THE WIND BLOWS THROUGH IT: DESIGN PROPOSAL FOR A NATURAL CAPITAL CENTRE IN THE SQUAMISH VALLEY

by

ERIKA J. MASHIG

B.Sc. Forestry, SUNY at The College of Environmental Science and Forestry, 1999

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

Master of Landscape Architecture

in

THE FACULTY OF GRADUATE STUDIES
(Landscape Architecture)

THE UNIVERSITY OF BRITISH COLUMBIA

October 2006

abstract

This project proposes ideas for a Natural Capital Centre in downtown Squamish. The District of Squamish and Ecotrust have stated that the Centre will serve as a tangible demonstration of the town's commitment to sustainable thought and action, including interpretive information related to the proposed windfarm on Alice Ridge.

Squamish has a reputation for being a very windy place. It is a word adapted from Sko-mish, the name of the native nation who first occupied the territory and has a general meaning of 'strong wind', or 'birthplace of the winds.'

The design solution for the NCC aims to tie these two ideas together, demonstrating a strong commitment to sustainabilty and reinforcing the identity of Squamish as the "birthplace of the great winds." The project framework explores the relationship between renewable energy and people- how people understand and experience natural forces of place, and the relationship between renewable energy and place- how local wind data may be translated into architectural design.

The proposed design interventions range from the fundamental organization of the site to small-scale detailing of the sensory experience of the wind. The intent is to inspire a mulititude of other ways to integrate the Squamish winds in future developments that strengthen a 'sense of place' in downtown Squamish.

"Sometimes the most important aspect of a given site is almost intangible. It is not necessarily what remains visible to the eye that matters most, but those forces and events that undergrid the evolution of place."

-- -- Christopher Girot

contents

list of figures and illustrations

acknowledgements

Thesis Committee:

Ron Kellet, Professor, School of Architecture and Landscape Architecture
Doug Paterson, Associate Professor, School of Architecture and Landscape Architecture
Dr. Stephen Sheppard, Professor, School of Architecture and Landscape Architecture, Faculty of Forestry

I would like to specifically thank the following people:

Doug Paterson and Stephen Sheppard for their insight and valuable comments.

Ron Kellet for being generous with his time, resources and for having a huge hand in shaping this project.

Dan McRae and Brent Leigh from the District of Squamish and James Griffiths and Danijela Vecei from Sea Breeze Power Corporation for providing maps and taking time to answer my questions.

Rachel Pachter from CapeWind for teaching me everything I know about wind energy.

Alex Kurnicki from PWL Partnership for his positive energy and great suggestions.

'The Jone's' for their architectural advice and humour.

Dave Ho and Claire for their critiques and for taking care of me and the garden- all summer long.

My sister, Jodie and her husband, Sean for financial support, love and encouragment.

And, of course, all of my wonderful friends that helped smooth out the bumps along the way-
Kristen and Yugi, Xenia, Leigh, Edward, Eric, Luke and Matt

setting the stage for this project

The District of Squamish and Ecotrust are working to create a Natural Capital Centre on Block 20 as part of educational/cultural zone identified in downtown Squamish. The Natural Capital Centre will be a 60,000 square foot facility with:

1/3 dedicated to the goals of the Centre
1/3 general community amenities (e.g. performing arts centre)
1/3 a core economic contributor (commercial, residential, etc.).

The District Council has said that the Centre will serve as a tangible demonstration of the town's commitment to sustainable thought and action, including interpretive information related to the proposed windfarm on Alice Ridge.

Because environmental forces do contribute to a sense of place and are often not recognized in urban places, we must ask the question "What makes a meaningful and educational place, connecting people to the larger environment?" in the context of "How can public places demonstrate stewardship of the natural resources that sustain us?"

The Jean Vollum Natural Capital Center EcoTrust Building located in the former industrial area known as the Pearl District of Portland, is an example of such a place. At the Jean Vollum Natural Capital Center, customers and visitors encounter a wide range of environmentally and socially responsible goods, services, and ideas. The three-story building, originally a warehouse built in 1895, was restored using several green building strategies. The following five elements were emphasized: reusing the existing building; selecting reclaimed, recycled, and otherwise low-impact materials; filtering and storing rainwater on-site; making the building as energy-efficient as possible; and creating inviting public spaces.

Ecotrust is a conservation non-profit based in Portland working to support the emergence of a conservation economy within its bioregion, the Pacific coastal temperate rainforest, which extends from San Francisco to Anchorage, Alaska. Ecotrust and the community of tenants (includes governmental, business and non-profit groups) in the welcome the public through generous public spaces for exhibits, events and spontaneous interactions.

The Center includes outdoor seating, a public atrium, a conference center, a resource center, and an outdoor terrace with fireplace. All floors incorporate display areas for exhibits and shared information.

The second story roof of the Jean Vollum Natural Capital Center is a 5,123 square feet of soil and native plants. The extensive ecoroof supports several native species of grasses, wildflowers and succulents. Excess stormwater from the ecoroof flows into bioswales in the parking lot, resulting in a thorough stormwater management plan for the building.

A visit to the Ecotrust Building includes a self-guided tour highlighting its most interesting "green" features. At the entrance of the building is a display of "Field Guides" which invite the visitor to take a hike through the building. The Field Guide includes a map of the building and information on what makes the building green. Symbols, icons and signage throughout the building denote stops on the tour.

For example, sign language is used to explain how the integration of natural systems in to the building benefits the Willamette watershed. Visitors learn that the NCC "ecoroof", together with street-level landscaping, filters and absorbs 100% of the site's rainwater, eliminating runoff to the overburdened Willamette River. The experience of "hiking" the building successfully connects people to the larger environment in demonstrating how stormwater can be diverted from the city's system to protect salmon, assist in the river cleanup and provide biodiversity in an urban setting.

The success of the Jean Vollum Natural Capital Center EcoTrust Building is the result of combining interpretive sign language with active engagement to unfold the complexity of the natural world and foster connections between people and the environment. The Center also successfully weaves restoration, reclamation and regeneration into the local community, thereby enhancing the quality of life for the entire neighborhood. These are a few of the ingredients for creating meaningful and educational places that connect people to the larger environment and foster stewardship of natural resources.

How can these qualities be integrated in the design of the Natural Capital Centre in Squamish?

The District Council of Squamish has defined the educational mission of the Natural Capital Centre with the dual priorities of encouraging environmental sensitivity and celebrating the wind as a natural resource. Assuming that the wind farm will be located on Alice Ridge (figure 1.1) and will be visible from downtown, the Squamish Natural Capital Centre presents an opportunity to visually and tangibly connect people to this energy source.

Just as visitors to the Jean Vollum Natural Capital Center EcoTrust Building learn about the impacts urban development has on the watershed, the proposed Natural Capital Centre for Squamish will demonstrate energy conscious building as it responds to and celebrates the strong winds that Squamish is named for. The design experiments with manipulation of micro-climatic conditions to protect spaces from wind, and to create optimal bioclimatic conditions for extending the seasonality of programs and activities in downtown Squamish. The proposed Centre also aims to teach visitors how the wind turbines they see spinning in the distance displaces the worrisome production of other forms of energy. Together, these aspects will create a distinct and educational experience for visitors and important amenities for the Squamish community.

This project approaches the planning and design of the Natural Captial Centre through an understanding of how people learn about environmental information. This understanding is combined with the translation of the specific climatic conditions into architectural design to explore the multifunctional nature of the Centre and its integral role in contributing to a sense of place while promoting 'green' tourism in downtown Squamish.

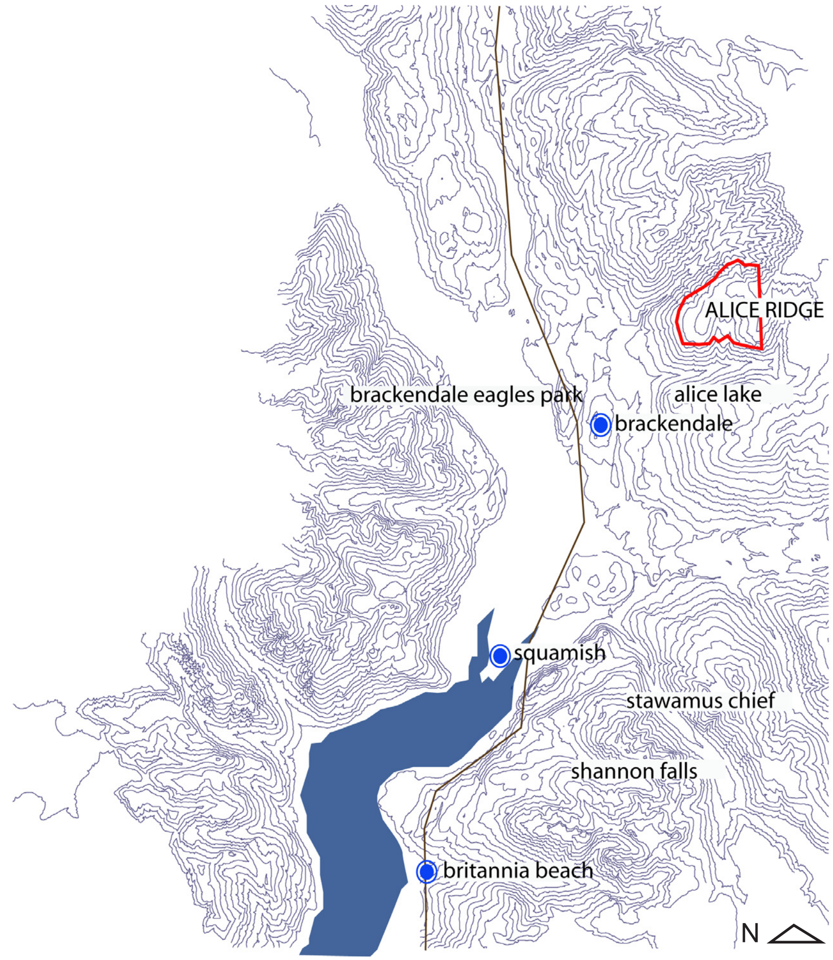
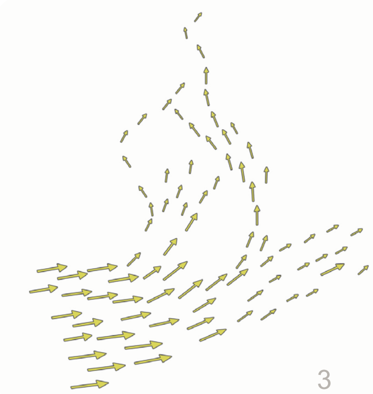


figure 1.1: Map highlighting location of the proposed windfarm on Alice Ridge (outlined in red), north of downtown Squamish.

section 1

context and project background



1.1 context and location in the Howe Sound

Squamish is situated at the head of Howe Sound and surrounded by mountains to the north, east and west. Six glacial rivers thread their way to the sea through pristine mountain peaks, pouring into the wide, green estuary where they meet before flowing into the fiord of Howe Sound and the Pacific.

figure 1.2: Map of the Howe Sound (highlighted in the red box).

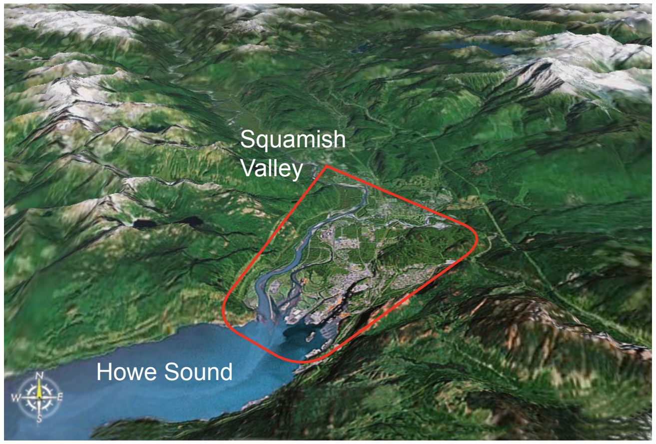


figure 1.3: The Squamish Valley located at the head of the Howe Sound

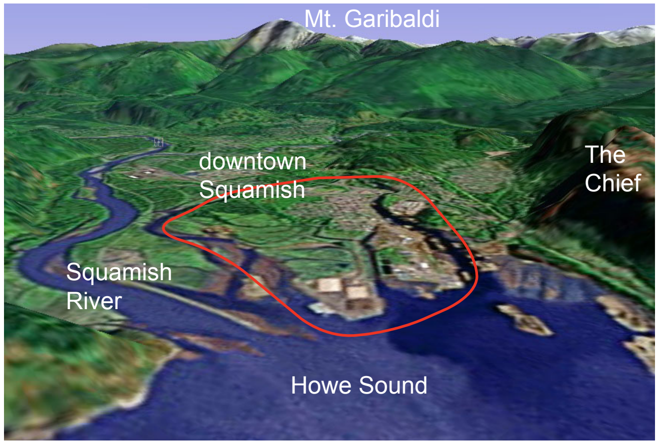


figure 1.4: Downtown Squamish

1.2 introduction to site

The proposed site for the Natural Captal Centre is located in downtown Squamish. The site is 30 meters wide and 172 meters long with an area of 60,000 square feet (about a half a block). The site is bordered by the Squamish Estuary to the west and the Mamquam Blind Channel to the east and will be connected to these natural areas with a pedestrian corridor.

figure 1.5: Site proposed by the District of Squamish for the Natural Capital Centre.

1.3 project objectives

The research and analysis portion of this project highlights climate patterns and associated programs and activities in downtown Squamish. This data and analysis culminates in a design proposal for the Natural Capital Centre that:

- allows people to understand, experience and enjoy the unique wind in Squamish

- increases the number of activities that may happen downtown, extending the shoulder season for tourism opportunities

- manipulates the wind for more useable indoor/outdoor spaces, while in other places, emphasizes the movement of the wind to demonstrate how wind moves through the Howe Sound windshed

Integrating climate responsiveness is important for the following goals of the Centre:

- demonstrating environmental sensitivity in design

- reducing energy consumption

- enhancing environmental awareness

- integrating wind energy in the downtown to foster public support for the windfarm on Alice Ridge

- reinforcing the identity of Squamish as the “birthplace of the winds”

1.4 background: smartgrowth in Squamish

The Squamish-Lillooet Regional District was the fastest-growing region in BC between 1996 and 2001. With the 2010 Olympics on the horizon, rapid growth is expected to continue (www.sgog.bc.ca). In April 2005, Smart Growth on the Ground (SGOG) partnered with the District Council to explore the best ways for Squamish to grow sustainably in the face of increased development pressure. Design principles were drafted by SGOG in response to input from the Squamish community and stakeholder groups. During the charrette workshop process, one of the primary principles stated in the concept plan for Squamish addresses the need/desire for green energy technology. The principle reads:

“With high growth pressure, strong environmental values, a limited land base, and the exposure that future events bring, Squamish is in a position to take a leadership role among growing and transitioning communities by demonstrating how a ‘greener’ approach to buildings and infrastructure costs less and provides more over the long-term.” (SGOG Squamish Design Brief, prepared by Design Centre for Sustainability at UBC, 2005)

Some of the goals associated with the implementation of “buildings and infrastructure that are greener, smarter and cheaper” include :

- Incorporating alternative technologies for buildings and infrastructure.
- Providing incentives for green buildings and infrastructure.
- Facilitating the use of energy from clean and renewable resources.

(SGOG Squamish Design Brief, prepared by Design Centre for Sustainability at UBC, 2005)

Among the wide range of renewable energy technologies, it has been determined that a wind turbine system is most appropriate for this area. As a visible commitment to sustainability, Squamish plans to incorporate 5-10 wind turbines in the landscape. The turbines will be strategically located on Alice Ridge to maximize wind capture, as well as to function as a “green” icon for Squamish (refer to figure 1.1).

There has been much talk about the need for sustainability and diversity in the new development plans for downtown Squamish. As stated in the design brief, Squamish has a genuine interest in delivering a sustainable development with a mixed living and working community. Opinions about building wind turbines in or around Squamish are bound to be mixed, but it might at least be argued that they would not be out of character with the industrial spirit of the location and new vision for sustinable energy sources.

The wind energy project is still in it’s early stages, but the imagery and ideas produced from the charrette combined with this analysis and design proposal suggest that in a few years time, Squamish could be a dynamic, innovative area with an attractive mix of activities and live-work opportunities with sustainable energy operating on many scales. Perhaps the most exciting aspect is the influence it could bring to the redevelopment of other small communities in British Columbia.

figure 1.6: Redevelopment proposal for downtown Squamish (SGOG Squamish Design Brief, prepared by Design Centre for Sustainability at UBC, 2005).

1.5 the squamish winds

The powerful winds that pour down the valley and into the Howe Sound are a special feature in Squamish and an important part of the town's story. The entire Squamish landscape has a meaning from its original inhabitants that lingers in ancient placenames and in legends of rock, sea and wind. The Squamish name is a word adapted from Sko-mish, the name of the native nation who occupied the territory (Mclane, 1994). It has a general meaning of 'strong wind' or 'birthplace of the winds' (Mclane, 1994).

To imagine the Squamish Natural Capital Centre as a unique and provocative place, we must ask the question "What attributes create sense of place in Squamish" in the context of "What makes a good place?" To understand how to strengthen sense of place, we need to first define the geographic concept of place.

One definition of place, proposed by geographer Yi-Fu Tuan, is that a place comes into existence when humans give meaning to a part of the larger, undifferentiated geographic space (Tuan,1974). Giving an identity or a name to a location separates it from the undefined space that surrounds it. Some places are said to have a strong "Sense of Place" because they have been given stronger meanings, names or definitions by society than others.

Squamish is known as a very windy place, very apt to anyone who has ever lived in the area. Most people would agree with the statement that wind is a part of daily life in Squamish. "In summertime the daily thermal breezes are a refreshing pleasure, but in winter wild outflow gales can shriek down from the north, accompanied by intense cold usually lasting for several days (Mclane, 1994). These harsh gales are often referred to as a 'Squamish' wind." (Mclane, 1994).

The Squamish winds have created opportunities for recreational tourism, attracting worldclass windsurfers and kitesurfers. The bay of Squamish where the ocean meets fresh water from five rivers resulting in dynamic and often optimal conditions for windsports, particularly off the spit at the mouth of the Squamish River. Surrounded by a dramatic landscape, mountains and wilderness, windsurfing in Squamish is a special experience (see figure 1.6).

A strong sense of place is also evident where an exhilarating fit between the human-built environment and the natural environment exists (Smartgrowth on the Ground, Foundation Research Bulletin: Squamish, No. 4, 2005). "A variety of ephemeral and physical features, the manner in which the town is ordered in the landscape, the nature of the commercial-industrial activities, the nature of how the town protects and manages itself, its festivals and events, and the imagination it brings to the why and how it builds, affect the town's sense of place (Smartgrowth on the Ground, Foundation Research Bulletin: Squamish, No. 4, 2005).

We can conclude from these definitions that a strong sense of place refers to the unique, distinctive and cherished aspects of a place that result from the invisible weave of culture (stories, festivals, art, memories, beliefs, histories, etc.) with the tangible physical aspects of a place (monuments, boundaries, climate, rivers, woods, architectural style, rural crafts styles, pathways, views, etc.).

Metaphorically, one aspect of this project attempts to sew together numerous layers of place that contribute to the experience of the Squamish Valley using the unique physical force of the wind as the thread. The design component demonstrates how research and analysis of the Squamish winds may be applied to a specific site to build better, more energy efficient places that contribute to a strong sense of place. "At the same time, well-located wind buffers, wind mills, wind sails, etc. could add an important creative dimension to the Town's story" (Smartgrowth on the Ground, Foundation Research Bulletin: Squamish, No. 4, 2005).

figure 1.7: Photo of kitesurfers taken from the Squamish spit (http://www.squamishwindsurfing.org/).

1.6 in the context of renewable energy

This project is both global and local in scope:

- Globally, it addresses the magnitude of changes due to global warming and the new methods of resource acquisition that will have to be implemented to respond to future energy resource supply and demand.

- Locally, this project considers a new set of incremental measures and conservation strategies that will be developed to support renewable energy resources in Squamish.

- Lastly, this project attempts to confront the changing face of landscape architecture in evaluating how to best adapt renewable energy to a given landscape and the local community it serves.

Energy production, distribution and consumption are processes that are deeply connected to the landscape and significantly impact human ecosystems on a global, regional and local scale. Conventional or non-renewable sources of energy such as oil, coal, nuclear and natural gas are not only finite, they also contribute to global warming and local climate change resulting in unpredictable environmental, social and economic consequences (see 'indicators for Climate Change in BC' in appendices section).

Since energy is so unrealistically cheap and seemingly abundant in North America, it is generally taken for granted, allowing people to consume far more energy than they need to survive. Individuals and families produce 23% of Canada's GHG emissions just from day-to-day activities like heating their home, driving a car and using electricity (www.bcsea.org/). On average each Canadian currently produces about five and a half tonnes of GHG emissions every year (www.bcsea.org/). However, as the price of non-renewable fuels increases coupled with a predicted decrease in their availability, it will become necessary to reduce consumption, build more efficiently and develop alternative energy sources. As our dependence on fossil fuels comes to an end, landscape architects will play an important role in the transition to more sustainable practices including renewable energy technology. Renewable energy systems do not pollute, are available locally and are affordable and efficient. Renewables of this nature are generally limited to solar, wind and hydroelectric energy but may include geothermal and biogas sources.

Wind energy is among the fastest growing renewable energy technologies in the world (www.canwea.ca/en/). Increasing by approximately 32% a year globally over the last five years, wind energy has proven to be a clean, abundant and completely renewable source of power (www.canwea.ca/en/WindEnergy.html). If placed in a suitable environment, wind energy is economical to produce and a very reliable source of electricity generation. In the past few years, wind energy production in Canada has grown to 1,049 MW (www.canwea.ca/en/WindEnergy.html). While this is encouraging, Canada still has vast untapped wind resources available with potential for wind energy to meet a full 20% of all electricity needs (www.canwea.ca/en/WindEnergy.html).

wind energy in Squamish, BC

The World Energy Council has rated BC's wind resources as the best in the world (www.seabreezepower.com/). The winds in Squamish have been identified as a potential energy resource, making it feasible for Squamish to house British Columbia's first wind towers. The Squamish alternative energy initiative has begun to gather community support and funding for a wind energy project. Through open houses, surveys and interviews, public support for the establishment of wind energy is "overwhelmingly positive" (Economic Development Initiatives, Squamish).

integrating wind energy in to this project

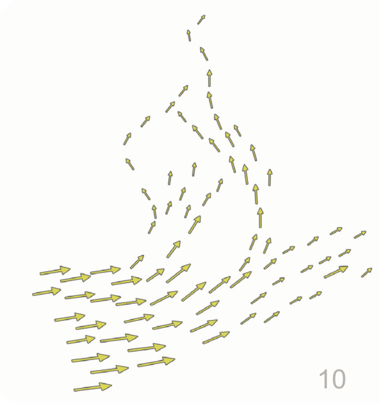
The integration of wind energy in the design of the Natural Capital Centre aims to:

- Contribute to the implementation of a windfarm on Alice Ridge that functions as a positive environmental symbol and to reinforce the identity of Squamish as "the birthplace of the great winds."

- Heighten awareness of wind as a resource, demonstrate energy conservation and promote "green" tourism in Squamish.

section 2 *project framework*

2.1 description of framework
2.2 renewable energy and people
2.3 renewable energy and place



2.1 project framework

To achieve the project objectives, a framework was formulated that explores the role of landscape architects in implementing renewable energy and the importance of revealing the underlying natural forces specific to a place.
Renewable energy has a relationship with four different, but connected realms: people, place, environment and economy (figure 2.1). If indeed renewable energy (RE) is critical to a sustainable future, this diagram begins to describe how landscape architects will play an important role in designing with RE technology and thus shape our perception of the work being done and the relationships at stake.

The four relationships to consider are:

1. RE and People
2. RE and Place
3. RE and Environment
4. RE and Economy

Below are lists of more specific characteristics for each of these four relationships that should be considered in renewable energy projects.

1. RE and People
    - Engages and delights
    - Educates and informs
    - Builds awareness
    - Alters consumption
    - Demonstrates renewable technology
    - Facilitates community participation
    - Restores a connection between people and natural resources

2. RE and Place
    - Gives place a green identity
    - Well-integrated
    - Contributes to placemaking
    - Adds experiential value to place
    - Provides legibility to environmental forces that exist in a place
    - Specific to the local landscape

3. RE and Environment
    - Transparent/visible energy source
    - Non-polluting
    - Locally managed
    - Directed towards self-sufficiency
    - Renewable
    - Contributes to global sustainability

4. RE and Economy
    - Stabilizes cost of energy
    - Shrinks energy footprint
    - Promotes green tourism
    - Creates new industry
    - Capitalizes on free energy

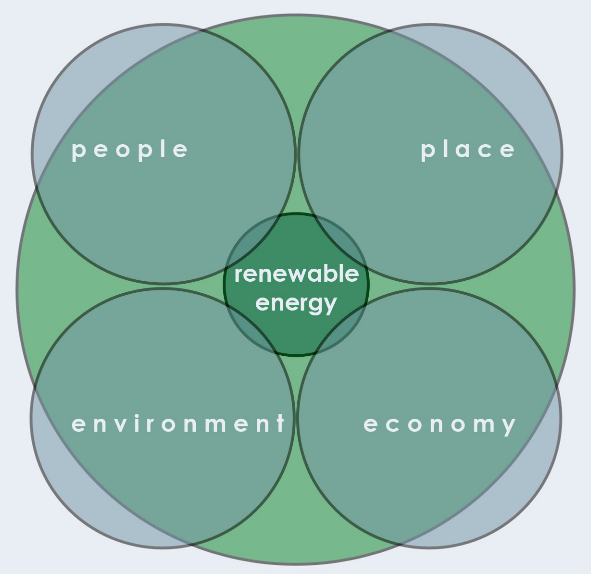


figure 2.1: Diagram showing the relationships RE has with people, place, environment and economy.

focusing on people and place

Two of these relationships are explored in greater detail, RE and People and RE and Place, to better understand how renewable energy relates to people and place. These relationships are of greatest interest to landscape architects because we are generally concerned with people, place and making connections that are often uniquely influenced by landscape processes. Focusing on people and place also highlights the significance of landscape context and the role of the landscape architect in RE projects.

The connections between RE and People and RE and Place are explored and analyzed individually. Two sets of design principles are formulated as a result of these analyses. It is important to be explicit about the level of application and the context in which these relationships are examined:

1. RE and People: The design principles extracted from examining the relationship between renewable energy and people have a global application. They inform designers about how people experience, understand and learn about environmental information and/or renewable energy.

2. RE and Place: The design principles extracted from examining the relationship between renewable energy and place have a very local application. These principles are derived from the landscape context of Squamish, utilizing very specific wind data and site analysis.

The two sets of design principles are then combined to formulate design recommendations for the Squamish Natural Capital Centre as it responds to local climate conditions and relates to the wind energy project.

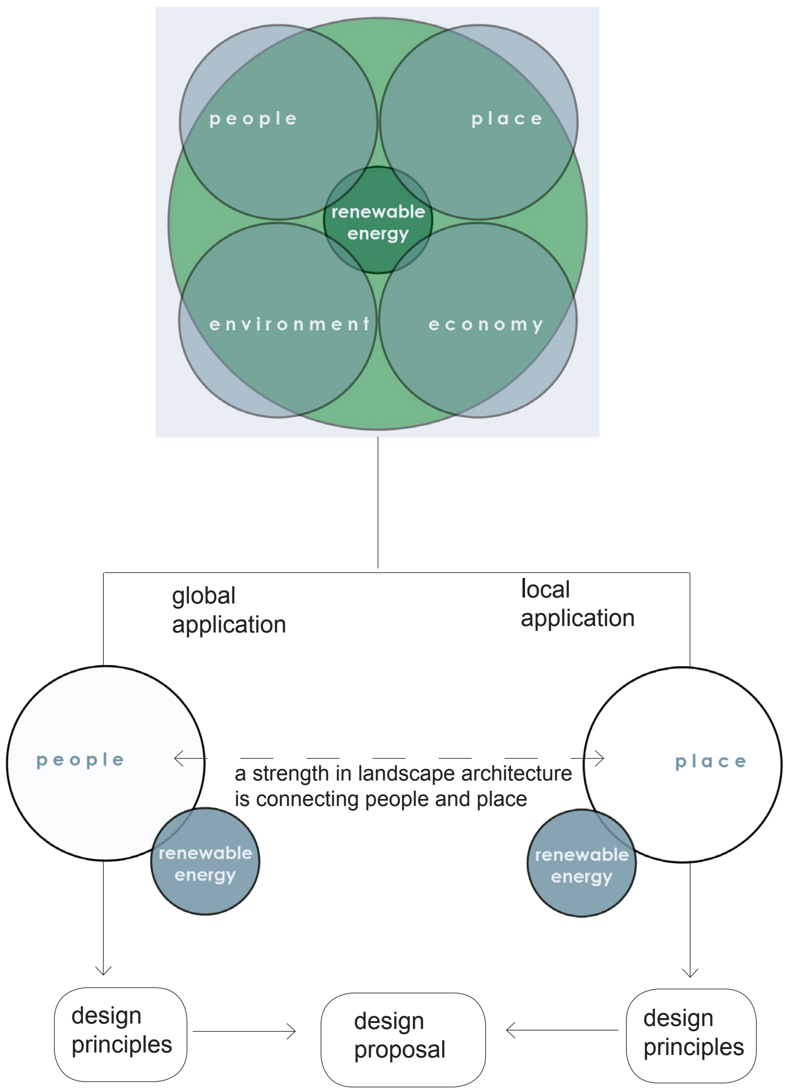


figure 2.2: Flow chart of project framework.

2.2 renewable energy and people

Until recently, the design and integration of renewable energy technologies into the built environment has often been articulated by architects and engineers. As these technologies improve, become cost-effective and more common in the landscape, landscape architects will have the opportunity to engage in the design of renewable energy systems. This study explores ways to better integrate renewable energy into the landscape and promote a sustainable culture.

The idea that landscape architects can make distinct and valuable contributions to the design of RE systems is explored using a series of case studies. The case study analysis explores the potential of designing with environmental forces and/or renewable technology. Most, but not all of the cases focus on designing wind and/or wind energy into the landscape, as they are directly applicable to the design objectives for Squamish. The elected projects exemplify how we can create meaningful and educational places as well as provoke new perceptions of our relationship to the larger environment.

A design principle was extracted from each of the case studies described in figure 2.3. Collectively, these seven principles inform designers about how people experience, understand and learn about environmental information and renewable energy. These principles are not specific to place, rather they suggest ways to engage people in the renewable energy landscape and should be integrated in the design of renewable energy systems.

design principles

These seven design principles are defined below (followed by the case studies they are derived from in fig. 2.3), suggesting how people understand environmental information, learn about renewable energy and become sensitized to the to the unique environmental forces around them:

1. DEMONSTRATION: A critical purpose of renewable energy in the landscape should be the demonstration and diffusion of environmentally and socially sustaining principles into common usage in the everyday world.

2. INTERACTIVE INTERPRETATION: The use of signage, symbols and icons is an effective way to convey information about renewable energy technology. Informational signage can help unfold the complexity of the natural world and foster connections between people and their energy source.

3. SYMBOLISM: Renewable energy can symbolize a commitment to sustainability, especially in the urban public realm. A wind turbine can exemplify this commitment on behalf of the larger community, neighbourhood, city or nation and stand as a vivid icon.

4. EMPHASIS ON UNIQUENESS OF PLACE: The use of physical forces unique to a region to articulate space and built forms, while integrating participants into the dynamics of these forces, strengthen a ‘sense of place’.

5. EXPERIENCE: Promote the idea of green tourism, combining recreational opportunities with the experience of renewable energy. Tourists gain knowledge about the implementation and inner workings of renewable energy systems.

6. REVELATORY DESIGN: Use artful interpretation that offers alternative ways to explore and make sense out of the unseen. Design that experiments with multi-sensory experience may open the mind of the public to understanding nature’s dynamics. Such interventions may relieve the tension between the educational intentions of designers and the search for enjoyment by visitors.

7. ENERGY EFFICIENCY: Demonstrate how bioclimatism may play a key role in sustainable development in reducing the energy needs of public buildings while providing thermal comfort in outdoor spaces for users.

figure 2.3: (following pages) Case studies that exemplify these seven design principles.

case studies

DEMONSTRATION

Centre for Alternative Technology (CAT) (Wales, United Kingdom)

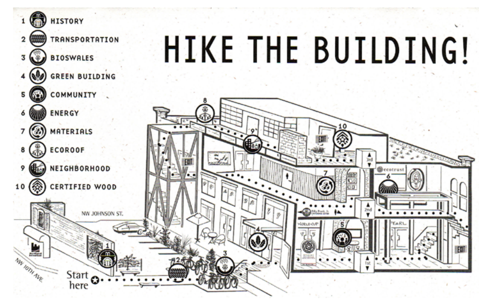
This educational centre is dedicated to exploring and demonstrating global sustainable, whole and ecologically sound technologies and ways of life. Using built examples and interactive displays, the seven-acre site demonstrates to visitors the power of wind, water and sun and has working examples of green buildings, energy conservation, organic growing and composting.

http://www.cat.org.uk/

INTERACTIVE INTERPRETATION

Jean Vollum Natural Capital Center, EcoTrust Building (Portland, Oregon)

The Ecotrust Building includes a self-guided tour which features its most interesting “green” features. At the entrance of the building is a display of “Field Guides” which invite the visitor to take a hike through the building and includes a map of the building and information on what makes the building green. Symbols, icons and signage throughout the building denote stops on the tour.



Natural Capital Center, Field Guide

SYMBOLISM

Urban Turbine Project (Toronto, Ontario)

A 30-storey-high turbine was built at Exhibition Place near Toronto’s waterfront to symbolize the benefits and the potential for wind energy in Ontario and across Canada. The high visibility of the urban turbine has given Toronto a new identity as, “a new, green Toronto”, and demonstrates that renewable energy is an option and helps familiarize the public with the infrastructure.

photo credit: Amanda Mitchell

EMPHASIS ON UNIQUENESS OF PLACE

Candlestick Point Cultural Park (San Francisco, California)

The design for this 18-acre park successfully incorporates the prevailing winds with the site and recognizes the tidal action of the bay. The entrance to Candlestick Point Park is through a 130-foot-long wind gate cut into a high screening mound. The windgate is a venturi that actually blows the visitor in and announces that event sonically- allowing visitors to listen to the landscape creates a powerful and memorable experience. Along with the force of the wind, the design utilizes local and found materials to heighten the 'sense of place' and make important historical references.

LAM, December 1995 (p. 48)

EXPERIENCE

Green Energy Island (Samsø Island, Denmark)

Since 1997, this island of 10,000 people has worked on converting to 100% renewable energy. Their aim is to become self-sufficient in heating and electricity by 2007. Another goal of the Samsø project is to serve as an exhibition for renewable energy solutions and attract "green tourism". Since gaining status as a "green island" the number of visitors taking bicycle holidays to Samsø has increased considerably and tourism-connected enterprises have joined the project. "Green tourism" attracts new visitors to Samsø who come to learn about the renewable energy project.

http://w2.djh.dk/international/2001/samso/Tourism/Pages/martah.html

Tauernwindpark Oberzeiring (Oberzeiring, Austria)

This ski area and 13 turbine windpark is situated in the Austrian Niedere Tauern mountain range, 1,900 metres above sea level. The Tauernwindpark can only be reached by car from the beginning of April to the end of October, in winter the site is accessible via ski tow or by foot. Tourism companies guide hikers, climbers and skiers on a tour to experience Europe´s highest wind park-integrating recreational opportunities with renewable energy education. The visitor's centre and cafe, built in the shape of a turbine blade, look out to the windpark and alpine views.

http://www.tauernwind.com/touris_e/adventurepark_tarch1_3_e.htm

REVELATORY

Wind, Sound and Movement, Candlestick Point Hill **(San Francisco, California)**

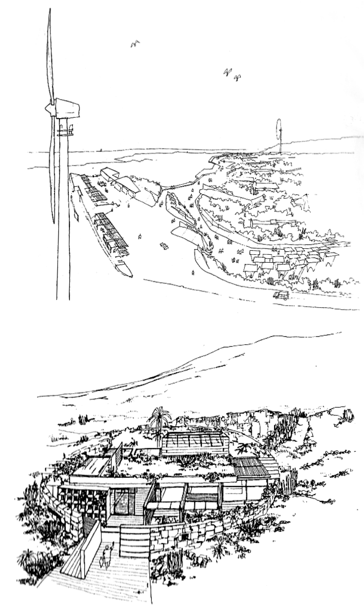
Using several hundred Mylar spinners, wind chimes and “sound chairs”, the varying intensities of the wind’s movement is revealed so the viewer can experience Wind, Sound and Movement both aurally and visually. This site exemplifies the goals of Revelatory Landscapes in that it reveals aspects of our cultural and physical landscape and educates the public (without spoiling the fun) about the significance of these elements of our local environment.

http://www.ggnltd.com/frame-sets/portfolio-fset.htm

ENERGY EFFICIENCY

Bioclimatic Dwellings **(Canary Islands, Spain)**
Instituto Tecnológico y de Energías Renovables (ITER)

Bioclimatic architecture is combined with renewable energy systems to reduce energy consumption for a housing development on land belonging to the Wind Park of Tenerife, the Canary Islands. The competition’s objective was to design an autonomous enclave, complete with open spaces and visitor centre, as a model for non-pollutant, ecologically conscious communities. The winning design proposal demonstrates how bioclimatism may play a key role in sustainable development in reducing the energy needs of inhabitants while providing thermal comfort in outdoor spaces.
The design comes from sensitive reading of landscape context and translation of the specific climatic conditions into architectural design. The circular lava-stone enclosures that manipulate micro-climatic conditions to protect space from sun, wind and rain to create optimal bioclimatic conditions were inspired by walls used on the islands to protect crops from strong winds.



EcoUrbanism, Sustainable Human Settlements: 60 Case Studies (p. 64)

2.3 renewable energy and place

This relationship explores place through its unique environmental conditions, more specifically the unique winds in Squamish. By matching the flows on a landscape to its inherent geometry, we allow ecological patterns to work for rather than against us (Van Der Ryn and Cowan, 1996). This analysis demonstrates how designer's can use climate data to work towards a steady convergence of natural forces, design and place. Connecting the town of Squamish to the larger Howe Sound windshed reminds us that nature is constantly linking wind on many scales, bringing together the regional windshed, the orientation of a town and a trembling aspen tree, all in a single gust.

Physical forces of this place can be revealed and used to build interesting, educational and energy efficient places that contribute to a 'sense of place' in Squamish. In this section, a detailed wind inventory and supplementary climate data is presented, organized and correlated with seasonal programs and activities in downtown Squamish. This data is then translated into design principles that inform the design of the Squamish NCC.

a scientific understanding of wind

To most, the wind is a capricious and invisible spirit, however, the wind does have a scientific explanation. Wind is air in motion, and it moves because of uneven heating of the surface of the Earth, thus the kinetic energy of the wind is solar energy (Schefter, 1982). Since the Earth's surface is not uniform, incoming solar energy is received and reradiated in different ways. Some surfaces absorb more heat than others, creating density and pressure differences that force the air to move from one place to another (Schefter, 1982). Land and water absorb heat differently, as do mountains and valleys, and this generates breezes (Schefter, 1982).

How the wind blows at a particular place is also affected by the distribution of land and water surfaces, and by the distribution and topography of land masses (see figure 2.4 and 2.5). Effects may be of a local character, generating breezes with a duration of hours, but they may also be of a hemispheric scale, with a duration of months, as with monsoons. Wind varies considerably by season, and in the temperate latitudes the strongest winds generally occur in winter and spring (Schefter, 1982).

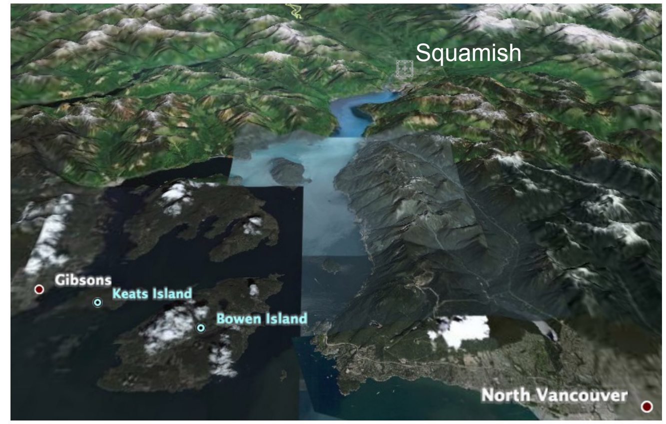
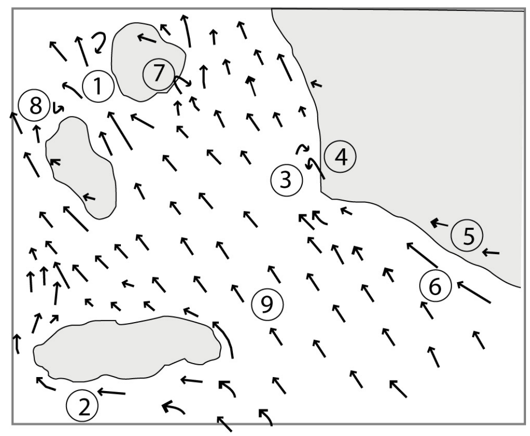


figure 2.4: Map of topography in the Howe Sound.

N



1 --- funneling
2 --- channeling
3 --- corner winds
4 --- lee eddies
5 --- backing over land
6 --- zone of strong winds offshore
7 --- cliff effects (back eddies)
8 --- lee shelter
9 --- zone of lighter winds offshore

figure 2.5: Diagram of nine topographical modifications of the winds in Howe Sound (after Lange, 1999).

the importance of connecting Squamish + it's windshed to the windfarm

Although a place is often identified with an individual terrain and a particular watershed, it could just as well be identified with a windshed. "To treat winds as no more than another energy source, is to disconnect them from the ways in which they have helped determine the character of local plant, animal and human communities and in the process to rob them of their individuality and their beauty." By the same token, unique windsheds need to be connected in specific (not simply functional) ways to wind turbines if the latter, in turn, are to share this beauty (Pasqualetti, etal 2002).

where do the winds come from and why is Squamish such a windy place?

Squamish is located near water and in a valley, therefore the winds in Squamish are thermally driven (see figure 2.6). In springtime, the warm air in Squamish causes the southerly "thermal inflows" to build, and in the summer the afternoon winds blow fast and steadily (Lange, 1999). The winds accelerate up Howe Sound through the valleys of the Sea-to-Sky Corridor, consistently at strengths between 15 - 25 knots (Lange, 1999). The more the sun shines, the stronger the winds blow. From time to time frontal systems pass through with strong winds and temporarily break up the regular pattern.

In winter, cold air builds to the east of the Coast Mountains and pours out through the mountain passes and down the valley past Lillooet and Pemberton, then out through Squamish and into Howe Sound (Lange, 1999). The term "Squamish winds" has become a generic term for these outflow air currents: winds that blow out of a valley or channel, often at speeds up to 100 kilometres per hour (Lange, 1999).

the Howe Sound windshed

The winds through the main, easternmost channel of Howe Sound are primarily northerly or southerly. During the period from November through February, almost 80% of all recorded winds are from the northwest, north or northeast. In the summer the frequency of northerly winds drops to about 35% (Lange, 1999).

The following analysis of the Howe Sound windshed is divided into two parts, first looking at the northerly pressure slopes and then the southerly pressure slopes. Examining the movement of wind through the greater Howe Sound windshed is the first step in understanding the local wind patterns in Squamish.

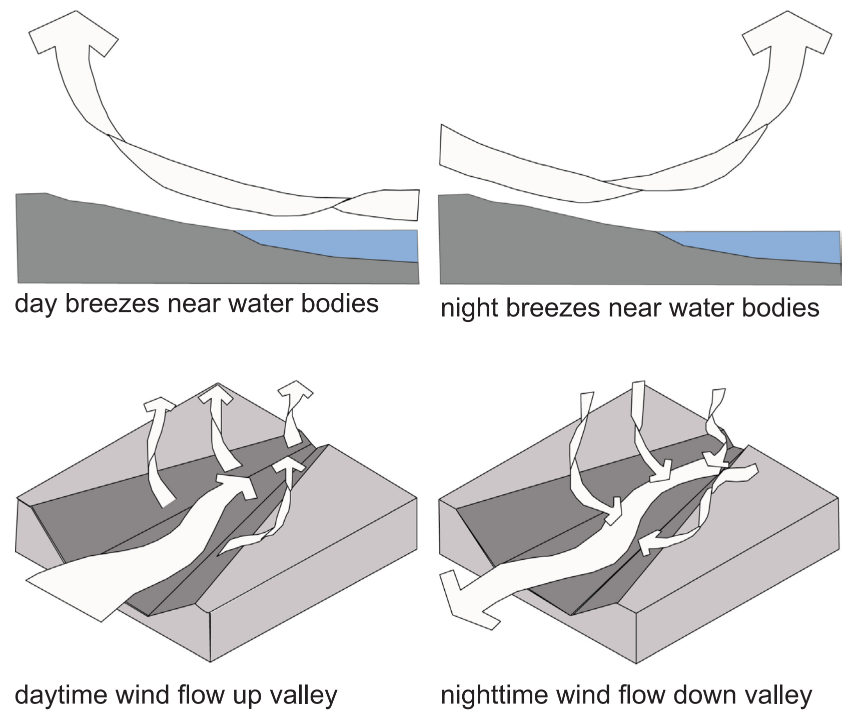
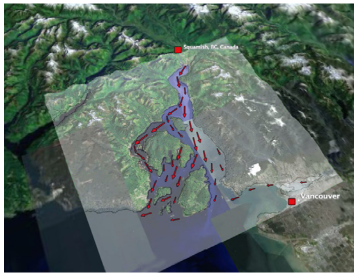
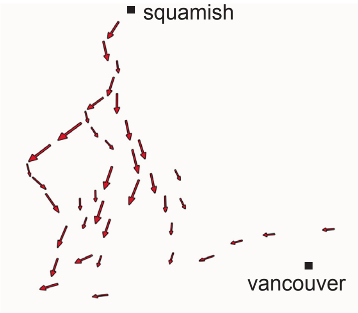


figure 2.6: Diagram of diurnal breezes near water bodies and in valleys (after Brown, 1985). These diagrams depict how a shift from a northerly to southerly wind can be very dramatic in Squamish.

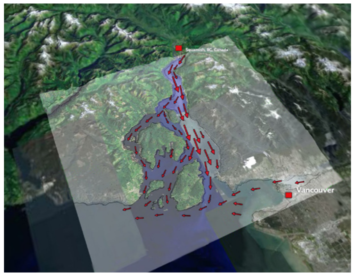
Howe Sound Northerly winds
Northerly, northeasterly and easterly pressure

northerly outflow





northeasterly outflow



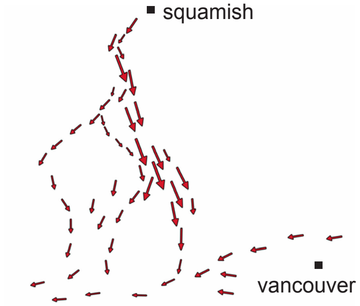


figure 2.7: Diagram of northerly outflows through the Howe Sound.

The strongest northerly winds occur with outflow events, with a ridge of high pressure over the Interior of British Columbia. "Northerly winds are often called "Squamish' winds or 'Squamishes,' after the community at the head of the Howe Sound" (Lange, 1999). Outflow winds through Howe Sound begin when temperatures fall and pressures rise over the Chilcotin plateau. The cold air that builds to the east of the Coast Mountains pours out through the mountain passes and down the valley past Lillooet and Pemberton, then out across Squamish into Howe Sound. "The air oscillates through the confines of the valley like water flowing around bends in the river" (Lange, 1999). The plume of outflow winds careens past Watts point onto the coast south of Woodfibre, then southward, banking Charlotte Channel. This is the normal path of the outflow plume and is often called a 'Northerly' (Lange, 1999).

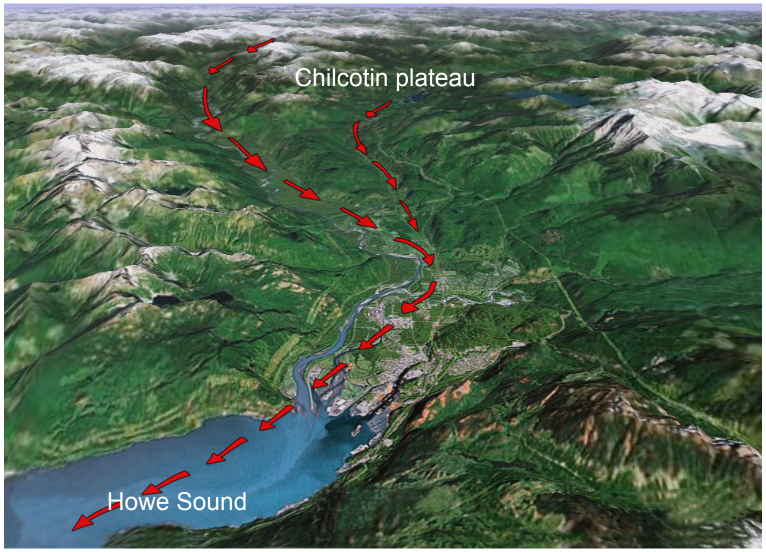
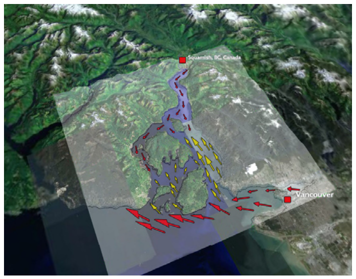


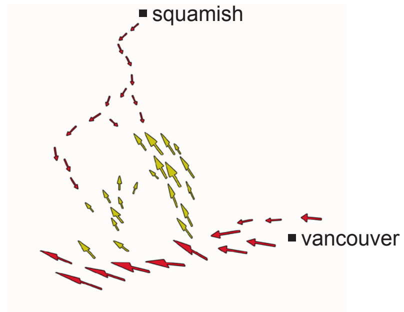
figure 2.8: The "squamishes" blowing through the Squamish Valley.

N

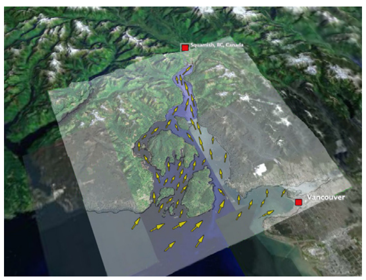
Howe Sound Southerly Winds
Southeasterly, southerly and south-westerly pressure slopes

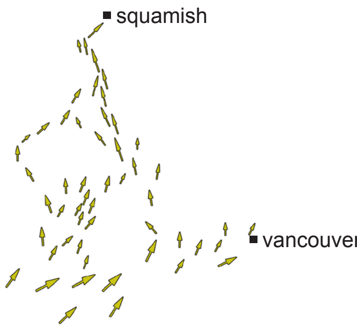
southerly winds moving
ahead of a front



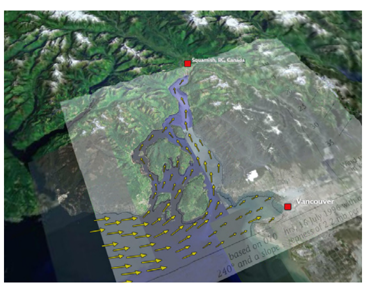


diurnal southerly inflow





southerly inflow



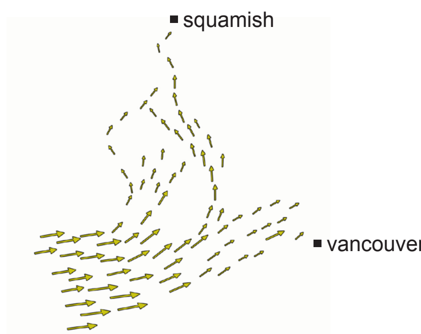


figure 2.9: Diagram of the southerly inflows through the Howe Sound.

Southerly winds in Howe Sound occur whenever the pressure is higher on the coast than it is over the interior. During a typical summer day, with a ridge of high pressure to the west of Vancouver Island, the pressure-slope direction will vary from the northwest during the morning hours to the southwest, or south, during the afternoon. The daytime heating of the mountain slopes around Howe Sound draws air up the mountains, which results in air being drawn into the sound to replace it. This is a cumulative process, with the winds gradually gaining more and more speed as they approach the head of the sound. Funnelling also helps the winds build, as the inlet is narrower near its head. As a result, the lightest winds in Howe Sound are at the mouth and the strongest winds are just south of Squamish (Lange, 1999).

When a front approaches the region from the southwest, a plume of strong southeast winds will extend through the Howe Sound, causing pressures to rise. The shift from northerly to southerly can be very dramatic. With the strongest of fronts, a shift from northerly 20 to 30 knots to southerly 40 to 45 knots can happen within minutes (Lange, 1999).

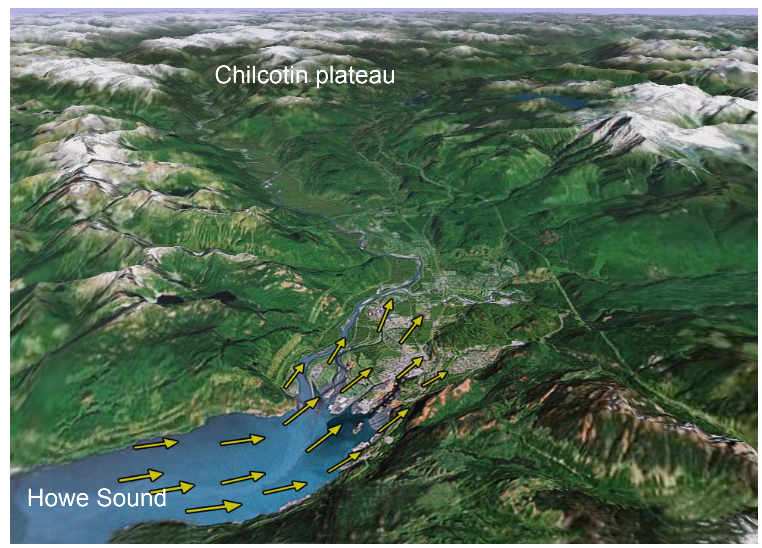
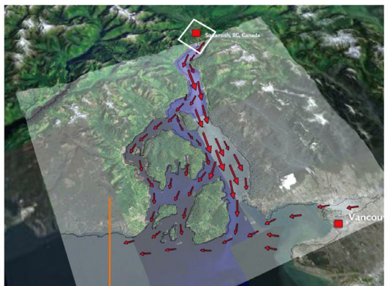


figure 2.10: Southerly winds blowing through the Squamish Valley.

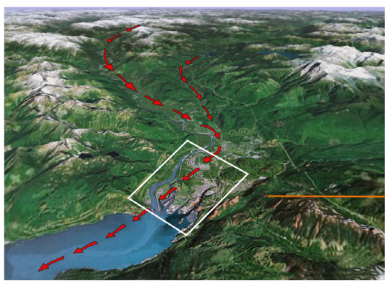
N

northerly winds in downtown Squamish

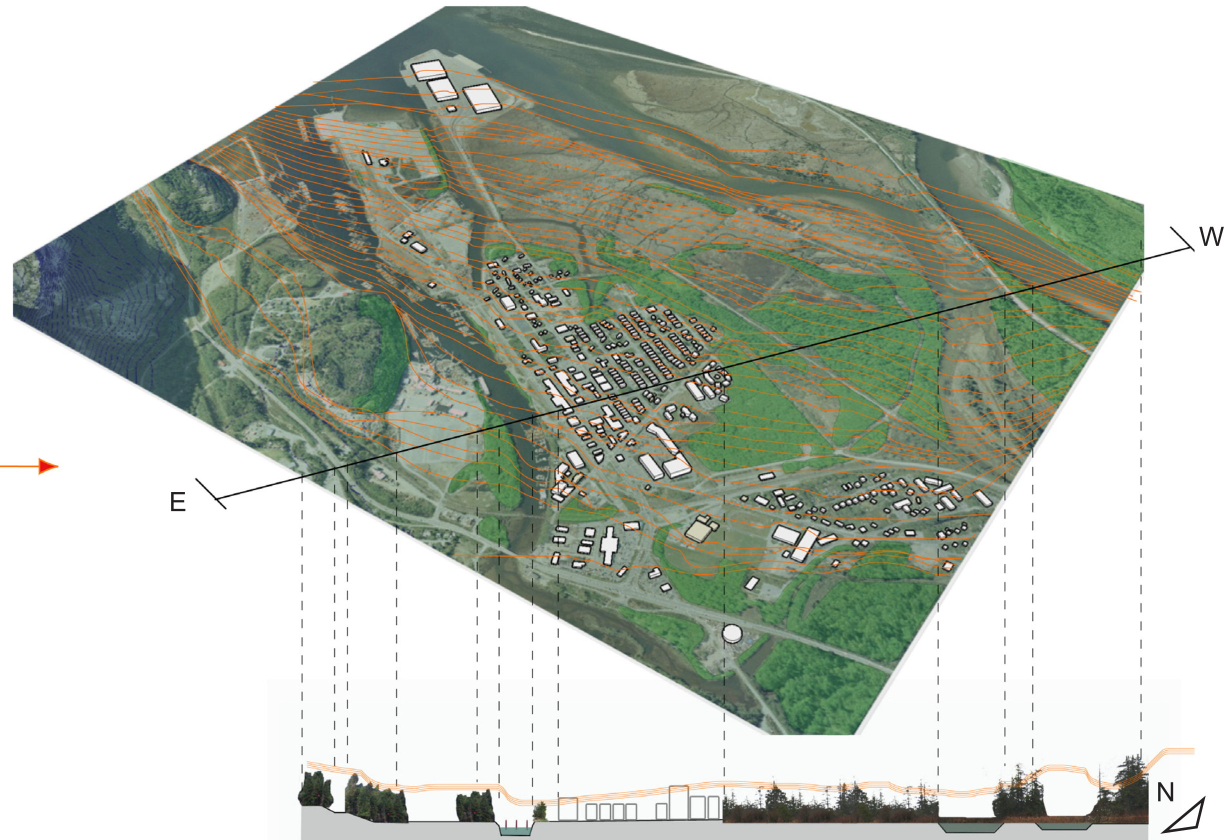
Linking wind on a regional, local and town scale helps us identify ecological patterns, allowing designer's to work towards a steady convergence of natural forces, design and place. Figures 2.11 and 2.12 illustrate the north-south orientation of town in relation to the northerly and southerly winds.



a) Howe Sound



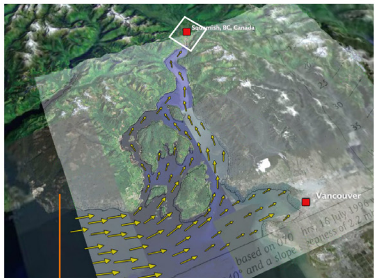
b) Squamish Valley



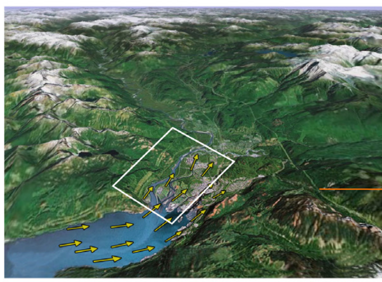
c) An east-west cross-section of downtown from the Sea to Sky highway, to the Squamish River. The orange vectors represent the northerly winds.

figure 2.11: Diagram of northerlies on various scales a) Howe Sound windshed b) Squamish Valley and c) downtown Squamish.
The orange lines are wind vectors, representing how wind weaves through the streets, buildings, vegetation and topography of downtown.

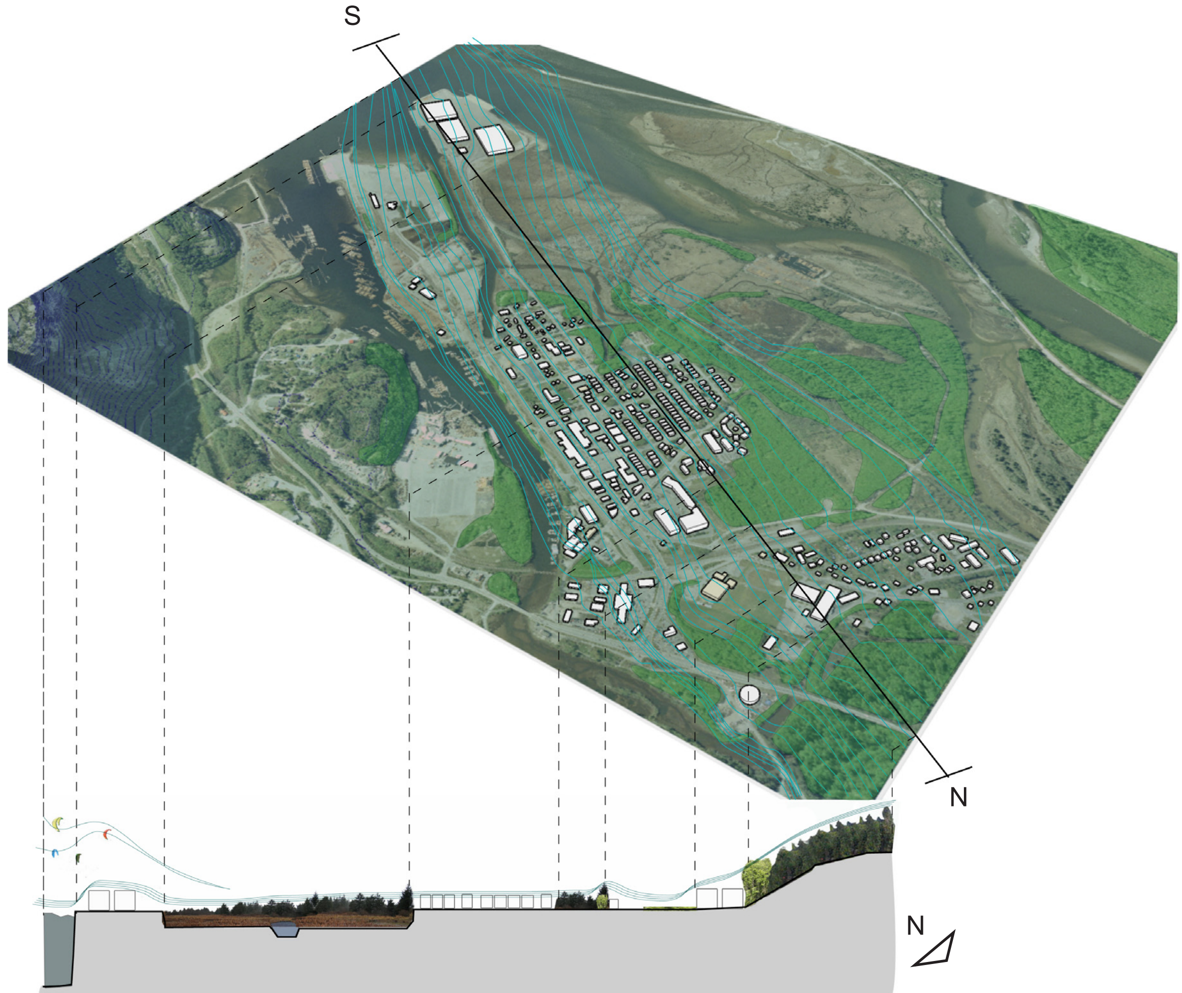
southerly winds in downtown Squamish



a) Howe Sound



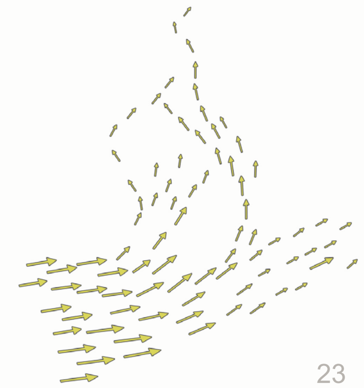
b) Squamish Valley



c) A south-north cross-section of downtown from the Squamish terminals and Howe Sound, to the uplands. The blue vectors represent the southerly winds.

figure 2.12: Diagram showing southerlies on various scales a) Howe Sound windshed b) Squamish Valley and c) downtown Squamish. The blue lines are wind vectors, representing how wind weaves through the streets, buildings, vegetation and topography of downtown.

section 3 wind inventory and climate data



3.1 visualization of wind in Squamish

Winds have a special value in their role of creating motion around the globe, using the inexhaustible energy of the sun, they produce images such as passling clouds, waving oceans and rippling grasses.

Besides the global circulation of winds, the dynamics of wind are also particularly interesting on a smaller scale, such as the level of the urban environment. The wind is, in simple terms, a form of energy that permeates the city and gives life to inanimate objects. In a sense, the wind can be visualized as a force flowing around buildings and other obstacles, through the intricate patterns of streets or through mazes of public spaces between buildings.

The ways in which wind interacts with both natural and human-built forms in Squamish are portrayed in Figure 3.1. These kinetic effects are visible in familiar scenes such as trembling aspen trees, flagged conifers, sand patterns, ocean waves, flags, sails, kites, deflected smoke plumes and spiraling ventilation systems on rooftops.

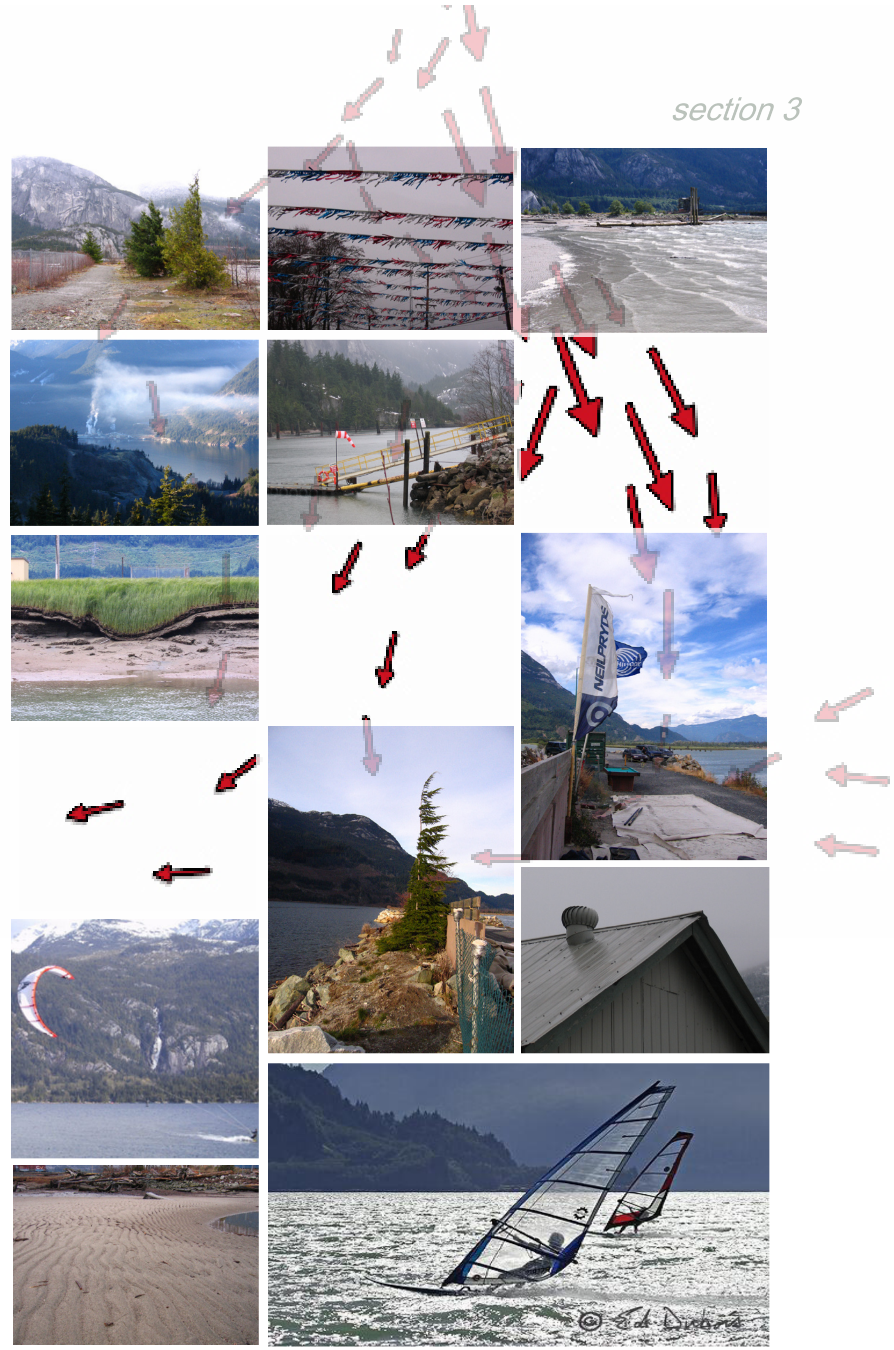


figure 3.1: Photos depicting how the town of Squamish is animated by wind.

3.2 wind inventory

Much of the sensed quality of a place resides in its climate, particularly in its microclimates (Lynch, 1972). There are well-developed techniques for describing these phenomena: wind roses, isotherms, combined indexes of temperature and humidity, the intensity of rain and snow, cloud and fog patterns, and so on (Lynch, 1972). Scientific data can be used to create impressionistic mappings where there are wind tunnels or wind reflectors, revealing locations for design interventions (eg. places where the public can shelter from rain or wind or sun). For example, places lacking public shelters from excessive wind would be identified as a target for action in Squamish.

sample wind data

The wind data used in the wind analysis for Squamish was supplied by iwindsurf.com, a website that reports daily wind speed and direction for various windsurfing hotspots across North America. For the Squamish site, wind data is collected by sensors- every 15 minutes from 6am to 8pm. The website organizes the data into graphs and archives them in to an accessible database. The wind archive is extremely comprehensive and spans from 1995 to present. It is a valuable resource for windsurfers, kiteboarders and sailors in determining whether or not the conditions are appropriate for a day out on the water.

The wind data for Squamish is collected at the Squamish Spit, behind the Squamish terminals. The Squamish Terminal complex consists of a number of football field sized buildings, all in the 40 ft tall range. The sensor is located at the back edge of the property so winds must travel over a couple of the warehouses before reaching the sensor. However, there is a 20 ft mast secured to the top of the collection building in order to reach the cleanest wind possible. This means that the sensors are approx. 50 ft above water level and around 1/2 mile downwind of the Spit.

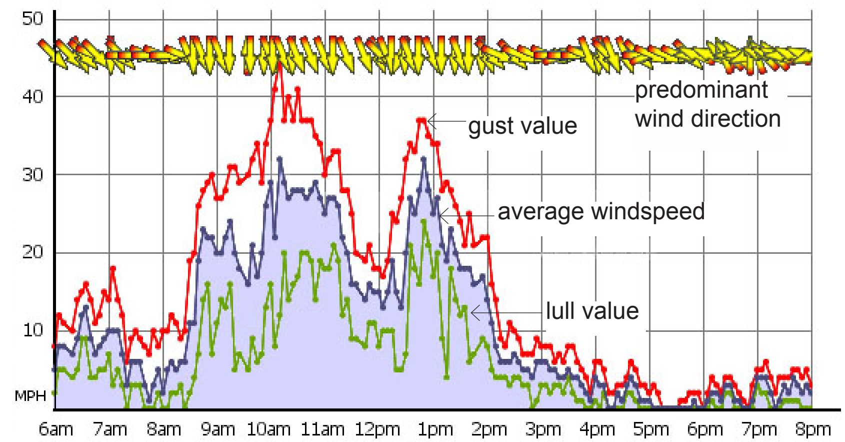


figure 3.2: Sample wind data collected on December 14, 2005 (iwindsurf.com). The wind graph displays observations as reported in miles per hour. The blue line and shaded area represents the average wind speed, the red represents gust value, and the green represents lull. Dots along the lines indicate time of data reported. The yellow arrows represent observed wind direction. An arrow pointing down indicates wind blowing from north to south, and is commonly referred as a “north wind”.

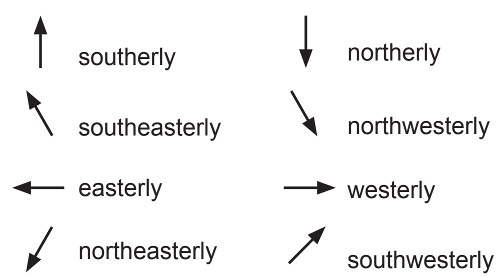
3.3 Squamish wind square

To make the wind data useful, the average windspeeds from 2004, 2005 and 2006 (data from iwindsurf.com) are averaged and summarized in a wind square. A wind square organizes wind direction and speed by time of day and month of the year (Brown, 2001). It tabulates, for one-hour periods and for each month, the predominant wind speed, the predominant wind direction at that speed, and the percentage of time that the wind blows from that direction (Brown, 2001).

The wind square lists wind speed by speed group and time of day in one-hour intervals. The highest frequency wind speed was chosen for each one-hour period and was assigned to the appropriate cell in the wind square. Next, the predominant wind direction for each one-hour period was selected and inserted in the appropriate cell.

Conclusions from the wind square can be drawn about the time of day and time of year the winds are strongest and which direction they are coming from.

predominant wind direction legend:



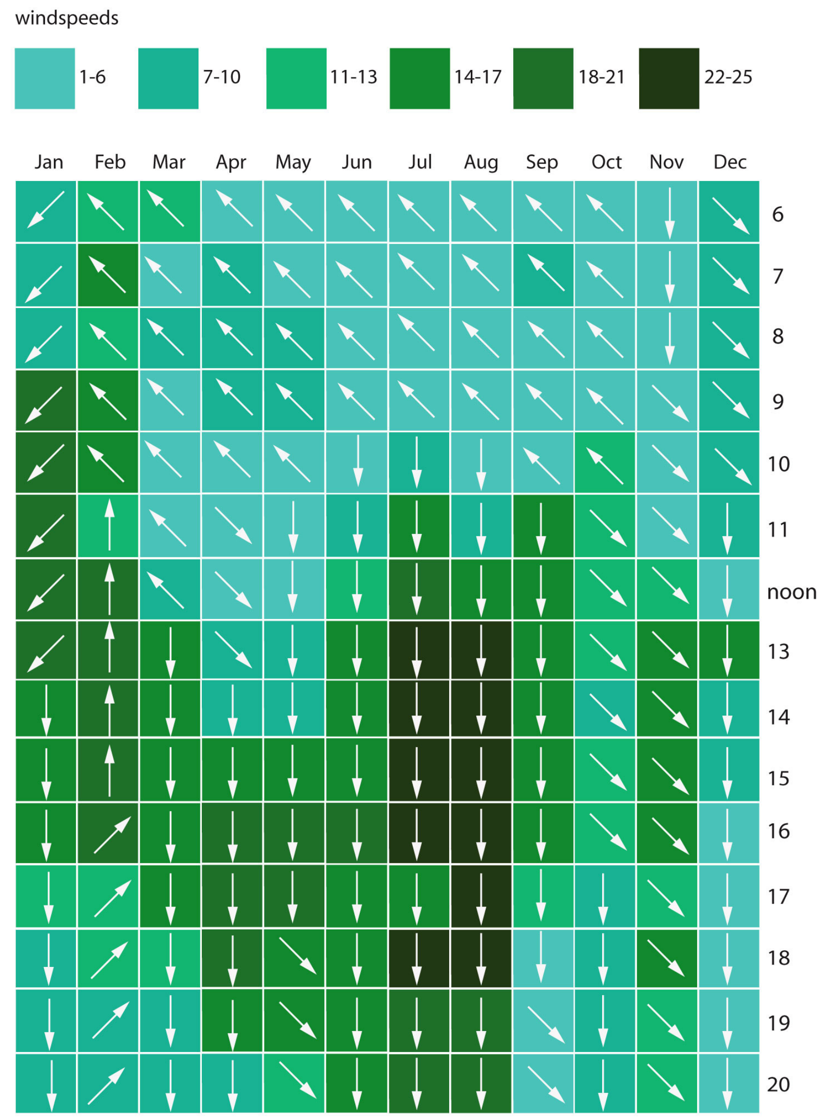


figure 3.3: Wind square for Squamish, BC.

conclusions from the wind square

From the Squamish wind square we can conclude that:

- The wind generally comes from the north or northeast in the winter (November, December and January). As evidenced in February, the winds can blow in from the south during the winter months. The winds are generally strongest in the afternoon.

- In spring (March, April and May), the wind comes from the southeast in the mornings and shifts to a northerly wind around noon. The winds are strongest in the afternoon and evenings from 2pm to 6pm.

- In summer (June, July and August), the wind blows in from the northeast in the early morning and shifts to a southerly wind in the late morning. The wind is strongest from 11am to 8pm.

- In autumn (September and October), the wind comes from southeast and shifts to a northerly wind in the late morning. The wind is strongest from 11am to 4pm.

From these conclusions it is clear that blocking the chilling winter winds and admitting the ventilating summer winds will be complex and necessitates a specific building orientation with multi-functional, flexible indoor/outdoor spaces.

Since the wind square is organized by month and time it can be used in conjunction with monthly temperatures and rainfall to understand how to utilize natural processes for energy conservation and to produce thermal comfort that extends the usefulness of outdoor spaces year round.

	predominant wind direction		time of strongest wind
	am	pm	
winter	↙ ↓	↙ ↓	12pm-6pm
spring	↖	↓	2pm-6pm
summer	↖	↓	11am-8pm
autumn	↘ ↖	↙ ↓	11am-4pm

figure 3.4: Summary of wind square for Squamish, BC.

3.4 average rainfall, temperature + wind data

Average monthly rainfall and temperature data are also important factors to consider in the design that manipulates microclimatic conditions. Average monthly rainfall, temperatures and wind speeds are compiled in a graph indicating seasonal climatic trends (refer to fig. 2.8 on the next page). Low temperatures combined with high rainfall and strong winds are characteristic of the winter months. The reverse is indicated for the summer months, where high temperatures, low rainfall and strong, warm winds prevail. The climatic conditions further indicate the seasonality of certain programs and activities that take place in Squamish.

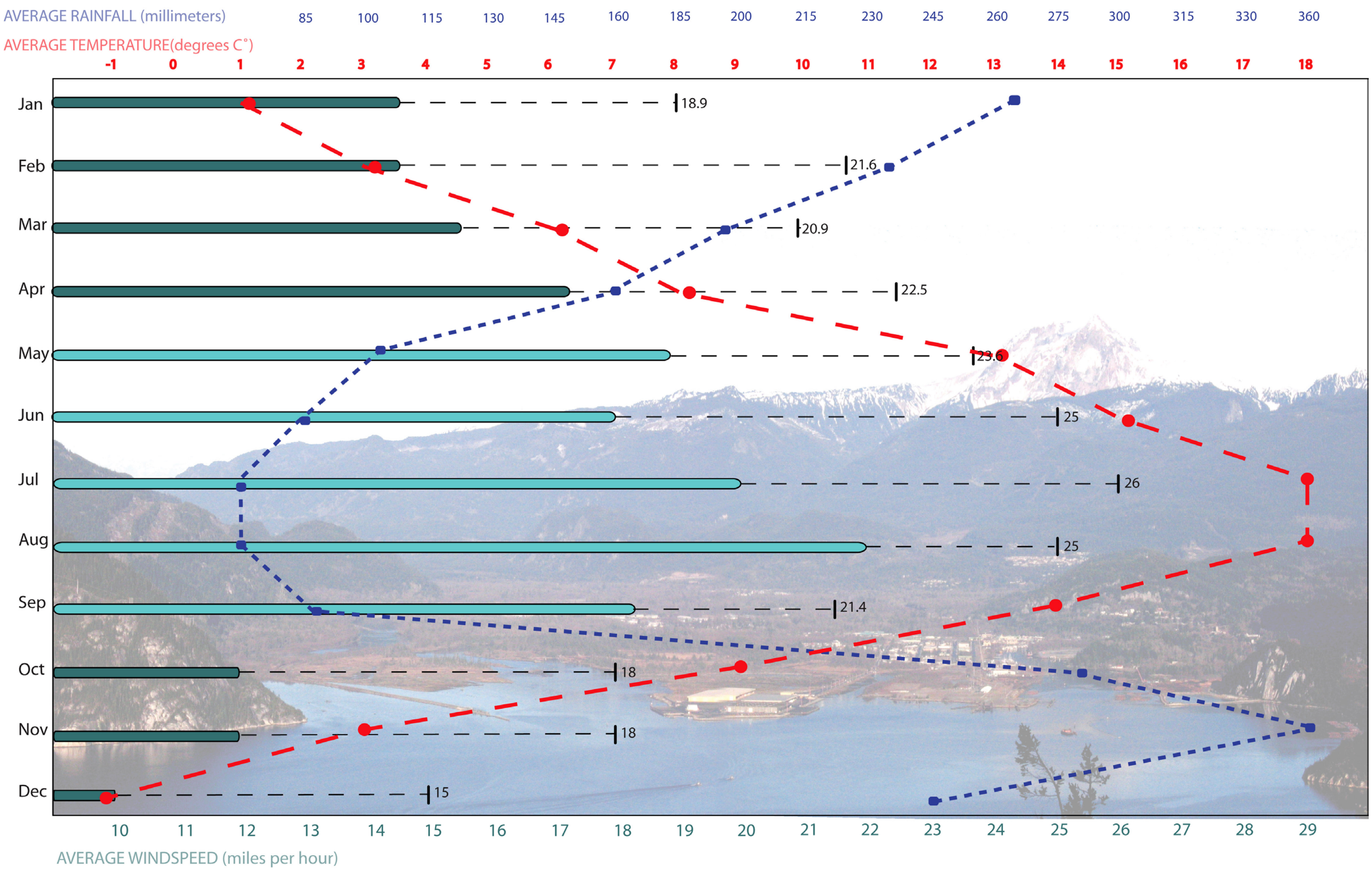


figure 3.5: Climate data compiled for Squamish (data from Environment Canada and iwindsurf.com)

3.5 program and activities inventory

Squamish is known as the "outdoor recreation capital of Canada" (www.squamishchamber.com). The Squamish Chamber of Commerce lists indoor and outdoor activities for residents and visitors in "101 things to do in Squamish" (www.squamishchamber.com). This information is organized in a chart to convey the type, amount and seasonality of programs and activities in Squamish (refer to fig. 2.8 on the next page). The programs are first categorized by 'land', 'water', 'air', 'winter' and 'indoors' (indoor activities are highlighted in orange). The blue bars represent passive recreational opportunities, the green bars represent active recreational opportunities and the red bars represent activities that depend on wind speed and direction. The size and position of the colored bars indicates which months these activities typically occur.

conclusions from the program and activities inventory

Layering this information with the climate data for Squamish suggests that there is a high concentration of recreational activities from April to September, when rainfall is low, temperatures are high and thermal winds are strong. From October to March, the colder, wetter months, there is less to do, particularly passive indoor/outdoor recreation opportunities. Theoretically then, if outdoor activities can be extended into the pre-equinox time of March and the post-equinox period of October more time may be spent outdoors and more activities enjoyed in downtown Squamish. This is one of the goals of the Natural Capital Centre, to extend the shoulder season for outdoor activities by manipulating microclimatic conditions.

Climate responsiveness is important for increasing environmental sensitivity in design, reducing energy consumption in buildings, and enhancing environmental awareness and enjoyment in users. According to Ogyay's and Arens (1963) ideas about solar radiation for heating and wind for cooling, the amount of time during which thermal comfort is achievable in unenclosed spaces can be increased by 17 - 34%, depending on location. Comfort zone definitions (which are discussed in the next section), wind pattern recognition and programmatic elements are the major driver's for the design of the Squamish NCC.

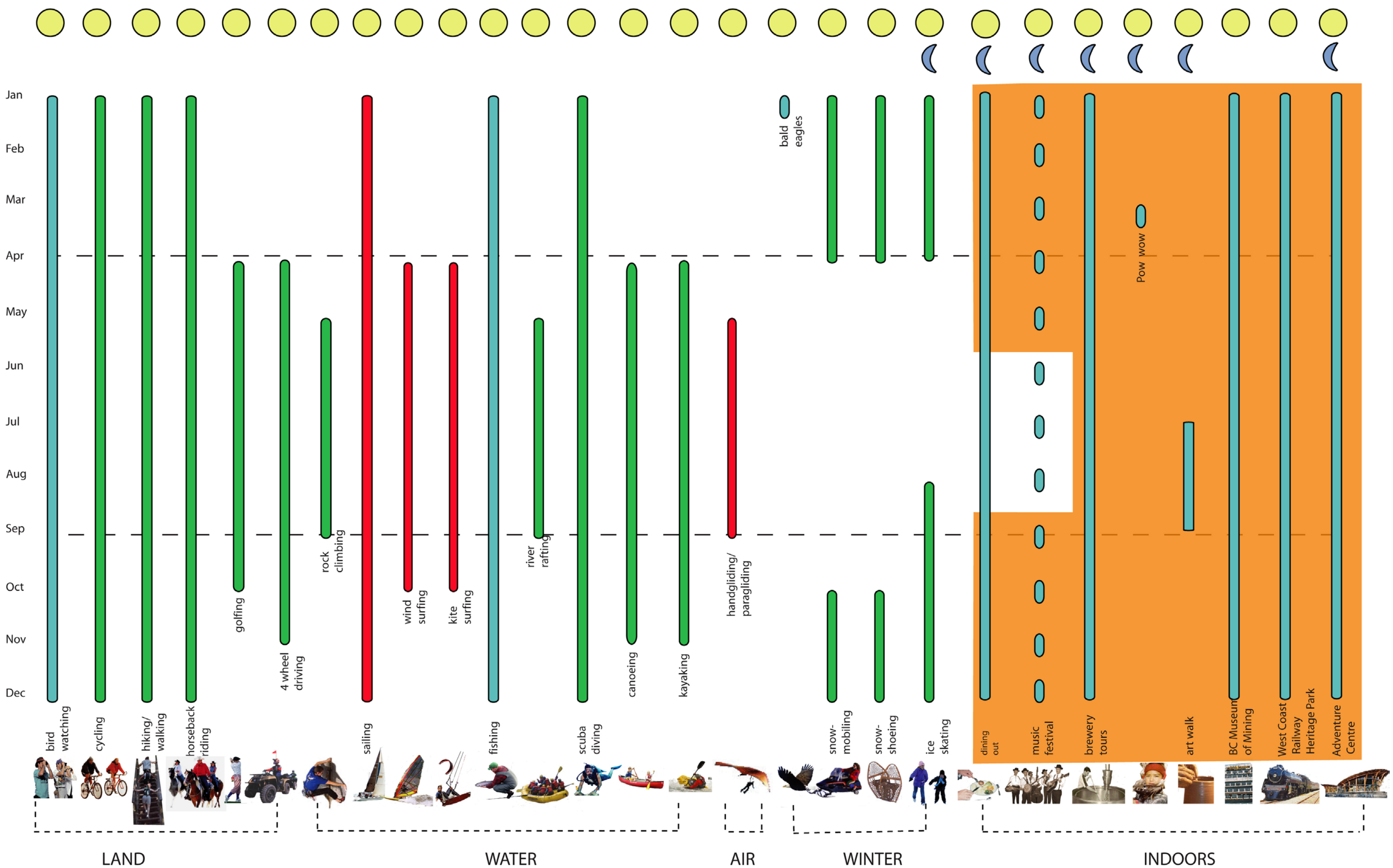
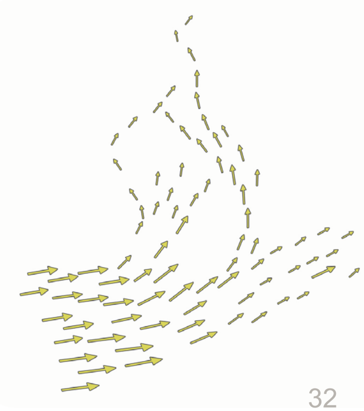


figure 3.6: Inventory and seasonality of programs and activities in downtown Squamish.

section 4 wind and human comfort



People's energy and health depend in large measure on the direct effects of his environment (Olgyay, 1963). Exterior spaces such as streets, plazas, parks, and yards, constitute 30 -70% of a city's ground level, and form important meeting and work places (Brown and Novitski, 1983). Using natural energy to produce thermal comfort extends the usefulness of these spaces, decreasing the pressure to build enclosed space to accommodate all activities at all times of the day and year. Designing for sun and wind access also results in the need for less built area per inhabitant and therefore less non-renewable energy consumption. As described by Brown and Novitski, an energy-conscious city provides the most livable area for the least energy cost (1983). If a primary goal the Squamish Natural Capital Centre is to demonstate a commitment to sustainable thought and action, an energy conscious design will be essential.

A Modified Comfort Zone (MCZ) is a range of temperature and humidity in which comfort is achievable with the appropriate moderation of sun and wind (Brown and Novitski, 1983). In simple terms, an outdoor space can be comfortable in chilly weather if the wind is blocked and the sun is available for warming, or in hot weather if the sun is blocked and the wind is available for cooling.

Use of the Bioclimatic Chart

Bioclimatic evaluation is the starting point for any design aiming at environmental climate balance (Olgyay, 1963). Prevailing climatic conditions for a particular site can be plotted on the bioclimatic chart in figure 3.1 and will indicate to the designer what modifications are needed to restore comfortable conditions. It is highly likely that these measures can be achieved by natural means, by adapting architectural and landscape architectural design to utilize climatic elements (Olgyay, 1963).

The Bioclimatic Chart

The bioclimatic chart (see fig. 3.1) was built with dry-bulb temperature on the y-axis and relative humidity as an x-axis. In the middle (shaded area) is the summer comfort zone, while the winter comfort zone lies a little lower (dashed area). Any climatic condition determined by dry bulb temperature and relative humidity can be plotted on the chart. If the point falls outside of the comfort zone, corrective measures are needed.

For purposes of this project, the bioclimatic chart indicates how admitting or blocking wind can restore the feeling of comfort, offsetting high or low temperatures.

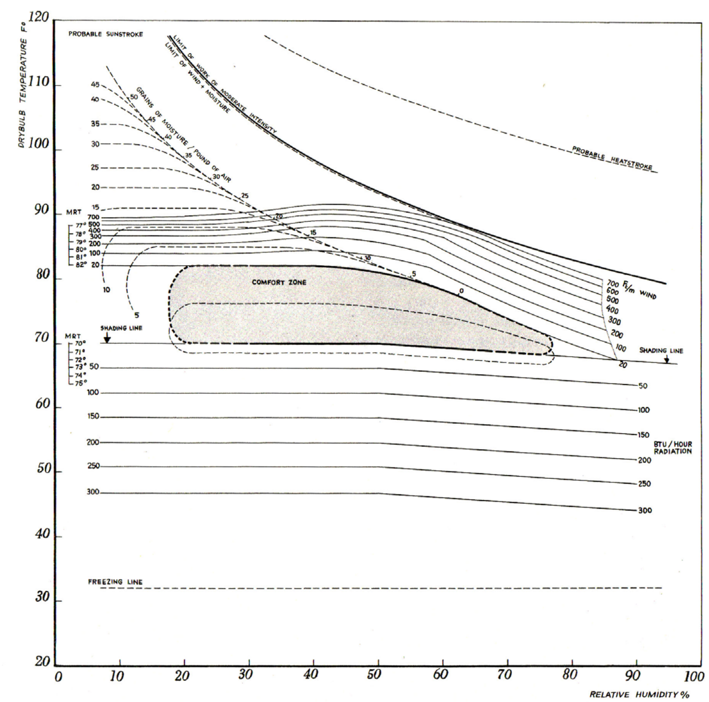


figure 4.1: Bioclimatic chart, for US moderate zone inhabitants (from Olgyay, 1963).

4.2 windchill

wind and the human body

Wind creates the transfer of sensible heat by convection, to and from the human body by disturbing the small layer of heated air next to the skin or clothing called the air boundary layer (Figure 4.2). The air boundary layer is heated by sensible heat from the body by way of conduction through clothing.

Wind in any environment can make the seated person uncomfortable very quickly even in the summertime. "At 2 m/s (4.5 mph) wind is felt on the face. At 4 m/s (9mph) newspaper reading becomes difficult, dust and paper are raised, hair is disarranged and clothing flaps." At 6 m/s (13.5 mph) control of walking begins to become impaired (Lynch and Hack, 1984; Aynsley 1980; Arens 1981; Matus 1988). Wind in downtown Squamish can nullify the positive effects of solar radiation and cause exposed skin of the hands and face to "feel" colder due to the effective removal of heat by the wind.

Burton and Edholm (1955) claim that during times of cool or cold air temperatures, "in outside conditions of sunshine, the windspeed becomes of greatest importance in determining the comfort and endurance of man. If the windspeed is 2 m/s (5 mph), the thermal [loss] for a resting man is about equal to the radiation [gain] for full sunshine, so that if the wind is greater than 2 m/s (5 mph) it will be colder to stand outside in the sun than inside a shelter at the same temperature". Wind through the Squamish Natural Capital Centre must therefore be reduced to tolerable and comfortable levels to extend the season of outdoor activities.

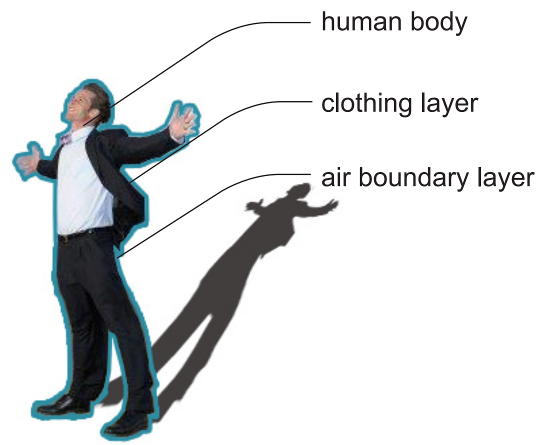


figure 4.2: Diagram of the human being and the air boundary layer (after Burton 1955).

windchill index

The wind chill index is based on research of how the human body loses heat in the cold and wind. The blowing of the wind against an object increases the rate of heat flow from the object to the surrounding air. The rate of heat loss rises as the wind speed rises. For example, if the outside temperature is -10° C and the wind chill is -20, it means that your face will feel as cold as it would on a calm day when the temperature is -20°C.

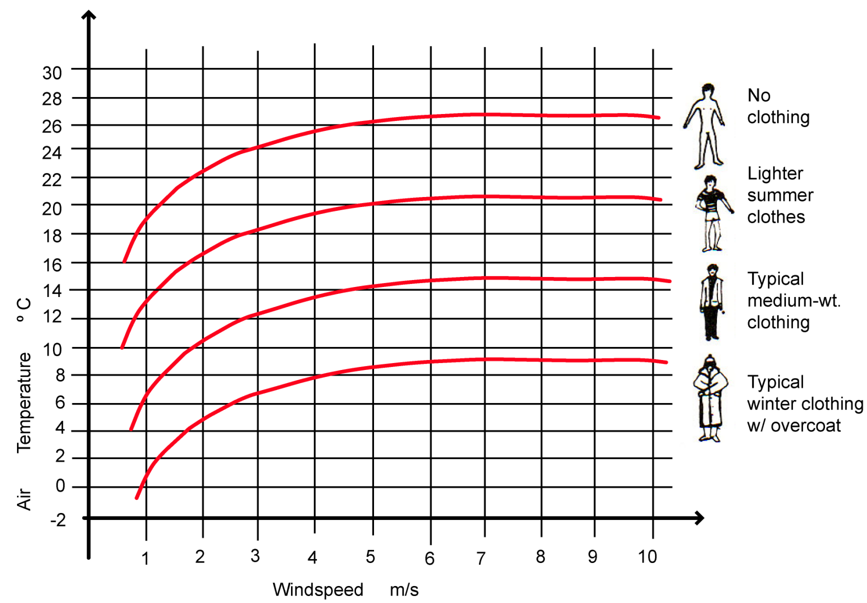


figure 4.3: Windchill index (after Siple 1951).

4.3 wind studies in architectural design

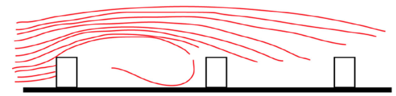
Figures 4.4 to 4.7 examine how the movement of wind is influenced by form on the scale of a neighbourhood, building and room. These studies by Olgyay are used to begin to explore how to translate the wind inventory for Squamish (in Section 3) into physical design of the NCC. Through these studies, we can begin to form notions of how to block or admit wind for energy conservation, programs and activities and bioclimatic comfort.

neighbourhood scale

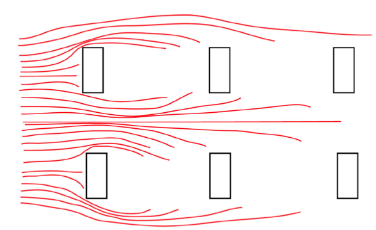
Buildings planned in row arrangements cause a wind shadow over the subsequent units, which is reinforced by the tendency of wind to channel through free spaces and pass by the units behind. An arrangement of staggered units takes advantage of the bouncing pattern of the wind since the buildings direct the flow to subsequent structures. Arrangements b and c in figure 4.4 provide wind protection while arrangement d utilizes the wind for ventilation.

building scale

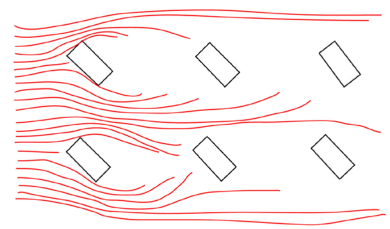
A building placed in the air stream slows down and piles up the moving air at its windward side, causing an area of relatively high pressure. The flow enveloping the building creates low-pressure areas on the sides adjacent to the windward face. At the leeward side a wind shadow with relatively low pressure is produced.



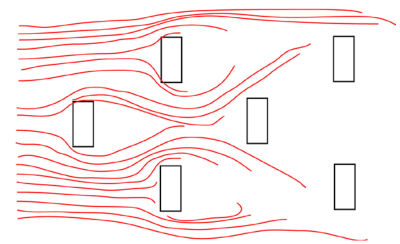
a) Section of windshow efffect at parallel rows.



b) WInd protection with linear arrangement.



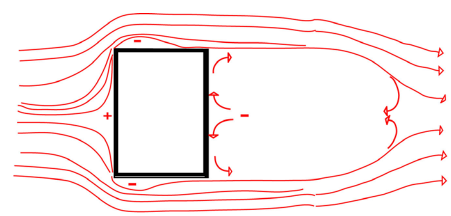
c) WInd protection with angled arrangement.



d) Utilization of breezes.

figure 4.4: Diagrams of wind and building layouts (after Olgyay, 1963).

a)



b)

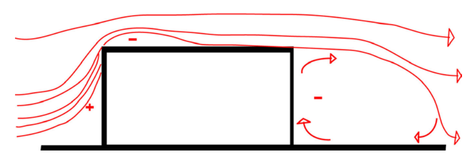


figure 4.5: Wind patterns around a building a) Pattern of air flow surounding a building b) Pattern of air movement at the section of a building (after Olgyay, 1963).

through a building

To receive air movements a building must have both inlet and outlet openings. If openings are placed opposite each other, and positioned at the high and low pressure areas respectively, they will provide maximum air exchange within the structure. A smaller sized inlet opening causes a "Venturi effect", causing maximum air speeds within the building. An inlet and outlet placed symmetrically will result in a straight inside-flow pattern since the external pressures are equal. Asymmetrically arranged openings cause air to enter at an oblique angle and eventually turn and flow toward the outlet.

Divisions within a building slows the movement of air. Any abrupt course change caused by furniture or partitions will significantly slow air speeds.

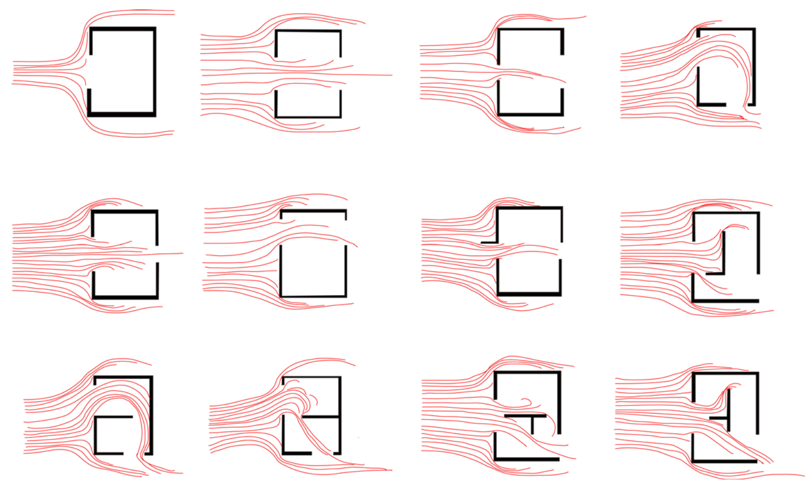


figure 4.6: Diagrams showing wind through buildings (plan view) (after Olgyay, 1963)

through a room

A large ratio of outlet to inlet size will cause an increase in air movement through a room. The location of the outlet is irrelevant to the pattern of incoming flow. This effect is shown in examples where the inlet position remains the same and, but the outlet is placed at ceiling height, midway or at floor level. On the other hand, where the outlet position is held constant, but the inlet is placed at high, middle or low positions, the pattern of flow is directed upward to the ceiling. The placement of the inlet governs the flow pattern within the room and can be regulated by the position, arrangement and type of inlet.

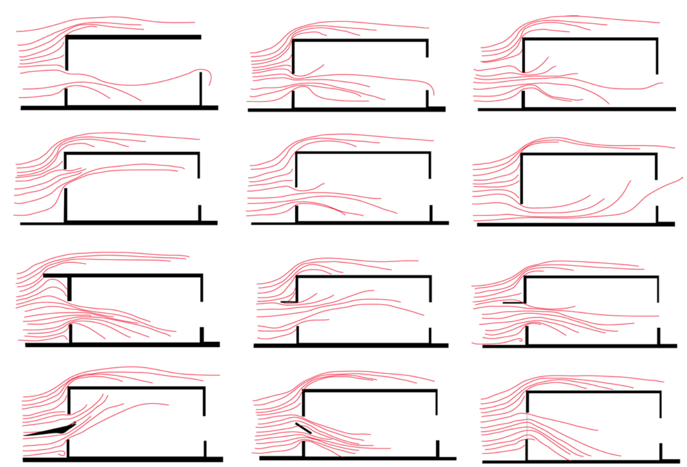


figure 4.7: Wind through rooms (in section) (after Olgyay, 1963).

4.4 techniques to block wind

The most important factors in the relationship of wind to convection "are speed and turbulence, or the degree to which movement occurs as random eddies rather than as steady, directed flow [of air]" (Lynch and Hack, 1984). "Eddies" in the air are created by wind movement around buildings, over fences, or through and over hedge rows, tree masses or windbreaks. Air eddies move similar to the way water flowing downstream flows back upstream behind a boulder in the middle of a rapids or along the shoreline of a stream or river.

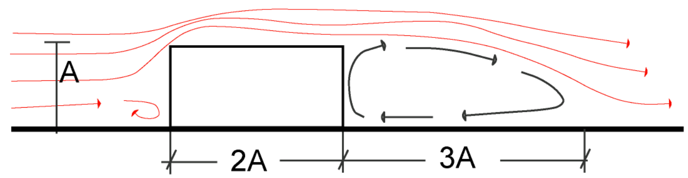


figure 4.9: Shielding effect of buildings (after Melaragno, 1982).

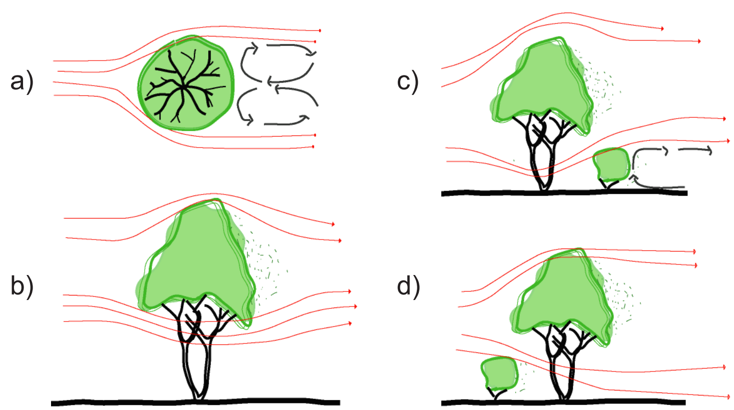
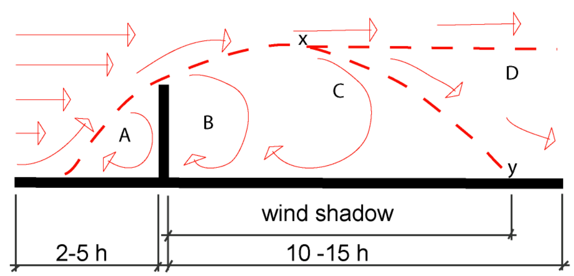


figure 4.8: WInd deflection behind a tree a) zone of higher speed behind tree b) sheltered area behind foliage c) low shrubs behind d) low shrubs in front
(after Melaragno, 1982).

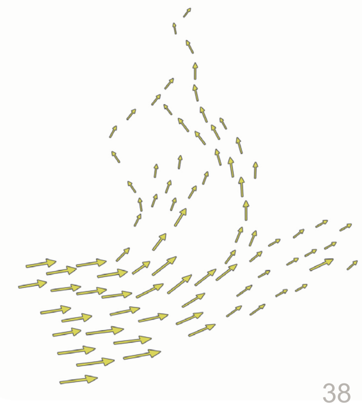


h height of barrier
A pressure eddy
B suction eddy
C turbulent wake
D small turbulence
XY boundary separating 'wind shadow' from rest of turbulence

figure 4.10: Eddy formation behind a windscreen (after Melaragno, 1982).

section 5 **site analysis**

5.1 character study
5.2 orientation and structure of downtown
5.3 viewshed analysis
5.4 site context



Squamish is situated in a dramatic setting at the head of the Howe Sound, where mountain, ocean and river ecosystems converge. While the natural setting is spectacular, it is the intertwining of these natural systems with the built environment that gives this place it's unique character.

The character study in figure 5.1 explores the local architecture, color and texture, each of which contributes to the character of the indigenous landscape of Squamish. For example, native plant communities give place a distinctive character, the frequent combination of a few species create a "local color" in Squamish.

A study of the existing character is important for enhancing a 'sense of place' in any future development in the downtown (ie. the NCC). The general aesthetic should be maintained through the retention of local color and plant material as well as using the existing industrial vernacular for the built elements.

figure 5.1: Character study of downtown Squamish. Starting from the upper left corner in a counterclockwise direction: (1) Stinky Pond, (2) Squamish Estuary, (3) Railroad tracks terminating at Squamish Terminals , (4) Squamish Beach, (5) The Spit, (6) Kitesurfers in Howe Sound, (7),(8),(9), (10), (11) Waterfront trail, (12) Marina (13) Howe Sound Brewery, (14) Waterfront trail, (15) Cleveland Ave., (16) Adventure Centre.

5.2 the orientation and structure of downtown Squamish

The town of Squamish has a north-south orientation, coinciding with the direction of the prevailing winds (see fig. 5.2). The important points about the existing structure of downtown illustrated in fig. 5.3 are:

- there is only one entrance into downtown Squamish.
- Cleveland Ave. is the entry corridor and acts as the primary N-S axis through downtown.
- Major viewsheds exist outwards from downtown Squamish.
- Access to the waterfront is limited in the current downtown configuration.

From these observations we can begin to understand how the design for the NCC may influence both the character and structure of downtown.

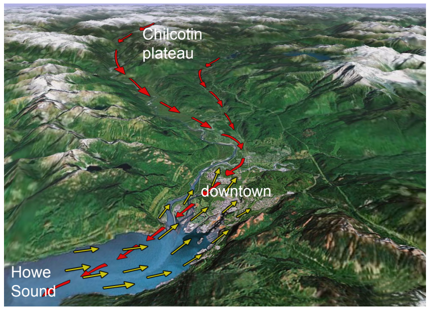


figure 5.2: Predominant winds through downtown.

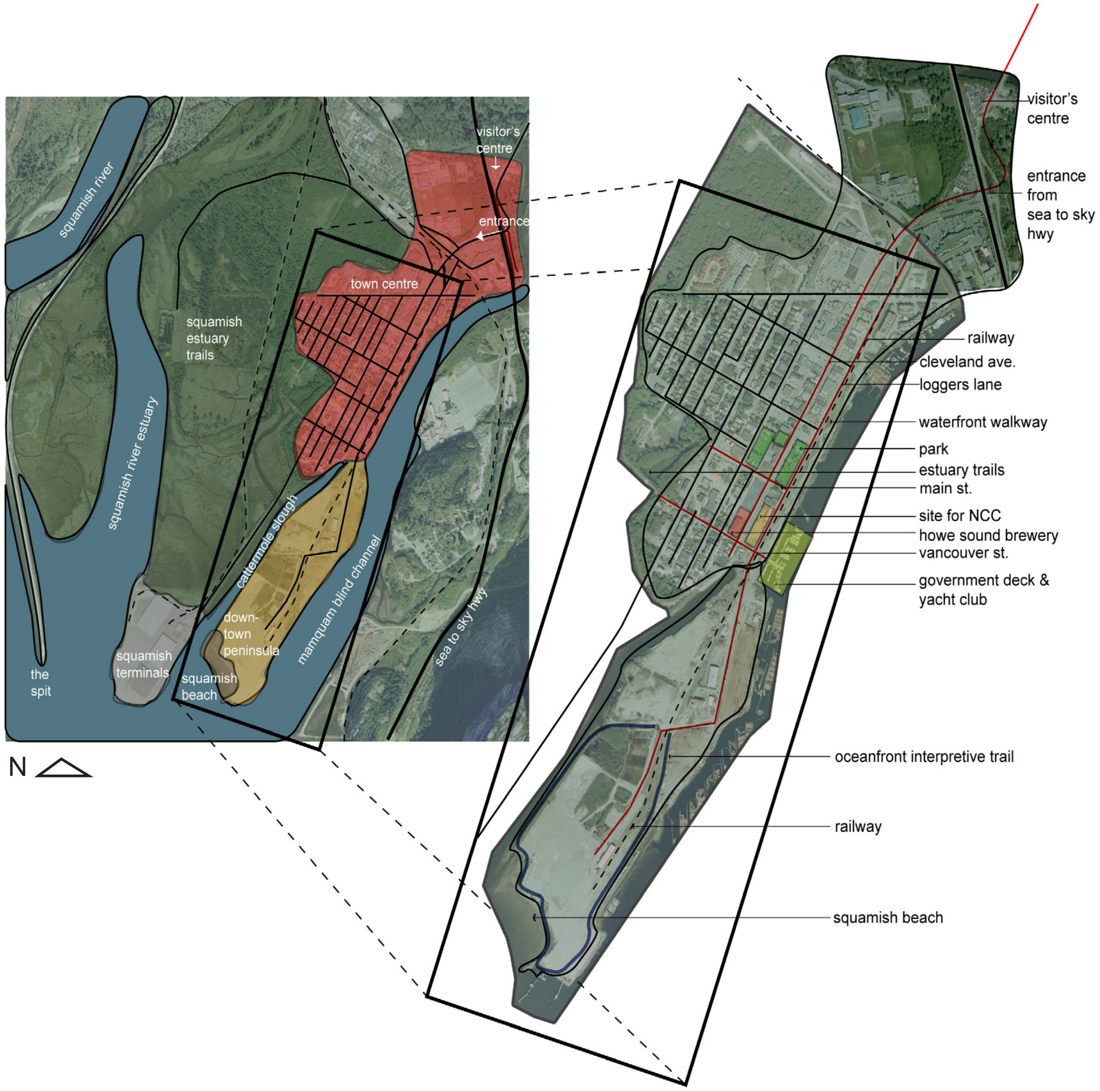


figure 5.3: Map of downtown Squamish divided into 3 major areas: the Squamish estuary (in green), town centre (in red) and the downtown peninsula (in yellow). The town centre and peninsula are extracted, highlighting important places near the proposed site for the NCC.

5.3 viewshed analysis

These analyses revealed the importance of visually connect the NCC to surrounding views from a view tower (six storeys tall) and from the waterfront. The ways in which the site leads people to waterfront be important in opening the dramatic views of the Howe Sound, Stawamus Chief, Mt. Garibaldi, Diamond Head Ridge and Alice Ridge.

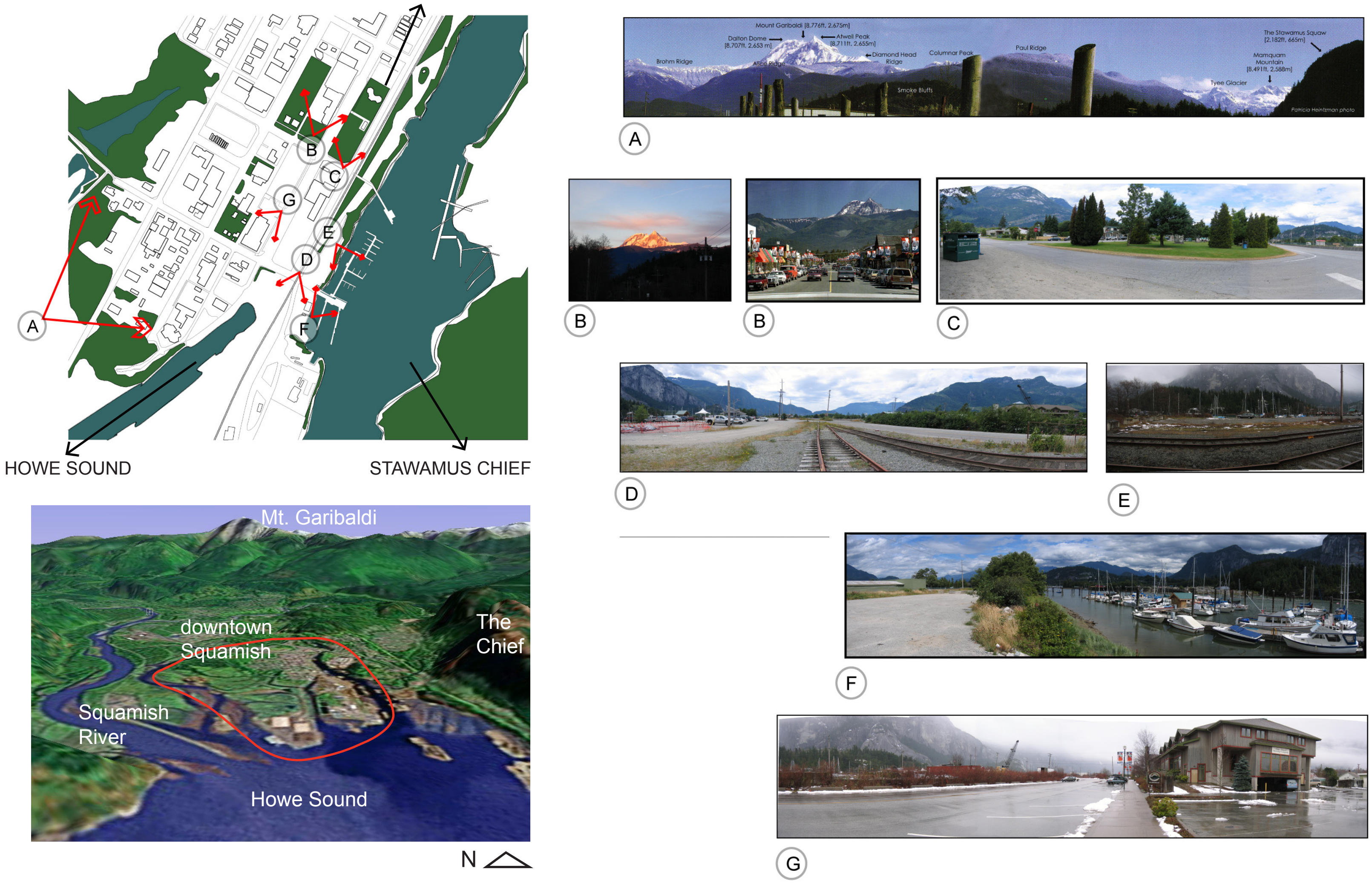


figure 5.4: Viewshed analysis: a) panoramic of alpine views from the waterfront trail b) views of Mt. Garibaldi from Cleveland Ave. c) park located north of the site d) view to the north along defunct railway e) looking east towards the Chief from the site f) view of marina in the Mamqum Blind Channel from the yacht club parking lot g) looking south on Cleveland Ave. with Howe Sound Brewery on the right side of the street.

5.4 site context

There are seven important contextual points to consider in the design of the NCC:

1. transition from the urban grid to the waterfront.
2. connection to proposed east-west pedestrian corridor from the estuary to the waterfront trail.
3. connection to the north-south waterfront trail
4. proximity to the proposed connection of Cattermole Slough and the Mamquam Blind Channel.
5. proximity to Stan Clark Park.
6. proximity to the new Capilano College campus in downtown.
7. connection to the downtown peninsula.

Figure 5.5 highlights the waterfront trail (in red), a corridor that begins in a concentrated urban area and leads pedestrians and cyclists south through the downtown along the Mamquam Blind Channel. The trail extends to the downtown peninsula and joins the Oceanfront Interpretive Trail (in yellow).

Figure 5.6 is an enlargement of the study area, showing the site for the NCC (with a red box) specified by the District of Squamish.

Figure 5.7 illustrates how the site sits in the existing condition of downtown.

Figure 5.8 illustrates the future condition of the study area (provided by the District). The proposed east-west pedestrian corridor is highlighted with a dashed red line, connecting the estuary to the waterfront trail. Another important connection proposed by the District is the joining of the Cattermole Slough and Mamquam Blind Channel. The site for the NCC sits near the junction of these two pedestrian corridors and the convergence of these two water bodies.

figure 5.5: Study area (in the white box) and waterfront trail in downtown Squamish.

figure 5.6: Location of site (proposed by the District) for the NCC in the study area.

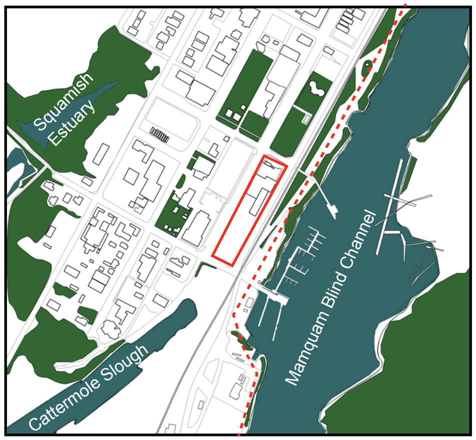


figure 5.7: Proposed site in context of existing condition of downtown.

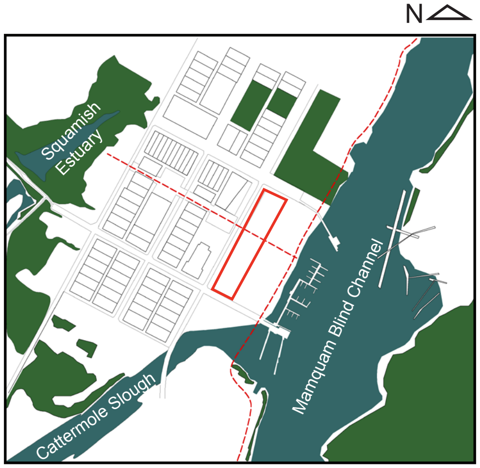
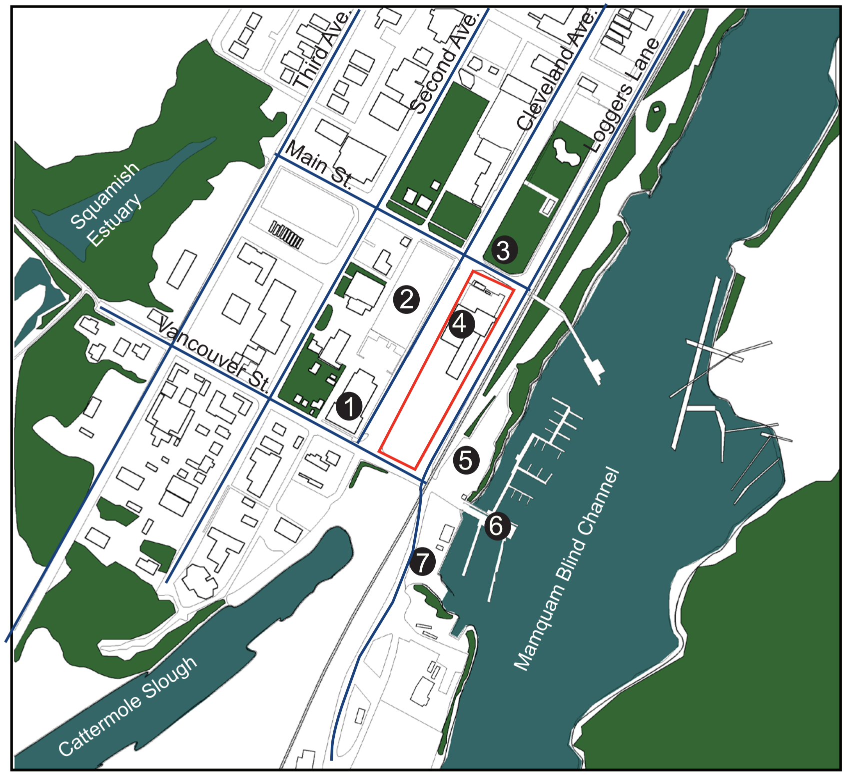


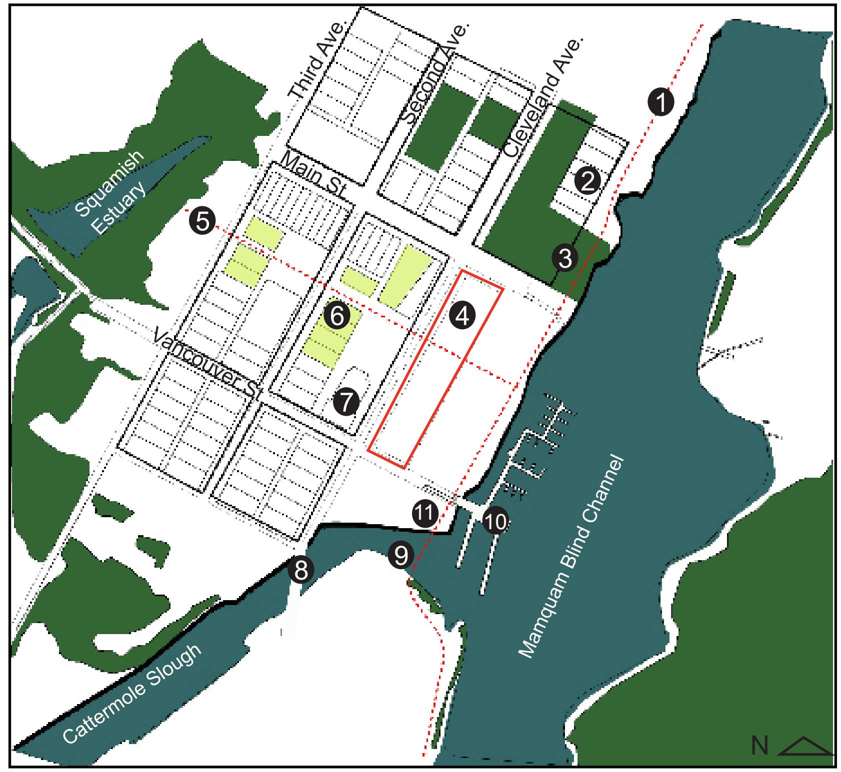
figure 5.8 : Proposed condition of downtown (specified by the District of Squamish).

existing and proposed condition of downtown



1. Howe Sound Brewery
2. vacant lot
3. Stan Clark Park
4. Landscape Supply
5. parking lot
6. Government Dock and Yacht Club
7. boat launch

figure 5.9: Context map of existing conditions, highlighting key places adjacent to the proposed site for the NCC (outlined in red).



1. Oceanfront trail
2. retail
3. Stan Clark Park expansion
4. proposed site for Natural Capital Centre
5. pedestrian corridor to waterfront
6. Capilano College Campus (yellow buildings)
7. Howe Sound Brewery
8. car bridge
9. pedestrian bridge
10. Government Dock and Yacht Club
11. boat launch

figure 5.10: Context map of proposed conditions, highlighting key places adjacent to the proposed site for the NCC (outlined in red).

site dimensions

As stated previously, the District of Squamish and Ecotrust are planning to build the Natural Capital Centre on Block 20 as part of educational/ cultural zone identified in downtown Squamish. Their proposal calls for a Centre that is 60,000 square foot facility. Figure 5.11 illustrates the dimensions of the site (32m x 172m) as specified by the District Council.

In light of the following five major moves proposed by the District of Squamish the site boundaries were reassessed in this study to better integrate the NCC with the urban fabric of downtown Squamish:

- expanding Stan Clark Park to the waterfront
- creating a continuous waterfront trail along the Mamquam Blind Channel to the Oceanfront Interpretive Trail
- moving the Capilano College campus to downtown
- connecting the estuary to the waterfront trail with a pedestrian corridor
- connecting the Cattermole Slough and the Mamquam Blind Channel

Figure 5.12 illustrates the proposed extension of the site to the water's edge to the east and to the south. This new boundary strengthens connections between the city and the waterfront and integrates the park to the north, the urban grid to the west, the peninsula to the south and the waterfront to the east. Expanding the site is a fundamental recommendation needed to incorporate the programming possibilities proposed for the NCC in the remainder of this report. Expanding the site also ensures that the drama of the views, the waterfront and wind needed to sense the role of the NCC in the downtown is not a lost opportunity.

The criteria pushing the design for the NCC are further illustrated in figures 5.13-5.17.

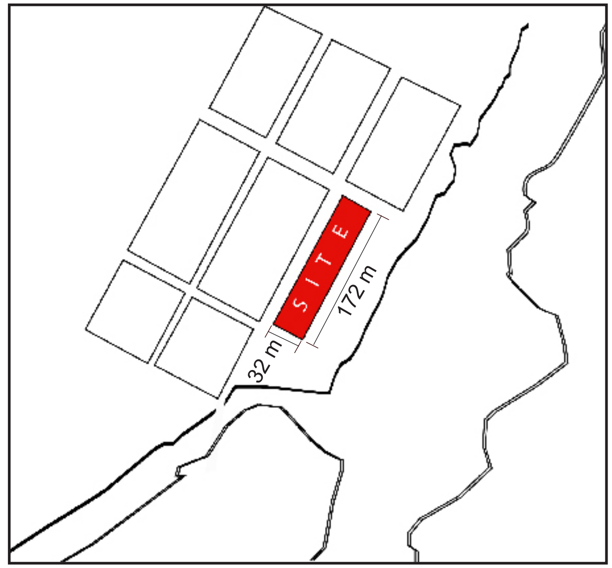


figure 5.11: Site dimensions proposed by the District.

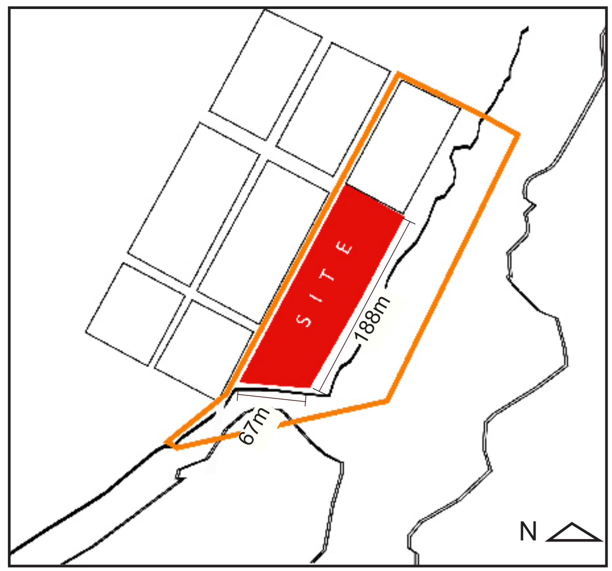


figure 5.12: Proposed site expansion and boundary of design intervention (outlined in orange).

Urban concepts

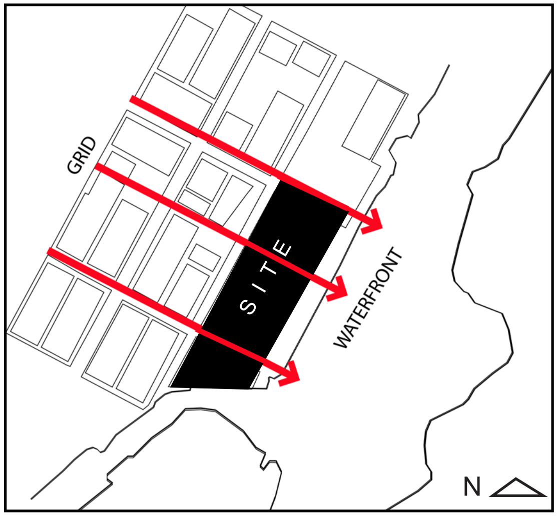


figure 5.13: Urban concepts diagram 1.
The site presents an opportunity to transition pedestrians from the urban grid to the waterfront.

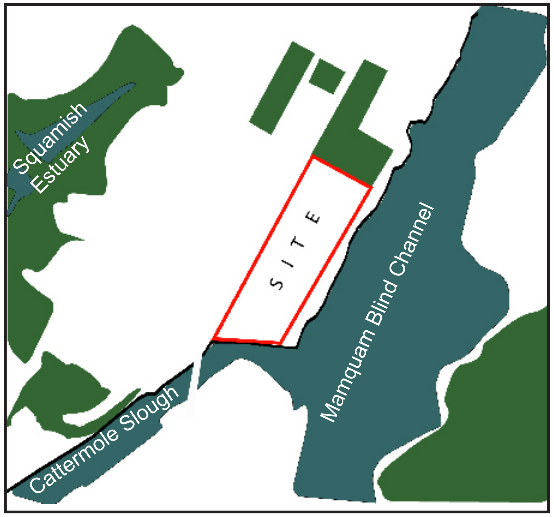


figure 5.14: Urban concepts diagram 2.
The site integrates adjacent natural areas- park and waterfront .

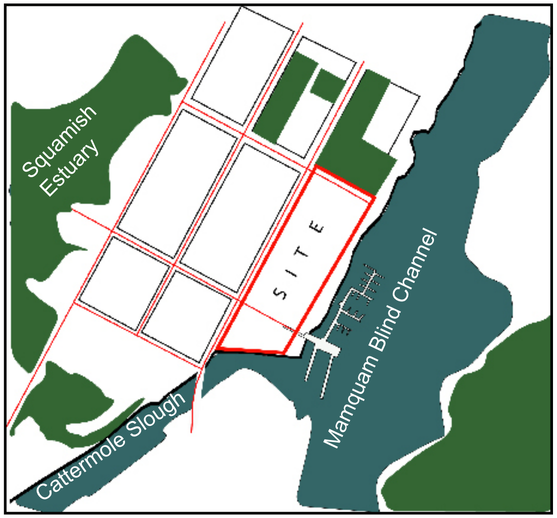


figure 5.15: Urban concepts diagram 3.
The site is part of and responds to the larger urban grid.

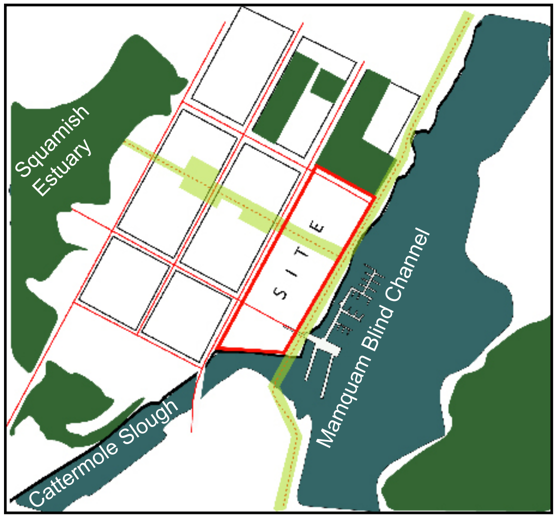


figure 5.16: Urban concepts diagram 4.
The site is connected to natural areas and the urban grid with pedestrian corridors (in yellow).

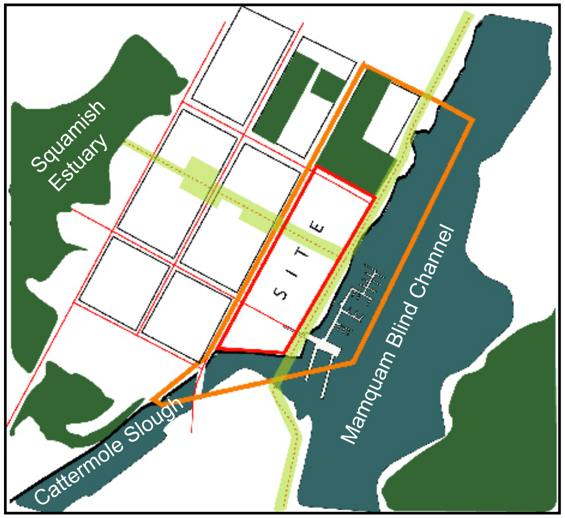
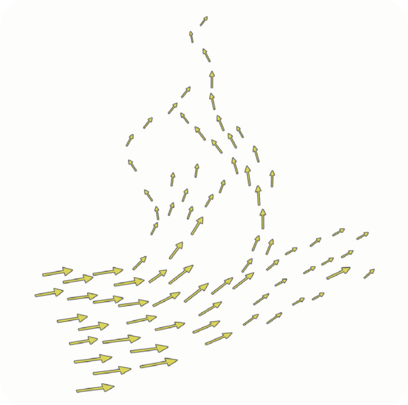


figure 5.17: Urban concepts diagram 5.
Boundary of design intervention outlined in orange.

section 6 design proposal



6.1 Concept: the wind blows through it

An acute sensitivity to place informs the following design proposal for the Natural Capital Centre. The concept envisioning the 60,000 sq. ft. volume is divided into four zones (1) a view tower, performance centre and events venue, (2) a wind energy research and education centre, (3) retail, restaurant and office space, and (4) a public plaza. While this is a major departure from the single, large volume envisioned by the District (described in “setting the stage for this project”), it can be argued that this arrangement takes better advantage of prevailing microclimates within the site by blocking and admitting wind for bioclimatic comfort. Additionally, the north to south orientation of the buildings maximizes wind shelter in the coldest months, providing for a diverse range of programs and activities that extend the use of outdoor spaces year round. The building scheme in figure 6.1 also:

- applies the metaphor of the larger windshed in the design to educate and engage visitors in the “funnelling”, “channelling” and other wonderful movements of the wind.
- creates opportunities for pedestrian access to the water to take advantage of 360 degree views.
- capitalizes on views from a view tower that situate Squamish in the larger region.
- demonstrates environmental sensitivity by using wind patterns as a driver for the design.
- integrates wind energy in the downtown by using urban turbines to supply electricity to the NCC.
- allows people to experience the unique winds in Squamish sensorially.

The site plan in figure 6.2 illustrates how this arrangement fits in the larger context of downtown Squamish.

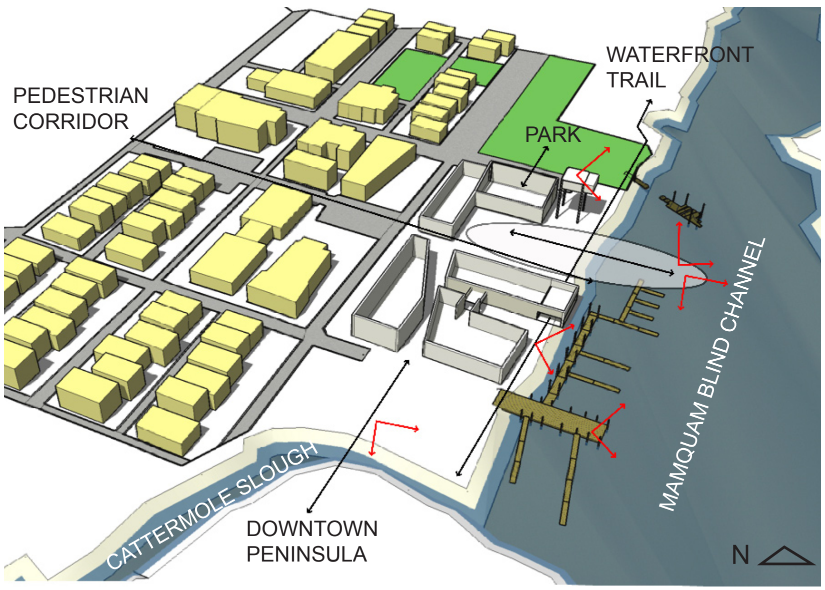


figure 6.1: Proposed building scheme and major connections. Red arrows indicate important viewpoints

6.2 Conceptual Masterplan

1:2000

LEGEND

a Howe Sound Brewery
b Capilano College Campus
c Squamish Estuary
d Cattermole Slough
e Downtown Peninsula
f Goverment Dock and Yacht Club
g Mamquam Blind Channel
h Stan Clark Park
i Retail
j Waterfront Trail

Natural Capital Centre

1a Performance Stage
1b Events Venue
2 Wind Energy Centre/ Offices/ Conference Centre
3 Retail/Offices
4 Restaurant/Cafe/Offices
5 View Tower

Materials Key

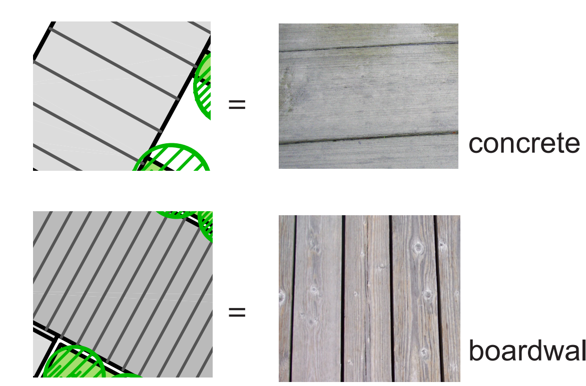


figure 6.2: Proposed site plan for the Natural Capital Centre.

6.3 building form and programming

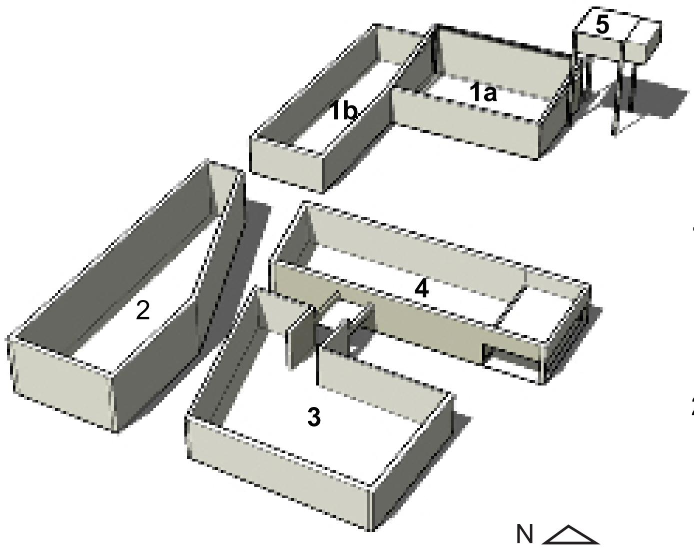
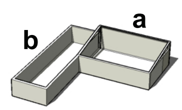
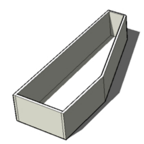
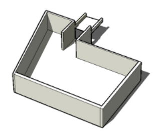
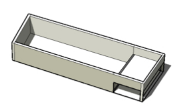


figure 6.3: Building form, program and area.

	Building	Program	Area
1		a. performance theatre (2/3 floors) b. events venue (2 floors)	22,000
2		floor 1: wind energy education and research centre floor 2: offices floor 3: conference centre	24,000
3		floor 1: retail floor 2: offices	16,000
4		floor 1: restaurant/cafe floor 2: offices	13,000
5		view tower (6 floors)	5,808

TOTAL AREA: 75,000 square feet

6.4 the howe sound windshed metaphor

The wind inventory research in section 3 of this report inspired the concept, “the wind blows through it” and the idea to simulate the dynamics of flow in the Howe Sound windshed through the NCC. Air, in a similar manner to the flow of water, flows downhill from higher to lower pressure, but with complex topography the flow can be steered in almost any direction. Figure 2.5 illustrates the nine topographical modifications of wind in the Howe Sound; five of these movements are translated into architectural design in figure 6.4. This translation into architectural language was the basis to understanding how to manipulate wind using architectural forms and resulted in the building massing proposed in figures 6.5 and 6.6.

The metaphor of how wind moves through the Howe Sound serves to inform people, by virtue of it’s experiential basis, of the dominant environmental force of wind in Squamish. As this section unfolds, it will become clear how the experience of the NCC engages people with the wind in exhilarating ways, reinforcing the identity of Squamish as the “birthplace of the great winds.”

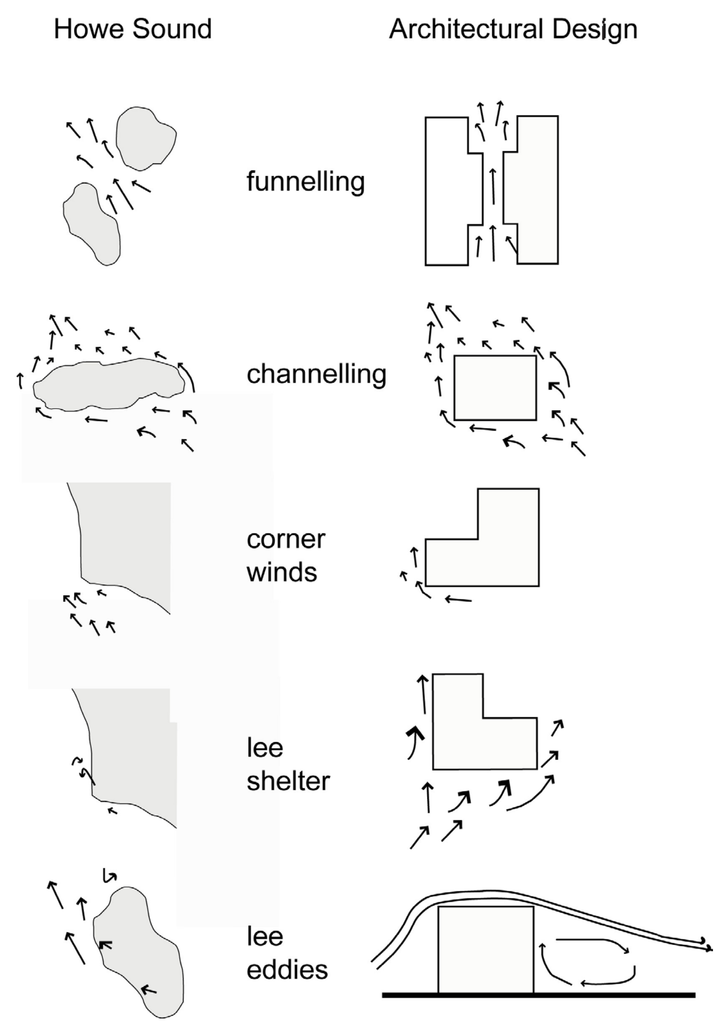


figure 6.4: Diagram of five of the nine topographical modifications of wind in Howe Sound (from fig. 2.5) translated into architectural design.

wind movements through the NCC

The following arrangement is one of many arrangements that may be used to satisfy the programmatic requirements of the NCC. This arrangement was chosen because it fulfills these programs and the building forms mimic the five topographical modifications of the winds in the Howe Sound. The proposed scheme manipulates the wind for bioclimatic comfort, while in other places, emphasizes the behaviour of the wind to demonstrate how wind moves through the Howe Sound windshed.

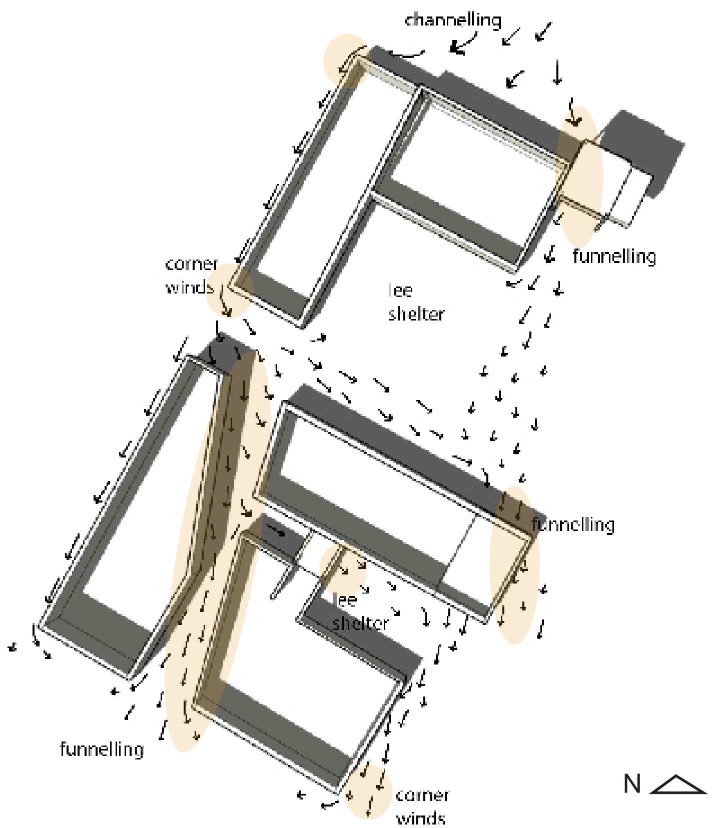


figure 6.5: Northerly winds mimic the five topographical modifications of the winds in the Howe Sound. (Note: lee eddies are not represented. These movements occur on the leeward side of all buildings and walls). Colored areas highlight wind “hotspots”.

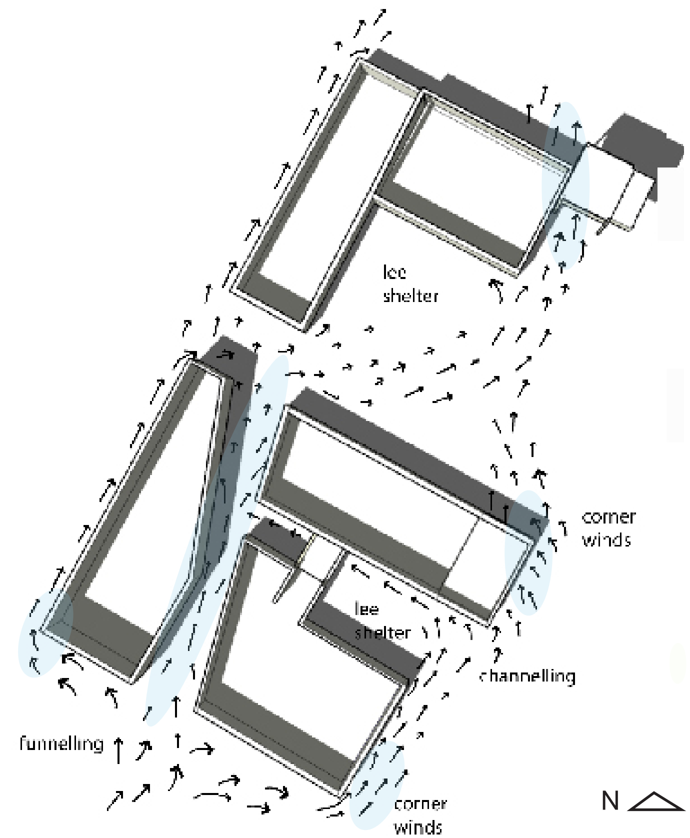


figure 6.6: Southerly winds mimic the five topographical modifications of the winds in the Howe Sound. (Note: lee eddies are not represented. These movements occur on the leeward side of all buildings and walls). Colored areas highlight wind “hotspots”.

6.5 admitting and blocking wind with the built form

Based on the wind studies in architectural design discussed in section 4.3 and illustrated in figures 4.4 - 4.7, we can predict how wind will move through the NCC. Figures 6.7 and 6.8 diagram the general movement of the predominant winds (northerly and southerly) in the exterior spaces of the NCC, when the performance stage is closed or open on both sides.

The wind square for Squamish (figure 3.2) indicates the time of year and day of the strongest winds, as well as the direction of these winds. From this information, we can begin to match appropriate programs and activities to spaces that change/adapt according to wind direction.

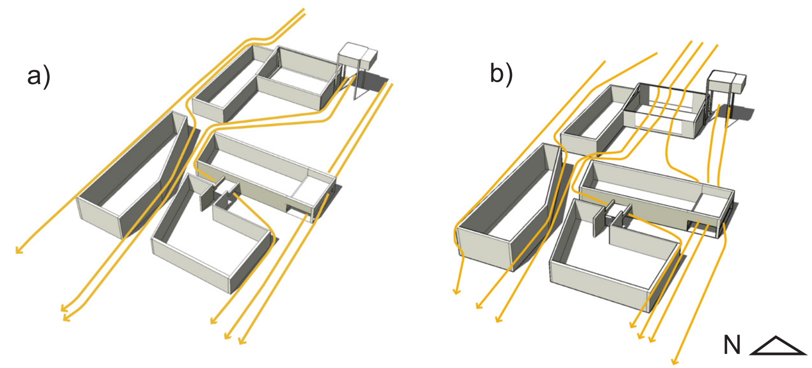


figure 6.7: Northerly winds through the NCC when a) performance stage is closed b) performance stage is open. Note: performance stage may be open to one side only, protecting the amphitheatre from wind.

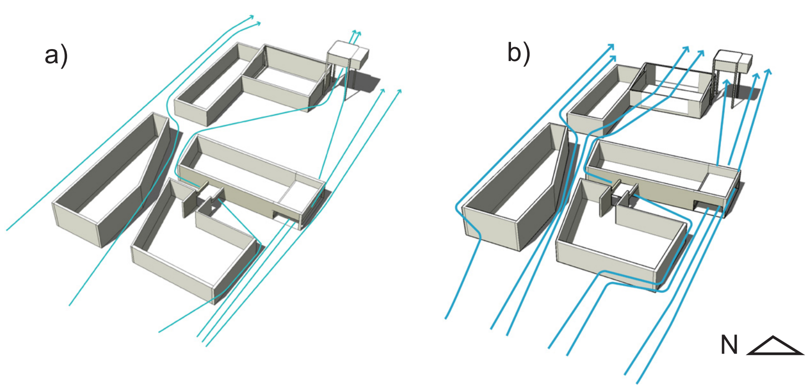


figure 6.8: Southerly winds through the NCC when a) performance stage is closed b) performance stage is open. Note: performance stage may be open to one side only, protecting the amphitheatre from wind.

6.6 design storyline

The following site diagrams illustrate the sequence of the design process and reads similar to a storyline, beginning with the conceptual masterplan.

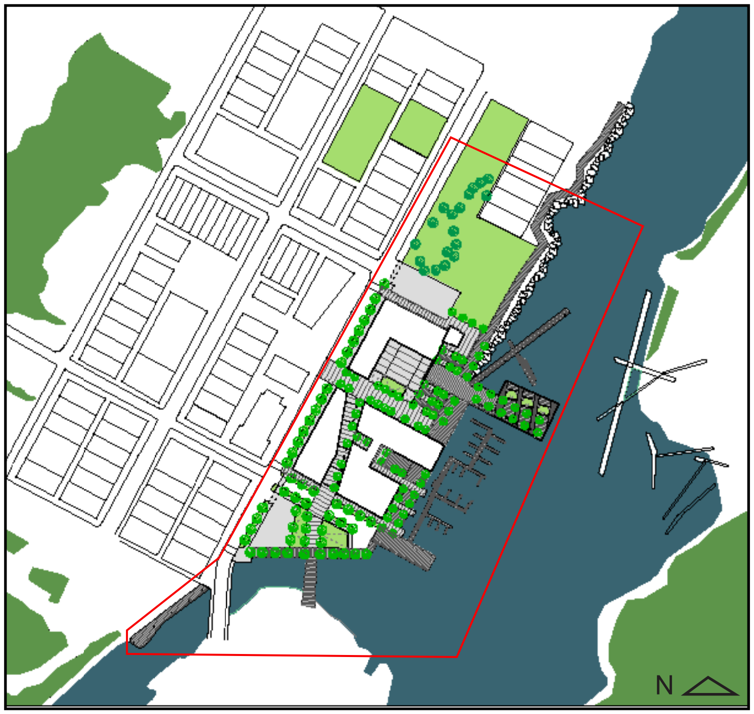


figure 6.9: The conceptual masterplan.

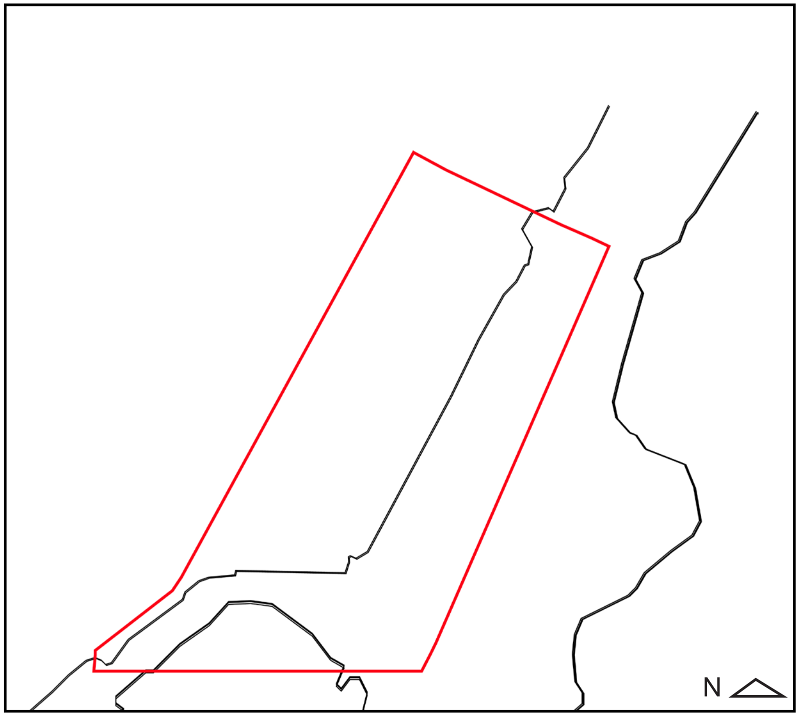


figure 6.10: Boundary of design intervention and shoreline. T he waterfront is well-integrated in the site plan.

figure 6.11: Site in the study area. T
he expanded Stan Clark Park is also integrated into the site plan.

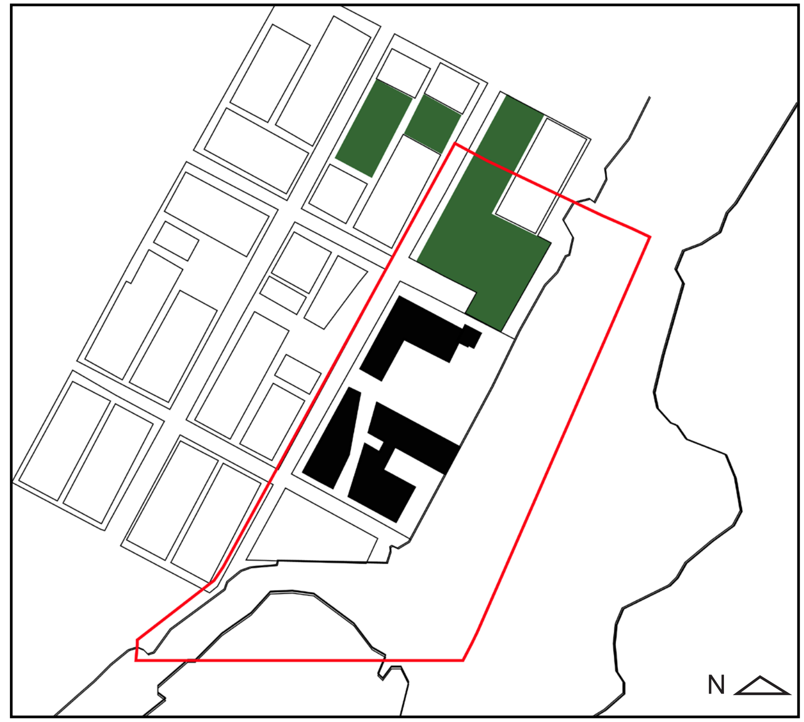


figure 6.12: Buildings.
The proposed buildings that comprise the NCC respond to the urban grid to the west and the irregualr shoreline to the east

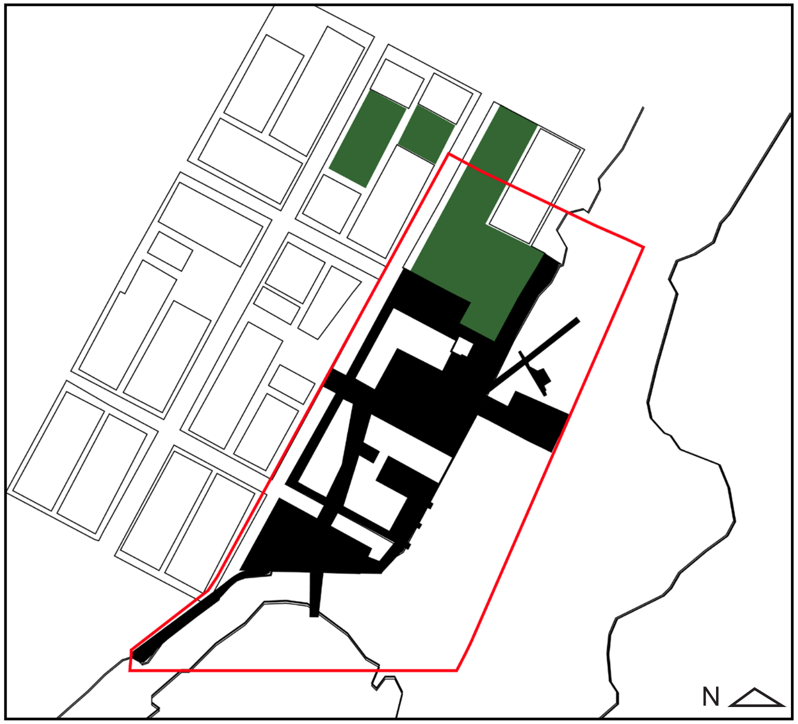


figure 6.13: Space between the buildings.
Spaces between proposed buildings that correspond to the programs described later in this section.

figure 6.14: Parking areas and boat launch.
Location of the proposed parking areas and boat launch in the NCC.

figure 6.15: East-west corridors.
All of the east-west pedestrian corridors through the site lead people to the waterfront.

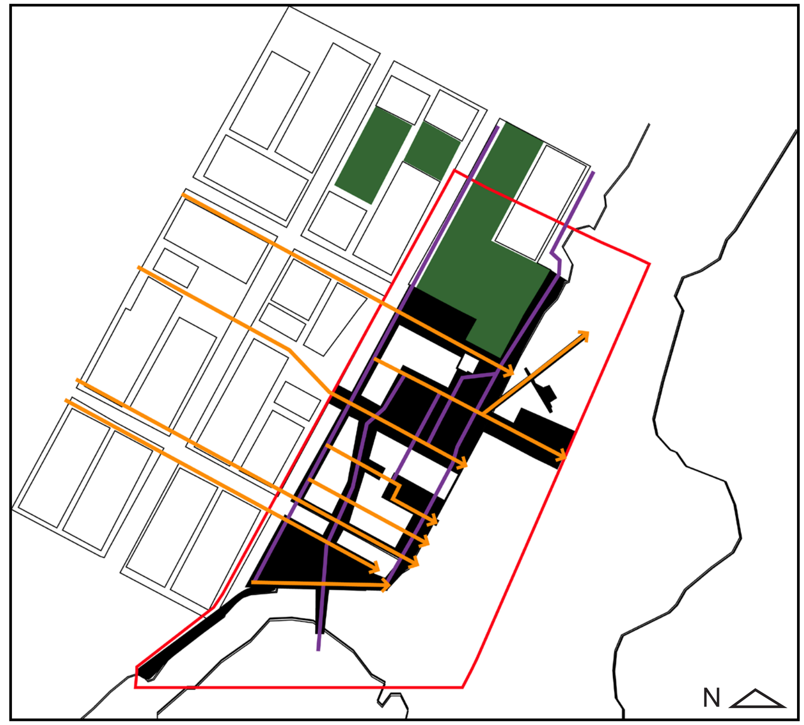


figure 6.16: North-south corridors.
The intersection of the east-west + north-south pedestian corridors in the site.

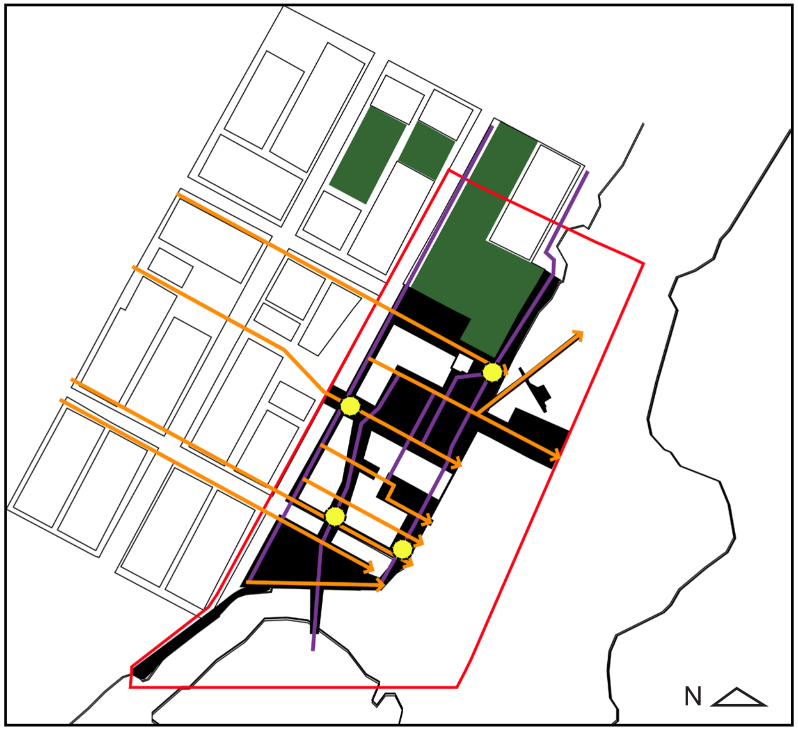


figure 6.17: Corridors and nodes.
The intersection of the east-west + north-south pedestrian corridors in the site and location of major nodes. These nodes serve as places to meet, stop and wayfind, people watch, and experience wind.

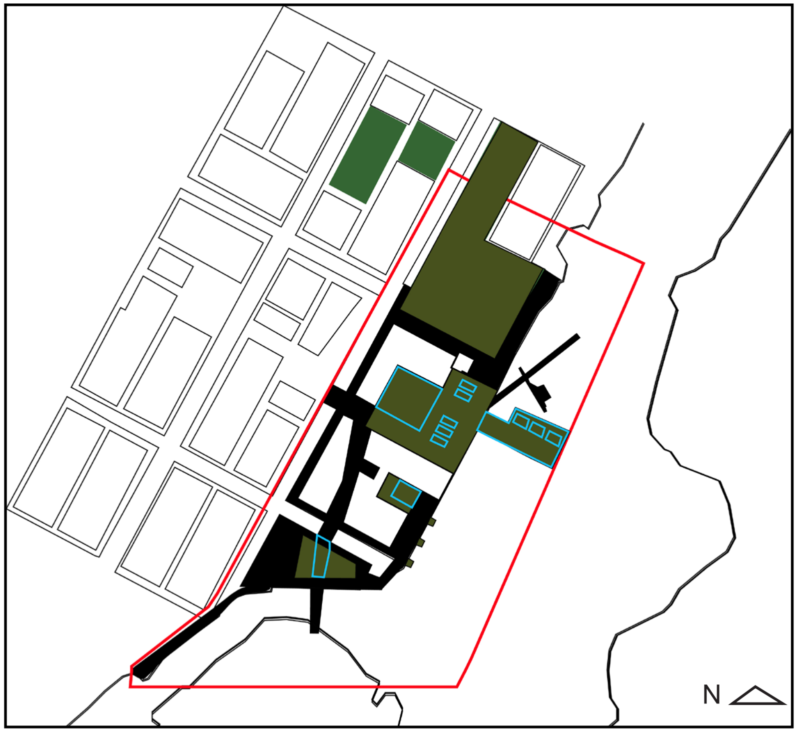


figure 6.18: Outdoor rooms
Outdoor rooms in green and ‘rooms within rooms’ outlined in blue. The larger outdoor rooms are designed for gathering groups of people. The smaller rooms within the larger rooms are designed as places to “duck out of the wind.” They are referred to as “lee shelter” areas for small groups of people to sit and talk, eat or to simply get out of the wind.

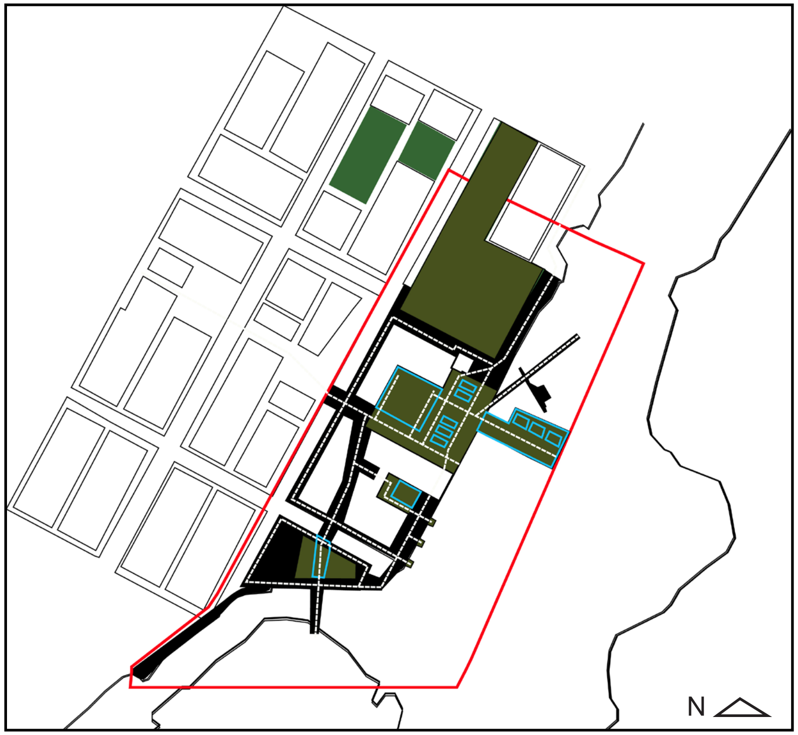


figure 6.19: Pedestrian circulation.
Outdoor rooms with pedestrian circulation through outdoor spaces.

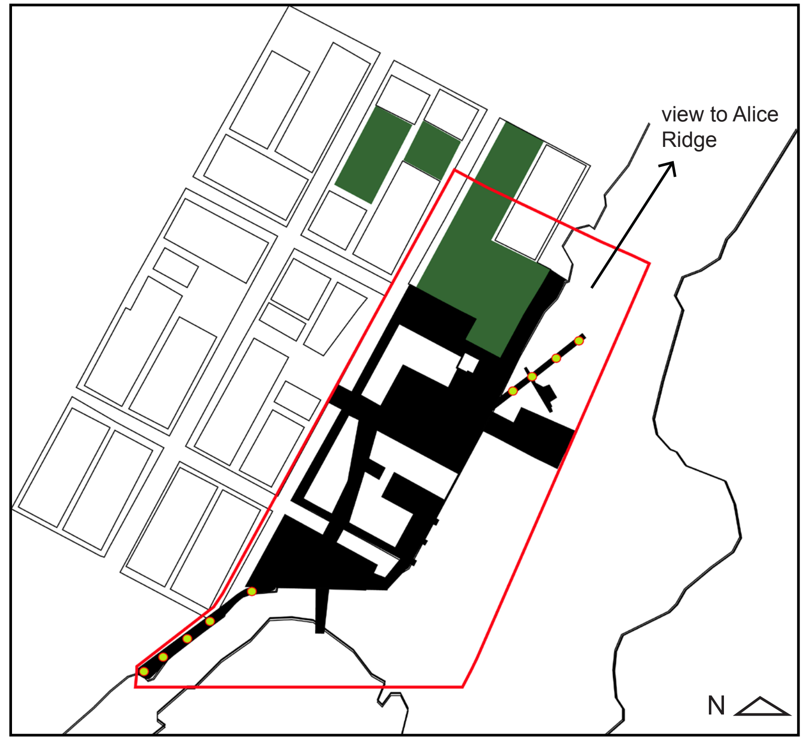


figure 6.20 : Placement of urban turbines.
Proposed placement of urban turbines on a northeast-southwest axis represented with yellow dots. This axis was chosen because it directs the eye of the visitor towards the turbines on Alice Ridge (NE direction from the site). This orientation also optimizes views of the urban turbines, highlights the predominant direction of the wind and gives the site order.

6.7 Ground-level site plan

1:1000

figure 6.21: Proposed site plan for the Natural Capital Centre.

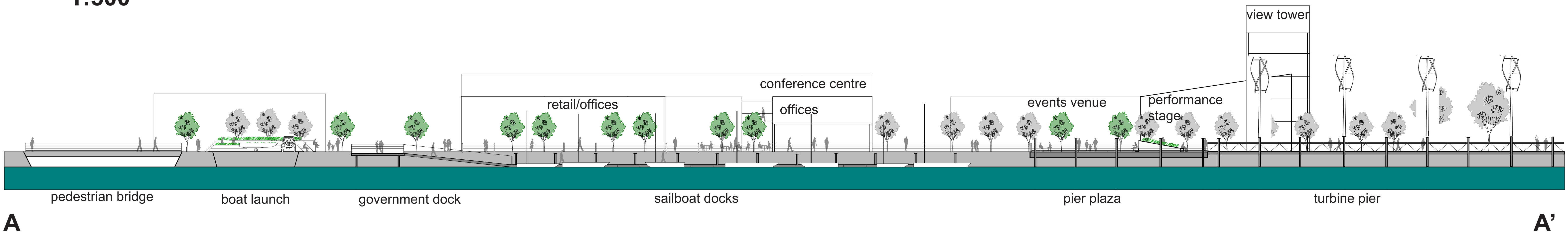
LEGEND

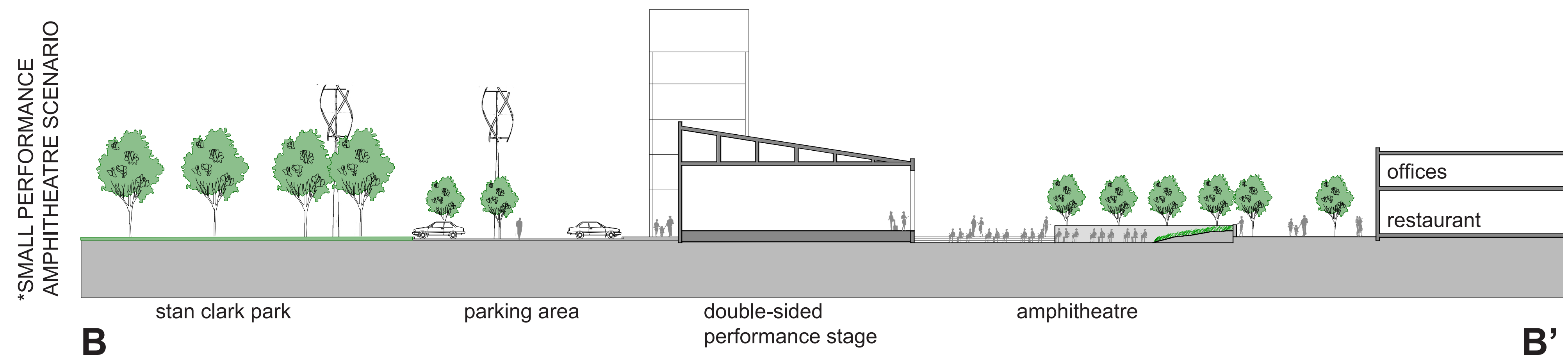
Natural Capital Centre

1 Waterfront trail
2 Natural shoreline
3a Parking area north
3b Parking area south
4 Tree planters and seating
5a Turbine pier north
5b Turbine pier south
6 Pier plaza
7 Raised grass berms + sheltered seating
8 Wind seats
9 Steps
10 Amphitheatre
11 Raised grass berm + standing wall
12 Lee shelter walkway to waterfront
13 Crosswalk
14 Cafe seating
15 Sound room
16 Funnelling corridor
17 Wind plaza
18 Raised grass berm
19 Sitting wall
20 Boat launch
21 Pedestrian bridge
22 View tower

6.8 site sections

1:500





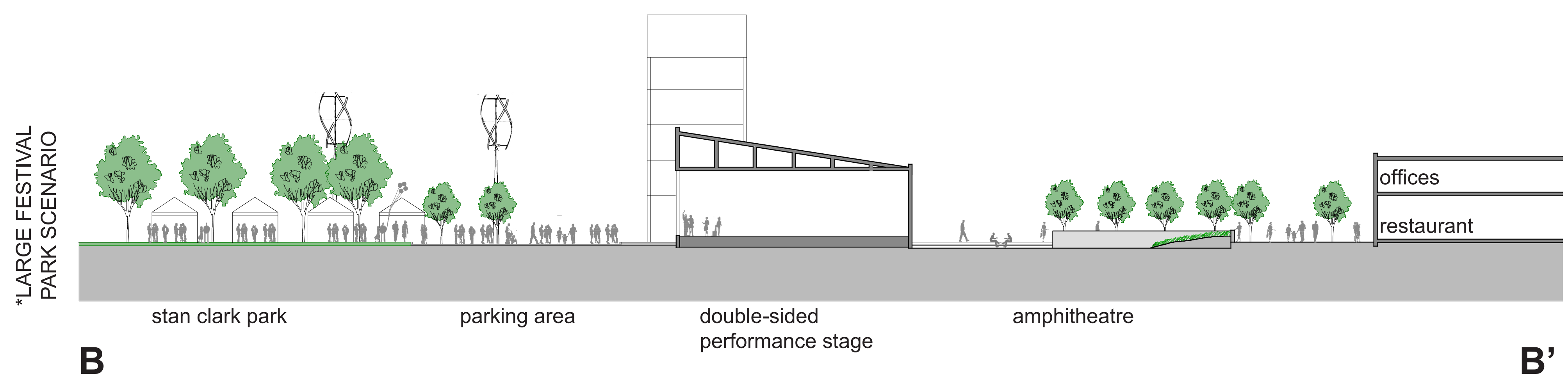


figure 6.22: Key plan and north-south site sections. See section 6.9- Amphitheatre description for explanation of the "small performance amphitheatre scenario" and the "large festival park scenario."

site sections

1:500

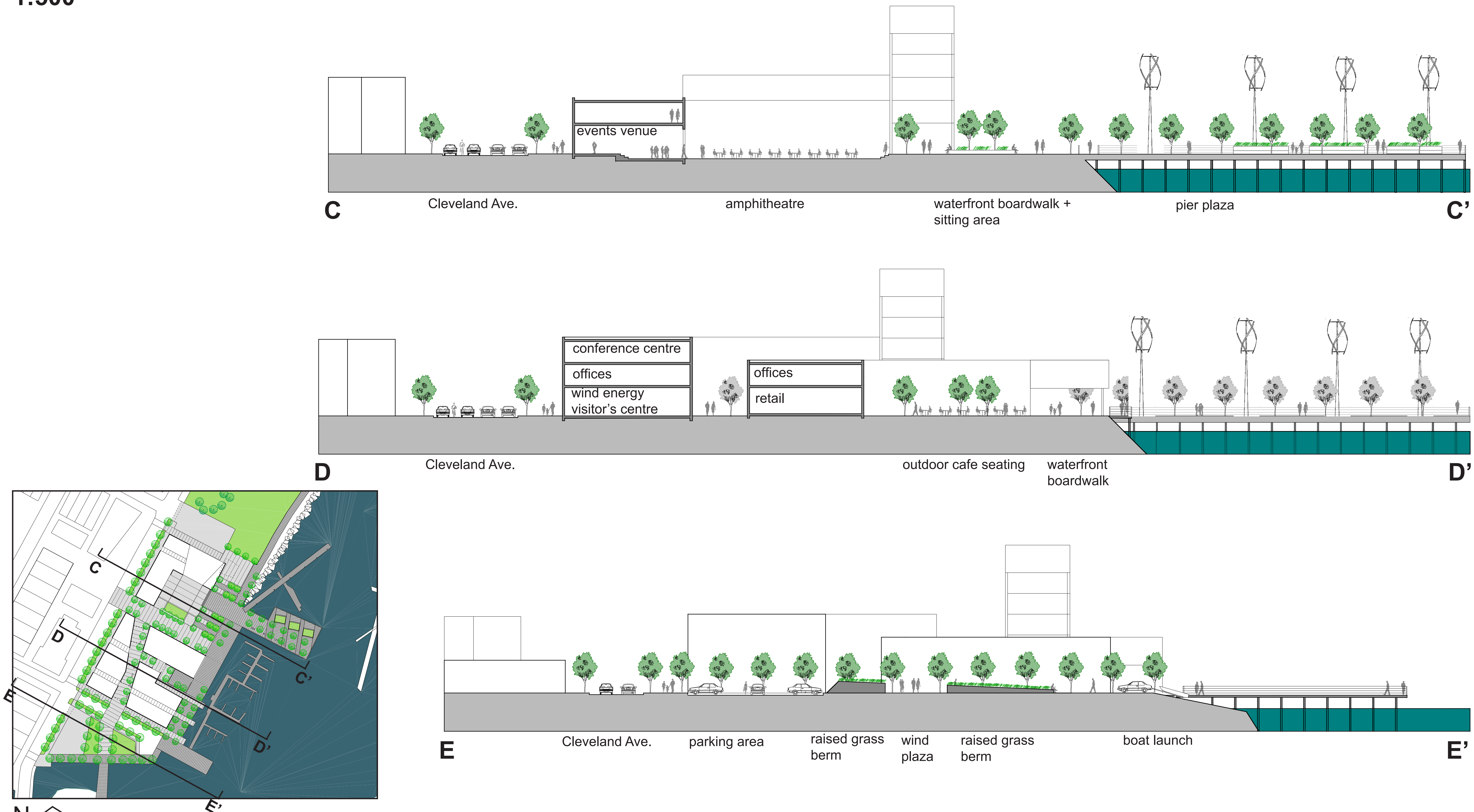


figure 6.23 : Key plan and east-west site sections.

6.9 programming of exterior spaces

Refer to ground-level site plan in figure 6.21 and the site sections in figures 6.22 and 6.23 to locate the places described in this section. THe numbers correspond to their location on the site plan.

1 **Waterfront trail**: The trail continues south along the waterfront and over a pedestrian bridge into the downtown peninsula. Pedestrians and cyclists travelling south on the trail transition to a boardwalk at the node east of the view tower. This is where the trail meets the Natural Capital Centre. At this point the trail splits in two, giving people the choice to continue on the waterfront trail boardwalk or walk the concrete path adjacent to the amphitheatre and into the NCC.

3 **Parking area**: Two parking areas are associated with the NCC. The smaller lot is located at the north end of the site, between Stan Clark Park and the performance stage (labelled as **3a** on the site plan). This parking area is occasionally closed-off for large festivals and events and is illustrated in section B-B' in fig. 6.22 (LARGE EVENT-PARK SCENARIO). The second parking area is located at the south end of the site (labelled as **3b** on the site plan) and is screened from the wind plaza by a sloping, raised grass berm (see section E-E' in fig. 6.23 and ill. 6.26). Additionally, there is existing angled parking along Cleveland Ave. The NCC is an optimal place to consider underground parking in downtown. Being in close proximity to Capilano College, this area will need quick and easy parking for large inflows of people.

5 **Turbine pier**: Two turbine piers are planned for the site, situated on a NE-SW axis. There may be four to six urban turbines spinning on each pier, generating electricity to sustain the NCC. Integrating the turbines into the design demonstrates wind energy operating in an urban environment and makes them accessible to the public- allowing people to walk up underneath them and experience how they work. See appendices for cost, dimensions and capacity of these turbines.

The NE pier is 70.5 meters long (labelled as 5a on the site plan) and the SW pier is 61.2 meters long (labelled as 5b on the site plan). These dimensions are intentional. The proposed windfarm on Alice Ridge will have five to ten, 2 MW turbines and will be visible from downtown Squamish and from the site on a clear day. These towers will be approx. 60 -70 meters tall, corresponding to the length of the piers. This enables visitor's to the NCC who are curious about the large turbines on the ridge to comprehend their scale. An interpretive map may be provided at the Visitor's Centre that explains these details.

6 **Pier plaza**: Pier plaza is architecturally reminiscent of the existing (and currently inaccessible) piers in the Mamquam Blind Channel. The plaza is 75.9 meters long and 12.4 meters wide. The pier widens to 22.5 meters as it opens to the water and significant views of Stawamus Chief, Mount Garibaldi, Alice Ridge and west facing valley walls.

On the north side of the pier, three raised grass berms in wooden planters provide sheltered seating from the cold northerly winds (see ill. 6.3). The long swaying grasses reveal the direction of the wind while the urban turbines spin in the background relative to the speed of the wind, framing views of the Alice Ridge windfarm.

Groups of windseats are dispersed along the south side of the plaza. These swiveling seats have tall backs and rudders that allow people to steer into or out of the wind (see ill. 6.27).

Pier plaza may be considered the "town's plaza", hosting large commnity events and festivals. Together, Stan Clark Park, the performance stage, the amphitheatre and Pier Plaza may function as a single outdoor room.

(10) **Amphitheatre**: The performance stage is double-sided with a sloping roof and large "industrial-style" sliding doors on both the north and south sides of the building. This orientation allows for two different scenarios: 1) the larger three-storey face opens to the park for large town festivals (see section B-B' in fig. 6.22 - LARGE FESTIVAL PARK SCENARIO) and 2) the smaller two-story face opens to a small amphitheatre (see section B-B' in fig. 6.22 - SMALL PERFORMANCE AMPHITHEATRE SCENARIO). This intimate amphitheatre is located in a "lee shelter" area to block northerly winds (see fig. 6.4 and 6.5). Furthermore, this area is sunk .5 meters below grade to provide better shelter from southerly winds and to seperate the space from the surrounding plaza. The space is 28.4 meters by 20.5 meters and is accessible by steps (also functioning as sitting steps) to the east, two ramps to the south or the events venue to the west. The amphitheatre is designed for flexible programming to accomodate community events such as talent shows, music concerts, theatre, films, dancing, outdoor classes, etc. The space may also be reserved for more private events such as dinner banquets and celebrations. The vertical doors to the events venue open to the amphitheatre for such events (see section D-D' in fig. 6.23)

(14) **Cafe seating**: Presently there are no places to eat outdoors on the waterfront in downtown Squamish. This type of experience may be desirable, but perhaps difficult because of the strong winds. A 10.5 meter x 10.5 meter outdoor patio is programmed in the outdoor room between the restaurant and the retail shops in a "lee shelter" area to divert the wind (see fig. 6.4 and 6.5). The cafe seating is connected to the south side of the restaurant with doors that open to the patio for a strong indoor/outdoor relationship (see section D-D' in fig. 6.23). Views of the waterfront and the Stawamus Chief are maintained.

(15) **Sound "room"**: Pedestrians passing through the NCC on the waterfront trail will surely experience the sound room. The underpass creates a wind funnel effect (see fig. 6.4 and 6.6) strong enough to orchestrate an aeolian harp. When the wind is blowing perpendicular to the harp, a shimmering sound is produced. The tone of the harp changes depending on the velocity of the wind and the ceiling of the sound room intensifies the sound for listeners (see ill. 6.29).

(16) **Funnelling corridor**: A wind tunnel or "venturi effect" is produced in this narrow, 56 meter long hallway, located between two buildings (see fig. 6.4 and 6.5). Visitor's will experience the strong force of the wind as they walk through the funnelling corridor, seeking shelter in the retail shops or the wind energy research and education centre. The sensory experience of the wind is enhanced with large sails strung across the corridor, flapping in the wind (see ill. 6.25).

(17) **Wind plaza**: The wind plaza is transition area (from the downtown peninsula to the NCC) located at the entry at the southern end of the site between two raised, sloping grass berms. The higher side (to the west) screens the parking area from view, while the lower side (to the east) provides visual access to the boat launch and the waterfront (see section E-E' in fig. 6.23). The long grasses flow with the wind, recognizing wind's dynamic nature presenting a moving picture rather than a still photograph of it (see ill. 6.26).

(22) **View Tower**: The town of Squamish has been described as being, "situated in the middle of one large, very grand room - a powerful valley room" (Smartgrowth on the Ground, Foundation Research Bulletin: Squamish, No. 4, 2005). The six-storey view tower in the northeast corner of the site provides a special opportunity to view this larger "valley room" from above. From this place, the wind intensifies, the views become more dramatic and the light reflected from the valley walls at dusk is enhanced. The tower also opens views to the windfarm on Alice Ridge (to the north), the greater Howe Sound (to the south) and the wind turbines (large and small), affirming the position of Squamish in the windshed. This prospect conveys the experience of the Natural Capital Centre and increases a sense of place for the town of Squamish.

While the proposed design ranges from the fundamental organization of the site to small-scale detailing, the overall effect is to create places unique to Squamish. The small-scale detailing includes the sensory experience of the NCC, enhancing how visitor's feel, see and hear wind in Squamish. Elaborating on the name of the NCC to include "windpark" (or something similar) may help prepare for the exhilirating experience of the wind.

These details use artful interpretation that offers alternative ways to explore and make sense out of the unseen. They experiment with multi-sensory experiences that may open the mind of the public to understanding the dynamics of the wind. Such interventions may also relieve the tension between the educational intentions of NCC and the search for enjoyment by visitors.

By revealing the movement of the wind, visitors to the NCC will not merely pass through the windy site reacting to its force by constantly pulling their hair out of their faces, but hopefully ducking in and out of the wind, engaging their body and mind in a deeper exploration that evoke powerful memories of this place.

The location of the following interventions correspond with the key plan in figure 6.24.

figure 6.24: Sensory experiences key plan.

N

1. Funnelling Corridor

   Wind can be experienced sensorially but is visible only when it causes an object to move. Large sails made of a translucent kite-material may hang vertically from one building to another and flap as wind is funnelled through this corridor. When the winds are strong enough to blow the sails into a horizontal position, they will form a grand translucent roof above the corridor.

illustration 6.25: Funnelling corridor

2. Wind Plaza

   The wind plaza will be the primary entry point at the southern end of the site. The long and narrow form of the plaza suggests the idea that people will feel “blown in to the site.” The movement of the long grasses and the trembling aspen trees will create a dance in which any variation in intensity or directional gusts of wind varies the performance, especially in the strong summer southerlies.

illustration 6.26: Wind plaza

3. Lee Shelter on Pier Plaza

Light breezes are generally loved for their powers to cool, cleanse and heal our bodies, while forceful winds take away our body heat and force us seek refuge. Sitting areas on the leeward side of the grass berms provide shelter from the cold northerly winds, also known as the 'Squamishes'. These areas of refuge are small rooms within a larger room called Pier plaza. Sitting in the lee shelter area visitor's are conscious of the presence of the wind because of the voice it gives to the aspen trees. Air dragging through leaves has a sound and visual that is capable of evoking powerful memories of place.

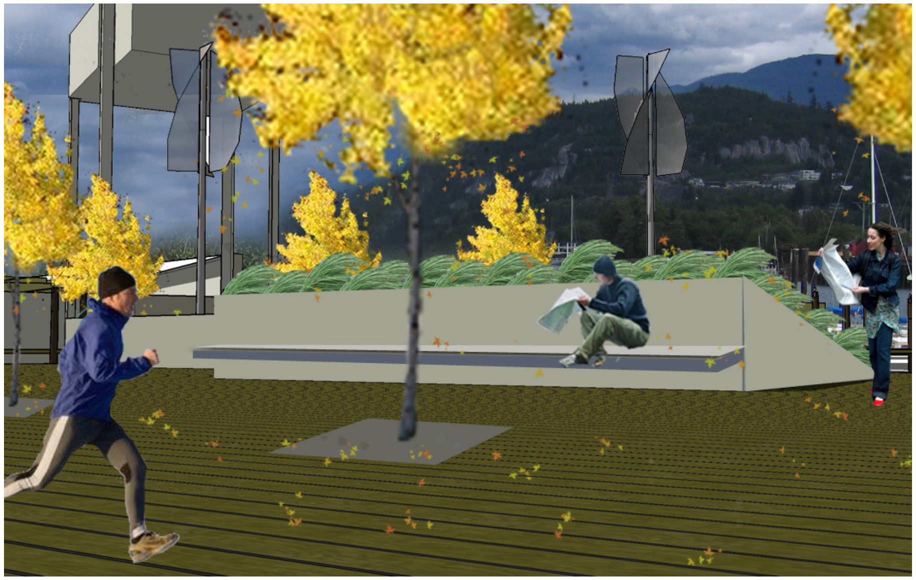


illustration 6.27: Lee shelter sitting area on the north side of Pier plaza.

4. Wind seats on Pier Plaza

Winds blow through Squamish, tousling grasses and trees and weaving through the mountains. The winds push anything that stands in their way, including the swiveling wind seats dispersed along the south side of Pier plaza. These special seats are equipped with tall backs and "rudders", shielding people from the wind and enabling them to steer their seat to enjoy 360 degree views.

illustration 6.28: Wind seats on the south side of Pier plaza.

5. The Sound Room

Wind harps, also called Aeolian harps, transforms wind energy into musical sounds known as aeolian tones, named after Aeolus, the god of wind in Greek mythology (www.appalachianheritagealliance.org/wind_harp_links.htm).

In principal, the wind harp is very simple. A number of strings are placed over a sound chamber and the wind causes the strings to vibrate and produce a sound. Wind velocity is directly related to the pitch heard by the listener; the greater the wind speed, the higher the activated overtone. The resulting tones have a shimmering, ringing quality.

The sound room is designed to engage the public in exploring wind phenomena and the sonic experience of wind. This interactive intervention attunes the listener's ears to the orchestration of the Squamish winds.

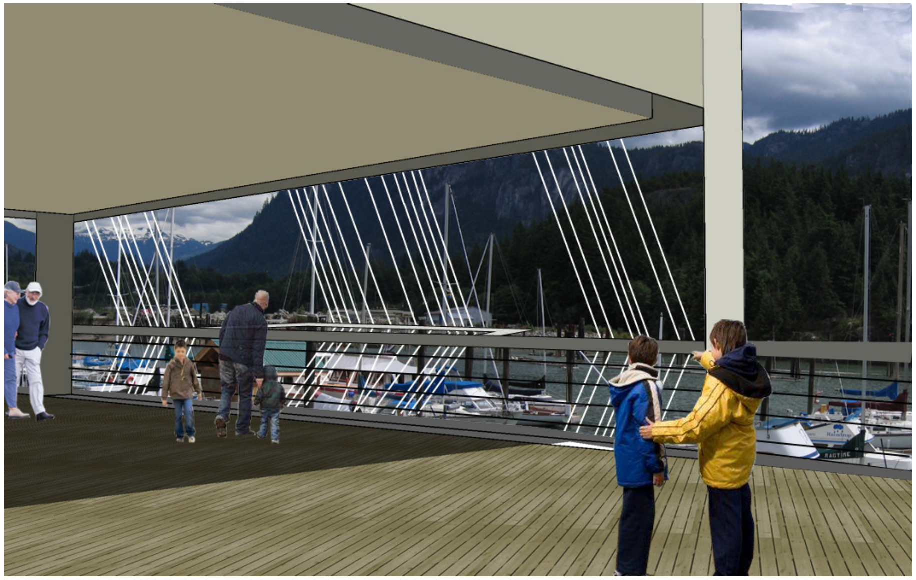


illustration 6.29: Aeolian harp in the sound room.

6.11 More ways to integrate wind

"Green Beer"

Building on the idea of "green tourism", the wind energy project in Squamish may attract tourism-connected enterprises to join the project. For example the Howe Sound Brewery located across the street from the proposed NCC, may brew their beer using 100% wind energy.

illustration 6.30: the Howe Sound Brewery sign

illustration 6.31: the Howe Sound Brewery sign with the addition of wind turbines

Annual Kite Festival

As a community event, Squamish may propose an annual kite festival that attracts people from all over to celebrate the wind by participating in synchronized kite flying. The kite festival could happen in a number of places in the downtown. The photo below proposes the Squamish Beach as a potential site for this event. The wind resource is strong, the sky is big and it borders the Howe Sound, allowing boaters, kitesurfers and windsurfers to participate.

illustration 6.32: the Squamish Beach

illustration 6.33: what a kite festival might look like

Buoyed Light Installation on the waterfront

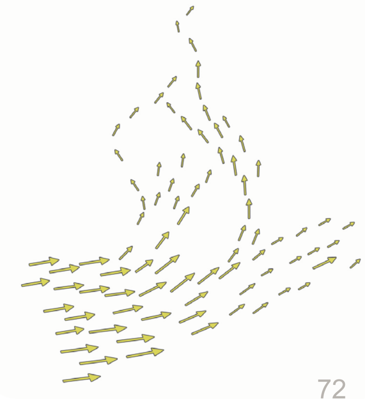
Lights on buoys use energy from the wind to create an interesting night time wind-related experience. The images below demonstrate how the tides generate electricity to power lights that appear to be 'dancing' on the water.

illustration 6.34: existing waterfront

illustration 6.35: waterfront with light installation

illustration 6.36: waterfront with light installation at night

conclusions



conclusions

The Squamish Wind Energy Project and design proposal for the NCC builds upon and is supported by the results from the Smartgrowth on the Ground design charrette- working towards a dynamic and innovative area with an attractive mix of activities and live-work opportunities with sustainable energy operating on many scales. Known as the "recreational capital of BC", the town of Squamish is interested in supplementing recreational tourism with "green" tourism. The turbines on Alice Ridge, coupled with the experience of the proposed NCC, begins this notion of integrating ideas for "green" tourism and promoting a more sustainable culture (see appendices section for more ideas).

The conclusions drawn from this research can be applied on two levels and, therefore, are presented in two sections. Section A discusses findings specific to the wind energy project and design proposal for the NCC. Section B is a list of larger design recommendations/implications for the redevelopment of downtown Squamish.

A. the Natural Capital Centre

Demonstrating sustainable thought and action in Squamish is not achieved solely by placing wind turbines on Alice Ridge, rather it is achieved through the exploration of the question, "What makes a meaningful and educational place, connecting people to the larger environment?" in the context of "How can public places demonstrate stewardship of the natural resources that sustain us?" The framework proposed in Section 2 begins to answer these questions through an understanding of the relationship that exists between 1) Renewable Energy and People and 2) Renewable Energy and Place.

1) Renewable Energy and People

The framework defines seven design principles that suggest ways in which people understand environmental information, learn about renewable energy and become sensitized to the unique environmental forces around them. These principles are listed along with a description of how they are integrated in the design response of the NCC:

PRINCIPLE	DESIGN RESPONSE
DEMONSTRATION	Energy generated by the urban turbines on Turbine pier is directly used in the NCC demonstrating, rather than showcasing, the use of environmentally sustainable technologies in the everyday world. Additionally, the Wind Energy Research and Education Centre will serve to promote the diffusion of renewables with displays and information about implementing wind energy in your backyard or community.
INTERACTIVE INTERPRETATION	The metaphor of how wind moves through the Howe Sound serves to inform people about the strong environmental force of wind in Squamish. Maps and/or interpretive signage may be used to convey these details and information about the small and large turbines operating in Squamish.
SYMBOLISM	The turbines, large and small, willl be highly visible and well-integrated into the public realm. This infrastructure serves as a “green” icon for the town of Squamish. Furthermore, the development of green technology in Squamish may influence sustainable redevelopment of other small communities in BC.
EMPHASIS ON UNIQUENESS OF PLACE	Detailed wind inventory and site analysis resulted in a design that is speciifc to Squamish, responding to local climate, the urban condition, prominent views, local plants, color and materials of downtown Squamish. The proposed design also responds to community programs and activities, as well as engages visitor’s in a number of “windy” experiences that evoke powerful memories of this place.
EXPERIENCE	The addition of large and small scale renewable energy in the public realm will add to the experience of downtown Squamish. The waterfront trail along the Mamquam Blind Channel allows people to explore downtown on foot or by bicycle. Traveller’s are lead through the NCC on the waterfront trail, combining recreational opportunities with green tourism. The mix of rich, experiential activities in the NCC include the wind energy education centre, restaurant, performance centre, retail shops, Turbine pier, Pier plaza, the view tower and, most importantly, the wind itself.
REVELATORY DESIGN	Using large swaths of long, flowing grass and trembling aspen trees throughout the NCC reveals the direction of the wind, making sense of this unseen force. The proposed interventions in section 6.1 heighten the sensory experience of the Squamish winds.
ENERGY EFFICIENCY	Bioclimatic architecture and wind energy systems reduce the energy footprint and extend the use of outdoor spaces in the NCC. Integrating climate responsiveness in the the design of the NCC demonstrates environmental awareness and increases thermal comfortability for user’s.

2) RE and Place

The design proposal for the NCC is specific to Squamish and strengthens a ‘sense of place’ in the following ways:

- the building scheme and programming respond to specific, local wind data.
- the programming of exterior spaces accomodates community activities, while providing rich experiences for visitor’s.
- the design integrates local color and materials.
- the view tower offers opportunities to climb above the “valley room” to further understand the context of this place.
- the design celebrates wind as part of the town’s story.
- the concepts reinforce the identity of Squamish as the “birthplace of the great winds.”

B. recommendations for the redevelopment of downtown Squamish

The ideas described and illustrated in this report are proposed for the NCC, however, the intention is to demonstrate these concepts as a way to start a larger of discussion as to how wind may be integrated in the redevelopment of downtown. The wind is one of many layers to be considered in the urban design vision for Squamish, contributing to the overall goal of creating a unique, differentiated and vibrant downtown core. The following principles are distilled from the proposed NCC and may be applied more generally to the downtown:

- design with environmental sensitivity (explicitly with wind in mind).
- provide opportunities to experience and protection from the Squamish winds.
- celebrate the wind as part of the town’s story in creative ways as well as practical ways.
- build places that accomodate tourism and educational opportunities, but also function as community amenities.
- connect the NCC to the water and it’s surroundings
- maintain the major views from the Centre that situate the NCC in the region.
- integrate visible renewable energy into new and retro-fitted buildings.

In summary, the design proposal for the NCC does weave cultural aspects of Squamish with the tangible physical force of the wind. The NCC and the windfarm will have a strong presence, however, when considered in the context of the redevelopment of downtown, they may be part of a larger series of design interventions that contribute to the unique experience of Squamish.

"BC Sustainable Energy Association" <http://www.bcsea.org/>.

Brown, G.Z. 1985. Sun, Wind and Light: Architectural Design Strategies. New York: John Wiley and Sons, Inc.

Brown, G.Z. and B.J. Novitski. 1983. Modifying the sun and wind to create favorable microclimates. Proc. of International Conf. on Passive and Low Energy Architecture. Chania, Crete, Greece.

Brown, G.Z. and B.J. Novitski. 1985b. Access to the sun and wind: the formation of public spaces in the city. Proc. of the Biennial Congress of the International Soalr Energy Society. Montreal, Canada.

Burton, A.C. and O.G. Edholm. 1955. Man in a Cold Environment. London: Edward Arnold (Publishers) Ltd.

"CANWEA: Canadian Wind Association" < http://www.canwea.ca/>

"CapeWind" <http://www.capewind.org/index.php>.

Collett, S. (1995). Wind farms and public opinion. NEW Review, The Magazine of New and Renewable Energy, Issue 25, May, p. 14-15

"Contemporary Aesthetics" <http://www.contempaesthetics.org>.

DeBlieu, Jan. Wind: How the Flow of Air Has Shaped Life, Myth and the Land. Boston: Houghton Mifflin Company, 1998.

Design Centre for Sustainability at UBC. Smart Growth on the Ground: Squamish. Prepared in April, 2005.

Ferber, R. (1977). Public reactions to wind energy devices. National Science Foundation and US Dept. of Energy, October.

Gipe, Paul. Wind Energy Basics. Vermont: Chelsea Green Publishing Company, 1999.

Gipe, Paul. Wind Energy Comes of Age. New York: John Wiley & Sons, 1995.

Gipe, P. (1993) The wind industry's experience with aesthetic criticism. Leonardo, 26, 243-248.

Hadrian, D.R., Bishop, I.D. and Mitcheltree, R. (1988) Automated mapping of visual impacts in utility corridors. Landscape and Urban Planning, 16, 261-283.

"Indicators of Climate Change for British Columbia 2002 Environmental Protection Division, Ministry of Environment" <http://www.env.gov.bc.ca/air/climate/indicat/index.html>

Kaplan, R. (1985) The analysis of perception via preference: a strategy for studying how the environment is experienced. Landscape Planning, 12, 161-176.

Kaplan, Rachel, Stephen Kaplan and Robert L. Ryan. With People in Mind: Design and Management of Everyday Nature.
Washington, D.C. : Island Press, 1998.

Lange, Owen S. and Environment Canada. The Wind Came All Ways: a quest to understand the winds, waves and weather in the Georgia Basin
Printed in Canada 1999

Louw, (ed.). Comparison of contemporary architectural thought. London: Routledge, 259-261.

Lyle, John. Design for Human Ecosystems. New York: Van Nostrand Reinhold, 1985.

Lynch, K. and G. Hack. 1984. Site Planning, 3rd ed. Cambridge, MA and London, England: MIT Press.

Melaragno, Michele, G. Wind In Architectural and Environmental Design. Cincinnati, New York: Van Nostrand Reinhold Company, 1982.

Nasar, J.L. (1988) Environmental aesthetics: theory, research and applications. Cambridge: Cambridge University Press.

Nielson, Frode Birk. Wind Turbines & the Landscape: Architecture & Aesthetics. Arhus, Denmark: Birk Nielsens Tegnestue, 1996.

Olgyay, V. 1963. Design with Climate. Princeton, NJ: Princeton Univ. Press.

“Our Shared Landscape: Integrating Ecological, Socio-Economic and Aesthetic Aspects in Landscape Planning and Management” <http://osl.ethz.ch/frames/frameConfInfo.htm>.

Parfit, Micheal. “Future Power: Where will the world get its next energy fix?” National Geographic. August, 2005.

Pasqualetti, Martin J., Paul Gipe and Robert W. Righter. Wind Power in View: Energy Landscapes in a Crowded World. San Diego: Academic Press, 2002.

“Quietrevolution” < http://www.quietrevolution.co.uk/qr5.htm>.

Ruano, Miguel. ECOURBANISM- Sustainable Human Settlements: 60 Case Studies. Editorial Gustavo Gili, SA, Barcelona, 1999.

“Sea Breeze Power Corp.” < http://www.seabreezepower.com/>.

Spirn, Anne Whiston. The Granite Garden: Urban Nature and Human Design. Basic Books, Inc., Publishers. New York, 1984.

“Squamish Windsports Society” <http://www.squamishwindsurfing.org>.

“Stockholm Environment Institute” <http://www.sei.se/atmosphere/overview.html>.

Swaffield, Simon. Theory in Landscape Architecture. Philadelphia: University of Philadelphia Press, 2002.

Thayer, Robert Jr., Gray World, Green Heart. New York: John Wiley, 1994.

Thayer, Robert L., Jr. 1989. “The Experience of Sustainable Landscapes.” Landscape Journal 8(2): 101-110.

Thayer, R.L. and Freeman, C.M. (1987) Altamount: public perception of a wind energy landscape. Landscape and Urban Planning, 14, 379-398.

Thayer, R. and Hansen, H. “Wind on the Landscape.” Landscape Architecture 78, No. 2: 68-75.

“The Beauty of Windfarms” <http://www.newscientist.com/channel/opinion/mg18624956.400>.

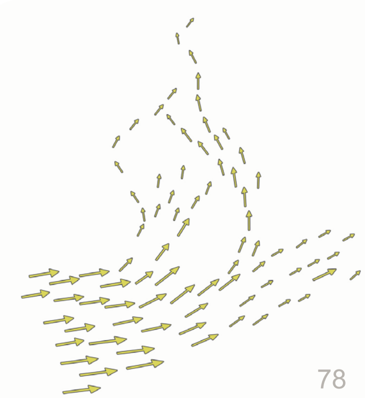
Tuan, Yi-Fu. Topophilia: A Study of Environmental Perceptions, Attitudes, and Values. New York: Columbia University Press, 1974.

Van Der Ryn, Sim and Stuart Cowan. Ecological Design. Washington, D.C.: Island Press, 1996.

“Wind Harp Links” <www.appalachianheritagealliance.org/wind_harp_links.htm>.

appendices

indicators of climate change for British Columbia 2002
facts about urban turbines and small wind



Indicators of Climate Change for British Columbia 2002

Environmental Protection Division, Ministry of Environment
http://www.env.gov.bc.ca/air/climate/indicat/index.html

Both the UN Intergovernmental Panel on Climate Change and the US National Academy of Science have concluded that the global atmosphere is warming. They agree, moreover, that most of the warming observed over the last 50 years can be attributed to human activities that release greenhouse gases into the atmosphere. British Columbia, for example, produced almost 16 tonnes of greenhouse gases per person in 1999, most through the burning of fossil fuels for transportation and industrial activity.

Atmospheric warming affects other parts of the climate system, including precipitation, air, wind and ocean currents, cloud cover, and the hydrological cycle. Climate change in turn affects other closely related physical systems, as well as biological systems, and the human communities that depend on these systems.

This report documents how the climate in British Columbia changed during the 20th century and the rates at which these changes occurred. It outlines the potential impacts of these changes on freshwater, marine, and terrestrial ecosystems and on human communities. It describes how climate change is likely to affect the province during the 21st century.

Past Impacts

Analysis of historical data indicates that many properties of climate have changed during the 20th century, affecting marine, freshwater, and terrestrial ecosystems in British Columbia.

- Average annual temperature warmed by 0.6ºC on the coast, 1.1ºC in the interior, and 1.7ºC in northern BC.
- Night-time temperatures increased across most of BC in spring and summer.
- Precipitation increased in southern BC by 2 to 4 percent per decade.
- Lakes and rivers become free of ice earlier in the spring.
- Sea surface temperatures increased by 0.9ºC to 1.8ºC along the BC coast.
- Sea level rose by 4 to 12 centimetres along most of the BC coast.
- Two large BC glaciers retreated by more than a kilometre each.
- The Fraser River discharges more of its total annual flow earlier in the year.
- Water in the Fraser River is warmer in summer.
- More heat energy is available for plant and insect growth.

Future Impacts

Climate models and scenarios suggest that the climate in British Columbia will continue to change during the 21st century. This will have ongoing impacts on ecosystems and communities.

- Average annual temperature in BC may increase by 1ºC to 4ºC.
- Average annual precipitation may increase by 10 to 20 percent.
- Sea level may rise by up to 88 centimetres along parts of the BC coast.
- Many small glaciers in southern BC may disappear.
- Some interior rivers may dry up during the summer and early fall.
- Salmon migration patterns and success in spawning are likely to change.
- The mountain pine beetle — an important pest — may expand its range.

The indicators presented in this report document some of the changes that have occurred during the past century. Many more potential indicators remain to be explored. For example, climate change may influence the frequency of extreme weather events, the extent of permafrost, ecosystem structures and processes, and species distribution and survival. It may affect provincial infrastructure, forestry, energy and other industries, insurance and other financial services, and human settlements. In addition, the impacts may vary from one region, ecosystem, species, industry, or community to the next. Research into the regional impacts of climate change is ongoing, and this report is therefore designed to be updated and expanded as new information becomes available.

RESPONDING TO CLIMATE CHANGE

The impacts of climate change on British Columbians will depend on the time, the place, and the individual. For example, homeowners may see a warmer climate as a benefit if it means lower home heating bills. Resort operators may see it as a cost if it means a shorter ski season. Farmers may see it as a benefit if it allows them to introduce new crops, and as a cost if it increases the need for irrigation. Overall, however, the risk of negative impacts increases with the magnitude of climate change.

Much attention has been paid over the last decades to slowing down the rate of climate change by reducing greenhouse gas emissions. Success in this area has been mixed. In BC, for example, total emissions actually increased by more than 20 percent between 1990 to 1999 as the population of the province grew. Even if mitigation efforts are successful in reducing greenhouse gas emissions, they cannot prevent climate change. The greenhouse gases humans have already added to the atmosphere will likely continue to drive global climate change for centuries to come. British Columbia and other jurisdictions will therefore have to adapt.

Through adaptation, we may be able to reduce some of the adverse impacts of climate change and enhance some of its potential benefits. Adaptation, however, will incur costs. It will probably be easier for human systems than for physical and biological systems to adapt to change. And countries and communities with access to technology, education, information, skills, and resources will be more able to adapt than those without such access.

A greater understanding of climate change trends and impacts is expected to help British Columbians prepare for and adapt to climate change at the same time as the province works to reduce the scale of future impacts through renewable energy, energy efficiency, sustainable transportation, new technology, water conservation, and other sustainable practices.

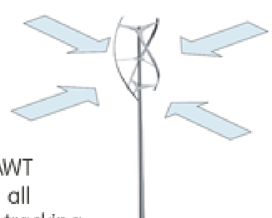
Quiet Revolution Ltd is a wind turbine company in the UK that develops and supplies elegant renewable energy solutions, especially small wind products optimized for use at the point of energy demand.

Source:
http://www.quietrevolution.co.uk/qr5.htm#image

About small wind

Of course, in an urban or built-up environment, some wind turbulence is inevitable unless the turbine is sited well above any surrounding buildings. Most of the time, turbulence from surrounding buildings will affect a wind turbine to some extent. This is the primary reason for opting for a vertical axis wind turbine, as such a design doesn't require wind from a consistent direction to continue producing power. Conversely, a horizontal axis wind turbine has to physically rotate into the wind every time the direction changes, wasting valuable resources.

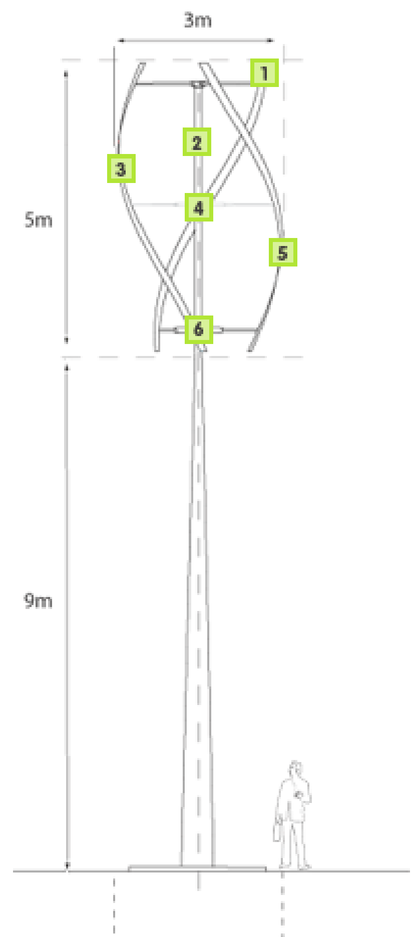
traditional HAWT
has to rotate to track wind



quiet**revolution** VAWT
collects wind from all
directions without tracking

The elegant helical (twisted) design of QR ensures a robust performance even in turbulent winds. It is also responsible for virtually eliminating all noise and vibration.

At five metres high and three metres in diameter, it is compact and easy to integrate, and with just one moving part, maintenance can be limited to an annual inspection.



turbine specifications

Physical dimensions: 5m high x 3.1m in diameter

Illustrative Payback Period:

Average Wind Speed: 5.8m/s

Annual energy generated (kWh): 10,000

Inflation in energy prices: 5%

Annual value generated: £1,827

QR price: £25,000 ($35,390 CAD)

Installation cost: £5000 ($7,078 CAD)

Total cost: £30,000 ($42,468 CAD)

Payback period: 15 years

carbon savings

quietrevolution will also save around .42kg of carbon dioxide per kilowatt hour of energy generated. This would equate to 4,200kg per year or 105,000kg over the design life of the turbine.

technical information

Generator: Direct drive, mechanically integrated,weather sealed 6kW permanent magnet generator

Power control: Peak power tracking constantly optimises turbine output for all sites and windspeeds

Operation mode-
Max wind speed: 16m/s; Min wind speed: 4m/s
Design life: 25 years (annual inspections recommended)

Roof mount- Minimum recommended height above buildings: 3m

Tower mount- Minimum mast height: 9m to bottom of blades.

How much energy does it generate?
The QR5 will generate around 10,000 kWh per year in a good wind site of 5.8m/s average. This is equivalent to five low-energy houses' electricity demand, or the electrical needs of a twenty man office (i.e. lights, computers, servers, printers, faxes and phones)

How are the turbines manufactured?
The turbines are predominantly manufactured and assembled in the UK. The blades and connection arms are made of carbon fibre and epoxy resin, optimised for strength and weight.

What wind speeds will it operate in?
Start-up wind speed is 4.5 metres per second, maximum is 16 m/s above which it will automatically shut down.

Is there a risk of birdstrike?
This is a problem that has most commonly beset large, horizontal axis turbines. The reason is that birds are not equipped to gauge whether they are on a collision path with a rotating blade. Vertical axis blades usually spin faster than horizontal axis blades, and the blurring this creates reduces the risk that birds in flight will collide with the blades.