

*Rehabilitation of Canadian National Railway  
Track Servicing Oil Sands in Northern Alberta*  
**The Athabasca Northern Railway**

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## Abstract:

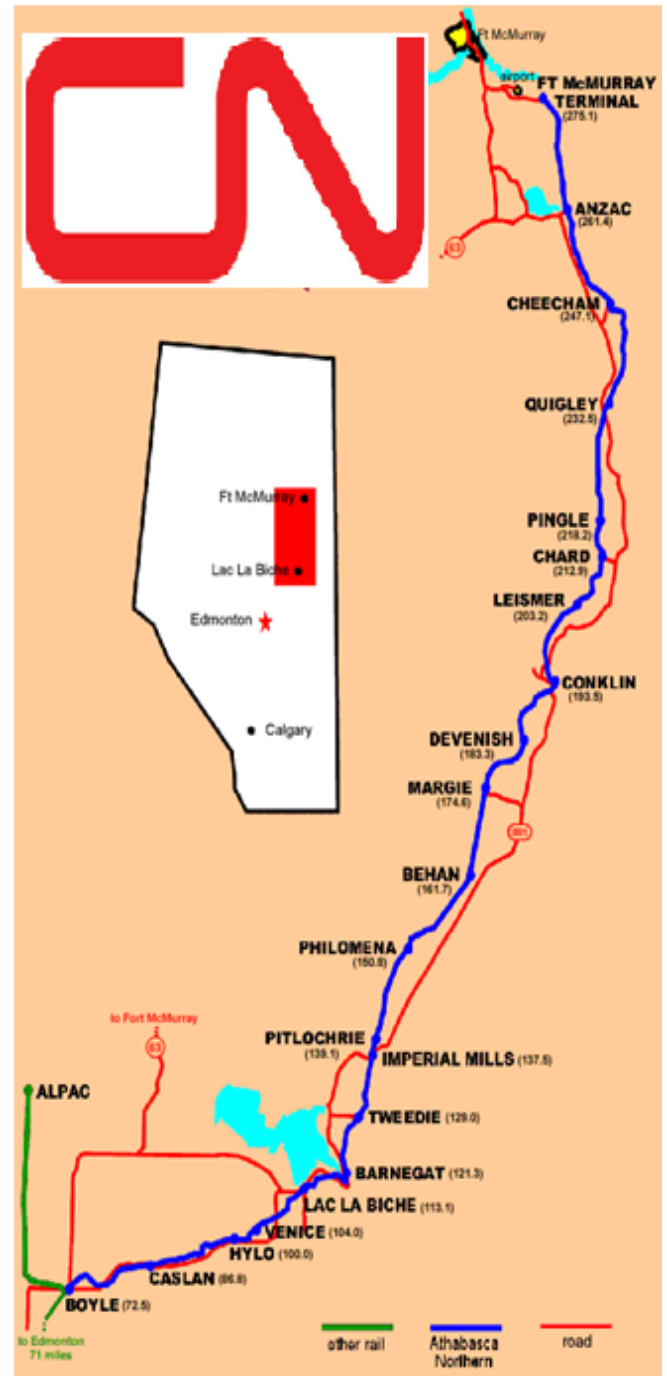
In 2007, Canadian National Railway (CN) purchased 201 miles of track from Athabasca Northern Railway.

CN planned to utilize the line for the transportation of materials needed to develop the oil sands. CN committed to upgrading the line to accommodate 25 mph traffic with 268,000-pound car loadings year round to provide reliable transportation of such materials.

Upon taking ownership, CN began employing various maintenance practices to upgrade the condition of the line. These practices included tie replacement, ballast distribution, rail replacement, and surfacing. In mid 2009, CN realized that it needed to consider alternative maintenance practices, as the maintenance practices to date had only provided temporary solutions. The track was continuing to sink back into the sub-grade after ballasting and surfacing efforts, prompting CN to investigate alternative methods of track rehabilitation.

Early investigations focused on undercutting and sledding, but high costs and low production rates made these unattractive options. CN then began discussions with Loram to develop a maintenance solution to address its needs. Over months of discussion and design efforts, CN and Loram determined a track lifting and sledding operation would tackle the unique problem. The track lifter provides a six to eight inch lift, while the sled levels off the cribs, creating a level grade for the track.

This paper will address the maintenance need that spurred the design of this “new-to-market” equipment, the maintenance process, the challenges overcome, and the results of the project.



(Fig 1 – ANY Subdivision)

## History:

The Athabasca Northern Railway (ANY) Subdivision was born as the Alberta and Great Waterways Railway (A&GWR). This historic railway of Canada was built from 1914 to 1919, running 201.9 miles between Boyle, Alberta and Fort McMurray, Alberta. This short line was built to access the rich natural resources and undeveloped land in northeast Alberta.

Due to financial issues associated with World War I, the A&GWR became part of the newly formed Northern Alberta Railways (NAR). As part of the NAR, this line proved to make significant contributions by transporting heavy equipment and supplies required for developing the surrounding communities and Oil Sands Projects in Fort McMurray.

In 1981, the CN incorporated all NAR lines into their network to allow for greater access to the north and west on secondary lines. In 1996, the CN identified the ANY Subdivision as a divestiture through sale and was subsequently sold in 2000 becoming the Athabasca Northern Railway Ltd (ANR). During ANR operation, the carload traffic grew from no cars in 2000 to nearly 12,000 carloads in 2007. With the added traffic, it soon became apparent that the line would require a massive upgrade to meet future traffic demands.

Due to rapid deterioration of track conditions resulting from the growth in traffic and the large resources required for an upgrade, the ANR could no longer remain viable and management determined the line would have to be abandoned in late 2007. Before abandonment was implemented, the line was re-acquired by

CN and a massive rehabilitation project was planned and is currently underway.

Through continued support from CN and various Fort McMurray industries the ANY Subdivision will remain a crucial link to the Oil Sands, and an important key to many future successes in Alberta.



## Rehabilitation Assessment Needs:

When rehabilitating a short line railroad, one needs to have a full understanding of the current physical condition of the railroad and potential future traffic demands. Upon requisition by CN, the ANY Subdivision had significant deterioration throughout the entire line. To save the short line from abandonment, detailed inspections were made and resources were deployed to make the track a viable self sustaining railroad once again.

Due to the traffic volumes on short line railroads, they are constructed, maintained, and degrade in a different manner than traditional mainline railways. Due to these differences, changes in traffic volume on a short line have much more of a significant impact on the physical structure than those of on a mainline. The ANY Subdivision has progressed from non-existent traffic in 2000 to 2.7 MGT in 2007 and 5.5 MGT in 2010 and current projections reflect traffic volumes are to double to 11 MGT by 2015.

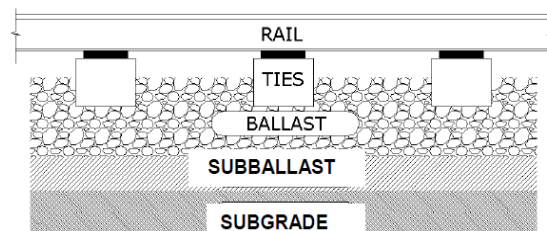
After CN took ownership of the ANY, an assessment of the track structure was conducted to determine the immediate needs to resurrect the subdivision. One determination utilized a Geometry (Geo) Test Car to analyze specific problems associated to failing track structure from Boyle to Fort McMurray. After the Geo Test Car analysis was completed, the track was deemed impassible and the test car was detained until repairs were made. Resources were immediately deployed to make all required emergency repairs to bring the track to a safe condition. Two weeks later the test car was allowed to

make the return trip to Boyle. Fig 2 is a picture taken during the inspection trip with the GEO Test Car in 2008.



(Fig 2 - CN - ANY Inspection, 2008)

Detailed planning of rehabilitation on a short line requires comprehension of the fundamental forces that are transmitted throughout the track structure, which are indicated in fig 3 below.



Stresses under car loading of 286K:

Track Foundation	PSI
Top of Rail	70 to 140K PSI
Top of Tie	100 to 400 PSI
Base of Tie	25 to 85 PSI
Top of Sub Ballast	25 to 90 PSI
Top of Sub Grade	8 to 25 PSI
Bottom of Subgrade	6 to 15 PSI

(Fig 3 - AREMA)

In addition, a detailed understanding of what are the current physical conditions of the existing tracks. This knowledge helps determine which repairs are necessary, as well as economical feasibility.

## Subsoil & Subgrade Layer

One factor present on the ANY Subdivision is the subsoil/natural ground is not the most desirable for supporting track structure. The soils common throughout the subdivision are Grey and Organic complex. Fig. 4 below maps out the soils on the ANY Subdivision.

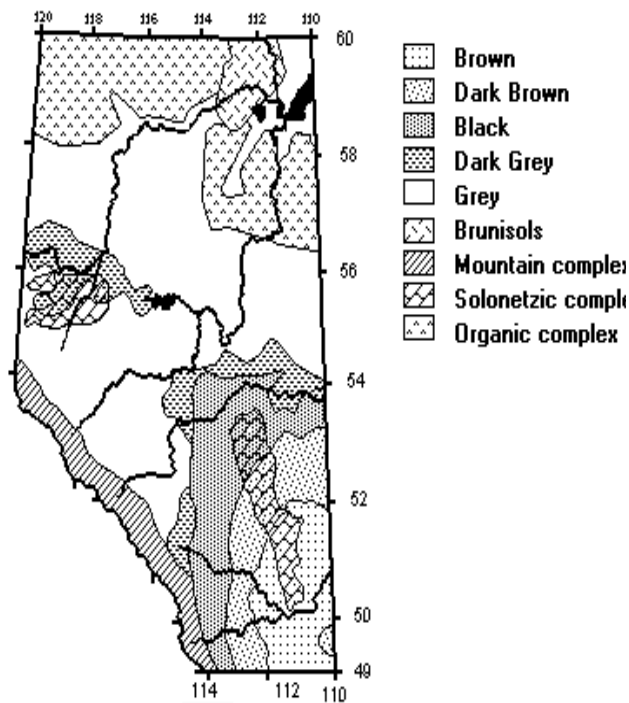


Fig 4 - (University of Alberta)

The natural properties of Grey and Organic are prone to poor drainage, frost heave, and a tendency to pump. The table in Appendix A on Page 14 represents the properties of these two soils and their suitability as subgrade materials. Having a poor subsoil layer esclates the need to have a soild track foundation that will evenly apply forces throughout the track layers, in turn eliminating surface irregularities.

## Ballast and Sub Ballast Layers

Typical mainline tamping cycles are accompanied by introducing new ballast to the track foundation. The frequency of tamping cycles is generally correlated to the gross tonnage received on a given track. Due to the low traffic volume of short lines, tamping and re-ballasting cycles are rather infrequent. The results of this over time equates to a rather thin layer of ballast, which can at times be limited to the ballast that was used to build the original track structure. Having a thin or non-existent ballast layer coupled with an increase in traffic volume on a short line can have catastrophic repercussions. When this situation occurs, it is typical to encounter considerable surface irregularities throughout the track. Consequently it will require exhaustive resources to repair the track accompanied with unacceptable traffic delays.

On traditional mainline track, ballast degradation and surface irregularities can be directly linked to: mechanical abrasion induced by repeated traffic loading, exposure to the elements generally amplified by freeze thaw cycles, handling during transport and unloading, and breakdown created through tamping.

Short lines can incur the same ballast degradation characteristics; however, there can be additional contributing factors that cause track surface irregularities that are not consistent to mainline track. These failures can be linked to the lack of compaction, combined with the shallow ballast depth. Due to these differences, the repair to correct the track foundation must be approached differently.

The tie, ballast, and subgrade structures combining function is to transmit the load applied to the rail down to the natural sub-soil layer. To have optimal success, one of the key factors is to have an equal distribution of pressure from the ties to the subgrade and subsoil/natural ground. This can be achieved by having a ballast depth between the bottom of the tie to the top of the subgrade that is equal to the center tie spacing.

Another integral way to reduce surface irregularities is to reduce the amount of deflection. Deflection is the best measure of the bearing capacity of the track foundation. Most of the deflection occurs in the ballast and subgrade (about 40% in each) with the remainder consisting of tie compression and bending of the rail. To reduce the deflection, it is necessary to provide a good track foundation coupled with routine maintenance. One of the main contributing causes of defects on the ANY Subdivision can be linked to the inadequate ballast depth, breakdown of subgrade, and poor quality subsoil/natural ground.

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Inspections of the ANY Subdivision indicated there was a consistent issue with the overall ballast depth throughout the line being too shallow to support current and future traffic volumes.

Undercutting, sledding, and raising the track were evaluated to repair the track foundation. Undercutting and sledding were ruled out for three reasons: the overall expense, the material that would be removed would provide an ideal sub-ballast section, and the low production rates of these practices. Increasing the overall ballast depth and providing an improved sub ballast layer through lifting with

tampers was determined to be the best and most cost effective approach.

## Ties

Tie life on a branch line with rather light density can vary from 20 to 40 years. There are several factors that contribute to the overall life of a tie such as: climate, traffic volume, grade of tie, preservation measures, curvature, drainage, ballast conditions, and condition of neighboring ties.

To prepare for a substantial increase in traffic, ties in a line carrying previously light traffic that are judged to be marginal should be replaced. Ties that look sufficient under a visual inspection can fail under the increased traffic and even under the stresses induced by raising and surfacing the track on new ballast. The wood cell deterioration is there all along; however, the light traffic volume is insufficient to cause the tie to fail. Therefore, when a significant increase in traffic occurred on the ANY Subdivision, tie failure and the breakdown of the track structure was experienced. A typical tie failure is indicated below in Fig 5.



(Fig 5 - Tie failure discovered while lifting on ANY)

CN management determined that a significant tie program was warranted to begin the project to ensure the track foundation could immediately handle the current needs, and preparation for potential future traffic demands. Fig 6 represents a post inspection of the extensive tie program that was completed on the ANY.



(Fig 6 -Ties replaced on the ANY, 2009)

Additional efforts were required in areas with a natural soil that consist of Muskeg. Ten foot ties, additional bank widening, and added depth of ballast was implemented to provide additional load bearing support throughout the foundation of the track. A representation of the ten foot ties installed in a muskeg region can be seen in fig 7.



(Fig 7 - Ten foot ties in muskeg soil area)

## Drainage

The main objective of track drainage is to keep the lower ballast and subgrade from being saturated. Providing good drainage near the roadbed will provide a stronger track foundation.

The main value in drainage is increasing the bearing capabilities of the track, which is directly related to the stability of track line and surface. The water saturation of the ballast and soils decreases the overall bearing capacity of these materials. When poor materials are used for construction, an increase in water content can have an adverse affect on track performance.

Another issue associated with water saturated soils involves frost heave created through expansion during freezing. Conversely, soils tend to liquefy when they thaw. When soils heave and liquefy, a track loses line and surface almost immediately.

Improvement to drainage is generally required in a short line rehabilitation project. Bank widening of cuts, ditch deepening, slicing down to the top of the subgrade shoulder, and cleaning culverts are typical necessities.

Due to the poor qualities of the existing natural soils on the ANY, drainage remediation was a must. Bank widening with dozers and excavators, utilization of the Loram Badger Ditcher and operation of a Loram Shoulder Cleaner was used throughout the line to enhance the drainage and improve the track structure. Fig 8 is an example of some of the drainage work completed during the rehabilitation project.





(Fig 8 - Drainage work on the ANY, 2009)

## Project Goals & Overview

### Goals

- Increase from Class 1 Track (10 MPH) to Class 2 Track (25 MPH)
- Increase car loads from 263K to 286K
- Prepare track structure to handle future demands of 11 MGT by 2015

### 2008

- 203,000 Ties (1000 ties/mile)
- Extensive Bridge Projects
  - Raise and Lower
- One complete Tamping Cycle
- Additional Tamping where needed
- 800+ cars of Ballast (4 cars/mile)
- 7 miles of rail replacement
- Rehabilitation of Radio Towers and Signals
- Rehabilitation of 40 Switches
- Bank Widening
- Anchor and Tie Plate Upgrades
- Crossing Rehab
- Culvert Rehabilitation

### 2009

- Continued Tamping Efforts
- GPR Assessment
- 10 miles of rail replacement
- 250+ cars of ballast
- Installation of long siding
- Continued Drainage Efforts
- Additional Bridge Rehabilitation
- Shoulder Ballast Cleaning

### 2010

- 40 miles of rail replacement
- Continued Tamping Efforts
- 100 miles of track lifting, 7 to 9 inches
- 3000+ cars of ballast
- Installation of Long Siding
- Continued Drainage Efforts

### 2011 Projections

- 20 miles of rail replacement
- 100 miles of track lifting, 7 to 9 inches
- 3200 cars of ballast
- Completion of long sidings
- Completion of line rehabilitation

During the first year of the project resources were deployed to raise the track through tamping. The efforts to raise the track in this manner had minor successes in correcting immediate surface irregularities. However, after a short period of time, the track began to sink to its original level. The overall goal was to create a 5 to 7 inch ballast section. Due to the limitations of the tamper and the current physical condition of the track structure, the process

became more of a mixing of fouled material with new ballast. It was apparent that many more passes would be required to reach the desired ballast depth and a reassessment of the project was needed.

To obtain more accurate empirical data, an additional inspection was completed through use of ground penetrating radar (GPR). The use of GPR validated surface inspections while providing additional data on depth of separate track foundation layers, fouled index, and depth of muskeg in troubled areas. Obtaining an in-depth knowledge of the track foundation provided CN management actionable intelligence to move forward with the ANY rehabilitation.

In 2009, assessment of the project continued. A new and innovative track lifter from Loram entered the market that removed the limitations encountered when utilizing tampers for lifting. CN and Loram joined together to assess the current needs of the ANY Subdivision. After making joint track inspections and completing several brainstorming sessions, it was determined that the Loram Track Lifter, with enhanced modifications, would be an ideal tool to rehabilitate the ANY Subdivision.

One of the main areas of risk identified during the planning process involved poor tie conditions encountered. It was decided that additional tie spiking efforts were required to ensure ties remained attached to the base of the rail during the lifting process. Due to the design of the machine and the lifting process, production would be halted on each occasion a dropped tie was encountered. Fig 9 exhibits issues that were encountered when lifting on the ANY Rehabilitation Project.



(Fig 9 - Dropped Tie on ANY Subdivision, 2010)

## Lifting Process

To begin the process of lifting track, a Loram Shoulder Cleaner was utilized throughout the entire ANY Subdivision. Shoulder Cleaning cleans the track shoulder 30 inches from the end of the tie and up to a depth of 8 inches below the bottom of the tie. An additional Scarfier can also be deployed to break up fouled material directly under the end of the tie.

Shoulder Cleaning provides a clean, free draining shoulder that improves overall track foundation drainage opening up voids in the ballast so a self cleaning process can begin. The newly opened voids in the shoulder provide space for water, fines, and mud to migrate from underneath the track whenever downward pressure is applied through traffic. The addition of naturally occurring precipitation also softens and lubricates the fouled track material which can speed up the migration to the open voids in the shoulder.

Periodic cycles should be maintained with the Shoulder Cleaner to reduce the progression of fines from filling the ballast voids thus keeping the track drainage at an optimal level. Fig 10 is a picture of a Ballast Cleaner working on the ANY Subdivision.



(Fig 10 - Loram Shoulder Cleaner)

CN moved forward with also deploying resources to assess spiking needs and complete the prescribed work in advance of the lifting. The process of plugging, also known as pin spiking, was used in these areas. Tie plugs have two functions: they help prevent water from entering the old loose spike hole, which reduces the potential of rot, and act to prevent a loose fit of the spike improving the track foundation. Due to the extensive tie project in 2008, resources were able to complete the spiking needs well in advance of lifting.

The next step in the process was pre-dumping of ballast, which is illustrated in Fig 11. This is done to speed up the track lifting process and ensure adequate ballast was available during the project. Pre-dumping of 15 cars per mile in advance was required to allow for a 5 to 8 inch lift. The ballast was dumped on the shoulder of the track to avoid applying additional weight on top of the ties, thereby reducing the amount of dropped ties through the process of lifting. Due to logistical challenges and distance to the nearest source of usable ballast, pre-dumping ballast generally occurred months to weeks in advance of lifting.



(Fig 11 - Pre Dump on the ANY, 2010)

After adequate rock was dumped in advance to ensure the gang could remain productive, the lifting gang was deployed to complete the work.

## Lifting Gang Equipment

- Loram Track Lifter
- Two Regulators
- Two Tampers
- Tie Spacing Machine
- Ballast Train

The Loram Track Lifter is a self propelled machine that can lift track up to 12 inches in one pass. The lifter is also equipped with a crib leveling bar that helps break up muddy cribs and provides a smooth level surface after the lift. Productivity of the lifter can vary depending on track conditions. During ideal conditions, it can lift track at speeds up to 4 MPH. The ANY Subdivision is predominantly jointed with 100 lbs. head free rail. Under these conditions, the track lifter worked between 1 to 2 mph. An example of the Track Lifter in operation is seen in Fig 12.



(Fig 12 - First day lifting on the ANY, 2010)

One of the main issues encountered while lifting was the abundance of joint bars that broke. Upon a visual inspection of the broken joint bars it was easily identifiable that internal defects were present. A typical angle bar failure is represented below in fig 13.



(Fig 13 - Defective joint bar on ANY, 2010)

Another minor correction required after lifting was that occasionally ties were skewed and needed to be repositioned to the correct spacing. Occasionally, tie skewing was present prior to lifting, but a majority of the skewing was due to the lifting process itself. To correct the tie skewing and eliminate this as a potential bottleneck in production, it was determined to incorporate tie spacing machines within the gang.

The final stage in lifting process was the final quality line and level of the track structure. This was achieved by utilizing two tampers and a regulator. Due to the rapid production of the Loram Track Lifter, this became the main bottleneck in production. Often production would have to be halted to ensure that all lifted track would be made passable and have the final line and level by the end of the work window. Completing all the prescribed work was essential to train operations by allowing traffic to travel at maximum authorized speed through the newly rehabilitated area.

There were two major accomplishments that resulted after completion of the lifting process.

- A new ballast layer of 6 to 8 inches was achieved while also providing a new sub ballast layer by utilizing the old existing ballast.
- An improved track foundation that will allow this subdivision to operate in a safe and efficient manner meeting both the current and future traffic demands.

## Conclusion:

Rehabilitating a deteriorated short line requires considerable planning, resources, and economical justification due to the large expense. One of the keys to a successful rehabilitation project is having a good understanding of the overall current physical condition of the track and an indication for what will be the future traffic demands.

With proper inspections and planning, extensive work was performed on the ANY to correct many of the subdivisions

problems. Fig 14 is a representation of the restored drainage and renewal of the supporting track structure that has once again allowed this subdivision to operate in a self sustaining viable manner.



(Fig 14 - Post lift results ANY, 2010)

It is also important to explore new emerging technologies that can potentially be more cost effective solutions than the traditional practices. Coupling together innovative personnel and equipment from both railroads and suppliers will help improve production and the cost effectiveness of large projects.

During post project debriefings, it was reinforced that the limiting factors for production were in two areas. Track availability to place ballast ahead of track lifting, which was successfully alleviated by utilizing pre-dumping. The second bottleneck to production was the final line and level with the tampers. In 2011, plans are being put into place that will attempt to double production of the gang by adding additional surfacing equipment. (Up to 4 miles per day)

## Future Plans:

Due to the success of the project, CN will continue to utilize the Track Lifter for various projects on its system. The overall

full potential of utilizing the track lifter will still require additional developmental activities.

Some recent conceptual ideas are to use the machine coupled with a Shoulder Ballast Cleaner as a direct alternative to out-of-face undercutting. In addition, trials will soon be underway to see if the lifter can be an effective tool for the replacement of cement tie pads.

There are many future opportunities for the Loram Track Lifter throughout North America. Continuing development efforts and collaborative efforts with railroads will continue to increase the overall value of this product and the performance it can offer.

## Appendix A

Classification of Soils and Their Suitability as Subgrade Material								
	Group Symbols	Soil Group and Lab Identification	Field Identification	Tendency to Frost Heave	Drainage	Suitability as Subgrade	Tendency to Pump	
Gravel	GW	Well graded Gravels and Gravel Sand mixtures. Trace to no silt or clay.	Wide range of grain sizes, substantial amounts of all intermediate sizes, no dry strength	None to very slight	Excellent	Excellent	None	
	GP	Poorly graded Gravels and Gravel Sand mixtures. Little or no fines.	Predominantly one size, or a range of sizes with some missing, no dry strength	None to very slight	Excellent	Excellent	None	
	GM	Gravel some Silt, Gravel, Sand, Silt mixtures Atterberg Limit < 4	Fines with low or no plasticity, slight to no dry strength	Slight to medium	Fair to very poor	Good	None	
	GC	Gravel some Clay, Gravel, Sand, Clay mixtures Atterberg Limit > 7	Plastic fines, medium to high dry strength	Slight to medium	Poor to very poor	Good	Slight	
Sands	SW	Well graded Sands and Sand Gravel, mixtures, trace to no silt or clay.	Wide range of grain sizes, substantial amounts of all intermediate sizes, no dry strength	None to very slight	Excellent	Excellent	None	
	SP	Poorly graded Sands and Sand Gravel mixtures, Traces to no silt or clay	Predominantly one size, or a range of sizes with some missing, no dry strength	None to very slight	Excellent	Good	None	
	SM	Sand - Silt mixtures Atterberg Limit < 4	Fines of low to no plasticity, slight to no dry strength	Slight to high	Fair to very poor	Poor	None to slight	
	SC	Sand Clay mixtures Atterberg Limit > 7	Plastic fines, medium to high dry strength	Slight to high	Very poor	Poor	Slight	
Silts & Clays	of high plasticity	ML	Silts, very fine Sands, Rock Flour Atterberg limit < 50	Fine grained, slight to no dry strength	Medium to very high	Fair to very poor	Poor	Slight to bad
		CL	Clays of low to medium plasticity Clay, Gravel, Sand, Silt mixtures	Medium to high dry strength	Medium to very high	Very poor	Bad	Bad
	of low plasticity	MH	Silts, Silt - Sand mixture of high plasticity Atterberg limit > 50	Slight to medium dry strength	Medium to very high	Poor to very poor	Bad	Very bad
		CH	Clays of high plasticity Atterberg limit > 50	Sticky when wet, high dry strength	Medium	Very poor	Bad	Very bad
Organic	OH	Organic Silts or Clays	High smell, dark color, mottled appearance, slight to high dry strength	Medium to high	Very poor	Bad	Very bad	
	PT	Muskeg, Peat	Dark color, spongy feel and fibrous texture	Slight to high	Poor	Remove completely	Very bad	

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## Biographies:

**Tom Bourgonje, Chief Engineer Western Region Canadian National Railway**, has over 30 years of experience working for CN. Tom has worked throughout CN's system in both transportation and engineering. Tom current role is Chief Engineer Western Region.

Tom holds a Bachelor of Science in Civil Engineering from Lakehead University.

**Scott Diercks, Product Development Manager at Loram Maintenance of Way**, has 18 years of progressively responsible experience managing New Product Launches, Equipment Operations, and Special Projects.

Scott is a member of American Society of Civil Engineers (ASCE), American Railway Engineering and Maintenance of Way Association (AREMA), and is certified in Lean Product Development.