

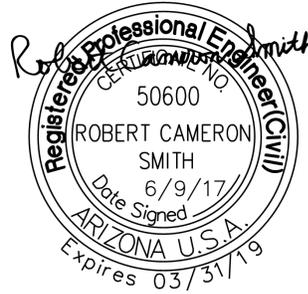
MEMORANDUM

To: Paul Bennett, P.E.
 Project Manager
 Pima County – Dept. of Transportation

From: Robert Smith, P.E.
 Matt Ashby, P.E.

Date: June 8, 2017

Subject: Lighting Report – Kolb Road, from Sunrise Drive to Sabino Canyon Road
 Pima County project 4KSCSD



1. Introduction

Pima County has asked Psomas to prepare a Draft Lighting Design Report for the Kolb Road project, for the following locations:

1. Kolb Road from Sunrise Drive to Territory Drive near the commercial center
2. Kolb Road and Snyder Road intersection
3. Kolb Road at the Rural Metro Fire Station

The analysis is to include the following:

- a) Assess adequacy of existing lighting.
- b) Develop up to three alternatives for future conditions (maintain existing lighting, new HPS luminaires, LED luminaires).

2. Kolb Road from Sunrise Drive to Territory Drive

Improvements to lighting are being considered for an 800-foot segment of Kolb Road south of Sunrise Drive. In this segment, the roadway width will vary from approximately 89 feet at the north end to approximately 48 feet at the south end. Within this segment there are three closely spaced intersections:

- 1) 220 feet south of the stop bar and luminaires at the south side of Sunrise Drive, there are commercial driveways on the east and west.
- 2) 260 feet further south, there are commercial driveways on the east and west.
- 3) 320 feet yet further south, Territory Drive is on the west and a commercial driveway is on the east.

There are no light poles at the two intersections of Kolb Road with the commercial driveways. At the intersection at Territory Drive, there are two 400W HPS dusk-to-dawn lights on the north and south corners, installed by TEP at the request of Pima County.

2.1. Lighting Requirements – Intersections

Lighting requirements for intersections are based on *Recommended Practice RP-8-14* from the *Illuminating Engineering Society of North America (IESNA)*, published in 2014. The limits for lighting levels are the minimum light levels presented in RP-8-14, and the maximum light levels presented in the *Pima County Outdoor Lighting Code (2012)*. These limits and other requirements are listed in Table 1. Modeling of illumination of intersections used the illuminance method.

Pedestrian activity: Low		
Units: fc = foot-candles		
Measure	Major / Collector intersection	Reference
1A: Average illuminance, E_{avg}	≥ 1.5 fc	IESNA RP-8-14, Table 8
1B: Average illuminance, E_{avg}	≤ 2.5 fc	PCOLC 2012, Chapter 8
2: Avg/Min illuminance, E_{avg} / E_{min}	≤ 3.0	IESNA RP-8-14, Table 8
3. Correlated Color Temperature	≤ 3000 K	Dark Sky Alliance
References:		
IESNA RP-8-14: ANSI/IES Recommended Practice for Roadway Lighting (2014).		
PCOLC: Pima County Outdoor Lighting Code (2012).		

Table 1. Illuminance Requirements for Major / Collector Intersections

2.2. Existing Intersection Lighting

An AGi32 plot in Appendix A, page A1-1 shows in red the boundary of the area within which traffic conflicts are likely to occur at the intersection of Kolb Road and Territory Drive, and within which illuminance values are measured for calculation of average illuminance and uniformity. The results for existing illumination on page A1-1 include an average illuminance of

2.42 fc, within the target range for a major / collector intersection. Average / minimum uniformity is 6.05, outside the target range; this is not surprising because there are luminaires on only two corners.

2.3. Intersection Lighting Improvements – HPS Luminaires

Uniformity of illumination could be improved for the two existing HPS luminaires. An AGi plot on appendix page A1-2 shows the results that would be expected if the luminaire arms were rotated approximately 45 degrees counterclockwise. Average illuminance would increase from 2.42 fc to 2.95 fc with the same two luminaires, and uniformity would improve from 6.05 to 1.97.

2.4. Intersection Lighting Improvements – LED Luminaires

Beyond the scope listed in the Introduction of this report, Pima County has also requested comparison of illumination at the Kolb / Territory intersection with LED luminaires versus HPS luminaires, on the two existing light poles. The results shown in Appendix pages A1-3 through A1-8 and summarized in Table 2 show that if the poles and luminaire arms are rotated, the ATBL D and ATBL G luminaires could produce adequate illuminance, with acceptable uniformity and less power than the existing HPS luminaires.

Mfr	Type	Model	LLF	Power (W)	Poles in existing orientations		Poles rotated CCW 45° +/-	
					E _{avg}	E _{avg} /E _{min}	E _{avg}	E _{avg} /E _{min}
GE	HPS	M-400 MDCL	0.72	468	2.42	6.05	2.95	1.97
AEL	LED	ATBL A	0.75	170	1.05	5.25	1.43	2.86
AEL	LED	ATBL D	0.75	209	1.44	7.20	1.82	2.28
AEL	LED	ATBL G	0.80	279	1.49	7.45	1.87	2.34

Table 2. Illumination of Kolb / Territory Intersection with Two Light Poles

2.5. Lighting Requirements – Continuous Street Lighting

An alternative to intersection lighting would be continuous street lighting. Because there are several access points between Sunrise Drive and Territory Drive, and because the crash rate is above the County average, the use of street lighting would be an effective safety countermeasure. Additional discussion on this issue is included in the Traffic Engineering Report.

Lighting requirements for roadway segments are based on the minimum light levels presented in RP-8-14, and the maximum light levels presented in the *Pima County Outdoor Lighting Code* (2012). These limits and other requirements are listed in Table 3. Modeling of illumination of roadway segments used the luminance method, as recommended by RP-8-14 for straight segments of roads and streets between intersections. The luminance method was used to model

illumination with the Roadway Optimizer tool of the program AGi32, supplied by Lighting Analysts, Inc.

Pedestrian activity: Low		
Units: cd/m ² = candelas per square meter		
Measure	Major street	Reference
1A: Average luminance, L _{avg}	≥0.6 cd/m ²	IESNA RP-8-14, Table 3
1B: Average luminance, L _{avg}	≤1.08 cd/m ²	PCOLC 2012, Chapter 8
2: Avg/Min luminance, L _{avg} / L _{min}	≤3.5	IESNA RP-8-14, Table 3
3: Veiling luminance, LV _{max} /L _{avg}	<0.3	IESNA RP-8-14, Table 3
4. Correlated Color Temperature	<3000K	Dark Sky Alliance
References:		
IESNA RP-8-14: ANSI/IES Recommended Practice for Roadway Lighting (2014).		
PCOLC: Pima County Outdoor Lighting Code (2012).		

Table 3. Roadway Lighting Requirements for Kolb Road

2.6. *Lighting Modeling – Continuous Street Lighting*

It is most practical for the County to be able to light the entire roadway segment with one type of luminaire. The HPS luminaire chosen for modeling is the 400W luminaire used by Pima County. General Electric lists its light distribution as MC3, and its IES photometric file lists the distribution as Type III, Medium.

As shown by the results in Table 4, the GE 400W HPS luminaire could provide adequate illumination, just slightly above the Pima County maximum, with good uniformity. Pima County’s new standard is to use LED luminaires for continuous street lighting. A luminaire that was tested extensively in Roadway Optimizer is the Autobahn ATBL with Performance Package A (ATBL A) manufactured by American Electric Lighting (AEL). As shown in Table 4, this luminaire could provide illumination with a staggered spacing of 123 feet, with all luminance parameters within target ranges. This is based on the average width of the segment of approximately 70 ft (the north end near sunrise Drive is wider, while the southern end near Territory Drive is narrower) The power consumption is 170 watts per luminaire.

Luminaire data			
Manufacturer		GE	AEL
Model		MDCL40	ATBL A
IES file		451002	No #
Light source		HPS	LED
Power (W)	Nominal	400	
	Fixture	480	170
Distribution	Per mfr	MC3	R3
	IES	III	III
	Longitudinal	Medium	Medium
Correlated Color Temperature		<3000K	3000K
Roadway Optimizer results			
Spacing (ft)		190	123
L_{avg} (cd/m ²)		1.09	0.83
L_{avg} / L_{min}		2.10	2.68
LV_{max} / L_{avg}		0.29	0.27

Table 4. Luminaire Data and Results of Modeling of Continuous Lighting from Sunrise Drive to Territory Drive

Pima County has requested AGi documentation of the results for continuous lighting by HPS and LED luminaires. The AGi Roadway Optimizer results that are summarized in Table 4 are shown on pages A2-1 and A2-2.

2.7. Roundabout Lighting

A roundabout is being considered as an improvement to the intersection of Kolb Road and Territory Drive. If Pima County decides to proceed with the roundabout alternative, Psomas will do a photometric analysis and lighting design for the roundabout during final design.

3. Kolb Road / Snyder Road

3.1. Lighting requirements

The intersection of Kolb Road with Snyder Road would be classified as a Major / Collector intersection in RP-8-14. The limits for intersection lighting levels are the minimum light levels presented in RP-8-14, and the maximum light levels presented in the *Pima County Outdoor Lighting Code* (2012). These limits and other requirements are listed in Table 1 in section 2.1 of this report.

3.2. Existing Illumination

The intersection of Kolb Road with Snyder Road presently is illuminated by four 250W HPS luminaires on signal poles, as designed in 2001 for Pima County project 4KOSNY. Each luminaire consumes approximately 305W of power. Modeling of the existing lighting with the program AGi32 (page A3-1) indicates average illuminance of 3.27 fc, which satisfies the IESNA recommended minimum of 1.5 fc (foot-candles). The average illuminance also exceeds the maximum limit of 2.5 fc set by the Pima County Outdoor Lighting Code (2012).

3.3. HPS Luminaire Improvements

By direction of the Pima County Traffic Engineering staff, the County's new standard is to use LED lighting on all new CIP projects, and a future program for converting from HPS is anticipated. Therefore, HPS luminaire improvements for the Kolb / Snyder intersection will not be considered.

3.4. LED Luminaire Improvements

To adhere to the lighting code and to save energy costs, it is recommended to replace the existing HPS luminaires with LED luminaires. Appendix A3 shows results of modeling of lighting for three luminaires manufactured by American Electric Lighting (AEL). The luminaires all produce illuminance within the target range of 1.5-2.5 fc, with acceptable uniformity and power consumption of 90W to 175W. Other luminaires by AEL and other manufacturers would also meet standards. Any LED luminaire to be installed for this project shall have a Correlated Color Temperature of 3000K, to adhere to both the Pima County code and recommendations of the Dark Sky Alliance.

Consideration should be given to adding approach lighting on a light pole on each leg of the intersection to aid adaptation of drivers' vision. These luminaires would produce less illumination than the luminaires at the intersection. The decision whether not to install the luminaires would take into account the concerns of residents on the east side of Kolb Road.

4. Kolb Road at Rural Metro Fire Station

4.1. Lighting requirements

The County could decide to illuminate the access for Rural Metro Fire Station 73. For this driveway, the closest intersection classification in IESNA's RP8-14 is an intersection between a major road and a local street (there is no classification for driveways). Table 8 of RP-8-14 shows a recommendation of at least 1.3 fc for a major / local intersection with low pedestrian activity.

The Pima Outdoor Lighting Code does not provide a maximum limit for intersections of major roadways with local roads. However, the listed intersection lighting levels are the sum of the lighting levels for each of the approach roadways. In this case, the combination of a major road

and a local road would result in a maximum level of $1.5 \text{ fc} + 0.4 \text{ fc} = 1.9 \text{ fc}$. Therefore, the illuminance target range would be between 1.3 and 1.9 fc.

4.2. Existing Illumination

There is no roadway illumination on Kolb Road at Rural Metro Fire Station 73, north of the intersection of Kolb Road / Sabino Canyon Road. The station is on the east side of Kolb Road, opposite East Cripple Creek Road.

4.3. HPS Luminaire Improvements

Because LED luminaires are more efficient and because those luminaires are the new standard for Pima County, the installation of any HPS luminaires is not recommended.

4.4. LED Luminaire Improvements

If it is decided that illumination is needed for the fire station driveway or at the intersection of the driveway with Kolb Road, it is recommended that light poles be added on the north and south sides of the fire station driveway. A model using two ATBM D luminaires (page A7) shows illuminance of 1.69 fc and an Avg/Min ratio of 2.82, meeting the targets listed above. An alternative would be to have luminaires farther from the driveway on each of two HAWK-style signal poles with flashers, which are used at some fire stations.

5. Adjacent Intersections

There are two major intersections just outside the limits of this project. These intersections are Kolb Road / Sabino Canyon Road, designed in 2000 for Pima County project 4TSCKR, and Kolb Road / Sunrise Drive, designed in 2009 for Pima County project 4SRCRA. Each intersection is lighted by eight 400W HPS luminaires on signal poles, which should supply illumination that satisfies RP-8-14 recommended minimum levels. Neither intersection has any approach / departure lighting to help drivers' vision adapt to entering and leaving the strongly lighted intersections.

6. Summary

The recommended improvements to existing lighting in this project are as follows:

Kolb Road from Sunrise Drive to Territory Drive

Add light poles with LED luminaires to illuminate the roadway. Poles would be in a staggered arrangement, and average pole spacing would be approximately 123 feet.

Kolb Road and Snyder Road intersection

Replace the 250W HPS luminaires on the signal poles with LED luminaires. Consider adding approach lighting by putting a smaller LED luminaire on a light pole on each leg of the intersection, to aid adaptation of drivers' vision.

Kolb Road at the Rural Metro Fire Station

Consider adding LED luminaires on two light poles, one on each side of the fire station driveway. As an alternative, consider adding LED luminaires on two HAWK-style fire station flasher poles.

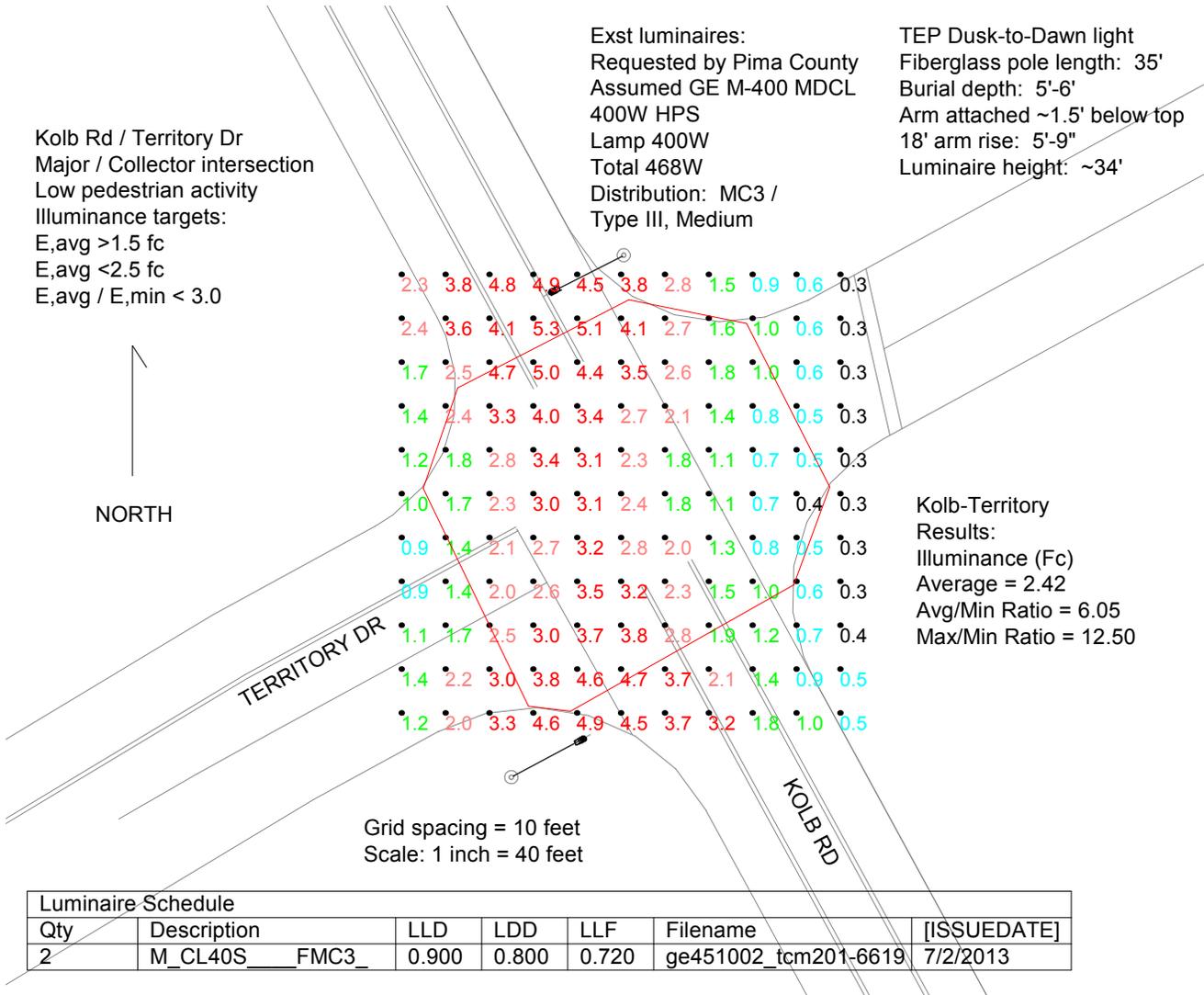
Appendix A1 – Kolb Road / Territory Drive Intersection

Kolb Rd / Territory Dr
 Major / Collector intersection
 Low pedestrian activity
 Illuminance targets:
 E,avg >1.5 fc
 E,avg <2.5 fc
 E,avg / E,min < 3.0



Exst luminaires:
 Requested by Pima County
 Assumed GE M-400 MDCL
 400W HPS
 Lamp 400W
 Total 468W
 Distribution: MC3 /
 Type III, Medium

TEP Dusk-to-Dawn light
 Fiberglass pole length: 35'
 Burial depth: 5'-6"
 Arm attached ~1.5' below top
 18' arm rise: 5'-9"
 Luminaire height: ~34'



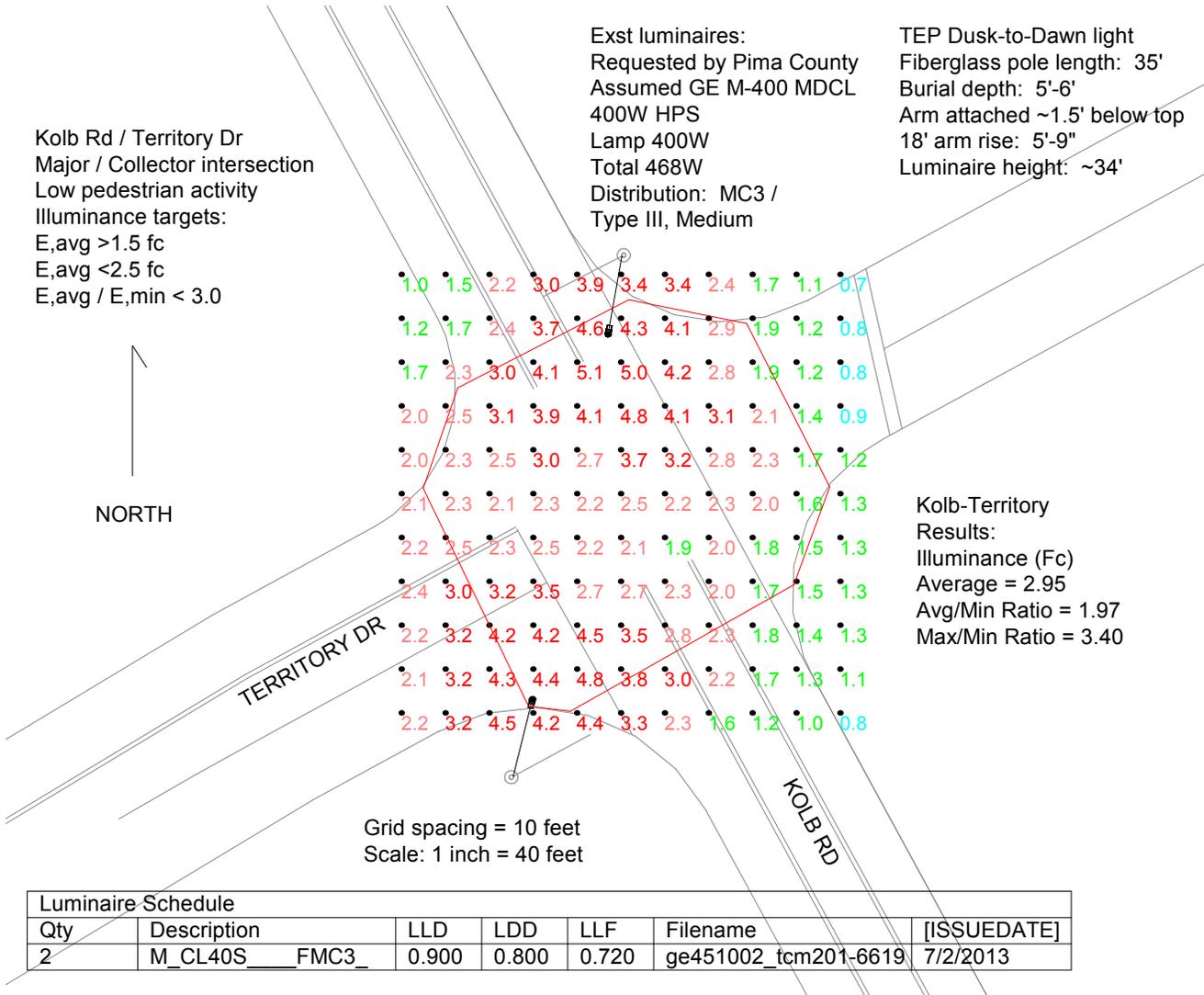
Kolb-Territory
 Results:
 Illuminance (Fc)
 Average = 2.42
 Avg/Min Ratio = 6.05
 Max/Min Ratio = 12.50

Kolb Rd / Territory Dr
 Major / Collector intersection
 Low pedestrian activity
 Illuminance targets:
 E,avg >1.5 fc
 E,avg <2.5 fc
 E,avg / E,min < 3.0



Exst luminaires:
 Requested by Pima County
 Assumed GE M-400 MDCL
 400W HPS
 Lamp 400W
 Total 468W
 Distribution: MC3 /
 Type III, Medium

TEP Dusk-to-Dawn light
 Fiberglass pole length: 35'
 Burial depth: 5'-6"
 Arm attached ~1.5' below top
 18' arm rise: 5'-9"
 Luminaire height: ~34'



Kolb-Territory
 Results:
 Illuminance (Fc)
 Average = 2.95
 Avg/Min Ratio = 1.97
 Max/Min Ratio = 3.40

Kolb Rd / Territory Dr
Major / Collector intersection
Low pedestrian activity
Illuminance targets:
E,avg >1.5 fc
E,avg <2.5 fc
E,avg / E,min < 3.0

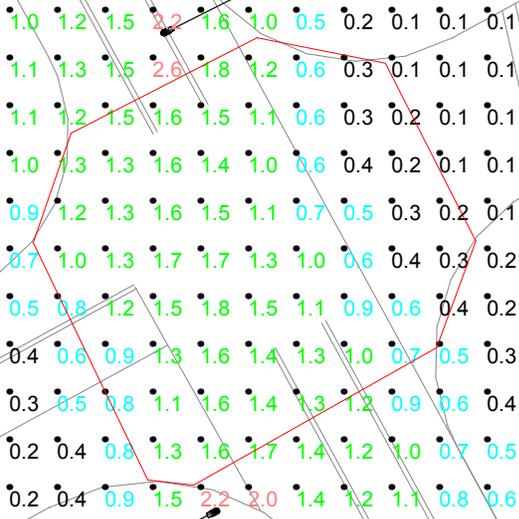
TEP Dusk-to-Dawn light
Fiberglass pole length: 35'
Burial depth: 5'-6"
Arm attached ~1.5' below top
18' arm rise: 5'-9"
Luminaire height: ~34'

NORTH

TERRITORY DR

KOLB RD

Grid spacing = 10 feet
Scale: 1 inch = 40 feet



Kolb-Territory
Results:
Illuminance (Fc)
Average = 1.05
Avg/Min Ratio = 5.25
Max/Min Ratio = 9.00

Luminaire Schedule						
Qty	Description	LLD	LDD	LLF	Filename	[ISSUEDATE]
2	ATBL A XXXXX R3 3K 2	0.940	0.800	0.752	ATBL_A_XXXXX_R3_3K	11/26/2016

Kolb Rd / Territory Dr
Major / Collector intersection
Low pedestrian activity
Illuminance targets:
E,avg >1.5 fc
E,avg <2.5 fc
E,avg / E,min < 3.0

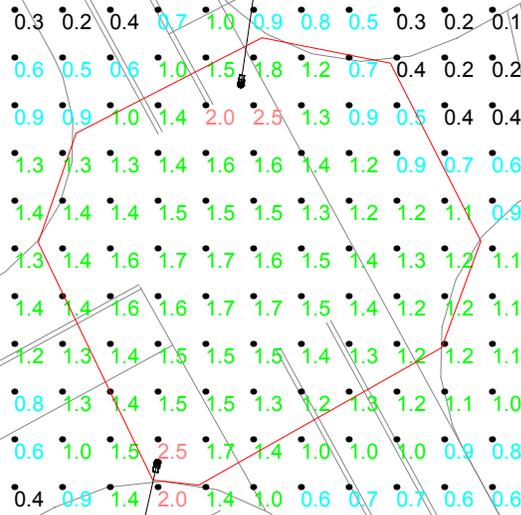
TEP Dusk-to-Dawn light
Fiberglass pole length: 35'
Burial depth: 5'-6"
Arm attached ~1.5' below top
18' arm rise: 5'-9"
Luminaire height: ~34'

NORTH

TERRITORY DR

KOLB RD

Grid spacing = 10 feet
Scale: 1 inch = 40 feet



Kolb-Territory
Results:
Illuminance (Fc)
Average = 1.43
Avg/Min Ratio = 2.86
Max/Min Ratio = 5.00

Luminaire Schedule						
Qty	Description	LLD	LDD	LLF	Filename	[ISSUEDATE]
2	ATBL A XXXXX R3 3K 2	0.940	0.800	0.752	ATBL_A_XXXXX_R3_3K	11/26/2016

Kolb Rd / Territory Dr
Major / Collector intersection
Low pedestrian activity
Illuminance targets:
E,avg >1.5 fc
E,avg <2.5 fc
E,avg / E,min < 3.0

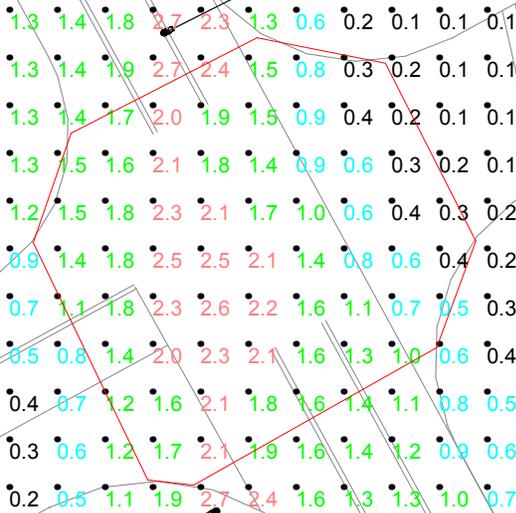
TEP Dusk-to-Dawn light
Fiberglass pole length: 35'
Burial depth: 5'-6"
Arm attached ~1.5' below top
18' arm rise: 5'-9"
Luminaire height: ~34'

NORTH

TERRITORY DR

KOLB RD

Grid spacing = 10 feet
Scale: 1 inch = 40 feet



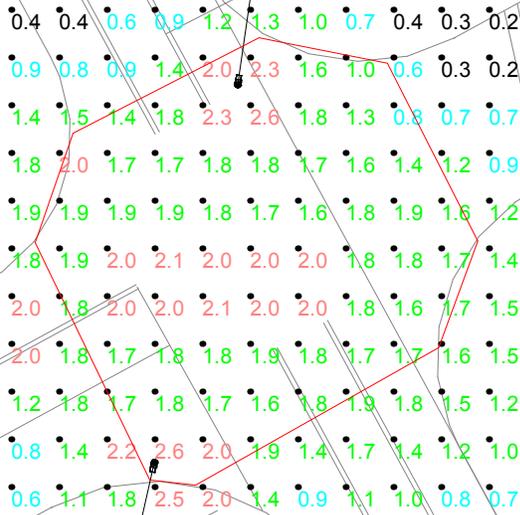
Kolb-Territory
Results:
Illuminance (Fc)
Average = 1.44
Avg/Min Ratio = 7.20
Max/Min Ratio = 13.00

Luminaire Schedule						
Qty	Description	LLD	LDD	LLF	Filename	[ISSUEDATE]
2	ATBL D XXXXX R3 3K 2	0.940	0.800	0.752	ATBL_D_XXXXX_R3_3K	i1/26/2016

Kolb Rd / Territory Dr
 Major / Collector intersection
 Low pedestrian activity
 Illuminance targets:
 E,avg >1.5 fc
 E,avg <2.5 fc
 E,avg / E,min < 3.0

TEP Dusk-to-Dawn light
 Fiberglass pole length: 35'
 Burial depth: 5'-6"
 Arm attached ~1.5' below top
 18' arm rise: 5'-9"
 Luminaire height: ~34'

NORTH



Kolb-Territory
 Results:
 Illuminance (Fc)
 Average = 1.82
 Avg/Min Ratio = 2.28
 Max/Min Ratio = 3.25

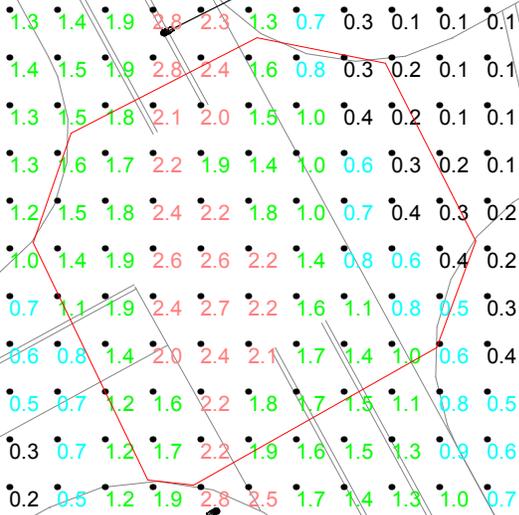
Grid spacing = 10 feet
 Scale: 1 inch = 40 feet

Luminaire Schedule						
Qty	Description	LLD	LDD	LLF	Filename	[ISSUEDATE]
2	ATBL D XXXXX R3 3K 2	0.940	0.800	0.752	ATBL_D_XXXXX_R3_3K	i1/26/2016

Kolb Rd / Territory Dr
Major / Collector intersection
Low pedestrian activity
Illuminance targets:
E,avg >1.5 fc
E,avg <2.5 fc
E,avg / E,min < 3.0

TEP Dusk-to-Dawn light
Fiberglass pole length: 35'
Burial depth: 5'-6"
Arm attached ~1.5' below top
18' arm rise: 5'-9"
Luminaire height: ~34'

NORTH



Kolb-Territory
Results:
Illuminance (Fc)
Average = 1.49
Avg/Min Ratio = 7.45
Max/Min Ratio = 13.50

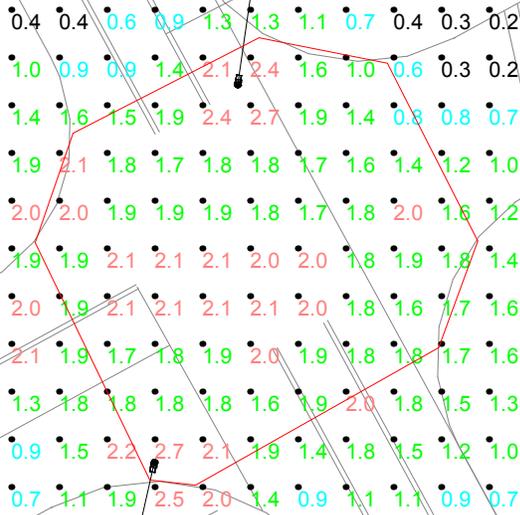
Grid spacing = 10 feet
Scale: 1 inch = 40 feet

Luminaire Schedule						
Qty	Description	LLD	LDD	LLF	Filename	[ISSUEDATE]
2	ATBL G XXXXX R3 3K 2	0.930	0.800	0.744	ATBL_G_XXXXX_R3_3K.i2/4/2016	

Kolb Rd / Territory Dr
 Major / Collector intersection
 Low pedestrian activity
 Illuminance targets:
 E,avg >1.5 fc
 E,avg <2.5 fc
 E,avg / E,min < 3.0

TEP Dusk-to-Dawn light
 Fiberglass pole length: 35'
 Burial depth: 5'-6"
 Arm attached ~1.5' below top
 18' arm rise: 5'-9"
 Luminaire height: ~34'

NORTH



Kolb-Territory
 Results:
 Illuminance (Fc)
 Average = 1.87
 Avg/Min Ratio = 2.34
 Max/Min Ratio = 3.38

Grid spacing = 10 feet
 Scale: 1 inch = 40 feet

Luminaire Schedule						
Qty	Description	LLD	LDD	LLF	Filename	[ISSUEDATE]
2	ATBL G XXXXX R3 3K 2	0.930	0.800	0.744	ATBL_G_XXXXX_R3_3K.i2/4/2016	

Appendix A2 – Continuous Street Lighting from Sunrise Drive to Territory Drive

The screenshot shows the 'Roadway Optimizer' software interface. The window title is 'Roadway Optimizer'. The interface is divided into several sections:

- Layout Section:**
 - Layout: 1 (selected), 2, 3, 4, 5. Buttons: Reset, Description.
 - General: Roadway Standard: IES RP-8-14; R-Table: R3 (Slightly Specular), Q0=0.07; Actual Q0 Value: 0.07.
 - Roadway Layout: Type: Two Rows, Staggered, With Median; 2R_STG_w/M; Roadway Width: 70; Median Width: 22.
 - Number Of Lanes: In Direction Of Travel: 2; In Opposite Direction: 0; Driver's Side Of Roadway: Right.
 - Calculation Area: Bottom (selected), Top.
 - Luminaire Layout Table:

Row	Label	MH	Setback	+Orient	Tilt	Spin	Spacing
Row 4	ATBM_H_XXXXXX_R2_3K	0	0		0	0	
Row 3	ATBM_H_XXXXXX_R2_3K	0	0		0	0	
Row 2	ge451002_tcm201-66198	35	0		0	0	
Row 1	ge451002_tcm201-66198	35	0		0	0	
 - Luminaire Coverage: Towards Observer: 272.4696 Ft; After Calculation Area: 12 x Max. MH; Override...
- Comparison Section:**
 - Optimization Criteria: Calculate Spacing To Achieve:

Inc	Criteria	Value
<input checked="" type="checkbox"/>	Average Luminance	0.84
<input type="checkbox"/>	Average Illuminance	0
<input type="checkbox"/>	Minimum Luminance	0
<input type="checkbox"/>	Minimum Illuminance	0
<input checked="" type="checkbox"/>	Avg/Min Lum Ratio	3
<input checked="" type="checkbox"/>	Avg/Min Illum Ratio	0
<input checked="" type="checkbox"/>	Max Lv Ratio	0.3
<input type="checkbox"/>	Max/Min Lum Ratio	0
<input type="checkbox"/>	Max/Min Illum Ratio	0
<input type="checkbox"/>	Max/Avg Lum Ratio	0
<input type="checkbox"/>	Max/Avg Illum Ratio	0
 - Calculate Based On Set Spacing: (selected)
- Results Section:**
 - Calculated Spacing: 190 (5 Iterations)
 - Tree view of results:
 - RoadOpt_1_Luminance: Avg=1.09, Max=1.99, Min=0.52, Avg/Min Ratio=2.10, Max/Min Ratio=3.83, Max/Avg Ratio=1.83
 - RoadOpt_1_Illum: Avg=1.6, Max=4.41, Min=0.37, Avg/Min Ratio=4.32, Max/Min Ratio=11.92, Max/Avg Ratio=2.76
 - RoadOpt_1_Vis_Level: STV=3.71
 - RoadOpt_1_Vis_Level_Bkgd_Lum: Avg=1.08, Max=1.98, Min=0.52

The screenshot displays the Roadway Optimizer software interface, which is divided into several functional areas:

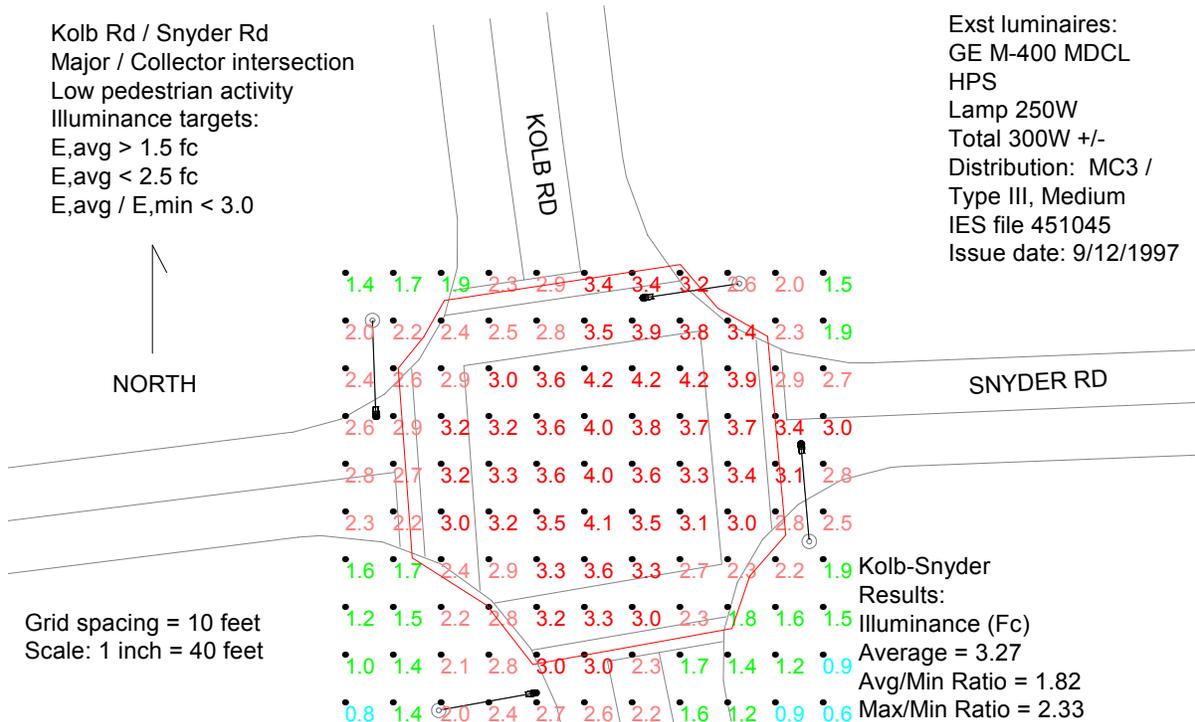
- Layout Section:**
 - General:** Roadway Standard is set to IES RP-8-14, and R-Table is R3 (Slightly Specular), Q0=0.07. The Actual Q0 Value is 0.07.
 - Roadway Layout:** Type is Two Rows, Staggered, With Median; 2R_STG_w/M. Roadway Width is 70 feet, and Median Width is 22 feet. Number of Lanes: 2 in the direction of travel, 0 in the opposite direction. Driver's Side of Roadway is set to Right.
 - Luminaire Layout:** A table lists four rows of luminaires with their respective labels, mounting heights (MH), setbacks, orientations, tilts, spins, and spacings.

Row	Label	MH	Setback	+Orient	Tilt	Spin	Spacing
Row 4	ATBM_H_XXXXXX_R2_3K	0	0		0	0	
Row 3	ATBM_H_XXXXXX_R2_3K	0	0		0	0	
Row 2	ATBL_A_XXXXXX_R3_3K	35	0		0	0	
Row 1	ATBL_A_XXXXXX_R3_3K	35	0		0	0	
- Comparison Section:**
 - Optimization Criteria:** A list of criteria to be calculated, with 'Average Luminance' highlighted at 0.84. Other criteria include Average Illuminance, Minimum Luminance, Minimum Illuminance, Avg/Min Lum Ratio (3), Avg/Min Illum Ratio (0), Max Lv Ratio (0.3), Max/Min Lum Ratio (0), Max/Min Illum Ratio (0), Max/Avg Lum Ratio (0), and Max/Avg Illum Ratio (0).
 - Results:** Calculated Spacing is 123 feet (2 iterations). A tree view shows results for RoadOpt_1_Luminance (Avg=0.83, Max=1.64, Min=0.31, Avg/Min Ratio=2.68), RoadOpt_1_Illum (Avg=1.12, Max=1.99, Min=0.37, Avg/Min Ratio=3.03, Max/Min Ratio=5.38, Max/Avg Ratio=1.78), RoadOpt_1_Vis_Level (STV=2.08), and RoadOpt_1_Vis_Level_Bkgd_Lum (Avg=0.83, Max=1.65, Min=0.30).

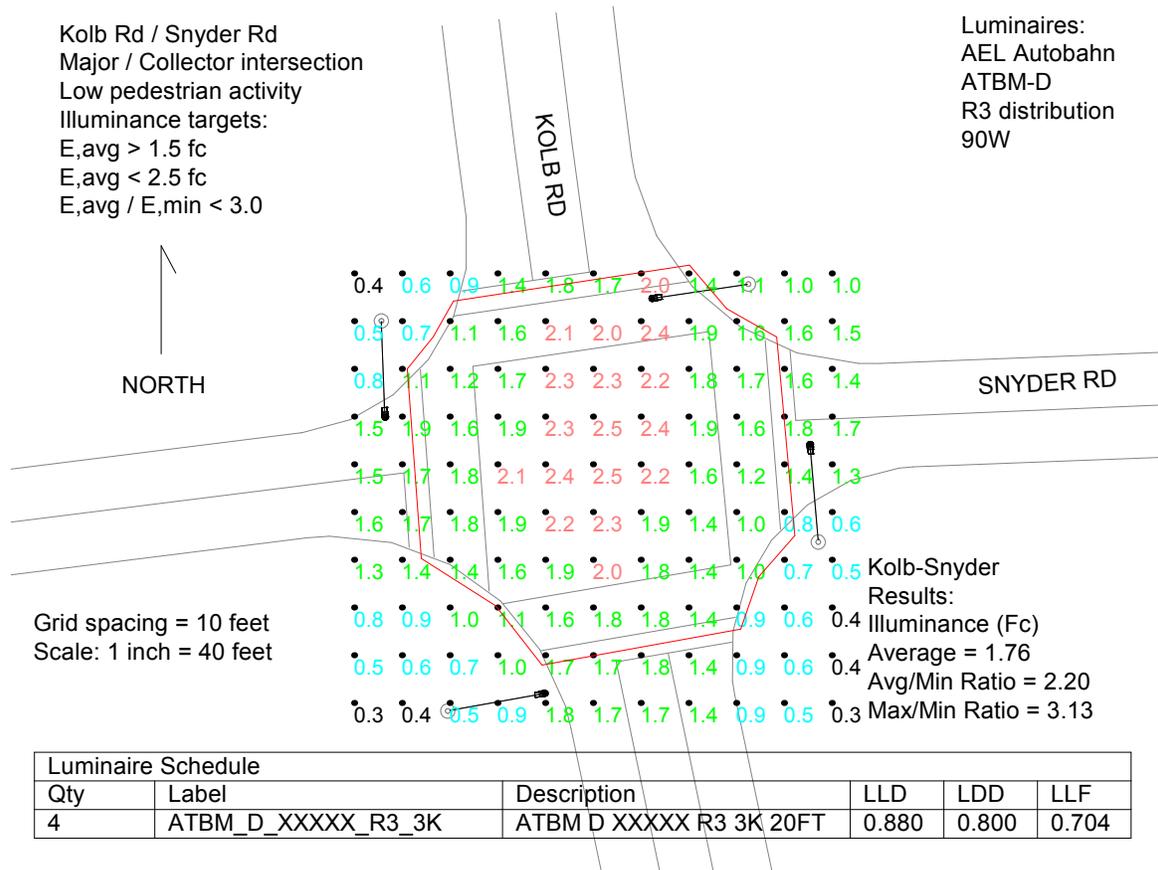
Appendix A3 – Kolb Road / Snyder Road lighting models

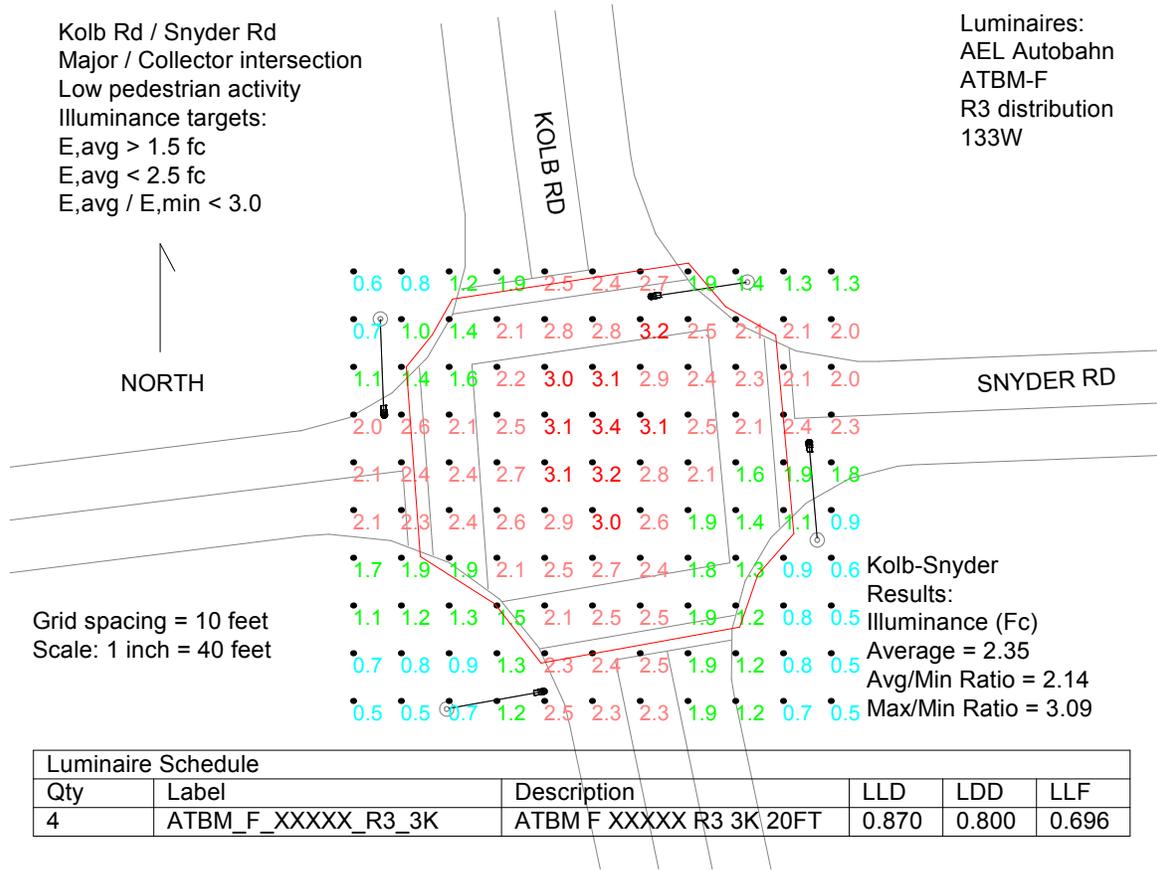
Kolb Rd / Snyder Rd
 Major / Collector intersection
 Low pedestrian activity
 Illuminance targets:
 E,avg > 1.5 fc
 E,avg < 2.5 fc
 E,avg / E,min < 3.0

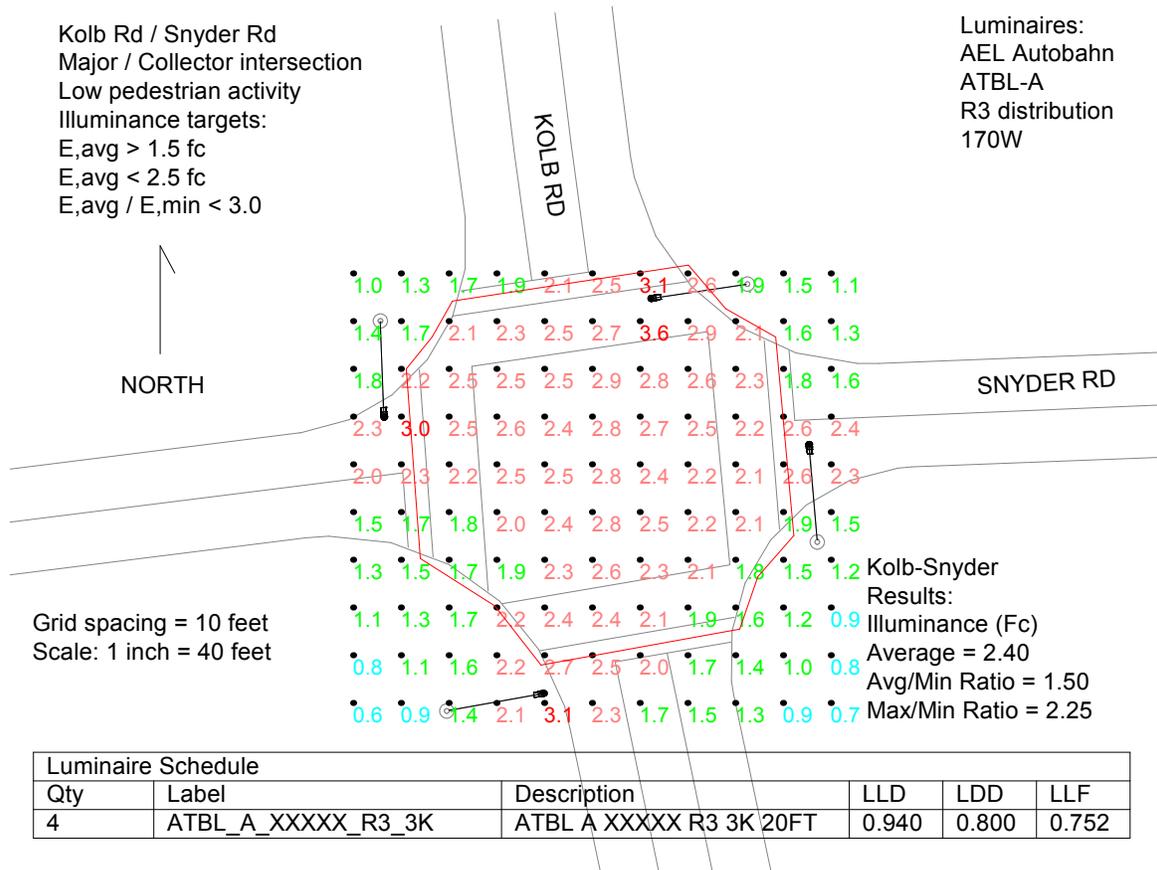
Exst luminaires:
 GE M-400 MDCL
 HPS
 Lamp 250W
 Total 300W +/-
 Distribution: MC3 /
 Type III, Medium
 IES file 451045
 Issue date: 9/12/1997



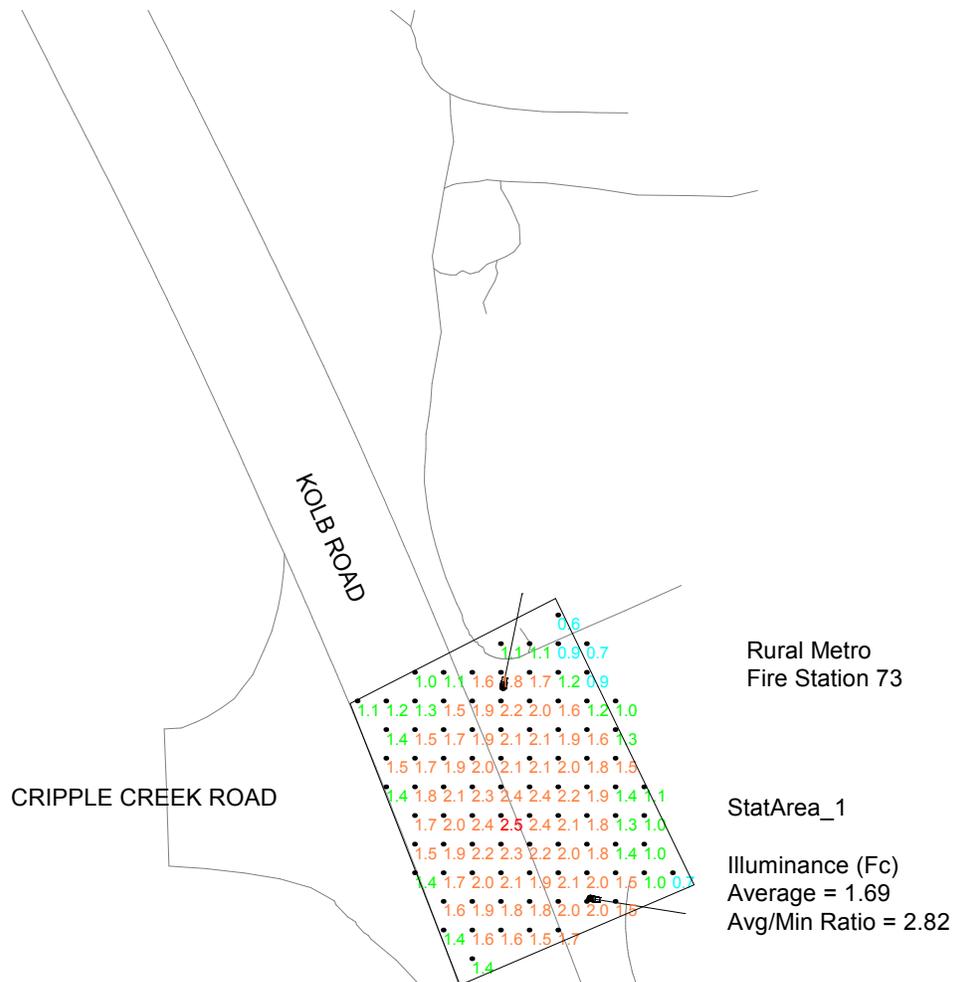
Luminaire Schedule						
Qty	Label	Description	LLD	LDD	LLF	
4	ge451045_tcm201-62422	M_CL25S_LMC3	0.900	0.800	0.720	







Appendix A4 – Fire Station 73 Lighting Model



Luminaire Schedule									
Qty	Label	Description	Lum. Lumens	Lum. Watts	LLD	LDD	LLF	Arm	[ISSUEDATE]
2	ATBM_D_XXXXX_R3_3K	ATBM D XXXXX R3 3K 20FT	10989	95	0.880	0.800	0.704	20	2/2/2016