Road Needs Study Report - 2017

Township of Douro-Dummer

D.M. Wills Project No.17-4647

D.M. Wills Associates Limited
PARTNERS IN ENGINEERING
Peterborough

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Prepared for
Township of Douro-Dummer

Executive Summary

The Township of Douro-Dummer (Township) retained the services of D.M. Wills Associates (Wills) to undertake a review of the Township's existing road network, and assess its physical condition as well as confirm various road attributes. Data collected during the field review was used to develop a prioritized listing of the road network needs, the results of which are documented in this report.

The Township's complete road infrastructure system spans a total of 260 km primarily within a rural setting, with small areas of urban and semi-urban development. The road network includes surfaces ranging from gravel to hot mix paved (asphalt). The Township has approximately 6 km of earth roads, 143 km of gravel roads, 105 km of surface treated roads (Low class bituminous (LCB)), and 6 km of hot mix asphalt paved roads (high class bituminous (HCB)).

5% of the road network has a structural "NOW" need, 4% has a structural "1-5" year need, and 8% of the road network has a structural "6-10" year need.

It should be noted that a structural "NOW" need does not explicitly mean that work must be undertaken on the road immediately (although this may be so in some cases). A structural "NOW" need means that the road's surface has reached the end of its useful service life and will require reconstruction or major rehabilitation to fully repair. Logically, a structural "1-5" year need is expected to become a "NOW" need in the next five years, and a "6-10" year need is expected to become a "NOW" need in the next 10 years. Note that many "6-10" year needs may be corrected by timely resurfacing, extending their service lives.

Capital Improvements

Prioritization and recommendations for planned capital improvements have been developed based on the condition rating and traffic demands on each road. Those roads identified as having a "NOW", 1 – 5 year, or 6 – 10 year structural need have been included in the capital improvement plan for rehabilitation.

A total length of approximately 40.2 km of roads were identified as having structural needs in the "NOW," 1 – 5 year, or 6 – 10 year periods. The estimated cost to improve these roads is approximately $ 2.4 M. An additional length of approximately 7.8 km of road is identified as having inadequate surface widths or surface type. Generally, provided no operational or safety concerns are identified, roads with surface width and/or type deficiencies are typically addressed / considered at the next full reconstruction cycle.

Resurfacing

In addition to addressing currently deficient roads (i.e. capital reconstruction), a dedicated preservation management approach is required, and perhaps even more important, to "keep the good roads good"; the fundamental principle being that it costs much less to maintain a good road than it does to let it fail and then reconstruct it, from a life cycle cost perspective. Ultimately the goal of preservation management is to

extend the useful life of a road, maximizing the municipality's investment over the road life-cycle.

Road resurfacing is an effective way of extending the overall life of the pavement structure. A road resurfacing program is therefore recommended in addition to capital improvements.

Based on typical degradation rates for gravel roads, surface treatment, and hot mix, a resurfacing program / budget is recommended as follows:

Hot Mix Paved Roads:

- 6.3 km of paved roads (HCB).
- Degradation rate 0.25 / year (surface rating drops from 10 to 5, over a 20-year period).
- Annual resurfacing 0.3 km / year.
- **Annual budget $67,800**: (0.3 km / year x $126,000 / ln **RMP1** x 2 lanes).

Surface Treated Roads:

- 105.1km of surface treated roads (LCB).
- Degradation rate 0.625 / year (surface rating drops from 10 to 5, over a 7-year period).
- Annual resurfacing 15.0 km / year.
- **Annual budget $360,000** (15.0 km / year x $24,000 / km **ST1**).

Gravel roads require regular maintenance. Maintenance includes regular grading and reapplication of new gravel. Typically, gravel roads should be resurfaced on a 3 – 5 year cycle.

Gravel Roads:

- 143.0 km of earth / gravel roads.
- 75mm gravel every 3-5 years.
- Annual gravelling of 28.6 km.
- Granular A ($19,000 / km).
- **Annual budget $543,400** (28.6 km / year x $19,000 **G**) **.

*** Cost based on supply and application of gravel by external forces.*

Generally speaking, gravel roads will be less expensive to preserve than surface treated roads, which are, in turn, less expensive to preserve than hot mix roads. Additionally, converting a gravel surface to surface treatment incurs a high initial capital cost. Surface Type conversions should not be undertaken without significant funding increases.

The total resurfacing program, (hot mix, surface treatment and gravel) is estimated at $971,200 per year.

Further, it is recommended that regular maintenance in the form of roadside ditch cleanout and clearing be undertaken in order to extend the useful service life of the existing roads.

Road System Inventory

Township of Douro-Dummer **Road System in Kilometers** **(As of November 2017)**		
A.	**Surface Type**	**Totals***
	Earth	6
	Gravel (loose Top Gravel)	143
	Surface Treatment (LCB)	105
	Hot Mix Asphalt (HCB)	6
	Total A	**260 km**
B.	**Roadside Environment**	
(i)	**Rural**	
	Earth	6
	Gravel (loose Top Gravel)	143
	Surface Treatment (LCB)	96
	Hot Mix Asphalt (HCB)	5
	Total Rural	**250 km**
(ii)	**Semi-Urban**	
	Gravel (loose Top Gravel)	0
	Surface Treatment (LCB)	9
	Hot Mix Asphalt (HCB)	1
	Total Semi-Urban	**10 km**
(iii)	**Urban**	
	Gravel (loose Top Gravel)	0
	Surface Treatment (LCB)	0
	Hot Mix Asphalt (HCB)	0
	Total Urban	**0km**
	Total B	**260 km**
**Estimated to the nearest kilometre.*		

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1.0 Purpose, Background and Study Method

1.1 Purpose

The purpose of the 2017 Road Needs Study Report is to update the current road inventory and road condition assessments within the Township of Douro-Dummer (Township). Using this information, a prioritized listing of the road network needs is developed. The information derived from the study and documented in this report will provide assistance to the Township for developing and executing a planned road maintenance and improvement program.

The Township retained the services of D.M. Wills Associates (Wills) to undertake a review of the existing road network, and assess its physical condition as well as confirm various attributes. Data collected as a result of the field review is used to develop a prioritized listing of the road and sidewalk network needs, the results of which are documented in this report.

1.2 Background

The Township of Douro-Dummer is located in central-eastern Ontario within Peterborough County. The Township is largely rural with some scattered semi-urban developments. The communities of Warsaw, Donwood and Douro serve as the Township's main population centres.

In 2009, a Road Needs Study Report was completed to inventory and document the Township's existing road assets. This current study (2017) utilizes and builds from the road asset information documented in the 2009 Road Needs Study.

1.3 Study Objectives

Based on the Request for Proposal and discussion with Township staff, the following study objectives were identified:

- Provide a current inventory and value of the Township's roads, assess road conditions and needs, and develop a priority listing for construction needs and improvements.
- Provide a prioritized list of capital projects for the Township to invest in.

1.4 Study Methodology

The procedure utilized to complete the study was generally in accordance with the MTO's Inventory Manual for Municipal Roads (February 1991).

During the field study the following road characteristics were reviewed and documented to assess the current adequacy of the road:

- Platform Width (overall width of road).
- Surface Width (width of pavement surface).
- Shoulder Width.
- Surface Type (gravel, low class bituminous, or high class bituminous).
- Drainage Type (open ditches vs. storm sewers etc.).
- Surface Condition (assigned based on Ride Condition Rating for this Study).
- Structural Adequacy.
- Maintenance Demand.
- Roadside Environment.
- Capacity.
- Alignment.

Critical Deficiencies

Critical deficiencies represent road characteristics that result in increased maintenance costs or lead to an inadequate level of service. Road sections may be assessed as critically deficient if any one (1) of the following characteristics fall below the minimum tolerable standards defined in the MTO Inventory Manual:

- Surface type - Insufficient surface type for traffic volumes.
- Surface width - Insufficient width of the road surface excluding the shoulders.
- Capacity - Inability of the road to accommodate traffic volumes at peak periods.
- Structural Adequacy - Inability of the road base to support vehicular traffic.
- Drainage - Increased frequency of flooding or excessive maintenance effort required to prevent flooding.

Surface Type

Wills assessed the adequacy of the road surface type based on the parameters listed in **Table 1**. Roads with traffic volumes (AADT) in excess of the values recommended below for various surface types were noted as critically deficient triggering a "Now" need.

Table 1 - Surface Type by Annual Average Daily Traffic (AADT)

Surface Type	Standard AADT Level	Tolerable AADT
Earth (E)	-	<50
Gravel (G)	0-199	<400
Low Class Bituminous (LCB)	200-399	<800
High Class Bituminous (HCB)	400+	-

Note that these ranges are guidelines and not necessarily meant to be rigidly applied. If a LCB road has a higher than recommended AADT (Annual Average Daily Traffic), but is performing at a desirable level, it may not need to be upgraded to HCB. Similarly, if a section of gravel road requires excessive maintenance (for example, on steep grades); LCB may be justified at lower traffic levels. Additionally, urban roads may require consideration for HCB surfaces to support drainage infrastructure i.e. curb & gutter, despite having low AADT.

Surface Width

Surface widths that fall below minimum tolerable standards, as detailed in the MTO Inventory Manual were noted as critically deficient triggering a "Now" need.

Capacity

An in-depth traffic capacity analysis was not completed as part of the scope of this Road Needs Study. Decisions with respect to expansion of roads should be made within the context of a Transportation Master Plan or Official Plan for the Township.

However, from a general perspective, a two-lane road can typically provide adequate service up to an AADT of approximately 12,000 vehicles. The functionality of a road from a capacity standpoint is of course dependent upon other factors in combination with volume. Adjacent land uses, and number of access points i.e. entrances and side roads etc. also have a significant impact on how the road functions.

A rural road with limited entrances and side roads will have a much greater capacity to flow traffic versus an urban street with many entrances and side road intersections. The AADT of 12,000 can be used as a 'rule of thumb' to trigger further analysis on the road capacity and operation. For the purposes of this study, a detailed capacity analysis was not undertaken as part of the scope of work. All roads were assigned to be adequate from a capacity perspective noting the highest traffic volume amongst all road segments of approximately 1100 AADT.

Structural Adequacy

In cases where road base or structure is showing distress over more than 20% of the length of the road section, a "Now" need is assessed.

Drainage

A road section is assessed as a "Now" need for drainage generally when a road becomes impassible due to water one or more times a year. This information is not readily accessible from inspection. Characteristics such as ditching, water ponding on or around the road, and evidence of past washouts were used to assess road drainage. As such, a road was given a "Now" need for drainage if there were evident drainage problems that would likely lead to an impassable road during a heavy rain or a rapid snow melt.

2.0 The Road System

2.1 Inventory and Classification

All roads in the municipal road system were inventoried according to the methods outlined in the MTO Inventory Manual for Municipal Roads.

The inventory procedure requires that each road in the system be studied as a separate unit. Initially, the road system was divided into sections so that each conformed, as close as possible, to the following requirements:

- Uniform traffic volume.
- Uniform terrain.
- Uniform physical conditions.
- Uniform adjacent land.

Depending on location with respect to the built up areas, roads were classified in a manner generally descriptive of the type of construction as follows:

- Urban - Roads with curb and gutter and storm sewer drainage.
- Semi-Urban - Roads in built up areas (development exceeds 50% of the frontage) without curb and gutter or curb and gutter on one (1) side only.
- Rural - Roads with development on less than 50% of the frontage.

Rural roads were further evaluated based on estimated traffic volumes; such as 0 to 50 vehicles per day, 51 to 200, and 201 to 400 etc. For the purpose of this study, traffic volumes were provided by the Township.

Table 2 summarizes the total road length in kilometres by surface type and road environment as of November 2017.

The existing road system consists of 261 km of roadway, 7 km of earth roads, 146 km of gravel roads, 102 km of surface treated roads (LCB) and 6 km of HCB (asphalt paved) roads; with all calculations being approximate and rounded to the nearest kilometre.

Table 2 - Road System Inventory

Township of Douro-Dummer **Road System in Kilometers** **(As of November 2017)**		
A.	**Surface Type**	**Totals***
	Earth	6
	Gravel (loose Top Gravel)	143
	Surface Treatment (LCB)	105
	Hot Mix Asphalt (HCB)	6
	Total A	**260 km**
B.	**Roadside Environment**	
(i)	**Rural**	
	Earth	6
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(ii)	**Semi-Urban**	
	Gravel (loose Top Gravel)	0
	Surface Treatment (LCB)	9
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	Total Semi-Urban	**10 km**
(iii)	**Urban**	
	Gravel (loose Top Gravel)	0
	Surface Treatment (LCB)	0
	Hot Mix Asphalt (HCB)	0
	Total Urban	**0km**
	Total B	**260 km**
**Estimated to the nearest kilometre.*		

3.0 Road Needs

The primary purpose of the study is to develop a list of all roads within the Township ranked according to priority with respect to road needs.

The method of evaluating road needs in terms of type, cost and timing of improvements is identified in the Inventory Manual for Municipal Roads.

It is important to note that budgetary restrictions will often influence the level of upgrades to the road system and therefore it is imperative to maximize the improvements based on availability of funds and needs priority.

3.1 Critical Deficiencies

The inventory of the road system revealed that certain road sections are now deficient or will become deficient during the study period.

As noted previously, critical deficiencies include road characteristics which result in increased maintenance costs and which inevitably lead to an inadequate level of service. A road section is critically deficient if any one of the following characteristics fall below the minimum tolerable standards defined in the Inventory Manual.

- Surface type - Incorrect surface type to suit traffic volumes on the roadway.
- Surface width - Insufficient width of the road surface excluding the shoulders.
- Capacity - Inability of the road to accommodate traffic volumes at peak periods.
- Structural Adequacy - Inability of the road base to support vehicular traffic.
- Drainage - Increased frequency of flooding or excessive maintenance effort required to prevent flooding.

Of the 260 km of roads inventoried, a total of 20.3 km had a critical deficiency. Of the 20.3 km, approximately 6.4 km represents roads with AADT of less than 50 vehicles. Regardless of condition, roads with AADT of fifty or less are typically assigned as "Adequate" (as per the Ministry protocol) for the purpose of the system adequacy calculation.

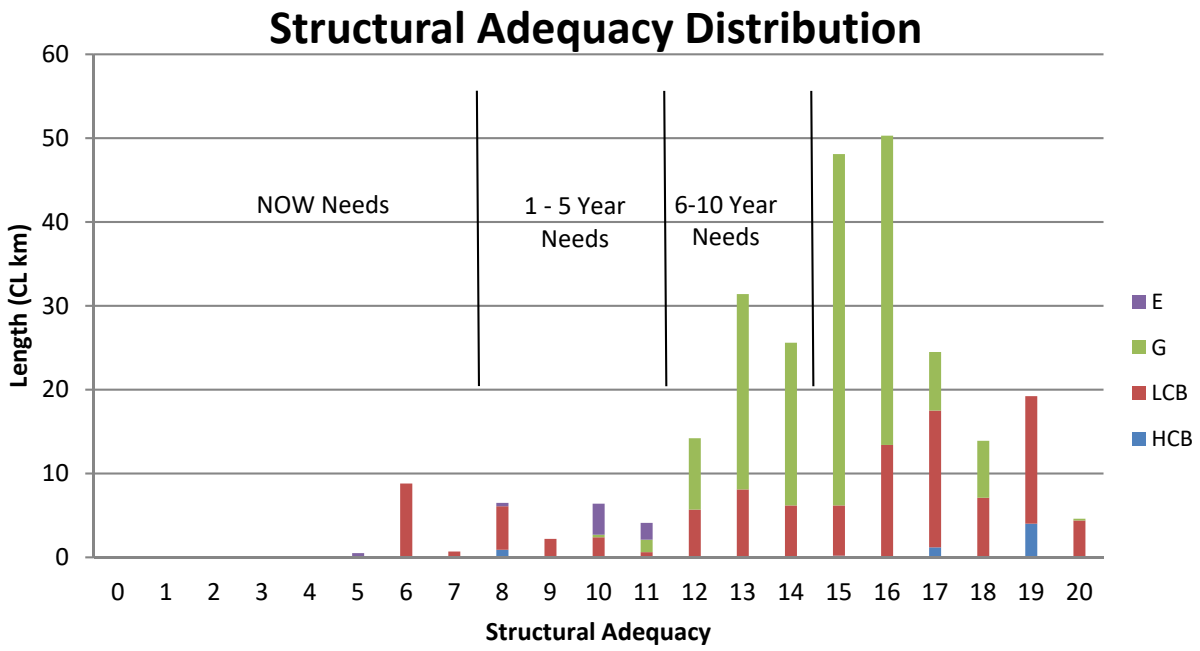
The overall system adequacy for the Township's road network, which is based upon the total road kilometres less the identified critically deficient ("NOW" needs) roads, is as follows:

$$\textbf{2017 System Adequacy} = \frac{\textbf{260 - (20.3 - 6.4)}}{\textbf{260}} \textbf{ x 100\% = 95\%}$$

The average surface condition rating of all roads is 7.7 / 10 while the average structural adequacy rating is 14.7 / 20. This suggests that the typical road has a good riding quality, and in fair to good condition.

Looking at the structural adequacy distribution of the township's roads reinforces this picture. A group of roads, over 60%, are in good condition (structural adequacy of 15 and over), and with regular resurfacing and preservative maintenance, should not require reconstruction in the next ten (10) years. Another 30% are in fair condition (structural adequacy from 12 to 14). The remaining 10% of the road network is well distributed over the poor to very poor range (structural adequacy from 5 to 11). Most of these roads will require reconstruction over the next five (5) years to fully repair them.

It is therefore recommended that, while the Township endeavors to repair the poor to very poor roads as part of its 10-year capital plan, every reasonable effort is made, through preservation management, to prevent the current cohort of good roads from becoming capital needs themselves.



3.2 Condition Rating

Although the condition rating is appropriate to use in the context of a road needs study, Wills has noted that using the Condition Rating as a general signifier of a road's condition can lead to odd comparisons. Since 45% of the rating may be scored for a road's width, alignment, or level of service, it is easy for a straight, wide road to have a better CR than good road that is narrow and windy.

For this reason, an Asset Condition Rating, or ACR, should be used outside the context of this report (i.e. in the Township's Asset Management Plan). The ACR considers only attributes that define the physical condition of the road. Explicitly, these attributes are Surface Condition, Structural Adequacy, Drainage, and Maintenance Demand.

The scoring systems for Condition Rating (CR) and Asset Condition Rating (ACR) is determined as per **Table 3**.

Table 3 – Scoring Systems

Attribute	Condition Rating (Standard Inventory Manual Approach)	Asset Condition Rating
Surface Condition	10	10
Structural Adequacy	20	20
Drainage	15	15
Maintenance Demand	10	10
Shoulder Width	10 (Rural Only)	
Surface Width	15 (Rural / Semi-Urban) 25 (Urban)	
Level of Service	20 (Urban / Semi-Urban Only)	
Horizontal Alignment	10 (Rural)	
Vertical Alignment	10 (Rural Only)	
Total	**100**	**55**

3.3 Priority Ratings of Roads

A mathematical empirical formula was used to calculate the priority rating for each road section. The priority rating is a weighted calculation which takes into account the existing traffic volume and overall condition rating of the road, as per the Inventory Manual Methodology.

This priority analysis is an impartial procedure to place the deficiencies in order of relative need. **A higher Priority Rating number indicates a relatively greater need for improvement.**

The formula takes into account the current traffic volume (AADT), whether it is from actual road counts or estimated road counts and the Condition Rating (CR) of the road at the time of this Road Needs Study Report. The formula is as follows:

Priority Rating = 0.2 x (100 - CR) x (AADT + 40) $^{0.25}$

In utilizing the above equation Wills identified a priority listing for review with Township staff. It is important to emphasize that the priority rating calculation considers only CR and traffic volumes.
When developing the recommended capital expenditure plan consideration may be given to the remaining useful service life of a road / roadbed with a view to coordinating major reconstruction efforts at / near the end of the road's life. Furthermore, while a priority rating will give a general idea of which roads should be improved before others, it does not prescribe an exact order for road improvements nor does it determine the timing of preservation and rehabilitation work. For example, it may be wise to defer the full reconstruction of a high priority road ("let the bad roads fail") in favour of resurfacing work on a medium priority road ("keep the good roads good").

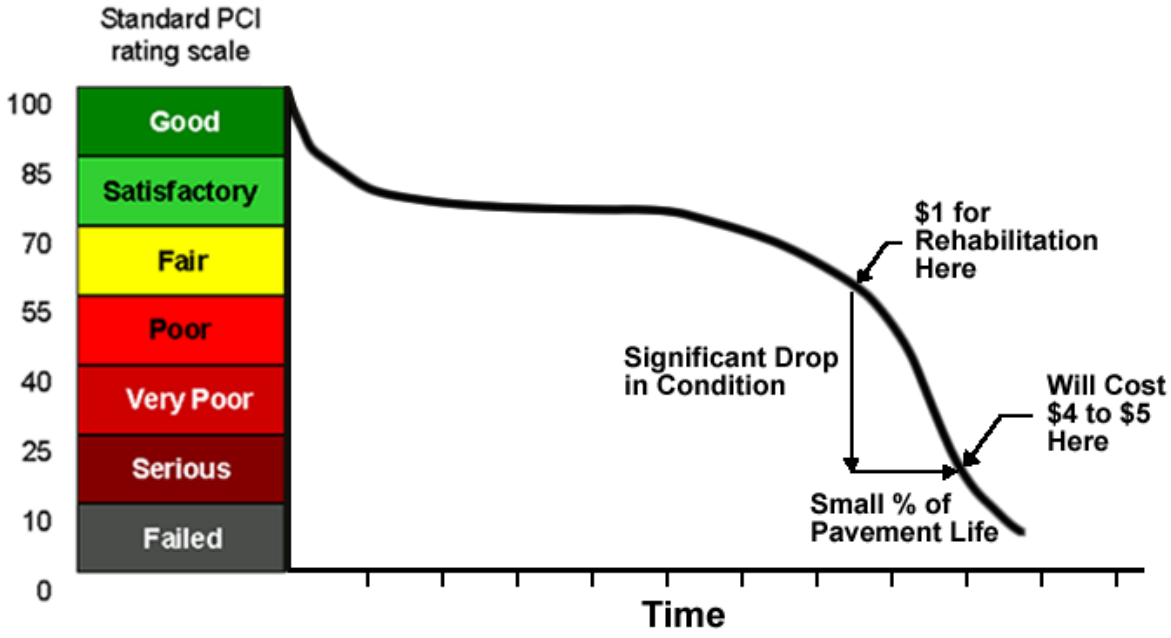
4.0 Roads Best Management Practices

The key to managing a pavement / road network is the timing of maintenance and rehabilitation activities. This idea evolves from the fact that a pavement's structural integrity does not fall constantly with time. A pavement generally provides a constant, acceptable condition for the first part of its service life and then begins to deteriorate very rapidly. In many cases, maintenance and rehabilitation measures are not taken until structural failure or noticeable changes in ride quality become apparent. This is the "fix it once it is already broken" approach.

The unfortunate consequence of this decision is that maintenance and rehabilitation becomes exponentially more expensive over the life of the pavement and is often overlooked until the pavement condition reaches a severe state of distress. There is opportunity for substantial cost savings when intervention is made *before* the pavement becomes severely compromised; i.e. "fix it before it breaks". **Figure 1** illustrates the underlying principle in support of a preservation management approach to pavement infrastructure. The principle also has application to each of the classes of roads maintained by the Township. Significant cost savings will result from proactive intervention rather than simply waiting as long as possible before performing maintenance.

Examples of approach to roads management with their associated cost implications over the lifecycle of a road are set out below in **Figure 1** and are provided as an illustration of the benefit of a "preservation management approach".

Figure 1- Typical Service Life of an Asphalt Pavement



4.1 Example Life Cycle Cost Analysis

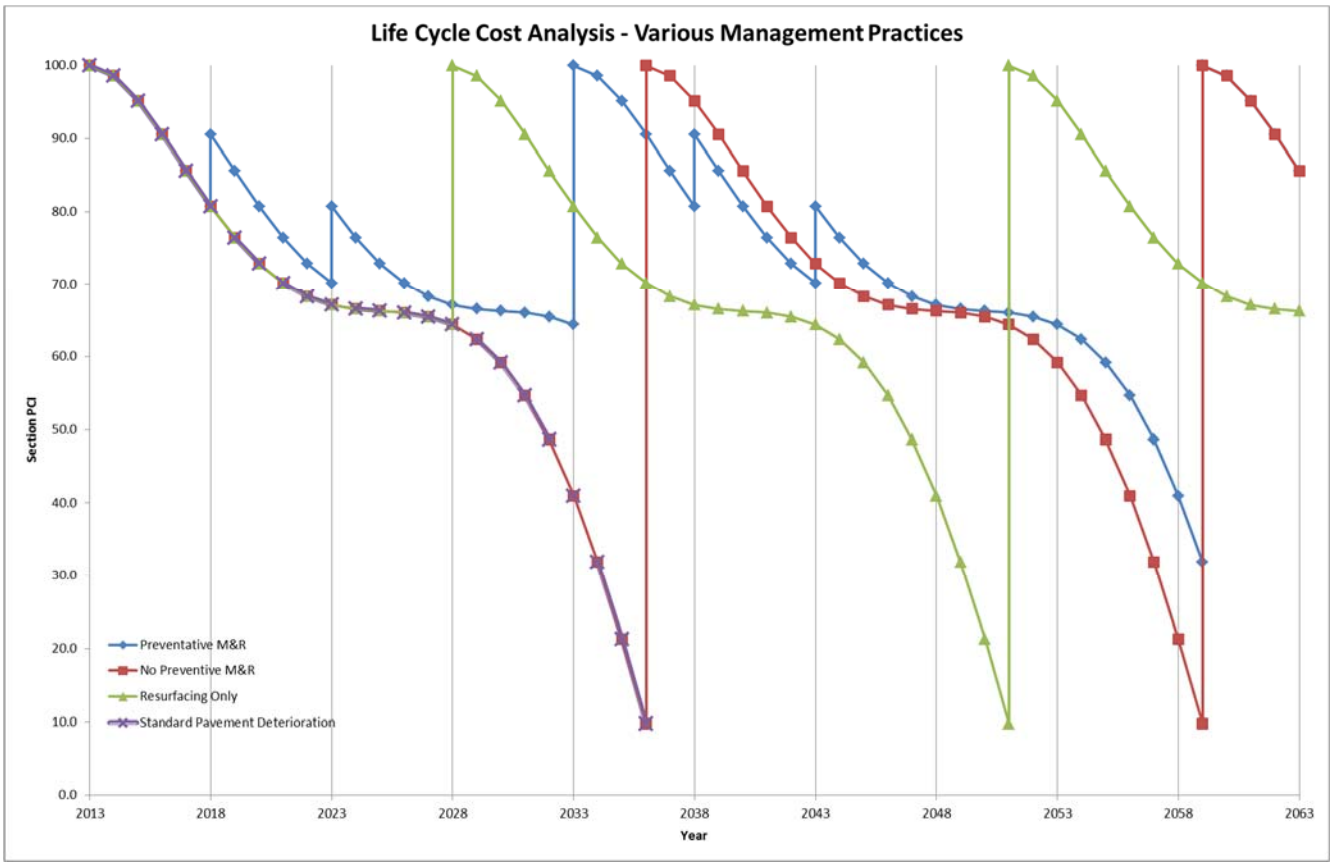
The following life cycle costs analysis compares three (3) different municipalities Municipality 1, Municipality 2 and Municipality 3; each with three (3) distinct approaches to pavement management. For this analysis we will assume each of the three (3) municipalities has 7000 m^2 of pavement, i.e. 1 km of asphalt paved road that is 7 m wide. In each scenario, the road is assumed to have been constructed in 2013 and will operate under normal traffic loading.

The Life Cycle Cost Analysis (LCCA) assumes no user costs. The LCCA uses a discount rate of 2.5% / year.

The LCCA shows the three (3) different municipalities and tracks their pavement management decisions and related condition over the specified time period. Municipality 1 represents decisions made based on strategic preventive maintenance and rehabilitation (M&R), Municipality 2 represents decisions based on no preventive M&R and Municipality 3 represents decisions based on resurfacing only.

Figure 2 below illustrates a time- pavement condition plot for each municipality.

Figure 2 - Time-Condition Plot for 3 Municipalities



The costs associated with the corresponding maintenance and rehabilitation decisions are outlined in the following three (3) charts:

Preventive M&R									
Year	**Age**	**Treatment**	**Δ PCI**	**PCI_q**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Present Worth**
		-- Annual Ditching/Clearing --							
2018	**5**	**Localized Preventive - Rout and Seal**	81-90	Satisfactory-Good	1000	m	$1.50	$1,500.00	**$1,325.78**
2023	**10**	**Global Preventive - Slurry Seal**	70-81	Satisfactory-Good	7000	m^2	$6.50	$45,500.00	**$35,544.53**
2033	**20**	**Surface Course**	64-100	Poor-Good					
		Mill and Dispose of Surface Course			7000	m^2	$12.00	$84,000.00	
		50mm Surface Course			892.5	t	$135.00	$120,487.50	
								$204,487.50	**$124,792.78**
2038	**25**	**Localized Preventive - Rout and Seal**	81-88	Satisfactory-Good	4500	m	$1.50	$6,750.00	**$3,640.89**
2043	**30**	**Global Preventive - Slurry Seal**	68-78	Satisfactory-Good	7000	m^2	$6.50	$45,500.00	**$21,691.79**
2048	**35**	**Safety/Stopgap Maintenance - AC Patching/Leveling**	N/A	N/A	5%	m^2	$30.00	$10,500.00	**$4,424.40**
2053	**40**	**Safety/Stopgap Maintenance - AC Patching/Leveling**	N/A	N/A	10%	m^2	$30.00	$21,000.00	**$7,821.04**
2058	**45**	**Full Reconstruction**	32-100	Serious-Good					
		Remove Asphalt Full Depth			7000	m^2	$15.00	$105,000.00	
		Add and Compact Corrective Aggregate/Correct Crossfall (25mm avg.)			420	t	$35.00	$14,700.00	
		40mm Base Course			686	t	$125.00	$85,750.00	
		50mm Surface Course			892.5	t	$135.00	$120,487.50	
								$325,937.50	**$107,290.28**
2063	**5**	**Localized Preventive - Rout and Seal**	81-90	Satisfactory-Good	1000	m	$1.50	$1,500.00	**$436.41**
		Final PCI in 2063:	**90**	**Good**				**Net:**	**$306,967.90**
								Residual Value:	**$85,346.08**
								Total Cost:	**$221,621.82**

The policy of Municipality 1 is to strategically intervene with preventative maintenance measures over the course of the pavement's service life. Two (2) significant maintenance measures are performed on the pavement at various times and ultimately extend the service life of the pavement, prorating the total cost of the pavement over a longer period of time. Eventually, a full reconstruction is required and this cycle repeats. The total life cycle costs are substantially less when compared to Municipality 2 and 3, at a total of $221,622 over 50 years.

No Preventive M&R									
Year	**Age**	**Treatment**	**Δ PCI**	**PCI_q**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Present Worth**
2023	**10**	**Safety/Stopgap Maintenance - AC Patching/Leveling**	N/A	N/A	5%	m^2	$30.00	$10,500.00	**$8,202.58**
2028	**15**	**Safety/Stopgap Maintenance - AC Patching/Leveling**	N/A	N/A	10%	m^2	$30.00	$21,000.00	**$14,499.78**
2030	**17**	**Safety/Stopgap Maintenance - AC Patching/Leveling**	N/A	N/A	20%	m^2	$30.00	$42,000.00	**$27,602.19**
2036	**23**	**Full Reconstruction**	10-100	Poor-Good					
		Remove Asphalt Full Depth			7000	m^2	$15.00	$105,000.00	
		Add and Compact Corrective Aggregate/Correct Crossfall (25mm avg.)			420	t	$35.00	$14,700.00	
		40mm Base Course			686	t	$125.00	$85,750.00	
		50mm Surface Course			892.5	t	$135.00	$120,487.50	
								$325,937.50	**$184,707.88**
2043	**7**	**Safety/Stopgap Maintenance - AC Patching/Leveling**	N/A	N/A	5%	m^2	$30.00	$10,500.00	**$5,005.80**
2048	**12**	**Safety/Stopgap Maintenance - AC Patching/Leveling**	N/A	N/A	10%	m^2	$30.00	$21,000.00	**$8,848.79**
2053	**17**	**Safety/Stopgap Maintenance - AC Patching/Leveling**	N/A	N/A	20%	m^2	$30.00	$42,000.00	**$15,642.09**
2059	**23**	**Full Reconstruction**	10-100	Poor-Good					
		Remove Asphalt Full Depth			7000	m^2	$15.00	$105,000.00	
		Add and Compact Corrective Aggregate/Correct Crossfall (25mm avg.)			420	t	$35.00	$14,700.00	
		40mm Base Course			686	t	$125.00	$85,750.00	
		50mm Surface Course			892.5	t	$135.00	$120,487.50	
								$325,937.50	**$104,673.45**
		Final PCI in 2063:	**86**	**Good**				**Net:**	**$369,182.56**
								Residiual Value:	**$81,552.92**
								Total Cost:	**$287,629.64**

The policy of Municipality 2 is to simply construct the pavement and wait until serious deficiencies begin to appear before acting. This approach unfortunately remains common still today. Over the last period of the pavement's life, maintenance is required to ensure safety and operation until the pavement becomes completely destroyed. Once the pavement has failed, a complete reconstruction is carried out restoring the pavement to new condition. This cycle repeats again until a second reconstruction is required. The total costs are substantial and total $287,630 over 50 years.

Resurfacing Only									
Year	**Age**	**Treatment**	**Δ PCI**	**PCI_q**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Present Worth**
2028	**15**	**Surface Course**	64-100	Poor-Good					
		Mill and Dispose of Surface Course			7000	m^2	$12.00	$84,000.00	
		50mm Surface Course			892.5	t	$135.00	$120,487.50	
								$204,487.50	**$141,191.58**
2051	**23**	**Full Reconstruction**	10-100	Serious-Good					
		Remove Asphalt Full Depth			7000	m^2	$15.00	$105,000.00	
		Add and Compact Corrective Aggregate/Correct Crossfall (25mm avg.)			420	t	$35.00	$14,700.00	
		40mm Base Course			686	t	$125.00	$85,750.00	
		50mm Surface Course			892.5	t	$135.00	$120,487.50	
								$325,937.50	**$127,534.43**
2067	**15**	**Surface Course**	64-100	Poor-Good					
		Mill and Dispose of Surface Course			7000	m^2	$12.00	$84,000.00	
		50mm Surface Course			892.5	t	$135.00	$120,487.50	
								$204,487.50	**$53,898.67**
		Final PCI in 2063:	**66**	**Good**				**Net:**	**$322,624.67**
								Residiual Value:	**$62,587.12**
								Total Cost:	**$260,037.55**

The policy of Municipality 3 is periodic resurfacing. The pavement is constructed and time passes until early signs of serious distress are observed. This occurs after the time when preventive maintenance is neither appropriate nor possible, but before the pavement becomes completely destroyed. Resurfacing is performed and restores the pavement to almost new condition. The pavement then deteriorates for the remainder of its life, requiring significant maintenance in the last years before it becomes completely destroyed. A full reconstruction is then carried out and the cycle continues. The total costs are in between that of Municipality 1 and 2 at $260,038 over 50 years.

It may be easy to see upfront cost savings by understanding that as long as any costs associated with maintaining the pavement are deferred as long as possible, money will be saved. The reality is that extending a pavements service life prorates the total cost of the pavement over a longer period of time and ultimately becomes more economical in the long run. If preventive maintenance measures are strategically planned and carried out then the service life of the pavement can be maximized and substantial reconstruction costs can be deferred for longer periods of time. In a time when economy and efficiency are becoming more and more important, this type of proactive management is essential in the management of infrastructure.

4.2 Preservation Management Approach

4.2.1 Gravel Roads

The proposed preservation management approach for this class of road is outlined in the following **Table 4** and **Table 5.**

Table 4 - Preservation Management Approach- Gravel Surface

Action	Frequency
Regrade surfaces to maintain smooth / safe driving surface and proper crossfall.	As needed, generally 2-3 times per year for higher volume gravel, or more frequently as necessary; 1-2 for lower volume.
Add calcium to tighten surface, retain aggregate and reduce dust.	Each spring on all roads of higher volume and as needed during summer months.
Ditching and brushing of right-of-ways to improve roadbed drainage and safety.	Complete road network every 10 years[1].

Table 5 - Capital Activities – Gravel Roads

Action	Frequency
Add layer (75 mm) of granular material to road surface.	Every 3-5 years for gravel roads.
Base and sub-base improvements.	As needed or as dictated by traffic volumes.
Reconstruct / convert to hard top.	As dictated by traffic volumes.

4.2.2 Surface Treated Roads

Surface treated roads have a hard wearing surface that must be preserved in order to be effective. Unlike gravel roads, a significant investment has been made in the surface and consequently these roads must be managed properly to obtain the longest possible service life from the surface.

Table 6 - Preservation Management Approach – Surface Treated Roads

Activity	Age (Years)	Ride Condition Rating	Estimated Service Life Extension (Years)
Slurry Seal[2]	3	8	4
Slurry Seal[2]	6	7	3
Double Surface Treatment	10	6	5
Pulverize and DST	14	<4	8

[1] A ten-year cycle is considered ideal. The Township is currently closer to a fifteen-year cycle as some roads require higher than normal effort to bring up to standard. After these roads are repaired in full, it is expected that the Township will be able to employ a ten-year cycle.
[2] The Township has been able to get better prices on surface treatment than slurry seal by bundling Township work with County of Peterborough Surface Treatment tenders. Should this economy of scale change in the future, the Township should consider including slurry seal in their program.

In addition to the above noted preservation approach in **Table 6**, the following best management practices may be employed to preserve the surface, extend the service life and reduce life cycle costs of surface treated roads:

1. Surface treatment shall be applied to the entire road platform, from "grass to grass", including any shoulders. This will eliminate grading on surface treated roads, which has a tendency to damage the edge of the surface treatment and cause premature failure of the surface.
2. Suitable new technologies will be utilized where they can be demonstrated to reduce life cycle costs, such as fiber-reinforced surface treatment. This technology can be used to mitigate reflective cracking (if cracks are narrow and inactive) when a single or double surface treatment is applied over an aging surface. It can eliminate the need for pulverizing the underlying surface in certain situations and can reduce overall costs.
3. Assess drainage and culvert needs prior to any significant renewal or rehabilitation strategy and complete any improvements concurrently. This will eliminate the need to cut / excavate a relatively new surface to replace a culvert.
4. Ditching and clearing (brushing) of the right-of-ways (ROW) to improve roadbed drainage and safety.

4.2.3 Asphalt Roads

Asphalt surfaces are the smoothest and most durable hard top surface used by the Township however; they are also the most expensive. Asphalt provides a constant, acceptable condition for the initial portion of its service life but then begins to deteriorate rapidly as it ages. Surface defects such as cracking and raveling are the first signs of the deterioration. If left untreated, the pavement will rapidly deteriorate to the point where reconstruction is the only option. A preservation management strategy can mitigate this by applying renewal treatments earlier in the pavements life before the conditions begin to deteriorate too far. **Table 7** below summarizes preservation management activities to be considered for asphalt roads:

Table 7 - Preservation Management Approach – Rural Asphalt Roads

Activity	Age (Years)	Ride Condition Rating	Estimated Service Life Extension (years)
Crack seal[3]	2-6	9	2
Slurry Seal / Microsurface[3]	4-8	8	4-6
Overlay	12-15	6-7	10
Pulverize and Pave	20-25	< 5	20
Reconstruct	30	< 4	30

Note: Slurry seal can be used on lower volume paved roads (less than 1000 vehicles per day). For roads with volumes in excess of 1000 AADT, microsurfacing should be considered.

[3] Due to the limited number of HCB roads, these techniques are not employed by the Township. They are referenced here for information.

In addition to the above noted preservation approach, the following best management practices may be employed to extend the service life and reduce life cycle costs of asphalt roads:

1. Review the condition of other infrastructure, particularly underground infrastructure prior to implementing any major renewal or rehabilitation of the pavement. Any repairs or capital upgrades to other infrastructure should be coordinated. This should reduce utility cuts in newer asphalt.
2. Repair potholes in the surface in a timely fashion to prevent saturation and weakening of road base.
3. Undertake regular shouldering program of rural paved roads to promote proper drainage. Poorly maintained shoulders allow surface water to pond and saturate the road base, which weakens the base and leads to cracking at the edge of pavements.
4. Undertake a ditching program to ensure there is adequate drainage for road base on rural roads. This will reduce the likelihood of structural distresses caused by softening of the road base due to poor drainage.
5. Specify the appropriate type of performance graded asphalt cement for the location.
6. Undertake a clearing program to reduce shading of the roadbed and remove roots / vegetation from the road base.

4.3 Application of Preservation Management Approach

The preservation management activities detailed in each of the tables above are not necessarily intended or required to be completed on each and every road. Road deterioration rates and the type of deterioration will dictate when action should be taken and what kind of treatment is most appropriate. The intention of the above is to outline the series of techniques to be considered in an effort to realize and extend the useful service life of the road asset for the lowest overall lifecycle cost while maintaining the highest overall condition. As detailed in the life cycle costs analysis presented above, the preservation management approach to roads is proven to yield the lowest overall life-cycle costs.

Each of the preservation management activities for gravel, surface treatment and asphalt roads identified above (including route and seal, slurry seal, resurfacing etc.), shall be considered as part of the regular Road Needs Study Report every five (5) years. Recommendations on the specific treatments required shall be documented and prioritized in this report.

5.0 Road Needs Study Summary Table

5.1 Types of Improvements

All roads were examined to appraise the extent and type of improvement necessary.

"Order of Magnitude" construction costs were developed for each of the below options on a per kilometre basis. An estimated cost for isolated frost heave repairs was also considered.

The below alternative rehabilitation strategies are considered preliminary in nature and are intended to assist in providing an order of magnitude cost estimate to rehabilitate the road. Further field investigations and engineering design is required to confirm and develop the rehabilitation strategies for each road.

5.1.1 Asphalt

High Class Bituminous roads (HCB) or hot mix asphalt roads have rehabilitation alternatives ranging from a simple overlay to complete reconstruction. The following is a listing of standard road rehabilitation techniques that were considered for HCB or hot mix asphalt roads.

RO1 Resurfacing, Single-Lift Overlay.

RO2 Resurfacing, Double-Lift Overlay.

RMP1 Resurfacing, Mill and Pave 1-Lift.

RMP2 Resurfacing, Mill and Pave 2-Lifts.

PP1 Pulverize and Pave 1-Lift.

PP2 Pulverize and Pave 2-Lifts.

Recon 1R Excavate and Reconstruct Road and Pave 1-Lift – Rural.

Recon 1S Excavate and Reconstruct Road and Pave 1-Lift – Semi-Urban.

Recon 2S Excavate and Reconstruct Road and Pave 2-Lifts – Semi-Urban.

Recon 2U Excavate and Reconstruct Urban Road and Pave 2-Lifts – Urban.

Upgrade 2U Excavate and Upgrade to Urban Cross-Section 2 Lifts – Urban.

SS Slurry Seal (Preventative Maintenance).

MS Microsurfacing (Preventative Maintenance).

RS Route and Seal (Preventative Maintenance).

5.1.2 Surface Treatment

Surface treated roads are generally able to be rehabilitated with either a single or double Low Class Bituminous (LCB) overlay treatment. They may also be upgraded to HCB pavement or downgraded to gravel. In some cases, previous resurfacing of LCB roads has occurred or the LCB surface or road structure has deteriorated to a state where a simple overlay surface treatment is not feasible. In these cases consideration can be given to removal or pulverizing of the existing surface treatment and placement of a new application. In some cases, where it is necessary to improve the overall roadbed structure, the addition of Granular A to build up the road and the reapplication of a surface treatment is recommended. The following is a listing of standard road rehabilitation techniques that were considered for LCB (surface treated) roads:

ST1 Single Surface Treatment.

ST2 Double Surface Treatment.

ST2R Double Surface Treatment, with Removal of Existing.

ST2A Double Surface Treatment, over New Granular A.

ST2PA Double Surface Treatment, over Pulverized Existing and New Granular A.

ST2PAW Double Surface Treatment, over Pulverized Existing and New Granular A with 1 m Widening.

SS Slurry Seal (Preventative Maintenance)

5.1.3 Gravel

Gravel roads can likewise be upgraded with the reapplication of Gravel (G) or surface treatments (ST1).

5.2 Benchmark Construction Costs

A Unit Price Form found in **Appendix A** is based on average prices for the local area was prepared. The unit prices were used to prepare an array of benchmark construction costs.

For the Township of Douro-Dummer, the following design standards, **Table 8,** were utilized for development of the benchmark cost estimate for reconstruction. It should be noted that these are suggested standards and therefore should not necessarily be used as standards for detail design of roadway improvements.

Table 8 - Design Standards for Construction Cost Estimates

Functional Classification	Surface Width (m)	Shoulder Width (m)	Granular A Depth (mm)	Granular B Depth (mm)	Hot Mix Depth (mm)*
Rural R200 (50 to 199 vpd)	6.0	1.5	150	450	-
Rural R300 (200 to 399 vpd)	6.0	1.5	150	450	16*
Rural R400 (400 to 999 vpd)	6.5	1.5	150	450	50
Semi - Urban Local Residential	6	1.5	150	450	50
Semi - Urban Local Industrial	6.5	1.5	150	450	50
Urban Local Residential	8.5	-	150	450	100
Urban Local Industrial	9.0	-	150	450	100

Note - Prime and Double Surface Treatment is based on 16 mm of Hot Mix.

6.0 Improvement Plan

6.1 Road Needs

The Capital Improvement Plan is included in **Appendix B**, noting recommendations in terms of priorities throughout the Township. AADT is based on counts / estimates provided by the Township. All costs are based on 2017 dollars and should be adjusted for inflation based on program year, for budgeting purposes. The capital improvements are listed based on need (Structural "NOW", 1-5 years, 6-10 years, needs as well as surface upgrades and widening needs) and in descending priority based on traffic volumes and Condition Rating, as described previously.

Following the study, a geotechnical investigation on several gravel roads conducted in 2015 and 2016 was provided to DM Wills. From these reports, included in **Appendix D**, it is clear that some gravel roads structural issues not captured under the 2017 (autumn) visual inspections suggested. Although the ratings and recommendations in this report reflect the ratings given in the original inspection, roads with geotechnical information supporting additional work are identified in the Capital Improvement Plan.

It should be noted that recommendations made are for benchmark costing only. They only consider the rating and traffic level of the road. Selection of actual pavement treatment should be made in detail design. In cases where the benchmark recommendation includes a surface type conversion, the Township should refer to the Township's Policy T-27, Criteria for Surface Treatment for definitive guidance.

Furthermore, work on the Township's boundary roads (Strickland Street, Division Road, Dummer Asphodel Road) needs to be coordinated with the neighboring municipality, as informed by their respective Boundary Road Agreements.

6.2 Annual Resurfacing Program

Based on typical degradation rates for gravel roads, surface treatment, and hot mix, a resurfacing program / budget is recommended, in addition to the noted capital construction works, as follows:

Hot Mix Paved Roads:

- 6.3 km of paved roads (HCB).
- Degradation rate 0.25 / year (surface rating drops from 10 to 5, over a 20-year period).
- Annual resurfacing 0.3 km / year.
- **Annual budget $67,800**: (0.3 km / year x $126,000 / ln **RMP1** x 2 lanes).

Surface Treated Roads:

- 105.1km of surface treated roads (LCB).
- Degradation rate 0.625 / year (surface rating drops from 10 to 5, over a 7-year period).
- Annual resurfacing 15.0 km / year.
- **Annual budget $360,000** (15.0 km / year x $24,000 / km **ST1**).

Gravel roads require regular maintenance. Maintenance includes regular grading and reapplication of new gravel. Typically, gravel roads should be resurfaced on a 3 - 5 year cycle.

Gravel Roads:

- 143.0 km of earth / gravel roads.
- 75mm gravel every 3-5 years.
- Annual gravelling of 28.6 km.
- Granular A ($19,000 / km).
- **Annual budget $543,400** (28.6 km / year x $19,000 **G**) **.

*** Cost based on use of Township's gravel pit*

Generally, the life-cycle cost of a gravel road is much lower than an LCB road, which in turn is much lower than an HCB road due to higher capital investment in the initial surface.

The total resurfacing program, (hot mix, surface treatment and gravel) is estimated at $971,200 per year.

Candidates for preservation / resurfacing include all roads with a 6-10 year structural need or are rated as structurally adequate. Although some of these roads will invariably

become capital needs, most can have their service lives extended at significantly less cost than reconstruction (i.e. keeping the good roads good).

Roads that are candidates for preservation / resurfacing are listed in **Appendix C**, Township of Douro-Dummer's Resurfacing List. Roads are listed in alphabetically for ease of reference.

6.3 Preservation Management

Preservation techniques seal the surface as to prevent water infiltration into the granular base. Route and Seal is used on HCB pavements to seal individual cracks. Slurry Seal / Microsurfacing is used on LCB and HCB pavements to seal large areas, although wide / active cracks will reflect through the treatment. An annual preservation management budget has been estimated as follows:

Route and Seal

- 6.3 km of paved roads (HCB).
- Assume that route and seal will be applied, on average, once per resurfacing cycle.
- 0.3 km of road to route and seal each year
- **Annual budget $1,200** (0.3 km x $4,000 / km In **Route and Seal**).

Given the Township's short total length of HCB roads, it is not be practical to fund an annual Route and Seal program. Alternatively, the Township may wish to program route and seal activities automatically 4 years after any new lift of HCB is paved.

Slurry Seal / Microsurfacing

- 6.3 km of paved roads (HCB).
- 102.3 km of surface treated roads (LCB).
- Assume that slurry seal / microsurfacing will be applied, on average, once per resurfacing cycle.
- 14.9 km of road to preserve per year (0.3 km HCB and 14.6 km of LCB).
- **Annual budget $194,900** (14.9 km x $13,000 / km **Slurry Sealing**).

Since the Township bundles surface treatment work with County of Peterborough tenders (gaining an economy of scale), the cost of slurry seal has not been historically competitive with surface treatment in the Township. Should this economic advantage change in the future, the Township should consider implementing a slurry seal program.

6.4 Road Maintenance

Preventative road and roadside maintenance is critical to prolonging the useful service life of a road and maximizing the capital investment. A continuous road and roadside maintenance program is recommended to reduce the road degradation rates. Ditch cleanout and clearing of vegetation from the right-of-way should be carried out on a regular basis. This can either be accomplished through dedicated internal Township forces or sub-contracting to private contractors. Consideration may be given to a dedicated capital program of ditch cleanout and clearing, to ensure resources are dedicated to these important activities.

7.0 Replacement Cost

In conjunction with this Road Needs Study Report, a replacement cost for the road asset was calculated based strictly on roadbed materials i.e. sub-base, base and surface. Road design standards noted in **Table 8** were used to estimate the existing depth of road bed materials for the purpose of the replacement cost calculation.

The total replacement cost for the Township's road infrastructure is approximately $30.3 M.

Note this cost represents the theoretical road bed materials costs only and does not include items such as removal of the existing road bed, installation of signs, pavement markings, lighting, drainage infrastructure, property etc.

8.0 Sidewalk Assessment

As part of the 2017 Road Needs Study an inventory/assessment of all township sidewalk was undertaken. The completed sidewalk inventory/assessment included documenting of the following:

- Material type.
- Width.
- Location (Side of Road).
- Length.
- AODA compliance.
- Condition.

The Sidewalk Summary Table, **Table 9**, lists the condition, width and AODA compliance issues for all sidewalks in the Township.

Table 9 - Sidewalk Summary Table

Road Section	Road Name	From	Length (m)	Side	Width	Condition	Notes on AODA Compliance
044	English Line (South)	County Road 4 - School Crosswalk	50	Even	1.5	G	Lacking TWSI at School crosswalk
045	Water Street	Mill Street to House 884	96	Even	1.2	P	Sidewalk is too narrow and lacks TWSI on curb ramps.
	County Road 4 (Water Street)	West Street – English Line	587	Odd	1.5	G	Lacking TWSI at Curb Ramps
	County Road 4 (Water Street)	Mill Street - West Street	270	Even	1.5	G	Lacking TWSI at Curb Ramps
	County Road 4 (Water Street)	Mill Street - West Street	270	Odd	1.5	G	Lacking TWSI at Curb Ramps
	County Road 4 (Mill Street)	Church Street - Water Street	80	Even	1.1	P	Sidewalk is too narrow and lacks TWSI on curb ramps.
	County Road 4 (Mill Street)	Church Street - Water Street	80	Odd	1.1	P	Sidewalk is too narrow and lacks TWSI on curb ramps.
	County Road 4	Ford Street - Mill Street	80	Even	1.1	P	Sidewalk is too narrow and lacks TWSI on curb ramps.
	County Road 38	Ford Street – Water Street	210	Even	1.5 – 1.3	F	Lacking TWSI at Curb Ramps
136	Douro 4th Line Road	County Road 8 to North End of Church	145	Even	1.2	P	Sidewalk is too narrow and lacks TWSI on curb ramps.
	County Road 8	Douro Limits - Douro 4th Line	80	Even	1.1	F	Sidewalk is too narrow and lacks TWSI on curb ramps.
	County Road 8	Douro Limits - Douro 4th Line	110	Odd	1.1	F	Sidewalk is too narrow and lacks TWSI on curb ramps.

All of the Township's sidewalks are concrete. Five sections are in poor condition, with the remaining section in good or fair condition. In terms of AODA compliance, all sections other than the newly installed ones on English Line, and on Water Street from Mill Street to English Line lack the 1.5 m width specified in the AODA. As these sidewalk sections are also in poor condition, a full reconstruction or asset removal is recommended.

Tactile Walking Surface Indicators (TWSI) were not present within the Township. These have recently become mandatory as per O. Reg. 191/11 on January 1, 2016.

9.0 Storm Sewer Assessment

As part of the 2017 Road Needs Study, the township's existing storm sewer system was also reviewed.

The Township currently has two (2) storm sewer systems in their inventory, both located within the village of Warsaw. The first system is located along West Street and contains two (2) catchbasins. This system includes a north inlet pipe and an outlet connecting to the County system at County Road No. 4. The second system contains eight (8) catchbasins and is located between Church Street and County Road 4. From the visual inspection undertaken by Wills, both systems appear to be in good condition.

It should be noted that the Township has what may be considered a third storm sewer system on Crowe's Landing Road. This storm sewer is irregular in its composition: catch basins are merely grates attached to vertical CSP's, with horizontal pipes outletting downstream. When this system is replaced, it should be upgraded to current standards.

10.0 Summary

D.M. Wills Associates (Wills) undertook a review of the Township of Douro-Dummer's (Township) existing road network to assess its physical condition and confirm various road attributes. Data collected as a result of the field review was used to develop a prioritized listing of the road network needs based primarily on condition and traffic volumes.

Wills undertook the field study in November of 2017. A visual assessment of each road within the Township was undertaken to assess surface and structural distress. A Condition Rating (CR) was calculated based on the identified deficiencies.

An overall road system adequacy has been calculated, consistent with the MTO Inventory Manual for Municipal Road (February 1991), based on a number of road characteristics including:

- Capacity
- Geometrics
- Surface Condition
- Shoulder and Road Widths
- Structural Adequacy
- Drainage
- Maintenance Demand

The average surface condition rating of all roads is 7.7 / 10 while the average structural adequacy rating is 14.7 / 20. This suggests that the typical road has a good riding quality, and in fair to good condition.

Capital Improvements

Prioritization and recommendations for planned capital improvements have been developed based on the condition rating and traffic demands on each road. Those roads identified as having a "NOW", 1 – 5 year, or 6 – 10 year structural needs have been included in the capital improvement plan for rehabilitation.

A total length of approximately 44.6 km of roads were identified as having structural needs in the "NOW," 1 – 5 year, or 6 – 10 year periods. The estimated cost to improve these roads is approximately $ 2.4 M. An additional length of approximately 7.8 km of road is identified as having inadequate surface widths or surface type. Generally, provided no operational or safety concerns are identified, roads with surface width and/or type deficiencies are typically addressed / considered at the next full reconstruction cycle.

Resurfacing

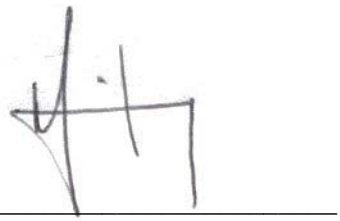
The total resurfacing program, (hot mix, surface treatment and gravel) is estimated at $971,200 per year.

Implementation / continuation of a road and roadside preventative maintenance program are strongly recommended. A concerted effort and funding for regular road maintenance can reduce the annual resurfacing / reconstruction requirements by prolonging the useful service life of a road.

The time of inspection plays a significant role in assessing a road's condition. Certain deficiencies, particularly for gravel roads, are only obvious during the "spring break-up" period. By midsummer, any evidence to suggest these deficiencies may have disappeared due to regular grading and grooming activities and general drying of the roadbed. The field work for this study was carried out in November 2017, by which time Any deficiencies specifically evident during the "spring break-up" were not visible.

We trust the above and attached information will be of benefit to the Township and appreciate the opportunity to assist the Township in developing its road improvement plan.

Respectfully submitted,



Michael Lang, P. Eng.
Manager, Transportation Engineering

ML/ESP/ms

Statement of Limitations

This report has been prepared by D.M. Wills Associates on behalf of the Township of Douro-Dummer. The conclusions and recommendations in this report are based on available background documentation and discussions with applicable Township staff at the time of preparation.

The report is intended to document the 2017 Roads Needs Study Report findings and assist the Township in developing budgetary plans for investment into their road network.

Any use which a third party makes of this report, other than as a Road Needs Study Report is the responsibility of such third parties. D.M. Wills Associates Limited accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or action taken based on using this report for purposes other than as a summary of the 2017 Road Needs Study Report findings.

Appendix A

Unit Price Form

ROAD IMPROVEMENT COSTS
Township of Douro-Dummer

Unit Costs	Units	Unit Cost
Granular A	t	$16.55
Crushed Granite	t	$18.00
Granular B	t	$10.00
Hot Mix	t	$130.00
Earth Excavation	m3	$12.00
Asphalt Removal	m2	$4.00
Asphalt Removal - Partial Depth	m2	$2.00
Removal of Concrete Curb & Gutter	m	$12.00
Concrete Curb & Gutter	m	$60.00
In-Place Full Depth Reclam. (Pulverizing)	m2	$1.50
Surface Treatment (single)	m2	$3.45
Surface Treatment (double)	m2	$5.40
Granular A Conversion	2.2	t/m3
Granular B Conversion	2	t/m3
Hot Mix Conversion	2.45	t/m3

Gravel (75mm)

Item	*Width - m*	*Depth - mm*	*Conversion Factor*	*Unit*		*Quantity*	*Unit Cost*	*Cost/km (x 1000)*
Granular A	7.0	75	2.2	t		1155	$16.55	$ 19
							G	**$ 19**

Frost Heave Treatment

Item	*Width - m*	*Depth - mm*	*Conversion Factor*	*Unit*		*Quantity*	*Unit Cost*	*Cost/50m Digout (x 1000)*
Earth Excavation	8.0	800		m3		320	$12.00	$ 4
Granular A	7.0	150	2.2	t		115.5	$16.55	$ 2
Granular B	8.0	650	2	t		520	$10.00	$ 5
							FT	**11**

Surface Treatment - Rural/Semi Urban - Single [ST1]

Item	*Width - m*	*Depth - mm*	*Conversion Factor*	*Unit*		*Quantity*	*Unit Cost*	*Cost/km (x 1000)*
Surface Treatment - Single (Overlay)	7.0			m2		7000	$3.45	$ 24
							ST1	**24**

Surface Treatment - Rural/Semi Urban - Double [ST2]

Item	*Width - m*	*Depth - mm*	*Conversion Factor*	*Unit*		*Quantity*	*Unit Cost*	*Cost/km (x 1000)*
Surface Treatment - Double (Overlay)	7.0			m2		7000	$5.40	$ 38
							ST2	**38**

Surface Treatment - Rural/Semi Urban - Double with Removal of Existing [ST2R]

Item	*Width - m*	*Depth - mm*	*Conversion Factor*	*Unit*	*Crossfall Correction*	*Quantity*	*Unit Cost*	*Cost/km (x 1000)*
Surface Treatment - Double	7.0			m2		7000	$5.40	$ 38
Removal Asphalt Pavement	7.0	16		m2		7000	$4.00	$ 28
							ST2R	**65.8**

Surface Treatment - Rural/Semi Urban - Double with Granular Base [ST2A]

Item	*Width - m*	*Depth - mm*	*Conversion Factor*	*Unit*	*Crossfall Correction*	*Quantity*	*Unit Cost*	*Cost/km (x 1000)*
Surface Treatment - Double	7.0			m2		7000	$5.40	$ 38
Granular A	7.0	100	2.2	t		1540	$16.55	$ 25
							ST2A	**63**

Surface Treatment - Rural/Semi Urban - Double with Pulverization and Granular Base [ST2PA]

Item	*Width - m*	*Depth - mm*	*Conversion Factor*	*Unit*	*Crossfall Correction*	*Quantity*	*Unit Cost*	*Cost/km (x 1000)*
Surface Treatment - Double	7.0			m2		7000	$5.40	$ 38
Granular A	7.0	90	2.2	t		1386	$16.55	$ 23
Pulverizing	7.0			m2		7000.0	$1.50	$ 11
Minor Items @ 25%								$ 3
							ST2PA	**74**

Surface Treatment - Rural/Semi Urban - Widening and Double with Pulverization and Granular Base [ST2PAW]

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)
Surface Treatment - Double	7.0			m2		7000	$5.40	$ 38
Granular A	7.0	300	2.2	t		4620	$16.55	$ 76
Pulverizing	7.0			m2		7000.0	$1.50	$ 11
Earth Excavation	2	450		m3		900	$12.00	$ 11
Granular B	1	300	2	t		600	$10.00	$ 6
Minor Items @ 25%								$ 7
							ST2PAW	**148**

Resurfacing - Rural/Semi Urban Single Lift Overlay [RO1]

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction **	Quantity	Unit Cost	Cost/km (x 1000)
Hot Mix	3	50	2.45	t	74	441	$130.00	$ 57
Granular A	1.5	50	2.2	t		165	$16.55	$ 3
Minor Items @ 15%								$ 9
							RO1	**69**

(per Lane Kilometre)

Resurfacing - Rural/Semi Urban - Double Lift Overlay [RO2]

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction **	Quantity	Unit Cost	Cost/km (x 1000)
Hot Mix	3	90	2.45	t	66	728	$130.00	$ 95
Granular A	1.5	90	2.2	t		297	$16.55	$ 5
Minor Items @ 15%								$ 15
							RO2	**114**

(per Lane Kilometre)

Resurfacing - Urban - Single Lift Mill and Pave [RMP1 - U]

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)
Hot Mix	4.25	50	2.45	t		521	$130.00	$ 68
Remove Curb and Gutter				m		200	$12.00	$ 2.40
Curb and Gutter - 20%				m		200	$60.00	$ 12.00
Milling	4.25			m2		4250	$2.00	$ 8.50
Minor Items @ 25%								$ 23
							RMP1	**113**

(per Lane Kilometre)

Resurfacing - Rural - Single Lift Mill and Pave [RMP1 - R]

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)
Hot Mix	4.25	50	2.45	t		521	$130.00	$ 68
Milling	4.25			m2		4250	$2.00	$ 8.50
Minor Items @ 35%								$ 27
							RMP1	**103**

(per Lane Kilometre)

Resurfacing - Urban - Double Lift Mill and Pave [RMP2]

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)
Hot Mix	4.25	90	2.45	t		937	$130.00	$ 122
Remove Curb and Gutter				m		200	$12.00	$ 2.40
Curb and Gutter - 20%				m		200	$60.00	$ 12.00
Milling	4.25			m2		4250	$3.00	$ 12.75
Minor Items @ 25%								$ 37
							RMP2	**186**

(per Lane Kilometre)

Pulverize and Pave One Lift Rural/Semi-Urban - With Additional Granular A [PP1A]

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)
Hot Mix	3	50	2.45	t		367.5	$130.00	$ 48
Granular A (Grade Raise)	4.5	150	2.2	t		1485	$16.55	$ 25
Granular A (Shoulders)	1.5	50	2.2	t		165	$16.55	$ 3
Pulverize	3			m2		3000	$1.50	$ 4.50
Minor Items @ 30%								$ 24
							PP1A	**103**

(per Lane Kilometre)

Pulverize and Pave One Lift [PP1] Rural/Semi-Urban

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Hot Mix	3	50	2.45	t		367.5	$130.00	$ 48	
Granular A	1.5	50	2.2	t		165	$16.55	$ 3	
Pulverize	3			m2		3000	$1.50	$ 4.50	
Minor Items @ 25%								$ 14	
							PP1	**69**	**(per Lane Kilometre)**

Pulverize and Pave Two Lifts [PP2] Rural/Semi-Urban

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Hot Mix	3	90	2.45	t		661.5	$130.00	$ 86	
Granular A	1.5	90	2.2	t		297	$16.55	$ 5	
Pulverize	3			m2		3000	$1.50	$ 5	
Minor Items @ 25%								$ 24	
							PP2	**119**	**(per Lane Kilometre)**

Semi-Urban: Resurfacing and Widening Residential (Single Lift Widening)

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction **	Quantity	Unit Cost	Cost/km (x 1000)	
Earth Excavation	2	500		m3		1000	$12.00	$ 12	
Granular A	5	150	2.2	t		1650	$16.55	$ 27	
Granular B	5	300	2	t		3000	$10.00	$ 30	
Hot Mix	8	50	2.45	t	196	1176	$130.00	$ 153	
Milling	4			m2		4000	$2.00	$ 8	
Minor Items @ 25%								$ 58	**(per Lane Kilometre)**
							RW1	**288**	**(widening one side)**

Commercial and Industrial (Double Lift Widening)

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Earth Excavation	2	600		m3		1200	$12.00	$ 14	
Granular A	5	150	2.2	t		1650	$16.55	$ 27	
Granular B	5	450	2	t		4500	$10.00	$ 45	
Hot Mix	8	90	2.45	t	353	2117	$130.00	$ 275	
Milling	4			m2		4000	$2.00	$ 8	
Minor Items @ 25%								$ 92	**(per Lane Kilometre)**
							RW2	**462**	**(widening one side)**

Gravel Road Widening

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Earth Excavation	2	450		m3		900	$12.00	$ 11	
Granular A	1	150	2.2	t		330	$16.55	$ 5	
Granular B	1	300	2	t		600	$10.00	$ 6	
Minor Items @ 25%								$ 6	**(per Lane Kilometre)**
							GW	**28**	**(widening one side)**

Rural: Full Excavation and Reconstruction - Gravel (6 m surface width)

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Earth Excavation	5	450		m3		2250	$12.00	$ 27	
Granular A	3	150	2.2	t		990	$16.55	$ 16	
Granular B	5	300	2	t		3000	$10.00	$ 30	
Minor Items @ 25%								$ 18	
							Recon G	**92**	**(per Lane Kilometre)**

Rural: Full Excavation and Reconstruction - 1 Lift

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Asphalt Removal - Full Depth	3			m2		3000	$4.00	$ 12	
Earth Excavation	5	500		m3		2500	$12.00	$ 30	
Granular A	4	150	2.2	t		1320	$16.55	$ 22	
Granular B	5	300	2	t		3000	$10.00	$ 30	
Hot Mix	3	50	2.45	t		368	$130.00	$ 48	
Minor Items @ 25%								$ 35	
							Recon 1R	**177**	**(per Lane Kilometre)**

Semi-Urban: Full Excavation and Reconstruction - 1 Lift

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Asphalt Removal - Full Depth	3			m2		3000	$4.00	$ 12	
Earth Excavation	5	500		m3		2500	$12.00	$ 30	
Granular A	4	150	2.2	t		1320	$16.55	$ 22	
Granular B	5	300	2	t		3000	$10.00	$ 30	
Hot Mix	3	50	2.45	t		368	$130.00	$ 48	
Minor Items @ 25%								$ 35	
							Recon 1S	**177**	**(per Lane Kilometre)**

Semi-Urban: Full Excavation and Reconstruction - 2 Lift

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Asphalt Removal - Full Depth	3			m2		3000	$4.00	$ 12	
Earth Excavation	5	500		m3		2500	$12.00	$ 30	
Granular A	4	150	2.2	t		1320	$16.55	$ 22	
Granular B	5	300	2	t		3000	$10.00	$ 30	
Hot Mix	3	90	2.45	t		662	$130.00	$ 86	
Minor Items @ 25%								$ 45	
							Recon 2S	**225**	**(per Lane Kilometre)**

Urban: Full Excavation and Reconstruction - 2 Lift

Item	Width - m	Depth - mm	Conversion Factor	Unit	Crossfall Correction	Quantity	Unit Cost	Cost/km (x 1000)	
Asphalt Removal - Full Depth	4.25			m2		4250	$4.00	$ 17	
Earth Excavation	5.5	500		m3		2750	$12.00	$ 33	
Granular A	4.5	150	2.2	t		1485	$16.55	$ 25	
Granular B	5.5	300	2	t		3300	$10.00	$ 33	
Hot Mix	4.25	90	2.45	t		937	$130.00	$ 122	
Remove Curb and Gutter				m		1000	$12.00	$ 12.00	
Curb and Gutter				m		1000	$60.00	$ 60.00	
Minor Items @ 25%								$ 57	
							Recon 2U	**359**	**(per Lane Kilometre)**

Rout and Seal

Item				Unit		Quantity	Unit Cost	Cost/km (x 1000)	
Rout and Seal				m		1000	$4.00	$ 4	
							RS	**4**	**(per Lane Kilometre)**

Slurry Seal

Item	Width - m			Unit		Quantity	Unit Cost	Cost/km (x 1000)	
Slurry Seal	7			m2		7000	$1.80	$ 13	
							SS	**13**	

Microsurfacing

Item	Width - m			Unit		Quantity	Unit Cost	Cost/km (x 1000)	
Microsurfacing	7			m2		7000	$4.00	$ 28	
							MS	**28**	

Stress Absorbing Membrane Interlayer - 1 Lift

Item	*Width - m*	*Depth - mm*	*Conversion Factor*	*Unit*	*Crossfall Correction*	*Quantity*	*Unit Cost*	*Cost/km (x 1000)*
SAMI	7			m2		7000	$7.50	$ 53
Hotmix	7	50	2.45	t		857.5	$130.00	$ 111
							SAMI-P1	**164**

Stress Absorbing Membrane Interlayer - Surface Treatment

Item	*Width - m*			*Unit*		*Quantity*	*Unit Cost*	*Cost/km (x 1000)*
SAMI	7			m2		7000	$7.50	$ 53
							SAMI-ST	**53**

Appendix B

Capital 10-Year Plan

Capital 10-Year Plan

Notes:

1. *Rehabilitation strategy to be confirmed by geotechnical investigations at detail design.*

2. *Timing of storm sewer/culvert work should be considered in conjunction with road reconstruction and vice versa, where applicable.*

3. *A structural "NOW" need does not explicitly mean that work must be undertaken on the road immediately. A structural "NOW" need means that the road's surface has reached the end of its useful service life and will require reconstruction or major rehabilitation to fully repair.*

Sect. No.	Road Name	From - To	Length (km)	AADT	Benchmark Costing Recommendation	Cost (x1000)	Surface Type Need	Surface Width Need
NOW Needs (Structural Adequacy is rated below 8/20)								
079	Daleview Drive	County Road 4-Division Road	0.70	385	*ST2PAW - Widening by 1 m, Double Surface Treatment, with Pulverization of Existing and Granular A*	*$104*	ADEQ	NOW
057	7th Line Road North Dummer	Centre Dummer-North Limit	1.20	49	*Recon G - Full Reconstruction 6m Gravel Road*	*$110*	ADEQ	ADEQ
012	White Lake Road West	County Road 6-South Limit	2.70	147	*ST2A - Double Surface Treatment with Granular A*	*$171*	ADEQ	ADEQ
153	Cooney Island Road	4th Line Road-East Limit	2.50	49	*Recon G - Full Reconstruction 6m Gravel Road*	*$229*	ADEQ	ADEQ
054	Douglas	Rock Road-4th Line Road	2.00	200	*ST2A - Double Surface Treatment with Granular A*	*$127*	ADEQ	ADEQ
039	Clifford Road	3rd Line Road South Dummer (west)-South Street	2.00	100	*ST2A - Double Surface Treatment with Granular A*	*$127*	ADEQ	ADEQ
167	Canal Road	County Road 4-North Limit	0.70	162	*ST2A - Double Surface Treatment with Granular A*	*$44*	ADEQ	ADEQ
008	Gilchrist Bay Road	County Road 6 (East)-County Road 6 (West)	1.30	49	*ST2A - Double Surface Treatment with Granular A*	*$82*	ADEQ	ADEQ
046	Mill Street	West Limit-Peterborough Street	0.10	49	*ST2A - Double Surface Treatment with Granular A*	*$6*	ADEQ	ADEQ

Sect. No.	Road Name	From - To	Length (km)	AADT	Benchmark Costing Recommendation	Cost (x1000)	Surface Type Need	Surface Width Need
1-5 Year Needs (Structural Adequacy is rated at 8/20 to 11/20)								
098	Strickland Street	Highway 28 (formerly Highway 134)-Westerly 500 m (Lakefield limits)	0.40	816	*ST2A - Double Surface Treatment with Granular A*	*$25*	ADEQ	ADEQ
094	McNab Avenue	County Road-South Limit	0.10	49	*ST2A - Double Surface Treatment with Granular A*	*$6*	ADEQ	ADEQ
205	Little Lane	County Road 6-Gilcrest Bay	0.10	49	*ST2A - Double Surface Treatment with Granular A*	*$6*	ADEQ	ADEQ
063	Cooper Road	4th Line Road-Caves Road	1.80	162	*ST2A - Double Surface Treatment with Granular A*	*$114*	ADEQ	ADEQ
095	Division Road	County Road 4-Burnham Line 10	0.80	498	*ST2A - Double Surface Treatment with Granular A*	*$51*	ADEQ	ADEQ
058	4th Line Road South Dummer	Clifford Road-Centre Dummer Road	1.20	109	*ST2A - Double Surface Treatment with Granular A*	*$76*	ADEQ	ADEQ
045	Water Street	Ford Street-Mill Street	0.20	49	*ST2A - Double Surface Treatment with Granular A*	*$13*	ADEQ	ADEQ
161	Douro 8th Line Road	County Road 4-250 m South	0.20	200	*ST2A - Double Surface Treatment with Granular A*	*$13*	ADEQ	ADEQ
093	Edgewood Avenue	County Road 4-South Limit	0.10	49	*ST2A - Double Surface Treatment with Granular A*	*$6*	ADEQ	ADEQ
179	Galloway Drive	McCracken Landing-West Limit	0.10	49	*ST2A - Double Surface Treatment with Granular A*	*$6*	ADEQ	ADEQ
156	Douro 5th Line Road	County Road 4-South Limit	0.01	49	*G - Gravel (75mm)*	*$0*	ADEQ	ADEQ
048	Church Street	Mill Street-West Street	0.20	49	*ST2A - Double Surface Treatment with Granular A*	*$13*	ADEQ	ADEQ
166	Lonsberry Lane	County Road 4-East Limit	0.60	49	*ST2A - Double Surface Treatment with Granular A*	*$38*	ADEQ	ADEQ
064	3rd Line Road North Dummer	Caves Road-County Road 6	2.10	298	*ST2A - Double Surface Treatment with Granular A*	*$133*	ADEQ	ADEQ
049	West Street	County Road 4-West Limit	0.20	49	*ST2A - Double Surface Treatment with Granular A*	*$13*	ADEQ	ADEQ

Sect. No.	Road Name	From - To	Length (km)	AADT	Benchmark Costing Recommendation	Cost (x1000)	Surface Type Need	Surface Width Need
052	Payne Line Road	County Road 4-Westerly	0.50	168	*ST2A - Double Surface Treatment with Granular A*	*$32*	ADEQ	ADEQ
023	11th Line South Dummer	Dummer-Asphodel Road-North Limit	0.90	200	*PP1A - Pulverize and Pave 1 Lift, with Grade Raise*	*$186*	ADEQ	ADEQ
6-10 Year Needs (Structural Adequacey is rated from 12/20 to 14/20)								
162	Bradfield Road	County Road 4-300 m South	0.30	76	*ST2 - Double Surface Treatment*	*$11*	ADEQ	ADEQ
013	Division Road	Highway 28 (formerly Highway 134)-Indian River Line	5.30	785	*ST2 - Double Surface Treatment*	*$200*	ADEQ	ADEQ
014	Division Road	Indian River Line-Carlow Line	2.70	578	*ST2 - Double Surface Treatment*	*$102*	ADEQ	ADEQ
132	Douro 2nd Line Road	County Road 4-County Road 8	2.00	142	*ST2 - Double Surface Treatment*	*$76*	ADEQ	ADEQ
144	Ayotte Crescent	8th Line Road-East Limit	0.20	49	*ST2 - Double Surface Treatment*	*$8*	ADEQ	ADEQ
044	English Line (South)	County Road 4-South Limit	0.20	108	*ST2 - Double Surface Treatment*	*$8*	ADEQ	ADEQ
069	4th Line Road North Dummer	Sawmill Road-North Limit	3.10	350	*ST2 - Double Surface Treatment*	*$117*	ADEQ	ADEQ
065	Caves Road	Cooper Road-County Road 4	1.60	134	*ST2 - Double Surface Treatment*	*$60*	ADEQ	ADEQ
206	Ironwoods Drive	County Road 4-South Limit	0.40	49	*ST2 - Double Surface Treatment*	*$15*	ADEQ	ADEQ
053	Rock Road	South Street-Douglas	1.70	353	*ST2 - Double Surface Treatment*	*$64*	ADEQ	ADEQ
Poorly Performing Gravel Roads as per 2015/2016 Geotechnical Investigations								
024	12th Line South Dummer	Forced Road Section-North Limit	6.30	100	*Refer to Geotechnical Reports*		ADEQ	ADEQ

Sect. No.	Road Name	From - To	Length (km)	AADT	Benchmark Costing Recommendation	Cost (x1000)	Surface Type Need	Surface Width Need
203	12th Line Road south Dummer (forced road section)	Highway No. 7-12th Line Road South Dummer (road allowance)	2.20	200	*Refer to Geotechnical Reports*		ADEQ	ADEQ
133	Douro 2nd Line Road	Cedar Cross Road-County Road 4	3.60	99	*Refer to Geotechnical Reports*		ADEQ	ADEQ
134	Center Road	Douro 3rd Line-Douro 5th Line	2.90	49	*Refer to Geotechnical Reports*		ADEQ	ADEQ
139	Center Road	Douro 5th Line Road-Highway 28 (formerly Highway 134)	1.30	151	*Refer to Geotechnical Reports*		ADEQ	ADEQ
138	Douro 5th Line Road	Center Road-County Road 4	1.80	103	*Refer to Geotechnical Reports*		ADEQ	ADEQ
135	Douro 4th Line Road	County Road 4-North Limit	3.90	113	*Refer to Geotechnical Reports*		ADEQ	ADEQ
133	Douro 2nd Line Road	Cedar Cross Road-County Road 4	3.60	99	*Refer to Geotechnical Reports*		ADEQ	ADEQ
145	Douro 7th Line Road	County Road 4-North Limit	1.70	36	*Refer to Geotechnical Reports*		ADEQ	ADEQ
137	Douro 5th Line Road	Center Road-North Limit	1.30	15	*Refer to Geotechnical Reports*		ADEQ	ADEQ

Appendix C

Resurfacing List

Township of Douro-Dummer Resurfacing List

Notes:

1. *Priorities in descending order. The higher the priority rating the greater the need.*
2. *Rehabilitation strategy to be confirmed by geotechnical investigations at detail design.*

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
172	10th Line of Dummer	Webster Road - Dummer-Asphodel Road	2.80	112	*G*	ADEQ	ADEQ
028	11th Line Road Mid Dummer	Mill Line Road - North Limit	0.90	49	*G*	ADEQ	ADEQ
073	11th Line Road North Dummer	County Road 6 - South Limit	1.20	250	*HCB*	ADEQ	ADEQ
204	12th Line Road South Dummer (road allowance)	Forced Road Section - Private Lane	0.20	49	*G*	ADEQ	ADEQ
203	12th Line Road south Dummer (forced road section)	Highway No. 7 - 12th Line Road South Dummer (road allowance)	2.20	200	*G*	ADEQ	ADEQ
024	12th Line South Dummer	Forced Road Section - North Limit	6.30	100	*G*	ADEQ	ADEQ
202	1st Line Road Douro	County Road 6 - South Limit	0.90	49	*G*	ADEQ	ADEQ
175	3rd Line Road North Dummer	County Road 6 - North Limit	0.20	49	*G*	ADEQ	ADEQ
035	3rd Line Road South Dummer	County Road 8 - South Limit	1.30	34	*G*	ADEQ	NOW
036	3rd Line Road South Dummer	County Road 8 - Clifford Road	3.00	53	*G*	ADEQ	ADEQ
034	3rd Line Road South Dummer	Division Road - North Limit	0.40	49	*G*	ADEQ	ADEQ
069	4th Line Road North Dummer	Sawmill Road - North Limit	3.10	350	*LCB*	ADEQ	ADEQ
033	4th Line Road South Dummer	County Road 8 - Division Road	3.10	99	*G*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
037	4th Line Road South Dummer	Clifford Road - County Road 8	3.20	120	*LCB*	ADEQ	ADEQ
059	4th Line Road South Dummer	Centre Dummer Road - Cooper Road	2.00	89	*G*	ADEQ	ADEQ
060	4th Line Road South Dummer	Cooper Road - North Limit	2.50	89	*G*	ADEQ	ADEQ
177	5th Line North Dummer	County Road 6 - North Limit	0.10	49	*G*	ADEQ	ADEQ
006	5th Line North Dummer	County Road 6 - South Limits to include entrance to farm owned by Township	1.40	49	*G*	ADEQ	ADEQ
032	5th Line Road South Dummer	Webster Road - North Limit	2.00	67	*G*	ADEQ	NOW
007	6th Line North Dummer	County Road 6 - End of Hawkins Lane	1.40	49	*G*	ADEQ	ADEQ
031	6th Line Road South Dummer	Webster Road - North Limit	1.90	49	*G*	ADEQ	ADEQ
178	6th Line South Dummer	County Road 6 - South Limit	0.20	49	*G*	ADEQ	ADEQ
200	6th Line South Dummer	Webster Road - County Rd 8	3.10	100	*G*	ADEQ	ADEQ
030	7th Line Road Mid-Dummer	Webster Road - North Limit	0.20	49	*G*	ADEQ	ADEQ
201	8th Line Dummer	Webster Road - County Rd. 8	2.90	100	*G*	ADEQ	ADEQ
077	8th Line Road North Dummer	County Road 6 - South Limit	0.60	108	*G*	ADEQ	ADEQ
019	8th Line South Dummer	Webster Road - North Limit	3.60	148	*G*	ADEQ	ADEQ
144	Ayotte Crescent	8th Line Road - East Limit	0.20	49	*LCB*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
040	Banks Avenue	County Road 8 - East Limit	0.20	49	*LCB*	ADEQ	ADEQ
070	Batten Lane	4th Line - East Limit	0.20	49	*G*	ADEQ	ADEQ
002	Birchview Road	McCrackens Landing - Camp Line Road	5.20	306	*LCB*	ADEQ	ADEQ
112	Birchview Road	Highway 28 - Camp Line Road	6.40	691	*LCB*	ADEQ	ADEQ
123	Block Road	Highway 28 (formerly Highway 134) - East Limit	0.10	49	*LCB*	ADEQ	ADEQ
162	Bradfield Road	County Road 4 - 300 m South	0.30	76	*LCB*	ADEQ	ADEQ
163	Bradfield Road	Douro 7th Line Road - West 1.2 km	1.20	49	*G*	ADEQ	ADEQ
003	Camp Line Road	Birchview Drive - Henderson Road	2.70	177	*LCB*	ADEQ	ADEQ
004	Camp Line Road	Henderson Road - County Road 6	1.80	177	*LCB*	ADEQ	ADEQ
148	Carlow Line Road	Division Road - County Road 8	3.40	110	*G*	ADEQ	NOW
065	Caves Road	Cooper Road - County Road 4	1.60	134	*LCB*	ADEQ	ADEQ
128	Cedar Cross Road	Douro 3rd Line - Payne Line Road	4.20	140	*G*	ADEQ	ADEQ
134	Center Road	Douro 3rd Line - Douro 5th Line	2.90	49	*G*	ADEQ	ADEQ
139	Center Road	Douro 5th Line Road - Highway 28 (formerly Highway 134)	1.30	151	*G*	ADEQ	ADEQ
140	Center Road	Highway 28 (formerly Highway 134) - County Road 32	2.70	92	*G*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
038	Clifford Road	4th Line South Dummer - 3rd Line Road	1.30	100	*G*	ADEQ	ADEQ
082	Clinton Avenue	Plati Avenue - Gifford Drive	0.40	181	*LCB*	ADEQ	ADEQ
062	Cooper Road	4th Line Road East - East Limit	1.40	49	*G*	ADEQ	ADEQ
086	Coral Drive	Television Road - East Limit	0.30	135	*LCB*	ADEQ	ADEQ
076	Crowes Landing Road	County Road 6 - North Limit	0.90	282	*LCB*	ADEQ	ADEQ
210	Crowe's Landing Road	9th Line Dummer - Stony Lake	0.20	100	*LCB*	ADEQ	ADEQ
013	Division Road	Highway 28 (formerly Highway 134) - Indian River Line	5.30	785	*LCB*	ADEQ	ADEQ
014	Division Road	Indian River Line - Carlow Line	2.70	578	*LCB*	ADEQ	ADEQ
096	Division Road	Burnham Line 10 - Douro 7th Line	4.20	476	*LCB*	ADEQ	ADEQ
097	Division Road	Douro 7th Line - Highway 28 (formerly Highway 134)	1.30	448	*LCB*	ADEQ	ADEQ
089	Donwood Drive	County Road 4 - Hillview Avenue	0.50	423	*LCB*	ADEQ	ADEQ
149	Douro 1st Line	Division Road - County Road 8	3.70	62	*G*	ADEQ	ADEQ
129	Douro 1st Line Road	Cedar Cross Road - North Limit	0.30	49	*G*	ADEQ	ADEQ
115	Douro 1st Line Road	County Road 6 - North Limit	1.30	49	*G*	ADEQ	ADEQ
131	Douro 1st Line Road	County Road 4 - South Limit	0.70	49	*G*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
130	Douro 1st Line Road	Cedar Cross Road - County Road 4	3.10	75	*G*	ADEQ	ADEQ
133	Douro 2nd Line Road	Cedar Cross Road - County Road 4	3.60	99	*G*	ADEQ	ADEQ
116	Douro 2nd Line Road	County Road 6 - South Limit	0.50	49	*G*	ADEQ	ADEQ
132	Douro 2nd Line Road	County Road 4 - County Road 8	2.00	142	*LCB*	ADEQ	ADEQ
150	Douro 2nd Line Road	Division Road - County Road 8	3.60	136	*LCB*	ADEQ	ADEQ
171	Douro 3rd Line Road	County Road 4 - South Limit	0.40	49	*G*	ADEQ	ADEQ
127	Douro 3rd Line Road	Lynch's Rock Road - County Road 4	5.30	78	*G*	ADEQ	ADEQ
165	Douro 3rd Line Road	Division Road - County Road 8	3.30	188	*G*	ADEQ	ADEQ
113	Douro 3rd Line Road	Birchview Road - South Limit	0.90	49	*G*	ADEQ	ADEQ
110	Douro 3rd Line Road	South Beach - Rishor Avenue	0.40	68	*LCB*	ADEQ	ADEQ
117	Douro 4th Line	County Road 6 - South Limit	4.00	49	*G*	ADEQ	ADEQ
135	Douro 4th Line Road	County Road 4 - North Limit	3.90	113	*G*	ADEQ	ADEQ
151	Douro 4th Line Road	Division Road - Cooney Island Road	1.80	121	*G*	ADEQ	ADEQ
119	Douro 4th Line Road	Highway 28 Intersection - Birchview Road	0.10	49	*G*	ADEQ	ADEQ
118	Douro 4th Line Road	County Road 6 - Highway 28	1.60	358	*LCB*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
136	Douro 4th Line Road	County Road 4 - County Road 8	1.50	305	*LCB*	ADEQ	ADEQ
169	Douro 4th Line Road	Highway 28 - North Limit	0.50	49	*G*	ADEQ	ADEQ
152	Douro 4th Line Road	Cooney Island Road - County Road 8	1.30	190	*LCB*	ADEQ	ADEQ
120	Douro 5th Line	County Rd #6 - Lynch Rock Road	1.50	131	*G*	ADEQ	ADEQ
137	Douro 5th Line Road	Center Road - North Limit	1.30	15	*G*	ADEQ	ADEQ
121	Douro 5th Line Road	Lynch Rock Road - Strickland Road	0.30	155	*LCB*	ADEQ	ADEQ
138	Douro 5th Line Road	Center Road - County Road 4	1.80	103	*G*	ADEQ	ADEQ
155	Douro 5th Line Road	Division Road - North Limit (County Road 8)	2.40	67	*G*	ADEQ	ADEQ
157	Douro 7th Line Road	County Road 4 - South Limit (Bradfield Road)	1.20	133	*LCB*	ADEQ	ADEQ
145	Douro 7th Line Road	County Road 4 - North Limit	1.70	36	*G*	ADEQ	ADEQ
158	Douro 7th Line Road	Division Road - North Limit (Bradfield)	1.90	49	*G*	ADEQ	ADEQ
160	Douro 8th Line Road	Division Road - North Limit	1.90	100	*G*	ADEQ	ADEQ
143	Douro 8th Line Road	County Road 32 - County Road 4	3.90	200	*G*	ADEQ	ADEQ
147	Douro 9th Line	County Road 32 - County Road 4	4.20	200	*G*	ADEQ	ADEQ
164	Douro 9th Line	County Road 4 - Division Road	1.20	100	*LCB*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
208	Dummer Asphodel Road	11th Line Dummer - East End	0.30	49	*G*	ADEQ	ADEQ
015	Dummer Asphodel Road	Carlow Line - County Road 38	1.40	488	*LCB*	ADEQ	ADEQ
017	Dummer Asphodel Road	Bridge - County Road 8	1.10	480	*LCB*	ADEQ	ADEQ
016	Dummer Asphodel Road	County Road 38 - 400 m East of 4th Line (at bridge)	3.30	480	*LCB*	ADEQ	ADEQ
021	Dummer Asphodel Road	County Road 40 - 11th Line South Dummer	2.80	100	*HCB*	ADEQ	ADEQ
055	Dummer Centre Road	4th Line Road - County Road 40	7.90	49	*G*	ADEQ	ADEQ
010	Dummer Lake Road East	County Road 6 - South Limit (to start of Private road)	1.30	137	*G*	ADEQ	ADEQ
044	English Line (South)	County Road 4 - South Limit	0.20	108	*LCB*	ADEQ	ADEQ
174	English Line North	County Road 6 - North Limit	0.90	49	*G*	ADEQ	ADEQ
043	Ford Street	East of South Street - Peterborough Street	0.20	950	*HCB*	ADEQ	ADEQ
083	Gifford Drive	Television Road - Kingsdale	0.50	205	*LCB*	ADEQ	ADEQ
005	Golf Course Road	McCrackens Landing - Barnes Road	2.20	100	*LCB*	ADEQ	ADEQ
114	Henderson Road	Camp Line - West Limit	0.70	49	*G*	ADEQ	ADEQ
141	Hickey Road	7th Line Road - County Road 32	0.50	33	*G*	ADEQ	ADEQ
173	Hickson Road	County Road 40 - West Limit	0.40	49	*G*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
087	Highland Avenue	County Road 4 - North Limit	0.20	49	*LCB*	ADEQ	ADEQ
105	Hilliard Way	Highway 28 - West Limit	0.20	49	*LCB*	ADEQ	ADEQ
090	Hillview Avenue	Donwood Drive - Orchard Crescent	0.20	49	*LCB*	ADEQ	ADEQ
009	Howard Drive	County Road 6 - South Limit	0.10	49	*G*	ADEQ	ADEQ
212	Indacom Drive	County Road 4 - South Limit	0.20	49	*G*	ADEQ	ADEQ
206	Ironwoods Drive	County Road 4 - South Limit	0.40	49	*LCB*	ADEQ	ADEQ
011	Ivandale Road	Dummer Lake Road East - West Limit	0.40	49	*G*	ADEQ	ADEQ
168	Kerr Road	County Road 8 - South Limit	0.10	49	*G*	ADEQ	ADEQ
084	Kingsdale Drive	County Road 4 - North Limit	0.60	280	*LCB*	ADEQ	ADEQ
176	Landfill Road	County Road 6 - to Transfer Station	0.40	49	*G*	ADEQ	ADEQ
126	Lynch's Rock Road	Douro 5th Line - Douro 3rd Line	2.80	177	*G*	ADEQ	ADEQ
092	Maryvale Road	County Road 4 - North Limit	0.40	116	*LCB*	ADEQ	ADEQ
001	McCrackens Landing	County Road 6 - North Limit (Stoney Lake)	1.70	501	*LCB*	ADEQ	ADEQ
072	McNaughton Drive	County Road 6 - McNaughton Lane	0.40	49	*G*	ADEQ	ADEQ
071	McNaughton Lane	McNaughton Drive - North Limit	0.20	49	*G*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
027	Mill Line Road	Bridge - East Limit	1.70	120	*G*	ADEQ	ADEQ
026	Mill Line Road	County Road 40 - Bridge (East End)	1.30	120	*G*	ADEQ	ADEQ
102	Moodie Drive	Stenner Road - East Limit	0.80	90	*LCB*	ADEQ	ADEQ
146	Nassau Road	9th Line - County Road 4	2.90	400	*LCB*	ADEQ	ADEQ
050	Oke Road	County Road 4 - Payne Line Road	1.40	60	*G*	ADEQ	ADEQ
159	Old Douro Road	Highway 28 (formerly Highway 134) - County Road 8	0.50	49	*G*	ADEQ	ADEQ
170	Old Highway 28	South Beach Road - North Limit	0.30	49	*LCB*	ADEQ	ADEQ
091	Orchard Crescent	Donwood Drive - Hillview Avenue	0.40	49	*LCB*	ADEQ	ADEQ
051	Payne Line Road	Oke Road - County Road 4	2.00	168	*G*	ADEQ	ADEQ
081	Plati Avenue	Kingsdale - Television Road	0.50	270	*LCB*	ADEQ	ADEQ
066	Rock Road	Cooper Road - Douglas	2.00	160	*LCB*	ADEQ	ADEQ
067	Rock Road	Rock Road - Douglas Road	0.50	160	*LCB*	ADEQ	ADEQ
053	Rock Road	South Street - Douglas	1.70	353	*LCB*	ADEQ	ADEQ
085	Roxton Road	Kingsdale Drive - East Limit	0.10	49	*LCB*	ADEQ	ADEQ
056	Rusaw Lane	County Road 40 - West Limit	1.40	49	*G*	ADEQ	ADEQ

Sect. No.	Road Name	From	Length (km)	AADT	Existing Surface Type	Surface Type Need	Surface Width Need
068	Sawmill Road	3rd Line Dummer - 4th Line Dummer	2.30	209	*LCB*	ADEQ	ADEQ
025	Simpson Road	12th Line - East Limit	0.90	100	*G*	ADEQ	ADEQ
074	South Bay Road	County Road 6 - North Limit	1.00	100	*LCB*	ADEQ	ADEQ
109	South Beach Road	Highway 28 - East Limit	0.60	127	*LCB*	ADEQ	ADEQ
100	Stenner Road	Highway 28 - North Limit	0.50	150	*LCB*	ADEQ	ADEQ
122	Strickland Road	Highway 28 (formerly Highway 134) - Douro 5th Line	1.20	316	*LCB*	ADEQ	ADEQ
211	Television Road	County Road 4 - North Limit	1.22	1096	*HCB*	ADEQ	ADEQ
108	Thelgar Road	Highway 28 - West Limit	0.30	49	*LCB*	ADEQ	ADEQ
209	Unnamed Road	McCracken's Landing Road - East Limit	0.10	49	*G*	ADEQ	ADEQ
088	Valleyview Avenue	Highland Avenue - County Road 4	0.20	49	*LCB*	ADEQ	ADEQ
020	Webster Road	County Road 40 - 10th Line South Dummer	1.30	60	*G*	ADEQ	ADEQ
029	Webster Road	County Road 40 - County Road 8 (5th Line Road South Dummer)	5.60	390	*LCB*	ADEQ	ADEQ

Appendix D

2015 / 2016 Geotechnical Investigations

May 31, 2016 Reference No. 11114440-02

Township of Douro-Dummer
Public Works
1422 County Road 4
Warsaw, Ontario
K0L 3A0

Attention: Harold Nelson (publicworks@dourodummer.on.ca)

Re: Gravel Roads in the Township of Douro-Dummer

1. Scope of Project

The Township of Douro Dummer has received reports from residents that were subsequently confirmed by staff, that immediately following precipitation events, isolated areas of softness and loss of consistency develop on the surface of some of the gravel roads in the Township. The softer consistency is not persistent and rapidly dissipates with time. In order to further study and understand the areas, the Township and GHD undertook to obtain a sample of the road surface. Immediately following a precipitation event, the roads were inspected by Douro Dummer staff and samples were obtained from the road surface in areas found to have a change in consistency. The samples were then split with a portion going for chemical testing to determine the ratio of salts present and the second portion was sent to the GHD geotechnical laboratory for gradation testing. Since a gravel roadway was also recently being constructed the gradations present at the surface were compared to the gradation of the new gravel purchased.

2. Road Surface Samples

The roadway surface was sampled at the following locations:

1 5th Line of Douro, adjacent to House 604
2 5th Line of Douro, adjacent to House 735
3 5th Line of Douro, adjacent to House 856
4 Center Road, adjacent to House 829
5 Center Road, adjacent to House 1045
6 4th Line of Douro adjacent to House 597
7 4th Line of Douro adjacent to House 798
8 4th Line of Douro adjacent to House 968
9 2nd Line of Douro adjacent to House 1117
10 2nd Line of Douro adjacent to House 719

Samples were obtained using stainless steel shovel and were stored in sealable plastic bags until transfer in the laboratory.

For this assignment, GHD used its Peterborough office and laboratory facilities to provide geotechnical laboratory testing services. The Peterborough Laboratory is certified by CCIL as a Type A and B Asphalt (Marshall and Superpave), Type C and D Aggregate, Type D Soils and CSA Category 2+ Additional Concrete testing facility. The Sodium Adsorption Ratio (SAR) testing was completed by SGS Laboratories in Lakefield, a CALA certified laboratory for the testing undertaken.

In addition the stockpile at Drains Brothers yard currently being used to supply gravel to the Douro Dummer Township road regrading was sampled and tested for comparative purposes.

3. Laboratory Results

All laboratory test results are included in the appendices of this report. Appendix A contains the gradation results, and Appendix B contains the SAR test results from SGS Laboratories.

3.1 Roadway Sample Gradation

The roadway granular results were divided into constituents of sand, silt and clay portions as defined in particle diameter by the Ministry of Transport OPSS Section 10.

Table 1 – Gradation Constituents of Road Granular Scraped From Existing

Sample No.	Road/House	Gravel	Sand	Silt	Clay
1	5th Line/604	21	58	18	3
2	5th Line/735	29	52	17	2
3	5th Line/856	16	60	21	3
4	Center Rd/829	21	58	18	3
5	Center Rd/1045	27	55	15	3
6	2nd Line/719	30	52	16	2
7	2nd Line/1117	21	59	18	2
8	4th Line/597	18	62	18	2
9	4th Line/798	18	62	18	2
10	4th Line/968	22	56	20	2

It should be noted that the results are not expected to meet the Ontario Provincial Standard Specifications since the roadway has been under use. Thus the original gravel would have been segregated where by gravel sized particles are pushed down and the road surface absorbs silt from winter sand and silt and clay from soil tracked onto the road from vehicles. By comparison the granular constituents from Drain Bros North Quarry and from Smith Quarry were found to have constituents that meet the OPSS 1010 requirements for Granular M and A as follows:

Table 2 – Gradation Constituents of Drain Bros Gravel in Stockpile vs OPSS

Sample No.	Quarry	Gravel	Sand	Silt	Clay
A	Smith east	46	47	7	0
2	North west	48	45	7	0
3	North east	56	37	7	0
4	OPS	45-65	33-63	2-10	0

The gravel can only absorb finer grained particles because the original grains create a matrix which is too small to allow sand to be absorbed. Thus the winter sand activities result in sand staying near the surface but silt and clay penetrating.

3.2 Roadway Salts

A second cause as to lower road stability and drainage was previously identified as salts. The samples scraped from the road surface were tested for salts. It was determined previously in samples obtained in fall of 2015 that the calcium ions varied from 12 to 96 ppm, the magnesium ions varied from 0.5 to 3 ppm and the sodium ions varied from 4 to 45 ppm. The current findings were as follows:

Table 3 – Salt Constiuents Granular

Sample No.	Road/House	Calcium	Magnesium	Sodium	SAR
1	5th Line/604	97.7	15.2	492	12.2
2	5th Line/735	55.6	8.1	407	13.5
3	5th Line/856	84.8	9.6	328	9.0
4	Center Rd/829	132	17	508	11.1
5	Center Rd/1045	54	8.3	227	7.6
6	2nd Line/719	97.9	14.8	463	11.5
7	2nd Line/1117	123	20.5	476	10.5
8	4th Line/597	249	26.1	507	8.17
9	4th Line/798	35.4	4.9	296	12.3
10	4th Line/968	74.5	13.2	413	11.6

The present results reflect a large increase in the sodium ion concentration due to addition of road salt for safety purposes. Thus the salt contribution for the temporary instability of the roads appears to be much more prevalent in the spring. The increase in calcium and magnesium may be attributable to dust suppression.

4. Discussion

It is concluded from the testing that the gravel imported to add to the roadway from local quarries is of proper gradation to start. As the gravel road ages the contributions of winter sand and salt coupled with soil from vehicles (farm, commercial, municipal and private) generally add fines soil particles to the upper layer, and sand to the surface. In addition salts build up in the granular through the winter.

This results in poorer drainage in the granular which prevents water from draining from the upper granular in the roadway. This creates a temporary change in consistency in the upper portion of the granular immediately after precipitation events.

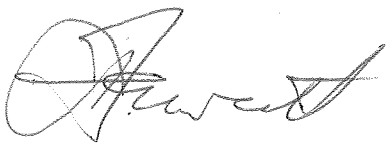
The strength of a gravel road is affected by the gradation (a stronger material is obtained when there is a scattering of grain sizes through the sand and gravel size range), and the ability of the material to drain water through it. The gravel is meant to spread tire loads sufficiently such that the underlying fine grained soil doesn't form ruts. When gravel becomes flooded the tire loads are not spread but are transferred straight to the subgrade.

In viewing the isolated nature of this problem and its transitory nature, it is not likely severe enough to warrant substantial budget resource allocation in the form of surface treatment. We would concur with the Townships intention to add a clearstone product that would add strength to the surface as the best option available.

If there are any further questions or concerns please do not hesitate to contact our office.

Sincerely,

GHD



Andy Fawcett, P.Eng.
Senior Engineer

AF/af/1

Encl. Appendix A – Sieve Analysis Test Results
Appendix B – Sodium Absorption Ration (SAR) Test Results

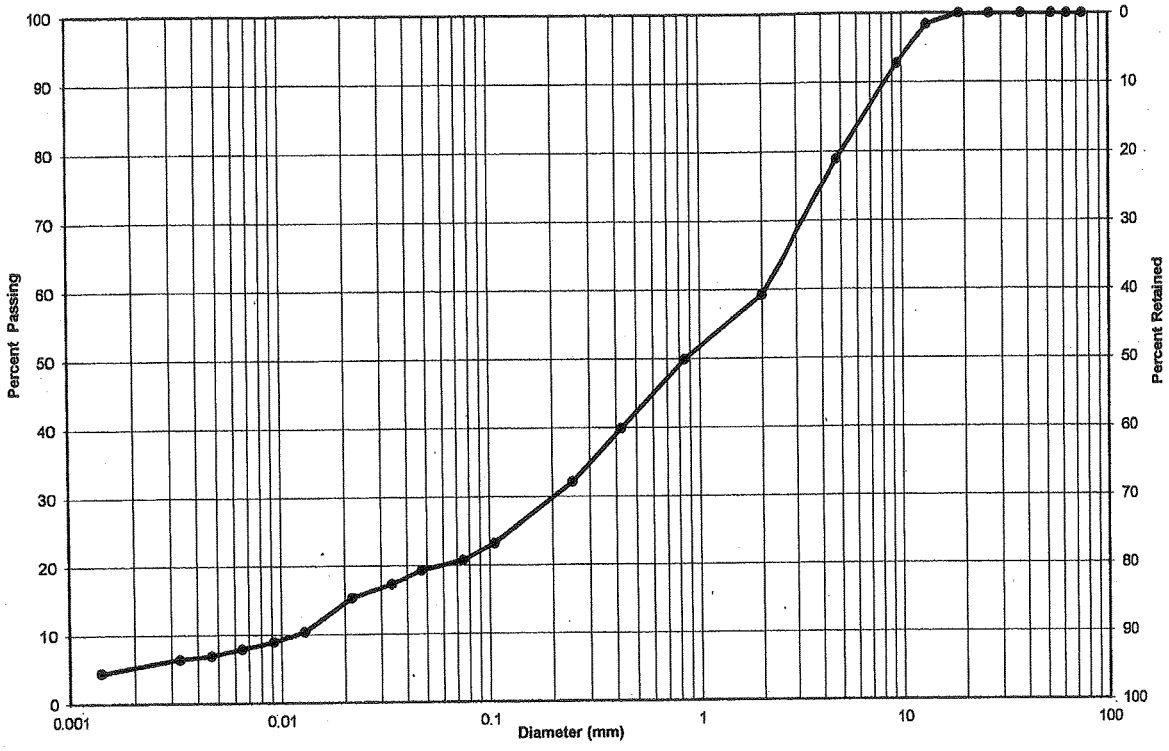
Enclosures

Appendix A
Sieve Analysis Test Results

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro-Dummer	**Lab no.:**	AG-16-87
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	5th line of Douro, 911 #604	Sample no.:	SA1
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA1	21	58	21

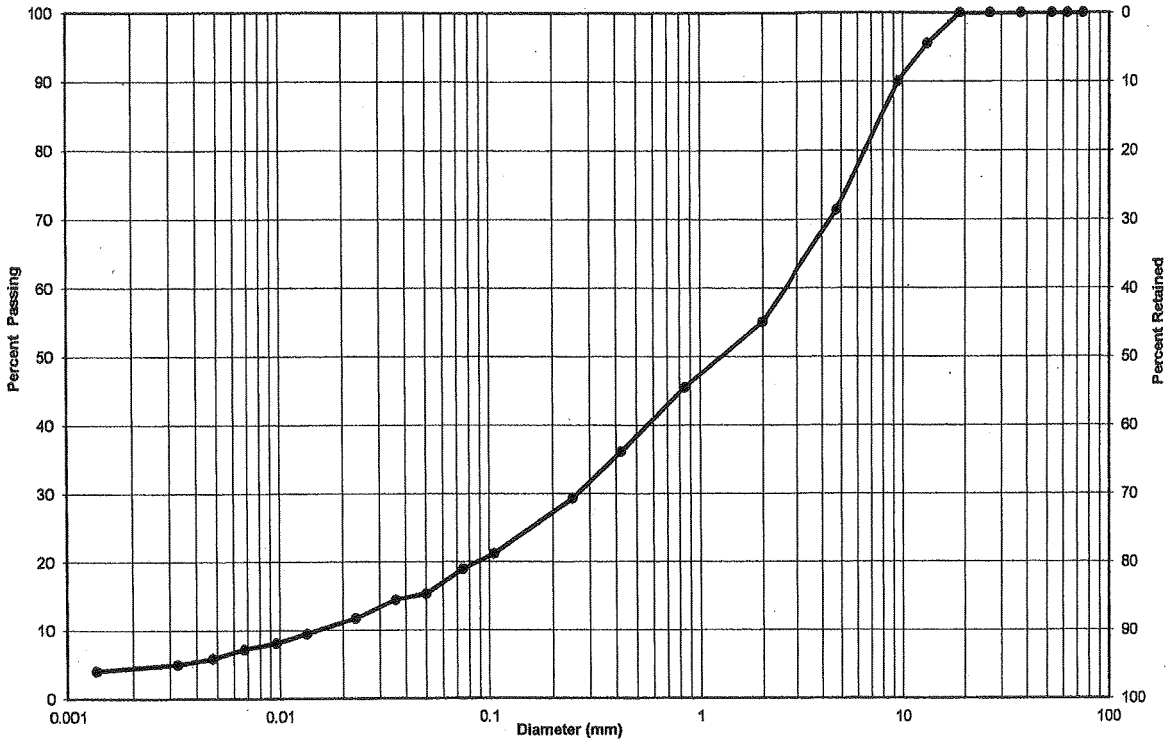
Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro- Dummer	**Lab no.:**	AG-16-88
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	5th Line of Douro, 911 #735	Sample no.:	SA2
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA2	29	52	19

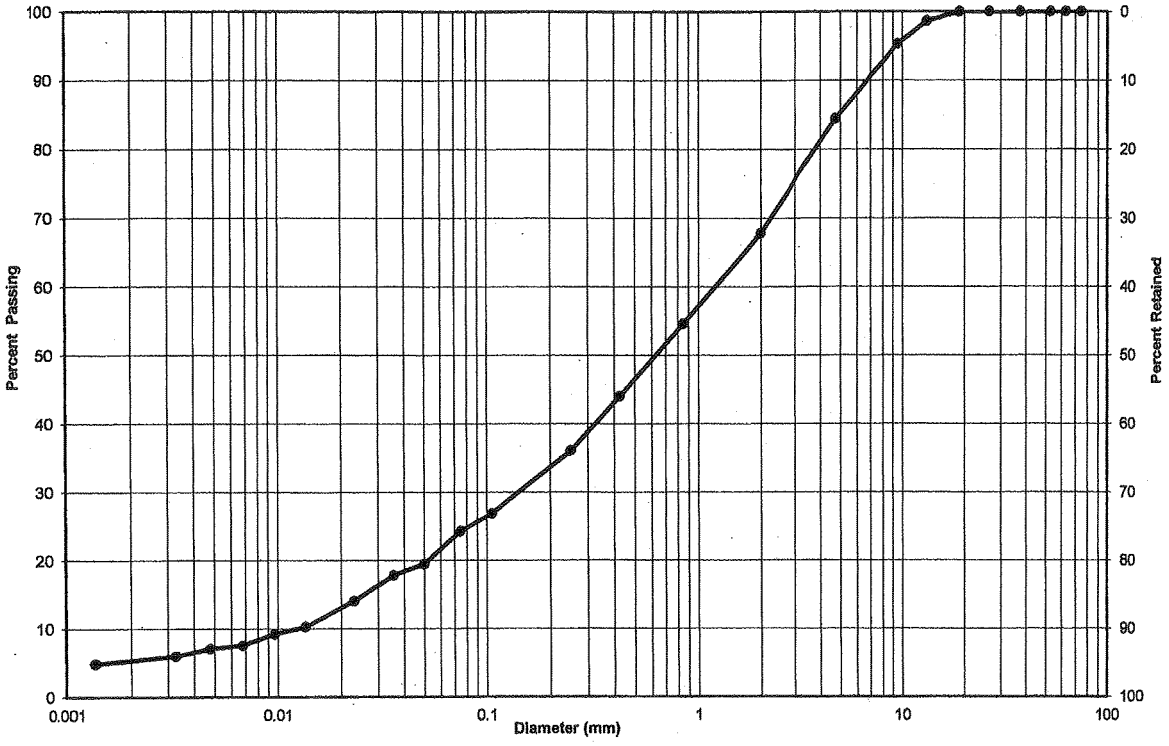
Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro- Dummer	**Lab no.:**	AG-16-89
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	5th Line of Douro, North of Center Rd, 911 #856	Sample no.:	SA3
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA3	16	60	24

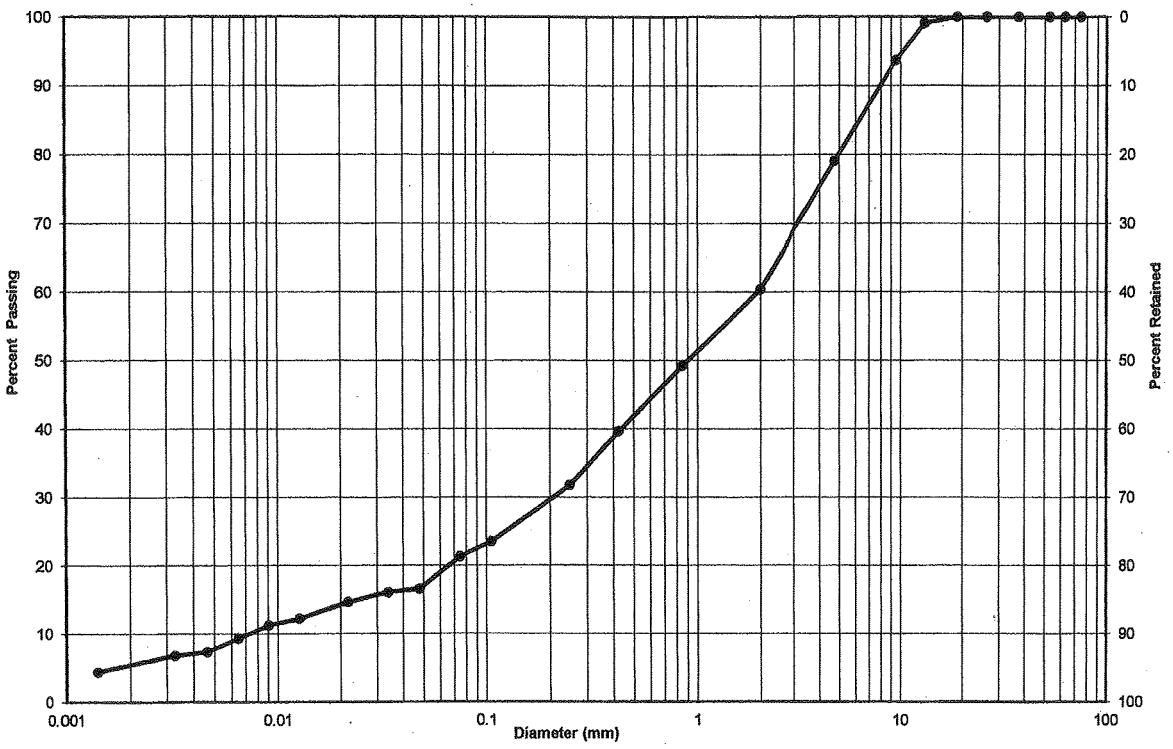
Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro-Dummer	**Lab no.:**	AG-16-90
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	Center Rd. 911 #829	Sample no.:	SA4
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA4	21	58	21

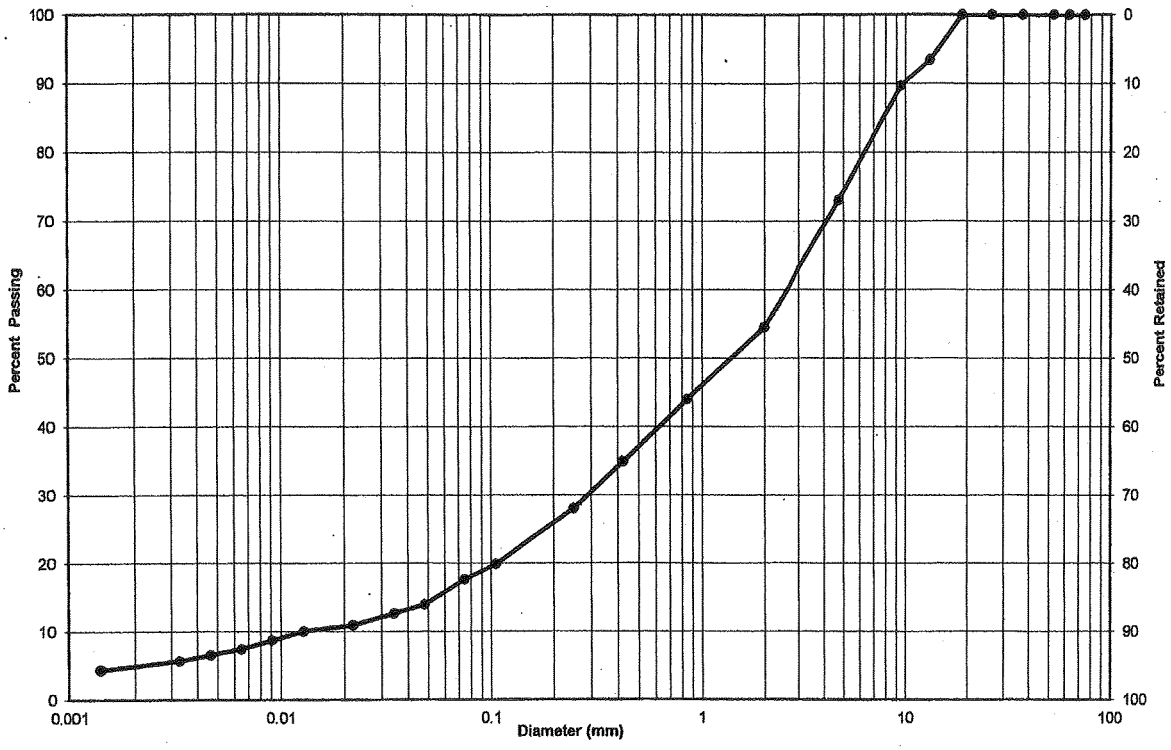
Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro-Dummer	**Lab no.:**	AG-16-91
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	Center Rd. 911 #1045	Sample no.:	SA5
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA5	27	55	18

Remarks:

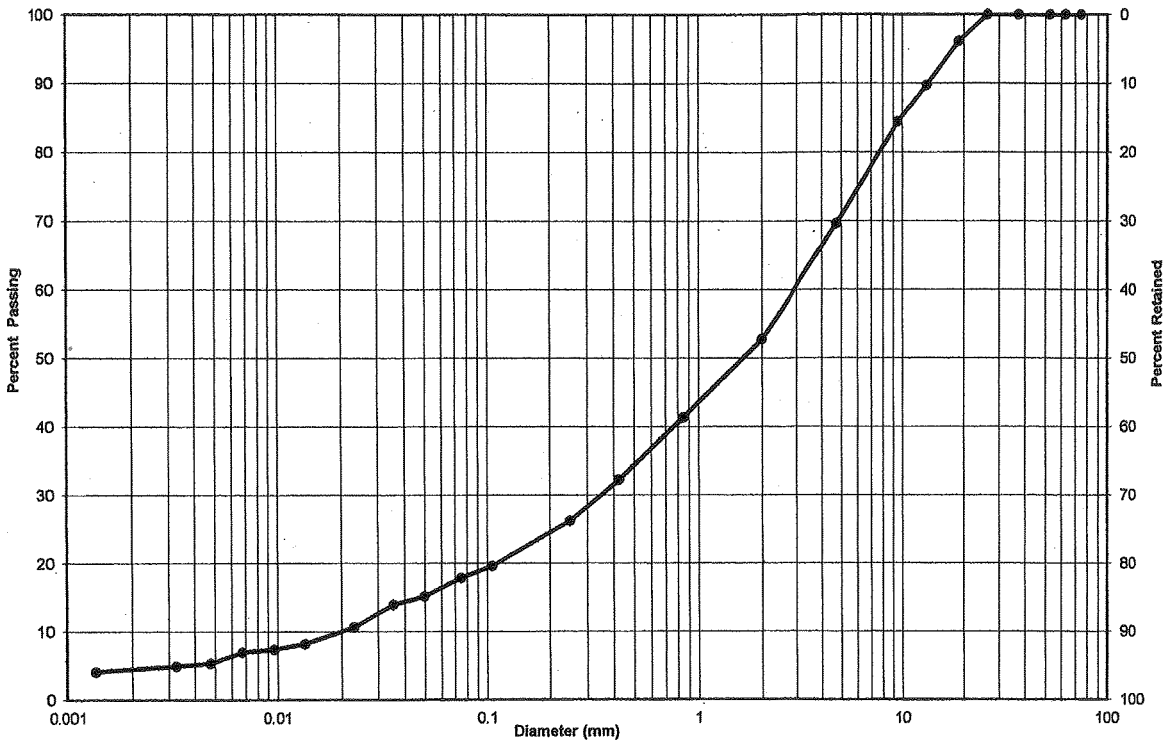
Performed by: [signature] **Date:** May 19, 2016

Verified by: [signature] **Date:** May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro-Dummer	**Lab no.:**	AC-16-96
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	2nd Line of Douro, 911 #719	Sample no.:	SA10
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA10	30	52	18

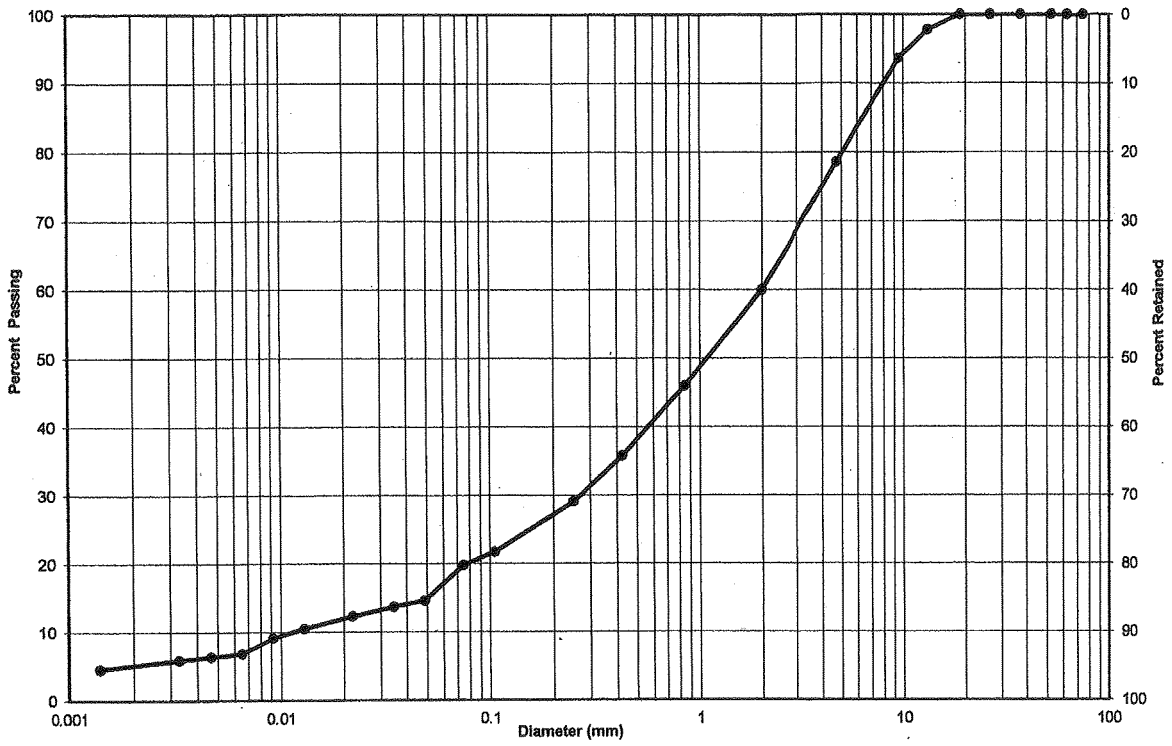
Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro-Dummer	**Lab no.:**	AG-16-95
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	2nd Line of Douro, 911 #1117	Sample no.:	SA9
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA9	21	59	20

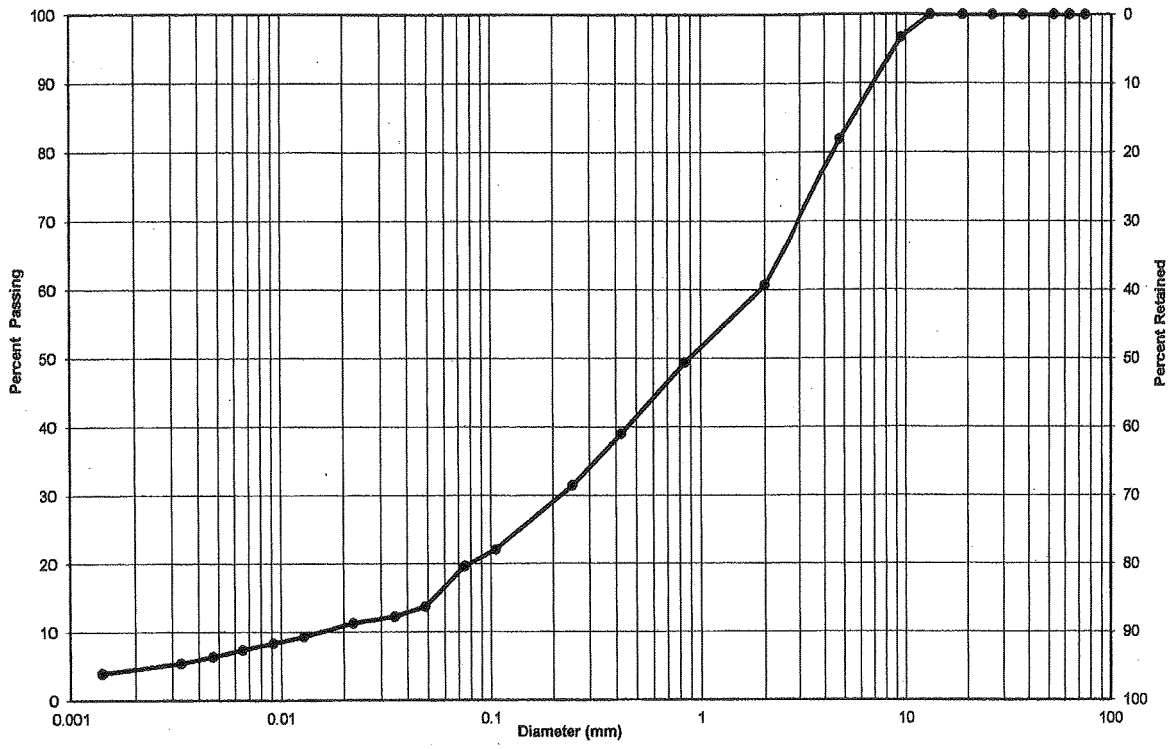
Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro-Dummer	**Lab no.:**	AG-16-92
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	4th Line of Douro, 911 #597	Sample no.:	SA6
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA6	18	62	20

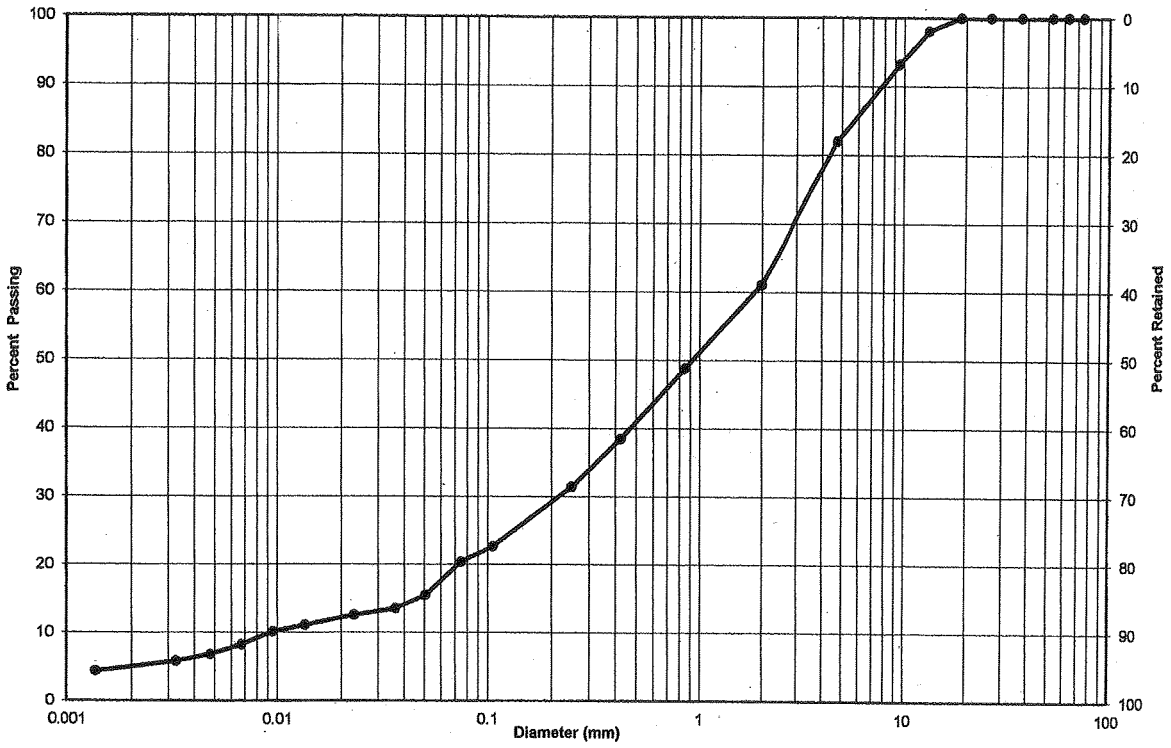
Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro-Dummer	**Lab no.:**	AG-16-93
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	4th Line of Douro, 911 #798	Sample no.:	SA7
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA7	18	62	20

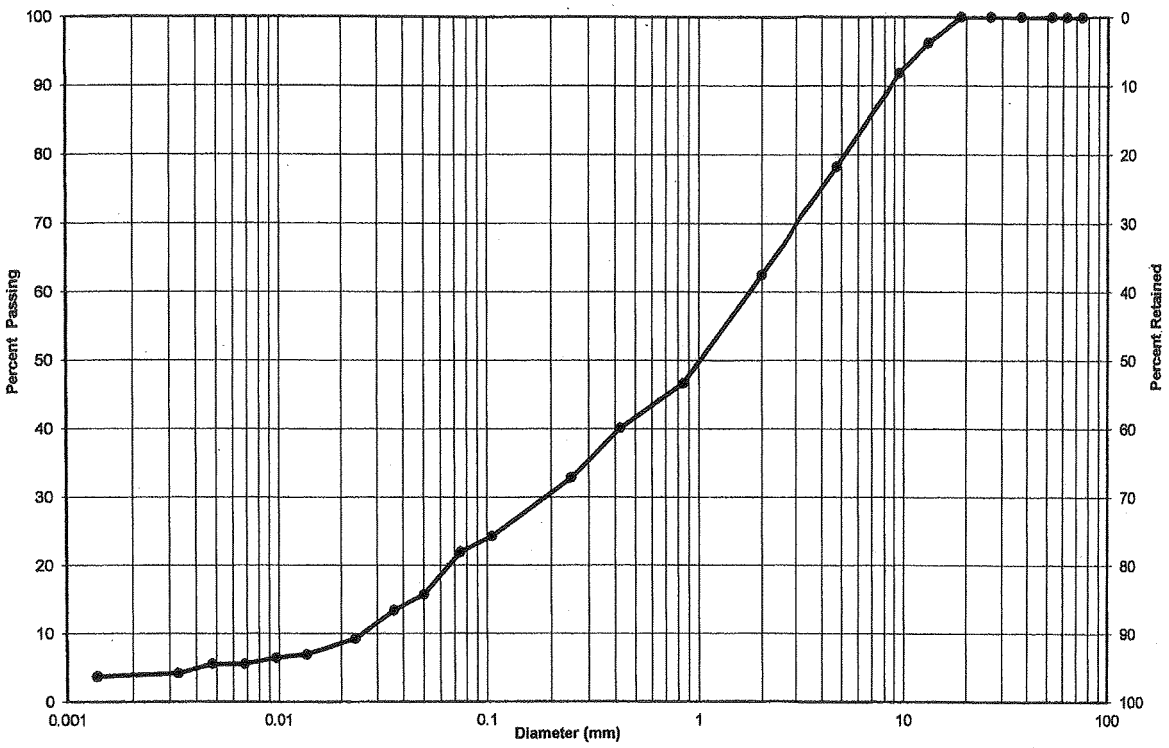
Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Township of Douro-Dummer	**Lab no.:**	AG-16-94
Project/Site:	Quality Testing	**Project no.:**	11114440-02

Source Info.:	4th Line of Douro, North of Center Rd., 911 #968	Sample no.:	SA8
Depth:	n/a	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel	Sand	Clay & Silt
SA8	22	56	22

Remarks:

Performed by:		**Date:**	May 19, 2016
Verified by:		**Date:**	May 19, 2016

Appendix B
Sodium Adsorption Ratio (SAR) Test Results

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

25-May-2016

GHD
Attn : Steve Gagne

347 Pido Rd., Unit #29
Peterborough, ON
K9J 6Z8,

Phone: 705-749-3317
Fax:

Date Rec. : 17 May 2016
LR Report: **CA14433-MAY16**
Reference: 11114440-02

Copy: #2

CERTIFICATE OF ANALYSIS
Final Report - Revised

Sample ID	Sample Date & Time	Sodium Adsorption Ratio ---	SAR Calcium mg/L	SAR Magnesium mg/L	SAR Sodium mg/L	Conductivity mS/cm
1: Date Extracted / Digested		24-May-16	20-May-16	20-May-16	20-May-16	20-May-16
2: Date Analyzed		24-May-16	21-May-16	21-May-16	21-May-16	20-May-16
3: Analysis Approval Date		24-May-16	24-May-16	24-May-16	24-May-16	24-May-16
4: Analysis Approval Time		10:38	09:42	09:42	09:42	13:20
5: Table 1 Agricultural or other Property Use		1	---	---	---	0.47
6: Table 1 Res / Park / Ins / Ind / Com/ Comm Property Use		2.4	---	---	---	0.57
7: RDL		0.01	0.02	0.003	0.01	0.002
8: GS-1	13-May-16	12.2	97.7	15.2	492	3.7
9: GS-2	13-May-16	13.5	55.6	8.08	407	2.7
10: GS-3	13-May-16	9.01	84.8	9.63	328	2.4
11: GS-4	13-May-16	11.1	132	17.2	508	4.1
12: GS-5	13-May-16	7.59	54.5	8.29	227	1.7
13: GS-6	13-May-16	11.5	97.9	14.8	463	4.0
14: GS-7	13-May-16	10.5	123	20.5	476	4.2
15: GS-8	13-May-16	8.17	249	26.1	507	2.4
16: GS-9	13-May-16	12.3	35.4	4.90	296	1.9
17: GS-10	13-May-16	11.6	74.5	13.2	413	2.5

Brian Graham B.Sc.
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0000688722

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

17-December-2015

GHD
Attn : Adam Bonner

347 Pido Rd., Unit #29
Peterborough, ON
K9J 6Z8,

Phone: 705-749-3317
Fax:

Date Rec. : 14 December 2015
LR Report: **CA14205-DEC15**
Reference: 11114440-01
Douro-Dummer
PO#73501948

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Sample ID	Sample Date & Time	Sodium Adsorption Ratio ---	SAR Calcium mg/L ---	SAR Magnesium mg/L ---	SAR Sodium mg/L ---
1: Date Extracted / Digested		16-Dec-15	16-Dec-15	16-Dec-15	16-Dec-15
2: Date Analyzed		16-Dec-15	16-Dec-15	16-Dec-15	16-Dec-15
3: Analysis Approval Date		17-Dec-15	16-Dec-15	16-Dec-15	16-Dec-15
4: Analysis Approval Time		13:34	16:16	16:16	16:16
5: Table 1 Agricultural or other Property Use		1	---	---	---
6: Table 1 Res / Park / Ins / Ind / Com/ Comm Property Use		2.4	---	---	---
7: RDL		0.01	0.02	0.003	0.01
8: TP-1	07-Dec-15	1.64	55.0	0.978	44.9
9: TP-2	07-Dec-15	1.23	29.2	0.686	24.6
10: TP-3	07-Dec-15	0.89	23.3	0.494	15.9
11: TP-4	07-Dec-15	0.20	31.7	1.76	4.27
12: TP-5	07-Dec-15	3.33	12.1	0.807	44.2
13: TP-6	07-Dec-15	0.72	25.6	2.60	14.3
14: TP-7	07-Dec-15	1.83	30.3	1.31	37.8
15: TP-8	07-Dec-15	0.93	19.7	1.08	15.6
16: TP-9	07-Dec-15	0.96	17.5	1.04	15.3
17: TP-10	07-Dec-15	1.08	96.3	2.68	39.3
18: TP-11	07-Dec-15	1.11	49.4	1.28	28.9

Brian Graham B.Sc.
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0000575772

January 19, 2016 Reference No. 11114440

Township of Douro-Dummer
Public Works
1422 County Road 4
Warsaw, Ontario
K0L 3A0

Attention: Harold Nelson (publicworks@dourodummer.on.ca)

Re: Test Pit Investigation of Gravel Roads in the Township of Douro-Dummer

1. Scope of Project

GHD was contacted to conduct an investigation of various gravel surfaced township roads to ascertain the causes of poor condition in the roads. The strength of a gravel road is affected by the gradation (a stronger material is obtained when there is a scattering of grain sizes through the sand and gravel size range), and the ability of the material to drain water through it. The gravel is meant to spread tire loads sufficiently such that the underlying fine grained soil doesn't form ruts. When gravel becomes flooded the tire loads are not spread but are transferred straight to the subgrade.

Salt is a necessary addition to the roads in winter for safety. However when the salt dissolves in the resulting melt water it infiltrates the sand and gravel in the road and when the water evaporates bonds with smaller particles. This is referred to as capilliarization, and forms a very hard road surface when dry. The surface can then be broken up by wheel loads or grading but still have silt sized particles bound making the material behave weaker. When water is added by rain the salt dissolves forming a plug in the granular and weakening the road. From the description of the conditions given, the roads under investigation are prone to forming a surface-slurry after rainfall and/or deteriorate after regrading at faster than expected rates. As per the original request and through phone discussions with Harold Nelson, GHD's scope of work included the following items:

1. Road base investigation on the following roads of concern in the following target locations:
    a. 12th Line of Dummer (3 sample locations)
    b. Douro 2nd Line, north of CR-4 (3 sample locations)
    c. Centre Road (1 sample location)
    d. Douro 7th Line, north of Nassau Road (1 sample location)
2. Comparative sampling was carried out at any one representative location on the following roads that are of newer construction and are not showing the slurry or deterioration:
    a. Carlow Line
    b. Douro 1st Line Rd
    c. Cedar Cross Rd

3. Measurement of cross section of roads at each sample location
4. Laboratory analysis of field samples for concerned roads (8 samples) and comparative roads (3 samples) for sieve analysis (gradation specification) and SAR (sodium adsorption rate including calcium, sodium, and potassium content)
5. Summary report including a discussion of field conditions, laboratory results, and provide any immediate remediation concerns

For this assignment, GHD used its Peterborough office and laboratory facilities to provide all technical support, consultation, field testing, and laboratory testing services. The Peterborough Laboratory is certified by CCIL as a Type A and B Asphalt (Marshall and Superpave), Type C and D Aggregate, Type D Soils and CSA Category 2+ Additional Concrete testing facility. The Sodium Adsorption Ratio (SAR) testing was completed by SGS Laboratories in Lakefield.

2. Field Processes

Locations for the test pit investigations were determined by visual observation of areas most severely affected. The Township supplied the mini excavator and an operator to conduct the test pit excavations. The upper 50-75mm of the granular was sampled and sealed in bags. Excavation was continued in each test pit to determine the underside of the base granular layer. In all test pits, subbase granular/fill was found on each road with no amount of organics noted in the subbase soils.

Table 2.1 – Test Pit Identification and Sample Locations

Test Pit No.	Road Name	Sample Location
TP-1	12th Line of Dummer	Approximate to house #174, 2.5m Rt (NBL)
TP-2	12th Line of Dummer	Approximately 600m north of Madeline, 2.2m Rt (NBL)
TP-3	12th Line of Dummer	Approximately 100m south of Hannon, 1.8m Lt (SBL)
TP-4	Carlow Line	Approximately 800m south of CR-8, 1.8m Lt (SBL)
TP-5	Douro 1st Line	Approximately 50m south of house #49, 1.5m Rt (NBL)
TP-6	Douro 2nd Line	Between houses #837 and #831, 1.8m Rt (NBL)
TP-7	Douro 2nd Line	Approximate to house #952, 1.9m Rt (NBL)
TP-8	Douro 2nd Line	Approximate to house #1059, 1.5m Rt (NBL)
TP-9	Cedar Cross Road	Approximately 300m east of 2nd Line, 1.8m Rt (EBL)
TP-10	Centre Road	Approximately 600m west of 4th Line, 1.7m Lt (WBL)
TP-11	Douro 7th Line	Between houses #427 and #513, 1.7m Rt (NBL)

Cross-sectional measurements of the road at each sample location were conducted to identify possible trending with surface drainage and condition of the road. Each cross-section was measured using a laser level assuming the centre-line of the road was the high point. Each measurement is represented in difference of elevation to the centre-line of road. Additionally, measurements were taken of ditches and of the widths of the lanes. Where ditches were too deep to be measured without transit, the measurement is given as “Deep”.

Table 2.2 – Cross-Section Measurements

Test Pit No.	Road/Sample	Ditch Left	Edge Left	Centre	Edge Right	Ditch Right	Lane Width
TP-1	12th Line A	-0.10m	-0.06m	0m	-0.12m	-0.02m	3.4m
TP-2	12th Line B	-0.77m	-0.15m	0m	-0.12m	Deep	3.3m
TP-3	12th Line C	-0.78m	-0.19m	0m	-0.18m	-0.89m	2.9m
TP-4	Carlow	-0.96m	-0.13m	0m	-0.07m	-0.66m	2.7m
TP-5	1st Line	-0.48m	-0.09m	0m	-0.08m	-0.66m	2.5m
TP-6	2nd Line A	-0.53m	-0.09m	0m	-0.12m	-0.71m	2.9m
TP-7	2nd Line B	-0.67m	-0.08m	0m	-0.13m	-0.66m	2.8m
TP-8	2nd Line C	-0.63m	-0.08m	0m	-0.10m	-0.59m	2.5m
TP-9	Cedar Cross	Deep	-0.10m	0m	-0.10m	Deep	3.0m
TP-10	Centre	-0.55m	-0.07m	0m	-0.13m	-0.53m	2.8m
TP-11	7th Line	-0.39m	-0.01m	0m	-0.06m	-0.43m	2.6m

Using the data from Table 2.2, the following cross-falls for each lane was calculated:

Table 2.3 – Cross-Fall Calculations

Test Pit No.	Road/Sample	Left Lane	Right Lane
TP-1	12th Line A	**1.8 %**	3.5 %
TP-2	12th Line B	4.5 %	3.6 %
TP-3	12th Line C	6.6 %	6.2 %
TP-4	Carlow	4.8 %	2.6 %
TP-5	1st Line	3.6 %	3.2 %
TP-6	2nd Line A	3.1 %	4.1 %
TP-7	2nd Line B	2.9 %	4.6 %
TP-8	2nd Line C	3.2 %	4.0 %
TP-9	Cedar Cross	3.3 %	3.3 %
TP-10	Centre	2.5 %	4.6 %
TP-11	7th Line	**0.4 %**	**2.3 %**

Upon returning to GHD laboratory, samples were submitted for testing. Each test pit sample was submitted for gradation testing to compare to Granular 'A' specifications. Each test pit sample was also submitted to SGS Laboratories in Lakefield for Sodium Adsorption Ratio (SAR) testing to determine salt content.

3. Laboratory Results

All laboratory test results are included in the appendices of this report. Appendix A contains the gradation sieve results, and Appendix B contains the SAR test results from SGS Laboratories.

3.1 Sieve Analysis

For all samples, the gradation test results show failure on multiple sieve sizes when compared to a quarry-sourced Granular 'A'. All samples failed to meet the criteria for Granular 'A', Granular 'B', and Granular 'M'. Common in all samples was a trend showing too much silt and too little medium-sized gravel. Of note, a trend is observed that for the comparison (control) road samples, the amount passing the 0.075mm sieve was lower than the roads of concern. This trend is further analyzed in Section 4 of this report, "Discussion".

3.2 Sodium Absorption Ratio (SAR) Analysis

Initial review of the results implies a relationship between the amounts of salt present in the samples and the general quality of the road. To confirm the correlation of the SAR results with the quality of the road sections, Spearman's Rank Correlation formula was used to compare each salt to a visual quality index of each road section determined through field observations.

$$(R) = 1 - \frac{6\sum d^2}{n^3 - n}$$

In determining the relevancy of the data that can be used in the calculation, two samples were ignored due to the composition of the gravel in the sample. For Douro 1st Line (TP-5), it is understood that the gravel came from a discontinued source that may not be present on the other roads. The source contained a higher level of intermediate igneous rock containing feldspar that is artificially inflating the sodium level in the test. In sample A of Douro 2nd Line (TP-6), a fresh surface repair was recently completed and the quality of the road section is lower for reasons likely not related to salt exposure.

The purpose (or hypothesis) of the ranked correlation is that the visually "worst" road section will contain the highest amount of salt. For the ranking in Table 3.1, the Visual Quality Index has been ranked in ascending order from "worst" to "best", and the SAR values are ranked in descending order from highest to lowest.

The ranked relationships for calcium and magnesium are not significant enough to conclude a relationship outside of pure chance. The ranked relationship for sodium, however, shows a strong relationship between the levels of sodium and the visual quality of the road 95% of the time.

Table 3.1 – SAR vs. Visual Quality Index Ranked Correlation

Test Pit No.	Road/Sample	Visual Quality Index	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
TP-1	12th Line A	2	2	8	1
TP-2	12th Line B	8	6	10	6
TP-3	12th Line C	5	8	11	7
TP-4	Carlow	11	4	3	11
TP-5	1st Line	9			
TP-6	2nd Line A	1			
TP-7	2nd Line B	6	5	4	4
TP-8	2nd Line C	7	9	6	8
TP-9	Cedar Cross	10	10	7	9
TP-10	Centre	3	1	1	3
TP-11	7th Line	4	3	5	5
Spearman's Rank Correlation Coefficient			0.400	-0.325	0.867

4. Discussion

Two trends were identified in the analysis of the soil samples:

1. The older roads of concern contained higher silt contents than the more recently repaired road sections (ie. more material passing the 0.075mm sieve)

2. The visually worse road section contained correlatively higher concentrations of sodium (salt) when statistically verified through rank correlation

Of the two trends, the poor sieve results of the soil samples are known to be indicative to road quality, especially the high levels of silt contained in all road sections including the "better" road sections used for control samples in the investigation. The high amount of silt in the granular base will lead to poor drainage of the gravel, and thereby retain water for longer periods of time leaving the roads in a muddy weaker condition.

The poor drainage in the granular not only prevents water from draining, but will also prevent salt from dissipating through the granular while dissolved in the melt water. Under normal conditions, salt accumulation from the winter will enter solution during the rain events of spring, summer, and fall. The salt in solution will either drain off the surface of the road or pass through the granular eventually dispersing into the ditches on either side of the road. As previously mention the salt bonds with the fines and can make compacting the gravel during regrading more difficult since the gravel behaves like a gap graded product. Thus the claim that the road becomes disturbed more quickly after regrading can more likely be attributed to the salt.

This investigation has confirmed the correlation between road condition and presence of salt, but there is not enough conclusive evidence that the poor condition of the roads was caused by the presence of the salt if there was not already a high content of silt in the granular. It is important to note some other details regarding the investigation and the laboratory testing performed:

1. Sample locations were not limited to the areas of muddy conditions, but also included areas of pitting and rippling. These multiple types of negative conditions can all be linked to the quality of the granular gradation.

2. The sieve analysis includes wash-sieving the fine aggregate which would have removed the salt from the sample. The material passing the 0.075mm sieve (the silt) includes some amount of salt inflating the values recorded.

3. The road crossfalls and measurements recorded noted a few items of concern. Table 2.3 has highlighted road sections with crossfalls less than 2.5%, which would have significantly reduced surface drainage. Some sections of the road noted shallow ditching which also slows the drainage of water away from the road.

4. Sample depths were taken in the upper 50-75mm of the road base. Aggregate segregation from vehicular traffic will cause finer material to rise and remain at the surface of the road. The samples collected only represent the condition of the surface of the road and not the granular base as a whole. This was done to focus the investigation on the poor conditions of the surface itself, and to provide more usable data from the SAR testing to identify the presence of salts (which was specifically requested in the investigation).

5. Remedial Recommendations

Any remedial plan to improve these roads should include enhancing the drainage characteristics of the road. This would include the use of OPS specified granular material, increasing crossfall where required, deepening and regrading ditches, or raising the profile of the road to increase elevation above watercourses and wetlands. Granular roads, by their design, require constant maintenance and regrading. Often mud from tires or wind blown dust is on the road, and the continuous cycle of grading can reduce the quality of the granular material. One strategy is to remove the surface inch in the spring with a grader directing it to a windrow, that is removed and replaced with fresh granular. Also the use of a water truck during regrading and the compacting of the granular with a vibratory roller will improve the ability of the granular to not become disturbed. For long-term quality, it would be worth considering the addition of surface treatment that would require less maintenance during its life-cycle. As the initial cost of surface treatment may seem expensive for roads with very few residents, if it is weighed against a continuous maintenance plan it may become more cost effective.

The following remedial recommendations are provided for the consideration of the township, including recommendations that are strongly advised and optional remediation plans to maintain road integrity over longer life spans.

5.1 Required Recommendations

- **Full Granular Replacement:** Although no AADT data (present traffic volumes) are known for these roads, the expected traffic level and interpreted subgrade characteristics require a Granular Base Equivalency (GBE) of 200 as per Structural Design Guidelines for Flexible Pavements for Secondary Roads. This will require either the removal of 200mm of existing material for full replacement with Granular ‘A’, or the addition of 200mm of Granular ‘A’ on the existing grade. Alternatively, the required GBE would also be met with the accommodation of 100mm of Granular ‘A’ and 150mm of Granular ‘B’, or as a third option the retention of 100 mm of existing granular ‘A’

the placement of a TX140 geogrid and 75 mm of fresh Granular 'A'. Please note that increasing the grade of the road will require widening the profile of the road to accommodate the higher slope at the edge of the shoulder/road.

- Grade the crossfall of each lane to create an ideal minimum grade of 3% for all roads and allow greater surface drainage.
- Where positive drainage of surface water allows, cleanout surface vegetation and grade ditches to transport water away from the roads faster without stagnation.
- Utilize a water truck during regrading along with smooth drum vibratory compactor.

5.2 Optional Recommendations

- **Double Surface Treatment or Single Surface Treatment with Prime:** For roads with an AADT between 200 and 1000, a surface treatment road design is recommended by provincial standards. For the township, this option is provided as a long term design recommendation that would significantly reduce the need for annual maintenance. It will require the full removal of the existing granular base (as noted above) to allow either 250mm of Granular 'A', or the placement of 150mm of Granular 'A' base over 150mm Granular 'B' subbase or the retention of 100 mm of existing granular 'A' the placement of a TX140 geogrid and 75 mm of fresh Granular 'A'. The surface treatment would then be applied over the prepared granular base. Crossfall and ditching improvements are still recommended where required.
- **Hot Mix Asphalt Design:** The current traffic loads for these county roads do not warrant the requirement for asphalt pavement, but the application of a single lift of hot mix asphalt will provide the best long-term road surface. Should traffic loads be forecast to increase, the minimum requirements for a hot mix asphalt design with AADT of 200 to 1000 will require a GBE of 410 usually made up of 50 mm HL3 or 4 asphalt, 150 mm Granular 'A' and 250 mm Granular 'B'. This would require the full removal of the existing granular base (as noted above) to allow the placement of this pavement profile, or a grade raise or 200 mm 150mm of new Granular 'A' base over the existing 250 mm Granulars as an equivalent Granular 'B' subbase. Where the granular was found to be deficient of the 250 mm thickness, the addition of a TX140 geogrid would be necessary. A single lift of 50mm of hot mix asphalt would then be paved over the prepared granular base. Suitable surficial HL mixes would include HL-3 or HL-4.

Please note that for all recommendations, GHD recommends that all granular material is compacted to 100% standard Proctor density. Due to the limitations of this investigation, it is also recommended that a proof-roll subgrade inspection be conducted for each road during construction to identify possible areas of subgrade instability that would reduce the integrity of the granular base. These areas, should they be identified, would require further excavation and replacement with approved granular material or crushed limestone if water is encountered in the excavation.

5.3 Design Review

Due to the preliminary nature of the design details at the time of this report, it is recommended that GHD's geotechnical group be allowed to review the roadway design, including utility profiles and final grading,

prior to its finalization. In addition, we strongly recommend that our firm be retained to review the grading proposals when they are available.

Geotechnical inspection and review of excavations and compaction procedures must be carried out to ensure compliance with our recommendations.

6. Statement of Limitations

The attached Statement of Limitations is an integral part of this report. Should questions arise regarding any aspect of this report, please contact our office.

Sincerely,

GHD

Adam MacKenzie Bonner, HBSc

Andy Fawcett, P.Eng.

AM/af/1

Encl. Appendix A – Sieve Analysis Test Results
Appendix B – Sodium Absorption Ration (SAR) Test Results

cc:

STATEMENT OF LIMITATIONS

This report is intended solely for the Township of Douro-Dummer and other parties explicitly identified in the report and is prohibited for use by others without GHD's prior written consent. This report is considered GHD's professional work product and shall remain the sole property of GHD. Any unauthorized reuse, redistribution of or reliance on the report shall be at the Client and recipient's sole risk, without liability to GHD. Client shall defend, indemnify and hold GHD harmless from any liability arising from or related to Client's unauthorized distribution of the report. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

The recommendations made in this report are in accordance with our present understanding of the project, the current site use, ground surface elevations and conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of geotechnical engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in the study report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study. We should be retained to review our recommendations when the drawings and specifications are complete. Without this review, GHD will not be liable for any misunderstanding of our recommendations or their application and adaptation into the final design.

By issuing this report, GHD is the geotechnical engineer of record. It is recommended that GHD be retained during construction of all foundations and during earthwork operations to confirm the conditions of the subsoil are actually similar to those observed during our study. The intent of this requirement is to verify that conditions encountered during construction are consistent with the findings in the report and that inherent knowledge developed as part of our study is correctly carried forward to the construction phases.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the eleven (11) test hole locations only. The subsurface conditions confirmed at the 11 test hole locations may vary at other locations. The subsurface conditions can also be significantly modified by construction activities on site (eg. excavation, dewatering and drainage, blasting, pile driving, etc.). These conditions can also be modified by exposure of soils or bedrock to humidity, dry periods or frost. Soil and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction which could not be detected or anticipated at the time of our investigation. Should any conditions at the site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations. If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by GHD is completed.

Enclosures

Appendix A
Sieve Analysis Test Results

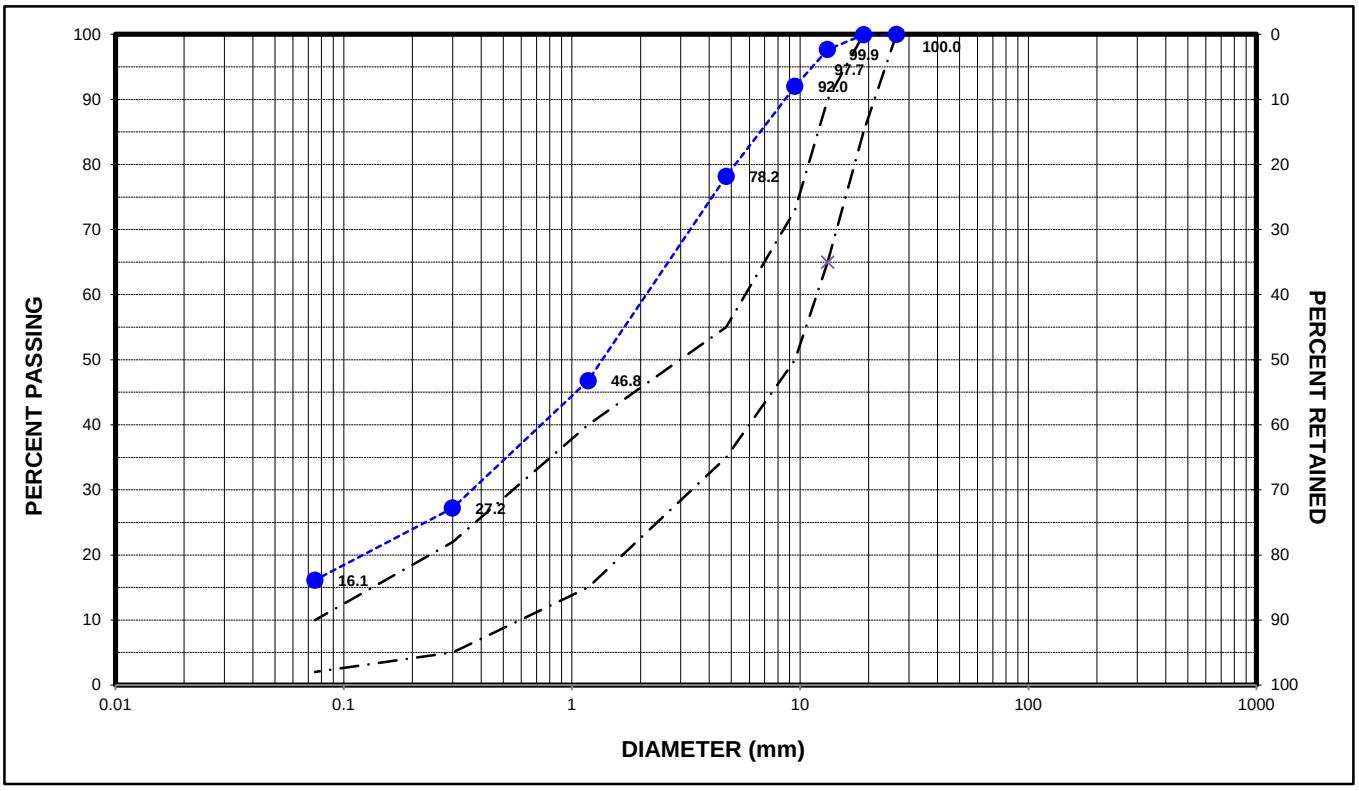
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-410
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-1

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)	Sample % Passing	OPSS Gradation Specification		
		Minimum %	-	Maximum %
26.5	**100.0**	100		
19.0	**99.9**	85	-	100
13.2	* **97.7**	65	-	90
9.50	* **92.0**	50	-	73
4.75	* **78.2**	35	-	55
1.18	* **46.8**	15	-	40
0.300	* **27.2**	5	-	22
0.075	* **16.1**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

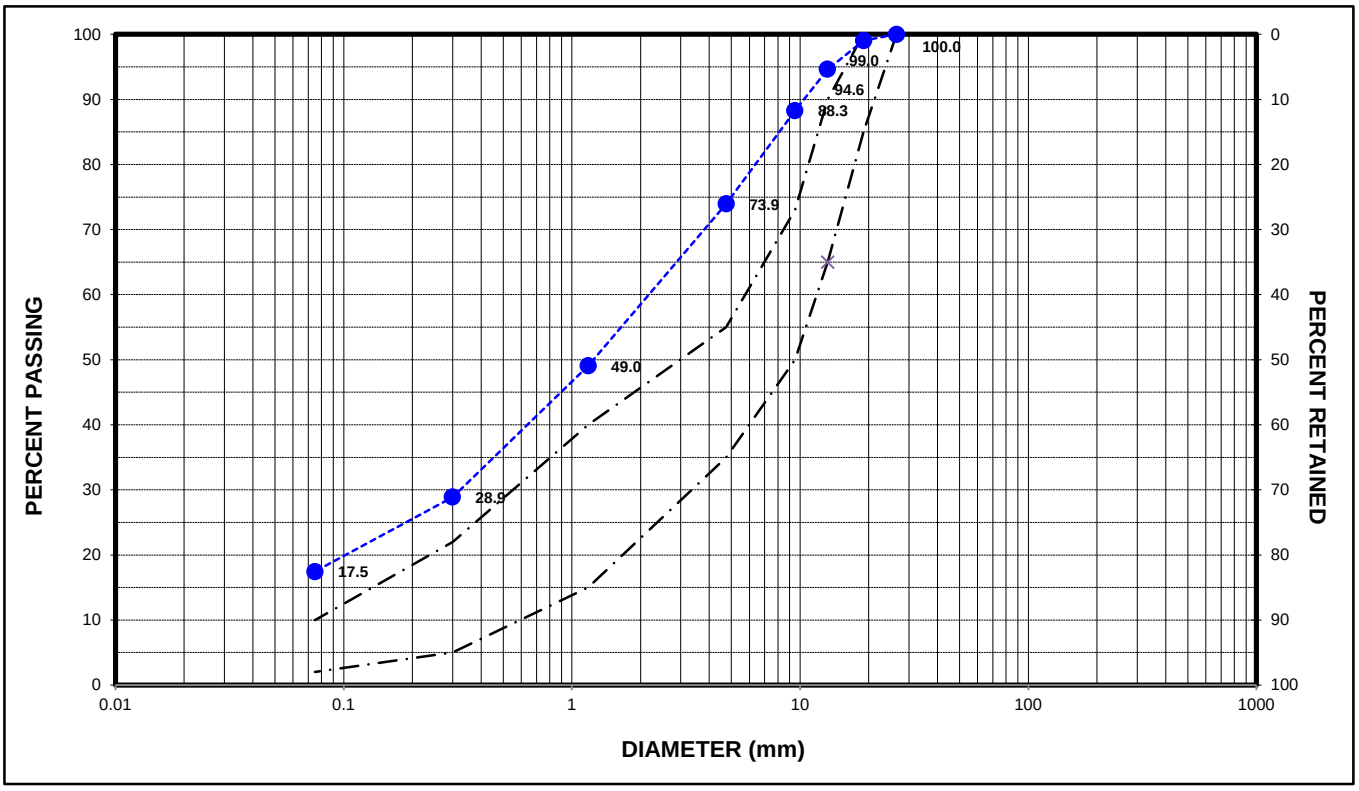
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-411
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-2

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)	Sample % Passing	OPSS Gradation Specification		
		Minimum %	-	Maximum %
26.5	**100.0**	100		
19.0	**99.0**	85	-	100
13.2	* **94.6**	65	-	90
9.50	* **88.3**	50	-	73
4.75	* **73.9**	35	-	55
1.18	* **49.0**	15	-	40
0.300	* **28.9**	5	-	22
0.075	* **17.5**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

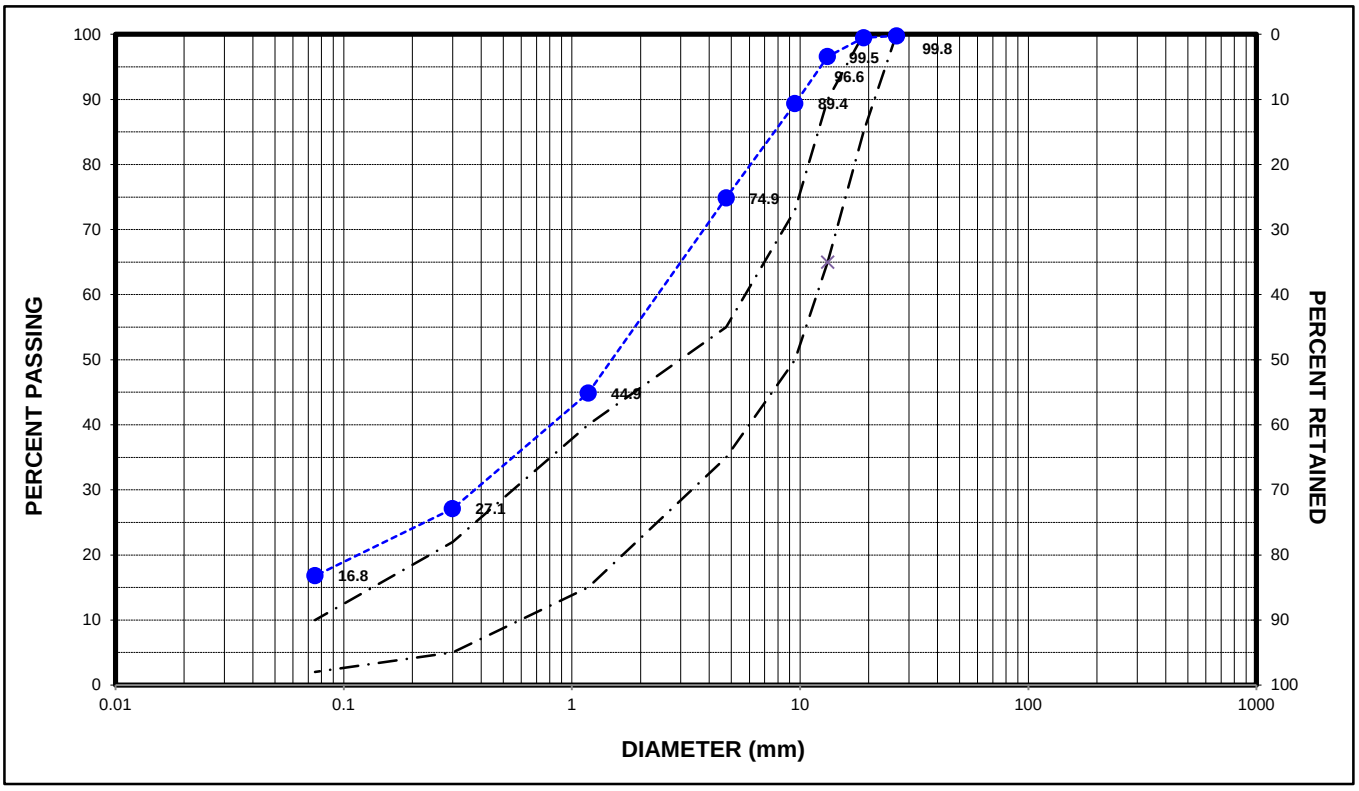
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-412
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-3

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)	Sample % Passing	OPSS Gradation Specification		
		Minimum %	-	Maximum %
26.5	* **99.8**	100		
19.0	**99.5**	85	-	100
13.2	* **96.6**	65	-	90
9.50	* **89.4**	50	-	73
4.75	* **74.9**	35	-	55
1.18	* **44.9**	15	-	40
0.300	* **27.1**	5	-	22
0.075	* **16.8**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

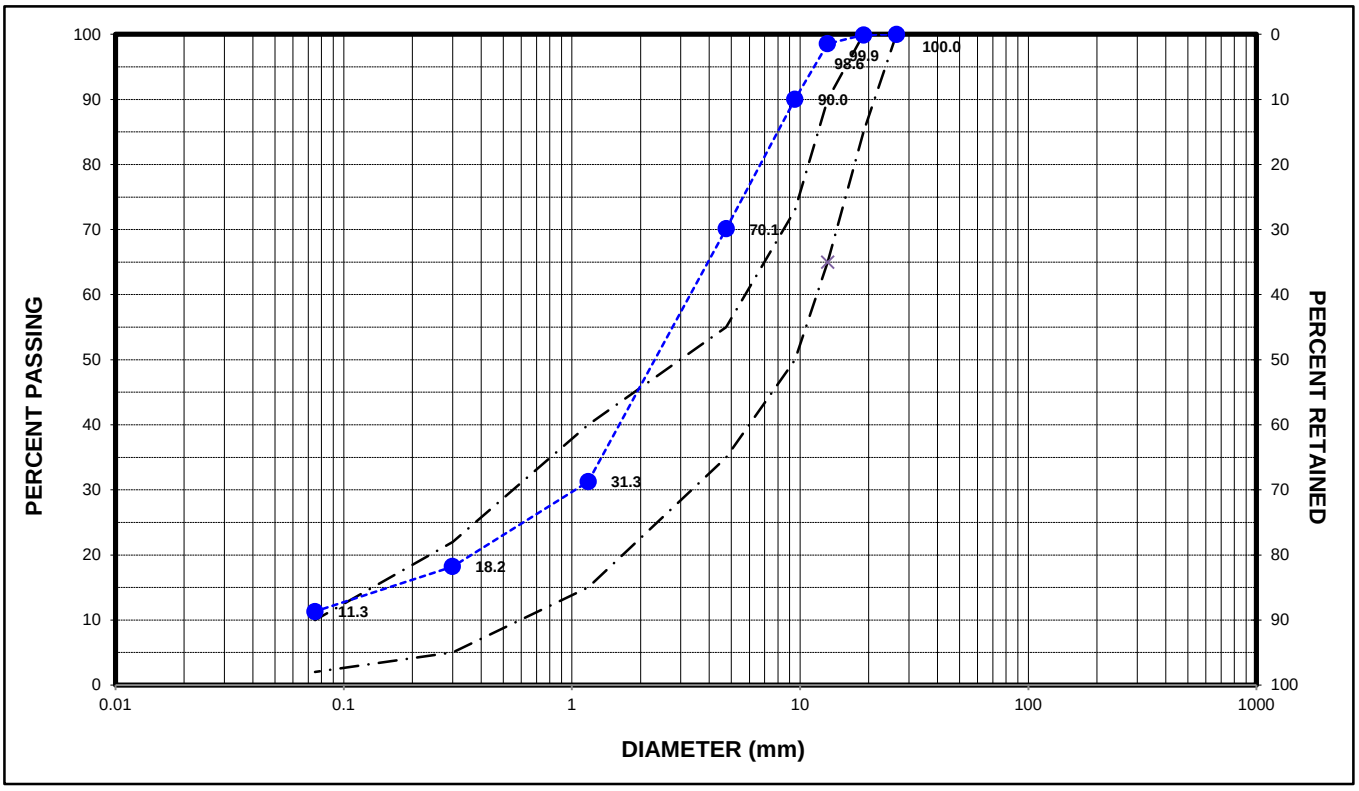
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-413
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-4

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)		Sample % Passing	OPSS Gradation Specification Minimum %	-	Maximum %
26.5		**100.0**	100		
19.0		**99.9**	85	-	100
13.2	*	**98.6**	65	-	90
9.50	*	**90.0**	50	-	73
4.75	*	**70.1**	35	-	55
1.18		**31.3**	15	-	40
0.300		**18.2**	5	-	22
0.075	*	**11.3**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

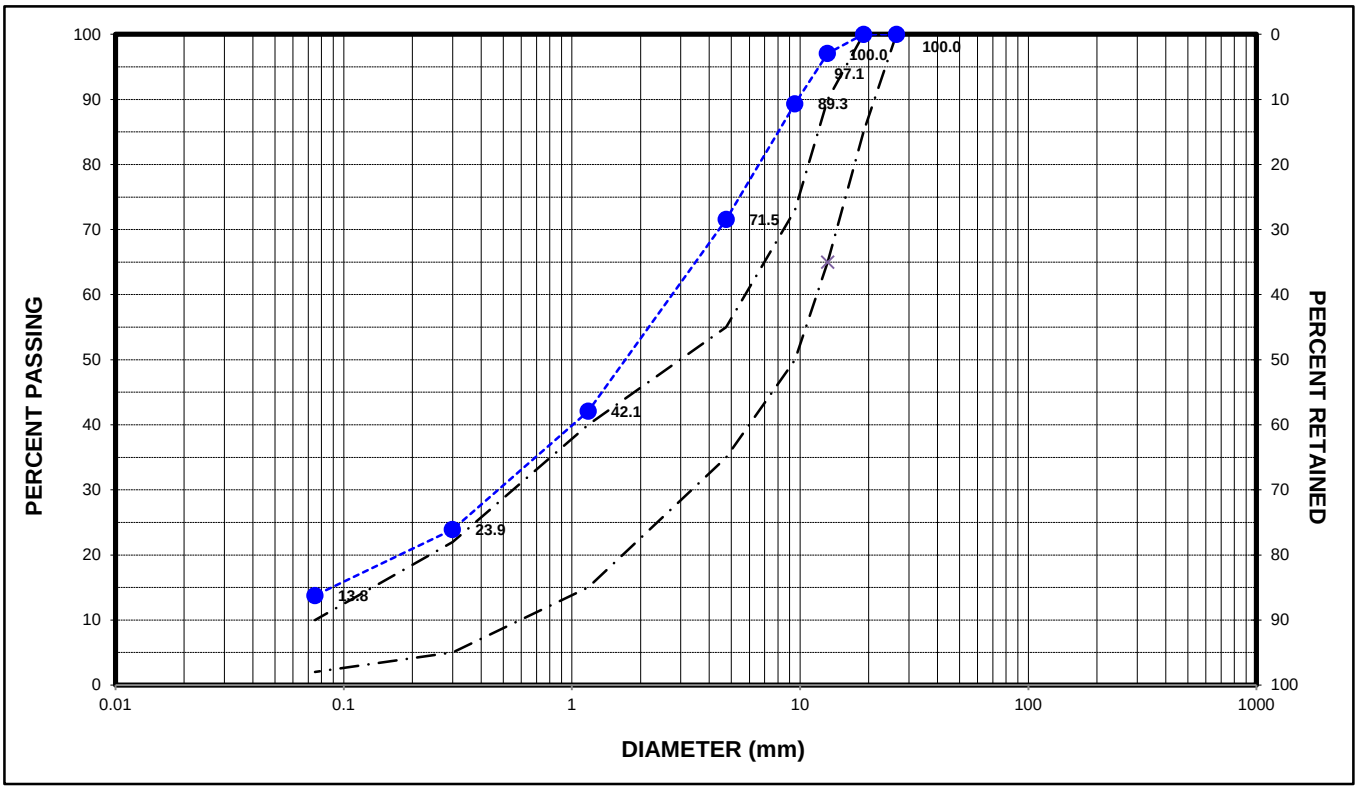
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-414
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-5

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)	Sample % Passing	OPSS Gradation Specification		
		Minimum %	-	Maximum %
26.5	**100.0**	100		
19.0	**100.0**	85	-	100
13.2	* **97.1**	65	-	90
9.50	* **89.3**	50	-	73
4.75	* **71.5**	35	-	55
1.18	* **42.1**	15	-	40
0.300	* **23.9**	5	-	22
0.075	* **13.8**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

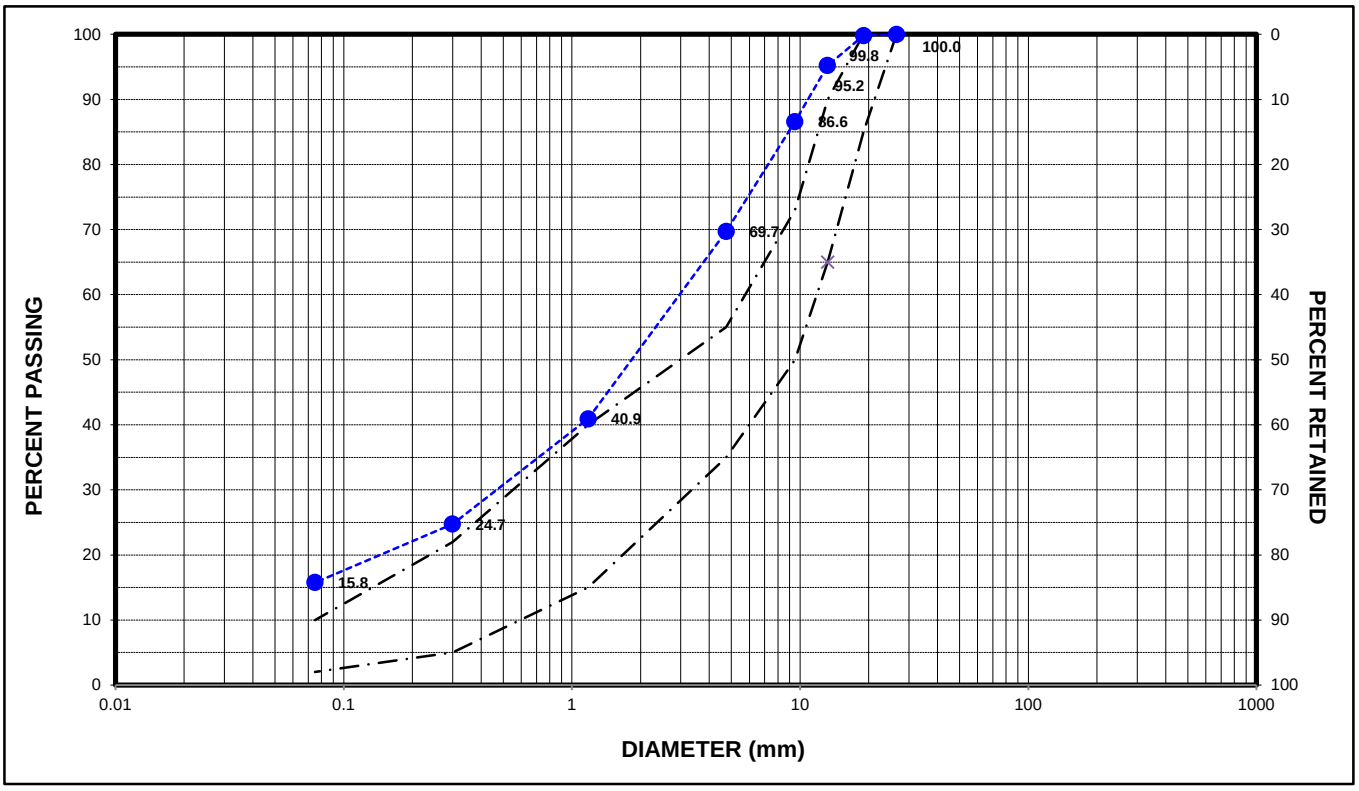
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-415
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-6

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)		Sample % Passing	OPSS Gradation Specification		
			Minimum %	-	Maximum %
26.5		**100.0**	100		
19.0		**99.8**	85	-	100
13.2	*	**95.2**	65	-	90
9.50	*	**86.6**	50	-	73
4.75	*	**69.7**	35	-	55
1.18	*	**40.9**	15	-	40
0.300	*	**24.7**	5	-	22
0.075	*	**15.8**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by:		**Date:**	December 12, 2015
Verified by:		**Date:**	December 12, 2015

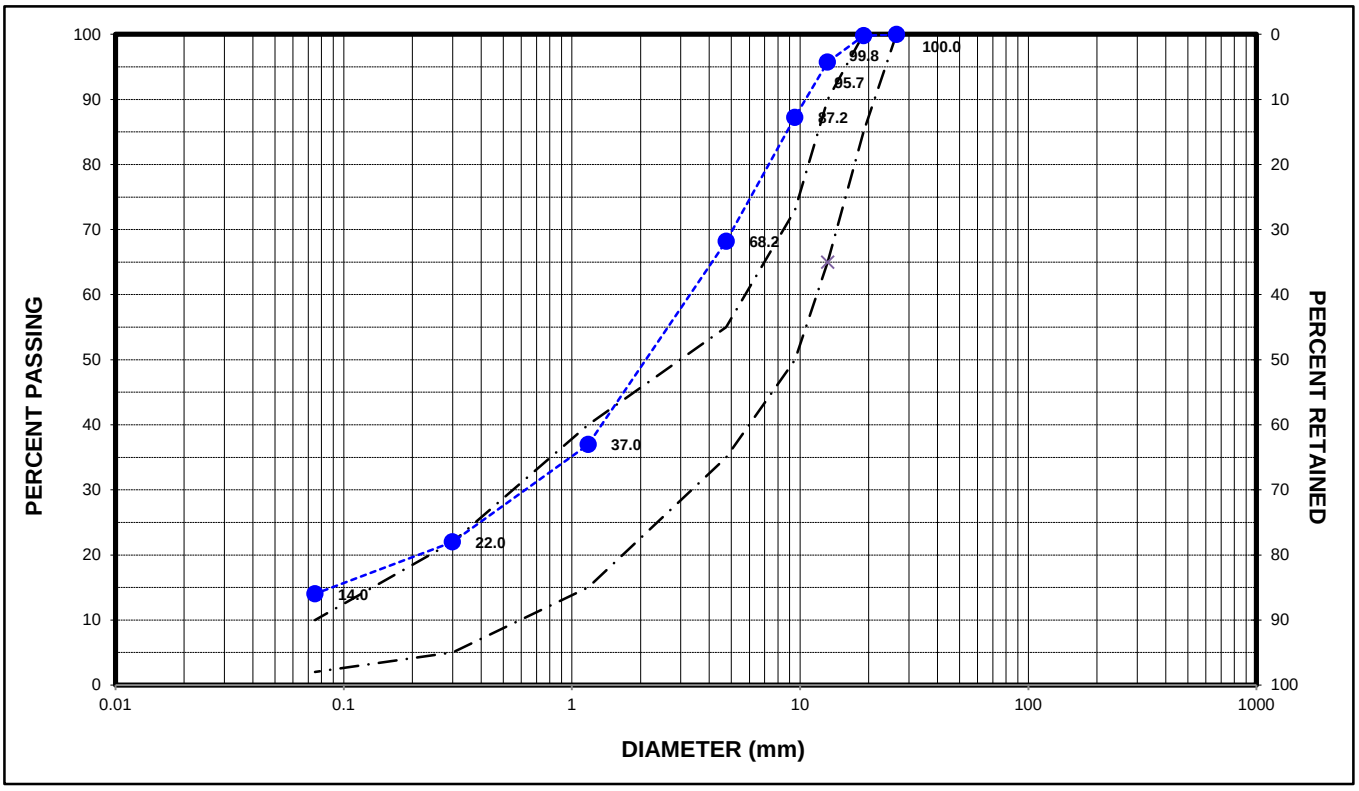
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-416
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-7

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)	Sample % Passing	OPSS Gradation Specification		
		Minimum %	-	Maximum %
26.5	**100.0**	100		
19.0	**99.8**	85	-	100
13.2	* **95.7**	65	-	90
9.50	* **87.2**	50	-	73
4.75	* **68.2**	35	-	55
1.18	**37.0**	15	-	40
0.300	**22.0**	5	-	22
0.075	* **14.0**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

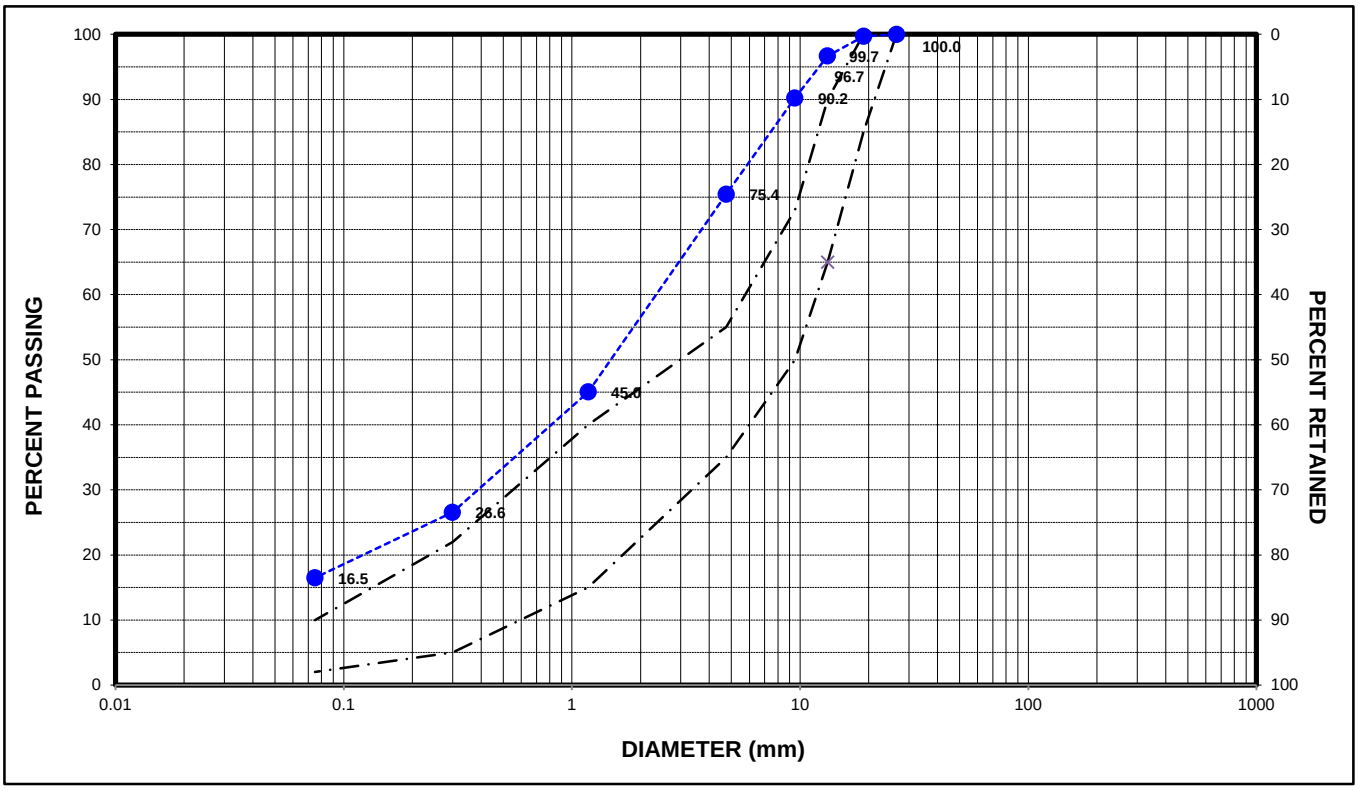
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-417
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-8

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)		Sample % Passing	OPSS Gradation Specification		
			Minimum %	-	Maximum %
26.5		**100.0**	100		
19.0		**99.7**	85	-	100
13.2	*	**96.7**	65	-	90
9.50	*	**90.2**	50	-	73
4.75	*	**75.4**	35	-	55
1.18	*	**45.0**	15	-	40
0.300	*	**26.6**	5	-	22
0.075	*	**16.5**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by:		**Date:**	December 12, 2015
Verified by:		**Date:**	December 12, 2015

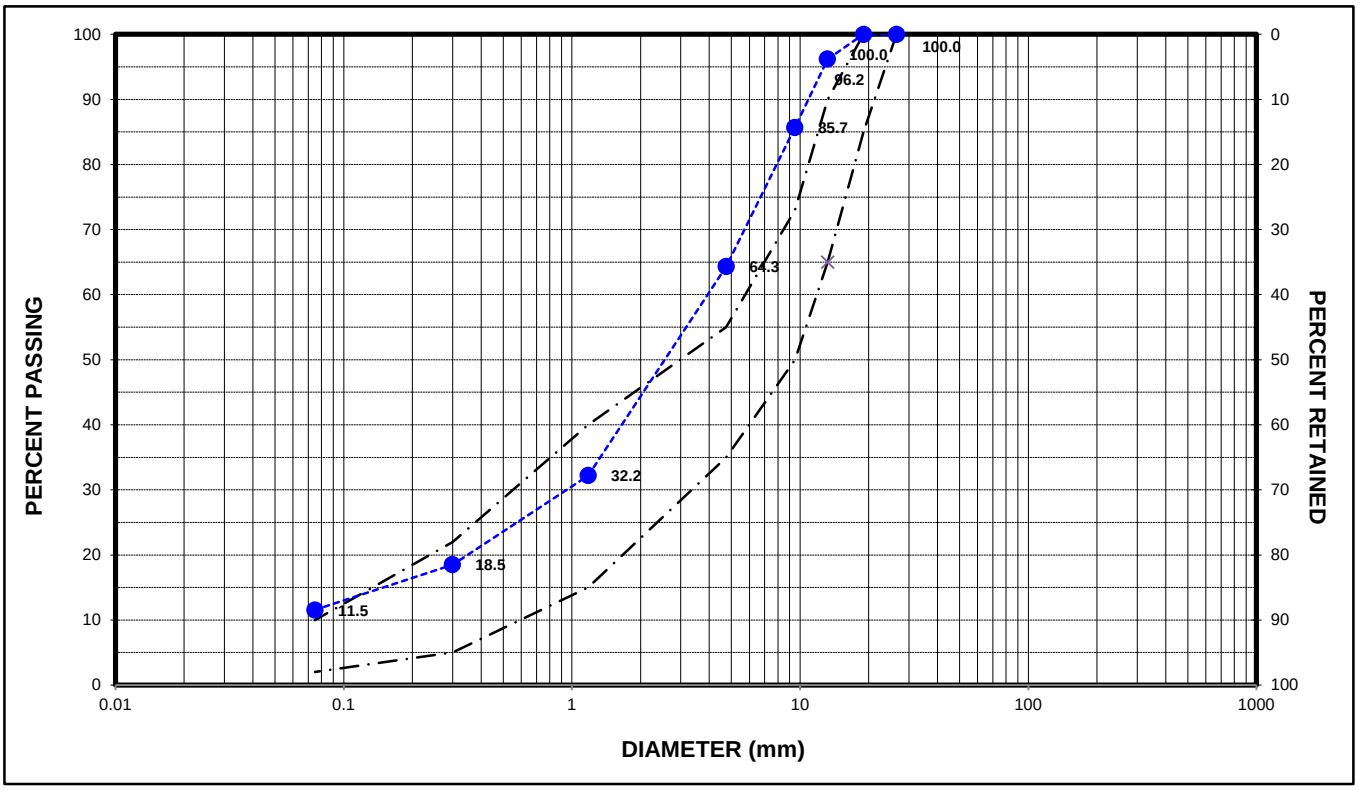
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-418
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-9

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)	Sample % Passing	OPSS Gradation Specification		
		Minimum %	-	Maximum %
26.5	**100.0**	100		
19.0	**100.0**	85	-	100
13.2	* **96.2**	65	-	90
9.50	* **85.7**	50	-	73
4.75	* **64.3**	35	-	55
1.18	**32.2**	15	-	40
0.300	**18.5**	5	-	22
0.075	* **11.5**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

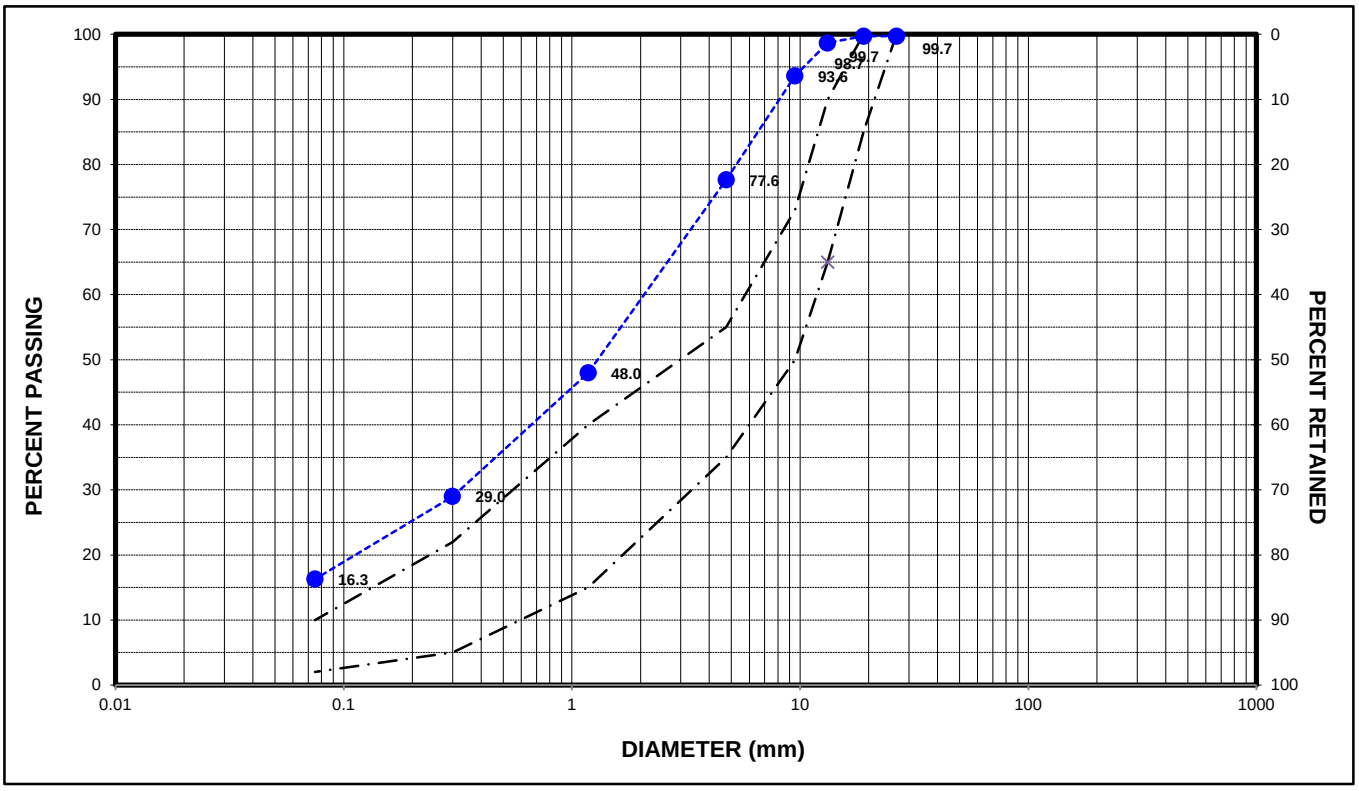
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-419
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-10

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)	Sample % Passing	OPSS Gradation Specification		
		Minimum %	-	Maximum %
26.5	* **99.7**	100		
19.0	**99.7**	85	-	100
13.2	* **98.7**	65	-	90
9.50	* **93.6**	50	-	73
4.75	* **77.6**	35	-	55
1.18	* **48.0**	15	-	40
0.300	* **29.0**	5	-	22
0.075	* **16.3**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

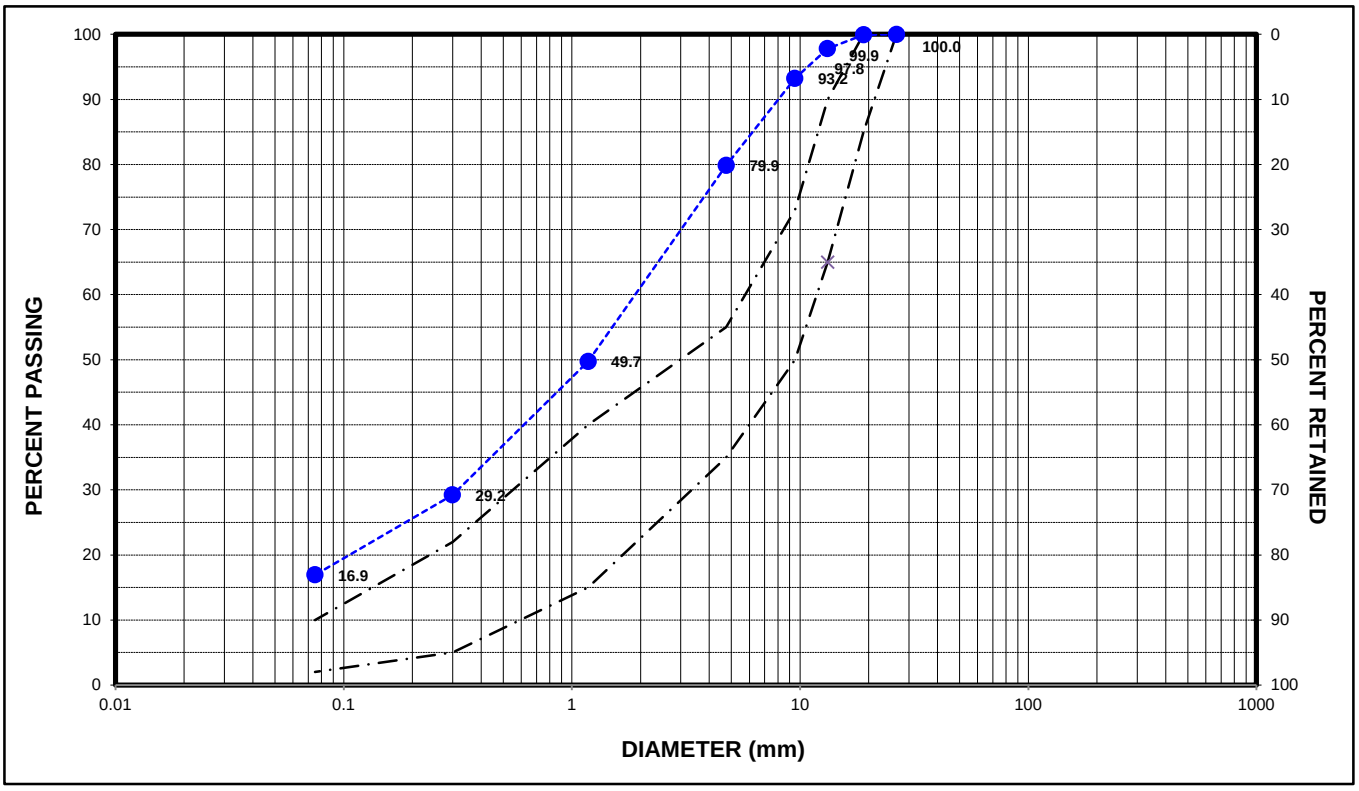
GRANULAR A - SIEVE ANALYSIS (QUARRY)
(LS-602)

Client:	Township of Douro - Dummer	**Lab no.:**	AG-15-420
Project/Site:	2015 Road Investigation	**Project no.:**	1114440-01

Source: TP-11

Sampled by: A.Bonner Date sampled: December 9, 2015

Sieve Size (mm)	Sample % Passing	OPSS Gradation Specification		
		Minimum %	-	Maximum %
26.5	**100.0**	100		
19.0	**99.9**	85	-	100
13.2	* **97.8**	65	-	90
9.50	* **93.2**	50	-	73
4.75	* **79.9**	35	-	55
1.18	* **49.7**	15	-	40
0.300	* **29.2**	5	-	22
0.075	* **16.9**	2		10



Remarks:

* Sieve result does not meet the OPSS Specification for: GRANULAR A - SIEVE ANALYSIS (QUARRY)

Performed by: _____ **Date:** December 12, 2015

Verified by: _____ **Date:** December 12, 2015

Appendix B
Sodium Adsorption Ratio (SAR) Test Results

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

17-December-2015

GHD
Attn : Adam Bonner

347 Pido Rd., Unit #29
Peterborough, ON
K9J 6Z8,

Phone: 705-749-3317
Fax:

Date Rec. : 14 December 2015
LR Report: **CA14205-DEC15**
Reference: 11114440-01
Douro-Dummer
PO#73501948

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Sample ID	Sample Date & Time	Sodium Adsorption Ratio ---	SAR Calcium mg/L	SAR Magnesium mg/L	SAR Sodium mg/L
1: Date Extracted / Digested		16-Dec-15	16-Dec-15	16-Dec-15	16-Dec-15
2: Date Analyzed		16-Dec-15	16-Dec-15	16-Dec-15	16-Dec-15
3: Analysis Approval Date		17-Dec-15	16-Dec-15	16-Dec-15	16-Dec-15
4: Analysis Approval Time		13:34	16:16	16:16	16:16
5: Table 1 Agricultural or other Property Use		1	---	---	---
6: Table 1 Res / Park / Ins / Ind / Com/ Comm Property Use		2.4	---	---	---
7: RDL		0.01	0.02	0.003	0.01
8: TP-1	07-Dec-15	1.64	55.0	0.978	44.9
9: TP-2	07-Dec-15	1.23	29.2	0.686	24.6
10: TP-3	07-Dec-15	0.89	23.3	0.494	15.9
11: TP-4	07-Dec-15	0.20	31.7	1.76	4.27
12: TP-5	07-Dec-15	3.33	12.1	0.807	44.2
13: TP-6	07-Dec-15	0.72	25.6	2.60	14.3
14: TP-7	07-Dec-15	1.83	30.3	1.31	37.8
15: TP-8	07-Dec-15	0.93	19.7	1.08	15.6
16: TP-9	07-Dec-15	0.96	17.5	1.04	15.3
17: TP-10	07-Dec-15	1.08	96.3	2.68	39.3
18: TP-11	07-Dec-15	1.11	49.4	1.28	28.9

Brian Graham B.Sc.
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0000575772

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Report : **CA14205-DEC15**

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Metals in aqueous samples - ICP-OES	ME-CA-[ENV]SPE-LAK-AN-003	MOE 4696e01/EPA 6010
Sodium adsorption ratio (SAR)	ME-CA-[ENV]ARD-LAK-AN-021	MOE 4696e01/EPA 6010

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Report : **CA14205-DEC15**

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD	Acceptance Criteria	LCS / Spike Blank			Matrix Spike / Reference Material		
							Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Metals in aqueous samples - ICP-OES - QCBatchID: ESG0055-DEC15												
SAR Calcium	0.02	mg/L	<0.02		0	20	100	80	120	72	70	130
SAR Magnesium	0.003	mg/L	<0.003		0	20	98	80	120	87	70	130
SAR Sodium	0.01	mg/L	<0.01		0	20	98	80	120	NV	70	130