City of Los Angeles
Bureau of Street Lighting

LED Equipment Evaluation
Pilot Project - Phase I

Prepared by:
The Bureau of Street Lighting

Disclaimer

This report was prepared by the City of Los Angeles for the sole purpose of promoting energy efficiency through the use of new technologies.

It does not recommend the use of any specific LED equipment nor does it recommend the use of a specific supplier.

The City of Los Angeles assumes no legal liability or responsibility for the accuracy, completeness, or usefulness of this report.

June 2009

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Introduction

Acknowledgements

The Bureau of Street Lighting would like to thank the following companies and organizations for their invaluable assistance in conducting our LED Pilot Project – Phase I evaluation:

The Department of Energy Solid-State Lighting Program, American Greenlight, Beta, Chips and Wafers, Duralight, IMS, IntenCity, LED Folio, Lemnis, Leotek, Lumec, Relume, and our own engineers and field crews who helped make this project a success.

Background

For several decades the high pressure sodium lamp has been considered a standard for roadway lighting around the world. However, recently there have been major technological advances in solid state lighting for street lighting purposes. The new solid-state fixtures use LEDs to produce a high quality white light, while using substantially less energy than the HPS fixtures currently being used by BSL. The LED fixtures have the potential to reduce maintenance and operation costs for the City's lighting district.

This being the case, The City of Los Angeles has committed itself to the long-term testing and evaluation of new LED street lighting technology. The Energy Efficiency Division of the Bureau of Street Lighting will evaluate new LED fixtures as they become commercially available. The fixtures that show the most potential will be chosen to participate in the City's LED Pilot Project and subjected to field testing for a period of 90 days. Manufacturers that have

participated in the LED Pilot Project and meet the Bureau's most recent LED specifications will be eligible to bid on City contracts.

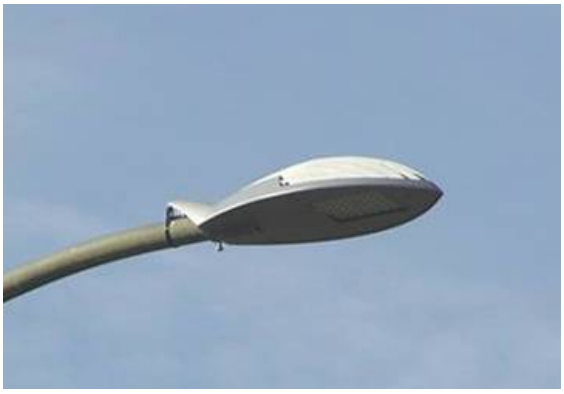
The equipment which is the subject of this report was selected to participate in the first phase of the LED Pilot Project. The following is a summary of the Pilot Project Phase I results.

Purpose of the LED Pilot Project Phase I

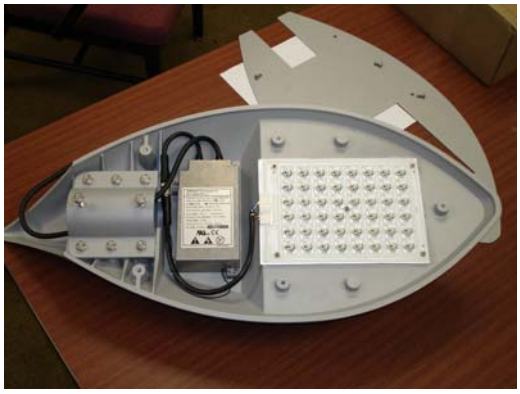
The purpose of this project is to determine a suitable replacement for a 100W HPS fixture on a local residential street. The replacement fixture must provide for at least a 40% energy savings. In this case, that means the entire lighting fixture must consume no more than 85W. (For a table showing power consumption for all units tested, refer to Table X.X on page 12)

The fixtures were evaluated based on BSL mechanical, electrical and lighting standards, as well as, newly introduced and accepted LED standards from the SSL industry. In addition, power consumption, voltage, and on/off cycles were monitored on a daily basis using a Remote Monitoring System. However, some of the test units were not equipped with a 3-prong locking ANSI C136.10 photocell receptacle. In those cases, periodic visual inspections were conducted to assure proper operation. The results of these evaluations were a major factor in determining which fixture will be used in future street lighting projects.

Pilot Project Phase I Test Units

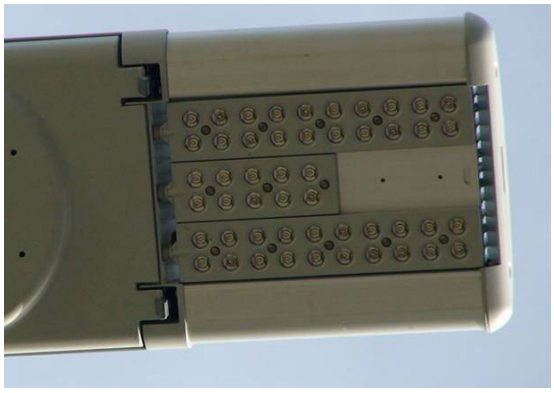


Manufacturer A



Manufacturer A

Manufacturer B



Manufacturer B

Manufacturer C

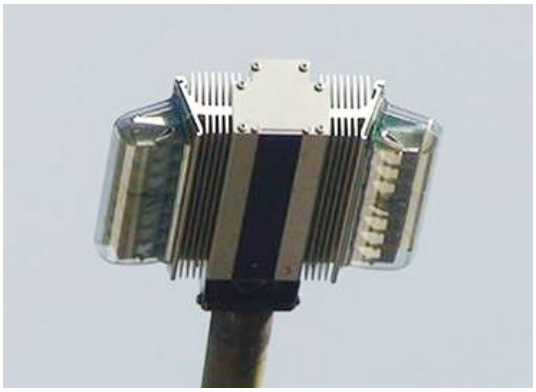
Manufacturer C

Manufacturer D

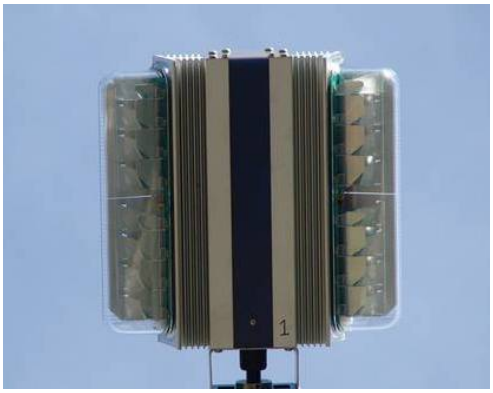
Manufacturer D

Manufacturer E

Manufacturer E



Manufacturer F



Manufacturer F

Manufacturer G

Manufacturer G

Manufacturer H

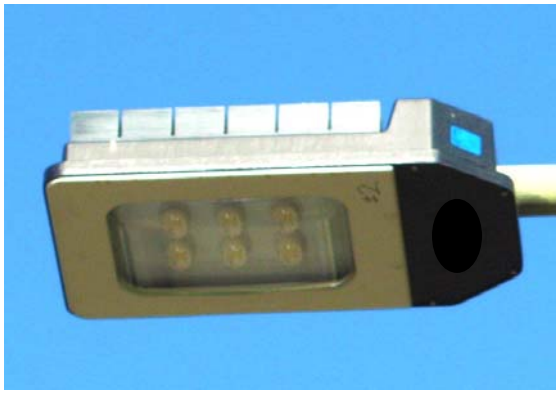
Manufacturer H

Manufacturer I

Manufacturer I

Manufacturer J

Manufacturer J



Manufacturer K

Manufacturer K

Manufacturer L

Manufacturer L

Section 1

Mechanical Evaluation

1.1 Evaluation method:

Mechanical evaluation of these units was based on luminaire mechanical requirements specified on page 40 of Special Specifications for the Construction of Street Lighting Systems ("The Blue Book"). This evaluation is carried out for all street lighting fixtures and was not developed specifically for solid state LED technology.

1.2 Evaluation conditions:

The evaluation was carried out in a controlled lab environment and also on an uncontrolled local, residential street.

1.3 Evaluation Summary:

These requirements are specified to ensure fixture durability, safety and ease of maintenance. The requirements are additional to any/all of those specified in "The Blue Book". The following shows how the various test units preformed when evaluated against our most important mechanical criteria.

Q1: Luminaire must be clearly labeled with the full catalog number.		
PASS	**FAIL**	**N/A**
C,D,F,I,K,L	A,B,E,G,H,J	

Q2: There shall be no sharp edges or corners near serviceable parts.		
PASS	**FAIL**	**N/A**
A,B,C,D,E,H,I,J,K,L	F,G	

Q4: Ballasts assembly components shall be mounted on an untied (one piece) ballast tray and must be easily accessible and removable for ease of maintenance.		
PASS	**FAIL**	**N/A**
A,B,C,D,G,H,I,J,L	E,F,K	

Q6: Disconnects for the starter and the ballast assembly are required for easy removal.		
PASS	**FAIL**	**N/A**
A,B,C,D,F,G,H,I,J,K,L	E	

Q13: Internal wiring must be rated for 105 C and routed away from heat generating components of the ballast assembly and must not interfere with the lighting distribution of the unit.		
PASS	**FAIL**	**N/A**
A,B,C,D,E,F,H,I,J,K,L	G	

Q16: Any covers provided for access to serviceable parts shall be securely attached but easily removable.		
PASS	**FAIL**	**N/A**
A,B,C,F,H,I,J,L	G,K	D,E

Section 2

Electrical Evaluation

2.1. Evaluation method:

Electrical evaluations of these units were based on a test procedure developed by ETSD/BSL.

2.2. Evaluation conditions:

Ambient temperature: 25ºC

2.3. Summary:

1. Input voltage 120 VAC, 50-60 HZ

   All Manufacturers Passed

2. Ballast factor:

   Not Specified

3. Power factor: Any manufacturer with a 0.9 or greater is considered Passing

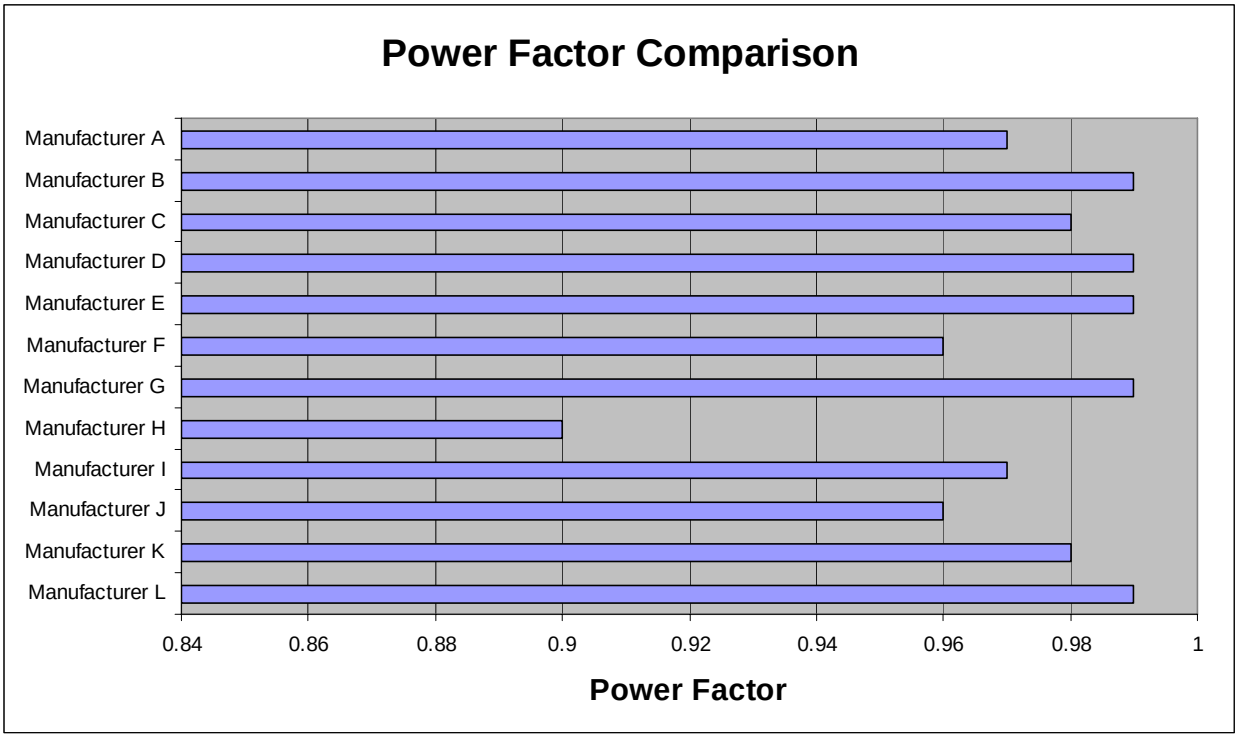


Figure 2.1: Power Factor Comparison

4. Total harmonic distortion: Less than 15% distortion is considered Passing

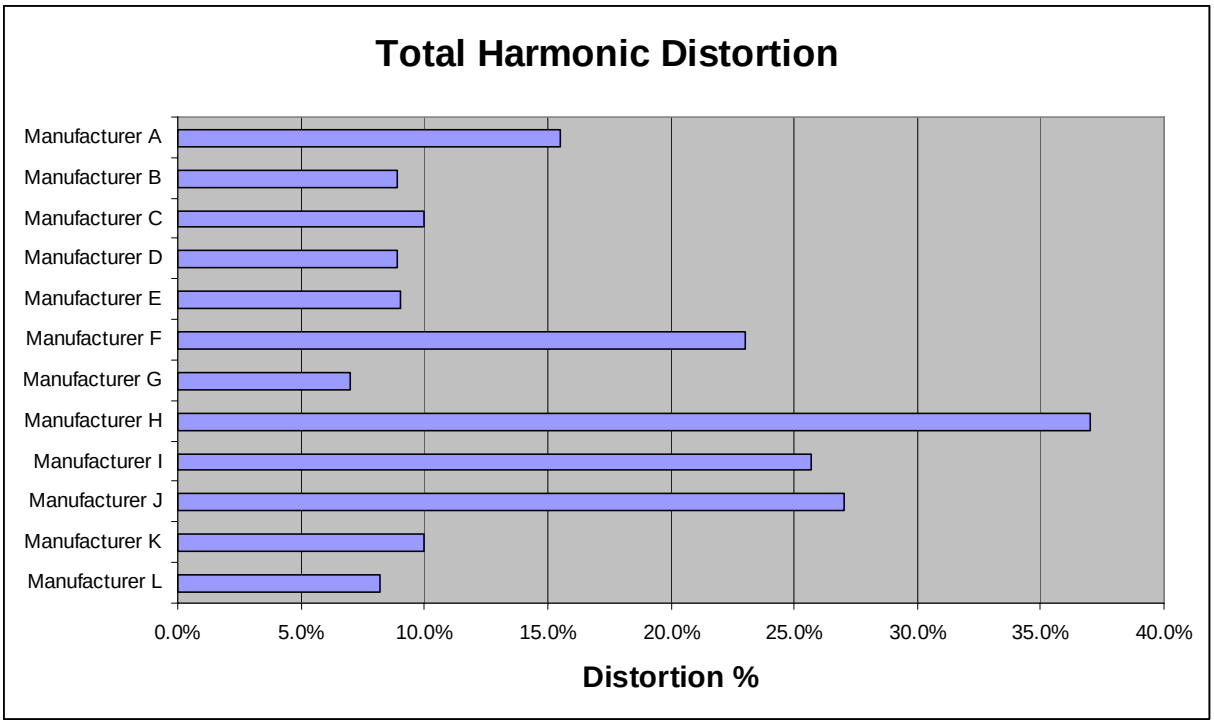


Figure 2.2: Total Harmonic Distortion

5. Manufacturer's Rated (lamp/LED) life in hours: 50,000 or more is Passing

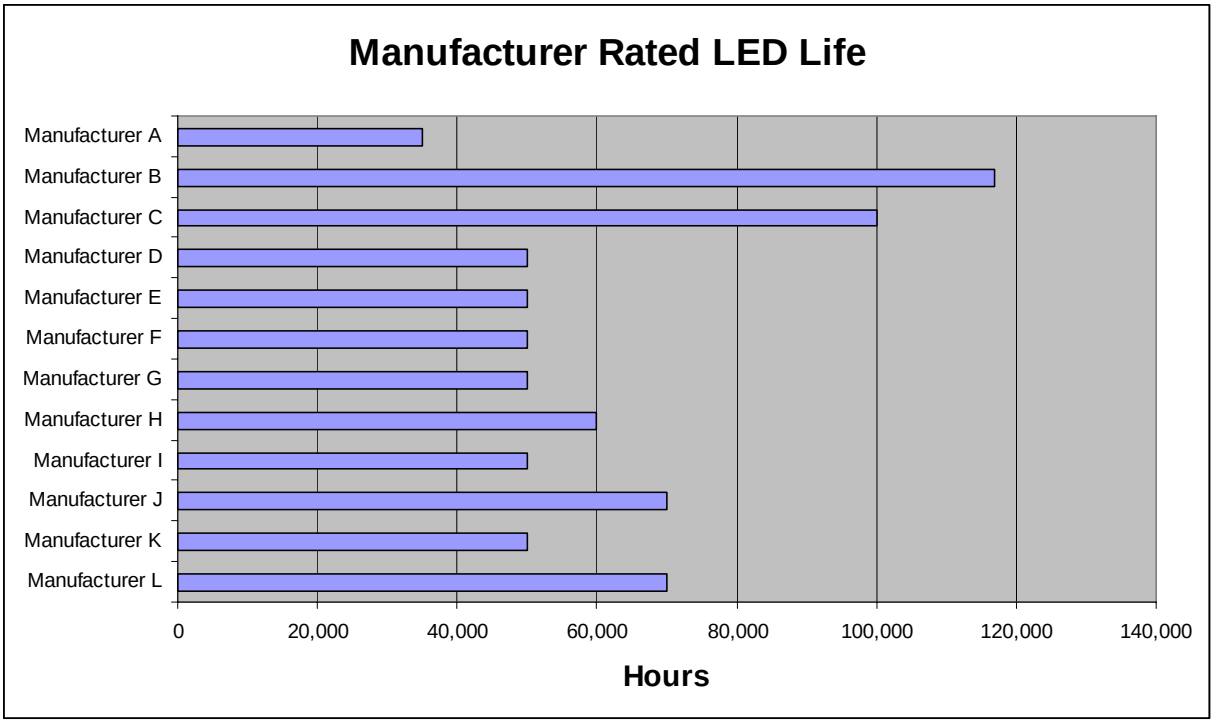


Figure 2.3: Manufacturer Rated LED Life

6. Power consumption:

The power was measured in our lab until it was determined that the test unit's power consumption had steadied. The fixtures were then moved to standard street lighting poles on residential streets. Daily readings were taken unless the unit was not equipped with a 3-prong locking ANSI C136.10 photocell receptacle which is needed to install our remote monitoring system.

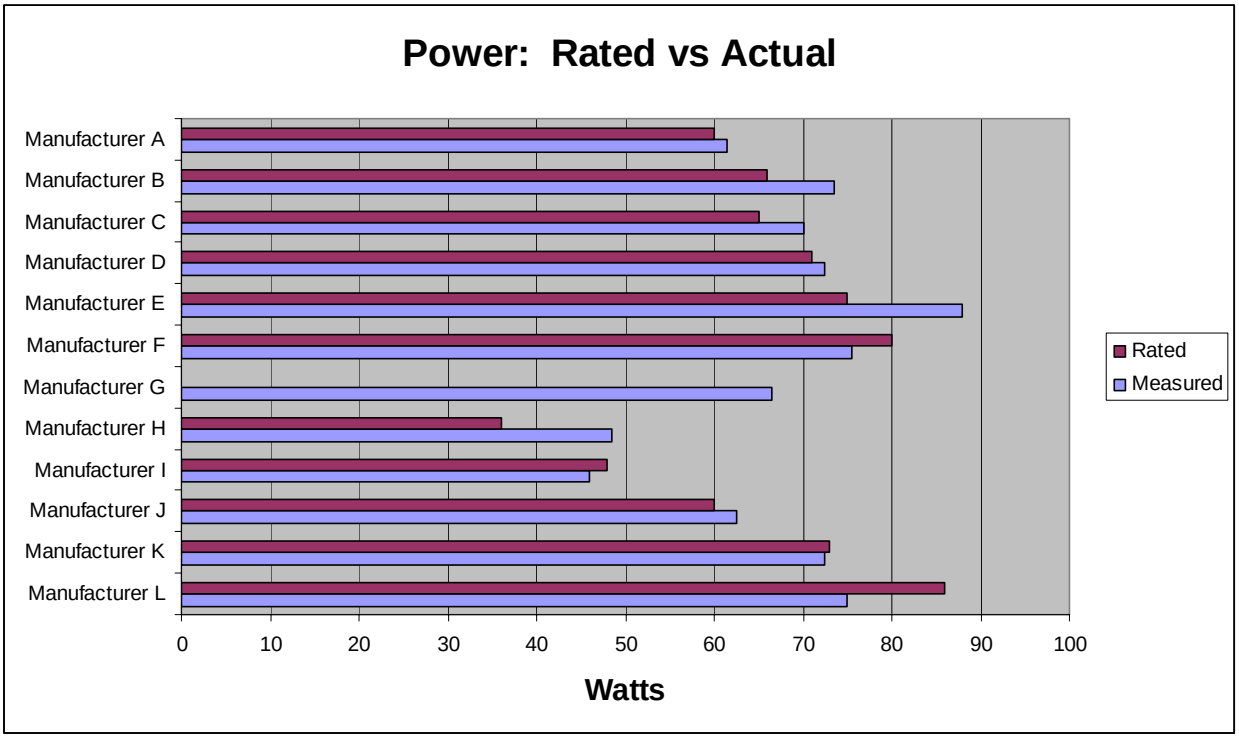


Figure 2.4: Power: Rated vs Actual

Note: Manufacturer G was a prototype and no rated power was submitted.

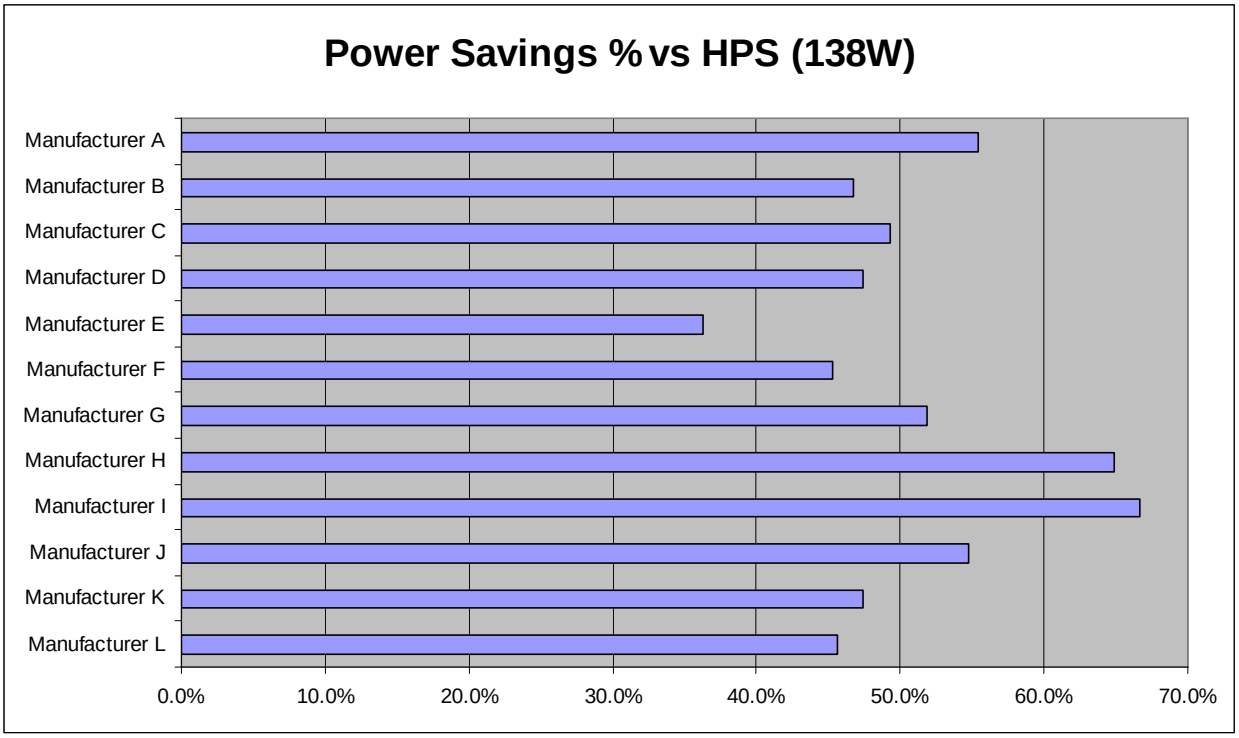


Figure 2.5: Power Savings vs HPS

Averaged Power Measurements				
Luminaire Type	**Voltage (V)**	**Current (A)**	**Power (W)**	**Power Factor**
Manufacturer A	120	0.5	61.5	0.97
Manufacturer B	120	0.6	73.5	0.99
Manufacturer C	120	0.6	70	0.98
Manufacturer D	121	0.6	72.5	0.99
Manufacturer E	120	0.8	88	0.99
Manufacturer F	121	0.7	75.5	0.96
Manufacturer G	121	0.6	66.5	0.99
Manufacturer H	122	0.4	48.5	0.89
Manufacturer I	121	0.4	46	0.97
Manufacturer J	119	0.8	62.5	0.96
Manufacturer K	120	0.6	72.5	0.98
Manufacturer L	120	0.7	75	0.99

Table 2.1: Averaged Power Measurements

Section 3

Lighting Evaluation

3.1 Photopic/Scotopic Illumination Measurements

3.1.1 Evaluation method:

For this evaluation, light readings were taken from a grid representing one half the existing pole spacing.

Grid Characteristics:

- Roadway - 10 foot increments parallel to curb for one half the pole spacing
- Roadway - 9 foot increments perpendicular to curb for 36 feet
- Sidewalk – 10 foot increments parallel to curb for one half the pole spacing
- Sidewalk - 5 foot increments perpendicular to curb for 10 feet

Illumination readings were recorded using a Solar Light SL-3101 scotopic/photopic meter. A total of 63 to 99 illumination measurements were taken based on pole spacing. Scotopic readings were taken for information purposes only.

3.1.2 Evaluation conditions:

The following conditions were present during the evaluation:

- Location – North Hills Pilot Project Site
- Roadway Characteristics – 36’ roadway with 10’ sidewalks
- Electrolier Description – CD951A with a 26.75’ mounting height and 4’ arm
- Some ambient light from porches and holiday decorations
- Minor tree interference
- The sky was clear with a full moon

For comparison purposes, the existing HPS system was evaluated under the same conditions.

3.1.3 Summary of data collected:

The following charts are used to show how the test LED units compare to the existing HPS lamps as well as each other. Because the pilot site had a range of pole spaces, there are four different charts that represent the actual spacing of the street lighting poles at our test site. Photopic and Scotopic illumination readings were taken for one half of the distance between poles.

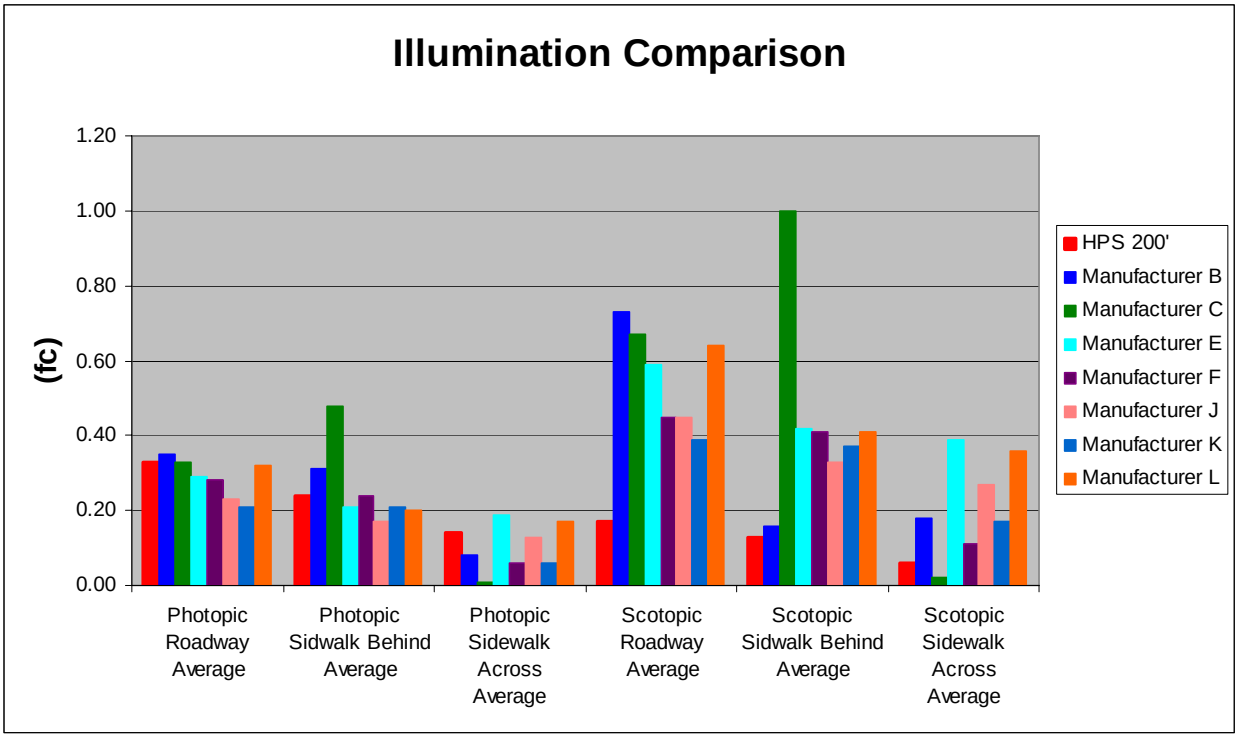


Figure 3.1: Illumination averages at 200'

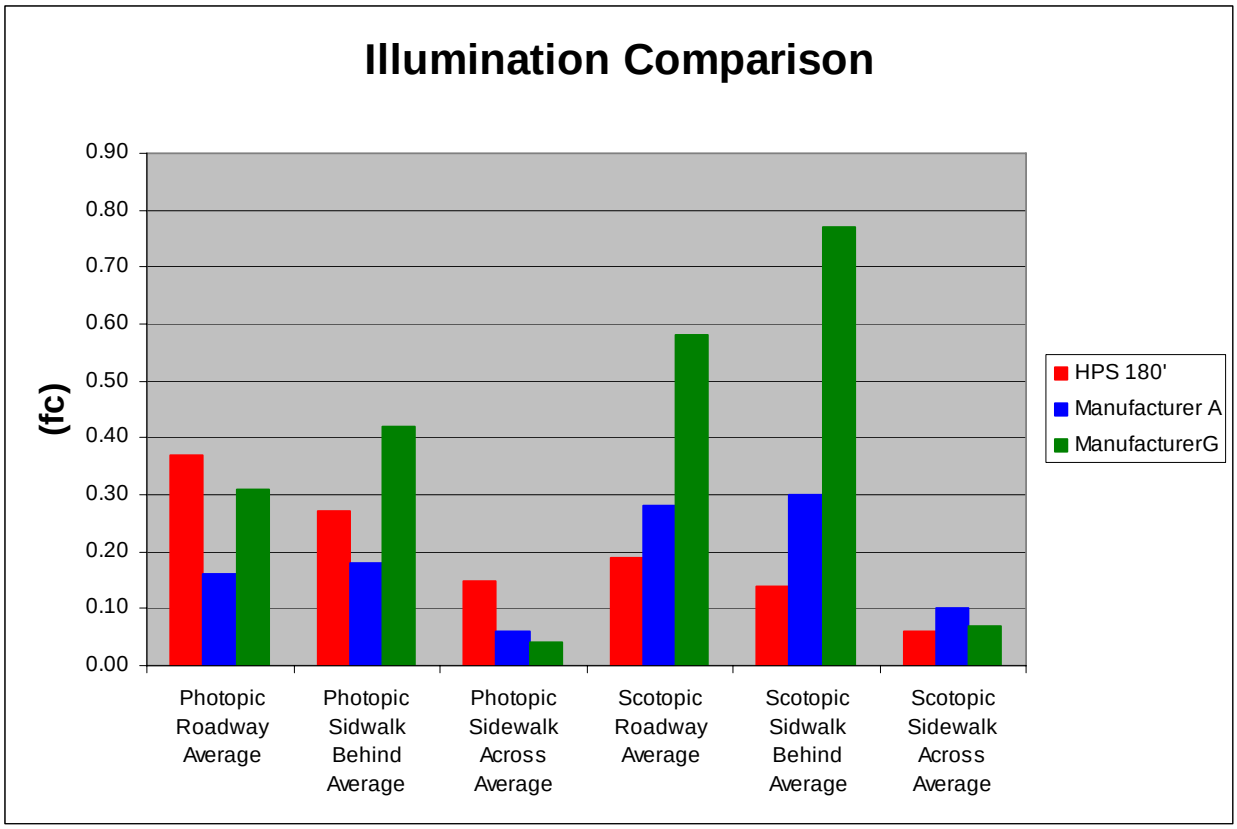


Figure 3.2: Illumination averages at 180’

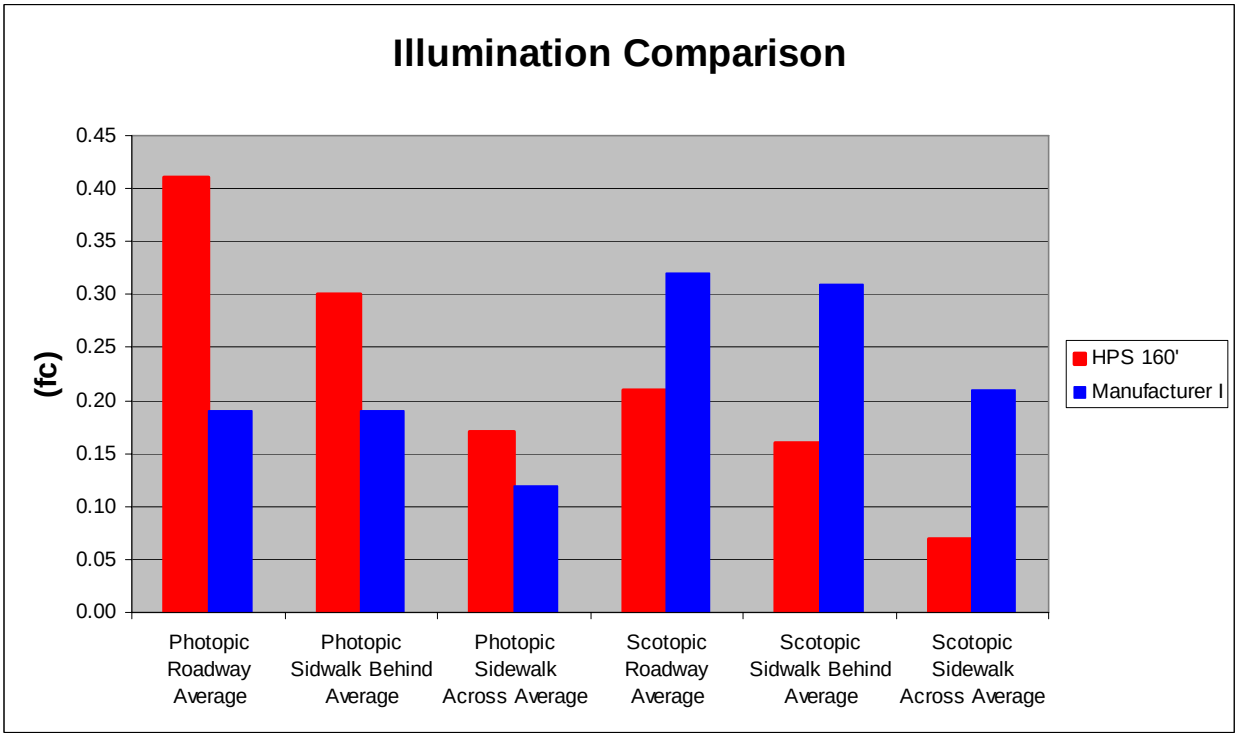


Figure 3.3: Illumination averages at 160’

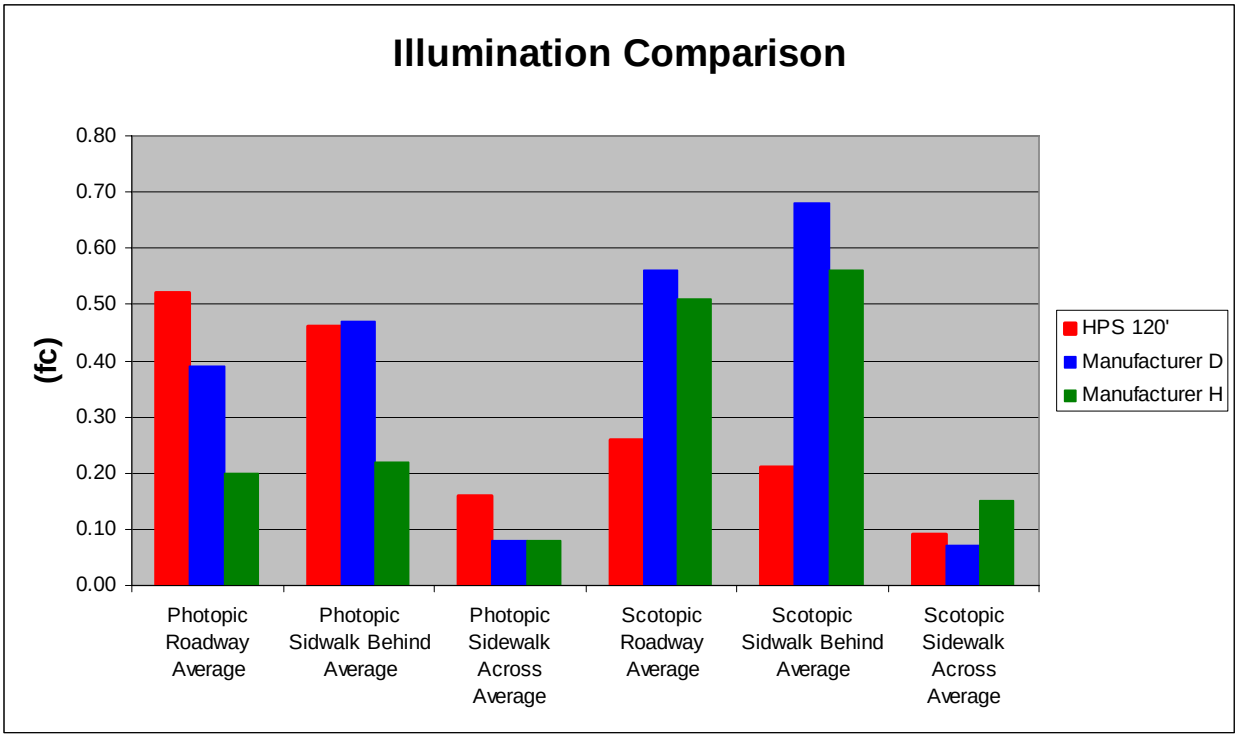


Figure 3.4: Illumination averages at 120'

Manufacturer A

Manufacturer B

Manufacturer C

Manufacturer D

Manufacturer E

Manufacturer F

Manufacturer G

Manufacturer H

Manufacturer I

Manufacturer J

Manufacturer K

Manufacturer L

3.2 Luminance Measurements

3.2.1 Evaluation method:

For this evaluation, light readings were taken from a grid representing one full length of the existing pole spacing. Luminance readings were taken about 273' (83 meters) from each target.

Grid Characteristics:

- Roadway – 15 foot increments parallel to curb for one full pole spacing
- Roadway – 9, 15, 21, 27 foot distances perpendicular to curb

Luminance readings were recorded using a Minolta Luminance Meter LS-100 at about 5' (eye level). A total of 32 to 52 luminance measurements were taken depending on pole spacing.

3.2.2 Evaluation conditions:

The following conditions were present during the evaluation:

- Location – North Hills Pilot Project Test Site
- Roadway Characteristics – 36' roadway with 10' sidewalks
- Electrolier Description – CD951A with a 26.75' mounting height and a 4' arm
- Minimal ambient light from porches and holiday decorations
- The sky was clear with a full moon

For comparison purposes, the existing HPS system was evaluated under the same conditions.

3.2.3 Summary of data collected:

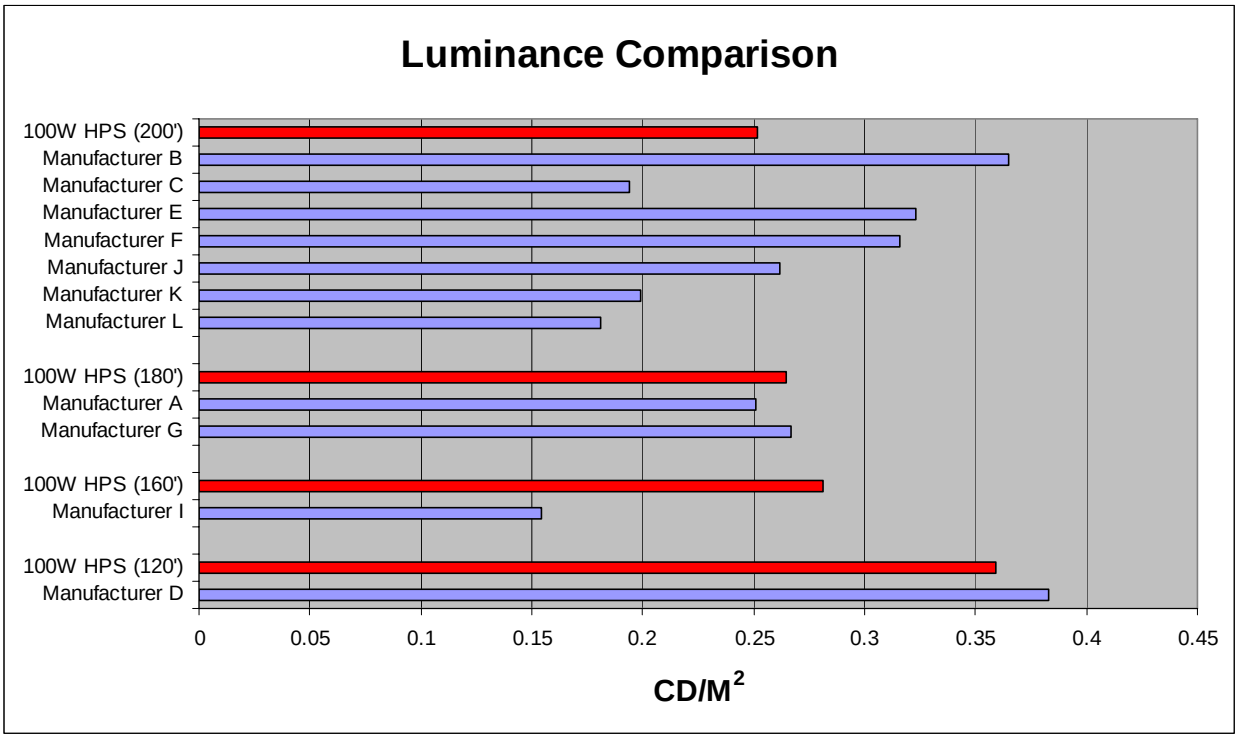


Figure 3.5: Luminance Average

3.3 Discomfort Glare Measurements

3.3.1 Evaluation method:

For this evaluation, light readings were taken from seven various locations where it was determined that glare sensitivity may exist and create a significant negative impact to drivers and pedestrians. Discomfort glare readings were recorded using a Minolta Luminance Meter LS-100 at eye level, aimed at our target luminaire.

3.3.2 Evaluation conditions:

The following conditions were present during the evaluation:

- Location – North Hills Pilot Project Test Site

- Roadway Characteristics – 36’ roadway with 10’ sidewalks
- Electrolier Description – CD951A with a 26.75’ mounting height and 4’ arm
- Some ambient light from porches
- The sky was clear with no visible moon

For comparison purposes, the existing HPS system was evaluated under the same conditions.

3.3.3 Summary of data collected:

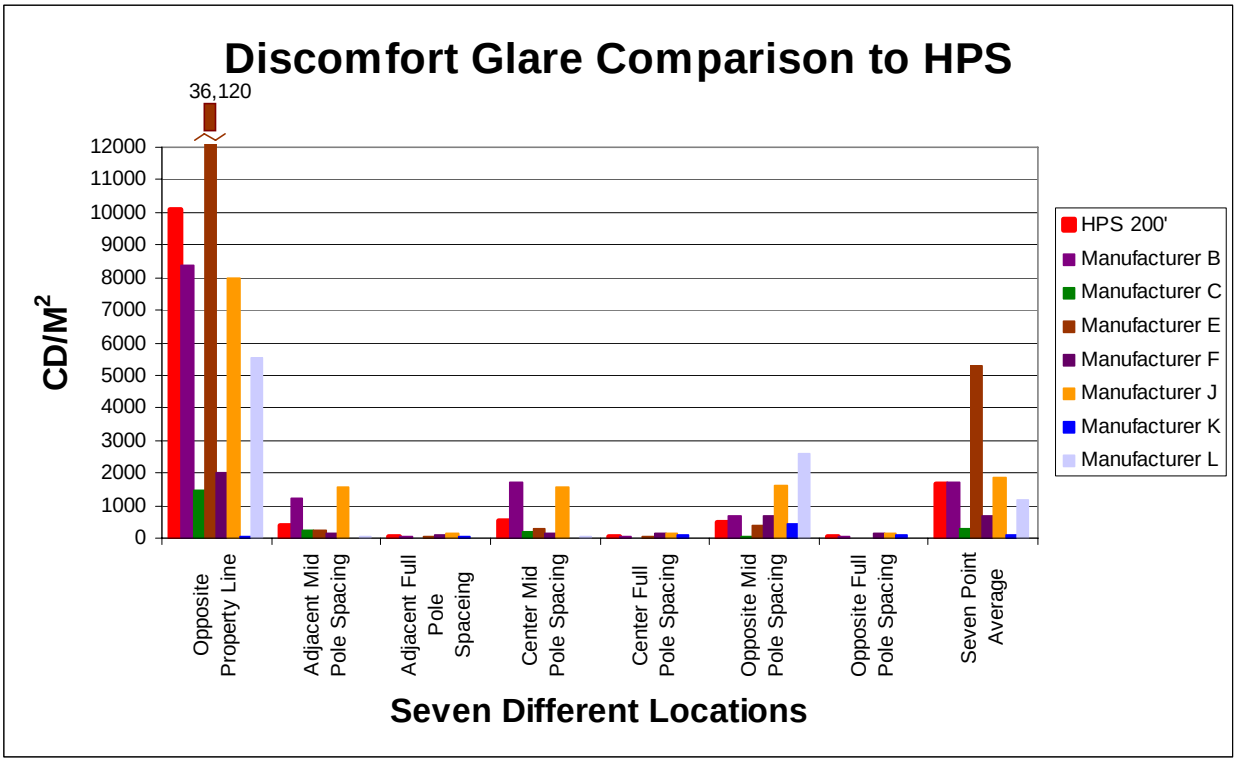


Figure 3.6: Discomfort Glare Measurements @ 200’ Spacing

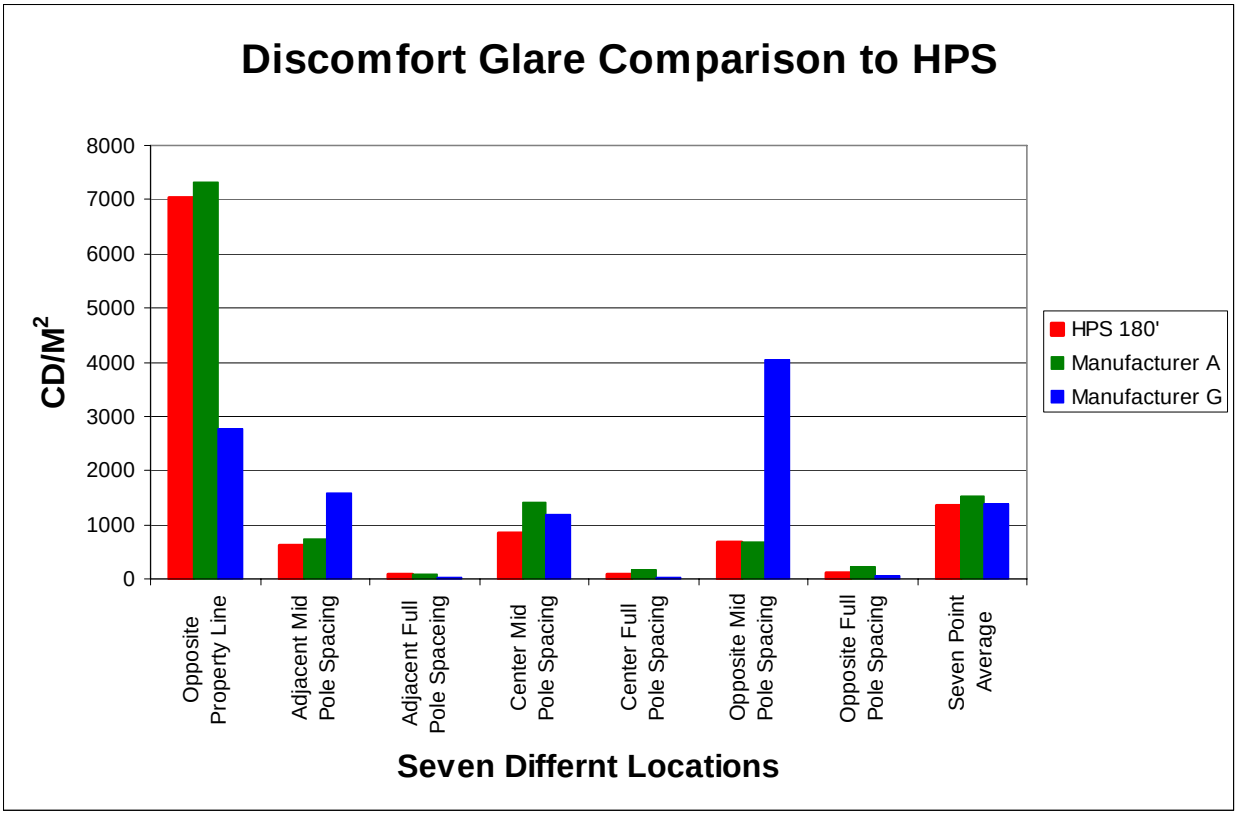


Figure 3.7: Discomfort Glare Measurements @ 180’ Spacing

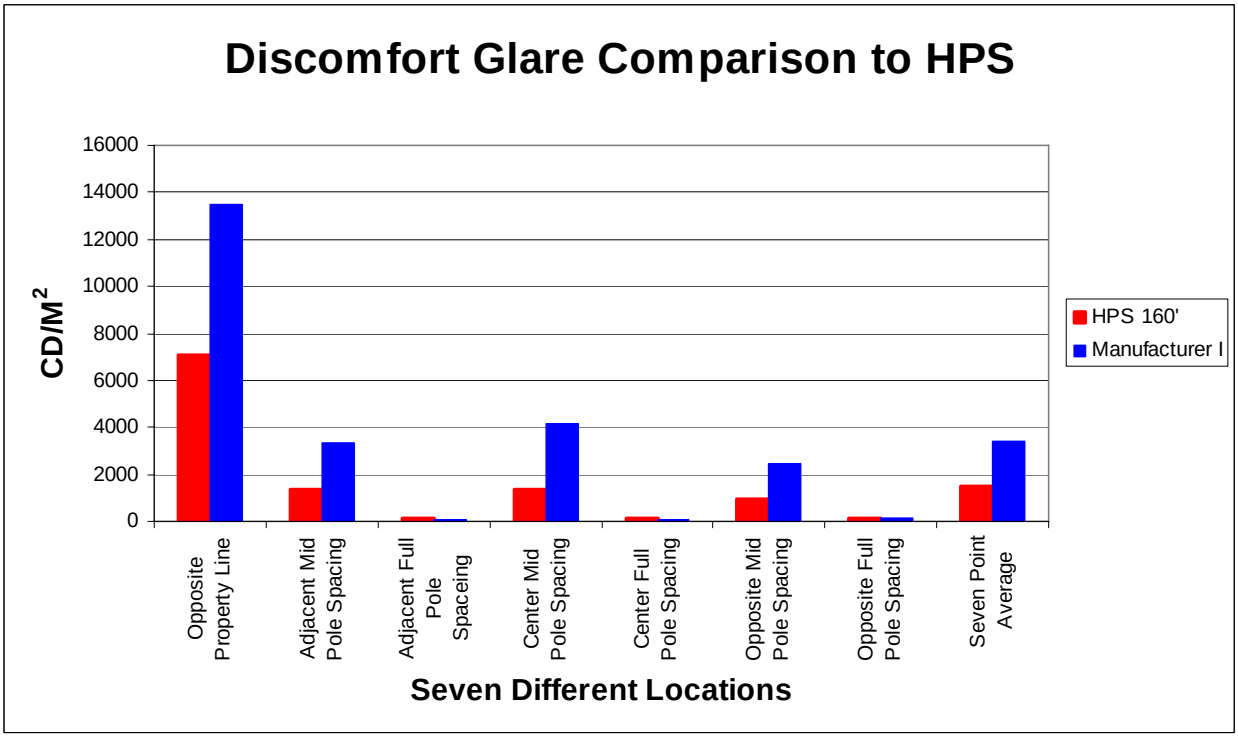


Figure 3.8: Discomfort Glare Measurements @ 160’ Spacing

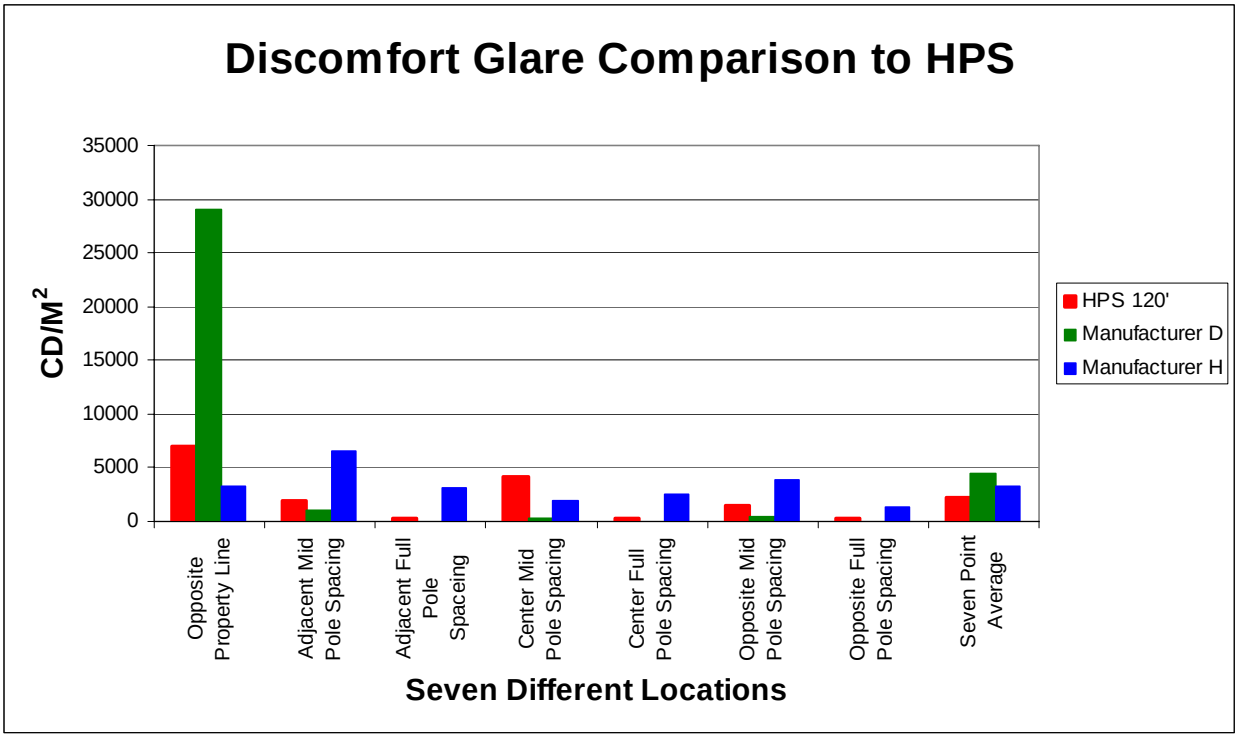


Figure 3.9: Discomfort Glare Measurements @ 120' Spacing

3.4 Evaluation in accordance with "LED Equipment Evaluation Rating Matrix" developed by BSL

The following categories were compiled to help differentiate each manufacture's performance and characteristics from each another. Each category was weighted individually based on relevance to our needs. Figure 3.10 shows the complete summary of the 13 categories with the weight included.

3.4.1 IES LM-79 compliance

3.4.1.1 The LED fixtures were evaluated based on their accordance with the definitions and standards set forth in IESNA LM-79. Standard methods of measurement

have been developed for luminous flux, electrical power, luminous intensity distribution, and chromaticity of solid-state lighting.

3.4.1.2

IES LM-79		
ACEJ	1	No IES files were submitted
DFGHKL	5	IES files submitted but LM-79 was not verified
BI	10	LM-79 Compliant

3.4.2 IES LM-80 compliance

3.4.2.1 The LED fixtures were evaluated based on their accordance with the definitions and standards set forth in IESNA LM-80. Standard procedures have been developed for determining lumen maintenance of LEDs and LED modules related to effective useful life of the product. (Does not apply to full luminaires.)

3.4.2.2

IES LM-80		
ALL	5	LM-80 Testing Incomplete
	10	LM-80 Compliant

3.4.3 Participation in DOE CALiPER testing program

3.4.3.1 DOE's SSL Commercially Available LED Product Evaluation and Reporting (CALiPER) program independently tests and provides unbiased information on the performance of commercially-available SSL products. CALiPER results were used to raise or lower the fixed score.

3.4.3.2

CALiPER									
1	2	3	4	5	6	7	8	9	10
Bad				N/A					Very Good
				ALL					

3.4.4 Energy Star certification

3.4.4.1 The Energy Star program for SSL establishes the industry wide criteria that manufactures can use to promote qualifying products. The fixtures were evaluated based on whether or not it has received Energy Star certification. If there is no certification, score will be based on how many of the Energy Star requirements are met by the unit.

3.4.4.2

Energy Star									
1	2	3	4	5	6	7	8	9	10
Bad				N/A					Very Good
				ALL					

3.4.5 Build Quality Evaluation

3.4.5.1 Fixtures were visually inspected by BSL engineers. Factors included material durability, quality manufacturing, weather proofing, etc.

3.4.5.2

Build Quality									
1	2	3	4	5	6	7	8	9	10
Bad									Very Good
		G	C	D	EFH KL	A	B	IJ	

3.4.6 Maintenance/Life Evaluation

3.4.6.1 Fixtures were scored based on manufacture's projected useful life. The end of useful life is generally considered to be when the fixture reaches 30% lumen depreciation.

3.4.6.2

Fixture Maintenance/Life (Hours)									
1	2	3	4	5	6	7	8	9	10
10k	20k	30k	40k	50k	60k	70k	80k	90k	100k
			A	B-L					

3.4.7 Ease of Installation Evaluation

3.4.7.1 Fixtures were evaluated based on effort and time needed for installation. Electrician field notes were considered.

3.4.7.2

Ease of Installation									
1	2	3	4	5	6	7	8	9	10
Bad									Very Good
J	EF	AD GL		HK			BCI		

3.4.8 Illuminance Evaluation

3.4.8.1 The illumination levels of the new fixtures were compared to the illumination levels of a typical 100W high pressure sodium fixture. The numbers used were an average of both roadway and sidewalk readings from an identical grid.

3.4.8.2

Illuminance									
1	2	3	4	5	6	7	8	9	10
30%	40%	50%	60%	70%	80%	90%	HPS*	110%	120%
	AH		K	J	DFG	EI	BCL		

*measured HPS illuminance = .33 fc @ 200' pole spacing
*measured HPS illuminance = .37 fc @ 180' pole spacing
*measured HPS illuminance = .41 fc @ 160' pole spacing
*measured HPS illuminance = .52 fc @ 120' pole spacing

3.4.9 Uniformity Ratio Evaluation (Ave/Min)

3.4.9.1 The uniformity ratio score of the new fixtures were based on the luminaires ability to meet minimum IES uniformity standards at various distances from the pole.

i.e. a score of 1 represents a failure to maintain a 6:1 ave/min ratio for < 50'

i.e. a score of 10 represents a fixture that maintains a 6:1 ave/min ratio for 100'

3.4.9.2

Uniformity Ratio									
1	2	3	4	5	6	7	8	9	10
<50									100
CG HL		DK		AE FJ		I	B*		

*****Type II fixture achieved a score of 9

3.4.10 Luminance Evaluation

3.4.10.1 The luminance levels of the new fixtures were compared to the luminance levels of a typical 100W high pressure sodium fixture. The numbers used were an average of roadway readings from an identical grid.

3.4.10.2

Luminance									
1	2	3	4	5	6	7	8	9	10
50%	60%	70%	80%	90%	HPS*	110%	120%	130%	140%
		L	CK	A	GIJ	D	BF	E	

*measured HPS luminance = .252 cd/m^2 @ 200' pole spacing
*measured HPS luminance = .265 cd/m^2 @ 180' pole spacing
*measured HPS luminance = .281 cd/m^2 @ 160' pole spacing
*measured HPS luminance = .359 cd/m^2 @ 120' pole spacing

3.4.11 Power Saving Evaluation

3.4.11.1 Fixtures were evaluated based on energy savings when compared to a typical 100W (Nominal 138 W) high pressure sodium fixture.

3.4.11.2

Power Saving									
1	2	3	4	5	6	7	8	9	10
10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
			DEL	BCF GIK	AJ	H			

3.4.12 Discomfort Glare Evaluation

3.4.12.1 Fixtures were evaluated based on discomfort glare when compared to a typical 100W high pressure sodium fixture. The discomfort glare was measured from seven points determined to be most critical. The average of the seven readings was used for comparison.

3.4.12.2

Discomfort Glare									
1	2	3	4	5	6	7	8	9	10
200%	180%	160%	140%	120%	HPS*	80%	60%	40%	20%
DEI			H	A	BJ	GL		F	KC

*measured HPS discomfort glare = 1656 cd/m^2 @ 200’ pole spacing
*measured HPS discomfort glare = 1356 cd/m^2 @ 180’ pole spacing
*measured HPS discomfort glare = 1520 cd/m^2 @ 160’ pole spacing
*measured HPS discomfort glare = 2221 cd/m^2 @ 120’ pole spacing

3.4.13 Warranty Evaluation

3.4.13.1 Fixtures were evaluated based on the warranty provided by the manufacturer. An average of the LED, driver, and housing warranties was used for comparison.

3.4.13.2

Warranty									
1	2	3	4	5	6	7	8	9	10
1 Yr	2 Yrs	3 Yrs	4 Yrs	5 Yrs	6 Yrs	7 Yrs	8 Yrs	9 Yrs	10 Yrs
	E			CDF GIJK	B	L			A

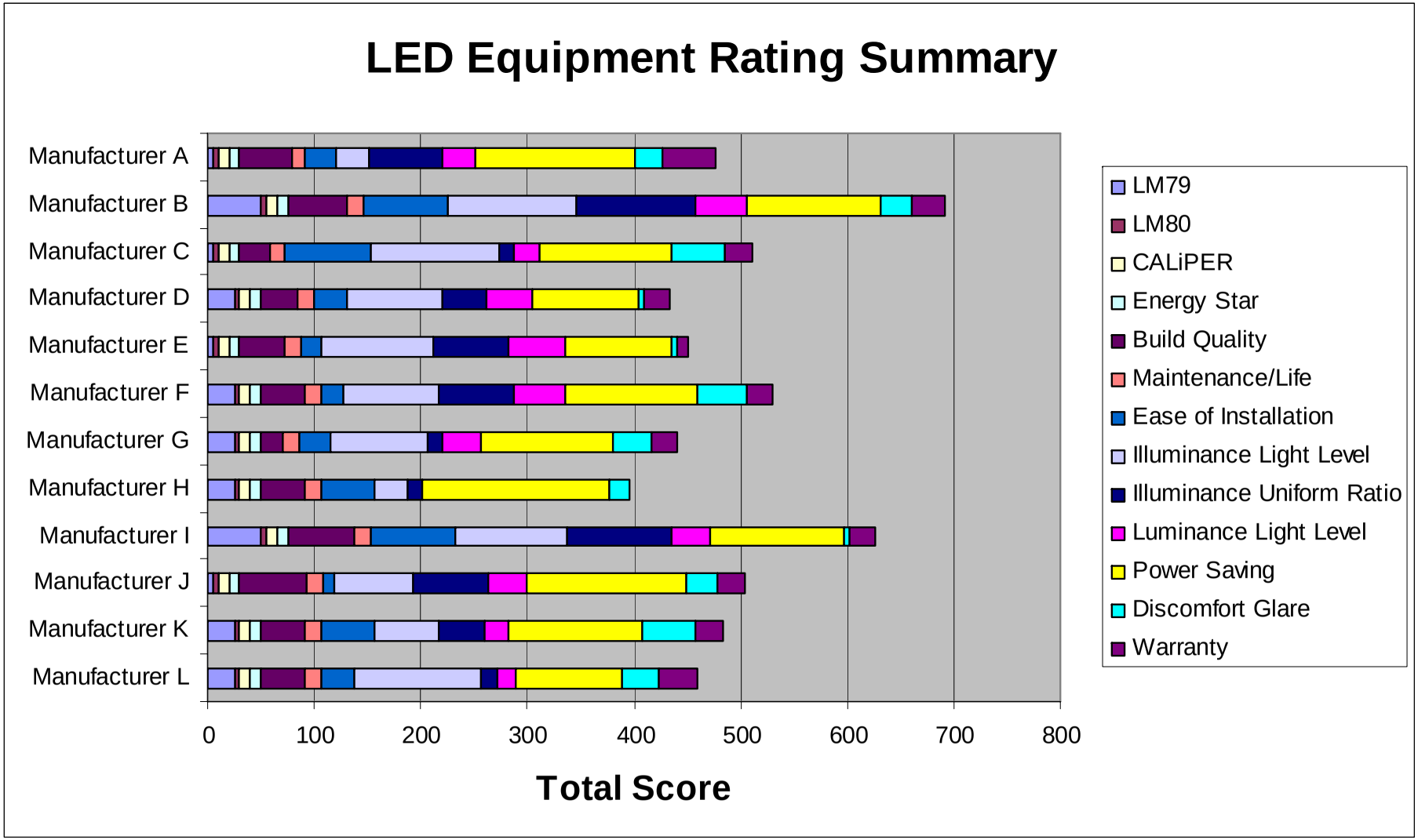


Figure 3.10: LED Equipment Rating Summary

Section 4

Public Comments

4.1 Evaluation Method:

In order to seek public comment, the Bureau of Street Lighting sent an LED street lighting survey to approximately 700 residents in the pilot project area. The survey consisted of 10 questions that included issues of pedestrian and motorist safety, glare, and aesthetics. The comments were tabulated and used to help evaluate specific streetlight equipment.

4.2 Summary of Comments Collected

A total of 94 surveys were returned by residents. Collectively, the following chart shows some of the survey responses for an overall public perception of LED luminaires.

All LED Public Perception Summary	
Question	**% of Resident response**
Improved or not improved driver visibility	59% “strongly improved” 16% “somewhat improved” 10% “somewhat not improved” 13% “strongly not improved” 2% no answer
Created more or fewer dark spots	39% “far fewer” 29% “somewhat fever” 12% “somewhat more” 12% “many more” 8% no answer
Right amount of light, too bright, too dim	64% “right amount of light” 8% “too bright” 23% “too dim” 4% no answer
Streetlight preference, new or old	59% “strongly prefer new” 10% “somewhat prefer new” 6% “somewhat prefer old” 21% “strongly prefer old” 3% no answer

Table 4.1: Public Perception Summary

Section 5

General Comments and Observations

The solid-state lighting industry is evolving rapidly. It became clear at the very start of our pilot project that there was a lack of industry standards regarding LED lighting performance and testing procedures. It also became clear that due to a lack of standards we would have to evaluate a wide variety of fixtures and subject those fixtures to a wide variety of tests. The following comments and observations are meant as an overview of our experience throughout this process.

First, due to the speed at which new products are being developed and shipped to market, it was sometimes difficult to access whether a piece of equipment that was submitted for testing, was in fact, a commercially available unit. In a least one case, a prototype unit was submitted. In another case, the equipment was physically altered after leaving the assembly line, in order to meet our specifications. Even the most advanced manufacturers sometimes had difficulty keeping catalogue numbers current as LEDs and driver technology changed. These issues should resolve themselves over time as the industry matures and stabilizes.

Every new street lighting fixture that is introduced into our system is evaluated from a mechanical standpoint. The new LED fixtures are being manufactured in several different countries by companies both large and small. There was a wide variation in quality control from company to company. Our widest variations were in consistency of housing castings and finishes. There were also issues of loose glass and poorly engineered fasteners. We found that some manufacturers had spent far more resources developing a fixture that could be produced in high

volume with consistent results. Also, we found that manufacturers took several different design approaches regarding maintenance. Some manufacturers assumed that no maintenance would be done in the field. Because of this, drivers were inaccessible or required substantial labor to remove. Because both dimming and communication technology are still evolving, we determined that it was essential to have the ability to remove and replace the LED driver if necessary. In addition, the optical systems varied widely from fixture to fixture. While some made use of surface mounted LEDS with individual optical refractors, others used recessed optical systems and a glass or polycarbonate lens. We found that both design approaches have potential, however issues of glare and durability were of concern, and should be reviewed on a case by case basis.

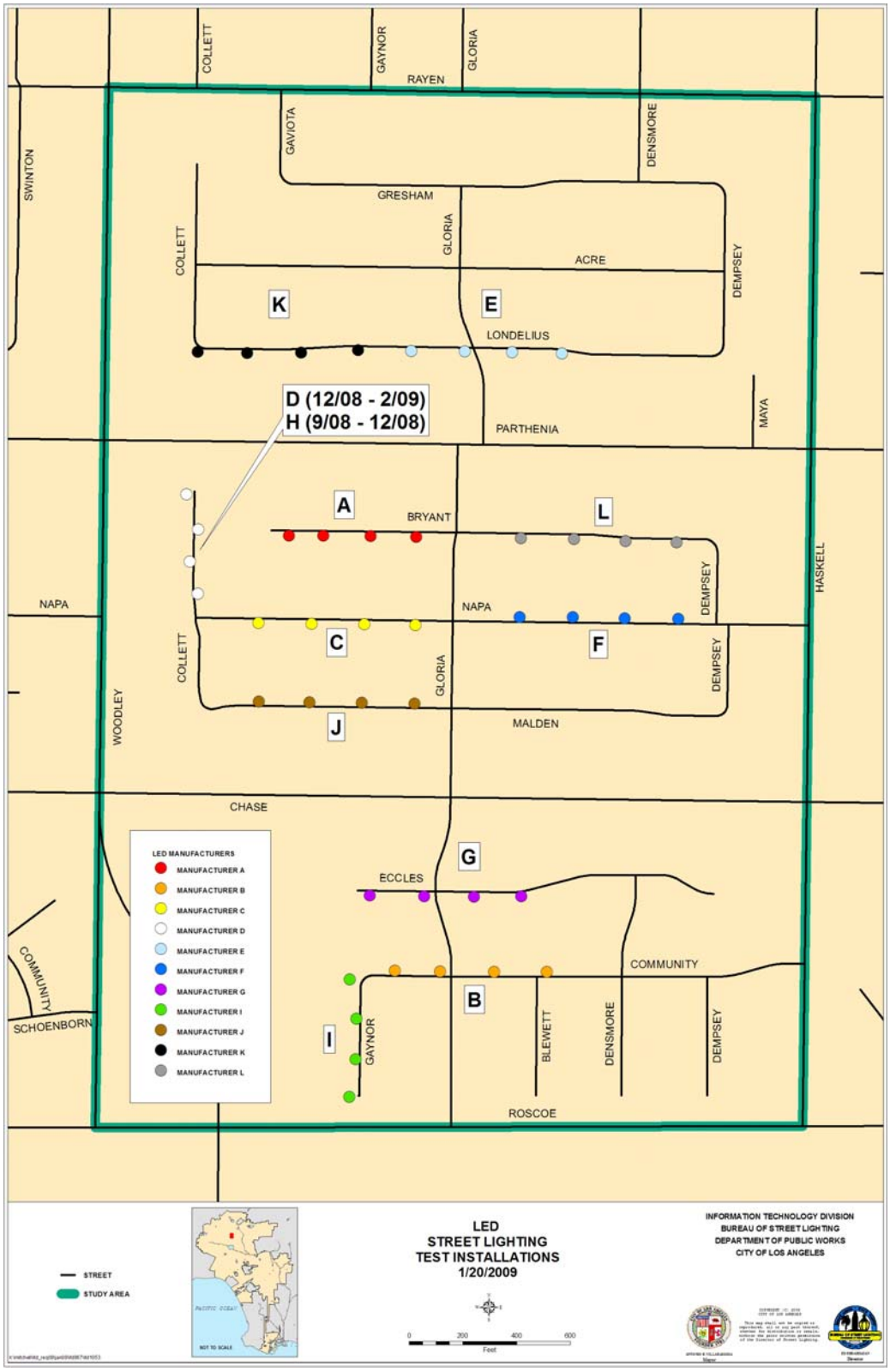
From an electrical and power standpoint, the LED equipment has, so far, exceeded our expectations. With the exception of several units that were not yet in full production, reliability has been very good. Our pilot project hoped to identify viable LED streetlights that would provide 40% energy savings when compared to our standard 100WHPS cobra-head fixture. Test units provided energy saving from approximately 35% to 65%. We expect those numbers to climb as new technology is introduced in the next two years. Overall, power factors were very good, with several units approaching .98. However, harmonic distortion was higher than expected on several units.

From a lighting standpoint, we have no doubt that LED technology, when incorporated into the right fixture, is suitable for a residential street lighting application. Several of our test units, dramatically improved lighting uniformity even at pole spacing greater than 180'. However, several units had poor optical systems and did not accurately produce a type III distribution pattern. This resulted in unacceptable dark areas on both the street and the sidewalk.

In general, the white light was well received by the residents. Although most manufacturers submitted test units with a correlated color temperature between 5500K-6000K, we found that this temperature produced a bluish light that was distracting to some people. As a result, we have specified a warmer correlated color temperature in the 4300K range. Specifying a warmer color temperature meant conceding a small portion of our energy savings; however we felt that the cost was justifiable, and that we would still easily surpass our goals for energy savings. Because the white light appears to be substantially brighter than the high pressure sodium source, more emphasis must be placed on choosing fixtures that minimize glare. The fixture design must allow for shielding, at least on the house side. By recognizing these potential issues, we should be able to reduce the number of complaints as a result of a citywide LED street lighting replacement program.

Appendix

6.1 LED Test location map:



6.2 Remote Monitoring System one week sample:

	Burn Hour Report for Los Angeles - City of Run Date: 04/08/2009 00:05:29 for April 2009																		
	Date Created	**Device ID**	**MacID**	**St #**	**Street Name**	**VoltageSystem**	**Latitude**	**Longitude**	**Lamp Wattage**	**Lamp Type**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Monthly Total**
Manufacturer G	12/11/2008		00161N000000C65F	15978	Eccles St	120	34.2237	-118.481	67	LED	**Hours**	9.53	9.77	9.5	9.49	9.47	9.46	9.46	66.68
											KWh	0.61	0.63	0.61	0.61	0.61	0.61	0.61	4.29
Manufacturer B	12/11/2008		00161N000000BED6	15967	Community St	120	34.2229	-118.48	74	LED	**Hours**	9.49	9.78	9.45	9.44	9.42	9.41	9.41	66.4
											KWh	0.71	0.74	0.71	0.71	0.7	0.7	0.7	4.97
Manufacturer I	12/11/2008		00161N000000C740	8309	Gaynor Ave	120	34.2217	-118.482	46	LED	**Hours**	9.56	9.79	9.52	9.53	9.51	9.5	9.5	66.91
											KWh	0.44	0.45	0.44	0.44	0.44	0.44	0.44	3.09
Manufacturer J	12/11/2008		00161N000000C862	16109	Malden St	120	34.2257	-118.483	63	LED	**Hours**	9.52	9.73	9.48	9.47	9.45	9.44	9.44	66.53
											KWh	0.59	0.6	0.59	0.6	0.59	0.59	0.59	4.15
Manufacturer C	12/11/2008		00161N000000BCDB	16030	Napa St	120	34.2265	-118.481	70	LED	**Hours**	9.48	9.8	9.45	9.44	9.42	9.4	9.4	66.39
											KWh	0.68	0.7	0.68	0.67	0.67	0.67	0.67	4.74
Manufacturer A	12/11/2008		00161N000000C071	16174	Bryant St	120	34.2274	-118.483	62	LED	**Hours**	9.49	9.76	9.46	9.45	9.43	9.43	9.43	66.45
											KWh	0.51	0.52	0.5	0.49	0.5	0.51	0.51	3.54
Manufacturer E	1/15/2009		00161N000000C597	16122	Londelius St	120	34.2293	-118.483	90	LED	**Hours**	9.54	9.78	9.51	9.5	9.48	9.47	9.47	66.75
											KWh	0.87	0.89	0.86	0.86	0.86	0.86	0.86	6.06
Manufacturer D	2/3/2009		00161N0000015190	8616	Collett Ave	120	34.2268	-118.484	72	LED	**Hours**	9.59	9.89	9.56	9.55	9.53	7.52	7.52	63.16
											KWh	0.74	0.78	0.74	0.74	0.73	0.57	0.57	4.87
Manufacturer K	2/25/2009		00161N0000015197	15930	Londelius St	120	34.2293	-118.48	73	LED	**Hours**	9.55	9.79	8.52	9.51	9.5	9.48	9.48	65.83
											KWh	0.71	0.73	0.63	0.7	0.7	0.7	0.7	4.87

6.3 Sample Field Readings:

Illumination Readings

Equipment: LED Test Unit
Location: Pilot Project Test Site

Mounting Height: 26.75'
Date: Dec 10 2008

Photopic Footcandles

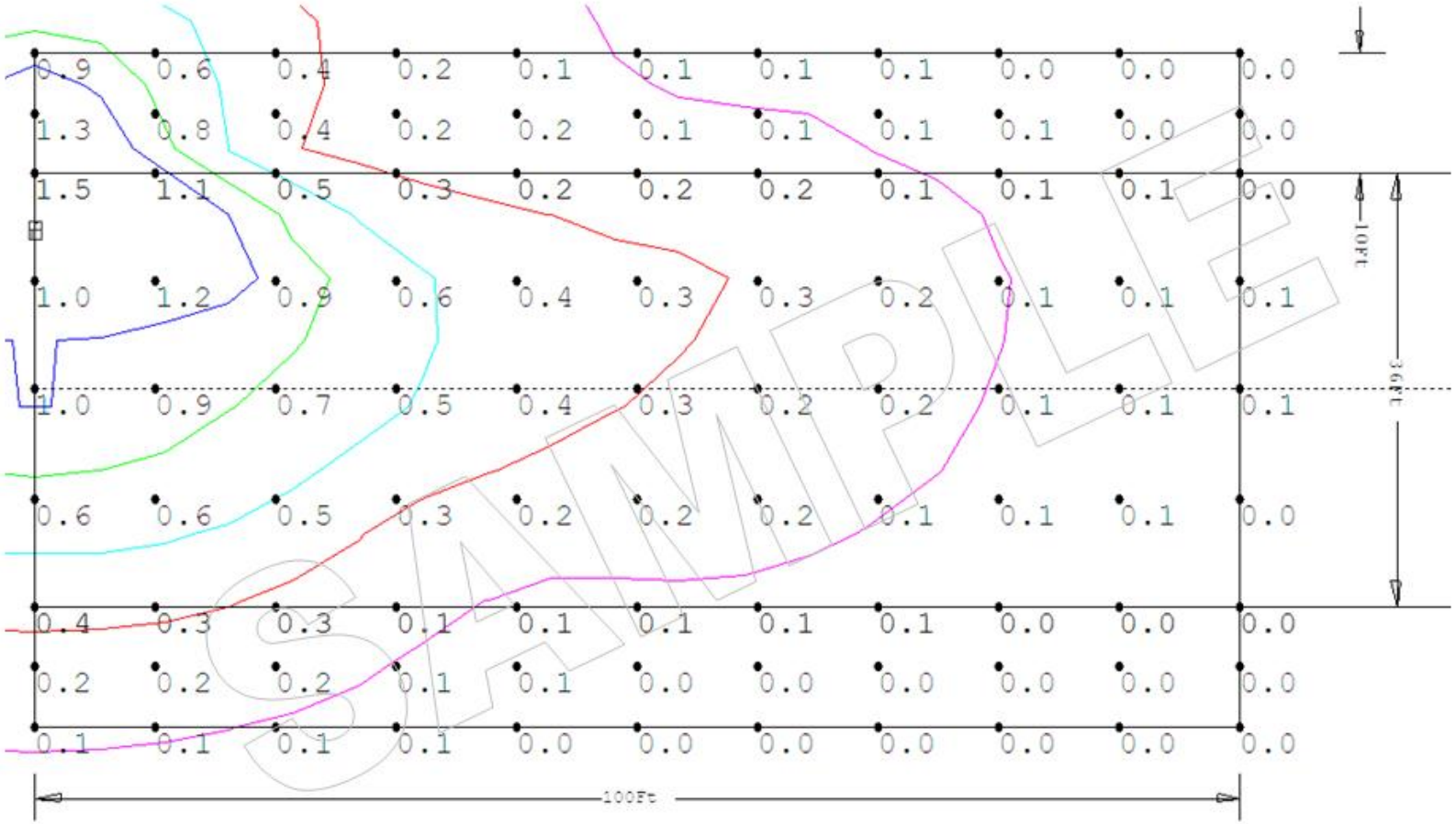
Field Conditions: Full moon, clear skies

minor tree interference

ambient light from porches

	ft	0	10	20	30	40	50	60	70	80	90	100
Side	-10	1.02	0.74	0.46	0.28	0.19	0.09	0.09	0.09	0.00	0.00	0.00
Walk	-5	1.39	0.83	0.46	0.28	0.19	0.09	0.09	0.09	0.00	0.00	0.00
	0	1.67	1.57	0.74	0.37	0.28	0.28	0.19	0.19	0.09	0.09	0.09
	9	1.39	1.30	1.02	0.65	0.46	0.37	0.28	0.19	0.09	0.09	0.00
	18	1.30	1.02	0.74	0.56	0.46	0.37	0.28	0.19	0.09	0.09	0.09
	27	0.65	0.65	0.56	0.28	0.19	0.19	0.19	0.09	0.09	0.09	0.00
	36	0.37	0.37	0.28	0.19	0.09	0.09	0.09	0.09	0.09	0.09	0.00
Side	41	0.19	0.19	0.09	0.09	0.00	0.00	0.00	0.00	0.09	0.00	0.00
Walk	46	0.09	0.09	0.09	0.09	0.09	0.09	0.00	0.00	0.00	0.00	0.00

6.4 Sample Computer Printout:



Sidewalk Near	Roadway	Sidewalk Far
Illuminance Values (Fc)	Illuminance Values (Fc)	Illuminance Values (Fc)
Average =0.33	Average =0.31	Average =0.10
Maximum =1.5	Maximum =1.5	Maximum =0.4
Minimum =0.0	Minimum =0.0	Minimum =0.0
Avg/Min Ratio=0.00	Avg/Min Ratio=0.00	Avg/Min Ratio=0.00