BIJLAGE F BEREKENING VERLICHTING

De volgende bijlages zijn bijgevoegd:

1. “Memo Nature 2000 contour line 0,1 lux”, kenmerk PLLS-5030-MEMO-EL-001-A, d.d. 08-07-2020.
2. “NATURA 2000 CONTOUR LINE 0,1 Lux”, kenmerk PLLS-5030-2AREIC-012-A, d.d. 07-07-2020.

TITLE	Memo Nature 2000 contour line 0,1 lux
DATE	08-07-2020
FROM	*Christian Klaver*
TO	*Rick van Lent, Michael van Kogelenberg, Ilse Vermeij*
CC	*Frank Schilders, Nestor De Lorenzo, Marco Visser*

1 PURPOSE

- This memo has been drawn up in response to Pallas (Arcadis) request to provide support for the permit application with regard to light pollution in the adjacent Natura 2000 area.
- The purpose of the memo is to substantiate the contour line of 0,1 lux caused by lighting on the Pallas plot with regard of the Natura 2000 area.

2 SCOPE

- The following systems and sub systems are part of the scope of this document:
  a. Non-Emergency Light and GPO (5031);
  b. Emergency Light and GPO (5032);
  c. Evacuation Light (5033);
  d. External Security Lighting (5760).
- This part of the engineering is pulled forward from the Detail Design works. During Detail Design changes to lighting design may cause changes to this contour.
- In this memo the following questions of Pallas (Arcadis) are answered:
  a. At what distance from the Pallas plot is the illuminance 0.1 lux (contour line)?
  b. What is the illuminance in [lux] 10 meters within the Natura 2000 area (contribution)?.

3 CONTOUR LINE

- The following principles were used to determine the 0,1 lux contour line.
  a. The displayed contour of 0,1 lux is bases on the exterior lighting from the PALLAS plot. The appearance of the interior lighting is not included.
  b. Light (interior and exterior) from other part of the plot is not taken into account.
  c. All light on the PALLAS plot is switched on.
  d. The contour line is drawn as if the light from the PALLAS plot is not been obstructed by any obstacle (structures, dunes).
  e. The light point height is 15 meters above ground level.

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4 CALCULATION

Two calculations have been made, one to indicate where the contour line of 0,1 lux is situated and one to indicate what the light intensity is within 10 meters of the Natura 2000 area. The outcome of the calculations are shown in Lay-out Natura 2000 contour line 0,1 lux [1].
The corners of the PALLAS plot were used for both calculations. See the letters A, B, C and D on the layout.

The following formula has been used to calculate the illuminance, in which:
E = illuminance in lux [Lx]
I = lightcurrent in candela [cd]
h = light point height above ground level [m]
α = angle with the perpendicular [°]

$$E = \frac{I}{h^2} * \cos^3 \alpha$$

Table 1 shows the light current for each luminaire.

Table 1: Light current

1	***Calculation of light current per luminaire derived from polar diagrams***	α	specific I at α	luminous flux	I at α
		[°]	[cd/1kLm]	Φ [Lm]	[cd]
2	V5, O52 LED DALI	86	100	5.000	500
3	V10, O52 LED DALI	86	100	10.000	1.000
4	V15, O52 LED DALI dim	86	100	15.000	1.500
5	X3,5, Next 0 LED 3500	86	50	3.500	175
6	Y3,5, O49 / CL/OP DALI	86	200	3.500	700
7	W35, O91 LED 35000 HF	86	100	35.000	3.500
8					
9	***Remark:***				
10	Because the choice of the luminaires is not yet determined, but we would like to be on the safe side, higher values have been used in the calculations than indicated in the polar diagrams (see chapter 5).				

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4.1 Contour line

In row 13, the distance between the corners of the PALLAS plot and the 0.1 lux is entered in the contour line calculations. The distance was entered in steps of 5 meters until the illuminance fell below 0,1 lux.

Using the data from table 1 and 2 and by the total number of luminaires shining in the direction of the relevant corner of the PALLAS plot, table 3 calculates the 0,1 lux contour line.

Table 2: Calculation of angle α

11	***Calculation of angle α***	NI		Parking area		Parking area		NI	
12	Distance	A - A'		B - B'		C - C'		D - D'	
13	Distance between corner of the PALLAS plot and the 1 Lx contour line	220	m	220	m	210	m	170	m
14	Light point height lph	15	m	15	m	15	m	15	m
15	tan α = distance / lph	14,67		14,67		14,00		11,33	
16	α = [degrees]	86,10		86,10		85,91		84,96	
17	Cos α	0,068		0,068		0,071		0,088	

Table 3: Calculation of illuminances

18	***Calculation of the illuminances***	Nuclear island			Parking area			Parking area			Nuclear island		
19		Qty.	Total I at α	E	Qty.	Total I at α	E	Qty.	Total I at α	E	Qty.	Total I at α	E
20			[cd]	[Lx]		[cd]	[Lx]		[cd]	[Lx]		[cd]	[Lx]
21	V5, O52 LED DALI	2	1000	0,0014	3	1500	0,0021				4	2000	0,0060
22	V10, O52 LED DALI	3	3000	0,0042	3	3000	0,0042	9	9000	0,0145			
23	V15, O52 LED DALI dim	5	7500	0,0105	15	22500	0,0315	15	22500	0,0362			
24	X3,5, Next 0 LED 3500	9	1575	0,0022	2	350	0,0005	4	700	0,0011	7	1225	0,0037
25	Y3,5, O49 / CL/OP DALI	12	8400	0,0118	12	8400	0,0118	7	4900	0,0079	4	2800	0,0084
26	W35, O91 LED 35000 HF	14	49000	0,0685	10	35000	0,0490	7	24500	0,0394	7	24500	0,0739
27	**Total illuminance [Lx]**			**0,0986**			**0,0990**			**0,0990**			**0,0921**

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4.2 Contribution

Row 32 shows the total distance from the corners of the PALLAS plot up to 10 meters in the Natura 2000 area.

Using the data from tables 1 and 4 and by the total number of luminaires shining in the direction of the relevant corner of the PALLAS plot, table 5 calculates the total illuminance, 10 meters within the Natura 2000 area.

Table 4: Calculation of angle α

28	***Calculation of angle α***	NI		Parking area		Parking area		NI	
29	Distance	A - A'		B - B'		C - C'		D - D'	
30	Shortest distance between the Nature 2000 area and the PALLAS plot	260	m	300	m	330	m	420	m
31	Border line for 0,1 Lx inside Natura 2000 area	10	m	10	m	10	m	10	m
32	Total distance	270	m	310	m	340	m	430	m
33	Light point height lph	15	m	15	m	15	m	15	m
34	tan α = distance / lph	18,00		20,67		22,67		28,67	
35	α = [degrees]	86,82		87,23		87,47		88,00	
36	Cos α	0,055		0,048		0,044		0,035	

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Table 5: Calculation of illuminances

37	***Calculation of the illuminances***	Nuclear island			Parking area			Parking area			Nuclear island		
38		Qty.	Total I at α	E	Qty.	Total I at α	E	Qty.	Total I at α	E	Qty.	Total I at α	E
40			[cd]	[Lx]		[cd]	[Lx]		[cd]	[Lx]		[cd]	[Lx]
41	V5, O52 LED DALI	2	1000	0,0008	3	1500	0,0008				4	2000	0,0004
42	V10, O52 LED DALI	3	3000	0,0023	3	3000	0,0015	9	9000	0,0034			
43	V15, O52 LED DALI dim	5	7500	0,0057	15	22500	0,0113	15	22500	0,0086			
44	X3,5, Next 0 LED 3500	9	1575	0,0012	2	350	0,0002	4	700	0,0003	7	1225	0,0002
45	Y3,5, O49 / CL/OP DALI	12	8400	0,0064	12	8400	0,0042	7	4900	0,0019	4	2800	0,0005
46	W35, O91 LED 35000 HF	14	49000	0,0372	10	35000	0,0176	7	24500	0,0093	7	24500	0,0046
47	**Total illuminance [Lx]**			**0,0535**			**0,0355**			**0,0234**			**0,0057**

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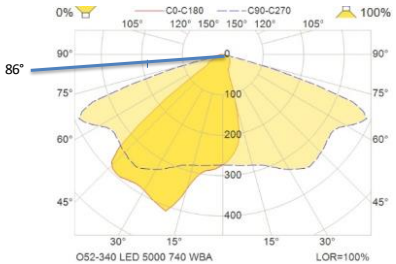
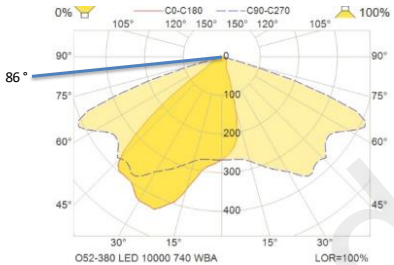
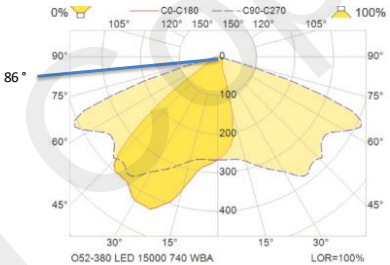
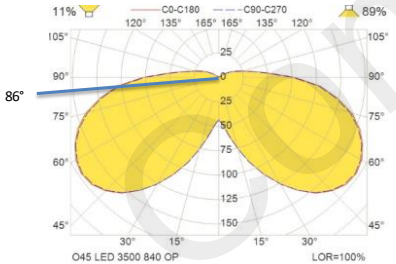
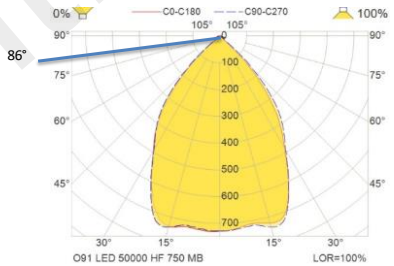
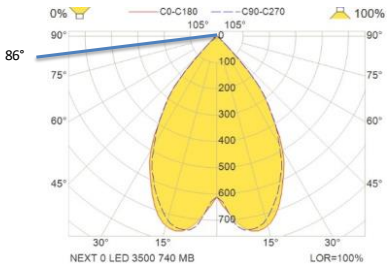
5 POLAR DIAGRAMS

Luminaire code	V5	V10	V15
Model	Glamox O52 LED DALI	Glamox O52 LED DALI	Glamox O52 LED DALI DIM
Luminous flux [Lm]	5000	10000	15000
Picture			
Polar Diagram Angle 86°			
Remarks			
Specific lightcurrent (I) at angle 86° [cd/kLm]	50	50	50

Luminaire code	Y3,5	W35	X3,5
Model	Glamox O49 CL/OP DALI	Glamox O91 LED 35000 ASY	Glamox Next 0
Luminous flux [Lm]	3500	35000	3300
Picture			
Polar Diagram Diagram O49 not available Diagram is O45 Angle			
Remarks			
Specific lightcurrent (I) at angle 86° [cd/kLm]	100	50	50

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6 REFERENCES

[1] PLLS-5030-2AREIC-012 Lay-out Nature 2000 contour line 0,1 lux

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Summary of the Document Signature Procedure: PLLS-5030-MEMO-EL-001-A

Description	Name	Date
Reviewed by	Ron Steentjes	07-20-2020
Reviewed by	Marticorena, Alfredo Agustin	07-25-2020
Reviewed by	Frank Schilders	07-20-2020
Reviewed by	Rick van Lent	07-20-2020
Approved by	De Lorenzo, Nestor Pedro Gabriel	07-27-2020

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Principles used in determining the 0,1 Lux contour line:

- The displayed 0,1 Lx contour line only applies to the outdoor lighting from the PALLAS terrain.
- Light from other parts of the site or from other structures is not taken into account.
- All lighting on the PALLAS site is switched on.
- The 0,1 Lx contour line is drawn as if the light from the PALLAS site is not obstructed by any obstacles (structures, dunes).
- It has been calculated that the light sources shining in the direction of the respective points A to D on the edge of the Natura 2000 area concentrate in the corresponding vertices of the PALLAS site.
- Light point height is 15m above ground level.

LEGEND:

NATURA 2000 AREA

Perimeter 0,1lx from the lighting sources on the PALLAS plot

Borderline for 0,1lx at 10m inside the NATURA 2000 area

SCALE 1:1000

0 10 20 30 40 50 60 70 80 90 100m

Responsible Dept.	Created by	Checked by	Technical reference	Approved by	Issue date
Electrical	Rafal Goc	Frank Schilders	Rick van Lent	Nestor de Lorenzo	07/07/2020

Layout RD 20.05

PALLAS

ICHOS

NATURA 2000
CONTOUR LINE 0,1 Lux

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Scale	Base document	Date of issue	Lang	Sheet
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