Land Use

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Mailing Address: P.O. Box 471 • Boulder, Colorado 80306 • **www.bouldercounty.org**

BOULDER COUNTY BOARD OF REVIEW
Agenda

Thursday, September 1, 2016
Afternoon Session – 3:00 P.M.

Caribou Room, Second Floor, Boulder County Courthouse Annex

PUBLIC HEARING

1. **Call to Order by the Chair**

2. **Roll Call of Board Members Present by the Secretary of the Board**

3. **Election of Chair and Vice-Chair for 2016**

4. **Approval of Minutes**
   Review of minutes for ***October 13, 2015*** Board of Review meeting

PUBLIC HEARING

5. **BORC-16-0001: MINOR AMENDMENTS TO BOULDER COUNTY BUILDING CODE**
   - Presentation by Gary Goodell of minor amendments to the Boulder County Building Code, including: 1) Utilizing the 2016 Structural Engineers Association of Colorado (SEAC) Colorado Design Snow Loads study to update the Boulder County Snow Load Map; 2) restoring participation in solar gardens as a means of compliance with the Boulder County BuildSmart program; 3) Limiting the use of the prescriptive path in BuildSmart to buildings with a glazing to floor area ration of 18% or less; 4) restoring definitions of "RECONSTRUCTED DWELLING" and "REMODEL/RENOVATION," and other minor editorial amendments as contained in the proposed Board of County Commissioners Resolution 2016-96.
   - General discussion, input, and feedback from the public
   - Questions and discussion by the Board
   - Action by the Board of Review
6. **Other Business**
   - Upcoming BOCC Hearing
     - **i.** Tuesday, September 20, 2016 @ 9:30am in the BOCC Hearing Room
7. **Adjourn**

Detailed information regarding these items, including maps and legal descriptions, is available for public examination on the Boulder County Land Use website at http://www.bouldercounty.org/lu
or at our office located at 2045 13th Street, Boulder, Colorado 303-441- 3930.

Webpage: www.bouldercounty.org/lu/agendas/index.htm

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Building Safety and Inspection Services Division (303) 441-3925

Boulder County
Board of Review

Minutes

Tuesday October 13, 2015
4:15 PM
Board of County Commissioners Hearing Room
3rd Floor, Main Courthouse, 1325 Pearl St, Boulder, CO 80302

On October 13, 2015, the Boulder County Board of Review met for a public meeting and to t**ake action and make a formal recommendation to the Board of County Commissioners on the 2015 Updates and Amendments to the Boulder County Building Code, as contained in proposed BOCC Resolution 2015-104.**

The meeting convened at 4:19 P.M.

Board Members Present: Henry Lopez, Douglas Greenspan, John Matthews, Gary Price and Bob Hunnes. Vern Seieroe was absent.

Staff Present: Gary Goodell (Chief Building Official), Ron Flax (Building Sustainability Examiner), Katherine Parker (Assistant Boulder County Attorney), Michelle Huebner (Plans Examiner Supervisor), Leslie Cline (Permit Specialist), Rick Hackett (Communications Specialist), Brian Nye (Building Inspector Supervisor), Dan Mastin (Plans Examiner).

Interested Others Present: 3 members of the public.

1. **Call to Order**
   Henry Lopez called the meeting to order. Gary Goodell conducted roll call of board members present.
2. **Approval of Minutes**
   Approval of board of Review Minutes from September 22, 2015.

Motion:	John Mathews moved to approve the minutes.
Second:	Gary Price.
Approved:	Motion passed unanimously.

3. BORC-15-0001: 2015 INTERNATIONAL CODES ADOPTION & AMENDMENTS AND PROPOSED BOCC RESOLUTION 2015-104

Gary Goodell provided copies of the proposed resolution to the Board. Gary addressed the 3 items the Board had concerns with:

1. 2015 Colorado Design Snow Loads Report. Although we'd like to use the latest snow load data available, the current study is still out for review and thus hasn't been finalized to date. In addition, staff hasn't had time to assess the potential impacts. The potential impact is that much of the plains area of the county could be raised from the current 30 psf rating to a 40 psf rating. The slight lowering of the existing snow loads in the mountainous portions of the county are probably not worth changing. One issue that has been raised is the impact on existing buildings or homes that were designed and constructed with the 30 psf snow load, but would be required to meet a 40 psf snow load for projects like reroofing or installing solar PV panels on existing roofs. Kathy Parker, Assistant County Attorney, has recommended adding the wording "as amended" to our text descriptions of the existing snow and wind load maps and that that will give us more flexibility in updating the maps in the future. We have now incorporated that language into proposed BOCC Resolution 2015-104. Rather than rush to incorporate the new data without further study and discussion of its potential impacts, staff will come back to the Board of Review as soon as possible when we are better prepared to discuss it, so we are proposing that the new snow load data and accompanying snow load changes not be incorporated into the proposed BOCC Resolution 2015-104 at this time.

2. and 3. "Thick Walls" and Basements. Staff is proposing that a single solution be used to address these two (2) issues. It is proposed that the definition of "*conditioned floor area*" be revised as follows:

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the *conditioned space*. For the purposes of this chapter, the *conditioned floor area* shall be measured as the floor area within the inside face of the interior *air barrier*.

This proposed revision does a number of things:

a. It defines "*conditioned floor area*" as exactly what it is. The area inside of the interior drywall is exactly the amount of floor area that is conditioned.

b. It somewhat lessens HERS rating requirements for all projects by removing the area of what is most typically an 8-inch-thick exterior wall. The "average" new home with 4,000 sq. ft. of conditioned floor area would typically have about 200 sq. ft. subtracted from the area that determines the HERS rating that must be achieved.

c. It provides more incentive for "thick walls" that are more carbon friendly (but have less *R*-value per inch), such as strawbale walls or walls insulated with cellulose insulation, by not penalizing them for their additional wall thickness. Under the proposed definition, a strawbale wall 16½ inches thick, for instance, would result in a 412-sq.-ft. reduction in the amount of conditioned floor area for an "average" 4,000 sq. ft. dwelling.

d. In order to meet either prescriptive or HERS rating requirements, a typical 8-inch-thick concrete foundation wall is typically furred out with 2 X 4s with insulation in the stud cavities, resulting in a 12-inch-thick wall. An average 4,000-sq.-ft. house would see a 300-sq.-ft. reduction in the area that is counted as *conditioned floor area*.

Note that other methods of giving basement walls more credit as being more energy efficient as well as more economically efficient are fraught with additional complexities. Is the basement a walkout? Is it a "raised ranch?" What percentage of the wall area is actually below grade? Staff

would rather give this credit by crediting the inherently thicker basement walls, and it is felt that the new definition of *conditioned floor area* accomplishes this.

Gary gave the Board direction as to what actions they may take; approval, approval with conditions or disapproval.

Gary concluded the staff presentation with the staff recommendation. **STAFF RECOMMENDATION: Staff recommends that the Board of Review recommend to the Board of County Commissioners <u>APPROVAL</u> of Docket #BOR-15-0001, the 2015 amendments to the Boulder County Building Code, and that the Board of County Commissioners <u>ADOPT</u> the proposed BOCC Resolution #2015-104.**

4. **Board Action: The Boulder County Board of Review recommended to the Board of Boulder County Commissioners to approve Docket #BOR-15-0001 and to adopt these building code proposals as BOCC Resolution #2015-104.**

   Motion: Gary Price
   Second: John Mathews
   The motion passed unanimously.

5. **Board Questions and Discussion**

   Henry suggested that the applicant could submit the conditioned space calculations with the drawings. The board had concerns with "repairs" due to damage pushing the project into BuildSmart requirements. Ron Flax clarified that the EnergySmart assessment is to be used as a tool to educate the homeowner as to which energy efficient options are available if he were to choose to incorporate them into the project. Ron also clarified how the HERS score change as a result of the basement turning into a walkout basement and can cause problems for the contractor. Henry mentioned that it would be easier if all jurisdictions were using the same frost depth. Bob brought up the idea of moving to a 6-year code adoption cycle and Gary G. suggested possibly addressing it when they reconvened to discuss the wind & snow loads.

Adjourned

Motion: Bob Hunnes moved to adjourn.
Second: John Matthews.

The meeting was adjourned at 5:15 P.M.

The official record of this meeting is on compact disc (CD). Detailed information regarding the docket items, including maps and legal descriptions are available for public use at the Land Use Department, 13th and Spruce, Boulder, CO. 303-441-3930.

RESOLUTION 2016-96

A resolution amending the adoption of the 2015 editions of the International Codes, additions and amendments, as the Boulder County Building Code for application within the unincorporated area of Boulder County

Recitals

A. The Board of County Commissioners is authorized by Resolution to alter and amend the Boulder County Building Code, pursuant to Title 30, Article 28, Section 204 of the Colorado Revised Statutes.

B. The Board of County Commissioners held a duly advertised public hearing on September 20, 2016, and adopted proposed Commissioners Resolution 2016-96 approving the 2016 Amendments to the Boulder County Building Code.

C. This Resolution shall be known as a portion of the "Boulder County Building Code," may be cited as such and will be referred to herein as "this code."

D. This code provides minimum standards to safeguard life or limb, health, property and public welfare by regulating the design, construction, quality of materials, use, occupancy and location of all construction or alteration of dwellings, buildings and structures together with fuel gas, plumbing, mechanical and electrical installations in all parts of Boulder County not including areas embraced within the limits of any incorporated city or town.

E. The purpose of this code is to provide for and promote the health, safety and welfare of the general public.

F. The provisions of this code shall apply to the erection, construction, reconstruction, alteration, remodeling, renovation or the change of use of all dwellings, buildings and structures including buildings or structures used for the purpose of providing shelter for agricultural implements, farm products, livestock, or poultry within the unincorporated territory of Boulder County, and shall include the authority over existing buildings and structures provided in the adoption of the *International Building Code*, the *International Existing Building Code* and the *International Residential Code.*

G. Pursuant to Title 30, Article 28, Section 205 of the Colorado Revised Statutes, the County Building Inspector, also referred to herein as the "building official," as authorized in Title 30, Article 28, Section 114 of the Colorado Revised Statutes, shall be authorized by the Board of County Commissioners to administer and enforce this code; and

H. The Land Use Director shall be responsible for enforcing and administering this code in the event of the absence or disability of the building official; and

I. Upon the adoption of this code, the Board of County Commissioners shall file certified copies thereof in its office, which copies shall be accessible to the public at a cost not to exceed that of printing the same. Copies of this code printed by authority of the Board of County Commissioners shall be prima facia evidence of the original text in all courts and tribunals of this state.

Therefore, the Board resolves:

The 2016 Amendments to the Boulder County Building Code, as adopted in Board of County Commissioners Resolution 2016-96, shall read as follows:

REFER TO EXHIBIT "A," ATTACHED AND INCORPORATED

EXHIBIT "A" TO COMMISSIONERS RESOLUTION 2016-96
ADOPTION OF MODEL CODES BY REFERENCE,
WITH DELETIONS AND AMENDMENTS

Except as modified by this resolution, the provisions of Board of County Commissioners Resolution 2015-104, "…a resolution approving the adoption of the 2015 editions of the International Codes, along with deletions and amendments, as the Boulder County Building Code for application within the unincorporated area of Boulder County," shall remain in full force and effect.

Additional Amendments to the Administrative Provisions, Boulder County Building Code

Chapter 1, the administrative provisions of the Boulder County Building Code

Note: The administrative provisions of the first chapters of all of the adopted model codes are combined into one Chapter 1 for the Boulder County Building Code, based upon Chapter 1 of the IBC, except as may be noted under the amendments to Chapter 1 under the individual adopted model codes.

BOULDER COUNTY BUILDING CODE
CHAPTER 1

PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION 110
INSPECTIONS

Note: Reinsert a provision from the 2012 International Codes adoption that permits insulation inspections for smaller projects to be inspected by county building inspectors.

110.3.7 Energy efficiency inspections. Inspections shall be made to determine compliance with IBC Chapter 13 or IRC Chapter 11 and shall include, but not be limited to, inspections for: envelope insulation R- and U-values, fenestration U-value, duct system R-value, and HVAC and water-heating equipment efficiency.

> **Exception:** Insulation inspections for projects exceeding 500 sq. ft. of conditioned floor area (CFA) must be performed by an *approved* third party energy rater. For projects of 500 sq. ft. of conditioned floor area (CFA) or less, an insulation inspection will be performed by the county upon request and the insulation installer shall post an insulation certificate in accordance with IRC Section N1101.14.

Additional Amendments to the International Building Code "IBC")

Modeled from the 2015 International Building Code

1. 2015 *International Building Code*, including specifically **Appendix Chapters C, I, J and K;** published by the International Code Council, with amendments to the following:

IBC CHAPTER 16
STRUCTURAL DESIGN

Discussion Note Only: International Existing Building Code ("IEBC") Sections 707.2, 807.4 and 907.3 do provide exceptions for existing buildings:

707.2 Addition or replacement of roofing or replacement of equipment. Where addition or replacement of roofing or replacement of equipment results in additional dead loads, structural components supporting such reroofing or equipment shall comply with the gravity load requirements of the *International Building Code*.

Exceptions:

1. Structural elements where the additional dead load from the roofing or equipment does not increase the force in the element by more than 5 percent.
2. Buildings constructed in accordance with the *International Residential Code* or the conventional light frame construction methods of the *International Building Code* and where the dead load from the roofing or equipment is not increased by more than 5 percent.

IBC SECTION 1608
SNOW LOADS

1608.2 Ground snow loads.

Note: Add an additional sentence to the end of the paragraph, as follows:

Snow loads shall be determined by the *building official* utilizing the Boulder County map, "Colorado Front Range Gust Map and Snow Load Design Data for Colorado," as amended. Snow loads are based upon the report, "2016 Colorado Design Snow Loads," prepared by the Structural Engineers Association of Colorado (SEAC) Snow Load Committee, April 2016.

IBC SECTION 1609
WIND LOADS

1609.3 Ultimate design wind speeds.

Note: Delete Section 1609.3.1, Equation 16-33 and Table 1609.3.1 and replace them with the following, in accordance with the report, "Colorado Front Range Gust map – ASCE 7-10 Compatible," dated November 18, 2013 by Jon A. Peterka, as follows:

1609.3.1 Wind speed conversion. The basic nominal design wind speed, in miles per hour (V_{asd}), for the determination of wind loads, shall be taken from the Boulder County map, "Colorado Front Range Gust Map and Snow Load Design Data for Colorado," as amended. When required, the nominal design wind speeds from this map shall be converted to ultimate design wind speeds, V_{ult}, using the amended Table 1609.3.1 or the amended Equation 16-33.

$F_{rc} = 0.36 + 0.10 \ln(12\ T)$ **(amended Equation 16-33)**

where:

T is the return period in years and F_{rc} is the ratio of the return period speed at T years to the return period at 50 years (note that Frc = 1.00 at T=50).

TABLE 1609.3.1[a]
3-SECOND WIND SPEEDS IN ASCE 7-10 FORMAT

2006 MAP GUST SPEED, MPH	ASCE 7-10 3-SECOND GUST SPEEDS, V_{ult}, IN MPH, FOR T, YEARS[b]						
	700	1700	300	10	25	50	100
90	115	120	105	75	85	90	95
100	125	135	120	85	95	100	105
110	140	150	130	90	100	110	120
120	150	160	140	100	110	120	130
130	165	175	155	110	120	130	140
140	175	190	165	115	130	140	150
180	225	245	210	150	165	180	190

[a] From the report, "Colorado Front Range Gust Map – ASCE 7-10 Compatible," prepared by Jon A. Peterka, Cermak Peterka Petersen, Inc., November 18, 2013.
[b] Wind speeds are rounded to the nearest 5 mph consistent with ASCE 7-10.

Additional Amendments to the International Residential Code

Modeled from the 2015 International Residential Code ("IRC")

2. International Residential Code, including specifically **Appendix Chapters E, F, H, R and S**, published by the International Code Council, with amendments to the following:

Part II—Definitions

CHAPTER 2
DEFINITIONS

Note: Restore two definitions from the 2012 International Codes adoption:

SECTION R202

DEFINITIONS

AREA, FLOOR. The area of the building, existing or new, under consideration including *basements* and attached garages calculated without deduction for corridors, stairways, closets, the thickness of interior walls, columns, or other features as measured from the exterior face of the exterior walls.

BASEMENT. That portion of a building that is partially or completely below grade (see *story above grade plane*). An under floor space below the first *story* of the building that does not meet the definition of *story above grade plane* and has a *ceiling height* measured from the *basement* floor to the bottom of the floor joists above of 6 feet 8 inches or more.

CRAWL SPACE. An under floor space below the first story floor of the building that does not meet the definition of *story above grade plane*, that has a *ceiling height* measured from the crawlspace grade or floor to the bottom of the floor joists above of less than six feet 8 inches, and that does not contain interior stairs, windows, wall, and ceiling finish materials, trim or finished flooring.

RECONSTRUCTED DWELLING. A dwelling which has been completely deconstructed, deconstructed to the foundation level, or deconstructed to the first floor level. For the purposes of this code, a reconstructed dwelling shall be considered a new dwelling.

REMODEL/RENOVATION. Work within the conditioned spaces of an existing dwelling that requires a building permit but does not increase the floor area of the dwelling.

Part III—Building Planning and Construction

IRC CHAPTER 3
BUILDING PLANNING

SECTION R301
DESIGN CRITERIA

Note: Amend Section R301.2.1 to include the Boulder County Wind Pressure Map and note that nominal design wind speeds from the map must be converted to ultimate design wind speeds for use in the code. The report, "Colorado Front Range Gust Map – ASCE 7-10 Compatible," dated November 18, 2013, by Jon A. Peterka, may be used to provide a wind speed conversion equation and table.

R301.2.1 Wind design criteria. Buildings and portions thereof shall be constructed in accordance with the wind provisions of this code using the nominal design wind speeds, V_{sd}, from the Boulder County Wind Pressure Map (titled the Wind Speed Map for the Front Range of Colorado) prepared by Jon A Peterka and dated February 28, 2006, titled "Colorado Front Range Gust Map and Snow Load Design Data for Colorado" and converting them to ultimate design wind speeds, V_{ult}. The structural provisions of this code for wind loads are not permitted where wind design is required as specified in Section R301.2.1.1. Where different construction methods and structural materials are used for various portions of a building, the applicable requirements of this section for each portion shall apply. Where not otherwise specified, the wind loads listed in Table R301.2(2) adjusted for height and exposure using Table R301.2(3) shall be used to determine design load performance requirements for wall coverings, curtain walls, roof coverings, exterior windows, skylights, garage doors and exterior doors. Asphalt shingles shall be designed for wind speeds in accordance with Section R905.2.4. A continuous load path shall be provided to transmit the applicable uplift forces in Section R802.11.1 from the roof assembly to the foundation.

Note: Amend Section R301.2.1.3 and Table R301.2.1.3 and add Equation 3-1 to allow for the conversion of the nominal design wind speeds on the Boulder County Wind Pressure Map to ultimate design wind speeds.

R301.2.1.3 Wind speed conversion. The nominal design wind speeds from the Boulder County Wind Pressure Map (titled the Wind Speed Map for the Front Range of Colorado) prepared by Jon A Peterka and dated February 28, 2006, titled "Colorado Front Range Gust Map and Snow Load Design Data for Colorado" may be converted to nominal design wind speeds, V_{asd}, using the added Equation 3-1 and the amended Table R301.2.1.3.

$$F_{rc} = 0.36 + 0.10 \ln(12\,T) \qquad \textbf{(Equation 3-1)}$$

where:

T is the return period in years and F_{rc} is the ratio of the return period speed at T years to the return period at 50 years (note that Frc = 1.00 at T=50).

TABLE R301.2.1.3[a]
3-SECOND WIND SPEEDS IN ASCE 7-10 FORMAT

2006 MAP GUST SPEED, MPH	ASCE 7-10 3-SECOND GUST SPEEDS, V_{ult}, IN MPH, FOR T, YEARS[b]						
	700	1700	300	10	25	50	100
90	115	120	105	75	85	90	95
100	125	135	120	85	95	100	105
110	140	150	130	90	100	110	120

120	150	160	140	100	110	120	130
130	165	175	155	110	120	130	140
140	175	190	165	115	130	140	150
180	225	245	210	150	165	180	190

[a] From the report, "Colorado Front Range Gust Map – ASCE 7-10 Compatible," prepared by Jon A. Peterka, Cermak Peterka Petersen, Inc., November 18, 2013.
[b] Wind speeds are rounded to the nearest 5 mph consistent with ASCE 7-10. Linear interpolation is permitted.

Note: Add a sentence at the beginning of Section R 301.2.3 to cite the Boulder County Snow Load Map, with the remainder of the section to remain as published.

R301.2.3 Snow Loads. ~~Ground snow loads shall be determined based on the Boulder County Snow Load Map prepared by the Structural Engineers Association of Colorado and dated October 1971, titled "Colorado Front Range Gust Map and Snow Load Design Data for Colorado, as amended."~~ Snow loads shall be determined by the building official utilizing the Boulder County map, "Colorado Front Range Gust Map and Snow Load Design Data for Colorado," as amended. Snow loads are based upon the report, "2016 Colorado Design Snow Loads," prepared by the Structural Engineers Association of Colorado (SEAC) Snow Load Committee, April 2016. Wood-framed construction, coldformed steel-framed construction and masonry and concrete construction, and structural insulated panel construction in regions with ground snow loads 70 pounds per square foot (3.35 kPa) or less, shall be in accordance with Chapters 5, 6 and 8. Buildings in regions with ground snow loads greater than 70 pounds per square foot (3.35 kPa) shall be designed in accordance with accepted engineering practice.

Note: Add a note stating that IRC Sections R325 and R326 remain as published, as otherwise the Boulder County amendments appear to skip from Section R324 to Section R327.

Note: Sections R325 and R326 remain as published. Add a Section R327 to require ignition-resistant construction and defensible space in wildfire hazard areas.

SECTION R327
IGNITION-RESISTANT MATERIALS AND CONSTRUCTION

Note: Correct an incorrect reference to another section in the ignition-resistant construction provisions.

R327.4.10 Exterior doors. Exterior doors and garage doors shall be approved noncombustible construction, metal clad, solid core wood not less than 1 3/4 inches in thickness, or have a fire protection rating of not less than 20 minutes. Windows within doors and glazed doors shall be in accordance with Section ~~R325.6.6~~ R327.4.9.

Exception: Vehicle access doors.

Part IV—Energy Conservation

IRC CHAPTER 11
ENERGY EFFICIENCY

Note: IRC Chapter 11 is amended in its entirety to contain the requirements of the Boulder County BuildSmart program for residential energy efficiency and sustainability. Amended as such, the provisions are not interchangeable with the residential energy [RE] provisions of the International Energy Conservation Code.

SECTION N1101
GENERAL

Note: Change "Dwellings" to "Buildings," as new detached accessory structures that are heated and/or cooled also need to meet BuildSmart requirements. The title of Table N1101.13.1 is also changed accordingly.

N1101.13 Compliance. Projects shall comply with one of the following:

N1101.13.1 New ~~Dwellings~~ Buildings. New ~~dwellings~~ buildings shall comply with the requirements of Figure N1101.13.1, "Options for New ~~Dwellings~~ Buildings."

N1101.13.2 Additions. Additions shall comply with the requirements of Figure N1101.13.2, "Options for Additions."

N1101.13.3 Alterations, Remodels, and Repairs. Alterations, Remodels, and Repairs shall comply with the requirements of Figure N1101.13.3 "Options for Alterations, Remodels, and Repairs."

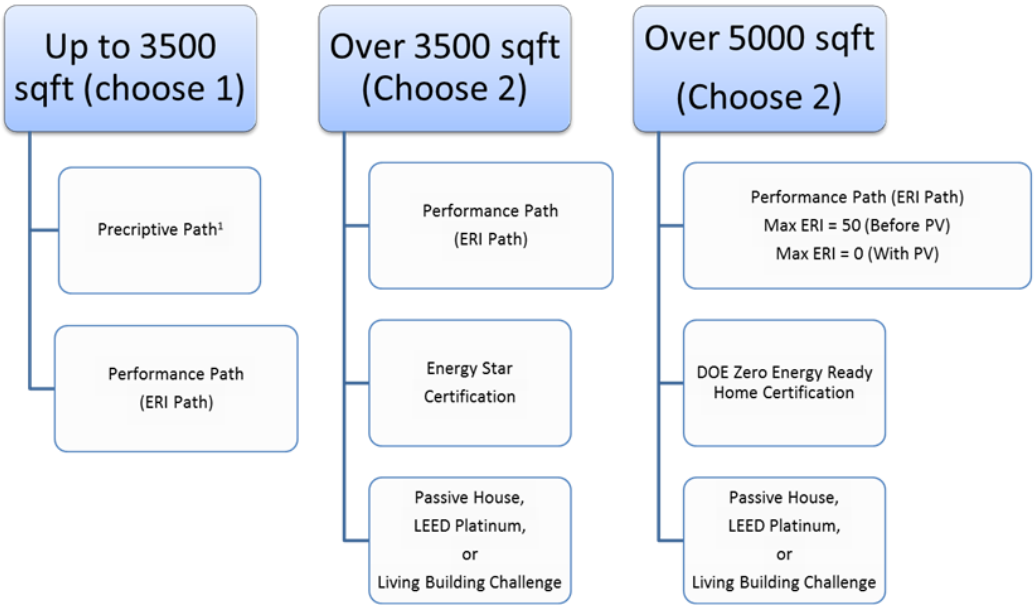
Note: Add a new sub-section that reinserts a provision from the 2012 International Codes adoption that permits participation in "solar gardens" or "solar farms" as a way to comply with the renewable energy requirements of the Buildsmart program.

N1101.18 Renewable energy requirements. Whenever renewable energy systems are required by this chapter, those systems must be constructed on-site.

Exception: If an applicant's property is situated in a part of the county where state law permits local utility companies to operate "solar gardens," "solar farms," or similar community renewable energy facilities, the renewable energy requirements of this chapter may be satisfied off-site through the purchase of an adequate share in a community facility, at the discretion of the *building official*. At a minimum, an "adequate" share in a community facility must (1) enable the production of an equivalent amount of power compared to what the applicant would otherwise be required to produce on-site; (2) be purchased from a facility located within Boulder County or a county contiguous to Boulder County; and (3) given that such shares do not automatically run with the applicant's land, include a mechanism that ensures the share cannot be sold or modified in any way without the consent of Boulder County, with the exception of legal transfer to the applicant's successors-in-interest for use on the same property. Written proof that these requirements are met must be filed with the Building Safety and Inspection Services Division prior to the final inspection approval or the issuance of a certificate of occupancy.

<u>Note:</u> Change "Dwellings" in the title of the table to "Buildings," as new detached accessory structures that are heated and/or cooled also need to meet BuildSmart requirements.

FIGURE N1101.13.1
OPTIONS FOR NEW <u>BUILDINGS</u> ~~DWELLINGS~~[a,b,c,d]



a. Buildings with glazing to floor area ratios that exceed 18% may not use the prescriptive path.

Exception: Passive solar designs in which 50% or more of the total glazing faces south.

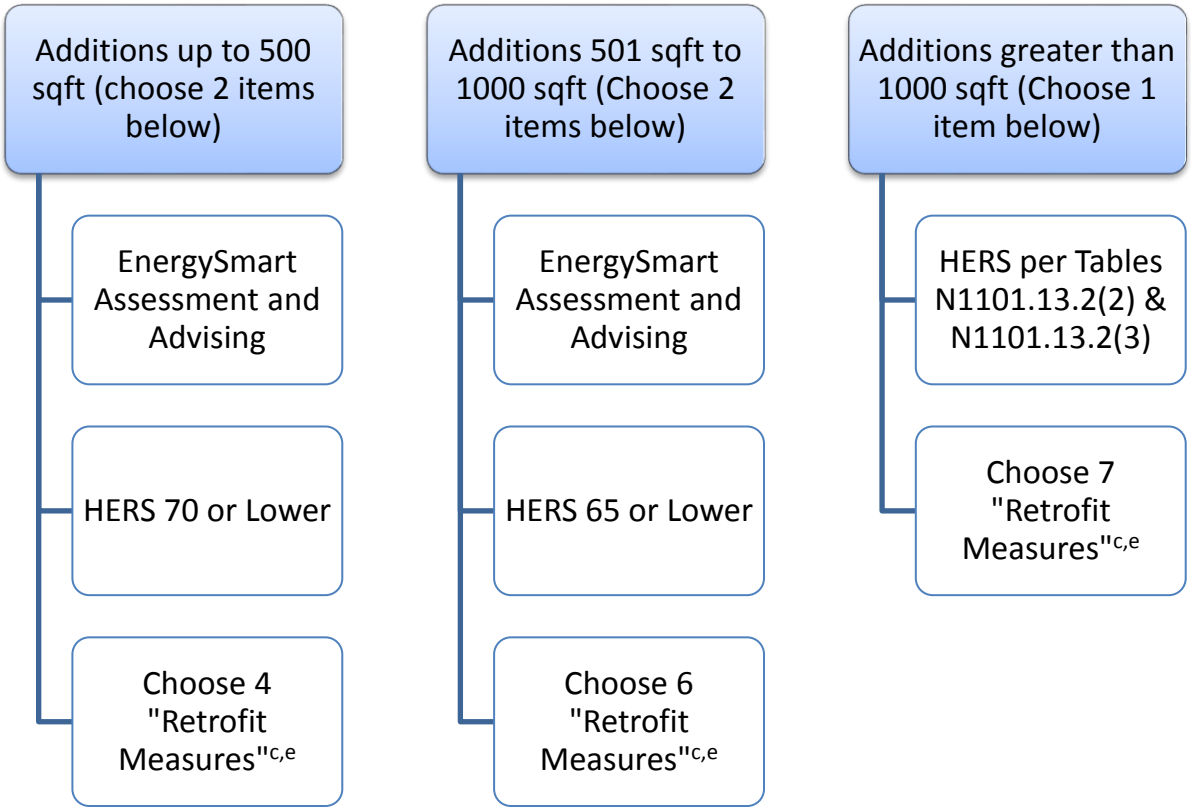
b. The energy efficiency requirements of BuildSmart are deemed to be met by buildings with an annual space conditioning requirement of less than 5kBtu/sqft/year.

c. When unconditioned floor area is being converted to *conditioned floor area* (except for basement finishes), the project is to meet the requirements for an addition.

d. All "sqft" numbers refer to *conditioned floor area* ("CFA") in square feet as defined in Section N1101.6.

FIGURE N1101.13.2(1)
OPTIONS FOR ADDITIONS[a,b,c,d,e]

Note: Add a footnote e identical to the previous table's footnote a noting that buildings with large amounts of glazing must use the performance path and obtain a HERS rating.



a. All new building components must meet the requirements of Section N1102.

Exception: Homes using the ERI (HERS) pathway.

b. For additions with greater than 200 square feet of floor area resulting in dwellings with greater than 3,500 square feet of *conditioned floor area*, existing plus proposed, Figure~~s~~ N1101.13.2(2) and Table N1101.13.2~~(3)~~ must be used.

c. "Retrofit Measures" are listed in Table N1101.13.3(2).

d. All "sqft" numbers refer to *conditioned floor area* ("CFA") in square feet as defined in Section N1101.6.

e. Buildings with glazing to floor area ratios that exceed 18% may not use the prescriptive path.

Exception: Passive solar designs in which 50% or more of the total glazing faces south.

TABLE ~~FIGURE~~ N1101.13.2~~(3)~~
OPTIONS FOR ADDITIONS---continued:
ERI (HERS) REQUIREMENTS FOR ADDITIONS

CFA, SQ FT*	MAXIMUM ERI
0	76
1500	76
1600	76
1700	75
1800	75
1900	74
2000	74
2100	73
2200	73
2300	72
2400	72
2500	71
2600	71
2700	70
2800	70
2900	69
3000	69
3100	68
3200	68
3300	67
3400	67

CFA, SQ FT*	MAXIMUM ERI
3500	66
3600	66
3700	65
3800	65
3900	64
4000	63
4100	62
4200	61
4300	60
4400	59
4500	58
4600	57
4700	56
4800	55
4900	54
5000	53
5100	51
5200	49
5300	47
5400	45
5500	43

CFA, SQ FT*	MAXIMUM ERI
5600	41
5700	39
5800	37
5900	35
6000	33
6100	31
6200	29
6300	27
6400	25
6500	23
6600	21
6700	19
6800	17
6900	15
7000	13
7100	11
7200	9
7300	7
7400	5
7500	3
7600	1
7700 or greater	0

**Conditioned floor area* (“CFA”) is to be rounded to the nearest 100 square feet.

SECTION N1102
BUILDING THERMAL ENVELOPE

TABLE N1102.1.2
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a,l,m]

Note: Add a footnote m stating that the prescriptive path may not be used for buildings with a glazing to floor area ratio of more than 18%.

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKY-LIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b,e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i,j]	FLOOR *R*-VALUE	BASE-MENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
Boulder County (modified 5 & Marine 4)	0.30	0.43	NR	54	19 + 5[h,k]	18/24	42[g]	15/20	15, 3 ft	15/20

For SI: 1 foot = 304.8 mm.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall not be less than the *R*-value specified in the table.

Exception: An *R*-19 batt installed in a 2 X 6 stud cavity shall be deemed to meet the requirements of this code.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

Exception: Skylights may be excluded from glazed fenestration SHGC requirements in Climate Zones 1 through 3 where the SHGC for such skylights does not exceed 0.30.

c. "15/19" means *R*-15 continuous insulation on the interior or exterior of the home or *R*-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with *R*-13 cavity insulation on the interior of the basement wall plus *R*-5 continuous insulation on the interior or exterior of the home. "10/13" means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.

d. R-10 shall be added to the required slab edge *R*-values for heated slabs.

e. Not Used.

f. Not Used.

g. Floors over conditioned space are exempt from this requirement.

h. The first value is cavity insulation, the second value is continuous insulation, so "19+5" means *R*-19 cavity insulation plus *R*-5 continuous insulation.

i. The second *R*-value applies when more than half the insulation is on the interior of the mass wall.

j. For strawbale construction, see Section AS108.

k. To reduce the potential for condensation within the wall assembly, it is recommended that exterior continuous insulation be a minimum of *R*-7.5. See also Table R702.7.1.

l. Overhead doors for garages and shops that contain conditioned floor area must have fully weather stripped overhead doors with a minimum R-value of 13. Such doors must be weather stripped at the top, sides and bottom and between the panels.

m. Buildings with glazing to floor area ratios that exceed 18% may not use the prescriptive path.

Exception: Passive solar designs in which 50% or more of the total glazing faces south.

TABLE N1102.1.4
EQUIVALENT *U*-FACTORS[a,c]

Note: Add a footnote c stating that the prescriptive path may not be used for buildings with a glazing to floor area ratio of more than 18%.

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
Boulder County (modified 5 & Marine 4)	0.30	0.43	0.020	0.045	0.056	0.026	0.067/0.05	0.05

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.

b. When more than half the insulation is on the interior, the mass wall *U*-factors shall be a maximum of 0.065.

c. Buildings with glazing to floor area ratios that exceed 18% may not use the prescriptive path.

Exception: Passive solar designs in which 50% or more of the total glazing faces south.

Validity and Effective Date

1. **Validity:** If any section, subsection, sentence, clause or phrase of this resolution is, for any reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this resolution. The Board of County Commissioners hereby declares that it would have passed this resolution, and each section, subsection, clause, or phrase thereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses and phrases be declared unconstitutional.

2. **Date Effective:** This Resolution shall be, and is hereby declared to be in full force and effect for all applications for building permits filed after January 1, 2017.

THIS RESOLUTION 2016-96 IS ADOPTED on this 20th day of September, 2016, as further specified in this resolution, above.

BOULDER COUNTY BOARD OF COMMISSIONERS

ELISE JONES, CHAIR	CINDY DOMENICO, VICE CHAIR

ATTEST:

Clerk to the Board	DEB GARDNER, COMMISSIONER

Design of Roofs to Support Colorado Snow Loads

February 12, 2016

Jeannette Torrents, P.E., SE., JVA Inc.
Abbie Liel, P.E., Ph.D., University of Colorado Boulder

Representing the SEAC Snow Load Committee:
Jim Harris, P.E., Ph.D| D. Jared DeBock, Ph.D.| Bob Pattillo, P.E.

Outline

I. New Colorado Ground Snow Loads
   i. History and Motivation for Change
   ii. Development of New Ground Snow Loads
   iii. Using the New Load Table & Map
   iv. Importance Factors and Serviceability
   v. Conclusions & Questions

II. Designing Roofs for Snow

Acknowledgments

Structural Engineers Association of Colorado Snow Load Committee

Jeannette Torrents, Jim Harris, Jared DeBock, Abbie Liel, Bob Pattillo, Michael DePaolo, Dick Cunningham

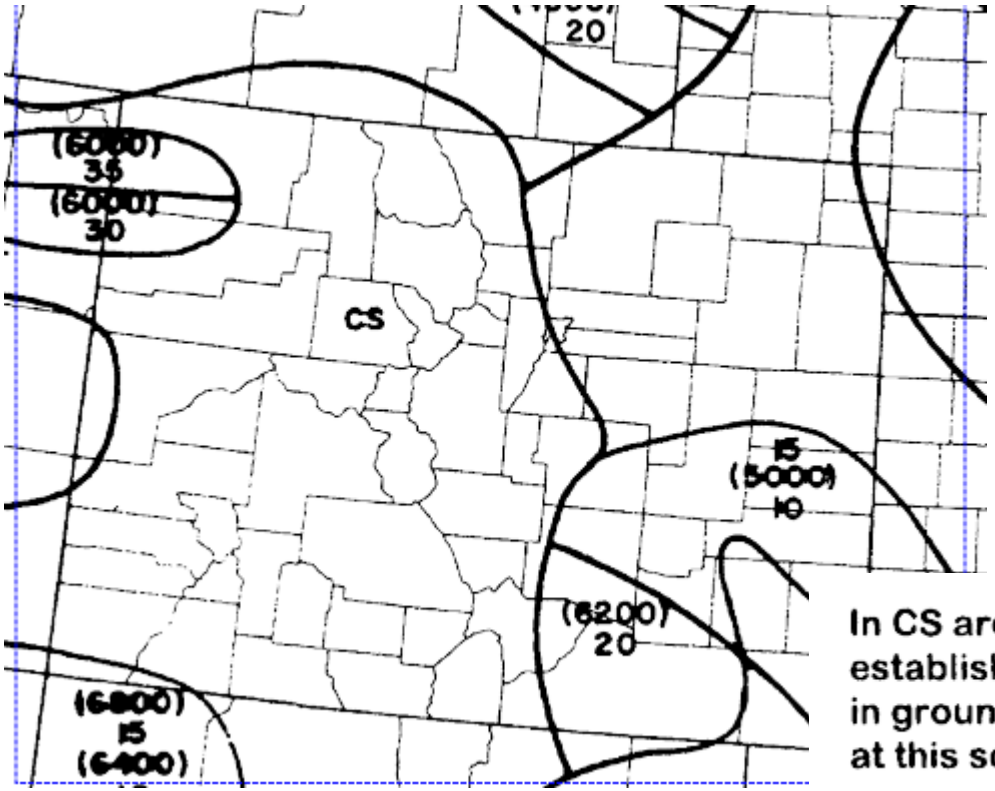
Technical Contributors

Bruce Ellingwood, Michael O'Rourke, Jamie Geis, Kristen Strobel, Derek Kozak, Dania Hussain

Technical Review

- Reviewed by Dr. Bruce Ellingwood, Former Vice-Chair of the SEI-ASCE Technical Council on Life-Cycle Performance, Safety, Reliability and Risk of Structural Systems
- Accepted by the ASCE 7 Snow and Rain Loads Committee for inclusion in ASCE 7-16
- Endorsed by the Structural Engineers Association of Colorado
- Loads included in 2016 Denver Building Code Amendments
- Presented at the 12th International Conference on Applications of Statistics and Probability in Civil Engineering

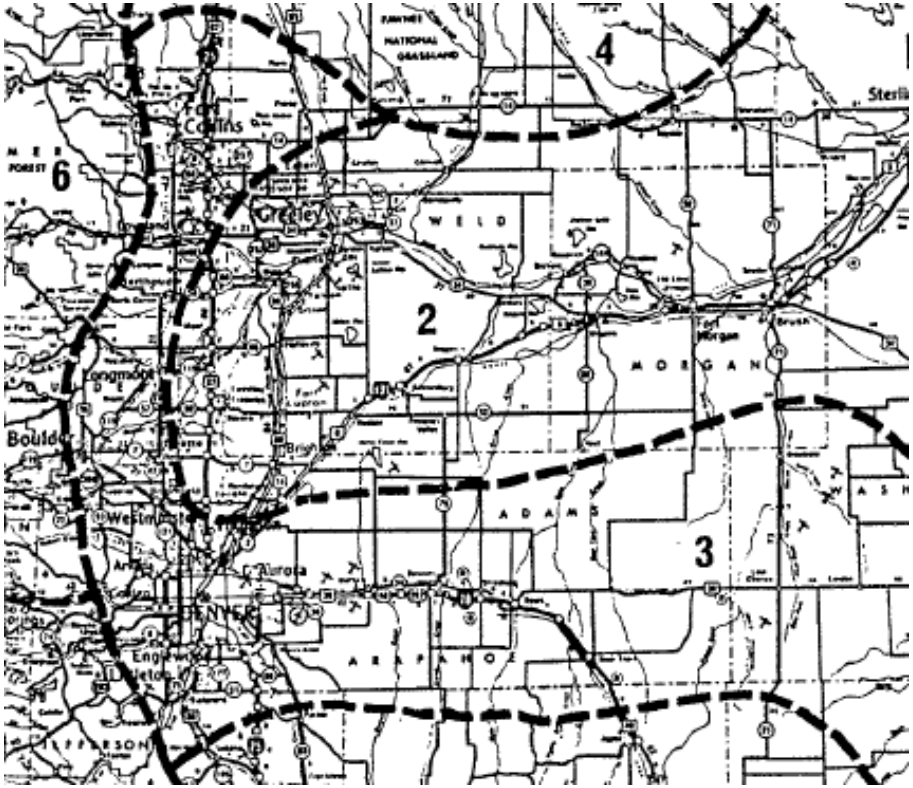
History of Snow Loads in Colorado



In CS areas, site-specific Case Studies are required to establish ground snow loads. Extreme local variations in ground snow loads in these areas preclude mapping at this scale.

2010: ASCE still defines much of Colorado as a Case Study area

History of Snow Loads in Colorado



THE NUMBER INDICATES THE VALUE OF K TO BE USED IN THE BASIC DESIGN LOAD EQUATION:

$$S = \frac{32}{K+12}\left(A - \frac{K}{2}\right)^2$$

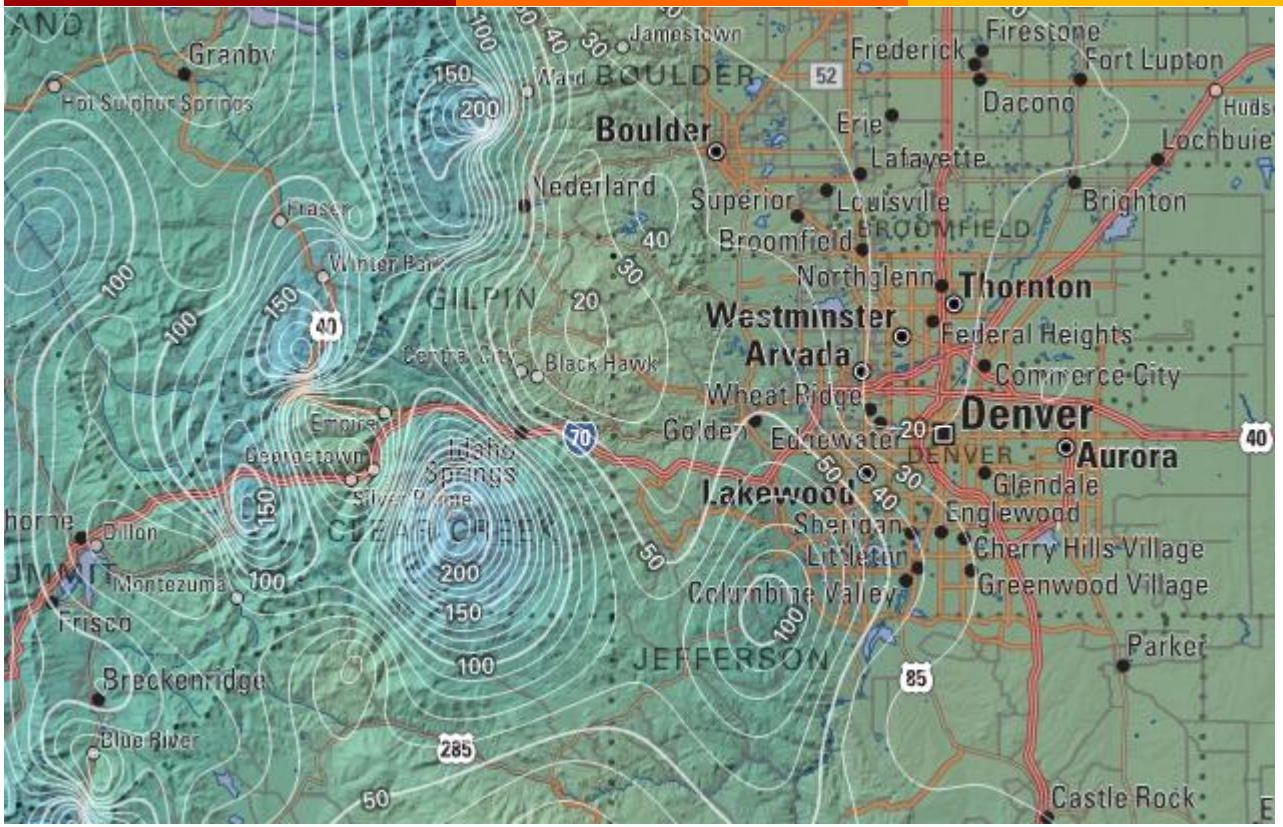
WHERE:

S IS THE RECOMENDED DESIGN LOAD IN P.S.F.

A IS THE ALTITUDE IN THOUSANDS OF FEET.

1971: SEAC published Snow Load Design Data for Colorado (Roof loads, 30 year MRI)

History of Snow Loads in Colorado



2007: SEAC published Colorado Ground Snow Loads (Ground loads, 50 year MRI)

Motivation for Change

Industry-wide Change in Philosophy:

Uniform Hazard vs. Uniform Risk

2007 study observed that 50-year load was not high enough for Denver and used a higher value

Reliability comparison of single-storm vs. accumulated snow sites showed that 50-year loads were conservative in the mountains and unconservative in the plains

State-wide reliability analysis

Motivation for Change

Then: Uniform Hazard

- 50-year snow load for design, corresponds to 2% annual probability of load occurring
- Produces varying probabilities of failure, from $\beta = 2$ (2.3% in 50 years) to $\beta = 3.25$ (0.16% in 50 years)

Now: Uniform Risk

- Probability of design load occurring varies
- Satisfies industry standard for all load and structure types to balance economy and safety corresponding to probability of failure for $\beta = 3$ (0.13% in 50 years)

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I. New Colorado Ground Snow Loads
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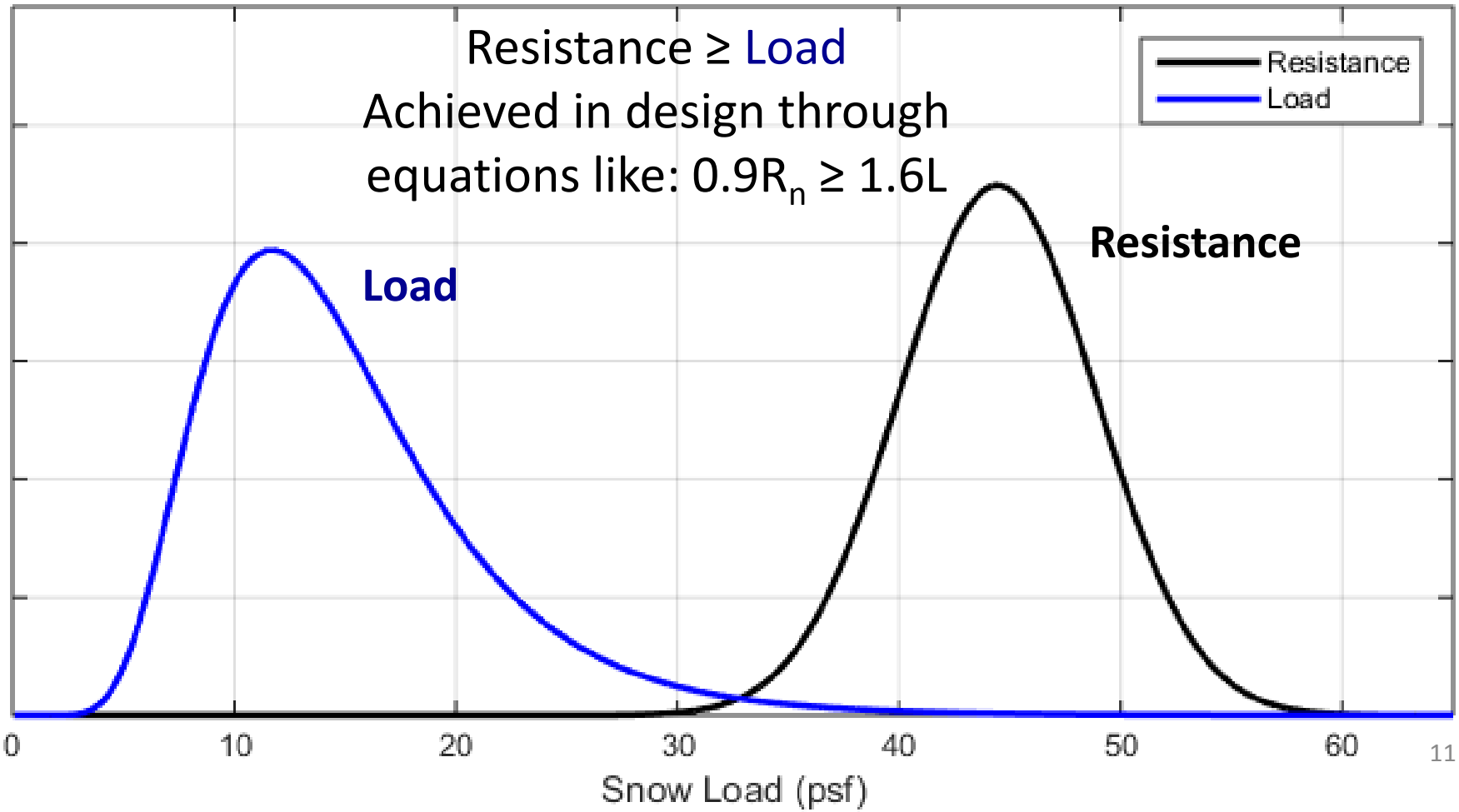
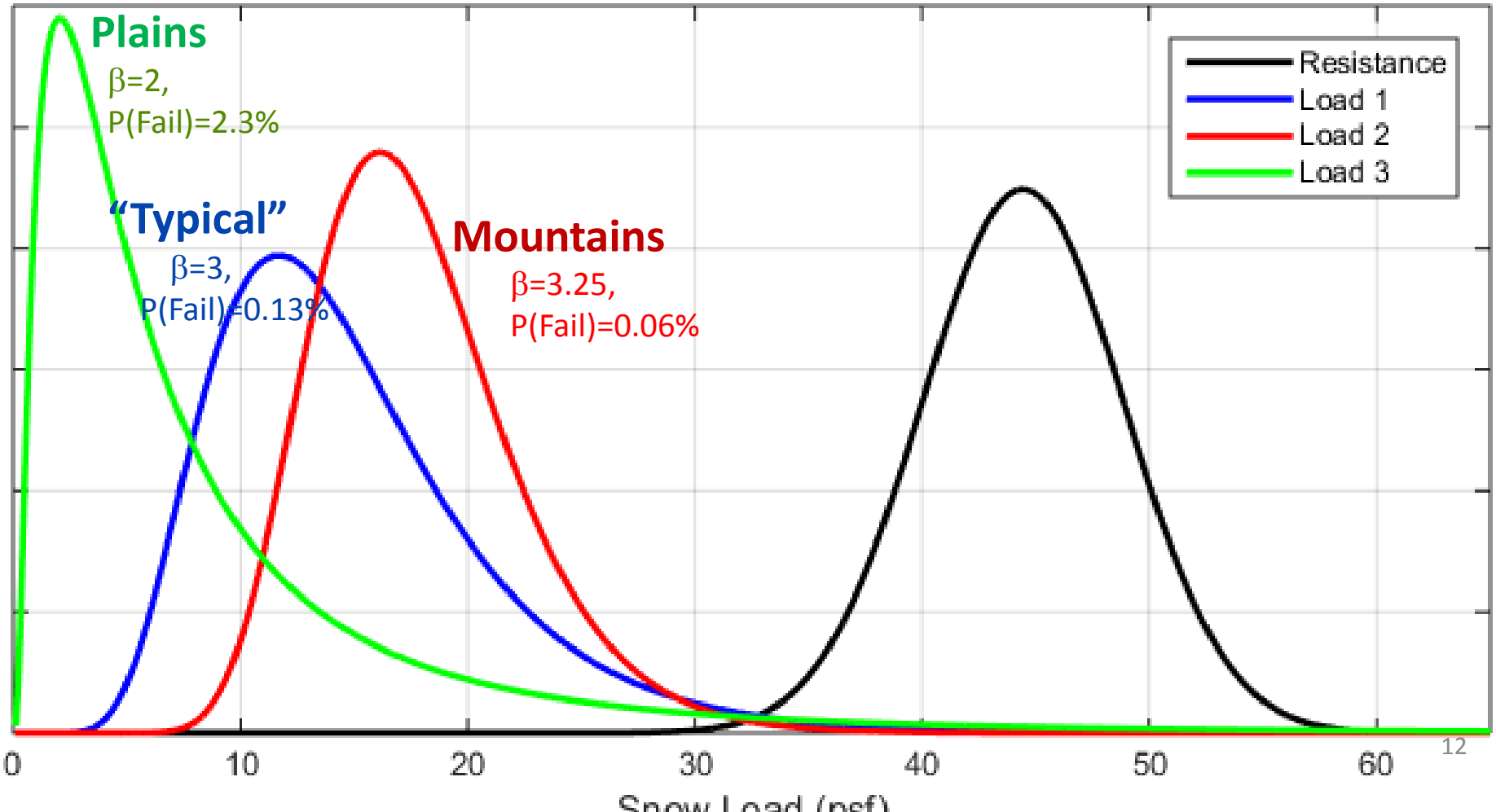
   v. Conclusions & Questions

II. Designing Roofs for Snow

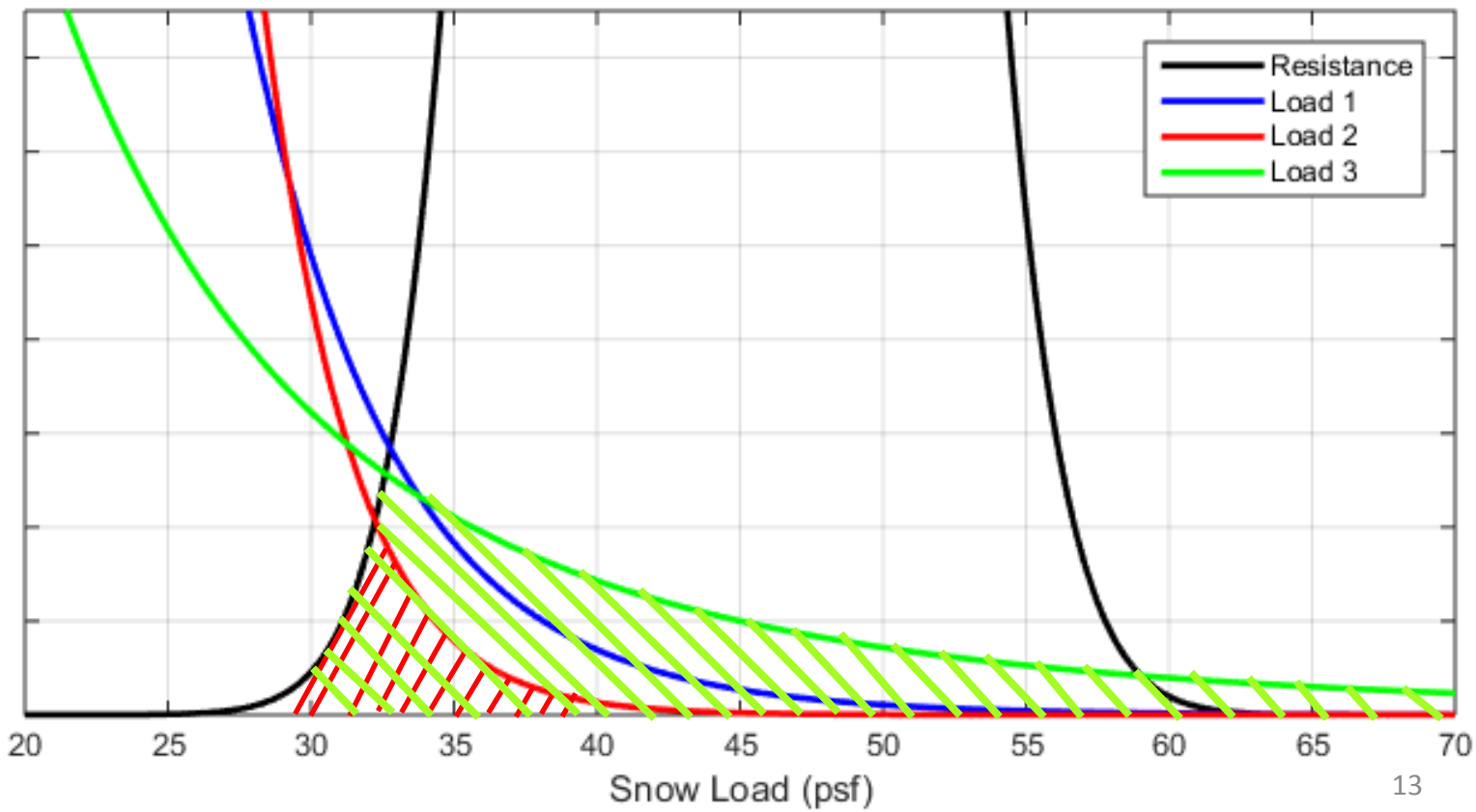
Structural Reliability Concepts



Structural Reliability of 50-year Colorado Snow Loads



Structural Reliability of 50-year Colorado Snow Loads



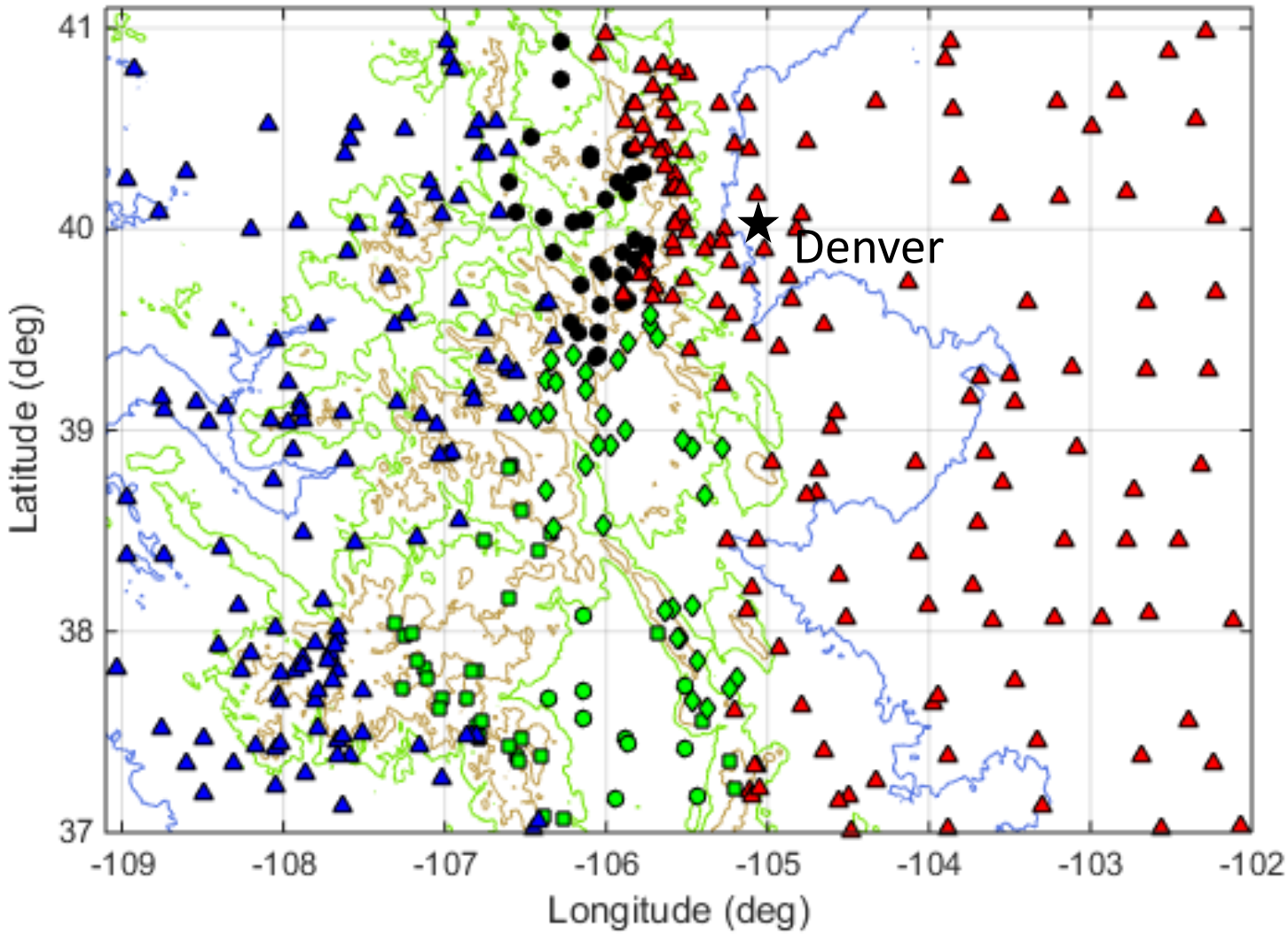
Data Sources

Snow Course

Snowpack Telemetry (SNOTEL)

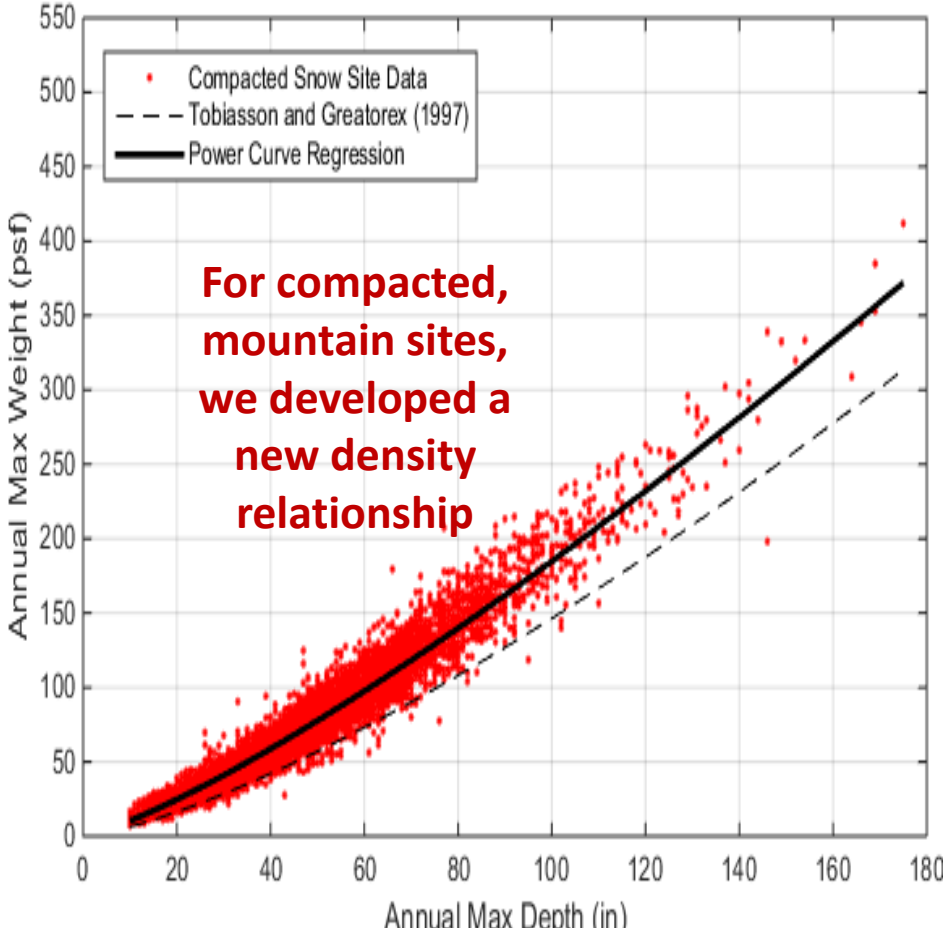
National Weather Service (NWS)

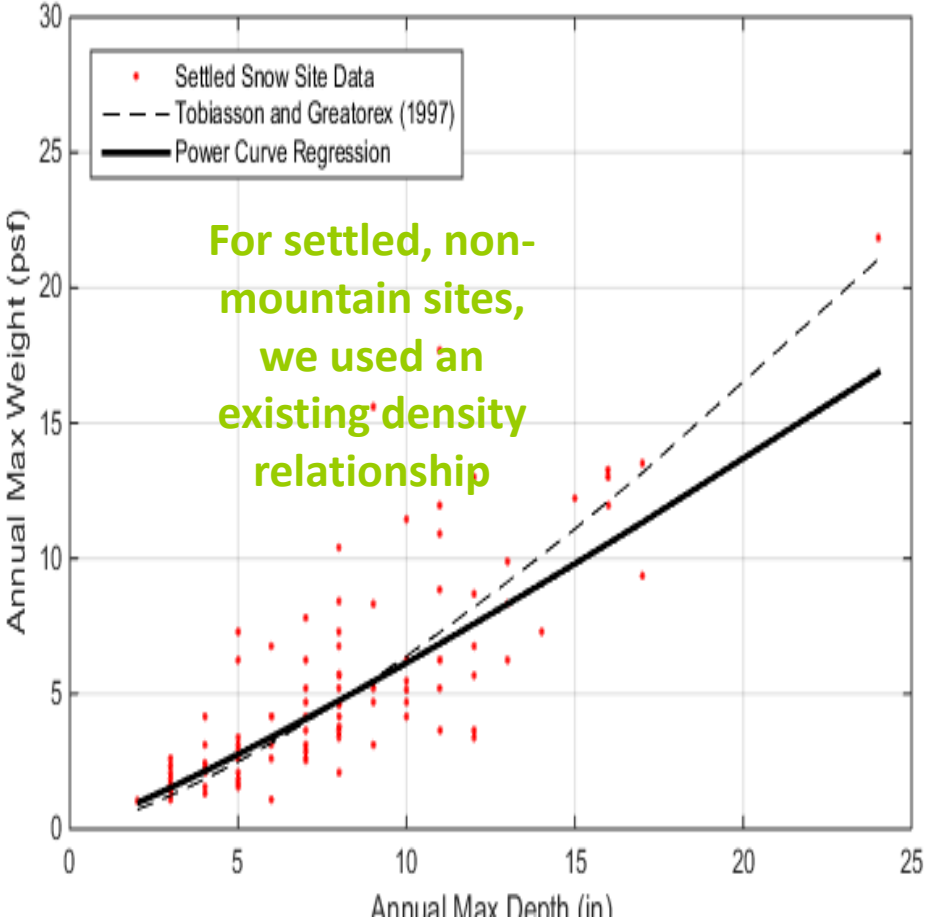
300+ Sites with > 30 Years of Data



Snow Depth vs. Snow Weight Measurements

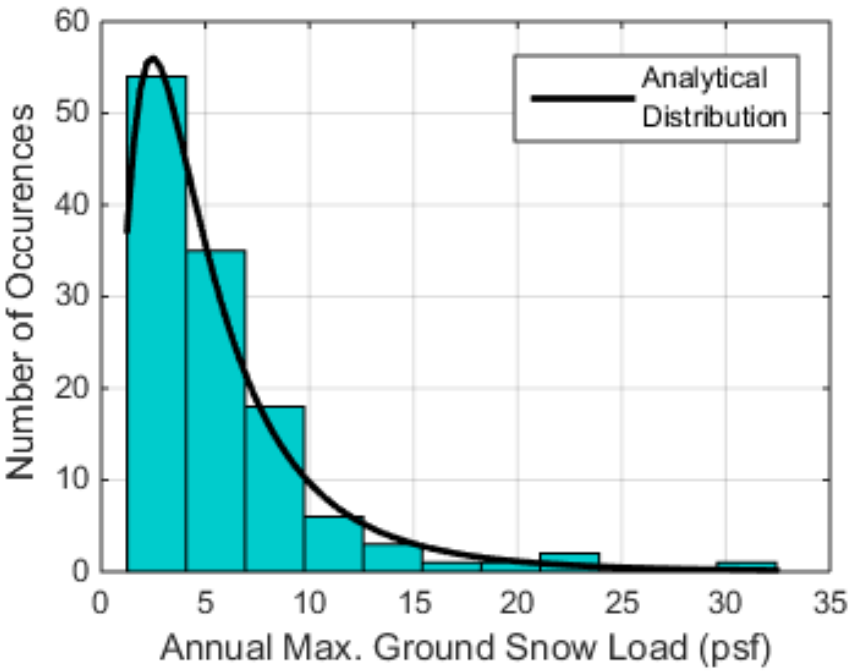
To convert to weight, we distinguish between sites where snow is expected to be **compacted** and those where it is **settled**



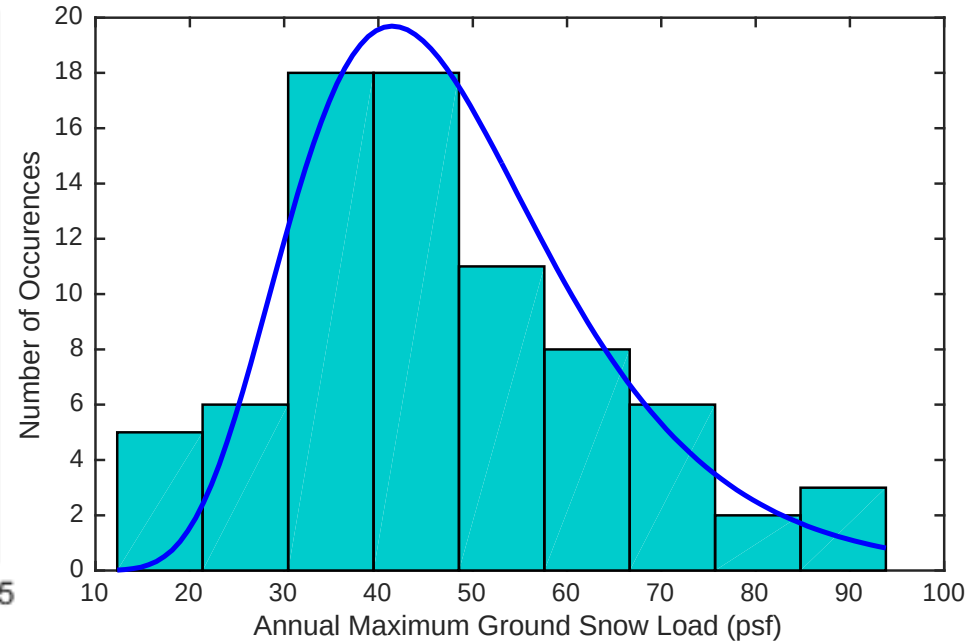


Ground Snow Loads

DENVER - single storm example



Aspen – winter accumulation



Our analysis illustrates an important distinction between sites where single storm dominates the snow loads, and those where loads accumulate over the winter season.

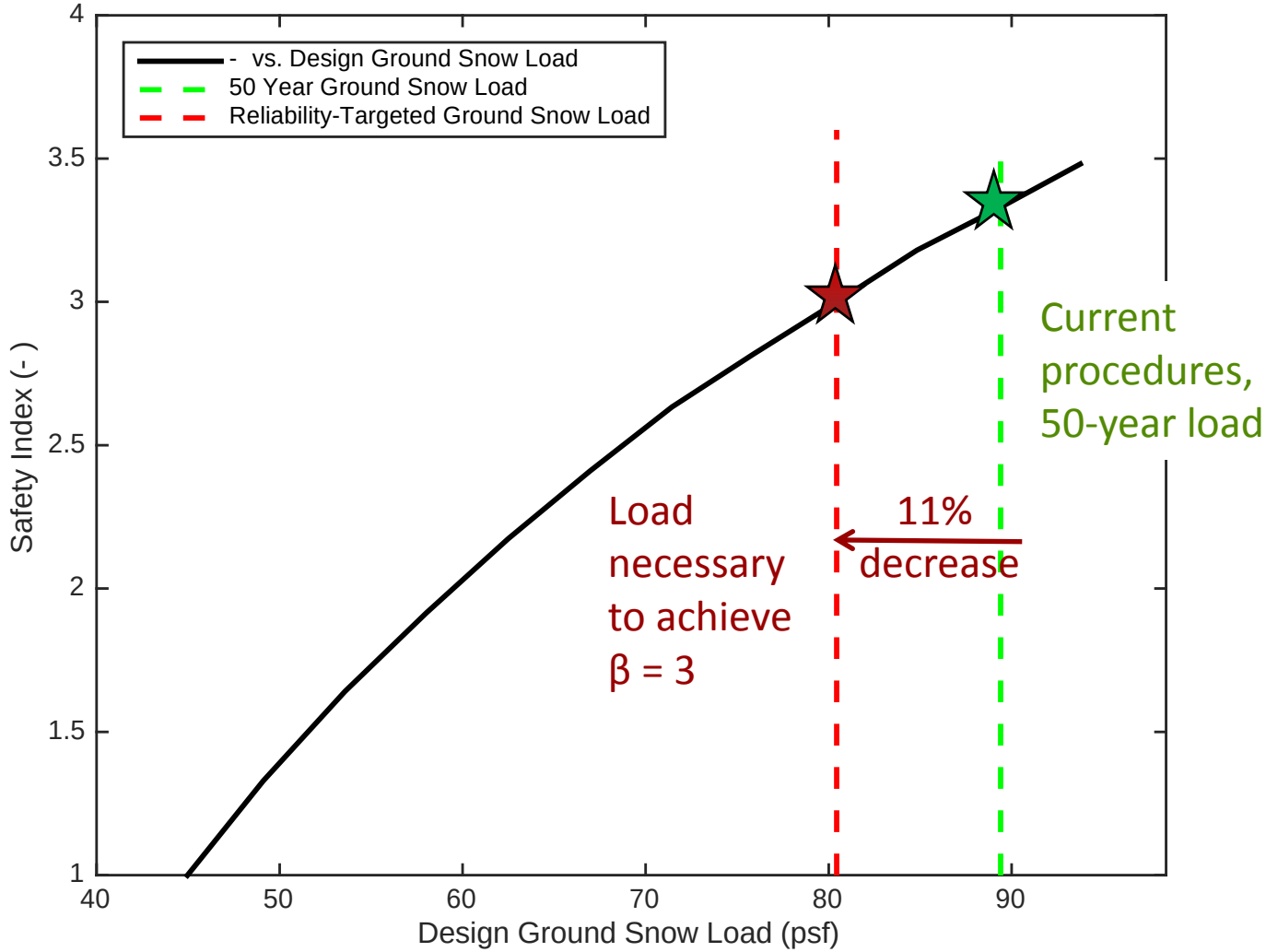
Reliability of Roofs under Snow Loads in Colorado

- Design flat roof "test" structure according to current approaches
- Use structural reliability methods to determine probability of failure and reliability index based on uncertainties in load on roof and resistance (capacity) of roof

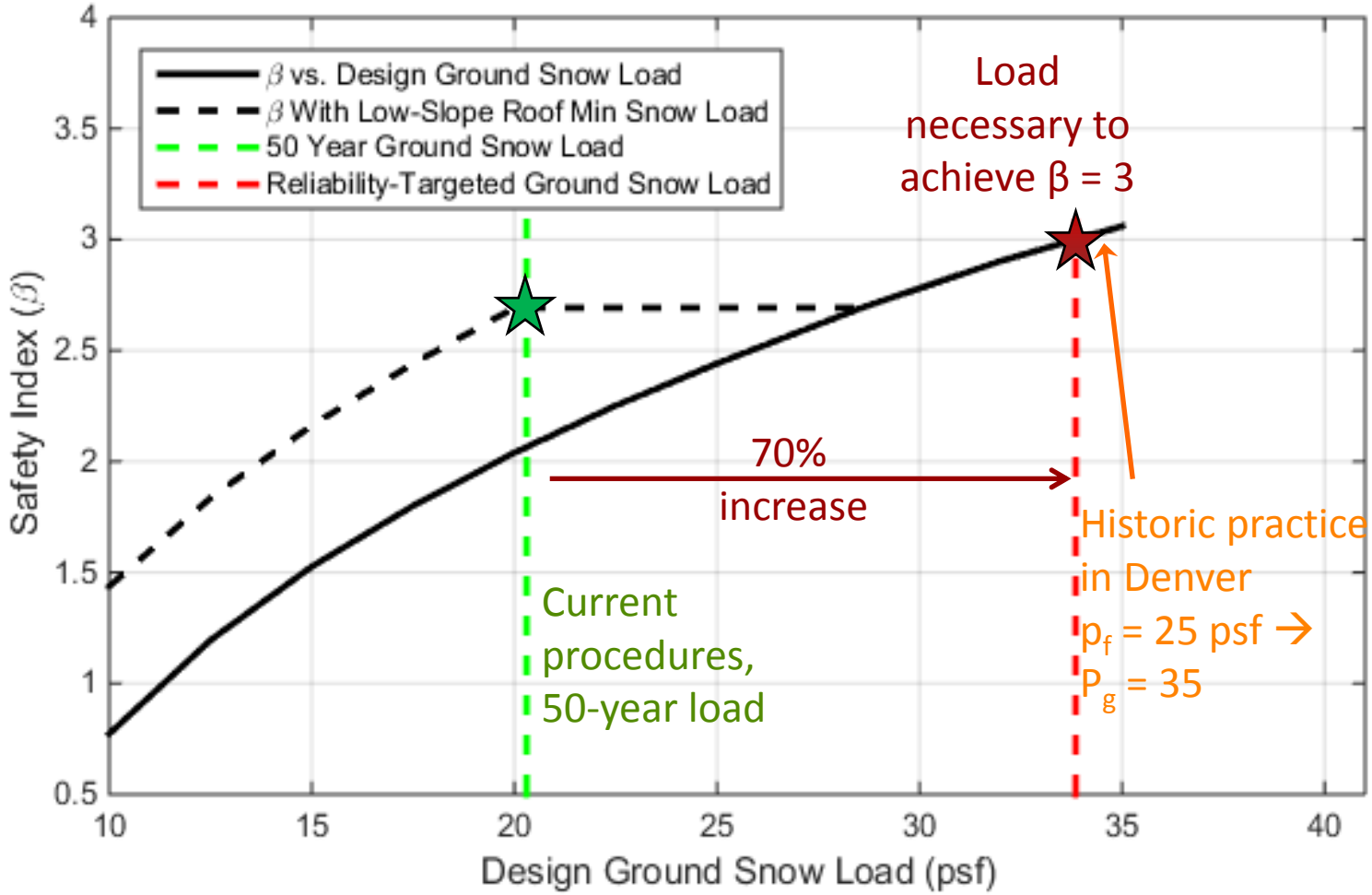
Test Structure

Design Quantity	Value
Roof Type	Simply-supported steel beam
Roof Span	30 ft
Tributary Span	30 ft
Dead Load	15 psf
Elastic Modulus	29000 ksi
Steel Yield Strength	50 ksi
Thermal, Exposure, Importance Factors	1

Example Results: Aspen

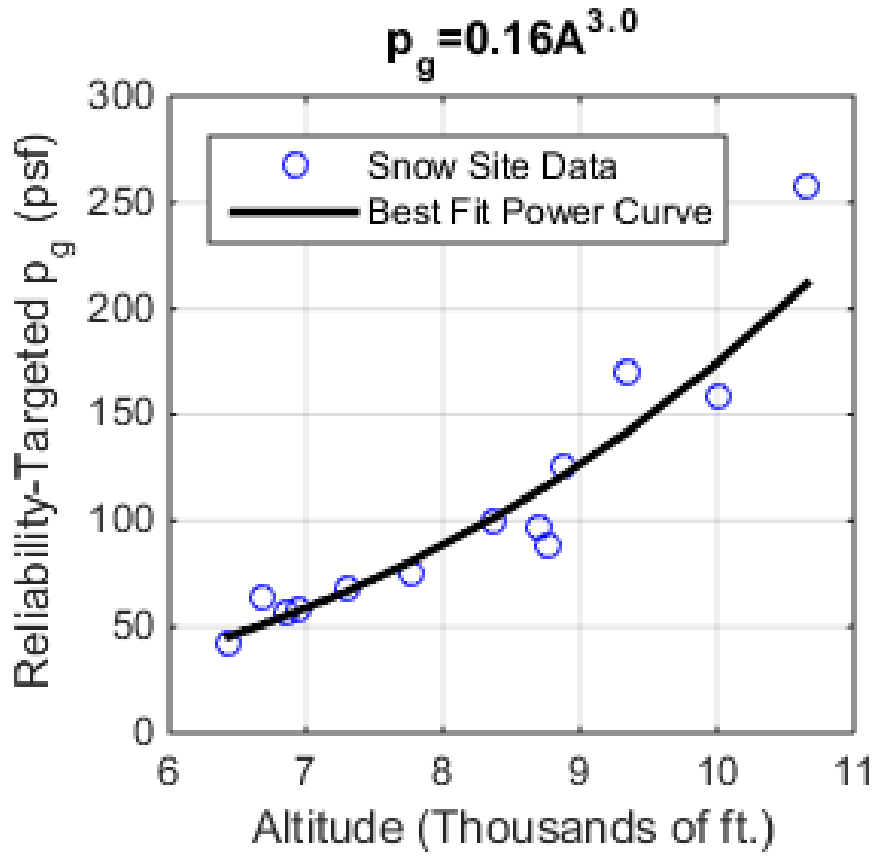


Example Results: Denver

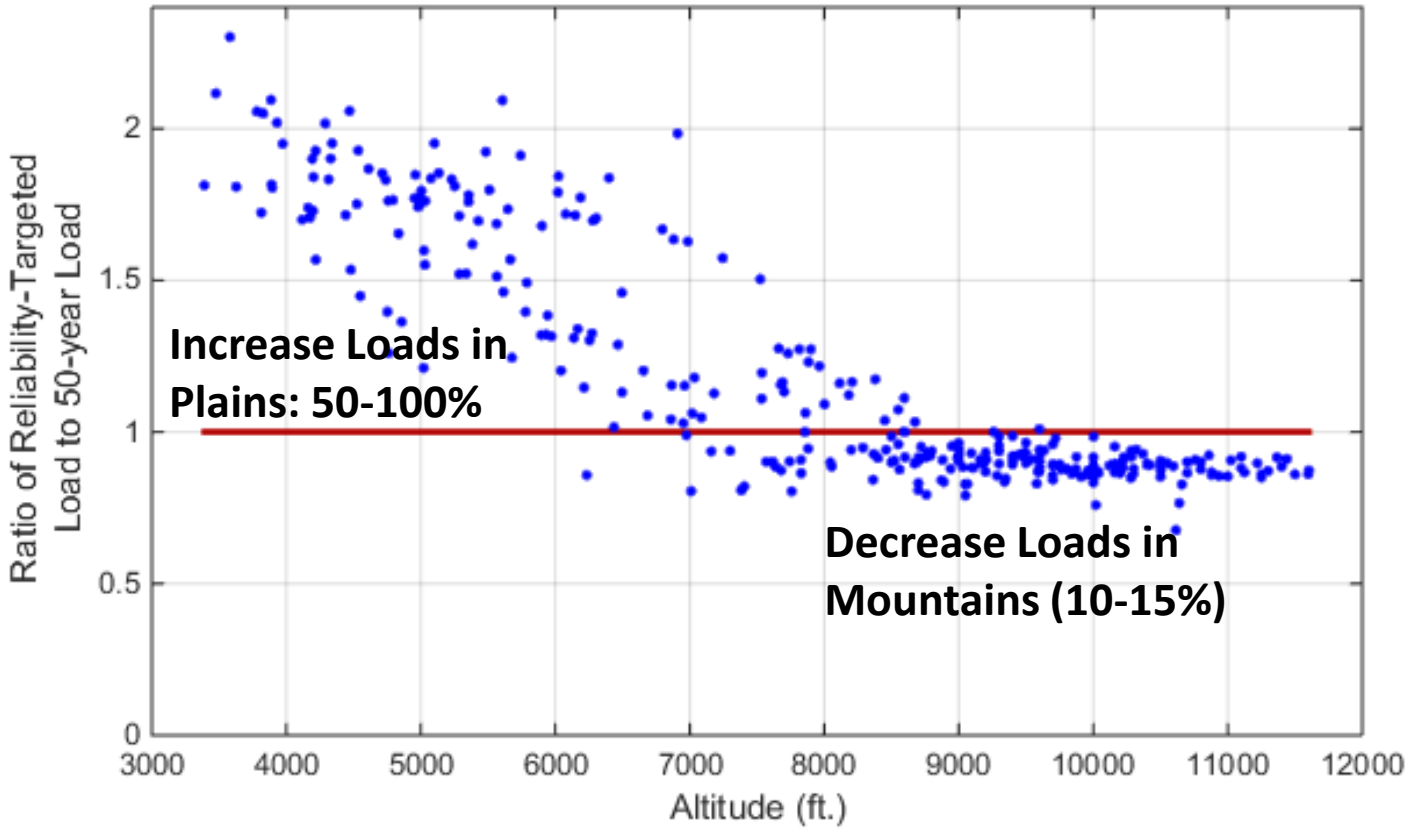


Variation of Snow Loads with Altitude

- Altitude especially important for mapping snow loads for location between snow sites
- Plains
  - *Snow load* ∝ *Altitude*
- Elsewhere
  - *Snow load* ∝ *Altitude*^{3}



Summary of Differences in New Loads



- ***Increase in plains is already the standard of practice for roof loads***

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Determination of Design Ground Snow Loads: From the Table

- Find your city/town and corresponding p_g

City/Town	County	Latitude (deg)	Longitude (deg)	Altitude (ft)	Design Ground Snow Load (p_g) (psf)*
Arvada	Jefferson	39.8	-105.09	5350	40
Aspen	Pitkin	39.19	-106.82	7890	75
Ault	Weld	40.58	-104.73	4940	35

- Apply altitude correction (if necessary*)

$$p_{g,site} = p_{g,tabulated} * \left(\frac{A_{site}}{A_{tabulated}}\right)^3$$

where A = Altitude in thousands of ft.

Determination of Design Ground Snow Loads: From the Map

- Determine latitude, longitude and altitude of your site (A_{site})
- Determine your region and compute p_g

1. *Eastern slope, below 6500 ft. altitude*

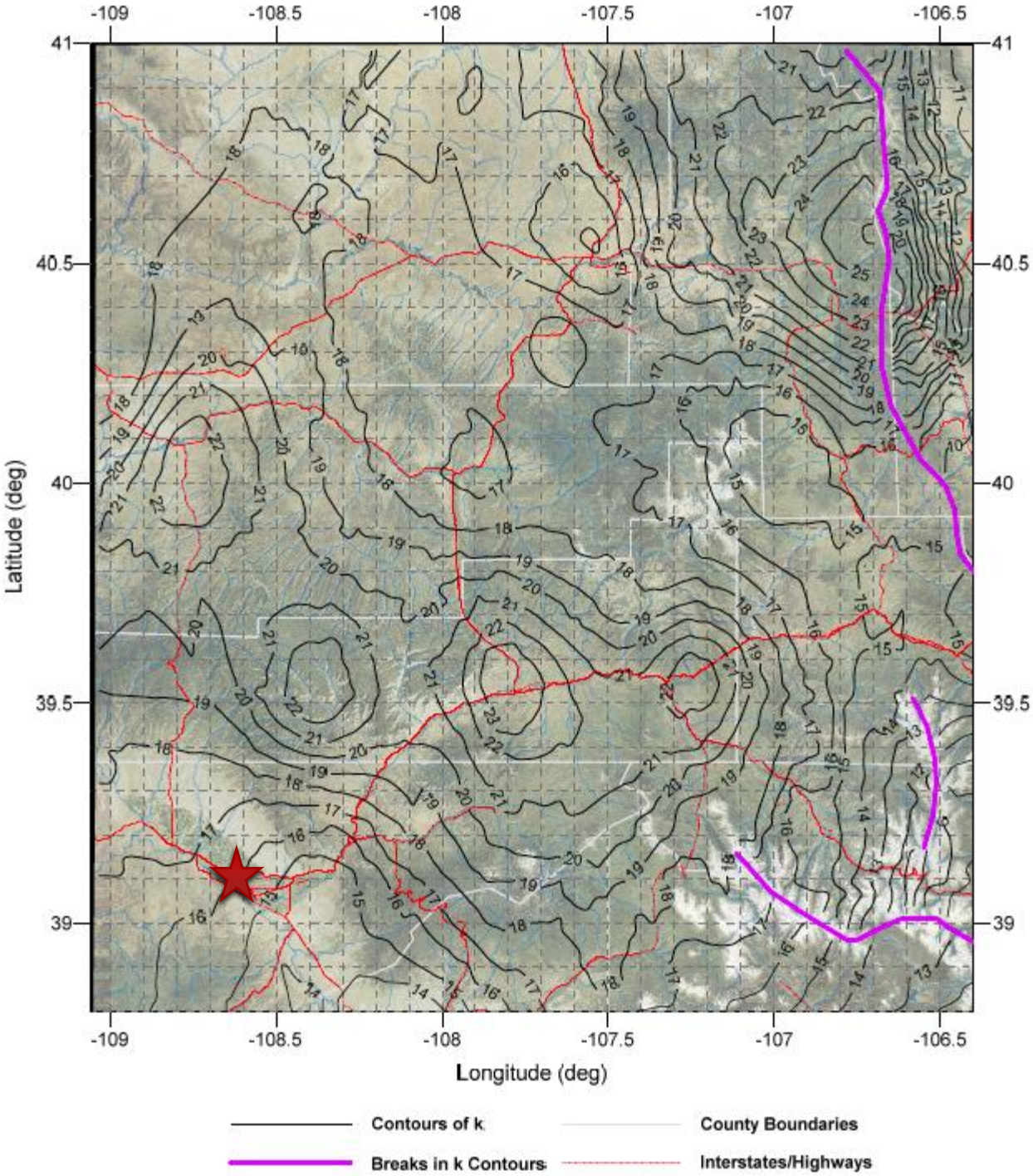
$$p_{g,site} = max[10A_{site} - 15\,, 30]$$

2. *Eastern slope, above 6500 ft. altitude*

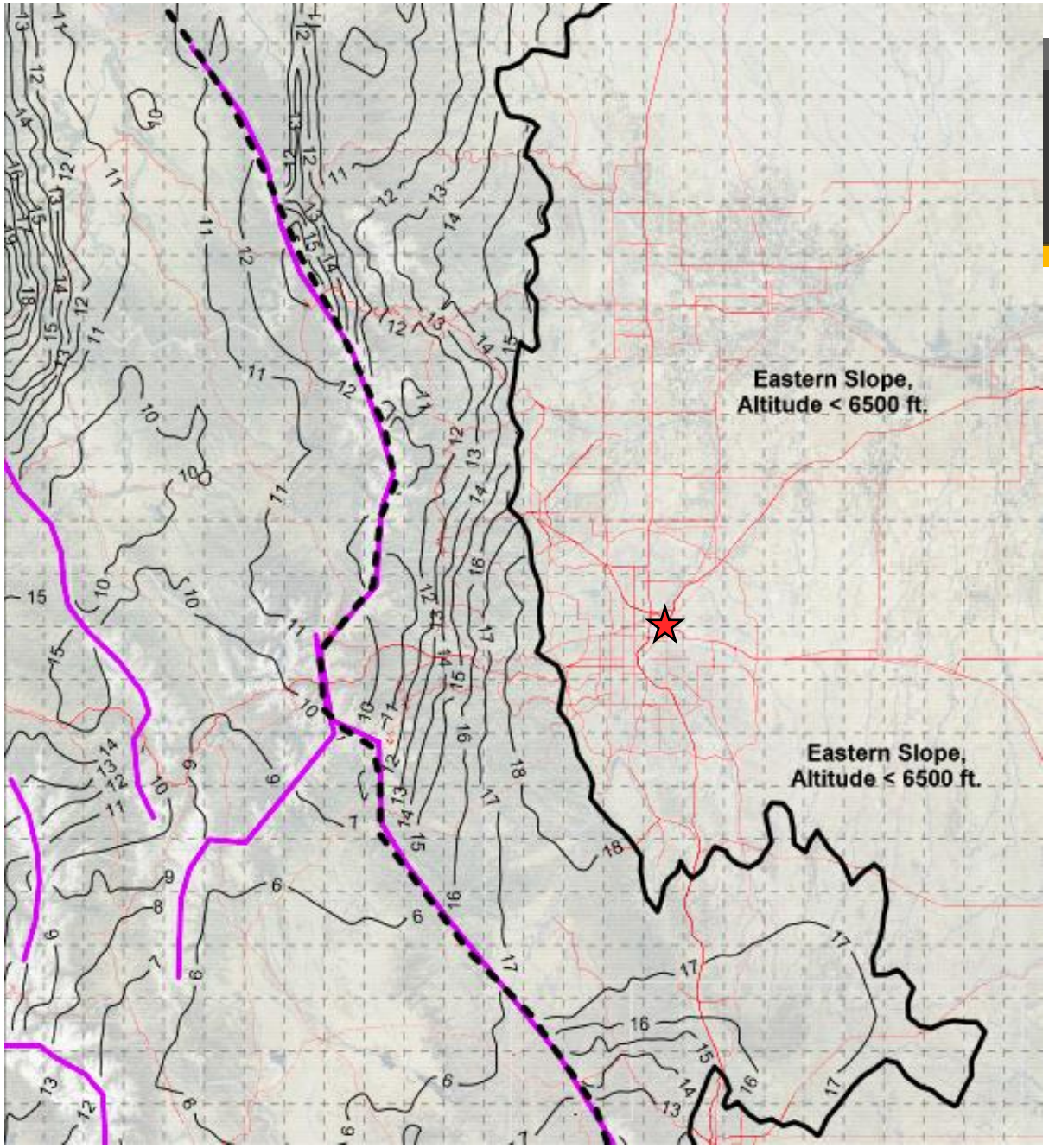
$$p_{g,site} = max\left[\frac{K_{site}}{100} * A_{site}^3, 50\right]$$

3. *All other locations*

$$p_{g,site} = max\left[\frac{K_{site}}{100} * A_{site}^3, 25\right]$$



Contour map (NW Colorado)



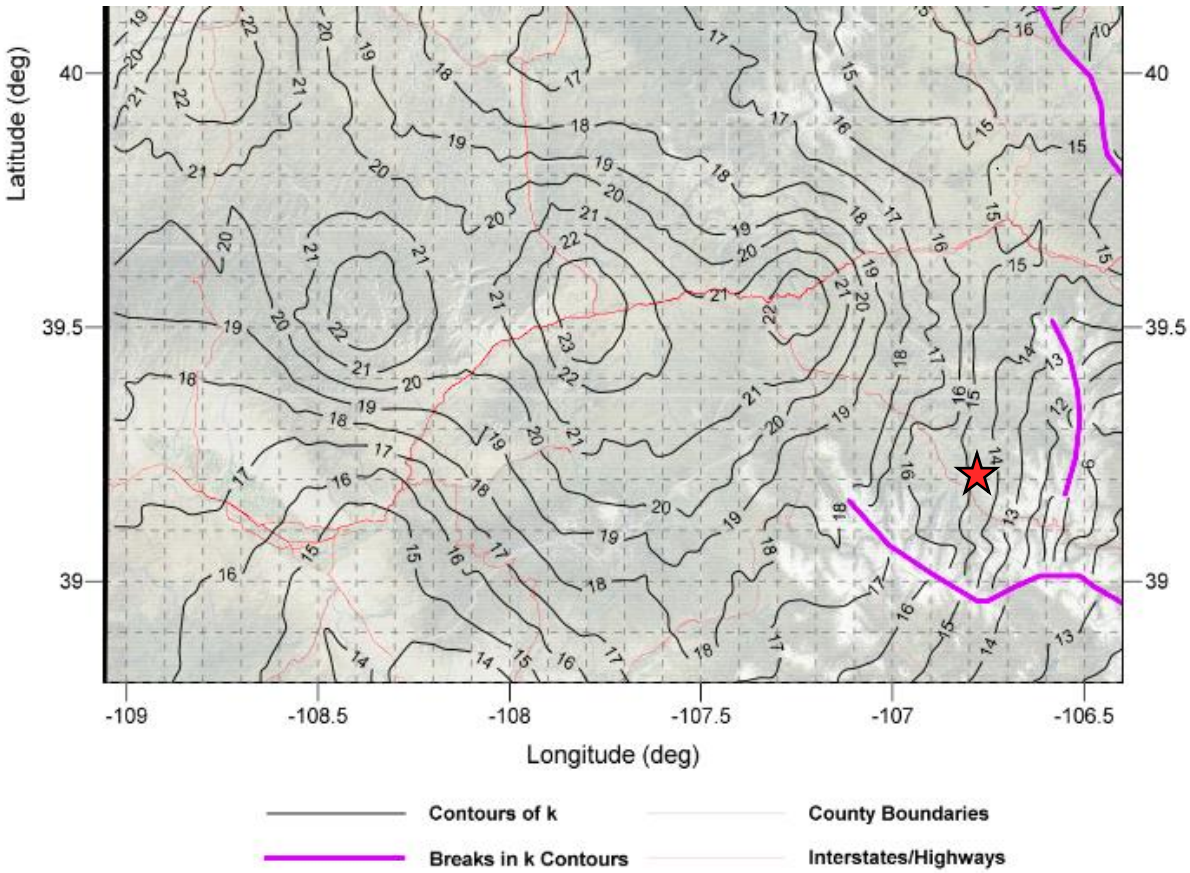
Example 1: Denver

- Site Location:
  - Lat = 39.7°
  - Lon = -105.0°
  - Alt = 5280 ft.
- Region: East of Rockies, <6500 ft.

$$p_g = max[10A_{site} - 15\,, 30]$$
$$= max[10 * 5.28 - 15\,, 30]$$
$$= \mathbf{37.8\ psf}$$

$$p_f = 0.7p_g = 26.5\ psf$$

Example 2: Aspen



- Site Location:
  - Lat = 39.19°
  - Lon = -106.82°
  - Alt = 7890 ft.
- Region: Not East of Rockies
  - K=15, from map

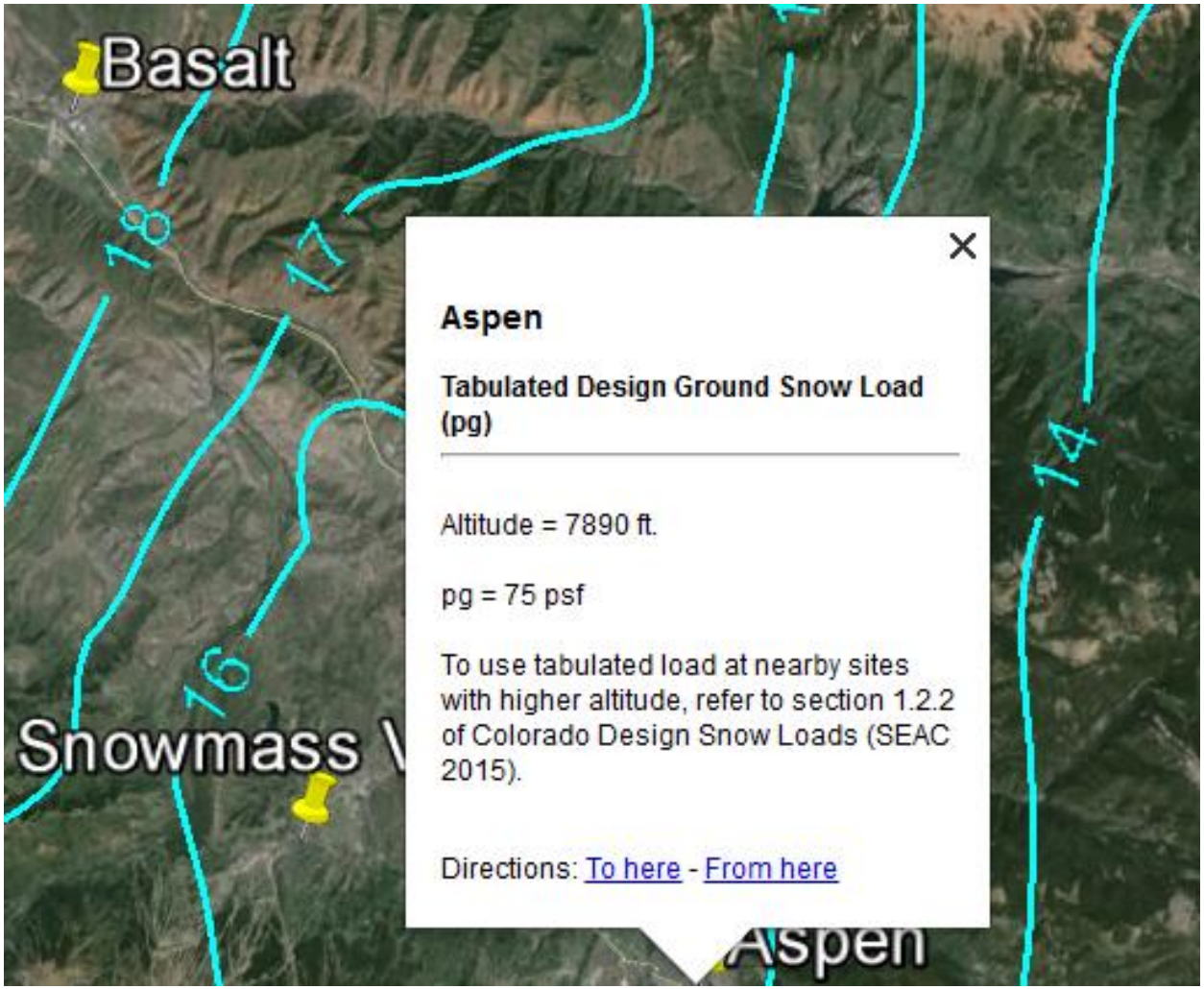
$$p_g = max\left[\frac{K}{100} * A^3, 25\right]$$

$$= max\left[\frac{15}{100} * 7.89^3, 25\right]$$

$$= \mathbf{74\ psf}$$

$$p_f = 0.7p_g = 52\ psf$$

Google Earth Overlay Combines Table and Map



Outline

I. New Colorado Ground Snow Loads
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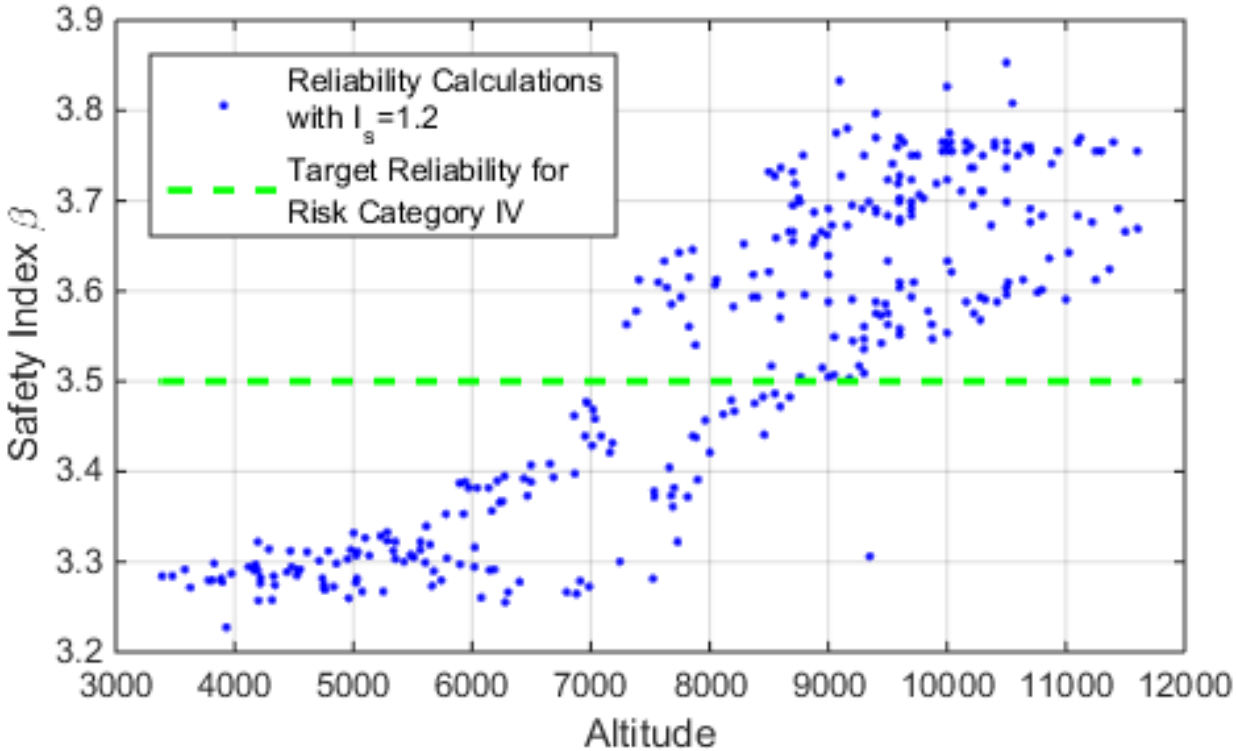
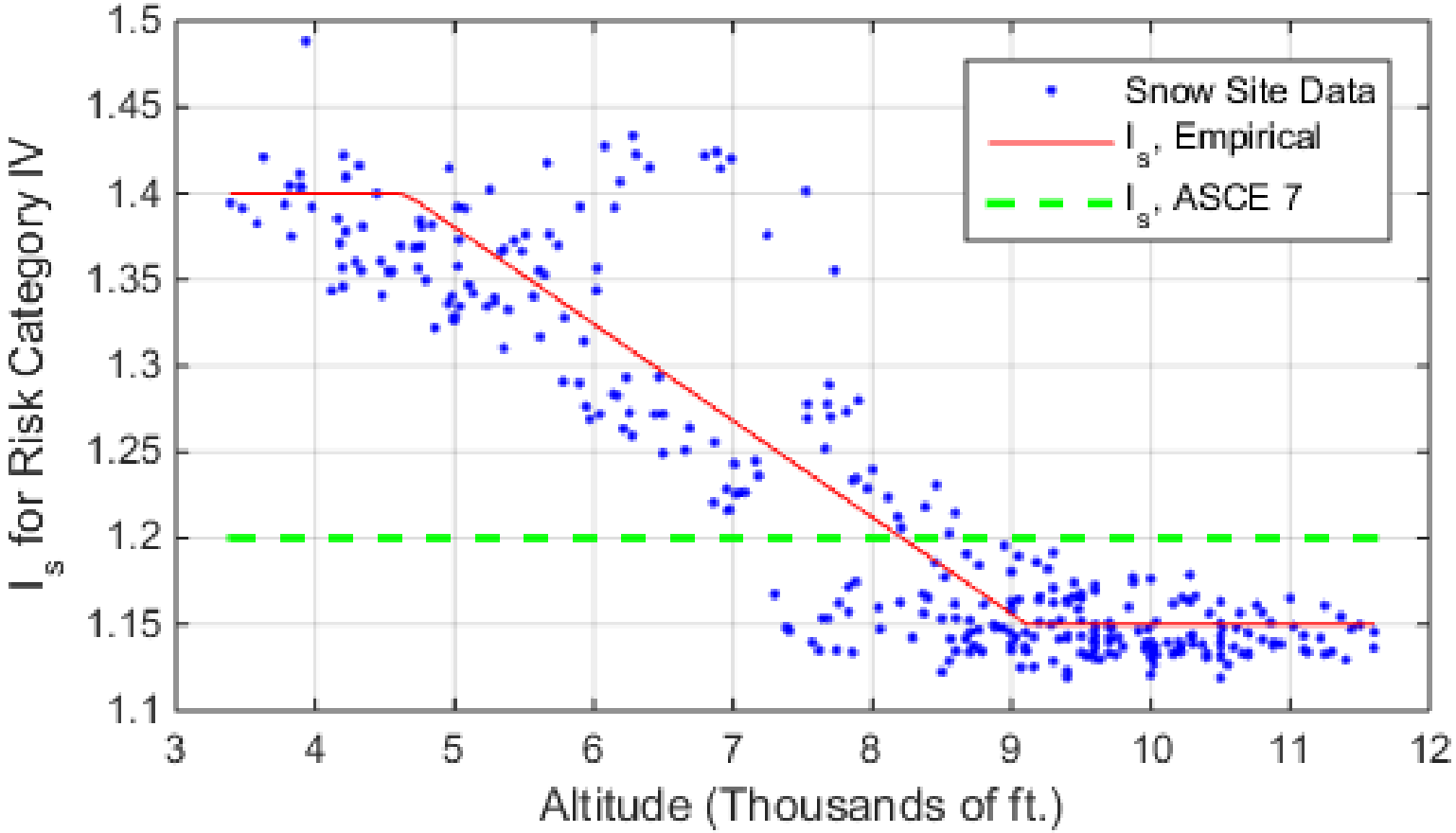
Importance Factors for Risk Categories > II

- Structures in higher Risk Categories require a higher safety index.
- Risk Category IV target reliability is $\beta_{target} = 3.5$.
- ASCE 7 defines Importance Factor of 1.2 for Risk Category IV.



Importance Factors for Risk Categories > II

- Importance Factors Vary with Altitude & K



Importance Factors for Risk Categories > II

- Risk Category IV Importance Factor:
  - $I_s = 1.15 \leq 1.66 - 0.056 * A \leq 1.4$
- A=altitude in thousands of feet
- Risk Category III Importance Factor: Is $= \frac{I_S\,(II)+I_S(IV)}{2}$
- **Denver Example, Risk Categories III and IV:**
- $I_s(IV) = 1.66 - .056 \times 5.28 = 1.4$
- $I_s(III) = \frac{1.0+1.36}{2} = 1.2$

Serviceability

- 50-year MRI loads may be appropriate for serviceability checks where deflection due to snow load does not lead to ponding instabilities (a concern where roof slope < ¼ in/ft)
  - $P_{service} = p_g * R_{service} >= 25$ psf
  - Detailed in SEAC snow report:
    - $R_{service} = 0.55 \leq .13*A-0.06 \leq 1.15$
- **Denver example.**
  - $R_{service} = 0.13*5.28-0.06=.63$
  - $P_{service} = 35*.63=22$

Conclusions & Questions

- Updates to snow load values
  - Consistent reliability
    - Decrease loads in mountains by ~10% to 20%
    - Increase loads in plains by ~50% to 100%
      - Generally consistent with present practice
  - Snow load is a function of altitude

- Where to find
  - www.seacolorado.org
  - ASCE 7-16

Outline

I. New Colorado Ground Snow Loads

II. Designing Roofs for Snow

- i. Ground vs. Roof Snow Load
- ii. Special Loading Conditions
  - i. Example: Unbalanced Loading on a Gable Roof
  - ii. Example: Drift on Lower Roof & Against Parapets and Projections
- iii. Questions

Ground vs. Roof Snow Load

Flat-Roof Snow Load

- $p_f = 0.7 * C_e * Ct * I_s * p_g$
- C_e = Exposure Factor
- C_t = Thermal Factor

Ground vs. Roof Snow Load

Table 7-2 Exposure Factor, C_e

Terrain Category	Exposure of Roof[a]		
	Fully Exposed	Partially Exposed	Sheltered
B (see Section 26.7)	0.9	1.0	1.2
C (see Section 26.7)	0.9	1.0	1.1
D (see Section 26.7)	0.8	0.9	1.0
Above the treeline in windswept mountainous areas.	0.7	0.8	N/A
In Alaska, in areas where trees do not exist within a 2-mile (3-km) radius of the site.	0.7	0.8	N/A

The terrain category and roof exposure condition chosen shall be representative of the anticipated conditions during the life of the structure. An exposure factor shall be determined for each roof of a structure.

[a]Definitions: Partially Exposed: All roofs except as indicated in the following text. Fully Exposed: Roofs exposed on all sides with no shelter[b] afforded by terrain, higher structures, or trees. Roofs that contain several large pieces of mechanical equipment, parapets that extend above the height of the balanced snow load (h_b), or other obstructions are not in this category. Sheltered: Roofs located tight in among conifers that qualify as obstructions.

[b]Obstructions within a distance of $10h_o$ provide "shelter," where h_o is the height of the obstruction above the roof level. If the only obstructions are a few deciduous trees that are leafless in winter, the "fully exposed" category shall be used. Note that these are heights above the roof. Heights used to establish the Exposure Category in Section 26.7 are heights above the ground.

Ground vs. Roof Snow Load

Table 7-3 Thermal Factor, C_t

Thermal Condition[a]	C_t
All structures except as indicated below	1.0
Structures kept just above freezing and others with cold, ventilated roofs in which the thermal resistance (R-value) between the ventilated space and the heated space exceeds 25 °F × h × ft^2/Btu (4.4 K × m^2/W).	1.1
Unheated and open air structures	1.2
Structures intentionally kept below freezing	1.3
Continuously heated greenhouses[b] with a roof having a thermal resistance (R-value) less than 2.0 °F × h × ft^2/Btu (0.4 K × m^2/W)	0.85

[a]These conditions shall be representative of the anticipated conditions during winters for the life of the structure.
[b]Greenhouses with a constantly maintained interior temperature of 50 °F (10 °C) or more at any point 3 ft above the floor level during winters and having either a maintenance attendant on duty at all times or a temperature alarm system to provide warning in the event of a heating failure.

Ground vs. Roof Snow Load

Sloped Roof Snow Load

- $p_s = C_s * p_f$
- Loads act on horizontal projection
- C_s depends on type of roof:
- Cold or Warm
- Surface: unobstructed slippery or other

Outline

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- i. Ground vs. Roof Snow Load
- ii. Special Loading Conditions
  - i. Example: Drift on Lower Roof & Against Parapets and Projections
  - ii. Example: Unbalanced Loading on a Gable Roof
- iii. Questions

Special Loading Conditions

- Ice Dams and Icicles Along Eaves
- Unbalanced Roof Snow Loads
  - Hip and Gable Roofs
  - Curved Roofs
  - Multiple Folded Plate, Sawtooth, & Barrel Vault Roofs
  - Dome Roofs
- Drifts
  - On Lower Roofs
  - Against Roof Projections and Parapets
- Sliding Snow

Special Loading Conditions

1603.1.3 Roof snow load data.
The ground snow load, P_g, shall be indicated. In areas where the ground snow load, P_g, exceeds 10 pounds per square foot (psf) (0.479 kN/m^2), the following additional information shall also be provided, regardless of whether snow loads govern the design of the roof:

1. Flat-roof snow load, P_f.

2. Snow exposure factor, C_e.

3. Snow load importance factor, I_s.

4. Thermal factor, C_t.

5. Drift surcharge load(s), P_d, where the sum of P_d and P_f exceeds 20 psf (0.96 kN/m^2).

6. Width of snow drift(s), w.

Drifted Snow on Lower Roof - Leeward

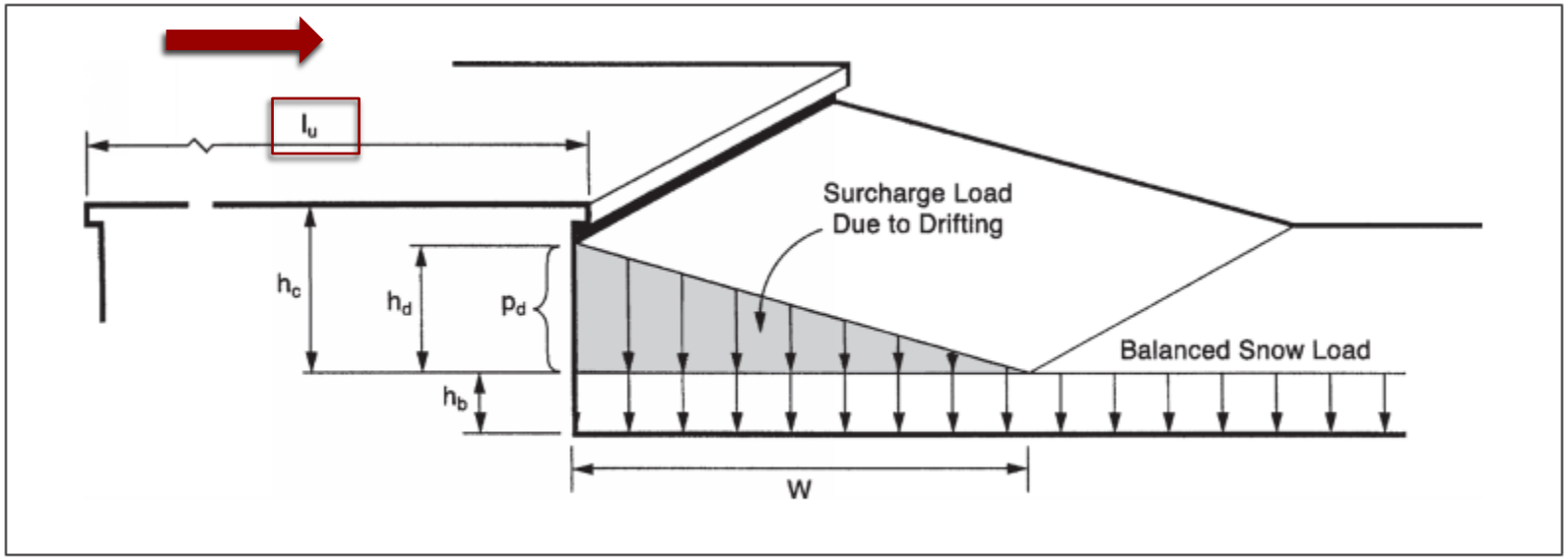
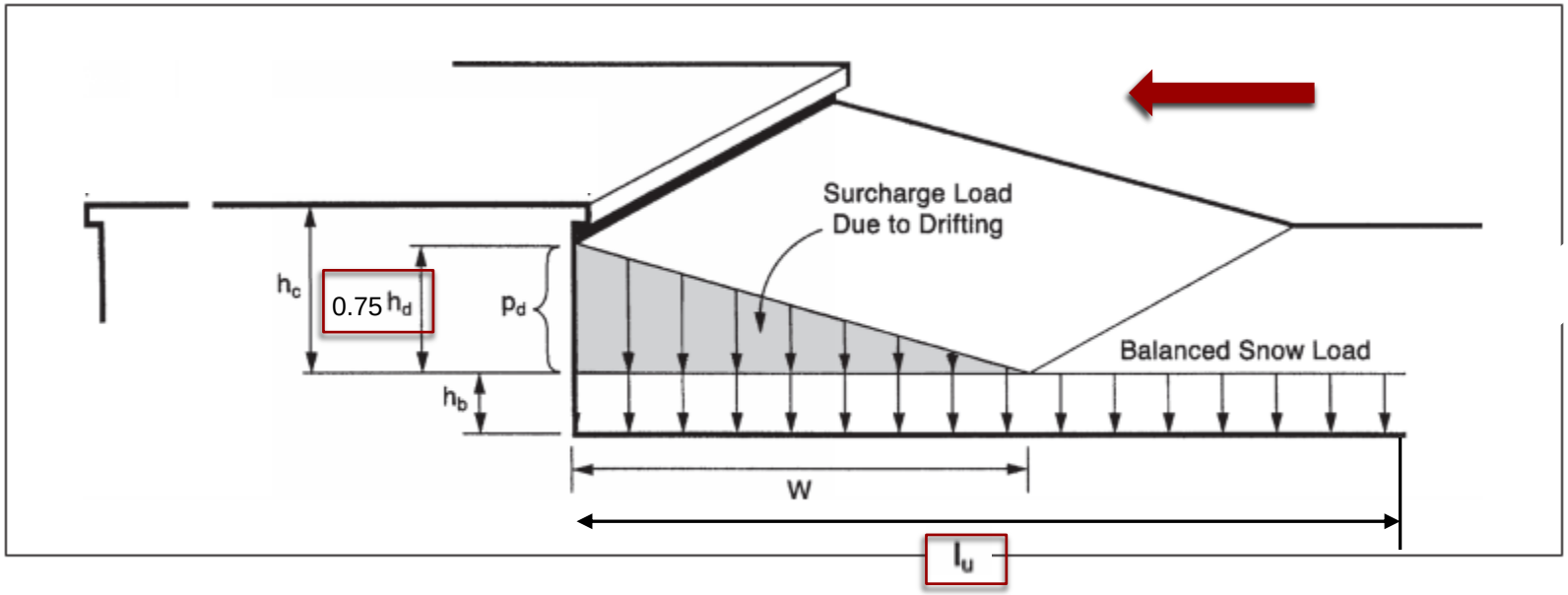
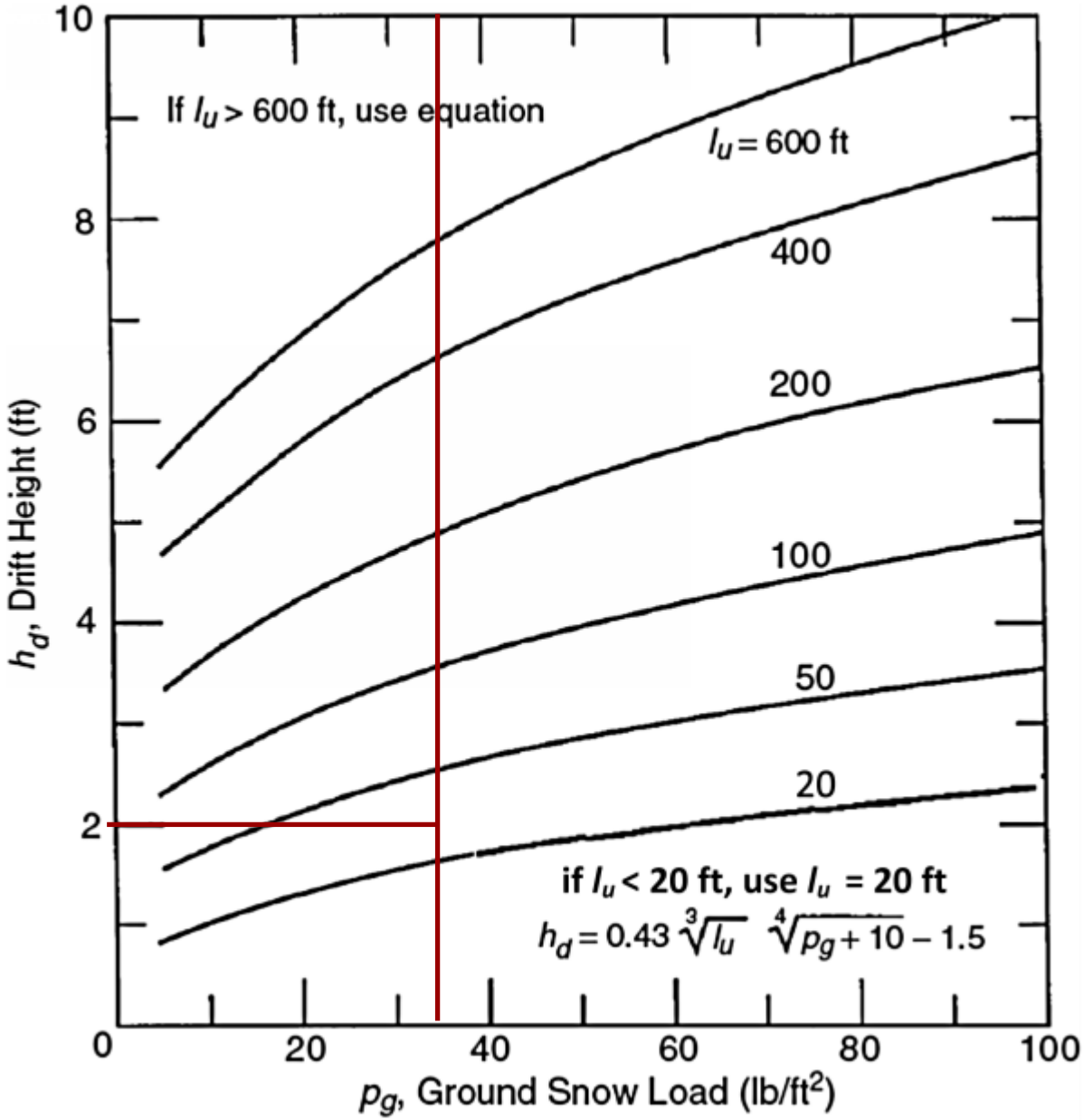


FIGURE 7-8 Configuration of Snow Drifts on Lower Roofs.

Drifted Snow on Lower Roof - Windward



Drift Load


If l_u > 600 ft, use equation
l_u = 600 ft
400
200
100
50
20
if l_u < 20 ft, use l_u = 20 ft
$h_d = 0.43\sqrt[3]{l_u}\ \sqrt[4]{p_g + 10} - 1.5$
h_d, Drift Height (ft)
p_g, Ground Snow Load (lb/ft^2)
0
2
4
6
8
10
20
40
60
80
100

Outline

I. New Colorado Ground Snow Loads

II. Designing Roofs for Snow

- i. Ground vs. Roof Snow Load
- ii. Special Loading Conditions
  - i. Example: Drift on Lower Roof & Against Parapets and Projections
  - ii. Example: Unbalanced Loading on a Gable Roof
- iii. Questions

Drift on Lower Roof & Against Parapets and Projections

1. Determine Ground Snow Load from SEAC Snow Load Report
2. Determine Exposure Factor from ASCE-7
3. Determine Thermal Factor from ASCE-7
4. Determine Importance Factor from SEAC Snow Load Report
5. Calculate Flat Roof Snow Load per ASCE-7
6. Calculate Minimum Snow Load for Low-Slope Roofs per ASCE-7

Drift on Lower Roof & Against Parapets and Projections

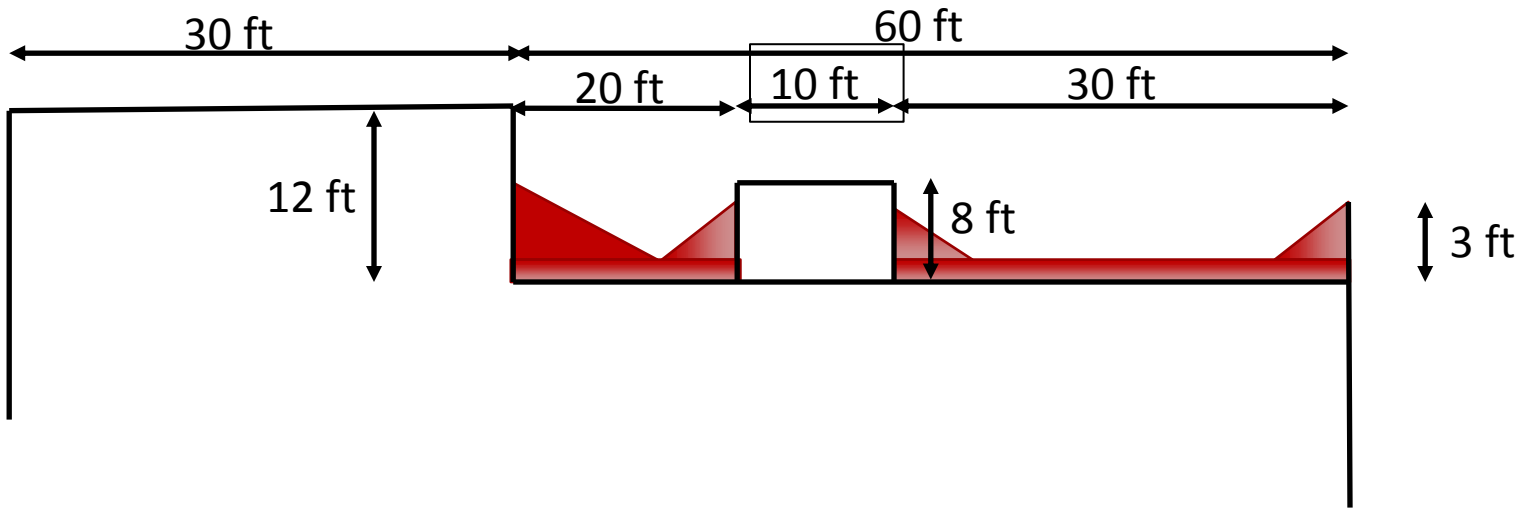
1. Denver → p_g = 35 psf
2. Exposure C, Partially Exposed→ C_e = 1.0
3. R=30, not ventilated→ C_t = 1.0
4. Risk Category III → I_s = 1.2
5. $p_f = 0.7*C_e*C_t*I_s*p_g$

   p_f = 0.7*1.0*1.0*1.2*35psf = 29 psf
6. p_g>20 psf → p_m = 20(Is) = 20*1.2 = 24 psf < **29 psf**

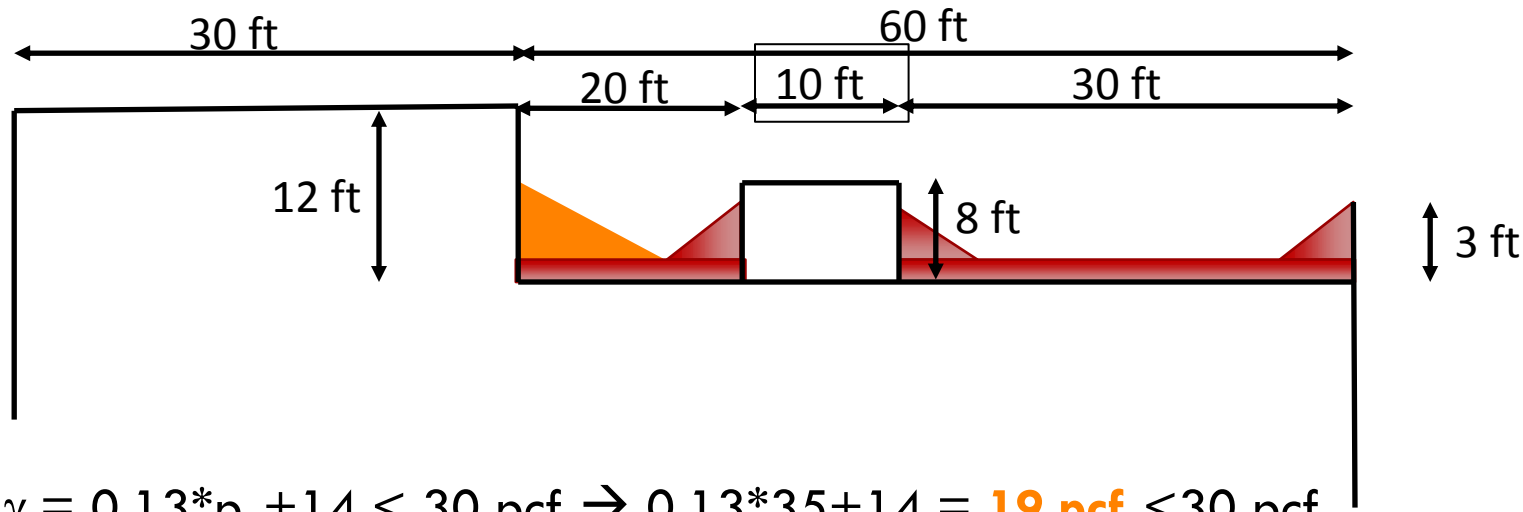
Drift on Lower Roof & Against Parapets and Projections

- Calculate h_b, height of balanced snow load
- Calculate h_c, clear height from top of balanced snow load to closest point on adjacent upper roof, top of parapet, or top of a projection on the roof
- Check to see if drift needs to be considered
- Calculate drift

Drift on Lower Roof & Against Parapets and Projections



Drift on Lower Roof



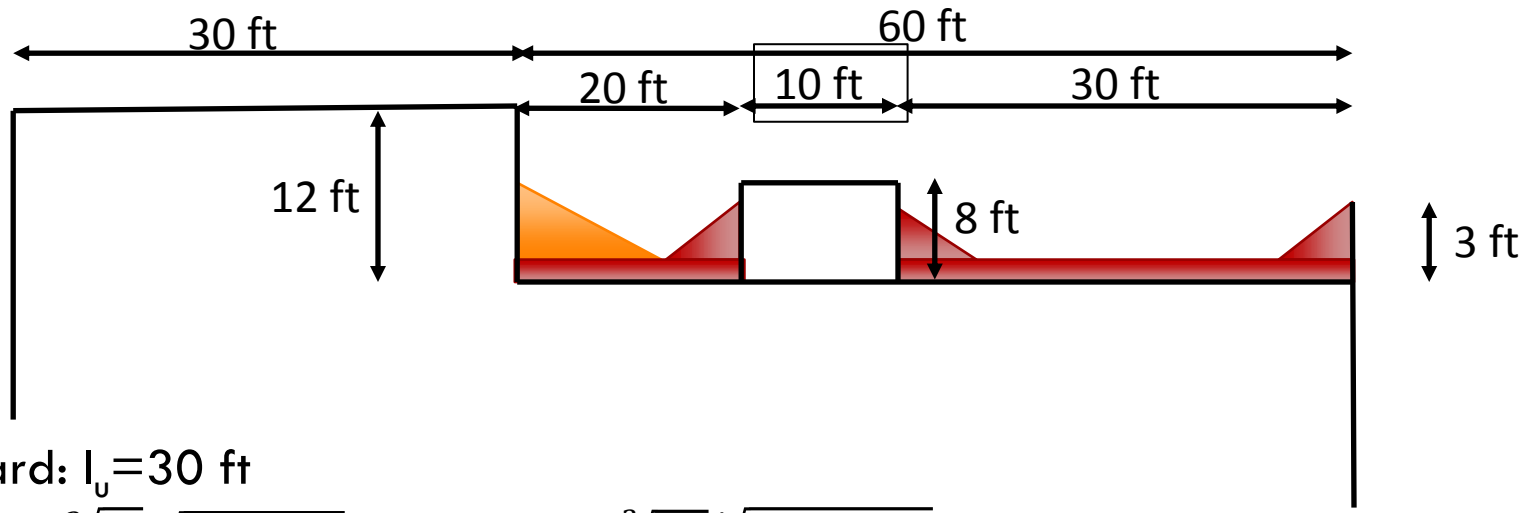
$\gamma = 0.13*p_g+14 \leq 30$ pcf → $0.13*35+14 =$ **19 pcf** ≤ 30 pcf

$h_b = p_s/\gamma$ → $h_b = 29$ psf/19 pcf $= 1.5$ ft

$h_c = h - h_b = 12\text{ft} - 1.5\text{ft} = 10.5$ ft

$h_c/h_b = 7 > 0.2$ → Drift should be considered

Drift on Lower Roof



Leeward: l_u=30 ft

$$h_d = .43\sqrt[3]{l_u}\sqrt[4]{p_g + 10} - 1.5 = 0.43\sqrt[3]{30}\sqrt[4]{35 + 10)} - 1.5 = 2.0\ ft$$

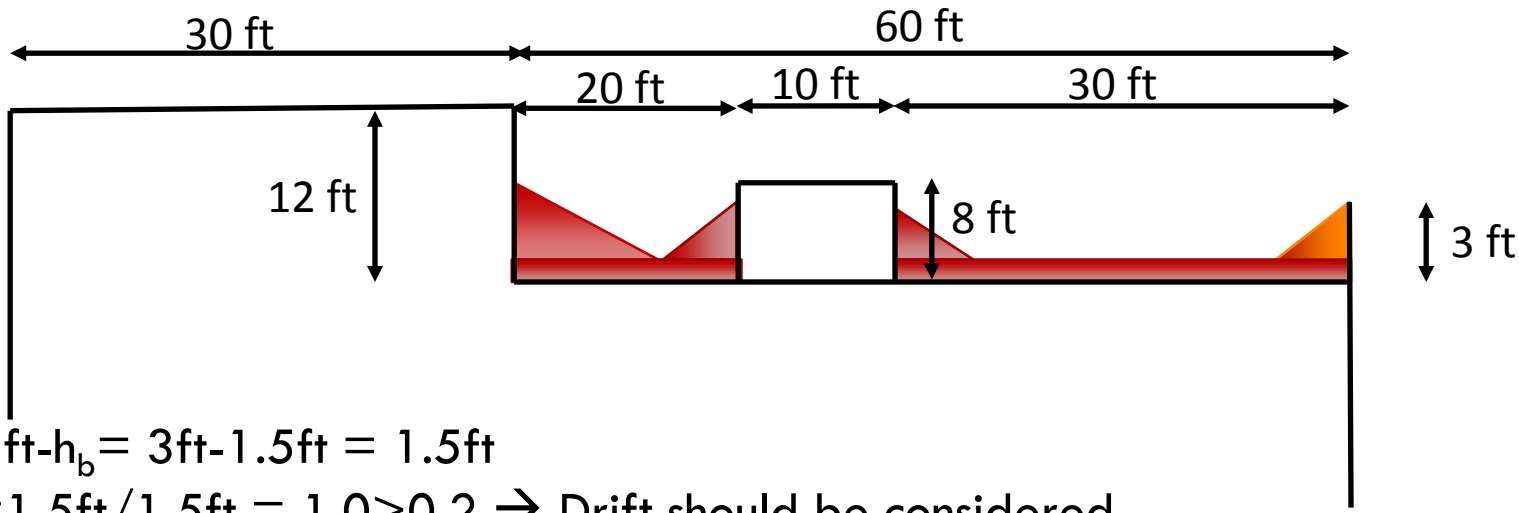
Windward: l_u= 60 ft

$$h_d = .75\left(.43\sqrt[3]{l_u}\sqrt[4]{p_g + 10} - 1.5\right) = .75\left(.43\sqrt[3]{60}\sqrt[4]{(35 + 10)} - 1.5\right) = 2.1\ ft$$

$h_d \leq h_c$ → w= $4h_d \leq 8h_c$ → 4*2.1ft ≤ 8*10.5ft → **8.4ft** ≤ 84ft

$p_d = h_d\gamma$ = 2.1ft*19pcf=**40 psf**

Drift Against Parapet



$h_c = 3\text{ ft} - h_b = 3\text{ft} - 1.5\text{ft} = 1.5\text{ft}$

$h_c/h_b = 1.5\text{ft}/1.5\text{ft} = 1.0 > 0.2$ → Drift should be considered

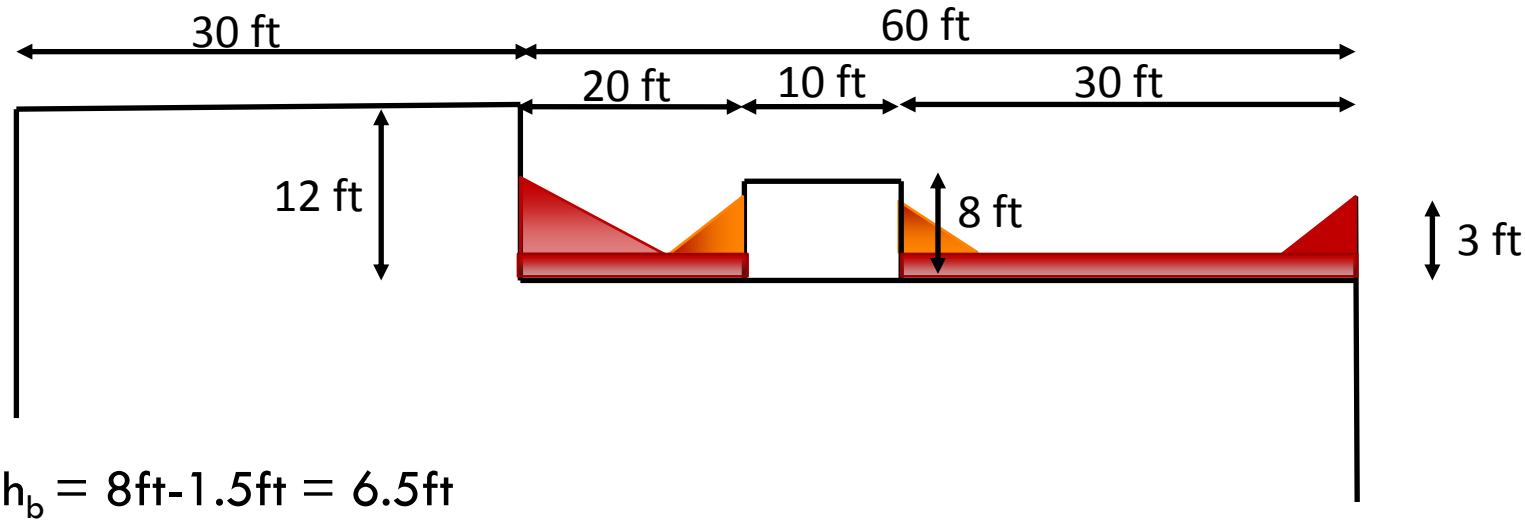
$$h_d = .75\left(.43\sqrt[3]{l_u}\sqrt[4]{p_g + 10} - 1.5\right) = .75\left(.43\sqrt[3]{60}\sqrt[4]{(35+10)} - 1.5\right) = 2.1\ ft$$

$h_d > h_c$ → drift height = h_c = **1.5 ft**

$w = 4h_d^2/h_c \leq 8h_c$ → $4*1.5^2/1.5 \leq 8*1.5\text{ft}$ → $6\text{ft} \leq$ **12ft**

$p_d = h_d\gamma = 1.5\text{ft}*19\text{pcf} =$ **28 psf**

Drift Against Projection



h_c = 8 ft-h_b = 8ft-1.5ft = 6.5ft

h_c/h_b= 6.5ft/1.5ft = 4.3 > 0.2 → Drift should be considered

l_u= max length of roof upwind or downwind of projection

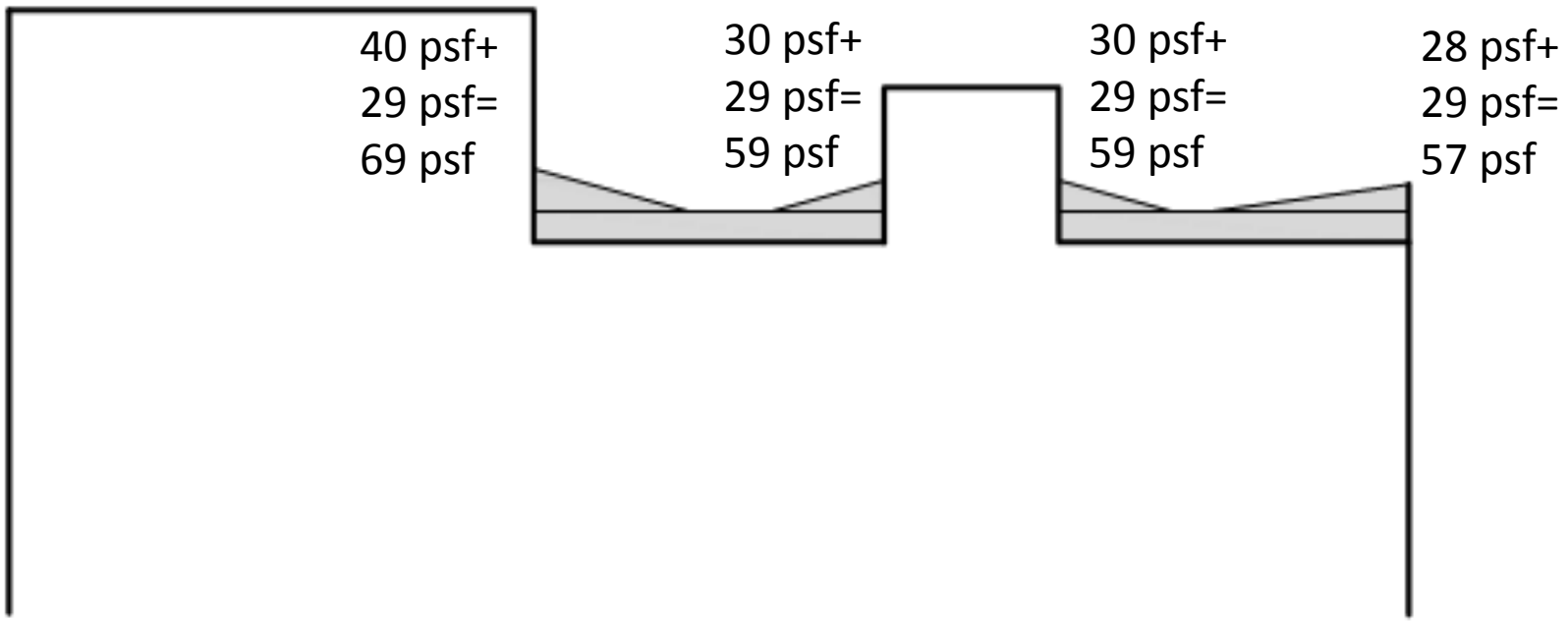
= max(25 ft, 35 ft) = 35 ft

$$h_d = .75\left(.43\sqrt[3]{l_u}\sqrt[4]{p_g + 10} - 1.5\right) = .75\left(.43\sqrt[3]{35}\sqrt[4]{(35+10)} - 1.5\right) = 1.6\,ft$$

$h_d \leq h_c$ → $w=4h_d \leq 8h_c$ → 4*1.6ft ≤ 8*6.5ft = **6.4ft** ≤51.2ft

$p_d = h_d\gamma$ = 1.6ft*19pcf = **30 psf**

Drift on Lower Roof & Against Parapets and Projections



Outline

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- i. Ground vs. Roof Snow Load
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  - ii. Example: Unbalanced Loading on a Gable Roof
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Unbalanced Loading on a Gable Roof

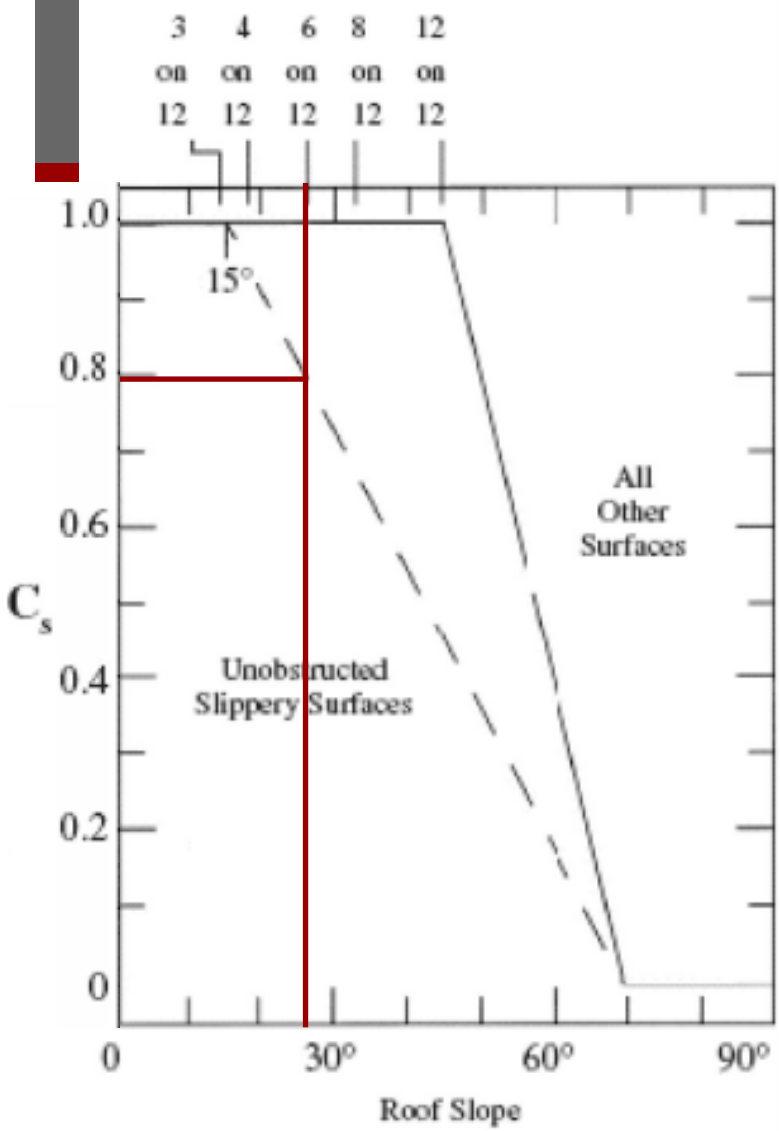
1. Determine Ground Snow Load from SEAC Snow Load Report
2. Determine Exposure Factor from ASCE-7
3. Determine Thermal Factor from ASCE-7
4. Determine Importance Factor from SEAC Snow Load Report
5. Calculate Flat Roof Snow Load per ASCE-7
6. Calculate Sloped Roof Snow Load per ASCE-7
7. Calculate Unbalanced Snow Load per ASCE-7

Unbalanced Loading on Gable Roof

1. Aspen → p_g = 75 psf
2. Exposure B, Sheltered→ C_e = 1.2
3. Unheated → C_t = 1.2
4. Risk Category II → I_s = 1.0
5. $p_f = 0.7*C_e*Ct*I_s*p_g$

   $p_f = 0.7*1.2*1.2*1.0*75psf = 75$ psf

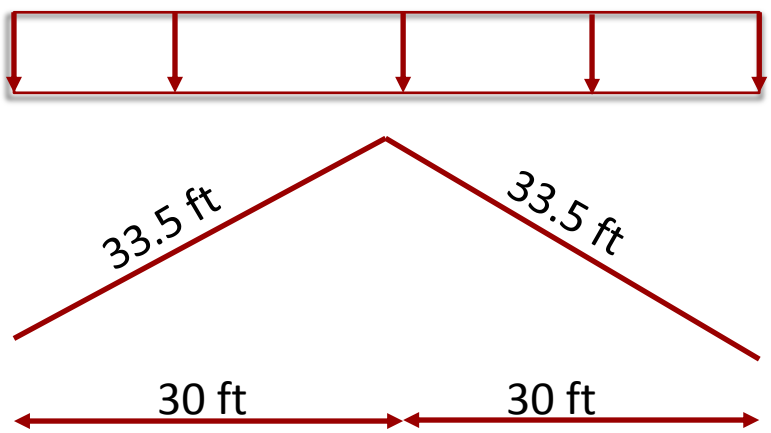
Unbalanced Loading on Gable Roof



7-2c: Cold roofs with C = 1.2 or larger

6. $p_s = C_s p_f$

   $p_s = 0.8*75$ psf = **60 psf**

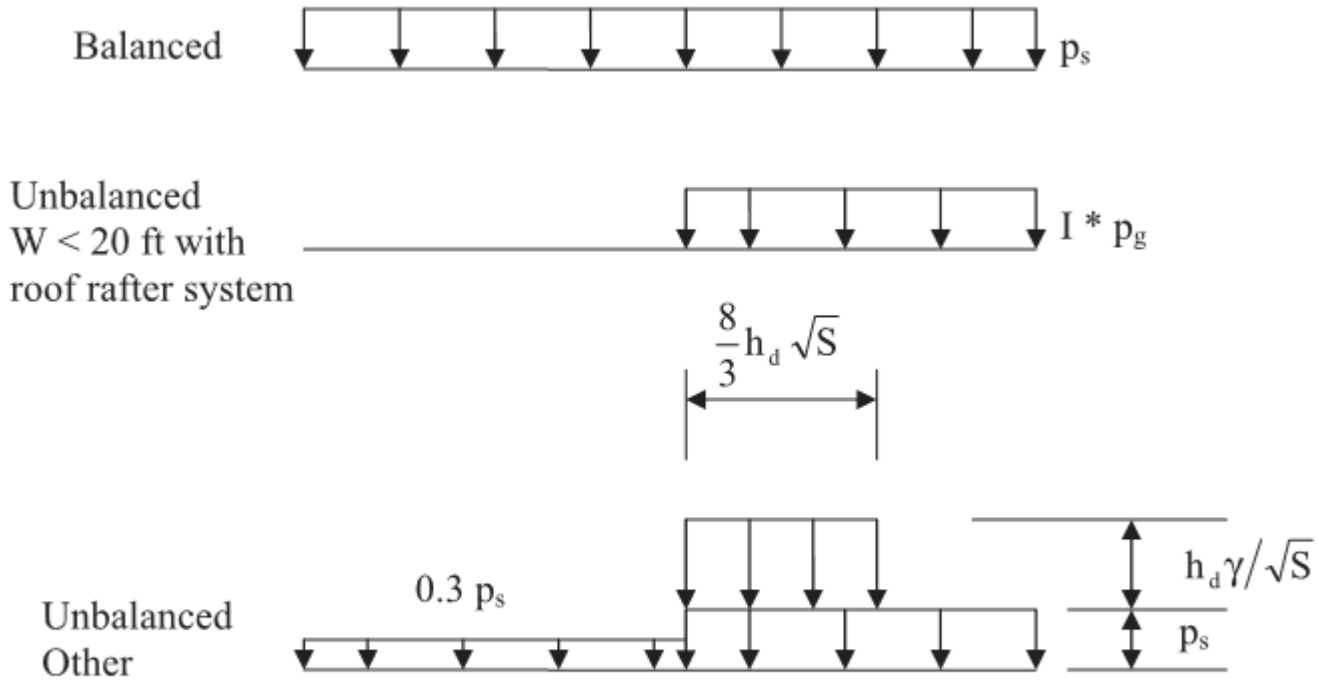


Total snow on roof =

60 psf * 60 ft = 3,600 plf

≤60 psf *67 ft = 4,020 plf

Unbalanced Loading on Gable Roof



Note: Unbalanced loads need not be considered for $\theta > 30.2°$ (7 on 12) or for $\theta \leq 2.38°$ (1/2 on 12).

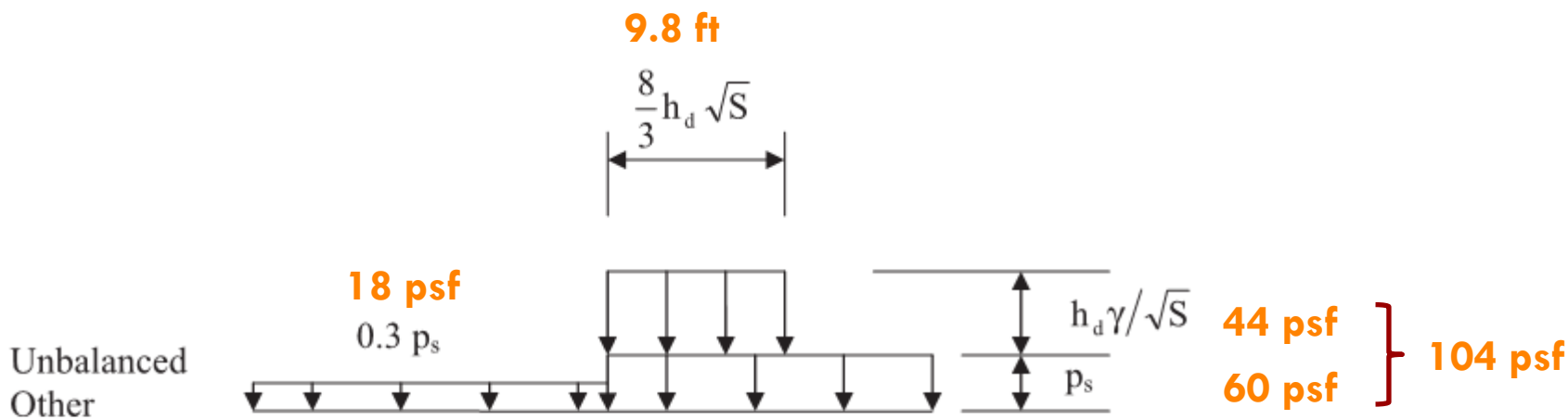
Unbalanced Loading on Gable Roof

$$h_d = .43\sqrt[3]{l_u}\sqrt[4]{p_g + 10} - 1.5 = 0.43\sqrt[3]{30}\sqrt[4]{(75 + 10)} - 1.5 = 2.6\ ft$$

L_u=W=horizontal distance from eave to ridge = 30 ft

S= roof slope run for a rise of one = 2

γ=snow density = $0.13p_g+14 \leq 30 = 0.13*75+14 = 24$ pcf



Note: Unbalanced loads need not be considered for $\theta > 30.2°$ (7 on 12) or for $\theta \leq 2.38°$ (1/2 on 12).

Questions?

SNOW LOADS: GUIDE TO THE SNOW LOAD PROVISIONS OF ASCE 7-10

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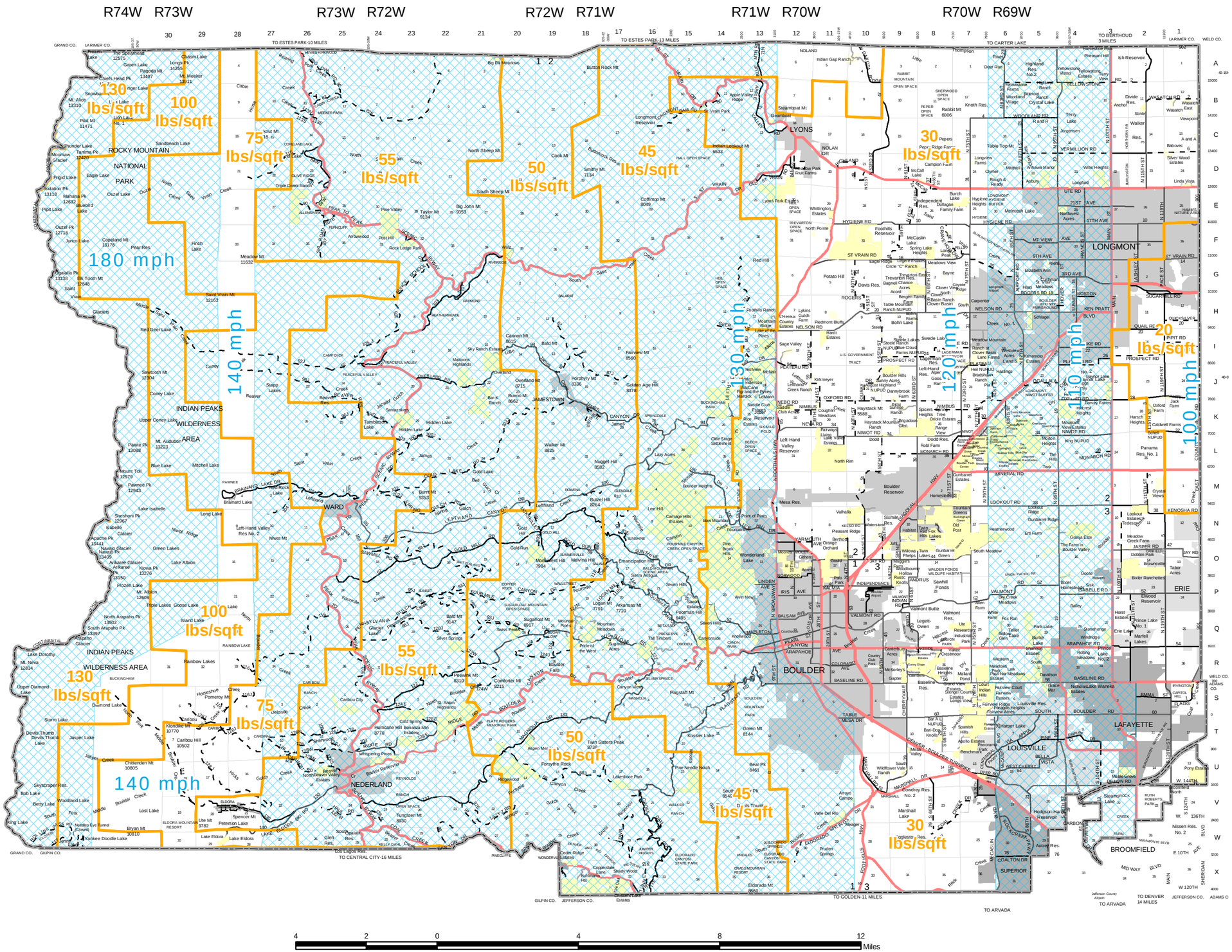
Colorado Front Range Gust Map and Snow Load Design Data for Colorado



LEGEND

140 mph

Design 3 Second Gust Wind Load

Interpolate between vertically labelled lines. Constant with horizontally labelled areas.

50 lbs/sqft

Design Ground Snow Load

Incorporated Areas

Subdivision or Platted Area

Note:

Snow load design data based on report on "Snow load design data for Colorado", prepared by the Structural Engineers Assoc. of Colorado, Oct, 1971. Modified by by the Boulder County building official as permitted in the International Building Code 2006 and International Residential Code 2006. This design data map provides the basic design ground snow loads for anywhere within Boulder County.

Wind Load design data based on a report titled "Colorado Front Range Gust Map" presented to the Structural Engineers Association of Colorado (SEAC) at its March 16, 2006 General Meeting, authored by Jon A. Peterka with the technical assistance of SEAC's Wind Load Committee

North

Boulder County

This map is for illustrative purposes only, and is not suitable for parcel-specific decision making. The areas depicted here are approximate. More site-specific studies may be required to draw accurate conclusions.

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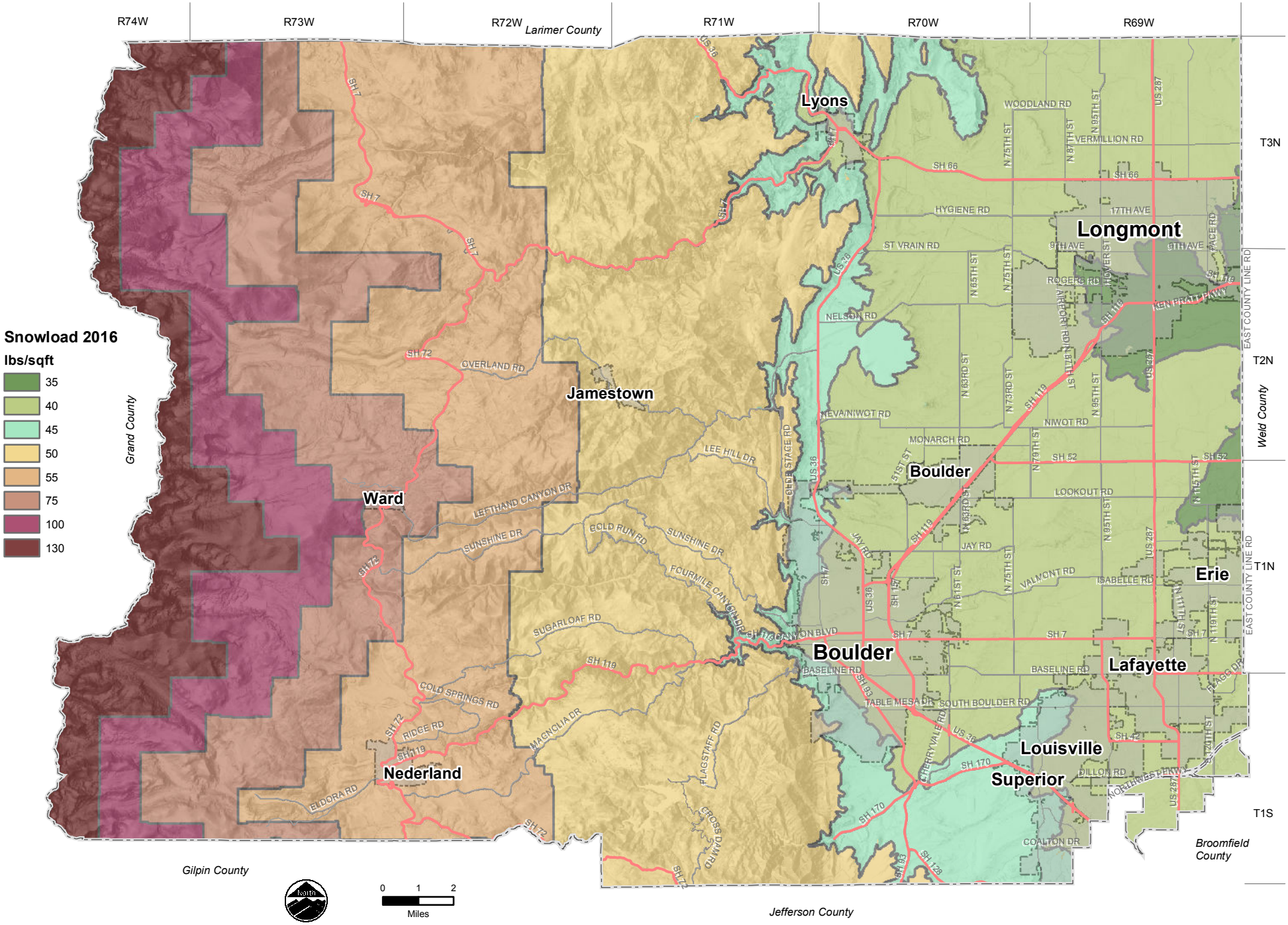
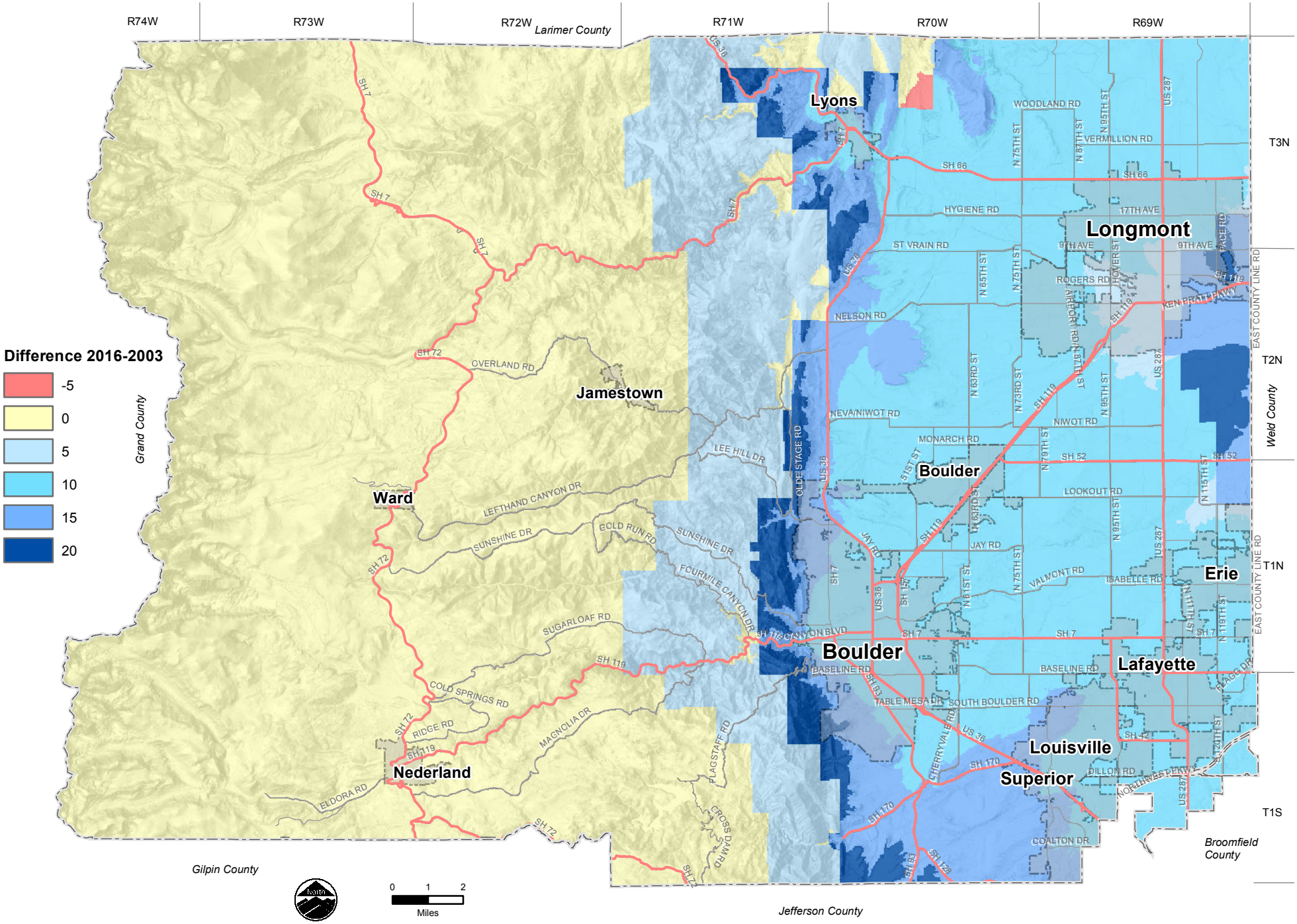
Proposed - 2016 Snow Load



Snow Load difference 2016-2003