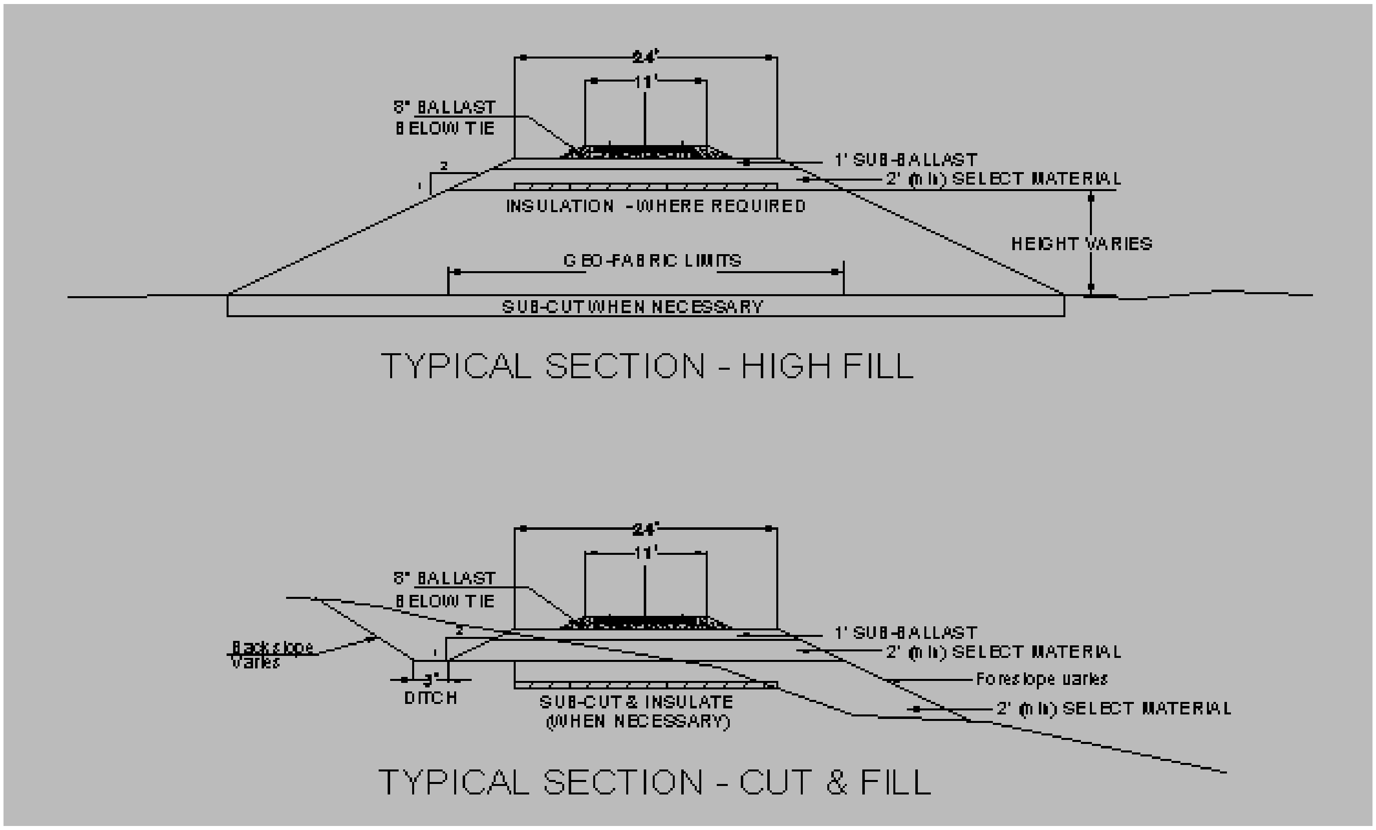
The highest design criteria were selected for the proposed railroad. The purpose in using the highest standard is twofold: sources of data used for technical analysis was limited in detail, thus the higher standard provides some ‘wiggle room’ should data prove more restrictive; and, the proposed project is lengthy, serving two countries – higher track speeds will be a more attractive alternative service when compared with delivery times of competing surface transport modes.

Design criteria are:	Design Speed -	79 mph (127 Kmh)
	Maximum Curve -	3 Degrees (1910 ft radius)
	Maximum Grade -	1.5 percent
	Track Weight -	141 lb
	Ties -	Concrete

There are no design exceptions to these criteria along the Highway Route. Both desired grades and curves are exceeded between MP 121 and MP 130 on the Ladue Route. This is an area with an 800 foot change in elevation in a short distance. This rapid change in elevation is a significant detraction from this alternative – both to and from Alaska.

1.2.1 Typical Section

Typical sections used for feasibility phase design purposes are:



1.2.2 Highway Crossings

Separate grade crossings are provided at all highway crossings.

<u>Alaska Highway Alternative</u>	Project Mile Post (MP)
Alaska Highway	98
Tok Cutoff Highway	109
Alaska Highway	152
Alaska Highway	157
Alaska Highway	173
Alaska Highway	177
Alaska Highway	184
Alaska Highway	191
<u>Ladue River Alternative</u>	
Taylor Highway	127

For the purpose of this evaluation, and with the exception of the crossing at MP 191, the tracks crossed under the highway within large diameter pipes designed to accommodate railroad clear space requirements. In general, highways are ramped up and over the pipes while maintaining vertical alignment to achieve allowable passing sight distances.

At Alaska Highway MP 190, the highway is situated on a local hog-back ridge and the track is routed beneath the roadway in a tunnel. Geotechnical conditions within this ridge are expected to be poor; either very unstable rock or glacieral till containing large boulders.

Local roads will be crossed at-grade with advanced warning signs and crossbucks.

1.3 Route Descriptions

The proposed railroad alignment begins at on the south side of Delta Junction, Alaska and continues to the Alaskan/Canadian border. Two major alternatives were evaluated; the Alaska Highway route and the Ladue River route which departs from the highway route at Tanacross.

1.3.1 Delta Junction to Tanacross

Delta Junction is the proposed terminus of the Moose Creek to Delta Junction Railroad Extension Project. That project contains routing through and around Delta Junction and ends at a proposed railroad station site. The project is in the preliminary design and environmental evaluation phase.

<u>MP 0 to MP 35</u> - The Alaska Canada Rail Link Project begins at Delta Junction. It continues parallel to the northeast side of the Alaska Highway from MP 0 to MP 35. This section of the route is virtually straight. There are no grade concerns. Foundation conditions are thought to be good to excellent. At MP 37 the alignment crosses the Grestle River. Grestle River is within a wide floodplain and is a tributary of the Tanana River.

<u>MP 35 to MP 40</u> At MP 35 the route continues to follow the highway to MP 40. The railroad is contained within a narrow corridor between the highway and Tanana River. Curves in this section remain at 2 degrees or less. There are no significant grade concerns. At Mile 39 the railroad crosses the Johnson River. Johnson River is also in a wide floodplain and is a tributary of the Tanana River. It enters the Tanana just over a mile downstream from the proposed crossing site. Foundation conditions are expected to be good. Some side hill construction is expected.

<u>MP 40 to MP 49</u> At MP 40, the Tanana River's valley narrows upstream to MP 49 where it begins to widen out again. In this segment the railroad moves away from the highway to take advantage of better alignment opportunities and to avoid a small lake. At MP 42 the alignment crosses a major slough of the Tanana River. At MP 47 it again crosses the same slough. Foundation conditions are expected to be fair to good; however, some overburden and frozen material will be encountered. Curves will remain at 2 degrees or less. There are no grade concerns.

<u>MP 49 to MP 60</u> At MP 49, where the Tanana River's valley begins to widen out upstream, the river is adjacent to the hill slopes on the north side of the valley. The highway is similarly located adjacent to the hills on the south side. In between, there is a broad band of wetlands that range from 1 to 2 miles in width. These wetlands are frozen silts that likely overlay frozen river-run gravel. The railroad alignment moves closer to the Tanana River to take advantage of the higher ground on the natural levee formed by high water deposits over time. Foundation conditions in this segment are expected to be fair to poor. Curves will remain at 2 degrees or less. There are no grade concerns.

This segment of the alignment will bypass the community of Dot Lake. Dot Lake is a small community on the Alaska Highway of about 25 people. It began as a work camp, known as Sears City, during the construction of the Alcan Highway during WWII. A small train stop shelter could be built where the alignment joins the highway, approximately 5 miles to the south or the rail alignment could be modified to bring the tracks to within one mile of the community. The wishes of the Dot Lake community would have significant influence regarding any modification.

<u>MP 60 to MP 75</u> At MP 60 the proposed alignment turns and proceeds almost due south for nearly 5 miles where it again joins with the Alaska Highway. It then parallels the highway for nearly 2 miles where it again veers away in a southeast direction for over 4 miles. The route then turns toward the south for over 4 miles where it crosses the Robertson River at MP 75 and again joins the highway. The Robertson River crossing is a little more than a mile above its confluence with the Tanana River. As with previous rivers, Robertson River is located in a wide flood plain. Curves remain at 3 three degrees or less. There are no significant grade concerns. Some full cuts and side hill cuts will be necessary. Foundation conditions are expected to be from fair to good.

<u>MP 75 to MP 85</u> In this segment the railroad alignment remains adjacent to the highway and the Tanana River valley becomes a canyon less than a mile wide before widening again beyond MP 85. Proposed curvature remains at 3 degrees or less. Short grades between 1 and 1.5 percent are anticipated. Most of this segment of track will be in full or side hill cut. Foundation conditions are expected to be good.

<u>MP 85 to MP 98</u> In this section the railroad deviates from the highway between MP 86 and MP 90 for terrain features. Beyond MP 90 the railroad alignment is parallel the highway. The junction between the Highway route and the Ladue River route is located at MP 98. All curves within this section are 3 degrees or less. There are no significant grade concerns. Foundation conditions are expected to be good to excellent.

The community of Tanacross is located at MP 98. A small train station will be needed to serve Tanacross.

1.3.2 Tanacross to Alaska Canada Border (Highway Route)

The community of Tanacross is a small community of approximately 150 people. It is located just off the Alaska Highway. The community has a 5000 foot paved runway that was built during WWII as an emergency airport for military aircraft flying to and through Alaska. Because of the good foundation conditions in the area, the airport is still in good shape although the paved surface has deteriorated but is still very useable. A rail link with this community’s airport and highway access creates economic potential. Natural resources to be exploited include timber, mining, agriculture, and tourism.

<u>MP 98 to MP 109</u> This section of alignment connects Tanacross with Tok, also a small community located at the junction of the Alaska Highway and Tok Cutoff Highway. At MP 98 the railroad alignment crosses the Alaska Highway using a pipe under crossing. After crossing the highway the railroad continues heading away from the highway for about 2 miles where it turns and then remains parallel to the highway for approximately 8 miles. There it intersects the Tok Cutoff Highway at MP 109. A pipe undercrossing is scheduled for the Tok Cutoff Highway, (rail under highway).

Tok is a local unincorporated community with a population of about 1,500. Its center is located at the intersection of the Alaska and Tok Cutoff Highway. Tok was established in 1942 as an Alaskan Road Commission construction and maintenance camp for the Alcan Highway. It has served as the 'Gateway to Alaska' since 1942 and served as a US Customs station until 1971. A small train station will be needed to serve Tok.

Four miles of this segment is located on, what may be, section line right of way. Foundation and grade conditions are excellent within this segment. Most, if not all, of the route construction is expected to overlay the natural ground.

MP 109 to MP 119 This segment of the alignment lies between the Tok Cutoff Highway and the Tanana River MP 119. At MP 114 the alignment crosses the Little Tok River. Foundation conditions are expected to be good. However, the meandering course of the Little Tok River suggests that some overburden, permafrost, and wetlands will be encountered. Curves in this segment do not exceed 1 degree. Vertical alignment poses no problems. Most, if not all, of the route construction in this segment is expected to overlay the natural ground.

Most of this segment is also located on what may be section line right of way.

Tanana River to Alaska Canada Border Overview Once the Tanana River is crossed at MP 119 the route encounters conditions which are very dissimilar from those conditions found between Delta and Tok. Here, the Alaska Highway has been constructed along the dividing line that is flanked to the north by a geological formation that consists of medium mountainous terrain extending north to the Yukon River. To the south, geological conditions consists of a river delta hosting numerous lakes, meandering streams and wetlands. Foundation conditions throughout this route are expected to be consistently fair to poor. Permafrost in silts and sands will be prevalent.

Material sources within the delta will contain mostly sands. Material sources located in uplands are expected to yield fair to poor quality shist and decomposed granite. Decomposed granite was used extensively between the Tanana River and border to surface the original Alcan highway built during WWII. It made for a smooth driving surface that held up well at the time.

Developing technology as well as research for new methods and embankment over soil conditions found in this section of the project hold promise of stronger and more stable road beds. If possible, and time permits, research and testing of these and other materials and methods, should be accelerated.

A segment by segment description follows:

MP 119 to MP 133 This segment of the alignment crosses over the Tanana River and closely follows the Alaska Highway alignment and ends at Midway Lake. The alignment is located on the southern side of the Alaska Highway. The horizontal alignment contains numerous 3 degree curves. Vertical alignment is not expected to pose significant problems. Slight to medium sidehill cuts are anticipated throughout this segment. Most areas will require separation fabric to assist in stabilizing the track embankment.

At Midway Lake, location of the railroad is confined to the space between the highway and lake shore. Encroachment into the highway right of way will likely be necessary.

MP 133 to MP 160 The segment between Midway Lake and MP 151 is similar in all respects to the previous segment. However, the segment between MP 151 and MP 160 poses the most engineering challenges within the entire Alaska Highway alternative. Between MP 151 through MP 152 the alignment traverses through a rock knob that protrudes into the Tanana River. Because the rock contained in the knob has withstood river erosion, suggests that material from the knob would be a unique source of construction material that may qualify for rip rap. There will be a significant demand for bank protection from the Tanana River, both up and down river from this site. In particular, bank protection will be needed at MP 148; MP 158; and MP 160. Additional bank protection for the highway may be needed between MP 153 and MP 155. The railroad alignment crosses the highway at MP 153 then back again at MP 160. Between these two MPs the railroad will be immediately left of the highway when driving towards the border. This segment of alignment will require a significant side hill cut and some highway reconstruction as well. All curves remain at 3 degrees or less and vertical alignment is not expected to pose significant problems.

At MP 156 the Nabesna and Chisana rivers join to form the Tanana River. This junction of rivers poses a significant hydrological concern because of it's proximately to the highway and the proposed railroad alignment. The Chisana River flows parallel to the road and rail alignment, but the Nabesna River flows at right angle to the Chisana River directly into the highway and proposed rail alignment.

While this segment poses engineering challenges, none are insurmountable; adequate quantities and quality material is available within the immediate area, minimum design criterion can be maintained. Alternatives to build this section would require relocating the highway further into the hillside and keep the railroad on the river side.

MP 160 to MP 176 At MP 160 the alignment crosses back under the highway and continues to closely follow the Alaska Highway. In situ terrain and geotechnical conditions are similar to the section between the Tanana River crossing and Midway Lake. There is only one 3 degree curve in this section. All others are 2 degrees or less. Grades are anticipated to vary between 0 and 1.5 percent resulting in a rolling grade. There will be overlay; sidehill cuts; and full cut sections within this segment. Most areas will require separation fabric to assist in stabilizing the track base.

At MP 160 the railroad will also cross the Northway access road. Northway is a small community located nine road miles off the Alaska Highway. The population of Northway is about 100. Like Tanacross, Northway was established around 1942 when the military constructed a runway to support military aircraft flying to and through Alaska. Unlike Tanacross, the Northway airport is noted for its poor runway condition. At the time of construction, sand was the only material available in the vicinity. Sand was use for both the runway base and pavement. It was heavily damaged by the November 3, 2002 Denali Fault earthquake. The Northway airport serves as a Port of Entry for light aircraft flying to Alaska.

The Railroad crossing Northway's access road will an at-grade crossing with crossbucks. A small railway shelter has been scheduled at this location for Northway residents.

At MP 173 the alignment again crosses the Alaska Highway. Relocating to the northern side of the highway avoids some adverse terrain features on the southern side and provides for a better crossing of Gardiner Creek at MP 176.

<u>MP 176 to MP 184</u> After crossing Gardiner Creek the alignment remains on the northern side of the highway until MP 178 where it crosses the highway again and continues on the southern side. At MP 180 the alignment again crosses the highway to take advantaged of gentler terrain. It remains on the northern side to MP 184 where it crosses back to the southern side.

The highway and proposed railroad alignment traverses ancient glacier moraines covered by wind blown silt causing rolling terrain and deep incised streams. The resulting jumbled geology is the reason the railroad alignment switches from one side of the highway to the other several times in this segment. The railroad needs to be on the side that offers the best alignment and grade conditions to remain within design criteria. Highways design criteria are much more flexible in such terrain.

Poor foundation conditions are expected to prevail throughout this section. In situ material is expected to silty, sandy gravels with large boulders. Foundation conditions will vary from the considerable cut and fills that will be necessary to maintain both desired horizontal and vertical alignments.

<u>MP 184 to MP 198</u> After crossing back to the southern side of the highway at MP 198, the railroad alignment moves away from the highway for as much as a mile and a half before it returns and crosses under the highway at MP 191. After crossing to the northern side of the highway the alignment moves away to the north where it crosses the border approximately 3 miles north of the highway.

Geotechnical conditions in this section differ somewhat from that of the previous section. It traverses the lower foothills of the higher mountain range to the north. The highway takes a higher and more direct route through this area. At MP 191 the highway is situated on a hog back ridge connecting two higher hills. The railroad alignment has been routed through the ridge via tunnel under the highway.

There are no realistic alternative to this tunnel if horizontal and vertical criteria are to be maintained. It would take a significant deviation from these criteria to avoid it and maintain the proposed routing.

An alternate routing extending to the south has been considered but has been dropped from further consideration at this time, for the following reasons:

- It would encroach approximately 7 miles into the Tetlin Wildlife Refuge;
- It would add up to 20 miles of track in the refuge;
- It would require a deviation from the desired criteria as both 4 and 5 degree curves would be necessary
- The alignment would traverse extremely poor foundation conditions.

Further analysis will be forthcoming on this possible alternative to better document the adverse conditions.

The proposed tunnel will be approximately one half mile in length. Rock conditions are expected to be poor and unstable. Consequently, the estimated cost of this tunnel includes lining for its entire length.

As previously noted, the proposed railroad routing remains well north of the highway after crossing under it. The northern routing avoids approximately 4 miles of wetlands that the highway crosses. The highway suffers major deformation in this area and requires constant maintenance attention.

The proposed ending point of this alignment is subject to modification to match alignments on the Canadian side of the border.

1.3.3 Tanacross to Alaska Canada Border (Ladue River Route)

The Ladue River Route alternative separates from the highway route at the community of Tanacross. A description of the Tanacross community was provided in Section 1.3.2. As noted, a small railroad station has been planned for the community.

MP 98 to MP 120 After reaching Tanacross the Ladue River route remains on the northern side of the Alaska Highway rather than crossing it as the highway route did. This alternative, as presented avoids all crossings of the Alaska Highway. However, the railroad will cross the Tanacross Village Road. An underpipe crossing has been planned for this road.

After leaving Tanacross the alignment continues parallel the Alaska Highway until reaching Tok at MP 109. At MP 113 the alignment crosses the Little Tok River. Foundation conditions are expected to be good. The alignment passes to the north of Tok and then turns in a northerly direction until reaching the Tanana River where it crosses the river and turns to the southeast and begins climbing at maximum grade towards the headwaters of the Ladue River.

Both Tanacross and Tok are located on a vast delta with excellent foundation conditions. Thus there is ample opportunity to make changes to the alignment to accommodate input from these communities regarding the final alignment and location of service facilities.

MP 120 to MP 131 This is the most onerous section of the Ladue River alternate. The grade begins at the east bank of the Tanana River at elevation 1650 msl and climbs to the headwaters of the Ladue River, elevation 2550 msl. The alignment must sustain a 1.5 % grade for the entire 11 miles in this section to achieve this 900 feet change in elevation. The route selected, is a combination of the many routes reviewed and appears to provide the minimum distance needed to achieve the 900 feet change in elevation. There are four, 4 degree curves within the section. These exceed the desired 3 degree maximum curve criteria. While the sustained grade is assumed to be 1.5 percent, there will no doubt be short stretches that will exceed 1.5 percent. Trestles will be needed in this section.

AT MP 127 the railroad crosses the Taylor Highway. As with other highways this crossing can be separated using an under crossing pipe.

A siding will be needed at the top of this grade to accommodate longer freight trains heading towards the border. This will complement a proposed track yard in Tok as extra engines can be used to pull this grade, an 18 mile run from Tok. More information regarding sidings is contained in paragraph 1.5.2 Sidings.

MP 131 to MP 147 This section of the Ladue River alternate maintains an alignment that favors the southern-facing side of the Ladue Canyon. There are several advantages of maintaining southern exposure:

- Foundation conditions are generally drier;
- Spring melting occurs sooner;
- Back slopes are less likely to ice rich material that flows when thawed;

Locating the alignment up slope also lowers the flood risk. However the avalanche risk is increased.

Foundation conditions are anticipated to be fair to good. Curves in this area do not exceed 3 degrees and vertical alignment can be sustained at or below desirable criteria.

MP 147 to MP 166 The first portion of this segment, between MP 147 to MP 151 is located in a narrow part of the Ladue Canyon. A short tunnel may be required at MP 150; however a large cut to avoid the tunnel is suggested, in order to take advantage of the excess material.

Bridges over the Ladue River will be required at MP 148 and MP 149.

The Ladue River begins to meander within the confines of the canyon in this alignment segment. Also, foundation conditions in the valley bottom begin to deteriorate and become progressive worse in both Alaska and Canada. The valley bottom was once the bed of glacial lakes that occurred when glacial runoff encountered natural dams that backed silt laden waters nearly to the headwaters of the Ladue River. The bed is composed of glacial silt and clay laden settlement which becomes greater in depth as the river progresses downstream.

Eventually, the lake found an outlet flowing into the Yukon River. The sedimentary lake bed remained. On one hand the bed provides a gentle grade from its headwaters through out Alaska and well into Canada. On the other hand, the uniform silt and clay deposits provides a ‘worse case’ scenario to construct on and is especially venerable to seismic activity.

MP 166 to MP 190 The South Fork of the Ladue River joins the Ladue River at MP 166 resulting in an order of magnitude increase in flows from the combined drainage areas. Here, the Ladue valley is littered with oxbow lakes created from the meandering streambed. Foundation conditions in the valley bottom are expected to be poor. As with previous sections the alignment is situated on southern exposed slopes as much as possible.

The alignment crosses the Ladue River at MP 181; MP 183; and MP 186. The Ladue River Alternative crossed the border into Alaska at MP 190.

1.3.4 Drainage & Bridges

This Chapter provides the reader with assumptions used to calculate the approximate costs to construct at bridges and culverts for both the Alaska Highway and Ladue River routes from Delta Junction, Alaska to the Canadian border.

1.3.4.1 Basis of Estimate

Bridge costs at various locations in the U.S. and Alaska were gathered and adjusted to equivalent Alaska costs. Data included cost and type of superstructure, substructure, and abutments. Mobilization, fill, and contingency costs are included in all cost estimates.

Alternative railroad bridge types were investigated for a given crossing. This information was used as a basis for selecting the most economical bridge structure. For example, bridge span vs. pier height was examined. Economics are based on:

- Historical data from highway bridges previously constructed in Alaska.
- Costs for railroad bridges constructed recently in other states.

Highway bridge costs were provided by the Bridge Design Section of the Alaska Department of Transportation and Public Facilities (AKDOT&PF). Costs for railroad bridges were provided by Tom McCune at HDR Engineering. The HDR railroad bridges were located in Kansas, Colorado, Washington, North Dakota, and Iowa. Costs for each were geographically corrected to Fairbanks, Alaska. Additional information related to the costs of railroad bridges were supplied by W.G. Byers at the Burlington Northern and Santa Fe Railway.

1.3.4.2 Design Criteria

Railroad bridges will meet the current AREMA standards. This standard has a provision that railroad bridges be designed to carry Cooper E80 loading, a much heavier load than the highway load. Subsequently, economical spans in railroad bridges are shorter than the spans for highway bridges.

Costs are based on a single track located on the bridge centerline. In this study, the bridge deck is assumed to be 18-ft wide between curbs, and the substructure pier caps and abutments widths were sized to match the width of the superstructure. Bridge costs are based on prestressed Bulb-Tee(s) with spans up to 100-ft or Steel plate girders with spans approximating 150-ft. The expected costs are nearly the same.

A pier height of 20 feet was used as the base height to approximate substructure costs. The most economical spans are between 45 and 50 feet for railroad bridges and about 130 feet for highway bridges. While short span railroad bridges are cost effective, the accumulation of debris and ice damage precludes spans shorter than 100 ft. Special design considerations for these crossings are:

- Use a superstructure width of 18-ft between curbs
- 24ft wide pier cap, 3 column pier, solid breast wall or round piles as pier columns
- 24 ft wide abutment with 8 H piles

- Each site is to be designed for a major seismic event. Design details should be included to prevent the superstructure from sliding off of the supports.

- Clearance between high-water and the superstructure should be 10 feet.

- Creeks and Rivers may be wide and braided or narrow and deep. Flows may leave large deposits of trees and debris. During spring thaws, large chunks of ice may impact the piers. Debris, ice and earthquakes my induce large forces Thus, the design criteria is:

- If possible, the minimum span will be 100-ft.
- Piers are to be armored to resist forces from ice flows and floating debris.
- It is recommended that the piers have a solid breast wall. This would help prevent trees and ice from wedging around the pier structure.

1.3.4.3 Alternative Routes

The assumptions used to estimate the costs of bridges and culvert crossings are presented herein. The number of bridges and culverts for the Alaska side of each route is discussed below. The Alaska Highway route is 198 miles long and the Ladue River Alternative is 190 miles long.

1.3.4.3 Structural costs

Costs at each bridge crossing are assumed to be a combination of the bridge structure, bridge approaches and stream protection. The structure costs are approximated as a unit cost foot times the bridge length. These costs are affected by the bridge width, span, subsurface conditions, location, material sources, and hydraulic considerations. Further the purpose of this study, costs for each bridge crossing is based on:

- 18-ft wide deck between curbs (overall width is 21-ft)
- pier caps and abutment widths are sized to match
- 10 –ft vertical clearance between high water and under side of the bridge
- A 0.25 mile approach at each abutment
- 100 yards of scour protection (riprap) upstream and downstream at each river bank.

1.3.4.4 Hydraulics

Waterway openings were selected to meet FHWA hydraulic design criteria. These provisions require a minimum bridge opening to be based on a flood with a 100 year return period or 500 year design period. Since there was no site specific hydraulic data available for this analysis, hydraulic data used to design nearby bridges on the Alaska Highway was used.

Other design criteria used include:

- A 2 foot clearance between design high water and bridge superstructure is considered minimum.

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- Except where debris accumulation is minimal, bridge spans shall be no less than 100 feet.

- A solid web pier is the preferred alternative.

1.3.4.5 Geotechnical Subsurface Conditions

No subsurface investigations were made. Nor were any significant subsurface data available. Bridge estimates assumed that foundations would be similar to that found elsewhere along the Alaska Highway.

1.3.4.6 Height Restrictions

A 10 foot clearance was assumed for evaluating possible pier heights. The height limitation was set to minimize possible build up of debris under the bridge under-carriage. The design height will be determined during permitting and input from the U.S. Coast Guard and their regulations.

1.3.4.6 Estimate Bridge Costs

Costs for each choice bridge may be approximated using a simple unit cost based on the square footage of the bridge deck. These costs are presented in the following table.

Table 1 Unit Bridge Costs

Items	**Width (ft)**	**Cost per sq ft**	**Cost per ft**
Railroad bridges:			
18-ft deck; 24-ft caps, 20-ft piers; length > 500-ft	21	$600	$12,600
18-ft deck, 24-ft caps, 20-ft piers, length < 500–ft	21	$690	$14,490
18-ft deck, 24-ft caps, 20-ft piers, length < 500–ft	21	$700	$14,700

These costs are to erect the bridge structure

At each bridge crossing, it is assumed that bridge approaches will add cost the project. A 0.25 mile length of approach is assumed at each end of the bridge. These additional costs are estimated at $1M /mile. <u>Thus, approach costs are $500,000 per crossing.</u>

At each bridge river crossing, riprap has been added for bank protection and pier protection. It is assumed that a 200 yard length of riprap is needed on each bank. The cost is estimated at $45 per cubic yard. <u>Costs of riprap for each bridge crossing are estimated at $160.000.</u>

Example- Consider a 550-ft long railroad bridge on this route. The bridge has a pier height of 20-ft. **C**alculations for the cost of this crossing are presented in the following table.

Item	**Calculations**	**Totals**
Cost of structure	$12,600(550)	$ 6,930,000
Approaches	$ 500,000	$ 500,000
Scour Protection	$ 160,000	$ 160,000
Totals		**$ 6,996,000**

1.3.4.6 Estimate Culvert Costs

The culvert costs presented herein were used for all crossings where the culvert was crossing an identifible stream. Costs for the smaller 24-inch and 36-inch drainage culverts are included with the track cost. Because of inadequate hydraulic data, it was assumed that the culvert costs will be the average of a box culvert (less than 50-ft wide) and a 57-inch x 36-inch galvanized pipe with head walls. <u>Average costs for these two options are estimated at $95,713.</u>

1.3.4.7 Estimate

The bridge and culvert costs do not include design costs. These additional administrative costs are provided for as part of the summary costs for each route. The costs for each route option are presented below.

Drainage investigations for this project have been divided into five distinct groups.

- Bridges over major rivers, these are over 500 feet long.
- Bridges will be located over all other rivers and stream crossings. These bridges are less than 500 feet long.
- Bridges have pier heights exceeding 20 feet.
- Smaller drainage courses will have large pipes – up to 6 feet in diameter with concrete headwalls. These drainage courses have been identified through topographical maps and aerial photographs.
- In addition smaller pipe sizes 36 and 24 inches in diameter are included for unidentified local drainage locations.

Additional costs were added for bridge approaches and bank protection.

Highway Route
Major Bridges are those over 500 feet in length, and with the exception of Grestle River, have piers over 20 feet high: They are located over the following named rivers:

River	Length (ft)	Estimated Cost (millions of dollars US)
Grestle River	1690	$22.0
Johnson River	900	$13.9
Robertson River	1840	$27.7
Tanana River	950	$14.6
	Total	$78.1

Bridges less than 500 feet in length and piers less than 20 feet are located at the following river and stream crossings:

Stream	Length (ft)	Estimated Cost (millions of dollars US)
Sawmill Creek	140	$2.7
Little Grestle River	200	$3.6
Dry Creek	300	$5.0
Johnson Slough	200	$3.6
Johnson Slough	200	$3.6
Chief Creek	40	$1.3
Bear Creek	80	$1.8
Cathedral Rapid 2	70	$1.6
Cathedral Rapid 1	70	$1.6
Yerrick Creek	190	$3.4
Tok River	240	$4.2
Beaver Creek	80	$1.8
Gardiner Creek	110	$2.3
	Total	$36.4

Bridges less than 500 feet in length and piers more than 20 feet are located at the following river and stream crossings:

Stream	Length (ft)	Estimated Cost (millions of dollars US)

Unnamed Slough	150	$2.8
Unnamed Slough	200	$3.6
Sheep Creek	100	$2.1
Cathedral Rapid 3	150	$2.8
Bitters Creek	100	$2.1
Silver Creek	100	$2.1
10 Mile River	100	$2.1
Sweet Water Creek	100	$2.1
Scotty Creek	100	$2.1
	Total	$21.8

In addition to the above bridges, there are 68 identified small drainage courses that will require large diameter culverts with headwalls. These are estimated to cost $95,700 each, for a total of $6.5 million.

Total bridge cost for the Highway Alternate is estimated at $142.9

Ladue Route

Major Bridges are those over 500 feet in length, and with the exception of Grestle River, have piers over 20 feet high: They are located over the following named rivers:

River	Length (ft)	Estimated Cost (millions of dollars US)
Grestle River	1690	$22.0
Johnson River	900	$13.9
Robertson River	1840	$27.7
Tanana River	950	$14.6
	Total	$78.1

Bridges less than 500 feet in length and piers less than 20 feet are located at the following river and stream crossings:

Stream	Length (ft)	Estimated Cost (millions of dollars US)
Sawmill Creek	140	$2.7
Little Grestle River	200	$3.6
Dry Creek	300	$5.0
Johnson Slough	200	$3.6
Johnson Slough	200	$3.6
Chief Creek	40	$1.3
Bear Creek	80	$1.8
Cathedral Rapid 2	70	$1.6
Cathedral Rapid 1	70	$1.6
Yerrick Creek	190	$3.4
Tok River	240	$4.2
	Total	$32.3

Bridges less than 500 feet in length and piers more than 20 feet are located at the following river and stream crossings:

Stream	Length (ft)	Estimated Cost (millions of dollars US)
Unnamed Slough	150	$2.8
Unnamed Slough	200	$3.6
Sheep Creek	100	$2.1
Cathedral Rapid 3	150	$2.8
Unnamed Creek	100	$2.1
Unnamed Creek	100	$2.1
Unnamed Creek	100	$2.1
Ladue River	150	$2.8
Ladue River	150	$2.8
Unnamed Creek	100	$2.1
Unnamed Creek	100	$2.1
Chicken Creek	100	$2.1
Unnamed Creek	100	$2.1
Ladue River	200	$3.6
Ladue River	200	$3.6
Ladue River	250	$4.3
McArthur Creek	100	$2.1
	Total	$45.3

In addition to the above bridges, there are 60 identified small drainage courses that will require large diameter culverts with headwalls. These are estimated to cost $95,700 each, for a total of $5.7 million.

Total bridge cost for the Ladue River Alternate is estimated at $161.4 million.

1.4.0 Avalanches

1.4.1 Avalanche Risk. There is little risk of avalanches on either route. The area has an average snow fall of 38.3 inches annually. In comparison, Fairbanks has over 60 inches and Valdez has nearly 330 inches.

The Alaska Department of Transportation and Public Facilities maintenance forces do not experience significant problems from avalanches in the area.

Some minor avalanching could occur in cuts with steep back slopes if left exposed. Such occurrences would not pose danger to life and limb but rather create maintenance headaches.

No funding has been included for snow sheds, avalanche diverters etc.

1.5.0 Sidings

1.5.1 General. Three types of sidings have been provided for in the Alaskan portion of the railroad: Major sidings that are 13,250 feet long; Standard sidings of 7,250 feet long; and Maintenance of Way (MOA) and bad car setout sidings that are 2000 feet long.

1.5.2 Major Sidings. Two major sidings are being proposed for both alternative routes.

A major siding has been located in the Tok or Tanacross area. Tok and Tanacross are separated by only a few miles and both have similar terrain features that include vast flat areas with good foundation conditions. They are located approximately 100 miles from Delta Junction and 200 miles from Fairbanks. It is the last very good site in Alaska for either the Highway or Ladue route.

A major siding in this area is envisioned to include a maintenance yard, and possible some train repair capabilities, as well as supplemental equipment. This latter would be very important if the Ladue route were selected. After departing this area when bound for the Canadian border, the train must cross the Tanana River and pull an eleven-mile maximum grade before reaching the headwaters of the Ladue River. Extra engines to assist this endeavor, as well as possible braking when going north would be stationed at this location. This site also has a significant labor force available to the railroad.

At this time there are no significant factors to point to either Tancross or Tok as a favored location. Tok is located approximately 10 miles closer to the Ladue Grade if that route is chosen.

Tanacross is in the vicinity where the Highway route crosses the Alaska Highway. Tanacross also has a 5000 foot paved runway which, with the highway and railroad, creates potential for a regional transportation hub. Tanacross has a local government while Tok does not.

The precise location will significantly depend upon the recommendations of the local communities.

A second major siding has been scheduled to be located close to the Alaskan/Canadian Border at either the Highway or Ladue route. Neither offers the ideal site that the Tanacross/Tok area does.

There are many operational functions to be handled at the border. These include both Canadian and Alaskan customs, crew changes, in addition to other common duties at major sidings. It seems prudent to consolidate these functions within one facility near the Alaskan/Canadian border. The area is remote from any major city in either country, however a small local community on either side of the border would benefit from the economy such a facility would add.

There are precedents locating border stations within a reasonable distance from the border rather than ON the border. For obvious reasons, Airports of Entry are located at airports often well away from the border. These serve commercial and importantly, also private air traffic. There is significant difference between commercial scheduled air service and air taxi service. While scheduled service remains under the full control of authorities, air taxi and charter operates with more latitude although there are strict regulations to enforce customs and immigration oversight. Civil aviation poses the most challenge for border authorities. Technology, cooperation, vigilance, and stiff penalties are the main tools of enforcement.

Highway border crossings are generally located within sight of the border although there have been some exceptions. For example, Tok, Alaska, nearly a hundred miles past the border, was the point of entry to the US in Alaska until 1971.

In Europe and other places passenger trains often stop at borders while officials pass through the train to check and stamp crossing papers.

All of these examples suggest that there is some latitude when locating entry points. This becomes an important consideration when considering the railroad border facility for this project. The highway route crosses the border over three miles north of the highway crossing. Consideration should be given to locate railroad customs for both Canada and the US at Snag in the Yukon Territory. Like Tanacross and Tok; Snag offers commercial and social support to a railroad customs operation. Beaver Creek also offers support, however Beaver Creek is not as conveniently located to serve this need.

The second major siding for the Ladue River route is also located at the border for the same reasons as the Highway route. However, there are no communities located near the Alaskan/Canadian border crossing on the Ladue River route to take advantage of the economic boost it would provide. Nor are there sites within the immediate vicinity on either side of the border that favorably stands out. Any facility to serve border crossing functions would have to contend with the same poor seismic foundation conditions that are beneath the track.

This is an issue to be further explored prior to finalizing this discussion. Regardless of where the border crossing is located, funding in the amount of $3.4 million for custom facilities plus $1.1 million for track sidings has been included in the estimate.

1.5.3 Standard Sidings. Standard sidings have been included at the following locations between Delta Junction and Tok, Alaska:

- MP 13 – This siding is 13 miles south of Delta Junction and located on good foundation conditions that slope gently to the northeast. This siding will serve an ongoing lumber production center.
- MP 40 – The siding at MP 40 has been located an appropriate interval from Delta Junction and to serve the Johnston River Highway Maintenance Camp.
- MP 65 – This siding will serve the Dot Lake community and will have a small station.
- MP 90 – The siding located at MP 90 will maintain an appropriate interval between major sidings. There are no other special reasons for this location and is subject to deletion or location change.

The next siding between MP 90 and Tok will be the Major siding located at either Tanacross or Tok.

The following standard sidings are located between Tok and the border on the Highway route.

- MP 127 - The siding located at MP 127 will also maintain an appropriate interval between major sidings. However, it has been sited to take advantage of better foundation conditions and a long tangent on the main line.
- MP 152 – The siding proposed for MP 152 has been sited to serve a potential quarry for rip rap or ballast.
- MP 160 – The siding proposed for MP 160 is located to serve the Village of Northway.
- MP 180 – The siding located at MP 189 maintains an appropriate interval between major sidings and also is located at the proposed tunnel site.

The following standard sidings are located between Tok and the border on the Ladue River route. With the exception of sidings located at MP 117 and MP 133; siding locations have been based on appropriate intervals and available tangents on the main line. They can be relocated to serve higher purposes.

- MP 117 – the major siding located at MP 117 is located at the bottom of the grade leading to the headwaters of the Ladue River.
- MP 133 – The major siding located at MP 133 is located at the headwaters of the Ladue River.
- MP 160 - The siding located at MP 160 will maintain an appropriate interval between major sidings. However, it has been sited to take advantage of better foundation conditions and a long tangent on the main line.
- MP 179 - The siding located at MP 179 will maintain an appropriate interval between major sidings. However, it has also been sited to take advantage of better foundation conditions and a long tangent on the main line

1.5.3 Maintenance of Way Sidings. Maintenance of Way and bad-car setouts sidings were not specifically located. However, the project estimate for each alternative contains funding for 20,000 feet of MOW sidings - approximately 10 sidings each.

1.6.0 Facilities

1.6.1 Funding for Support facilities contained in this report include a modest passenger facility in the Tanacross and Tok area and smaller shelters at Northway and Dot Lake. A larger multifunctional station has been included near the Alaska/Canada Border for border crossing purposes. Siding costs reflect these modest facilities and include structures and site development. All of these facilities would be located in conjunction of major sidings thus no additional cost have been added for track work. Comprehensive maintenance facilities may be desired at either Tok or Tanacross but such cost has not been included.

1.7.0 Construction Costs

Construction costs have been estimated for each alternative. Estimates include costs for mainline track, bridges, sidings, and support facilities for both the railroad and border stations. These are summarize below, cost are in U.S. Dollars in millions of dollars:

DISCRIPTION	HIGHWAY ROUTE	LADUE ROUTE
Track	561.6	456.0
Bridges	142.9	161.4
Facilities	6.0	5.1
Subtotal	$**710.5**	**$622.5**
Contingencies (20%)	142.1	124.5
Construction Engineering (15%)	106.6	93.4
Total	**$959.2**	**$840.4**
Design Engineering	178.1	170.9
Right 0f Way	0.5	0.5
Environmental Permitting	25.0	25.0
Grand Total	**$1,162.8**	**$1,036.8**

Appendix ___ contain detailed spread sheets for each of the alternatives.

1.8.0 Maintenance Costs

For budgeting purposes, the Alaska Railroad Corporation currently estimates $37,000 per mile annually for system maintenance. This equates to $7.3 million for the Alaska Highway Route and $7 million for the Ladue Route.

These numbers should be used with some caution. The last 100 miles prior to reaching the Canadian border is fraught with ice rich soils on either the Highway or the Ladue River route. Further, the Ladue River route is very vulnerable to seismic activity.

1.9.0 Foundation Research

There are dramatic changes in foundation conditions once either alignment crosses the Tanana River and continues to the Alaskan Canadian Border – and for several hundred miles beyond. The Alaskan Highway is evidence of the changed geological conditions.

Traditional construction methods used through this area has met with little success and requires an inordinate amount of maintenance effort to keep the road in fair to poor condition. A traditional constructed railroad will encounter similar challenges. Maintaining a 79 mph track will be difficult and costly to maintain.

Elsewhere, throughout the northern hemisphere, transportation construction in similar conditions has been mitigated through the use of Geofoam. Other methods that provided some success include passive thermo facilities to freeze and maintain a frozen foundation; and through the use of geofabric that go beyond its use as separation fabric.

These mitigation measures base their performance upon three basic objectives:

- Maintaining a frozen subgrade;
- Preventing frost susceptible material from contaminating the subgrade; and
- Reducing the infrastructure weight through the use of lightweight construction material.

While these technologies have been proven effective and are no longer considered experimental; applying them to this project will require further in-situ evaluation to fine-tune the most effective method or combination of methods, as well as specific designs, to best stabilize the foundation within the area of concerns.

It is recommended that, as a part of project development, a test project be designed and constructed with these objectives in mind. The Goldstream Valley near Fairbanks and the University of Alaska provides an ideal investigation and demonstration site. Foundation conditions are similar to what will be encountered near the Alaskan Border. The Alaska Railroad traverses through the Goldstream Valley and the track requires high maintenance and must reduce speeds through the area.

The project would be planned and implemented adjacent to the existing railroad. Once constructed, the railroad would utilize the investigative track to determine performance under actual conditions.

The project would be divided into four phases:

- Phase 1 would be inclusive of establishing the scope, objectives, investigative team; roles of participating entities; budgets; and project management.
- Phase 2 would be inclusive of permitting and design;
- Phase 3 would focus on construction; and
- Phase 4 would be inclusive of operating, monitoring, evaluation, and reporting conclusions and recommendations.

It is envision that the Goldstream track performance project would be implemented in a timely manner so as not to delay the rail connection Alaskan and the Canadian railroad. Much of the alignment and design, both in Alaska and Canada, is through areas where conventional designs are appropriate. Alignments within those areas of special concern would also be established, but embankment designs would be scheduled to take advantage of investigative results of the Goldstream track performance project.