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# STRUCTURAL ANALYSIS

61.0m Guyed Tower

## Northpine, BC

June 26, 2018

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Vincent Communications Project:  
Tower Load Bearing Study

*Prepared for:*  
Vincent  
Communications

*Structure Owner:*  
Peace River  
Regional District

*Varcon Job #:*  
80257

*Distribution:*  
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Communications



**VARCON Inc.**  
Consulting Engineers

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## **1.0 Introduction**

As per your instructions, we have analyzed the 61.0m triangular, guyed tower located at Northpine, BC. The structural analysis was performed to assess whether the tower meets the strength requirements of CSA S37-13 under the loading shown on the attached tower profile.

### Structure Details

Height:	61.0m
Type:	Guyed Mast
Name:	Northpine, BC
Latitude:	56° 22' 9.7" (N)
Longitude:	120° 49' 29.6" (W)

### Analysis Parameters

Standard:	CSA S37-13
Ice Loading:	10.0mm
Wind Loading:	456 Pa (Site Specific Wind)
Earthquake Loading:	0.095
Earthquake Class:	Life Safety Performance Level 1 (PL1)
Reliability Class:	I
Serviceability Factor:	1.00
Loading Combinations:	24 Load Cases (12 bare, 12 iced)

### Sources of Information

Structural Mapping:	2018, Varcon Inc. Structural Mapping
Reports:	1991, Hardy BBT Limited Geotechnical Investigation 1990, BC Ministry of Regional and Economic Development Site and System Inspection Record
Environmental Data:	2018, Environment Canada Site Specific Wind Data CSA S37-13 Ice Map 2010, National Building Code Seismic Hazard Calculation
Correspondence:	2018, Email Correspondence with Vincent Communications

### Missing Information:

Drawings:	As-Built Tower and Foundation Drawings
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## **2.0 Assumptions**

Several assumptions were made in order to facilitate our analysis. If you have any knowledge which would indicate they do not accurately represent the existing tower, proposed and existing antenna and transmission line arrangements, or site specific information, we must be notified so that we can make the appropriate changes to our analysis, conclusions and any recommendations.

Assumptions utilized in completing our structural analysis include:

1. The tower and antenna loading considered in our analysis includes all existing antennas and transmission lines as identified by the 2018 Structural Mapping completed by Varcon Inc. The proposed loading is as per email correspondence with Vincent Communications. The complete loading scenario is as shown in Appendix A.
2. The tower members, connections and other relevant components are in good condition and are capable of carrying their full design capacity.
3. The yield strength was taken as 300MPa for the tower legs, diagonals and horizontals.
4. The manufacturer of the shackles and turnbuckles for various guy wires are unknown. We have assumed that these elements do not limit the capacity of the guy wires.

## **3.0 Analysis Results**

Based on the above information and assumptions, our analysis results indicate that the tower mast is in conformance with the strength requirements of CSA S37-13.

Due to lack of information as detailed in section 1.0 above, we are unable to review or verify the capacities of the existing tower foundations. We cannot comment on the suitability of the foundations at this time without site specific foundation details.

Graphical tower loading and capacity results are provided in Appendix B.

Based on the above information and assumptions, our analysis results indicate that the mount at elevation 25.0m experiences overloads under a fall arrest scenario in accordance with Canada Occupational Health and Safety Regulations, Section 12.10 requirements.

During our analysis we assessed the site specific spectral ground acceleration parameters. Since  $S_a(0.2)$  is below 0.35g, this site does not require earthquake loading analysis per CSA S37-13.

Table 1: Microwave Antenna Serviceability Deflections

<b>Description</b>	<b>Elevation (m)</b>	<b>Owner</b>	<b>Calculated Rotation (Degrees)</b>	<b>Allowable Rotation (Degrees)</b>
0.6m HP Dish	55.8	PRIS	0.90	-
0.6m HP Dish	34.4	PRIS	0.54	-
0.9m PL Dish w/ Radome	25.0	PRIS	0.52	-
0.6m HP Dish	20.7	PRIS	0.44	-
0.6m PL Dish w/ Radome	19.5	PRIS	0.42	-

Microwave antenna deflections are taken with a serviceability factor ( $\tau$ ) of 1.0.

For your information, we have attached the following appendices:

- A. Tower Profile and Antenna Loading
- B. Graphical Analysis Results
- C. Site Specific Wind

## 4.0 Conclusions

Based on the above information and assumptions, our analysis results indicate that the tower mast meets the strength requirements of CSA S37-13.

The existing mount at 25.0m is not adequate to resist the forces resulting from a fall arrest scenario. If there are going to be upgrades to the antennas at this elevation we recommend the mount be replaced to meet the Canada Occupational Health and Safety Regulations, Section 12.10 fall arrest requirements.

It should be noted that the capacity of the tower foundations could not be verified. If foundation drawings exist for this site, they should be forwarded to Varcon Inc. so that we can complete a review of the foundation.

We trust the forgoing is satisfactory. If you have any questions or comments, please contact the undersigned.



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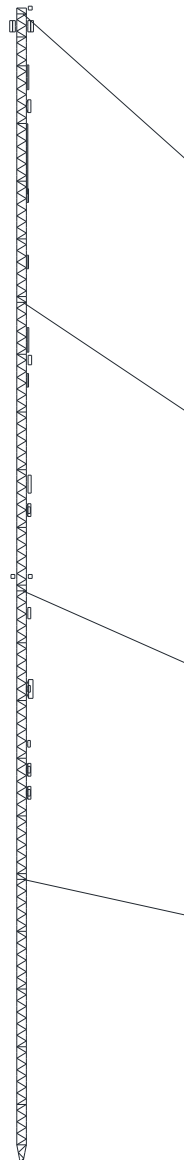
## **5.0 General Notes**

1. Results, conclusions and recommendations derived from this analysis report are as accurate as the information provided to Varcon Inc. and are prepared for the exclusive use of the Client noted. Any use, which a third party makes of this report or reliance on or decisions made based on it are the responsibility of such third parties. Varcon Inc. accepts no responsibility for damages, if any, suffered by any third party or use of the report information by anyone, outside the specific indicated scope, as a result of decisions made or actions based on this report. Further, any use outside the specific indicated scope is done so at the full responsibility of the user.
2. Results, conclusions and recommendations are based on analysis results for Reliability Class I. This is the most conservative case whereby no probability of failure is tolerated, since any failure would result in unacceptable risk of injury and/or interrupted service. Should the Client wish to accept some measure of risk, Varcon Inc. can re-evaluate the results, conclusions and recommendations based on either Reliability Class II or III at the Client's request.
3. This analysis is completed in accordance with the strength/safety (Ultimate Limit States-ULS) and antenna service (Serviceability Limit States-SLS) requirements of CSA S37-13.
4. In our analysis, twenty-four (24) load cases are evaluated: twelve (12) wind directions under (a) full design wind pressure without ice and (b) half design wind plus full ice thickness.
5. Our assessment is based on the minimum CSA S37-13 recommended ice thickness. These figures are general in nature and based on Environment Canada data. Site specific ice loading could change considerably. If you have any site specific information which would indicate that greater uniform accumulations of ice are likely to occur, please contact us immediately and our analysis results will be modified accordingly.
6. ULS evaluation compares the minimum factored resistance governed by either members or connections with factored loads resulting from wind and/or ice (maximum governing) applied to the structure.
7. SLS evaluation reports deflection of microwave antenna beams as a result of applied service loads, if applicable. Unless specified by the owner, total deflection is compared against antenna manufacturer data for ½ antenna beam width. The owner may also specify operational availability for the analysis, used in calculating service loads (default for our analyses is a serviceability factor of 1).
8. All existing antenna mounts are modeled with regard to their impact on the tower mast. We have not completed a structural assessment of mount components or connection interface with the tower structure. We assume the mounts have been properly designed for site specific conditions by others.
9. The analysis does not constitute an approval/disapproval of the physical condition of the structure. Unless noted otherwise, Varcon Inc. assumes the physical condition of the structure does not impair its performance under ULS or SLS. A thorough inspection of the actual tower conditions is recommended by CSA S37-13 prior to any analysis or modifications to the structure. This should be completed by qualified engineering personnel if it has not been done immediately prior to the analysis. Varcon Inc. cannot comment on any capacity effects due to degradation of subsurface foundations unless a thorough on-site evaluation is performed.
10. Azimuths are generally referenced to True North unless otherwise indicated.
11. This report is only valid if antennas and lines are installed as listed above. Any changes should be forwarded to Varcon Inc. for further assessment.
12. All cost estimates for reinforcement is order of magnitude only and may change dependant on location, time of year and market conditions. Detailed estimates should be based on finalized design documents.

## ***Appendix A***

### **Tower Profile and Antenna Loading**

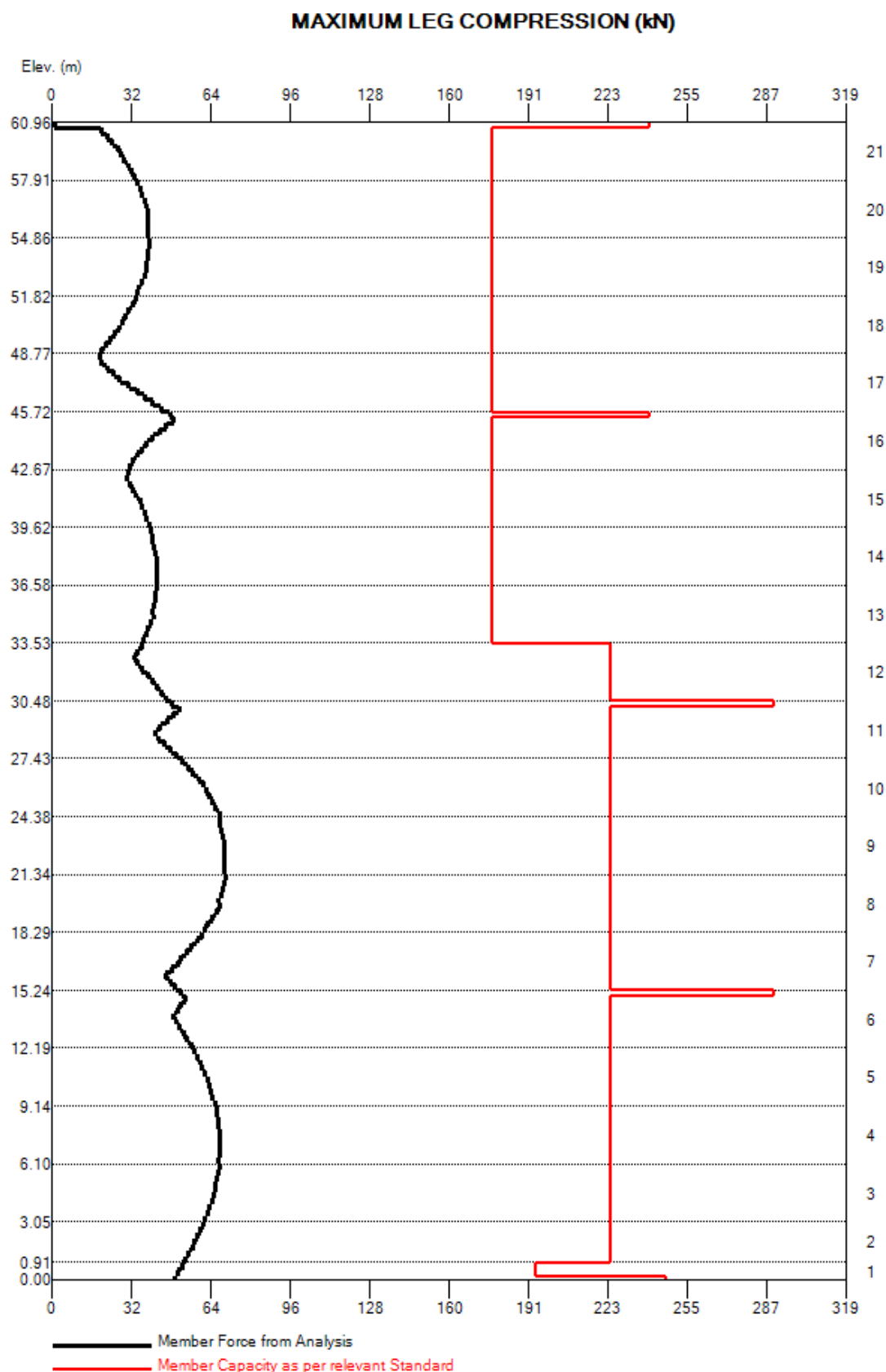


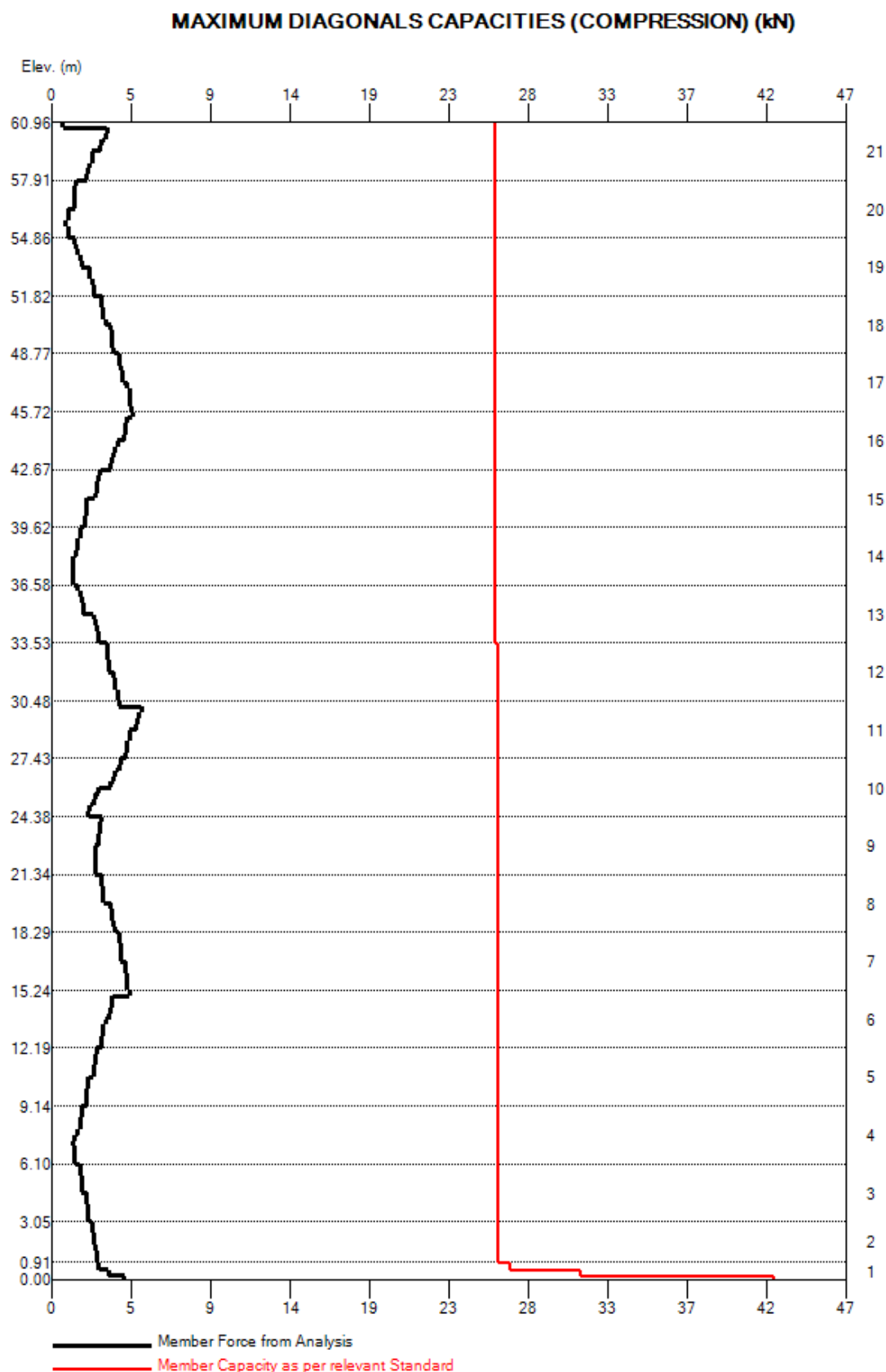


#	Owner	Status	Antenna	Elev. (m)	Additional Equipment	Tx-Line	AZ. (TN°)
1	PRRD	To Be Removed	Scala SL-8 Paraslot UHF-TV Antenna	62.6	-	(1) 49mm OD Coax	Omni
2	PRRD	Existing	DOL	61.0	-	(1) Teck	-
3	Vincent Communications	Proposed	PMP450i	60.0	-	(1) Cat5e	0
4	Vincent Communications	Proposed	PMP450i	60.0	-	(1) Cat5e	90
5	Vincent Communications	Proposed	PMP450i	60.0	-	(1) Cat5e	180
6	Vincent Communications	Proposed	PMP450i	60.0	-	(1) Cat5e	270
7	PRIS	Existing	TRH2412016	57.3	-	(1) Cat5e	0
8	PRIS	Existing	0.6m HP Dish	55.8	-	(1) Cat5e	12
9	Sunrise Media	Proposed	SD210-HF7PASNM	53.0	-	(1) LMR600	300
10	PRIS	Existing	AM-V5G-Ti	51.1	-	(1) Cat5e	0
11	PRIS	Existing	AM-V5G-Ti	47.5	-	(1) Cat5e	120
12	PRIS	Existing	TRH2412016	43.4	(1) RRU	(1) Cat5e	90
13	PRIS	Existing	AM-V5G-Ti	41.3	-	(1) Cat5e	240
14	PRIS	Existing	Unknown Panel	35.8	-	(1) Cat5e	245
15	PRIS	Existing	0.6m HP Dish	34.4	(1) ODU	(1) Cat5e	320
16	PRRD	Existing	(2) DOL	30.9	-	(1) Teck	-
17	Vincent Communications	Proposed	PTP650	29.0	-	(1) Cat5e	174
18	PRIS	Existing	0.9m PL Dish w/ Radome	25.0	(1) ODU	(1) Cat5e	155
19	PRIS	Existing	-	22.1	(1) ODU	(1) Cat5e	-
20	PRIS	Existing	0.6m HP Dish	20.7	(1) ODU	(1) Cat5e	180
21	PRIS	Existing	0.6m PL Dish w/ Radome	19.5	(1) ODU	(1) Cat5e	180

## ***Appendix B***

### **Graphical Analysis Results**





**Guy Tensions, Anchor Loads, and Base Loads**

Guy Elevation (m)	Guy Size	Initial Tension (kN)	Max. Tension at Mast (kN)	Assessment Ratio %
14.9	GS 10	6.0	17.3	48.0 %
30.2	GS 10	6.0	19.9	55.0 %
45.4	GS 11	8.7	26.4	51.0 %
60.7	GS 11	8.7	25.2	49.0 %

Tower Base	Vertical (kN)	Shear (kN)	Moment (kNm)	Torsion (kNm)
	143.7	2.4	0.0	-0.5

Anchor #	Azimuth (deg)	Radius (m)	Horiz. Load (kN)	Vertical Load (kN)	Resultant (kN)
1	80.0	69.9	72.5	41.8	83.7
2	200.0	68.8	74.1	41.9	85.1
3	320.0	65.6	74.6	40.4	84.8

## *Appendix C*

### **Site Specific Wind**

# Site-Specific 10-yr. Wind Pressure Report (V2.1 2016-01-04 Format)

## Site Information:

Name: Northpine, BC  
 Latitude: 56° 22' 9.7" N  
 Longitude: 120° 49' 29.6" W  
 Tower Height (m): 61  
 Elevation MSL (m): 762

## Results:

**Note:** Following direction from the S37 Committee,  $Q_e$  can no longer be provided.

$Q_{nbc}$ (Pa): 300	$Q_{nbc} = 300(Z/10)^{0.2}$	$V_{nbc} = 48.19$ mph
Icing: As per CAN/CSA S37-13		
$Q_{Min}$ (Pa) 250	$Q_{Min} = 250(Z/10)^{0.2}$	$V_{Min} = 43.99$ mph

## Wind Pressure Formula (for z in metres and result in Pa):

$$Q_h = 0.12919 \{ [0.1326 e^{(-0.0033 z)} + 1.0000 \ln(z/0.1000) / \ln(z_0/0.1000)] 46.30 \}^2 (z/10)^{0.218}$$

## Profile Formula General Form:

$$Q_h = 0.12919 \{ [a_1 e^{(-a_2 z)} + a_3 \ln(z/z_h) / \ln(z/z_{01})] v_{01} \}^2 (z/10)^{0.218}$$

## Site Values of Coefficients:

$$a_1 = 0.1326, a_2 = 0.0033, a_3 = 1.0000, z_h = 0.1000, z_{01} = 0.1000, v_{01} = 46.30 \text{ mph}$$

## Definitions

**Tower Height:** Height of the tower from ground level at the base of the tower to the top of the structure.

**$Q_{nbc}$ :** Regionally representative reference wind pressure at 10 m in the format of the National Building Code of Canada and the  $Q_{nbc}$  value is profiled with the  $^{2/10}$  power law.

**$Q_{Min}$ :** Minimum reference wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the  $^{2/10}$  power law as per Section 5.4.1 of S37-13.

**Wind Pressure Formula:** Formula for the design wind pressure as a function of height. (Ref.: S37-13, 5.3.1)

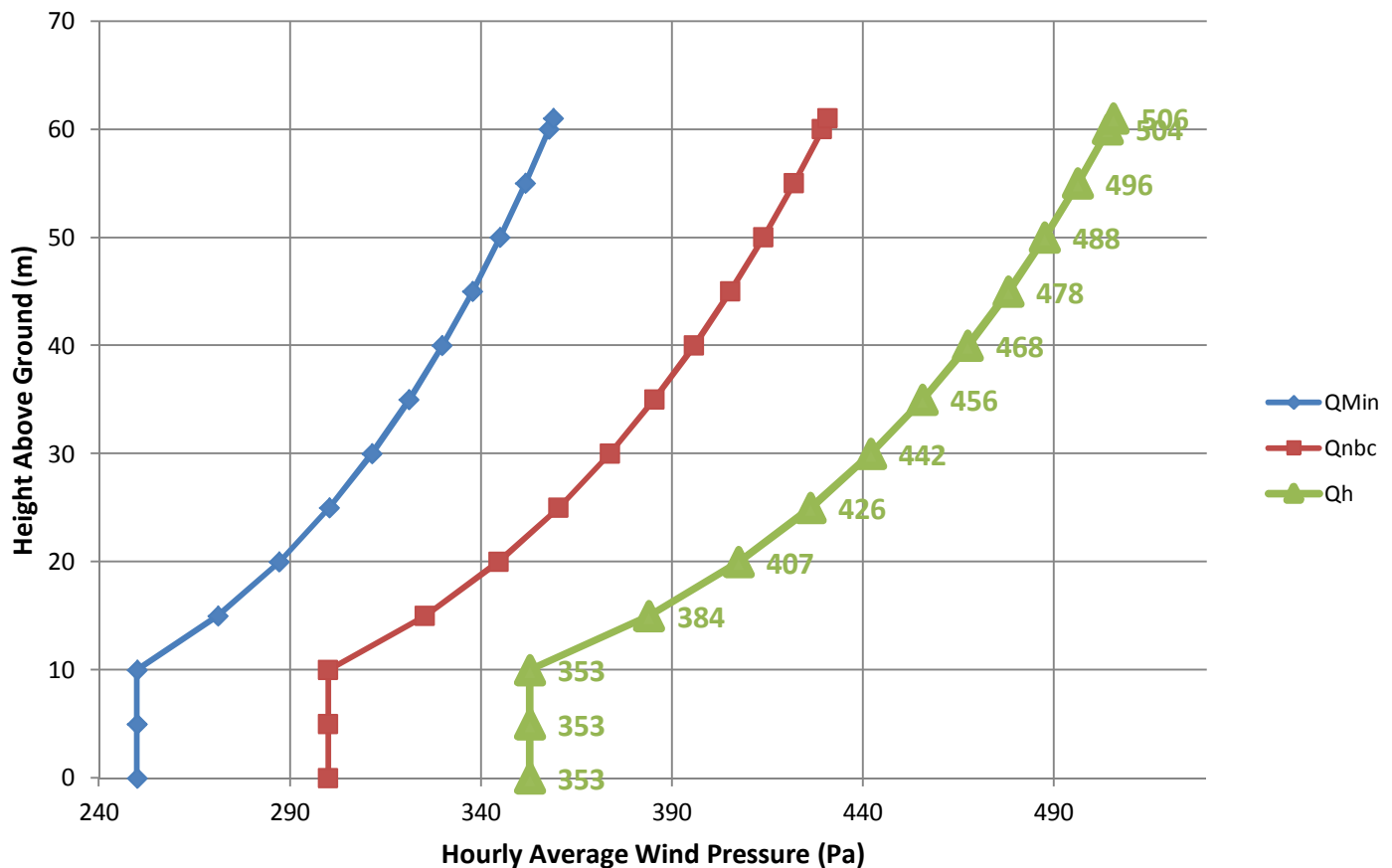
**Height (Z):** the vertical distance (m) above ground level at the base of the tower.

**Note:** No wind pressure value less than 90% of the value at 10 m should be used for heights less than 10 m a.g.l.

These wind pressures were evaluated using a version of the methods described by Taylor and Lee (1984) "Simple Guidelines for Estimating Wind Speed Variations Due to Small Scale Topographic Features", Climatological Bulletin 18 2, using the Boyd (1969) analysis of thirty year return period wind speeds (which is also used for the National Building Code of Canada), modified by a technique described by Wieringa (1980) "Representativeness of Wind Observations at Airports" Bulletin of the American Meteorological Society, 61 9, as input data. The uncertainty in NBCC regionally representative reference wind pressures is about [+15%,-15%].

Environment Canada has not made and does not make any representations or warranties, either expressed or implied, arising by law or otherwise, respecting the accuracy of recommended climatic information. In no event will Environment Canada be responsible for any prejudice, loss or damages which may occur as a result of the use of design wind pressure recommendations.

10-yr. Wind Pressure Profile Graph for Northpine, BC 61m Tower



Q<sub>nbc</sub> Profile: Regionally representative reference wind profiled with the  $z/10$  power law.

Q<sub>Min</sub> Profile: Minimum site-specific wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the  $z/10$  power law.

Q<sub>h</sub> Profile: The site-specific wind pressure profile directly from the Taylor and Lee (1984) simple guidelines.

#### Explanatory notes regarding the new report format and changes to calculation methods.

1. The most significant change from the previous versions of the reports is that the exponent used in the  $Q_h$  equation is no longer fixed at 0.2. The exponent now varies continuously from 0.2 for open terrain to 0.32 for closed terrain.
2. A new  $Q_{min}$  profile has been added to the graphs and it represents the minimum acceptable reference wind pressure profile. It starts with the minimum 10-metre reference wind pressure of 320 Pa for a 50-year return period as per section 5.4.1 of S37-13 and then uses the same  $z/10$  power law formulation as the  $Q_{NBC}$  profile to generate the curve. The corresponding 10-metre reference wind pressures for the 10-year and 30-year return periods are 250 Pa and 300 Pa respectively.
3.  $Q_h$  will always be plotted even when they are less than  $Q_{Min}$ . This will allow designers to see how  $Q_h$  varies over the height of the tower. Also, in rough terrain and for taller towers, the  $Q_h$  profile might cross the  $Q_{Min}$  profile.
4. The coefficients for the  $Q_h$  equation will now always be given regardless of the  $Q_{NBC}$  or  $Q_{Min}$  values.
5. The wind speeds will be given for each of the 4 equations ( $Q_h$ ,  $Q_{NBC}$ , or  $Q_{Min}$ ) too.



# Site-Specific 30-yr. Wind Pressure Report (V2.1 2016-01-04 Format)

## Site Information:

Name: Northpine, BC  
 Latitude: 56° 22' 9.7" N  
 Longitude: 120° 49' 29.6" W  
 Tower Height (m): 61  
 Elevation MSL (m): 762

## Results:

**Note:** Following direction from the S37 Committee,  $Q_e$  can no longer be provided.

$Q_{nbc}$ (Pa): 360	$Q_{nbc} = 360(Z/10)^{0.2}$	$V_{nbc} = 52.79$ mph
Icing: As per CAN/CSA S37-13		
$Q_{Min}$ (Pa) 300	$Q_{Min} = 300(Z/10)^{0.2}$	$V_{Min} = 48.19$ mph

## Wind Pressure Formula (for z in metres and result in Pa):

$$Q_h = 0.12919 \{ [0.1326 e^{(-0.0033 z)} + 1.0000 \ln(z/0.1000) / \ln(z_0/0.1000)] 50.68 \}^2 (z/10)^{0.218}$$

## Profile Formula General Form:

$$Q_h = 0.12919 \{ [a_1 e^{(-a_2 z)} + a_3 \ln(z/z_h) / \ln(z/z_{01})] v_{01} \}^2 (z/10)^{0.218}$$

## Site Values of Coefficients:

$$a_1 = 0.1326, a_2 = 0.0033, a_3 = 1.0000, z_h = 0.1000, z_{01} = 0.1000, v_{01} = 50.68 \text{ mph}$$

## Definitions

**Tower Height:** Height of the tower from ground level at the base of the tower to the top of the structure.

**$Q_{nbc}$ :** Regionally representative reference wind pressure at 10 m in the format of the National Building Code of Canada and the  $Q_{nbc}$  value is profiled with the  $^{2/10}$  power law.

**$Q_{Min}$ :** Minimum reference wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the  $^{2/10}$  power law as per Section 5.4.1 of S37-13.

**Wind Pressure Formula:** Formula for the design wind pressure as a function of height. (Ref.: S37-13, 5.3.1)

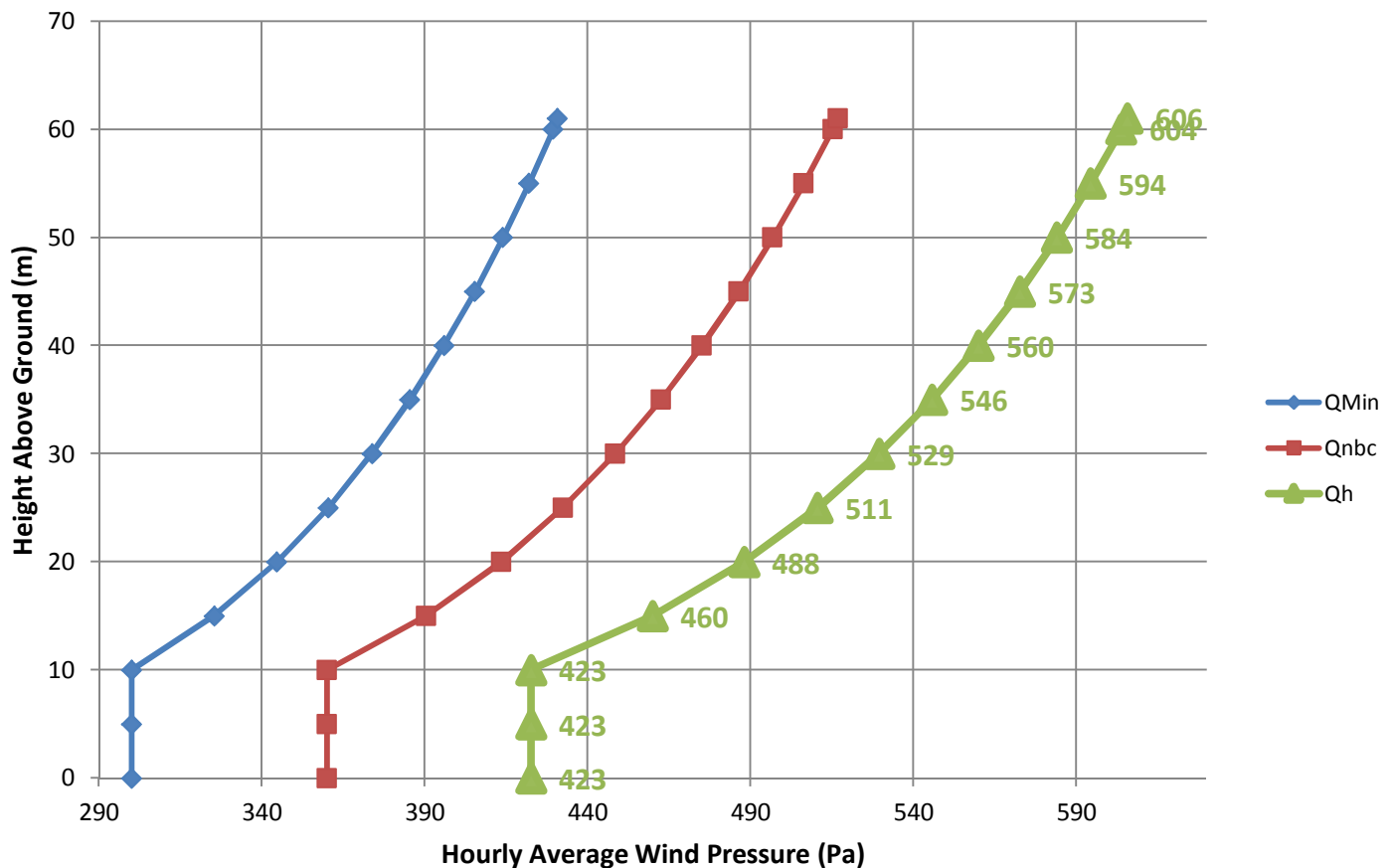
**Height (Z):** the vertical distance (m) above ground level at the base of the tower.

**Note:** No wind pressure value less than 90% of the value at 10 m should be used for heights less than 10 m a.g.l.

These wind pressures were evaluated using a version of the methods described by Taylor and Lee (1984) "Simple Guidelines for Estimating Wind Speed Variations Due to Small Scale Topographic Features", Climatological Bulletin 18 2, using the Boyd (1969) analysis of thirty year return period wind speeds (which is also used for the National Building Code of Canada), modified by a technique described by Wieringa (1980) "Representativeness of Wind Observations at Airports" Bulletin of the American Meteorological Society, 61 9, as input data. The uncertainty in NBCC regionally representative reference wind pressures is about [+15%,-15%].

Environment Canada has not made and does not make any representations or warranties, either expressed or implied, arising by law or otherwise, respecting the accuracy of recommended climatic information. In no event will Environment Canada be responsible for any prejudice, loss or damages which may occur as a result of the use of design wind pressure recommendations.

30-yr. Wind Pressure Profile Graph for Northpine, BC 61m Tower



Q<sub>nbc</sub> Profile: Regionally representative reference wind profiled with the  $z/10$  power law.

Q<sub>Min</sub> Profile: Minimum site-specific wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the  $z/10$  power law.

Q<sub>h</sub> Profile: The site-specific wind pressure profile directly from the Taylor and Lee (1984) simple guidelines.

#### Explanatory notes regarding the new report format and changes to calculation methods.

1. The most significant change from the previous versions of the reports is that the exponent used in the  $Q_h$  equation is no longer fixed at 0.2. The exponent now varies continuously from 0.2 for open terrain to 0.32 for closed terrain.
2. A new  $Q_{min}$  profile has been added to the graphs and it represents the minimum acceptable reference wind pressure profile. It starts with the minimum 10-metre reference wind pressure of 320 Pa for a 50-year return period as per section 5.4.1 of S37-13 and then uses the same  $z/10$  power law formulation as the  $Q_{NBC}$  profile to generate the curve. The corresponding 10-metre reference wind pressures for the 10-year and 30-year return periods are 250 Pa and 300 Pa respectively.
3.  $Q_h$  will always be plotted even when they are less than  $Q_{Min}$ . This will allow designers to see how  $Q_h$  varies over the height of the tower. Also, in rough terrain and for taller towers, the  $Q_h$  profile might cross the  $Q_{Min}$  profile.
4. The coefficients for the  $Q_h$  equation will now always be given regardless of the  $Q_{NBC}$  or  $Q_{Min}$  values.
5. The wind speeds will be given for each of the 4 equations ( $Q_h$ ,  $Q_{NBC}$ , or  $Q_{Min}$ ) too.

# Site-Specific 50-yr. Wind Pressure Report (V2.1 2016-01-04 Format)

## Site Information:

Name: Northpine, BC  
 Latitude: 56° 22' 9.7" N  
 Longitude: 120° 49' 29.6" W  
 Tower Height (m): 61  
 Elevation MSL (m): 762

## Results:

**Note:** Following direction from the S37 Committee,  $Q_e$  can no longer be provided.

$Q_{nbc}$ (Pa): 390	$Q_{nbc} = 390(Z/10)^{0.2}$	$V_{nbc} = 54.94$ mph
Icing: As per CAN/CSA S37-13		
$Q_{Min}$ (Pa) 320	$Q_{Min} = 320(Z/10)^{0.2}$	$V_{Min} = 49.77$ mph

## Wind Pressure Formula (for z in metres and result in Pa):

$$Q_h = 0.12919 \{ [0.1326 e^{(-0.0033 z)} + 1.0000 \ln(z/0.1000) / \ln(z_0/0.1000)] 52.68 \}^2 (z/10)^{0.218}$$

## Profile Formula General Form:

$$Q_h = 0.12919 \{ [a_1 e^{(-a_2 z)} + a_3 \ln(z/z_h) / \ln(z/z_{01})] v_{01} \}^2 (z/10)^{0.218}$$

## Site Values of Coefficients:

$$a_1 = 0.1326, a_2 = 0.0033, a_3 = 1.0000, z_h = 0.1000, z_{01} = 0.1000, v_{01} = 52.68 \text{ mph}$$

## Definitions

**Tower Height:** Height of the tower from ground level at the base of the tower to the top of the structure.

**$Q_{nbc}$ :** Regionally representative reference wind pressure at 10 m in the format of the National Building Code of Canada and the  $Q_{nbc}$  value is profiled with the  $^{2/10}$  power law.

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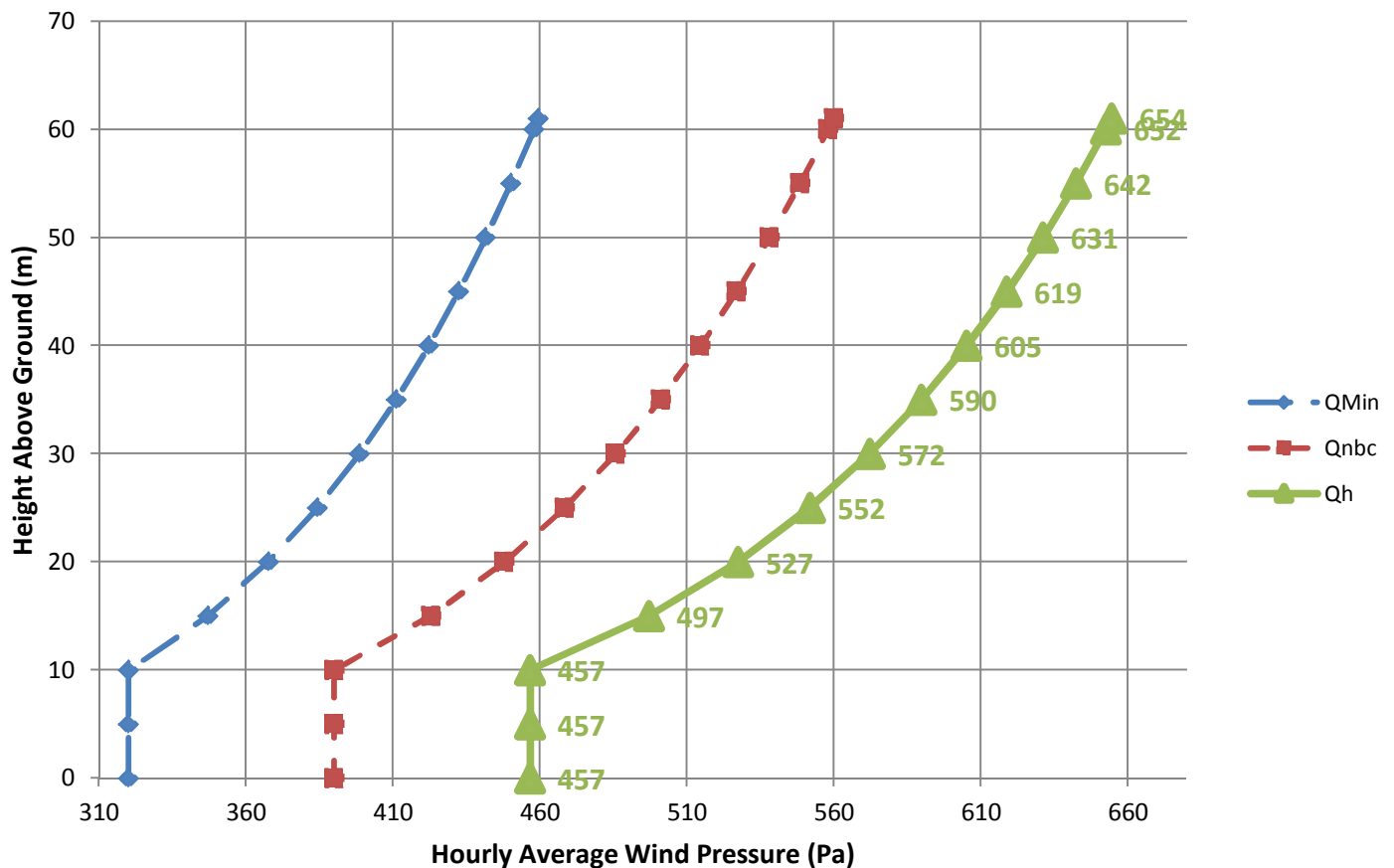
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50-yr. Wind Pressure Profile Graph for Northpine, BC 61m Tower



$Q_{nbc}$  Profile: Regionally representative reference wind profiled with the  $z^{2/10}$  power law.

$Q_{Min}$  Profile: Minimum site-specific wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the  $z^{2/10}$  power law.

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4. The coefficients for the  $Q_h$  equation will now always be given regardless of the  $Q_{NBC}$  or  $Q_{Min}$  values.
5. The wind speeds will be given for each of the 4 equations ( $Q_h$ ,  $Q_{NBC}$ , or  $Q_{Min}$ ) too.