BEFORE THE HEARING PANEL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan

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STATEMENT OF EVIDENCE OF JOHN KINROSS MCKENSEY

(Lighting – Significant Natural Areas)

14 April 2023

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INTRODUCTION

1. My full name is John Kinross Mckensey.

2. I am employed as an Executive Engineer of LDP Ltd (Leading Design Professionals).

3. I hold a Bachelor of Engineering (Electrical) degree from the Queensland Institute of Technology. I have completed the Consulting Engineering Practice and Management programme at the University of Melbourne.

4. I am a member of several relevant associations including:

    a) Member, Illuminating Engineering Society of Australia and New Zealand (MIES).

    b) Chartered Member of Engineering New Zealand (CMEngNZ).

    c) Chartered Member of the Institution of Engineers Australia (MIE Aust).

    d) Chartered Professional Engineer Australia (CPEng Aust).

    e) National Engineers Register, Australia (NER).

    f) APEC Engineer.

    g) International Professional Engineer, Australia (IntPE).

    h) Member of the Resource Management Law Association.

    i) Member of the International Dark Sky Association.

5. I have over 40 years' experience in lighting design, providing consultancy services for a wide range of clients including local authorities, developers,

road controlling authorities and infrastructure sectors. My experience includes:

a) Lighting advisor to Auckland Council during the Proposed Auckland Unitary Plan process.

b) Lighting advisor to Christchurch City Council during the Replacement District Plan process.

c) Author or co-author of five local government codes of practice with respect to exterior lighting, each containing environmental considerations.

d) Author of the Auckland Council Sportsfield Lighting Guidelines.

e) Lighting advisor to Auckland Transport.

f) Lighting advisor to Waka Kotahi NZ Transport Agency.

6. I also have over 20 years' experience advising as to environmental lighting effects. I have provided consultancy services for private client applicants and local government regarding the assessment of lighting effects for a wide variety of activities and have previous experience in designing lighting to manage effects on the New Zealand long-tailed bat (**LTB**). In particular, I have prepared lighting assessment of effects for exterior lighting installations for the following local projects:

a) Lighting advice to Hamilton City Council (**HCC**) to inform Plan Change 5 (**PC5**) related to the Peacocke Structure Plan Area, which included consideration of the effects of lighting on residents, motorists and the LTB.

b) Lighting advice to Titanium Park Ltd & Rukuhia Properties Ltd (**TPL/RPL**) as applicant, to inform Private Plan Change 20 to the

Waipa District Plan (**WDP**), related to the Northern Precinct adjacent Hamilton Airport, which included consideration of the effects of lighting on residents, motorists and the LTB.

7. I was engaged by HCC in February 2023 to provide lighting advice in relation to proposed Plan Change 9 to the Hamilton City District Plan (**PC9**), particularly in relation to effects to the LTB.

CODE OF CONDUCT

8. I am familiar with the Code of Conduct for Expert Witnesses (Environment Court Practice Note 2023) and although I note this is a Council hearing, I agree to comply with this code. The evidence I will present is within my area of expertise, except where I state that I am relying on information provided by another party. I have not knowingly omitted facts or information that might alter or detract from opinions I express.

SCOPE OF EVIDENCE

9. I provide a technical analysis of anticipated effects and possible mitigation, respond to matters raised in submissions and comment on the updated PC9 provisions.

EXECUTIVE SUMMARY

10. I have over 20 years' experience advising as to environmental lighting effects. I have provided consultancy services for private client applicants and local government regarding the assessment of lighting effects for a wide variety of activities and have previous experience in designing lighting to manage effects on the LTB, including in relation to development within the Peacocke Structure Plan Area.

11. I am generally in agreement with the lighting provisions in PC9 as notified, but recommend additions and amendments to the provisions as set out in paragraph 46 of my evidence.

12. The recommended additions and amendments respond to the fact that many of the proposed SNAs are located adjacent to existing urban areas, where light spill already occurs lawfully. In this regard the context differs from the situation I addressed in relation to Plan Change 5 and development within the Peacocke Structure Plan Area. For PC9, the lighting provisions need to reflect the existing environment, while controlling the effects of new and additional light sources.

13. For that reason, I recommend an addition to the PC9 lighting provisions which addresses the control of new light sources within that existing environment. The additional provisions address internal light spill, and exterior lighting effects.

14. For internal light spill I have modelled the extent of light spill from single and multiple storey buildings. I consider that for ground level buildings, provided they are set back 5 metres from the SNA boundary, light spill effects will be acceptable. For multiple level buildings, which have greater light spill effects, the setback needs to increase to 10 metres. If buildings encroach within these setbacks, they must not have light emitting apertures (e.g. windows) within the setback facing the SNA boundary.

15. For external lighting, I recommend that controls be placed on the lighting direction, colour temperature, and duration.

16. These recommended provisions are set out at paragraph 46 of my evidence.

TECHNICAL ANALYSIS

Context re Plan Change 5

17. Specific lighting controls were developed for the Greenfield area of Hamilton referred to as the Peacocke Structure Plan area under PC5.

18. The PC5 decision contains changes to the Operative District Plan (**ODP**) Section 25.6, intended to provide protection for the LTB in terms of obtrusive light effects. PC5 related to Greenfield space and as such, obtrusive lighting controls can readily be set without the complication of existing consented artificial lighting. In this case a 0.3 lux limit for added illuminance from artificial lighting (at the boundary of the bat habitat) was set as well as additional technical parameters relating to lighting design/type.

19. The lighting provisions in PC5 require the following additions to the ODP Section 25.6 – Lighting and Glare:

> **25.6.4.4 Peacocke Medium Density Zone: Peacocke Precinct**
>
> a) Added illuminance from artificial outdoor lighting shall not exceed 0.3 lux (horizontal and vertical) at any height at the external boundary of the Significant Bat Habitat Area (SBHA).
>
> b) Artificial outdoor lighting shall be fixed artificial outdoor lighting. Lighting attached to a vehicle is not considered to be fixed.
>
> c) Artificial outdoor lighting on land adjoining a SBHA, including land immediately on the opposite side of a road which adjoins a SBHA, must;
>
> i) Emit zero direct upward light.
> ii) Be installed with the light emitting surface facing directly down and be mounted as low as practical.
> iii) Be white LED with a maximum colour temperature of:
>
> - 3000K on land with a residential use where separated from a SBHA by a public road with maximum 2700K lighting
> - 2700K for land with a residential use directly abutting a SBHA
> - 2700K for all other uses.

iv) In the case of exterior security lighting, be controlled by a motion sensor with a short duration timer (5 minutes).

d) Artificial outdoor lighting within a SBHA is only permitted for the express use of providing emergency lighting for an essential public service that could require unavoidable maintenance at night – e.g. a waste water pumping station. The lighting must be white LED with a maximum 2700K colour temperature, installed with the light emitting surface facing directly down, emit zero direct upward light and be mounted as low as practical.

Advisory Notes:

1. The term 'Added Illuminance' means illuminance added by artificial outdoor lighting that is therefore additional to illuminance present from natural ambient lighting. The Ambient Illuminance should be measured at a nearby proxy location on the same night and for the same sky conditions (clouds, weather, etc). The proxy location must have an unobstructed view of the sky, sufficient to ensure that the measurement is not affected. The Added Illuminance may then be determined by subtracting the Ambient Illuminance from the Measured Illuminance.

2. Any illuminance meter must be recently calibrated by a suitably accredited laboratory. The calibration should consider the spectral response and the meter must accurately read to 0.01 lux.

20. PC5 addresses Greenfield new-build areas within the Peacocke Structure Plan Area. These lighting rules can be readily applied in that situation, while developments are being designed, as there are no pre-existing lighting conditions to be considered. For ease of reference and comparison, I set out the relevant PC5 provisions at **Attachment 1** to my evidence.

21. The PC5 provisions should not simply be replicated in PC9, as it is not possible to apply the same rules in areas where existing lighting may already exceed the controls required under PC5. Unlike PC5, in those areas affected by PC9, each SNA is located in an existing built environment where it is not possible to add new 'no-build and no-light' buffer zones beyond the SNA. Instead, there needs to be a method of controlling additional light sources within the existing urban environment.

Lighting Guidelines

22. In the absence of specific New Zealand guidelines regarding bats in general

and specifically the LTB, there are two international guidelines that have typically been referenced in recent consents. These being the ILP Guidance Note 08/18 (**ILP8**)[1] and EUROBATS Publication No. 8 (**EUROBATS8**)[2].

23. Both documents were produced in 2018 and have very similar recommendations. EUROBATS8 has been more commonly referenced in my experience. Hence, for consistency, I recommend referencing the EUROBATS8.

24. Having reviewed these Guidelines, I have discussed and agreed with Dr Hannah Mueller, who is providing Ecology advice and evidence for HCC, that the following principles would be desirable to apply, where lighting may affect an SNA:

    a) Using lighting only where required.

    b) Adaptive lighting controls, such as dimmers and motion sensors wherever possible, such as for security lighting.

    c) Keeping lighting intensity low, with a limit of 0.3 lux emitted at all property boundaries facing any potential bat roosting areas, such as the forest remnants.

    d) Screen planting where vehicle lighting could affect potential bat roosting and foraging areas.

    e) Choosing warmer colour lighting with a colour temperature of no more than 2700K for public lighting, and no more than 3000K for residential lighting.

    f) Using downwards facing lighting that is close to the ground and

[1] ILP Guidance note 08/18: Bats and artificial lighting in the UK" (UK Bat Guidelines) [a joint publication by the Bat Conservation Trust & the Institution of Lighting Engineers] - 2018
[2] EUROBATS Publication Series No. 8: Guidelines for consideration of bats in lighting projects - 2018

avoids upwards light spill.

g) Avoiding bright, reflective surfaces, if they are likely to cause upward obtrusive light.

25. These recommendations have been considered in formulating my opinion regarding lighting provisions for PC9.

26. One area of difference is that in the case of both Weston Lea[3] and PC5, the colour temperature limit applied to outdoor lighting within a residential lot abutting an SNA was set at 2700K rather than 3000K. Hence, for PC9, I recommend 2700K in such situations for consistency. I do however note that this setting is uncommon in most retail lighting stores, and therefore more costly and difficult to source, while the setting of 3000K is the more commonly stocked, and more reasonably priced.

Existing Effects

27. While there will be numerous existing variations in terms of dwelling design, boundary separation, style of lighting, preferences for using curtains/blinds and so forth, I have endeavoured to model an exemplar single story house to determine the potential spill light effects from interior and exterior (security) lighting.

28. In the s42A report Ms Emily Buckingham notes that she has reviewed Council GIS maps and observed that "*existing houses near the notified SNAs are set back varying distances, as close as about one meter but more commonly 5-10 meters away".*

29. I have prepared lighting models for various conditions for an exemplar single storey house nominally 10m from a SNA boundary and include the results in **Attachment 2** to my evidence.

[3] Weston Lea – Amberfield Development – Environment Court decision NZEnvC 111 - 2021

30. While the exemplar house is positioned 10m from the boundary, the results in **Attachment 2** also show the spill light present at 1m intervals from the house.

31. Based on the results shown in **Attachment 2**, for the exemplar house:

    a) Scenario 1: With all interior house lights on, all curtains open and any exterior lights off, the distance from the house to diminish to 0.3 lux spill is approximately 11 meters.

    b) Scenario 2: As for scenario 1, but with security lights on and tilted up 60 degrees, the distance from the house to diminish to 0.3 lux spill is approximately 29 meters.

    c) Scenario 3: As for scenario 1, but with curtains closed (to nominal 90% obscuration), the distance from the house to diminish to 0.3 lux spill is approximately four meters.

32. In my opinion, Scenario 3 is likely to represent a typical situation on most occasions – through screening, switching, dimming or a combination of those measures. However, Scenario 1 & 2 are also possible.

33. Hence, it is evident that for examples such as these, a requirement to meet a 0.3 lux limit at the SNA boundary is impractical under scenarios 1 & 2, but is achievable under scenario 3.

34. Based on this, I am of the opinion that it would be impractical to set a universally applied 0.3 lux limit at the SNA boundary for locations addressed under PC9. Some other form of control is needed to deliver a workable solution.

Lighting Controls

35. In my opinion, it is impractical to impose a specific spill light limit in this situation, since it is possible that any such limit may already be exceeded by lighting that has been installed lawfully under existing consents. The best that can be achieved is a control on new and additional light sources, both internal and external.

36. For the internal light spill, as evidenced by the lighting modelling in **Attachment 2** of my evidence, the light spill generated by interior lighting will most likely be significantly less than that generated by outdoor lighting (e.g. security lighting). Scenario 3 is a reasonable representation of land use in this context, and so a single storey building set back at least 5m from the boundary of an SNA will be unlikely to add illuminance beyond an additional 0.3 lux. Accordingly, in order to control light spill from internal sources, I recommend that a permitted activity set back of five meters be applied to single storey buildings, with buildings inside the setback being required to limit any sources of additional light spill. This can be achieved by ensuring there are no light emitting apertures (e.g. windows, doors, skylights etc) facing the SNA.

37. My modelling results show that for buildings that are two or more levels, the internal light spill is greater than that generated by a single level dwelling, and so a larger setback is required to mitigate the effect.

38. **Attachment 3** of my evidence shows the cumulative effect beginning with a single level dwelling with lighting adjusted to produce 0.3 lux at five meters distance, then progressively adding additional levels with the same light output from each. As shown, in order to achieve no more than 0.3 lux, the building to boundary separation will need to increase as additional levels are added.

39. Based on this modelling, I recommend that the separation distance from any new building to a SNA should be 5m for a single level building, 7.5 meters for two levels and 10 meters for three levels.

40. A permitted activity rule which controls these effects is set out at rule 25.6.4.5(a) as shown at paragraph 46.

41. For outdoor light spill, I recommend a specific set of controls that are measurable as a permitted activity standard. Those controls address lighting direction, colour temperature, and duration. These controls are set out at paragraph 44 below.

RESPONSE TO SUBMISSIONS

42. **Submission #333 Royal Forest and Bird** seeks consideration of the impact of light spill and glare on indigenous fauna within SNAs. **#428 Kāinga Ora** supports the purpose and objectives for lighting and glare as notified. **#425 Director-General of Conservation** supports Policy 25.6.1a, but requests the addition of best practice lighting design principles for consideration for activities adjacent to or within an SNA. It also requests a specific lighting rule be added requiring that lighting not exceed 0.3 lux (horizontal and vertical) when measured at the external boundary of an SNA. The **Director-General of Conservation** also seeks a building setback of 5m or 50m from SNAs (depending upon the significance of the SNA), which relates to managing light spill and glare effects. **#326 J Badham** seeks that the provisions in the Amberfield consent decision be applied city-wide, including control of artificial lighting.

43. Responding to specific matters raised in submissions:

    a) Best practice lighting design principles: These are included in my recommendations as far as reasonably practical.

b) 0.3 lux limit at SNA boundary: This is not practical to apply in existing built environments.

c) Building setback: These are useful but not practical for existing consented buildings.

d) City wide application of *Amberfield* conditions: This is not practical in existing built environments. *Amberfield* is a special case as it is a greenfield area and is in close proximity to SNAs with identified LTB activity. The conditions developed for *Amberfield* recognise those unique circumstances. In my opinion, it would not be appropriate nor practical to apply those conditions verbatim in existing built environments. In my opinion, the rules proposed at my paragraph 46 apply the *Amberfield* conditions as far as reasonably practical.

UPDATED PC9 PROVISIONS

44. The notified updates to ODP section 25.6 Lighting and Glare include some adjustments to Purpose, Objectives and Policies, to acknowledge potential lighting effects to indigenous fauna in a SNA.

45. I support the notified changes with respect to lighting effects.

46. In my opinion, the following rule should be added to the notified provisions of PC9 to provide a practical and workable limit on the introduction on new light sources to existing urban areas adjacent to SNAs:

> **25.6.4.5 Site in proximity to or within SNAs (excluding Peacocke Precinct)**
>
> a) Any part of a new or extended building that is located on a site adjacent to an SNA shall have no light emitting apertures facing the SNA if located within the following setbacks from the SNA boundary:
>
> i. For a ground level building – 5m from the SNA boundary
> ii. For each level of a two level building – 7.5m from the SNA boundary
> iii. For each level of a three or more level building – 10m from the SNA boundary

b) Additional artificial outdoor lighting installed within 20m of a SNA must;

- Emit zero upward light,
- Be installed with the light emitting surface facing directly down and mounted as low as practical,
- Be white LED with a maximum colour temperature of 2700K, and
- In the case of exterior security lighting, be controlled by a motion sensor with a short duration timer (5 minutes)

c) Additional artificial outdoor lighting within a SNA is only permitted for the express use of providing emergency lighting for an essential public service that could require unavoidable maintenance at night – e.g. a waste water pumping station. The lighting must be white LED with a maximum 2700K colour temperature, installed with the light emitting surface facing directly down, emit zero direct upward light and be mounted as low as practical.

Advisory Notes:

1. The term "light emitting apertures" means windows, doors, skylights, translucent roofing or similar which emit light.
2. The term "additional" with respect to lighting in this context, means additional to lighting that was existing and legitimate when this rule took effect.

CONCLUSION

47. I agree with the lighting provisions in PC9 as notified, but recommend the addition to the provisions as set out in paragraph 46 of my evidence.

48. In my opinion, the PC9 provisions, amended as I have proposed, will mitigate lighting effects to the LTB as far as reasonably practical given the existing environment.

John Kinross Mckensey

14 April 2023

25.6 Lighting and Glare

25.6.1 Purpose

a) Intrusive lighting is lighting that causes a nuisance to other people, usually by glare or light spill on to other people or properties. The District Plan manages these effects to protect amenity and safety values.

Plan Change 5 Peacocke Structure Plan

25.6.2 Objectives and Policies: Lighting and Glare

Objective	Policies
25.6.2.1 An environment free from the adverse effects of intrusive lighting.	**25.6.2.1a** Ensure that light spill and glare do not detract from the amenity values of other properties, compromise traffic safety, or have a negative effect on people's health and general welfare.
25.6.2.2 *Lighting in the Peacocke Structure Plan Area is managed to ensure areas identified as Significant Bat Habitat Area retain their usability and functionality for bat activity.*	***25.6.2.2a*** *Manage light spill and glare of fixed lighting at the boundary of the Significant Bat Habitat Area to ensure that the useability of long-tailed bat habitat is maintained while maintaining safety on adjoining properties. (55.389)*
	25.6.2.2b *Ensure that fixed lighting in public spaces, such as parks and road corridors is designed to minimise the effects of lighting and glare on Significant Bat Habitat Area while also achieving a safe public realm for the community. (55.389)*
Explanation	

Intrusive lighting may include light from floodlights, security lights and activities such as welding. Light spill and glare have the potential to disturb people's sleep, which could adversely affect their health and general welfare. Unlike other adverse effects of activities, like smoke or noise, which are difficult to contain completely, light spill is reasonably simple to avoid by correct aiming or baffling (shading) of the light source.

The Peacocke Precinct is an important habitat for long-tail bats which are a threatened native species. Due to the presence of bats in the area, it is important the effects of development are managed to ensure bats are able to continue to move and forage through the area. This needs to be balanced against the safety needs of the community (55.389). Bats are particularly sensitive to light, which has the potential to inhibit their movement and feeding habits. For this reason it is important that those area of Peacocke identified as being Significant Bat Habitat Areas are protected from the effects of excessive (55.389) lighting and glare.

25.6.3 Rules – General Standards

a) Artificial lighting shall not result in illumination on transport corridors which may dazzle or distract transport corridor users or train drivers, or interfere with any traffic aids or signals. The relevant clauses of Australian Standard AS4282 1997 Control of the Obtrusive Effects of Outdoor Lighting shall apply with respect to the effect of artificial lighting on traffic.

b) Lighting designed to illuminate public spaces and transport corridors, including roads, public car parks and amenity areas, shall be designed in accordance with the Australian and New Zealand AS/NZS suite of standards.

Note

1. Acceptable means of compliance for the provision, design and construction of transport corridor lighting is contained within the Hamilton City Infrastructure Technical Specifications.

25.6.4 Rules – Specific Standards

25.6.4.1 Residential, Special Character, Future Urban and Community Facilities Zones

a) For any activity in any Residential or Special Character Zones, or the Future Urban or Community Facilities Zones, the spill of light from artificial lighting (excluding street and navigation lights and traffic signals) on to any other site shall not exceed 3 lux (horizontal and vertical) when measured or calculated at points 1.5m within the boundary of any other site.

25.6.4.2 Open Space Zones

a) Light spill from artificial lighting (excluding street and navigation lights and traffic signals) used in Open Space Zones shall comply with the following standards.

Location of light source (site in Open Space Zone)	Where measured	Standard
i. Sport and Recreation, Neighbourhood, and Natural Open Space	Measured horizontally or vertically, at points 1.5m within the boundary of any other site	Maximum 3 lux

25.6.4.4 *Peacocke Medium Density Zone: Peacocke Precinct*

a) *~~Lighting~~ Added illuminance from artificial outdoor lighting shall not exceed 0.3 lux (horizontal and vertical) at any height ~~when measured~~ at the external boundary of the Significant Bat Habitat Area (SBHA)(30.4/ 23.16).*

b) *Artificial outdoor lighting shall be fixed artificial outdoor lighting. Lighting attached to a vehicle is not considered to be fixed (30.4).*

c) *Artificial outdoor lighting on land adjoining a SBHA, including land immediately on the opposite side of the road which adjoins a SBHA, must; (30.4)*

   i. *Emit zero direct upward light. (30.4)*

   ii. *Be installed with the light emitting surface facing directly down and be mounted as low as practical. (30.4)*

   iii. *Be white LED, a maximum colour temperature of;*

      - *3000K on land with a residential use where separated from a SBHA by a public road with maximum 2700K lighting*
      - *2700K for land with a residential use, directly abutting a SBHA*
      - *2700K for all other uses (30.4)*

   iv. *In the case of exterior security lighting, be controlled by a motion sensor with a short duration timer (5 minutes). (30.4)*

d) *Artificial exterior lighting within a SBHA is only permitted for the express use of providing emergency lighting for an essential public service that could require unavoidable maintenance at night – e.g. a waste water pumping station. The lighting must be white LED with a maximum 2700k colour temperature, installed with the light emitting surface facing directly down, emit zero direct upward light and be mounted as low as practical (30.4).*

Advisory notes

1. The term 'Added Illuminance' means illuminance added by artificial outdoor lighting that is therefore additional to illuminance present from natural ambient lighting. The Ambient Illuminance should be measured at a nearby proxy location on the same night and for the same sky conditions (clouds, weather, etc). The proxy location must have an unobstructed view of the sky, sufficient to ensure that the measurement is not affected. The Added Illuminance may then be determined by subtracting the Ambient Illuminance from the Measured Illuminance.

2. Any illuminance meter must be recently calibrated by a suitably accredited laboratory. The calibration should consider the spectral response and the meter must accurately read 100.1 lux (30.4).

25.6.4.5 All Other Zones

a) The spill of light from artificial lighting (excluding street and navigation lights and traffic signals) on to any other site shall not exceed 10 lux (horizontal and vertical)

ATTACHMENT 2: EXEMPLAR HOUSE – LIGHT SPILL MODELLING

Caveat

The following examples, of potential spill light effects that could be generated by indoor and outdoor lighting provide, in my opinion, a reasonably conservative indication of what could be expected for a single story house adjacent an SNA.
The considerable number of potential variables are such that I do not propose, nor recommend, the use of specific calculated values in ODP rules.
The model assumes that all lights are operating in every room facing the SNA at 100% output. In my opinion this is unlikely to occur on most occasions as in practice, lighting tends only to be turned on in rooms that are in use at the time.

Basis of Model

The model assumes a significant area of glazing as shown, with 80% light transmittance and no attenuation from curtains, blinds, planting, etc other than as noted. Relatively high interior illuminance values of approximately 90-150 lux average have been assumed. Also, the interior surface reflectance used ignores potential losses from furniture and the reflectance values are conservative in my opinion (Ceiling: 80%, walls: 50% & floor: 20%).

Possible variables

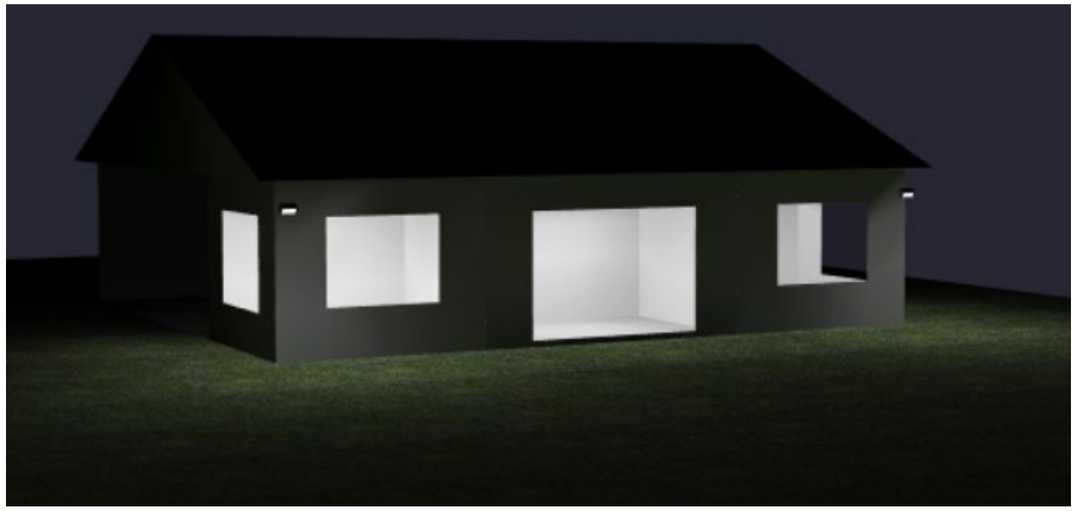
While not exhaustive, variables could include;

- Interior & exterior lighting types, quantities, aiming, age, cleanliness and actual room average illuminance
- Glazing area & light transmittance
- Screening
- Overall house dimensions and separation from the SNA
- Proximity of neighbouring houses
- Building height and number of stories
- Site topography

Summary of Results

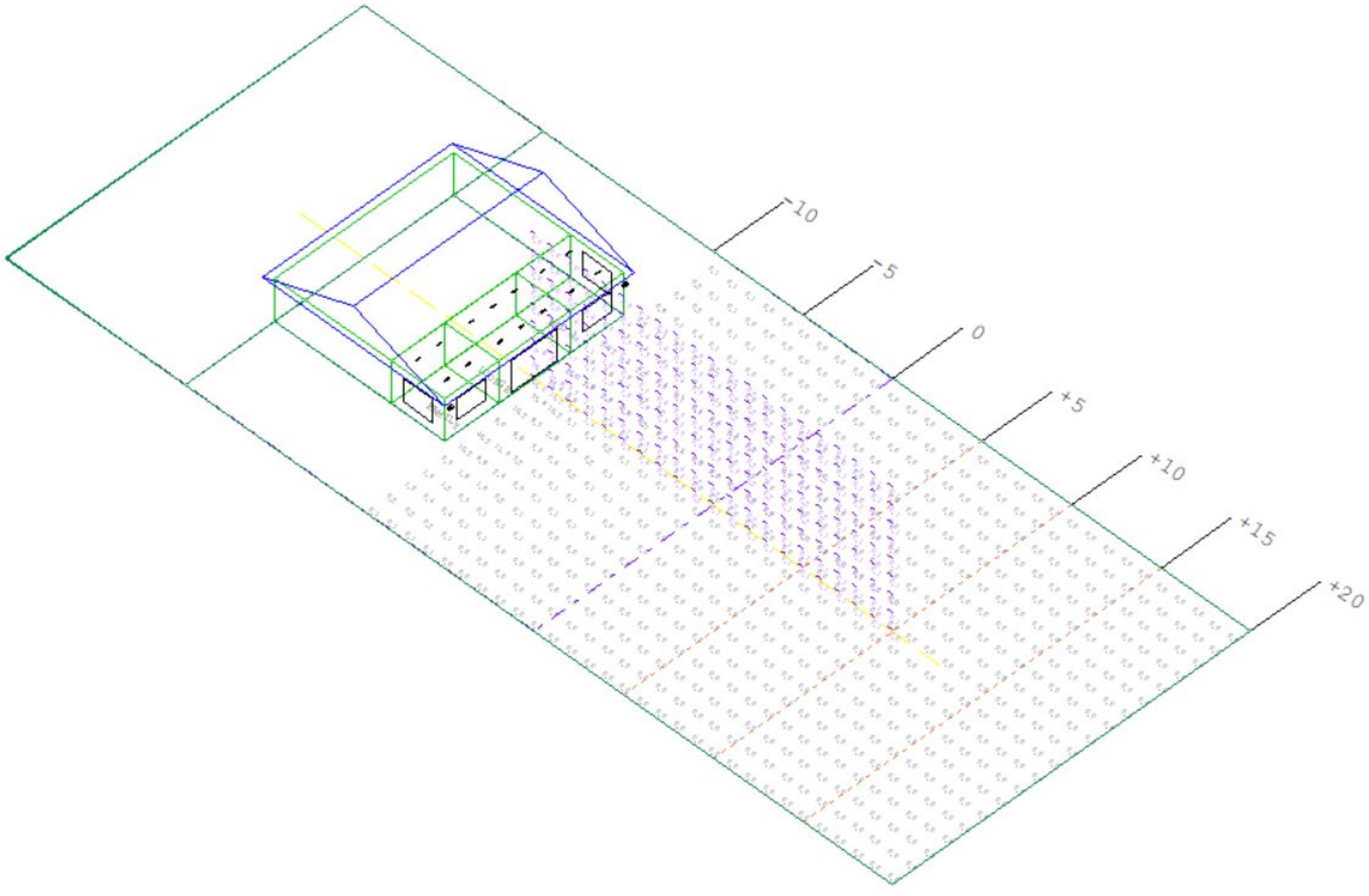
SCENARIO	DESCRIPTION	DISTANCE FROM HOUSE TO 0.3 LUX	
		HORIZONTAL	VERTICAL
1	All interior lights ON. No screening. All exterior lights OFF	4.5m	11m
2	All interior lights ON. No screening. All exterior lights ON	14.5m	29m
3	All interior lights ON. Curtains closed (90% screening). All exterior lights OFF	3.3m	4m

Rendered view – rear of building (similar for all scenarios)

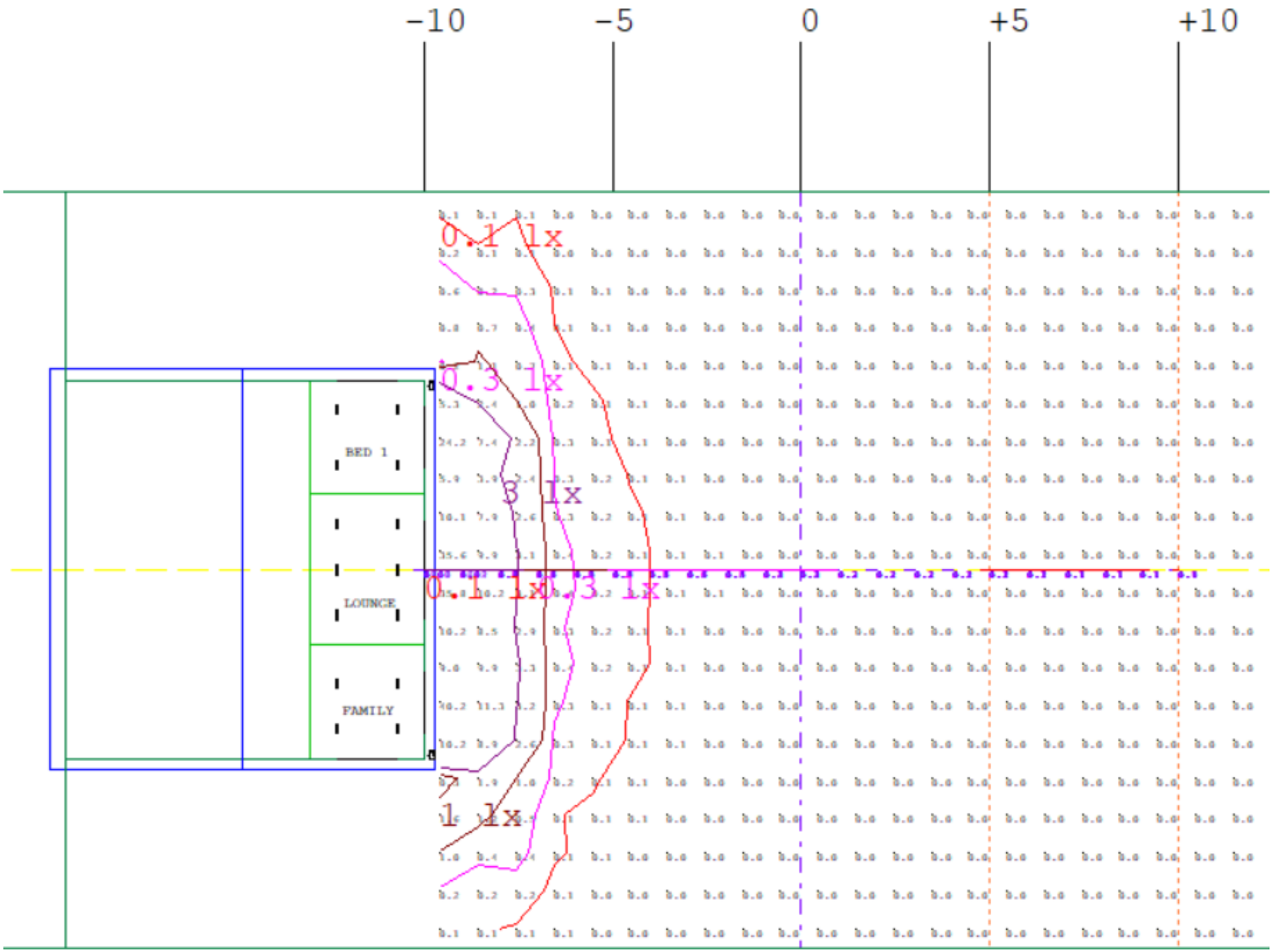


<u>SCENARIO 1:</u> All interior lights ON. No screening. All exterior lights OFF.

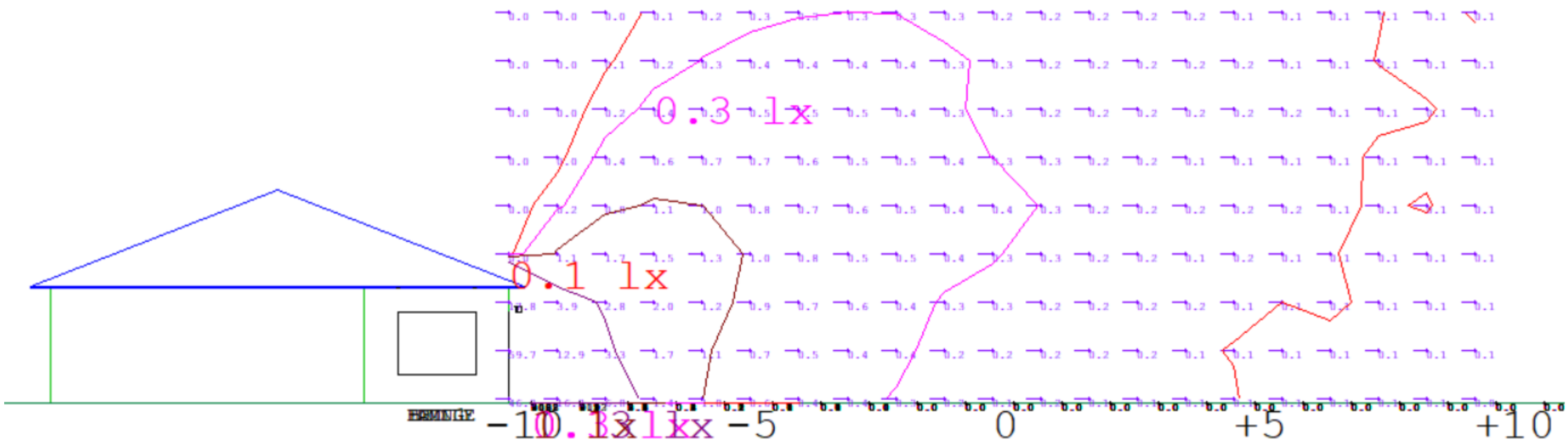
1.0 Isometric view (to aid understanding of calculation planes)



1.1 Plan view (Horizontal illuminance [lux] – ground level – 1m x 1m grid):

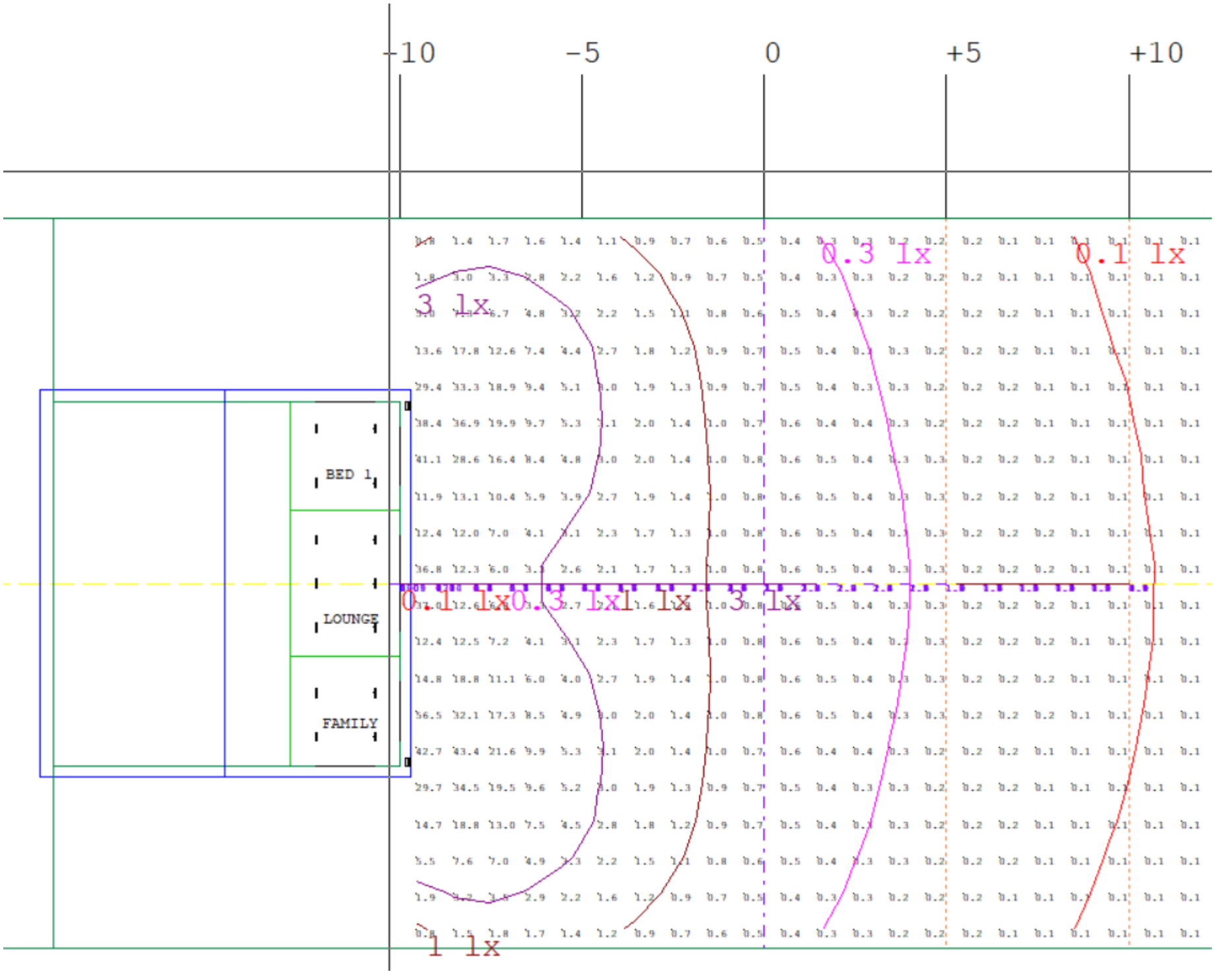


1.2 Side view (Vertical illuminance [lux] – 0m to 8m high – 1m x 1m grid):

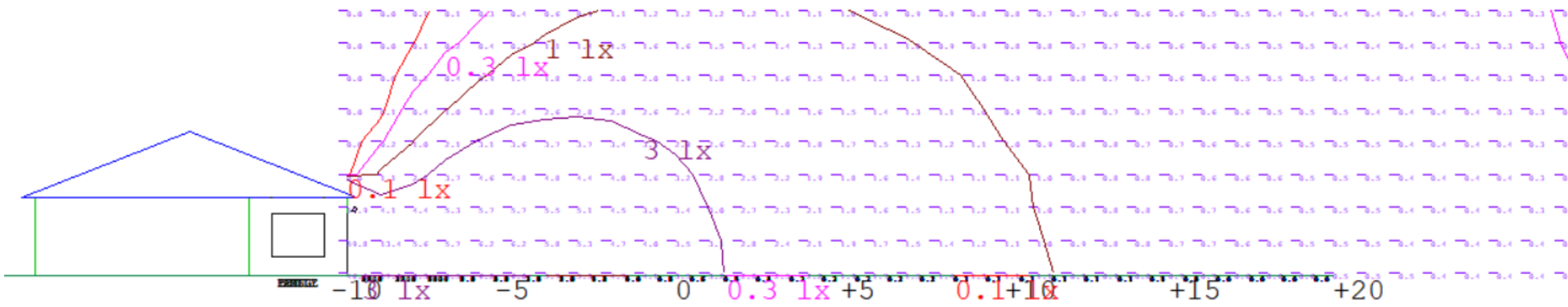


<u>SCENARIO 2:</u> All interior lights ON. No screening. All exterior lights ON.

2.1 Plan view (Horizontal illuminance [lux] – ground level – 1m x 1m grid):

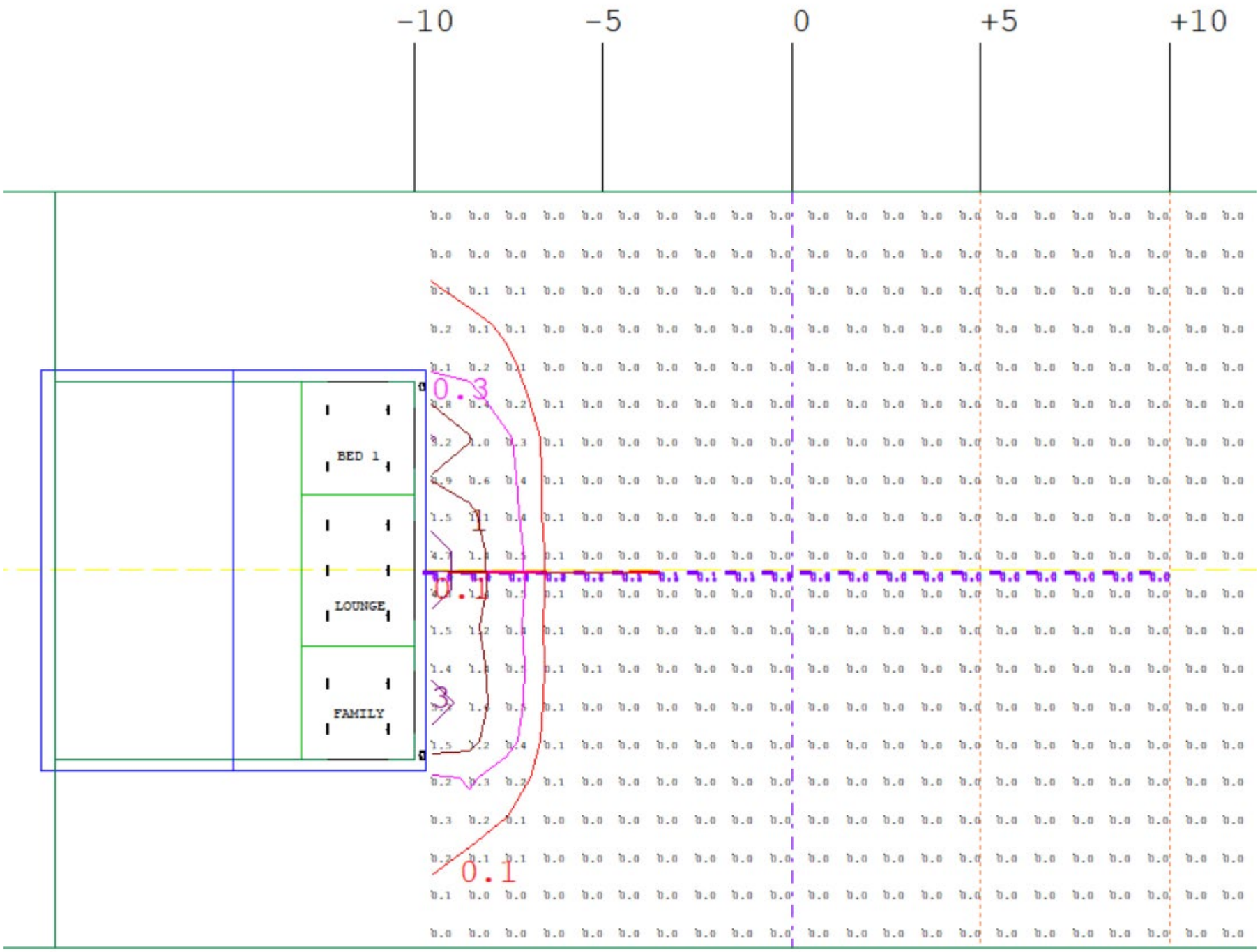


2.2 Side view (Vertical illuminance [lux] – 0m to 8m high – 1m x 1m grid):



<u>SCENARIO 3:</u> All interior lights ON. Curtains closed (90% screening). All exterior lights OFF.

3.1 Plan view (Horizontal illuminance [lux] – ground level – 1m x 1m grid):



3.2 Side view (Vertical illuminance [lux] – 0m to 8m high – 1m x 1m grid):

ATTACHMENT 3: EXEMPLAR 3 STORY BUILDING – LIGHT SPILL MODELLING

Caveat

The following examples, of potential spill light effects that could be generated by indoor lighting extrapolate the cumulative light spill effect for identical interior lighting effects generated per level for 1, 2 or 3 stories.

For the sake of simplicity, the light spill for any one level has been normalised to 0.3 lux at 5m from the building.

Basis of Model

As per the model in Appendix B.

Possible variables

As per the model in Appendix B.

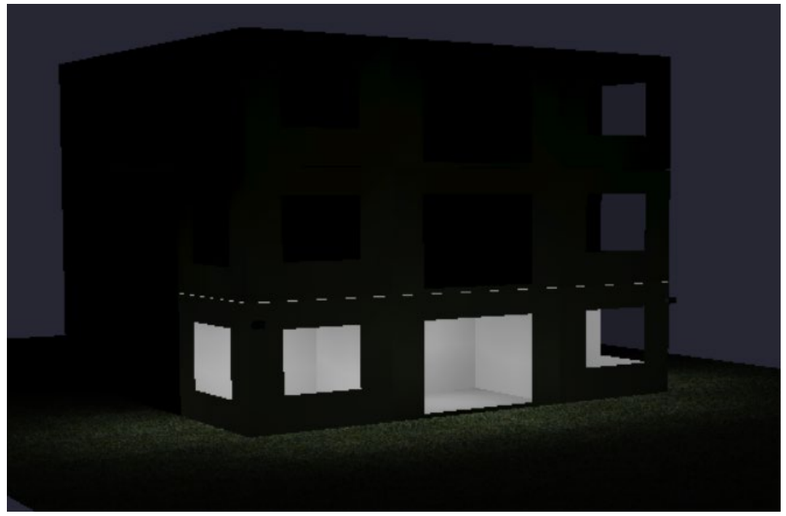
Summary of Results

Since the exemplar house has established that the vertical plane illuminance will consistently be greater than that in the horizontal plane, the vertical plane results are summarised below.

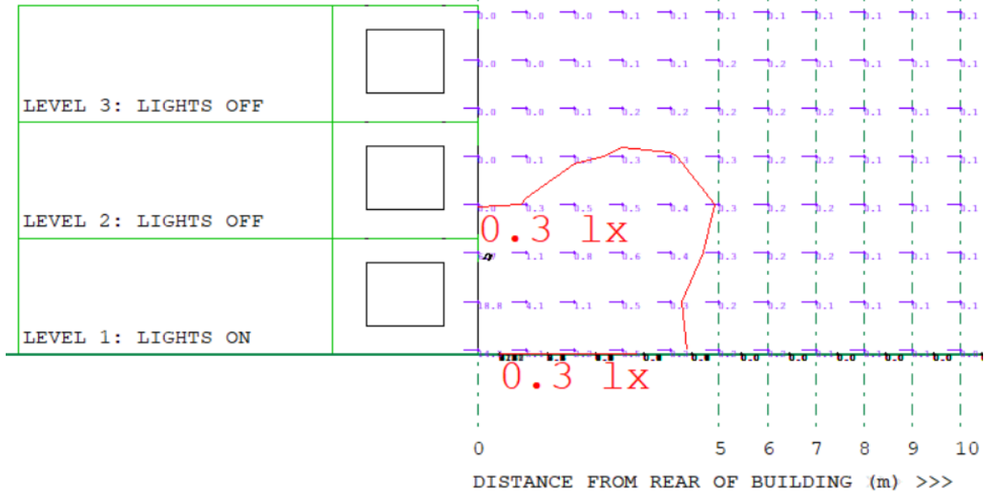
SCENARIO	DESCRIPTION	DISTANCE FROM BUILDING TO 0.3 LUX
1	Lights on: 1 storey	5m
2	Lights on: 2 stories	7.5m
3	Lights on: 3 stories	10m

LIGHTS ON: LEVEL 1 ONLY

Rendered view – rear of building

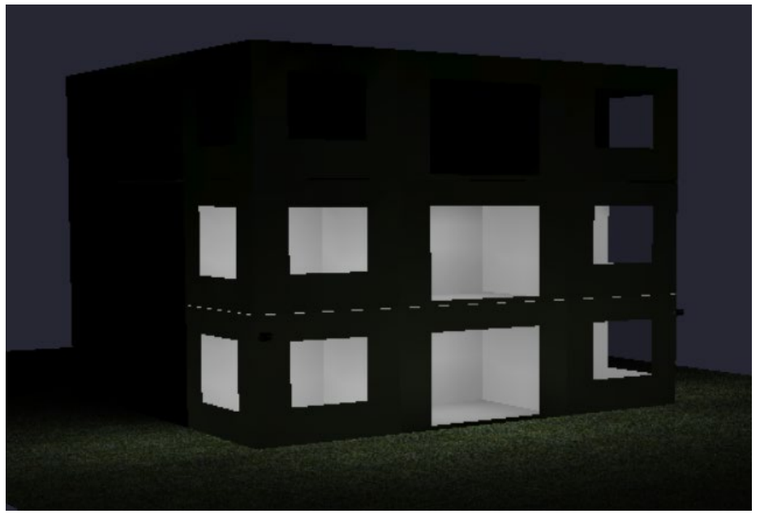


Light Spill (lux) – vertical plane along the centreline of the building – Side view

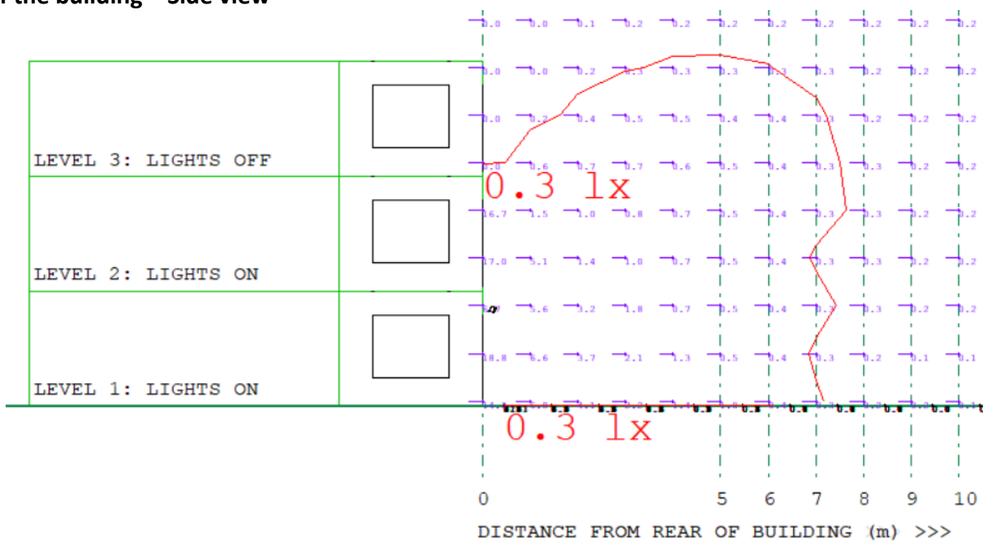


LIGHTS ON: LEVELS 1 + 2

Rendered view – rear of building

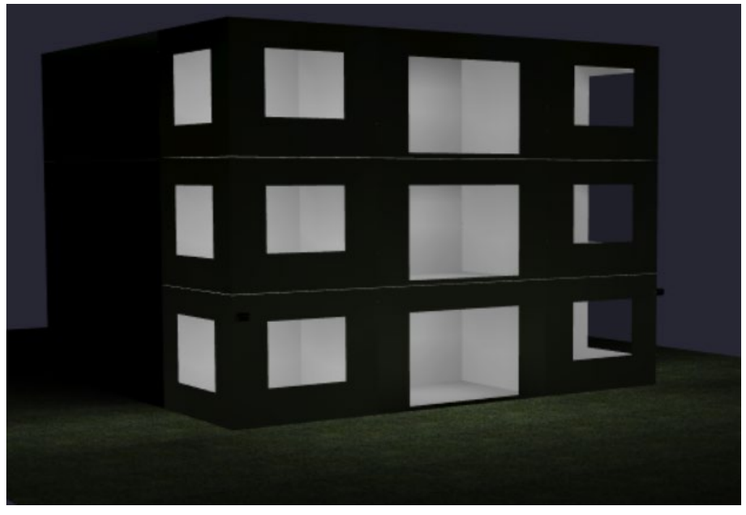


Light Spill (lux) – vertical plane along the centreline of the building – Side view



LIGHTS ON: LEVELS 1 + 2 + 3

Rendered view – rear of building



Light Spill (lux) – vertical plane along the centreline of the building – Side view