RELIABILITY TARGETED ALASKA GROUND SNOW LOADS FOR THE 2022 EDITION OF ASCE 7 STANDARD

by

Structural Engineers Association of Alaska (SEAAK)
Snow Loads Committee
December 2020

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EXECUTIVE SUMMARY

Reliability-targeted ground snow loads are presented for 50 locations in the state of Alaska. These values are used to update the Alaska design ground snow loads in the 2022 edition of the ASCE 7 Standard.

These reliability-targeted loads have been generated by converting 50-year MRI loads produced by a previous study, “Alaska Snow Loads for the 2022 Update of ASCE 7” (December 2019).

For additional locations in Alaska, the methods contained in this document can be applied to other 50-year MRI data found at: https://seaak.net/alaska-snow-loads

1.0 BACKGROUND

The University of Alaska Anchorage (UAA) and the Structural Engineers Association of Alaska (SEAAK) developed an updated list of 50-year ground snow load values[1] for locations in Alaska for the purpose of updating the 2022 edition of the ASCE 7 Standard. These updated values were reviewed and approved by the ASCE 7 Rain and Snow Subcommittee in December 2019.

After this proposal was approved, the ASCE 7 Rain and Snow Subcommittee decided to transition to using reliability-targeted ground snow loads as part of a project to update the ground snow load map for the contiguous 48 states. This made it necessary for the updated Alaska ground snow loads to be modified from their 50-year values to reliability-targeted values to ensure alignment with the rest of the standard.

Once this was fully understood, there remained only a few months left in the development schedule for the standard. Inadequate time was available to develop and review reliability-targeted loads for Alaska following the methods developed for other locations.

Therefore, SEAAK chose to start with the previously vetted 50-year values and convert them to reliability-targeted values. This conversion was supported by the team that developed the new ground snow load values for the contiguous 48 states.

2.0 2019 SEAAK WHITEPAPER

In December 2019 UAA and SEAAK published a white paper [1] providing ground snow loads with a 50-year mean reoccurrence interval (MRI) for 50 locations in Alaska. These values are used as the basis for converting to reliability-targeted loads.

A copy of this whitepaper can be found in Appendix A.

Snow load values from this analysis will be referred to in this discussion as ‘SEAAK values’

Additional information on previous research on snow loads in Alaska can be found at https://seaak.net/alaska-snow-loads.

3.0 ASCE 7-22 GROUND SNOW LOAD RESEARCH

In early 2020, the ASCE 7-22 Rain & Snow Subcommittee initiated a project to update the ground snow load map for the contiguous 48 states. During this project the method of reporting ground snow loads was revised from using a 50-year MRI value to a reliability-targeted value based on the recommendations of ASCE 7 Chapter 1.

The final result of this research was a series of ground snow load maps for the contiguous 48 states based on risk categories. These were developed using an innovative data analysis method that utilized machine learning [2].

Snow load values from this analysis will be referred to in this discussion as 'GSL values'

4.0 METHOD OF CONVERSION

The 50-year MRI ground snow load values from the SEAAK white paper were converted into reliability-targeted values by the following method:

1. Risk-targeted load for Category II structures are calculated by multiplying 50-yr MRI value by a conversion factor of 1.6
2. Risk-targeted loads for other category facilities are calculated by factoring Category II value by:
    a. Category I: 0.80
    b. Category III: 1.15
    c. Category IV: 1.25

4.1 Conversion Factor

The conversion factor of 1.6 was determined based on an analysis of preliminary reliability-targeted loads generated for Alaska by the GSL research team.

SEAAK 50-year MRI loads were compared to the GSL Risk Category II loads. While individual locations varied, the average ratio between the values was found to be 1.60. A summary of this data can be found in Table 6.1 below.

With this conversion factor applied, the converted SEAAK loads were found to have an average safety factor of 1.84 as compared to an average safety factor of 1.77 found in the GSL data[1]. Therefore, on average the converted risk-targeted snow loads are conservative.

The SEAAK snow load committee considered and rejected using the GSL generated values for updating the code because there was inadequate time available to thoroughly vet the values. In generating the 50-year MRI values, experienced Alaskan engineers had thoroughly reviewed the recorded data and associated statistical analysis for each location and considered local conditions and discrepancies in the data. Many locations encompassed multiple and sometimes contradicting data records, for which averaging the resulting values was inappropriate and non-conservative. Without time to complete a similar consensus review process on the reliability-targeted data, SEAAK did not have confidence in the accuracy of the GSL-generated values.

4.2 Risk Category Factors

The Risk Category Factors were calculated as the average 'importance factors', or the average ratio between the risk categories, found in the GSL data. That is, the three ratios of the GSL RT load (Risk Categories I, II, and IV) with respect to the Risk Category II loads were determined for each station, and these ratios were averaged over all stations for which GSL values were provided. See Table 6.1 below for details.

These factors were applied to the converted SEAAK 50-year MRI Risk Category II loads to determine the reliability targeted loads for risk categories I, II and IV.

5.0 CONCLUSIONS AND RECOMMENDATION

The reliability-targeted ground snow loads for Alaska generated by converted the 50-year MRI loads are appropriate for use in the 2022 edition of the ASCE 7 Standard. See Table 6.2 below for the final values.

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[1] Safety factor is calculated by comparing the converted reliability-targeted loads to 50-year MRI loads generated from the GSL data.

Future review of this data is recommended to consider individual locations where the GSL data diverges from the converted SEAAK data to improve the accuracy of the reliability targeted loads.

6.0 TABULATED DATA

Table 6.1: Snow Load Data and Conversion Factors

City/Town[1]	SEAAK Loads 50 yr MRI (psf)	GSL Preliminary Reliability Targeted Loads[2] (psf)				Conversion Factor[3]	Risk Category Factors (Importance Factors)		
		Risk Category					Risk Category		
		I	II	III	IV		I	III	IV
Average						**1.60**	**0.8**	**1.12**	**1.25**
Adak	25	43	55	63	72	2.20	0.78	1.15	1.31
Anchorage/Eagle River[4]	50	62	79	88	98	1.58	0.78	1.11	1.24
Arctic Village	30	NA	NA	NA	NA	NA	NA	NA	NA
Bethel	40	49	64	72	84	1.60	0.77	1.13	1.31
Bettles	80	119	146	161	178	1.83	0.82	1.10	1.22
Cantwell	85	NA	NA	NA	NA	NA	NA	NA	NA
Cold Bay	35	31	40	46	53	1.14	0.78	1.15	1.33
Cordova	100	129	160	177	198	1.60	0.81	1.11	1.24
Deadhorse	25	NA	NA	NA	NA	NA	NA	NA	NA
Delta Junction	40	57	72	82	92	1.80	0.79	1.14	1.28
Dillingham	110	145	179	200	216	1.63	0.81	1.12	1.21
Emmonak	100	95	118	130	143	1.18	0.81	1.10	1.21
Fairbanks	60	70	86	95	104	1.43	0.81	1.10	1.21
Fort Yukon	50	59	72	80	88	1.44	0.82	1.11	1.22
Galena	60	77	95	105	115	1.58	0.81	1.11	1.21
Girdwood	140	232	285	317	344	2.04	0.81	1.11	1.21
Glennallen	45	77	96	107	119	2.13	0.80	1.11	1.24
Haines	185	162	201	223	248	1.09	0.81	1.11	1.23
Holy Cross	120	124	152	168	186	1.27	0.82	1.11	1.22
Homer[4]	45	61	79	89	100	1.76	0.77	1.13	1.27
Iliamna	80	91	116	128	144	1.45	0.78	1.10	1.24
Juneau	70	85	105	115	127	1.50	0.81	1.10	1.21
Kaktovik	45	67	87	99	114	1.93	0.77	1.14	1.31
Kenai/Soldotna	65	72	90	100	112	1.38	0.80	1.11	1.24
Ketchikan	30	43	56	64	73	1.87	0.77	1.14	1.30
Kobuk	90	NA	NA	NA	NA	NA	NA	NA	NA
Kodiak	35	32	42	49	56	1.05	0.76	1.17	1.33
Kotzebue	60	82	103	116	130	1.72	0.80	1.13	1.26
McGrath	65	88	110	122	133	1.69	0.80	1.11	1.21
Nenana	75	94	117	130	143	1.56	0.80	1.11	1.22
Nikiski	80	NA	NA	NA	NA	NA	NA	NA	NA
Nome	70	76	98	110	123	1.40	0.78	1.12	1.26

Table 6.1: Snow Load Data and Conversion Factors

City/Town[1]	SEAAK Loads 50 yr MRI (psf)	GSL Preliminary Reliability Targeted Loads[2] (psf)				Conversion Factor[3]	Risk Category Factors (Importance Factors)		
		Risk Category					Risk Category		
		I	II	III	IV		I	III	IV
Palmer/Wasilla	50	53	67	74	83	1.34	0.79	1.10	1.24
Petersburg	95	103	131	146	166	1.46	0.79	1.11	1.27
Point Hope	45	55	70	80	90	1.56	0.79	1.14	1.29
Saint Lawrence Island	95	NA	NA	NA	NA	NA	NA	NA	NA
Saint Paul Island	40	47	61	70	79	1.53	0.77	1.15	1.30
Seward	60	85	106	116	128	1.77	0.80	1.09	1.21
Sitka	50	54	71	81	93	1.42	0.76	1.14	1.31
Talkeetna	120	134	165	181	200	1.38	0.81	1.10	1.21
Tok	35	50	62	68	76	1.77	0.81	1.10	1.23
Umiat	30	45	56	61	67	1.87	0.80	1.09	1.20
Unalakleet	35	40	52	60	71	1.49	0.77	1.15	1.37
Unalaska	75	NA	NA	NA	NA	NA	NA	NA	NA
Utqiaġvik (Barrow)	25	43	55	62	70	2.20	0.78	1.13	1.27
Valdez	160	215	259	284	309	1.62	0.83	1.10	1.19
Wainwright	25	26	31	35	39	1.24	0.84	1.13	1.26
Whittier	270	322	395	434	480	1.46	0.82	1.10	1.22
Willow	80	136	167	184	205	2.09	0.81	1.10	1.23
Yakutat	140	179	221	245	266	1.58	0.81	1.11	1.20

Table Notes:

NA = Locations where inadequate meteorological data available to compute a reliability targeted value.

1) Where data for multiple station was provided for a single location, the most conservative RT_II value is typically reported. The exceptions are in Anchorage/Eagle River and Homer where the most conservative value below 500 ft elevation is used.

2) Provided by email on 10/2/20. Subject: reliability-targeted loads for Alaska.

3) Conversion factor is calculated by dividing the GSL Risk Cat.II load by the SEAAK 50-yr load.

4) Values for Anchorage/Eagle River and Homer are modified at elevations higher than 500 ft. Table only includes values below this elevation.

Table 6.2: Ground Snow Loads, p_g, for Alaskan Locations

City/Town[1]	Elevation (ft)	Risk Category			
		I	II	III	IV
Adak	100	32	40	46	50
Anchorage/Eagle River[2]	500	64	80	92	100
Arctic Village	2,100	38	48	55	60
Bethel	100	51	64	74	80
Bettles	700	102	128	147	160
Cantwell	2,100	109	136	156	170
Cold Bay	100	45	56	64	70
Cordova	100	128	160	184	200
Deadhorse	100	32	40	46	50
Delta Junction	400	51	64	74	80
Dillingham	100	141	176	202	220
Emmonak	100	128	160	184	200
Fairbanks	1200	77	96	110	120
Fort Yukon	400	64	80	92	100
Galena	200	77	96	110	120
Girdwood	200	179	224	258	280
Glennallen	1,400	58	72	83	90
Haines	100	237	296	340	370
Holy Cross	100	154	192	221	240
Homer[2]	500	58	72	83	90
Iliamna	200	102	128	147	160
Juneau	100	90	112	129	140
Kaktovik	100	58	72	83	90
Kenai/Soldotna	200	83	104	120	130
Ketchikan	100	38	48	55	60
Kobuk	200	115	144	166	180
Kodiak	100	45	56	64	70
Kotzebue	100	77	96	110	120
McGrath	400	83	104	120	130
Nenana	400	96	120	138	150
Nikiski	200	102	128	147	160
Nome	100	90	112	129	140
Palmer/Wasilla	500	64	80	92	100
Petersburg	100	122	152	175	190
Point Hope	100	58	72	83	90
Saint Lawrence Island	100	122	152	175	190
Saint Paul Island	100	51	64	74	80

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City/Town[1]	Elevation (ft)	Risk Category			
		I	II	III	IV
Seward	100	77	96	110	120
Sitka	100	64	80	92	100
Talkeetna	400	154	192	221	240
Tok	1,700	45	56	64	70
Umiat	300	38	48	55	60
Unalakleet	100	45	56	64	70
Unalaska	100	96	120	138	150
Utqiaġvik (Barrow)	100	32	40	46	50
Valdez	100	205	256	294	320
Wainwright	100	32	40	46	50
Whittier	100	346	432	497	540
Willow	300	102	128	147	160
Yakutat	100	179	224	258	280

Table Notes:

1) For locations where there is substantial change in altitude over the city/town, the load applies at and below the cited elevation within the jurisdiction and up to 100 ft above the cited elevation unless otherwise noted.
2) For locations in Anchorage/Eagle River and Homer above the cited elevation, the ground snow load shall be increased by 15% for every 100 ft above the cited elevation.

7.0 REFERENCES

[1] Structural Engineers Association of Alaska (2019). *Alaska Snow Loads for the 2022 update of ASCE 7*. Structural Engineers Association of Alaska, Anchorage. https://seaak.net/s/AK-SEAAK-Snow-Load-White-Paper-December-2019-v5.pdf

[2] Bean, B., Maguire, M., Sun, Y., Wagstaff, J., Al-Rubaye, S., Wheeler, J., Rogers, M., and Jarman, S. (2020) Reliability Analysis for Design Ground Snow Loads in the Contiguous United States' for more information.

APPENDIX A

What follows is a copy of the 2019 SEAAK whitepaper entitled "Alaska Snow Loads for the 2022 Update of ASCE 7".

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by

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Disclaimer

The ground snow load values (in pounds per square foot) represent 50-year ground snow load estimates for a particular site at the given elevation. Further details regarding the results outlined in this report are found in [1], [2].

The following analyses were performed using MATLAB R2018a [3] and confirmed with R statistical software [4]. While great effort has been made to ensure these predictions are as accurate as possible; designers must use expert judgment to ensure that such predictions are appropriate for their particular project. The Structural Engineers Association of Alaska (SEAAK) and the authors cannot accept responsibility for prediction errors or any consequences resulting therefrom. Responsibility for the final design snow loads rests with the builder or designer in charge of the project.

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ABSTRACT

This report represents the results of the SEAAK Committee's professional assessment and recommendations for ground snow loads in Alaska. These recommendations are derived from a statistical analysis of snow loads and depths using historical data acquired from the Global Historical Climate Network. One of four statistical distributions (Normal, Lognormal, Gamma, and Weibull) was used to represent each station's data and predict the 50-year Mean Reoccurrence Interval (MRI). The 50-year MRI results were then utilized for stations with both load and depth measurements to develop regression equations that relate snow load to snow depth, which were in turn, used to predict ground snow loads at stations with recorded depth measurements only.

It was found that the statewide load-depth equation was very similar to one proposed by Tobiasson and Greatorex in 1996 [5]. In addition, it was found that snow in the colder northern and interior parts of Alaska is generally drier than that found in the wetter southeast and south-central regions. Regression equations were generated and utilized individually for each region. 50-year MRI loads, and predicted depths, along with local knowledge and historical accounts were then used by the Authoring Committee to evaluate and come to a consensus on the recommended ground snow load for 50 communities in Alaska.

The project was partially supported by ConocoPhillips Arctic Science and Engineering Foundation, UAA, and the Structural Engineers Association of Alaska (SEAAK).

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1.0 BACKGROUND

Historically, design engineers in Alaska have used the American Society of Civil Engineers (ASCE) and Structural Engineers Institute (SEI) ASCE 7 [6] to design for snow loads on structures. However, the snow load data in ASCE/SEI 7 states the data used to create the snow contour maps is current through the 1991-1992 winter [6].

Alaskan Snow Loads [7], which was published in 1973, was the first serious attempt at determining snow loads in this vast state. It presented ground snow loads for one hundred thirty-seven sites presented. At that time the authors stated, "Most design loads currently in use in Alaska are essentially opinions based on experience." The conversion densities used to convert snow depth to snow load in that report were regionalized and ranged from 12 pcf to 28 pcf.

The second and most recent major publication on the subject is entitled *Snow Loads in Alaska* by the Arctic Environmental Information and Data Center (AEIDC), Lynn Leslie, James Wise and Jill Fredston in 1987 [8]. This report presents maximum predicted ground snow loads at 315 sites throughout the state. A second printing was issued in 1989. However, due to a mathematical error, it has not been particularly useful for structural engineers.

One other notable publication, an article called "An Overview of Snow Loads for Fairbanks, Alaska", written in 1992 by Tabiasson and Greatorex [9] explains the development of the loads in the 1987 paper and points out a mathematical error that affects their values.

Two theses from the University of Alaska Anchorage (UAA) have yielded minor updates or have functioned as precursors to this document. *A Study of Alaskan Snow Loads* (1994) by John Andrew Stember [10] provided values correcting the mathematical error in the 1987 AEIDC paper. Ironically, while this thesis did not have significant academic influence, the inclusion of the correct values for the 315 sites originally published by Leslie et. al [8]. has meant that this thesis has been the go-to source for loads by Alaskan engineers for the last 25 years. *Using Satellite Data to Estimate Snow Loads in Alaska* (2015), a thesis by Russell Frith [11] was the result of early work on the current project.

Two recent documents outline efforts by a team of UAA snow load researchers that provides the underpinnings for this report: *Alaska Snow Depth and Water Equivalent Snow Depth: An Analysis of Relationships and the Distributions of Measured Data* (2018) by Kurt Meehleis [1], and *Snow Cover in Alaska: Comprehensive Review* (2018) by Gienko et al. [2]. The latter also includes a more complete history of the methodologies and generation of snow loads in Alaska in the documents mentioned above.

Alaska is long overdue for a thorough snow load analysis; it has been more than 30 years since the last major research effort to analyze statewide historic snow station data.

2.0 SCOPE

The scope of this document is to provide ground snow loads with a 50-year mean reoccurrence interval (MRI) for 50 locations in Alaska that include geographic and climactic diversity for various communities in the state. Data for additional locations can be found in Geinko et al (2018), and recommended values will be provided in a subsequent report by SEAAK.

3.0 METHODOLOGY

This report and the recommended snow load values are based on the work by the Snow Loads Committee of SEAAK, and the aforementioned research project at UAA. This section describes the methods that the SEAAK committee used to determine the recommended snow load values at the 50 cities.

3.1 Data Acquisition

The Global Historical Climatology Network (GHCN) portal from the National Oceanic and Atmospheric Administrations (NOAA) National Centers for Environmental Information was used to acquire the project data:

https://catalog.data.gov/dataset/global-historical-climatology-network-daily-ghcn-daily-version-3.

The data for all Alaska stations were located using the following geographical limits:

- Latitude: from 51 degrees North to 72 degrees North
- Longitude: from 172 degrees East to 130 degrees West

The Alaska dataset (including several stations in Canada and Russia within the bounding box) comprises 1,201 stations spanning a period ranging from 1905 to 2017. It should be noted many stations have gaps in time where data is either missing or was not collected. The following climate variables were extracted for each station:

- station ID
- date (dd-mmm-yyyy)

- snow Depth (mm)
- water equivalent of snow on the ground (tenths of a mm)
- elevation (meters)
- latitude (decimal degrees)
- longitude (decimal degrees)

Of the 1,201 stations above, 951 have snow depth data available, 125 have snow-water equivalent (SWE) data, and 122 stations have both Depth and SWE readings. It should be noted that the GHCN data for Depth is recorded in mm, and the data for SWE is recorded in tenths of a mm. This makes the conversion from water depth to snow weight a simple conversion as 1/10 mm of water at 4° C = 1 Pa.

3.2 Data pre-processing

Sites with 10 or fewer years of data were rejected, which is consistent with other studies used in ASCE7 [6]. A minimum of 11 years of collected data is not an ideal sample size. However, due to the scarcity of data across Alaska, this criterion was established. For a site with 11 seasonal maximum readings, there is a 62 percent chance the average value of the measurements is the average value of the total population (at a 95% level of confidence).

Zero-value readings, as well as constant-value readings (all readings in a given year are the same) were removed. After this, a polynomial-based cleaning method was used. A 3rd degree polynomial line was fit to each season of data for each station. A season is considered the time between July 1st and June 30th. The 3^{rd} degree polynomial requires at least 4 data points to evaluate, so any season with less than 4 readings was excluded. Then all the data points for that season were compared to the fit curve, and if a point was more than 3.3 standard deviations from the curve, it was excluded as an outlier. At the 95% confidence interval, this number of standard deviations should encompass 99.9% of data. In addition, a 3^{rd} degree polynomial was fit to all data for a given station (all years) and data points that were more than 7 standard deviations from this overall polynomial line were removed. The seven standard deviations range was selected by trial and error to remove obvious outliers while still preserving valid data.

No further mathematical or manual cleaning of the data was undertaken for all stations, but each stations' data was inspected by the committee, and the apparent validity of the data influenced the final recommended ground snow load value. One exception to this was the stations that contained both depth and SWE data. The data for these stations was closely inspected for anomalous years, because the data from these stations directly affect the density equations discussed in section 3.4 . Years with data that appeared incorrect were removed. This resulted in several years being removed in a handful of stations, in particular between 2002 and 2006.

The cleaned and inspected final dataset used for analysis consists of 11 stations with only SWE values and 429 stations with only Depth values (Figure 3.1). In addition to these, there were 42 stations with both depth and SWE information, or so-called "First Order Stations".

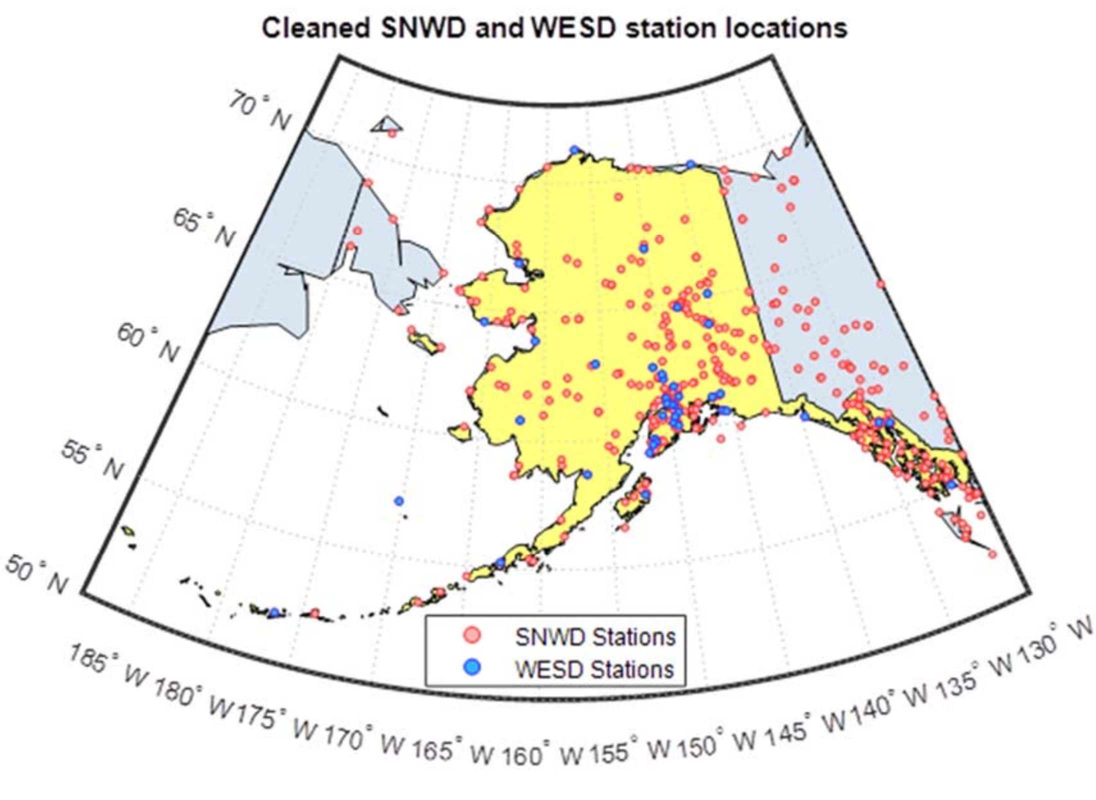

Figure 3.1: Map of Alaska depicting the location of 429 depth stations and 42 first order stations.

For each of these stations, only the seasonal maximum value (of either depth or SWE) was recorded and used for the analyses outlined in the following sections. For stations with both depth and SWE data, seasonal maximums often did not occur on the same date. In addition, the record years of SWE and depth data for a particular station did not always correlate. For example, a site might contain SWE data for some years, depth data for others, and data for both values for still other years.

3.3 Statistical Distributions

Given the inconsistent methodologies that have been used in the history of Alaskan snow loads, an in-depth analysis was conducted to identify the best fit distribution of the seasonal maximum data for both depth and SWE values. A full discussion of this analysis can be found in Geinko et al [2]. This analysis began by using the "fitdist" function in Matlab to fit each station's data to 11 distributions, and then selecting the distribution that best fit the data using several metrics. Further analysis showed that many of the distribution functions provided only very minor variations, and the list of distributions was further narrowed to four: Normal, Lognormal, Gamma, and Weibull. These four distributions capture within a few percent the characterization of all 11 original distributions. In addition, they all have historical use in either snow or hydrologic studies.

Each station's record of seasonal maximums was fit to the four distributions using the "allfitdist" function in matlab, which evaluates the NLogL (Negative log-likelihood for multivariate regression) as part of the regression. The distribution with the greatest NLogL score was selected as the "assigned" distribution. The result of the number of stations assigned to each distribution can be seen in Figure 3.2. Due to its prevalence in snow-load studies in the contiguous United States, the Lognormal distribution was also evaluated for each station. It should be noted that the assigned distribution for the SWE of first-order stations is not necessarily the same as the distribution chosen for the Depth at that station.

The results of the statistical analysis for each station can be found in Appendix B.

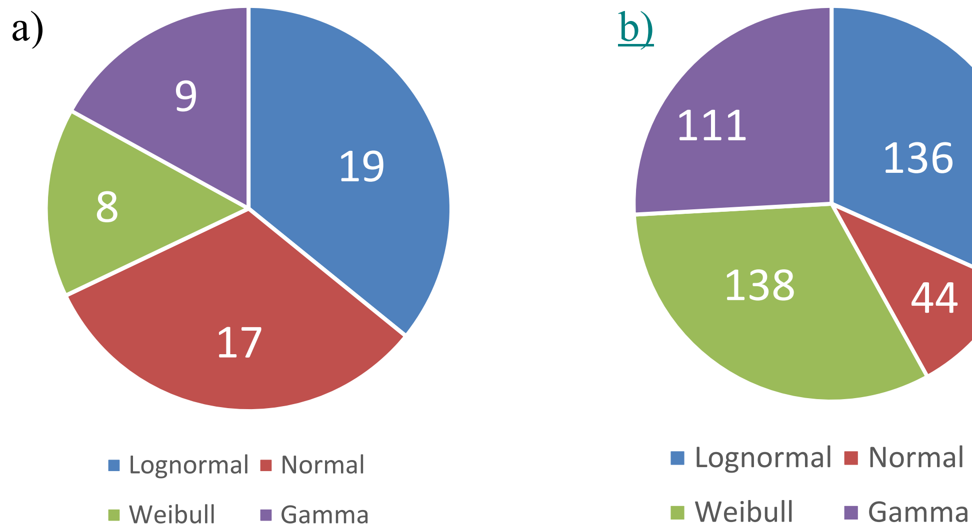

Figure 3.2: a) Distributions assigned for 53 sites with SWE data, b) Distributions assigned for 429 sites with Depth data.

3.4 Density Equations

In order to evaluate the snow load at stations with only depth information, a load-depth relationship at that site must be assumed. Historically, this can be done by establishing a pseudo-density relationship with depth, or by deducing a load-depth equation directly. The "pseudo" name is a result of the fact that the values calculated are not actual densities of snow, because the date of the maximum depth is generally different than the date of the maximum load. The committee chose to utilize a "power-law" equation for the load-depth relationship.

While examples of power-law equations exist and have been used for the contiguous United States, it has been suggested by previous authors that Alaskan snow is "different", and the committee chose to derive its own equations using the available data. There were 42 validated, first-order stations with at least 11 years of data in both depth and SWE records. Examination of these stations indicated that the pseudo-density relationship could be inaccurate if the depth and SWE records were "unbalanced", that is, there is a much longer record of one parameter than the other. This appears to be particularly true if one of the records is extremely short. For example, at the Cordova Airport, there is a 102-year long, high quality record of depth that include a number of large snow years, and it is expected that that record produces a 50-year MRI of depth that has a high confidence of being representative. However, it is paired with a short, 13-year record of SWE without any obvious large annual maximums. It is likely that this data will produce an unrepresentative 50-year MRI for SWE, thus skewing the resulting pseudo-density. As such, the following criteria were developed and enforced to remove 1st order stations from the analysis:

1) If the number of annual maximums of one parameter is more than 4 times the number of annual maximums of the other; or
2) If the number of annual maximums of one parameter is more than 2 times the number of annual maximums of the other AND the lower number of annual maximums is less than 20.

Using this criteria, the following five stations were removed from the density equation analysis: Indian Pass, Cooper Lake, Cordova Airport, Anchor River Divide, and Adak. In addition to these five stations, there were two other stations that met the above criteria, but were not removed from the record. Turnagain Pass has a SWE record (35 years) that is 3 times as long as its depth record (11 years), but there are so few stations with 50 years MRI load values over 300 psf, that it was decided not to disregard this station. In addition, the Talkeetna Airport station has an 81-year depth record and only a 24-year SWE record. However, because the entire SWE record was contained within the depth record, and because this is an important station geographically, falling between the coastal and interior stations, the station depth record was modified so that the years of the two records matched, and then the 50-year MRIs were recalculated for the purpose of determining the density. The station records for the first-order stations can be found in Appendix A.

With the unbalanced stations removed, there were 37 validated, first-order stations. Using the 50-year MRIs from these stations, a regression analysis was performed to fit the depth (inches) vs load (psf) data to a power-law equation. This resulted in the following equation:

$$p_g = 0.340 \cdot h_g^{\ 1.323} \qquad (3\text{-}1)$$

where p_g is the predicted ground snow load in psf and h_g is the 50-year MRI depth in inches.

Examining the data, however, revealed that this equation closely followed the equation proposed by Tobiasson and Greatorex (T&G) [5], which is:

$$p_g = 0.279 \cdot h_g^{\ 1.36} \tag{3-2}$$

It should also be noted, that these same authors also suggest an Alaska-specific density equation, which is found in an Appendix of the Cold Regions Utilities Monograph [12] . This equation is:

$$p_g = 0.222 \cdot h_g^{\ 1.39} \tag{3-3}$$

A depth vs load plot of these observations can be seen in Figure 3.3. It can be seen from this figure that while the new Statewide equation (Eq 3-1) is relatively close to the previous T&G US equation, it is less well-aligned with the Alaska-specific equation. It is not known what or how many stations the 1996 Alaska equation was based on, but it appears from the data that it may have been skewed toward interior stations. For the purposes of this analysis, the established equation for the US (Eq 3-2) will be used to represent the average density.

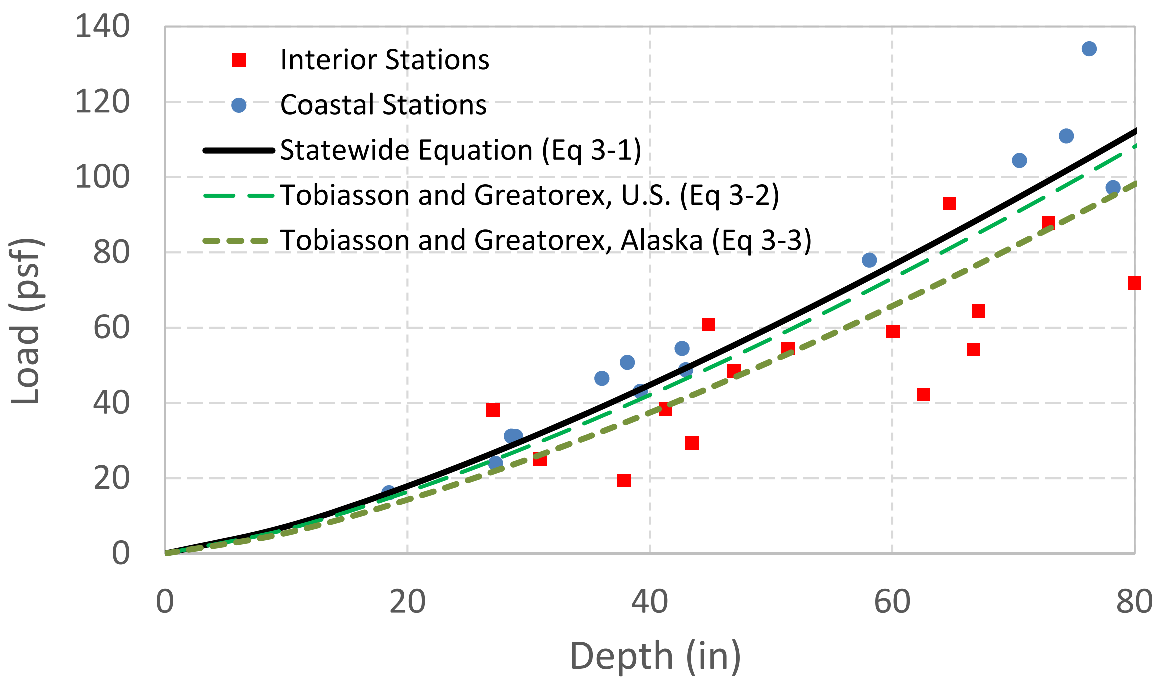

Figure 3.3: Depth vs Load results for first-order stations indicating the different densities of interior vs coastal stations.

A close examination of Figure 3.3, which shows the fitted equations along with the first-order station data, reveals that most of the points below the average equations (both Eq 3-1 and Eq 3-2) are in the interior or western coast of Alaska, while most of the points above the average are on the southern coast. This suggests that snowfall in the very cold interior and north is relatively light and dry, while snow on the southern coast, particularly with adjacent inland mountain ranges, is relatively wet and heavy. This phenomenon of the statistical data agrees with local observations and climate phenomena.

Using this supposition, a geographic area of "wet" snow was defined as (a) south of a line drawn between the following latitude and longitude coordinates: (55ºN,-168ºE) and (62ºN,-152°E), or (b) east of that area and south of 62 degrees latitude north. This area is shown in Figure 3.4.

Using the results of these two defined regions, a regression analysis on the first-order stations in the south-central region was conducted to create a "wet" snow equation. There were 3 stations within this region from high elevations with very large snow loads (>300 psf) that were excluded from this regression, as there was insufficient data to determine if these stations follow the wet or the dry trend. This resulted in 19 first-order stations that were used to produce the "wet" snow equation:

$$p_g = 0.402 \cdot h_g^{\ 1.301} \qquad (3\text{-}4)$$

(Wet Snow Equation)

The remaining 15 stations in the interior and western coasts were also evaluated in a separate regression analysis to create a "dry" snow equation:

$$p_g = 0.175 \cdot h_g^{\ 1.425} \qquad (3\text{-}5)$$

(Dry Snow Equation)

The resulting equations, along with the first-order data, can be seen in **Figure 3.5** and **Figure 3.6.**

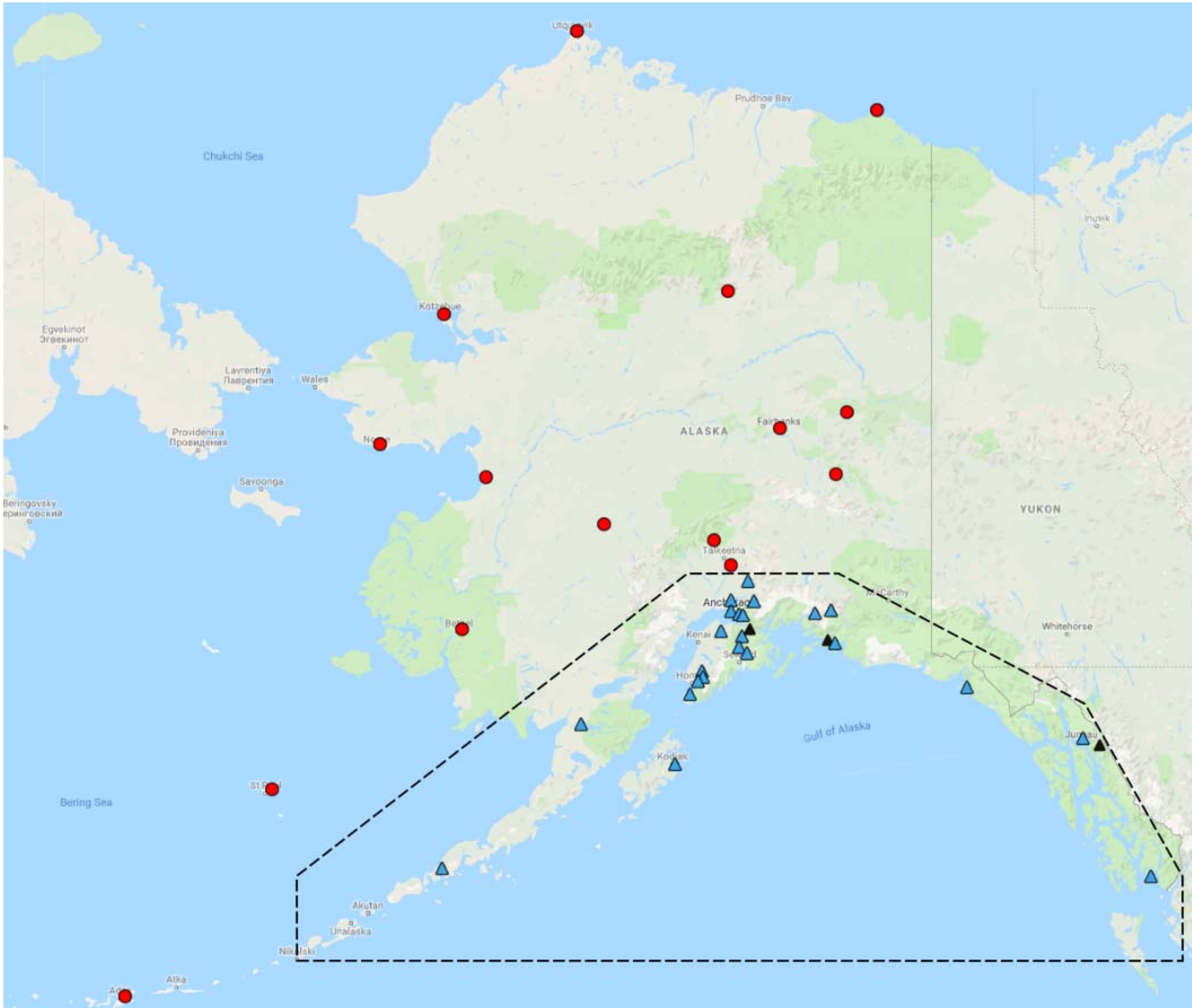

Figure 3.4: Area of "Wet" snowfall. Blue triangles indicate first order stations within the defined wet region, while red circles are stations outside this region. Black triangles indicate stations with snowfall greater than 300 psf.

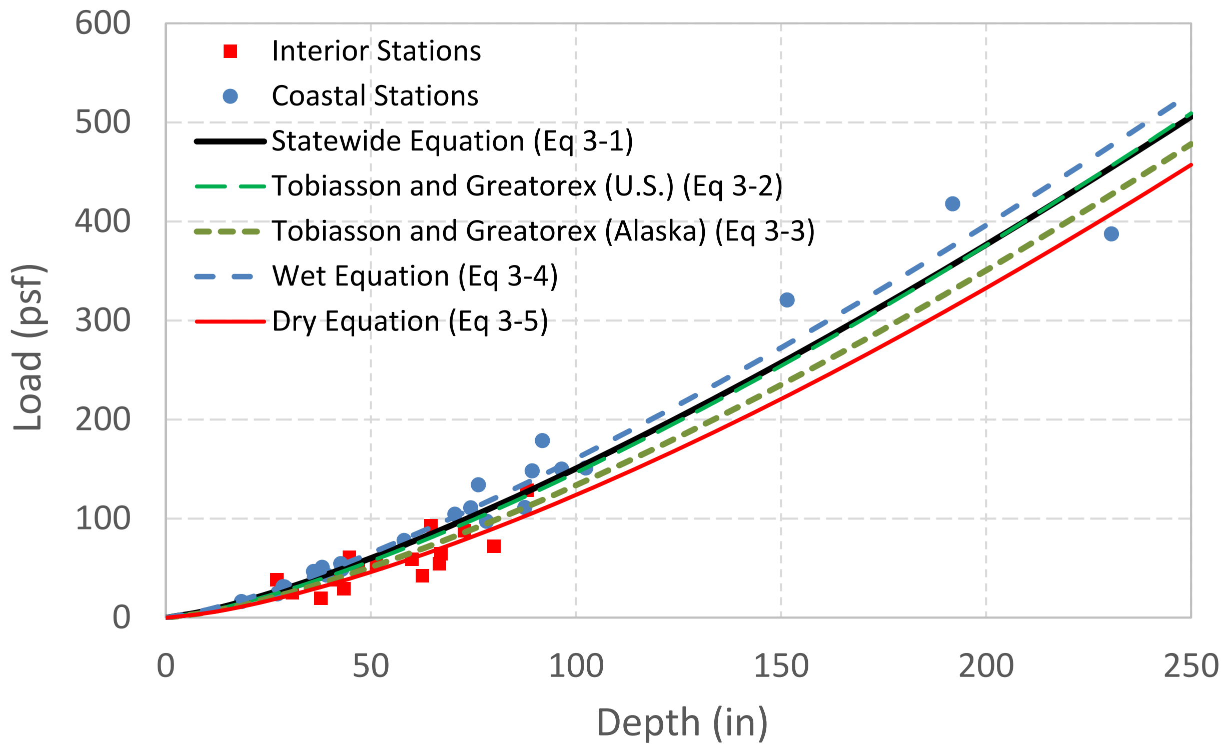

Figure 3.5: Assigned Depth vs Load showing data from first-order stations and various power-law regression equations.

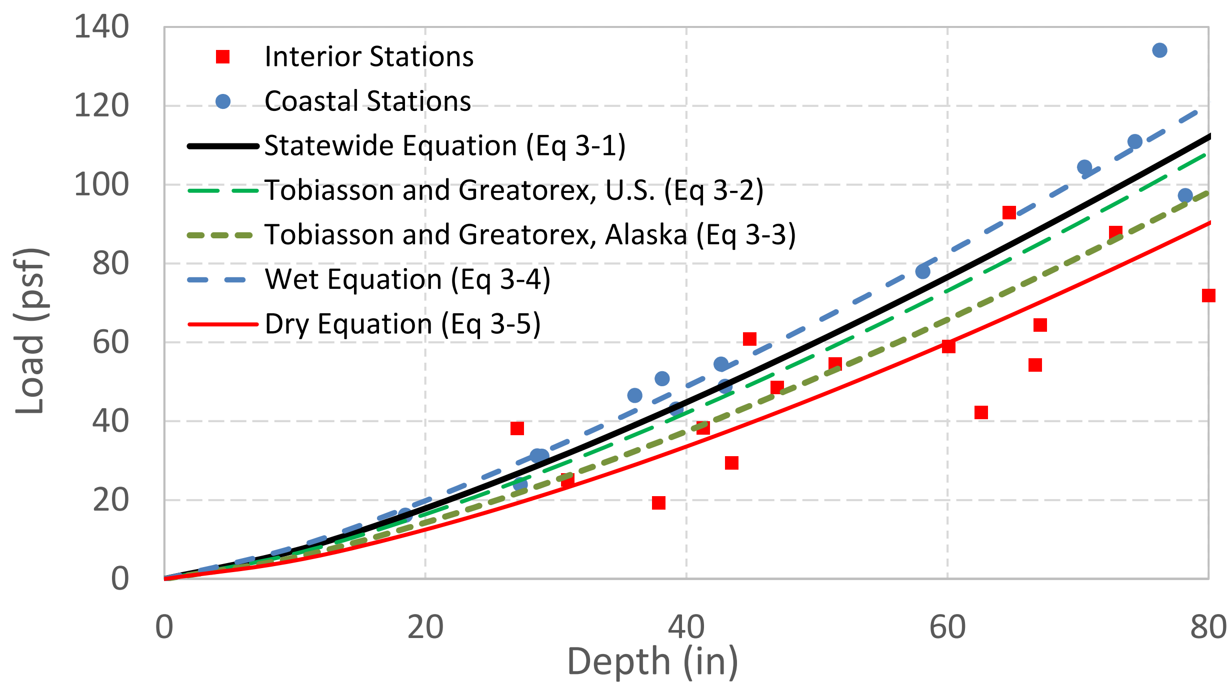

Figure 3.6: Assigned Depth vs Load showing data from first-order stations and various power-law equations for depths less than 80 inches.

3.5 Committee Assessment

The selection of 50 communities, snow load recommendations, and relevant elevations was completed by a committee made up of practicing engineers and the research team from UAA. The process for evaluating the recommended community loads and elevations entailed the following:

1. Each committee member was assigned to one of three regions in the state. Then each team prepared a list of communities that should be included from their region.
2. Once each team provided their list of desired communities to include in the report, the list was paired down to 50 communities. Communities with larger populations were given priority, as were communities with frequent construction projects and other communities that would bolster regional diversity.
3. Each member evaluated all of the proposed communities and provided a ground snow load recommendation based on the 50-year MRI data provided by the UAA research team, personal experience working in the community, contacting local authorities with familiarity of the community, or referring to local ordinances establishing design load requirements. When evaluating the 50-year MRI data for each community the actual community station and nearby stations were considered. Additionally, for communities with multiple stations at different elevations a consideration was given to station locations, local topology, and community layout; an elevation-based equation was established to provide accurate data (see Section 4.1). Stations with depth-only measurements were evaluated by examining loads that were generated from appropriate wet or dry density equations (Eq 3-6 or Eq 3-7). Unfortunately, at the time of the committee evaluations, the data cleaning and statistics analysis had not yet been fully refined. Thus, for this step and the next, the following older iterations of the wet and dry equations, respectively, were used during evaluation:

$$p_g = 0.511 \cdot h_g^{1.230} \tag{3-6}$$

and:

$$p_g = 0.199 \cdot h_g^{1.397} \tag{3-7}$$

Communities with both first-order and depth-only stations were evaluated by examining the 50-year loads derived from both the load-based station(s) and the depth-based station(s), with extra weight given to load-based measurements.

4. Following the individual evaluations, the entire committee gathered to evaluate each community. For each community the committee would compare the individual recommendations.
    a. When the recommendations were all within 5 psf of each other, typically the higher value would be selected unless an individual presented a sound argument to select the lower value.
    b. When the recommendations were within 10 psf of each other, the median or mode value would typically be selected.
    c. When recommendations varied by more than 10 psf between the members, they would take more time to determine why each individual value was recommended and through debate the committee would come to an agreement on a final recommendation.
    d. It should be noted that for communities where the 50-year MRI data had decades of readings with well-formed seasonal accumulations the committee recommendations were typically all within 5 psf of each other. For communities where the 50-year MRI data was sparse the committee members relied more on personal experience and local authorities.
    e. Elevations reported for each location were also reviewed by the committee to ensure they encompassed the local built environment. Where multiple stations were present in a single community, consideration was given to the station locations, local topology and community layout. For locations with significant elevation change within a community and elevation-based equation was established to provide accurate data (see Section 4.1).

4.0 RESULTS

As described in the previous section, the committee evaluated the station data for each recording station within the immediate proximity of the town or city under consideration. Data from depth stations were converted to load using several equations in order to provide the committee with a possible range of loads. All of this information has been compiled into **Table 4.1**. The resulting loads are then summarized in **Table 4.2**. These results are compared to the current ground snow load values in ASCE 7-16 in **Table 4.3**.

4.1 Elevation-based Equations

In addition to the loads shown in **Table 4.2**, there were two communities in which there were enough stations to establish a relationship between snow load and elevation. The results of the load vs elevation analysis can be found in **Figure 4.1** for Anchorage and **Figure 4.2** for Homer. The 50-year MRI depths were converted to loads using the "Wet" snow load equation (Eq 3-4), because this equation captures the density most accurately for the first-order stations in those communities.

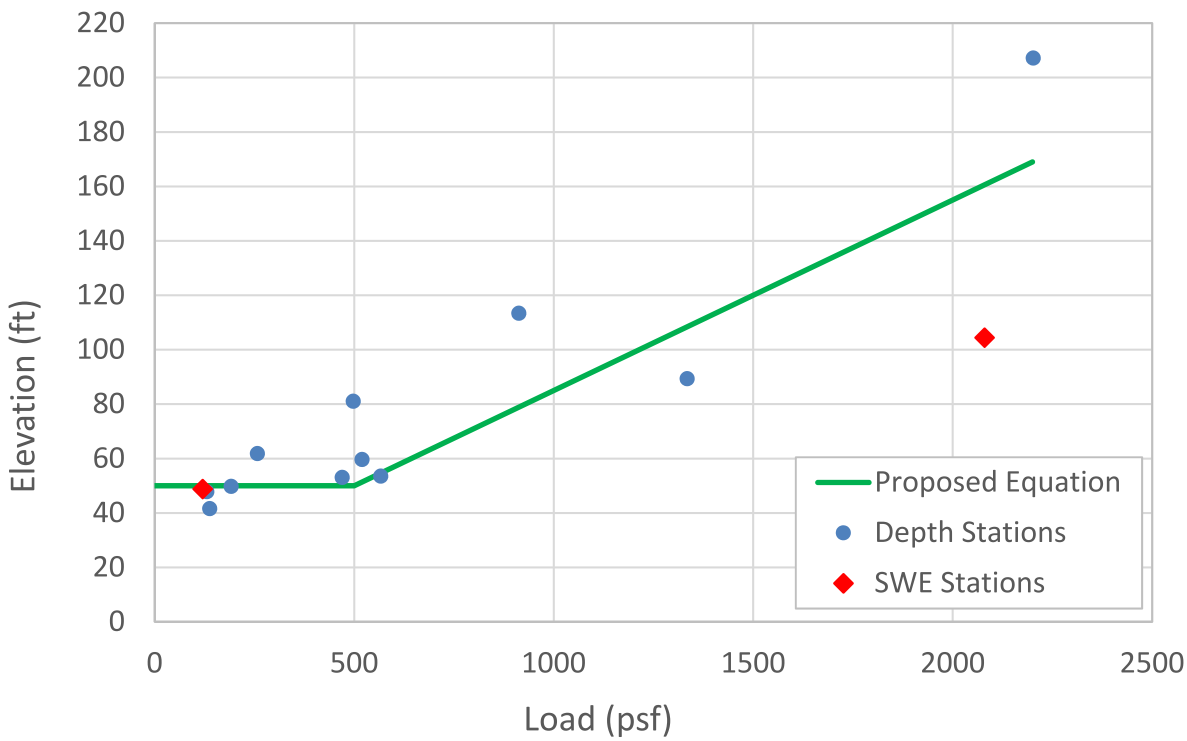

Figure 4.1: Load vs Elevation for Anchorage, AK. Proposed equation is 50psf + 7psf per 100 feet of elevation above 500 feet.

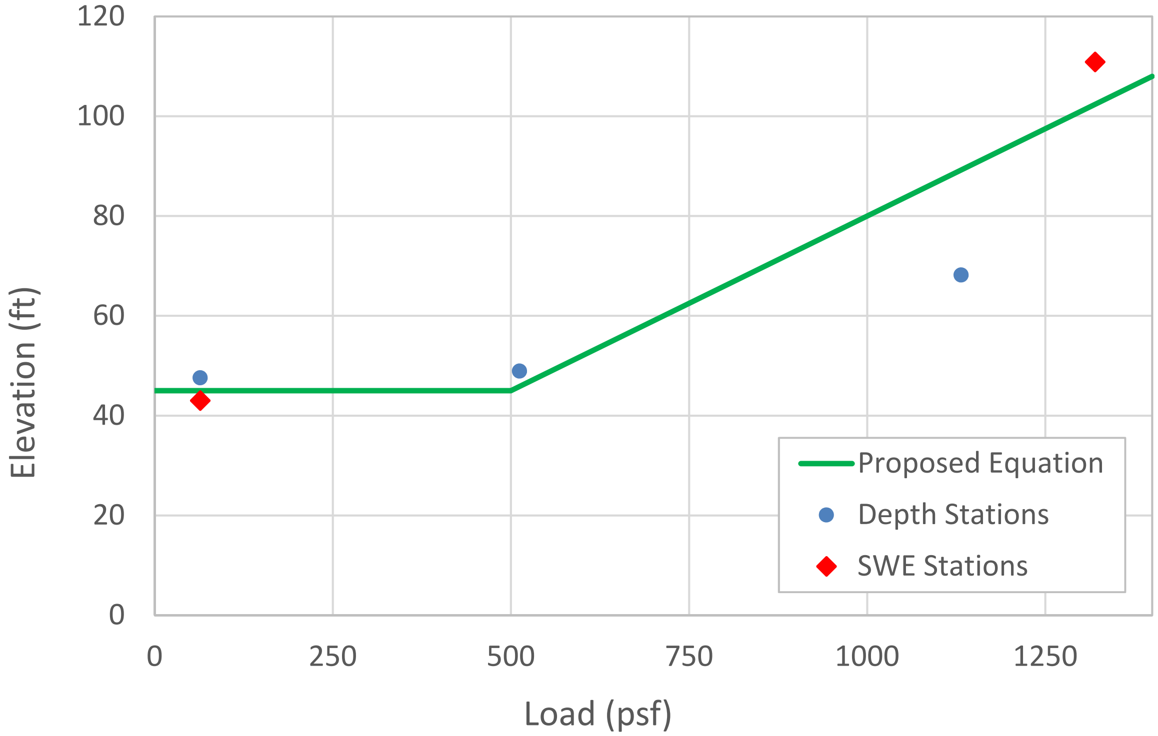

Figure 4.2: Load vs Elevation for Homer, AK. Proposed equation is 45psf + 7psf per 100 feet of elevation above 500 feet.

Table 4.1: Data and analysis used to develop suggested snow loads for Alaskan cities.

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
Adak (100 FT)											
	Adak - WESD	USW00025704	WESD	17	10	17.5		dry			25
	Adak - SNWD	USW00025704	SNWD	17	54		28.2	dry	26.2	20.4	
Anchorage/Eagle River (500 FT)											
	EAGLE RVR GAKONA CIRCLE	USC00502645	SNWD	562	15		42.9	wet	46.3	53.5	54
	EAGLE RVR 5 SE	USC00502656	SNWD	493	27		59.0	wet	71.5	81.0	50
	ELMENDORF AFB	USW00026401	SNWD	190	47		40.6	wet	43.0	49.7	
	EAGLE RVR NATURE CTR	USC00502642	SNWD	515	15		46.6	wet	51.9	59.6	51
	FT RICHARDSON WTP	USC00503163	SNWD	466	21		42.6	wet	45.9	53.0	
	ANCHORAGE MERRILL FLD	USW00026409	SNWD	137	45		35.3	wet	35.6	41.5	
	ANCHORAGE INTL AP	USW00026451	WESD	119	47	48.8		wet			
	ANCHORAGE INTL AP	USW00026451	SNWD	119	65		43.0	wet	46.4	53.6	50
	CAMPBELL CREEK SCI CR	USC00501220	SNWD	255	15		47.9	wet	53.9	61.8	
	ANCHORAGE FORECAST OFFICE	USC00500275	SNWD	130	20		39.3	wet	41.2	47.7	
	Anchorage Hillside	USS0049M22S	WESD	2061	13	104.4		wet			159
	Anchorage Hillside	USS0049M22S	SNWD	2061	12		70.5	wet	91.0	102.1	159
	ANCHORAGE UPPER DEARMOUN	USC00500281	SNWD	1322	12		63.6	wet	79.1	89.3	108
	GLEN ALPS	USC00503299	SNWD	2181	38		121.5	wet	190.8	207.1	168
	ANCHORAGE RABBIT CREEK #2	USC00500284	SNWD	904	11		76.4	wet	101.6	113.3	78
Arctic Village (2100 FT)											
	ARCTIC VILLAGE	USC00500396	SNWD	2061	12		33.0	dry	32.4	25.5	30

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
Bethel (100 FT)											
	BETHEL AP	USW00026615	WESD	101	46	38.3		dry			40
	BETHEL AP	USW00026615	SNWD	101	91		41.3	dry	44.0	35.1	
Bettles (700 FT)											
	Bettles Field	USS0051R01S	WESD	634	37	66.8		dry			80
	BETTLES AP	USW00026533	SNWD	636	67		73.8	dry	96.8	80.3	
Cantwell (2100 FT)											85
	CANTWELL 2 E	USC00501243	SNWD	2112	27		76.2	dry	101.2	84.2	
Cold Bay (100 FT)											
	COLD BAY AP	USW00025624	WESD	77	37	31.1		wet			35
	COLD BAY AP	USW00025624	SNWD	77	66		28.9	wet	27.1	32.0	
Cordova (100 FT)											
	CORDOVA N	USC00502173	SNWD	25	43		72.5	wet	94.6	105.9	
	CORDOVA M K SMITH AP	USW00026410	WESD	31	13	92.9		wet			100
	CORDOVA M K SMITH AP	USW00026410	SNWD	31	102		64.7	wet	81.0	91.3	
Deadhorse (100 FT)											25
	PRUDHOE BAY	USC00507780	SNWD	74	14		11.3	dry	7.5	5.5	
Delta Junction (400 FT)											
	DELTA 6N	USC00502339	SNWD	1049	21		20.2	dry	16.6	12.7	
	DELTA 5 NE	USC00502350	SNWD	1050	21		22.7	dry	19.4	14.9	
	CLEARWATER	USC00502019	SNWD	1090	30		42.6	dry	45.9	36.7	
	BIG DELTA AP	USW00026415	SNWD	1265	60		43.0	dry	46.5	37.2	40
	DELTA JUNCTION 20SE	USC00502352	SNWD	1114	23		20.9	dry	17.5	13.3	
	Granite Crk	USS0045O04S	WESD	1229	29	38.1		dry			
	Granite Crk	USS0045O04S	SNWD	1229	16		27.1	dry	24.7	19.2	

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
Dillingham (100 FT)											110
	DILLINGHAM FAA AP	USC00502457	SNWD	85	56		76.1	wet	100.9	112.6	
Emmonak (100 FT)											100
	EMMONAK	USC00502825	SNWD	14	17		85.0	dry	117.4	98.3	
Fairbanks (1200 FT)											60
	COLLEGE 5 NW	USC00502112	SNWD	969	38		46.0	dry	50.9	40.9	
	KEYSTONE RIDGE	USC00504621	SNWD	1585	21		50.3	dry	57.4	46.5	
	ESTER 5NE	USC00502871	SNWD	624	20		35.1	dry	35.2	27.8	
	ESTER DOME	USC00502868	SNWD	2156	11		48.9	dry	55.4	44.7	
	COLLEGE OBSY	USC00502107	SNWD	592	69		50.4	dry	57.6	46.6	
	UNIVERSITY EXP STN	USC00509641	SNWD	471	103		47.2	dry	52.7	42.5	
	AURORA	USC00500490	SNWD	439	13		34.4	dry	34.3	27.1	
	Fairbanks F.O.	USS0047P03S	WESD	446	34	50.0		dry			
	LADD AAB	USW00026403	SNWD	481	13		45.4	dry	50.1	40.3	
	ESTER	USC00502870	SNWD	649	14		32.6	dry	31.9	25.1	
	FAIRBANKS MIDTOWN	USC00502970	SNWD	436	17		35.1	dry	35.2	27.8	
	LADD AFB	USC00505318	SNWD	455	17		50.3	dry	57.6	46.6	
	CHENA RIDGE	USC00501557	SNWD	1107	14		38.0	dry	39.3	31.2	
	FAIRBANKS AP #2	USC00502965	SNWD	423	18		35.7	dry	36.1	28.5	
	FAIRBANKS INTL AP	USW00026411	WESD	428	49	54.4		dry			
	FAIRBANKS INTL AP	USW00026411	SNWD	428	88		51.4	dry	59.2	48.0	
	WOODSMOKE	USC00509891	SNWD	475	19		37.5	dry	38.6	30.6	
	N POLE	USC00506581	SNWD	471	49		48.4	dry	54.6	44.0	

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
Fort Yukon (400 FT)											
	FT YUKON	USW00026413	SNWD	429	59		48.8	dry	55.2	44.5	50
	Fort Yukon	USS0045R01S	SNWD	426	16		30.0	dry	28.5	22.3	
Galena (200 FT)											
	GALENA	USC00503212	SNWD	150	19		58.0	dry	69.8	57.0	60
	GALENA AP	USW00026501	SNWD	151	18		42.6	dry	45.9	36.7	
Girdwood (200 FT)											
	ALYESKA	USC00500243	SNWD	269	49		91.1	wet	129.0	142.5	140
	GIRDWOOD	USC00503283	SNWD	20	17		70.1	wet	90.3	101.3	
Glennallen (1400 FT)											
	GULKANA AP	USW00026425	SNWD	1547	67		47.7	dry	53.5	43.1	
	GLENNALLEN KCAM	USC00503304	SNWD	1370	48		46.5	dry	51.6	41.6	45
	COPPER CTR	USC00502156	SNWD	991	27		31.9	dry	31.0	24.3	
Haines (100 FT)											
	HAINES TERMINAL	USC00503500	SNWD	173	24		56.1	wet	66.7	75.8	
	HAINES AP	USW00025323	SNWD	15	30		88.4	wet	123.9	137.0	185
	HAINES #2	USC00503502	SNWD	81	17		113.5	wet	173.9	189.5	
Holy Cross (100 FT)											120
	HOLY CROSS	USC00503655	SNWD	20	57		99.0	dry	144.4	122.1	
Homer (500 FT)											
	HOMER 8 NW	USC00503672	SNWD	1070	40		69.7	wet	89.6	100.5	85
	Mcneil Canyon	USS0051K14S	WESD	1307	30	110.9		wet			102
	Mcneil Canyon	USS0051K14S	SNWD	1307	17		74.4	wet	97.9	109.4	102
	HOMER 9 E	USC00503682	SNWD	507	23		40.1	wet	42.2	48.9	46

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
	HOMER 5 NW	USC00503670	SNWD	1121	22		51.7	wet	59.7	68.2	88
	HOMER AP	USW00025507	WESD	63	26	43.0		wet			45
	HOMER AP	USW00025507	SNWD	63	71		39.2	wet	41.0	47.6	45
Iliamna (200 FT)											80
	ILIAMNA AP	USW00025506	SNWD	142	65		64.1	dry	80.0	65.8	
Juneau (100 FT)											
	JUNEAU 9 NW	USC00504110	SNWD	120	14		53.7	wet	62.8	71.6	70
	POINT RETREAT LT STN	USC00507451	SNWD	20	20		56.1	wet	66.7	75.8	
	JUNEAU MILE 17	USC00504109	SNWD	243	12		56.4	wet	67.2	76.3	CS
	JUNEAU FORECAST OFFICE	USC00504103	SNWD	105	16		48.2	wet	54.3	62.3	
	JUNEAU LENA PT	USC00504107	SNWD	35	18		59.4	wet	72.1	81.6	
	AUKE BAY	USC00500464	SNWD	44	55		46.1	wet	51.1	58.8	
	JUNEAU INTL AP	USW00025309	WESD	16	31	54.4		wet			70
	JUNEAU INTL AP	USW00025309	SNWD	16	71		42.7	wet	46.0	53.1	
	JUNEAU DWTN	USC00504092	SNWD	169	22		63.9	wet	79.7	89.9	
	JUNEAU DWTN	USC00504094	SNWD	49	42		37.1	wet	38.0	44.3	
Kaktovik (100 FT)											
	BARTER ISLAND WSO AP	USW00027401	WESD	39	29	48.5		dry			45
	BARTER ISLAND WSO AP	USW00027401	SNWD	39	42		47.0	dry	52.4	42.2	
Kenai/Soldotna (200 FT)											
	KENAI MUNI AP	USW00026523	SNWD	90	65		50.1	wet	57.3	65.5	
	TRI NAL ACRES	USC00509421	SNWD	322	16		35.9	wet	36.3	42.4	65
	SOLDOTNA 5SSW	USC00508615	SNWD	178	13		43.3	wet	47.0	54.2	
	KASILOF 3 NW	USC00504425	SNWD	69	63		45.9	wet	50.7	58.3	

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
Ketchikan (100 FT)											30
	KETCHIKAN INTL AP	USW00025325	SNWD	75	49		28.1	wet	26.1	30.9	
Kobuk (200 FT)											90
	KOBUK	USC00504964	SNWD	139	17		78.5	dry	105.3	87.7	
Kodiak (100 FT)											
	KODIAK WWTP	USC00504991	SNWD	54	12		38.4	wet	39.8	46.2	
	KODIAK	USC00504984	SNWD	150	33		26.2	wet	23.7	28.1	35
	KODIAK AP	USW00025501	WESD	79	40	31.1		wet			
	KODIAK AP	USW00025501	SNWD	79	69		28.6	wet	26.7	31.5	
Kotzebue (100 FT)											
	KOTZEBUE 25 N	USC00505051	SNWD	30	13		50.7	dry	58.1	47.0	60
	KOTZEBUE RALPH WEIN AP	USW00026616	WESD	30	39	42.2		dry			
	KOTZEBUE RALPH WEIN AP	USW00026616	SNWD	30	82		62.6	dry	77.4	63.6	
McGrath (400 FT)											
	MCGRATH AP	USW00026510	WESD	330	52	59.0		dry			65
	MCGRATH AP	USW00026510	SNWD	330	76		60.1	dry	73.2	60.0	
Nenana (400 FT)											75
	NENANA MUNI AP	USW00026435	SNWD	357	63		68.0	dry	86.6	71.5	
Nikiski (200 FT)											80
	KENAI 9N	USC00504550	SNWD	125	23		59.7	wet	72.5	82.1	
Nome (100 FT)											
	NOME MUNI AP	USW00026617	WESD	13	45	54.2		dry			70
	NOME MUNI AP	USW00026617	SNWD	13	108		66.7	dry	84.4	69.6	

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
Palmer/Wasilla (500 FT)											
	PALMER 1 N	USC00506871	SNWD	218	24		23.7	wet	20.7	24.7	
	WASILLA 2 NE	USC00509765	SNWD	495	16		31.4	wet	30.3	35.6	
	PALMER JOB CORPS	USC00506870	SNWD	214	61		35.4	wet	35.6	41.6	
	MATANUSKA EXP FARM	USC00505733	SNWD	170	98		28.5	wet	26.6	31.4	50
	BENS FARM	USC00500707	SNWD	126	28		36.0	wet	36.5	42.5	
	MATANUSKA VALLEY 2	USC00505721	SNWD	178	12		28.1	wet	26.0	30.8	
	PLANT MATERIALS CTR	USC00507352	SNWD	66	19		28.4	wet	26.4	31.2	
	WASILLA 3 S	USC00509759	SNWD	49	42		45.2	wet	49.7	57.2	
Petersburg (100 FT)											95
	PETERSBURG 1	USW00025329	SNWD	106	81		65.7	wet	82.7	93.1	
Point Hope (100 FT)											
	CAPE LISBURNE	USC00501312	SNWD	45	22		42.7	dry	46.0	36.8	
	CAPE LISBURNE AFS	USW00026631	SNWD	51	19		47.7	dry	53.5	43.2	45
	POINT HOPE	USC00507431	SNWD	10	12		62.2	dry	76.8	63.0	
Saint Lawrence Island (100 FT)											
	GAMBELL	USW00026703	SNWD	27	23		92.3	dry	131.4	110.6	
	MYS UELEN	RSM00025399	SNWD	16	32		77.4	dry	103.4	86.1	95
	NORTHEAST CAPE	USW00026632	SNWD	30	16		59.9	dry	73.0	59.7	
Saint Paul Island (100 FT)											
	ST PAUL ISLAND AP	USW00025713	WESD	35	25	29.4		dry			40
	ST PAUL ISLAND AP	USW00025713	SNWD	35	68		43.5	dry	47.2	37.8	
Seward (100 FT)											60
	SEWARD AP	USW00026438	SNWD	22	85		47.0	wet	52.4	60.1	

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
Sitka (100 FT)											
	SITKA MAGNETIC OBSY	USC00508503	SNWD	66	75		38.9	wet	40.5	47.0	50
	SITKA AIRPORT	USW00025333	SNWD	14	49		33.4	wet	32.9	38.5	
Talkeetna (400 FT)											
	TALKEETNA AP	USW00026528	WESD	347	24	71.9		dry			120
	TALKEETNA AP	USW00026528	SNWD	347	81		80.0	dry	108.1	90.1	
Tok (1700 FT)											35
	TOK SCHOOL	USC00509313	SNWD	1619	55		32.6	dry	31.9	25.1	
Umiat (300 FT)											30
	UMIAT	USW00026508	SNWD	264	36		32.2	dry	31.4	24.7	
Unalakleet (100 FT)											
	UNALAKLEET FLD	USW00026627	WESD	18	32	19.3		dry			35
	UNALAKLEET FLD	USW00026627	SNWD	18	57		37.9	dry	39.1	31.1	
Unalaska (100 FT)											75
	DUTCH HARBOR	USC00502587	SNWD	10	53		58.5	dry	70.5	57.6	
Utqiaġvik (Barrow) (100 FT)											
	BARROW POST ROGERS AP	USW00027502	WESD	31	41	25.1		dry			25
	BARROW POST ROGERS AP	USW00027502	SNWD	31	103		30.9	dry	29.7	23.3	
Valdez (100 FT)											
	VALDEZ AIRPORT	USC00509685	SNWD	59	11		369.3	wet	865.5	879.8	
	VALDEZ WSO	USW00026442	WESD	94	30	151.0		wet			160
	VALDEZ WSO	USW00026442	SNWD	94	93		102.5	wet	151.3	165.9	
Wainwright (100 FT)											25
	WAINWRIGHT AP	USW00027503	SNWD	30	29		17.6	dry	13.8	10.2	

City/Town (Elevation)	Station Name	ID	Data Type	Elev. (ft)	Years of Record	50 Yr MRI (psf)	50-year MRI (in)	Wet/ Dry	T&G 50-year MRI [1] (psf)	Wet/Dry 50-year MRI (psf)	Suggested Load [2] (psf)
Whittier (100 FT)											270
	WHITTIER	USC00509829	SNWD	59	48		150.0	wet	254.2	268.9	
Willow (300 FT)											
	WILLOW HWY CAMP	USC00509864	SNWD	228	14		56.4	wet	67.2	83.8	80
	WILLOW WEST	USC00509861	SNWD	203	27		86.2	wet	119.6	138.9	
Yakutat (100 FT)											
	YAKUTAT STATE AP	USW00025339	WESD	33	51	111.2		wet			140
	YAKUTAT STATE AP	USW00025339	SNWD	33	98		87.6	wet	122.2	135.2	

1. Tobiasson and Greatorex, US Equation
2. Suggested Minimum Code Required Ground Snow Load

Table 4.2: Table of Ground Snow Loads proposed for ASCE7-22.

City/Town	**Ground Snow Load (lb/ft^2)**	**Elevation (ft)**
Adak	25	100
Anchorage/Eagle River (3)	50	500
Arctic Village	30	2100
Bethel	40	100
Bettles	80	700
Cantwell	85	2100
Cold Bay	35	100
Cordova	100	100
Deadhorse	25	100
Delta Junction	40	400
Dillingham	110	100
Emmonak	100	100
Fairbanks	60	1200
Fort Yukon	50	400
Galena	60	200
Girdwood	140	200
Glennallen	45	1400
Haines	185	100
Holy Cross	120	100
Homer (3)	45	500
Iliamna	80	200
Juneau	70	100
Kaktovik	45	100
Kenai/Soldotna	65	200
Ketchikan	30	100
Kobuk	90	200
Kodiak	35	100
Kotzebue	60	100
McGrath	65	400
Nenana	75	400
Nikiski	80	200
Nome	70	100
Palmer/Wasilla	50	500
Petersburg	95	100
Point Hope	45	100
Saint Lawrence Island	95	100
Saint Paul Island	40	100
Seward	60	100
Sitka	50	100

Talkeetna	120	400
Tok	35	1700
Umiat	30	300
Unalakleet	35	100
Unalaska	75	100
Utqiaġvik (Barrow)	25	100
Valdez	160	100
Wainwright	25	100
Whittier	270	100
Willow	80	300
Yakutat	140	100

Note: To convert lb/ft^2 to kN/m^2, multiply by 0.0479. To convert feet to meters, multiply by 0.3048.
1) Statutory requirements of the Authority Having Jurisdiction are not included in this state ground snow load table.
2) For locations where there is substantial change in altitude over the city/town, the load applies at and below the cited elevation within the jurisdiction and up to 100 ft above the cited elevation unless otherwise noted.
3) For locations in Anchorage/Eagle River and Homer above the cited elevation, the ground snow load shall be increased by 7.0 lb/ft2 for every 100 ft above the cited elevation.
4) For other locations in Alaska, see https://seaak.net/alaska-snow-loads.

Table 4.3: Comparison of proposed values to currently values in ASCE 7-16 Table 7.2

	Current ASCE 7-16	Proposed ASCE 7-22	% difference
Location	**lb/ft²**	**lb/ft²**	
Adak	30	25	-17%
Anchorage	50	50	0%
Angoon	70	*eliminated*	-
Barrow *(now Utqiaġvik)*	25	25	0%
Barter *(now Kaktovick)*	35	45	+29%
Bethel	40	40	0%
Big Delta *(now Delta Junction)*	50	40	-20%
Cold Bay	25	35	+40%
Cordova	100	100	0%
Fairbanks	60	60	0%
Fort Yukon	60	50	-17%
Galena	60	60	0%
Gulkana	70	*eliminated*	-
Homer	40	45	+13%
Juneau	60	70	+17%
Kenai	70	65	-7%
Kodiak	30	35	+17%
Kotzebue	60	60	0%
McGrath	70	65	-7%
Nenana	80	75	-6%
Nome	70	70	0%
Palmer	50	50	0%
Petersburg	150	95	-37%
Saint Paul	40	40	0%
Seward	50	60	+20%
Shemya	25	*eliminated*	-
Sitka	50	50	0%
Talkeetna	120	120	0%
Unalakleet	50	35	-30%
Valdez	160	160	0%
Whittier	300	270	-10%
Wrangell	60	*eliminated*	-
Yakutat	150	140	-7%

5.0 CONCLUSIONS AND RECOMMENDATION

This report represents the results of the SEAAK Committee's professional assessment and recommendations for ground snow loads in Alaska. These recommendations are derived from a statistical analysis of snow loads and depths using historical data acquired from the Global Historical Climate Network. The measurements of snow depth and snow water equivalence were collected for Alaska stations a period ranging from 1905 to 2017. After some minor cleaning of the data, an evaluation of statistical distributions revealed that each station's data could be represented by one of four distributions (Normal, Lognormal, Gamma, and Weibull).

These distributions were used to predict the snow load or depth for each station with a 50-year Mean Reoccurrence Interval (MRI). The 50-year MRI results were then utilized for stations with both load and depth measurements to develop regression equations that relate snow load to snow depth. The load-depth regression equations were then used to predict ground snow loads at stations with recorded depth measurements only.

It was found that the statewide load-depth equation was very similar to one proposed by Tobiasson and Greatorex for the United States in 1996 [5]. In addition, it was found that snow in the colder northern and interior parts of Alaska is generally drier than that found in the wetter southeast and south-central regions. Regression equations were generated and utilized individually for each region to provide more information on determining consensus load values.

It should be pointed out that in many cases, the number of years of record is much less than the preferred 30 years of data. As such, the assigned distribution only provides an approximate value of the 50-year MRI depth or SWE. In addition, it is clear from the figures in section 4 that the regression equations only provide good approximations of predicted snow load values given the 50-year MRI depth. The committee was mindful of these factors when evaluating the recommended ground snow loads for each site.

Alaska is an enormous State with a huge amount of geographic and climatological diversity. While the committee feels that this document represents a significant step forward from previously available snow load information, snow load data is still greatly lacking in the state of Alaska. The committee recommends future funding of weather stations throughout the state to better capture snow load data in remote areas.

6.0 REFERENCES

[1] K. A. Meehleis, “Alaska Snow Depth and Water Equivalent Snow Depth: an Analysis of Relationships and the Distributions of Measured Data,” University of Alaska Anchorage, 2018.

[2] G. Gienko, R. Lang, S. Hamel, K. Meehleis, and T. Folan, “Snow Cover in Alaska : Comprehensive Review Final Report Prepared by : Principal Investigator : Gennady Gienko Kurt Meehleis,” Anchorage, AK, 2018.

[3] “MATLAB.” The MathWorks, Inc., Natick, Massachusetts, 2018.

[4] R Core Team, “R: A Language and Environment for Statistical Computing.” R Foundation for Statistical Computing, Vienna, Austria, 2017.

[5] W. Tobiasson and A. Greatorex, “Database and Methodology for Conducting Site Specific Snow Load Case Studies for the United States in Snow Engineering,” in *3 rd International Conference on Snow Engineering*, 1997, pp. 249–256.

[6] *Minimum Design Loads for Buildings and Other Structures, ASCE 7-10*. American Society of Civil Engineers, 2013.

[7] W. Tobiasson and R. Redfield, “Alaskan Snow Loads,” Hanover, NH, 1973.

[8] L. D. Leslie, J. Wise, and J. Fredston, “Snow loads in Alaska,” University of Alaska Fairbanks, 1987.

[9] W. Tobiasson and A. Greatorex, “An Overview of Snow Loads for Fairbanks Alaska,” in *SECOND INTERNATIONAL CONFERENCE ON SNOW ENGINEERING*, 1992, pp. 393–404.

[10] J. A. Stember, “A Study of Alaskan Snow Loads,” Anchorage, AK, 1994.

[11] R. Frith, “Using Satellite Data to Estimate Snow Loads in Alaska,” Anchorage, AK, 2015.

[12] D. Smith, *Cold regions utilities monograph*. 1996.