

# LED Equipment Evaluation

## PHASE V: 100W HPS Equivalent



Prepared by:  
Bureau of Street Lighting  
City of Los Angeles

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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.

Date of test: 2/28/2011 to 9/14/2011

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## **Introduction**

### ***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.

As a result, 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.

### ***Purpose of the Report***

During this phase of testing there were five manufacturers who submitted products which passed our preliminary review. Those products were then given a complete evaluation to determine if it can be used to replace a 100W HPS cobra-head luminaire on a local residential street. The fixture was 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. The results of these evaluations are presented in this report and will be a major factor in determining whether BSL will use this fixture in future street lighting projects.

Manufacturer A



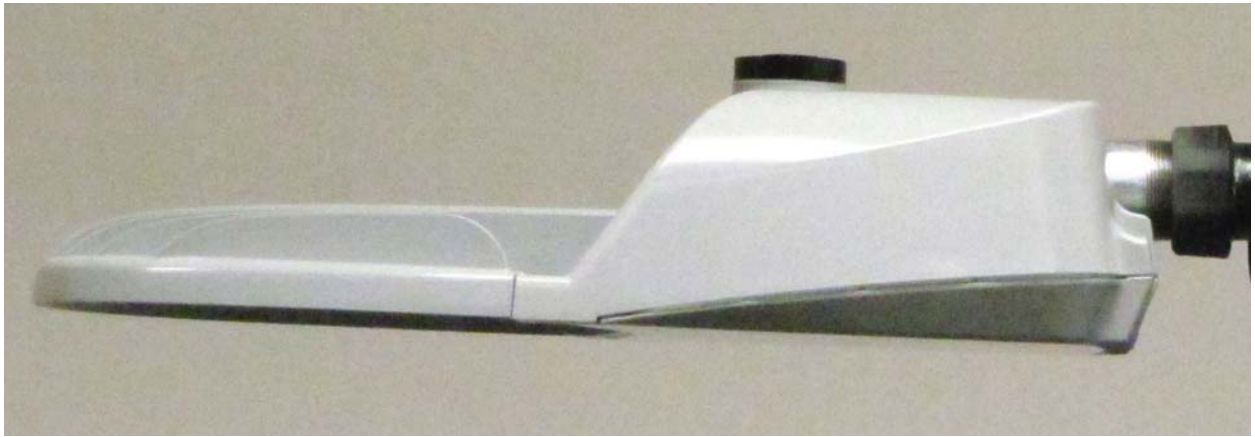
Manufacturer B



Manufacturer C



Manufacturer D



Manufacturer E



## **Section 1: Luminaire Testing and Evaluation**

### ***1.1 Mechanical Build Quality***

#### **Evaluation Method**

The fixture was visually inspected by BSL engineers. Criteria included material durability, quality manufacturing, weather proofing, etc.

The mechanical evaluation of this unit was based on luminaire mechanical requirements specified on page 40 of Special Specifications for the Construction of Street Lighting Systems (“The Blue Book”), as well as, criteria developed by BSL specifically for LED luminaires.

#### **Evaluation Conditions**

The evaluation was carried out in a controlled lab environment.

#### **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”.

<p><b>Luminaire must be clearly labeled with the full catalog number in accordance with ANSI C136.22.</b></p>
---

**Passed: A, B, D, E**

**Failed: C**

**There shall be no sharp edges or corners near serviceable parts.**

**Passed: C, D, E**

**Failed: A - Driver mount very sharp**

**B - Sharp near latch**

**All access doors shall have the ability to remain in a fully open position during maintenance without manual assistance.**

**Passed: ALL**

**Failed: NONE**

**All components shall be securely fastened so it will not become a dropping hazard.**

**Passed: ALL**

**Failed: NONE**

**Drivers shall be easily assessable and removable for ease of maintenance. "Quick Disconnects" are required.**

**Passed: D, E**

**Failed: A, B, C - Quick Disconnects there, but needs screwdriver to remove driver**

**All solid-state electronic components shall be sealed to IP 66. This may be accomplished either through component or luminaire housing design.**

**Passed: ALL**

**Failed: NONE**

**All capacitors must have a minimum temperature rating of 90 degrees Celsius.**

*N/A: No capacitors outside sealed driver*

**All internal wiring shall be rated for 105 C and routed away from heat generating components of the driver assembly and LED panels. Wire shall not interfere with light distribution.**

**Passed: A, C, D, E**

**Failed: B - Wires touching heat sink**

**Neither housing nor lens shall be constructed with poly carbonate/plastic that will discolor over time.**

**Passed: ALL**

**Failed: NONE**

**All access doors shall have rubber (non-foam) gaskets. Gaskets shall be securely fastened.**

*N/A: No gasket necessary since door is for access to driver which is fully sealed*

**Adhesive compounds shall not degrade when subjected to normal operating temperatures.**

**Passed: ALL**

**Failed: NONE**

**Optical assemblies that can be installed in different positions shall be labeled so that field crews do not need supplemental instructions.**

*N/A: All units can not be changed*

**The reflector shall be sturdy and not easily bent.**

*N/A: No units have a reflector*

**Screws on the luminaire housing shall be captive and all the same type.**

**Passed: B, C, D, E**

**Failed: A - Tool less entry, but driver screws not captive**

<b>Mechanical Build Quality Score</b>									
1	2	3	4	5	6	7	8	9	10
Bad									Very Good
					B	A	C, E	D	

## ***1.2 Electrical Build Quality***

### **Evaluation Method**

The electrical evaluation of this unit was based on a test procedure developed by EED/BSL.

### **Evaluation Conditions**

The evaluation was carried out in a controlled lab environment.

Ambient temperature: 25°C

### **Evaluation Summary**

**Input voltage 120 VAC, 50-60 HZ**

*Passed (ALL)*



**Power factor: >0.9**

*Passed (ALL)*

**Total harmonic distortion: <15%**

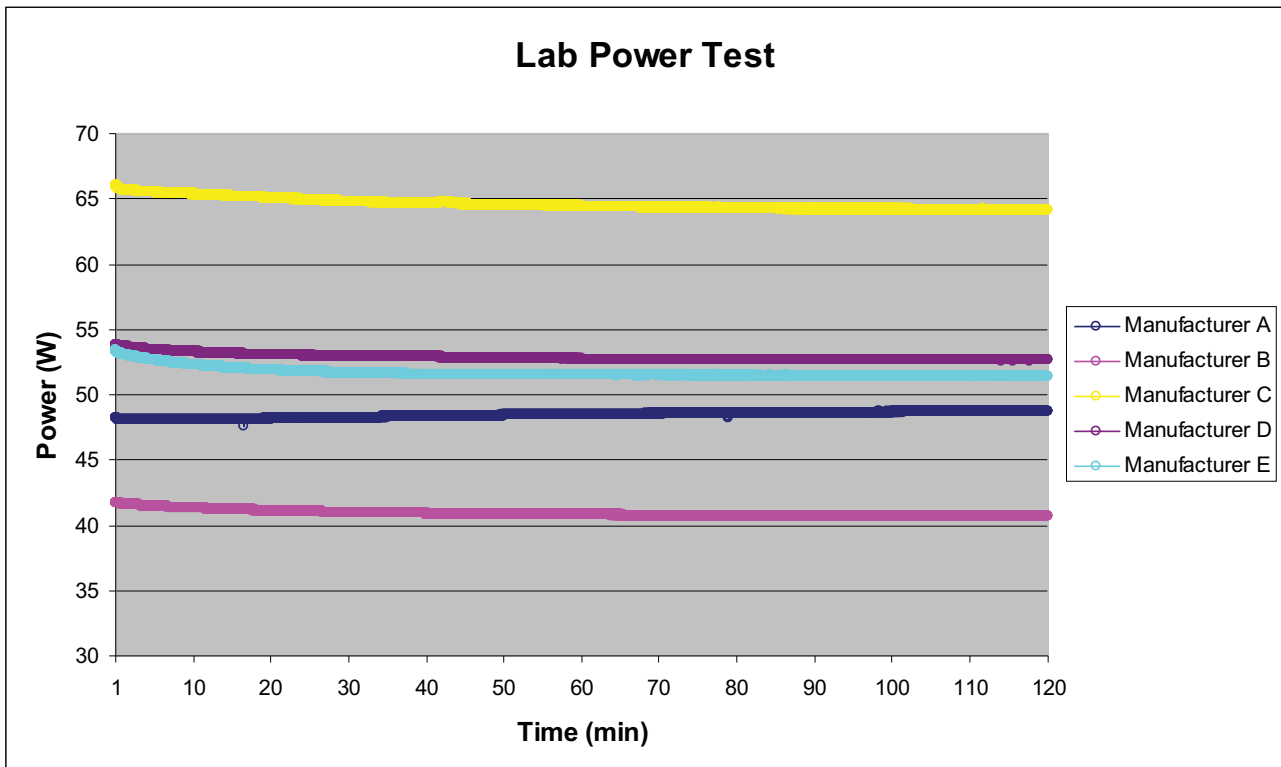
*Passed (ALL)*

**Rated (lamp/LED) life in hours: 50,000**

*Passed based on manufacturer's claims/warranty (ALL)*

**Power consumption:**

*The power was measured for approximately 2 hours in our lab until it was determined that the test unit's power consumption had steadied (shown below). The fixtures were then moved to standard street lighting pole on a residential street. Power readings were taken daily with the use of a Remote Monitoring System (RMS). The RMS readings showed the luminaire continued to function normally for its duration at the test site. (Manufacturer C was measured in the lab at a higher wattage and then dimmed in the field for illumination measurements.)*



Electrical Build Quality Score									
1	2	3	4	5	6	7	8	9	10
Bad									Very Good
						B	A,E	C, D	

### ***1.3 Maintenance and Life Expectancy***

#### **Evaluation Method**

The fixture was 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.

#### **Evaluation Conditions**

N/A

#### **Evaluation Summary**

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

### ***1.4 Ease of Installation***

#### **Evaluation Method**

The fixture was scored on a scale 1 to 10 based on time and effort needed for installation. Electrician field notes were considered.

#### **Evaluation Conditions**

The evaluation was carried out in the lab as well as the uncontrolled field site.

#### **Evaluation Summary**

<b>Ease of Installation</b>									
1	2	3	4	5	6	7	8	9	10
Difficult									Easy
				B	A		C, D	E	

### ***1.5 Driver Controls***

#### **Evaluation Method**

The fixture was scored on a scale of 1 to 10 as to driver control functionality. The ability to easily adjust operating current would be considered most desirable.

#### **Evaluation Conditions**

The evaluation was carried out in a controlled lab environment.

#### **Evaluation Summary**

<b>Driver Controls</b>									
1	2	3	4	5	6	7	8	9	10
Difficult									Easy
B							D, E	A	C

### ***1.6 Driver Access***

#### **Evaluation Method**

The fixture was scored on a scale of 1 to 10 as to ease of driver access.

#### **Evaluation Conditions**

The evaluation was carried out in a controlled lab environment.

#### **Evaluation Summary**

<b>Driver Access</b>									
1	2	3	4	5	6	7	8	9	10
Difficult									Easy
								C	A, B, D, E

### ***1.7 Illuminance Light Level (Street)***

#### **Evaluation Method**

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing typical 100WHPS streetlight installed in the City of Los Angeles.

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 70 feet
- Roadway – 7.5 foot increments perpendicular to curb for 30 feet

Illumination readings were recorded using a Solar Light SL-3101 scotopic/photopic meter. Scotopic readings were taken for possible use in the future to calculate S/P ratios.

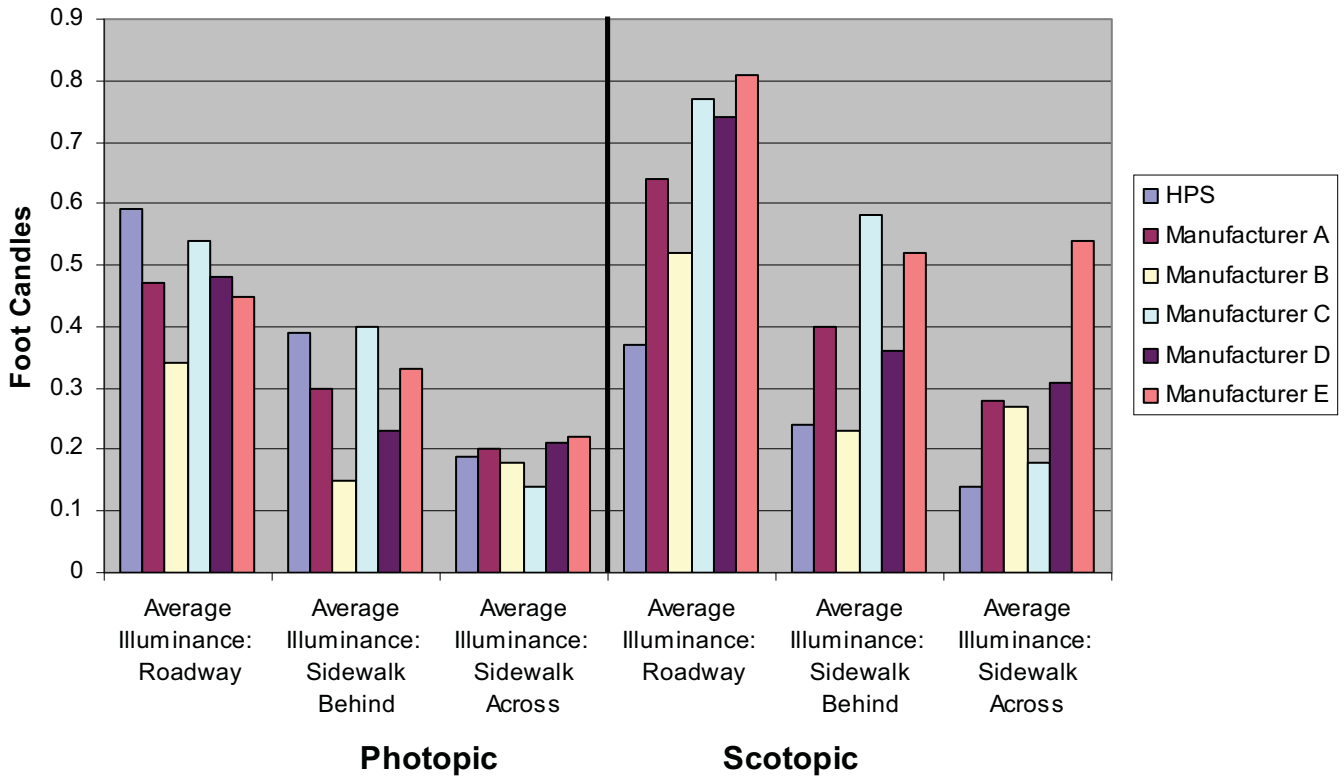
### **Evaluation Conditions**

The illumination readings were taken between May 24<sup>th</sup> 2011 and September 14<sup>th</sup> 2011. The readings were taken at our test site location (see map and pictures in appendix). Field conditions fairly similar each night. The street was open to traffic, and there was some minor ambient light pollution from private property.

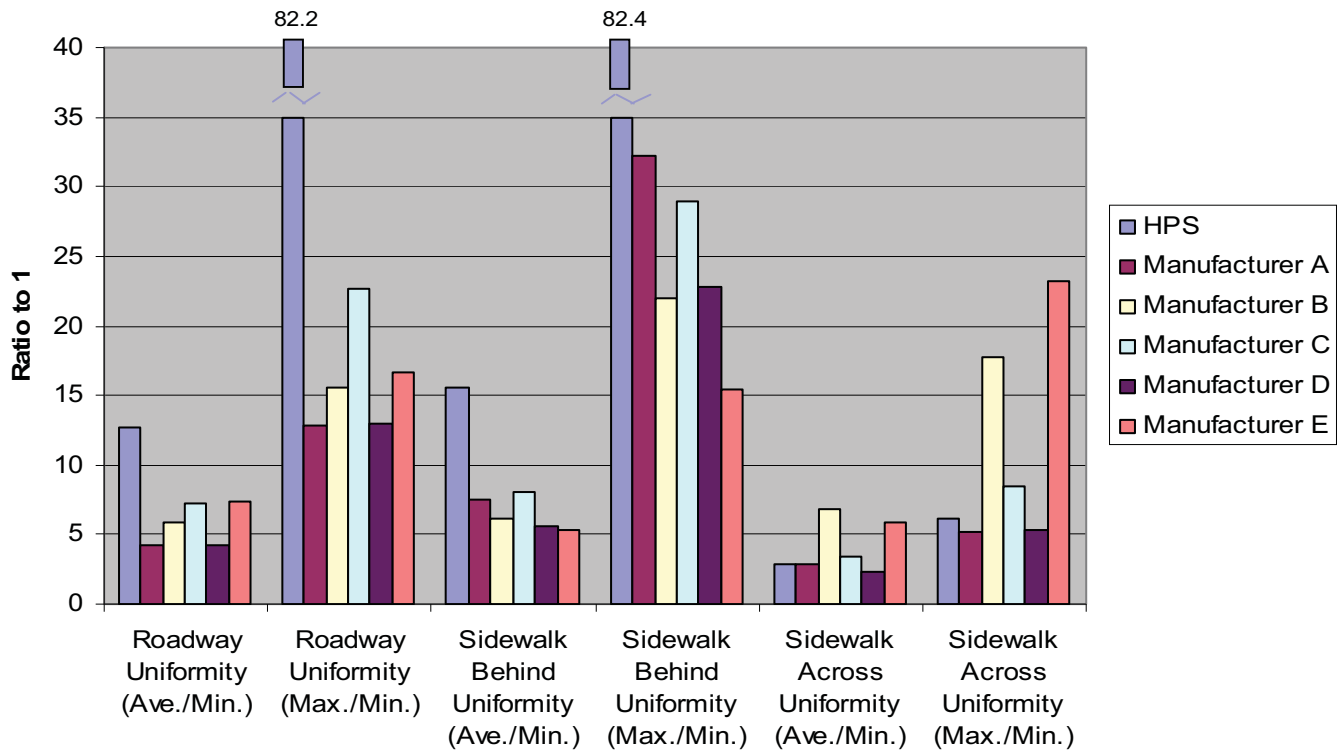
### **Evaluation Summary**

<b>Illuminance Light Level (Street)</b>									
0	0	0	4	5	6	7	8	9	10
		<60%	60%	70%	80%	90%	HPS	110%	120%
		B		E	A, D	C			

## Photopic/Scotopic Illumination



## Photopic Uniformity



### ***1.8 Illuminance Uniformity Ratio (Street)***

#### **Evaluation Method**

This fixture was scored on a scale from 1 to 10 based on how uniform the illumination was.

An average to minimum uniformity ratio of  $\leq 3:1$  would receive a 10.

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

Grid Characteristics:

(Same as illumination grid 1.7)

#### **Evaluation Conditions**

(Same as evaluation conditions for 1.7)

#### **Evaluation Summary**

<b>Illuminance Uniformity Ratio (Street)</b>									
1	2	3	4	5	6	7	8	9	10
$\geq 12:1$	11:1	10:1	9:1	8:1	7:1	6:1	5:1	4:1	$\leq 3:1$
					C	B, E	A, D		

### ***1.9 Illuminance Light Level (Sidewalk Near)***

#### **Evaluation Method**

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing 100WHPS streetlight.

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

Grid Characteristics:

- Sidewalk – 10 foot increments parallel to curb for 70 feet

- Sidewalk – 7.5 foot increments perpendicular to curb for 15 feet

Illumination readings were recorded using a Solar Light SL-3101 scotopic/photopic meter.

Scotopic readings were taken for possible use in the future to calculate S/P ratios.

**Evaluation Conditions**

(Same as evaluation conditions for 1.7)

**Evaluation Summary**

Illuminance Light Level (Sidewalk Near)									
0	0	3	4	5	6	7	8	9	10
	<50%	50%	60%	70%	80%	90%	HPS	110%	120%
	B		D	A, E			C		

**1.10 Illuminance Uniformity (Sidewalk Near)**

**Evaluation Method**

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing 100WHPS streetlight.

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

Grid Characteristics:

- Sidewalk – 10 foot increments parallel to curb for 70 feet
- Sidewalk – 7.5 foot increments perpendicular to curb for 15 feet

Illumination readings were recorded using a Solar Light SL-3101 scotopic/photopic meter.

Scotopic readings were taken for possible use in the future to calculate S/P ratios.

**Evaluation Conditions**

(Same as evaluation conditions for 1.7)

## Evaluation Summary

Illuminance Uniformity Ratio (Sidewalk Near)									
1	2	3	4	5	6	7	8	9	10
≥ 16:1	15:1	14:1	13:1	12:1	11:1	10:1	9:1	8:1	≤ 7:1
				A				C	B, D, E

### 1.11 Illuminance Light Level (Sidewalk Far)

#### Evaluation Method

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing 100WHPS streetlight.

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

Grid Characteristics:

- Sidewalk – 10 foot increments parallel to curb for 70 feet
- Sidewalk – 7.5 foot increments perpendicular to curb for 15 feet

Illumination readings were recorded using a Solar Light SL-3101 scotopic/photopic meter.

Scotopic readings were taken for possible use in the future to calculate S/P ratios.

#### Evaluation Conditions

(Same as evaluation conditions for 1.7)

#### Evaluation Summary

Illuminance Light Level (Sidewalk Far)									
0	0	3	4	5	6	7	8	9	10
	<50%	50%	60%	70%	80%	90%	HPS	110%	120%
				C		B	A	D	E



### ***1.12 Illuminance Uniformity Ratio (Sidewalk Far)***

#### **Evaluation Method**

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing 100WHPS streetlight.

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

Grid Characteristics:

- Sidewalk – 10 foot increments parallel to curb for 70 feet
- Sidewalk – 7.5 foot increments perpendicular to curb for 15 feet

Illumination readings were recorded using a Solar Light SL-3101 scotopic/photopic meter.

Scotopic readings were taken for possible use in the future to calculate S/P ratios.

#### **Evaluation Conditions**

(Same as evaluation conditions for 1.7)

#### **Evaluation Summary**

<b>Illuminance Uniformity Ratio (Sidewalk Far)</b>									
1	2	3	4	5	6	7	8	9	10
≥ 16:1	15:1	14:1	13:1	12:1	11:1	10:1	9:1	8:1	≤ 7:1
									ALL

### ***1.13 Photometric Data Reliability***

#### **Evaluation Method**

The LED fixture field measurements were compared to the LM-79 compliant IES photometric file. A score was based on how accurate a computer model can be designed to match our field readings.

### Evaluation Conditions

The evaluation was carried out in a controlled lab environment and an uncontrolled field environment.

### Evaluation Summary

LM-79 and Photometric Data (% Difference Files Vs. Field)									
0	1.5	2	3	4.5	5	6	7.5	9	10
No Files	>25%		20-25%	15-20%		10-15%	5-10%		0%-5%
				B, E		A, D			C

## 1.14 Photometric Spacing Performance

### Evaluation Method

The fixture was scored on a scale of 1 to 10 based on predicted illumination performance at various pole spacings. LM-79 IES photometric files provided by the manufacturer were used to model performance.

### Evaluation Conditions

The evaluation was carried out in a controlled lab environment.

### Evaluation Summary

Photometric Spacing Performance									
0	0	0	4	5	6	7	8	9	10
150'	155'	160'	165'	170'	175'	180'	185'	190'	≥ 195'
			A	E	C				B, D

## 1.15 Light Trespass

### Evaluation Method

The fixture was scored on a scale of 1 to 10 based on the amount light trespass compared to the 100W HPS fixture. The readings were taken with a light meter along the property line

on both sides of the street. The meter was held vertically to take illuminance readings at approximately 5' from the ground. Readings were taken at 10' increments to correspond with the illumination grid readings.

### Evaluation Conditions

(Same as evaluation conditions for 1.7)

### Evaluation Summary

Light Trespass									
1	2	3	4	5	6	7	8	9	10
≥110%	HPS	90%	80%	70%	60%	50%	40%	30%	≤20%
					A, E	D		B, C	

## 1.16 Power Saving

### Evaluation Method

The fixture was scored on a scale of 5 to 10 based on power savings when compared to a 100W HPS fixture. A score of 10 would indicate a savings of over 65%. A power savings of less than 40% would result in a score of 0.

### Evaluation Conditions

The evaluation was based on official manufacturer specifications and verified in a controlled lab environment.

### Evaluation Summary

Power Savings									
0	0	0	0	5	6	7	8	9	10
			<40%	40-45%	45-50%	50-55%	55-60%	60-65%	>65%
								A, C, D, E	B

## 1.17 Discomfort Glare

### Evaluation Method

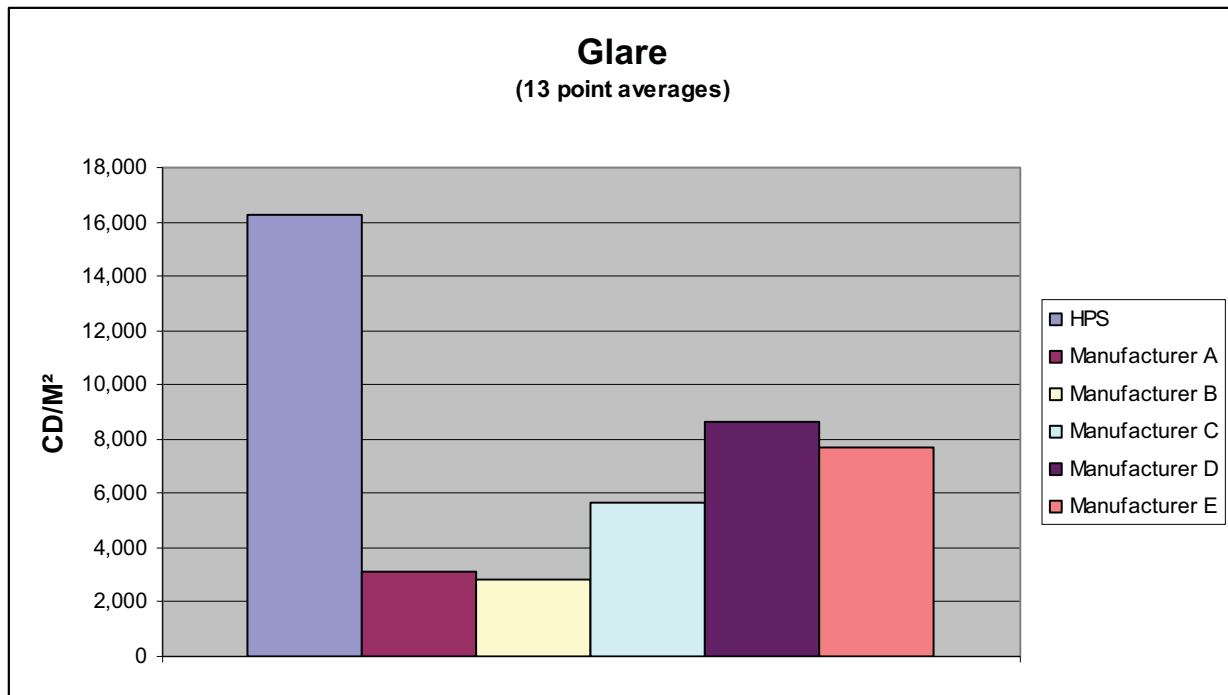
Light readings were taken from thirteen various locations where it was determined that glare sensitivity may exist and create a significant negative impact to drivers and pedestrians. Luminance readings were recorded using a Minolta Luminance Meter LS-100 at an average eye level, aimed at our target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

### Evaluation Conditions

(Same as evaluation conditions for 1.7)

### Evaluation Summary

Discomfort Glare									
1	2	3	4	5	6	7	8	9	10
200%	180%	160%	140%	120%	HPS	80%	60%	40%	20%
							D, E	C	A,B



### ***1.18 Light Patterns on Street***

#### **Evaluation Method**

The fixture was scored from a scale of 1 to 10 based on the existence and severity of any light pattern anomalies. A score of 10 would indicate no noticeable light patterns.

#### **Evaluation Condition**

The evaluation was carried out in an uncontrolled field environment.

#### **Evaluation Summary**

<b>Light Patterns</b>									
1	2	3	4	5	6	7	8	9	10
Distinct									None
									ALL

### ***1.19 Packaging***

#### **Evaluation Method**

This fixture was scored on a scale of 1 to 10 based on the quality of the packaging. In addition to protecting the fixture, the packaging must be easy to handle and have a minimal impact on the environment in order to achieve a high score.

#### **Evaluation Conditions**

The evaluation was carried out in a controlled lab environment.

#### **Evaluation Summary**

<b>Packaging</b>									
1	2	3	4	5	6	7	8	9	10
Excessive									Minimal
		B				A, C		D	E

## **Section 2: Conclusion**

### ***Conclusion***

The solid state industry of streetlights has advanced tremendously in the past couple years. Our last published testing phase was just over two years ago, and the positive advancements that we have seen in this short time with LED streetlights has been exceptional. As with every phase of testing that we have completed here, the products continue to surpass each other in performance; Phase V was no different.

The preliminary screening process used, narrowed our testing field down to five potential products. Based on photometric files and published documents, the five products were thought to meet the standards of the Bureau of Street Lighting. In order to verify we put the luminaires through a full evaluation.

The first evaluation was the mechanical review. Aesthetically, four of the five units were similar in design, low profile with an optical distribution lens over each LED. The fourth unit was much larger and rounder, similar to that of a semi-sphere. It had rows of LEDs with a single refractor covering each row. Only one of the five units passed all the mechanical questions, but it was determined that even though some of the products did not pass all the criteria, the issues of concern were easily fixable. For those reasons, all five units continued to our electrical and field testing. During our electrical testing it was noticed that this group of luminaires all used around 50W of power, with the exception of one unit that was closer to 41W. This is over 60% power

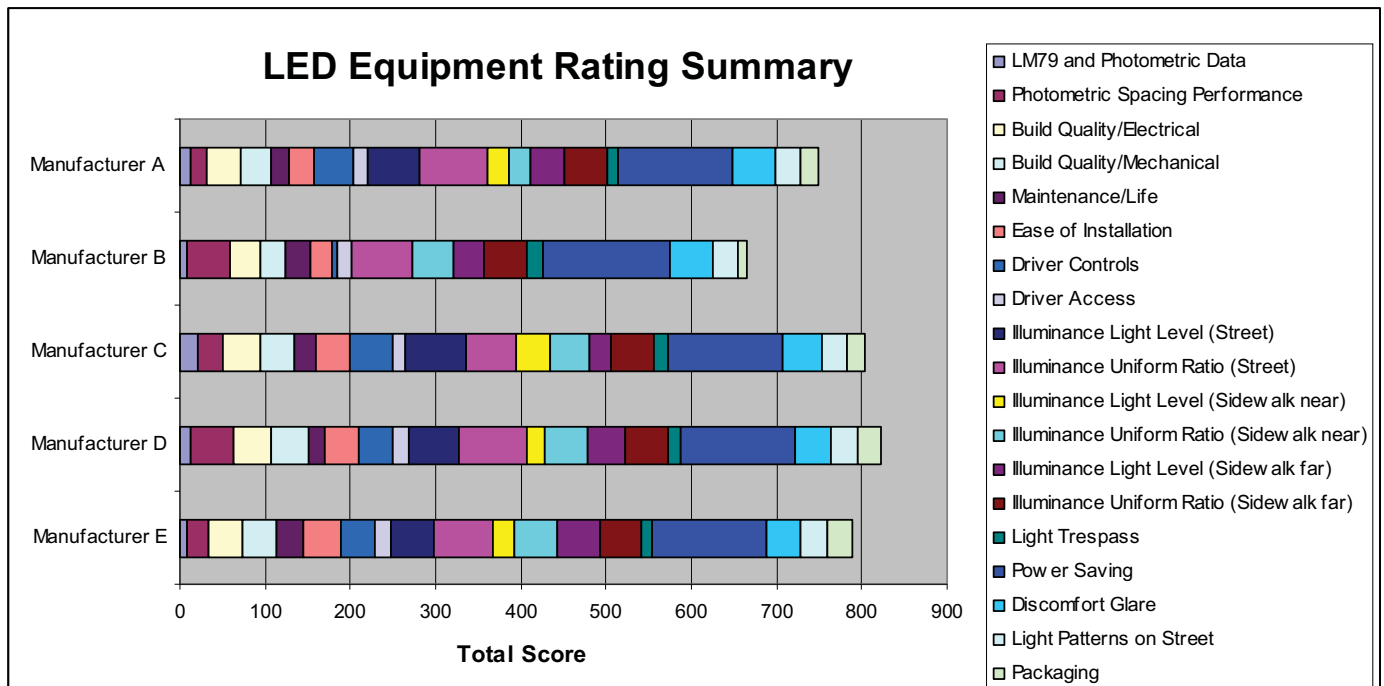
savings from that of a 100W HPS fixture and 20% more savings than what we expected just two years ago when the program started.

Installation played a key roll in equipment approval. There was definitely some disparity in the different units. Issues of concern ranged from terminal block location to weight and size of the fixture, and even packaging was taken into account. We also considered how much space the unit with the packaging takes up on the installation truck. This is because we want to minimize the time consumed back and forth re-stocking the installation truck.

The results from our field testing were very positive even though our measurements did not meet the existing HPS field conditions. With that in mind four of the five units did meet IES local residential roadway standards. The biggest difference between our LED test fixtures and the existing HPS was the roadway uniformity. The existing HPS luminaire produced an average to minimum uniformity ratio twice as high as all our LED test units, and the maximum to minimum uniformity ratio for the HPS units were four times as high as the LED units. This confirms in numbers what we see visually when looking at streets with LED luminaires installed. The smooth roadway coverage of light is one of the major advantages of LED streetlights to that of HPS streetlights. Another aspect confirmed about LED luminaires is the control of the light distribution onto the roadways and sidewalks only. Light spilling onto private property can be a nuisance and all of our test subjects performed better than the existing HPS luminaire. However, a few of our samples did perform better than the others. Our final field test was to see how much glare passing motorists and pedestrians would incur in comparison to the existing HPS fixture.

While our samples varied in the amount of glare produced, it was clear that all the LED units outperformed the HPS by a substantial margin.

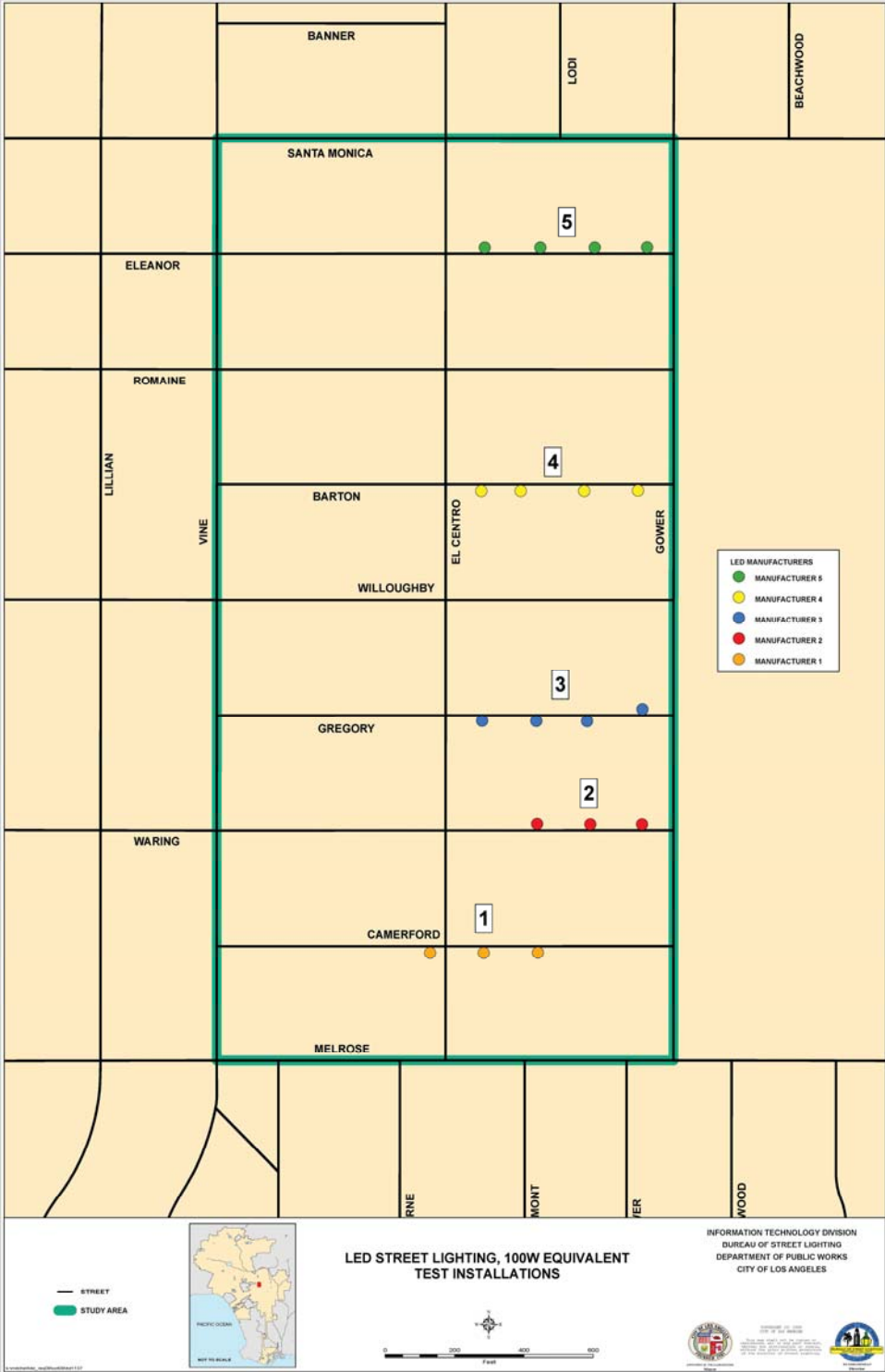
When we compiled all of our test results and observations, it was obvious how much the technology and products have improved over the last two years. Having power savings now up to over 60% while illumination levels still meet IES standards highlights this phase. At the conclusion of our first phase of testing, we felt only one of the twelve units we tested met our standards. After we completed Phase V, we approved or conditionally approved four of the five units we put through a full evaluation for city wide HPS replacement. Below are the final scores for each of the five products we evaluated in Phase V. Each of the 19 scoring categories were weighted based on what we felt was more relevant in choosing luminaires for city wide replacement. When added all together this was the final result.





# Appendix

## LED Test Location Map



*LED Field Installations*

Manufacturer A



Manufacturer B



Manufacturer C



Manufacturer D



Manufacturer E



# Remote Monitoring System Sample

		Date Range: 5/10/2011 thru 06/08/2011																											
		MacID / DeviceID	Location	Type	19	20	21	22	23	24	25	26	27	28	29	30	31	01	02	03	04	05	06	07					
				Watt	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T					
<input type="checkbox"/>		00161N0000014769	5812 Gregory Ave 34,08617,-118,32263	LED 53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
<input type="checkbox"/>		00161N000000FB48	5838 Gregory Ave 34,08619,-118,32313	LED 53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
<input type="checkbox"/>		00161N000000FB50	5865 Gregory Ave 34,08621,-118,32363	LED 53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
<input type="checkbox"/>	A	00161N0000013043	5890 Gregory Ave 34,08619,-118,32416	LED 53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					