

# Sun and Shadow Study

## Terms of Reference

---



May 2019. Prepared for the City of Guelph by R. Bouwmeester & Associates

### Introduction

Sun and shadow studies illustrate the impact of proposed development on public and private spaces.

As per the Official Plan of the City of Guelph, sun and shadow studies may be required in support of development applications to demonstrate that the height and/or location of a proposed building will be compatible with and not cause excessive shade on the surrounding neighbourhood including parks, adjacent residential uses, public open space, private amenity space and retail streets. In addition to the above, the Official Plan deems that shadows on cultural heritage resources create a negative impact if they “alter the appearance of a heritage attribute or change the viability of a natural feature or plantings, such as a garden.”

These standards are intended to ensure adequate sun exposure on the above at specified times of day and year. Additional study times and analysis may be required prior to final approval to properly determine the degree of impact.

It is noted that **incremental shadows** do not necessarily represent adverse or undue impacts. Accordingly, each proposal, while expected to meet the criteria outlined herein, will be assessed on its own merits on a case-by-case basis.

### When is a sun and shadow study required?

Generally, as part of the pre-consultation process, a Sun and Shadow Study may be required as part of a development application including site plan applications, rezoning applications, Official Plan amendments, etc. Generally, they will be required if a building is higher than five storeys and/or 16.5 m. However, they will generally not be required where a development conforms to the Zoning Bylaw. This being said, on a case-by-case basis the City may still require a Sun and Shadow Study for shorter buildings or in other cases such as:

- where additional height is being requested;
- near shade-sensitive uses; and/or
- on sites where different massing/height configurations are possible.

## Who is qualified to do the study?

The Sun and Shadow Study shall be completed by a licenced design professional such as an architect, engineer, or planner qualified or experienced in this field, and the Study shall include the name of the firm and individual who prepared it.

The City of Guelph reserves the right to request peer reviews, the cost of which will be borne by the applicant.

## Background

The solstices, June 21 and December 21, represent the seasonal extremes in terms of length of daylight and **altitude** of the sun—June 21 being the longest day of the year with the highest sun angles and shortest shadows, and December 21 being the shortest day of the year with the lowest sun angles and longest shadows. The equinoxes, around March 21 and September 21, represent the seasonal averages.

In order to provide a spring-time test date other than March 21<sup>1</sup>, April 21 has been selected. This is an appropriate alternative because daily average temperatures in Guelph in late April are similar to those in late September (about 9°C and 12°C, respectively) according to Environment Canada. In addition, April 21 shadow directions and lengths are about midway between those on March 21 and June 21.

Based on the above, the criteria described below apply to one or more of April 21, June 21, September 21 and December 21 on the even hours between 1.5 hours after sunrise to 1.5 hours before sunset.

See Tables 1 to 4 - Guelph Sun Angle Data attached for the test times required on each of the above test dates.

## Shadow Impact Criteria

Adequate sunlight should be ensured on

- 1. Residential amenity spaces** to maximize their utility during spring, summer and fall.

Shadows from proposed developments should not last for more than one hour per day on areas such as yards, decks, and (rooftop) patios and pools on

- April 21
- June 21, and
- September 21

---

<sup>1</sup> Since the Daylight Saving Time rule change that took effect in 2007, shadow patterns on March 21 and September 21 essentially follow the same path.

This criterion is met if **incremental shadows** occur for no more than two consecutive test times (see Tables 1 to 4 - Guelph Sun Angle Data).

The point of assessment shall be the centre of decks and (rooftop) patios and pools, where applicable, or 3 m from the midpoint of the rear wall of the dwelling. In cases where there is existing shade, the addition of new net shadows should result in not less than two hours of sunlight. Where less than two hours of sunlight already exists, no new net shade may be added.

Balconies are exempt unless they are the only outdoor living area available to the resident, and they are at least 4 m deep, outside the building façade, and unenclosed.

- 2. Places where children play including school yards, tot-lots, play areas and park features such as wading pools or other outdoor sun-sensitive activity areas, and outdoor amenity areas used by seniors and those associated with commercial and employment areas** during spring, summer, fall and winter.

**Incremental shadows** from proposed developments should allow for a balance of sun and shade on the above places on each of the following dates between the hours of 10:00 a.m. and 2:00 p.m. On an average basis during this period, at least half of the area must be in sun (e.g. full sun half the time, or 50 per cent sun coverage all the time).

- April 21
- June 21
- September 21
- December 21 (applicable to school yards, tot-lots and play areas only)

If the period of prime use can be clearly identified, the above need only apply to that period – not all the test times.

This criterion is met if the **Sun Access Factor** (see page 13 for sample calculation) is at least 50 per cent on each of the test dates, calculated as follows:

- Measure the total area ( $A_T$ ) of the feature.
- Measure the area in sunshine ( $A_S$ ) at each of the five hourly test times.
- Find the average area ( $A_{AS}$ ) for each of the four one-hour periods.
- Find the overall average area ( $A_{S(ave)}$ ) of the four  $A_{AS}$  values.
- Sun Access Factor =  $A_{S(ave)} / A_T$  (passes if  $> 0.50$ ).

See example calculation in Attachments.

This criterion applies to off-site public areas as well as those common outdoor amenity areas that are part of a proposed development.

**3. Public realm including sidewalks, open spaces and plazas** to maximize their use during the shoulder (spring and fall) seasons.

**3.1.** Developments should be designed to provide full sunlight to the opposite sidewalk in mixed-use, commercial, employment and high-density residential areas with pedestrian traffic on September 21

- for at least four full hours total including the two-hour period between 12 and 2 p.m., plus any two additional one-hour periods between either 9 and 11 a.m. or 3 and 5 p.m.

This criterion is met if there is no **incremental shadow** from the proposed development at 12, 1 and 2 p.m., and at any two consecutive times in each of the morning and afternoon groups or three consecutive times in either the morning or afternoon group.

See Table 5 and Figures 2 and 3 for angular planes that will achieve these criteria on Guelph's main street grid (i.e. NW-SE and SW-NE). Note that the Table and Figures are provided for information only and are applicable to only the main street grid of Guelph. For further details, see notes included with the Table and Figures.

**3.2** Developments should also be designed to provide a **Sun Access Factor\*** of at least 50 per cent on public open spaces and plazas on September 21 (\*See Criteria 2 for explanation.).

**4. Community gardens, and turf and flower gardens in public parks** during the growing season March to October by providing at least 6 hours of direct sun on September 21.

This criterion is met if full sun is provided on any 7 test times on September 21.

**5. Cultural heritage resources** to ensure that shadows do not create a negative impact by altering the appearance of identified cultural heritage attributes such as historical buildings and landmarks, buildings with elaborate or carved elements that rely on sun/shadow patterns, and stained glass windows, or by changing the viability of a natural feature or plantings, such as gardens or heritage trees. (Resources shall be identified in consultation with City.)

**Incremental shadows**, if any, must be identified in the sun and shadow study, and the determination of negative impact will be made by the City on a case-by-case basis.

This criterion is met if no **incremental shadows** fall on identified cultural heritage resources on any of the test dates and times.

# Material to be submitted with a Sun and Shadow Study

1. The Sun and Shadow Study must include shadow drawings for the dates and test times shown in Tables 1 to 4 - Guelph Sun Angle Data attached (i.e. excluding sunrise, sunset, and 1.5 hours after sunrise and 1.5 hours before sunset).
2. The drawings shall at the very least:
  - include a north arrow, scale bar, legend, key street names, project name, date, preparer's company name;
  - be oriented with true north pointing straight up;
  - include a reference bearing (astronomic) for the site; and
  - be drawn to a scale suitable to show the entire shadow coverage area.
3. Base mapping must include a minimum coverage area as follows:
  - to the north – 3.3 x building height
  - to the south – 0.7 x building height
  - to the east – 2.7 x building height
  - to the west – 3.6 x building height

See Figure 4 attached for details.

  - The size of the shaded area is proportional to the height of the building.
  - Properties within the shaded area have the potential to be shadowed.
  - Properties outside the shaded area cannot be reached by shadows from the proposed development at the test dates and times.
4. The drawings may be based on 2D mapping or air photos showing shadows from only the proposal, or they may be based on mapping including 3D buildings and their shadows. This applies to all buildings within the coverage area.
5. It may be advantageous for the proponent to consider topography since uphill grades from the subject site lead to shorter shadows, which in turn may reduce the shadow impact. On the other hand, the City may require topography to be taken into account where the grade falls away from the subject site resulting in longer shadows. Digital contour data is available from the [City's GeoDataHub website](#).
6. Proposed and as-of-right shadow outlines (based on the subject site only) should be shown (by lines or shading/hatching of contrasting colour/pattern) on the ground plane in the absence of existing buildings and shadows. Shading/hatching shall be translucent such that underlying features remain clearly visible.

7. Since only **incremental shadows** are considered in the determination of impact, it may be helpful to include existing buildings and shadows so that **incremental shadows** can be netted out and highlighted. Where possible,
    - existing and **incremental shadows** should be shown in differential hatching or colour. (Trees are not considered to be part of the existing or proposed shadow context.); and
    - approved but not yet built buildings should be shown in contrasting colour. Their shadows are considered part of the existing shadow context.
  8. The Sun and Shadow Study must include a written report including:
    - confirmation of site **latitude** and **longitude** used.
    - the origin/source of base mapping used.
    - a statement as to how astronomic north was determined. Care should be taken to ensure that the base mapping is oriented with respect to astronomic (true) north.
    - a description of all locations/uses of areas not meeting the Shadow Impact Criteria (including a key plan for reference).
    - a quantification and assessment of the impact in the areas not meeting the Shadow Impact Criteria.
    - a summary outlining how the Shadow Impact Criteria have been met including a description of any mitigating features that have been incorporated into the site and building design.
    - the full name and professional designation of the person(s) who prepared the drawings and report.
- 

## For more information

City of Guelph  
Planning Services  
519-822-1260 extension 5616  
TTY 519-826-9771  
planning@guelph.ca

Alternate formats are available as per the Accessibility for Ontarians with Disabilities Act.

# Attachments

## Sun Angles to be used for Guelph sun and shadow studies

Angles are based on City of Guelph City Hall **latitude** and **longitude**.

**Latitude:** 43° 32' 35" N

**Longitude:** 80° 14' 55" W

**Time Zone:** Eastern

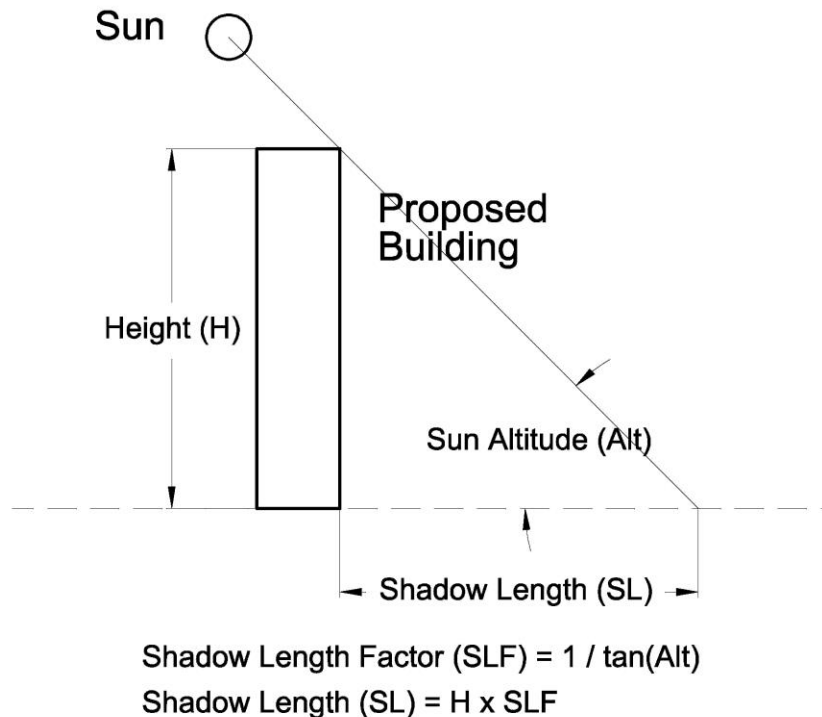
Standard Time (EST): UTC\* – 5 hours (applies December 21)

Daylight Saving Time (EDT): UTC\* – 4 hours (applies April, June and September 21)

\*Note: UTC denotes Coordinated Universal Time (i.e. Greenwich Mean Time).

Multiply building height by **Shadow Length Factor (SLF)** to determine shadow length as follows: Shadow Length = Building Height x **SLF**. See Figure 1.

**Figure 1 – Determining Shadow Length**



See Tables 1 to 4 - Guelph Sun Angle Data following for **SLF** data.

**Table 1 - Guelph Sun Angle Data – April 21**

Date	Shadow Direction and Length		Comments
	Az (deg)	SLF ratio length/height	
21-Apr			
Local Time EDT			
6:29	252.62		Rise (for info only)
7:59			Rise + 1.5 hr (for info only)
8:00	268.09	3.6163	test time
9:00	278.69	2.0226	test time
10:00	290.75	1.3356	test time
11:00	305.68	0.9517	test time
12:00	325.39	0.7246	test time
13:00	350.85	0.6205	test time
14:00	18.48	0.6420	test time
15:00	42.09	0.7873	test time
16:00	59.97	1.0601	test time
17:00	73.73	1.5198	test time
18:00	85.17	2.3934	test time
18:41			Set - 1.5 hr (for info only)
20:11	107.66		Set (for info only)

**Table 2 - Guelph Sun Angle Data – June 21**

Date	Shadow Direction and Length		Comments
	Az (deg)	SLF ratio length/height	
21-Jun			
Local Time EDT			
5:40	235.76		Rise (for info only)
7:10			Rise + 1.5 hr (for info only)
8:00	258.38	2.4230	test time
9:00	268.07	1.5277	test time
10:00	278.97	1.0339	test time
11:00	292.79	0.7135	test time
12:00	313.04	0.4953	test time
13:00	345.00	0.3769	test time
14:00	23.82	0.3942	test time
15:00	52.67	0.5392	test time
16:00	70.92	0.7793	test time
17:00	83.82	1.1314	test time
18:00	94.31	1.6898	test time
19:00	103.86	2.7632	test time
19:36			Set - 1.5 hr (for info only)
21:06	124.23		Set (for info only)



**Table 3 - Guelph Sun Angle Data – September 21**

Date	Shadow Direction and Length		Comments
	Az (deg)	SLF ratio length/height	
21-Sep Local Time EDT			
7:07	268.34		Rise (for info only)
8:37			Rise + 1.5 hr (for info only)
9:00	288.51	2.8564	test time
10:00	300.94	1.7927	test time
11:00	315.78	1.2951	test time
12:00	333.85	1.0376	test time
13:00	354.88	0.9366	test time
14:00	16.61	0.9737	test time
15:00	36.18	1.1548	test time
16:00	52.44	1.5241	test time
17:00	65.84	2.2541	test time
17:50			Set - 1.5 hr (for info only)
19:20	91.38		Set (for info only)

**Table 4 - Guelph Sun Angle Data – December 21**

Date	Shadow Direction and Length		Comments
	Az (deg)	SLF ratio length/height	
21-Dec Local Time EST			
7:51	302.34		Rise (for info only)
9:21			Rise + 1.5 hr (for info only)
10:00	327.05	3.5339	test time
11:00	340.63	2.6606	test time
12:00	355.23	2.3700	test time
13:00	10.13	2.4301	test time
14:00	24.43	2.8825	test time
15:00	37.52	4.1549	test time
15:17			Set - 1.5 hr (for info only)
16:47	57.66		Set (for info only)

Note: Az denotes shadow **azimuth** measured clockwise in decimal degrees from astronomic (true) north.

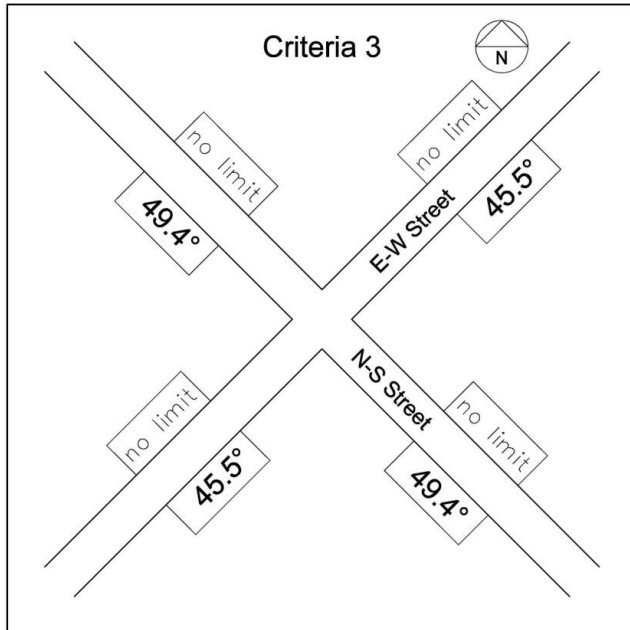
**Table 5 – Maximum Allowable Angular Planes**  
 (to protect opposite side sidewalks as per Criteria 3)

	<b>Criteria 3</b> mixed use, commercial, employment, and high-density residential areas with pedestrian traffic
<b>E-W Street</b>	
Proposed bldg on north side	No limit
Proposed bldg on south side	45.5°
<b>N-S Street</b>	
Proposed bldg on west side	49.4°
Proposed bldg on east side	No limit

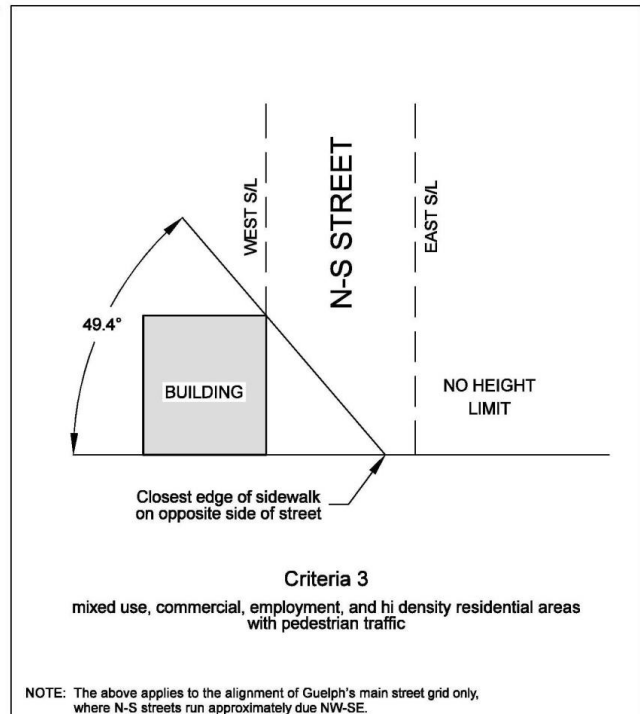
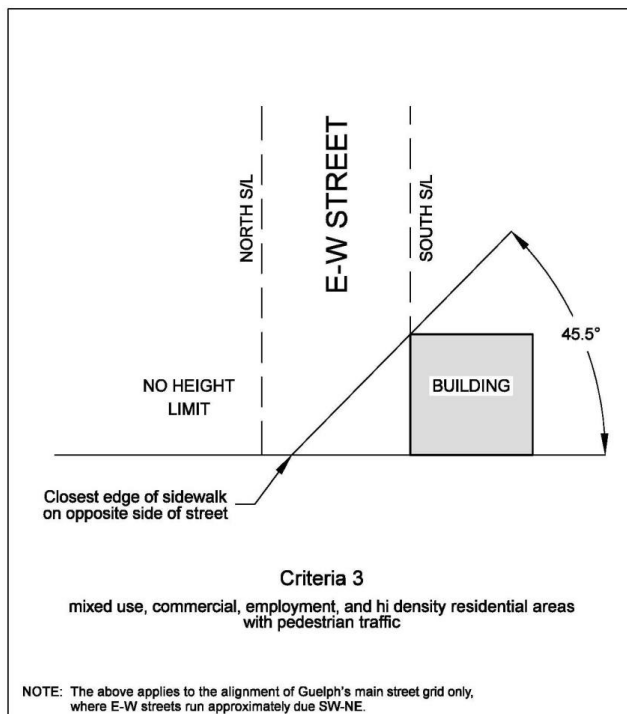
**Notes:**

1. The angular planes given above apply only to the alignment of Guelph’s main street grid which runs approximately due SW-NE and due NW-SE. (See Figure 2.) These are provided for information only, and angular planes along other streets will vary. Ultimately, Criteria 3 governs.
2. Angular planes are measured from closest edge of opposite sidewalk. See Figure 3.
3. Angular planes are measured up from grade, in a direction perpendicular to street line.
4. Proposed buildings lying under the angular plane limits given will in most cases meet the requirements of Criteria 3. Ultimately, the requirements of Criteria 3 govern.
5. See Figures 2 and 3 for diagrams of the angular plane limits for Guelph’s main street grid.

**Figure 2 – Maximum Allowable Angular Planes**  
 (to protect opposite side sidewalks as per Criteria 3)



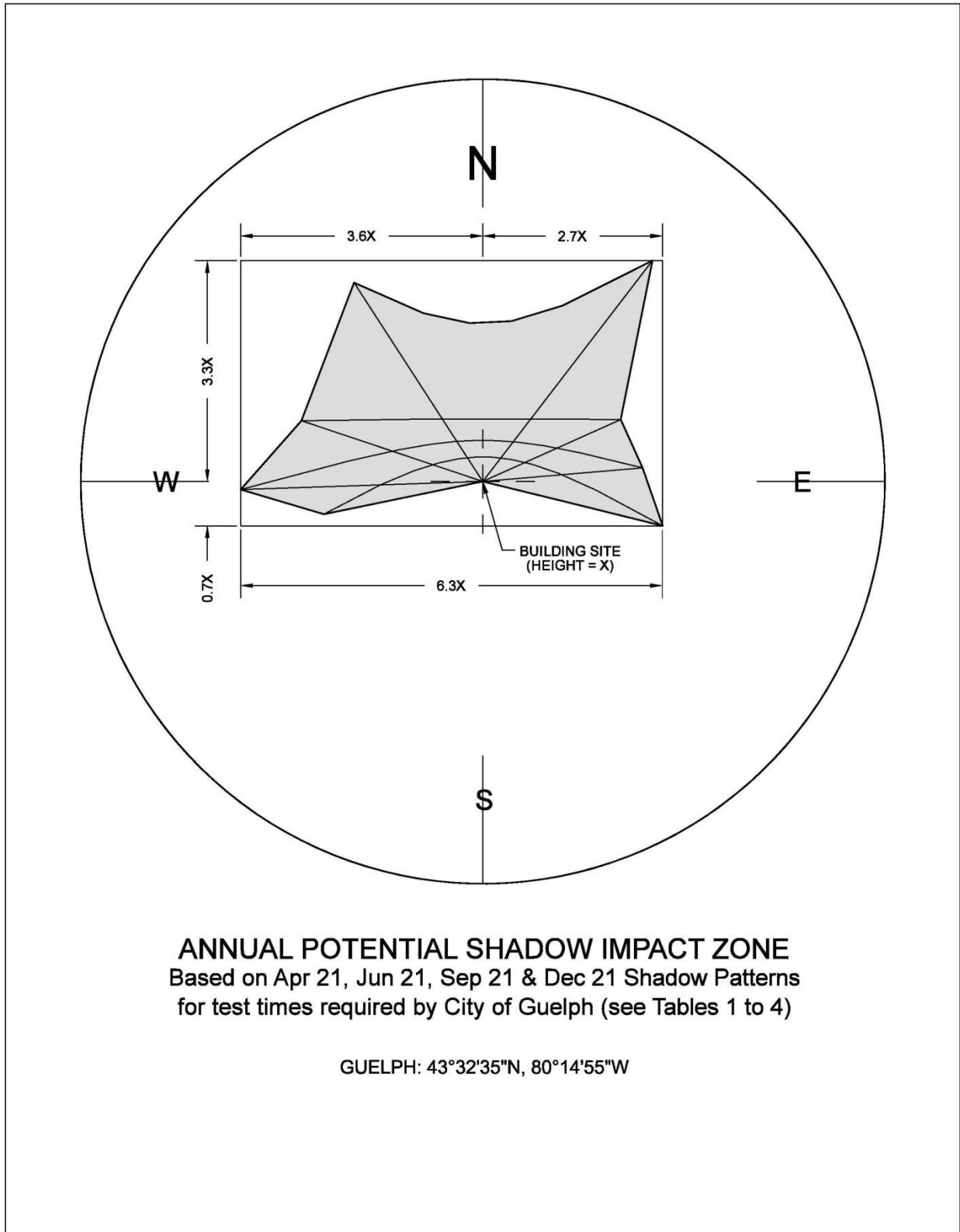
**Figure 3 – Angular Plane Section Views**



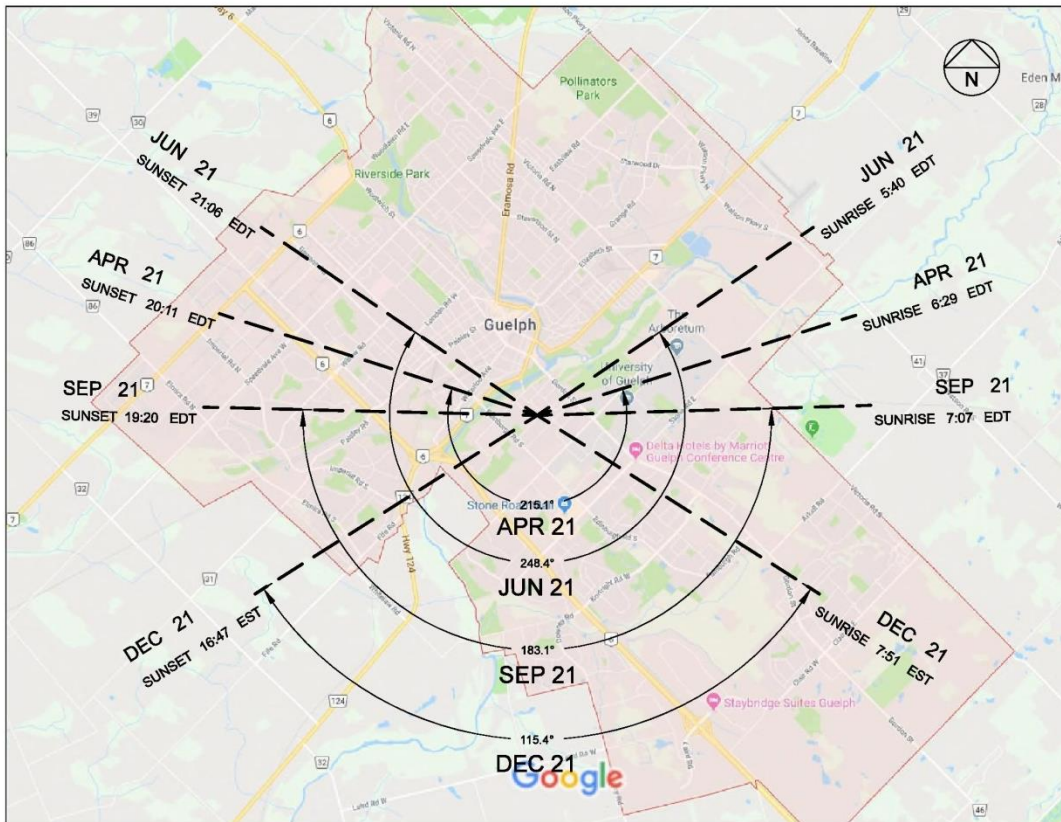
NOTE: The above applies to the alignment of Guelph's main street grid only, where E-W streets run approximately due SW-NE.

NOTE: The above applies to the alignment of Guelph's main street grid only, where N-S streets run approximately due NW-SE.

**Figure 4 – Sun and Shadow Study Coverage Area**  
(See notes in Item 3 on page 5.)



**Figure 5 – Seasonal Sun Rise/Set Angles and Times**



**SEASONAL SOLAR ANGLE RANGE  
GUELPH: 43°32'35"N, 80°14'55"W**

**Sun Access Factor – Sample Calculation**

- Area of feature ( $A_T$ ) is 100 sm.
- Areas in sunshine ( $A_S$ ) at each hourly test time 10 a.m. to 2 p.m. are 20 sm, 60 sm, 100 sm, 60 sm and 20 sm.
- The averages ( $A_{AS}$ ) for the four one-hour periods are 40 sm, 80 sm, 80 sm and 40 sm.
- The overall average area ( $A_{AS(ave)}$ ) in sunshine is 60 sm resulting in a Sun Access Factor of 0.60 - which passes the 50 per cent test.

# Definitions

**Altitude** - the vertical angular distance, measured in degrees, between the horizon and the centre of the sun's disk (positive above horizon).

**Azimuth** - the bearing, or direction of the sun, as viewed by an observer, measured in degrees clockwise from north (e.g. North = 0, East = 90, South = 180, West = 270).

**Coordinated Universal Time (UTC)** – commonly used synonym for Greenwich Mean Time (GMT).

**Daylight Saving Time** - *Standard Time* adjusted by adding 1 hour. Starting in 2007, daylight time begins in North America on the second Sunday in March and ends on the first Sunday in November. (On the second Sunday in March, clocks are set ahead one hour at 2:00 a.m. local *Standard Time*, which becomes 3:00 a.m. local daylight time. On the first Sunday in November, clocks are set back one hour at 2:00 a.m. local daylight time, which becomes 1:00 a.m. local *Standard Time*.)

**Declination** - the angular distance, measured in degrees, between the celestial equator and the direction of the observer to sun. It is equivalent to latitude. By convention, when the sun lies north of the equator, **declination** is positive (Mar 21 to Sep 21); similarly, south of the equator is negative (Sep 21 to Mar 21). Maximum of  $+23.5^\circ$  occurs about Jun 21; minimum of  $-23.5^\circ$  occurs about Dec 21.

**Equation of Time** - also known as the "Sundial Correction", this time correction factor takes into account the variations in the earth's velocity as it travels through its elliptical orbit.

**Hour Angle** - the angle between an observer's *Meridian* and the sun's meridian. Measured from south; west of south is positive, east is negative.

**Incremental Shadows** - net new shadows over and above all existing building shadows and as-of-right shadows from the approved zoning massing envelope for the subject site along with shadows from approved but not yet built buildings.

**Latitude** - the angular distance, measured in degrees, between the equator and an observer's location. North of the equator is positive; south is negative.

**Local Civil Time** - Standard Time corrected for one's actual location based on Longitude east or west of the Time Zone's central Meridian. (Correction applied at the rate of 4 minutes per degree.)

**Local Time** - local watch time (Standard Time or Daylight Saving Time).

**Longitude** - the angular distance, measured in degrees, between the Prime Meridian (0 degrees Longitude at Greenwich, England) and an observer's location. West of Greenwich is negative; east is positive.

**Meridian** - a line of Longitude.

**Prime Meridian** - Longitude "zero" which runs through Greenwich, England.

**Shadow Length Factor (SLF)** - ratio of shadow length to object height. It is the factor by which to multiply an object's height to find its shadow length. ( $SLF = 1 / \tan \text{Altitude}$ )

**Solar Noon** - local time at which the sun crosses the local Meridian. At Solar Noon the sun is due south and reaches its peak. It is approximately the midpoint between Sunrise and Sunset.

**Standard Time** - the time within a specified time zone. Usually varies from Greenwich Mean Time (GMT) by an even number of hours. (e.g. EST = UTC -5)

**Sun Access Factor** - the ratio of sun duration over a given area expressed in percent (e.g. a 50% sun access factor can mean 50% sun coverage 100% of the time, or 100% sun coverage 50% of the time).

**Sunrise/Sunset Time** - local time at which the upper edge of the sun's disk appears on the horizon. The time takes into account average refraction conditions (34 arc minutes) and half the sun's diameter (16 arc minutes).

**Time Zone** - a 15° wide zone within which all watch times are the same for the sake of convenience. Each zone represents one hour, and they are measured in about 15° increments east and west from the Prime Meridian, which is the centre of the first zone. (The central meridians of some sample time zones occur at longitudes 15, 30, 45, 60, 75 degrees west, etc. Guelph lies in the Eastern Standard Time zone centred on longitude 75° west. Since each 15 degrees represents one hour, EST is 5 hours behind Greenwich Mean Time.)

**True Solar Time** - Local Civil Time + Equation of Time.