

Report #1

Sky Quality Meter Readings for the Municipality of Northern Bruce Peninsula

a Bruce Peninsula Biosphere Association Project

November 2010

1. Purpose

To establish baseline readings for the quality (darkness) of the nighttime skies over the Municipality of Northern Bruce Peninsula (MNBP), recording current light levels. Future sky quality readings to be compared to these baseline readings to determine a) the degree of increased encroachment of light pollution from southern Ontario, and b) the effectiveness of future light pollution mitigation measures undertaken in the MNBP.

2. Constraints

- readings to represent as much of the MNBP as possible, and be spaced as evenly as possible within the Municipality (i.e. no two metering locations to be within 10 km of each other, if possible)
- reading sites to be accessible by car during recording periods, due to relatively large distances in the survey area (note: the roads to Emmet Lake and Cabot Head are not plowed during winter)
- readings to be taken both during “tourist season” (many people staying on the Bruce Peninsula) and “off season” (many fewer people staying on the Bruce) to reflect possible differences in lighting levels
- reading sites to be repeatable over time, utilizing easy to identify locations (e.g. road intersections), with GPS data for each site recorded
- sky to be truly dark during the survey period, without light from the sun or the moon impinging on the readings, and with “seeing” conditions excellent, and ideally with the Milky Way not directly overhead)
- metering equipment and its use, as well as data recording, to be standardized to ensure data consistency

3. Equipment

Sky Quality Meter with Lens (SQM_L) by Unihedron (www.unihedron.com) was used to make measurements of the sky's darkness in "magnitudes per square arc second" ($\text{mag}/\text{arcsec}^2$). The meter has a Half Width Half Maximum (HWHM) of the angular sensitivity is $\sim 10^\circ$, making it far less sensitive to impinging lateral light sources, and therefore more accurate than previous sky quality meter models. The meter's range is from 16 $\text{mag}/\text{arcsec}^2$ to 21 $\text{mag}/\text{arcsec}^2$, a difference of 100 times in the darkness. The SQM_L, while independent of ambient temperature, also displays the sensor temperature.

The lower the reading, the more light there is in the atmosphere, indicating light pollution. Downtown Toronto would be 16.00 at best! The higher the number, the less light pollution is being measured, and the better the "sky quality". Readings in the Municipality of Northern Bruce Peninsula are consistently well over 21.00, indicating "dark skies".

4. Methodology

- readings to be taken only on nights when the conditions (darkness, cloud cover, transparency, seeing, & humidity) are excellent, as determined by the "Clear Sky Chart" for Quetican Astronomical Observatory, near Lions Head, ON, (<http://cleardarksky.com/c/QuetcnObONkey.html?1>)
- readings to be taken at least one hour after evening astronomical dusk ends and at least one hour before morning astronomical darkness begins
- moon to be at least one hour below the horizon (either before rising or after setting)
- on a single given night, 2 survey teams to cover the 11 pre-established reading sites on the 2 pre-established routes within the study area; 5 sites in the northern Bruce Peninsula and 6 sites in the central Bruce Peninsula (all within the MNP) **** See Appendix 1, below.**
- SQM_L readings to be made with sensor pointing directly at the zenith (the point on the sky directly overhead) and without direct glare from any nearby nighttime lighting
- 5 SQM_L readings to be recorded for each site, with a "median" value (less susceptible to extremes in the range of readings) established for each site

5. Observations

- observations were made on two separate nights; November 9 and November 10, 2010, with start times of 10:00 PM DST. These nights were chosen because of the “Clear Sky Clock” predictions for excellent “seeing”
- Area “A” (central Bruce Peninsula) survey was completed by Doug Cunningham, Graham Thomas, & Jim Kuellmer on both November 9 & 10
- Area “B” (northern Bruce Peninsula) survey was completed by Rod Steinacher, Elizabeth Thorn & Jeremy Thorn on November 09, and by Rod Steinacher on November 10
- While the arithmetic **mean** is commonly used to report central tendencies in data sets, it is not a robust statistic, being greatly influenced by data outliers. For skewed distributions, or data with wide ranges such as was recorded for many survey stations on either/both November 09 & 10, the arithmetic mean may not adequately represent the “middle” of the data set. A more robust statistic, such as the **median**, is a better description of central tendency. Mode was deemed to not be an appropriate tool, due to the data not being in “classes”. (Fowler, J. A., Cohen, L. & Jarvis, P. (2004) *Practical Statistics for Field Biology, 2nd ed.: Measuring the data*. John Wiley. pp. 26-34) . **Median** value was chosen to represent the sky quality for each metering location. These median values can then be arithmetically averaged to develop means, as needed.
- observations were compiled by Rod Steinacher and Doug Cunningham
**** See Appendix 3, below.**

6. Conclusions

(based on sky quality field data gathered on the nights of Tues., Nov. 09 & Wed., Nov. 10, 2010 for both Area “A” & Area “B”, by two teams of observers)

- sky quality readings show the MNBP to have “dark skies”, with a SQM_L meter mean value of **21.29** mag/arcsec² for the entire survey area over the two nights monitored (Area “A” = **21.28** mag/arcsec², Area “B” = **21.31** mag/arcsec²)
- sky quality did not match expectations from the prediction made (for Nov. 10) using the “Clear Sky Clock” for the area, and were approximately 0.2 to 0.3 mag/arcsec² lower than expected **** See Appendix 2, below**
- humidity levels, somewhat elevated from optimal, may have contributed to the high degree of “atmospheric variability” noted in the “range” of recorded SQM_L values at many survey stations, and the small patches of ground fog observed on the night of Nov. 10

7. Future Considerations

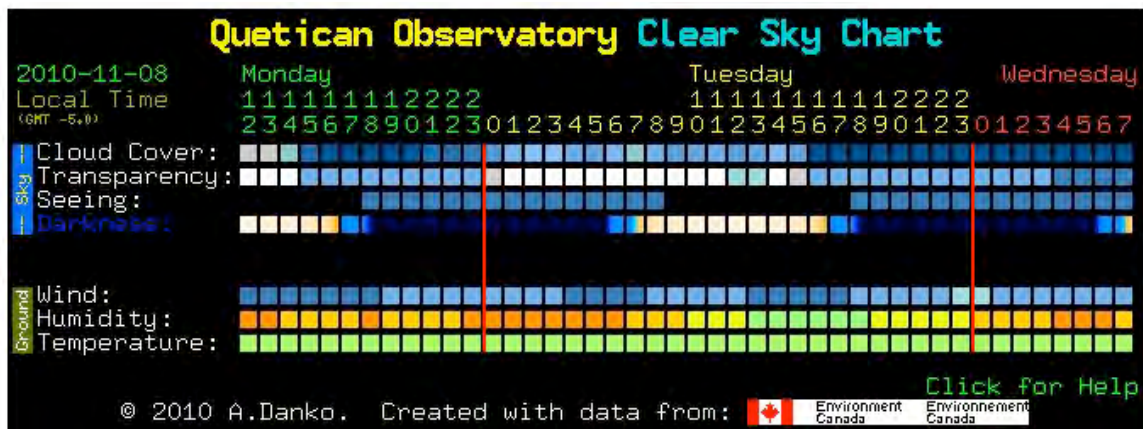
- during next survey round, site "A5" will be moved southward to the Cape Chin South area, UTM 0447914/4993796, avoiding overlap with existing site "B4" (maps and record sheets will be adjusted accordingly)
- during next survey round, both start and finish temperatures for the survey route, and possibly the temperature for each data station, will be recorded, (as changes in temperature can affect sky conditions near the ground, including fog development)
- data will not be gathered on nights when the dew point would be reached during the survey period
- inclusion of "relative humidity" for each data station may provide insight into the high degree of atmospheric variability prevalent on the Bruce Peninsula
- consideration should be given to recording 10 SQM_L readings for each survey site, to align survey methodology with the Royal Astronomical Society of Canada's ongoing sky quality data gathering program
- consideration should be given to recording the locations for each survey site to "lat/long" (latitude and longitude) from "UTM"s (northings & eastings), to align survey methodology with the Royal Astronomical Society of Canada's ongoing sky quality data gathering program
- additional study of the causes, impact, and mitigation of the noted atmospheric variability factor will be necessary before further field data is acquired
- consideration should be given to modifying the survey methodology to mitigate the effects of atmospheric variability, possibly having more observers taking more frequent readings from a fewer number of observing sights, reducing the effect of temperature, humidity, and atmospheric condition changes over the longer time needed to complete the existing longer survey route
- further data will be gathered at future dates, incorporating information previously gathered and processed from the first preliminary field surveys and discussed in this report

8. Appendices

Appendix 1: Sky quality metering sites for the Municipality of Northern Bruce Peninsula, divided into two survey routes (A1 to A6 & B1 to B5)



Appendix 2: Clear Sky Clock for nights of Tues., Nov. 09, 2010 & Wed., Nov. 11, for Quetican Astronomical Observatory, Lions Head, ON (MNBP)



Appendix 3: Sky Quality Meter_L readings within the Municipality of Northern Bruce Peninsula, for the nights of November 09 & 10, 2010

Appendix 3_1: Field Data for Area "A", November 09, 2010

SQM_L Values for Central Bruce Peninsula Sites (Area "A")

Date: yy 2010 /mm 11 /dd 09 (dd 10 Z)	Start time: 03 : 00 Z	Finish time: 6 : 30 Z
Temperature: 5 ° C	Cloud cover: 0 %	Seeing: EX <u>VG</u> G

Site ID	Site Description	UTM northing	UTM easting	median SQM rdng	reading Range	rdng #1	rdng #2	rdng #3	rdng #4	rdng #5
A1	Pike Bay Rd - ~4.75 km W of Hwy 6 (at stream crossing)	0475036	4970424	21.43	0.10	21.43	21.47	21.47	21.42	21.37
A2	Hopeness Rd - at Tower Rd intersection	0489293	4976344	21.40	0.07	21.39	21.45	21.40	21.38	21.43
A3	Con Road 4 - ~0.65 km S of Bruce Rd 9 (at laneway)	0479432	4979935	21.43	0.07	21.40	21.47	21.46	21.43	21.40
A4	Clark's Road - ~400 m E of tavern	0470887	4985967	21.41	0.06	21.43	21.42	21.38	21.41	21.37
A5	Cape Chin North Rd - 75 m S of the Borchardt Rd intersection (at green fence gate)	0474892	4996645	21.42	0.05	21.45	21.42	21.40	21.43	21.42
A6	Little Pine Tree Harbour - boat launch parking area	0462024	4989239	21.37	0.10	21.34	21.44	21.37	21.37	21.43

Observer(s) Area "A": Doug Cunningham, Graham Thomas, Jim Kuellmer

Notes

- SQ readings very consistent from site to site
- very faint circular haze around Jupiter
- a good representation of Peninsula skies (although could have been more transparent)

Appendix 3_2: Field Data for Area "A", November 10, 2010

SQM_L Values for Central Bruce Peninsula Sites (Area "A")

Date: yy 2010 /mm 11 /dd 10 (dd 11 Z)	Start time: 03 : 00 Z	Finish time: 06 : 00 Z
Temperature: 3 ° C	Cloud cover: 0 %	Seeing: EX VG <u>G</u>

Site ID	Site Description	UTM northing	UTM easting	median SQM rdng	reading Range	rdng #1	rdng #2	rdng #3	rdng #4	rdng #5
A1	Pike Bay Rd - ~4.75 km W of Hwy 6 (at stream crossing)	0475036	4970424	21.43	0.12	21.50	21.43	21.43	21.41	21.38
A2	Hopeness Rd - at Tower Rd intersection	0489293	4976344	20.47	0.83	21.11	20.28	20.45	20.81	20.47
A3	Con Road 4 - ~0.65 km S of Bruce Rd 9 (at laneway)	0479432	4979935	21.34	0.05	21.34	21.36	21.38	21.31	21.33
A4	Clark's Road - ~400 m E of tavern	0470887	4985967	21.30	0.11	21.27	21.30	21.30	21.38	21.35
A5	Cape Chin North Rd - 75 m S of the Borchardt Rd intersection (at green fence gate)	0474892	4996645	20.90	1.19	20.90	21.00	19.99	21.18	20.66
A6	Little Pine Tree Harbour - boat launch parking area	0462024	4989239	21.37	0.04	21.40	21.37	21.36	21.37	21.36

Observer(s) Area "A": Doug Cunningham, Graham Thomas, Jim Kuellmer

Notes

- atmospherics quite variable (esp. at Hopeness & Cape Chin N.)
- circle of light haze around Jupiter that changed from site to site
- local intermittent mid atmospheric fog patches present

Appendix 3_3: Field Data for Area "B", November 09, 2010

SQM_L Values for Central Bruce Peninsula Sites (Area "B")

Date: yy 2010 /mm 11 /dd 09 (dd 10 Z)	Start time: 03 : 00 Z	Finish time: 7 : 30 Z
Temperature: Start: 5 ° C Finish: 3 ° C	Cloud cover: 0 %	Seeing: EX <u>VG</u> G

Site ID	Site Description	UTM northing	UTM easting	median SQM reading	reading Range	rdng #1	rdng #2	rdng #3	rdng #4	rdng #5
B1	National Park Visitor Center - back parking lot (~15 m W of lot exit)	0448539	5011669	21.16	0.01	21.16	21.15	21.15	21.16	21.16
B2	Johnson Harbour Rd - at Ada Crescent	0453593	5001501	21.21	0.02	21.20	21.21	21.21	21.22	21.20
B3	Halfway Log Dump access - middle of parking lot	0462281	5008320	21.20	0.04	21.20	21.20	21.20	21.24	21.22
B4	Crane Lake Rd - ~0.6 km north of Dyers Bay Rd (opposite farm gate)	0470424	5000948	21.25	0.38	21.11	20.63	21.25	21.25	21.25
B5	Cabot Head - middle of visitors' parking lot	0477067	5010097	21.20	0.23	21.02	21.25	21.22	21.17	21.20

Observer(s) Area "B": Rod Steinacher, Elizabeth & Jeremy Thorn

Notes

- Rod did readings at B1 as demo, Elizabeth did remainder of readings at B2 - B5, Jeremy recorded values
- all pre-selected metering locations were good, no changes made in field
- Milky Way still almost directly overhead for entire survey period
- sky quality readings surprisingly bright, esp. B3 - B5, haze around Jupiter suggested higher atmospheric moisture
- small pack of Coyotes howling near B2 (thrilling!)
- called for both ESOW and GHOW at B4 with both responding (2 ESOW, one close & 1 GHOW, medium distance) ... nice!

Appendix 3_4: Field Data for Area "B", November 10, 2010

SQM_L Values for Central Bruce Peninsula Sites (Area "B")

Date: yy 2010 /mm 11 /dd 10 (dd 11 Z)	Start time: 03 : 10 Z	Finish time: 05 : 50 Z
Temperature: Start: 3 ° C Finish: 8 ° C	Cloud cover: 0 %	Seeing: EX <u>VG</u> G

Site ID	Site Description	UTM northing	UTM easting	median SQM reading	reading Range	rdng #1	rdng #2	rdng #3	rdng #4	rdng #5
B1	National Park Visitor Center - back parking lot (~15 m W of lot exit)	0448539	5011669	21.35	0.21	21.28	21.48	21.38	21.27	21.35
B2	Johnson Harbour Rd - at Ada Crescent	0453593	5001501	21.36	0.16	21.41	21.25	21.36	21.36	21.39
B3	Halfway Log Dump access - middle of parking lot	0462281	5008320	21.36	0.05	21.32	21.36	21.37	21.35	21.37
B4	Crane Lake Rd - ~0.6 km north of Dyers Bay Rd (opposite farm gate)	0470424	5000948	21.31	0.10	21.37	21.30	21.27	21.31	21.32
B5	Cabot Head - middle of visitors' parking lot	0477067	5010097	21.46	0.24	21.58	21.46	21.40	21.34	21.48

Observer(s) Area "B": Rod Steinacher

Notes

- little apparent difference in sky quality from last night (Nov. 09/10)
- small patches of ground fog beginning to form in lower areas - not in area where readings was taken
- temp at Dyers Bay = 8°C • temp 9 km inland = 0°C