DMD & Associates Ltd.

REPORT

Nova Scotia LED Roadway Lighting Pilot Installations

Prepared by

DMD & Associates Ltd

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1 Pilot Project Overview

LED Roadway Lighting Limited (LRL), ecoNova Scotia, Conserve Nova Scotia, and Natural Resources Canada have partnered in a pilot project to retrofit existing street lights with new LED street lights in 19 communities throughout Nova Scotia. To the best of our knowledge this is one of the largest LED street light demonstration projects undertaken to date in Canada.

Eleven hundred (1,100) existing high pressure sodium cobra head street lights have been converted to LRL's LED Satellite series street lights. The installation typically involved street lighting on various municipal roads, Halifax's Stanfield International Airport roads and parking lot and provincial highways.

DMD and Associates Ltd. were retained to review the computer lighting calculations and design factors brought forward by the supplier, review testing procedures and calculate energy savings for this pilot.

2 LED Technology Overview

2.1 LED Education

An LED is an electronic light source. The LED was discovered in the early 20th century and introduced as a practical electronic component in 1962.

LEDs are based on the semiconductor diode. When the diode is forward biased (switched on), electrons are able to recombine with holes and energy is released in the form of light. This effect is called electroluminescence.

Figure 1 - Typical LED

LEDs have many advantages over traditional light sources, including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching and the ability to be dimmed easily. However, they require more precise current and heat management than traditional light sources.

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The first high-brightness, blue LED was invented by Nichia Corporation (www.nichia.com). The existence of blue LEDs and high efficiency LEDs quickly led to the development of the first white LED, also invented by Nichia. These high brightness white LEDs employ a phosphor coating to mix yellow (down-converted) light with blue to produce light that appears white.

3 Lighting Technology Comparison

3.1 LED Satellite Series Roadway Luminaire

Some LED street lights are now outperforming traditional light sources in general lighting applications. However, unlike many traditional luminaires, not all LED-based luminaires provide reliable performance. While the LED itself may have good quality and performance as a bare device, its integration into a luminaire and that luminaire's installation environment are keys to the final product performance.

It is also important to note that all LEDs are not created equal. The color and light output can vary greatly. Manufacturing variations in both die and phosphor processes affect light output and color resulting in bins. Bins may vary for each manufacturer. Also, the higher the junction temperature, the shorter the life expectancy of the LED.

It should also be noted that since the LED devices have been shown to have life expectancy up to 20 years without failing, the reliability of the power supply driver is critical if overall life expectancy for the entire luminaire system is to be equal to the life expectancy of the LED devices. Today, many LED street light luminaires utilize commercial grade power supply switching drivers for the LEDs. Such commercial power supplies do not employ the kind of topographical design or integrated circuit component devices that would meet the reliability and life expectancy that is exhibited by the LED devices they power. The custom LRL designed power supply drivers used in LRL Satellite series provide an LED street light luminaire with a life expectancy of 20 years, which is substantially more than the current 4-5 years with existing high-pressure sodium lamps. The LRL power supply drivers include highly reliable electronics components, similar to those that are typically specified for automotive high temperature performance and aircraft grade reliability. In particular, a number of electronic components are known to have significant early failure potential, such as commercial grade capacitors and opto-couplers typically used for electrical isolation, have been eliminated since they are often the first devices that fail, often in a time frame of 5 to 7 years under normal environmental stress (20 degrees Centigrade). The use of a high reliability power supply driver in LED street light luminaires that are meant to have long life expectancy is a notable feature of the LRL LED Satellite series street light luminaires.

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Figure 2 - LED Roadway Lighting, Satellite Series Roadway Luminaire

3.2 Cobra Head Roadway Luminaire

The most popular roadway luminaire used to light streets are "cobra head" luminaires. It exists on many of the roads in Nova Scotia and other cities throughout North America. Most cobra head luminaires use a sodium vapor gas discharge lamp which uses sodium in an excited state to produce light. There are two varieties of such lamps: low pressure (LPS) and high pressure (HPS). The most common is HPS. In terms of color (appearance), HPS fixtures tend to be yellowish, rather than the white and bluish color light emitted from the LED luminaire.

By contrast, a LPS lamp tends to be an even more yellow color of light than the HPS fixtures, tending towards a dim orange color in appearance.

This luminaire is relatively inexpensive and proven over many years. It has been well refined over the last 40 plus years.

Figure 3 - Typical Cobra Head Style Roadway Luminaire

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4 Barriers with LED Roadway Lighting

In our opinion there are a few barriers to market acceptance of LED street lights. Some of these barriers are:

1. Cost - The unit cost can be quite high compared to standard cobra head luminaries. In North America, we are focused on low product cost. We must assess products by life cycle cost to truly get the best value for the dollar. The low-cost product seldom has the best overall life cycle cost. Better quality LED street lights can be over $1,000 whereas a typical cobra head luminaire is typically around $200.
2. Heat - LED luminaires have varying heat management systems. This is significant as the higher the junction temperature, the shorter the life expectancy of the LEDs. Overdriving LEDs may shorten their life. Furthermore, the higher the junction temperature during the operation of the LED, the higher its light loss factor will be over time. It has been shown in LM-80 reports (this is a report specified by the Illuminating Engineering Society of America that defines a test method used to determine data that shows the rate of output loss from an LED over time at different junction temperatures) that an increase in LED junction temperature of 40 degrees Centigrade results in an additional loss in light output of approximately 10% over 20 years.
3. Standardization - LED roadway luminaires are relatively new to the market and as such there is a lack of proven luminaire specifications.
4. Lacking in Proven Long Term Performance - As LED roadway luminaires are new to the industry, long term performance has not been confirmed. This leads to some level of risk to the owner.

5 Industry Standards

Current industry design standards must be followed when using LED luminaires for roadway lighting. The same design criteria must be followed regardless of the light source.

There is a currently a lack of industry product standards when it comes to roadway lighting with LEDs. As standards are updated and published, the industry should see the inclusion of LEDs in those documents.

One organization, leading the way in developing guidelines for performance and testing LED's, is the Illuminating Engineering Society of North America (IESNA). The IESNA does not typically prepare specific product standards.

5.1 The Illuminating Engineering Society of North America (IESNA)

The Illuminating Engineering Society of North America (IESNA) defines standards for roadway lighting used across North America. The IESNA produces a number of recommended practice and design guides, technical memorandums, and lighting measurement documents used for roadway lighting. The organization also provides education programs and certifications. The IESNA has committees consisting of engineers, manufacturers, city and government staff, and others that commonly practice within the lighting industry who author their documents.

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An important resource for lighting designers is the IESNA's comprehensive listing of lighting products and suppliers. More information on the IESNA can be found on their web site at www.iesna.org.

The following publications are of value to those involved in roadway lighting:

1. IESNA Lighting Handbook (9th Edition),
2. IESNA RP-8 American National Standard Practice for Roadway Lighting
3. IESNA RP-33 Recommended Practice on Lighting Exterior Environments
4. IESNA DG-4 Design Guide for Roadway Lighting Maintenance

IESNA guidelines were used as the basis for defining lighting criteria for this pilot.

5.2 Roadways with Varying Pedestrian Conflict Levels

The amount of light provided by a street lighting installation is typically based on two significant engineering criteria, the classification of the roadway itself and the level of pedestrian conflict (also known as pedestrian activity). In North America, the criteria and associated lighting levels are established by IESNA publication RP-8, and are shown in Table 1 - IESNA Illuminance Criteria for Roadways (from IESNA RP-8-05). The table shows variables in defining lighting levels being Road, Pedestrian Conflict Area and Pavement Classification which are defined below. As noted in the table, for a given roadway classification, higher illuminance levels are required for higher levels of pedestrian conflict/activity.

Road - The road classifications which would apply in this pilot include Major (also known as Arterial), Collector and Local. Lighting requirements for each road classification are listed in Table 1.

Pedestrian Conflict/Activity - The pedestrian conflict/activity levels are established by estimating the number of pedestrians on the sidewalk in a single block (or 200m segment) for a given one-hour nighttime sample period (typically between 18:00 and 19:00 hours). The sample period is typically the hour of highest nighttime pedestrian conflict. If 100 or more pedestrians are counted, the pedestrian activity conflict level is high; if 11 to 99 pedestrians are counted, the pedestrian activity conflict level is medium; if 10 or fewer pedestrians are counted, the pedestrian activity conflict level is low. Lighting requirements for each pedestrian conflict level are listed in Table 1.

LRL worked in conjunction with the local jurisdictions to determine the levels of pedestrian conflict/activity. Most of the roads in this pilot are located in rural locations with less than 10 pedestrians in any given hour of the hour of the night. A pedestrian conflict/activity level of low will therefore apply for all but a few roads in this pilot project.

Pavement Classification - The values defined under the R2/R3 pavement classification will apply for all roads in this pilot. Listed under the pavement classification in Table 1 are the required Lux/fc levels.

Uniformity Ratio - This is the uniformity of light levels across an area. This is expressed as a ratio of average to minimum illuminance levels. Listed in Table1 is the required Eavg/Emin ratio.

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Veiling Luminance - Stray light within the eye produces a veiling luminance which is superimposed upon the retinal image of the object to be seen. This alters the apparent brightness of any object within the visual field and the background against which it is viewed. Veiling luminance (VL) is a ratio of the maximum luminance to the average luminance as listed in Table 1.

Road and Pedestrian Conflict Area		Pavement Classification (Minimum Manintained Average Values)			Uniformity Ratio	Veiling Luminance Ratio
Road	Pedestrian Conflict Area	R1 lux/fc	R2 & R3 lux/fc	R4 lux/fc	E_{avg}/E_{min}	L_{vmax}/L_{avg}
Freeway Class A		6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Freeway Class B		4.0/0.4	6.0/0.6	5.0/0.5	3.0	0.3
Expressway	High	10.0/1.0	14.0/1.4	13.0/1.3	3.0	0.3
	Medium	8.0/0.8	12.0/1.2	10.0/1.0	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Major	High	12.0/1.2	17.0/1.7	15.0/1.5	3.0	0.3
	Medium	9.0/0.9	13.0/1.3	11.0/1.1	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Collector	High	8.0/0.8	12.0/1.2	10.0/1.0	4.0	0.4
	Medium	6.0/0.6	9.0/0.9	8.0/0.8	4.0	0.4
	Low	4.0/0.4	6.0/0.6	5.0/0.5	4.0	0.4
Local	High	6.0/0.6	9.0/0.9	8.0/0.8	6.0	0.4
	Medium	5.0/0.5	7.0/0.7	6.0/0.6	6.0	0.4
	Low	3.0/0.3	4.0/0.4	4.0/0.4	6.0	0.4

Table 1 - IESNA Illuminance Criteria for Roadways (from IESNA RP-8-05)

6 Calculations

All sites that were chosen for this pilot were visited by an LRL technician along with local engineers and maintenance contractors to verify the pole heights, pole setbacks, arm lengths, existing luminaire wattages, pole spacing and road widths. The pedestrian conflict was also determined by these personnel by using their familiarity and knowledge of these areas. This information was then input into a computer lighting program called "Visual" produced by Acuity Brands Lighting (www.visual-3d.com). A minimum of two calculations were performed for each pilot site. One was done using the existing cobra head luminaire; the second was done for the LRL LED luminaire. A summary of these calculations by pilot site is included in the Appendix.

Upon our review of these calculations, DMD & Associates Ltd has determined that LRL was able to meet current lighting standards for this Pilot Project in all of the chosen locations.

The light loss factor that was used in the calculations was provided by LRL. The following is a summary of how LRL determined the light loss factor.

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6.1 Light Loss Factor

Defining a light loss factor that can be applied to LED luminaires is more complicated than a typical lighting factor for a cobra head luminaire. LED Roadway Lighting has determined a light loss factor of 0.72. This has been determined as a result of the following calculations.

Light Loss Factor = 0.84 (LLD) x 0.90 (LDD) x 0.95 (EF) = 0.72

6.1.1 Lamp Lumen Depreciation (LLD)

A lamp lumen depreciation of 0.84 has been applied. The lumen depreciation is determined from data provided by the LED manufacturer (shown in Figure 4 below).

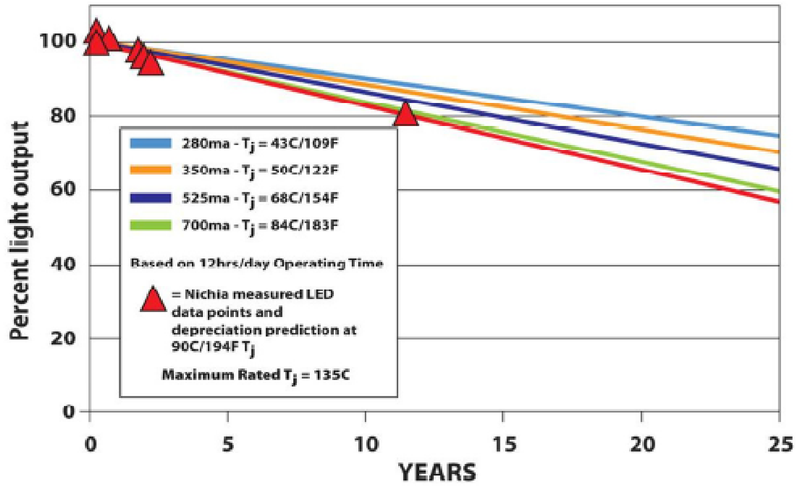

Figure 4 - Thermal Performance and Light Depreciation of LEDs

LED Roadway Lighting under-drives the LEDs at 280mA, with a resulting junction temperature (Tj) of 43°C (at 21°C ambient). At Tj = 90ºC (measured by Nichia) the lumen depreciation is 20% at 12 years. Because depreciation is an inverse linear function of Tj we can extrapolate:

- 43ºC/90ºC = 0.478 (so 43°C is 47.8% - a little less than half - of 90°C).
- Depreciation at 90°C is 20% at 12 years as per graph above.
- 47.8% of 20% depreciation is 9.6% depreciation at 12 years.
- 9.6% at 12 years is 9.6 ÷ 12 x 20 = 15.9% at 20 years

Therefore we assume 16% lumen depreciation at 20 years giving LLD of 0.84.

According to Nichia there is approximately +8°C transmitted from the solder pad (Tpad) to LED junction (Tj). Following in-situ temperature tests performed in the LRL optics laboratory as per UL 1598 we can confirm the difference between ambient (Tamb) and solder pad temperature is 14°C.

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Note that this test data is representative of the average temperature of the hottest LED in the fixture.

- Tpad = Tamb + 14°C.
- Tj = Tamb + 22°C.

Therefore an average ambient temperature of 21°C will result in a junction temperature (Tj) of 43°C.

The low junction temperature is achieved through a thermal management system with cooling fins integrated into the fixture housing. A metal clad printed circuit board is used for the light engine to conduct heat away from the LED (rather than the non-conductive fiberglass circuit boards which are traditionally used in electronics). The curved design is self cleaning preventing the build-up of dirt and debris which could adversely affect heat dissipation.

6.1.2 Luminaire Dirt Depreciation (LDD)

A factor of 0.9 has been applied as the fixture is IP-66 rated. This means it is completely impervious to dust and water spray. The lenses are mounted at 30° angles on the underside of the fixture meaning they are protected from the elements. In more extreme conditions some dirt could blow up into the fixture but the mounting angles make the lenses self cleaning.

The lenses are made of UV resistant acrylic which should not discolor. In most conditions it is estimated the LED lens will optically depreciate by up to 10% over 20 years.

6.1.3 Equipment Factor (EF)

An equipment factor of 0.95 has been applied. LRL's in-house designed power supply has been manufactured using aircraft and automotive grade, high temperature and vibration resistant, high reliability components. Depreciation has been calculated by the LRL electronics design team. The depreciation was determined to be 5% over 20 years under normal conditions (ambient temperature assumed to be 20 degrees Centigrade).

6.2 DMD Opinion

The light loss factor that LRL has determined seems reasonable to DMD & Associates Ltd. We would recommend that the Satellite fixtures be cleaned at least once within their 20 year lifespan. Letting the fixture just sit without cleaning within the lifespan could result in a higher light loss factor depending on the levels of dirt and debris in the surrounding area. We recommend that the fixtures optical system be cleaned at least every 10 years.

7 Photometric Files

Photometric files were provided to DMD & Associates Ltd. in IESNA format. The files were developed by Luminaire Testing Laboratory, Inc. (an independent testing lab located in

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Allentown, Pennsylvania) in accordance with IESNA LM-79-80 and LM-80-08 as explained below. All photometric files are based on photopic lumens.

1. **IESNA LM-79-08 -** Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products - This approved method describes performing reproducible measurements of total luminous flux, electrical power, luminous intensity distribution and chromaticity of solid-state lighting (SSL) products for illumination purposes under standard conditions. It includes LED-based LLS products with control electronics and heat sinks incorporated. It excludes external operating circuits or external heat sinks (e.g., LED chips, LED packages, and LED modules) and uses absolute photometry rather than relative photometry (historically the lighting industry standard) for the measurement of SSL.
2. **IESNA LM-80-08 -** IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources - The purpose of LM-80-08 is to allow a reliable comparison of test results among laboratories by establishing uniform test methods. It addresses the measurement of lumen maintenance testing for LED light sources including LED packages, arrays and modules only. It does not provide guidance or recommendations regarding prediction estimations or extrapolations for lumen maintenance beyond the limits of the lumen maintenance values determined from actual measurements. It includes Definitions/Ambient Physical Conditions/Electrical and Thermal Conditions/Test and Measurement Procedures/Lumen Maintenance Testing Method for LED Sight Sources/Test Report.

8 Summary of Testing Methods Performed

LRL has had third party testing performed on the Satellite Series fixtures by Environmental Simulation Labs of Dartmouth, Nova Scotia, Canada. In brief, the fixtures were tested for temperature, humidity, vibration, and shock. Upon reviewing the testing data, we can conclude that LRL has undergone thorough testing of their Satellite Series fixtures. A summary of key tests performed are noted in the sections below.

8.1 Hurricane Testing

The Satellite has been rigorously tested for top performance in any environment. To that end, the fixture has been tested to Category 3 hurricane force winds in the National Research Council laboratory in Ottawa, Canada.

8.2 Vibration Testing

Most street lights will undergo tremendous stress during the course of their life. In some applications, such as bridges and overpasses, the fixtures will undergo extreme vibration. The Satellite Series fixture has been tested to 100,000 cycles between 5Hz and 30Hz, and remained operational and maintained its structural integrity.

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8.3 Ingress Protection (IP) Testing

To verify the dust and water jet tight seal of the Satellite Series optics and power supply chambers, IP66 testing has been conducted. A fire hose was turned on to high power and the jet spray administered to the fixture at all angles. The fixture passed the test flawlessly, with no moisture entry into any of the sealed chambers.

8.4 Impact Testing

The Satellite fixture is made from a single, industrial grade, aluminum casing. Not only does this prevent ingress, it also increases the general durability of the fixture. In this test, a fully-powered and illuminated fixture was thrown from a 22-foot high rooftop, achieving a total arc of over 30 feet, onto an asphalt parking lot below. The fixture remained fully-functional after this very violent test.

Once installed, lighting fixtures are sometimes exposed to gunfire and other projectiles. To verify that the Satellite Series fixture would not be affected by projectiles, the fixture was shot 100 times with a BB Gun Air Pistol from a distance of 6m. The fixture sustained only minimal cosmetic damage. None of the LEDs or plastic casings were damaged and the fixture remained fully functional.

8.4.1 On/Off Cycling Testing

In order to test the Satellite's electronics and design life the fixture was put through a test in which it was powered on and off over 85,000 times which is equal to being turned on and off every 12 hours for 233 years.

8.5 Thermal Cycling

The Satellite has been tested for the ability to continue functioning through extreme fluctuations in extreme climate. The fixture worked flawlessly through 130 thermal cycles whereby one cycle = -40°C to 60°C to -40°C.

9 Pilot Installation

The photo below shows the lighting conditions of the Robie Street pilot installation. The photograph contains both High Pressure Sodium (the yellow/orange colored light) and LED (the white colored light). This photo was provided by LRL to DMD for use in this report, and was not generated independently by DMD. It is important to note that this photograph is included to demonstrate a general representation of color rendering and overall lighting quality. When assessing photometric performance of a lighting fixture, photometric calculations should be carried out according to IESNA methods to compare overall lighting performance.

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Figure 5 - HPS and LED Lighting Condition Comparison

10 Energy Savings

Based on the information provided by LRL, an overall energy savings of 53% was achieved by the installation of the Satellite LED streetlights at the pilot locations, while still meeting IESNA roadway lighting recommended levels. For a detailed breakdown of the estimated energy savings per site location refer to Table 2 - Estimated Energy Savings below.

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Location	Existing Fixture	Wattage Used Per Fixture	LED Roadway Replacement Fixture	Wattage Used Per Fixture	Energy Savings	Number of Fixtures Replaced	Total Wattages	
							Before	After
Annapolis	100W HPS	137	S96M	88	36%	102	13,974	8,976
Annapolis	70W HPS	94	S48M	44	53%	10	940	440
Annapolis	400W HPS	465	S96M	88	81%	15	6,975	1,320
Annapolis	100W HPS	137	S96M	88	36%	8	1,096	704
Yarmouth	100W HPS	137	S96M	88	36%	24	3,288	2,112
HRM	150W HPS	193	S96M	88	54%	40	7,720	3,520
HRM	100W HPS	137	S96M	88	36%	14	1,918	1,232
HRM	150W HPS	193	S96M	88	54%	27	5,211	2,376
HRM	70W HPS	94	S48M	44	53%	32	3,008	1,408
HRM	70W HPS	94	S96M	88	6%	32	3,008	2,816
Yarmouth	70W HPS	94	S72M	66	30%	34	3,196	2,244
Yarmouth	250W HPS	292	S96M	88	70%	2	584	176
Bridgewater	70W HPS	94	S48M	44	53%	31	2,914	1,364
Bridgewater	70W HPS	94	S48M	44	53%	13	1,222	572
Bridgewater	150W HPS	193	S96M	88	54%	16	3,088	1,408
Wolfville	100W HPS	137	S96M	88	36%	7	959	616
Grand Pre	100W HPS	137	S96M	88	36%	3	411	264
Truro	100W HPS	137	S96M	88	36%	16	2,192	1,408
Stanfield Airport	250W HPS	292	S96M	88	70%	14	4,088	1,232
Stanfield Airport	150W HPS	193	S96M	88	54%	11	2,123	968
Berwick	250W HPS *	292	S96M	88	40%	60	4,088	2,464
Parrsboro	400W HPS	465	S96M	88	81%	20	9,300	1,760
Parrsboro	100W HPS	137	S72M	66	52%	19	2,603	1,254
Parrsboro	250W HPS	292	S96M	88	70%	11	3,212	968
Port Hawkesbury	250W HPS	292	S96M	88	70%	10	2,920	880
Richmond County	70W HPS	94	S96M	88	6%	7	658	616
Amherst	100W HPS	137	S96M	88	36%	90	12,330	7,920
Springhill	70W HPS	94	S48M	44	53%	4	376	176
Springhill	100W HPS	137	S72M	66	52%	6	822	396
St Peters	100W HPS	137	S72M	66	52%	9	1,233	594
Arachat	100W HPS	137	S48M	44	68%	9	1,233	396
New Glasgow	250W HPS	292	S96M	88	70%	17	4,964	1,496
New Glasgow	100W HPS	137	S48M	44	68%	43	5,891	1,892
Antigonish	100W HPS	137	S72M	66	52%	60	8,220	3,960
Lunenburg	100W HPS	137	S72M	66	52%	60	8,220	3,960
HRM	70W HPS	94	S48M	44	53%	10	940	440
HRM	150W HPS	193	S96M	88	54%	24	4,632	2,112
HRM	100W HPS	137	S72M	66	52%	10	1,370	660
HRM	100W HPS	137	S72M	66	52%	34	4,658	2,244
Bedford	150W HPS	193	S96M	88	54%	15	2,895	1,320
Bedford	100W HPS	137	S72M	66	52%	15	2,055	990
Dartmouth	150W HPS	193	S96M	88	54%	7	1,351	616
Dartmouth	250W HPS	292	S96M	88	70%	8	2,336	704
Dartmouth	150W HPS	193	S96M	88	54%	18	3,474	1,584
Dept of Trans IR	180W LPS	220	S96M	88	60%	48	10,560	4,224
Dept of Trans IR	180W LPS	220	S96M	88	60%	34	7,480	2,992
HRM	100W HPS	137	S96M	88	36%	1	137	88

Note: At Berwick location, LED Roadway changed 14 x 250W HPS fixtures to 28 x S6200 fixtures

Totals 1,100 175,873 81,862

Total Estimated Energy Savings 53%

Table 2 - Estimated Energy Savings

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11 Public Opinion

As LED street lights are fairly new, LRL and its funding partners were interested in obtaining public opinion. LRL has stated to DMD that they consistently follow up on their products after installation.

To gather public opinion on the pilot, LRL sent out 250 comment cards to a random sample of local residents. Questions and results of responses were as follows:

Question - Do you view the installations of the LED fixture positively?
Response - 95% of the residents responded "yes".

Question - Would you like to see more in your Municipality?
Response - 92% of residents responded "yes".

12 Conclusion

DMD finds that all LRL lighting calculations are to be reasonable and in line with IESNA street lighting design practice. An energy savings of 53% will be gained from retrofitting the 1100 existing cobra head luminaires with the LRL Satellite luminaires.

LRL has stated that they will continue to monitor the long term performance of the LED street lighting luminaires in cooperation with the participating communities. LRL has asked participating communities to provide any feedback on fixture performance or failure, and will track and record any adverse performance.

If additional research funding is available, it is recommended the long term results of this pilot be measured and the results published.

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Appendix

Summary of Lighting Calculations

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

Approach to Combined Services		
Road Width	5.81m	5.81m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	150W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	4.57m	4.57m
Setback	4.57m	4.57m
Spacing	46m	46m
Lamp Lumens	16000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.4 cd/m2	0.7 cd/m2
Avg/Min	2	1.8
Max/Min	3.5	3.2
Illuminance		
Average	7.3 lux	9.2 lux
Avg/Min	4.3	3.3
Lv Ratio	0.2	0.3

Amherst		
Road Width	7.32m	7.32m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	0.9m	0.9m
Setback	0.9m	0.9m
Spacing	55m	55m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.4 cd/m2	0.6 cd/m2
Avg/Min	2	2
Max/Min	3.5	5
Illuminance		
Average	5.3 lux	7.6 lux
Avg/Min	6.6	5.8
Lv Ratio	0.3	0.3

Causeway		
Road Width	7.62m	7.62m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	70W HPS	S48M
Mounting Height	9.14m	9.14m
Arm Length	1.22m	1.22m
Setback	1.22m	1.22m
Spacing	37m	37m
Lamp Lumens	6300	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.4 cd/m2	0.4 cd/m2
Avg/Min	1.3	2
Max/Min	2	4
Illuminance		
Average	5.8 lux	5.4 lux
Avg/Min	2.3	2.1
Lv Ratio	0.2	0.2

Annapolis - St. George St.		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	400W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	30m	30m
Lamp Lumens	50000	Absolute
Light Loss Factor	0.7	0.72
Luminance		
Average	2.74 cd/m2	0.93 cd/m2
Avg/Min	1.81	2.38
Max/Min	3	5
Illuminance		
Average	40.8 lux	12.5 lux
Avg/Min	1.81	1.74
Lv Ratio	0.18	0.2

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

Annapolis (the rest)		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S96M
Mounting Height	7.62m	7.62m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	76m	76m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.26 cd/m2	0.4 cd/m2
Avg/Min	13	8
Max/Min	50	52
Illuminance		
Average	3.9 lux	5.1 lux
Avg/Min	35.45	23.18
Lv Ratio	0.6	0.66

Antigonish		
Road Width	10.36m	10.36m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S72M
Mounting Height	7.62m	7.62m
Arm Length	1.22m	1.22m
Setback	0.61m	0.61m
Spacing	52m	52m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.4 cd/m2	0.4 cd/m2
Avg/Min	4	4
Max/Min	9	17
Illuminance		
Average	5.6 lux	5.3 lux
Avg/Min	8	5.9
Lv Ratio	0.4	0.4

Arichat		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S96M
Mounting Height	7.62m	7.62m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	40m	40m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.5 cd/m2	0.8 cd/m2
Avg/Min	2.5	4
Max/Min	4.5	10.5
Illuminance		
Average	7.4 lux	10.7 lux
Avg/Min	2.3	2.7
Lv Ratio	0.2	0.3

Bedford 1		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	150W HPS	S96M
Mounting Height	7.9m	7.9m
Arm Length	2.44m	2.44m
Setback	2.44m	2.44m
Spacing	46m	46m
Lamp Lumens	16000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.4 cd/m2	0.7 cd/m2
Avg/Min	4	3.5
Max/Min	9	10.5
Illuminance		
Average	8.1 lux	9 lux
Avg/Min	7.4	3.7
Lv Ratio	0.3	0.3

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Bedford 2		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S48M
Mounting Height	7.32m	7.32m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	38m	38m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.5 cd/m2	0.4 cd/m2
Avg/Min	2.5	4
Max/Min	5	10
Illuminance		
Average	7.9 lux	5.5 lux
Avg/Min	3	3.1
Lv Ratio	0.3	0.3

Bell Blvd		
Road Width	11.28m	11.28m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	250W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	4.88m	4.88m
Setback	4.57m	4.57m
Spacing	91m	91m
Lamp Lumens	28500	Absolute
Light Loss Factor	0.65	0.65
Luminance		
Average	1.0 cd/m2	0.5 cd/m2
Avg/Min	3.3	5
Max/Min	6.7	13
Illuminance		
Average	14.0 lux	6.5 lux
Avg/Min	2.6	3.6
Lv Ratio	0.2	0.3

Berwick (175W)		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	175W MV	S96M
Mounting Height	7.62m	7.62m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	53m	53m
Lamp Lumens	7900	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.3 cd/m2	0.6 cd/m2
Avg/Min	2.31	6
Max/Min	6	25
Illuminance		
Average	5.1 lux	7.5 lux
Avg/Min	10.5	5.86
Lv Ratio	0.35	0.37

Berwick (250W)		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	250W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	76m	76m
Lamp Lumens	28500	Absolute
Light Loss Factor	0.7	0.72
Luminance		
Average	0.6 cd/m2	0.4 cd/m2
Avg/Min	5	5.71
Max/Min	17	25
Illuminance		
Average	9.4 lux	5.1 lux
Avg/Min	15.21	13.08
Lv Ratio	0.35	0.41

DMD

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

Bridgewater 1		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	70W HPS	S48M
Mounting Height	7.32m	7.32m
Arm Length	1.22m	1.22m
Setback	1.22m	1.22m
Spacing	32m	32m
Lamp Lumens	6300	Absolute
Light Loss Factor	0.7	0.72
Luminance		
Average	0.5 cd/m2	0.4 cd/m2
Avg/Min	2.5	4
Max/Min	4.5	11
Illuminance		
Average	7.1 lux	6.6 lux
Avg/Min	2.2	2.7
Lv Ratio	0.3	0.3

Bridgewater 2		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	150W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	1.22m	1.22m
Setback	0.6m	0.6m
Spacing	46m	46m
Lamp Lumens	16000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.4 cd/m2	0.6 cd/m2
Avg/Min	2	2
Max/Min	3.5	4.3
Illuminance		
Average	7.3 lux	8.7 lux
Avg/Min	4.6	3.5
Lv Ratio	0.2	0.3

Bridgewater 3		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	70W HPS	S48M
Mounting Height	7.62m	7.62m
Arm Length	1.22m	1.22m
Setback	0.91m	0.91m
Spacing	38m	38m
Lamp Lumens	6300	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.3 cd/m2	0.4 cd/m2
Avg/Min	3	4
Max/Min	9	8
Illuminance		
Average	4.9 lux	5.4 lux
Avg/Min	2.2	3
Lv Ratio	0.5	0.3

Dartmouth 1 (150W)		
Road Width	18.6m	18.6m
Number of Lanes	4	4
Median Width	n/a	n/a
Luminaire	150W HPS	S72M
Mounting Height	9.14m	9.14m
Arm Length	2.74m	2.74m
Setback	2.44m	2.44m
Spacing	56m	56m
Lamp Lumens	16000	Absolute
Light Loss Factor	0.65	0.65
Luminance		
Average	0.5 cd/m2	0.4 cd/m2
Avg/Min	2.5	2
Max/Min	4	5
Illuminance		
Average	9.0 lux	5.8 lux
Avg/Min	5	5.8
Lv Ratio	0.2	0.3

DMD

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

Dartmouth 1 (250W)		
Road Width	18.6m	18.6m
Number of Lanes	4	4
Median Width	n/a	n/a
Luminaire	250W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	2.74m	2.74m
Setback	2.44m	2.44m
Spacing	56m	56m
Lamp Lumens	28500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	1.0 cd/m2	0.6 cd/m2
Avg/Min	1.7	2
Max/Min	3.2	4.3
Illuminance		
Average	15.3 lux	8.1 lux
Avg/Min	2.8	5.4
Lv Ratio	0.2	0.3

Dartmouth 2		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	150W HPS	S72M
Mounting Height	8.23m	8.23m
Arm Length	1.82m	1.82m
Setback	2.74m	2.74m
Spacing	40m	40m
Lamp Lumens	16000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.5 cd/m2	0.5 cd/m2
Avg/Min	2.5	5
Max/Min	4	12
Illuminance		
Average	8.7 lux	7.1 lux
Avg/Min	3.3	3.2
Lv Ratio	0.3	0.3

HRM 1		
Road Width	19.82m	19.82m
Number of Lanes	4	4
Median Width	2.74m	2.74m
Luminaire	150W HPS	S96M
Mounting Height	8.53m	8.53m
Arm Length	1.83m	1.83m
Setback	1.22m	1.22m
Spacing	30m	30m
Lamp Lumens	16000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.9 cd/m2	1.1 cd/m2
Avg/Min	1.5	1.8
Max/Min	2.2	3.2
Illuminance		
Average	16.3 lux	14.5 lux
Avg/Min	2	1.7
Lv Ratio	0.2	0.2

HRM 2		
Road Width	18.59m	18.59m
Number of Lanes	4	4
Median Width	3.35m	3.35m
Luminaire	100W HPS	S96M
Mounting Height	8.53m	8.53m
Arm Length	1.83m	1.83m
Setback	1.52m	1.52m
Spacing	37m	37m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.7 cd/m2	1.0 cd/m2
Avg/Min	1.8	1.7
Max/Min	2.2	3.2
Illuminance		
Average	9.8 lux	13 lux
Avg/Min	2.9	2.5
Lv Ratio	0.2	0.2

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

HRM 3		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	70W HPS	S48M
Mounting Height	7.32m	7.32m
Arm Length	1.52m	1.52m
Setback	0.61m	0.61m
Spacing	37m	37m
Lamp Lumens	6300	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.2 cd/m2	0.4 cd/m2
Avg/Min	2	4
Max/Min	4	10
Illuminance		
Average	4.3 lux	5.7 lux
Avg/Min	4.3	4.1
Lv Ratio	0.3	0.3

HRM 4		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	70W HPS	S48M
Mounting Height	7.62m	7.62m
Arm Length	1.52m	1.52m
Setback	0.61m	0.61m
Spacing	43m	43m
Lamp Lumens	6300	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.3 cd/m2	0.3 cd/m2
Avg/Min	3	3
Max/Min	9	10
Illuminance		
Average	4.5 lux	4.8 lux
Avg/Min	4.5	6
Lv Ratio	0.5	0.3

HRM 4.1		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S48M
Mounting Height	8.53m	8.53m
Arm Length	1.83m	1.83m
Setback	1.22m	1.22m
Spacing	34m	34m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.6 cd/m2	0.4 cd/m2
Avg/Min	2	2
Max/Min	3	4.5
Illuminance		
Average	8.6 lux	5.8 lux
Avg/Min	2.5	2.1
Lv Ratio	0.2	0.2

HRM 5		
Road Width	10.36m	10.36m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	150W HPS	S96M
Mounting Height	7.32m	7.32m
Arm Length	1.83m	1.83m
Setback	0.61m	0.61m
Spacing	32m	32m
Lamp Lumens	16000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.7 cd/m2	0.9 cd/m2
Avg/Min	2.3	3
Max/Min	3.7	8
Illuminance		
Average	12.4 lux	12.5 lux
Avg/Min	3.1	2.4
Lv Ratio	0.2	0.3

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LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

HRM 6		
Road Width	9.76m	9.76m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	70W HPS	S48M
Mounting Height	6.71m	6.71m
Arm Length	1.52m	1.52m
Setback	1.22m	1.22m
Spacing	37m	37m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.3 cd/m2	0.4 cd/m2
Avg/Min	3	4
Max/Min	12	12
Illuminance		
Average	5.1 lux	5.6 lux
Avg/Min	3.2	4.3
Lv Ratio	0.5	0.4

HRM 7		
Road Width	9.76m	9.76m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	150W HPS	S96M
Mounting Height	9.75m	9.75m
Arm Length	1.83m	1.83m
Setback	0.3m	0.3m
Spacing	32m	32m
Lamp Lumens	16000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.6 cd/m2	0.9 cd/m2
Avg/Min	1.5	1.8
Max/Min	1.8	3.4
Illuminance		
Average	10.5 lux	11.6 lux
Avg/Min	1.8	2.1
Lv Ratio	0.1	0.2

HRM 8		
Road Width	7.62m	7.62m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S72M
Mounting Height	9.14m	9.14m
Arm Length	1.84m	1.84m
Setback	0.91m	0.91m
Spacing	32m	32m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.6 cd/m2	0.7 cd/m2
Avg/Min	1.5	1.8
Max/Min	2	3
Illuminance		
Average	9.1 lux	8.9 lux
Avg/Min	2.5	2.1
Lv Ratio	0.2	0.2

HRM 9		
Road Width	9.76m	9.76m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S72M
Mounting Height	8.53m	8.53m
Arm Length	1.52m	1.52m
Setback	0.61m	0.61m
Spacing	37m	37m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.5 cd/m2	0.5 cd/m2
Avg/Min	2.5	2.5
Max/Min	4	6.5
Illuminance		
Average	7.6 lux	7.7 lux
Avg/Min	3	2.7
Lv Ratio	0.2	0.3

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

Lunenburg		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S96M
Mounting Height	8.23m	8.23m
Arm Length	1.22m	1.22m
Setback	1.52m	1.52m
Spacing	40m	40m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.5 cd/m2	0.7 cd/m2
Avg/Min	1.7	3.5
Max/Min	2.7	10
Illuminance		
Average	6.9 lux	10.4 lux
Avg/Min	3.1	2.4
Lv Ratio	0.3	0.3

New Glasgow 1		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	250W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	1.52m	1.52m
Setback	0.3m	0.3m
Spacing	26m	26m
Lamp Lumens	29000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	2.1 cd/m2	1.1 cd/m2
Avg/Min	1.4	1.6
Max/Min	1.9	3
Illuminance		
Average	33.8 lux	14.6 lux
Avg/Min	1.8	1.9
Lv Ratio	0.1	0.2

New Glasgow 2		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S72M
Mounting Height	7.62m	7.62m
Arm Length	1.52m	1.52m
Setback	0.61m	0.61m
Spacing	38m	38m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.5 cd/m2	0.6 cd/m2
Avg/Min	2.5	3
Max/Min	5	7
Illuminance		
Average	8.1 lux	8.1 lux
Avg/Min	4.3	3.7
Lv Ratio	0.3	0.3

NWA 1		
Road Width	22.26m	22.26m
Number of Lanes	4	4
Median Width	5.18m	5.18m
Luminaire	185W LPS	S96M
Mounting Height	12.2m	12.2m
Arm Length	2.44m	2.44m
Setback	n/a	n/a
Spacing	59m	59m
Lamp Lumens	29000	Absolute
Light Loss Factor	0.85	0.85
Luminance		
Average	1.4 cd/m2	0.5 cd/m2
Avg/Min	1.8	1.7
Max/Min	2.6	3.7
Illuminance		
Average	15.7 lux	7 lux
Avg/Min	2	2.7
Lv Ratio	0.3	0.2

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

NWA 2		
Road Width	22.26m	22.26m
Number of Lanes	4	4
Median Width	5.18m	5.18m
Luminaire	185W LPS	S96M
Mounting Height	12.2m	12.2m
Arm Length	2.44m	2.44m
Setback	1.83m	1.83m
Spacing	59m	59m
Lamp Lumens	33000	Absolute
Light Loss Factor	0.85	0.85
Luminance		
Average	1.2 cd/m2	0.6 cd/m2
Avg/Min	1.5	2
Max/Min	2	3.7
Illuminance		
Average	12.9 lux	7.4 lux
Avg/Min	2	3.5
Lv Ratio	0.2	0.2

Parrsboro 1		
Road Width	12.2m	12.2m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	400W HPS	S96M
Mounting Height	9.14m	9.14m
Arm Length	2.13m	2.13m
Setback	0.3m	0.3m
Spacing	35m	35m
Lamp Lumens	50000	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	2.2 cd/m2	0.7 cd/m2
Avg/Min	3.1	2.3
Max/Min	5.9	5.3
Illuminance		
Average	29.5 lux	9.4 lux
Avg/Min	2.1	2.2
Lv Ratio	0.2	0.3

Parrsboro 2		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S96M
Mounting Height	7.62m	7.62m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	53m	53m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.4 cd/m2	0.6 cd/m2
Avg/Min	4	3
Max/Min	10	11
Illuminance		
Average	5.6 lux	7.8 lux
Avg/Min	7	7.1
Lv Ratio	0.4	0.4

Parrsboro 3		
Road Width	8.54m	8.54m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	250W HPS	S96M
Mounting Height	7.62m	7.62m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	35m	35m
Lamp Lumens	28500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	1.7 cd/m2	0.9 cd/m2
Avg/Min	3.4	3
Max/Min	6.4	7
Illuminance		
Average	24.6 lux	12.8 lux
Avg/Min	2.1	2.5
Lv Ratio	0.2	0.3

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

Port Hawkesbury		
Road Width	12.8m	12.8m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	250W HPS	S96M
Mounting Height	8.53m	8.53m
Arm Length	1.52m	1.52m
Setback	0.3m	0.3m
Spacing	38m	38m
Lamp Lumens	28500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	1.3 cd/m2	0.6 cd/m2
Avg/Min	4.3	3
Max/Min	8.3	8
Illuminance		
Average	18.1 lux	8.8 lux
Avg/Min	2.4	3.5
Lv Ratio	0.2	0.3

Springhill 1		
Road Width	8.54m	8.54m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	70W HPS	S48M
Mounting Height	8.23m	8.23m
Arm Length	1.52m	1.52m
Setback	1.52m	1.52m
Spacing	38m	38m
Lamp Lumens	6300	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.4 cd/m2	0.4 cd/m2
Avg/Min	2	4
Max/Min	3.5	8
Illuminance		
Average	5.4 lux	5.4 lux
Avg/Min	3.2	2.6
Lv Ratio	0.3	0.2

St Peters		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S96M
Mounting Height	8.53m	8.53m
Arm Length	1.22m	1.22m
Setback	0.6m	0.6m
Spacing	38m	38m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.5 cd/m2	0.8 cd/m2
Avg/Min	2.5	2.7
Max/Min	4	6
Illuminance		
Average	7.5 lux	10.7 lux
Avg/Min	3.1	2.5
Lv Ratio	0.2	0.2

Truro		
Road Width	10.66m	10.66m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S96M
Mounting Height	8.23m	8.23m
Arm Length	1.52m	1.52m
Setback	0.3m	0.3m
Spacing	61m	61m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.3 cd/m2	0.5 cd/m2
Avg/Min	3	5
Max/Min	8	21
Illuminance		
Average	4.6 lux	6.2 lux
Avg/Min	11.5	8.9
Lv Ratio	0.4	0.4

LED ROADWAY LIGHTING PILOT INSTALLATIONS
SUMMARY OF LIGHTING CALCULATIONS

Yarmouth (70W)		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	70W HPS	S96M
Mounting Height	7.62m	7.62m
Arm Length	1.22m	1.22m
Setback	1.22m	1.22m
Spacing	61m	61m
Lamp Lumens	6400	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.3 cd/m2	0.5 cd/m2
Avg/Min	4.29	8.33
Max/Min	11	44
Illuminance		
Average	3.8 lux	6.4 lux
Avg/Min	19	10.67
Lv Ratio	0.5	0.5

Yarmouth (100W)		
Road Width	9.14m	9.14m
Number of Lanes	2	2
Median Width	n/a	n/a
Luminaire	100W HPS	S96M
Mounting Height	7.62m	7.62m
Arm Length	1.22m	1.22m
Setback	1.22m	1.22m
Spacing	61m	61m
Lamp Lumens	9500	Absolute
Light Loss Factor	0.72	0.72
Luminance		
Average	0.5 cd/m2	0.3 cd/m2
Avg/Min	3.75	3.85
Max/Min	12	17
Illuminance		
Average	4.9 lux	6.8 lux
Avg/Min	12.25	13.6
Lv Ratio	0.5	0.5