APPENDIX F – RESILIENCE CHECKLIST

CLIMATE CHANGE RESILIENCE CHECKLIST FOR NEW DEVELOPMENT

WHY DO WE NEED A RESILIENCE CHECKLIST?

In 2014, the City of Toronto adopted the Resilient City – Preparing for a Changing Climate report, which outlines a series of actions and strategies to improve the city's resilience and reduce its contributions to climate change. Improving the ability of the city's buildings to withstand the impacts of climate change is an important step in this work and key to protecting the health and well-being of the city's residents and businesses. The aim of this checklist is to help improve the resilience to climate change of Toronto buildings. It has been specifically designed to ensure that new buildings constructed in the City of Toronto are resilient to the impacts of a changing climate and extreme weather events.

WHAT CAN WE EXPECT FROM A FUTURE CLIMATE?

The need for a climate change resilience checklist is based on the expected changes in weather patterns and extreme weather events projected by climate change scenarios. The City of Toronto's Future Weather and Climate Driver Study (2011) provides a series of climate projections for the city for the years 2040 to 2049.[xx] These projections give us a greater understanding of the changes to Toronto's climate that we can anticipate in the future, and that should therefore be considered in building design (see Table 1). Some of the key predictions presented in the report are summarized below:

An increase in average annual temperatures

- Average annual temperatures will increase by 4.4°C
- The projected average winter temperature will increase by 5.7°C
- The projected average summer temperature will increase by 3.8°C
- Extreme daily minimum temperatures will increase by 13°C
- The number of days above 20°C will increase from 133 days to 160 days
- The number of days above 0°C will increase by 16%
- The number of "heat waves" (i.e. events with more than three consecutive days of temperatures greater than 32°C) is expected to increase from an average of 0.57 occurrences per year to five occurrences per year
- An increase in the number of days requiring air conditioning from 10 to 180
- A decrease in the number days requiring extra heating from 440 to 60

Changes to precipitation and wind speed

- Slightly more precipitation (snow plus rainfall) is expected overall, with the highest increases expected for the months of July (+80%) and August (+50%)
- Less snow and more rain in the winter is expected, with 26 fewer snow days expected per year
- A smaller number of storm events is expected, but the amount of precipitation in these events will increase
- Extreme daily rainfall will increase threefold in the month of June
- Overall wind speeds will remain the same, while maximum wind speeds will decrease

Table 1: Projected Future Weather Changes for 2040-2049 (replicated directly from Toronto's Future Weather and Climate Driver Study, Volume 1, 2011)

Weather Type	Parameter	2000-2009	2040-2049
Extreme precipitation	Maximum in one day (in mm)	66	166
	Number of days with more than 25 mm	19	9
	Mean annual daily maximum in mm	48	86
	100 year return period maximum daily (in mm)	81	204
	10 year return period maximum daily (in mm)	62	135
	10 year maximum return hourly (in mm)	20	39
Extreme rain	Maximum in one day (in mm)	66	166
	Number of days with more 25mm	16	9
Extreme snowfall	Maximum in one day (in cm)	24	18
	Number of days with more than 5cm	16	3
Extreme heat	Maximum daily (in °C)	33	44
	Number of days with more than 30°C	20	66
Extreme cold	Minimum daily (in °C)	-17	-11
	Number of days with less than -10°C	24.6	0.3
	Number of days with minimum less than 0°C	128	70
Wind chill	Extreme daily	-24	-17
	Number of days with less than -20°C	12	0
Degree days	Number of degree days greater than 24°C (air conditioning required)	10	180
	Number of degree days less than 0°C	3452	4857
	Number of degree days less than 0°C (extra heating required)	440	66
Extreme wind	Maximum hourly speed in km/hour	92	48
	Maximum gust speed in km/hour	130	75
	Number of days with wind speed greater than 52 km/hour	0.9	0.0
	Number of days with wind speed greater than 63 km/hour	0.3	0.0
Humidex	Maximum (in °C)	48	57
	Number of days greater than 40 °C	9	39
Storms	Average number of storms per year	30	23
	Average number of summer storms in one year	17	17
	Average number of winter storms in one year	14	6
	Average SRH (vortices potential) in one year	1281	691
	Average CAPE (convective energy potential) in one year	3841	4097
	Average EHI (combination of SRH and CAPE) in one year	3.6	4.3

WHAT RESPONSES WILL HELP IMPROVE BUILDING RESILIENCE?

The overall impact of these changes in climate on the building sector will be primarily experienced in Toronto as a higher risk of flooding events, extreme heat events, and power outages.

To reduce the impact of these expected changes in climate on Toronto's building sector, new buildings must be constructed in such a way as to mitigate flood events, improve thermal resilience, and extend the duration of back-up power generation. The achievement of these measures can already be facilitated by achieving compliance with the Toronto Green Standard (TGS), the City of Toronto's performance standard for sustainable buildings. However, this checklist provides additional assurance that new construction will safeguard the wellbeing of Toronto residents and improve the reliability of its infrastructure.

FLOODING EVENTS An increase in the overall volume of precipitation and the volume of precipitation during individual storm events creates a higher risk of flooding events in certain areas of Toronto. The Toronto and Region Conservation Authority (TRCA) has instituted several measures and resources for the regulation of flooding in Toronto, including flood plain mapping resources that help identify flood-prone areas of the city.[xxi]

The TGS's section on Stormwater Retention also outlines several measures to reduce new buildings' impact on overland runoff. These include:

- **Stormwater balance (Tier 1):** Retain stormwater on-site to same level of annual volume of overland runoff allowable under pre-development conditions.
- **Stormwater retention and reuse (Tier 2):** Retain at least the first 5mm from each rainfall through rainwater reuse, on-site infiltration and evapotranspiration.
- **Enhanced stormwater retention and reuse (Tier 2):** Retain 10 mm of each 24 hour rainfall event, or 70% of total average annual rainfall depth, for rainwater reuse, on-site infiltration and/or evapotranspiration.

However, while these measures help to ensure new buildings reduce overall stormwater runoff in the city, this checklist includes specific measures intended to reduce the potential impact of flooding events on building systems themselves. These will in turn remove the burden of costly repairs to building systems for building managers, and protect citizens from damage and risk from flooding events.

EXTREME HEAT EVENTS The risks associated with the impact of extreme heat events on vulnerable populations have been documented at length by City of Toronto authorities (e.g. Toronto Board of Health). The Board of Health has presented research that indicates a potential doubling of current heat-related illness and death under a warmer climate to 2049.[xxii] Measures to protect at-risk residents (e.g. the elderly, socially isolated, those with pre-existing illness, and young children) and those without access to air conditioning from excessive heat will therefore be important to include into the design and operation of Toronto's buildings.

PASSIVE SURVIVABILITY refers to a building's ability to maintain critical life-support functions and conditions for its occupants during extended periods of absence of power, heating fuel, and/or water.

THERMAL RESILIENCE is one dimension of passive survivability, and refers to a building's ability to maintain liveable temperatures in the event of a power outage or disruption in fuel supply for prolonged periods of time.

Energy modelling conducted in the development of Version 3 of the TGS has shown a correlation between the achievement of higher levels of building energy performance and improved thermal resilience. Buildings designed with thicker building envelopes, lower glazing ratios, lower incidences of thermal bridging, or other highly efficient building strategies help to maintain liveable indoor temperatures with less energy and for longer periods of time under power outages. Buildings with lower overall energy use intensity (EUI) and superior thermal performance also require less back-up fuel during periods of power outages, lengthening the duration of back-up generation reserves or energy storage. Specific strategies to reduce residents' vulnerability to extreme heat events may take many forms, but can be arranged into a hierarchy of descending priority:[xxiii]

1. Minimize internal heat generation through energy efficient design;
2. Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls;
3. Manage the heat within the building through exposed internal thermal mass and high ceilings;
4. Passive ventilation;
5. Mechanical ventilation; and
6. Active cooling systems (ensuring they are the lowest carbon options).

Other strategies may be more operational, including the provision of support, guidelines and resources for property managers, operators, and residents to cope with extreme heat events. A local example of such a resource is the *Off ce of Emergency Management's Get Emergency Ready: High-rise Living* guide for high-rise apartment dwellers.[xxiv]

POWER OUTAGES Finally, the impact of a warmer climate and more extreme weather events can have an effect on the reliability of our power supply. As temperatures rise, our use of air conditioning also increases, putting stress on the ability of the power grid to deliver electricity. Periods of extreme heat are increasingly leading to brownouts and blackouts, as are events in the fall/winter such as Toronto's December 2013 ice storm. Research from past events of this nature has shown that power restoration can take as long as 3 days for several areas of the city. Ensuring that new building are constructed in such a way that their reliance on the power grid is minimized and/or back-up generation supplies last longer will reduce both the likelihood and the impact of possible power outages.

HOW DO I SUBMIT MY CHECKLIST?

- TBD by City of Toronto staff
- Details will include when the checklist must be submitted, with what other TGS documentation, and to whom
- To include link to website for more info + contact for assistance

CHECKLIST REQUIREMENTS

A. APPLICATION STATUS

☐ Site Plan Control ☐ Zoning Bylaw Amendment ☐ Draft Plan of Subdivision

☐ Official Plan Amendment

B. PROJECT INFORMATION

Applicant Name: ______________________________

Telephone: ______________ Email: ______________________________

Project Address: ______________________________

Registered Owner: ______________________________

Architect: ______________________________

Engineer: ______________________________

C. BUILDING INFORMATION

Building purpose/intended use: ______________________________

Principal construction type (wood frame, masonry, steel frame, concrete): ______________

First floor use(s): ______________________________

Site area (m2): ______________ Gross Floor Area (m2): ______________

Number of units: ______________ Number of storeys: ______________

Number of below-grade levels: ______________ Projected occupancy: ______________

D. ENERGY PERFORMANCE

For clarity on modelled energy performance, consult the TGS Energy Modelling Guidelines at [link].

Tier of TGS to be achieved: Tier 1 ☐ Tier 2 ☐

Other green building certification to be achieved (if applicable): ______________

Modelled Energy Use Intensity (kWh/m2/yr.): ______________

Modelled Thermal Energy Demand Intensity (kWh/m2/yr.): ______________

Modelled Peak Energy Demand Intensity (kW/m2/yr.): ______________

Overall R value: ______________

E. MODELLING ASSUMPTIONS

For expected changes in climate across the Greater Toronto Area, consult Toronto's Future Weather and Climate Driver Study.

Has any enhanced modelling using future climate data been conducted for the building site?
No Yes

If yes, what time period was considered? ______________________________
What temperature minimums/maximums were considered in building design?
Temperature Low (°C) ______________ Temperature High (°C): ______________________

What variables were assumed for extreme heat events, if any?

Temperature Max (°C): ____________ Duration of events (days): ______________________

Frequency (events/year): __________

What variables were assumed for extreme flooding events, if any?

Daily rainfall max (mm): ____________ Duration of extreme rainfall events (days): __________

Frequency (events/year): ___________

F. THERMAL RESILIENCE AND SAFETY

What measures have been taken to reduce the impacts of heat waves?

Building - passive

☐ Higher roof R values ☐ Operable windows ☐ External window shading devices

☐ Higher envelope R values ☐ Window films ☐ Triple glazed windows

☐ Cool/green roof materials ☐ Ceiling fans ☐ High albedo envelope

☐ Tenant emergency preparedness guides ☐ Other passive ventilation strategies

Building – active

☐ Indoor refuge area with cooling

☐ Centralized air conditioning

Building – site

☐ High albedo landscaping materials ☐ Soft landscaping ☐ Shade trees/shrubs

☐ External pools (e.g. splash pads) ☐ Reduced hardscapes ☐ Use of solar PV as shades

☐ Shade structures ☐ Outdoor shaded space with seating

☐ High albedo hardscapes, including parking lots

Has a refuge area with cooling been provided in the building (MURB only)? Yes No

If so, what is the total area? (m2) ___________________

Refuge areas should be a minimum of 93m2 (1000 square feet), and/or 0.5m2/occupant.

What services are provided? ____

____

If not, what measures will be taken to provide residents with access to cooling centres? __________

____

____

G. BACK-UP GENERATION

Consult the City of Toronto's Minimum Backup Power Guidelines for MURBs[xxv] for additional information on critical services in residential buildings.

What measures have been used to reduce the building's energy demand on the grid?

☐ On-site solar PV ☐ CHP system ☐ District energy ready

☐ On-site solar thermal ☐ Ground source heat pump ☐ Smart grid ready

☐ On-site storage ☐ Microgrid connected ☐ Building-integrated wind turbines

☐ Other ____

What form of back-up power/emergency generator system has been selected? ________________

____

Is storage adequate to provide 72 hours of back-up generation (MURB only)?

☐ Yes ☐ No

Total storage capacity (kW): ______________Total back-up generation fuel (units): _________________

What critical services have been included into back-up power generation calculations?

☐ Passenger elevator(s) ☐ Security systems ☐ Sump pumps

☐ Unit space heating ☐ Unit space cooling ☐ Refuge area heating

☐ Refuge area cooling ☐ Refuge area lighting ☐ Refuge area electricity

☐ Hot water boilers/pumps ☐ Domestic water booster pumps

☐ Other ____

What is the peak energy demand of critical systems in event of a power outage? ____________________________

How many hours will critical services remain operable under a power outage? ______________________________

H. FLOOD MITIGATION

List any flood prevention measures used to mitigate the impact of heavy rainfall events and associated risk of flooding within the building:

Electrical and HVAC Systems located above 1st floor

Back-up generator/fuel located above 1st floor

Ground floor electrical circuits located in ceiling

Waste water back flow prevention

Water tight utility conduits

Storm water back flow prevention

Deployable barricades

List the strategies used to accommodate heavy rainfall events under the Stormwater Retention (Water Balance) section of the TGS (as identified in your Storm Water management Report): _____

Is the building site located in a flood plain? Yes No

If so, what is the regional storm elevation? ______________________

For more information on regional storm elevations, consult the Toronto Regional Conservation Authority's Flood Plain Management and Flood Mapping Resources.

I. MANAGER & TENANT PREPAREDNESS

Will building management have access to a vulnerable person's list? Yes No

Will a 72-hour preparedness kit available in the building? Yes No

If so, has building management been made aware of the location of the preparedness kit?

Yes No

What additional resources for emergency preparedness have been made available to building managers, operators, and/or tenants?