Appendix 'J' – Eastern Lake Ontario / Upper St. Lawrence River Intake Protection Zone Study Vulnerability Classification

Introduction

Each intake protection zone (IPZ) is to be assigned a vulnerability score (V) based on the following criteria. The intake zone vulnerability score is a multiplication of two factors, the area vulnerability factor (**Vf_a**) and the source vulnerability factor (**Vf_s**) (MOE, 2009).

$$V = Vf_a \times Vf_s$$

Area Vulnerability Factor (Vf_a)

The criteria for assigning Vf_a are laid out in the Technical Rules: Assessment Report (MOE, 2009).

- All IPZ 1 (Type 'A', 'B', 'C' and 'D' intakes) are assigned a Vf_a of ten.
- All IPZ 2 (Type 'A', 'B', 'C' and 'D' intakes) are assigned a Vf_a of between seven and nine.
- All IPZ 3 (Type 'C' and 'D' intakes only) are assigned a Vf_a of between one and nine.
- Further, the Vf_a of IPZ 3 must be lower than IPZ 2.

To identify the Vf_a for IPZ 2 and IPZ 3, consideration can be given to:

i) the percentage of the IPZ that is composed of land,

ii) the land cover, soil type, land impermeability, and slope of setbacks,

iii) the hydrological and hydrogeological conditions in the area that allow water to enter the IPZ through transport pathways, and

iv) in the case of IPZ 3, the proximity of the IPZ 3 to the intake.

Given that all eight of the intakes in the CSPA are Type 'A' or Type 'B', no vulnerability scoring is considered for IPZ 3.

The six Lake Ontario intakes are classified as Type 'A' intakes. The two St. Lawrence River intakes are classified as Type 'B' intakes, where, IPZ 1 was delineated as a half-circle in the upstream direction around the intake (one kilometre), with a rectangle in the downstream direction (100 metres).

For all of the Cataraqui IPZs, the majority of the zones are water. We have considered the ratio of land to water of a one kilometre radius circle around the intake, including the setback on land from the shoreline, as well as the IPZ 2 delineation including land setback. A combination of the regulation limit and a 120 metre high water mark setback is used for the IPZ 1 setbacks on land, in accordance with the Technical Rules.

Table 1 lists each intake, and the IPZ component of land versus water.

Table 1: Surface Component of Intake Protection Zones

(IPZ 1 not included as part of IPZ 2)

Intake	IPZ 1 Area (km^2)			IPZ 2 Area (km^2)		
	Water	% Water	Land	Water	% Water	Land
Brockville	2.1	82.7	0.44	2.7	52.5	2.5
Brockville w/ USA	2.1	82.7	0.44	5.3	47.4	5.9
James W. King (Gananoque)	2.2	83.3	0.44	0.5	21.3	1.9
Kingston Central	3.1	95.4	0.15	14.3	71.9	5.6
Point Pleasant (Kingston West)	2.7	88.4	0.35	16.4	90.1	1.8
Fairfield (Amherstview)	2.2	88.9	0.27	0.7	18.8	3.0
Bath	1.7	82.0	0.37	0.7	7.8	8.4
A.L. Dafoe (Napanee)	1.6	85.7	0.27	0.8	68.1	0.4
Sandhurst Shores	2.0	88.3	0.27	2.1	53.9	1.8

Given that most of the IPZs are in fact water, it could be expected that the vulnerability might be lower. However, the vulnerability increases due to the following factors:

- the land areas are composed largely of shallow soils over fractured bedrock, which increases the probability of contaminants using this transport pathway to enter the water.
- there are many direct transport pathways to the water, including roadways, ditches, and storm, sanitary, and combined sewer pipes that discharge directly to surface water (particularly where the intakes are located), which can allow direct release of contaminants into the IPZs. The area of land versus water for each of the intake IPZs is very similar. The exception is the Kingston IPZs, where the intakes are further offshore, but are also subject to a greater number of transport pathways.

- The shallow depth of water throughout the Cataraqui area also provides an additional consideration, that of mixing. The shallow water allows for no temperature stratification (layering) of the water column, which means that the column can undergo complete vertical mixing. This means that anything released on the surface could easily mix into the entire water column, and reach the intakes located on the lake bottom.

Table 2 shows the percentage of land in each IPZ 2, and the corresponding consideration for the vulnerability score assigned to IPZ 2.

Table 2: Percentage of Land Consideration for Vulnerability Scoring

Intake	Percentage of Land	Scoring Adjustment
Brockville	50%	higher score
James W. King (Gananoque)	80%	highest score
Kingston Central	30%	lower score
Point Pleasant (Kingston West)	10%	lower score
Fairfield (Amherstview)	80%	highest score
Bath	90%	highest score
A.L. Dafoe (Napanee)	30%	lower score
Sandhurst Shores	50%	higher score

As per Technical Rule 92(2) (MOE, 2009) we must also consider land cover, soil type, soil permeability of the land and the slope of the land when assigning an area vulnerability score (Vf_a). The following list provides the considerations for the various conditions in the CSPA:

- urban land cover - quick runoff, no infiltration - higher score
- agricultural land cover - slower runoff, good infiltration - medium score
- loam soil - good infiltration - lower score
- clay soil - poor infiltration - higher score
- medium permeability - better infiltration, less runoff - medium score
- low permeability - poor infiltration, more runoff - higher score
- high slope - more runoff, less infiltration - higher score
- medium slope - medium runoff, medium infiltration - medium score
- low slope - less runoff, more infiltration - lower score.

Table 3 shows the overall soil and land cover considerations for the CSPA intakes, and their effect on the vulnerability scores.

Table 3: Land Cover, Soil and Slope Consideration for Vulnerability Scoring

Intake	Land Cover	Soil Type	Soil Permeability	Slope of Land	Scoring Adjustment
Brockville	urban	loam	medium	high	higher score
James W. King (Gananoque)	urban	loam, clay	medium	medium	higher score
Kingston Central	urban	clay, asphalt	low	medium	higher score
Point Pleasant (Kingston West)	urban	clay	low	low	medium score
Fairfield (Amherstview)	urban	loam, clay	medium	low	higher score
Bath	urban, agricultural	clay	low	medium	higher score
A.L. Dafoe (Napanee)	agricultural	clay	low	low	medium score
Sandhurst Shores	agricultural	clay	low	low	medium score

As per Technical Rule 92(3) (MOE, 2009) we must also consider the hydrological and hydrogeological conditions in the area that contributes water to the IPZ through transport pathways. **Table 4** shows the details of the vulnerability score consideration with respect to these conditions.

The entire CSPA is underlain by fractured bedrock. Any contaminant release on the surface can very easily penetrate into the bedrock, and groundwater, through these fractures. Given this fact, all the CSPA intakes should have a higher vulnerability score. Most of the IPZ areas are in urban areas, but a few have agricultural areas as their dominant land use. The urban areas should have a higher vulnerability due to the speed of runoff from the hard surfaces, but slightly less for agricultural areas.

Table 4: Hydrological and Hydrogeological Consideration for Vulnerability Scoring

Intake	Hydrological Conditions	Hydrogeological Conditions	Scoring Adjustment
Brockville	urban areas	fractured bedrock	higher score
James W. King (Gananoque)	urban areas	fractured bedrock	higher score
Kingston Central	urban areas	fractured bedrock	higher score
Point Pleasant (Kingston West)	urban areas	fractured bedrock	higher score
Fairfield (Amherstview)	urban areas	fractured bedrock	higher score
Bath	urban & agricultural areas	fractured bedrock	higher score
A.L. Dafoe (Napanee)	agricultural areas	fractured bedrock	medium score
Sandhurst Shores	agricultural areas	fractured bedrock	medium score

Considering all the above noted factors, **Table 5** shows the final Area Vulnerability Factors (Vf_a) for each intake.

Table 5: Cataraqui Intake Area Vulnerability Factors (Vf_a)

Intake	Intake Type	IPZ 1	IPZ 2	IPZ 2 Vf_a Range
Brockville	B	10	9	7 – 9
James W. King (Gananoque)	B	10	9	7 – 9
Kingston Central	A	10	8	7 – 9
Point Pleasant (Kingston West)	A	10	7	7 – 9
Fairfield (Amherstview)	A	10	9	7 – 9
Bath	A	10	9	7 – 9
A.L. Dafoe (Napanee)	A	10	8	7 – 9
Sandhurst Shores	A	10	8	7 – 9

Source Vulnerability Factor (Vf_s)

The criteria for assigning Vf_s are laid out in the Technical Rules (MOE, 2009).

The Vf_s relates to the intake itself; consideration is to be given to:

i) the depth of the intake below the water surface,
ii) the distance of the intake from land, and
iii) the number of recorded water quality issues related to the intake.

There are also specific ranges for the Vf_s parameters based on the type of intake.

- Type 'A' intakes (Great Lakes) can range from 0.5 to 0.7.
- Type 'B' intakes (Connecting Channels) can range from 0.7 to 0.9.
- Type 'C' intakes (Inland Rivers and Streams) can range from 0.9 to 1.0.
- Type 'D' intakes (Other water bodies not categorized) can range from 0.8 to 1.0.

Table 6 lists each intake, and its characteristics, as detailed in the Watershed Characterization Report: Cataraqui Source Protection Area (CRCA, 2008).

Table 6: Intake Characteristics

Intake	Depth (m)	Distance from Shore (m)	WQ Issues?	Scoring Adjustment
Brockville	10.7	273*, 190**	Yes	higher score
James W. King (Gananoque)	6	250	Yes	higher score
Kingston Central	18	870	Yes	lower score
Point Pleasant (Kingston West)	17	570	Yes	lower score
Fairfield (Amherstview)	3.6	134	Yes	highest score
Bath	3.4	85	Yes	highest score
A.L. Dafoe (Napanee)	3.4	53	Yes	highest score
Sandhurst Shores	12	270	Yes	higher score

* from the mainland, ** from islands

It is difficult to compare the water quality issues that have occurred at the various intakes. The records contain varying sample parameters, and varying sample lengths. The number of water quality issues for a specific parameter at the Cataraqui intakes ranges from zero for hundreds of samples, to six of 12 samples. We know there are exceedances of the Ontario Drinking Water Standards in the raw water at all of the drinking water plants. The intakes that are further from shore appear to have fewer exceedances. To be conservative, we maximized the impact associated with this particular portion of the scoring.

The intakes are generally shallow and close to shore. Considering the temperature stratification issue, Vf_s values have been maximized in most locations. The type B intakes represented by the Brockville and James W. King (Gananoque) IPZs are given the maximum score of 0.9 to account for their close proximity to the shore and shallow depth. Similarly, the Lake Ontario intakes (with the exception of the Kingston intakes) also receive high scores; being shallow and close to shore.

The Kingston intakes are considerably deeper, and further from shore, than all the other intakes, justifying a lesser Vf_s (moderate) score in comparison. However, the score for these intakes has been increased to reflect the proximity to the surface, and the lack of temperature stratification (and therefore abundance of mixing potential).

The final column in **Table 7** below summarizes the approach used to determine the Vf_s values.

Table 7: Analysis of Intake Characteristics

Intake	Depth of Intake		Distance of Intake from Shore		Water Quality Issues	Approach
	Shallow < 15 m	Deep > 15 m	Near-shore < 500 m	Offshore > 500 m		
Brockville	✓		✓		✓	Higher score
James W. King (Gananoque)	✓		✓		✓	Higher score
Kingston Central		✓		✓	✓	Moderate score
Point Pleasant (Kingston West)		✓		✓	✓	Moderate score
Fairfield (Amherstview)	✓		✓		✓	Higher score
Bath	✓		✓		✓	Higher score
A.L. Dafoe (Napanee)	✓		✓		✓	Higher score
Sandhurst Shores	✓		✓		✓	Higher score

Table 8 shows the final Source Vulnerability Factors (Vf_s) for each intake.

Table 8: Cataraqui Intake Source Vulnerability Factors (Vf_s)

Intake	Intake Type	Factor	Vf_s Range
Brockville	B	0.9	0.7 – 0.9
James W. King (Gananoque)	B	0.9	0.7 – 0.9
Kingston Central	A	0.6	0.5 – 0.7
Point Pleasant (Kingston West)	A	0.6	0.5 – 0.7
Fairfield (Amherstview)	A	0.7	0.5 – 0.7
Bath	A	0.7	0.5 – 0.7
A.L. Dafoe (Napanee)	A	0.7	0.5 – 0.7
Sandhurst Shores	A	0.7	0.5 – 0.7

Another aspect worth considering, although it has no influence on the vulnerability scoring determination, is the recreational boating areas and the shipping route of the St. Lawrence Seaway.

In the Kingston and Gananoque area, there is particularly high in-water traffic related to recreational boating. While the Kingston intakes are further offshore than other intakes in the CSPA, there could still be some impact as anecdotal evidence suggests some recreational boaters release black water (toilet waste) from their vessels in Ontario waters. These boaters are primarily from New York and do not know Canadian law. This practice is apparently legal in New York State (New York State Parks, 2006), but not in Ontario (MOE, 2007). It is legal to discharge grey water (sink and shower waste) in both New York and Ontario.

Through the shipping route of the St. Lawrence Seaway, some shoreline factories within the Cataraqui area ship and receive products via water. Similar to boaters described above, shipping vessels sometimes discharge waste water including bilge water, as well as black and grey water into the Seaway. In addition, spills relating to refilling on the waterways have occurred in the CSPA. For example, in 2008 a diesel spill occurred at the Wolfe Island ferry dock during the refilling of a tugboat.

Overall Vulnerability (V)

Table J-8 gives the Area Vulnerability Factors (Vf_a), Source Vulnerability Factor (Vf_s), and then overall Vulnerability Score (V).

Table J-8: Overall Vulnerability Scores (Vf_a x Vf_s = V)

Intake	IPZ 1		IPZ 2	
	Vf_a x Vf_s	= V	Vf_a x Vf_s	= V
Brockville	10 x 0.9	**9**	9 x 0.9	**8.1**
James W. King (Gananoque)	10 x 0.9	**9**	9 x 0.9	**8.1**
Kingston Central	10 x 0.6	**6**	8 x 0.6	**4.8**
Point Pleasant (Kingston West)	10 x 0.6	**6**	7 x 0.6	**4.2**
Fairfield (Amherstview)	10 x 0.7	**7**	9 x 0.7	**6.3**
Bath	10 x 0.7	**7**	9 x 0.7	**6.3**
A.L. Dafoe (Napanee)	10 x 0.7	**7**	8 x 0.7	**5.6**
Sandhurst Shores	10 x 0.7	**7**	8 x 0.7	**5.6**

Uncertainty

The uncertainty associated with the vulnerability scoring for these IPZs is considered to be low, as per Technical Rules 13 and 14 and the fact the intakes are generally shallow in depth (lack of temperature stratification) and close to the shore.