T · H · E

BALSAMS

SITE PLAN REVIEW APPLICATION
FOR
SKI AREA EXPANSION – PHASE 1

THE BALSAMS PLANNED UNIT DEVELOPMENT
DD – RESORT

UNINCORPORATED PLACES OF COÖS COUNTY NH

Supplemental Information for 2/15/2023 Meeting

Table of Contents

1.

Responses to 1/12/2023 Questions from Tara Bamford

The Balsams – Ski Area Expansion Site Plan Application 1-18-23

Responses to Jan 12th Comments

A.1 **Parking:** Parking information is attached.

A.2. **Off-street loading facilities:**

Construction staging: The base of the existing ski area will be the primary staging area for ski area construction. Additional staging to serve specific construction needs will be located in the following areas:

a- Future and existing parking areas identified on the Lake Gloriette House site plans
b- The utility corridor located adjacent to the main snowmaking pump house off Rt 26
c- Areas adjacent to the bottom terminals of lifts 11 & 13
d- Portions of the existing wind tower access road and clearings

Operations Loading facilities: The existing maintenance facilities at Valley Road and the existing ski area base will provide loading facilities for normal business operations of the ski area. These may also be used for construction loading and staging.

A.3. **Public Highway System:** Preliminary trip projections are being prepared and will be provide to the Board and NHDOT when available. Board will be made aware of NHDOT scoping meeting schedule when known.

B. **Landscaping and Screening:** The applicant does not anticipate any footings or foundations within 200' of Rt 26 to be visible from traffic on Rt 26, and therefore, did not propose any screening. If footings or foundations are visible from Rt 26 traffic, the applicant will consult with the Board and will install screening. Areas disturbed by construction will be restored as required by the AoT permit, to include planting grass or other vegetation as the AoT permit dictates.

C. **Stormwater:** A letter regarding compliance with county stormwater regulations is attached along with a Stormwater Maintenance Manual. AoT plans and stormwater calculations are available at this link.

F. **Utilities:** The applicant requested will serve letters from NH Electrical Cooperative. A copy of the letter will be submitted to the board when it is received.

H. & I. **Compliance with Zoning and Subdivision Regulations:** Best Management Practices (BMPs) for protection districts within the site are attached.

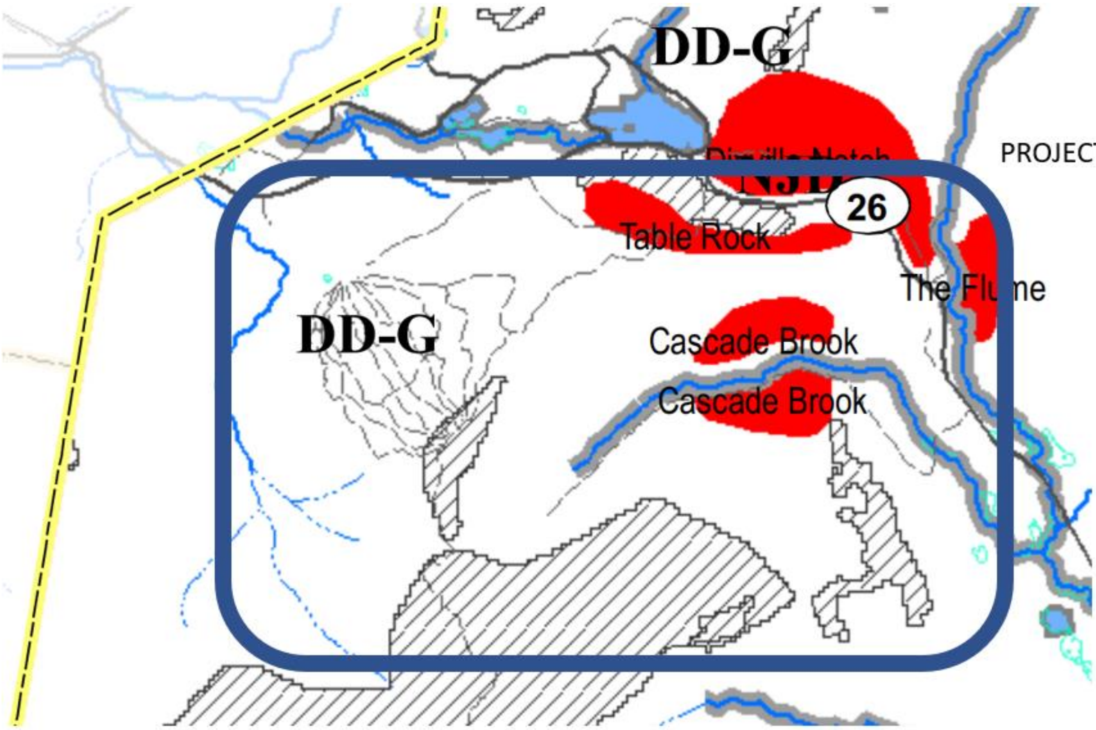
2.

Coos County Protection District BMP Narrative

BALSAMS SKI AREA CONSTRUCTION

COOS COUNTY PROTECTION DISTRICT BEST MANAGEMENT PRACTICES

The Balsams Ski Area project area encompasses three of the listed Coos County protection districts. These include PD5 Steep Slope and High Elevation areas adjacent to the top of the existing Wilderness Ski area and Dixville Peak, PD6 Shoreline Area adjacent to Cascade Brook, and PD8 Unique Areas adjacent to Table Rock and Cascade Brook. A list of construction Best Management Practices has been developed for each of the relevant protection districts is outlined below.

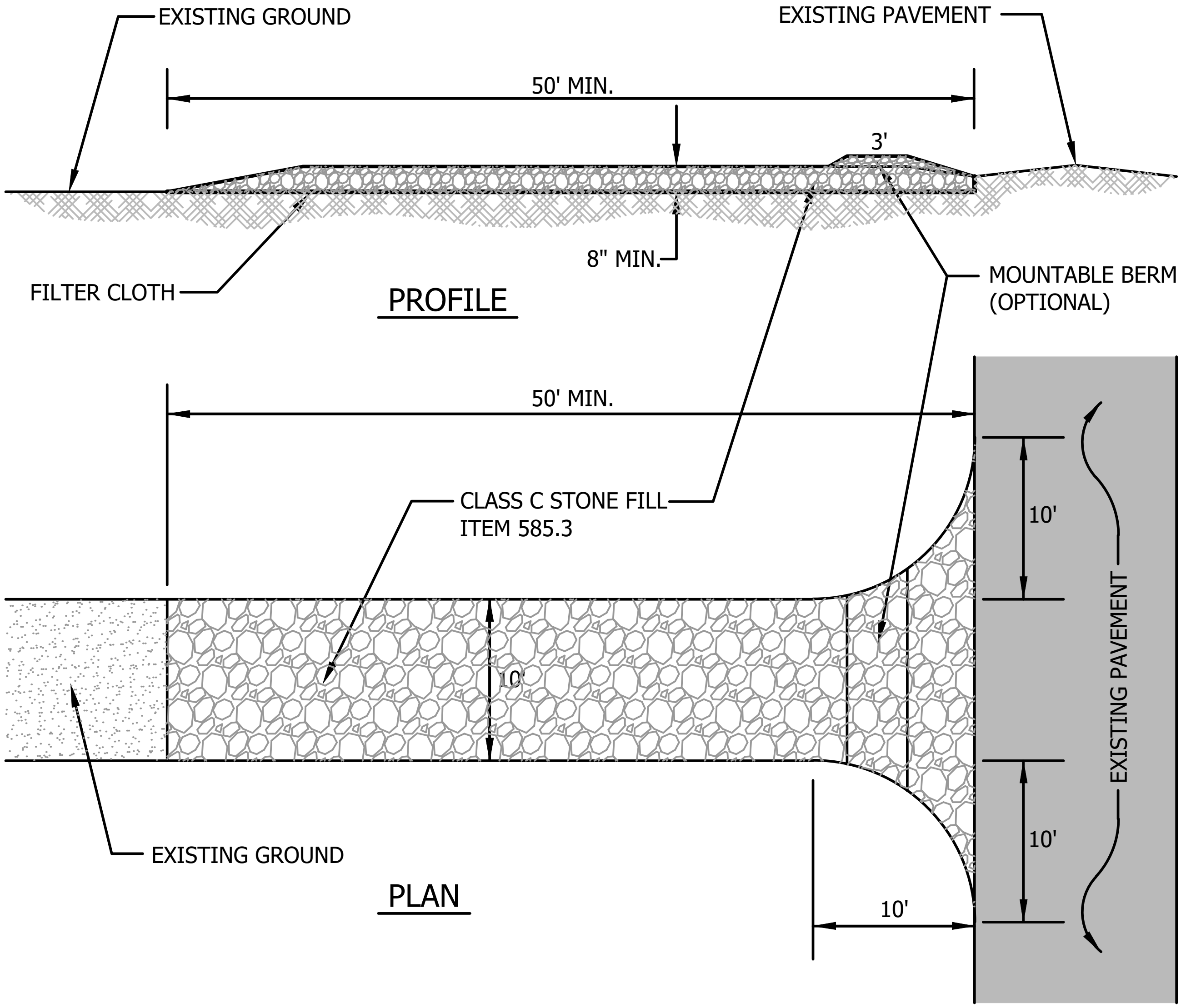


PD5 Steep Slopes- County-designated steep slope areas include the area to the southeast of the top of the existing Wilderness Ski Area, the area near Dixville Peak, and the area to the south of Cascade Brook. Construction in steep slope areas will follow temporary erosion control measures outlined in the project Alteration of Terrain permit documents and Stormwater Pollution Prevention Plan. Non-stabilized open areas will be limited to those necessary to facilitate construction activities. Vegetation will be preserved wherever practical. A summary of standard construction best management practices is attached.

PD6 Shoreline –County-designated shoreline areas within the project are limited to the north and south flanks of Cascade Brook in the eastern portion of the project. All project work will be completed in compliance with the existing New Hampshire Department of Environmental Services Wetlands Permit (201500425). Impacts to perennial and intermittent streams will be conducted under conditions outlined in the permit. Vegetation clearing will be limited within the shoreland buffer area. All work will follow the attached construction best management practice standard details.

PD8 Special Areas - Two areas designated PD-8 straddle Cascade Brook adjacent to the Dixville Notch State Park boundary and extend part way up the valley slopes. As contemplated in the PUD, ski trails, lifts, and associated utilities and snowmaking infrastructure will be within the PD8 areas. Though it is unclear why these two PD8 areas are designated "Unusual" and suitable as a protection district, the applicant will minimize impacts to the areas as follows:

1- No buildings, other operator stations required for lifts, will be located within the two PD8 areas.
2- No clearing or grading will be done within 25' of the state park boundary except as required to maintain forest health and safety or to maintain hiking trails.



STABILIZED CONSTRUCTION ENTRANCE/EXIT

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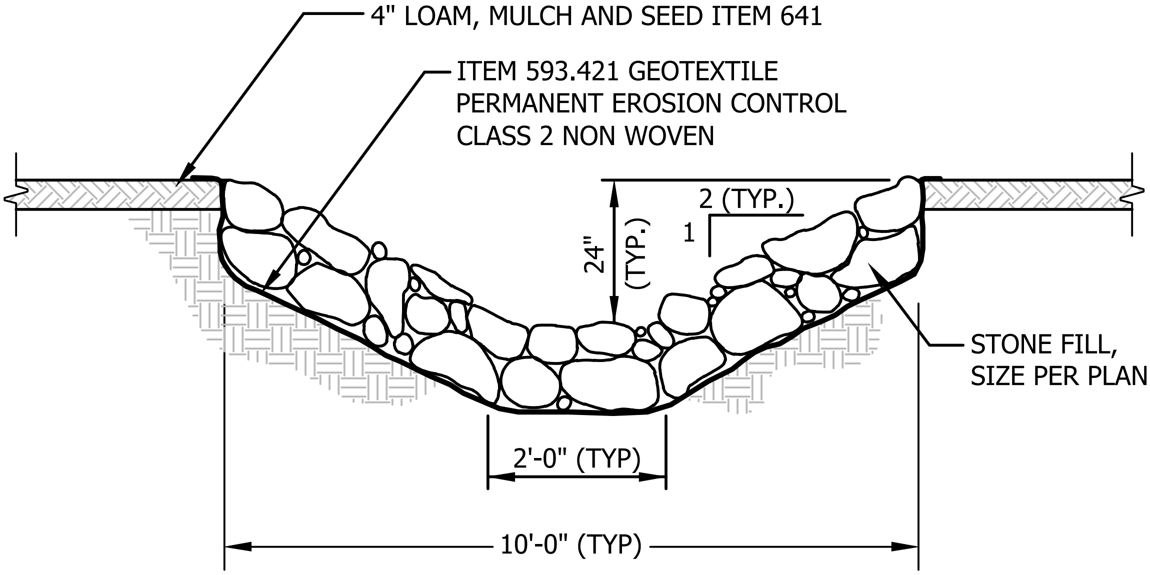
DATE: FEB. 2023



STONE LINED DITCH DETAIL

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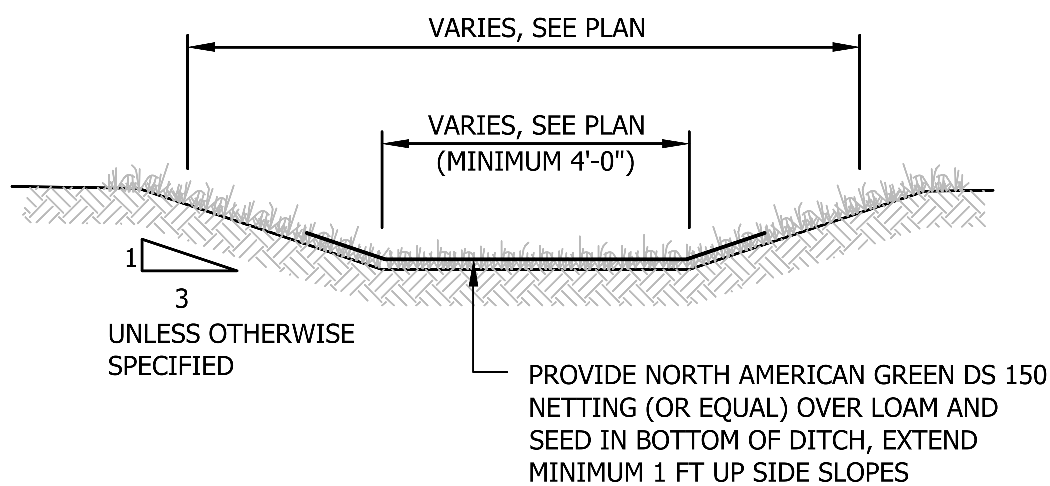

GRASS LINED SWALE DETAIL

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GRASS LINED AND STONE LINED DITCH DETAILS

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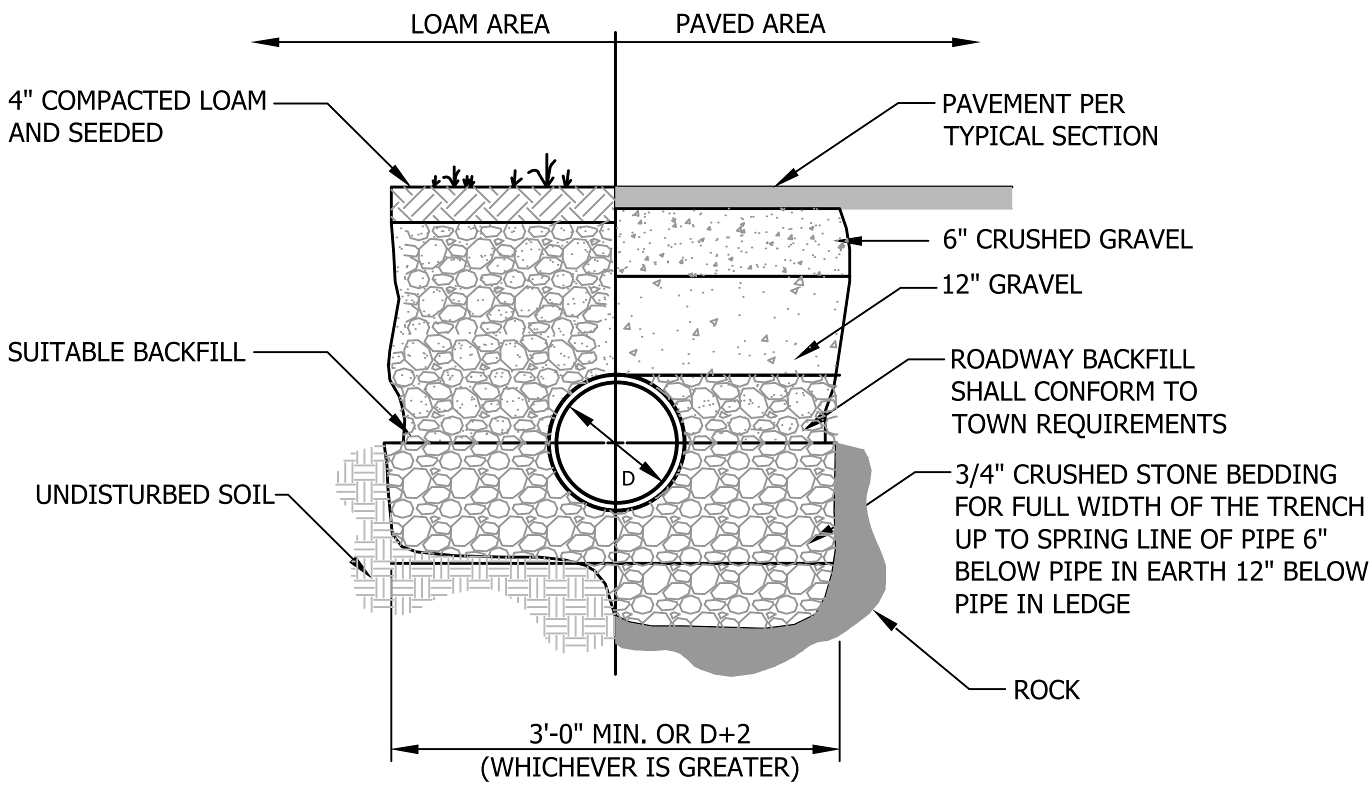

TYPICAL CULVERT TRENCH DETAIL

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TYPICAL CULVERT TRENCH DETAIL

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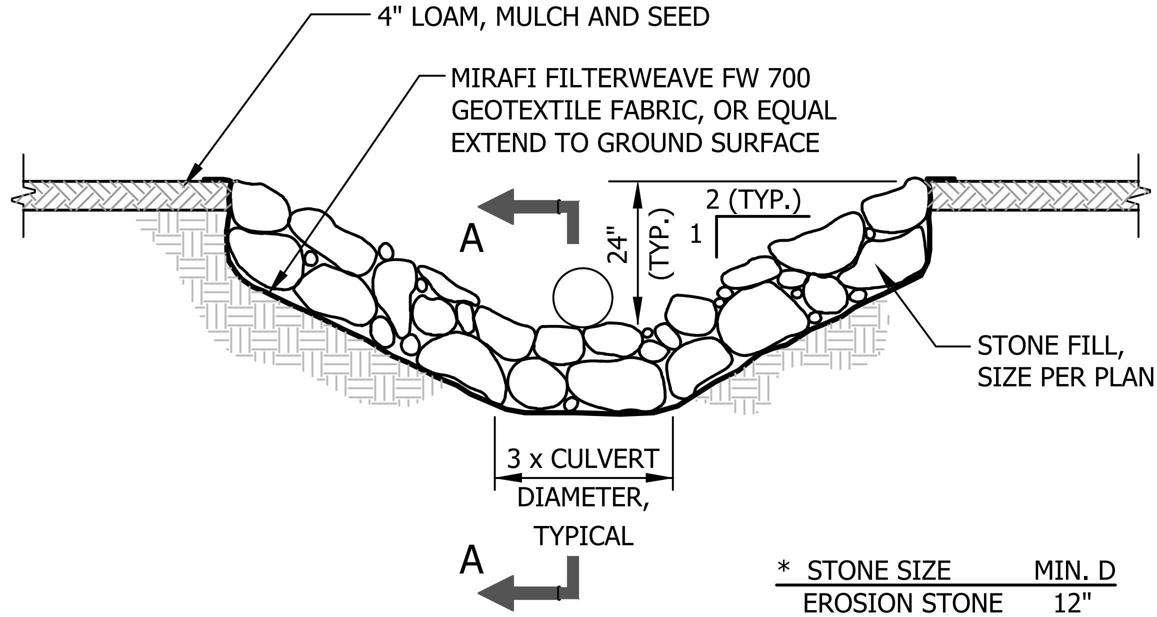
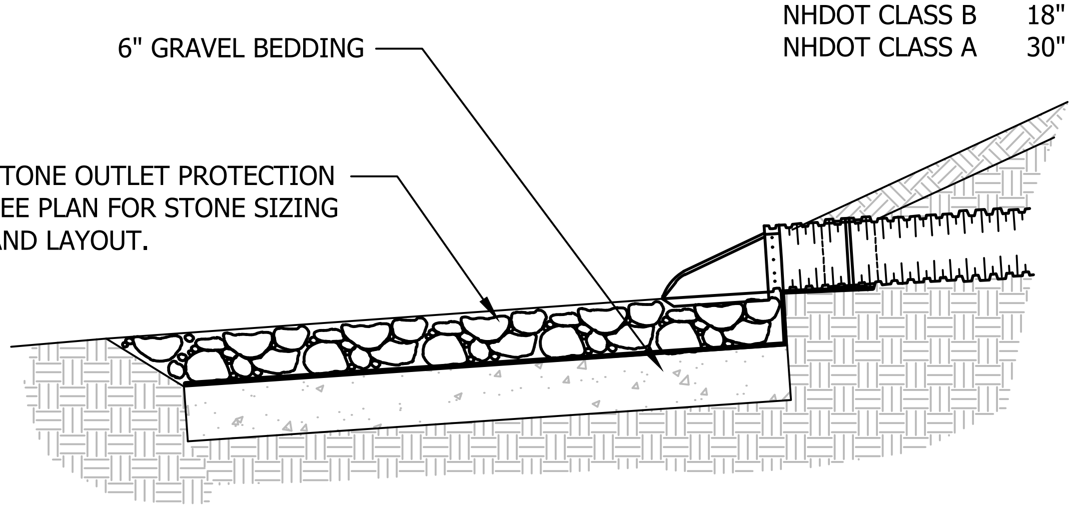


* STONE SIZE	MIN. D
EROSION STONE	12"
NHDOT CLASS C	12"
NHDOT CLASS B	18"
NHDOT CLASS A	30"



SECTION A-A

STONE LINED OUTLET DETAIL

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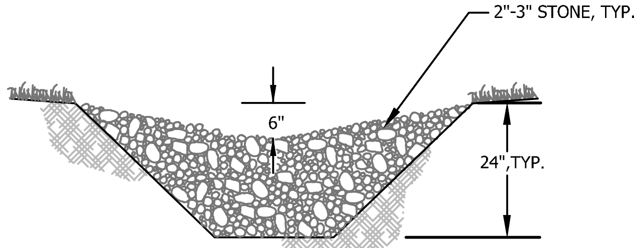
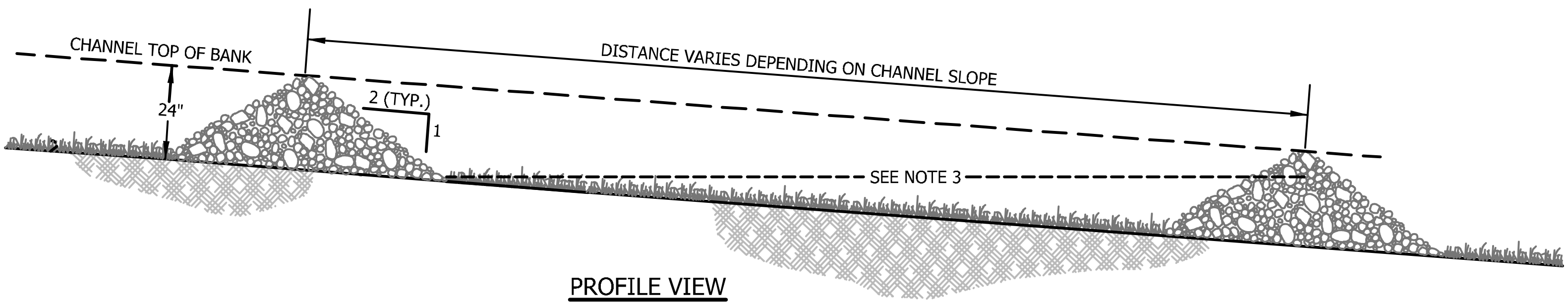


SECTION VIEW

NOTES

1. CONSTRUCT ROCK CHECK DAMS WHERE INDICATED ON THE PLANS OR AS NECESSARY.
2. CONSTRUCT SPILLWAY IN CENTER OF ROCK CHECK DAM 6" BELOW TOP OF CHANNEL.
3. THE MAXIMUM SPACING BETWEEN THE CHECK DAMS SHOULD BE SUCH THAT THE TOE OF THE UPSTREAM CHECK DAM IS AT THE SAME ELEVATION AS THE SPILLWAY ELEVATION OF THE DOWNSTREAM CHECK DAM, THIS WILL VARY DEPENDING ON THE SLOPE OF THE CHANNEL.
4. ROCK CHECK DAMS SHALL CONSIST OF A WELL GRADED MIXTURE OF 2" - 3" STONE.
5. REMOVE ROCK CHECK DAMS AND ANY ACCUMULATED SILT IN CHANNEL ONCE PERMANENT CHANNEL LININGS HAVE BEEN ESTABLISHED AND STABILIZED.



PROFILE VIEW

ROCK CHECK DAM DETAIL

NO SCALE

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ROCK CHECK DAM

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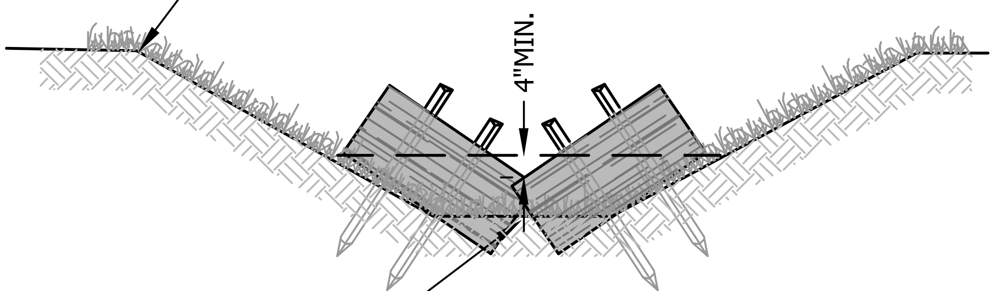

SECTION VIEW

HAY BALE CHECK DAM

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HAY BALE CHECK DAM

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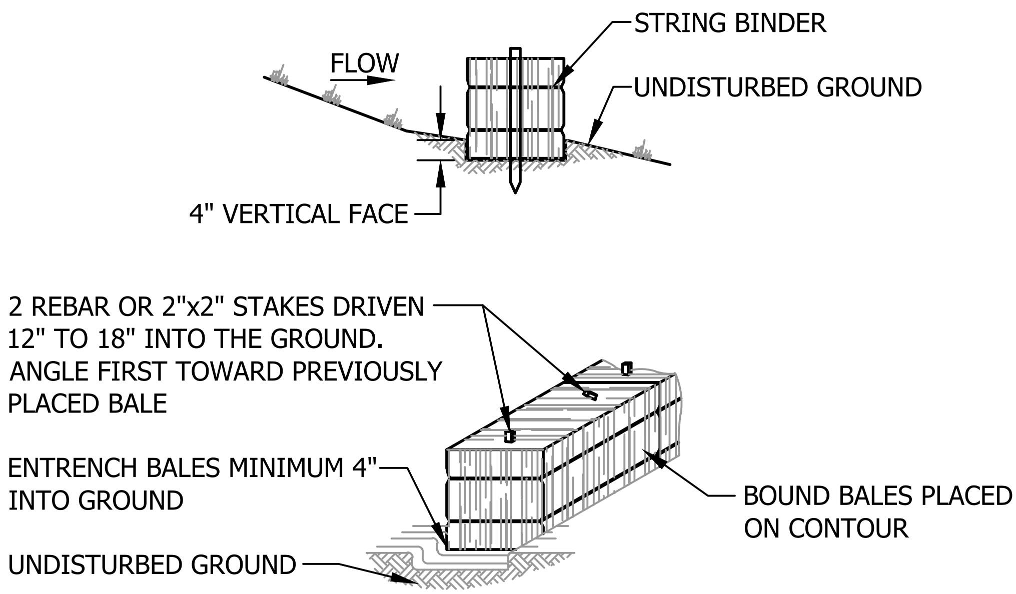

HAY BALE DIKE

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HAY BALE DIKE

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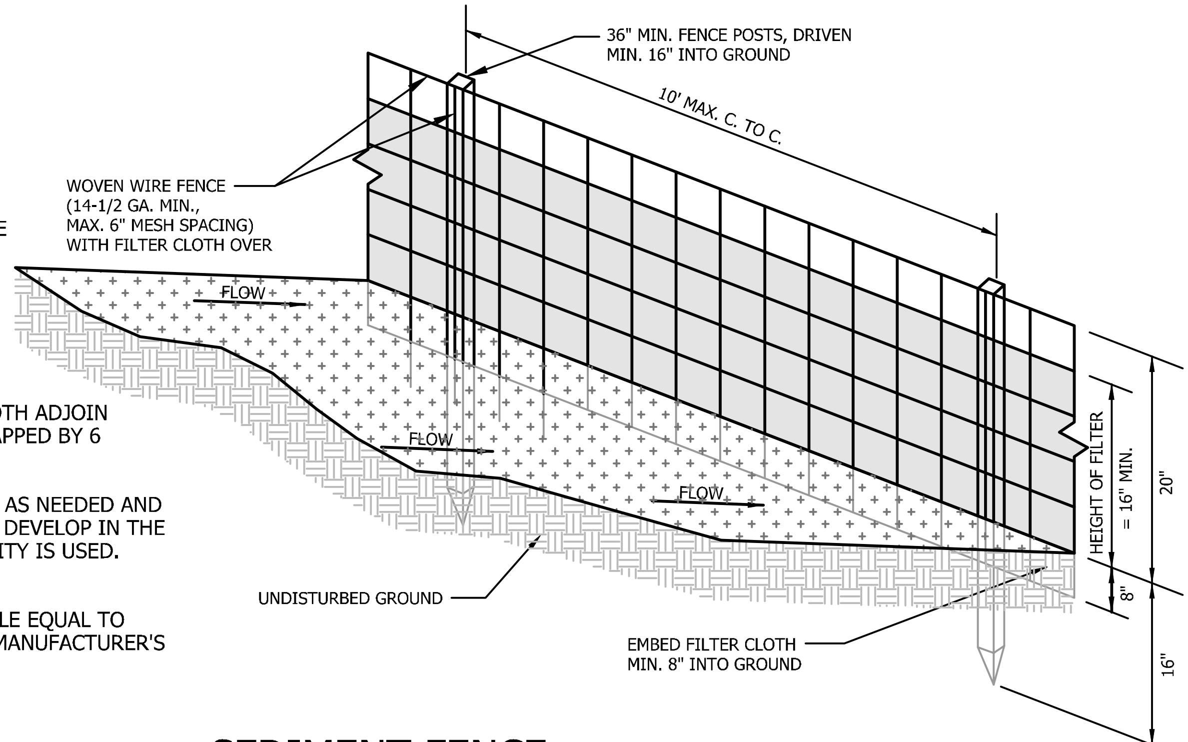
CONSTRUCTION NOTES FOR SEDIMENT FENCE

1. WOVEN WIRE FENCE, IF REQUIRED, TO BE FASTENED SECURELY TO FENCE POSTS WITH WIRE TIES OR STAPLES.
2. FILTER CLOTH TO BE FASTENED SECURELY TO WOVEN WIRE FENCE WITH TIES SPACED EVERY 24" AT TOP, MID SECTION, AND BOTTOM.
3. WHEN TWO SECTIONS OF FILTER CLOTH ADJOIN EACH OTHER, THEY SHALL BE OVERLAPPED BY 6 INCHES, FOLDED AND STAPLED.
4. MAINTENANCE SHALL BE PERFORMED AS NEEDED AND MATERIAL REMOVED WHEN "BULGES" DEVELOP IN THE SEDIMENT FENCE, OR 50% OF CAPACITY IS USED.
5. FILTREXX SILTSOXX SHALL BE CONSIDERED AN ACCEPTABLE EQUAL TO SEDIMENT FENCE IF INSTALLED PER MANUFACTURER'S RECOMMENDATIONS.



SEDIMENT FENCE

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SEDIMENT FENCE

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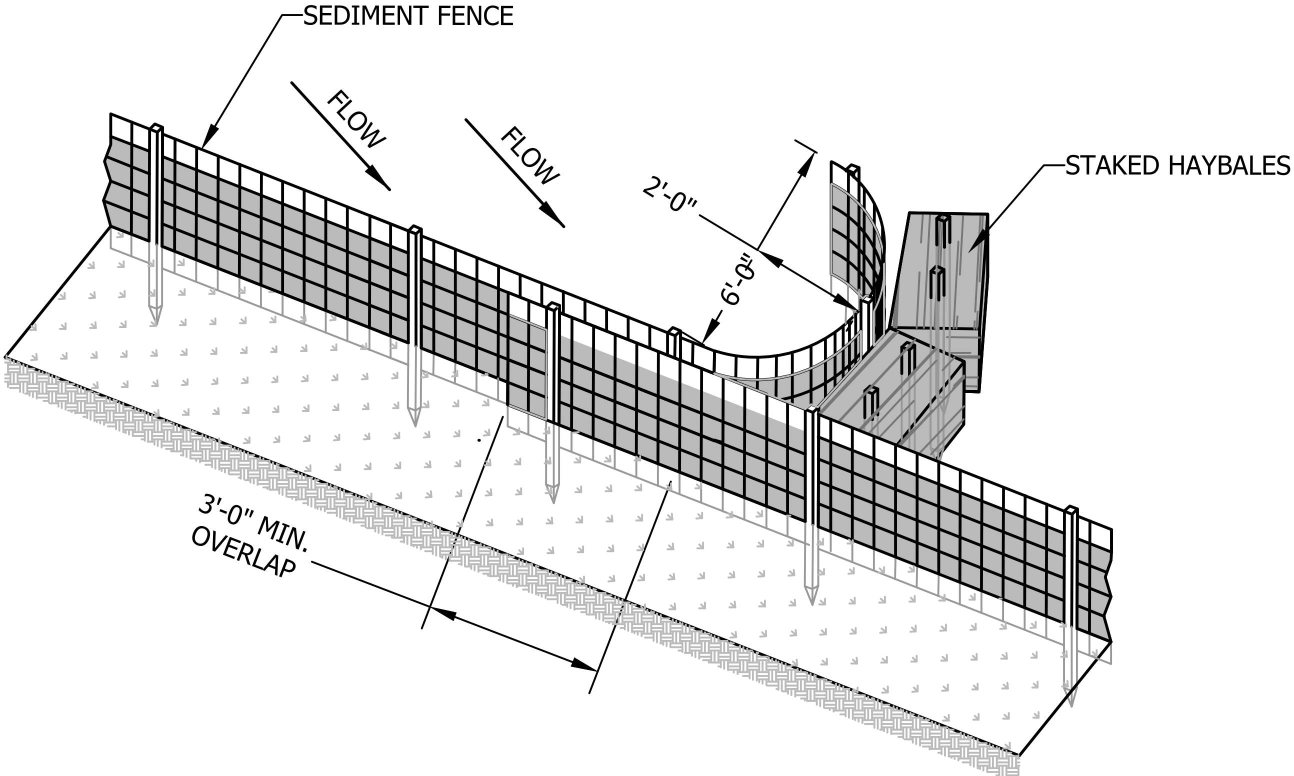

SEDIMENT FENCE POCKET

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SEDIMENT FENCE POCKET

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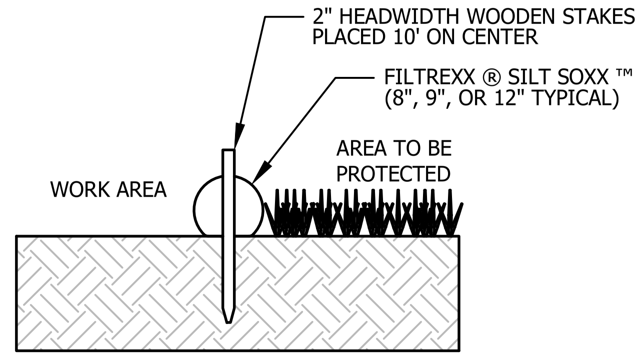
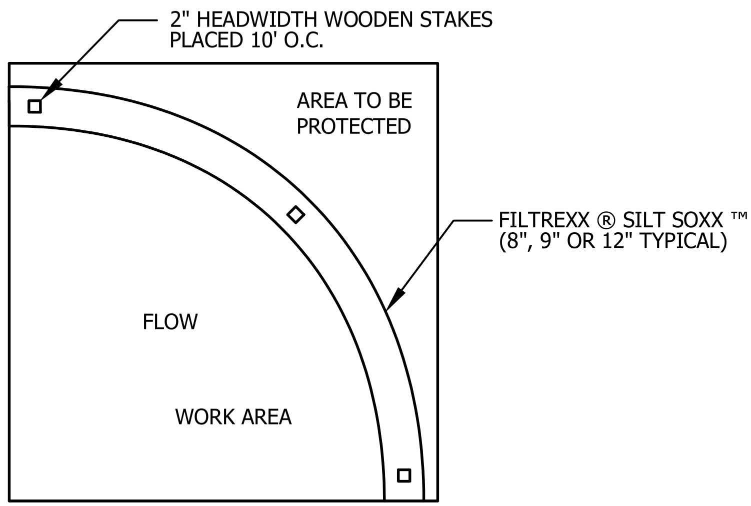
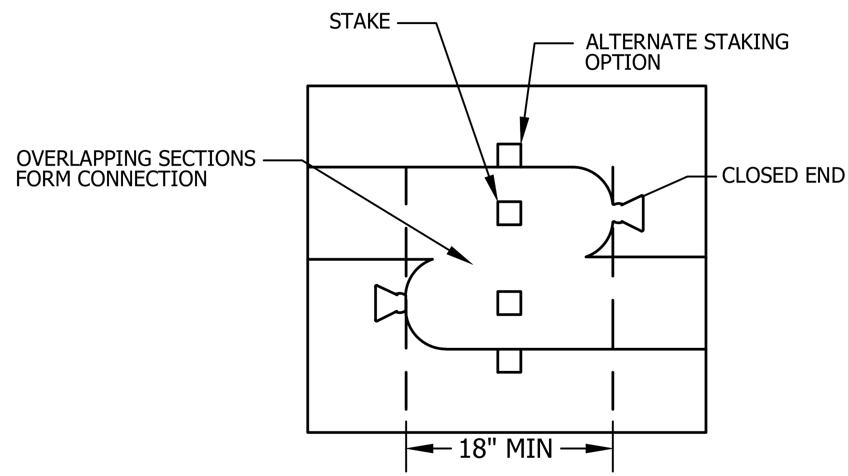


SECTION VIEW



TOP VIEW



COMPOST SOCK CONNECTION/ATTACHMENT DETAIL

NOTES:
1. ALL MATERIAL TO MEET FILTREXX ® SPECIFICATIONS.
2. SILT SOXX ™ FILL TO MEET APPLICATION REQUIREMENTS.
3. COMPOST MATERIAL TO BE DISPERSED ON SITE, AS DETERMINED BY ENGINEER.

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SILT SOXX DETAILS

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LEVEL LIP SPREADER INSTALLATION

1. CONSTRUCT THE LEVEL SPREADER LIP ON A ZERO PERCENT GRADE TO INSURE UNIFORM SPREADING OF RUNOFF.

2. LEVEL SPREADER SHALL BE CONSTRUCTED ON UNDISTURBED SOIL AND NOT ON FILL.

3. AN EROSION STOP SHALL BE PLACED VERTICALLY A MINIMUM OF SIX INCHES DEEP IN A SLIT TRENCH ONE FOOT BACK OF THE LEVEL LIP AND PARALLEL TO THE LIP. THE EROSION STOP SHALL EXTEND THE ENTIRE LENGTH OF THE LEVEL LIP.

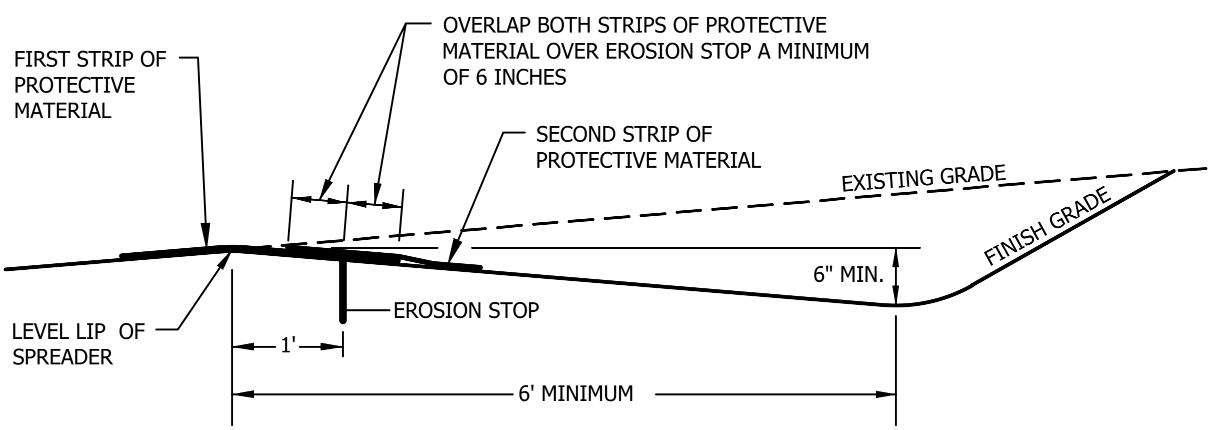
4. THE ENTIRE LEVEL LIP AREA SHALL BE PROTECTED BY PLACING TWO STRIPS OF JUTE OR EXCELSIOR MATTING ALONG THE LIP. EACH STRIP SHALL OVERLAP THE EROSION STOP BY AT LEAST SIX INCHES.

5. THE ENTRANCE CHANNEL TO THE LEVEL SPREADER SHALL NOT EXCEED A 1 PERCENT GRADE FOR AT LEAST 50 FEET BEFORE ENTERING INTO THE SPREADER.

6. THE FLOW FROM THE LEVEL SPREADER SHALL OUTLET ONTO STABILIZED AREAS. WATER SHOULD NOT RE-CONCENTRATE IMMEDIATELY BELOW THE SPREADER.

7. PERIODIC INSPECTION AND REQUIRED MAINTENANCE SHALL BE PERFORMED.

8. PROTECTIVE MATERIAL AND EROSION STOP SHALL BE NORTH AMERICAN GREEN C125 EROSION CONTROL BLANKET OR APPROVED EQUAL.



LEVEL SPREADER DETAIL

NO SCALE

SOURCE: ROCKINGHAM COUNTY CONSERVATION SERVICE

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LEVEL SPREADER DETAIL AND NOTES

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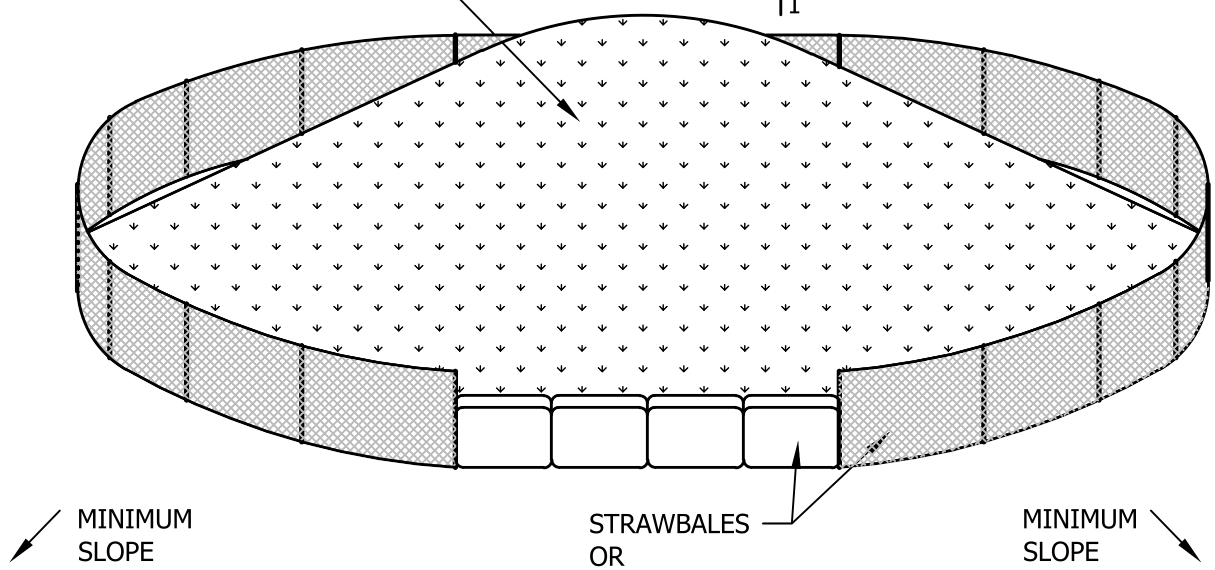

SOIL STOCKPILING IS TO BE USED WHERE TOPSOIL IS NECESSARY FOR REGRADING AND VEGETATING DISTURBED AREAS.

TEMPORARY STOCKPILE STABILIZATION MEASURES INCLUDE VEGETATIVE COVERS, MULCH, NON-VEGETATIVE COVERS, AND PERIPHERAL SEDIMENT TRAPPING BARRIERS. THE STABILIZATION MEASURE(S) SELECTED SHOULD BE APPROPRIATE FOR THE TIME OF YEAR, SITE CONDITIONS, AND REQUIRED PERIOD OF USE.

INSTALLATION NOTES:

1. AREA CHOSEN FOR STOCKPILING OPERATIONS SHALL BE DRY AND STABLE.
2. MAXIMUM SLOPE OF STOCKPILE SHALL BE 2:1.
3. UPON COMPLETION OF SOIL STOCKPILING, EACH PILE SHALL BE SURROUNDED WITH EITHER SILT FENCING OR STRAWBALES AND THEN STABILIZED WITH VEGETATION OR COVERED.

SOIL STOCKPILING DETAIL

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SOIL STOCKPILE DETAIL

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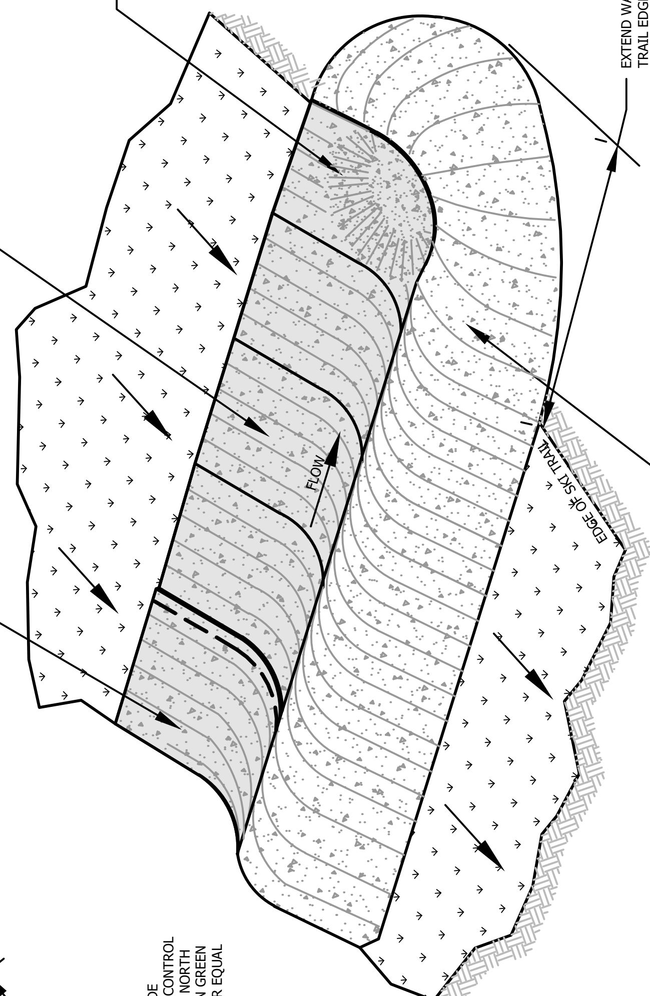
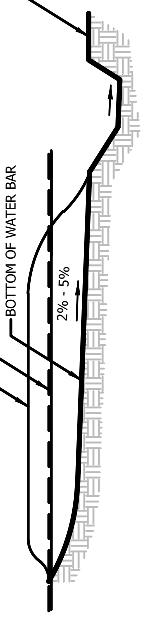
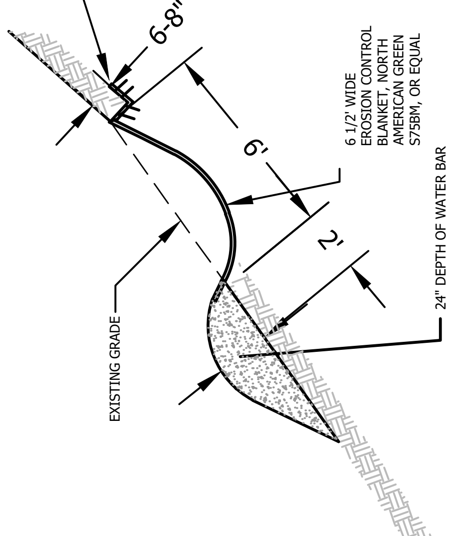


PERSPECTIVE VIEW





WATER BAR SECTION

NOTES

1. LOCATE WATER BARS CAREFULLY. DIVERT WATER INTO NATURAL UNDISTURBED GROUND.
2. WATER BARS ON SKI SLOPES SHALL BE IN LOCATIONS SHOWN IN PLANS. CONTRACTOR SHALL INSTALL ADDITIONAL WATER BARS (AS NEEDED) TO MAINTAIN SLOPE STABILITY.
3. SEDIMENT TRAPS SHOULD BE CONSTRUCTED AT THE END OF ALL WATER BARS , IF SUCH WATER BARS DISCHARGE WITHIN 100' OF WETLANDS OR STREAMS..
4. WATER BARS SHALL BE MACHINE COMPACTED AND SHOULD NOT CONTAIN FOREIGN MATERIAL OR LOOSE ROCKS AND ROOTS.
5. WATER BARS MAY BE STABILIZED WITH SEED AND MULCH WHERE FEASIBLE. IF EROSION MAT IS NOT USED AND EROSION OCCURS IN THE WATER BAR, THE WATER BAR SHALL BE REPAIRED AND LINED WITH EROSION CONTROL BLANKET, NORTH AMERICAN GREEN S75BN OR APPROVED EQUAL.
6. SEED, MULCH, AND STABILIZE IMMEDIATELY AFTER SOIL DISTURBANCE.

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WATERBAR DETAIL

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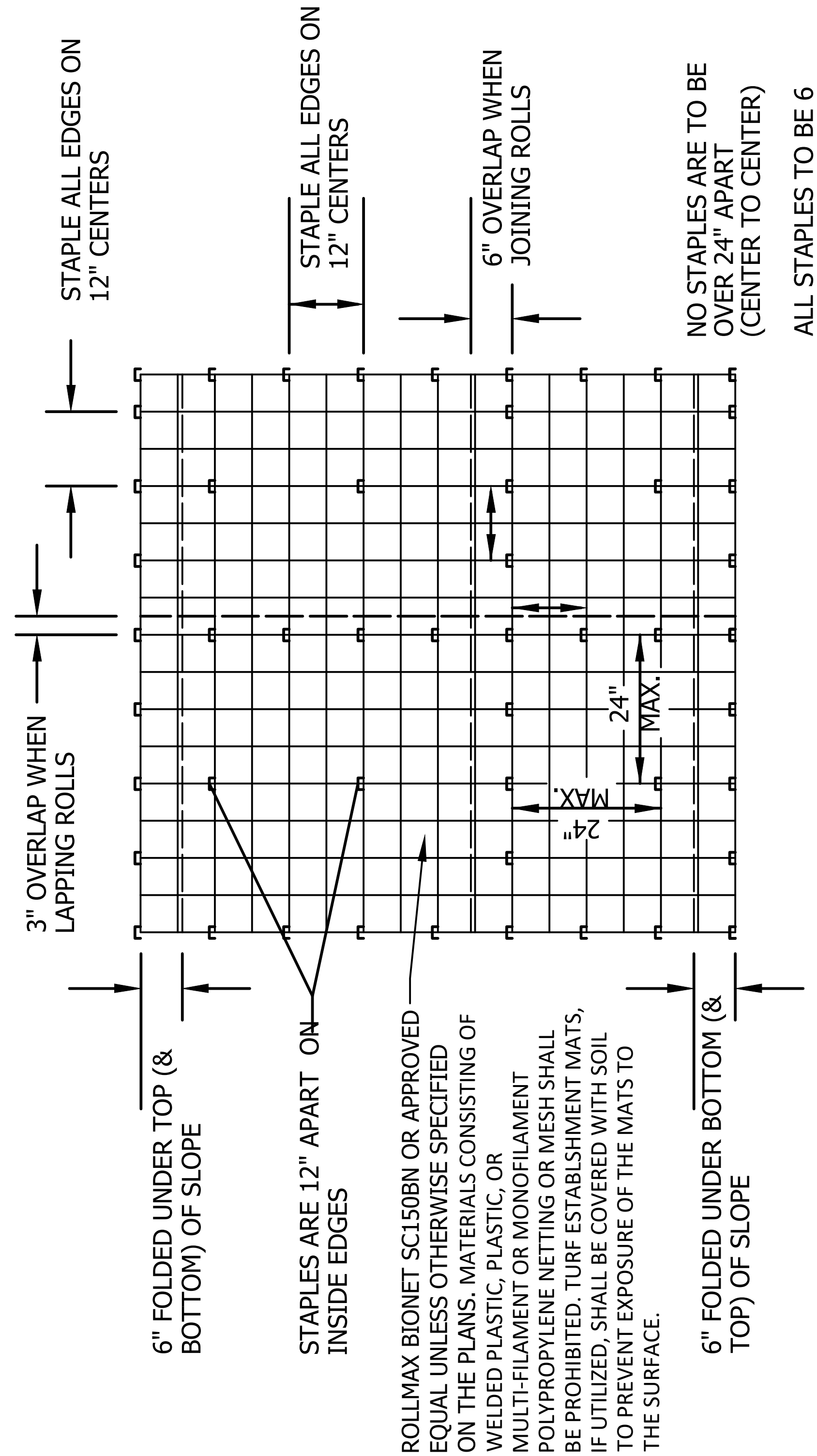

MULCH NETTING DETAIL

SOURCE: USDA SOIL CONSERVATION SERVICE

NO SCALE

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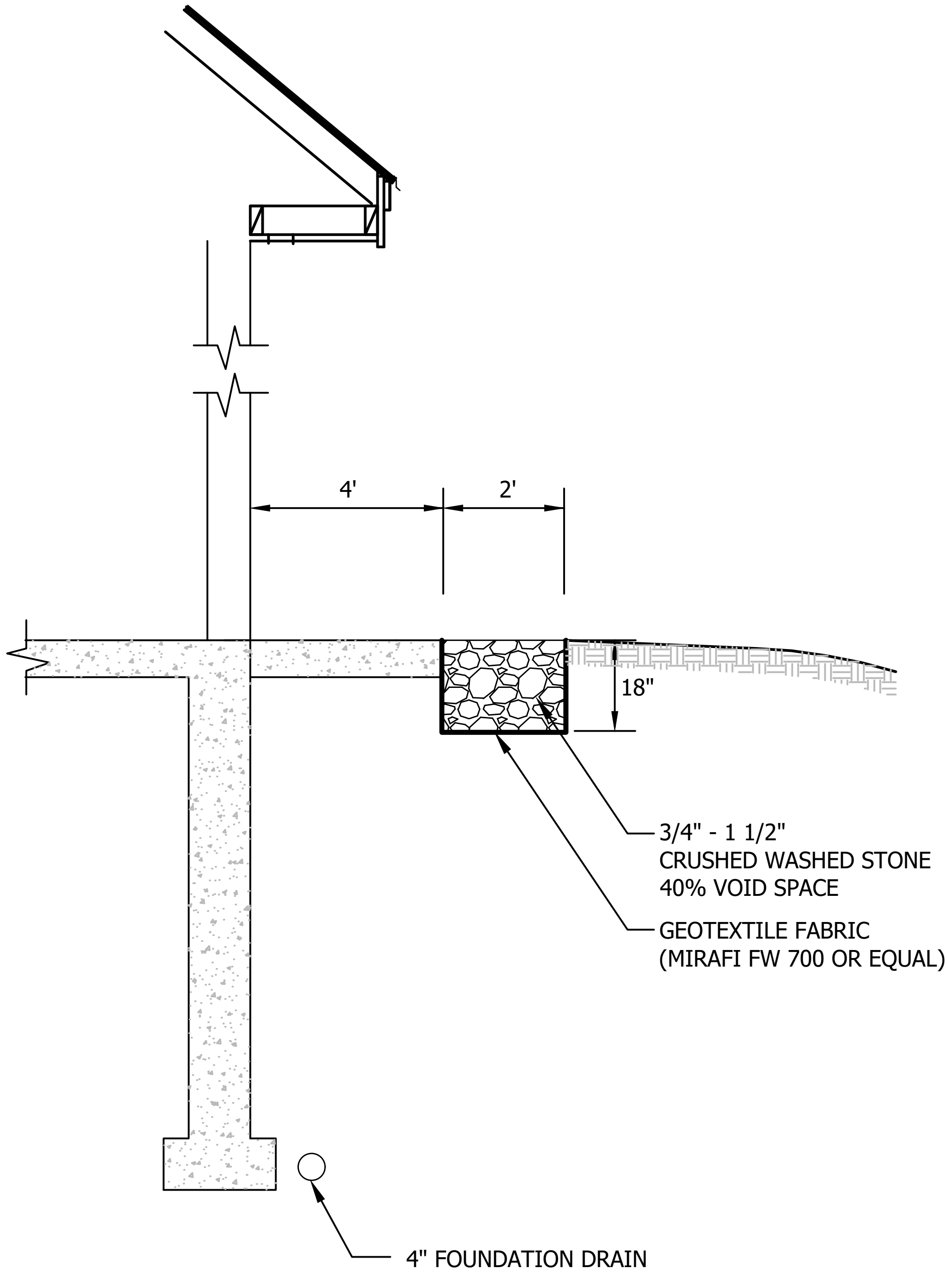

STONE DRIP EDGE DETAIL

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STONE DRIP EDGE DETAIL

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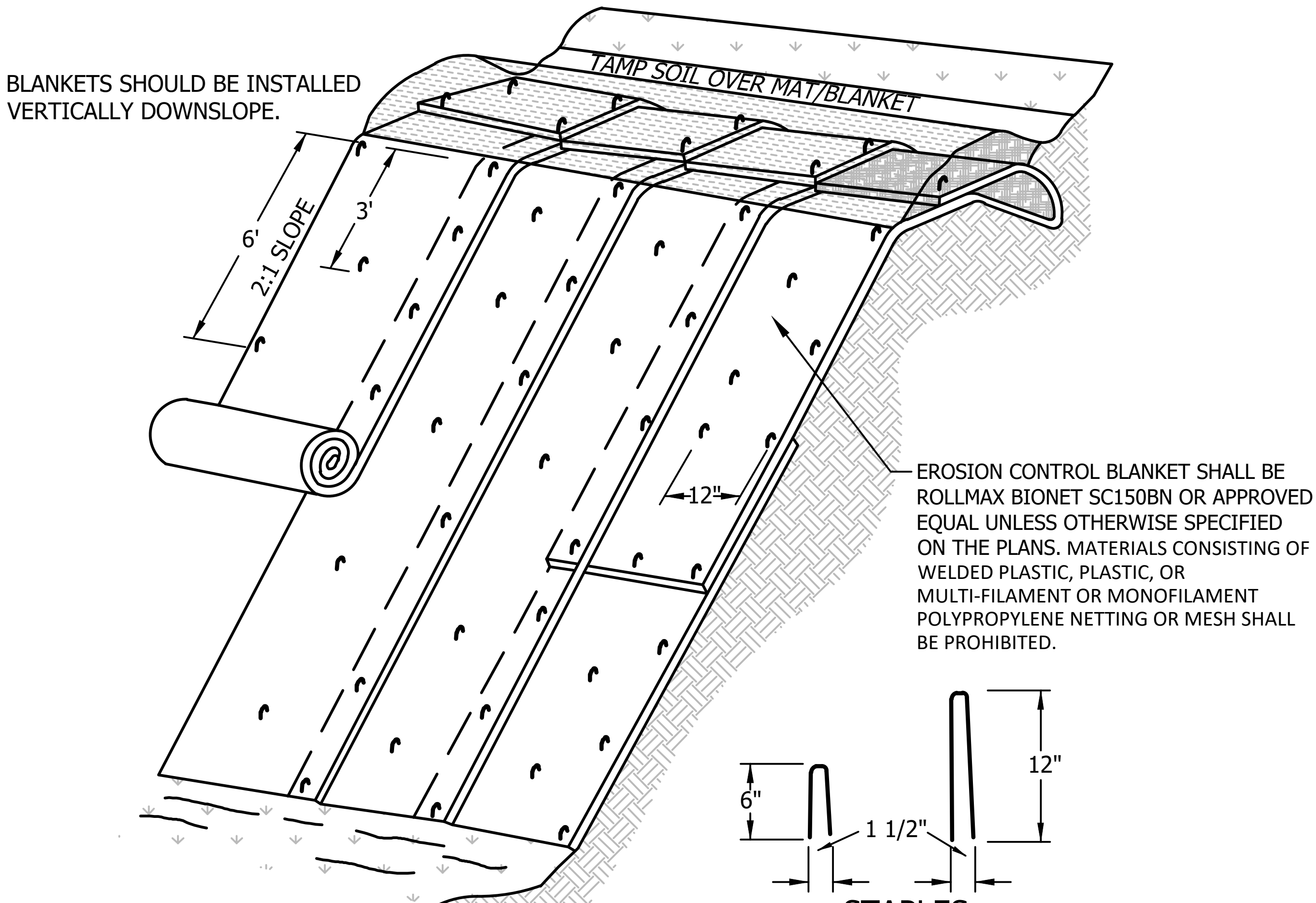
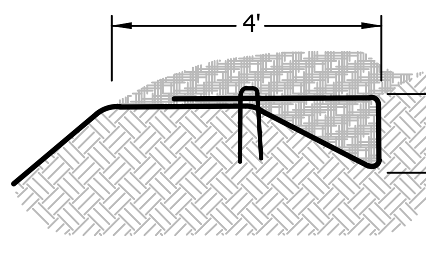


ISOMETRIC VIEW

STAPLES



NOTES:

1. DIMENSION GIVEN IN THE DRAWINGS ARE EXAMPLES; DEVICE SHOULD BE INSTALLED PER MANUFACTURER'S SPECIFICATIONS.

2. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/BLANKETS SHALL HAVE GOOD SOIL CONTACT.

3. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.

4. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

DETAIL DIGITIZED FROM NEW HAMPSHIRE STORMWATER MANUAL, VOLUME 3, NHDES 2008

EROSION CONTROL BLANKET INSTALLATION DETAIL

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EROSION CONTROL BLANKET
INSTALLATION DETAIL

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3.

Ski Area Parking Information

The Balsams Ski Area Expansion

Ski Area Parking

Parking for this initial phase of ski area expansion will be located at the existing and planned parking lots north of Rt 26 near the Lake Gloriette hotels and amenities. Site Plan approval for the Lake Gloriette House included 1332 new and existing parking spaces, whereas only 410 spaces were required for the hotels. The excess spaces were included to provide day skier parking for initial ski area expansion.

Skier services such as ticketing, ski rentals, food and beverage, and other services typically located near parking are in the lower level of Lake Gloriette House adjacent to the gondola and ski back-bridge, which will provide access to and from the ski area for Phase 1.

Destination ski resorts typically require less parking than a typical ski area since a large percentage of skiers stay in on-site lodging. Also, destination resorts are typically located further from urban areas, thereby reducing day skier usage. While the current parking requirement of 1 space per 9 persons of uphill capacity is expected to be excessive for The Balsams, until we have operating data to support a lower rate, we have based parking plans on the county's standard rate.

When the ski area initially re-opens, we expect 5 lifts to be operational, including the gondola. Annual skier visits are expected to increase over time. To accommodate this increase, the lifts will initially have fewer "carriers" (chairs or gondola cabs) than maximum and therefore, the lifts' uphill capacity will be lower. Carriers will be added as demand increases. The minimum and maximum uphill capacities for first 5 fts are shown in the table along with parking needs per county standards. The timing of construction for 2 additional lifts will depend on market conditions. Maximum parking needs for all 7 lifts in this expansion phase are also shown in the table.

As a destination resort, the number of skiers implied by the maximum uphill capacities shown will not be realized without additional on-site lodging. Rather than projecting the timing of additional lodging, however, the parking requirement table only includes the currently approved lodging.

The ski area layout uses the gondola to transport guests to the ski area. As a transport lift, with only one ski back trail returning to the gondola base, the gondola does not increase the number of skiers the ski area can handle, often measured by comfortable carrying capacity or skiers-at-one-time. To be conservative with initial parking requirements, it's included in the year-1 minimum parking calculations. It is excluded for future projections.

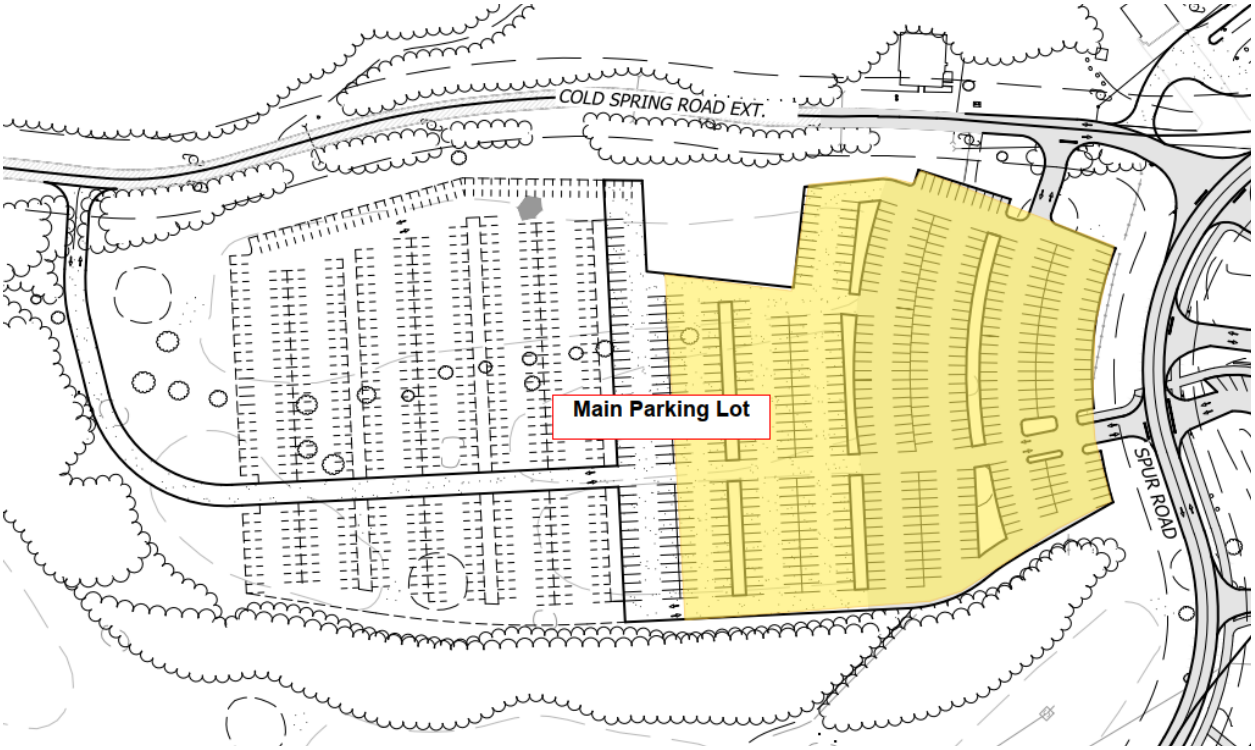
Parking at the existing ski area base is expected to primarily be used for staff and overflow parking during initial years of operation. While the maximum calculated spaces in the table indicate this lot will be required eventually, we anticipate operating experience will show lower parking needs and the resort will seek an amendment in advance of any significant use of the lot.

Required Skier Parking:

		first 5 lifts		seven lifts	
		(year 1) minimum	intermediate	maximum	
1	intial uphill capacity	5,400	5,400	5,400	skiers per hour with initial carriers
2	future capacity with added carriers & lifts		6,600	10,200	
3		5,400	12,000	15,600	
4	exclude gondola		(2,400)	(2,400)	transport lift - negligable ccc
5	net uphill capacity	5,400	9,600	13,200	
6	county parking rate	9	9	9	spaces/9 persons/hour of uphill capacity
7	**total ski area parking spaces (county rate)**	**600**	**1,067**	**1,467**	required spaces per county requirements
8					
9	parking required for approved lodging	410	410	410	
10	lodging guests who are skiers	80%	80%	80%	
11	lodging spaces used by skiers	328	328	328	
12	required additional ski area parking	272	739	1,139	total ski area less lodging skier spaces
13	total required ski and lodging spaces	682	1,149	1,549	
14	existing & approved parking - Lake Gloriette area	1,332	1,332	1,332	
15	excess/(shortfall) parking - Lake Gloriette area	650	183	(217)	
16	existing ski area parking			374	(overflow and ski employee parking)

The Alteration of Terrain and wetlands permit for the Lake Gloriette area development include the entire main parking lot as well as other parking shown on the circulation plan and below. Actual construction of the main parking lot may be completed in whole or in two or more phases as skier visits and uphill capacity increase.

The minimum required parking for both hotel and ski area uses during the first year is 682 spaces. The exact location and amount of dedicated and shared-use spaces will be managed by the resort to provide the best overall guest experience. In general, the closest spaces to the hotels will be used for the hotels. Day skier parking is expected to primarily be in the main parking lot. If phased, the approximate extent of initial parking lot construction is shown highlighted below, providing approximately 750 spaces. Additional parking will be constructed as uphill capacity is increased to maintain the required parking per county standards.


COLD SPRING ROAD EXT.
Main Parking Lot
SPUR ROAD

4.

Dixville Stormwater Letter from Horizons Engineering

February 8, 2023

Coos County Planning Board
P.O. Box 10
West Stewartstown, NH 03597

Subject: Balsams Ski Area Design – Compliance with Coos County Stormwater Requirements

Dear Members of the Board:

Horizons Engineering, Inc. (Horizons) has recently completed the engineering design for the Balsams Resort Ski Area, including grading and drainage of the proposed ski trails and lift corridors. Horizons has reviewed the Coos County Zoning Ordinance stormwater requirements and completed the project design in compliance with both the ordinance and the State of New Hampshire Department of Environmental Services (NHDES) stormwater requirements.

Requirements outlined in the Coos County Zoning Ordinance, and associated responses are summarized below:

5.07 Stormwater: All development shall be designed in a manner that will minimize and treat stormwater runoff and prevent erosion.

(a) All stormwater management and erosion control measures in the plan shall adhere to the "New Hampshire Stormwater Manual," current edition, published by NHDES, to the extent practicable.

Response – The project has been designed to meet current New Hampshire Alteration of Terrain permit requirements, including stormwater management and erosion control measures outlined in Volumes 1-3 of the 2008 New Hampshire Stormwater Manual.

(b) The smallest practical area of land should be exposed at any one time during development.

Response – The project earthwork will be phased following New Hampshire Alteration of Terrain requirements in order to minimize non-stabilized land area. These requirements will be included in the Erosion Control Notes and Details plans.

(c) When land is exposed during development, the exposure should be kept to the shortest practical period of time. Land should not be left exposed during the winter months.

Response – The project earthwork will be phased following New Hampshire Alteration of Terrain requirements in order to minimize the time areas remain non-stabilized, and areas will be temporarily or permanently stabilized prior to seasonal work shutdowns. These requirements will be included in the Erosion Control Notes and Details plans.

(d) Where necessary, temporary vegetation and/or mulching and structural measures should be used to protect areas exposed during development.

Response – The project earthwork will follow construction best management practices outlined in the State of New Hampshire Alteration of Terrain Permit. Temporary stabilization measures will be implemented as required by the US Environmental Protection Agency in compliance with the EPA-mandated project Stormwater Pollution Prevention Plan. Seeding requirements and project specific best management practices will be included in the Erosion Control Notes and Details.

(e) Provisions should be made to effectively accommodate the increased run-off caused by the changed soil and surface conditions during and after development.

Response – Project stormwater control measures are designed to effectively accommodate and disperse runoff resulting from the project disturbance. The project has been designed to result in no net increase in post-development runoff following NHDES standards for the clearing, grubbing and grading work for the proposed ski trails, lift lines and maintenance trails. Future design work in the project disturbance area will be designed as well to result in no net increase in post-development runoff following NHDES standards.

(f) The permanent, final vegetation and structures should be installed as soon as practical in the development.

Response – The project earthwork phasing will follow the construction requirements of the Alteration of Terrain permit. Permit requirements include the need to construct and stabilize permanent stormwater management structures as early in the construction process as practical. These requirements will be included in the Erosion Control Notes and Details plans.

(g) The development plan should be fitted to the topography and soils so as to create the least erosion potential.

Response – The project has been designed to minimize grading to the extent practical in an effort to minimize erosion potential. Best management practices for erosion control have been included to aid efforts to minimize erosion potential.

(h) Whenever feasible, natural vegetation should be retained and protected.

Response – Natural vegetated buffers will remain following NHDES requirements, and vegetation removal will be completed only as necessary to facilitate the construction of the project. Limits of disturbance for vegetation removal will be included in the proposed design plans.

(i) The applicant shall bear final responsibility for the installation, construction, and establishment of provisions for ongoing maintenance of all stormwater and erosion control measures required by the Planning Board. Final approval will not be granted until the plan and a mechanism for ensuring ongoing maintenance are approved by the Planning Board.

Response – Per New Hampshire Alteration of Terrain requirements, an Inspection and Maintenance manual will be included with the submittal for the clearing, grubbing and grading work for the proposed ski trails, lift lines and maintenance trails for NHDES and County approval. Future design work in the project disturbance area will include Inspection and Maintenance manuals for proposed project-specific best management practices for NHDES and County approvals as well.

(j) Flow volume and velocity shall not be increased, nor water quality decreased at the property line.

Response – Project HydroCad stormwater calculations demonstrate that the project has been designed to result in no net increase in the volume or velocity of stormwater runoff at the property line.   The project design will comply with New Hampshire stormwater water quality criteria and is not anticipated to result in a degradation of water quality at the property line for the clearing, grubbing and grading work for the proposed ski trails, lift lines and maintenance trails. Future design work in the project disturbance area will be designed as well to result in no net increase in in the volume or velocity of stormwater runoff following NHDES standards and will comply with the New Hampshire stormwater runoff at the property line.

Copies of project design plans and associated HydroCad stormwater model output demonstrating compliance with the ordinance have been submitted under a separate cover.

Please do not hesitate to contact me should you have any questions.

Sincerely,

Matthew Graber, P.E.
Senior Project Engineer
NH PE License # 17499

STATE OF NEW HAMPSHIRE - PROFESSIONAL ENGINEER
MATTHEW S GRABER
No. 17499
LICENSED
2-8-2023

5.

Ski Stormwater Management Manual

34 SCHOOL STREET • LITTLETON, NH 03561 • PHONE 603-444-4111 • FAX 603-444-1343 • www.horizonsengineering.com

STORMWATER MAINTENANCE MANUAL

DIXVILLE CAPITAL, LLC.
THE BALSAMS GRAND RESORT
Dixville, New Hampshire

34 SCHOOL STREET • LITTLETON, NH 03561 • PHONE 603-444-4111 • FAX 603-444-1343 • www.horizonsengineering.com

STORMWATER MAINTAINANCE MANUAL
FOR
DIXVILLE CAPITAL, LLC
THE BALSAMS – SKI LIFT AND TRAILS EXPANSION
DIXVILLE, NH

FEBRUARY 2023

PROJECT NUMBER 220115

Horizons Engineering, Inc.

MAINE • NEW HAMPSHIRE • VERMONT

Inspection and Maintenance Plan

For
DIXVILLE CAPTIAL, LLC
The Balsams – Ski Trails and Lifts
Dixville, NH

Introduction

This document is intended to provide a unified procedure for the party(ies) responsible for inspecting and maintaining the stormwater management device(s) that are located within the site development (see Design Plan for the device locations).

Responsible Parties

The ultimate responsibility for complying with this plan rests with the owners of the Property.

Owner's Name: Dixville Capital, LLC

Parties assigned to complete inspection and maintenance tasks are presented in the following table:

DEVICE	TASK	PARTY RESPONSIBLE
Structural Stormwater Devices		
Ditches	Inspection	OWNER
	Maintenance	OWNER
	Reporting	OWNER
Water Bars	Inspection	OWNER
	Maintenance	OWNER
	Reporting	OWNER

Frequency of Activities

The best time to perform inspections is during the onset of rain. To the extent practicable, inspections should be timed to coincide with moderate storms that do not have the potential for severe (thunderstorms, etc) precipitation. The frequency of inspection and maintenance will vary by intensity of use; however, the following shall serve as the minimum inspection frequency:

- Pretreatment measures (Ditches and Water Bars) should be inspected and cleaned at least seasonally.

Maintenance frequencies will be determined based upon the results of the inspections and if specific maintenance thresholds are observed to have been crossed during inspections.

All inspection activities shall be recorded on the appropriate attached Inspection Form. One form shall be used for each stormwater device.

Records

A record of inspection and maintenance activities shall be recorded on the Inspection and Maintenance Log presented below. Records of Inspection Forms and Inspection and Maintenance Logs shall be made available upon request.

______________________   BMP Name

Ditches and Water Bars

Inspection Form

The Balsams – Ski Trails and Lifts, Dixville, NH

Date of today's inspection__/__/__ Inspector Name_________________________
Date of last inspection (of this BMP) __/__/__

Recent Weather history

Storm date(s)	Storm duration	Rainfall amount	Did runoff occur?

Today's Weather________________

INSPECTION AREAS	LOOK FOR	CIRCLE ONE		IF YES
Ditches				
	Sediment or debris in Ditch? Erosion of bank or bottom?	Y	N	Remove sediment, leaves & debris as needed. Inspect ditch and clean if necessary. Ensure positive drainage is maintained.
Water bars				
	Sediment or debris at water bar inlet or outlets? Sediment traps greater than 50% full?	Y	N	Remove sediment, leaves and debris as needed from water bar and inlet/outlet sediment traps. Inspect water bar and clean stone or replace stone if necessary. Ensure positive drainage is maintained.

CONTROL OF INVASIVE PLANTS

During maintenance activities, check for the presence of invasive plants and remove in a safe manner as described on the following pages. They should be controlled as described on the following pages.

Background:

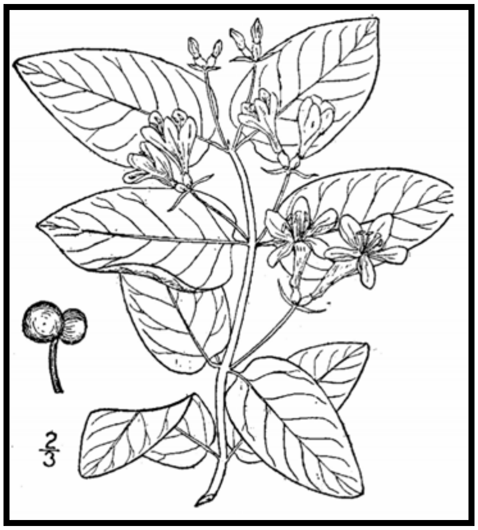
Invasive plants are introduced, alien, or non-native plants, which have been moved by people from their native habitat to a new area. Some exotic plants are imported for human use such as landscaping, erosion control, or food crops. They also can arrive as "hitchhikers" among shipments of other plants, seeds, packing materials, or fresh produce. Some exotic plants become invasive and cause harm by:

- becoming weedy and overgrown;
- killing established shade trees;
- obstructing pipes and drainage systems;
- forming dense beds in water;
- lowering water levels in lakes, streams, and wetlands;
- destroying natural communities;
- promoting erosion on stream banks and hillsides; and
- resisting control except by hazardous chemical.

UNIVERSITY of NEW HAMPSHIRE COOPERATIVE EXTENSION

Methods for Disposing Non-Native Invasive Plants

Prepared by the Invasives Species Outreach Group, volunteers interested in helping people control invasive plants. Assistance provided by the Piscataquog Land Conservancy and the NH Invasives Species Committee. Edited by Karen Bennett, Extension Forestry Professor and Specialist.



Tatarian honeysuckle
Lonicera tatarica
USDA-NRCS PLANTS Database / Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions.* Vol. 3: 282.

Non-native invasive plants crowd out natives in natural and managed landscapes. They cost taxpayers billions of dollars each year from lost agricultural and forest crops, decreased biodiversity, impacts to natural resources and the environment, and the cost to control and eradicate them.

Invasive plants grow well even in less than desirable conditions such as sandy soils along roadsides, shaded wooded areas, and in wetlands. In ideal conditions, they grow and spread even faster. There are many ways to remove these non-native invasives, but once removed, care is needed to dispose the removed plant material so the plants don't grow where disposed.

Knowing how a particular plant reproduces indicates its method of spread and helps determine the appropriate disposal method. Most are spread by seed and are dispersed by wind, water, animals, or people. Some reproduce by vegetative means from pieces of stems or roots forming new plants. Others spread through both seed and vegetative means.

Because movement and disposal of viable plant parts is restricted (see NH Regulations), viable invasive parts can't be brought to most transfer stations in the state. Check with your transfer station to see if there is an approved, designated area for invasives disposal. This fact sheet gives recommendations for rendering plant parts non-viable.

Control of invasives is beyond the scope of this fact sheet. For information about control visit www.nhinvasives.org or contact your UNH Cooperative Extension office.

New Hampshire Regulations

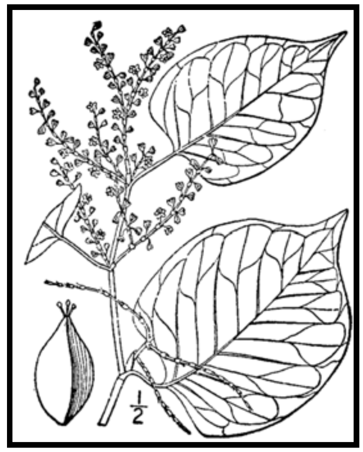
Prohibited invasive species shall only be disposed of in a manner that renders them nonliving and nonviable. (Agr. 3802.04)

No person shall collect, transport, import, export, move, buy, sell, distribute, propagate or transplant any living and viable portion of any plant species, which includes all of their cultivars and varieties, listed in Table 3800.1 of the New Hampshire prohibited invasive species list. (Agr 3802.01)

How and When to Dispose of Invasives?

To prevent seed from spreading remove invasive plants before seeds are set (produced). Some plants continue to grow, flower and set seed even after pulling or cutting. Seeds can remain viable in the ground for many years. If the plant has flowers or seeds, place the flowers and seeds in a heavy plastic bag "head first" at the weeding site and transport to the disposal site. The following are general descriptions of disposal methods. See the chart for recommendations by species.

Burning: Large woody branches and trunks can be used as firewood or burned in piles. For outside burning, a written fire permit from the local forest fire warden is required unless the ground is covered in snow. Brush larger than 5 inches in diameter can't be burned. Invasive plants with easily airborne seeds like black swallow-wort with mature seed pods (indicated by their brown color) shouldn't be burned as the seeds may disperse by the hot air created by the fire.



Japanese knotweed
Polygonum cuspidatum
USDA-NRCS PLANTS Database / Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. Vol. 1: 676.

Bagging (solarization): Use this technique with softer-tissue plants. Use heavy black or clear plastic bags (contractor grade), making sure that no parts of the plants poke through. Allow the bags to sit in the sun for several weeks and on dark pavement for the best effect.

Tarping and Drying: Pile material on a sheet of plastic and cover with a tarp, fastening the tarp to the ground and monitoring it for escapes. Let the material dry for several weeks, or until it is clearly nonviable.

Chipping: Use this method for woody plants that don't reproduce vegetatively.

Burying: This is risky, but can be done with watchful diligence. Lay thick plastic in a deep pit before placing the cut up plant material in the hole. Place the material away from the edge of the plastic before covering it with more heavy plastic. Eliminate as much air as possible and toss in soil to weight down the material in the pit. Note that the top of the buried material should be at least three feet underground. Japanese knotweed should be at least 5 feet underground!

Drowning: Fill a large barrel with water and place soft-tissue plants in the water. Check after a few weeks and look for rotted plant material (roots, stems, leaves, flowers). Well-rotted plant material may be composted. A word of caution- seeds may still be viable after using this method. Do this before seeds are set. This method isn't used often. Be prepared for an awful stink!

Composting: Invasive plants can take root in compost. Don't compost any invasives unless you know there is no viable (living) plant material left. Use one of the above techniques (bagging, tarping, drying, chipping, or drowning) to render the plants nonviable before composting. Closely examine the plant before composting and avoid composting seeds.

Be diligent looking for seedlings for *years* in areas where removal and disposal took place.

Suggested Disposal Methods for Non-Native Invasive Plants

This table provides information concerning the disposal of removed invasive plant material. If the infestation is treated with herbicide and left in place, these guidelines don't apply. Don't bring invasives to a local transfer station, unless there is a designated area for their disposal, or they have been rendered non-viable. This listing includes wetland and upland plants from the New Hampshire Prohibited Invasive Species List. The disposal of aquatic plants isn't addressed.

Woody Plants	Method of Reproducing	Methods of Disposal
Norway maple *(Acer platanoides)* European barberry *(Berberis vulgaris)* Japanese barberry *(Berberis thunbergii)* autumn olive *(Elaeagnus umbellata)* burning bush *(Euonymus alatus)* Morrow's honeysuckle *(Lonicera morrowii)* Tatarian honeysuckle *(Lonicera tatarica)* showy bush honeysuckle *(Lonicera x bella)* common buckthorn *(Rhamnus cathartica)* glossy buckthorn *(Frangula alnus)*	**Fruit and Seeds**	**Prior to fruit/seed ripening** Seedlings and small plants ▪ Pull or cut and leave on site with roots exposed. No special care needed. Larger plants ▪ Use as firewood. ▪ Make a brush pile. ▪ Chip. ▪ Burn.
		After fruit/seed is ripe Don't remove from site. ▪ Burn. ▪ Make a covered brush pile. ▪ Chip once all fruit has dropped from branches. ▪ Leave resulting chips on site and monitor.
oriental bittersweet *(Celastrus orbiculatus)* multiflora rose *(Rosa multiflora)*	**Fruits, Seeds, Plant Fragments**	**Prior to fruit/seed ripening** Seedlings and small plants ▪ Pull or cut and leave on site with roots exposed. No special care needed. Larger plants ▪ Make a brush pile. ▪ Burn.
		After fruit/seed is ripe Don't remove from site. ▪ Burn. ▪ Make a covered brush pile. ▪ Chip – only after material has fully dried (1 year) and all fruit has dropped from branches. Leave resulting chips on site and monitor.

<table>
<tr><th>Non-Woody Plants</th><th>Method of Reproducing</th><th>Methods of Disposal</th></tr>
<tr><td rowspan="2">garlic mustard
(Alliaria petiolata)
spotted knapweed
(Centaurea maculosa)
▪ Sap of related knapweed can cause skin irritation and tumors. Wear gloves when handling.
black swallow-wort
(Cynanchum nigrum)
▪ May cause skin rash. Wear gloves and long sleeves when handling.
pale swallow-wort
(Cynanchum rossicum)
giant hogweed
(Heracleum mantegazzianum)
▪ Can cause major skin rash. Wear gloves and long sleeves when handling.
dame's rocket
(Hesperis matronalis)
perennial pepperweed
(Lepidium latifolium)
purple loosestrife
(Lythrum salicaria)
Japanese stilt grass
(Microstegium vimineum)
mile-a-minute weed
(Polygonum perfoliatum)</td><td rowspan="2">Fruits and Seeds</td><td>Prior to flowering
Depends on scale of infestation
Small infestation
▪ Pull or cut plant and leave on site with roots exposed.

Large infestation
▪ Pull or cut plant and pile. (You can pile onto or cover with plastic sheeting).
▪ Monitor. Remove any re-sprouting material.</td></tr>
<tr><td>During and following flowering
Do nothing until the following year or remove flowering heads and bag and let rot.

Small infestation
▪ Pull or cut plant and leave on site with roots exposed.

Large infestation
▪ Pull or cut plant and pile remaining material. (You can pile onto plastic or cover with plastic sheeting).
▪ Monitor. Remove any re-sprouting material.</td></tr>
<tr><td>common reed
(Phragmites australis)
Japanese knotweed
(Polygonum cuspidatum)
Bohemian knotweed
(Polygonum x bohemicum)</td><td>Fruits, Seeds, Plant Fragments
Primary means of spread in these species is by plant parts. Although all care should be given to preventing the dispersal of seed during control activities, the presence of seed doesn't materially influence disposal activities.</td><td>Small infestation
▪ Bag all plant material and let rot.
▪ Never pile and use resulting material as compost.
▪ Burn.

Large infestation
▪ Remove material to unsuitable habitat (dry, hot and sunny or dry and shaded location) and scatter or pile.
▪ Monitor and remove any sprouting material.
▪ Pile, let dry, and burn.</td></tr>
</table>

January 2010

6.

Operating Plan Packet 02072023

THE BALSAMS

SITE PLAN REVIEW APPLICATION
FOR
SKI AREA EXPANSION – PHASE 1

THE BALSAMS PLANNED UNIT DEVELOPMENT
DD – RESORT

UNINCORPORATED PLACES OF COÖS COUNTY NH

Wind Turbine Safety Operating Plan – Full Packet for CCPB Review
Including all related files to date: 7 February 2023

Table of Contents

To: Coos County Planning Board
CC: Tara Bamford
From: The Balsams Team
7 February 2023

Subject: Operating Plan for Icing Conditions

At the beginning of this application process, we submitted an operating plan to address skier safety within 837' when potential wind turbine icing conditions are present. In conjunction with this, two icing studies were submitted. One study prepared for Brookfield Renewable Energy, was completed by AWS Truepower. A second study, prepared for the applicant, was completed by DNV-GL. Both established that the appropriate setback distance for skiers on our site would be 837'. The Balsams team intends to utilize this operating plan for Balsams guests during ski season.

At the board's request, we identified and engaged Bruce Bailey, an expert on wind turbine icing to review our proposed operating plan. Mr. Bruce Bailey, an author of the AWS Truepower study referenced above, provided us his input for our operating plan in the form of a letter which you've previously reviewed. Bruce Bailey, now retired from Underwriters Laboratory (UL), whom he sold his company AWS Truepower to and then worked for, spent his forty-year career in wind turbines and their study. He has an undergraduate degree in Meteorology and a PhD in Engineering Management, for which his thesis was completed on the topic of icing on wind turbines in the Northeast. We've submitted Dr. Bailey's biographical information as well. Dr. Bailey found our operating plan to be reasonable which was what the Board had requested.

Upon further request, we identified and engaged a second expert with a Professional Engineering license to review the proposed operating plan. Dan Bernadett has spent his 30-year career so far working in the space of wind turbines and their design and analysis. He worked for AWS Truepower for a large part of his career, transitioned to UL when AWS Truepower was acquired by UL, and now works for ArcVera. Mr. Bernadett's PE license number in the state of NY is 073489 and can be looked up within the NY database at: https://www.op.nysed.gov/verification-search. Mr. Bernadett's resume and his review of our plan, finding it reasonable and thorough, is included with this submittal.

The question of turbine failures arose during a previous Board discussion. ArcVera is involved with 70% of the wind turbines in the US, and Mr. Bernadett shared with us that ArcVera doesn't have any record of any member of the public ever being injured by an operating wind turbine, from ice or other means. DNV (the company which provided one of the original icing safety studies) also agrees with this statistic.[1] We found that the US Department of Energy states that "Turbine failures are considered rare events" and that "a failure in which a turbine blade becomes detached mid-operation, are virtually non-existent."[2]

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[1] News article citing DNV statement – Oregon Live News, August, 2022
[2] US Department of Energy - https://windexchange.energy.gov/projects/safety

As discussed during the January 18th Board meeting, the turbine manufacturer's operating manual identified by Tara included a reference to a 1300' setback but no explanation as to why. Mr. Bernadette contacted Vestas and as noted in his attached letter, Vestas stated the source of the 1300' number was "elusive," and that it was previously removed from the latest version of the manual.

Before providing insurance to businesses, insurance companies evaluate the risks. Our insurance company has insured other ski areas which have wind towers in close proximity to ski trails. They have reviewed our icing plan. In comparison to typical societal risks faced by ski areas and others every day, the insurer does not see the wind towers posing significant additional risks.

Please find in this packet the following materials:

- The Balsams Operating Plan in current form
- Written responses to Tara's 1/12/2023 questions from Dan Bernadett
- A letter from our insurance company addressing the risk of the turbines for skiers
- Examples of other Northeast wind turbines located near public uses

Previously provided and included materials:

- Dr. Bailey's letter regarding our operating plan
- Dr. Bailey's biography
- Dan Bernadett's letter regarding our operating plan
- Dan Bernadett's resume and an image of his PE certification
- Icing Study completed by AWS Truepower
- Icing Study completed by DNV-GL

For consideration, there have been thousands of snowmobilers and ATV riders coming within several hundred feet of these towers for the last 12 years with no report of injury or ice hitting anyone. Granite Reliable, in cooperation with the NH Bureau of Trails and Tillotson Corporation, moved the snowmobile and ATV trail to 650' away intentionally and gated just the turbine access road, considering this a safe distance. The Cohos hiking trail goes through the turbines' area without regard to any setback. For 12 years there have been no fences, other gates, or signs in place suggesting a further setback and no issues or injuries reported.

Additionally, Mr. Bernadett will attend the public hearing with the Planning Board on February 15, 2023, to answer any questions.

Respectfully submitted,
The Balsams Development Team

2

The Balsams Operating Plan

THE BALSAMS

Operating Plan for Wind Turbine Icing (Revision 1)

This Operating Plan sets forth how public access to trails within 837' of wind turbines will be managed to address potential turbine icing conditions.

1- The Balsams will install a weather station at the top of lift 4 or in closer proximity to wind turbines 4, 5 and 6 which will include temperature, relative humidity, and heated sensors for wind speed and direction.
2- Weather data will be monitored and logged in 15-minute increments by Dispatch beginning 30 minutes prior to opening lift 4 and during the time the lift remains open. Weather data will also be logged throughout the night and reviewed in the morning prior to opening.
3- Prior to opening Lift 4:
    a. A visual inspection of blades on Turbines 4, 5 and 6 will be made to detect the indications of icing on the blades.
    b. The ski patrol director or their designee will be responsible for inspection.
    c. All inspectors will be trained to identify indications of icing.
    d. If ice is observed the affected trail will be closed.
    e. If a visual inspection is not possible due to conditions and temperatures are or were 35F or lower during the prior night, the trail will be closed.
4- Once the trail is open:
    a. If the temperature is 35F or below and weather conditions change such that the possibility of icing develops, the turbines will be visually inspected, and the trail closed if icing is observed.
    b. If the temperature is 35F or lower and the turbines become not visible for more than one hour, the trail will be closed.
5- If the trail is closed due to an icing event, it may be reopened when the blades no longer have visible icing.
6- In the event the turbines are not operating the trail will be subject to the normal trail open and closed procedures of the resort.
7- Whenever this plan indicates a trail closure, the wind turbines creating the need for closure may be shut down in lieu of closing the trail.
8- If a wind turbine is restarted while a trail is open and the temperature is 35F or lower, the trail will be closed until the turbine is inspected per #3 above.

Date: 6 December 2022
Mountain Operations: ___________________________________

3

Written Response to Tara Bamford's 1/12/2023 Questions from Dan Bernadett

31 January 2023

Hannah Campbell
The Balsams Resort

Re: Response to Planning Board Questions received by ArcVera 18 January 2023

This Letter contains responses to Planning Board questions received via e-mail from you on 18 January 2023. ArcVera understands that you will forward our responses to the Planning Board.

1. ArcVera understands that turbine #4 is included in the most recent version of the "Operating Plan for Wind Turbine Icing" (the Plan).
2. Affected trail means any trail within 837 feet of a wind turbine. No lifts have been proposed within 837 feet of a wind turbine.
3. The DNV-GL report dated 7 October 2014 contains a statement on page 26 that "Setback #3 is based on a historic generic formula[4], when no site specific modeling tool was available." ArcVera considers that the formula applied [4](Hub height + rotor diameter, multiplied by 1.5) [Siefert equation] is appropriate and specific to the hub height and rotor diameter of the project. ArcVera does not find a recommendation in the DNV-GL report to do more site-specific modeling. In fact, the DNV-GL report itself used the Siefert equation to determine the proposed icing setback. ArcVera finds that the Siefert equation is sufficiently specific to this site since it accounts for both the hub height and rotor diameter and that more site-specific modeling is not necessary. The 837 foot icing setback is specific to the hub height and rotor diameter of the project. Thus the modeling of the icing setback for this project is specific to the site.
4. As listed in the Plan, the ski patrol director or their designee will be responsible for inspection.
5. The Plan states that weather data will be gathered including temperature, relative humidity, wind speed, and direction. ArcVera considers these parameters sufficient to determine whether conditions exist for the formation of icing. ArcVera considers that provisions of the Plan are sufficient to address all types of icing from previous weather events.
6. The Balsams has identified the persons responsible for preparing the Plan and their backgrounds.

ArcVera finds that the Plan adequately addresses all contingencies. In particular, ArcVera finds it unnecessary to determine the operating condition of the turbine. The trail will be closed if the wind turbine is iced, regardless of whether it is running or not. The trail will not be re-opened until the wind turbine is free of ice. ArcVera finds that the Plan already covers all contingencies of turbine operation. The 837 foot setback covers normal operation, shut down, and start up, so it is unnecessary to add additional contingency parameters since all contingencies have been covered by the Plan.

On 30 December 2022, ArcVera issued a letter reviewing the Plan. This letter documents the experience and background of the independent reviewer (Dan Bernadett).

ArcVera reached out to Vestas to inquire regarding the 1300 foot value. Vestas responded that the source of the 1300 foot value was "elusive". They note that this value has been removed from the most recent version of the "Mechanical Operating and Maintenance Manual". Based on the fact that Vestas has removed this value from their official documents, ArcVera considers that this value is not relevant to the present discussion.

ArcVera has evaluated 70% of the wind projects in the US. I am not aware of any member of the public being injured by a wind turbine.

Please contact me if any questions arise regarding this analysis.

Sincerely,

Daniel W. Bernadett

Daniel W. Bernadett, P.E.
Global Director of Wind Engineering

4

A Letter from Balsams Insurance Company Addressing the Risk of Turbines for Skiers

AMWINS

PROGRAM UNDERWRITERS

January 30, 2023

Dixville Capital, LLC
PO Box 547
Bethel, ME 04217

To whom it may concern,

Our MountainGuard ski resort insurance program, the largest in the U.S. has been around since 1962 and I've been involved in running the program for the past 44 years. As you are aware, there are numerous inherent risks in the sport of skiing. These risks include but are not limited to natural and manmade obstacles resulting in claims. Mechanical failures, building fires, building explosions, helicopter crashes, building loss to avalanche and flood, inadvertent loss due to explosive devices for avalanche control are all some liability claims we have dealt with over the decades.

The risks of wind turbines in proximity to ski resort physical assets and ski resort guests pale in comparison. I'm aware of two wind turbines located on ski resort properties, Jiminy Peak, MA and Bolton Valley, VT. We do/have insured both and have no concern whatsoever with respect to whatever imaginable risks or exposure may come to mind. I've had several discussions with some of your team over the past 5 years about the future development of the Balsams and am well aware of the 7 wind turbines currently in place and operating on the proposed developable property.

I can assure you that if things progress as you and I hope they will that our program, along with our AIG underwriting partner, will have no concern providing the necessary Property and Liability insurance coverage for the entire resort and all "abutting" exposures that may come into play.

To clarify that this is not a sales pitch. I can speak on behalf of our main competitor, as well as a third minor player in this space, that they too would be of the same position. The risks associated with the wind turbines do not pose exposures that should be of concern if you follow the proposed icing plan. I'm more than happy to discuss this with you or your business affiliates further if you like.

As an aside, I drove home this evening from North Conway, NH to Rochester, NH and in the 44 years of making this drive north and south, never in my life have I seen such north bound traffic! It's going to be a record weekend coming up and a need for another great resort in the future!

All the best,

Roger C. Adams
Senior Vice President, MountainGuard

Amwins Program Underwriters
145 Maplewood Avenue, Suite 220
Portsmouth, NH 03801

T 603.334.3002
F 603.334.3090
amwins.com/apu

5

Examples of other Wind Turbines which are near Public Use Areas for Comparison

Data sourced from US Wind Turbine Database:
https://eerscmap.usgs.gov/uswtdb/viewer/#3/37.25/-96.25

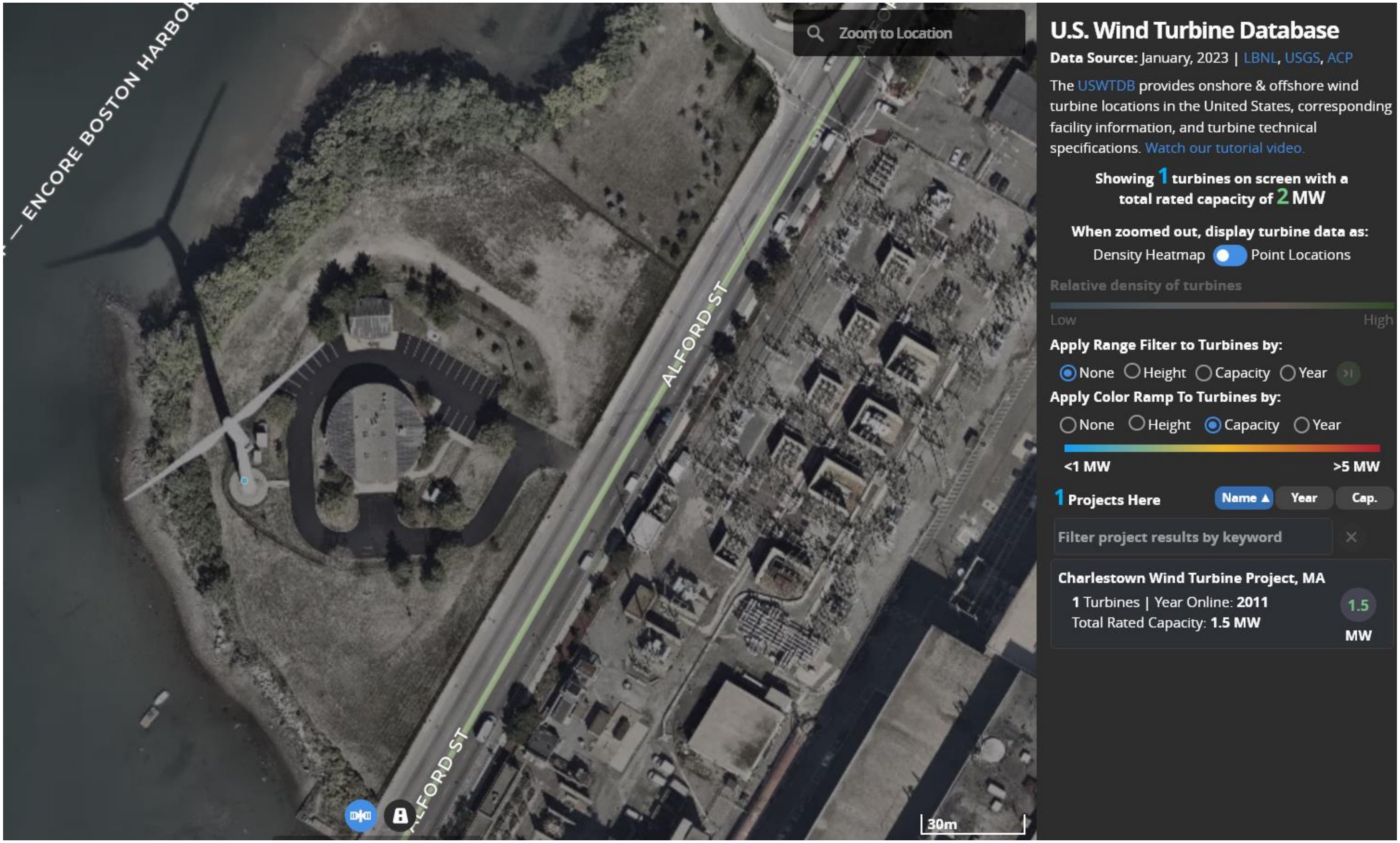
Purpose: to show comparisons of wind turbines in urban or populated settings where dwellings, schools, recreational facilities, and other human activities co-exist with wind energy. The calculated setback using the Seifert equation (d=(D+H)*1.5) and the database information is provided for reference.

Table: Comparison Wind Turbines Near Public Uses

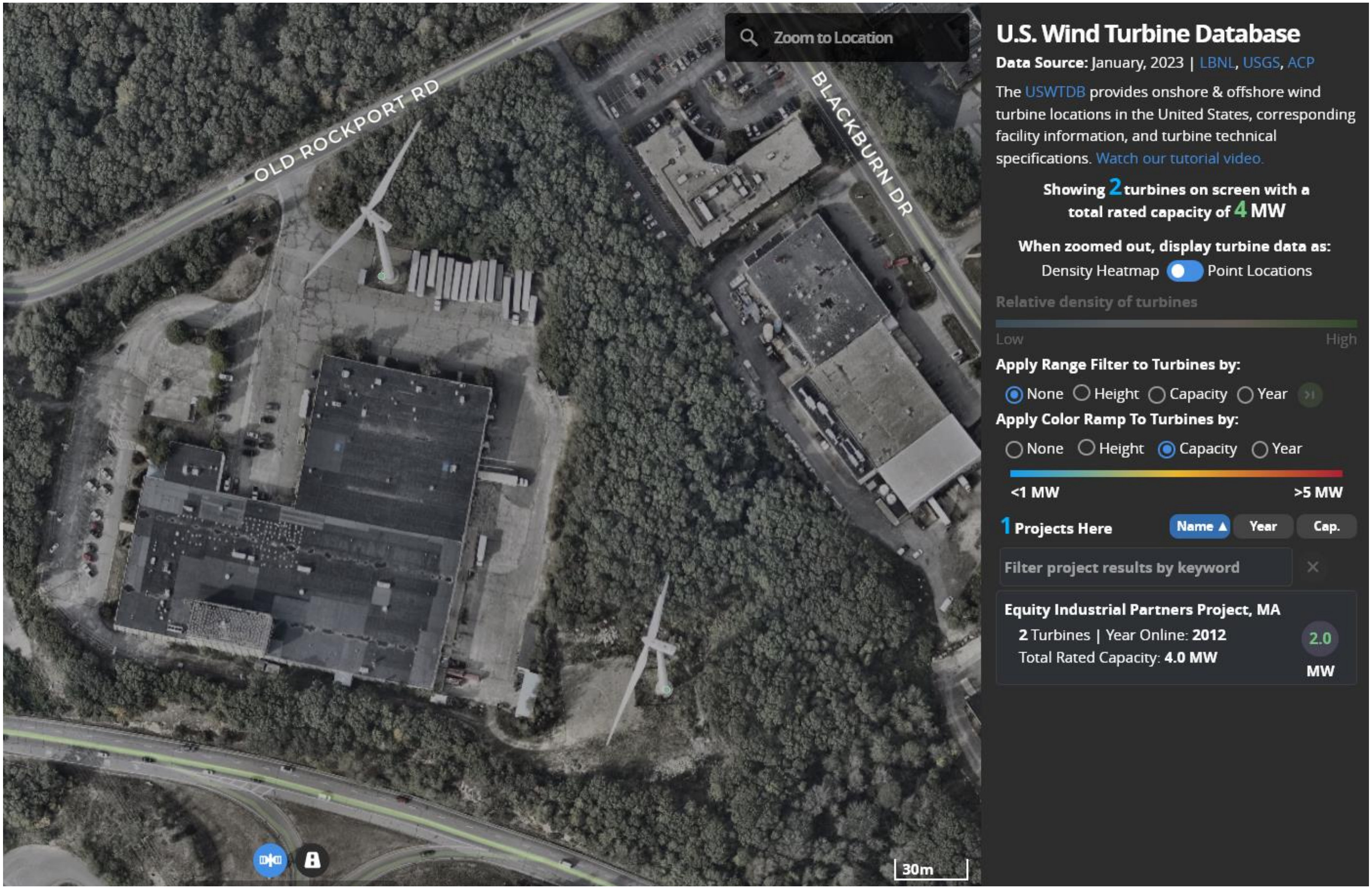
Corresponding to-scale images on following pages

Location	Adjacent Use	Turbine Height	Rotor Diameter	Seifert Setback
Chelsea, MA	Pump Station	70m	82m	228m or 748’
Gloucester, MA	Industrial	78m	90m	252m or 827’
Hull, MA	School, ballfields	50m	47m	145.5m or 477’
Bourne, MA	School, ballfields	50m	47m	145.5m or 477’
Portsmouth, RI	School, ballfields	85m	82m	250.5m or 822’
Providence, RI	Wastewater Sys.	70m	82m	228m or 748’
Worcester, MA	School, ballfields	50m	47m	145.5m or 477’
Templeton, MA	School, ballfields	80m	77m	235.5m or 773’
Bolton Valley, VT	Ski area	37m	21m	87m or 285’
Jiminy Peak, MA	Ski area	80m	77m	235.5m or 773’

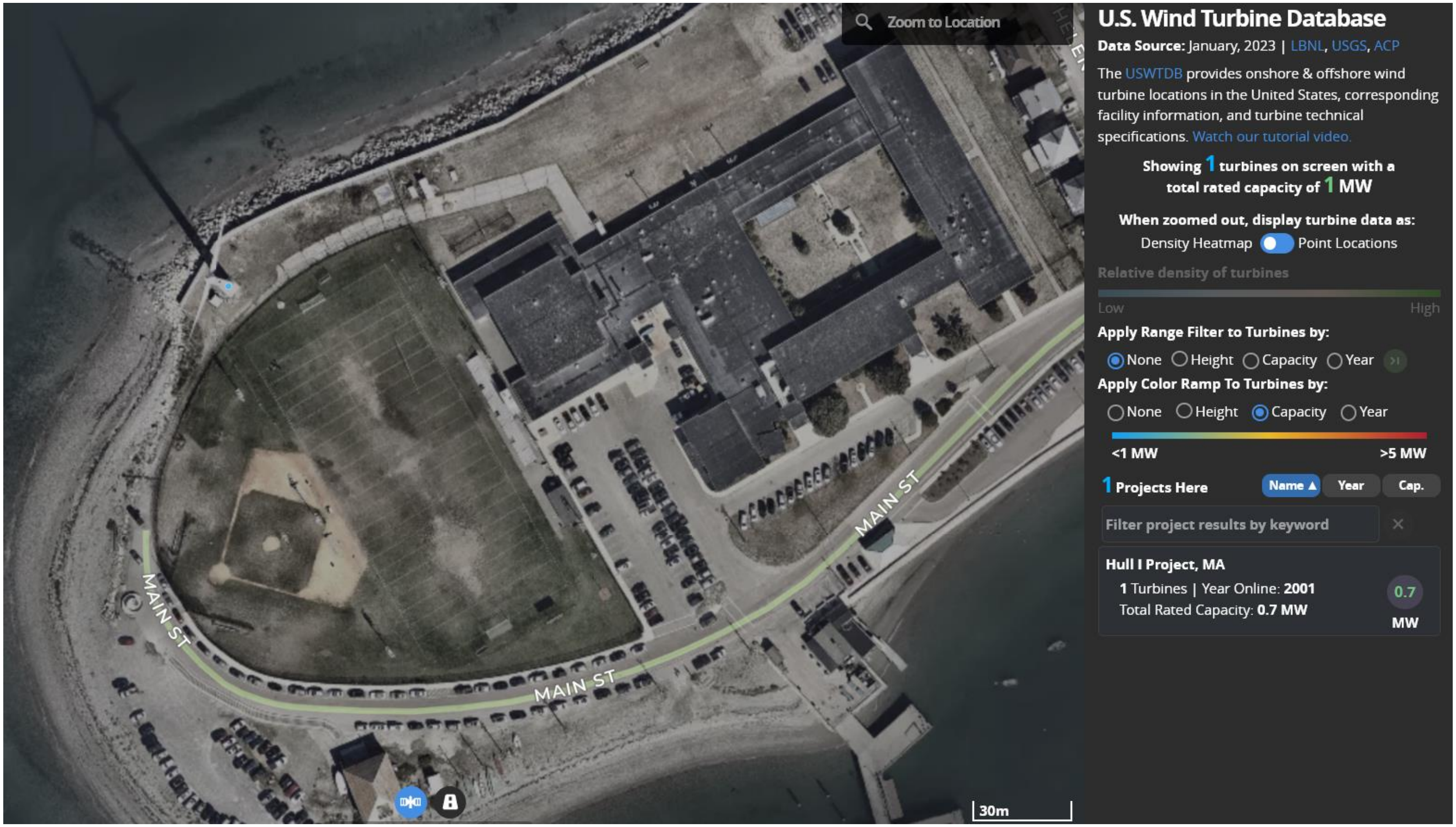
Chelsea, MA


ENCORE BOSTON HARBOR
ALFORD ST
ALFORD ST
Zoom to Location
30m
U.S. Wind Turbine Database
Data Source: January, 2023 | LBNL, USGS, ACP
The USWTDB provides onshore & offshore wind turbine locations in the United States, corresponding facility information, and turbine technical specifications. Watch our tutorial video.
Showing 1 turbines on screen with a total rated capacity of 2 MW
When zoomed out, display turbine data as:
Density Heatmap Point Locations
Relative density of turbines
Low
High
Apply Range Filter to Turbines by:
None Height Capacity Year
Apply Color Ramp To Turbines by:
None Height Capacity Year
<1 MW
>5 MW
1 Projects Here
Name ▲
Year
Cap.
Filter project results by keyword
Charlestown Wind Turbine Project, MA
1 Turbines | Year Online: 2011
Total Rated Capacity: 1.5 MW
1.5
MW

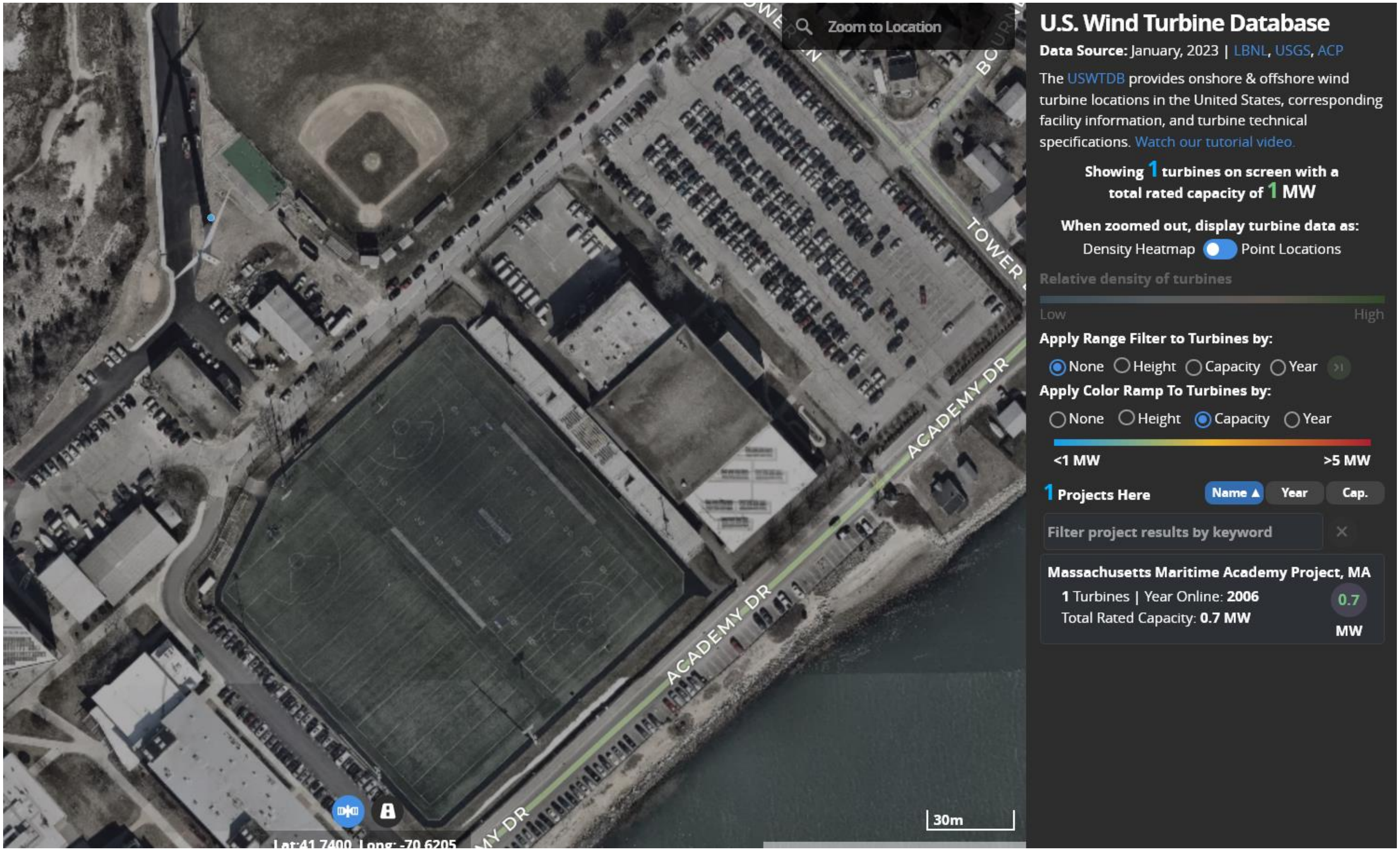
Gloucester, MA



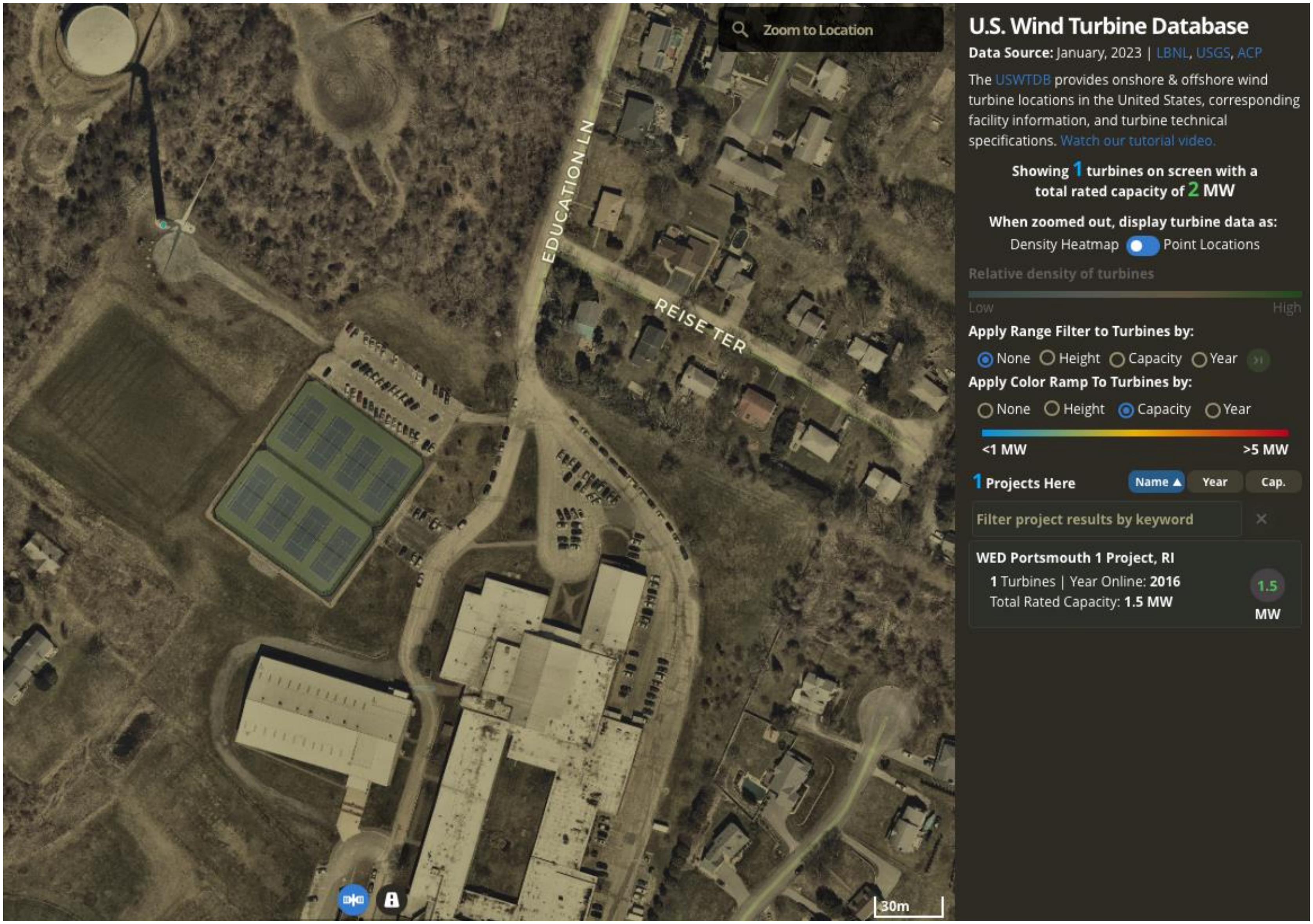
Hull, MA


Zoom to Location
U.S. Wind Turbine Database
Data Source: January, 2023 | LBNL, USGS, ACP
The USWTDB provides onshore & offshore wind turbine locations in the United States, corresponding facility information, and turbine technical specifications. Watch our tutorial video.
Showing 1 turbines on screen with a total rated capacity of 1 MW
When zoomed out, display turbine data as:
Density Heatmap Point Locations
Relative density of turbines
Low High
Apply Range Filter to Turbines by:
None Height Capacity Year
Apply Color Ramp To Turbines by:
None Height Capacity Year
<1 MW >5 MW
1 Projects Here
Name Year Cap.
Filter project results by keyword
Hull I Project, MA
1 Turbines | Year Online: 2001
Total Rated Capacity: 0.7 MW
0.7 MW
MAIN ST
MAIN ST
MAIN ST
30m

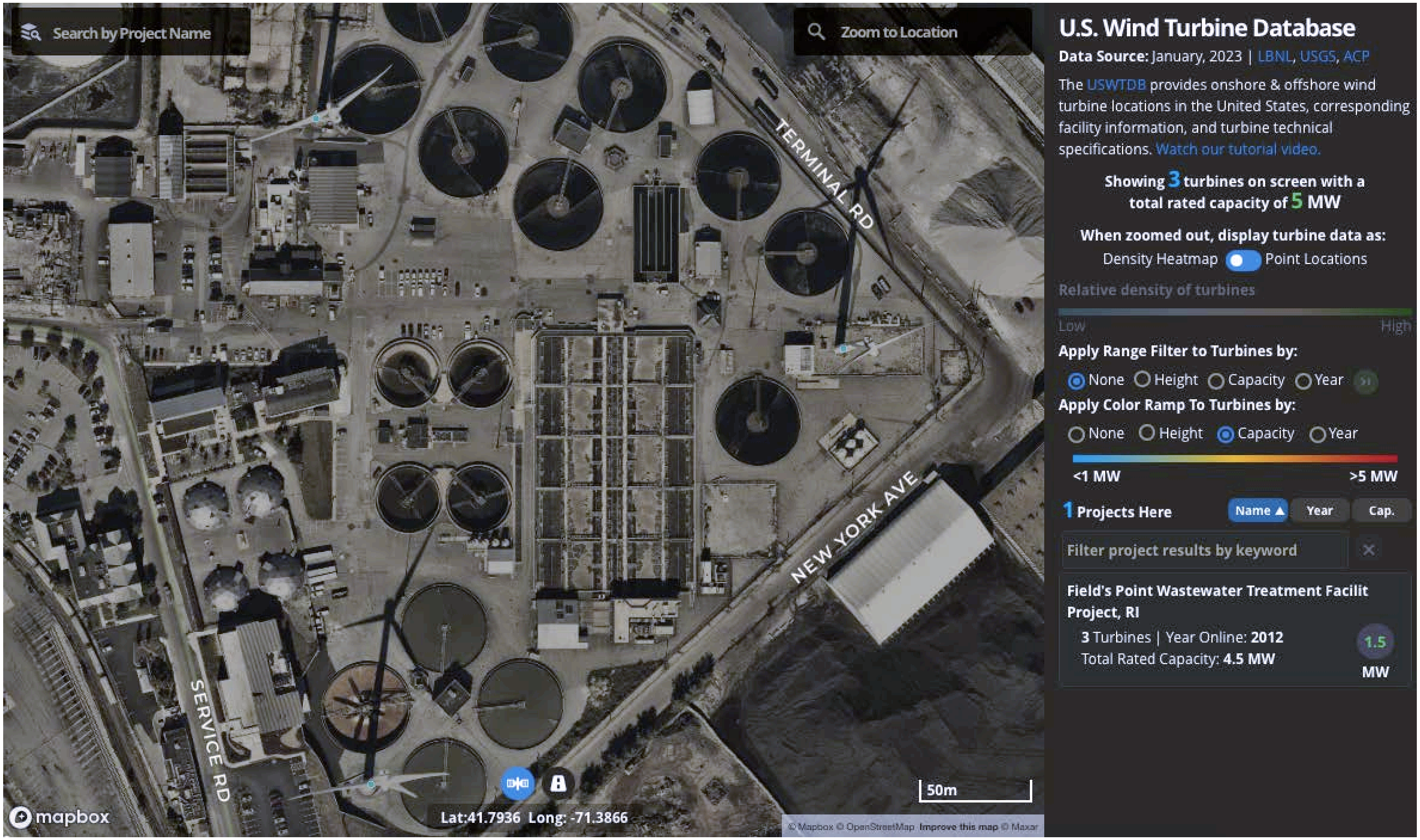
Bourne, MA


Zoom to Location
TOWER
BO
TOWER
ACADEMY DR
ACADEMY DR
MY DR
30m
Lat:41.7400 Long:-70.6205
U.S. Wind Turbine Database
Data Source: January, 2023 | LBNL, USGS, ACP
The USWTDB provides onshore & offshore wind turbine locations in the United States, corresponding facility information, and turbine technical specifications. Watch our tutorial video.
Showing 1 turbines on screen with a total rated capacity of 1 MW
When zoomed out, display turbine data as:
Density Heatmap
Point Locations
Relative density of turbines
Low
High
Apply Range Filter to Turbines by:
None
Height
Capacity
Year
Apply Color Ramp To Turbines by:
None
Height
Capacity
Year
<1 MW
>5 MW
1 Projects Here
Name
Year
Cap.
Filter project results by keyword
Massachusetts Maritime Academy Project, MA
1 Turbines | Year Online: 2006
Total Rated Capacity: 0.7 MW
0.7
MW

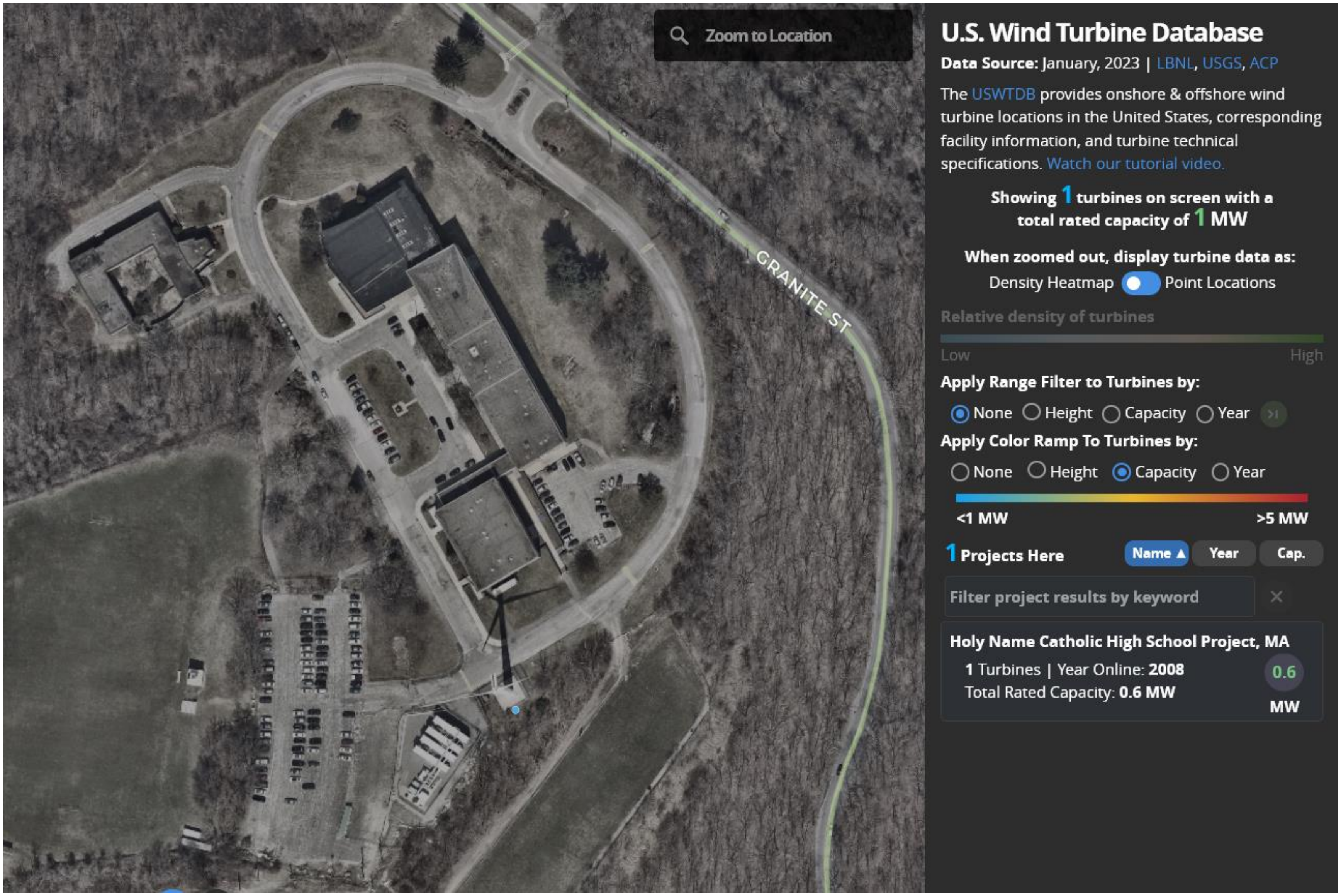
Portsmouth, RI



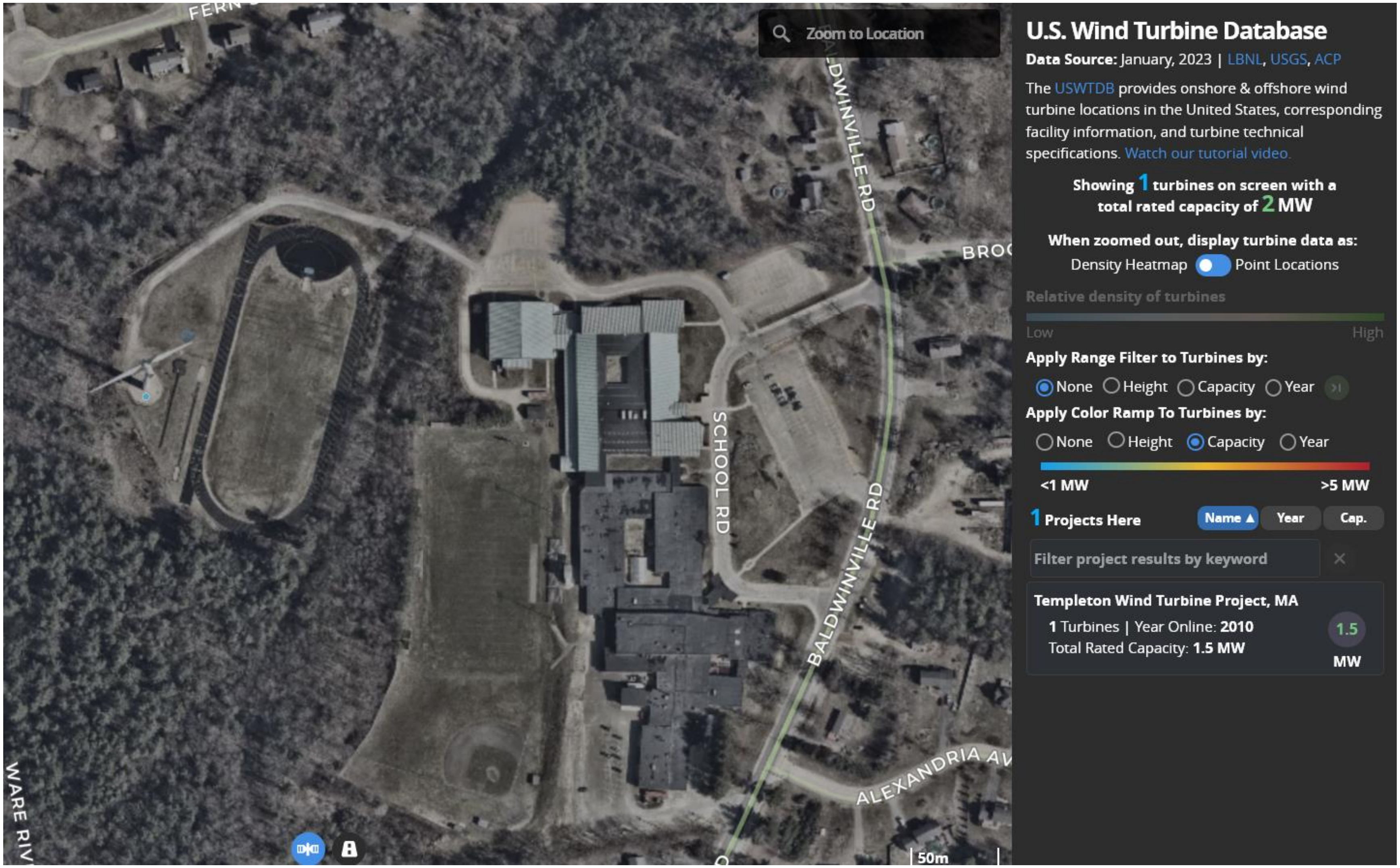
Providence, RI



Worcester, MA

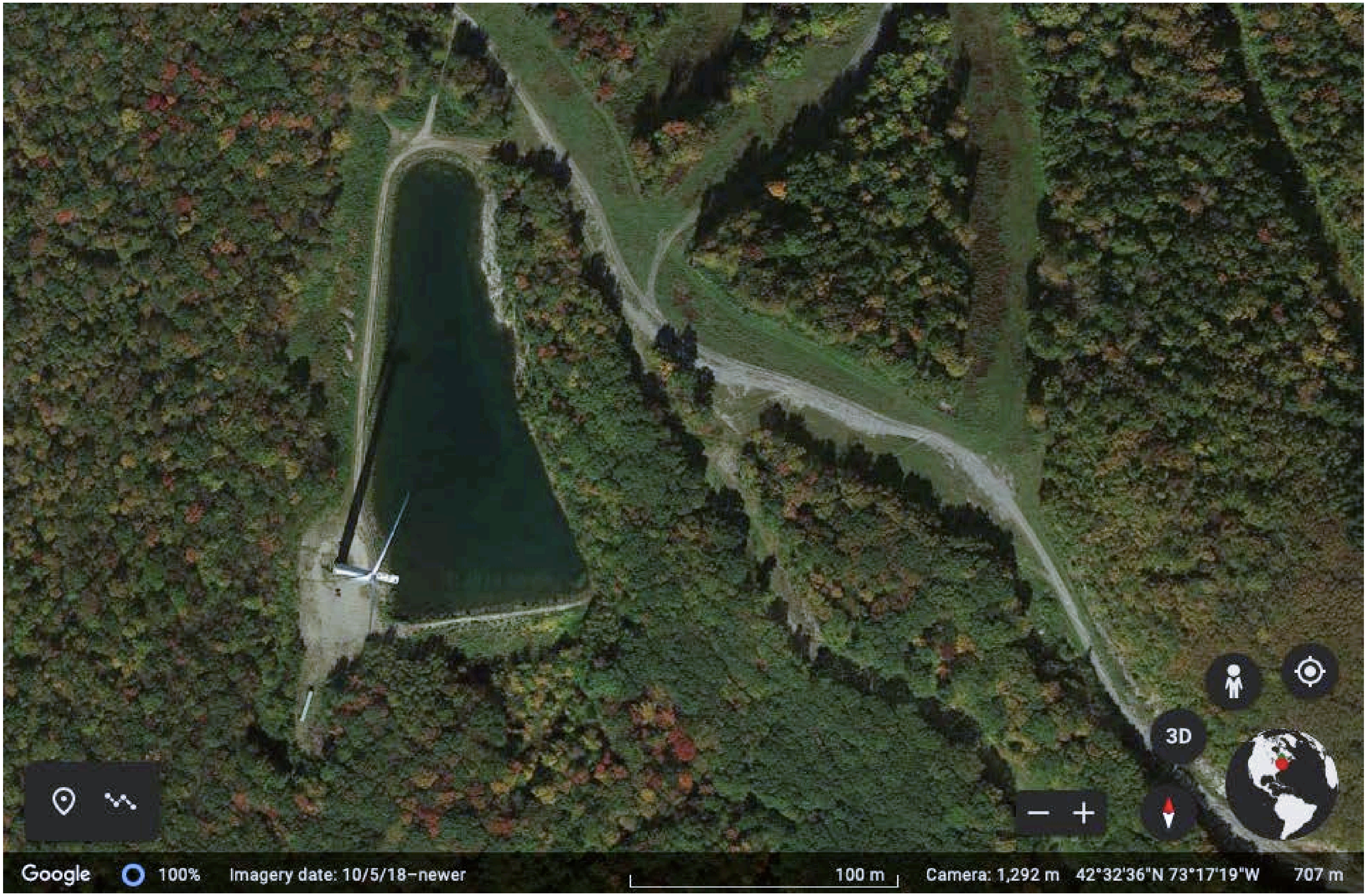


Templeton, MA



Bolton Valley, VT

Jiminy Peak, MA



6

Dr. Bailey’s Letter Regarding The Balsams Operating Plan

The Balsams Resort
1000 Cold Spring Road
Dixville, NH 03576

December 7, 2022

Dear Ms. Campbell:

I have reviewed the attached amended document titled "Operating Plan for Wind Turbine Icing" dated 6 December 2022, which outlines a safety plan for managing ski trail access when wind turbine icing exists or may exist. I find the plan to be comprehensive in its approach and reasonable to implement. Therefore, there are no further changes required in my opinion.

Let me add that my professional background spanning over 40 years includes extensive experience with the assessment of icing on wind turbines and associated risks. I was the co-author of the report titled "Ice Throw Risk Assessment for Dixville Peak", which was prepared for Brookfield Renewable Energy in 2015. I have conducted assessments of icing risks for scores of other existing and proposed wind energy projects throughout North America. I have degrees in meteorology and engineering management, and am currently an Executive in Residence with the Atmospheric Sciences Research Center at the University at Albany.

Please do not hesitate to contact me if you have any questions.

Sincerely,

Bruce H. Bailey, Ph.D.
Latham, NY
bbailey8@nycap.rr.com

T · H · E
BALSAMS

Operating Plan for Wind Turbine Icing

This Operating Plan sets forth how public access to trails within 837’ of wind turbines will be managed to address potential turbine icing conditions.

1- The Balsams will install a weather station at the top of lift 4 or in closer proximity to wind turbines 5 and 6 which will include temperature, relative humidity, wind speed and direction.
2- Weather data will be monitored and logged in 15-minute increments by Dispatch beginning 30 minutes prior to opening lift 4 and during the time the lift remains open. Weather data will also be logged throughout the night and reviewed in the morning prior to opening.
3- Prior to opening Lift 4:
    a. A visual inspection of blades on Turbines 5 and 6 will be made to detect the indications of icing on the blades.
    b. The ski patrol director or their designee will be responsible for inspection.
    c. All inspectors will be trained to identify indications of icing.
    d. If ice is observed the affected trail will be closed.
    e. If a visual inspection is not possible due to conditions and temperatures are or were 35F or lower during the prior night, the trail will be closed.
4- Once the trail is open:
    a. If the temperature is 35F or below and weather conditions change such that the possibility of icing develops, the turbines will be visually inspected, and the trail closed if icing is observed.
    b. If the temperature is 35F or lower and the turbines become not visible for more than one hour, the trail will be closed.
5- If the trail is closed due to an icing event, it may be reopened when the blades no longer have visible icing.
6- In the event the turbines are not operating the trail will be subject to the normal trail open and closed procedures of the resort.
7- Whenever this plan indicates a trail closure, the wind turbines creating the need for closure may be shut down in lieu of closing the trail.
8- If a wind turbine is restarted while a trail is open and the temperature is 35F or lower, the trail will be closed until the turbine is inspected per #3 above.

Date: 6 December 2022

Mountain Operations: ___________________________________

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Dr. Bailey’s Biography

Biography for Dr. Bruce H. Bailey

Dr. Bruce Bailey has worked for over 45 years in the renewable energy industry. His career began in the mid-1970s at the State University of New York at Albany (UAlbany) as a research associate where he became the manager of wind energy programs. In the mid-1980s he left the university to run a technical consulting firm specializing in meteorological and engineering-related services to the clean energy and clean air sectors. The firm—AWS Truepower—grew to become one of the renewable energy sector's largest and most-respected consultancies, with offices established on four continents. Major client groups included utilities, government agencies, banks, and project developers. In late 2016 the firm was acquired by UL, a global safety science company. Dr. Bailey became Underwriter's Laboratory's (UL) Vice President for Renewables and retired from UL at the end of 2019.

Dr. Bailey's technical expertise includes renewable energy and smart technology systems evaluation, risk analysis, and the application of meteorological/climate analysis on engineering, environmental and economic planning. He has overseen the evaluation of over 140,000 megawatts of proposed and operating wind and solar projects throughout the world. He has contributed to more than 100 publications and 150 presentations at international conferences, and is a technical reviewer for the *Renewable Energy* journal.

He has an undergraduate degree in Atmospheric Sciences from Cornell University and a doctorate in Engineering Management from California Coast University. His doctoral dissertation addressed the climatology of icing events in the northeastern US and subsequent impacts on wind turbines. Relatedly, he has assessed icing risks for numerous proposed and existing wind energy projects throughout North America.

In his semi-retirement, Dr. Bailey serves as the Executive in Residence at UAlbany's Atmospheric Sciences Research Center where he engages in wind energy research and teaches students. He also serves on multiple boards: Chair of the Advisory Council for Cornell University's Department of Earth and Atmospheric Sciences; the Cornell Atkinson Center for Sustainability; and two international companies working in the renewable energy and environmental sciences arenas.

8

Dan Bernadett's Letter Regarding The Balsams Operating Plan

ARCVERA RENEWABLES

18 January 2023

Hannah Campbell
The Balsams Resort

Re: Review of "Operating Plan for Wind Turbine Icing"

This Letter Report summarizes my review of the "Operating Plan for Wind Turbine Icing" (Revision 1) (the Plan) dated 6 Dec 2022. The Plan is included for reference at the end of this document. The Plan describes how public access to trails within 837 feet (255m) of wind turbines will be managed to address potential icing conditions at the proposed expansion of the Balsams ski area in northern New Hampshire adjacent to the existing wind turbines at Dixville Peak. The amended Plan contains my suggestion to include heated sensors to measure wind speed and direction. In my experience, heated sensors are necessary in icing conditions in order to get an accurate reading of wind speed and direction.

I find the Plan to be comprehensive, conservative, and appropriate for application in this situation.

SCOPE:

In developing the opinion above, I reviewed the following documents:

- 17a. Appendix A - Windtower Setbacks and Operating Plan for Icing Conditions -rev12-12.pdf, which contains the "Operating Plan for Wind Turbine Icing"
- 17b. Appendix A - Expert Opinion Operating Plan for Wind Turbine Icing.pdf
- 17c. Appendix A - aws truepower wind study.pdf
- 17d. Appendix A - dnv-gl wind study.pdf
- 17e. Appendix A - Ski Trail Concept-01-Wind Tower Setbacks.pdf

Dan Bernadett background:

I currently serve as Global Director of Wind Engineering for ArcVera, a global wind energy consulting company. I began my career in wind energy in 1993. I was on-site at Dixville Peak as part of the team that installed the original meteorological towers that confirmed the wind resource estimates used when the existing wind turbines were installed. I have Bachelor's degrees in Mechanical and Aeronautical Engineering and a Master's degree in Mechanical Engineering. I am currently a registered Professional Engineer in New York State.

Analysis of similar projects:

A comparison is made between a wind turbine installed by Jiminy Peak Mountain Resort, LLC ski area in 2007 located in Hancock, Massachusetts and the ski trail configuration proposed by the Balsams near the existing turbines at Dixville Peak in northern New Hampshire. The turbine at Jiminy Peak was installed 150m from an active ski trail. The minimum distance proposed by the Balsams from the existing turbines is 600 feet (182.9m). The ski trail at Jiminy Peak is closer than the trail proposed by the Balsams. Jiminy has not reported ice fall on any ski trail. This creates a useful precedent for reference.

ArcVera spoke to Christie Moran, who is in charge of the wind turbine at Jiminy Peak. Christie reported that during the 15 years of operational experience with their wind turbine, they did not see any ice on any ski trails. Jiminy's Ski Patrol inspects trails prior to opening and throughout the day until the closing of the trails and has not observed any ice shed from the wind turbine. Jiminy staff know what evidence of ice shedding looks like. Since they are responsible for the wind turbine, they have inspected the ground within 1 blade length of the tower after an icing event has passed. At this proximity to the turbine, significant evidence of ice shedding was present.

Jiminy does not shut down the trail during wind turbine icing events and does not independently initiate commands to shut down the turbine during icing events. The turbine shuts down during icing events using its own internal protocols.

Arc Vera notes that the hub height of both the Jiminy Peak and Dixville Peak wind turbines is 80m. However, the rotor diameter of the Dixville Peak wind turbines is 90m while the rotor diameter of the Jiminy Peak turbine is only 77m. In order to account for this difference in rotor diameter, we used the equation given by Siefert et al. (2003) to estimate the maximum throwing distance of ice from a rotating wind turbine on flat terrain:

$d=(D+H)*1.5$

For Jiminy Peak, D (Diameter of Rotor) = 77m and H (Height of the Hub) = 80m. Using the equation above, d=(77m+80m)*1.5=235.5m. This means that the maximum throwing distance for ice is 235.5m at Jiminy Peak. The minimum proximity (P) from the turbine to the trail at Jiminy Peak is 150m. The ratio P/d is 150m/235.5m=63.7%.

For the Dixville Peak wind turbines, D (Diameter of the Rotor) = 90m and H (Height of the Hub) = 80m. Using the equation from Seifert, d=(90m+80m)*1.5=255m for the Dixville peak turbines. This means that the maximum throwing distance for ice is 255m at Dixville Peak. The minimum proximity (P) from the trail in question to the closest turbine (Turbine 5) is 600 feet (182.9m). The ratio P/d is 182.9m/255m=71.7%.

Thus the trail at Jiminy Peak is only 63.7% of the maximum throwing distance, whereas the trail at Dixville Peak is 71.7% of the maximum throwing distance. In other words, after adjusting for differences in hub height and rotor diameter, Jiminy Peak has a trail closer to the turbine than the configuration proposed by the Balsams at Dixville Peak.

ArcVera notes that the elevation of the Jiminy Peak turbine is approximately 634m. The Dixville turbines are much higher, 986m. Since the Dixville turbines are at higher elevation, they are more likely to spend significant time within the cloud layer. Consequently, Dixville is expected to experience icing more often than Jiminy Peak. However, ArcVera finds that the Plan proposed by the Balsams adequately mitigates risk of falling ice by shutting down the trail if icing conditions exist.

Please contact me if any questions arise regarding this analysis.

Sincerely,

Daniel W. Bernadett

Daniel W. Bernadett, P.E.
Global Director of Wind Engineering

T · H · E BALSAMS

Operating Plan for Wind Turbine Icing (Revision 1)

This Operating Plan sets forth how public access to trails within 837’ of wind turbines will be managed to address potential turbine icing conditions.

1- The Balsams will install a weather station at the top of lift 4 or in closer proximity to wind turbines 4, 5 and 6 which will include temperature, relative humidity, and heated sensors for wind speed and direction.
2- Weather data will be monitored and logged in 15-minute increments by Dispatch beginning 30 minutes prior to opening lift 4 and during the time the lift remains open. Weather data will also be logged throughout the night and reviewed in the morning prior to opening.
3- Prior to opening Lift 4:
    a. A visual inspection of blades on Turbines 4, 5 and 6 will be made to detect the indications of icing on the blades.
    b. The ski patrol director or their designee will be responsible for inspection.
    c. All inspectors will be trained to identify indications of icing.
    d. If ice is observed the affected trail will be closed.
    e. If a visual inspection is not possible due to conditions and temperatures are or were 35F or lower during the prior night, the trail will be closed.
4- Once the trail is open:
    a. If the temperature is 35F or below and weather conditions change such that the possibility of icing develops, the turbines will be visually inspected, and the trail closed if icing is observed.
    b. If the temperature is 35F or lower and the turbines become not visible for more than one hour, the trail will be closed.
5- If the trail is closed due to an icing event, it may be reopened when the blades no longer have visible icing.
6- In the event the turbines are not operating the trail will be subject to the normal trail open and closed procedures of the resort.
7- Whenever this plan indicates a trail closure, the wind turbines creating the need for closure may be shut down in lieu of closing the trail.
8- If a wind turbine is restarted while a trail is open and the temperature is 35F or lower, the trail will be closed until the turbine is inspected per #3 above.

Date: 6 December 2022
Mountain Operations: ________________________________

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Dan Bernadett's Resume and Image of his PE Certificate

Daniel Bernadett
Global Director of Engineering
New York, United States

Summary

Mr. Bernadett has over 30 years of experience in the wind industry and has been working for UL, formerly AWS Truepower, since 1993. Mr. Bernadett works to provide value to customers, ensuring that his global team is able to meet customer needs in markets throughout the world. With an extensive range of industry experience, Mr. Bernadett is able to bring together diverse issues to address risk and optimize project profitability.

Professional Experience

2022- present

ArcVera Renewables - Remote, USA

Global Director of Wind Engineering

- Leader of Lender's Technical Adviser (LTA), Independent Engineering (IE), Owners' Engineer (OE), and Due Diligence
- Leader of Root Cause Analysis (RCA) and End of Warranty (EOW) Inspections
- Leader of Power Performance Testing (PPT) and other testing servicesPower Performance Testing, Loads Testing, and Power Quality Testing
- Meteorological tower installation and wind resource assessment testing
- Lightning detector installation, commissioning, and testing

2017 - 2022

UL - New York, USA

Global Service Line Leader for Power Performance Testing Renewables

- Managed a global team of 37 technical staff in six countries with an annual budget over $10 million;
- Oversaw staff in the major wind energy markets worldwide including the US, Germany, Spain, India, China, and Brazil;
- Provided high quality testing services at competitive prices. By providing both traditional and innovative services.

2004-2016

AWS Truepower, LLC - New York, USA

Chief Engineer

- Led the performance engineering team and consulted with clients and internal staff regarding turbine technical issues;
- Participated in setting global methods on energy estimation and reviewing energy production reports;
- Determined if turbines were working as advertised and optimized performance on wind farms;

- Worked with investors to identify and mitigate technical risks and has led technical due diligence reviews for several large portfolio acquisitions.

1993-2004
AWS Scientific, Inc. - New York, USA
Senior Project Engineer

- Power Performance Testing, Loads Testing, and Power Quality Testing
- Meteorological tower installation and wind resource assessment testing
- Lightning detector installation, commissioning, and testing

Education

- 1989 **-** B.S. in Aeronautical Engineering, University of California – Davis
- 1989 **-** B.S. in Mechanical Engineering, University of California – Davis
- 1991 **-** M.S. in Mechanical Engineering, University of California – Davis

Professional Affiliations & Activities; Certifications

- Bernadett, Daniel; 2019. Power Performance Testing without Met Towers, webinar presentation.
- Bernadett, Daniel; 2019. Power Curve Prediction Method Verification, poster paper presented at AWEA Windpower conference, Houston, Texas, USA.
- Bernadett, Daniel; 2019. Reflections and experiences from power performance testing under IEC 61400-12-1 (Edition 2:2017), podium presentation at AWEA Windpower conference, Houston, Texas, USA.
- Bernadett, Daniel; 2018. Verification of Performance Enhancements, podium presentation at China Windpower, Beijing, China.
- Bernadett, Daniel; 2017. Plant Power Curves, podium presentation at China Windpower, Beijing, China.
- Bernadett, Daniel; 2016. Power Performance Measurements: Better, Cheaper, Faster, webinar presentation.

SEE BACK FOR IMPORTANT INFORMATION

The University of the State of New York
Education Department
Office of the Professions
REGISTRATION CERTIFICATE
Do not accept a copy of this certificate

License Number: 073489-01 Certificate Number: 0919197

BERNADETT DANIEL WILL
23 WEST MEADOW DR
ALBANY NY 12203-0000

is registered to practice in New York State through 05/31/2023 as a(n)
PROFESSIONAL ENGINEER

LICENSEE/REGISTRANT

INTERIM COMMISSIONER OF EDUCATION

EXECUTIVE SECRETARY

DEPUTY COMMISSIONER
FOR THE PROFESSIONS

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10

Icing Study completed by AWS Truepower

AWS Truepower

PREPARED FOR

BROOKFIELD RENEWABLE ENERGY

ICE THROW RISK ASSESSMENT FOR DIXVILLE PEAK

MAY 29, 2015

GRANITE RELIABLE WIND FARM

NEW HAMPSHIRE

163
+15

CLASSIFICATION
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INTRODUCTION

The purpose of this study is to provide Brookfield Renewable Power with an ice throw risk assessment from wind turbines within the Dixville Peak portion of the Granite Reliable Wind Farm in northern New Hampshire. Currently, a 396 m (1300 ft) safety buffer exists in which public access is discouraged due to the risk of impacts from ice fragments potentially being thrown from the wind turbines during the cold season. How this buffer size was originally determined is unknown to AWS Truepower, however it is not inconsistent with some general industry guidance that was available at the time the wind farm was permitted.

This assessment takes into account the available literature on ice throw mechanisms and trajectory determination as well the wind farm-specific turbine specifications and meteorology. The key result provided is an estimate of the maximum potential throwing distance of an ice fragment from a turbine on Dixville Peak.

FORMS OF WIND TURBINE ICING

There are three main types of icing observed at elevated terrain sites in the northeastern US: glaze, hard rime, and soft rime. The differences in icing types play a role in how ice accumulates on, and is shed by, wind turbines. Glaze is a relatively smooth, hard, and transparent form of ice and is the most dense (~900 kg/m^3). It is deposited either by a freezing rain or drizzle event, or by exposure to supercooled cloud (or fog), especially during windy conditions, when the air temperature is slightly below freezing (0° C). Rime ice occurs under similar in-cloud conditions but at lower air temperatures. While riming entraps more air than glaze ice and is thus opaque or white in appearance, the freezing rate of cloud droplets on surfaces determines whether the rime is of the hard or soft variety. A slower freezing rate produces hard rime (density of 600-900 kg/m^3) which still has strong adhesive properties, although not as strong as glaze. A faster freezing rate entraps more air to form soft rime, which is the most brittle and least dense form of icing (<600 kg/ m^3).

Rime ice tends to form on the upwind side of structures and on the leading edge of blades; ice feathers that grow into the wind are a common signature. Glaze is more evenly distributed and adapts to the shape of the object; icicles can form as well.

All three icing types occur at Dixville Peak, with rime icing being the most frequent due to the site's high elevation and exposure to low-level cloud. Average cloud base height (above sea level) for the region has been observed to be in the range of 760-915 m (2500-3000 ft) (Warren et al., 1986). Low-level cloudiness occurs most frequently from late fall to early spring across the mountains of New England. At Dixville Peak, the frequency of low-level cloud during the cold season is on the order of 15% (Bailey, 1990).

DESCRIPTION OF DIXVILLE PEAK TURBINES, WINDS AND ICING FREQUENCY

The Granite Reliable wind project is located in northern New Hampshire, roughly 18 km southeast of Colebrook, NH and 38 km north-northwest of Berlin, NH. The wind farm is located in a region of complex terrain and is comprised of a series of small ridgelines and isolated features covering a north-south distance of approximately 12 km. The project consists of 33 Vestas V90-3MW turbines with a rotor diameter of 90 m and a hub height of 80 m. The turbines have a rotational speed of 18.4 rpm at rated speed and a maximum blade tip speed on the order of 89.4 m/s (200 mph). The turbines are positioned in small clearings within a region of dense forest. Figure 1 presents the locations of the 7 turbines on Dixville Peak, which are the turbines of interest for this analysis. These turbines are at a mean base elevation of 986 m, about 80 m higher in elevation than the array-average.

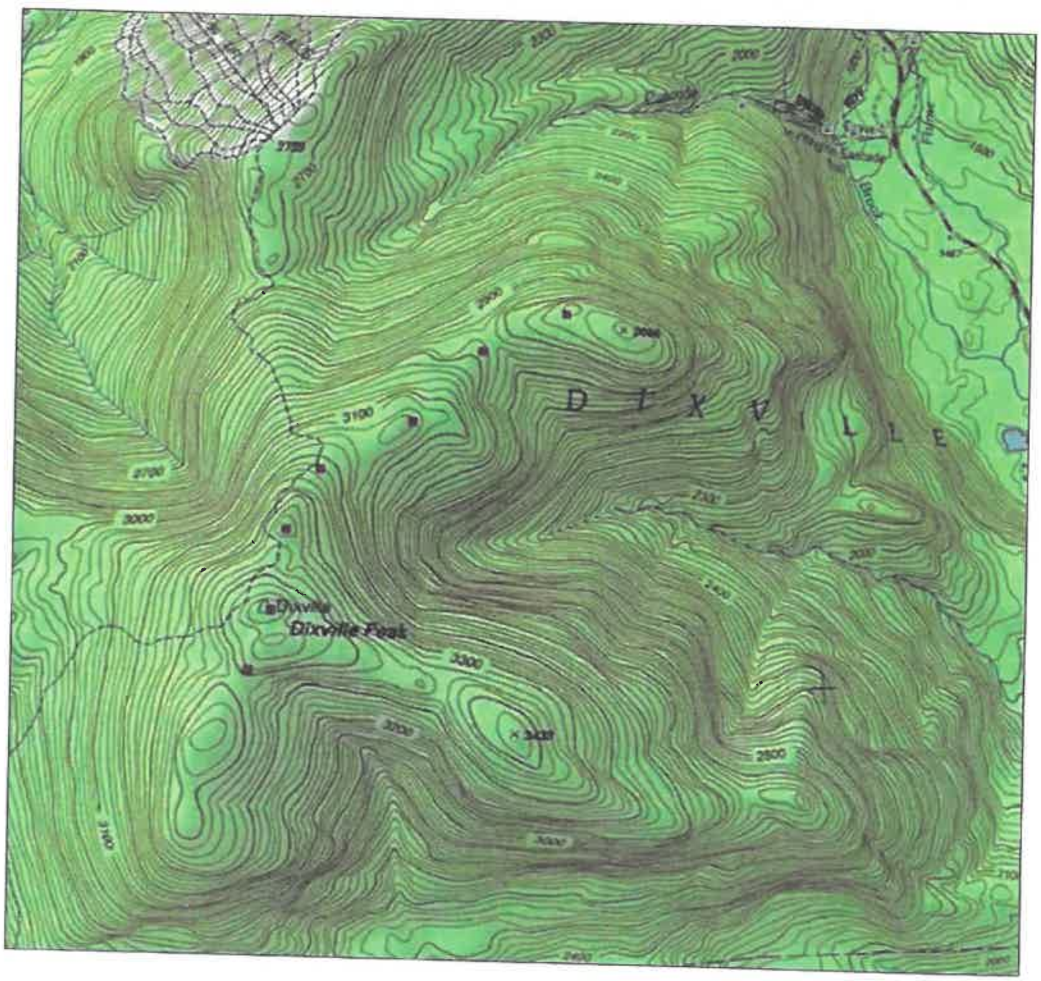

Figure 1. Granite Reliable Project – Dixville Peak Wind Turbines

The 80-m array-average wind speed of the 33 Granite Reliable wind turbines was estimated previously by AWS Truepower to be 8.71 m/s (19.5 mph). The predicted mean wind speed for the 7 Dixville Peak turbines is substantially higher, about 9.93 m/s (22.2 mph), since they are at a higher mean elevation. On a seasonal basis, the strongest winds are normally observed during the late fall to springs months. The mean wind speeds during the November to April timeframe average about 17% higher than the site's annual mean.

The annual wind frequency and energy by direction plot (wind rose) for Mast 0040, one of the previous on-site masts with more than two years of data, is presented below in Figure 2. Also plotted in this figure is the wind rose from the same mast for the icing season, defined as the months of November through April. The wind rose indicates a predominant west-northwest to northwest wind flow, which is dictated both by the site's high elevation and the directional orientation of the ridgeline that the project is built on. The annual and icing season wind roses are similar and indicate that approximately 70% of the energy available from the wind is observed in the west through northwest direction sectors.

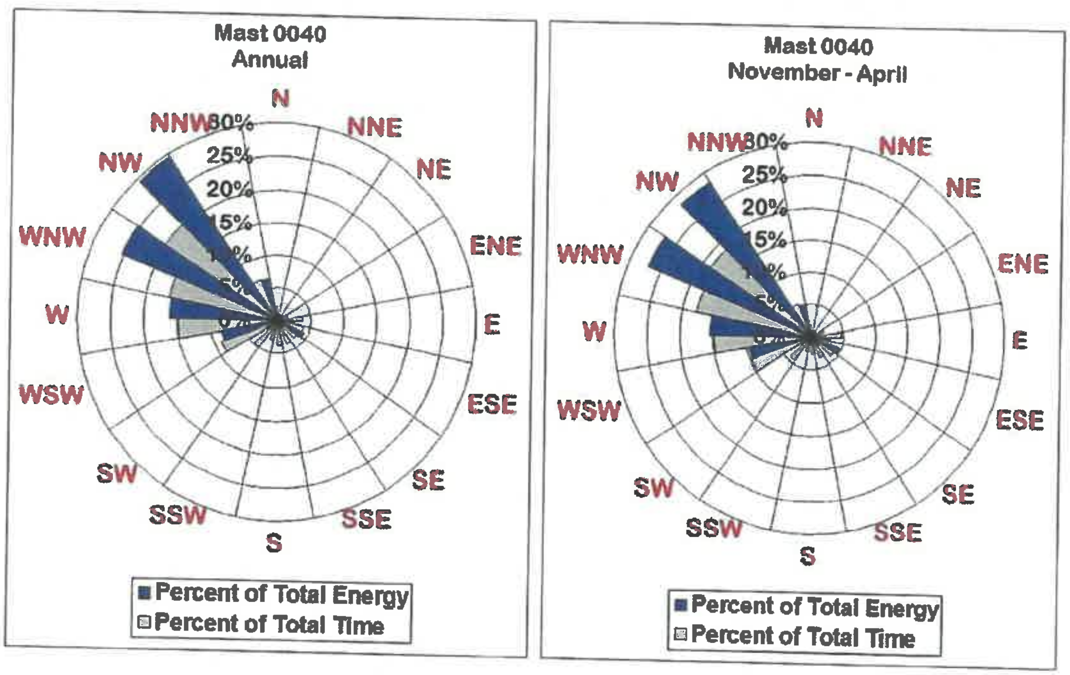

Figure 2. Granite Reliable Mast 0040 Annual and Icing Season Wind Roses

A wind speed frequency distribution, which provides the number of observations within 1 m/s (2.2 mph) wind speed bins, was created for the Dixville Peak turbines at hub height for the November to April period using 10-minute wind speed data from Mast 0040. The estimated distribution is presented in Figure 3. The results suggest that 80 m wind speeds in excess of 20 m/s (44.8 mph) can be expected to occur about 8% of the time near these turbines during the icing season. Wind speeds in excess of 25 m/s (56.0 mph; e.g. the turbine cut-out speed) are expected to occur just less than 2% of the time.

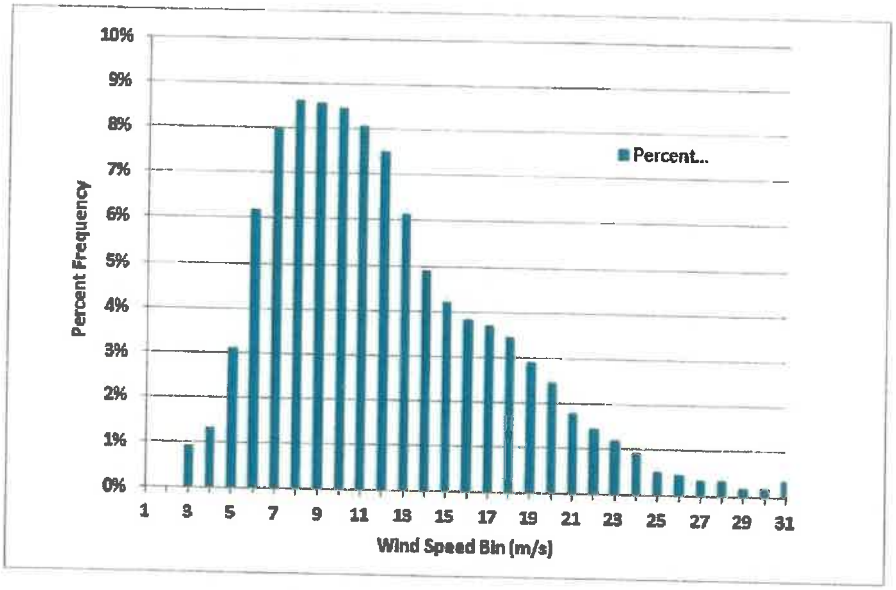

Figure 3. Dixville Peak Wind Turbines Estimated Wind Speed Frequency Distribution (November – April)

The frequency of icing at the Granite Reliable site has been estimated using the on-site tall tower measurements, specifically by analyzing the readings and response of the wind vanes and anemometers. Wind vanes tend to be more sensitive to icing and often ice over more quickly than cup anemometers since their overall movement is inherently more limited when compared to a rotating anemometer. Icing on the anemometry can sometimes be harder to detect, for example when a small buildup of ice on the tower's anemometry causes a roughly uniform slowdown in the recorded wind speeds on all anemometers. For this study, the frequency of icing on Mast 0040 was determined using the wind vane data during the winters of 2007-2008 and 2008-2009. The average icing frequency on the mast during these two winter seasons was about 11.5%. This value is in good agreement with the results from an icing frequency map generated by AWS Truepower for the United States and southern Canada.

INDUSTRY METHODS FOR ESTIMATING POTENTIAL ICE THROW DISTANCES

The estimation of ice throw distances from structures such as wind turbines has been addressed by various studies using theoretical approaches which take into account such factors as ice characteristics, wind conditions, and structural dimensions. Figure 4 is an illustration of an ice fragment trajectory (from Biswas et al., 2011), which is a function of four primary factors: the properties (shape, mass, density) of the ice fragment itself, the turbine dimensions and rotational speed, the position of the blade and the location of the fragment on the blade when it detaches, and the wind speed. These factors combine to affect the total distance the ice fragment travels and where it ultimately lands. When an ice fragment detaches from a moving blade, it will initially have the same speed and direction of the blade; the speed is greatest at the blade tip and slowest near the root. The ice trajectory will be in-plane, or lateral, such that ice will be thrown upward if the blade is ascending, or downward if descending. The ambient wind will also play a factor by blowing the fragment downwind. The downwind distance will depend on the wind speed, the position and movement of the rotor at the time of release, and the mass and shape of the fragment. The shape and area of the fragment will also influence the drag forces, which will be larger for fragments having a large cross-sectional area such as a sheet of ice.

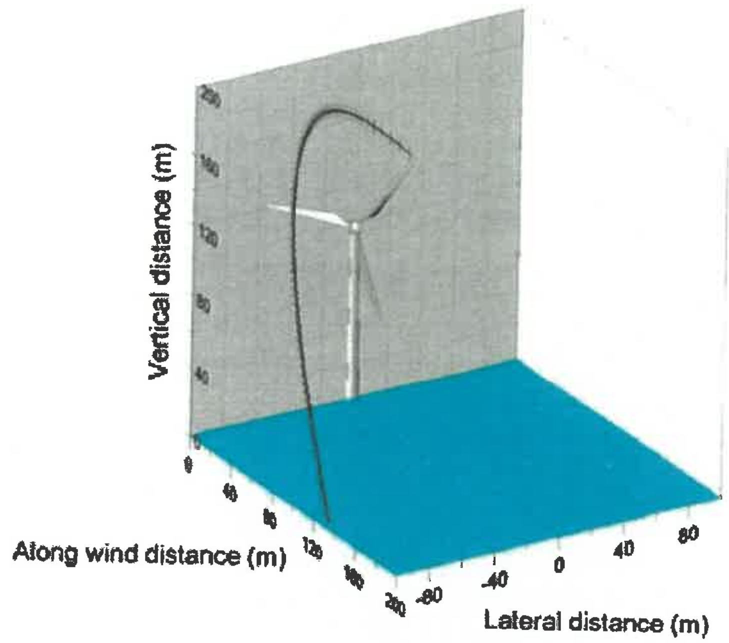

Figure 4. Illustration of an ice fragment trajectory (from Biswas et al., 2011)

For the simulated case shown in Figure 4, the ice fragment detaches from a blade tip at an angle of 45° (from horizontal) as it rotates upwards; the wind speed was 15 m/s (33.6 mph). The rotor diameter is 90 m, the hub height is 100 m, and the rotor's rotational speed is 14.5 rpm. Assuming a typical drag force, the fragment lands 127 m (417 ft) downwind and 100 m (328 ft) laterally, or 162 m (531 ft) from the base of the turbine (assuming flat ground). Figure 5 presents an array of potential trajectories from the blade tip (the most conservative scenario) using the same turbine assumptions. The plot assumes that the reader is looking upwind and the turbine is rotating counter-clockwise.

Figure 6 shows the general pattern of ground strike locations for ice fragments ejected from the blade tip at different rotational blade locations. The pattern approximates an oval, with all ice spreading laterally downwind of the turbine. The width of the oval depends on the hub height wind speed, with stronger speeds transporting fragments further downwind. The ice striking the ground closest to the turbine occurs when the blade is near the bottom of its rotation. The farthest flights of ice occur when the blade is rotating upward within 30-45° of horizontal; these fragments land downwind and off to the side of the turbine but not directly downwind.

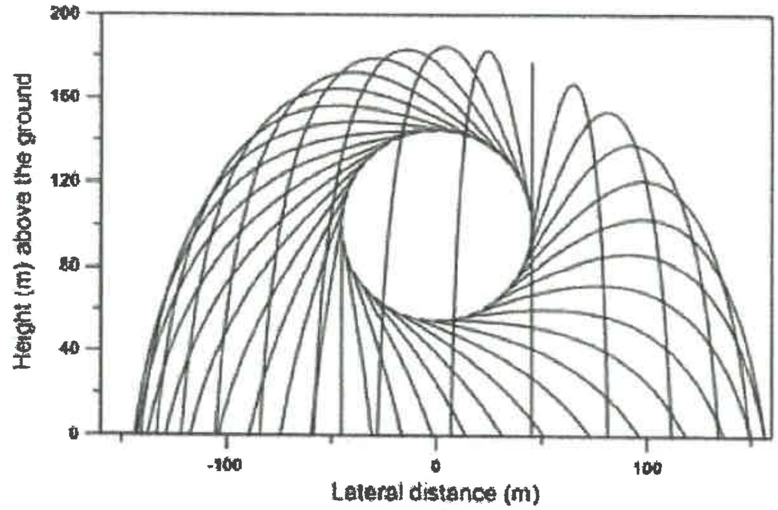

Figure 5. Simulated trajectories of ice fragments launched at various angles (from Biswas et al., 2011).

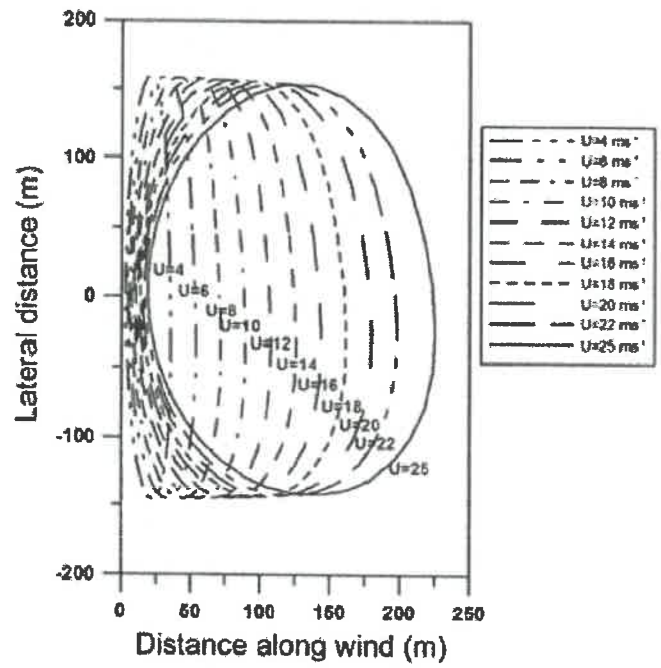

Figure 6. Simulated impact locations for ice fragments released from the blade tip at different blade positions, for different hub height wind speeds (from Biswas et al., 2011).

There are a limited number of published field studies of ice throws from wind turbines. In a 2003 study, a survey (Seifert et al., 2003) of European wind farm operators found that ice fragments are rarely thrown beyond 125 m (410 ft; see Figure 7); the majority of turbines at that time had rotor diameters of 40 m or less. Data available from a Tacke TW600 wind turbine near Kincardine, Ontario, Canada for six winter seasons noted icing on 13 occasions, with ice fragments observed up to 100 m (328 ft) from the tower (Leblanc, 2007). In a 2-year field study of a 600 kW Enercon E-40 wind turbine in the Swiss Alps, Cattlin et al. (2007) observed a maximum ice throw distance of 92 m (302 ft). For this body of cases, thrown fragments weighed 0.1 to 1.1 kg (0.2 to 2.2 lb), with some observations noting a tendency for the ice to shatter in flight. Guidance from research in northern Europe recommends that signs be located at least 150 m (336 ft) from a turbine in all directions (T. Laakso et al., 2010).

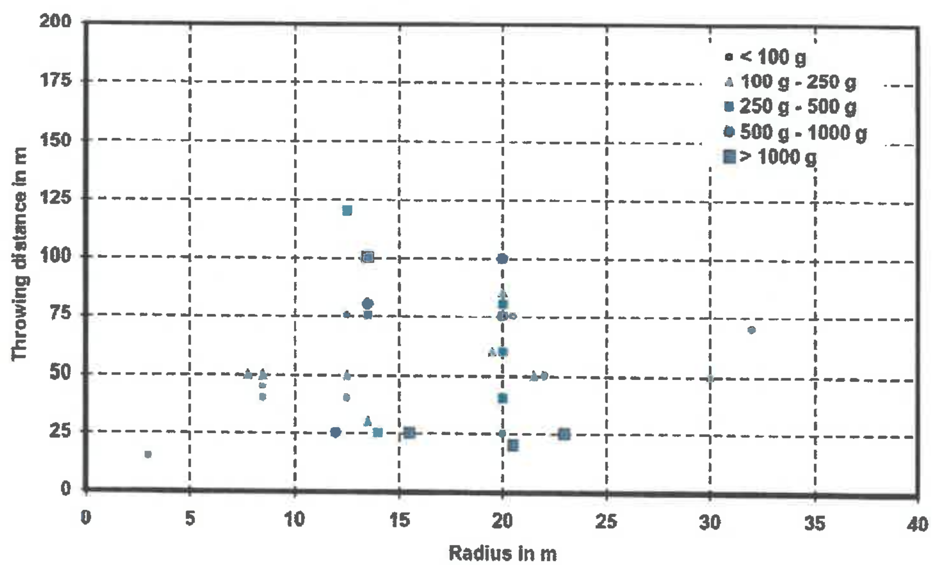

Figure 7. Observed ice fragments from the Wind Energy Production in Cold Climate database. (from Seifert et al., 2003)

In an assessment of ice throw risk potential in Ontario Province, Leblanc (2007) calculated the distance-dependent probability per square meter of ground that a single ice fragment strike would occur for an 80 m hub-height turbine and 80 m rotor diameter. The analysis employed a Monte Carlo simulation of 100,000 ice fragments shed from the blades of a turbine. A critical distance of 220 m (722 ft) from a turbine was determined, beyond which the probability of an impact from thrown ice diminishes rapidly. The assumed mean wind speed was 8.0 m/s (17.9 mph). Using the technique developed by Biswas et al. (2011), Taylor et al. (2012) calculated ice throw distances for a range of turbine models and hub heights assuming a 10 m/s (22.4 mph) mean wind speed for a potential project in Ontario, Canada. The determined maximum throw distances were between 175 m (574 ft) and 195 m (640 ft). Other results from this study show a probability of an ice strike per square meter of ground to be less than one in tenthousand at 100 m (328 ft) from a turbine, with 3.1% of all fragments landing beyond 100 m, and 0.02% beyond 200 m (656 ft). These results compare well with those from Biswas et al. (2011) where the sensitivity of ice shed distances for varying model parameters, including wind speed and blade tip speed, was examined. They indicate that the maximum distance a 1 kg ice fragment could travel is 200 m (656 ft; Jowitt, 2013).

A simplified empirical equation was introduced by Seifert et al. (2003) to estimate the maximum throwing distance of ice from a rotating wind turbine on flat terrain:

$$d = (D + H) * 1.5$$

where d = maximum throwing distance in meters; D = rotor diameter (m); and H = turbine hub height (m). When compared to observations and simulations of maximum ice throw, this equation provides a reasonable if not conservative prediction. For the simulations presented in Figures 1 through 3, the equation predicts a maximum ice throw distance of 285 m (935 ft), which is somewhat higher than the longest distance (~260 m, or 853 ft) calculated for a wind speed of 25 m/s (56.0 mph). For the 2003 Seifert survey, the equation determines the maximum distance to be 150 m (336 ft; assuming a 60 m hub height and 40 m rotor diameter), which compares to the 125 m (410 ft) observed value. In the field study in the Swiss Alps by Cattlin et al. (2007), the observed maximum ice throw distance of 92 m (302 ft) compared to a predicted maximum of 135 m (443 ft) using the equation. This equation has also constituted guidance used by GE Energy, the certifying agencies Germanischer Lloyd (GL) and Deutsches Windenergie-Institut (DEWI) (Wahl and Giguere, 2006), Lloyd's Register Consulting (Bredesen et al., 2014), and the Massachusetts Department of Environmental Protection (2012).

PROBABILITIES OF LAND STRIKES FROM THROWN ICE

The concept of expressing ice fragment strike probabilities within a square meter area of ground as a function of distance from a turbine in one year was introduced in 1997 (Tammelin et al., 1997) as part of a European Union research program. The program was named Wind Energy Production in Cold Climate (WECO). The ice throw assessment guidelines produced by this program were based on a combination of numerical modeling and observations. The numerical modeling involved Monte Carlo simulations of numerous ice build-up and shedding scenarios.

An application of this approach is shown in Figure 8. An analysis was performed by GL Garrad Hassan in 2010 for a Vestas V112 turbine (hub height 84 m, 112 m rotor diameter) on a ridgeline in Vermont. The analysis assumed a frequency of 25 days of icing per year. Two sets of analysis were conducted for fragments weighing either 0.5 kg or 1.0 kg: one for ice falls when the blades are stationary, and the other for thrown ice when the blades are rotating. For thrown ice, it was estimated that 90% of events would occur within 160 m (525 ft) of the turbine. At this distance the probability of a ground strike from a thrown ice fragment is once every 100 years. At 260 m (853 ft) the probability is once every 1000 years, and at 290 m (951 ft) the probability is approximately once every 10,000 years. This last distance is equivalent to the maximum ice throw distance using the equation above.

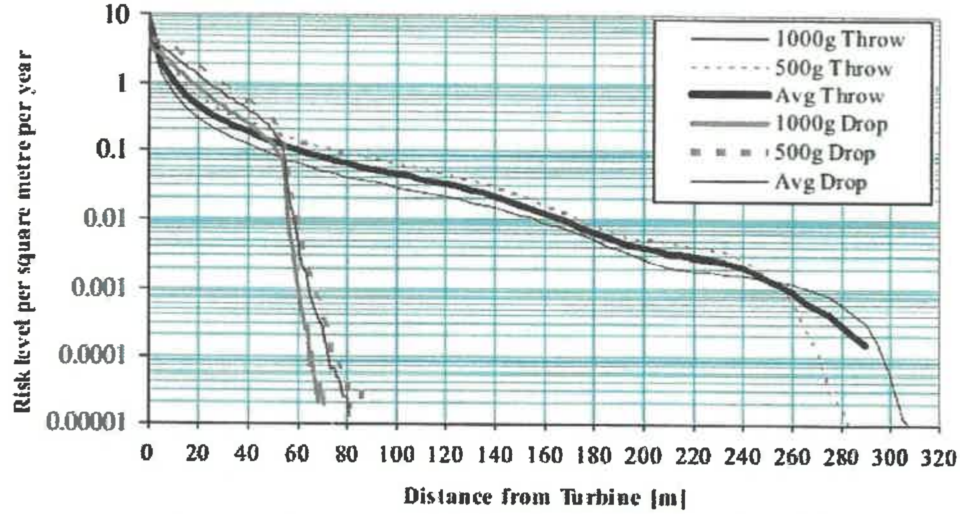

Figure 8. Ice Fragment Strikes Estimated Per Unit Area Per Year (from Boucetta and Heraud, 2010)

When the equation is used for the Dixville Peak turbines, the maximum ice throw distance is calculated to be 255 m, or 836 ft. This value is consistent with the trajectory analysis approach developed by Biswas et al. (2011) and is significantly less than the 396 m (1300 ft) setback currently observed by the project. Note that this distance assumes flat terrain; where the terrain slopes downward away from the turbines, as is the case for Dixville Peak, the actual distance when following the contour of the ground will be somewhat longer (up to 5% longer for the steepest slopes). If a simple 2-dimensional setback radius is overlaid onto a topographic map, it will automatically encompass the areas where the actual ground distance is longer (relative to flat ground). Given that wind directions at Dixville Peak blow out of the northwest and west the large majority of the time, the area most vulnerable to ice throws is to the southeast and east of the line of turbines.

It is important to recognize that the maximize ice throw calculations are based largely on modeling approaches that have not been rigorously validated by field data. Wind farms are generally unmanned, and surveys of ice throws are not routine practice. Although the field observations that do exist agree with current prediction techniques, the observational database remains relatively small and limited to between one and six winter seasons at any one site. Hence, a case can be made to apply a safety margin to prediction results until substantially more field observations are accumulated.

On the other hand, it is equally important to note that the ice throw analyses are by nature conservative and assume worst case conditions. For example, the maximum ice throw calculations apply to the densest form of ice detaching from the blade tip, which is the fastest part of the blade. Most of the blade ice, however, will form on the inboard portions of the blade. Further, ice accretion on blades degrades airfoil performance, so the turbine rotor is unlikely to reach its design rotational speed when heavy icing is occurring. Lastly, icing often causes rotor imbalances and vibration sensor alarms that will automatically stop turbine operation. Without the centrifugal force imparted by blade rotation, ice shedding will impact the ground only in close proximity to the turbine base.

As for probabilities of ground strikes by thrown ice as a function of distance from a turbine, the analysis by Boucetta and Heraud for the Green Mountains (Figure 8) project is expected to be fairly representative of Dixville Peak. The turbines on Dixville Peak have a somewhat lower hub height and slower tip speed, but the wind speeds are stronger. The estimated frequency of icing events is comparable. Therefore, at a distance of 255 m (836 ft) from a turbine, the probability of an ice ground strike (under worst case scenarios) is on the order of 1 in 1000 years. There is unlikely to be a significant cumulative effect of ice strike probability at a particular location exposed to multiple turbines. This is because of the existing turbine spacing of approximately 230-390 m (755-1280 ft).

SUMMARY AND CONCLUSIONS

At Brookfield's request, AWS Truepower conducted an assessment of the potential ice throw distance from seven wind turbines within the Dixville Peak portion of the Granite Reliable Wind Farm in New Hampshire. Based on local observations, icing conditions are estimated to occur approximately 11% of the time during the cold season. While a range of icing types are expected, the predominant forms are expected to be hard and soft rime, which have a lower density than glaze ice. Due to the frequency of low-level cloud, the primary icing process is the deposition of supercooled cloud droplets on turbine blades. The assessment reviewed industry literature from Europe and North America regarding icing and shedding mechanisms for wind turbines, observations of ice throw distances, and techniques to calculate ice throw distances under different assumptions and weather scenarios.

The maximum ice throw distance for wind turbines on Dixville Peak is conservatively predicted to be 255 m (836 ft) when expressed horizontally from the base of the turbines. This value assumes worst case conditions during which a dense ice fragment (e.g. glaze) is shed from the fastest moving portion of the blade at the optimum point of its rotation during very windy conditions to achieve the longest trajectory. This trajectory would result in a ground impact downwind and lateral to the plane of the turbine rotor. The probability of an ice impact within a square meter area of ground at this maximum ice throw distance is estimated to be on the order of once every 1000 years.

Under normal operating conditions, it is expected that the large majority of ice falls and throws from the turbines will occur within 100 m of the tower base. Given the site's prevailing winds from the west and northwest, the areas most vulnerable to ice impacts will be to the east and southeast of the turbines. However, because winds at the site occasionally blow from other directions, the possibility exists for ice impacts to occur in most directions surrounding the turbines.

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Icing Study completed by DNV-GL

BALSAMS SKI DEVELOPMENT

Wind Turbine Ice Throw Modeling and Operating Protocol Review for Balsams Ski Development

Dixville Capital, LLC

Document No.: 702891-USSD-T-01
Date: 7 October 2014

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Project name:	Balsams Ski Development	DNV GL - Energy
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Customer:	Dixville Capital, LLC,	
Contact person:	Burt Mills	
Date of issue:	7 October 2014	
Project No.:	702891	
Document No.:	702891-USSD-T-01	
Issue:	B	
Status:	Final	

Task and objective:

Review of operating protocol of Balsams Ski resort for planned development in the neighborhood of Granite Reliable Wind Farm. The analysis is to provide a better understanding of the risks and therefore help in establishing adequate and site-specific setbacks between the operating wind turbines and ski slopes.

Prepared by:	Verified by:	Approved by:
D. Faghani, Eng. Senior Engineer	S. Dokouzian, Eng. Senior Project Manager	D. Eaton, P. Eng. Team Leader, Engineer

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Keywords:
Ice throw, Risk mitigation, Operating protocol, Ski resort

Reference to part of this report which may lead to misinterpretation is not permissible.

Issue	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	23 September 2014	Draft for comments			
B	7 October 2014	Final	D. Faghani	S. Dokouzian	D. Eaton

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EXECUTIVE SUMMARY

Dixville Capital, LLC retained DNV GL to assess their risk-based protocol designed to manage the operation of the Balsams Ski Development given the proximity of operational wind turbines. DNV GL reviewed the efficacy and robustness of the proposed protocol as described below.

Efficacy of the proposed risk-based operating protocol

DNV GL modeled the risk of ice throw by turbine blades on planned ski trails and ski lifts in order to quantify the residual risks of ice fragment hit, assuming a full and perfect application of the proposed operating protocol.

DNV GL concluded that the residual risks, after the application of the proposed protocol, were somewhat higher than the thresholds suggested by its analysis. Consequently, DNV GL proposed modifications to the proposed ski trail setbacks and ski lift tracks to reduce the residual risks. The residual risks, assuming a thorough and successful application of the operating protocol, are presented in the table below. For the sake of comparison, this table also presents national risks of injury at US ski resorts and the odds of being hit by lightning, the latter being considered as a typical societal risk for outdoor activities.

	Residual ice fragment hit risk (Original Balsams protocol)	Residual ice fragment hit risk (DNV GL Scenario 1/Option 2)	Reference US Statistics
Overall Resort Risk			Fatal or serious injury at a ski resorts
Risk Level	1 hit in 19-20 years	1 hit in 33+ years	1 per year[1]
Risk to individual guests (societal risk)			Odds of being struck by lightning
Risk Level	1 hit in 1,000+ years	1 hit in 500,000+ years	1 in 960,000 years[2]

1: Fatal or serious injury at US ski resorts accepting the same number of guests as Balsams – Source: National Ski Areas Association.
2: Odds of being struck by lightning in a given year according – Source: NOAA.

Robustness of the proposed risk-based operating protocol

DNV GL reviewed the critical elements of the operating protocol and provided minor comments to enhance its robustness, notably with respect to turbine blade ice detection means.

DNV GL notes that reducing the risk of ice throw by employing wind turbine ice detection hardware and/or wind turbine icing event operation protocols (such as pre-emptive shut downs, de-icing, start-up with no ice present on blades, etc.), provide enhanced risk mitigation.

1 INTRODUCTION

Dixville Capital, LLC (or the "**Dixville**") is considering the expansion of the Balsams downhill ski resort ("**Balsams**") located near Dixville Notch, New Hampshire. The expansion project known as Balsams Ski Development is planned around Dixville Peak where seven (7) Vestas V90-3MW wind turbines at a hub height of 80 m are operating along the ridge. These wind turbines are part of the Granite Reliable ("**GR**") wind farm, a 99 MW wind farm operated by Brookfield Renewable Energy Partners ("**Brookfield**"), commissioned in 2011 in Millsfield and Dixville, Coos County, New Hampshire. An aerial view of the existing Balsams ski resort and the seven (7) GR wind farm turbines where the Balsams development is planned is presented in Figure 1-1.

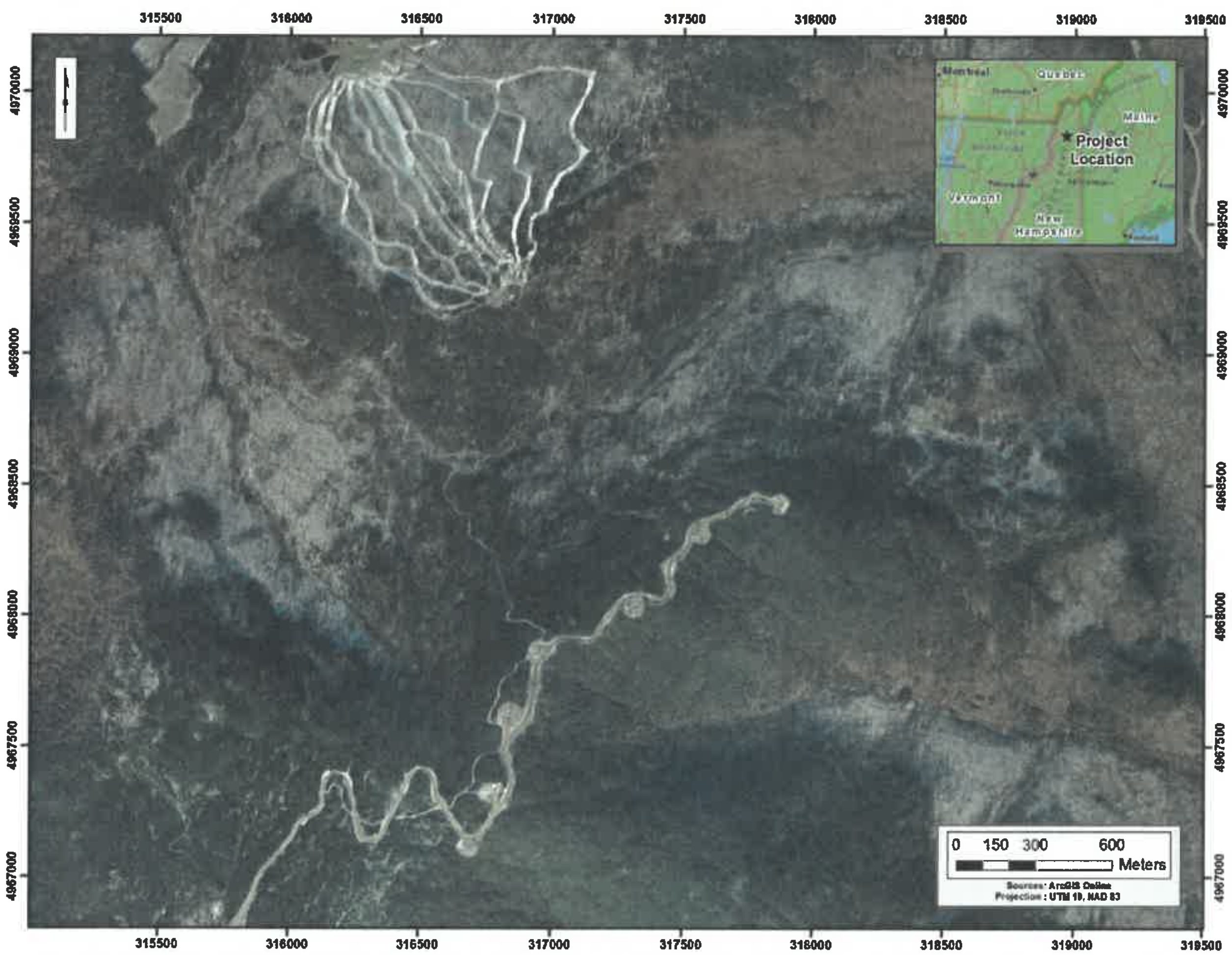

Figure 1-1: Partial aerial view of Balsams ski resort and GR wind farm.

Dixville is currently developing a risk-based protocol (Balsams Operating Protocol) to manage the operation of the Balsams Ski Development given the proximity of the wind turbines.

Garrad Hassan America Inc. ("**DNV GL**") performed an independent review of Dixville's development plans and Balsams Operating Protocol. First, DNV GL quantified the risk of ice fragment throw on the ground and ice fragment hits to Balsams guests at a given distance from the turbines to help define areas at risk and their corresponding risk levels. Then, DNV GL reviewed Dixville's proposed risk-based operating protocol in light of industry practice and national risk statistics.

This report presents the results of DNV GL analysis and is organized as follows:

- Section 2: modeling and assessment of the risk of ice fragment hit at Balsams;
- Section 3: review of industry practice and selection of acceptable risk management approaches;
- Section 4: review of the proposed Balsams Operating Protocol and assessment of its residual risks;
- Section 5: suggestions for modifications to Balsams Operating Protocol; and
- Section 6: conclusions.

2 ASSESSMENT OF RISKS

As a first step, and in order to establish the base case, the risk of ice fragment hits to Balsams guests was assessed assuming no risk management or specific operating protocols to mitigate the risks. DNV GL's risk assessment was based on modelling the following probabilities:

- Probability of ice throw by wind turbines, defined as the probability of an ice fragment thrown by a turbine blade hitting a unit area on the ground at any time during the winter season; and
- Probability of ice fragment hit, defined as the probability of a Balsam's guest being hit by an ice fragment thrown by a turbine blade; which requires the presence of the guest at the same time and location as the ice fragment bound to hit the ground.

Figure 2-1 below presents the approach used to determine the risk of ice fragment hits and the methodology used to provide recommendations to mitigate said risks.

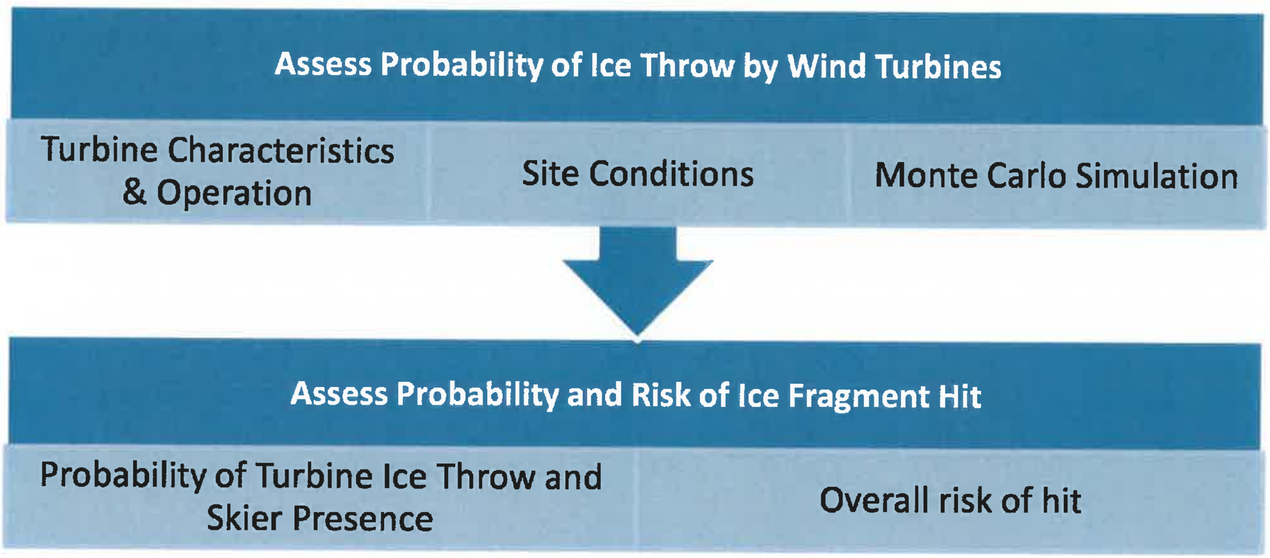

Figure 2-1: Methodology

The following sections provide the details of each step in the risk assessment methodology.

2.1 Probability of ice throw by turbines

2.1.1 Turbine characteristics and operation

Ice throw by the wind turbines is driven by their dimensions, characteristics and operational protocol. Turbine characteristics reported in

Table 2-1 were based on technical specifications; while the operational protocol was provided by Brookfield [1].

DNV GL understands that there is no specific hardware means of detecting ice build-up on the GR wind turbine blades. Icing is detected by monitoring the aerodynamic performance of the blades through examination of expected power output versus actual power output as reported by the wind farm SCADA.

DNV GL also understands that the wind turbines are *occasionally* paused and restarted after on-site inspection. DNV GL notes that the probability of ice throw, as opposed to ice fall, is present at GR and may be increased at turbine restart.

Based on the above information; DNV GL assumed that the risk of ice throw is not significantly mitigated by the current GR wind farm operational protocol.

Additionally, assuming that the turbines may only be paused and restarted during regular working hours, the probability of ice throw is assumed to generally occur during the day, which coincides with the operating hours of Balsams. This assumption is motivated by the fact that heating by the sun may promote local ice melting and detachment during the day. It is expected that this assumption could be revisited after some operational experience is gathered on site.

The main assumptions on turbine characteristics and operational protocol are summarized in
Table 2-1.

2.1.2 Site conditions

Ice throw at a given site is also governed by the meteorological conditions. Hence, meteorological data were considered using data from two met masts erected during the preconstruction phase of the GR wind farm, provided by Brookfield [2]. Industry-practice procedures were used to extrapolate meteorological and wind resource conditions at turbine locations. Based on the gathered information and performed analyses, and DNV GL's general experience and knowledge of the area, DNV GL concluded that typically, from October to April, up to a total of seventy-five (75) days of wind turbine blade icing could be expected for turbines on Dixville Peak.

Although GR provided SCADA data from the operating turbines on Dixville Peak, the data were deemed insufficient to modify the estimated long-term site conditions.

Following this analysis, a representative hub height long-term winter wind speed and wind direction distribution was developed by DNV GL for the period when ice accretion is deemed to occur on site (October to April). This distribution, presented graphically in Figure 2-2, was used as the primary meteorological input for this analysis.

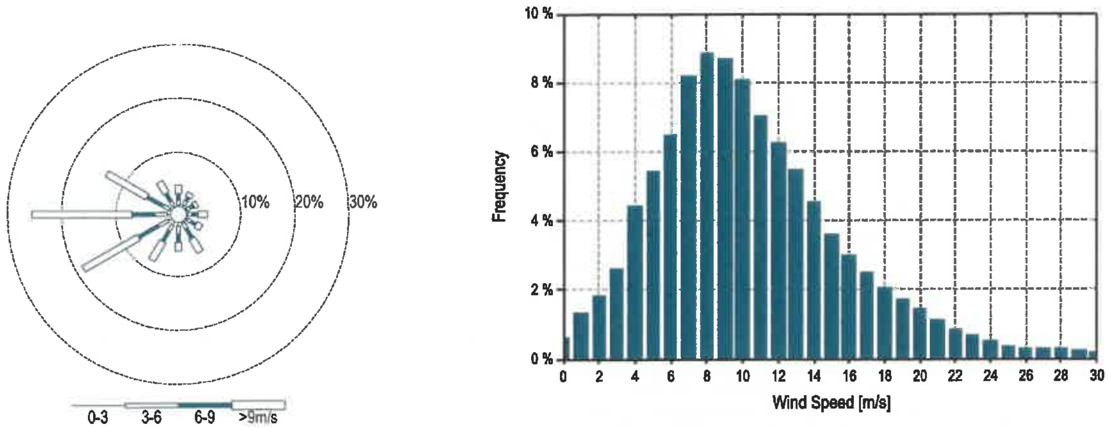

Figure 2-2: Long-term winter wind characteristics at turbine hub height.

The main site conditions assumptions are presented in Table 2-1.

2.1.3 Main assumptions and modeling

The assessment methodology used is based on the approach developed by DNV GL in conjunction with the Finnish Meteorological Institute and Deutsches Windenergie-Institut (DEWI) as part of a research project on the implementation of Wind Energy in Cold Climates (WECO). This research project was primarily funded by the European Union and also supported in part by the United Kingdom Department of Trade and Industry [3]. The guidelines for safety assessments related to ice throw were developed by DNV GL in the context of the WECO project and the work was summarized in a series of conference papers [4][5][6]. These guidelines have been applied to the Project site by considering the proposed turbine type, the terrain of the site and surrounding area of the study.

The overall approach is based on the following staged approach:

- Determine the periods when ice accretion on wind turbines are likely to occur, based on historical climatic observations.
- Within those periods, determine when the wind speed conditions are within the operational range of the wind turbines.
- Within the resulting periods, if applicable, exclude those periods when the wind turbines will be shut down automatically by the wind turbine control system or by remote operators. As discussed in Section 2.1.1, such automatic shutdown occasionally occurs at GR, and has therefore not been considered in the probability computations herein.
- Based on the estimate of icing occurrence described above, use Monte Carlo simulations to derive the probability of fragments landing at distances from the turbines of interest, at actual terrain elevation based on digital topography maps.
- Derive an estimate of the total probability of any unit area (1 m^2) struck by ice fragments.

Table 2-1 presents the main assumptions used by DNV GL to model the cumulative probability of ice throw on the ground by the seven (7) wind turbines of the GR wind farm considered in this study.

Table 2-1: Turbine Ice Throw Assumptions.

Item	Assumption used	Source
Turbine Characteristics	• Vestas V90 3 MW machines at 80m hub height • Blade length: 45 m • Cut-in/Rated/Cut-out wind speed: 4/15/25 m/s • Rotor start/rated speed: 8.6/18.4 rpm	Vestas technical specifications
Site conditions	• 75 days of blade icing from October to April • Air density (at 1000 m amsl[1]): 1.14 kg/m^3	DNV GL
Ice throw diurnal profile	• All ice shed/thrown during daytime operation hours of the ski resort	DNV GL

2.1.4 Comments on model assumptions

It is noted that the DNV GL model includes a number of conservative assumptions as follows:

- The ice fragment mass is assumed to be 1 kg; which represents the longer range fragments thrown by turbine blades. In practice, some fragments will have different masses and will fly shorter ranges than modelled. However, in the absence of onsite data, the conservative mass of 1 kg was used.
- All ice accreted on the blade is thrown by the model. In practice, some fraction will fall as opposed to be thrown.
- Wind turbines are considered to be operational during all icing events.
- The blade ice density is assumed to be 970 g/m^3 which corresponds to very dense ice without air bubbles. In practice, it is expected that the actual ice accreted on the blades will contain some amount of air bubbles (e.g. rime ice) with a lower density. Should DNV GL model be used with a lower ice density, fewer ice fragments would be thrown. However, in the absence of onsite data, the conservative ice density of 970 g/m^3 was used.

DNV GL did not perform any sensitivity analysis to estimate the potential impact of these conservative assumptions.

2.1.5 Results

Figure 2-3 represents the results obtained by DNV GL for the cumulative probability (i.e. combining all wind turbines) of ice fragment strikes per unit area (1 square meter) at ground level by the 7 wind turbines considered. The various risk levels are presented in shades of blue from one strike in 10 years close to wind

[1] Above mean see level.

turbines down to one strike in 10,000 to 1,000,000 years farther away[2]. The map also presents the turbine topple risk areas (dotted yellow line) and the generic setback historically used to mitigate ice throw risks without detailed modeling (dotted green line) for information [5].

The purple areas represent the proposed new ski trails, while the blue indicates the proposed new skier chairlifts.

DNV GL typically considers that probabilities of 1 in 500,000 years per unit area represent low enough risks which not require particular mitigation measures. As seen in Figure 2-3, the generic setback (dotted green line) does not ensure such low-level risks; which is partly due to site topography and the relatively high number of icing days at the site.

It is noted that the probability map in Figure 2-3 does not directly represent the risk levels for skiers; although it is a major driver for such risks. Indeed, risk levels for skiers are based on the combined probability of ice throw and skier presence as further discussed in the next section.

[2] DNV GL considers that risk levels below 1 in 1,000,000 years are not significant and can be neglected.

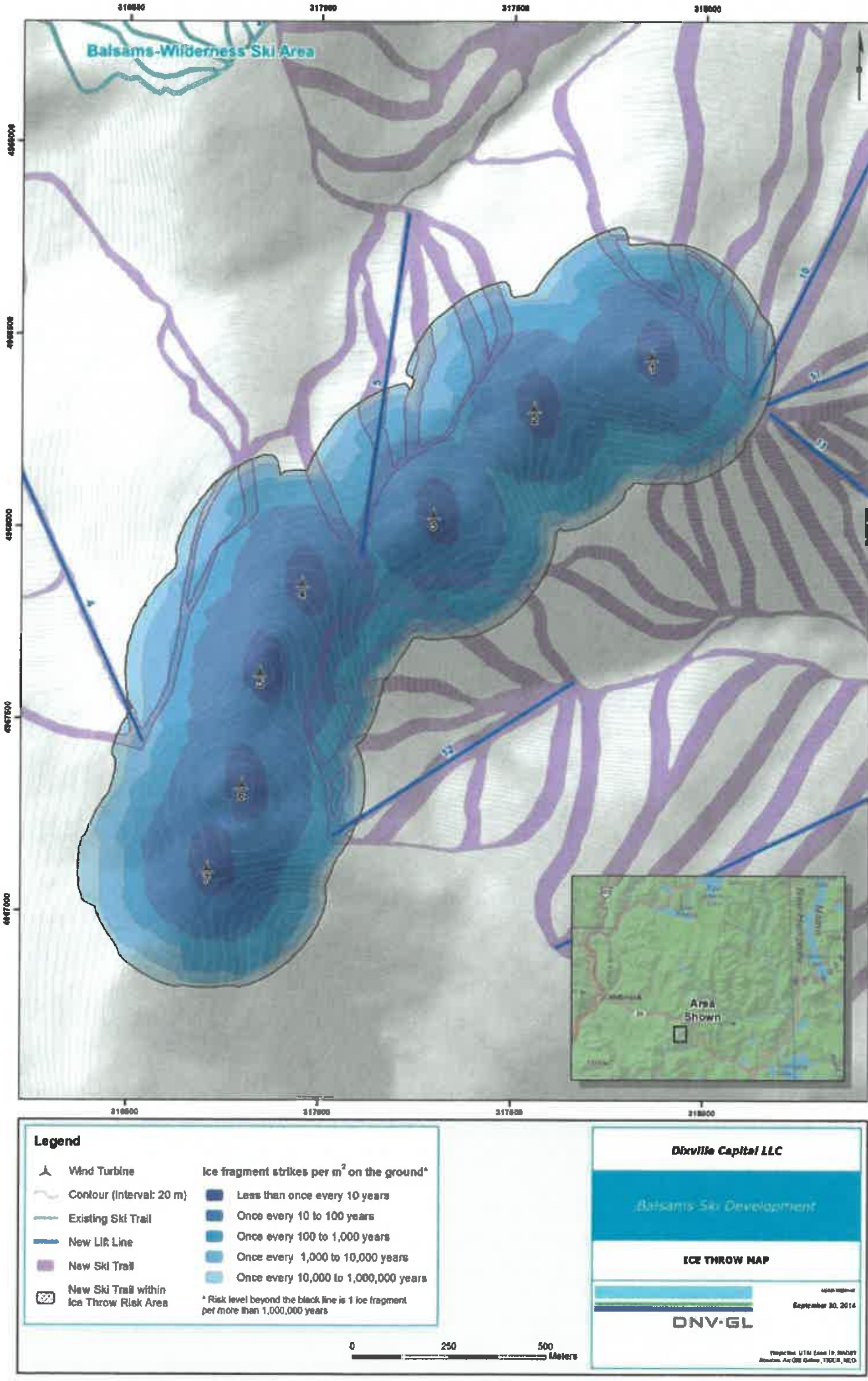

Figure 2-3: Risk of ice fragment strikes on the ground.

2.2 Risk of ice fragment hit

As previously discussed, Figure 2-3 above does not represent the probability of ice throw hits on skiers. Instead, it presents the probability (per $1m^2$ unit area) for a static object on the ground which would remain motionless at its location during the entire period of time between October and April. In order to assess the risk of ice fragment hits to individuals (probability of hit), DNV GL further considered the probability of skier present as described below. Finally, individual risks for skiers must be summed up to assess the risk of ice fragment hit at Balsams.

Two cases were distinguished, namely skiers on trails and skiers on ski lifts. The reason for this distinction is that on average, the number of skiers per unit area is higher on the lifts than on the trails. Additionally, the lifts are on average 25 ft above ground level, which could potentially represent different levels of probability of ice hit when compared to those at ground level depicted in Figure 2-3.

The following Sections presents results of the DNV GL analysis of ice fragment hit to skiers prior to the application of any mitigation measure such as a risk-based operating protocol.

2.2.1 Skiers on ski trails

2.2.1.1 Probability of ice throw and skier presence

To estimate the probability of simultaneous presence of skier and ice throw strike on ski trails; DNV GL calculated the ratio of the total area occupied by all skiers over the total skiable area available. This resulted in a constant probability presented in Table 2-2, which is considered constant in time, or by location on the ski trails.

Table 2-2: Ski trails assumptions.

Item	Assumption used	Source
Total ski trail area	2,100 acres	Dixville
Number of skiers on ski trails	3,300 skiers per day on average; assuming a 33% average utilization rate over the season and 10,000 skiers on peak days.	Dixville
Average number of skiers on ski trails	3,300 skiers, 100% of the time	DNV GL
Typical skier footprint	$1\ m^2$	DNV GL
Probability of skier presence	**$4.6x10^{-4}$**	**DNV GL**

DNV GL recognizes that this is a simplifying assumption as the skier density per unit area may vary with location (higher close to ski lift arrivals) and time (e.g. weekends, or peak days). While more precise assumptions could be made; the following simplified assumptions are used:

- Constant probability in time: Instead of assuming a constant 33% utilization rate 100% of the time, other distributions could be used. However, no further information was available to tailor a specific distribution. Additionally, a constant probability in time is consistent with the constant probability in time for ice throw.
- Constant probability in space: While the probability of skier presence is higher around ski lift arrivals, those areas are also closer to wind turbines where the probability of ice throw is higher too. As a result, it is expected (and supported in this analysis) that risk levels are already above acceptable threshold in those areas even with this simplifying assumption. Away from those areas, the assumption is probably conservative as the density of skiers is expected to be lower than the assumed value.

The probability of hit, in this report, is defined as the simultaneous probability of skier presence on ski trail and ice throw strike is defined as the product of the probability of ice throw and the probability of skier presence.

Figure 2-4 depicts the probability of hit per unit area (1 m^2) on ski trails. Green and yellow-shaded areas represent probabilities not exceeding 1 hit in 500,000 years. DNV GL considers that at these low levels of probability, no risk mitigation is required.

Areas shaded in orange or red present significant risks (above 1 hit in 500,000 years) and require mitigation means such as trail closure.

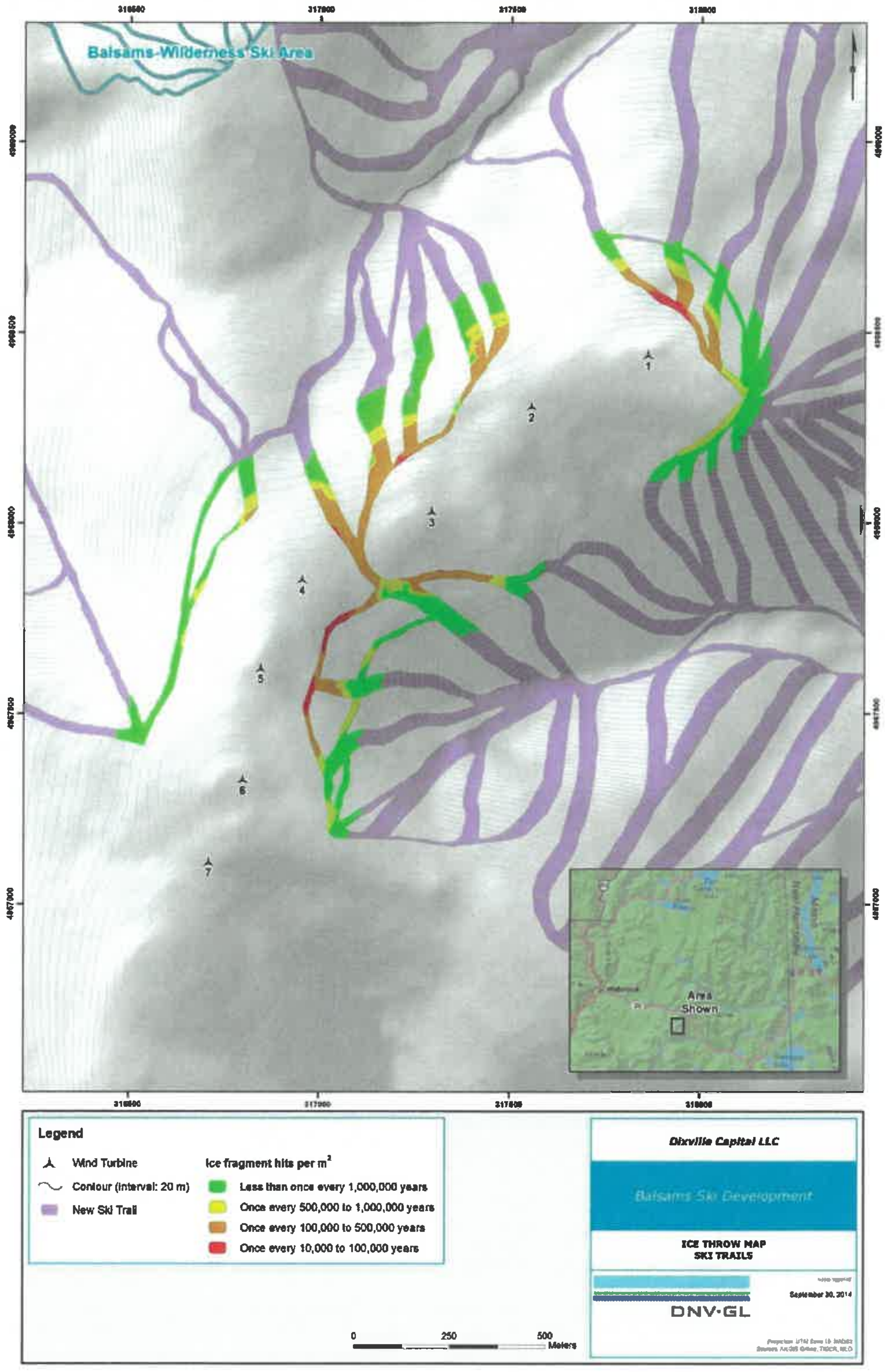

Figure 2-4: Risk of ice hit to skiers on the ground.

2.2.1.2 Risk of ice fragment hit on ski trails

The overall probability of hit in Balsams (risk of hit) for skiers on ski trails in presented in Table 2-3, as a function of the area that would remain open to skiers during ice throw events. This table presents the summation of all probabilities for all skiers present on ski trails.

Table 2-3: Overall ice fragmemt hit risk on ski trails.

Area that remain open	Cumulative Risk for the Resort
Purple + Green	1 hit in 28-29 years
Purple + Green + Yellow	1 hit in 13-14 years
Orange / Red	Not reported as the risk is deemed very high

This table helps establish setbacks for a risk-based operating protocol. For instance, according to Table 2-3, by limiting skiers' access to purple and green areas during ice throw risk periods, one ice fragment hit is expected in 28-29 years, over the whole facility. By relaxing the limited area to the purple, green and yellow areas, the risk increases to one hit in 13-14 years.

2.2.2 Skiers on ski lifts

2.2.2.1 Probability of ice throw and skier presence

To estimate the probability of simultaneous presence of skier and ice throw strike on ski lifts; DNV GL used a similar approach discussed above for ski trails. The main assumptions are summarized in
Table 2-4.

Table 2-4: Ski lifts assumptions.

Item	Assumption used	Source
Chair separation	60 ft	Dixville
Chair width	5 ft	Dixville
Number of lifts	6	Dixville
Average ski lift height	25 ft	Dixville
Chair capacity	4 skiers	DNV GL; based on information from Dixville
Lift speed	500 ft/min	Dixville
Lift utilization rate	30% of full capacity	DNV GL; based on 8 runs per skier per day for a total of 3,300 skiers per day using the 6 lifts
Probability of skier presence	**4.3×10^{-2}**	**DNV GL**

The following remarks provide the rationale behind the assumptions presented in Table 2-4:

- Chair capacity: According to Balsams, amongst the 6 ski lifts considered, 4 have 4-skier chairs, one has 3-skier chairs and one has 2-skier chairs; which translates to a mean value of 3.5 skiers per chair. The value used by DNV GL is considered to a reasonable assumption providing slightly conservative results.

- Lift utilization risk: By assuming, conservatively, that all 3,300 skiers will continuously and exclusively use the 6 ski lifts considered, DNV GL estimates that each skier would achieve more than 25 ski runs during the day. By considering a more realistic value of 7-8 runs per skier per day, an average utilization rate of 30% is obtained.

- Average ski lift height: It is expected that at a given distance from a wind turbine, the probability of ice throw strike at 25 ft above the ground is lower than its probability of hitting the ground. As such, the probability levels per unit area estimated in Section 2.1.5 (see Figure 2-3) might be slightly conservative. A rough estimate shows that by using a more precise calculation, the end results may change by some 5 to 10 meters, i.e. the risk lines shown in the figures would move 5 to 10 meters towards the wind turbines. However, DNV GL estimates that such lengths are within the model uncertainty. Additionally, DNV GL notes that the skiers are at ground level at ski lift arrivals. Therefore, the ice throw probability per unit area used was the same as the one calculated at ground level and no modifications were used to account for the varying ski lift heights. DNV GL estimates this assumption to be conservative.

The probability of hit, defined as the simultaneous probability of skier presence on ski lift and ice throw strike is defined as the product of the probability of ice throw and the probability of skier presence; assuming the two events are independent.

Figure 2-5 depicts the probability of hit per unit area (1 m^2) on ski lifts. Areas shaded in orange, red or dark red present significant risks (above 1 hit in 500,000) and require mitigation means such as lift closure. It is noted that these areas lie outside the generic setback distance (doted yellow line) which was historically used when no modeling tool was available. Green and yellow-shaded areas represent probabilities not exceeding 1 hit in 500,000 years. As previously mentioned, DNV GL usually considers that at these low levels of probability, no risk mitigation may be required. However, this statement must be considered along with the overall risk as discussed below.

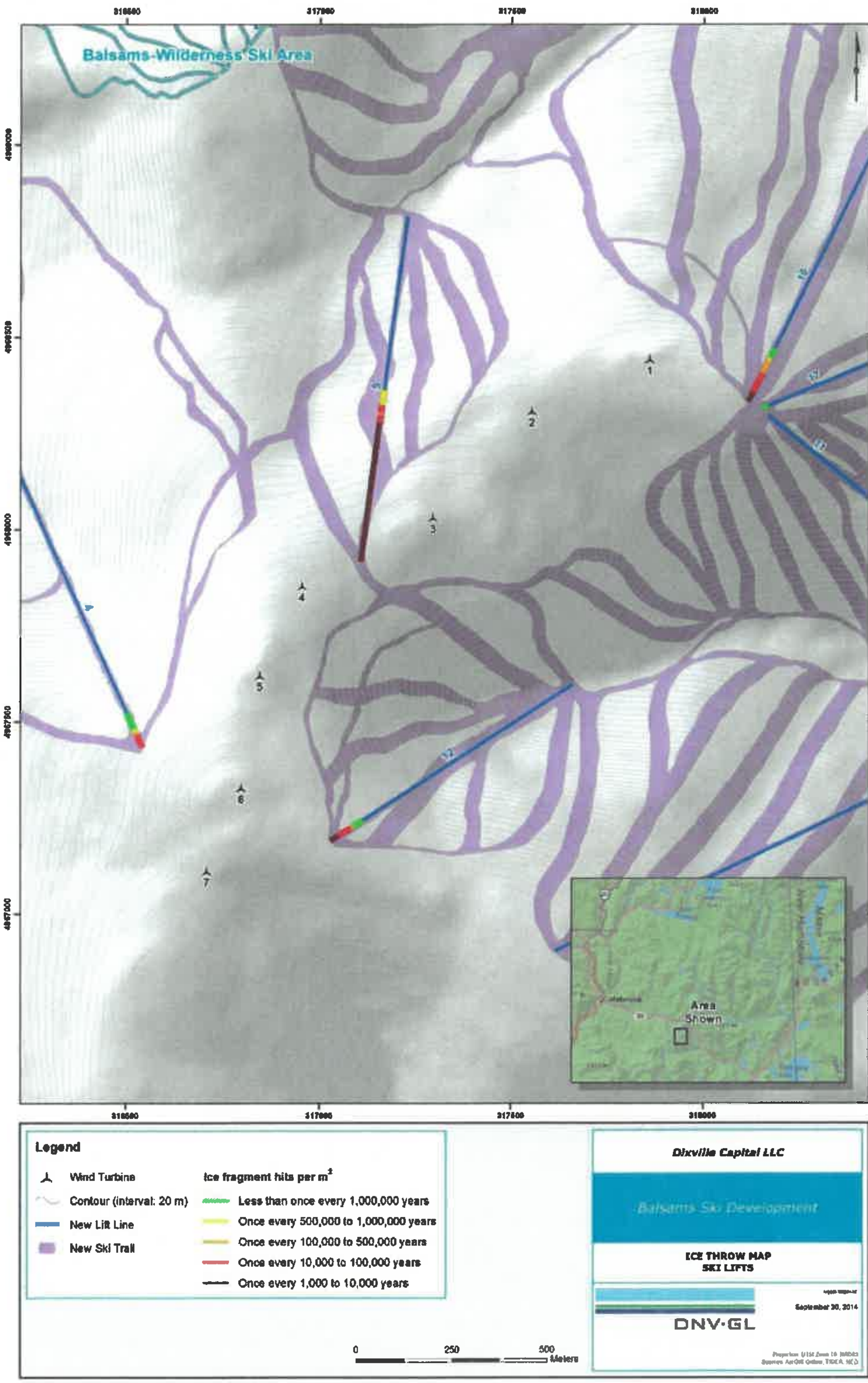

Figure 2-5: Risk of ice hit to skiers on ski lifts.

2.2.2.2 Risk of ice fragment hit on ski lifts

The overall probability of hit in Balsams (risk of hit) for skiers on ski lifts in presented in Table 2-5, as a function of the area that would remain open to skiers on ski lifts during ice throw events. This table summarizes the summation of all probabilities for all skiers present on ski lifts.

Table 2-5: Overall ice fragmemt hit risk on ski lifts.

Area that remains open	Cumulative Risk for the Resort
Blue + Green	1 hit in 31,000+ years
Blue + Green + Yellow	1 hit in 8,400+ years
Blue + Green + Yellow + Orange	1 hit in 1,200+ years
Blue + Green + Yellow + Orange + Red	1 hit in 115+ years
All	1 hit in 4-5 years

This table helps establish setbacks for a risk-based operating protocol. For instance, according to Table 2-5, the level of risk, should all lifts be operational even during ice-throw-risk periods, is one hit every 4-5 years, for the whole facility. By ensuring that no skier is present in dark red regions (green, yellow, orange and red allowed), the risk of ice fragment hit is reduced to one in 115 years. This may be done by changing the current siting of the ski lift location or by enforcing ski lift shut-downs during which blade ice throw risk is present.

2.3 Overall risk assessment

The overall risk of ice fragment at Balsams is the sum of risk on ski trails and ski lifts. Based on the results presented above, the ski trails have lower levels of risk but potentially affect a larger number of skiers while ski lifts have higher risk levels but fewer skiers are at risk.

The overall risk of ice hit, primarily driven by the ski trail risk, ranges from 1 hit in 4-5 years down to 1 hit in 28-29 years based on a specific scenario of trail and lift operational protocol and potential setbacks to be established by such a protocol. These are further discussed in Section 3.

When analysing these results, it should be noted that a number of simplifying assumptions as described in Sections 2.2.1.1 and 2.2.2.1 were used. Additionally, as mentioned in Section 2.1.4, in the absence of sufficient onsite data, a number of conservative assumptions were used in the ice throw Monte Carlo simulations.

It shall also be noted that the above represents an ice throw hit, and not necessarily an injury resulting from the hit.

3 INDUSTRY PRACTICE

Dixville plans to implement a risk-based operational protocol, namely Balsams Operating Protocol, to mitigate such risks. DNV GL selectively reviewed industry practice and national ski activity and societal risks to substantiate its comments and recommendations presented in Sections 4 and 5 below. This section summarizes the results of DNV GL's review.

3.1 Brief industry survey

In order to sense the current industry practice, DNV GL tried to contact ski resorts which *coexist* alongside operational wind turbines. Unfortunately, DNV GL was not able to identify an ideal case study due to a number of challenges, and notably the limited number of similar cases. Two facilities, one in Quebec and one in Sweden, were eventually identified and contacted. It is noted that unlike Balsams, the ski resorts were developed well before the wind turbines were installed in their vicinity.

3.1.1 Ski resort in Quebec

DNV GL contacted representative of a ski resort [14] located in Quebec, Canada presenting similarities with Balsams development. Downhill ski trails are located on the western face of a ridge which reaches some 850 m amsl. Seven 80 m hub height turbines are installed on the ridge at approximately 350 m from the ski resort according to the contacted representative; although DNV GL notes from publically available aerial imagery[3] that a few turbines appear to be less than 200 m away from some ski trails. Access roads to the turbines are signalled but remain open at all times.

After more than 5 years of operation, the ski resort has not reported any ice throws to date; although it recognizes detecting ice fragments on the ground is very challenging and one cannot definitely exclude the possibility of ice fragments having landed on the ski resort property since the wind farm was commissioned.

According to the ski resort representative, a very limited level of communication exists with the wind farm operator. DNV GL understands that no specific protocol is in place to coordinate ski resort and wind farm operations.

Finally, the ski resort representative mentioned a nacelle fire during which resulted in blade fragments being thrown as far as 150 m away from the turbine tower. The ski resort closed the nearest ski trail proactively. Several fiberglass fragments were observed on ski resort property following this incident but no injuries were reported.

3.1.2 Ski resort in Sweden

DNV GL contacted a Swedish company [15] who operates 3 wind turbines sited close to ski slopes in eastern Sweden. According to the contacted representative, one of the turbines was commissioned as early as 1996 at top of a ski slope. Routine daily inspections are performed to assess blade icing risk; and the turbine is shut off as soon as ice build-up is observed. The representative mentions that during some winter seasons the turbine may remain shut for several weeks as the operator is fully responsible for the safety of the skiers.

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[3] Googlemap.

The ski representative reports that 2 more recent turbines were commissioned in 2012 at approximately 500 – 600 m from the ski slopes. Despite this setback distance, because the area is considered as a recreational zone, turbine blades are equipped with heating systems and visual inspections are routinely performed to detect potential ice build-up. Additionally, specific signage around the turbines warns against risk of ice and/or snow fall.

3.1.3 Industry practice conclusions

A brief review of the two case studies above shows that:

- Lack of communication, clear definition of roles and responsibilities, and mutually agreed operational protocols between the wind farm and the ski resort may result in an increased level of hazard;
- Access to wind farm roads and turbines must be restricted and sufficient signalling should be used to warn the public against the hazards;
- Routine and regular daily visual inspections are performed to detect ice build-up on blades; and
- Blade heating and ice detection may largely mitigate the risk of ice throw; although visual inspection remains necessary.

DNV GL notes that amongst the above, routine and regular visual inspection of turbine blades, performed under strict safety rules, is of paramount importance in any risk-based operating protocol.

3.2 US ski resorts and societal risks

In order to grasp the meaning of the risks quantified in Section 2 for Balsams, it is useful to set meaningful risk levels for comparison. The following two paragraphs present such risk levels to help understand the severity of quantified risks and set the thresholds of acceptable risks to be achieved by risk control and mitigation measures at Balsams.

3.2.1 Fatality and injury risks related to skiing activity

According to the National Ski Areas Association (NSAA) [7], on average during the past 10 years, skiers/snowboarders have suffered 49 serious injuries per season; which translated to 0.86 serious injuries per million skier visits. Given that Dixville plans about half a million visitors per season, one (1) serious injury is expected every 2-3 years. With respect to fatal injuries, NSAA reports 0.44 incidents per million visits in 2012/2013 [7], which was significantly lower than the 1.06 incidents per million visits in 2011/2012 [9]. For Balsams, using the 2011/2012 national statistics which is generally in line with the average long-term statistics as per Dixville, one fatality could be expected every 2 years.

With respect to ski lifts [8], based on statistics from the State of Colorado, NSAA reports 227 falls from lifts between 2001/2002 and 2011/2012 in CO (or 22.7 falls per year). NSAA reports that only 4 instances were due to mechanical/operator error; while 19 were due to unknown causes. 4 falls due to operator/mechanical errors over a period of 10 years translates to one such incidence every 2.5 years.

Based on the above statistics reported by NSAA, by adding fatal and serious injury statistics, one fatal or serious injury could be expected during each season due to the inherent risk of the activity.

3.2.2 Societal risks

In addition to the specific risks of skiing, DNV GL also considered the societal risks defined as risks commonly experienced in society.

A number of such risks are reported below:

Risk Type	Probability
Fatal rail travel accidents (annual risk – commuter) [10] *2 daily journeys, 45 weeks per year* [10]	1 in 95,000+ years
Fatal aircraft Accident (annual risk – vacationer) *2 flights per annum* [10]	1 in 62.5 million years
Odds of being struck by lightning in a given year *Based on US averages for 2004-2013* [12]	1 in 960,000 years
5,700 pedestrians killed in the US *Injury Facts, 2013 edition reported by NSAA* [8]	1 in 52,600+ years (a US population of 300 million is assumed by DNV GL)

One societal risk commonly used in the industry is the risk of lightning strike, considered as a typical risk for outdoor activities. According to NOAA [11], the national statistics of lightning fatalities by state during the 2003-2012 period range from 0 to 0.77 per million per year. NOAA estimates that the national risk of death or injury is 1 in 960,000 years [12].

NOAA reports that during the 2003-2012 period, no lightning strike-related fatalities have been reported in New Hampshire. This can be explained by the fact that lightning strike frequencies are indeed very low in New Hampshire. They range from 0.5 flashes per km^2 per year in the north to 2 flashes per km^2 per year in the south of the state [13]. For Balsams, a strike rate of 0.5-1 flash per km^2 per year is reported; resulting in a rate of 1 strike per m^2 in 1-2 million years. Assuming a footprint of 1 m^2 for a person, this is a risk of 1 strike in 1-2 million years, which is indeed almost twice as low as the national average.

3.2.3 Suggested risk levels

Based on the previous review of risks, DNV GL suggests using the following thresholds for Balsams guests, based on the third-party information presented above:

- Balsams overall risk – Overall risk of ice fragment hit: 1 hit in 50-100 years; and
- Societal risk – Probability of ice fragment hit per unit area: 1 in 500,000 years or less.

These risks, while not zero, are deemed significantly low *compared* to ski-specific and societal risks at the national level. However, DNV GL makes no conclusion on an acceptable risk. These are further discussed below.

4 REVIEW OF BALSAMS OPERATING PROTOCOL

As demonstrated in Section 2, the overall risk of ice fragment hit to Balsams' guests requires specific risk mitigation means. DNV GL reviewed Balsams Operating Protocol prepared by Dixville [16] defining a risk-based approach where ski trails and lifts are closed upon detection of blade ice throw hazard and re-opened when the conditions are considered as safe.

This section presents the results of DNV GL analyses and review.

4.1 Balsams Operating Protocol

The protocol defines three exclusion zones around wind turbines:

1. Operations Setback #1: An area 50 meters (165 feet) in radius from a turbine base creating an exclusion zone to Balsams personnel and equipment;
2. Resort Operational Setback #2: An area 135 meters (445 feet) in radius from a turbine base creating a Balsams guest exclusion zone; and
3. Special Event Setback #3 – An area 255 meters (837 feet) in radius from a turbine base creating a Balsams guest exclusion zone put in place during periods prone to blade ice throw risk.

Setback #1 radius is based on the blade length of the wind turbine (approximately 40 m), plus an additional 10 m.

Setback #2 radius is based on the total height (tip height) of the wind turbine (approximately 125 m), plus an additional 10 m.

Setback #3 is based on an historic generic formula[4], when no site specific modeling tool was available.

In Figure 4-1, the constant 135 m radius Setback #2 and 255 m radius Setback #3 are presented as yellow and green dotted line.

[4] Hub height + rotor diameter, multiplied by 1.5. As per [4]

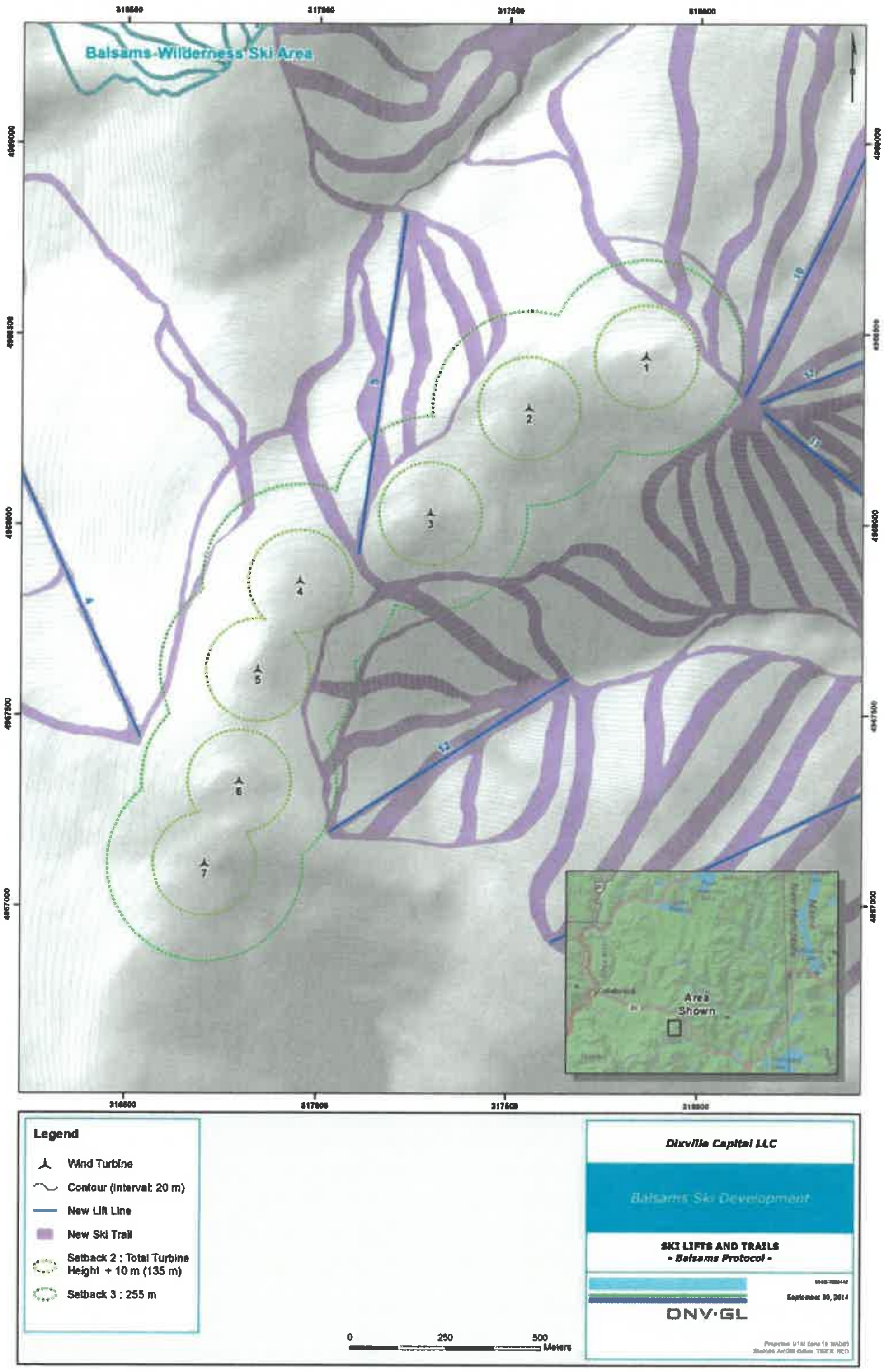

Figure 4-1: Proposed Balsams Operarting Protocol Setbacks.

The protocol is indeed based on a risk management approach where, instead of completely avoiding the risk of ice throw by closing the resort, some level of residual risk is accepted by closing specific trails and lifts only. Setbacks #2 and #3, depicted in Figure 4-1, show that by applying the proposed operating protocol, ski trails included in Setback #3 along with ski lift #5 will be closed should blade ice throw risk be identified by Balsams personnel. Such an approach may be valid provided the residual risk is acceptable to Dixville and Balsams and the protocol is robust.

The following paragraphs provide a high-level review of the proposed protocol by focusing on:

- Residual operating risks – assuming the protocol is thoroughly applied; and
- Protocol robustness – analysing potential items which may hinder the full application of the protocol.

4.2 Residual risks of the protocol

The residual risks of applying the proposed Setbacks #1, #2 and #3 were reviewed with a focus on ice fragment hit residual risks. For Setback #3, DNV GL performed a more detailed and quantitative analysis. More precisely, based on DNV GL's understanding of the proposed operating protocol, Balsams' guests will be evacuated from the areas delimited by Setback#3 if ice fragment hit risk is present. As a result, the risk of ice fragment hit to guests is limited to the areas lying outside of this perimeter.

Figure 4-2 presents the proposed Balsam's operating protocol setbacks superimposed to ice fragment hit risk levels estimated by DNV GL. The estimated risk of ice fragment hit for the resort and for individual guests using the modelling results of Section 2 are summarized in Table 4-1 and discussed in Table 4-2.

Table 4-1 Residual risks of currently proposed Operating Protocol.

Risk source	Resort risk	Skier risk
A. Ski Trails	1 hit in 27-28 years	1 hit in 500,000+ years
B. Ski Lifts	1 hit in 72-73 years	As high as 1 hit in 1,000-10,000 years
Total (A+B)	1 hit in 19-20 years	As high as 1 hit in 1,000-10,000 years

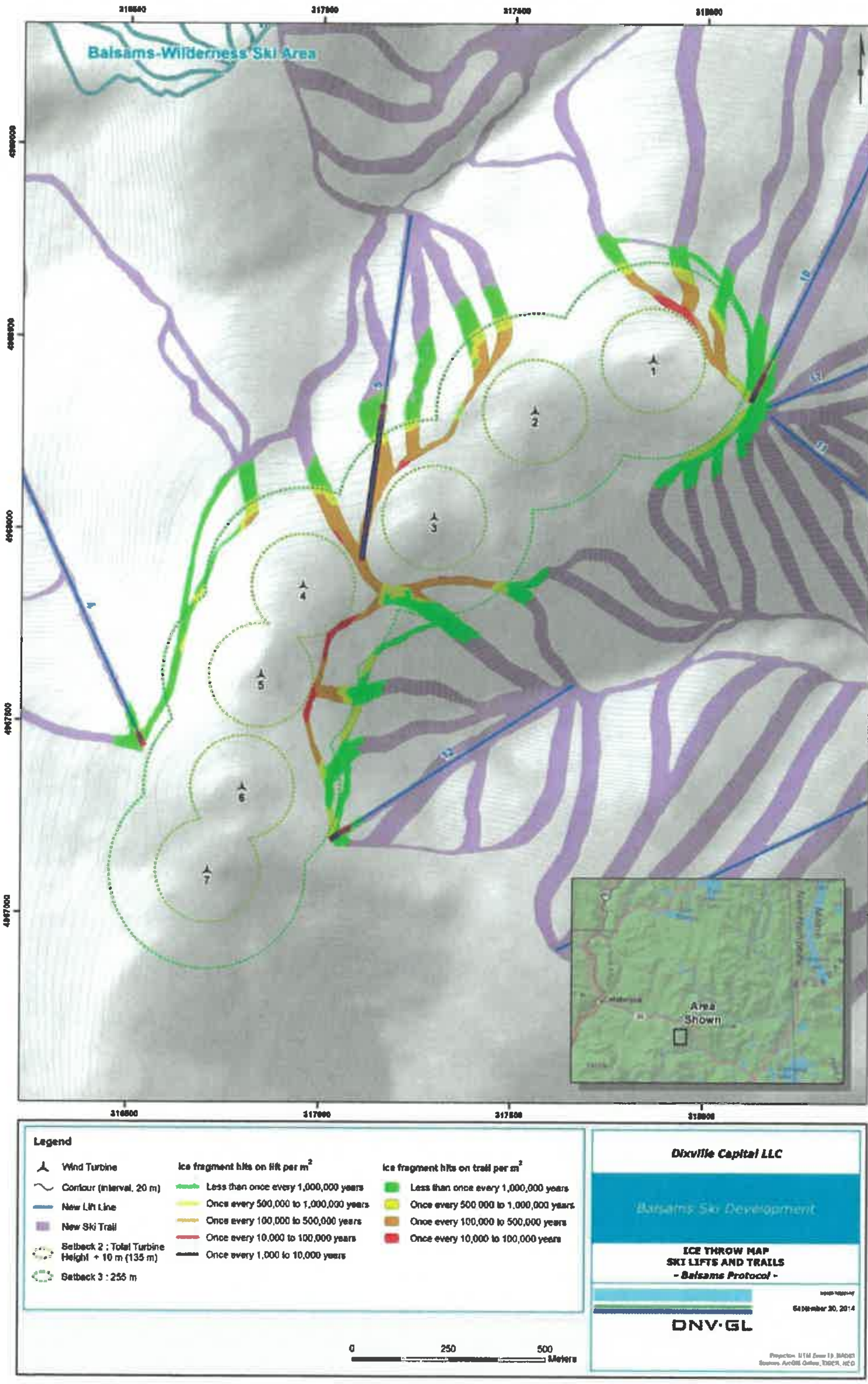

Figure 4-2: Proposed Balsams Operarting Protocol Setbacks vs. Ice fragment hit risk.

Table 4-2: Review of operating protocol residual risks.

Setback	Purpose	Description	DNV GL Comments and Conclusion
Operations Setback #1	Avoid falling objects	Applies at all times and at all Balsams personnel and equipment. In conjunction with Setback #2, also applies to Balsams guests.	In line with best practice; residual risk is deemed to be negligible. Area should be clearly signaled and exclusion enforced.
Resort Operational Setback #2	Avoid tip-over and minor icing events	Applies at all times to Balsams guests. Balsams staff may penetrate if no ice is detected on blades.	In line with best practice; residual risk is deemed to be negligible. Balsams personnel penetrating the area should be aware of potential ice throw risks when penetrating this zone. Zone entry should be prohibited and be exceptionally granted to Balsams personnel (presence of two recommended) only when required.
Special Event Setback #3	Mitigate risk of ice fragment hit	Applies to Balsams guests when ice throw risk is identified.	Overall resort risk: Residual risk for the resort is about 1 hit in 19-20 years, which is lower than expected rate of fatality or serious injury due to skiing activity (1 per year); but well above the suggested threshold (1 in 50-100 years, see section 3.2.3). Individual skier risk (societal risk): Residual ski trail risks comply with suggested threshold (less than 1 in 500,000 years, see Figure 2-4). Ski lifts 4, 10 & 12 exceed the suggested threshold as they represent risks levels as high as 1 hit in 1,000 – 10,000 years. It is noted that Balsams' operating protocol implies the closure of ski lift 5, which also exceeds the threshold.

DNV GL concludes that the residual risk of ice fragment hit (Setback #3), provided the operating protocol is thoroughly applied without hindrance, is not compliant with suggested thresholds described in Section 3.2.3.

DNV GL recognizes that a number of conservative assumptions have been embedded in the risk modeling (see Section 2.1.4) which might temper the above statements and conclusions. However, it is still recommended to:

- Modify Setback #3 from a fixed distance in all directions from a given wind turbine, to a setback tailored to specific ski trails; and
- Modify the location of ski lift 4, 10 & 12 arrivals to achieve lower risk levels.

Such scenarios are proposed in Section 6 for Dixville's consideration.

4.3 Robustness of the protocol

As previously noted, the risk-based approach is based on the acceptance of a non-zero but low-enough residual risk level if the operating protocol is fully enforced. The previous residual risk assessments are not valid if the protocol is not applied in a full and timely manner. The following table presents a number of critical items identified and discussed by DNV GL.

Table 4-3 Review of the robustness of the proposed protocol.

Item	DNV GL comments
Enforcement of Setback #2	It is recommended that guests be *physically* prevented from penetrating the zone delimited by Setback #2 at all times. Sufficient signage should be provided to inform them on risks of trespassing.
Ice Detection	Blade ice detection using binoculars may be hindered by atmospheric conditions. Balsams personnel should have a clear understanding of how to complete their inspection tasks under such circumstances. Balsams' personnel training, preparation and equipment should comply with the risk of ice fragment throws even in areas where the risk is deemed low. It is notably recommended, though not required, that they work in pairs when inspecting the turbines for the presence of blade ice. The criteria triggering the enforcement of Setback #3 should be defined and implemented in the procedures. It is suggested that observation of blade ice on any one turbine trigger enforcement of Setback #3 at neighbouring, if not all, turbines. Further inspection of those turbines should be performed before relaxing the Setback at any location. It is recommended that ice detection hardware (camera, vibration-based detector, etc.) be implemented on wind turbine blades to improve the efficiency

Item	DNV GL comments
	of ice detection.
Enforcement of Setback #3	If blade ice is detected after the resort is opened to guests, the time elapsed before the ski trails and lifts are cleared and Setback #3 is enforced should be minimized. Balsams personnel should follow a clear procedure which deals with all potential situations. For instance, they should know how to handle those skiers who are already on a ski lift. Setback #3 should be clearly visible and ideally physically prevent guests from penetrating the exclusion areas, with appropriate signage. High level of diligence should be kept to monitor the absence of guests on ski trails and lifts until the blade ice throw risk is cleared. A turbine-specific chart should clearly specify which ski lifts and trails are deemed affected when blade ice is detected on any given turbine.
Communication	Communication between Balsams and GR is especially important when re-opening decision is made based on turbine shut down by GR. Communication between Balsams personnel is critical, notably when establishing or clearing Setback #3. Collaboration between Balsams and GR is essential in identifying icing events and improving the protocol. The risk of ice throw should be communicated to Balsams guests, on days with potential ice throw, before they embark on a ski lift leading to Dixville Peak.
Decision to re-open	The chart of decision authorities and responsibilities should be clearly established. This chart should not rely on 3rd parties such as GR personnel as Balsams is deemed responsible for its guests.

DNV GL expects that experience will be gained as Balsams personnel will use the operating protocol. It is also recommended that ice fragments observed on Balsams grounds be reported if/when observed. This feedback along with those from GR personnel and Balsams guests should be used to update and improve the operating protocol continuously.

5 SUGGESTED MODIFICATIONS TO REDUCE RESIDUAL RISKS OF THE PROTOCOL

Based on the estimates of the residual risks of Balsams Operating Protocol presented in Section 4, and given the national risk levels presented for US ski resorts and societal risks, DNV GL suggests some modifications to the proposed protocol. More precisely, DNV GL suggests replacing the fixed-radius Setback #3 to selective trail closures; and modifying a number of ski lifts as described in this Section.

5.1 Ski trails

DNV GL and Dixville attempted to define a location-specific exclusion zone designed to replace the generic and constant 255 meter (837 feet) radius areas around turbine bases (Setback #3) by applying the following guidelines:

- Maximize the number of trails which could remain open;
- Lower the overall resort risk to the extent possible; and
- Comply with the societal risk threshold of 1 hit in 500,000+ years.

The results of this exercise are depicted in Figure 5-1 and are referred to as Scenario 1. In this Figure, it is proposed to replace Setback #3 by the grey-shaded exclusion area – Ski Trails Closed (Scenario 1). In this scenario, DNV GL has assumed that no skiers would be present on grey-shaded trail areas or downhill of trails closed uphill, and that no skier would attempt climbing uphill. By enforcing this exclusion zone during periods of time blade ice throw is expected, the overall risk for the resort is 1 hit in 33-34 years; this is still marginally higher than the threshold suggested in Section 3.2.3, but lower than the risk associated with the currently proposed setback (green dashed line in Figure 5-1). With respect to individual skier risk (societal risk), all ski trails outside of the proposed exclusion area lie in zones where the risk of ice fragment hit is less than 1 in 500,000 years (green and yellow areas in), which complies with the threshold suggested in Section 3.2.3.

Table 5-1 Residual risk of suggested scenarios for ski trail closure.

Ski trails options	Resort risk	Skier risk
Original operational protocol (255 m fixed setback #3)	1 hit in 28-29 years	1 hit in 500,000+ years
Scenario 1 (Selective trail closure)	1 hit in 33-34 years	1 hit in 500,000+ years

The suggested scenario, while not fully complying with thresholds suggested in Section3.2.3, presents a lower level of risk than the originally proposed Setback #3 and, potentially allows keeping some additional ski trails open.

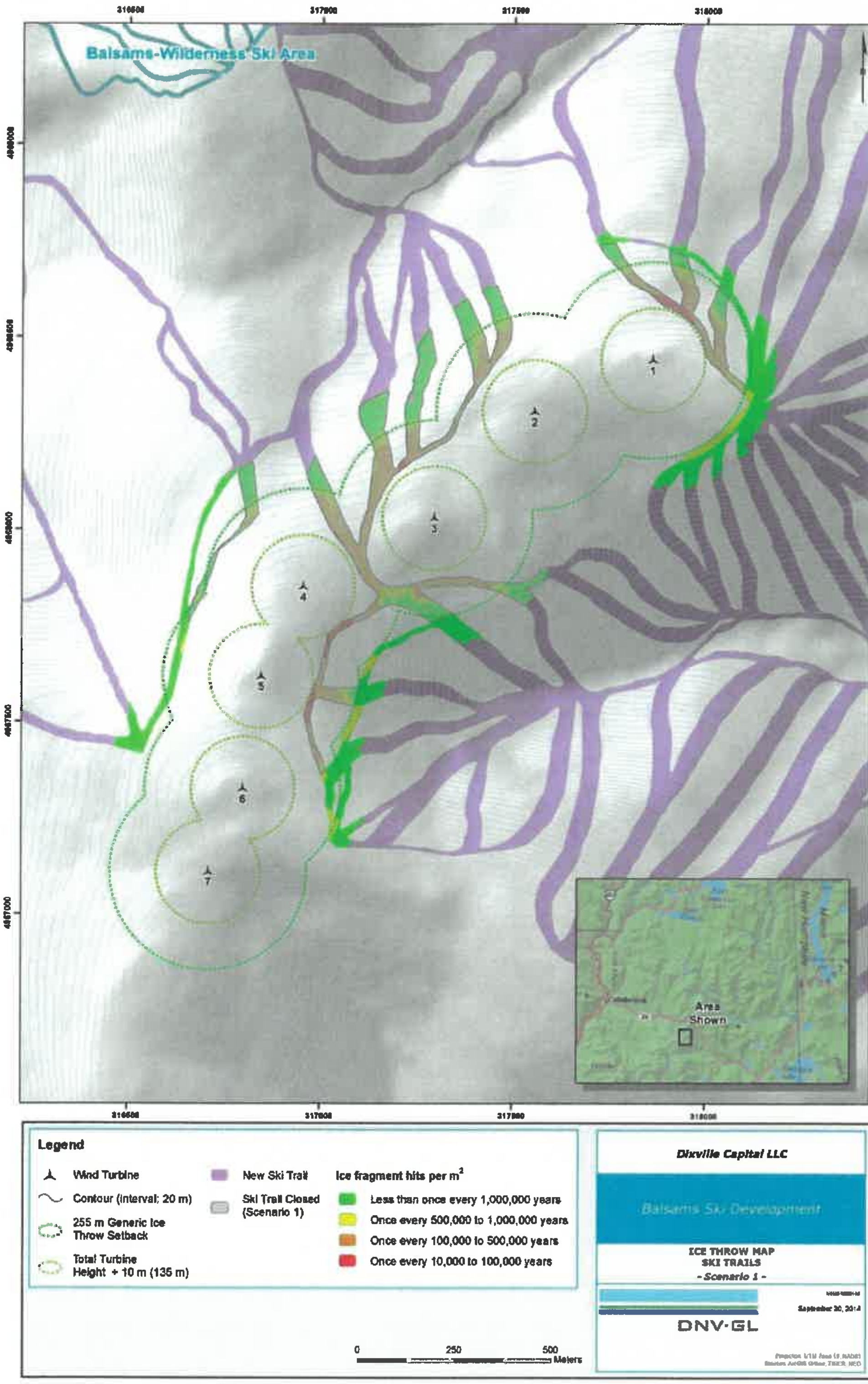

Figure 5-1: Suggested ski trail exclusion area (Setback #3).

5.2 Ski lifts

Concerning the ski lifts, DNV GL notes that ski lift #5 is to be closed during icing events, if suggested risks levels are to be achievable.

Ski lift #10 and #12 present risks of the order of 1 hit in 1,000 to 10,000 years around their respective arrival points (see Figure 2-5). Ski lift #4 presents somewhat lower risk levels of the order of 1 hit in 10,000 – 100,000 years. DNV GL suggests these lifts be modified in such a way that their respective risk levels drops to at least 1 hit in 100,000+ years or less. Two such configurations or options are presented in Figure 5-2 where ski lifts #4, #10 and #12 are relocated (Options 1 & 2) and shown along with their original tracks. The suggestion modifications to these ski lifts are summarized in Table 5-2.

Table 5-2 Suggested modifications to ski lifts*.

Ski lift #	Option 1	Option 2
4	Arrival point to be moved approximately 15 m southwest of current position	Arrival point to be moved approximately 30 m southwest of current position
10	Arrival point to be moved approximately 25 m southeast of current position	Arrival point to be moved approximately 55 m southeast of current position
12	Arrival point to be moved approximately 30 m southeast of current position	Arrival point to be moved approximately 45 m southeast of current position

*: Ski lift #5 is assumed closed in all cases.

Table 5-3 presents the risk levels of the original and modified ski lifts.

Table 5-3 Residual risk of suggested options for ski lift modifications*.

Ski lift options	Resort risk	Skier risk
Original operating protocol	1 hit in 72-73 years	As high as 1 hit in 1,000 to 10,000 years
Option 1	1 hit in 750+ years	1 hit in 10,000+ years
Option 2	1 hit in 3,400+ years	1 hit in 500,000+ years

*: Ski lift #5 is assumed closed in all cases.

Option 2 complies with thresholds suggested in Section 3.2.3 while option 1 would require the closure of ski lifts #4 and #10 (in addition to #5) to fully comply with suggested risks levels when blade ice throw risk is observed at site.

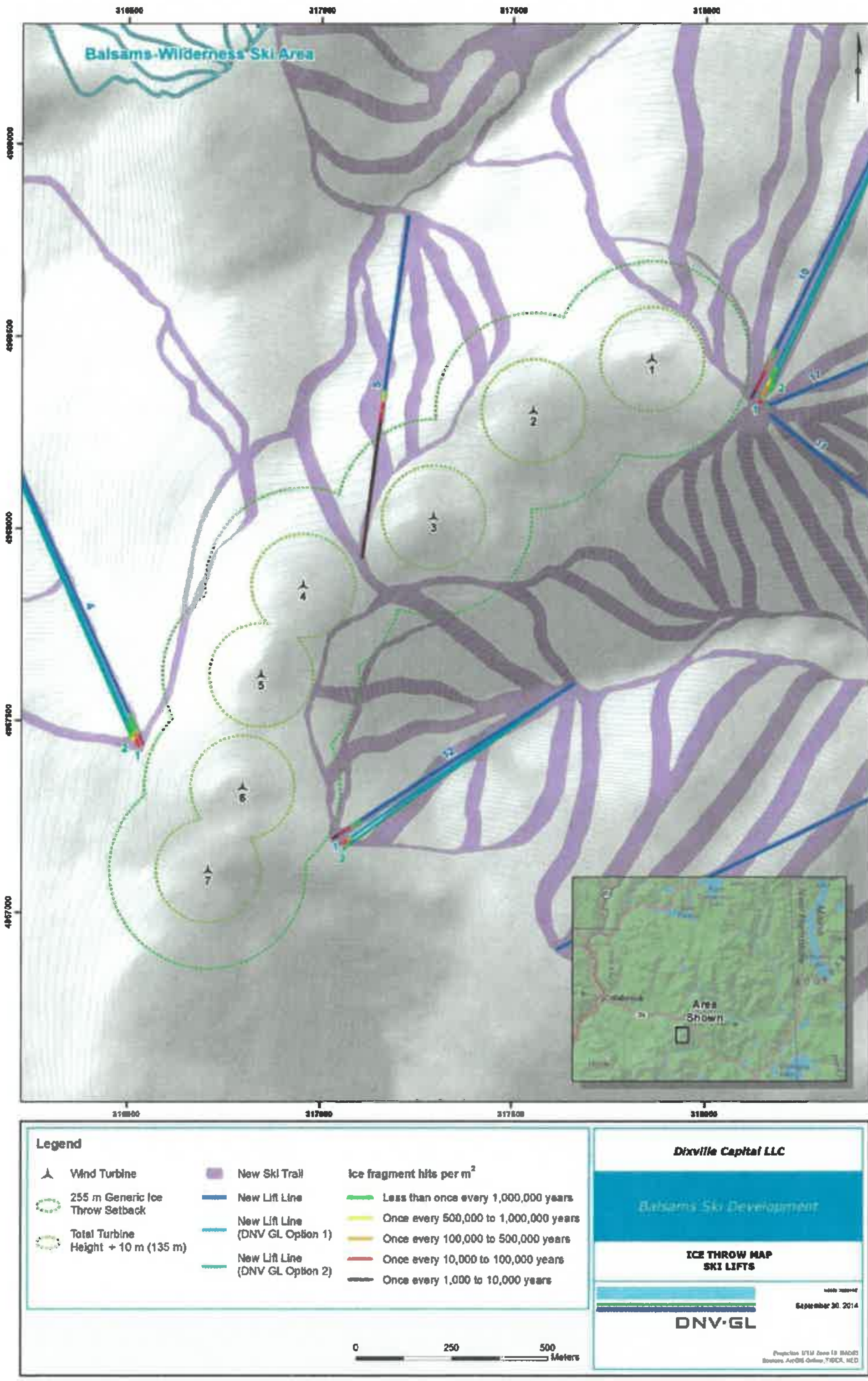

Figure 5-2: Suggested Ski Lift Modifications.

5.3 Overall residual risks

Figure 5-3 presents the ski trail Scenario 1 and ski lift Options 1 & 2 discussed above. Table 5-4 below summarizes the residual risks assuming various operating protocols as described in the first column.

Table 5-4 Overall residual risk of suggested scenarios and options.

Scenario/Option	Resort risk	Skier risk
Original operational protocol (ski lift and trails)	1 hit in 19-20 years	As high as 1 hit in 1,000-10,000 years
Ski trail Scenario 1 (Selective closure) Ski lift #5 closed during icing events	1 hit in 22-23 years	As high as 1 hit in 1,000-10,000 years
Ski trail Scenario 1 (Selective closure)		
Ski lift Option 1	1 hit in 31-32 years	1 hit in 10,000+ years
Ski lift Option 2	**1 hit in 33-34 years**	**1 hit in 500,000+ years**

DNV GL notes that Scenario 1/Option 2 pair (bold face in Table 5-4) presents the lowest level of risk and the closest configuration to suggested thresholds. If this scenario were adopted, during periods of time where blade ice throw is expected, the grey-shaded ski trails – Ski Trail Closed (Scenario 1) in Figure 5-3 – would need to be closed and guests be evacuated by Balsams personnel. Concurrently, ski lift #5 should also be closed and guests be evacuated by the personnel.

It should be noted that the above relates to risk of ice throw hit to skiers. The risk of ice impacting the ground[5] is higher and fragments are expected to land in areas within the purple-shaded areas, depicted in Figure 5-1. Skiers may see ice throws or encounter ice fragments on the ground at higher rates than estimated above.

[5] Skiers are not continuously present at any given location 24/7 during the whole winter season.

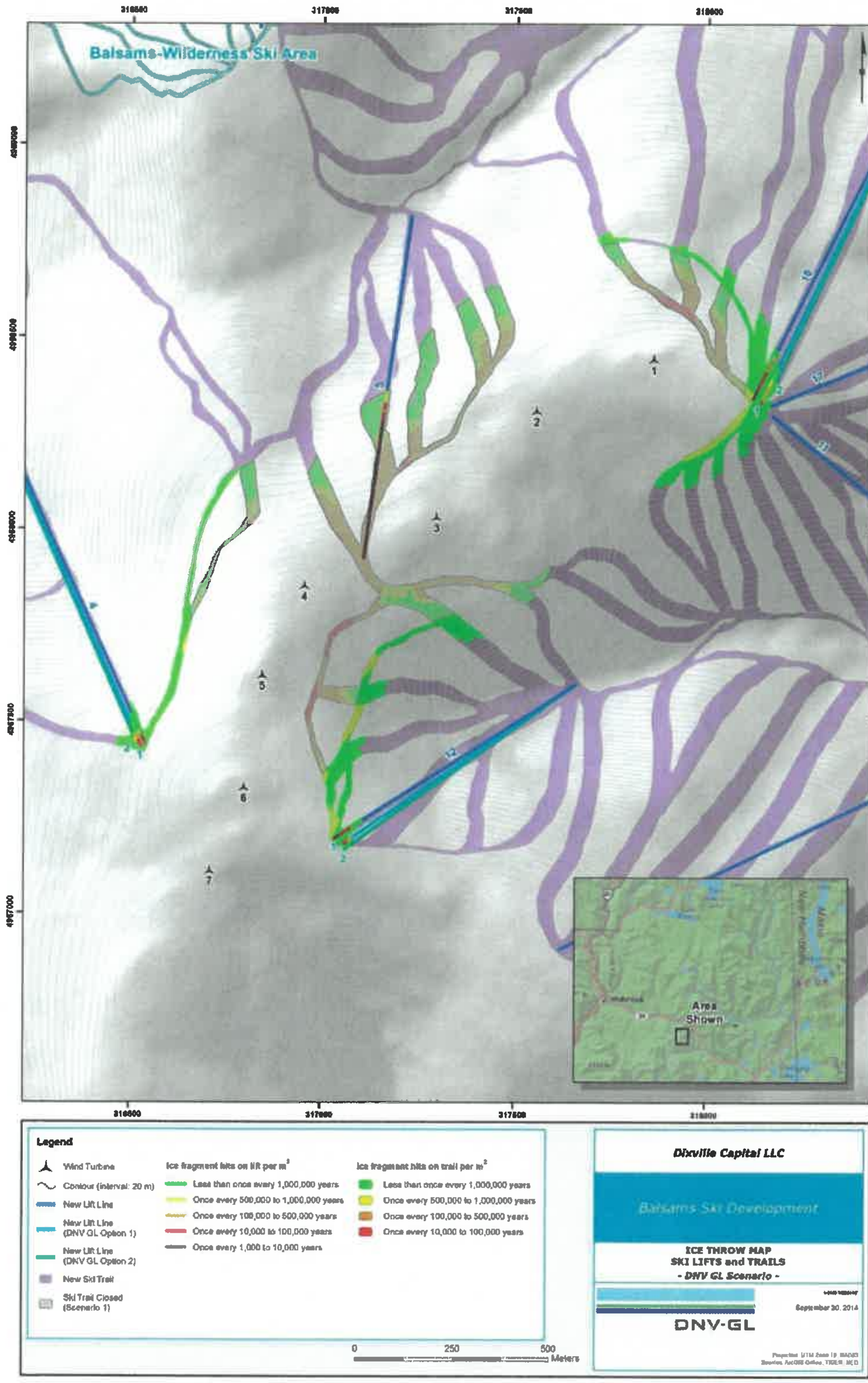

Figure 5-3: Suggested ski trail scenario and ski lift options.

6 CONCLUSIONS

DNV GL reviewed the operating protocol prepared by Dixville, and designed to mitigate the risk of ice throw by the GR wind farm turbine blades to future guests of Balsams Development Project at Dixville Peak, New Hampshire. The operating protocol is part of a risk-based approach where a limited level of residual risk is deemed acceptable.

DNV GL assessed the residual risk of ice throw to the ski resort guests assuming the thorough and full implementation of the protocol. The assessment was based on available onsite data, information obtained from GR and from Dixville, and DNV GL experience and proprietary probabilistic modeling tools.

The residual risk was compared to national statistics of fatal or serious injuries at US ski resorts; and to societal risks such as lightning strike. This exercise was aimed at suggesting a residual risk, which is an additional risk due to the presence of turbine blade ice throw, which would be low compared to the level of risk expected at an average US ski resort; or a societal risk. DNV GL makes no conclusion on an acceptable risk.

DNV GL concluded that the setbacks in the proposed operating protocol and the siting of ski lift arrivals could be modified according to scenarios and options presented in section 5 to lower the residual risk of ice fragment hit to Balsams guests. By implementing the suggested modifications, the residual risks could be as low as the numbers presented below.

Table 6-1 Overall residual risk of suggested scenarios and options vs. national statistics.

	Residual ice fragment hit risk (Original Balsams protocol)	Residual ice fragment hit risk (DNV GL Scenario 1/Option 2)	Reference US Statistics
Overall Resort Risk			Fatal or serious injury at a ski resorts
Risk Level	1 hit in 19-20 years	1 hit in 33+ years	1 per year (source: [8])
Risk to individual guests (societal risk)			Odds of being struck by lightning
Risk Level	1 hit in 1,000+ years	1 hit in 500,000+ years	1 in 960,000 years (Source: [11])

DNV GL notes that the above estimates or residual ice throw risks are to be considered in the context of a number of inherently conservative assumptions made due to the lack of more precise information or data. DNV GL notably highlights the following:

- Blade ice fragment hits do not necessarily result in fatal or serious injuries;
- The total number of annual ice fragments to be thrown is based on conservative assumptions;
- The ballistics of ice fragment throw were based on conservative fragment mass and density;
- All ice fragments were assumed to be thrown during operating hours of the ski resort.

DNV GL also reviewed the critical elements of the operating protocol and provided limited comments to enhance its robustness. The comments notably concern the turbine blade ice detection means, practical issues in enforcing the required setbacks, communication protocols and decision making chain of authority.

DNV GL notes that reducing the risk of ice throw by employing wind turbine ice detection hardware and/or wind turbine icing event operation protocols (such as pre-emptive shut downs, de-icing, start-up with no ice present on blades, etc.), provide enhanced risk mitigation.

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