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Fire Flow Analysis Report

For

Tofino Affordable & Attainable Housing
District Lot 114, THC Development
Tofino, BC

Phase 1

Prepared For

Tofino Housing Corporation
121 Third Street
Tofino BC V0R 2Z0

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Celerity Project: 18056

Executive Summary

Celerity Engineering Ltd has reviewed the fire flow requirements for the proposed development of District Lot 114, in Tofino, British Columbia. The British Columbia Building Code requires that all buildings are provided with "an adequate water supply for firefighting", however does not reference a specific standard. Four separate relevant recognized standards were assessed to determine the most applicable methodologies for the project site. The standards assessed are as follows:

- Master Municipal Construction Documents, including Water Supply for Public Fire Protection published by the Fire Underwriters Survey (FUS)
- NFPA 1142
- ISO "Needed Fire Flow"
- American Water Works Association "Distribution Requirements for Fire Protection"

The significant findings of the review were that sprinkler protection of a building provides a high level of fire protection that reduces the required fire flow, and that the available methodologies used to calculate adequate fire flow, are largely focused on unsprinklered buildings. Although these methodologies reviewed acknowledge the effectiveness of sprinkler protection and note that a reduction in fire flow is applicable where sprinkler protection of a building is provided, the amount of the reduction and the method in which it is to be applied within the given fire flow equations, is generally not specifically outlined.

All buildings within the development are proposed to be provided with sprinkler protection. As such, we recommend the appropriate method for determining adequate fire flow to be calculated as the sprinkler flow for the most demanding building, a firefighting hose demand, plus the sprinkler flow for one additional building. This approach is consistent to the Insurance Service Office Needed Fire Flow (ISO NFF) method and conservatively includes an added hose allowance. Our recommended method also incorporates the fire flow requirements for an additional multi storey building to the total required Fire Flow. This helps account for the possibility of two fire events simultaneously and recognizes the particularities of the Tofino jurisdiction. The combined water supply to the development is then calculated as the fire flow plus the domestic and non-domestic water demand.

Our review also demonstrates that Fire Underwriter Survey method for determining required fire flows for sprinklered buildings is out of step with other accepted methods used in other jurisdictions and referenced by the BC Building Code. This is in contrast to a generalized consistency across all other methods reviewed with respect to the requirements in non-sprinklered buildings.

The methods applied demonstrate a need for a Fire Flow of 47.3 l/s plus domestic and non-domestic demand for the proposed project. The proposed development project, Phase 1, consists of two apartment buildings (72 units), and six duplex homes (12 potential suites). The project buildings are proposed to be a maximum of 4 storeys in building height and do not contain underground parking. Based on the build-out scenario analyzed in this report (84 units) a total water supply of approximately 52.2 l/s is required (total water supply, including domestic demand). This recommended minimum Fire Flow is in line with the minimum fire flows calculated using the ISO NFF and NFPA 1142 methods but uses a functional and practical analysis approach.

This report aims to provide information to the developer and the District of Tofino regarding the technical basis for the determination of an adequate fire flow water supply for the proposed development.

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1 Introduction

It is proposed to develop District Lot 114 in the District of Tofino into multiple lots containing affordable housing buildings. The available water flow to District Lot 114 does not meet the minimum requirements of the flows outlined in the Master Municipal Construction Documents Association Design Guidelines. The Master Municipal Construction Documents (MMCD) are standardized documents developed and maintained by the Master Municipal Construction Document Association and are deemed acceptable and used within municipalities of British Columbia. This Fire Flow Analysis Report provides an overview of the major requirements that are specific to the proposed development.

1.1 Scope

This Fire Flow Analysis Report provides an overview of the methodologies used within the different standards available for determining the minimum required fire flow. This analysis reviews the Water Supply for Public Fire Protection[1] published by the Fire Underwrites Survey (FUS), a reference document within the MMCD Design Guidelines, as well as the MMCD Design Guidelines themselves. NFPA 1142 "Standard on Water Supplies for Suburban and Rural Fire Fighting"[2], American Water Works Association "Distribution Requirements for Fire Protection"[3], and ISO "Needed Fire Flow Guide"[4] have also been included in the review. A brief review of the applicable NFPA 13 standards and the BC Plumbing Code to determine the demand for sprinkler protection and the domestic demand, respectively, have been included to aid in evaluating the system water supply requirements as a whole. This report was completed based on the information from the client and the CHPA drawings included in the presentation package provided to us dated, September 30th, 2019.

1.2 Project Description

The proposed development consists of six townhouses and two apartment buildings. The proposed development build-out evaluated in this report is 84 units with associated parking stalls (See Picture 1 below). All buildings within the development are proposed to be protected by an automatic sprinkler system.

[1] Water Supply for Public Fire Protection, Fire Underwrites Survey 1999
[2] NFPA 1142, Standard on Water Supplies for Suburban and Rural Fire Fighting, 2017
[3] American Water Works Association, Distribution Requirements for Fire Protection, 2008
[4] Insurance Services Office, "Guide for Determination of Needed Fire Flow", 2014

Picture 1: CHPA's Proposed Site Plan

1.3 Applicable Codes and Standards

The applicable codes and standards referenced in this report are as follows:

- Master Municipal Construction Documents (MMCD)
- Water Supply for Public Fire Protection, Fire Underwriters Survey (FUS),
- NFPA 1142, Standard on Water Supplies for Suburban and Rural Fire Fighting,
- Insurance Services Office (ISO), "Needed Fire Flow Guide",
- American Water Works Association "Distribution Requirements for Fire Protection",
- NFPA 13, "Installation of Sprinkler Systems",
- NFPA 13R, "Installation of Sprinkler Systems in Low-rise Residential Occupancies",
- NFPA 13D, "Installation of Sprinkler System in One-and-Two Family Dwellings and Manufactured Homes"
- ASHRAE, and
- 2018 British Columbia Building Code (BCBC)
- 2018 British Columbia Plumbing Code

2 Documentation on Fire Flow Calculations

There are a variety of documents which provide a guide to calculating fire flows.

The British Columbia Building Code 2018 (BCBC) requires that all buildings are provided with "an adequate water supply for firefighting", however does not reference a specific standard. Although no specific standard is required, the Notes to Part 3 in A-3.2.5.7.(1). provide a list of three documents useful for calculating the adequate water supply

requirements for firefighting. These documents include Insurance Services Office (ISO), “Needed Fire Flow Guide”; NFPA 1142, “Standard on Water Supplies for suburban and Rural Fire Fighting”; and American Water Works Association “Distribution Requirements for Fire Protection”. These documents have been reviewed for assessment of this project.

The MMCD forms a standardized set of guidelines which has been adopted for the design and construction of infrastructure within Tofino District. The MMCD has been included in the review, as well as “Water Supply for Public Fire Protection – A Guide to Recommended Practice”, published by FUS, a document referenced within the MMCD.

2.1 Master Municipal Construction Documents (MMCD)

The MMCD was created to improve construction documents within municipal services; essentially, the MMCD provided a foundation for municipal infrastructure projects. It is highlighted within these guidelines that they are not a substitute for good engineering practice and experience and further state that the standards used within the guidelines are provided to assist in making professional judgement and do not cover all cases. Within the MMCD Design Guidelines two criteria are given for fire flows; firstly, stating that fire flow should be determined in accordance with “Water Supply for Public Fire Protection – A Guide to Recommended Practice”, published by FUS, and secondly the Guidelines provided in Table 2.5, which outlines minimum requirements for fire flows. This Table takes a general and conservative approach with little focus on building details, including location, construction or use. It should be noted that Table 2.5 is for developments without sprinklers, as noted in the table, and therefore would not be applicable to the project where all buildings are proposed to be sprinklered throughout.

Looking closely at the referenced FUS document “Water Supply for Public Fire Protection – A Guide to Recommended Practice” that was published in 1999, sprinkler protection of buildings is acknowledged as providing a significant contribution to fire protection of the community as stated in the Adequacy and Reliability Section of Part I. While Part I of the document provides information, Part II provides an equation to calculate an estimate for the fire flow for a given building or group of buildings. The equation incorporates construction type and floor area and notes further factoring of the equation based on sprinkler coverage and exposure. Although sprinkler protection is mentioned as a factor for reducing the required fire flow and maximum percentages are allocated to system design, supervision, and water supply, there is no method described to determine or calculate these percentages. Due to the lack of information provided within the FUS document for calculating a reduction to the required flow on the basis that sprinkler protection is provided; this calculating method cannot be accurately applied to the project. Specifically, the information within the FUS document is vague and comments on a maximum of 50% reduction may be applied for a complete automatic sprinkler system depending on the adequacy of the system and then further states that a maximum of 30% reduction for an adequately designed system conforming to NFPA 13 and other NFPA standards.

It is acknowledged that the methods used within the FUS document were establish primarily for surveyors to simply estimate fire flow requirements for municipal fire protection. FUS is a national organization that provides data on public fire protection for fire insurance statistical work and underwriting purposes of subscribing insurance companies.

It is noted that other municipalities, specifically Fraser Valley Regional District, which use the MMCD have deleted the minimum requirements outlined in Table 2.5 for apartments, townhouses commercial, institutional and industrial uses. This can be seen within Fraser Valley Regional District Subdivision and Development Servicing Bylaw No. 13199, 2015, page 25. This emphasizes that project areas need not all comply with one Table but can be evaluated individually based on building and area features.

2.2 NFPA 1142

NFPA 1142 provides a method for determining the minimum requirements for alternative water supplies for structural firefighting purposes in areas where the existing water supply is not adequate or reliable. Within the NFPA 1142 Standard, there is a differentiation between alternative water supply for firefighting and municipal-type water systems.

NFPA 1142 provides an equation for calculating the minimum water supply for firefighting purposes; this equation considers the total volume of the structure, the occupancy of the building, the construction type, and exposure hazards. Where sprinkler protection is provided and fully meets the requirements of NFPA 13, NFPA 13D, or NFPA 13R, the water supply for firefighting is permitted to be reduced. As noted in Section 4.4.1. of Annex A of the Standard, a minimum fire flow to a 1 and 2-family dwellings, not exceeding 5 000 ft² (334.5 m²) with an approved sprinkler system, is permitted to be reduced by 50% and by an additional 25% reduction when the building is separated from all other buildings by 30 ft (9.1 m). Regardless of reductions, minimum fire flow requirements are outlined to ensure adequate fire flow is provided. The minimum fire flow listed for 1 and 2-family dwellings, not exceeding 5 000 ft² (334.5 m²) is 500 gpm (1 900 L/min) for a minimum duration of 1 hour.

In considering other buildings and 1 and 2-family dwellings exceeding 5 000 ft² (334.5 m²), reductions up to 75% are permitted for protection by an approved sprinkler system throughout, which utilizes quick response sprinkler heads. Within Annex A of the Standard, specifically A-4.4., a minimum fire flow for sprinklered buildings is mentioned as 600 gpm (2270 L/min).

2.3 ISO "Needed Fire Flow"

ISO "Needed Fire Flow", is another guide that was prepared to assist in estimating the required amount of water for municipal fire protection. The ISO guide evaluates the fire suppression delivery system for insurers' purposes. Within their evaluation a methodology is used to determine the amount of water necessary for fire protection at select locations throughout the community and is referred to as the Needed Fire Flow (NFF). The ISO serves insurers, agents, insurance regulators, fire departments and other government agencies in the US and around the world.

This document provides an estimate for the amount of water required to fight a fire in individual non-sprinklered buildings, as outline in Chapter 1 of the document. Therefore, it will not be applicable to the project based on all buildings equipped with automatic sprinkler protection. Notes within Chapter 1 indicate that sprinkler protection of buildings requires a different approach and suggests that the NFF for sprinklered buildings be calculated as follows:

> Commercial occupancies protected by automatic sprinkler systems designed to NFPA13 have an NFF equal to the sprinkler demand at the base of the sprinkler riser plus the inside/outside hose stream demands, with minimum flow and duration per NFPA 13 requirements.
>
> Residential buildings, such as apartments, protected by sprinkler systems designed to NFPA 13R, have an NFF equal to demand at the base of the automatic sprinkler riser, with a minimum NFF of 1000gpm (63.1 l/s) at 20psi for 2 hours.
>
> 1-or 2 family dwellings protected by a sprinkler system designed to NFPA 13D have an NFF equal to the demand at the base of the sprinkler riser, with a minimum NFF of 500 gpm (32 l/s) at 20 psi for 1-hour.

2.4 American Water Works Association," Distribution Requirements for Fire Protection"

The American Water Works Association (AWWA) is a scientific and educational society dedicated to providing total water solutions, assuring the effective management of water. The document titled "Distribution Requirements for Fire Protection" published in 2008 discusses fire flow requirements. The document describes required fire flow as the rate of water that is necessary to control a major fire in a specific structure, and acknowledges that both the rate of flow and the total amount of water that must be applied to control the fire requires determination.

The document discusses the fact that all fires are different due to random variations including: structure, contents, exposure, weather, temperature, and length of time the fire has been burning for. Four different methods of calculating fire flow are provided within the document. These include: Insurance Service Office (ISO), Iowa State University (ISU), the National Fire Academy, and the Illinois Institute of Technology Research Institute (IITRI). Since the ISO's technique for calculating the NFF is included within the acceptable methods of this document, only a brief review of the other methods was completed.

The comparison provided within the document confirmed the ISO NFF provided a calculated fire flow in the middle range of all four methods discussed. Of most importance within Chapter 1, the document discusses the fire flow limits of sprinklered buildings. The required fire flow for sprinklered buildings is stated as the sum of the sprinkler flow required at the base of the riser, plus a hose stream allowance. This is the same as outlined in the ISO NFF.

The document limits the maximum fire flow for a single fire event to 12 000 gpm (757 L/sec), and provides fire flow duration recommendations of 2 hr for fire flows of 2 500 gpm or less.

3 Foundation of Fire Flow Calculations

Fire flow can be defined as the amount of water available for fire protection purposes, including firefighter hose streams and sprinkler demands. The fire flow water supply is in excess of that required for other purposes, such as domestic demand.

The volume of water required for the fire flow is dependent on several factors including building size, construction type, occupancy, exposure to other buildings, and sprinkler protection. These factors are addressed uniquely within different calculation methods.

3.1 Sprinkler Protection

The demand for a buildings sprinkler system is determined based on the requirements of NFPA 13, NFPA 13R or NFPA 13D installation standards, based on the building application. These sprinkler standards outline specific minimum sprinkler and hose stream flows. With the exception of low-rise residential building, the minimum flow requirements are based on an operating area, which is dependent on building configuration and use as well as the determined water spray density, which is based on the specific hazard classification (use). NFPA 13, 13R, and 13D calculate only the demand for the sprinkler system within a building, with no consideration for domestic or industrial/process demands. These demands must be calculated through other appropriate methods.

The effectiveness of automatic sprinkler systems has been demonstrated and documented. As discussed in NFPA 1142, 96% of all fire within sprinklered buildings are controlled and extinguished by the sprinkler system, with a large percentage of the fires controlled by not more than 2 or 3 sprinkler heads. As such, sprinkler protection is acknowledged as providing built-in fire protection which reduces the manual fire suppression burden, as well as the water supply needed by the fire department to fight the fire. Specifically, sprinklered buildings which are designed

and installed in accordance with the applicable standard, are given a reduction or compensation factor in required fire flow to support this fact.

Each methodology reviewed provides an individual approach to calculations and applying this reduction; noting that most calculation methods are specific for non-sprinklered buildings.

3.2 Building Configuration

The building itself plays an important role within determining the required fire flow. Factors such as building construction, building size, building height, as well as building occupancy and the contents are taken into consideration.

A difference noted between the various calculation methods reviewed is the approach to analysing the building volume used within the equations. Specifically:

- The FUS method incorporates the building volume based on area of all floors into the equation,
- NFPA 1142 uses the total building volume, which accounts for high ceiling spaces,
- The ISO NFF uses a more specific effective area, which considers the construction and allows the effective area to be calculated as a percentage of adjoining floors.

The building volume and area used within the equations, effects the required fire flow and therefore, limiting the volume or area considered will reduce the calculated fire flow.

3.3 Exposure Evaluation

Consideration of proximity to adjacent buildings, as well as exterior wall construction and openings, is another important factor in fire flow calculations. The risk of fire spreading to another building, increases the required fire flow. Differences with respect to exposure consideration can be seen within the various guidelines.

The FUS does not include a specific exposure hazard factor, whereas the ISO NFF calculation does. Specifically, the exposure hazard factor within the ISO NFF calculation is based on construction type, a length-height factor for the exterior walls, as well as the distance between buildings. Various exceptions are provided, with the most important being buildings sprinklered throughout.

NFPA 1142 provides separate equations for both structures with and without exposure hazards, for calculating the minimum fire flow water supply. Essentially, the fire flow is increased by 50% where an exposure hazards is present.

An exposure hazard is defined to exist in NFPA 1142 under two conditions:

- The building is 100 ft² or larger in area and is within 50 ft of another structure.
- The structure contains occupancy hazard classification 3 or 4 and is within 50 ft of another structure.

An additional reduction is noted within Annex A of NFPA 1142, of up to 25% for 1 and 2-family dwellings, where the buildings are separated a minimum of 30 ft (9.1 m) from an adjacent building, noting that the required fire flow is not permitted to be less than 500 gpm. It is noted that exposure reductions for other buildings are not discussed, only reductions for sprinklering. As stated in Annex A, A.4.4, the reductions of fire flow are based on NFPA 1, Fire Code, Section 18.4.

4 Review of Current Fire Flow Requirements

In accordance with the BCBC, Article 3.2.5.7. of Division B, it is required that every building to be provided with adequate water supply for firefighting. Sentence 3.2.5.7.(2), however, provides an exemption to this where the building is sprinklered throughout in conformance with NFPA 13, NFPA 13R, or NFPA 13D.

Adequate water supply for firefighting is explained within Appendix A of the BCBC, as implying that water will be readily available and of sufficient volume and pressures to enable emergency responders to control any fire growth, prevent fire spread to adjacent buildings, and to provide limited measures for property protection.

The exemption for adequate water supply for firefighting is made within the BCBC based on the installation of sprinkler protection throughout the building. It is noted that within NFPA 13, NFPA 13R and NFPA 13D, requirements specific to the water supply for the sprinkler system are imposed; thereby confirming the water supply for fire protection will be provided to the building. It is further noted that verification is required to confirm that adequate water is available to the site and meets the required quantities and pressures to operate the sprinkler system.

In situations where buildings are not served by municipal water supply systems, determining the minimum required water supply is important. As noted previously, Appendix A of the BCBC provides a list of documents which can be used to design an adequate water supply. This list includes: ISO "Needed Fire Flow Guide", NFPA 1142, and American Water Works Association "Distribution Requirements of Fire Protection". It is noted that the MMCD is not part of this reference list.

NFPA 1142 made changes to their document within the 2017 addition, which included the removal of tables and text relative to fire flow requirements and has moved towards using the ISO website as outlined in the Origin and Development of NFPA 1142, section of the document. This method allows for a more encompassing and descriptive approach to building fire flow calculations rather than the previous more generalized calculations which can lead to oversupply. It is emphasized, however, that the ISO "Need Fire Flow Guide" document is specific for non-sprinklered buildings.

5 Comparison of Fire Flow Calculations

Below is a table outlining the fire flow calculations for the described calculation methods.

	MMCD Guidelines	FUS – Water Supply for Public Fire Protection 1999 Part II (Includes ISO copyrighted material)	NFPA 1142	ISO-Needed Fire Flow 2014
Basis		Unsprinklered building	All Buildings	Unsprinklerd Buildings With discussions regarding sprinklered buildings
Basic Equation	References FUS, but provides minimum flows	Fire flow $F = 220C\sqrt{Area}$	Water Supply $WS = (V \div OH) \times C \times EH$ V = Building Volume OH = Occupancy classification number C = construction classification number EH = Exposure hazards	Needed Fire Flow $NFF = \left(18F\sqrt{A}\right)O(1.0 + (X + P))$ F= construction class coef. A = effective area O= occupancy coef. X = exposure hazard factor P= communication hazard factor

Factors:				
Building Size	Not considered	Building Area used, includes all storeys, excluding basements. Consideration given for fire-resistive buildings. Area is equal to two largest adjoining floors plus 50% of each and any floors immediately above, up to 8; however, if vertical openings are protected (1-hour rating) then area = only 2 largest floors plus 25% of each of the two immediately adjoining floors.	Total volume of structure used	Uses effective area; provides consideration for division walls. Considers largest floor area plus percentage of other floors dependant on construction class, and includes additional consideration for protection of vertical openings.
Building Height	Not considered	Included in total area calculations	Incorporated by volume calculation	Incorporated within effective area calculations, as well as exposure hazards.
Occupancy (OH)	General occupancy accounted for within minimum requirements table	Not considered	Classification #3-7; 3 being most severe (OH 4=high hazard & 7 =light hazard)	Occupancy factor here reflects the combustibility of the contents of the structure. Factors range from 0.75-1.25 0.75 -noncombustible 1.25 - rapid burning or flash burning Apartment classified as limited combustible; O=0.85
Construction (C)	Not considered	Construction is broken down into 4 classification which coefficients are applied. 1.5 -wood frame 1.0 -ordinary 0.8 -non-combustible 0.6- fire resistive construction (fully protected frame, floors roof)	Construction number based on materials used and Fire Resistance Rating Type I-V, Number ranges from 0.5-1.5 Dwelling have a max Classification number of 1.0	Coefficient for construction classification ranges from 1.5- 0.6 Construction factor C $C = 18F\sqrt{A}$ Not to be less than 500 gpm (32 l/s), rounded to the nearest 250 gpm. Not to exceed: 8,000 gpm (505 l/s)– const. class 1-2 6,000 gpm (379 l/s)– const. class 3-6, 6,000 gpm (379 l/s) - any 1-storey building any const. class
Exposure	Not considered	Does not provide calculation method where separation distance is less than 45m. Just states various conditions shall be considered. Does	Exposure hazard present when -Area of structure is 100 ft² or greater and within 50 ft of another structure, or -Any area, but Class 3 or 4 occupancy	Exposure considered within 40 ft of exterior wall. Limited to a factor of 0.6, both exposure and communication together.

		Provides maximum increases: 0 to 3m: 25% 3.1 to 10m: 20% 10.1 to 20m: 15% 20.1 to 30m: 10% 30.1 to 45m: 5%	hazard and is within 50 ft Exposure hazard present multiply WS by 1.5 (A4.4: based on NFPA 1, permits 25% reduction 1-2family dwelling 30ft separation distance) Note: either all or nothing approach	
Communication	Not considered	Not considered	Not considered	Communication factor included with exposure which includes a passageway to the building. Limited to a factor of 0.6, both exposure and communication together.
Sprinklers Protection	The minimum requirements table specific to non sprinklered buildings.	Specific to non sprinklered buildings. Vaguely suggests that sprinklered buildings can be provided a reduction of 50%.	1-2 Family Dwellings (bldg. area <5000ft²) 50% reduction if protected by spk 75% reduction for spk of other buildings. (per Annex A of NFPA 1142)	Allows a property to be considered as sprinkler protected based on specified condition. This allows for exposure hazard to be excluded. NFPA sprinkler protection, included in Notes. Typically, NFF is demand at base of the sprinkler riser. NFF for Residential occupancies (apartments NFPA 13R) is the demand at the base of the automatic sprinkler riser;
Result:	n/a	n/a	Water supply calculated; rate determine by Table 4.6.1.	
Minimums:				
SFD without sprinklers	60 l/s	Not provided	Not provided	Not provided
1-2 Family dwellings	Not provided	Not provided	63 l/s unsprinklered 31.5 l/s sprinklered	With sprinklers - 500 gpm (32 l/s) at 20 psi for 1 -hr
Low rise residential, 4-storerys or less	Not provided	Not provided	Not provided	With Sprinklers - minimum is 1,000 gpm (63 l/s) at 20 psi for 2 hrs.
Townhouses without sprinklers	90 l/s	Not provided	Not provided	Not provided
Other Buildings	Not provided	Not provided	63 l/s unsprinklered 37.9 l/s sprinklered-per Annex A	Not provided
Commercial	150 l/s	Not provided	Not provided	Not provided
Any structure with exposure	Not considered	Not provided	31.5 l/s (3000 gal)	Not provided

Any structure without exposure	Not considered	Not provided	15.8 l/s (2000 gal)	Not provided
Overall flow	Not provided	Not provided	Not less than 15.8 l/s (250 gpm) 1-2 family dwellings, and 600 gpm for other.	Not provided

6 Fire Flow Calculations

Calculations for the proposed development have been performed based on the relevant methods discussed above and are included in Appendix A of this report.

Assumptions were made in the calculations for fire flow as the development is currently in the conceptual design phase. The assumptions include the construction type of the buildings (assumed to be wood frame) and building sizes - detailed calculation are included in Appendix A of this report.

No specific data was found on the likelihood of multiple fires occurring simultaneously within a development; however, consideration has been given to the number of firefighters, the majority of whom are volunteer as well as the firefighting vehicles and equipment of the District. In assessing these factors, it is assumed only one fire with responding firefighters will occur at one time within the development. A conservative approach for water supply was taken to account for the possibility that two fires occur simultaneously in the development, with firefighter response only being available at one location.

The fire flow calculated from the NFPA 13 (sprinkler) demand as well as an additional manual firefighting (hose) demand appears to be a practical approach based on fire fighting operations and is consistent with the ISO Needed Fire Flow method. As noted above, it is recommended to include an additional demand of a second building fire (NFPA 13 demand only) to the fire flow for the development. The total water supply is recommended to be calculated as the fire flow required for the most demanding building, plus hose allowance (manual firefighting demand), plus the sprinkler demand of one additional building within the development, plus the domestic demand and non-domestic demand.

Looking at the fire fighting (hose) demand applied within the recommended approach, which follows NFPA 13 requirements, we see that a 100 gpm hose demand is applicable to light hazard occupancies such as residential buildings; however, a hose demand of 250 gpm has been applied. This fire fighting hose demand of 250 gpm is typically used within NFPA 13 for ordinary hazard occupancies. While it is noted that the current development contains only residential buildings, based on the location of the development the more demanding value has been applied and seems appropriate.

The calculated fire flow determined by the NFPA 1142 method was the same as that calculated from NFPA 13 (sprinkler) demand as well as an additional manual firefighting (hose); however, it is noted that the NFPA 1142 minimum (600 gpm) superseded the calculated NFPA 1142 value. This results in a higher fire flow required by the NFPA 1142 method. Since the recommend approach incorporates a sprinkler demand for a second building, the resultant recommended fire flow exceeds the minimum within NFPA 1142. The calculated fire flow method of the FUS Water Supply for Pubic Fire Protection, was significantly higher. This difference can be allocated to the minimal instruction and allowance for buildings protected by an automatic sprinkler system in the FUS method.

7 Additional Water Demand Calculation

Part of the total water supply demand calculation is the determination of the demand for domestic, industrial/process water, and any other water demands, including irrigation.

The proposed development is primarily residential, so there will be limited, or no industrial/process water demands.

To calculate the domestic water demand for the development, the 2018 British Columbia Plumbing Code was referenced to determine the number of fixture units could be expected based on the estimated number of dwelling units being contemplated in the development. The total domestic flow rate, was determined using the Modified Hunter Curve, published by American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The calculations are included in detail in Appendix A of this report.

Water demand for irrigation has not been determined as part of this report.

8 Summary

The following table provides a summary of the calculation findings:

	Calculated Fire Flow Based on Most Demanding Building (FFMDB)		**Calculated Fire Flow plus added Sprinkler Demand For Small Multi-Storey Building (FFMDB + SDSMB)**		**Calculated Water Supply (Domestic Demand + Fire Flow)**	
	gpm	**l/s**	**gpm**	**l/s**	**gpm**	**l/s**
NFPA 1142	600	37.8			678	42.8
NFPA13 + hose stream	500	31.5	750	47.3	828	52.2
ISO NFF minimum	1000	63.1			1078	68
FUS	3156	199			3234	204

The calculations provided in Appendix A of this report, list each method and the calculations used to calculate the fire flow required for the project as well as the total water supply demand. Looking at the proposed development we recommend providing a fire flow based on the sprinkler demand of most restrictive building, plus a 250 gpm (15.8 l/s) hose allowance for manual firefighting purposes, plus an additional sprinkler demand for a second building within the development. The recommended fire flow is based on the principles described in ISO NFF and incorporates additional flows such as hose demand and second building sprinkler demand, resulting in a reasonable yet conservative fire flow demand.

From the calculations and review of the methods discussed in this report, in our opinion we recommend a minimum fire flow of 750 gpm (47.3 l/s) be provided for the development. This flow is the sum of 250 gpm (15.8 l/s) for the most demanding building sprinkler system, plus 250 gpm (15.8 l/s) for additional manual firefighting demands, and lastly 250 gpm (15.8 l/s) for the sprinkler demand of another building to address the risk of conflagration.

It is acknowledged the method use to determine the recommended fire flow for the project is less than the minimum allowable 1000 gpm (63.1 l/s) outlined in the ISO NFF document, and greater than that of the fire flow required by NFPA 1142 methods of 600 gpm (37.9 l/s).

As the proposed development is considered Phase 1, including only residential buildings 4 storey or less with no underground parking, it is noted that should additional phases be proposed a detail review of the water supply will be required to ensure the impact of all future buildings will be accounted for. Particular attention will be required

should future buildings include any multi-storey buildings with underground parking or building designed for commercial use.

From the calculations, the total water supply for the development would be a minimum of approximately 830 gpm [52.2 l/s], to meet both domestic and fire flow demands. Additional water demand may also be required if irrigation and other water demands are determined to be likely within the development.

Regards;

CELERITY ENGINEERING LIMITED

Corie Lubben, EIT
Code Consultant

Reviewed By:

21 January 2020

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Principal

Appendix A

Summary of Calculations and Calculations

Project 18056
June 28, 2018
Revised Janaury 20, 2020

Tofino Housing Corportation - Development DL114

Fire Flow Analysis Calcuations - PHASE 1

Sprinkler Notes:
Based on all buildings sprinkelr per NFPA 13R; applicable with 4 storey or less and NO underground parking

residential spk: minimum 0.05gpm/ft² to design area

Project Building Info

bldg	# untis	# storeys
L1	37	3
L2	35	4
TH1	4	3
TH2	4	3
TH3	4	3

NFPA 13 Sprinkler Demand Calculations

Building	**Hazard Classification**	**Rate**	**hose demand**	
L1 -residential	light hazard	0.1 gpm/sqft	100 gpm	
L2 - residentail	light hazard	0.1 gpm/sqft	100 gpm	per 11.2.3.1

Townhouse TH1, 2, 3 NFPA 13R 4 heads at 13gpm/head

Buildings	**Bldg Height**	**rate**	**gpm**	**l/sec**	**in/out hose allownace gpm**	**total gpm**	**l/sec**
L1	3	0.1gpm/ft² at 1500ft²	150	9.5	100	250	15.8
L2	4	0.1gpm/ft² at 1500ft²	150	9.5	100	250	15.8
TH1	3	4 heads	52	3.3	0	52	3.3
TH2	3	4 heads	52	3.3	0	52	3.3
TH3	3	4 heads	52	3.3	0	52	3.3

Sprinkler demand = 250 gpm (most restrictive)
16 l/sec

Manual Fire Fighting Demand = 250 gpm
15.8 l/sec

Note: NFPA 13, permits 100 gpm for light hazard, however 250 gpm, equal to ordinary hazard occupancies has been applied as based on project location

Domestic Requirements
2018 BC Plumbing Code
Based on T2.6.3.2A

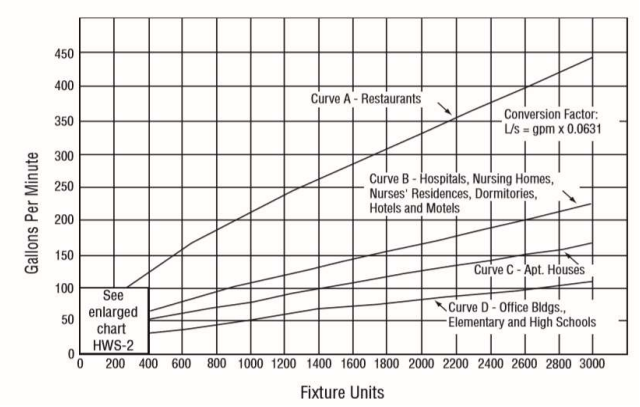
2/3 Bdrm Units:	Quantity	fixture units (f.u)	total f.u.
bath	2	6	12
kitchen sink	1	1.4	1.4
washer	1	1.4	1.4
dishwasher	1	1.4	1.4
		total =	**16.2**

Studio/1 Bdrm Units:	Quantity	fixture units	total f.u.
bath	1	6	6
kitchen sink	1	1.4	1.4
washer	1	1.4	1.4
dishwasher	1	1.4	1.4
		total =	**10.2**

Dwelling unit Breakdown

84 dwelling in development	Quantity	Total f.u.
studio/1 bdrm room	47	479.4
2/3 bdrm	37	599.4
	total	**1078.8**

Chart 12-1



Based on Modified Hunter Curve	Total Fixture Units	Demand (gpm)	Based on Modified Hunter Curve (above)
Residentail	1078.8	78	Residential Curve C

Total domestic = 78 gpm
4.9 l/s

Master Municpal Construction (MMC)

Minimum flows: town/apt. 90 l/s

fire flow + max. daily demand = 150 kPa

Implies FUS to be used for fire flows calcs.

Fire Underwriters Survey (FUS)
(Part 11 - ISO Guide)
based on Part 11

F=220C(A)1/2

reduction permitted for low content fire hazard
15% limited combustibles
further reduce for spk (30% NFPA 13)
futher reduce if water supply is standard for both the system and the FD hose lines
Increased due to exposure
total % sum for all sides (not greater than 75%)

Not permitted to be less than 2000 l/m [33.3 l/s]
Not permitted to exceed 45,000 l/m [750 l/s]

Fire Underwriters Survey (FUS) continued

Calc:
Constuction type;
floor area
storeys
formaula plug in
f=220c(a)1/2
(c = 1.5 wood frame)
add increases and decreases; low content fire hazard, exposure hazard, sprinkelr protection

NOTE:
fire-resitance building = fully protected frame and floors and roof ,
based on definition not applicable to these buildings(differs area calc)

Bldg	(sqm) Area	Number of storeys	c	l/min F	w/ content reduction l/min F	w/ exposure hazard l/min F	30% spk reduction F
L1	1020	3	1.5	18255	15516	17068	11948
L2	750	4	1.5	18075	15364	16900	11830
TH1	120	3	1.5	6261	5322	5854	4098
TH2	120	3	1.5	6261	5322	6387	4471
TH3	120	3	1.5	6261	5322	6120	4284

Total fire flow= 11948 l/min Sprinkler protection within all buildings
3156 gpm
199 l/sec

Imposed a 30% reduction due to spk - conservative estimate (noting no direction as to application of percentages or percent determination)

If project were to be **unsprinklered**: fire flow = 17068 l/min
4509 gpm
284 l/sec

NFPA 1142 Fire Flow Calculations

Occ Classifiacation = 7

Constr Class (max 1 for dwellings) =1

No exposure

WS = Volume/Occ Haz * Constr Class

min = 2000 gal (7600 liters)

Exposure

WS = Volume/Occ Haz * Constr Class*1.5

min = 250 gpm (15.8 l/s)

min = 3000 gal (11355 lites)

NOTE:

8ft floor to floor height assumed

L1, L2, TH1, & TH3 - no exposure hazard

TH2 - exposure hazard

Table 4.6.1 Water Delivery Rate

Total Water Supply Required		Water Delivery Rate	
gal	L	gpm	L/min
<2,500	9,459	250	950
2,500–9,999	9,460–37,849	500	1,900
10,000—19,999	37,850–75,699	750	2,850
≥20,000	≥75,700	1,000	3,800

	Area		# of	Volume	Calc Suppy	Calc Supply	Delivery rate		Reduction due to spk Supply	Deli rate	Minimum
	sqm	sqft	storeys	(cubic ft)	gal	L	L/min	gpm	L	gpm	gpm
L1	1020	10979	3	263501	37643	142478	3800	1000	35620	500	600
L2	750	8073	4	258334	36905	139685	3800	1000	34921	500	600
TH1	120	1292	3	31000	4429	16762	950	750	8381	250	600
TH2	120	1292	3	31000	6643	25143	1900	750	12572	500	600
TH3	120	1292	3	31000	4429	16762	950	750	8381	250	600

Minumum water supply required for any structure **without exposure hazard** to be not less than 7600L/2000 gal

Minumum water supply required for any structure **with exposure hazard** to be not less than 11,355 L / 3000 gal (500 gpm)

Noting 600 gpm minimum mentioned within Annex A for sprinklered buildings.

I hr fire flow duration required

Total fire flow= 1000 gpm no sprinkler reduction

500 gpm sprinklered reduction - minimum governs

600 gpm sprinklered reduction

Reductions: Up to 75% permitted for Residentail >5000 sqft and protected by spk system, w/ quick response heads

50% for 1 and 2 family dwellings spk (< 5000 sqft)

Calculated Water Supply Summary

Fire Flow Water Supply

	gpm	l/sec
NFPA 13 + FFD Hose Demand	500	31.5
NFPA 1142	600	37.9
FUS	3156	199

Minimum Outlined in documents

ISO NFF minimum = 1000 gpm (63 l/sec)

NFPA 1142 minimum = 600 gpm (31.5 l/sec)

MMCD =90 l/s minimum in table

Recommended Approach

To include an additional sprinkler demand for a building in the development; Suggested added Spk demand = 250 gpm

Recommended Fire Flow = NFPA 13(most restrictive bldg) + FFD + Sprinkler demand for another building

Recommended Fire Flow = 750 gpm 250

47.3 l/sec 15.8

For Comparison

Fire Flow = NFPA 1142 + added spk demand

850.0 gpm

53.6 l/sec

Total Water Supply

	gpm	l/sec
NFPA 13 + FFD + Domestic =	578	36.5
NFPA 13 + FFD + Add Spk + Domestic =	828	52.2
ISO minimum + Domestic =	1078	68.0
NFPA 1142 + Domestic =	678	42.8
FUS + Domestic =	3234	204.0

Appendix B

Summary of Assumptions

Tofino Affordable & Attainable Housing
District Lot 114, THC Development

Assumptions

Building construction is wood frame (combustible construction)

All buildings to be sprinklered in accordance with applicable NFPA standard.

Proposed buildings, including height and units, outlined in Calculation Summary- Appendix A

Domestic Assumptions

Studio/Single bedroom units		**Two-bedroom units**	
Fixture	# supplies	Fixture	# supplies
Bath	1	Bath	2
Kitchen sink	1	Kitchen sink	1
Dishwasher	1	Dishwasher	1
Washing machine	1	Washing machine	1
Three-bedroom units		**Duplex units**	
Fixture	# supplies	Fixture	# supplies
Bath	2	Bath	3
Kitchen sink	1	Kitchen sink	2
Dishwasher	1	Dishwasher	2
Washing machine	1	Washing machine	2

Appendix C

Qualifications

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Qualifications

Celerity Engineering Limited is a Canadian Code Consulting and Fire Protection Engineering located in Victoria and Vancouver, British Columbia. The firm is led by Brian Fraser, P.Eng., C.P. and has been providing services to the design and construction community since 2011.

Brian Fraser is registered as a Professional Engineer in British Columbia, Alberta and Saskatchewan. He obtained his Bachelor of Engineering, Mechanical Engineering, from the University of Victoria in 2002 and has worked as a consulting engineer in the construction industry since 2005. Earlier in Brian's career, before focusing on Code Consulting and Fire Protection engineering, he worked as a design engineer and project manager on projects ranging from heavy industrial plants, light industrial plants, commercial buildings, tenant improvements and residential developments. As such, Brian has developed an excellent understanding of the multi-disciplinary requirements involved in the construction of new and alteration of existing buildings. Brian utilizes this knowledge when applying Fire Protection principles and Code Consulting services.

Brian successfully completed the Certified Professional (CP) course administered by the Association of Professional Engineers and Geoscientists of British Columbia and the Architectural Institute of British Columbia, in February 2012. As a CP, Brian is a recognized as an expert in the application of Part 3 and the administrative components of the British Columbia Building Code and Vancouver Building Bylaw. Brian is also adept in the application of the National Building Code of Canada and the Alberta Building Code.

Brian is a member of the National Fire Protection Association (NFPA), and regularly completes training with NFPA in order to keep current on the developments in fire protection and building code development research and to provide clients with solutions based on the current state of the art. Brian also works regularly with the NFPA standards and codes, and the International Building Code (IBC) as a means of providing compliance and perspective in projects.