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WAIHI NORTH PROJECT

ASSESSMENT OF ENVIRONMENTAL EFFECTS: LIGHTING

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TECHNICAL REPORT
WAIHI NORTH PROJECT – ASSESSMENT OF ENVIRONMENTAL EFFECTS – LIGHTING
GENERAL AREA 000

QUALITY ASSURANCE STATEMENT

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EXECUTIVE SUMMARY

Pedersen Read has been asked to undertake an assessment of environmental effects (AEE) for the artificial lighting associated with the proposed Waihi North Project (WNP) at the Oceana Gold (New Zealand) Limited (OGNZL) Waihi Mine, in the Hauraki District of the North Island.

The assessment has been based upon the descriptions of the project provided in OceanaGold's, "*Waihi North Project – Fast-track Approval, Project Description*", information provided by Mitchell Daysh and OceanaGold on the proposed construction, operation, and remediation of each of the WNP areas, and various visual simulations and reports. Refer to Appendix A: "*Bibliography"* for the list of documents and activities that have informed the review.

The proposed lighting has been assessed against the Hauraki District Plan for "*Glare and Lighting"*, and Australian and New Zealand Standard AS/NZS 4282: 2023, "*Control of the obtrusive effects of outdoor lighting*". AS/NZS 4282 is the recognised standard in Australasia for managing the effects of outdoor lighting. The latest revision of this Standard now includes reference to the "*National Light Pollution Guidelines for Wildlife"* published by the Australian Government's Department of Climate Change, Energy, the Environment and Water.

The impact of artificial lighting on the night-time environment is defined in AS/NZS 4282:2023 as the following effects, spill light, glare, and sky glow.

- Spill Light:
  "*Light emitted by a lighting installation that falls outside the boundaries of the property for which the lighting installation is designed*".
- Glare:
  A "*Condition of vision in which there is discomfort or a reduction in ability to see, or both, caused by an unsuitable distribution or range of luminance, or to extreme contrasts in the field of vision*".
- Sky Glow:
  The *"brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered from the constituents of the atmosphere (gas molecules, aerosols and particulate matter), in the direction of observation".*

The aim of the National Light Pollution Guidelines for Wildlife is that artificial light is managed so that wildlife is:

- Not disrupted within, or displaced from, important habitat.
- Able to undertake critical behaviours such as foraging, reproduction and dispersal.

The guidelines recognise that animals perceive light differently from humans, with most animals being sensitive to ultraviolet (UV)/violet/blue light.

The guidelines recommend:

1. Always using best practice lighting design to reduce light pollution and minimise the effect on wildlife.
2. Undertaking an environmental impact assessment of effects of artificial light on listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.

According to the guidelines, best practice lighting design incorporates the following design principles:

1. Start with natural darkness and only add light for specific purposes.
2. Use adaptive light controls to manage light timing, intensity and colour.
3. Light only the object or area intended – keep lights close to the ground, directed, and shielded to avoid light spill.
4. Use the lowest intensity lighting appropriate for the task.
5. Use non-reflective, dark-coloured surfaces.
6. Use lights with reduced or filtered blue, violet and ultraviolet wavelengths.

In almost all WNP situations, direct spill light should be able to be contained to comply with the Hauraki District Plan requirement for a maximum of 8.0 lux (lumens per square metre) “at any point on or directly above the boundary of any adjacent site or road” (Reference: Hauraki District Plan, Section 8.2.5.3 (2)).

Potential exceptions to this are the use of mobile lighting plant associated with the services trench construction, lighting to the Willows Surface Facilities Area (Willows SFA) site entry gate, and lighting associated with areas in the conservation estate (i.e. exploration drill, camp, pump, manned portable rig, geotechnical, pumping test, and vent shaft sites).

Artificial lighting associated with services trench construction would be used sparsely, with the majority of activities to be undertaken during daytime. Permanent lighting to the Willows Road / SH25 intersection would be designed and installed in accordance with Waka Kotahi’s standards.

Lighting associated with sites in the conservation estate should be designed and installed in accordance with the National Light Pollution Guidelines for Wildlife. In particular, luminaires with reduced or filtered blue, violet and ultraviolet wavelengths should be used. This combined with careful aiming of luminaires into the site should help reduce spill light effects.

The area for the Wharekirauponga Underground Mine (WUG) Surface Facilities Area (SFA), mine portal, and rock stack, is presently sparsely illuminated. Above-ground construction activities requiring artificial lighting would result in an increase in both glare and sky-glow from locations with a view of the area. Mobile lighting plant has the most potential to create these effects, however, they could be mitigated by careful lighting plant selection, location, and luminaire orientation and aiming (i.e., into the site). Mobile lighting plant should also be designed and used in accordance with the National Light Pollution Guidelines for Wildlife. Such management should be included in the procedures for the use of mobile lighting plant. If appropriate management combined with careful lighting control is undertaken, then the potential effects are expected to be minor given their temporary nature and them predominantly occurring during day shift operations. Wherever practicable, activities in areas of lighting sensitivity should be undertaken during daylight hours.

Permanent lighting to the Willows SFA should be designed to minimise both glare and sky glow effects such that they are less than minor.

The GOP and Processing Plant areas of the WNP occur in proximity to existing mining operations. As such, these areas presently either have some form of artificial lighting to support operations or would be set against the backdrop of existing operational areas.

The NRS and TSF3 areas may operate during darkness, requiring both vehicle lighting (head, tail, task, and security) and mobile lighting equipment. In addition to lighting intensity, rapidly changing lighting, such as vehicle security lighting, can be obtrusive and be visible from several kilometres away. Both locations would produce lighting effects that would be visible from various locations outside of the mine site. The extent of effects would depend upon the perspective of the viewer, and the viewing location. Whilst the effects from vehicle lighting (head, task, and security) would be remotely visible, AS/NZS 4282:2023 does not apply to such lighting. The effects from mobile lighting equipment mitigated in accordance with the National Pollution Guidelines for Wildlife, could range from "Moderate – Low" to "Moderate" for those residents who value the existing darkened night environment (using Boffa Miskell's visual effect ratings).

Mobile lighting plant has the most potential to create glare and sky glow effects, given the need to illuminate large construction activities and/or changing operational areas. The effects are expected to be minor given their proximity to existing mining operations, temporary nature and the Standard Operating Procedure to position the lighting towers so that they "Do not shine towards a public road or buildings". Mobile lighting plant should also be designed and used in accordance with the National Light Pollution Guidelines for Wildlife.

Permanent lighting to these areas is likely to be an improvement over that presently installed throughout the existing mine, with lesser effects from glare and sky glow due to the change to LED lighting technology and appropriate luminaire selection, orientation, and aiming. The effects are expected to be less than minor in the context of the existing mine lighting.

Ecological Effects:

The local ecology from the perspective of the assessment includes terrestrial invertebrates, native frogs, native lizards, bats, and native birds. Non-lethal stressors, such as artificial light can generate response such as heightened stress (and potential loss of condition as a consequence), avoidance behaviours, altered behaviour (e.g. change in volume or pitch of bird calls, reduced emergence) and reduced / failed reproduction.

With respect to the Willows (SFA), the greatest lighting effects are likely to occur during the SFA and Tunnel construction stages when mobile lighting plant is used for the construction of the Willows SFA, the mine portal, and during movements to and from the Willows Rock Stack. Mobile lighting has the greatest potential to effect fauna through skyglow and luminaire light source visibility (glare) from distance when luminaires are not oriented "flat glass". However, the location of mobile lighting plant would be expected to vary as construction works progressed reducing the effects in any given location.

Permanent lighting associated with the Willows SFA would be designed using principles to reduce adverse lighting effects as outlined in section 3.3.2 of this document.

Boffa Miskell's ecologists assess the magnitude of effect of lighting impacts at the Willows SFA as **LOW** and the ecological value of the fauna as **LOW**. Therefore, the level of effect of artificial lighting on the ecology is assessed as **LOW**.

Boffa Miskell's ecologists note that because of the absence of existing artificial light, fauna within the Coromandel Forest Park would be naïve to artificial lighting effects and would be expected to respond more strongly than those in urban / semi urban environments – where many of the study sites in scientific literature are located.

In their summary of the effects of artificial lighting, Boffa Miskell ecologists note that Coromandel Forest Park provides important habitat for native species to undertake biologically important activities such as foraging, breeding, roosting or dispersal. They also consider the localised nature of the lighting effect in the context of the whole forest park and the short duration of the effect at any on particular site (from a few days to several months, from their perspective, temporary). The effects of artificial lighting are expected to be immediately reversible once the drill rig / camp site / pump is removed.

They assess the magnitude of effects of lighting impacts in Coromandel Forest Park from an ecological perspective, if the effects are mitigated to the extent possible using proposed controls, to be **Low - Moderate**. They note that the ecological value of the fauna is **Very High** and therefore the level of effect of artificial lighting is assessed as **Moderate**.

To minimise ecological effects in the Willows SFA and within the Coromandel Forest Park, lighting installations would follow the best practice principles in the National Light Pollution Guidelines for Wildlife.

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1. INTRODUCTION

Pedersen Read has been asked to undertake an assessment of environmental effects (AEE) for the artificial lighting associated with the proposed Waihi North Project (WNP) at the Oceana Gold (New Zealand) Limited (OGNZL) Waihi Mine, in the Hauraki District of the North Island.

The assessment is based upon the description of the project provided in OceanaGold's, "*Waihi North Project – Fast-track Approval, Project Description*", information provided by Mitchell Daysh and OceanaGold on the proposed construction, operation, and remediation of each of the WNP areas, and various visual simulations and reports. Refer to Appendix A: "*Bibliography"* for the list of documents and activities that have informed the review.

A day and night visit to the mine site was undertaken on Thursday the 18th of November 2021 in conjunction with a review of the surrounding environs on the night of Wednesday the 17th of November 2021.

The night-time visit to the mine site occurred on Thursday 18th November between 21:00 and 21:30. (On that day Nautical dusk was at 21:13 and Astronomical Dusk at 21:53). Weather conditions were clear with a north-northwest wind of 17km/h. The moon was full, with moonrise at 19:00 and the moon at a low altitude (19 to 27°) during the site visit.

The night-time visit of the surrounding environs occurred on Wednesday 17th November between 21:00 and 22:30. (On that day Nautical dusk was at 21:12 and Astronomical Dusk at 21:51). Weather conditions were high overcast with a westerly wind of 15km/h. The moon was full, albeit predominantly obscured by high cloud, with moonrise at 18:01 and the moon at between 29 to 39° altitude during the site visit.

2. SITUATION

2.1 GENERAL

The Waihi North Project would build upon the existing mining activities in and around the township of Waihi and consists of the following key areas to be considered from an artificial lighting perspective:

a. **Wharekirauponga Underground Mine (WUG)**: A new underground mine at Wharekirauponga, just north of Waihi. This mine would have associated above ground infrastructure on private land at the end of Willows Road, Waihi. This above ground infrastructure would be known as the Willows Surface Facilities Area (Willows SFA).

b. **Waihi North Project Services Trench (WNPST):** To be established between the Waihi Surface Facilities Area and the Willows SFA associated with the WUG to carry electricity, fibre, and water services within buried pipelines

c. **Gladstone Open Pit (GOP)**: A new opencast mine directly to the west of the existing OGNZL Waihi Processing Plant.

d. **Northern Rock Stack (NRS)**: A rock storage facility to the north of the current tailings storage facilities.

e. **Processing Plant and Water Treatment Plant Upgrades**: Upgrade of the Processing Plant and Water Treatment Plant to provide more capacity.

f. **Tailings Storage**: A new tailings storage facility (TSF3) to be developed to the east of the current facilities. Additional tailings storage would also occur within the GOP once mining there is complete.

g. **Exploration Drill, Camp, Pump, Manned Portable Rig, Geotechnical, Pumping Test, and Vent Shaft Sites**: A series of sites within the conservation estate – the Coromandel Forest Park.

The above ground infrastructure area associated with the WUG would be located on farmland at the northern end of Willows Road and south of the Coromandel Forest Park - in an area referred to as the Willows SFA. (Reference Figure 1)

The balance of the proposed project areas are adjacent to the existing mining activities at the Waihi mine. (Reference Figure 2)

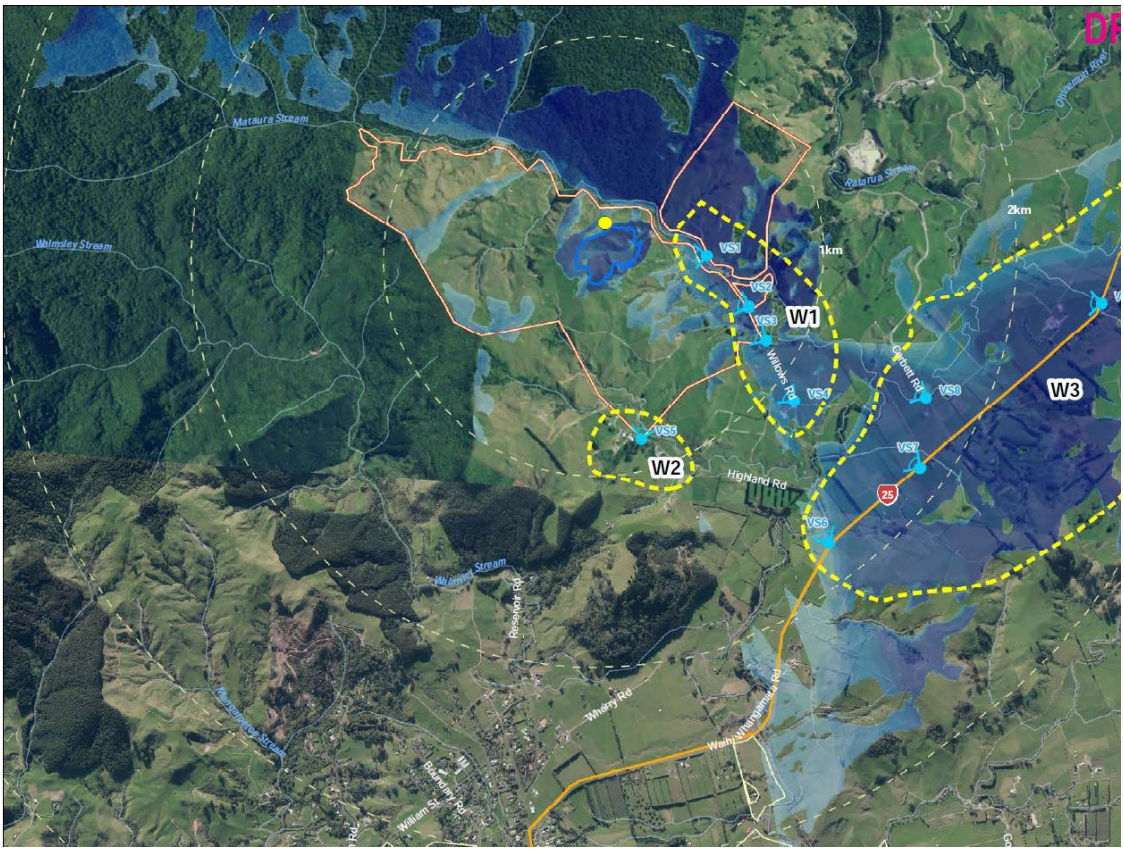


Figure 1: Willows Surface Facilities Area (Boffa Miskell Willows Road Visual Appraisal, Figure 8, 27 September 2024, Rev 5)

Figure 2: WNP Overview around existing mine operations (Boffa Miskell Figure 21b, September 2024 Rev 4)

2.2 EXISTING LIGHTING ENVIRONMENT

The Willows SFA is set in the context of open farmland against the backdrop of the unilluminated Coromandel Forest Park.

Existing lighting in the area is limited to that directly associated with the few farm buildings at the northern end of Willows Road.

The WNP Services Trench links the Willows SFA to the existing underground mine site and traverses three distinct sections:

- Willows Road: The section from Willows Farm along Willows Road to the intersection with SH25,
- State Highway 25: The section adjacent to SH25 from the intersection with Willows Road to the point that the trench leaves State Highway 25 just to the southwest of the Ohinemuri River Bridge,
- SH25 to Waihi Operations Plant: The section just southwest of the Ohinemuri River Bridge to the existing Waihi mine site.

The Willows Road section is set in the context of open farmland against the backdrop of the unilluminated Coromandel Forest Park.

Existing lighting in the area is limited to that directly associated with the few farm buildings at the northern end of Willows Road.

The section adjacent to State Highway 25 runs through open farmland with several rural properties along the route. The highway has no roadway lighting, with lighting limited to that associated with residential and farm buildings.

The section from SH25 to the existing Waihi operations plant runs through open farmland until it crosses Golden Valley Road. The trench then follows a vehicle track until it meets with the eastern section of Moore St adjacent to the existing mine operations site.

This section of the route passes close to two private properties and Department of Conservation riparian areas. There is existing street lighting where Golden Valley Road passes through the town. This lighting stops just prior to the intersection with the eastern end of Moore St – well before the point where the Services Trench would cross Golden Valley Road. It is understood that there is no lighting on Moore Street.

The existing mine site is bounded on the north/northwest by Waihi township and by farmland throughout the balance of its perimeter. Outside of the township, the site is circumnavigated by a series of rural roads at distances varying from a few hundred metres to a couple of kilometres from the mine perimeter. State Highway No. 2 passes north west /south east on the western side of the mine. On the rural roads, houses and farm buildings are generally located nearer to the roads.

Lighting in the township of Waihi is characteristic of a small township in rural New Zealand.

Lighting throughout the town includes traditional streetlighting luminaries providing higher illumination levels nearer the town centre and lower levels in the surrounding suburbs. Lighting associated with supermarket parking, service station forecourts, restaurants, and domestic housing is also typical. Tower mounted floodlighting is also provided to the tennis courts in Morgan Park, Clarke Street. Street lighting stops at the township boundary. The historical Cornish Pumphouse and headframe are illuminated at night using coloured lighting and upward directed floodlights.

Whilst pole mounted street lighting is provided to some of the rural road intersections, predominantly those on State Highway No.2 and the Waihi Beach Road/Trig Road (North/South) intersection, most of the rural roads are not artificially illuminated.

Artificial lighting away from Waihi township is predominantly associated with rural houses and farm buildings.

Sections of the existing mine are illuminated at night for operational and/or safety reasons. Fixed artificial lighting is provided to the following main areas of the existing mine:

- Kenny Street and Baxter Road entry gates
- Processing Plant and central parking area,
- Main conveyor structure

Exterior lighting in these areas consists of a mixture of general street lighting luminaires, area floodlights, bulkhead luminaires, and task lights. Interior lighting spills outside through windows and open doorways.

The existing conservation estate, Coromandel Forest Park, has no artificial lighting within it, other than that associated with existing exploration or camp sites.

3. LIGHTING EFFECTS

3.1 BASIS FOR ASSESSMENT

The Hauraki District Plan addresses lighting effects in section 8.2.5 “Glare and Lighting”.

Section 8.2.5.1 (2) notes that lighting has the potential to create glare which can create a hazard and/or detraction from amenities. The section also notes that

> *“lighting can be a cause of disturbance to residential amenities in a similar manner to noise”.*

Section 8.2.5.1 (4) notes that:

> *“Lighting can be orientated or shaded in order that the spill of lighting remains within the site”.*

Section 8.2.5.2 (1) sets an environmental result that requires lighting to be managed in a way that “*does not detract from the amenities of adjoining properties or zones and does not create a hazard to traffic*”.

The lighting standard set by section 8.2.5.3 (2) is:

> *“In all zones, artificial lighting shall be installed, designed, shaded and arranged in order that the level of lighting measured horizontally or vertically at any point on or directly above the boundary of any adjacent site or road is no greater than 8.0 lux.”*

As illuminance (measured in lux) reduces in proportion to the inverse square of the distance from the luminaire, whilst applicable in many urban situations, this Rule does not adequately address potential lighting effects in a rural environment where light sources are often a significant distance from potentially affected locations. The effect being managed by the Rule, spill light (measured in lux), is often not the most relevant effect in rural locations.

Australian and New Zealand Standard AS/NZS 4282: 2023, “*Control of the obtrusive effects of outdoor lighting*”, is the recognised standard in Australasia for managing the effects of outdoor lighting. AS/NZS 4282:2023 considers the effects of outdoor lighting, interior lighting that emits directly into the outdoor environment, and the lighting associated with lit vertical surfaces.

The latest revision of this Standard now includes reference to the “*National Light Pollution Guidelines for Wildlife*” published by the Australian Government’s Department of Climate Change, Energy, the Environment and Water, version 2.0, May 2023.

The Waihi North Project has therefore been assessed against the Hauraki District Plan, the principles of AS/NZS 4282:2023, and where applicable in accordance with the National Light Pollution Guidelines for Wildlife.

The potential lighting installations at each area of the WNP site are based upon the information provided in the Mitchell Daysh AEE, on observations made during the site visit, and on lighting practices normally employed during construction and operation of similar facilities. The lighting proposed at each mine location to support the construction and operation of the Waihi North Project is outlined below.

Specific lighting design has not been undertaken, rather the lighting solutions are based upon those which could reasonably be required.

Where appropriate, construction and operational lighting are considered at each mine location.

No assessment is made of lighting associated with closure and rehabilitation except as noted, as it is understood that such works would only be undertaken during daylight hours.

In terms of the application of the above documents, the Hauraki District Plan does not specify the type of lighting it applies to i.e. fixed / permanent, mobile, temporary, vehicle, etc.

AS/NZS 4282: 2023 states that its objective is "*to provide a common basis for assessment of the potential obtrusiveness of the effects from the lighting of developments that involve the provision of outdoor* lighting". With respect to the WNP the standard specifically excludes emergency warning, way finding lights / marker lights, navigation lights, all traffic signals, traffic signage and vehicle headlights, including working lights mounted on moving vehicles and plant, and temporary lighting operating for less than on month. By implication, the standard does apply to temporary (mobile) lighting operating for more than one month.

We have been advised that in the past the Department of Conservation (DoC) only applied these guidelines to fixed lighting. The previous version of 4282 (2019) made no reference to temporary lighting which may have been the basis for previous positions by DoC.

This assessment considers fixed / permanent lighting and mobile lighting which is likely to be operating for more than on month. Mobile lighting that is likely to be operating for less than one month; vehicle headlights, task lights, and safety lights are identified where relevant to put the lighting effects into context.

The assessment of each WNP area separately considers lighting associated with construction phase works and the completed installation's permanent lighting.

3.2 ASSESSMENT CRITERIA

The impact of artificial lighting on the night-time environment can be characterised by the following effects (refer to Appendix C for a Glossary of Lighting Terms):

a. Spill Light

b. Glare

c. Sky Glow

AS/NZS 4282: 2023, Section 2.3.1 "*Effects on Residents*" outlines the specific effects that need to be considered with respect to residents:

> ***"2.3.1 Effects on residents***
>
> *Effects on residents generally involve a perceived reduction of amenity arising from light technical factors such as the following:*
>
> (a) *The* ***illumination from spill light being obtrusive****, particularly where the* ***light enters habitable rooms****. The illuminance on surfaces, particularly vertical surfaces, is an indicator of this effect.*

(b) *The **direct view of bright luminaires** from normal viewing directions causing annoyance, distraction or even discomfort or disability glare. The luminous intensity of a luminaire, in a nominated direction, is an indicator of this effect.*

(c) Changes in luminance in the peripheral vision due to effects such as variable content in signage or trees moving across bright lights.

*The **tolerable levels of** each of these **light technical parameters** will be **influenced by** the **ambient lighting existing** in the environment where the light technical parameters are being calculated."*

*(Note: "**Bolding**" of text added in this document).*

"Obtrusive" light is defined as follows:

"1.3.21 Obtrusive light

Spill light which, because of quantitative or directional attributes, gives rise to annoyance, discomfort, distraction or a reduction in the ability to see essential information such as transport signals."

It is noted that obtrusive light includes the impact on humans and environmental receivers i.e.

"any identified living species (plants, animals and other organisms) and their locations indicated, that may be impacted by the proposed lighting system"

(Reference AS/NZS 4282: 2023, Section 1.3.13)

AS/NZS 4282: 2023 Section 2.3.4.2 "*Cultural impacts*" recognises the impact that visibility of the night sky has to many cultures around the world. Mitigations for the preservation of culture are similar to the controls for astronomy.

Section 2.3.4.3 references the impact of lighting on flora and fauna whilst Section 2.3.4.4 references the impact of the spectral content of light. Both of these issues are addressed in more detail in the National Light Pollution Guidelines for Wildlife.

AS/NZS 4282: 2023 uses various Light Technical Parameters (LTP) to assess potential lighting effects. Different limits for the parameters are applied based upon the ambient light conditions. These ambient conditions are set for various environmental zones.

AS/NZS 4282: 2023 introduces the concept of lighting curfew periods, during which lower light technical parameters are set. Unless otherwise specified by the controlling authority, the lighting curfew period is taken as between 11:00pm and 06:00am. The Standard requires that where there are affected properties which are, or which include, an environmentally sensitive area, then the lower light technical parameters shall apply at all times.

The environmental zones (AS/NZS 4282: 2023 Table 3.1 "*Environmental Zones*") potentially applicable to the various WNP locations are as follows:

a. **Environmental Zone A0:** Described as "*Intrinsically dark"* with examples: *"UNESCO Starlight Reserve"* and *"Other accreditations for dark sky places for example astrotourism, heritage value, astronomical importance, wildlife/ecosystem protection".*

b. **Environmental Zone A1:** Described as "*Dark*" with examples: "*Relatively uninhabited rural areas (including terrestrial, marine, aquatic and coastal areas)*" and "*Generally roadways without streetlighting through rural areas*"

c. **Environmental Zone A2:** Described as "*Low district brightness*" with examples: "*Sparsely inhabited rural and semi-rural areas*" and "*Generally roadways without streetlighting through suburban, rural or semi-rural areas other than intersections"*

d. **Environmental Zone A3:** Described as "*Medium district brightness*" with examples: "*Suburban areas in towns and cities*" and "*Generally roadways with streetlighting through suburban, rural or semi-rural areas".*

In considering the locations of the various elements of the WNP they could be assessed as follows:

a. Willows SFA: Zone A1 or A2

b. Services Trench: Zone A1 or A2

c. Gladstone Pit: Zone A2 or A3

d. Northern Rock Stack: Zone A2

e. Processing Plant: Zone A2 or A3

f. Tailings Storage Facility TF3: Zone A2

g. Exploration Areas: Zone A0

3.2.1 Spill Light

Spill light is defined by AS/NZS 4282: 2023 as "*Light emitted by a lighting installation that falls outside the boundaries of the property for which the lighting installation is designed*".

AS/NZS 4282 identifies light technical parameter (LTP) Vertical Illuminance with respect to spill lighting.

Vertical Illuminance (EV) (measured in lux) is the total luminous flux (measured in Lumens) incident on a vertical surface, per unit area. The maximum non-curfew limits in the Standard are; 0 lux (or as close to zero as practicable without impacting safety considerations) (for Zone A0), 2 lux (for Zone A1), 5 lux (for Zone A2), and 10 lux (for Zone A3) and maximum curfew limits are 0.0 lux (for Zone A0), 0.1 lux (for Zone A1), 1 lux (for Zone A2), and 2 lux (for Zone A3).

AS/NZS 4282: 2023 accepts that a higher level of light may be less obtrusive in the early hours of the evening when there is more activity, and most people are awake.

For later times (in the curfew period) lower limits are applied. Unless otherwise specified by the controlling authority, the curfew period is taken as between 11:00pm and 06:00am.

The Hauraki District Plan specifies a spill light maximum, measured horizontally or vertically of no greater than 8.0 lux. This level is comparable with the A2 and A3 zones in the standard. The Plan does not specify a curfew period for Glare and Lighting.

With respect to the Waihi North Project, the Hauraki District Plan spill light level of 8.0 lux (lumens per square metre) is used as the general basis for assessment except for those locations within or directly adjacent to the conservation estate.

3.2.2 Glare

Glare is defined by AS/NZS 4282:2023 as a:

> *Condition of vision in which there is discomfort or a reduction in ability to see, or both, caused by an unsuitable distribution or range of luminance, or to extreme contrasts in the field of vision.*

The two terms that are normally used to describe the effects of glare on the ability to see are disability and discomfort. AS/NZS 4282: 2023 defines these as:

> *Disability Glare: Glare that impairs the visibility of objects without necessarily causing discomfort.*
>
> *Discomfort Glare: Glare that causes discomfort without necessarily impairing the visibility of objects.*

Whilst the Hauraki District Plan's Section 8.2.5 is titled "Glare and Lighting", it does not provide a basis for measurement or assessment of glare from artificial lighting – it only provides a basis for control of spill light.

Glare's impact on visual amenity depends very much on the situation in which it occurs.

Wherever there is the potential for a direct view of luminaires there is the potential for glare.

Where the viewing location is remote from the lighting source, the primary effect would be Disability Glare, i.e., glare that impairs the visibility of objects without necessarily causing discomfort.

AS/NZS 4282 identifies the following light technical parameters related to glare:

a. **LTP Luminous Intensity (I):** Luminous intensity (measured in candela (cd)) of a light source is the emitted luminous flux per unit solid angle – stated simply it is the light sources brightness in a given direction. The luminous intensities for the potential environmental zones identified for the WNP are as follows:
    i. **Zone A0:** The non-curfew levels should be as close to zero as practicable without impacting safety considerations. The curfew level should be 0 cd.
    ii. **Zone A1:** 2,500 cd (non-curfew) and 500 cd (curfew)
    iii. **Zone A2:** 7,500 cd (non-curfew) and 1,000 cd (curfew)
    iv. **Zone A3:** 12,500 cd (non-curfew) and 2,500 cd (curfew)
b. **LTP Threshold Increment (TI):** "*The measure of disability glare expressed as the percentage increase in luminance contrast threshold required between an object and its background for it to be seen equally well with a source of glare present. Note: Increasing values of threshold increment correspond to increasing disability glare.*" (Definition from AS/NZS 4282: 2023)

Vehicle headlight, task, and safety lighting, whilst often excluded from Plan Rules, can result in adverse effects – particularly in rural environments. AS/NZS 4282: 2023 notes that it does not apply to vehicle headlights or working lights mounted on moving vehicles and plant. With respect to glare, the extent of any effects would depend upon lighting intensity, visibility from outside of the site, and rapid intensity change (i.e., flashing). It would be expected that notices would be provided at mine exits reminding vehicles to turn off their flashing lights.

3.2.3 Sky Glow

Sky Glow is defined by AS/NZS 4282:2023 as the:

> *"brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered from the constituents of the atmosphere (gas molecules, aerosols and particulate matter), in the direction of observation."*

Whilst AS/NZS 4282:2023 considers both natural and man-made sky glow, this review only considers the effects of man-made sky glow which is defined as:

> *"Man-made Sky Glow: part of the sky glow that is attributable to man-made sources of radiation (e.g., outdoor lighting)".*
>
> (Note: A gender-neutral term for this would be more appropriate, e.g. "artificial sky glow" or "human generated sky glow")

Light reflected off the ground and buildings can be difficult to control without careful consideration of where the light is being aimed, because it is dependent upon the reflective characteristics of the material being worked with. However, direct light spill can be effectively controlled by appropriate luminaire selection and use.

The extent of sky glow that occurs is affected not just by the amount of light that is directed into the sky, but also the climatic conditions. More sky glow is apparent when there are particles in the air for the light to reflect off. This occurs in cloudy, foggy, and drizzly conditions, and if there are dust particles in the air.

The Hauraki District Plan does not mention sky glow.

AS/NZS 4282 identifies the following light technical parameter related to sky glow:

a. **LTP Upward Light Ratio (Luminaire) (ULR_L):** "*ratio of the luminous flux of a luminaire that is emitted, at and above the horizontal, divided by the total luminaire flux when the luminaire is mounted in its designed position.*"

b. **LTP Upward Light Ratio (System) (ULR_S): "***ratio of the luminous flux of all luminaires in the system that is emitted directly into the night sky, divided by the total flux of all the luminaires, when the luminaire(s) is (are) mounted in its design position(s), and excluding reflected light from surfaces or obstructions."*

   (Definitions from AS/NZS 4282: 2023).

To minimise sky glow, all luminaires would ideally be of the type that emit zero light above the horizontal plane. Guidance is provided within AS/NZS 4282:2023, specifically Appendix A Section A.6.3 "*Selection of luminaires and light distribution*", which notes:

> *"The selection of luminaires can have a significant effect on the ability to control the light that is emitted outside the boundary of the properties. It is important that the selected luminaire has a light distribution that is appropriate not only for the overall lighting task, but also to minimize obtrusive light. As a general principal* [sic] *lighting installations that control obtrusive light well will be generally more efficient at lighting the task.*
>
> *Figure A1 (*Figure 3*) gives simplified indication of the different types of luminaires and the impact that it has on obtrusive light. It shows preferred and non-preferred luminaire light distributions.*

*Figure A2 (*Figure 4*) indicates how the distribution of the luminaire can affect the ability to control obtrusive light. Avoid the use of luminaires that do not have the ability to control, shape, or shield the spread of the light, particularly at the edges of the beam. A lighting installation may benefit from a variety of different distribution types that have different abilities to restrict over-spill at the front of the beam, back-spill, and side-spill."*

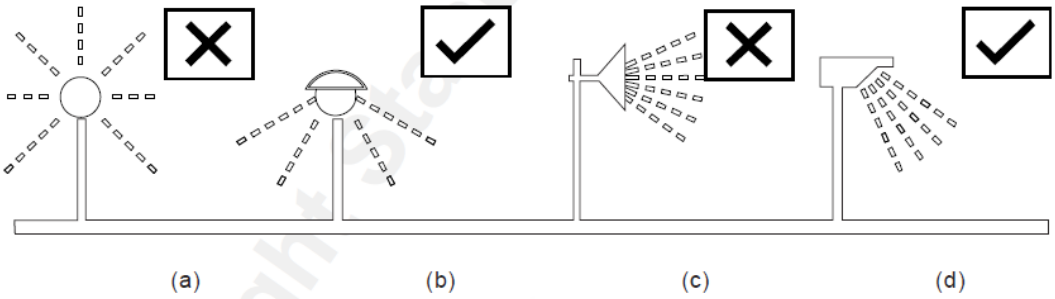


FIGURE A1 SIMPLIFIED LIGHTING TYPES AND THEIR ABILITY TO CONTROL OBTRUSIVE LIGHT

Figure 3: AS/NZS 4282: 2023 Appendix A Figure A1

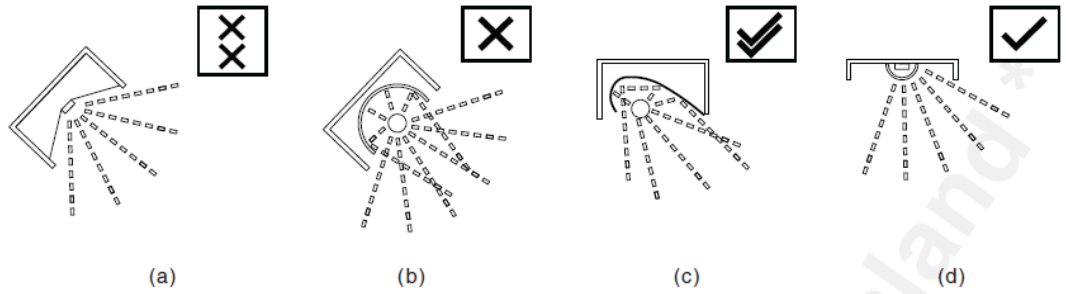


FIGURE A2 EFFECT OF THE LIGHT DISTRIBUTION OF THE LUMINAIRE ON THE ABILITY TO CONTROL OBTRUSIVE LIGHT

Figure 4: AS/NZS 4282: 2023 Appendix A Figure A2

Vehicle headlights, task lights, and safety lights have the potential to cause skyglow, the extent of which depending on their intensity, aiming configuration, and location. For example, vehicle headlights on high-beam would create more skyglow than those on dipped-beam and a vehicle driving up to the crest of a hill would produce more than one driving down a hill.

3.2.4 National Light Pollution Guidelines for Wildlife

The aim of the guidelines is that artificial light is managed so that wildlife is:

1. Not disrupted within, or displaced from, important habitat
2. Able to undertake critical behaviours such as foraging, reproduction and dispersal.

The guidelines recognise that animals perceive light differently from humans, with most animals being sensitive to ultraviolet (UV)/violet/blue light. Figure 5 is taken directly from the guidelines (Guidelines Figure 2) and shows comparative light perception among different species groups.

It is noted that the guidelines state that "*The guidelines do not infringe on human safety obligations. Where there are competing objectives for lighting, there may be a need for creative solutions that meet both human safety requirements for artificial light and threatened and migratory species conservation*".

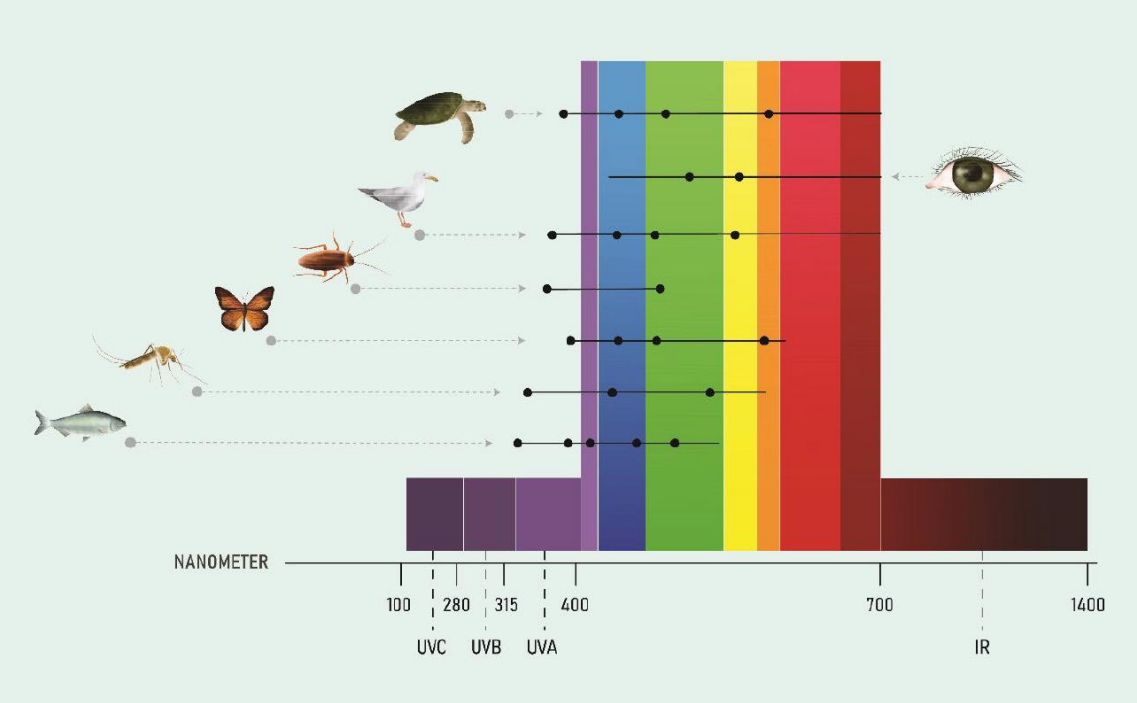


Figure 5: Comparative light perception among different species groups

(Ability to perceive different wavelengths of light in humans and wildlife shown by horizontal lines. Black dots represent report peak sensitivities.)

The guidelines recommend:

1. Always using best practice lighting design to reduce light pollution and minimise the effect on wildlife.
2. Undertaking an environmental impact assessment of effects of artificial light on listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.

According to the guidelines, best practice lighting design incorporates the following design principles:

1. Start with natural darkness and only add light for specific purposes.
2. Use adaptive light controls to manage light timing, intensity and colour.
3. Light only the object or area intended – keep lights close to the ground, directed, and shielded to avoid light spill.
4. Use the lowest intensity lighting appropriate for the task.
5. Use non-reflective, dark-coloured surfaces.
6. Use lights with reduced or filtered blue, violet and ultraviolet wavelengths.

The guidelines represent the principles of best practice lighting design in the following figure (Figure 6).

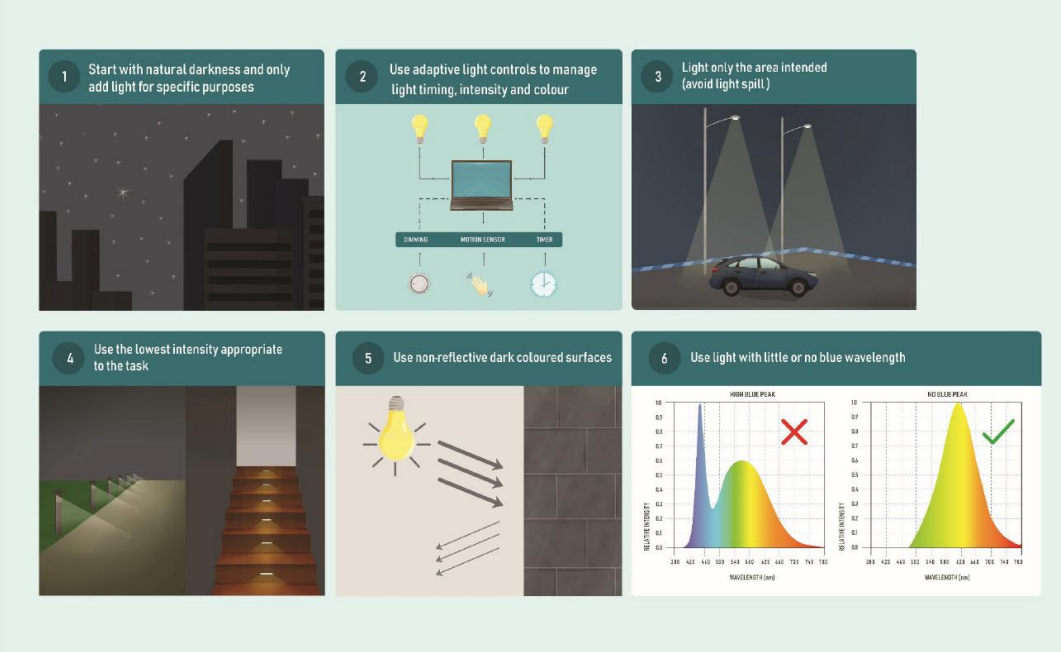


Figure 6: Principles of Best Practice Lighting Design

The guidelines are supported by a series of technical appendices that provide additional information on topics including: "*Best practice lighting design"*, "*What is light and how does wildlife perceive it?*", Management of artificial light for taxa including seabirds, bats, terrestrial mammals, and ecological communities.

An environmental impact assessment (EIA) process is recommended if there are species that are known to be affected by artificial light within 20km of a project.

There are 5 steps involved in assessing the potential effects of artificial light on wildlife, and the adaptive management of artificial light requires a continuing improvement process (Reference Figure 7)

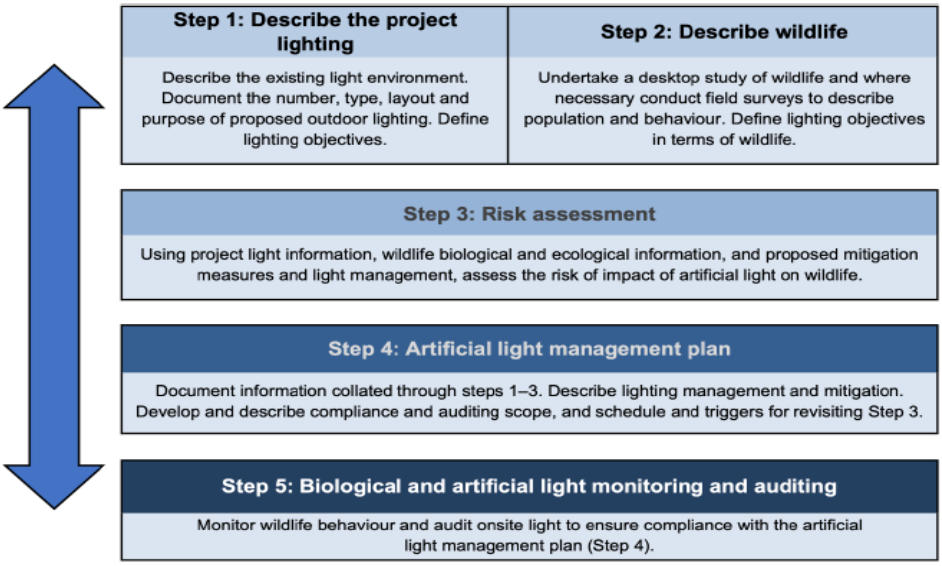


Figure 7: Flow chart describing the environmental impact assessment process

3.3 WHAREKIRAUPONGA UNDERGROUND MINE

3.3.1 Existing Lighting

Most of the area proposed for the Willows SFA is presently farmland with no permanent lighting. There is limited lighting in the wider area - associated with the few residential buildings and farm outbuildings.

No road lighting exists in the immediate area of the surface infrastructure.

The lighting appears as disparate light sources within a predominantly dark environment.

3.3.2 Proposed Lighting

The majority of the WUG site would be below ground, such that below ground artificial lighting effects would not be visible externally. It is noted that no major facilities would be located underground in the first 4 to 5 years.

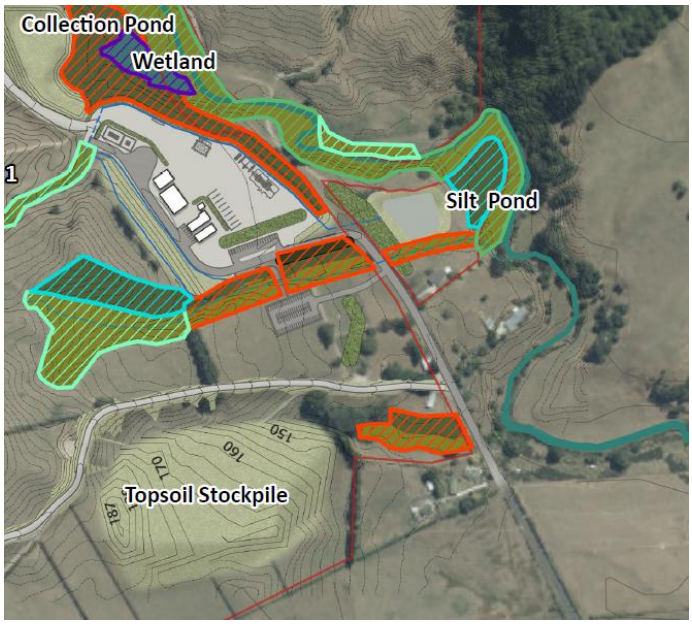
Permanent surface infrastructure to support mining operations would be constructed in the Willows SFA.

Artificial lighting would be required to support the project through its four key stages namely:

- Willows SFA Construction
- Tunnel Construction
- Production
- Closure

The lighting associated with each of these project stages is outlined below.

Screen planting is proposed in the area between the SFA and the top end of Willows Road which could provide some shielding from lighting effects (Reference Figure 9 and Figure 8).



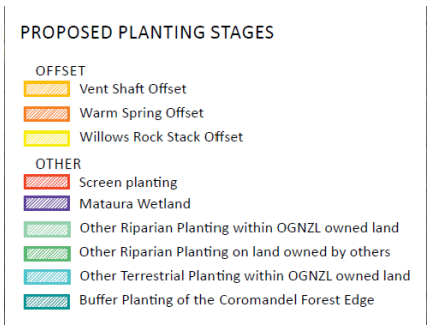


Figure 8: Screen planting legend

Figure 9: Screen planting between the SFA and the top end of Willows Road (Part Plan) (Boffa Miskell Drawing: Proposed Integrated Mitigation Planting Stages Rev 0)

3.3.2.1 SFA Construction Stage

Works to construct the SFA associated with the Wharekirauponga site would be undertaken between the hours of 7am to 7pm Monday to Saturday and Figure **10** for a plan showing the proposed permanent above-ground facilities). The works would be undertaken in shifts and consist of bulk earthworks and building/civil works construction.

It is reasonable to expect that artificial lighting would be required to support construction activities during the shorter daylight hours in the winter months. It would also be expected that some form of security lighting would be provided for construction buildings and plant.

Temporary workshops and facilities would be established within the Willows SFA to support the initial construction and tunnelling works.

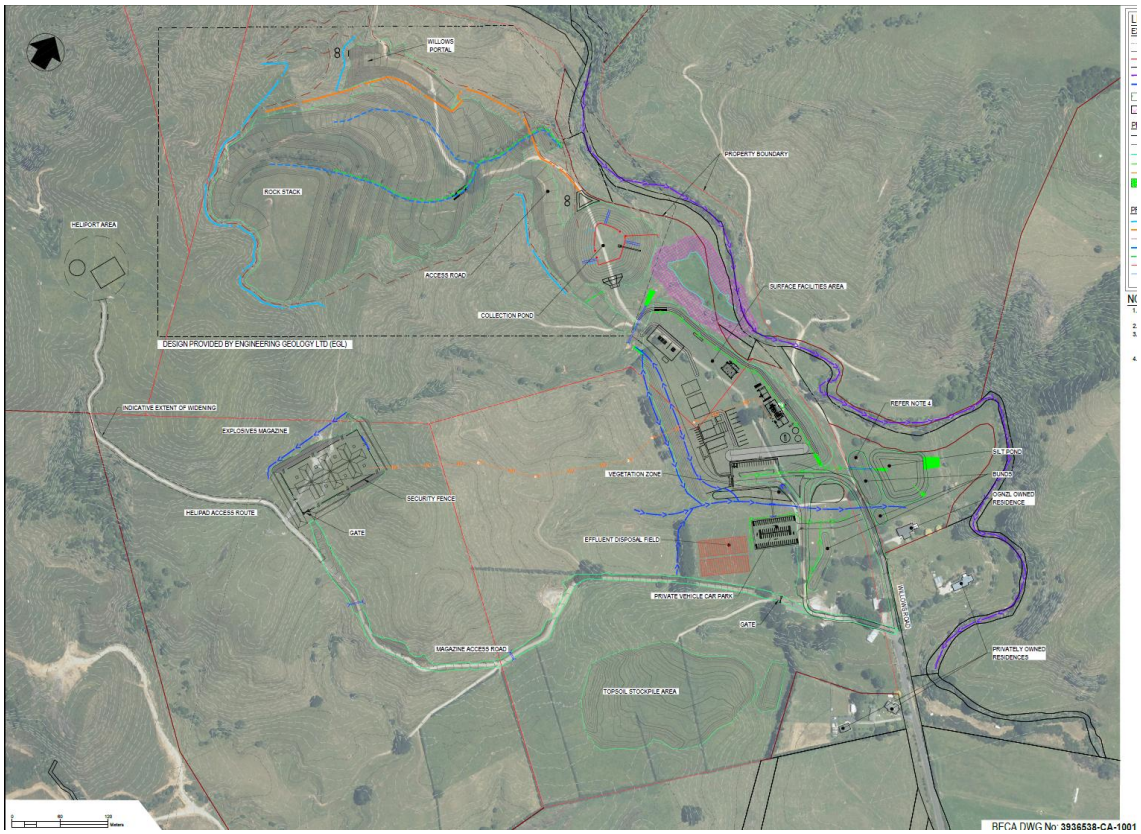


Figure 10: Willows SFA, Beca DWG: WAI-981-000-DWG-CI-1001 Rev O (in Part)

It is expected that artificial lighting to support construction activities could consist of the following:

- Mobile lighting plant.
    - Typically, these would consist of diesel-powered LED lighting plant, with 3No. to 6No. LED floodlights mounted on 9m extension poles (Reference Figure 11 for a typical configuration). Luminaires would typically be aimed at a high angle to the ground to provide broad lighting coverage across the construction area.

Figure 11: Typical Mobile Lighting Plant

- Mobile plant location and orientation would vary over time in response to construction activities and locations.

- Vehicle mounted rotating or flashing amber security beacons.
  - All vehicles operating on site would be required to have roof mounted security beacons unless parked in designated areas.
- Standard vehicle head and tail lights.
  - Required to be used in low light conditions and possibly during some construction activities and at some locations.
- Permanent exterior lighting – pole and building mounted
  - Exterior luminaires would use 3000K, or warmer, LEDs wherever practicable to minimise the lighting wavelengths at the cooler end of the spectrum. LEDs at the warmer end of the spectrum (3000K) are more friendly to night sky observers and fauna than those at the cooler end of the spectrum (4000K).
  - Permanent lighting would consist of LED luminaires designed and installed with minimal upward light output configuration to minimise direct upward light spill. Where luminaires are required to be tilted, they would be aimed away from primary external viewing locations to minimise direct glare effects.
  - A small amount of security lighting would be provided to the vehicle parking areas, the water ponds, and pedestrian pathways.
  - All exterior lighting and interior lighting which is visible externally would be designed and installed in accordance with the National Light Pollution Guidelines for Wildlife, in particular with the use of luminaires with reduced blue wavelengths.
  - All exterior lighting and interior lighting would be subject to compliance with a Lighting Management Plan.

- Site Entrance from Willows Road: Pole mounted luminaire(s) would be provided adjacent to the site entry gate at the northern end of Willows Road. It is understood that the gate would be located to the north of the proposed screen planting at the top end of Willows Road. Depending on the location of the site entry gate with respect to Willows Road, spill light from the luminaire(s) may exceed the Hauraki District Plan requirement for a maximum of 8.0 lux direct spill onto a road. Direct light spill would be very localised to the lighting pole(s) with effects minimised by the use of flat-glass (zero upward component) luminaire(s), backlight shielding (if required), luminaire orientation, and the use of 3000K LED technology. Backlight shields are barriers mounted on or in the luminaire to minimise light spilling behind the primary aiming direction of the light.

- Permanent interior lighting visible through unshielded windows.
  - Interior lighting within temporary construction related buildings would most likely consist of modern LED luminaires or older style linear fluorescent fittings. Interior lighting should be shielded from external view with blackout blinds or curtains.
- Occupancy and daylight sensor control of lighting would be considered in less frequently accessed locations. The use of sensor control would be tempered against the distraction that might occur to neighbours from luminaires turning on and off on a regular basis.

3.3.2.2 Tunnel Construction Stage

Tunnel construction works would typically involve:

- Dump trucks between the Willows Portal and the rock stack – 24 hours per day.
- Various light and heavy equipment in and out of the portal area and to/from the SFA. This would occur 24 hours per day except when works are near the Willows Road end of the site when for other environmental reasons operations may occur under more limited time constraints. At such times works would predominantly occur during the dayshift with minimal vehicle movements during the nightshift (7pm to 7am)
- Deliveries (primarily during daylight hours)
- Vehicles entering and exiting at shift change (between 6 to 8am/pm)
- Un-planned and planned maintenance trips that cannot be completed during dayshift could occur during the nightshift (7pm to 7am).
- Where there is the potential for adverse lighting effects due to nighttime operations associated with vehicle movement between the portal and the Willows Rock Stack, mitigation measures should be undertaken to reduce effects. These might include naturally screening of works by topography and / or timing the location and type of works.

Lighting to support tunnel construction would consist of mobile lighting plant, permanent exterior safety and security lighting, and vehicle mounted lighting as outlined for the SFA construction stage.

Specific lighting would be provided to support construction activities as follows:

- Head, tail, and security lighting to vehicles moving in and out of the portal, to/from the rock stack and the magazine, and to/from the SFA.
- Fixed lighting within the SFA to buildings (workshops, changerooms, crib room, fuel bowser) and to carparks and pedestrian walkways.
- Mobile lighting plant at the rock stack for activities outside daylight hours.
- Portal lighting

3.3.2.3 Production Stage

During the mine's production stage, many of the support facilities would be located underground, including workshops, crib rooms, explosives magazines and re-fuelling bowsers. Vehicle movements within the site would therefore be greatly reduced.

During the first two years of this period there would be no dump truck movements to the rock stack. After the first two years, these would then commence as waste rock is returned underground.

Permanent lighting would be provided to specific locations throughout the Willows SFA but the whole site would **not** be fully illuminated.

Operational, safety, and security lighting would be required to support the production stage as follows:

- **Luminaire Colour Temperature:** Exterior luminaires would use 3000K, or warmer, LEDs wherever practicable to minimise the lighting wavelengths at the cooler end of the spectrum. LEDs at the warmer end of the spectrum (3000K) are more friendly to night sky observers and fauna than those at the cooler end of the spectrum (4000K). Luminaires would use reduced or filtered blue / violet / and ultraviolet wavelength light in accordance with the National Light Pollution Guidelines for Wildlife.
- **Luminaire Orientation**: Permanent lighting would consist of LED luminaires designed and installed with minimal upward light output configuration to minimise direct upward light spill. Where luminaires are required to be tilted, they would be aimed away from primary external viewing locations to minimise direct glare effects.
- **National Light Pollution Guidelines:** All exterior lighting and interior lighting which is visible externally would be designed and installed in accordance with the National Light Pollution Guidelines for Wildlife.
- **Lighting Management Plan:** All exterior lighting and interior lighting which is visible externally would be subject to compliance with a Lighting Management Plan.
- **Occupancy and Daylight Sensor Control:** Occupancy and daylight sensor control of lighting would be provided in less frequently accessed locations. The use of sensor control would be tempered against the distraction that might occur to neighbours from luminaires turning on and off on a regular basis.
- **Site Entrance from Willows Road:** Pole mounted luminaire(s) adjacent to the site entry gate at the northern end of Willows Road.

- **Car/Vehicle Parking areas, Bus Stop, Pedestrian Walkways, Roadways:** Pole mounted luminaires mounted in horizontal flat glass configuration with zero upward light component. Pole heights in the range of 7 metres to 12 metres.
- **Buildings:** Building mounted bulkhead lighting (ideally with zero upward light component)
- **Workshop Exterior:** Lighting to the exterior maintenance area would consist of asymmetric LED luminaires (with backlight shields if required to minimise lighting to vertical facades and roofs) mounted in horizontal flat glass configuration with zero upward light component, to minimise lighting effects. Backlight shields are barriers mounted on or in the luminaire to minimise light spilling behind the primary aiming direction of the light. Existing lighting in the Baxter Road Process Plant area consists of area floodlights aimed outwards from the façade of the building (Reference Figure 12). It is understood that these are to be replaced with asymmetric LED luminaires as noted above.
- **Interior Lighting:** Interior lighting within buildings would most likely consist of modern LED luminaires or older style linear fluorescent fittings which provide little if any glare control. Windows should be provided with blackout blinds to minimise lighting effects both directly from the luminaires and from light reflected off interior surfaces.
- Vehicle mounted rotating or flashing amber security beacons (24 hours per day).
- Standard vehicle head and tail lights (24 hours per day in and out of the mine).
- **Mine Portal:** Lighting would be provided adjacent to the mine portal using area floodlights and bulkhead luminaires. Ideally floodlights would be mounted in horizontal flat glass configuration with zero upward light component, to minimise lighting effects.

Figure 12: Existing Exterior Lighting Baxter Road Workshops

3.3.2.4 Closure Stage

The closure stage of the project would involve construction, earthworks, etc and would be undertaken during dayshift.

Lighting to support the closure stage could include the following:

- Vehicle mounted rotating or flashing amber security beacons.
- Standard vehicle head and tail lights.
- Security lighting associated with the site entry gate and service facilities to support personnel working on the site.

3.4 WAIHI NORTH PROJECT SERVICES TRENCH (WNPST)

3.4.1 Existing Lighting

The Waihi North Project Services Trench would be established between the Waihi Surface Facilities Area and the Willows SFA to carry electricity, fibre, wastewater, and water services within buried pipelines.

No artificial lighting would be associated with the completed trench however lighting is likely to be required during the construction of the trench. Lighting to the intersection of Willows Road and State Highway 25 (SH25) would be installed after the completion of the services trench.

The extent of the trench is outlined in Figure 13 and Appendix B.

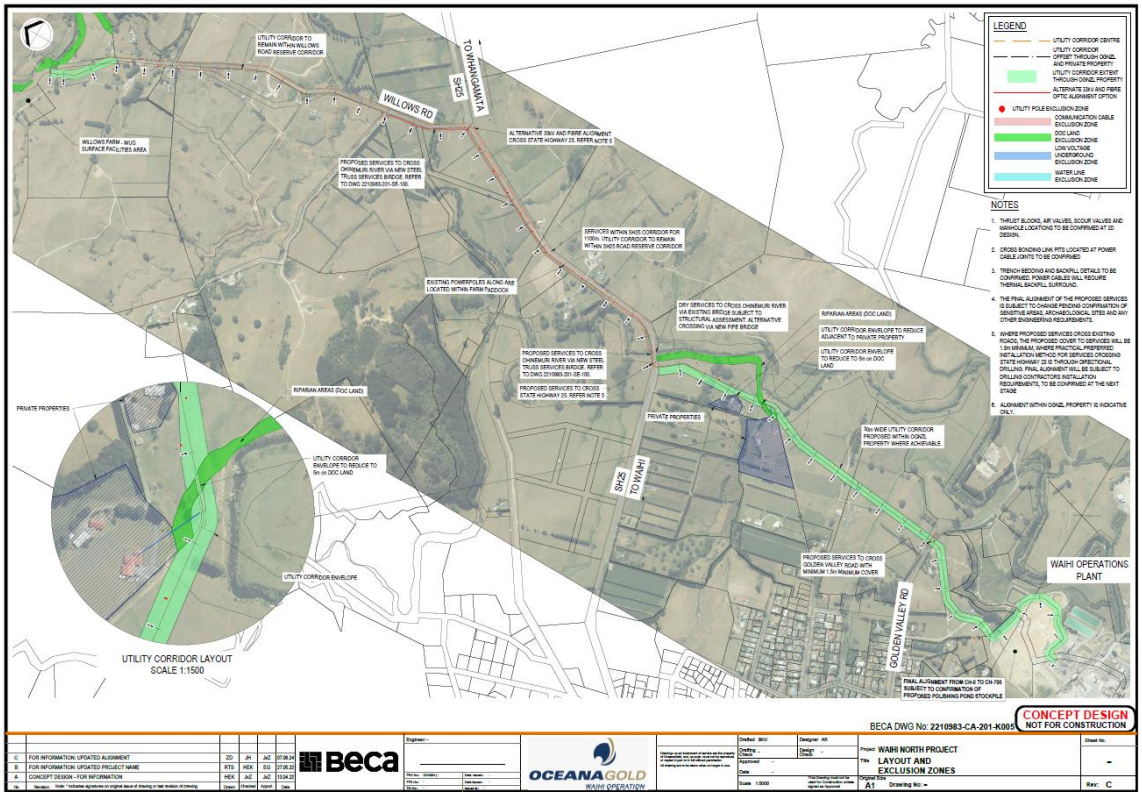


Figure 13: Waihi North Project Services Trench Layout Plan

From a lighting perspective, the WNPST traverses three distinct sections:

- Willows Road: The section from Willows Farm along Willows Road to the intersection with SH25,
- State Highway 25: The section adjacent to SH25 from the intersection with Willows Road to the point that the trench leaves State Highway 25 just to the southwest of the Ohinemuri River Bridge,
- SH25 to Waihi Operations Plant: The section just southwest of the Ohinemuri River Bridge to the existing Waihi mine site.

The Willows Road section is set in the context of open farmland against the backdrop of the unilluminated Coromandel Forest Park.

Existing lighting in the area is limited to that directly associated with the few farm buildings at the northern end of Willows Road.

The section adjacent to State Highway 25 runs through open farmland with several rural properties along the route. The highway has no roadway lighting with lighting limited to that associated with residential and farm buildings.

The section from SH25 to the existing Waihi operations plant runs through open farmland until it crosses Golden Valley Road. The trench then follows a vehicle track until it meets with the eastern section of Moore St adjacent to the existing Waihi Surface Facilities Area.

While much of this later section of the route crosses land owned by OGNZL, it passes close to two private properties and Department of Conservation riparian areas. There is existing street lighting where Golden Valley Road passes through the town. This lighting stops just prior to the intersection with the eastern end of Moore St – well before the point where the Services Trench will cross Golden Valley Road. It is understood that there is no lighting on Moore Street.

3.4.2 Proposed Lighting

3.4.2.1 Construction Phase

Most of the construction works for all sections of the Services Trench are expected to occur during daylight hours, 7am to 7pm Monday to Saturday. However, there would be periods where night or early evening works would be required for practical reasons (i.e. at the Willows Road / SH25 intersection and where the Services Trench crosses SH25), noting that these are expected to be the exception rather than the norm. However, it could be that yet unknown circumstances could require sections of the Services Trench to be constructed outside of daylight hours.

Where lighting is required to support construction, particularly in the vicinity of dwellings, then mitigations as outlined below should be employed to ensure that any effects are minimised to the extent that they are less than minor.

To minimise the effects on certain dwellings, OGNZL have advised that they will restrict works in the vicinity of those properties to daylight hours only. The specific dwellings are numbers 2, 3, 4, 9, 16, 17, and 18 as shown on Figure 4 "*Land Ownership and Dwellings in the Vicinity of the Services Trench*" of the Mitchell Daysh "*Resource Consent Application and Assessment of Environmental Effects*", Draft, 1 October 2024. (Reference Appendix C).

Given their proximity to SH25, residents at dwellings 11, 12, 13, 14, and 15 would periodically be faced with maintenance works on the state highway that might be undertaken after dark and hence need lighting. They have therefore been excluded from the need to limit the timing of works to daylight hours.

The proposed Services Trench would also pass through a 5m wide riparian area (Department of Conservation land) in the SH25 to Waihi Operations Plant area. It is understood that the riparian area that the trench would go through is passive reserve land and that the district and regional planning maps do not note any ecological features within the trench alignment. There are no standards or restrictions for lighting provided for this zone in the District Plan. It is possible that artificial lighting may be required to support trench construction in this area which is also close to dwellings (Reference: Figure 14). If there is a requirement to minimise impact on local ecology and / or on dwellings and the mobile lighting plant is in place for an extended period (over a month), then mitigations should be developed and included in a Lighting Management Plan.

It would be expected that the Services Trench construction contractor would undertake a risk analysis on the lighting requirements for each task and duration at hand. Initially vehicle headlights or sidelights would be used until a better lighting solution became paramount at which point mobile lighting plant would be used. A typical mobile lighting plant is show in Figure 15 and a typical civil works contract use of mobile lighting is shown in Figure 16.

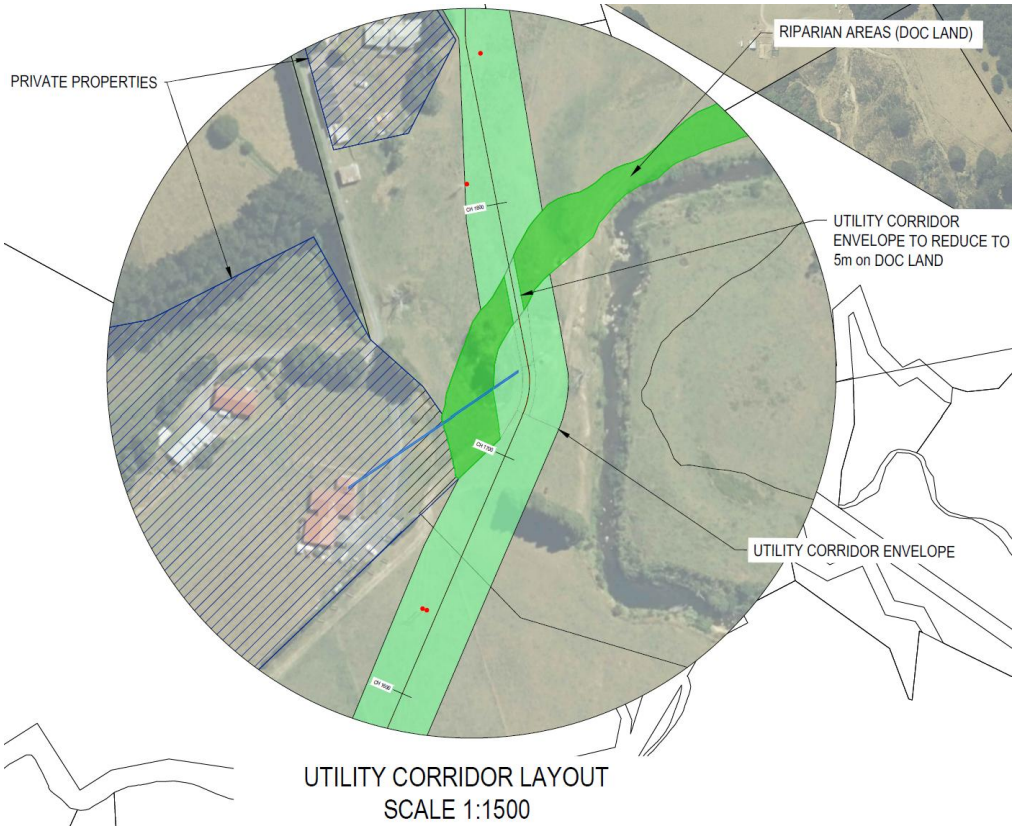


Figure 14: Services Trench Detail at Riparian Area Crossing (taken from layout plan in Figure 13)

Figure 15: Typical Mobile Lighting Plant

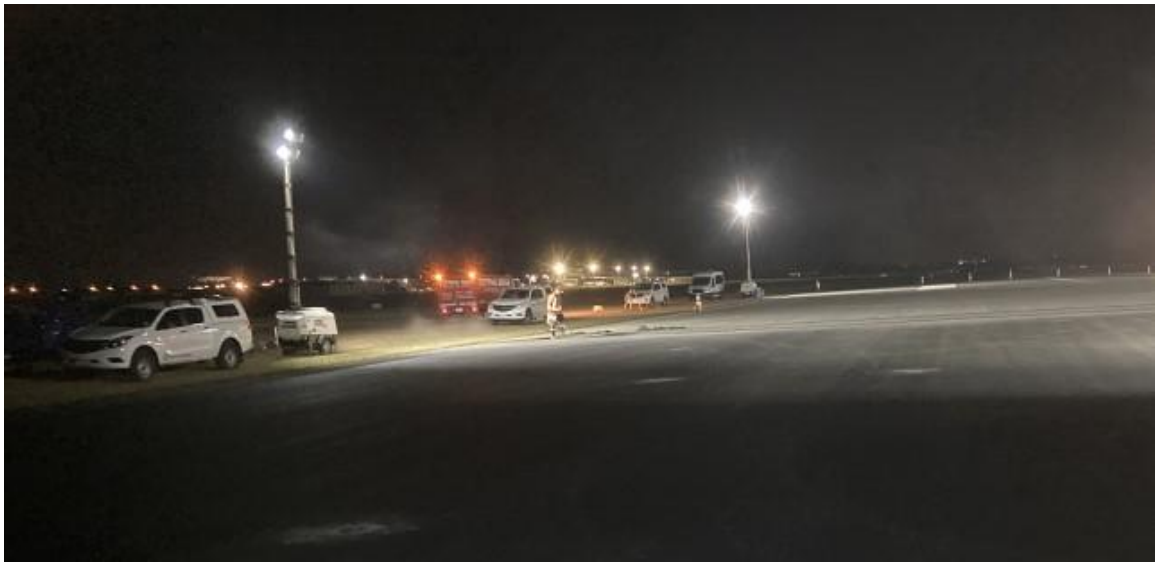


Figure 16: Typical Civil Works Mobile Lighting

Lighting associated with all sections of the Services Trench construction is expected to consist of the following at all times:

- Vehicle mounted rotating or flashing security beacons.

- All vehicles operating on the construction of the Services Trench are likely to require roof mounted security beacons unless parked in designated areas.

Where construction works are undertaken outside of daylight hours the following additional lighting is likely to be required:

- Standard vehicle head and taillights.
  - Required to be used in low light conditions and possibly during some construction activities and at some locations.
- Mobile lighting plant.
  - Typically, these would consist of diesel-powered LED lighting plant, with 3No. to 6No. LED floodlights mounted on extendable poles – normally in the order of 9m high (Reference Figure 15 for a typical mobile lighting plant). Luminaires would typically be aimed at a high angle to the ground to provide broad lighting coverage across the construction area. Luminaires traditionally use 4000 to 6000+ Kelvin correlated colour temperature lamps with high components in the blue area of the lighting spectrum.
  - Mobile plant location and orientation would vary over time in response to construction activities and locations. There may be situations where mobile lighting is required to protect construction work areas overnight.
- Construction Support Portacom Facilities.
  - Interior lighting would typically consist of surface mounted 4000K LED luminaires mounted at ceiling level. Portacoms do not typically have blinds on windows so that any interior lighting and illuminated surfaces would be visible externally into the evening and at night. Such buildings would not normally have any exterior security lighting unless there was a high risk of theft.
- Construction area security lighting.
  - Construction wheeled vehicles would normally be returned to a yard compound when not in use.
  - Tracked equipment would generally be left at the workface as it would be operationally challenging to move them every day over any distance.
  - In both above situations, security lighting would normally only be installed where theft (mainly diesel) or material damage were thought to be a risk. In such circumstances the lighting is likely to be designed to deter criminal activity – illuminating the area around, and the vertical faces of, the equipment.

3.4.2.2 Permanent Lighting

Permanent pole mounted lighting would be installed at the intersection of Willows Road and State Highway 25 as part of the Services Trench project. The lighting would be designed and installed in accordance with the AS/NZS 1158 suite of standards (*Lighting for roads and public spaces*) and Waka Kotahi's (New Zealand Transport Agency) approved designs. Ideally the luminaires would be of the "flat glass" pattern to minimise upward light spill and glare. Ideally the luminaires would use LED's with a warm colour temperature and with low spectral density at the blue end of the spectrum however, safety of road users is paramount and the luminaires would therefore be of standard Waka Kotahi approval.

It is understood that no other permanent lighting is to be installed as part of the Services Trench project.

3.5 GLADSTONE OPEN PIT

3.5.1 Existing Lighting

There is no permanent lighting in the area proposed for the Gladstone Open Pit (GOP), other than that associated with the existing Favona portal.

3.5.2 Proposed Lighting

The proposed GOP would be located adjacent to the existing Processing Plant area and into the existing Gladstone Hill and part of the Winner Hill (Reference Figure 17).

Mining could occur up to 24 hours per day, 7 days per week, subject to complying with noise limitations.

Artificial lighting would be required to enable mining operations outside of daylight hours.

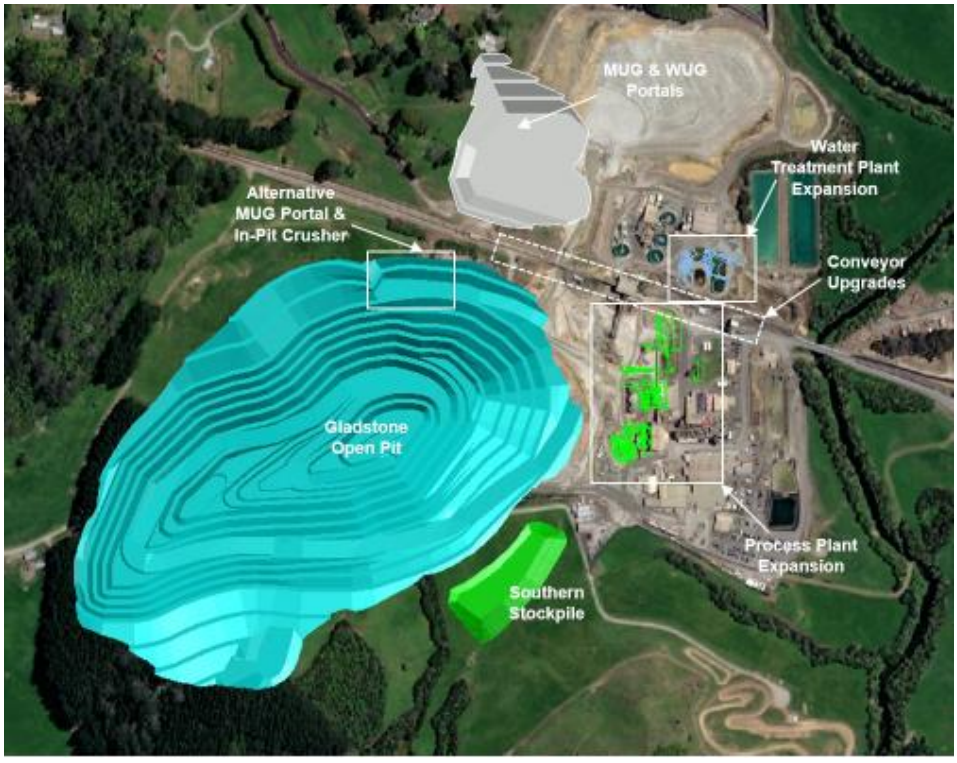


Figure 17: Gladstone Pit and Surface Infrastructure

Lighting to support mining operations is likely to consist of the following:

- Mobile lighting plant.
    - Typically, these would consist of diesel-powered LED lighting plant, with 3No. to 6No. LED floodlights mounted on 9m extension poles (Reference Figure 11 for a typical configuration). Luminaires would typically be aimed at a high angle (measured from the vertical below the luminaire to the centre peak aiming point) to the ground to provide broad lighting coverage across the mining area. Where practicable, lighting towers would be aimed into the mine site rather than outwards towards the mine boundary.
    - Luminaires would use 3000K, or warmer, LEDs wherever practicable to minimise the lighting wavelengths at the cooler end of the spectrum. LEDs at the warmer end of the spectrum (3000K) are more friendly to night sky observers and fauna than those at the cooler end of the spectrum (4000K). Luminaires would use reduced or filtered blue / violet / and ultraviolet wavelength light in accordance with the National Light Pollution Guidelines for Wildlife.
    - Mobile lighting plant may be located at key haul road intersections if required for vehicle safety
    - Mobile plant location and orientation would vary over time in response to mining activities and locations.
    - OGNZL has a Standard Operating Procedure for "*Towing and Setting up Lighting Plants*". The procedure includes a note "*Do not shine towards a public road or buildings"*.
- Vehicle mounted rotating or flashing amber security beacons.
    - All vehicles on site would be required to have roof mounted security beacons operating unless parked in designated areas.
- Vehicle mounted task lighting may be used to support mining operations.
    - This would consist of vehicle mounted floodlights to illuminate the immediate work area.
- Standard vehicle head and tail lights.
    - Required to be used in low light conditions and possibly during some mining activities and in some locations.
- Permanent Lighting for New Crusher and interconnecting Conveyor for transporting waste rock to the NRS
    - Lighting would typically be provided to operational areas of plant including access walkways, adjacent to control panels, service access locations, etc. Lighting would be permanent and would consist of LED luminaires mounted either directly on the plant or on lighting poles associated with the plant or independently. Existing conveyor lighting is shown in Figure 18.

Figure 18: Lighting to Existing Conveyor Systems

- Where practicable, luminaires with minimal upward light component and low glare would be selected.
- Luminaires would use 3000K, or warmer, LEDs wherever practicable to minimise the lighting wavelengths at the cooler end of the spectrum. LEDs at the warmer end of the spectrum (3000K) are more friendly to night sky observers and fauna than those at the cooler end of the spectrum (4000K). Luminaires would use reduced or filtered blue / violet / and ultraviolet wavelength light in accordance with the National Light Pollution Guidelines for Wildlife.

- Lighting to Mine portals and associated infrastructure
  - Lighting would typically be provided adjacent to the entries to mine portals. Lighting would be permanent and would consist of LED luminaires mounted on lighting poles in the vicinity to the portals.
  - Where practicable, luminaires would be mounted so that there is zero upward light component.
  - Luminaires would use 3000K, or warmer, LEDs wherever practicable to minimise the lighting wavelengths at the cooler end of the spectrum. LEDs at the warmer end of the spectrum (3000K) are more friendly to night sky observers and fauna than those at the cooler end of the spectrum (4000K). Luminaires would use reduced or filtered blue / violet / and ultraviolet wavelength light in accordance with the National Light Pollution Guidelines for Wildlife.

3.6 NORTHERN ROCK STACK

3.6.1 Existing Lighting

Minimal permanent lighting exists in the area of the proposed Northern Rock Stack (NRS).

Lighting is associated with the existing conveyor directly to the south of the proposed NRS. The lighting consists of building and plant located bulkhead and floodlight luminaires similar to those shown on the elevated conveyor in Figure 18.

Lighting is also installed around the existing workshop structure and at the Company owned single storey dwelling at 699 Golden Valley Road.

3.6.2 Proposed Lighting

The existing workshop structure, fuel bowser, and grease storage facilities would need to be relocated approximately 160m south west of their present location (reference Figure 19). The location and orientation of lighting associated with the relocated facilities would be considered to ensure obtrusive effects are minimised.

The permanent lighting associated with the conveyor, loadout, workshops, and office blocks would be maintained as part of these works.

Artificial lighting would be required to enable rock stacking operations to occur outside of daylight hours.

Preparatory and operational works for the NRS, and rock disposal activities would occur during the following hours:

- *Monday-Saturday 7 am to 10 pm*.*

* Note: Planned works are not proposed between 7pm and 10pm however OGNZL may need to do so in certain circumstances.

Lighting associated with works between 10pm and 7am is expected to be of a similar type to that required during the "normal' operational period.

Lighting to support rock stacking operations is likely to consist of the following:

- Mobile lighting plant.
    - Typically, these would consist of diesel-powered LED lighting plant, with 3No. to 6No. LED floodlights mounted on 9m extension poles (Reference Figure 11 for a typical configuration). Luminaires would typically be aimed at a high angle to the ground to provide broad lighting coverage across the rock stacking area. Where practicable, lighting towers would be aimed into the rock stack rather than outwards towards the site boundary.
    - Luminaires would use 3000K, or warmer, LEDs wherever practicable to minimise the lighting wavelengths at the cooler end of the spectrum. LEDs at the warmer end of the spectrum (3000K) are more friendly to night sky observers and fauna than those at the cooler end of the spectrum (4000K). Luminaires would use reduced or filtered blue / violet / and ultraviolet wavelength light in accordance with the National Light Pollution Guidelines for Wildlife.
    - Mobile plant location and orientation would vary over time in response to rock stacking activities and locations.
    - OceanaGold has a Standard Operating Procedure for "*Towing and Setting up Lighting Plants*". The procedure includes a note "*Do not shine towards a public road or buildings"*.

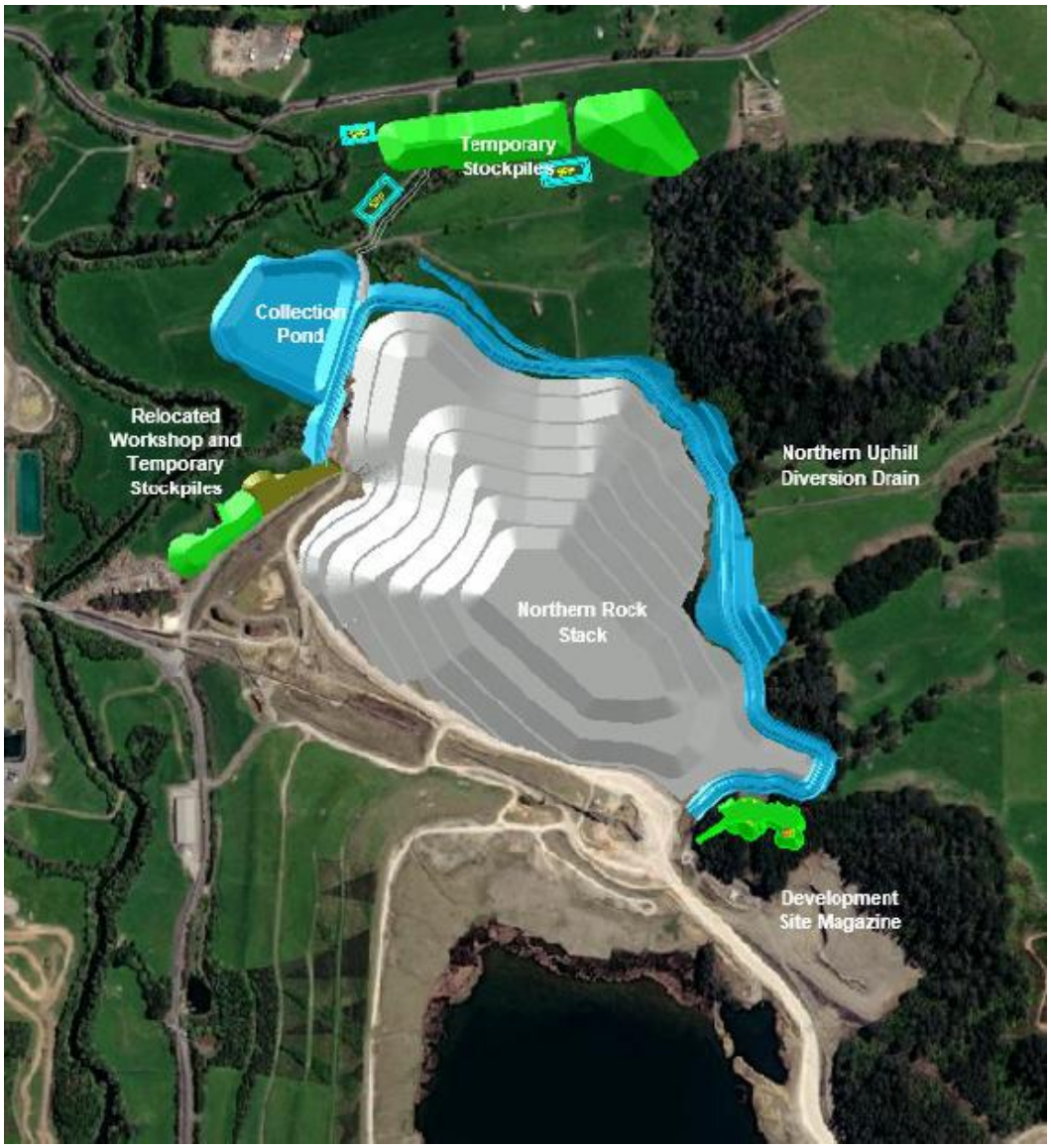


Figure 19: Northern Rock Stack (NRS) Location and Footprint

- Vehicle mounted rotating or flashing amber security beacons.
    - All vehicles operating on site would be required to have roof mounted security beacons unless parked in designated areas.
- Vehicle mounted task lighting may be used to support rock stacking operations.
    - This would consist of vehicle mounted floodlights to illuminate the immediate work area.
- Standard vehicle head and tail lights.
    - Required to be used in low light conditions and possibly during some mining activities and in some locations.

3.7 PROCESSING PLANT AND WATER TREATMENT PLANT

3.7.1 Existing Lighting

The existing Processing Plant and Water Treatment Plant areas feature lighting systems typical of industrial plant.

Lighting is provided throughout the exterior and interior of the Processing Plant area and the exterior of the Water Treatment Plant.

Luminaires represent a mixture of lamp sources including High Pressure Sodium (orange colour), metal halide (cool white colour), fluorescent (cool white colour), and Light Emitting Diode (LED) (cool white colour).

Lighting includes the following:

- Area floodlighting luminaires (High pressure sodium, metal halide, and LED sources) mounted on buildings and dedicated lighting poles. Luminaires are installed with the face of the luminaire at various aiming angles (Reference Figure **12**, Figure **20**, and Figure **21**).
- Conveyor walkway pole mounted bulkhead luminaires (Figure 22 and Figure 23)
- Lighting within the interior of buildings is visible externally through windows and open doorways (reference Figure 24, Figure 25, Figure 26, Figure 27, and Figure 28)
- Typical streetlighting luminaires (Reference Figure 27 – left side)

Figure 20: Typical Pole Mounted LED Area Light

Figure 21: Typical Building Mounted Floodlight

Figure 22: Conveyor Walkway Pole Mounted Bulkhead Luminaire

Figure 23: Conveyor Walkway Pole Mounted Bulkhead Luminaire 2

Figure 24: Processing Plant Area - Existing Lighting View 1

Figure 25: Processing Plant Area - Existing Lighting View 2

Figure 26: Processing Plant Area - Existing Lighting View 3

Figure 27: Processing Plant Area - Existing Lighting View 4

Figure 28: Processing Plant Area - Existing Lighting View 5

A recent review was undertaken of the existing lighting to improve performance, energy efficiency, operating life, and minimise adverse effects.

The review recommended the replacement of existing lamp technologies (high pressure sodium, metal halide, and fluorescent) with modern LED technology. It also recommended the use of appropriate luminaire selection and installation practices to minimise adverse effects such as upward light spill, reflection off walls/roofs, and glare.

3.7.2 Proposed Lighting

The expanded and reconfigured Processing Plant and Water Treatment Plant areas would be illuminated using modern lighting design principles to minimise adverse lighting effects.

Improved lighting would be installed along the existing conveyor, at the crusher and at the new SAG & Ball Mill.

Lighting may also be installed to support temporary project facilities, such as project offices, vehicle parking and equipment laydown yards, during the construction of the upgrades to the Processing Plant and Water Treatment Plant. These facilities would be built within the current footprint of the Processing Plant and would be removed once the upgrade work is complete.

The Processing Plant and Water Treatment Plant would continue to operate 24 hours per day, seven days per week.

Figure 29 shows the scale and location of the proposed Processing Plant expansion overlaid over the existing Processing Plant.

Figure 29: Proposed Processing Plant Layout – Truescape Render Area 5 View 2

It is understood that whilst some changes to the current layout of the Processing Plant would be required to accommodate the new infrastructure, all infrastructure would remain within the footprint of the existing Processing Plant.

The Water Treatment Plant expansion would occur in the area to the north of the “Water Tanks” label in Figure 29, on the far side of the existing conveyor.

3.8 TAILING STORAGE FACILITY 3 (TSF3)

3.8.1 Existing Lighting

The area of the proposed TSF3 has no permanent artificial lighting at present.

3.8.2 Proposed Lighting

Generally, permanent lighting would not be provided for the TSF3 area with the exception at particular plant locations i.e. decant pumps, switchrooms, etc. (Reference Figure 30 TSF3 overview). Permanent lighting in these locations is expected to be of horizontal flat glass configuration to minimise glare and upward light component. Sensor control of lighting would be considered.

Artificial lighting would be required to enable TSF construction to occur outside of daylight hours.

Preparatory and operational works for TFS3 activities would occur during the following hours:

- *Monday-Saturday 7 am to 10 pm*.*

* Note: Planned works are not proposed between 7pm and 10pm however OGNZL may need to do so in certain circumstances.

Lighting associated with construction works between 10pm and 7am is expected to be of a similar type to that required during the "normal' operational period.

Lighting to support TSF3 construction and operations is likely to consist of the following:

- Mobile lighting plant.
    - Typically, these would consist of diesel-powered LED lighting plant, with 3No. to 6No. LED floodlights mounted on 9m extension poles (Reference Figure 11 for a typical configuration). Luminaires would typically be aimed at a high angle to the ground to provide broad lighting coverage across the rock stacking area. Where practicable, lighting towers would be aimed into the rock stack rather than outwards towards the site boundary.
    - Luminaires would use 3000K, or warmer, LEDs wherever practicable to minimise the lighting wavelengths at the cooler end of the spectrum. LEDs at the warmer end of the spectrum (3000K) are more friendly to night sky observers and fauna than those at the cooler end of the spectrum (4000K). Luminaires would use reduced or filtered blue / violet / and ultraviolet wavelength light in accordance with the National Light Pollution Guidelines for Wildlife.
    - Mobile plant location and orientation would vary over time in response to construction activities and locations.
    - OceanaGold has a Standard Operating Procedure for "*Towing and Setting up Lighting Plants*". The procedure includes a note "*Do not shine towards a public road or buildings"*.
- Vehicle mounted rotating or flashing amber security beacons.
    - All vehicles operating on site would be required to have roof mounted security beacons unless parked in designated areas.

- Vehicle mounted task lighting may be used to support operations.
    - This would consist of vehicle mounted floodlights to illuminate the immediate work area.
- Standard vehicle head and tail lights.
    - Required to be used in low light conditions and possibly during some mining activities and in some locations.

Vehicle access to and from, and within, the TSF3 site would involve the use of amber flashing or rotating beacons on all vehicles and possibly head and tail lights during periods of low visibility.

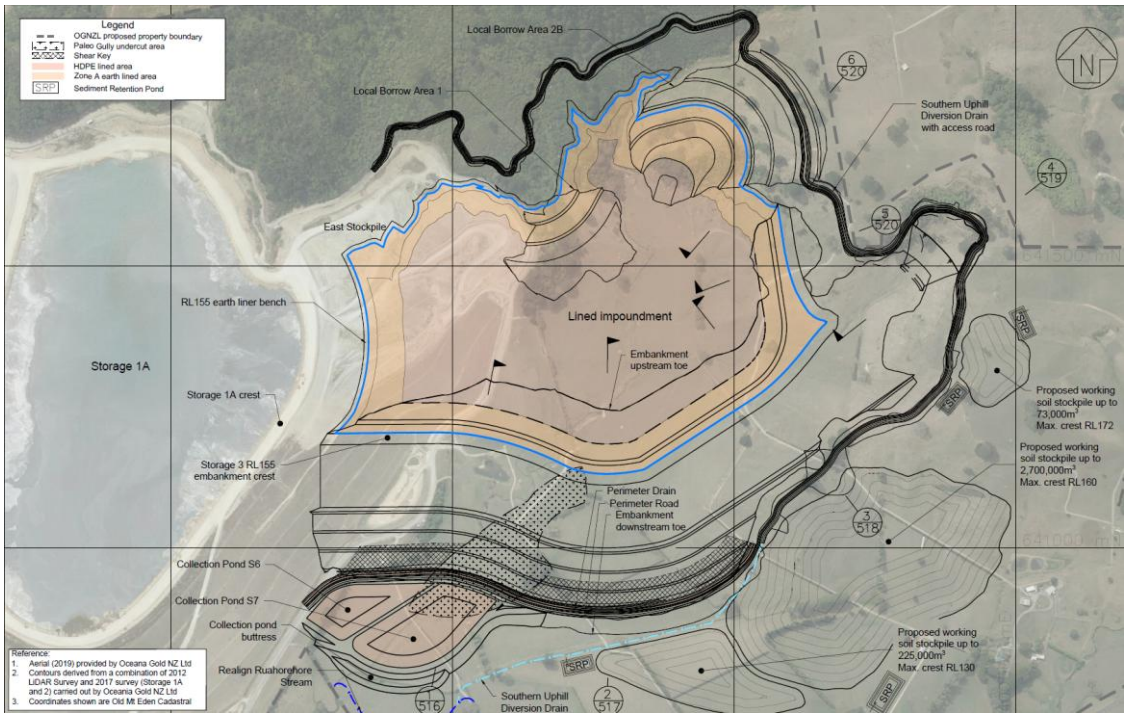


Figure 30: Proposed Tailings Storage Facility (TSF3) outlined in blue to the east of TSF1(shown as Storage 1A in figure): Part EGL Drawing *WAI-983-080-DWG-CI-0513 Revision D*

3.9 EXPLORATION DRILL, CAMP, VENT SHAFT, ETC. SITES

3.9.1 Existing Lighting

Artificial lighting is provided to existing exploration drill and camp sites where works are to be undertaken outside daylight hours.

These sites are predominantly located within Coromandel Forest Park where there would be no artificial lighting except associated with these facilities. It is expected that artificial lighting could be part of many of the sites within the conservation estate, namely, Exploration Drill, Camp, Pump, Manned Portable Rig, Geotechnical, Pumping Test, and (during construction) Vent Shaft Sites.

Existing fixed lighting (lighting that is associated with the operation of the plant or camp and would be removed when the facilities are removed) consists generally of the following:

Camp Interior and Outdoor Living Areas (Figure 31 and Figure 32):

- Linear surface mounted LED luminaires with switchable correlated colour temperature between 3000K and 4000K (note that the majority appear to be set at 4000K)

Exploration Drill Sites (Figure 33, Figure 34, and Figure 35):

- Round LED floodlights with flood beam distribution – probably 4000K or greater.
- LED awning lights surface/ roof mounted

Figure 31: Camp Mess Area

Figure 32: Camp Kitchen

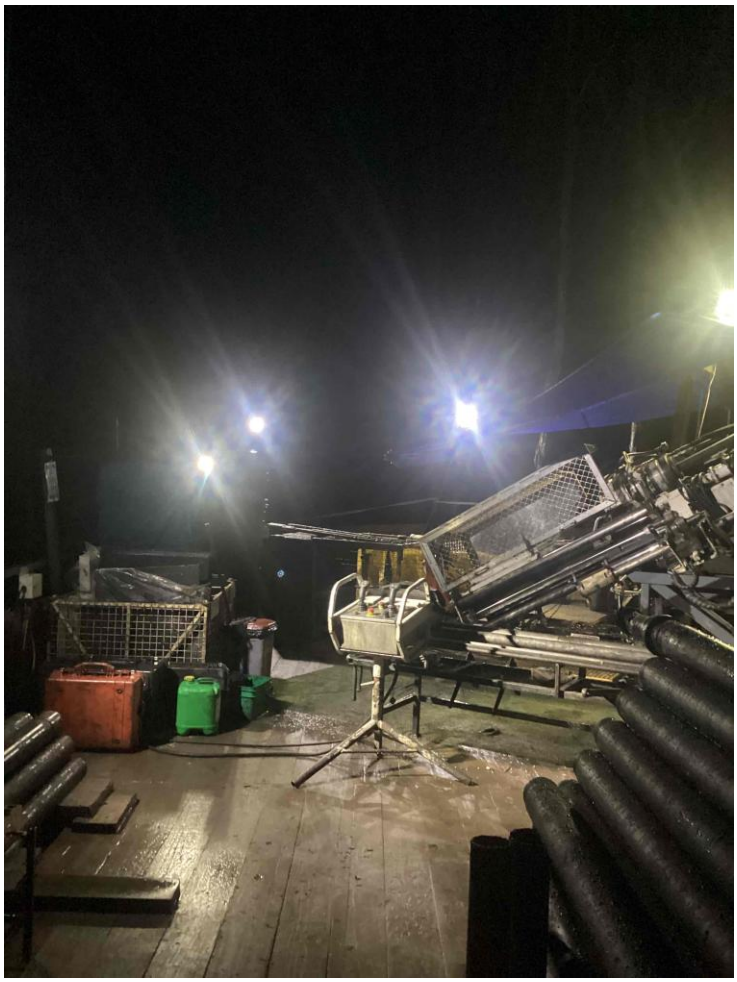


Figure 33: Drilling Site Lighting – Nighttime 1

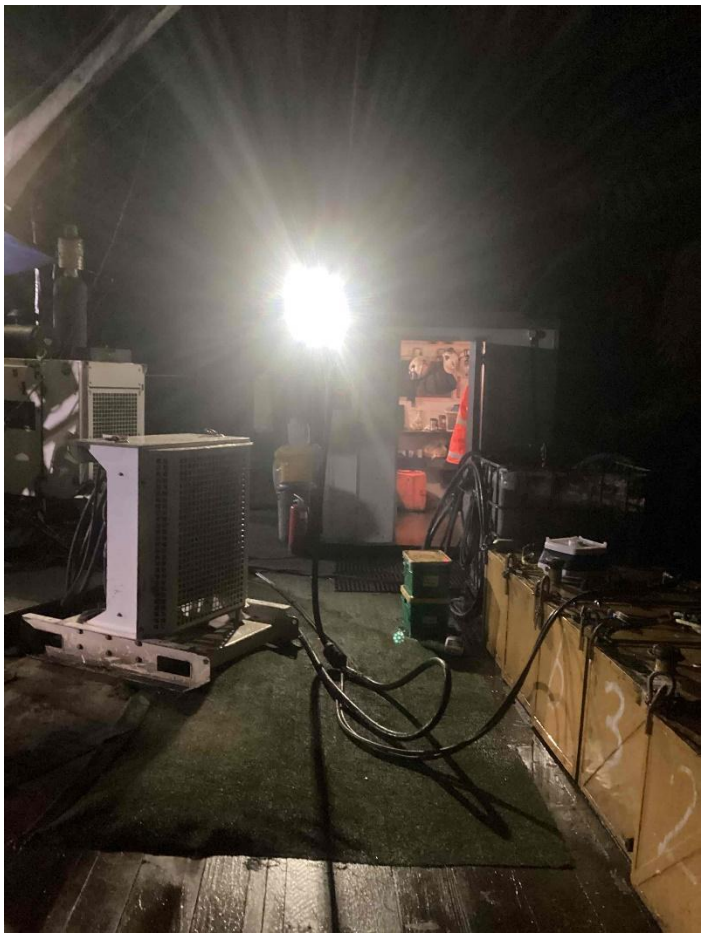


Figure 34: Drilling Site Lighting - Nighttime 2

Figure 35: Drilling Site Lighting - Daytime

3.9.2 Proposed Lighting

Given the location of these sites within the conservation estate, artificial lighting would need to be carefully considered to mitigate potential ecological effects.

Lighting would be designed to meet the best practice lighting design principles of the National Light Pollution Guidelines for Wildlife, namely:

1. Start with natural darkness and only add light for specific purposes.
2. Use adaptive light controls to manage light timing, intensity and colour.
3. Light only the object or area intended – keep lights close to the ground, directed, and shielded to avoid light spill.
4. Use the lowest intensity lighting appropriate for the task.
5. Use non-reflective, dark-coloured surfaces.
6. Use lights with reduced or filtered blue, violet and ultraviolet wavelengths.

Environmental impact assessments have been undertaken by Boffa Miskell's ecologists to determine the potential effects of lighting on the relevant fauna.

It is expected that operations within the conservation estate would occur 24 hours per day and that lighting to support this is likely to consist of the following. Note that these requirements differ from the existing lighting described above for such sites.

- Exterior Lighting
    - Luminaires would use 3000K, or warmer, LEDs wherever practicable to minimise the lighting wavelengths at the cooler (blue, violet and ultraviolet) end of the spectrum. LEDs at the warmer end of the spectrum (3000K) are more friendly to night sky observers and fauna than those at the cooler end of the spectrum (4000K). Luminaires would use reduced or filtered blue / violet / and ultraviolet wavelength light in accordance with the National Light Pollution Guidelines for Wildlife.
    - Luminaires aimed in towards the middle of the site to minimise light spill into the surrounding bush areas.
    - Luminaires installed with their light producing faces horizontal (i.e. parallel) to the ground and with flat glass (no dropped lenses). This may require the use of luminaires with asymmetric distribution.
    - Luminaires dimmable to reduce intensity when full output is not required.
- Interior Lighting
    - This lighting can be as outlined in the description of existing lighting above provided that the light is shield from the outside by blinds or screens on windows and exterior doors are closed.

A Lighting Management Plan should be prepared by a suitably qualified and experienced professional which would set out the requirements for all exterior, and externally visible interior, artificial lighting to be used as a part of sites within the conservation estate. The objective of the lighting management plan would be to balance the health, safety, and operational requirements of the lighting with the minimisation of effects on the local ecology.

3.10 ASSESSMENT OF EFFECTS

3.10.1 Spill Light Effects

In almost all WNP situations, direct spill light should be able to be contained to comply with the Hauraki District Plan requirement for a maximum of 8.0 lux (lumens per square metre) "*at any point on or directly above the boundary of any adjacent site or road*" (Reference: Hauraki District Plan, Section 8.2.5.3 (2)).

Potential exceptions to this are the use of mobile lighting plant associated with the services trench construction, lighting to the Willows SFA site entry gate, and lighting associated with areas in the conservation estate (i.e. exploration drill, camp, pump, manned portable rig, geotechnical, pumping test, and vent shaft sites). The edge of each mine site within the conservation estate is deemed to be the boundary at which to assess lighting effects on ecology within the estate.

Mobile lighting plant traditionally uses luminaires that flood the area to be illuminated with light, with minimal or no control over spill light. Where mobile lighting might be used during the services trench construction, it is expected that it would only be in one specific location and luminaire orientation for relatively short durations – maybe for a few nights.

Permanent lighting to the Willows Road / SH25 intersection would be designed and installed in accordance with Waka Kotahi's standards and, whilst not specifically stated in the Hauraki District Plan, would normally be excluded from compliance with the Plan rules. Roadway lighting is also excluded from AS/NZS 4282.

Any spill lighting from the roadway luminaires would be very localised in nature.

Lighting to the Willows SFA site entry gate where a streetlight(s) is/are installed for safety may exceed the 8.0 lux spill on to Willows Road. The extent, if any, of spill light would depend on the proximity of the entry gate to the road. Direct light spill would be very localised to the lighting pole(s) with effects minimised by using flat-glass (zero upward component) luminaire(s), backlight shielding (if required), appropriate luminaire orientation, and the use of 3000K LED technology.

Lighting associated with sites in the conservation estate would be designed and installed in accordance with the National Light Pollution Guidelines for Wildlife. In particular, luminaires with reduced or filtered blue, violet and ultraviolet wavelengths would be used. This combined with careful aiming of luminaires into the site should help reduce spill light effects.

However, given that the sites are directly surrounded by wildlife areas, it is expected that for operational and safety reasons, some light would spill over the boundaries of the specific site such that spill light levels would exceed the 8.0 lux spill. Such spill is likely to be localised and mitigated somewhat by the selection of luminaires with reduced blue wavelengths. Given that the light intensity reduces with the square of the distance from the light source, effects should be localised and will be temporary for sites within the Conservation Estate.

3.10.2 Glare Effects

Mobile lighting plant has the potential to result in glare effects as the luminaires are traditionally installed with their light producing faces aimed at a high level to the ground (Reference Figure 15) - to flood an area with light. Any lighting which is not installed with horizontal flat glass, such that lamp sources are visible from outside the site, may cause glare effects. Given the increasing elevation of both the NRS and TSF3 as they develop, with respect to the surrounding countryside, even flat glass luminaire installation may result in glare effects external to the site. A similar situation may occur during initial mining of the GOP at the top of hill.

After dark activities associated with the WUG rock stack which require the use of mobile lighting plant, have the potential to produce glare effects when the stack's height exceeds the height of the surrounding hillsides (reference: Boffa Miskell, Waihi North, Landscape Assessment, Appendix 3: Visual Simulations, Views 1 to 9). Similar glare effects could occur with lighting associated with activities at the NRS (Visual Simulations, Views 15 to 17) and TSF3 (Visual Simulations, Views 18 to 21).

These effects would be visible from the various public and residential viewing locations described in Boffa Miskell's "*Waihi North Project, Landscape, Natural Character and Visual Effects Assessment, Prepared for Oceana Gold New Zealand Limited*".

With respect to the WUG, the Boffa Miskell assessments of the level of visual effects associated with these works range from "Very Low" to "Moderate-Low" for the locations identified in visual simulations 1 to 9. The lighting effects, however, have the potential to be more significant given that they would be viewed in the context of a darkened foreground and background. The extent of effects would depend upon the perspective of the viewer, the viewing location, and the type of controls placed upon the use of mobile lighting plant. For those residents who value the existing darkened night environment, such effects could range from "Moderate-Low" to Moderate-High" (using Boffa Miskell's rating system).

With respect to the services trench construction, any lighting has the potential to create glare effects where the lighting is viewed in the context of a darkened foreground or background. The effects are expected to be less than minor given their expected short duration in any given location and in conjunction with expected mitigation measures including aiming of luminaires to minimise the effects on dwellings and transport. To minimise the effects on certain dwellings, OGNZL have advised that they will restrict works in the vicinity of those properties to daylight hours only.

Views of mobile lighting associated with the NRS would initially be seen against the backdrop of existing conveyor lighting and consequently the effects should be "Low". Any effects from lighting associated with the construction of the temporary stockpile could be expected to be "Moderate" to "Moderate-High" where the viewing location is in Golden Valley Road (View 15). From more remote locations (Views 16), the effects from mobile lighting plant would predominantly be screened by existing vegetation and landscapes.

Views of mobile lighting associated with TSF3 would occur from a broad range of locations (Views 18 to 21). Direct glare effects could be visible from relatively distant locations (several kilometres) and would be in the context of a predominantly rural environment with limited lighting from the existing mine and localised farm building lights. The extent of effects would depend upon the perspective of the viewer, the viewing location, and the type of controls placed upon the use of mobile lighting plant. For those residents who value the existing darkened night environment, such effects could range from “Moderate-Low” to Moderate-High”.

Permanent lighting may result in glare effects if it is of the type as presently installed on site, however lighting designed to minimise adverse effects should result in minimal, if any, direct glare effects. The actual effects would depend upon the visibility of the lighting from outside of the site.

Compliance with the recommended limits for luminous intensity in AS/NZS 4282 would depend upon the actual luminaires used, their location, and orientation.

Vehicle headlight, taillight, task, and safety lighting, whilst often excluded from Plan Rules, can result in adverse effects – particularly in rural environments. With respect to glare, the extent of any effects would depend upon lighting intensity, visibility from outside of the site, and rapid intensity change (i.e., flashing)

Lighting associated with vehicles moving within the WUG SFA, and between the SFA and the Portal, would be visible from outside of the site at the north end of Willows Road until the noise bunds have been constructed and proposed planting mitigation has grown sufficiently to directly screen vehicles from view (reference: Boffa Miskell, Waihi North, Landscape Assessment, Appendix 3: Visual Simulations, Views 1 and 2). Vehicle lighting may also be visible from more remote locations with views of the rock stack. Movement associated with head, tail, and task lighting would be visible along with rotating or flashing security beacons. The extent of effects would depend upon the perspective of the viewer, and the viewing location. For those residents who value the existing darkened night environment, the changing lighting effects could range from “Moderate- Low” to Moderate”.

Lighting associated with vehicles travelling to and from the proposed explosives magazine may be visible from some locations on Highland Road (Visual Simulation View 5), however an average of only two trips per night shift for security checks are expected to occur after dark. It is not known whether permanent lighting associated with the magazine would be visible from locations in Highland Road, however, it is reasonable to expect that any such lighting would be designed to minimise effects from external viewing locations.

Similar vehicle lighting effects to those expected at the WUG would be expected at the NRS and TSF3. Those at the NRS would initially be against the background of existing conveyor lighting such that effects should be “Low”.

Vehicle lighting effects associated with TSF3 are likely to be visible from multiple locations with views of the area. Movement associated with head, tail, and task lighting would be visible along with rotating or flashing security beacons. The extent of effects would depend upon the perspective of the viewer, and the viewing location. For those residents who value the existing darkened night environment, the changing lighting effects could range from “Moderate” to Moderate-High”.

Lighting proposed by Waka Kotahi for the Willows Road / State Highway 25 intersection, would be expected to be of flat-glass (zero upward light component) design which should minimise glare effects.

Lighting associated with sites in the conservation estate could produce glare effects when exterior luminaires need to be aimed above the horizontal to provide operational and safety lighting for work areas. Whilst luminaires would be aimed into each site, the relatively small site sizes would mean that theoretically both disability and discomfort glare effects could occur. Given that the sites within the conversation estates are remote, it is not expected that anyone other than Ocean Gold staff and contractors would be present at the sites at night. Such personnel would be aware of and expecting any glare effects.

3.10.3 Sky Glow Effects

Generally, whenever luminaires are installed with their light producing faces aimed above the horizontal, there is the potential to produce direct sky glow effects.

Mobile construction lighting as shown in Figure 15 and Figure 16, would produce direct sky glow which could be visible from several hundred metres away. The effects would depend upon the viewing location and the backdrop to the area being viewed.

With respect to the Willows SFA, from viewing locations towards the backdrop of the unilluminated farmland and Coromandel Forest Park, this effect would be more than minor with no mitigation employed.

With respect to the services trench construction, mobile lighting is primarily expected to be used for the Willows Road / SH25 intersection, where the trench crosses SH25 and heads to the operations plant, and in selected other areas as part of overall effects mitigations to dwellings. Whilst these effects could be assessed as “Moderate”, the expected short duration should reduce this effect from “Low” to “Moderate-Low”.

With respect to the GOP, NRS, Processing Plant, and TSF3, whilst sky glow would be expected to be generated – particularly by mobile lighting plant – the location adjacent to the existing mine facilities and the Waihi township should result in less than minor effects.

Reflected light from luminaires would produce sky glow in varying amounts depending upon the situation. Light would be reflected from the ground below the luminaires - with greater reflection in wet conditions, with light concrete ground construction, and less reflection with darker asphalt construction. Reflected light into the atmosphere would also occur in misty and foggy conditions – exhibiting as halos of light around the luminaires.

Vehicle head, task, and security lighting could contribute to the sky glow effects seen from outside of the site. The effect would depend upon the location of the source and the viewing location. It might be expected that the duration of such lighting, and hence the effects, would be short relative to the other forms of lighting on the site as vehicles might be expected to move through the site rather than remaining stationary for extended periods. Increased duration of sky glow effects would be expected where vehicles were undertaking construction and operational tasks requiring them to remain in an area for an extended period. Vehicle head, task, and security lighting associated with the construction of the services trench, could contribute to the skyglow. Given the limited duration of construction activities being undertaken outside of daylight hours, the effects would be expected to be from “Low” to “Moderate-Low”.

Permanent lighting proposed by Waka Kotahi for the Willows Road / State Highway 25 intersection, would be expected to be of flat-glass (zero upward light component) design which should minimise direct sky glow effects.

3.10.4 Ecological Effects

Ecologists at Boffa Miskell have reviewed the potential responses of fauna to non-lethal disturbance and stressors associated with artificial light (Reference: Boffa Miskell, Waihi North Project, "*Terrestrial Ecology Values and Effects of the WUG*", WAI-985-000-REP-LC-0007. Rev 0, 29 October 2024).

The report notes that fauna responses to non-lethal stresses (in this instance artificial light at night (ALAN)) may include heightened stress (and potential loss of condition as a consequence), avoidance behaviours, altered behaviour (e.g. change in volume or pitch of bird calls, reduced emergence) and reduced / failed reproduction. The ability to move away from these stressors varies between individuals, species, and factors like mobility, habitat requirements, exposure to predators, reproductive state and dormancy / torpor (if applicable).

The light effects assessment considers terrestrial invertebrates, native frogs, native lizards, bats, and native birds. The Boffa Miskell report identifies the following potential effects of ALAN.

Terrestrial invertebrates:

Effects on terrestrial invertebrate will vary, with the severity of impact depending on the overlap between the spectral sensitivity of the insect and the spectral emission and intensity of the light sources.

Insects which are attracted to light can become trapped in a "light sink" – wasting energy and unable to forage, attract mates, or reproduce.

Such insects can then be preyed upon by ruru / morepork and bats.

Native Frogs:

Native frogs are nocturnal and are expected to have a similar response to ALAN as other species. There is an increased risk of predation by rats and ruru / morepork in brightly illuminated areas.

The response of frogs to artificial light has not been studied however it is expected that frogs would avoid brightly lit areas.

Native Lizards:

Of the two species of native lizards recorded as part of Boffa Miskell's investigations, one was diurnal (elegant gecko) and the other was cathermeral (sporadic and random intervals of activity during the day or night) (forest gecko).

Responses to ALAN may be varied, with brightly illuminated areas having a higher density of invertebrate prey but also making the lizards more visible to predators.

The report notes that there is a suggestion that native lizards may be able to adapt to ALAN as they are observed in urban settings and along road margins.

Bats:

The Boffa Miskell report notes that studies have shown that bat activity decreases in response to streetlights or brighter illumination which suggests that bats may avoid brightly illuminated areas. Studies have also shown that artificial lighting may impact circadian cycle, natural emergence clues and may reduce foraging duration and extent of foraging available. There is also anecdotal evidence of long-tailed bats feeding around streetlights in urban areas suggesting a potential attraction to light for foraging.

The National Light Pollution Guidelines for Wildlife has a specific appendix on bats. Whilst the document is focused on Australian bats, it might be expected that similar effects could occur on the species involved here. The potential effects of ALAN include attraction to artificial lights, changes in prey availability, habitat degradation and avoidance of artificial light.

The guidelines identify key management measures including:

- Maintaining natural darkness in and near bat species' habitats.
- Maintenance of dark roost site, creating dark corridors from roosts to foraging / watering sites
- Keeping light intensities low and direct light away from habitats.
- Using longer wavelength (red) light to reduce the impact of light effects

Native Birds:

The effects of ALAN on birds are specific to the species and the type of light (wavelength and intensity. ALAN effects can include changes to bird vocalisation, orientation, and foraging behaviours.

The National Light Pollution Guidelines for Wildlife note that natural daylength plays a key role in regulating the breeding behaviour and physiology of birds. Light pollution can therefore result in adverse effects by masking natural daylength.

The guidelines also note that taken together, the effects of artificial light on reproduction, behaviour, predator-prey dynamics, natural food webs and individual physiology of birds have the potential to reduce or fragment populations of birds, alter birds' distribution in the landscape, or exclude them from illuminated patches altogether.

3.10.4.1 Willows SFA Lighting Effects

The Willows SFA is set in the context of open farmland against the backdrop of the unilluminated Coromandel Forest Park.

The greatest lighting effects are likely to occur during the SFA and Tunnel construction stages when mobile lighting plant is used for the construction of the Willows SFA, the mine portal, and during movements to and from the Willows Rock Stack. Mobile lighting has the greatest potential to effect fauna through skyglow and luminaire light source visibility (glare) from distance when luminaires are not oriented "flat glass". However, the location of mobile lighting plant would be expected to vary as construction works progressed reducing the effects in any given location.

Permanent lighting associated with the Willows SFA would be designed using principles to reduce adverse lighting effects as outlined in section 3.3.2 of this document.

Boffa Miskell's report assess the magnitude of effect of lighting impacts at the Willows SFA as **LOW** and the ecological value of the fauna as **LOW**. Therefore, the level of effect of artificial lighting on the ecology is assessed as **LOW**.

3.10.4.2 Coromandel Forest Park Lighting Effects

Artificial lighting will be required to illuminate construction, work, and camp sites during and outside daylight hours in the Coromandel Forest Park, as outlined in section 3.9.2 of this report.

Other than lighting associated with existing mine facilities, there is no artificial lighting in any of the proposed CFP sites.

Boffa Miskell's ecologists note that as a consequence, fauna within the Coromandel Forest Park would be naïve to artificial lighting effects and would be expected to respond more strongly than those in urban / semi urban environments – where many of the study sites in scientific literature are located.

Spill Light:

Given the relatively small footprints of the mine sites, spill lighting into the surrounding forest park is likely to exceed the Hauraki District Plan limit of 8.0 lux. However, on the basis that light intensity reduces with the square of distance from the light source and that edge vegetation will also impede light spill into the forest, the spill light effects should be localised around the mine sites.

Use of light sources with reduced or filtered blue, violet, and ultraviolet wavelengths combined with careful aiming of luminaires into the site, should minimise spill light effects.

Boffa Miskell note that localised spill may attract invertebrates and their predators (ruru / morepork, geckos and bats, if present). Other taxa groups, including native frogs, invertebrates, and native birds may experience disruption to orientation, foraging and environmental cues for particular behaviours (e.g., emergence). The level of this effect would depend on the animal's sensitivity to artificial light and how close they are to the light source.

Glare Effects:

Lighting associated with sites in the conservation estate could produce glare effects when exterior luminaires need to be aimed above the horizontal to provide operational and safety lighting for work areas. Whilst luminaires would be aimed into each site, the relatively small site sizes would mean that glare effects would occur.

Fauna that is attracted to light can be adversely impacted by glare effects from unshielded light sources which, depending on forest density, could extend for several hundred metres to kilometres away.

In addition to the direct visibility of luminaire sources, light reflected off buildings and structures within each site may also be remotely visible. Lightly coloured buildings and structures will create more adverse effects than darker coloured structures.

Sky Glow:

Generally, whenever luminaires are installed with their light producing faces aimed above the horizontal, there is the potential to produce direct sky glow effects.

It is expected that localised sky glow could adversely affect the fauna as outlined above.

Boffa Miskell note in their summary of the effects of artificial lighting that, Coromandel Forest Park provides important habitat for native species to undertake biologically important activities such as foraging, breeding, roosting or dispersal. In their assessment, they also consider the localised nature of the lighting effect in the context of the whole forest park and the short duration of the effect at any one particular site (from a few days to several months, from their perspective, temporary). The effects of artificial lighting are expected to be immediately reversible once the drill rig / camp site / pump is removed.

Boffa Miskell assess the magnitude of effect of lighting impacts in CFP from an ecological perspective and if effects are minimised to the extent possible using controls described below, to be **Low - Moderate**. They note that the ecological value of the fauna is **Very High** and therefore the level of effect of artificial lighting is assessed as **Moderate**.

3.10.4.3 Ecological Summary

The project plans to implement wide scale intensive pest animal control over an area of 633 ha. Boffa Miskell advise that this pest control is expected to compensate for the potential impacts of environmental stressors resulting from the surface exploration drilling and pump testing (e.g. artificial light effects) and the temporary loss of habitat whereby the carrying capacity of the surrounding forest will be increased by the removal of predators and subsequent forest regeneration.

3.10.5 Potential Mitigation Measures

To minimize effects to neighbours and the environment, where luminaires are visible from external locations and / or have the potential to create spill light, glare, or sky glow, they should be configured as follows:

- Selection of appropriate luminaires for purpose (e.g. asymmetric vs symmetric, appropriate lumen outputs, warm colour temperature, sensor-activated, glare shields)
- Installed such that their light producing faces are horizontal to the ground and not directed against reflective surfaces such as walls/roofs,
- Luminaires aimed away from external locations i.e., into the site,
- Of luminous intensity not exceeding the limits set out in AS/NZS 4282 for the applicable environmental zone.
- Where mobile lighting plant is to be used for extensive periods during the mine's development, i.e. everywhere except for the services trench construction, it should be designed and installed using the best practice principles in the National Light Pollution Guidelines for Wildlife – particularly with respect to using luminaires with reduced blue wavelengths and using luminaires with a lighting distribution which was asymmetrical in the vertical plane such that the light emitting surface could be horizontal to the ground.
- With respect to services trench mobile lighting usage, mitigation measures should include careful luminaire aiming to minimise spill light and glare effects i.e. aim lights away from dwelling and sensitive ecological areas.
- Where practicable, reduce the intensity/output of lighting fittings to suit the application.
- Wherever practicable, activities in areas of lighting sensitivity should be undertaken during daylight hours
- Locate and aim lighting adjacent to roadways and intersections to ensure safety of road users is not compromised whilst minimising the effects to dwellings.
- Install blinds to windows and glass doors where site support facilities are to be used after dark.
- Undertake a risk analysis for any proposed lighting to ensure operational health and safety is not compromised and effects to neighbours are minimised.

- Work with Waka Kotahi to use environmentally friendly luminaires for the Willows Road / SH25 intersection i.e. use LED's with a warm colour temperature and with low spectral density at the blue end of the spectrum installed in "flat glass" configuration with zero upward light component. The luminaires selected must be to Waka Kotahi approval and ensure the safety of all road users is paramount.
- During construction of the services trench, the use of vehicle headlight and security lighting is expected to be a fundamental part of the safety management systems. As such the lighting effects are unlikely to be able to be practicably mitigated. Certainly, security lighting (i.e. rotating or flashing beacons) can be expected to be present on most vehicles during construction. Vehicle head lights would be used whenever vehicles are being operated in low light conditions.
- For the services trench works, the limited duration and variable location of the mobile lighting plant, combined with the suggested mitigations outlined above, mean that the type of mobile lighting plant regularly used in civil works construction (high colour temperature luminaires (4000 kelvin or greater), general floodlights, etc – i.e. as shown in Figure 15) would be acceptable. If, however, mobile lighting plant was to become semi-permanent in a given location and orientation for say a month or more, then additional mitigation measures should be considered to minimise effects on residents.

To minimize ecological effects in the Willows SFA and adjacent to the mine sites within the Coromandel Forest Park, lighting installations should be configured as follows in addition to the general requirements outlined above:

- Lighting should be designed and installed using the best practice principles in the National Light Pollution Guidelines for Wildlife – particularly with respect to using luminaires with reduced blue wavelengths and using luminaires with a lighting distribution which is asymmetrical in the vertical plane such that the light emitting surface would be horizontal to the ground.
- The best practice principles in the National Light Pollution Guidelines for Wildlife include:
    1. Start with natural darkness and only add light for specific purposes.
    2. Use adaptive light controls to manage light timing, intensity and colour.
    3. Light only the object or area intended – keep lights close to the ground, directed, and shielded to avoid light spill.
    4. Use the lowest intensity lighting appropriate for the task.
    5. Use non-reflective, dark-coloured surfaces.
    6. Use lights with reduced or filtered blue, violet and ultraviolet wavelengths.
- Mobile lighting plant should be carefully located, and luminaires aimed and orientated, to minimise lighting effects in ecologically sensitive areas.
- Lighting controls and luminaire output dimming should be used with permanent lighting installations.

3.10.6 Lighting Management Plan

A Lighting Management Plan should be prepared by a suitably qualified and experienced professional which would set out the requirements for all fixed/permanent, mobile, and construction artificial lighting to be used as a part of the WNP. The objective of the lighting management plan would be to ensure that lighting effects on residents and wildlife are avoided or adequately mitigated without compromising health and safety.

The Plan would provisionally include the following:

- Plan purpose
- Applicable legislation and standards
- Key roles and responsibilities
- Requirements for lighting design and installation to balance operational and safety requirements with best practice lighting design in cognisance of the:
    - Hauraki District plan requirements
    - AS/NZS 4282: 2023 "*Obtrusive effects of outdoor lighting"*
    - The Australian Government's "*National Light Pollution Guidelines for Wildlife".*
- Specific Operational Requirements (if any)
- Lighting Audit Requirements and Periodic Review
- Definitions/Glossary
- Reference Documents

The Plan would incorporate the mitigation principles and specifics outlined in the Potential Mitigation Measures section above.

4. CONCLUSION

Artificial lighting would be required to support WNP construction and on-going operations whenever activities are undertaken outside of daylight hours.

In almost all WNP situations, direct spill light should be able to be contained to comply with the Hauraki District Plan requirement for a maximum of 8.0 lux (lumens per square metre) "*at any point on or directly above the boundary of any adjacent site or road*" (Reference: Hauraki District Plan, Section 8.2.5.3 (2)).

Potential exceptions to this are the use of mobile lighting plant associated with the services trench construction, lighting to the Willows SFA site entry gate, and lighting associated with areas in the conservation estate (i.e. exploration drill, camp, pump, manned portable rig, geotechnical, pumping test, and vent shaft construction sites). The edge of each mine site within the conservation estate is deemed to be the boundary at which to assess lighting effects on ecology within the estate.

Artificial lighting associated with services trench construction would be used sparsely, with the majority of activities to be undertaken during daytime. Permanent lighting to the Willows Road / SH25 intersection would be designed and installed in accordance with Waka Kotahi's standards.

Lighting associated with sites in the conservation estate would be designed and installed in accordance with the National Light Pollution Guidelines for Wildlife. In particular, luminaires with reduced or filtered blue, violet and ultraviolet wavelengths would be used. This combined with careful aiming of luminaires into the site should help reduce spill light effects.

The area for the WUG SFA, mine portal, and rock stack, is presently sparsely illuminated. Above-ground construction activities requiring artificial lighting would result in an increase in both glare and sky-glow from locations with a view of the area. Mobile lighting plant has the most potential to create these effects, however, they could be mitigated by careful plant selection, location, and luminaire orientation and aiming (i.e., into the site). It is understood that trucking waste onto and off the Willows rock stack would occur 24 hours per day. However, when works are near the Willows Road end of the SFA then they are likely to occur under more limited time constraints for other environmental reasons.

Where there is the potential for adverse lighting effects due to nighttime operations associated with vehicle movement between the portal and the Willows Rock Stack, mitigation measures should be undertaken to reduce effects. These might include naturally screening of works by topography and / or timing the location and type of works. Such management should be included in the procedures for the use of mobile lighting plant. If appropriate management combined with careful lighting control is undertaken, then the potential effects are expected to be minor given their temporary nature and them predominantly occurring during day shift operations. Wherever practicable, activities in areas of lighting sensitivity should be undertaken during daylight hours.

Permanent lighting to the Willows SFA would be designed to minimise both glare and sky glow effects such that they are less than minor.

The GOP and Processing Plant areas of the WNP occur in proximity to existing mining operations. As such, these areas presently either have some form of artificial lighting to support operations or would be set against the backdrop of existing operational areas.

The NRS and TSF3 areas may operate during darkness, requiring both vehicle lighting (head, tail, task, and security) and mobile lighting equipment. In addition to lighting intensity, rapidly changing lighting, such as vehicle security lighting, can be obtrusive and be visible from several kilometres away. Both locations would produce lighting effects that would be visible from various locations outside of the mine site. The extent of effects would depend upon the perspective of the viewer, and the viewing location. Whilst the effects from vehicle lighting (head, task, and security) would be remotely visible, AS/NZS 4282:2023 does not apply to such lighting. The effects from mobile lighting equipment mitigated in accordance with the National Pollution Guidelines for Wildlife, could range from "Moderate – Low" to "Moderate" for those residents who value the existing darkened night environment (using Boffa Miskell's visual effect ratings).

Mobile lighting plant has the most potential to create glare and sky glow effects, given the need to illuminate large construction activities and/or changing operational areas. The effects are expected to be minor given their proximity to existing mining operations, temporary nature and the Standard Operating Procedure to position the lighting towers so that they "*Do not shine towards a public road or buildings"*.

Permanent lighting to these areas is likely to be an improvement over that presently installed throughout the existing mine, with lesser effects from glare and sky glow due to the change to LED lighting technology and appropriate luminaire selection, orientation, and aiming. The effects are expected to be less than minor in the context of the existing mine lighting.

Ecological Effects:

Boffa Miskell have reviewed and assessed the effects of the proposed lighting on the local ecology in the Willow Road SFA and associated with the construction, camp, and work sites in the Coromandel Forest Park.

The local ecology from the perspective of the assessment includes terrestrial invertebrates, native frogs, native lizards, bats, and native birds. Non-lethal stressors, such as artificial light can generate response such as heightened stress (and potential loss of condition as a consequence), avoidance behaviours, altered behaviour (e.g. change in volume or pitch of bird calls, reduced emergence) and reduced / failed reproduction.

With respect to the Willows SFA, the greatest lighting effects are likely to occur during the SFA and Tunnel construction stages when mobile lighting plant is used for the construction of the Willows SFA, the mine portal, and during movements to and from the Willows Rock Stack. Mobile lighting has the greatest potential to effect fauna through skyglow and luminaire light source visibility (glare) from distance when luminaires are not oriented "flat glass". However, the location of mobile lighting plant would be expected to vary as construction works progressed reducing the effects in any given location.

Permanent lighting associated with the Willows SFA would be designed using principles to reduce adverse lighting effects as outlined in section 3.3.2 of this document.

Boffa Miskell's report assesses the magnitude of effect of lighting impacts at the Willows SFA as **LOW** and the ecological value of the fauna as **LOW**. Therefore, the level of effect of artificial lighting on the ecology is assessed as **LOW**.

Boffa Miskell's ecologists note that because of the absence of existing artificial light, fauna within the Coromandel Forest Park would be naïve to artificial lighting effects and would be expected to respond more strongly than those in urban / semi urban environments – where many of the study sites in scientific literature are located.

In their summary of the effects of artificial lighting, Boffa Miskell ecologists note that Coromandel Forest Park provides important habitat for native species to undertake biologically important activities such as foraging, breeding, roosting or dispersal. They also consider the localised nature of the lighting effect in the context of the whole forest park and the short duration of the effect at any on particular site (from a few days to several months, in effect, temporary). The effects of artificial lighting are expected to be immediately reversible once the drill rig / camp site / pump is removed.

Boffa Miskell assess the magnitude of effects of lighting impacts in CFP from an ecological perspective, if the effects are mitigated to the extent possible using proposed controls, to be **Low - Moderate**. They note that the ecological value of the fauna is **Very High** and therefore the level of effect of artificial lighting is assessed as **Moderate**.

To minimise ecological effects in the Willows SFA and within the Coromandel Forest Park, lighting installations would follow the best practice principles in the National Light Pollution Guidelines for Wildlife, namely:

1. Start with natural darkness and only add light for specific purposes.
2. Use adaptive light controls to manage light timing, intensity and colour.
3. Light only the object or area intended – keep lights close to the ground, directed, and shielded to avoid light spill.
4. Use the lowest intensity lighting appropriate for the task.
5. Use non-reflective, dark-coloured surfaces.
6. Use lights with reduced or filtered blue, violet and ultraviolet wavelengths.

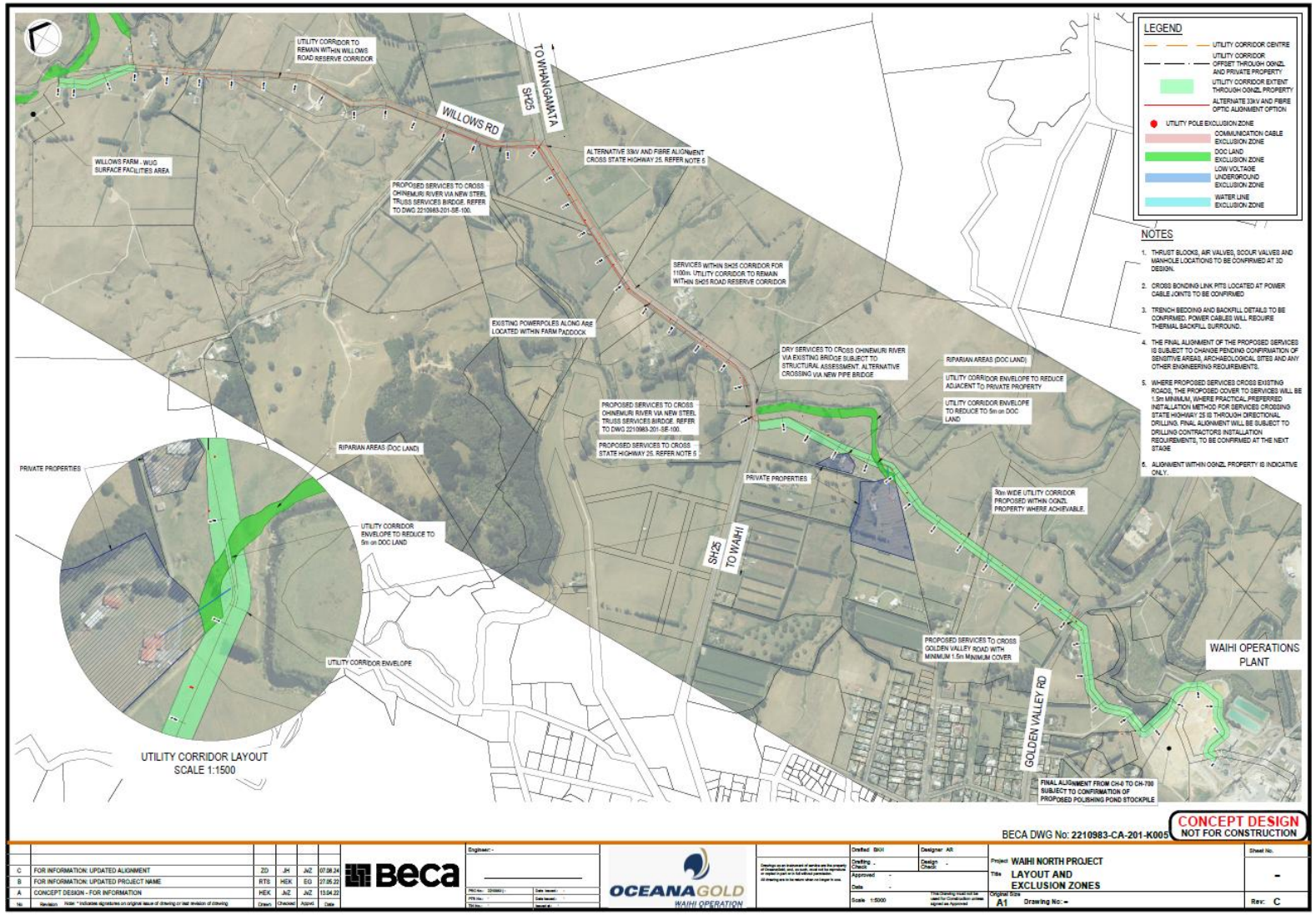
APPENDICES

Appendix A Bibliography

The following information / activities have informed this review:

1. Information provided by Mitchell Daysh and OceanaGold on the proposed construction, operation, and remediation of each of the WNP areas.
2. A day and night visit to the mine site, undertaken on Thursday the 18th of November 2021 in conjunction with a review of the surrounding environs on the night of Wednesday the 17th of November 2021.
3. The Hauraki District Plan Rules with respect to Glare and Lighting.
4. Australian / New Zealand Standard AS/NZS 4282: 2023, *"Control of the obtrusive effects of outdoor lighting*".
5. Boffa Miskell, "*Waihi North Project, DRAFT Landscape, Natural Character and Visual Effects Assessment, Prepared for Oceana Gold New Zealand Limited*", Version 2, 16 October 2024.
6. Boffa Miskell, Waihi North Project, "*Terrestrial Ecology Values and Effects of the WUG*", WAI-985-000-REP-LC-0007. Rev 0, 29 October 2024.
7. Boffa Miskell, "*Waihi North, Landscape Assessment, Appendix 5: Figures",* October 2024, WAI-985-000-REP-LC-0021
8. Boffa Miskell, "*Waihi North, Landscape Assessment, Appendix 6: Visual Simulations"*, September 2024
    a. Boffa Miskell, *Waihi North, Landscape Assessment, Appendix 2:* Figures, May 2022.
    b. Boffa Miskell, *Waihi North Landscape Assessment, Appendix 3: Visual Simulations*, May 2022.
9. Beca Drawing, *Wharekirauponga Exploration Decline Project, Willows Road Surface Infrastructure Layout*, Drawing Number WAI-981-000-DWG-CI-1001 Revision O.
10. Beca Drawing, *Wharekirauponga Exploration Decline Project,* Truescape Renders: *Area 2 Views 1, 2, and 3*.
11. OceanaGold Standard Operating Procedure "*Towing and Setting up Lighting Plants"*, MAC-351-PRO-006, Revision 8, September 2021.
12. Australian Government, Department of Climate Change, Energy, the Environment and Water, "*National Light Pollution Guidelines for Wildlife*", May 2023, Version 2.0
13. Beca Drawing No/ 2210983-CA-201-K005, "*Layout and Exclusion Zones*", Rev C.
14. Fulton Hogan, "*Service Trench Construction Methodology Report"*, 16 August 2024, including an outline of the possible civil construction process that might be undertaken after dark with associated artificial lighting systems.
15. OceanaGold, "*Waihi North Project – Fast-track Approval, Project Description"*, Document No.: WAI-985-000-SOW-GE-0002, August 2024
16. Truescape Render: Area 5 View 2.
17. Engineering Geology Ltd. Drawing *WAI-983-080-DWG-CI-0513 Revision D "Layout Plan, Storage 3 RL155 Embankment Tails / Waste Rock 080"*.
18. Images of typical camp and exploration drilling sites provided by OceanaGold including information on the light fittings typically used – received 28/08/2024.

Appendix B WNP: Services Trench Layout Plan



Appendix C Glossary of Lighting Terms

The following simple definitions are based upon those within Australian/New Zealand Standard AS/NZS 4282:2023 "*Control of the obtrusive effects of outdoor lighting"* and apply to terms used in this report:

ALAN

ALAN is artificial light at night. It refers to artificial light that is visible outdoors at night.

Asymmetric and Symmetrical Light Distribution

The term asymmetric light output is the term to describe a system where light is directed sideways (or in an asymmetric pattern). Symmetrical lighting in comparison spreads the light equally in all directions.

BACKLIGHT SHIELDS

Backlight shields are barriers mounted on or in the luminaire to minimise light spilling behind the primary aiming direction of the light.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

An environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, considering the inter-related socio-economic, cultural and human safety impacts, both beneficial and adverse.

GLARE

Condition of vision in which there is discomfort or a reduction in the ability to see, or both, caused by an unsuitable distribution or range of luminance, or extreme contrasts in the field of vision.

Visual impairment or discomfort resulting from the intensity of a light source and the brightness contrast with the associated surroundings. It is affected by the light source size and intensity, background brightness, and the location relative to the viewing position.

The two terms that are normally used to describe the effects of glare on the ability to see are *disability* and *discomfort*.

Disability Glare: Glare that impairs the visibility of objects without necessarily causing discomfort.
A typical example of *disability* glare is the glare from approaching headlights on the open highway at night, which prevent anything else being seen on the road. The eye is unable to adapt to the bright headlight and to the significantly lower brightness on the road at the same time. Hence the glare is having a disabling effect. This disabling effect is related to the intensity of the source in the direction of the eye with respect to the brightness of the surroundings. As a comparison, the same car approaching with its headlights on during the day would cause almost no disability because of the brightness of the surroundings.

Discomfort Glare: Glare that causes discomfort without necessarily impairing the visibility of objects.

An example of *discomfort* glare is a bright sky on a sunny day can cause discomfort, particularly to those used to wearing sunglasses who are without them, however the ability to see is not impaired.

The key difference between the two is that *disability* glare has a physiological effect and can be objectively measured, whereas *discomfort* glare has a psychological effect and is much more subjective. What may not cause discomfort to one person may cause significant discomfort to another person.

Note: Both *disability* and *discomfort* glare may be present concurrently.

ILLUMINANCE

The measure of illumination level, which is the amount of light or luminous flux (i.e. Lumens) incident on a surface, per unit area, measured in Lux (1 Lux = 1 Lumen /m^2).

LUMINAIRE

The international term for a lighting fitting, which is the assembly that contains a light source and distributes the light output.

LUMINANCE

The measure of brightness, which is a function of concentration or density of luminous intensity (i.e. Candelas) in a given direction per unit area, measured in Candela/m^2 (Cd/m^2).

LUX

The International System (SI) unit of illuminance and luminous emittance, measuring luminous flux per unit area. It is equal to one lumen per square metre.

SKYGLOW

The brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered from the constituents of the atmosphere (gas molecules, aerosols and particulate matter), in the direction of observation.

It comprises two separate components as follows:

Natural Sky Glow: That part of the sky glow that is attributable to radiation from celestial sources and luminescent processes in Earth's upper atmosphere.

Man-Made Sky Glow: That part of the sky glow that is attributable to man-made sources of radiation (e.g. outdoor lighting).

SPILL LIGHT

Light emitted by a lighting installation that falls outside the boundaries of the property for which the lighting installation is designed.