Gibsons Population and Aquifer Supply

Sustainable Carrying Capacity

A Risk Management Approach

(Summary Document)

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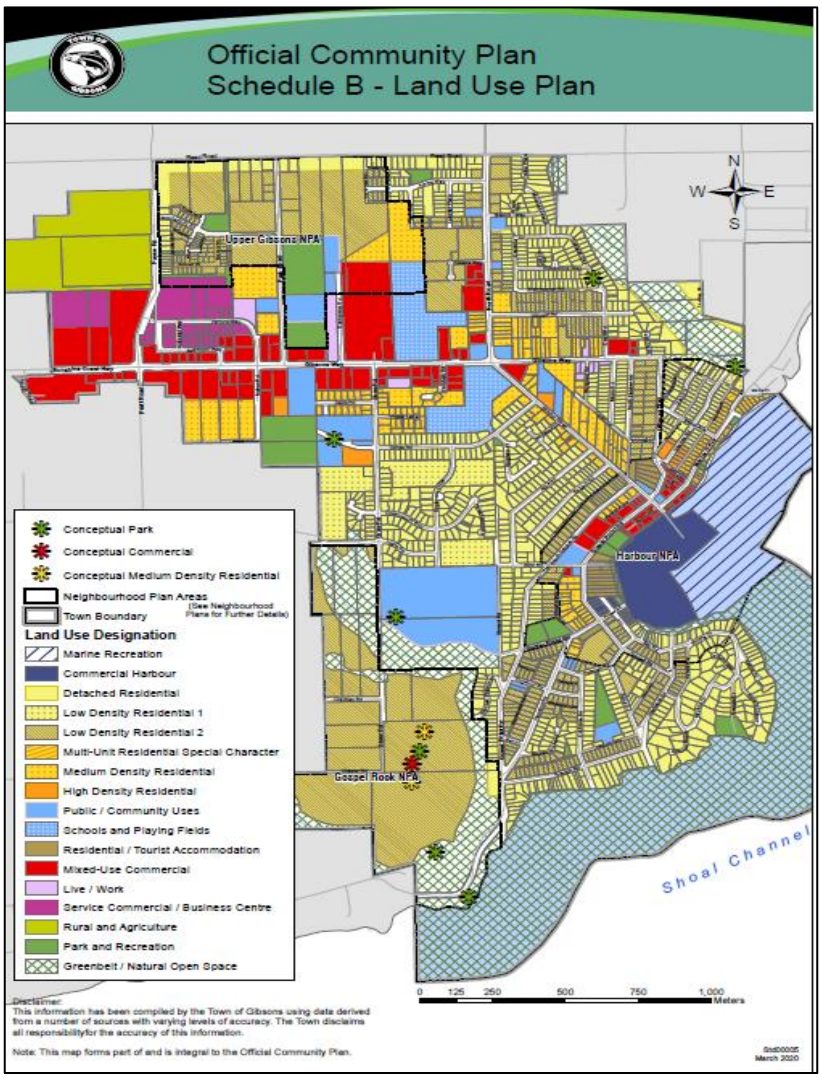

Risk Based Land Management

Good risk management contributes to the achievement of an organization's goals and objectives through the systematic and repetitive application of risk management processes and systems. By identifying, analyzing, and evaluating the risk variables, risk drivers[1] and risk controls[2]; risk managers[3] can anticipate risks, identify priorities, implement risk controls, and make informed and proactive decisions on a course of action to maximize the chance of gain while minimizing the chance of loss.

The CAN/CSA ISO 31000:18 Risk Management – Principles and Guidelines (ISO 31000) defines risk as "the effect of uncertainty on objectives", for which precautionary principle is a fundamental risk control for decision making in an environment of data quality, quantity, available modelling, science, and traditional knowledge uncertainties. By defining risk as "the effect of uncertainty on objectives" the ISO 31000 acknowledges that achieving objectives will usually involve some risk and that there will be a variety and degree of uncertainties in defining that risk. The culmination of these uncertainties could be offsetting or cumulative.

By expressing risk as "the effect of uncertainty on objectives" the ISO 31000 becomes a supporting framework and process of Management by Objectives (MBO). The practice of MBO is noted for "you can't manage what you can't measure".

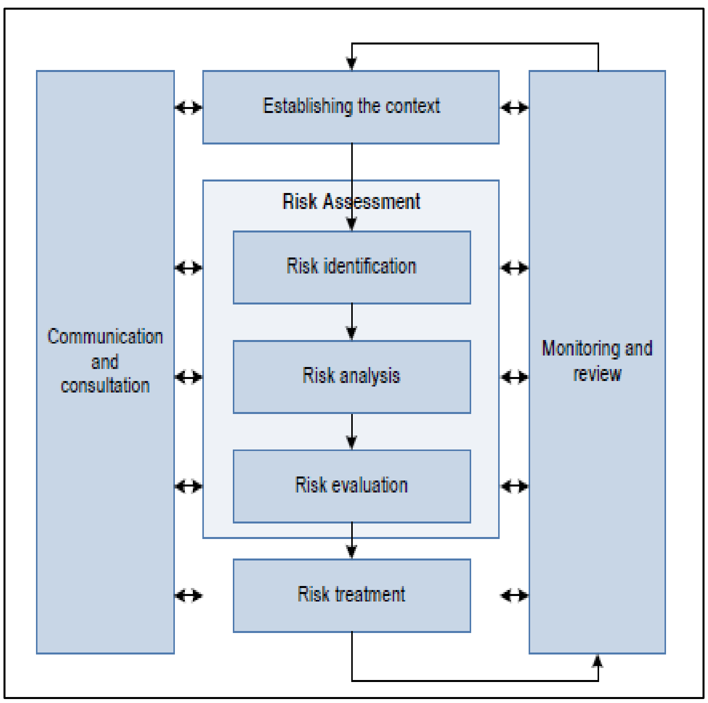

Figure 1. CAN/CSA ISO 31000:18 Risk Management – Principles and Guidelines

[1] A risk driver is a variable that contributes to a risk frequently in combination with other risk drivers in a systems effect (I.e., climate change could be a risk driver, aquifer breaching, changing demographics, are examples of potential risk drivers).
[2] Risk controls are the methods by which risk managers seek to modify the risks (I.e., precautionary principle, aquifer infrastructure monitoring, routine maintenance, water meters, are examples of risk controls).
[3] A risk manager is any person who has the authority, responsibility, and accountability to make decisions on a course of action in an environment of uncertainty.

The ISO 31000 is a systematic and cyclic process that involves five primary elements (Figure 1).

1. Establishing the Context
2. Risk Identification
3. Risk Analysis
4. Risk Evaluation
5. Risk Treatment

These five elements are supported by two enabling activities, Communication and Consultation, and Monitoring and Review for enabling an adaptive management and continuous improvement function to the risk management process (Figure 1).

The ISO 31000 provides the framework and process where the best available science, traditional knowledge, and data is synthesized so risk management cause and effect scenarios can be evaluated, and silo decision making can be avoided. Through the Monitor and Review process it is a progressive, continuous improvement practice.

I.e., when the data and modelling from the Source to Sea project and the 2013 Aquifer Mapping update becomes available it can be seamlessly integrated, and the Sustainable Carrying Capacity modelling examples presented in this document can be quickly and consistently updated. As can any what-if scenario testing.

This is a summary document that does not include the detailing of the quality of the input data or a robust risk evaluation discussion. This is because this risk analysis model has been largely developed by the input and guidance of a few people, whereas the risk evaluation requires the active participation of the citizens of Gibsons. This degree of engagement and decision making is required because of the depth of impact to sustainability as defined by the Brundtland Report (1987), “Sustainable means meeting the needs of the present without compromising the ability of future generations to meet their own needs” and referenced in the Town of Gibsons (ToG) Official Community Plan 2015. In risk based sustainable land management it requires a mindset that understands the synonymous relationship of sustainability and perpetuity (for all time, forever). This requires a level of decision making and endorsement far beyond the ToG town and council.

To put this in perspective, the magnitude of not getting this correct, strikes at the very heart of “Sustainability”. To leave this likelihood and consequence of decision making to the risk tolerance and appetite of just a few people is exceptionally unfair to those people. The citizens of Gibsons need to roll up their sleeves and get involved. Mayor Beamish opened the door for citizen participation in the decision-making process in the ToG Strategic Plan 2019 – 2022. It is time for the ToG citizens to step through it.

Baseline Population and Aquifer Supply Analysis:

The following analysis provides a conservative outlook for a population based sustainable aquifer carrying capacity and how it relates to the ToG "Current Inventory" (Chart 1) of dwelling units from the Statistics Canada 2021 Census Report. Plus, the number of dwelling units that may be constructed in the foreseeable future but would not have registered as being occupied in the 2021 census survey (referenced as being in the "Construction Queue", Chart 1). The "Residual" inventory (Chart 1) is the vacant lands that have been zoned as something residential, and land parcels that would be desirable to demolish and develop interests. An interest that has been popular with developers in recent times and real estate marketing.

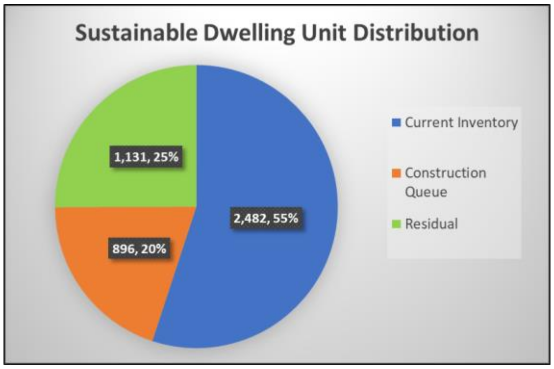

Chart 1. Baseline, Sustainable Dwelling Unit Distribution

Table 1 is the input screen of the risk model where the variables of Aquifer Population Supply and Average Household Size are entered. It is these two variables that are adjusted in analyzing future what-if scenarios for informing present day decision making. Under present day conditions with the best available data (Sustainable Aquifer Supply Population – 10,370 and Average Household Size – 2.3 Persons) the OCP (2015) Table 5-1 will need to reduce the units per hectare densities across all zones by 69% (Tables 1 and 2).

This is a result of the aquifer supply of 10,370 people and the average household size of 2.3 persons requiring 4,509 dwelling units that cannot not be exceeded unless there is an increase in water supply and/or a reduction in average household size (Chart 1)

Population & Aquifer Supply --- Risk Model *(All variable cells are in light yellow fill)*							
Aquifer Population Limit	**Household Size**						
10,370	2.3						
Precautionary Principle - Resiliency Factor	**Precautionary Principle - Resiliency Factor**		**Low Density Factor %**	**High Density Factor %**			
0%	0%		-69%	-69%			
		Aquifer Population - ***Under Capacity*** - ***(Excess)***			**Current and Queue**	**Total Low Density**	**Total High Density**
Aquifer Population Limit	**Household Size**	**Residual Population & Dwelling Units**	**Total OCP Low**	**Total OCP High**	**Population km^2**	**Population km^2**	**Population km^2**
10,370	2.3	***2,601***	***1,006***	***0***	1,794	2,162	2,395
		Dwelling Unit - ***Under Supply*** - ***(Overbuild)***			**Rank**	**Rank**	**Rank**
		1,131	***438***	***0***	**5 of 11**	**4 of 11**	**4 of 11**

Table 1. Baseline, Population & Aquifer Supply - Risk Model Variable Input Screen

Table 2 is the adjusted OCP (2015) Table 5-1 with the values reduced by 69% to maintain a sustainable carrying capacity.

Table 5-1: Land Use Designations *(Carrying Capacity)*												
Land Use Designation	**Description and Intent**											
Detached Residential	To permit single-detached dwellings, and duplex housing.											
	Units per Hectare	2	to	6	Maximum		FSR	0.05	to	0.04	Maximum	
Low Density Residential 1	To permit small lot single-detached dwellings, duplexes, cluster housing, or multi-unit housing in a single-detached building form.											
	Units per Hectare	6	to	8	Maximum		FSR	0.06	to	0.15	Maximum	
Low Density Residential 2	To permit small lot single-detached dwellings, duplexes, cluster housing, townhouses, and multi-unit housing in a single-detached building form. multi-unit housing in a single-detached building form.											
	Units per Hectare	8	to	13	Maximum		FSR	0.09	to	0.18	Maximum	
Multi-unit Residential Special Character	To permit single detached dwellings and multiple unit residential in a single-detached building form. On the south-east side of Marine Drive between Beach Avenue and Jacks Lane, the residential use may be combined with compatible marine related uses.											
single-detached	Units per Hectare	6	to	8	Maximum		FSR	0.06	to	0.15	Maximum	
multiple unit	Units per Hectare	8	to	13	Maximum		FSR	0.09	to	0.18	Maximum	
Medium Density Residential	To permit townhouses, stacked townhouses and 2 to 3 storey apartments.											
	Units per Hectare	13	to	24	Maximum		FSR	0.18	to	0.29	Maximum	
High Density Residential	To permit multi-unit residential buildings (apartments and condominiums) greater than 3 storeys.											
	Units per Hectare	19	to	35	Maximum		FSR	0.26	to	0.44	Maximum	

Table 2. Baseline, Sustainable Carrying Capacity Adjusted Zone Unit Densities

Risk Analysis Scenarios

The utility of this built for purpose risk analysis model is its ability to produce what-if scenarios quickly and consistently. The future is full of uncertainties that may never be precisely understood but it is critical to sustainable carrying capacity to evaluate the variances in the data, and the science. Climate change being one of the most prominent uncertainties we face these days. While there is near total acceptance that the climate is changing there isn't perfect agreement in the modelling. But decisions need to be made today based upon the best available information and consequence of error. The greater the potential consequence requires a more prudent application of the "precautionary principle" risk control.

This built-for-purpose risk analysis model has the utility to adjust the input variables and produce the modelled outputs in a few seconds.

Aquifer Service Capacity Decrease

The Waterline Resources Aquifer Mapping Study (2013) highlighted the risks of breaches and/or contamination that might produce irreparable damage. Urban Systems – Town of Gibsons Water Supply Strategy Update (2017) provided a quantifiable "Distribution Risk Assessment" for a failure that impacted >100 people or produced a $5 million dollar loss as catastrophic.

For this what-if scenario the aquifer water supply was reduced by 25% (Table 3). This was a randomly selected value that might be the result of an aquifer breach, contamination, recharge reduction or a combination of all. This reduction produced an associated reduction in the sustainable population to 7,778. It also necessitated an OCP (2015) Table 5-1 unit density correction of 100% (Tables 3 and 4).

Population & Aquifer Supply --- Risk Model *(All variable cells are in light yellow fill)*							
Aquifer Population Limit	Household Size						
10,370	2.3						
Precautionary Principle - Resiliency Factor	Precautionary Principle - Resiliency Factor		Low Density Factor %	High Density Factor %			
-25%	0%		-100%	-100%			
		Aquifer Population - ***Under Capacity*** - *(Excess)*			Current and Queue	Total Low Density	Total High Density
Aquifer Population Limit	Household Size	Residual Population & Dwelling Units	Total OCP Low	Total OCP High	Population km^2	Population km^2	Population km^2
7,778	2.3	*8*	*3*	*0*	1,794	1,795	1,796
		Dwelling Unit - ***Under Supply*** - *(Overbuild)*			Rank	Rank	Rank
		4	*1*	*0*	5 of 11	5 of 11	5 of 11

Table 3. Aquifer Service Capacity Decrease, Population & Aquifer Supply - Risk Model Variable Input Screen

Mathematically, there would be 4 dwelling units left over to be distributed to a lot of land parcels with development interests (Chart 2). This is an uncertainty that needs to be evaluated in today's sustainable land management planning. The "Likelihood and the Consequences".

As described in the Baseline analysis the sustainable carry capacity of 4,509 dwelling units only changes with an increase in water supply and/or a decrease in average household size. As Chart 2 displays, the "Current" inventory doesn't change, nor does the "Construction Queue" inventory which was held static under the premise that it would be difficult to claw back any of these already approved dwelling units without some conflict.

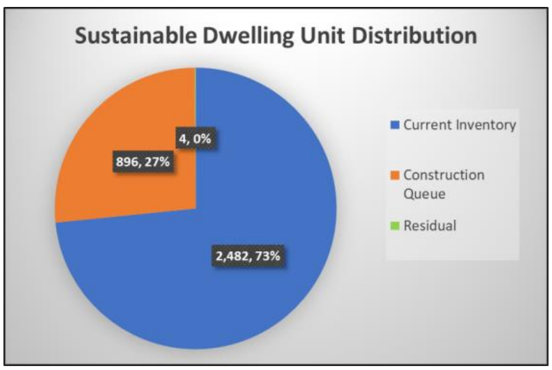

Chart 2. Aquifer Supply Capacity Decrease, Sustainable Dwelling Unit Distribution

As the adjusted OCP (2015) Table 5-1 reveals (Table 4), there isn't any remaining capacity for additional development beyond what is already in the "Construction Queue". Whether this would meet the Urban Systems (2017) definition of "Catastrophic", or not, would likely depend upon individual perspectives. A developer with a land parcel that would have been in the "Residual" inventory is not likely to be very pleased.

Table 5-1: Land Use Designations *(Carrying Capacity)*	
Land Use Designation	**Description and Intent**
Detached Residential	To permit single-detached dwellings, and duplex housing. Units per Hectare 0 to 0 Maximum FSR 0.00 to 0.00 Maximum
Low Density Residential 1	To permit small lot single-detached dwellings, duplexes, cluster housing, or multi-unit housing in a single-detached building form. Units per Hectare 0 to 0 Maximum FSR 0.00 to 0.00 Maximum
Low Density Residential 2	To permit small lot single-detached dwellings, duplexes, cluster housing, townhouses, and multi-unit housing in a single-detached building form. multi-unit housing in a single-detached building form. Units per Hectare 0 to 0 Maximum FSR 0.00 to 0.00 Maximum
Multi-unit Residential Special Character	To permit single detached dwellings and multiple unit residential in a single-detached building form. On the south-east side of Marine Drive between Beach Avenue and Jacks Lane, the residential use may be combined with compatible marine related uses. single-detached Units per Hectare 0 to 0 Maximum FSR 0.00 to 0.00 Maximum multiple unit Units per Hectare 0 to 0 Maximum FSR 0.00 to 0.00 Maximum
Medium Density Residential	To permit townhouses, stacked townhouses and 2 to 3 storey apartments. Units per Hectare 0 to 0 Maximum FSR 0.00 to 0.00 Maximum
High Density Residential	To permit multi-unit residential buildings (apartments and condominiums) greater than 3 storeys. Units per Hectare 0 to 0 Maximum FSR 0.00 to 0.00 Maximum

Table 4. Aquifer Service Capacity Decrease, Sustainable Carrying Capacity Adjusted Zone Unit Densities

Demographic Shift – Average Household Size Increase (2.4)

This scenario is not dissimilar to the previous Aquifer Service Capacity Decrease scenario, in that it provides the utility to evaluate each variable individually. This scenario increases the Urban Systems (2017) suggested average household size of 2.3 persons by 5% to 2.4 persons with the aquifer supply held constant at 10,370 people.

This resulted in a unit density correction of 75% to maintain the sustainable carrying capacity (Table 5).

Population & Aquifer Supply --- Risk Model *(All variable cells are in light yellow fill)*

Aquifer Population Limit	Household Size		Low Density Factor %	High Density Factor %
10,370	2.3			
Precautionary Principle - Resiliency Factor	Precautionary Principle - Resiliency Factor			
0%	5%		-75%	-75%

		Aquifer Population - ***Under Capacity*** - ***(Excess)***			Current and Queue	Total Low Density	Total High Density
Aquifer Population Limit	**Household Size**	**Residual Population & Dwelling Units**	**Total OCP Low**	**Total OCP High**	**Population km²**	**Population km²**	**Population km²**
10,370	2.4	***2,212***	***856***	***0***	1,884	2,197	2,395
		Dwelling Unit - ***Under Supply*** - ***(Overbuild)***			**Rank**	**Rank**	**Rank**
		916	***355***	***0***	**5 of 11**	**4 of 11**	**4 of 11**

Table 5. Average Household Size Increase (2.4), Population & Aquifer Supply - Risk Model Variable Input Screen

While not as dramatic as the 25% aquifer supply reduction this still necessitated a reduction in the "Residual" inventory from 1,131 dwelling units (Baseline Chart 1) to 916 dwelling units to be distributed fair and equitably (Chart 3).

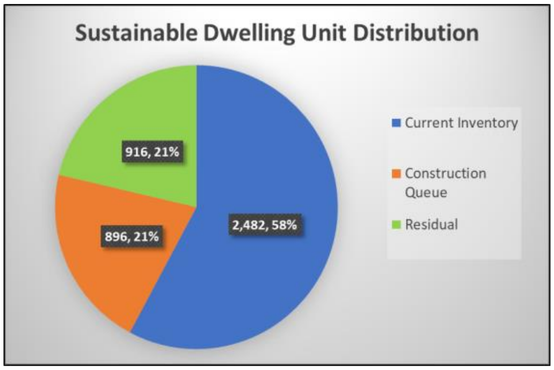

Chart 3. Average Household Size Increase (2.4), Sustainable Dwelling Unit Distribution

Fair and equitable distribution of the 916 remaining "Residual" dwelling units is administered in the adjusted OCP (2015) Table 5-1 (Table 6).

Table 5-1: Land Use Designations *(Carrying Capacity)*

Land Use Designation	Description and Intent
Detached Residential	To permit single-detached dwellings, and duplex housing. Units per Hectare 1 to 5 Maximum FSR 0.04 to 0.03 Maximum
Low Density Residential 1	To permit small lot single-detached dwellings, duplexes, cluster housing, or multi-unit housing in a single-detached building form. Units per Hectare 5 to 6 Maximum FSR 0.05 to 0.12 Maximum
Low Density Residential 2	To permit small lot single-detached dwellings, duplexes, cluster housing, townhouses, and multi-unit housing in a single-detached building form. multi-unit housing in a single-detached building form. Units per Hectare 6 to 10 Maximum FSR 0.08 to 0.15 Maximum
Multi-unit Residential Special Character	To permit single detached dwellings and multiple unit residential in a single-detached building form. On the south-east side of Marine Drive between Beach Avenue and Jacks Lane, the residential use may be combined with compatible marine related uses.
single-detached	Units per Hectare 5 to 6 Maximum FSR 0.05 to 0.12 Maximum
multiple unit	Units per Hectare 6 to 10 Maximum FSR 0.08 to 0.15 Maximum
Medium Density Residential	To permit townhouses, stacked townhouses and 2 to 3 storey apartments. Units per Hectare 10 to 19 Maximum FSR 0.14 to 0.24 Maximum
High Density Residential	To permit multi-unit residential buildings (apartments and condominiums) greater than 3 storeys. Units per Hectare 15 to 28 Maximum FSR 0.21 to 0.35 Maximum

Table 6. Average Household Size Increase (2.4), Sustainable Carrying Capacity Adjusted Zone Unit Densities

Aquifer Supply Decrease and Household Size Increase

This scenario is a combination of the previous two scenarios. It combines the 25% aquifer supply decrease and the 5% increase in household size to 2.4 persons (Table 7). This combination pushes the sustainable carrying capacity into a deficit that would require a unit density correction of 104%. Which is only achievable with a reduction of the "Current Inventory" and/or the "Construction Queue" inventory by 158 dwelling units. Which may well introduce a new risk in terms of conflict resolution.

Population & Aquifer Supply --- Risk Model *(All variable cells are in light yellow fill)*							
Aquifer Population Limit	**Household Size**						
10,370	2.3						
Precautionary Principle - Resiliency Factor	**Precautionary Principle - Resiliency Factor**		**Low Density Factor %**	**High Density Factor %**			
-25%	5%		-104%	-104%			
		Aquifer Population - ***Under Capacity*** - *(Excess)*			**Current and Queue**	**Total Low Density**	**Total High Density**
Aquifer Population Limit	**Household Size**	**Residual Population & Dwelling Units**	**Total OCP Low**	**Total OCP High**	**Population km^2**	**Population km^2**	**Population km^2**
7,778	2.4	*(380)*	*(147)*	***0***	1,884	1,830	1,796
		Dwelling Unit - ***Under Supply*** - *(Overbuild)*			**Rank**	**Rank**	**Rank**
		(158)	*(61)*	***0***	**5 of 11**	**5 of 11**	**5 of 11**

Table 7. Aquifer Supply Decrease and Household Size Increase, Population & Aquifer Supply - Risk Model Variable Input Screen

Chart 4 reveals a deficit of -158 dwelling units in the "Residual" inventory. As this is only achievable mathematically, this dwelling unit deficit would have to be clawed back from the "Current Inventory" and/or the "Construction Queue" inventory. As described previously this may produce another risk.

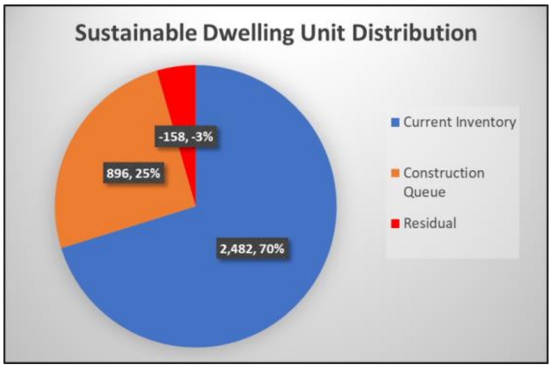

Chart 4. Aquifer Supply Decrease and Household Size Increase, Sustainable Dwelling Unit Distribution

The adjusted OCP (2015) reflects this deficit in the negative units per hectare values (Table 8). It is likely that this scenario would fit the Urban Systems "Catastrophic" definition. In terms of the risk "Likelihood and Consequence" the consequence has been well defined. The remaining component that needs to be evaluated is the "Likelihood" of such a scenario materializing. Such a likelihood evaluation would go back to the science and the respective technical specialists, and the risk can then be better defined. Plus, what sort of risk controls can be established to modify this likelihood. It is unlikely that a Household Size Restriction Bylaw would be well received or enforceable. By process of elimination, it points to aquifer breaching and contamination risk controls, and unit density risk controls.

Table 5-1: Land Use Designations *(Carrying Capacity)*												
Land Use Designation	**Description and Intent**											
Detached Residential	To permit single-detached dwellings, and duplex housing.											
	Units per Hectare	0	to	-1	Maximum		FSR	-0.01	to	-0.01	Maximum	
Low Density Residential 1	To permit small lot single-detached dwellings, duplexes, cluster housing, or multi-unit housing in a single-detached building form.											
	Units per Hectare	-1	to	-1	Maximum		FSR	-0.01	to	-0.02	Maximum	
Low Density Residential 2	To permit small lot single-detached dwellings, duplexes, cluster housing, townhouses, and multi-unit housing in a single-detached building form. multi-unit housing in a single-detached building form.											
	Units per Hectare	-1	to	-2	Maximum		FSR	-0.01	to	-0.03	Maximum	
Multi-unit Residential Special Character	To permit single detached dwellings and multiple unit residential in a single-detached building form. On the south-east side of Marine Drive between Beach Avenue and Jacks Lane, the residential use may be combined with compatible marine related uses.											
single-detached	Units per Hectare	-1	to	-1	Maximum		FSR	-0.01	to	-0.02	Maximum	
multiple unit	Units per Hectare	-1	to	-2	Maximum		FSR	-0.01	to	-0.03	Maximum	
Medium Density Residential	To permit townhouses, stacked townhouses and 2 to 3 storey apartments.											
	Units per Hectare	-2	to	-3	Maximum		FSR	-0.02	to	-0.04	Maximum	
High Density Residential	To permit multi-unit residential buildings (apartments and condominiums) greater than 3 storeys.											
	Units per Hectare	-3	to	-5	Maximum		FSR	-0.04	to	-0.06	Maximum	

Table 8. Aquifer Supply Decrease and Household Size Increase, Sustainable Carrying Capacity Adjusted Zone Unit Densities

Summary

Risk management is an exercise in continuous improvement in any risk environment because the risk drivers can be in a continuous state of flux, the data quantity and quality are changing, and the science is evolving. It is an environment of uncertainty that risk managers must be able to navigate because decisions must be made on a course of action regardless of the business or enterprise.

The Baseline risk analysis is an analysis and evaluation of where we are currently, based upon the best available data and science. There will be uncertainties in this risk environment for many reasons, especially when attempting to evaluate the future state-of-the-environment. Nonetheless, risk managers need to make informed decisions today that may influence that future state-of-the-environment. Even well-informed sustainable land management decisions may not produce the desired future outcomes. But they have a better likelihood of success than poorly informed decisions for which any success is a product of good luck as opposed to good risk management.

It is expected that the Source to Sea project and the Aquifer Mapping update will provide improved data from which this risk model can provide improved risk analysis outputs.

Under the Baseline analysis or any of the risk scenarios presented here, the most critical sustainability goals and objectives of the ToG Strategic Plan (2019 – 2022) will not be achieved and may be going in reverse. This enables the very principle of risk modelling and MBO, "you can't manage what you can't measure" and we are not on track to achieve these "measurable" goals and objectives. But we could be if the ToG citizens rolled up their sleeves and got involved in the decision-making process (Strategic Plan 2019 – 2022).

- Planning for Sustainable Development
    - "long-term approach"
    - "preserve green spaces"
- Respond to a Changing Climate
    - "apply a climate lens to planning"
- Manage our Assets
    - "human, natural and engineered"