Lightscape Management Plan
for the AURA Observatory in Chile:
El Totoral Site in the Elqui Valley

1. Basic Policy Foundations of the Lightscape Management Plan

This AURA-O Lightscape Management Plan will be the governing lighting policy document for the AURA-O site in the Elqui Valley of the Region of Coquimbo, Chile, encompassing Cerro Tololo, Cerro Pachón, and Cerro Morado. This includes the mountaintop telescope sites of the Cerro Tololo Inter-American Observatory, the Gemini South telescope, the Large Synoptic Survey Telescope, the SOAR telescope, and other smaller facilities on the property. The property is owned and operated by the AURA Observatory, protected under Chilean law, and is subject to Chilean lighting regulations.

This policy on night-time lighting applies to the whole AURA-O observatory property – the legally-protected area also known as the El Totoral Reserve. This policy shall be binding upon all areas of the site, from the gate-house to the summits of Cerro Tololo, Cerro Pachón, and Cerro Morado.

Safety is of the highest consideration for AURA-O employees and visitors and cannot be compromised. None of these policies shall be constructed or construed as limitations that can compromise safe operations at the Observatory. It is noted that the Observatory functions 24 hours a day, specifically with astronomical observations occurring all night long almost every night of the year.

This management plan is subject to regular review by AURA legal and safety teams.

2. Policy Tenets of the Lightscape Management Plan

2.1. The fundamental basis of AURA-O night-time lighting policy is to only use the minimum light when it is needed, where it is needed, and in the appropriate amount for safe activities in a given area. The illumination level produced by all light fixtures should be as low as practical.

For the purposes of this policy, only functioning lights used on a regular basis are subject to this policy. Regular is defined as daily, weekly, or monthly. Lights that are used regularly that are not in compliance with this policy will be changed, disabled, and/or removed as part of the long-term plan for the sanctuary. Lights that are not used regularly (e.g., emergency lights) are exempted from this policy. In general, lights no longer in use will be removed as this plan is put into full impementation.

2.2. This policy conforms to all local, regional and national regulations and exceeds applicable guidelines from the Chilean lighting regulations. If there is a conflict between

Chilean regulations and this policy, Chilean law will prevail. Note: There is no identified conflict at this time.

3. General Guidelines for Outdoor Lighting on the Site

3.1. We explicitly adopt the fundamental aspects of the 2013 Lighting Regulation as published by the Chilean government. Aspects of the regulation that may be applicable to our environment include:

a) All general outdoor lighting must be full-cut-off, which means 0.49cd/Klumen at 90º (i.e., no light distribution above horizontal).
b) Spectral restrictions: The spectral restriction is divided into three regulated regions of the visible spectrum (as compared to the total light emission between 380 and 780nm): (a) not more than 15% for the range 300 to 380nm; (b) not more than 15% for the range 380 to 499nm; and (c) not more than 50% for 781nm to 1micron.
c) Illumination is restricted to not more than 20% over the Chilean standard (NSEG 9 n71) for minimal levels in public lighting.
d) Lighting for externally illuminated signs must be installed horizontally, pointing downward, and must also be full cut off.

3.2. Outdoor lighting fixtures with luminous flux levels of greater than 500 initial lumens that are in regular use will be fully shielded throughout the reserve. Full shielding is defined as emitting no light at or above the horizontal plane passing through the light-emitting elements or optic of the fixture closest to the ground. Outdoor lights that are not needed continuously, or that should be turned off when not needed, will be on timers or motion sensors. Fixtures that are not fully shielded may not be used except on an irregular, interim, or emergency basis.

3.3. Outdoor lighting of less than 500 lumens should also be fully shielded. Units that are unshielded will not be used except on an irregular, interim, or emergency basis.

3.4. All installed outdoor lighting will have a correlated color temperature of no more than 3,000K. A limit of 2,700K is recommended for most uses.

3.5. All special (non-emergency) uses of non-compliant lighting, including both greater than or less than 500 lumens or with color temperatures of greater than 3,000K, used on an interim basis in the reserve must be approved in writing by the AURA-O Director.

4. Area-Specific Guidelines for Outdoor Lighting on the Site

The Royal Astronomical Society of Canada's/IDA Guidelines for Outdoor Lighting (GOL) dated March, 2008 and adopted by IDA in November 2012 give a detailed rationale, evidence, and guidance on night-time lighting policy that is directly relevant to this policy and the AURA-O Lightscape Management Plan.

We have used Section 4 of the GOL as the basis for detailed outdoor lighting planning and guidance where directly applicable, relevant, and safe. The policies set forth below are designed to meet or exceed those described in the GOL.

4.1. Buildings

4.1.1. External lighting

All external lighting in regular use attached to or associated with offices, dormitories, dining rooms, technical support facilities, or other buildings shall be fully-shielded (in compliance with 3.2) and have correlated color temperature of no more than 3,000K. This includes illumination of doorways and steps leading to buildings.

All such lighting should be turned off no later than astronomical twilight. Use of timing circuits or motion sensors is highly recommended.

4.1.2. Interior Lighting and Windows

During day and night, interior lighting should be used only when necessary, and in general should be turned off when rooms are unoccupied.

Window coverings should be installed on all windows, and should be used so that interior lighting will not shine outside at any time past 30 minutes after sunset.

4.1.3. Public facilities

If any public facilities (toilets, vending machines, etc.) are installed on the site, they should be installed in such a way that no light is emitted to the outside after sunset.

4.2. Parking Lots

Parking lots on the site shall have no night-time illumination.

4.3. Roadways and Entrances

Roadways on the site shall have no night-time illumination, except for at the entrance to the Site (the gate house), which will remain illuminated for safety reasons with lighting that complies with the regulations in section 3 of this document.

4.4. Pathways

Pathways around the site shall generally have no night-time illumination. Exceptions may be granted by the AURA-O Director for areas of high traffic or for safety reasons (for example, stairways). Lighting in these exceptions shall be close to the ground (generally <1m), and comply with the regulations stated in section 3 of this document (specifically full cut-off and color temperature <3000K). Use of motion sensors for these installations is highly recommended.

4.5. Signage

Signs within the site shall have no night-time illumination.

4.6. Tower Beacons
Towers erected on the site shall not be fitted with nighttime navigation beacons or other lighting unless strictly required by Chilean authorities.

4.7. Transportation
A major source of intermittent light pollution is related to vehicular lights as staff drive around at night.

Around the telescopes, after astronomical twilight, vehicles shall not use headlights unless it is fully overcast to avoid interference with observations. Conductors should use either the flashing parking lights (emergency lights) or parking lights while driving around the telescope areas at night.

Off summit (off the paved areas), normal headlights should be used at night for safety.

Long-Term Actions to Support the Plan

1. A comprehensive study of all outdoor lighting will be undertaken at the site to describe all outdoor lights and to improve or eliminate any that are unnecessary. Many older lights are broken, disabled, or not in use and will be identified for future action to fix or remove them.

This study will be similar to the one conducted by NOAO-Tucson of its facility. The purpose of the study at El Totoral will be to insure that the sanctuary is an exemplary site in outdoor lighting practice and that older lights be eliminated so that tours of the facility do not give the impression that we are using poorly shielded lights. Dr. Malcolm Smith (CTIO) and Pedro Sanhueza, Director of the Oficina de Protección de la Calidad del Cielo del Norte de Chile (OPCC), will supervise the study. Once implemented, we will also invite local authorities to review our installations, both to ensure compliance with the strict new Chilean lighting regulations and to serve as a model for other installations in the region.

2. A comprehensive education program on outdoor lighting is an important part of our long-term goal for education and outreach on quality outdoor lighting to the larger region surrounding the sanctuary. To achieve this goal, we will use the Quality Lighting Teaching kits being developed at NOAO for the International Year of Light 2015. We will translate the kits and make significant numbers available for use in classrooms and outreach programs in the Region of Coquimbo, where the reserve is located.

3. The long-term support of this reserve relies greatly upon the efforts of the Oficina de Protección de la Calidad del Cielo del Norte de Chile (OPCC). It will be important for OPCC to have the field test instrumentation, in addition to its current laboratory test instrumentation, to evaluate any replacement lights installed in the sanctuary or in surrounding towns. OPCC especially needs to test lights outside the sanctuary for

compliance with the new regulations. To this end, AURA-O will support the Oficina de Protección de la Calidad del Cielo del Norte de Chile (OPCC) in obtaining instruments that can be used in the field to assess the spectral distribution of a luminaire. This instrumentation will be used for quickly measuring the color correlated color temperature of new lighting. This field measurement capability will support the new regulation.

An inventory of all the external illumination of the property will be kept by the administration of the Observatory, and it will be updated on an annual basis, along with the sky measurements taken throughout the sanctuary to monitor the darkness of the skies.

Appendix 3a: Decreto Supremo No. 99 de 1977, declaration of AURA-O site as "Area of Scientific Interest" by the Chilean Government
(see attached file: A3a_Decreto99_1977.pdf)